# Linear Technology Chronicle

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# Products of the Month

## Complete 12-Bit, 400ksps A/D Converter in SO-8 Package

The **LTC®1400** is the world's first 400ksps 12-bit analog-to-digital (A/D) converter that fits in an SO-8 package. It is complete with a 200ns sample-and-hold and a precision reference. The LTC1400 converts 0V to 4.096V unipolar analog signals from a single 5V supply and ±2.048V bipolar inputs from a ±5V supply. Unipolar and bipolar conversion modes and a 3-wire serial port make this device quite flexible for a variety of microprocessor, microcontroller and DSP applications where speed and small size are essential. Figure 1 shows the main parts of this complete A/D converter.

The LTC1400 draws 75mW from a 5V or ±5V source while performing conversions at 400ksps. It also operates under two power saving modes. In Nap mode, it consumes only 6mW and can wake up and convert immediately. In Sleep mode, it uses just 30µW, where a reference ready signal is available in the serial data word to indicate that the reference has settled and the chip is ready to convert. These Nap and Sleep modes can be used for reducing power consumption at lower sample rates (Figure 2).

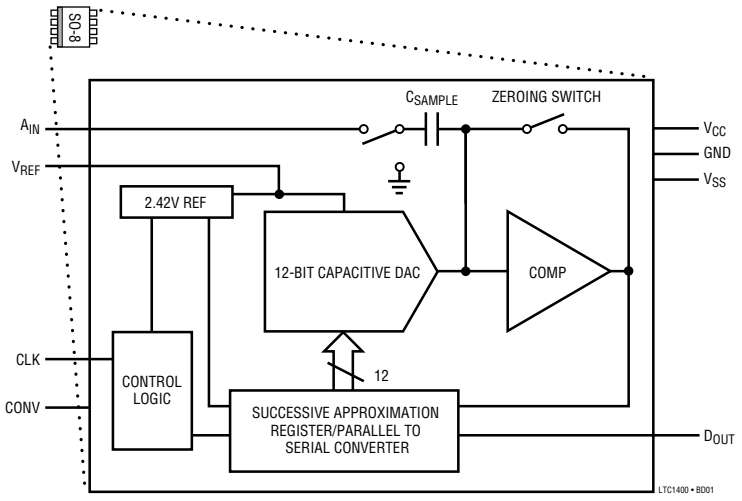


**Figure 1. Functional Block Diagram of the LTC1400**

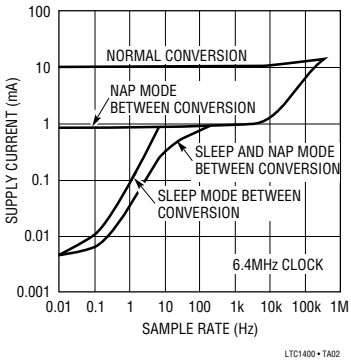


**Figure 2. Using Sleep and Nap Modes Reduces Power Consumption at Low Sample Rates**

Excellent DC specs include ±1LSB maximum differential nonlinearity (DNL), ±1LSB integral nonlinearity (INL), and a 25ppm/°C drift over temperature. Guaranteed AC performance over temperature includes 70dB signal-to-noise + distortion [S/(N + D)] and 76dB total harmonic distortion (THD) at an input frequency of 100kHz. The LTC1400 is ideally suited for telecom, portable test equipment, PCMCIA data acquisition and DSP applications. It is available in commercial and industrial temperature versions. Contact your local Linear Technology sales office for a data sheet and evaluation samples.

## Rail-To-Rail Input and Output, Precision Op Amps Draw Only 50µA

The dual **LT®1490** and quad **LT1491** are rail-to-rail input and output op amps requiring less than 50µA of supply current per amplifier. They can operate on any split or single supply with a total voltage of 2.5V up to 44V, the widest among any micropower rail-to-rail op amp. The output voltage swings to within 50mV of the supply rail at no load while the input common mode voltage can range up to 44V above the op amp's negative rail independent of the voltage on the positive rail.

