# Micropower Voltage Reference Diode

**Check for Samples: LM185-2.5QML**

## FEATURES

- **Operating Current of 20 µA to 20 mA**
- **0.6Ω Dynamic Impedance (A grade)**
- **Low Temperature Coefficient**
- **Low Voltage Reference—2.5V**

## DESCRIPTION

The LM185-2.5 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 LM185-2.5 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.

### Connection Diagram

**CLGA Package**

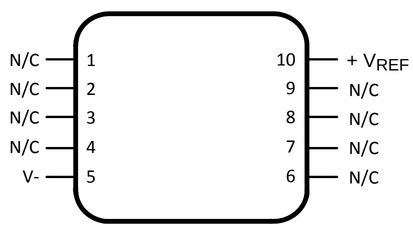



**Figure 1. Top View**
**See Package Number NAC**

**PFM Metal Can Package**

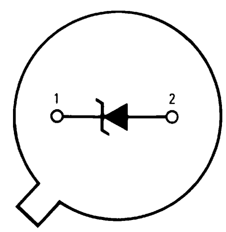
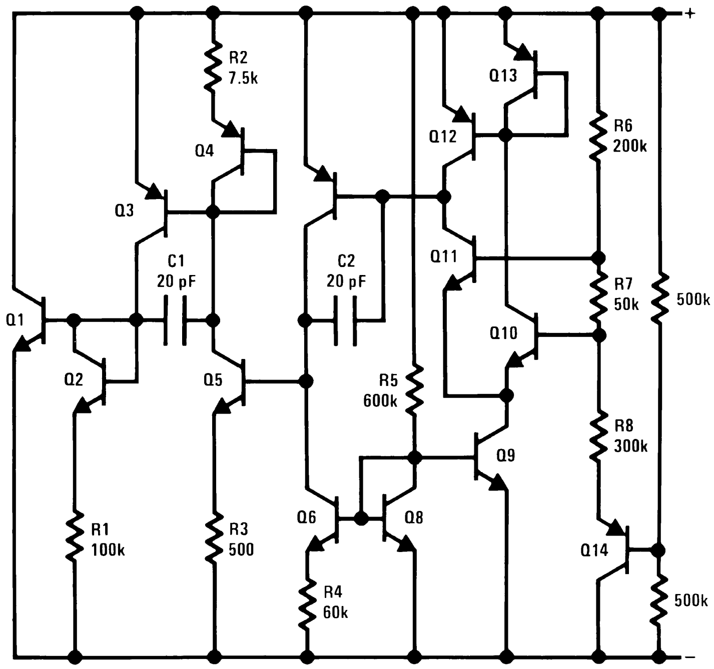



**Figure 2. Bottom View**
**See Package Number NDU**

## Schematic Diagram




These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## Absolute Maximum Ratings(1)

| | | | |
|---|---|---|---|
| Reverse Current | | | 30 mA |
| Forward Current | | | 10 mA |
| Operating Temperature Range | | | $-55°C \le T_A \le +125°C$ |
| Storage Temperature | | | $-55°C \le T_A \le +150°C$ |
| Maximum Junction Temperature ($T_{Jmax}$) (2) | | | 150°C |
| Lead Temperature (Soldering, 10 sec) | | PFM Metal Can | 300°C |
| | | Ceramic CLGA | 260°C |
| Thermal Resistance | $\theta_{JA}$ | PFM Metal Can (Still Air) | 300°C/W |
| | | PFM Metal Can (500LF / Min Air Flow) | 139°C/W |
| | | Ceramic CLGA (Still Air) | 194°C/W |
| | | Ceramic CLGA (500LF / Min Air Flow) | 128°C/W |
| | $\theta_{JC}$ | PFM Metal Can | 57°C/W |
| | | Ceramic CLGA | 23°C/W |
| Package Weight (Typical) | | PFM Metal Can | TBD |
| | | Ceramic CLGA | 210 mg |
| ESD Tolerance (3) | | | 4000V |

