

# MMBT4401L, SMMBT4401L

## Switching Transistor

### NPN Silicon

#### 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

#### 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) @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	225 1.8	mW mW/ $^\circ\text{C}$
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	556	$^\circ\text{C}/\text{W}$
Total Device Dissipation Alumina Substrate (Note 2) @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	300 2.4	mW 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.

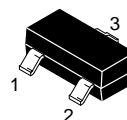
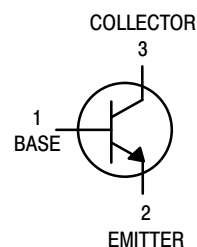
\*Transient pulses must not cause the junction temperature to be exceeded.

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.



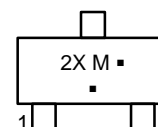
ON Semiconductor®

[www.onsemi.com](http://www.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 SMMBT4401LT1G	SOT–23 (Pb–Free)	3000 / Tape & Reel
MMBT4401LT3G	SOT–23 (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.

# MMBT4401L, SMMBT4401L

## 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) ( $I_C = 1.0\text{ mAdc}$ , $I_B = 0$ )	$V_{(BR)CEO}$	40	–	Vdc
Collector–Base Breakdown Voltage ( $I_C = 0.1\text{ mAdc}$ , $I_E = 0$ )	$V_{(BR)CBO}$	60	–	Vdc
Emitter–Base Breakdown Voltage ( $I_E = 0.1\text{ mAdc}$ , $I_C = 0$ )	$V_{(BR)EBO}$	6.0	–	Vdc
Base Cutoff Current ( $V_{CE} = 35\text{ Vdc}$ , $V_{EB} = 0.4\text{ Vdc}$ )	$I_{BEV}$	–	0.1	$\mu\text{A}$ dc
Collector Cutoff Current ( $V_{CE} = 35\text{ Vdc}$ , $V_{EB} = 0.4\text{ Vdc}$ )	$I_{CEX}$	–	0.1	$\mu\text{A}$ dc

## ON CHARACTERISTICS (Note 3)

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

## SMALL–SIGNAL CHARACTERISTICS

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

## SWITCHING CHARACTERISTICS

Delay Time	( $V_{CC} = 30\text{ Vdc}$ , $V_{EB} = 2.0\text{ Vdc}$ , $I_C = 150\text{ mAdc}$ , $I_{B1} = 15\text{ mAdc}$ )	$t_d$	–	15	ns
Rise Time		$t_r$	–	20	
Storage Time	( $V_{CC} = 30\text{ Vdc}$ , $I_C = 150\text{ mAdc}$ , $I_{B1} = I_{B2} = 15\text{ mAdc}$ )	$t_s$	–	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  $\leq 300\ \mu\text{s}$ , Duty Cycle  $\leq 2.0\%$ .