*Continued on page 2*

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*LT1490/LT1491 from page 1*

Although it is a micropower op amp, the LT1490 20mA output can drive 5000pF capacitive loads without oscillating. Ruggedized inputs withstand voltages 22V below negative supply and it is protected against reverse supply voltages of up to 18V. Their wide supply voltage range and low power consumption make the LT1490 and LT1491 well suited for portable and higher voltage industrial applications, such as battery- or solar-powered systems, portable instrumentation, micropower active filters and 4mA to 20mA current loop transmitters. Figure 1 illustrates the LT1491 used as a battery monitor, where current is measured into or out of the battery.

The LT1490 is offered in 8-pin PDIP and SO-8 packages. The LT1491 is available in 14-pin PDIP and SO packages. Call your local Linear Technology sales office for a data sheet and evaluation samples.

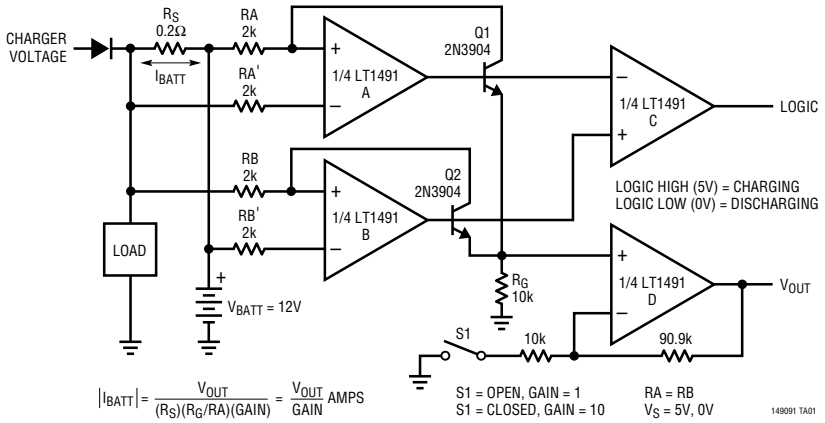



**Figure 1. The LT1491's Wide Input Voltage Range Makes it Suitable as a Battery Monitor**

# *Precision Quad Filter Building Block Fits in 28-Lead SSOP, Works on 3.3V Supply*

The **LTC1068** quad universal filter building block consists of four identical 2nd order filters that fit in a small 28-pin SSOP package. It allows building high precision, high performance filters using a single power supply as low as 3.3V. Each building block, together with 3 to 5 resistors, can provide various 2nd order filter functions such as lowpass, highpass, bandpass or notch filters. An LTC1068 switched-capacitor filter replaces up to 12 discrete op amps and 8 integrator capacitors that normally would be needed in building a discrete component version of an 8th order filter.

The LTC1068 can be used in any filter application that has a cutoff frequency of less than 56kHz. The center frequency of each 2nd order section is tuned by an external clock ($f_O$ error is less than ±0.3%) with the clock-to-center frequency ratio set to 100:1. (This ratio may also be altered with external resistors.) The internal sampling rate is twice the clock frequency. The maximum input frequency can approach twice the clock frequency before aliasing occurs.

The LTC1068 input noise is less than 40μ$V_{RMS}$ per 2nd order section, which results in a dynamic range of more than 80dB even with the supply voltage as low as 3.3V. This rivals the performance of op amp RC filters. Power supply current is typically 8mA at ±5V and drops to 2.5mA at 3.3V over the full operating temperature range of 0°C to 70°C.

Interstage and op amp matching is superior to a discrete component design because all on-chip components and amplifiers are precision matched. Figure 1 shows the response of a dual Butterworth bandpass filter implemented with the LTC1068 using a single 3.3V supply.

The LTC1068 quad universal filter building block is quite versatile and is well suited for a variety of other filter applications. For example, it can be used in building precision phase matched, audio equalizer and noise cancellation filters. The LTC1068 is immediately available in both commercial and industrial temperature versions. For a data sheet and evaluation samples, contact your local Linear Technology sales office.

