Sampling filters simplify converter's offset measurement

by Dennis Knowlton, *National Center for Atmospheric Research, Research Aviation Facility, Boulder, Colo.*

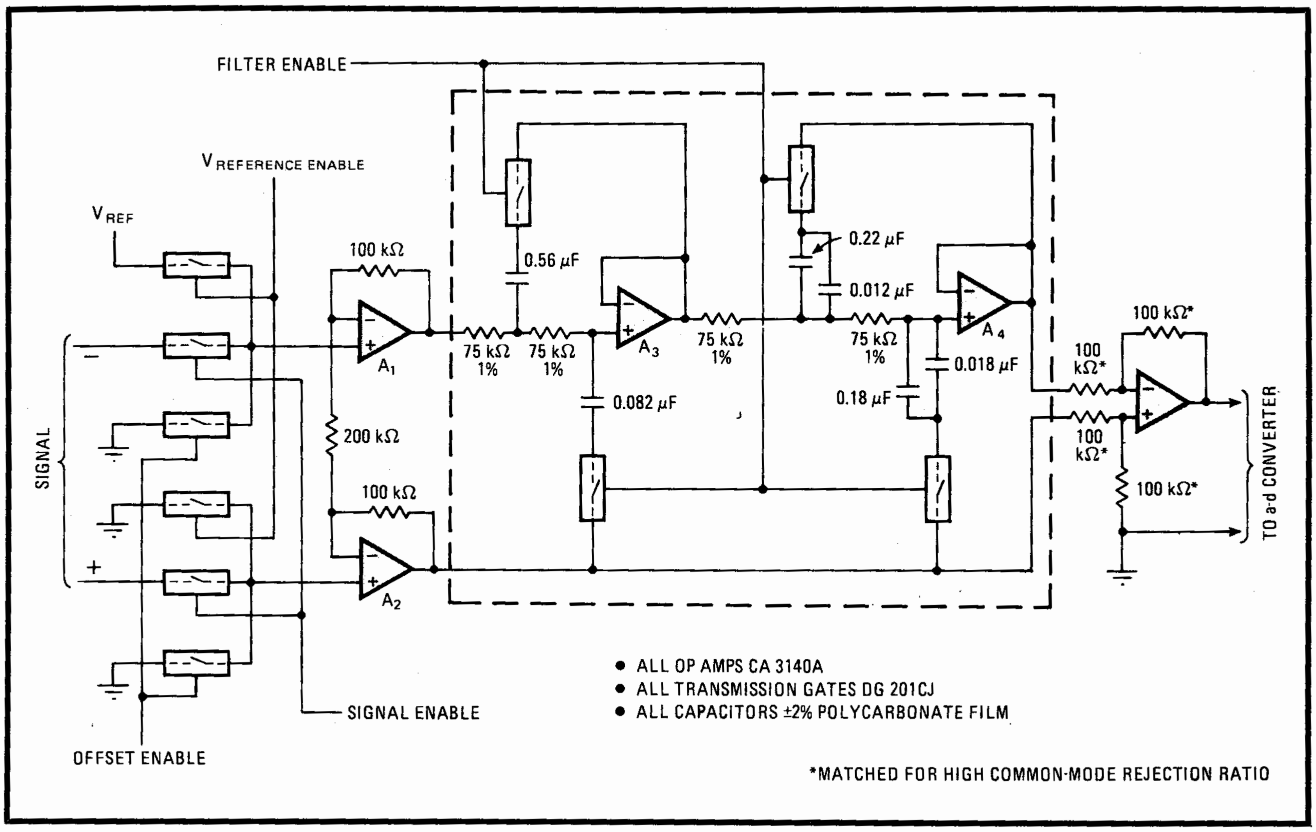
A microprocessor-based data-acquisition system has difficulty in making corrections for input offset and gain drift when it uses active filters to remove the effects of aliasing, or system noise. In such circumstances, the filters' frequency response and settling time vary as a function of the sampling rate and the magnitude of the input signal. However, the difficulties encountered with these sampled-data systems may be overcome by means of a switched aliasing filter, so that the anomalies in filter response may be virtually neglected and the offset and gain drift may be readily determined under software control.

In the typical input stage leading to the system's a-d converter, the noninverting ports of op amps A_1 and A_2 are periodically switched to ground and to a reference voltage so that the circuit can be isolated from all external stimuli and its inherent offset and gain determined. This scheme eliminates potentiometers and the requirement for precision components. It also leaves the measuring task to the software routine, where time and temperature have no effect on system accuracy, and where the data can be corrected for actual gain and offset by means of look-up tables.

Because of sampling, however, the filter's frequency-domain response becomes a factor and thus a significant amount of signal data can be lost during the filter's settling time. Switching the filter out at a very slow rate compared with the signal sampling rate, and doing so at a low duty cycle, eliminates the problem.

The key to the success of the circuit lies in the fact that in the standard active filter, the only energy-storage elements are capacitors. Switching these elements out of the circuit periodically transforms the filter into one that has a very high cutoff frequency; thus the filter is essentially out of the circuit and its op amps' offset and gain drift can be easily measured. When the capacitors, which store the instantaneous value of the driving signal, are switched back into the circuit, they perform their basic filtering function. Thus, assuming the use of fast op amps, a high-speed a-d converter, and low-leakage capacitors in the filter, the signal-path response of the filter is unchanged; yet, offset and gain drift can be determined.

Shown in the circuit example is a simple four-pole filter built around A_3 and A_4 whose components are selected to reject aliasing noise at 10 hertz. Signal-path sampling is done at 50 Hz and capacitor switching at 0.1 Hz for a duration of 12 microseconds. The input and output stages of the circuit all utilize standard differential amplifiers. □



Indeterminate. Aliasing filter A_3–A_4 for data-acquisition system makes it impossible to ascertain input offset and gain drift unless it is itself of the sampling type. Filter's signal-path response will be unchanged, but stages' inherent imperfections can then be measured.