

## FEATURES

- *Guaranteed* 0.5 ppm/°C temperature coefficient
- *Guaranteed* 1.0  $\Omega$  max. dynamic impedance
- *Guaranteed* 20 $\mu$ V RMS max. noise
- *Guaranteed* initial tolerance of 2%
- Wide operating current range

## APPLICATIONS

- Precision voltage reference for multimeters
- Calibration equipment voltage standards
- Laboratory measurement equipment
- Industrial monitor/control instruments
- High accuracy data converters

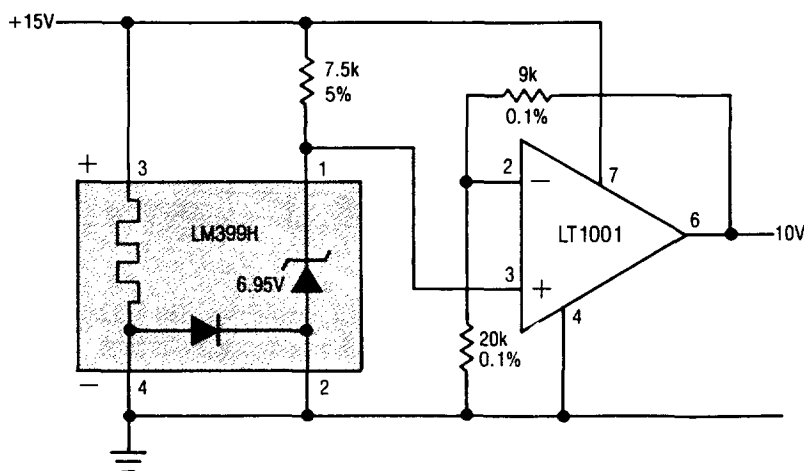
## DESCRIPTION

The LM199/399 precision 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.

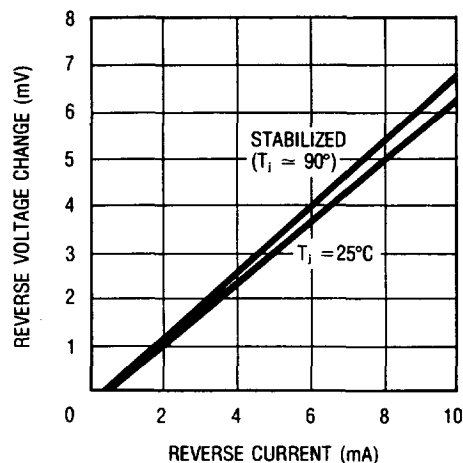
Ideal applications for the LM199/399 include digital voltmeters, precision calibration equipment, current sources and a variety of other precision low cost references. A 10 volt buffered reference application is shown below.

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### 10 Volt Buffered Reference



### Reverse Voltage Change



# LM199/LM399 LM199A/LM399A

## ABSOLUTE MAXIMUM RATINGS

|   |                |
|---|----------------|
| Temperature Stabilizer .....                                | 40V            |
| Reverse Breakdown Current .....                             | 20mA           |
| Forward Current .....                                       | 1mA            |
| Reference to Substrate Voltage $V_{(RS)}$ , (Note 1). ..... | -0.1V          |
| Operating Temperature Range                                 |                |
| LM199/199A .....  | -55°C to 125°C |
| LM399/399A .....  | 0°C to 70°C    |
| Storage Temperature Range                                   |                |
| LM199/199A .....  | -65°C to 150°C |
| LM399/399A .....  | -65°C to 150°C |
| Lead Temperature (Soldering, 10 sec.) .....                 | 300°C          |

