The Ultimate Fuse

— ac overload protection

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Recently, while working on the design for a new power supply, I managed to blow over a dozen fuses. My regular ham buddy was on a weekend fishing trip, so I kept making the same, simple error. After the trouble was located and corrected, it somehow struck me: There's got to be a better way!

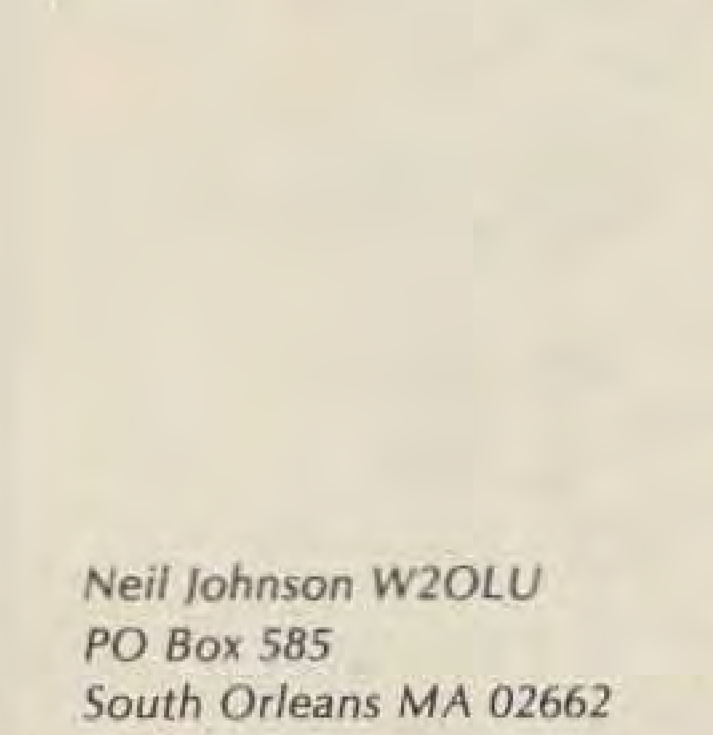

Fig. 1. The early circuitry was fairly simple, but half-wave rectification from the 120-volt winding caused the setup to be less sensitive than desired. Added components shown connected with dotted lines are needed to keep the relay locked up after an overload has caused the circuit to be broken. (Note: Relay shown at rest, i.e., non-energized.)

In the past, hams who built their own power supplies could depend on manufacturers to offer several different types of relays, some with manual reset capabilities and some with electrical reset features, but such items are no longer available to the amateur builder. In view of this deficiency, a few years ago I offered a homely solution to the dc overload-relay problem: how to homebrew what you can no longer purchase.[1]

It is common practice for commercial and military installations to provide circuitry to protect their power supplies, both as to input and output. Dc overload relays are properly installed in the output of the rectifier or filter circuits, and ac overload relays are installed in the primary circuits of the various power supplies, and so on. But I had yet to see how an amateur experimenter might put together a suitable substitute for an ac overload relay.

In an earnest effort to devise some sort of simple circuitry for such a need, it came to mind that several factors had to be taken into consideration. The system had to be simple, foolproof, and, above all else, inexpensive. There is no logic in providing an expensive method for the sort of thing which a typical amateur might wish to protect. The setup to be described satisfies all of the foregoing.

