FEATURES
- Lowpass Filter with No DC Error
- Low Passband Noise
- Operates DC to 20kHz
- Operates on a Single 5V Supply or Up to ±8V
- 5th Order Filter
- Maximally Flat Response
- Internal or External Clock
- Cascadable for Faster Rolloff
- Buffer Available
- 8 Pin DIP Package

DESCRIPTION
The LTC1062 is a 5th order all pole maximally flat lowpass filter with no DC error. Its unusual architecture puts the filter outside the DC path so DC offset and low frequency noise problems are eliminated. This makes the LTC1062 very useful for lowpass filters where DC accuracy is important.

The filter input and output are simultaneously taken across an external resistor. The LTC1062 is coupled to the signal through an external capacitor. This R,C reacts with the internal switched capacitor network to form a 5th order rolloff at the output.

The filter cutoff frequency is set by an internal clock which can be externally driven. The clock to cutoff frequency ratio is typically 100:1, allowing the clock ripple to be easily removed.

Two LTC1062s can be cascaded to form a 10th order quasi max flat lowpass filter. The device can be operated with single or dual supplies ranging from ±2.5V to ±9V.

The LTC1062 is manufactured using Linear Technology's enhanced LTCMOS™ silicon gate process.

LTCMOS™ is a trademark of Linear Technology Corp.

APPLICATIONS
- 60Hz Lowpass Filters
- Anti-Aliasing Filter
- Low Level Filtering
- Rolling Off AC Signals from High DC Voltages
- Digital Voltmeters
- Scales
- Strain Gauges

TYPICAL APPLICATION
10Hz 5th Order Butterworth Lowpass Filter

NOTE: TO ADJUST OSCILLATOR FREQUENCY, USE A 0.001µF CAPACITOR IN SERIES WITH A 50K POT FROM PIN 5 TO GROUND.
### Absolute Maximum Ratings

- Total Supply Voltage (V+ to V-) ................. 18V
- Input Voltage at Any Pin ....... V- - 0.3V ≤ VIN ≤ V+ + 0.3V
- Operating Temperature Range
  - LTC1062M .................................. -55°C ≤ TAMB ≤ 125°C
  - LTC1062C .................................. -40°C ≤ TAMB ≤ 85°C
- Storage Temperature Range ................. -65°C to 150°C
- Lead Temperature Range (Soldering, 10 sec.) .... 300°C

<table>
<thead>
<tr>
<th>Package/Order Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOP VIEW</td>
</tr>
<tr>
<td>LTC1062MJ8</td>
</tr>
<tr>
<td>LTC1062CN8</td>
</tr>
</tbody>
</table>

### Electrical Characteristics

Test Conditions: V+ = +5V, V- = -5V, TAMB = 25°C unless otherwise specified, AC output measured at pin 7, Figure 1

