

# 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.

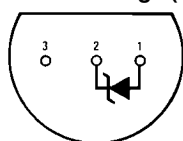
The LM185-1.2 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range while the LM285-1.2 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385-1.2  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185-1.2/LM285-1.2 are available in a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

**TO-92  
Plastic Package (Z)**

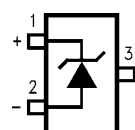


551810

**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**

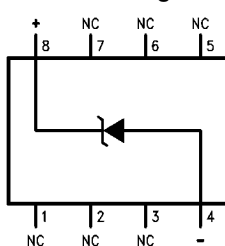


551833

\* 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

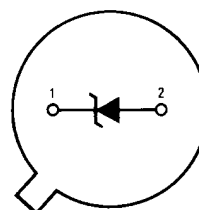
**SO Package**



551809

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)**



551806

**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     |

ESD Susceptibility (Note 9)

2kV

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>$10\mu\text{A} \leq I_R \leq 20\text{mA}$                          | 1.23<br>5 | 1.223                                                                              |                          | 1.223                                    |                          | 1.205                    |                          | V(Min)                              |
|                                               |                                                                                                  |           | 1.247                                                                              |                          | 1.247                                    |                          | 1.260                    |                          | V(Max)                              |
| Minimum Operating Current                     |                                                                                                  | 8         | 10                                                                                 | 20                       | 15                                       | 20                       | 15                       | 20                       | $\mu\text{A}$<br>(Max)              |
|                                               | LM385M3-1.2                                                                                      |           |                                                                                    |                          |                                          |                          | 10                       | 15                       |                                     |
| Reverse Breakdown Voltage Change with Current | $10\mu\text{A} \leq I_R \leq 1\text{mA}$                                                         |           | 1                                                                                  | 1.5                      | 1                                        | 1.5                      | 1                        | 1.5                      | mV<br>(Max)                         |
|                                               | $1\text{mA} \leq I_R \leq 20\text{mA}$                                                           |           | 10                                                                                 | 20                       | 20                                       | 25                       | 20                       | 25                       | 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                                     |           | 30<br>50                                                                           | 150                      | 30<br>50                                 | 150                      |                          | 150                      | ppm/°C<br>ppm/°C<br>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.

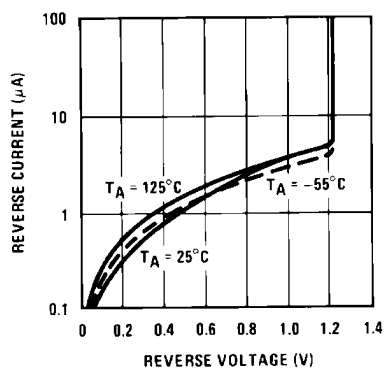
**Note 7:** The average temperature coefficient is defined as the maximum deviation of reference voltage at all measured temperatures between the operating  $T_{MAX}$  and  $T_{MIN}$ , divided by  $T_{MAX} - T_{MIN}$ . The measured temperatures are  $-55^\circ\text{C}$ ,  $-40^\circ\text{C}$ ,  $0^\circ\text{C}$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

