Ultra Precision Reference

FEATURES

- 1.2μV_{P-P} Noise
- 2μV/√kHr Long-Term Stability
- Very Low Hysteresis
- 0.05ppm/°C Drift
- Temperature Stabilized
- 400°C/W Thermal Resistance for LTZ1000A Reduces Insulation Requirements
- Specified for –55°C to 125°C Temperature Range
- Offered in TO-99 package

APPLICATIONS

- Voltmeters
- Calibrators
- Standard Cells
- Scales
- Low Noise RF Oscillators

DESCRIPTION

The LTZ1000 and LTZ1000A are ultra-stable temperature controllable references. They are designed to provide 7V outputs with temperature drifts of 0.05ppm/°C, about 1.2μV_{P-P} of noise and long-term stability of 2μV/√kHr.

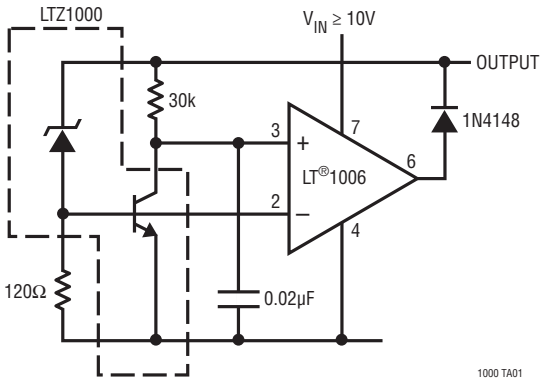
Included on the chip is a subsurface zener reference, a heater resistor for temperature stabilization, and a temperature sensing transistor. External circuitry is used to set operating currents and to temperature stabilize the reference. This allows maximum flexibility and best long-term stability and noise.

The LTZ1000 and LTZ1000A references can provide superior performance to older devices such as the LM199, provided that the user implements the heater control and properly manages the thermal layout. To simplify thermal insulation, the LTZ1000A uses a proprietary die attach method to provide significantly higher thermal resistance than the LTZ1000.

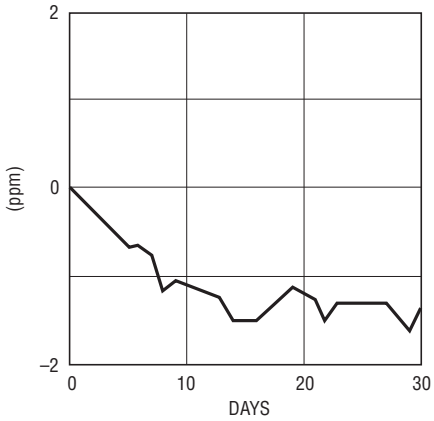
LT, LTC and LTM are registered trademarks of Linear Technology Corporation.
All other trademarks are the property of their respective owners.

TYPICAL APPLICATION

Low Noise Reference



Long-Term Stability



LONG-TERM STABILITY OF A TYPICAL DEVICE FROM TIME = 0
WITH NO PRECONDITIONING OR AGING

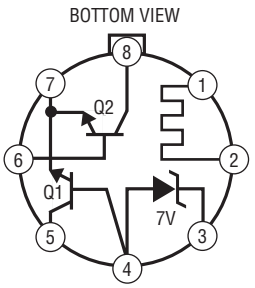
1000 TA01b

ABSOLUTE MAXIMUM RATINGS

(Note 1)

Heater to Substrate 35V
Collector Emitter Breakdown Q1 .....15V
Collector Emitter Breakdown Q2 .....35V
Emitter Base Reverse Bias 2V
Operating Temperature Range.....–55°C ≤ T_A ≤ 125°C
Storage Temperature Range.....–65°C ≤ T_A ≤ 150°C
Substrate Forward Bias.....0.1V