## SWITCHING TIME EQUIVALENT TEST CIRCUITS

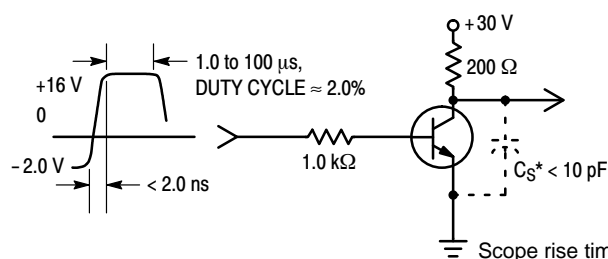


Figure 1. Turn–On Time

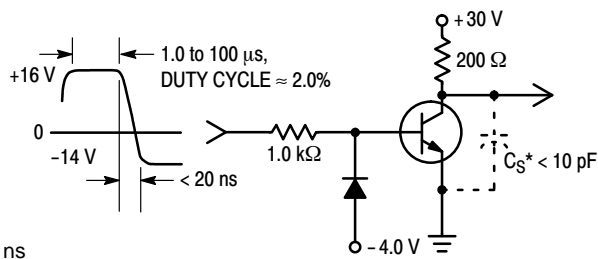


Figure 2. Turn–Off Time

# MMBT4401L, SMMBT4401L

## TRANSIENT CHARACTERISTICS

— 25°C    - - - 100°C

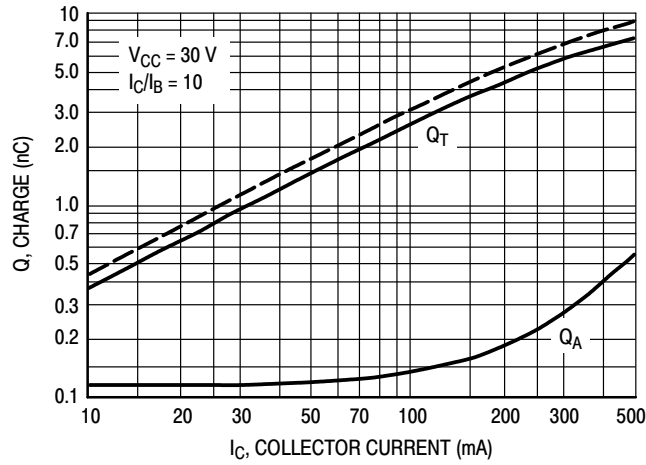


Figure 3. Charge Data

