

# 1MHz/500kHz Continuous Time, Low Noise, Lowpass Elliptic Filter

## FEATURES

- 5th Order, 1MHz Elliptic Filter in SO-8 Package
- Pin Selectable 1MHz/500kHz Cutoff Frequency
- Signal-to-Noise Ratio (SNR): 75dB
- Signal-to-Noise Ratio with –63dB THD: 69dB
- Passband Ripple ( $f_{\text{CUTOFF}} = 1\text{MHz}$ ):  $\pm 0.3\text{dB}$
- Stopband Attenuation Better Than 60dB
- No External Components Required

## APPLICATIONS

- Antialiasing Filters
- Smoothing or Reconstruction Filters
- Communication Filters

## DESCRIPTION

The LTC<sup>®</sup>1560-1 is a 5th order, continuous-time, lowpass filter. *The elliptic transfer function of the LTC1560-1 was carefully chosen to reach a compromise between selectivity, for antialiasing applications, and transient response.* The filter cutoff frequency,  $f_{\text{CUTOFF}}$ , is pin selectable to

either 500kHz (Pin 5 to  $V^+$ ) or 1MHz (Pin 5 to  $V^-$ ). When programmed for 1MHz, the passband ripple is typically  $\pm 0.2\text{dB}$  up to  $0.55f_{\text{CUTOFF}}$  and  $\pm 0.3\text{dB}$  to  $0.9f_{\text{CUTOFF}}$ . The transition band gain is  $-24\text{dB}$  at  $1.4f_{\text{CUTOFF}}$  and  $-51\text{dB}$  at  $2f_{\text{CUTOFF}}$ . Stopband attenuation is  $63\text{dB}$  at  $2.43f_{\text{CUTOFF}}$  and above, remaining at least  $60\text{dB}$  to  $10\text{MHz}$  with proper board layout. When the LTC1560-1 is programmed for  $f_{\text{CUTOFF}} = 500\text{kHz}$ , the filter response closely follows the 1MHz case with the exception of passband flatness near the cutoff frequency; the gain at  $f_{\text{CUTOFF}}$  is  $-1.3\text{dB}$ .

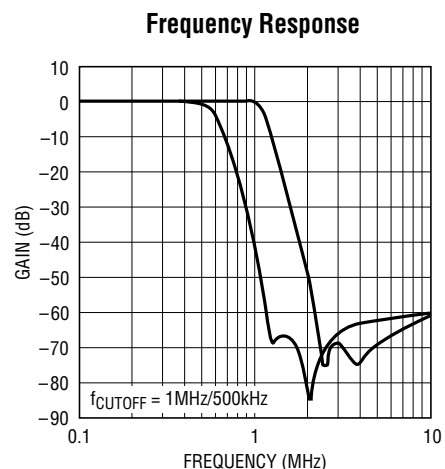
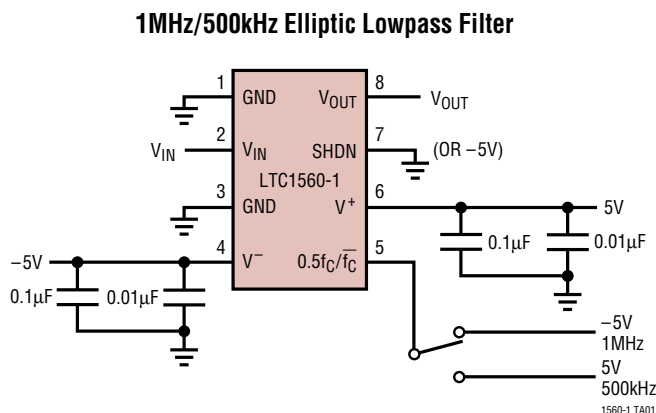
The LTC1560-1, unlike other high frequency filters, is designed for low noise and low distortion. With a  $1V_{\text{RMS}}$  input signal, the signal-to-noise ratio is  $69\text{dB}$  and the THD is  $-63\text{dB}$ . The maximum SNR of  $75\text{dB}$  is obtained with a  $2.1V_{\text{RMS}}$  input signal. This results in  $-46\text{dB}$  THD.