PIN CONFIGURATION



H8 PACKAGE
TO-5 METAL CAN

T_{JMAX} = 80°C, θ_{JA} = 400°C/W

ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LTZ1000ACH#PBF	LTZ1000ACH#TRPBF		8-Lead TO-5 Metal Can (.200 Inch PCD)	–55°C to 125°C
LTZ1000CH#PBF	LTZ1000CH#TRPBF		8-Lead TO-5 Metal Can (.200 Inch PCD)	–55°C to 125°C
LEAD BASED FINISH	**TAPE AND REEL**	**PART MARKING**	**PACKAGE DESCRIPTION**	**TEMPERATURE RANGE**
LTZ1000ACH	LTZ1000ACH#TR		8-Lead TO-5 Metal Can (.200 Inch PCD)	–55°C to 125°C
LTZ1000CH	LTZ1000CH#TR		8-Lead TO-5 Metal Can (.200 Inch PCD)	–55°C to 125°C

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

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 (Note 2)

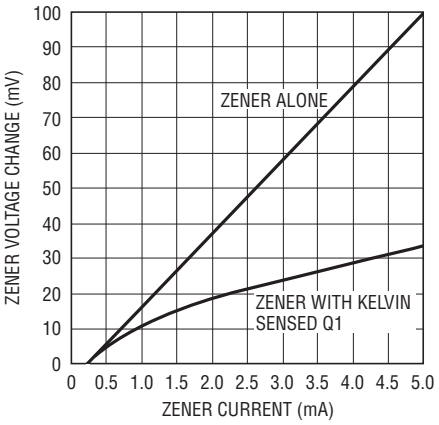
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Zener Voltage	I_Z = 5mA, (V_Z + VBE_{Q1}) I_{Q1} = 100µA I_Z = 1mA, (V_Z + VBE_{Q1}) I_{Q1} = 100µA	7.0 6.9	7.2 7.15	7.5 7.45	V V
Zener Change with Current	1mA ≤ I_Z < 5mA		80	240	mV
Zener Leakage Current	V_Z = 5V		20	200	µA
Zener Noise	I_Z = 5mA, 0.1Hz < f < 10Hz 1_{Q1} = 100µA		1.2	2	μV_{P-P}
Heater Resistance	I_L ≤ 100µA	200	300	420	Ω
Heater Breakdown Voltage		35			V
Transistor Q1 Breakdown	I_C = 10µA, LVCEO	15	20		V
Transistor Q2 Breakdown	I_C = 10µA, LVCEO	35	50		V
Q1, Q2 Current Gain	I_C = 100µA	80	200	450	
Thermal Resistance	LTZ1000 Time = 5 Minutes LTZ1000A Time = 5 Minutes		80 400		°C/W °C/W
Long-Term Stability	T = 65°C		2		$\mu V\sqrt{kHr}$

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: All testing is done at 25°C. Pulse testing is used for LTZ1000A to minimize temperature rise during testing. LTZ1000 and LTZ1000A devices are QA tested at –55°C and 125°C.