**Note 8:** A military RETS electrical specification is available on request.

**Note 9:** The human body model is a 100 pF capacitor discharged through a 1.5 k $\Omega$  resistor into each pin.

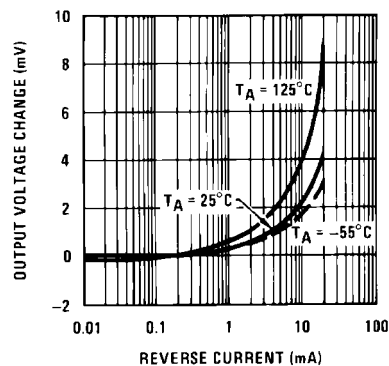
## Typical Performance Characteristics

Reverse Characteristics



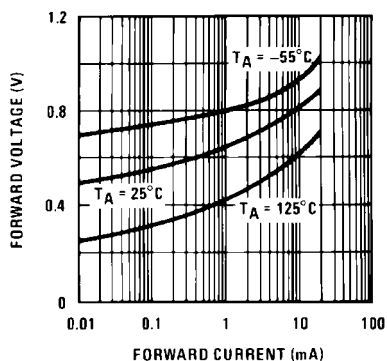
551813

Reverse Characteristics



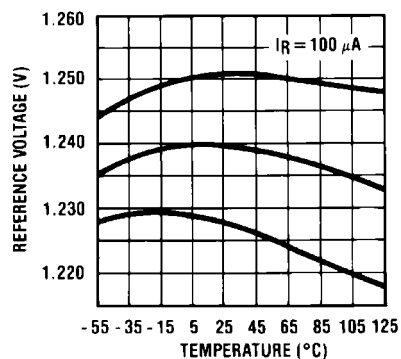
551814

Forward Characteristics



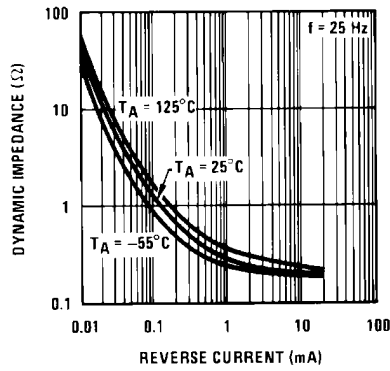
551815

Temperature Drift of 3 Representative Units



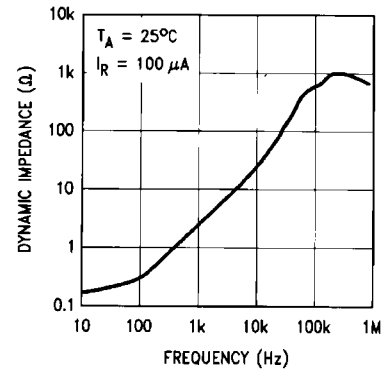
551816

Reverse Dynamic Impedance



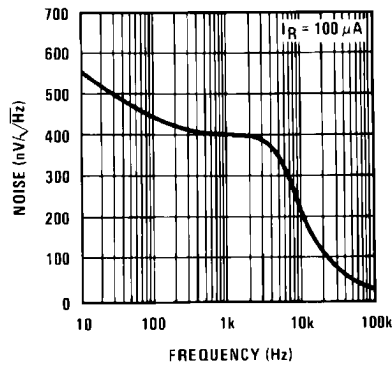
551817

Reverse Dynamic Impedance



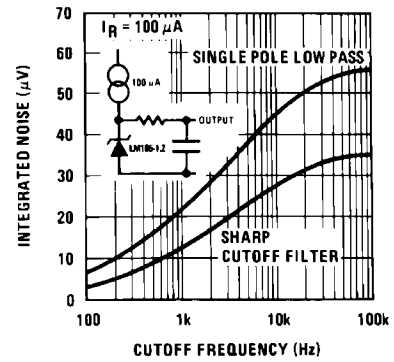
551818

Noise Voltage



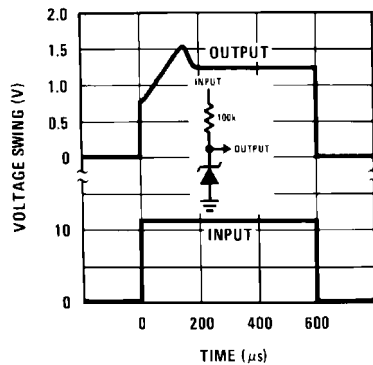
551819

Filtered Output Noise



551820

Response Time

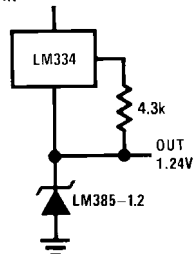


551821

## Typical Applications

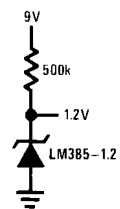
Wide Input  
Range Reference

