LM199/LM299/LM399 Precision Reference

Check for Samples: LM199, LM299, LM399, LM3999

FEATURES

- **0.0001%/°C Temperature Coefficient**
- **Low Dynamic Impedance — 0.5Ω**
- **Initial Tolerance on Breakdown Voltage — 2%**
- **Sharp Breakdown at 400 μA**
- **Wide Operating Current — 500 μA to 10 mA**
- **Wide Supply Range for Temperature Stabilizer**
- **Low Noise**
- **Low Power for Stabilization — 300 mW at 25°C**
- **Proven Reliability, Low-Stress Packaging in TO-46 Integrated-Circuit Hermetic Package, for Low Hysteresis after Thermal Cycling. 33 Million Hours MTBF at T_A = +25°C (T_J = +86°C)**

DESCRIPTION

The LM199 series are precision, temperature-stabilized monolithic zeners offering temperature coefficients a factor of ten better than high quality reference zeners. Constructed on a single monolithic chip is a temperature stabilizer circuit and an active reference zener. The active circuitry reduces the dynamic impedance of the zener to about 0.5Ω and allows the zener to operate over 0.5 mA to 10 mA current range with essentially no change in voltage or temperature coefficient. Further, a new subsurface zener structure gives low noise and excellent long term stability compared to ordinary monolithic zeners. The package is supplied with a thermal shield to minimize heater power and improve temperature regulation.

The LM199 series references are exceptionally easy to use and free of the problems that are often experienced with ordinary zeners. There is virtually no hysteresis in reference voltage with temperature cycling. Also, the LM199 is free of voltage shifts due to stress on the leads. Finally, since the unit is temperature stabilized, warm up time is fast.

The LM199 can be used in almost any application in place of ordinary zeners with improved performance. Some ideal applications are analog to digital converters, calibration standards, precision voltage or current sources or precision power supplies. Further in many cases the LM199 can replace references in existing equipment with a minimum of wiring changes.

The LM199 series devices are packaged in a standard hermetic TO-46 package inside a thermal shield. The LM199 is rated for operation from −55°C to +125°C while the LM299 is rated for operation from −25°C to +85°C and the LM399 is rated from 0°C to +70°C.

Connection Diagram

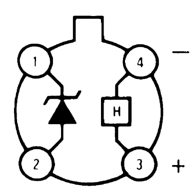


Figure 1. Metal Can Package (TO-46) Top View
Package Number NER0004D

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings[(1)(2)]

Temperature Stabilizer Voltage	LM199/LM299/LM399	40V
Reverse Breakdown Current		20 mA
Forward Current, LM199/LM299/LM399		1 mA
Reference to Substrate Voltage $V_{(RS)}$ [(3)]		40V −0.1V
Operating Temperature Range	LM199	−55°C to +125°C
	LM299	−25°C to +85°C
	LM399	−0°C to +70°C
Storage Temperature Range		−55°C to +150°C
Soldering Information, TO-46 package (10 sec.)		+300°C

(1) “Absolute Maximum Ratings” indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits.
(2) Specifications for Military/Aerospace products are not contained in this datasheet. Refer to the following Reliability Electrical Test Specifications documents: MNLM199A-X and SMD#5962-88561.
(3) The substrate is electrically connected to the negative terminal of the temperature stabilizer. The voltage that can be applied to either terminal of the reference is 40V more positive or 0.1V more negative than the substrate.

Electrical Characteristics[(1)(2)]

Parameter	Conditions		LM299H			LM399H			Units
			Min	Typ	Max	Min	Typ	Max	
Reverse Breakdown Voltage	0.5 mA ≤ I_R ≤ 10 mA		6.8	6.95	7.1	6.6	6.95	7.3	V
Reverse Breakdown Voltage Change with Current	0.5 mA ≤ I_R ≤ 10 mA			6	9		6	12	mV
Reverse Dynamic Impedance	I_R = 1 mA			0.5	1		0.5	1.5	Ω
Reverse Btreakdown Temperature Coefficient RMS Noise	−25°C≤T_A≤85°C	LM299		0.00003	0.0001				%/°C
	0°C≤T_A≤+70°C	LM399					0.00003	0.0002	%/°C
	10 Hz ≤ f ≤ 10 kHz			7	20		7	50	μV
Long Term Stability	Stabilized, 22°C≤T_A≤28°C, 1000 Hours, I_R=1 mA±0.1%			20			20		ppm
Temperature Stabilizer	T_A=25°C, Still Air, V_S=30V			8.5	14		8.5	15	mA
Supply Current	T_A =− 55°C			22	28				
Temperature Stabilizer Supply Voltage			9		40	9		40	V
Warm-Up Time to 0.05%	V_S = 30V, T_A = 25°C			3			3		sec.
Initial Turn-on Current	9≤V_S≤40, T_A=+25°C [(3)]			140	200		140	200	mA

