

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

SLVS022J – JANUARY 1989 – REVISED AUGUST 2003

- **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**

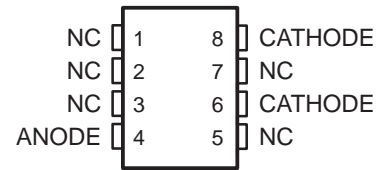
## description/ordering information

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.

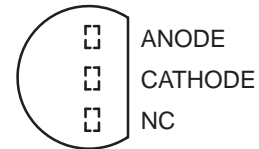
The LT1004C is characterized for operation from 0°C to 70°C. The LT1004I is characterized for operation from –40°C to 85°C.

**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



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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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## description/ordering information (continued)

### ORDERING INFORMATION

TA	Vz 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)	Bulk of 1000	LT1004CLP-1-2	1004C12
		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
	Reel of 2500			LT1004CDR-2-5	
	TO-226 / TO-92 (LP)		Bulk of 1000	LT1004CLP-2-5	1004C25
	Reel of 2000		LT1004CLPM-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
Reel of 2500				LT1004IDR-1-2	
TO-226 / TO-92 (LP)			Bulk of 1000	LT1004ILP-1-2	1004I12
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
		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](http://www.ti.com/sc/package).

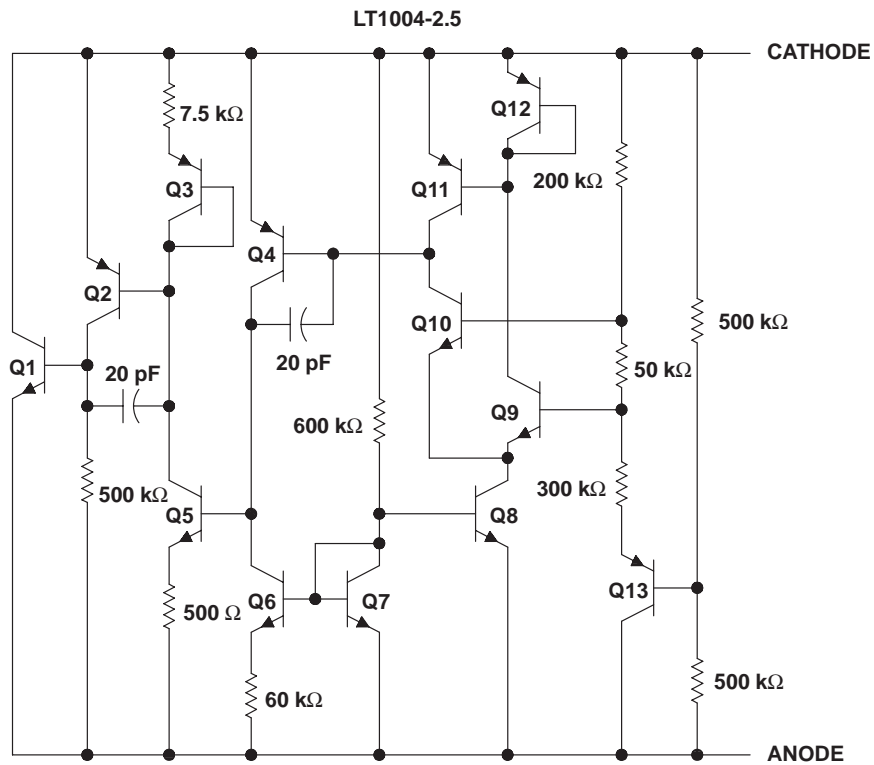
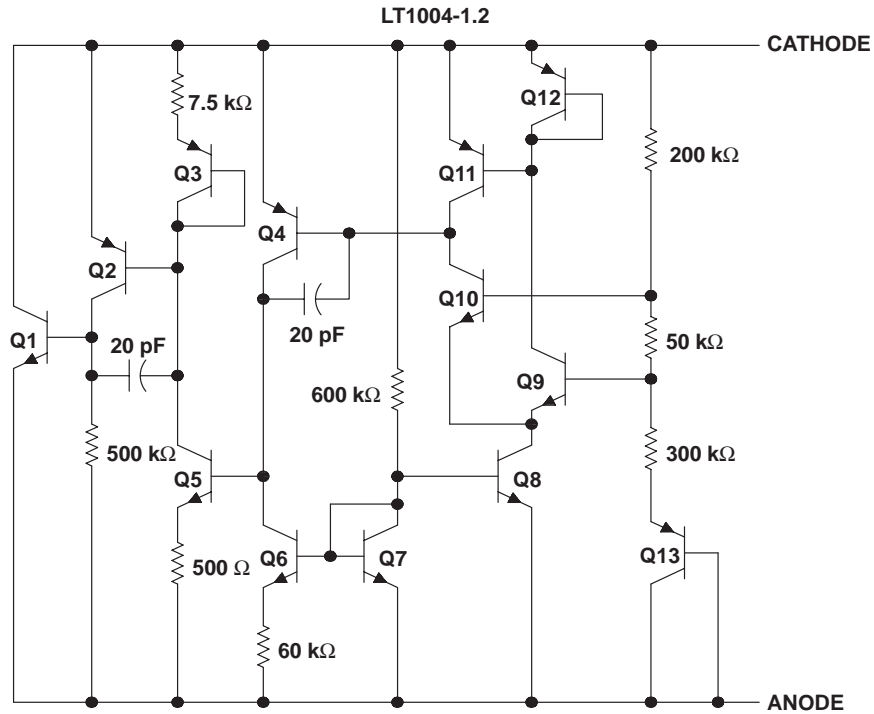
## symbol



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

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## schematic



NOTE A: All component values shown are nominal.

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## 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, $\theta_{JA}$ (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  $T_J(\max)$ ,  $\theta_{JA}$ , 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	$I_Z = 100 \mu A$	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		
$\alpha_{V_Z}$ Average temperature coefficient of reference voltage§	$I_Z = 10 \mu A$	25°C	20						ppm/°C
	$I_Z = 20 \mu A$					20			
$\Delta V_Z$ 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	$I_Z = 100 \mu A$	25°C	20			20			ppm/hr
$I_Z(\min)$ Minimum reference current		Full range	8 10			12 20			$\mu A$
$z_Z$ Reference impedance	$I_Z = 100 \mu A$	25°C	0.2 0.6			0.2 0.6			$\Omega$
		Full range	1.5			1.5			
$V_n$ Broadband noise voltage	$I_Z = 100 \mu A$ , $f = 10$ Hz to 10 kHz	25°C	60			120			$\mu V$

