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# 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.

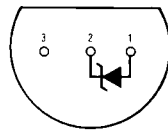
The LM185-2.5 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range while the LM285-2.5 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385-2.5  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185-2.5/LM285-2.5 are available in a 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

TO-92  
Plastic Package

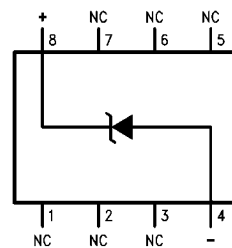


551908

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

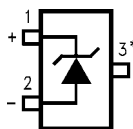
SO Package



551911

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

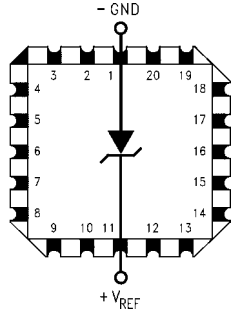


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\* Pin 3 is attached to the Die Attach Pad (DAP) and should be connected to Pin 2 or left floating.

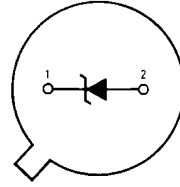
Order Number LM385M3-2.5  
See NS Package Number MA03B

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



551914  
**Order Number LM185E-2.5/883**  
**See NS Package Number E20A**

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



551913  
**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

ESD Susceptibility (Note 9)	2kV
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	$I_R = 100 \mu A$	2.500	2.480		V(Min)
		<b>2.500</b>	2.520	<b>2.470</b> <b>2.530</b>	V(Max) V(Min) V(Max)
Minimum Operating Current		12	18	<b>20</b>	$\mu A$ (Max)
Reverse Breakdown Voltage Change with Current	$I_{MIN} \leq I_R \leq 1 mA$		1	<b>1.5</b>	mV (Max)
	$1 mA \leq I_R \leq 20 mA$		10	<b>20</b>	mV (Max)
Reverse Dynamic Impedance	$I_R = 100 \mu A,$ $f = 20 Hz$	0.2		0.6	$\Omega$
				<b>1.5</b>	
Wideband Noise (rms)	$I_R = 100 \mu A$ $10 Hz \leq f \leq 10 kHz$	120			$\mu V$
Long Term Stability	$I_R = 100 \mu A,$ $T = 1000 Hr,$ $T_A = 25^\circ C \pm 0.1^\circ C$	20			ppm
Average Temperature Coefficient (Note 7)	$I_{MIN} \leq I_R \leq 20 mA$ X Suffix Y Suffix All Others		<b>30</b>		ppm/ $^\circ C$ (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 (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	$T_A = 25^\circ\text{C}$ ,	2.5	2.462		2.462		2.425		V(Min)
	$20\ \mu\text{A} \leq I_R \leq 20\ \text{mA}$		2.538		2.538		2.575		V(Max)
Minimum Operating Current		13	20	<b>30</b>	20	<b>30</b>	20	<b>30</b>	$\mu\text{A}$
	LM385M3-2.5						15	<b>20</b>	(Max)
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		<b>50</b>	<b>150</b>	<b>50</b>	<b>150</b>		<b>150</b>	ppm/ $^\circ\text{C}$
All Others								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.

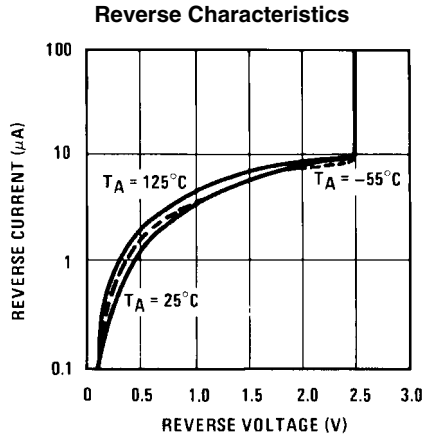
**Note 6:** Guaranteed, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.

**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  $-55^\circ\text{C}$ ,  $-40^\circ\text{C}$ ,  $0^\circ\text{C}$ ,  $25^\circ\text{C}$ ,  $70^\circ\text{C}$ ,  $85^\circ\text{C}$ ,  $125^\circ\text{C}$ .

