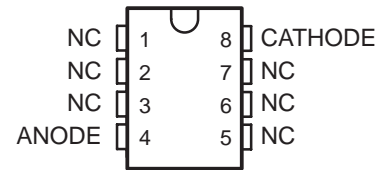


LM285-2.5, LM385-2.5, LM385B-2.5 MICROPOWER VOLTAGE REFERENCES

SLVS023J – JANUARY 1989 – REVISED MARCH 2005

- Operating Current Range . . . 20 μ A to 20 mA
- 1.5% and 3% Initial Voltage Tolerance
- Reference Impedance
 - LM385 . . . 1 Ω Max at 25°C
 - All Devices . . . 1.5 Ω Max Over Full Temperature Range
- Very Low Power Consumption
- Applications
 - Portable Meter References
 - Portable Test Instruments
 - Battery-Operated Systems
 - Current-Loop Instrumentation
 - Panel Meters
- Interchangeable With Industry-Standard LM285-2.5 and LM385-2.5

LM285-2.5 . . . D PACKAGE
LM385-2.5, LM385B-2.5 . . . D OR PW PACKAGE
(TOP VIEW)



NC – No internal connection

LM285-2.5, LM385-2.5, LM385B-2.5 . . . LP PACKAGE
(TOP VIEW)



NC – No internal connection

description/ordering information

These micropower two-terminal band-gap voltage references operate over a 20- μ A to 20-mA current range and feature exceptionally low dynamic impedance and good temperature stability. On-chip trimming provides tight voltage tolerance. The band-gap reference for these devices has low noise and long-term stability.

ORDERING INFORMATION

| TA | VZ TOLERANCE | PACKAGE† | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---------------|--------------|------------------|--------------|-----------------------|------------------|
| 0°C to 70°C | 3% | SOIC (D) | Tube of 75 | LM385D-2-5 | 385-25 |
| | | | Reel of 2000 | LM385DR-2-5 | |
| | | TO226/TO-92 (LP) | Tube of 1000 | LM385LP-2-5 | 385-25 |
| | | | Reel of 2000 | LM385LPR-2-5 | |
| | | TSSOP (PW) | Tube of 150 | LM385PW-2-5 | 385-25 |
| | | | Reel of 2000 | LM385PWR-2-5 | |
| | 1.5% | SOIC (D) | Tube of 75 | LM385BD-2-5 | 385B25 |
| | | | Reel of 2000 | LM385BDR-2-5 | |
| | | TO226/TO-92 (LP) | Tube of 1000 | LM385BLP-2-5 | 385-25 |
| | | | Reel of 2000 | LM385BLPR-2-5 | |
| | | TSSOP (PW) | Tube of 150 | LM385BPW-2-5 | 385B25 |
| | | | Reel of 2000 | LM385BPWR-2-5 | |
| –40°C to 85°C | 1.5% | SOIC (D) | Tube of 75 | LM285D-2-5 | 285-25 |
| | | | Reel of 2000 | LM285DR-2-5 | |
| | | TO226/TO-92 (LP) | Tube of 1000 | LM285LP-2-5 | 285-25 |
| | | | Reel of 2000 | LM285LPR-2-5 | |

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



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LM285-2.5, LM385-2.5, LM385B-2.5 MICROPOWER VOLTAGE REFERENCES

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description/ordering information (continued)

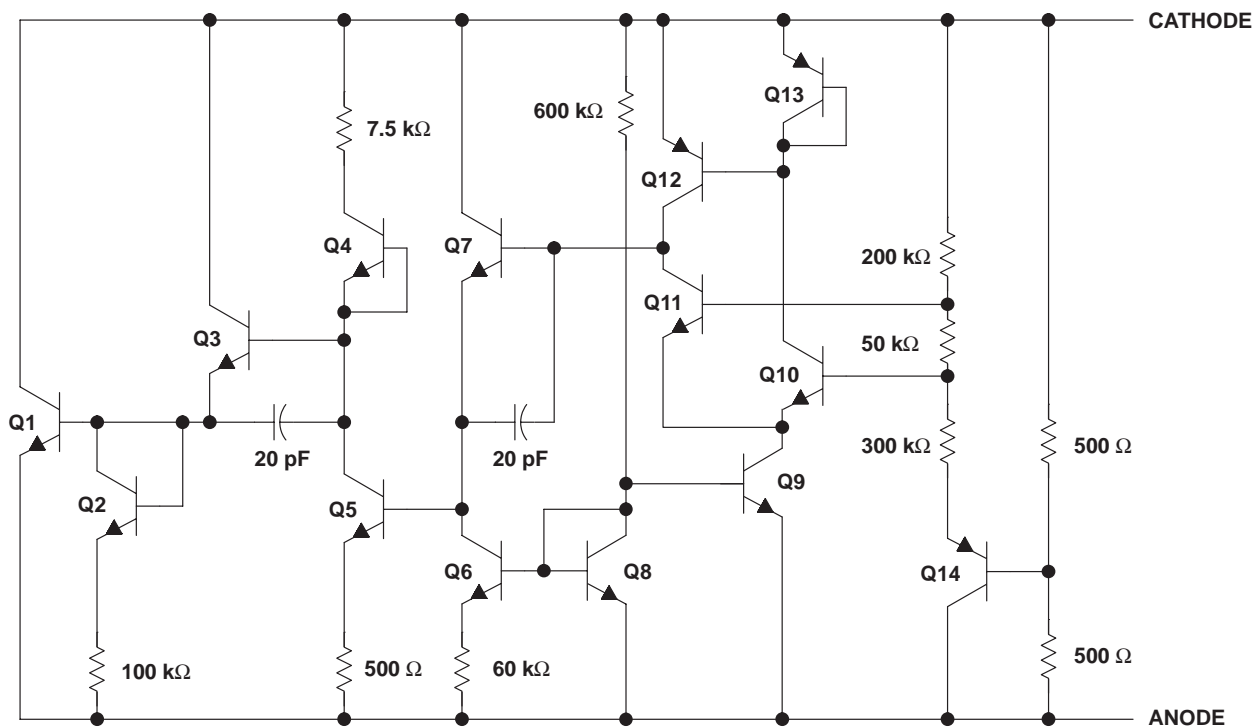
The design makes these devices exceptionally tolerant of capacitive loading and, thus, easier to use in most reference applications. The wide dynamic operating temperature range accommodates varying current supplies, with excellent regulation.

