National Semiconductor

January 30, 2008

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 µA 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.

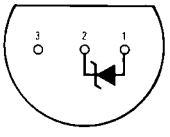
The LM185-2.5 is rated for operation over a –55°C to 125°C temperature range while the LM285-2.5 is rated –40°C to 85° C and the LM385-2.5 0°C to 70°C. The LM185-2.5/LM285-2.5 are available in a hermetic TO-46 package and the LM285-2.5/LM385-2.5 are also available in a low-cost TO-92 molded package,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

Features

- ±20 mV (±0.8%) max. initial tolerance (A grade)
- Operating current of 20 µA to 20 mA
- 0.6Ω 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



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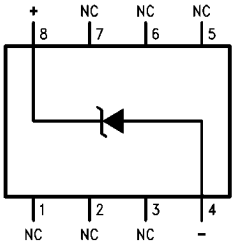
Bottom View
Order Number LM285Z-2.5,
LM285BXZ-2.5, LM285BYZ-2.5
LM385Z-2.5, LM385AXZ-2.5
LM385AYZ-2.5, LM385BZ-2.5,
LM385BXZ-2.5 or LM385BYZ-2.5
See NS Package Number Z03A

SO Package



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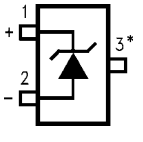
Order Number LM285M-2.5,
LM285BXM-2.5, LM285BYM-2.5
LM385M-2.5, LM385BM-2.5
LM385BXM-2.5 or LM385BYM-2.5
See NS Package Number M08A

SOT-23



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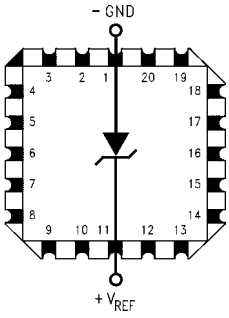
* Pin 3 is attached to the Die Attach Pad (DAP) and should be connected to Pin 2 or left floating.

Order Number LM385M3-2.5
See NS Package Number MA03B

LCC
Leadless Chip Carrier



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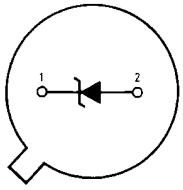
Order Number LM185E-2.5/883
See NS Package Number E20A

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 µA	2.500	2.480		V(Min)
			2.520		V(Max)
		2.500		**2.470**	V(Min)
				2.530	V(Max)
Minimum Operating Current		12	18	**20**	µA (Max)
Reverse Breakdown Voltage Change with Current	$I_{MIN} \le I_R \le$ 1mA		1	**1.5**	mV (Max)
	1 mA ≤ I_R ≤ 20 mA		10	**20**	mV (Max)
Reverse Dynamic Impedance	I_R = 100 µA, f = 20 Hz	0.2		0.6	Ω
				1.5	
Wideband Noise (rms)	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	120			µV
Long Term Stability	I_R = 100 µA, T = 1000 Hr, T_A = 25°C ±0.1°C	20			ppm
Average Temperature Coefficient (Note 7)	$I_{MIN} \le I_R \le$ 20 mA				
	X Suffix		**30**		ppm/°C
	Y Suffix		**50**		(Max)
	All Others			**150**	

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°C,	2.5	2.462		2.462		2.425		V(Min)
	20 µA ≤ I_R ≤ 20 mA		2.538		2.538		2.575		V(Max)
Minimum Operating Current		13	20	**30**	20	**30**	20	**30**	µA
	LM385M3-2.5						15	**20**	(Max)
Reverse Breakdown Voltage Change with Current	20 µA ≤ I_R ≤ 1 mA		1	**1.5**	2.0	**2.5**	2.0	**2.5**	mV (Max)
	1 mA ≤ I_R ≤ 20 mA		10	**20**	20	**25**	20	**25**	mV (Max)
Reverse Dynamic Impedance	I_R = 100 µA, f = 20 Hz	1							Ω
Wideband Noise (rms)	I_R = 100 µA, 10 Hz ≤ f ≤ 10 kHz	120							µV
Long Term Stability	I_R = 100 µA, T = 1000 Hr, T_A = 25°C ±0.1°C	20							ppm
Average Temperature Coefficient (Note 7)	I_R = 100 µA								
	X Suffix		**30**		**30**				ppm/°C
	Y Suffix		**50**		**50**				ppm/°C
	All Others			**150**		**150**		**150**	ppm/°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, $T_{J\,MAX}$ is:

LM185 150°C
LM285 125°C
LM385 100°C

Thermal Resistance	TO-92	TO-46	SO-8	SOT-23
θ_{ja} (Junction to Ambient)	180°C/W (0.4″ Leads) 170°C/W (0.125″ Leads)	440°C/W	165°C/W	283°C/W
θ_{jc} (Junction to Case)	N/A	80°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°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.