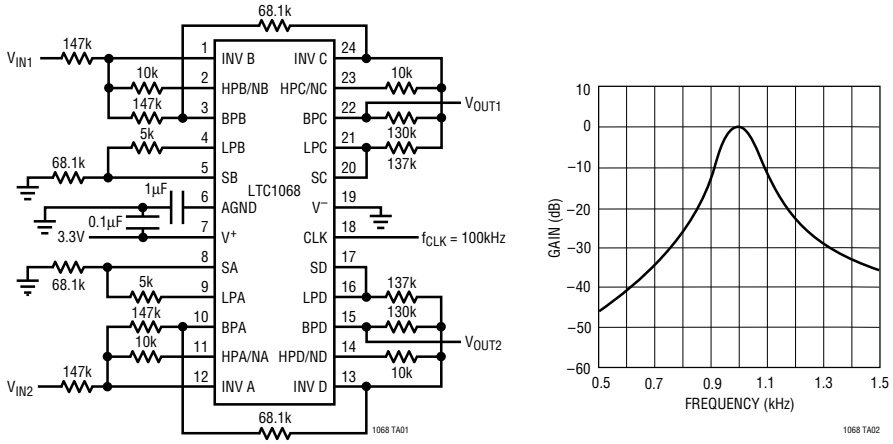






**Figure 1. Frequency Response of Dual Butterworth Bandpass Filter**

# Application of the Month

## Power Supplies for Subscriber Line Interface Circuits

As the demand for world wide networking grows, so will the need for advanced data transmission products. In particular, ISDN services have become popular because of the recent development of the Internet. ISDN provides higher speed data transmission than standard modems used in PCs. Also, ISDN supports the standard telephone interface (voice and fax), which includes the Subscriber Line Interface Circuit. A Subscriber Line Interface Circuit requires a negative power supply for the interface and the ringer voltages. The power supplies described herein are designed for these applications. Specifically, these designs address the AMD79R79 SLIC device with on-chip ringing.

Figure 1 shows a current mode flyback power supply using the LT1171CQ device. This current mode device has a wide input voltage range of 3V to 60V, current limit protection and an on-chip 65V, 0.30Ω bipolar switch. The input voltage range for the circuit is 9V to 18V. This circuit is intended for small wall adapters that power ISDN boxes. The output voltages are –23.8V at 50mA and –71.5V at 60mA.

The circuit shown in Figure 1 uses the LT1171 in standard flyback topology. The transformer's turns ratio is 1:1:1:1, where 23.8V appears across each secondary winding and the primary during the switch off time. The remaining secondary windings are stacked in series to develop –47V. The –47V section is then stacked onto the –23.8V section to get –71.5V. This technique provides very good cross regulation, lowers the voltage rating required on the output capacitors and lowers the RMS currents, allowing the use of cheaper output capacitors. Either the –23.8V output or the –71.5V output can be at full load without affecting the other corresponding output. The circuit's step response is very good; no significant overshoot occurs after either output is shorted and released. Also, the transformer windings are all quadrafilar to lower the leakage inductance and cost.

Figure 2 shows a current mode flyback power supply using the LT1269CQ device. This current mode device has a wide input voltage range, current limit protection and an onboard 60V, 0.20Ω bipolar switch. The input voltage range for the circuit is 5V to 18V. This design provides a wider input voltage range and greater output power than that of Figure 1. The output voltages are –23.5V at 60mA and –71.5V at 120mA (8.6W). This circuit is designed to power two SLIC devices. The circuit operation is identical to Figure 1, except for a larger switching regulator device (VR1) and a different transformer (T1). These changes allow for 5V operation and higher output power. This circuit is designed for full load on the –71V or –23.5V output. This accommodates the ringing on two SLICs or off hook on two SLICs. R5 and R6 are preload resistors for maintaining an accurate –23.5V output at full load with the –71V output at minimum load.

Complete information on thermal and layout considerations and a complete bill of materials are available. Contact the factory or call your local LTC sales office and ask for Design Note 130.