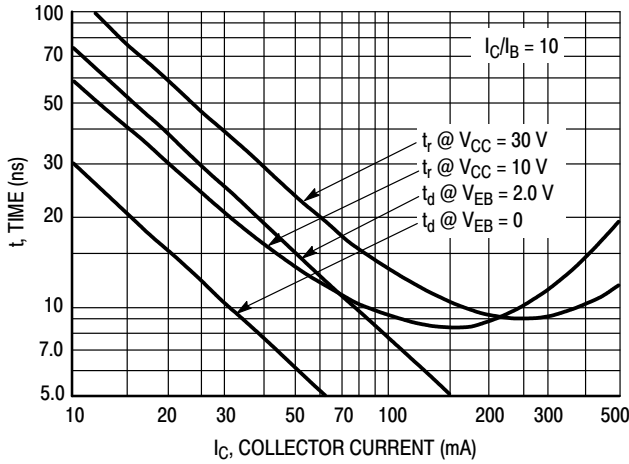


Figure 4. Turn-On Time

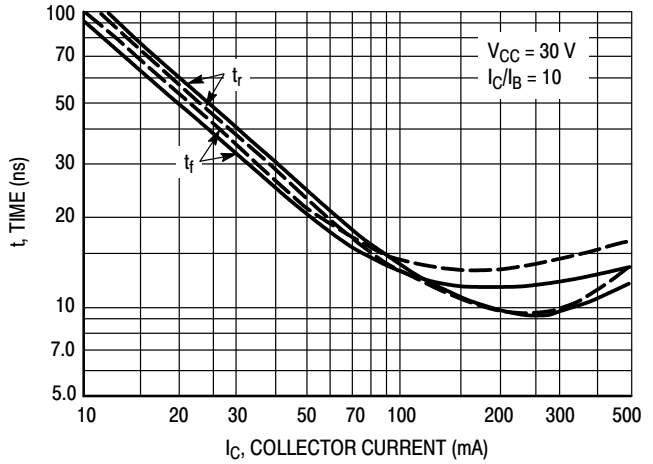


Figure 5. Rise and Fall Times

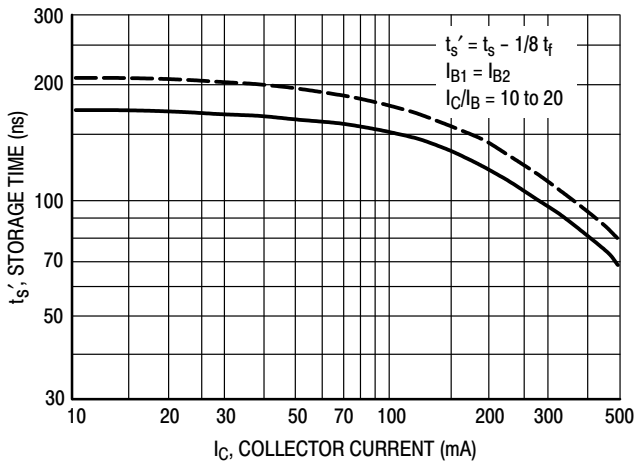


Figure 6. Storage Time

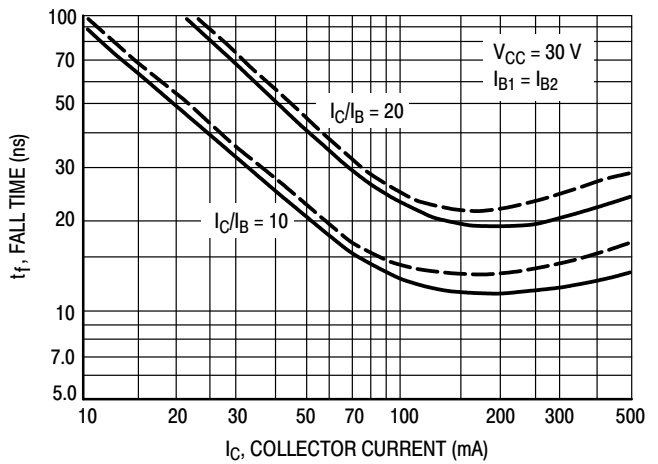


Figure 7. Fall Time

