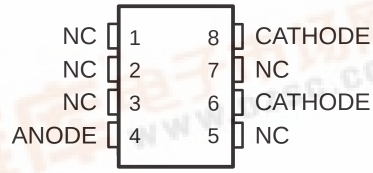
# LT1004-1.2, LT1004-2.5
# MICROPOWER INTEGRATED VOLTAGE REFERENCES

SLVS022H – JANUARY 1989 – REVISED JULY 1999

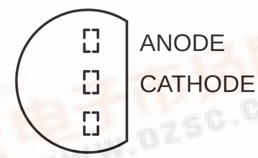
- **Initial Accuracy**
  - **±4 mV for LT1004-1.2**
  - **±20 mV for LT1004-2.5**
- **Micropower Operation**
- **Operates up to 20 mA**
- **Very Low Reference Impedance**
- **Applications:**
  - **Portable Meter Reference**
  - **Portable Test Instruments**
  - **Battery-Operated Systems**
  - **Current-Loop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

**D PACKAGE**
**(TOP VIEW)**




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

**LP PACKAGE**
**(TOP VIEW)**



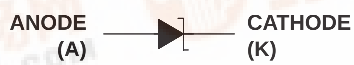

## description

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 was previously 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.

## symbol




**AVAILABLE OPTIONS**

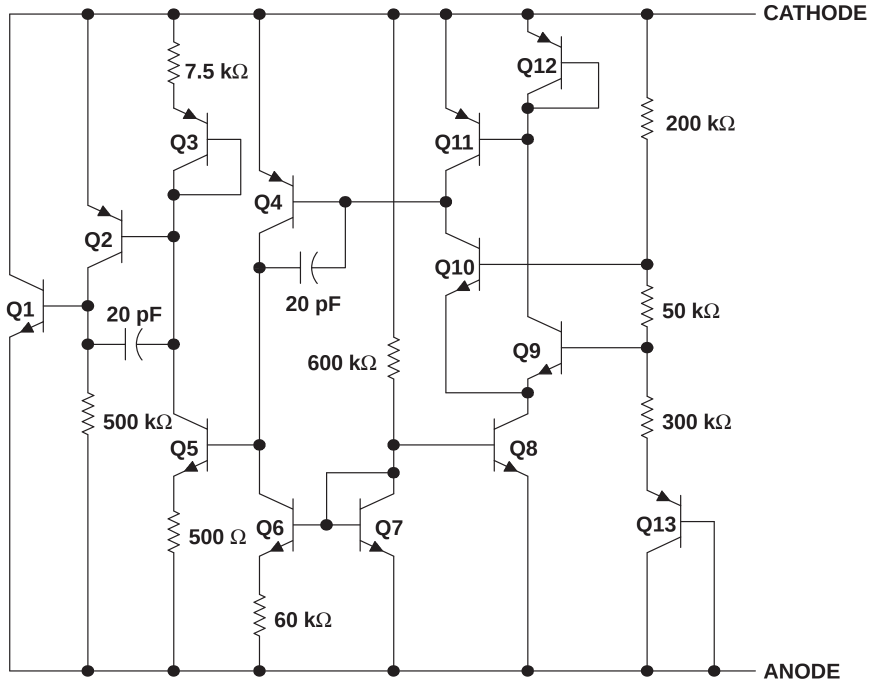
| $T_A$ | $V_Z$ TYP | PACKAGED DEVICES SMALL OUTLINE (D) | PACKAGED DEVICES PLASTIC (LP) | CHIP FORM (Y) |
|---|---|---|---|---|
| 0°C to 70°C | 1.2 V | LT1004CD-1.2 | LT1004CLP-1.2 | LT1004Y-1.2 |
| | 2.5 V | LT1004CD-2.5 | LT1004CLP-2.5 | LT1004Y-2.5 |
| –40°C to 85°C | 1.2 V | LT1004ID-1.2 | LT1004ILP-1.2 | — |
| | 2.5 V | LT1004ID-2.5 | LT1004ILP-2.5 | — |

For ordering purposes, the decimal point in the part number must be replaced with a hyphen (e.g., show the -1.2 suffix as -1-2 and the -2.5 suffix as -2-5). The D package is available taped and reeled. Add the R suffix to the device type (e.g., LT1004CDR-1-2). Chip forms are tested at 25°C.

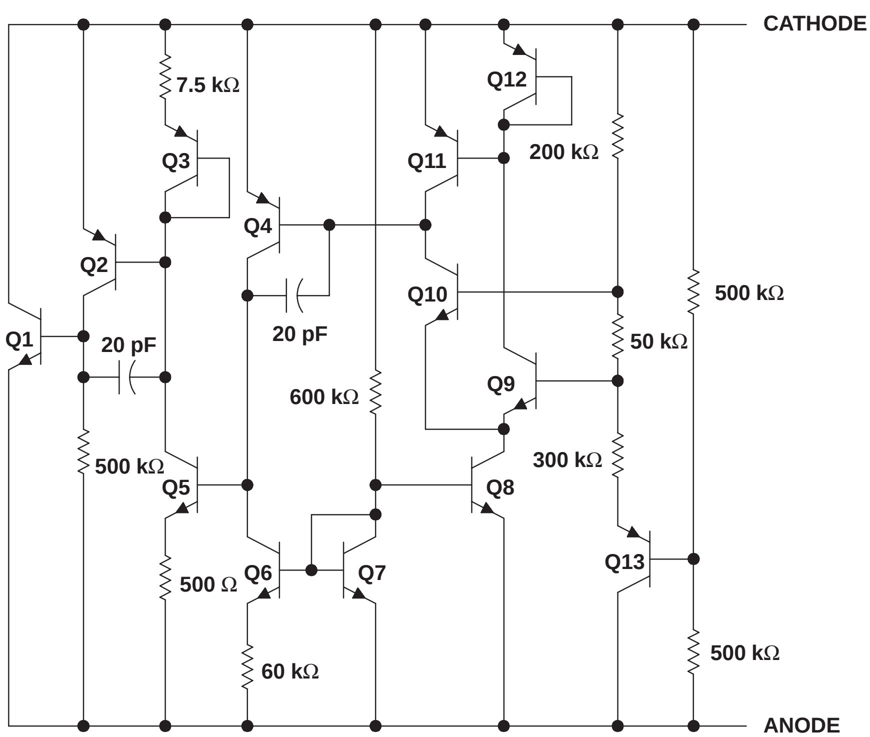
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

