

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

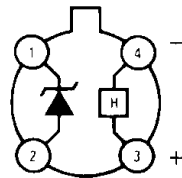
The LM199 series are precision, temperature-stabilized monolithic zeners offering temperature coefficients a factor of ten better than high quality reference zeners. Constructed on a single monolithic chip is a temperature stabilizer circuit and an active reference zener. The active circuitry reduces 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**



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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⁾

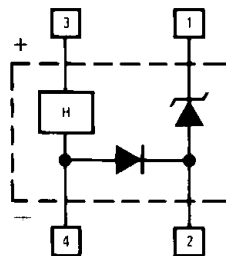
| Parameter | Conditions | LM299H | | | LM399H | | | Units |
|--|--|--------|---------|--------|--------|---------|--------|---------------|
| | | Min | Typ | Max | Min | Typ | Max | |
| Reverse Breakdown Voltage | $0.5 \text{ mA} \leq I_R \leq 10 \text{ mA}$ | 6.8 | 6.95 | 7.1 | 6.6 | 6.95 | 7.3 | V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

- (1) These specifications apply for 30V applied to the temperature stabilizer and $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ for the LM199; $-25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ for the LM299 and $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$ 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 | | | LM399AH | | | Units |
|---|---|-----------------------|---------|---------|---------|---------|--------|---------------|
| | | Min | Typ | Max | Min | Typ | Max | |
| Reverse Breakdown Voltage | $0.5 \text{ mA} \leq I_R \leq 10 \text{ mA}$ | 6.8 | 6.95 | 7.1 | 6.6 | 6.95 | 7.3 | V |
| Reverse Breakdown Voltage | $0.5 \text{ mA} \leq I_R \leq 10 \text{ mA}$ | | 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 | $-55^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ | LM199A ⁽³⁾ | 0.00002 | 0.00005 | | | | %/°C |
| | $+85^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ | | 0.0005 | 0.0010 | | | | %/°C |
| | $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$ | LM399A | | | | 0.00003 | 0.0001 | %/°C |
| RMS Noise | $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$ | | 7 | 20 | | 7 | 50 | μV |
| Long Term Stability | Stabilized, $22^\circ\text{C} \leq T_A \leq 28^\circ\text{C}$, 1000 Hours, $I_R = 1 \text{ mA} \pm 0.1\%$ | | 20 | | | 20 | | ppm |
| Temperature Stabilizer Supply Current | $T_A = 25^\circ\text{C}$, Still Air, $V_S = 30\text{V}$ $T_A = -55^\circ\text{C}$ | | 8.5 | 14 | | 8.5 | 15 | mA |
| | | | 22 | 28 | | | | |
| Temperature Stabilizer Supply Voltage | | 9 | | 40 | 9 | | 40 | V |
| Warm-Up Time to 0.05% | $V_S = 30\text{V}$, $T_A = 25^\circ\text{C}$ | | 3 | | | 3 | | sec. |
| Initial Turn-on Current | $9 \leq V_S \leq 40$, $T_A = +25^\circ\text{C}$, ⁽⁴⁾ | | 140 | 200 | | 140 | 200 | mA |

- (1) These specifications apply for 30V applied to the temperature stabilizer and $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ for the LM199; $-25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ for the LM299 and $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$ 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

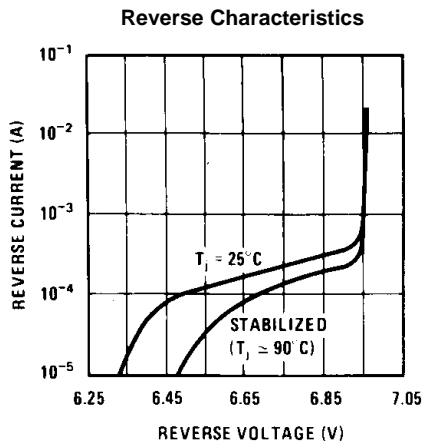


Figure 3.

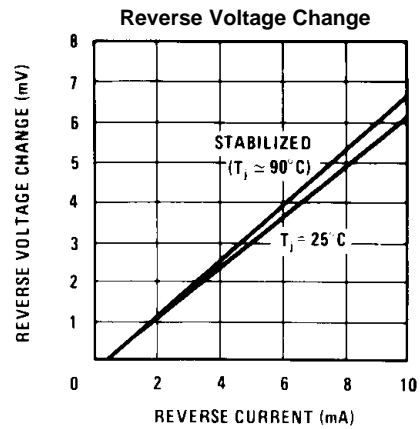


Figure 4.

