Application Note 1160: Aug 05, 2002

Power Meter Is ±1% Accurate

This application note describes the use of a high-side current-sense amplifier and a four quadrant analog multiplier to produce an output voltage proportional to the power being delivered to a load. While a high-side current-sense amplifier can monitor over-currents and short circuits, some energy sources have variable voltage and current output (for example AC to DC wall adapters). In these circuits it is desirable to monitor the voltage and current multiplication product to detect the power being delivered. Adjustments for offset voltages and gain precision allow overall accuracy of better than 1%.

Power meters provide an early warning of thermal overload by monitoring the power consumption in high-reliability systems. Power monitoring is especially suitable for systems in which the load voltage and current are both variable; as for industrial heating and motor controllers. Such a power-meter/controller (Figure 1) is based on the principle that power equals the product of current and voltage. Its typical accuracy is better than 1%.

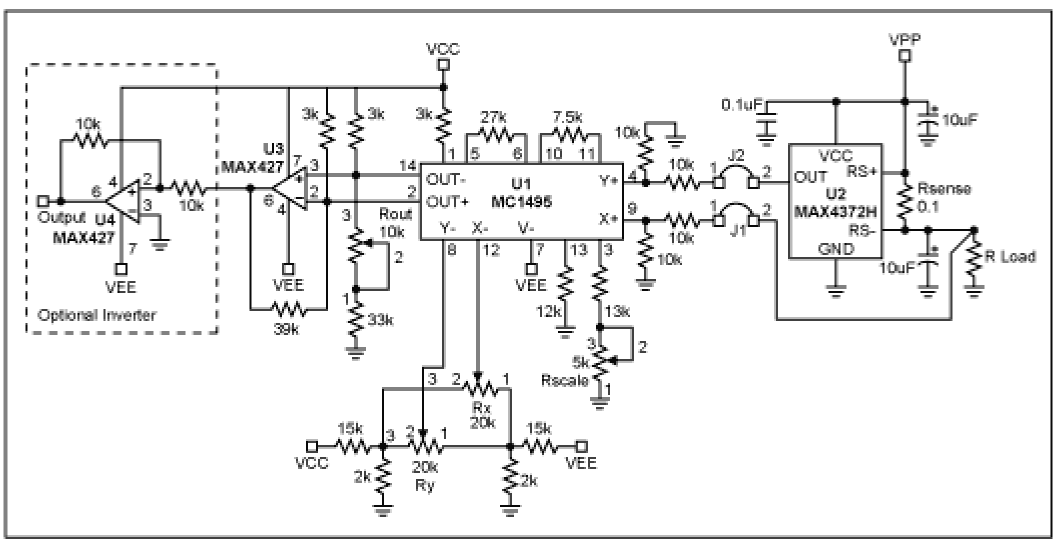

Figure 1. This power meter, whose output voltage is proportional to load power, achieves ±1% accuracy.

A current sensor (U2) measures output current, and a 4-quadrant analog voltage multiplier (U1 and U3) generates the product of output voltage and current. An optional unity-gain inverter (U4) inverts the inverted multiplier output. This power meter is most accurate for multiplier inputs (J1 and J2) between 3V and 15V. Choose the current-sense resistor R_{sense} as follows:

$$R_{sense}(\Omega) = \frac{1}{P(W)}$$

where R_{sense} is in ohms and P is the output power in watts. If power delivery to the load is 10W, for instance, choose R_{sense} = 0.1Ω. The Figure 1 circuit with 0.1Ω sense resistor has a unity-gain transfer function, in which the output voltage is proportional to load power. For instance, the output voltage is 10V when the load power is 10W. To change the gain transfer function, change the sense resistor as follows:

$$Gain = 10R_{sense}$$

For the Figure 1 circuit, Figure 2 compares power-measurement error with load power. Note that accuracy is better than ±1% for load power in the range 3W to 14W.

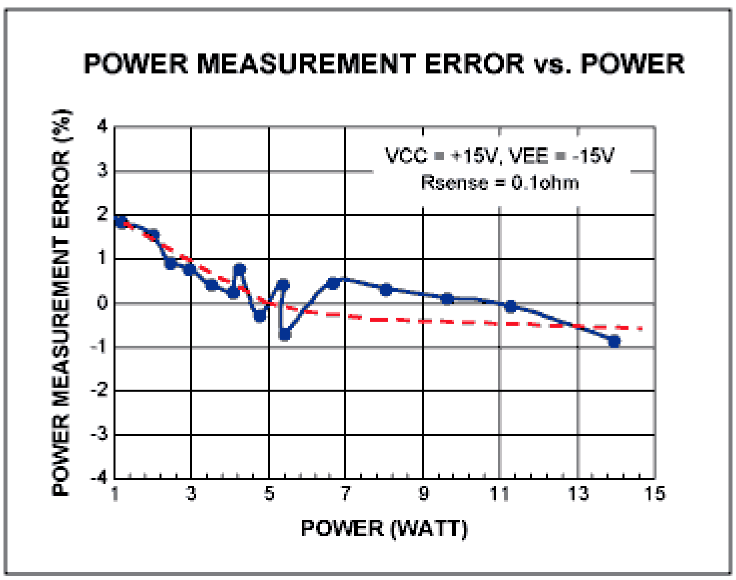

Figure 2. The measured power is better than ±1% accurate for power levels between 3W and 14W.

For proper operation, the analog multiplier must first be calibrated according to the following procedure (which also appears in Motorola's MC1495 data sheet). Remove jumper J1 (X-input) and J2 (Y-input) before calibration:

- **X-input offset adjustment**: Connect a 1.0kHz, 5Vpp sinewave to the Y-input, and connect the X-input to ground. Using an oscilloscope to monitor the output, adjust Rx for an AC null (zero amplitude) in the sinewave.

- **Y-input offset adjustment**: Connect a 1.0kHz, 5Vpp sinewave to the X-input, and connect the Y-input to ground. Using an oscilloscope to monitor the output, adjust Ry for an AC null (zero amplitude) in the sinewave.
- **Output offset adjustment**: Connect both X- and Y- inputs to ground. Adjust Rout until the output DC voltage is zero.
- **Scale factor (Gain)**: Connect both X- and Y- inputs to +10VDC. Adjust Rscale until the output voltage is +10VDC.
- Repeat steps 1 through 4 as necessary.

A similar version of this article appeared in the May 30, 2002 issue of *EDN* magazine.

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