

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

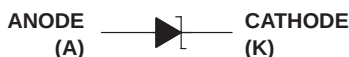
description

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.

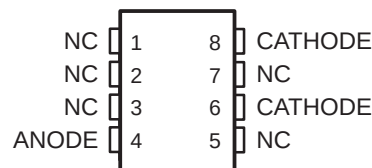
The LT1004 is a pin-for-pin replacement for the LM285 and LM385 series of references, with improved specifications. It is an excellent device for use in systems in which accuracy was previously attained at the expense of power consumption and trimming.

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



**D PACKAGE
(TOP VIEW)**



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

**LP PACKAGE
(TOP VIEW)**



AVAILABLE OPTIONS

T_A	V_Z TYP	PACKAGED DEVICES		CHIP FORM (Y)
		SMALL OUTLINE (D)	PLASTIC (LP)	
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.

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**

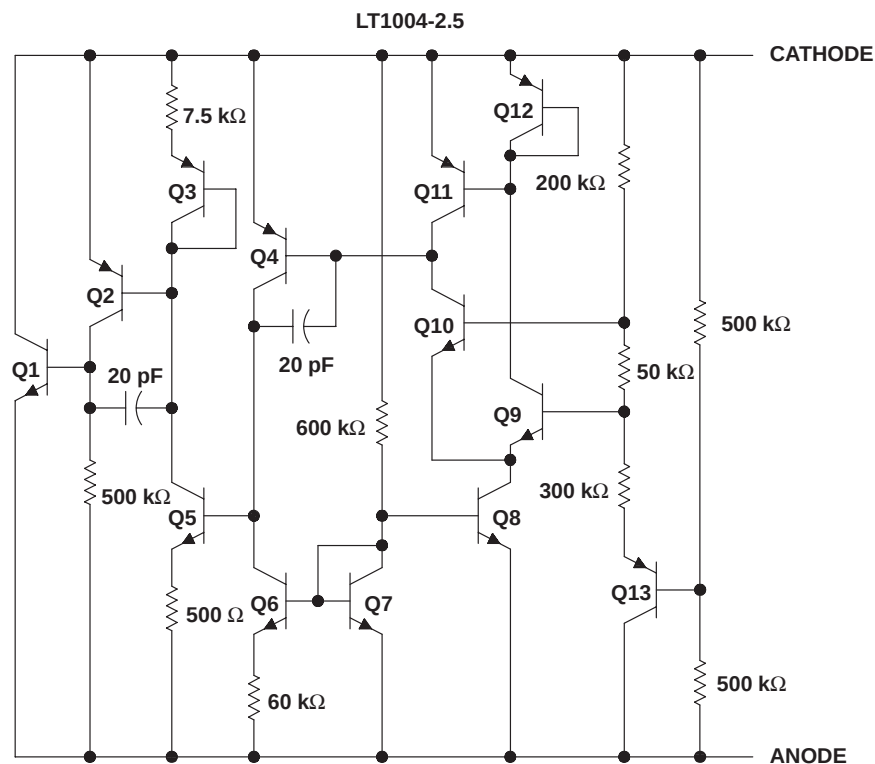
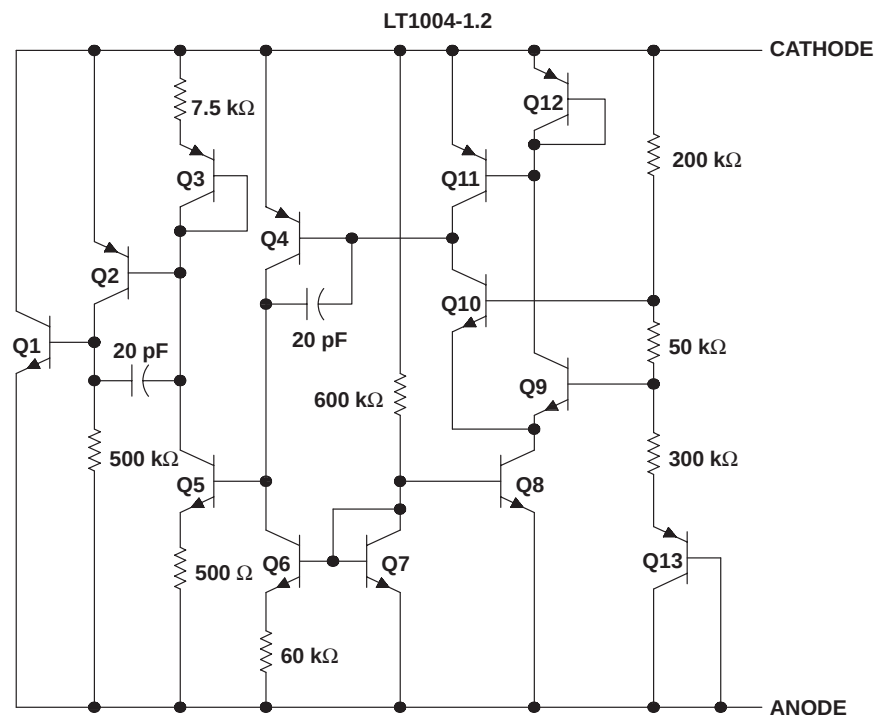
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schematic



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, θ_{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 $T_J(\max)$, 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 impact reliability.
2. The package thermal impedance is calculated in accordance with JEDEC 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			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				
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.



