

## 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.

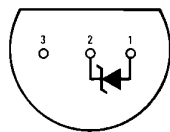
The LM185-1.2 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range while the LM285-1.2 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385-1.2  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185-1.2/LM285-1.2 are available in a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

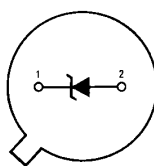


TL/H/5518-10

**Bottom View**

Order Number LM285Z-1.2,  
LM285AZ-1.2, LM285AXZ-1.2,  
LM285AYZ-1.2, 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

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

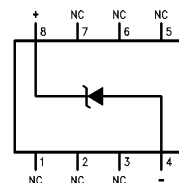


TL/H/5518-6

**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

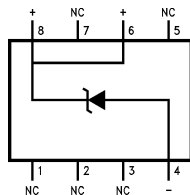
**SO Package**



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**

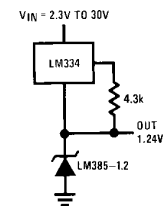


TL/H/5518-11

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

### Typical Application

**Wide Input  
Range Reference**



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<br>LM285AX-1.2<br>LM285AY-1.2 |                                 |                              | LM385A-1.2<br>LM385AX-1.2<br>LM385AY-1.2 |                             |                              | Units<br>(Limit)                     |
|-----------------------------------------------|-----------------------------------------------------------------------------|------------------------------------------|---------------------------------|------------------------------|------------------------------------------|-----------------------------|------------------------------|--------------------------------------|
|                                               |                                                                             | Typ                                      | Tested<br>Limit<br>(Notes 5, 8) | Design<br>Limit<br>(Note 6)  | Typ                                      | Tested<br>Limit<br>(Note 5) | Design<br>Limit<br>(Note 6)  |                                      |
| Reverse Breakdown Voltage                     | $I_R = 100 \mu A$                                                           | 1.235<br><b>1.230</b>                    | 1.231<br>1.239                  | <b>1.220</b><br><b>1.245</b> | 1.235<br><b>1.235</b>                    | 1.231<br>1.239              | <b>1.225</b><br><b>1.245</b> | V(Min)<br>V(Max)<br>V(Min)<br>V(Max) |
| Minimum Operating Current                     |                                                                             | 7                                        | 8                               | <b>10</b>                    | 7                                        | 8                           | <b>10</b>                    | $\mu A$<br>(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<br>(Max)                          |
|                                               | $1 \text{ mA} \leq I_R \leq 20 \text{ mA}$                                  |                                          | 10                              | <b>20</b>                    |                                          | 10                          | <b>20</b>                    | mV<br>(Max)                          |
| Reverse Dynamic Impedance                     | $I_R = 100 \mu A, f = 20 \text{ Hz}$                                        | 0.2                                      |                                 | 0.6<br><b>1.5</b>            | 0.2                                      |                             | 0.6<br><b>1.5</b>            | $\Omega$<br>(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)      | $I_{MIN} \leq I_R \leq 20 \text{ mA}$<br>X Suffix<br>Y Suffix<br>All Others |                                          | <b>30</b><br><b>50</b>          | <b>150</b>                   |                                          | <b>30</b><br><b>50</b>      | <b>150</b>                   | ppm/ $^\circ C$<br>(Max)             |

