

LT1008

ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage	±20V	Operating Temperature Range	
Differential Input Current (Note 2)	±10mA	LT1008M (OBSOLETE)	-55°C to 125°C
Input Voltage	±20V	LT1008C	0°C to 70°C
Output Short-Circuit Duration	Indefinite	LT1008I	-40°C to 85°C
Storage Temperature Range	-65°C to 150°C	Lead Temperature (Soldering, 10 sec)	300°C

PACKAGE/ORDER INFORMATION

<p>TOP VIEW COMP2 COMP1 -IN +IN V⁻ (CASE) H PACKAGE 8-LEAD TO-5 METAL CAN T_{JMAX} = 150°C, θ_{JA} = 150°C/W, θ_{JC} = 45°C/W</p>	<p>TOP VIEW COMP1 -IN +IN V⁻ N8 PACKAGE 8-LEAD PDIP T_{JMAX} = 150°C, θ_{JA} = 130°C/W</p>	<p>TOP VIEW COMP1 -IN +IN V⁻ S8 PACKAGE 8-LEAD PLASTIC SO T_{JMAX} = 150°C, θ_{JA} = 190°C/W</p>		
<p>ORDER PART NUMBER</p> <p>LT1008MH LT1008CH</p> <p>OBSOLETE PACKAGES Consider N8 or S8 Package for Alternate Source</p>	<p>ORDER PART NUMBER</p> <p>LT1008MJ8 LT1008CJ8</p>	<p>ORDER PART NUMBER</p> <p>LT1008CN8 LT1008IN8</p>	<p>ORDER PART NUMBER</p> <p>LT1008S8</p>	<p>S8 PART MARKING</p> <p>1008</p>
<p>Order Options Tape and Reel: Add #TR Lead Free: Add #PBF Lead Free Tape and Reel: Add #TRPBF Lead Free Part Marking: http://www.linear.com/leadfree/</p>				

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

ELECTRICAL CHARACTERISTICS V_S = ±15V, V_{CM} = 0V, T_A = 25°C, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1008M/I			LT1008C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V _{OS}	Input Offset Voltage	(Note 3)	30	120		30	120		μV
	Long-Term Input Offset Voltage Stability		40	180		40	180		μV
			0.3			0.3			μV/Month
I _{OS}	Input Offset Current	(Note 3)	30	100		30	100		pA
			40	150		40	150		pA
I _B	Input Bias Current	(Note 3)	±30	±100		±30	±100		pA
			±40	±150		±40	±150		pA
e _n	Input Noise Voltage	0.1Hz to 10Hz	0.5			0.5			μV _{p-p}
	Input Noise Voltage Density	f ₀ = 10Hz (Note 4) f ₀ = 1000Hz (Note 5)	17	30		17	30		nV/√Hz
			14	22		14	22		nV/√Hz
i _n	Input Noise Current Density	f ₀ = 10Hz	20			20			fA/√Hz
A _{VOL}	Large-Signal Voltage Gain	V _{OUT} = ±12V, R _L ≥ 10k	200	2000		200	2000		V/mV
		V _{OUT} = ±10V, R _L ≥ 2k	120	600		120	600		V/mV

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ELECTRICAL CHARACTERISTICS $V_S = \pm 15V, V_{CM} = 0V, T_A = 25^\circ C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1008M/I			LT1008C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13.5V$	114	132		114	132		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2V$ to $\pm 20V$	114	132		114	132		dB
	Input Voltage Range		± 13.5	± 14		± 13.5	± 14		V
V_{OUT}	Output Voltage Swing	$R_L = 10k$	± 13	± 14		± 13	± 14		V
	Slew Rate	$C_F = 30pF$	0.1	0.2		0.1	0.2		V/ μs
I_S	Supply Current	(Note 3)		380	600		380	600	μA

The ● indicates specifications which apply over the full operating temperature range of $-55^\circ C \leq T_A \leq 125^\circ C$ for the LT1008M, $-40^\circ C \leq T_A \leq 85^\circ C$ for the LT1008I and $0^\circ C \leq T_A \leq 70^\circ C$ for the LT1008C. $V_S = \pm 15V, V_{CM} = 0V$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1008M/I			LT1008C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	(Note 3)	●	50	250		40	180	μV
			●	60	320		50	250	μV
	Average Temperature Coefficient of Input Offset Voltage		●	0.2	1.5		0.2	1.5	$\mu V/^\circ C$
I_{OS}	Input Offset Current	(Note 3)	●	60	250		40	180	pA
			●	80	350		50	250	pA
	Average Temperature Coefficient of Input Offset Current		●	0.4	2.5		0.4	2.5	pA/ $^\circ C$
I_B	Input Bias Current	(Note 3)	●	± 80	± 600		± 40	± 180	pA
			●	± 150	± 800		± 50	± 250	pA
	Average Temperature Coefficient of Input Bias Current		●	0.6	6		0.4	2.5	pA/ $^\circ C$
A_{VOL}	Large-Signal Voltage Gain	$V_{OUT} = \pm 12V, R_L \geq 10k$	●	100	1000		150	1500	V/mV
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13.5V$	●	108	128		110	130	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2.5V$ to $\pm 20V$	●	108	126		110	128	dB
	Input Voltage Range		●	± 13.5			± 13.5		V
V_{OUT}	Output Voltage Swing	$R_L = 10k$	●	± 13	± 14		± 13	± 14	V
I_S	Supply Current		●	400	800		400	800	μA

(LT1008S8 only) $V_S = \pm 15V, V_{CM} = 0V, T_A = 25^\circ C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	(Note 3)		30	200	μV
					40	250
	Long-Term Input Offset Voltage Stability			0.3		$\mu V/$ Month
I_{OS}	Input Offset Current	(Note 3)		100	280	pA
					120	380
I_B	Input Bias Current	(Note 3)		± 100	± 300	pA
					± 120	± 400
e_n	Input Noise Voltage	0.1Hz to 10Hz		0.5		μV_{P-P}
	Input Noise Voltage Density	$f_0 = 10Hz$ (Note 5) $f_0 = 1000Hz$ (Note 5)		17	30	nV/ \sqrt{Hz}
				14	22	nV/ \sqrt{Hz}

ELECTRICAL CHARACTERISTICS (LT1008S8 only) $V_S = \pm 15V$, $V_{CM} = 0V$, $T_A = 25^\circ C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
i_n	Input Noise Current Density	$f_0 = 10Hz$		20		fA/ \sqrt{Hz}
A_{VOL}	Large-Signal Voltage Gain	$V_{OUT} = \pm 12V, R_L \geq 10k$ $V_{OUT} = \pm 10V, R_L \geq 2k$	200 120	2000 600		V/mV V/mV
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13.5V$	110	132		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2V$ to $\pm 20V$	110	132		dB
	Input Voltage Range		± 13.5	± 14		V
V_{OUT}	Output Voltage Swing	$R_L = 10k$	± 13	± 14		V
	Slew Rate	$C_F = 30pF$	0.1	0.2		V/ μs
I_S	Supply Current	(Note 3)		380	600	μA

