

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 μ A to 20mA 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.

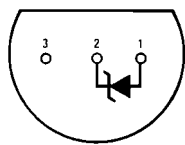
The LM185-1.2 is rated for operation over a -55°C to 125°C temperature range while the LM285-1.2 is rated -40°C to 85°C and the LM385-1.2 0°C to 70°C . The LM185-1.2/LM285-1.2 are available in a hermetic TO-46 package and the LM285-1.2/LM385-1.2 are also available in a low-cost TO-92 molded package,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

Features

- $\pm 1\%$ and 2% initial tolerance
- Operating current of 10 μ A to 20mA
- 1Ω dynamic impedance
- 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

T0-92
Plastic Package (Z)

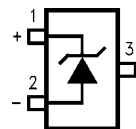


551810

Bottom View

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

SOT23

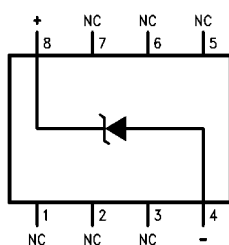


551833

* 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 MF03A

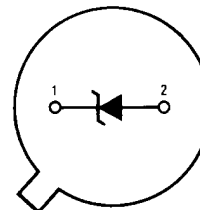
SO Package



551809

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

TO-46
Metal Can Package (H)



551806

Bottom View
Order Number LM185H-1.2, LM185H-1.2/883,
LM185BXH-1.2, LM185BYH-1.2
LM285H-1.2 or LM285BXH-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	30mA
Forward Current	10mA
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

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 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	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	$T_A = 25^\circ\text{C}$, $10\mu\text{A} \leq I_R \leq 20\text{mA}$	1.23 5	1.223		1.223		1.205		V(Min)
			1.247		1.247		1.260		V(Max)
Minimum Operating Current	LM385M3-1.2	8	10	20	15	20	15	20	μA (Max)
Reverse Breakdown Voltage Change with Current	$10\mu\text{A} \leq I_R \leq 1\text{mA}$		1	1.5	1	1.5	1	1.5	mV (Max)
	$1\text{mA} \leq I_R \leq 20\text{mA}$		10	20	20	25	20	25	mV (Max)
Reverse Dynamic Impedance	$I_R = 100\mu\text{A}$, $f = 20\text{Hz}$	1							Ω
Wideband Noise (rms)	$I_R = 100\mu\text{A}$, $10\text{Hz} \leq f \leq 10\text{kHz}$	60							μV
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		30 50		30 50		150	150	ppm/ $^\circ\text{C}$ 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-1.2 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	SOT23
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 $T_A = T_J = 25^\circ\text{C}$.

Note 5: Guaranteed and 100% production tested.

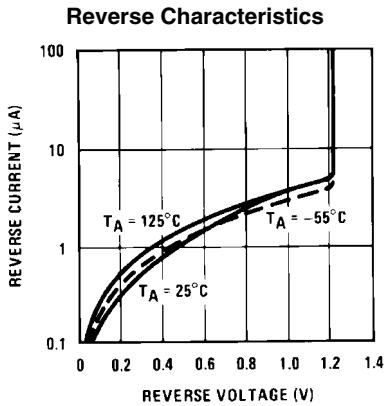
Note 6: Guaranteed, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.

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°C , -40°C , 0°C , 25°C , 70°C , 85°C , 125°C .

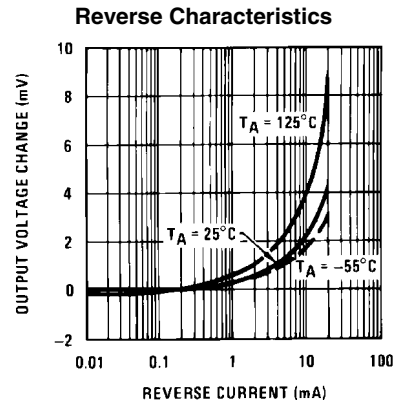
Note 8: A military RETS electrical specification is available on request.

