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## 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  $\mu\text{A}$  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 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.

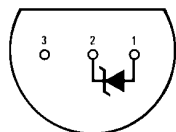
The LM185-1.2 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range while the LM285-1.2 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385-1.2  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185-1.2/LM285-1.2 are available in a 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

- $\pm 4$  mV ( $\pm 0.3\%$ ) max. initial tolerance (A grade)
- Operating current of 10  $\mu\text{A}$  to 20 mA
- $0.6\Omega$  max dynamic impedance (A grade)
- 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

**TO-92  
Plastic Package (Z)**

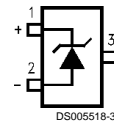


DS005518-10

#### Bottom View

Order Number LM285Z-1.2,  
LM285AZ-1.2, LM285AXZ-1.2,  
LM285AYZ-1.2, LM285BXZ-1.2,  
LM285BYZ-1.2, LM385Z-1.2,  
LM385AZ-1.2, LM385AXZ-1.2,  
LM385AYZ-1.2, LM385BZ-1.2,  
LM385BXZ-1.2 or LM385BYZ-1.2  
See NS Package Number Z03A

**SOT23**

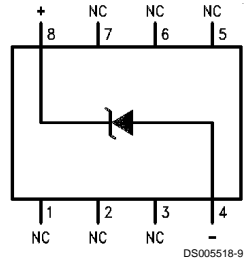


DS005518-33

Order Number LM385M3-1.2  
See NS Package Number MA03B

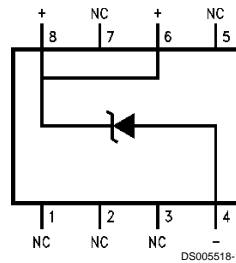
## Connection Diagrams (Continued)

SO Package



Order Number LM285M-1.2,  
LM285AM-1.2, LM285AXM-1.2,  
LM285AYM-1.2, LM285BXM-1.2,  
LM285BYM-1.2, LM385M-1.2,  
LM385AM-1.2, LM385AXM-1.2,  
LM385AYM-1.2, LM385BM-1.2,  
LM385BXM-1.2 or LM385BYM-1.2  
See NS Package Number M08A

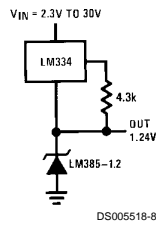
SO Package  
Alternate Pinout



Order Number LM385SM-1.2,  
LM385ASM-1.2 or LM385BSM-1.2  
See NS Package Number M08A

## Typical Application

Wide Input  
Range Reference



## 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	30 mA
Forward Current	10 mA
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	LM285A-1.2 LM285AX-1.2 LM285AY-1.2			LM385A-1.2 LM385AX-1.2 LM385AY-1.2			Units (Limit)	
		Typ	Tested Limit (Notes 5, 8)	Design Limit (Note 6)	Typ	Tested Limit (Note 5)	Design Limit (Note 6)		
Reverse Breakdown Voltage	$I_R = 100 \mu A$	1.235	1.231		1.235	1.231		V(Min)	
		<b>1.230</b>	1.239	<b>1.220</b> <b>1.245</b>	<b>1.235</b>	1.239	<b>1.225</b> <b>1.245</b>	V(Max)	
Minimum Operating Current		7	8	<b>10</b>	7	8	<b>10</b>	$\mu A$ (Max)	
Reverse Breakdown Voltage Change with Current	$I_{MIN} \leq I_R \leq 1 \text{ mA}$		1	<b>1.5</b>		1	<b>1.5</b>	mV (Max)	
	$1 \text{ mA} \leq I_R \leq 20 \text{ mA}$		10	<b>20</b>		10	<b>20</b>	mV (Max)	
Reverse Dynamic Impedance	$I_R = 100 \mu A, f = 20 \text{ Hz}$	0.2		0.6 <b>1.5</b>	0.2		0.6 <b>1.5</b>	$\Omega$ (Max)	
Wideband Noise (rms)	$I_R = 100 \mu A,$ $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	60			60			$\mu V$	
Long Term Stability	$I_R = 100 \mu A, T = 1000 \text{ Hr},$ $T_A = 25^\circ C \pm 0.1^\circ C$	20			20			ppm	
Average Temperature Coefficient (Note 7)	$I_{MIN} \leq I_R \leq 20 \text{ mA}$		<b>30</b>			<b>30</b>		ppm/°C (Max)	
		X Suffix	<b>50</b>			<b>50</b>			
		Y Suffix			<b>150</b>				<b>150</b>
		All Others							