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electrical characteristics, $T_A = 25^\circ\text{C}$

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
α _{V_Z}	Average temperature coefficient of reference voltage†	I _Z = 10 μA	20						ppm/°C
		I _Z = 20 μA				20			
ΔV _Z /Δt	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

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LT1004x-1.2	
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Reference impedance vs Reference current	12
Noise voltage vs Frequency	13
Filtered output noise voltage vs Cutoff frequency	14
Transient response	15

TYPICAL CHARACTERISTICS†

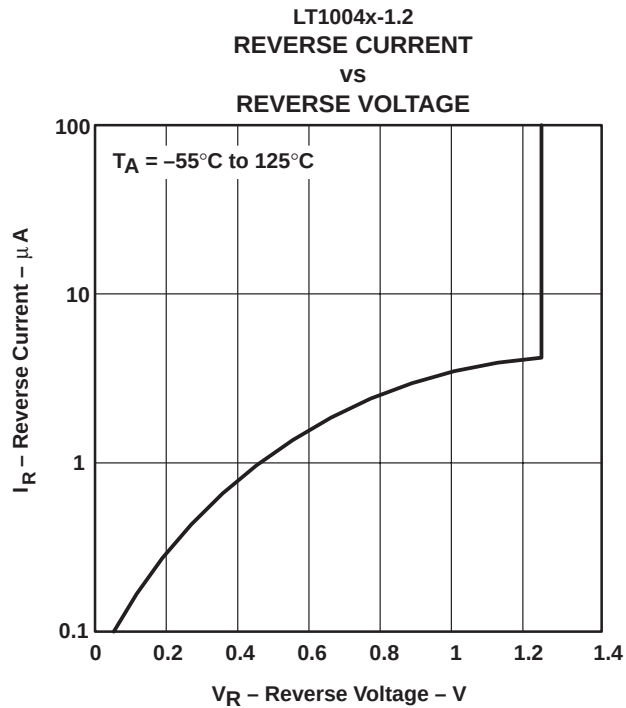


Figure 1

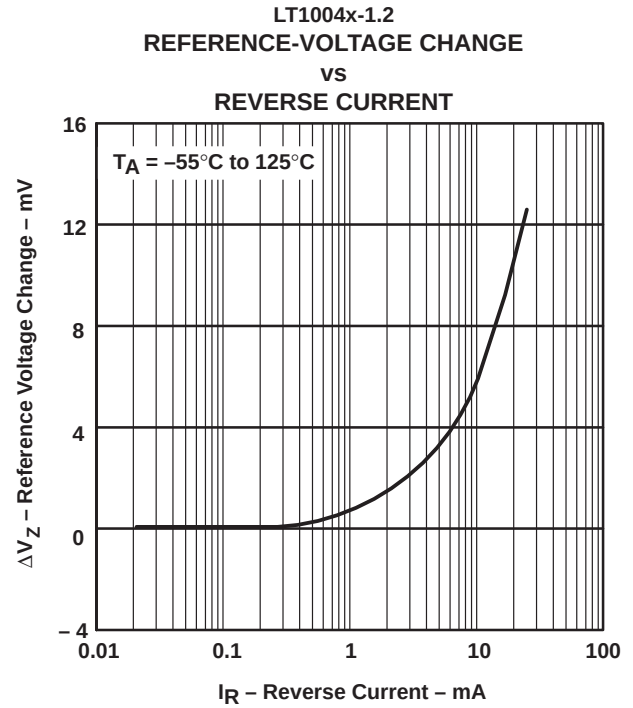


Figure 2

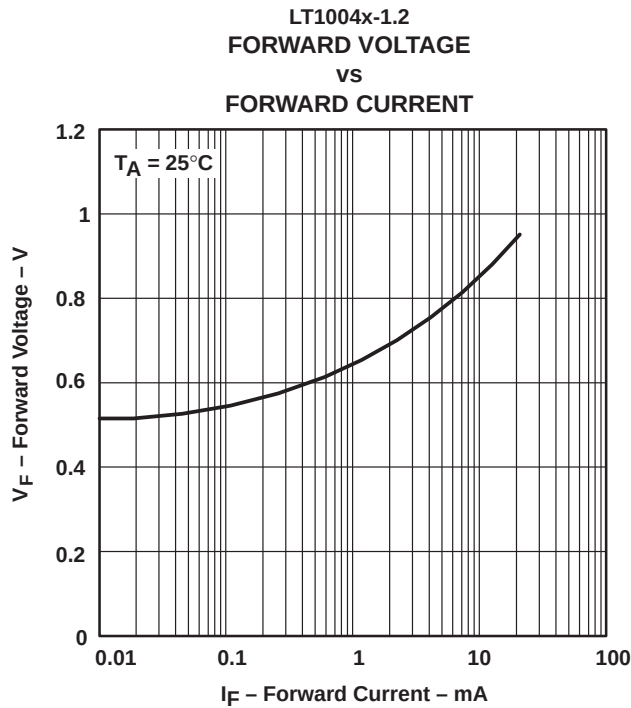