The extremely low power drain of this series makes them useful for micropower circuitry. These voltage references can be used to make portable meters, regulators, or general-purpose analog circuitry, with battery life approaching shelf life. The wide operating current range allows them to replace older references with tighter-tolerance parts.

symbol



schematic



NOTE A: All component values shown are nominal.

LM285-2.5, LM385-2.5, LM385B-2.5 MICROPOWER VOLTAGE REFERENCES

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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

| | |
|---|----------------|
| Reverse current, I_R | 30 mA |
| Forward current, I_F | 10 mA |
| Package thermal impedance, θ_{JA} (see Notes 1 and 2): D package | 97°C/W |
| LP package | 140°C/W |
| PW package | 149°C/W |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds | 260°C |
| Storage temperature range, T_{Stg} | –65°C to 150°C |

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. Maximum power dissipation is a function of $T_{J(max)}$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_{J(max)} - T_A)/\theta_{JA}$. Operation at the absolute maximum T_J of 150°C can affect reliability.
 2. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions

| | | MIN | MAX | UNIT |
|-------|--------------------------------------|-----------------------|-----|------|
| I_Z | Reference current | 0.02 | 20 | mA |
| T_A | Operating free-air temperature range | LM285-2.5 | –40 | 85 |
| | | LM385-2.5, LM385B-2.5 | 0 | 70 |
| | | | | °C |

electrical characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T_A ‡ | LM285-2.5 | | | LM385-2.5 | | | LM385B-2.5 | | | UNIT | |
|-----------------------|---|--|------------|---------|-----|-----------|-------|-----|------------|-------|-----|-------|---------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | | |
| V_Z | Reference voltage | $I_Z = 20 \mu A$ to 20 mA | 25°C | 2.462 | 2.5 | 2.538 | 2.425 | 2.5 | 2.575 | 2.462 | 2.5 | 2.538 | V |
| α_{VZ} | Average temperature coefficient of reference voltage§ | $I_Z = 20 \mu A$ to 20 mA | Full range | ±20 | | | ±20 | | | ±20 | | | ppm/°C |
| ΔV_Z | Change in reference voltage with current | $I_Z = 20 \mu A$ to 1 mA | 25°C | 1 | | | 2 | | | 2 | | | mV |
| | | | Full range | 1.5 | | | 2 | | | 2 | | | |
| | | $I_Z = 1 mA$ to 20 mA | 25°C | 10 | | | 20 | | | 20 | | | |
| | | | Full range | 30 | | | 30 | | | 30 | | | |
| $\Delta V_Z/\Delta t$ | Long-term change in reference voltage | $I_Z = 100 \mu A$ | 25°C | ±20 | | | ±20 | | | ±20 | | | ppm/khr |
| $I_Z(min)$ | Minimum reference current | | Full range | 8 20 | | | 8 20 | | | 8 20 | | | μA |
| Z_Z | Reference impedance | $I_Z = 100 \mu A$ | 25°C | 0.2 0.6 | | | 0.4 1 | | | 0.4 1 | | | Ω |
| | | | Full range | 1.5 | | | 1.5 | | | 1.5 | | | |
| V_n | Broadband noise voltage | $I_Z = 100 \mu A$, $f = 10 Hz$ to 10 kHz | 25°C | 120 | | | 120 | | | 120 | | | μV |

‡ Full range is 0°C to 70°C for the LM385-2.5 and LM385B-2.5, and –40°C to 85°C for the LM285-2.5.

§ The average temperature coefficient of reference voltage is defined as the total change in reference voltage divided by the specified temperature range.

