

## LM185/LM285/LM385 Adjustable Micropower Voltage References

### General Description

The LM185/LM285/LM385 are micropower 3-terminal adjustable band-gap voltage reference diodes. Operating from 1.24 to 5.3V and 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 band-gap reference uses only transistors and resistors, low noise and good long-term stability result.

Careful design of the LM185 has made the device 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 makes it useful for micropower circuitry. This voltage reference can be used to make portable meters, regulators or general purpose an-

alog circuitry with battery life approaching shelf life. Further, the wide operating current allows it to replace older references with a tighter tolerance part.

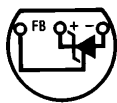
The LM185 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range, while the LM285 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185 is available in a hermetic TO-46 package and a leadless chip carrier package, while the LM285/LM385 are available in a low-cost TO-92 molded package, as well as S.O.

### Features

- Adjustable from 1.24V to 5.30V
- Operating current of 10  $\mu$ A to 20 mA
- 1% and 2% initial tolerance
- 1  $\Omega$  dynamic impedance
- Low temperature coefficient

### Connection Diagrams

TO-92  
Plastic Package

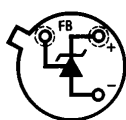


TL/H/5250-9

Bottom View

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

TO-46  
Metal Can Package

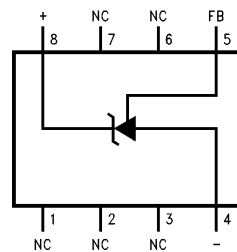


TL/H/5250-1

Bottom View

Order Number  
LM185BH, LM185BH/883,  
LM185BYH or LM185BYH/883  
See NS Package Number H03H