## Electrical Characteristics (Continued) (Note 4)

| Parameter                                     | Conditions                                                                                           | Typ   | LM185-1.2<br>LM185BX-1.2<br>LM185BY-1.2<br>LM285-1.2<br>LM285BX-1.2<br>LM285BY-1.2 |                             | LM385B-1.2<br>LM385BX-1.2<br>LM385BY-1.2 |                             | LM385-1.2                   |                             | Units<br>(Limit)                                                                 |
|-----------------------------------------------|------------------------------------------------------------------------------------------------------|-------|------------------------------------------------------------------------------------|-----------------------------|------------------------------------------|-----------------------------|-----------------------------|-----------------------------|----------------------------------------------------------------------------------|
|                                               |                                                                                                      |       | Tested<br>Limit<br>(Notes 5, 8)                                                    | 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) |                                                                                  |
| Reverse Breakdown Voltage                     | $T_A = 25^\circ\text{C}$ ,<br>$10\ \mu\text{A} \leq I_R \leq 20\ \text{mA}$                          | 1.235 | 1.223<br>1.247                                                                     |                             | 1.223<br>1.247                           |                             | 1.205<br>1.260              |                             | V(Min)<br>V(Max)                                                                 |
| Minimum Operating Current                     |                                                                                                      | 8     | 10                                                                                 | <b>20</b>                   | 15                                       | <b>20</b>                   | 15                          | <b>20</b>                   | $\mu\text{A}$<br>(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<br>(Max)                                                                      |
|                                               | $1\ \text{mA} \leq I_R \leq 20\ \text{mA}$                                                           |       | 10                                                                                 | <b>20</b>                   | 20                                       | <b>25</b>                   | 20                          | <b>25</b>                   | mV<br>(Max)                                                                      |
| Reverse Dynamic Impedance                     | $I_R = 100\ \mu\text{A}$ , $f = 20\ \text{Hz}$                                                       | 1     |                                                                                    |                             |                                          |                             |                             |                             | $\Omega$                                                                         |
| Wideband Noise (rms)                          | $I_R = 100\ \mu\text{A}$ ,<br>$10\ \text{Hz} \leq f \leq 10\ \text{kHz}$                             | 60    |                                                                                    |                             |                                          |                             |                             |                             | $\mu\text{V}$                                                                    |
| Long Term Stability                           | $I_R = 100\ \mu\text{A}$ , $T = 1000\ \text{Hr}$ ,<br>$T_A = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ | 20    |                                                                                    |                             |                                          |                             |                             |                             | ppm                                                                              |
| Average Temperature Coefficient (Note 7)      | $I_R = 100\ \mu\text{A}$<br>X Suffix<br>Y Suffix<br>All Others                                       |       | <b>30</b><br><b>50</b>                                                             | <b>150</b>                  | <b>30</b><br><b>50</b>                   | <b>150</b>                  |                             | <b>150</b>                  | ppm/ $^\circ\text{C}$<br>ppm/ $^\circ\text{C}$<br>ppm/ $^\circ\text{C}$<br>(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)<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     |

**Note 4:** Parameters identified with **boldface type** apply at temperature extremes. All other numbers apply at  $T_A = T_J = 25^\circ\text{C}$ .

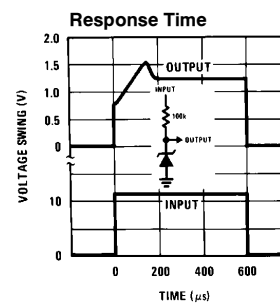
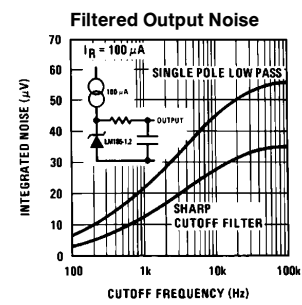
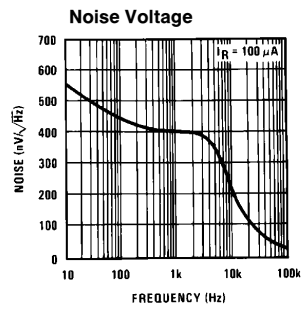
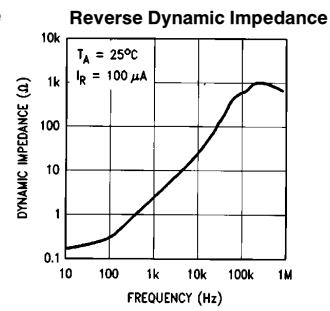
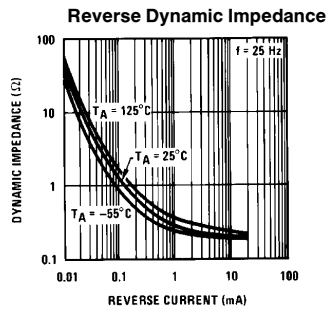
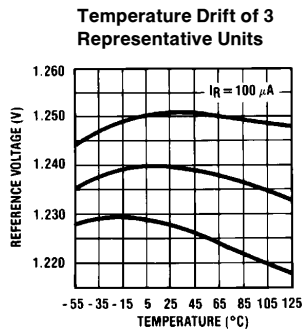
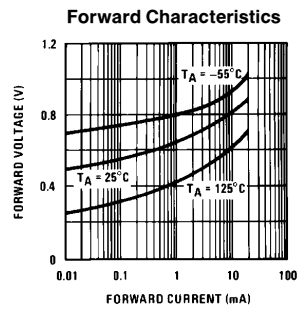
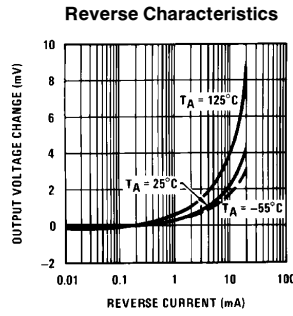
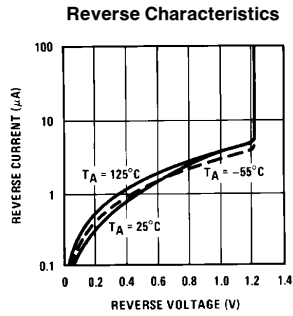
**Note 5:** Guaranteed and 100% production tested.

