

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

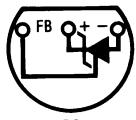
The LM185 is rated for operation over a -55°C to 125°C temperature range, while the LM285 is rated -40°C to 85°C and the LM385 0°C to 70°C. The LM185 is available in a hermetic TO-46 package and a leadless chip carrier package, while the LM285/LM385 are available in a low-cost TO-92 molded package, as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

### Features

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

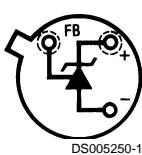
### Connection Diagrams

**TO-92  
Plastic Package**



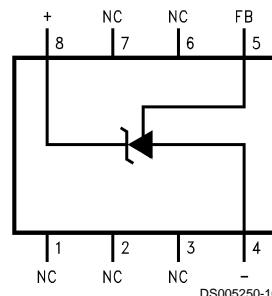
**Bottom View**

**TO-46  
Metal Can Package**



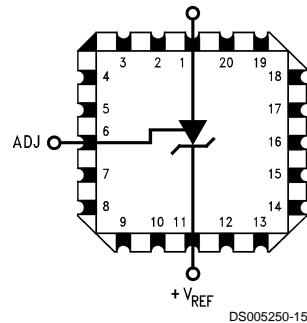
**Bottom View**

**SOIC Package**



**Top View**

**20-Leadless Chip Carrier**

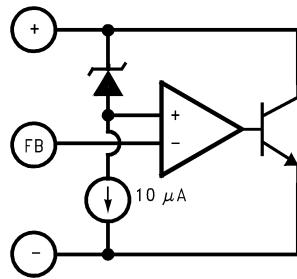


**Top View**

## Ordering Information

Package	Temperature Range			NSC Drawing
	-55°C to 125°C	-40°C to 85°C	0°C to 70°C	
TO-46	LM185BH			H03H
	LM185BH/883			
	LM185BYH			
	LM185BYH/883			
TO-92		LM285BXZ	LM385BXZ	Z03A
		LM285BYZ	LM385BYZ	
		LM285Z	LM385BZ	
			LM385Z	
8-Pin SOIC		LM285M	LM385M	M08A
		LM285BYM	LM385BM	
20-Leadless Chip Carrier	LM185BE/883			E20A

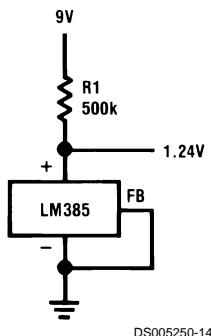
## Block Diagram



DS005250-13

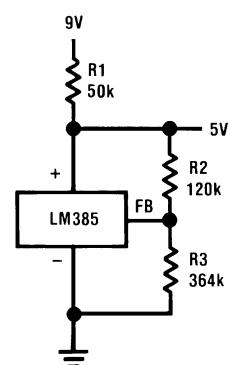
## Typical Applications

1.2V Reference



DS005250-14

5.0V Reference



DS005250-2

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

## 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	30mA
Forward Current	10mA
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		LM285		Typ	LM385BX, LM385BY			
			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>	1.240	1.252 <b>1.255</b>	1.265 <b>1.270</b>	1.265 <b>1.270</b>	V (max)	
Reference Voltage Change with Current	$I_{MIN} < I_R < 1mA$ $1mA < I_R < 20mA$	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	
Dynamic Output Impedance	$I_R = 100\mu A, f = 100Hz$ $I_{AC} = 0.1 I_R$ $V_{OUT} = V_{REF}$ $V_{OUT} = 5.3V$	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	
Feedback Current		13	20	<b>25</b>	20	<b>25</b>	16	30	<b>35</b>	30	
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	
Output Wideband Noise	$I_R = 100\mu A, 10Hz < f < 10kHz$ $V_{OUT} = V_{REF}$ $V_{OUT} = 5.3V$	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>			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,  $T_{Jmax}$  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

## Electrical Characteristics (Note 4) (Continued)

**Note 4:** Parameters identified with **boldface** type apply at temperature extremes. All other numbers apply at  $T_A = T_J = 25^\circ\text{C}$ . Unless otherwise specified, all parameters apply for  $V_{\text{REF}} < V_{\text{OUT}} < 5.3\text{V}$ .

