

# 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  $\mu$ 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.

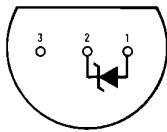
The LM185-1.2 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range while the LM285-1.2 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385-1.2  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185-1.2/LM285-1.2 are available in a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

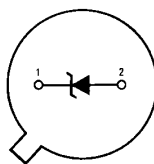


TL/H/5518-10

**Bottom View**

**Order Number LM285Z-1.2, LM285AZ-1.2, LM285AXZ-1.2, LM285AYZ-1.2, LM285BZX-1.2, LM285BYZ-1.2, LM385Z-1.2, LM385AZ-1.2, LM385AXZ-1.2, LM385AYZ-1.2, LM385BZ-1.2, LM385BZX-1.2 or LM385BYZ-1.2**  
See NS Package Number Z03A

**TO-46  
Metal Can Package (H)**

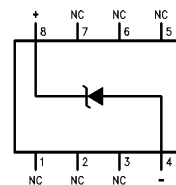


TL/H/5518-6

**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

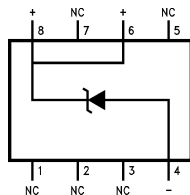
**SO Package**



TL/H/5518-9

**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**



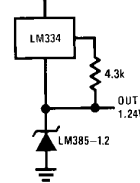
TL/H/5518-11

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

## Typical Application

**Wide Input  
Range Reference**

$V_{IN} = 2.3\text{V TO } 30\text{V}$



TL/H/5518-8

## 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 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	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 <b>1.230</b>	1.231 1.239	<b>1.220</b> <b>1.245</b>	1.235 <b>1.235</b>	1.231 1.239	<b>1.225</b> <b>1.245</b>	V(Min) V(Max) V(Min) 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)	$I_{MIN} \leq I_R \leq 20 \text{ mA}$							ppm/ $^\circ C$ (Max)
	X Suffix		<b>30</b>			<b>30</b>		
	Y Suffix		<b>50</b>			<b>50</b>		
	All Others			<b>150</b>			<b>150</b>	

## Electrical Characteristics (Continued) (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		8	10	<b>20</b>	15	<b>20</b>	15	<b>20</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 Y Suffix All Others		<b>30</b> <b>50</b>	<b>150</b>	<b>30</b> <b>50</b>	<b>150</b>		<b>150</b>	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
$\theta_{JA}$ (junction to ambient)	180°C/W (0.4" leads) 170°C/W (0.125" leads)	440°C/W	165°C/W
$\theta_{JC}$ (junction to case)	N/A	80°C/W	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.

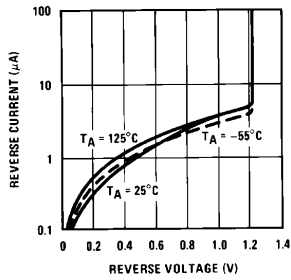
**Note 6:** Guaranteed, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.

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

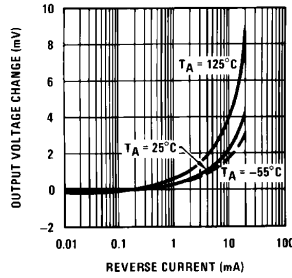
**Note 8:** A military RETS electrical specification is available on request.

# Typical Performance Characteristics

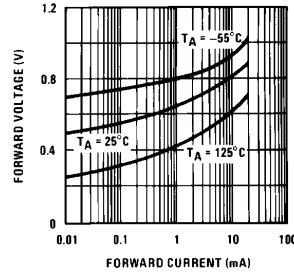
Reverse Characteristics



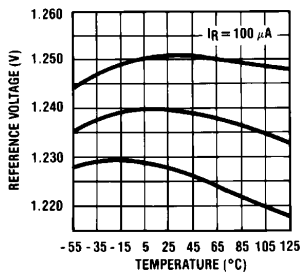
Reverse Characteristics



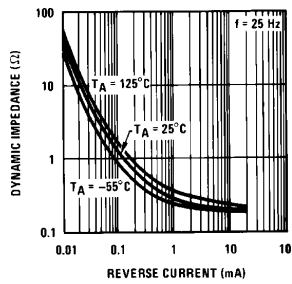
Forward Characteristics



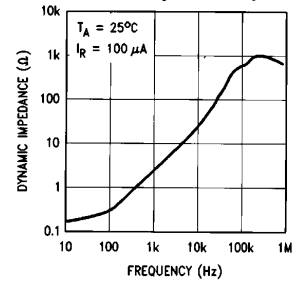
Temperature Drift of 3 Representative Units