## schematic

LT1004-1.2




LT1004-2.5




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, $\theta_{JA}$ (see Notes 1 and 2): D package . . . . . . . . . . 97°C/W
LP package . . . . . . . . . . 156°C/W
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 impact reliability.
2. The package thermal impedance is calculated in accordance with JESD 51, except for through-hole packages, which use a trace length of zero.

## recommended operating conditions

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Operating free-air temperature, $T_A$ | LT1004C | 0 | 70 | °C |
| | LT1004I | –40 | 85 | |

## electrical characteristics at specified free-air temperature

| PARAMETER | | TEST CONDITIONS | $T_A$‡ | | LT1004-1.2 MIN | LT1004-1.2 TYP | LT1004-1.2 MAX | LT1004-2.5 MIN | LT1004-2.5 TYP | LT1004-2.5 MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_Z$ | 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 | |
| $\alpha_{V_Z}$ | Average temperature coefficient of reference voltage§ | $I_Z$ = 10 µA | 25°C | | | 20 | | | | | ppm/°C |
| | | $I_Z$ = 20 µA | | | | | | | 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 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.

## electrical characteristics, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | LT1004Y-1.2 | | | LT1004Y-2.5 | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_Z$ | Reference voltage | $I_Z$ = 100 µA | 1.231 | 1.235 | 1.239 | 2.48 | 2.5 | 2.52 | V |
| $\alpha_{V_Z}$ | Average temperature coefficient of reference voltage† | $I_Z$ = 10 µA | | 20 | | | | | ppm/°C |
| | | $I_Z$ = 20 µA | | | | | 20 | | |
| $\Delta V_Z/\Delta t$ | Long-term change in reference voltage | $I_Z$ = 100 µA | | 20 | | | 20 | | ppm/khr |
| $I_Z$(min) | Minimum reference current | | | 8 | | | 12 | | µA |
| $z_Z$ | Reference impedance | $I_Z$ = 100 µA | | 0.2 | 0.6 | | 0.2 | 0.6 | Ω |
| $V_n$ | Broadband noise voltage | $I_Z$ = 100 µA, f = 10 Hz to 10 kHz | | 60 | | | 120 | | µV |

† 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

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| **LT1004x-1.2** | |
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## TYPICAL CHARACTERISTICS†