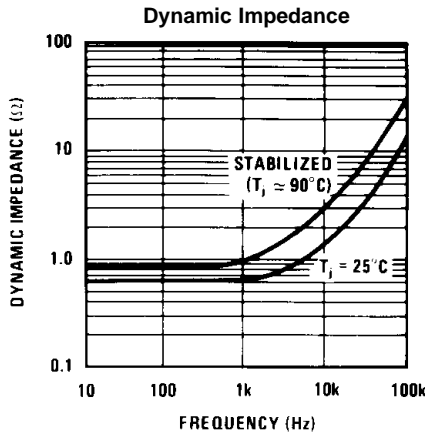


Figure 5.

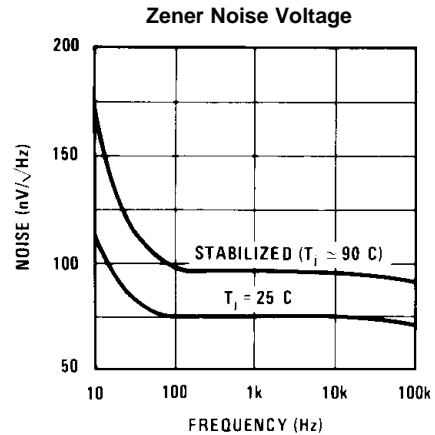


Figure 6.

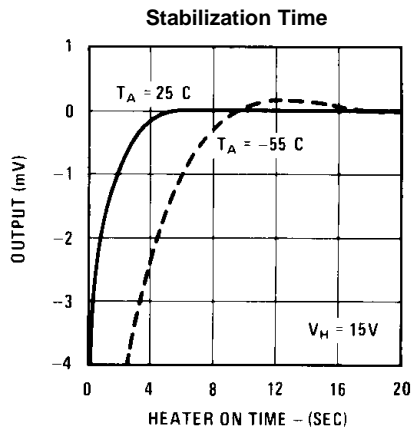


Figure 7.

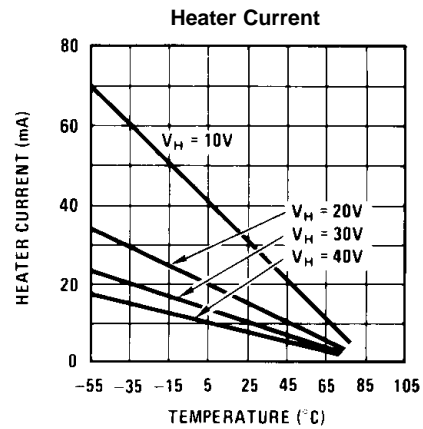


Figure 8.

Typical Performance Characteristics (continued)

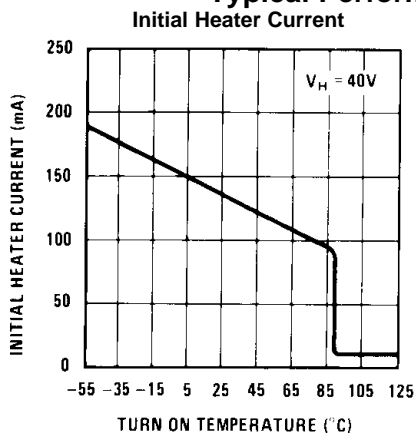


Figure 9.

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

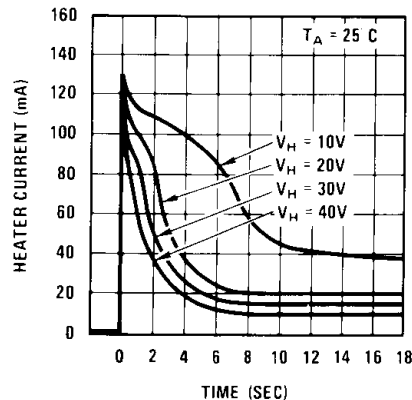


Figure 10.