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply Current</td>
<td>CREF (Pin 5 to V+) = 100 pF</td>
<td>4.5</td>
<td>7</td>
<td>10</td>
<td>mA</td>
</tr>
<tr>
<td>Input Frequency Range</td>
<td></td>
<td>0-20k</td>
<td>Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter Gain at f0 = 0</td>
<td>f0 = 0.5fC (Note 1)</td>
<td>0</td>
<td>0.02</td>
<td>0.3</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>f0 = fC</td>
<td>-2</td>
<td>-3</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f0 = 2fC</td>
<td>-28</td>
<td>30</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f0 = 4fC</td>
<td>-54</td>
<td>-60</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Clock to Cutoff Frequency Ratio, fC/f0</td>
<td>Same as above</td>
<td>-45</td>
<td>-52</td>
<td>ppm°C</td>
<td></td>
</tr>
<tr>
<td>Filter Gain at f0 = 1kHz</td>
<td>CREF = 400kHz, Pin 4 at V+</td>
<td>-45</td>
<td>-52</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CREF = 30pF, R = 6.5k</td>
<td>10</td>
<td>ppm°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fC/f0 Tempco</td>
<td>Pin 7 buffered with an external op amp</td>
<td>± 3.5</td>
<td>± 3.8</td>
<td>ppm°C</td>
<td></td>
</tr>
<tr>
<td>Clock Feedthrough</td>
<td></td>
<td>1</td>
<td>mVp-p</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Buffer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bias Current</td>
<td></td>
<td>2</td>
<td>50</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>Bias Current</td>
<td></td>
<td></td>
<td>170</td>
<td>1000</td>
<td>µA</td>
</tr>
<tr>
<td>Offset Voltage</td>
<td></td>
<td>2</td>
<td>20</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Voltage Swing</td>
<td>RREF = 20kΩ</td>
<td>± 3.5</td>
<td>± 3.8</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Short Circuit Current Source/Sink</td>
<td></td>
<td></td>
<td></td>
<td>4033</td>
<td>mA</td>
</tr>
<tr>
<td>Clock (Note 3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Oscillator Frequency</td>
<td>CREF (Pin 5 to V+) = 100pF</td>
<td>25</td>
<td>32</td>
<td>50</td>
<td>kHz</td>
</tr>
<tr>
<td></td>
<td>CREF (Pin 5 to V+) = 100pF</td>
<td>15</td>
<td>15</td>
<td>65</td>
<td>kHz</td>
</tr>
<tr>
<td>Max Clock Frequency</td>
<td></td>
<td>4</td>
<td>MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pin 5 Source or Sink Current</td>
<td></td>
<td>40</td>
<td>50</td>
<td>µA</td>
<td></td>
</tr>
</tbody>
</table>

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

Note 1: f0 is the frequency where the gain is -3dB with respect to the input signal.

Note 2: The LTC1062M operates from -55°C ≤ TAMB ≤ 125°C, the LTC1062C operates from -40°C ≤ TAMB ≤ 85°C.

Note 3: The external or driven clock frequency is divided by either 1, 2, or 4 depending upon the voltage at pin 4. When pin 4 = V+, ratio = 1; when pin 4 = GND, ratio = 2; when pin 4 = V−, ratio = 4.
**BLOCK DIAGRAM**

By connecting pin 4 to V+, AGND, or V- the output frequency of the internal clock generator is the oscillator frequency divided by 1.24. The (fosc/1.24) ratio of 100:1 is with respect to the internal clock generator output frequency. Pin 5 can be driven with an external CMOS level clock. The LTC1062 can also be self-clocking by connecting an external capacitor (Cosc) to ground (or to V- if fosc is polarized). Under this condition and with a 5V supply, the internal oscillator frequency is:

\[
\text{fosc} = \frac{1400 \text{Hz}}{330 \text{pf} / (330 \text{pf} + \text{Cosc})}
\]

For adjusting oscillator frequency, insert a 50K pot in series with \( \text{Cosc} \). Use two times calculated \( \text{Cosc} \).

![Figure 1. AC Test Circuit](image)

**TYPICAL PERFORMANCE CHARACTERISTICS**

**Amplitude Response Normalized to the Cutoff Frequency**

**Amplitude Response Normalized to the Cutoff Frequency**

**Passband Gain vs Input Frequency**
TYPICAL PERFORMANCE CHARACTERISTICS

Passband Gain vs Input Frequency

Passband Phase Shift vs Input Frequency

Filter Noise Spectral Density

Normalized Oscillator Frequency, fosc vs Supply Voltage

Oscillator Frequency, fosc vs Ambient Temperature

Power Supply Current vs Power Supply Voltage

APPLICATIONS INFORMATION

Filter Input Voltage Range

Every node of the LTC1062 typically swings within 1V of either voltage supply, positive or negative. With the appropriate external (R,C) values, the amplitude response of all the internal or external nodes does not exceed a gain of 0 dB with the exception of pin 1. The amplitude response of the feedback node (pin 1) is shown in Figure 2. For an input frequency around 0.8 x fC, the gain is 1.7 V/V and, with ±5V supplies, the peak-to-peak input voltage should not exceed 4.7V. If the input voltage goes beyond this value, clipping and distortion of the output waveform occur, but the filter will not get damaged nor will it oscillate. Also, the absolute maximum input voltage should not exceed the power supplies.
APPLICATIONS INFORMATION

Internal Buffer

The internal buffer out (pin 8) and pin 1 are part of the signal AC path. Excessive capacitive loading will cause gain errors in the passband, especially around the cutoff frequency. The internal buffer gain at DC is typically 0.006dB. The internal buffer output can be used as a filter output, however it has a few millivolts of DC offset. The temperature coefficient of the internal buffer is typically $1\mu$V/°C.

