

# 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.

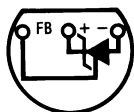
The LM185 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range, while the LM285 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185 is available in a hermetic TO-46 package and 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 20mA
- 1% and 2% initial tolerance
- 1 $\Omega$  dynamic impedance
- Low temperature coefficient

## Connection Diagrams

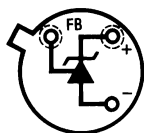
TO-92  
Plastic Package



DS005250-9

Bottom View

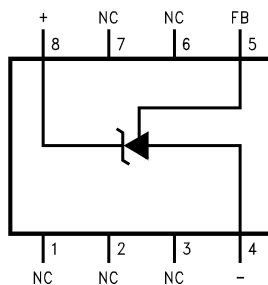
TO-46  
Metal Can Package



DS005250-1

Bottom View

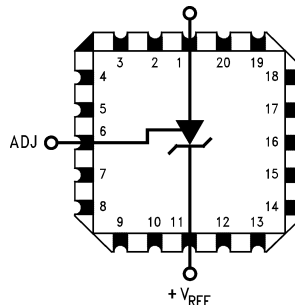
SOIC Package



DS005250-10

Top View

20-Leadless Chip Carrier



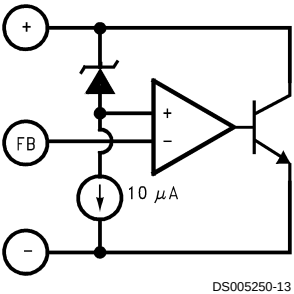
DS005250-15

Top View

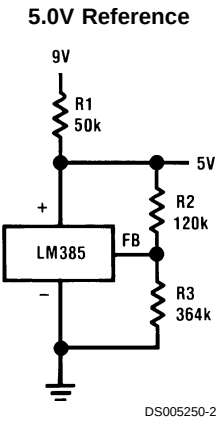
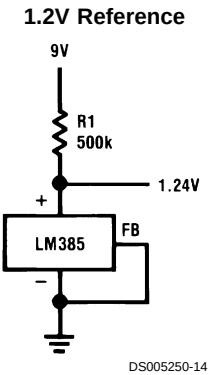
Ordering Information

| 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



Typical Applications



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

**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<br>(Limit)             |
|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------------|-------------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|--------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|------------------------------|
|                                                    |                                                                                                                                             | Typ            | LM185BX,<br>LM185BY<br>LM185B,<br>LM285BX,<br>LM285BY |                             | LM285                       |                             | Typ          | LM385BX,<br>LM385BY         |                             | LM385                       |                             |                              |
|                                                    |                                                                                                                                             |                | Tested<br>Limit<br>(Note 5)                           | Design<br>Limit<br>(Note 6) | Tested<br>Limit<br>(Note 5) | Design<br>Limit<br>(Note 6) |              | Tested<br>Limit<br>(Note 5) | Design<br>Limit<br>(Note 6) | Tested<br>Limit<br>(Note 5) | Design<br>Limit<br>(Note 6) |                              |
| Reference Voltage                                  | I <sub>R</sub> = 100μA                                                                                                                      | 1.240          | 1.252<br><br>1.255<br><br>1.228<br><br>1.215          |                             | 1.265<br><br>1.215          | 1.270<br><br>1.205          | 1.240        | 1.252<br><br>1.228          | 1.255<br><br>1.215          | 1.265<br><br>1.215          | 1.270<br><br>1.205          | V<br>(max)<br><br>V<br>(min) |
| Reference Voltage<br>Change with Current           | I <sub>MIN</sub> < I <sub>R</sub> < 1mA<br>1mA < I <sub>R</sub> < 20mA                                                                      | 0.2<br>4       | 1<br>10                                               | 1.5<br>20                   | 1<br>10                     | 1.5<br>20                   | 0.2<br>5     | 1<br>15                     | 1.5<br>25                   | 1<br>15                     | 1.5<br>25                   | mV<br>(max)                  |
| Dynamic Output<br>Impedance                        | I <sub>R</sub> = 100μA, f = 100Hz<br>I <sub>AC</sub> = 0.1 I <sub>R</sub><br>V <sub>OUT</sub> = V <sub>REF</sub><br>V <sub>OUT</sub> = 5.3V | 0.3<br><br>0.7 |                                                       |                             |                             |                             | 0.4<br><br>1 |                             |                             |                             |                             | Ω                            |
| Reference Voltage<br>Change with Output<br>Voltage | I <sub>R</sub> = 100μA                                                                                                                      | 1              | 3                                                     | 6                           | 3                           | 6                           | 2            | 5                           | 10                          | 5                           | 10                          | mV<br>(max)                  |
| Feedback Current                                   |                                                                                                                                             | 13             | 20                                                    | 25                          | 20                          | 25                          | 16           | 30                          | 35                          | 30                          | 35                          | nA<br>(max)                  |
| Minimum Operating<br>Current (see curve)           | V <sub>OUT</sub> = V <sub>REF</sub><br>V <sub>OUT</sub> = 5.3V                                                                              | 6<br>30        | 9<br>45                                               | 10<br>50                    | 9<br>45                     | 10<br>50                    | 7<br>35      | 11<br>55                    | 13<br>60                    | 11<br>55                    | 13<br>60                    | μA<br>(max)                  |
| Output Wideband<br>Noise                           | I <sub>R</sub> = 100μA, 10Hz < f < 10kHz<br>V <sub>OUT</sub> = V <sub>REF</sub><br>V <sub>OUT</sub> = 5.3V                                  | 50<br>170      |                                                       |                             |                             |                             | 50<br>170    |                             |                             |                             |                             | μV <sub>rms</sub>            |
| Average<br>Temperature<br>Coefficient (Note 7)     | I <sub>R</sub> = 100μA X Suffix<br><br>Y Suffix<br><br>All Others                                                                           |                | 30<br><br>50                                          |                             |                             |                             |              | 30<br><br>50                |                             |                             |                             | ppm/°C<br>(max)              |
| Long Term Stability                                | I <sub>R</sub> = 100μA, T = 1000 Hr,<br>T <sub>A</sub> = 25°C ± 0.1°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)<br>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  $V_{\text{REF}} < V_{\text{OUT}} < 5.3\text{V}$ .