LT1004x-1.2
**REVERSE CURRENT vs REVERSE VOLTAGE**

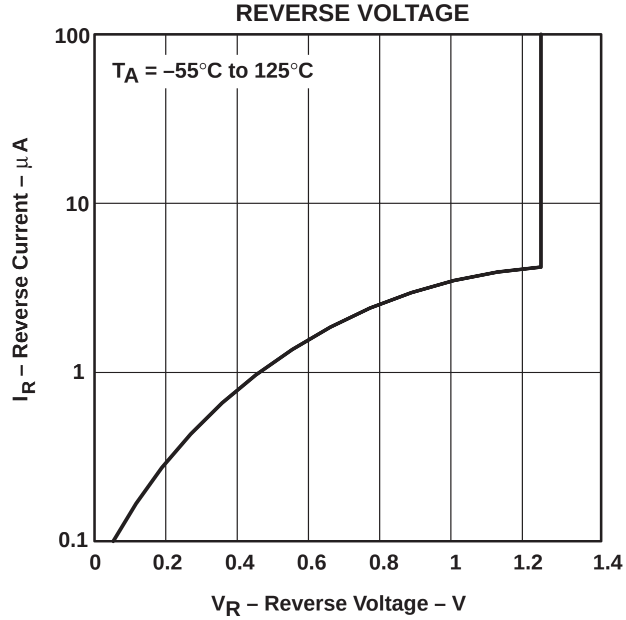



**Figure 1**

LT1004x-1.2
**REFERENCE-VOLTAGE CHANGE vs REVERSE CURRENT**

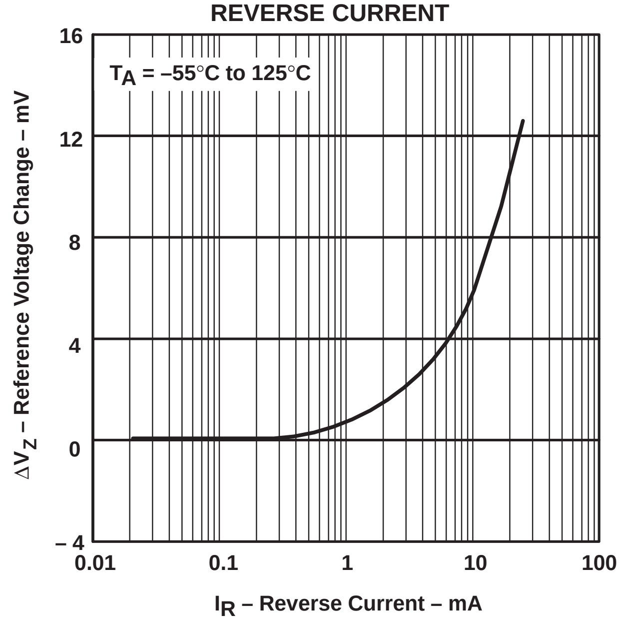



**Figure 2**

LT1004x-1.2
**FORWARD VOLTAGE vs FORWARD CURRENT**

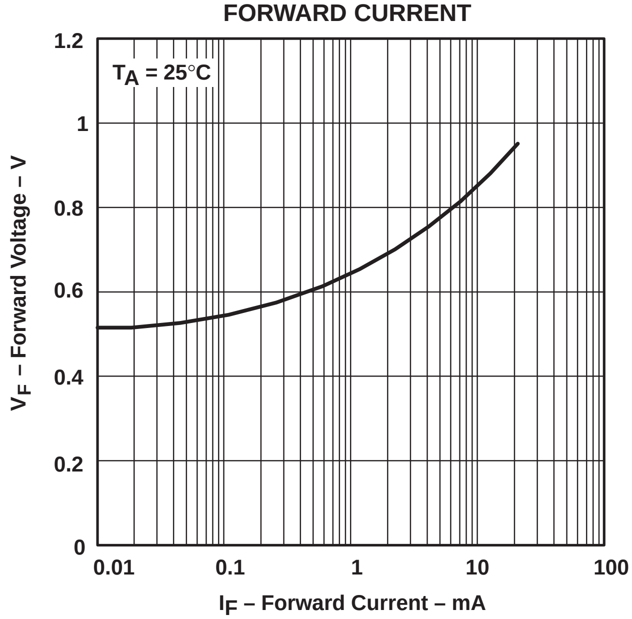



**Figure 3**

LT1004x-1.2
**REFERENCE VOLTAGE vs FREE-AIR TEMPERATURE**

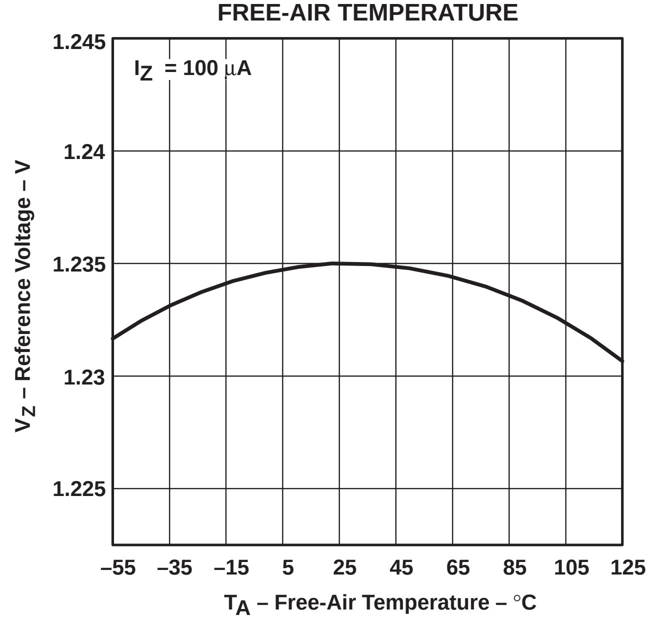



