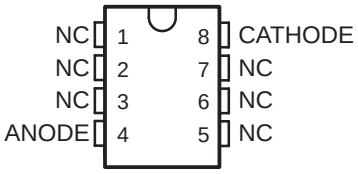
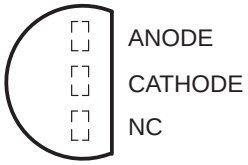
- **Operating Current Range**
  - **LM285 . . . 10 μA to 20 mA**
  - **LM385 . . . 15 μA to 20 mA**
  - **LM385B . . . 15 μA to 20 mA**
- **1% and 2% Initial Voltage Tolerance**
- **Reference Impedance**
  - **LM385 . . . 1 Ω Max at 25°C**
  - **All Devices . . . 1.5 Ω Max Over Full Temperature Range**
- **Very Low Power Consumption**
- **Applications**
  - **Portable Meter References**
  - **Portable Test Instruments**
  - **Battery-Operated Systems**
  - **Current-Loop Instrumentation**
  - **Panel Meters**
- **Interchangeable With Industry Standard LM285-1.2 and LM385-1.2**

LM285-1.2 . . . D PACKAGE
LM385-1.2 . . . D, PS, OR PW PACKAGE
LM385B-1.2 . . . D OR PW PACKAGE
(TOP VIEW)



NC − No internal connection

LM285-1.2, LM385-1.2, LM385B-1.2 . . . LP PACKAGE
(TOP VIEW)



NC − No internal connection

description/ordering information

These micropower, two-terminal, band-gap voltage references operate over a 10-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	2%	SOIC (D)	Tube of 75	LM385D-1-2	385-12
			Reel of 2000	LM385DR-1-2	
		SOP (PS)	Reel of 2000	LM385PSR-1-2	L385-12
		TO-226 / TO-92 (LP)	Tube of 1000	LM385LP-1-2	385-12
			Reel of 2000	LM385LPR-1-2	
		TSSOP (PW)	Tube of 150	LM385PW-1-2	385-12
			Reel of 2000	LM385PWR-1-2	
	1%	SOIC (D)	Tube of 75	LM385BD-1-2	385B12
			Reel of 2000	LM385BDR-1-2	
		TO-226 / TO-92 (LP)	Tube of 1000	LM385BLP-1-2	385B12
			Reel of 2000	LM385BLPR-1-2	
		TSSOP (PW)	Tube of 150	LM385BPW-1-2	385B12
			Reel of 2000	LM385BPWR-1-2	
−40°C to 85°C	1%	SOIC (D)	Tube of 75	LM285D-1-2	285-12
			Reel of 2000	LM285DR-1-2	
		TO-226 / TO-92 (LP)	Tube of 1000	LM285LP-1-2	285-12

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

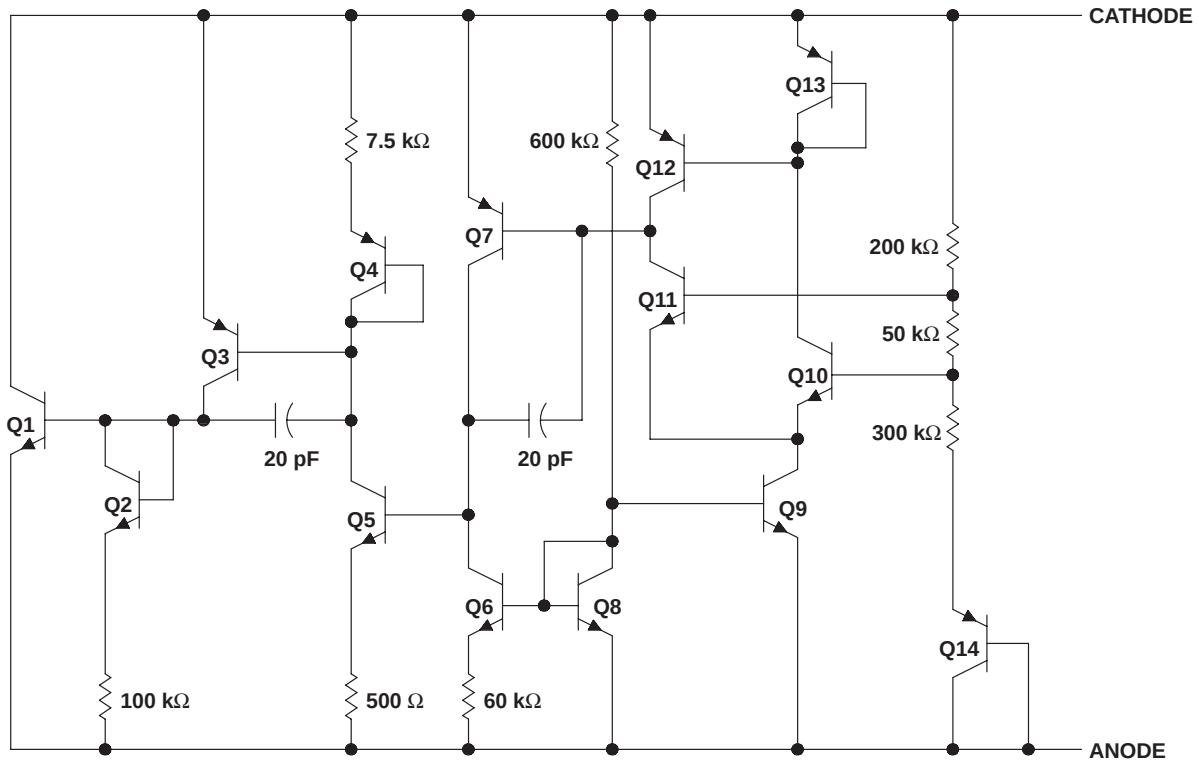
description/ordering information (continued)

