DESIGN NOTES

A Family of 8th Order Monolithic Filters in an SO-8 Package

Design Note 147

LTC's Filter Group

The LTC®1069-X family of monolithic filters offers economical solutions for a wide variety of signal processing applications.

Members of the LTC1069-X family are available as standard products or as user-specified, semicustom filters. Both products are fully integrated and are available in small SO-8 packages. They require only power supply decoupling capacitors and a clock source to set the cutoff frequency and form a complete filter.

As semicustom filters, the LTC1069-X can be configured as a single 8th order filter or as two 4th order filters with either identical or independent characteristics. The technology allows the user to specify and optimize the filter response, sampling rate and power consumption for each application. The LTC1069-X can realize lowpass, bandpass, highpass, notch and allpass responses.

The LTC1069-X family also includes standard products, the LTC1069-1, LTC1069-6 and LTC1069-7.

The LTC1069-1 and LTC1069-6 offer either low or very low power, 8th order elliptic lowpass response for dual- or single-supply applications. The LTC1069-7, although it uses the same technology as the LTC1069-1 and LTC1069-6, has completely different characteristics: it provides lowpass filtering with linear phase response and cutoff frequencies up to 200kHz. All three products have the same pinout.

LTC1069-1: Low Power Elliptic Antialiasing Filter Works from Single 3.3V to ±5V Supplies

The LTC1069-1 amplitude response features a very flat passband up to $0.95f_{CUTOFF}$, and a sharp 20dB attenuation in the vicinity of the cutoff frequency (that is, at $1.2f_{CUTOFF}$). The transition band reaches 52dB attenuation at $1.4f_{CUTOFF}$, and keeps rolling off instead of "bouncing" back as textbook elliptic filters do. Figure 1 illustrates this "progressive rolloff."

Figure 2 shows typical connections for both single 5V and ±5V supplies. A precision internal resistive divider

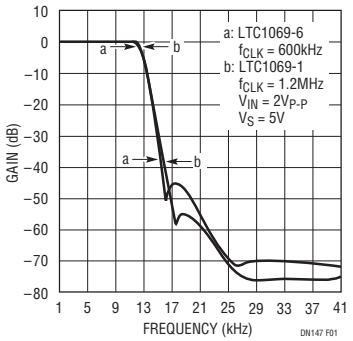

Figure 1. Amplitude Response Comparison: LTC1069-1 vs LTC1069-6

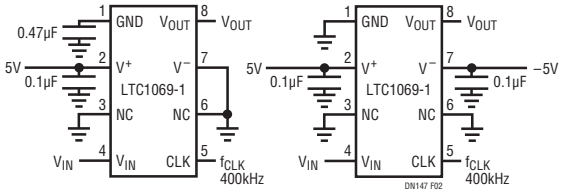

Figure 2. Single 5V or Dual ±5V Supply 4kHz Elliptic Lowpass Filter

biases the analog ground pin to one-half the total power supply voltage. For single supply applications, only an external decoupling capacitor is needed to lower the AC impedance of the pin.

The LTC1069-1 cutoff frequency is clock tuned and the clock-to-cutoff frequency ratio and the internal sampling rate are 100:1. The power consumption and the maximum cutoff frequency are illustrated in Table 1.

Table 1. LTC1069-1 Maximum Cutoff Frequency and Resulting Power Consumption

V_S	$I_{SUPPLY(TYP)}$	$f_{CUTOFF(MAX)}$
±5V	3.8mA	12kHz
5V	2.5mA	8kHz
3.3V	1.5mA	4kHz

Despite its low power consumption, the device's dynamic range is not compromised. The widest dynamic range is obtained with ±5V supplies, where a S/(N+THD) ratio of better than 70dB is reached with input voltages between $0.34V_{RMS}$ and $2.5V_{RMS}$.

LTC1069-6: 8th Order Elliptic Lowpass Works on Single 3V, Consumes 1mA

The LTC1069-6 is designed for minimal power consumption and for single 3V and 5V supplies. The low supply current, 1mA for a 3V supply and 1.2mA for a 5V supply, includes the current spent to bias the analog ground pin for optimum dynamic range and for ease of use in single supply applications.