**Figure 4**

†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**

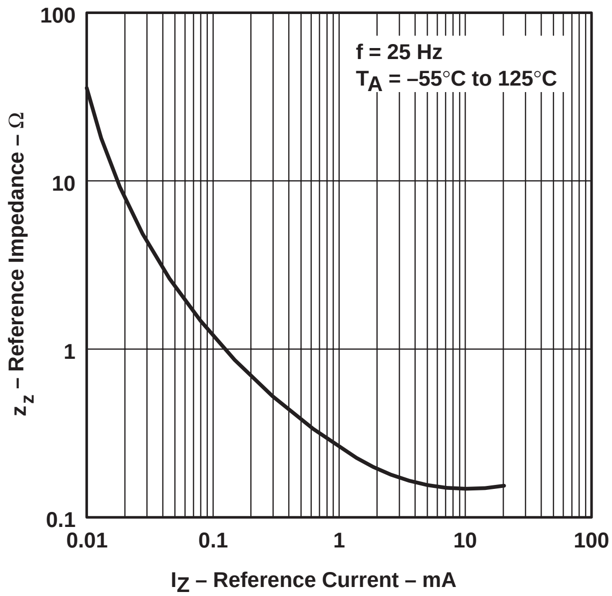



**Figure 5**

**LT1004x-1.2**
**NOISE VOLTAGE**
**vs**
**FREQUENCY**

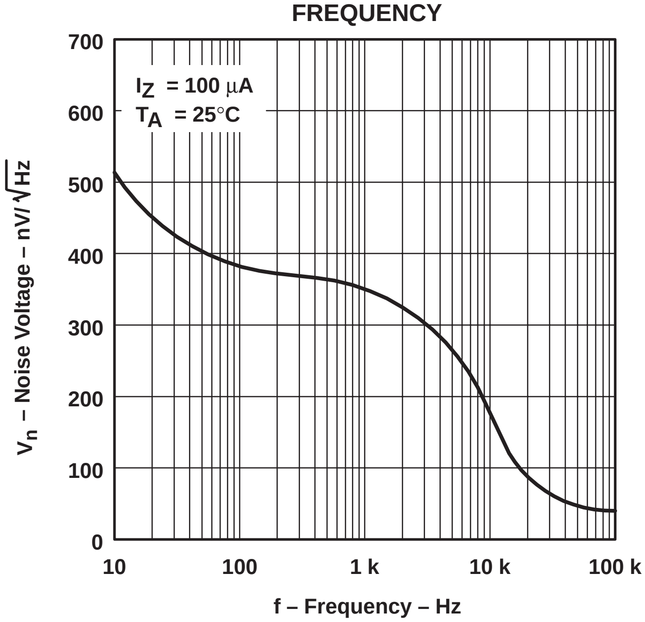



**Figure 6**

**TL1004x-1.2**
**FILTERED OUTPUT NOISE VOLTAGE**
**vs**
**CUTOFF FREQUENCY**

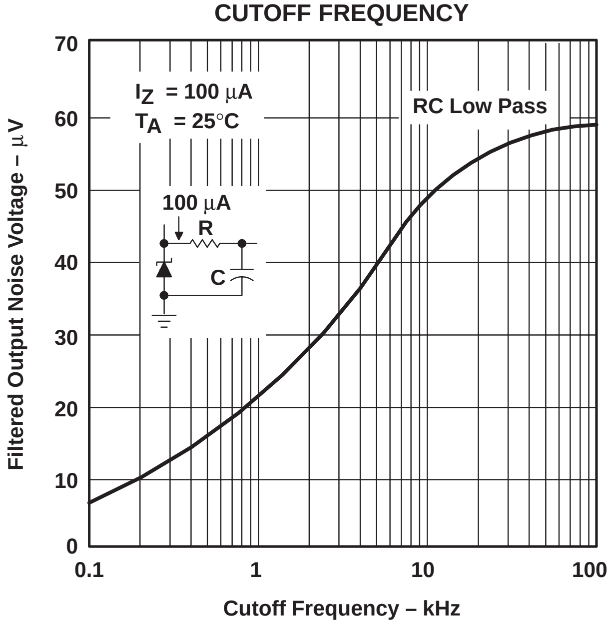



**Figure 7**

**LT1004x-2.5**
**TRANSIENT RESPONSE**

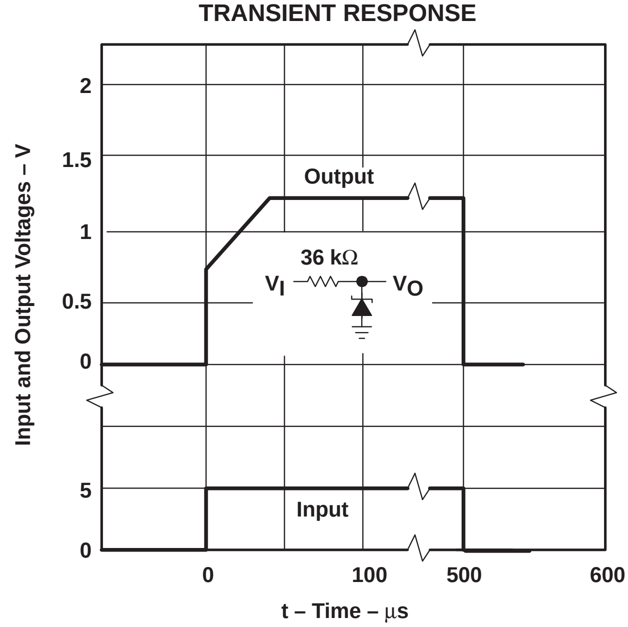



