Charge-balancing modulator aids analog-signal isolation

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For engineers trying to solve ground loop problems in industrial instrumentation, here is a novel and inexpensive isolation circuit for analog signals. It employs a voltage–to–pulse-width modulator to convert analog signals into digital ones so that the job can be handled easily by low-cost opto-isolators. This is done by using a clock-synchronized charge-balancing scheme to economically achieve an accuracy of within 0.01%.

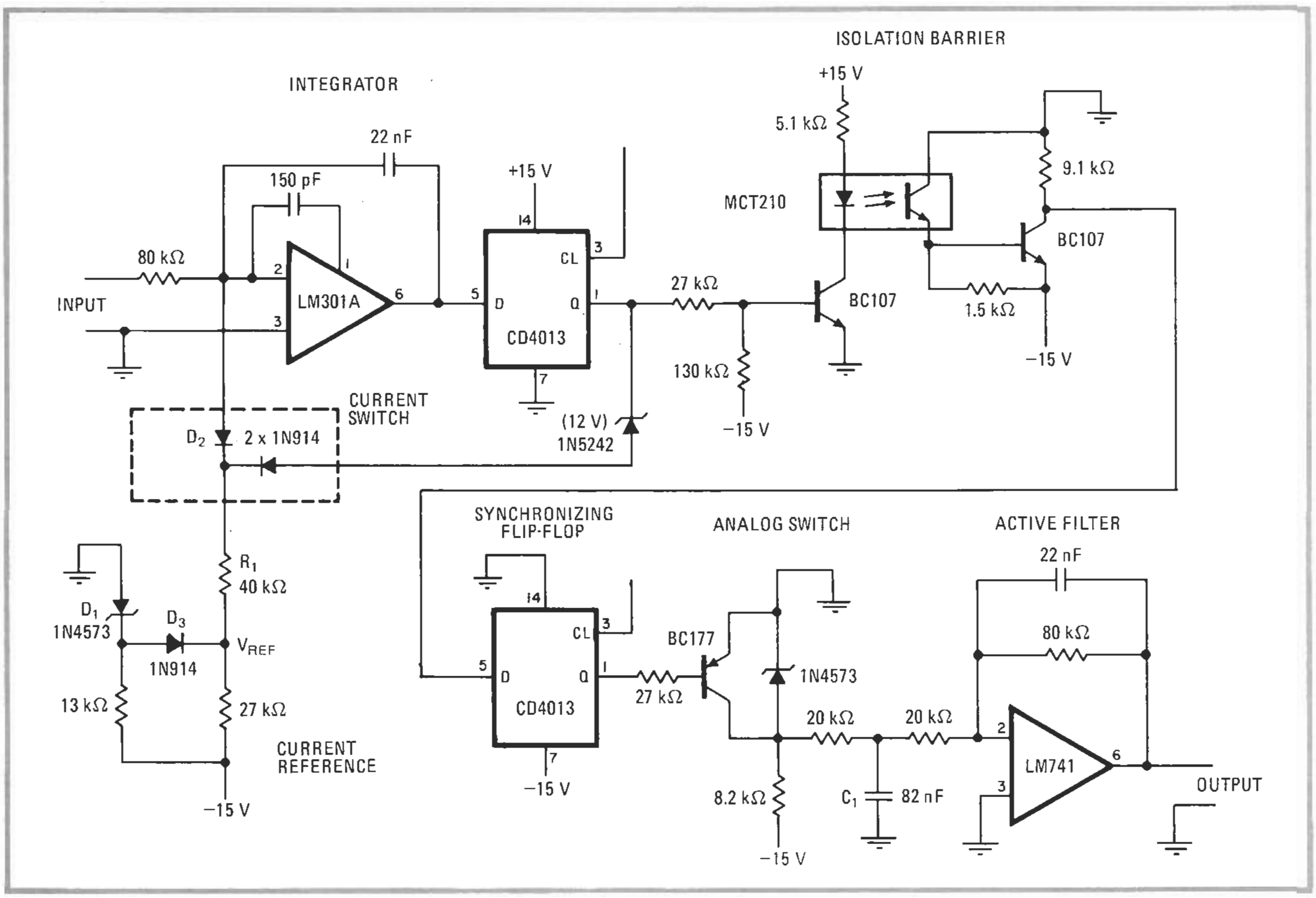
The charge-balancing modulator consists of an operational-amplifier integrator on the input that feeds the D input of a flip-flop. A constant-current sink and switch are driven by the flip-flop to produce a pulse whose width is proportional to the input voltage. This signal feeds the opto-isolator, the output of which is converted back into a voltage by the demodulator consisting of a synchronized flip-flop, a current sink, and an op-amp low-pass filter.

The voltage–to–pulse-width conversion is facilitated by switching the constant-current sink from the output of the flip-flop to the input summing mode of the op amp. Initially, the current switch is open, so that when the input voltage is applied, a negative-going ramp is produced at the integrator's output. When this voltage passes the flip-flop's input threshold voltage, it changes state synchronously with the next clock pulse, thereby closing the current switch. This action causes the reference current (which is always greater than the maximum input current) to be subtracted from the integrator's input current, producing a negative-going ramp at its output that eventually causes the flip-flop to toggle again. The time between toggles is proportional to the input voltage, and a transistor converts that time into a corresponding pulse width that drives the opto-isolator.

The current reference is actually a voltage-reference diode, D_1, and a resistor, R_1, that uses the fact that the integrator summing node is at virtual ground (0 volts) thus making the reference current equal to V_{REF}/R_1. Diode D_3 compensates for temperature-caused variations in diode D_2.

The demodulator relies on a synchronized flip-flop (driven from the same clock source) that can switch another current source on to charge capacitor C_1 to the original input voltage. The active filter smoothes the demodulator's response.

The analog-signal isolator can handle signals between ±10 V accurately to within 0.01% and has a frequency range of 0 (dc) to 100 hertz with a common-mode rejection of 100 decibels and an isolation of over 2,500 V dc between inputs and outputs. □



1. Analog-signal isolator. Input voltages are converted into proportional pulse widths that are fed to an inexpensive opto-isolator. The pulse is then converted back into a voltage that tracks the input voltage accurately to within 0.01%. The circuit uses a minimum of precision parts.