MMUN2211LT1 Series

Preferred Devices

Bias Resistor Transistor

NPN Silicon Surface Mount Transistor with Monolithic Bias Resistor Network

This new series of digital transistors is designed to replace a single device and its external resistor bias network. The BRT (Bias Resistor Transistor) contains a single transistor with a monolithic bias network consisting of two resistors; a series base resistor and a base-emitter resistor. The BRT eliminates these individual components by integrating them into a single device. The use of a BRT can reduce both system cost and board space. The device is housed in the SOT-23 package which is designed for low power surface mount applications.

- Simplifies Circuit Design
- Reduces Board Space and Component Count
- The SOT-23 package can be soldered using wave or reflow. The modified gull-winged leads absorb thermal stress during soldering eliminating the possibility of damage to the die.
- Available in 8 mm embossed tape and reel. Use the Device Number to order the 7 inch/3000 unit reel. Replace "T1" with "T3" in the Device Number to order the13 inch/10,000 unit reel.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector Current	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C (Note 1.) Derate above 25°C	P_D	200 1.6	mW mW/°C

DEVICE MARKING AND RESISTOR VALUES

Device	Marking	R1(K)	R2(K)
MMUN2211LT1	A8A	10	10
MMUN2212LT1	A8B	22	22
MMUN2213LT1	A8C	47	47
MMUN2214LT1	A8D	10	47
MMUN2215LT1	A8E	10	∞
MMUN2216LT1	A8F	4.7	∞
MMUN2230LT1	A8G	1.0	1.0
MMUN2231LT1	A8H	2.2	2.2
MMUN2232LT1	A8J	4.7	4.7
MMUN2233LT1	A8K	4.7	47
MMUN2234LT1	A8L	22	47
MMUN2235LT1	A8M	2.2	47
MMUN2238LT1	A8R	2.2	∞
MMUN2241LT1	A8U	100	∞

1. Device mounted on a FR-4 glass epoxy printed circuit board using the minimum recommended footprint.

ON Semiconductor™

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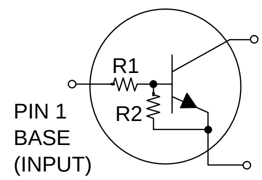
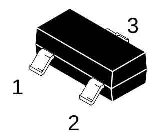
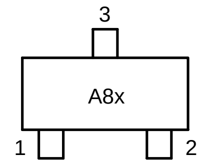




SOT–23
CASE 318
STYLE 6

MARKING DIAGRAM



A8x = Device Code
x = (See Table)

ORDERING INFORMATION

Device	Package	Shipping
MMUN2211LT1	SOT–23	3000/Tape & Reel
MMUN2212LT1	SOT–23	3000/Tape & Reel
MMUN2213LT1	SOT–23	3000/Tape & Reel
MMUN2214LT1	SOT–23	3000/Tape & Reel
MMUN2215LT1	SOT–23	3000/Tape & Reel
MMUN2216LT1	SOT–23	3000/Tape & Reel
MMUN2230LT1	SOT–23	3000/Tape & Reel
MMUN2231LT1	SOT–23	3000/Tape & Reel
MMUN2232LT1	SOT–23	3000/Tape & Reel
MMUN2233LT1	SOT–23	3000/Tape & Reel
MMUN2234LT1	SOT–23	3000/Tape & Reel
MMUN2235LT1	SOT–23	3000/Tape & Reel
MMUN2238LT1	SOT–23	3000/Tape & Reel
MMUN2241LT1	SOT–23	3000/Tape & Reel

Preferred devices are recommended choices for future use and best overall value.

November, 2001 – Rev. 3

Publication Order Number:
MMUN2211LT1/D

THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Resistance – Junction-to-Ambient (surface mounted)	$R_{\theta JA}$	625	°C/W
Operating and Storage Temperature Range	T_J, T_{stg}	–65 to +150	°C
Maximum Temperature for Soldering Purposes, Time in Solder Bath	T_L	260 10	°C Sec

ELECTRICAL CHARACTERISTICS (T$_A$ = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Cutoff Current (V_{CB} = 50 V, I_E = 0)		I_{CBO}	–	–	100	nAdc
Collector-Emitter Cutoff Current (V_{CE} = 50 V, I_B = 0)		I_{CEO}	–	–	500	nAdc
Emitter-Base Cutoff Current (V_{EB} = 6.0 V, I_C = 0)	MMUN2211LT1	I_{EBO}	–	–	0.5	mAdc
	MMUN2212LT1		–	–	0.2	
	MMUN2213LT1		–	–	0.1	
	MMUN2214LT1		–	–	0.2	
	MMUN2215LT1		–	–	0.9	
	MMUN2216LT1		–	–	1.9	
	MMUN2230LT1		–	–	4.3	
	MMUN2231LT1		–	–	2.3	
	MMUN2232LT1		–	–	1.5	
	MMUN2233LT1		–	–	0.18	
	MMUN2234LT1		–	–	0.13	
	MMUN2235LT1		–	–	0.2	
	MMUN2238LT1		–	–	4.0	
	MMUN2241LT1		–	–	0.1	
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)		$V_{(BR)CBO}$	50	–	–	Vdc
Collector-Emitter Breakdown Voltage (Note 2.), (I_C = 2.0 mA, I_B = 0)		$V_{(BR)CEO}$	50	–	–	Vdc
ON CHARACTERISTICS (Note 2.)						
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA)	MMUN2211LT1	h_{FE}	35	60	–	
	MMUN2212LT1		60	100	–	
	MMUN2213LT1		80	140	–	
	MMUN2214LT1		80	140	–	
	MMUN2215LT1		160	350	–	
	MMUN2216LT1		160	350	–	
	MMUN2230LT1		3.0	5.0	–	
	MMUN2231LT1		8.0	15	–	
	MMUN2232LT1		15	30	–	
	MMUN2233LT1		80	200	–	
	MMUN2234LT1		80	150	–	
	MMUN2235LT1		80	140	–	
	MMUN2238LT1		160	350	–	
	MMUN2241LT1		160	350	–	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.3 mA) (I_C = 10 mA, I_B = 5 mA) MMUN2230LT1/MMUN2231LT1 (I_C = 10 mA, I_B = 1 mA) MMUN2215LT1/MMUN2216LT1 MMUN2232LT1/MMUN2233LT1/MMUN2234LT1/ MMUN2235LT1/MMUN2238LT1		$V_{CE(sat)}$	–	–	0.25	Vdc

2. Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.