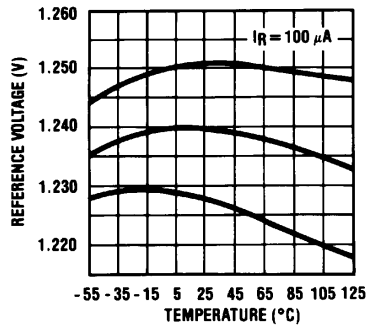
**Note 5:** Guaranteed and 100% production tested.

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

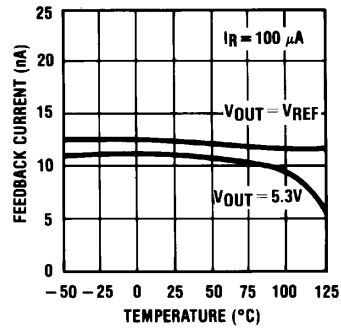
**Note 7:** The average temperature coefficient is defined as the maximum deviation of reference voltage at all measured temperatures from  $T_{\text{MIN}}$  to  $T_{\text{MAX}}$ , divided by  $T_{\text{MAX}} - T_{\text{MIN}}$ . The measured temperatures are  $-55, -40, 0, 25, 70, 85, 125^\circ\text{C}$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

## Typical Performance Characteristics

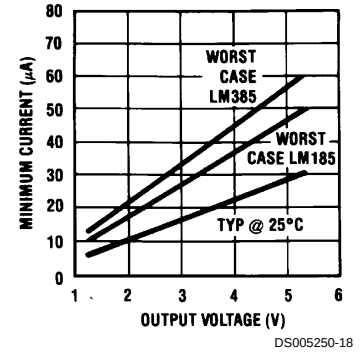
Temperature Drift of 3 Representative Units



