National Semiconductor

May 2003

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 10µA 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.

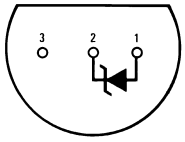
The LM185-1.2 is rated for operation over a –55˚C to 125˚C temperature range while the LM285-1.2 is rated –40˚C to 85˚C and the LM385-1.2 0˚C to 70˚C. The LM185-1.2/LM285-1.2 are available in a hermetic TO-46 package and the LM285-1.2/LM385-1.2 are also available in a low-cost TO-92 molded package, as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

Features

- ±1% and 2% initial tolerance
- Operating current of 10µA 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

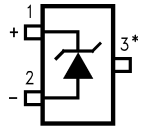
T0-92
Plastic Package (Z)



00551810

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



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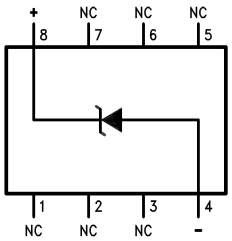
* Pin 3 is attached to the Die Attach Pad (DAP) and should be connected to Pin 2 or left floating.

Order Number LM385M3-1.2
See NS Package Number MF03A

Connection Diagrams (Continued)

SO Package



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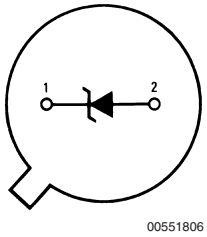
Order Number LM285M-1.2,
LM285BXM-1.2, LM285BYM-1.2
LM385M-1.2, LM385BM-1.2
LM385BXM-1.2 or LM385BYM-1.2
See NS Package Number M08A

TO-46
Metal Can Package (H)



00551806

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
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˚C, 10µA ≤ I_R ≤ 20mA	1.235	1.223 1.247		1.223 1.247		1.205 1.260		V(Min) V(Max)
Minimum Operating Current		8	10	**20**	15	**20**	15	**20**	µA
	LM385M3-1.2						10	**15**	(Max)
Reverse Breakdown Voltage Change with Current	10µA ≤ I_R ≤ 1mA		1	**1.5**	1	**1.5**	1	**1.5**	mV (Max)
	1mA ≤ I_R ≤ 20mA		10	**20**	20	**25**	20	**25**	mV (Max)
Reverse Dynamic Impedance	I_R = 100µA, f = 20Hz	1							Ω
Wideband Noise (rms)	I_R = 100µA, 10Hz ≤ f ≤ 10kHz	60							µV
Long Term Stability	I_R = 100µA, T = 1000 Hr, T_A = 25˚C ±0.1˚C	20							ppm
Average Temperature Coefficient (Note 7)	I_R = 100µA								
	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-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 $T_A = T_J = 25˚C$.

Note 5: Guaranteed and 100% production tested.

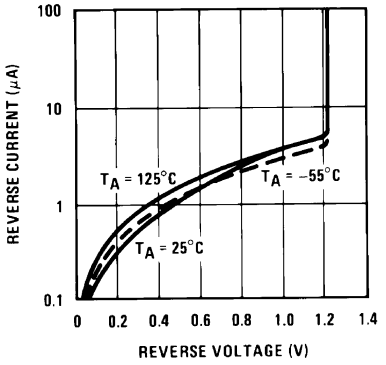
Note 6: Guaranteed, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.

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.

