

# 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 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 LM185-1.2 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.

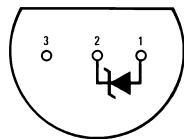
The LM185-1.2 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range while the LM285-1.2 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385-1.2  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185-1.2/LM285-1.2 are available in a 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 SO and SOT-23. The LM185-1.2 is also available in a hermetic leadless chip carrier package.

### Features

- $\pm 1\%$  and 2% initial tolerance
- Operating current of 10 $\mu$ A to 20mA
- 1 $\Omega$  dynamic impedance
- 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

T0-92  
Plastic Package (Z)

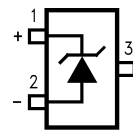


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#### Bottom View

Order Number LM285Z-1.2,  
LM285BXZ-1.2, LM285BYZ-1.2  
LM385Z-1.2, LM385BZ-1.2  
LM385BXZ-1.2 or LM385BYZ-1.2  
See NS Package Number Z03A

SOT23

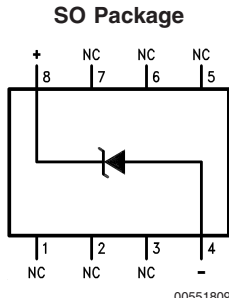


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\* Pin 3 is attached to the Die Attach Pad (DAP) and should be connected to Pin 2 or left floating.

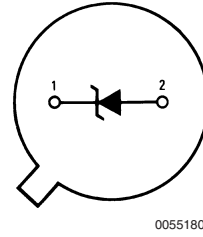
Order Number LM385M3-1.2  
See NS Package Number MF03A

**Connection Diagrams** (Continued)



**Order Number LM285M-1.2,  
LM285BXM-1.2, LM285BYM-1.2  
LM385M-1.2, LM385BM-1.2  
LM385BXM-1.2 or LM385BYM-1.2  
See NS Package Number M08A**

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



**Bottom View**

**Order Number LM185H-1.2, LM185H-1.2/883,  
LM185BXH-1.2, LM185BYH-1.2  
LM285H-1.2 or LM285BXH-1.2  
See NS Package Number H02A**

## 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) |                 |
| LM185-1.2                            | -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 and SOT Pkg.   |                 |
| 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   | 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 Limit<br>(Notes 5, 8)   | Design Limit<br>(Note 6) | Tested Limit<br>(Note 5)                 | Design Limit<br>(Note 6) | Tested Limit<br>(Note 5) | Design 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  |                          | 1.223                                    |                          | 1.205                    |                          | V(Min)           |
|   |  |       | 1.247  |                          | 1.247                                    |                          | 1.260                    |                          | V(Max)           |
| Minimum Operating Current                     |  | 8     | 10   | <b>20</b>                | 15                                       | <b>20</b>                | 15                       | <b>20</b>                | $\mu\text{A}$    |
|   | LM385M3-1.2  |       |  |                          |  |                          | 10                       | <b>15</b>                | (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)      | $I_R = 100\mu\text{A}$   |       |  |                          |  |                          |                          |                          |                  |
|   | X Suffix   |       | <b>30</b>  |                          | <b>30</b>                                |                          |                          |                          | ppm/°C           |
|   | Y Suffix   |       | <b>50</b>  |                          | <b>50</b>                                |                          |                          |                          | ppm/°C           |
|   | All Others   |       |  | <b>150</b>               |  | <b>150</b>               |                          | <b>150</b>               | ppm/°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    | SOT23   |
|-------------------------------------|--|---------|---------|---------|
| $\theta_{JA}$ (junction to ambient) | 180°C/W (0.4" leads)<br>170°C/W (0.125" leads) | 440°C/W | 165°C/W | 283°C/W |
| $\theta_{JC}$ (junction to case)    | N/A  | 80°C/W  | N/A     | 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.

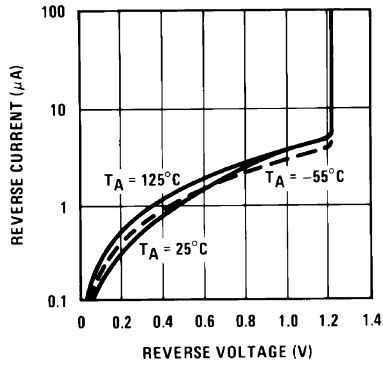
**Note 6:** Guaranteed, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.