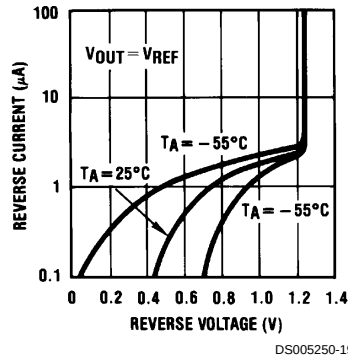
Feedback Current



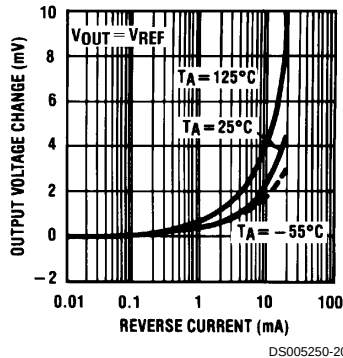
Minimum Operating Current



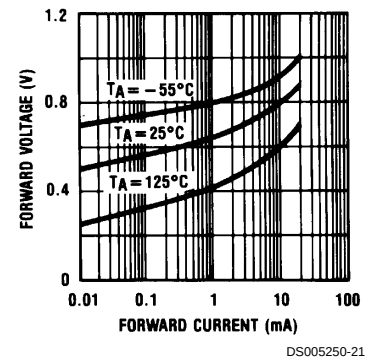
Reverse Characteristics



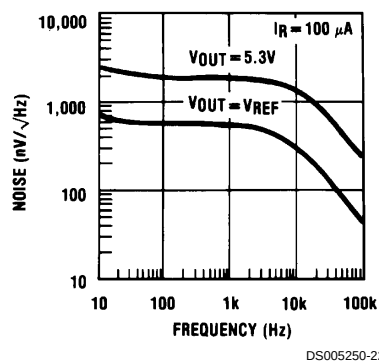
Reverse Characteristics



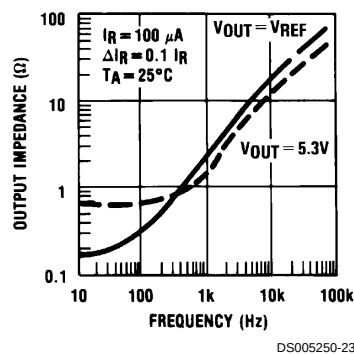
Forward Characteristics



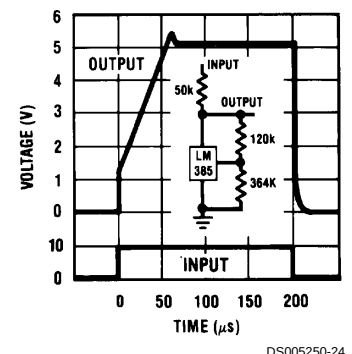
Output Noise Voltage



Dynamic Output Impedance

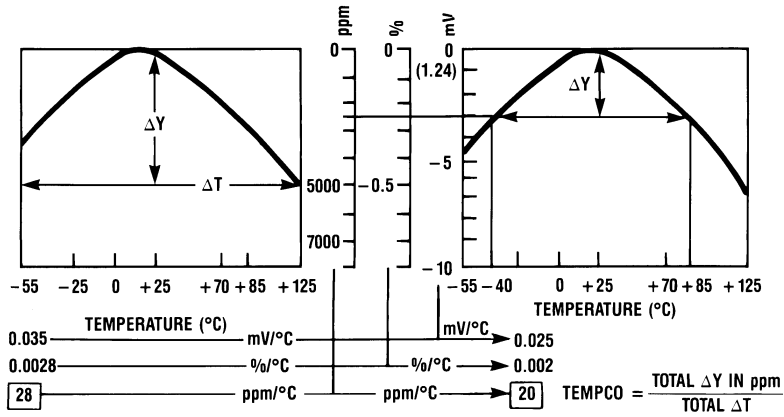


Response Time

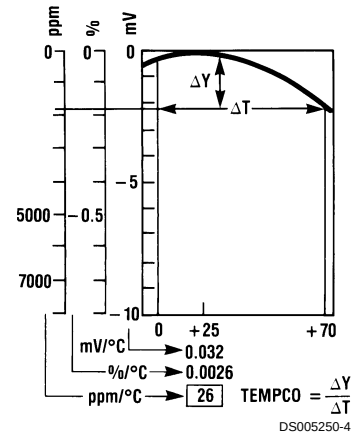