Typical Performance Characteristics

Reverse Characteristics



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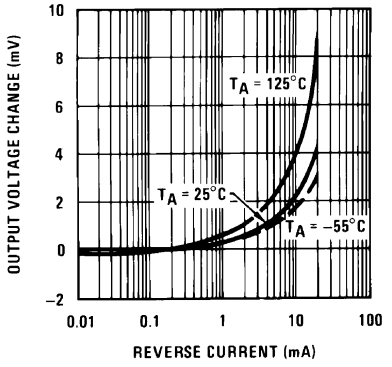
Reverse Characteristics



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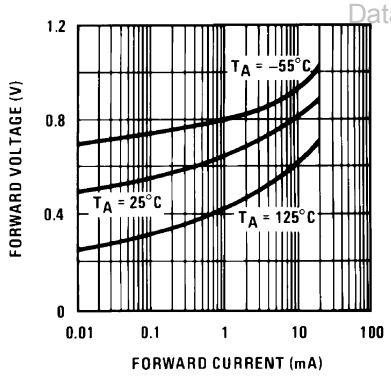
Forward Characteristics



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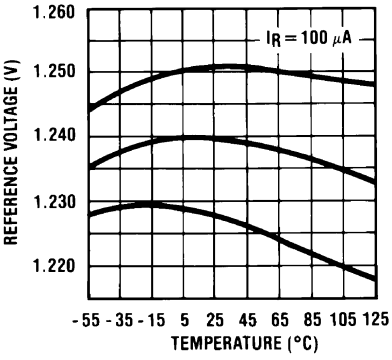
Temperature Drift of 3 Representative Units



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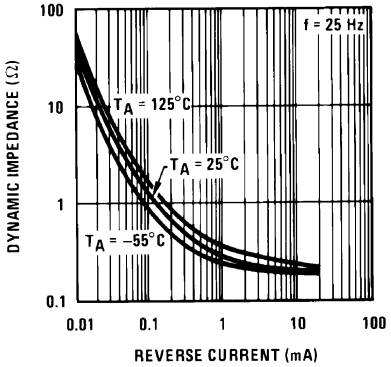
Reverse Dynamic Impedance



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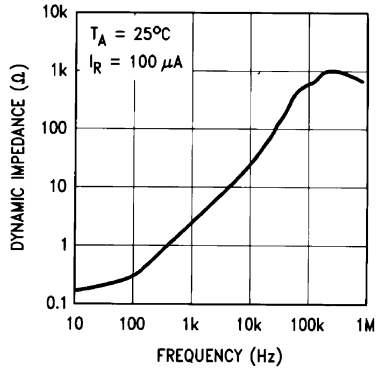
Reverse Dynamic Impedance



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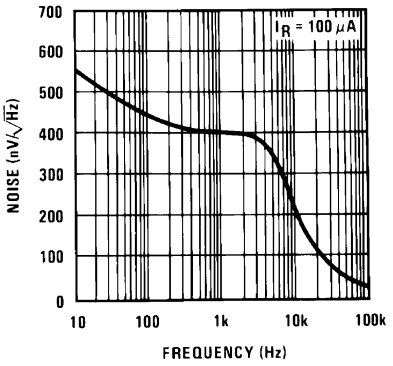
Typical Performance Characteristics (Continued)

Noise Voltage



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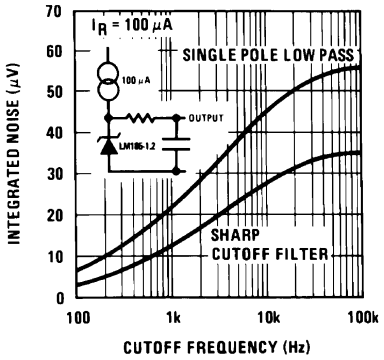
Filtered Output Noise



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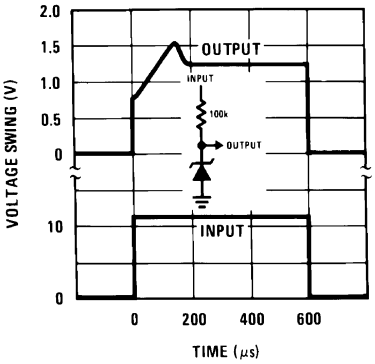
Response Time



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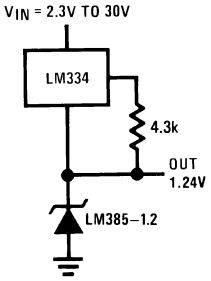
Typical Applications