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
(2) The maximum power dissipation must be derated at elevated temperatures and is dictated by $T_{Jmax}$ (maximum junction temperature), $\theta_{JA}$ (package junction to ambient thermal resistance), and $T_A$ (ambient temperature). The maximum allowable power dissipation at any temperature is $P_{Dmax} = (T_{Jmax} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower.
(3) Human body model, 1.5 kΩ in series with 100 pF

### Table 1. Quality Conformance Inspection(1)

| Subgroup | Description | Temp °C |
|---|---|---|
| 1 | Static tests at | 25 |
| 2 | Static tests at | 125 |
| 3 | Static tests at | -55 |
| 4 | Dynamic tests at | 25 |
| 5 | Dynamic tests at | 125 |
| 6 | Dynamic tests at | -55 |
| 7 | Functional tests at | 25 |
| 8A | Functional tests at | 125 |
| 8B | Functional tests at | -55 |
| 9 | Switching tests at | 25 |
| 10 | Switching tests at | 125 |
| 11 | Switching tests at | -55 |
| 12 | Settling time at | 25 |
| 13 | Settling time at | 125 |
| 14 | Settling time at | -55 |

(1) Mil-Std-883, Method 5005 - Group A

## LM185–2.5 Electrical Characteristics DC Parameters

| Symbol | Parameter | Conditions | Notes | Min | Max | Units | Sub-groups |
|---|---|---|---|---|---|---|---|
| $V_{Ref}$ | Reverse Breakdown Voltage | $I_R$ = 20µA | | 2.462 | 2.538 | V | 1 |
| | | $I_R$ = 30µA | | 2.425 | 2.575 | V | 2, 3 |
| | | $I_R$ = 1mA | | 2.462 | 2.538 | V | 1 |
| | | | | 2.425 | 2.575 | V | 2, 3 |
| | | $I_R$ = 20mA | | 2.462 | 2.538 | V | 1 |
| | | | | 2.425 | 2.575 | V | 2, 3 |
| $\Delta V_{Ref} / \Delta I_R$ | Reverse Breakdown Voltage Change with Current | 20µA ≤ $I_R$ ≤ 1mA | | -1.0 | 1.0 | mV | 1 |
| | | 30µA ≤ $I_R$ ≤ 1mA | | -1.5 | 1.5 | mV | 2, 3 |
| | | 1mA ≤ $I_R$ ≤ 20mA | | -10.0 | 10.0 | mV | 1 |
| | | | | -20.0 | 20.0 | mV | 2, 3 |
| $V_F$ | Forward Bias Voltage | $I_F$ = 2mA | | -1.0 | -0.4 | V | 1 |

## LM185–2.5 Electrical Characteristics DC Drift Parameters

Delta calculations performed on QMLV devices at group B , subgroup 5, unless otherwise specified on IPI.

| Symbol | Parameter | Conditions | Notes | Min | Max | Units | Sub-groups |
|---|---|---|---|---|---|---|---|
| $V_{Ref}$ | Reverse Breakdown Voltage | $I_R$ = 20µA | | -10 | 10 | mV | 1 |
| | | $I_R$ = 20mA | | -10 | 10 | mV | 1 |

## LM185BY–2.5 Electrical Characteristics DC Parameters

| Symbol | Parameter | Conditions | Notes | Min | Max | Units | Sub-groups |
|---|---|---|---|---|---|---|---|
| $V_{Ref}$ | Reverse Breakdown Voltage | $I_R$ = 20µA | | 2.462 | 2.538 | V | 1 |
| | | $I_R$ = 30µA | | 2.425 | 2.575 | V | 2, 3 |
| | | $I_R$ = 1mA | | 2.462 | 2.538 | V | 1 |
| | | | | 2.425 | 2.575 | V | 2, 3 |
| | | $I_R$ = 20mA | | 2.462 | 2.538 | V | 1 |
| | | | | 2.425 | 2.575 | V | 2, 3 |
| $\Delta V_{Ref} / \Delta I_R$ | Reverse Breakdown Voltage Change with Current | 20µA ≤ $I_R$ ≤ 1mA | | -1.0 | 1.0 | mV | 1 |
| | | 30µA ≤ $I_R$ ≤ 1mA | | -1.5 | 1.5 | mV | 2, 3 |
| | | 1mA ≤ $I_R$ ≤ 20mA | | -10.0 | 10.0 | mV | 1 |
| | | | | -20.0 | 20.0 | mV | 2, 3 |
| $V_F$ | Forward Bias Voltage | $I_F$ = 2mA | | −1.0 | −0.4 | V | 1 |
| $T_C$ | Temperature Coefficient | | (1) | | 50 | PPM/°C | 2, 3 |

