

# Dual Micropower Zero-Drift Operational Amplifier with Internal Capacitors

## FEATURES

- No External Components Required
- Maximum Offset Voltage: 10 $\mu$ V
- Maximum Offset Voltage Drift: 50nV/°C
- Supply Current: 80 $\mu$ A
- Minimum CMRR: 110dB
- Minimum PSRR: 105dB
- Single Supply Operation: 4.75V to 16V
- Common Mode Range Includes GND
- Output Swings to GND
- Typical Overload Recovery Time: 70ms
- Pin Compatible with Industry Standard Dual Op Amps

## APPLICATIONS

- Thermocouple Amplifiers
- Electronic Scales
- Battery Powered Instrumentation
- Strain Gauge Amplifiers
- Remote Located Sensors

## DESCRIPTION

The LTC<sup>®</sup>1047 is a micropower, high performance dual zero-drift operational amplifier. The sample-and-hold capacitors usually required by other chopper amplifiers are integrated on-chip, minimizing the need for external components.

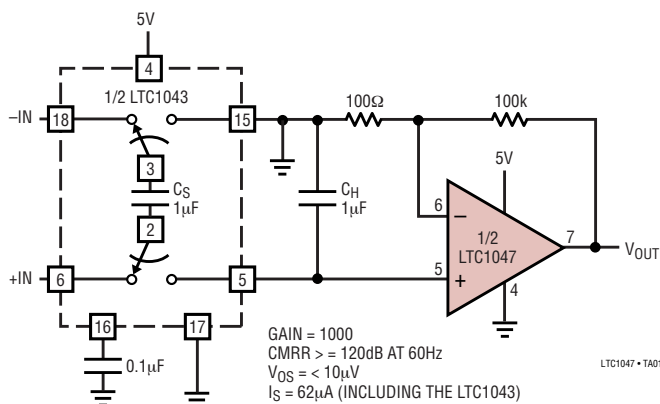
The LTC1047 has a typical offset voltage of 3 $\mu$ V, drift of 10nV/°C, input noise voltage typically 3.5 $\mu$ V<sub>p-p</sub>, and typical voltage gain of 150dB. The common mode rejection is 110dB minimum, with minimum power supply rejection of 105dB. The LTC1047 also offers a 0.2V/ $\mu$ s slew rate and a gain bandwidth product of 200kHz. Overload recovery time from saturation is 70ms, four times faster than chopper amplifiers with external capacitors.

The LTC1047 is available in a standard plastic 8-pin PDIP as well as a 16-pin SW package. The LTC1047 is a plug-in replacement for most dual op amps with improved DC performance and substantial power savings.

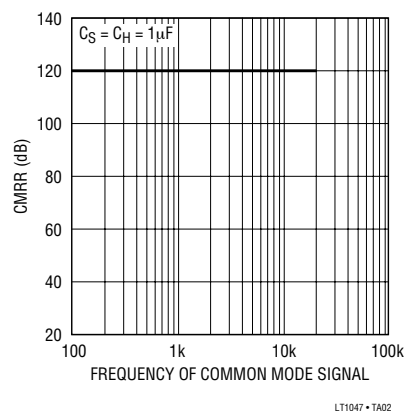
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## TYPICAL APPLICATION

Micropower Single Supply Instrumentation Amplifier



CMRR vs Frequency

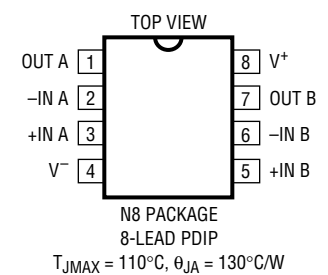
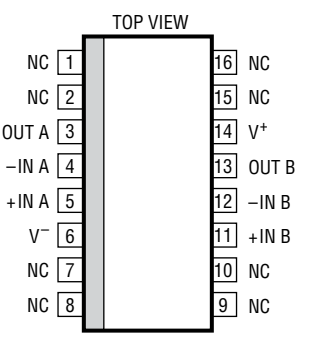