(LT1008S8 only) The ● indicates specifications which apply over the full operating temperature range of $0^\circ C \leq T_A \leq 70^\circ C$. $V_S = \pm 15V$, $V_{CM} = 0V$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	(Note 3)	●	40	280	μV
			●	50	340	μV
	Average Temperature Coefficient of Input Offset Voltage		●	0.2	1.8	$\mu V/^\circ C$
I_{OS}	Input Offset Current	(Note 3)	●	120	380	pA
			●	140	500	pA
	Average Temperature Coefficient of Input Offset Current		●	0.4	4	pA/ $^\circ C$
I_B	Input Bias Current	(Note 3)	●	± 120	± 420	pA
			●	± 140	± 550	pA
	Average Temperature Coefficient of Input Bias Current		●	0.4	5	pA/ $^\circ C$
A_{VOL}	Large-Signal Voltage Gain	$V_{OUT} = \pm 12V, R_L \geq 10k$	●	150	1500	V/mV
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13.5V$	●	108	130	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2.5V$ to $\pm 20V$	●	108	128	dB
	Input Voltage Range		●	± 13.5		V
V_{OUT}	Output Voltage Swing	$R_L = 10k$	●	± 13	± 14	V
I_S	Supply Current		●	400	800	μA

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: Differential input voltages greater than 1V will cause excessive current to flow through the input protection diodes unless current limiting resistors are used.

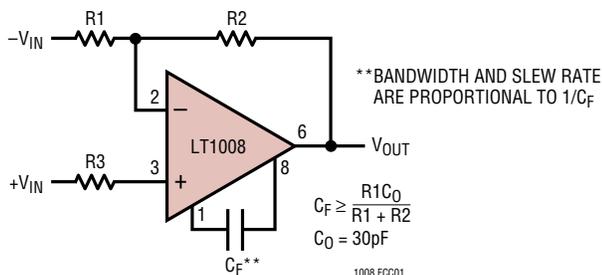
Note 3: These specifications apply for $\pm 2V \leq V_S \leq \pm 20V$ ($\pm 2.5V \leq V_S \leq \pm 20V$ over the temperature range) and $-13.5V \leq V_{CM} \leq 13.5V$ (for $V_S = \pm 15V$).

Note 4: 10Hz noise voltage density is sample tested on every lot. Devices 100% tested at 10Hz are available on request.

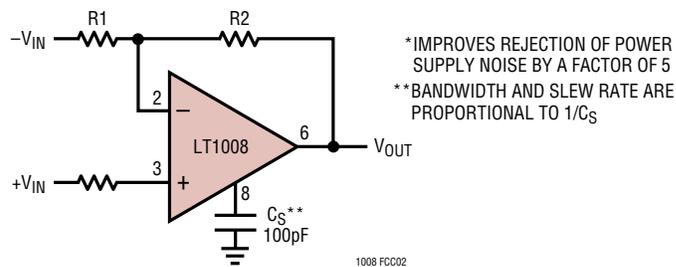
Note 5: This parameter is tested on a sample basis only.

FREQUENCY COMPENSATION CIRCUITS

Standard Compensation Circuit



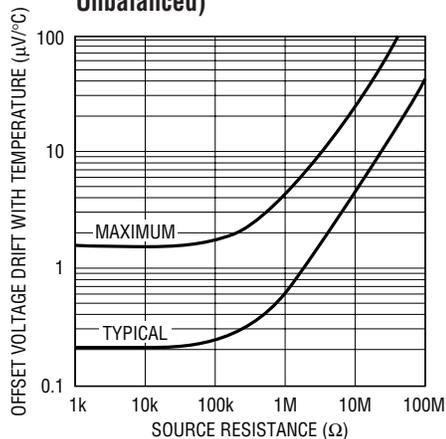
Alternate* Frequency Compensation



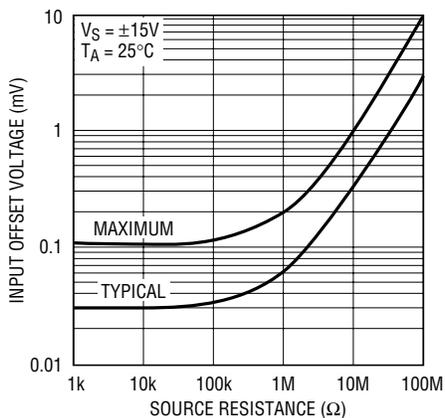
FOR $\frac{R_2}{R_1} > 200$, NO EXTERNAL FREQUENCY COMPENSATION IS NECESSARY

TYPICAL PERFORMANCE CHARACTERISTICS

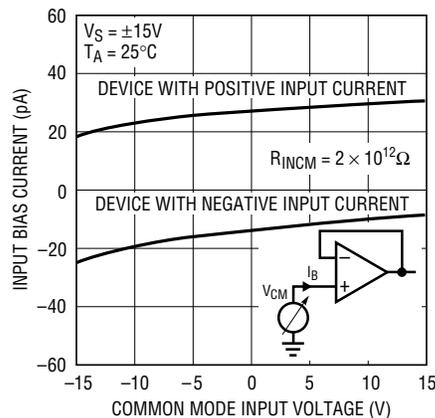
Offset Voltage Drift vs Source Resistance (Balanced or Unbalanced)



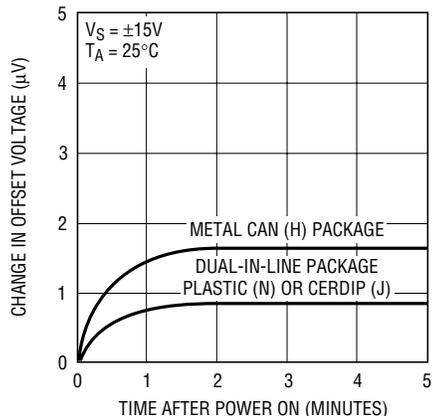
Offset Voltage vs Source Resistance (Balanced or Unbalanced)



