National Semiconductor

April 2005

LM199/LM299/LM399 Precision Reference

General 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.

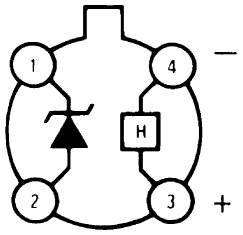
The LM199 series devices are packaged in a standard hermetic TO-46 package inside a thermal shield. The LM199 is rated for operation from −55˚C to +125˚C while the LM299 is rated for operation from −25˚C to +85˚C and the LM399 is rated from 0˚C to +70˚C.

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)

Connection Diagram

Metal Can Package (TO-46)



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Top View
NS Package Number H04D

Ordering Information

Order Number	Initial Tolerance	Ambient Temperature	Package Marking	Transport Method	NSC Package
LM199AH	±2%	-50˚C to +125˚C	LM199AH	Box of 500	H04A
LM199AH/883	±2%	-50˚C to +125˚C	LM199AH/Q	Tray of 20	H04A
LM299H	±2%	-25˚C to +85˚C	LM299H	Box of 500	H04A
LM399AH	±5%	0˚C to +70˚C	LM399AH	Box of 500	H04A
LM399H	±5%	0˚C to +70˚C	LM399H	Box of 500	H04A

Absolute Maximum Ratings (Note 1)

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 .

Temperature Stabilizer Voltage	
LM199/LM299/LM399	40V
Reverse Breakdown Current	20 mA
Forward Current	
LM199/LM299/LM399	1 mA
Reference to Substrate Voltage $V_{(RS)}$ (Note 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

Electrical Characteristics (Notes 3, 6)

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	−25˚C≤T_A≤85˚C	LM299		0.00003	0.0001				%/˚C
	0˚C≤T_A≤+70˚C	LM399					0.00003	0.0002	%/˚C
RMS Noise	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 Supply Current	T_A=25˚C, Still Air, V_S=30V			8.5	14		8.5	15	mA
	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, (Note 4)			140	200		140	200	mA

Electrical Characteristics (Notes 3, 6)

Parameter	Conditions		LM199AH			LM399AH			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 Breakdown Temperature Coefficient	−55˚C≤T_A≤+85˚C	LM199A		0.00002	0.00005				%/˚C
	+85˚C≤T_A≤+125˚C	LM199A		0.0005	0.0010				%/˚C
	0˚C≤T_A≤+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≤T_A≤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				
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, (Note 4)			140	200		140	200	mA

Electrical Characteristics (Notes 3, 6) (Continued)

Note 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.

Note 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.

Note 3: These specifications apply for 30V applied to the temperature stabilizer and $-55^{\circ}C \leq T_A \leq +125^{\circ}C$ for the LM199; $-25^{\circ}C \leq T_A \leq +85^{\circ}C$ for the LM299 and $0^{\circ}C \leq T_A \leq +70^{\circ}C$ for the LM399.

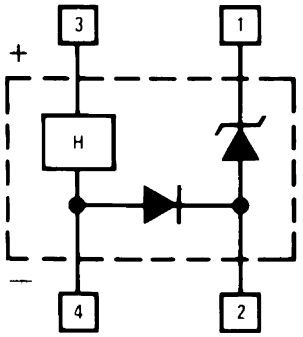
Note 4: This initial current can be reduced by adding an appropriate resistor and capacitor to the heater circuit. See the performance characteristic graphs to determine values.

Note 5: Do not wash the LM199 with its polysulfone thermal shield in TCE.

Note 6: A military data sheet is available for the LM199AH/833 and LM199AH-SMD (SMD#5962-88561) upon request.

Functional Block Diagram

LM199/LM299/LM399



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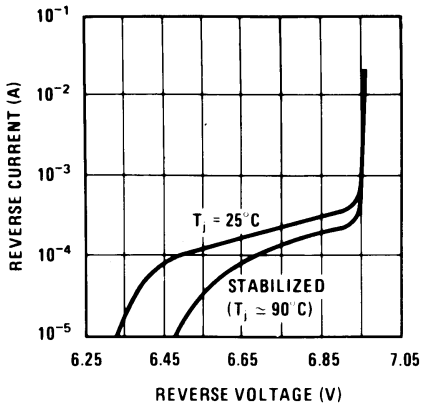
Typical Performance Characteristics