‡ 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**

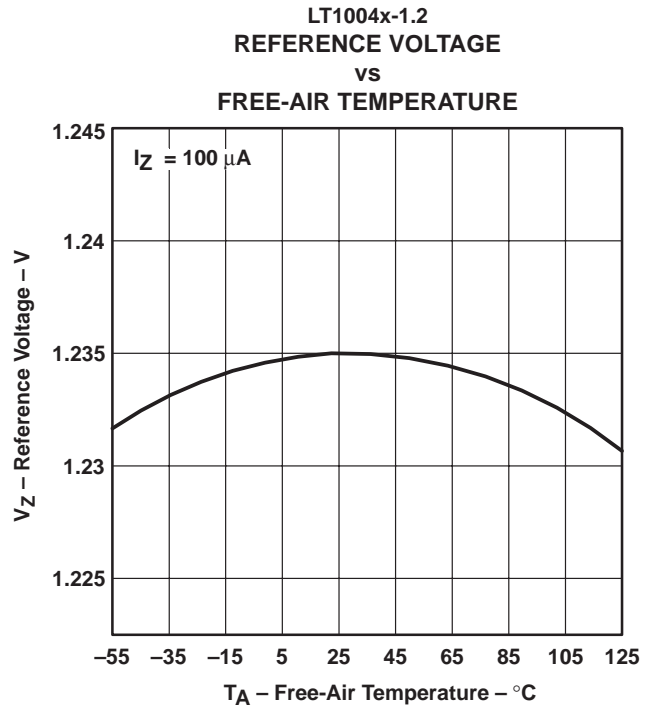
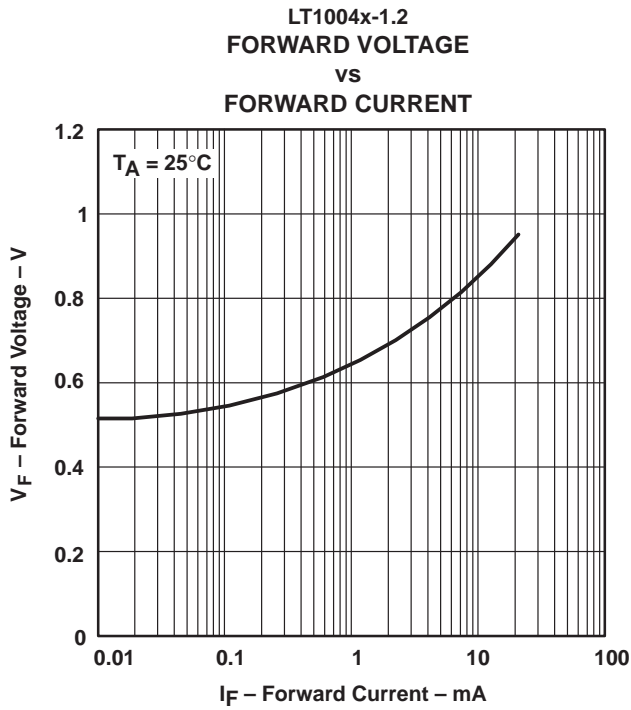
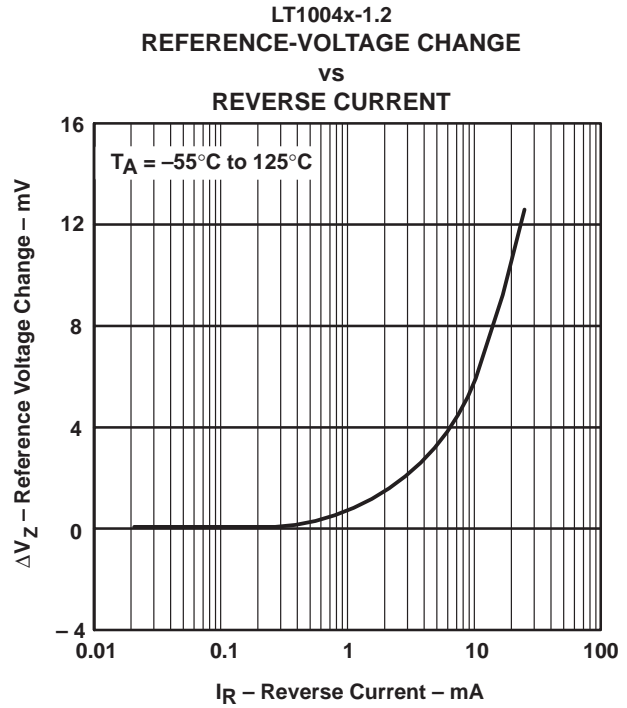
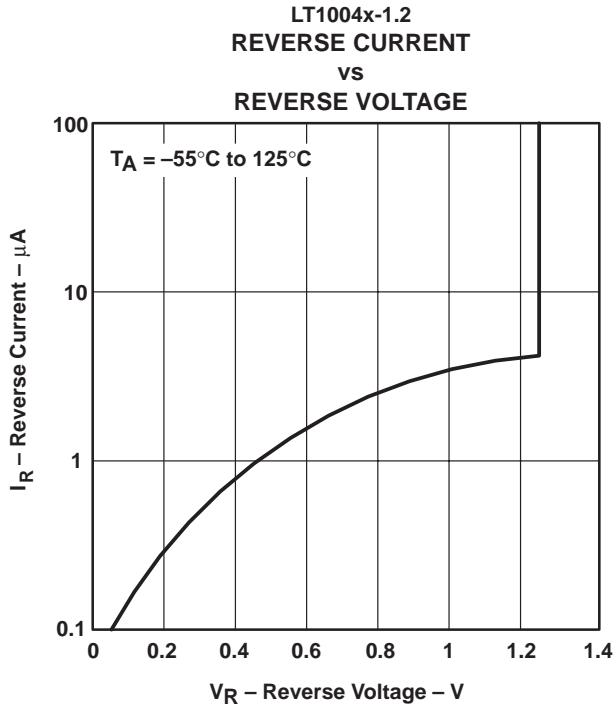
**Table of Graphs**

GRAPH TITLE	FIGURE
<b>LT1004x-1.2</b>	
Reverse current vs Reverse voltage	1
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Noise voltage vs Frequency	13
Filtered output noise voltage vs Cutoff frequency	14
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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†

