

LT1004-1.2, LT1004-2.5 MICROPOWER INTEGRATED VOLTAGE REFERENCES

SLVS022J – JANUARY 1989 – REVISED AUGUST 2003

- **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**

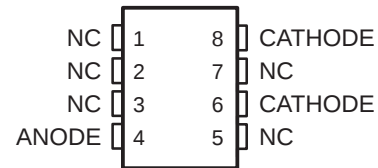
description/ordering information

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**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 2003, Texas Instruments Incorporated

LT1004-1.2, LT1004-2.5

MICROPOWER INTEGRATED VOLTAGE REFERENCES

SLVS022J – JANUARY 1989 – REVISED AUGUST 2003

description/ordering information (continued)

ORDERING INFORMATION

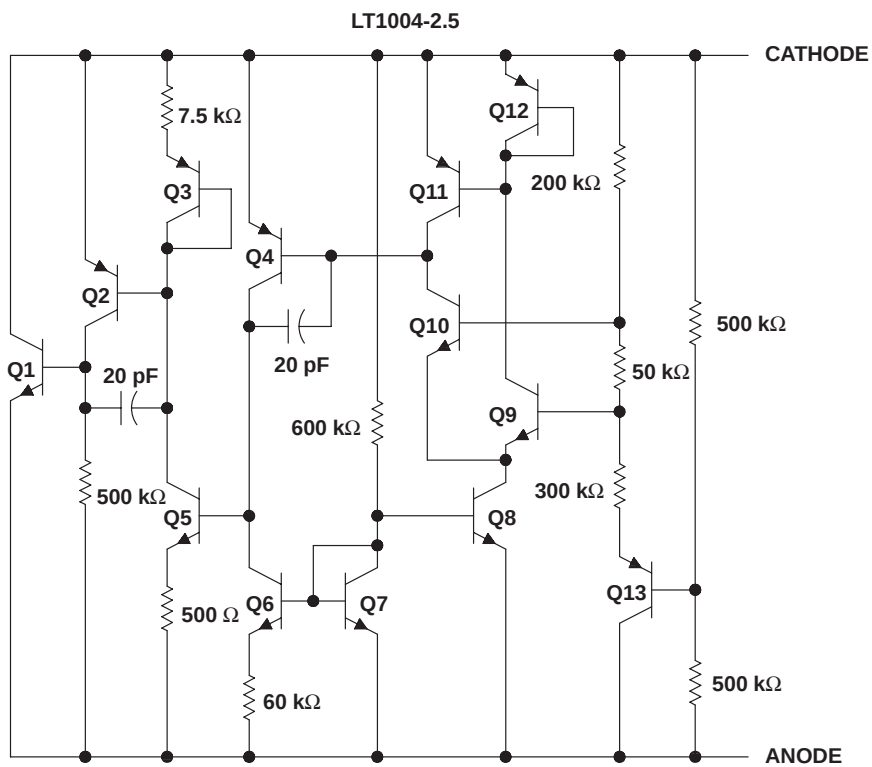
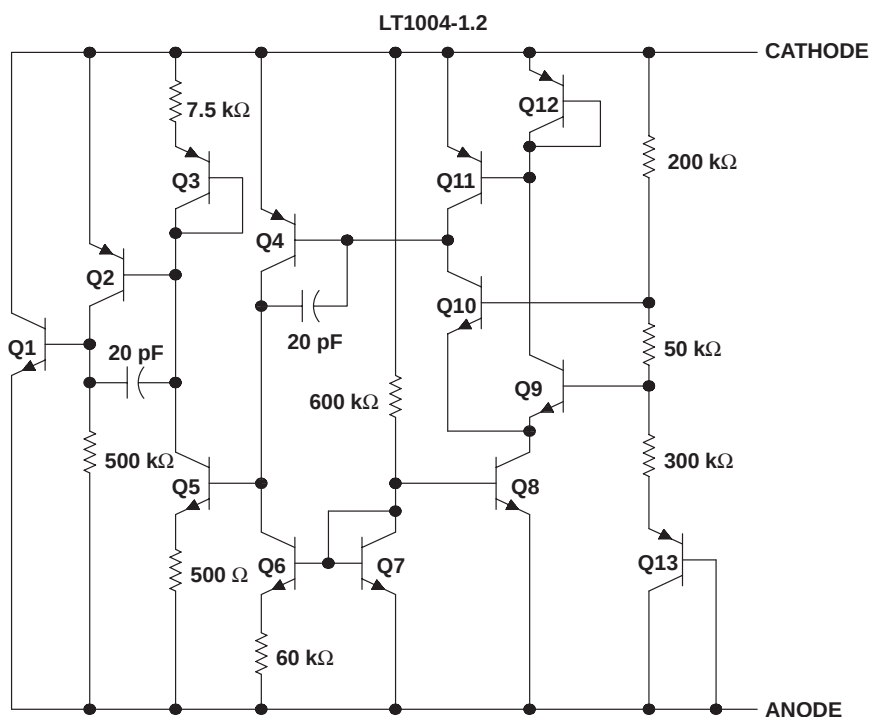
T _A	V _Z TYP	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	1.2 V	SOIC (D)	Tube of 75	LT1004CD-1-2	4C-12
			Reel of 2500	LT1004CDR-1-2	
		TO-226 / TO-92 (LP)	Bulk of 1000	LT1004CLP-1-2	1004C12
	2.5 V	TSSOP (PW)	Tube of 150	LT1004CPW-1-2	4C-12
			Reel of 2000	LT1004CPWR-1-2	
		SOIC (D)	Tube of 75	LT1004CD-2-5	4C-25
			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	4I-12
			Reel of 2500	LT1004IDR-1-2	
		TO-226 / TO-92 (LP)	Bulk of 1000	LT1004ILP-1-2	1004I12
	2.5 V	TSSOP (PW)	Tube of 150	LT1004IPW-1-2	4I-12
			Reel of 2000	LT1004IPWR-1-2	
		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.

LT1004-1.2, LT1004-2.5

MICROPOWER INTEGRATED VOLTAGE REFERENCES

SLVS022J – JANUARY 1989 – REVISED AUGUST 2003

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 $T_J(\text{max})$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$. 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			20			ppm/°C	
		I _Z = 20 μA										
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				
ΔV _Z /Δt	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.



POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TYPICAL CHARACTERISTICS

Table of Graphs

GRAPH TITLE	FIGURE
LT1004x-1.2	
Reverse current vs Reverse voltage	1
Reference-voltage change vs Reverse current	2
Forward voltage vs Forward current	3
Reference voltage vs Free-air temperature	4
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

LT1004-1.2, LT1004-2.5 MICROPOWER INTEGRATED VOLTAGE REFERENCES

SLVS022J – JANUARY 1989 – REVISED AUGUST 2003

TYPICAL CHARACTERISTICS†

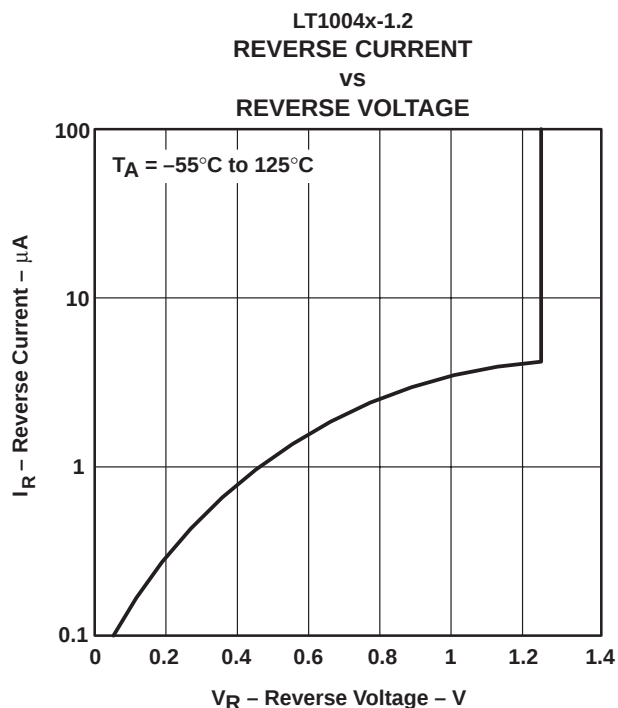


Figure 1

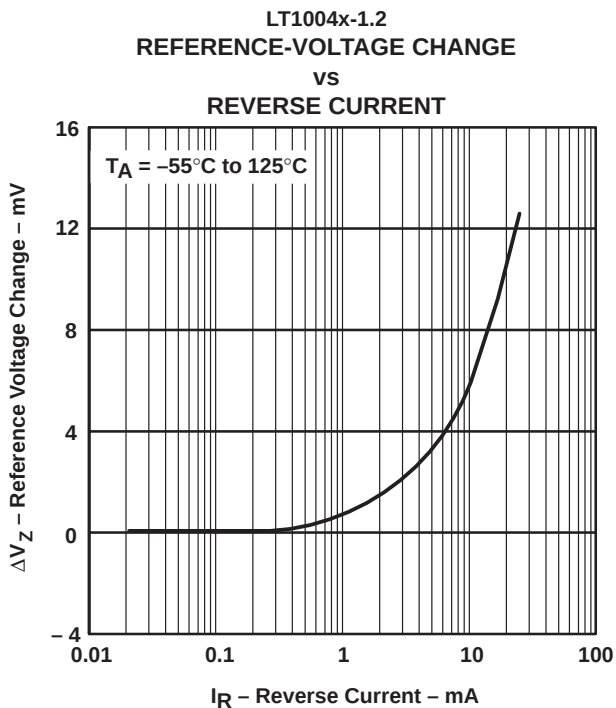


Figure 2

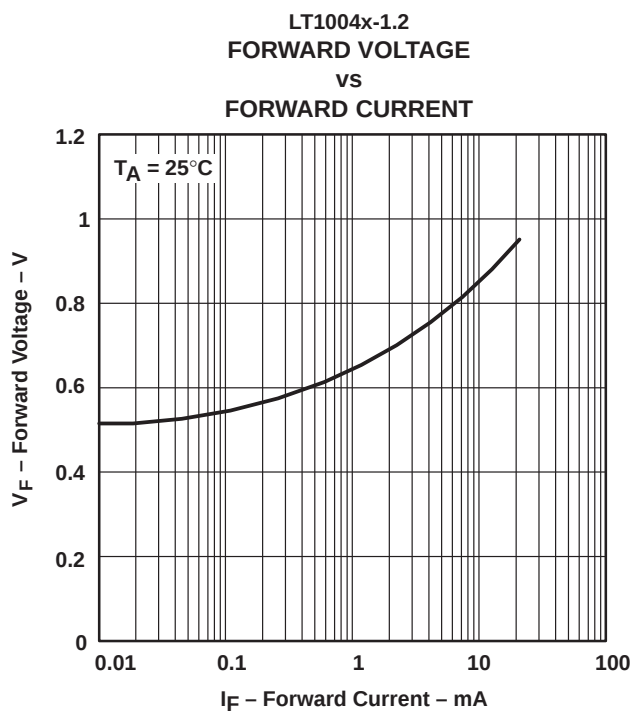


Figure 3

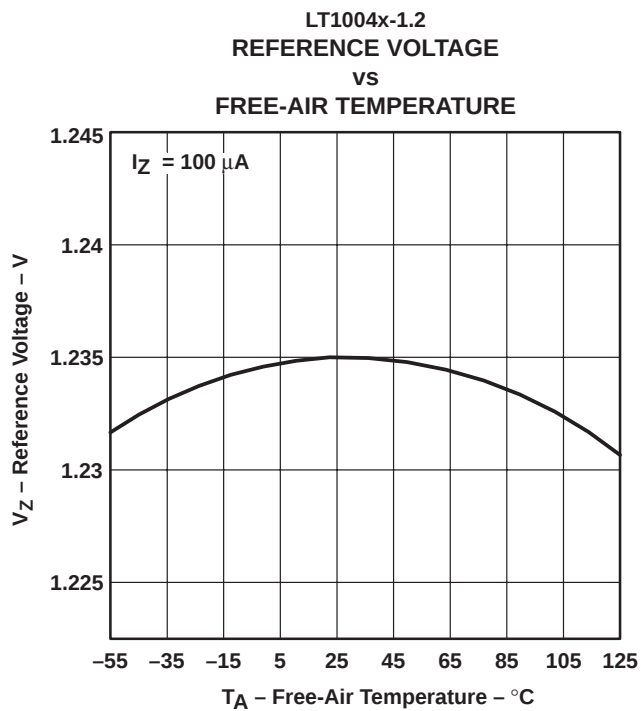


Figure 4

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

TYPICAL CHARACTERISTICS†

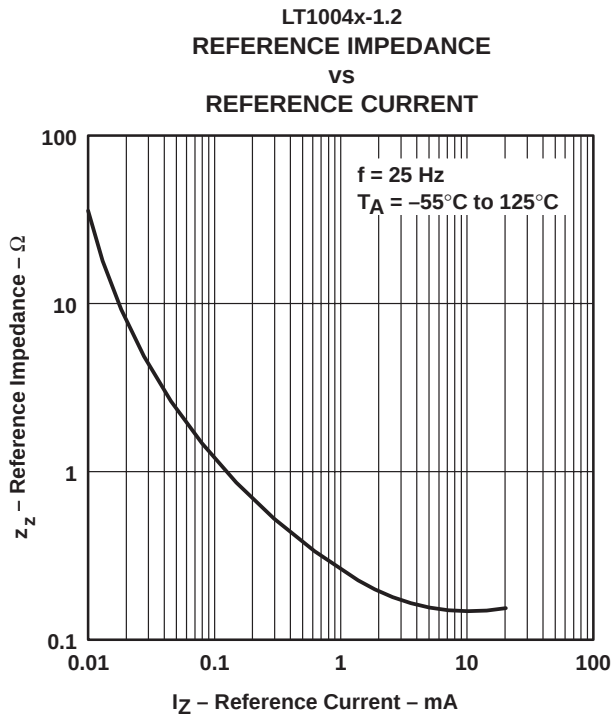


Figure 5

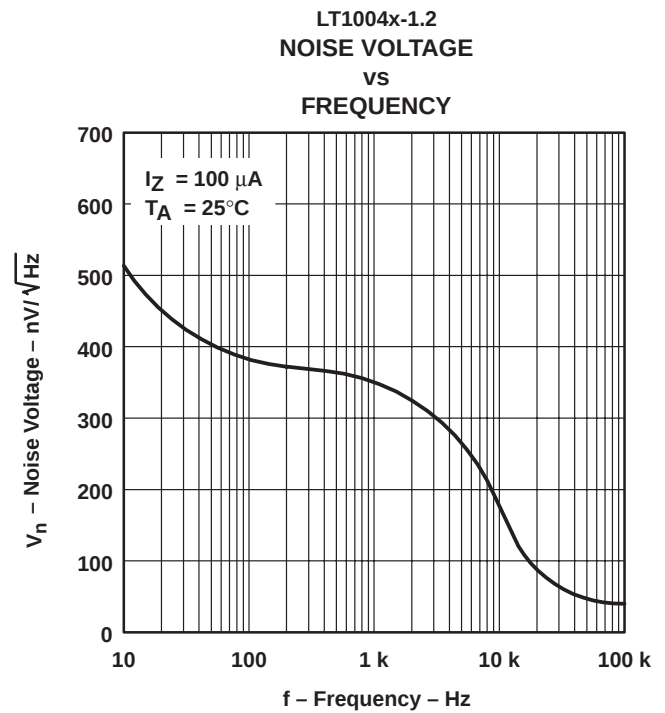


Figure 6