Figure 3

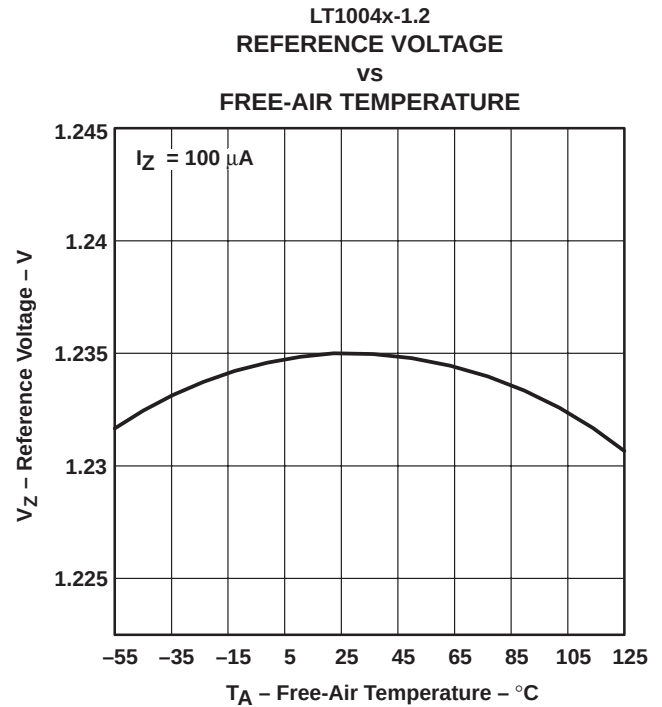


Figure 4

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

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TYPICAL CHARACTERISTICS†

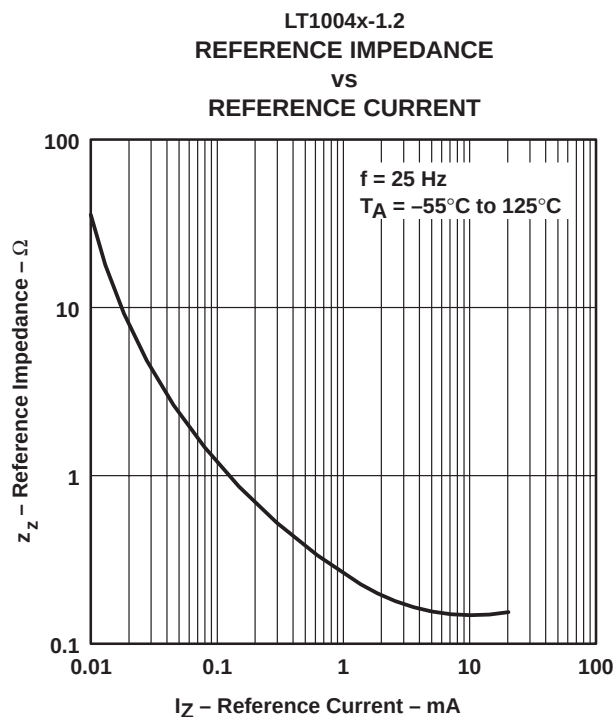


Figure 5

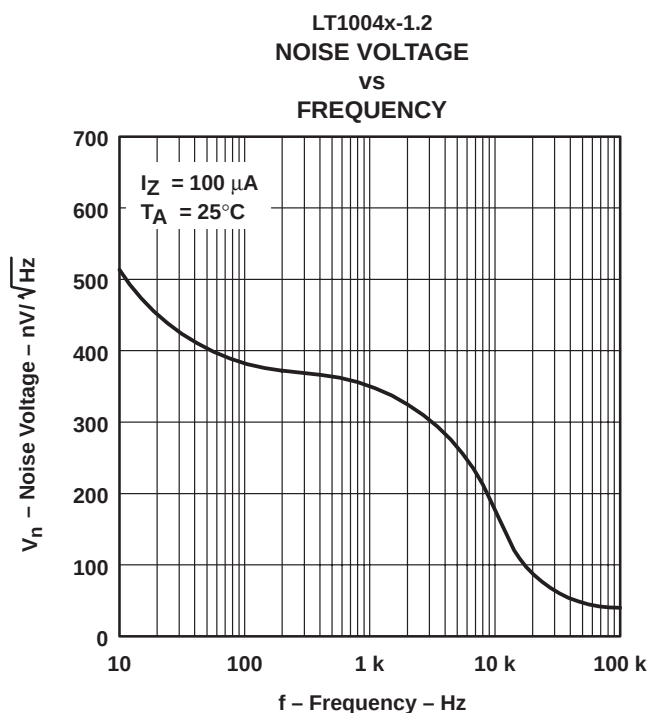


Figure 6

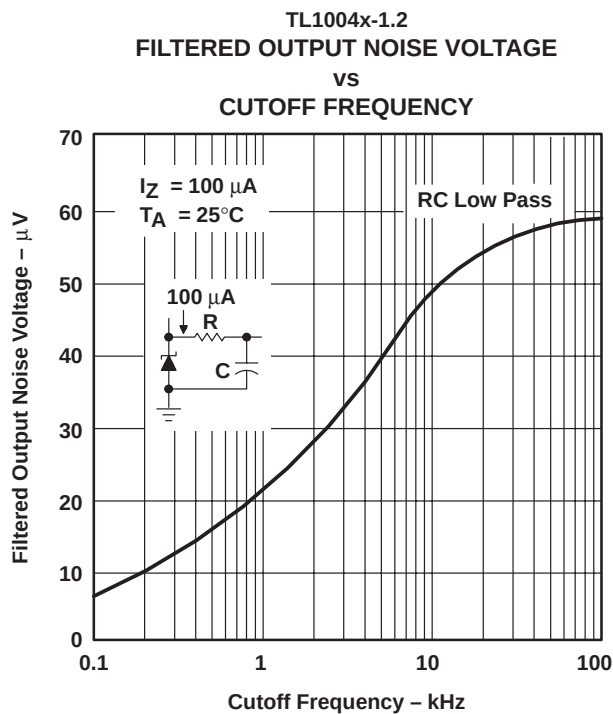


Figure 7

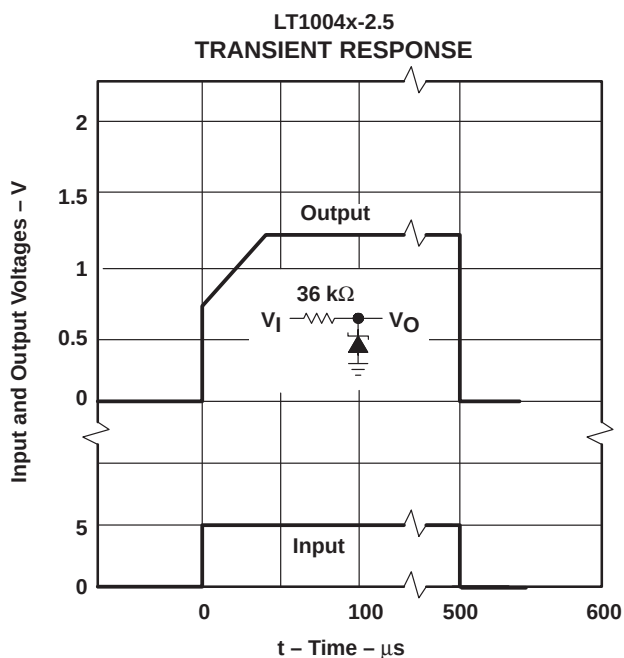