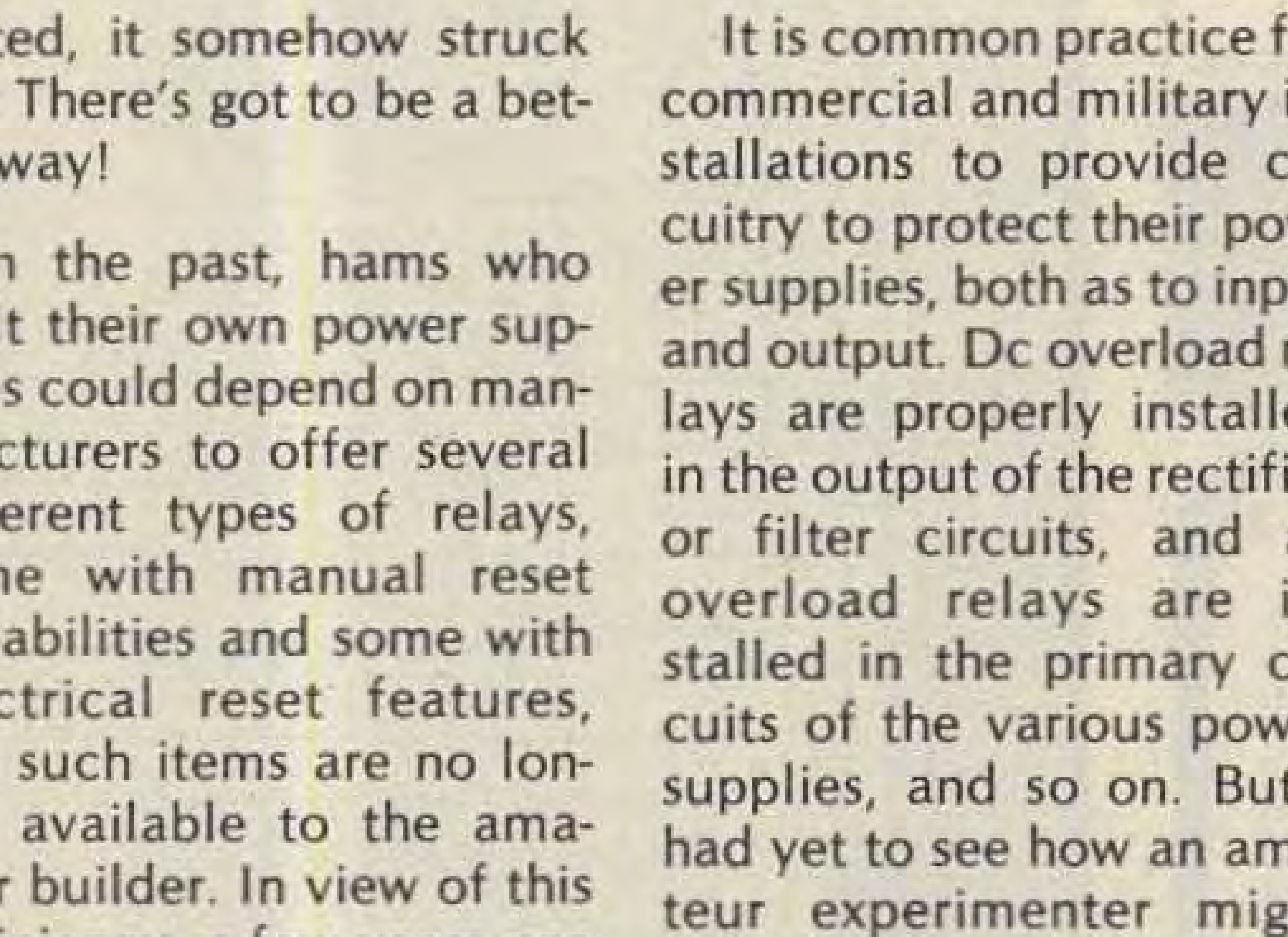

Fig. 2. Final version of overload relay. SW1 selects 2.5-, 5-, or 10-Amp kickout points.

The heart of the protective circuit lies in the utilization of a surplus 24-volt dc relay. These are widely available at low cost. If such a relay can be incorporated into a simple circuit, then we should end up with a satisfactory combination for taking care of ac overloads.

Refer to Fig. 1. Note that we have incorporated a surplus 2.5-volt filament transformer of 10-Ampere rating. Since silicon diodes came into play as substitutes for mercury-vapor tubes, such transformers have become a drug on the market. But a suitable transformer of similar ratings should serve; that is, a low-voltage secondary and rather high current rating.