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

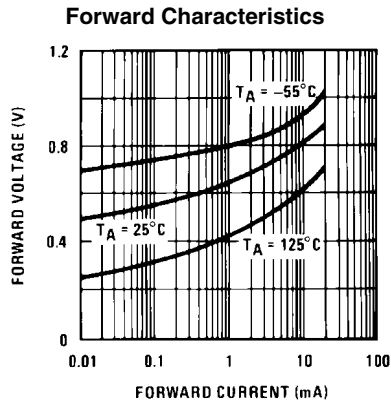
Typical Performance Characteristics



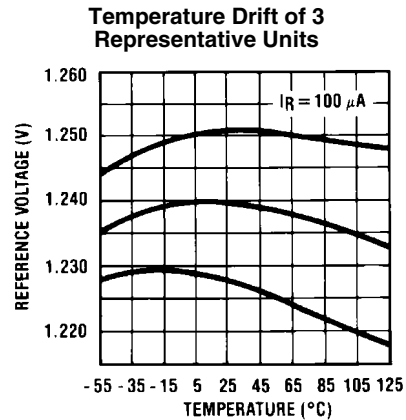
551813



551814

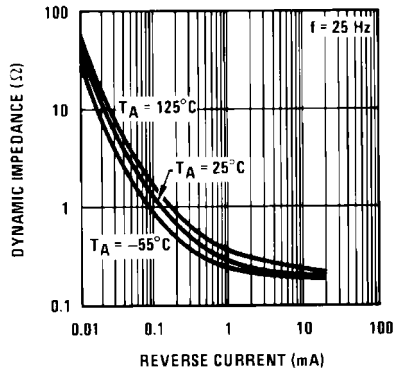


551815



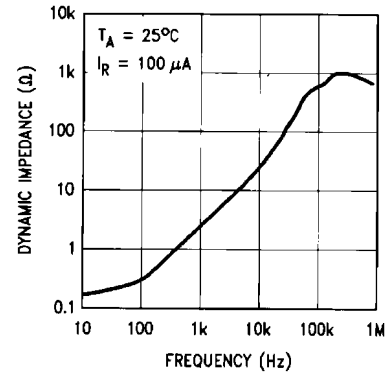
551816

Reverse Dynamic Impedance



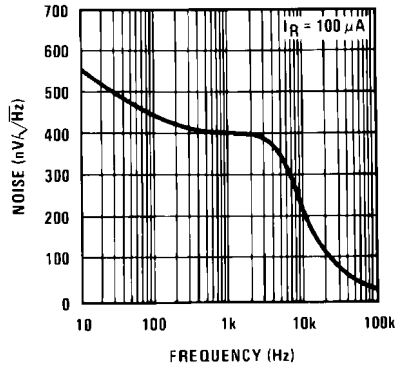
551817

Reverse Dynamic Impedance



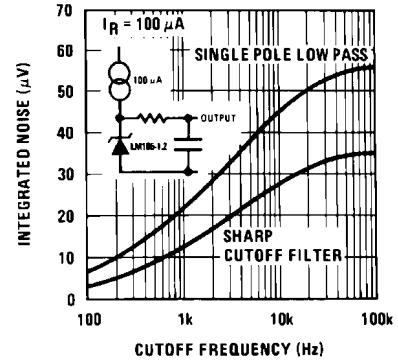
551818

Noise Voltage



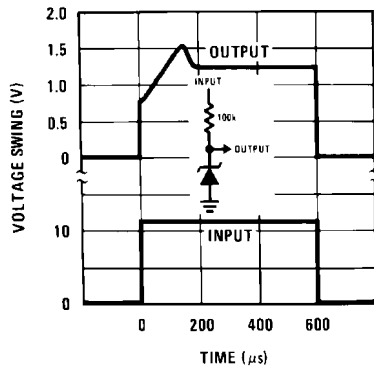
551819

Filtered Output Noise



551820

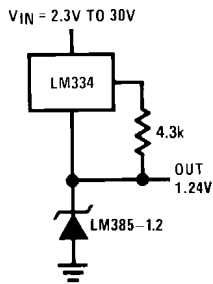
Response Time



551821

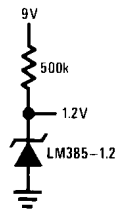
Typical Applications

Wide Input Range Reference



551808

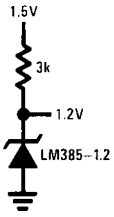
Micropower Reference from 9V Battery



551822

Reference from