# Typical Performance Characteristics (Continued)

Temperature Coefficient Typical  
LM185

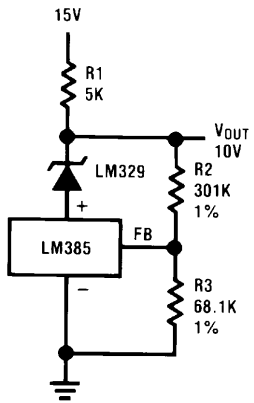


LM385

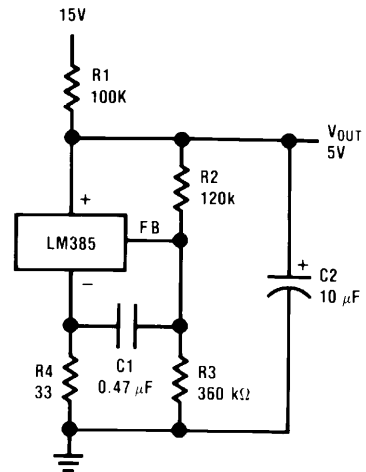


## Typical Applications

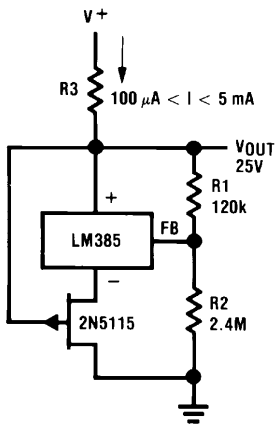
Precision 10V Reference



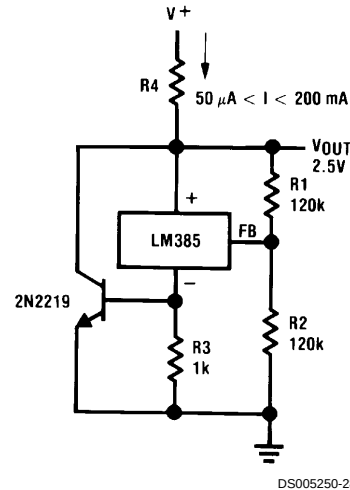
Low AC Noise Reference



25V Low Current Shunt Regulator

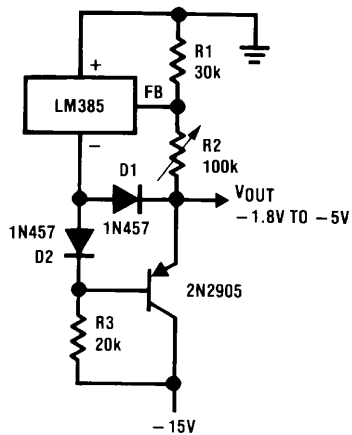


200 mA Shunt Regulator



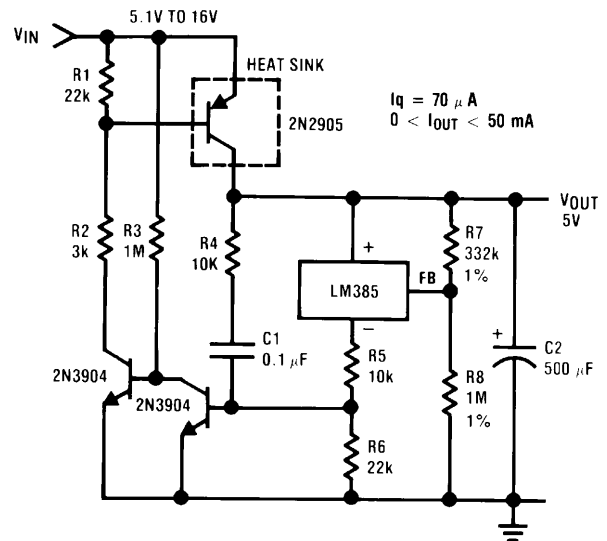
## Typical Applications (Continued)

