

## LM185-2.5/LM285-2.5/LM385-2.5 Micropower Voltage Reference Diode

### General Description

The LM185-2.5/LM285-2.5/LM385-2.5 are micropower 2-terminal band-gap voltage regulator diodes. Operating over a 20  $\mu$ 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 LM-185-2.5 band-gap reference uses only transistors and resistors, low noise and good long term stability result.

Careful design of the LM185-2.5 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 LM185-2.5 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. For applications requiring 1.2V see LM185-1.2.

The LM185-2.5 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range while the LM285-2.5 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385-2.5  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185-2.5/LM285-2.5 are available in a hermetic TO-46 package and the LM285-2.5/LM385-2.5 are also available in a low-cost TO-92 molded package, as well as S.O. and SOT-23. The LM185-2.5 is also available in a hermetic leadless chip carrier package.

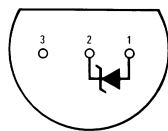
### Features

- $\pm 20$  mV ( $\pm 0.8\%$ ) max. initial tolerance (A grade)
- Operating current of 20  $\mu$ A to 20 mA
- $0.6\Omega$  dynamic impedance (A grade)
- Low temperature coefficient
- Low voltage reference—2.5V
- 1.2V device and adjustable device also available—LM185-1.2 series and LM185 series, respectively

### Connection Diagrams

DataSheet4U.com

TO-92  
Plastic Package

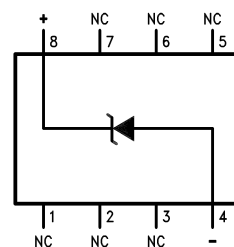


00551908

Bottom View

Order Number LM285Z-2.5,  
LM285BXZ-2.5, LM285BYZ-2.5  
LM385Z-2.5, LM385AXZ-2.5  
LM385AYZ-2.5, LM385BZ-2.5,  
LM385BXZ-2.5 or LM385BYZ-2.5  
See NS Package Number Z03A

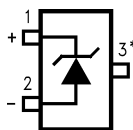
SO Package



00551911

Order Number LM285M-2.5,  
LM285BXM-2.5, LM285BYM-2.5  
LM385M-2.5, LM385BM-2.5  
LM385BXM-2.5 or LM385BYM-2.5  
See NS Package Number M08A

SOT-23



00551929

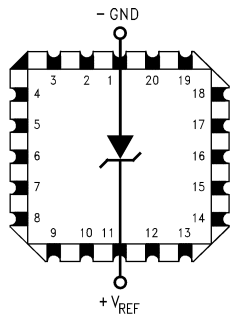
\* Pin 3 is attached to the Die Attach Pad (DAP) and should be connected to Pin 2 or left floating.

Order Number LM385M3-2.5  
See NS Package Number MA03B

LM185-2.5/LM285-2.5/LM385-2.5

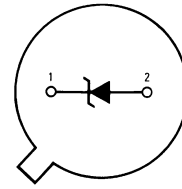
### Connection Diagrams (Continued)

**LCC**  
**Leadless Chip Carrier**



00551914  
**Order Number LM185E-2.5/883**  
**See NS Package Number E20A**

**TO-46**  
**Metal Can Package**



00551913  
**Bottom View**  
**Order Number LM185H-2.5,**  
**LM185H-2.5/883, LM185BXH-2.5,**  
**LM185BXH-2.5/883, LM185BYH-2.5,**  
**LM185BYH2.5/883, LM285H-2.5,**  
**or LM285BYH-2.5**  
**See NS Package Number H02A**

**Absolute Maximum Ratings** (Notes 1,

2)

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

Reverse Current	30 mA
Forward Current	10 mA
Operating Temperature Range (Note 3)	
LM185-2.5	-55°C to + 125°C
LM285-2.5	-40°C to + 85°C