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: 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
PS package . . . . . 95°C/W
PW package . . . . . 149°C/W
Operating virtual junction temperature, T_J . . . . . 150°C
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		0.01	20	mA
T_A	Operating free-air temperature range	LM285-1.2	−40	85	°C
		LM385-1.2, LM385B-1.2	0	70	

electrical characteristics at specified free-air temperature

PARAMETER		TEST CONDITIONS	T_A†	LM285-1.2			LM385-1.2			LM385B-1.2			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reference voltage	I_Z = I(min) to 20 mA‡	25°C	1.223	1.235	1.247	1.21	1.235	1.26	1.223	1.235	1.247	V
α_{VZ}	Average temperature coefficient of reference voltage§	I_Z = I(min) to 20 mA‡	Full range		±20			±20			±20		ppm/°C
ΔV_Z	Change in reference voltage with current	I_Z = I(min) to 1 mA‡	25°C			1			1			1	mV
			Full range			1.5			1.5			1.5	
		I_Z = 1 mA to 20 mA	25°C			12			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	10		8	15		8	15	μA
z_z	Reference impedance	I_Z = 100 μA, f = 25 Hz	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		60			60			60		μV

† Full range is −40°C to 85°C for the LM285-1.2 and 0°C to 70°C for the LM385-1.2 and LM385B-1.2.
‡ I(min) = 10 μA for the LM285-1.2 and 15 μA for the LM385-1.2 and LM385B-1.2
§ 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