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

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (Note 3.)						
Output Voltage (on)		V_{OL}				Vdc
(V_{CC} = 5.0 V, V_B = 2.5 V, R_L = 1.0 k Ω)	MMUN2211LT1		–	–	0.2	
	MMUN2212LT1		–	–	0.2	
	MMUN2214LT1		–	–	0.2	
	MMUN2215LT1		–	–	0.2	
	MMUN2216LT1		–	–	0.2	
	MMUN2230LT1		–	–	0.2	
	MMUN2231LT1		–	–	0.2	
	MMUN2232LT1		–	–	0.2	
	MMUN2233LT1		–	–	0.2	
	MMUN2234LT1		–	–	0.2	
	MMUN2235LT1		–	–	0.2	
	MMUN2238LT1		–	–	0.2	
(V_{CC} = 5.0 V, V_B = 3.5 V, R_L = 1.0 k Ω)	MMUN2213LT1		–	–	0.2	
(V_{CC} = 5.0 V, V_B = 5.0 V, R_L = 1.0 k Ω)	MMUN2241LT1		–	–	0.2	
Output Voltage (off) (V_{CC} = 5.0 V, V_B = 0.5 V, R_L = 1.0 k Ω)		V_{OH}	4.9	–	–	Vdc
(V_{CC} = 5.0 V, V_B = 0.050 V, R_L = 1.0 k Ω)	MMUN2230LT1					
(V_{CC} = 5.0 V, V_B = 0.25 V, R_L = 1.0 k Ω)	MMUN2215LT1					
	MMUN2216LT1					
	MMUN2233LT1					
	MMUN2238LT1					
Input Resistor	MMUN2211LT1	R1	7.0	10	13	kΩ
	MMUN2212LT1		15.4	22	28.6	
	MMUN2213LT1		32.9	47	61.1	
	MMUN2214LT1		7.0	10	13	
	MMUN2215LT1		7.0	10	13	
	MMUN2216LT1		3.3	4.7	6.1	
	MMUN2230LT1		0.7	1.0	1.3	
	MMUN2231LT1		1.5	2.2	2.9	
	MMUN2232LT1		3.3	4.7	6.1	
	MMUN2233LT1		3.3	4.7	6.1	
	MMUN2234LT1		15.4	22	28.6	
	MMUN2235LT1		1.54	2.2	2.86	
	MMUN2238LT1		1.54	2.2	2.88	
	MMUN2241LT1		70	100	130	
Resistor Ratio	MMUN2211LT1/MMUN2212LT1/MMUN2213LT1	R1/R2	0.8	1.0	1.2	
	MMUN2214LT1		0.17	0.21	0.25	
	MMUN2215LT1/MMUN2216LT1/MMUN2238LT1		–	–	–	
	MMUN2241LT1		–	–	–	
	MMUN2230LT1/MMUN2231LT1/MMUN2232LT1		0.8	1.0	1.2	
	MMUN2233LT1		0.055	0.1	0.185	
	MMUN2234LT1		0.38	0.47	0.56	
	MMUN2235LT1		0.038	0.047	0.056	