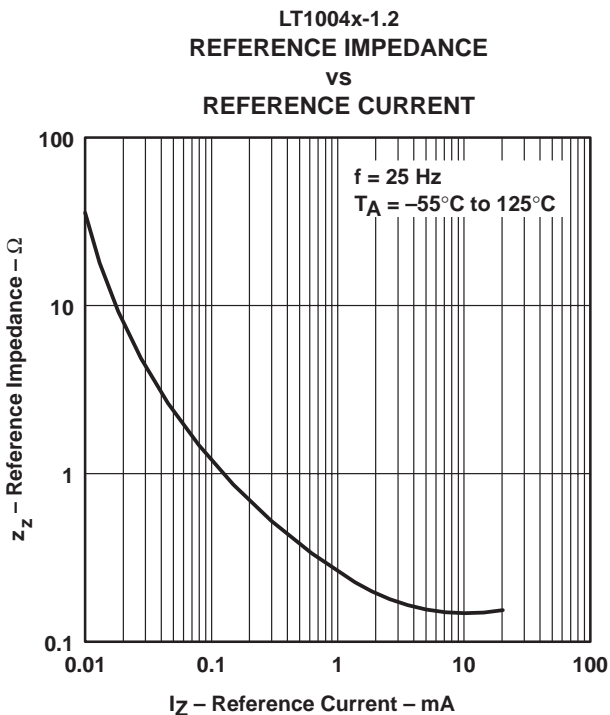


Figure 5

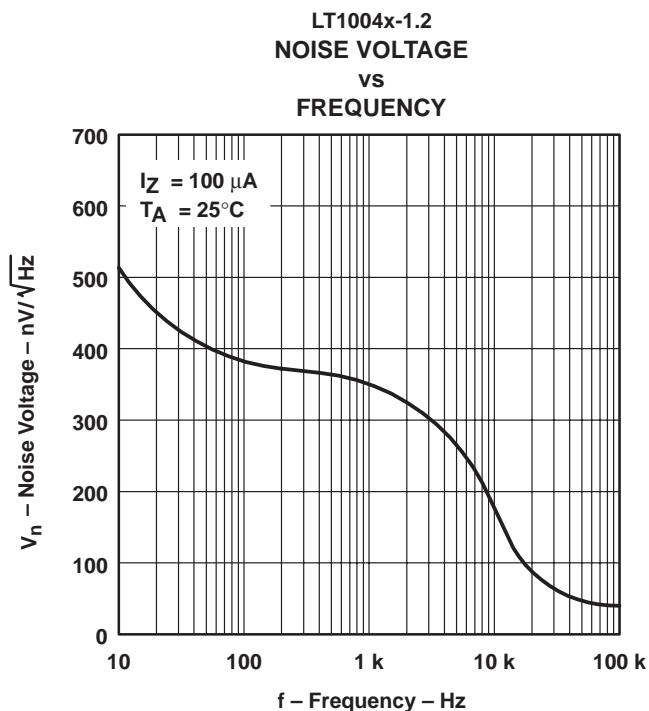


Figure 6

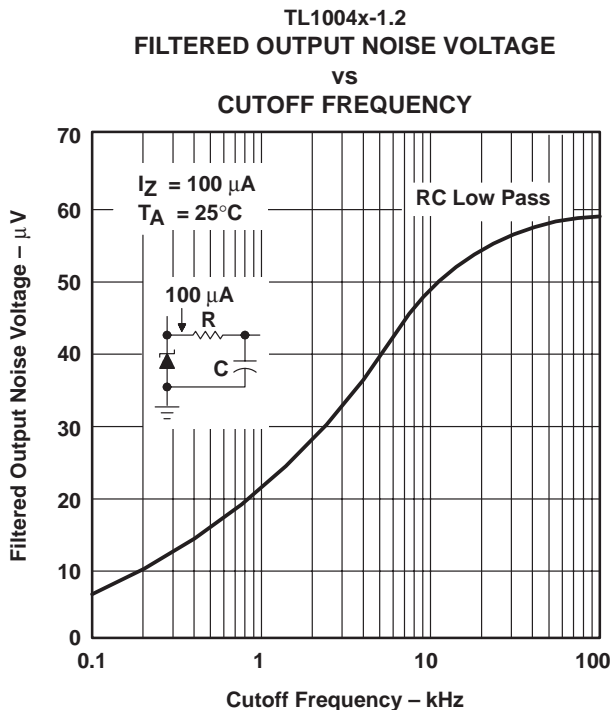


Figure 7

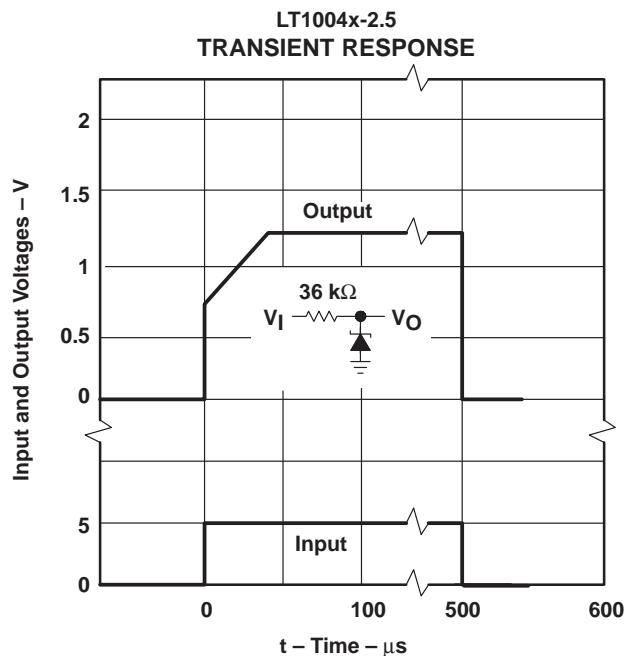


Figure 8

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

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## TYPICAL CHARACTERISTICS†

