

## FEATURES

- 6.95V Shunt Reference
- Guaranteed 0.5ppm/°C Temperature Coefficient
- Guaranteed 1Ω Maximum Dynamic Impedance
- Guaranteed 20μV<sub>RMS</sub> Maximum Noise
- Guaranteed Initial Tolerance of 2%
- Wide Operating Current Range
- Available in 4-Lead TO-46 Metal Can

## APPLICATIONS

- Precision Voltage Reference for Multimeters
- Calibration Equipment Voltage Standards
- Laboratory Measurement Equipment
- Industrial Monitor/Control Instruments
- High Accuracy Data Converters

## DESCRIPTION

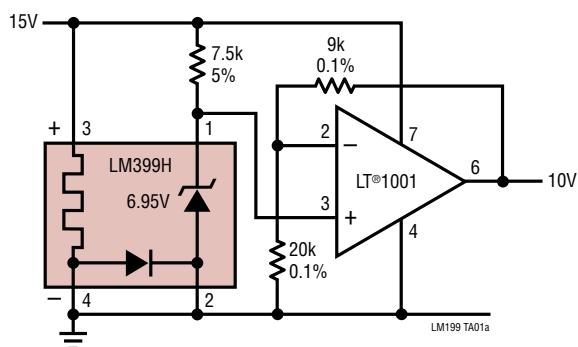
The **LM199/LM399** precision shunt reference features excellent temperature stability over a wide range of voltage, temperature and operating current conditions. A stabilizing heater is incorporated with the active Zener on a monolithic substrate which nearly eliminates changes in voltage with temperature. The subsurface Zener operates over a current range of 0.5mA to 10mA, and offers minimal noise and excellent long-term stability.

Ideal applications for the LM199/LM399 include digital voltmeters, precision calibration equipment, current sources and a variety of other precision low cost references. A 10V buffered reference application is shown below.

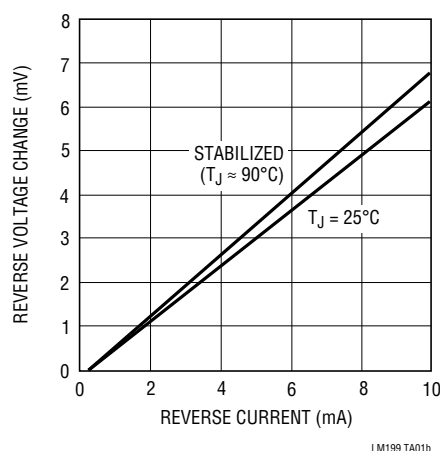
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## TYPICAL APPLICATION

10V Buffered Reference



Reverse Voltage Change



# LM199/LM399

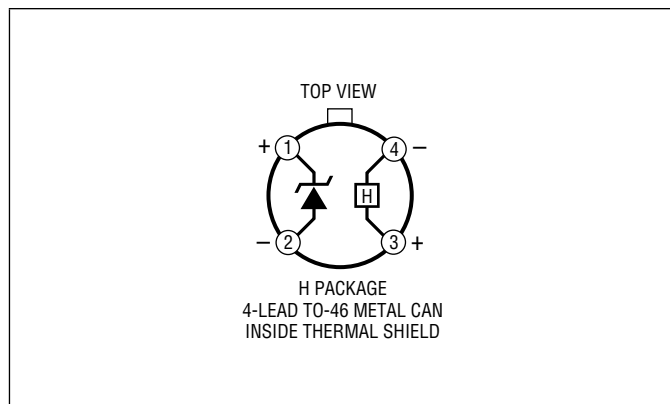
## LM199A/LM399A

### ABSOLUTE MAXIMUM RATINGS

(Note 1)

|                                                         |                |
|---------------------------------------------------------|----------------|
| Temperature Stabilizer .....                            | 40V            |
| Reverse Breakdown Current.....                          | 20mA           |
| Forward Current.....                                    | 1mA            |
| Reference to Substrate Voltage, $V_{RS}$ (Note 2) ..... | -0.1V          |
| Operating Temperature Range                             |                |
| LM199/LM199A (OBSOLETE) .....                           | -55°C to 125°C |
| LM399/LM399A .....                                      | 0°C to 70°C    |
| Storage Temperature Range                               |                |
| LM199/LM199A (OBSOLETE) .....                           | -65°C to 150°C |
| LM399/LM399A .....                                      | -65°C to 150°C |
| Lead Temperature (Soldering, 10 sec).....               | 300°C          |