$V_{IN} = 2.3\text{V TO } 30\text{V}$



551808

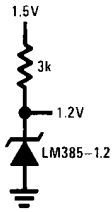
Micropower Reference  
from 9V Battery



551822

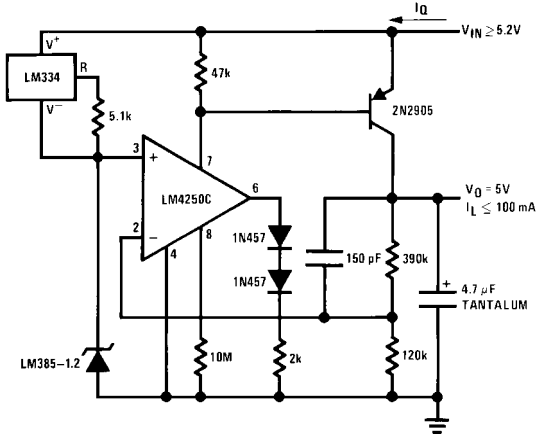
Reference from

### 1.5V Battery



551823

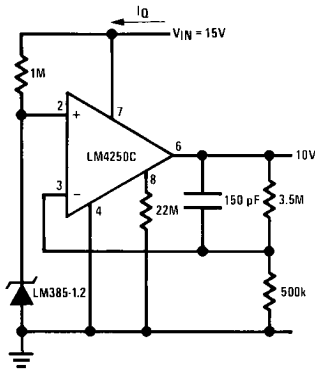
### Micropower\* 5V Regulator



551824

\* $I_Q \approx 30\mu A$

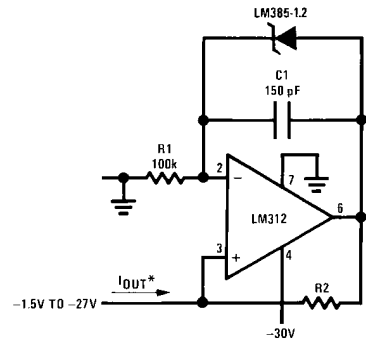
### Micropower\* 10V Reference



551825

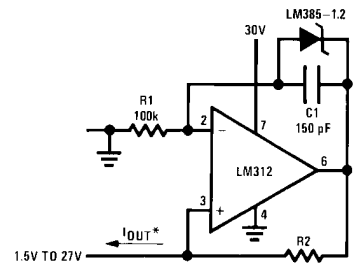
\* $I_Q \approx 20\mu A$  standby current

### Precision 1 $\mu A$ to 1mA Current Sources



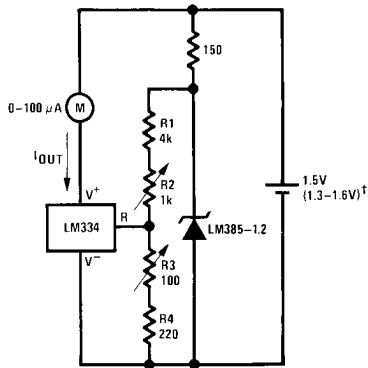
551826

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



551827

METER THERMOMETERS  
0°C–100°C Thermometer

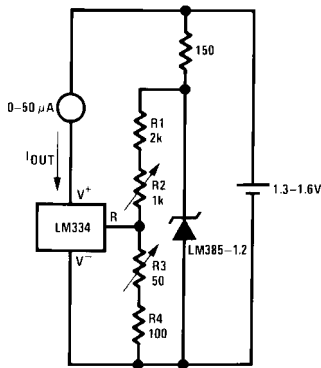


551828

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

0°F–50°F Thermometer

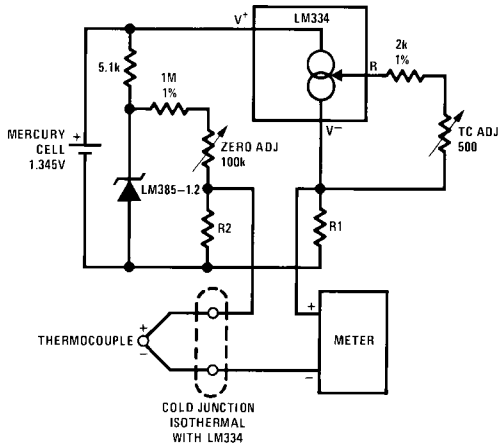


551830

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  $^{\circ}F$

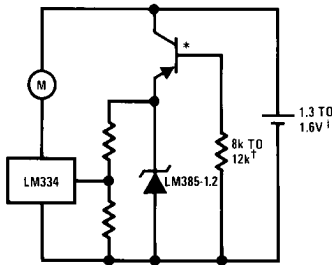
Micropower Thermocouple Cold Junction Compensator



