

Product of the Month

New SO-8 ADCs: Speed and Accuracy Are "Best in Class"

LTC[®]1401: 200ksps on 3V Supply/LTC1404: 600ksps on 5V Supply

Linear Technology introduces two top new performers in their field: The 200ksps **LTC1401** is the fastest 12-bit, 3V supply ADC in an SO-8 package. The **LTC1404** is the industry's fastest 12-bit ADC in an SO-8 package. Both guarantee ± 1 LSB DNL error and ± 1 LSB INL.

The LTC1401/LTC1404 offer an internal built-in reference plus Nap and Sleep modes for dramatically lower power consumption.

LTC1401: Single Supply 3V Operation, Speed and Low Power

The LTC1401 provides 12-bit resolution for 0V to 2.048V unipolar inputs. The 200ksps data sampling speed is a breakthrough for 3V-powered ADCs. Dynamic performance is excellent at 3V too: 68dB S/(N + D) and -72 dB THD at 50kHz. This easy-to-use device comes complete with a 315ns sample-and-hold and a precision reference as required by all converters. For ultra

power sensitive applications, the LTC1401 draws only 15mA from a single 3V supply. For long inactive periods between conversions, the LTC1401 can be placed in a 13.5 μ W Shutdown mode for increased power savings.

LTC1404: Fastest Speed, Accuracy and Minimum Board Space

The LTC1404 provides very fast speed plus high accuracy. This easy-to-use device comes complete with a 160ns sample-and-hold and a precision internal reference. Despite its high speed, the product is low power, consuming only 75mW typically and also offering Nap and Sleep modes. Get both very high speed and low power with the LTC1404. Guaranteed AC performance specs include 69dB S/(N+D) (SINAD) and -76 dB THD over temperature at an input frequency of 100kHz.

Serial Data Applications

Both the LTC1401 and the LTC1404 provide a 3-wire serial data port for compact and efficient data transfer to a wide range of microprocessors, microcontrollers and DSP circuits. In the Nap mode, both circuits wake up and convert immediately upon command. Upon power-up from the Sleep mode, a ready signal is provided to indicate that the reference has settled and the circuit is awake and ready to convert.

The 3V LTC1401 is well-suited for small, low power data acquisition equipment such as handheld or portable instruments or medical instruments. Other products that need very low power to run cool or that need to make efficient use of board space can benefit from the LTC1401, too. Such products include automatic test equipment, modems and mobile communications products.

The 600ksps LTC1404 is perfect for improved performance in portable communications equipment and portable instruments. The serial interface will hook up easily to DSPs for high speed signal processing. Multiplexed data acquisition

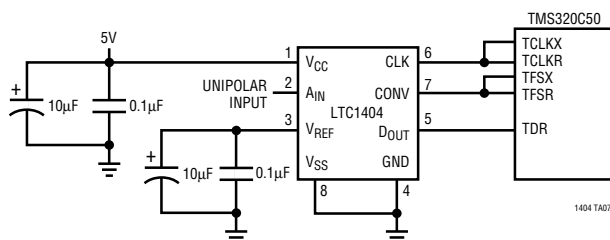


Figure 1. LTC1404 Interface to TMS320C50 Running at 5MHz Without External Clock

Table 1. High Speed SO-8, 12-Bit ADCs

Guaranteed Limits	LTC1401	LTC1400	LTC1404
Min Supply Voltage	3V	5V	5V
Max Sampling Rate	200ksps	400ksps	600ksps
Max DNL Error	± 1 LSB	± 1 LSB	± 1 LSB
Max INL Error	± 1 LSB	± 1 LSB	± 1 LSB
Internal Reference	1.2V \pm 20mV 45ppm/ $^{\circ}$ C Max	1.2V \pm 20mV 45ppm/ $^{\circ}$ C Max	1.2V \pm 20mV 45ppm/ $^{\circ}$ C Max
Supply Current*	10mA	30mA	30mA
Nap Mode Current*	1mA	3mA	3mA
Sleep Mode Current*	15 μ A	20 μ A	20 μ A
Shutdown Mode*	10 μ A	—	—

*Currents stated are maximum values. Typical values are half or less of these numbers.