Reverse Characteristics



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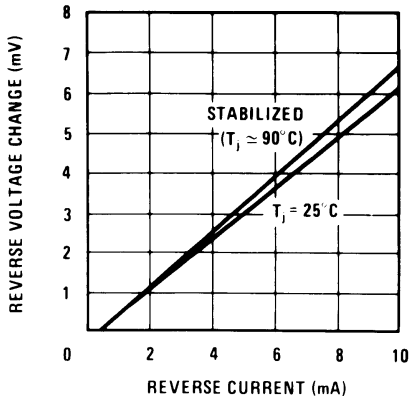
Reverse Voltage Change



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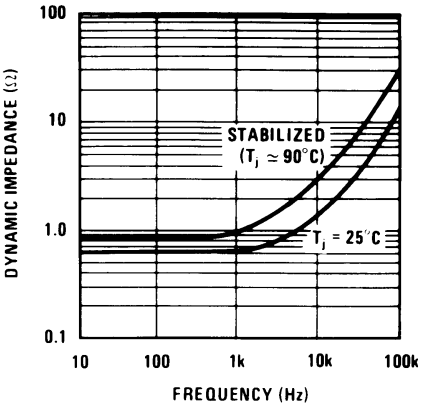
Dynamic Impedance



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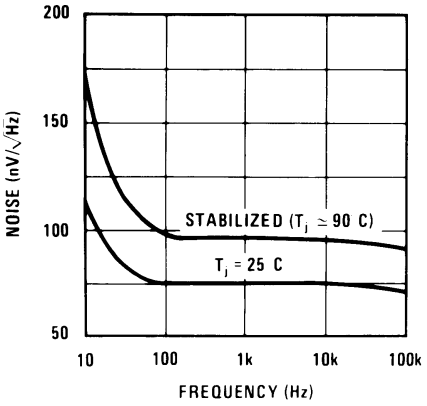
Zener Noise Voltage



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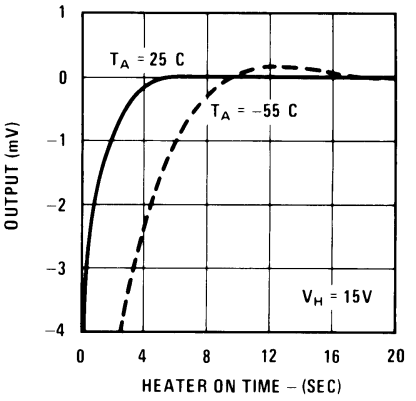
Stabilization Time



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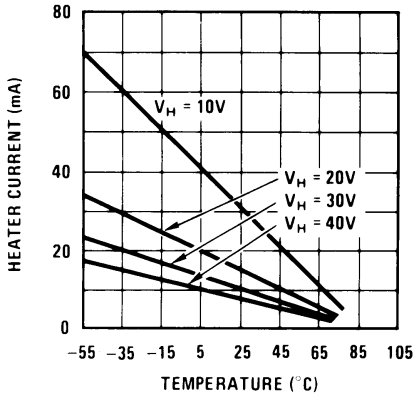
Heater Current



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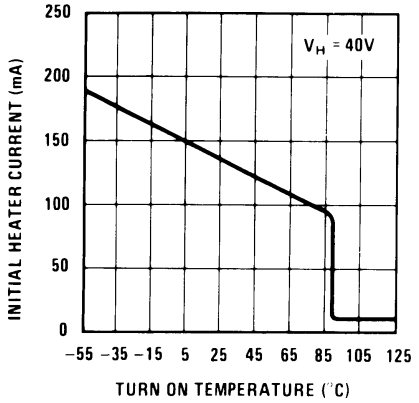
Typical Performance Characteristics (Continued)

Initial Heater Current



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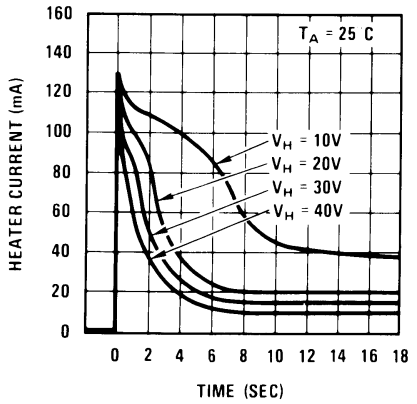
Heater Current (To Limit This Surge, See Next Graph)