# MMBT4401L, SMMBT4401L

## SMALL-SIGNAL CHARACTERISTICS NOISE FIGURE

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

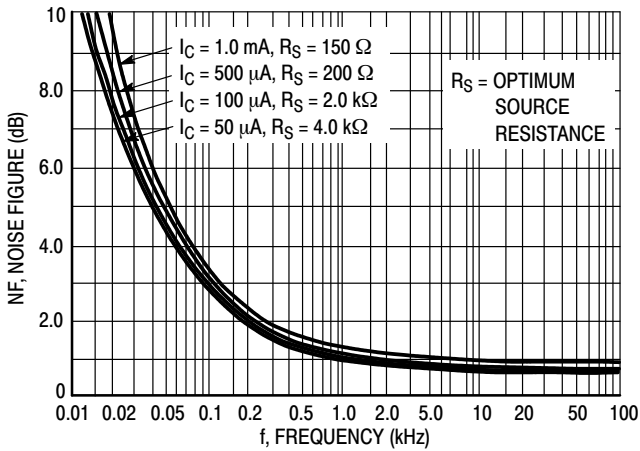


Figure 8. Frequency Effects

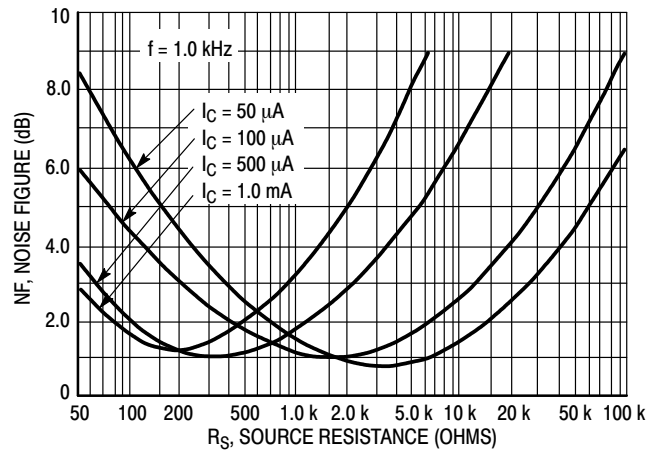


Figure 9. Source Resistance Effects

## 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.

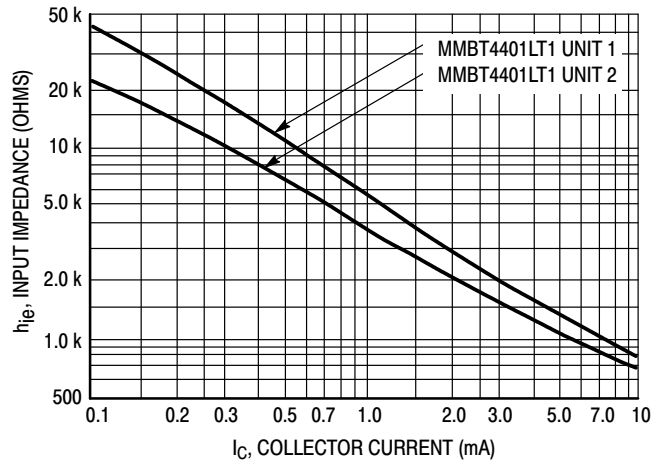