To save power, the clock-to-cutoff frequency range is lowered to 50:1, but the internal sampling rate remains at 100:1. The amplitude response of the filter is also progressive elliptic, as shown in Figure 1.

When compared to the LTC1069-1, the LTC1069-6 has a sharper rolloff in the vicinity of its cutoff frequency, the key feature being 42dB attenuation at $1.27f_{CUTOFF}$. Conversely, the LTC1069-1 has better stopband attenuation, a flatter passband and 5dB more dynamic range.

The LTC1069-6 excels in optimizing speed for power consumption. Table 2 shows that a cutoff frequency of up to 20kHz can be obtained with a single 5V supply and 1.2mA typical power supply current.

Table 2. LTC1069-6 Maximum Cutoff Frequencies and Resulting Power Consumption

V_S	$I_{SUPPLY(TYP)}$	$f_{CUTOFF(MAX)}$	$f_{CLK(MAX)}$
3V	1mA	14kHz	700kHz
5V	1.2mA	20kHz	1MHz

LTC1069-7: Linear-Phase Communication Filter Delivers Up to 200kHz Cutoff Frequency and Symmetrical Impulse Response

The amplitude response of the IC approximates a "textbook" raised cosine, alpha-of-one filter. The phase of the LTC1069-7 is linearized over the entire passband to provide the fully symmetrical impulse response expected from a raised cosine filter (see Figure 3). When compared to a conventional linear phase filter of the same order, such as an LTC1064-3, 8th order Bessel lowpass, the LTC1069-7 has a steeper rolloff in the vicinity of its cutoff frequency, as shown in Figure 4. This type of filter is useful in digital communications, where compromises between selectivity and good transient response are always sought.

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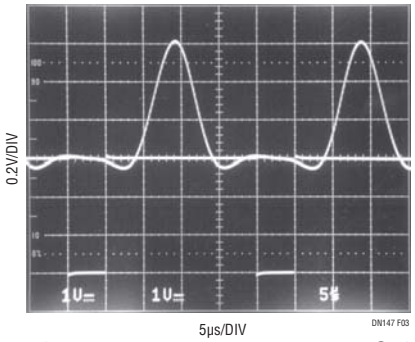

Figure 3. The Pulse Response of the LTC1069-7 is Fully Symmetrical

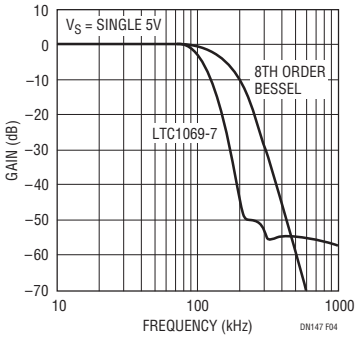

Figure 4. Frequency Response

Note that the raised cosine response is not related to the classical all-pole responses of Butterworth, Chebyshev or Bessel filters. The realization of a raised cosine filter with discrete RC active techniques requires many precision passive and active components.

The LTC1069-7 trades power consumption and sampling rate for speed. The maximum cutoff frequency is 200kHz, the internal sampling rate is 50:1 and the clock-to-cutoff frequency ratio is 25:1. Table 3 illustrates the maximum cutoff frequency of the device for single 5V and ±5V supplies.

Table 3. LTC1069-7 Maximum Cuttoff Frequencies and Resulting Power Consumption

V_S	$I_{SUPPLY(TYP)}$	$f_{CUTOFF(MAX)}$
±5V	18mA	200kHz
5V	12mA	140kHz
3V	8mA	70kHz

Conclusion

A flexible and economic filter technology is available today; it trades power consumption for speed and provides cutoff frequencies ranging from a few Hertz up to 200kHz. All of the filters come in SO-8 packages. The filter group of Linear Technology has accumulated years of experience and is always happy to hear from you and talk filters.

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