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

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2211LT1

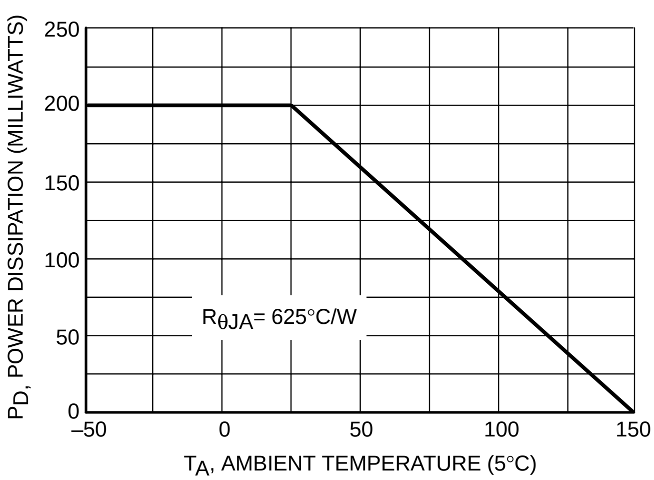


Figure 1. Derating Curve

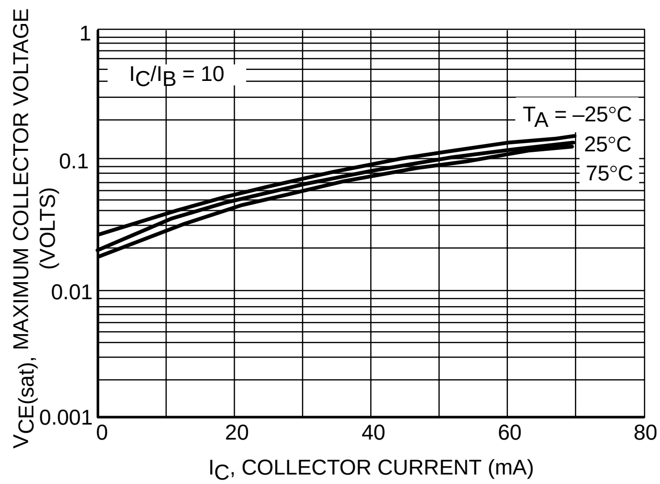


Figure 2. $V_{CE(sat)}$ vs. I_C

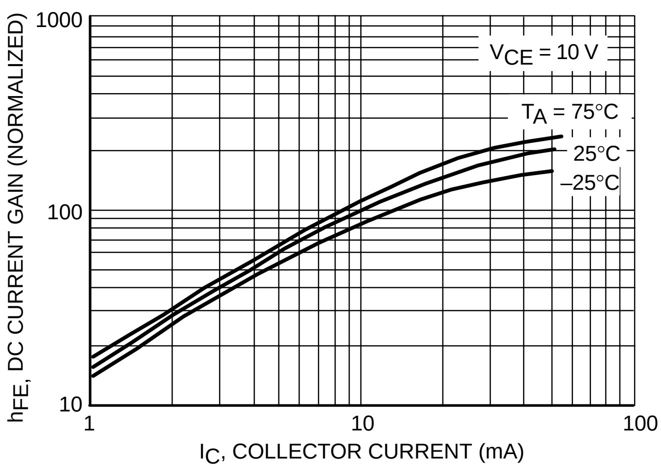


Figure 3. DC Current Gain

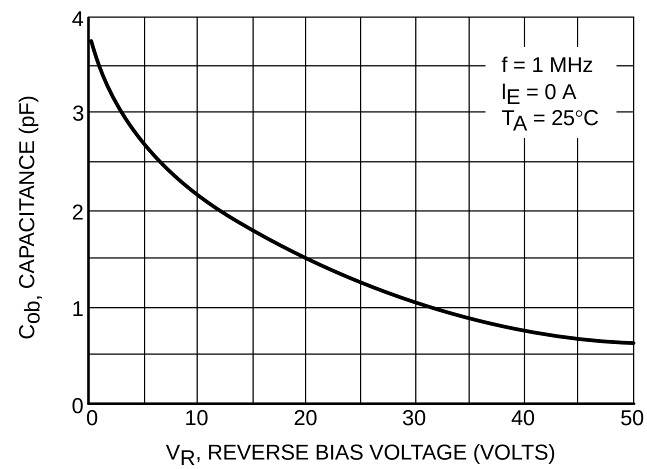


Figure 4. Output Capcitance

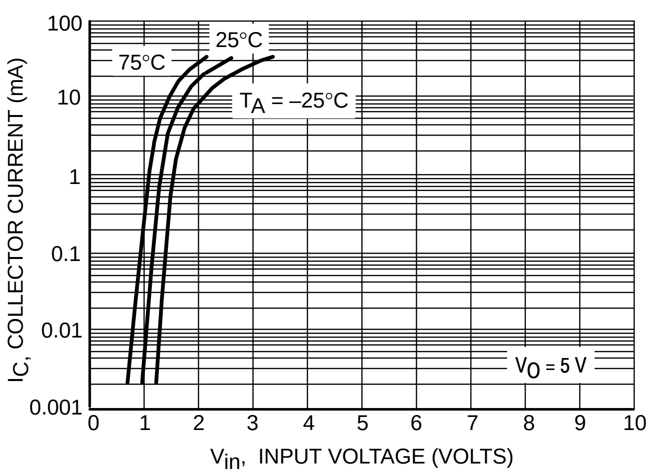


Figure 5. Output Current vs. Input Voltage

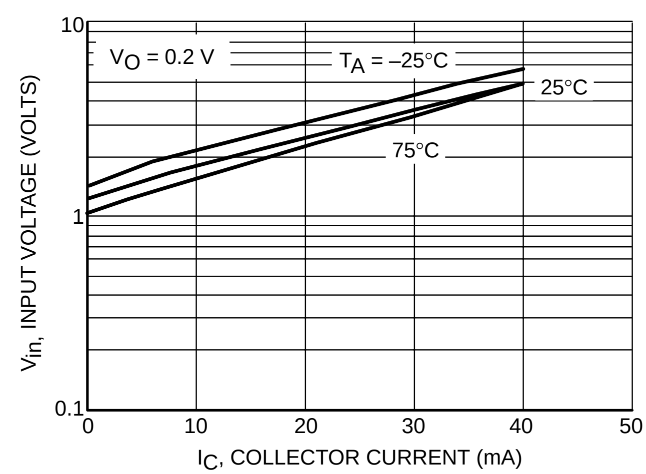


Figure 6. Input Voltage vs. Output Current

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2212LT1

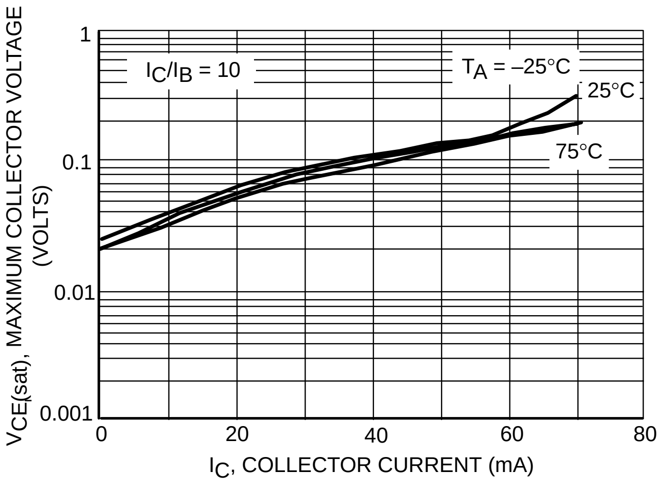


Figure 7. $V_{CE(sat)}$ vs. I_C