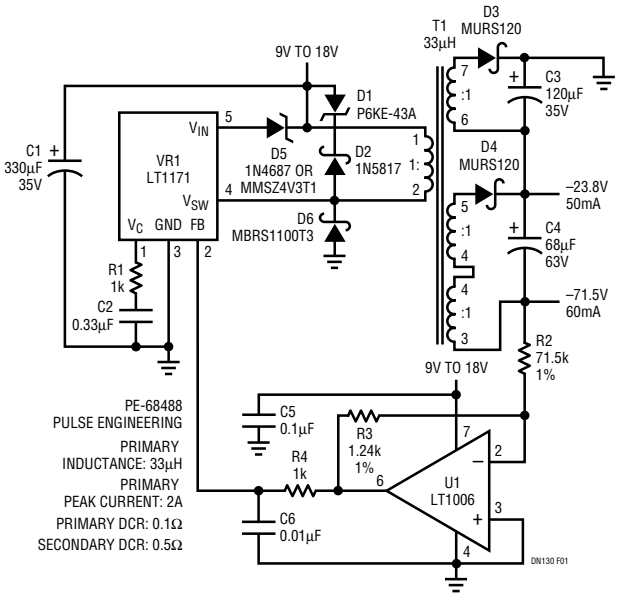



**Figure 1. LT1171 Supplies –23.8V at 50mA and –71.5V at 60mA**

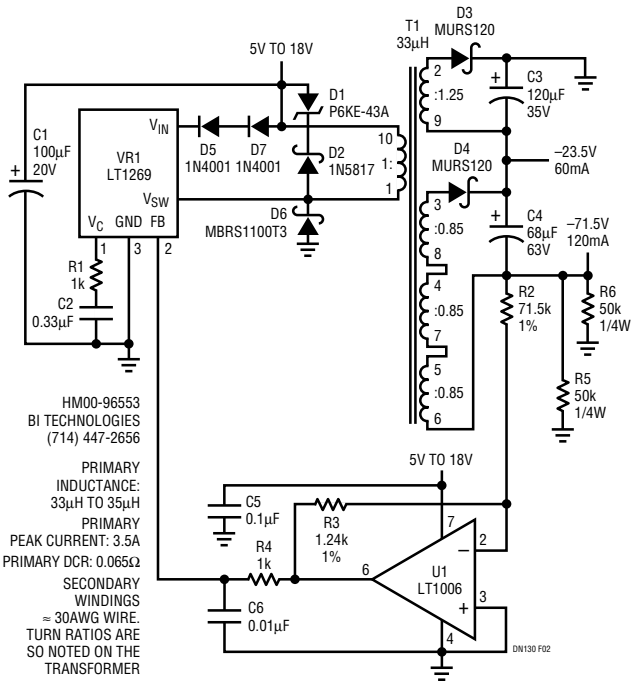



**Figure 2. LT1269 Supplies –23.5V at 60mA and –71.5V at 120mA from 5V Input**

# 200V/µs Op Amp Uses Only 250µA Supply Current

The **LT1351** op amp offers a gain bandwidth of 3MHz and a 250V/µs slew rate while drawing only 250µA of supply current. This C-Load™ stable op amp drives capacitive loads in excess of 10,000pF and has a 700ns settling time to 0.1% (10V step). Its excellent DC precision, high slew rate and fast settling time make it ideal for use in low power data acquisition systems.

Maximum input offset voltage is 600µV while maximum input bias current and input offset current are 75nA and 20nA respectively. Minimum DC gain for a 2k load is 30V/mV and input noise voltage is specified at 14nV/√Hz. The LT1351 operates with supplies as low as ±2.5V. Minimum output swing into 1k is ±13V with a ±15V supply and into a 500Ω load is ±3.4V with a ±5V supply. A shutdown function further reduces supply current from 250µA down to 10µA.

The LT1351 low power requirements make it attractive for battery-powered systems, needing wideband amplifiers, buffers and filters. (Figure 1 shows the device used as an instrumentation amplifier.) The LT1351 stability with any capacitive load makes it useful in buffer or cable driver applications. Figure 2 shows the frequency response for various capacitive loads from 10pF up to 5000pF.

The LT1351 is immediately available in volume from stock in either 8-lead PDIP or SO-8 surface mount packages. Contact your local Linear Technology sales office for a data sheet and evaluation samples.

C-Load is a trademark of Linear Technology Corporation.

