LT1097

Low Cost, Low Power Precision Op Amp

FEATURES

- Offset Voltage 50μV Max
- Offset Voltage Drift 1.0μV/°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
- Price (1000's) for Above Specs $0.97

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

The LT1097 achieves a new standard in combining low price and outstanding precision performance.

On all operational amplifier datasheets, 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 datasheet.

The LT1097 does not have any selected grades, the outstanding specifications shown in the features section are for its only grade — priced at 97 cents in thousands.

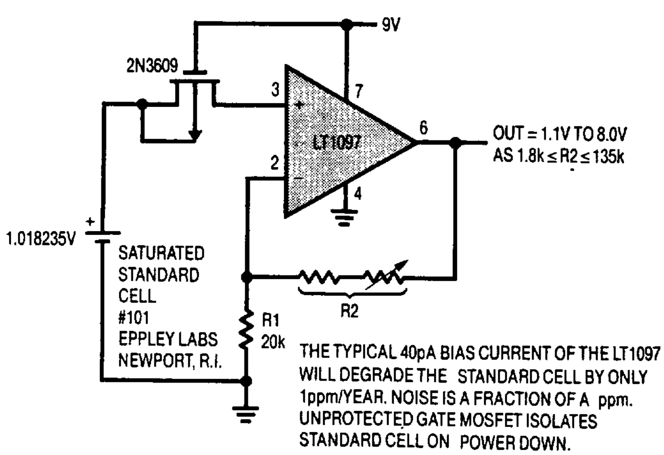
The design effort of the LT1097 concentrated on optimizing the performance of all precision specs — at only 350μA of supply current. Typical values are 10μV offset voltage, 40pA bias and offset currents, 0.2μV/°C and 0.4pA/°C drift. Common mode and power supply rejections, voltage gain are typically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

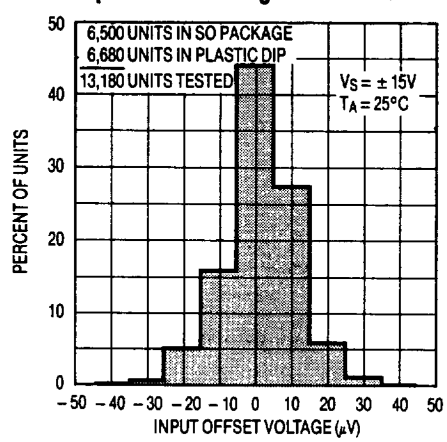
Protected by U.S. patents 4,575,685; 4,775,884 and 4,837,496

TYPICAL APPLICATION

Saturated Standard Cell Amplifier



Input Offset Voltage Distribution

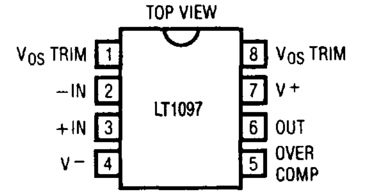


ABSOLUTE MAXIMUM RATINGS

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

TOP VIEW

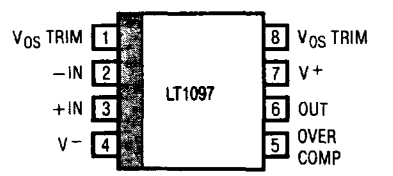


N PACKAGE
8-LEAD PLASTIC DIP

ORDER PART NUMBER

LT1097CN8

TOP VIEW



SO PACKAGE
8-LEAD PLASTIC SOIC

LT1097S8

PART MARKING

1097

2

ELECTRICAL CHARACTERISTICS $V_S = \pm15V$, $V_{CM} = 0V$, $T_A = 25°C$, unless 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_0 = 10Hz f_0 = 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_0 = 10Hz f_0 = 1000Hz		0.030 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 ±13.0		±13 ±11.5	±13.8 ±13.0		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	TYP	MAX	LT1097S8 MIN	TYP	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		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	$V_{OUT} = \pm 12V$, $R_L \ge 10k\Omega$ $V_{OUT} = \pm 10V$, $R_L \ge 2k\Omega$	● ●	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	$R_L = 10k\Omega$	●	±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	TYP	MAX	LT1097S8 MIN	TYP	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	$V_{OUT} = \pm 12V$, $R_L \ge 10k\Omega$ $V_{OUT} = \pm 10V$, $R_L \ge 2k\Omega$	● ●	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	±14.0		±13.5	±14.0		V
V_{OUT}	Output Voltage Swing	$R_L = 10k\Omega$	●	±13	±13.6		±13	±13.6		V
I_S	Supply Current		●		400	800		400	800	μA

The ● denotes the 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.

