**LM185/LM285/LM385 Adjustable Micropower Voltage References**

### General Description

The LM185/LM285/LM385 are micropower 3-terminal adjustable band-gap voltage reference diodes. Operating from 1.24 to 5.3V and over a 10 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 LM185 band-gap reference uses only transistors and resistors, low noise and good long-term stability result.

Careful design of the LM185 has made the device 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 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 is rated for operation over a −55°C to 125°C temperature range, while the LM285 is rated −40°C to 85°C and the LM385 0°C to 70°C. The LM185 is available in a hermetic TO-46 package and a leadless chip carrier package, while the LM285/LM385 are available in a low-cost TO-92 molded package, as well as S.O.

### Features

- Adjustable from 1.24V to 5.30V
- Operating current of 10 μA to 20 mA
- 1% and 2% initial tolerance
- 1 Ω dynamic impedance
- Low temperature coefficient

### Connection Diagrams

- **TO-92 Plastic Package**
  - Bottom View
  - See NS Package Number Z03A

- **TO-46 Metal Can Package**
  - Bottom View
  - Order Number LM185BH, LM185BH/883, LM185BYH or LM185BYH/883
  - See NS Package Number H03H

- **SO Package**
  - Order Number LM285M, LM285BYM, LM385BM or LM385M
  - See NS Package Number M08A

### Block Diagram

- **1.2V Reference**
- **5.0V Reference**

### Typical Applications

- **1.2V Reference**
  - 1.24V
  - VOUT = 1.24 × (R3 / R2 + 1)
  - LM385

- **5.0V Reference**
  - 5V
  - VOUT = 5V
  - LM385

© 1995 National Semiconductor Corporation  TL/H/5250

This document is part of the National Semiconductor library of data sheets. The information contained herein is subject to change without notice. National Semiconductor assumes no responsibility for its use.
### 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 Series**: -55°C to 125°C
- **LM285 Series**: -40°C to 85°C
- **LM385 Series**: 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)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LM185, LM285</th>
<th>LM385</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LM185BX, LM185BY</strong>, <strong>LM285BY</strong></td>
<td><strong>Typ</strong></td>
<td><strong>Tested Limit (Note 5)</strong></td>
<td><strong>Design Limit (Note 6)</strong></td>
</tr>
<tr>
<td><strong>Reference Voltage</strong></td>
<td>$I_{REF}$</td>
<td>100 μA</td>
<td>1.252</td>
</tr>
<tr>
<td></td>
<td>$I_{MIN}$</td>
<td>0.2 mA</td>
<td>1.252</td>
</tr>
<tr>
<td><strong>Dynamic Output Impedance</strong></td>
<td>$I_{OUT}$</td>
<td>100 μA</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>$I_{AC}$</td>
<td>100 μA</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Reference Voltage Change with Output Voltage</strong></td>
<td>$I_{OUT}$</td>
<td>100 μA</td>
<td>6</td>
</tr>
<tr>
<td><strong>Minimum Operating Current (see curve)</strong></td>
<td>$V_{OUT} = V_{REF}$</td>
<td>5.3V</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>$I_{MIN}$</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td><strong>Output Wideband Noise</strong></td>
<td>$I_{OUT}$</td>
<td>100 μA</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>$I_{NOISE}$</td>
<td>10 Hz</td>
<td>170</td>
</tr>
<tr>
<td><strong>Average Temperature Coefficient (Note 7)</strong></td>
<td>$R_{A}$</td>
<td>30°C X Suffix</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y Suffix</td>
<td>All Others</td>
</tr>
<tr>
<td><strong>Long Term Stability</strong></td>
<td>$I_{MIN}$</td>
<td>100 μA</td>
<td>20</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 for military specifications.

Note 3: For elevated temperature operation, $T_j$ max is:
- **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 $T_A = T_j = 25°C$. Unless otherwise specified, all parameters apply for $V_{REF} < V_{OUT} < 5.3V$.

Note 5: Guaranteed and 100% production tested.

Note 6: Guaranteed, but not 100% production tested. These limits are not to be 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 from $V_{REF}$ to $T_{max}$ divided by $T_{max} - T_{typ}$. The measured temperatures are $-55$, $-40$, $0$, $25$, $70$, $85$, $125°C$. 