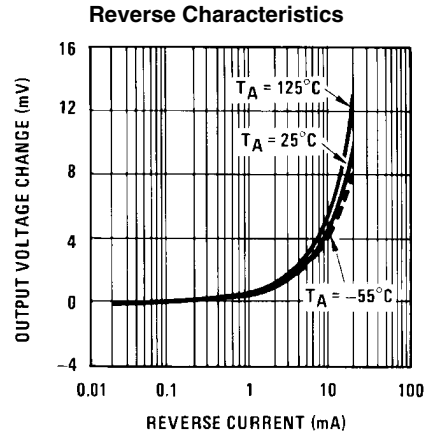
**Note 8:** A military RETS electrical specification available on request.

**Note 9:** The human body model is a 100 pF capacitor discharged through a 1.5 k $\Omega$  resistor into each pin.

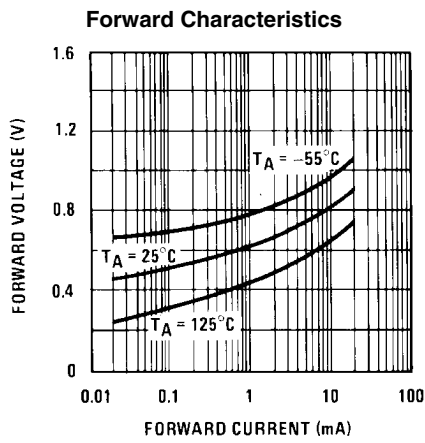
# Typical Performance Characteristics



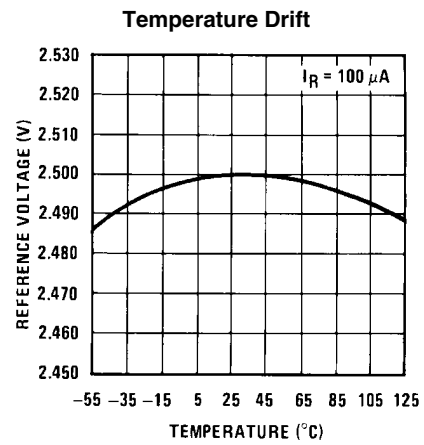
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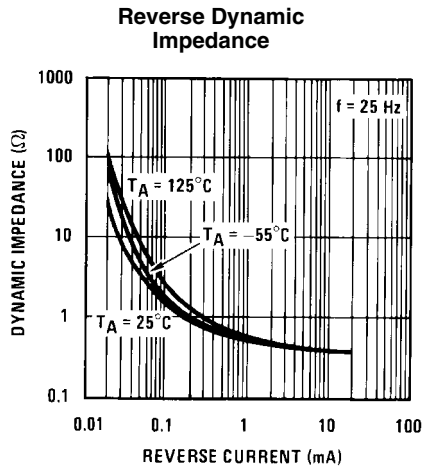
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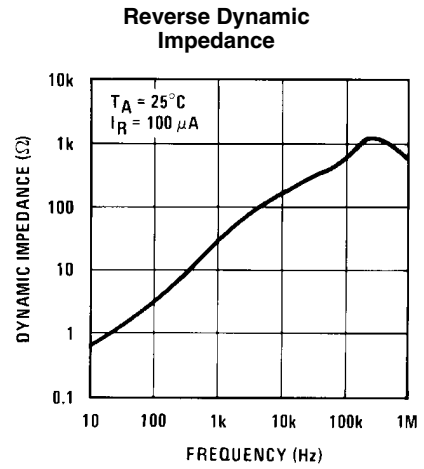
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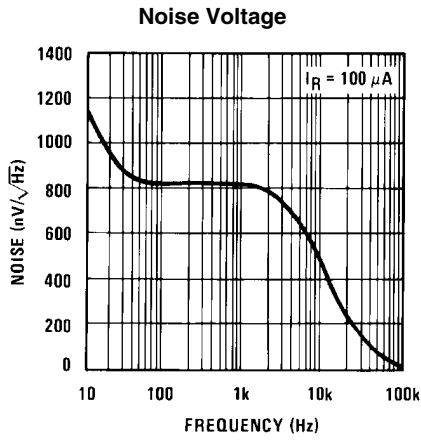
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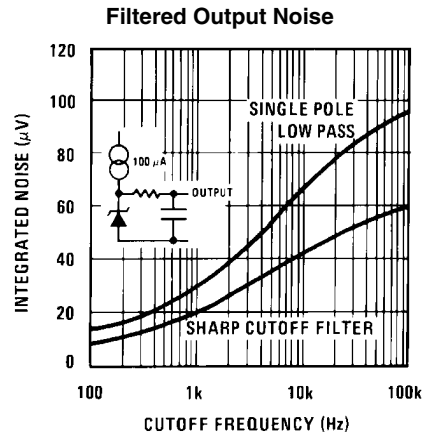
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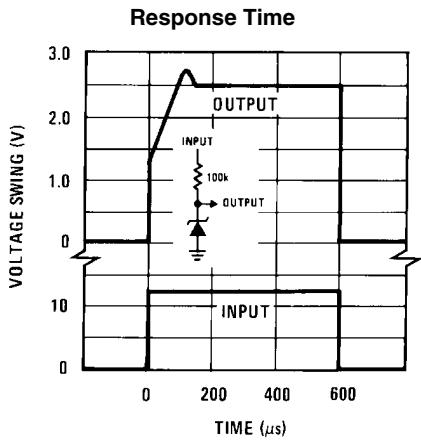
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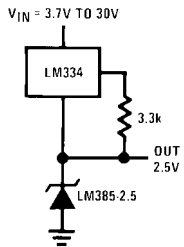
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551923

