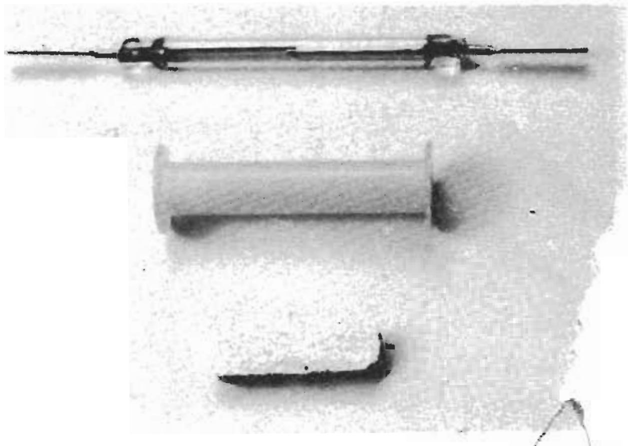
Using Reed Switches



How inexpensive, versatile reeds can be used in a variety of switching circuits.

Reed switches would appear to have been neglected by many circuit designers. Often they are superior to either a relay or a solid-state switching device. Some of their advantages are:

Economical—a reed usually costs considerably less than a relay with equivalent sensitivity.

Rugged—they'll take more abuse than most relays and are not position critical.

Trouble free—being sealed in glass they are not subject to fouling of the contacts and, as they are usually sealed in an inert gas, point arcing is not a problem. They don't have the temperature sensitivity of most solid-state devices.

Fast—while they don't approach transistor or SCR switching rates they're much faster than relays and may be used in inexpensive choppers, flip-flops etc.

Versatile—reeds may be activated either electrically or mechanically (with a magnet). The same unit may be used either normally open or normally closed and latching circuits are simple to achieve and they may be biased. By using a few milliamps to switch several amps, quite high "amplification" may be obtained.

Basic Reed Operation

Figure 1 (a) shows the basic reed circuit. Closing S1, a standard slide or toggle switch, allows current to flow in the coil activating the reed. The resistor limits coil current to the proper value; if the control voltage is matched to the coil it can be eliminated. With the low voltage and current requirements of reed coils this circuit permits simple remote control over considerable distance. Figure 1 (b) shows a self-latching circuit with the load in series with the reed coil. Closing S1 momentarily permits current to flow in the coil which closes the reed and maintains the current flow. Momentarily pushing S2 breaks the circuit. This circuit is limited by the need for the current requirements of the reed coil and the load to be similiar. This can be overcome, to some extent, if the load's current requirements exceed the coil's, by using a resistor in parallel with the coil. Figure 1 (c) is an improved version whereby the load parallels the coil, the resistor limiting coil current to the proper value. Obviously the two foregoing circuits are limited to use where it is desired to switch the control voltage in the load circuit When total isolation of the two circuits is desired the circuit of Figure 1 (d) can be used. This is achieved by enclosing two reeds in the same coil. The same thing can also be done by using two coils in series.

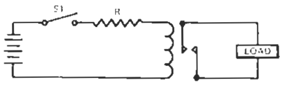


Figure 1(a)

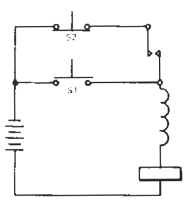


Figure 1(b)

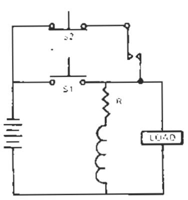


Figure 1(c)

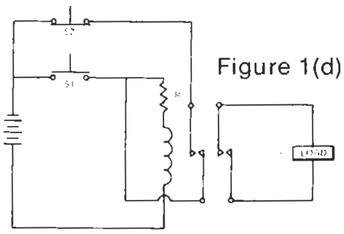


Figure 1(d)

Figure 1—Basic reed switch circuit.
(a) Basic reed circuit.
(b) Self-latching, series load.
(c) Self-latching, parallel load.
(d) Self-latching, isolated load.

Coils

I think that one of the factors that has held the use of reeds to a minimum is the assumption that it is necessary to custom wind coils for reeds. I know the idea of winding a five-to-ten thousand turn coil doesn't really appeal to me. Actually this is not necessary, for most uses an inexpensive, readily available, slug-tuned RF coil, TV width coils are an example, will do a good job; remove the tuning slug and you're in business. Theoretically it's preferable to wind the coil to suit the reed and the application; unfortunately this doesn't always work. Two supposedly identical reeds I checked had a difference of 20 ma in their pull-in current requirements. So even if you know the supposed specifications of the reed and go through the calculations and work involved to design the coil to suit the application you may be disappointed. Unless a special coil is needed e.g., for two reeds in the same coil or for two windings on one or two reeds, de-slugged RF coils are ideal. In special cases, I random wind a few thousand turns of wire and then determine the operating characteristics.