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

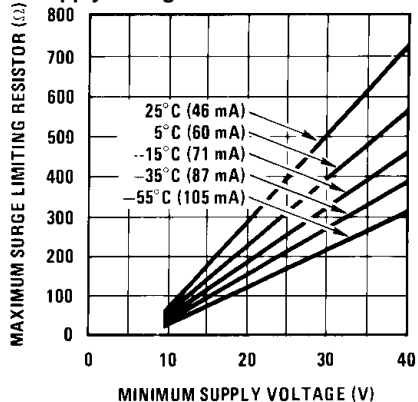


Figure 11.

Response Time

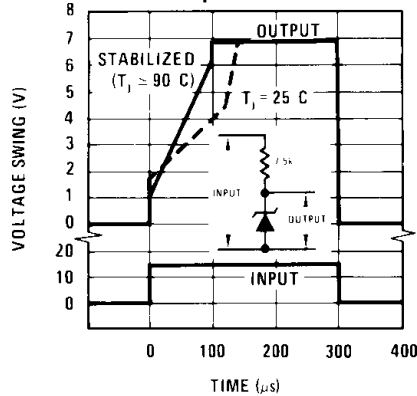


Figure 12.

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

Low Frequency Noise Voltage

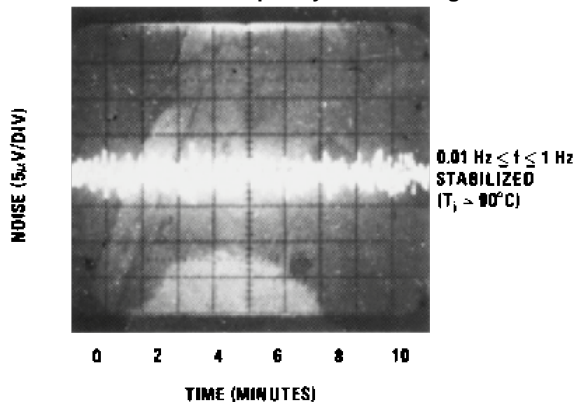


Figure 13.

