Why would you be interested in transformer polarity? Here are three examples in which polarity can have a definite impact:

1. You just finished a tube amplifier project. The last step is hooking up the negative feedback to the speaker side of the audio output transformer. Hook it up wrong, and you will hear the howl of destructive positive feedback oscillation.

2. You have an unmarked power transformer with two 120V AC primary windings, so it can be used on either 120 or 240V AC power mains. The windings must be paralleled to work properly with 120V AC power lines. Hook up the windings out-of-phase, and it's a race as to whether the fuse clears before the transformer windings burn out.

3. You have a step-down transformer with two equal secondary windings that can be connected in series to double the output voltage. Hook up the windings out-of-phase, and instead of twice the voltage, you get nothing.

Fortunately, transformers usually have diagrams or wire color codes to guide you in making the kinds of connections I just discussed. But what if you have a transformer with only the rating data, and no obvious polarity markings? With multiple secondaries, you can hook them up in series and observe which connection gives the highest voltage, and therefore the correct phase relationship.

But this still doesn't tell you the phase relationship between primary and secondaries. You can hook up the transformer to a suitable AC voltage source and, with a dual-trace scope, observe the phase relation between primary and secondary waveforms to determine polarity. Or you can build this simple transformer polarity tester (*Photo 1*).

HOW IT WORKS

ANSI/IEEE C57.12.80-1978 defines transformer polarity as the relative instantaneous direction of the currents in the windings of a transformer. Primary and secondary leads have the same polarity when, at any given instant, the current enters the primary lead in question and leaves the secondary lead in question in mentary pushbutton switch S1. This applies 12V DC through power resistor R1 to the selected primary winding of the transformer under test. It also applies 12V DC to the circuit, which monitors the output voltage pulse from the selected secondary winding.

If the windings are in-phase, a positive voltage pulse will develop across R2 and couple to the gate of SCR1. This will cause SCR1 to fire, and anode current will flow through R3 and the green LED. At the same time, the low ON voltage at the anode of SCR1 will cut off the base drive to Q1, preventing the red LED from illuminating. CR2 provides the additional voltage drop necessary to ensure that no base voltage will appear at Q1.

If the windings are out-of-phase, the output voltage pulse across R2 will be negative and SCR1 will remain off. CR1 will clamp this voltage to protect the gate of SCR1. With SCR1 off, Q1 will receive base drive through R4 and R5, turning on the red LED via R6. R4 is used to limit the voltage drop across the green LED to a value below that where it illuminates. C1 prevents switching transients from false-firing SCR1.

Once the test is complete and S1 is released, 12V DC is removed from the circuit, and SCR1 can reset if it had been triggered on. This is important, since removing the primary current will cause an opposite flux change in the transformer core, producing an output pulse whose voltage polarity is the opposite of that produced when S1 was pressed. Thus, an out-of-phase connection will produce a positive voltage pulse across R2 when S1 is released. If power isn't removed from the indicating circuits at the same time the DC current through the selected primary is removed, SCR1 could fire and give an erroneous indication.

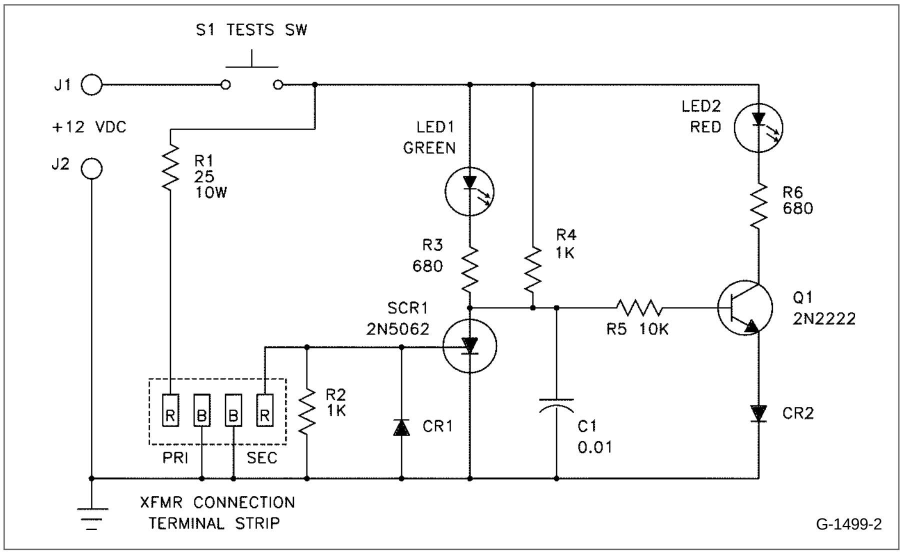

FIGURE 2: Schematic of the polarity tester.

