

National Semiconductor is now part of  
Texas Instruments.

Search <http://www.ti.com/> for the latest technical  
information and details on our current products and services.

## LM185-1.2/LM285-1.2/LM385-1.2 Micropower Voltage Reference Diode

### General Description

The LM185-1.2/LM285-1.2/LM385-1.2 are micropower 2-terminal band-gap voltage regulator diodes. Operating over a 10  $\mu$ A to 20 mA current range, they feature exceptionally low dynamic impedance and good temperature stability. On-chip trimming is used to provide tight voltage tolerance. Since the LM185-1.2 band-gap reference uses only transistors and resistors, low noise and good long term stability result.

Careful design of the LM185-1.2 has made the device exceptionally tolerant of capacitive loading, making it easy to use in almost any reference application. The wide dynamic operating range allows its use with widely varying supplies with excellent regulation.

The extremely low power drain of the LM185-1.2 makes it useful for micropower circuitry. This voltage reference can be used to make portable meters, regulators or general purpose analog circuitry with battery life approaching shelf life.

Further, the wide operating current allows it to replace older references with a tighter tolerance part.

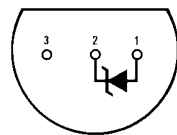
The LM185-1.2 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range while the LM285-1.2 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385-1.2  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185-1.2/LM285-1.2 are available in a hermetic TO-46 package and the LM285-1.2/LM385-1.2 are also available in a low-cost TO-92 molded package, as well as SO and SOT-23. The LM185-1.2 is also available in a hermetic leadless chip carrier package.

### Features

- $\pm 4$  mV ( $\pm 0.3\%$ ) max. initial tolerance (A grade)
- Operating current of 10  $\mu$ A to 20 mA
- $0.6\Omega$  max dynamic impedance (A grade)
- Low temperature coefficient
- Low voltage reference—1.235V
- 2.5V device and adjustable device also available
- LM185-2.5 series and LM185 series, respectively

### Connection Diagrams

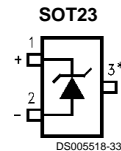
TO-92  
Plastic Package (Z)



DS005518-10

#### Bottom View

Order Number LM285Z-1.2,  
LM285AYZ-1.2, LM285BXZ-1.2,  
LM285BYZ-1.2, LM385Z-1.2,  
LM385AXZ-1.2, LM385BZ-1.2  
LM385BXZ-1.2 or LM385BYZ-1.2  
See NS Package Number Z03A

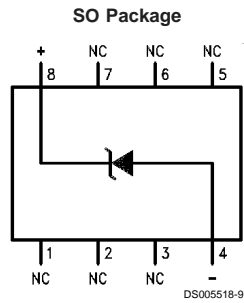


DS005518-33

\* Pin 3 is attached to the Die Attach Pad (DAP) and should be connected to Pin 2 or left floating.

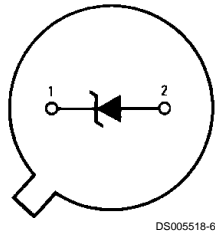
Order Number LM385M3-1.2  
See NS Package Number MA03B

**Connection Diagrams** (Continued)



Order Number LM285M-1.2,  
 LM285BXM-1.2, LM285BYM-1.2  
 LM385M-1.2, LM385AM-1.2  
 LM385AYM-1.2, LM385BM-1.2,  
 LM385BXM-1.2 or LM385BYM-1.2  
 See NS Package Number M08A

**TO-46  
 Metal Can Package (H)**



**Bottom View**  
 Order Number LM185H-1.2, LM185H-1.2/883,  
 LM185BXH-1.2, LM185BYH-1.2/883,  
 LM285H-1.2, LM285BXH-1.2 or LM285BYH-1.2  
 See NS Package Number H02A

**Absolute Maximum Ratings** (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

(Note 2)

Reverse Current 30 mA  
Forward Current 10 mA

Operating Temperature Range (Note 3)

LM185-1.2 -55°C to +125°C

LM285-1.2 -40°C to +85°C

LM385-1.2 0°C to 70°C

Storage Temperature -55°C to +150°C

Soldering Information

TO-92 package: 10 sec. 260°C

TO-46 package: 10 sec. 300°C

SO and SOT Pkg.

