

# LTC1069-1

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

Total Supply Voltage ( $V^+$  to  $V^-$ ) ..... 12V  
 Maximum Voltage at  
 Any Pin ..... ( $V^- - 0.3V$ )  $\leq V \leq$  ( $V^+ + 0.3V$ )

Operating Temperature Range

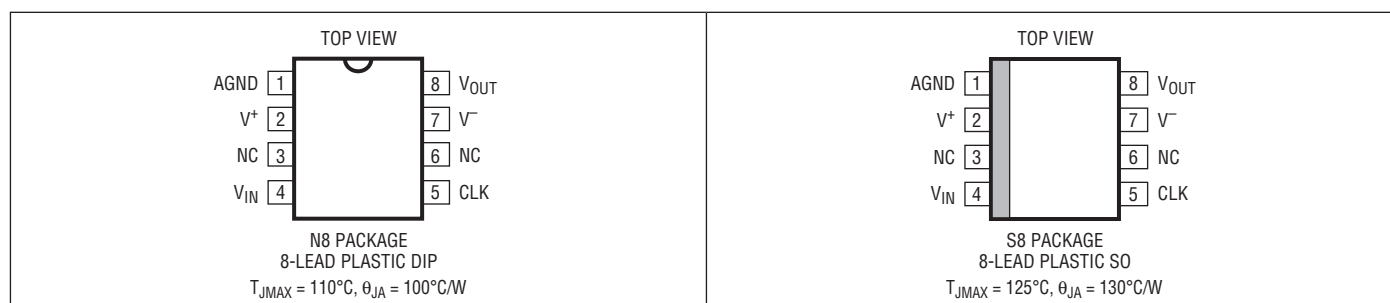
LTC1069C-1 ..... 0°C to 70°C

LTC1069I-1 ..... -40°C to 85°C

Storage Temperature ..... -65°C to 150°C

Lead Temperature (Soldering, 10 sec) ..... 300°C

## PIN CONFIGURATION



## ORDER INFORMATION

| LEAD FREE FINISH | TAPE AND REEL      | PART MARKING* | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE |
|------------------|--------------------|---------------|---------------------|-----------------------------|
| LTC1069-1CN8#PBF |                    | LTC1069-1     | 8-Lead Plastic DIP  | 0°C to 70°C                 |
| LTC1069-1IN8#PBF |                    | LTC1069-1     | 8-Lead Plastic DIP  | -40°C to 85°C               |
| LTC1069-1CS8#PBF | LTC1069-1CS8#TRPBF | 10691         | 8-Lead Plastic SO   | 0°C to 70°C                 |
| LTC1069-1IS8#PBF | LTC1069-1IS8#TRPBF | 10691I        | 8-Lead Plastic SO   | -40°C to 85°C               |

Consult LTC Marketing for parts specified with wider operating temperature ranges. \*The temperature grade is identified by a label on the shipping container. Consult LTC Marketing for information on non-standard lead based finish parts.

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

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $f_{\text{CUTOFF}}$  is the filter's cutoff frequency and is equal to  $f_{\text{CLK}}/100$ . The  $f_{\text{CLK}}$  signal level is TTL or CMOS (clock rise or fall time  $\leq 1\mu\text{s}$ ),  $V_S = 3.3\text{V}$  to  $\pm 5\text{V}$ ,  $R_L = 10\text{k}$ , unless otherwise noted. All AC gains are measured relative to the passband gain.

| PARAMETER  | CONDITIONS  | MIN            | TYP | MAX          | UNITS |
|--|---|----------------|-----|--------------|-------|
| Passband Gain ( $f_{\text{IN}} \leq 0.25f_{\text{CUTOFF}}$ ) | $V_S = \pm 5\text{V}$ , $f_{\text{CLK}} = 500\text{kHz}$<br>$f_{\text{TEST}} = 1.25\text{kHz}$ , $V_{\text{IN}} = 1\text{V}_{\text{RMS}}$ | -0.30<br>-0.35 | 0.2 | 0.70<br>0.75 | dB    |
|  | $V_S = 3.3\text{V}$ , $f_{\text{CLK}} = 200\text{kHz}$<br>$f_{\text{TEST}} = 0.5\text{kHz}$ , $V_{\text{IN}} = 0.5\text{V}_{\text{RMS}}$  | -0.30<br>-0.35 | 0.2 | 0.70<br>0.75 | dB    |

