
General Description

The LM185-2.5/LM285-2.5/LM385-2.5 are micropower 2-terminal band-gap voltage regulator diodes. Operating over a 20 µA 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 LM-185-2.5 band-gap reference uses only transistors and resistors, low noise and good long term stability result.

Careful design of the LM185-2.5 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 LM185-2.5 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. For applications requiring 1.2V see LM185-1.2.

Features

- ±20 mV (±0.8%) max. initial tolerance (A grade)
- Operating current of 20 µA to 20 mA
- 0.6Ω dynamic impedance (A grade)
- Low temperature coefficient
- Low voltage reference — 2.5V
- 1.2V device and adjustable device also available — LM185-1.2 series and LM185 series, respectively

Connection Diagrams

<table>
<thead>
<tr>
<th>TO-92 Plastic Package</th>
<th>SO Package</th>
</tr>
</thead>
</table>

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

Order Number LM385M3-2.5 See NS Package Number MA03B
Connection Diagrams (Continued)

LCC
Leadless Chip Carrier

Order Number LM185E-2.5/883
See NS Package Number E20A

TO-46
Metal Can Package

Bottom View
Order Number LM185H-2.5,
LM185H-2.5/883, LM185BXH-2.5,
LM185BXH-2.5/883, LM185BYH-2.5,
LM185BYH2.5/883, LM285H-2.5,
or LM285BYH-2.5
See NS Package Number H02A
**Absolute Maximum Ratings** (Notes 1, 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Typ</th>
<th>LM385A-2.5</th>
<th>LM385AX-2.5</th>
<th>LM385AY-2.5</th>
<th>Units (Limits)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tested Limit (Note 5)</td>
</tr>
<tr>
<td>Reverse Breakdown Voltage</td>
<td>$I_R = 100 \mu A$</td>
<td>2.500</td>
<td>2.480</td>
<td>2.470</td>
<td>V (Min)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.500</td>
<td>2.520</td>
<td>2.530</td>
<td>V (Max)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum Operating Current</td>
<td>12</td>
<td>18</td>
<td>20</td>
<td>$\mu A$ (Max)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reverse Breakdown Voltage Change with Current</td>
<td>$I_{MIN} \leq I_R \leq 1 mA$</td>
<td>1</td>
<td>1.5</td>
<td>mV (Max)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 mA $\leq I_R \leq 20 mA$</td>
<td>10</td>
<td>20</td>
<td>mV (Max)</td>
<td></td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>$I_R = 100 \mu A$, $f = 20 Hz$</td>
<td>0.2</td>
<td>0.6</td>
<td>0.6</td>
<td>$\Omega$</td>
<td></td>
</tr>
<tr>
<td>Wideband Noise (rms)</td>
<td>$I_R = 100 \mu A$, $10 Hz \leq f \leq 10 kHz$</td>
<td>120</td>
<td>1.5</td>
<td>1.5</td>
<td>$\mu V$</td>
<td></td>
</tr>
<tr>
<td>Long Term Stability</td>
<td>$I_R = 100 \mu A$, $T = 1000 Hr$, $T_A = 25^\circ C \pm 0.1^\circ C$</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>ppm</td>
<td></td>
</tr>
<tr>
<td>Average Temperature Coefficient (Note 7)</td>
<td>$I_{MIN} \leq I_R \leq 20 mA$</td>
<td>X Suffix</td>
<td>30</td>
<td>30</td>
<td>ppm/°C (Max)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Y Suffix</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>ppm/°C (Max)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Electrical Characteristics (Continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Typ</th>
<th>Tested Limit</th>
<th>Design Limit</th>
<th>Tested Limit</th>
<th>Design Limit</th>
<th>Tested Limit</th>
<th>Design Limit</th>
<th>Units (Limit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse Breakdown Voltage</td>
<td>T_A = 25˚C, 20 µA ≤ I_R ≤ 20 mA</td>
<td>2.5</td>
<td>2.462</td>
<td>2.462</td>
<td>2.425</td>
<td>2.575</td>
<td></td>
<td></td>
<td>V(Min)</td>
</tr>
<tr>
<td>Minimum Operating Current</td>
<td></td>
<td>13</td>
<td>20</td>
<td>30</td>
<td>20</td>
<td>30</td>
<td></td>
<td></td>
<td>µA (Max)</td>
</tr>
<tr>
<td>Reverse Breakdown Voltage Change with Current</td>
<td>20 µA ≤ I_R ≤ 1 mA</td>
<td>1</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
<td>mV (Max)</td>
</tr>
<tr>
<td></td>
<td>1 mA ≤ I_R ≤ 20 mA</td>
<td>10</td>
<td>20</td>
<td>25</td>
<td>20</td>
<td>25</td>
<td></td>
<td></td>
<td>mV (Max)</td>
</tr>
<tr>
<td>Reverse Dynamic Impedance</td>
<td>I_R = 100 µA, f = 20 Hz</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>Wideband Noise (rms)</td>
<td>I_R = 100 µA, 10 Hz ≤ f ≤ 10 kHz</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>µV</td>
</tr>
<tr>
<td>Long Term Stability</td>
<td>I_R = 100 µA, T = 1000 Hr, T_A = 25˚C ± 0.1˚C</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ppm</td>
</tr>
<tr>
<td>Average Temperature Coefficient (Note 7)</td>
<td>I_R = 100 µA, X Suffix, Y Suffix, All Others</td>
<td>30</td>
<td>50</td>
<td>150</td>
<td>30</td>
<td>50</td>
<td>150</td>
<td>150</td>
<td>ppm/˚C (Max)</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-2.5 for military specifications.