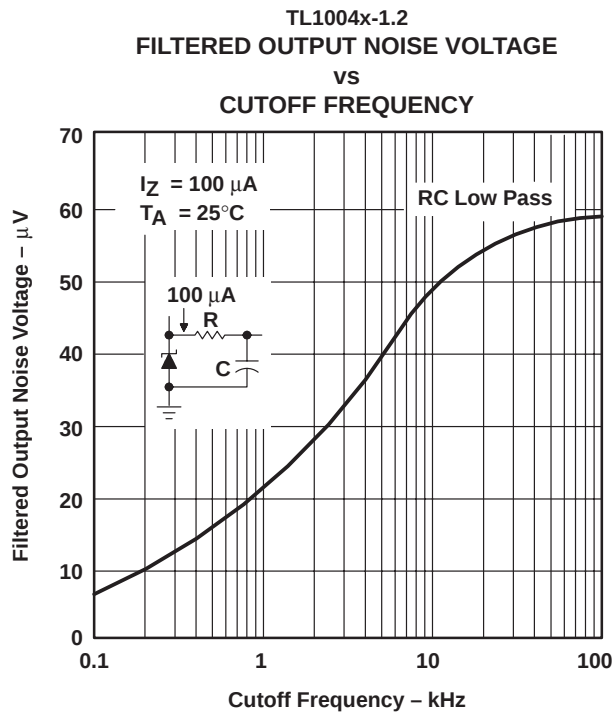


Figure 7

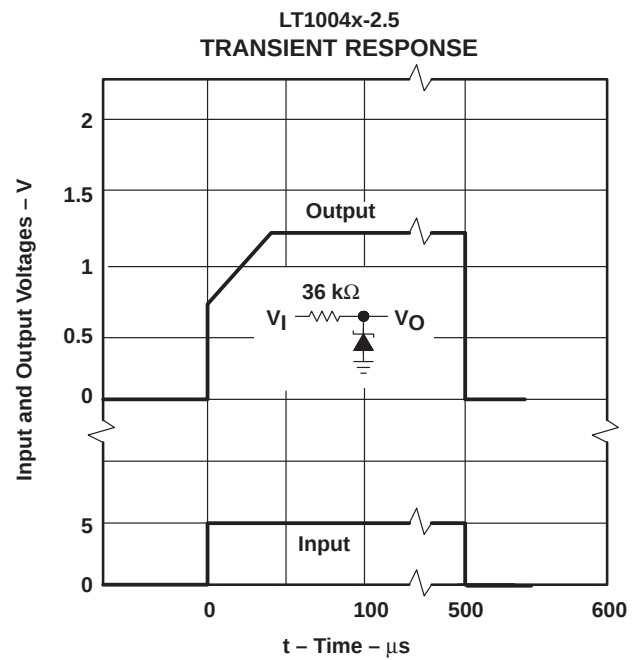


Figure 8

† 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

SLVS022J – JANUARY 1989 – REVISED AUGUST 2003

TYPICAL CHARACTERISTICS†

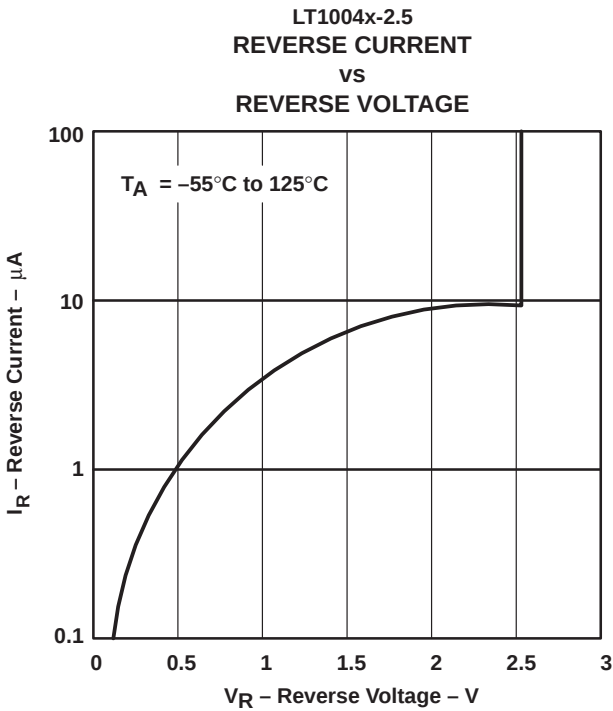


Figure 9

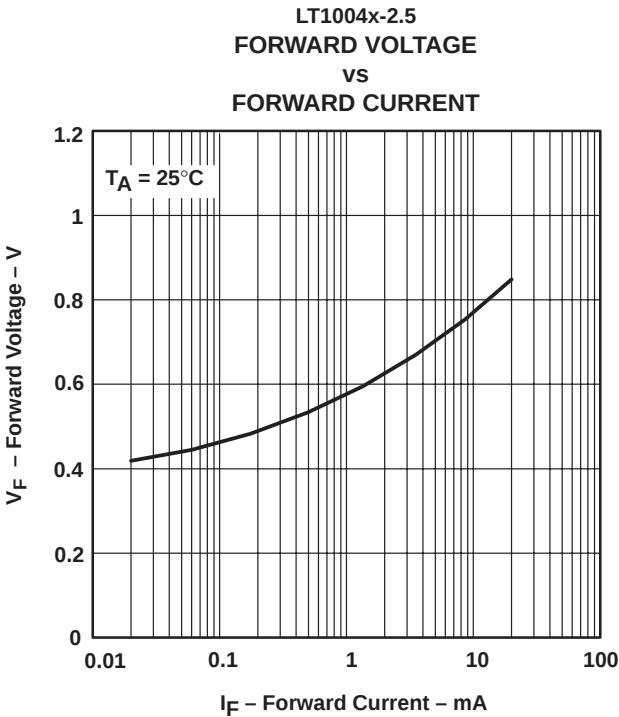


Figure 10

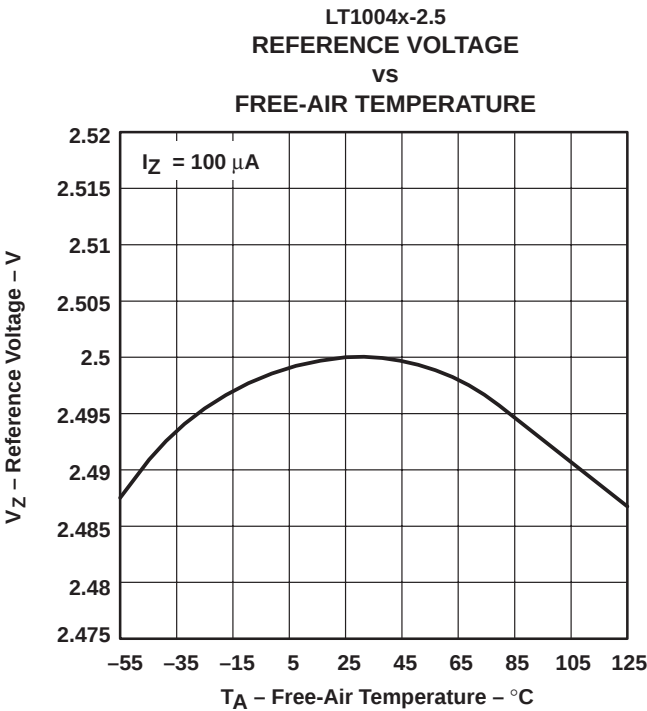


Figure 11

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

TYPICAL CHARACTERISTICS†