**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.

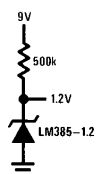
## Typical Performance Characteristics



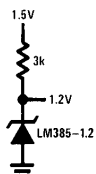
TL/H/5518-3

## Typical Applications (Continued)

**Micropower Reference from 9V Battery**

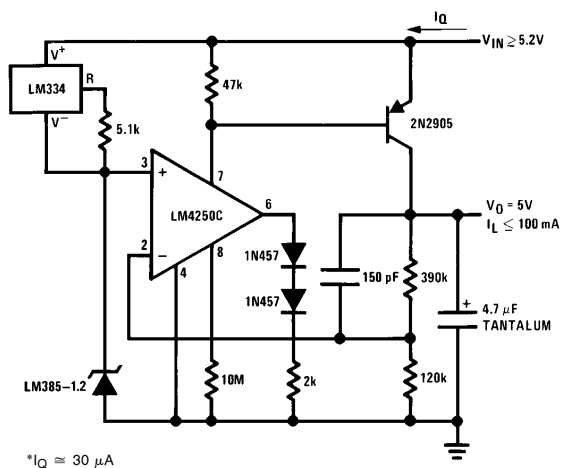


**Reference from 1.5V Battery**

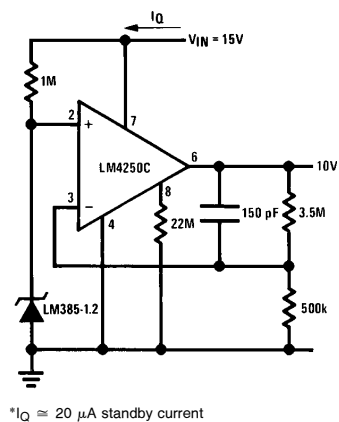


TL/H/5518-2

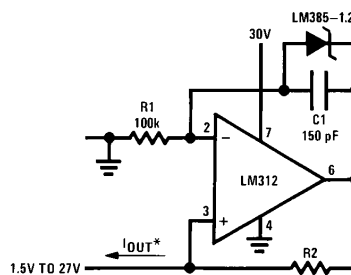
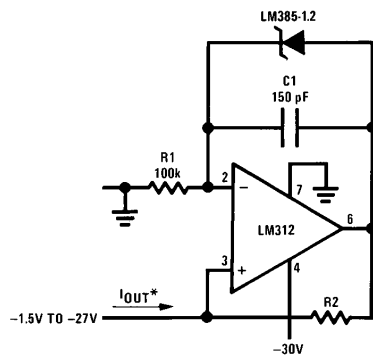
**Micropower\* 5V Regulator**