TYPICAL APPLICATIONS

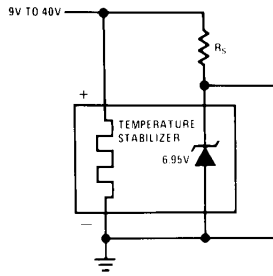


Figure 14. Single Supply Operation

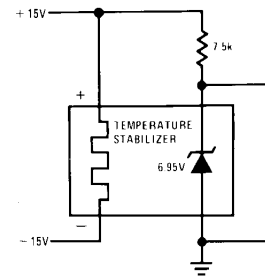


Figure 15. Split Supply Operation

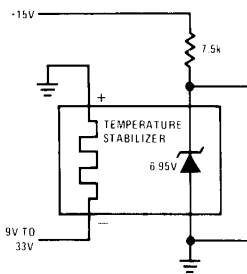


Figure 16. Negative Heater Supply with Positive Reference

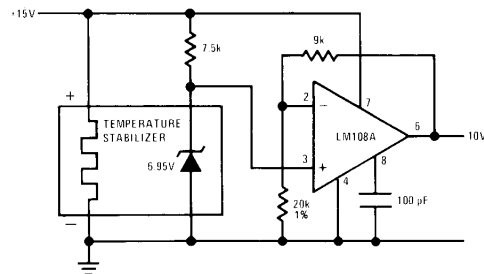


Figure 17. Buffered Reference With Single Supply

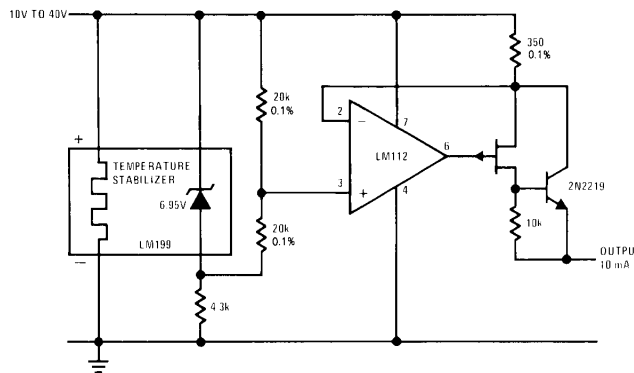


Figure 18. Positive Current Source

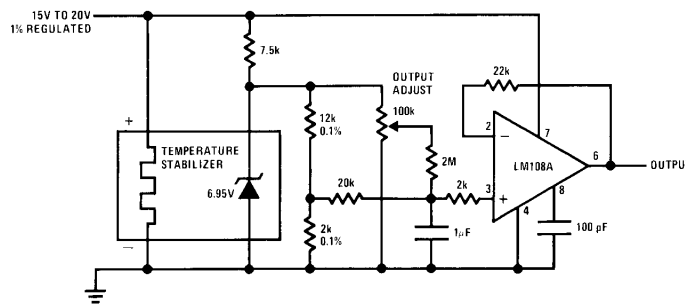


Figure 19. Standard Cell Replacement

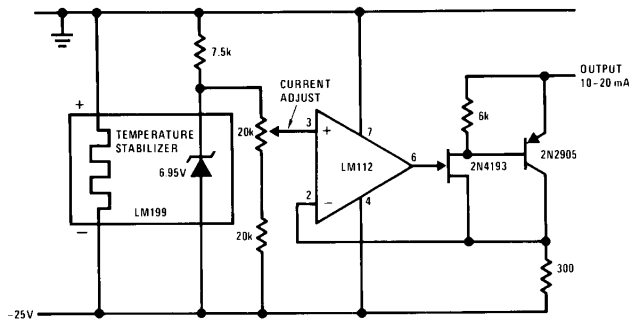


Figure 20. Negative Current Source

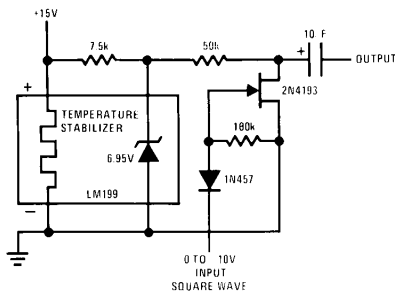
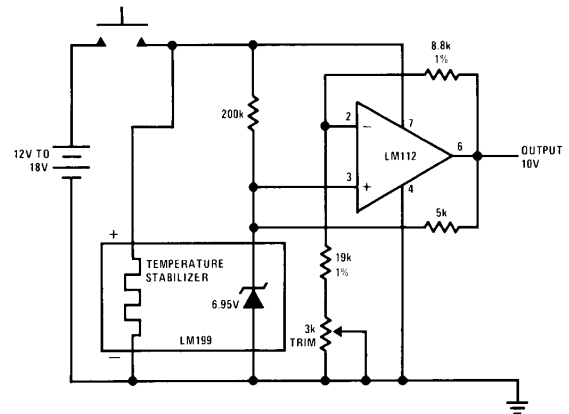


Figure 21. Square Wave Voltage Reference



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

Figure 22. Portable Calibrator*

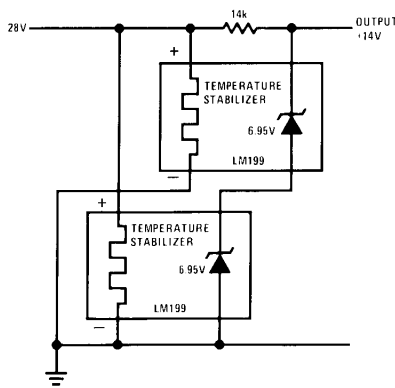
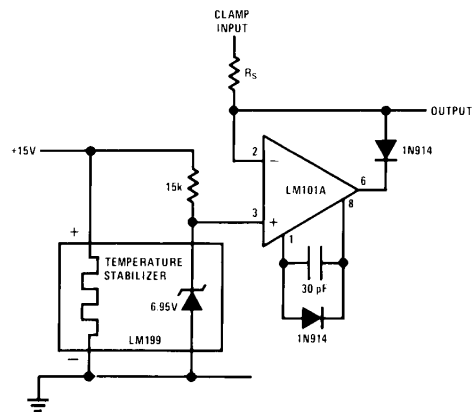