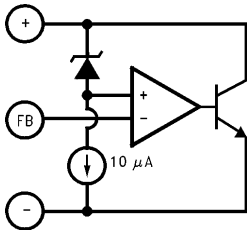
SO Package



TL/H/5250-10

Order Number LM285M, LM285BYM,  
LM385BM or LM385M  
See NS Package Number M08A

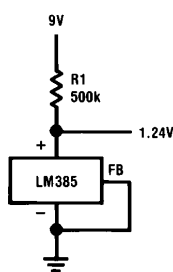
### Block Diagram



TL/H/5250-13

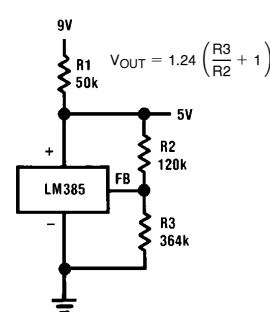
### Typical Applications

1.2V Reference



TL/H/5250-14

5.0V Reference



TL/H/5250-2

$$V_{OUT} = 1.24 \left( \frac{R3}{R2} + 1 \right)$$

## 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 Series	−55°C to 125°C
LM285 Series	−40°C to 85°C
LM385 Series	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	LM185, LM285				LM385				Units (Limit)		
		Typ	LM185BX, LM185BY LM185B, LM285BX, LM285BY		LM285		Typ	LM385BX, LM385BY			LM385	
			Tested Limit (Note 5)	Design Limit (Note 6)	Tested Limit (Note 5)	Design Limit (Note 6)		Tested Limit (Note 5)	Design Limit (Note 6)		Tested Limit (Note 5)	Design Limit (Note 6)
Reference Voltage	$I_R = 100 \mu A$	1.240	1.252 <b>1.255</b> 1.228 <b>1.215</b>		1.265 <b>1.270</b> 1.215 <b>1.205</b>	1.240	1.252 <b>1.255</b> 1.228 <b>1.215</b>	1.265 <b>1.270</b> 1.215 <b>1.205</b>		V (max) V (min)		
Reference Voltage Change with Current	$I_{MIN} < I_R < 1 \text{ mA}$ $1 \text{ mA} < I_R < 20 \text{ mA}$	0.2 4	1 10	<b>1.5</b> <b>20</b>	1 10	<b>1.5</b> <b>20</b>	0.2 5	1 15	<b>1.5</b> <b>25</b>	1 15	<b>1.5</b> <b>25</b>	mV (max)
Dynamic Output Impedance	$I_R = 100 \mu A, f = 100 \text{ Hz}$ $I_{AC} = 0.1 I_R, V_{OUT} = V_{REF}$ $V_{OUT} = 5.3V$	0.3 0.7					0.4 1					$\Omega$
Reference Voltage Change with Output Voltage	$I_R = 100 \mu A$	1	3	<b>6</b>	3	<b>6</b>	2	5	<b>10</b>	5	<b>10</b>	mV (max)
Feedback Current		13	20	<b>25</b>	20	<b>25</b>	16	30	<b>35</b>	30	<b>35</b>	nA (max)
Minimum Operating Current (see curve)	$V_{OUT} = V_{REF}$ $V_{OUT} = 5.3V$	6 30	9 45	<b>10</b> <b>50</b>	9 45	<b>10</b> <b>50</b>	7 35	11 55	<b>13</b> <b>60</b>	11 55	<b>13</b> <b>60</b>	$\mu A$ (max)
Output Wideband Noise	$I_R = 100 \mu A, 10 \text{ Hz} < f < 10 \text{ kHz}$ $V_{OUT} = V_{REF}$ $V_{OUT} = 5.3V$	50 170					50 170					$\mu V_{rms}$
Average Temperature Coefficient (Note 7)	$I_R = 100 \mu A$ 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>30</b> <b>50</b>	<b>150</b>	<b>30</b> <b>50</b>	<b>150</b>	ppm/°C (max)
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

**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 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  $T_A = T_J = 25^\circ C$ . Unless otherwise specified, all parameters apply for  $V_{REF} < V_{OUT} < 5.3V$ .

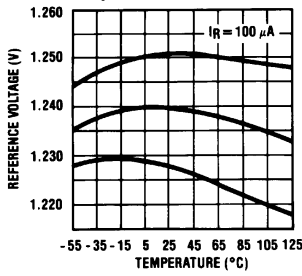
**Note 5:** Guaranteed and 100% production tested.

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

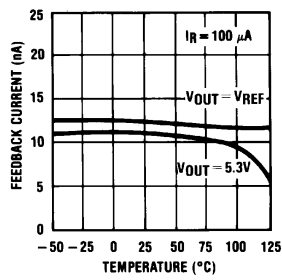
**Note 7:** The average temperature coefficient is defined as the maximum deviation of reference voltage at all measured temperatures from  $T_{min}$  to  $T_{max}$ , divided by  $T_{max} - T_{min}$ . The measured temperatures are −55, −40, 0, 25, 70, 85, 125°C.

# Typical Performance Characteristics

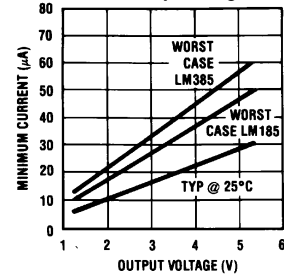
Temperature Drift of 3 Representative Units