Filter Attenuation

The LTC1062 rolloff is typically 30dB/octave. When the clock, and the cutoff frequencies increase, the filter's maximum attenuation decreases. This is shown in the Typical Performance Characteristics. The decrease of the maximum attenuation, is due to the roll off at higher frequencies of the loop gains of the various internal feedback paths and not to the increase of the noise floor. For instance, for a 100kHz clock and 1kHz cutoff frequency, the maximum attenuation is about 64dB. A 4kHz, 1Vrms input signal will be predictably attenuated by 60dB at the output. A 6kHz, 1Vrms input signal will be attenuated by 64dB and not by 77dB as an ideal 5th order maximum flat filter would have dictated. The LTC1062 output at 6kHz will be about 630µVrms. The measured rms noise from DC to 17kHz was 100µVrms which is 16dB below the filter output.

COSC, Pin 5

The COSC, pin 5, can be used with an external capacitor. COSC, connected from pin 5 to ground. If COSC is polarized it should be connected from pin 5 to the negative supply, pin 3. COSC lowers the internal oscillator frequency. If pin 5 is floating, an internal 33pF capacitor plus the external interpin capacitance set the oscillator frequency around 140kHz with ±5V supply. An external COSC will bring the oscillator frequency down by the ratio (33pF)/(33pF + COSC). The typical performance characteristics curves provide the necessary information to get the internal oscillator frequency for various power supply ranges. Pin 5 can also be driven with an external CMOS clock to override the internal oscillator. Although standard 7400 series CMOS gates do not guarantee CMOS levels with the current source and sink requirements of pin 5, they will, in reality, drive the COSC pin. CMOS gates conforming to standard B series output drive have the appropriate voltage levels and more than enough output current to simultaneously drive several LTC1062 COSC pins. The typical trip levels of the internal Schmitt trigger which input is pin 5, are given below.

<table>
<thead>
<tr>
<th>V SUPPLY</th>
<th>Vθ+</th>
<th>Vθ-</th>
</tr>
</thead>
<tbody>
<tr>
<td>±2.5V</td>
<td>+0.9V</td>
<td>-1V</td>
</tr>
<tr>
<td>±5V</td>
<td>+1.3V</td>
<td>-2.1V</td>
</tr>
<tr>
<td>±6V</td>
<td>+1.7V</td>
<td>-2.5V</td>
</tr>
<tr>
<td>±7V</td>
<td>+1.75V</td>
<td>-2.9V</td>
</tr>
</tbody>
</table>

Figure 2. Amplitude Response of Pin 1
APPLICATIONS INFORMATION

Divide By 1, 2, 4 (Pin 4)

By connecting pin 4 to V+, to mid supplies or to V−, the clock frequency driving the internal switched capacitor network is the oscillator frequency divided by 1, 2, 4, respectively. Note that the fCLK/fC ratio of 100:1 is with respect to the internal clock generator output frequency. The internal divider is useful for applications where octave tuning is required. The ±2 threshold is typically ±1V from the mid supply voltage.

Transient Response

Figure 3 shows the LTC1062 response to a 1V input step.

Filter Noise

The filter wideband rms noise is typically 100µVrms for ±5V supply and it is nearly independent from the value of the cutoff frequency. For single 5V supply the rms noise is 80µVrms. Sixty-two percent of the wideband noise is in the passband, that is from DC to fC. The noise spectral density, unlike conventional active filters, is nearly zero for frequencies below 0.1 × fC. This is shown in the typical performance characteristics section. Table 1 shows the LTC1062 rms noise for different noise bandwidths.