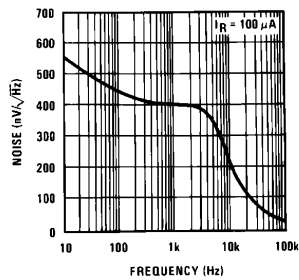
Reverse Dynamic Impedance



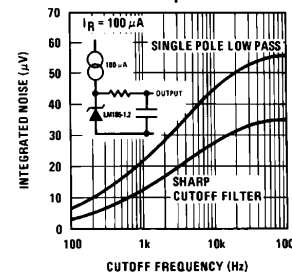
Reverse Dynamic Impedance



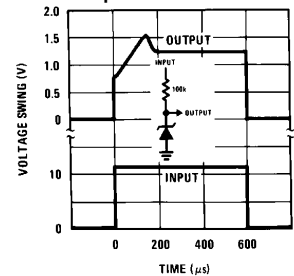
Noise Voltage



Filtered Output Noise



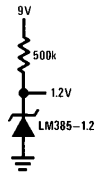
Response Time



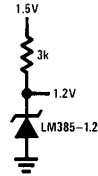
TL/H/5518-3

## Typical Applications (Continued)

### Micropower Reference from 9V Battery

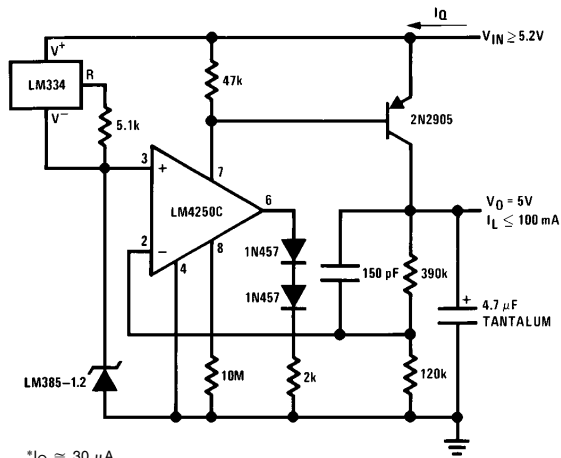


### Reference from 1.5V Battery



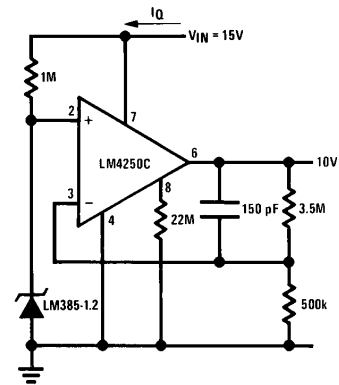
TL/H/5518-2

### Micropower\* 5V Regulator



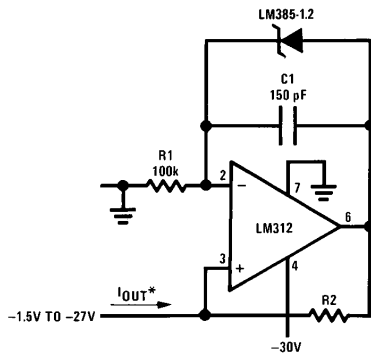
\* $I_Q \approx 30 \mu A$

### Micropower\* 10V Reference

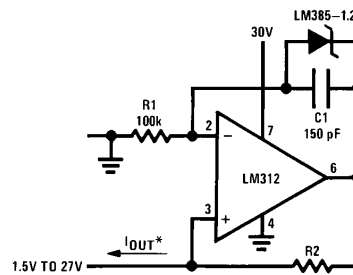


\* $I_Q \approx 20 \mu A$  standby current

### Precision 1 $\mu A$ to 1 mA Current Sources



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

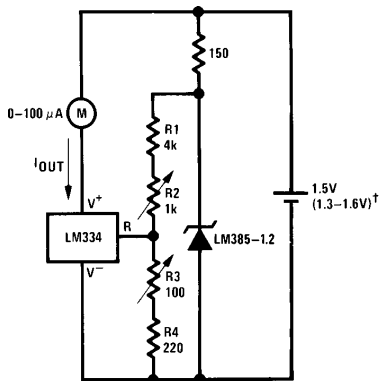


TL/H/5518-4

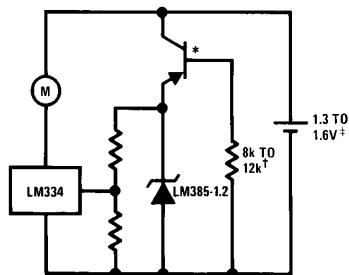
