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Title: Incompatibility Between Vacuum-Tube and Solid-State Equipment
Author: Dallas Williams, WA0MRG

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Hints and Kinks

Conducted By David Newkirk, AK7M
Assistant Technical Editor

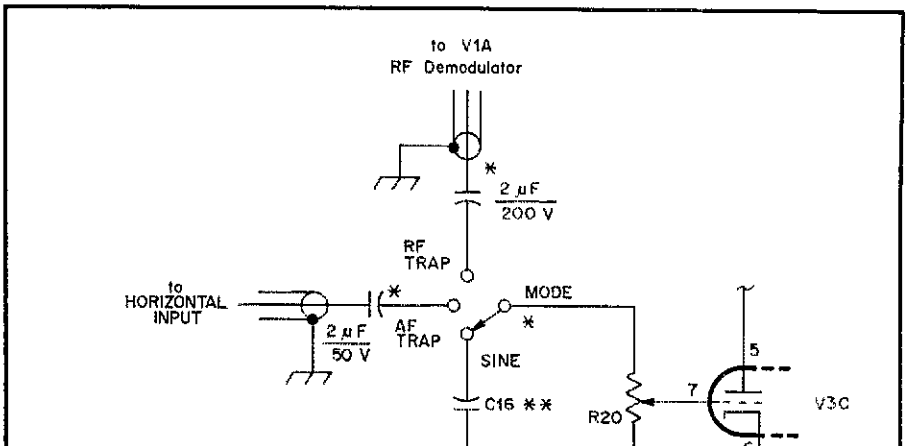
INCOMPATIBILITY BETWEEN VACUUM-TUBE AND SOLID-STATE EQUIPMENT

☐ The growing popularity of modem-based digital communication (RTTY, packet radio, and so on) has led to the increased use of small, used oscilloscopes—often based on vacuum tubes instead of transistors—as tuning aids. Although tube-based scopes can be well suited to tuning-indicator applications, they should be thoroughly checked for compatibility before solid-state gear is connected to them.

The Heath® HO-10 monitor scope is an example of why such caution is necessary. This 3-inch-CRT oscilloscope was produced a number of years ago and is common at swap meets. Unmodified, the vacuum-tube-based HO-10 may damage solid-state equipment connected to it. Here's why—and how to modify the HO-10 for compatibility with solid-state gear.

The first fix involves the HO-10's MODE or FUNCTION switch. (This switch is marked MODE on the HO-10 schematic, but is labeled FUNCTION on the scope's front panel.) With age, this switch (see Fig 1A) may deteriorate to the point that it acts as a shorting switch (a switch containing moving contacts that connect to one circuit before breaking contact with another) instead of the *non-shorting* switch it was intended to be. When this happens, 170 V dc may appear at the HO-10's HORIZONTAL INPUT jack as the MODE switch is moved from SINE to AF TRAP. A voltage of this magnitude can instantly destroy low-voltage, solid-state circuitry. Cure: Replace the defective MODE switch with a switch that reliably breaks one circuit before making contact with another.

The second of the HO-10's problems is C16, the coupling capacitor between the HO-16's MODE switch and horizontal amplifier V3C. When the MODE switch is in the SINE position, C16 (2 µF at 200 WVDC) charges to about 170 V. If this happens, moving the MODE switch to AF TRAP (the position selected when the HO-10 is used as a RTTY tuning indicator)