# LTC1047

## ABSOLUTE MAXIMUM RATINGS (Note 1)

Total Supply Voltage ( $V^+$ to $V^-$ ) .....	16V	Storage Temperature Range .....	$-65^{\circ}\text{C}$ to $150^{\circ}\text{C}$
Input Voltage (Note 2) .....	$(V^+ + 0.3\text{V})$ to $(V^- - 0.3\text{V})$	Operating Temperature Range .....	$0^{\circ}\text{C}$ to $70^{\circ}\text{C}$
Output Short-Circuit Duration .....	Indefinite	Lead Temperature (Soldering, 10 sec) .....	$300^{\circ}\text{C}$

## PACKAGE/ORDER INFORMATION

 <p>N8 PACKAGE 8-LEAD PDIP <math>T_{JMAX} = 110^{\circ}\text{C}</math>, <math>\theta_{JA} = 130^{\circ}\text{C/W}</math></p>	ORDER PART NUMBER	 <p>SW PACKAGE 16-LEAD PLASTIC SO WIDE <math>T_{JMAX} = 110^{\circ}\text{C}</math>, <math>\theta_{JA} = 200^{\circ}\text{C/W}</math></p>	ORDER PART NUMBER
	LTC1047CN8		LTC1047CSW

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

## ELECTRICAL CHARACTERISTICS The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^{\circ}\text{C}$ . $V_S = \pm 5\text{V}$ , unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^{\circ}\text{C}$ (Note 3)		$\pm 3$	$\pm 10$	$\mu\text{V}$
Average Input Offset Voltage Drift	(Note 3)	●	$\pm 0.01$	$\pm 0.05$	$\mu\text{V}/^{\circ}\text{C}$
Long Term Offset Drift			100		$\text{nV}/\sqrt{\text{mo}}$
Input Bias Current		●	$\pm 5$	$\pm 30$ $\pm 300$	$\text{pA}$ $\text{pA}$
Input Offset Current		●	$\pm 10$	$\pm 60$ $\pm 150$	$\text{pA}$ $\text{pA}$
Input Noise Voltage	0.1Hz to 10Hz		3.5		$\mu\text{V}_{\text{p-p}}$
	0.1Hz to 1Hz		0.8		$\mu\text{V}_{\text{p-p}}$
Input Noise Current	$f = 10\text{Hz}$ (Note 4)		1.5		$\text{fA}/\sqrt{\text{Hz}}$
Common Mode Rejection Ratio	$V_{\text{CM}} = V^-$ to $2.7\text{V}$ , $T_A = 25^{\circ}\text{C}$	●	110 105	130	$\text{dB}$ $\text{dB}$
Power Supply Rejection Ratio	$V_S = \pm 2.375\text{V}$ to $\pm 8\text{V}$	●	105	122	$\text{dB}$
Large-Signal Voltage Gain	$R_L = 100\text{k}$ , $V_{\text{OUT}} = \pm 4\text{V}$	●	120	150	$\text{dB}$
Maximum Output Voltage Swing	$R_L = 10\text{k}$			4.3/-4.8	V
	$R_L = 100\text{k}$	●	4.8/-4.9	$\pm 4.95$	V

**ELECTRICAL CHARACTERISTICS** The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_S = \pm 5\text{V}$ , unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Slew Rate	$R_L = 100\text{k}, C_L = 50\text{pF}$		0.2		$\text{V}/\mu\text{s}$
Gain Bandwidth Product			200		$\text{kHz}$
Supply Current/Amplifier	No Load, $25^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$		60	150	$\mu\text{A}$
	No Load, $0^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$		80	275	$\mu\text{A}$
Internal Sampling Frequency			680		$\text{Hz}$

