

# LT1004-1.2, LT1004-2.5 MICROPOWER INTEGRATED VOLTAGE REFERENCES

SLVS022M – JANUARY 1989 – REVISED MAY 2008

- **Initial Accuracy**
  - $\pm 4$  mV for LT1004-1.2
  - $\pm 20$  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**

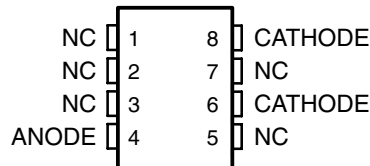
## description/ordering information

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.

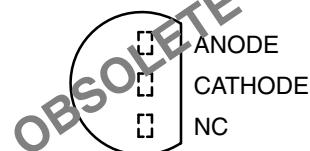
The LT1004C is characterized for operation from 0°C to 70°C. The LT1004I is characterized for operation from –40°C to 85°C.

### 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



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS  
INSTRUMENTS**

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# LT1004-1.2, LT1004-2.5 MICROPOWER INTEGRATED VOLTAGE REFERENCES

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## description/ordering information (continued)

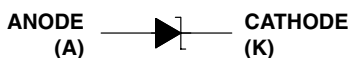
### ORDERING INFORMATION†

T <sub>A</sub>	V <sub>Z</sub> 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	
		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	
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	
		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	

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at <http://www.ti.com>.

‡ Package drawings, thermal data, and symbolization are available at <http://www.ti.com/packaging>.

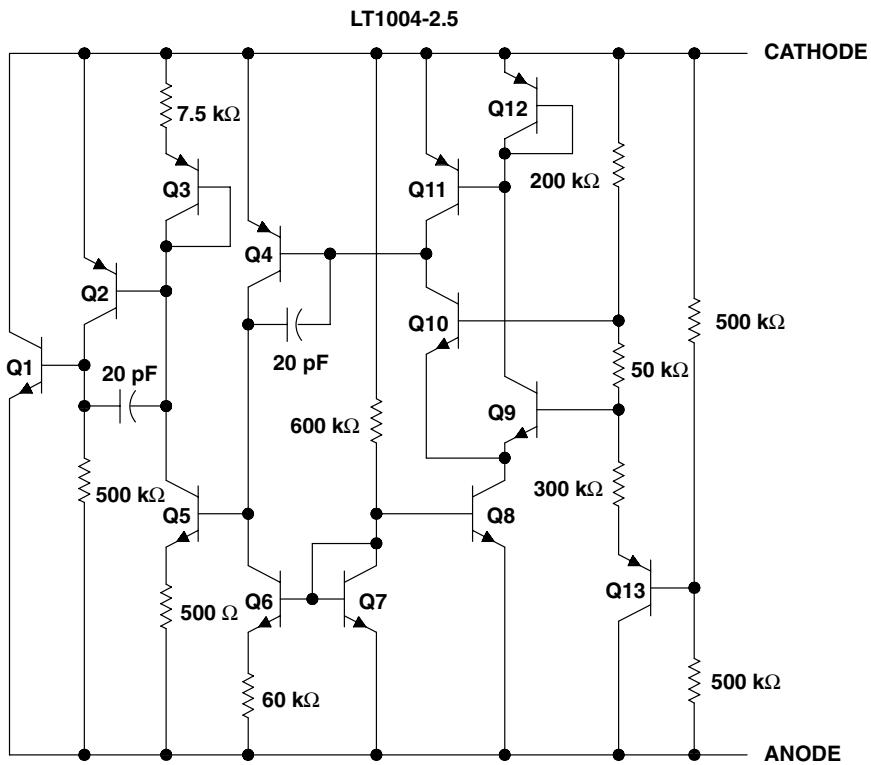
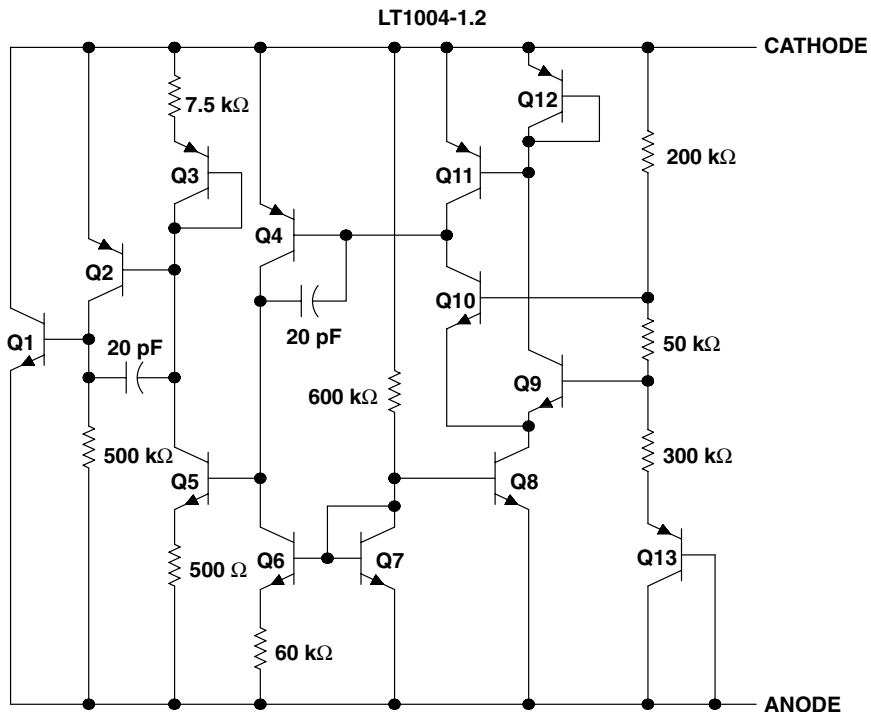
## symbol



# LT1004-1.2, LT1004-2.5 MICROPOWER INTEGRATED VOLTAGE REFERENCES

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## schematic



NOTE A: All component values shown are nominal.