The LTC1560-1 operates with  $\pm 5\text{V}$  supplies, has a power saving mode and is available in an SO-8 surface mount package.

Other cutoff frequencies from  $450\text{kHz}$  to  $1.5\text{MHz}$  can be obtained. Demo board DC135A is available for the LTC1560-1. For more information please contact LTC Marketing.

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## TYPICAL APPLICATION



## ABSOLUTE MAXIMUM RATINGS

Total Supply Voltage ( $V^+$ to $V^-$ )	12V
Power Dissipation	400mW
Burn-In Voltage	$\pm 5.5V$
Operating Temperature Range	
LTC1560-1C	0°C to 70°C
LTC1560-1I	-40°C to 85°C
Maximum Junction Temperature	150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

## PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER
	LTC1560-1CS8 LTC1560-1IS8
	S8 PART MARKING
	15601 15601I

Consult factory for Military grade parts.

## ELECTRICAL CHARACTERISTICS

 $V_S = \pm 5V$ ,  $T_A = 25^\circ C$ , Pin 5 = -5V ( $f_{CUTOFF} = 1MHz$ ), Pin 7 = 0V unless otherwise specified.

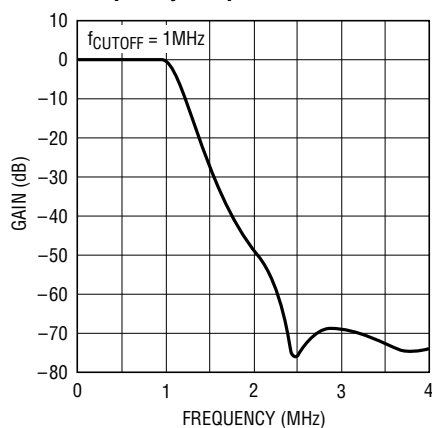
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Supply Voltage Range		$\pm 4.5$	$\pm 5.0$	$\pm 5.5$	V
Passband Gain ( $f_{CUTOFF} = 1MHz$ )	$V_{IN} = 0.5V_{RMS}$ , $f_{IN} = 20kHz$ $f_{IN} = 100kHz$ $f_{IN} = 300kHz$ $f_{IN} = 550kHz$ (Gain Relative to 100kHz) $f_{IN} = 850kHz$ (Gain Relative to 100kHz) $f_{IN} = 950kHz$ (Gain Relative to 100kHz) $f_{IN} = f_{CUTOFF} = 1MHz$ (Gain Relative to 100kHz)	● -0.3 ● -0.35 ● -0.8 ● -3.0 ● -5.0	0.17 0.18 0.08 0.05 -0.3 0.6 0.5 -1.0	0.6	dB dB dB dB dB dB dB dB
Transition Band Gain (Note 1)	$V_{IN} = 0.5V_{RMS}$ , $f_{IN} = 1.4MHz$ $f_{IN} = 1.9MHz$ $f_{IN} = 2.0MHz$	●	-24 -42 -51	-18	dB dB dB
Stopband Gain ( $f_{CUTOFF} = 1MHz$ ) (Note 2)	$f_{IN} = 2.44MHz$ $f_{IN} = 3.0MHz$ $f_{IN} = 6.0MHz$	●	-70 -68 -66.1	-65	dB dB dB
Passband Gain ( $f_{CUTOFF} = 500kHz$ )	$f_{IN} = 100kHz$ , Pin 5 = 5V $f_{IN} = f_{CUTOFF} = 500kHz$ $f_{IN} = 1.4MHz$	●	-4 -1.6 -45	0.5	dB dB dB
Output Voltage Swing	$R_L = 5k$	●	$\pm 1.9$	$\pm 3$	V
Output DC Offset ( $V_{OS}$ )			$\pm 250$		mV
Power Supply Current ( $I_S$ )		●	22	29	mA
Power Supply Current in Shutdown Mode	Pin 7 at 5V		1		mA
Total Output Noise	$V_{IN}$ (Pin 2) Tied to Ground, $f_{CUTOFF} = 1MHz$ , BW = 2MHz $V_{IN}$ (Pin 2) Tied to Ground, $f_{CUTOFF} = 0.5MHz$ , BW = 1MHz		350 322		$\mu V_{RMS}$ $\mu V_{RMS}$
Total Harmonic Distortion (THD)	$V_{IN} = 1V_{RMS}$ , $f_{IN} = 200kHz$ , $f_{CUTOFF} = 1MHz$ , BW = 1MHz $f_{IN} = 300kHz$ , $f_{CUTOFF} = 1MHz$ , BW = 1MHz $f_{IN} = 1MHz$ , $f_{CUTOFF} = 1MHz$ , BW = 2MHz		-63 -61 -62		dB dB dB
	$f_{IN} = 300kHz$ , $f_{CUTOFF} = 0.5MHz$ , BW = 1MHz $f_{IN} = 500kHz$ , $f_{CUTOFF} = 0.5MHz$ , BW = 1MHz		-62 -63		dB dB
Input Resistance ( $R_{IN}$ )		●	6	8	10 k $\Omega$

