TS-940 overvoltage protection

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A known problem of the TS-940 is the failure of the power supply regulator transistors Q101 and 102 (2N5885) or their drivers. Usually one will go short circuit, causing the 28 volt supply of the PA board to rise up to about 40 volts. Serious damage to the PA transistors will result, such as burning of the driver transistors (MRF485). This may happen before the internal fuse blows (figure 1). The low-hfe MRF485, which are required, are no more available. Complex repair procedures are necessary.

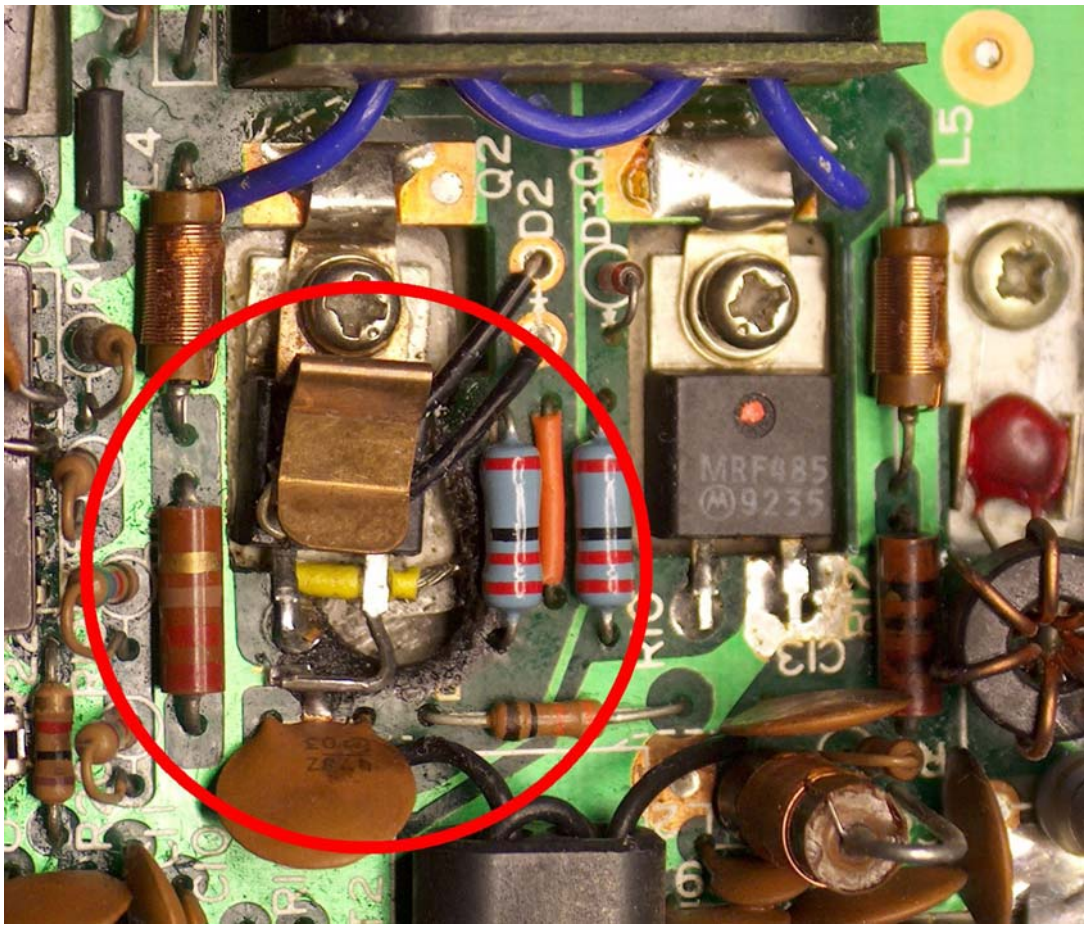

Figure 1: Driver section of the TS-940 PA. This unit is an example how severe damage may be, if overvoltage causes burning of a driver transistor. Note that part of the board around Q2 has vaporized (red circle). I got this board from an ebay auction. Somebody repaired the board by replacement of the driver transistors and reconstruction of the burnt wiring.

