LM185-2.5-N/LM285-2.5-N/LM385-2.5-N Micropower Voltage Reference Diode

Check for Samples: LM185-2.5-N, LM285-2.5-N, LM385-2.5-N

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**

DESCRIPTION

The LM185-2.5-N/LM285-2.5-N/LM385-2.5-N 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-N band-gap reference uses only transistors and resistors, low noise and good long term stability result.

Careful design of the LM185-2.5-N 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-N 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.

The LM185-2.5-N is rated for operation over a −55°C to 125°C temperature range while the LM285-2.5-N is rated −40°C to 85°C and the LM385-2.5-N 0°C to 70°C. The LM185-2.5-N/LM285-2.5-N are available in a hermetic TO package and the LM285-2.5-N/LM385-2.5-N are also available in a low-cost TO-92 molded package, as well as SOIC and SOT-23. The LM185-2.5-N is also available in a hermetic leadless chip carrier package.

Connection Diagram

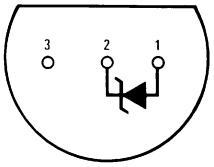


Figure 1. TO-92 Package
(Bottom View)
See Package Number LP0003A

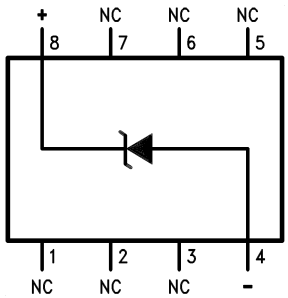
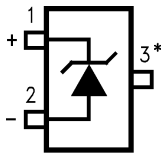


Figure 2. SOIC Package
See Package Number D0008A



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

Figure 3. SOT-23

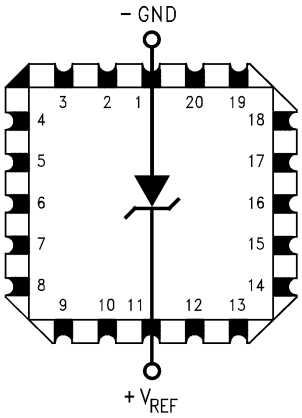


Figure 4. LCCC Leadless Chip Carrier
See Package Number NAJ0020A

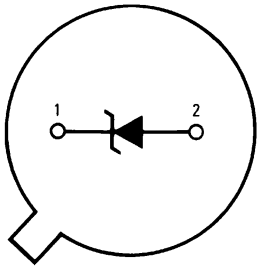


Figure 5. TO Package
(Bottom View)
See Package Number NDU0002A

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)(2)(3)

Reverse Current			30 mA
Forward Current			10 mA
Operating Temperature Range(4)	LM185-2.5-N		−55°C to + 125°C
	LM285-2.5-N		−40°C to + 85°C
	LM385-2.5-N		0°C to 70°C
ESD Susceptibility(5)			2kV
Storage Temperature			−55°C to + 150°C
Soldering Information	TO-92 Package (10 sec.)		260°C
	TO Package (10 sec.)		300°C
	SOIC and SOT-23 Package	Vapor Phase (60 sec.)	215°C
		Infrared (15 sec.)	220°C
See http://www.ti.com for other methods of soldering surface mount devices.			

(1) Refer to RETS185H-2.5 for military specifications.
(2) 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 ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed.
(3) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(4) For elevated temperature operation, $T_{J\ MAX}$ is:
LM185-N: 150°C
LM285-N: 125°C
LM385-N: 100°C
See THERMAL CHARACTERISTICS.
(5) The human body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin.

THERMAL CHARACTERISTICS

over operating free-air temperature range (unless otherwise noted)

Thermal Resistance	**LM185**	**150°C**	**SOIC-8**	**SOT-23**
	LM285	**125°C**		
	LM385	**100°C**		
	TO-92	**TO**		
θ_{ja} (Junction to Ambient)	180°C/W (0.4″ Leads)	440°C/W	165°C/W	283°C/W
	170°C/W (0.125″ Leads)			
θ_{jc} (Junction to Case)	N/A	80°C/W	N/A	N/A

ELECTRICAL CHARACTERISTICS

Parameter	Conditions	Typ	LM385A-2.5-N LM385AX-2.5-N LM385AY-2.5-N		Units (Limits)
			Tested Limit(2)	Design Limit(3)	
Reverse Breakdown Voltage	I_R = 100 µA	2.500	2.480		V(Min)
			2.520		V(Max)
		2.500		**2.470**	V(Min)
				2.530	V(Max)
Minimum Operating Current		12	18	**20**	µA (Max)
Reverse Breakdown Voltage Change with Current	$I_{MIN} \le I_R \le$ 1mA		1	**1.5**	mV (Max)
	1 mA ≤ I_R ≤ 20 mA		10	**20**	mV (Max)
Reverse Dynamic Impedance	I_R = 100 µA, f = 20 Hz	0.2		0.6	Ω
				1.5	
Wideband Noise (rms)	I_R = 100 µA, 10 Hz ≤ f ≤ 10 kHz	120			µV
Long Term Stability	I_R = 100 µA, T = 1000 Hr, T_A = 25°C ±0.1°C	20			ppm
Average Temperature Coefficient(4)	$I_{MIN} \le I_R \le$ 20 mA				
	X Suffix		**30**		ppm/°C (Max)
	Y Suffix		**50**		
	All Others			**150**	

(1) Parameters identified with boldface type apply at temperature extremes. All other numbers apply at $T_A = T_J$ = 25°C.
(2) Specified and 100% production tested.
(3) Specified, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.
(4) 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.