LM285-2.5, LM385-2.5, LM385B-2.5 MICROPOWER VOLTAGE REFERENCES

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TYPICAL CHARACTERISTICS†

REVERSE CURRENT
vs
REVERSE VOLTAGE

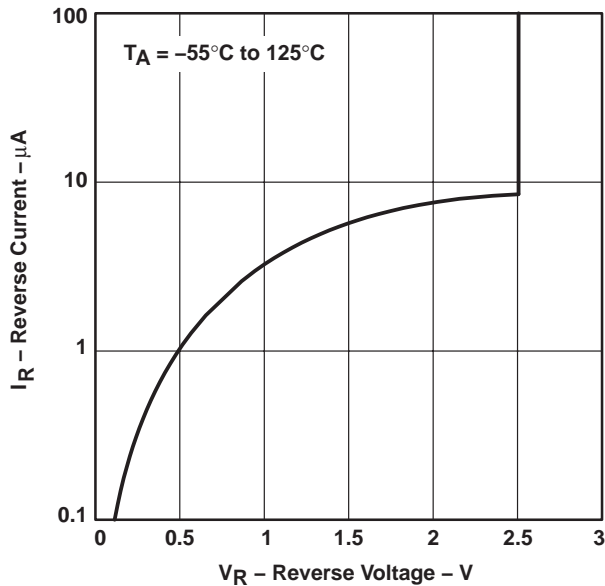


Figure 1

REFERENCE VOLTAGE CHANGE
vs
REVERSE CURRENT

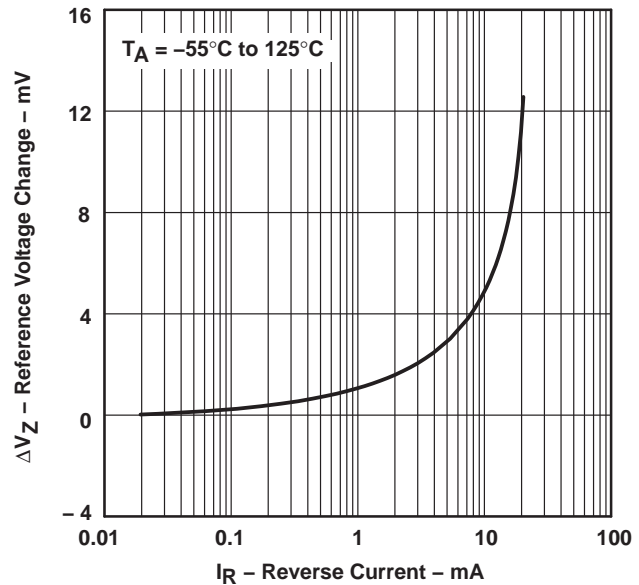


Figure 2

FORWARD VOLTAGE
vs
FORWARD CURRENT

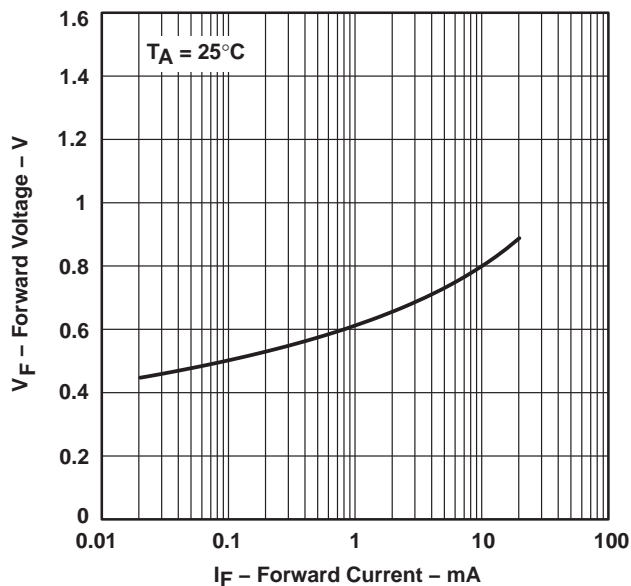


Figure 3

REFERENCE VOLTAGE
vs
FREE-AIR TEMPERATURE

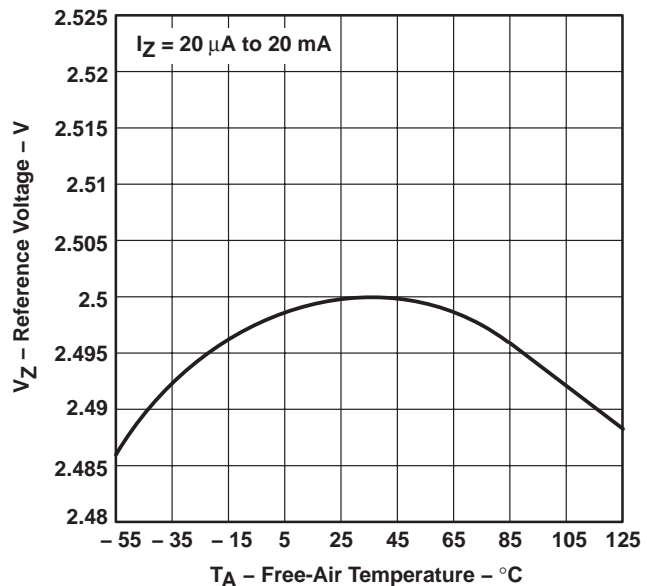


Figure 4

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS†

REFERENCE IMPEDANCE
vs
REFERENCE CURRENT