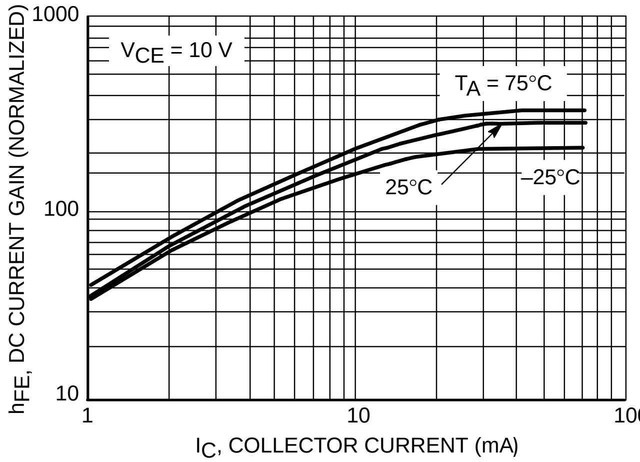


Figure 8. DC Current Gain

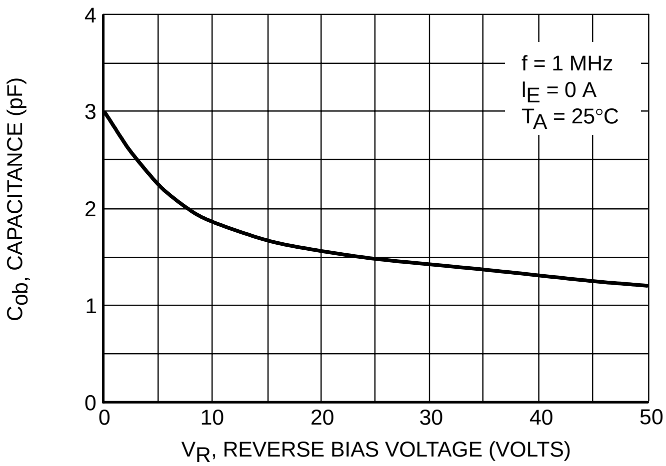


Figure 9. Output Capacitance

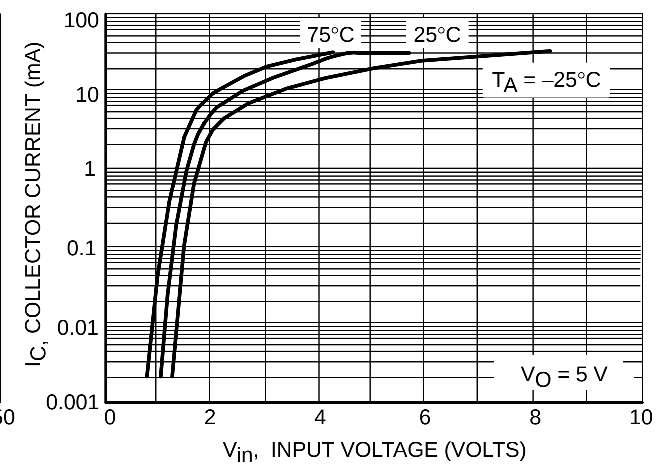


Figure 10. Output Current vs. Input Voltage

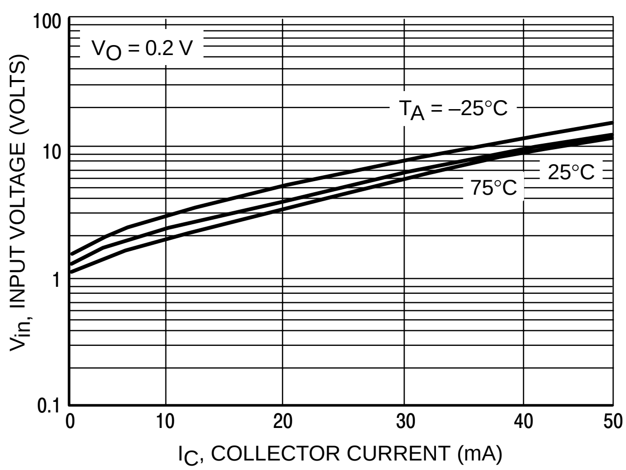


Figure 11. Input Voltage vs. Output Current

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2213LT1

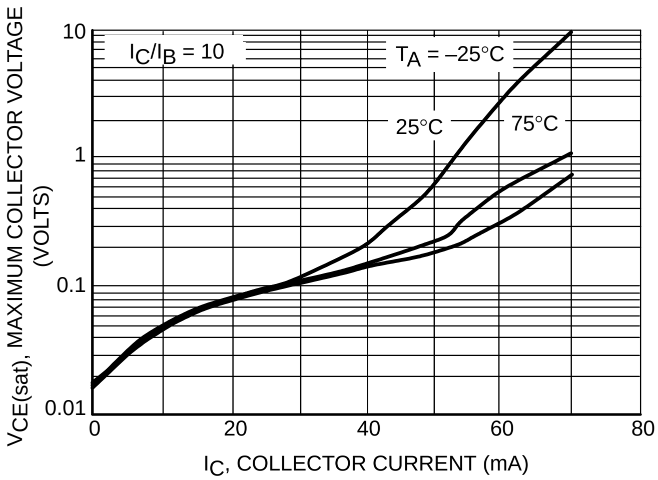


Figure 12. $V_{CE(sat)}$ vs. I_C

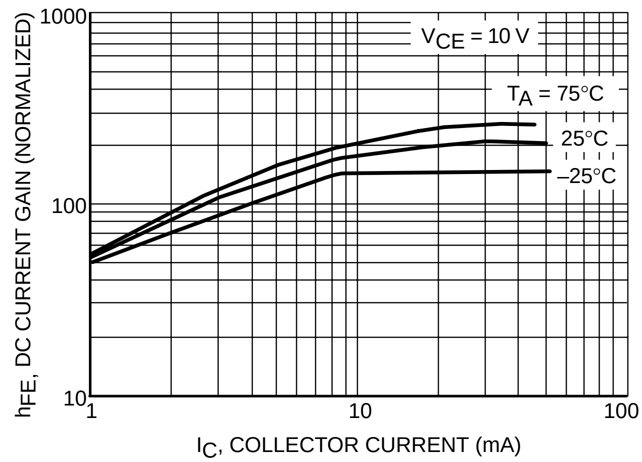


Figure 13. DC Current Gain

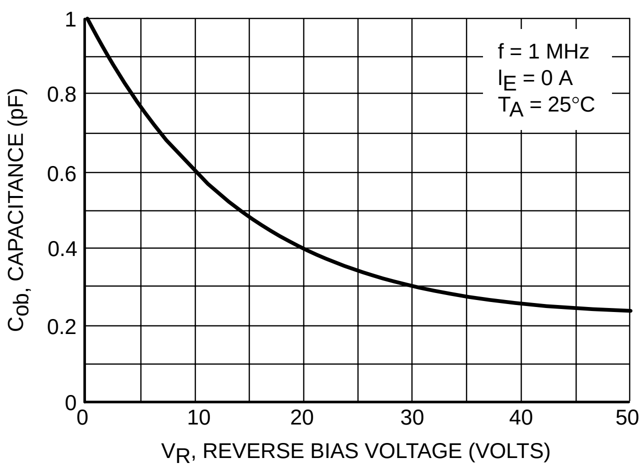


Figure 14. Output Capacitance

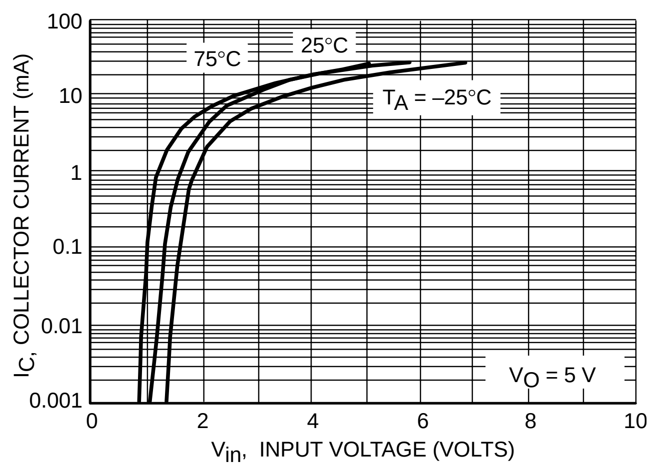


Figure 15. Output Current vs. Input Voltage

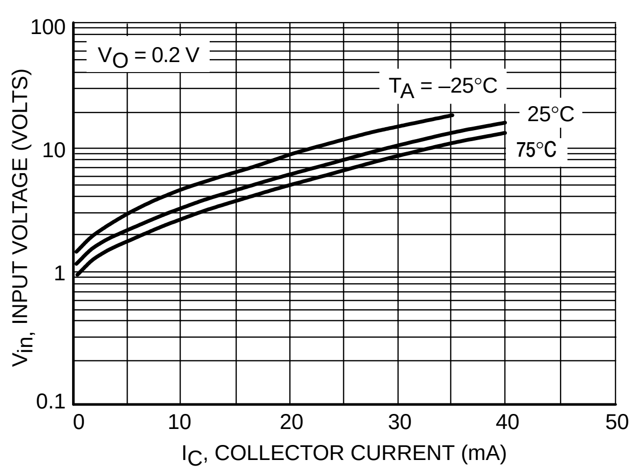