Wide Input Range Reference



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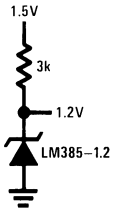
Reference from 1.5V Battery



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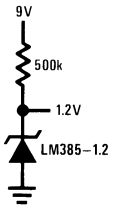
Micropower Reference from 9V Battery



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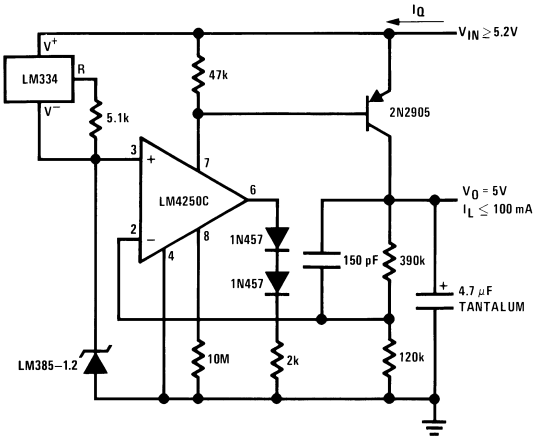
Typical Applications (Continued)

Micropower* 5V Regulator



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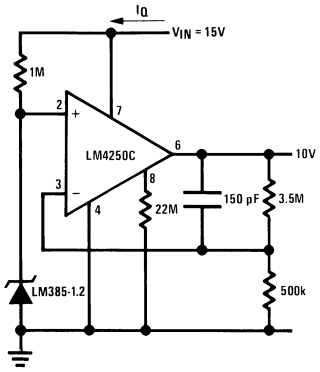
*$I_Q \simeq 30\mu A$

Micropower* 10V Reference



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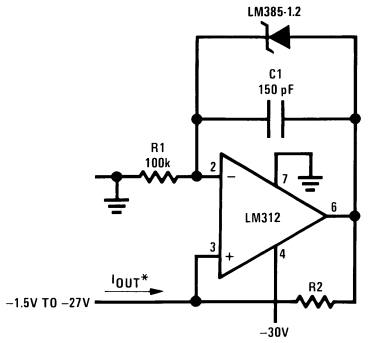
*$I_Q \simeq 20\mu A$ standby current

Precision 1μA to 1mA Current Sources



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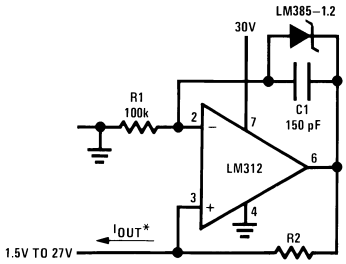
$$*I_{OUT} = \frac{1.23V}{R2}$$



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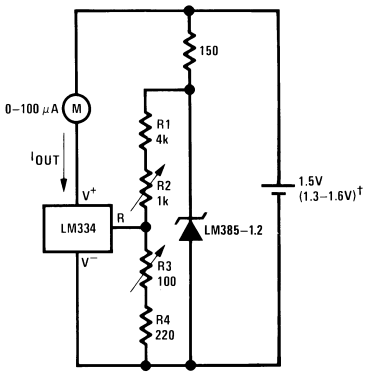
Typical Applications (Continued)