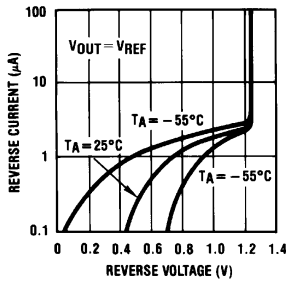
Feedback Current



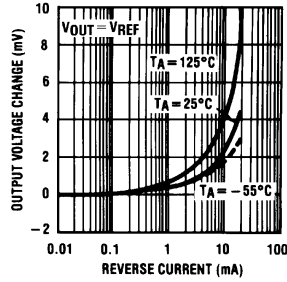
Minimum Operating Current



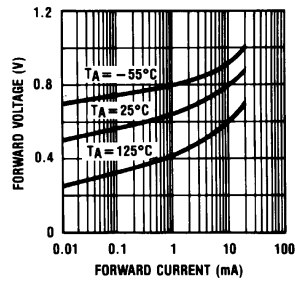
Reverse Characteristics



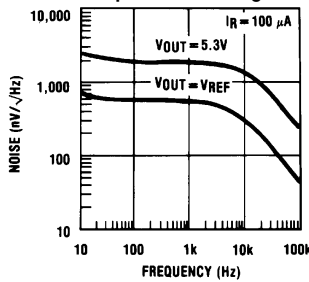
Reverse Characteristics



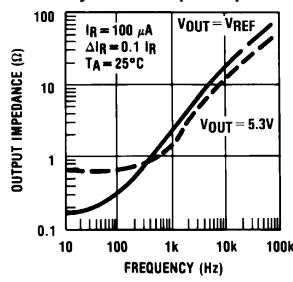
Forward Characteristics



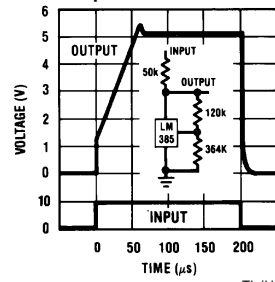
Output Noise Voltage



Dynamic Output Impedance

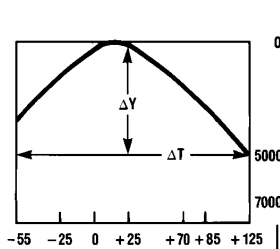


Response Time

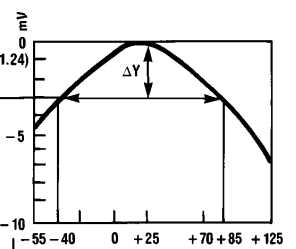


TL/H/5250-3

LM185 Temperature Coefficient Typical



LM285 Temperature Coefficient Typical

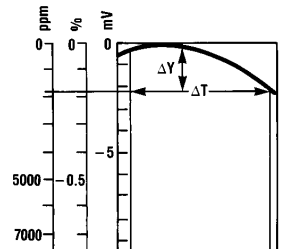


0.035 mV/°C  
0.0028 %/°C  
28 ppm/°C

0.025 mV/°C  
0.002 %/°C  
20 ppm/°C

TEMPCO =  $\frac{\text{TOTAL } \Delta Y \text{ IN ppm}}{\text{TOTAL } \Delta T}$

LM385 Temperature Coefficient Typical



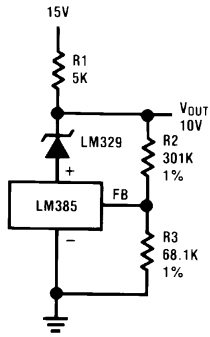