Figure 16. Input Voltage vs. Output Current

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2214LT1

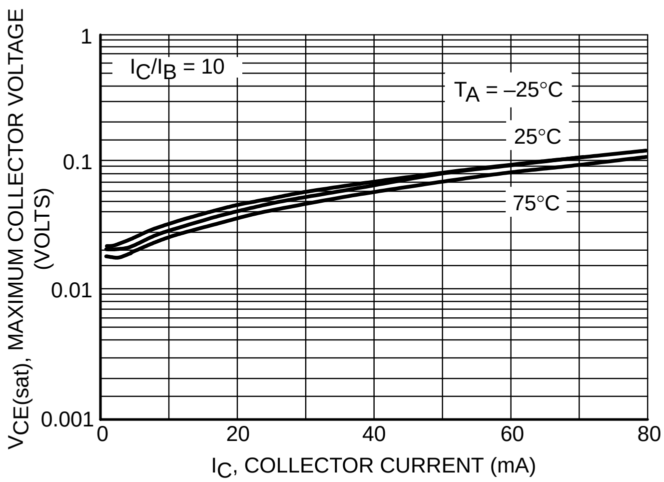


Figure 17. $V_{CE(sat)}$ vs. I_C

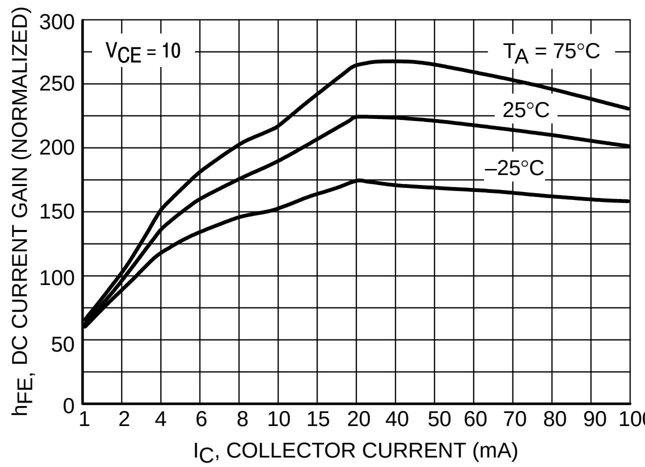


Figure 18. DC Current Gain

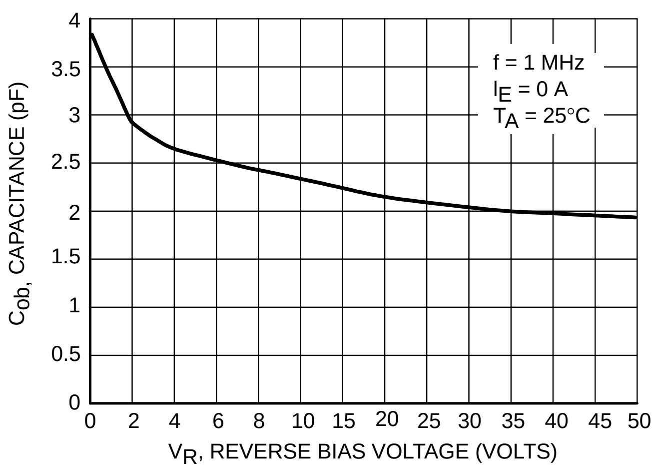


Figure 19. Output Capacitance

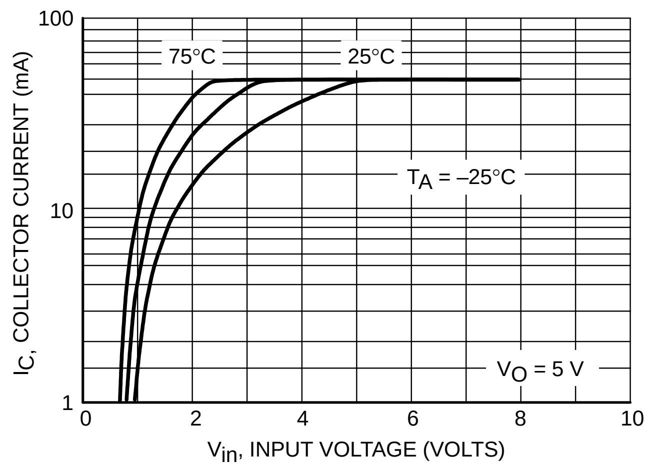


Figure 20. Output Current vs. Input Voltage

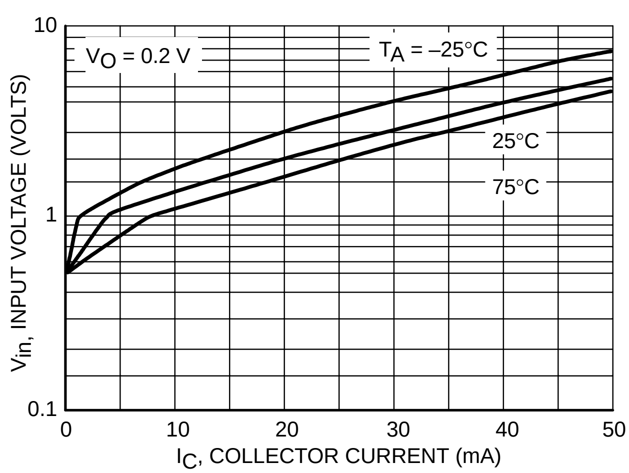


Figure 21. Input Voltage vs. Output Current

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2232LT1

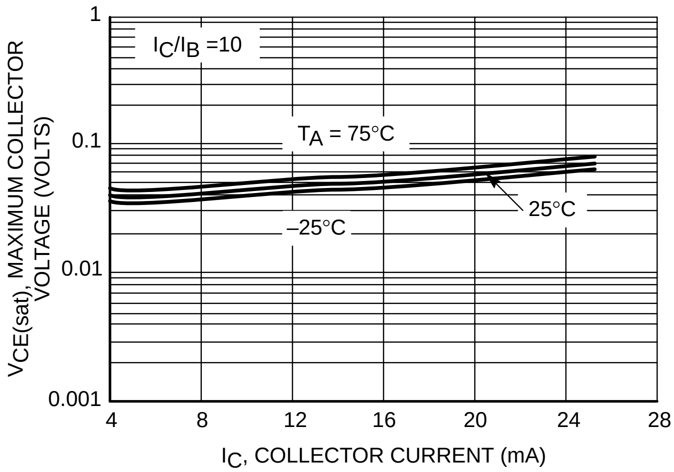


Figure 22. $V_{CE(sat)}$ vs. I_C

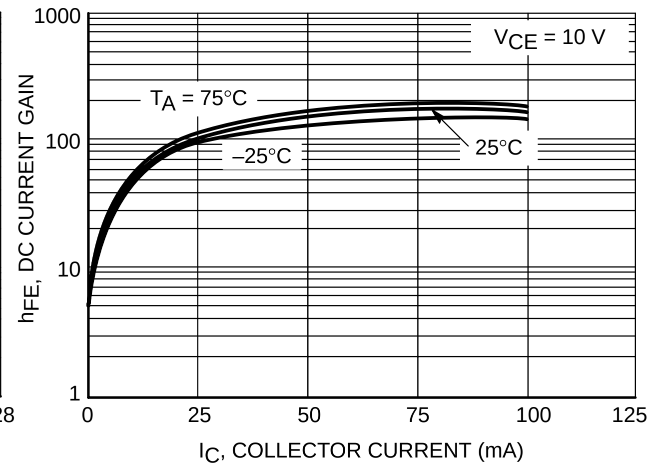


Figure 23. DC Current Gain