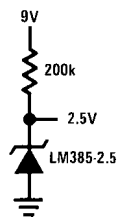
## Applications

### Wide Input Range Reference



551912

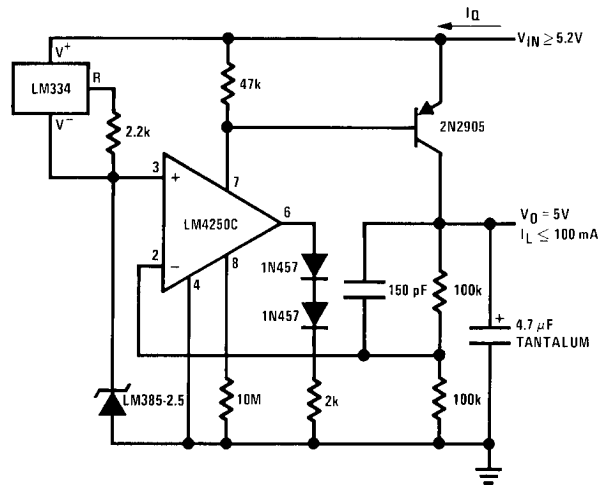
### Micropower Reference from 9V Battery



551902

## LM385-2.5 Applications

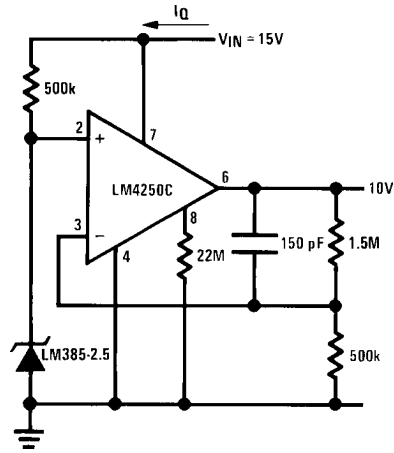
### Micropower 5V Reference



Note 10:  $I_Q = 40 \mu A$

551909

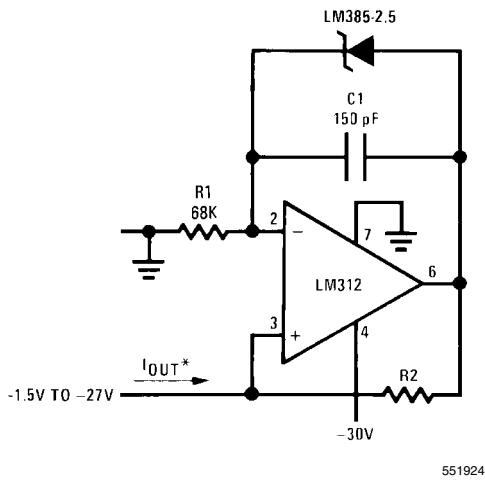
**Micropower 10V Reference**



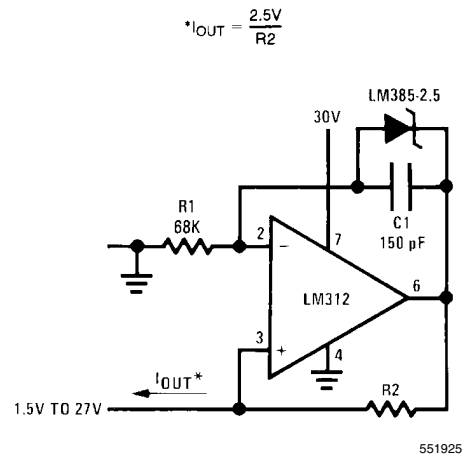
551910

**Note 11:**  $I_Q \approx 30 \mu\text{A}$  standby current

**PRECISION 1  $\mu\text{A}$  to 1 mA CURRENT SOURCES**



551924



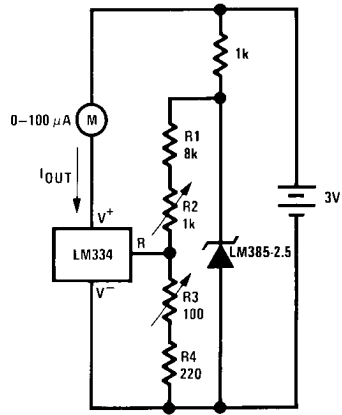
551925

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



METER THERMOMETERS

0°C–100°C Thermometer

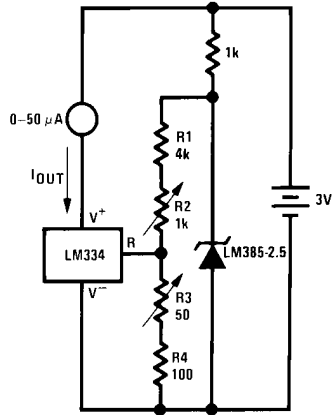