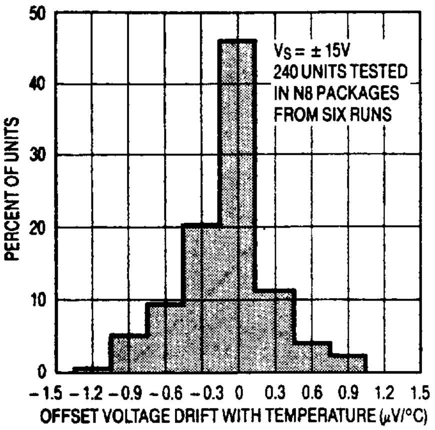
Note 3: Power supply rejection ratio is measured at the minimum supply voltage.

Note 4: This parameter is not 100% tested.

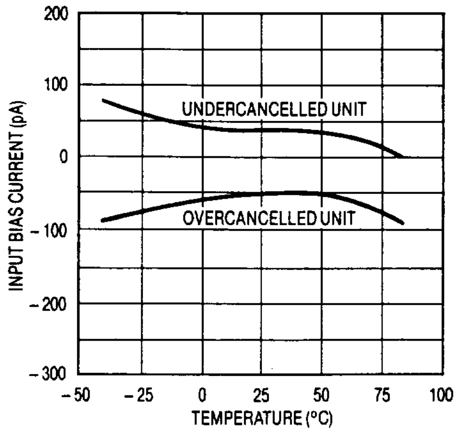
Note 5: The LT1097 is not tested and is not quality-assurance-sampled at −40°C and at 85°C. These specifications are guaranteed by design, correlation and/or inference from 0°C, 25°C and/or 70°C tests.

TYPICAL PERFORMANCE CHARACTERISTICS

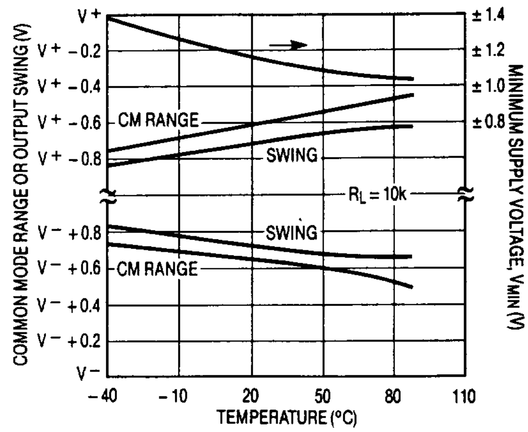
Distribution of Offset Voltage Drift with Temperature



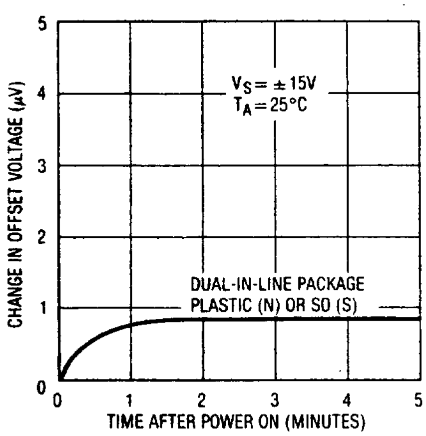
Input Bias Current vs Temperature



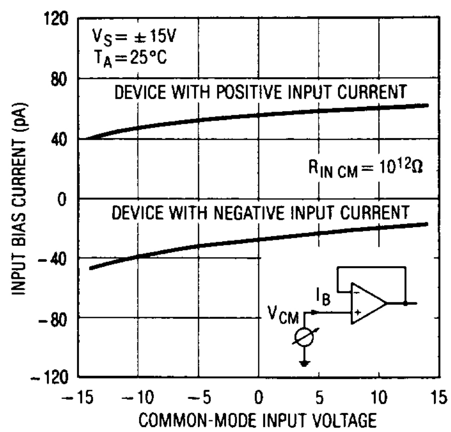
Minimum Supply Voltage, Common Mode Range and Voltage Swing at V_{MIN}



