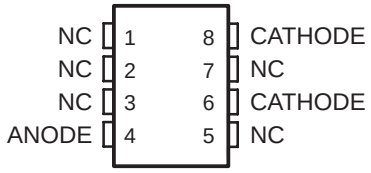
SLVS022K − JANUARY 1989 − REVISED MAY 2005

- **Initial Accuracy**
  - **±4 mV for LT1004-1.2**
  - **±20 mV for LT1004-2.5**
- **Micropower Operation**
- **Operates up to 20 mA**
- **Very Low Reference Impedance**
- **Applications:**
  - **Portable Meter Reference**
  - **Portable Test Instruments**
  - **Battery-Operated Systems**
  - **Current-Loop Instrumentation**

D OR PW PACKAGE
(TOP VIEW)



NC − No internal connection
Terminals 6 and 8 are internally connected.

LP PACKAGE
(TOP VIEW)

NC − No internal connection

description/ordering information

The LT1004 micropower voltage reference is a two-terminal band-gap reference diode designed to provide high accuracy and excellent temperature characteristics at very low operating currents. Optimizing the key parameters in the design, processing, and testing of the device results in specifications previously attainable only with selected units.

The LT1004 is a pin-for-pin replacement for the LM285 and LM385 series of references, with improved specifications. It is an excellent device for use in systems in which accuracy previously was attained at the expense of power consumption and trimming.

The LT1004C is characterized for operation from 0°C to 70°C. The LT1004I is characterized for operation from −40°C to 85°C.

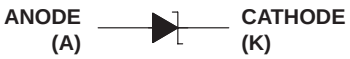
description/ordering information (continued)

ORDERING INFORMATION

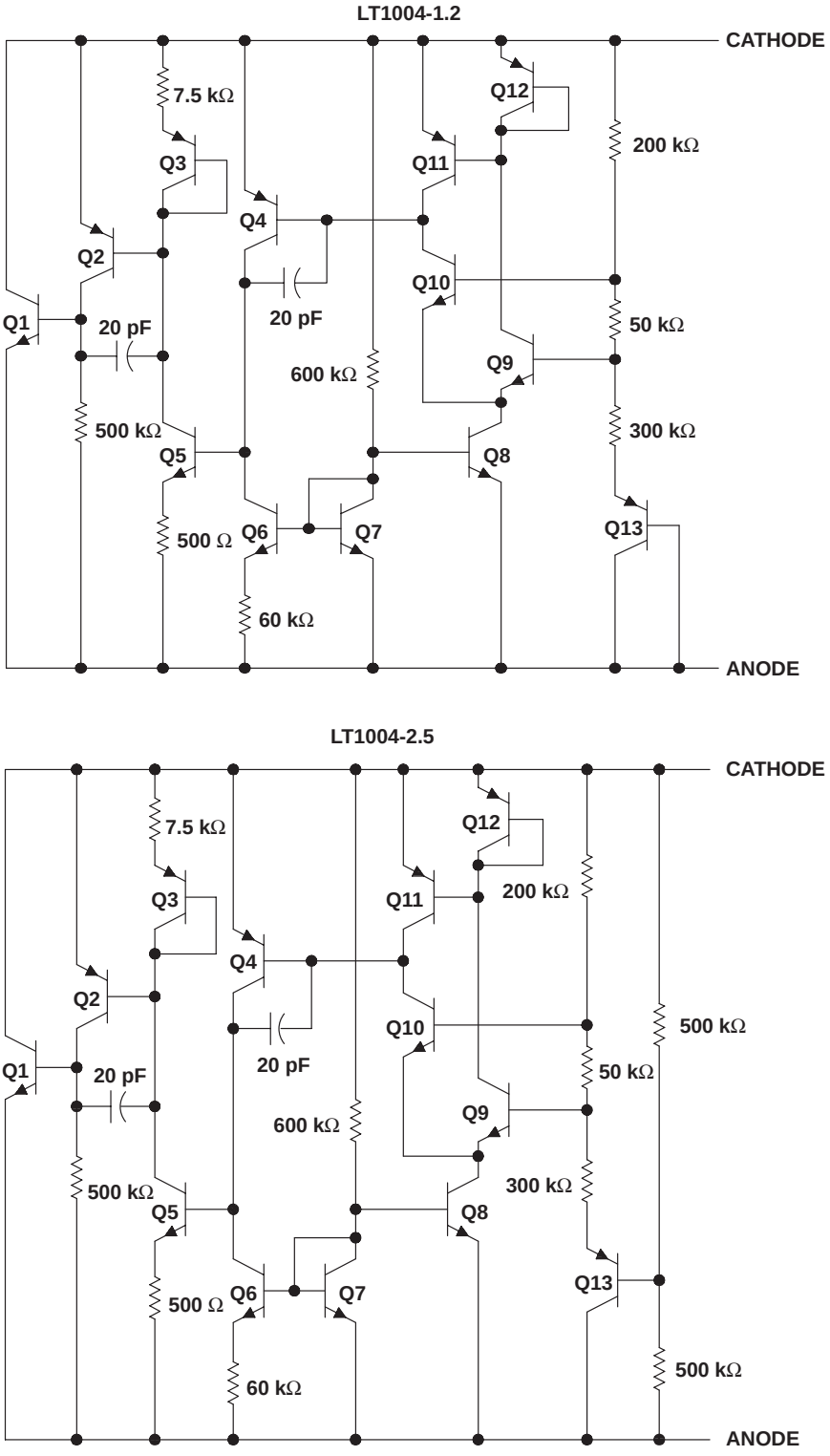
T_A	V_Z TYP	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	1.2 V	SOIC (D)	Tube of 75	LT1004CD-1-2	4C-12
			Reel of 2500	LT1004CDR-1-2	
		TO-226 / TO-92 (LP)	Ammo of 2000, formed lead	LT1004CLPM-1-2	1004C12
			Reel of 2000, formed lead	LT1004CLPR-1-2	
			Bulk of 1000, straight lead	LT1004CLP-1-2	
		TSSOP (PW)	Tube of 150	LT1004CPW-1-2	4C-12
			Reel of 2000	LT1004CPWR-1-2	
	2.5 V	SOIC (D)	Tube of 75	LT1004CD-2-5	4C-25
			Reel of 2500	LT1004CDR-2-5	
		TO-226 / TO-92 (LP)	Ammo of 2000, formed lead	LT1004CLPM-2-5	1004C25
			Reel of 2000, formed lead	LT1004CLPR-2-5	
			Bulk of 1000, straight lead	LT1004CLP-2-5	
		TSSOP (PW)	Tube of 150	LT1004CPW-2-5	4C-25
			Reel of 2000	LT1004CPWR-2-5	
−40°C to 85°C	1.2 V	SOIC (D)	Tube of 75	LT1004ID-1-2	4I-12
			Reel of 2500	LT1004IDR-1-2	
		TO-226 / TO-92 (LP)	Ammo of 2000, formed lead	LT1004ILPM-1-2	1004I12
			Reel of 2000, formed lead	LT1004ILPR-1-2	
			Bulk of 1000, straight lead	LT1004ILP-1-2	
		TSSOP (PW)	Tube of 150	LT1004IPW-1-2	4I-12
			Reel of 2000	LT1004IPWR-1-2	
	2.5 V	SOIC (D)	Tube of 75	LT1004ID-2-5	4I-25
			Reel of 2500	LT1004IDR-2-5	
		TSSOP (PW)	Tube of 150	LT1004IPW-2-5	4I-25
			Reel of 2000	LT1004IPWR-2-5	

