Radio Fire brings you… Mach-One Margaritas!

As soon as I started showing the Radio Fire prototypes around at launches, I started getting questions about using the device to control all sorts of gadgets. People wanted to use the Radio Fire to operate the lights on their night launch rockets. They wanted to be able to open and close oxidizer valves. They wanted remote control for their onboard 9-speed Waring blenders.

"Sorry", was always my answer. The Radio Fire was designed for a rather narrow task. I built it for use on my own rockets because I wanted a manual backup mechanism for the altimeter parachute deployment. As such, its outputs are designed specifically to ignite electric matches, and aren't directly suitable for other uses.

This application note gives some suggestions that an adventurous rocketry enthusiast might use to interface the Radio Fire to other types of devices. Beware that this may not be for the faint of heart. Successfully applying this information will require some understanding of electronic theory, and a bit of skill at electronic construction.

Thinking Like an Electric Match

The outputs of the Radio Fire were not designed to ignite just any old electric match. They were designed specifically for matches such as the Daveyfire 28B and the Oxral. These devices require only a very brief pulse of current. The Daveyfire, for example, requires roughly 1 ampere for 2 milliseconds.

Actually, the Radio Fire does a little bit more than provide the required brief pulse. Most of the time, the unit will indeed be firing electric matches, but I also had to accommodate the need for testing. With the supplied LEDs attached to the outputs, a user can figure out which output is which, and make sure the device is still functional after a ballistic landing. However, if only the brief pulse were produced, the test LEDs would be hard to see in bright sunlight. So after providing the brief, high-current jolt needed by the electric match, the output remains on for about a quarter of a second, although at a lower current level. Then, if the transmitter stick continues to be held in the "fire" position, the process repeats, so the LED will blink, further aiding in its visibility. If a real electric match is in place instead of the LED, the subsequent pulses are

irrelevant, because the match already burned in the first few milliseconds of the first pulse.

The key to interfacing other equipment to the Radio Fire is to add circuitry and components that can make use of the DC pulses produced by the unit. There are several ways to do this. For example, since the outputs are already compatible with LEDs, opto-isolators could be used to intercept the output signals, with appropriate latching logic added as needed. This has possibilities, but would result in a fairly complex bit of additional circuitry.

As it happens, a latching relay makes a very simple means of capturing the output pulses and putting them to work to control your external device. In particular, a dual-coil latching relay is a natural fit for the Radio Fire's pattern of outputs. Such a relay has two states, and two separate coils. When you apply a DC pulse to one of the coils, the SET coil, the relay mechanism moves to one side of its travel and places the switch contacts in one of their two possible states. When the pulse ends, the relay remains in this state. It will stay in this state until a pulse is applied to the other coil, the RESET coil. At that point, the mechanism will move to the other side of its travel, placing the switch contacts in their opposite state. Once again, the relay stays in this state by itself after the RESET pulse ends. The relay "remembers" what state it is in, even without any signal applied.

Putting it Into Practice

Figure One shows an example of one possible circuit for adding a latching relay to a Radio Fire. This is from a one-of-a-kind prototype that I built for a night launch rocket. (OK, I admit it. Even I occasionally want to control things other than electric matches with my Radio Fires.) The relay I used was an Omron G6HK-2, which is readily available from vendors such as Digi-Key (www.digikey.com). Many other relays would work too, as long as you select a dual-coil latching relay with 5-volt DC coils. The coil current should be no more than about 100 milliamps. When selecting your relay, be sure that the contact ratings are sufficient for your load. For example, the G6HK-2 has contacts rated for 1 amp at 30 volts, which is insufficient for many solenoid valves. Note that the diagram in Figure One is only a schematic, and does not identify the pin definitions for the relay. You'll need to get the pin assignments for your particular relay from the

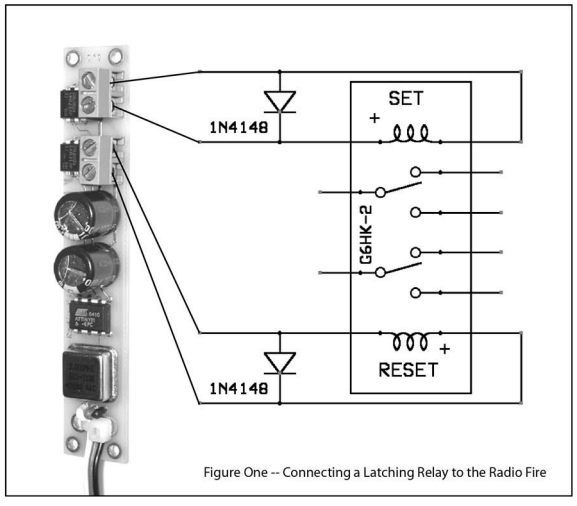

Figure One -- Connecting a Latching Relay to the Radio Fire

manufacturer's data sheet. A data sheet for the Omron G6HK-2 relay can be found at www.omron.com.

