Low Cost, Low Power Precision Op Amp

FEATURES

- Offset Voltage 50μV Max
- Offset Voltage Drift 1μV/°C Max
- Bias Current 250pA Max
- Offset Current 250pA Max
- Bias and Offset Current Drift 4pA/°C Max
- Supply Current 560μA Max
- 0.1Hz to 10Hz Noise 0.5μVp-p, 2.2pAp-p
- CMRR 115dB Min
- Voltage Gain 117dB Min
- PSRR 114dB Min
- Guaranteed Operation on Two NiCad Batteries

APPLICATIONS

- Replaces OP-07/OP-77/OP-97/OP-177/AD707/ LT1001 with Improved Price/Performance
- High Impedance Difference Amplifiers
- Logarithmic Amplifiers (Wide Dynamic Range)
- Thermocouple Amplifiers
- Precision Instrumentation
- Active Filters (with Small Capacitors)

DESCRIPTION

LT®1097 achieves a new standard in combining low price and outstanding precision performance.

On all operational amplifier data sheets, the specifications listed on the front page are for highly selected, expensive grades, while the specs for the low cost grades are buried deep in the data sheet.

The LT1097 does not have any selected grades, the outstanding specifications shown in the Features section are for its only grade.

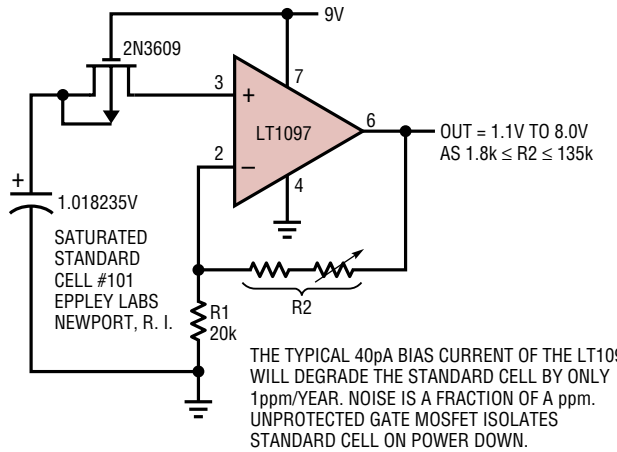
The design effort of the LT1097 concentrated on optimizing the performance of all precision specs—at only 350μA of supply current. Typical values are 10μV offset voltage, 40pA bias and offset currents, 0.2μV/°C and 0.4pA/°C drift. Common mode and power supply rejections, voltage gain are typically in excess of 128dB.

All parameters that are important for precision, low power op amps have been optimized. Consequently, using the LT1097 error budget calculations in most applications is unnecessary.

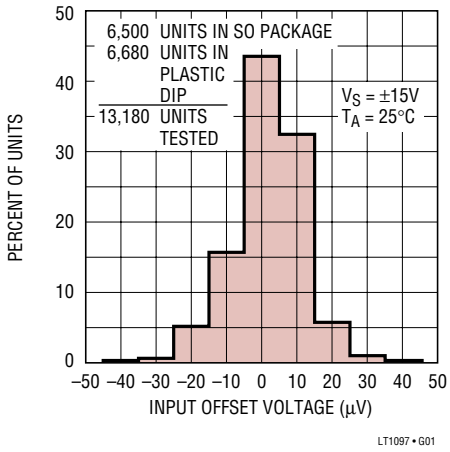
LT, LTC and LT are registered trademarks of Linear Technology Corporation.

TYPICAL APPLICATION

Saturated Standard Cell Amplifier



Input Offset Voltage Distribution

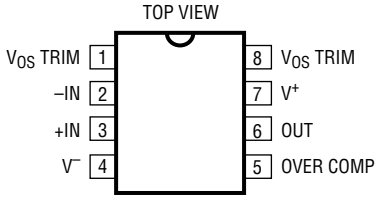


ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... ±20V
Differential Input Current (Note 1) ..... ±10mA
Input Voltage ..... ±20V
Output Short Circuit Duration ..... Indefinite

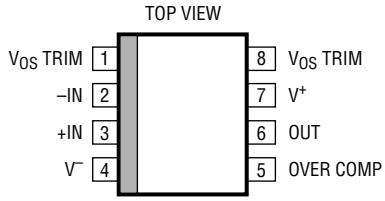
Operating Temperature Range .....–40°C to 85°C
Storage Temperature Range .....–65°C to 150°C
Lead Temperature (Soldering, 10 sec)..... 300°C