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

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
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 $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating 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
T_A	Operating free-air temperature	LT1004C	0	70	°C
		LT1004I	−40	85	

electrical characteristics at specified free-air temperature

PARAMETER		TEST CONDITIONS	T_A‡		LT1004-1.2			LT1004-2.5			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V_Z	Reference voltage	I_Z = 100 µA	25°C		1.231	1.235	1.239	2.48	2.5	2.52	V
			Full range	LT1004C	1.225		1.245	2.47		2.53	
				LT1004I	1.225		1.245	2.47		2.53	
α_{V_Z}	Average temperature coefficient of reference voltage§	I_Z = 10 µA	25°C			20					ppm/°C
		I_Z = 20 µA							20		
ΔV_Z	Change in reference voltage with current	$I_Z = I_Z(min)$ to 1 mA	25°C				1			1	mV
			Full range				1.5			1.5	
		I_Z = 1 mA to 20 mA	25°C				10			10	
			Full range				20			20	
$\Delta V_Z/\Delta t$	Long-term change in reference voltage	I_Z = 100 µA	25°C			20			20		ppm/khr
$I_Z(min)$	Minimum reference current		Full range			8	10		12	20	µA
z_z	Reference impedance	I_Z = 100 µA	25°C			0.2	0.6		0.2	0.6	Ω
			Full range				1.5			1.5	
V_n	Broadband noise voltage	I_Z = 100 µA, f = 10 Hz to 10 kHz	25°C			60			120		µV

‡ Full range is 0°C to 70°C for the LT1004C and −40°C to 85°C for the LT1004I.

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

TYPICAL CHARACTERISTICS

Table of Graphs

GRAPH TITLE	FIGURE
LT1004x-1.2	
Reverse current vs Reverse voltage	1
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Forward voltage vs Forward current	3
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Reference impedance vs Reference current	5
Noise voltage vs Frequency	6
Filtered output noise voltage vs Cutoff frequency	7
LT1004x-2.5	
Transient response	8
Reverse current vs Reverse voltage	9
Forward voltage vs Forward current	10
Reference voltage vs Free-air temperature	11
Reference impedance vs Reference current	12
Noise voltage vs Frequency	13
Filtered output noise voltage vs Cutoff frequency	14
Transient response	15