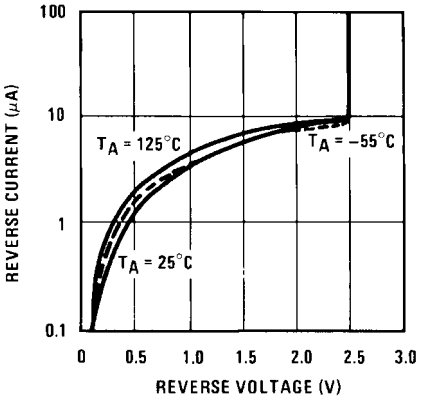
Note 7: The average temperature coefficient is defined as the maximum deviation of reference voltage at all measured temperatures between the operating T_{MAX} and T_{MIN}, divided by T_{MAX}–T_{MIN}. The measured temperatures are –55°C, –40°C, 0°C, 25°C, 70°C, 85°C, 125°C.

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 kΩ resistor into each pin.

Typical Performance Characteristics

Reverse Characteristics



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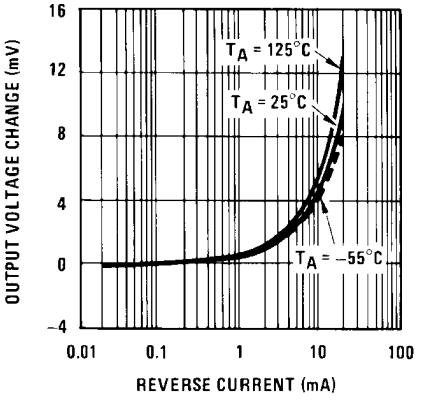
Reverse Characteristics



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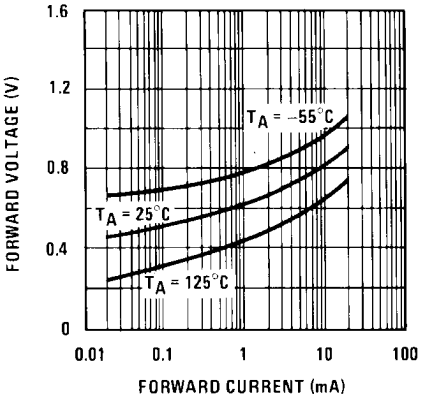
Forward Characteristics



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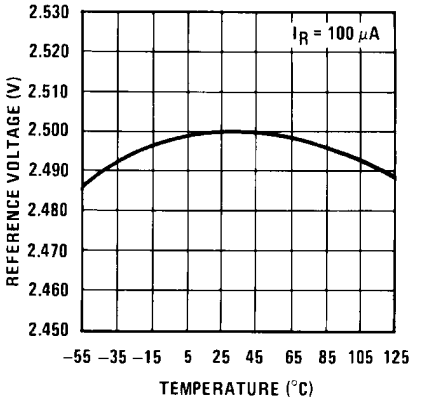
Temperature Drift



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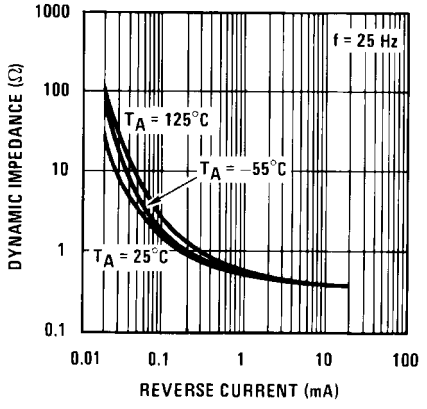
Reverse Dynamic Impedance