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

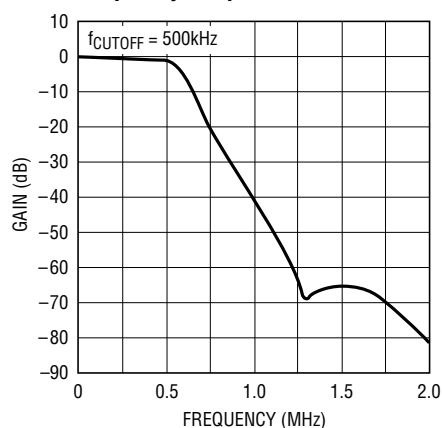
**Note 1:** To properly measure high frequency characteristics of the filter, a noninverting output buffer is recommended as shown on the demo boardconnection diagram, Figure 2. A small resistor (e.g. 100 $\Omega$ ) can also be used instead of the buffer to isolate any high capacitive load ( $C_L > 10pF$ ) from the filter output.**Note 2:** The stopband gain at 2.44MHz is guaranteed by design.

# TYPICAL PERFORMANCE CHARACTERISTICS

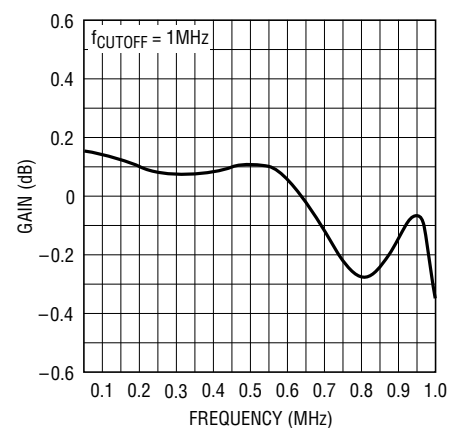
## Frequency Response



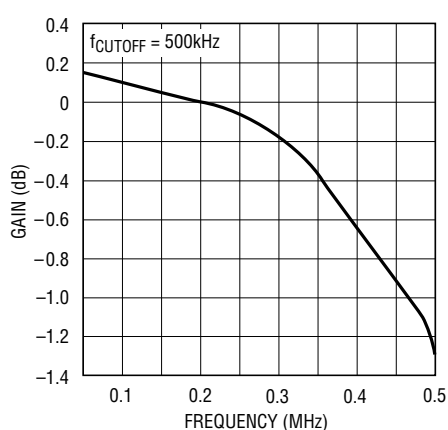
## Frequency Response



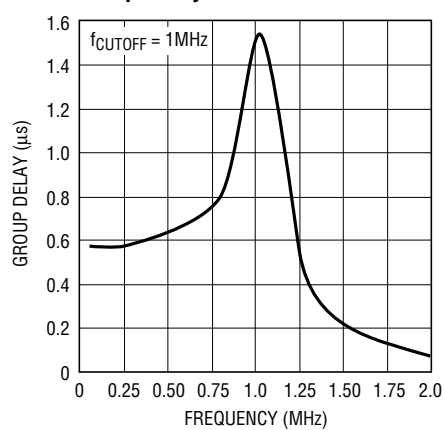
## Passband Gain



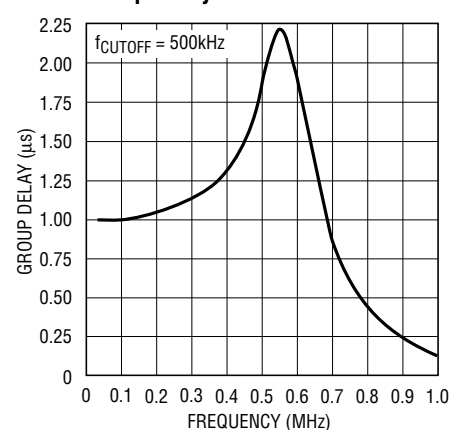
## Passband Gain



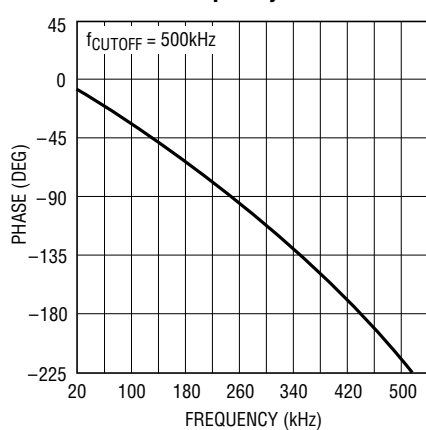
## Group Delay



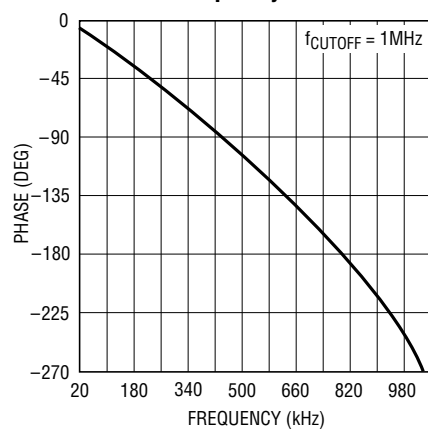