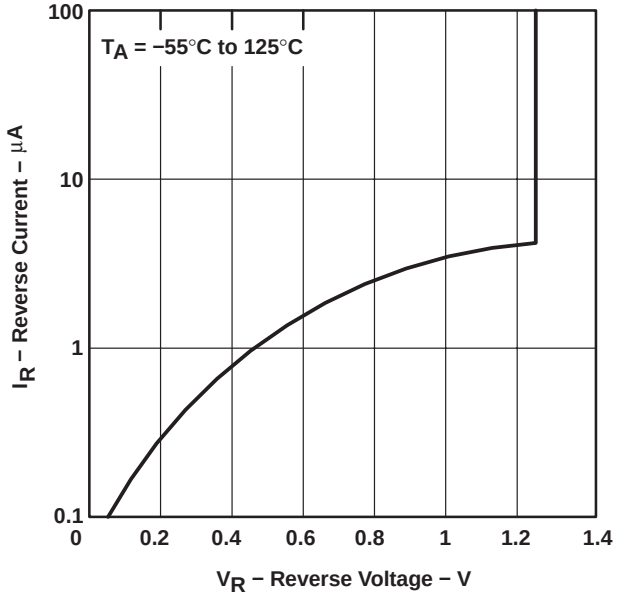


Figure 1

REFERENCE VOLTAGE CHANGE vs REVERSE CURRENT

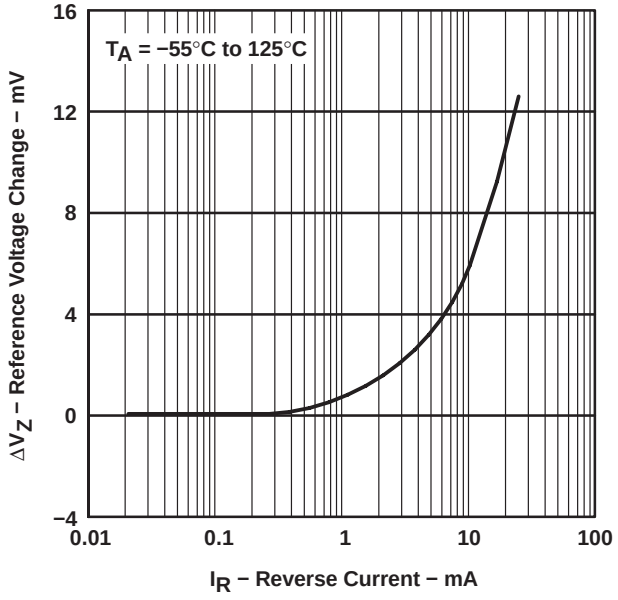


Figure 2

FORWARD VOLTAGE vs FORWARD CURRENT

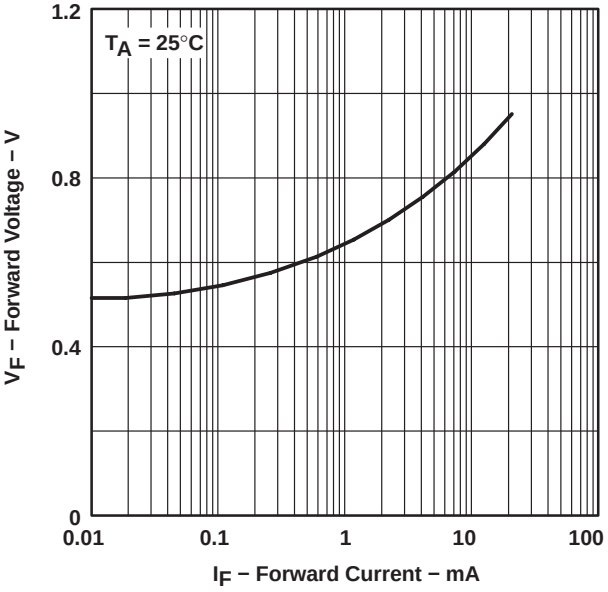


Figure 3

REFERENCE VOLTAGE vs FREE-AIR TEMPERATURE

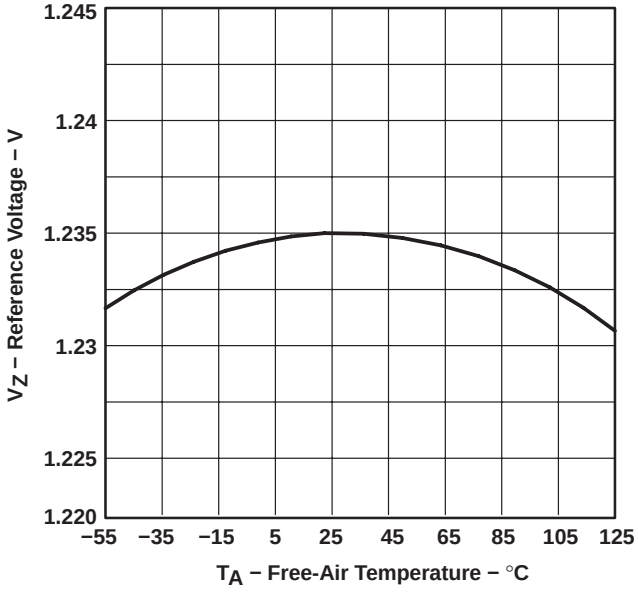


Figure 4

† 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

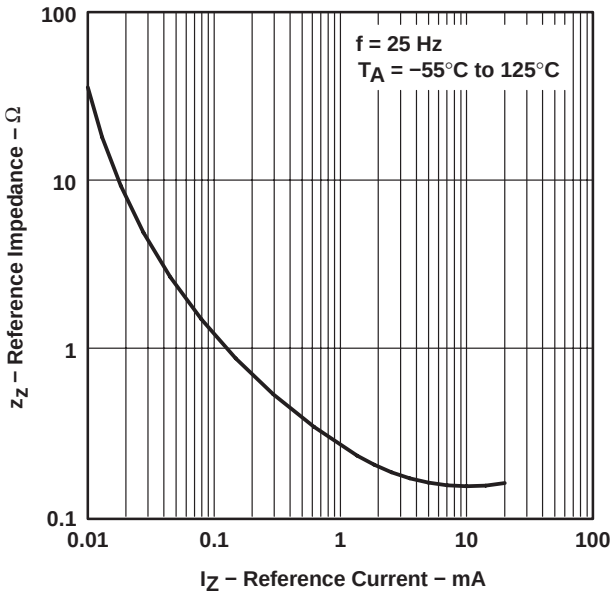


Figure 5

NOISE VOLTAGE vs FREQUENCY

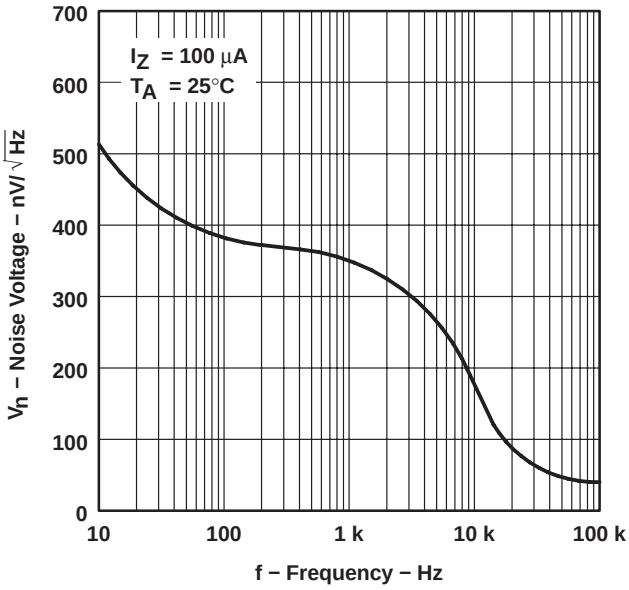


Figure 6

OUTPUT NOISE VOLTAGE vs CUTOFF FREQUENCY

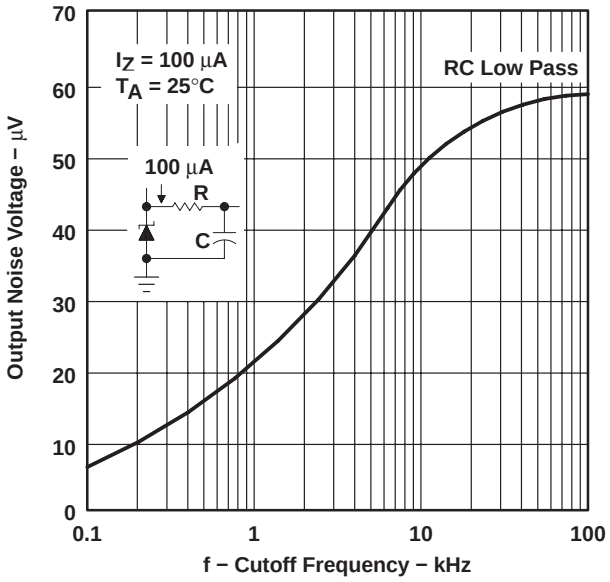


Figure 7

TRANSIENT RESPONSE

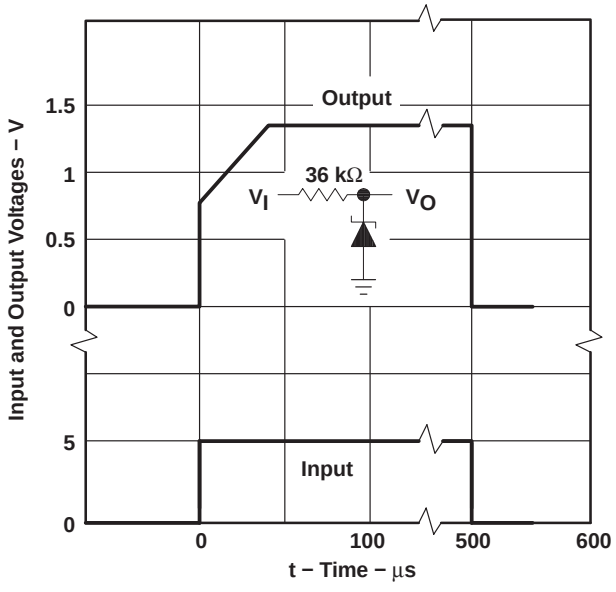
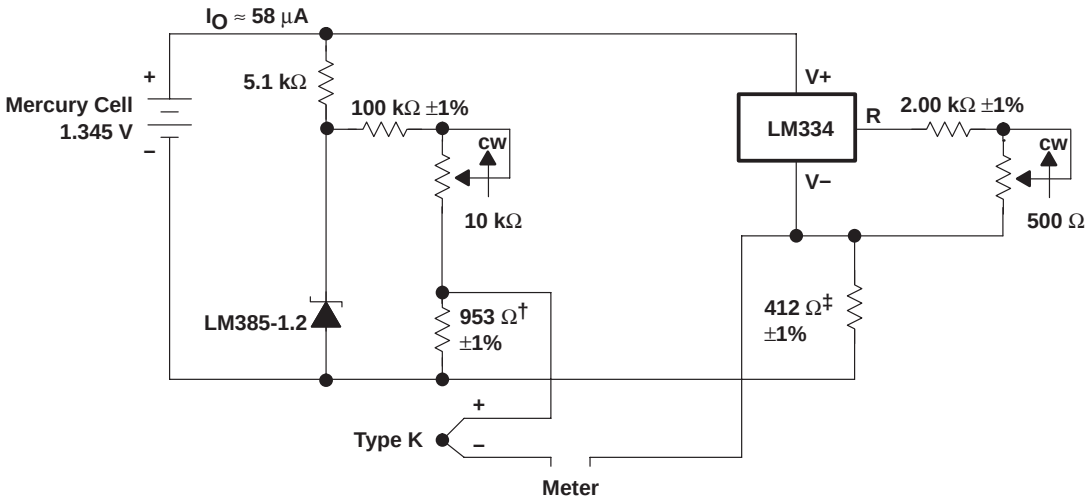


Figure 8

† 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 11.15 mV at 25°C across 953 Ω
‡ Adjust for 12.17 mV at 25°C across 412 Ω

Figure 9. Thermocouple Cold-Junction Compensator

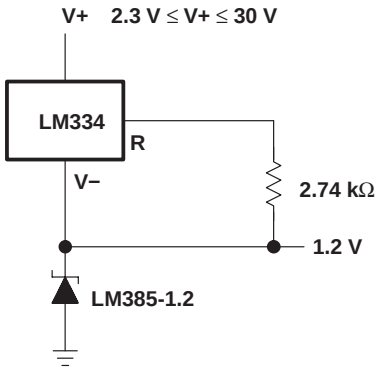


Figure 10. Operation Over a Wide Supply Range

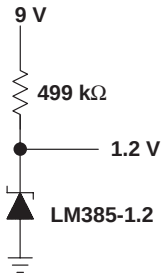


Figure 11. Reference From a 9-V Battery

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM285D-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	285-12	Samples
LM285DE4-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	285-12	Samples
LM285DG4-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	285-12	Samples
LM285DR-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	285-12	Samples
LM285DRE4-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	285-12	Samples
LM285DRG4-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	285-12	Samples
LM285LP-1-2	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	-40 to 85	285-12	Samples
LM285LPE3-1-2	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	-40 to 85	285-12	Samples
LM285LPRE3-1-2	ACTIVE	TO-92	LP	3	2000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	-40 to 85	285-12	Samples
LM385BD-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385B12	Samples