LM385-2.5	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 Package	
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	Typ	LM385A-2.5 LM385AX-2.5 LM385AY-2.5		Units (Limits)
			Tested Limit (Note 5)	Design Limit (Note 6)	
Reverse Breakdown Voltage	$I_R = 100 \mu\text{A}$	2.500	2.480 2.520		V(Min) V(Max) V(Min) V(Max)
		<b>2.500</b>		<b>2.470</b> <b>2.530</b>	
Minimum Operating Current		12	18	<b>20</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>	mV (Max)
	$1\text{mA} \leq I_R \leq 20\text{mA}$		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>	$\Omega$
Wideband Noise (rms)	$I_R = 100 \mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	120			$\mu\text{V}$
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)	$I_{\text{MIN}} \leq I_R \leq 20\text{mA}$ X Suffix Y Suffix All Others		<b>30</b>		ppm/°C (Max)
			<b>50</b>		
				<b>150</b>	

## Electrical Characteristics

Parameter	Conditions	Typ	LM185-2.5 LM185BX-2.5 LM185BY-2.5 LM285-2.5 LM285BX-2.5 LM285BY-2.5		LM385B-2.5 LM385BX-2.5 LM385BY-2.5		LM385-2.5		Units (Limit)
			Tested Limit (Note 5) (Note 8)	Design Limit (Note 6)	Tested Limit (Note 5)	Design Limit (Note 6)	Tested Limit (Note 5)	Design Limit (Note 6)	
Reverse Breakdown Voltage	$T_A = 25^\circ\text{C}$ , $20\ \mu\text{A} \leq I_R \leq 20\ \text{mA}$	2.5	2.462		2.462		2.425		V(Min)
			2.538		2.538		2.575		V(Max)
Minimum Operating Current		13	20	<b>30</b>	20	<b>30</b>	20	<b>30</b>	$\mu\text{A}$ (Max)
	LM385M3-2.5						15	<b>20</b>	
Reverse Breakdown Voltage Change with Current	$20\ \mu\text{A} \leq I_R \leq 1\ \text{mA}$		1	<b>1.5</b>	2.0	<b>2.5</b>	2.0	<b>2.5</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)	$I_R = 100\ \mu\text{A}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$	120							$\mu\text{V}$
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		<b>30</b>		<b>30</b>				ppm/ $^\circ\text{C}$
	Y Suffix All Others		<b>50</b>	<b>150</b>	<b>50</b>	<b>150</b>		<b>150</b>	ppm/ $^\circ\text{C}$ 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-2.5 for military specifications.