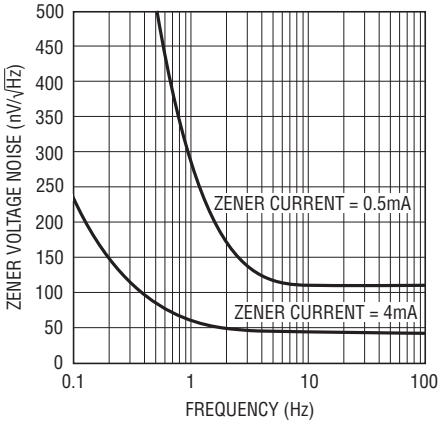
TYPICAL PERFORMANCE CHARACTERISTICS

Zener Voltage vs Current



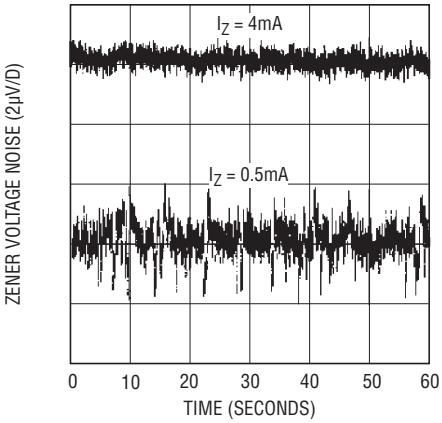
1000 G01

Zener Voltage Noise Spectrum



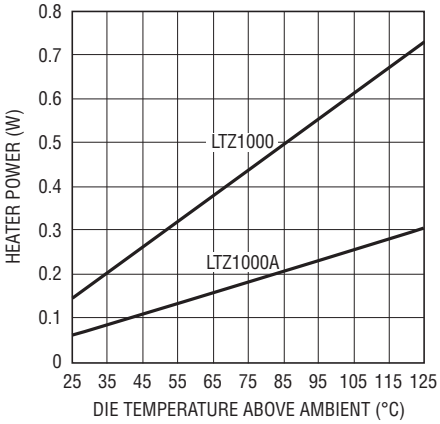
1000 G02

Zener Noise



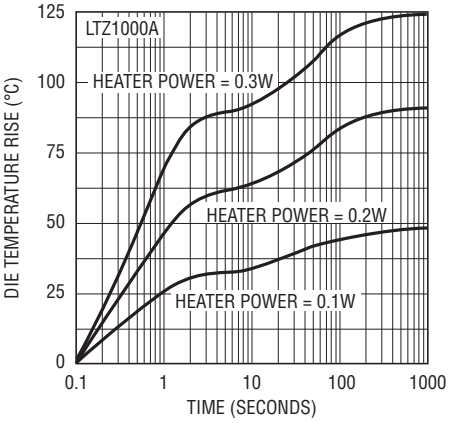
1000 G03

Die Temperature Rise vs Heater Power



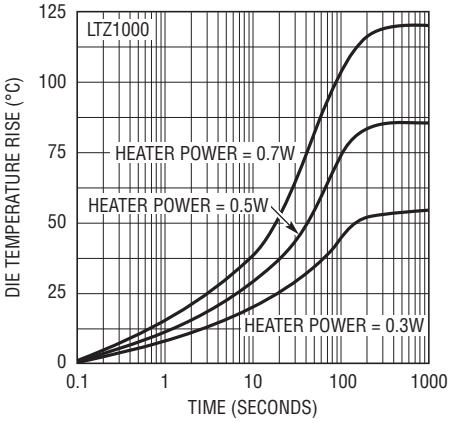
1000 G04

Die Temperature vs Time



1000 G05

Die Temperature Rise vs Time



1000 G06

PIN FUNCTIONS

Pin 1: Heater Positive. Must have a higher positive value than Pin 2 and Pin 4.

Pin 2: Heater Negative. Must have a higher positive value than Pin 4. Must have equal or lower potential than Pin 1.

Pin 3: Zener Positive. Must have a higher positive value than Pin 4.

Pin 4: Substrate and Zener Negative. Must have a higher positive value than Pin 7. If Q1 is zenered (about 7V) a permanent degradation in beta will result.

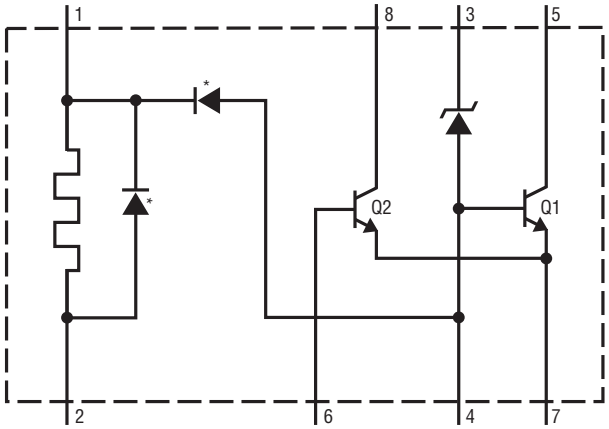
Pin 5: Temperature Compensating Transistor Collector.

Pin 6: Temperature Sensing Transistor Base. If the base emitter junction is zenered (about 7V) the transistor will suffer permanent beta degradation.

Pin 7: Emitter of Sensing and Compensating Transistors.

Pin 8: Collector of Sensing Transistor.