### PIN CONFIGURATION



### ORDER INFORMATION

| LEAD FREE FINISH        | TAPE AND REEL    | PART MARKING | PACKAGE DESCRIPTION    | TEMPERATURE RANGE |
|-------------------------|------------------|--------------|------------------------|-------------------|
| LM399H                  | LM399H#TRPBF     | LM399H       | 4-Lead TO-46 Metal Can | 0°C to 70°C       |
| LM399AH                 | LM399AH#TRPBF    | LM399AH      | 4-Lead TO-46 Metal Can | 0°C to 70°C       |
| <b>OBSOLETE PACKAGE</b> |                  |              |                        |                   |
| LM199H                  | LM199H#TRPBF     |              | 4-Lead TO-46 Metal Can | -55°C to 125°C    |
| LM199AH                 | LM199AH#TRPBF    |              | 4-Lead TO-46 Metal Can | -55°C to 125°C    |
| LM199AH-20              | LM199AH-20#TRPBF |              | 4-Lead TO-46 Metal Can | -55°C to 125°C    |
| LM399AH-20              | LM399AH-20#TRPBF |              | 4-Lead TO-46 Metal Can | 0°C to 70°C       |
| LM399AH-50              | LM399AH-50#TRPBF |              | 4-Lead TO-46 Metal Can | 0°C to 70°C       |

Consult LTC Marketing for parts specified with wider operating temperature ranges.

Consult LTC Marketing for information on nonstandard lead based finish parts.

For more information on lead free part marking, go to: <http://www.linear.com/leadfree/>

For more information on tape and reel specifications, go to: <http://www.linear.com/tapeandreel/>

### ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ . (Note 3)

| SYMBOL                                  | PARAMETER                                     | CONDITIONS                                                                                                                                                   |   | LM199/LM199A |          |           | LM399/LM399A |      |     | UNITS                      |
|-----------------------------------------|-----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--------------|----------|-----------|--------------|------|-----|----------------------------|
|                                         |                                               |                                                                                                                                                              |   | MIN          | TYP      | MAX       | MIN          | TYP  | MAX |                            |
| $V_Z$                                   | Reverse Breakdown Voltage                     | $0.5\text{mA} \leq I_R \leq 10\text{mA}$                                                                                                                     | ● | 6.8          | 6.95     | 7.1       | 6.75         | 6.95 | 7.3 | V                          |
| $\Delta V_Z$                            | Reverse Breakdown Voltage Change with Current | $0.5\text{mA} \leq I_R \leq 10\text{mA}$                                                                                                                     | ● |              | 6        | 9         |              | 6    | 12  | mV                         |
| $r_Z$                                   | Reverse Dynamic Impedance                     | $I_R = 1\text{mA}$ (Note 6) ( $10\text{Hz} \leq f \leq 100\text{Hz}$ )                                                                                       | ● |              | 0.5      | 1         |              | 0.5  | 1.5 | $\Omega$                   |
| $\frac{\Delta V_Z}{\Delta \text{Temp}}$ | Temperature Coefficient LM199/LM399           | $-55^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$<br>$85^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$<br>$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ |   |              | 0.3<br>5 | 1<br>15   |              | 0.3  | 2   | ppm/°C<br>ppm/°C<br>ppm/°C |
|                                         | LM199A/LM399A                                 | $-55^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$<br>$85^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$<br>$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ |   |              | 0.2<br>5 | 0.5<br>10 |              | 0.3  | 1   | ppm/°C<br>ppm/°C<br>ppm/°C |
| $e_n$                                   | RMS Noise                                     | $10\text{Hz} \leq f \leq 10\text{kHz}$                                                                                                                       | ● |              | 7        | 20        |              | 7    | 50  | $\mu\text{V}$              |

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## ELECTRICAL CHARACTERISTICS