## 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	$T_A = 25^\circ\text{C}$ , $10\ \mu\text{A} \leq I_R \leq 20\ \text{mA}$	1.235	1.223 1.247		1.223 1.247		1.205 1.260		V(Min) V(Max)
Minimum Operating Current	LM385M3-1.2	8	10	<b>20</b>	15	<b>20</b>	15 10	<b>20</b> <b>15</b>	$\mu\text{A}$ (Max)
Reverse Breakdown Voltage Change with Current	$10\ \mu\text{A} \leq I_R \leq 1\ \text{mA}$		1	<b>1.5</b>	1	<b>1.5</b>	1	<b>1.5</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)	$I_R = 100\ \mu\text{A}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$	60							$\mu\text{V}$
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>50</b>				ppm/ $^\circ\text{C}$
	All Others			<b>150</b>		<b>150</b>		<b>150</b>	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
$\theta_{JA}$ (junction to ambient)	180°C/W (0.4" leads) 170°C/W (0.125" leads)	440°C/W	165°C/W	283°C/W
$\theta_{JC}$ (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.

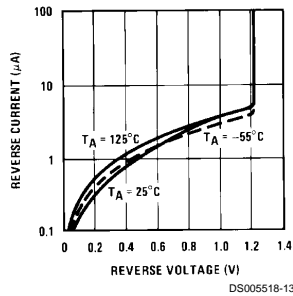
**Note 6:** Guaranteed, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.

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

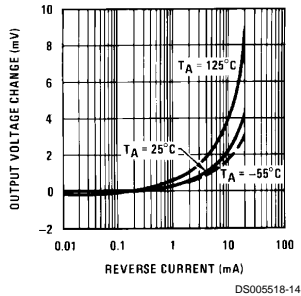
**Note 8:** A military RETS electrical specification is available on request.

# Typical Performance Characteristics

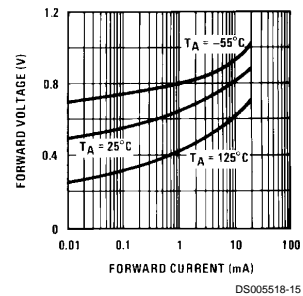
## Reverse Characteristics



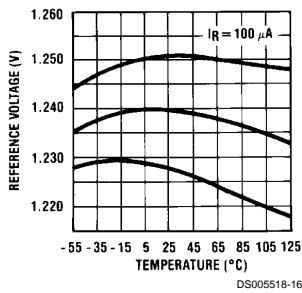
## Reverse Characteristics



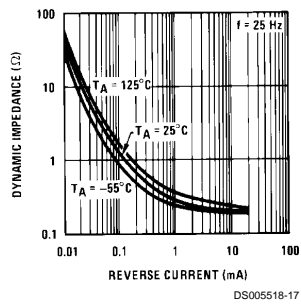
## Forward Characteristics



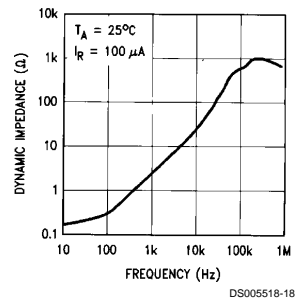
## Temperature Drift of 3 Representative Units



