

"CROWBAR" OVER-VOLTAGE PROTECTION

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Every airplane with an electrical system should be fitted with some means for dealing comfortably with an over-voltage condition. If you are flying a small, 8-12 amp, permanent magnet alternator, the alternator's capability to drive system voltages up quickly is limited. For these aircraft, an over-voltage warning light is sufficient announcement prompting a pilot to shut off a failed system. The battery will soak up excess charging current until the pilot can react. For systems which carry wound-field alternators of 35 amps or more, some form of automatic over-voltage protection is required.

The majority of over-voltage protection devices are called "over-voltage relays." This is because most certified aircraft does indeed use a relay for disconnecting a faulted alternator system. Their operation is quite simple: Referring to Figure 1, a sensor and precision voltage reference monitors bus voltage. If bus voltage exceeds 15.5 to 16.0 volts (on a 14-volt airplane), the relay is energized and latched. When the relay is energized, the alternator field circuit is broken and alternator output falls to zero.

Relays are electro-mechanical devices subject to ravages of age exacerbated by vibration, heat, moisture and corrosive atmosphere. For the past 10 years or so, solid-state technology for over-voltage protection has been evolving in electronic products, most notably computers. It has been dubbed "crowbar" over-voltage protection in reference to its mode of operation. During an over-voltage condition, the system deliberately pops a supply circuit breaker or fuse which disconnects the protected circuit.

The crowbar device is a silicon controlled rectifier (SCR). This small device is inexpensive, compact and totally immune to conditions which age or destroy relays. Figure 1 shows that an over-voltage relay simply breaks the power feed line to an offending voltage regulator. Latching is achieved by using a small (100 milliamp) SCR to control the relay.

... once triggered, an SCR remains in a conducting mode until power is removed. Momentarily opening the alternator field switch allows a relay to "drop out" thus resetting the over-voltage circuit. Crowbar module operation is almost identical to the over-voltage relay except the SCR is much larger (50 amp). When triggered by an over-voltage sensor, it forms a "dead short" across the line. For this application, the SCR must be rated for peak currents of up to 300 amps or so ... that may seem like a lot but it lasts only for milliseconds, until the breaker opens.

Caution

The breaker between the bus bar and crowbar over-voltage module MUST be in good condition and KNOWN to work! Breakers seldom operate on any airplane. Unless they've been cycled at least once you have no way to know if the thing really works! I have installed crowbar over-voltage protection modules downstream of a bad circuit breaker and later managed to burn some wires when the over-voltage module tripped and the breaker failed to operate. When installing a crowbar over-voltage protection module, check the upstream breaker for proper operation. Use a jumper wire with alligator clips to power up a heavy load (landing light) through the alternator field circuit breaker. A landing light represents a 1.5 to 2.5 times over-load on a 5 amp breaker; it may take 20-30 seconds to trip it. The important thing to check is that IT DOES OPEN. The 200-300 amp load of a triggered over-voltage module will open it in milliseconds. If your alternator field supply breaker is old and/or of unknown condition, consider purchasing a new, quality breaker to replace it.

Some Notes On The "Grumman Alternative"

Grumman Aircraft has used a form of crowbar over-voltage protection on some production models. Their technique uses a 1-watt, 16-volt zener diode connected from field supply breaker to ground. The common failure mode for the zener is to SHORT when over loaded. The idea is rather clever and you can't beat it for simplicity! I do not recommend duplication of this scheme for the

following reasons:

1. Using a zener in this application depends on qualities not specified by the zener manufacturer. The zener is designed to be a voltage regulator, not an "anti-fuse." To have some level of confidence in this unspecified operating mode, hundreds of zeners from various manufacturers would have to be tested. All would have to (1) fail consistently in a shorted mode and (2) pop the field breaker without blowing apart!

2. Once the zener is shorted and the alternator is taken off line, the system cannot be reset. If a regulator has failed, causing an over-voltage condition, then over-voltage "protection" has been accomplished by deliberately failing another device which must also be replaced.

This technique has obviously passed muster with the FAA and I will concede that it probably provides adequate protection for Grumman's airplanes. Using a zener for "anti-fuse," crowbar o.v. protection is on shaky ground unless one is ready to exactly duplicate all parameters of the Grumman electrical system. 'Nuf said.