## PACKAGE/ORDER INFORMATION

TOP VIEW  
H PKG.  
TO-46 METAL CAN INSIDE THERMAL SHIELD

ORDER PART NO.  
LM199H, LM199AH  
LM399H, LM399AH  
LM199AH-20, LM399AH-50

FUNCTIONAL BLOCK DIAGRAM

## ELECTRICAL CHARACTERISTICS (See Note 2)

| SYMBOL                                  | PARAMETER                                     | CONDITIONS  | LM199/199A |      |        | LM399/399A |      |        | 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 5) ( $10 \leq f \leq 100\text{Hz}$ )   | ●          | 0.5  | 1      |            | 0.5  | 1.5    | $\Omega$                   |
| $\frac{\Delta V_Z}{\Delta \text{Temp}}$ | Temperature Coefficient<br>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  | 1      |            | 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  | 0.5    |            |      | 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     | $\mu\text{V}$              |
| $\frac{\Delta V_Z}{\Delta \text{Time}}$ | Long Term Stability                           | Stabilized, $22^\circ\text{C} \leq T_A \leq 28^\circ\text{C}$<br>1000 Hours, $I_R = 1\text{mA} \pm 0.1\%$   |            | 8    | Note 3 |            | 8    | Note 3 | ppm/ $\sqrt{\text{kHz}}$   |
| $I_H$                                   | 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 4)  |            | 8.5  | 14     |            | 8.5  | 15     | mA                         |
| $V_H$                                   | Temperature Stabilizer Supply Voltage         |   | ●          | 9    | 40     |            | 9    | 40     | V                          |
|   | Warm-up Time to $\pm 0.05\% V_Z$              | $V_H = 30\text{V}$ , $T_A = 25^\circ\text{C}$   |            | 3    |        |            | 3    |        | Seconds                    |
|   | Initial Turn-on Current                       | $9\text{V} \leq V_H \leq 40\text{V}$ , $T_A = 25^\circ\text{C}$ , (See Note 4)  |            | 140  | 200    |            | 140  | 200    | mA                         |

The ● denotes the specifications which apply over full operating temperature range.

**Note 1:** 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 2:** 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.

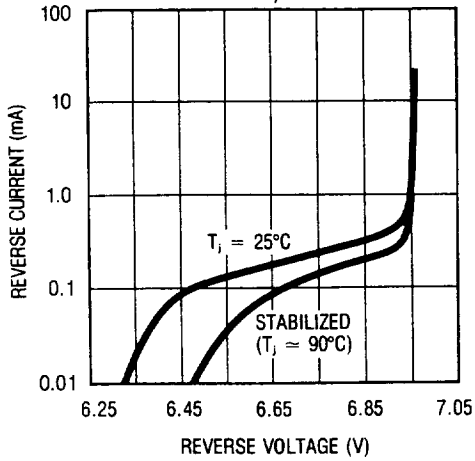
**Note 3:** Devices with maximum guaranteed long term stability of 20 ppm/ $\sqrt{\text{kHz}}$  are available. Drift decreases with time.

**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.

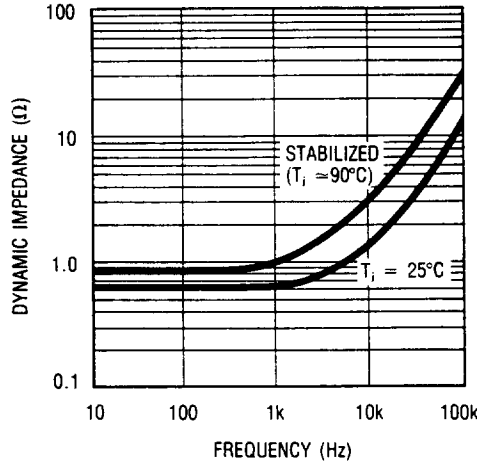
**Note 5:** Guaranteed by "Reverse Breakdown Change with Current."