BLOCK DIAGRAM



*SUBSTRATE DEVICES–DO NOT FORWARD BIAS

1000 TA07

APPLICATIONS INFORMATION

LTZ1000 and LTZ1000A are capable of providing ultimate voltage reference performance. Temperature drifts of better than 0.03ppm/°C and long-term stability on the order of 1µV per month can be achieved. Noise of about 0.15ppm can also be obtained. This performance is at the expense of circuit complexity, since external influences can easily cause output voltage shifts of more than 1ppm.

Thermocouple effects are one of the worst problems and can give apparent drifts of many ppm/°C as well as cause low frequency noise. The kovar input leads of the TO-5 package form thermocouples when connected to copper PC boards. These thermocouples generate outputs of 35µV/°C. It is mandatory to keep the zener and transistor leads at the same temperature, otherwise 1ppm to 5ppm shifts in the output voltage can easily be expected from these thermocouples.

Air currents blowing across the leads can also cause small temperature variations, especially since the package is heated. This will look like 1ppm to 5ppm of low frequency noise occurring over a several minute period. For best results, the device should be located in an enclosed area and well shielded from air currents.

Certainly, any temperature gradient externally generated, say from a power supply, should not appear across the critical circuitry. The leads to the transistor and zener should be connected to equal size PC traces to equalize the heat loss and maintain them at similar temperatures. The bottom portion of the PC board should be shielded against air currents as well.

Resistors, as well as having resistance temperature coefficients, can generate thermocouple effects. Some types of resistors can generate hundreds of microvolts of thermocouple voltage. These thermocouple effects in the resistor can also interfere with the output voltage. Wire wound resistors usually have the lowest thermocouple voltage, while tin oxide type resistors have very high thermocouple voltage. Film resistors, especially Vishay precision film resistors, can have low thermocouple voltage.

Ordinary breadboarding techniques are not good enough to give stable output voltage with the LTZ1000 family devices. For breadboarding, it is suggested that a small printed circuit board be made up using the reference, the amplifier and wire wound resistors. Care must be taken to ensure that heater current does not flow through the same ground lead as the negative side of the reference (emitter of Q1). Current changes in the heater could add to, or subtract from, the reference voltage causing errors with temperature. Single point grounding using low resistance wiring is suggested.

APPLICATIONS INFORMATION

Setting Control Temperature

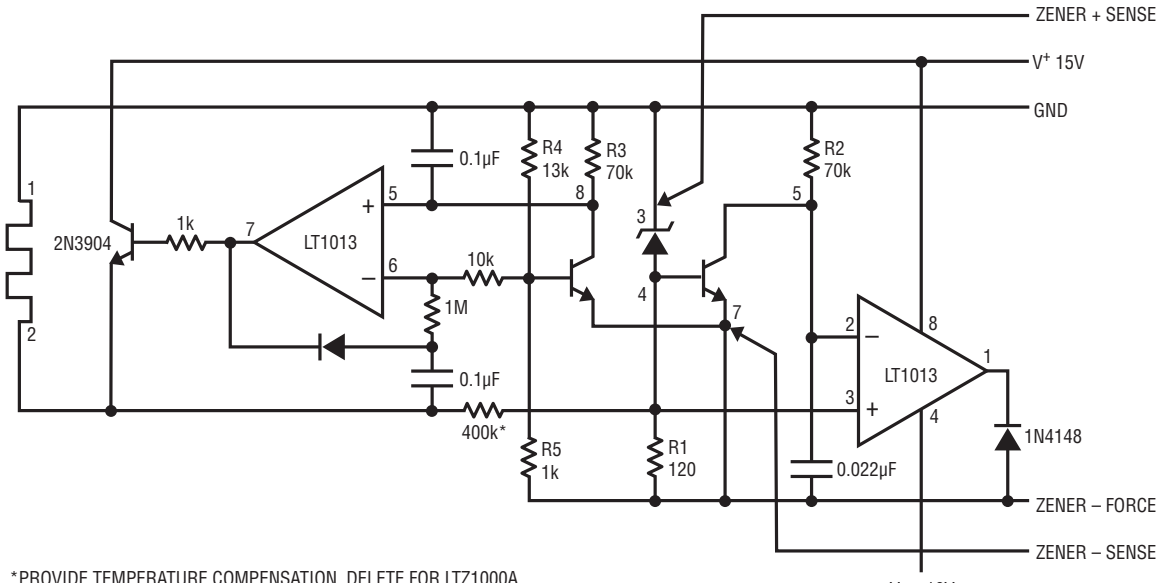
The emitter-base voltage of the control transistor sets the stabilization temperature for the LTZ1000. With the values given in the applications, temperature is normally 60°C. This provides 15°C of margin above a maximum ambient of 45°C, for example. Production variations in emitter-base voltage will typically cause about ±10°C variation. Since the emitter-base voltage changes about 2mV/°C and is very predictable, other temperatures are easily set.