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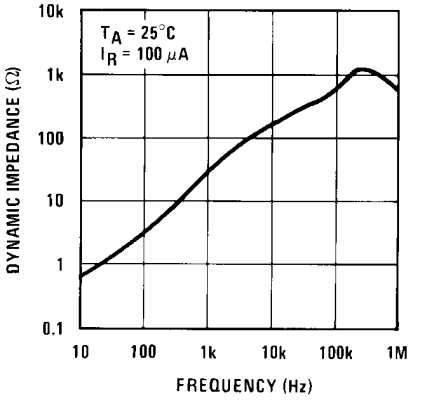
Reverse Dynamic Impedance



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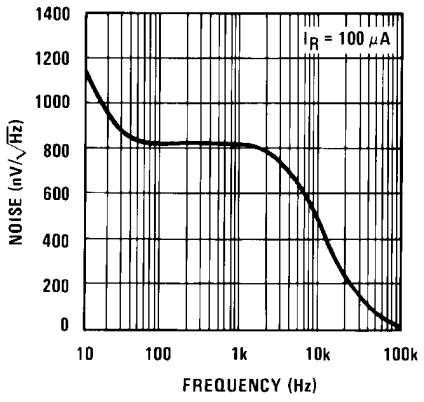
Noise Voltage



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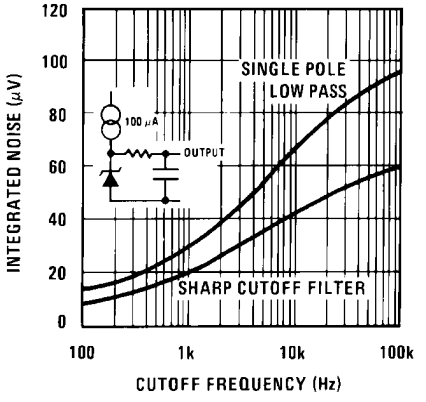
Filtered Output Noise



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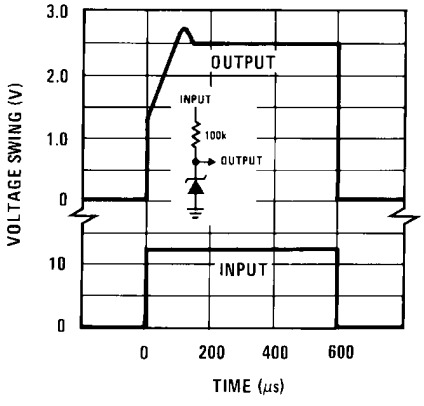
Response Time



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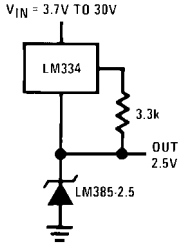
Applications

LM385-2.5 Applications

Wide Input Range Reference



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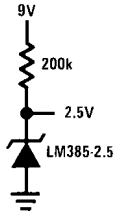
Micropower Reference from 9V Battery



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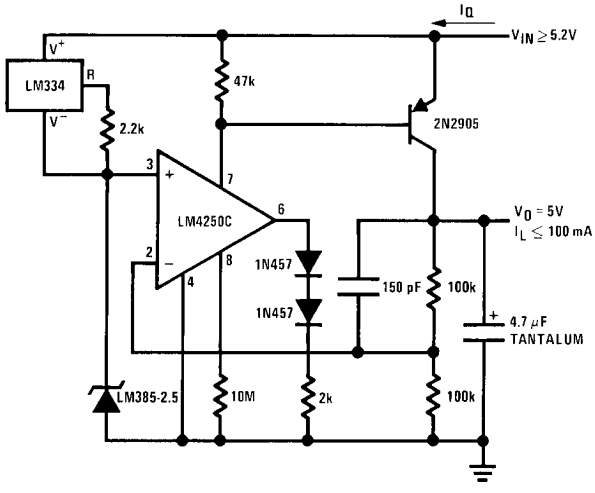
Micropower 5V Reference



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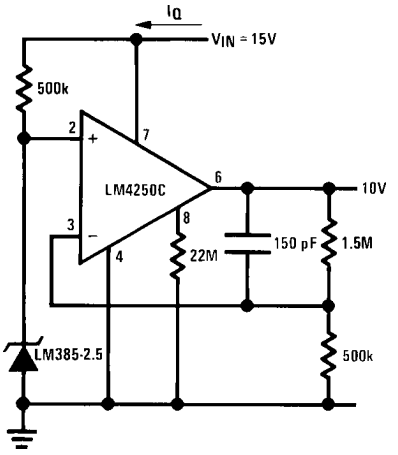
Note 10: $I_Q \approx 40$ µA