**TYPICAL CHARACTERISTICS**

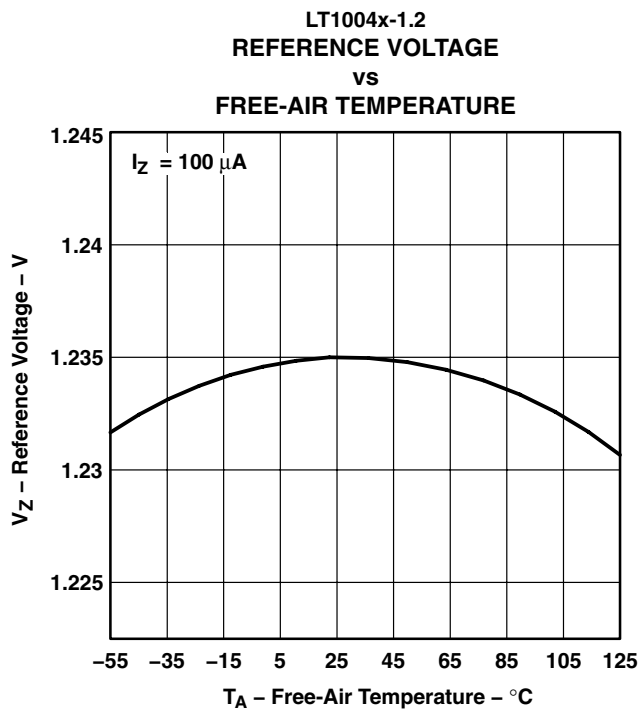
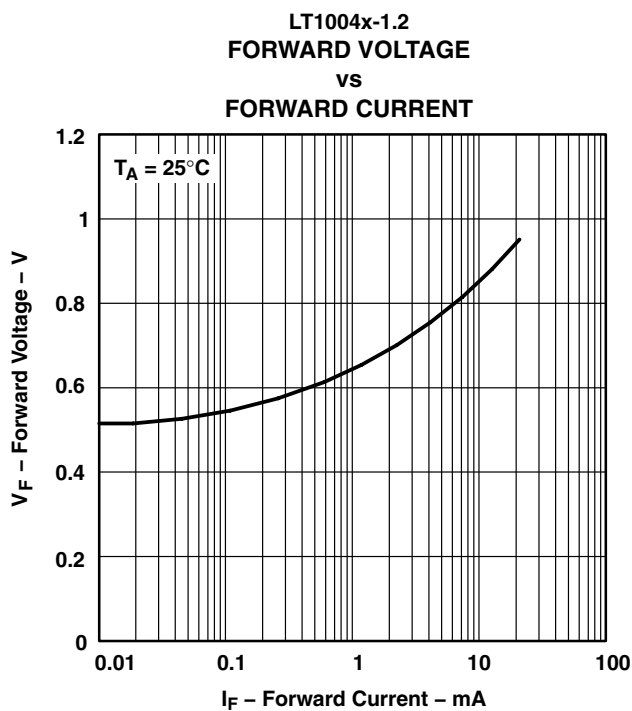
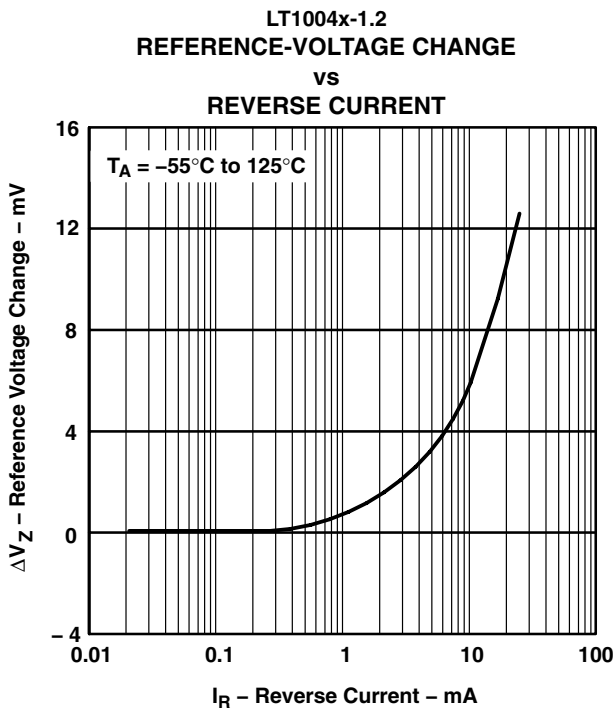
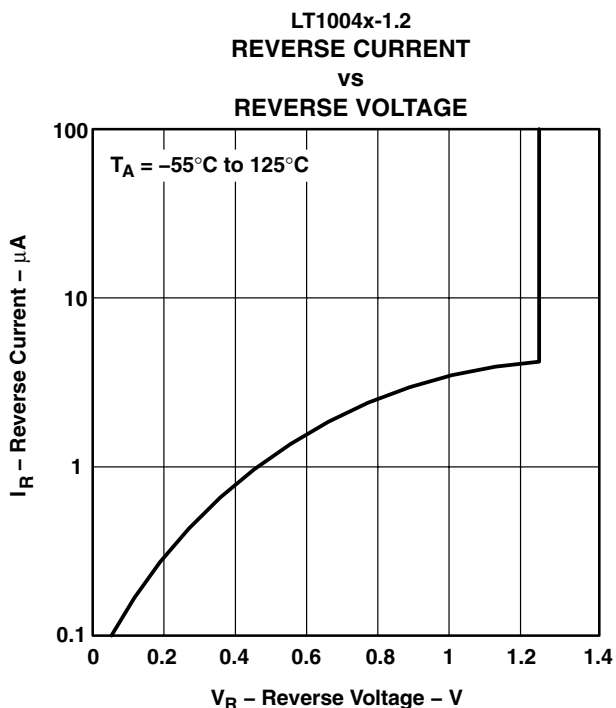
**Table of Graphs**

GRAPH TITLE	FIGURE
<b>LT1004x-1.2</b>	
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
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Transient response	8
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Reference impedance vs Reference current	12
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Filtered output noise voltage vs Cutoff frequency	14
Transient response	15