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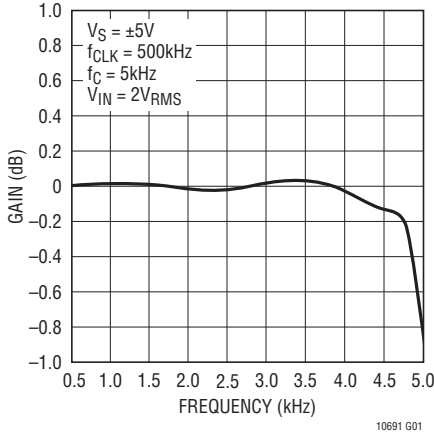
**ELECTRICAL CHARACTERISTICS** The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $f_{\text{CUTOFF}}$  is the filter's cutoff frequency and is equal to  $f_{\text{CLK}}/100$ . The  $f_{\text{CLK}}$  signal level is TTL or CMOS (clock rise or fall time  $\leq 1\mu\text{s}$ ),  $V_S = 3.3\text{V}$  to  $\pm 5\text{V}$ ,  $R_L = 10\text{k}$ , unless otherwise noted. All AC gains are measured relative to the passband gain.

| PARAMETER                        | CONDITIONS   | MIN            | TYP       | MAX                | UNITS            |
|----------------------------------|--|----------------|-----------|--------------------|------------------|
| Gain at $0.50f_{\text{CUTOFF}}$  | $V_S = \pm 5\text{V}$ , $f_{\text{CLK}} = 500\text{kHz}$<br>$f_{\text{TEST}} = 2.5\text{kHz}$ , $V_{\text{IN}} = 1V_{\text{RMS}}$ ●  | -0.10<br>-0.11 | -0.03     | 0.10<br>0.11       | dB<br>dB         |
|                                  | $V_S = 3.3\text{V}$ , $f_{\text{CLK}} = 200\text{kHz}$<br>$f_{\text{TEST}} = 1\text{kHz}$ , $V_{\text{IN}} = 0.5V_{\text{RMS}}$ ●    | -0.10<br>-0.11 | -0.03     | 0.10<br>0.11       | dB<br>dB         |
| Gain at $0.75f_{\text{CUTOFF}}$  | $V_S = \pm 5\text{V}$ , $f_{\text{CLK}} = 500\text{kHz}$<br>$f_{\text{TEST}} = 3.75\text{kHz}$ , $V_{\text{IN}} = 1V_{\text{RMS}}$ ● | -0.20<br>-0.25 | 0.04      | 0.20<br>0.25       | dB<br>dB         |
|                                  | $V_S = 3.3\text{V}$ , $f_{\text{CLK}} = 200\text{kHz}$<br>$f_{\text{TEST}} = 1.5\text{kHz}$ , $V_{\text{IN}} = 0.5V_{\text{RMS}}$ ●  | -0.20<br>-0.25 | 0.04      | 0.20<br>0.25       | dB<br>dB         |
| Gain at $0.90f_{\text{CUTOFF}}$  | $V_S = \pm 5\text{V}$ , $f_{\text{CLK}} = 500\text{kHz}$<br>$f_{\text{TEST}} = 4.5\text{kHz}$ , $V_{\text{IN}} = 1V_{\text{RMS}}$ ●  | -0.20<br>-0.25 | -0.01     | 0.20<br>0.25       | dB<br>dB         |
|                                  | $V_S = 3.3\text{V}$ , $f_{\text{CLK}} = 200\text{kHz}$<br>$f_{\text{TEST}} = 1.8\text{kHz}$ , $V_{\text{IN}} = 0.5V_{\text{RMS}}$ ●  | -0.20<br>-0.25 | -0.01     | 0.20<br>0.25       | dB<br>dB         |
| Gain at $0.95f_{\text{CUTOFF}}$  | $V_S = \pm 5\text{V}$ , $f_{\text{CLK}} = 500\text{kHz}$<br>$f_{\text{TEST}} = 4.75\text{kHz}$ , $V_{\text{IN}} = 1V_{\text{RMS}}$ ● | -0.30<br>-0.35 | -0.05     | 0.30<br>0.35       | dB<br>dB         |
|                                  | $V_S = 3.3\text{V}$ , $f_{\text{CLK}} = 200\text{kHz}$<br>$f_{\text{TEST}} = 1.9\text{kHz}$ , $V_{\text{IN}} = 0.5V_{\text{RMS}}$ ●  | -0.30<br>-0.35 | -0.04     | 0.30<br>0.35       | dB<br>dB         |
| Gain at $f_{\text{CUTOFF}}$      | $V_S = \pm 5\text{V}$ , $f_{\text{CLK}} = 500\text{kHz}$<br>$f_{\text{TEST}} = 5.0\text{kHz}$ , $V_{\text{IN}} = 1V_{\text{RMS}}$ ●  | -1.25<br>-1.35 | -0.70     | -0.25<br>-0.15     | dB<br>dB         |
|                                  | $V_S = 3.3\text{V}$ , $f_{\text{CLK}} = 200\text{kHz}$<br>$f_{\text{TEST}} = 2.0\text{kHz}$ , $V_{\text{IN}} = 0.5V_{\text{RMS}}$ ●  | -1.25<br>-1.35 | -0.61     | -0.25<br>-0.15     | dB<br>dB         |