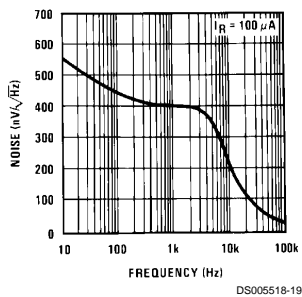
## Reverse Dynamic Impedance



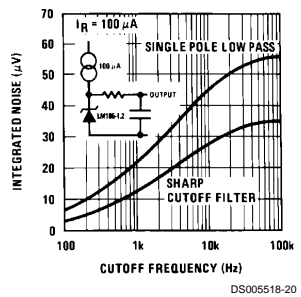
## Reverse Dynamic Impedance



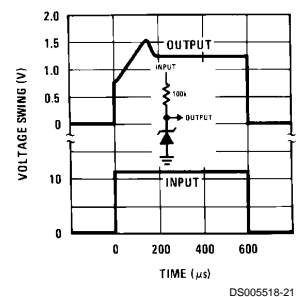
## Noise Voltage



## Filtered Output Noise

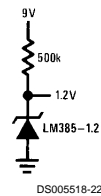


## Response Time

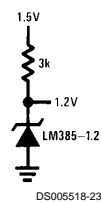


# Typical Applications

## Micropower Reference from 9V Battery

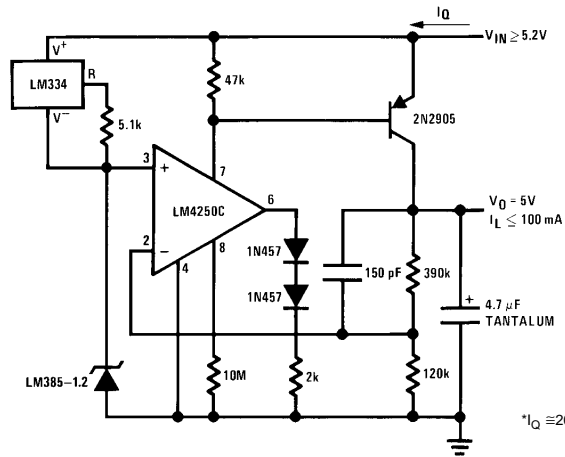


## Reference from 1.5V Battery

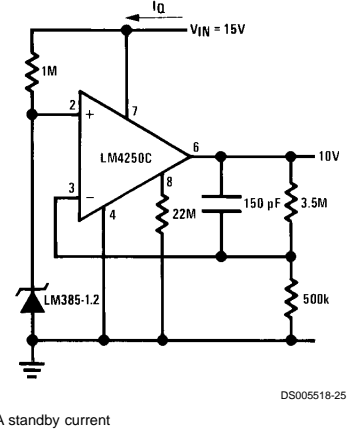


## Typical Applications (Continued)

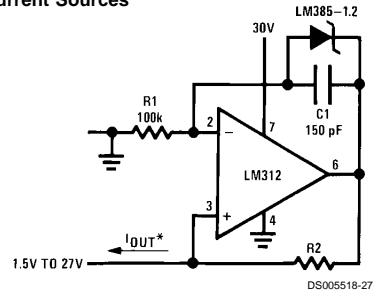
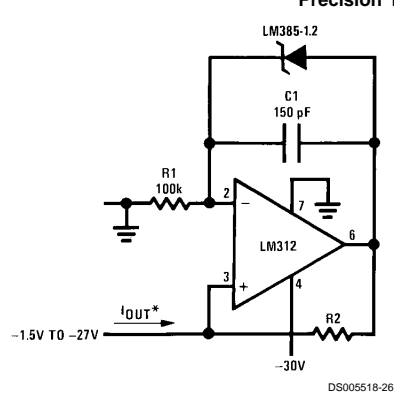
### Micropower\* 5V Regulator