# LT1004-1.2, LT1004-2.5 MICROPOWER INTEGRATED VOLTAGE REFERENCES

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## TYPICAL CHARACTERISTICS†



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

TYPICAL CHARACTERISTICS†

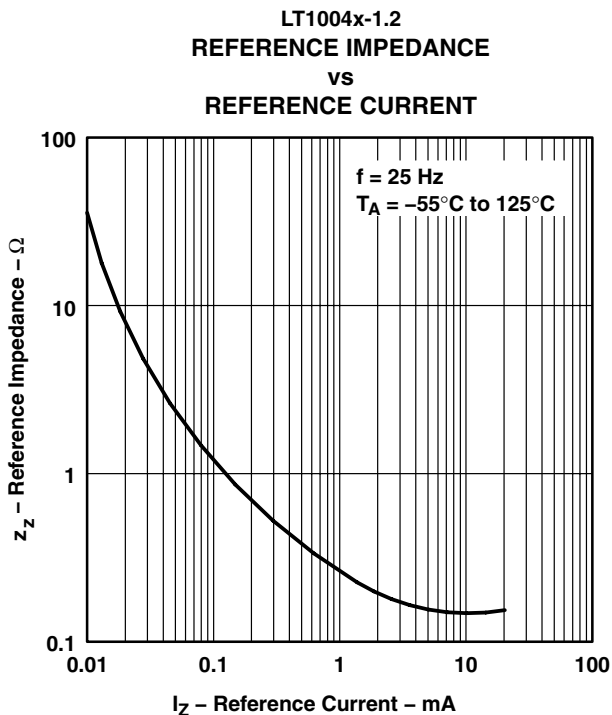


Figure 5

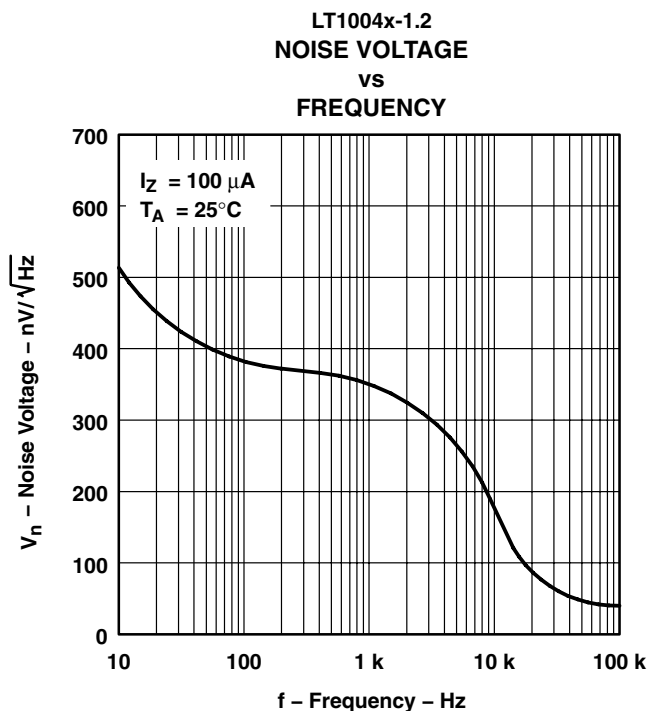


Figure 6

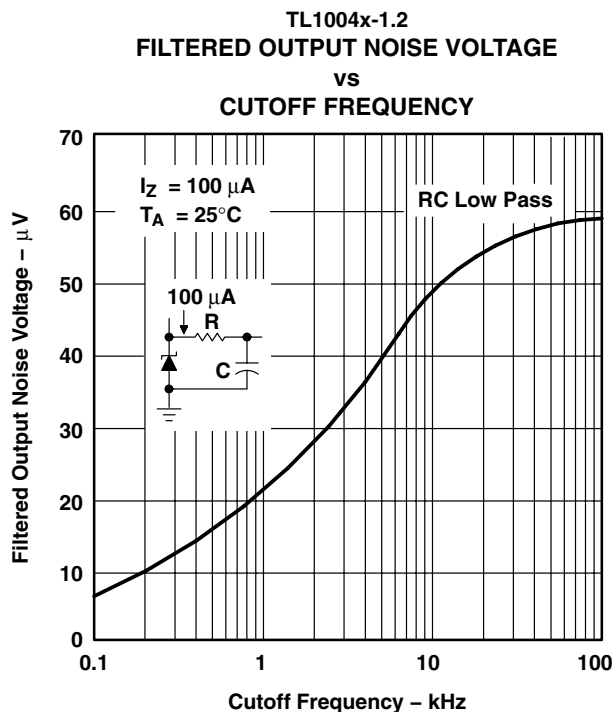


Figure 7

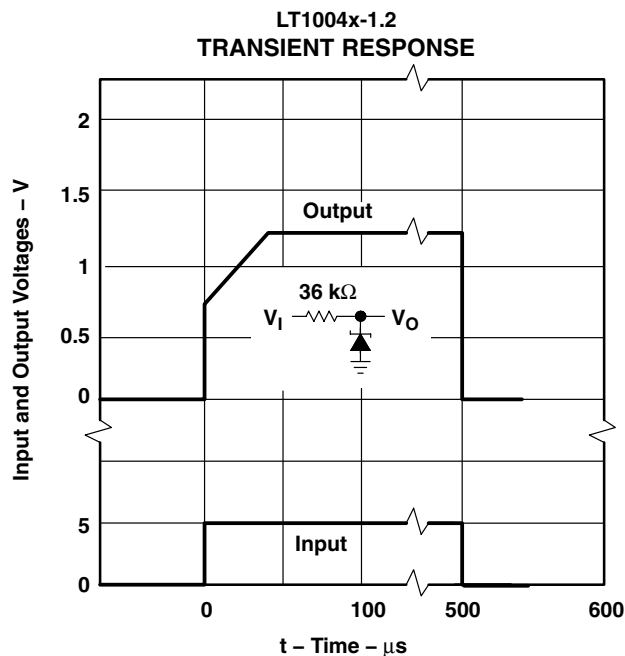


Figure 8

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