| Gain at $1.25f_{\text{CUTOFF}}$  | $V_S = \pm 5\text{V}$ , $f_{\text{CLK}} = 500\text{kHz}$<br>$f_{\text{TEST}} = 6.25\text{kHz}$ , $V_{\text{IN}} = 1V_{\text{RMS}}$ ● | -30<br>-31     | -27       | -25<br>-24         | dB<br>dB         |
|                                  | $V_S = 3.3\text{V}$ , $f_{\text{CLK}} = 200\text{kHz}$<br>$f_{\text{TEST}} = 2.5\text{kHz}$ , $V_{\text{IN}} = 0.5V_{\text{RMS}}$ ●  | -30<br>-31     | -27       | -25<br>-24         | dB<br>dB         |
| Gain at $1.50f_{\text{CUTOFF}}$  | $V_S = \pm 5\text{V}$ , $f_{\text{CLK}} = 500\text{kHz}$<br>$f_{\text{TEST}} = 7.5\text{kHz}$ , $V_{\text{IN}} = 1V_{\text{RMS}}$ ●  | -58<br>-59     | -53       | -50<br>-49         | dB<br>dB         |
|                                  | $V_S = 3.3\text{V}$ , $f_{\text{CLK}} = 200\text{kHz}$<br>$f_{\text{TEST}} = 3\text{kHz}$ , $V_{\text{IN}} = 0.5V_{\text{RMS}}$ ●    | -58<br>-59     | -53       | -50<br>-49         | dB<br>dB         |
| Output DC Offset (Input at AGND) | $V_S = \pm 5\text{V}$ , $f_{\text{CLK}} = 500\text{kHz}$   |                | 30        | 150                | mV               |
|                                  | $V_S = 4.75\text{V}$ , $f_{\text{CLK}} = 400\text{kHz}$  |                | 20        |                    | mV               |
|                                  | $V_S = 3.3\text{V}$ , $f_{\text{CLK}} = 200\text{kHz}$   |                | 15        | 100                | mV               |
| Output Voltage Swing             | $V_S = \pm 5\text{V}$ ●  | -3.25          | $\pm 4.0$ | 3.25               | V                |
|                                  | $V_S = 4.75\text{V}$ ●   | -1.50          | $\pm 1.7$ | 1.25               | V                |
|                                  | $V_S = 3.3\text{V}$ ●  | -0.70          | $\pm 0.9$ | 0.60               | V                |
| Power Supply Current             | $V_S = \pm 5\text{V}$ , $f_{\text{CLK}} = 500\text{kHz}$ ●   |                | 3.8       | 5.5                | mA               |
|                                  | $V_S = 4.75\text{V}$ , $f_{\text{CLK}} = 400\text{kHz}$ ●  |                | 2.5       | 4.5                | mA               |
|                                  | $V_S = 3.3\text{V}$ , $f_{\text{CLK}} = 200\text{kHz}$ ●   |                | 2.0       | 3.5                | mA               |
| Maximum Clock Frequency          | $V_S = \pm 5\text{V}$  |                | 1.2       |                    | MHz              |
|                                  | $V_S = 4.75\text{V}$   |                | 0.8       |                    | MHz              |
|                                  | $V_S = 3.3\text{V}$  |                | 0.5       |                    | MHz              |
| Input Frequency Range            |  | 0              |           | $f_{\text{CLK}}/2$ | MHz              |
| Input Resistance                 |  | 30             | 43        | 70                 | $\text{k}\Omega$ |
| Operating Power Supply Voltage   |  | $\pm 1.57$     |           | $\pm 5.5$          | V                |