**Figure 8**

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

## TYPICAL CHARACTERISTICS†

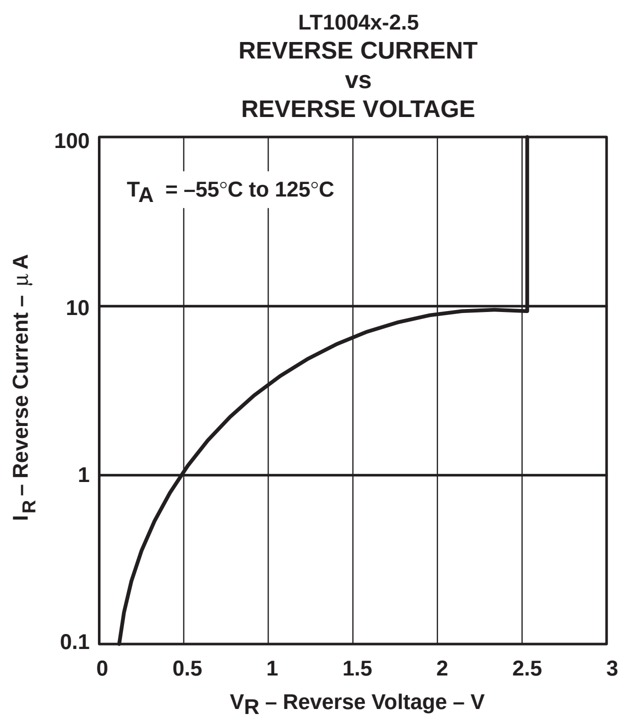



Figure 9

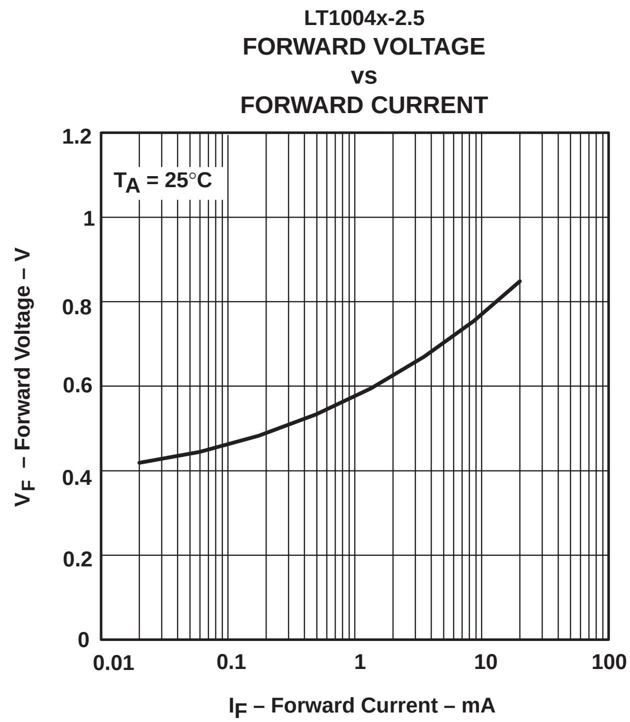



Figure 10

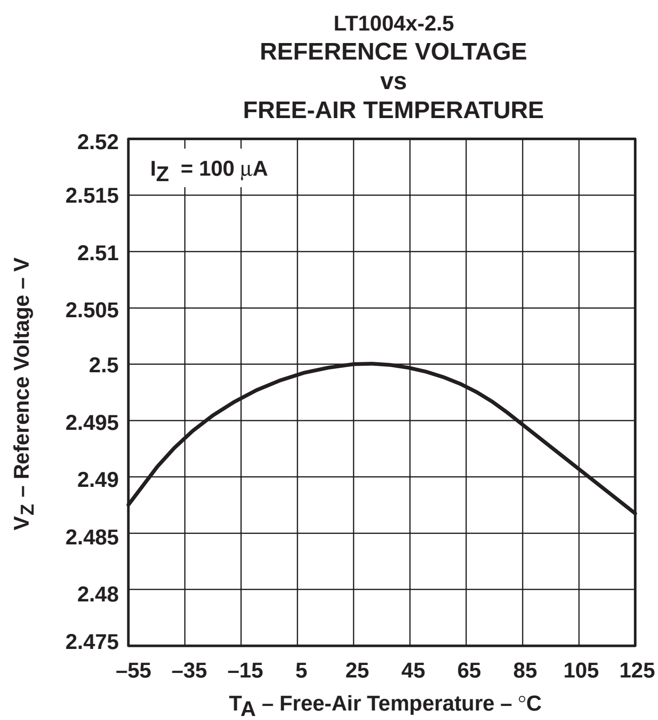



Figure 11

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

## TYPICAL CHARACTERISTICS†

**LT1004x-2.5**
**REFERENCE IMPEDANCE**
**vs**
**REFERENCE CURRENT**

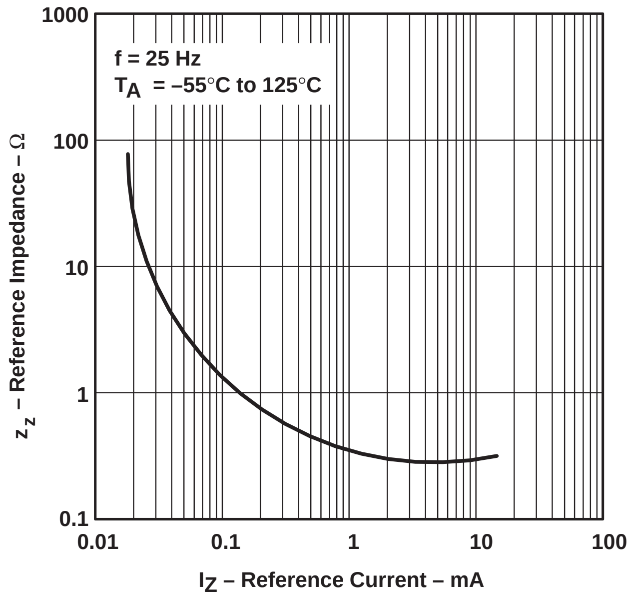