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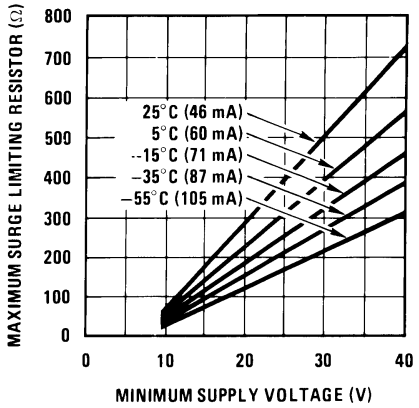
Heater Surge Limit Resistor vs Minimum Supply Voltage at Various Minimum Temperatures



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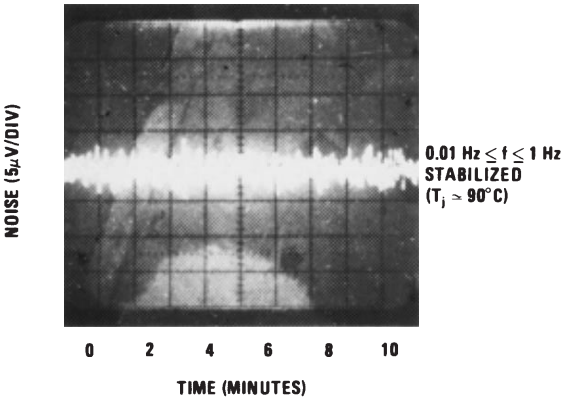
*Heater must be bypassed with a 2 µF or larger tantalum capacitor if resistors are used.

Low Frequency Noise Voltage



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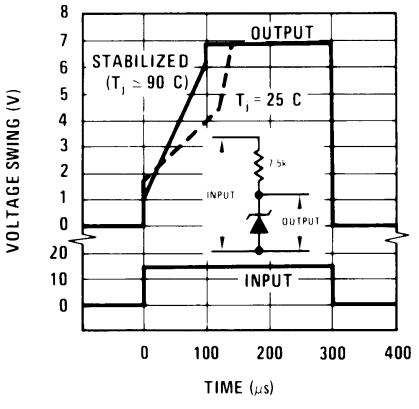
Response Time



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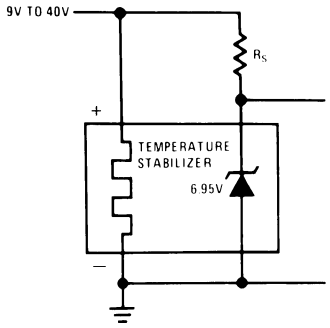
Typical Applications

Single Supply Operation



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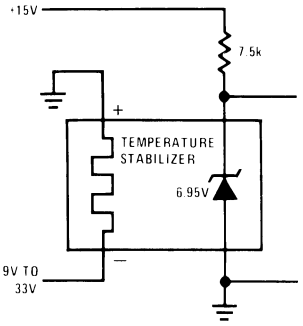
Negative Heater Supply with Positive Reference



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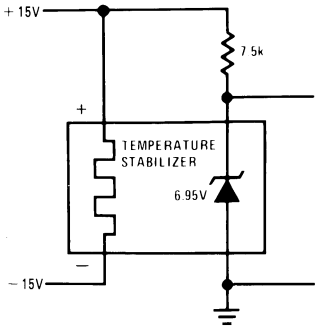
Split Supply Operation



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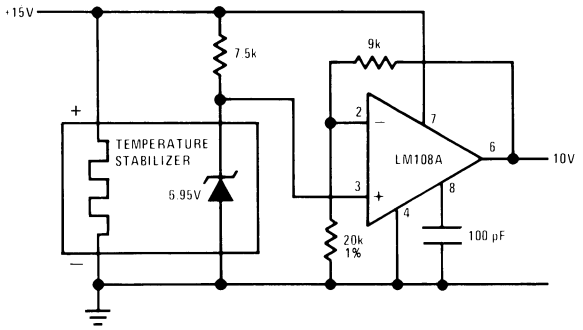
Buffered Reference With Single Sypply