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20Msps 8-Bit ADC: High Dynamic Performance

LTC1406: Differential Input, 250MHz Input Bandwidth

Linear Technology announces a 20Msps (Mega samples per second) analog-to-digital converter circuit, the LTC1406. In addition to the high sampling rate, the product offers exceptional dynamic performance at high frequencies. The LTC1406 is an 8-bit, sampling A/D converter that draws only 150mW from a single 5V supply and takes up a small amount of board space (see Figure 1).

Features Summary

The LTC1406 is a differential input, parallel output pipelined ADC. The key features are:

- 20Msps sampling rate: fast enough for communications and high-end imaging; 250MHz input bandwidth allows for undersampling.
- 8-bit "no missing codes": guarantees ± 1 LSB DNL error. Larger DNL errors show up as discontinuities in color gradients in digital images.
- 47.5dB SINAD at 10MHz: provides 7.6 effective bits of resolution up to 10MHz. (Many 8-bit, 20Msps ADC circuits are only good for oversampling.)
- 7 ENOBs at 70MHz: can be used for undersampling applications and maintain 7-bit resolution even at very high frequencies.
- Low power (200mW): low power when converting and also provides shutdown for power savings when not in use.
- GN-24 package: saves precious board space, smaller than any competing ADC in this range.

In its power-down mode, the circuit draws only 1 μ A. Its full-scale input range is ± 1 V. The inputs can be driven differentially

or one input can be tied to a fixed voltage and the other driven with a ± 1 V bipolar input.

Unique Sample-and-Hold for High Performance

The LTC1406 includes a unique sample-and-hold circuit that is key to its dynamic performance. The circuit can acquire single-ended or differential input signals up to its 250MHz bandwidth. The true differential inputs reject common mode noise, allowing users to eliminate ground loops and common mode noise by measuring signals differentially from the source. The combination of 20Msps sampling rate and 250MHz small-signal input bandwidth makes the LTC1406 the best choice for high-end imaging and wireless communications. The ADC is able to undersample input signals with frequencies well beyond the converter's Nyquist frequency of 10MHz. Undersampling techniques can be used for 70MHz IF stages, eliminating a mixer and filter stage and saving system cost.

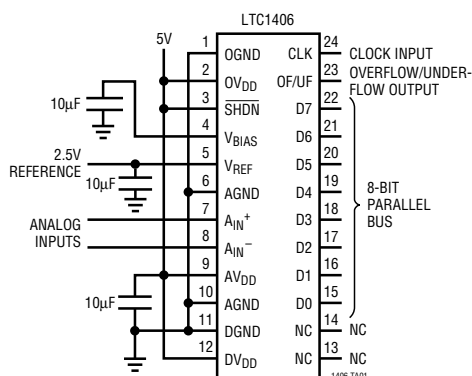


Figure 1. Low Power, 20MHz, 8-Bit Sampling ADC

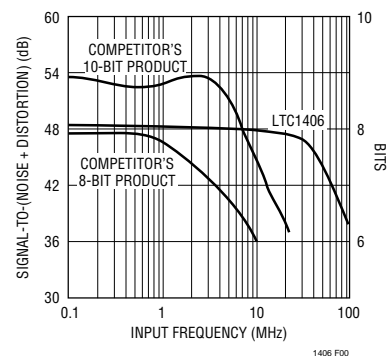


Figure 2. LTC1406 Has 7-ENOB Performance to 70MHz, Making It Ideal in Undersampled Applications

The effective number of bits remains near ideal up to and beyond 10MHz. Figure 2 shows the "order of magnitude" improvement as compared to competing 20Mbps 8- and 10-bit ADCs. Only the LTC1406 remains an "8-bit" ADC at 70MHz.

More Features, More Applications

The LTC1406 has other features that make interfacing to specific applications easier. The overrange/underrange (overflow/underflow) bit provides information to the processor when the signal exceeds the input range. The parallel output can easily be interfaced to 3V logic. The ± 1 V input range can be driven differentially, or biased anywhere within the supply rails.

With very high sampling rate plus excellent high frequency dynamic performance, the LTC1406 is ideal for additional high end applications such as fiber optic test equipment, digital cellular telephones and high speed data acquisition.

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LTC1401/LTC1404 from page 1

systems, audio and telecom processing, digital radio and spectrum analysis can all benefit from the LTC1404.