Using the circuit shown in Figure 2 the operating parameters of any

Continued on p. 44

Reed Switches *(from p. 42)*

coil/reed combination may be readily determined. Any practical go/no-go indicator may be used; I found flashlight batteries and a bulb to be the handiest; they give a definite visual indication that the reed is activated. Decrease the value of R1 until the reed closes and the meter will give the pull-in current. If you know, or can measure, the DC resistance of the coil, Ohm's law will give you the operating voltage, or you can measure it across the coil. Once a reed is activated it requires less current to hold it closed. To determine the holding current increase R1 until the reed opens. If you do not have a milliamp meter, put a 1,000 ohm resistor in series with the coil and read the voltage drop across it directly in ma.

To give you an idea of some of the values involved the following are the parameters obtained using a GE-X7 reed. With a 5-43 mH choke: pull-in 53 ma, drop out, 25 ma. With a 250-500 mh choke: 16 ma pull-in, 3 ma drop out. These figures are with no biasing; with biasing the first coil pulled in at 33 ma and dropped out at 1 ma, the second had a 16 ma pull-in current and dropped out at .6 ma.

Bias

Aside from being used to actitivate reeds instead of coil activation a small bar magnet may be used to bias a coil-activated reed to considerably reduce the current

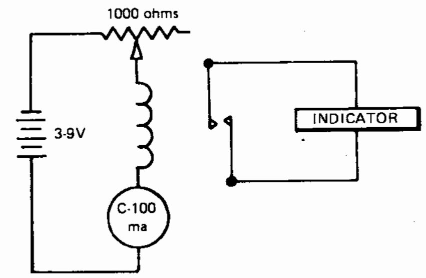


Figure 2—Circuit to determine reed/coil operating parameters.

requirements. Magnets are most effective when they are parallel to, and centered on, the reed. To determine the effect a magnet has use the Figure 2 circuit thusly: With the power off bring the magnet up to the reed until it closes. Gradually withdraw the magnet until the reed opens again (the magnet will hold the reed closed at considerably more distance than it will close it) and afix the magnet there. Now run tests as previously. Keep in mind that the magnet can aid or oppose the coil's magnetic field so it may be necessary to rotate the magnet 180° if it doesn't work properly in its initial position.

Magnetic biasing can also be used to obtain normally-closed operation with a reed. Bring the magnet just up to the point where the reed closes and afix it there. If the magnet orientation is correct, applying current through the coil should now cause the reed to open; in this application you want the magnetic fields to oppose each other. Current requirements will be almost identical to those required to operate the biased normally-open switch.

Various combinations of these circuits may be used for many functions. Even flip-flops, AND, and OR gates may be obtained.

Car Intruder Alarm

When I acquired my present vehicle it was evident the hardtop design made it ridiculously easy to enter without benefit of a key. As theft of contents is much more common than car theft, I felt the need for an entry alarm system. Being of a slightly forgetful nature it would have to be one that functioned automatically without my having to do anything. With this in mind I worked out the circuit shown in Figure 3 which features a delayed alarm. I can enter the car and turn it off before it sounds, the turn-off function being accomplished in the regular course of turning on the ignition. It also has a delayed arming circuit so that it is set to operate after I leave the car without having to do anything specific other than getting out of the car within the time limit allowed.

Switch S1 is the usual door-mounted courtesy-light switch which operates the dome light (DL1) in the car. As these switches are in parallel, hooking into the switched side of the circuit means the opening of any door with a courtesy-light switch will activate the alarm. If desired, protection could be extended to the trunk and the hood by paralleling S1 at these locations with a normally-open micro, mercury or button switch if you don't mind the dome light coming on when they're opened.

When S1 closes current flows through the coil of RS1 to ground closing its reed. This allows current flow from the hot side of S1

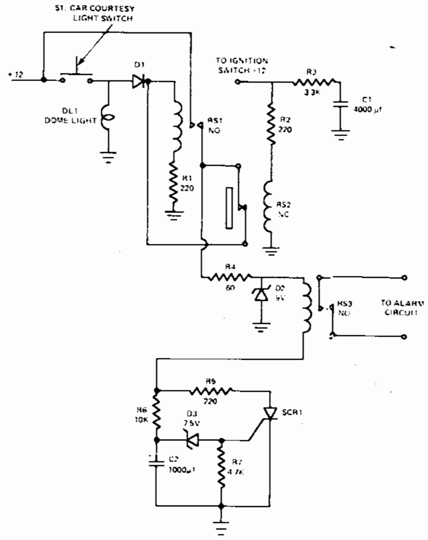


Figure 3—Car burglar alarm with delayed on and delayed arm.

to pass through reed RS1 and reed RS2 to the top of the RS1 coil, latching RS1 and assuring that if the car door is opened even momentarily the circuit will continue to function, so that even if the door is closed again before the built-in delay is ended the alarm will still sound. Diode D1 blocks current to the dome light once S1 is open again, and should be chosen to carry the dome-light current. If you'd prefer the dome light to stay on to remind you the alarm is functioning D1 should be left out of the circuit.