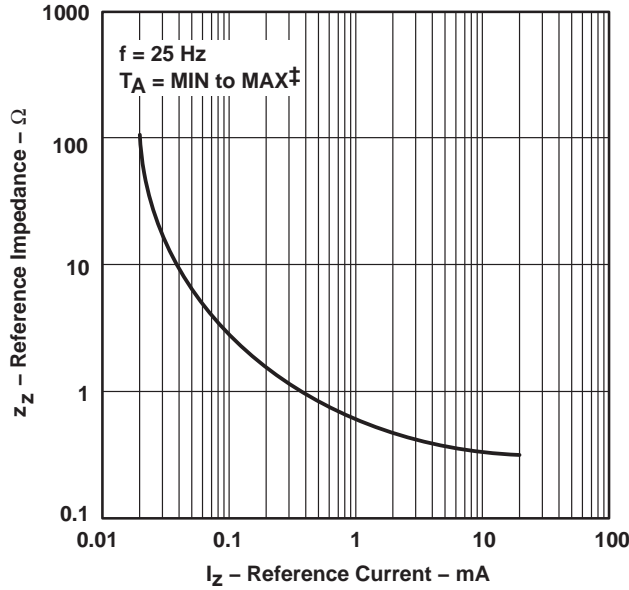


Figure 5

REFERENCE IMPEDANCE
vs
FREQUENCY

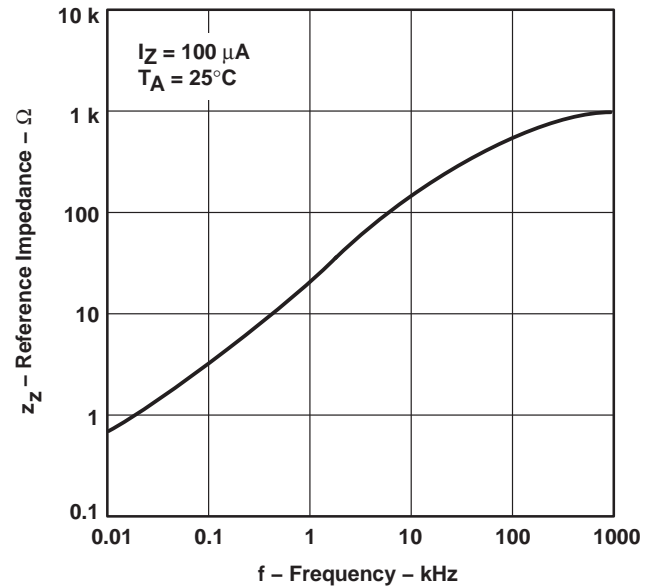


Figure 6

NOISE VOLTAGE
vs
FREQUENCY

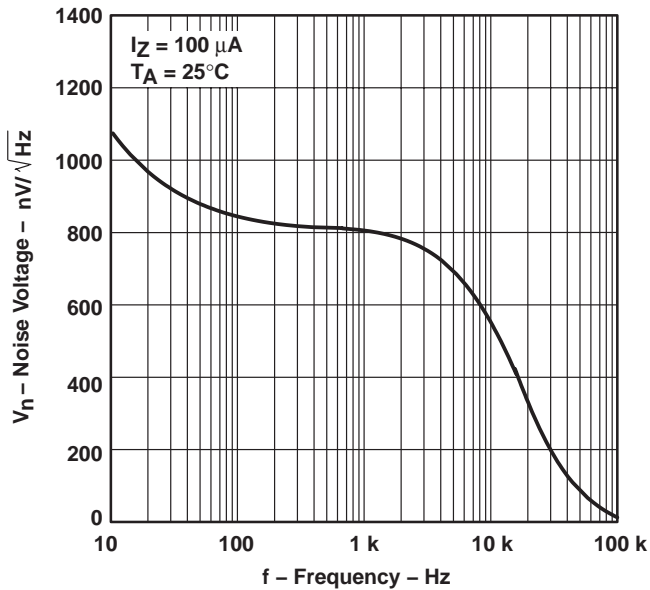


Figure 7

FILTERED RMS OUTPUT NOISE VOLTAGE
vs
FREQUENCY

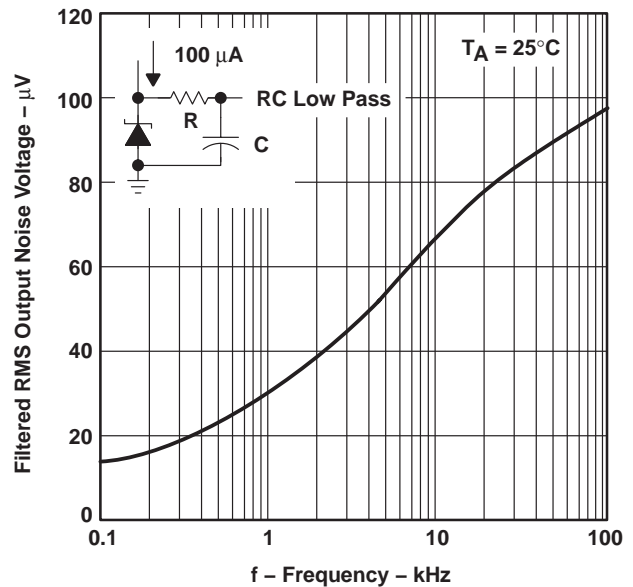


Figure 8

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

LM285-2.5, LM385-2.5, LM385B-2.5 MICROPOWER VOLTAGE REFERENCES

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TYPICAL CHARACTERISTICS†

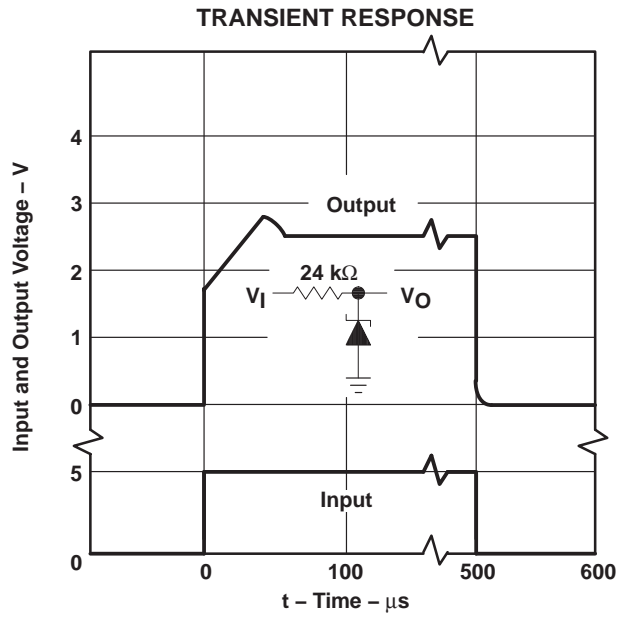
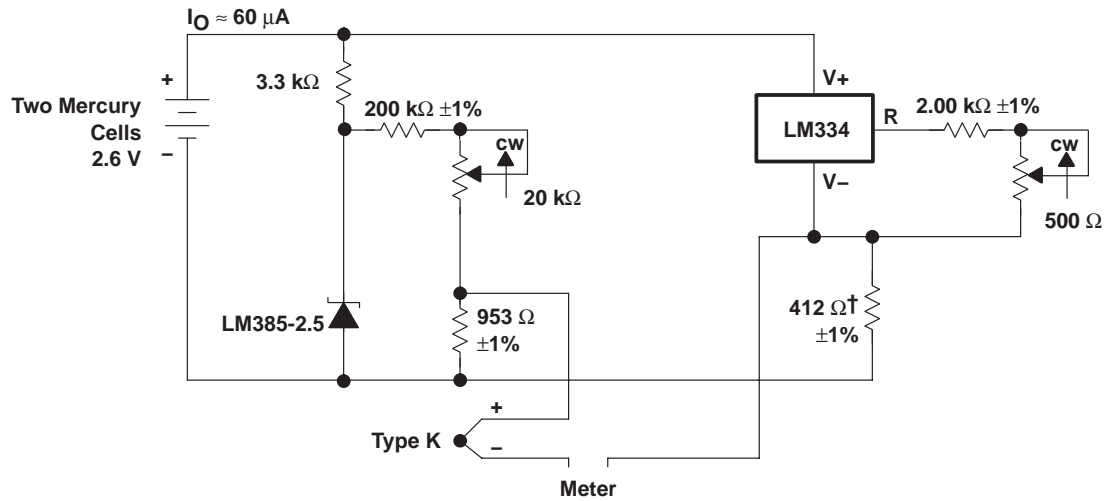