551926

Calibration

1. Short LM385-2.5, adjust R3 for  $I_{OUT} = \text{temp}$  at  $1 \mu\text{A}/^\circ\text{K}$   
Remove short, adjust R2 for correct reading in centigrade

0°F–50°F Thermometer

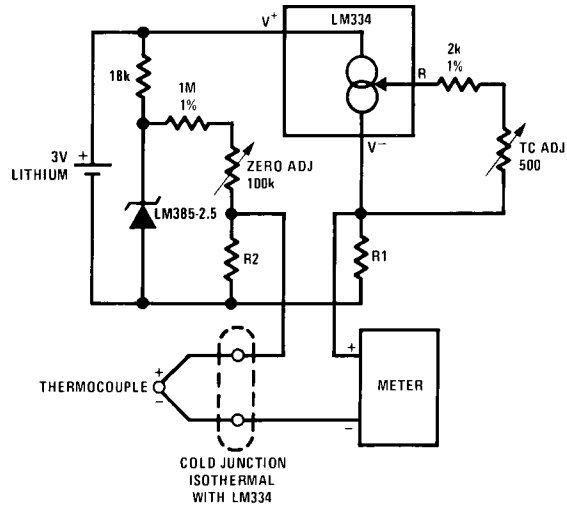


551927

Calibration

1. Short LM385-2.5, adjust R3 for  $I_{OUT} = \text{temp}$  at  $1.8 \mu\text{A}/^\circ\text{K}$   
Remove short, adjust R2 for correct reading in °F

**Micropower Thermocouple Cold Junction Compensator**



551906

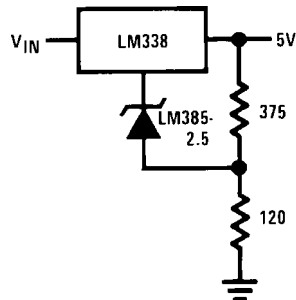
**Adjustment Procedure**

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 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

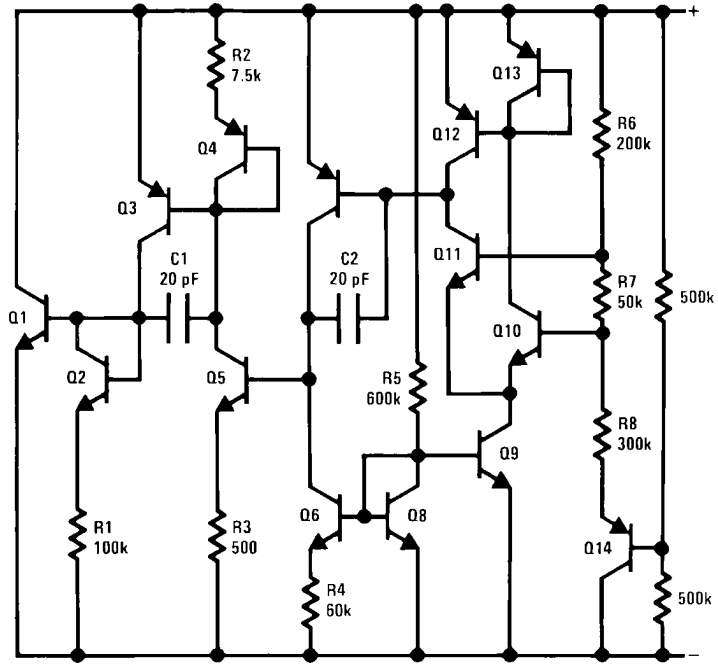
Typical supply current 50  $\mu\text{A}$