# LT1004-1.2, LT1004-2.5 MICROPOWER INTEGRATED VOLTAGE REFERENCES

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## TYPICAL CHARACTERISTICS†

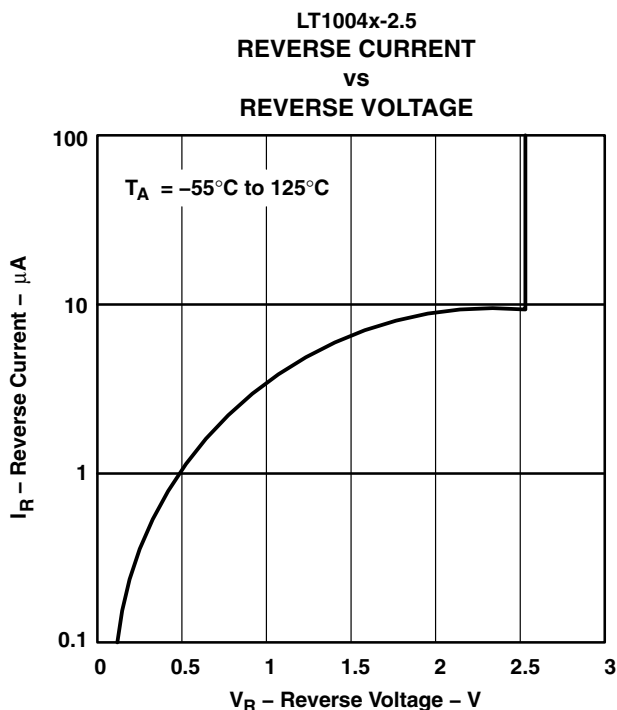


Figure 9

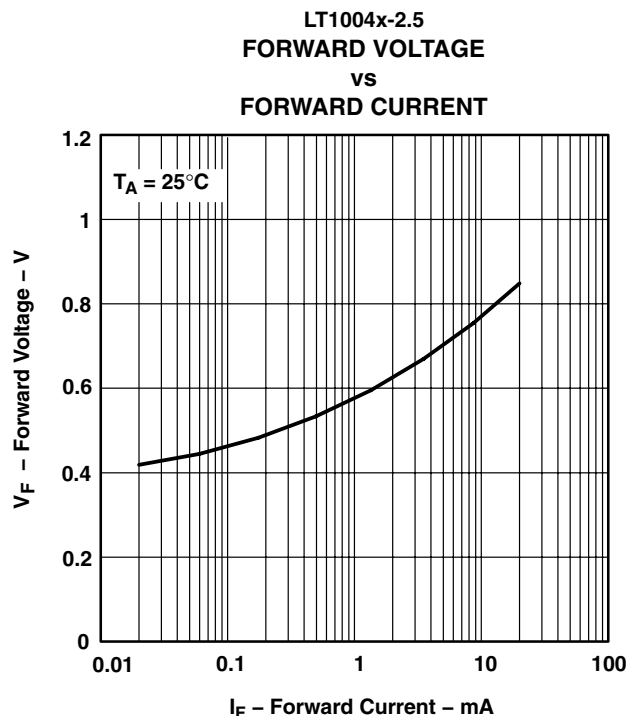


Figure 10

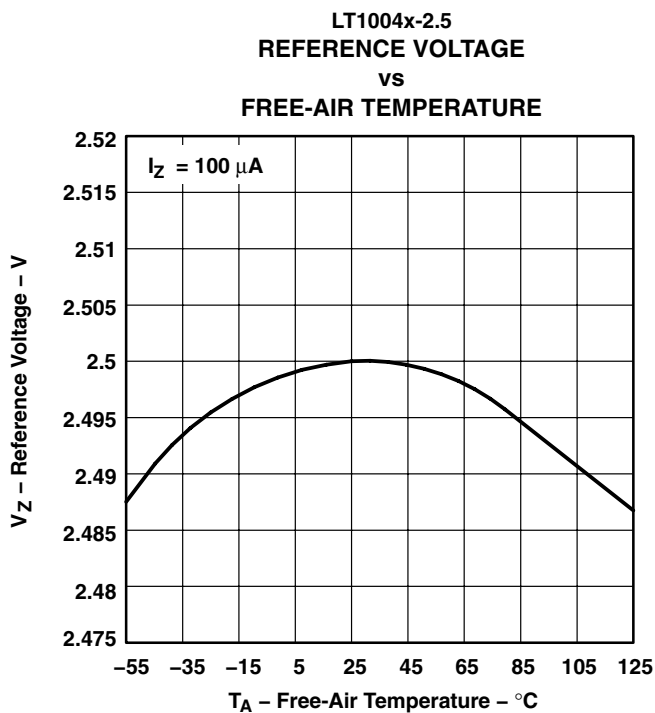
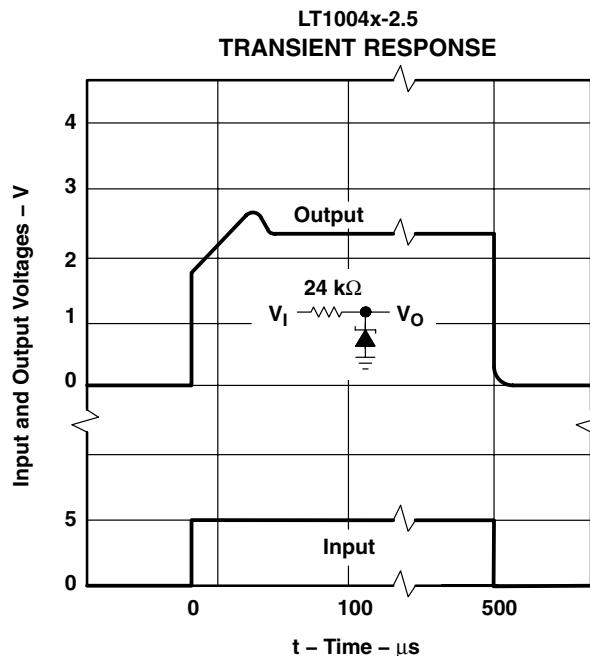
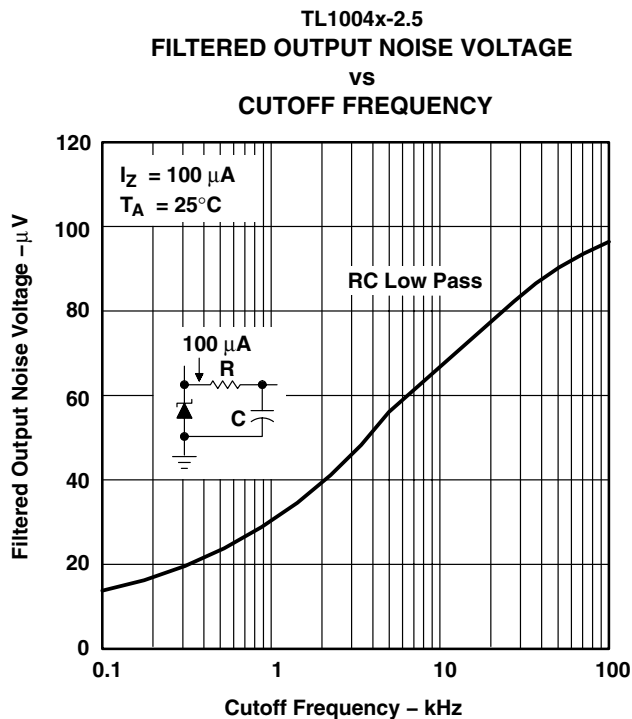
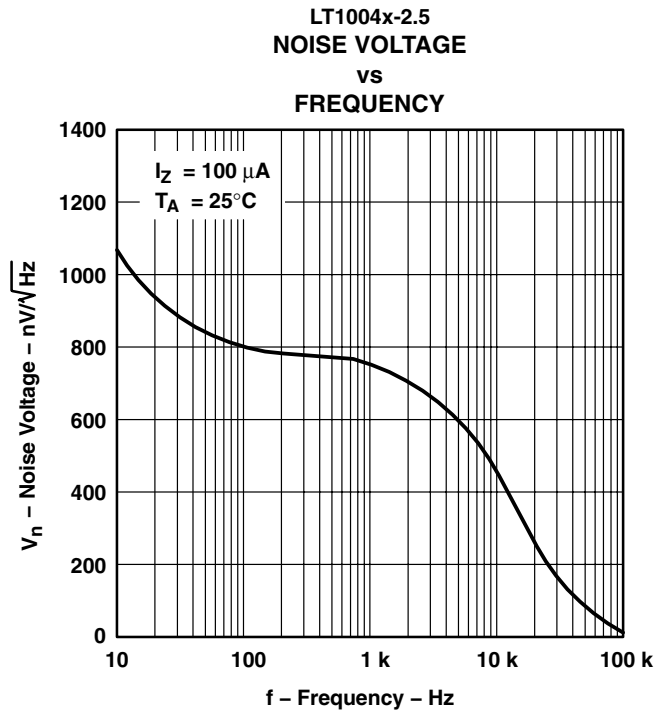
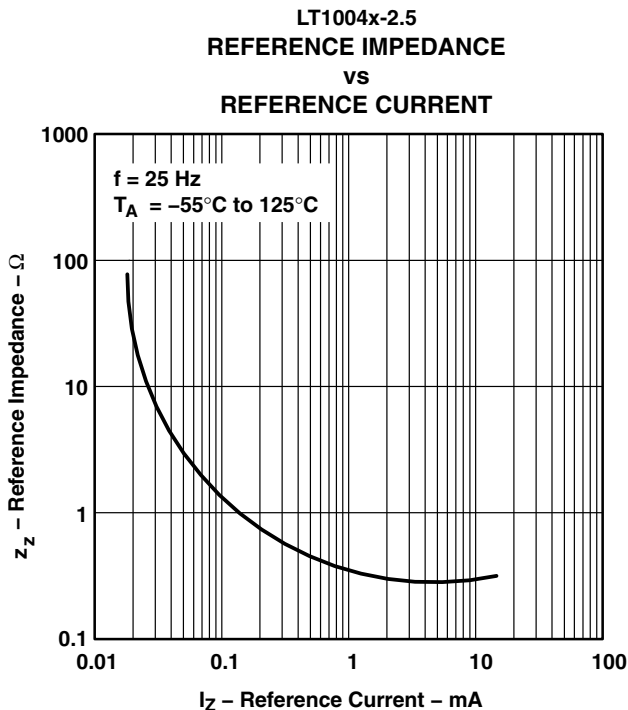