Figure 8

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

TYPICAL CHARACTERISTICS†

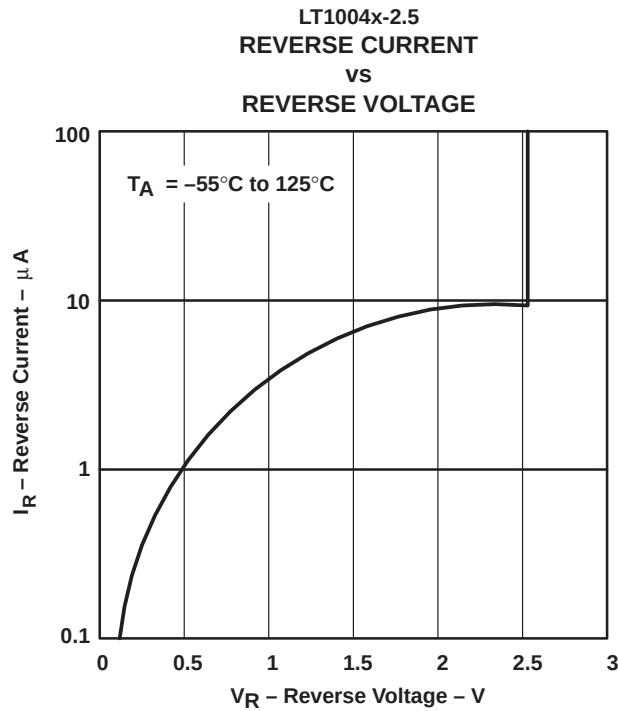


Figure 9

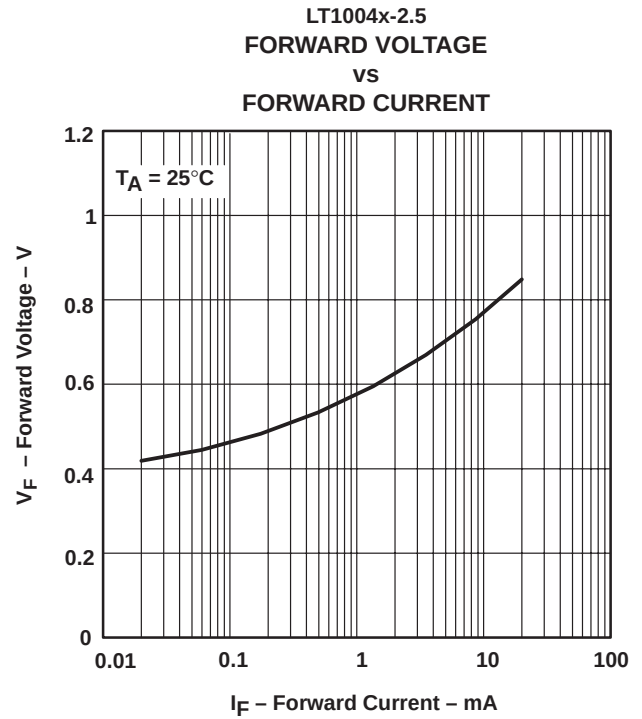


Figure 10

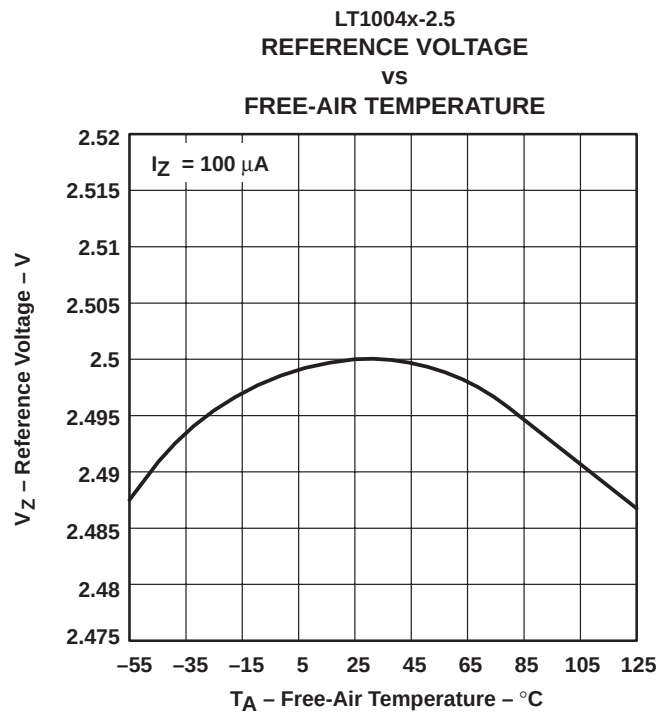


Figure 11

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

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TYPICAL CHARACTERISTICS†