### Series-Shunt 20 mA Regulator



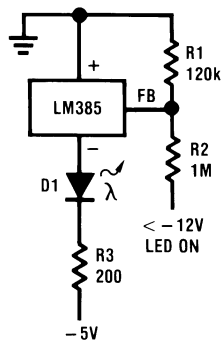
DS005250-29

### High Efficiency Low Power Regulator



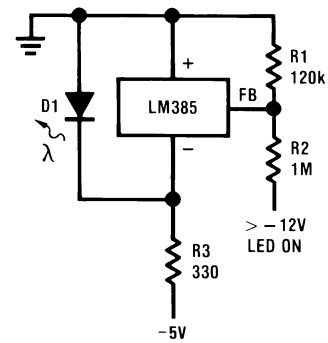
DS005250-30

### Voltage Level Detector



DS005250-31

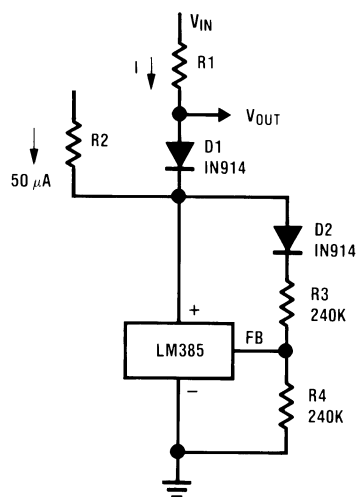
### Voltage Level Detector



DS005250-32

### Fast Positive Clamp

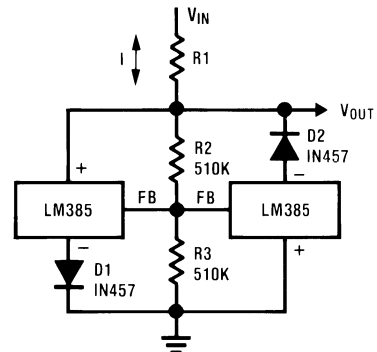
$2.4V + \Delta V_{D1}$



DS005250-33

### Bidirectional Clamp

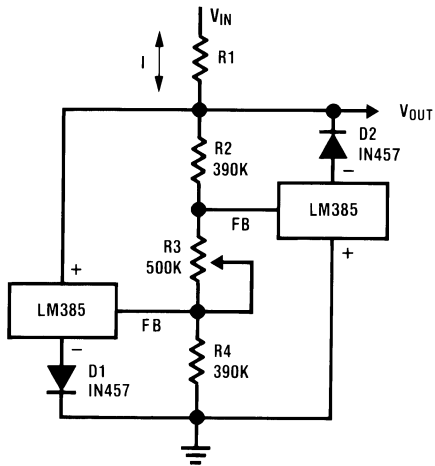
$\pm 2.4V$



DS005250-34

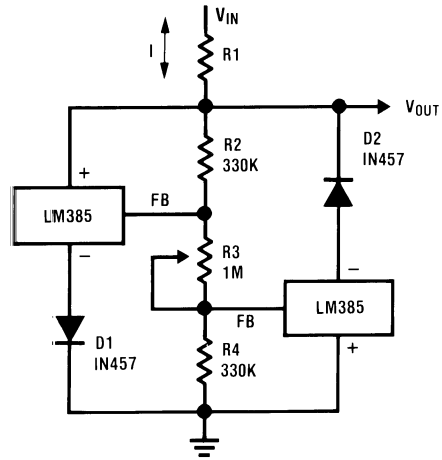
## Typical Applications (Continued)