0.032 mV/°C  
0.0026 %/°C  
26 ppm/°C

TEMPCO =  $\frac{\Delta Y}{\Delta T}$

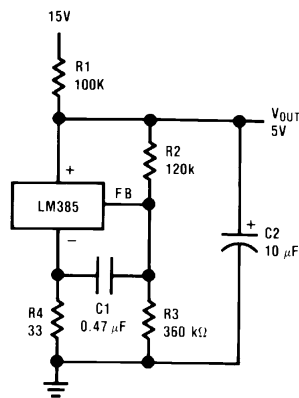
TL/H/5250-4

## Typical Applications (Continued)

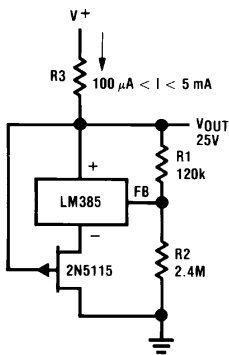
### Precision 10V Reference



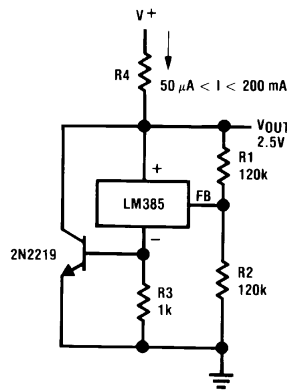
### Low AC Noise Reference



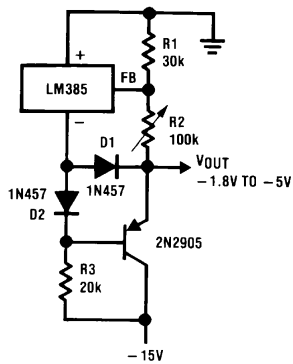
### 25V Low Current Shunt Regulator



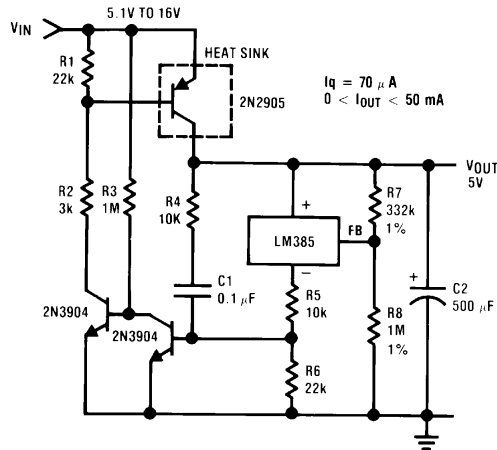
### 200 mA Shunt Regulator



### Series-Shunt 20 mA Regulator



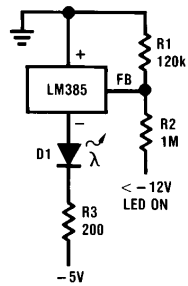
### High Efficiency Low Power Regulator



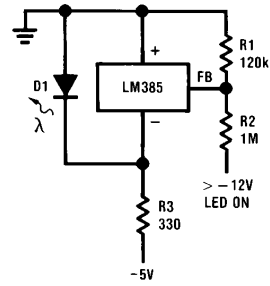
TL/H/5250-5

## Typical Applications (Continued)

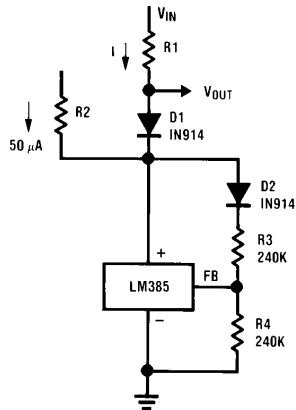
### Voltage Level Detector



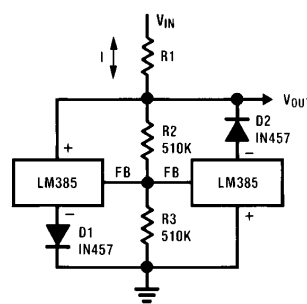
### Voltage Level Detector



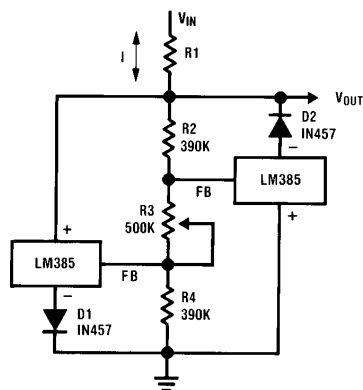
### Fast Positive Clamp $2.4V + \Delta V_{D1}$