551831

$\dagger I_Q$  at 1.3V/500μA  
 $I_Q$  at 1.6V/2.4mA

Lower Power Thermometer



551829

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

$\dagger$ Select for operation at 1.3V

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

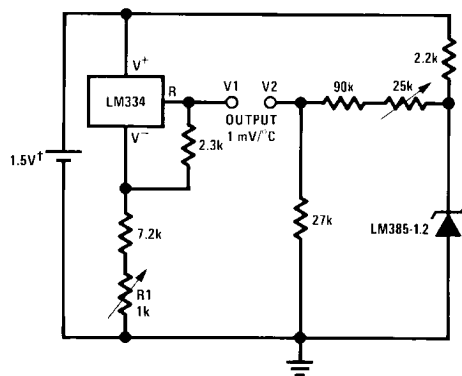
Adjustment Procedure

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                                      | 52              | 1.2 3 4k        | 15.60                         | 14.32                  |
| T                 | 42.8                                      | 43              | 1k 2            | 12.77                         | 11.78                  |
| K                 | 40.8                                      | 41              | 95 2 3Ω         | 12.17                         | 11.17                  |
| S                 | 6.4                                       | 63.             | 15 4 0Ω         | 1.908                         | 1.766                  |

Typical supply current 50μA

### Centigrade Thermometer



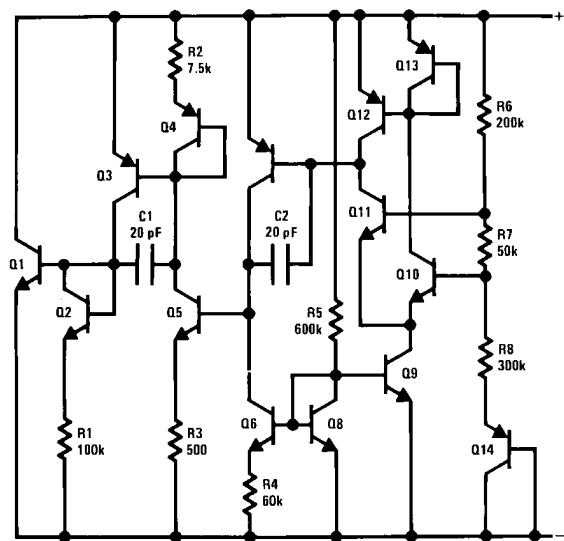
551801

## Calibration

1. Adjust R1 so that  $V_1 = \text{temp}$  at  $1\text{mV}/^\circ\text{K}$
2. Adjust V2 to  $273.2\text{mV}$

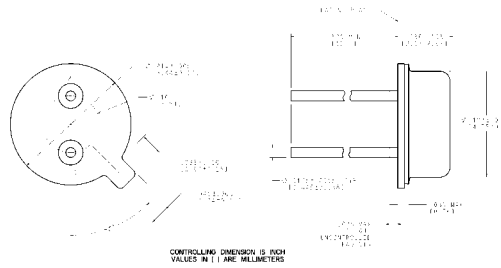
$I_Q$  for 1.3V to 1.6V battery voltage = 50 $\mu$ A to 150 $\mu$ A

### Schematic Diagram



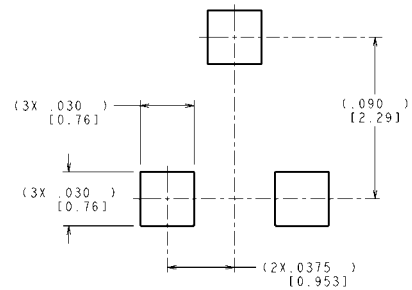
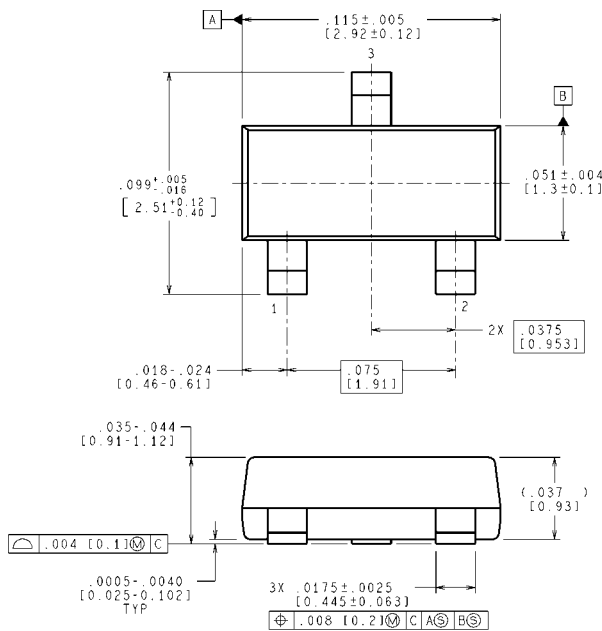
551807