METER THERMOMETERS

0˚C–100˚C Thermometer



00551828

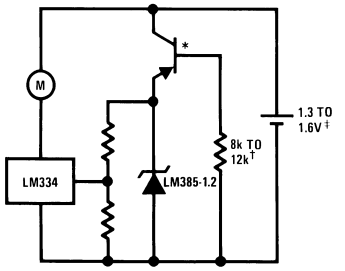
Calibration

1. Short LM385-1.2, adjust R3 for I_{OUT}= temp at 1μA/˚K
2. Remove short, adjust R2 for correct reading in centigrade

†I_Q at 1.3V≃500μA

I_Q at 1.6V≃2.4mA

Lower Power Thermometer



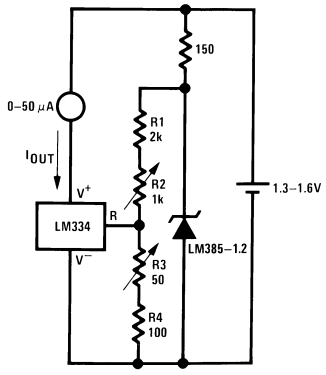
00551829

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

†Select for operation at 1.3V

‡I_Q ≃ 600μA to 900μA

0˚F–50˚F Thermometer



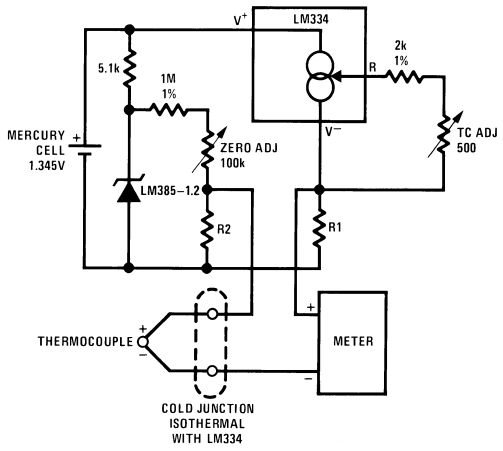
00551830

Calibration

1. Short LM385-1.2, adjust R3 for I_{OUT}= temp at 1.8μA/˚K
2. Remove short, adjust R2 for correct reading in ˚F

Typical supply current 50μA

Micropower Thermocouple Cold Junction Compensator



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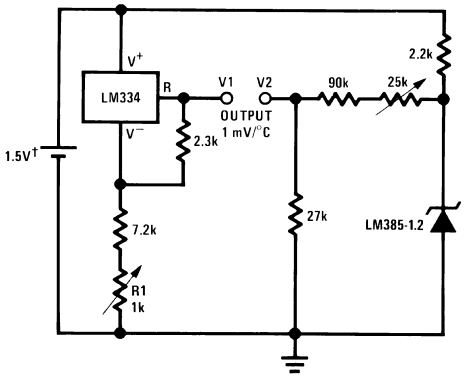
Adjustment Procedure

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 Coefficient (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 Applications (Continued)