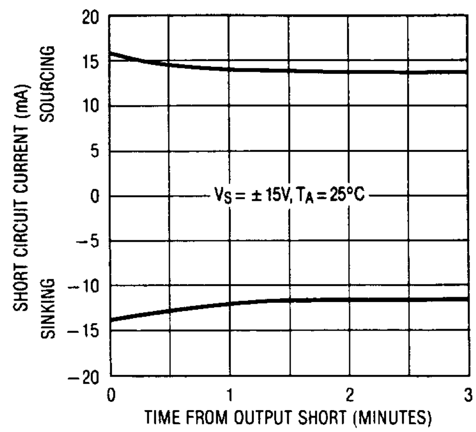
Warm-Up Drift



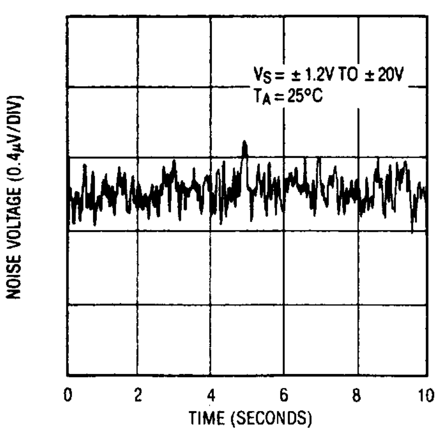
Input Bias Current Over Common Mode Range