(1) These specifications apply for 30V applied to the temperature stabilizer and −55°C≤T_A≤+125°C for the LM199; −25°C≤T_A≤+85°C for the LM299 and 0°C≤T_A≤+70°C for the LM399.
(2) A military data sheet is available for the LM199AH/833 and LM199AH-SMD (SMD#5962-88561) upon request.
(3) This initial current can be reduced by adding an appropriate resistor and capacitor to the heater circuit. See the performance characteristic graphs to determine values.

Electrical Characteristics[1][2]

Parameter	Conditions		LM199AH Min	LM199AH Typ	LM199AH Max	LM399AH Min	LM399AH Typ	LM399AH Max	Units
Reverse Breakdown Voltage	$0.5\text{ mA} \le I_R \le 10\text{ mA}$		6.8	6.95	7.1	6.6	6.95	7.3	V
Reverse Breakdown Voltage	$0.5\text{ mA} \le I_R \le 10\text{ mA}$			6	9		6	12	mV
Change with Current									
Reverse Dynamic Impedance	$I_R = 1\text{ mA}$			0.5	1		0.5	1.5	Ω
Reverse Breakdown Temperature Coefficient	$-55°C \le T_A \le +85°C$	LM199A[3]		0.00002	0.00005				%/°C
	$+85°C \le T_A \le +125°C$	LM199A[3]		0.0005	0.0010				%/°C
	$0°C \le T_A \le +70°C$	LM399A					0.00003	0.0001	%/°C
RMS Noise	10 Hz ≤ f ≤ 10 kHz			7	20		7	50	μV
Long Term Stability	Stabilized, $22°C \le T_A \le 28°C$, 1000 Hours, I_R=1 mA±0.1%			20			20		ppm
Temperature Stabilizer Supply Current	T_A=25°C, Still Air, V_S=30V			8.5	14		8.5	15	mA
	T_A =− 55°C			22	28				mA
Temperature Stabilizer Supply Voltage			9		40	9		40	V
Warm-Up Time to 0.05%	V_S = 30V, T_A = 25°C			3			3		sec.
Initial Turn-on Current	$9 \le V_S \le 40$, T_A=+25°C, [4]			140	200		140	200	mA

(1) These specifications apply for 30V applied to the temperature stabilizer and $-55°C \le T_A \le +125°C$ for the LM199; $-25°C \le T_A \le +85°C$ for the LM299 and $0°C \le T_A \le +70°C$ for the LM399.
(2) A military data sheet is available for the LM199AH/833 and LM199AH-SMD (SMD#5962-88561) upon request.
(3) Do not wash the LM199 with its polysulfone thermal shield in TCE.
(4) This initial current can be reduced by adding an appropriate resistor and capacitor to the heater circuit. See the performance characteristic graphs to determine values.

Functional Block Diagram

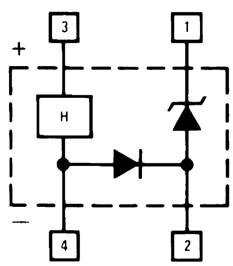


Figure 2. LM199/LM299/LM399

Typical Performance Characteristics

Reverse Characteristics

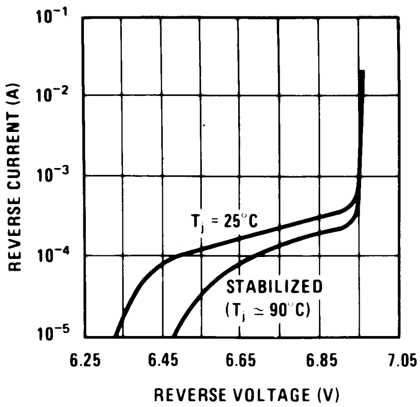


Figure 3.