PACKAGE/ORDER INFORMATION



N8 PACKAGE
8-LEAD PLASTIC DIP

ORDER PART NUMBER
LT1097CN8



S8 PACKAGE
8-LEAD PLASTIC SO

ORDER PART NUMBER
LT1097S8

ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER	CONDITIONS	LT1097CN8 MIN	LT1097CN8 TYP	LT1097CN8 MAX	LT1097S8 MIN	LT1097S8 TYP	LT1097S8 MAX	UNITS
V_{OS}	Input Offset Voltage			10	50		10	60	µV
$\frac{\Delta V_{OS}}{\Delta TIME}$	Long Term Input Offset Voltage Stability			0.3			0.3		µV/Mo
I_{OS}	Input Offset Current			40	250		60	350	pA
I_B	Input Bias Current			±40	±250		±50	±350	pA
e_n	Input Noise Voltage	0.1Hz to 10Hz		0.5			0.5		µVp-p
	Input Noise Voltage Density	f_O = 10Hz f_O = 1000Hz		16 14			16 14		nV/√Hz nV/√Hz
i_n	Input Noise Current	0.1Hz to 10Hz		2.2			2.4		pAp-p
	Input Noise Current Density	f_O = 10Hz f_O = 1000Hz		0.03 0.008			0.035 0.008		pA/√Hz pA/√Hz
	Input Resistance Differential Mode Common Mode	(Note 2)	 30	 80 10^{12}		 25	 70 $8•10^{11}$		 MΩ Ω
	Input Voltage Range		±13.5	±14.3		±13.5	±14.3		V
CMRR	Common Mode Rejection Ratio	V_{CM} = ±13.5V	115	130		115	130		dB
PSRR	Power Supply Rejection Ratio	V_S = ±1.2V to ±20V	114	130		114	130		dB
A_{VOL}	Large Signal Voltage Gain	V_O = ±12V, R_L = 10k V_O = ±10V, R_L = 2k	700 250	2500 1000		700 250	2500 1000		V/mV V/mV
V_{OUT}	Output Voltage Swing	R_L = 10k R_L = 2k	±13 ±11.5	±13.8 ±13		±13 ±11.5	±13.8 ±13		V V
SR	Slew Rate		0.1	0.2		0.1	0.2		V/µs
GBW	Gain Bandwidth Product			700			700		kHz
I_S	Supply Current			350	560		350	560	µA
	Offset Adjustment Range	R_{POT} = 10k, Wiper to V^+		±600			±600		µV
	Minimum Supply Voltage	(Note 3)	±1.2	—		±1.2	—		V

ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $V_{CM} = 0V$, $0°C \le T_A \le 70°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		LT1097CN8 MIN	LT1097CN8 TYP	LT1097CN8 MAX	LT1097S8 MIN	LT1097S8 TYP	LT1097S8 MAX	UNITS
V_{OS}	Input Offset Voltage		●		20	100		20	130	µV
	Average Temperature Coefficient of Input Offset Voltage	(Note 4)	●		0.2	1		0.2	1.4	µV/°C
I_{OS}	Input Offset Current		●		60	430		75	570	pA
	Average Temperature Coefficient of Input Offset Current	(Note 4)	●		0.4	4		0.5	5	pA/°C
I_B	Input Bias Current		●		±60	±430		±75	±570	pA
	Average Temperature Coefficient of Input Bias Current	(Note 4)	●		0.4	4		0.5	5	pA/°C
A_{VOL}	Large Signal Voltage Gain	$V_{OUT} = \pm 12V$, $R_L \ge 10k$ $V_{OUT} = \pm 10V$, $R_L \ge 2k$	● ●	450 180	2000 800		450 180	2000 800		V/mV V/mV
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13.5V$	●	112	128		112	128		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 1.3V$ to $\pm 20V$	●	111	128		111	128		dB
	Input Voltage Range		●	±13.5	±14.2		±13.5	±14.2		V
V_{OUT}	Output Voltage Swing	$R_L = 10k$	●	±13	±13.7		±13	±13.7		V
I_S	Supply Current		●		380	700		380	700	µA

ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $V_{CM} = 0V$, $-40°C \le T_A \le 85°C$, unless otherwise noted. (Note 5)

SYMBOL	PARAMETER	CONDITIONS		LT1097CN8 MIN	LT1097CN8 TYP	LT1097CN8 MAX	LT1097S8 MIN	LT1097S8 TYP	LT1097S8 MAX	UNITS
V_{OS}	Input Offset Voltage		●		25	130		30	170	µV
	Average Temperature Coefficient of Input Offset Voltage		●		0.3	1.2		0.3	1.6	µV/°C
I_{OS}	Input Offset Current		●		70	600		85	750	pA
	Average Temperature Coefficient of Input Offset Current		●		0.5	5		0.6	6	pA/°C
I_B	Input Bias Current		●		±70	±600		±85	±750	pA
	Average Temperature Coefficient of Input Bias Current		●		0.5	5		0.6	6	pA/°C
A_{VOL}	Large Signal Voltage Gain	$V_{OUT} = \pm 12V$, $R_L \ge 10k$ $V_{OUT} = \pm 10V$, $R_L \ge 2k$	● ●	300	1700 700		300	1700 700		V/mV V/mV
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13.5V$	●	108	127		108	127		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 1.5V$ to $\pm 20V$	●	108	127		108	127		dB
	Input Voltage Range		●	±13.5	±14		±13.5	±14		V
V_{OUT}	Output Voltage Swing	$R_L = 10k$	●	±13	±13.6		±13	±13.6		V
I_S	Supply Current		●		400	800		400	800	µA

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

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

Note 2: This parameter is guaranteed by design and is not tested.