Figure 9

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

APPLICATION INFORMATION



† Adjust for 12.17 mV at 25°C across 412 Ω

Figure 10. Thermocouple Cold-Junction Compensator

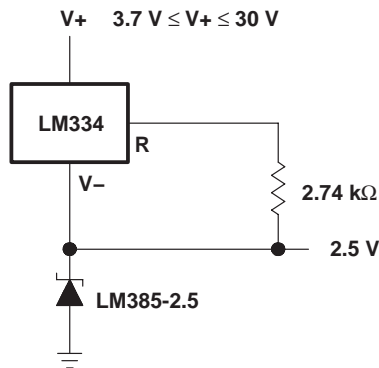


Figure 11. Operation Over a Wide Supply Range

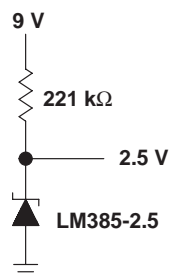


Figure 12. Reference From a 9-V Battery

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| LM285D-2-5 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM285DE4-2-5 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM285DG4-2-5 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM285DR-2-5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM285DRE4-2-5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM285DRG4-2-5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM285LP-2-5 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM285LPE3-2-5 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM285LPR-2-5 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM285LPRE3-2-5 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM385BD-2-5 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385BDE4-2-5 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385BDG4-2-5 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385BDR-2-5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385BDRE4-2-5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385BDRG4-2-5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385BLP-2-5 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM385BLPE3-2-5 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM385BLPR-2-5 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM385BLPRE3-2-5 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM385BPW-2-5 | ACTIVE | TSSOP | PW | 8 | 150 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385BPWE4-2-5 | ACTIVE | TSSOP | PW | 8 | 150 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385BPWG4-2-5 | ACTIVE | TSSOP | PW | 8 | 150 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385BPWR-2-5 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385BPWRE4-2-5 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| LM385BPWRG4-2-5 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385D-2-5 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385DE4-2-5 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385DG4-2-5 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385DR-2-5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385DRE4-2-5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385DRG4-2-5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385LP-2-5 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM385LPE3-2-5 | ACTIVE | TO-92 | LP | 3 | 1000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM385LPR-2-5 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM385LPRE3-2-5 | ACTIVE | TO-92 | LP | 3 | 2000 | Pb-Free (RoHS) | CU SN | N / A for Pkg Type |
| LM385PW-2-5 | ACTIVE | TSSOP | PW | 8 | 150 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385PWE4-2-5 | ACTIVE | TSSOP | PW | 8 | 150 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385PWG4-2-5 | ACTIVE | TSSOP | PW | 8 | 150 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385PWR-2-5 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385PWRE4-2-5 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| LM385PWRG4-2-5 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

⁽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.

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TAPE AND REEL INFORMATION



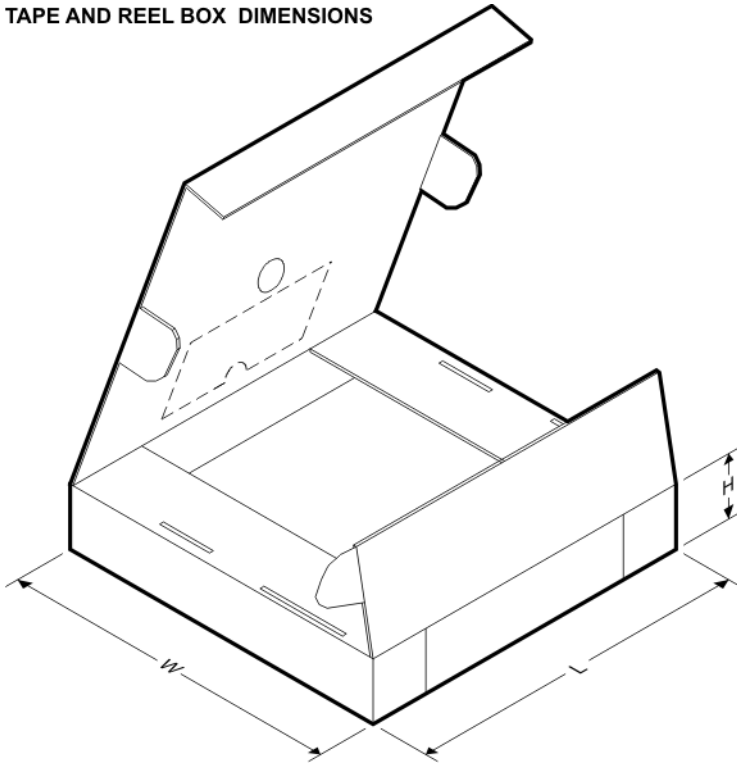
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM285DR-2-5 | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| LM385BDR-2-5 | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| LM385BPWR-2-5 | TSSOP | PW | 8 | 2000 | 330.0 | 12.4 | 7.0 | 3.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM385DR-2-5 | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| LM385PWR-2-5 | TSSOP | PW | 8 | 2000 | 330.0 | 12.4 | 7.0 | 3.6 | 1.6 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