Centigrade Thermometer



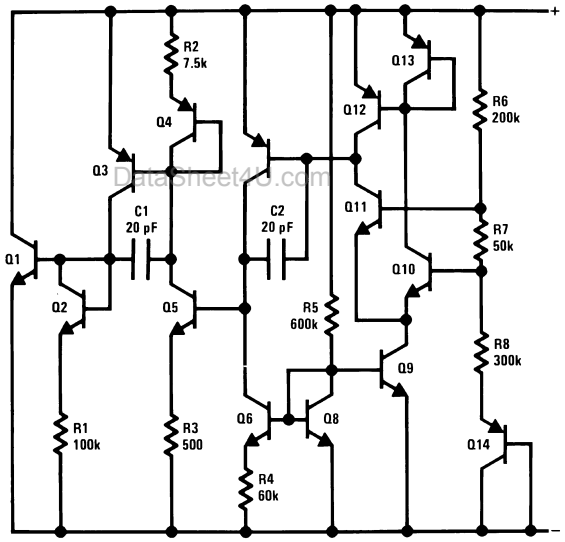
00551801

Calibration

1. Adjust R1 so that V1 = temp at 1mV/°K
2. Adjust V2 to 273.2mV

†I_Q for 1.3V to 1.6V battery voltage = 50µA to 150µA

Schematic Diagram



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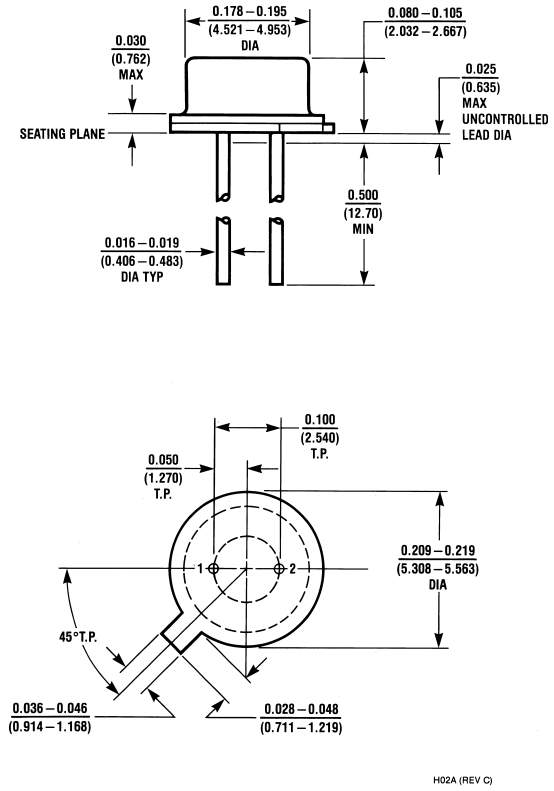
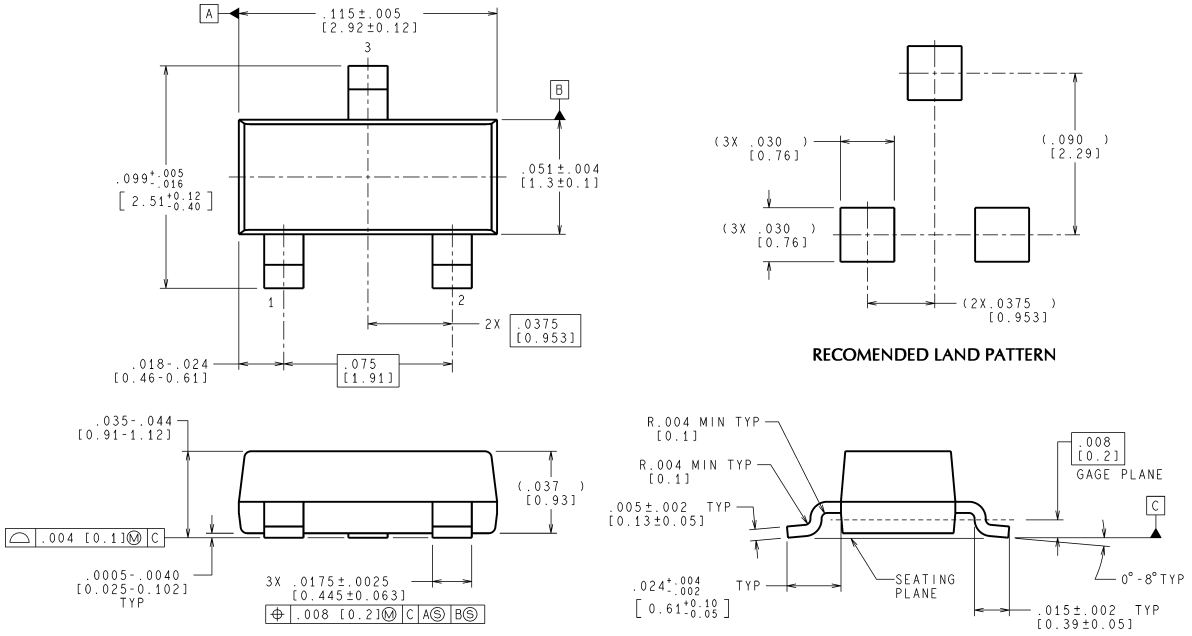
Physical Dimensions inches (millimeters) unless otherwise noted