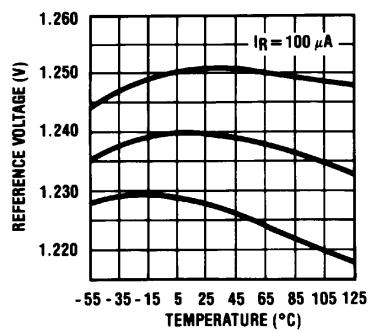
**Note 5:** Guaranteed and 100% production tested.

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

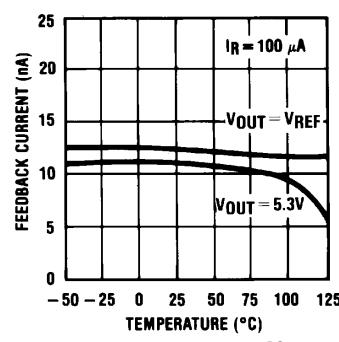
**Note 7:** The average temperature coefficient is defined as the maximum deviation of reference voltage at all measured temperatures from  $T_{\text{MIN}}$  to  $T_{\text{MAX}}$ , divided by  $T_{\text{MAX}} - T_{\text{MIN}}$ . The measured temperatures are  $-55, -40, 0, 25, 70, 85, 125^\circ\text{C}$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

## Typical Performance Characteristics

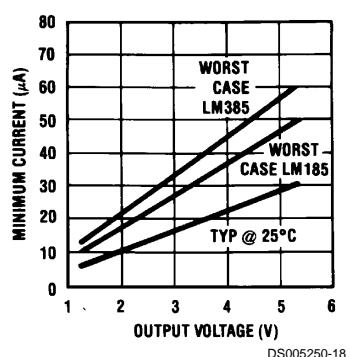
Temperature Drift of 3 Representative Units



