

LM199/LM299/LM399 Precision Reference

 Check for Samples: [LM199](#), [LM299](#), [LM399](#), [LM3999](#)

FEATURES

- **Guaranteed 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**
- **Guaranteed 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

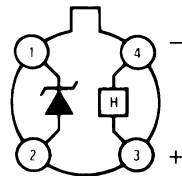
The LM199 series are precision, temperature-stabilized monolithic zeners offering temperature coefficients a factor of ten better than high quality reference zeners. Constructed on a single monolithic chip is a temperature stabilizer circuit and an active reference zener. The active circuitry reduces 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
NS Package Number H04D**



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.



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Absolute Maximum Ratings ⁽¹⁾

Specifications for Military/Aerospace products are not contained in this datasheet. Refer to the following Reliability Electrical Test Specifications documents: MNL199A-X and SMD#5962-88561.

Temperature Stabilizer Voltage	
LM199/LM299/LM399	40V
Reverse Breakdown Current	20 mA
Forward Current, LM199/LM299/LM399	1 mA
Reference to Substrate Voltage $V_{(RS)}$ ⁽²⁾	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 guarantee specific performance limits.
- (2) 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	$0.5 \text{ mA} \leq I_R \leq 10 \text{ mA}$			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	$-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	LM299		0.00003	0.0001				%/°C
	$0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$	LM399					0.00003	0.0002	%/°C
RMS Noise	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}$			7	20		7	50	μV
Long Term Stability	Stabilized, $22^\circ\text{C} \leq T_A \leq 28^\circ\text{C}$,			20			20		ppm
	1000 Hours, $I_R = 1 \text{ mA} \pm 0.1\%$								
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			9		40	9		40	V
Supply Voltage									
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	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	$T_A = 25^\circ\text{C}$, 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			9	40	9		40	V
Supply Voltage								
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.

Functional Block Diagram

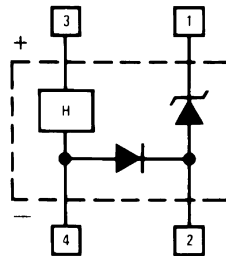
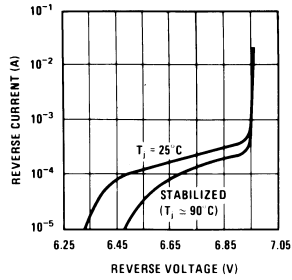


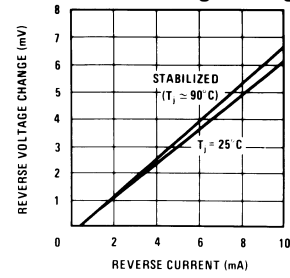
Figure 2. LM199/LM299/LM399

Typical Performance Characteristics

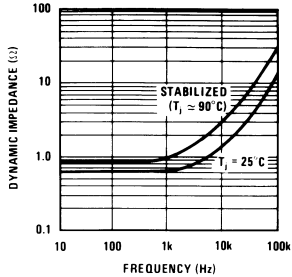
Reverse Characteristics



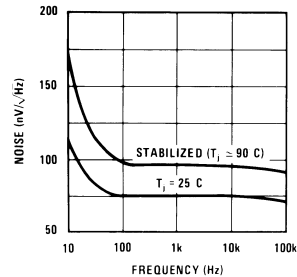
Reverse Voltage Change



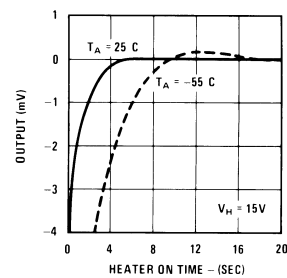
Dynamic Impedance



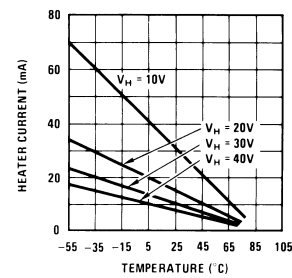
Zener Noise Voltage



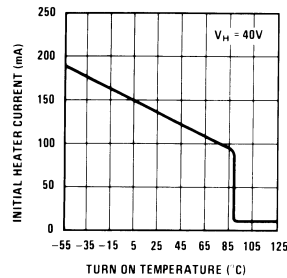
Stabilization Time



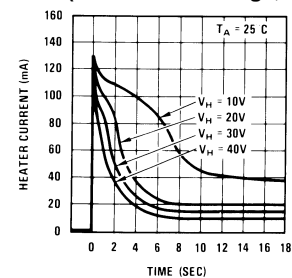
Heater Current



Initial Heater Current



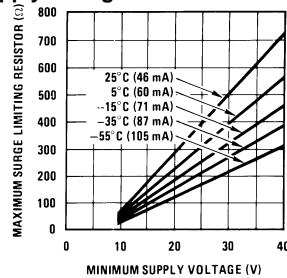
Heater Current (To Limit This Surge, See Next Graph)