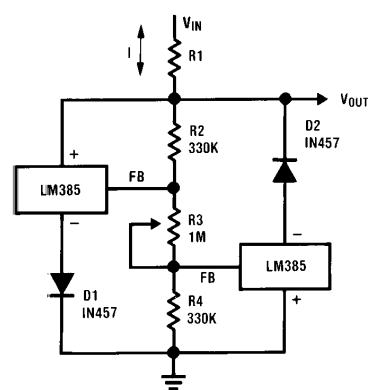
### Bidirectional Clamp $\pm 2.4V$



### Bidirectional Adjustable Clamp $\pm 1.8V$ to $\pm 2.4V$



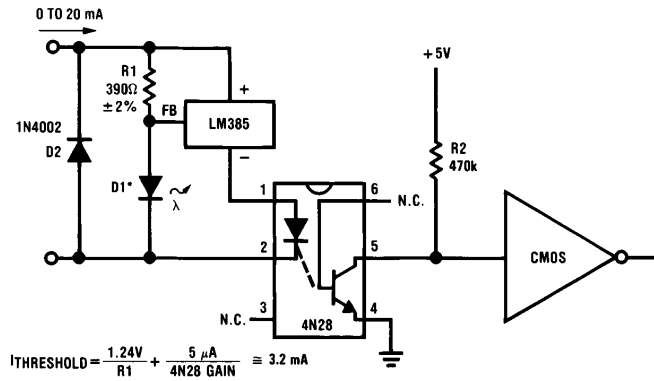
### Bidirectional Adjustable Clamp $\pm 2.4V$ to $\pm 6V$



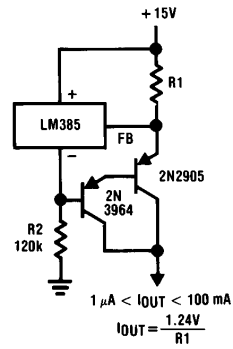
TL/H/5250-6

## Typical Applications (Continued)

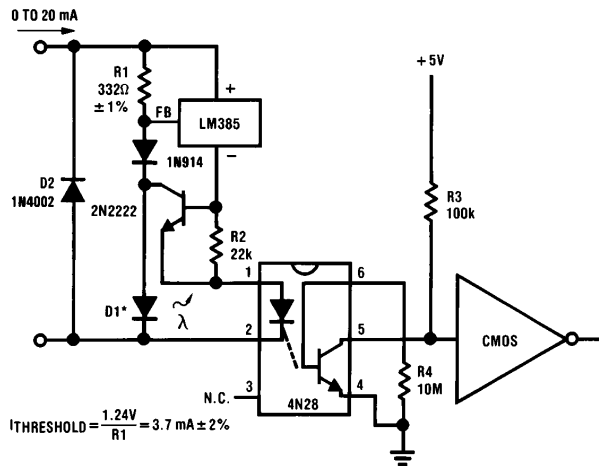
### Simple Floating Current Detector



### Current Source



### Precision Floating Current Detector

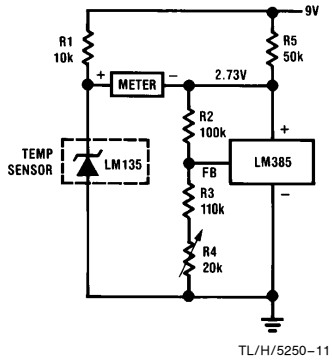


\* D1 can be any LED,  $V_F = 1.5\text{V to } 2.2\text{V}$  at 3 mA. D1 may act as an indicator. D1 will be on if  $I_{\text{THRESHOLD}}$  falls below the threshold current, except with  $I = 0$ .