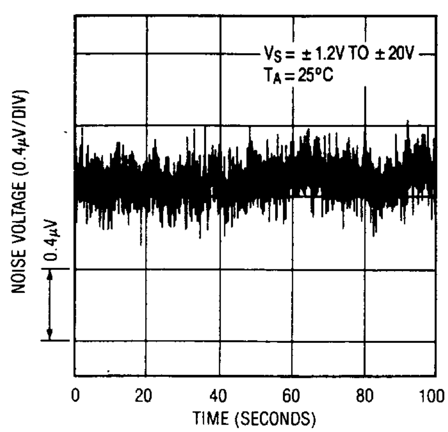
Output Short Circuit Current vs Time



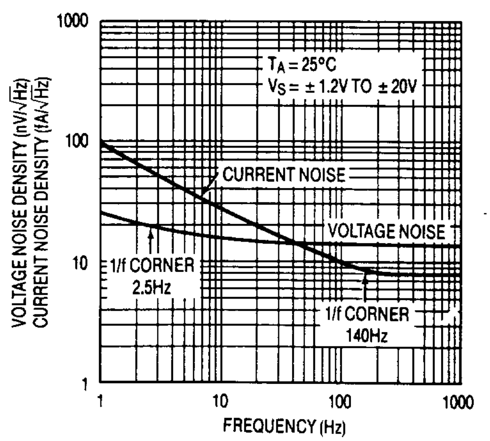
0.1Hz to 10Hz Noise



0.01Hz to 10Hz Noise

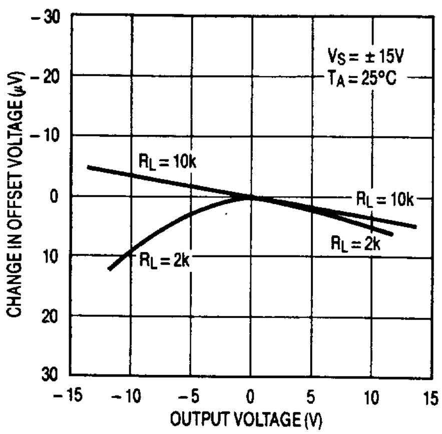


Noise Spectrum

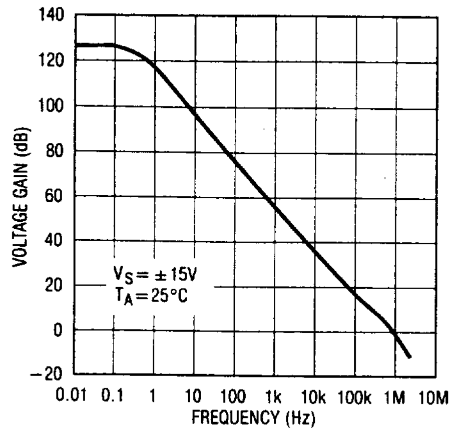


TYPICAL PERFORMANCE CHARACTERISTICS

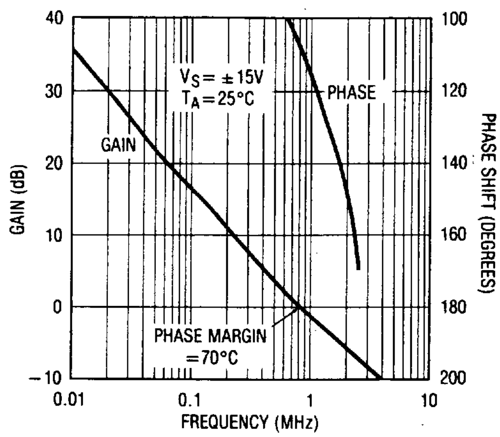
Voltage Gain



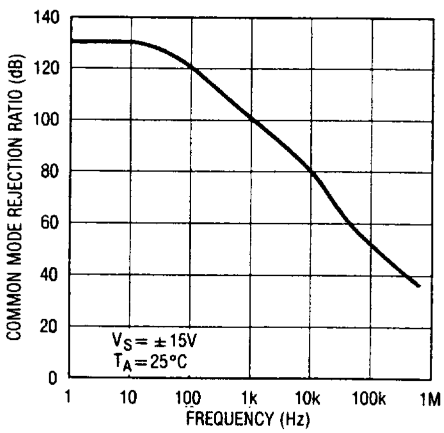
Voltage Gain vs Frequency



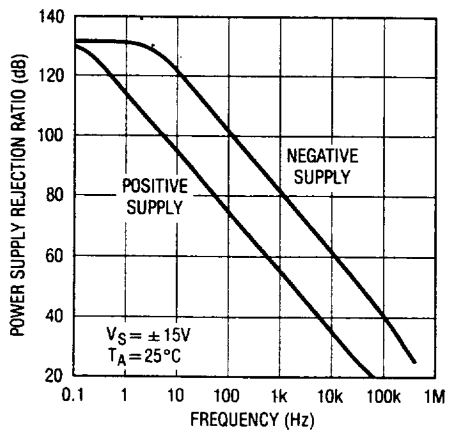
Gain, Phase Shift vs Frequency



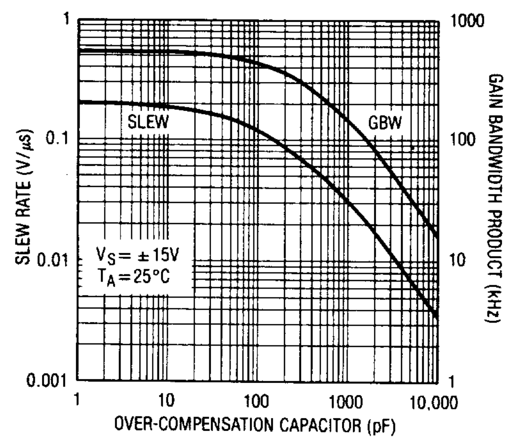
Common Mode Rejection vs Frequency



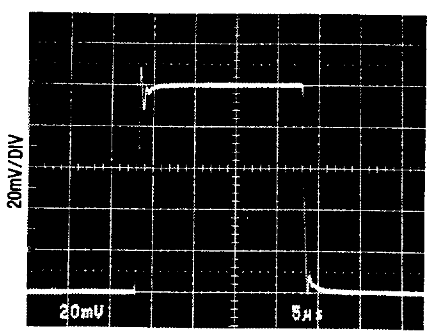
Power Supply Rejection vs Frequency



Slew Rate, Gain Bandwidth Product vs Over-Compensation Capacitor

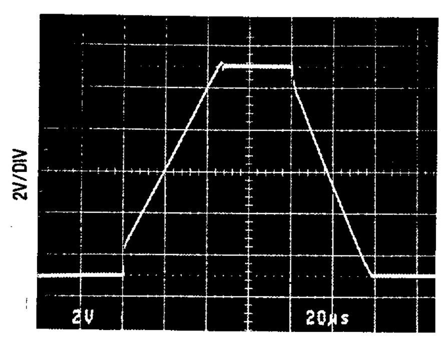


Small Signal Transient Response



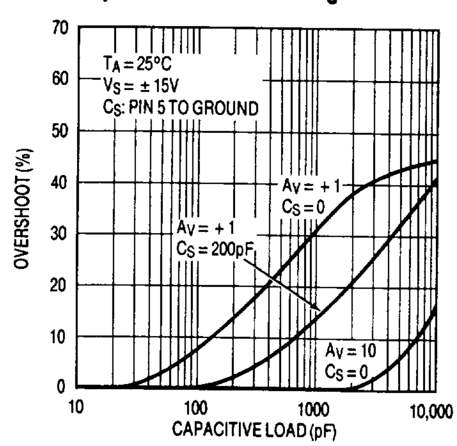
$A_V = +1$, $C_{LOAD} = 100pF$, 5µs/DIV

Large Signal Transient Response



$A_V = +1$, 20µs/DIV

Capacitive Load Handling

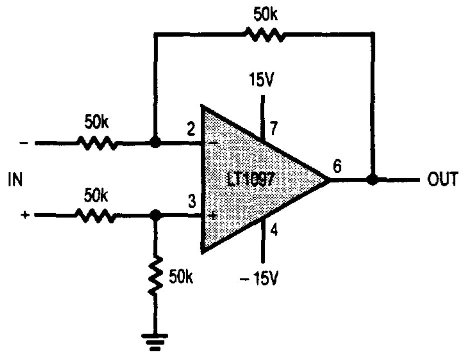


APPLICATIONS INFORMATION

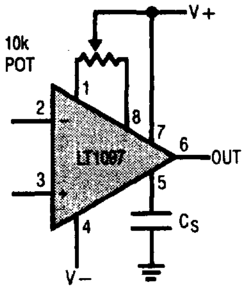