Vapor phase (60 sec.) 215°C

Infrared (15 sec.) 220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

**Electrical Characteristics** (Note 4)

Parameter	Conditions	LM285A-1.2 LM285AX-1.2 LM285AY-1.2			LM385A-1.2 LM385AX-1.2 LM385AY-1.2			Units (Limit)
		Typ	Tested Limit (Notes 5, 8)	Design Limit (Note 6)	Typ	Tested Limit (Note 5)	Design Limit (Note 6)	
Reverse Breakdown Voltage	$I_R = 100 \mu\text{A}$	1.235	1.231		1.235	1.231		V(Min)
		<b>1.230</b>	1.239	<b>1.220</b> <b>1.245</b>	<b>1.235</b>	1.239	<b>1.225</b> <b>1.245</b>	V(Max) V(Min) V(Max)
Minimum Operating Current		7	8	<b>10</b>	7	8	<b>10</b>	$\mu\text{A}$ (Max)
Reverse Breakdown Voltage Change with Current	$I_{\text{MIN}} \leq I_R \leq 1 \text{ mA}$		1	<b>1.5</b>		1	<b>1.5</b>	mV (Max)
	$1 \text{ mA} \leq I_R \leq 20 \text{ mA}$		10	<b>20</b>		10	<b>20</b>	mV (Max)
Reverse Dynamic Impedance	$I_R = 100 \mu\text{A}$ , $f = 20 \text{ Hz}$	0.2		0.6 <b>1.5</b>	0.2		0.6 <b>1.5</b>	$\Omega$ (Max)
Wideband Noise (rms)	$I_R = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	60			60			$\mu\text{V}$
Long Term Stability	$I_R = 100 \mu\text{A}$ , $T = 1000 \text{ Hr}$ , $T_A = 25^\circ\text{C} \pm 0.1^\circ\text{C}$	20			20			ppm
Average Temperature Coefficient (Note 7)	$I_{\text{MIN}} \leq I_R \leq 20 \text{ mA}$ X Suffix Y Suffix All Others		<b>30</b> <b>50</b>			<b>30</b> <b>50</b>		ppm/°C (Max)
				<b>150</b>			<b>150</b>	

## Electrical Characteristics (Note 4)

Parameter	Conditions	Typ	LM185-1.2 LM185BX-1.2 LM185BY-1.2 LM285-1.2 LM285BX-1.2 LM285BY-1.2		LM385B-1.2 LM385BX-1.2 LM385BY-1.2		LM385-1.2		Units (Limit)
			Tested Limit (Notes 5, 8)	Design Limit (Note 6)	Tested Limit (Note 5)	Design Limit (Note 6)	Tested Limit (Note 5)	Design Limit (Note 6)	
Reverse Breakdown Voltage	$T_A = 25^\circ\text{C}$ , $10\ \mu\text{A} \leq I_R \leq 20\ \text{mA}$	1,235	1,223		1,223		1,205		V(Min)
			1,247		1,247		1,260		V(Max)
Minimum Operating Current		8	10	<b>20</b>	15	<b>20</b>	15	<b>20</b>	$\mu\text{A}$
	LM385M3-1.2						10	<b>15</b>	(Max)
Reverse Breakdown Voltage Change with Current	$10\ \mu\text{A} \leq I_R \leq 1\ \text{mA}$		1	<b>1.5</b>	1	<b>1.5</b>	1	<b>1.5</b>	mV (Max)
	$1\ \text{mA} \leq I_R \leq 20\ \text{mA}$		10	<b>20</b>	20	<b>25</b>	20	<b>25</b>	mV (Max)
Reverse Dynamic Impedance	$I_R = 100\ \mu\text{A}$ , $f = 20\ \text{Hz}$	1							$\Omega$
Wideband Noise (rms)	$I_R = 100\ \mu\text{A}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$	60							$\mu\text{V}$
Long Term Stability	$I_R = 100\ \mu\text{A}$ , $T = 1000\ \text{Hr}$ , $T_A = 25^\circ\text{C} \pm 0.1^\circ\text{C}$	20							ppm
Average Temperature Coefficient (Note 7)	$I_R = 100\ \mu\text{A}$ X Suffix Y Suffix All Others		<b>30</b>		<b>30</b>				ppm/ $^\circ\text{C}$
			<b>50</b>		<b>50</b>				ppm/ $^\circ\text{C}$
				<b>150</b>		<b>150</b>		<b>150</b>	ppm/ $^\circ\text{C}$ (Max)

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed.