Figure 11

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



TYPICAL CHARACTERISTICS†

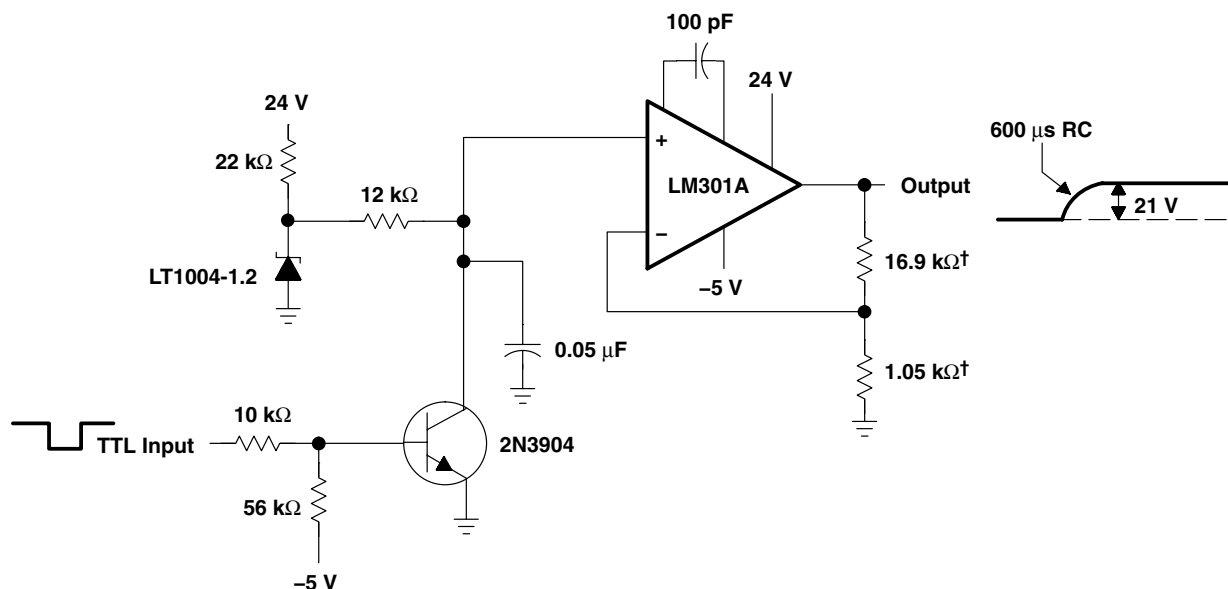


† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

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## APPLICATION INFORMATION



† 1% metal-film resistors

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

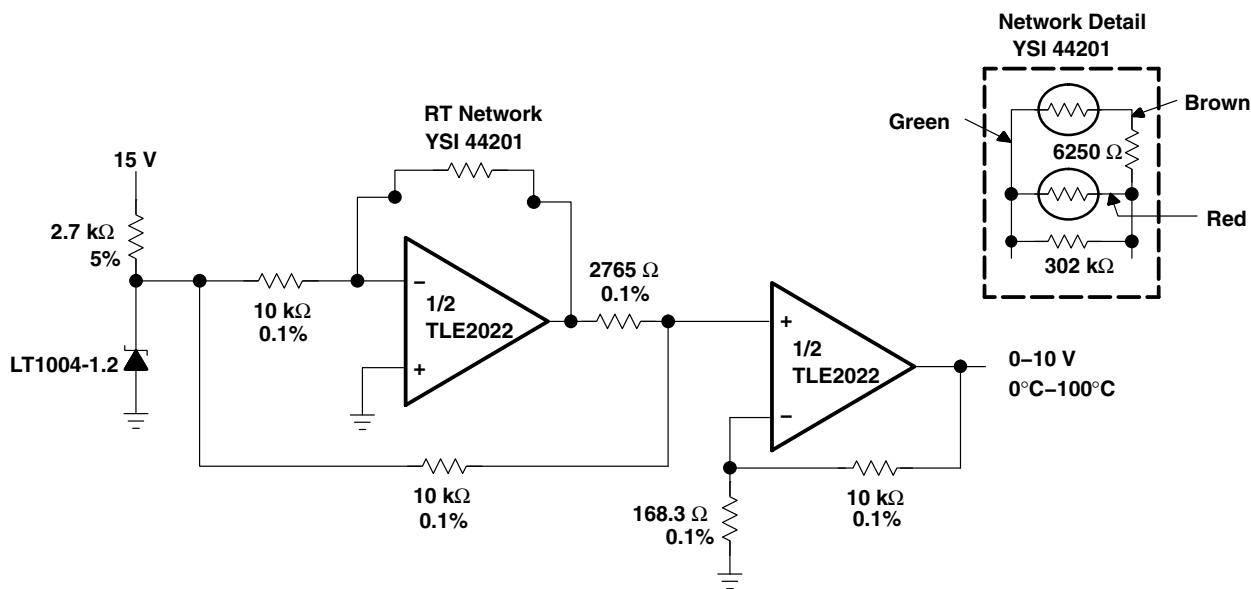


Figure 17. 0°C-to-100°C Linear-Output Thermometer

APPLICATION INFORMATION

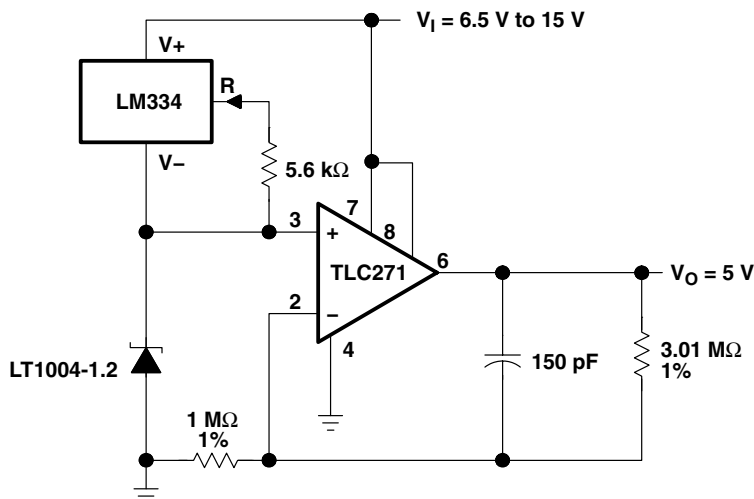


Figure 18. Micropower 5-V Reference

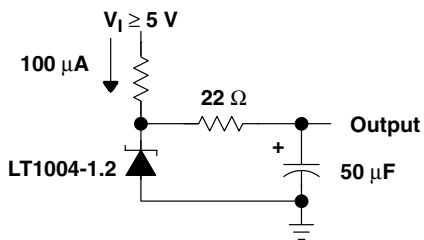


Figure 19. Low-Noise Reference

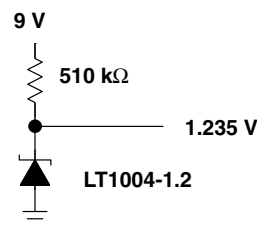
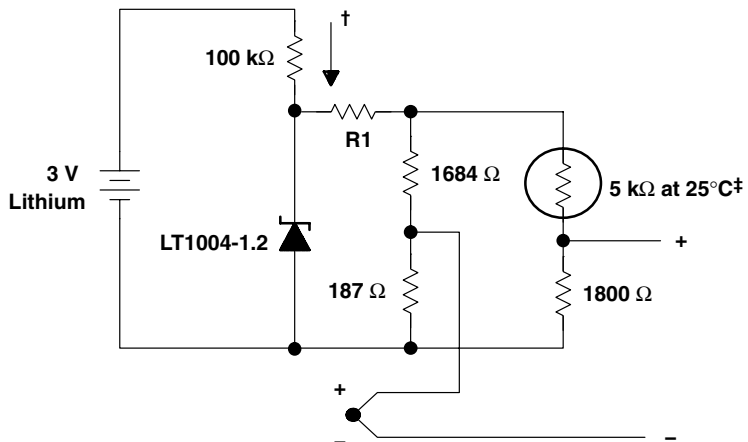


Figure 20. Micropower Reference From 9-V Battery



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

† Quiescent current  $\cong 15 \mu\text{A}$

‡ Yellow Springs Inst. Co., Part #44007

NOTE A: This application compensates within  $\pm 1^\circ\text{C}$  from  $0^\circ\text{C}$  to  $60^\circ\text{C}$ .

