DESIGN NOTES

The LTC1096 and 1098: Micropower, SO-8, 8-Bit ADCs Sample at 1kHz on 3μA of Supply Current – Design Note 60

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The LTC1096 and LTC1098 are the lowest power, most compact, sampling analog-to-digital converters in the world. These new 8-bit micropower, sampling ADCs typically draw 100μA of supply current when sampling at 33kHz. Supply current drops linearly as the sample rate is reduced as shown in Figure 1. At a 1kHz sample rate, the supply current is only 3μA. The ADCs automatically power down when not performing conversions, drawing only leakage current.

They are packaged in 8-pin SO packages and operate on 3V to 9V supplies or batteries. Both are fabricated on Linear Technology's proprietary LTBiCMOS™ process.

Two Micropower ADCs

The LTC1096 and LTC1098 use a switched-capacitor, successive-approximation (SAR) architecture. Micropower operation is achieved through three design innovations:

1. An architecture which automatically powers up and down as conversions are requested
2. An ultra low power comparator design, and
3. The use of a proprietary BiCMOS process.

Although they share the same basic design, the LTC1096 and LTC1098 differ in some respects. The LTC1096 has a differential input and has an external reference input pin. It can measure signals floating on a DC common-mode voltage and can operate with reduced spans down to 250mV. Reducing the span allows it to achieve 1mV resolution. The LTC1098 has a two-channel input multiplexer and can convert either channel with respect to ground or the difference between the two.

Longer Battery Life

Tremendous gains in battery life are possible because of the wide supply voltage range, the low supply current, and the automatic power shut down between conversions. Eliminating the voltage regulator and operating directly off the battery saves the power lost in the regulator. At a sample rate of 1kHz, the 3μA supply current is below the self-discharge rate of many batteries. As an example, the circuit of Figure 2, sampling at 1kHz, will run off a Panasonic CR1632 3V lithium coin cell for five years.

The automatic shutdown has great advantages over the alternative of high-side switching a higher power ADC, shown in Figure 3. First, no switching signal or hardware is required. Second, power consumption is orders of magnitude lower with the LTC1096/8. This is because, when an

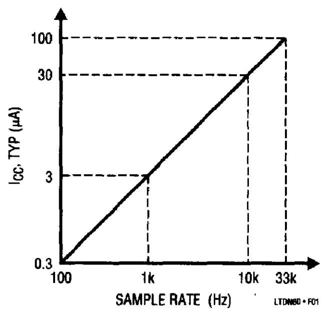

Figure 1. Automatic power shutdown between conversions allows power consumption to drop with sample rate.

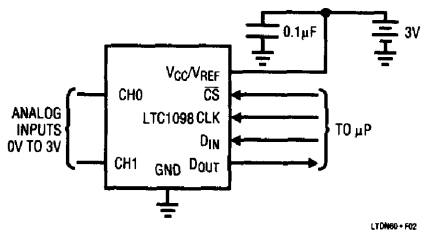

Figure 2. Sampling at 1kHz, this circuit draws only 3μA and will run off a 120mAhr CR1632 3V lithium coin cell for 5 years.

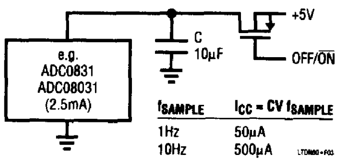

Figure 3. High-side switching a power-hungry ADC wastes power. Repeatedly switching the required bypass capacitor consumes 500μA even when taking readings at only 10Hz.

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ADC is high-side switched, the current consumed in charging the required bypass capacitor is large, even at very low sample rates. In fact, a 10µF bypass capacitor, high-side switched at only 10Hz, will consume 500µA!

A/D Conversion for 3V Systems

The LTC1096/8 are ideal for 3V systems. Figure 4 shows a 3V to 6V battery current monitor which draws only 70µA from the battery it monitors. The battery current is sensed with the 0.02Ω resistor and amplified by the LT1178. The LTC1096 digitizes the amplifier output and sends it to the microprocessor in serial format. The LT1004 provides the full scale reference for the ADC. The other half of the LTC1178 is used to provide low battery detection. The circuit's 70µA supply current is dominated by the op amps and the reference. The circuit can be located near the battery and data transmitted serially to the microprocessor.