ELECTRICAL CHARACTERISTICS

Parameter	Conditions	Typ	LM185-2.5-N LM185BX-2.5-N LM185BY-2.5-N LM285-2.5-N LM285BX-2.5-N LM285BY-2.5-N		LM385B-2.5-N LM385BX-2.5-N LM385BY-2.5-N		LM385-2.5-N		Units (Limit)
			Tested Limit(1)(2)	Design Limit(3)	Tested Limit(1)	Design Limit(3)	Tested Limit(1)	Design Limit(3)	
Reverse Breakdown Voltage	T_A = 25°C, 20 µA ≤ I_R ≤ 20 mA	2.5	2.462 2.538		2.462 2.538		2.425 2.575		V(Min) V(Max)
Minimum Operating Current	 LM385M3-2.5-N	13	20	**30**	20	**30**	20 15	**30** **20**	µA (Max)
Reverse Breakdown Voltage Change with Current	20 µA ≤ I_R ≤ 1 mA 1 mA ≤ I_R ≤ 20 mA		1 10	**1.5** **20**	2.0 20	**2.5** **25**	2.0 20	**2.5** **25**	mV (Max) mV (Max)
Reverse Dynamic Impedance	I_R = 100 µA, f = 20 Hz	1							Ω
Wideband Noise (rms)	I_R = 100 µA, 10 Hz ≤ f ≤ 10 kHz	120							µV
Long Term Stability	I_R = 100 µA, T = 1000 Hr, T_A = 25°C ±0.1°C	20							ppm
Average Temperature Coefficient(4)	I_R = 100 µA X Suffix Y Suffix All Others		 **30** **50**	 **150**	 **30** **50**	 **150**	 	 **150**	 ppm/°C ppm/°C ppm/°C (Max)

(1) Specified and 100% production tested.
(2) A military RETS electrical specification available on request.
(3) Specified, but not 100% production tested. These limits are not used to calculate average outgoing quality levels.
(4) 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.

TYPICAL PERFORMANCE CHARACTERISTICS

Reverse Characteristics

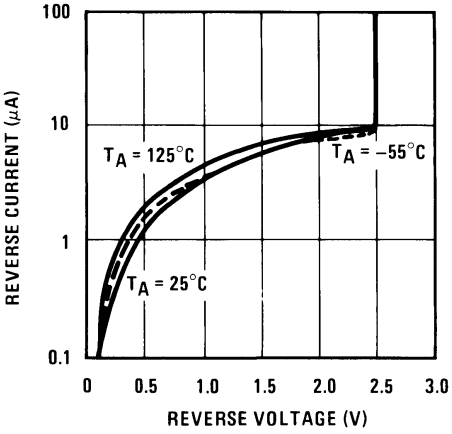


Figure 6.

Reverse Characteristics

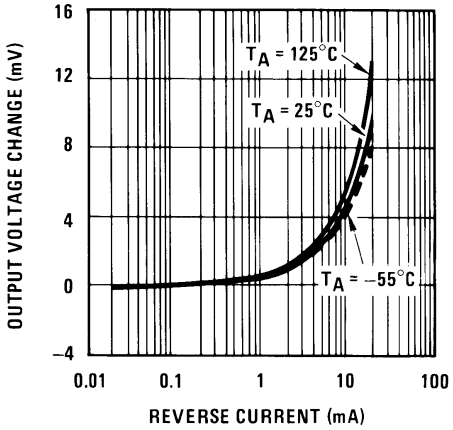


Figure 7.

Forward Characteristics

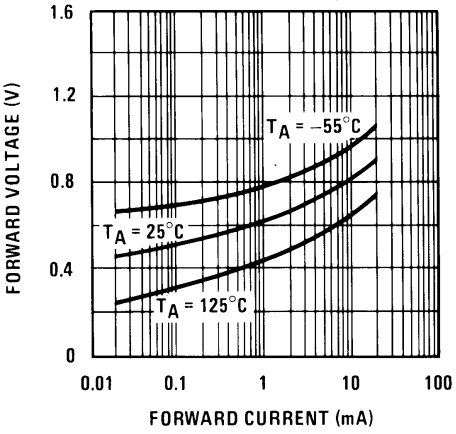


Figure 8.

Temperature Drift

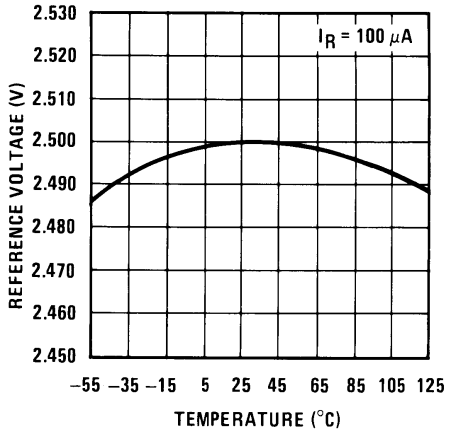


Figure 9.

Reverse Dynamic Impedance

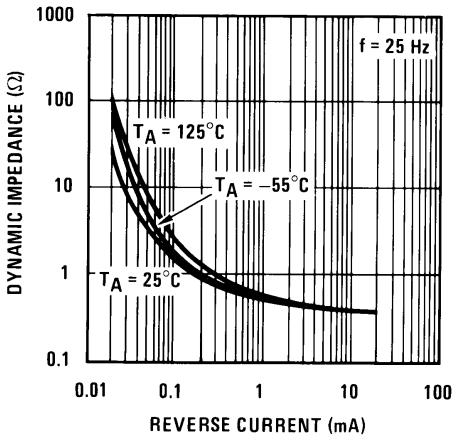


Figure 10.