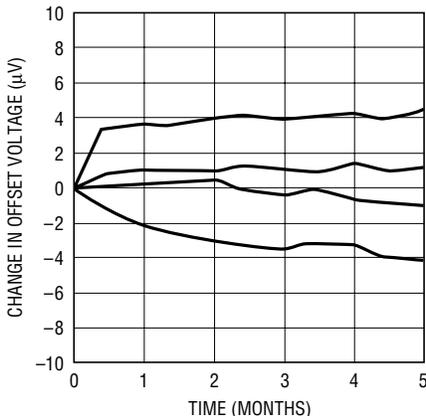
Input Bias Current vs Common Mode Range



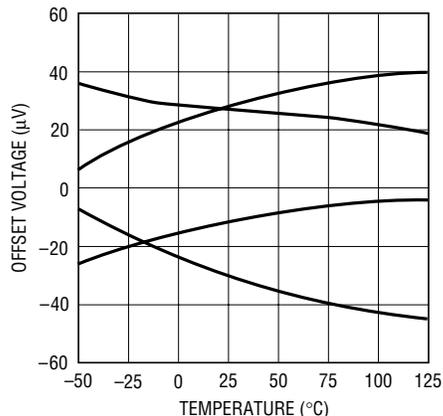
Warm-Up Drift



Long-Term Stability of Four Representative Units

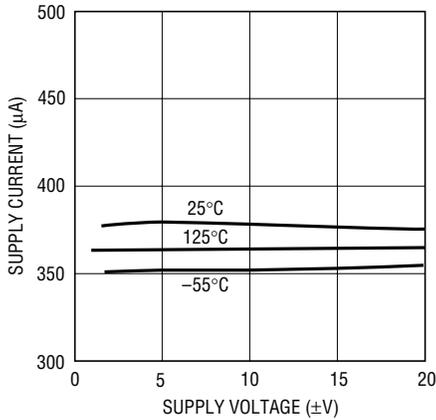


Offset Voltage Drift with Temperature of Four Representative Units



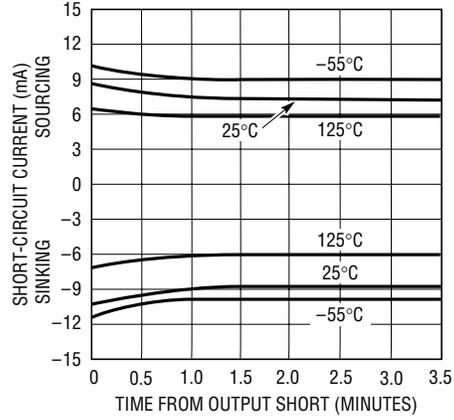
TYPICAL PERFORMANCE CHARACTERISTICS

Supply Current vs Supply Voltage



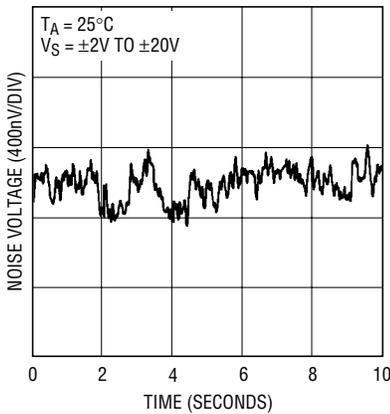
1008 G07

Output Short-Circuit Current vs Time



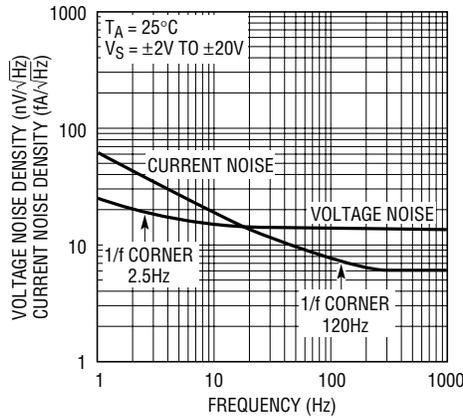
1008 G08

0.1Hz to 10Hz Noise



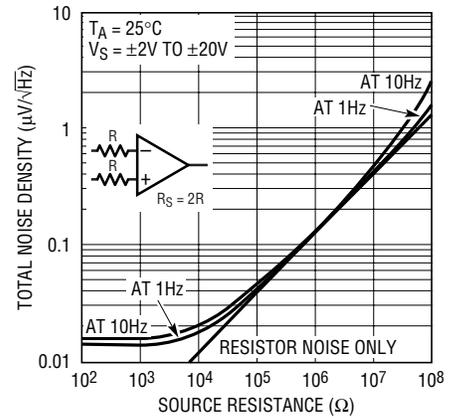
1008 G09

Noise Spectrum



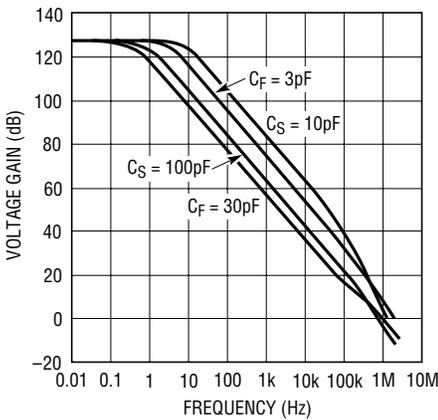
1008 G10

Total Noise vs Source Resistance



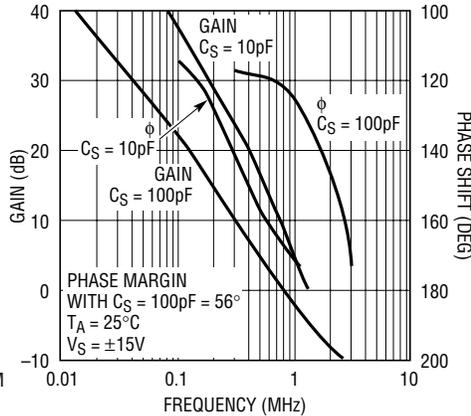
1008 G11

Voltage Gain vs Frequency



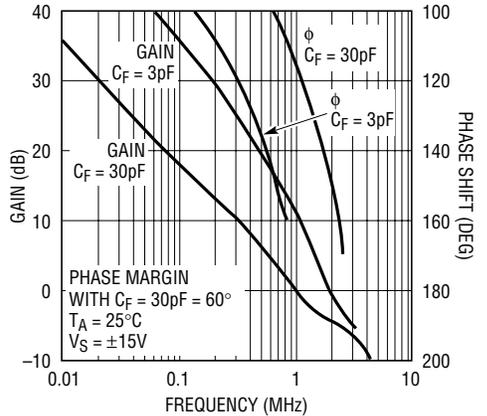
1008 G12

Gain, Phase Shift vs Frequency with Alternate Compensation



1008 G13

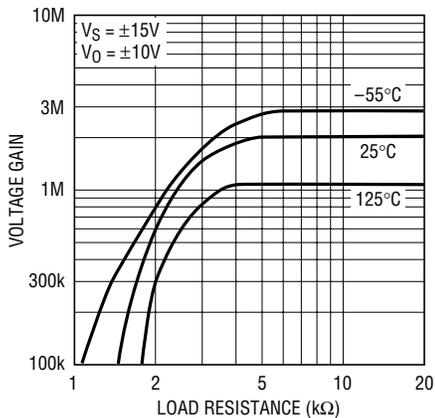
Gain, Phase Shift vs Frequency with Standard (Feedback) Compensation