Features and Spec Comparison

The LTC1400 is the previously introduced, general purpose member of Linear Technology's serial 12-bit ADC family (see Table 1). Where 400ksps is fast enough, users can save cost with the LTC1400 and save a small amount of power in the Sleep mode. The LTC1400 and LTC1404 are pin-compatible so an application can be later upgraded to a faster sampling speed as

required (with minor modifications to software timing).

Speed and Accuracy, with Low Power and Small Size

High performance attributes are ever more crucial in the application of fast-paced technological developments. Stay ahead with data converters from Linear Technology Corp. For data sheets and evaluation samples, contact your local Linear Technology sales office. For more information, visit our web site at www.linear-tech.com.

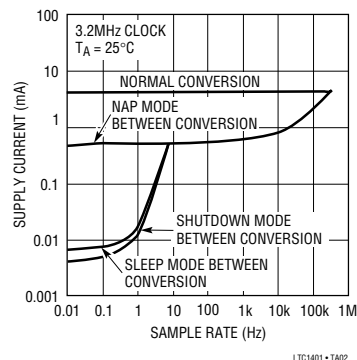


Figure 2. Power Consumption vs Sample Rate

Application of the Month

The “Smart Rock”: A Micropower Transponder

A “smart rock” is a locating device that is buried at a specific site. It is interrogated by a portable source and responds with information about its position, identification number or any data that it has collected since its last interrogation. A smart rock buried on a nature trail might send its identification number to a traveler’s handheld transponder, which would decode the identification number and play a message describing the surrounding sights. Smart rocks are sometimes placed along the edges of cliffs so that interrogators built into vehicles, such as bulldozers, will cause them to stop before they get too close to the edge.

The Micropower Subcircuits

Ultralow Power Crystal Oscillator

Figure 1, Section A shows the LTC1440 implementing a micropower oscillator. This circuit provides the references for both voltage and frequency needed in our rock; it draws only a few microamps of battery current.

Ultralow Power IF Amplifier

Figure 1, Section B details the IF amplifier, which has a gain of 2500 at a center frequency of 20Hz. By selecting the LT1495 for our amplifier, we can do this while consuming only 2 μ A.

Hefty Driver with Ultralow Sleep Current

Figure 1, Section C shows the LTC1480 ultralow standby power RS485 transceiver. We use the LTC1480 in its transmit mode, where it provides currents of about 100mA. The rest of the time the LTC1480 is shut down, drawing a microampere of quiescent current.


Receiver

The 32kHz reference frequency generated by Y1 and U1B is divided by eleven in U2 and by two in U3A to yield 1489.5Hz, the local oscillator frequency. This LO output is applied to mixer Q3 while Q1 and Q2 are fully enhanced, causing C4 and L1 to act as a parallel resonant antenna. The output of the mixer, Q3, is fed into the IF

amplifier created by U5A and U5B, where the signal is multiplied by approximately 2500. When the signal on U5B Pin 7 reaches 1.2V_{P-P}, Q4 turns on, pulling the START signal line low.

Transmitter

Once the interrogating tone burst is over and the IF amplifier’s output has decayed below 1.2V_{P-P}, Q4 stays off and R11 is allowed to charge C11, raising the voltage on the START node. D3 pulls the START signal low, preventing an early termination of a transmit cycle caused by IF overload. Q1 and Q2 turn off, causing C4 and L1 to form a series resonant circuit connected to the output of U4 (the power driver). At the same time, U4 is enabled and drives the LO frequency into the series resonant tank circuit. This transmitting action continues until R12 discharges C12 to the threshold of the reset pin (Pin 13) of U3B. For more information, see Design Note 161.

Linear Technology offers an extensive line of micropower ICs, including precision op amps, comparators, voltage references, A-to-D converters and line drivers and receivers. 