LM385BDE4-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385B12	Samples
LM385BDG4-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385B12	Samples
LM385BDR-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385B12	Samples
LM385BDRG4-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385B12	Samples
LM385BLP-1-2	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	0 to 70	385B12	Samples
LM385BLPE3-1-2	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	0 to 70	385B12	Samples
LM385BLPR-1-2	ACTIVE	TO-92	LP	3	2000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	0 to 70	385B12	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM385BLPRE3-1-2	ACTIVE	TO-92	LP	3	2000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	0 to 70	385B12	Samples
LM385BPW-1-2	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385B12	Samples
LM385BPWR-1-2	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385B12	Samples
LM385D-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385-12	Samples
LM385DG4-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385-12	Samples
LM385DR-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385-12	Samples
LM385DRG4-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385-12	Samples
LM385LP-1-2	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	0 to 70	385-12	Samples
LM385LPE3-1-2	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	0 to 70	385-12	Samples
LM385LPR-1-2	ACTIVE	TO-92	LP	3	2000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	0 to 70	385-12	Samples
LM385LPRE3-1-2	ACTIVE	TO-92	LP	3	2000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type	0 to 70	385-12	Samples
LM385PW-1-2	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385-12	Samples
LM385PWE4-1-2	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385-12	Samples
LM385PWR-1-2	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385-12	Samples
LM385PWRE4-1-2	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	385-12	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.