**Note 2:** Refer to RETS185H-1.2 for military specifications.

**Note 3:** For elevated temperature operation,  $T_J$  max is:

LM185  $150^\circ\text{C}$

LM285  $125^\circ\text{C}$

LM385  $100^\circ\text{C}$

Thermal Resistance	TO-92	TO-46	SO-8	SOT23
$\theta_{JA}$ (junction to ambient)	$180^\circ\text{C/W}$ (0.4" leads) $170^\circ\text{C/W}$ (0.125" leads)	$440^\circ\text{C/W}$	$165^\circ\text{C/W}$	$283^\circ\text{C/W}$
$\theta_{JC}$ (junction to case)	N/A	$80^\circ\text{C/W}$	N/A	N/A

**Note 4:** Parameters identified with boldface type apply at temperature extremes. All other numbers apply at  $T_A = T_J = 25^\circ\text{C}$ .

**Note 5:** Guaranteed and 100% production tested.

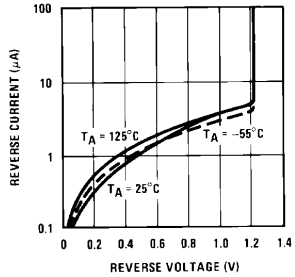
**Note 6:** Guaranteed, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.

**Note 7:** The average temperature coefficient is defined as the maximum deviation of reference voltage at all measured temperatures between the operating  $T_{MAX}$  and  $T_{MIN}$ , divided by  $T_{MAX} - T_{MIN}$ . The measured temperatures are  $-55^\circ\text{C}$ ,  $-40^\circ\text{C}$ ,  $0^\circ\text{C}$ ,  $25^\circ\text{C}$ ,  $70^\circ\text{C}$ ,  $85^\circ\text{C}$ ,  $125^\circ\text{C}$ .

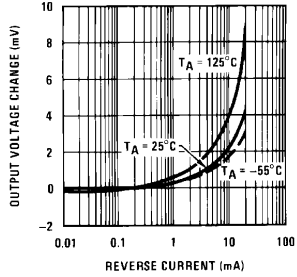
**Note 8:** A military RETS electrical specification is available on request.

## Typical Performance Characteristics

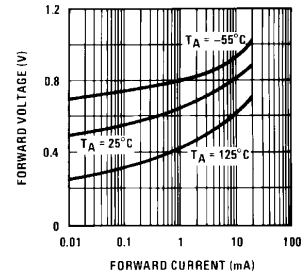
Reverse Characteristics



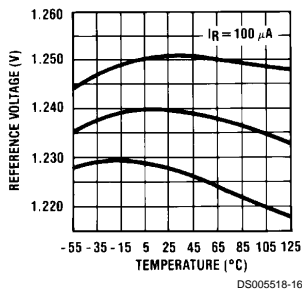
Reverse Characteristics



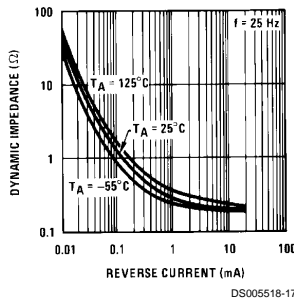
Forward Characteristics



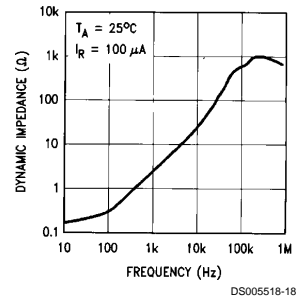
Temperature Drift of 3 Representative Units



