Process Signals from Millivolts to ±10 V Directly with a Versatile Single-Supply 3/5-V Charge-Balancing A/D Converter

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The *AD7707*, shown in Figure 1, is an oversampling A/D converter with on-chip digital filtering. It is intended for the measurement of wide-dynamic-range, low-frequency signals, such as those encountered in industrial control or process-control applications. It contains a multiplexer, programmable-gain amplifier, sigma-delta (charge-balancing) ADC, a calibration microcontroller with on-chip static RAM, a clock oscillator, a digital filter and a bi-directional serial communications port. The AD7707's three analog input channels include two low-level quasi-differential inputs and one high-level single-ended channel.

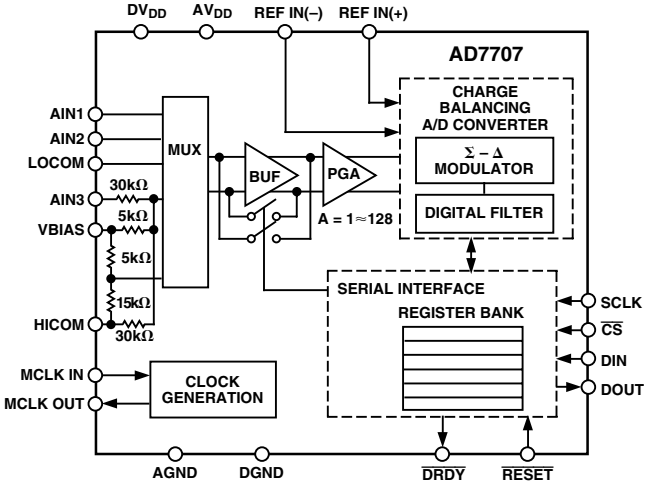

Figure 1. AD7707: a complete front end for low-frequency measurement applications.

The low-level input channels (AIN1 and AIN2) handle unipolar input signals ranging from 0 to 20 mV up to 0 to 2.5 V, and bipolar input ranges from ±20 mV to ±2.5 V, depending on the selected gain. These low level input channels allow direct measurement of signals from strain-gauges and other low-level transducers, eliminating a considerable amount of external signal conditioning. The high-level channel (AIN3) has thin-film scaling resistors to allow inputs of ±10 V, ±5 V, 0 to +10 V and 0 to +5 V to be directly accommodated without requiring split supplies or charge pumps.

The AD7707's sigma-delta conversion technique realizes up to 16 bits with no missing codes. The selected input signal is applied to a proprietary programmable-gain front end with an analog modulator. The modulator output is processed by an on-chip digital filter. The first notch of this digital filter can be programmed via an on-chip control register to allow adjustment of the filter cutoff and output update rate.

Featuring a serial interface that can be configured for three-wire operation, the AD7707 is ideal for use in smart microcontroller- or DSP-based systems. Gain settings, signal polarity and update-rate selection can be configured in software using the input serial port. The device contains both self-calibration and system-calibration options; these allow gain and offset errors, either on its own part or in the system as a whole, to be corrected.

The AD7707 operates from a single 3-V (2.7 to 3.3) or 5-V (4.75 to 5.25) supply. Consuming less than 1 mW with 3 V supplies, using a 1-MHz master clock, it is ideal for use in low-power systems; in *standby* mode it draws less than 8 μA. The AD7707 is available in both a 20-lead 0.3"-wide small-outline (SOIC) package and a low profile 20-lead TSSOP. The combination of low power and small footprint makes the device ideally suited for use in field equipment. The versatility of its high-resolution-and-accuracy high- and low-level input voltage channels comes at a low cost (a major factor in selecting data acquisition components), just $4.46* (1000s).

The AD7707 is well-suited to applications in data acquisition requiring true bipolar input capability in a single supply system. These opportunities include low-level direct transducer interface applications, such as those found in pressure- and temperature measurement applications, smart-valve/actuator control systems, smart transmitters and chart recorders.

SMART-VALVE/ACTUATOR CONTROL

In this example (Figure 2), the desired valve set point is established remotely in the control room and communicated to the AD7707 with low sensitivity to noise, using a 4-to-20-mA current-loop. This control signal is converted by the AD7707 to digital, along with the valve-position signal, and they are compared by a microcontroller, which operates the valve actuator, closing the loop. Both devices operate at low voltage from single supplies.

The 4-to-20-mA valve-position control signal is translated from digital in the control room by an *AD420* DAC, with 4-to-20-mA output. The current, delivered to the valve's vicinity via a noise-rejecting twisted pair, is sensed by the AD7707's low-level input channel, and the resulting voltage is converted to digital. The valve position is monitored using a high-quality servo-potentiometer with ±10-V output range and applied as a high-level analog input to the AD7707. The controller, the valve, and the AD7707 thus form a closed loop control system.

