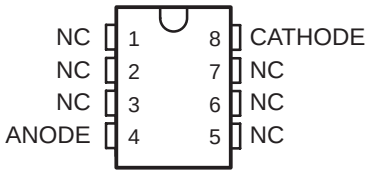
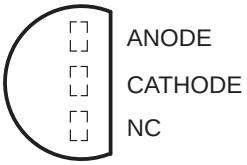
- **Operating Current Range . . . 20 μA to 20 mA**
- **1.5% and 3% Initial Voltage Tolerance**
- **Reference Impedance**
  - **LM385 . . . 1 Ω Max at 25°C**
  - **All Devices . . . 1.5 Ω Max Over Full Temperature Range**
- **Very Low Power Consumption**
- **Applications**
  - **Portable Meter References**
  - **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-μA 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

T_A	V_Z 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	285-25

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

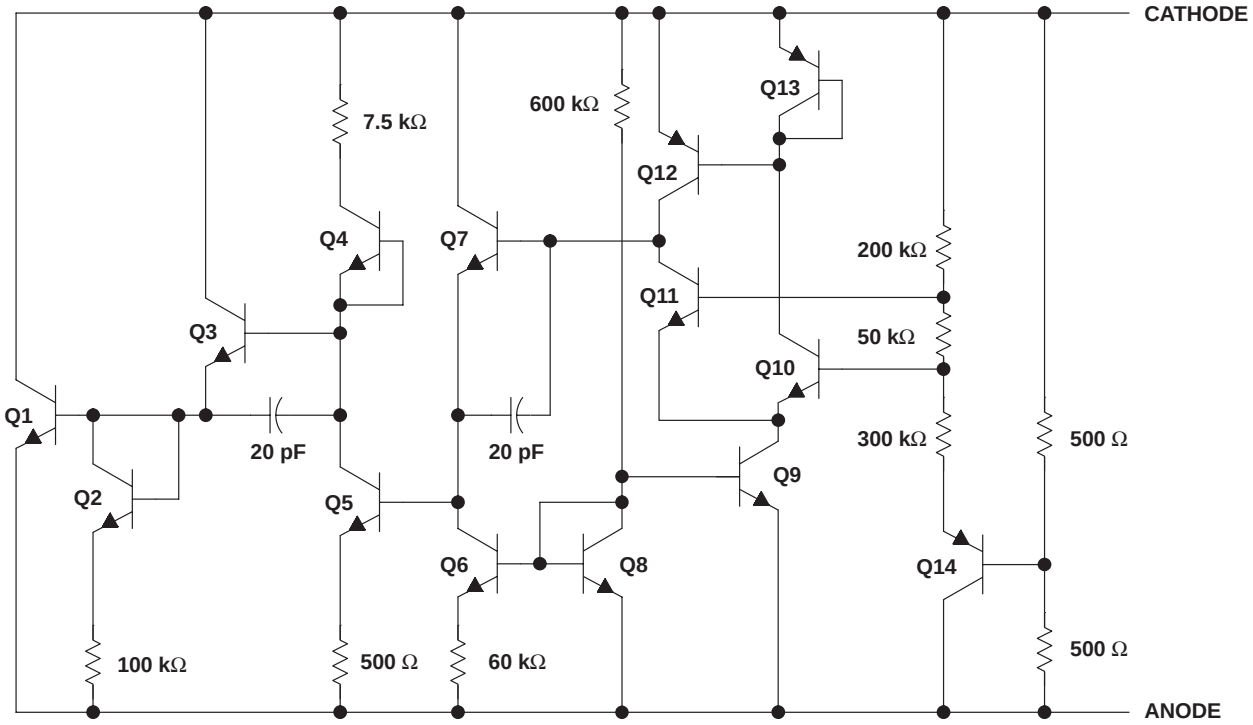
description/ordering information (continued)

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.

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	°C
		LM385-2.5, LM385B-2.5	0	70	

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 µA 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 µA to 20 mA	Full range		±20			±20			±20		ppm/°C
ΔV_Z	Change in reference voltage with current	I_Z = 20 µA to 1 mA	25°C			1			2			2	mV
			Full range			1.5			2			2	
		I_Z = 1 µA 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 µA	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 µA	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 µA, 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.