**Bidirectional Adjustable Clamp**  
 $\pm 1.8\text{V}$  to  $\pm 2.4\text{V}$



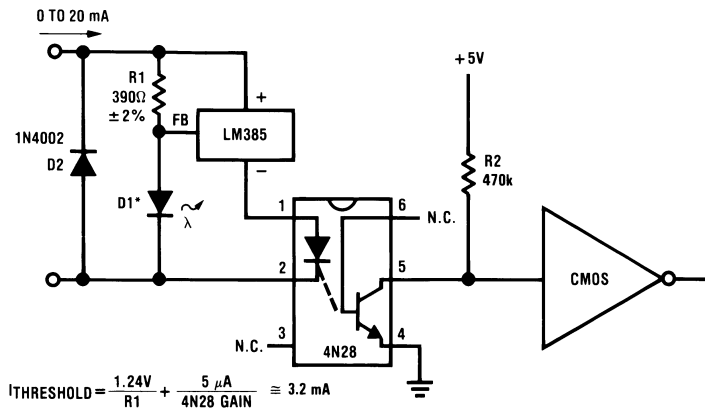
DS005250-35

**Bidirectional Adjustable Clamp**  
 $\pm 2.4\text{V}$  to  $\pm 6\text{V}$



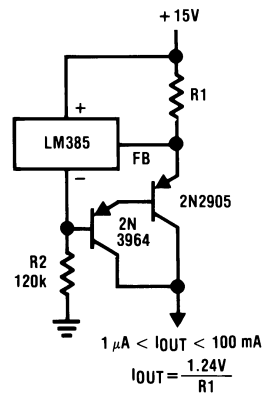
DS005250-36

**Simple Floating Current Detector**



DS005250-37

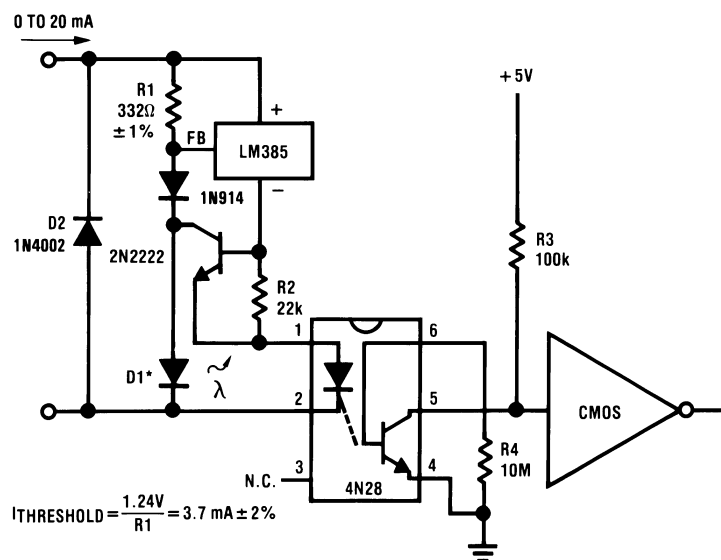
**Current Source**



DS005250-38

## Typical Applications (Continued)

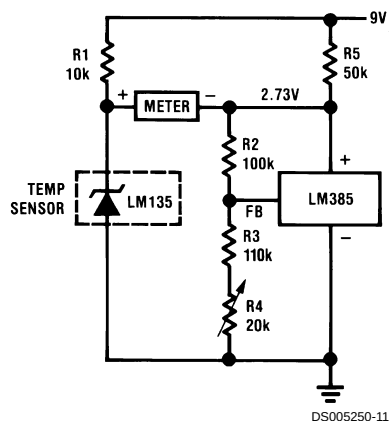
### Precision Floating Current Detector



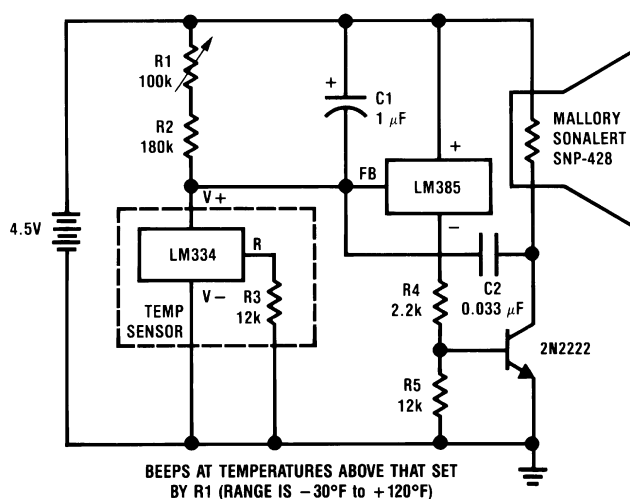
DS005250-39

\*D1 can be any LED,  $V_F = 1.5\text{V to } 2.2\text{V}$  at 3 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, 10mV/°C