**Micropower\* 10V Reference**



**Precision 1 μA to 1 mA Current Sources**



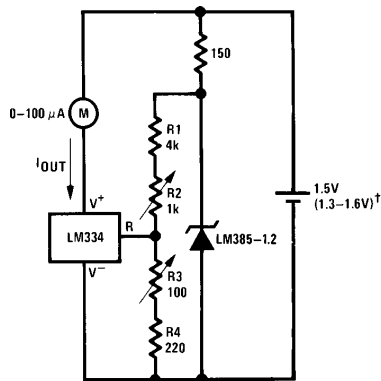
$$I_{OUT} = \frac{1.23V}{R_2}$$

TL/H/5518-4

## Typical Applications (Continued)

### METER THERMOMETERS

#### 0°C – 100°C Thermometer



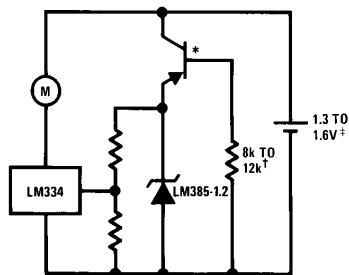
#### Calibration

1. Short LM385-1.2, adjust R3 for  $I_{OUT}$  = 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  $\approx 2.4 mA$

#### Lower Power Thermometer

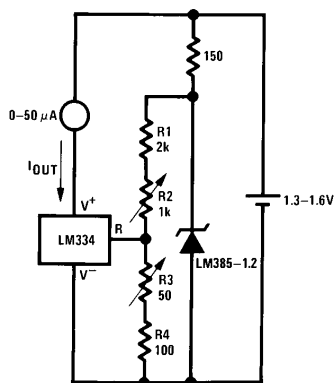


\* 2N3638 or 2N2907 select for inverse  $H_{FE} \approx 5$

† Select for operation at 1.3V

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

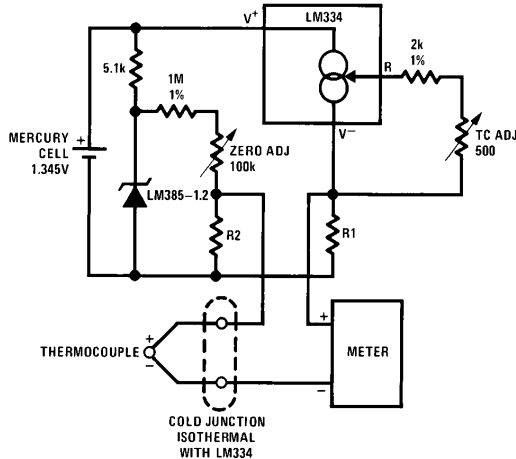
#### 0°F – 50°F Thermometer



#### Calibration

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

#### Micropower Thermocouple Cold Junction Compensator



TL/H/5518-5

#### Adjustment Procedure

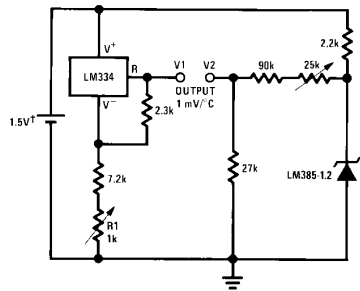
1. Adjust TC ADJ pot until voltage across R1 equals Kelvin temperature multiplied by the thermocouple Seebeck coefficient.
2. Adjust zero ADJ pot until voltage across R2 equals the thermocouple Seebeck coefficient multiplied by 273.2.

| 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

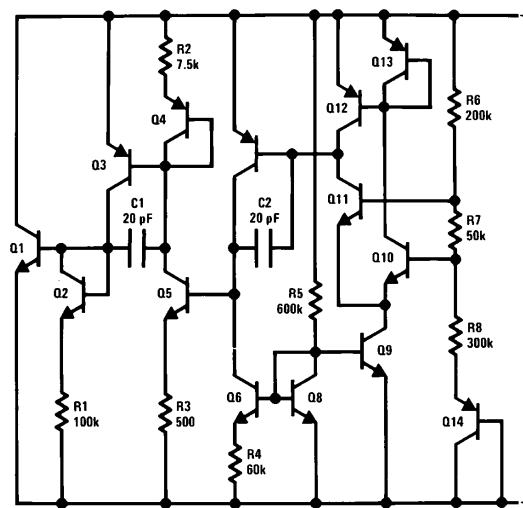


#### Calibration

1. Adjust R1 so that  $V_1 = \text{temp at } 1 \text{ mV}/^\circ\text{C}$
  2. Adjust V2 to 273.2 mV
- $I_Q$  for 1.3V to 1.6V battery voltage =  $50 \mu\text{A}$  to  $150 \mu\text{A}$