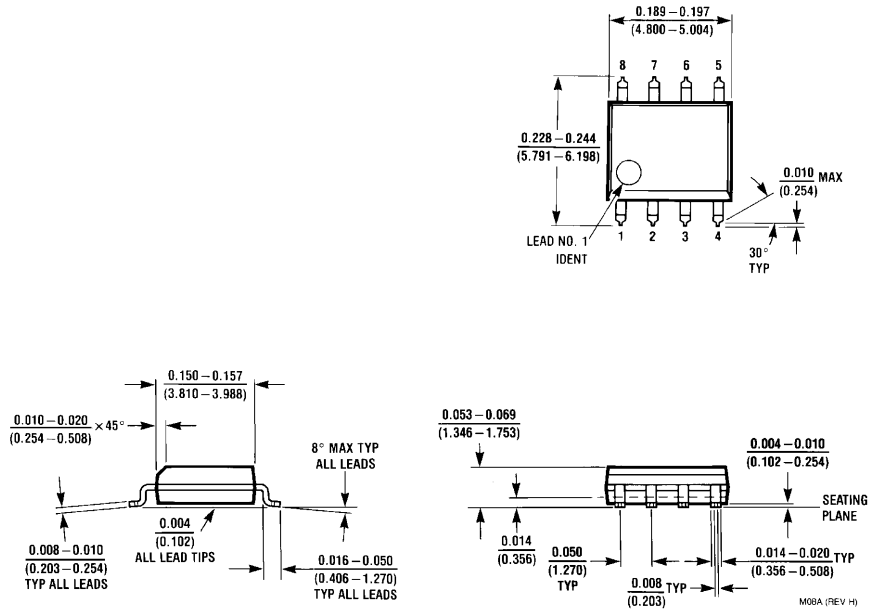


TO-46 Metal Can Package (H)
Order Number LM185H-1.2, LM185H-1.2/883, LM185BXH-1.2, LM185BYH-1.2, LM285H-1.2, or LM285BXH-1.2
NS Package Number H02A

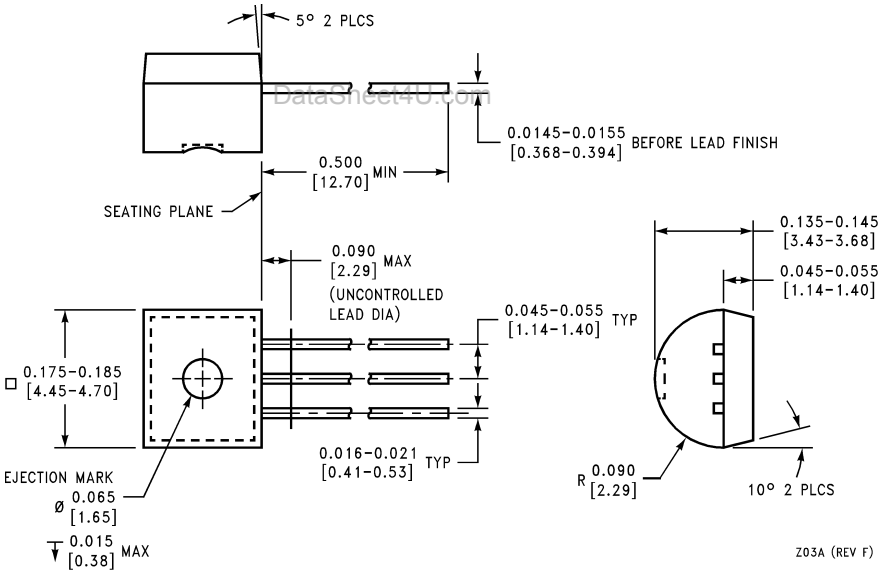


SOT-23 Package (M3)
Order Number LM385M3-1.2
NS Package Number MF03A

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, LM385BM-1.2, LM385BXM-1.2, LM385BYM-1.2
NS Package Number M08A



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

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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.

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