**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.

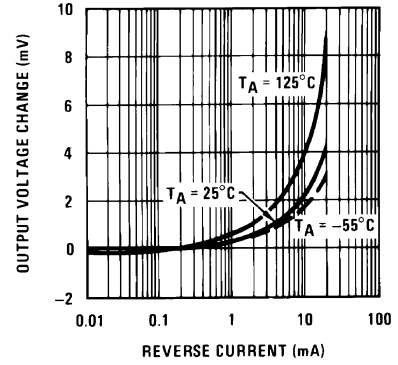
## Typical Performance Characteristics

Reverse Characteristics



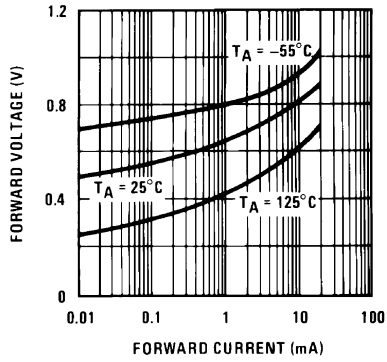
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Reverse Characteristics



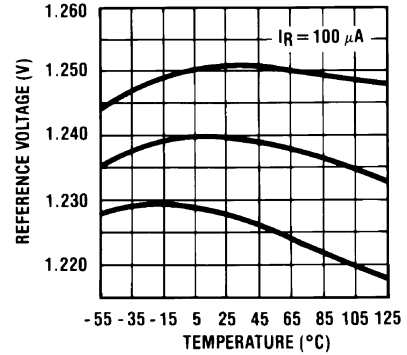
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Forward Characteristics



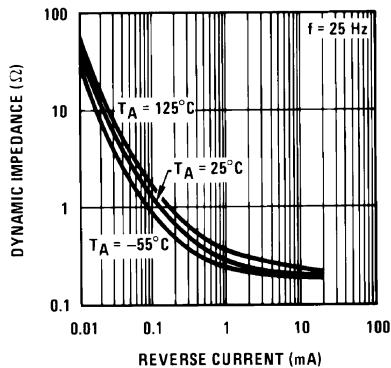
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Temperature Drift of 3 Representative Units



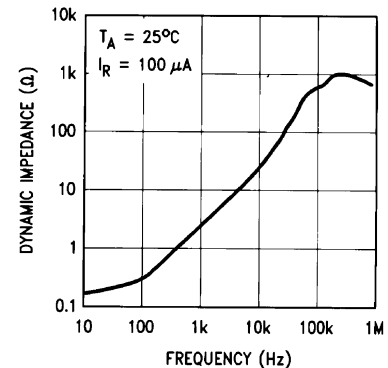
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Reverse Dynamic Impedance



00551817

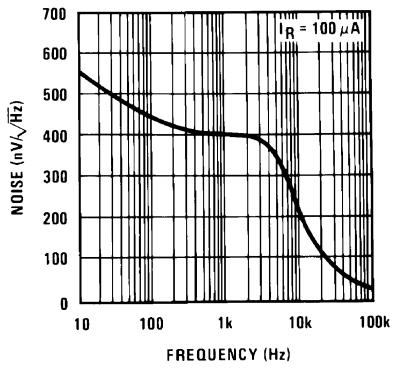
Reverse Dynamic Impedance



00551818

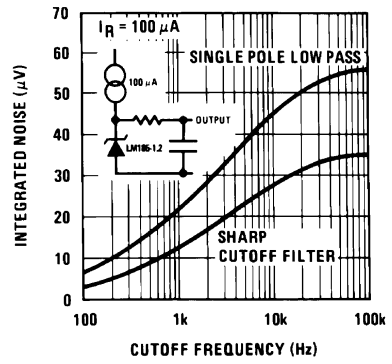
# Typical Performance Characteristics (Continued)

**Noise Voltage**



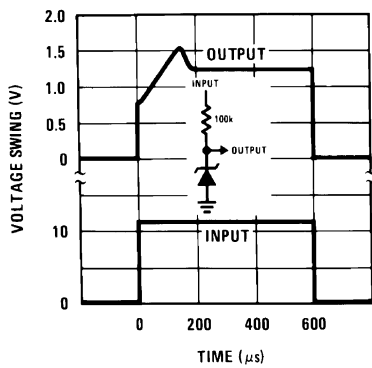
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**Filtered Output Noise**