Rolling Your Own

For those who are interested in building a crowbar over-voltage module, I will supply a schematic with a list of materials to any who send a #10, self-addressed, stamped envelope to me at the address below. The information sheet also describes proper incorporation of the low cost, replacement "Ford" voltage regulators into airplanes.

Bibliography

Written coverage plus real-time consulting services by the author on this and other electrical systems topics are available from the AeroElectric Connection, [REDACTED] Wichita, KS 67226-1008. [REDACTED] USD buys all materials in print (13 chapters, lots of illustrations, 5 appendices, 200+ pages) plus one year's subscription to newsletters and the next issue of chapters on specific topics. Overseas subscribers add [REDACTED] USD for airmail postage. MasterCard and Visa are accepted. The author may be contacted directly at [REDACTED] or Compuserve

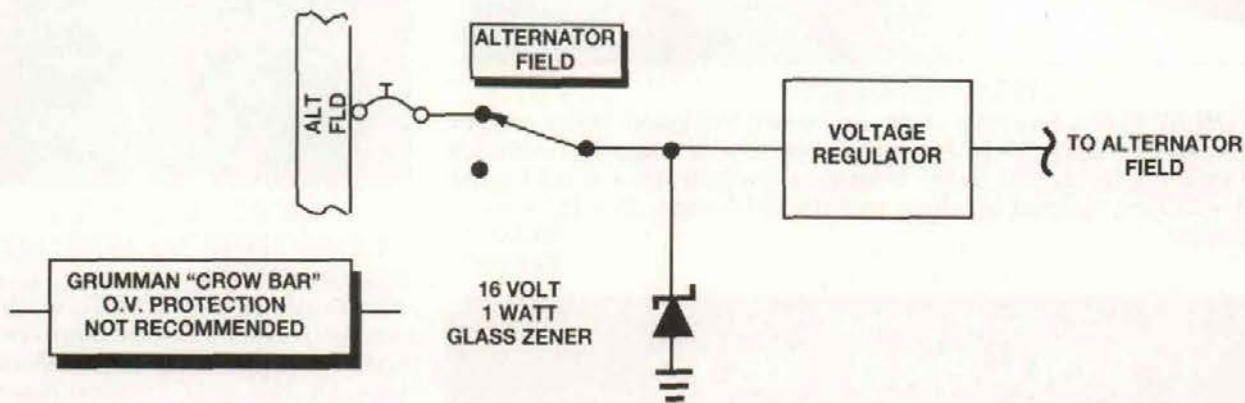
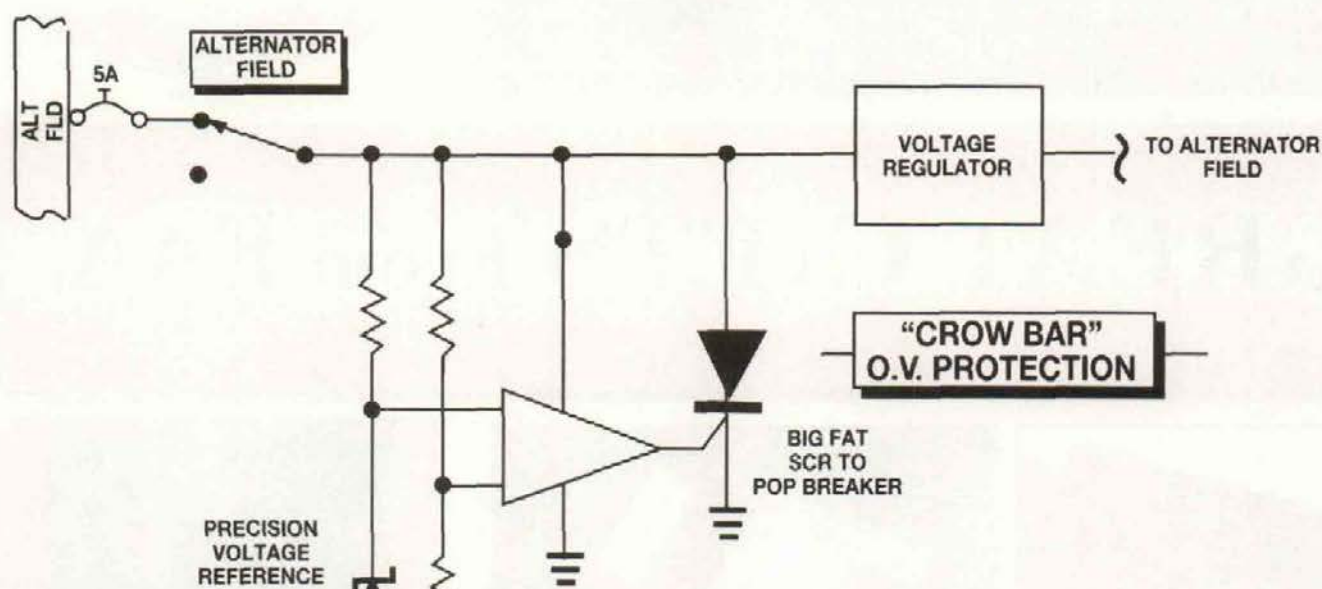
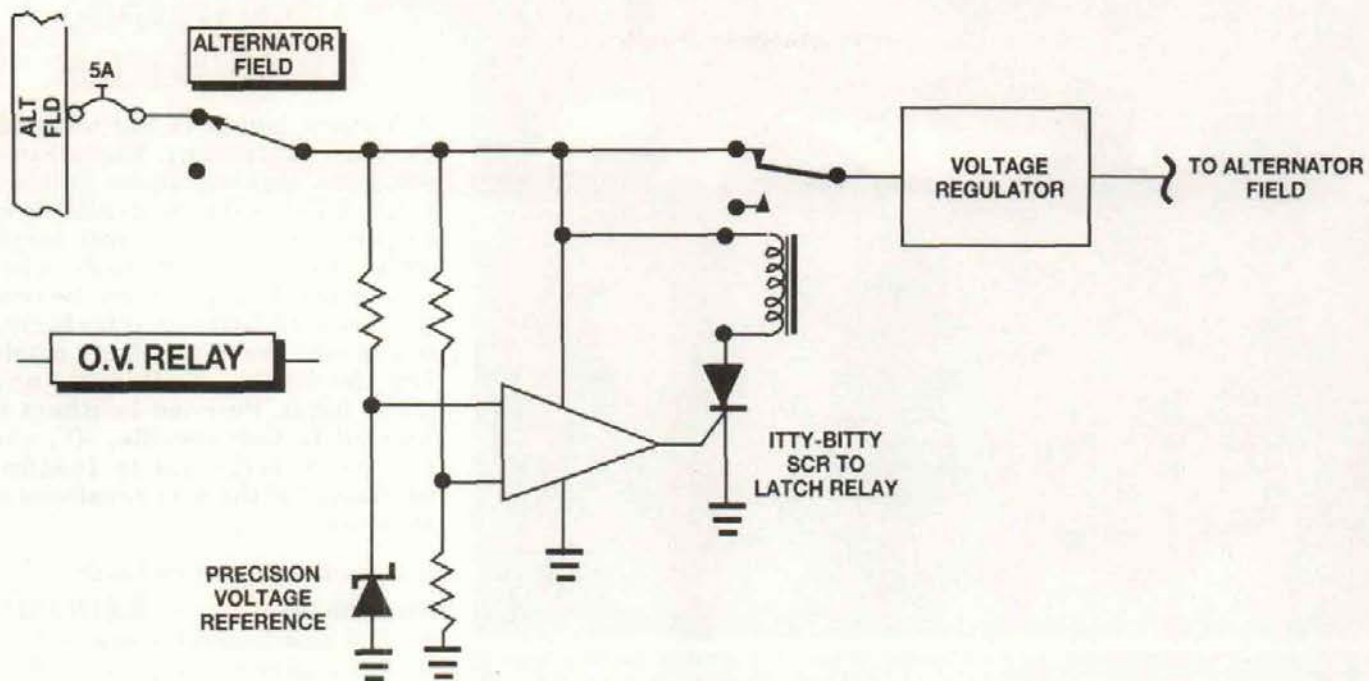


FIGURE 1