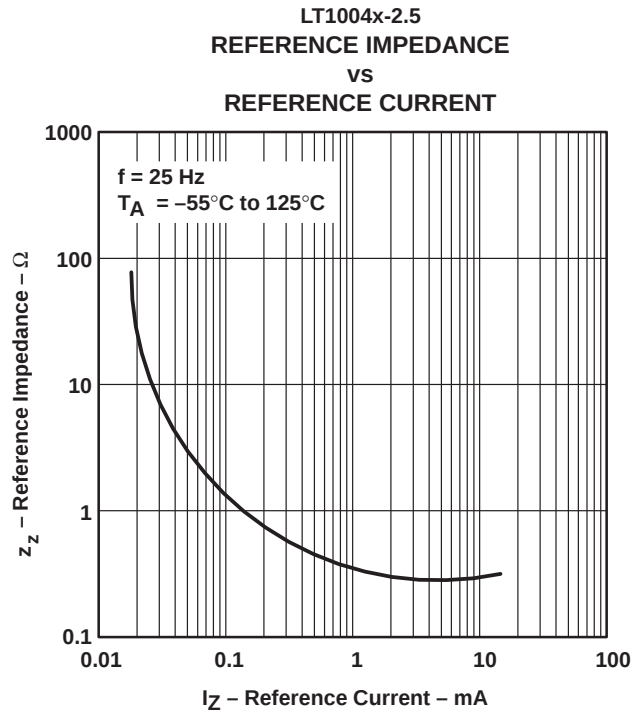


Figure 12

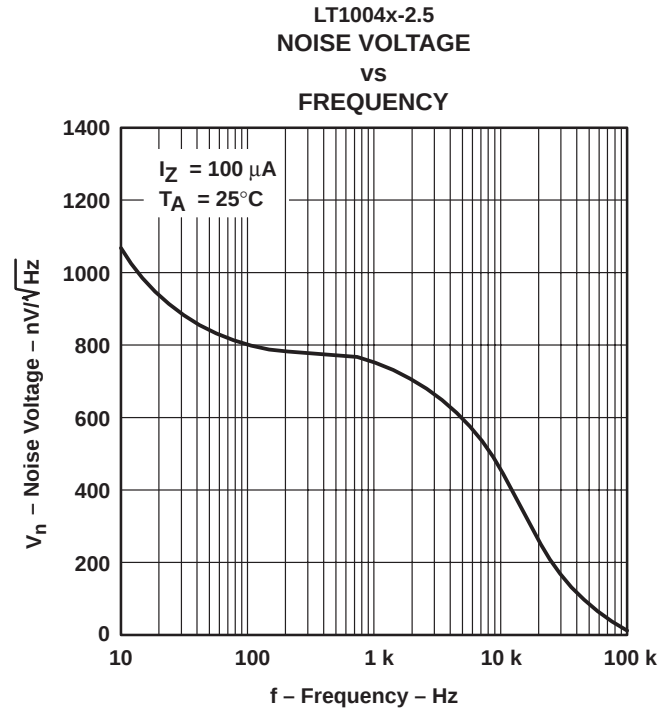


Figure 13

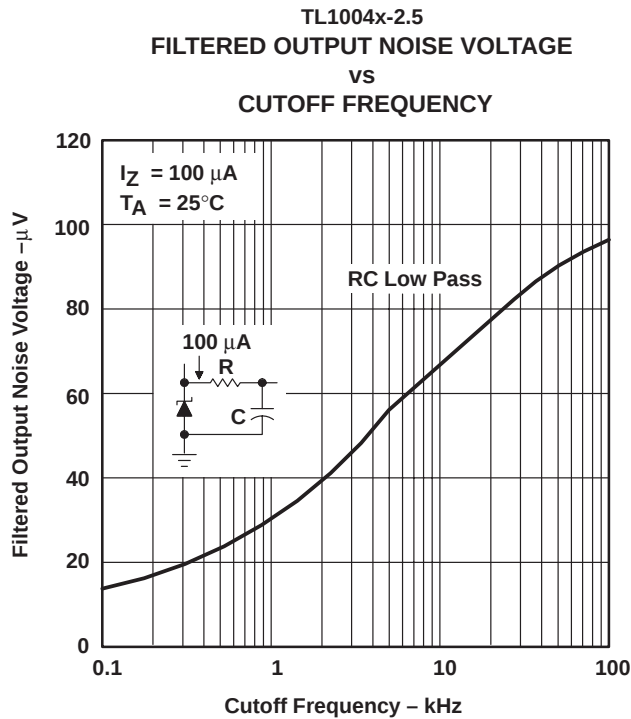


Figure 14

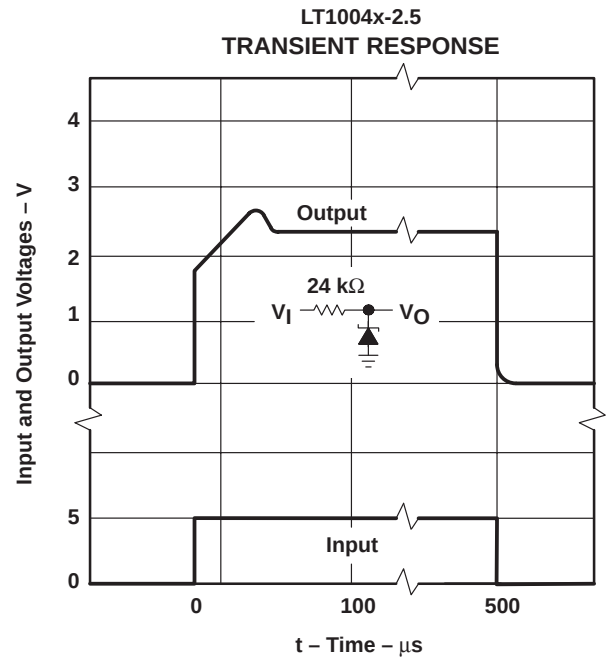


Figure 15

† 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

SLVS022J – JANUARY 1989 – REVISED AUGUST 2003

APPLICATION INFORMATION

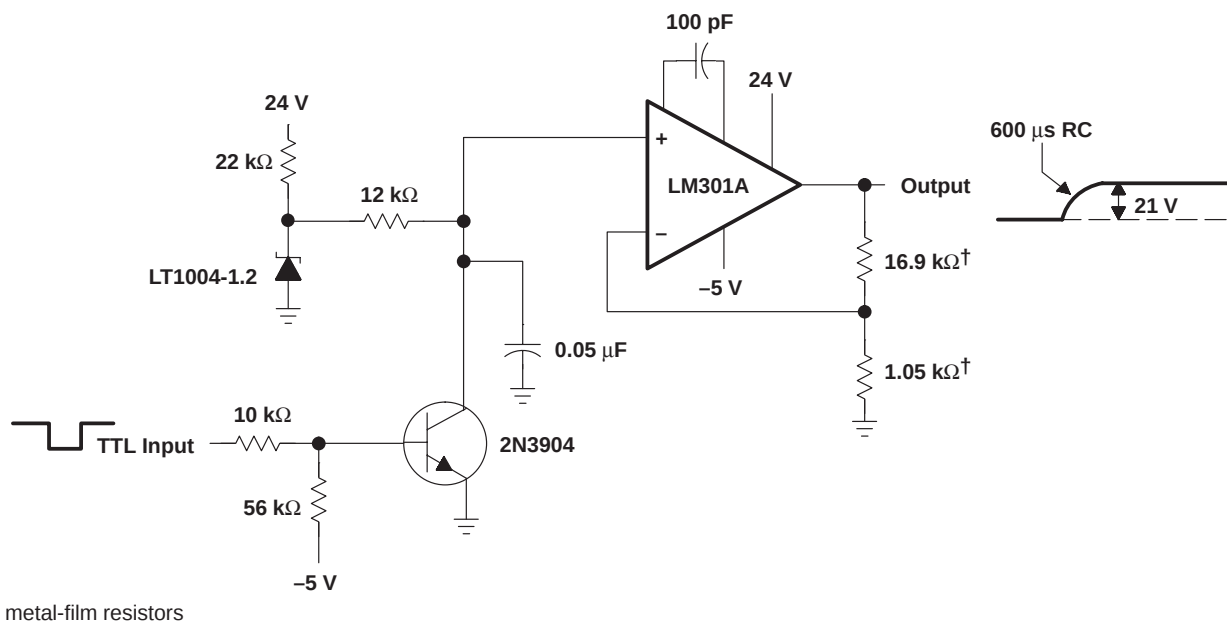


Figure 16. V_{I(PP)} Generator for EPROMs (No Trim Required)