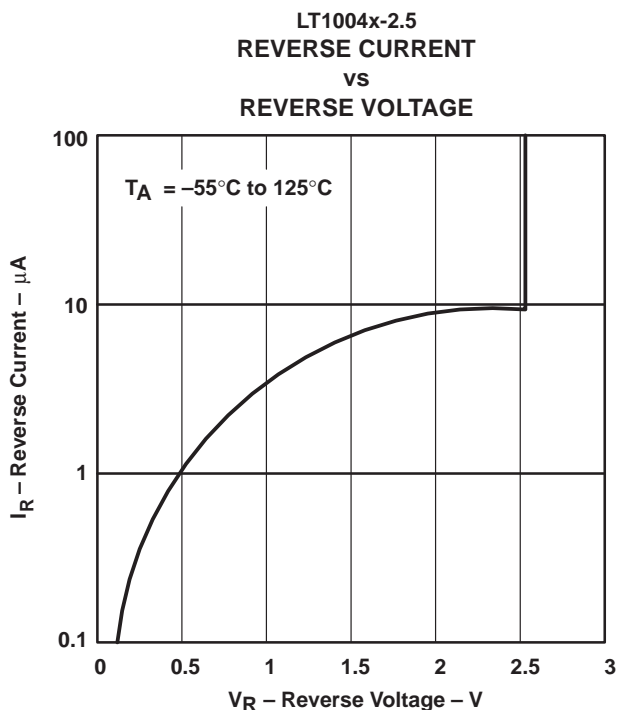


Figure 9

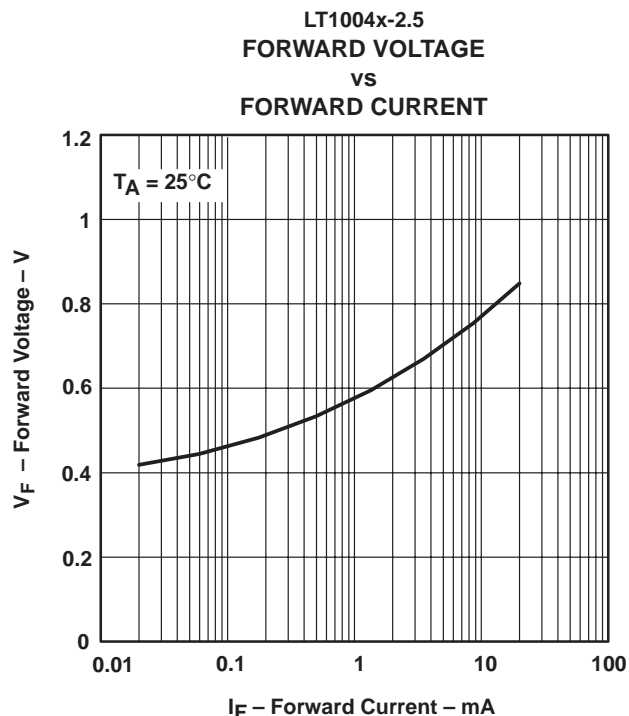


Figure 10

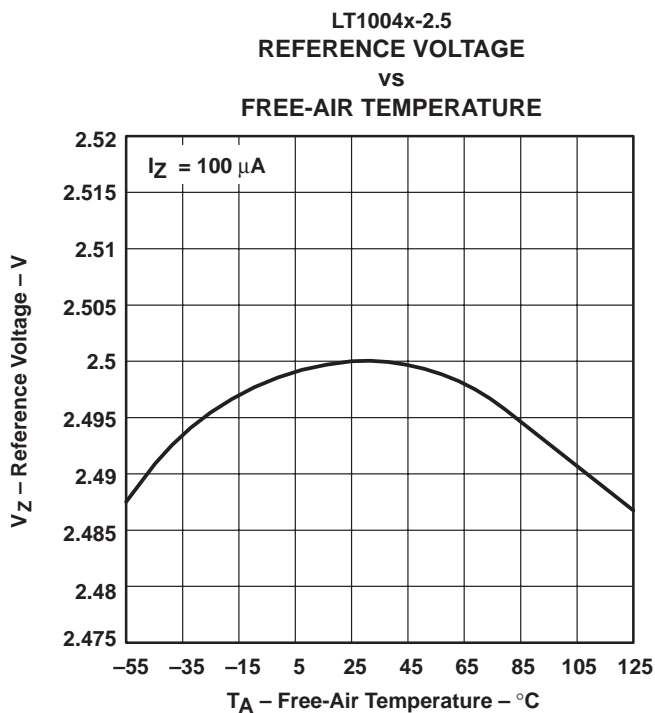


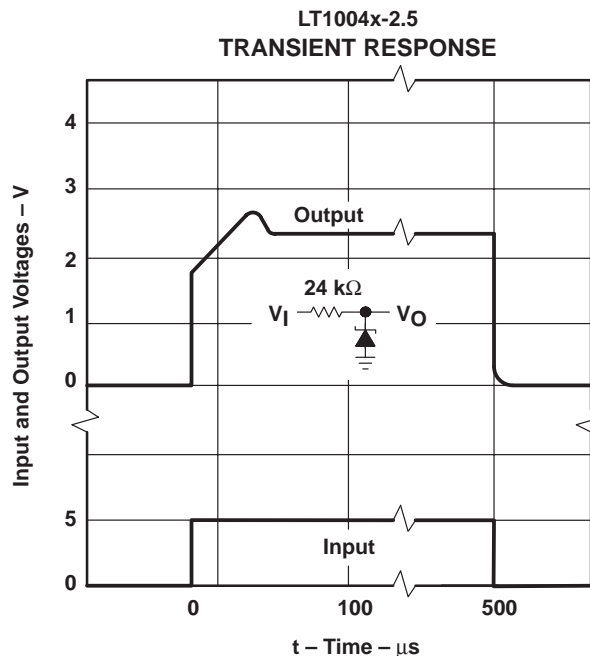
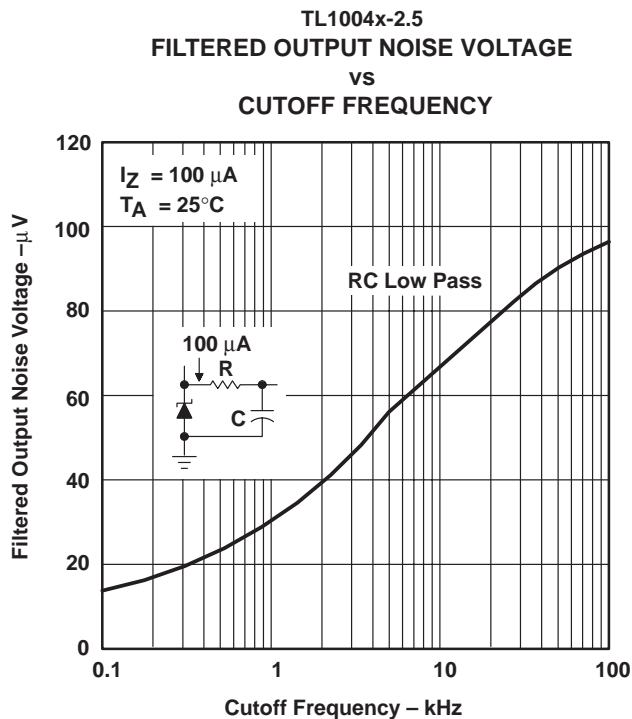
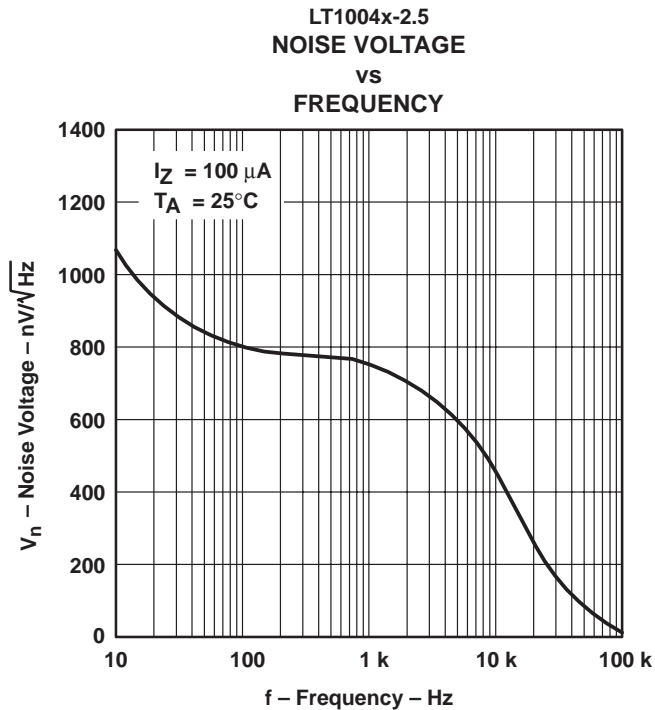
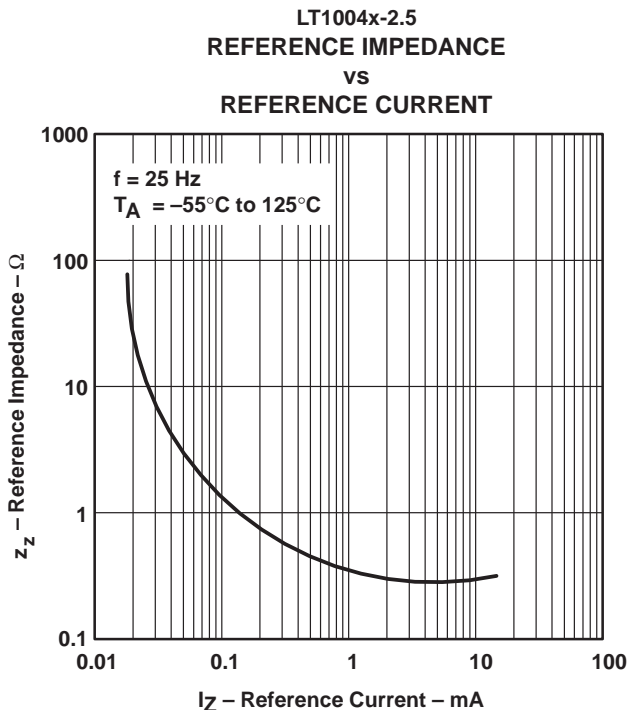
Figure 11

