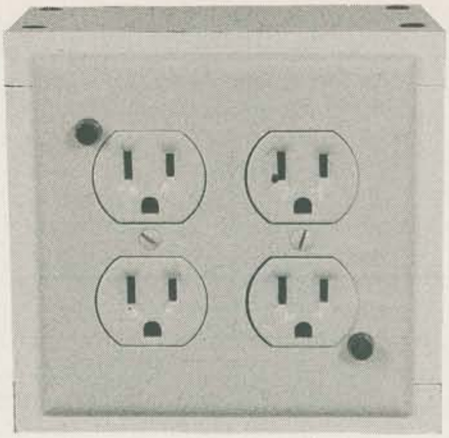


# BUILD THE SOCKET SENTINEL

*You don't have to put up with unsightly powerstrips to control multiple devices with one switch. Our device senses current flowing into one device and automatically turns on up to three others!*

BY JOHN YACONO AND MARC SPIWAK

Most people would agree that it's a good idea to have some kind of protection on any AC outlet used to power a computer. That kind of thinking probably came about not just because computers are more sensitive to line fluctuations than most appliances, but because they were more expensive in the past as well. And while many computers are still quite expensive, it's very likely that most computer owners have a video system that's worth a lot more than their computer. Also, the damage done to a TV or VCR by a line surge will probably be much more costly than to a PC—after all, a PC's power supply can be replaced for under $100. So, it stands to reason that just about any expensive electrical appliance should be protected from line surges.

As you're probably aware, you can buy surge-protected outlet strips for a reasonable price these days. They'll not only provide the protection you need, but they'll also give you the convenience of being able to turn on many different things from one switch. However, the major problem with them is that the master switch must be accessible in order to turn everything on. And, with several things plugged into it, it can be an unsightly rat's nest of line cords.

But imagine plugging a number of items into a surge-protected outlet box that could be hidden from view, and being able to turn on all of them by merely turning one item on using its own on/off switch. That's what the *Socket Sentinel* discribed in this article is designed to do.

The unit has one "master" outlet and three "slave" outlets. When the Sentinel is plugged in, the master outlet is always hot and ready to go. An AC-powered device plugged into the master outlet will function normally. A neon indicator next to that socket is always on to both identify the master outlet, and to tell you that the surge protectors are in good condition. If the device connected to the master outlet is off (*i.e.* draws no current), the three slave outlets remain unpowered. It's only when the master device is turned on that the three slave outlets become hot, and a second neon indicator (at the opposite corner of the Sentinel) turns on. That's to let you know that the slave outlets are alive, and anything plugged into them will receive power.

The prototype unit has been designed to withstand only moderate current levels. Our unit has been built to provide the master outlet with up to 1 amp of current, and can provide the slave outlets with a combined output of 6 amps. However, those limits are not written in stone; later we'll describe ways to increase the unit's current capacity. Furthermore, you can add more slave and master sockets, if you wish, as long as you don't violate the current ratings of the components that you use in your unit.

There are many possible uses for the unit. One obvious use is to have your entire computer turn on when you turn on your monitor. Or your stereo or video system can be turned on in a similar manner. It would also be neat to have some of your test equipment turn on when you turn on a shop lamp.

**Triacs.** The Sentinel uses a Triac to switch power on and off, so a few words about Triac operation are in order. (If you are already familiar with quadrant-I and -III firing of Triacs, you might want to skip down to the next section.)

Triacs are multi-layered three-terminal semiconductor devices. Their three terminals are commonly denoted G, MT1, and MT2 (which stand for gate, main-terminal 1, and main-terminal 2, respectively), as shown in Fig. 1. Each terminal has a different function.

To help you understand how they operate, take a look at Fig. 2, which is a "characteristic curve" of a Triac. Let's consider quadrant I—the upper right—of the graph first. That's where the current and voltage are both positive. The voltage (V) is applied between the two main terminals, and the current (I) is the current that flows between those terminals.

As you can see, if you apply voltage across the main terminals, they will not conduct significant amounts of current until the voltage reaches a certain value called the *breakdown voltage*. At that point the Triac's resistance suddenly drops, allowing current to flow freely. After breakdown, the voltage across the main terminals can drop to a low value without the Triac turning off. As you can see, that behavior forms a "knee-bend" in the characteristic curve.