(1) The average temperature coefficient is defined as the maximum deviation of reference voltage, at all measured temperatures between the operating $T_{Min}$ & $T_{Max}$, divided by ($T_{Max} - T_{Min}$). The measured temperatures ($T_{Measured}$) are −55°C, 25°C, & 125°C or $\Delta V_{Ref}$ / ($T_{Max} - T_{Min}$)

## LM185BY–2.5 Electrical Characteristics DC Drift Parameters

Delta calculations performed on QMLV devices at group B , subgroup 5, unless otherwise specified on IPI.

| Symbol | Parameter | Conditions | Notes | Min | Max | Units | Sub-groups |
|---|---|---|---|---|---|---|---|
| $V_{Ref}$ 1 | Reverse Breakdown Voltage | $I_R$ = 20µA | | -10 | 10 | mV | 1 |
| $V_{Ref}$ 2 | Reverse Breakdown Voltage | $I_R$ = 20mA | | -10 | 10 | mV | 1 |

## Typical Performance Characteristics

**Reverse Characteristics**

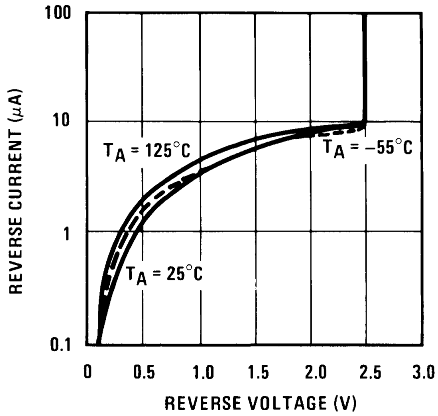



**Figure 3.**

**Reverse Characteristics**

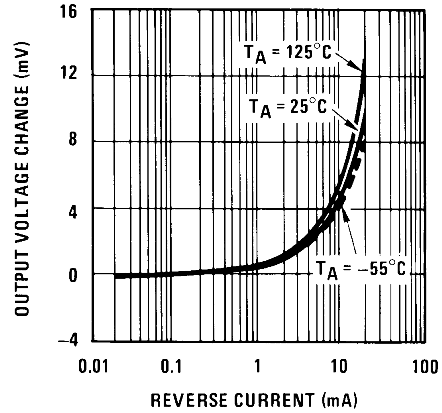