![Figure 3. Step Response to a 1V Peak Input Step](image)

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOISE BW</td>
</tr>
<tr>
<td>DC − 0.1 × fC</td>
</tr>
<tr>
<td>DC − 0.25 × fC</td>
</tr>
<tr>
<td>DC − 0.5 × fC</td>
</tr>
<tr>
<td>DC − 1 × fC</td>
</tr>
<tr>
<td>DC − 2 × fC</td>
</tr>
</tbody>
</table>
TYPICAL APPLICATIONS

AC Coupling an External CMOS Clock Powered from a Single Positive Supply, $V^+$

Adding an External ($R_1, C_1$) to Eliminate the Clock Feedthrough and to Improve the High Frequency Attenuation Floor

Filtering AC Signals from High DC Voltages

Example: $f_{DC} = 100$ kHz, $f_c = 1$ kHz. The filter accurately passes the high DC input and acts as a 5th order LP filter for the AC signals rising on the DC. The amplitude response in the passband is shown below.
Cascading Two LTC1062s to Form a Very Selective Clock Sweepable Bandpass Filter

Clock Tunable Notch Filter
For simplicity use R3 = R4 = R5 = 10k;
R1 = 1.234, f_{CLK} = 79.3
R2 = 1.234, f_{notch} = 1

Frequency Response of the Bandpass Filter

Notch Response
TYPICAL APPLICATIONS

Simple Cascading Technique

10kHz, 10th ORDER DC ACCURATE LOW PASS FILTER
60dB/OCTAVE ROLLOFF
0.5dB PASSBAND ERROR, 0dB DC GAIN
MAXIMUM ATTENUATION 110dB (f\text{CLK} = 10kHz)
100dB (f\text{CLK} = 1kHz)
95dB (f\text{CLK} = 1MHz)

100Hz, 50Hz, 25Hz 5th Order DC Accurate LP Filter

CONTROL (HIGH, GROUND, LOW)

BY CONNECTING PIN 4 OF THE LTC1052 HIGH/GROUND/LOW THE FILTER CUTOFF FREQUENCY IS 100kHz/50kHz/25kHz.

TO PIN 3 OF CD4016

TO PIN 13 OF CD4015
**LTC1062**

**TYPICAL APPLICATIONS**

7th Order 100Hz Lowpass Filter with Continuous Output Filtering, Output Buffering and Gain Adjustment

THE LTC1052 IS CONNECTED AS A 2nd ORDER SALLER AND KEY LOWPASS FILTER WITH A CUTOFF FREQUENCY EQUAL TO THE LTC1082. THE ADDITIONAL FILTERING ELIMINATES ANY 10kHz CLOCK FEED THROUGH PLUS DECREASES THE WIDEBAND NOISE OF THE FILTER.

DC OUTPUT OFFSET (REFERRED TO A DC GAIN OF UNITY) = 5μV MAX.

WIDEBAND NOISE (REFERRED TO A DC GAIN OF UNITY) = 60μVRms

### OUTPUT FILTER COMPONENT VALUES

<table>
<thead>
<tr>
<th>DC GAIN</th>
<th>R3</th>
<th>R4</th>
<th>R1</th>
<th>R2</th>
<th>C1</th>
<th>C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>∞</td>
<td>0</td>
<td>14.3k</td>
<td>53.6k</td>
<td>0.1μF</td>
<td>0.033μF</td>
</tr>
<tr>
<td>10</td>
<td>3.57k</td>
<td>32.4k</td>
<td>46k</td>
<td>274k</td>
<td>0.01μF</td>
<td>0.003μF</td>
</tr>
</tbody>
</table>

**Single 5V Supply 5th Order LP Filter**

FOR A 10Hz FILTER R = 29.4k, C = 1μF, f_{CLK} = 1kHz

THE FILTER IS MAXIMALLY FLAT FOR \( \frac{1}{2\pi R C} = 1.84 \)
TYPICAL APPLICATIONS

A Lowpass Filter with a 60Hz Notch

Frequency Response of the Above Lowpass Filter with the Notch $f_{\text{NOTCH}} = \frac{f_{\text{CLK}}}{47.3}$

A Low Frequency, 5Hz Filter using Back-to-Back Solid Tantalum Capacitors
PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

J8 Package
8 Lead Hermetic DIP

N8 Package
8 Lead Plastic