HOBBY CORNER

Sensing circuits

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

THIS MONTH, WE'LL BEGIN OUR DISCUSSION with three related questions. The first one is from George Rodriguez (FL) who is looking for a device that will give an indication when a certain circuit in his car is activated. We assume that he has considered all the obvious ways to do so, which would include using a mechanical relay, an SCR or a Triac.

The related questions are from S. Kinsey (NY) and Kelly Walder (FPO, NY), who asked about using a coil to detect the presence of current in a circuit. A part of the answer to George's inquiry applies to the needs of those fellows, which brings into play three more ways to detect an activated circuit. Those methods are: (1) a phototransistor switch, (2) a sensing coil, and (3) a series dropping resistor. We'll give you the basic ideas behind each of the three so that you can choose the one that best suits your needs.

Phototransistor switch

If the circuit contains a light-producing device (panel lamp, trunk light, or overhead light) you can couple a phototransistor switch to it. Here, the phototransister is activated when the light goes on and that, in turn, switches on an alarm circuit or other such device. That is a straightforward application and you should need no further details.

Sensing coil

The second sensing method uses a coil to take advantage of the relationship between current and magnetism. (Kelly and Kinsey, are you reading?) What we're going to do is to make a simple transformer. Take a look at Fig. 1-a: As you can see, coil L1 is carrying a current and that current generates a magnetic field about the coil. Now, let's put another coil, L2, right next to L1, as shown in Fig. 1-b. The

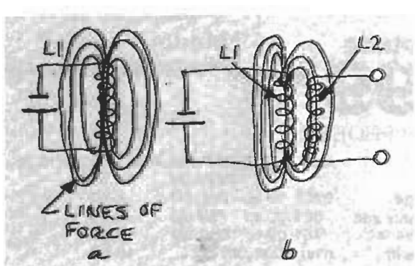

FIG. 1

second coil, L2, is affected by the magnetic field (lines of force) that surround L1.

Every time the lines of force from L1 *cut* across the wires in L2, a voltage is generated or induced in L2. (Note that the key word here is "cut".) If neither the coil nor the lines of force are moved, there'd be no voltage generated in the second coil. In other words, when more or fewer lines cut across the wire (or the field intensity is varied) a voltage is induced in the second coil. (A mechanical generator moves the coils, but a transformer moves the lines of force.)

Let's try a little experiment. It's not much trouble and it will help you to understand the principles involved here. Besides, nothing beats "hands-on" experience. In addition, you'll have a head start in designing a circuit to suit your specific needs. All that's needed is a flashlight battery; a flashlight bulb; a couple of coils, and a low-range voltmeter. The coils can be made, bought, or salvaged from almost anything—we've used coils from relays, RF chokes, hand-wound coils of few or many turns, and even two spools of hook-up wire. (Incidentally, you can wind a coil easily by putting a nail or wooden dowel in a drill and feeding the wire on as it turns.)

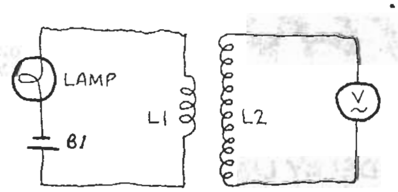

FIG. 2

Place the coils side-by-side and wire-up the circuit as shown in Fig. 2. Let the larger coil (the one with the greater number of turns of wire) be the output coil. Have it all done? What's happening? Nothing! Remember that L2 must be cut by the lines of force that surround L1. As you can see, at this point L2 is just lying there in the magnetic field and the result is nil (as far as this experiment is concerned).

One way to cause the cutting action is to move one of the coils. Let's very quickly move coil L2 away from L1, you should see an indication on the meter. Now, put it back and you will see another indication. Say, that's fun, but it's a heck of a way to get an output and very tiring, to say the least! Let's get the cutting action another way. With the coils side-by-side again, make and break the current path by turning the bulb on and off (the bulb acts as the switch in the circuit). Each time the bulb is turned on or off you will get an indication on the meter. Obviously, the wires of the coil are being cut by the magnetic lines of force. How?...When the current in L1 is turned off, the lines collapse into (or tighten-up around) L1, cutting across the wires of L2 in the process. When the current in the circuit is turned on, the magnetic field around L1 expands and L2 is again cut by the lines of force. Another way of saying that is: When the field around L1 is varied in intensity the magnetic lines of force cut across the wires of L2 and thus induce a voltage in L2.