Figure 10. Input Impedance

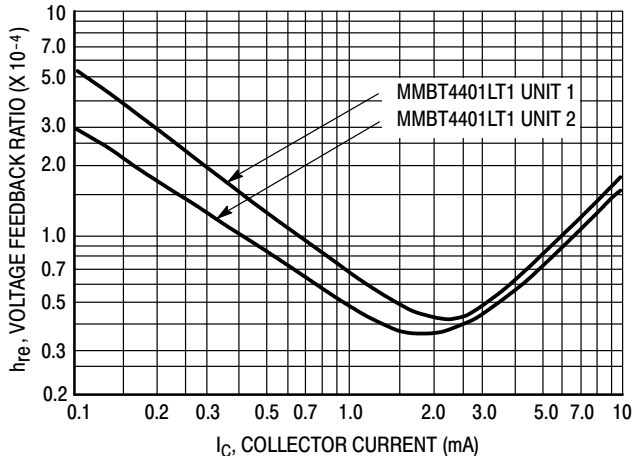


Figure 11. Voltage Feedback Ratio

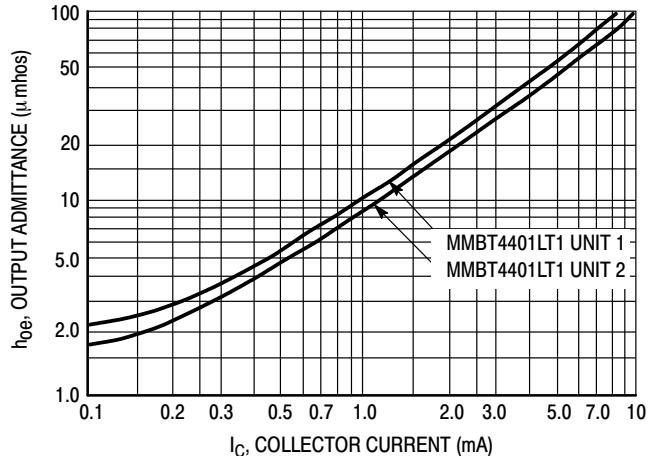


Figure 12. Output Admittance

# MMBT4401L, SMMBT4401L

## STATIC CHARACTERISTICS

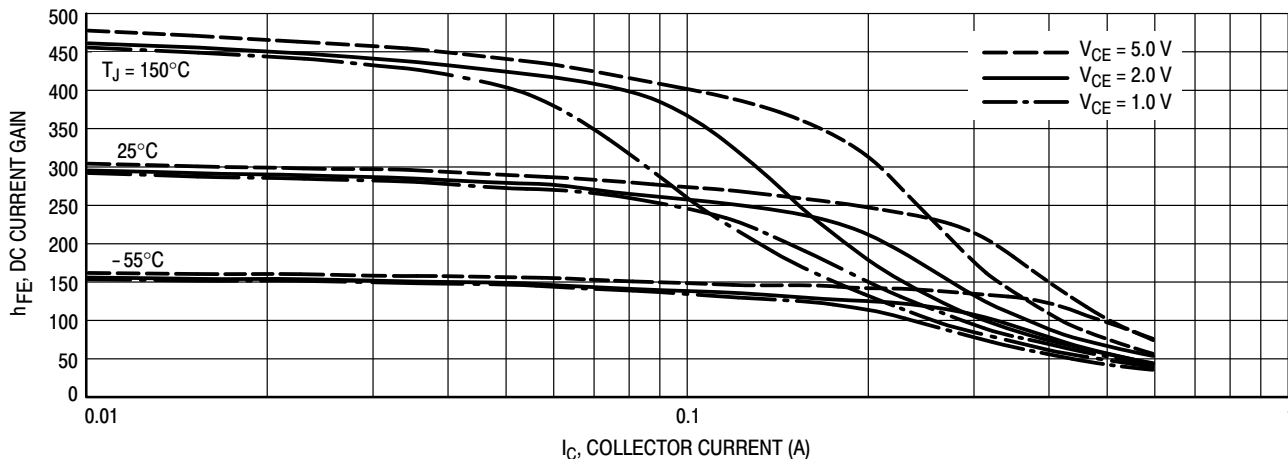