TYPICAL CHARACTERISTICS†

REVERSE CURRENT vs REVERSE VOLTAGE

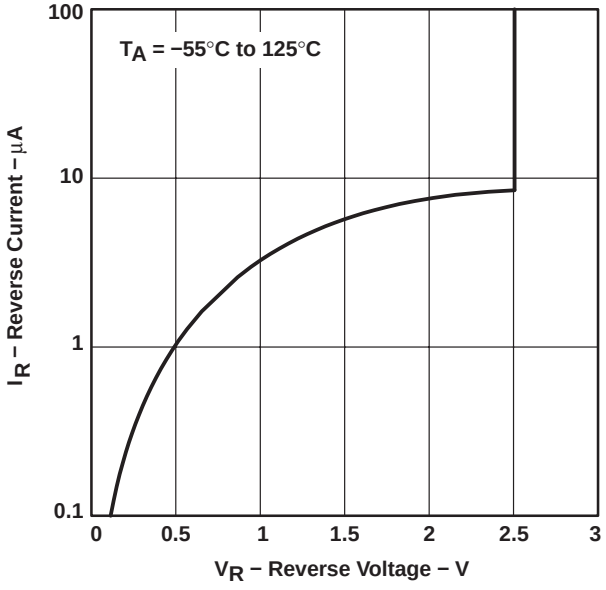


Figure 1

REFERENCE VOLTAGE CHANGE vs REVERSE CURRENT

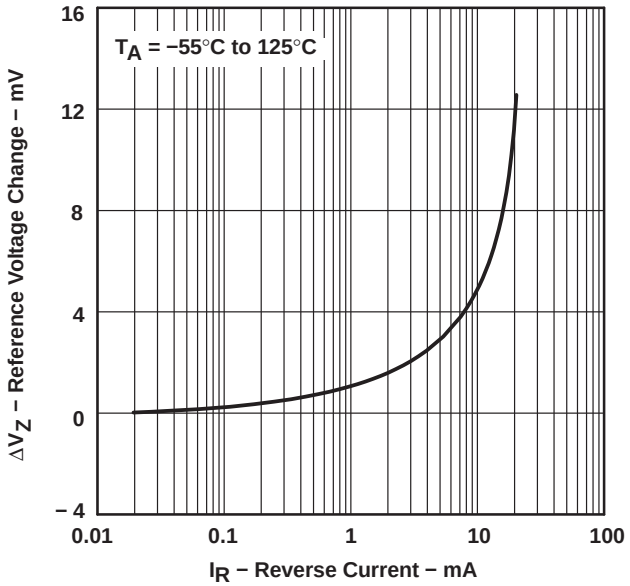


Figure 2

FORWARD VOLTAGE vs FORWARD CURRENT

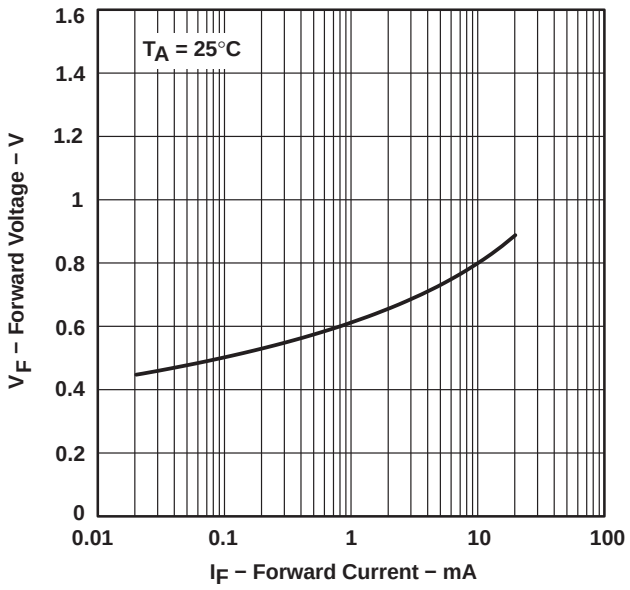


Figure 3