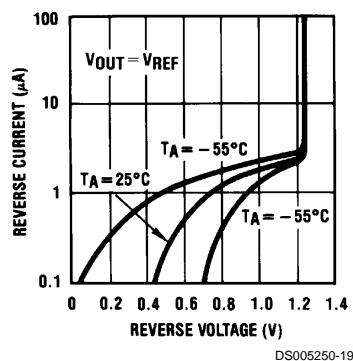
Feedback Current



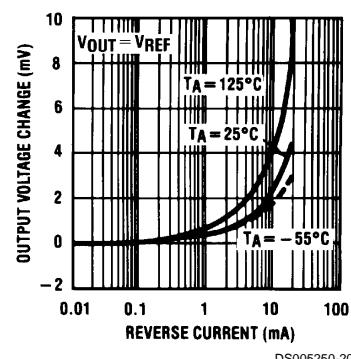
Minimum Operating Current



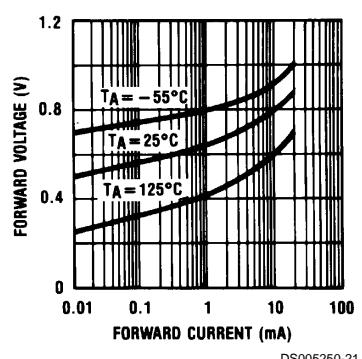
Reverse Characteristics



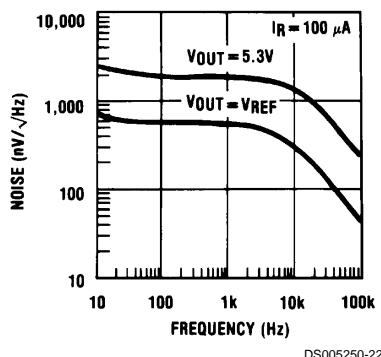
Reverse Characteristics



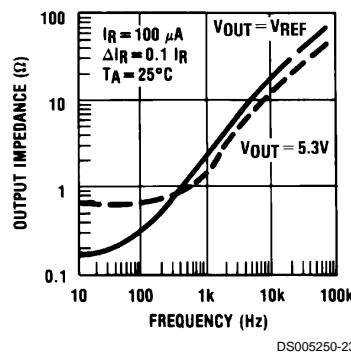
Forward Characteristics



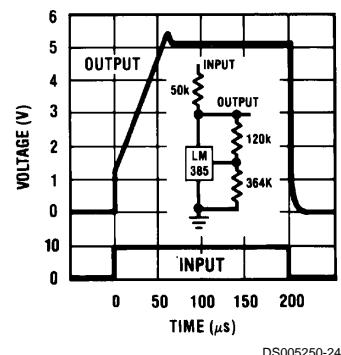
Output Noise Voltage



Dynamic Output Impedance

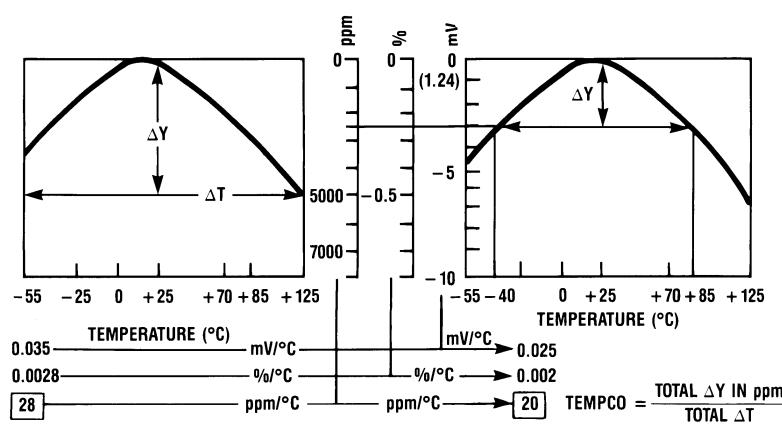


Response Time



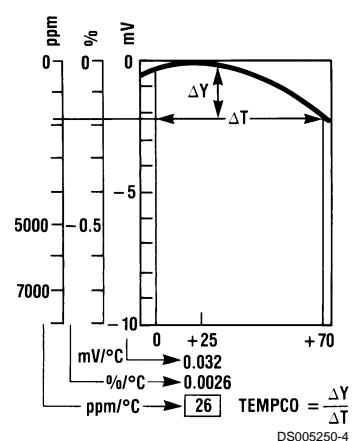
## Typical Performance Characteristics (Continued)