**Figure 4.**

**Forward Characteristics**

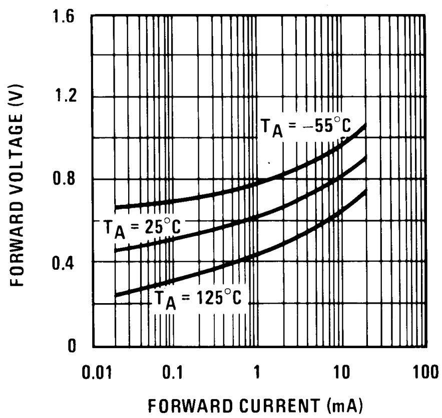



**Figure 5.**

**Temperature Drift**

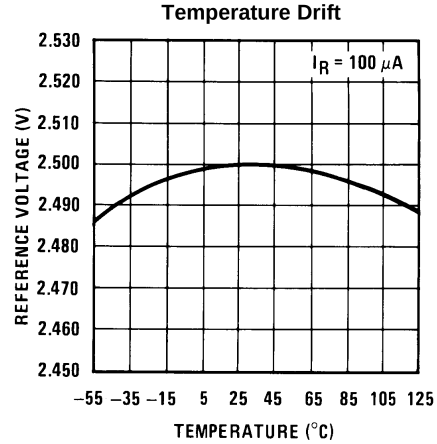



**Figure 6.**

**Reverse Dynamic Impedance**

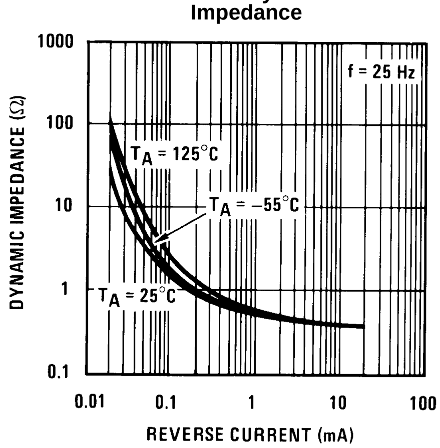



**Figure 7.**

**Reverse Dynamic Impedance**

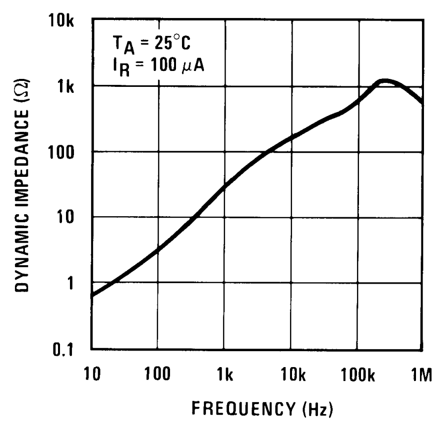



**Figure 8.**

## Typical Performance Characteristics (continued)

**Noise Voltage**

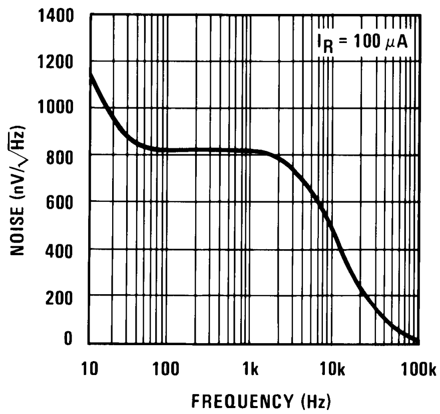



**Figure 9.**

**Filtered Output Noise**

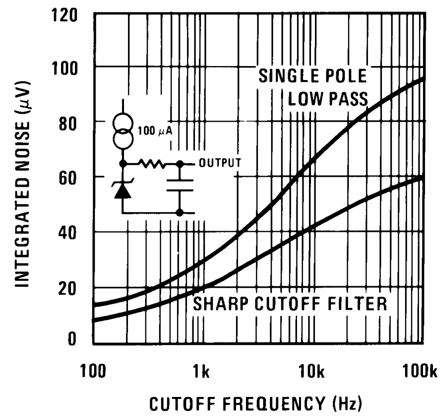



**Figure 10.**

**Response Time**

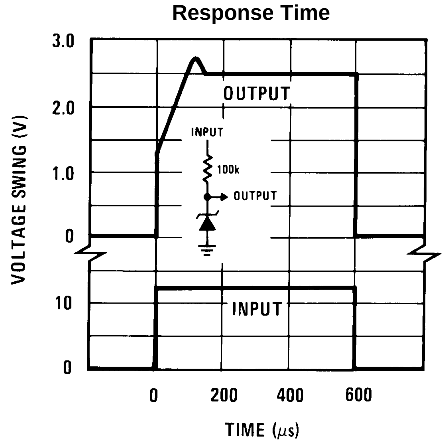



**Figure 11.**

## APPLICATIONS

**Figure 12. Wide Input Range Reference**

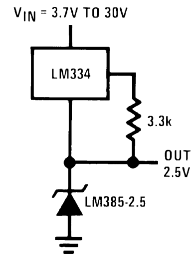



**Figure 13. Micropower Reference from 9V Battery**

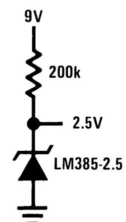
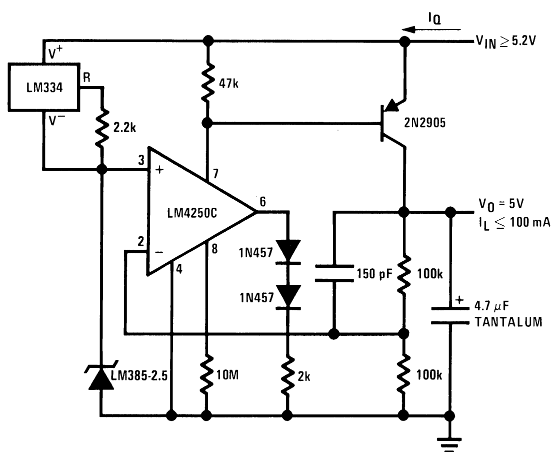
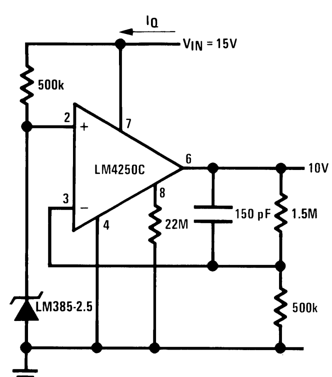