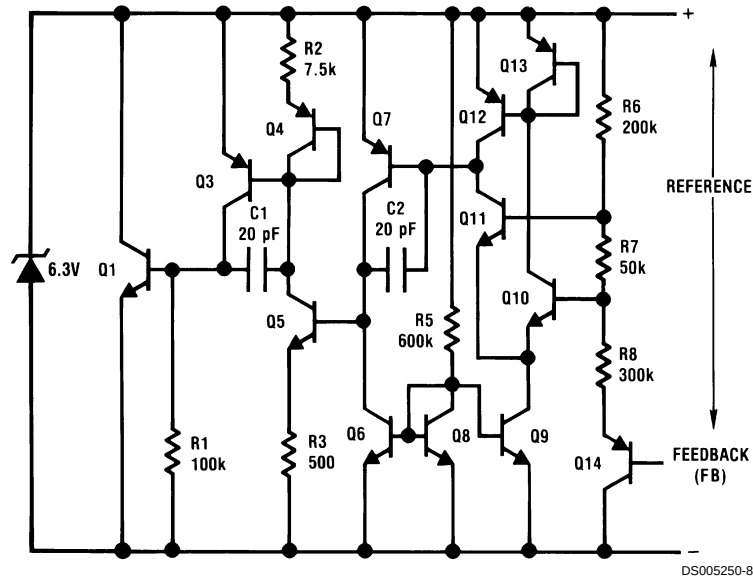
### Freezer Alarm



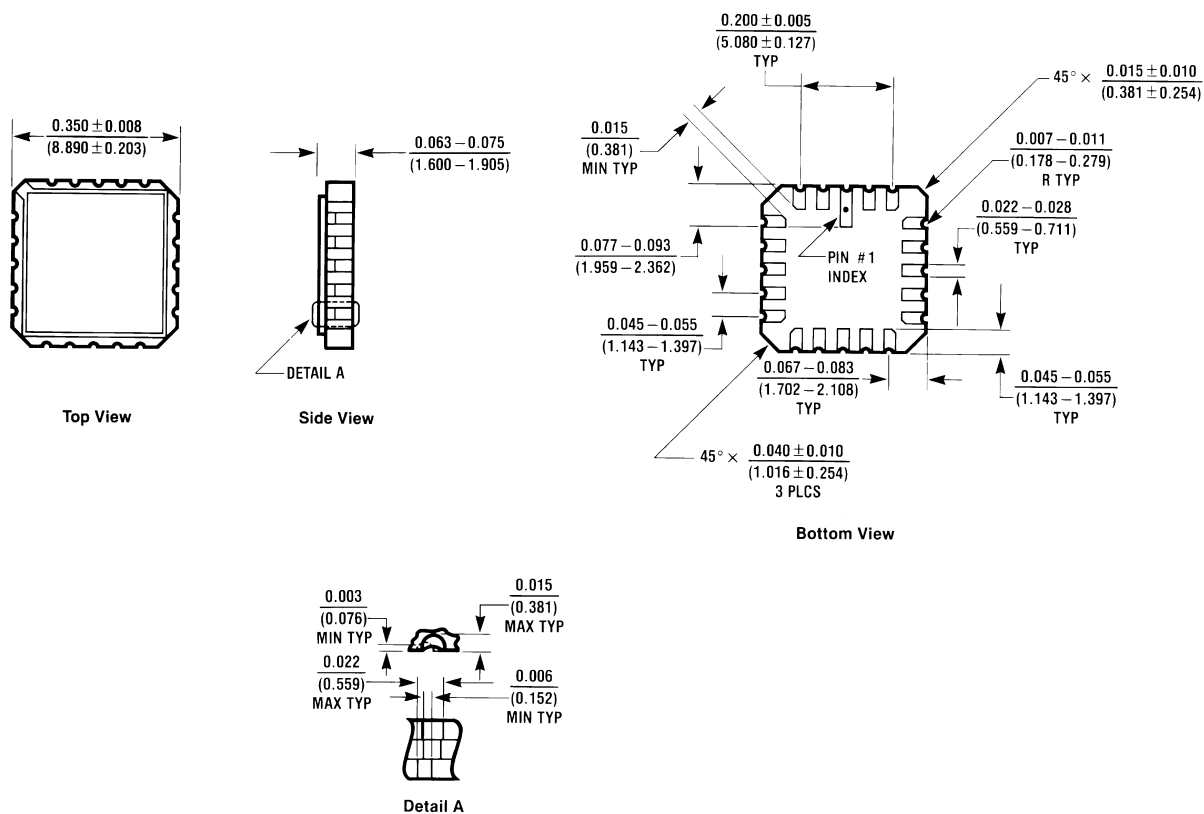
DS005250-12



## Schematic Diagram

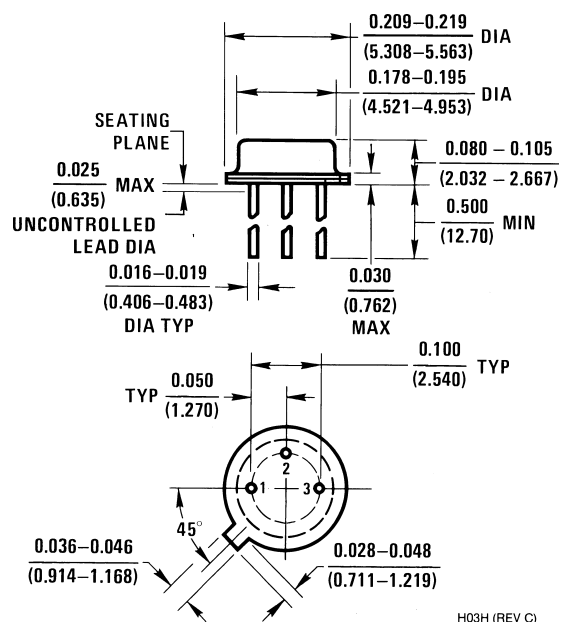


# Physical Dimensions inches (millimeters) unless otherwise noted



E20A (REV D)