Micropower 10V Reference



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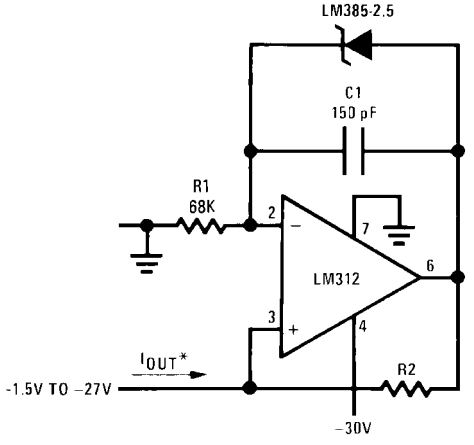
Note 11: $I_Q \approx 30\ \mu A$ standby current

PRECISION 1 µA to 1 mA CURRENT SOURCES



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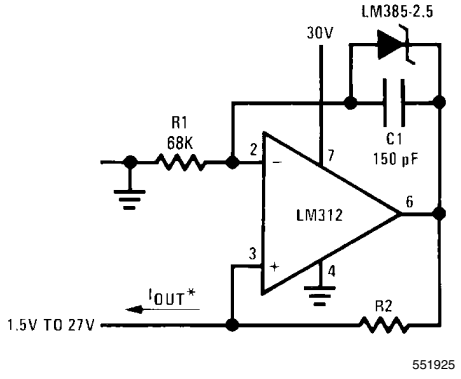
$^*I_{OUT} = \frac{2.5V}{R2}$



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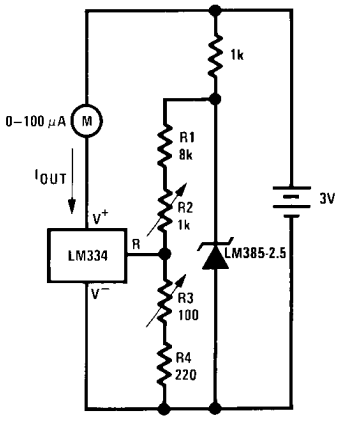
METER THERMOMETERS

0°C–100°C Thermomemter



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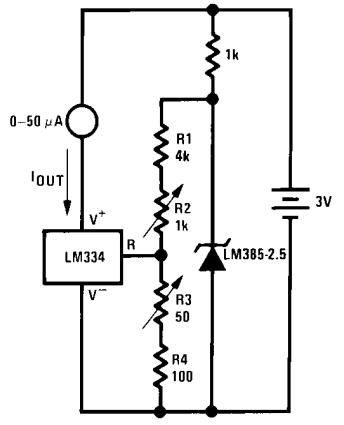
Calibration

1. Short LM385-2.5, adjust R3 for I_{OUT}=temp at 1µA/°K
   Remove short, adjust R2 for correct reading in centigrade

0°F–50°F Thermomemter

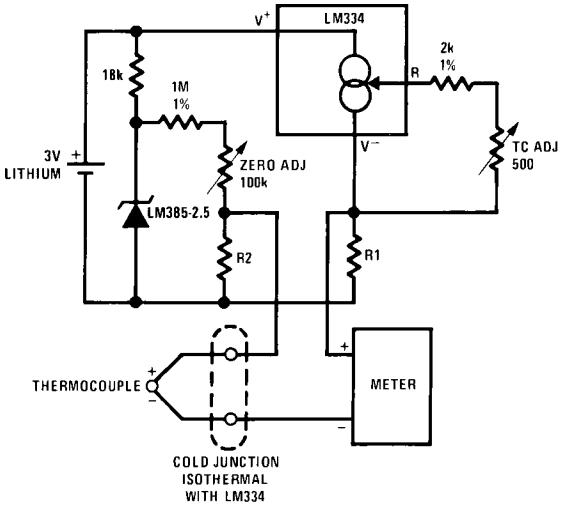


551927

Calibration

1. Short LM385-2.5, adjust R3 for I_{OUT}=temp at 1.8 µA/°K
   Remove short, adjust R2 for correct reading in °F

Micropower Thermocouple Cold Junction Compensator



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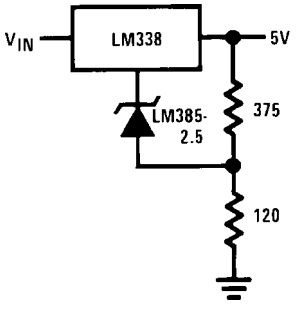
Adjustment Procedure