Some time ago a failure of Q101/102 occured in the power supply of my TS-940, but fortunately the emitter-collector path opened and no secondary damage occured. Nevertheless, I thought I may not be as lucky if this happens again.

Therefore, I added the following overvoltage protection circuit to the AVR board of my TS-940.

Overvoltage protection circuit

A useful concept of an overvoltage protection is the ´crowbar´, as described on Jeff King´s excellent TS-940 page (http://www.jking.kol.co.nz/crowbar.htm). I did some experimentation and found the following, relatively simple circuit appropriate (figure 2).

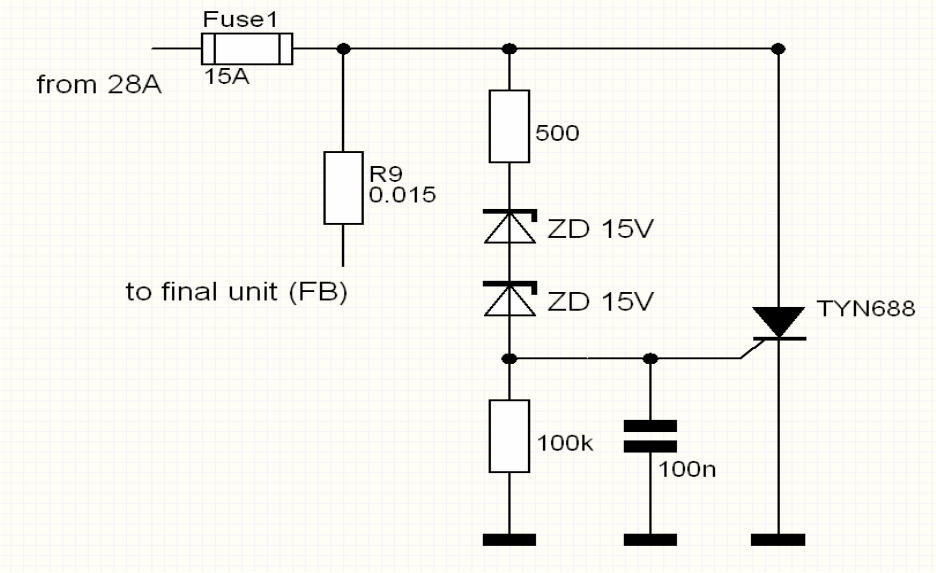

Figure 2: Circuit diagram of the crowbar overvoltage protection.

The Zener diodes normally hold off the positive regulated voltage from appearing at the thyristor gate as long as the avalanche voltage is not exceeded. If this happens (overvoltage), the thyristor will open. Zener diode current is limited by the 500 Ohm resistor. The capacitor between the thyristor gate and ground may be useful to remove RF from the gate, although I did not implement it yet and had no problems. When a voltage overshoot triggers the thyristor gate, DC is shortened and fuse 1 (F1) will blow.

To check this circuit, I built an experimental high-current 26 V supply with two fully charged 12V, 15Ah lead acid batteries in series. This supply was connected between ground and the open end of a 20 A fuse (higher than original fuse F1). The upper end of the 500 Ohm resistor was separated from the circuit and connected to a regulated power supply, able to deliver 0 to 40 V versus ground. Then, I slowly increased the output voltage of the regulated supply. The thyristor opened at about 32 V and safely blew the 20 A fuse, without damage to the thyristor. I selected the TYN688 because of its physical size (TO-220) and because there were some in my junkbox from earlier projects. Other rugged thyristor models may work as well.

Construction details

It was necessary to remove the AVR board for this modification. To keep the connections between tyristor, ground and fuse F1 as short as possible (high current expected when thyristor opens), the thyristor was mounted directly on the AVR board (figure 3). Some holes had to be drilled into the AVR board (red dots, top of figure 3). The resistors and Zener diodes were directly soldered to the tyristor gate (see bottom of figure 3).