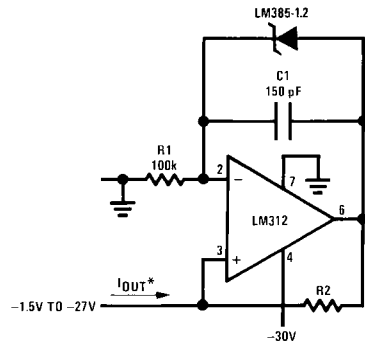
1.5V Battery



551823

* $I_Q \approx 20\mu\text{A}$ standby current

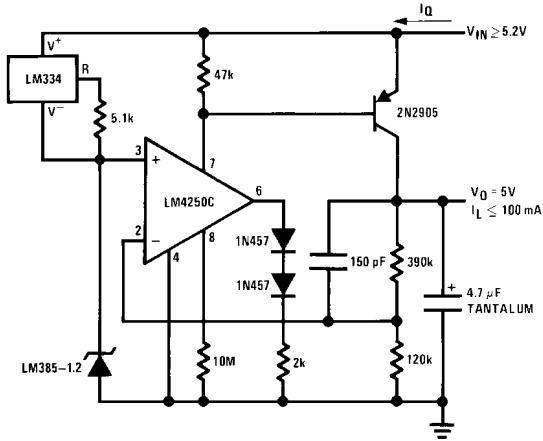
Precision $1\mu\text{A}$ to 1mA Current Sources



551826

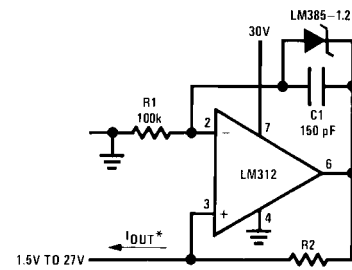
$$*I_{OUT} = \frac{1.23V}{R2}$$

Micropower* 5V Regulator



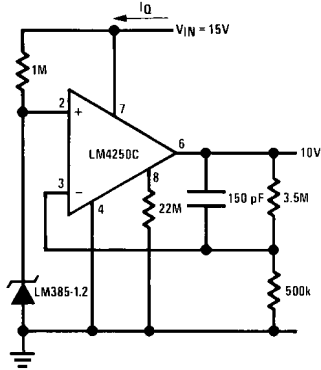
551824

* $I_Q \approx 30\mu\text{A}$



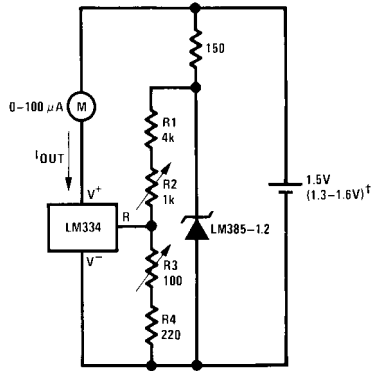
551827

Micropower* 10V Reference



551825

METER THERMOMETERS
0°C–100°C Thermometer

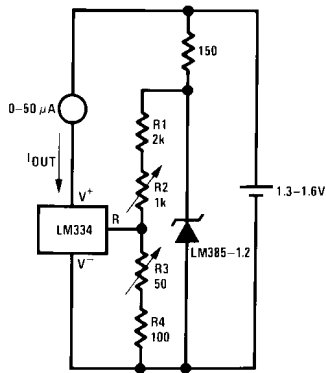


551828

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

0°F–50°F Thermometer

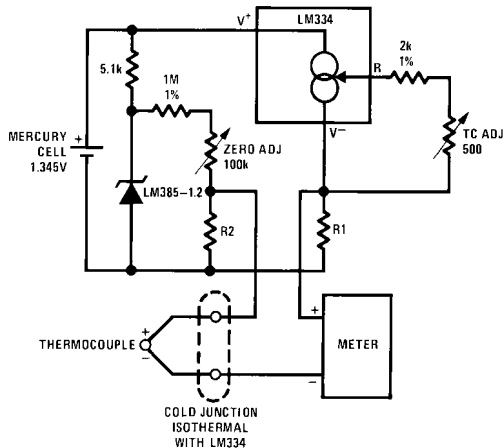


551830

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

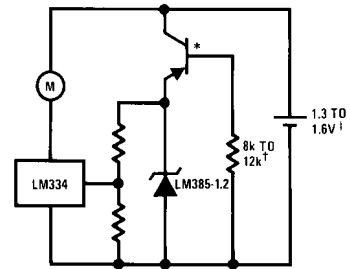
Micropower Thermocouple Cold Junction Compensator