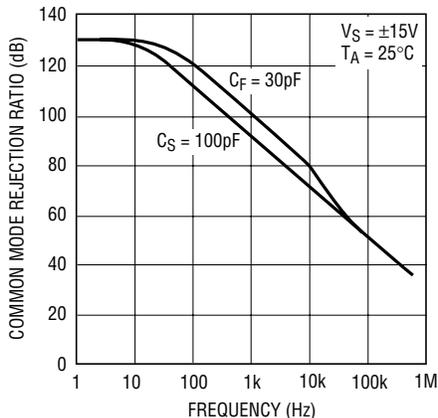
1008 G14

TYPICAL PERFORMANCE CHARACTERISTICS

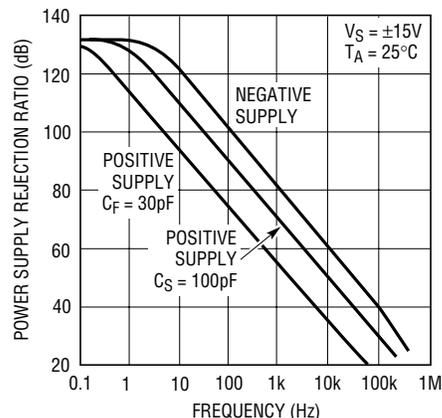
Voltage Gain vs Load Resistance



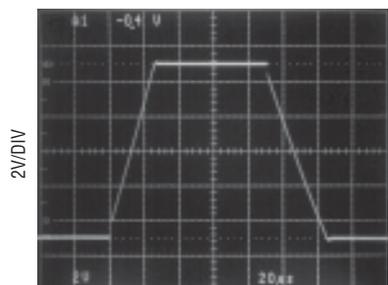
Common Mode Rejection vs Frequency



Power Supply Rejection vs Frequency

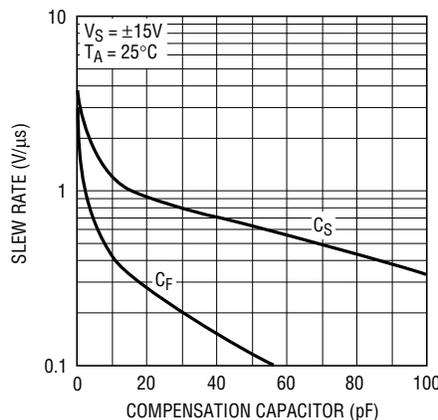


Large-Signal Transient Response

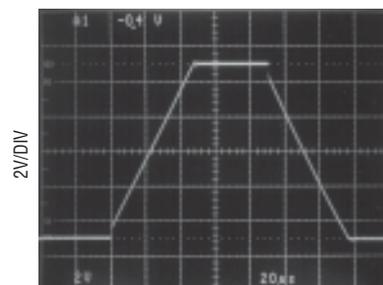


$A_V = 1$
 $C_S = 100\text{pF}$

Slew Rate vs Compensation Capacitance

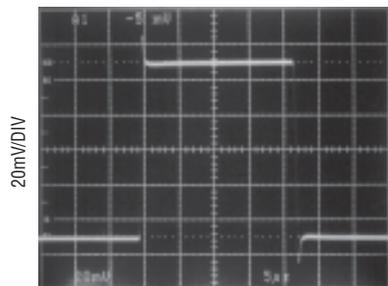


Large-Signal Transient Response



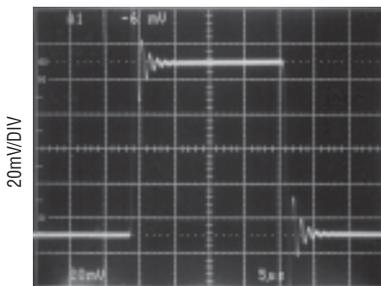
$A_V = 1$
 $C_F = 30\text{pF}$

Small-Signal Transient Response



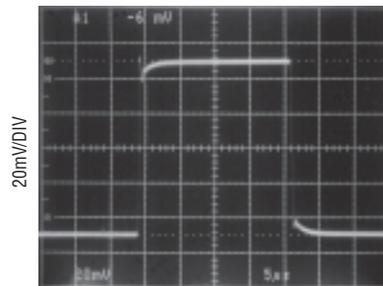
$A_V = 1$
 $C_S = 100\text{pF}$
 $C_{LOAD} = 100\text{pF}$

Small-Signal Transient Response



$A_V = 1$
 $C_S = 100\text{pF}$
 $C_{LOAD} = 600\text{pF}$

Small-Signal Transient Response



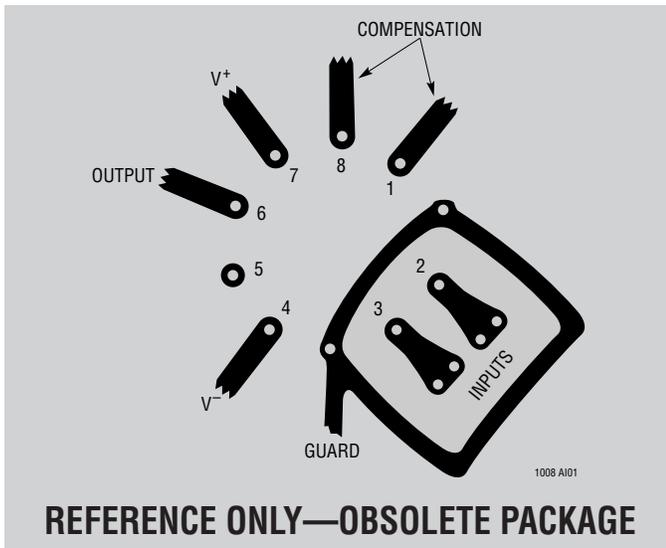
$A_V = 1$
 $C_F = 30\text{pF}$
 $C_{LOAD} = 100\text{pF}$

APPLICATIONS INFORMATION

Achieving Picoampere/Microvolt Performance

In order to realize the picoampere—microvolt level accuracy of the LT1008, proper care must be exercised. For example, leakage currents in circuitry external to the op amp can significantly degrade performance. High quality insulation should be used (e.g., Teflon™, Kel-F); cleaning of all insulating surfaces to remove fluxes and other residues will probably be required. Surface coating may be necessary to provide a moisture barrier in high humidity environments.

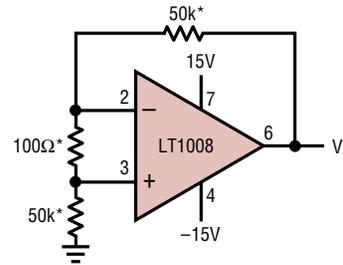
Board leakage can be minimized by encircling the input circuitry with a guard ring operated at a potential close to that of the inputs: in inverting configurations the guard ring should be tied to ground, in noninverting connections to the inverting input at Pin 2. Guarding both sides of the printed circuit board is required. Bulk leakage reduction depends on the guard ring width. Nanoampere level leakage into the compensation terminals can affect offset voltage and drift with temperature.



Microvolt level error voltages can also be generated in the external circuitry. Thermocouple effects caused by temperature gradients across dissimilar metals at the contacts to the input terminals can exceed the inherent drift of the amplifier. Air currents over device leads should be minimized, package leads should be short, and the two input leads should be as close together as possible and maintained at the same temperature.

The LT1008 is specified over a wide range of power supply voltages from ±2V to ±18V. Operation with lower supplies is possible down to ±1.2V (two Ni-Cad batteries).

Test Circuit for Offset Voltage and Its Drift with Temperature



* RESISTORS MUST HAVE LOW THERMOELECTRIC POTENTIAL
THIS CIRCUIT IS ALSO USED AS THE BURN-IN CONFIGURATION FOR THE LT1008 WITH SUPPLY VOLTAGES INCREASED TO ±20V
V_O = 1000V_{OS}

1008 AI02

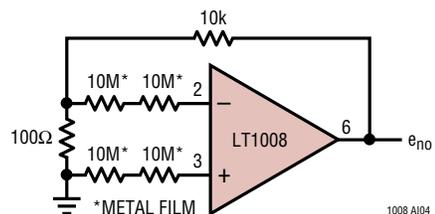
Noise Testing

The 0.1Hz to 10Hz peak-to-peak noise of the LT1008 is measured in the test circuit shown. The frequency response of this noise tester indicates that the 0.1Hz corner is defined by only one zero. The test time to measure 0.1Hz to 10Hz noise should not exceed 10 seconds, as this time limit acts as an additional zero to eliminate noise contributions from the frequency band below 0.1Hz.

A noise voltage density test is recommended when measuring noise on a large number of units. A 10Hz noise voltage density measurement will correlate well with a 0.1Hz to 10Hz peak-to-peak noise reading since both results are determined by the white noise and the location of the 1/f corner frequency.