**Figure 14. Micropower 5V Reference**



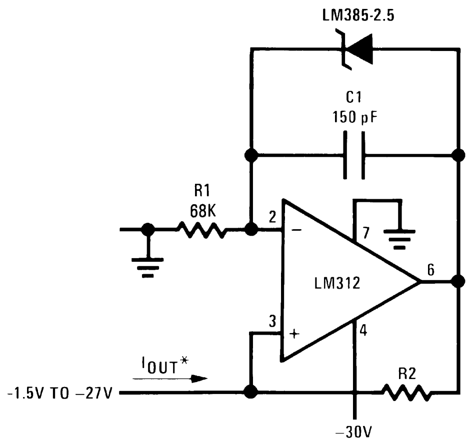

$I_Q \approx 40\ \mu A$

**Figure 15. Micropower 10V Reference**

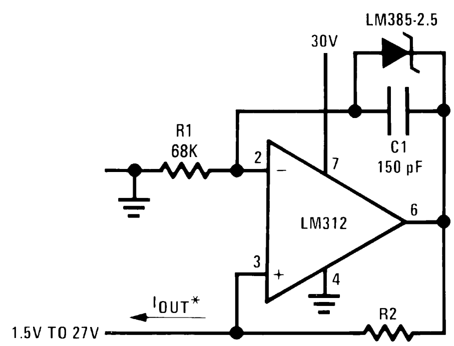



$I_Q \approx 30\ \mu A$ standby current

## Precision 1 μA to 1 mA Current Sources

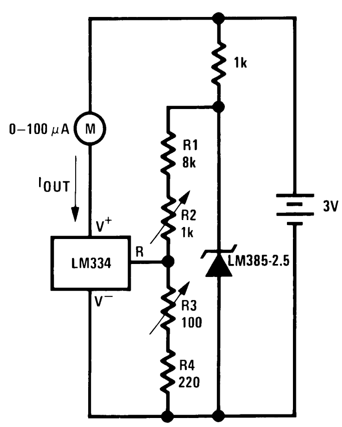



*$I_{OUT} = \frac{2.5V}{R2}$




## METER THERMOMETERS

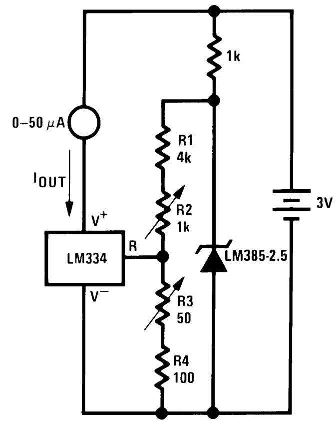
**Figure 16. 0°C–100°C Thermometer**




Calibration

1. Short LM385-2.5, adjust R3 for $I_{OUT}$= temp at 1μA/°K
2. Remove short, adjust R2 for correct reading in centigrade

**Figure 17. 0°F–50°F Thermometer**




Calibration

1. Short LM385-2.5, adjust R3 for $I_{OUT}$=temp at 1.8 μA/°K
2. Remove short, adjust R2 for correct reading in °F

**Figure 18. Improving Regulation of Adjustable Regulators**

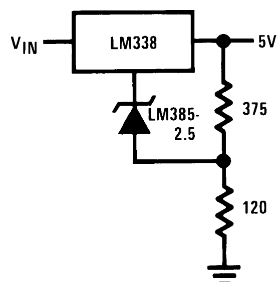
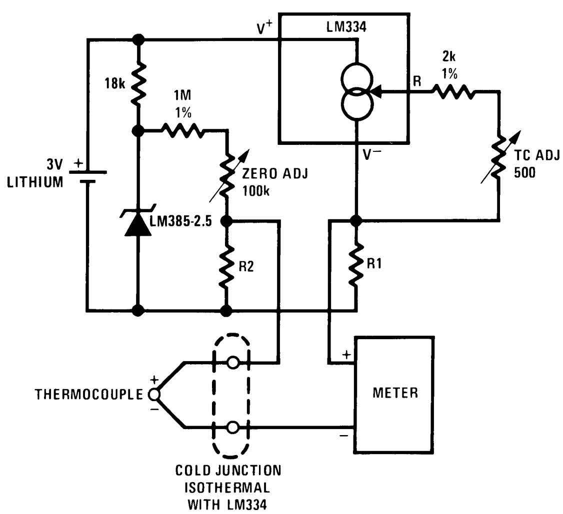



**Figure 19. Micropower Thermocouple Cold Junction Compensator**




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.

| Thermocouple Type | Seebeck Co-efficient (µV/°C) | R1 (Ω) | R2 (Ω) | Voltage Across R1 @25°C (mV) | Voltage Across R2 (mV) |
|---|---|---|---|---|---|
| J | 52.3 | 523 | 1.24k | 15.60 | 14.32 |
| T | 42.8 | 432 | 1k | 12.77 | 11.78 |
| K | 40.8 | 412 | 953Ω | 12.17 | 11.17 |
| S | 6.4 | 63.4 | 150Ω | 1.908 | 1.766 |

## REVISION HISTORY SECTION

| Released | Revision | Section | Originator | Changes |
|---|---|---|---|---|
