# Improved current monitor delivers proportional-voltage output

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This Design Idea expands the capabilities of a previously published one (**Reference 1**). The original version featured a current transformer whose secondary winding formed part of an oscillator's tank circuit. Under normal conditions, direct current flowing through the current transformer's single-turn primary winding kept the circuit from oscillating until primary current flow ceased. Although the circuit acted as a power-interruption detector, when you add a few components, the operating principle lends itself to measurement applications. This revised circuit delivers an accurate linear-voltage output that's proportional to direct current flow through current-sense transformer $T_1$'s primary winding (**Figure 1**). In addition, the circuit also offers possibilities as an ac current sensor.

To achieve improved performance, the design retains the original oscillating-circuit concept and adds a PLL circuit and one additional winding to the current transformer whose secondary forms an LC oscillator's resonant circuit. Integrating a 74HC4046, $IC_1$, the PLL measures the frequency of an LC oscillator comprising $Q_1$ and its associated components and compares it with a fixed-frequency internal VCO (voltage-controlled oscillator). The PLL's phase-comparator output drives a current source comprising $Q_2$ and $Q_3$, which in turn feeds current to an additional winding on the current-sense transformer's core.

Sources of $T_1$'s ferrite core include Epcos (www.epcos.com), which offers the B64290L 632×87-toroid 20×10×7 material N87; Pramet (wwwpramet.com), which offers Fonox Type T20 material H60; Vacuumschmelze (www.vacuumschmelze.com), with the VAC T60006L2020-W409-52; and other manufacturers. Depending on the ferrite material you use, the circuit will operate to some degree with virtually any ferrite toroidal core. (It is difficult to simulate this circuit using PSpice or other simulators; for accurate results, you need a complex model that accurately portrays the core's nonlinear behavior at various current levels.)

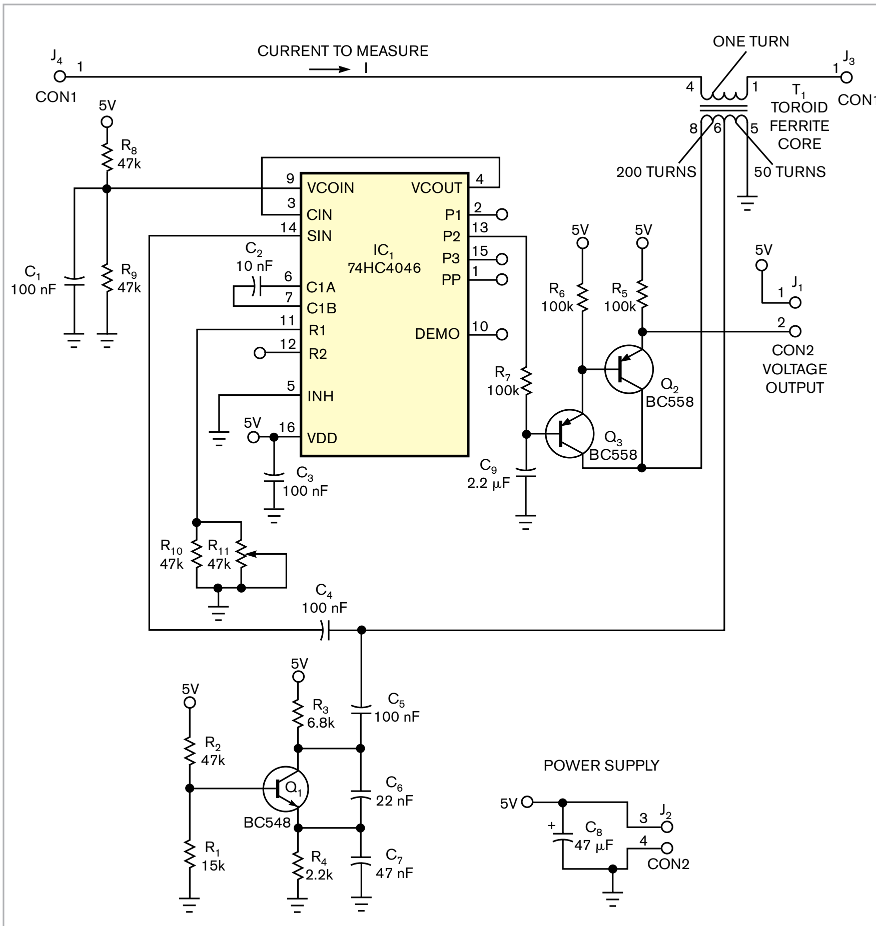


Figure 1 This current sensor uses a variable-frequency oscillator, $Q_1$, and a PLL, $IC_1$, to measure current in an isolated circuit.

The added winding induces magnetic flux in the core, decreasing its permeability and inductance and raising the LC oscillator's frequency. When the oscillator's frequency matches the VCO (reference) frequency, the circuit reaches an equilibrium state. An increasing or decreasing current through the compensation coil balances any additional magnetic flux that dc current flowing through the measurement coil produces.

Within the PLL's frequency-tracking range, the current waveform through the compensation coil has the same shape as fluctuations of the measured current. The turns ratio of 1-to-250, which also represents the ratio of currents in transformer $T_1$, establishes a secondary current of 10 mA for a primary current of 2.5A. If the PLL circuit's gain is sufficient and the ferrite core's region of operation avoids saturation, the circuit's closed-loop configuration maintains the core's magnetic flux at a constant value and thus minimizes the effects of core-material nonlinearities.

Measuring the voltage difference across resistor $R_5$ shows that the circuit's output voltage is linearly proportional to the compensation current, and $R_5$'s resistance scales the voltage output. For 100Ω at $R_5$, a 1V output corresponds to a primary-side current of 2.5A. With zero current flowing in the single-turn primary winding, calibrate the circuit's range by adjusting potentiometer $R_{11}$ to a set operating point. A voltage drop of 2V across $R_5$ sets a measurement range of +5 to −5A. To accommodate other measurement ranges, you can alter $T_1$'s turns ratio or vary the compensation current by using different values for $R_5$ and $R_{11}$. Use a well-regulated power supply to provide power for the circuit. You may be able to replace the 74HC4046 with a software PLL-emulation routine that uses a microcontroller's spare processing resources. EDN

## REFERENCE


1. Ackerley, Kevin, "Impedance transformer flags failed fuse," *EDN*, Dec 17, 2004, pg 67, www.edn.com/article/CA486572.