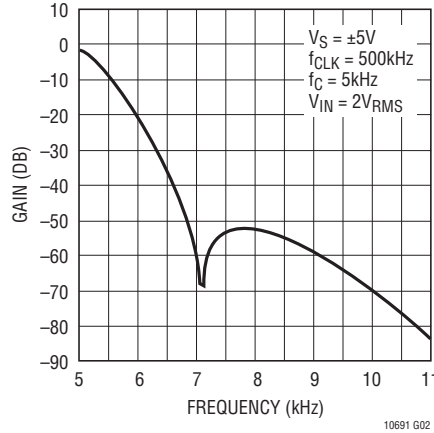
**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

# TYPICAL PERFORMANCE CHARACTERISTICS

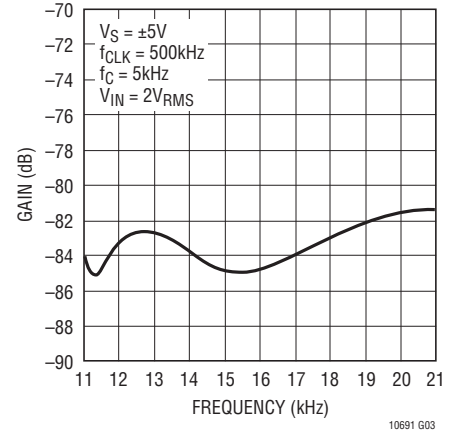
Passband Gain vs Frequency



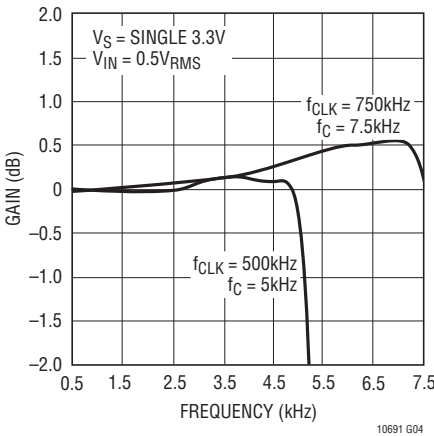
Transition Band Gain vs Frequency



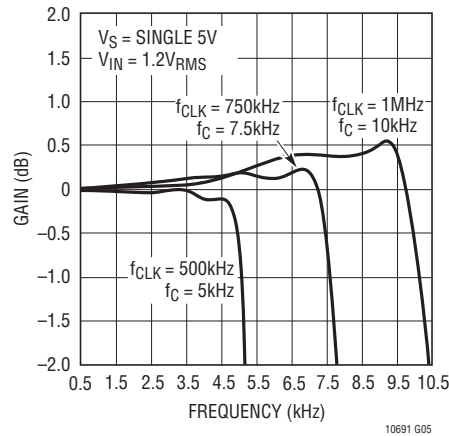
Stopband Gain vs Frequency



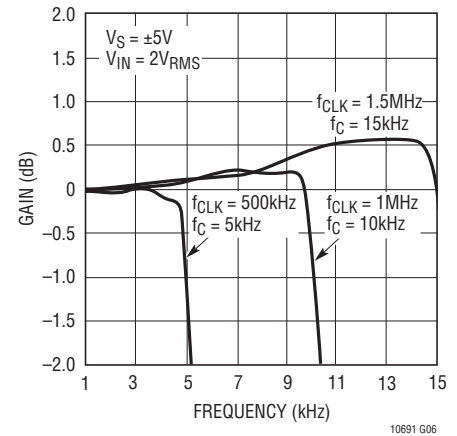
Passband Gain vs Clock Frequency,  $V_S$  = Single 3.3V



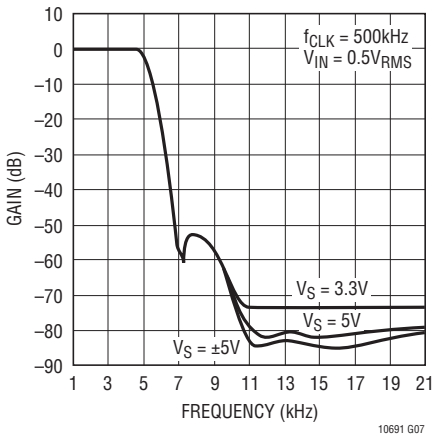
Passband Gain vs Clock Frequency,  $V_S$  = Single 5V



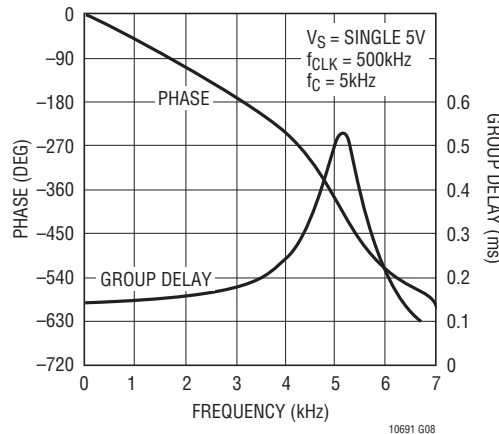
Passband Gain vs Clock Frequency,  $V_S$  = ±5V