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





TYPICAL CHARACTERISTICS†

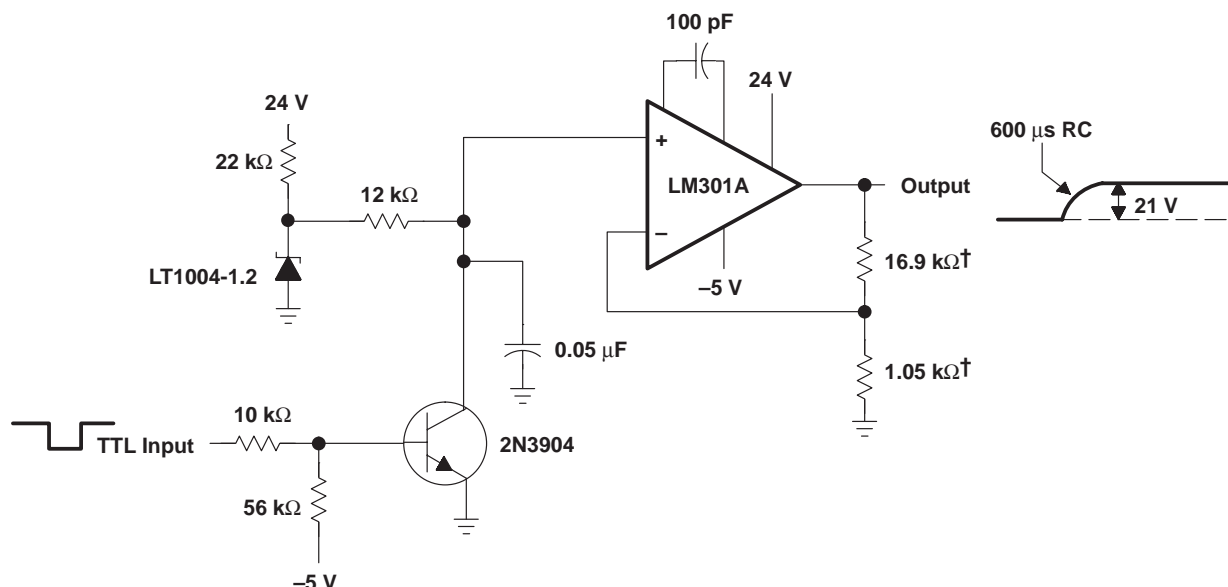


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# LT1004-1.2, LT1004-2.5 MICROPOWER INTEGRATED VOLTAGE REFERENCES

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## APPLICATION INFORMATION



† 1% metal-film resistors

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

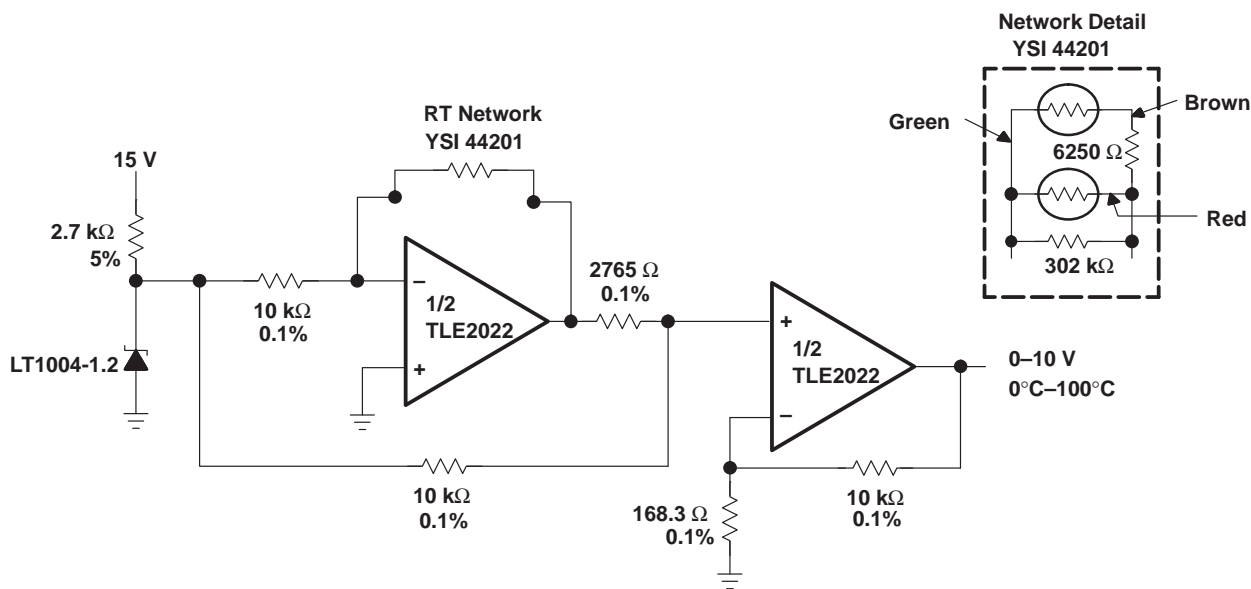


Figure 17. 0°C-to-100°C Linear-Output Thermometer

APPLICATION INFORMATION

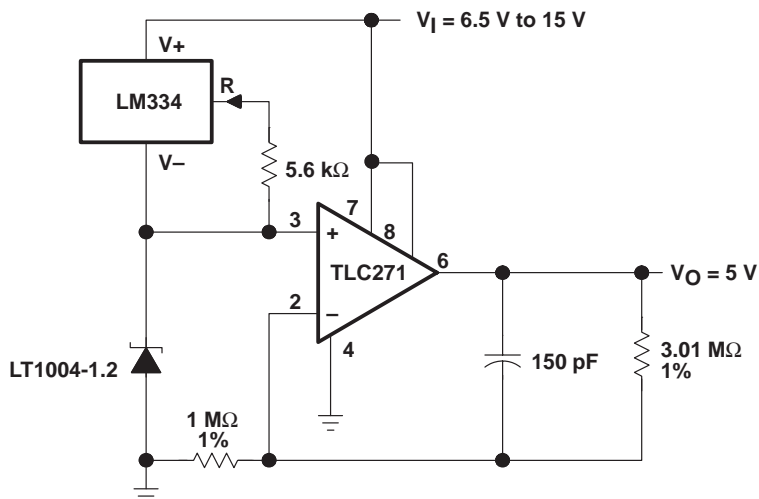


Figure 18. Micropower 5-V Reference

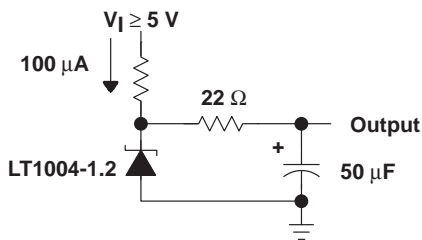


Figure 19. Low-Noise Reference

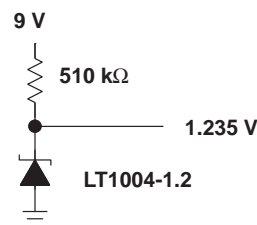
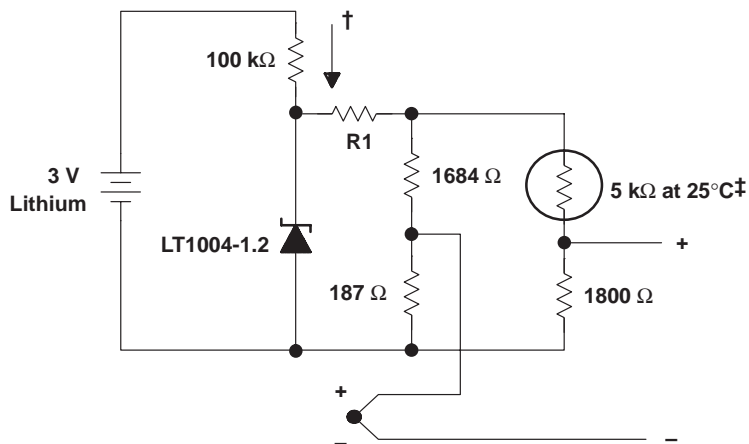