# TYPICAL PERFORMANCE CHARACTERISTICS

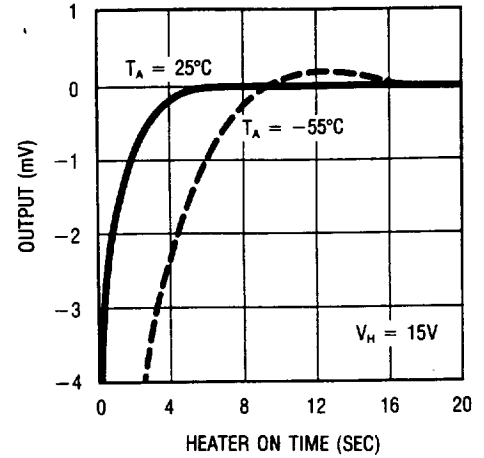
**Reverse Characteristics**



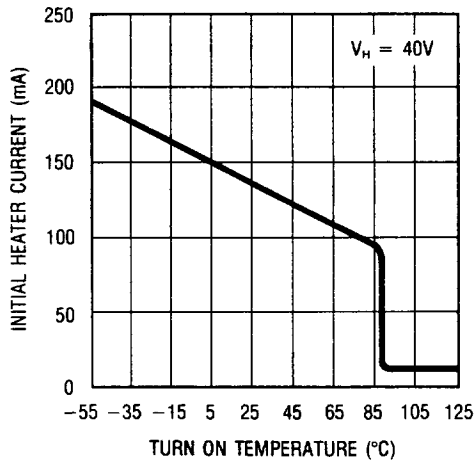
**Dynamic Impedance**



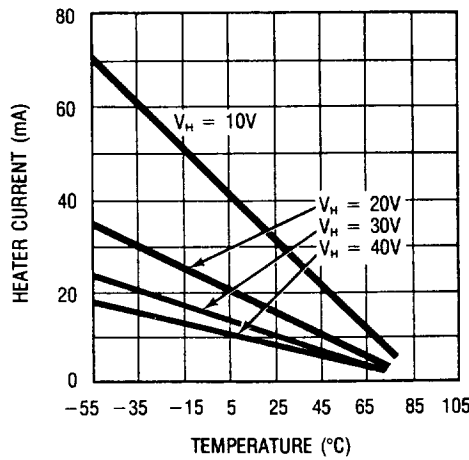
**Stabilization Time**



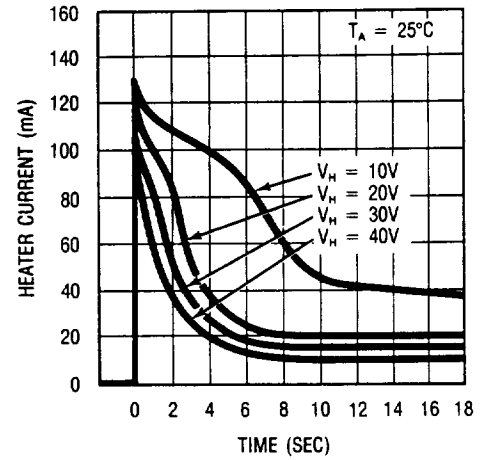
**Initial Heater Current**



**Heater Current**

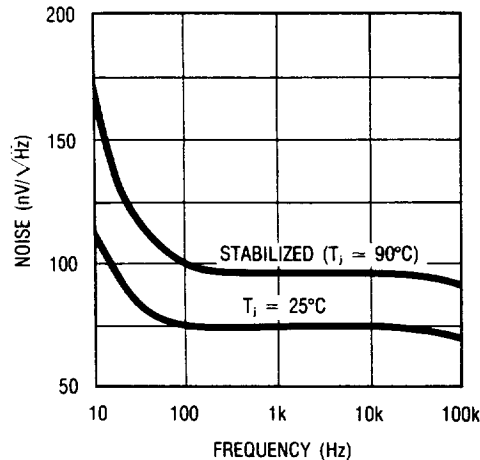


**Heater Current**

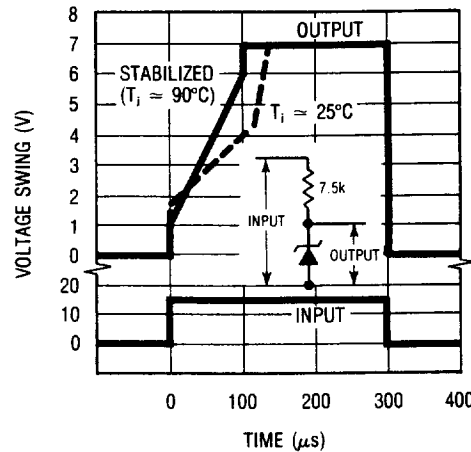


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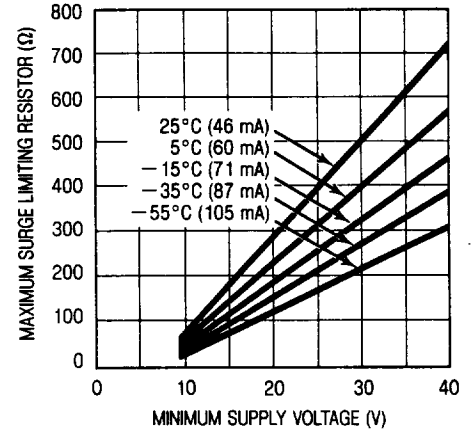
**Zener Noise Voltage**