Reverse Voltage Change

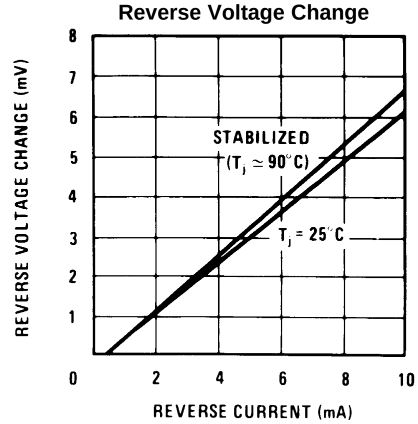


Figure 4.

Dynamic Impedance

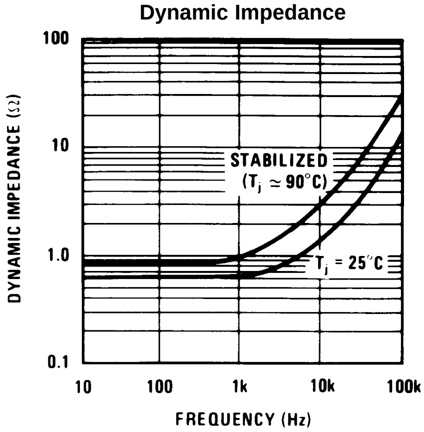


Figure 5.

Zener Noise Voltage

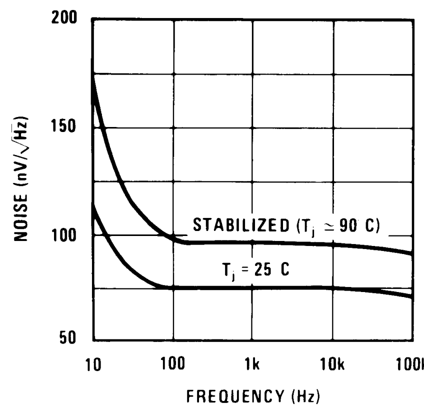


Figure 6.

Stabilization Time

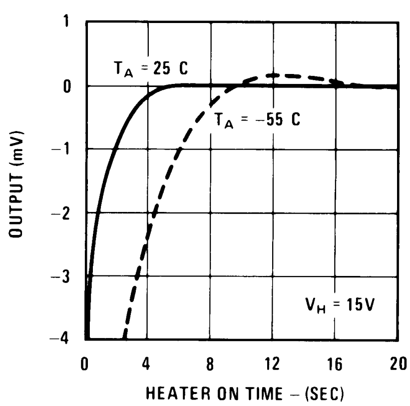


Figure 7.

Heater Current

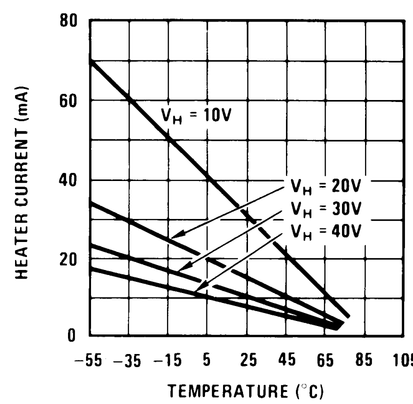


Figure 8.

Typical Performance Characteristics (continued)

Initial Heater Current

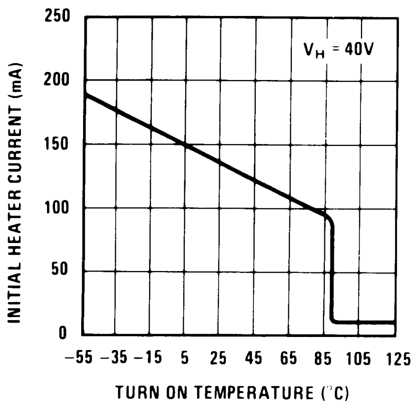


Figure 9.

Heater Current (To Limit This Surge, See Next Graph)

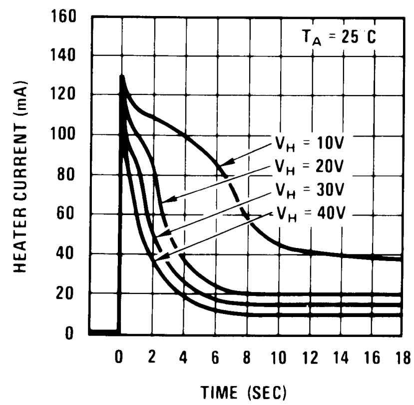
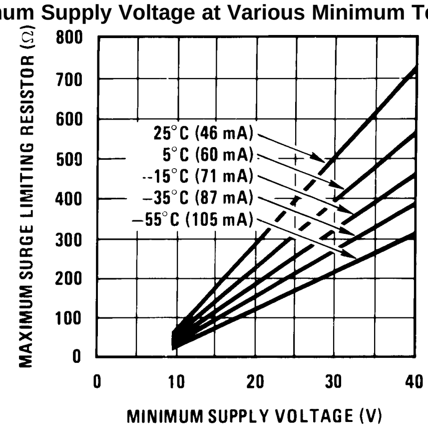


Figure 10.