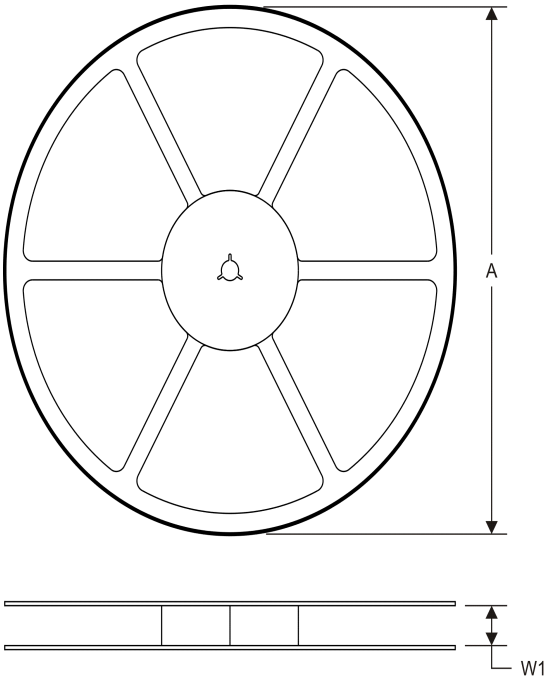
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device 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 Device Marking for that device.

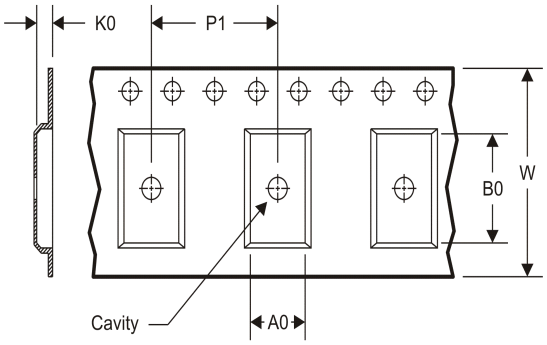
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



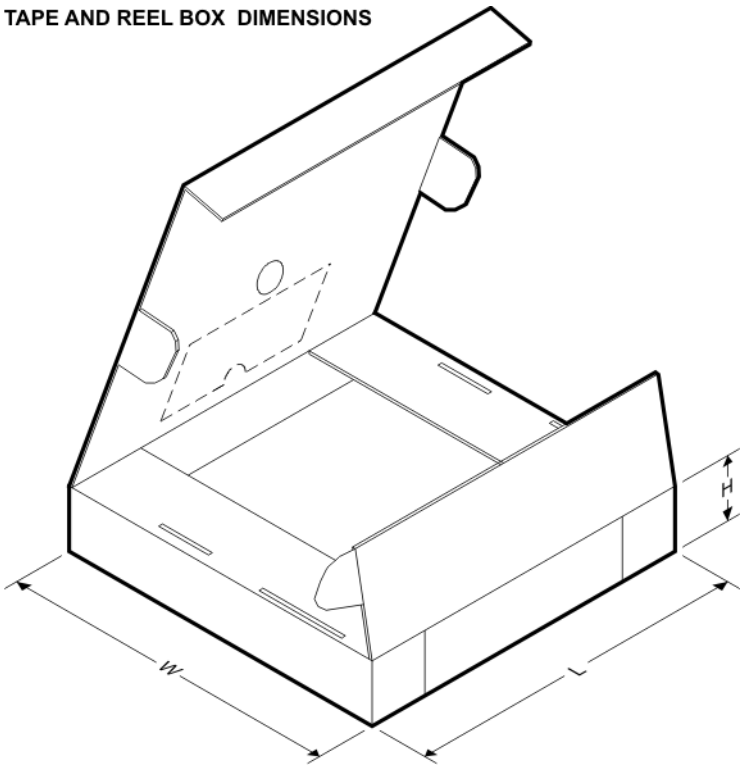
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*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-1-2	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM385BDR-1-2	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM385BPWR-1-2	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM385DR-1-2	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM385PWR-1-2	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1

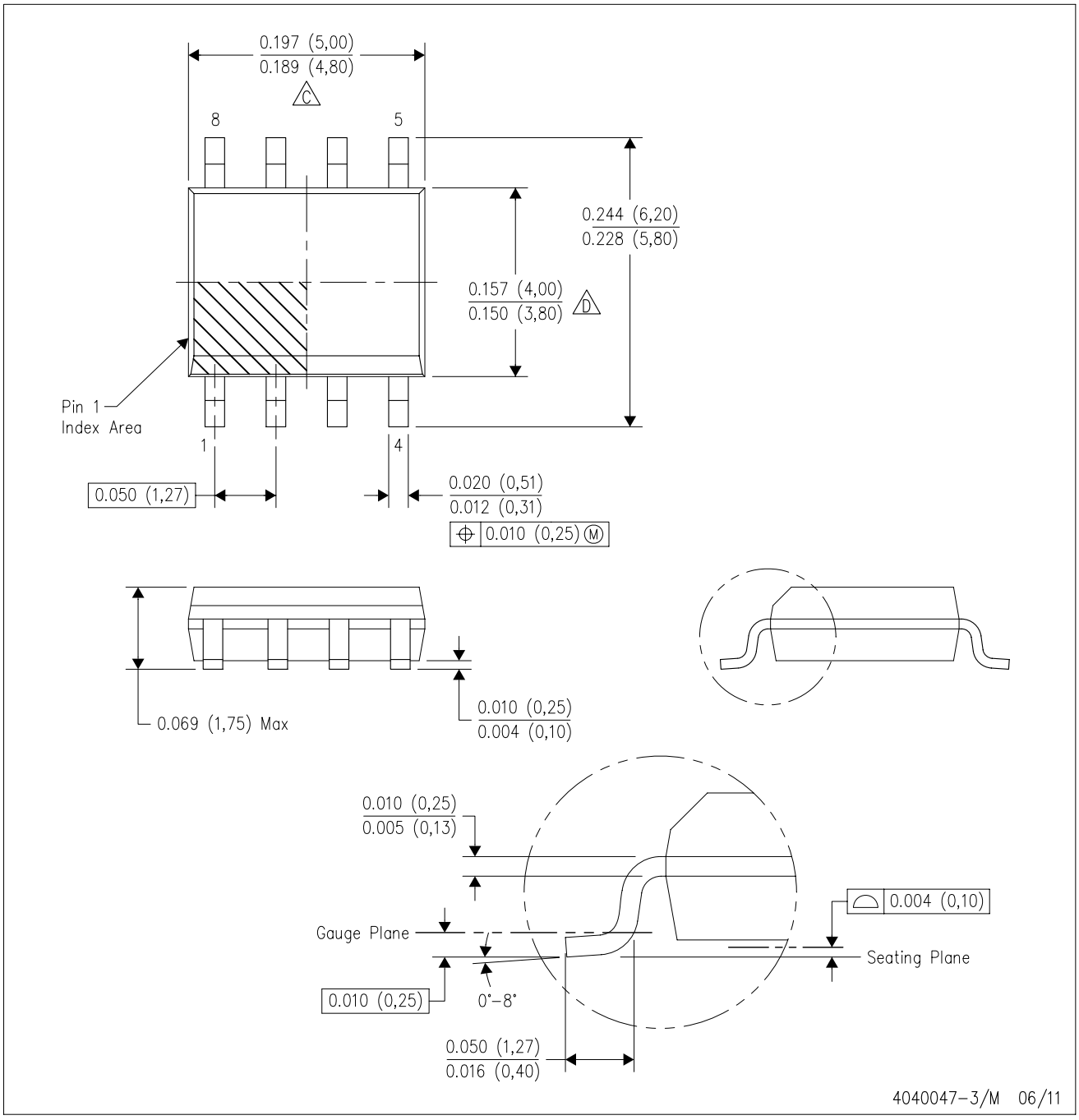
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