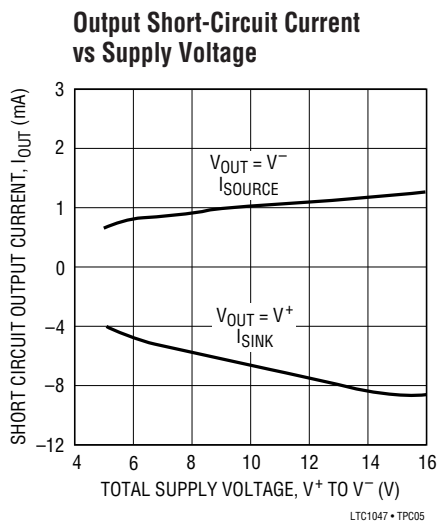
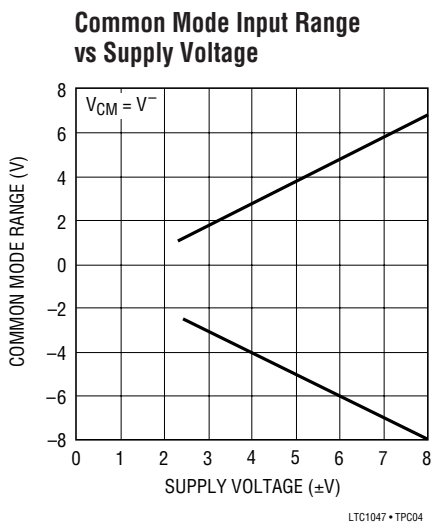
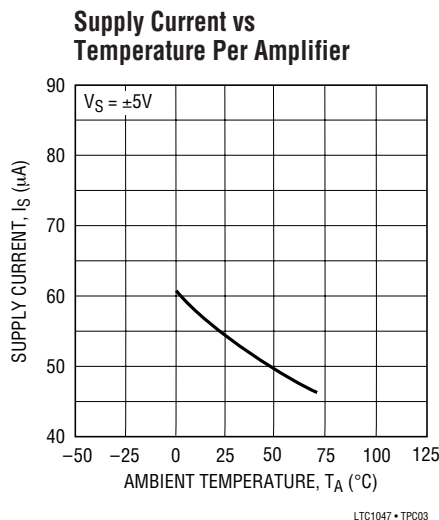
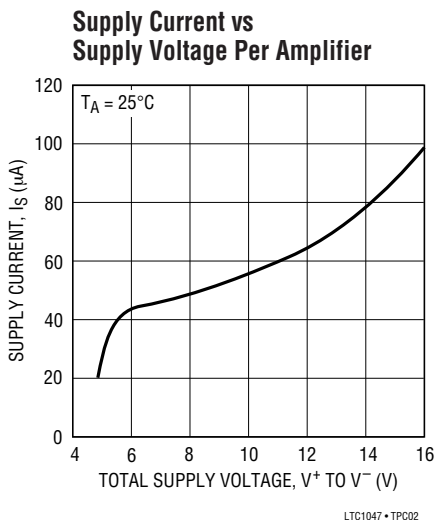
**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** Connecting any terminal to voltages greater than  $V^+$  or less than  $V^-$  may cause destructive latch-up. It is recommended that no sources operating from external supplies be applied prior to power-up of the LTC1047.

