**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 10μA 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.

**Features**

- ±1% and 2% initial tolerance
- Operating current of 10μA to 20mA
- 1Ω 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)**
  - Bottom View
  - Order Number LM285Z-1.2, LM285BZ-1.2, LM285BY-1.2
  - LM385Z-1.2, LM385BX-1.2
  - LM385BY-1.2
  - See NS Package Number Z03A

- **SOT23**
  - Order Number LM385M3-1.2
  - See NS Package Number MF03A

- **SO Package**
  - 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, LM185BHX-1.2, LM185BHY-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.
(Not 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.
TO-46 package: 10 sec.
SO and SOT Pkg.
Vapor phase (60 sec.)
Infrared (15 sec.) 215°C
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)

<table>
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<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LM185-1.2</th>
<th>LM185BX-1.2</th>
<th>LM185BY-1.2</th>
<th>LM285-1.2</th>
<th>LM285BX-1.2</th>
<th>LM285BY-1.2</th>
<th>LM385-1.2</th>
<th>LM385BX-1.2</th>
<th>LM385BY-1.2</th>
<th>LM385M3-1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse Breakdown Voltage</td>
<td>$T_A = 25°C,$</td>
<td>1.235</td>
<td>1.223</td>
<td>1.223</td>
<td>1.205</td>
<td>1.205</td>
<td>1.205</td>
<td>1.260</td>
<td>1.260</td>
<td>1.260</td>
<td>V(Max)</td>
</tr>
<tr>
<td></td>
<td>$10\mu A \leq I_R \leq 20mA$</td>
<td>1.247</td>
<td>1.247</td>
<td>1.247</td>
<td>1.260</td>
<td>1.260</td>
<td>1.260</td>
<td></td>
<td></td>
<td></td>
<td>V(Max)</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td>LM385M3-1.2</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td>20</td>
<td>20</td>
<td>10</td>
<td>15</td>
<td>15</td>
<td>μA (Max)</td>
</tr>
<tr>
<td>Reverse Breakdown Voltage Change with Current</td>
<td>$10\mu A \leq I_R \leq 1mA$</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>mV (Max)</td>
</tr>
<tr>
<td></td>
<td>$1mA \leq I_R \leq 20mA$</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>25</td>
<td>20</td>
<td>25</td>
<td>10</td>
<td>15</td>
<td>15</td>
<td>mV (Max)</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>$I_R = 100\mu A,$</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td></td>
<td>$f = 20Hz$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wideband Noise (rms)</td>
<td>$I_R = 100\mu A,$</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>μV</td>
</tr>
<tr>
<td></td>
<td>$10Hz \leq f \leq 10kHz$</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long Term Stability</td>
<td>$I_R = 100\mu A,$</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ppm</td>
</tr>
<tr>
<td></td>
<td>$T = 1000 Hr,$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>$T_A = 25°C \pm 0.1°C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Temperature Coefficient</td>
<td>$I_R = 100\mu A$</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>ppm/°C</td>
</tr>
<tr>
<td>(Note 7)</td>
<td>X Suffix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ppm/°C</td>
</tr>
<tr>
<td></td>
<td>Y Suffix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ppm/°C (Max)</td>
</tr>
<tr>
<td></td>
<td>All Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ppm/°C</td>
</tr>
</tbody>
</table>

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, $T_j \text{ max}$ is:
- LM185 150°C
- LM285 125°C
- LM385 100°C

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<th>Thermal Resistance</th>
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<th>SO-8</th>
<th>SOT23</th>
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<td>$\theta_{JA}$ (junction to ambient)</td>
<td>180°C/W (0.4&quot; leads)</td>
<td>440°C/W</td>
<td>165°C/W</td>
<td>283°C/W</td>
</tr>
<tr>
<td></td>
<td>170°C/W (0.125&quot; leads)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\theta_{JC}$ (junction to case)</td>
<td>N/A</td>
<td>80°C/W</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Note 4:** Parameters identified with boldface type apply at temperature extremes. All other numbers apply at $T_A = T_J = 25°C$.

**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°C, −40°C, 0°C, 25°C, 70°C, 85°C, 125°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 kΩ resistor into each pin.

**Typical Performance Characteristics**
Reverse Dynamic Impedance

![Graph showing reverse dynamic impedance with dynamic impedance (Ω) on the y-axis and reverse current (mA) on the x-axis.]

Noise Voltage

![Graph showing noise voltage with noise (μV/√Hz) on the y-axis and frequency (Hz) on the x-axis.]

Response Time

![Graph showing response time with voltage swing (V) on the y-axis and time (μs) on the x-axis.]

Typical Applications

Wide Input Range Reference

- ![Circuit diagram for wide input range reference with LM334 and LM385-1.2.]

Micropower Reference from 9V Battery

- ![Circuit diagram for micropower reference from 9V battery with LM385-1.2 and 12V.]

Reference from www.national.com
1.5V Battery

Micropower* 5V Regulator

Micropower* 10V Reference

Precision 1μA to 1mA Current Sources

*The standby current is 0.030mA

*The standby current is 0.020mA

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METER THERMOMETERS

0°C−100°C Thermometer

Calibration
1. Short LM385-1.2, adjust R3 for $I_{OUT} =$ temp at 1μA/°K
2. Remove short, adjust R2 for correct reading in centigrade

0°F−50°F Thermometer

Calibration
1. Short LM385-1.2, adjust R3 for $I_{OUT} =$ temp at 1.8μA/°K
2. Remove short, adjust R2 for correct reading in °F

Micropower Thermocouple Cold Junction Compensator

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.

<table>
<thead>
<tr>
<th>Thermocouple Type</th>
<th>Seebeck Coefficient (μV/°C) @ 25°C</th>
<th>Across R1 (mV)</th>
<th>Across R2 (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>52.3</td>
<td>15.60</td>
<td>14.32</td>
</tr>
<tr>
<td>T</td>
<td>42.8</td>
<td>12.77</td>
<td>11.78</td>
</tr>
<tr>
<td>K</td>
<td>40.8</td>
<td>12.17</td>
<td>11.17</td>
</tr>
<tr>
<td>S</td>
<td>6.4</td>
<td>1.908</td>
<td>1.766</td>
</tr>
</tbody>
</table>

Typical supply current 50μA
**Calibration**

1. Adjust R1 so that V1 = temp at 1mV/°K
2. Adjust V2 to 273.2mV

†Iq for 1.3V to 1.6V battery voltage = 50μA to 150μA

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

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

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

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