REFERENCE VOLTAGE vs FREE-AIR TEMPERATURE

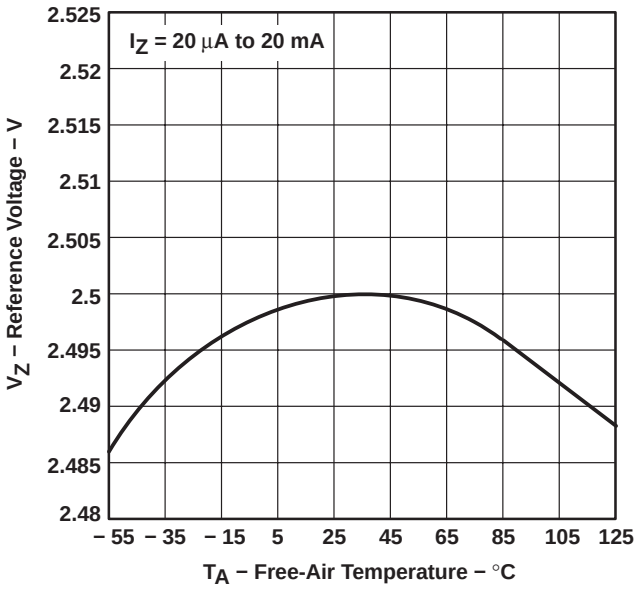


Figure 4

† 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

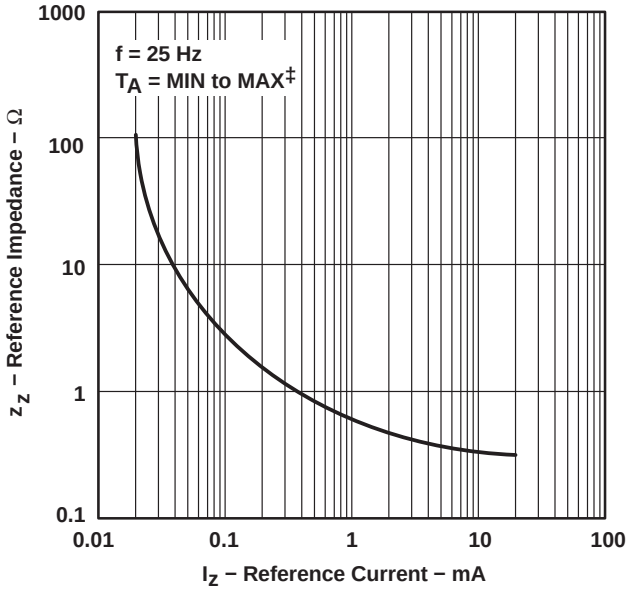


Figure 5

REFERENCE IMPEDANCE vs FREQUENCY

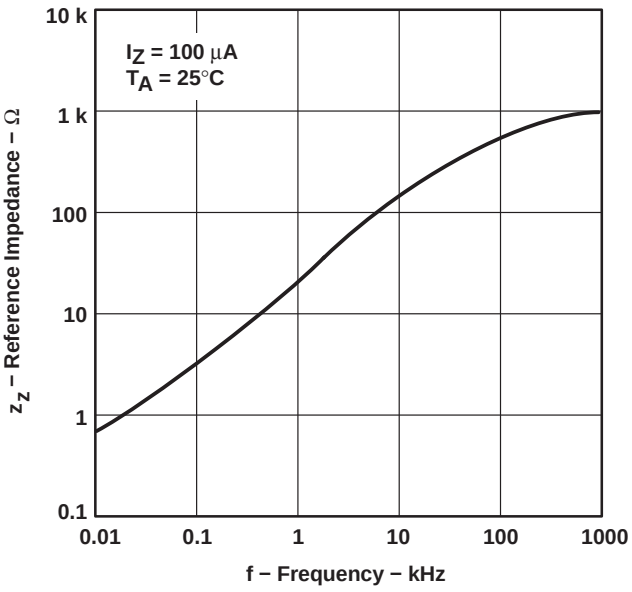


Figure 6

NOISE VOLTAGE vs FREQUENCY