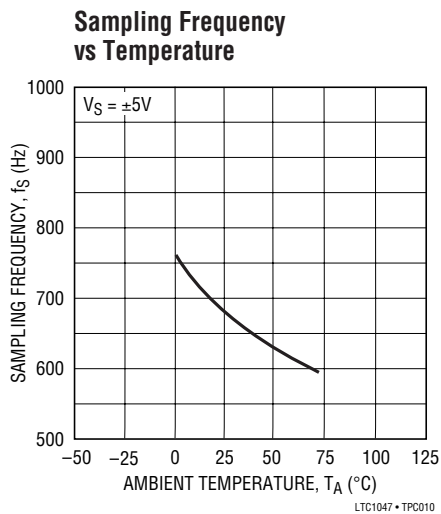
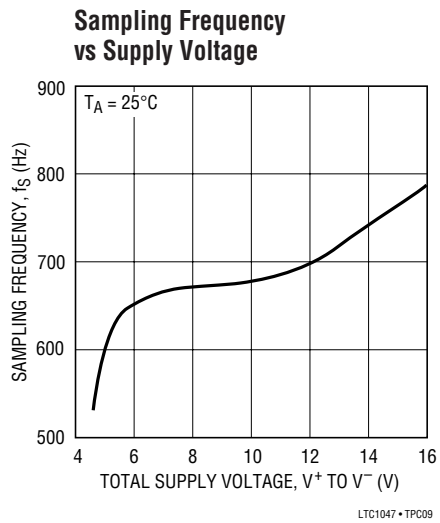
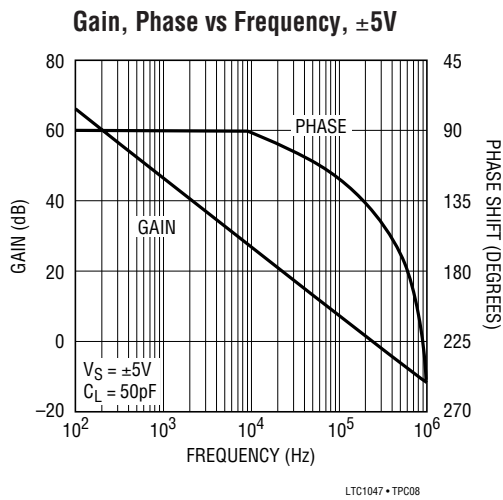
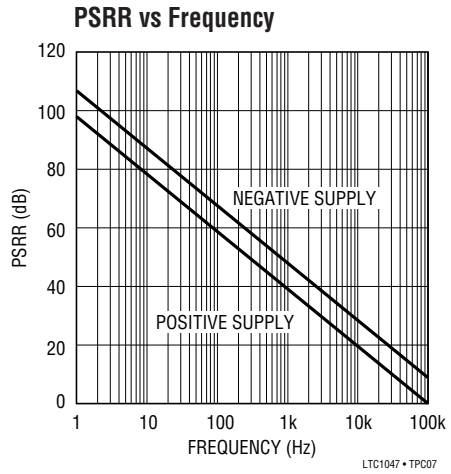
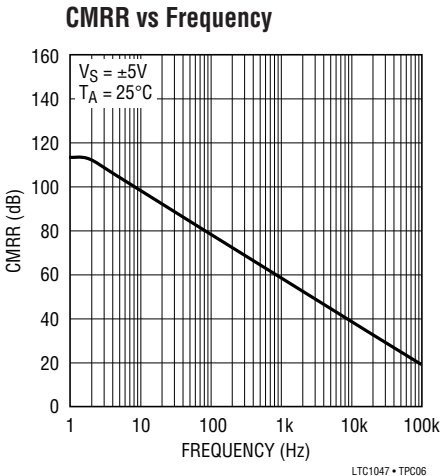
**Note 3:** These parameters are guaranteed by design. Thermocouple effects preclude measurements of these voltage levels in high speed automatic test systems.  $V_{OS}$  is measured to a limit determined by test equipment capability.

**Note 4:** Current Noise is calculated from the formula:  $I_n = \sqrt{2q \cdot |I_B|}$  where  $q = 1.6 \cdot 10^{-19}$  Coulomb.