If a voltage is applied between the gate and main-terminal 1, current flows through the gate. The flow of gate current causes a decrease in the value of

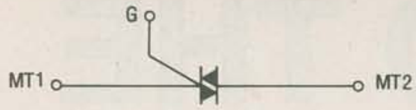



*Fig. 1. Triacs are multi-layered three-terminal semiconductor devices. Each terminal has a different function.*

breakdown voltage needed to turn on the Triac. In other words, the knee-bend becomes less sharp. You can increase the gate current to the point where the knee-bend is hardly noticeable. At that point, it only takes a small voltage across the main terminals to turn the Triac on and the Triac can be considered similar to a low-value resistor. That is called "quadrant-I operation."

The same knee-bend behavior can be seen when the polarity of the voltage across the Triac is reversed. In that situation, applying voltage to the gate still reduces the breakdown voltage, but the gate voltage must be more *negative* than main-terminal 1. As you may have guessed, this is called quadrant III operation.

To handle alternating current, the gate voltage must be positive with respect to MT1 when MT2 is more positive than MT1, and negative with respect to MT1 when MT2 is more negative than MT1. That is almost always accomplished by connecting some electrical component between MT2 and the gate. That has the effect of pulling the gate voltage toward MT2, and thus away from MT1, thereby providing the necessary potential between the gate and MT1.

As you'll see, our unit does just the opposite. A potential of the right voltage and polarity is applied between MT1 and the gate without the assistance of MT2. That is accomplished though an unusual diode network.

**The Circuit.** To do its job, the Sentinel uses some basic components in an unusual fashion (see Fig. 3). The unit is protected from surges by the two metal-oxide varistors or MOV's (MOV1 and MOV2). An MOV is basically a component that appears as an open circuit until the voltage across it exceeds a certain value. It then appears as a short circuit so that any voltage spikes large enough to cause it to short can be harmlessly shunted to ground.

Neon indicator NE1 is used to show that the MOV's are okay, as you'll see in a moment. If the MOV's ever have to divert a surge with a current of more than seven amps, fuse F1 will blow. That opens the circuit to NE1, which then goes out to let you know that the MOV's may be "unhealthy." As long as NE1 is on, the MOV's should be okay, and the devices plugged into the Sentinel are protected.

The protection circuit is designed that way because the only way to tell if an MOV is good is to expose it to high voltage and measure its impedance. But it's a good bet that a surge of over seven amps will damage one.

The rest of the circuit is responsible for monitoring current through socket SO1-a (the master socket), and turning on sockets SO1-b, SO2-a, and SO2-b (the slave sockets). The sockets are labeled SO1 and SO2, -a and -b, because they are common two-outlet type wall sockets.

Ignoring R1 for the moment, if a device plugged into SO1-a starts to draw current, the current will flow through the diode network. Current will flow through one string of three diodes during positive alterations of the AC line, and through the other set of three during negative alternations.

### PARTS LIST FOR THE SOCKET SENTINEL

**SEMICONDUCTORS**

TR1—6-amp, 400-PIV Triac (ECG5616 or equivalent, see text)
D1–D6—1N4004 1-amp, 400-PIV, silicon rectifier diode (see text)
MOV1, MOV2—V130LA120A high-power, metal-oxide varistor

**ADDITIONAL PARTS AND MATERIALS**

R1—10,000-ohm, ¼-watt, 5% resistor
F1—7-amp fast-acting Pico II fuse
NE1, NE2—Neon power indicators with built-in resistors (Radio Shack 272-712 or equivalent)
PL1—Three-conductor AC-line cord with plug
SO1, SO2—Dual-outlet wall socket
Heavy gauge wire, heat sink, heat-sink grease, perfboard, junction box, wood, screws, solder, etc.

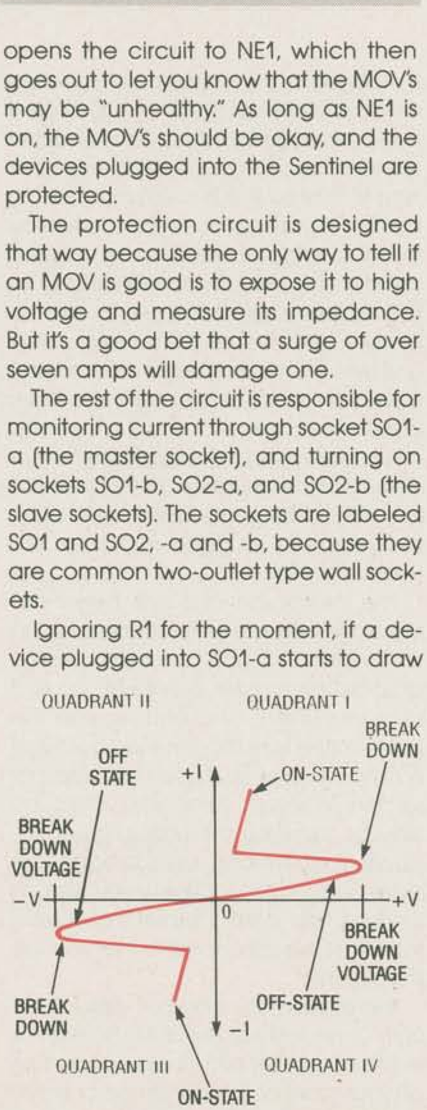



*Fig. 2. This is the characteristic curve of a Triac without gate current. It is a plot of the voltage across the main terminals versus the current through them.*

