

## 60-Hz modulator records process variables

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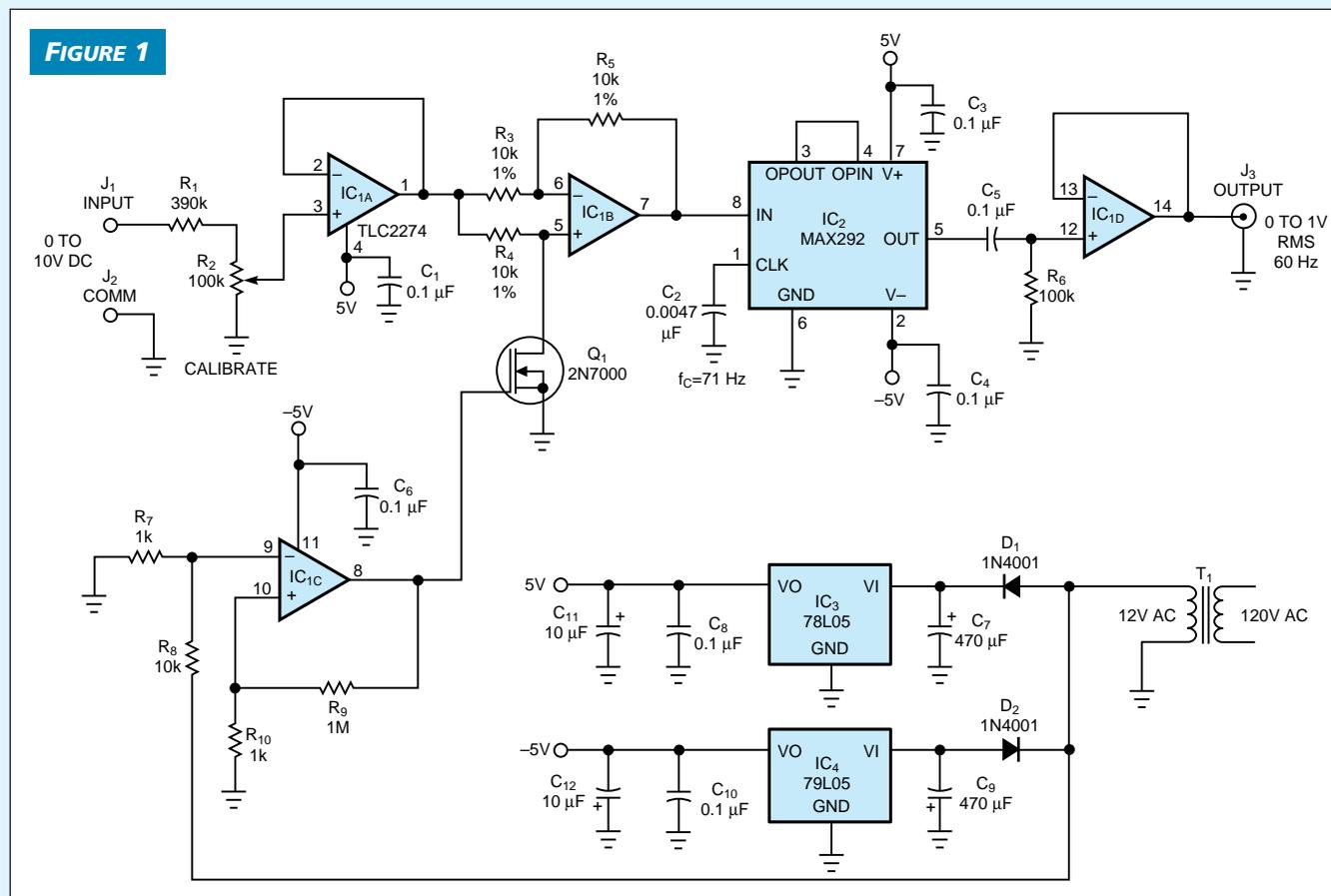
The circuit in **Figure 1** allows you to record process variables (4 to 20 mA, 0 to 10V dc) on a three-phase power monitor designed to record only ac waveforms. Many of these recorders have a seventh channel, normally used for recording neutral current, which you can use as a process-variable input. The circuit operates by generating a 0 to 1V-rms output sine wave whose amplitude is a function of a 0 to 10V-dc input signal. IC<sub>1</sub> can be any rail-to-rail quad op amp rated for  $\pm 5V$  power supplies. Input stage IC<sub>1A</sub> buffers the input-voltage divider R<sub>1</sub>-R<sub>2</sub> and drives the two-quadrant multiplier, IC<sub>1B</sub>. IC<sub>1B</sub> acts as a multiplier by using Q<sub>1</sub> to switch its gain from 1 to -1.

When Q<sub>1</sub> is off, IC<sub>1B</sub> has a gain of -1. Switching Q<sub>1</sub> at 60 Hz chops the dc signal applied to the input into a 60-Hz square wave whose amplitude is proportional to the input signal. The chopping signal comes from Schmitt trigger IC<sub>1C</sub>. A portion of the ac power signal goes to IC<sub>1C</sub> through voltage divider R<sub>3</sub>-R<sub>7</sub>. R<sub>9</sub> and R<sub>10</sub> provide a small amount of hysteresis to prevent oscillation and ensure fast switching. The output of IC<sub>1C</sub> is the 60-Hz square wave that controls Q<sub>1</sub>. The

chopped signal from IC<sub>1B</sub> connects to the switched-capacitor filter, IC<sub>2</sub>. This eight-pole lowpass filter converts the square wave from IC<sub>1B</sub> to a sine wave.

Capacitor C<sub>2</sub> sets the filter's 71-Hz cutoff frequency. C<sub>5</sub> and R<sub>6</sub> form a 16-Hz highpass filter that removes any dc offset from the output of the switched-capacitor filter. IC<sub>1D</sub> buffers the filter and provides a 0 to 1V-rms, 60-Hz output. Calibration involves applying a 10V-dc signal to the input and adjusting R<sub>2</sub> until the output reads 1V rms on an ac voltmeter. Measurements show linearity within  $\pm 1\%$  over the entire input range. To use the recorder, connect the input to the process variable under measurement, and connect the output to any voltage-input channel on the 1V-rms power recorder. You can also use the circuit on current-input channels designed to use low-voltage, 1V-rms current clamps. To record 4- to 20-mA signals, shunt the input with a 500 $\Omega$  resistor. (DI #2157)

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Chopper techniques convert a dc input signal from a process variable to a 60-Hz ac signal for measurement on a three-phase power monitor.