Current flows via RS1, R4, RS3 reed to the delay timing circuit R6/C2. At this point the flow is not heavy enough to activate RS3. C2 gradually charges up to 7.5 volts at which point Zener diode D3 breaks over supplying gate voltage to SCR1 which switches to the "on" state and permits the necessary current to flow, via R5, to activate RS3.

Because a car's voltage isn't always a full 12 volts the voltage-critical circuitry of SCR1 is designed to function at 9 volts and Zener D2, with its associated limiting resistor R4, is included for voltage regulation. Turning on the ignition activates RS2, which is biased normally closed, opening the latching loop and disabling the circuit.

Continued on p. 66

Reed Switches *(from p. 44)*

When the ignition is turned off, R3/C1 provides the delayed arming necessary to permit leaving the car without starting the alarm cycle. C1, which has been charged to the full supply voltage level, slowly discharges through RS2 holding its reed open for a predetermined time.

The drawback to using the ignition switch is that if someone can jump the ignition within the time lapse he can steal the car without the alarm sounding. If this additional protection of the vehicle itself is desired use a separate underdash switch for the alarm.

The reed of RS3 can be used to activate just about any type of alarm.

Circuit Variables

Using GE-X7 reeds and coils requiring 50 ma (actually only 35 ma was required, an extra 15 ma was allowed as a safety margin) the circuit in Figure 3 has a turn-on time of 26 seconds and a delayed-arming time of 26 seconds. These times are actual and are lower than what would be calculated from the component values shown due to leakage in C2 and C1. These capacitors should be top quality to keep this effect to a minimum. This is particularly important in the R6/C2 combination: it takes very little leakage for the capacitor to discharge as fast as it charges and the Zener operating voltage is never reached. The quality of D3 is also critical; don't use one of the low-priced hobbyist Zeners here, it will probably have too much leakage.

The charge time can be increased or decreased by making the value of either C2 or R6 larger or smaller. If the value of R6 is raised it will also be necessary to raise the value of R7 to hold the SCR gate voltage at its proper value; if R6 is lowered, lower R7.

The time delay can be worked out by multiplying the resistance in ohms by the capacitance in farads. This gives 1 time constant in seconds. 1 time constant is the time required for the capacitor to charge to 63% of the supply voltage. The 7.5 volts Zener voltage is 83.5% of 9 volts so 1.6 TC is required for the capacitor to charge to the Zener breakover voltage. This ignores the effect of any possible leakage in the capacitor. The holding time of R3/C1 is a little trickier to work out as it depends to a great extent on the holding current required for RS2; the best method is to breadboard it and determine the values experimentaly.

The GE-X7 reeds used are actually much heavier than required for this circuit—they happened to be at hand. If you use smaller reeds or different coils, the current requirements will be different in which case resistors R1, R2 and R5 will need to be changed. It's a simple Ohm's law calculation: the supply voltage divided by the coil current required equals the total circuit resistance. Subtract the resistance of the coil and what's left over is the limiting resistance required. The SCR used here has a voltage drop of approximately 1 volt, if you use a different one the specs will give this info.

Resistor R4 is the current limiting resistor for Zener D2 and is useable as long as the RS3 coil/SCR1 circuitry doesn't require more than 50 ma of current. If higher current is required it's another simple Ohm's law problem: supply voltage minus the Zener voltage divided by the circuit current equals the resistance value. Also, multiply the Zener voltage by the circuit current value to determine the Zener wattage required.

If you live in one of the colder sections of the country you may want to use an adjustable resistor for R7 so you can adjust it for winter operation when low temperatures will effect the operation of SCR1 (you might consider doing a little experimenting with a thermistor). With the foregoing information it should be possible to adapt the circuit given to just about any combination of coil and reed you choose.

PARTS LIST

D1—diode—see text
D2—Zener diode, 9V, .5 W.
D3—Zener diode, 7.5 V, .01 W.
R1, R2, R5,—220 ohms, .5 W.
R3—3,300 ohms, .25 W.
R4—60 ohms, .5 W.
R6—10,000 ohms, .5 W.
R7—4,700 ohms, .25 W.
C1—4,000 uf, 25 V.
C2—1,000 uf, 15V.
SCR1—silicon controlled rectifier, 2N5787
RS1, RS2, RS3—GE-X7 reed switches with 5-43 mh RF choke coils, magnetically biased (see text).