As you probably know, there is a voltage drop across any diode when it's forward biased. For the rectifying diodes specified, that drop is around 0.8 volt. So when the three diodes on the left are forward biased, each drops 0.8 volt, giving a total of 2.4 volts across the entire string of three (3 × 0.8). When the string of diodes on the right is forward biased, it also drops a total of 2.4 volts, but with the opposite polarity.

That voltage looks very much like an AC squarewave if viewed on an oscilloscope. That squarewave is sent to the gate of the Triac (TR1) and used as a trigger signal. To summarize, if current flows to the master socket, the diode network supplies TR1 with a voltage-limited gate signal of the proper polarity. The Triac then turns on and supplies power to the slave sockets. Indicator NE2 then comes on to indicate that power is available at the slave sockets.

There are brief intervals when the voltage across the diodes is above −2.4 volts, but below +2.4 volts. During those times, both sets of diodes don't conduct. That would cause the Triac to shut off briefly because there would be no gate current. Resistor R1 allows some current to flow during those intervals so that TR1 can deliver uninterrupted power.

By the way, it is the Triac itself that limits the combined output current of the slave outlets to 6 amps, because that's the rating of the unit used in the prototype. Of course, if you use a beefier Triac, your slaves will be that much more powerful. Triacs of 10, 15, 25, and 40 amps are available as common replacement parts.

To increase the current-handling capacity of the master socket or to add more master sockets, use hardier diodes. The current rating of the diodes should be at least equal to the maximum current required by the master socket (or the total of all the sockets in a unit with multiple master sockets). Note that you don't have to replace R1 with a higher-wattage resistor because it will never see more than ±2.4 volts.

You may be wondering why we didn't just use a resistor in place of the diodes. Well, the voltage drop across a resistor would vary with the current to SO1-a. Since too much gate voltage would blow the Triac, you would have to adjust the value of the resistor to suit the device plugged into SO1-a, which would be quite cumbersome. Also, if the device draws different amounts of current at different times, adjustment of the unit would become impractical.

**Construction.** There's not much to say concerning the construction of the circuit itself. Basically all of the parts, with the exception of the neon lamps, are mounted on a piece of perfboard with the low-power interconnections made with bits of bus wire. That's with the exception of certain component leads that were simply twisted together and soldered—the string of diodes, for example. The connections to and from the board, as well as any other connections that carry heavy current loads were made with 12-gauge stranded wire. The connections to the Triac leads were first wrapped tightly around the leads and then soldered. We also provided the Triac with a heat sink, as it is common practice with such devices.

The unit described here doesn't handle extreme current loads, so soldering is adequate. But keep in mind that solder will melt at relatively low temperatures, so the mechanical connections between leads must be strong to begin with. If you wish to power larger devices from the slave outlets, you must not only use a larger Triac, but the wiring should also be beefed up accordingly. As a matter of fact, the connections to the leads of a larger Triac might have to be twisted and secured with a wire nut. Whatever you do though, be extremely careful to avoid shorts and potential future shorts by keeping live connections well spaced.

Keep in mind that you can build your own Socket Sentinel with as many slave outlets as you like, as long as the parts you use can handle the total load. Do make sure that the line cord, as well as the outlet that you plug the entire unit into, can handle the total current.

You don't have to go crazy with the wiring for the surge-protection circuitry. It will never have to handle continuous high-current loads, and a surge of seven amps will blow the fuse anyway. The same goes for the neon lamps, as they do not draw much current.

As mentioned before, the sockets are of the duplex (double-outlet) type. So, in order to have the master *and* one of the slaves on the same assembly, the tab that connects the two socket's hot terminals together must be broken off with a pair of pliers (modern duplex sockets have tabs that are designed to be broken).