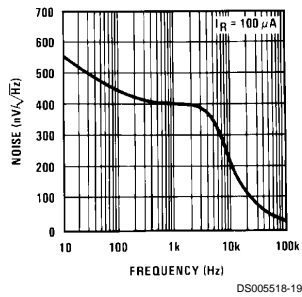
Reverse Dynamic Impedance



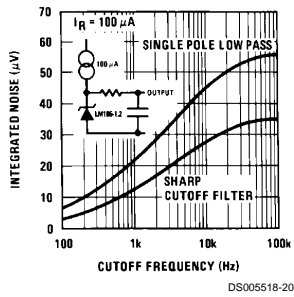
Reverse Dynamic Impedance



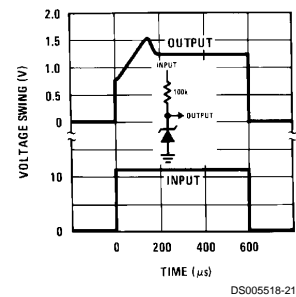
Noise Voltage



Filtered Output Noise

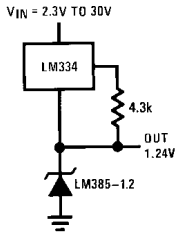


Response Time



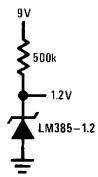
## Typical Applications

**Wide Input Range Reference**



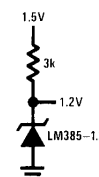
DS005518-8

**Micropower Reference from 9V Battery**



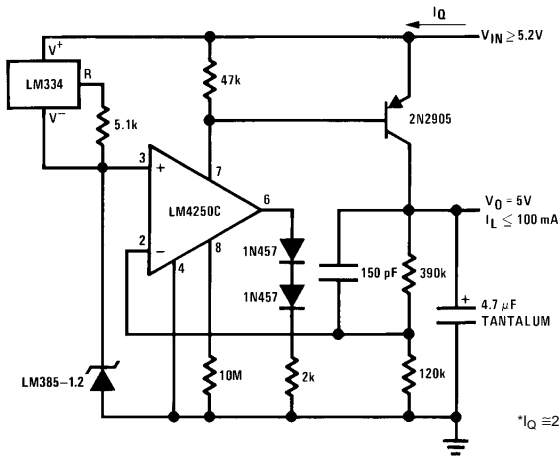
DS005518-22

**Reference from 1.5V Battery**



DS005518-23

**Micropower\* 5V Regulator**

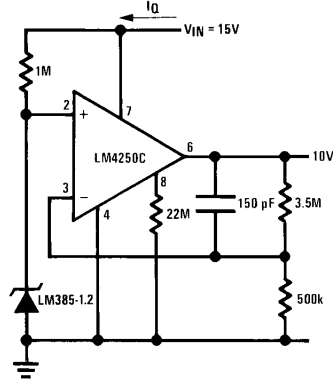


\*IQ ≅ 20 μA standby current

DS005518-24

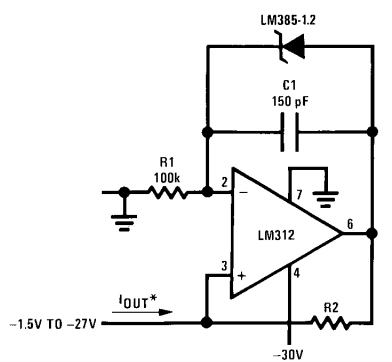
\*IQ ≅ 30 μA

**Micropower\* 10V Reference**



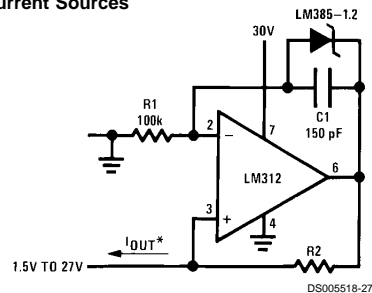
DS005518-25

**Precision 1 μA to 1 mA Current Sources**



DS005518-26

$$I_{OUT} = \frac{1.23V}{R2}$$

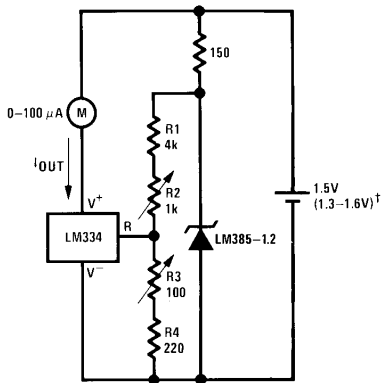


DS005518-27

## Typical Applications (Continued)

### METER THERMOMETERS

0°C–100°C Thermometer

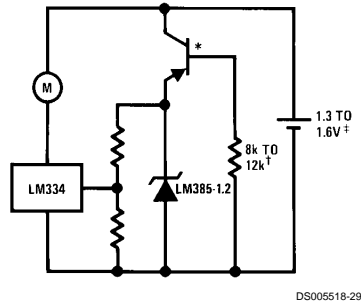


DS005518-28

**Calibration**

1. Short LM385-1.2, adjust R3 for  $I_{OUT} = \text{temp at } 1 \mu\text{A}/^\circ\text{K}$
  2. Remove short, adjust R2 for correct reading in centigrade