00551820

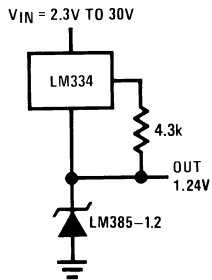
**Response Time**



00551821

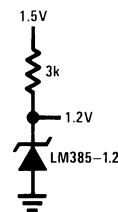
## Typical Applications

**Wide Input Range Reference**



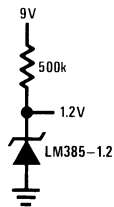
00551808

**Reference from 1.5V Battery**



00551823

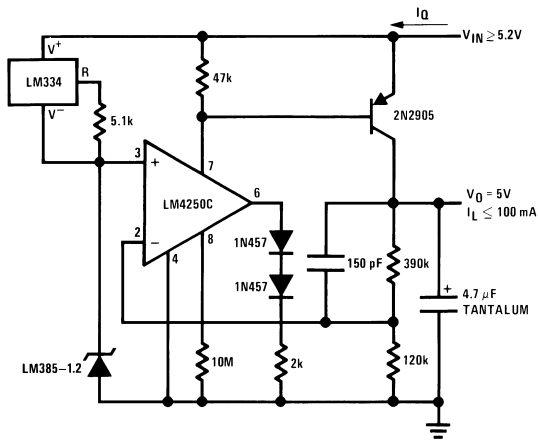
**Micropower Reference from 9V Battery**



00551822

## Typical Applications (Continued)

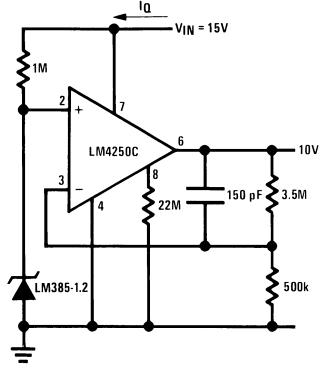
### Micropower\* 5V Regulator



\*I<sub>Q</sub> ≈ 30μA

00551824

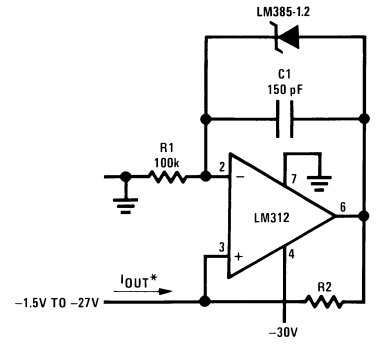
### Micropower\* 10V Reference



\*I<sub>Q</sub> ≈ 20μA standby current

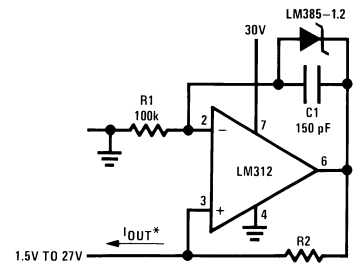
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### Precision 1μA to 1mA Current Sources



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$$I_{OUT} = \frac{1.23V}{R2}$$

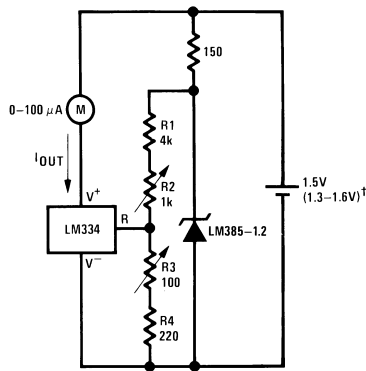


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# Typical Applications (Continued)

## METER THERMOMETERS

### 0°C–100°C Thermometer

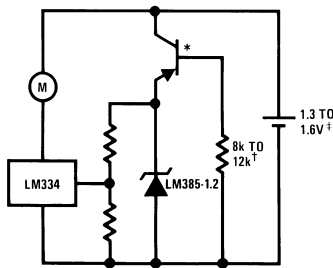


00551828

#### Calibration

1. Short LM385-1.2, adjust R3 for  $I_{OUT} = \text{temp}$  at  $1\mu\text{A}/^\circ\text{K}$
2. Remove short, adjust R2 for correct reading in centigrade  $^\circ\text{C}$  at  $1.3\text{V} \approx 500\mu\text{A}$   
 $I_Q$  at  $1.6\text{V} \approx 2.4\text{mA}$