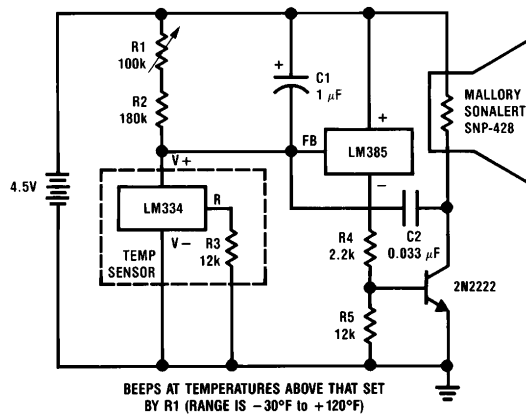
TL/H/5250-7

## Typical Applications (Continued)

Centigrade Thermometer, 10 mV/°C

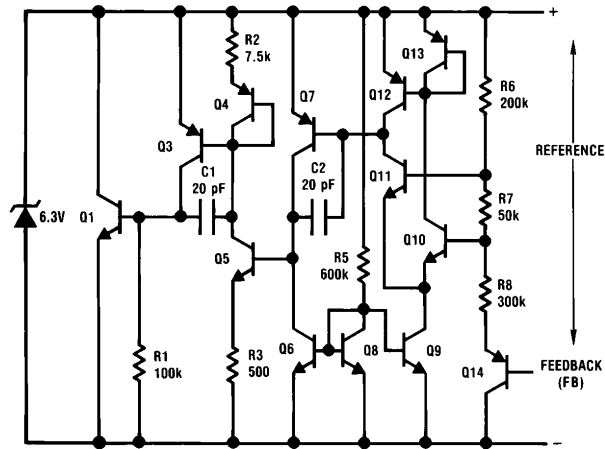


Freezer Alarm



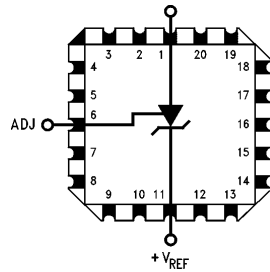
TL/H/5250-12

## Schematic Diagram



TL/H/5250-8

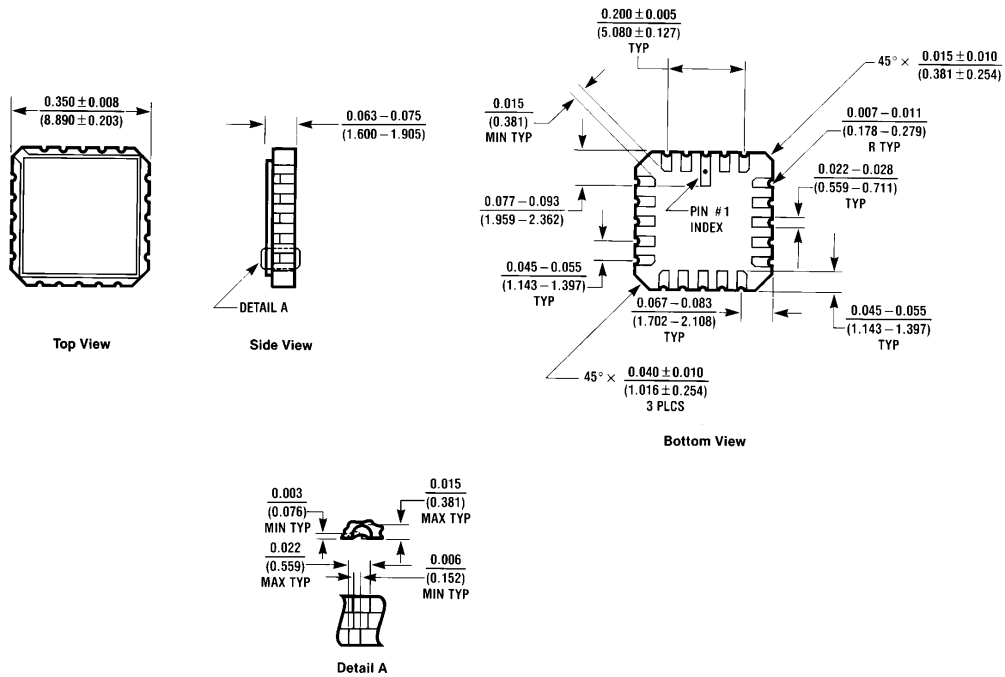
## Connection Diagrams (Continued)