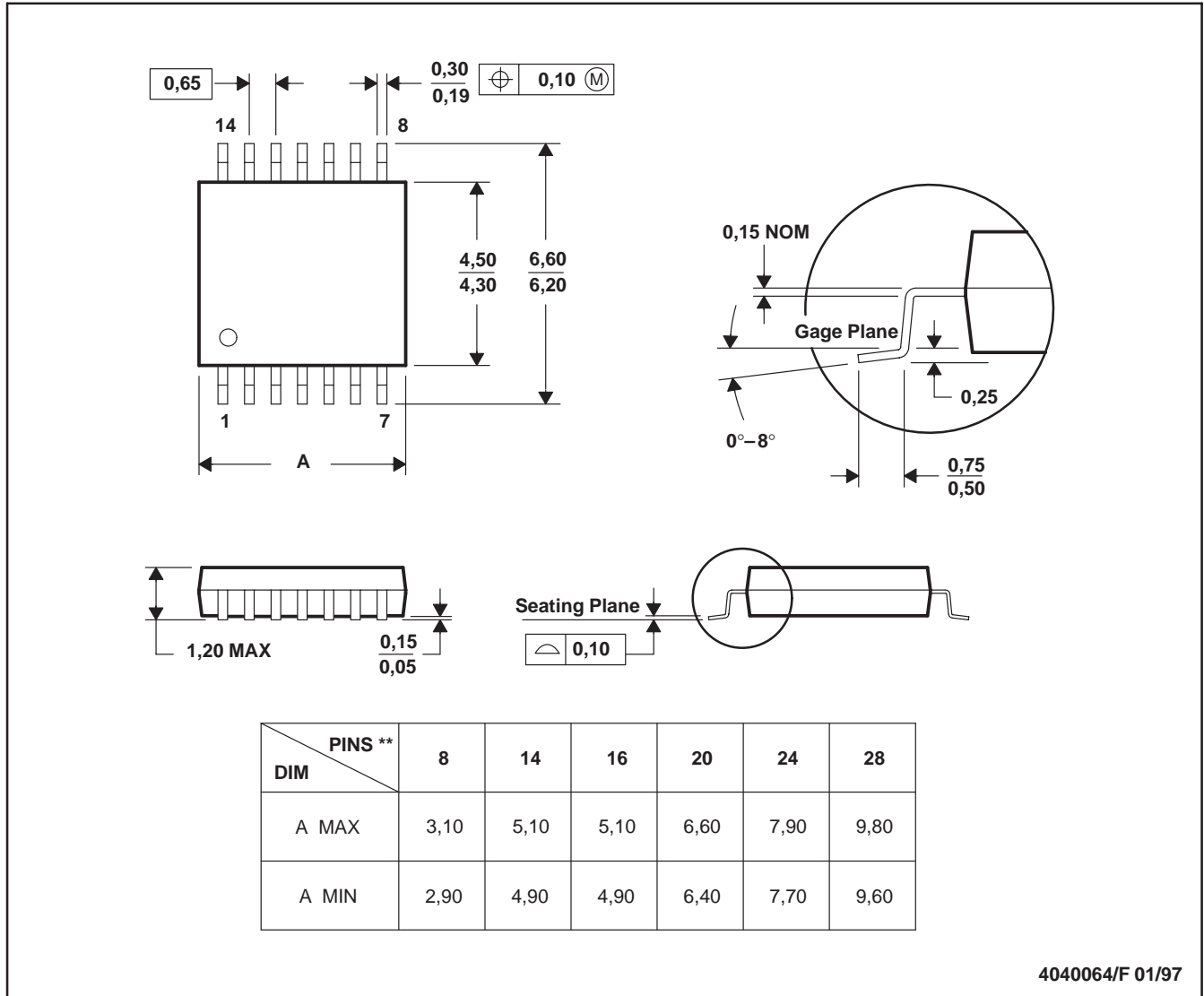
*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM285DR-2-5 | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| LM385BDR-2-5 | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| LM385BPWR-2-5 | TSSOP | PW | 8 | 2000 | 346.0 | 346.0 | 29.0 |
| LM385DR-2-5 | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| LM385PWR-2-5 | TSSOP | PW | 8 | 2000 | 346.0 | 346.0 | 29.0 |