### Lower Power Thermometer



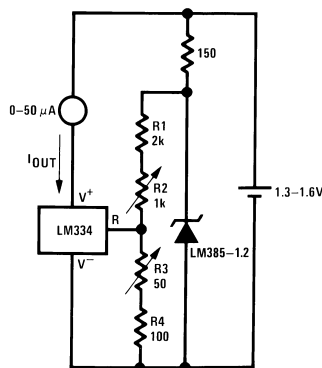
00551829

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

†Select for operation at 1.3V

‡ $I_Q \approx 600\mu\text{A}$  to  $900\mu\text{A}$

### 0°F–50°F Thermometer



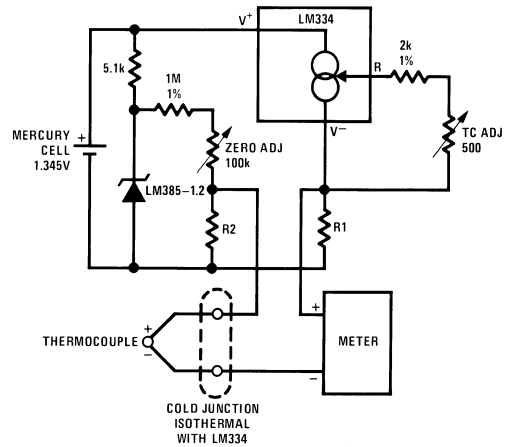
00551830

#### Calibration

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

Typical supply current  $50\mu\text{A}$

### Micropower Thermocouple Cold Junction Compensator



00551831

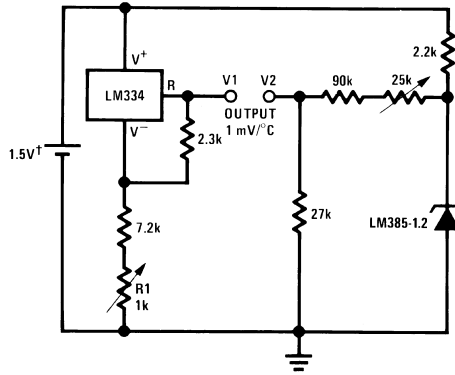
#### Adjustment Procedure

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 ( $\mu\text{V}/^\circ\text{C}$ ) | R1 ( $\Omega$ ) | R2 ( $\Omega$ ) | Voltage Across R1 @ 25°C (mV) | Voltage Across R2 (mV) |
|-------------------|--|-----------------|-----------------|-------------------------------|------------------------|
| J                 | 52.3   | 523             | 24k             | 15.60                         | 14.32                  |
| T                 | 42.8   | 432             | 1k              | 12.77                         | 11.78                  |
| K                 | 40.8   | 412             | 53 $\Omega$     | 12.17                         | 11.17                  |
| S                 | 6.4  | 63.4            | 450 $\Omega$    | 1.908                         | 1.766                  |

## Typical Applications (Continued)

Centigrade Thermometer

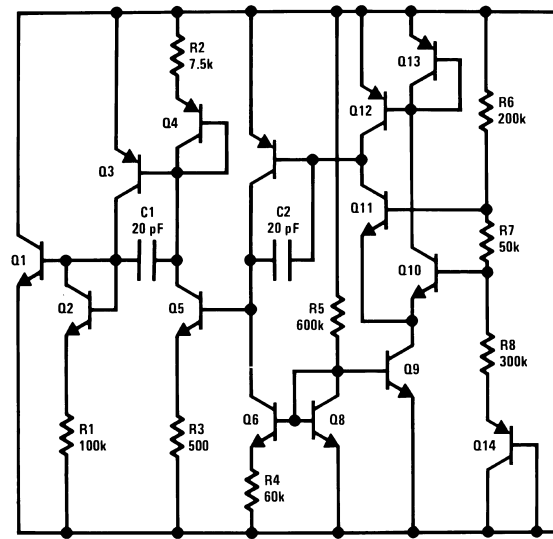


00551801

### Calibration

1. Adjust R1 so that V1 = temp at 1mV/°K
  2. Adjust V2 to 273.2mV
- $I_Q$  for 1.3V to 1.6V battery voltage = 50 $\mu$ A to 150 $\mu$ A