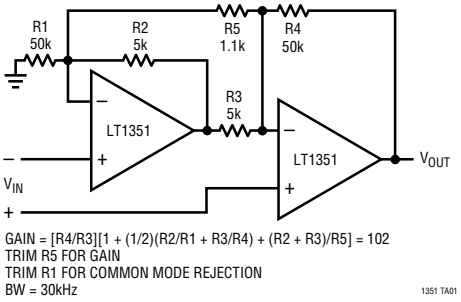



**Figure 1. LT1351 Used as an Instrumentation Amplifier**

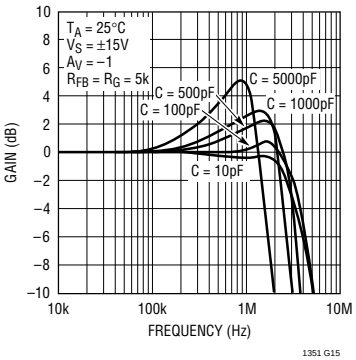



**Figure 2. Frequency Response of the LT1351 for Various Capacitive Loads**

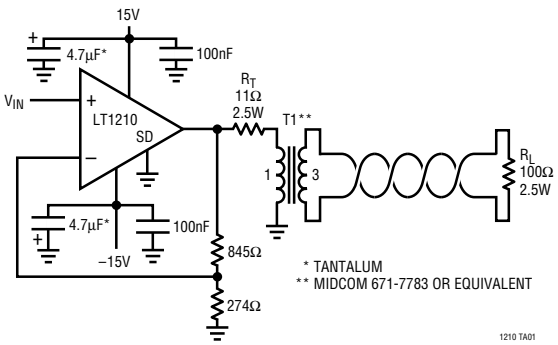
# 1.1A Output, Current Feedback Amp Has 35MHz Bandwidth, 700V/µs Slew Rate

The **LT1210** current feedback amplifier (CFA) provides a 1.1A minimum output drive current and 900V/µs slew rate over a 1MHz to 2MHz frequency range. This C-Load stable op amp has a typical bandwidth of 35MHz and can drive capacitive loads greater than 10,000pF without oscillation. For example, the device's excellent large-signal characteristics and the combination of high slew rate and output drive enables the LT1210 to deliver ±10V into a 10Ω load (5W) at 2 MHz.

The LT1210 operates over a wide supply range of ±5V to ±15V and draws 35mA supply current. A shutdown function reduces the quiescent supply current to less than 200µA when the Shutdown pin is open. The LT1210 can also operate in a multiplexing mode. By attaching a resistor to the Shutdown pin, quiescent supply current can be reduced to 15mA. Bandwidth is reduced but the full output current capability of the LT1210 is maintained.

As a C-Load device, the LT1210 is well suited for any application that requires driving a large output current into a load, even a highly capacitive load, and often can replace two components—an op amp and a buffer. Applications include cable drivers, driving twisted pairs (as shown in Figure 1), test equipment amplifiers, buffers and video amplifiers. The LT1210 can be used in telecommunications applications such as driving data into the primary of a transformer for systems implementing HDSL (High Bit Rate Digital Subscriber Loop). The LT1210 is also appropriate for ADSL (Asymmetric Digital Subscriber Loop) applications where large output currents are needed for the transmitter.

The LT1210 is offered in three packages—a 16-pin surface mount SO package (LT1210CS), a 7-pin TO-220 (LT1210CT7) and a 7-pin DD (LT1210CR). The SO-16 package is only recommended for ±5V applications where the power dissipation requirements are less. Call your local Linear Technology sales office for a data sheet and evaluation samples.



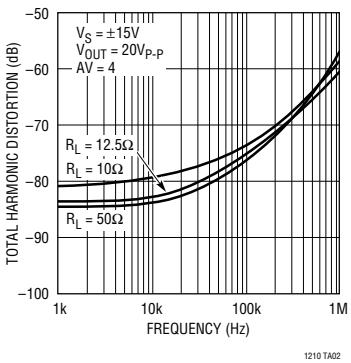




**Figure 1. LT1210 as a Twisted-Pair Driver and Resulting Harmonic Distortion Over Frequency**

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