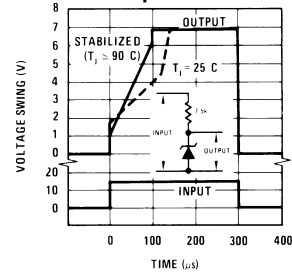
Heater Surge Limit Resistor

vs

Minimum Supply Voltage at Various Minimum Temperatures

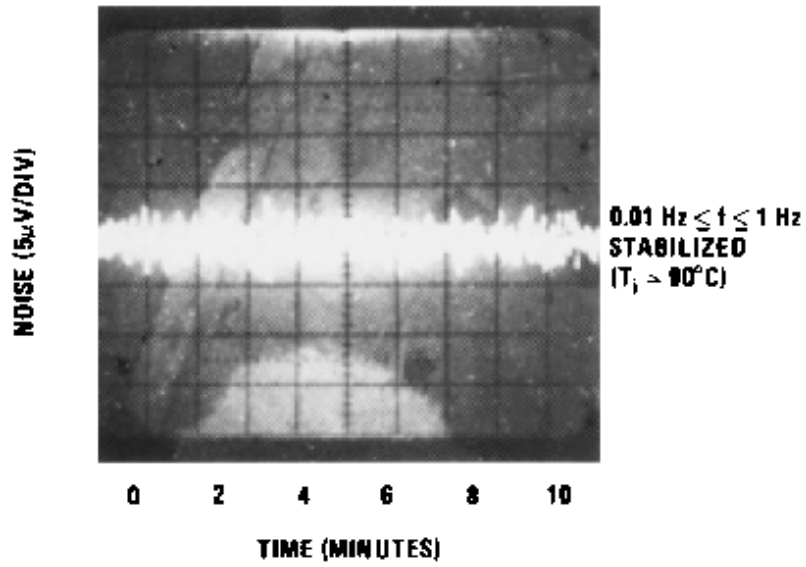


Response Time



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

Typical Performance Characteristics (continued)
Low Frequency Noise Voltage



Typical Applications

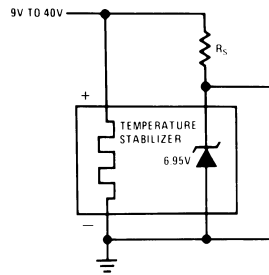


Figure 3. Single Supply Operation

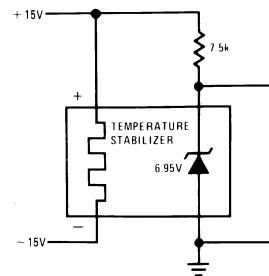


Figure 4. Split Supply Operation

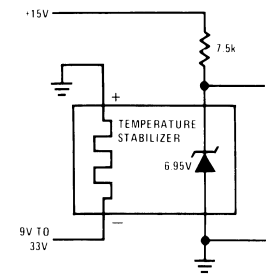


Figure 5. Negative Heater Supply with Positive Reference