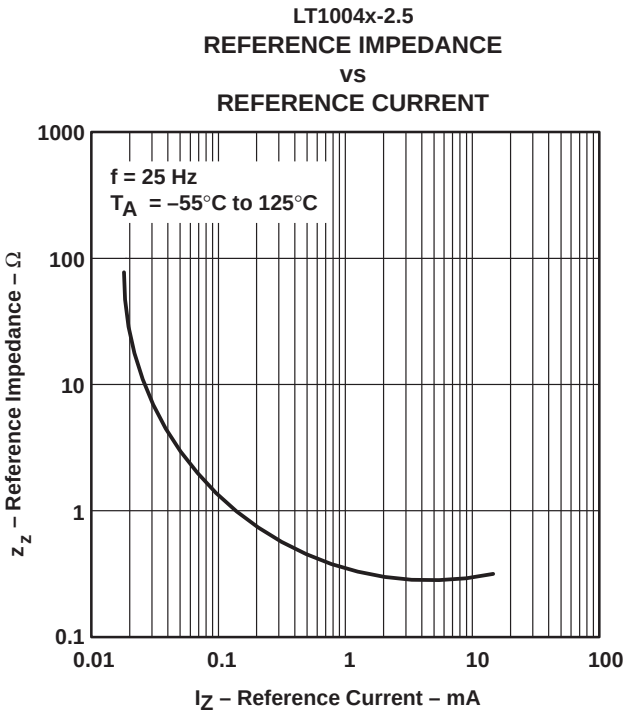


Figure 12

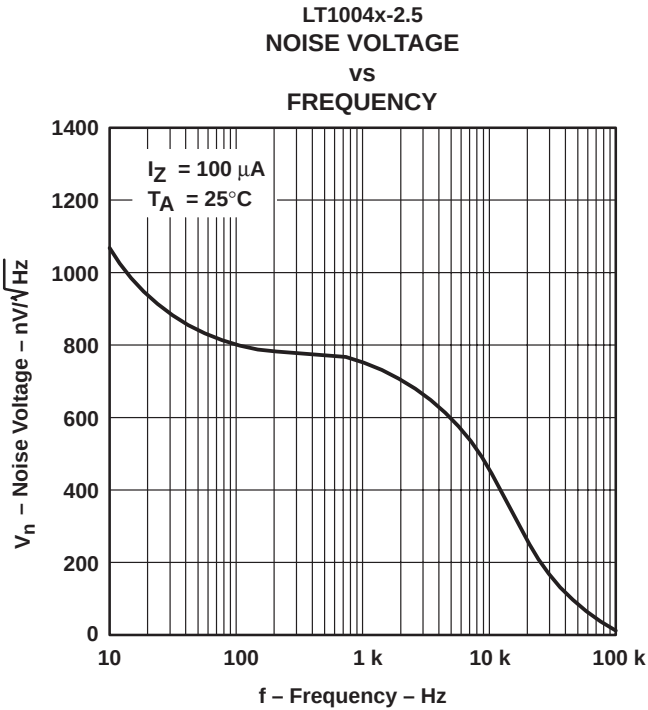


Figure 13

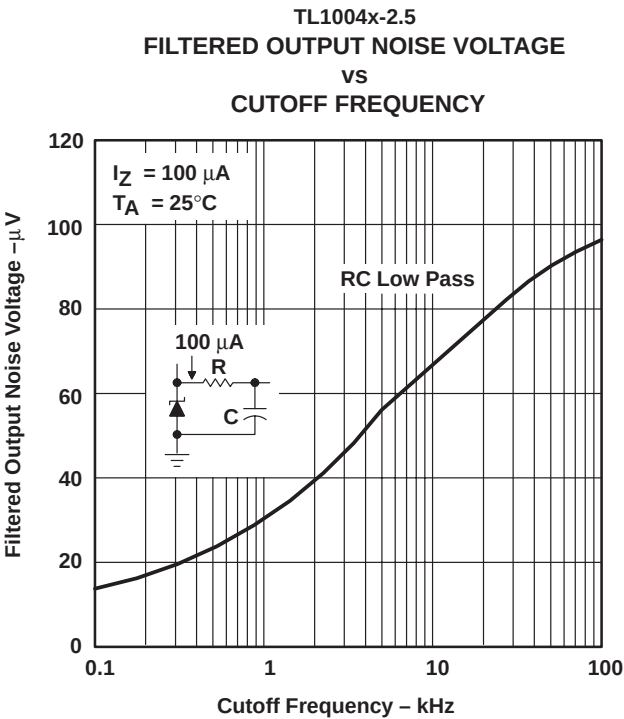


Figure 14

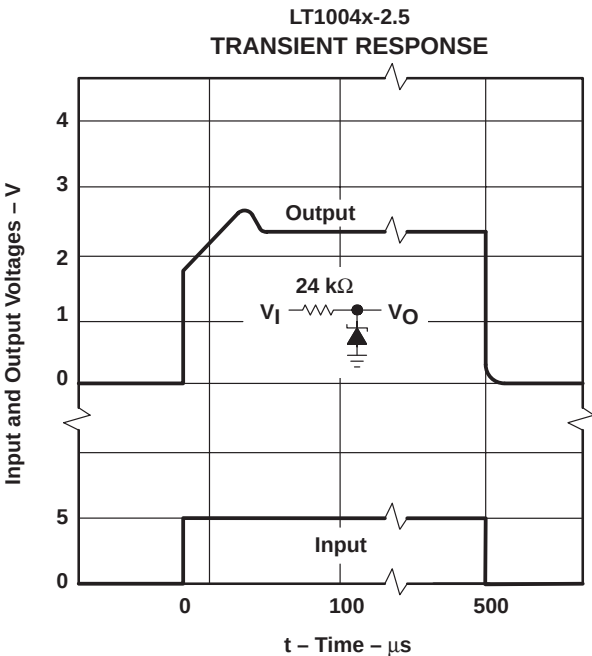


Figure 15

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

APPLICATION INFORMATION

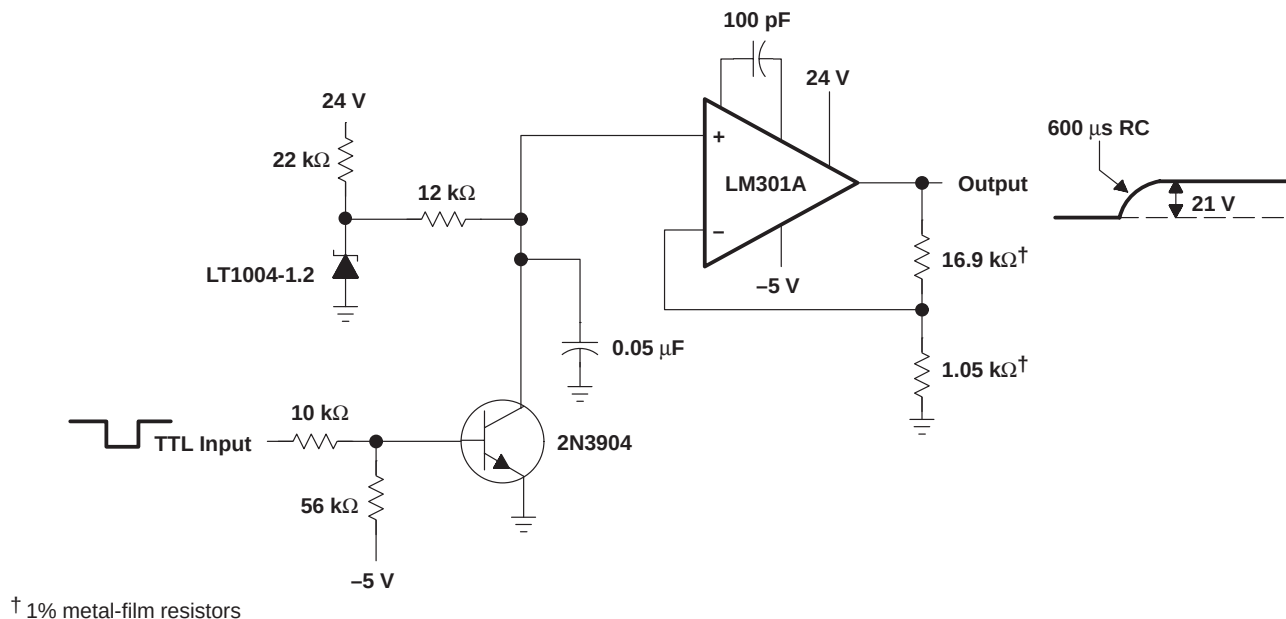


Figure 16. $V_{I(PP)}$ Generator for EPROMs (No Trim Required)