Current noise is measured in the circuit shown and calculated by the following formula where the noise of the source resistors is subtracted.

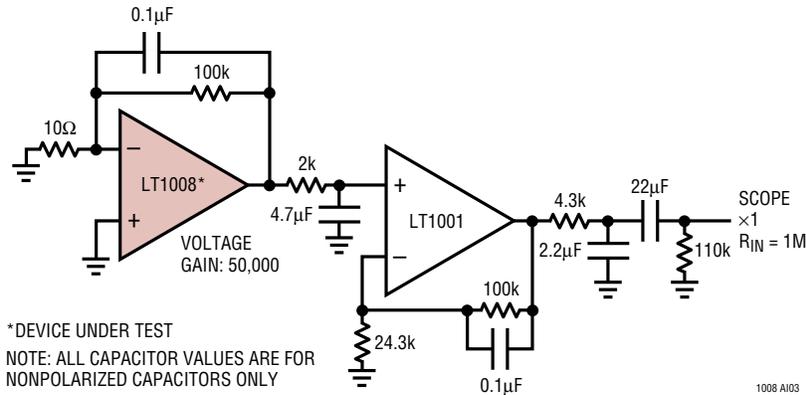
$$i_n = \frac{[e^2_{no} - (820nV)^2]^{1/2}}{40M\Omega \times 100}$$



1008 AI04

APPLICATIONS INFORMATION

0.1Hz to 10Hz Noise Test Circuit



Frequency Compensation

The LT1008 is externally frequency compensated with a single capacitor. The two standard compensation circuits shown earlier are identical to the LM108A/LM308A frequency compensation schemes. Therefore, the LT1008 operational amplifiers can be inserted directly into LM108A/LM308A sockets, with similar AC and upgraded DC performance.

External frequency compensation provides the user with additional flexibility in shaping the frequency response of the amplifier. For example, for a voltage gain of ten and $C_F = 3\text{pF}$, a gain bandwidth product of 5MHz and slew rate of $1.2\text{V}/\mu\text{s}$ can be realized. For closed-loop gains in excess of 200, no external compensation is necessary, and slew rate increases to $4\text{V}/\mu\text{s}$. The LT1008 can also be overcompensated (i.e., $C_F > 30\text{pF}$ or $C_S > 100\text{pF}$) to improve capacitive load handling capability or to narrow noise bandwidth. In many applications, the feedback loop around the amplifier has gain (e.g., logarithmic amplifiers); overcompensation can stabilize these circuits with a single capacitor.

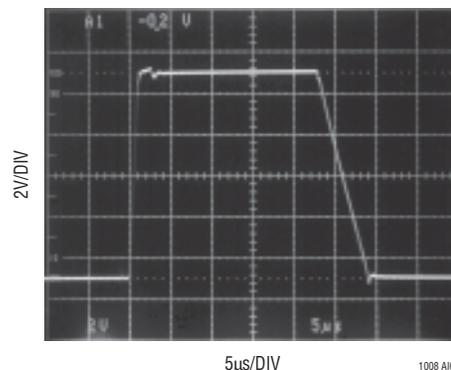
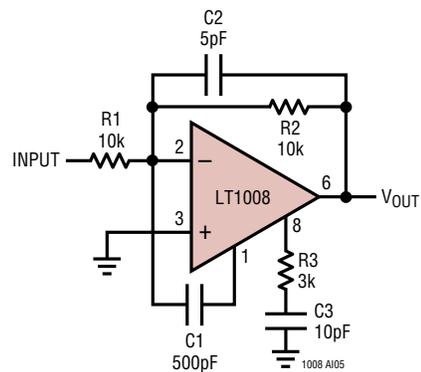
The availability of the compensation terminals permits the use of feedforward frequency compensation to enhance slew rate in low closed-loop gain configurations. The inverter slew rate is increased to $1.4\text{V}/\mu\text{s}$. The voltage follower feedforward scheme bypasses the amplifier's gain stages and slews at nearly $10\text{V}/\mu\text{s}$.

The inputs of the LT1008 are protected with back-to-back diodes. Current limiting resistors are not used, because the leakage of these resistors would prevent the realization of picoampere level bias currents at elevated temperatures.

In the voltage follower configuration, when the input is driven by a fast, large-signal pulse ($>1\text{V}$), the input protection diodes effectively short the output to the input during slewing, and a current, limited only by the output short-circuit protection, will flow through the diodes.

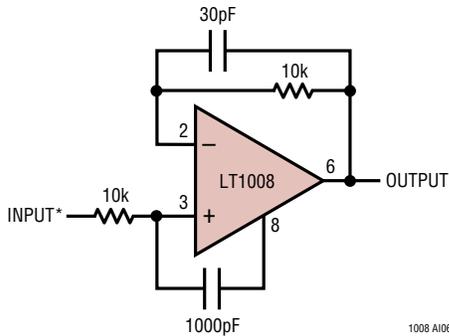
The use of a feedback resistor, as shown in the voltage follower feedforward diagram, is recommended because this resistor keeps the current below the short-circuit limit, resulting in faster recovery and settling of the output.