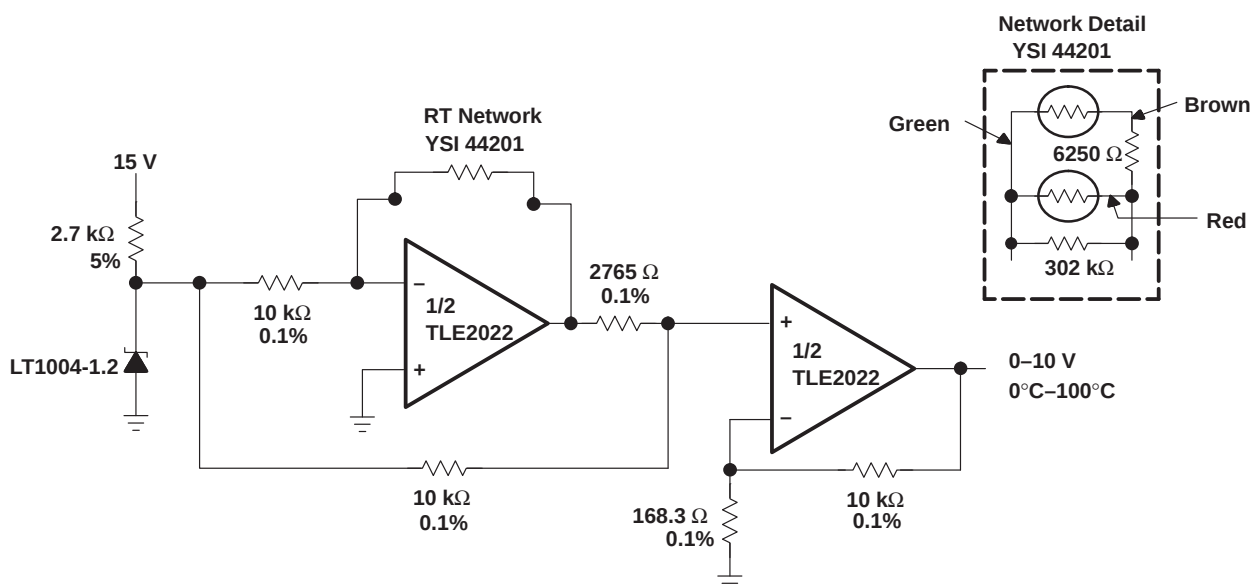


Figure 17. 0°C-to-100°C Linear-Output Thermometer

APPLICATION INFORMATION

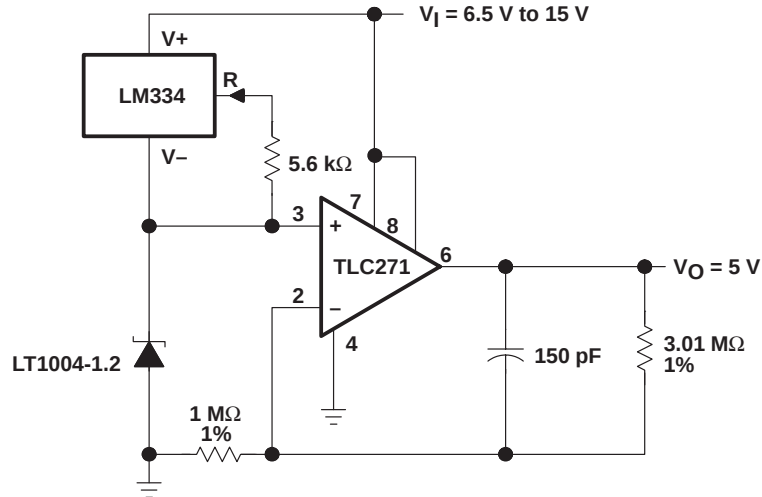


Figure 18. Micropower 5-V Reference

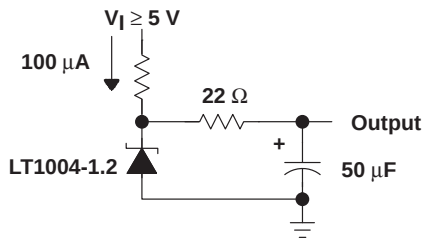


Figure 19. Low-Noise Reference

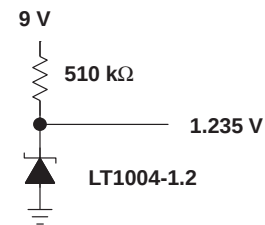
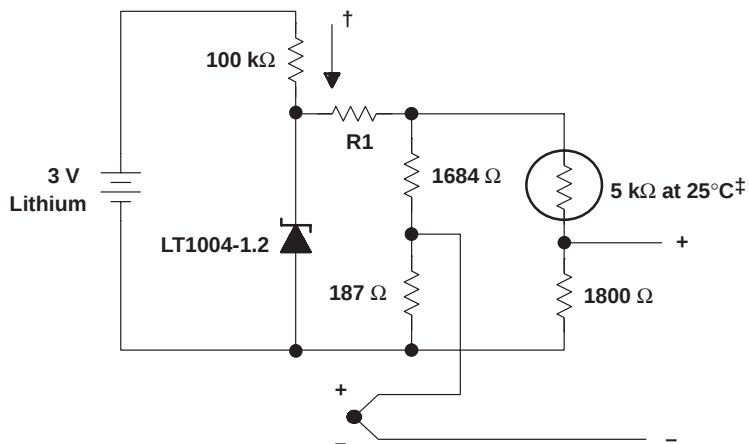


Figure 20. Micropower Reference From 9-V Battery



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°C to 60°C .

Figure 21. Micropower Cold-Junction Compensation for Thermocouples

LT1004-1.2, LT1004-2.5 MICROPOWER INTEGRATED VOLTAGE REFERENCES

SLVS022J – JANUARY 1989 – REVISED AUGUST 2003

APPLICATION INFORMATION

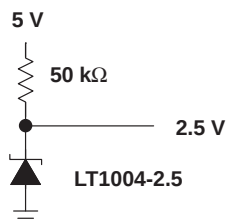


Figure 22. 2.5-V Reference

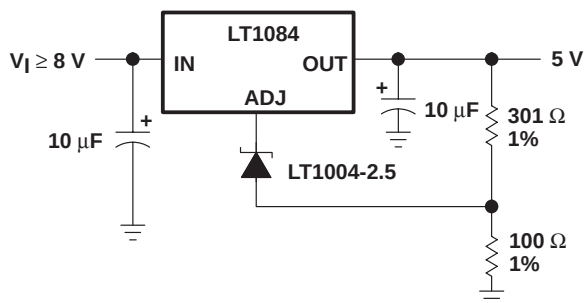
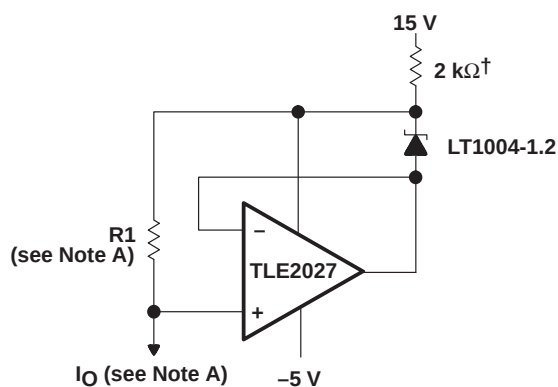


Figure 23. High-Stability 5-V Regulator



† 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

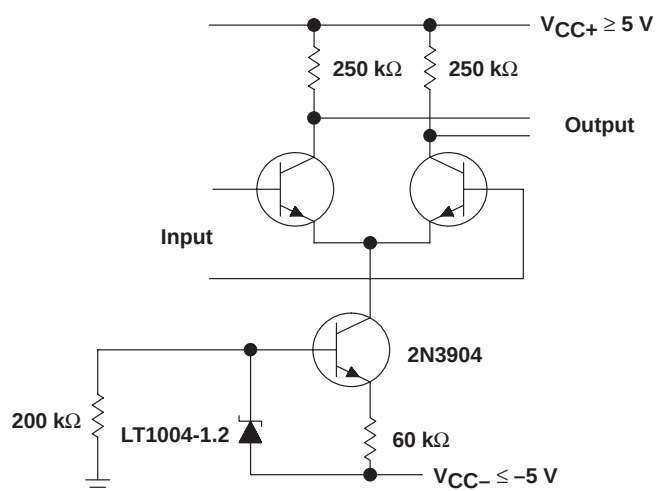
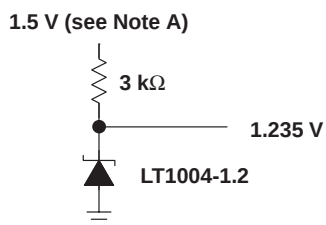


Figure 25. Amplifier With Constant Gain Over Temperature



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

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

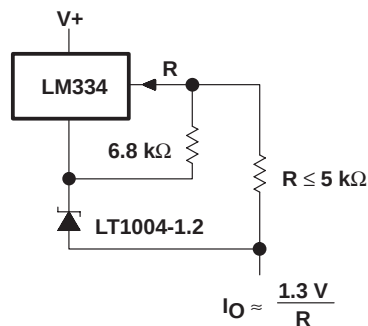
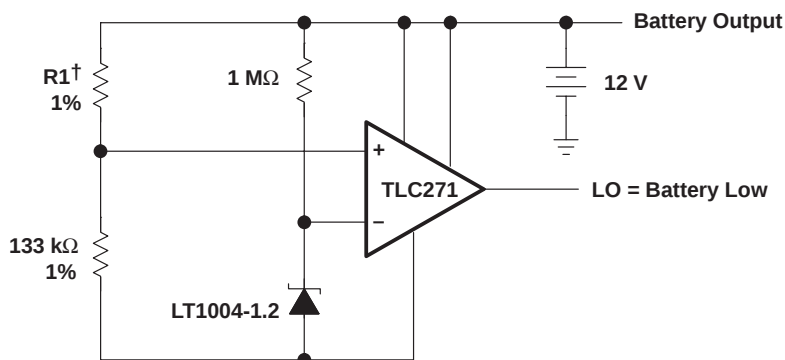