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| SYMBOL                                  | PARAMETER                             | CONDITIONS                                                                                               | LM199/LM199A |           |          | LM399/LM399A |     |          | UNITS                   |
|-----------------------------------------|---------------------------------------|----------------------------------------------------------------------------------------------------------|--------------|-----------|----------|--------------|-----|----------|-------------------------|
|                                         |                                       |                                                                                                          | MIN          | TYP       | MAX      | MIN          | TYP | MAX      |                         |
| $\frac{\Delta V_Z}{\Delta \text{Time}}$ | Long-Term Stability                   | Stabilized, $22^\circ\text{C} \leq T_A \leq 28^\circ\text{C}$ , 1000 Hours, $I_R = 1\text{mA} \pm 0.1\%$ |              | 8         | (Note 4) |              | 8   | (Note 4) | ppm/ $\sqrt{\text{kH}}$ |
| $I_H$                                   | Temperature Stabilizer Supply Current | $T_A = 25^\circ\text{C}$ , Still Air, $V_H = 30\text{V}$<br>$T_A = -55^\circ\text{C}$ (Note 5)           |              | 8.5<br>22 | 14<br>28 |              | 8.5 | 15       | mA                      |
| $V_H$                                   | Temperature Stabilizer Supply Voltage | ●                                                                                                        | 9            |           | 40       | 9            |     | 40       | V                       |
|                                         | Warm-Up Time to $\pm 0.05\% V_Z$      | $V_H = 30\text{V}$                                                                                       |              | 3         |          |              | 3   |          | Seconds                 |
|                                         | Initial Turn-On Current               | $9\text{V} \leq V_H \leq 40\text{V}$ (Note 5)                                                            |              | 140       | 200      |              | 140 | 200      | mA                      |

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**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  $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$  for the LM199; and  $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$  for the LM399.

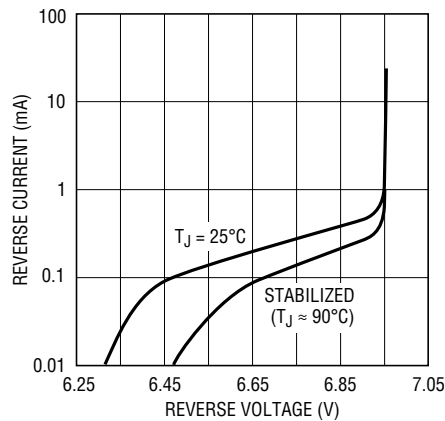
**Note 4:** Devices with maximum guaranteed long-term stability of 20ppm/ $\sqrt{\text{kH}}$  are available. Drift decreases with time.

**Note 5:** This initial current can be reduced by adding an appropriate resistor and capacitor to the heater circuit. See the Typical Performance Characteristics graphs to determine values.

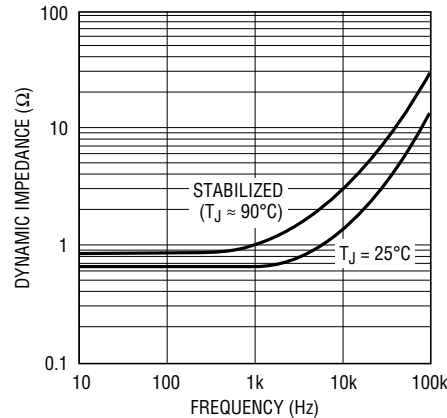
**Note 6:** Guaranteed by "Reverse Breakdown Change with Current."