## Typical Applications (Continued)

### METER THERMOMETERS

#### 0°C – 100°C Thermometer



#### Lower Power Thermometer



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

† Select for operation at 1.3V

‡  $I_Q \approx 600 \mu A$  to  $900 \mu A$

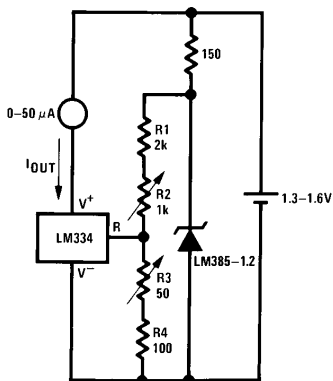
#### Calibration

1. Short LM385-1.2, adjust R3 for  $I_{OUT} = \text{temp}$  at  $1 \mu A/^{\circ}K$
2. Remove short, adjust R2 for correct reading in centigrade

†  $I_Q$  at 1.3V  $\approx 500 \mu A$

$I_Q$  at 1.6V  $\approx 2.4 \text{ mA}$

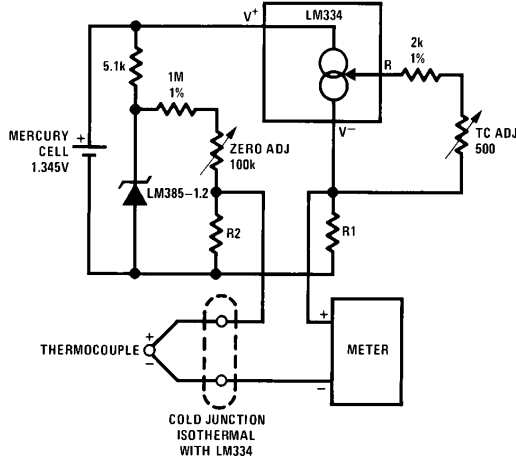
#### 0°F – 50°F Thermometer



#### Calibration

1. Short LM385-1.2, adjust R3 for  $I_{OUT} = \text{temp}$  at  $1.8 \mu A/^{\circ}K$
2. Remove short, adjust R2 for correct reading in °F

#### Micropower Thermocouple Cold Junction Compensator



TL/H/5518-5

#### Adjustment Procedure

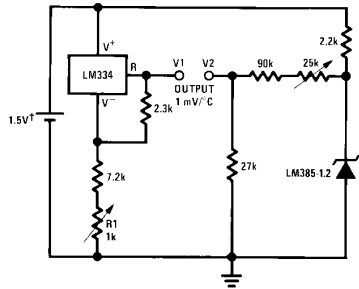
1. Adjust TC ADJ pot until voltage across R1 equals Kelvin temperature multiplied by the thermocouple Seebeck coefficient.
2. Adjust zero ADJ pot until voltage across R2 equals the thermocouple Seebeck coefficient multiplied by 273.2.