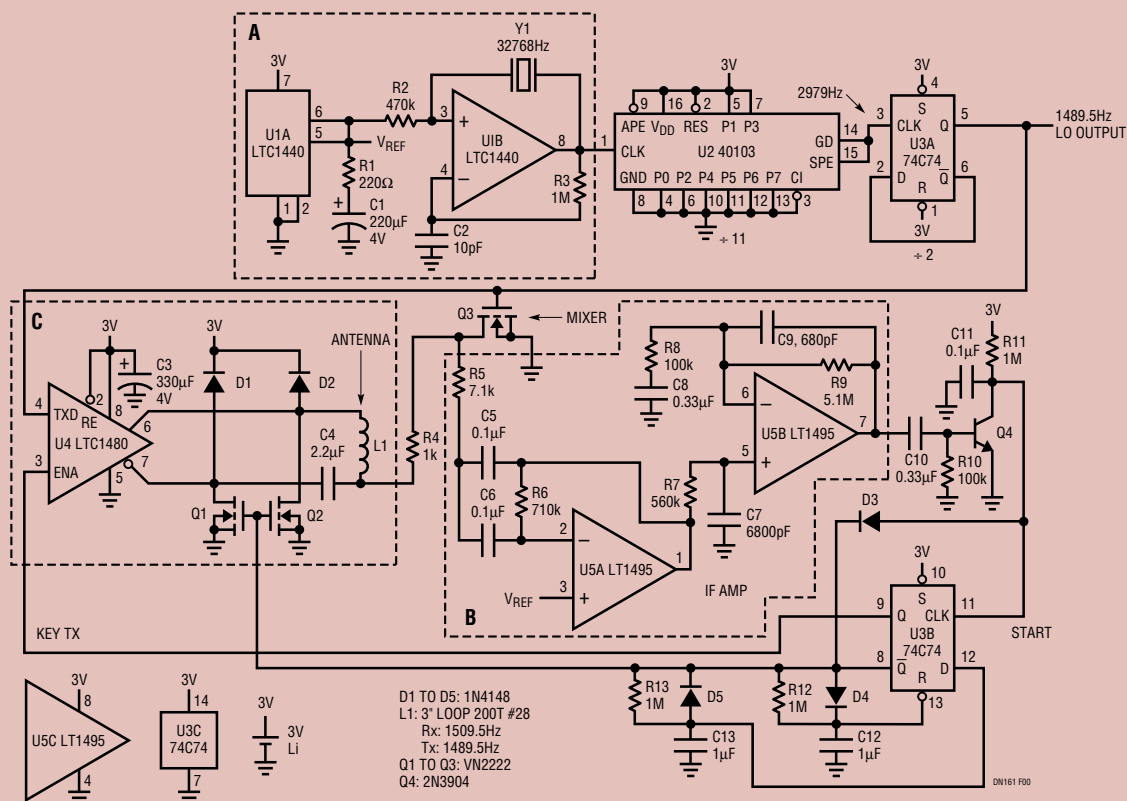


Figure 1. (Lapis Orbus Astutus)

The LTC1562: Quad Operational Filter!

Continuous-Time, Universal, Building-Block Filter

Linear Technology announces a new type of integrated filter IC. An Operational Filter is a building block that is as versatile to use as the ubiquitous operational amplifier. The new **LTC1562** meets the criteria of being easily configured for a wide variety of filter responses.

The LTC1562 is an active RC quad universal filter combining wide dynamic range, DC accuracy and easy programmability. Its features and its compact, 20-pin SSOP package make it superior to discrete filters in a wide range of signal processing and data communications applications.

The LTC1562 lets the user set the filter configuration, the center frequency and the gain and Q values using only inexpensive resistors. It contains four 2nd order filter sections and features very low noise and low distortion, rail-to-rail inputs and outputs, and a center frequency of 10kHz to 200kHz. (See Table 1.)

Table 1. Key Features and Specs (Typical)

Parameter	LTC1562
Supply Current ($V_S = \pm 15V$)	19mA
Shutdown Supply Current	1.5 μA
Output Offset Voltage (LP Out)	3mV
Output Swing, $R_L = 5k$, $V_S = \pm 5V$	9.8V _{P-P}
Optimized Center Frequency	10kHz to 150kHz
Maximum Center Frequency	200kHz
Center Frequency Accuracy	$\pm 0.5\%$
Center Frequency Temperature Coefficient	25ppm/ $^{\circ}C$
Maximum Q Accuracy (Unadjusted)	3%
Wideband Output Noise (200kHz)	24 μV_{RMS}
20kHz THD, 2.8V _{P-P}	-96dB
100kHz THD, 2.8V _{P-P}	-78dB
Surface Mount Package	20-Pin SSOP