The LT1097 is pin compatible to, and directly replaces such precision op amps as the OP-07, OP-77, AD707, OP-97, OP-177, LM607, and LT1001 with improved price/performance. Compatibility includes externally nulling the offset voltage, as all of the above devices are trimmed with a potentiometer between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

±27V Common Mode Range Difference Amplifier



Frequency Compensation and Optional Offset Nulling



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.

Guaranteed Performance, $V_S = \pm 15V$, $T_A = 25°C$

PARAMETER/UNITS	LT1097CN8	OP-77GP	AD707JN	OP-177GP	OP-97FP
Error Terms in μV					
V_{OS} Max	50	100	90	60	75
I_{OS} Max x 25k	6	70	50	70	4
Gain Min, 10V Out	14	5	3	5	50
CMRR, Min, ±25V In	22	20	13	22	39
PSRR, Min, $V_S = \pm 15V \pm 10\%$	6	9	9	9	9
Sum of All Error Terms, μV	98	204	165	166	177
0.1Hz to 10Hz Noise, μVp-p Typ					
Voltage Noise	0.50	0.38	0.23	0.38	0.50
Current Noise x 50k	0.11	0.75	0.70	0.75	0.10
Resistor Noise	0.55	0.55	0.55	0.55	0.55
RMS Sum μVp-p	0.75	1.00	0.92	1.00	0.75
Drift with Temp, μV/°C					
TCV_{OS} Max	1.0	1.2	1.0	1.2	2.0
TCI_{OS} Max x 25k	0.1	2.1	1.0	2.1	0.2
Sum of Drift Terms μV/°C	1.1	3.3	2.0	3.3	2.2
Supply Current Max, mA	0.56	2.0	3.0	2.0	0.60
Price, 1000's, $	0.97		SIMILAR OR HIGHER		HIGHER

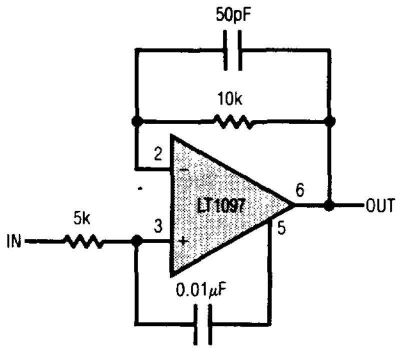
APPLICATIONS INFORMATION

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.