**Note 3:** For elevated temperature operation,  $T_{J\ \text{MAX}}$  is:

LM185       $150^\circ\text{C}$

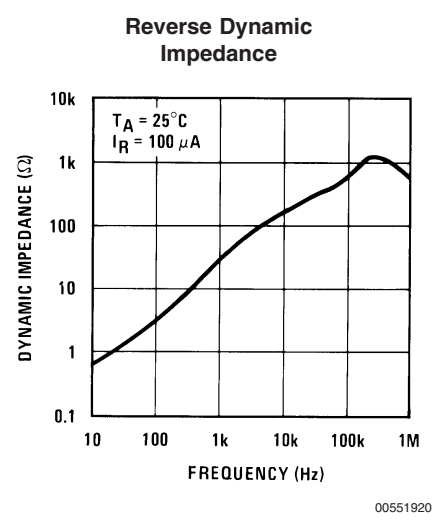
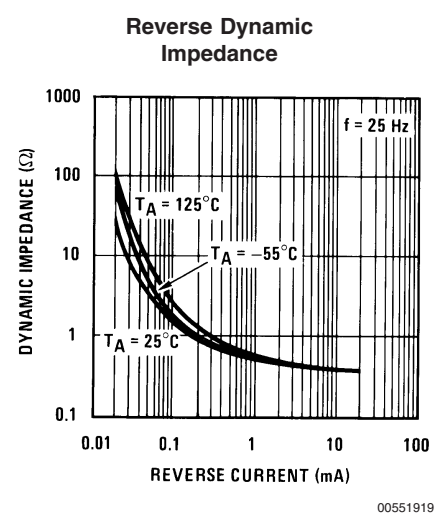
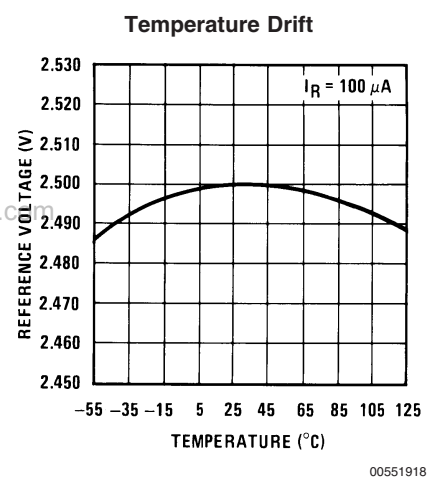
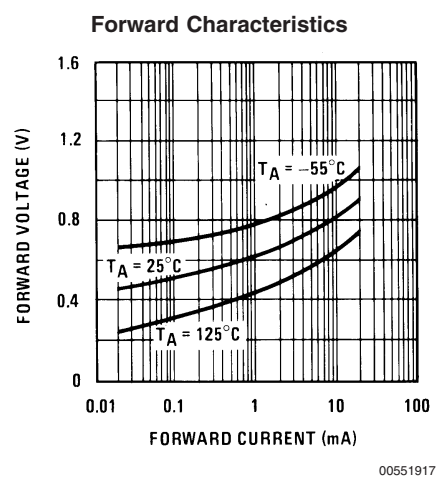
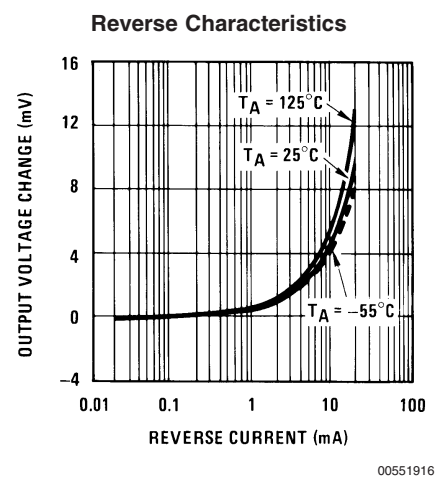
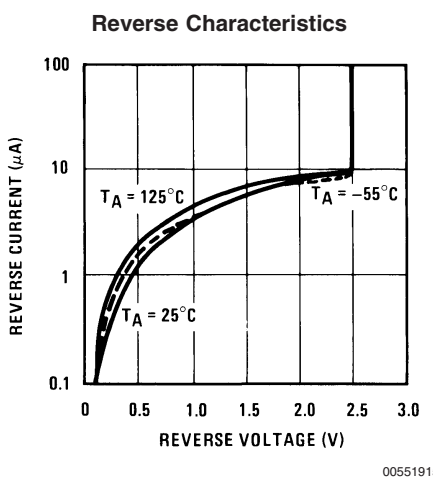
LM285       $125^\circ\text{C}$

LM385       $100^\circ\text{C}$

Thermal Resistance	TO-92	TO-46	SO-8	SOT-23
$\theta_{ja}$ (Junction to Ambient)	180 $^\circ\text{C}/\text{W}$ (0.4" Leads) 170 $^\circ\text{C}/\text{W}$ (0.125" Leads)	440 $^\circ\text{C}/\text{W}$	165 $^\circ\text{C}/\text{W}$	283 $^\circ\text{C}/\text{W}$
$\theta_{jc}$ (Junction to Case)	N/A	80 $^\circ\text{C}/\text{W}$	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  $T_{\text{MAX}}$  and  $T_{\text{MIN}}$ , divided by  $T_{\text{MAX}} - T_{\text{MIN}}$ . 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 available on request.