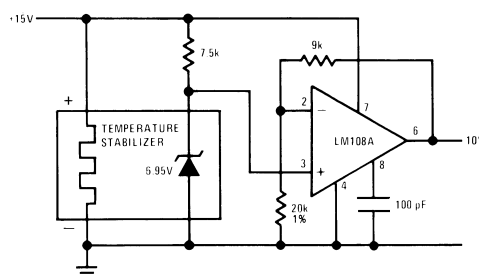


Figure 6. Buffered Reference With Single Supply

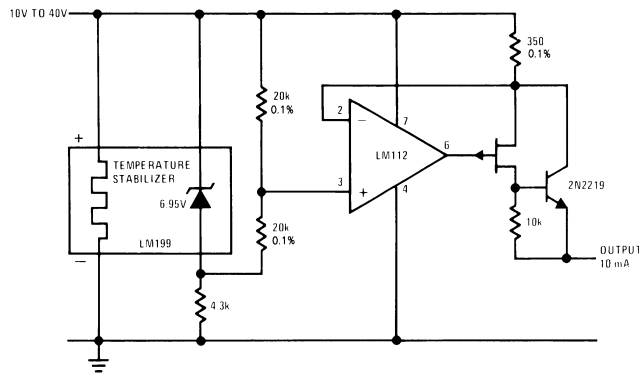


Figure 7. Positive Current Source

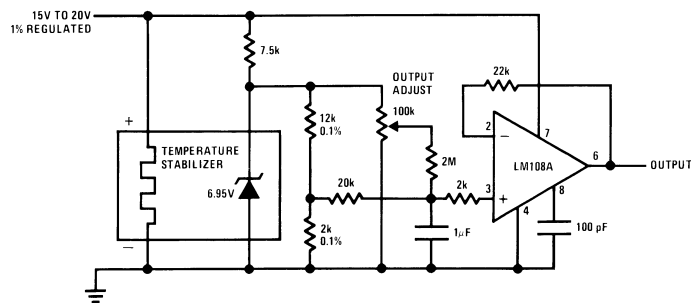


Figure 8. Standard Cell Replacement

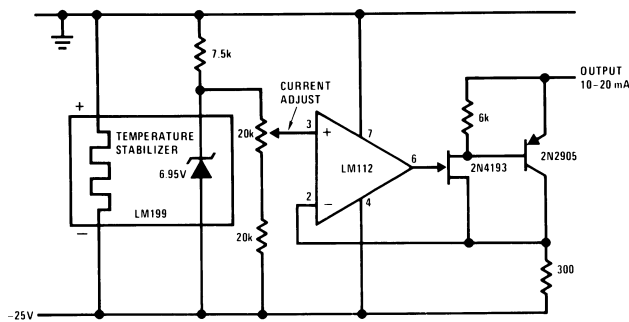


Figure 9. Negative Current Source

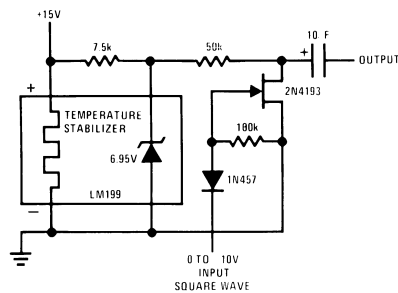
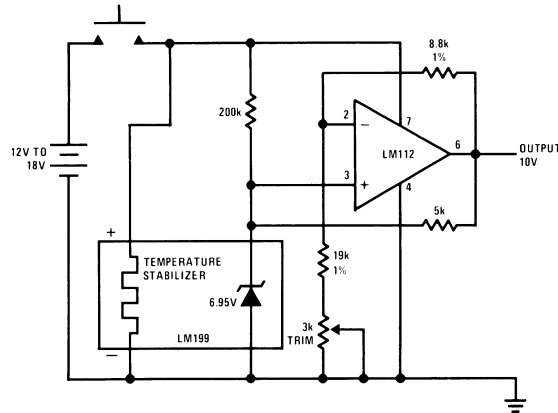


Figure 10. Square Wave Voltage Reference

Figure 11.



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

Figure 12. Portable Calibrator*

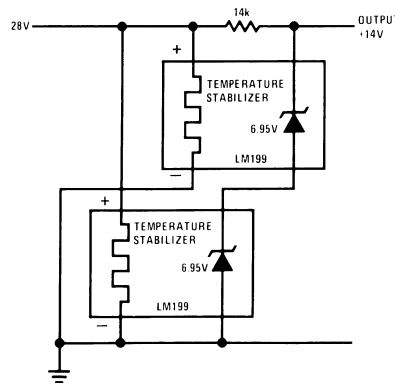
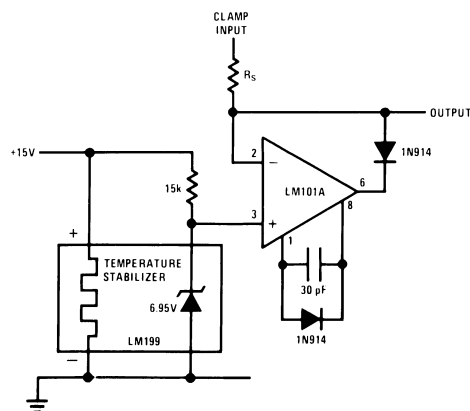