The two diodes shown in the diagram are used to provide a path for current when the coil is de-energized. Note that each diode is connected 'backwards', so that it will normally not conduct any current. Conduction occurs only when the relay coil is switched off. At that moment, current tries to continue flowing through the coil and is harmlessly shunted through the diode. This protects the Radio Fire from potentially damaging voltage spikes. These protection diodes should be general-purpose signal diodes such as the 1N4148.

When the Radio Fire is used to fire electric matches, each Radio Fire, and each channel on your R/C transmitter, can control two different functions. Moving the stick to the up position, for example, could actuate the drogue parachute, and stick-down could be used for the main. Because of the two-state nature of the latching relay, each R/C channel, and each Radio Fire, will now control only one function. Using a radio channel on your transmitter that has a spring return-to-center, stick-up will be "turn the blender on", stick-down will be "turn the blender off", and stick-neutral will leave the blender either on or off, depending on your last stick-up or stick-down command. Be aware of this behavior when controlling potentially critical systems such as oxidizer valves. Just because the power is off to the Radio Fire and the control relay, it does not mean that your valve is necessarily closed. You must explicitly put the relay into the state you want.

When building your circuit, it is important to observe the polarity of the Radio Fire outputs and those of the relay coils. On each of the Radio Fire's two terminal blocks, the connector nearest the servo lead is the positive connector. This should be connected to the positive side of the appropriate coil on the relay. This is illustrated in the schematic in Figure One. Note that there is not a common ground or common VCC between the two Radio Fire outputs, so you should not connect any of the Radio Fire's terminals directly to each other.

This circuit is simple enough that is can be built on a piece of perf board or constructed "dead bug" style – with the diodes and wiring soldered directly to the relay's leads. For ruggedness (Hey, my rockets *always* land gently, don't yours?) I decided to make a little printed circuit board for my relay from a scrap of copper clad board. The board is about an inch square, and provides solder pads for all of the relay's contacts, even though my current night launch project uses only two of them. The layout for the circuit board is illustrated in Figure Two. The traces are shown as seen from the bottom of the board. (Because I can't control actual reproduction size when this electronically distributed document is printed, the image is not to any particular scale.) In Figure Three

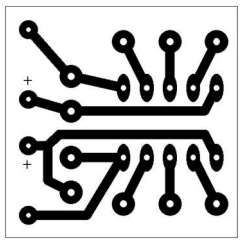

Figure Two -- PCB Layout

you can see how the board connects to the Radio Fire, as well as the component placement on the board. Notice the gray bar that is printed on the top of the relay to aid in orientation. Take care that the diodes, seen under the wires leading to the Radio Fire, are correctly oriented, with the cathode (that's the end with the stripe on it) toward the outside of the board.

The Radio Fire was designed specifically for actuating low current electric matches, and is not recommended for any other task. On the other hand, rocketeers are not always known for following recommendations. With some ingenuity and a small investment in hardware, I'm sure you can adapt your Radio Fire for that fascinating application you've been considering. Have fun. Play safe.

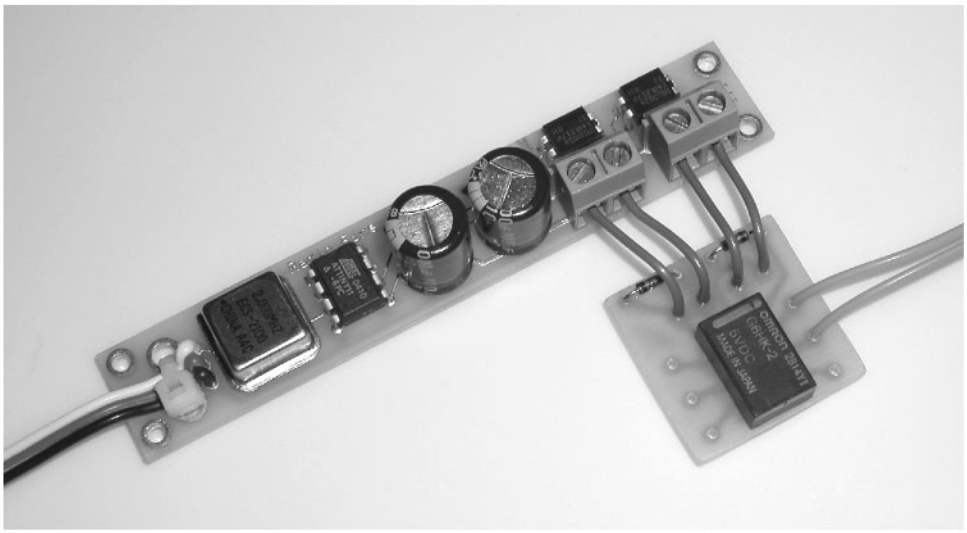

Figure Three -- Prototype Relay Board Connected to Radio Fire