Temperature Coefficient Typical  
LM185



LM285

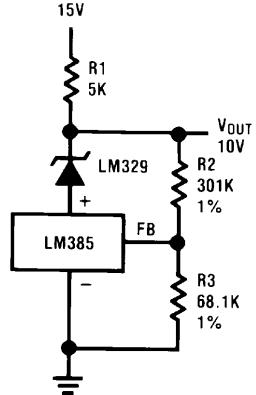
LM385



DS005250-4

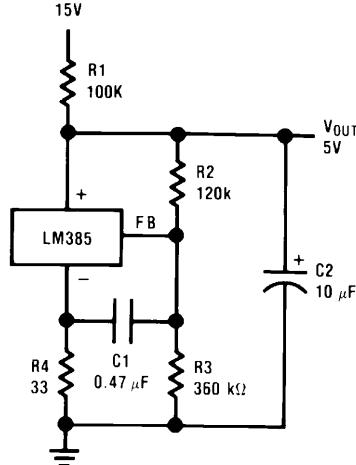
## Typical Applications

Precision 10V Reference



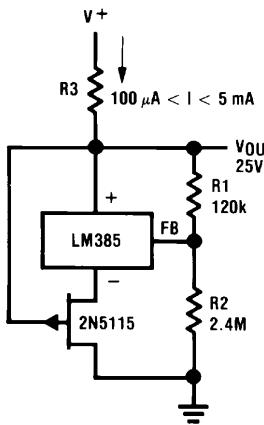
DS005250-25

Low AC Noise Reference



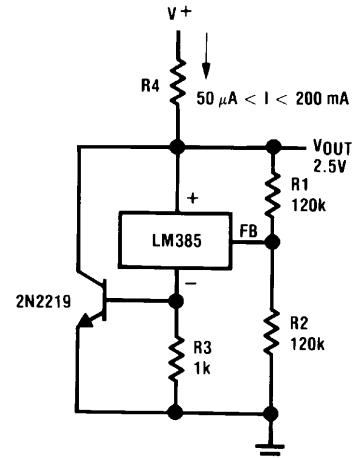
DS005250-26

25V Low Current Shunt Regulator



DS005250-27

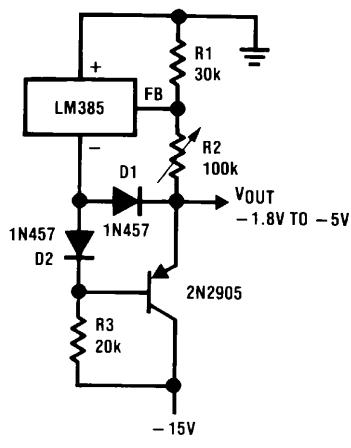
200 mA Shunt Regulator



DS005250-28

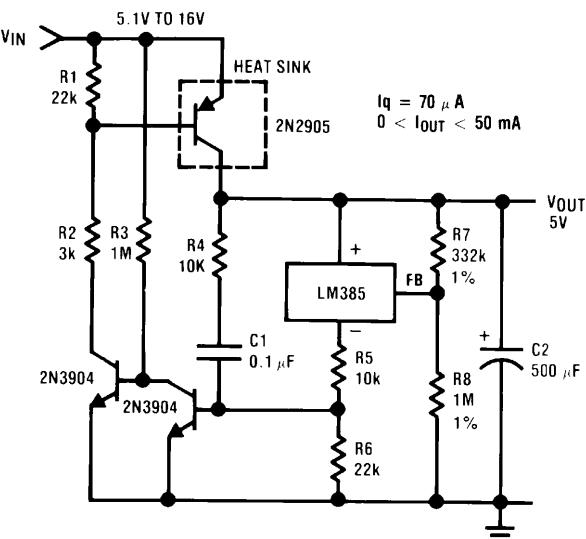
## Typical Applications (Continued)