**Improving Regulation of Adjustable Regulators**



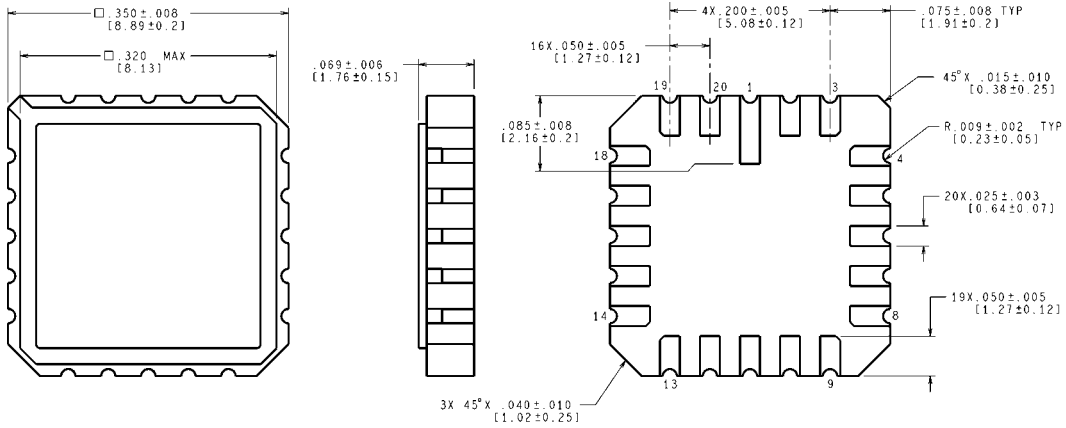
551907

# Schematic Diagram



551901

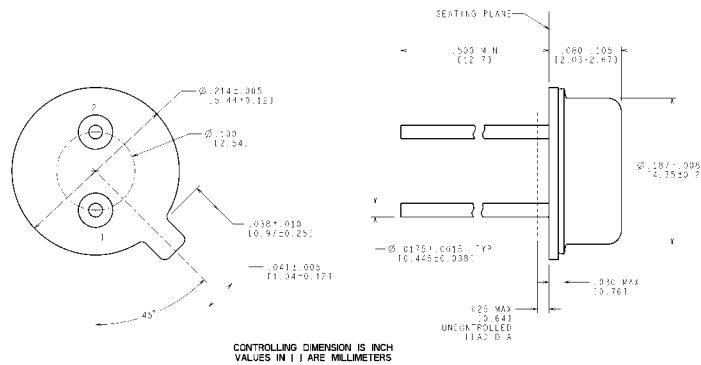
**Physical Dimensions** inches (millimeters) unless otherwise noted



CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS

E20A (Rev F)