# Physical Dimensions inches (millimeters) unless otherwise noted

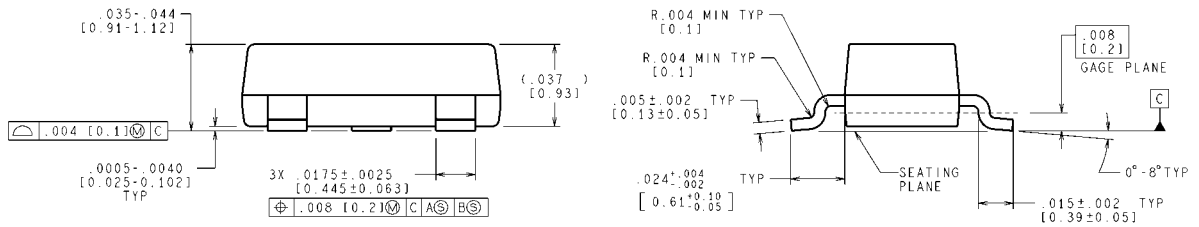


H02A (Rev F)

**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**



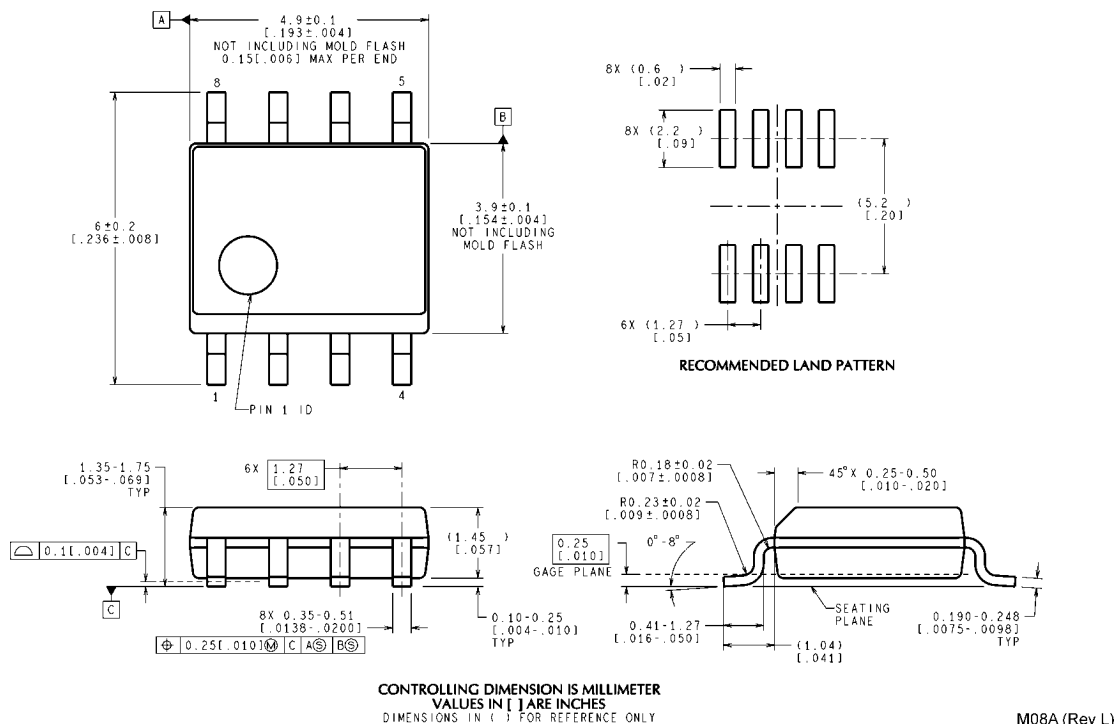
RECOMMENDED LAND PATTERN



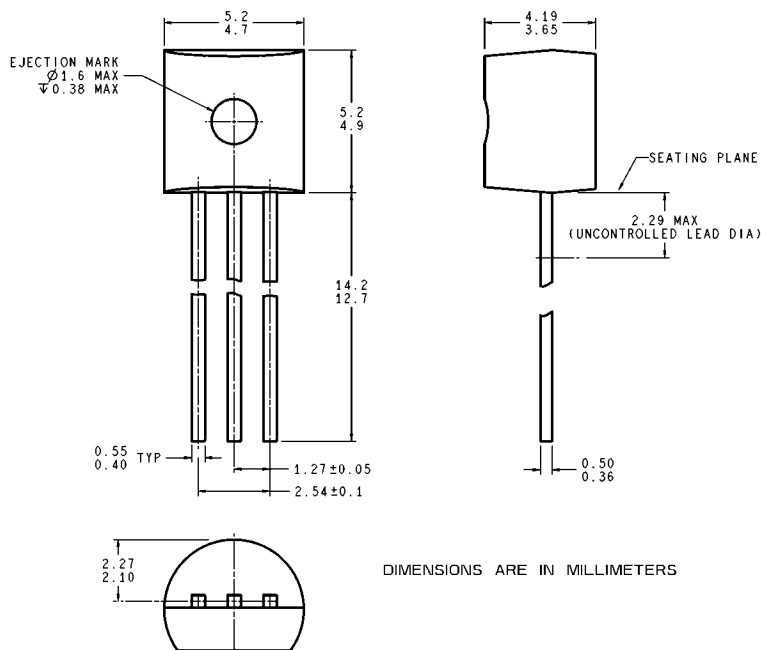
CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS

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

MF03A (Rev B)



**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**



**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**

## Notes

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| Audio                          | <a href="http://www.national.com/audio">www.national.com/audio</a>             | Analog University       | <a href="http://www.national.com/AU">www.national.com/AU</a>                       |
| Clock Conditioners             | <a href="http://www.national.com/timing">www.national.com/timing</a>           | App Notes               | <a href="http://www.national.com/appnotes">www.national.com/appnotes</a>           |
| Data Converters                | <a href="http://www.national.com/adc">www.national.com/adc</a>                 | Distributors            | <a href="http://www.national.com/contacts">www.national.com/contacts</a>           |
| Displays                       | <a href="http://www.national.com/displays">www.national.com/displays</a>       | Green Compliance        | <a href="http://www.national.com/quality/green">www.national.com/quality/green</a> |
| Ethernet                       | <a href="http://www.national.com/ethernet">www.national.com/ethernet</a>       | Packaging               | <a href="http://www.national.com/packaging">www.national.com/packaging</a>         |
| Interface                      | <a href="http://www.national.com/interface">www.national.com/interface</a>     | Quality and Reliability | <a href="http://www.national.com/quality">www.national.com/quality</a>             |