## TYPICAL PERFORMANCE CHARACTERISTICS

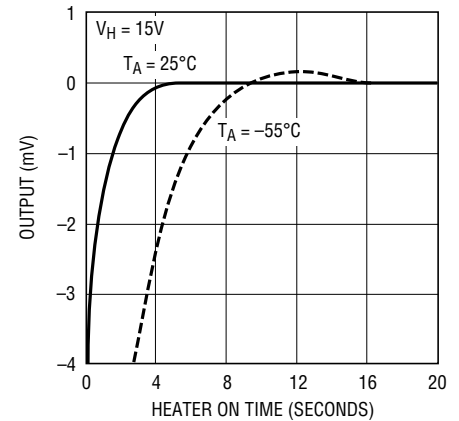
Reverse Characteristics



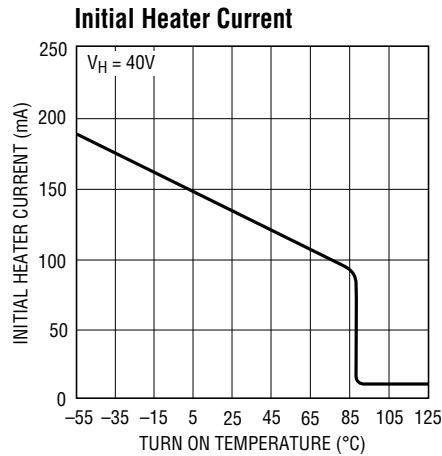
Dynamic Impedance



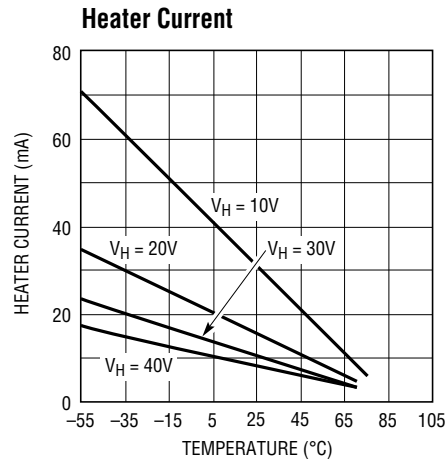
Stabilization Time



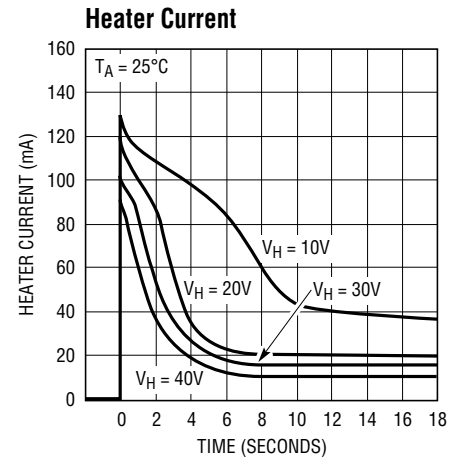
## TYPICAL PERFORMANCE CHARACTERISTICS



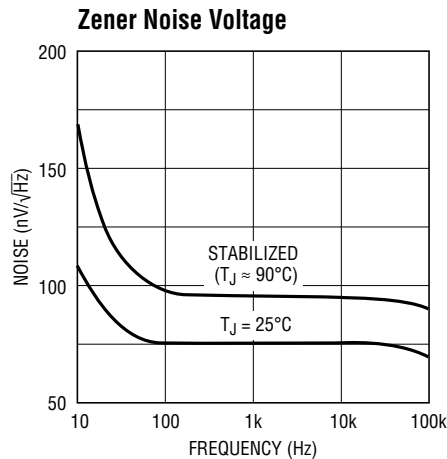
LM199 G04



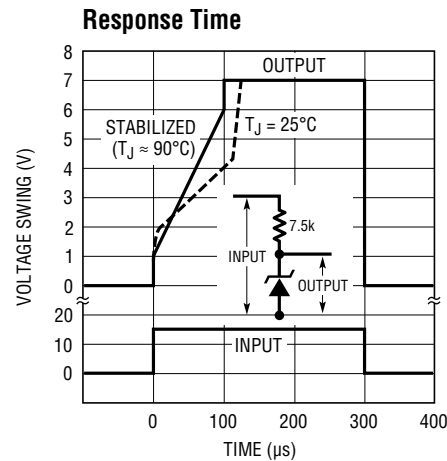
LM199 G05



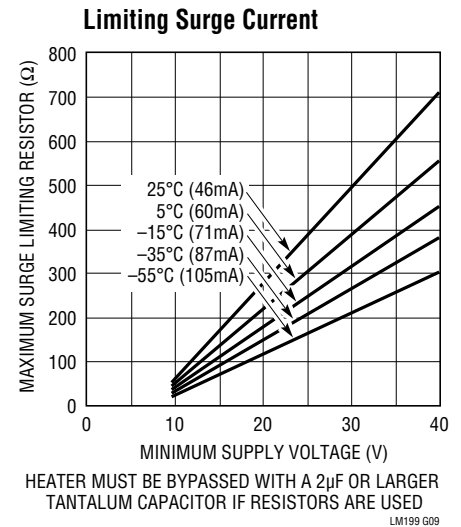
LM199 G06



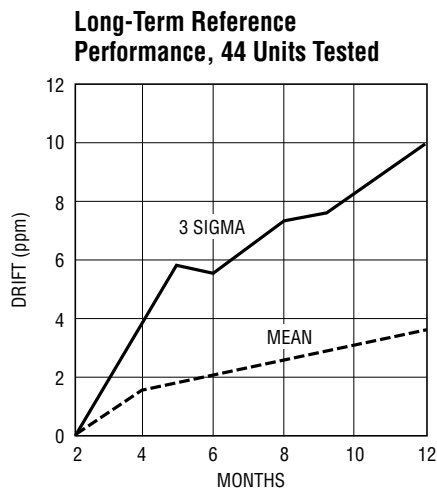
LM199 G07



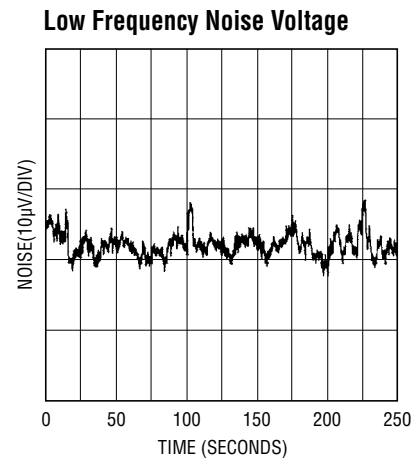
LM199 G08



LM199 G09

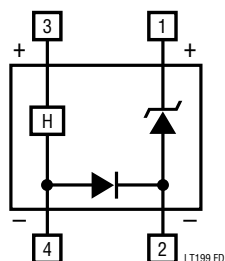


LM199 G10



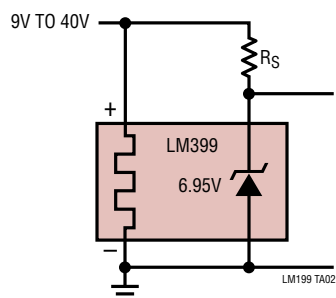
LM199 G11

## FUNCTIONAL BLOCK DIAGRAM

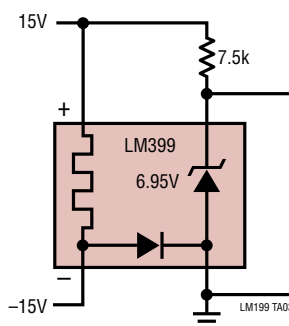


## TYPICAL APPLICATIONS

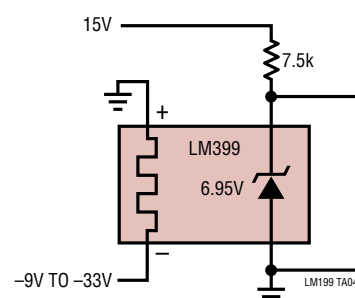
Single Supply Operation



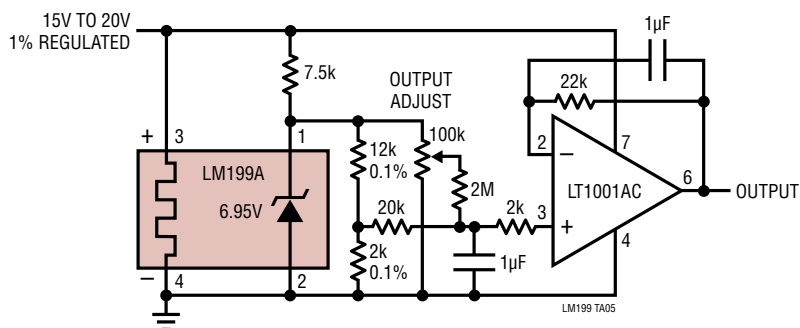
Split Supply Operation



Negative Heater Supply with Positive Reference



Standard Cell Replacement



The diagram shows a precision 10V reference circuit. A 12V to 18V DC source is connected to the circuit. The LM399 is configured as a precision centrabuck, with its output set to 6.95V. This output is connected to the non-inverting input (pin 3) of the LT1001AC. The inverting input (pin 2) is connected to the same 12V to 18V source through a 200k resistor. The output of the