551831

† I_Q at 1.3V 500 μA
 I_Q at 1.6V 2.4mA

Lower Power Thermometer



551829

*2N3638 or 2N2907 select for inverse $H_{FE} = 5$

†Select for operation at 1.3V

‡ $I_Q = 600\mu\text{A}$ to $900\mu\text{A}$

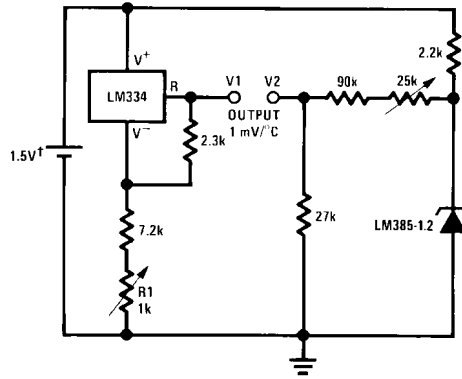
Adjustment Procedure

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 (Ω)	R2 (Ω)	Voltage Across R1 @ 25°C (mV)	Voltage Across R2 (mV)
J	52.3	52	1.2	15.60	14.32
		3	4k		
T	42.8	43	1k	12.77	11.78
		2			
K	40.8	41	95	12.17	11.17
		2	3 Ω		
S	6.4	63	15	1.908	1.766
		4	0 Ω		

Typical supply current 50 μA

Centigrade Thermometer

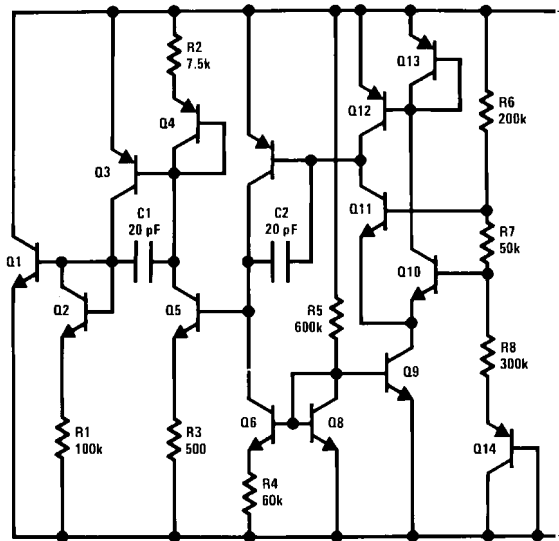


551801

Calibration

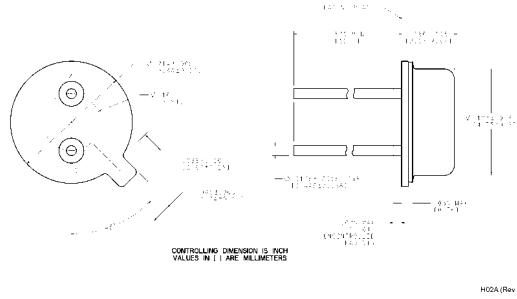
1. Adjust R1 so that V1 = temp at 1mV/°K
 2. Adjust V2 to 273.2mV
- †I_O for 1.3V to 1.6V battery voltage = 50μA to 150μA