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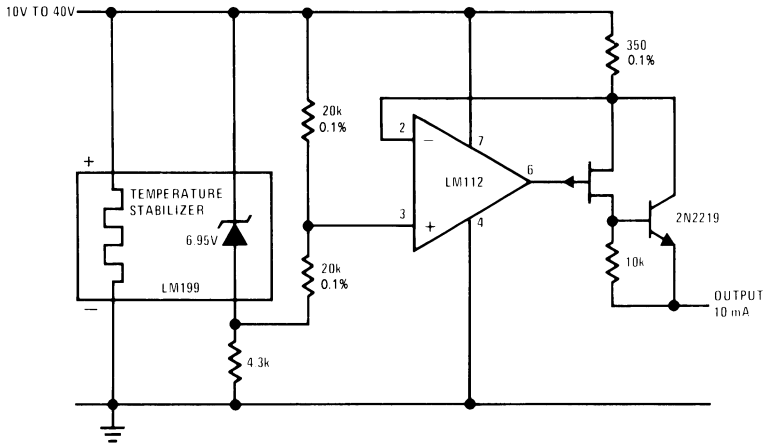
Positive Current Source



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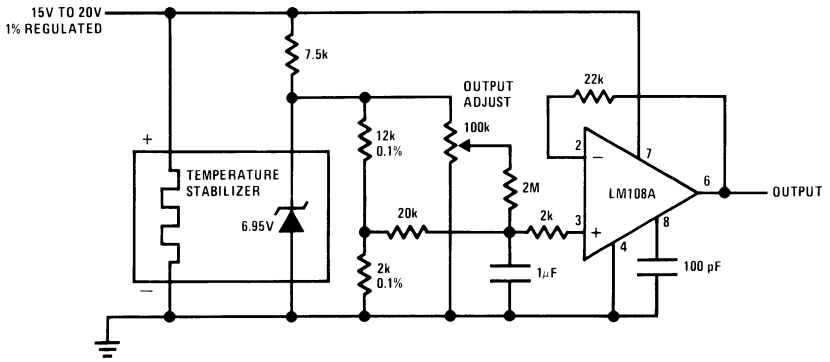
Typical Applications (Continued)

Standard Cell Replacement



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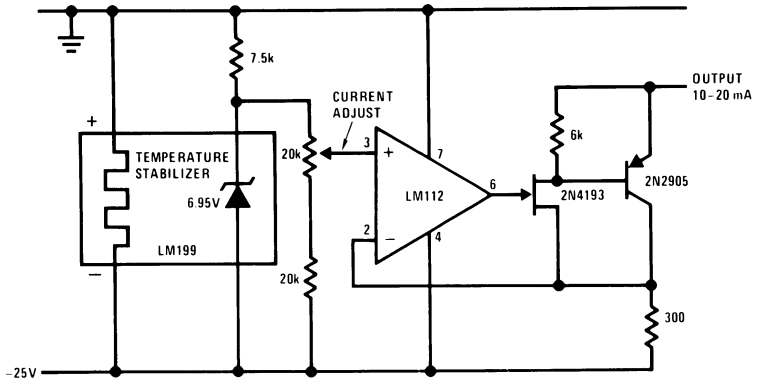
Negative Current Source



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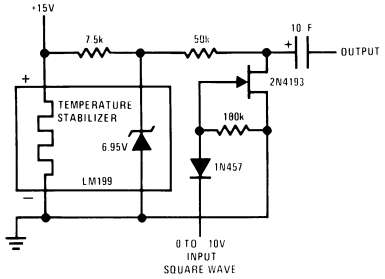
Square Wave Voltage Reference



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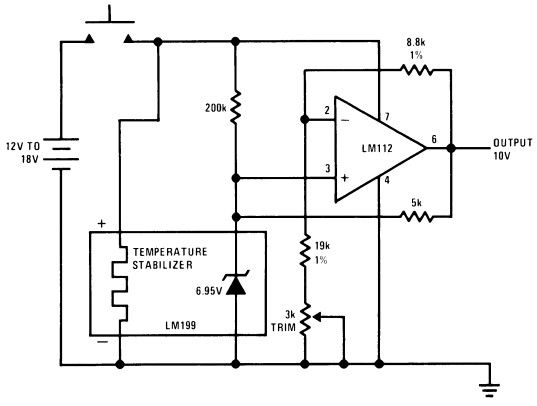
Portable Calibrator*



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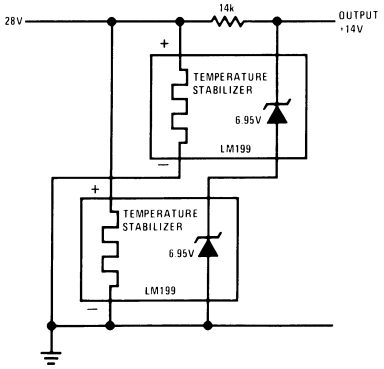
*Warm-up time 10 seconds; intermittent operation does not degrade long term stability.