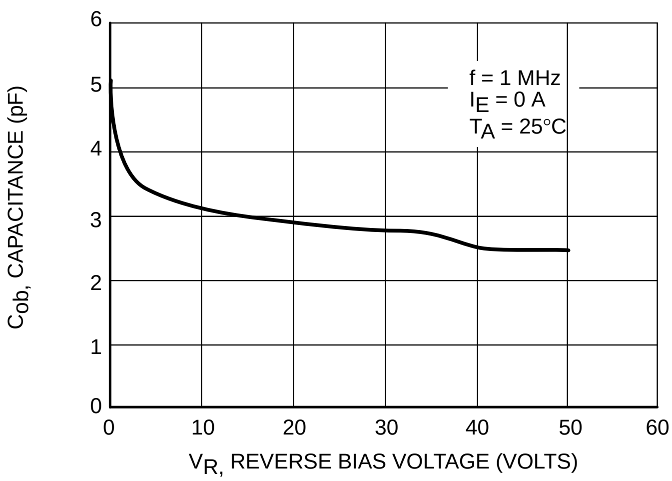


Figure 24. Output Capacitance

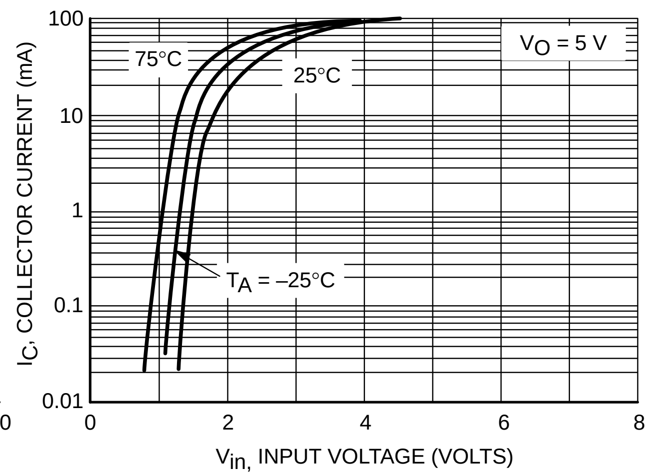


Figure 25. Output Current vs. Input Voltage

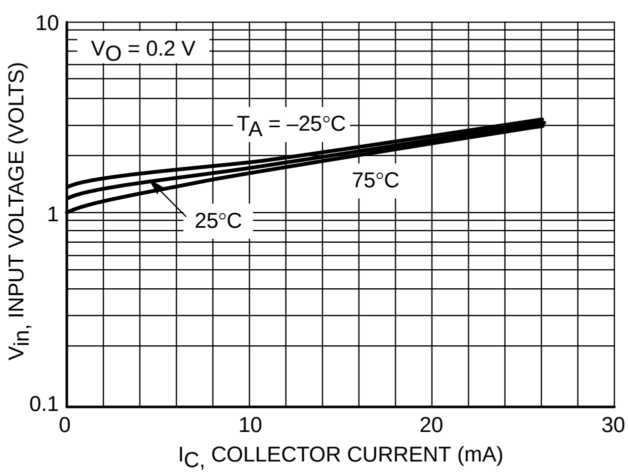


Figure 26. Output Voltage vs. Input Current

TYPICAL ELECTRICAL CHARACTERISTICS
MMUN2233LT1

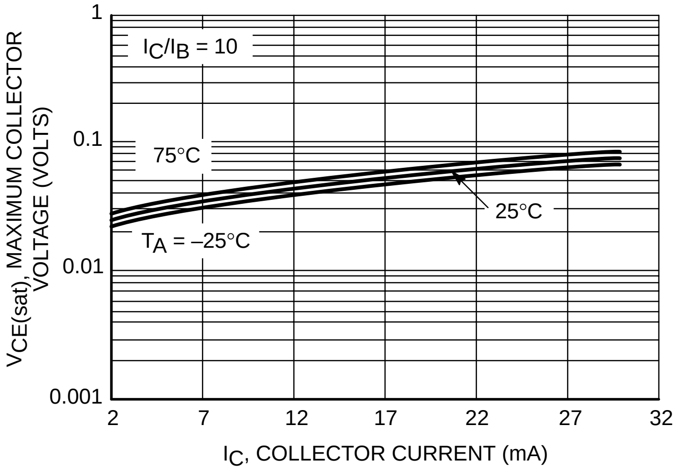


Figure 27. $V_{CE(sat)}$ vs. I_C

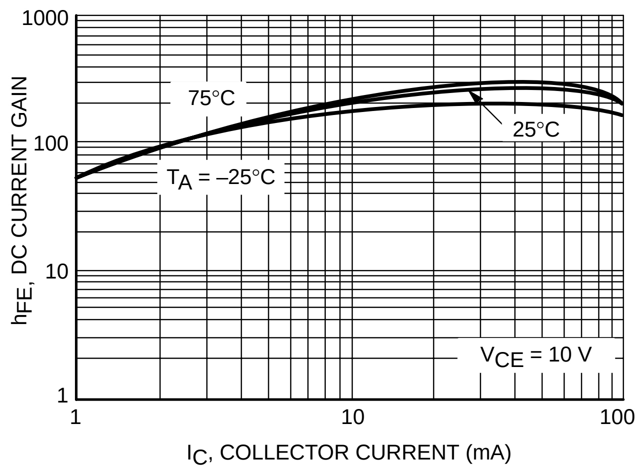


Figure 28. DC Current Gain

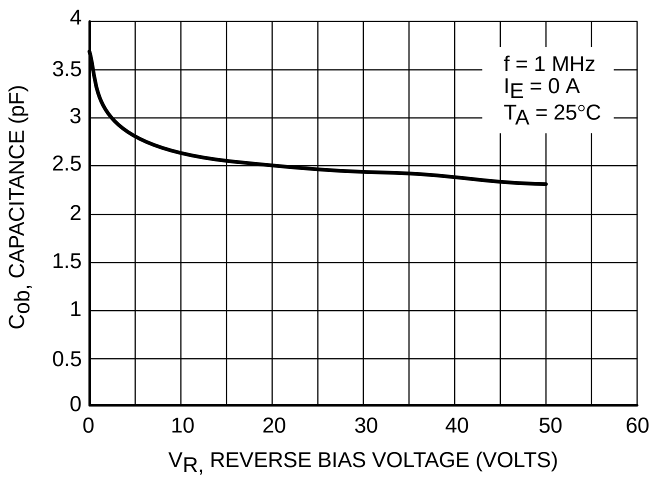


Figure 29. Output Capacitance

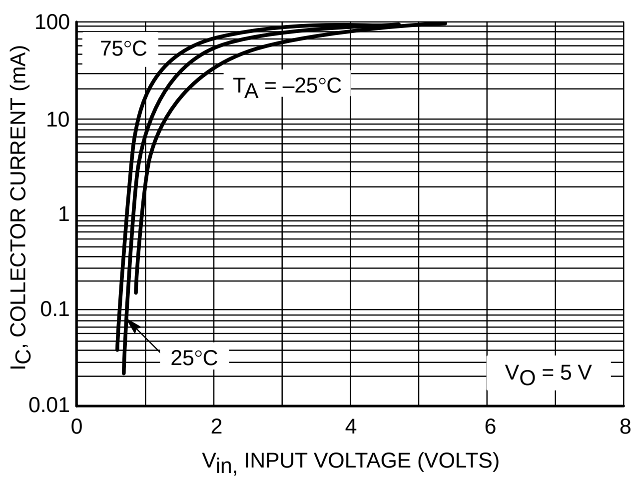


Figure 30. Output Current vs. Input Voltage

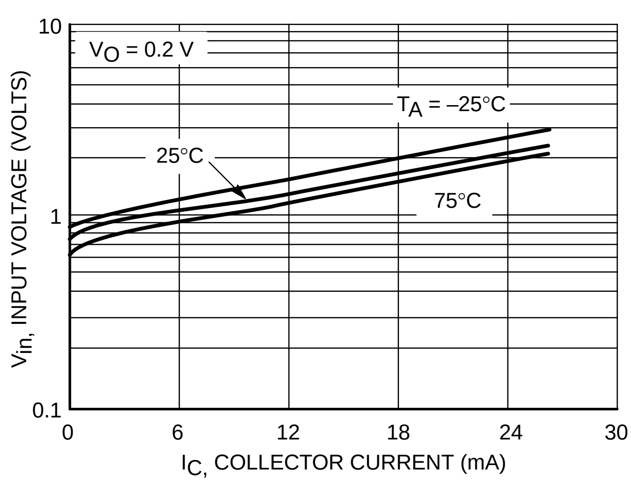


Figure 31. Input Voltage vs. Output Current

TYPICAL APPLICATIONS FOR NPN BRTs