The Active RC Filter Design

The LTC1562 is an active RC filter, not a switched-capacitor filter. It contains four matched, 2nd order, 3-terminal, universal continuous-time filter blocks, each with a virtual-ground input node and two rail-to-rail outputs. In the most basic application, one such block and three external resistors provide 2nd order lowpass and bandpass filtering functions simultaneously, or the four blocks may be combined to form an 8-pole response. The three resistors program f_O , Q and gain. The LTC1562 is trimmed so

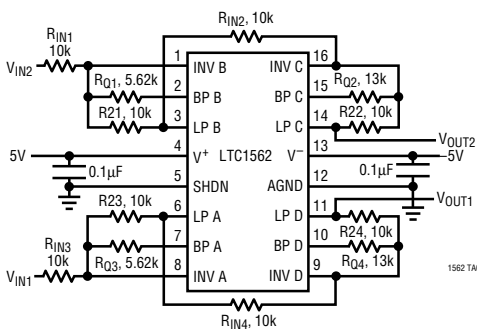
that f_O will be $100kHz \pm 0.5\%$ when an external resistor is exactly $10k\Omega$. Moreover, the virtual-ground input gives each 2nd order section the capability for analog operations such as gain, summing and weighting of multiple inputs, or accepting current or charge signals directly.

Multiple 2nd order sections can be cascaded for higher order filters (Figures 1 and 2). Advanced applications exploit the virtual-ground input in feed-forward configurations to obtain elliptic and notch-type frequency responses. See recent articles in the *Linear Technology* magazine. Since the input is virtual-ground, voltages applied to the series input resistor can readily exceed the power supply rails.

The LTC1562 vs Op Amp Filters

Compact: The LTC1562 replaces eight precision capacitors, four precision resistors and 12 high performance op amps.

Precise: An equivalent discrete op amp design would require eight 0.25%-tolerance capacitors plus four 0.5%-tolerance resistors.



DC ACCURATE, NONINVERTING, UNITY-GAIN, RAIL-TO-RAIL INPUT AND OUTPUTS. PEAK SNR = 100dB WITH $\pm 5V$ SUPPLIES

Figure 1. Dual 4th Order 100kHz Butterworth Lowpass Filter Application

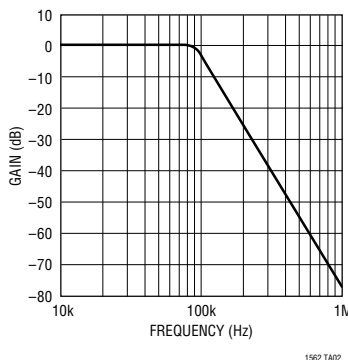


Figure 2. Frequency Response of Filter

Flexible: One qualified device serves multiple filter applications with the change of only inexpensive external resistors.

The LTC1562 can be configured for a wide variety of configurations:

- Multiple filters, different orders: single 8th order, dual 4th order, quad 2nd, etc.
- Multiple responses: lowpass, highpass, bandpass, notch, allpass
- Multiple response forms: Butterworth, Chebychev, elliptic, Cauer, Bessel, linear phase, Equiripple delay

High Dynamic Range, Many Applications

The LTC1562 is designed for applications where dynamic range is important. Signal-to-noise ratios over 100dB are routinely realized. Input-referred noise falls with increased designed gain of the filter, permitting dynamic ranges as high as 118dB. Application areas include the following:

- High resolution systems (14 bits to 16 bits)
- Antialiasing filters
- Smoothing or reconstruction filters
- Data communications and telecommunications equalizers
- Dual (I-and-Q) channel filters (two matched 4th order filters in one package)

For data sheets and evaluation samples, contact your local Linear Technology sales office. For more information, visit our web site at www.linear-tech.com.

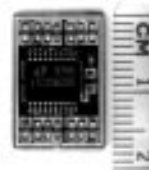


Figure 3. Complete LTC1562 Universal Analog Filter, Fully Configured for Single or Dual Supplies, with Supply Bypass Capacitors and All Programming Resistors. Total Board Area Is 155mm² (0.24in²)

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