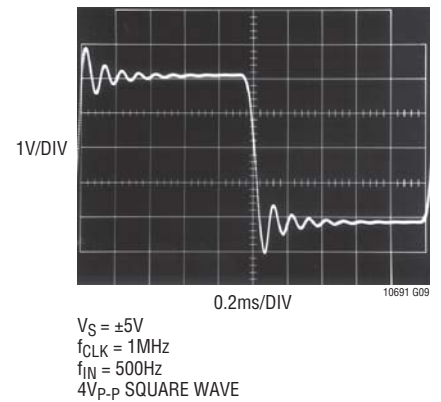
Gain vs Supply Voltage



Phase and Group Delay vs Frequency

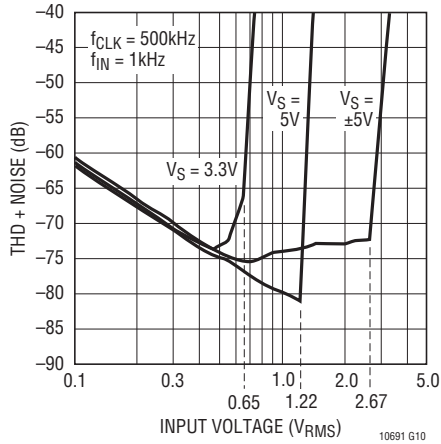


Transient Response

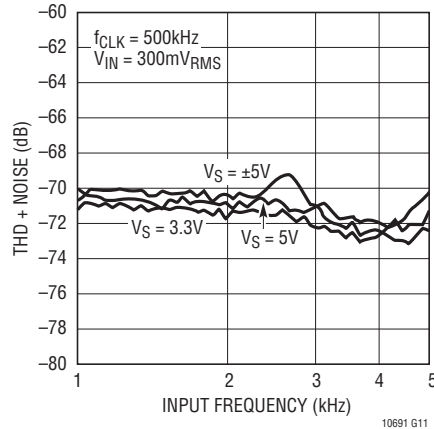


# TYPICAL PERFORMANCE CHARACTERISTICS

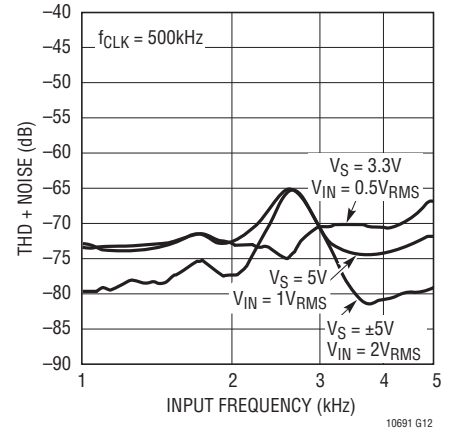
**Dynamic Range**  
**THD + Noise vs  $V_{IN}$  ( $V_{RMS}$ )**



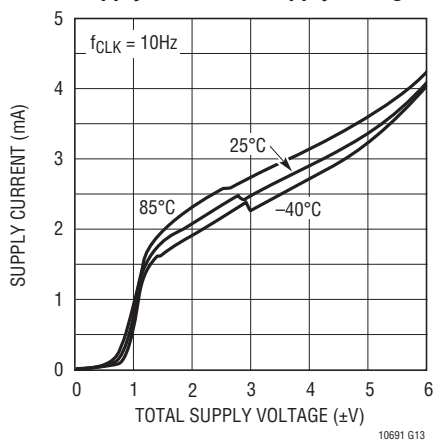
**THD + Noise vs Frequency**



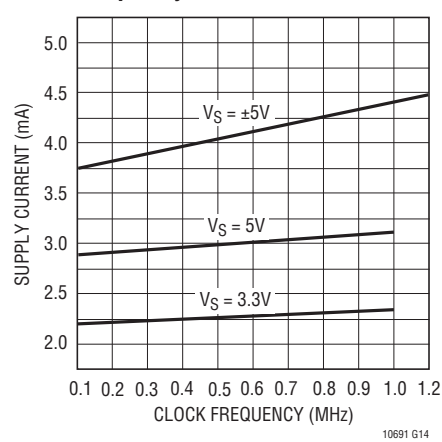
**THD + Noise vs Frequency**



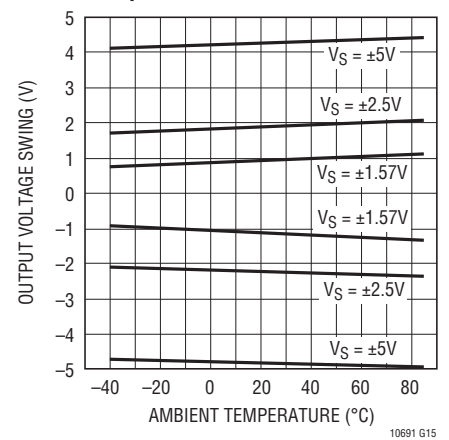
**Supply Current vs Supply Voltage**



**Supply Current vs Clock Frequency**



**Output Voltage Swing vs Temperature**



## PIN FUNCTIONS

**AGND (Pin 1):** Analog Ground. The quality of the analog signal ground can affect the filter performance. For either single or dual supply operation, an analog ground plane surrounding the package is recommended. The analog ground plane should be connected to any digital ground at a single point. For dual supply operation Pin 1 should be connected to the analog ground plane.

For single supply operation Pin 1 should be bypassed to the analog ground plane with a  $0.47\mu\text{F}$  or larger capacitor. An internal resistive divider biases Pin 1 to  $1/2$  the total power supply. Pin 1 should be buffered if used to bias other ICs. Figure 1 shows the connections for single supply operation.