Figure 13. DC Current Gain

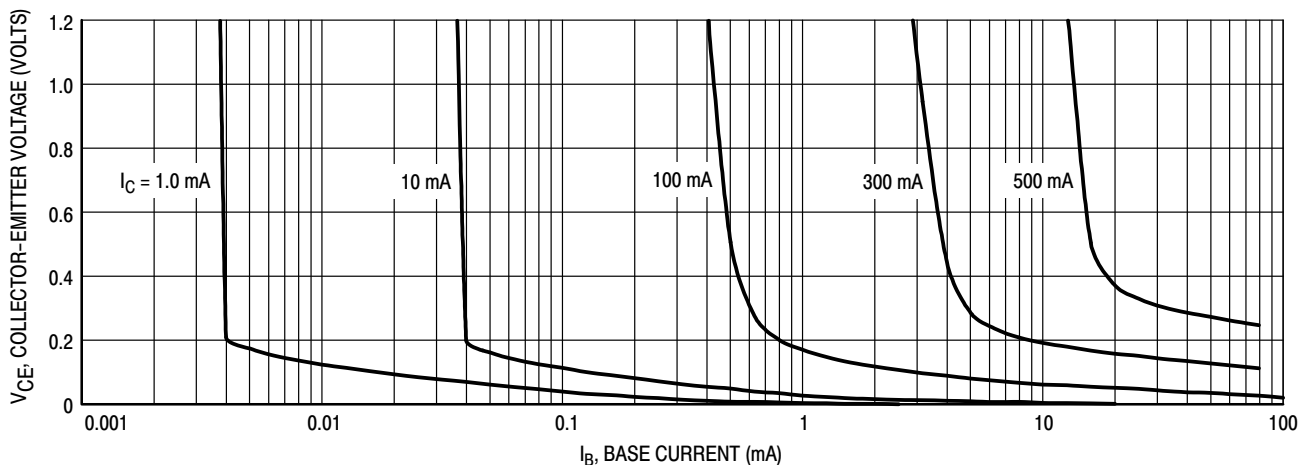


Figure 14. Collector Saturation Region

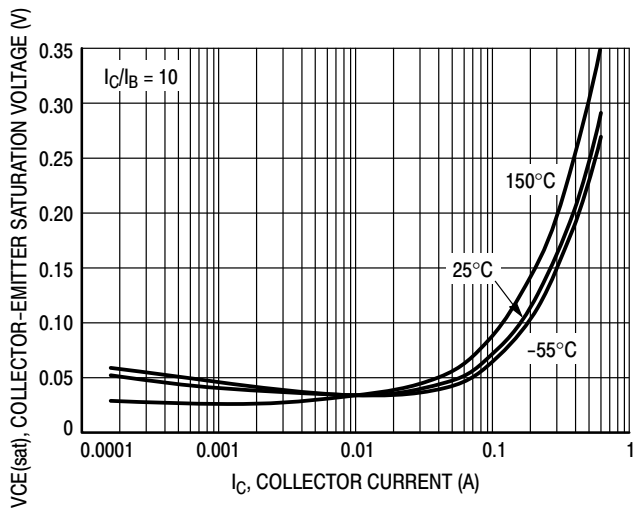


Figure 15. Collector-Emitter Saturation Voltage vs. Collector Current

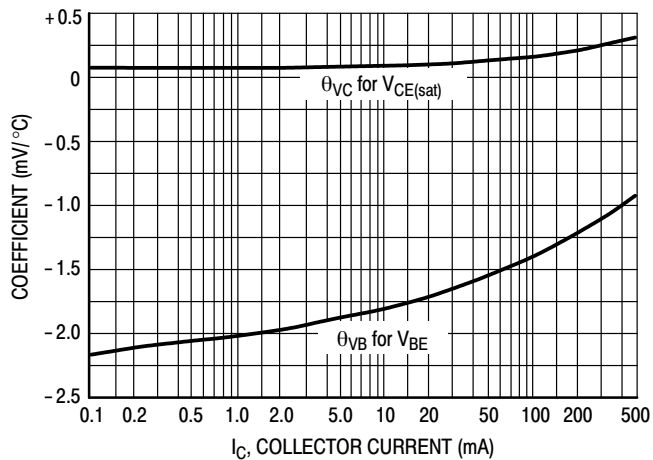
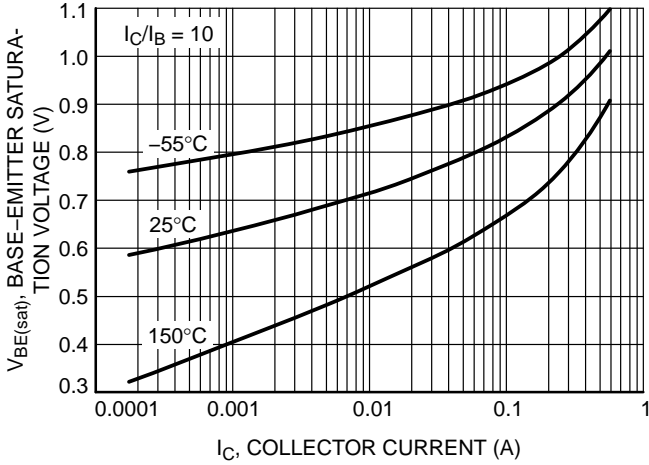