Figure 27. Terminal Current Source With Low Temperature Coefficient

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

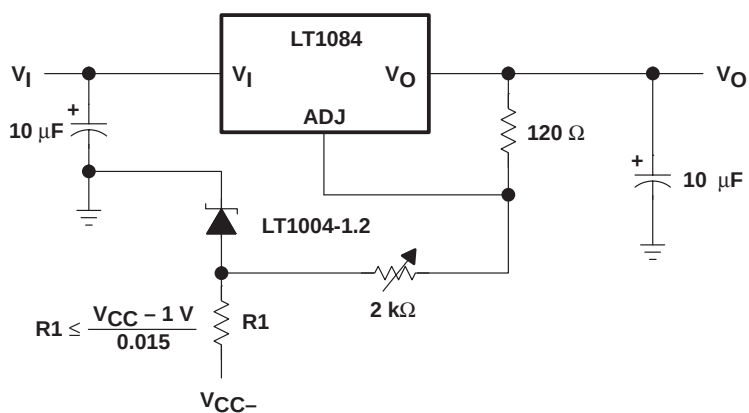


Figure 29. Variable-Voltage Supply

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
LT1004CD-1-2	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LT1004CD-2-5	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LT1004CDR-1-2	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LT1004CDR-2-5	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LT1004CLP-1-2	ACTIVE	TO-92	LP	3	1000	None	Call TI	Level-NC-NC-NC
LT1004CLP-2-5	ACTIVE	TO-92	LP	3	1000	None	Call TI	Level-NC-NC-NC
LT1004CPW-1-2	ACTIVE	TSSOP	PW	8	150	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LT1004CPW-2-5	ACTIVE	TSSOP	PW	8	150	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LT1004CPWR-1-2	ACTIVE	TSSOP	PW	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LT1004CPWR-2-5	ACTIVE	TSSOP	PW	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LT1004ID-1-2	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LT1004ID-2-5	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LT1004IDR-1-2	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LT1004IDR-2-5	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR
LT1004ILP-1-2	ACTIVE	TO-92	LP	3	1000	None	Call TI	Level-NC-NC-NC
LT1004ILP-2-5	OBSOLETE	TO-92	LP	3		None	Call TI	Call TI
LT1004IPW-1-2	ACTIVE	TSSOP	PW	8	150	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LT1004IPW-2-5	ACTIVE	TSSOP	PW	8	150	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LT1004IPWR-1-2	ACTIVE	TSSOP	PW	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LT1004IPWR-2-5	ACTIVE	TSSOP	PW	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LT1004MD-1-2	OBSOLETE	SOIC	D	8		None	Call TI	Call TI
LT1004MD-2-5	OBSOLETE	SOIC	D	8		None	Call TI	Call TI
LT1004MDR-1-2	OBSOLETE	SOIC	D	8		None	Call TI	Call TI
LT1004MDR-2-5	OBSOLETE	SOIC	D	8		None	Call TI	Call TI
LT1004MLP-1-2	OBSOLETE	TO-92	LP	3		None	Call TI	Call TI
LT1004MLP-2-5	OBSOLETE	TO-92	LP	3		None	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.

OBSELETE: 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.

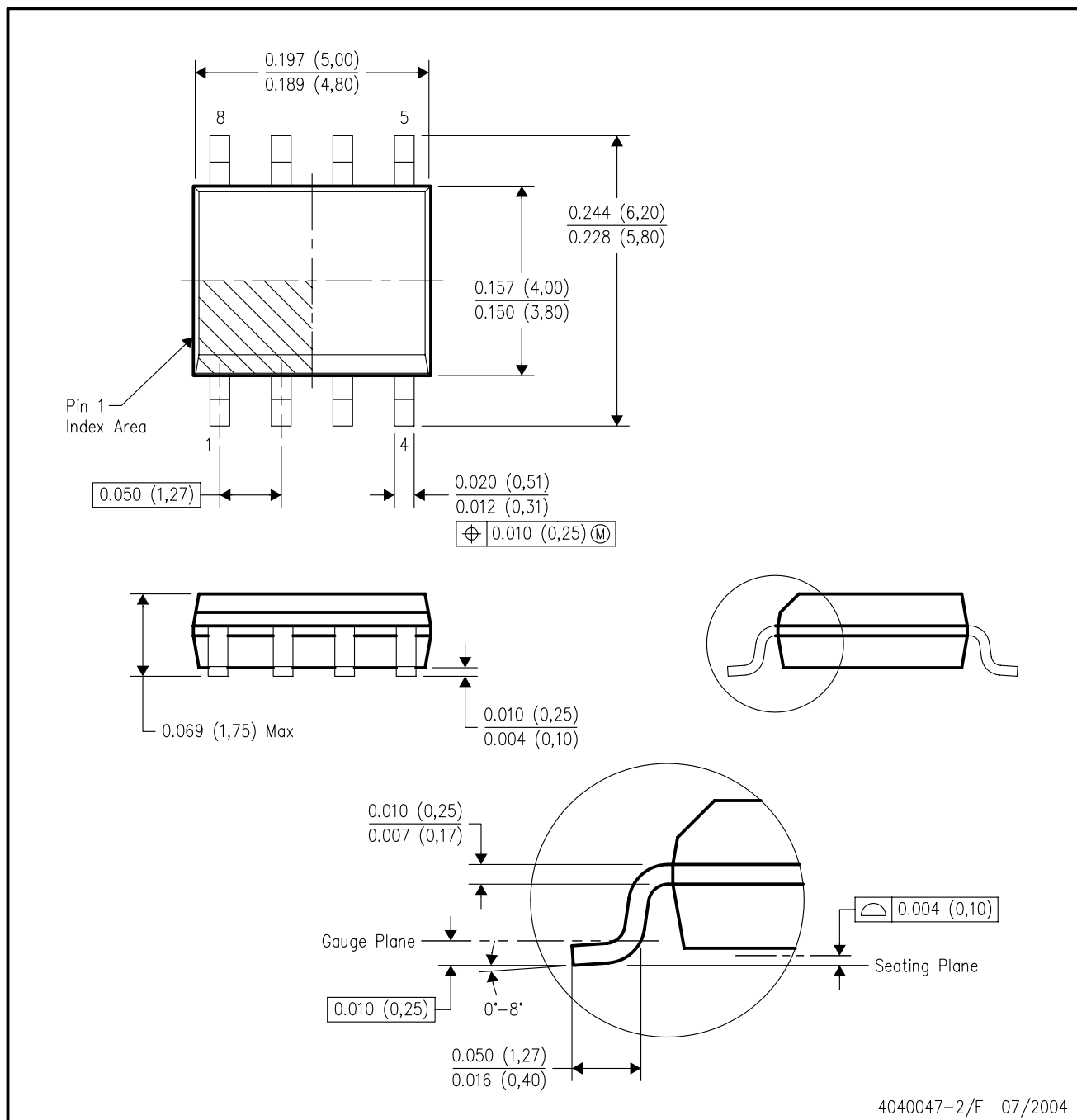
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited 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)