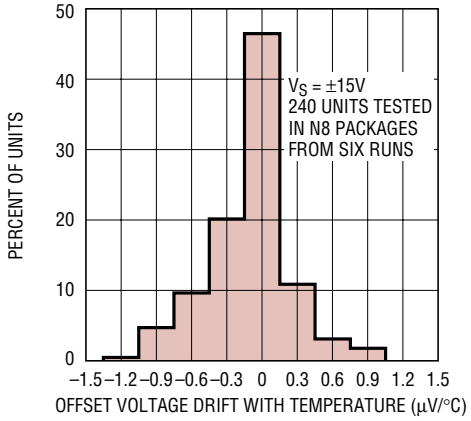
Note 3: Power supply rejection ratio is measured at the minimum supply voltage.

Note 4: This parameter is not 100% tested.

Note 5: The LT1097 is designed, characterized and expected to meet these extended temperature limits, but is not tested at –40°C and 85°C. Guaranteed I grade parts are available; consult factory.

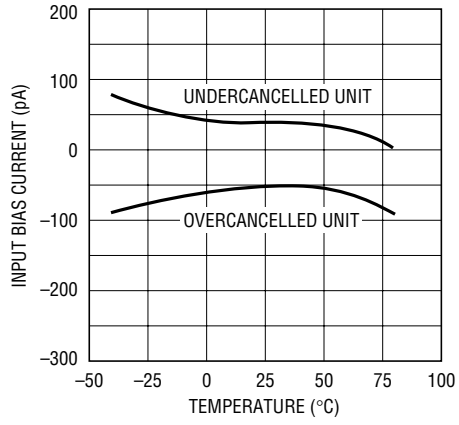
TYPICAL PERFORMANCE CHARACTERISTICS

Distribution to Offset Voltage Drift with Temperature



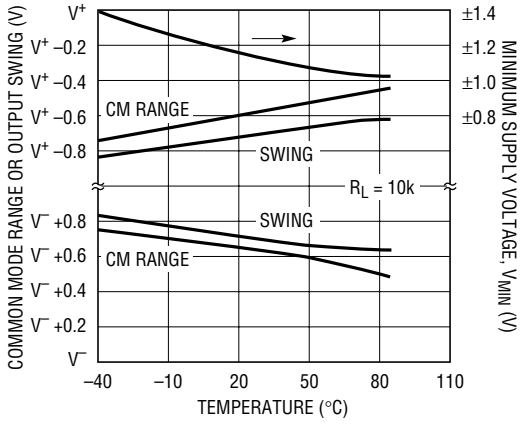
LT1097 • G02

Input Bias Current vs Temperature



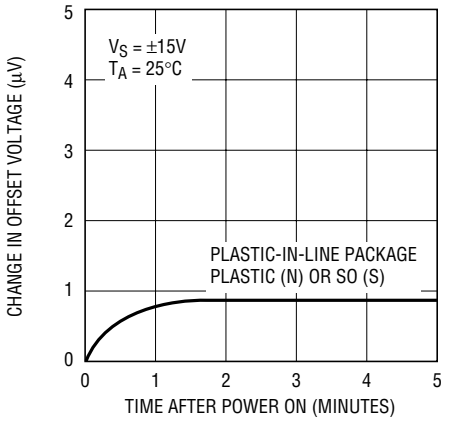
1097 • G03

Minimum Supply Voltage, Common Mode Range and Voltage Swing at V_{MIN}



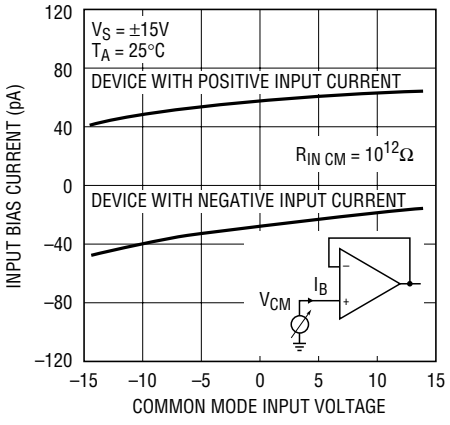
1097 • G04

Warm-Up Drift



1097 • G05

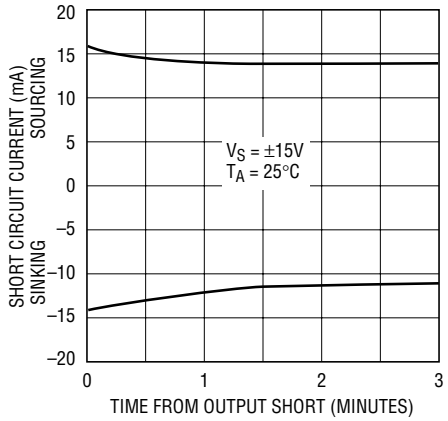
Input Bias Current Over Common Mode Range



