

Ultralow Power 16-Bit High Speed Signal Chain Solution for Portable Sampling Systems

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The LTC2195 family of ultralow power, dual 16-bit, 25Msps to 125Msps analog-to-digital converters (ADCs) dissipate half the power of competing 16-bit solutions, extending battery run times in portable electronics. Despite consuming only ~1.5mW/Msps per channel, the LTC2195 does not shirk performance to save power, yielding a 76.8dB signal-to-noise ratio (SNR) and 90dB of spurious free dynamic range (SFDR) at base-band (0MHz–62.5MHz, the first Nyquist zone). Serial LVDS outputs reduce the number of data lines required for routing the ADC data while minimizing digital feedback.

SIGNAL PATH DESIGN

The LTC2195 family is an ideal solution for applications that require 16-bit performance and ultralow power consumption to extend battery life. Portable medical imaging equipment is a perfect example. In many imaging applications the signal from the image sensor must be conditioned before being sampled by the ADC. For this task, it is important to choose a low noise, low power amplifier that matches the performance of the ADC, such as the LTC6406, which makes a good match for the LTC2195 family.

The LTC6406 is a fully differential amplifier with low noise ($1.6\text{nV}/\sqrt{\text{Hz}}$ at the input) and high linearity (+44dBm OIP3 at 20MHz) in a small 3mm × 3mm

QFN package. External resistors set the gain, giving the user maximum design flexibility. Low power consumption (59mW with a 3.3V supply) minimizes the effect on the system power budget. This amplifier also has a common mode voltage range that extends down to 0.5V meaning it can be paired seamlessly with the LTC2195, which has a nominal common mode voltage of 0.9V.

Typically the output of an image sensor is single-ended. This requires a single-ended to differential translation before being sampled by the ADC. If response to DC is also required, a transformer cannot be used. This situation mandates a low noise amplifier that is

capable of doing single-ended to differential translation, like the LTC6406.

The amplifier must be followed by a filter to reduce the wideband noise of the amplifier and to isolate the output of the amplifier from the ADC inputs—the ADC inputs produce common mode glitches associated with the commutation of the sample caps. A filter helps attenuate these glitches, protecting the amplifier. A high order filter is not required, since the noise of the amplifier is fairly low. With a corner frequency of 12MHz, the filter used here is adequate—it does not degrade the performance of the ADC.

The final filter should be designed to reduce only the wideband noise of the amplifier, not as a selectivity filter with a

Table 1. The new generation of ultralow power 16-bit ADCs

		25Msps	40Msps	65Msps	80Msps	105Msps	125Msps
SINGLE CHANNEL	7 × 7 QFN 1.8V Single ADCs, Parallel Outputs	2160	2161	2162	2163	2164	2165
	9 × 9 QFN 1.8V Dual ADCs Parallel Outputs	2180	2181	2182	2183	2184	2185
DUAL CHANNEL	7 × 8 QFN 1.8V Dual ADCs, Serial LVDS Outputs	2190	2191	2192	2193	2194	2195
POWER	(mW/Ch)	40	60	80	100	155	185

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step transition band. A step transition band in the filter increases insertion loss and degrades the OMP_3 of the amplifier, which leads to distortion of the signal from the image sensor. The circuit shown in Figure 1 accomplishes this goal.

RESULTS

Figure 2 shows the performance of this circuit. The results show that the linearity of the amplifier does not degrade the SFDR of the ADC at low input frequencies. The SNR also remains unchanged at 76.5dB. The LTC6406 does not degrade the SNR or the SFDR of the LTC2195 when using it at unity gain.

MODIFICATIONS

For this design there are some trade-offs that can be made to change the performance of the system. First, the gain can change by increasing the feedback resistors, or decreasing the source resistors. Typically the source resistors are set by the output impedance of the sensor itself. The feedback resistors are then used to modify the gain of the amplifier. The LTC6406 can

be used to produce attenuation or gain depending on the output of the image sensor. As the gain of the amplifier increases, the amount of compensation capacitance required to stabilize the amplifier decreases. In this unity gain application 1.8pF is enough to produce good results. If the amplifier is used to attenuate the signal, more capacitance is required.