Reverse Dynamic Impedance

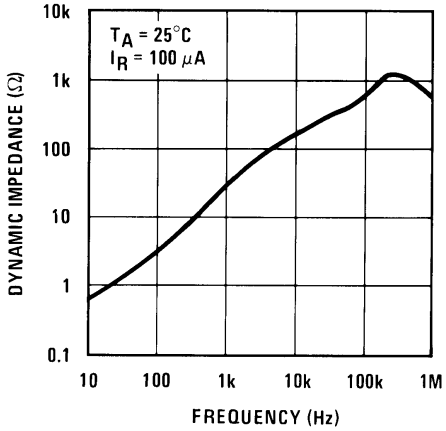


Figure 11.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Noise Voltage

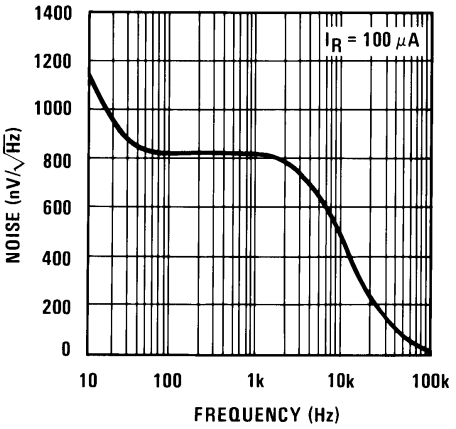


Figure 12.

Filtered Output Noise

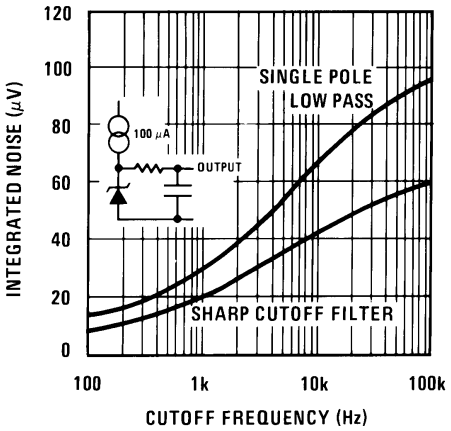


Figure 13.

Response Time

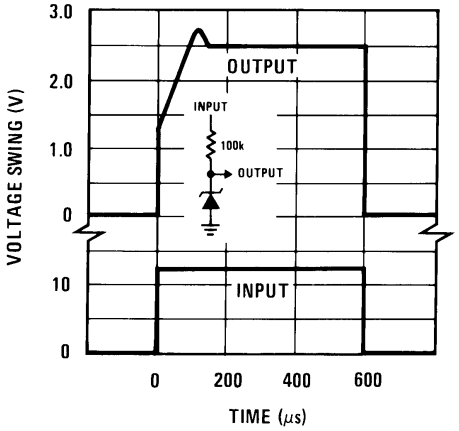


Figure 14.

APPLICATIONS

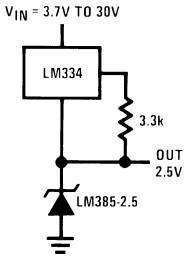


Figure 15. Wide Input Range Reference

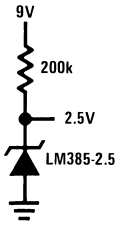
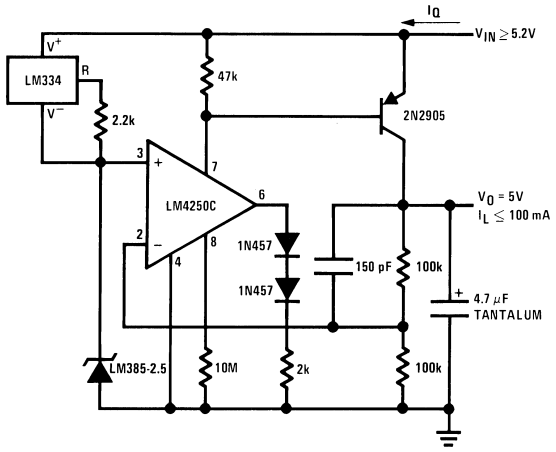


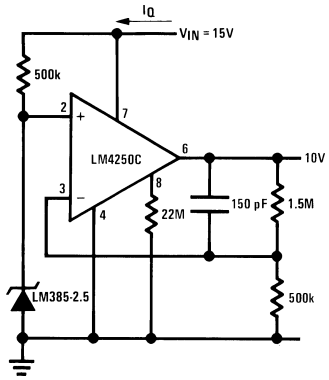
Figure 16. Micropower Reference from 9V Battery

LM385-2.5-N Applications



$I_Q \approx 40\ \mu A$

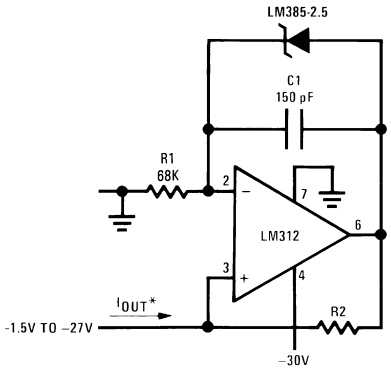
Figure 17. Micropower 5V Reference



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

Figure 18. Micropower 10V Reference

PRECISION 1 µA to 1 mA CURRENT SOURCES



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

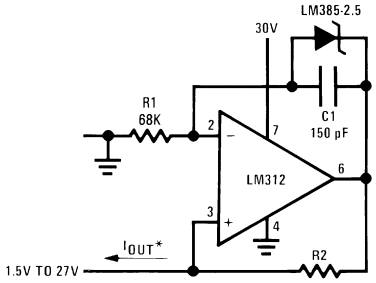
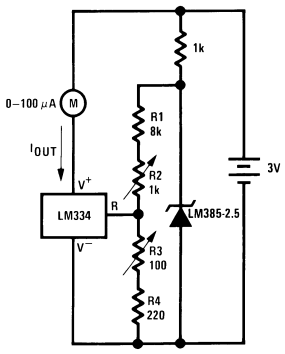


Figure 19.