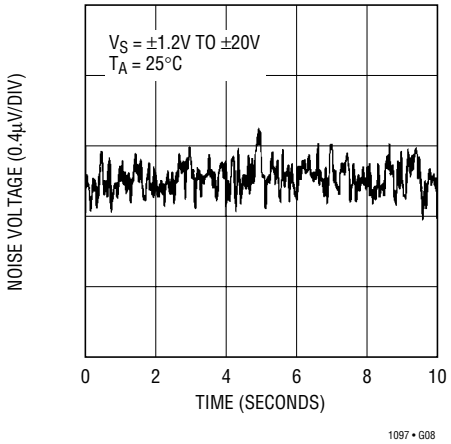
1097 • G06

TYPICAL PERFORMANCE CHARACTERISTICS

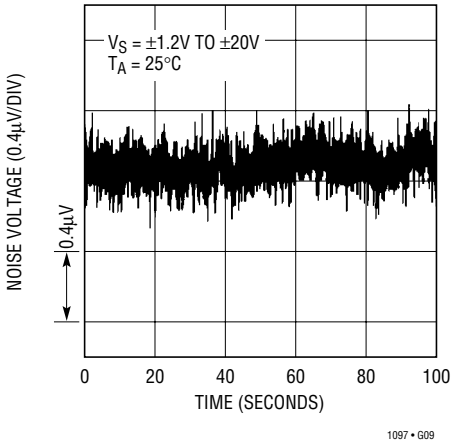
Output Short Circuit Current vs Time



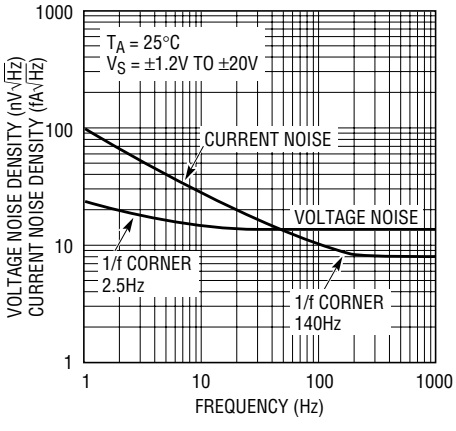
0.1Hz to 10Hz Noise



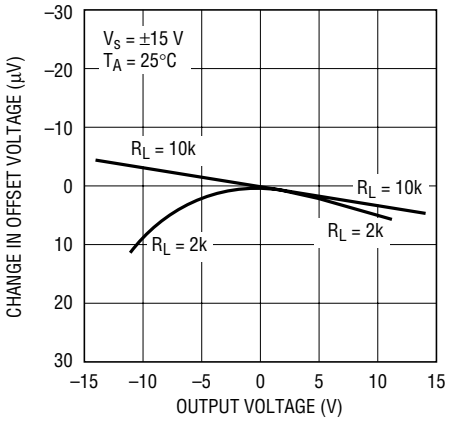
0.01Hz to 10Hz Noise



Noise Spectrum

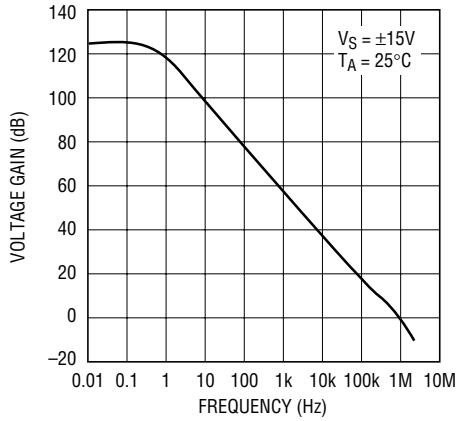


Voltage Gain



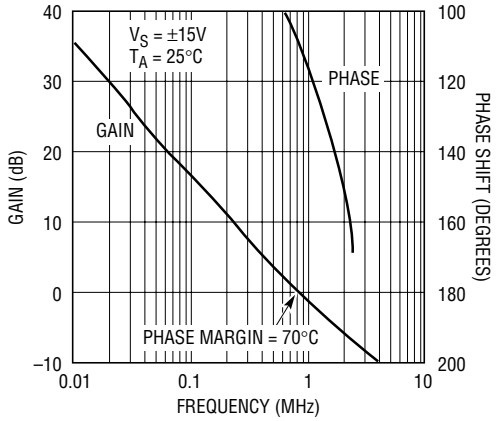
TYPICAL PERFORMANCE CHARACTERISTICS