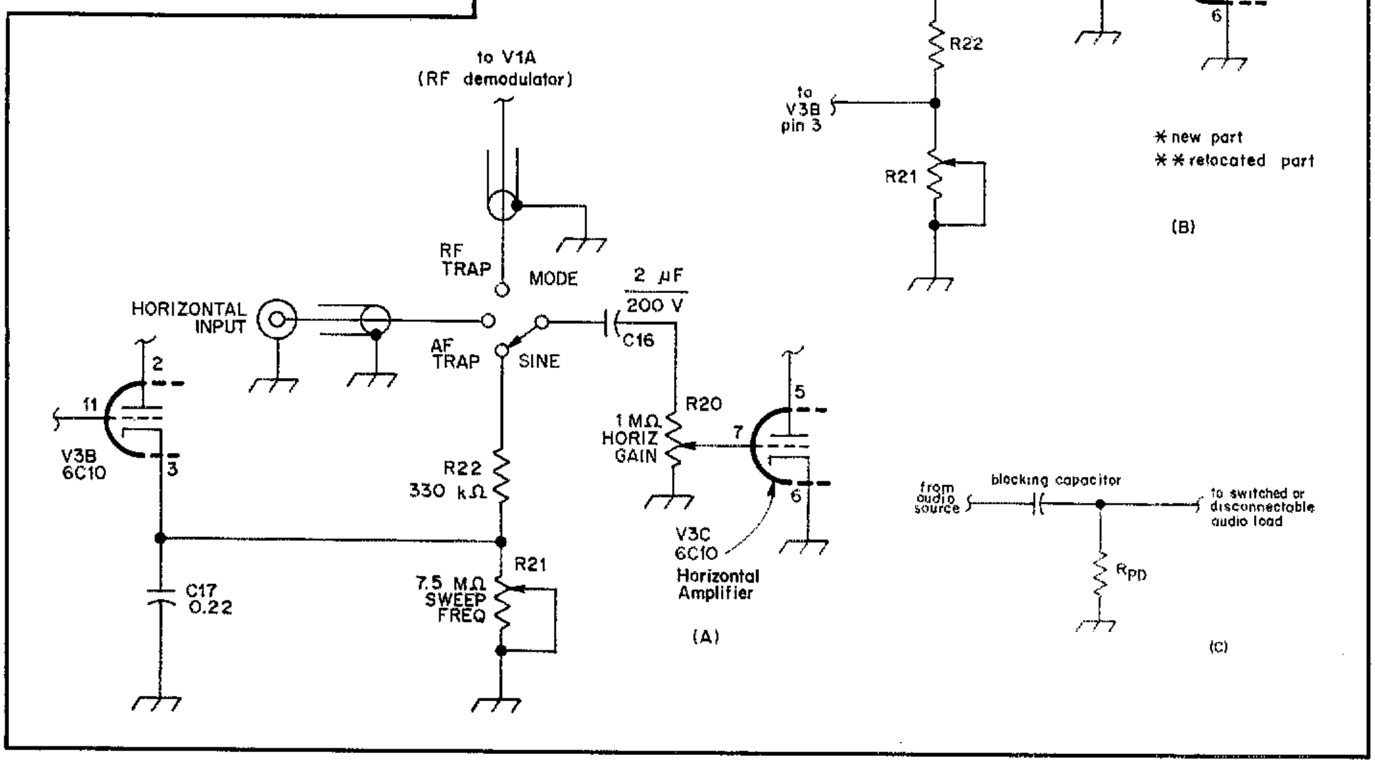


Fig 1—Deterioration of the Heath HO-10's MODE switch can cause momentary short circuits between the switch's AF TRAP and SINE terminals when the switch is cycled (A). When this occurs, V3B's cathode potential (as high as 170 V) appears at the HORIZONTAL INPUT jack, spelling almost certain doom for solid-state equipment connected to the jack. Dallas Williams suggests curing this with a new MODE switch. Even if the HO-10's MODE switch is in good shape, however, the high-voltage charge C16 acquires with the MODE switch in the SINE position is applied to the HORIZONTAL INPUT jack when the switch is moved from SINE to AF TRAP. Dallas's solution to this consists of moving C16 and adding two capacitors as shown at B. (The 2-µF capacitors are nonpolarized paper- or plastic-dielectric units.) C shows your editor's high-tech fix to thumps caused by sudden charging of blocking capacitors in audio circuits. To keep circuit loading negligible, make the resistance of pull-down resistor R_{PD} at least ten times the impedance at the point across which the resistor is connected.

connects the charged capacitor across the HO-10's HORIZONTAL INPUT jack. A voltage of 170 can be fatal to a solid-state device connected to the HORIZONTAL INPUT jack. Cure: Add two 2-μF, 200-WVDC capacitors and relocate C16 as shown in Fig 1B.

Modified in this way, the Heath HO-10 makes a fine tuning aid for digital communications. It's likely that other monitor scopes—and, for that matter, other vacuum-tube-based equipment—may have similar problems. Because of this, it's a good idea to check vacuum-tube gear for safe operation before connecting it to solid-state equipment.—*Dallas Williams, WA0MRG, PO Box 1, Sedgwick, CO 80749-0001*

AK7M: Although Dallas's equipment-compatibility hint may seem to be equipment-specific, it isn't. One of the first facts we learn about capacitors is that they can "block dc while allowing ac to pass." This quoted statement is a bit simplistic: A capacitor can block dc *only after it has charged to the dc voltage it's expected to block.* If the simplistic view were true, you could connect one lead of a 0.01-μF, 1-kV capacitor to, say, 500 V and grab the capacitor's free lead with no ill effect. In fact—and depending on how close your body is to ground potential—you may receive a short, *dangerous* jolt as the capacitor charges to 500 V *through you.* This happens because an uncharged capacitor "looks like" a short circuit until it charges.