Preliminary experiments

led me to develop the most elementary circuitry to fulfill the concept. When current is passed through the 2.5-volt winding a current will be induced into the 120-volt winding (now the secondary). After rectifying and filtering, the dc voltage is used to actuate the 24-volt dc relay. The variable resistor, R, can be adjusted to allow various ac currents to pass before the relay will trip and open the ac circuit.

This will not completely suffice, however, since the relay will buzz back and forth between on and off unless some form of lockup is provided. The added components, shown by dotted lines, attend to this function. Lock-up is obtained with lower current than is required for pull-in, and simple half-wave rectification will serve. Reset is furnished by opening the switch, which is normally closed.

The system that finally evolved is shown in Fig. 2. The full-wave bridge rectifier furnished more voltage than the original half-wave circuit and allows the relay to trip out at a lower current. In a thorough search for a relay of better suitabilities, over a dozen relays were checked out experimentally. Finally, it was decided to opt for a relatively sensitive unit which has the added advantage of having three sets of contacts, all rated at 10 Amperes. To be on the safe side, these are wired in parallel.

My thoughts then were directed to the feasibility of obtaining a suitable variable resistor, in order to enable the relay to actuate at various current settings. Easier said than done!

The three principal calibrating resistors are used in place of a "nice to have" 3000-Ohm, 10-Watt wirewound potentiometer. The 5-Watt, 1000-Ohm size is a fairly common item in all stores which cater to radio and TV servicemen. Additional resistors were added to cause the setup to kick out at 2.5, 5, and 10 Amperes. This 4-to-1 range is in line with what the commercial makers of such relays—Westinghouse for example—design into their products.

Other design factors worth mentioning are:
(a) The 100-uF electrolytic capacitor seems to be about right in this setup. A lower value may cause the dc relay to buzz, and a higher value can cause a time delay to take place—definitely undesirable in any form of protective circuitry where high power is involved; and (b) Avoid carbon resistors in the 1000-Ohm positions. Careful checks show that a 1000-Ohm, 2-Watt carbon resistor will be dissipating 1.6 Watts or 80% of its full value. This will cause upward change in the resistance, and, indirectly, "calibration creep" in the finished instrument.

Random thoughts at this juncture: Others have asked me whether simpler devices, such as the thermal overload units commonly found on the back of TV sets, would suffice. These have been tried and their use cannot be justified since the time delay is intolerable where an expensive unit requires protection. Personally, I almost lost a very nice Powerstat® while attempting to live with such protection.

Perhaps solid-state devices might be designed to furnish the same function? I would be disinclined to depend upon such a setup in view of the relatively high-voltage spikes which are encountered when a highly inductive component—such as the power transformer in a large amateur rig—needs to have its primary circuit interrupted. For that reason, I chose 1000-volt silicon diodes, type 1N4007, for service in this unit.

So we have an ac overload relay which is simple, inexpensive, and dependable. Furthermore, it can be calibrated to kick out at several different amperages at the flick of a switch. I have yet to see such a simple item described in print, and I thought it would be nice to share this knowledge with other members of the amateur fraternity. So, why not try this out and experiment at ease, without blowing box after box of fuses?

All of the foregoing calibrations were obtained with ac loads consisting of non-inductive heater coils. If your circuit to be protected is highly reactive, you may find the relay kickout points to be slightly different. ■

Parts List

- T— 2.5-volt, 10-A filament transformer
- D— all diodes type 1N4007
- C— 100 μF, 35 volts
- S1— Rotary switch with 3 positions
- S2— Momentary-contact switch, wired for normally-closed operation (Radio Shack 275-619)
- K— Potter & Brumfield type KUP 14D15 (Fair Radio Sales, Lima, Ohio, $2.50)
- R1-R3—1000 Ohms, 5-Watt, wirewound
- R4, R5—330 Ohms, 1-Watt
- R6—15k Ohms, 1-Watt
- R7—2700 Ohms, 2-Watt
- Small cabinet or chassis, 3-wire ac cord, and 5-way output terminals

Reference

1. "Son of the Overload Relay," *73 Magazine*, January, 1977, p. 140.

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