**V<sup>+</sup>, V<sup>-</sup> (Pins 2, 7):** Power Supply Pins. The V<sup>+</sup> (Pin 2) and the V<sup>-</sup> (Pin 7) should be bypassed with a  $0.1\mu\text{F}$  capacitor to an adequate analog ground. The filter's power supplies should be isolated from other digital or high voltage analog supplies. A low noise linear supply is recommended. Using switching power supplies will lower the signal-to-noise ratio of the filter. Unlike previous monolithic filters, the power supplies can be applied at any order, that is, the positive supply can be applied before the negative supply and vice versa. Figure 2 shows the connection for dual supply operation.

**NC (Pins 3, 6):** No Connection. Pins 3 and 6 are not connected to any internal circuitry; they should be preferably tied to ground.

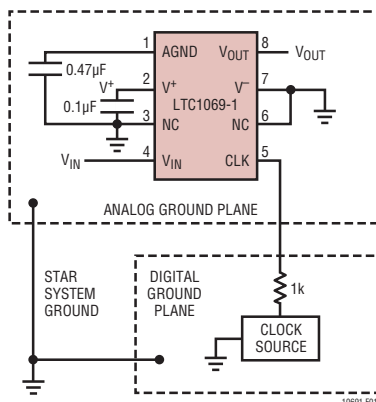
**V<sub>IN</sub> (Pin 4):** Filter Input Pin. The filter input pin is internally connected to the inverting input of an op amp through a  $43\text{k}\Omega$  resistor.

**CLK (Pin 5):** Clock Input Pin. Any TTL or CMOS clock source with a square wave output and 50% duty cycle ( $\pm 10\%$ ) is an adequate clock source for the device. The power supply for the clock source should not necessarily be the filter's power supply. The analog ground of the filter should be connected to clock's ground at a single point only. Table 1 shows the clock's low and high level threshold value for a dual or a single supply operation. A pulse generator can be used as a clock source provided the high level ON time is greater than  $0.42\mu\text{s}$  ( $V_S = \pm 5\text{V}$ ). Sine waves less than  $100\text{kHz}$  are not recommended for clock signal because excessive slow clock rise or fall times generate internal clock jitter. The maximum clock rise or fall is  $1\mu\text{s}$ . The clock signal should be routed from the right side of the IC package to avoid coupling into any input or output analog signal path. A  $1\text{k}\Omega$  resistor between the clock source and the clock input pin (5) will slow down the rise and fall times of the clock to further reduce charge coupling, Figure 1.

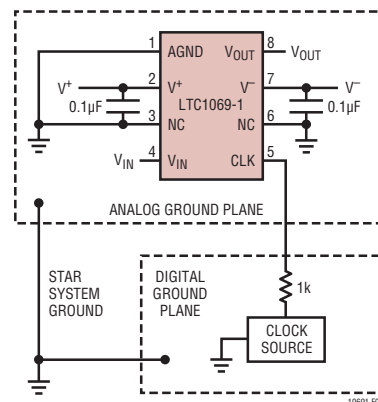
**Table 1. Clock Source High and Low Thresholds**

| POWER SUPPLY                  | HIGH LEVEL | LOW LEVEL |
|-------------------------------|------------|-----------|
| Dual Supply = $\pm 5\text{V}$ | 1.5V       | 0.5V      |
| Single Supply = 10V           | 6.5V       | 5.5V      |
| Single Supply = 5V            | 1.5V       | 0.5V      |
| Single Supply = 3.3V          | 1.2V       | 0.5V      |

**V<sub>OUT</sub> (Pin 8):** Filter Output Pin. Pin 8 is the output of the filter and it can source or sink  $1\text{mA}$ . Driving coaxial cables or resistive loads less than  $20\text{k}\Omega$  will degrade the total harmonic distortion of the filter. When evaluating the device's dynamic range, a buffer is required to isolate the filter's output from coax cables and instruments.



**Figure 1. Connections for Single Supply Operation**



**Figure 2. Connections for Dual Supply Operation**

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## APPLICATIONS INFORMATION

### Temperature Behavior

The power supply current of the LTC1069-1 has a positive temperature coefficient. The GBW product of its internal op amps is nearly constant and the speed of the device does not degrade at high temperatures. Figures 3a, 3b and 3c show the behavior of the maximum passband of the device for various supplies and temperatures. The filter, especially at  $\pm 5V$  supply, has a passband behavior which is nearly temperature independent.

### Clock Feedthrough

The clock feedthrough is defined as the RMS value of the clock frequency and its harmonics that are present at the filter's output pin (8). The clock feedthrough is tested with the input pin (4) shorted to the AGND pin and depends on PC board layout and on the value of the power supplies. With proper layout techniques the values of the clock feedthrough are shown on Table 2.