TYPICAL CHARACTERISTICS†

LT1004x-1.2
REVERSE CURRENT
vs
REVERSE VOLTAGE

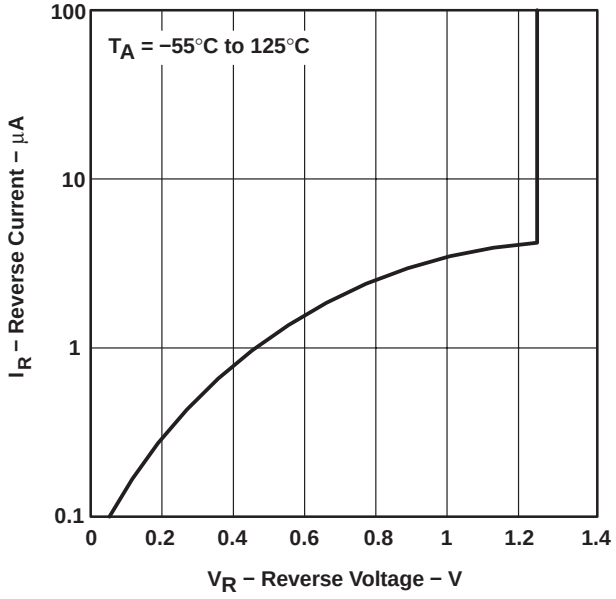


Figure 1

LT1004x-1.2
REFERENCE-VOLTAGE CHANGE
vs
REVERSE CURRENT

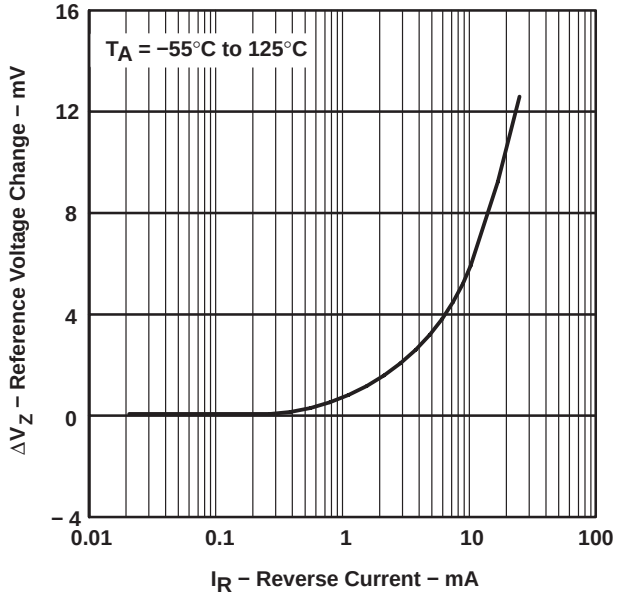


Figure 2

LT1004x-1.2
FORWARD VOLTAGE
vs
FORWARD CURRENT

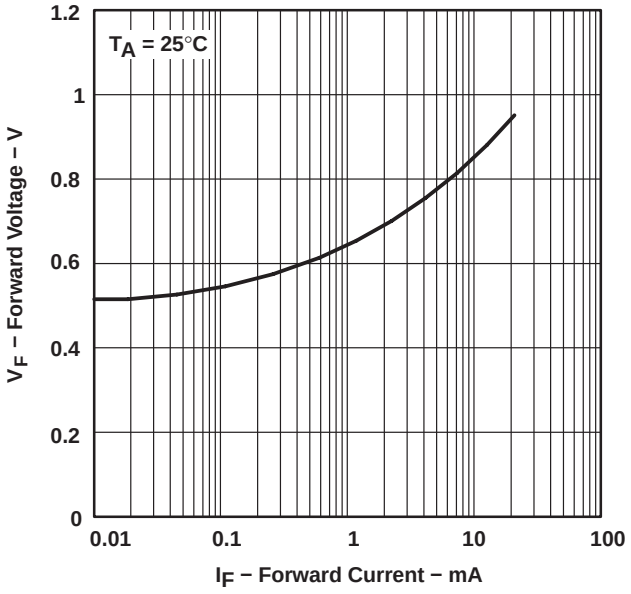


Figure 3

LT1004x-1.2
REFERENCE VOLTAGE
vs
FREE-AIR TEMPERATURE

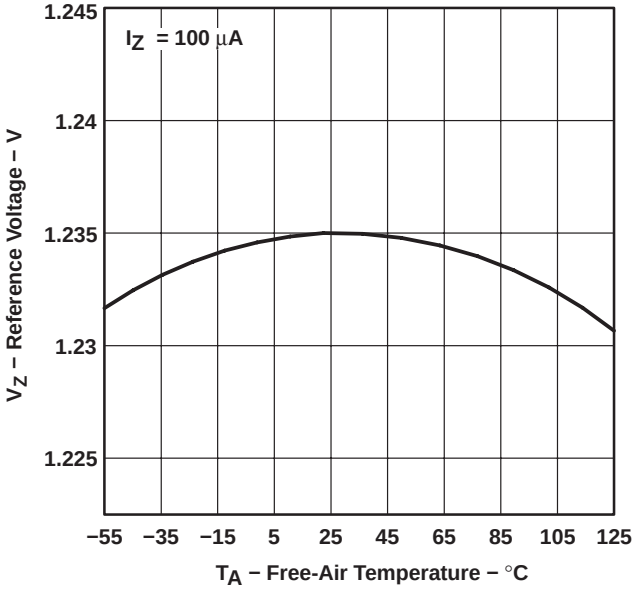


Figure 4

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

TYPICAL CHARACTERISTICS†

LT1004x-1.2
REFERENCE IMPEDANCE
vs
REFERENCE CURRENT

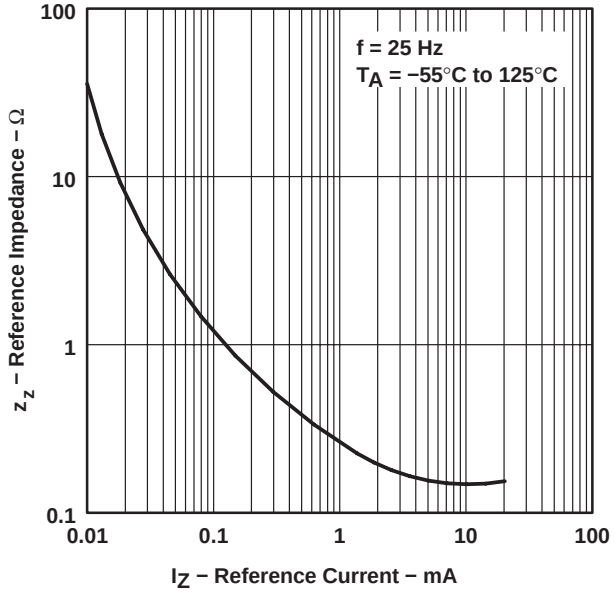


Figure 5

LT1004x-1.2
NOISE VOLTAGE
vs
FREQUENCY

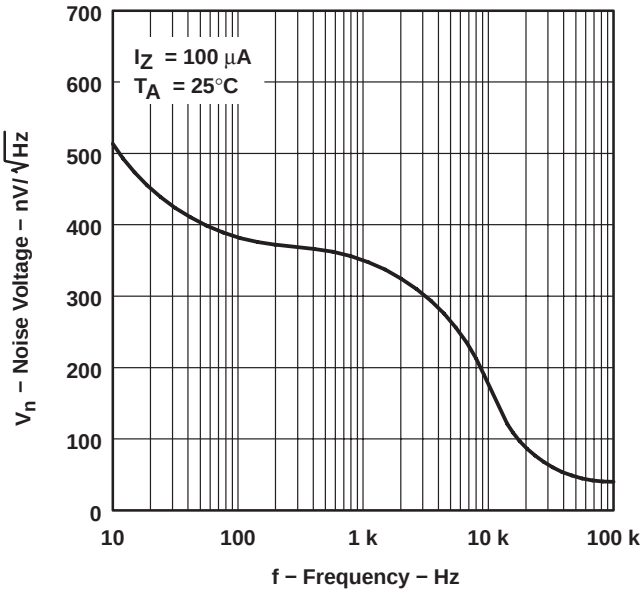


Figure 6

TL1004x-1.2
FILTERED OUTPUT NOISE VOLTAGE
vs
CUTOFF FREQUENCY

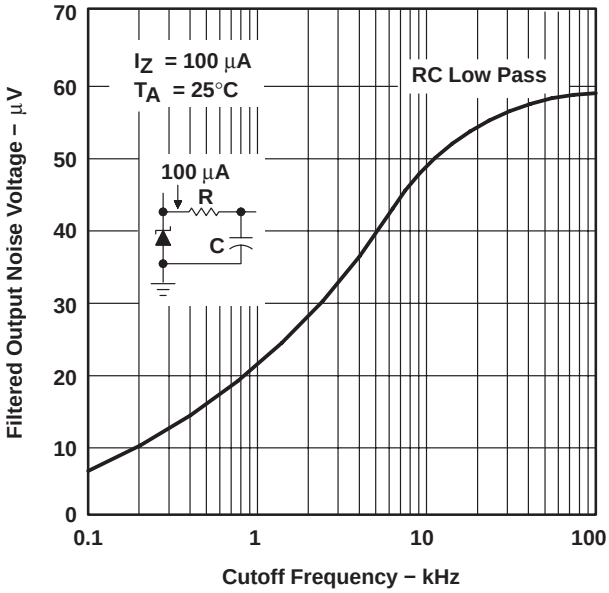


Figure 7

LT1004x-2.5
TRANSIENT RESPONSE