| 11/08/05 | A | New Release, Corporate format | L. Lytle | 2 MDS data sheets converted into one Corp. data sheet format. MNLM185-2.5-X Rev 2A2 and MNLM185-2.5BY-X Rev 1B1 will be archived. |

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Op Temp (°C) | Top-Side Markings (4) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5962-8759402XA | ACTIVE | TO | NDU | 2 | 20 | TBD | Call TI | Call TI | -55 to 125 | 8759402XA Q | Samples |
| 5962-8759402YA | ACTIVE | CLGA | NAC | 10 | 54 | TBD | Call TI | Call TI | -55 to 125 | LM185WG-2.5/883 Q 5962-87594 02YA ACO 02YA >T | Samples |
| 5962-8759406VXA | ACTIVE | TO | NDU | 2 | 20 | TBD | Call TI | Call TI | -55 to 125 | 8759406VXA Q | Samples |
| LM185BYH2.5-QV | ACTIVE | TO | NDU | 2 | 20 | TBD | Call TI | Call TI | -55 to 125 | 8759406VXA Q | Samples |
| LM185BYH2.5/883 | ACTIVE | TO | NDU | 2 | 20 | TBD | Call TI | Call TI | -55 to 125 | LM185BY2.5 Q | Samples |
| LM185H-2.5-SMD | ACTIVE | TO | NDU | 2 | 20 | TBD | Call TI | Call TI | -55 to 125 | 8759402XA Q | Samples |
| LM185H-2.5/883 | ACTIVE | TO | NDU | 2 | 20 | TBD | Call TI | Call TI | -55 to 125 | LM185-2.5 Q | Samples |
| LM185WG-2.5/883 | ACTIVE | CLGA | NAC | 10 | 54 | TBD | Call TI | Call TI | -55 to 125 | LM185WG-2.5/883 Q 5962-87594 02YA ACO 02YA >T | Samples |

(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
**TBD:** The Pb-Free/Green conversion plan has not been defined.
**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Only one of markings shown within the brackets will appear on the physical device.