### Micropower\* 10V Reference



### Precision 1 uA to 1 mA Current Sources

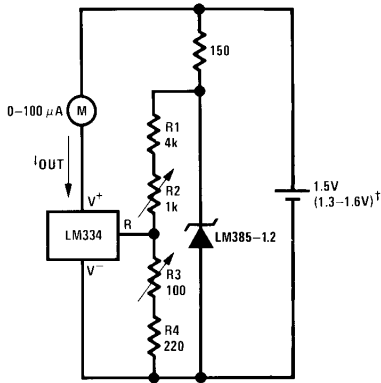


$$I_{OUT}^* = \frac{1.23V}{R_2}$$

## Typical Applications (Continued)

### METER THERMOMETERS

#### 0°C–100°C Thermometer

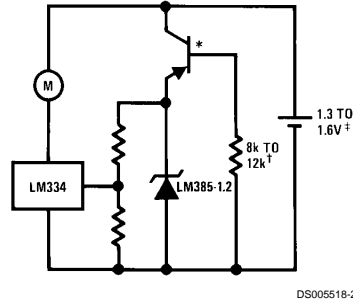


DS005518-28

#### 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
- † $I_Q$  at 1.3V  $\approx 500 \mu\text{A}$   
 $I_Q$  at 1.6V  $\approx 2.4 \text{ mA}$

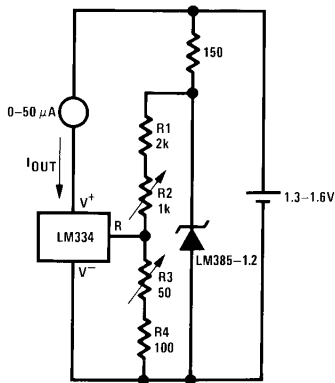
#### Lower Power Thermometer



DS005518-29

- \*2N3638 or 2N2907 select for inverse  $H_{FE} \approx 5$   
 †Select for operation at 1.3V  
 ‡ $I_Q \approx 600 \mu\text{A}$  to  $900 \mu\text{A}$

#### 0°F–50°F Thermometer

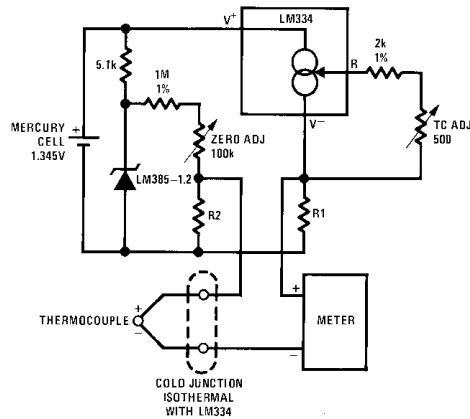


DS005518-30

#### 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



DS005518-31

#### 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.

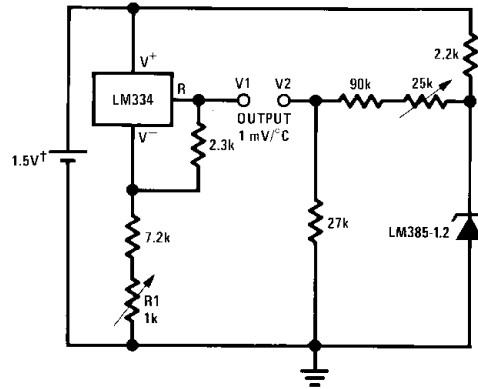
Thermocouple Type	Seebeck Coefficient ( $\mu\text{V}/^\circ\text{C}$ )	R1 ( $\Omega$ )	R2 ( $\Omega$ )	Voltage Across R1 @ 25°C (mV)	Voltage Across R2 (mV)
J	52.3	523	1.24k	15.60	14.32
T	42.8	432	1k	12.77	11.78
K	40.8	412	953 $\Omega$	12.17	11.17
S	6.4	63.4	150 $\Omega$	1.908	1.766