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LM185BY</th>
<th>LM385BY</th>
<th>LM385</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tested Limit (Note 5)</strong></td>
<td><strong>Design Limit (Note 6)</strong></td>
<td><strong>Tested Limit (Note 5)</strong></td>
<td><strong>Design Limit (Note 6)</strong></td>
</tr>
<tr>
<td><strong>Reference Voltage</strong></td>
<td>100 μA</td>
<td>1.252</td>
<td>1.265</td>
</tr>
<tr>
<td></td>
<td>$I_{MIN}$</td>
<td>0.2 mA</td>
<td>1.252</td>
</tr>
<tr>
<td><strong>Dynamic Output Impedance</strong></td>
<td>$I_{OUT}$</td>
<td>100 μA</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>$I_{AC}$</td>
<td>100 μA</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Reference Voltage Change with Output Voltage</strong></td>
<td>$I_{OUT}$</td>
<td>100 μA</td>
<td>6</td>
</tr>
<tr>
<td><strong>Minimum Operating Current (see curve)</strong></td>
<td>$V_{OUT} = V_{REF}$</td>
<td>5.3V</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>$I_{MIN}$</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td><strong>Output Wideband Noise</strong></td>
<td>$I_{OUT}$</td>
<td>100 μA</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>$I_{NOISE}$</td>
<td>10 Hz</td>
<td>170</td>
</tr>
<tr>
<td><strong>Average Temperature Coefficient (Note 7)</strong></td>
<td>$R_{A}$</td>
<td>30°C X Suffix</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y Suffix</td>
<td>All Others</td>
</tr>
<tr>
<td><strong>Long Term Stability</strong></td>
<td>$I_{MIN}$</td>
<td>100 μA</td>
<td>20</td>
</tr>
</tbody>
</table>
Typical Performance Characteristics

Temperature Drift of 3 Representative Units

- Output Noise Voltage
- Dynamic Output Impedance
- Response Time

Feedback Current

Minimum Operating Current

Reverse Characteristics

Forward Characteristics

Output Noise Voltage

Dynamic Output Impedance

Response Time

LM185

Temperature Coefficient Typical

LM285

Temperature Coefficient Typical

LM385

Temperature Coefficient Typical
**Typical Applications (Continued)**

**Precision 10V Reference**

- 15V
- R1 5k
- LM326
- VOUT 10V
- R2 30k 1%
- R3 88.1k 1%
- FB

**25V Low Current Shunt Regulator**

- V+ 100μA < I < 5 mA
- LM385
- 2N5115

**200 mA Shunt Regulator**

- V+ 50μA < I < 200 mA
- LM385
- 2N2219

**Series-Shunt 20 mA Regulator**

- 5.1V TO 16V
- R1 30k
- 1N457
- D2
- R2 20k
- 2N2905
- −15V

**High Efficiency Low Power Regulator**

- HEAT SINK
- 2N2905
- Iq = 70 μA
- 0 < IOUT < 50 mA

- R1 27k
- R2 3k
- R3 1k
- R4 1k
- R5 1k
- C1 0.1μF
- FB

- LM385
- 2N3904
- 2N3904
- 2N3904
- 2N3904
- 2N3904
- R6 22k
- C2 500μF
**Typical Applications (Continued)**

**Voltage Level Detector**

**Fast Positive Clamp**

\[ V_{D1} = 2.4V \]

**Bidirectional Clamp**

\[ V_{D1} = 1.8V \text{ to } 2.4V \]

\[ V_{D1} = 2.4V \text{ to } 6V \]

**Bidirectional Adjustable Clamp**

\[ V_{D1} = \pm 1.8V \text{ to } \pm 2.4V \]

\[ V_{D1} = \pm 2.4V \text{ to } \pm 6V \]

[Diagram of circuits for each application]
Typical Applications (Continued)

Simple Floating Current Detector

D1 can be any LED, $V_F \approx 1.5V$ to 2.2V at 3 mA. D1 may act as an indicator. D1 will be on if $I_{\text{THRESHOLD}}$ falls below the threshold current, except with $I_{\text{E}}$.

Precision Floating Current Detector

* D1 can be any LED, $V_F \approx 1.5V$ to 2.2V at 3 mA. D1 may act as an indicator. D1 will be on if $I_{\text{THRESHOLD}}$ falls below the threshold current, except with $I_{\text{E}}$. 

TLH/6260-7
**Typical Applications (Continued)**

- **Centigrade Thermometer, 10 mV/°C**
  
  ![Diagram of Centigrade Thermometer](image)

- **Freezer Alarm**
  
  ![Diagram of Freezer Alarm](image)

**Schematic Diagram**

![Schematic Diagram](image)

**Connection Diagrams (Continued)**

![Connection Diagrams](image)

Order Number LM185BE/883
See NS Package Number E20A
Physical Dimensions inches (millimeters) (Continued)

TO-46 Metal Can Package (H)
Order Number LM185BH, LM185BH/883,
LM185BYH or LM185BYH/883
NS Package Number H03H

SO Package (M)
Order Number LM285M, LM285BYM, LM385BM or LM385M
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 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.