Typical Applications (Continued)

14V Reference



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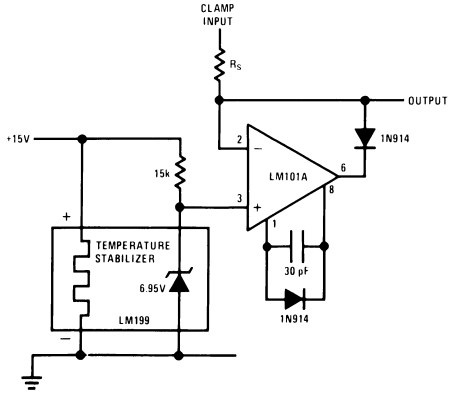
Precision Clamp*



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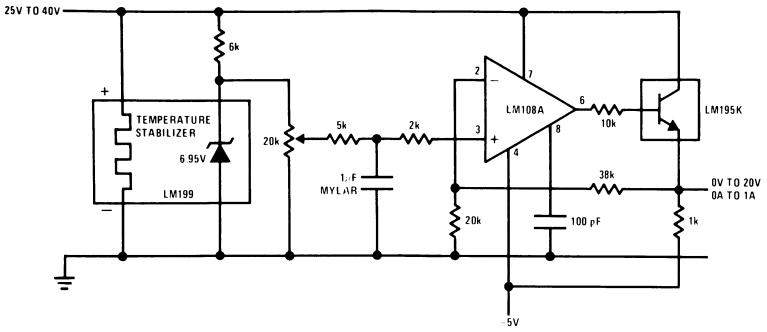
*Clamp will sink 5 mA when input goes more positive than reference

0V to 20V Power Reference



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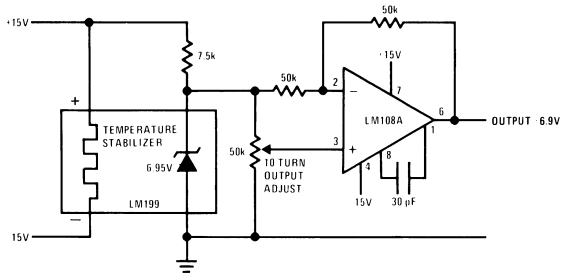
Bipolar Output Reference



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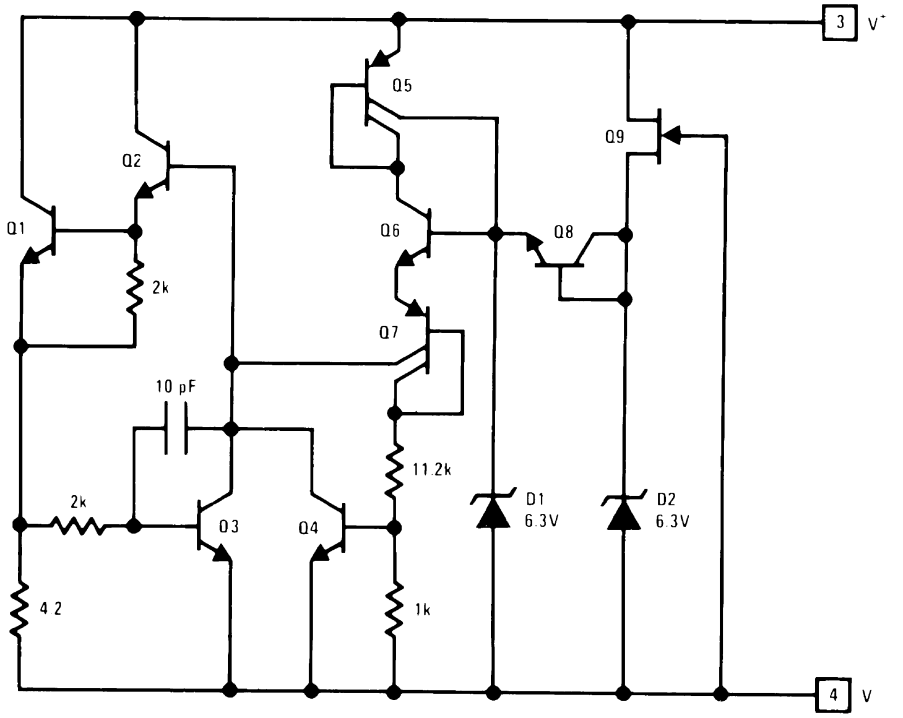
Schematic Diagrams