LT1001AC (pin 6) is connected to the non-inverting input through an 8.8k 1% resistor and to ground through a 5k resistor. A 19k 1% resistor is connected between the output and the inverting input, forming a feedback loop. A 3k TRIM potentiometer is connected between the output and ground. The final output is taken from the output pin (pin 6) and is labeled 'OUTPUT 10V'. The LM399 is labeled 'LM399 6.95V' and the LT1001AC is labeled 'LT1001AC'.

## SCHEMATIC DIAGRAMS

[illegible]



# LM199/LM399

## LM199A/LM399A

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### RELATED PARTS

| PART NUMBER             | DESCRIPTION                                        | COMMENTS                                 |
|-------------------------|----------------------------------------------------|------------------------------------------|
| <a href="#">LT®1021</a> | Precision References for Series or Shunt Operation | Industry Standard Pinout, -40°C to 125°C |
| <a href="#">LT1389</a>  | 1.25V, 2.5V, 4V and 5V Nanopower Shunt Reference   | 800nA, 0.05% Accuracy, 10ppm/°C Drift    |
| <a href="#">LT1634</a>  | 1.25 and 2.5V Micropower Shunt Reference           | 0.05%, 10ppm/°C, 10µA Current            |
| <a href="#">LTZ1000</a> | 7V Ultra Precision, Stable Shunt Reference         | 0.05ppm/°C, 1.2mV <sub>P-P</sub> Noise   |





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