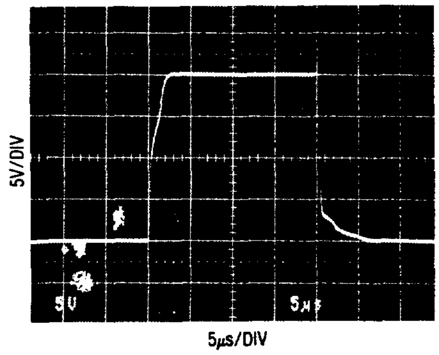
The inputs of the LT1097 are protected with back-to-back diodes. In the voltage follower configuration, when the input is driven by a fast, large signal pulse (>1V), the input protection diodes effectively short the output to the input during slewing, and a current, limited only by the output short circuit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

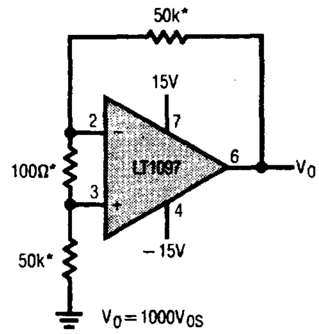
Follower Feedforward Compensation



Pulse Response of Feedforward Compensation



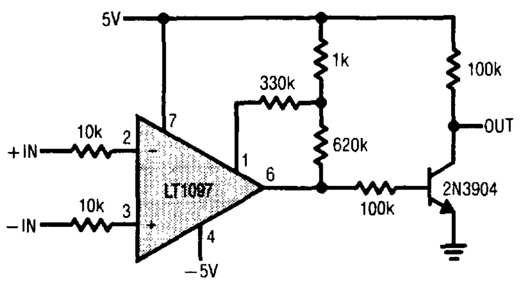
Test Circuit for Offset Voltage and its Drift with Temperature



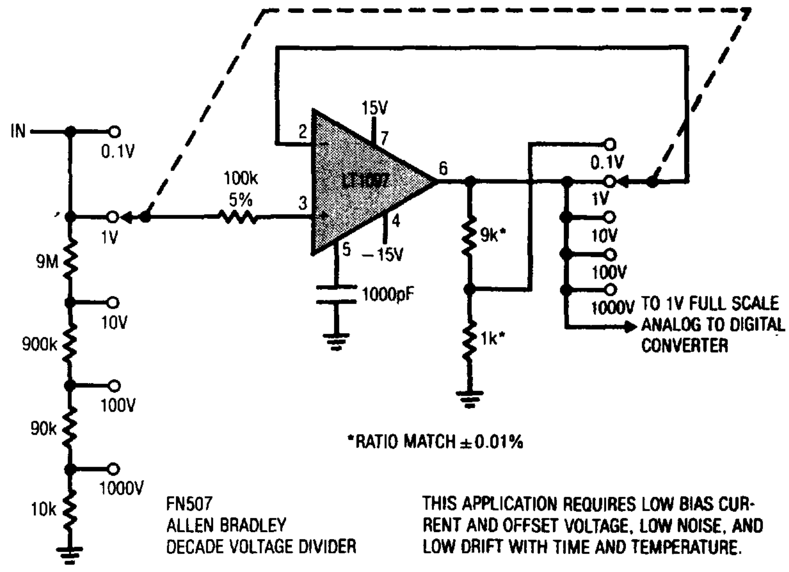
*RESISTORS MUST HAVE LOW THERMOELECTRIC POTENTIAL

TYPICAL APPLICATIONS

Low Power Comparator with <10µV Hysteresis



Input Amplifier for 4 1/2 Digit Voltmeter



THIS APPLICATION REQUIRES LOW BIAS CURRENT AND OFFSET VOLTAGE, LOW NOISE, AND LOW DRIFT WITH TIME AND TEMPERATURE.

SCHEMATIC DIAGRAM