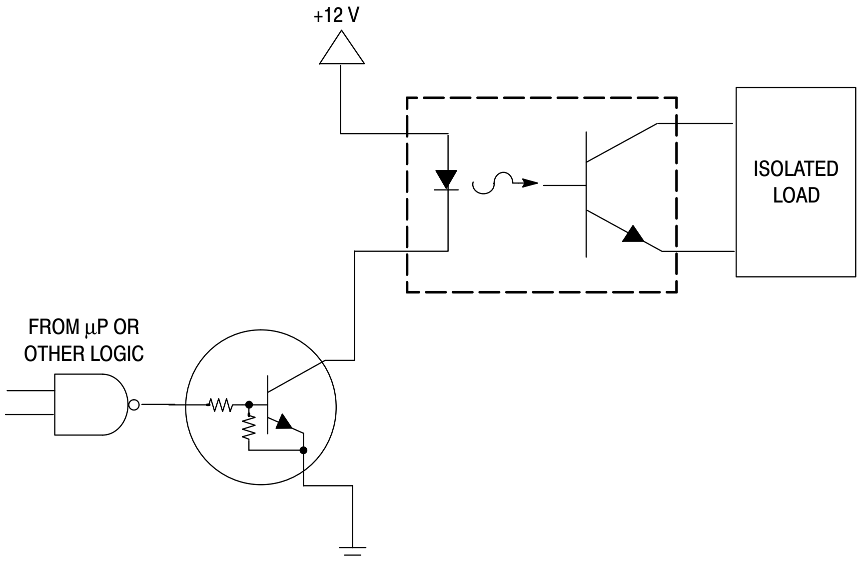


Figure 32. Level Shifter: Connects 12 or 24 Volt Circuits to Logic

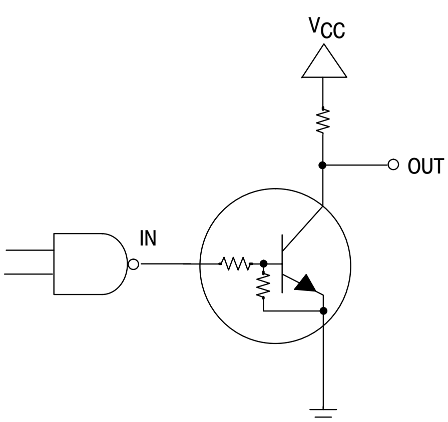


Figure 33. Open Collector Inverter: Inverts the Input Signal

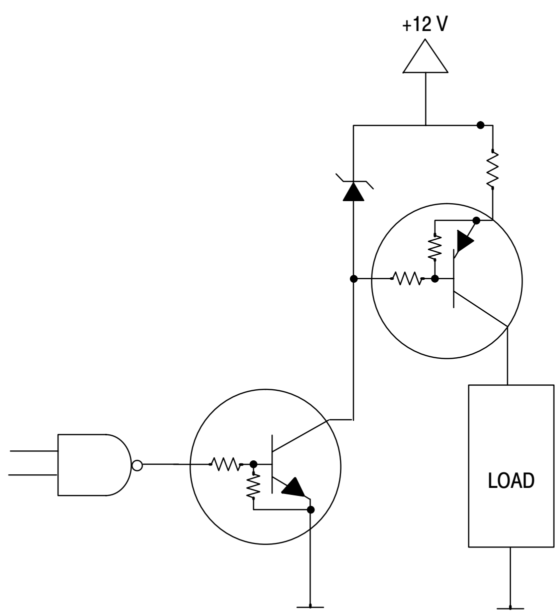
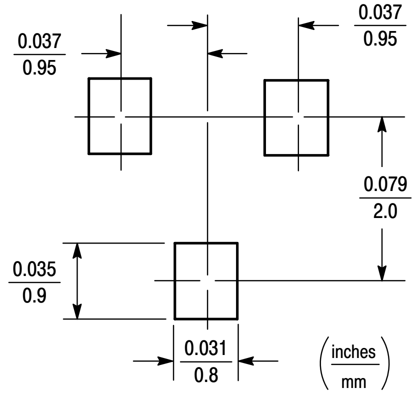


Figure 34. Inexpensive, Unregulated Current Source

INFORMATION FOR USING THE SOT–23 SURFACE MOUNT PACKAGE

MINIMUM RECOMMENDED FOOTPRINT FOR SURFACE MOUNTED APPLICATIONS

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to insure proper solder connection interface between the board and the package. With the correct pad geometry, the packages will self align when subjected to a solder reflow process.