## Group Delay



## Phase vs Frequency

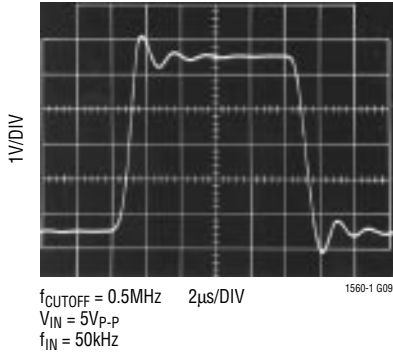


## Phase vs Frequency

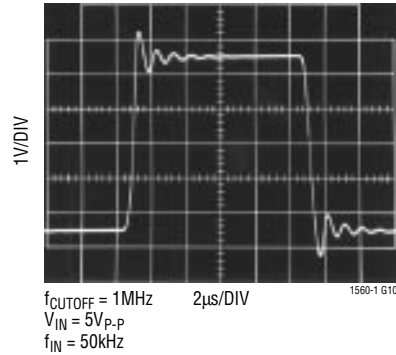


# TYPICAL PERFORMANCE CHARACTERISTICS

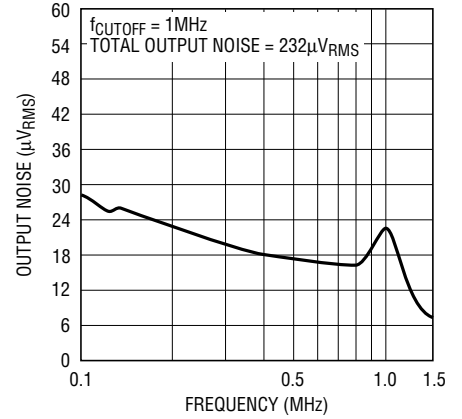
Transient Response



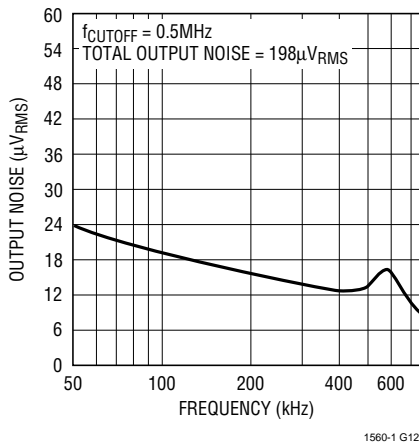
Transient Response



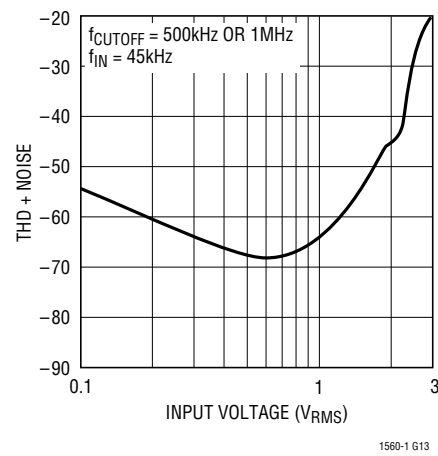
Output Noise vs Frequency



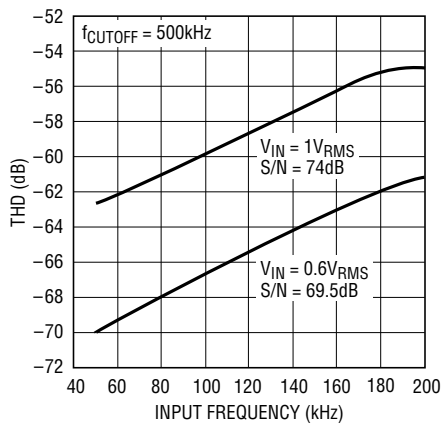
Output Noise vs Frequency



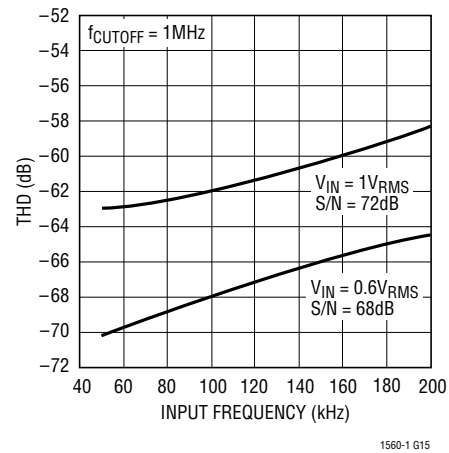
Dynamic Range



THD + Noise vs Input Frequency



THD + Noise vs Input Frequency



## PIN FUNCTIONS

**GND (Pins 1, 3):** Analog Ground Pins. The quality of the analog ground can affect the filter performance. For dual supply operation the analog ground pin should be connected to an analog ground plane surrounding the package. The analog ground plane should be connected to a digital ground plane (if any) at a single point. For single supply operation, the analog ground pin should be biased at one-half the power supply across the device (see Figure 1) and the analog ground plane should then be connected to  $V^-$  (Pin 4).

**$V_{IN}$  (Pin 2):** The filter input is internally connected to the inverting input of a high frequency op amp through an 8k resistor.

**$V^-$ ,  $V^+$  (Pins 4, 6):** Power Supply Pins. The negative and positive power supply (Pins 4 and 6 respectively) should be decoupled with a  $0.1\mu\text{F}$  capacitor in parallel with a  $0.01\mu\text{F}$ . Both capacitors should be types designed for decoupling video frequencies and they should be placed as close as possible to the power supply pins of the filter. Parallel routing of high frequency signal paths should be avoided; they will couple into the device's power supply pins and cause gain inaccuracy and stopband degradation.