Using the high level input channel on the ±10-volt input range, peak to peak resolutions of 16 bits can be achieved with update rates of up to 60 samples per second. The low-level input channels also provide 16-bit peak to peak resolution when operating at a gain of one, using a 125-ohm sense resistor on the 4-to-20-mA loop. With a 10-Hz update rate, filter notches are placed at both 50 and 60 Hz, simultaneously rejecting components at both frequencies—a key requirement in industrial applications.

*Prices are recommended resale prices (U.S. Dollars) FOB U.S.A. Prices are subject to change without notice. For specific price quotations, get in touch with our sales offices or distributors.

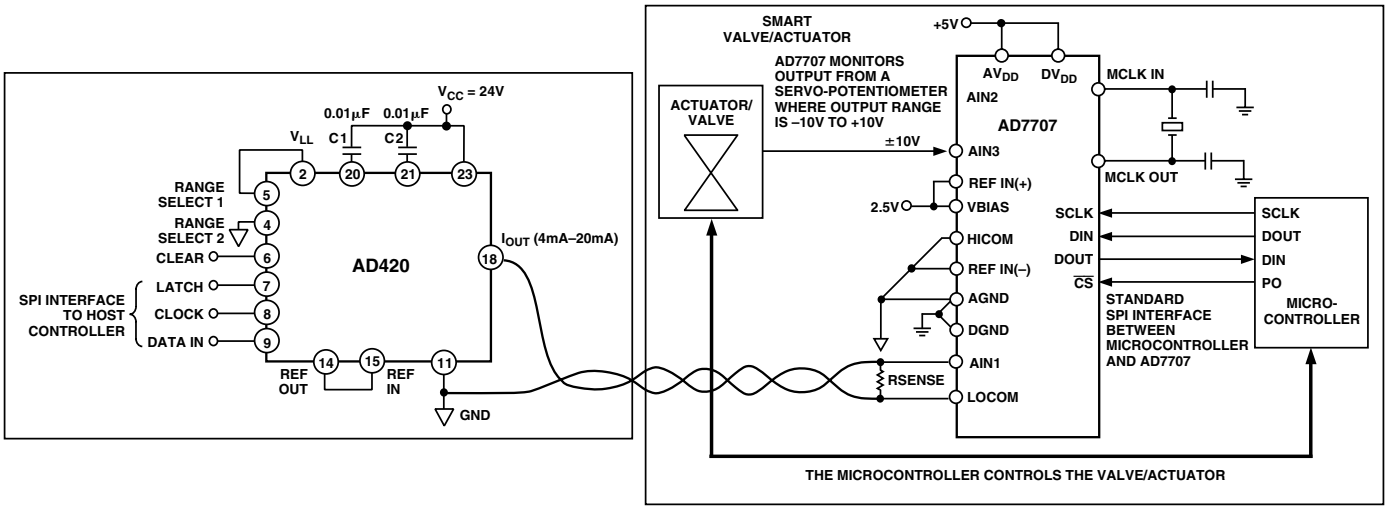

Figure 2. Smart-valve/actuator control using the AD7707.

This, and many other applications, benefit from the use of an ADC operating from a single supply, ability to deal with both high and low level analog input voltages, and high-resolution analog-to-digital conversion at low cost. The use of sigma-delta architecture for the analog-to-digital function provides a degree of immunity to noisy environments. This, combined with a programmable gain amplifier, a digital filter and calibration options, makes the ADC ideal for use in industrial and process control applications. The AD7707, with its excellent system noise performance and lack of need for high-quality external capacitors, manifestly provides far more system level functionality than off-the-shelf integrating ADCs.

CHART RECORDERS

Another area where both high- and low level input channels are usually required is in chart recorder applications. Circular chart recorders generally have two requirements. The first would utilize the low-level input channels of the AD7707 to measure directly inputs from thermocouples, RTDs, and pressure sensors. The second requirement, to be able to measure dc input voltage ranges up to ±10 V, would be provided by the high-level input channel without needing external signal conditioning. These requirements can be satisfied by the AD7707's combination of input channels without external signal-conditioning components, split supplies, or charge pumps. It also meets the key requirement of low-power operation in portable data acquisition equipment, which is also a feature of the AD7707.

Brief Performance Summary

Input	AIN3	AIN1, AIN2	AIN1, AIN2
Range	±10 V	±20 mV	±20 mV
Update Rate	60 Hz	10 Hz	60 Hz
Resolution	16 Bits	14.5 Bits	13 Bits
Remarks	G = 2	Unbuffered; 5-V Supplies; 2.5-V Reference	