Because higher temperatures accelerate aging and decrease long-term stability, the lowest temperature consistent with the operating environment should be used. The LTZ1000A should be set about 10°C higher than the LTZ1000. This is because normal operating power dissipation in the LTZ1000A causes a temperature rise of about 10°C. Of course both types of devices should be insulated from ambient. Several minutes of warm-up is usual.

For applications not requiring the extreme precision or the low noise of the LTZ1000, Linear Technology makes a broad line of voltage references. Devices like the LT1021 can provide drifts as low as 2ppm/°C and devices such as the LM399A can provide drifts of 1ppm/°C. Only applications requiring the very low noise or low drift with time of the LTZ1000 should use this device. See Application Notes AN-82 and AN-86 for further information. Consult the Linear Technology Applications department for additional help.

TYPICAL APPLICATIONS

Negative Voltage Reference



*PROVIDE TEMPERATURE COMPENSATION, DELETE FOR LTZ1000A

APPROXIMATE CHANGE IN REFERENCE VOLTAGE FOR A 100ppm CHANGE IN RESISTOR VALUES:

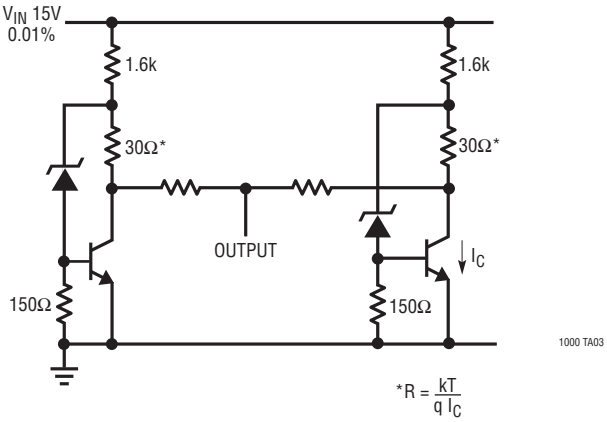
	100ppm = ΔR(Ω)	ΔV_Z
R1	0.012Ω	1ppm
R2	7Ω	0.3ppm
R3	7Ω	0.2ppm
R4/R5 RATIO	ΔR = 0.01%	1ppm