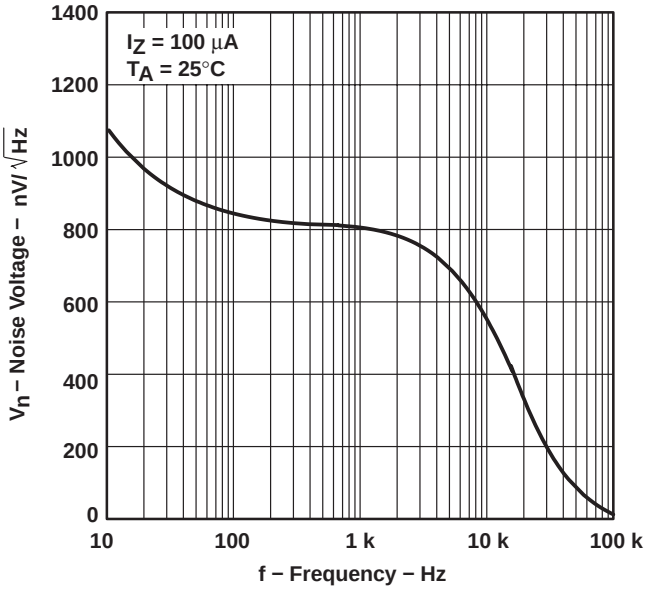


Figure 7

FILTERED RMS OUTPUT NOISE VOLTAGE vs FREQUENCY

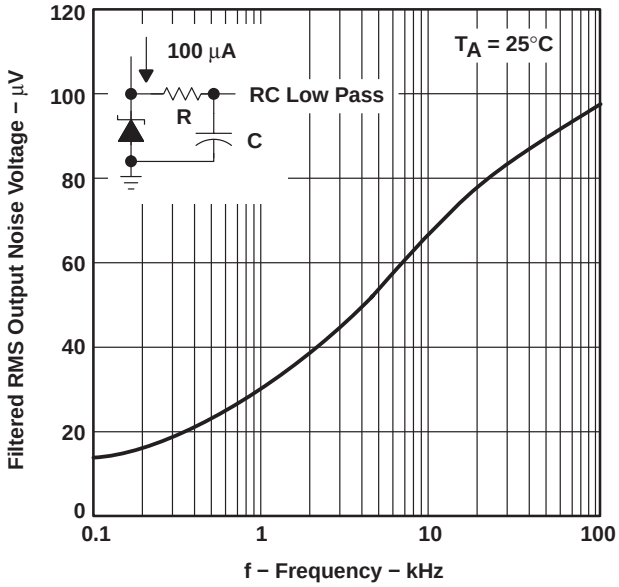


Figure 8

† 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.

TYPICAL CHARACTERISTICS†

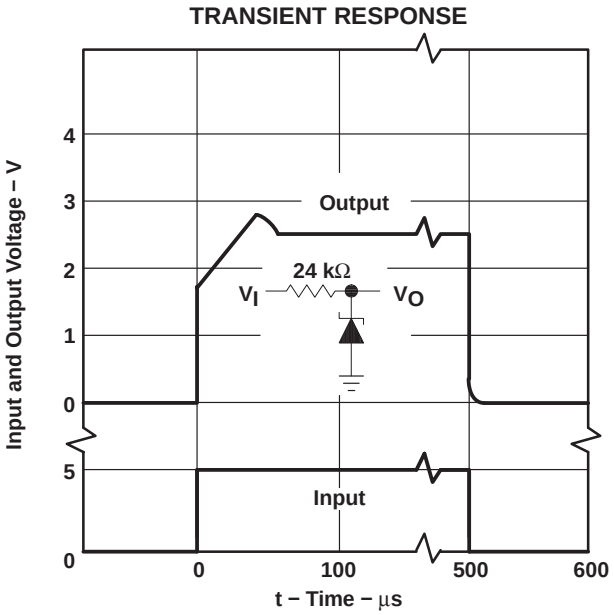
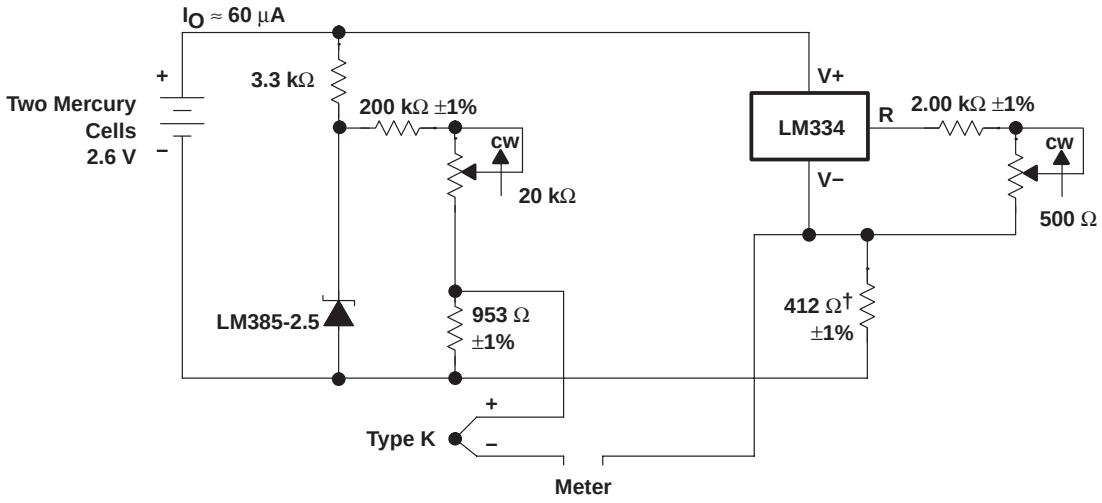