**Table 2. Clock Feedthrough**

| $V_S$    | CLOCK FEEDTHROUGH |
|----------|-------------------|
| 3.3V     | $10\mu V_{RMS}$   |
| 5V       | $40\mu V_{RMS}$   |
| $\pm 5V$ | $160\mu V_{RMS}$  |

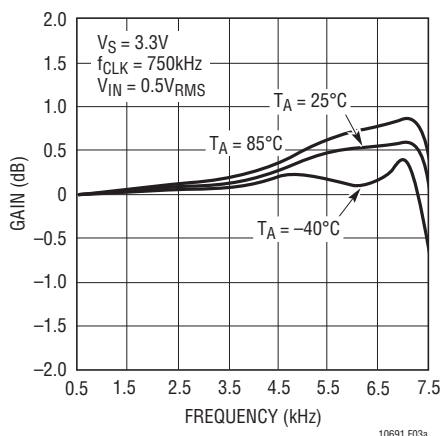
Any parasitic switching transients during the rise and fall edges of the incoming clock are not part of the clock feedthrough specifications. Switching transients have frequency contents much higher than the applied clock; their amplitude strongly depends on scope probing techniques as well as grounding and power supply bypassing. The clock feedthrough can be reduced, if bothersome, by adding a single RC lowpass filter at the output pin (8) of the LTC1069-1.

### Wideband Noise

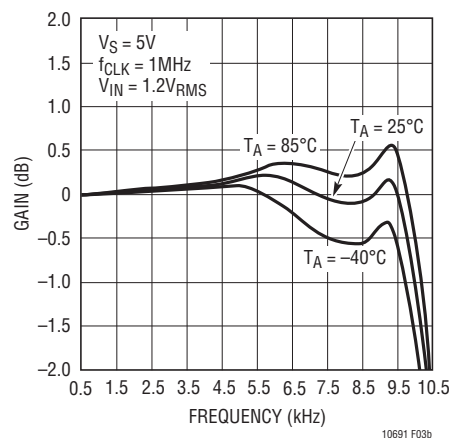
The wideband noise of the filter is the total RMS value of the device's noise spectral density and determines the operating signal-to-noise ratio. Most of the wideband noise frequency contents lie within the filter passband. The wideband noise cannot be reduced by adding post filtering. The total wideband noise is nearly independent of the clock frequency and depends slightly on the power supply voltage (see Table 3). The clock feedthrough specifications are not part of the wideband noise.

**Table 3. Wideband Noise**

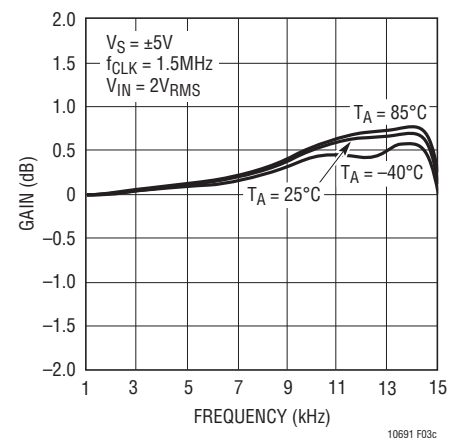
| $V_S$    | WIDEBAND NOISE   |
|----------|------------------|
| 3.3V     | $100\mu V_{RMS}$ |
| 5V       | $108\mu V_{RMS}$ |
| $\pm 5V$ | $112\mu V_{RMS}$ |