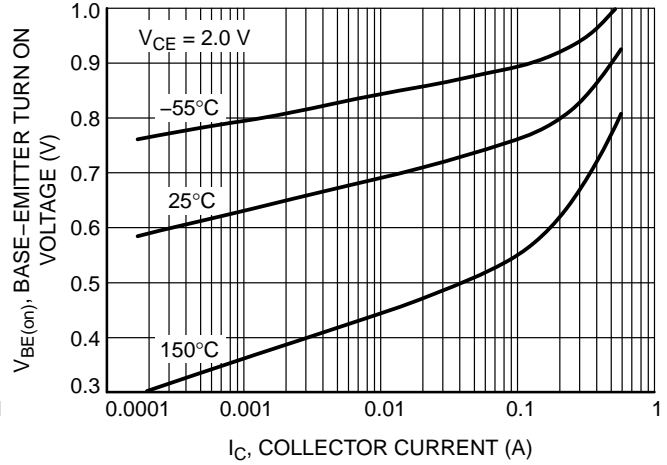
Figure 16. Temperature Coefficients

# MMBT4401L, SMMBT4401L

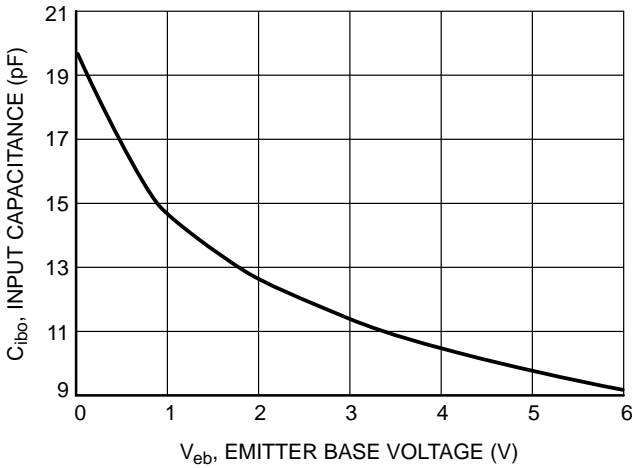
## STATIC CHARACTERISTICS



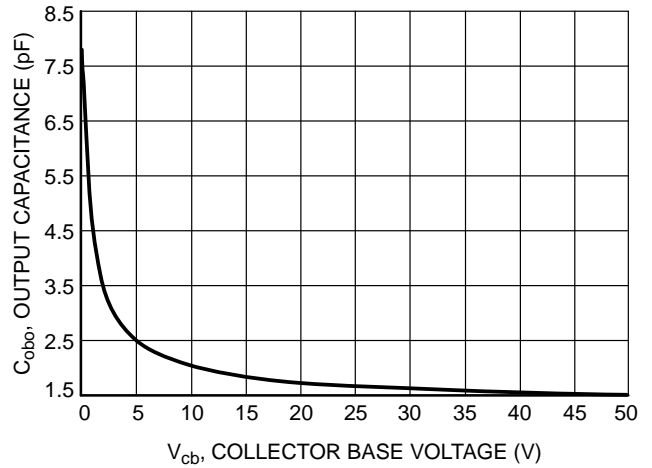
**Figure 17. Base-Emitter Saturation Voltage vs. Collector Current**



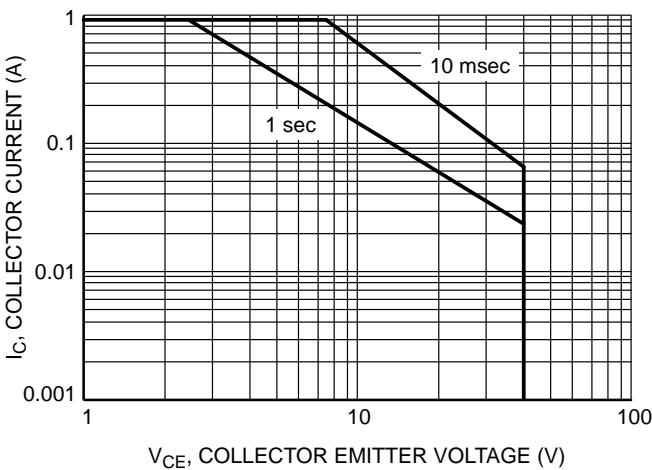
**Figure 18. Base-Emitter Turn On Voltage vs. Collector Current**



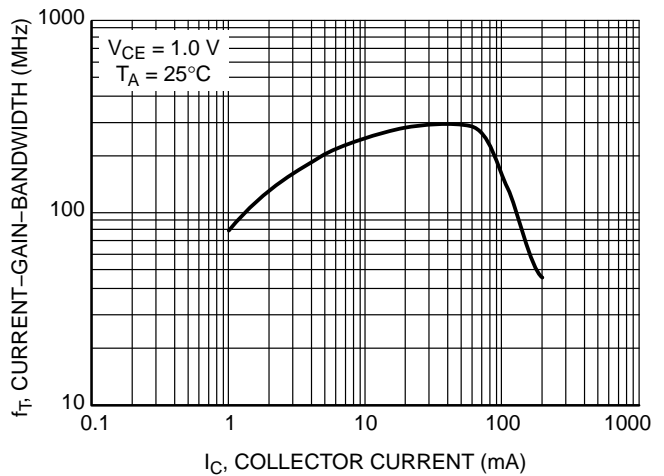
**Figure 19. Input Capacitance vs. Emitter Base Voltage**



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



**Figure 21. Safe Operating Area**



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

# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



**SOT-23 (TO-236)**  
CASE 318  
ISSUE AT

DATE 01 MAR 2023

SCALE 4:1



**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M,1994.
2. CONTROLLING DIMENSION: 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.

DIM	MILLIMETERS			INCHES		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.89	1.00	1.11	0.035	0.039	0.044
A1	0.01	0.06	0.10	0.000	0.002	0.004
b	0.37	0.44	0.50	0.015	0.017	0.020
c	0.08	0.14	0.20	0.003	0.006	0.008
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	0.080
L	0.30	0.43	0.55	0.012	0.017	0.022
L1	0.35	0.54	0.69	0.014	0.021	0.027
H <sub>E</sub>	2.10	2.40	2.64	0.083	0.094	0.104
T	0°	---	10°	0°	---	10°

**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.



**RECOMMENDED MOUNTING 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.

**STYLES ON PAGE 2**

<b>DOCUMENT NUMBER:</b>	<b>98ASB42226B</b>	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.
<b>DESCRIPTION:</b>	<b>SOT-23 (TO-236)</b>	<b>PAGE 1 OF 2</b>

onsemi and ONSEMI are trademarks of Semiconductor Components Industries, LLC dba onsemi or its subsidiaries in the United States and/or other countries. onsemi reserves the right to make changes without further notice to any products herein. onsemi makes no warranty, representation or guarantee regarding the 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. onsemi does not convey any license under its patent rights nor the rights of others.