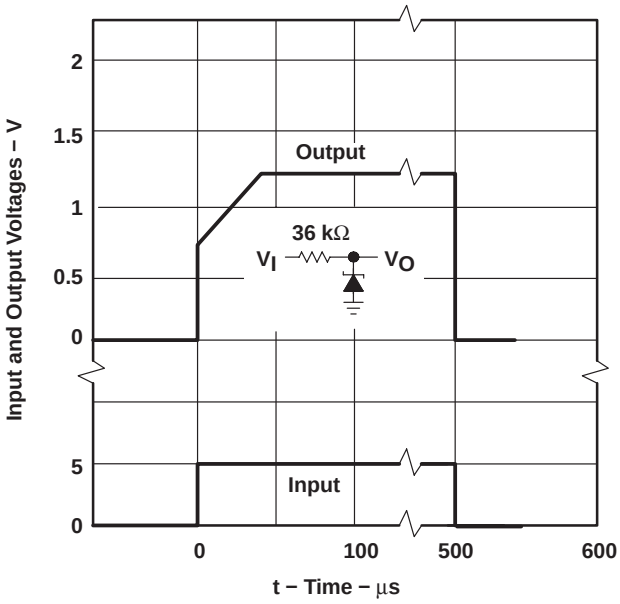


Figure 8

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

TYPICAL CHARACTERISTICS†

LT1004x-2.5
REVERSE CURRENT
vs
REVERSE VOLTAGE

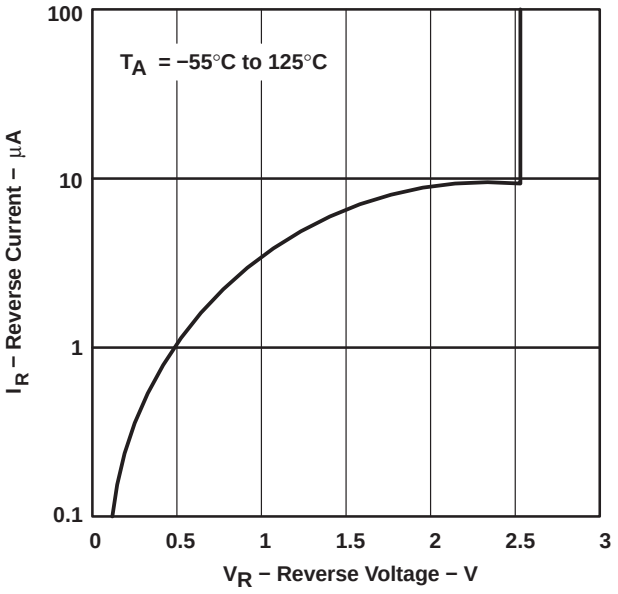


Figure 9

LT1004x-2.5
FORWARD VOLTAGE
vs
FORWARD CURRENT

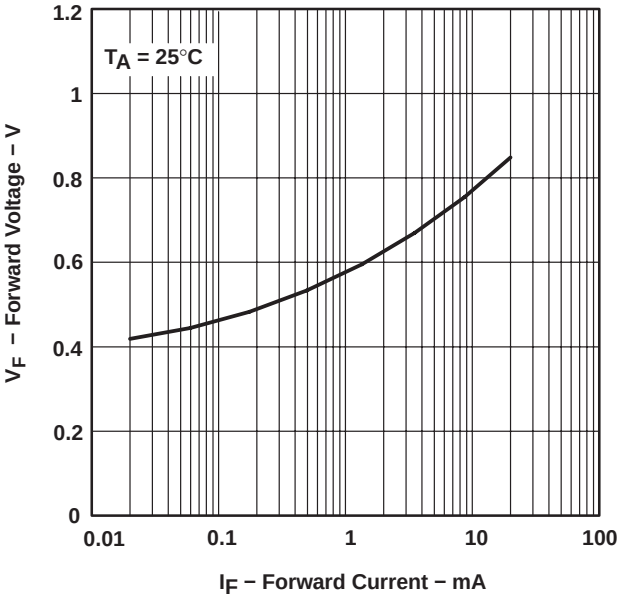


Figure 10

LT1004x-2.5
REFERENCE VOLTAGE
vs
FREE-AIR TEMPERATURE

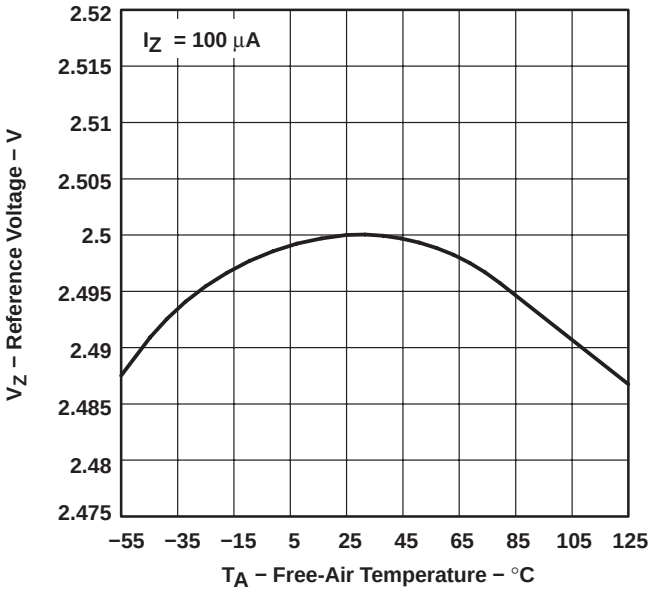


Figure 11

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

TYPICAL CHARACTERISTICS†

LT1004x-2.5
REFERENCE IMPEDANCE
vs
REFERENCE CURRENT

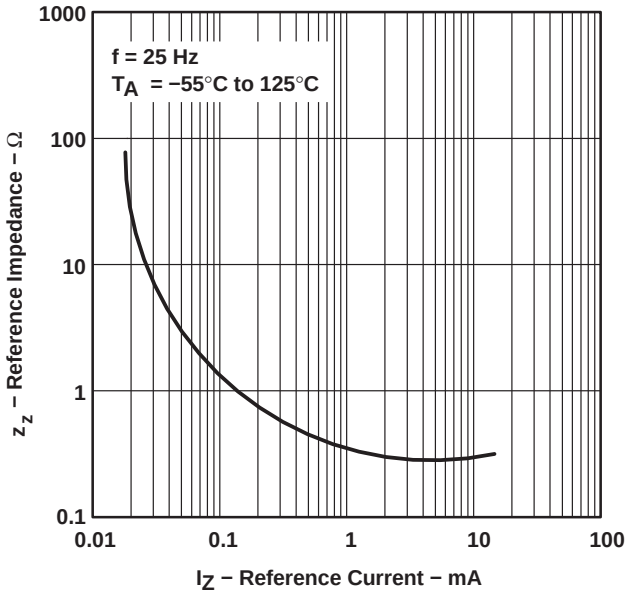


Figure 12

LT1004x-2.5
NOISE VOLTAGE
vs
FREQUENCY

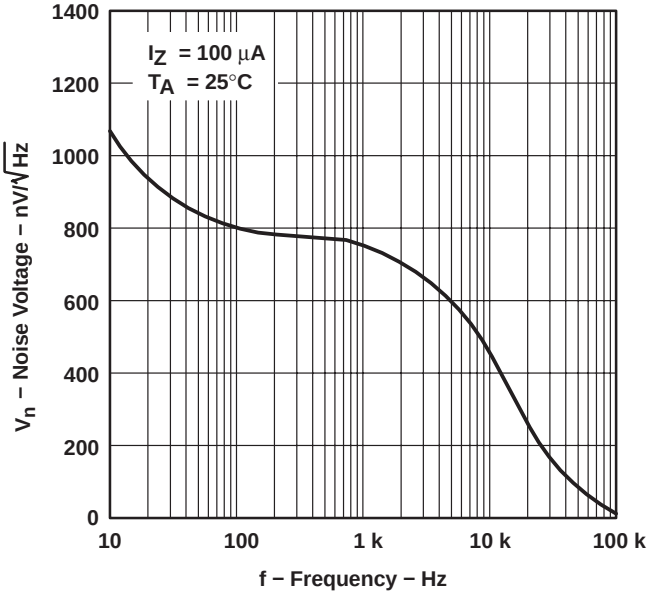


Figure 13

TL1004x-2.5
FILTERED OUTPUT NOISE VOLTAGE
vs
CUTOFF FREQUENCY

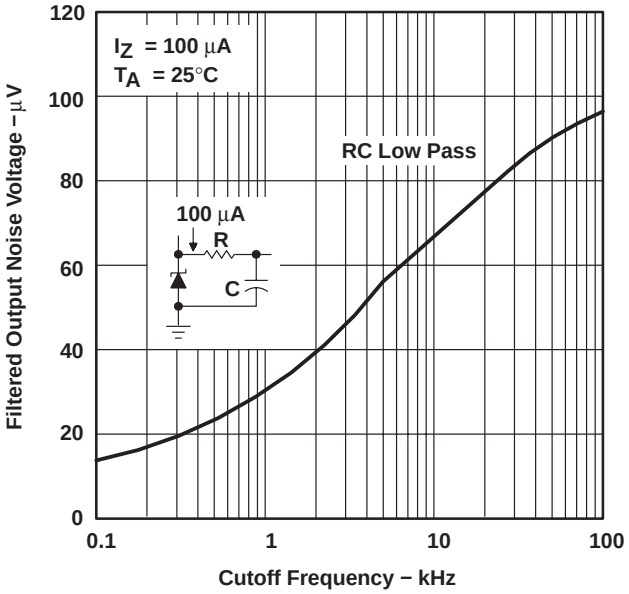


Figure 14

LT1004x-2.5
TRANSIENT RESPONSE