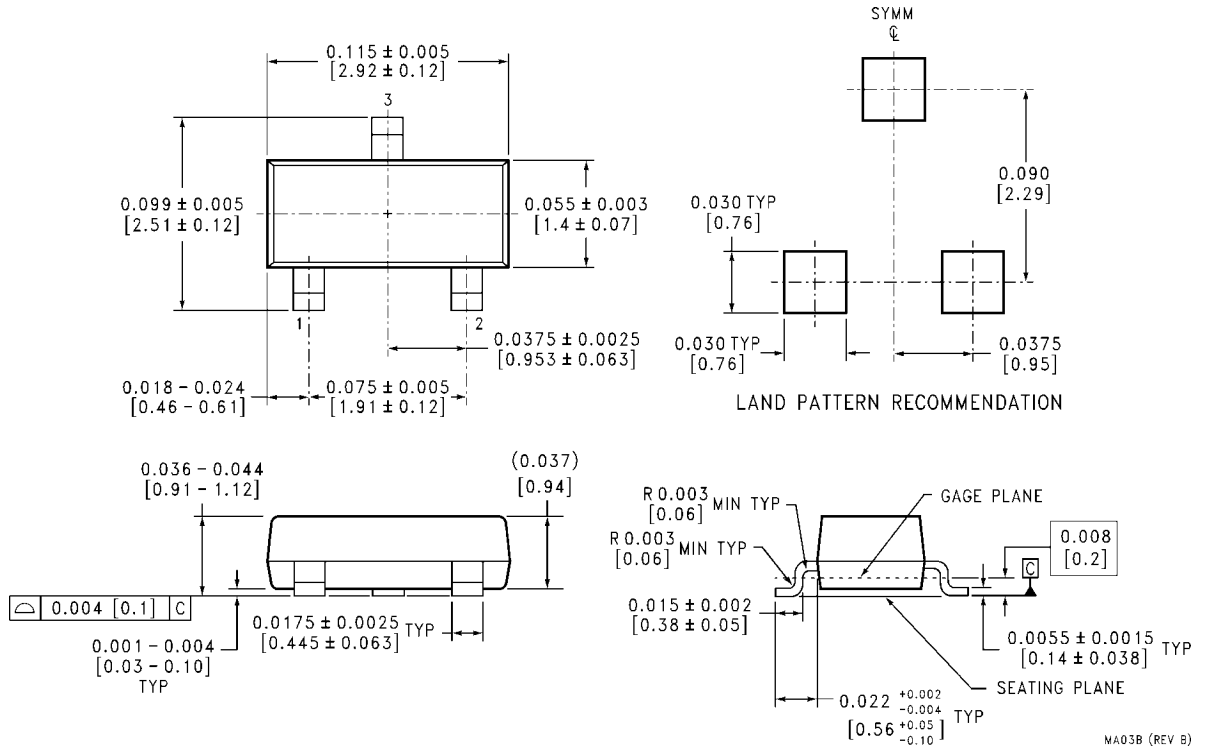
**Order Number LM185E-2.5/883**  
**NS Package Number E20A**



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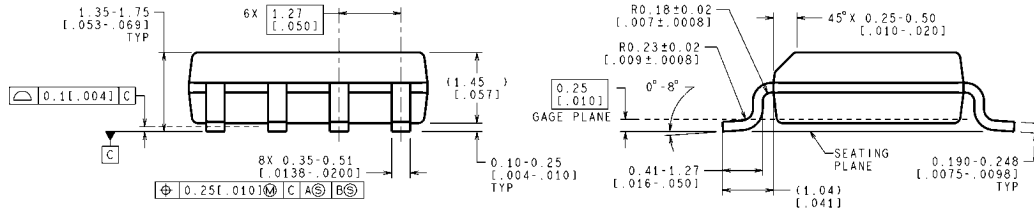
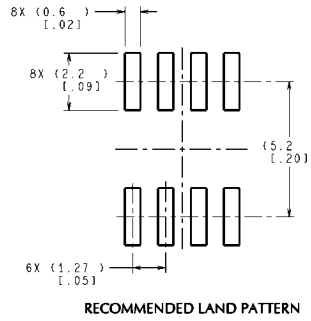
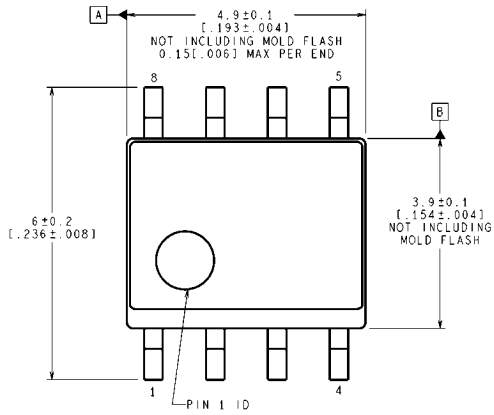
H02A (Rev F)