| LVDS                           | <a href="http://www.national.com/lvds">www.national.com/lvds</a>               | Reference Designs       | <a href="http://www.national.com/refdesigns">www.national.com/refdesigns</a>       |
| Power Management               | <a href="http://www.national.com/power">www.national.com/power</a>             | Feedback                | <a href="http://www.national.com/feedback">www.national.com/feedback</a>           |
| Switching Regulators           | <a href="http://www.national.com/switchers">www.national.com/switchers</a>     |                         |                                                                                    |
| LDOs                           | <a href="http://www.national.com/ldo">www.national.com/ldo</a>                 |                         |                                                                                    |
| LED Lighting                   | <a href="http://www.national.com/led">www.national.com/led</a>                 |                         |                                                                                    |
| PowerWise                      | <a href="http://www.national.com/powerwise">www.national.com/powerwise</a>     |                         |                                                                                    |
| Serial Digital Interface (SDI) | <a href="http://www.national.com/sdi">www.national.com/sdi</a>                 |                         |                                                                                    |
| Temperature Sensors            | <a href="http://www.national.com/tempsensors">www.national.com/tempsensors</a> |                         |                                                                                    |
| Wireless (PLL/VCO)             | <a href="http://www.national.com/wireless">www.national.com/wireless</a>       |                         |                                                                                    |

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