Figure 9

† 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

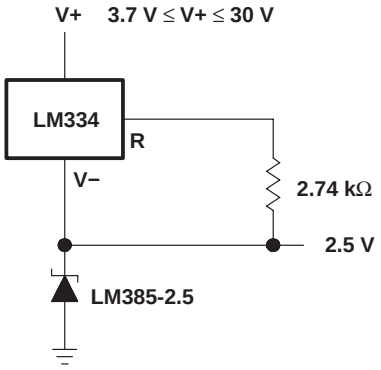


Figure 11. Operation Over a Wide Supply Range

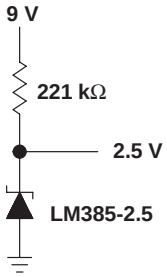


Figure 12. Reference From a 9-V Battery

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	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LM285DR-2-5	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LM285LP-2-5	ACTIVE	TO-92	LP	3	1000	None	Call TI	Level-NC-NC-NC
LM285LPR-2-5	ACTIVE	TO-92	LP	3	2000	None	Call TI	Level-NC-NC-NC
LM385BD-2-5	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LM385BDR-2-5	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LM385BLP-2-5	ACTIVE	TO-92	LP	3	1000	None	Call TI	Level-NC-NC-NC
LM385BLPR-2-5	ACTIVE	TO-92	LP	3	2000	None	Call TI	Level-NC-NC-NC
LM385BPW-2-5	ACTIVE	TSSOP	PW	8	150	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LM385BPWR-2-5	ACTIVE	TSSOP	PW	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LM385D-2-5	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LM385DR-2-5	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LM385LP-2-5	ACTIVE	TO-92	LP	3	1000	None	Call TI	Level-NC-NC-NC
LM385LPR-2-5	ACTIVE	TO-92	LP	3	2000	None	Call TI	Level-NC-NC-NC
LM385PW-2-5	ACTIVE	TSSOP	PW	8	150	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LM385PWR-2-5	ACTIVE	TSSOP	PW	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-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.