## Typical Performance Characteristics

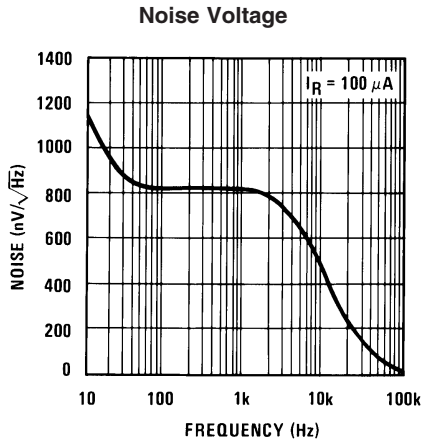


et4U.com

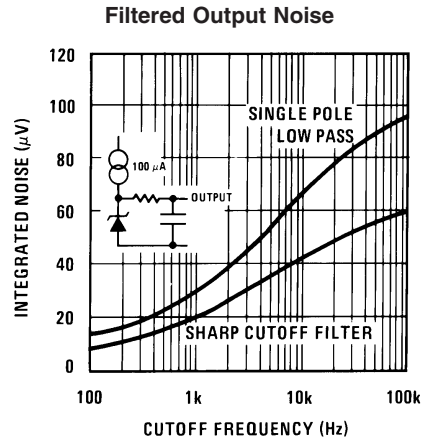
DataSheet4U.com

DataShee

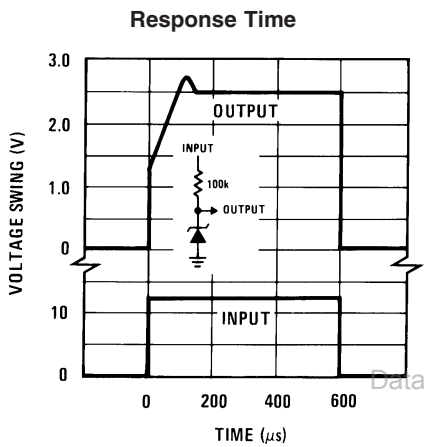
## Typical Performance Characteristics (Continued)



00551921



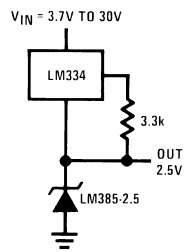
00551922



00551923

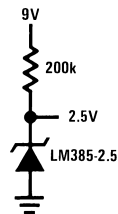
## Applications

### Wide Input Range Reference



00551912

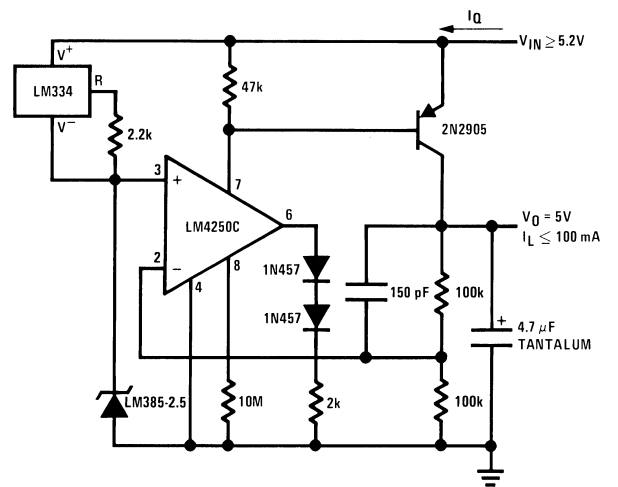
### Micropower Reference from 9V Battery