Schematic Diagram

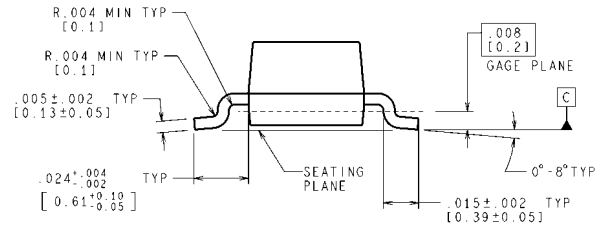
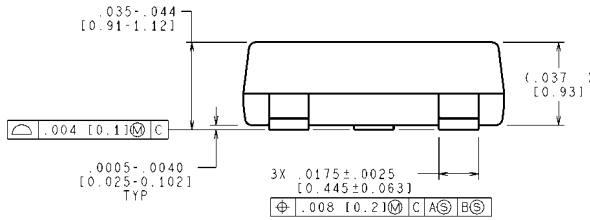
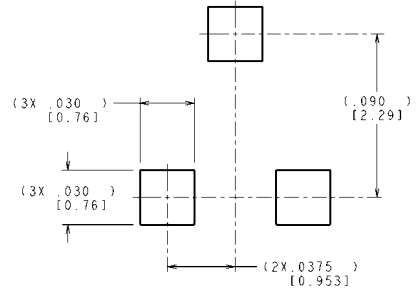
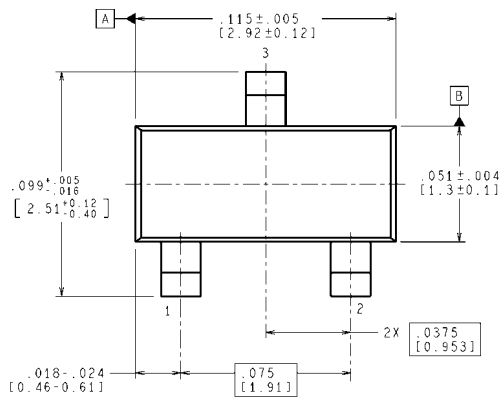


551807

Physical Dimensions inches (millimeters) unless otherwise noted



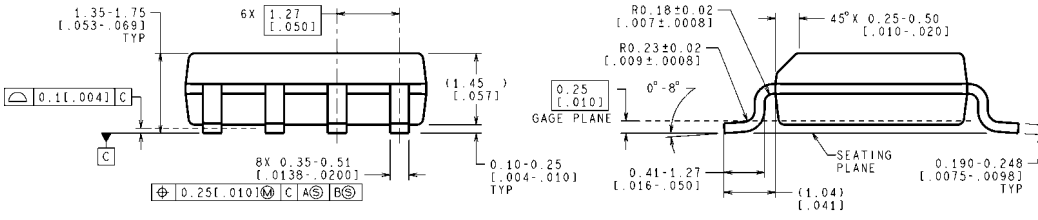
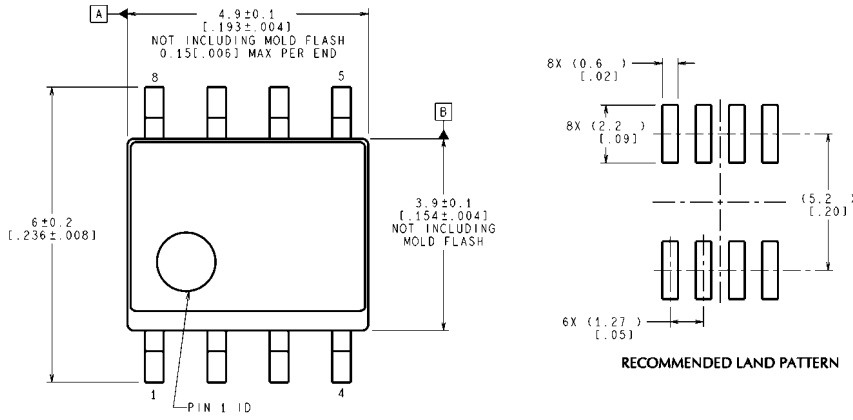
TO-46 Metal Can Package (H)
Order Number LM185H-1.2, LM185H-1.2/883, LM185BXH-1.2, LM185BYH-1.2, LM285H-1.2, or LM285BXH-1.2
NS Package Number H02A



CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS

MF03A (Rev B)