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 (μV/°C)	R1 (Ω)	R2 (Ω)	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	953Ω	12.17	11.17
S	6.4	63.4	150Ω	1.908	1.766

Typical supply current 50 µA

Improving Regulation of Adjstable Regulators



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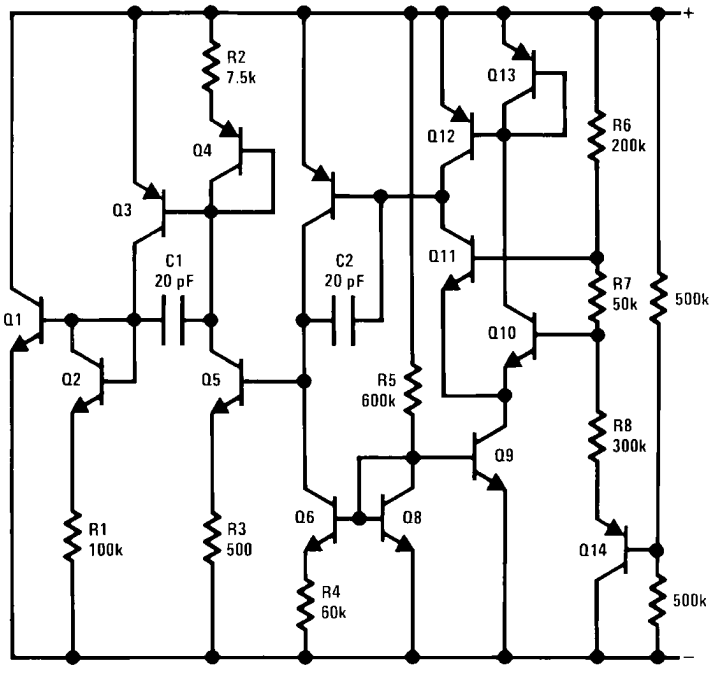
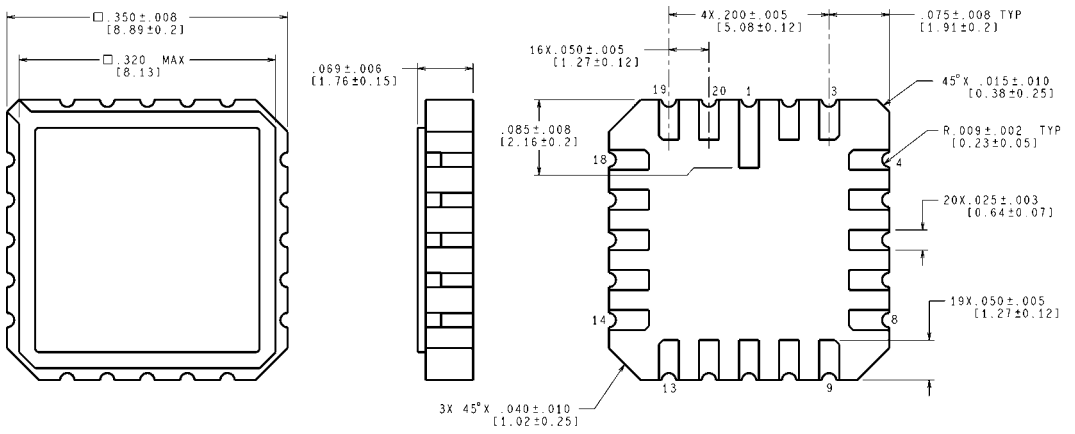
Schematic Diagram