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN

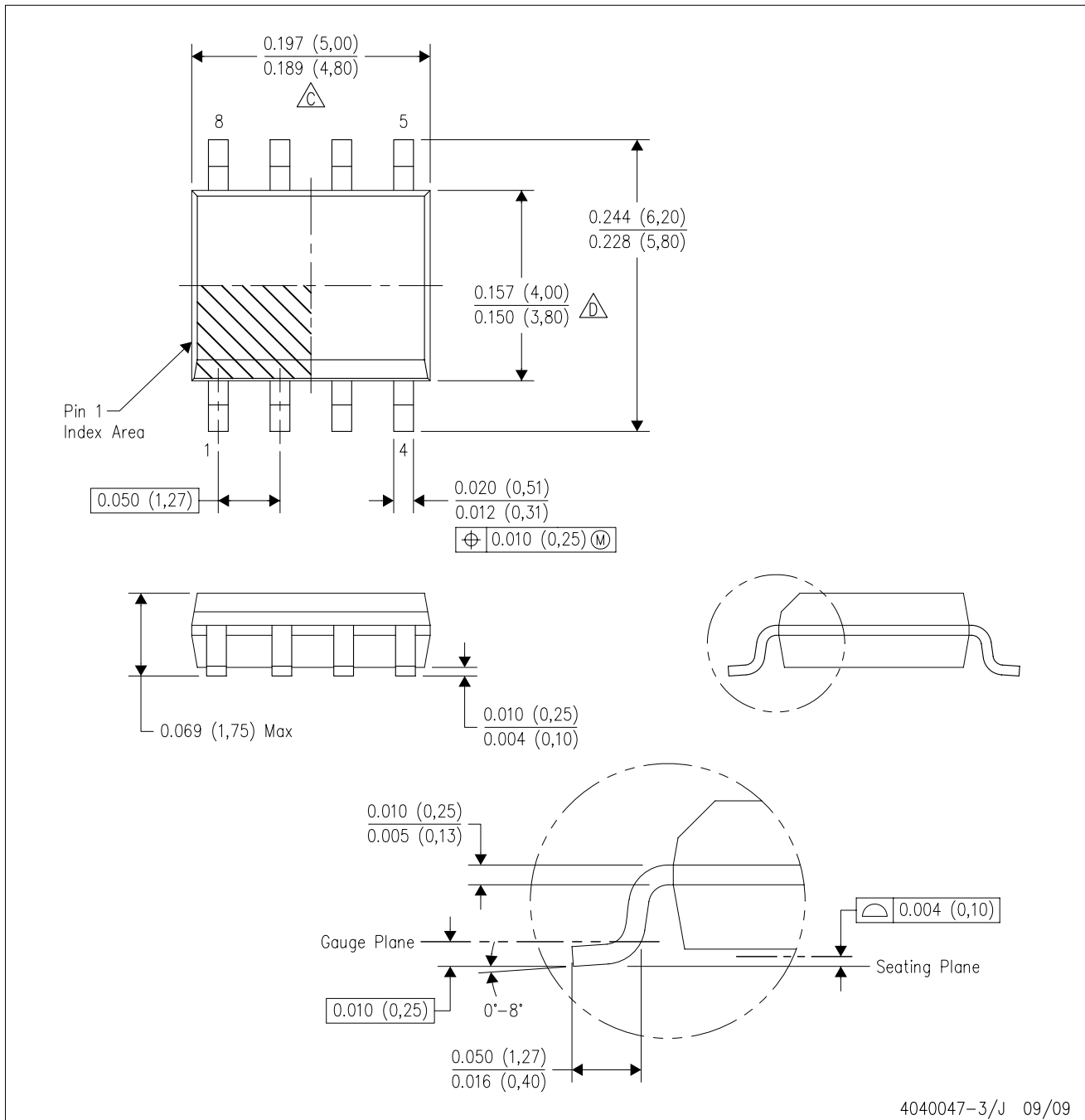


4040064/F 01/97

- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-153

D (R-PDSO-G8)

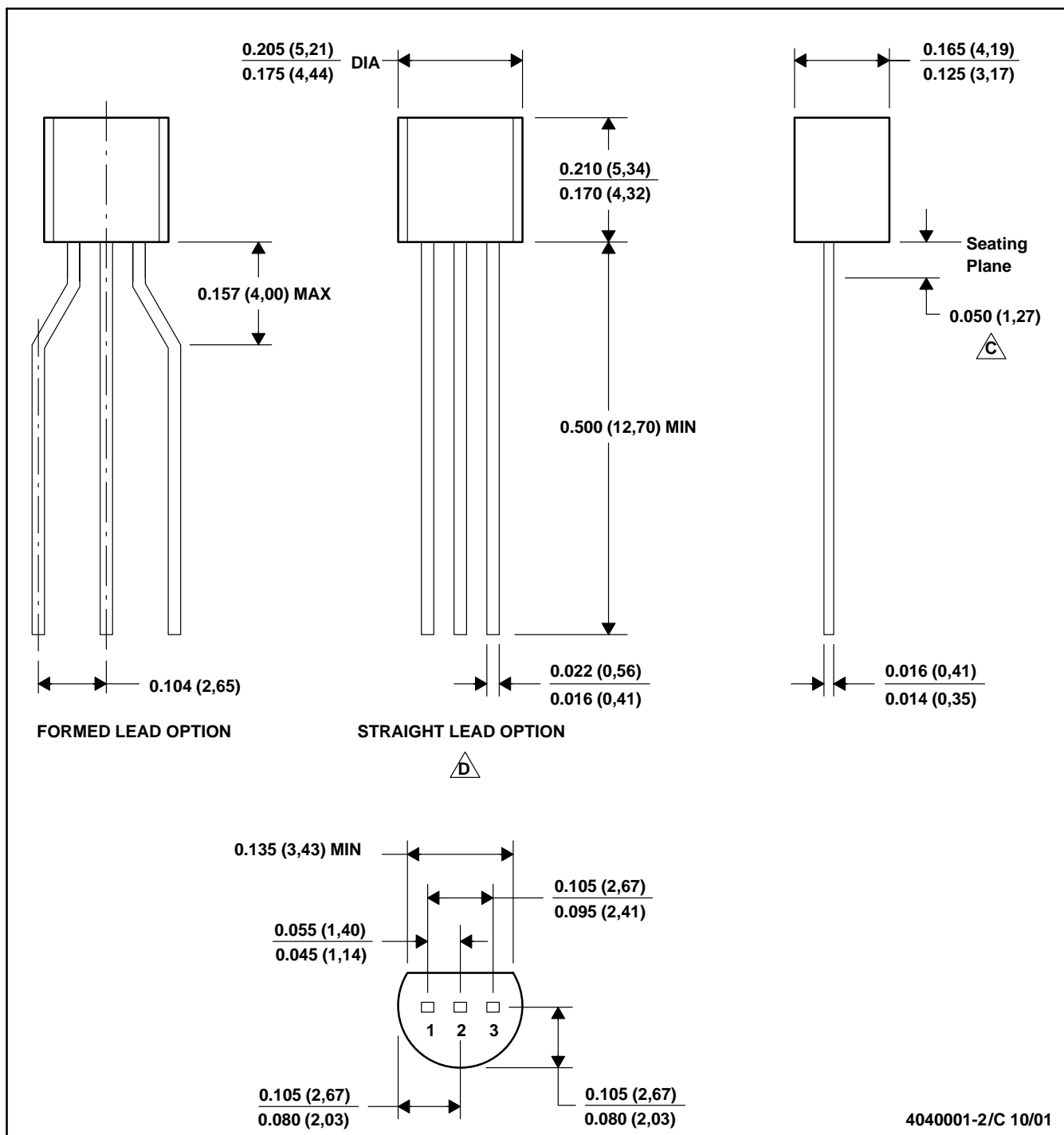
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
 - Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
 - Reference JEDEC MS-012 variation AA.

LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



4040001-2/C 10/01

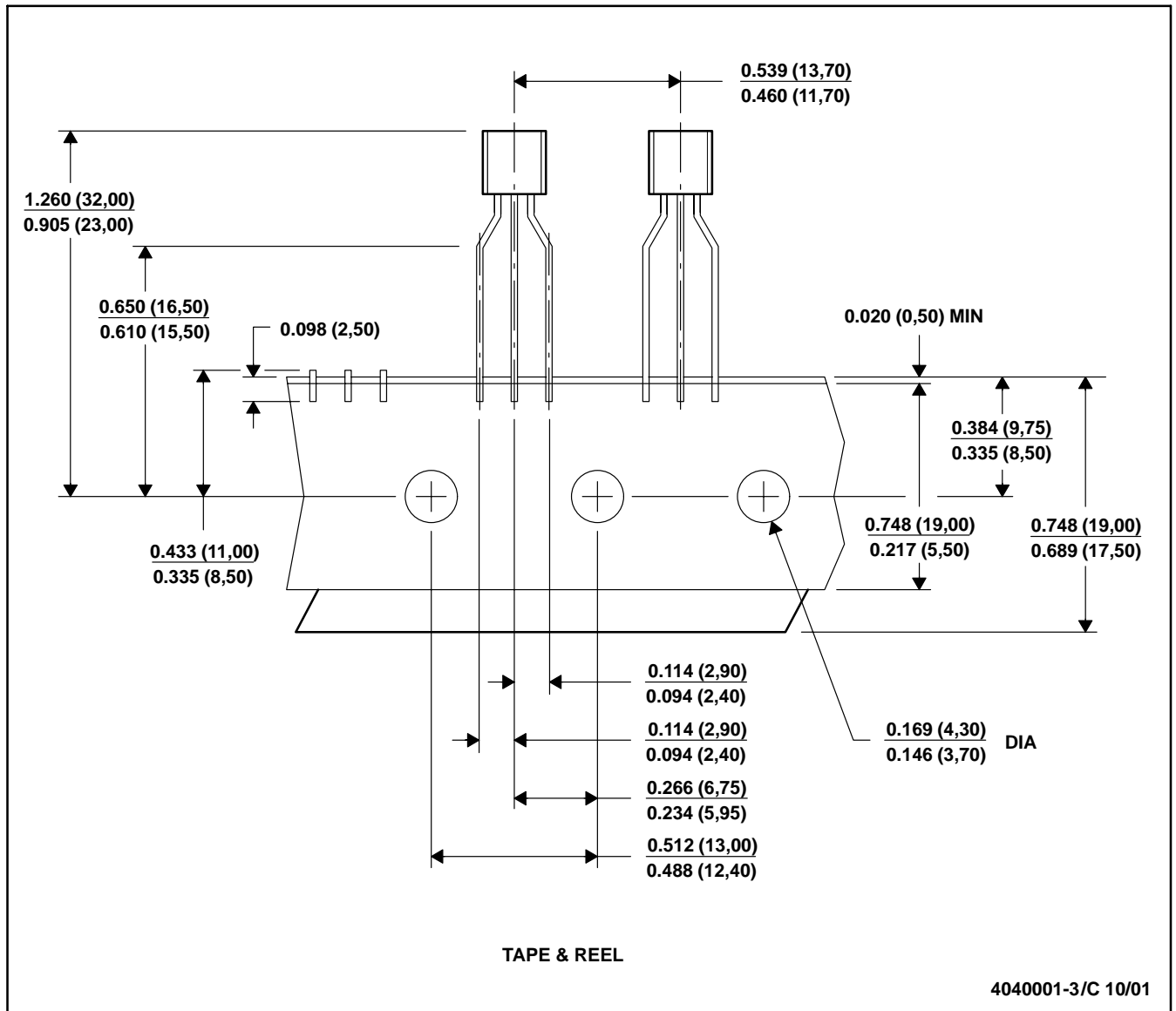
- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
C Lead dimensions are not controlled within this area
D Falls within JEDEC TO -226 Variation AA (TO-226 replaces TO-92)
 E. Shipping Method:
 Straight lead option available in bulk pack only.
 Formed lead option available in tape & reel or ammo pack.

MECHANICAL DATA

MSOT002A – OCTOBER 1994 – REVISED NOVEMBER 2001

LP (O-PBCY-W3)

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 B. This drawing is subject to change without notice.
 C. Tape and Reel information for the Format Lead Option package.

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