**Response Time**



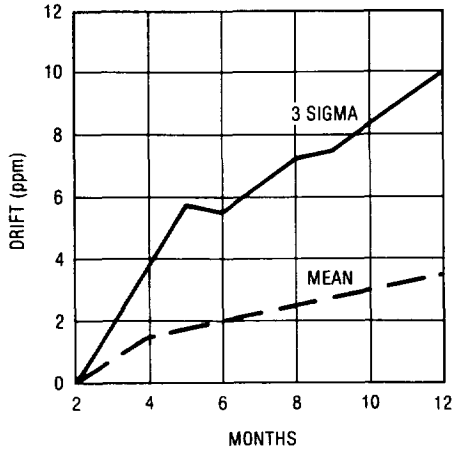
**Limiting Surge Current**



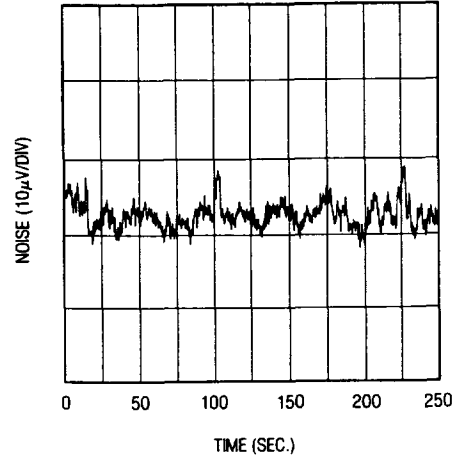
\*Heater must be bypassed with a  $2\ \mu\text{F}$  or larger tantalum capacitor if resistors are used.

## TYPICAL PERFORMANCE CHARACTERISTICS

Long Term Reference Performance  
44 Units Tested

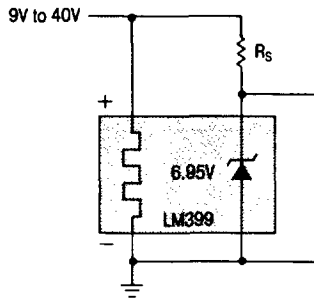


Low Frequency Noise Voltage

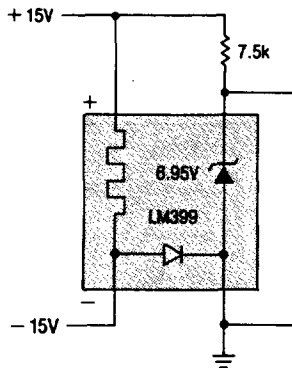


## TYPICAL APPLICATIONS

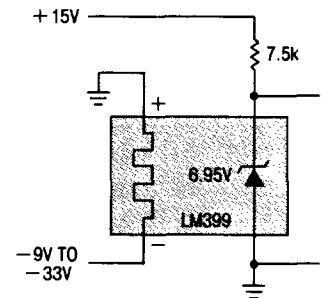
Single Supply Operation



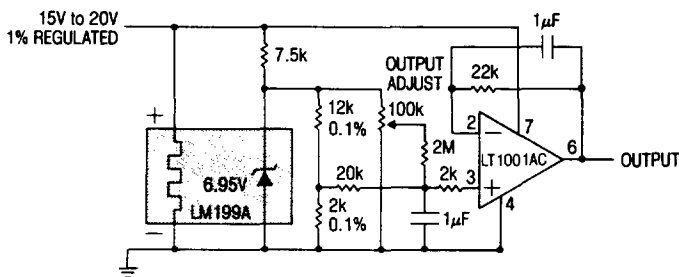
Split Supply Operation



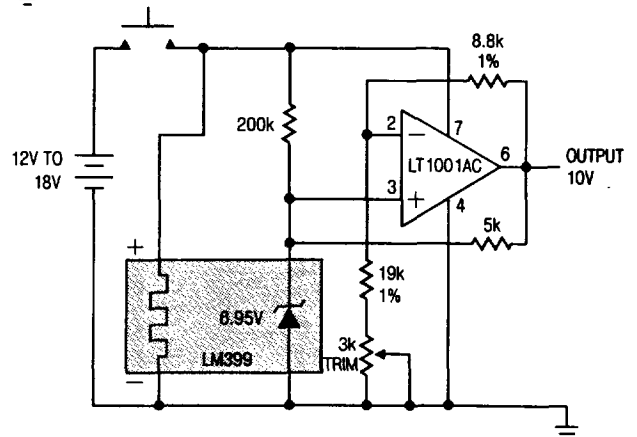
Negative Heater Supply with Positive Reference