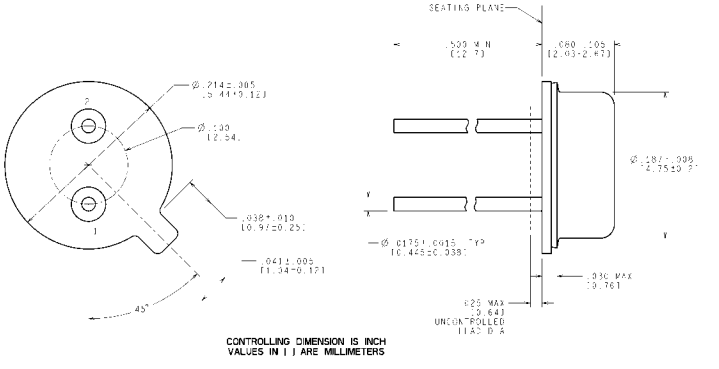


Physical Dimensions inches (millimeters) unless otherwise noted



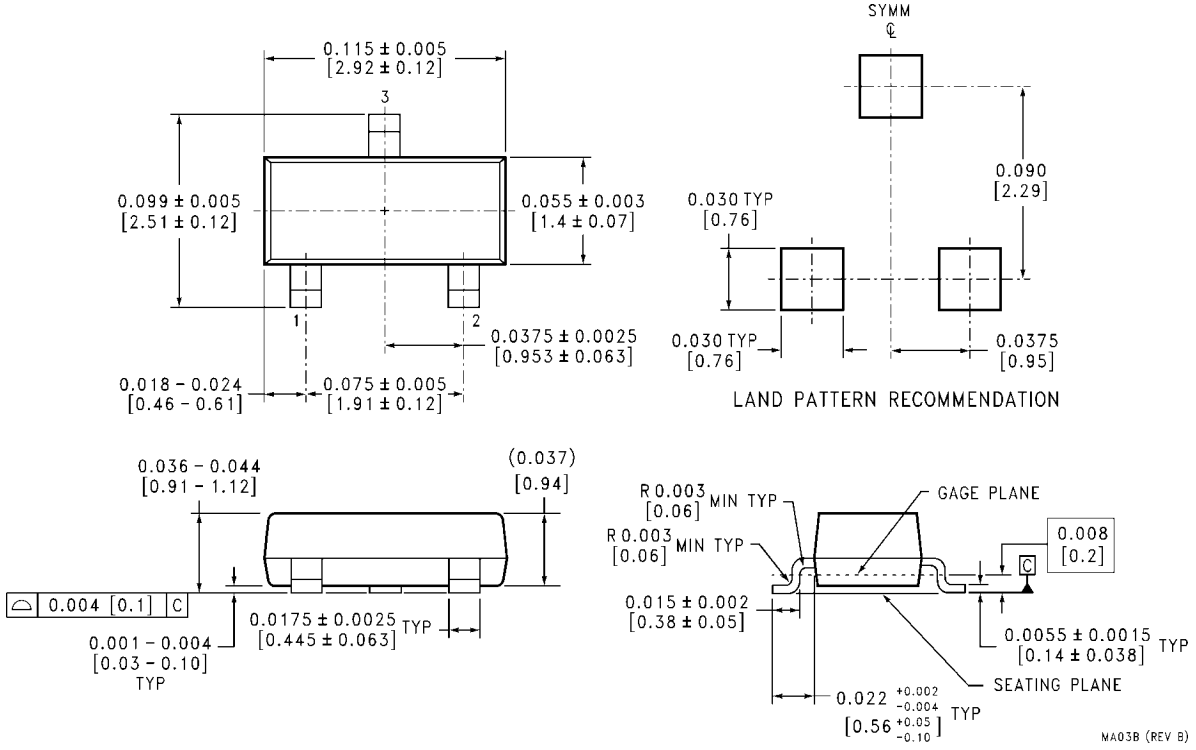
E20A (Rev F)