The low order, low pass filter in Figure 1 attenuates the wideband noise of the amplifier with a cutoff frequency of 12MHz. This cutoff frequency can be increased by decreasing the value of the final capacitors. Because the amplifier cannot drive a low impedance, and the ADC wants to see a low impedance at its analog inputs the impedance of the filter has been optimized to satisfy both the amplifier and the ADC. If a higher order filter is required, it should be located prior to the final drive amplifier, and more gain should be used in the amplifier stage to accommodate for the insertion loss in the filter. Some filtering is required between the final amplifier and the ADC. Even a

simple RC low pass filter is better than driving the ADC directly into the amplifier.

ABOUT THE LTC2195

The LTC2195 is a 16-bit 125MSPS, simultaneous sampling, dual ADC operating from a single 1.8V supply. This circuit can be easily applied to the 14- or 12-bit members of the family or to converters that sample at much lower sample rates. The LTC2195 family also contains dual and single channel ADCs with parallel outputs. The LTC2185, 2-channel ADC and the LTC2165 single channel ADC have the same excellent 16-bit performance and low power as the LTC2195, but with parallel outputs that can simplify the FPGA code required to collect data. These flexible ADCs include the choice of CMOS, DDR CMOS or DDR LVDS outputs with programmable digital output timing, programmable LVDS output current and optional LVDS output termination. The LTC2185 and LTC2165 also have the popular randomizer and alternate bit polarity features that help to reduce digital feedback. More information about alternate bit polarity mode and

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Figure 1. Imaging application

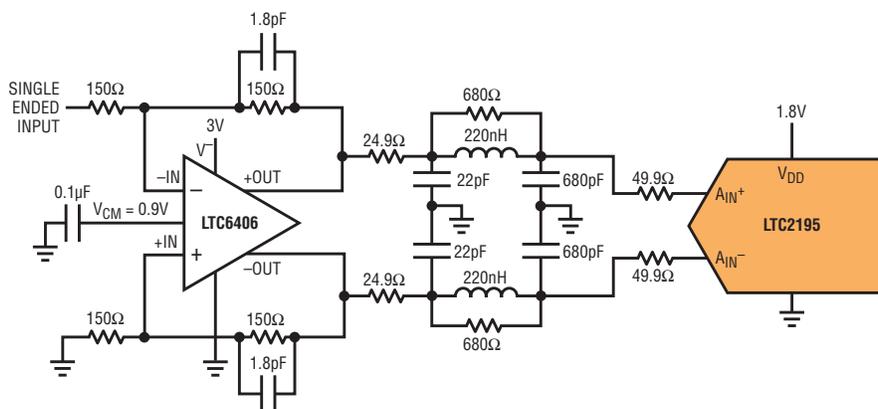
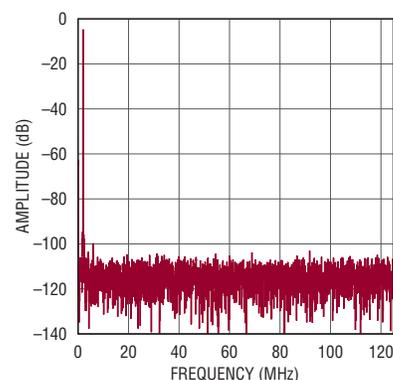


Figure 2. FFT results of circuit in Figure 1 with $F_S = 125\text{MSPS}$ $F_{IN} = 1\text{MHz}$



voltage. Safety features include bad-battery detection and NTC resistor input with fault indicator suitable for use with a LED. An internal input reverse voltage blocking diode is available to prevent leakage current from the battery when the power source is not present. The LTM8061 and LTM8062 are available in an ROHS compliant 9mm × 15mm × 4.32mm LGA package.