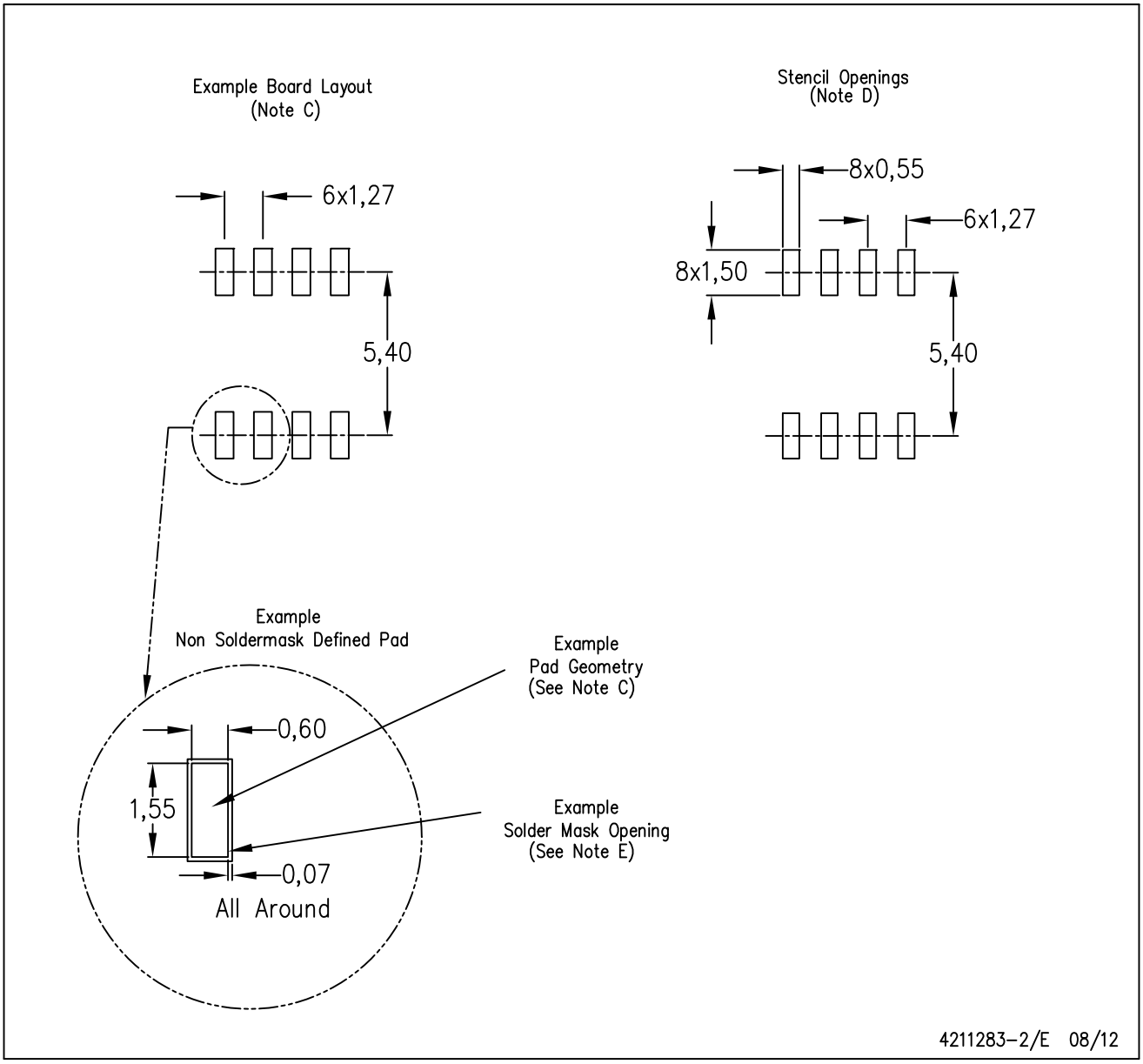
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM285DR-1-2	SOIC	D	8	2500	340.5	338.1	20.6
LM385BDR-1-2	SOIC	D	8	2500	340.5	338.1	20.6
LM385BPWR-1-2	TSSOP	PW	8	2000	367.0	367.0	35.0
LM385DR-1-2	SOIC	D	8	2500	340.5	338.1	20.6
LM385PWR-1-2	TSSOP	PW	8	2000	367.0	367.0	35.0