Figure 13. 14V Reference



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

Figure 14. Precision Clamp*

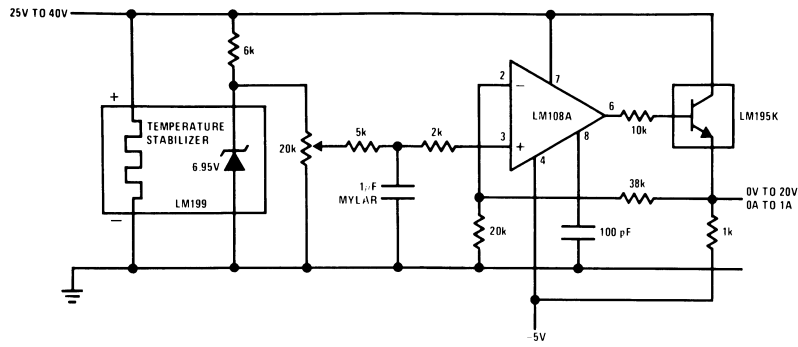


Figure 15. 0V to 20V Power Reference

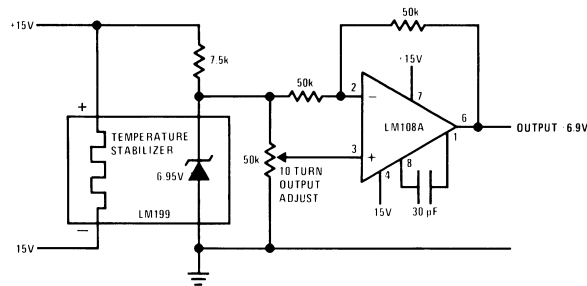


Figure 16. Bipolar Output Reference

Schematic Diagrams

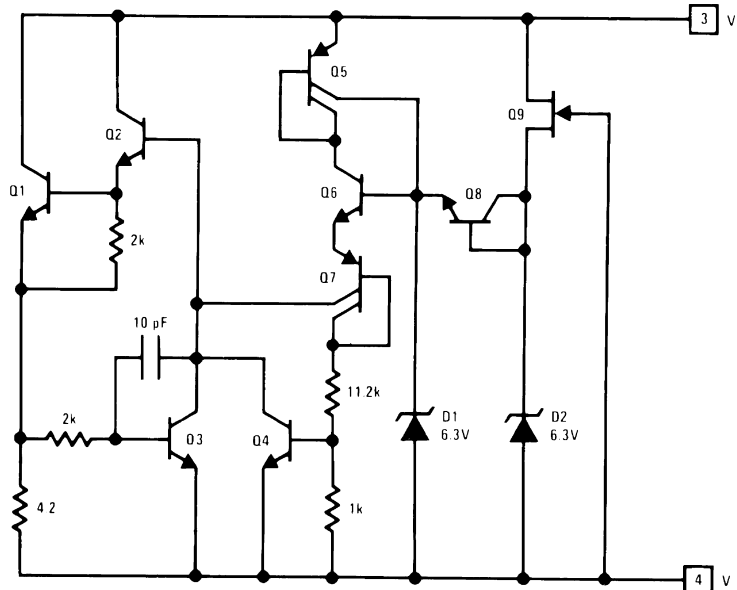


Figure 17. Temperature Stabilizer

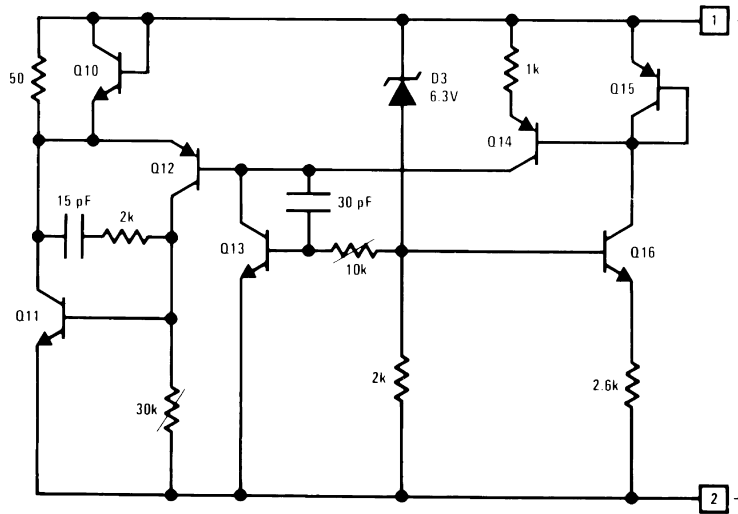


Figure 18. Reference

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