Thermocouple Type	Seebeck Coefficient ( $\mu V/^{\circ}C$ )	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  $\mu A$

## Typical Applications (Continued)

### Centigrade Thermometer



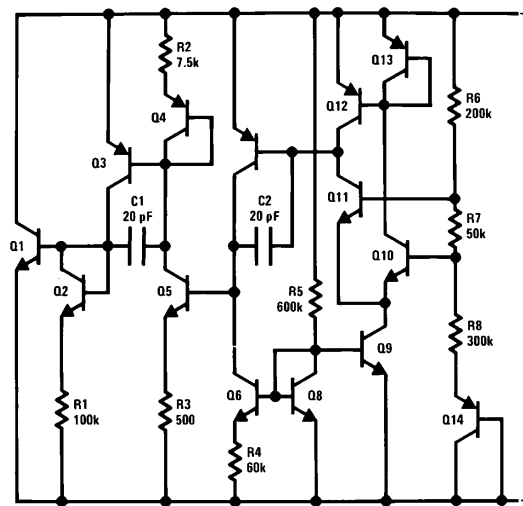
#### Calibration

1. Adjust R1 so that  $V1 = \text{temp at } 1 \text{ mV}/^\circ\text{C}$
2. Adjust V2 to 273.2 mV

$I_Q$  for 1.3V to 1.6V battery voltage =  $50 \mu\text{A}$  to  $150 \mu\text{A}$

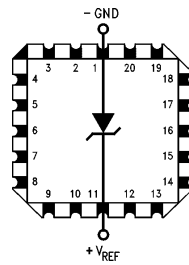
TL/H/5518-1

## Schematic Diagram



TL/H/5518-7

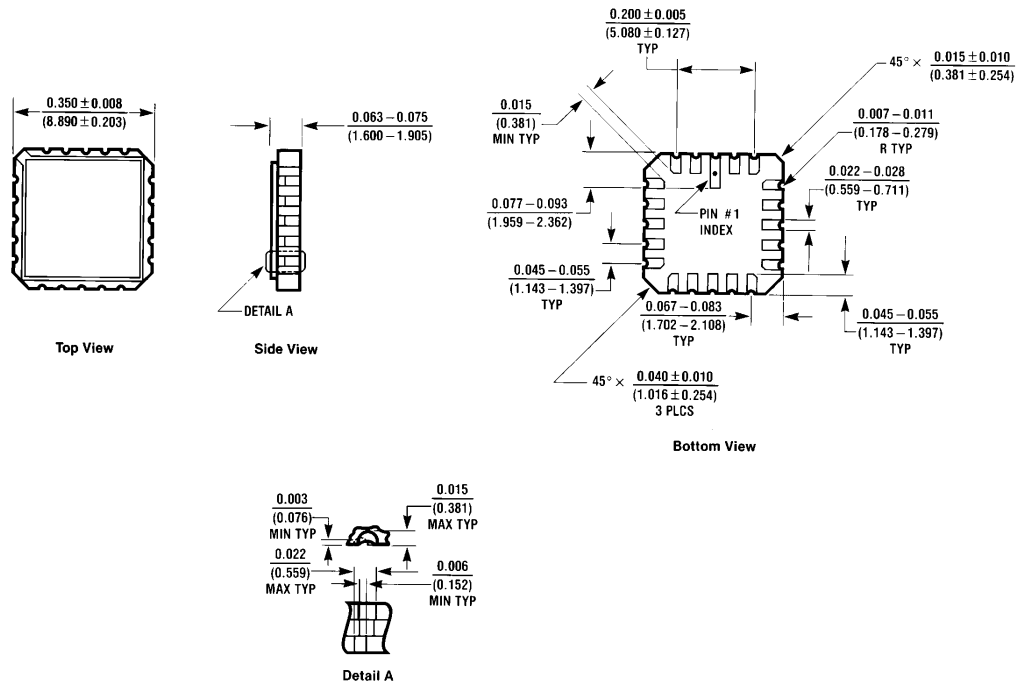
## Connection Diagrams (Continued)