Inverter Feedforward Compensation



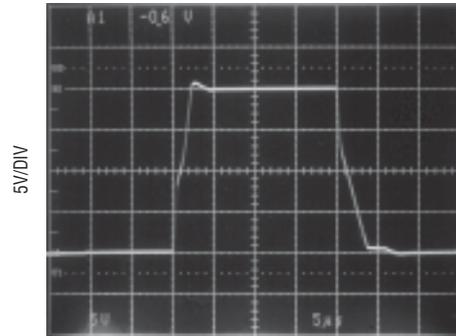
APPLICATIONS INFORMATION

Follower Feedforward Compensation



*SOURCE RESISTANCE $\leq 15k$ FOR STABILITY

1008 A106

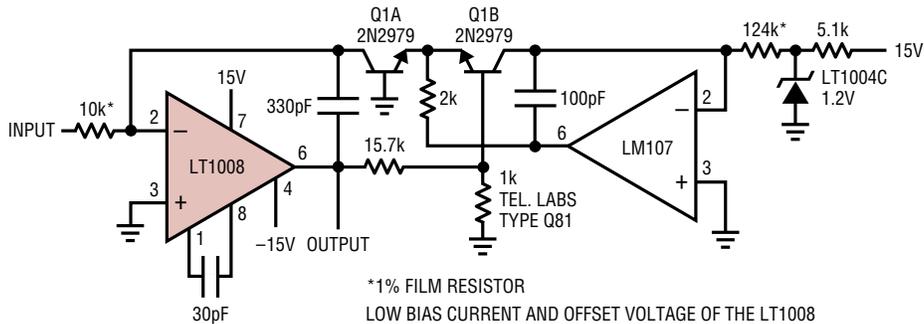


5µs/DIV

1008 A107

TYPICAL APPLICATIONS

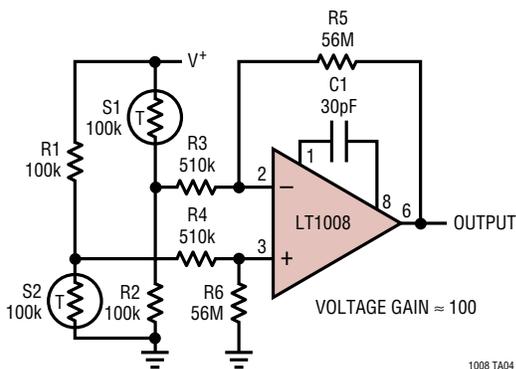
Logarithmic Amplifier



*1% FILM RESISTOR

LOW BIAS CURRENT AND OFFSET VOLTAGE OF THE LT1008 ALLOW 4.5 DECADES OF VOLTAGE INPUT LOGGING

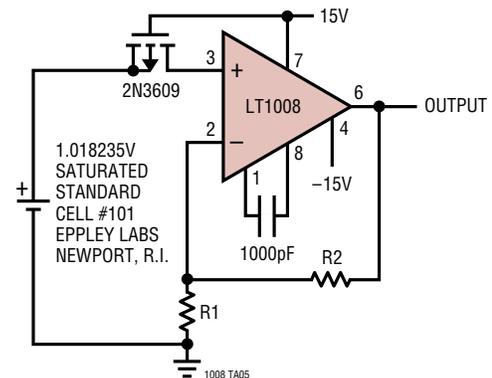
Amplifier for Bridge Transducers



VOLTAGE GAIN = 100

1008 TA04

Saturated Standard Cell Amplifier

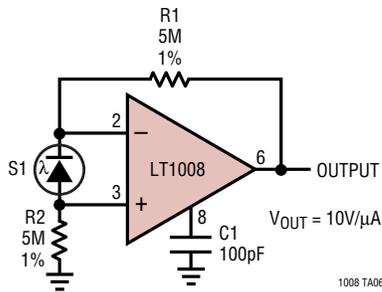


THE TYPICAL 30pA BIAS CURRENT OF THE LT1008 WILL DEGRADE THE STANDARD CELL BY ONLY 1ppm/YEAR. NOISE IS A FRACTION OF A ppm. UNPROTECTED GATE MOSFET ISOLATES STANDARD CELL ON POWER DOWN

1008fb

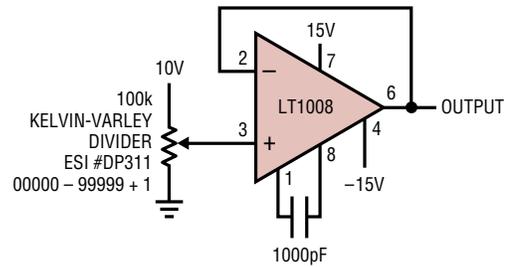
TYPICAL APPLICATIONS

Amplifier for Photodiode Sensor



1008 TA06

Five Decade Kelvin-Varley Divider Buffered by the LT1008

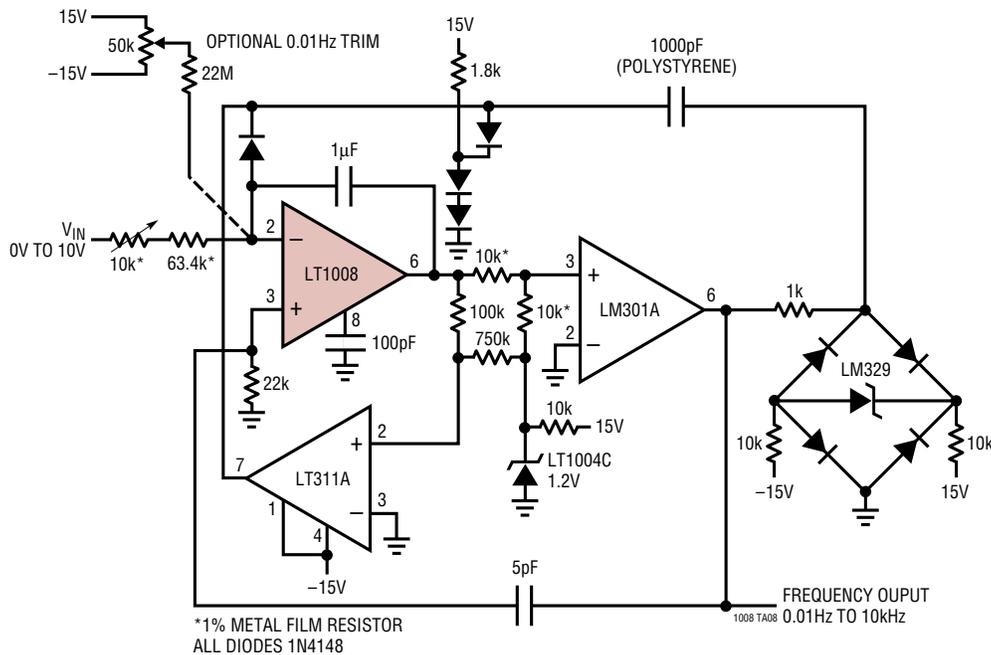


APPROXIMATE ERROR DUE TO NOISE, BIAS CURRENT, COMMON MODE REJECTION. VOLTAGE GAIN OF THE AMPLIFIER IS 1/5 OF A LEAST SIGNIFICANT BIT

1008 TA07

The LT1008 integrator extends low frequency range. Total dynamic range is 0.01Hz to 10kHz (or 120dB) with 0.01% linearity.