TL/H/5250-15

Order Number LM185BE/883  
See NS Package Number E20A

**Physical Dimensions** inches (millimeters)

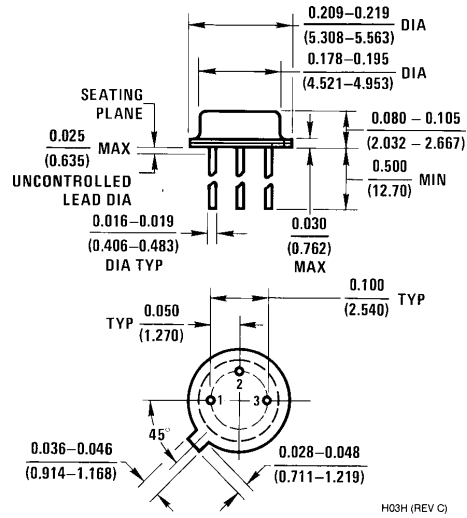


E20A (REV D)

**20-Leadless Chip Carrier (E)**  
**Order Number LM185BE/883**  
**NS Package Number E20A**

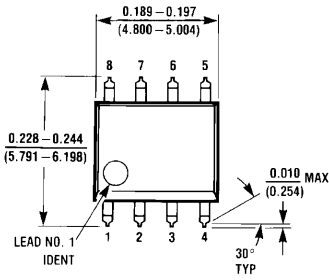


**Physical Dimensions** inches (millimeters) (Continued)



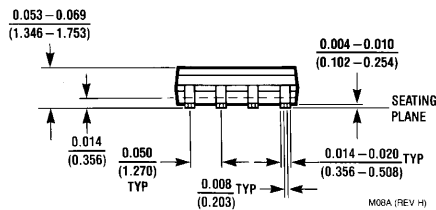
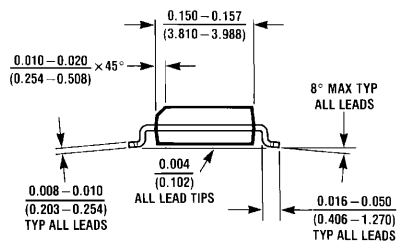
**TO-46 Metal Can Package (H)**  
 Order Number LM185BH, LM185BH/883,  
 LM185BYH or LM185BYH/883  
 NS Package Number H03H

H03H (REV C)

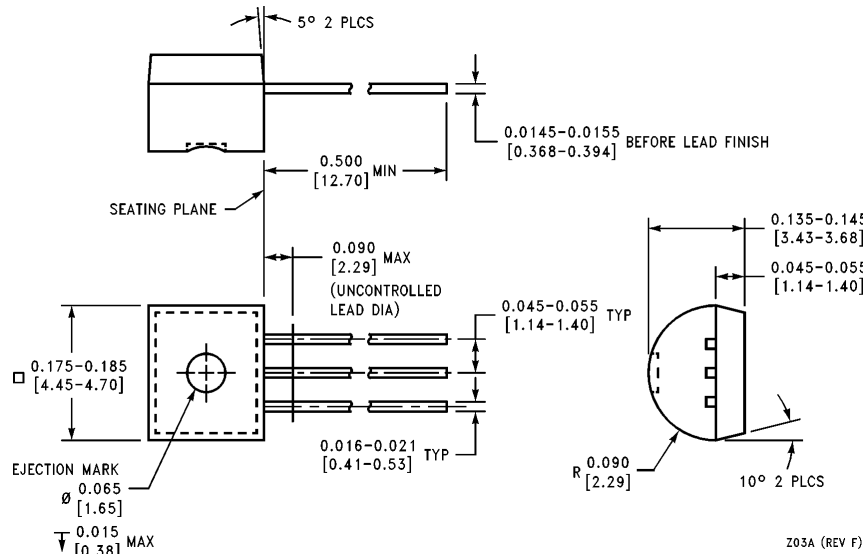


**SO Package (M)**  
 Order Number LM285M, LM285BYM, LM385BM or LM385M  
 NS Package Number M08A

M08A (REV H)



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



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

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