Figure 20. Micropower Reference From 9-V Battery



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

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

‡ 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

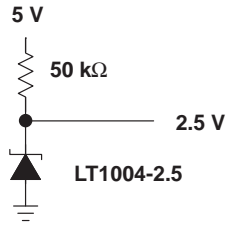


Figure 22. 2.5-V Reference

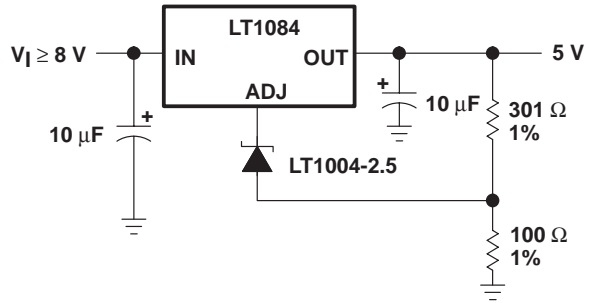
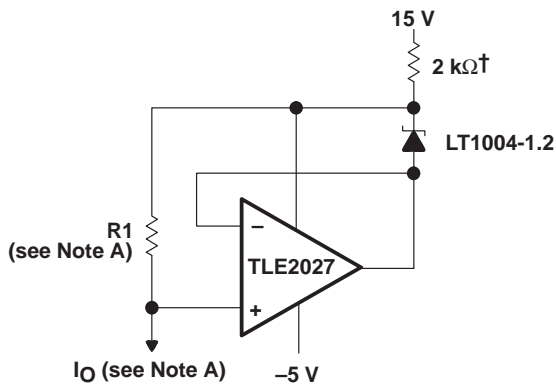


Figure 23. High-Stability 5-V Regulator



† 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

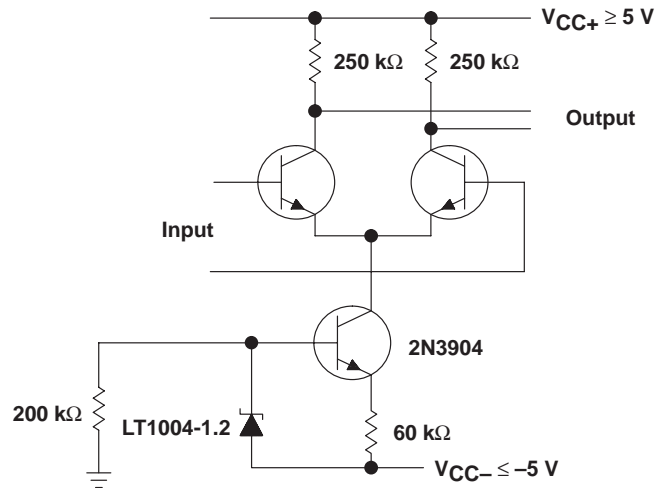
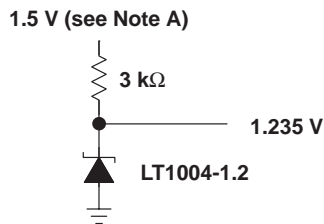


Figure 25. Amplifier With Constant Gain Over Temperature



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

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

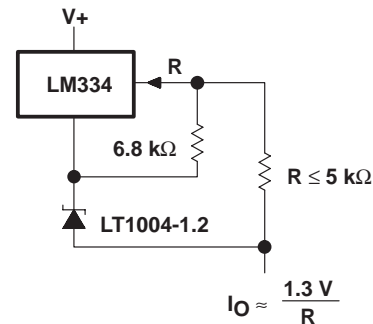
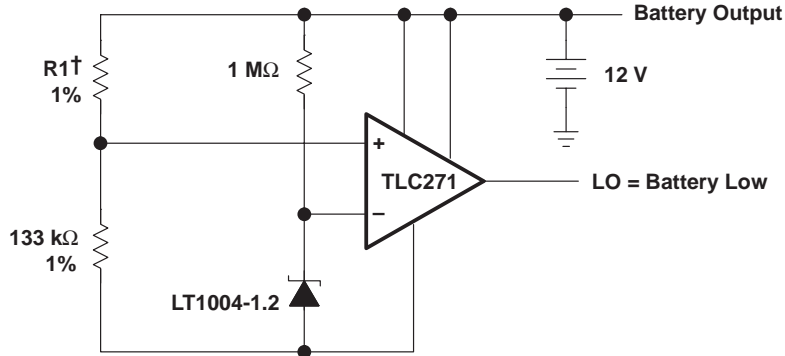