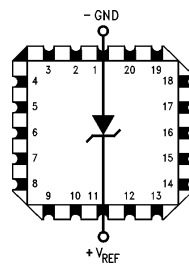
TL/H/5518-1

## Schematic Diagram



TL/H/5518-7

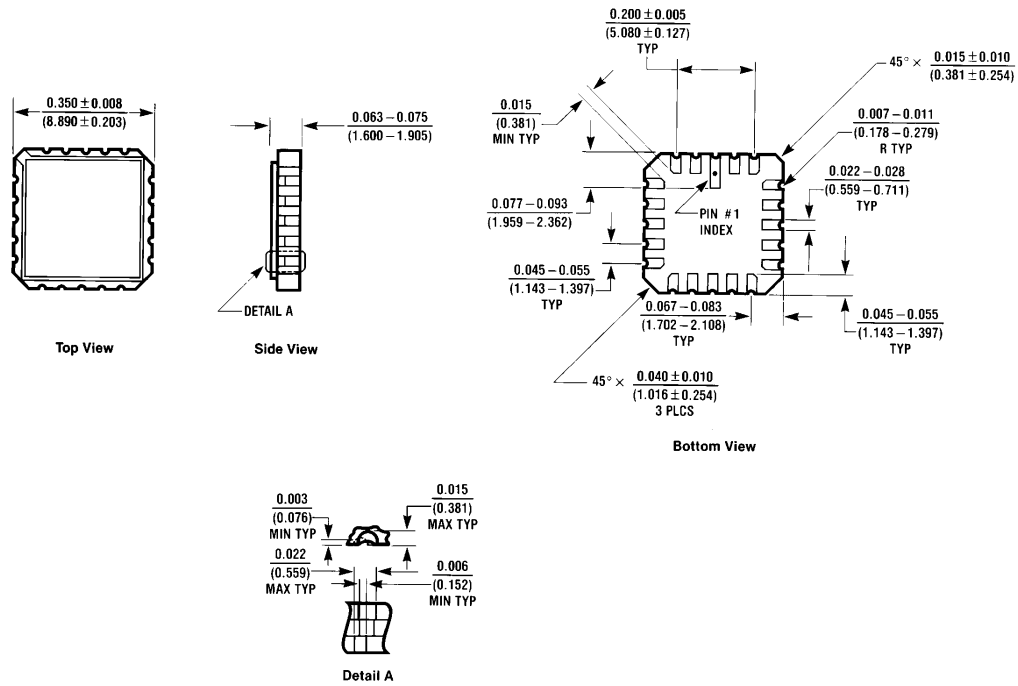
## Connection Diagrams (Continued)



TL/H/5518-12

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

# Physical Dimensions inches (millimeters)

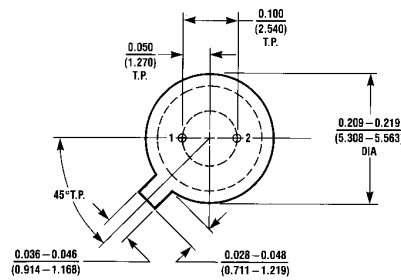
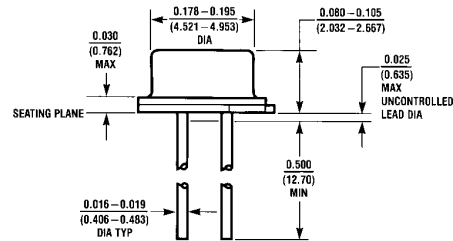


E20A (REV D)

Order Number LM185E-1.2/883  
NS Package Number E20A



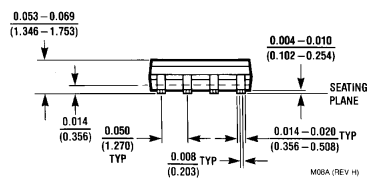
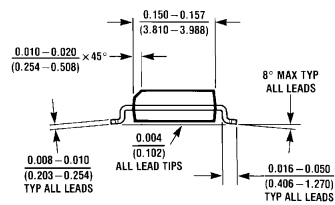
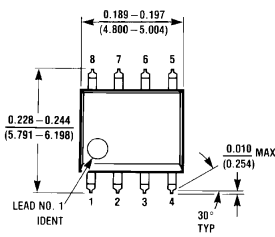
## Physical Dimensions inches (millimeters) (Continued)



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

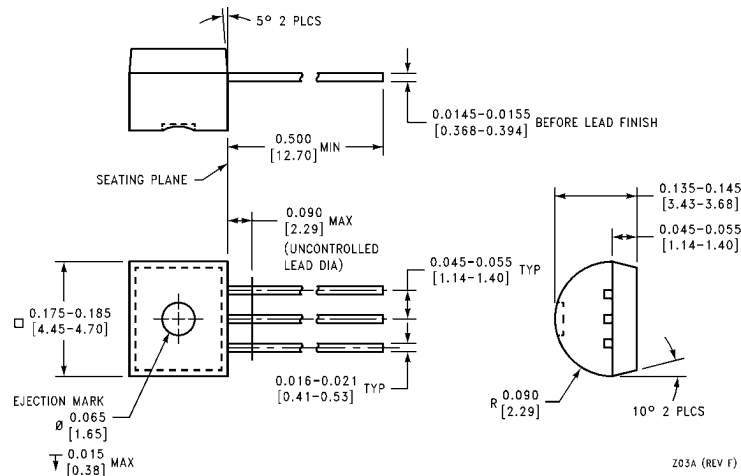


M08A (REV H)

### 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

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