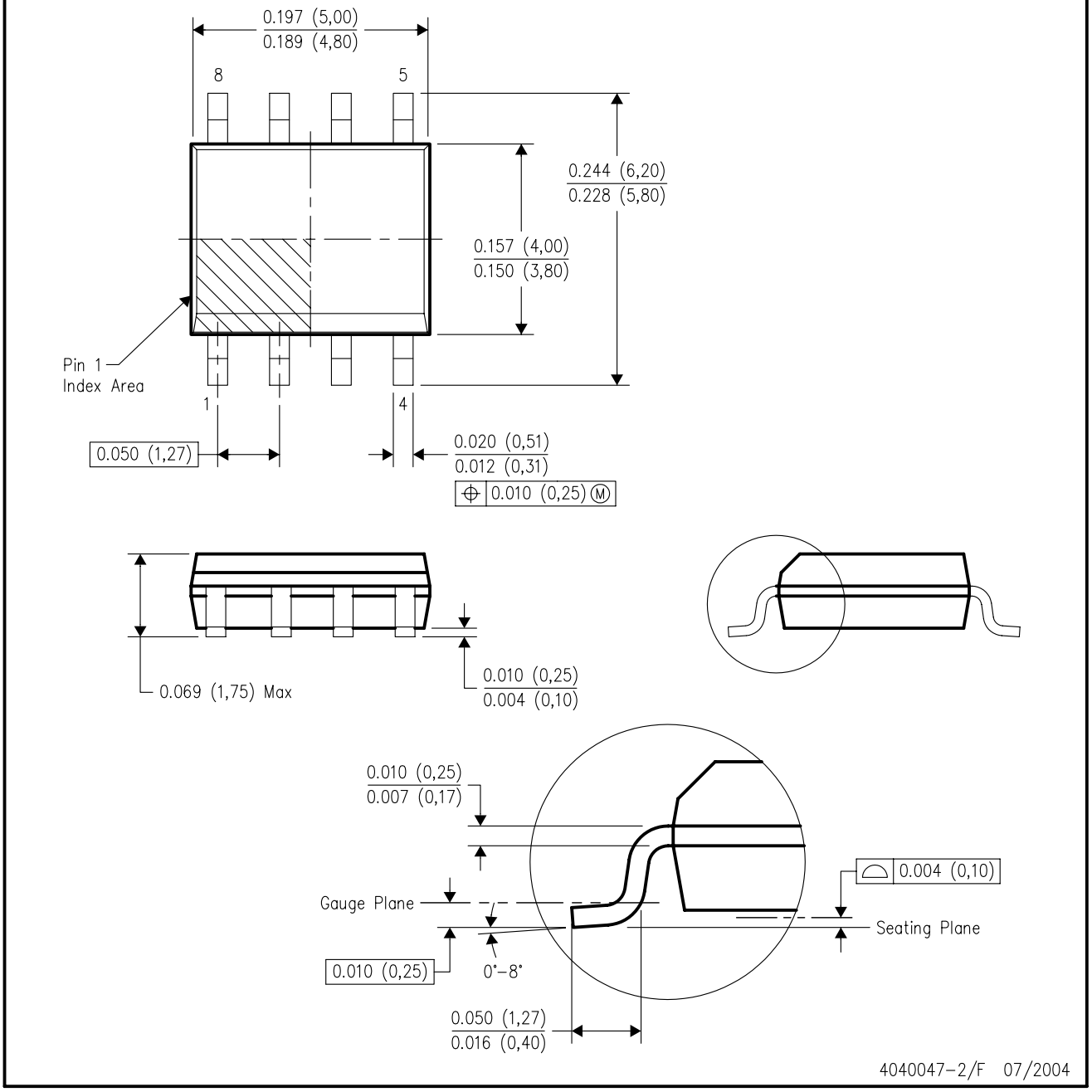
[2] Eco Plan - May not be currently available - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
None: Not yet available Lead (Pb-Free).
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are 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.
Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDECindustry standard classifications, and peak solder temperature.

information may not be available for release.