Figure 23. 14V Reference



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

Figure 24. Precision Clamp*

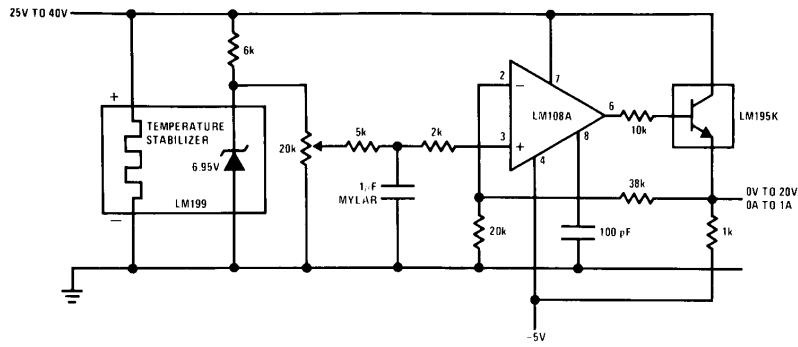


Figure 25. 0V to 20V Power Reference

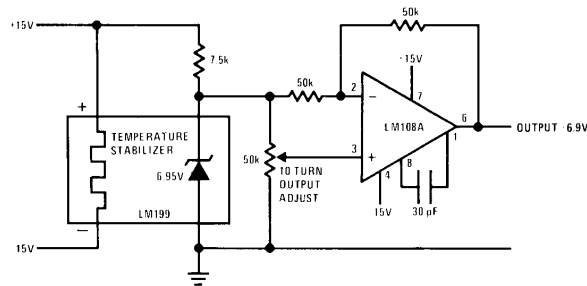


Figure 26. Bipolar Output Reference

Schematic Diagrams

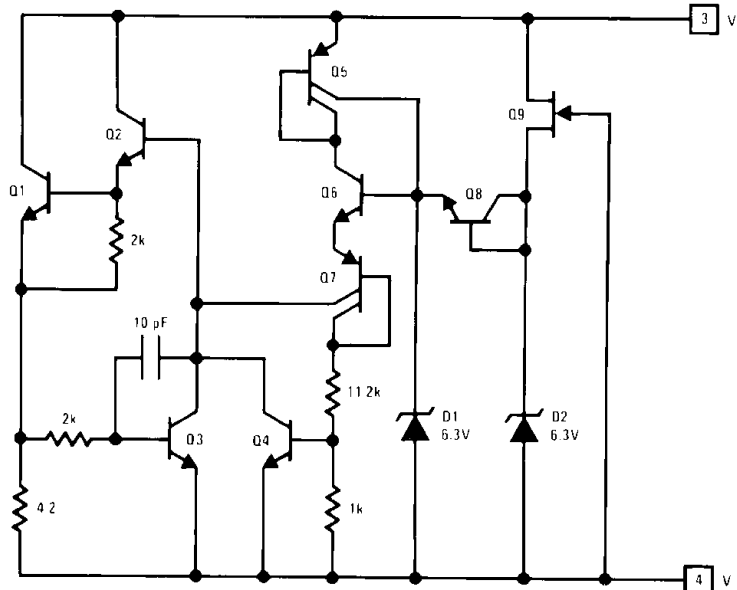


Figure 27. Temperature Stabilizer

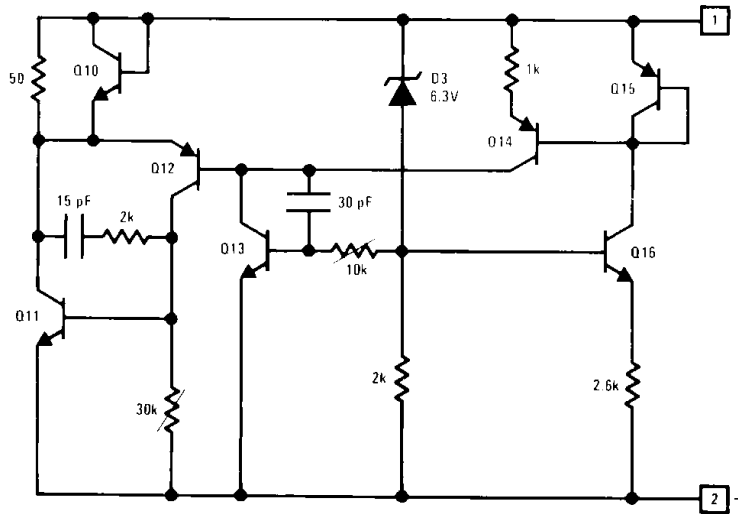


Figure 28. Reference

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