The principle of the CMV transformer relies on magnetic coupling between the primary and the secondary, such that any voltage that appears across the primary induces an equal and opposite voltage in the secondary, thus canceling it. You can easily extend the principle to multiple signal channels simply by adding more secondary windings—one secondary for each channel (**Figure 2**).

However, the Achilles' heel of the CMV transformer is the fact that the decibels of cancellation fall off at the low-frequency end of the noise spectrum. This situation occurs because noise cancellation depends on the fact that the inductive reactance of the windings must be much larger than the impedance of the cable. Hundreds of millihenries of inductance are necessary to satisfy this criterion for frequencies as low as 60 Hz. For multichannel applications requiring cancellation for frequencies as low as 60 Hz, this fact translates to lots of copper, core, bulk, and weight. However, if you don't mind if your designs consume a little power, then a work-around exists: actively driving the CMV core.

In **Figure 3**, the power amplifier comprising the LT1797 high-frequency op amp and MOSFET forces the driven core to precisely cancel CMV as sensed in the ground-reference connection. The result is such a large multiplication of the apparent winding inductance that you can reduce the "windings" to a simple single pass-through of the toroid core. In other words, you need to thread a multiconductor-signal cable only once through the "hole in the doughnut" to achieve CMV of 40-dB or more cancellation, extending from tens to millions of hertz.**EDN**

REFERENCE

[1] Woodward, W Stephen, "Amplifier cancels common-mode voltage," *EDN*, May 10, 2007, pg 82, www.edn.com/article/CA6437955.

Improved optocoupler circuits reduce current draw, resist LED aging

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It seems deceptively simple to establish galvanic isolation with the help of optocouplers between circuits that operate at different ground potentials. Optocouplers draw power from the isolated circuit, and switching can be relatively slow and uncertain because of LED aging. Substitutes without optocouplers, such as the ADUM12xx from Analog Devices (www.analog.com) or ISO72x from Texas Instruments (www.ti.com), are available. This Design Idea describes a method of improving the simple optocoupler.

Figure 1 shows two popular designs of 0V synchronization with ac. An attempt to reduce power draw from the isolated circuit by decreasing the optocoupler's LED current with a corresponding increase of the optocoupler's load resistor yields slower and more uncertain switching. To achieve faster and sharper switching, you would have to sacrifice power efficiency; however, the benefit of this sacrifice is limited because of the inverse relationship between power efficiency and the ac-voltage magnitude.

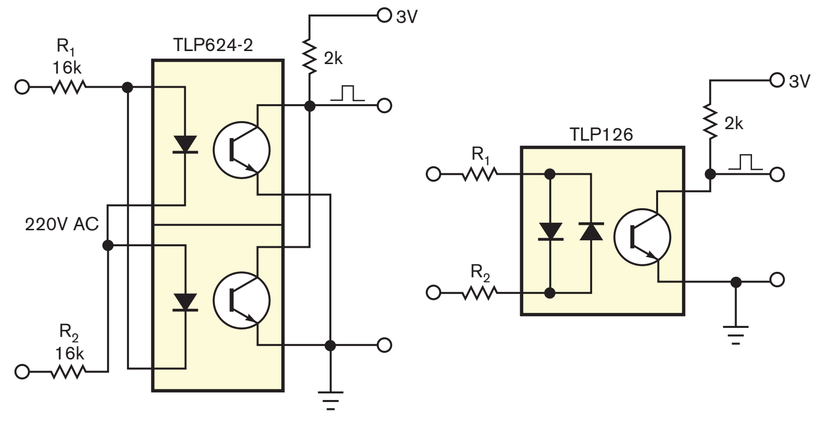

Figure 1 Establishing galvanic isolation with the help of optocouplers between circuits that operate at different ground potentials looks deceptively simple. Optocouplers draw power from the isolated circuit, and switching can be relatively slow and uncertain because of LED aging.

An optocoupler's LED emits almost continuously during nearly all ac cycles exceeding the nominal, leading to low power efficiency and relatively fast aging of the optocoupler. One more drawback is excessively large and nearly uncontrollable zero-crossing error; the circuit's sensitivity threshold depends on the parameters of the optocoupler. The designs in **Figure 1** do not provide an ideal approach. With respect to efficiency, they can draw 5 to 100 mA, depending on the optocoupler's current-transfer ratio and the ac amplitude.