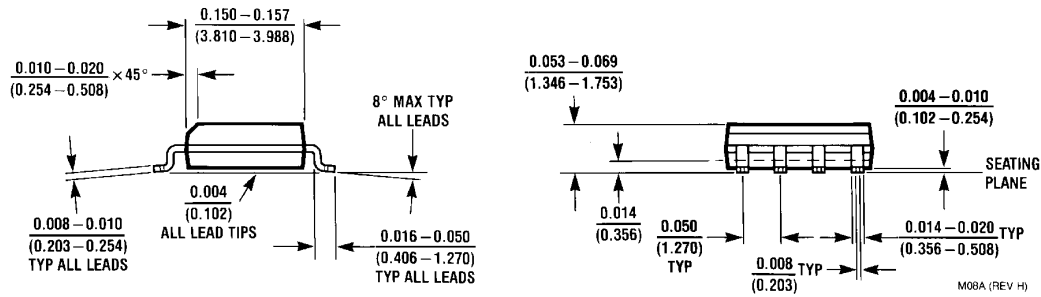
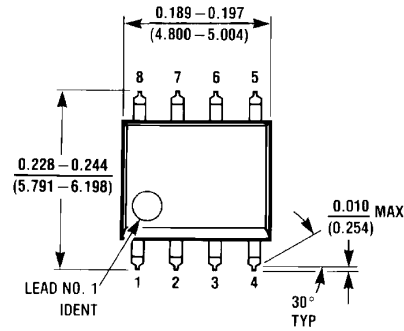
## 20-Leadless Chip Carrier (E) NS Package Number E20A



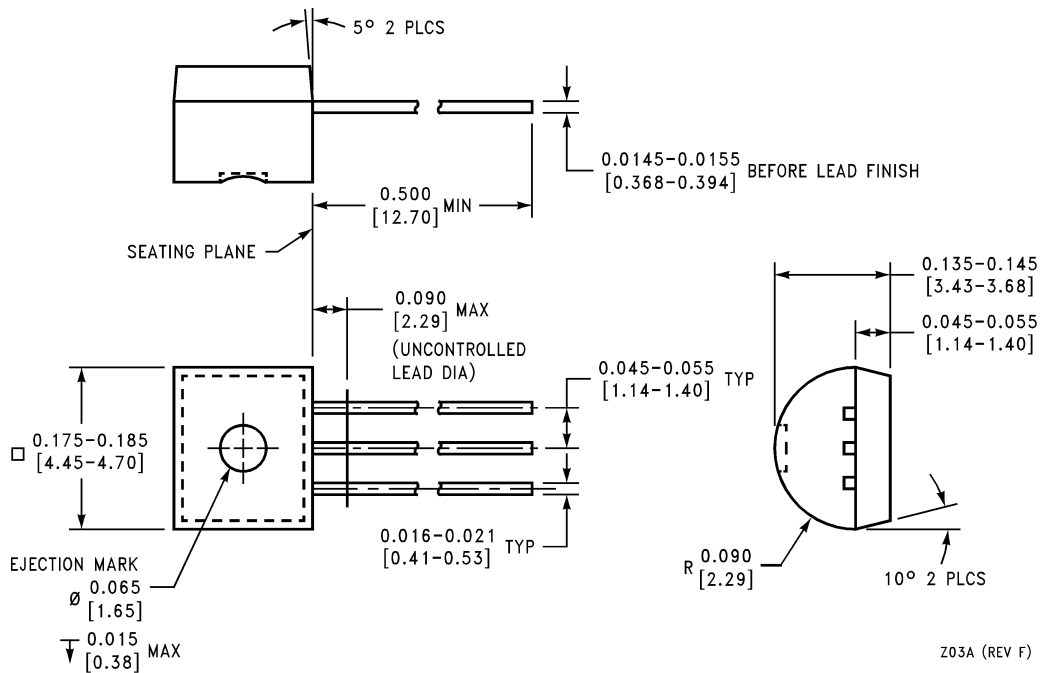
H03H (REV C)

## 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

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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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