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



## Typical Applications (Continued)

### Centigrade Thermometer

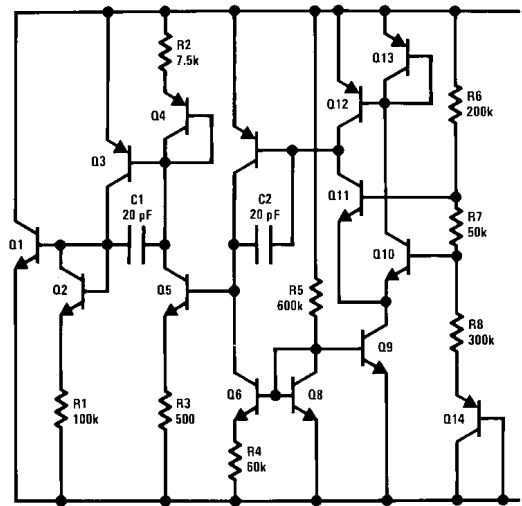


DS005518-1

#### Calibration

1. Adjust R1 so that  $V1 = \text{temp at } 1 \text{ mV}/^\circ\text{K}$
  2. Adjust V2 to 273.2 mV
- $I_Q$  for 1.3V to 1.6V battery voltage = 50  $\mu\text{A}$  to 150  $\mu\text{A}$

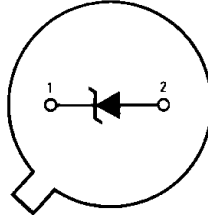
## Schematic Diagram



DS005518-7

## Connection Diagrams

TO-46  
Metal Can Package (H)



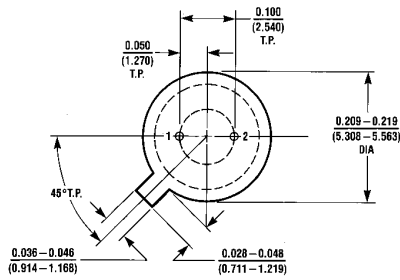
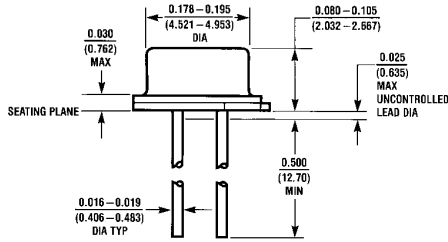
DS005518-6

Bottom View

Order Number LM185H-1.2, LM185H-1.2/883, LM185BXH-1.2, LM185BYH-1.2/883, LM285H-1.2, LM285BXH-1.2 or  
LM285BYH-1.2

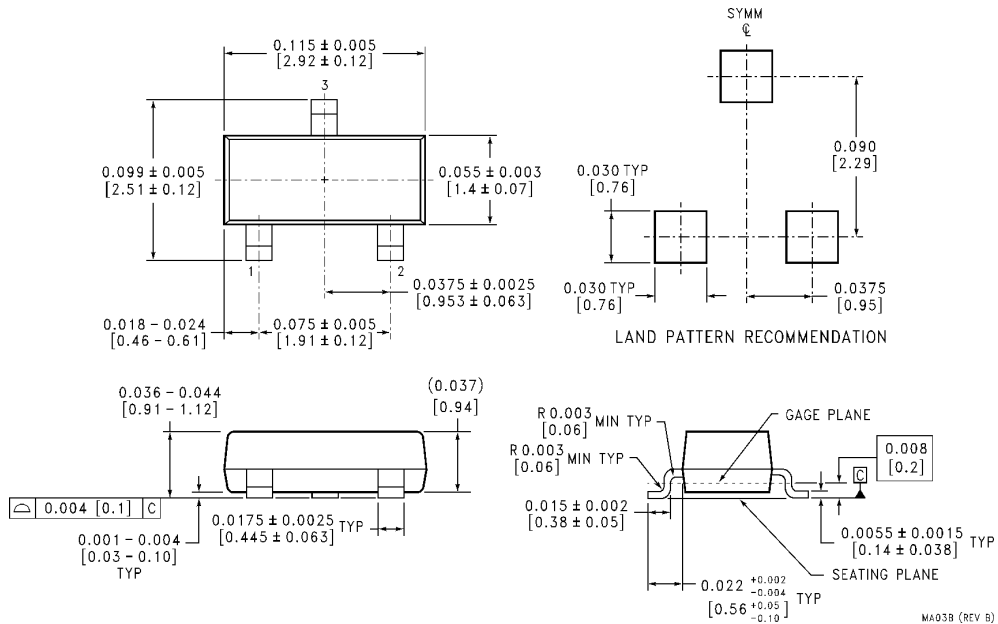
See NS Package Number H02A

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



H02A (REV C)