**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**



**SOT-23 Package (M3)**  
**Order Number LM385M3-2.5**  
**NS Package Number MA03B**

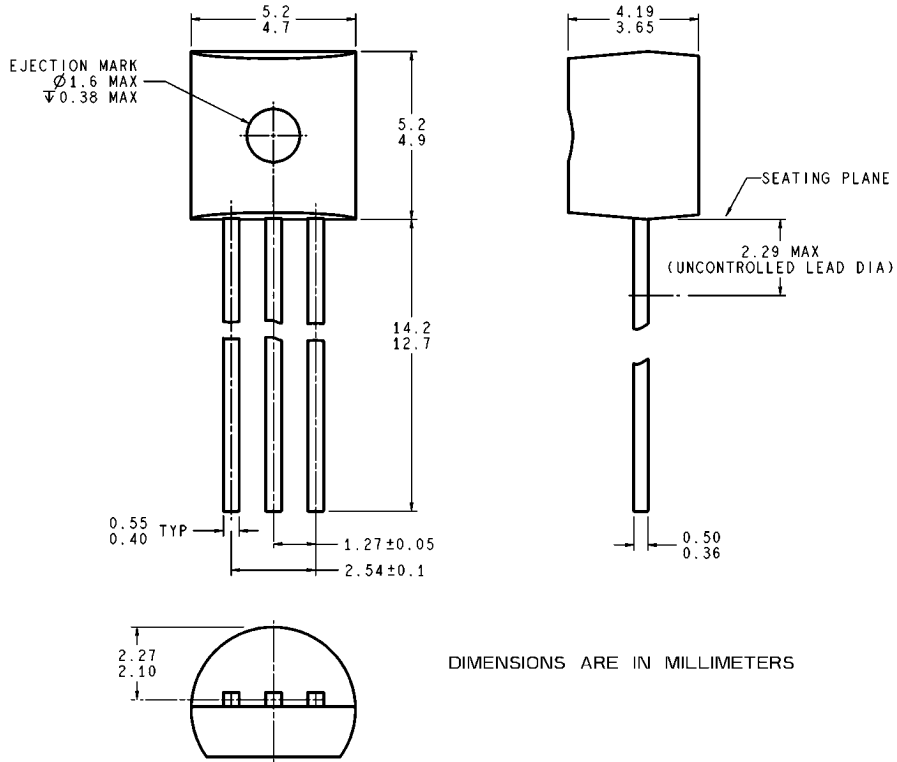
MA03B (REV B)



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

**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**

M08A (Rev L)



DIMENSIONS ARE IN MILLIMETERS

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**

# Notes

LM185-2.5/LM285-2.5/LM385-2.5



## Notes

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Clock Conditioners	<a href="http://www.national.com/timing">www.national.com/timing</a>	App Notes	<a href="http://www.national.com/appnotes">www.national.com/appnotes</a>
Data Converters	<a href="http://www.national.com/adc">www.national.com/adc</a>	Distributors	<a href="http://www.national.com/contacts">www.national.com/contacts</a>
Displays	<a href="http://www.national.com/displays">www.national.com/displays</a>	Green Compliance	<a href="http://www.national.com/quality/green">www.national.com/quality/green</a>
Ethernet	<a href="http://www.national.com/ethernet">www.national.com/ethernet</a>	Packaging	<a href="http://www.national.com/packaging">www.national.com/packaging</a>
Interface	<a href="http://www.national.com/interface">www.national.com/interface</a>	Quality and Reliability	<a href="http://www.national.com/quality">www.national.com/quality</a>
LVDS	<a href="http://www.national.com/lvds">www.national.com/lvds</a>	Reference Designs	<a href="http://www.national.com/refdesigns">www.national.com/refdesigns</a>
Power Management	<a href="http://www.national.com/power">www.national.com/power</a>	Feedback	<a href="http://www.national.com/feedback">www.national.com/feedback</a>
Switching Regulators	<a href="http://www.national.com/switchers">www.national.com/switchers</a>		
LDOs	<a href="http://www.national.com/ldo">www.national.com/ldo</a>		
LED Lighting	<a href="http://www.national.com/led">www.national.com/led</a>		
PowerWise	<a href="http://www.national.com/powerwise">www.national.com/powerwise</a>		
Serial Digital Interface (SDI)	<a href="http://www.national.com/sdi">www.national.com/sdi</a>		
Temperature Sensors	<a href="http://www.national.com/tempsensors">www.national.com/tempsensors</a>		
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## LM185-2.5 - Micropower Voltage Reference Diode



[Datasheet](#)

[Packaging](#)

[Samples & Pricing](#)

[Knowledge Base](#)

### 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

### General Description

The LM185-2.5/LM285-2.5/LM385-2.5 are micropower 2-terminal band-gap voltage regulator diodes. [More...](#)

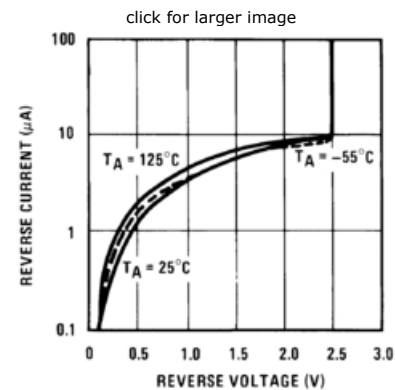
### Typical Application

[See Datasheet for Application Information](#)