Heater Surge Limit Resistor vs Minimum Supply Voltage at Various Minimum Temperatures



*Heater must be bypassed with a 2 µF or larger tantalum capacitor if resistors are used.

Figure 11.

Response Time

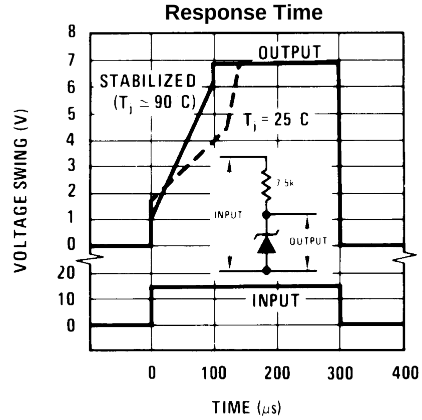


Figure 12.

Low Frequency Noise Voltage

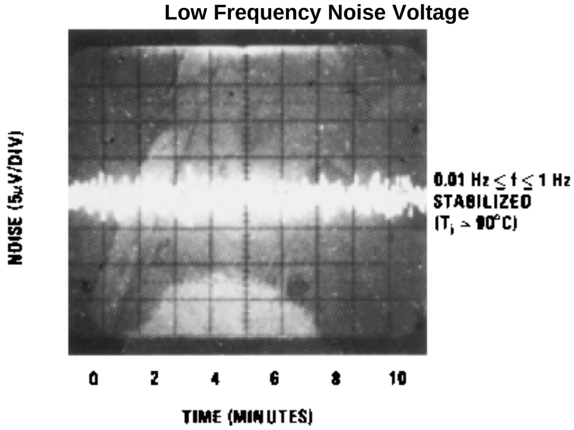


Figure 13.