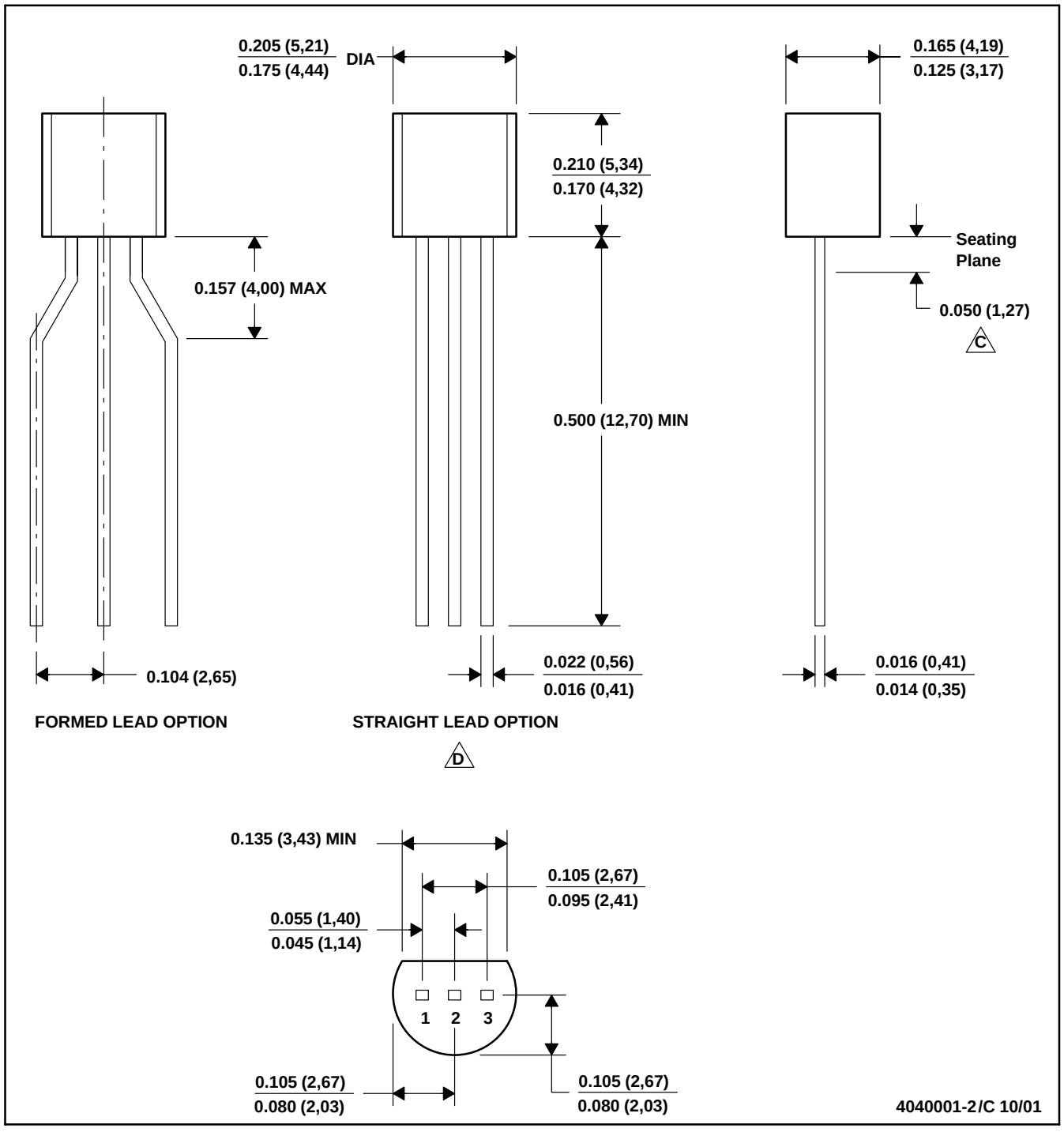
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

D (R–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



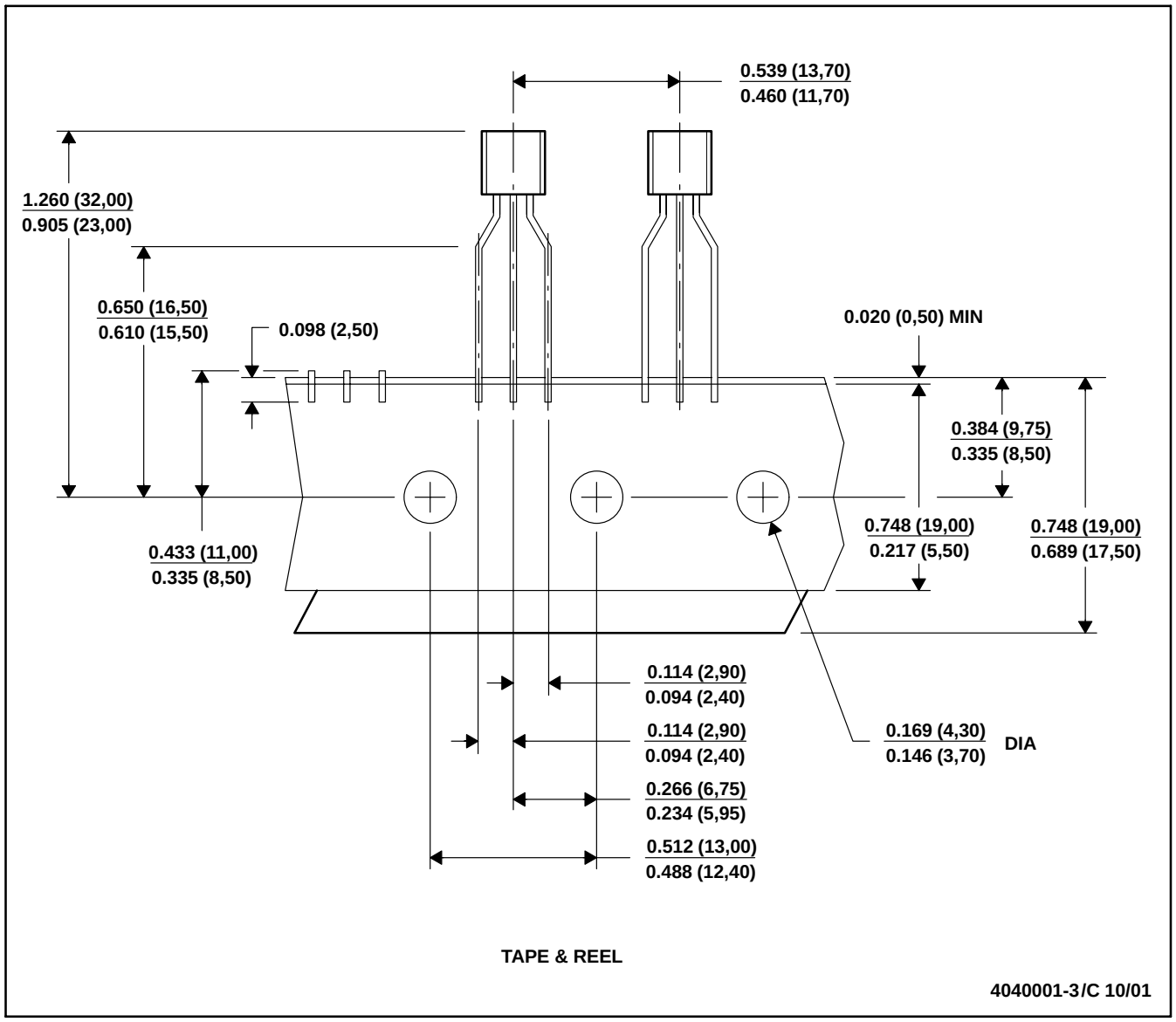
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS–012 variation AA.