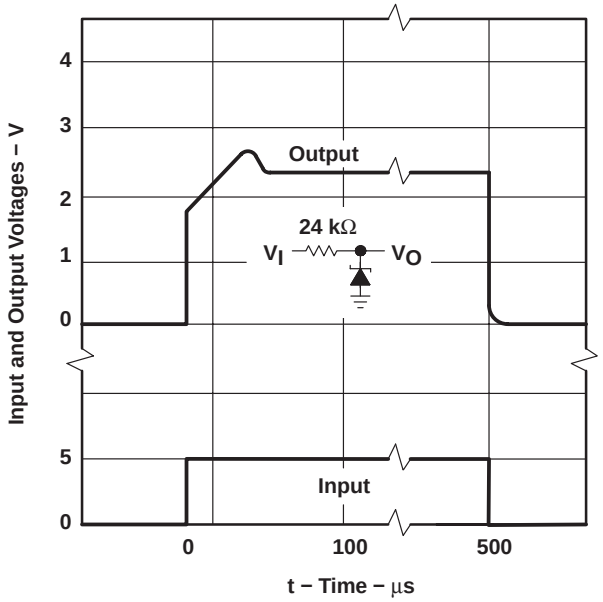
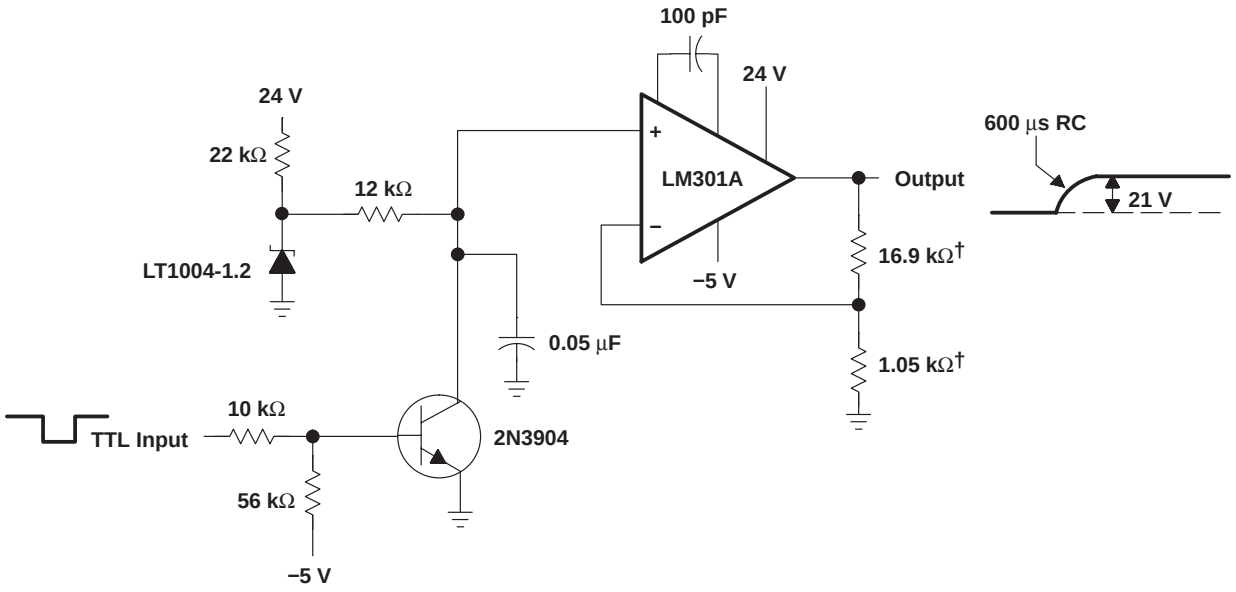


Figure 15

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

APPLICATION INFORMATION



† 1% metal-film resistors

Figure 16. $V_{I(PP)}$ Generator for EPROMs (No Trim Required)

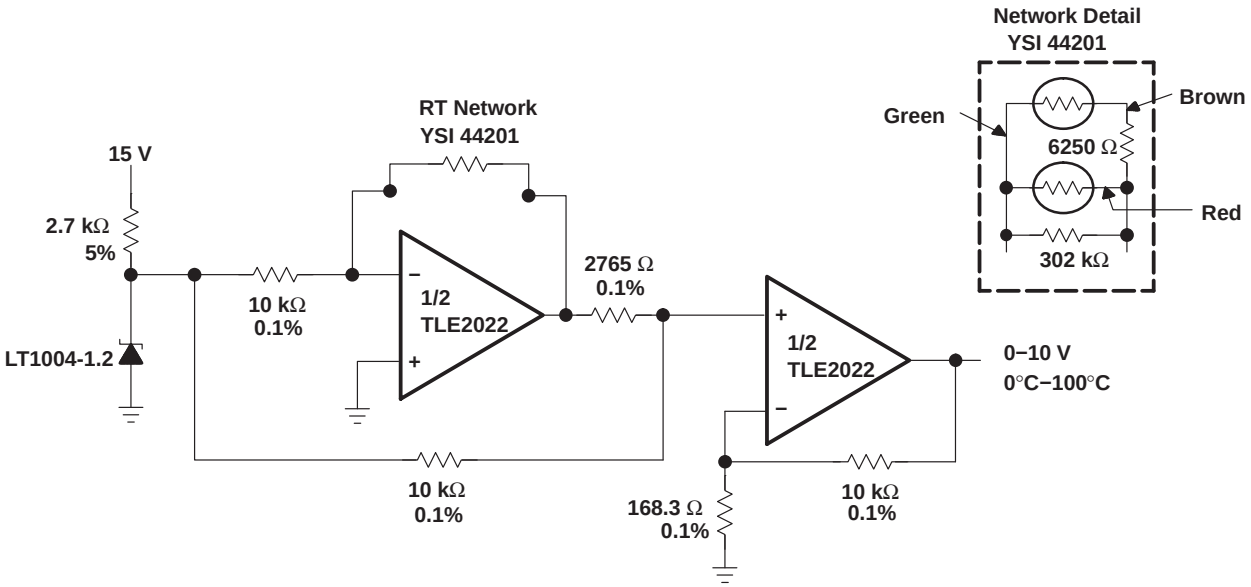


Figure 17. 0°C-to-100°C Linear-Output Thermometer

APPLICATION INFORMATION

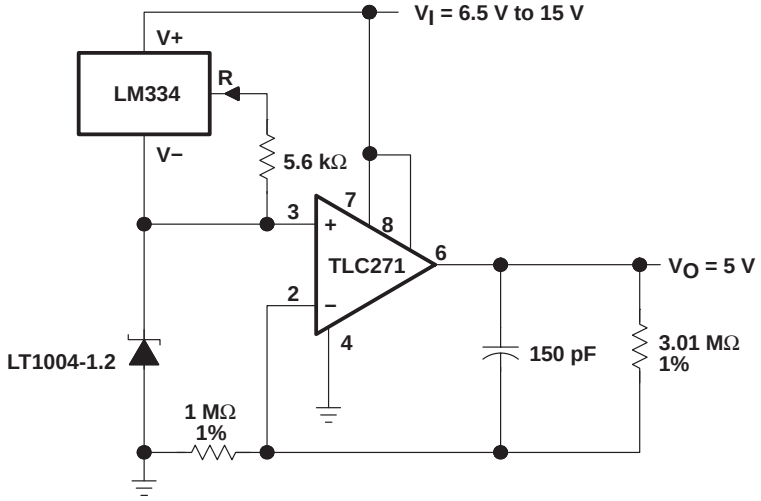


Figure 18. Micropower 5-V Reference

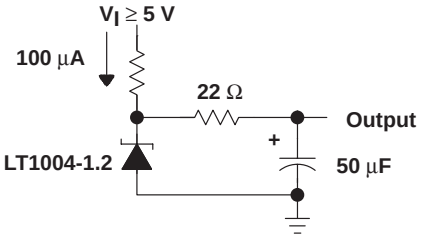


Figure 19. Low-Noise Reference

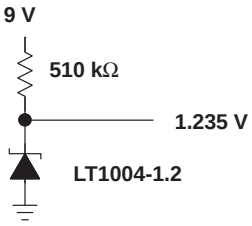
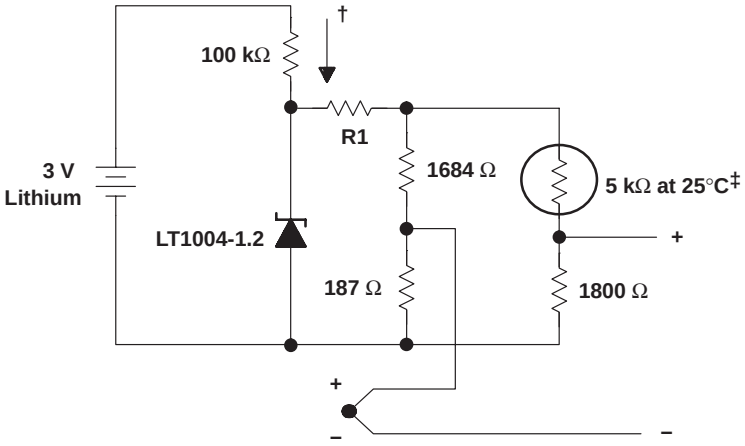


Figure 20. Micropower Reference From 9-V Battery



THERMOCOUPLE TYPE	R1
J	232 kΩ
K	298 kΩ
T	301 kΩ
S	2.1 MΩ

† Quiescent current ≅ 15 μA
‡ Yellow Springs Inst. Co., Part #44007
NOTE A: This application compensates within ±1°C from 0°C to 60°C.