Figure 21. Micropower Cold-Junction Compensation for Thermocouples

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## APPLICATION INFORMATION

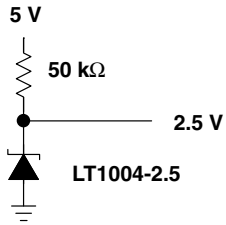


Figure 22. 2.5-V Reference

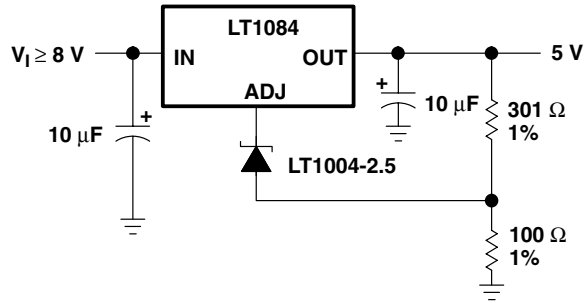
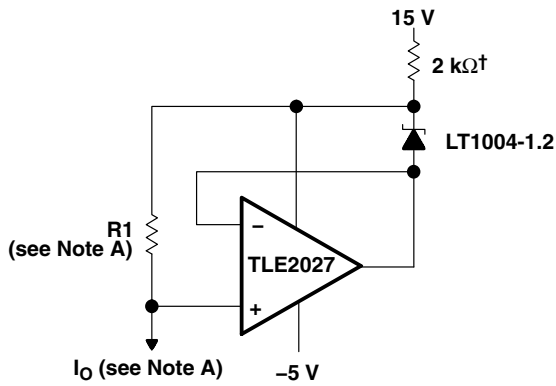


Figure 23. High-Stability 5-V Regulator



† May be increased for small output currents  
NOTE A:  $R1 \approx \frac{2V}{I_O + 10\mu A}$ ,  $I_O = \frac{1.235V}{R1}$

Figure 24. Ground-Referenced Current Source

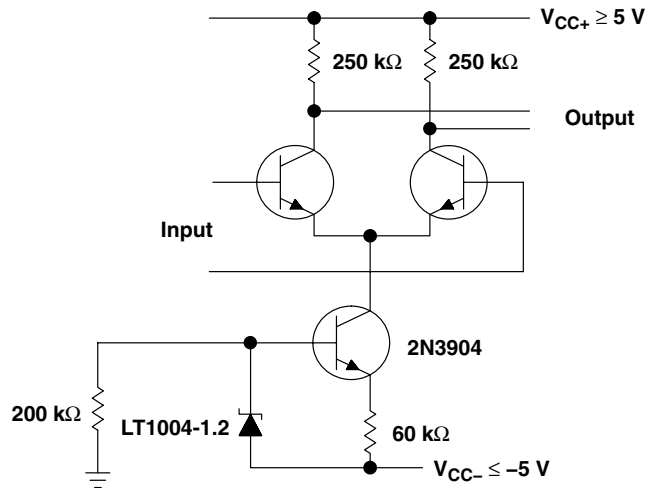
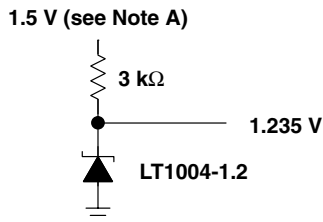


Figure 25. Amplifier With Constant Gain Over Temperature



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

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

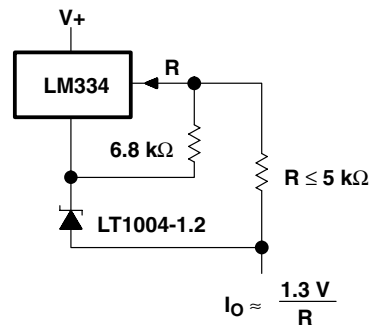
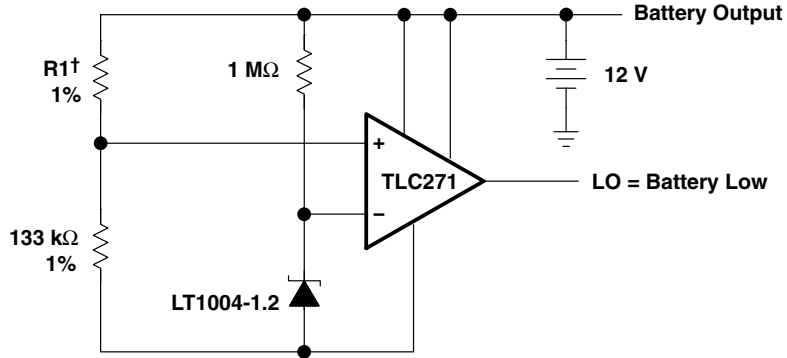


Figure 27. Terminal Current Source With Low Temperature Coefficient

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

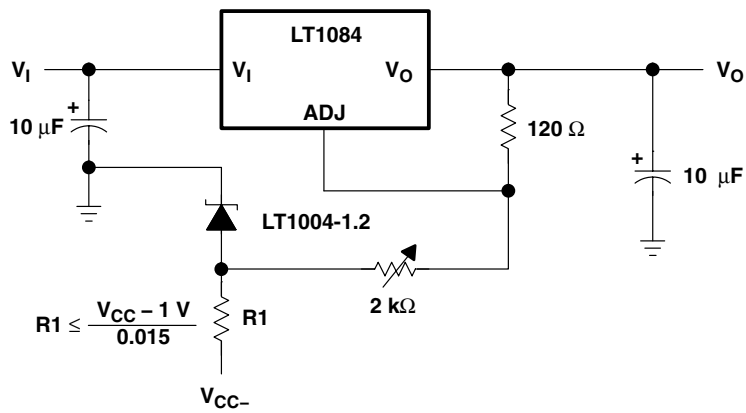


Figure 29. Variable-Voltage Supply

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LT1004CD-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	4C-12	<a href="#">Samples</a>
LT1004CD-2-5	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	4C-25	<a href="#">Samples</a>
LT1004CD-2-5G4	ACTIVE	SOIC	D	8		TBD	Call TI	Call TI	0 to 70		<a href="#">Samples</a>
LT1004CDG4-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	4C-12	<a href="#">Samples</a>
LT1004CDR-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	4C-12	<a href="#">Samples</a>
LT1004CDR-2-5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	4C-25	<a href="#">Samples</a>
LT1004CDRG4-2-5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	4C-25	<a href="#">Samples</a>
LT1004CLP-1-2	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI	0 to 70		
LT1004CLP-2-5	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI	0 to 70		
LT1004CPW-1-2	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4C-12	<a href="#">Samples</a>
LT1004CPWR-1-2	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	4C-12	<a href="#">Samples</a>
LT1004CPWR-2-5	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	4C-25	<a href="#">Samples</a>
LT1004ID-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-12	<a href="#">Samples</a>
LT1004ID-2-5	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-25	<a href="#">Samples</a>
LT1004IDG4-1-2	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-12	<a href="#">Samples</a>
LT1004IDG4-2-5	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-25	<a href="#">Samples</a>
LT1004IDR-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-12	<a href="#">Samples</a>
LT1004IDR-2-5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-25	<a href="#">Samples</a>

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
LT1004IDRE4-2-5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-25	<a href="#">Samples</a>
LT1004IDRG4-1-2	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-12	<a href="#">Samples</a>
LT1004ILP-2-5	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI	-40 to 85		
LT1004IPW-1-2	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-12	<a href="#">Samples</a>
LT1004IPW-2-5	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-25	<a href="#">Samples</a>
LT1004IPWR-1-2	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-12	<a href="#">Samples</a>
LT1004IPWR-2-5	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	4I-25	<a href="#">Samples</a>
LT1004MD-1-2	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI	-55 to 125		
LT1004MD-2-5	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI	-55 to 125		
LT1004MDR-1-2	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI	-55 to 125		
LT1004MDR-2-5	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI	-55 to 125		
LT1004MLP-1-2	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI	-55 to 125		
LT1004MLP-2-5	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI	-55 to 125		

(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.