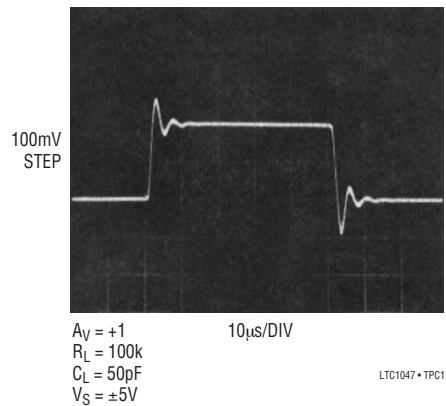
**TYPICAL PERFORMANCE CHARACTERISTICS**



## TYPICAL PERFORMANCE CHARACTERISTICS

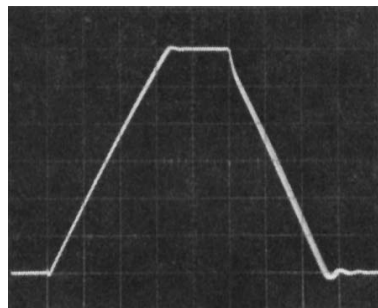


### Small-Signal Transient Response



# TYPICAL PERFORMANCE CHARACTERISTICS

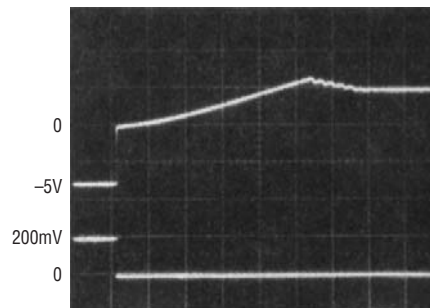
Large-Signal Transient Response



$A_V = +1$   
 $R_L = 100k$   
 $C_L = 50pF$   
 $V_S = \pm 5V$

LTC1047 • TPC12

Overload Recovery

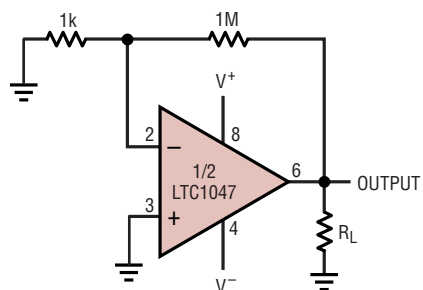


$A_V = 100$   
 $V_S = \pm 5V$

LTC1047 • TPC13

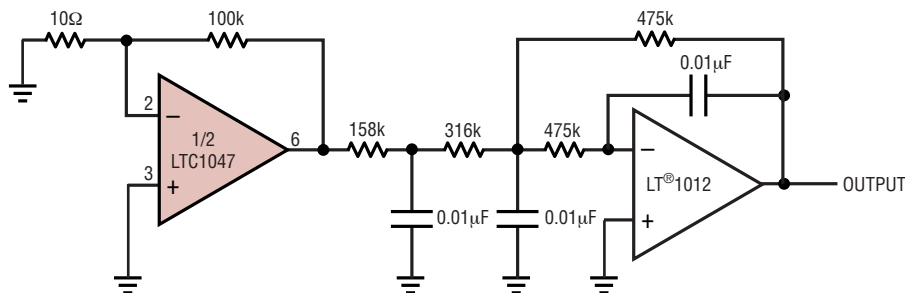
# TEST CIRCUITS

Electrical Characteristics Test Circuit



LTC1047 • TC01

DC to 10Hz Noise Test Circuit



FOR 1Hz NOISE BANDWIDTH, INCREASE ALL CAPACITORS BY A FACTOR OF 10

LTC1047 • TC02

## APPLICATIONS INFORMATION

### Input Considerations

Frequently circuits built with parts as precise as the LTC1047 show errors at the output far greater than the designer expects. Rarely is the problem the op amp; more often the surrounding circuitry is causing errors several orders of magnitude greater than those due to the LTC1047. Such obscure effects as leakage between pins, due to residual solder flux and thermocouple effects between the tin/lead solder and the copper PC board traces, can overwhelm the pA-level bias currents and the  $\mu\text{V}$ -level offset of the LTC1047. For a more complete description of these types of problems (and some advice on avoiding them), see the LTC1051/LTC1053 data sheet.

### Input Capacitance

The LTC1047 has approximately 12pF of capacitance at each input pin. This will react with large series resistors to form a pole at the input, degrading the LTC1047's phase margin. The problem is especially common with micropower parts like the LTC1047 because high value resistors are often used to minimize power dissipation. As a rule of thumb, bypass feedback resistors larger than 7k with a 20pF capacitor to minimize this effect.

### Aliasing

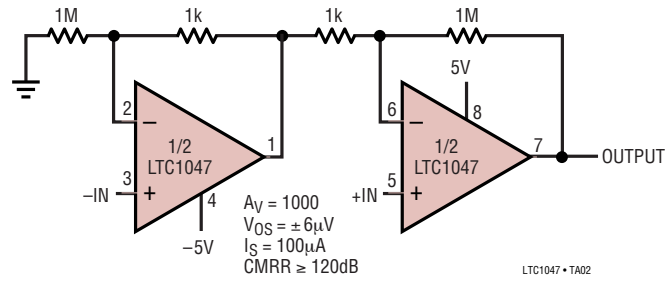
Like all sampled data systems, the LTC1047 will alias input signals near its internal sampling frequency. The design includes internal circuitry to minimize this effect; as a result, most applications do not exhibit aliasing problems. For a complete discussion of the correction circuitry and aliasing behavior, refer to the LTC1051/LTC1053 data sheet.