Extended Range Charge Pump Voltage to Frequency Converter

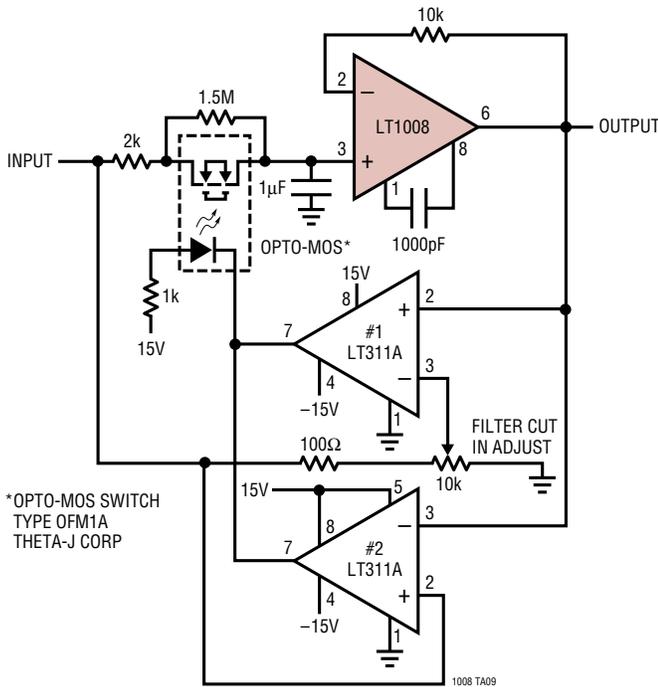


*1% METAL FILM RESISTOR
ALL DIODES 1N4148

1008 TA08 0.01Hz TO 10kHz

TYPICAL APPLICATIONS

Precision, Fast Settling, Lowpass Filter



*OPTO-MOS SWITCH
TYPE OFM1A
THETA-J CORP

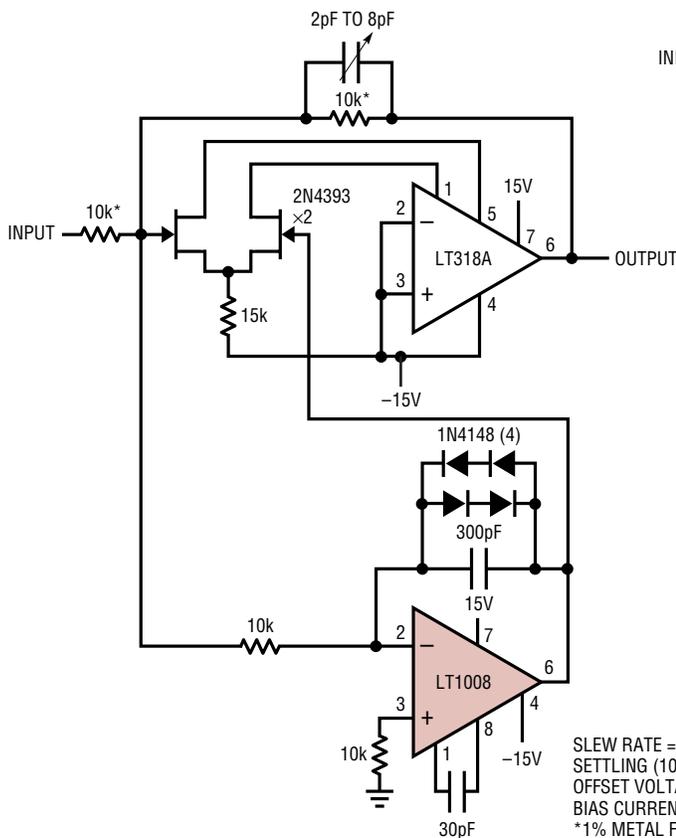
1008 TA09

This circuit is useful where fast signal acquisition and high precision are required, as in electronic scales.

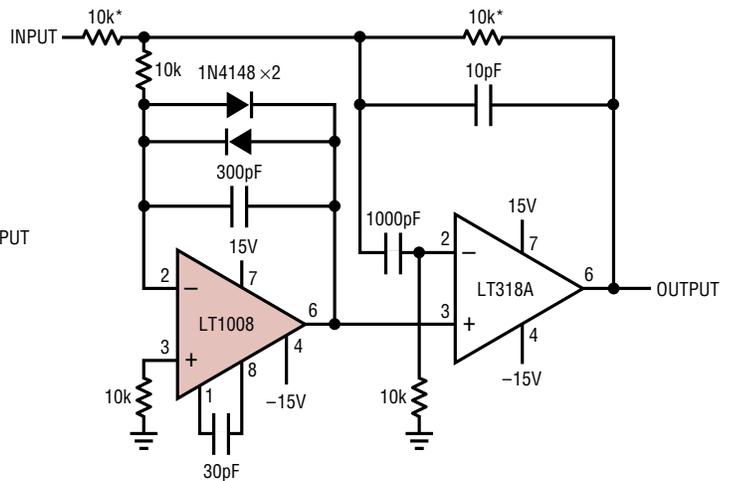
The filter's time constant is set by the 2k resistor and the 1µF capacitor until comparator 1 switches. The time constant is then set by the 1.5M resistor and the 1µF capacitor. Comparator 2 provides a quick reset.

The circuit settles to a final value three times as fast as a simple 1.5M-1µF filter with almost no DC error.

Fast Precision Inverters



SLEW RATE = 100V/µs
SETTLING (10V STEP) = 5µs TO 0.01%
OFFSET VOLTAGE = 30µV
BIAS CURRENT DC = 30pA
*1% METAL FILM

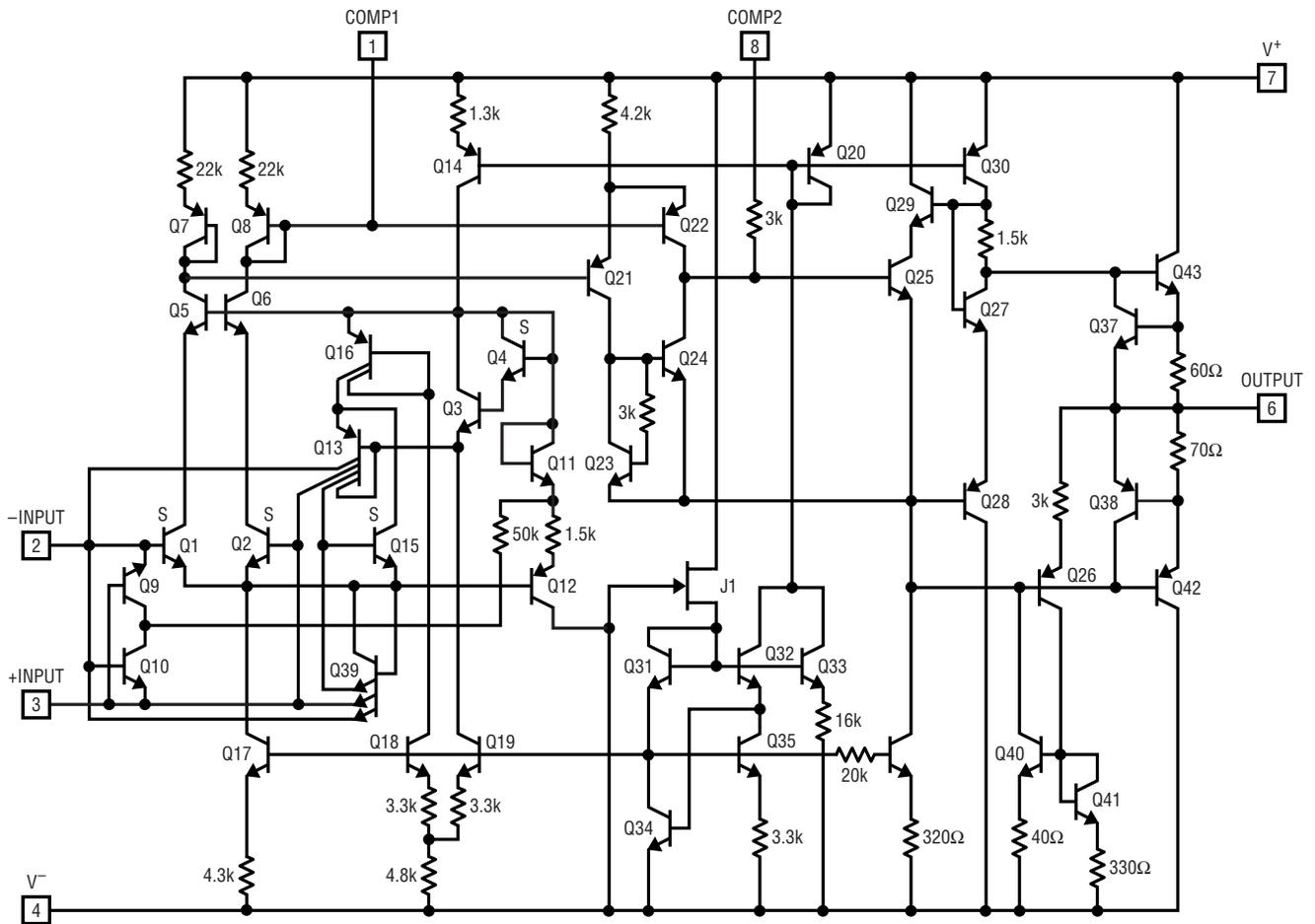


FULL POWER BANDWIDTH = 2MHz
SLEW RATE AT 50V/µs
SETTLING (10V STEP) = 12µs TO 0.01%
BIAS CURRENT DC = 30pA
OFFSET DRIFT = 0.3µV/°C
OFFSET VOLTAGE = 30µV
*1% METAL FILM