BOTH A1 AND A2 CONTRIBUTE LESS THAN 2µV OF OUTPUT DRIFT OVER A 50°C RANGE

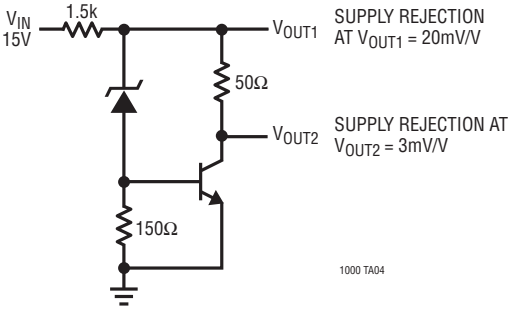
1000 TA02

TYPICAL APPLICATIONS

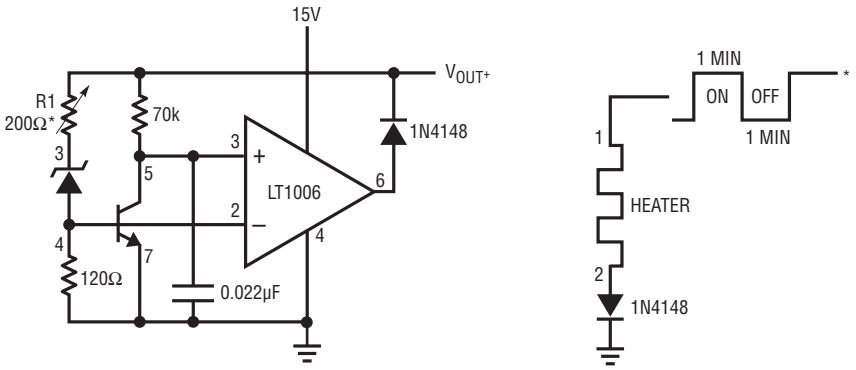
Averaging Reference Voltage for Lower Noise and Better Stability



Improving Supply Rejection



Adjusting Temperature Coefficient in Unstabilized Applications

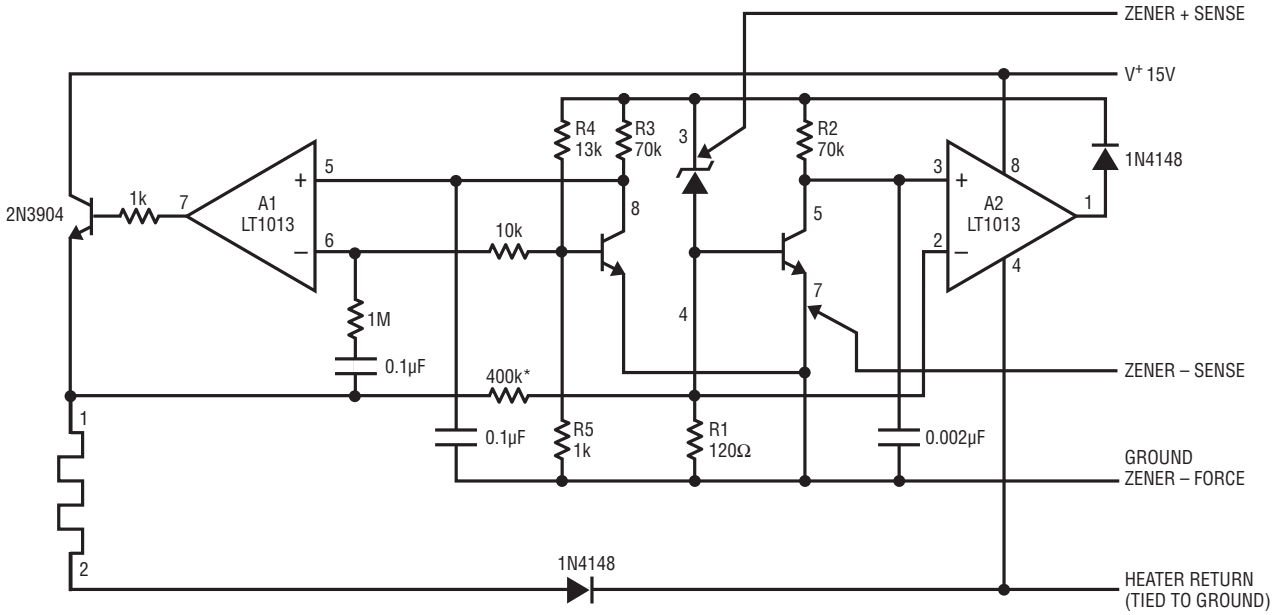


* PULSE HEATER ON AND OFF TO HEAT AND COOL THE REFERENCE. ADJUST R1 FOR MINIMUM VOLTAGE CHANGE THROUGH A TEMPERATURE CYCLE. THE –2mV/°C TEMPCO OF THE V_{BE} CANCELS THE +2mV/°C TEMPCO OF THE ZENER.