The power supplies can be applied in any order, that is, the positive supply can be applied before the negative supply and vice versa. Switching power supplies are not recommended.

**$0.5f_c/\bar{f}_c$  (Pin 5):** By tying Pin 5 high the filter cutoff frequency is internally programmed for 500kHz. By tying Pin 5 low the cutoff frequency will switch to 1MHz. Pin 5 should not be left floating. The logic threshold of Pin 5 is approximately 0.4 times the total power supply across the device.

**SHDN (Pin 7):** Shutdown. Under normal operating conditions, Pin 7 should be shorted either to the analog ground (Pin 1) or to  $V^-$  (Pin 4). If Pin 7 is pulled high to  $V^+$ , the filter operation will stop and the IC will be placed in a power saving mode. The power supply current will then be reduced to 1mA. For a  $\pm 5\text{V}$  supply, the logic threshold of Pin 7 is 2.5V. Pin 7 is internally connected to the analog ground pin via a 50k resistor.

**$V_{OUT}$  (Pin 8):** The filter output pin can sink or source 1mA. The total harmonic distortion of the filter will degrade when driving coaxial cables or loads less than 10k without an output buffer.

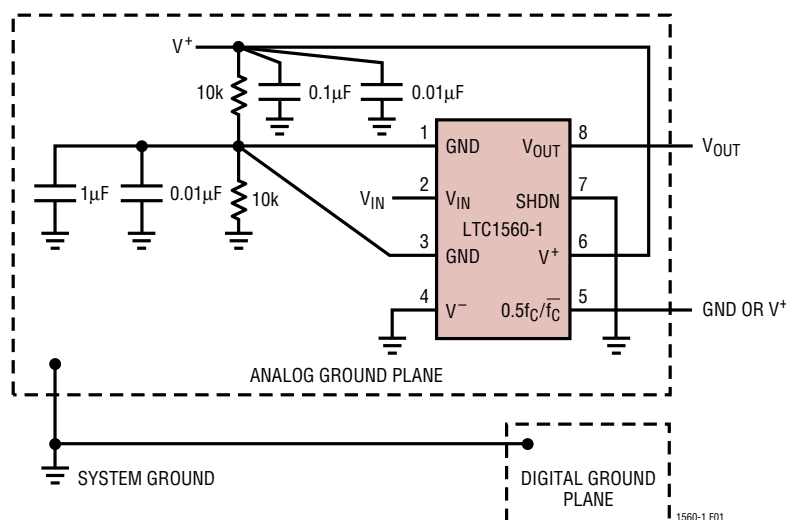
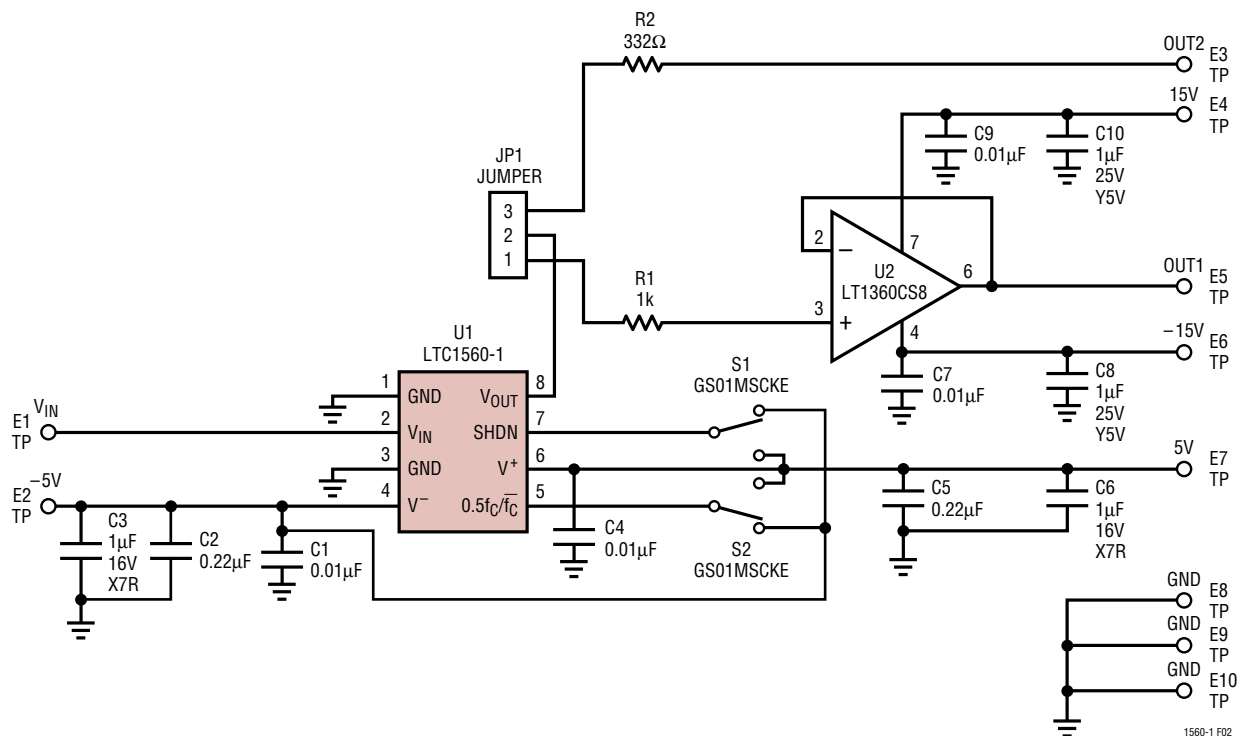