00551902

## LM385-2.5 Applications

### Micropower 5V Reference (Note 9)

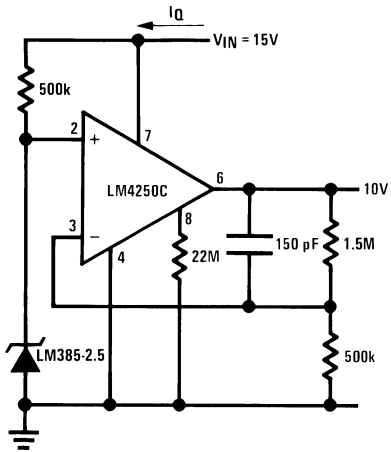


Note 9:  $I_Q \approx 40 \mu A$

00551909

# LM385-2.5 Applications (Continued)

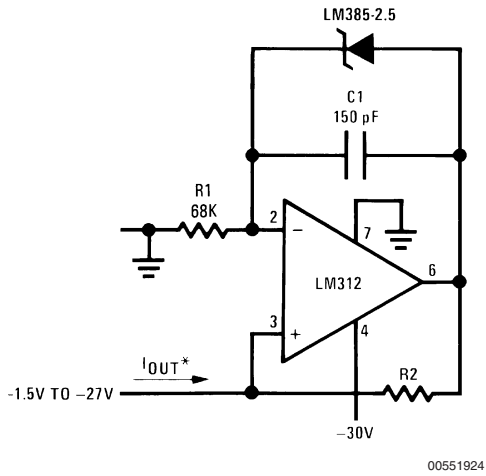
## Micropower 10V Reference (Note 10)



00551910

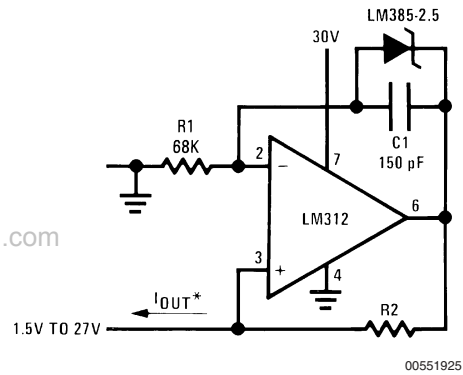
Note 10:  $I_Q = 30 \mu A$  standby current