Figure 21. Micropower Cold-Junction Compensation for Thermocouples

APPLICATION INFORMATION

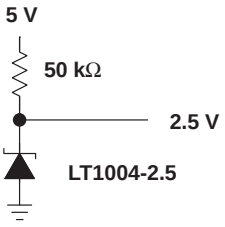


Figure 22. 2.5-V Reference

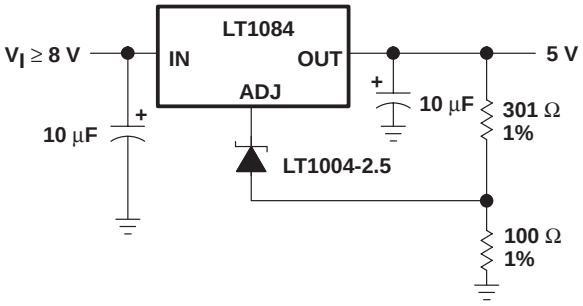
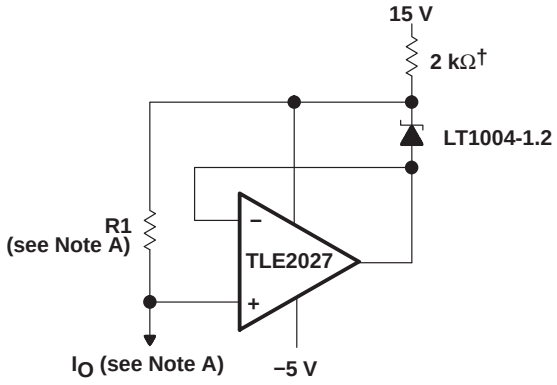


Figure 23. High-Stability 5-V Regulator



† May be increased for small output currents

NOTE A: $R1 \approx \frac{2\text{ V}}{I_O + 10\ \mu\text{A}}$, $I_O = \frac{1.235\text{ V}}{R1}$

Figure 24. Ground-Referenced Current Source

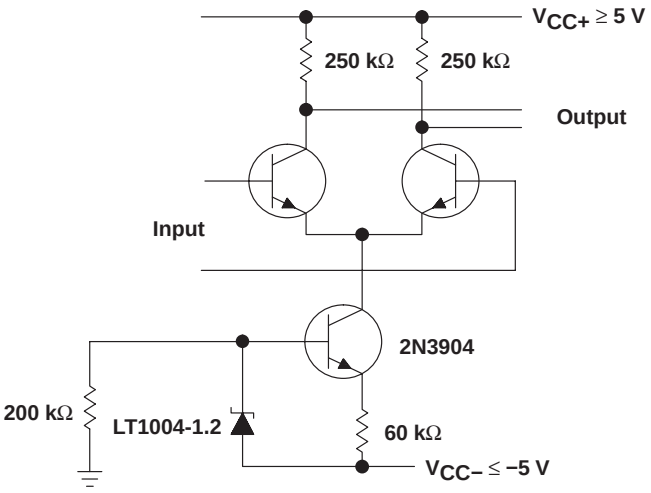
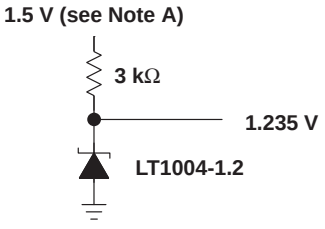


Figure 25. Amplifier With Constant Gain Over Temperature



NOTE A: Output regulates down to 1.285 V for $I_O = 0$.

Figure 26. 1.2-V Reference From 1.5-V Battery

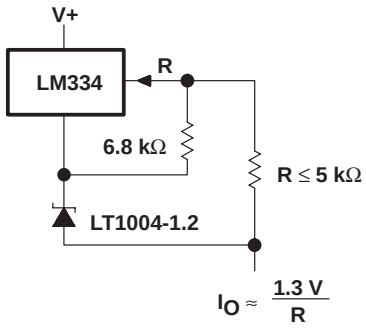
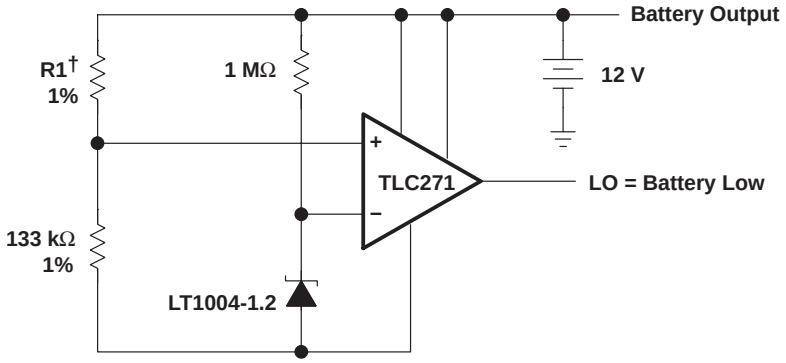


Figure 27. Terminal Current Source With Low Temperature Coefficient

APPLICATION INFORMATION



† R1 sets trip point, 60.4 kΩ per cell for 1.8 V per cell.