SOT–23

SOT–23 POWER DISSIPATION

The power dissipation of the SOT–23 is a function of the pad size. This can vary from the minimum pad size for soldering to a pad size given for maximum power dissipation. Power dissipation for a surface mount device is determined by $T_{J(max)}$, the maximum rated junction temperature of the die, $R_{\theta JA}$, the thermal resistance from the device junction to ambient, and the operating temperature, T_A. Using the values provided on the data sheet for the SOT–23 package, P_D can be calculated as follows:

$$P_D = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

The values for the equation are found in the maximum ratings table on the data sheet. Substituting these values into the equation for an ambient temperature T_A of 25°C, one can calculate the power dissipation of the device which in this case is 225 milliwatts.

$$P_D = \frac{150°C - 25°C}{556°C/W} = 225 \text{ milliwatts}$$

The 556°C/W for the SOT–23 package assumes the use of the recommended footprint on a glass epoxy printed circuit board to achieve a power dissipation of 225 milliwatts. There are other alternatives to achieving higher power dissipation from the SOT–23 package. Another alternative would be to use a ceramic substrate or an aluminum core board such as Thermal Clad™. Using a board material such as Thermal Clad, an aluminum core board, the power dissipation can be doubled using the same footprint.

SOLDERING PRECAUTIONS

The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device.
- The delta temperature between the preheat and soldering should be 100°C or less.*
- When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference shall be a maximum of 10°C.
- The soldering temperature and time shall not exceed 260°C for more than 10 seconds.
- When shifting from preheating to soldering, the maximum temperature gradient shall be 5°C or less.
- After soldering has been completed, the device should be allowed to cool naturally for at least three minutes. Gradual cooling should be used as the use of forced cooling will increase the temperature gradient and result in latent failure due to mechanical stress.
- Mechanical stress or shock should not be applied during cooling.

* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device.

SOLDER STENCIL GUIDELINES

Prior to placing surface mount components onto a printed circuit board, solder paste must be applied to the pads. A solder stencil is required to screen the optimum amount of solder paste onto the footprint. The stencil is made of brass or stainless steel with a typical thickness of 0.008 inches. The stencil opening size for the surface mounted package should be the same as the pad size on the printed circuit board, i.e., a 1:1 registration.

TYPICAL SOLDER HEATING PROFILE

For any given circuit board, there will be a group of control settings that will give the desired heat pattern. The operator must set temperatures for several heating zones, and a figure for belt speed. Taken together, these control settings make up a heating "profile" for that particular circuit board. On machines controlled by a computer, the computer remembers these profiles from one operating session to the next. Figure 7 shows a typical heating profile for use when soldering a surface mount device to a printed circuit board. This profile will vary among soldering systems but it is a good starting point. Factors that can affect the profile include the type of soldering system in use, density and types of components on the board, type of solder used, and the type of board or substrate material being used. This profile shows temperature versus time. The line on the graph shows the actual temperature that might be experienced on the surface of a test board at or near a central solder joint. The two profiles are based on a high density and a low density board. The Vitronics SMD310 convection/infrared reflow soldering system was used to generate this profile. The type of solder used was 62/36/2 Tin Lead Silver with a melting point between 177–189°C. When this type of furnace is used for solder reflow work, the circuit boards and solder joints tend to heat first. The components on the board are then heated by conduction. The circuit board, because it has a large surface area, absorbs the thermal energy more efficiently, then distributes this energy to the components. Because of this effect, the main body of a component may be up to 30 degrees cooler than the adjacent solder joints.

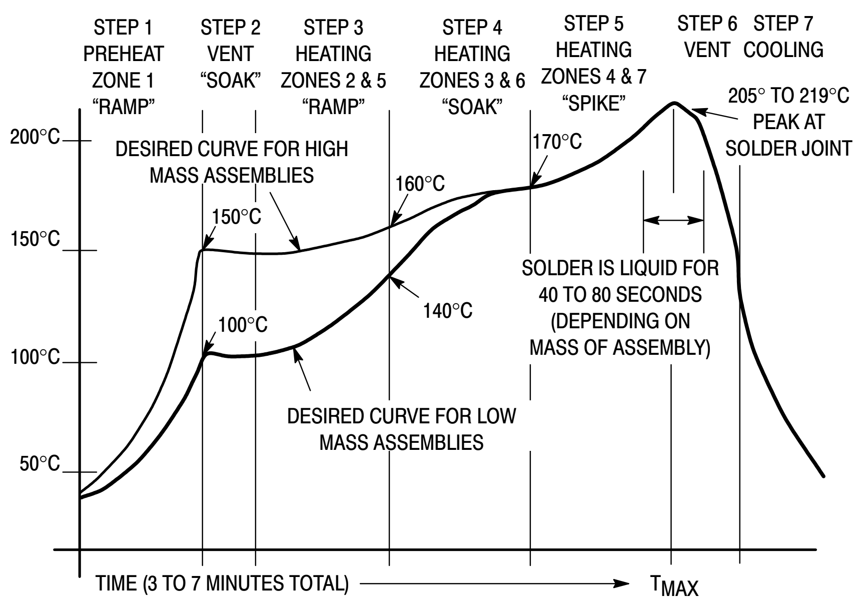
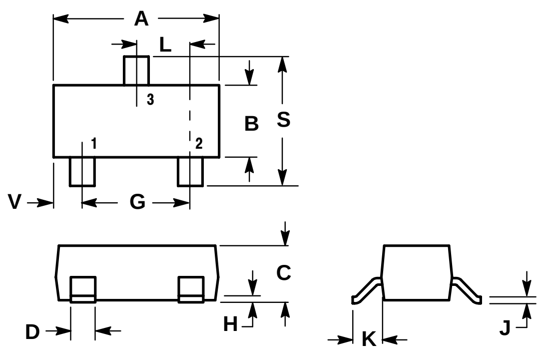


Figure 35. Typical Solder Heating Profile

PACKAGE DIMENSIONS

SOT–23
CASE 318–08
ISSUE AF



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.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.1102	0.1197	2.80	3.04
B	0.0472	0.0551	1.20	1.40
C	0.0350	0.0440	0.89	1.11
D	0.0150	0.0200	0.37	0.50
G	0.0701	0.0807	1.78	2.04
H	0.0005	0.0040	0.013	0.100
J	0.0034	0.0070	0.085	0.177
K	0.0140	0.0285	0.35	0.69
L	0.0350	0.0401	0.89	1.02
S	0.0830	0.1039	2.10	2.64
V	0.0177	0.0236	0.45	0.60

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

Notes

Notes

Thermal Clad is a trademark of the Bergquist Company.

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