Figure 1. Connections for Single Supply Operation

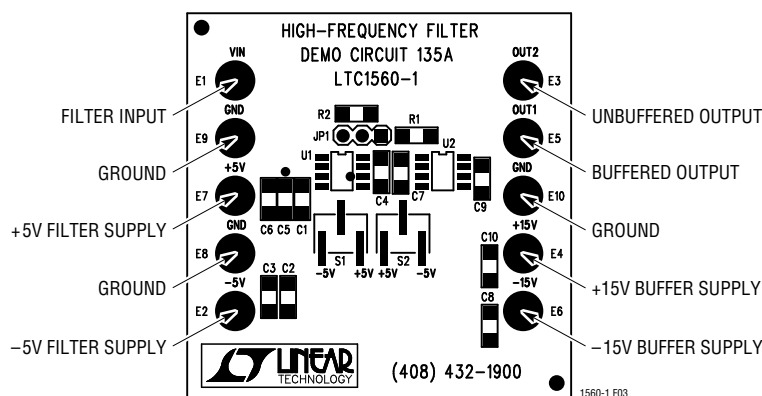
## APPLICATIONS INFORMATION

The performance of the LTC1560-1 can be easily evaluated by using demo board 135A which can be obtained through LTC marketing. Figure 2 shows the circuit connection of the LTC1560-1 in demo board 135A. The filter cutoff frequency can be switched via S2 and the power savings

mode can also be activated via S1. The output of the filter is buffered by U2, an LT<sup>®</sup>1360 op amp. The buffering can be bypassed by using jumper JP1. Figure 3 shows the demo board layout.