Series-Shunt 20 mA Regulator



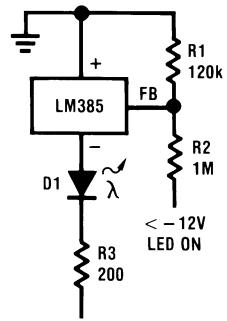
DS005250-29

High Efficiency Low Power Regulator



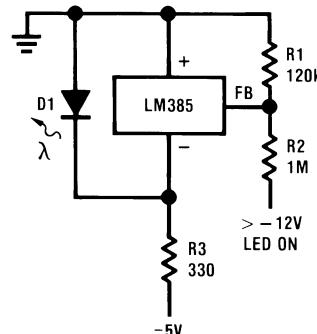
DS005250-30

Voltage Level Detector



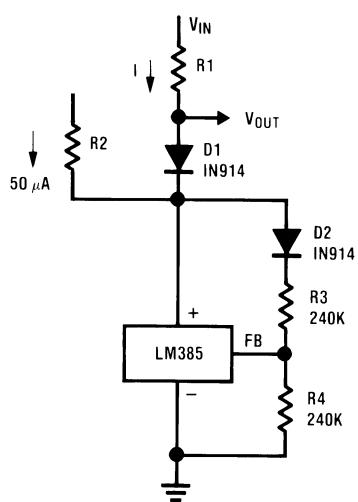
DS005250-31

Voltage Level Detector



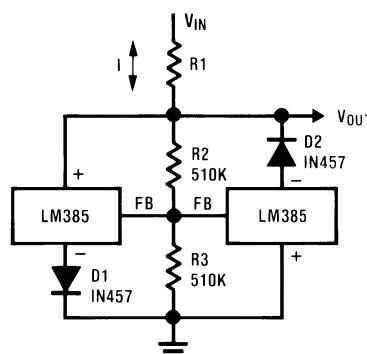
DS005250-32

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



DS005250-33

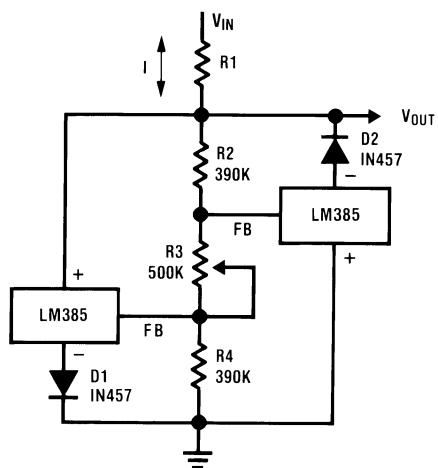
Bidirectional Clamp  
±2.4V



DS005250-34

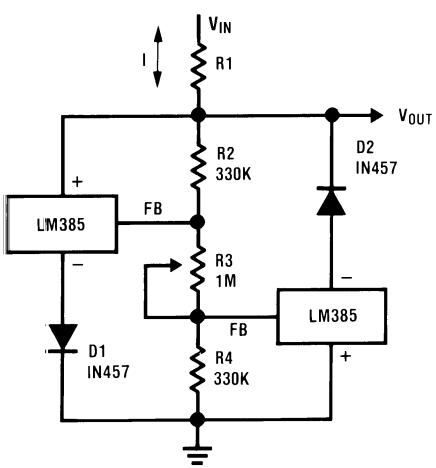
## Typical Applications (Continued)

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



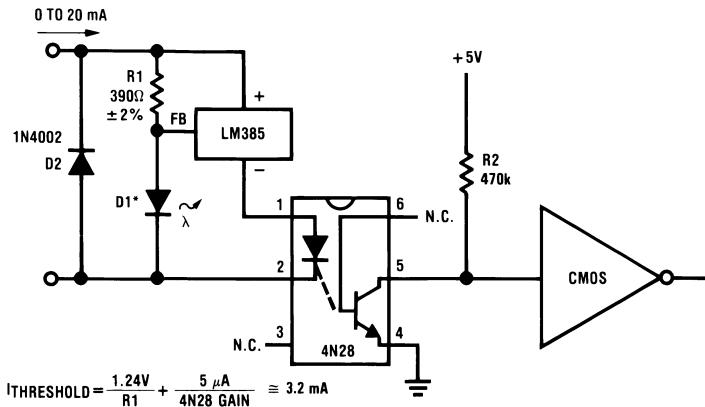
DS005250-35

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



DS005250-36

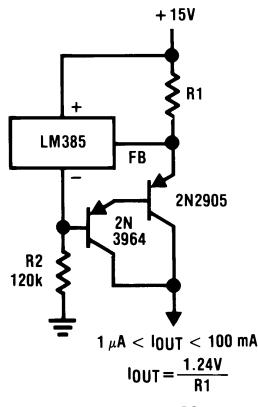
**Simple Floating Current Detector**



$$I_{\text{THRESHOLD}} = \frac{1.24V}{R1} + \frac{5 \mu A}{4N28 \text{ GAIN}} \approx 3.2 \text{ mA}$$

DS005250-37

**Current Source**



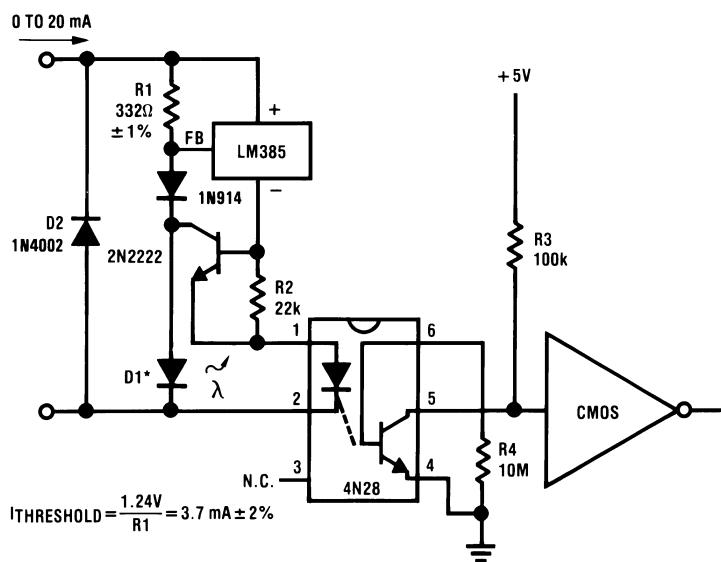
$$1 \mu A < I_{\text{OUT}} < 100 \text{ mA}$$