**Figure 12**

**LT1004x-2.5**
**NOISE VOLTAGE**
**vs**
**FREQUENCY**

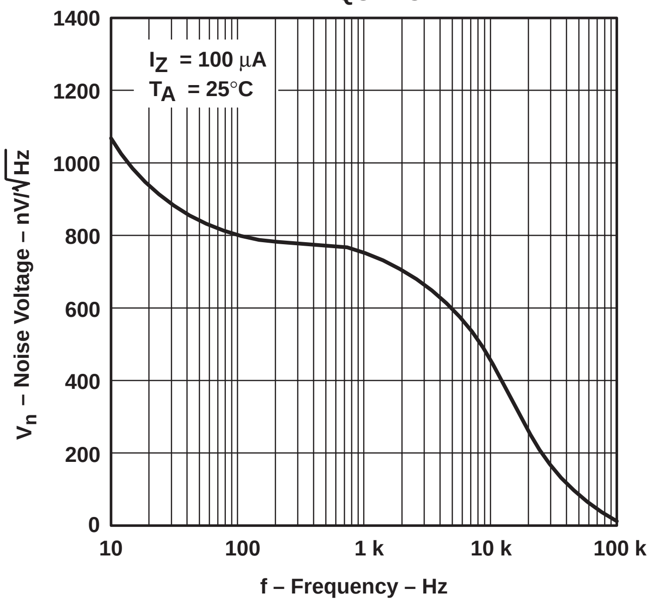



**Figure 13**

**TL1004x-2.5**
**FILTERED OUTPUT NOISE VOLTAGE**
**vs**
**CUTOFF FREQUENCY**

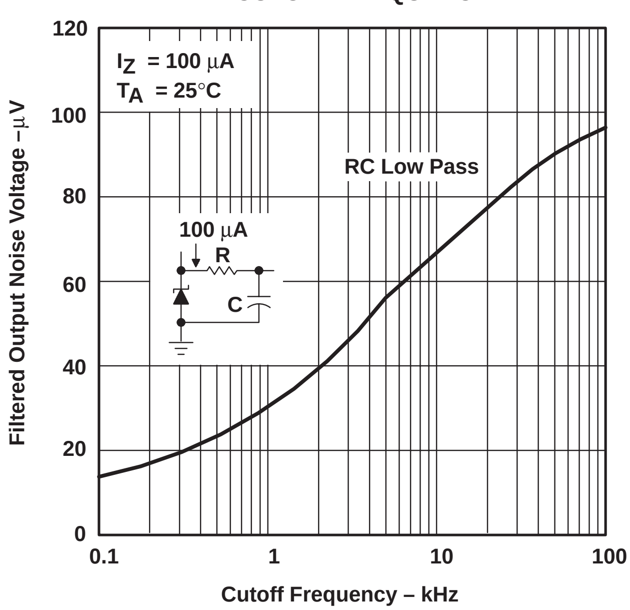



**Figure 14**

**LT1004x-2.5**
**TRANSIENT RESPONSE**

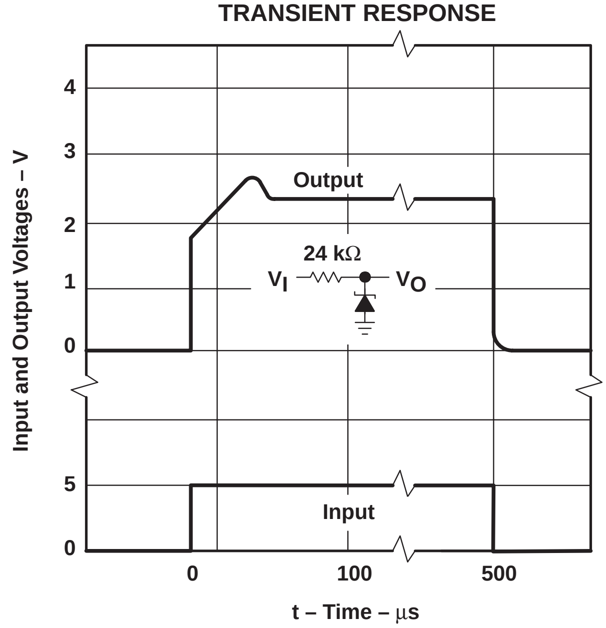
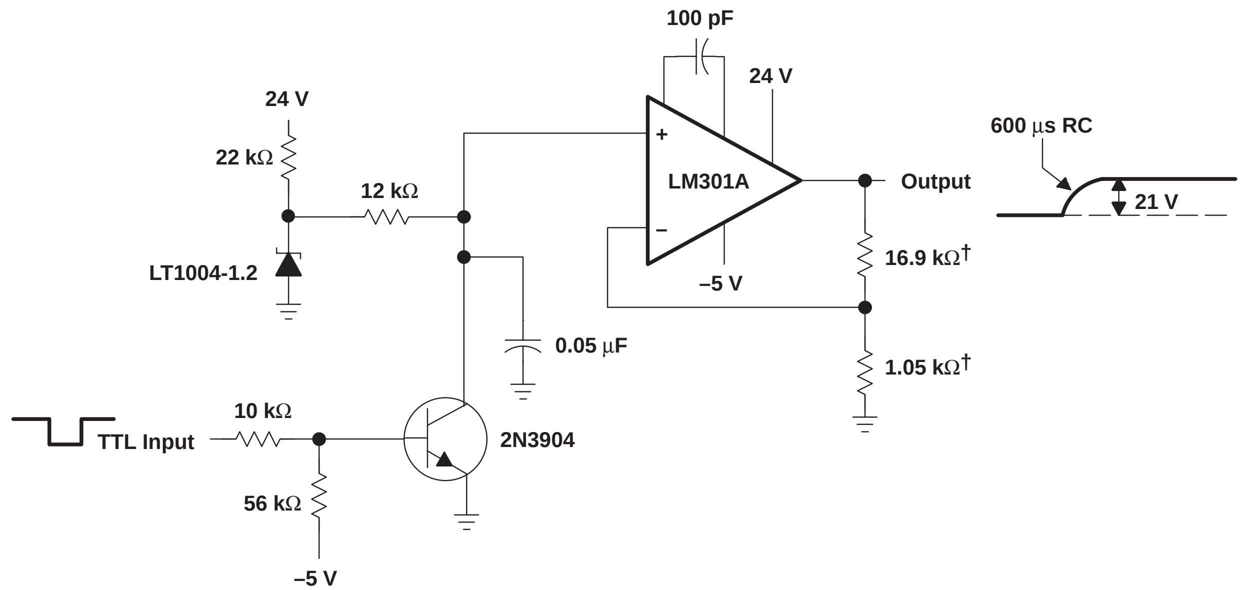