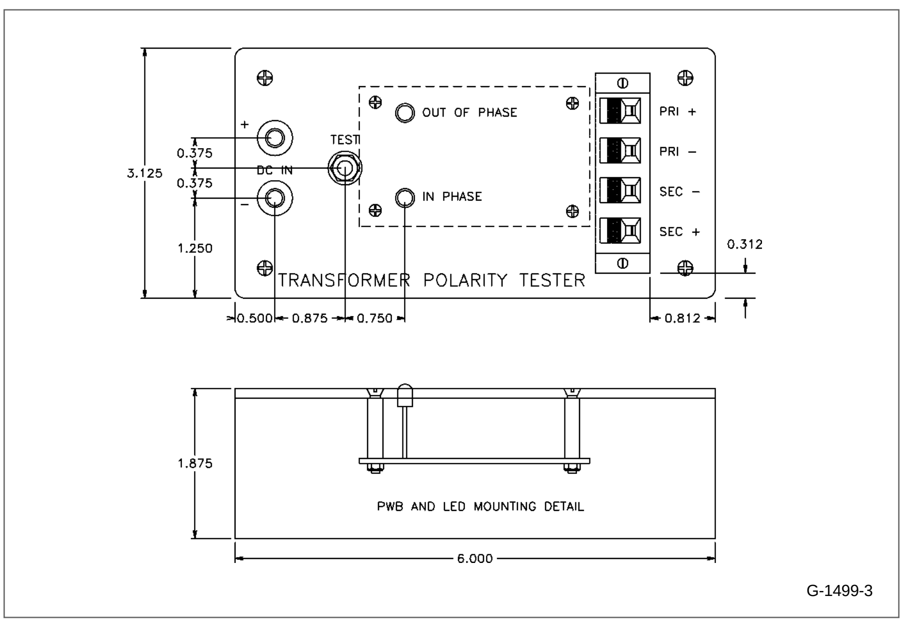

FIGURE 3: Project box layout.

CONSTRUCTION

Figure 3 is a dimensioned drawing of the project box I used for the chassis. I used a four-position pushbutton speaker terminal strip to allow fast and easy connections to the transformer lead wires. Install the transformer test connector, the test switch, and the two power jacks on the top cover of the project box.

Figure 4 shows the components layout and the wiring to the parts located off the PC board. The 6 × 3³⁄₁₆ × 1⅞-inch enclosure shown in the components list (*Table 1*) has sufficient room for the perfboard and chassis-mounted components. I painted the cover white and used black lettering for the various designations. The semiconductor pin assignments are also shown, from the top view. Note that I used a TO-18 metal can 2N2222 transistor. The plastic package may have a different pin layout.

I built the prototype on a wire-wrapped perfboard. Since the gate circuit of an SCR is sensitive to noise, I suggest that you use the parts layout and the connections for R2, CR1, and SCR1 shown in *Fig. 4* to avoid a ground loop with the primary current through R1, which could false-trigger SCR1. Otherwise, the circuit layout is not critical. You could even make yourself a PC board based on this layout.

In keeping with good assembly practice, install the least sensitive parts first, followed by the more sensitive parts. Solder in passive parts (resistors, then capacitor). Wire the leads from the circuit board to the cover components. Finally, install the semiconductors. Double-check the orientation of the polarized components.

The circuit board mounting holes use four 4-40 screws with flat washers. In the prototype the LED leads were ¾″ long, and since I used ¾″ circuit board spacers, the LEDs came through holes in the project box cover without the need for separate mounting lenses. You can see this in the side view in *Photo 2*.