TYPICAL APPLICATIONS

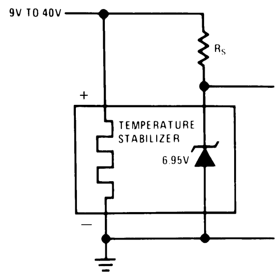


Figure 14. Single Supply Operation

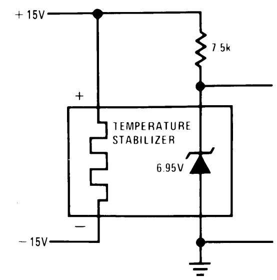


Figure 15. Split Supply Operation

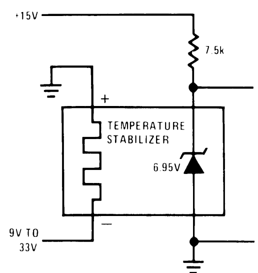


Figure 16. Negative Heater Supply with Positive Reference

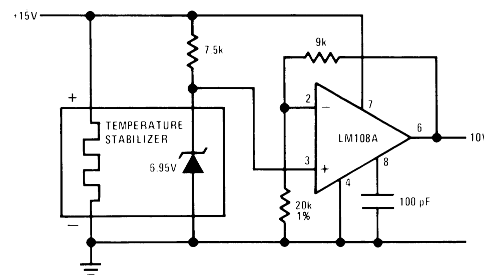


Figure 17. Buffered Reference With Single Sypply

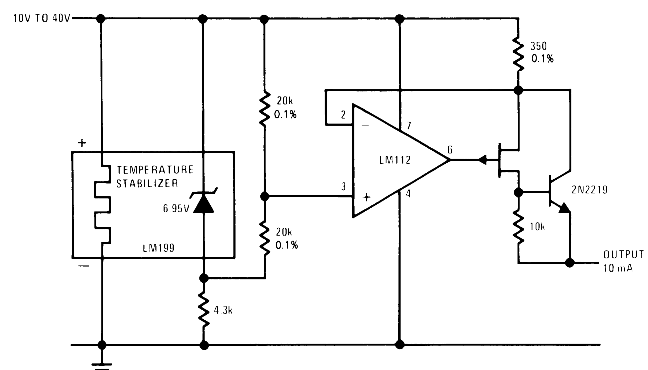


Figure 18. Positive Current Source

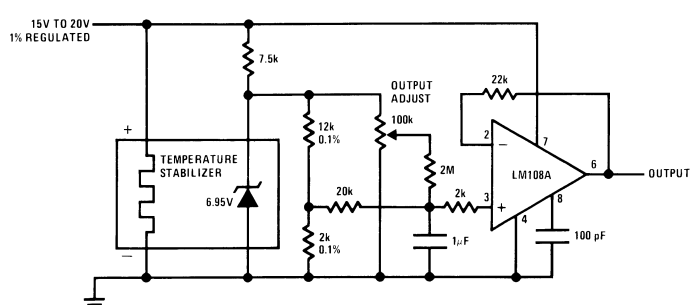


Figure 19. Standard Cell Replacement

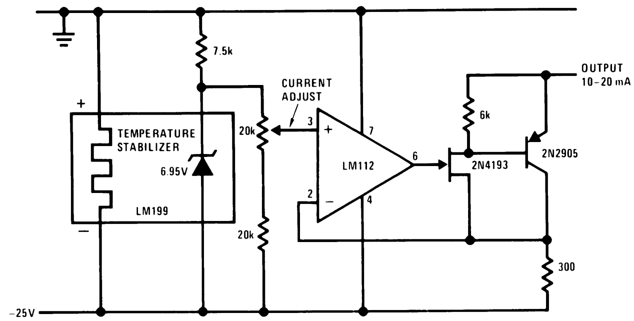


Figure 20. Negative Current Source

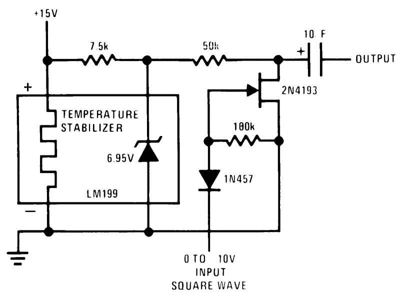
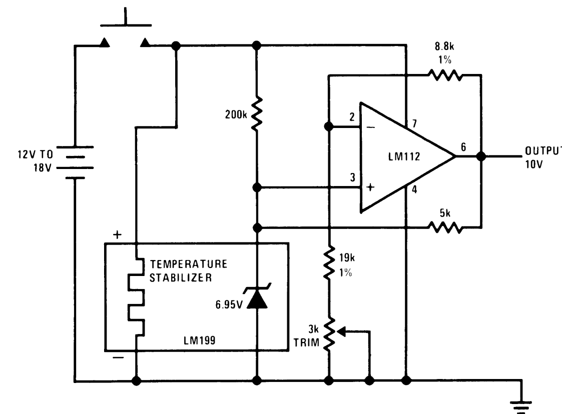


Figure 21. Square Wave Voltage Reference



*Warm-up time 10 seconds; intermittent operation does not degrade long term stability.

Figure 22. Portable Calibrator*

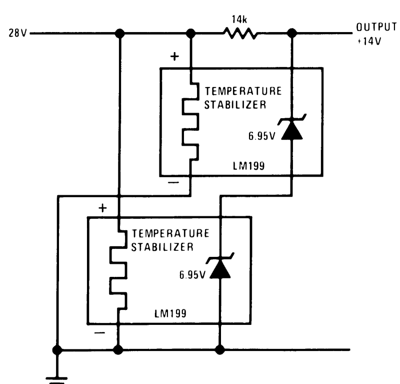
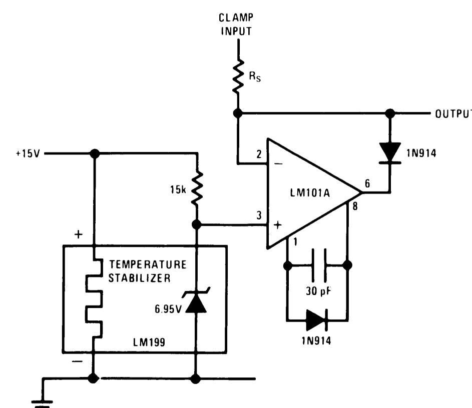