$$I_{\text{OUT}} = \frac{1.24V}{R1}$$

DS005250-38

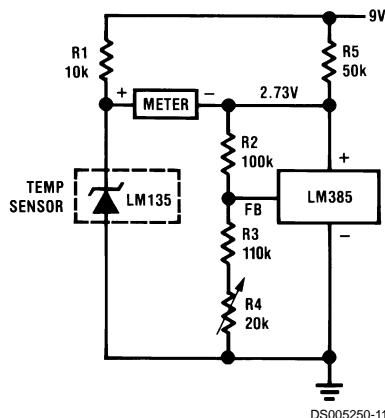
## Typical Applications (Continued)

## Precision Floating Current Detector



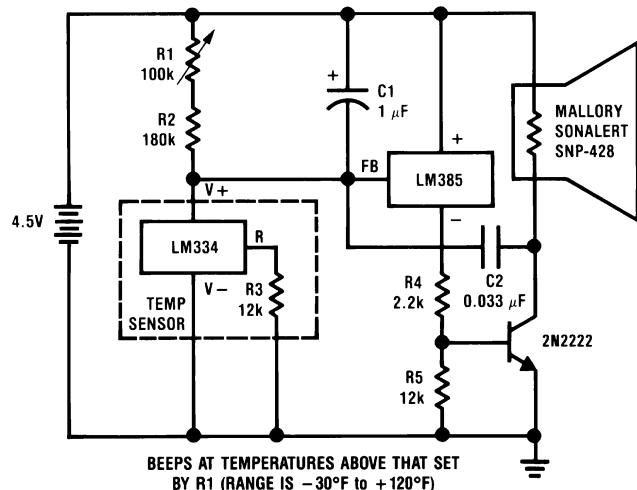
DS005250-39

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

Centigrade Thermometer,  $10\text{mV}/^{\circ}\text{C}$ 