Voltage Gain vs Frequency



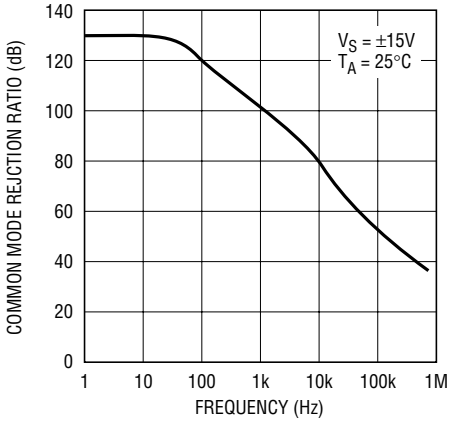
1097 • G12

Gain, Phase Shift vs Frequency



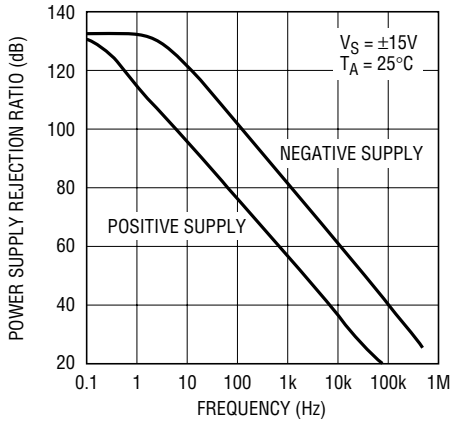
1097 • G13

Common Mode Rejection vs Frequency



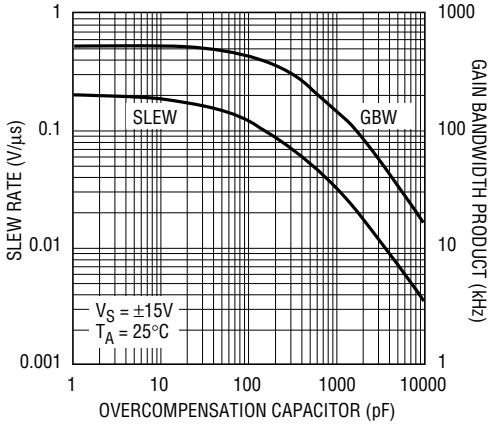
1097 • G14

Power Supply Rejection vs Frequency



1097 • G15

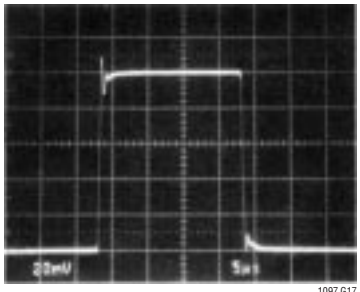
Slew Rate, Gain Bandwidth Product vs Overcompensation Capacitor