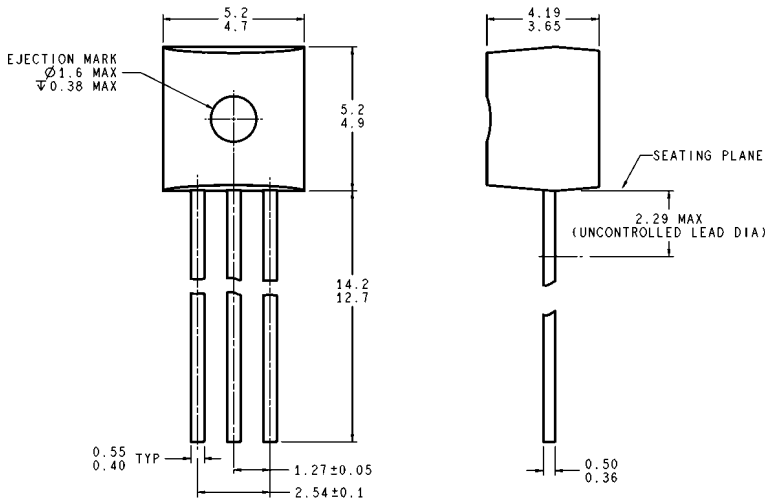
SOT-23 Package (M3)
Order Number LM385M3-1.2
NS Package Number MF03A



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

M08A (Rev L)

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



DIMENSIONS ARE IN MILLIMETERS

Z03A (Rev G)

TO-92 Plastic Package (Z)
Order Number LM285Z-1.2, LM285BXZ-1.2
LM285BYZ-1.2, LM385Z-1.2, LM385BZ-1.2
LM385BXZ-1.2 or LM385BYZ-1.2
NS Package Number Z03A

Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at:

Products		Design Support	
Amplifiers	www.national.com/amplifiers	WEBENCH	www.national.com/webench
Audio	www.national.com/audio	Analog University	www.national.com/AU
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		
Wireless (PLL/VCO)	www.national.com/wireless		

THE CONTENTS OF THIS DOCUMENT ARE PROVIDED IN CONNECTION WITH NATIONAL SEMICONDUCTOR CORPORATION ("NATIONAL") PRODUCTS. NATIONAL MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS PUBLICATION AND RESERVES THE RIGHT TO MAKE CHANGES TO SPECIFICATIONS AND PRODUCT DESCRIPTIONS AT ANY TIME WITHOUT NOTICE. NO LICENSE, WHETHER EXPRESS, IMPLIED, ARISING BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT.

TESTING AND OTHER QUALITY CONTROLS ARE USED TO THE EXTENT NATIONAL DEEMS NECESSARY TO SUPPORT NATIONAL'S PRODUCT WARRANTY. EXCEPT WHERE MANDATED BY GOVERNMENT REQUIREMENTS, TESTING OF ALL PARAMETERS OF EACH PRODUCT IS NOT NECESSARILY PERFORMED. NATIONAL ASSUMES NO LIABILITY FOR APPLICATIONS ASSISTANCE OR BUYER PRODUCT DESIGN. BUYERS ARE RESPONSIBLE FOR THEIR PRODUCTS AND APPLICATIONS USING NATIONAL COMPONENTS. PRIOR TO USING OR DISTRIBUTING ANY PRODUCTS THAT INCLUDE NATIONAL COMPONENTS, BUYERS SHOULD PROVIDE ADEQUATE DESIGN, TESTING AND OPERATING SAFEGUARDS.

EXCEPT AS PROVIDED IN NATIONAL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, NATIONAL ASSUMES NO LIABILITY WHATSOEVER, AND NATIONAL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THE SALE AND/OR USE OF NATIONAL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

LIFE SUPPORT POLICY

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

Life support devices or systems are devices 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. A critical component is any component in 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 and the National Semiconductor logo are registered trademarks of National Semiconductor Corporation. All other brand or product names may be trademarks or registered trademarks of their respective holders.

Copyright© 2008 National Semiconductor Corporation

For the most current product information visit us at www.national.com



**National Semiconductor
Americas Technical
Support Center**
Email:
new.feedback@nsc.com
Tel: 1-800-272-9959

**National Semiconductor Europe
Technical Support Center**
Email: europe.support@nsc.com
German Tel: +49 (0) 180 5010 771
English Tel: +44 (0) 870 850 4288

**National Semiconductor Asia
Pacific Technical Support Center**
Email: ap.support@nsc.com

**National Semiconductor Japan
Technical Support Center**
Email: jpn.feedback@nsc.com