## Precision 1 $\mu A$ to 1 mA Current Sources



00551924

$$*I_{OUT} = \frac{2.5V}{R2}$$



00551925

et4U.com

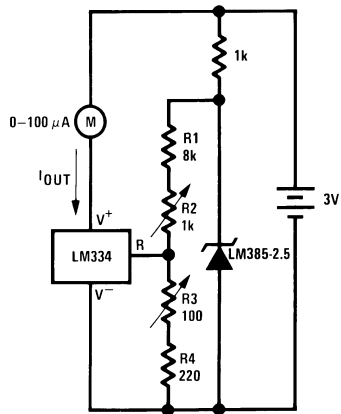
DataSheet4U.com

DataShee

# LM385-2.5 Applications (Continued)

## METER THERMOMETERS

0°C–100°C Thermometer

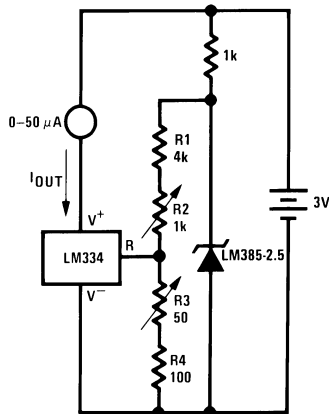


00551926

### Calibration

1. Short LM385-2.5, 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

0°F–50°F Thermometer

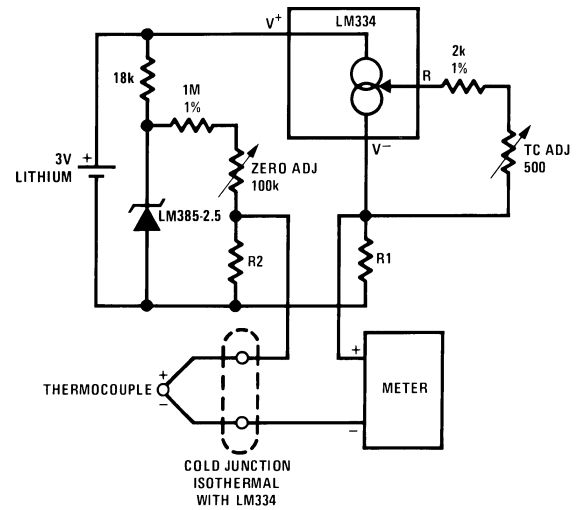


00551927

### Calibration

1. Short LM385-2.5, 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



00551906

### 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.

DataSheet4U.com

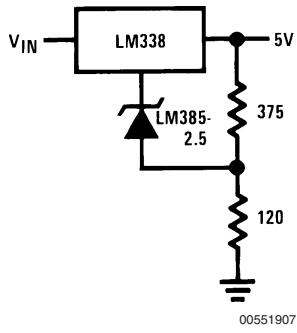
Thermocouple Type	Seebeck Co-efficient ( $\mu\text{V}/^\circ\text{C}$ )	R1 ( $\Omega$ )	R2 ( $\Omega$ )	Voltage Across R1 @25°C (mV)	Voltage Across R2 (mV)
J	52.3	523	1.24k	15.60	14.32
T	42.8	432	1k	12.77	11.78
K	40.8	412	953 $\Omega$	12.17	11.17
S	6.4	63.4	150 $\Omega$	1.908	1.766