**Figure 15**

†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)**

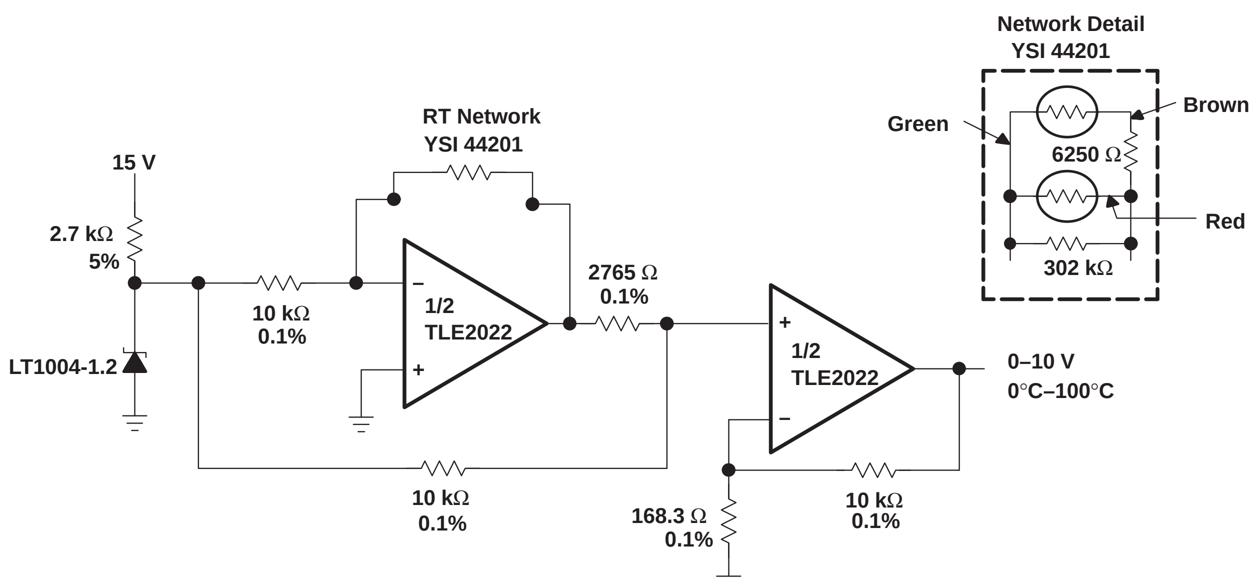



**Figure 17. 0°C-to-100°C Linear-Output Thermometer**

## APPLICATION INFORMATION

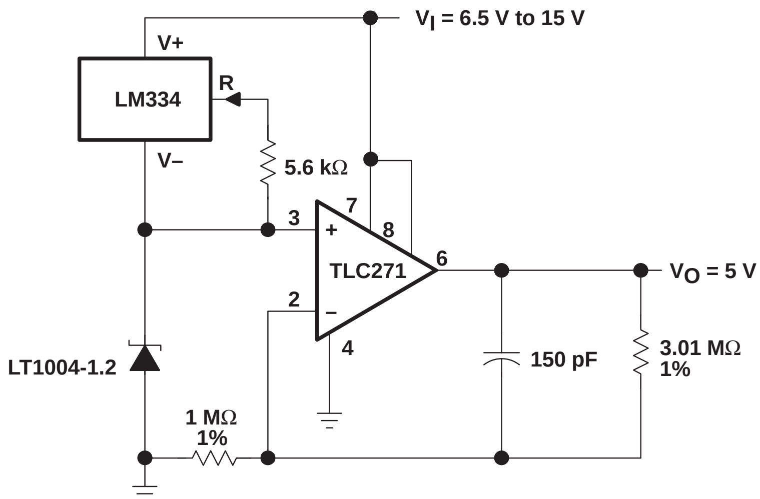



**Figure 18. Micropower 5-V Reference**

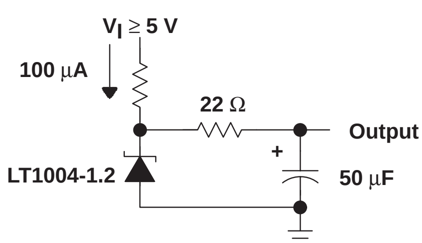



**Figure 19. Low-Noise Reference**

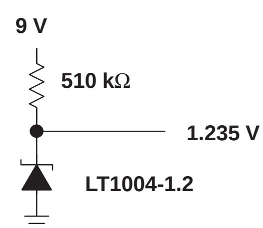
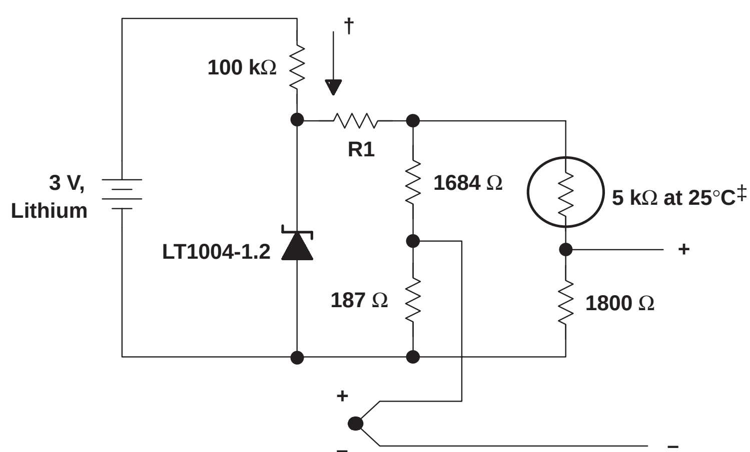