Figure 28. Lead-Acid Low-Battery-Voltage Detector

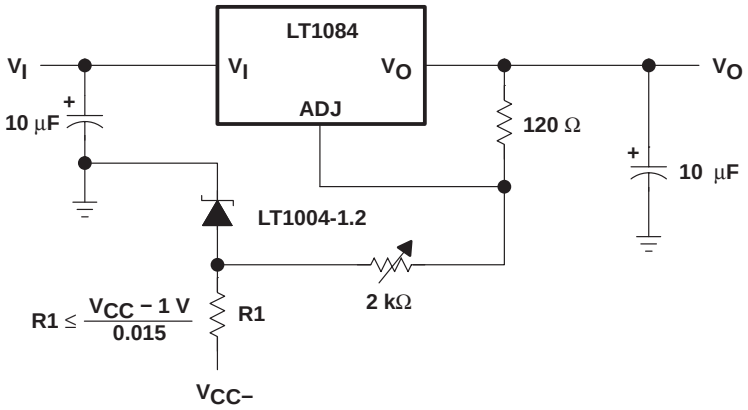


Figure 29. Variable-Voltage Supply

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
LT1004CD-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CD-2-5	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CD-2-5G4	ACTIVE	SOIC	D	8		TBD	Call TI	Call TI
LT1004CDE4-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CDE4-2-5	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CDG4-2-5	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CDR-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CDR-2-5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CDRE4-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CDRE4-2-5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CLP-1-2	ACTIVE	TO-92	LP	3	1000	TBD	CU SNPB	N / A for Pkg Type
LT1004CLP-2-5	ACTIVE	TO-92	LP	3	1000	TBD	CU SNPB	N / A for Pkg Type
LT1004CLPE3-1-2	ACTIVE	TO-92	LP	3	1000	TBD	Call TI	Call TI
LT1004CLPE3-2-5	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
LT1004CLPR-2-5	ACTIVE	TO-92	LP	3	2000	TBD	Call TI	Call TI
LT1004CLPRE3-1-2	ACTIVE	TO-92	LP	3	2000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
LT1004CPW-1-2	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CPW-2-5	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CPWE4-1-2	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CPWE4-2-5	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CPWR-1-2	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CPWR-2-5	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CPWRE4-1-2	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004CPWRE4-2-5	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004ID-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004ID-2-5	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IDE4-1-2	ACTIVE	SOIC	D	8	75	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]
LT1004IDE4-2-5	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IDR-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IDR-2-5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IDRE4-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IDRE4-2-5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004ILP-1-2	ACTIVE	TO-92	LP	3	1000	TBD	Call TI	Call TI
LT1004ILP-2-5	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI
LT1004IPW-1-2	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IPW-2-5	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IPWE4-1-2	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IPWE4-2-5	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IPWR-1-2	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IPWR-2-5	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IPWRE4-1-2	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004IPWRE4-2-5	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1004MD-1-2	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI
LT1004MD-2-5	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI
LT1004MDR-1-2	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI
LT1004MDR-2-5	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI
LT1004MLP-1-2	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI
LT1004MLP-2-5	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI

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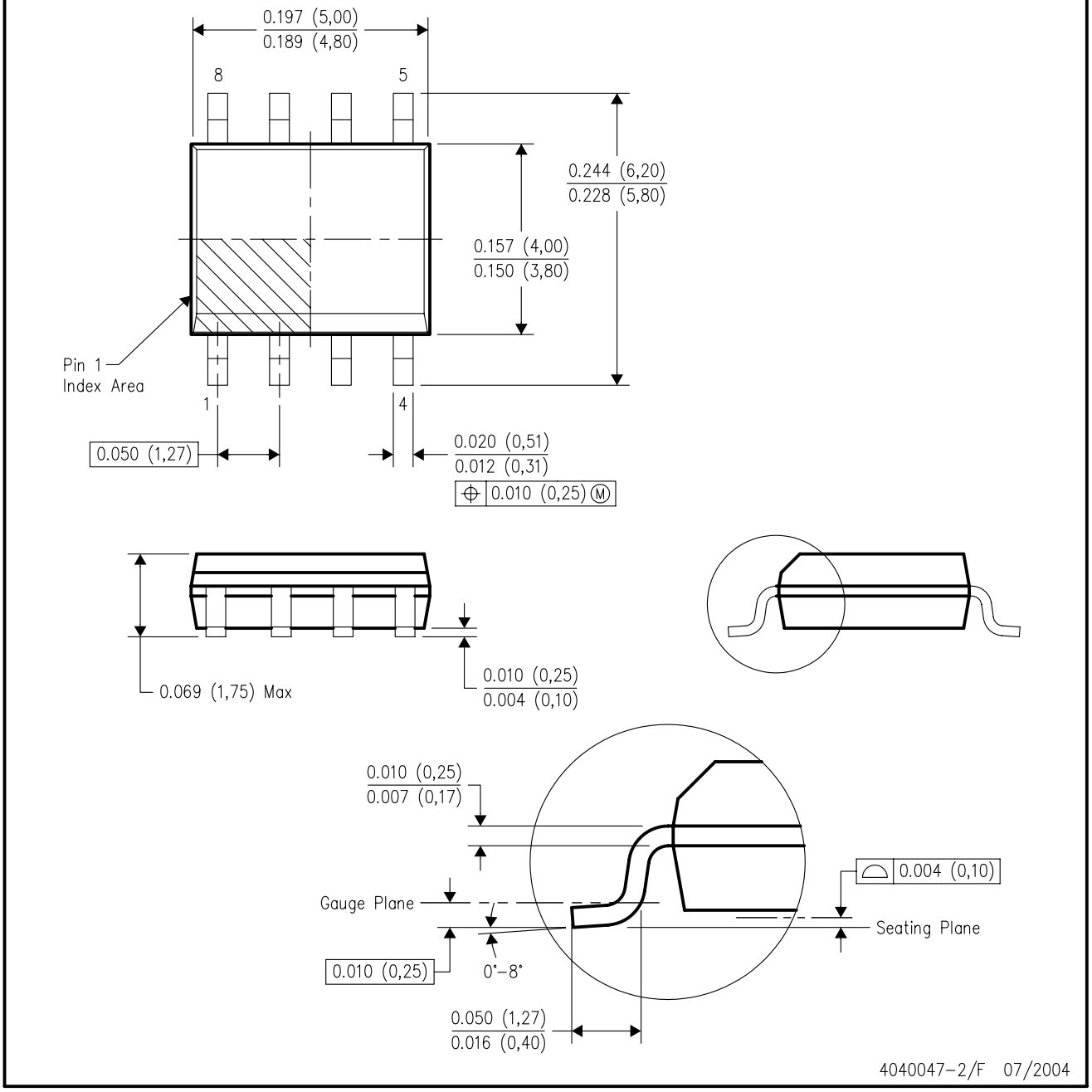
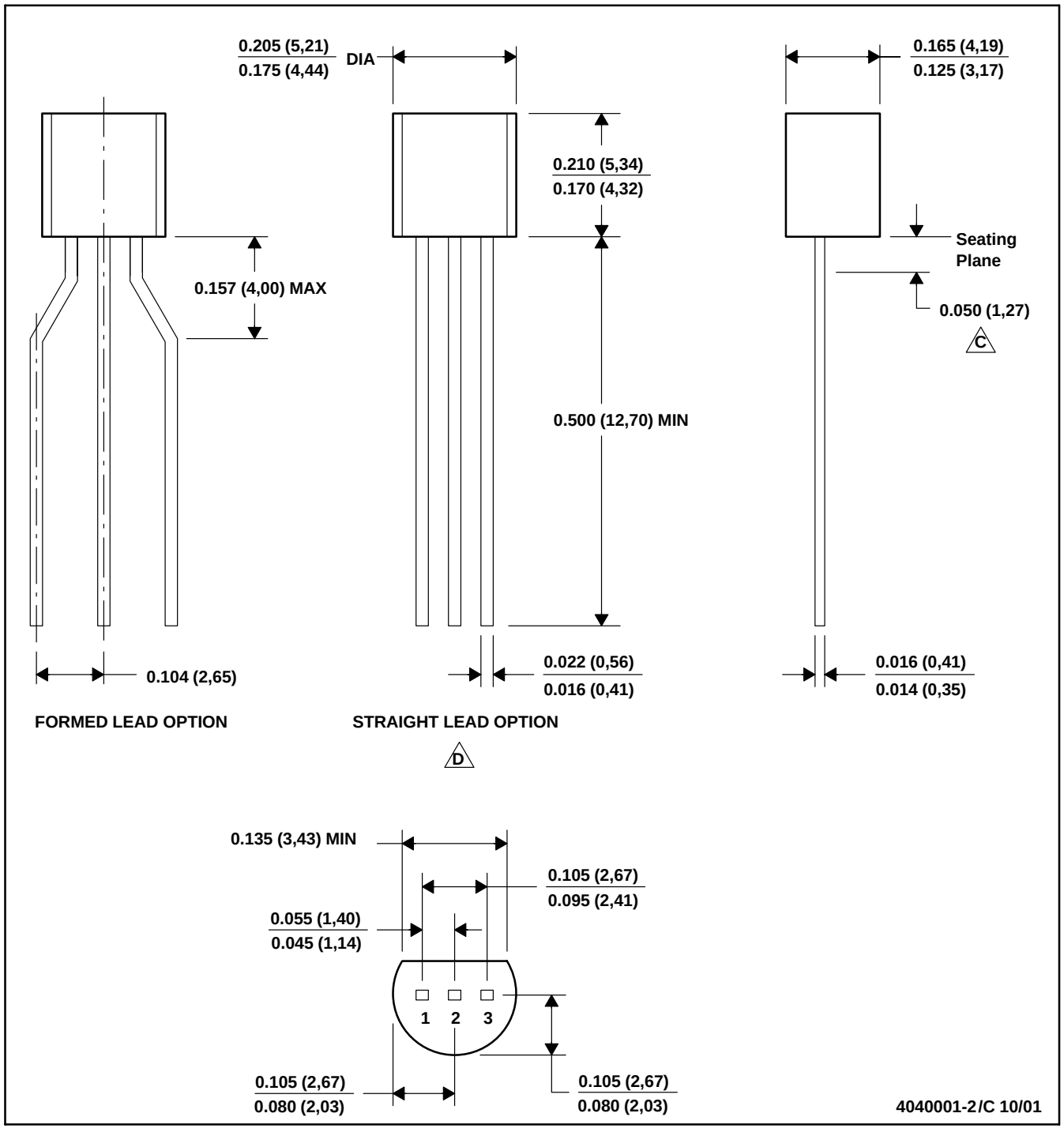
D (R–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