Smaller Instrument Size

The LTC1096 and LTC1098 can save board space in compact designs in a number of ways. The SO-8 package saves space. Operating the ADC directly off batteries can eliminate the space taken by a voltage regulator. The LTC1096/8 can also operate with small, 0.1µF or 0.01µF chip bypass capacitors. The serial I/O requires fewer PC traces and fewer microprocessor pins than a parallel-port ADC. Connecting the ADC directly to sensors can eliminate op amps and gain stages. Finally, the ADCs do not need an external sample-and-hold.

AC and DC Performance

The LTC1096/8 are offered with +/– 0.5LSB total unadjusted error for applications that require DC accuracy. The ADCs also have a lot to offer in designs that require AC performance.

Figure 5 shows remarkable sampling performance for a device that draws only 100µA running at full speed. Dynamic performance of 7.5 effective bits is maintained up to an input frequency of over 40kHz.

In undersampling applications, this 40kHz input bandwidth remains intact as the sample rate (and power consumption) are reduced. A 40kHz waveform can be undersampled at 1kHz with 7.5 bits of accuracy on a supply current of 3µA!

Conclusion

Extremely low power consumption, 3V operation, small size and other benefits will help the LTC1096 and LTC1098 find their way into a variety of micropower, low-voltage, battery-powered and compact systems. For more information, refer to the LTC1096/8 data sheet, Linear Technology Magazine (Volume II Number 1) and application notes.

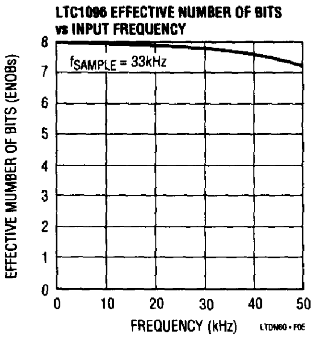

Figure 5. Dynamic accuracy is maintained up to an input frequency of over 40kHz.

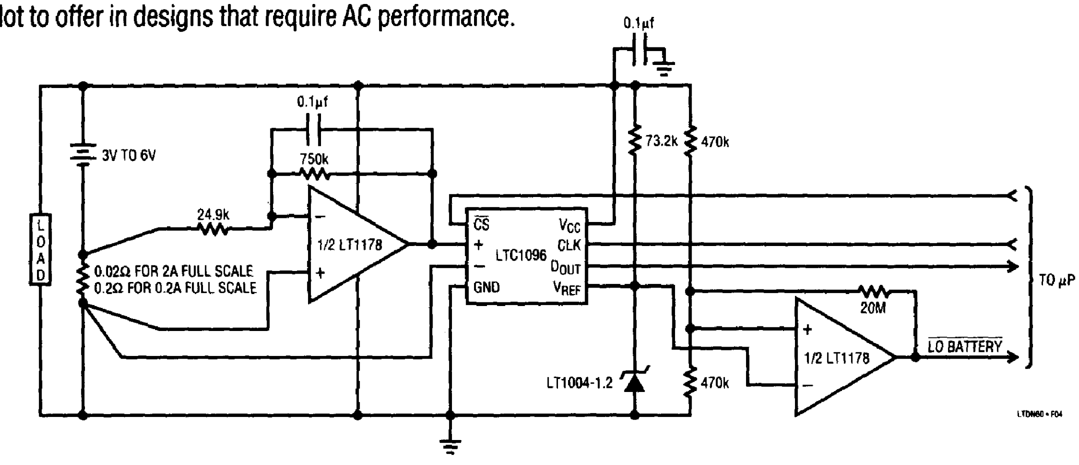

Figure 4. This 0 to 2A battery current monitor draws only 70µA from a 3V to 6V battery.

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