1097 • G16

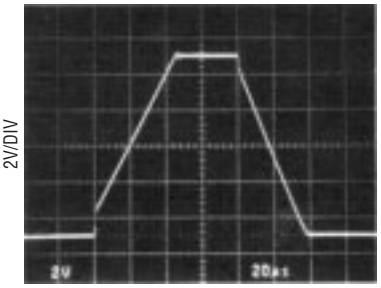
TYPICAL PERFORMANCE CHARACTERISTICS

Small Signal Transient Response



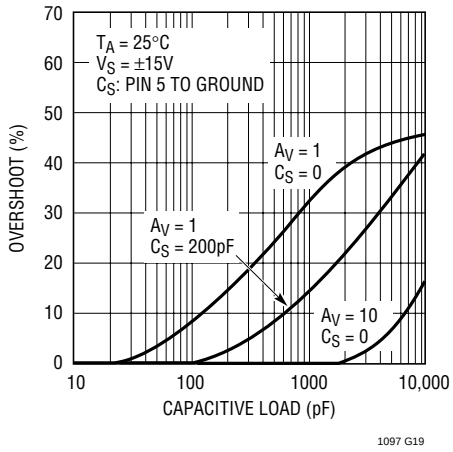
A_V = 1, C_{LOAD} = 100pF, 5µs/DIV

Large Signal Transient Response

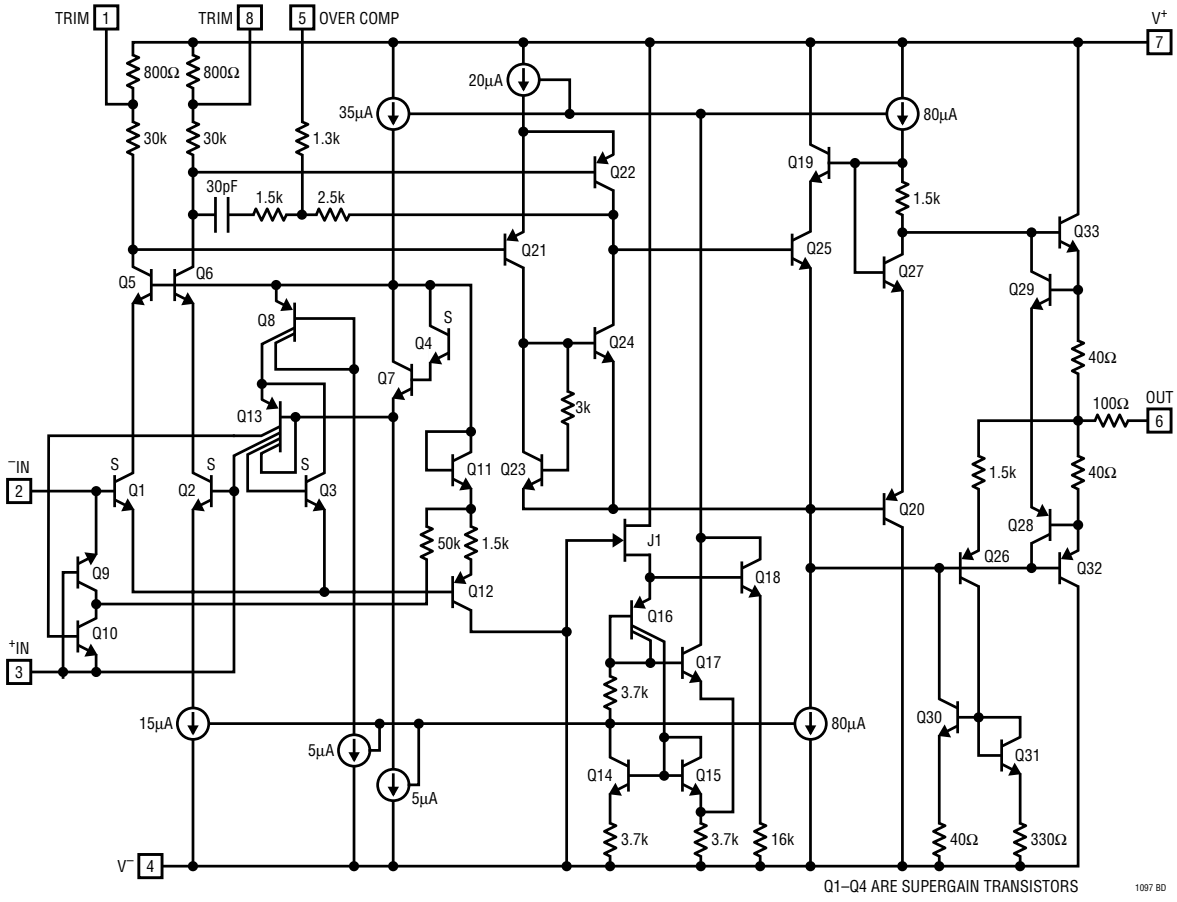


A_V = 1, 20µs/DIV

Capacitive Load Handling



SCHEMATIC DIAGRAM



APPLICATIONS INFORMATION

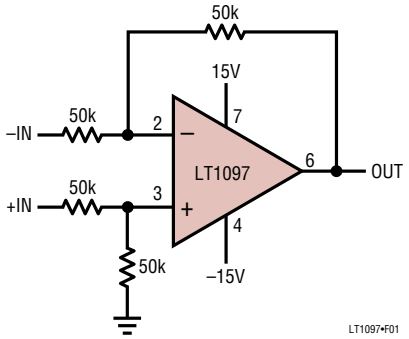
The LT1097 is pin compatible to and directly replaces such precision op amps as the OP-07, OP-77, AD707, OP-97, OP-177, LM607 and LT1001 with improved price/performance. Compatibility includes externally nulling the offset voltage, as all of the above devices are trimmed with a potentiometer between Pin 1 and Pin 8 and the wiper tied to V^+.

The simple difference amplifier can be used to illustrate the all-around excellence of the LT1097. The 50k input resistance is selected to be large enough compared to input signal source resistance. Simultaneously, the 50k resistors should not dominate the precision and noise error budget. Assuming perfect matching between the four resistors, the following table summarizes the input referred performance obtained using the LT1097 and other popular, low cost precision op amps.

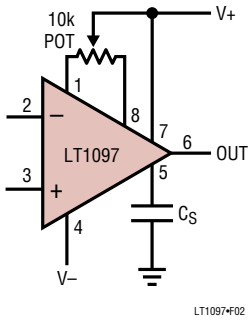
Input offset voltage can be adjusted over a ±600µV range with a 10k potentiometer.

The LT1097 is internally compensated for unity gain stability. As shown on the Capacitive Load Handling plot, the LT1097 is stable with any capacitive load. However, the overcompensation capacitor, C_S, can be used to reduce overshoot with heavy capacitive loads, to narrow noise bandwidth or to stabilize circuits with gain in the feedback loop.