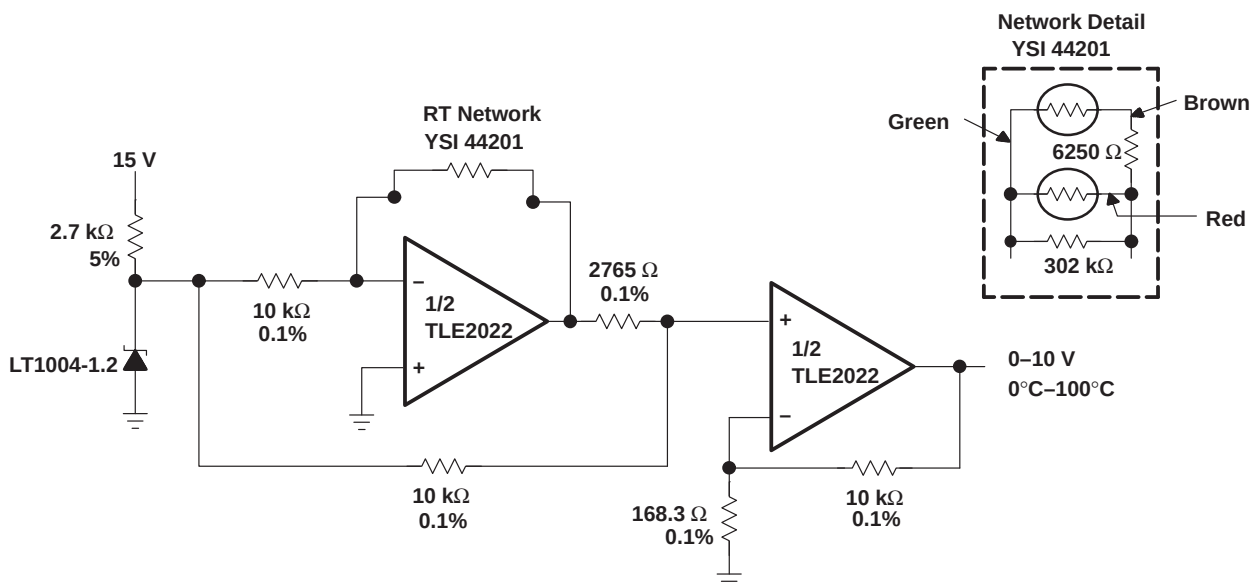


Figure 17. 0°C-to-100°C Linear-Output Thermometer

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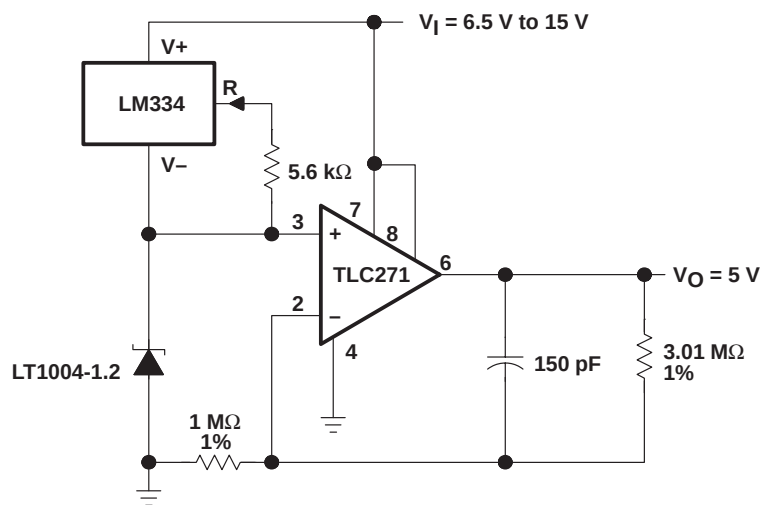


Figure 18. Micropower 5-V Reference

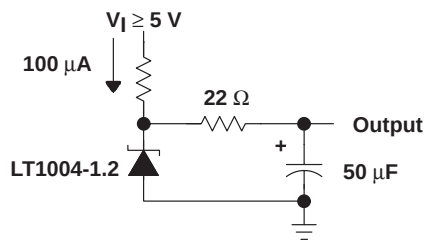


Figure 19. Low-Noise Reference

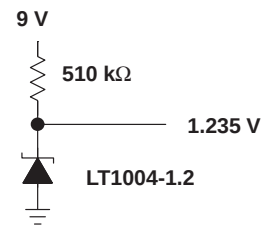
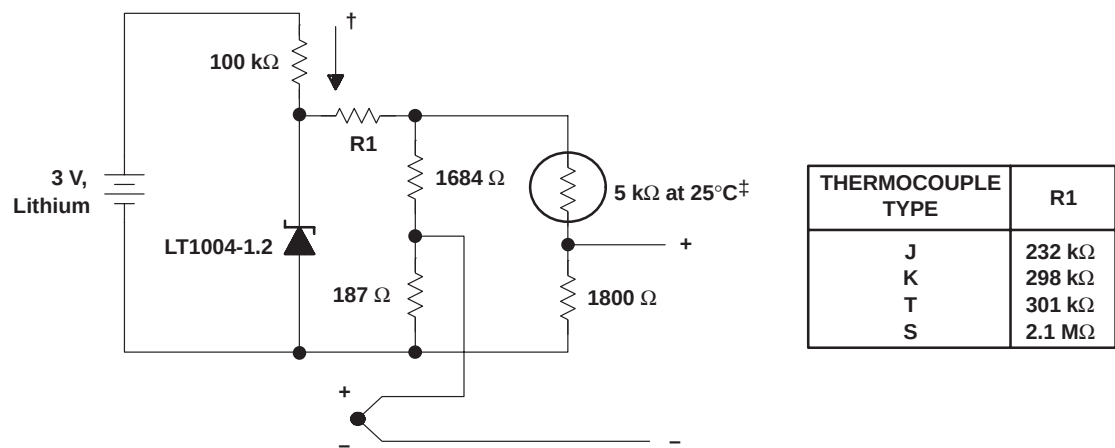


Figure 20. Micropower Reference From 9-V Battery



† 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°C to 60°C .