- $I_Q$  at 1.3V  $\approx$  500  $\mu\text{A}$   
 $I_Q$  at 1.6V  $\approx$  2.4 mA

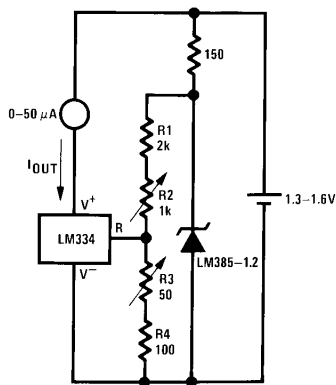
Lower Power Thermometer



DS005518-29

- \*2N3638 or 2N2907 select for inverse  $H_{FE} \approx 5$   
 †Select for operation at 1.3V  
 ‡ $I_Q \approx 600 \mu\text{A}$  to 900  $\mu\text{A}$

0°F–50°F Thermometer

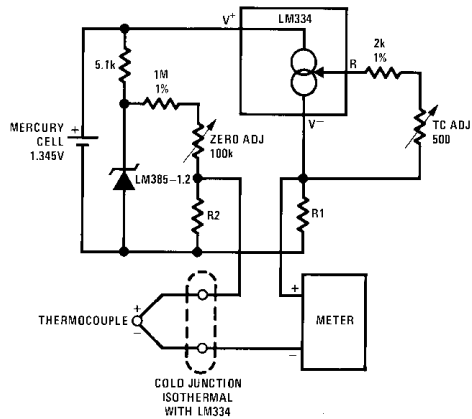


DS005518-30

**Calibration**

1. Short LM385-1.2, adjust R3 for  $I_{OUT} = \text{temp at } 1.8 \mu\text{A}/^\circ\text{K}$
2. Remove short, adjust R2 for correct reading in °F

Micropower Thermocouple Cold Junction Compensator



DS005518-31

**Adjustment Procedure**

1. Adjust TC ADJ pot until voltage across R1 equals Kelvin temperature multiplied by the thermocouple Seebeck coefficient.
2. Adjust zero ADJ pot until voltage across R2 equals the thermocouple Seebeck coefficient multiplied by 273.2.

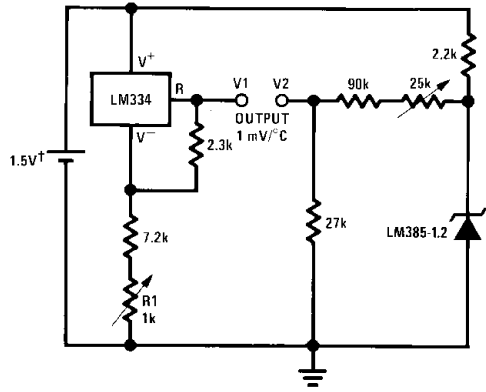
Thermocouple Type	Seebeck Coefficient ( $\mu\text{V}/^\circ\text{C}$ )	R1 ( $\Omega$ )	R2 ( $\Omega$ )	Voltage Across R1 @ 25°C (mV)	Voltage Across R2 (mV)
J	52.3	523	1.24k	15.60	14.32
T	42.8	432	1k	12.77	11.78
K	40.8	412	953 $\Omega$	12.17	11.17
S	6.4	63.4	150 $\Omega$	1.908	1.766

Typical supply current 50  $\mu\text{A}$



Typical Applications (Continued)