**Figure 3a**



**Figure 3b**

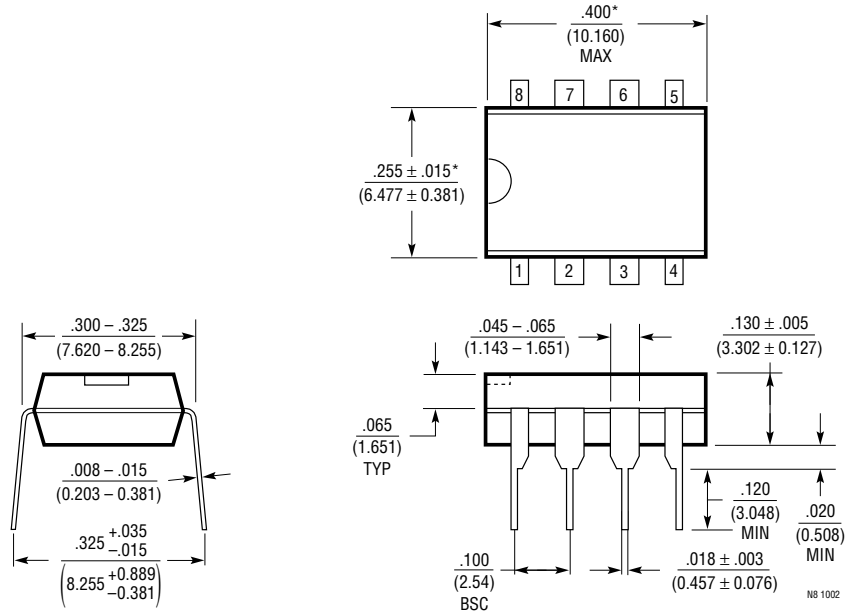


**Figure 3c**



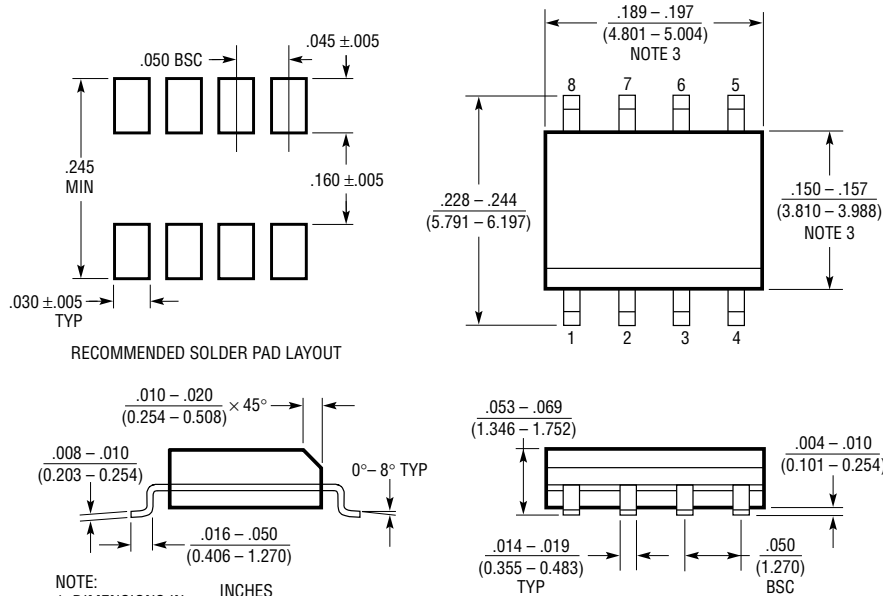
## PACKAGE DESCRIPTION

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



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

### S8 Package 8-Lead Plastic Small Outline (Narrow .150 Inch) (Reference LTC DWG # 05-08-1610)



NOTE:  
1. DIMENSIONS IN INCHES  
(MILLIMETERS)  
2. DRAWING NOT TO SCALE  
3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006\* (0.15mm)

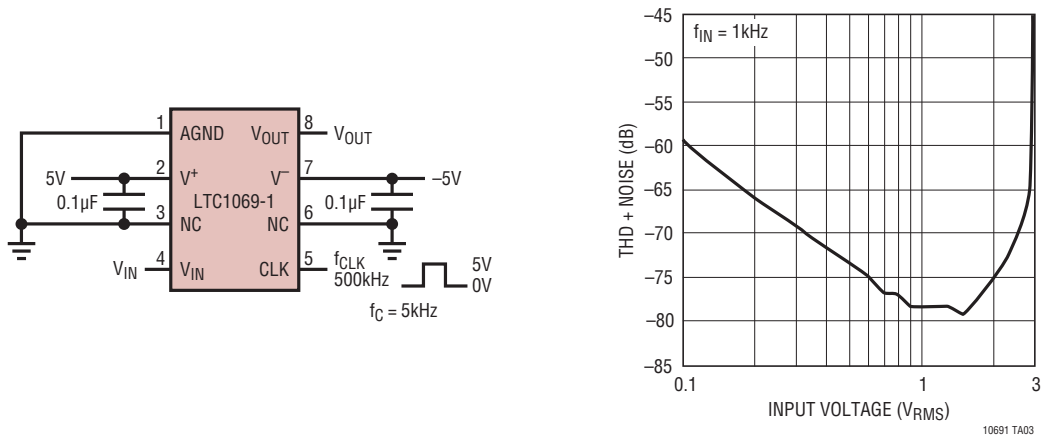
S08 0303

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TYPICAL APPLICATION

Dual Supply Operation



RELATED PARTS

| PART NUMBER | DESCRIPTION   | COMMENTS  |
|-------------|---|---|
| LTC1068     | Very Low Noise, High Accuracy, Quad Universal Filter Building Block | User-Configurable, SSOP Package                               |
| LTC1069-6   | Single Supply, Very Low Power, Elliptic LPF                         | 50:1 f <sub>CLK</sub> /f <sub>C</sub> Ratio, 8-Pin SO Package |
| LTC1164-5   | Low Power 8th Order Butterworth LPF                                 | 100:1 and 50:1 f <sub>CLK</sub> /f <sub>C</sub> Ratio         |
| LTC1164-6   | Low Power 8th Order Elliptic LPF                                    | 100:1 and 50:1 f <sub>CLK</sub> /f <sub>C</sub> Ratio         |
| LTC1164-7   | Low Power 8th Order Linear Phase LPF                                | 100:1 and 50:1 f <sub>CLK</sub> /f <sub>C</sub> Ratio         |