±27V Common Mode Range Difference Amplifier



Frequency Compensation and Optional Offset Nulling



Guaranteed Perfomance, V_S = ±15V, T_A = 25°C

PARAMETER	LT1097CN8	OP-77GP	AD707JN	OP-177GP	OP-97FP	UNITS
Error Terms						
V_{OS} Max	50	100	90	60	75	µV
I_{OS} Max•25k	6	70	50	70	4	µV
Gain Min, 10V Out	14	5	3	5	50	µV
CMRR, Min, ±25V In	22	20	13	22	39	µV
PSRR, Min, V_S = ±15V ±10%	6	9	9	9	9	µV
Sum of All Error Terms	98	204	165	166	177	µV
0.1Hz to 10Hz Noise						
Voltage Noise	0.5	0.38	0.23	0.38	0.5	µVp-p Typ
Current Noise•50k	0.11	0.75	0.7	0.75	0.1	µVp-p Typ
Resistor Noise	0.55	0.55	0.55	0.55	0.55	µVp-p Typ
RMS sum	0.75	1	0.92	1	0.75	µVp-p
Drift with Temp						
TCV_{OS} Max	1	1.2	1	1.2	2	µV/°C
TCI_{OS} Max•25k	0.1	2.1	1	2.1	0.2	µV/°C
Sum of Drift Terms	1.1	3.3	2	3.3	2.2	µV/°C
Supply Current Max	0.56	2	3	2	0.6	mA

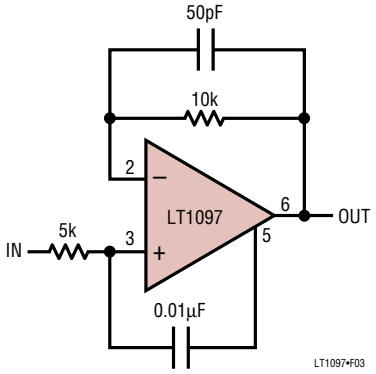
APPLICATIONS INFORMATION

The availability of the compensation terminal permits the use of feedforward frequency compensation to enhance slew rate. The voltage follower feedforward scheme bypasses the amplifier's gain stages and slews at nearly 10V/μs.

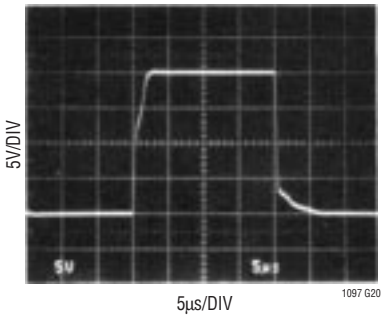
The inputs of the LT1097 are protected with back-to-back diodes. In the voltage follower configuration, when the input is driven by a fast, large signal pulse (>1V), the input protection diodes effectively short the output to the input during slewing, and a current, limited only by the output short circuit 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.

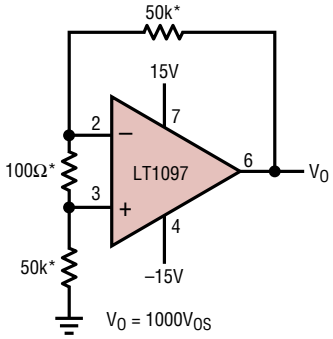
Follower Feedforward Compensation



Pulse Response of Feedforward Compensation

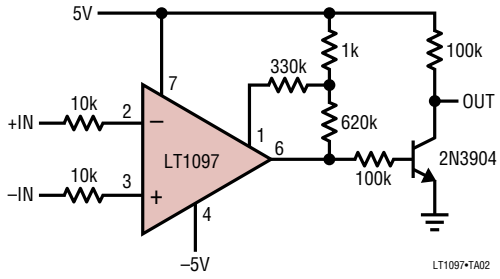


Test Circuit for Offset Voltage and its Drift with Temperature



TYPICAL APPLICATION

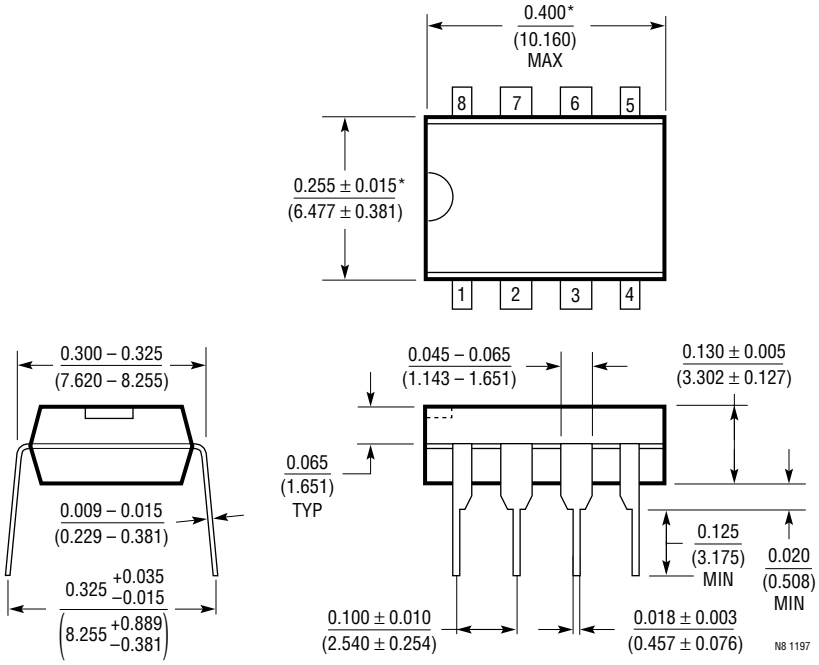
Low Power Comparator with <10μV Hysteresis