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

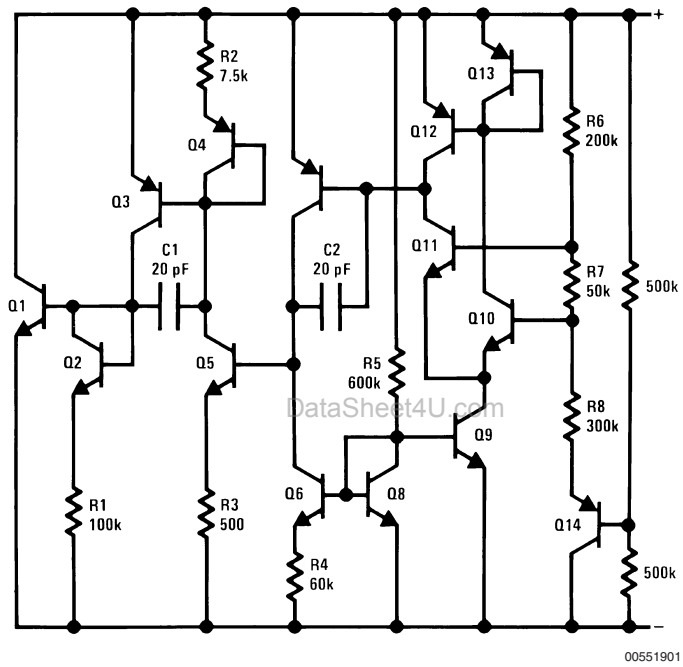


# LM385-2.5 Applications (Continued)

## Improving Regulation of Adjustable Regulators



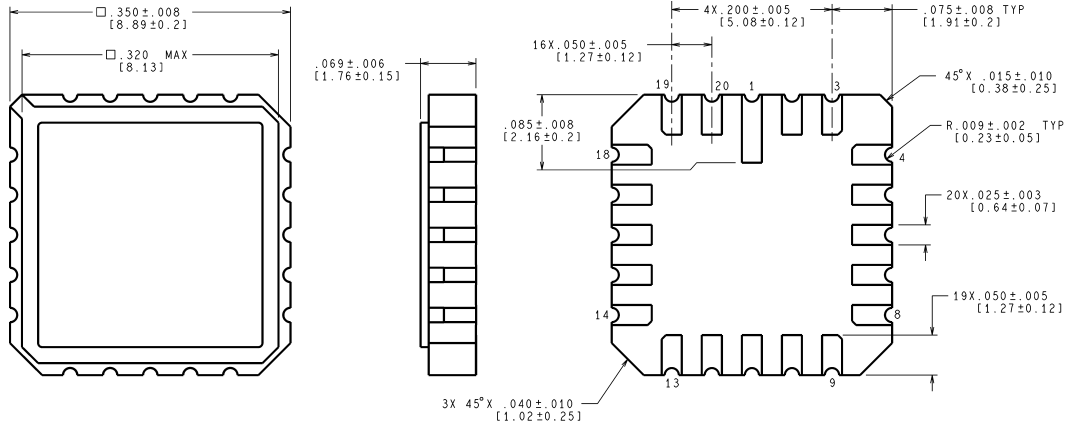
## Schematic Diagram



LM185-2.5/LM285-2.5/LM385-2.5

### Physical Dimensions inches (millimeters)

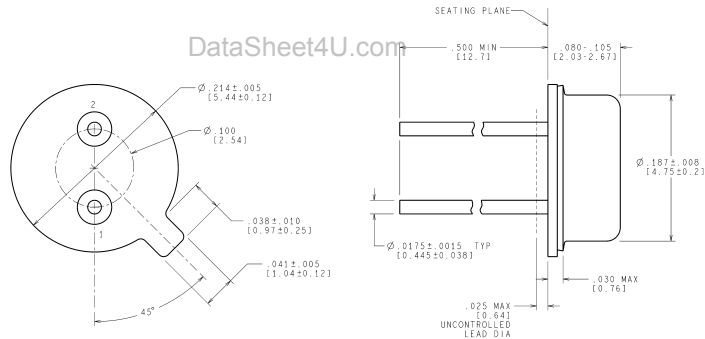
unless otherwise noted



CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS

E20A (Rev F)

Order Number LM185E-2.5/883  
NS Package Number E20A



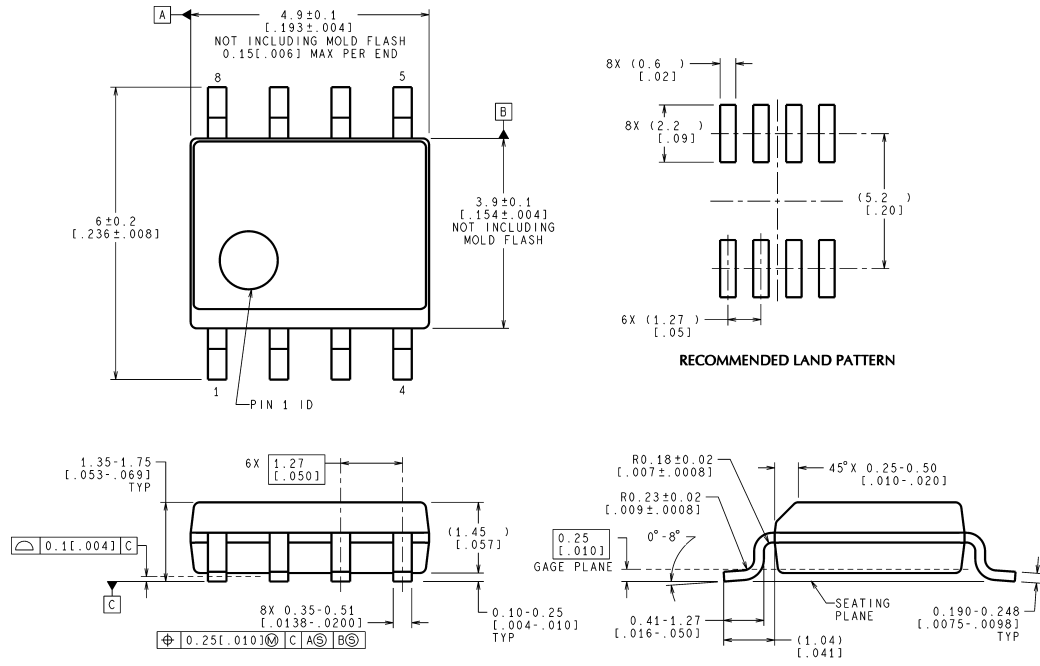
CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS

H02A (Rev F)

TO-46 Metal Can Package (H)  
Order Number LM185H-2.5, LM185H-2.5/883, LM185BXH-2.5, LM185BYH-2.5, LM185BYH-2.5/883, LM285H-2.5, or LM285BYH-2.5  
NS Package Number H02A