The design in **Figure 2** overcomes the problems of excessive power consumption, uncertain switching, and LED aging. It lends itself well to wide-ac-range applications. Compared with the circuit in **Figure 1**, **Figure 2**'s LED emits only in close vicinity of the zero-crossing point and receives its power from the previously charged capacitor, so you can reduce the average current draw by a factor of 10 to 100. The design also provides faster, more

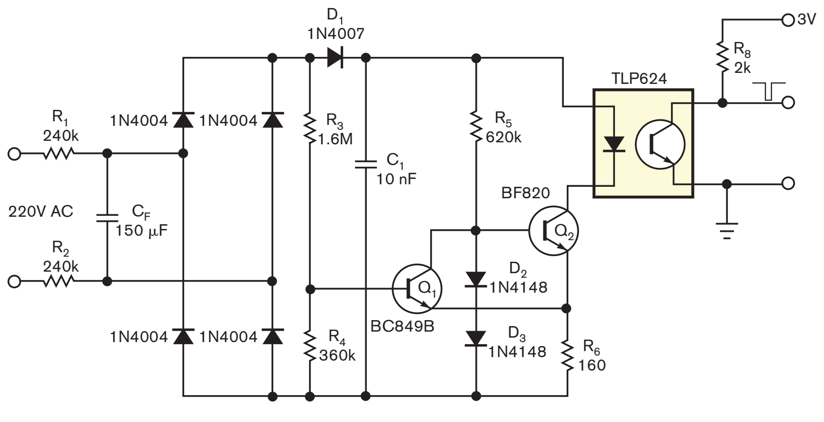

Figure 2 This circuit overcomes problems of excessive power consumption, uncertain switching, and LED aging.

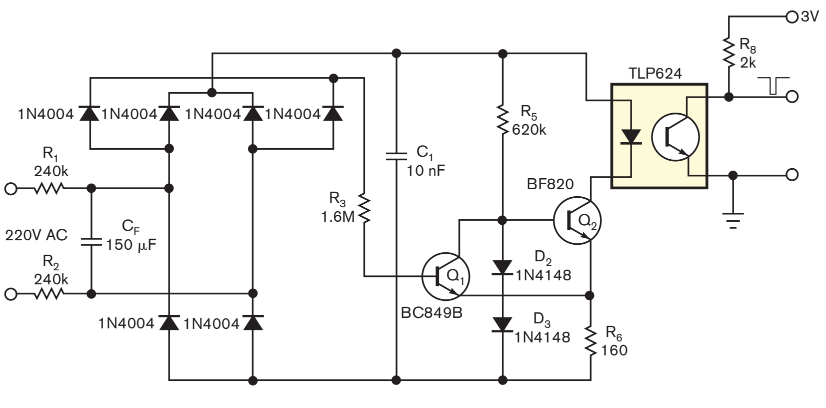

Figure 3 Another variant of this design shows how to manage without a requirement for minimal reverse current in D_1.

deterministic, and sharper switching. What's more, you can expect slower LED aging. Resistors R_1 and R_2 in **Figure 1** dissipate no less than 1.5W of power as waste heat, so changing them to 0.1W devices allows placement of additional components on the same board area (**Figure 2**).

The circuit's main components comprise amplitude detector D_1, capacitor C_1, and Schmitt trigger Q_1/Q_2 to control a current through the optocoupler's LED. D_2 and D_3 stabilize the base voltage of Q_2 and, hence, its collector current, which activates the optocoupler. Capacitor C_1 charges up through R_1, R_2, and D_1.

During nearly all of the ac-cycle time, except in the vicinity of the zero-crossing point, Q_1 is on, and Q_2 is off. Then, approaching the zero-crossing point, the state of Schmitt trigger Q_1 and Q_2 changes, and Q_2 discharges capacitor C_1 with the constant current, because the circuit comprising Q_2, D_2, D_3, R_5, and R_6 stabilizes current as $I=(2\times V_D-V_{BE2})/R_6$, where V_D is the voltage drop on D_2 or D_3 and V_{BE2} is the base-emitter voltage of Q_2.

Some applications require none of the hysteresis that is inherent to a Schmitt trigger; **Figure 3** shows such a design. It also shows how to manage without a requirement for minimal reverse current in D_1. This circuit, however, better suits pure synchronization and not thyristor control. Because of the stability of LED current, these designs provide an expanded input-ac-voltage range, which may be useful for a multistandard ac-powered gadget; an opportunity to set the LED current without the risk of overloading the LED; and a reduced influence of the optocoupler's instability. One more advantage of these designs is their inherently safer nature. In the case of a short circuit in their terminals, optocouplers deliver 10 to 100 times less current between the isolated and the nonisolated sides than the circuit in **Figure 1**. The optocoupler also offers advantages. Thanks to the low duty cycle, you can freely reduce the value of the optocoupler's load resistor, R_8, without sacrificing power efficiency. This reduction results in low zero-crossing error.**EDN**

Cascade two decade counters to obtain 19-step sequential counter

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This Design Idea offers a practical approach to cascading two or more Johnson counters together with a bare minimum of parts.

The CD4017 Johnson decade counter finds use in simple circuits ranging from sound effects to LED displays. The counter's outputs are normally low and go high only at their respective decoded time slot. Each decoded output remains high for one full clock cycle. The dc-supply voltage can range from approximately 3 to 18V dc. The dc-current drain per each output pin (Q0 to Q9) is 10 mA. The circuit has passed tests at 12V dc at 0 to 150°F without anomalies.