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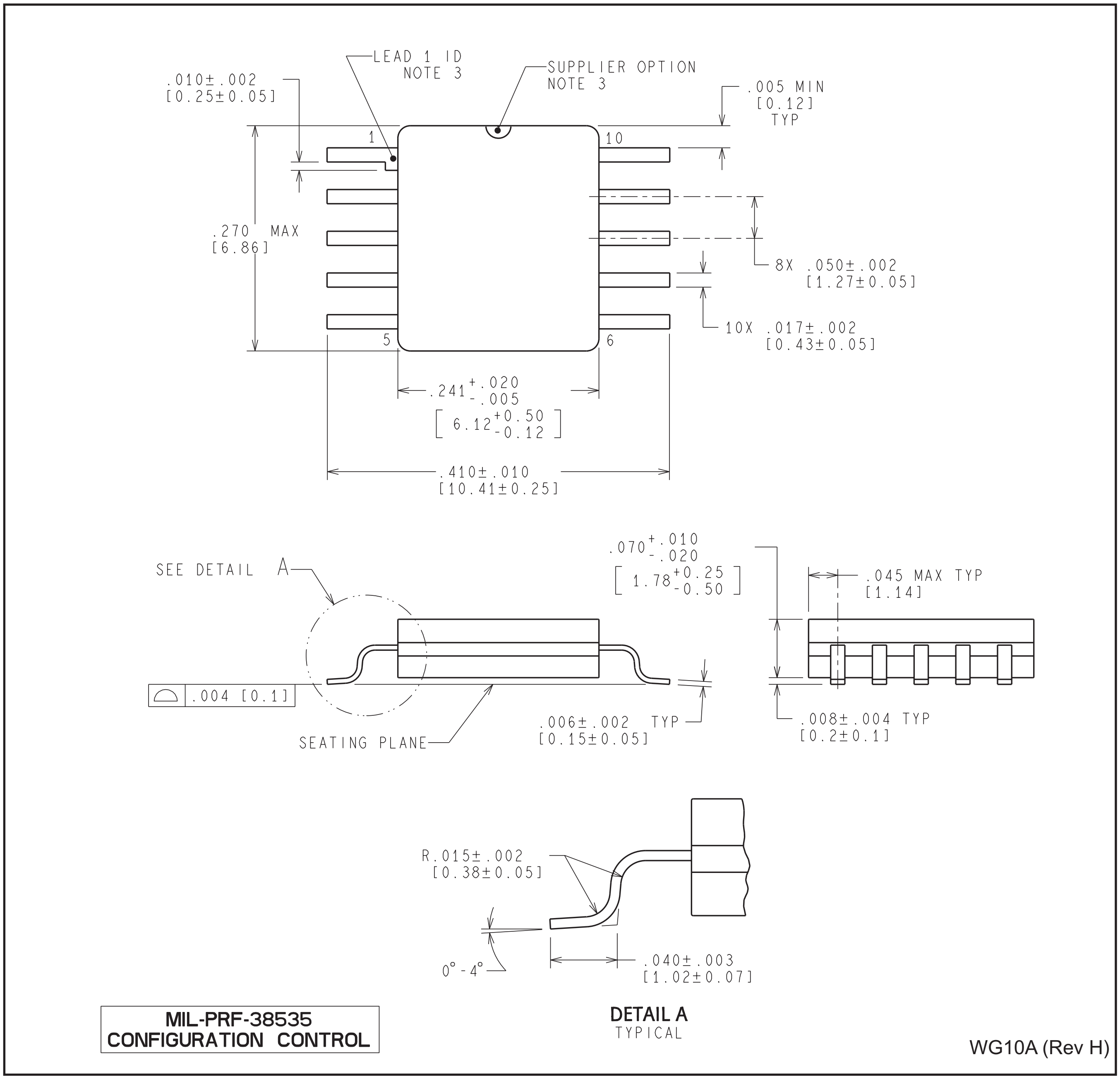
**OTHER QUALIFIED VERSIONS OF LM185-2.5QML, LM185-2.5QML-SP :**