Temperature Stabilizer



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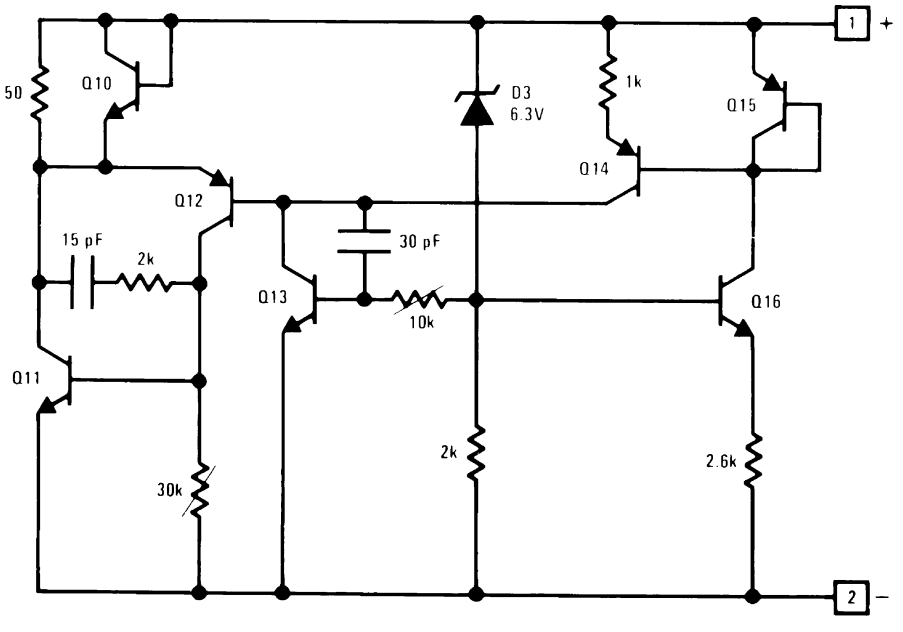
Reference



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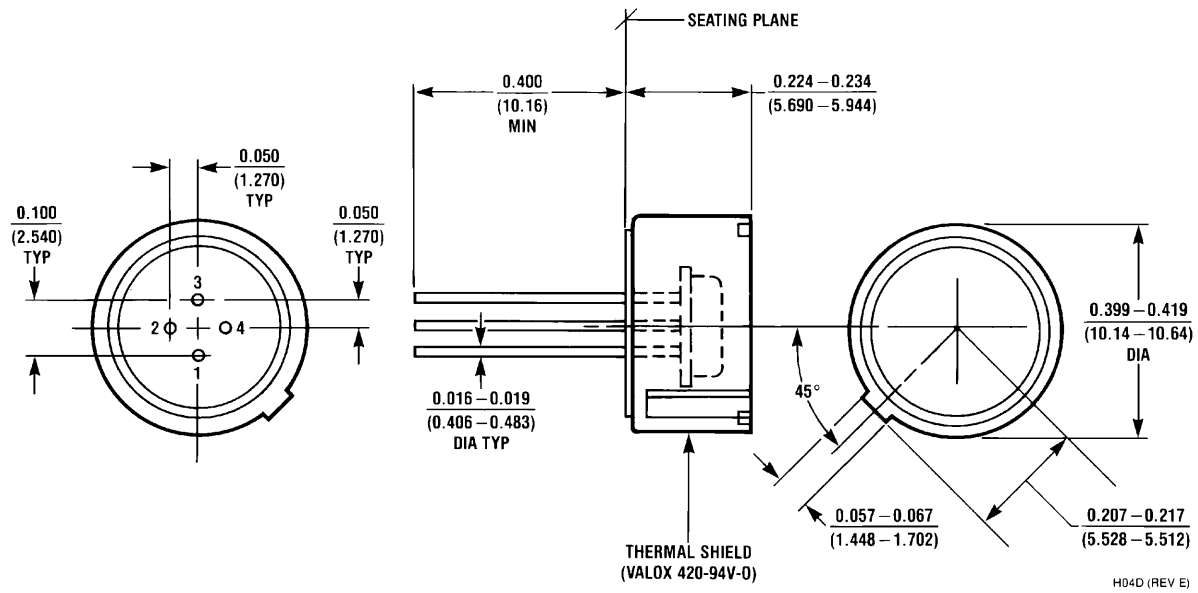
Physical Dimensions inches (millimeters)

unless otherwise noted



NS Package H04D

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