### Single Supply Operation

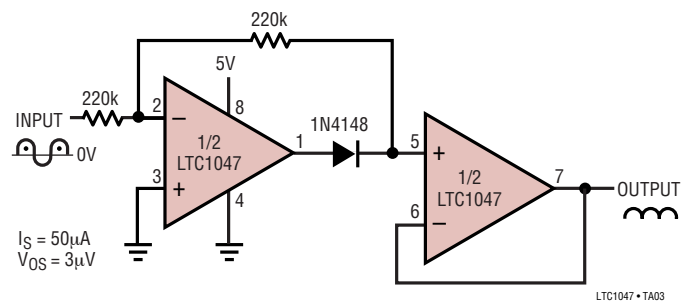
The LTC1047 is compatible with all single supply applications. It has an input common mode range which includes  $V^-$ , and an output which will swing within millivolts of the negative power supply. The LTC1047 is guaranteed functional down to 4.75V total supply, allowing it to run from minimum TTL voltage all the way up to 16V. See the Typical Applications section for examples of single supply operation.

# TYPICAL APPLICATIONS

Low Offset, Low Drift Instrumentation Amplifier

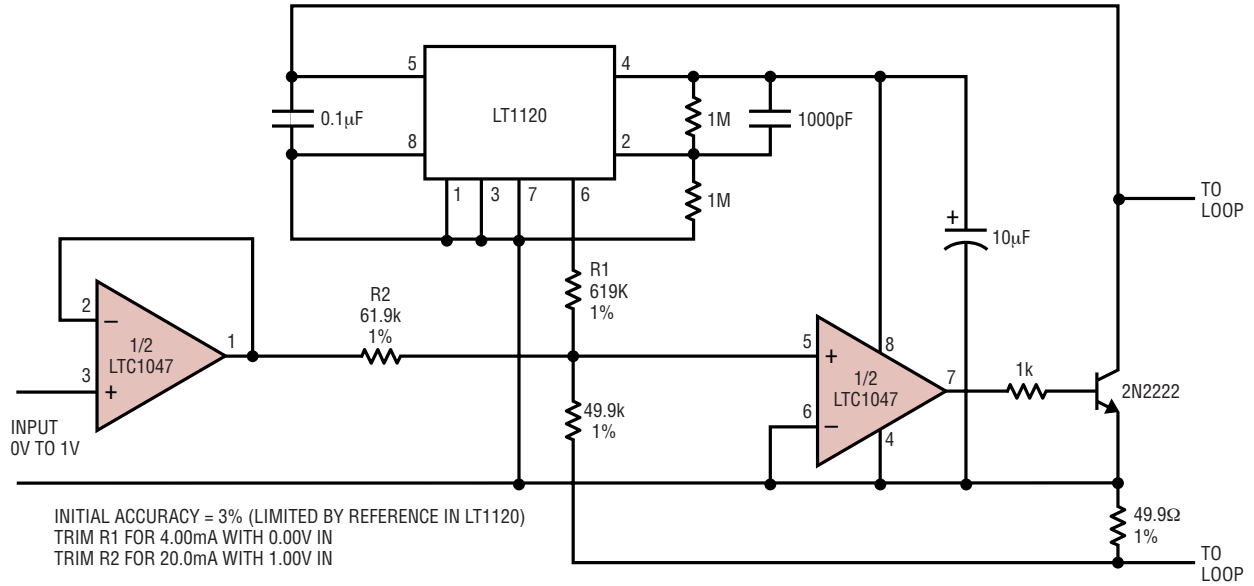


Precise DC Full-Wave Rectifier (Absolute Value Circuit)