1008 TA10

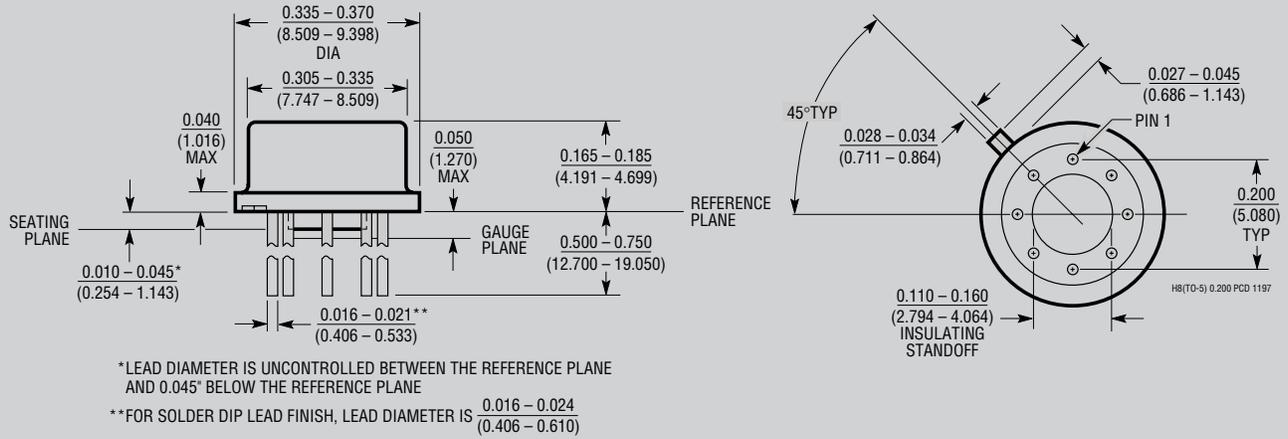
1008fb

SCHEMATIC DIAGRAM

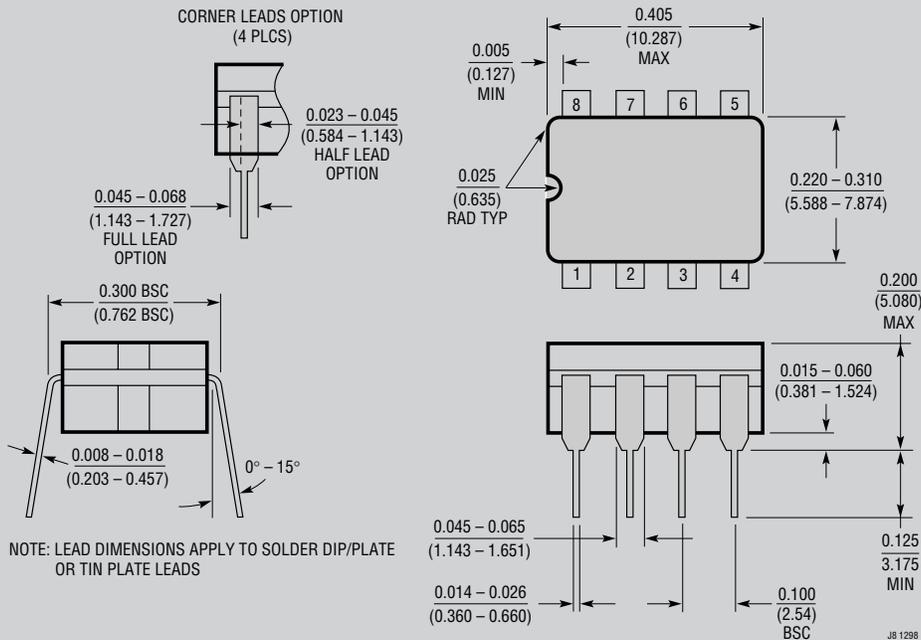


PACKAGE DESCRIPTION

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



J8 Package
8-Lead CERDIP (Narrow .300 Inch, Hermetic)
 (Reference LTC DWG # 05-08-1110)



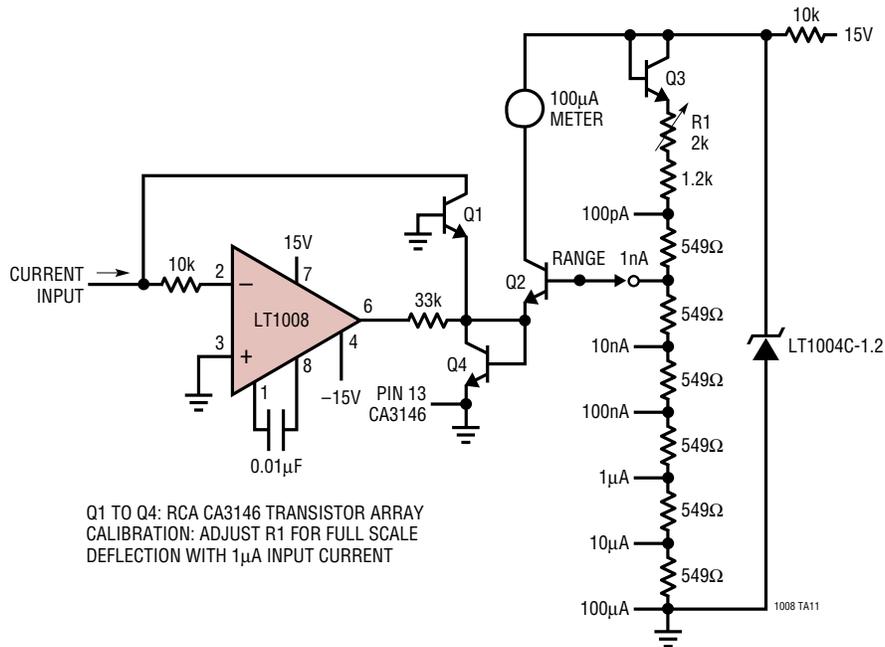
OBSOLETE PACKAGES

TYPICAL APPLICATION

Ammeter measures currents from 100pA to 100μA without the use of expensive high value resistors. Accuracy at

100μA is limited by the offset voltage between Q1 and Q2 and at 100pA by the inverting bias current of the LT1008.

Ammeter with Six Decade Range



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1012	Picoamp Input Current, Microvolt Offset, Low Noise Op Amp	Internally Compensated LT1008
LT1112	Dual Low Power, Precision, Picoamp Input Op Amp	Dual LT1012
LT1880	SOT-23, Rail-to-Rail Output, Picoamp Input Current Precision Op Amp	Single SOT-23 Version of LT1884
LT1881/LT1882	Dual and Quad Rail-to-Rail Output, Picoamp Input Precision Op Amps	Dual/Quad C _{LOAD} Stable
LT1884/LT1885	Dual and Quad Rail-to-Rail Output, Picoamp Input Precision Op Amps	Dual/Quad Faster LT1881/LT1882