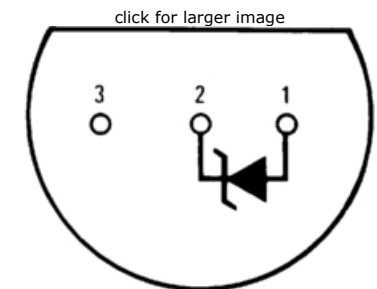
### Parametric Table [expand](#)





Reference Voltage	2.5 V
Operating Current	0.02 mA
Output Current	20 mA

### Typical Performance



### Connection Diagram



 <a href="#">RoHS Compliance Information</a>	Size in Kbytes	Date			
LM185-2.5/LM285-2.5/LM385-2.5 Micropower Voltage Reference Diode	334 Kbytes	30-Jan-08	<a href="#">View Online</a>	<a href="#">Download</a>	<a href="#">Receive via Email</a>
LM185-2.5QML Micropower Voltage Reference Diode	647 Kbytes	8-Nov-05	<a href="#">View Online</a>	<a href="#">Download</a>	<a href="#">Receive via Email</a>

If you have trouble printing or viewing PDF file(s), see [Printing Problems](#).

#### Package Availability, Models, Samples & Pricing

Part Number	Package							Factory Lead Time		Models	Samples & Electronic Orders	Budgetary Pricing		Std Pack Size	Package Marking Format	
	Type	Pins	Spec.	MSL Rating	Peak Reflow	RoHS Report	CAD Symbols	Weeks	Qty			Qty	\$US each			
LM185BXH-2.5	TO-46	2	STD	1	NA	RoHS	N/A	Full production		N/A		1K+	\$15.60	box of 1000	NSXYTTE# LM185BXH-2.5	
								6 weeks	2000							
LM185BYH-2.5	TO-46	2	STD	1	NA	RoHS	N/A	Full production		N/A		1K+	\$12.50	box of 1000	NSXYTTE# LM185BYH-2.5	
								6 weeks	2000							
5962-8759406XA (LM185BYH2.5-SMD)	TO-46	2					RoHS	N/A	Obsolete		N/A		50+	\$18.00	tray of 20	NSZSSXXYYA 8759406XA Q
			10 weeks	500												
LM185BYH2.5/883	TO-46	2	STD	1	NA	RoHS	N/A	Full production		N/A	<a href="#">Buy Now</a>	50+	\$20.70	tray of 20	NSZSSXXYYA LM185BYH2.5 Q	
								8 weeks	100							
5962-8759402XA (LM185H-2.5-SMD)	TO-46	2					RoHS	N/A	Full production		N/A	<a href="#">Buy Now</a>	50+	\$20.70	tray of 20	NSZSSXXYYA 8759402XA Q
			8 weeks	1000												
LM185H-2.5/883	TO-46	2	STD	1	NA	RoHS	N/A	Full production		N/A	<a href="#">Buy Now</a>	50+	\$20.70	tray of 20	NSZSSXXYYA LM185H-2.5 Q	
								8 weeks	500							
LM185WG-2.5/883	CERPACK	10	STD	1	NA	RoHS	N/A	Lifetime buy		N/A		50+	\$21.60	tray of 54	NS ZSSXXYYA 8759402YA LM185WG-2.5/883 Q	
								10 weeks	100							
5962-8759406VXA (LM185BYH2.5-QV)	TO-46	2					RoHS	N/A	Full production		N/A		50+	\$296.00	tray of 20	NSZSSXXYYA 8759406VXA Q
			N/A	50												
LM185WG-2.5-QV	CERPACK	10	STD	1	NA	RoHS	N/A	Lifetime buy		N/A			CALL	tray of N/A	NS ZSSXXYYA 8759402VY A LM185W G-2.5-QV	
								N/A	500							
LM185BYH2.5-MLS	TO-46	2					RoHS	N/A	Lifetime buy		N/A			CALL	tray of N/A	NSZSSXXYYALM185BYH2.5MLS
			N/A	N/A												
LM185-2.5 MD8	Unpackaged Die							Full production		N/A			CALL	tray of N/A	-	
	N/A	2500														

## Obsolete Parts

Obsolete Part	Alternate Part or Supplier	Source	Last Time Buy Date
LM185-2.5G MW8	NONE	NONE	09/08/99

### General Description

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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.

*[Information as of 29-Apr-2008]*