60V BATTERY CHARGING CONTROLLER AND POWER MANAGER

The LTC4000 is a high voltage controller and power manager that converts virtually any externally compensated DC/DC power supply into a full-featured battery charger. The LTC4000 is capable of driving typical DC/DC converter topologies, including buck, boost, buck-boost, SEPIC and flyback. The device offers precision input and charge current regulation and operates across a wide 3V to 60V input and output

voltage range—compatible with a variety of different input voltage sources, battery stacks and chemistries. Typical applications include high power battery charger systems, high performance portable instruments, battery back-up systems, industrial battery-equipped devices and notebook/sub-notebook computers.

The LTC4000 features an intelligent PowerPath™ topology that preferentially provides power to the system load when input power is limited. The LTC4000 controls external PFETs to provide low loss reverse current protection, efficient charging and discharging of the battery and instant-on operation to ensure that system power is available at plug-in even with a dead or deeply discharged battery. External sense resistors and precision sensing enable accurate currents at high efficiency, allowing the LTC4000 to

work with converters that span the power range from milliwatts to kilowatts.

The LTC4000's full-featured controller charges a variety of battery chemistries including lithium-ion/polymer/phosphate, sealed lead acid (SLA), and nickel-based. The device also provides charge status indicators through its FLT and CHRG pins. Other features of the battery charger include: ±0.2% programmable float voltage, selectable timer or C/X current termination, temperature-qualified charging using an NTC thermistor, automatic recharge, C/10 trickle charge for deeply discharged cells and bad battery detection.

The LTC4000 is housed in a low profile (0.75mm) 28-pin 4mm × 5mm QFN package and a 28-lead SSOP package. ■

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digital feedback can be found in the video “Reduce Digital Feedback in High Speed Data Conversion Systems - LTC2261” at www.linear.com. There are also pin-compatible 14- and 12-bit versions of the dual LTC2185 that also provide excellent performance, and extremely low power consumption for high speed ADCs. The complete family can be seen in Table 1.

CONCLUSION

The LTC2195 is the perfect ADC for power-conscious, high resolution sensor applications, while the LTC6406 is a good match as a driver amplifier—it does not compromise the performance of the LTC2195 and its power requirements are also low. Data sheet performance of the ADC can be easily achieved by using a relatively low order

filter to reduce the wideband noise of the amplifier. The pairing of the LTC2195 and the LTC6406 is the ideal combination for any portable image sensor application, combining excellent performance with low power consumption. For more information about the LTC2195 family and the LTC6406 visit www.linear.com. ■

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allow smaller inductors and capacitors, but use more power and have a smaller allowable step-down range due to the minimum on and off time constraints.

This brings us to the difference between the LT3694 and the LT3694-1. The LT3694 switching frequency can be synchronized to an external clock by connecting it to the SYNC pin. The resistor on the RT pin should be set provide a free running frequency 20% below the sync frequency. The LT3694-1 replaces the SYNC pin with a CLKOUT pin, allowing

the LT3694-1 to be used as the master clock for synchronizing other switching regulators. The CLKOUT produces a clock signal running at ~50% duty cycle.

TRIPLE-OUTPUT CONVERTER WITH VOLTAGE TRACKING

Figure 1 shows a wide input range, 6.3V to 36V, converter that generates three outputs: 5V, 3.3V and 2.5V. The outputs track ratiometrically, set via a common TRK/SS connection. Figure 2 shows the start-up waveforms of the three outputs along with the enable signal.

Figure 3 shows the switching regulator efficiency at different input voltages.

CONCLUSION

The LT3694/LT3694-1 offers robust, compact power supply solutions by squeezing three regulators into a tiny 4mm × 5mm QFN or a 20-lead TSSOP package. One regulator is an efficient switching regulator and the other two are low noise, low dropout linear regulators. Just a few small external components are needed to create an extremely compact triple output solution. ■