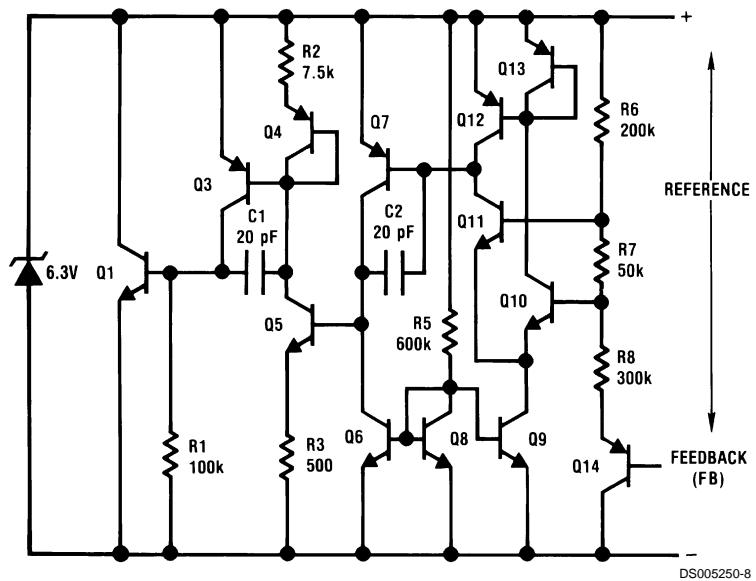
DS005250-11

## Freezer Alarm



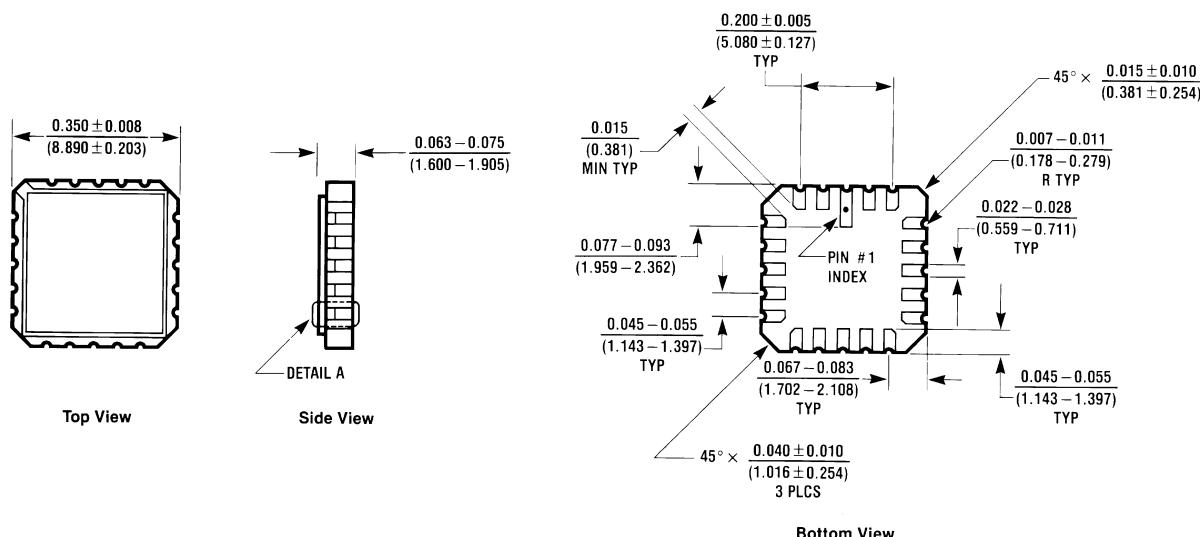
DS005250-12

## Schematic Diagram



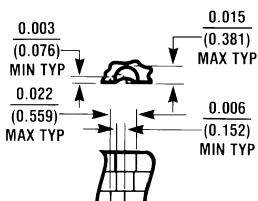
## Physical Dimensions

inches (millimeters) unless otherwise noted



Side View

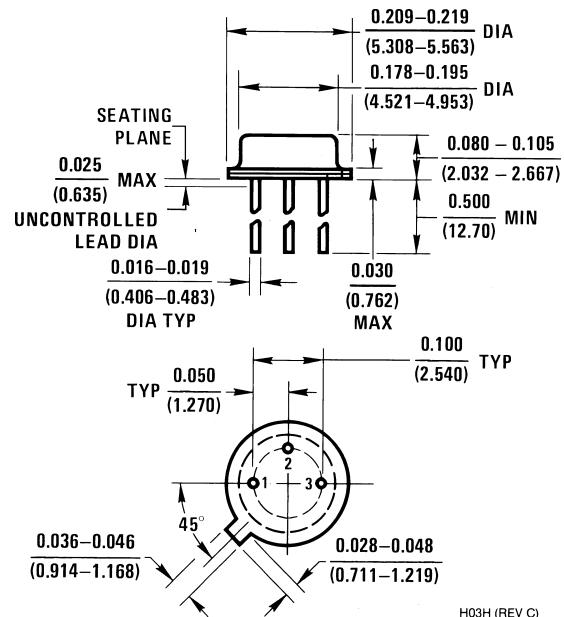
Bottom View



Detail A

E20A (REV D)