TL/H/5518-12

Order Number LM185E-1.2/883  
See NS Package Number E20A

**Physical Dimensions** inches (millimeters)

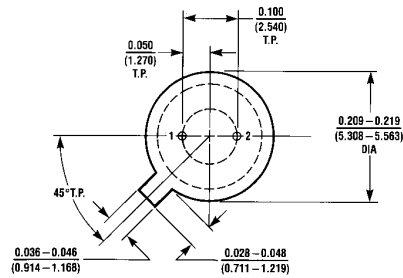
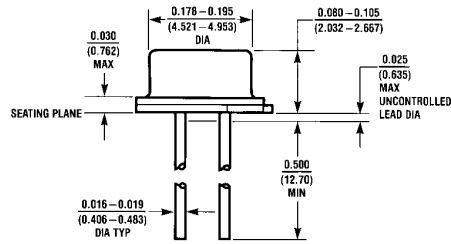


**Order Number LM185E-1.2/883**  
**NS Package Number E20A**

E20A (REV D)



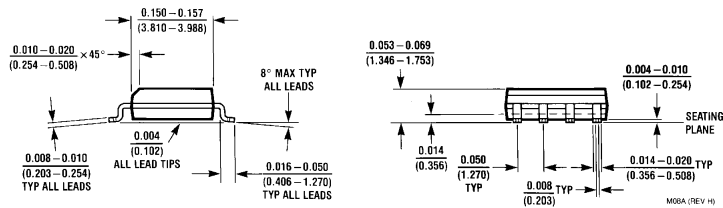
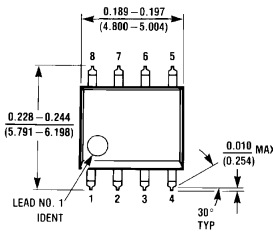
**Physical Dimensions** inches (millimeters) (Continued)



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

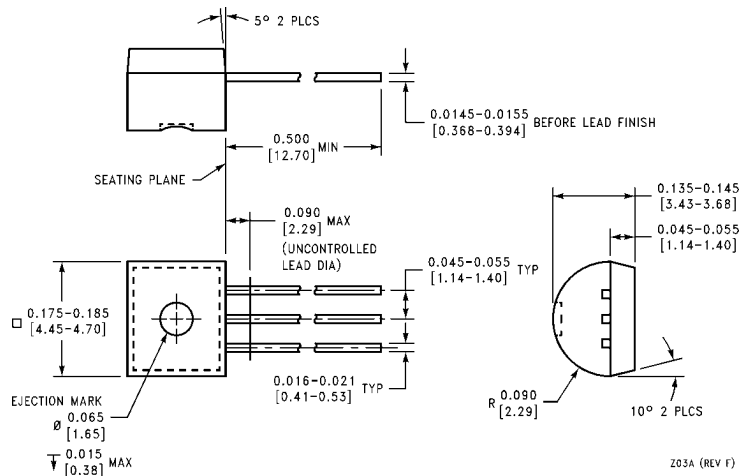


M08A (REV H)

**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

**Physical Dimensions** inches (millimeters) (Continued)



**TO-92 Plastic Package (Z)**  
**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**  
**NS Package Number Z03A**

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems 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.
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.



**National Semiconductor Corporation**  
 1111 West Bardin Road  
 Arlington, TX 76017  
 Tel: 1(800) 272-9959  
 Fax: 1(800) 737-7018

**National Semiconductor Europe**  
 Fax: (+49) 0-180-530 85 86  
 Email: cnjwge@tevm2.nsc.com  
 Deutsch Tel: (+49) 0-180-530 85 85  
 English Tel: (+49) 0-180-532 78 32  
 Français Tel: (+49) 0-180-532 93 58  
 Italiano Tel: (+49) 0-180-534 16 80

**National Semiconductor Hong Kong Ltd.**  
 19th Floor, Straight Block,  
 Ocean Centre, 5 Canton Rd.  
 Tsimshatsui, Kowloon  
 Hong Kong  
 Tel: (852) 2737-1600  
 Fax: (852) 2736-9960

**National Semiconductor Japan Ltd.**  
 Tel: 81-043-299-2309  
 Fax: 81-043-299-2408

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.