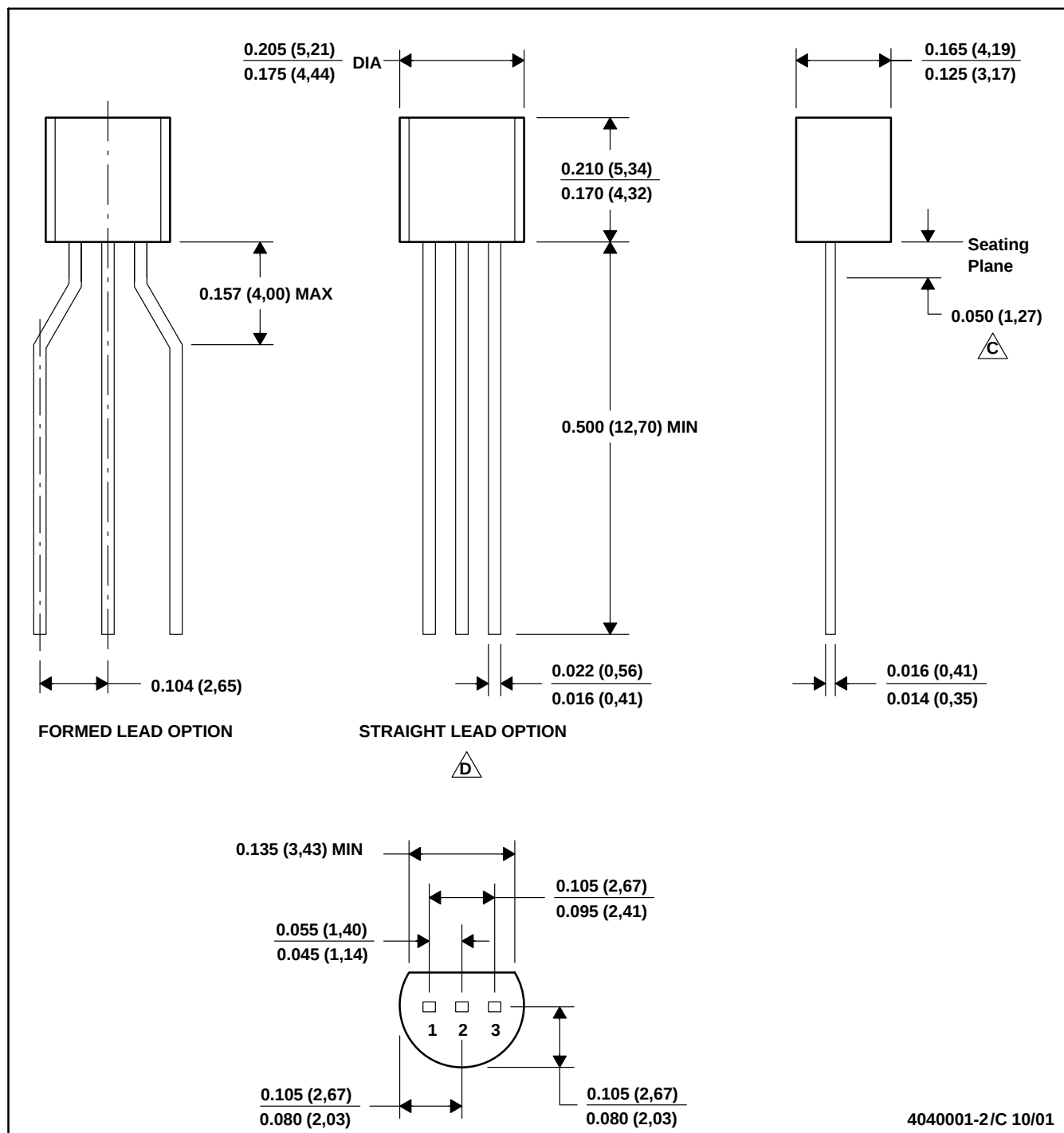
PLASTIC SMALL-OUTLINE PACKAGE



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

LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



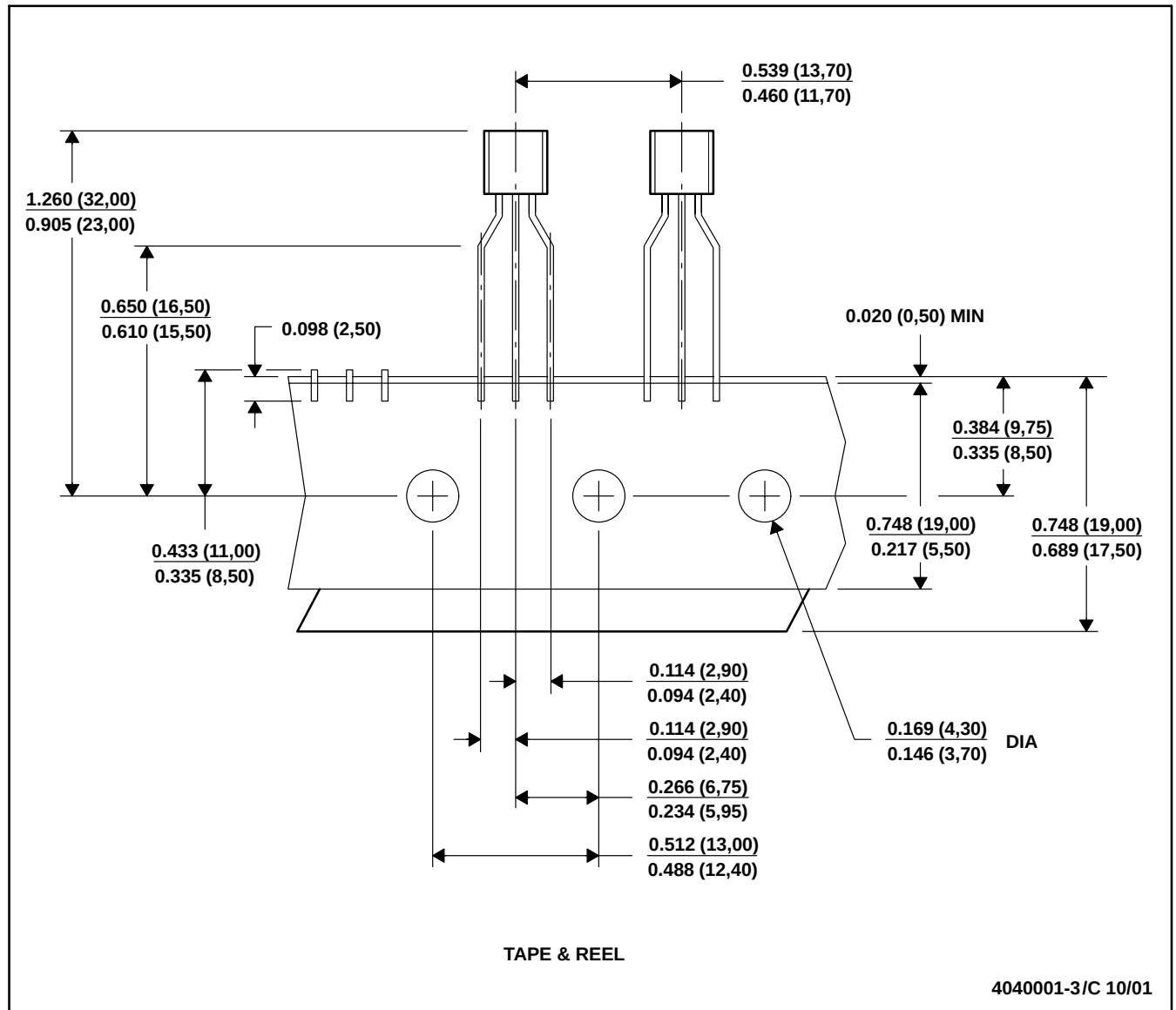
- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Lead dimensions are not controlled within this area.
 D. Falls within JEDEC TO -226 Variation AA (TO-226 replaces TO-92).
 E. Shipping Method:
 Straight lead option available in bulk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

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



- 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

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265

Copyright © 2005, Texas Instruments Incorporated