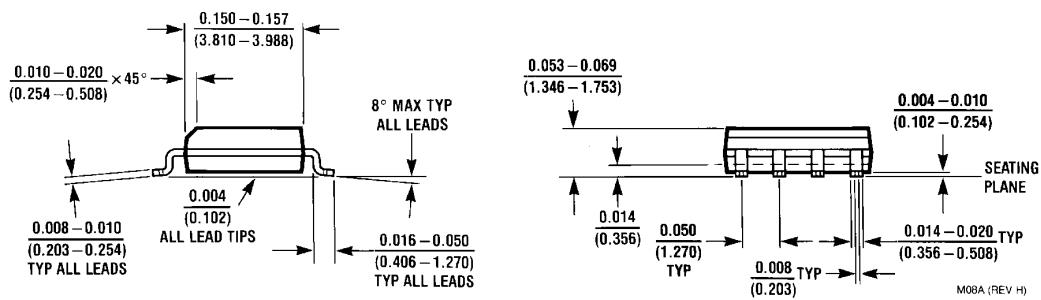
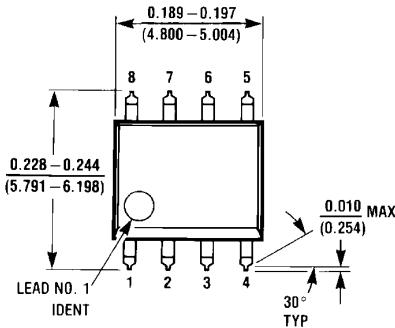
**20-Leadless Chip Carrier (E)**  
NS Package Number E20A



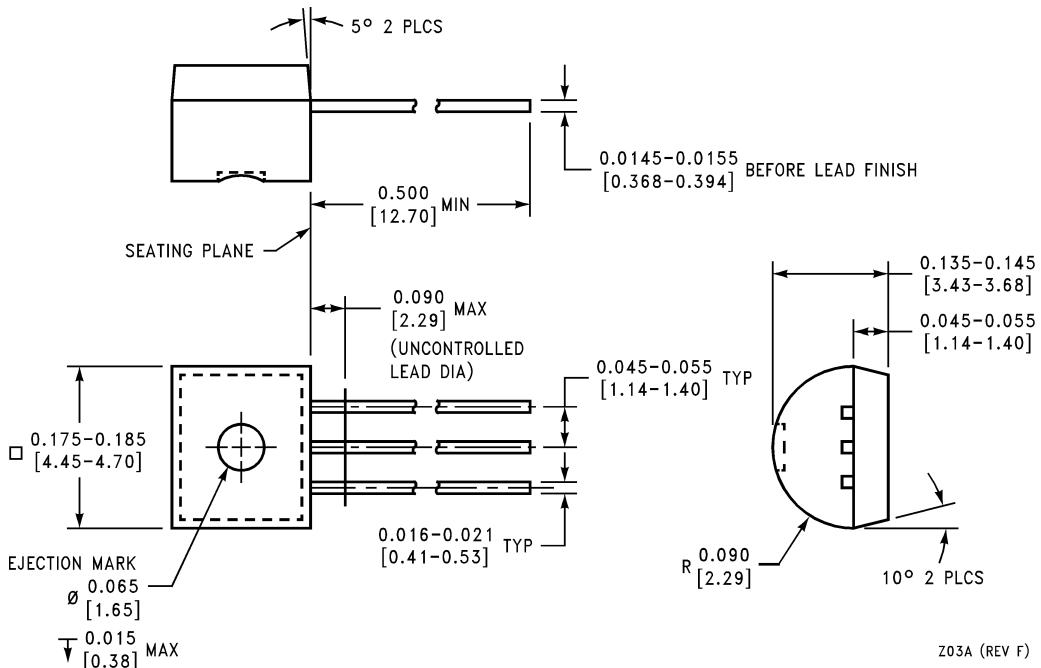
**TO-46 Metal Can Package (H)**  
NS Package Number H03H

## Physical Dimensions

inches (millimeters) unless otherwise noted (Continued)



**SO Package (M)**  
NS Package Number M08A



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

## Notes

### 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 AND GENERAL COUNSEL 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**  
Americas  
Tel: 1-800-272-9959  
Fax: 1-800-737-7018  
Email: support@nsc.com  
www.national.com

**National Semiconductor Europe**  
Fax: +49 (0) 180-530 85 86  
Email: europe.support@nsc.com  
Deutsch Tel: +49 (0) 69 9508 6208  
English Tel: +44 (0) 870 24 0 2171  
Français Tel: +33 (0) 1 41 91 8790

**National Semiconductor Asia Pacific Customer Response Group**  
Tel: 65-2544466  
Fax: 65-2504466  
Email: ap.support@nsc.com

**National Semiconductor Japan Ltd.**  
Tel: 81-3-5639-7560  
Fax: 81-3-5639-7507