Figure 21. Micropower Cold-Junction Compensation for Thermocouples

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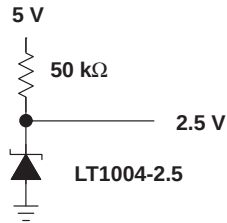


Figure 22. 2.5-V Reference

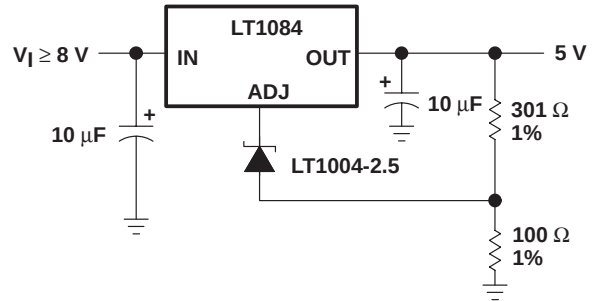
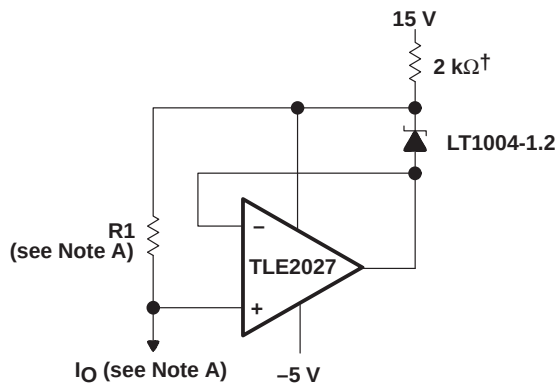


Figure 23. High-Stability 5-V Regulator



† 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

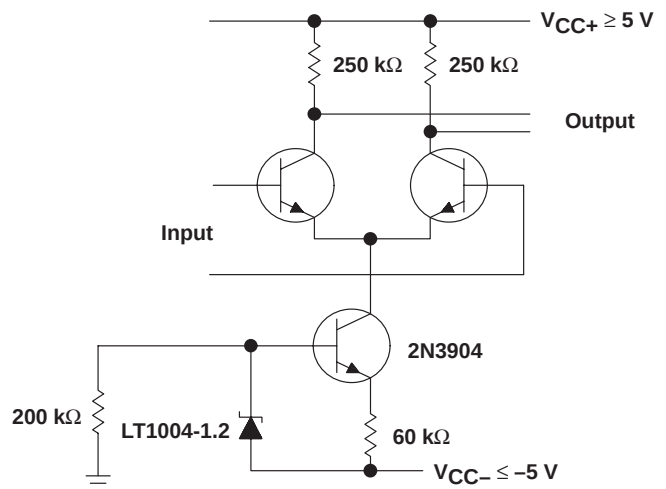
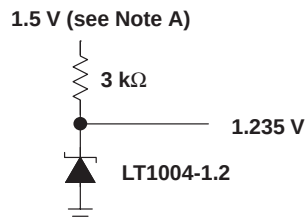


Figure 25. Amplifier With Constant Gain Over Temperature



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

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

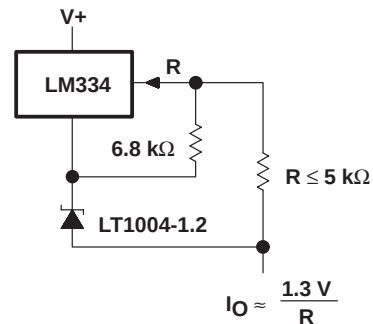


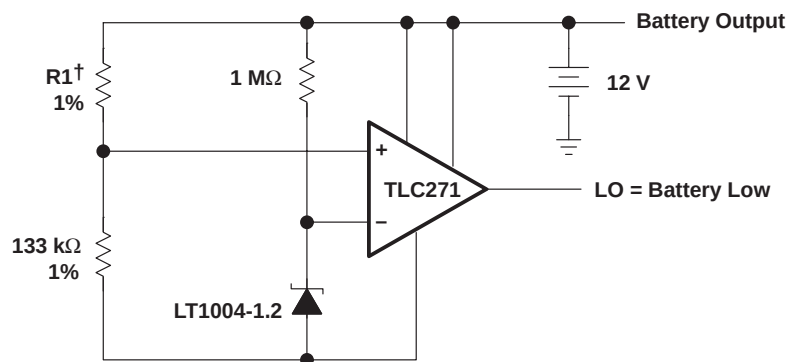
Figure 27. Terminal Current Source With Low Temperature Coefficient

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

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

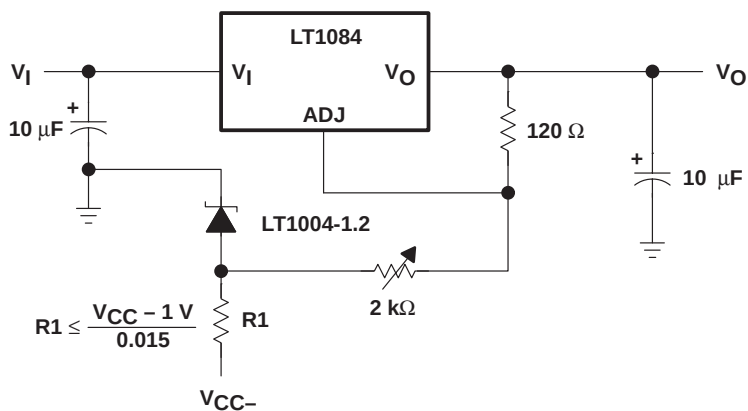


Figure 29. Variable-Voltage Supply

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