TYPICAL APPLICATIONS

4mA to 20mA Transducer Amplifier

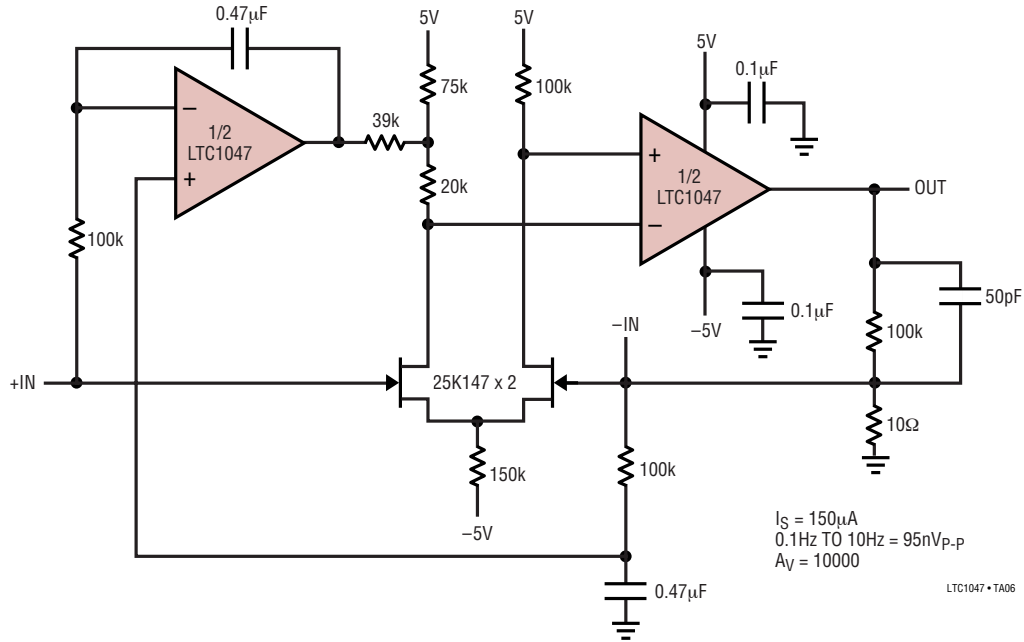


LTC1047 • TA04

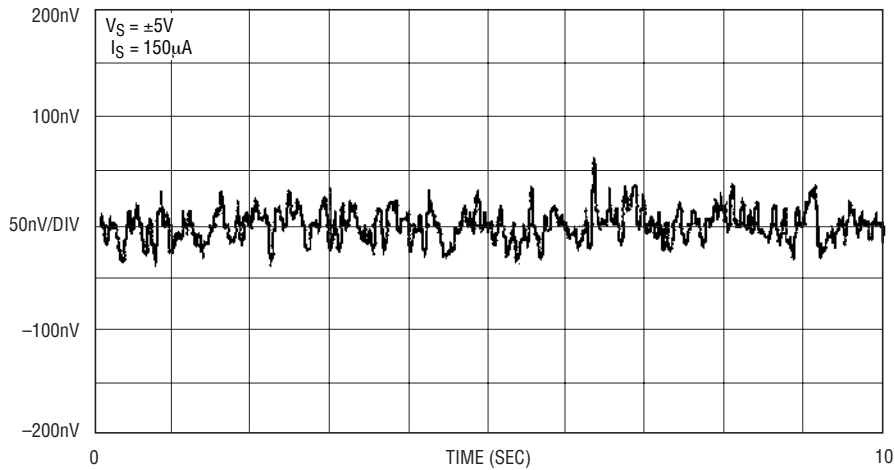


# TYPICAL APPLICATIONS

### Ultralow Noise Micropower Chopper



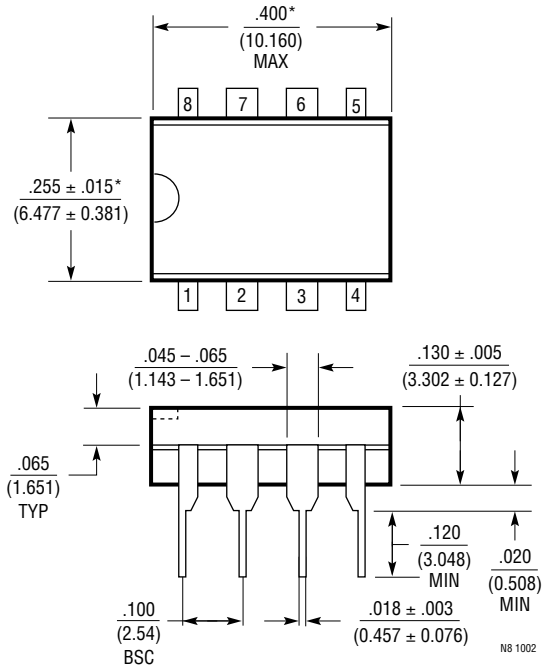
### 0.1Hz to 10Hz Noise (Input Referred)