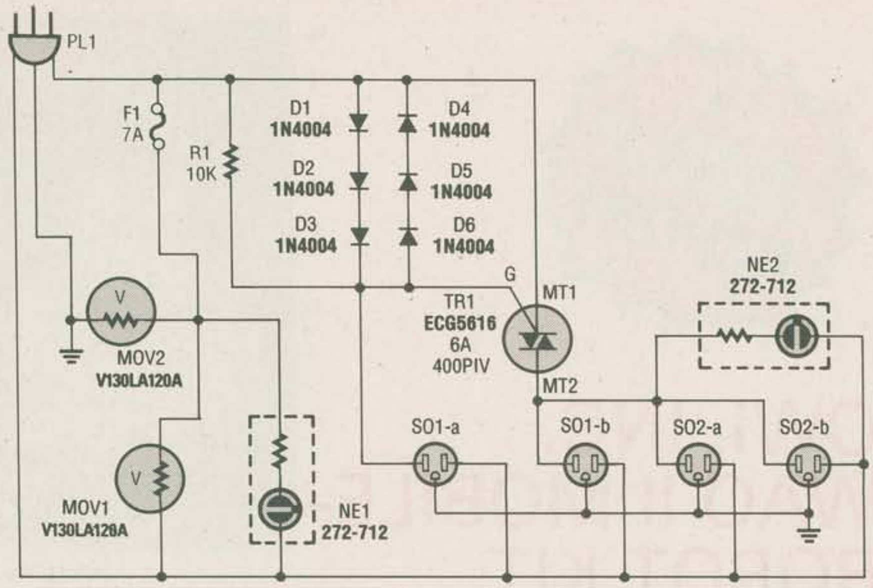
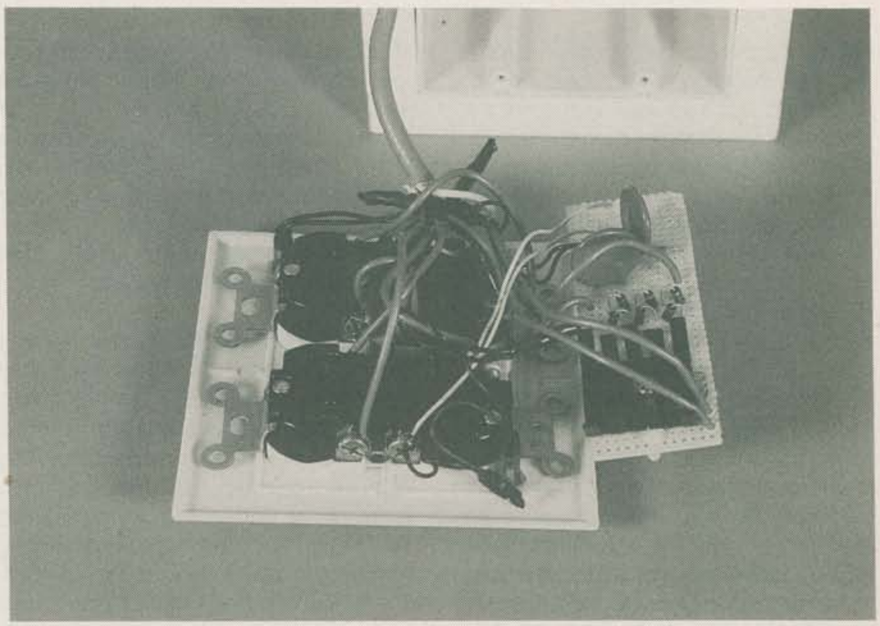



*Fig. 3. This circuit for the Socket Sentinel looks odd, but it works very well. The diodes provide the Triac gate with a voltage-limited gate signal.*



*This internal view of the Sentinel should give you some idea of what gauge wire goes where. Be sure to give the components plenty of room to prevent shorts.*

The neon lamps, which were purchased from Radio Shack (see Parts List), come complete with internal current-limiting resistors, panel-mounting red lenses, and pre-wired leads. Appropriately sized holes were drilled in the plastic outlet plate that covers the top of the unit to accommodate the lamps. Remember to mount the neon bulbs before making the electrical connections to the rest of the circuit as the leads must go through the mounting holes.

A plastic outlet box, designed to be nailed directly to a wood beam, greatly simplified the assembly of the cabinet. The tabs for the nails were cut off, and two holes were drilled in the bottom to secure the circuit board with two nylon screws. If you use metal screws, beware of potential shorts. The socket assemblies are simply mounted directly in the preformed holes in the plastic box, and the outlet panel is attached by screws to the sockets—just as it is in your wall.

As a nice finishing touch, a box was made from white particle board to enclose the plastic box. That step is unnecessary, as you can simply paint the box or leave it unfinished—it can, after all, be hidden from view. ■