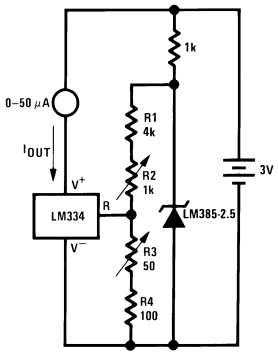
METER THERMOMETERS



Calibration

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

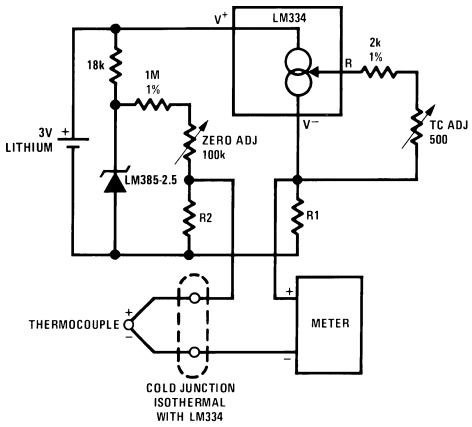
Figure 20. 0°C–100°C Thermomemter



Calibration

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

Figure 21. 0°F–50°F Thermomemter



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.

Figure 22. Micropower Thermocouple Cold Junction Compensator

Thermocouple Type(1)	Seebeck Coefficient (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

(1) Typical supply current 50 μA

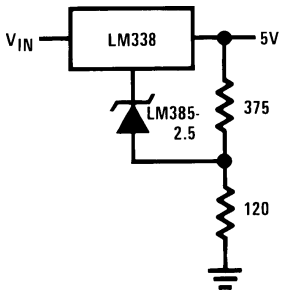
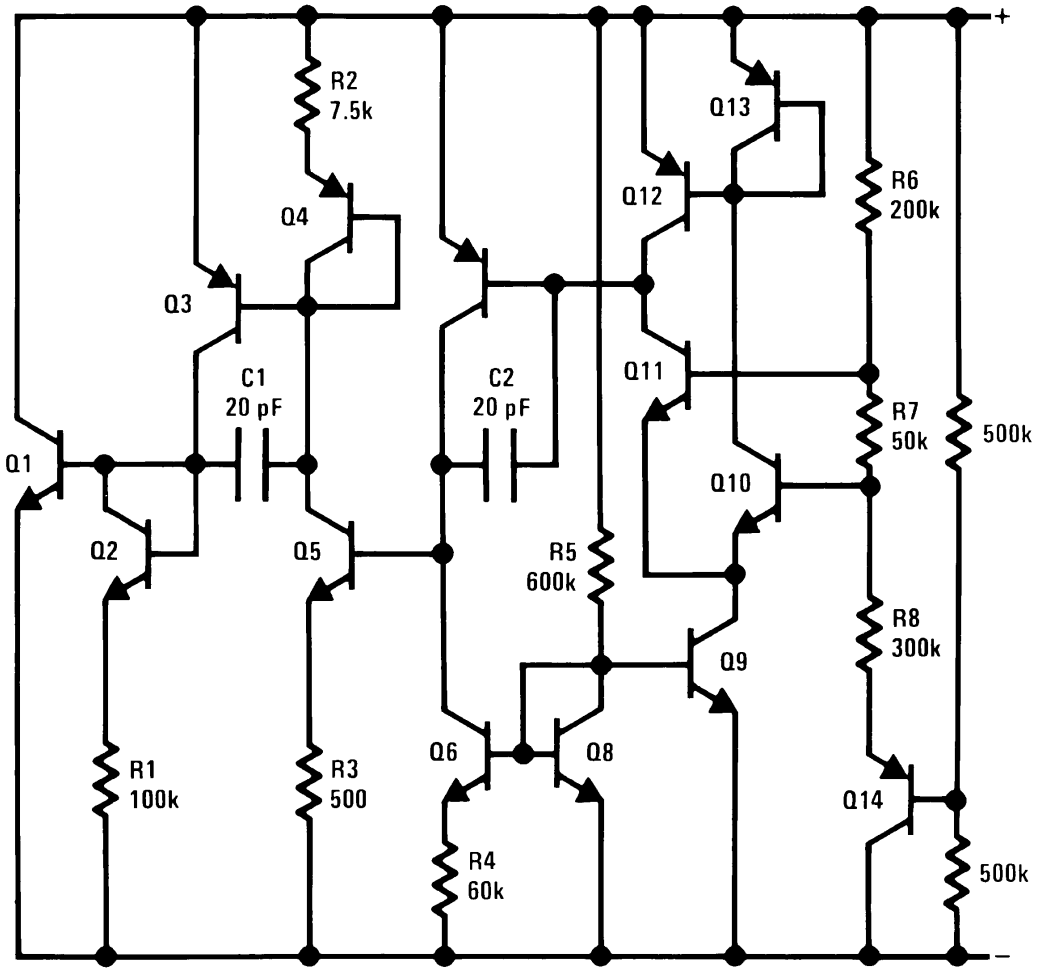


Figure 23. Improving Regulation of Adjstable Regulators

Schematic Diagram



REVISION HISTORY

Changes from Revision C (March 2013) to Revision D	Page
• Changed layout of National Data Sheet to TI format	9