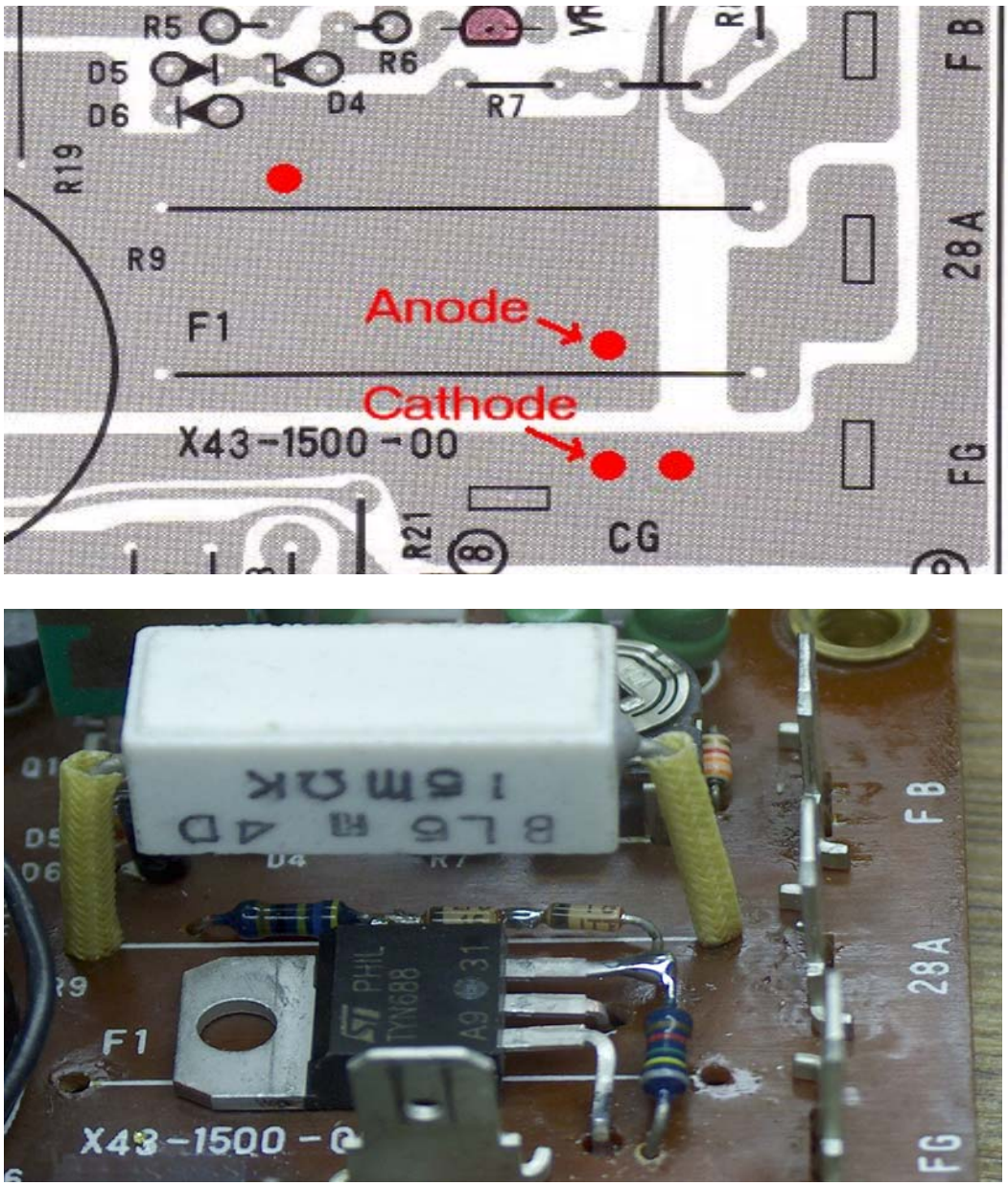

Figure 3: Top: Details of the modification on the AVR board (top view of PCB layout). The red dots mark the holes to be drilled. Bottom: Thyristor and additional parts. Fuse F1 has been temporarily removed for better access. Its long legs leave enough space underneath for the thyristor and all other parts.

This overvoltage protection may well be combined with other modifications which can prevent severe damage from other causes. For example, it makes sense to build an additional circuit that shuts down the TS-940 upon overheating of the power supply, as may occur after fan failure.

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Please note:
This modification requires some technical experience and equipment. I can not guarantee that my report is free of mistakes. I will not be responsible of any damage which may occur.