Figure 27. Terminal Current Source With Low Temperature Coefficient

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

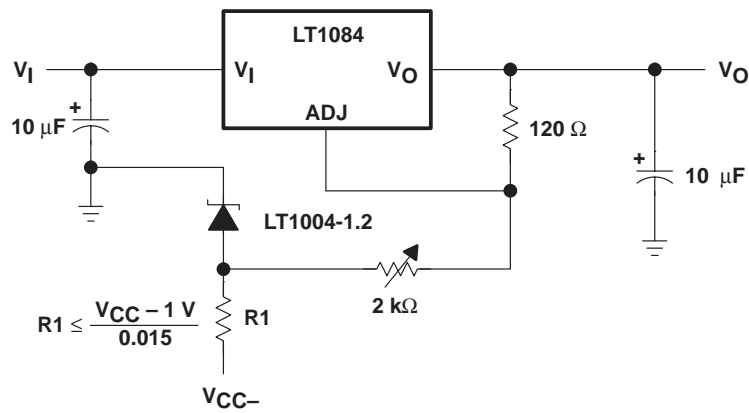
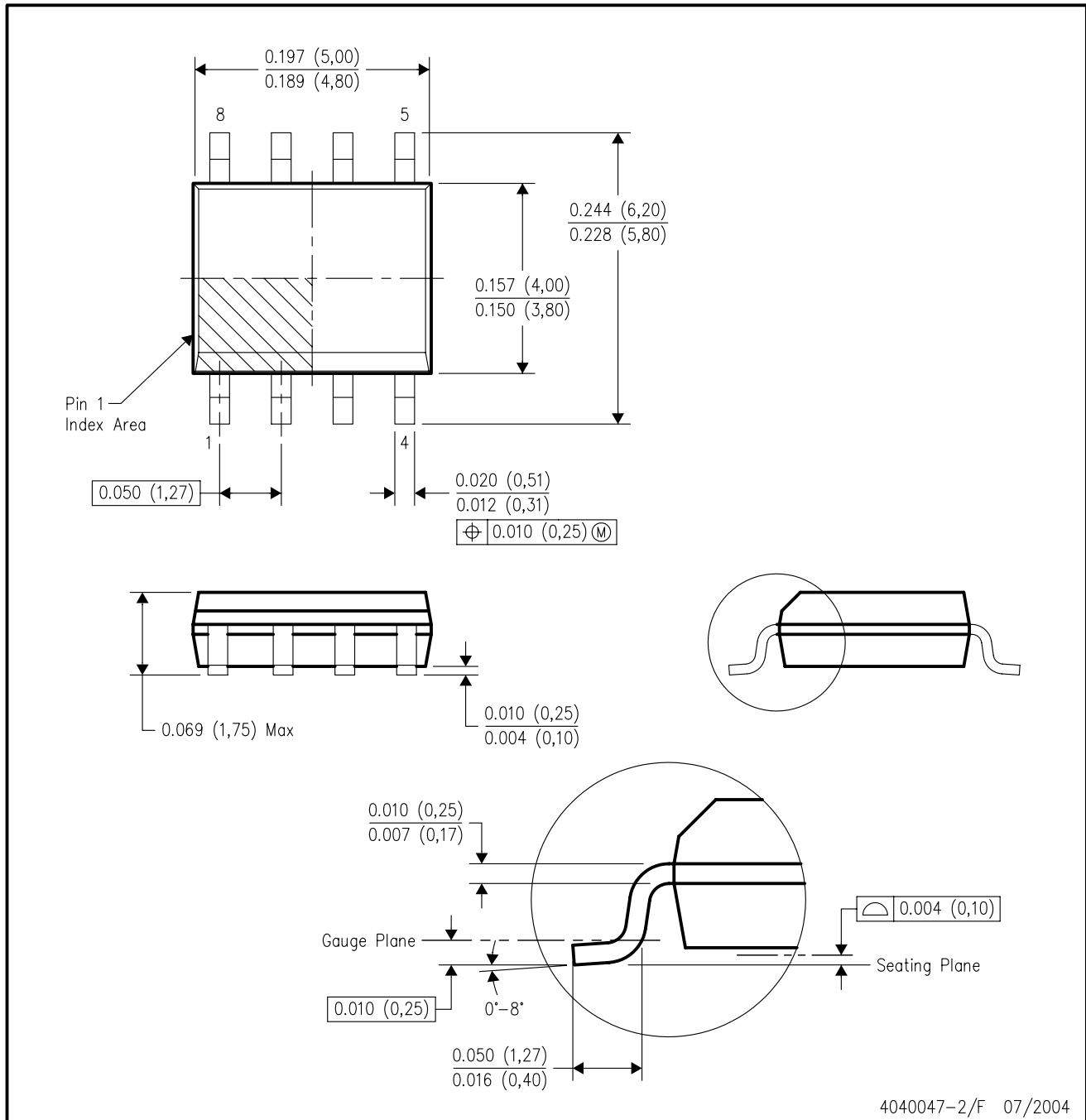


Figure 29. Variable-Voltage Supply

D (R-PDSO-G8)