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
LM185BXH-2.5	ACTIVE	TO	NDU	2	1000	TBD	Call TI	Call TI	-55 to 125	LM185BXH2.5	Samples
LM185BXH-2.5/NOPB	ACTIVE	TO	NDU	2	1000	Green (RoHS & no Sb/Br)	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM185BXH2.5	Samples
LM185BYH-2.5	ACTIVE	TO	NDU	2	1000	TBD	Call TI	Call TI	-55 to 125	LM185BYH2.5	Samples
LM185BYH-2.5/NOPB	ACTIVE	TO	NDU	2	1000	Green (RoHS & no Sb/Br)	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM185BYH2.5	Samples
LM285BXM-2.5/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	285BX M2.5	Samples
LM285BXMX-2.5/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	285BX M2.5	Samples
LM285BXZ-2.5/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM	-40 to 85	285BX Z2.5	Samples
LM285BYM-2.5/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	285BY M2.5	Samples
LM285BYMX-2.5/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	285BY M2.5	Samples
LM285BYZ-2.5/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM	-40 to 85	285BY Z2.5	Samples
LM285M-2.5/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	LM285 M2.5	Samples
LM285MX-2.5/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	LM285 M2.5	Samples
LM285Z-2.5/LFT7	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM		LM285 Z-2.5	Samples
LM285Z-2.5/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM	-40 to 85	LM285 Z-2.5	Samples
LM385BM-2.5	ACTIVE	SOIC	D	8	95	TBD	Call TI	Call TI	0 to 70	LM385 BM2.5	Samples
LM385BM-2.5/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	LM385 BM2.5	Samples
LM385BMX-2.5	ACTIVE	SOIC	D	8	2500	TBD	Call TI	Call TI	0 to 70	LM385 BM2.5	Samples

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
LM385BMX-2.5/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	LM385 BM2.5	Samples
LM385BXM-2.5	ACTIVE	SOIC	D	8	95	TBD	Call TI	Call TI	0 to 70	385BX M2.5	Samples
LM385BXM-2.5/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	385BX M2.5	Samples
LM385BXMX-2.5/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	385BX M2.5	Samples
LM385BXZ-2.5/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM	0 to 70	385BX Z-2.5	Samples
LM385BYM-2.5/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	385BY M2.5	Samples
LM385BYMX-2.5/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	385BY M2.5	Samples
LM385BYZ-2.5/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM	0 to 70	385BY Z-2.5	Samples
LM385BZ-2.5/LFT7	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM		LM385 BZ2.5	Samples
LM385BZ-2.5/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM	0 to 70	LM385 BZ2.5	Samples
LM385M-2.5/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	LM385 M2.5	Samples
LM385M3-2.5	ACTIVE	SOT-23	DBZ	3	1000	TBD	Call TI	Call TI	0 to 70	R12	Samples
LM385M3-2.5/NOPB	ACTIVE	SOT-23	DBZ	3	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	R12	Samples
LM385M3X-2.5	ACTIVE	SOT-23	DBZ	3	3000	TBD	Call TI	Call TI	0 to 70	R12	Samples
LM385M3X-2.5/NOPB	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	R12	Samples
LM385MX-2.5	ACTIVE	SOIC	D	8	2500	TBD	Call TI	Call TI	0 to 70	LM385 M2.5	Samples
LM385MX-2.5/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	LM385 M2.5	Samples
LM385Z-2.5/LFT1	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM		LM385 Z2.5	Samples

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
LM385Z-2.5/LFT2	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM		LM385 Z2.5	Samples
LM385Z-2.5/LFT3	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM		LM385 Z2.5	Samples
LM385Z-2.5/LFT7	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM		LM385 Z2.5	Samples
LM385Z-2.5/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SNCU	Level-1-NA-UNLIM	0 to 70	LM385 Z2.5	Samples

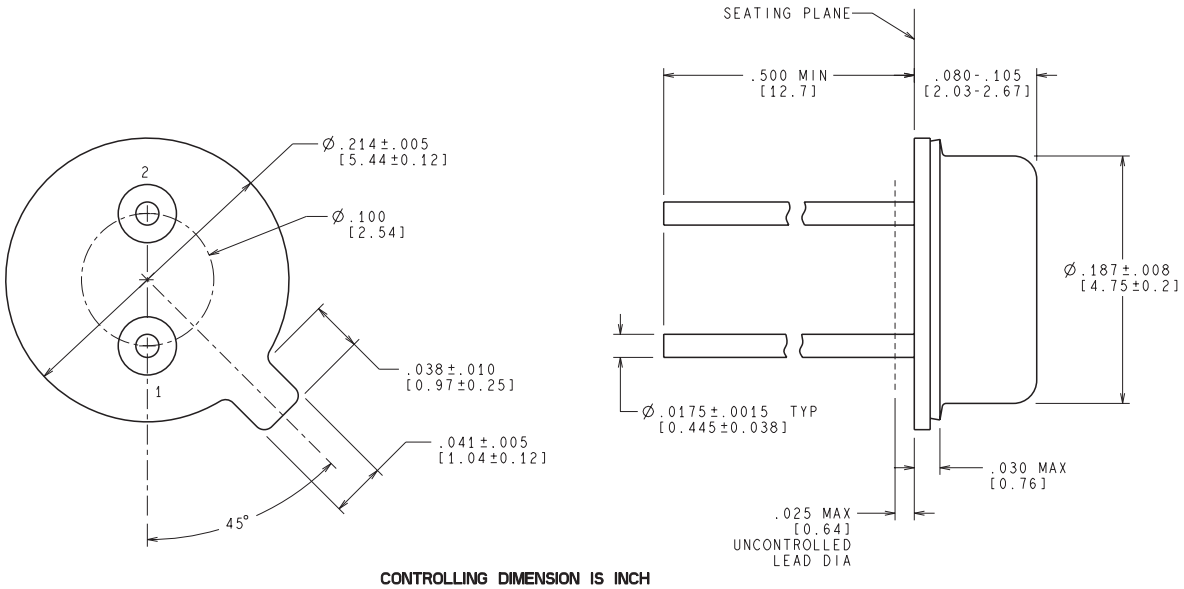
(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, 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) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