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

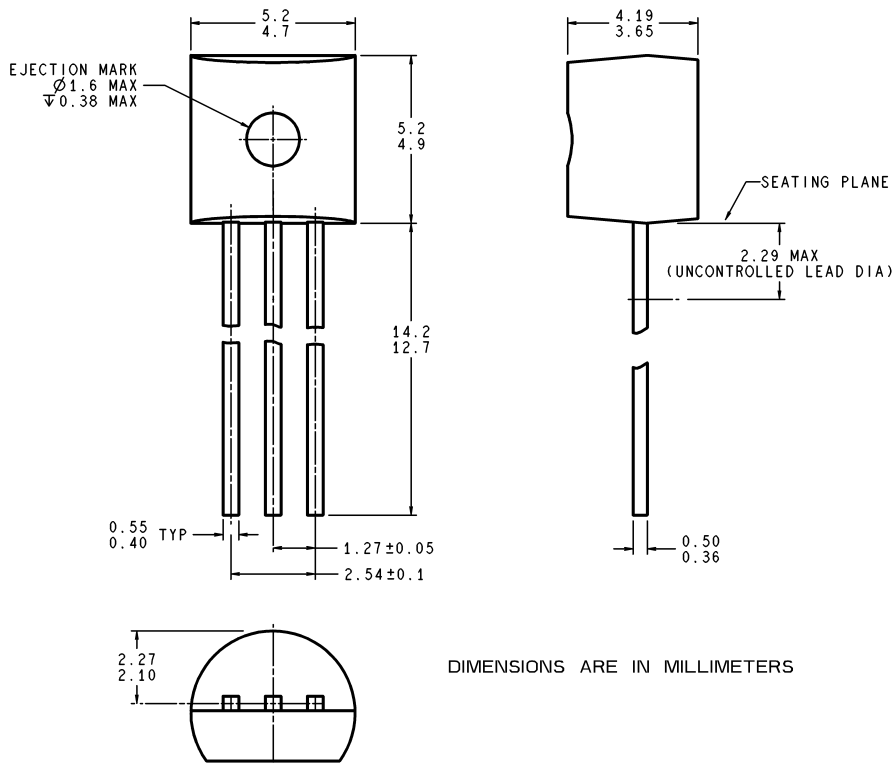


CONTROLLING DIMENSION IS MILLIMETER  
VALUES IN [ ] ARE INCHES  
DIMENSIONS IN ( ) FOR REFERENCE ONLY

M08A (Rev K)

**Small Outline (SO-8) Package (M)**  
**Order Number LM285M-2.5, LM285BXM-2.5, LM285BYM-2.5,**  
**LM385M-2.5, LM385BM-2.5, LM385BXM-2.5 or LM385BYM-2.5**  
**NS Package Number M08A**

DataSheet4U.com

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

Z03A (Rev G)

**TO-92 Plastic Package (Z)**  
**Order Number LM285Z-2.5, LM285BXZ-2.5, LM285BYZ-2.5,**  
**LM385Z-2.5, LM385AXZ-2.5, LM385AYZ-2.5,**  
**LM385BZ-2.5, LM385BXZ-2.5 or LM385BYZ-2.5**  
**NS Package Number Z03A**

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

For the most current product information visit us at [www.national.com](http://www.national.com).

**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.

**BANNED SUBSTANCE COMPLIANCE**

National Semiconductor manufactures products and uses packing materials that meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.



**National Semiconductor**  
**Americas Customer**  
**Support Center**  
 Email: [new.feedback@nsc.com](mailto:new.feedback@nsc.com)  
 Tel: 1-800-272-9959

**National Semiconductor**  
**Europe Customer Support Center**  
 Fax: +49 (0) 180-530 85 86  
 Email: [europa.support@nsc.com](mailto:europa.support@nsc.com)  
 Deutsch Tel: +49 (0) 69 9508 6208  
 English Tel: +44 (0) 870 24 0 2171  
 Français Tel: +33 (0) 1 41 91 8790

**National Semiconductor**  
**Asia Pacific Customer**  
**Support Center**  
 Email: [ap.support@nsc.com](mailto:ap.support@nsc.com)

**National Semiconductor**  
**Japan Customer Support Center**  
 Fax: 81-3-5639-7507  
 Email: [jpn.feedback@nsc.com](mailto:jpn.feedback@nsc.com)  
 Tel: 81-3-5639-7560

[www.national.com](http://www.national.com)