Now, take the bulb out of the circuit (temporarily) and make and break the circuit. The meter will jump higher because there is a greater current flow in the circuit without the bulb to limit it. Actually, you've made a crude transformer and that experiment has also shown why a transformer will not work on DC current (no cutting of wires by lines of force). As you know, AC current reverses itself with each half-cycle, in effect, turning the current on and off with each alternation.

There are several variations of that experiment that you should try while you have the circuit set up. First, add an automatic "maker/breaker" to the circuit. That can be done in either of two ways. One way is to put L1 in series with an LED and connect it to the output of a 555 astable oscillator (see past issues of the "Hobby Corner" for 555 circuits). The 555 will turn the current on and off faster and more regularly than you can, without getting tired. An easier way is to apply an AC voltage to the input as shown in Fig. 3. Either method will give a constant input and enable you to get a meaningful output measurement.

Here are the variations you should try. Don't forget to make a record of the output measurements. If either or both of your coils do not have iron cores, stick a nail through the center and watch the effect that that has on the output. Try the coils in various positions—side-by-side, end-to-end, parallel, perpendicular, close, and not-so-close. Exchange those coils for others that you have on hand and try them in various combinations.

One final experiment: Wrap a dozen or so turns of wire around your output coil and use those turns for the input coil. Measure the output of the base coil. Now take off all but three or four turns of the input coil. Measure the output and compare it with the previous measurement. By this time you have learned a lot by observing the results of your experimentation.

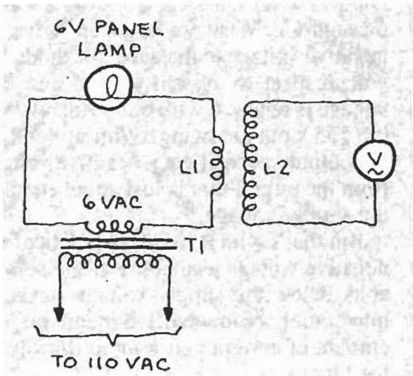

FIG. 3

Let's summarize:

1. Iron cores give greater output than air cores.
2. The closer the coupling of the coils—that is, the closer the input and output coils are positioned—the greater the output.
3. The closest coupling (and greatest output) is obtained when one coil is wound on top of the other.
4. The greater the ratio of the number of turns on the coils (output to input), the greater the output.
5. The greater the current through the input coil, the greater the output.
6. DC current produces output only when it is turned on or off.

Now, fellows, you're ready to make your sensing device. All you have to do is to make a coil out of some of the wire in the automobile (or other) circuit that you want to cause the action. The number of turns needed in the coil will be determined by the amount of current going through it and the amount of output you need to operate your signalling device. If the input circuit is straight DC, you will get only a pulse in the output. If it is AC or pulsating DC (as in the small 12-volt line to the distributor of a car), you will get a constant voltage output that can be rectified to operate the signaling device.

One further word on this sensing method: if the input current is very heavy, as in the case of a car-battery cable when using the starter, one turn may produce enough output for your needs.

Series dropping resistor

The third sensing method mentioned earlier, uses a series dropping resistor. As shown in Fig. 4, you can place a resistor in any circuit and a "voltage drop" will develop across it. That voltage can be picked off and used to operate another device. Of course, that voltage is subtracted from the

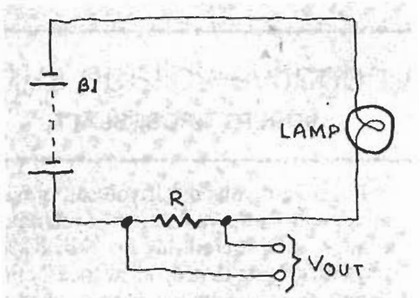

FIG. 4

voltage that would otherwise be available to the normal load (the lamp in the illustration). The amount of voltage dropped across the resistor can be determined experimentally or by using Ohm's Law ($E = I \times R$). Depending upon the nature of the circuit, you may have to exercise special care to determine the power rating (wattage) necessary for the resistor. That's best found by using the formula $P = I^2 \times R$. Also it's a good idea to allow a safety margin by using a resistor with a power rating that's about 50% greater than the formula indicates. R-E