Standard Cell Replacement

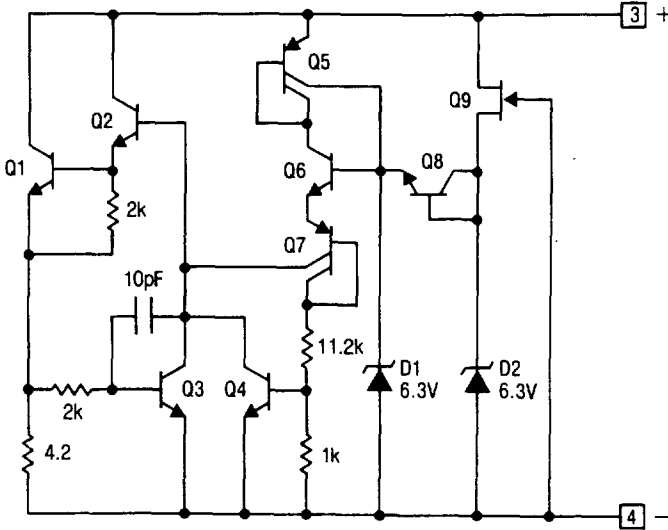


Portable Calibrator

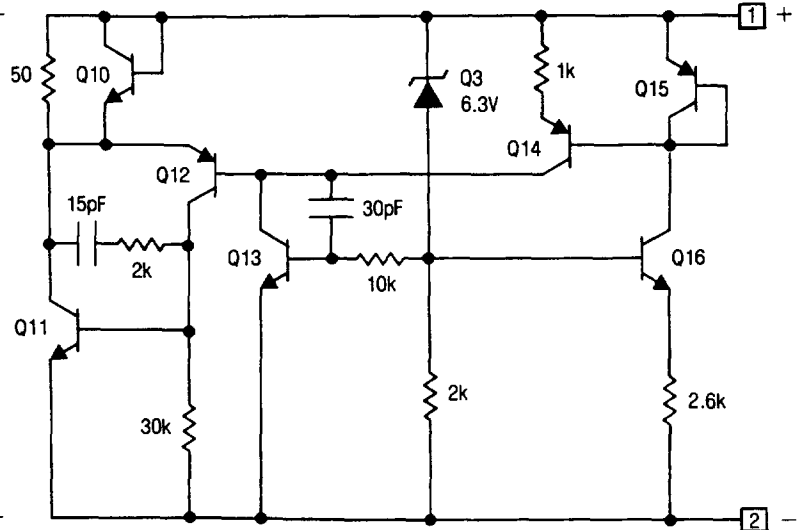


# SCHEMATIC DIAGRAMS

Temperature Stabilizer



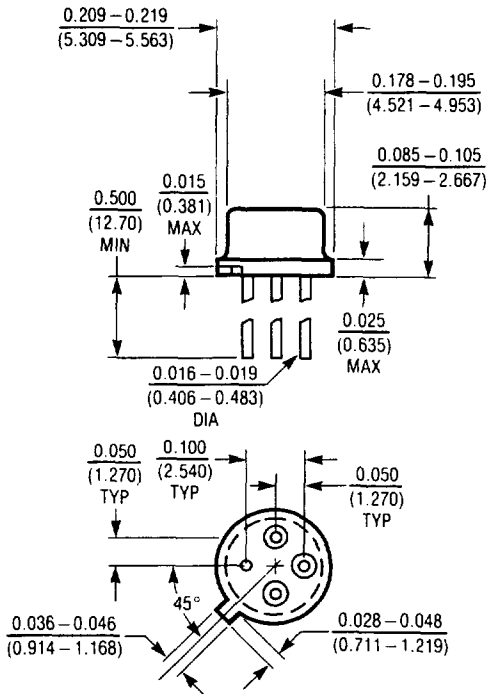
Reference



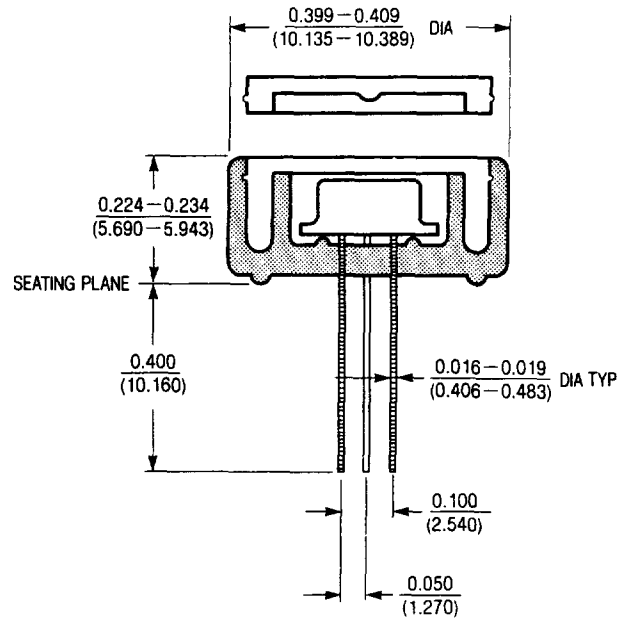
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# PACKAGE DESCRIPTION

H Package, 4 Lead  
TO-46 Metal Can



Thermal Shield\*  
For TO-46, H Package



\*Thermal Shield Material is Valox™  
Valox is a registered trademark of General Electric