1000 TA05

TYPICAL APPLICATIONS

7V Positive Reference Circuit



*PROVIDES TC COMPENSATION, DELETE FOR LTZ1000A

APPROXIMATE CHANGE IN REFERENCE VOLTAGE FOR A 100ppm (0.01%) CHANGE IN RESISTOR VALUES:

	$\Delta R(\Omega)$	ΔV_Z
R1	0.012Ω	1ppm
R2	7Ω	0.3ppm
R3	7Ω	0.2ppm
R4/R5 RATIO	ΔR = 0.01%	1ppm

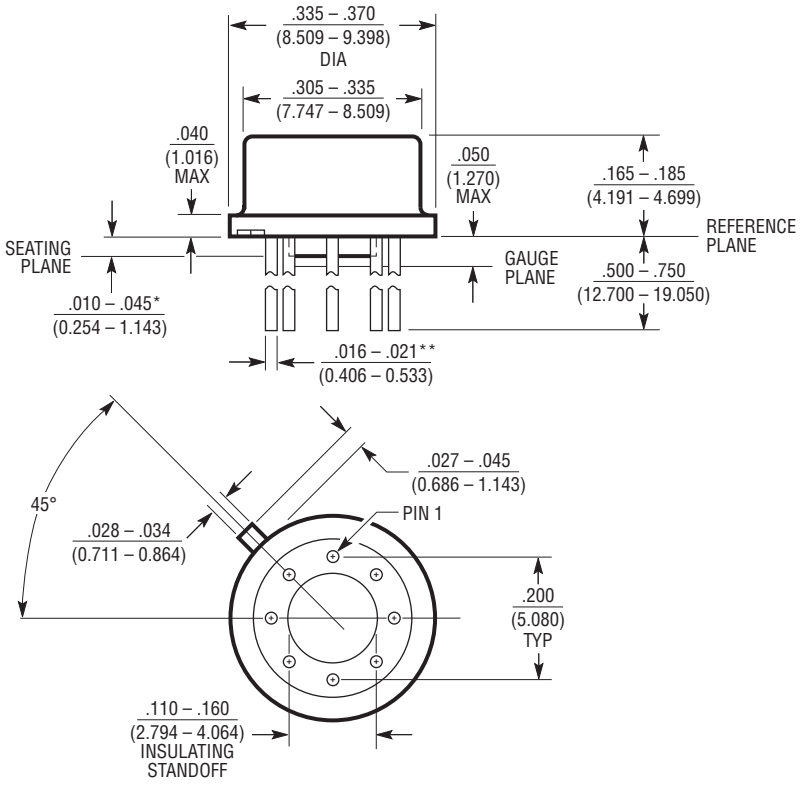
BOTH A1 AND A2 CONTRIBUTE LESS THAN 2µV OF OUTPUT DRIFT OVER A 50°C RANGE

1000 TA06

Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.

PACKAGE DESCRIPTION

H Package
8-Lead TO-5 Metal Can (.200 Inch PCD)
(Reference LTC DWG # 05-08-1320)



*LEAD DIAMETER IS UNCONTROLLED BETWEEN THE REFERENCE PLANE AND THE SEATING PLANE

**FOR SOLDER DIP LEAD FINISH, LEAD DIAMETER IS .016 – .024 (0.406 – 0.610)

H8(TO-5) 0.200 PCD 0204

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LM399	7V Precision Shunt Reference	0.2% Accuracy, 0.5ppm/°C Drift, 20μV_{RMS} Noise
LT1021	5V, 7V and 10V Precision Reference	Available in TO-5, –55°C to 125°C, Series or Shunt Operation
LT1236	5V and 10V Low Drift Precision Reference	0.05% Accuracy, 5ppm/°C Drift, Series or Shunt Operation
LT1389	1.25V, 2.5V, 4V and 5V Nanopower Shunt Reference	800nA, 0.05% Accuracy, 10ppm/°C Drift
LT1634	1.25V and 2.5V Micropower Shunt Reference	0.05%, 10ppm/°C, 10μA Current

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • www.linear.com

LT 1207 REV C • PRINTED IN USA

© LINEAR TECHNOLOGY CORPORATION 1987