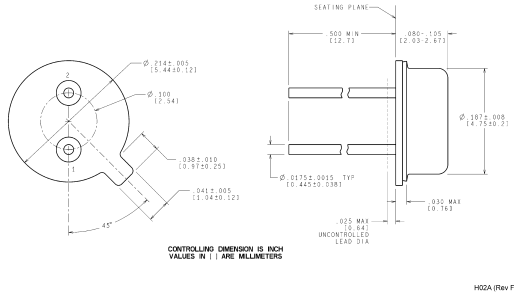
### Schematic Diagram



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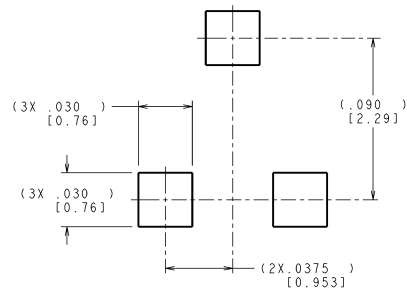
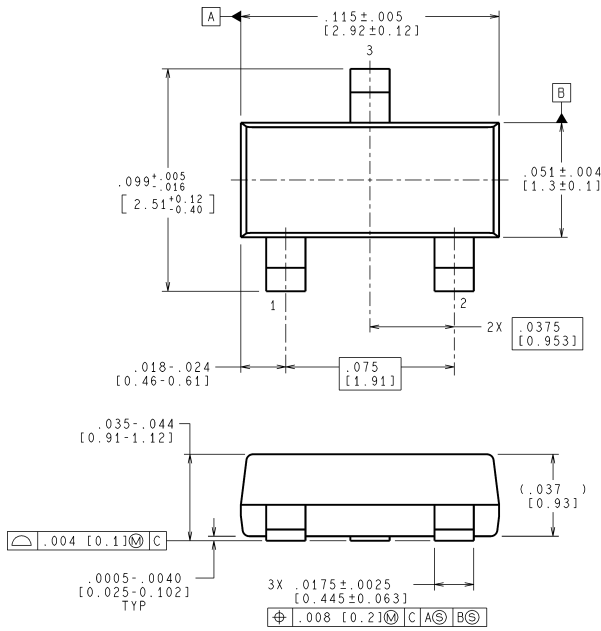


**Physical Dimensions** inches (millimeters) unless otherwise noted

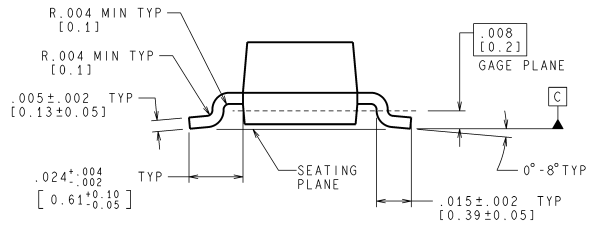


H02A (REV F)

**TO-46 Metal Can Package (H)**  
**Order Number LM185H-1.2, LM185H-1.2/883, LM185BXH-1.2, LM185BYH-1.2, LM285H-1.2, or LM285BXH-1.2**  
**NS Package Number H02A**