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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
LT1004CDR-1-2	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LT1004CDR-1-2	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LT1004CDR-2-5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LT1004IDR-1-2	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LT1004IDR-2-5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LT1004IPWR-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)
LT1004CDR-1-2	SOIC	D	8	2500	367.0	367.0	35.0
LT1004CDR-1-2	SOIC	D	8	2500	340.5	338.1	20.6
LT1004CDR-2-5	SOIC	D	8	2500	340.5	338.1	20.6
LT1004IDR-1-2	SOIC	D	8	2500	340.5	338.1	20.6
LT1004IDR-2-5	SOIC	D	8	2500	340.5	338.1	20.6
LT1004IPWR-2-5	TSSOP	PW	8	2000	367.0	367.0	35.0

PW0008A



# PACKAGE OUTLINE

## TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



NOTES:

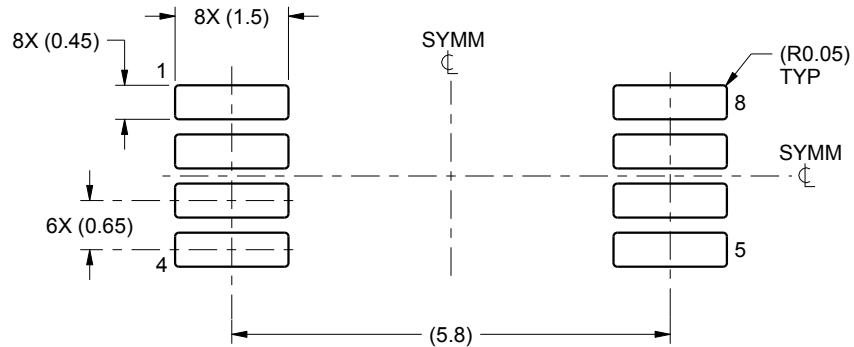
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153, variation AA.

# EXAMPLE BOARD LAYOUT

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
SCALE:10X



SOLDER MASK DETAILS  
NOT TO SCALE

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NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:10X

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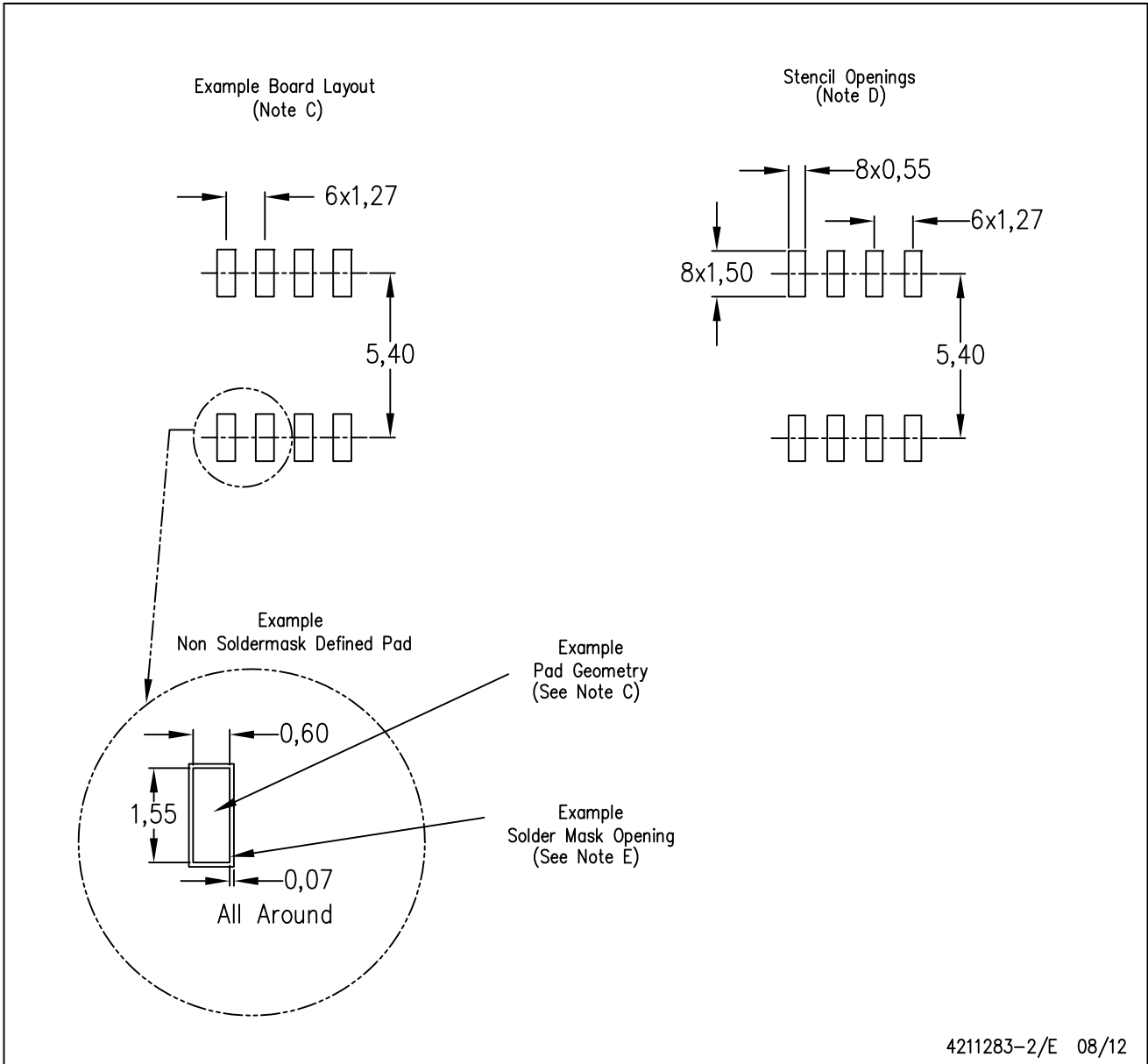
NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.