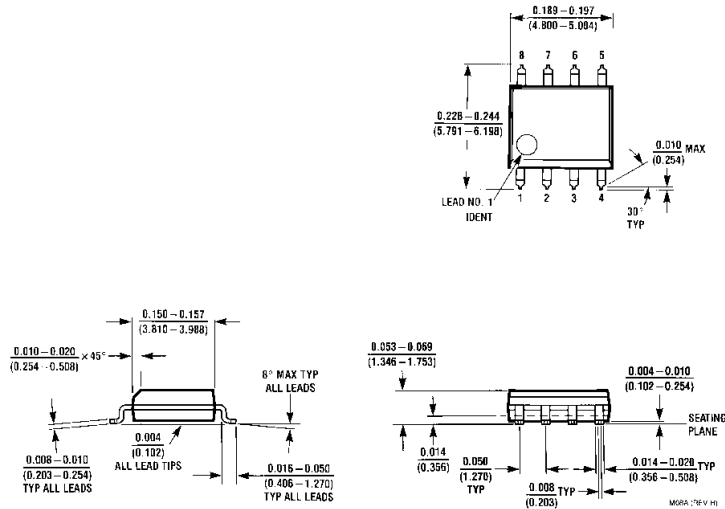
**TO-46 Metal Can Package (H)**  
 Order Number LM185H-1.2, LM185H-1.2/883, LM185BXH-1.2, LM285H-1.2, LM285BXH-1.2 or LM285BYH-1.2  
 NS Package Number H02A



MA03B (REV B)

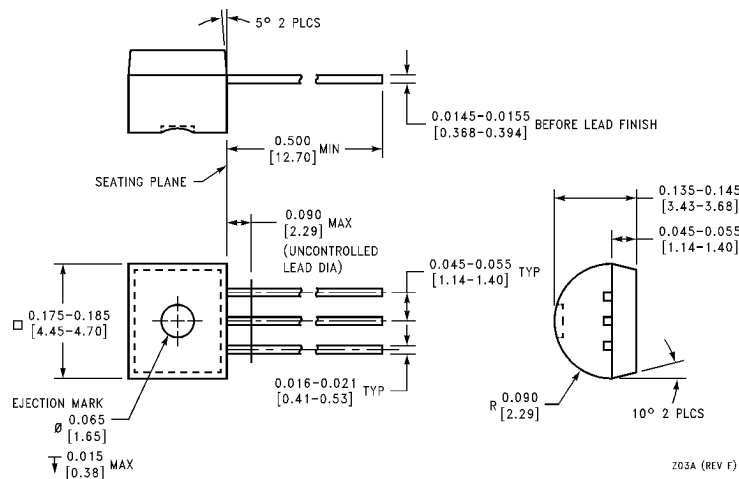
**SOT-23 Package (M3)**  
 Order Number LM385M3-1.2  
 NS Package Number MA03B

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



**Small Outline (SO-8) Package**

Order Number LM285M-1.2, LM285AM-1.2, LM285AXM-1.2, LM285AYM-1.2, LM285BXM-1.2, LM285BYM-1.2, LM385M-1.2, LM385AM-1.2, LM385AXM-1.2, LM385AYM-1.2, LM385BM-1.2, LM385BXM-1.2, LM385BYM-1.2, LM385SM-1.2, LM385ASM-1.2 or LM385BSM-1.2  
NS Package Number M08A



**TO-92 Plastic Package (Z)**

Order Number LM285Z-1.2, LM285AZ-1.2, LM285AXZ-1.2, LM285AYZ-1.2, LM285BZ-1.2, LM285BYZ-1.2, LM385Z-1.2, LM385AZ-1.2, LM385AXZ-1.2, LM385AYZ-1.2, LM385BZ-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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