**Figure 20. Micropower Reference From 9-V Battery**




| 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

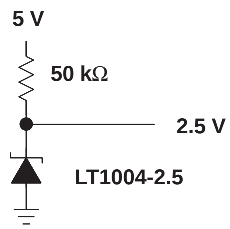



Figure 22. 2.5-V Reference

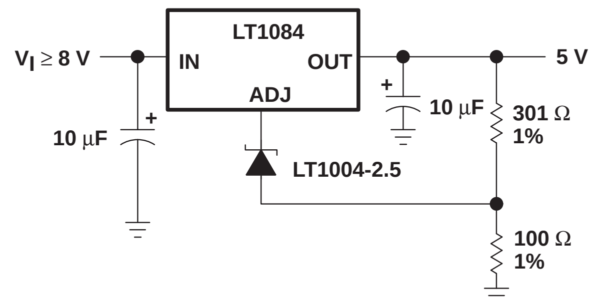
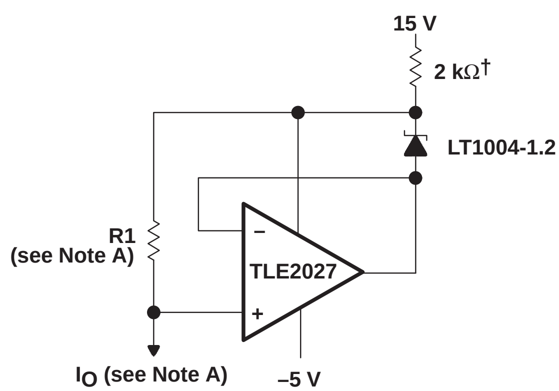



Figure 23. High-Stability 5-V Regulator




† May be increased for small output currents

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

Figure 24. Ground-Referenced Current Source

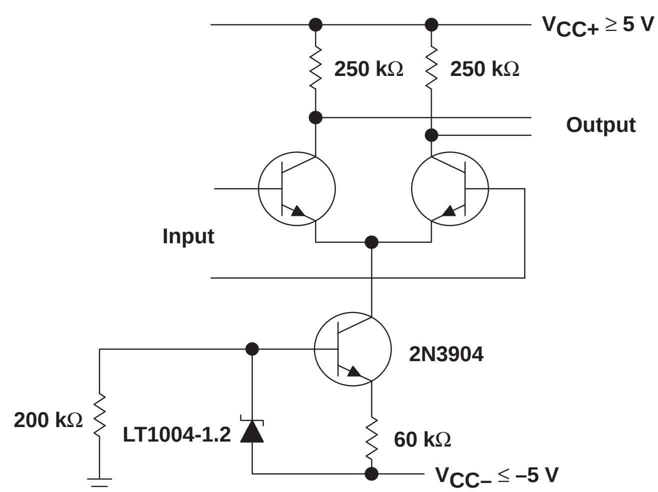
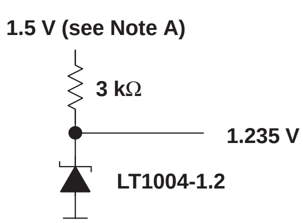



Figure 25. Amplifier With Constant Gain Over Temperature




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

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

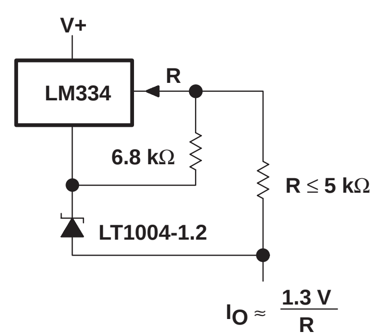
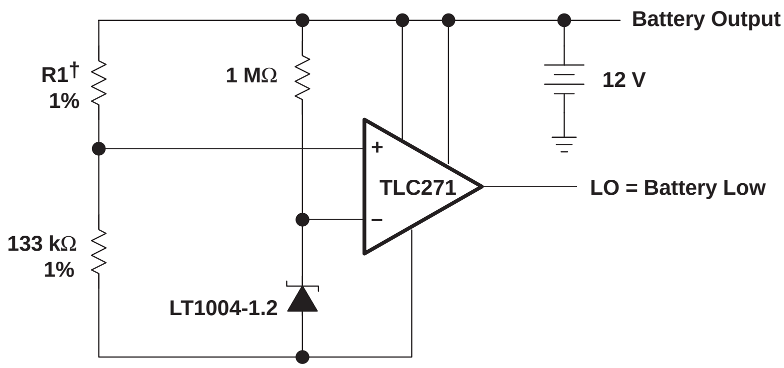



Figure 27. Terminal Current Source With Low Temperature Coefficient

## 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**

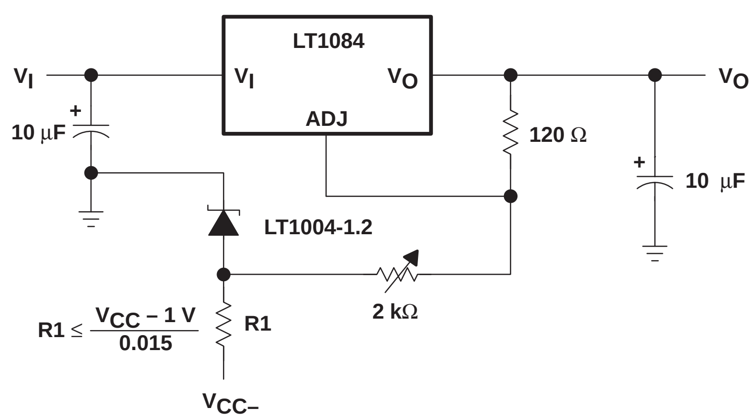



**Figure 29. Variable-Voltage Supply**

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