- Military: LM185-2.5QML
- Space: LM185-2.5QML-SP

NOTE: Qualified Version Definitions:

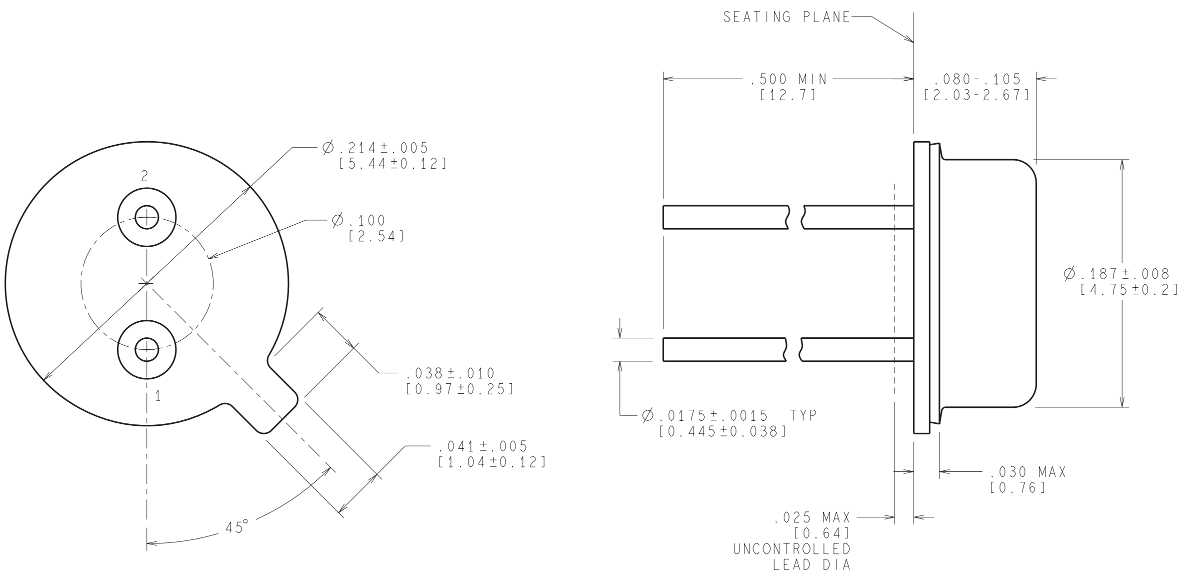
- Military - QML certified for Military and Defense Applications
- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

# NAC0010A



LEAD 1 ID
NOTE 3
SUPPLIER OPTION
NOTE 3
.010±.002
[0.25±0.05]
.005 MIN
[0.12]
TYP
1
10
.270 MAX
[6.86]
8X .050±.002
[1.27±0.05]
10X .017±.002
[0.43±0.05]
5
6
.241 +.020 -.005
[ 6.12 +0.50 -0.12 ]
.410±.010
[10.41±0.25]
.070 +.010 -.020
[ 1.78 +0.25 -0.50 ]
SEE DETAIL A
.045 MAX TYP
[1.14]
.004 [0.1]
.006±.002 TYP
[0.15±0.05]
.008±.004 TYP
[0.2±0.1]
SEATING PLANE
R.015±.002
[0.38±0.05]
0°-4°
.040±.003
[1.02±0.07]
MIL-PRF-38535
CONFIGURATION CONTROL
DETAIL A
TYPICAL
WG10A (Rev H)

# NDU0002A




CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS

H02A (Rev F)