LTC1047 • TA07

**PACKAGE DESCRIPTION**

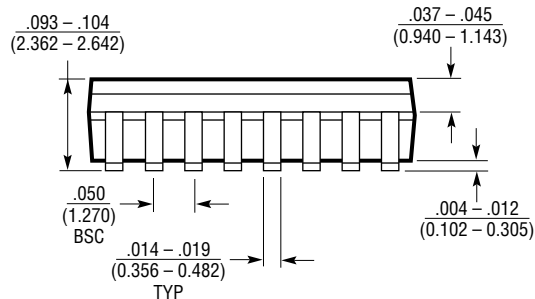
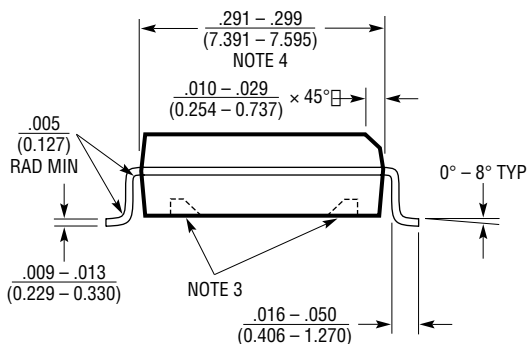
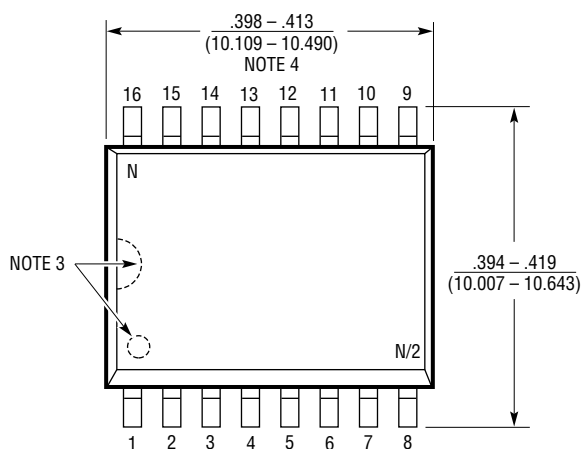
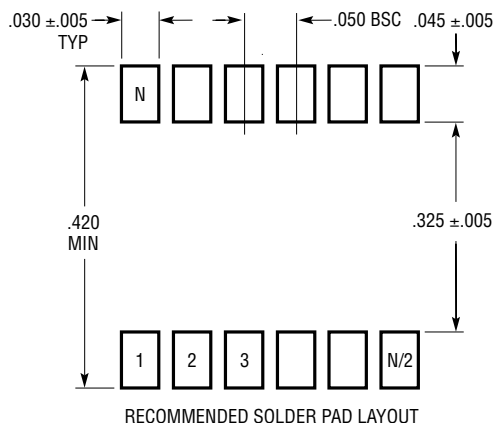
**N8 Package**  
**8-Lead PDIP (Narrow .300 Inch)**  
 (Reference LTC DWG # 05-08-1510)



NOTE:  
 1. DIMENSIONS ARE  $\frac{\text{INCHES}}{\text{MILLIMETERS}}$   
 \*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
 MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

# PACKAGE DESCRIPTION

## SW Package 16-Lead Plastic Small Outline (Wide .300 Inch) (Reference LTC DWG # 05-08-1620)



- NOTE:
1. DIMENSIONS IN  $\frac{\text{INCHES}}{\text{MILLIMETERS}}$
  2. DRAWING NOT TO SCALE
  3. PIN 1 IDENT, NOTCH ON TOP AND CAVITIES ON THE BOTTOM OF PACKAGES ARE THE MANUFACTURING OPTIONS. THE PART MAY BE SUPPLIED WITH OR WITHOUT ANY OF THE OPTIONS
  4. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

S16 (WIDE) 0502

**TYPICAL APPLICATION**

**Low Noise, Low Drift Composite Amplifier**