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. 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.

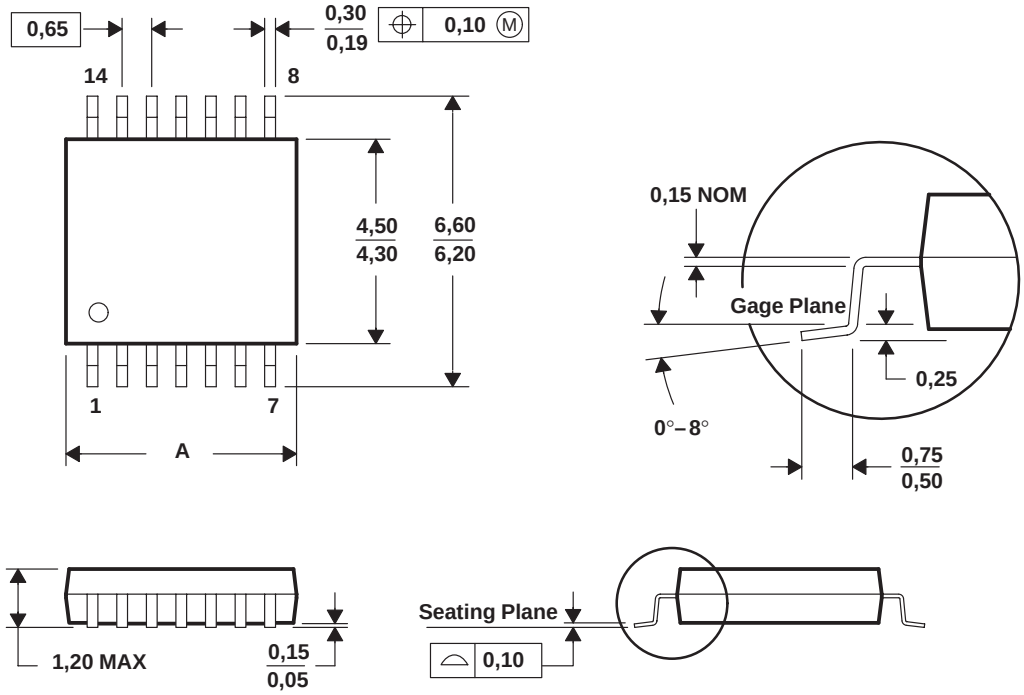
LP (O-PBCY-W3) **PLASTIC CYLINDRICAL PACKAGE**



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 Format Lead Option package.

PW (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PINS SHOWN



DIM \ PINS **	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

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

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