D (R-PDSO-G8)

PLASTIC SMALL OUTLINE

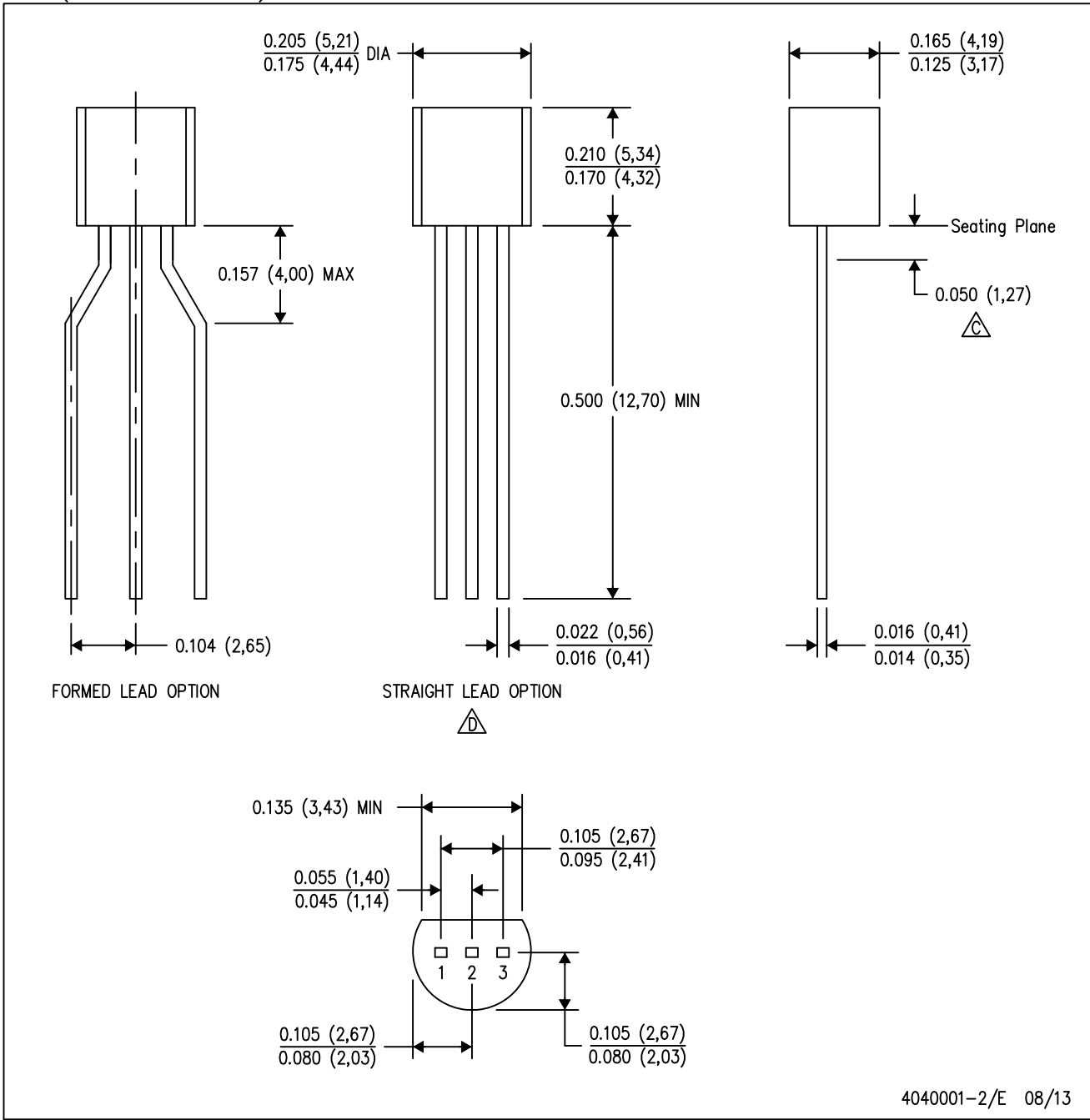


- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers 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.

**MECHANICAL DATA**

LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



4040001-2/E 08/13

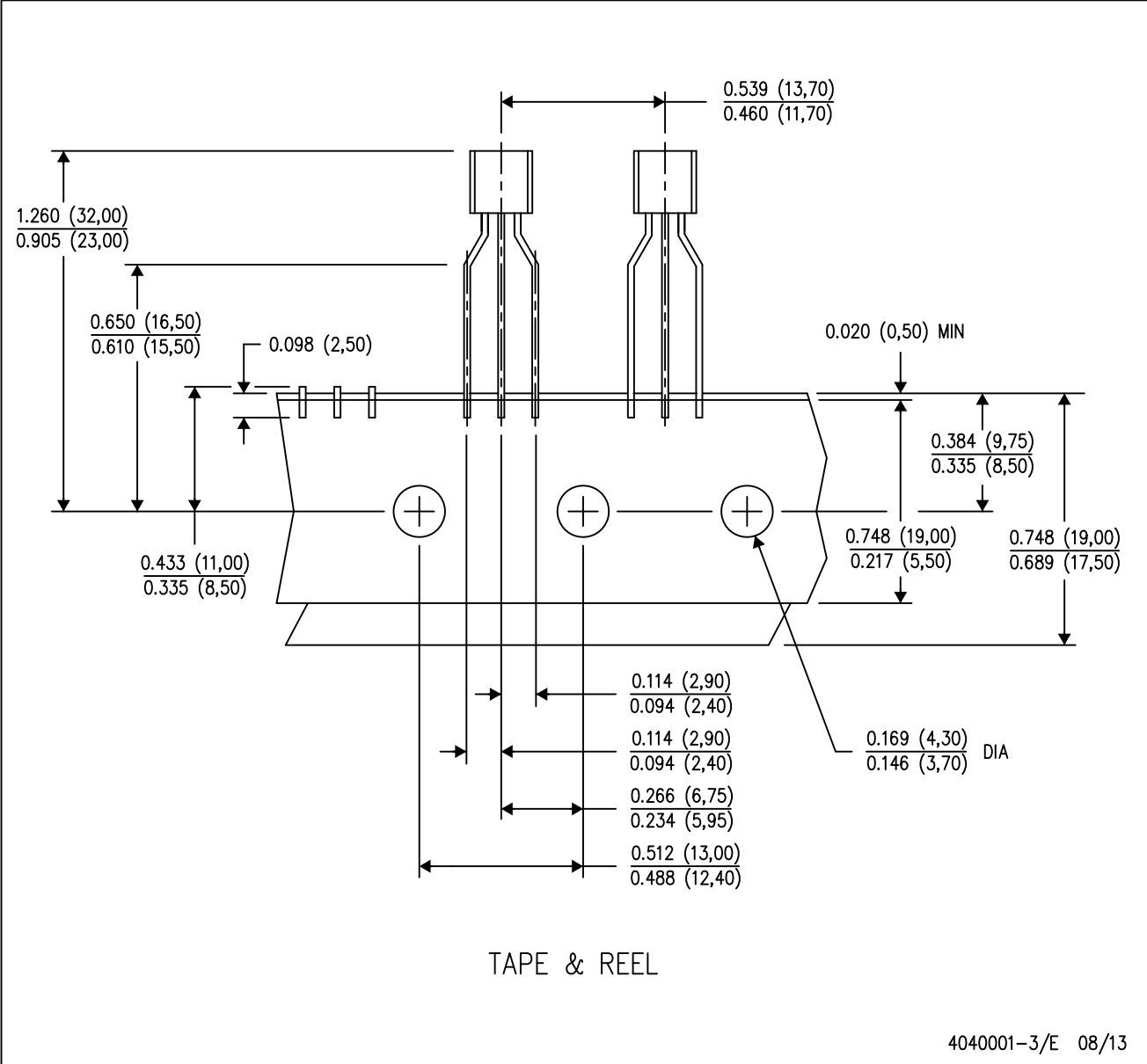
- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - Lead dimensions are not controlled within this area.
  - Falls within JEDEC TO-226 Variation AA (TO-226 replaces TO-92).
  - E. Shipping Method:
    - Straight lead option available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



**MECHANICAL DATA**

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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Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
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