Figure 23. 14V Reference



*Clamp will sink 5 mA when input goes more positive than reference

Figure 24. Precision Clamp*

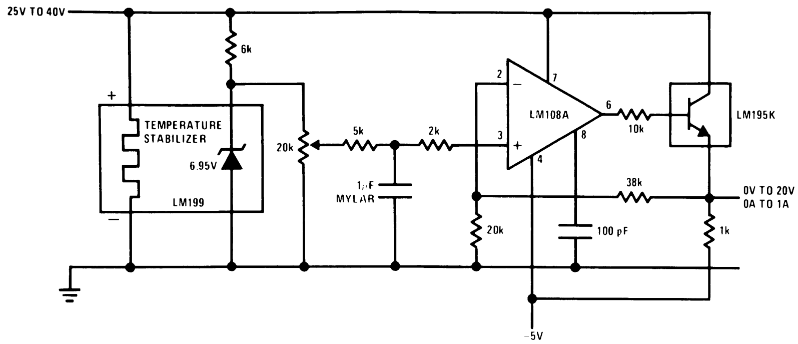


Figure 25. 0V to 20V Power Reference

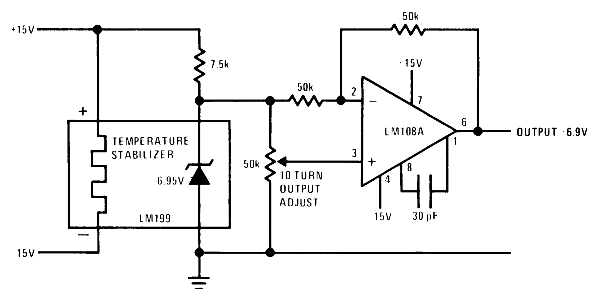


Figure 26. Bipolar Output Reference

Schematic Diagrams

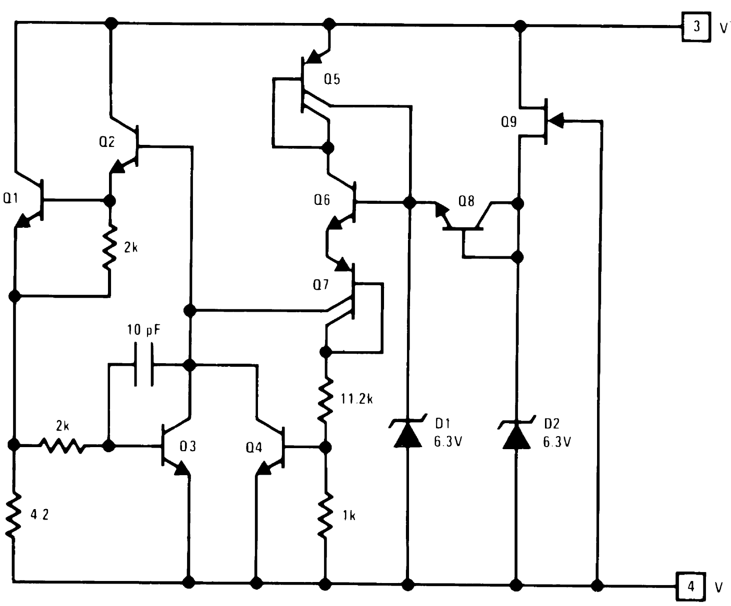


Figure 27. Temperature Stabilizer

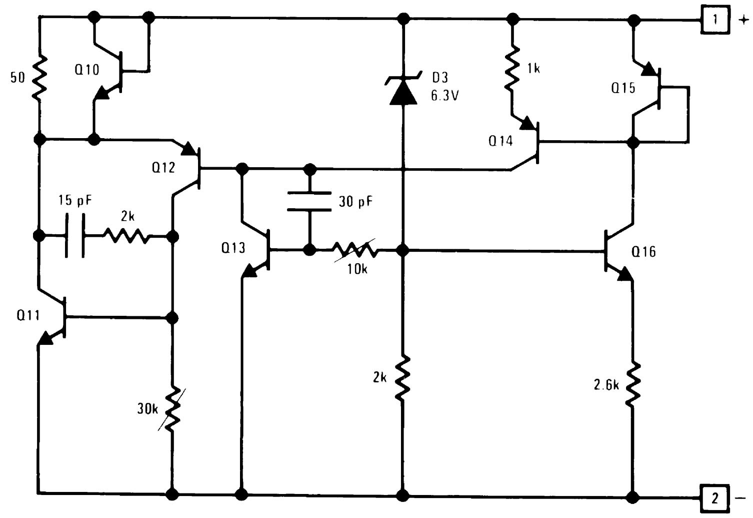


Figure 28. Reference