Order Number LM185E-2.5/883
NS Package Number E20A

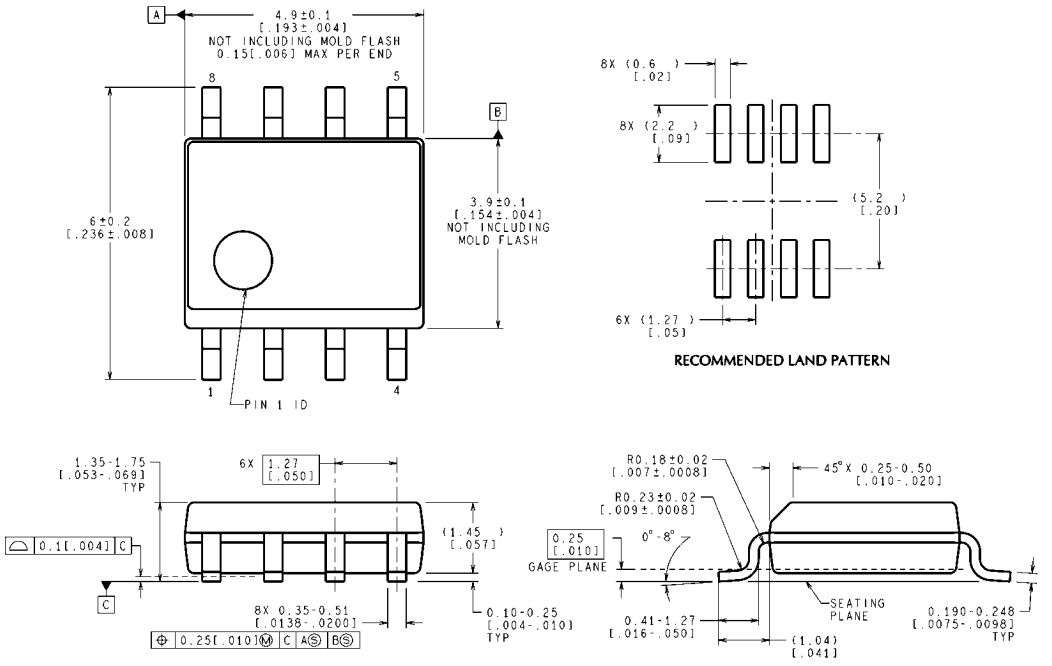


H02A (Rev F)

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

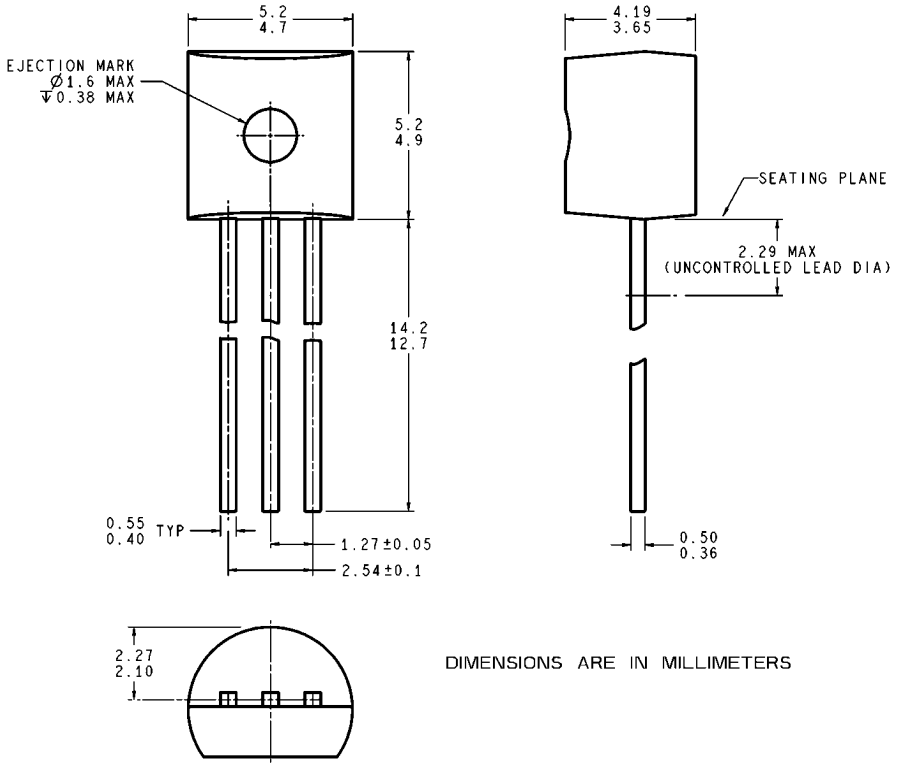


SOT-23 Package (M3)
Order Number LM385M3-2.5
NS Package Number MA03B



M08A (Rev L)

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



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

Notes

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