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



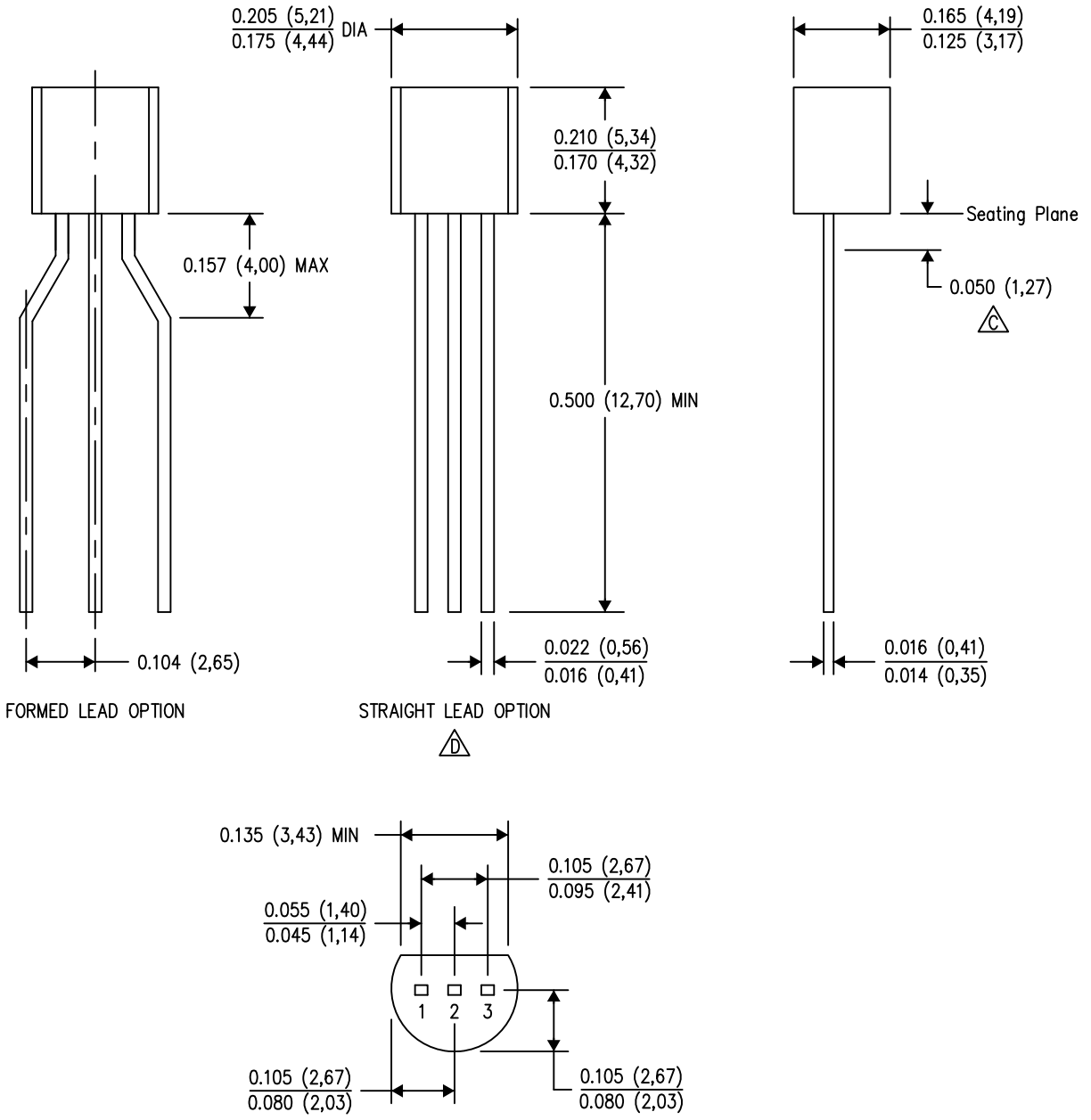
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead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