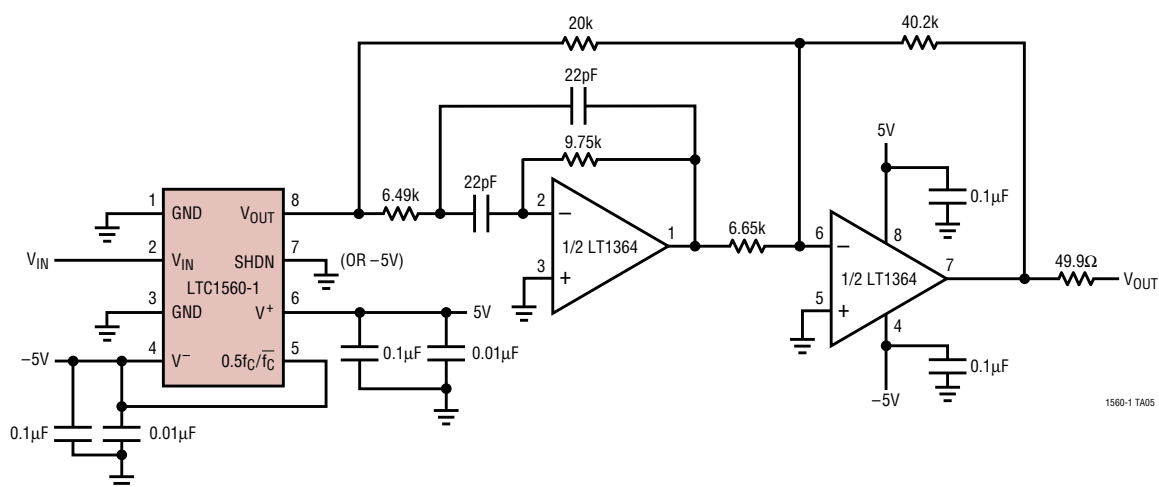
**Figure 2. Demo Board 135A Connection Diagram**



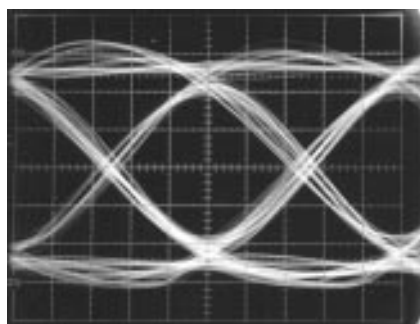
### Figure 3. Demo Board 135A Layout

## TYPICAL APPLICATIONS

### Augmenting the LTC1560-1 for Improved Delay Flatness



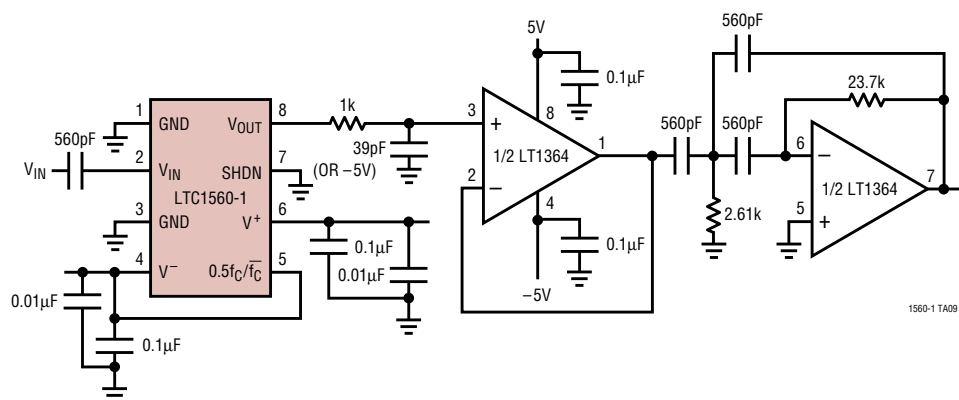
### 2-Level Eye Diagram of the Equalized Filter



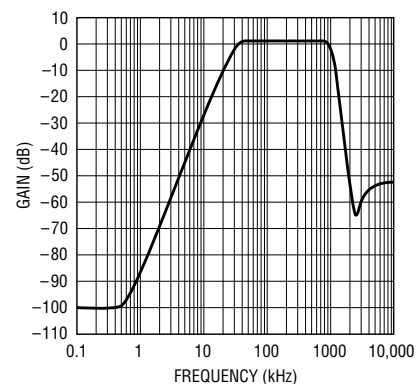
2Mbps/s

1560-1 TA06

### 1MHz Lowpass Filter Cascaded with a 30kHz 3rd Order Highpass Filter



### Gain vs Frequency



1560-1 TA10