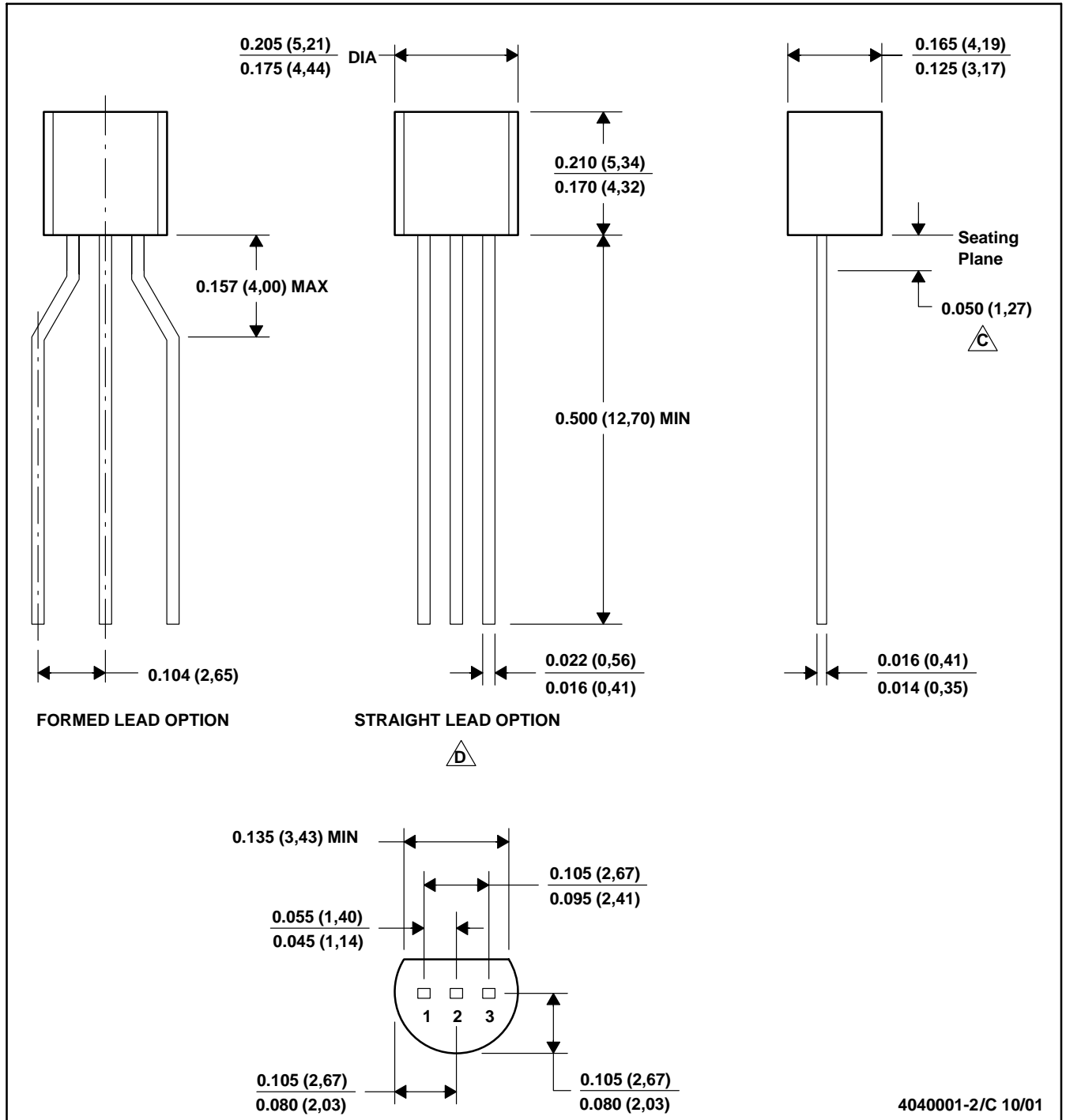
PLASTIC SMALL-OUTLINE PACKAGE



- 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



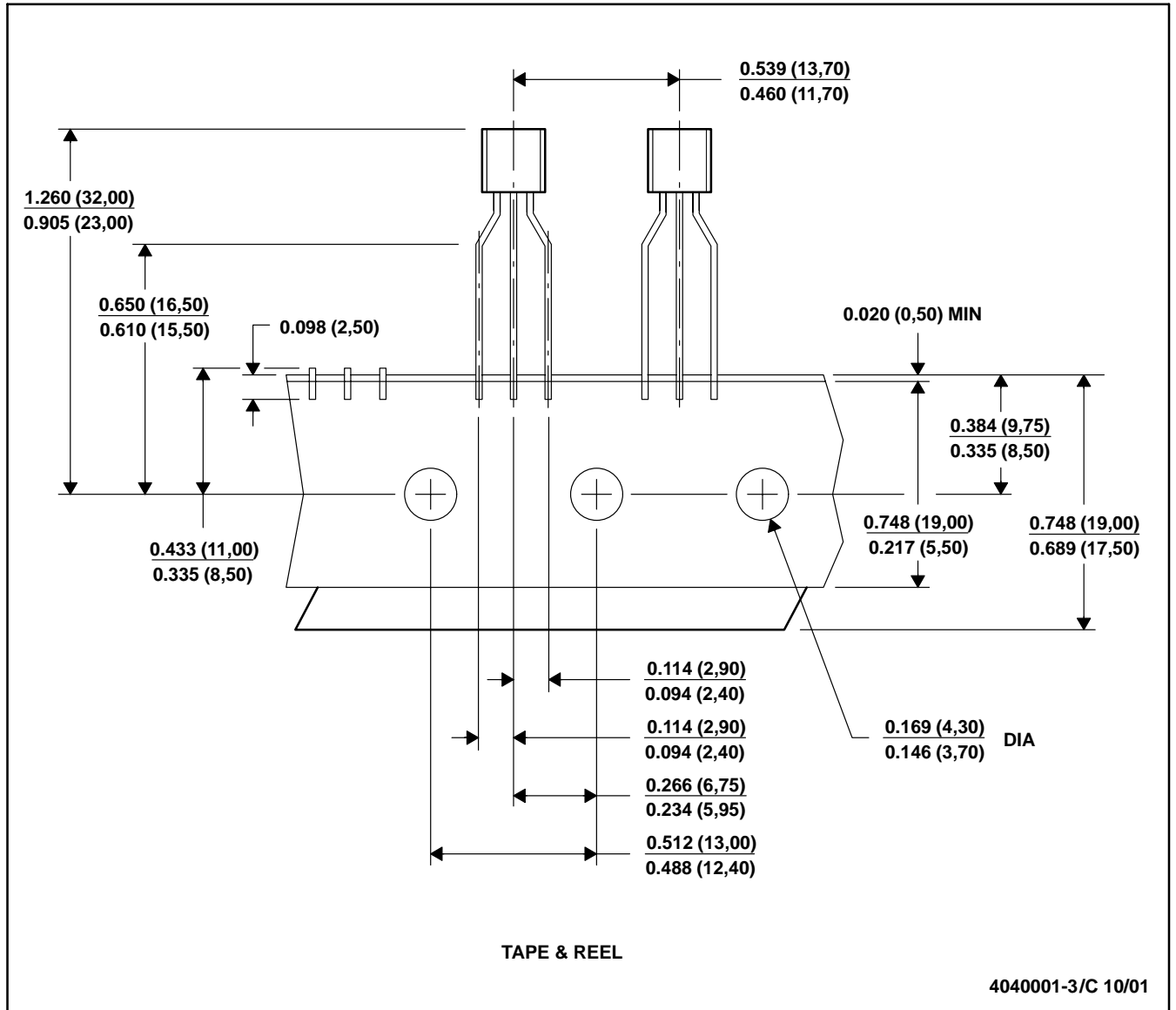
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# MECHANICAL DATA

MSOT002A – OCTOBER 1994 – REVISED NOVEMBER 2001

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



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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Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
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Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
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