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



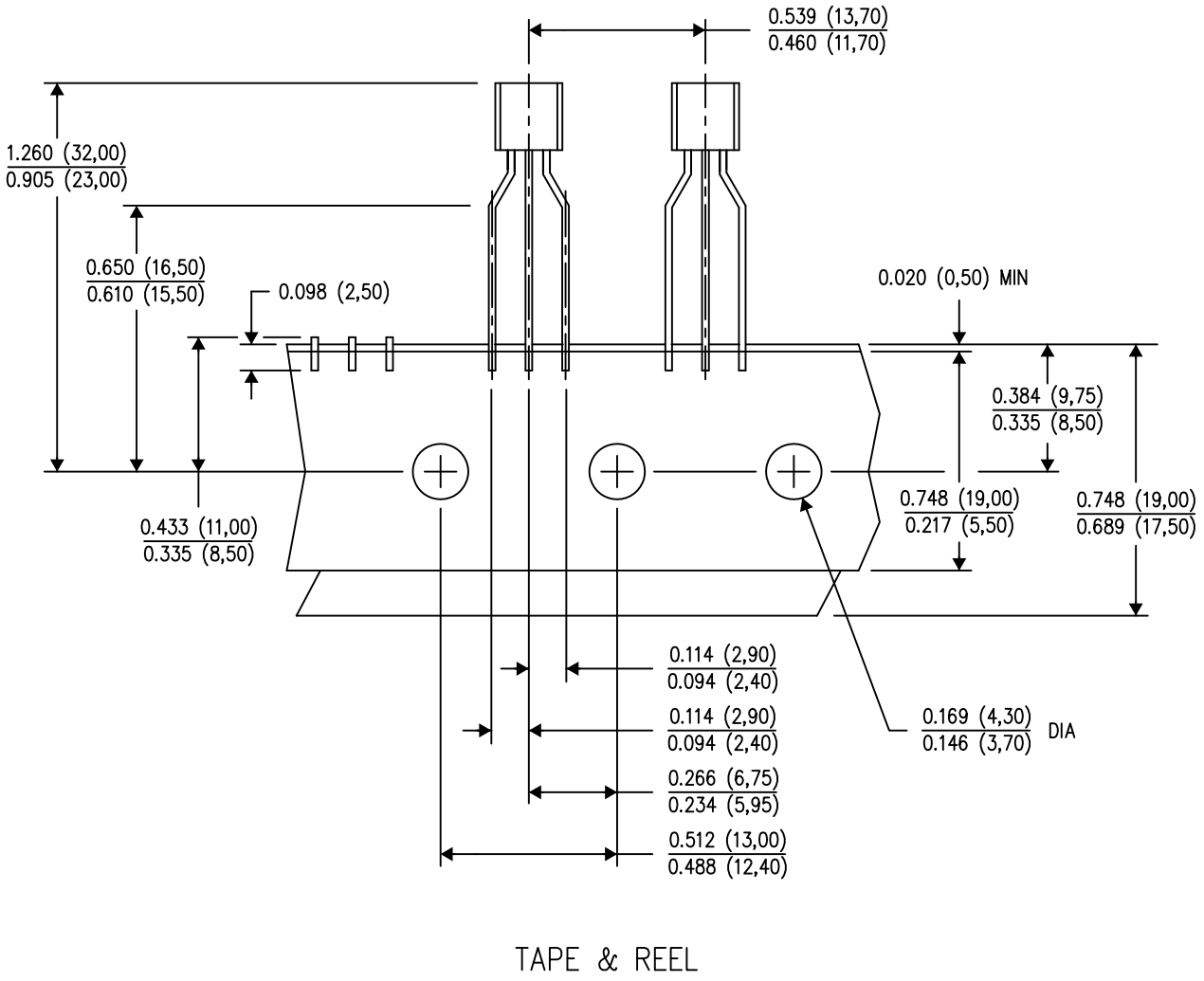
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

LP (O–PBCY–W3) PLASTIC CYLINDRICAL PACKAGE



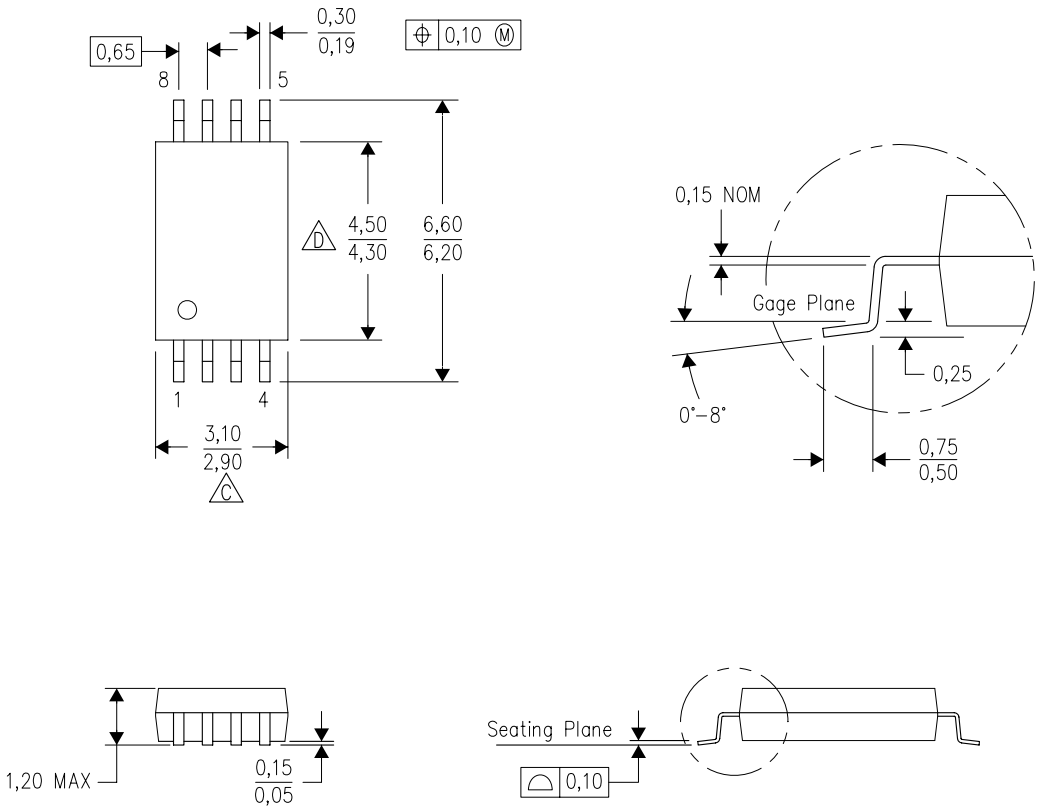
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Lead dimensions are not controlled within this area.
D. Falls within JEDEC TO–226 Variation AA (TO–226 replaces TO–92).
E. Shipping Method:
Straight lead option available in bulk pack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

PW (R–PDSO–G8) PLASTIC SMALL OUTLINE



4040064–2/G 02/11

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. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
E. Falls within JEDEC MO–153

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