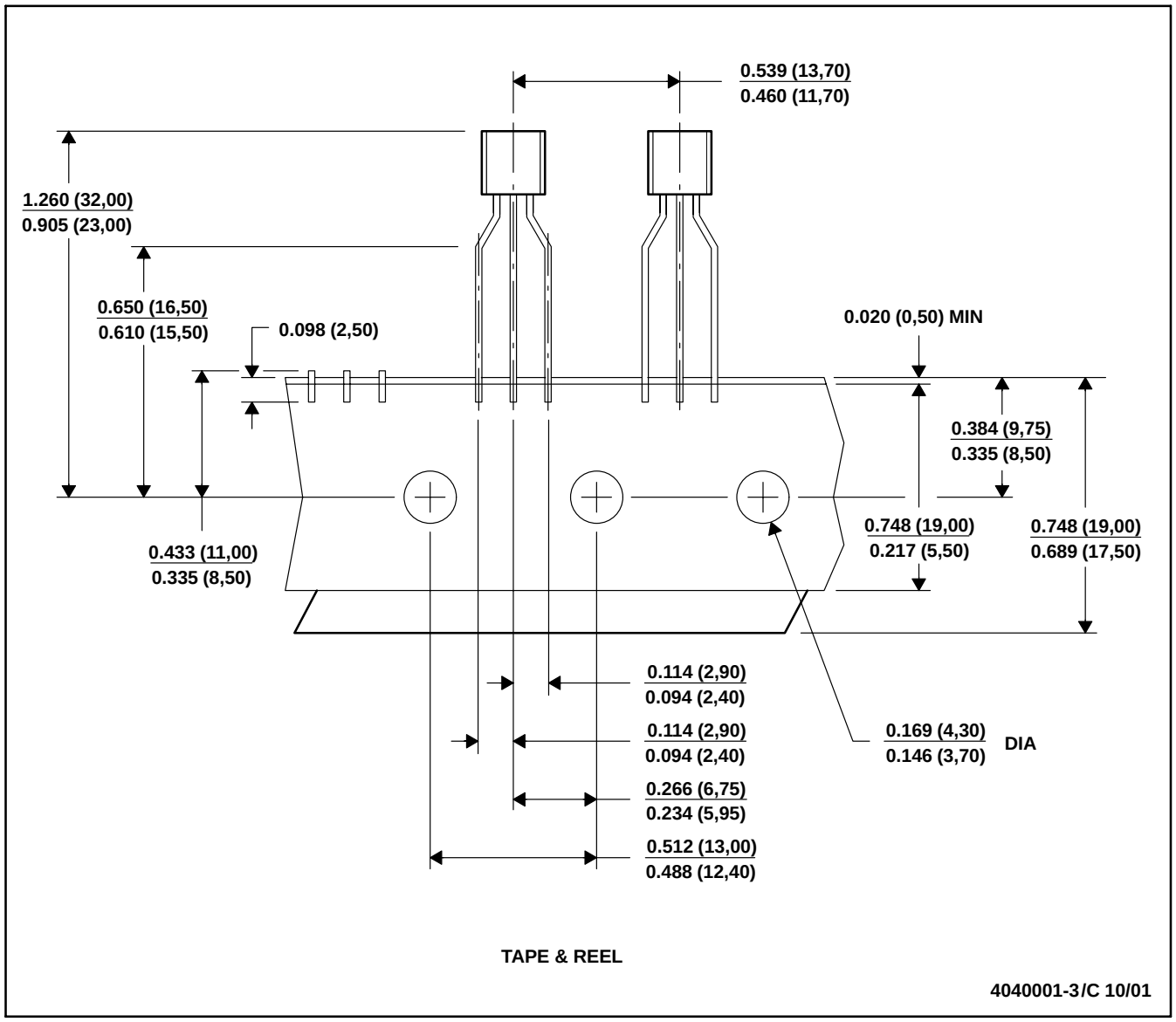
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS–012 variation AA.

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.

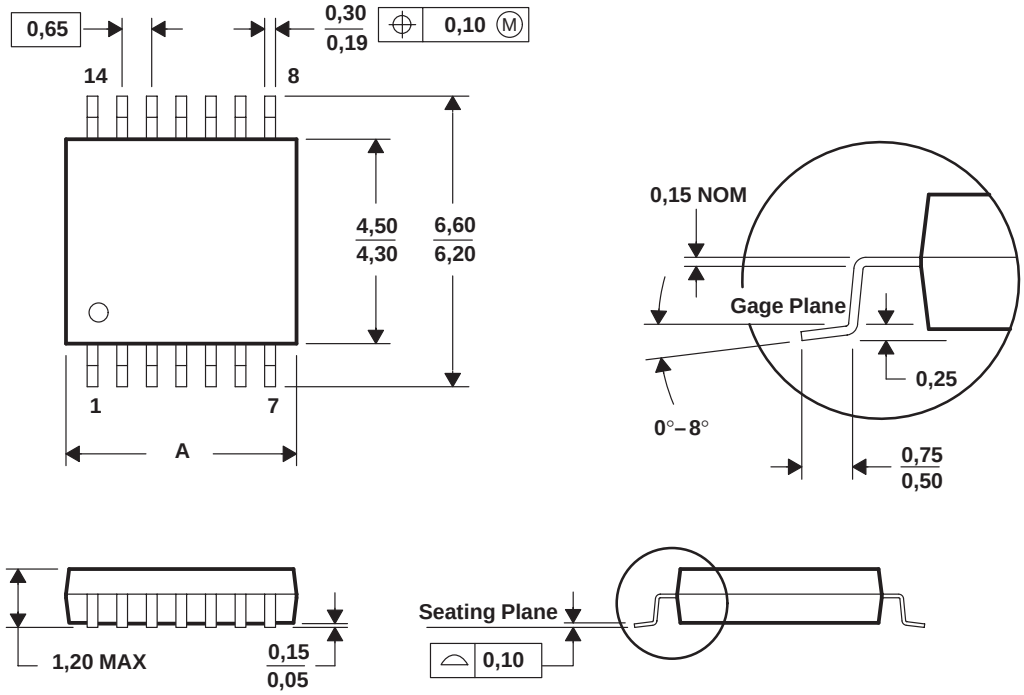
LP (O-PBCY-W3) **PLASTIC CYLINDRICAL PACKAGE**



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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