SOURCES

Jameco (1-800-831-4242)

Radio Shack—local store

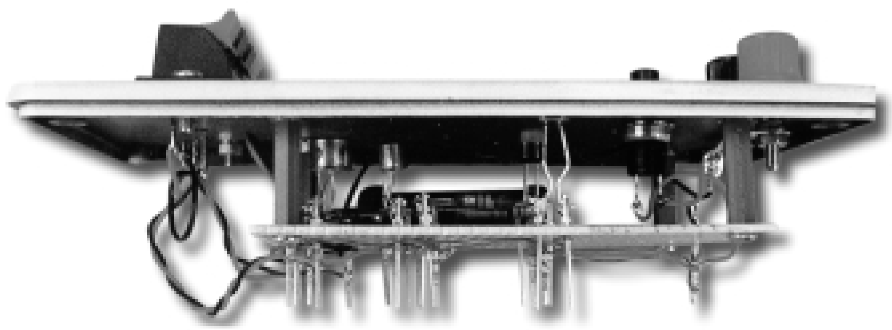

PHOTO 2: Side view of unit with circuit board mounted to cover.

USING THE TESTER

You can connect any winding of the transformer under test to the tester as the "primary," but the circuit works best if you connect the lower impedance winding to the primary terminals of the tester. The current is higher and produces a larger flux and a higher output pulse voltage. However, I successfully tested the circuit with numerous power, pulse, audio, and switching transformers using all the winding connection configurations. Due to the possibility of high DC current in the windings of small transformers, S1 should be held down only long enough to observe the polarity reading.

You should check both polarities when using the tester to ensure that SCR1 is actually receiving a gate pulse in one of the two polarity positions. If both connections give a red LED indication, this suggests that there may be some problem with the transformer under test such as a shorted turn, which you may not notice with an ohmmeter check.

The tester also works with toroidal current measuring transformers, although it may be necessary to put more than one turn through the primary window so that sufficient voltage can be developed at the secondary to give a proper indication. If all connections give a red LED indication, more primary turns are needed. ❖

TABLE 1
PARTS LIST

C1	10nF, ceramic-disk
CR1, CR2	1N914
J1	Red binding post
J2	Black binding post
LED1	Green T 1¾ LED
LED2	Red T 1¾ LED
Q1	2N2222A NPN transistor (Jameco p/n 38236 or equiv.)
R1	25Ω 10W wire-wound
R2, R4	1k ¼W 5%
R3, R6	680Ω ¼W 5%
R5	10k ¼W 5%
SCR1	2N5062 (Jameco p/n 120070 or equiv.)
S1	N.O. pushbutton switch
MISC:	Project case (Radio Shack 270-223), four-position pushbutton speaker terminal strip (Radio Shack 274-622), hookup wire, standoffs, hardware, etc.

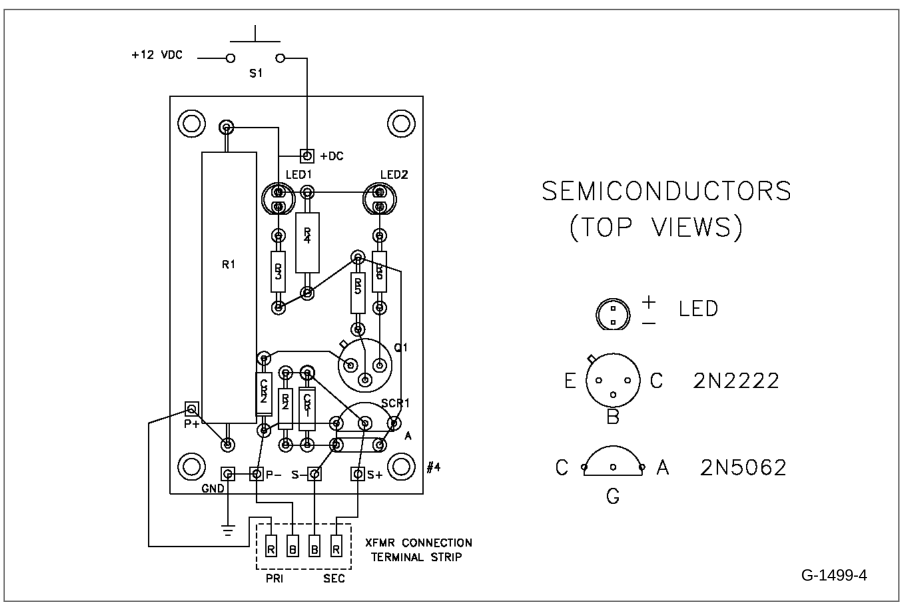

FIGURE 4: Components layout.