Centigrade Thermometer

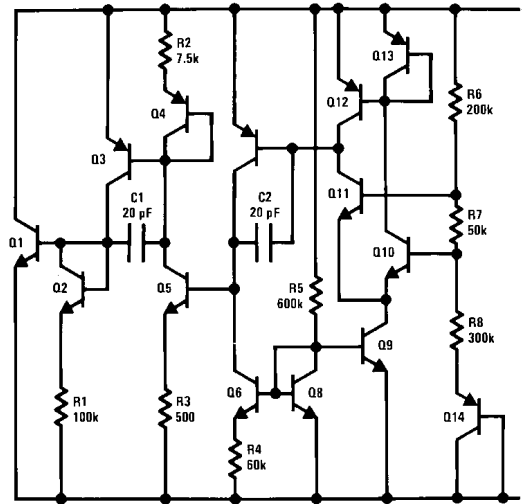


DS005518-1

Calibration

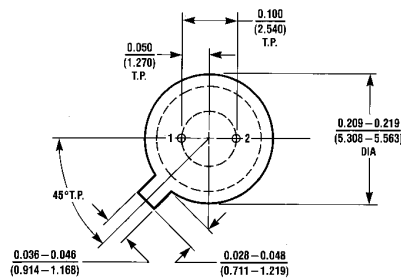
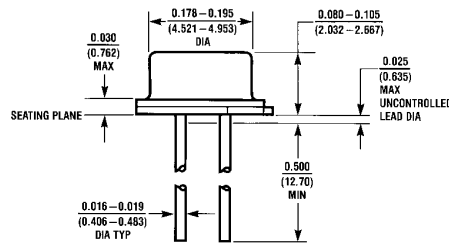
1. Adjust R1 so that V1 = temp at 1 mV/°K
  2. Adjust V2 to 273.2 mV
- $I_Q$  for 1.3V to 1.6V battery voltage = 50  $\mu$ A to 150  $\mu$ A

Schematic Diagram



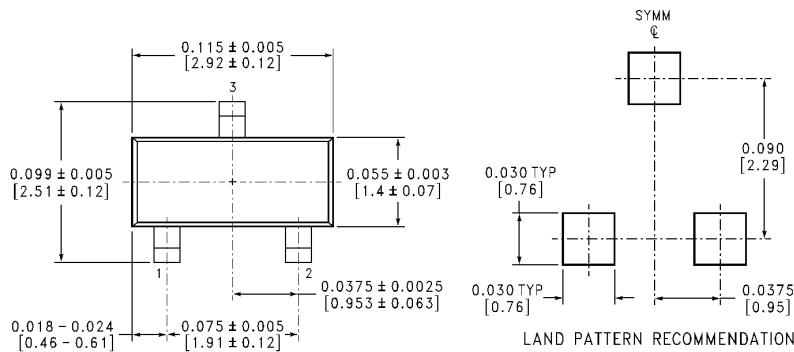
DS005518-7

**Physical Dimensions** inches (millimeters) unless otherwise noted

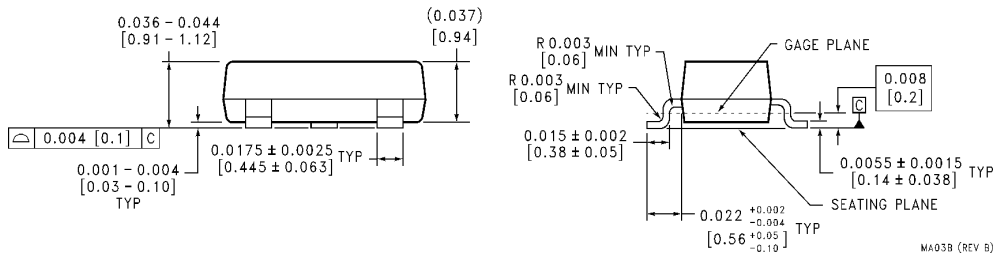


H02A (REV. C)

**TO-46 Metal Can Package (H)**  
**Order Number LM185H-1.2, LM185H-1.2/883, LM185BXH-1.2, LM285H-1.2, LM285BXH-1.2 or LM285BYH-1.2**  
**NS Package Number H02A**