**MECHANICAL CASE OUTLINE**  
**PACKAGE DIMENSIONS**



**SOT-23 (TO-236)**  
**CASE 318**  
**ISSUE AT**

DATE 01 MAR 2023

- |   |   |   |   |   |   |
|---|---|---|---|---|---|
| STYLE 1 THRU 5:<br>CANCELLED                            | STYLE 6:<br>PIN 1. BASE<br>2. EMITTER<br>3. COLLECTOR | STYLE 7:<br>PIN 1. EMITTER<br>2. BASE<br>3. COLLECTOR       | STYLE 8:<br>PIN 1. ANODE<br>2. NO CONNECTION<br>3. CATHODE  |   |   |
| STYLE 9:<br>PIN 1. ANODE<br>2. ANODE<br>3. CATHODE      | STYLE 10:<br>PIN 1. DRAIN<br>2. SOURCE<br>3. GATE     | STYLE 11:<br>PIN 1. ANODE<br>2. CATHODE<br>3. CATHODE-ANODE | STYLE 12:<br>PIN 1. CATHODE<br>2. CATHODE<br>3. ANODE       | STYLE 13:<br>PIN 1. SOURCE<br>2. DRAIN<br>3. GATE           | STYLE 14:<br>PIN 1. CATHODE<br>2. GATE<br>3. ANODE          |
| STYLE 15:<br>PIN 1. GATE<br>2. CATHODE<br>3. ANODE      | STYLE 16:<br>PIN 1. ANODE<br>2. CATHODE<br>3. CATHODE | STYLE 17:<br>PIN 1. NO CONNECTION<br>2. ANODE<br>3. CATHODE | STYLE 18:<br>PIN 1. NO CONNECTION<br>2. CATHODE<br>3. ANODE | STYLE 19:<br>PIN 1. CATHODE<br>2. ANODE<br>3. CATHODE-ANODE | STYLE 20:<br>PIN 1. CATHODE<br>2. ANODE<br>3. GATE          |
| STYLE 21:<br>PIN 1. GATE<br>2. SOURCE<br>3. DRAIN       | STYLE 22:<br>PIN 1. RETURN<br>2. OUTPUT<br>3. INPUT   | STYLE 23:<br>PIN 1. ANODE<br>2. ANODE<br>3. CATHODE         | STYLE 24:<br>PIN 1. GATE<br>2. DRAIN<br>3. SOURCE           | STYLE 25:<br>PIN 1. ANODE<br>2. CATHODE<br>3. GATE          | STYLE 26:<br>PIN 1. CATHODE<br>2. ANODE<br>3. NO CONNECTION |
| STYLE 27:<br>PIN 1. CATHODE<br>2. CATHODE<br>3. CATHODE | STYLE 28:<br>PIN 1. ANODE<br>2. ANODE<br>3. ANODE     |   |   |   |   |

<b>DOCUMENT NUMBER:</b>	<b>98ASB42226B</b>	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.
<b>DESCRIPTION:</b>	<b>SOT-23 (TO-236)</b>	<b>PAGE 2 OF 2</b>

**onsemi** and **ONSEMI** are trademarks of Semiconductor Components Industries, LLC dba **onsemi** or its subsidiaries in the United States and/or other countries. **onsemi** reserves the right to make changes without further notice to any products herein. **onsemi** makes no warranty, representation or guarantee regarding the 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. **onsemi** does not convey any license under its patent rights nor the rights of others.



**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](http://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.

## PUBLICATION ORDERING INFORMATION

### LITERATURE FULFILLMENT:

Email Requests to: [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

**onsemi Website:** [www.onsemi.com](http://www.onsemi.com)

### TECHNICAL SUPPORT

**North American Technical Support:**

Voice Mail: 1 800-282-9855 Toll Free USA/Canada

Phone: 011 421 33 790 2910

**Europe, Middle East and Africa Technical Support:**

Phone: 00421 33 790 2910

For additional information, please contact your local Sales Representative