PACKAGE DESCRIPTION

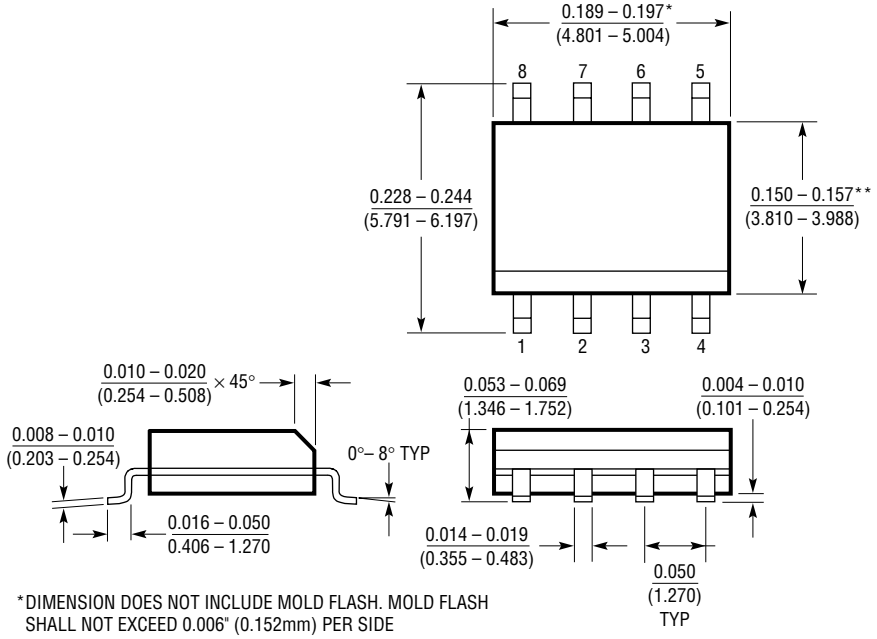
Dimensions in inches (millimeters) unless otherwise noted.

N8 Package
8-Lead PDIP (Narrow 0.300)
(LTC DWG # 05-08-1510)



*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

S8 Package
8-Lead Plastic Small Outline (Narrow 0.150)
(LTC DWG # 05-08-1610)



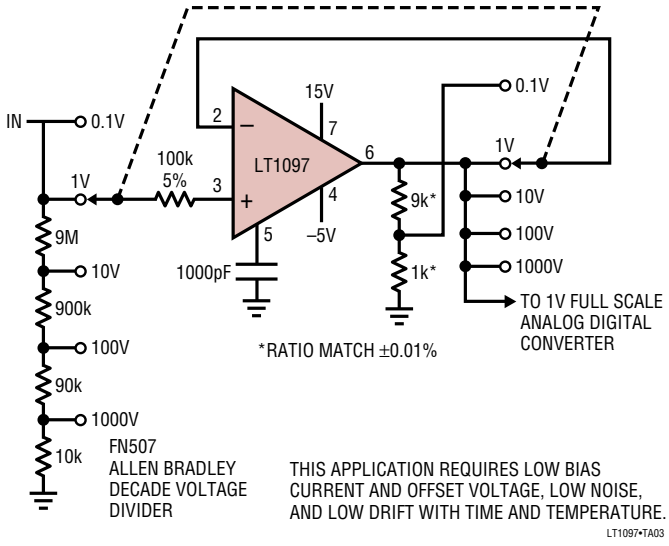
*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

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.

TYPICAL APPLICATION

Input Amplifier for 4 1/2 Digit Voltmeter



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1490/LT1491	Dual/Quad General Purpose Micropower Rail-to-Rail Op Amps	Over-The-Top™ Inputs, 50µA Supply Current Per Amplifier, 2V to 44V Supply Range, 180kHz GBW
LT1492/LT1493	Dual/Quad 5MHz Low Power Single Supply Op Amps	180µV V_{OS} Max, 3V/µs Slew Rate, 550µA Supply Per Amplifier
LT1077	Single Micropower Low V_{OS} Op Amp	60µV V_{OS} Max, 68µA Supply Current, 230kHz GBW, Optimized for 5V Supplies

Over-The-Top is a trademark of Linear Technology Corporation.

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417• (408)432-1900
FAX: (408) 434-0507•TELEX: 499-3977 • www.linear-tech.com
1097fas sn1097 LT/TP 0398 2K REV A • PRINTED IN USA
© LINEAR TECHNOLOGY CORPORATION 1989