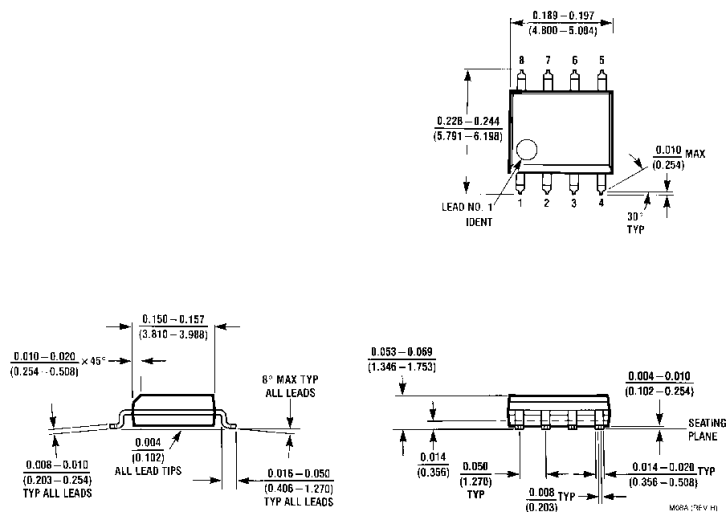
LAND PATTERN RECOMMENDATION



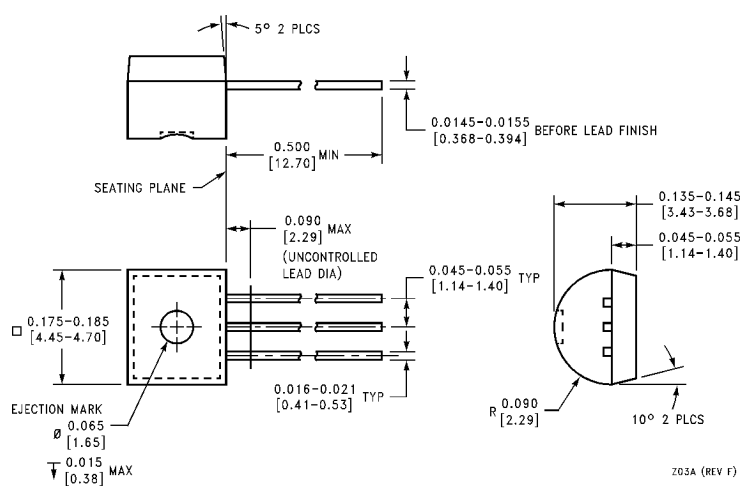
MA03B (REV. B)

**SOT-23 Package (M3)**  
**Order Number LM385M3-1.2**  
**NS Package Number MA03B**

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



**Small Outline (SO-8) Package**  
**Order Number LM285M-1.2, LM285BXM-1.2, LM285BYM-1.2**  
**LM385M-1.2, LM385AM-1.2, LM385AYM-1.2, LM385BM-1.2,**  
**LM385BXM-1.2, LM385BYM-1.2**  
**NS Package Number M08A**




**TO-92 Plastic Package (Z)**  
**Order Number LM285Z-1.2, LM285AYZ-1.2,**  
**LM285BZX-1.2, LM285BYZ-1.2, LM385Z-1.2, LM385AXZ-1.2,**  
**LM385BZ-1.2, LM385BXZ-1.2 or LM385BYZ-1.2**  
**NS Package Number Z03A**

## Notes

### LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

 **National Semiconductor Corporation**  
Americas  
Tel: 1-800-272-9959  
Fax: 1-800-737-7018  
Email: support@nsc.com

www.national.com

**National Semiconductor Europe**  
Fax: +49 (0) 1 80-530 85 86  
Email: europe.support@nsc.com  
Deutsch Tel: +49 (0) 1 80-530 85 85  
English Tel: +49 (0) 1 80-532 78 32  
Français Tel: +49 (0) 1 80-532 93 58  
Italiano Tel: +49 (0) 1 80-534 16 80

**National Semiconductor Asia Pacific Customer Response Group**  
Tel: 65-2544466  
Fax: 65-2504466  
Email: sea.support@nsc.com

**National Semiconductor Japan Ltd.**  
Tel: 81-3-5639-7560  
Fax: 81-3-5639-7507