RECOMMENDED LAND PATTERN

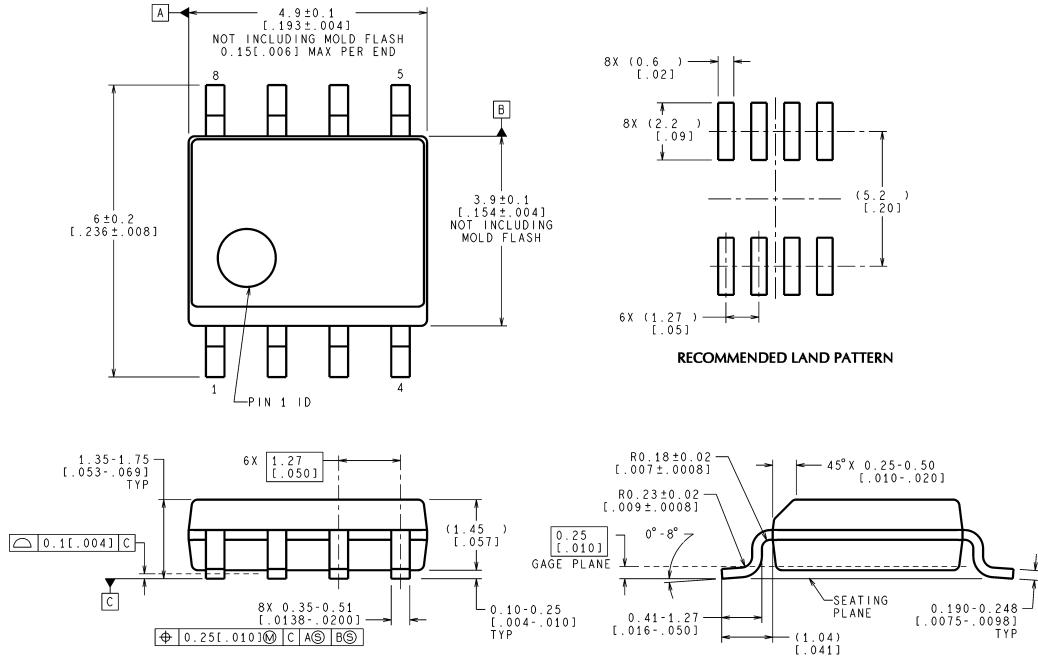


CONTROLLING DIMENSION IS INCH  
 VALUES IN [ ] ARE MILLIMETERS

MF03A (Rev B)

**SOT-23 Package (M3)**  
**Order Number LM385M3-1.2**  
**NS Package Number MF03A**

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)

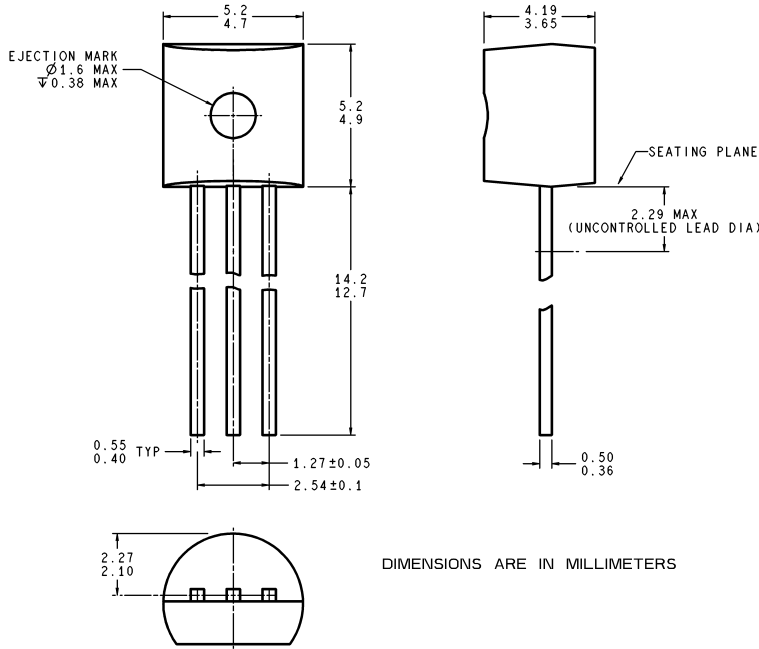


CONTROLLING DIMENSION IS MILLIMETER  
VALUES IN [ ] ARE INCHES  
DIMENSIONS IN ( ) FOR REFERENCE ONLY

M08A (Rev K)

**Small Outline (SO-8) Package**  
**Order Number LM285M-1.2, LM285BXM-1.2, LM285BYM-1.2**  
**LM385M-1.2, LM385BM-1.2, LM385BXM-1.2, LM385BYM-1.2**  
**NS Package Number M08A**

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



Z03A (REV 6)

**TO-92 Plastic Package (Z)**  
**Order Number LM285Z-1.2, LM285BXZ-1.2**  
**LM285BYZ-1.2, LM385Z-1.2, LM385BZ-1.2**  
**LM385BXZ-1.2 or LM385BYZ-1.2**  
**NS Package Number Z03A**

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