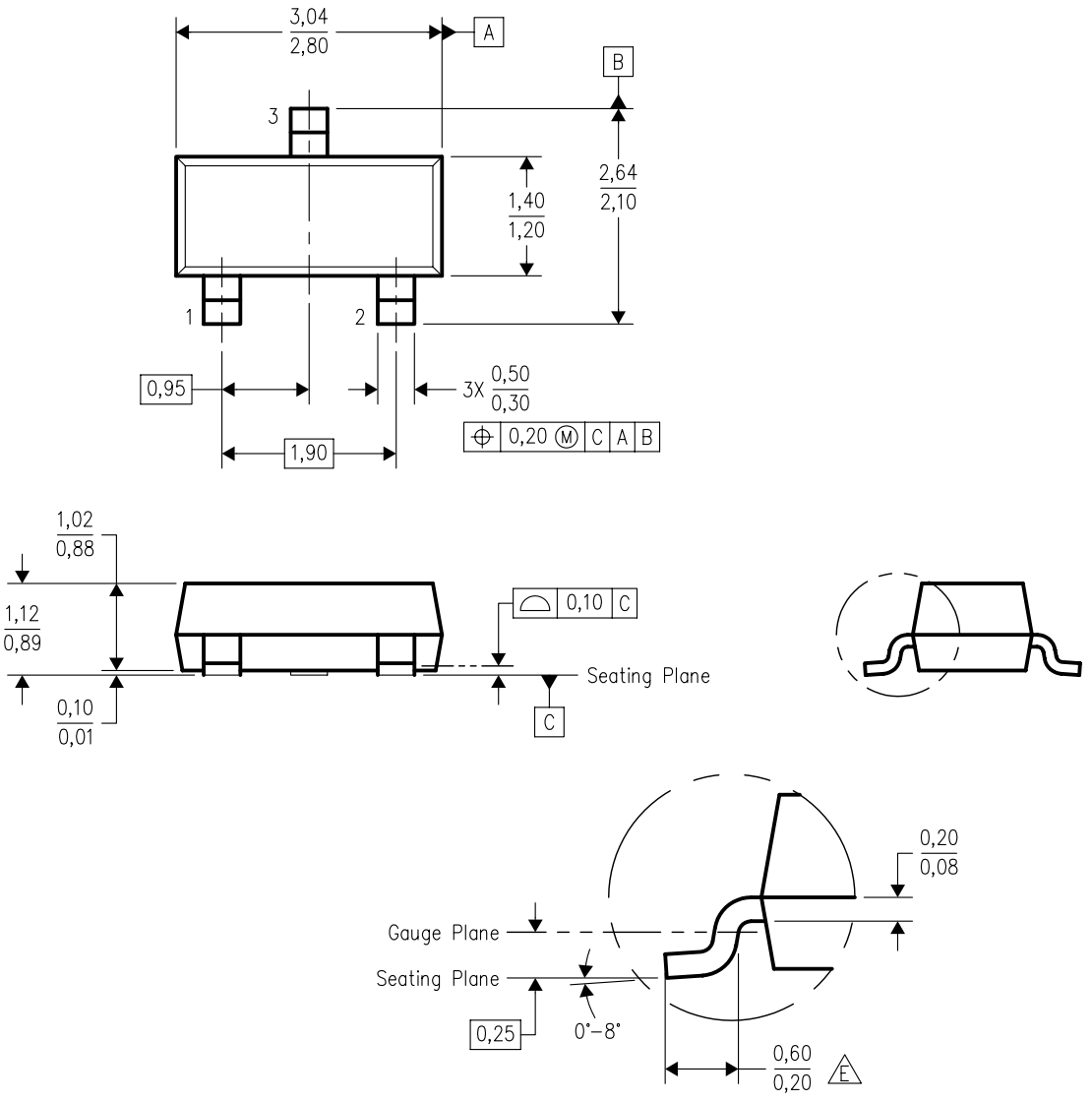
NDU0002A



CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS

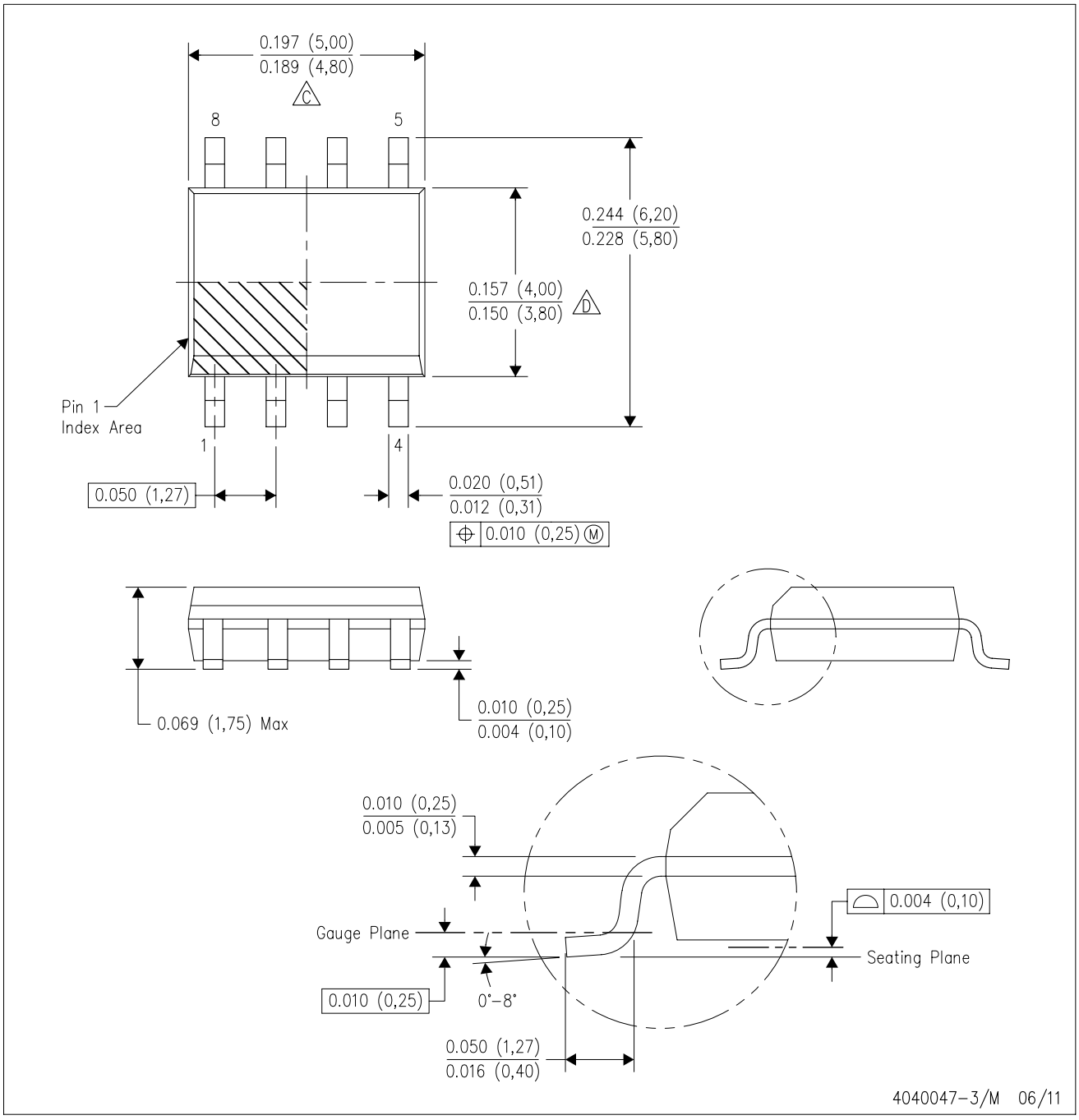
H02A (Rev F)

DBZ (R–PDSO–G3) PLASTIC SMALL–OUTLINE



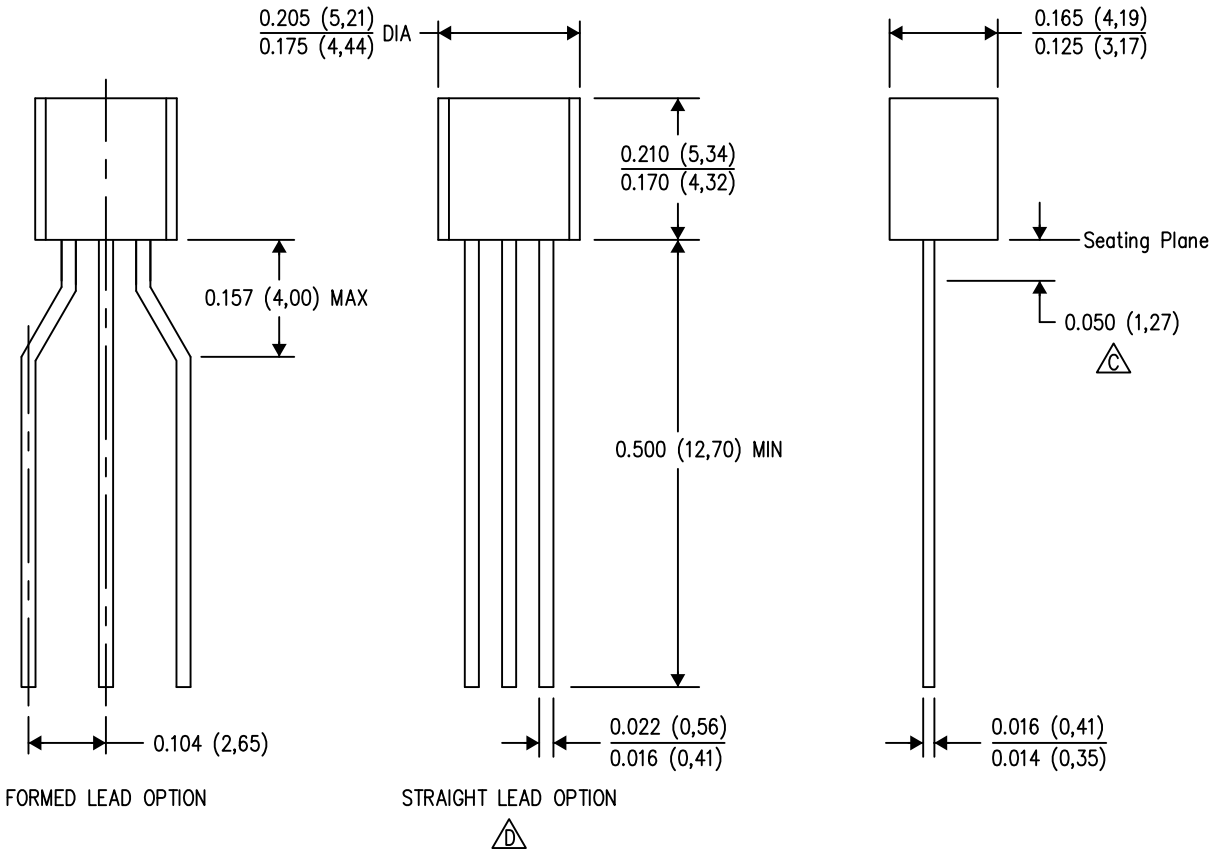
NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. Lead dimensions are inclusive of plating.
D. Body dimensions are exclusive of mold flash and protrusion. Mold flash and protrusion not to exceed 0.25 per side.
E. Falls within JEDEC TO–236 variation AB, except minimum foot length.