Note 3: For elevated temperature operation, T_J MAX:
- LM185: 150˚C
- LM285: 125˚C
- LM385: 100˚C

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 available on request.
Typical Performance Characteristics

Applications

LM385-2.5 Applications
LM358-2.5 Applications

Micropower 5V Reference (Note 9)

\[
V^+ \quad 0 \quad 2.2k \quad 47k \quad 2\mu 2k65 \quad 1M857 \quad 18k657 \quad 100n \quad 100n \quad 4.7 \mu F \quad \text{TANTALUM}
\]

\[V_{\text{in}} \geq 5.2V\]

\[\text{Note 9: } I_Q \approx 40 \mu A\]

Micropower 10V Reference (Note 10)

\[
\text{Note 10: } I_Q \approx 30 \mu A \text{ standby current}
\]
LM385-2.5 Applications (Continued)

Precision 1 µA to 1 mA Current Sources

\[ i_{\text{OUT}}^* \sim \frac{2.5V}{R_2} \]

METER THERMOMETERS

0°C–100°C Thermometer

1. Short LM385-2.5, adjust R3 for \( i_{\text{OUT}}^* = \text{temp at } 1\mu A/\text{°K} \)
2. Remove short, adjust R2 for correct reading in centigrade

0°F–50°F Thermometer

1. Short LM385-2.5, adjust R3 for \( i_{\text{OUT}}^* = \text{temp at } 1.8\mu A/\text{°K} \)
2. Remove short, adjust R2 for correct reading in °F
LM385-2.5 Applications (Continued)

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)</th>
<th>R1 (Ω)</th>
<th>R2 (Ω)</th>
<th>Voltage Across R1 @25°C (mV)</th>
<th>Voltage Across R2 (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>52.3</td>
<td>523</td>
<td>1.24k</td>
<td>15.60</td>
<td>14.32</td>
</tr>
<tr>
<td>T</td>
<td>42.8</td>
<td>432</td>
<td>1k</td>
<td>12.77</td>
<td>11.78</td>
</tr>
<tr>
<td>K</td>
<td>40.8</td>
<td>412</td>
<td>953Ω</td>
<td>12.17</td>
<td>11.17</td>
</tr>
<tr>
<td>S</td>
<td>6.4</td>
<td>63.4</td>
<td>150Ω</td>
<td>1.908</td>
<td>1.766</td>
</tr>
</tbody>
</table>

Typical supply current 50 µA

Improving Regulation of Adjustable Regulators

www.national.com 8
Physical Dimensions  inches (millimeters) unless otherwise noted (Continued)

TO-46 Metal Can Package (H)
Order Number LM185H-2.5, LM185H-2.5/883, LM185BXH-2.5, LM185BXH-2.5/883,
NS Package Number H02A
Physical Dimensions  inches (millimeters) unless otherwise noted (Continued)

SOT-23 Package (M3)
Order Number LM385M3-2.5
NS Package Number MA03B
Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

Small Outline (SO-8) Package (M)
NS Package Number M08A
LIFE SUPPORT POLICY

NATIONAL’S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.

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.

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.