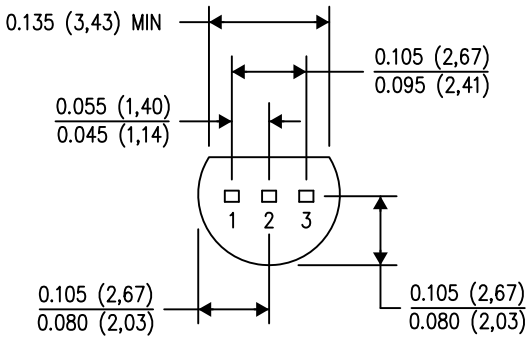
D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AA.

LP (O–PBCY–W3) PLASTIC CYLINDRICAL PACKAGE

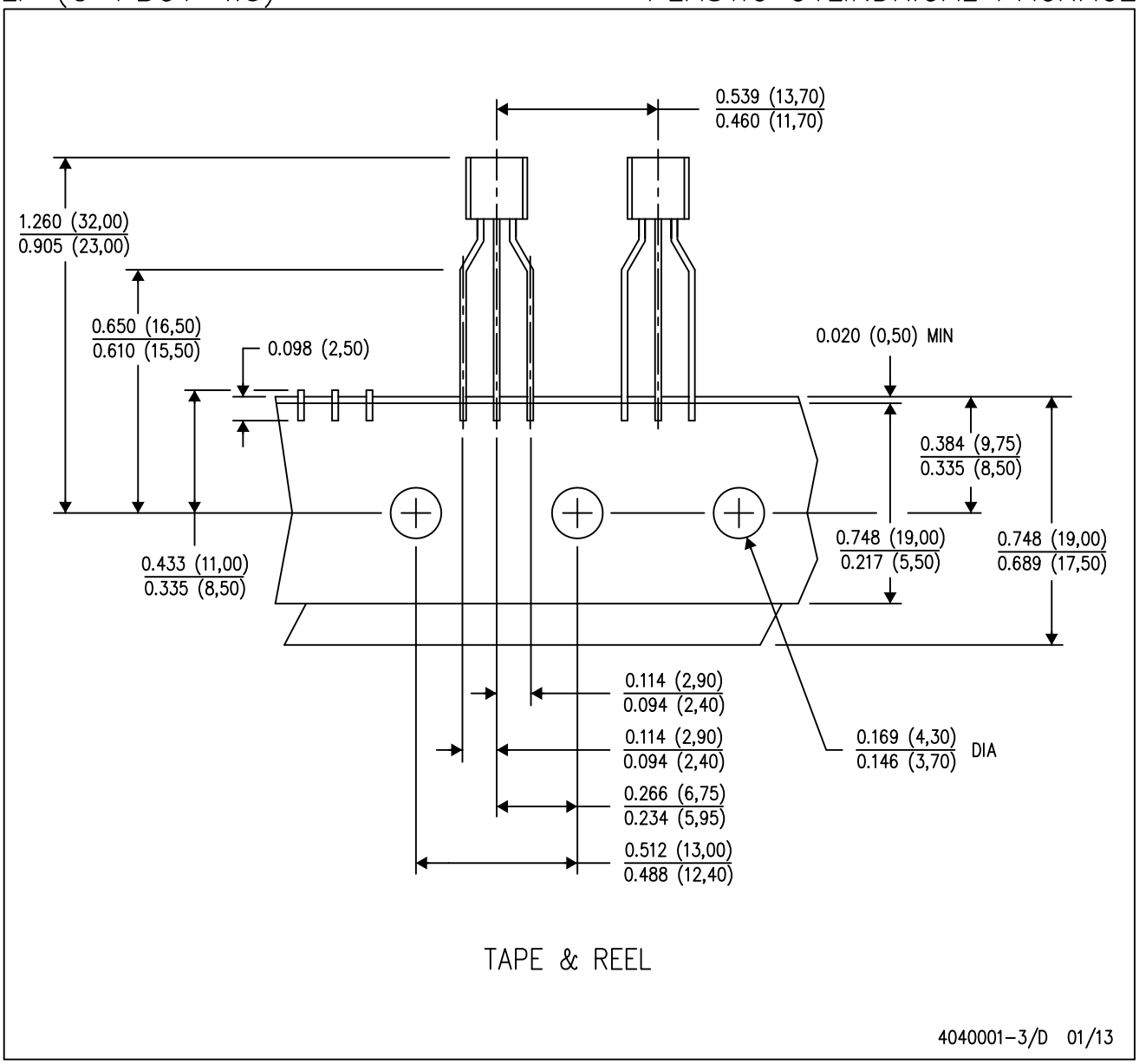




4040001–2/D 01/13

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 either bulk pack or tape & reel.
Formed lead option available in tape & reel or ammo pack.
Specific products can be offered in limited combinations of shipping mediums and lead options.
Consult product folder for more information on available options.

LP (O–PBCY–W3) PLASTIC CYLINDRICAL PACKAGE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Tape and Reel information for the Formed Lead Option package.

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