Unplanned-for capacitor-charging effects may be no more than annoying. Have you ever put a pair of headphones on *before* plugging them into an unloaded solid-state audio amplifier and heard a deafening *thump* as you plugged the headphones in? Such thumps occur when an amplifier's dc-blocking output capacitor charges through the output transducer (your headphones or speaker). This situation can be more than an annoyance: I once blew the headphone-circuit blocking capacitor in a 1930s-vintage ham receiver merely by plugging in headphones. The capacitor had been on the verge of failure; the sudden charging-current pulse finished it off and caused a headphone pop that made my ears ring for several minutes. What would have happened if I'd plugged in a solid-state amplifier instead of headphones?

If component failure causes voltage to appear where it doesn't belong, the cure is simple: Replace the failed component. If suboptimal circuit design is the cause, the circuit can be modified for safer (or less annoying) operation. Audio thumps or clicks that occur when a load is connected or switched can often be cured simply by the addition of pull-down resistors at the "floating" side of culprit capacitors (Fig 1C).

INSULATION SUPPORTS AS RADIAL TIE-DOWNS

☐ Verticals are useful antennas for DX work on the low bands. For many hams, the tedious job of burying radials for a vertical-antenna ground system is a major drawback. Some studies have shown that radials laid *on* the ground, rather than buried in it, provide a more-efficient RF ground than buried radials. On-ground radials require special installation techniques, however: They must be securely fastened to the ground so that they do not trip people or foul lawn mowers.

For several years, I have successfully used insulation supports as on-ground-radial tie-downs. Insulation supports resemble very long, headless nails and are pointed at both ends. Designed to support thermal insulation between house floor joists, they are generally sold by building supply houses in 16- and 24-inch sizes at $12 to $15 per thousand.

Install the insulation supports on a given radial as follows: Lay the radial wire on the ground in its proper position. Prepare a dozen or so of the supports by bending them into a *U* shape. Drive these "staples" into the ground and over the radial every few feet along the radial. Space the staples closely enough along the length of each radial to secure the wire and keep flush with the ground.

The best time to install surface-mounted radials on a lawn is during colder months when grass is dormant: Turf will cover the radials as soon as warm weather arrives and the grass resumes growth. As a warm-weather alternative, mow the grass just before installing the radials.—*Drayton Cooper, N4LBJ, Bowling Green Presbyterian Church, PO Box 5, Bowling Green, SC 29703*

AN IMPROVED CIRCUIT FOR INTERCONNECTING THE SB-200 AMPLIFIER AND SOLID-STATE TRANSCEIVERS

☐ I encountered a problem similar to that discussed by James Hebert ("Using the SB-220 Amplifier with Solid-State Transceivers," *QST*, Jan 1988, p 45), when I sought to drive my Heath® SB-200 amplifier with a newly acquired Kenwood TS-940S transceiver. The hot contact of the SB-200's relay-control jack exhibits an open circuit voltage of −130 to ground; the short-circuit current of the SB-200's relay-control circuit is 50 mA. The open-circuit voltage could rise to as high as 170 under fault conditions in the SB-200. The Kenwood manual states that the TS-940's control relay is intended for low-current applications; I infer that "low current" also means "low voltage." As a result, I did not want to connect the SB-200's 130-V control line to my TS-940S. Instead, and in order to get on the air quickly, I used a relay between the TS-940S and SB-200. I wasn't satisfied for long: It seemed ridiculous—and rather noisy—to use the transceiver relay to drive another relay that finally switched *another* relay in the SB-200.

To solve this problem, I designed an interface circuit (Fig 2) that uses a high-voltage, P-channel MOS power transistor—an IRF9612—as a switch. The IRF9612 has a source-to-drain breakdown voltage of 200, can switch up to 1.5 A, exhibits a channel resistance of 4.5 Ω when turned on, comes in a TO-220 plastic package, and costs $3.50/unit in small quantities. The IRF9612 also includes an integral drain-to-source protection diode capable of clamping transients that can result from switching inductive loads.

The circuit is powered by a 9-V battery, which provides enough voltage to drive the MOSFET in this low-current switching application. The 1-kΩ resistor limits the peak current flowing in the transceiver relay to approximately 9 mA and sets the MOSFET turn-on time to approximately 0.3 μs (this assumes that the MOSFET's effective input capacitance is 300 pF). The 470-kΩ resistor sets the turn-off time constant to 140 μs and limits the closed-circuit current to 20 μA. The 15-V Zener diode protects the transceiver should the MOSFET develop a gate-to-drain short circuit. (In that unlikely event, the Zener diode will limit the voltage applied to the transceiver to −24. If you intend to substitute a diode with a different Zener voltage for this part, remember that the Zener diode's breakdown rating must comfortably exceed the battery voltage [9

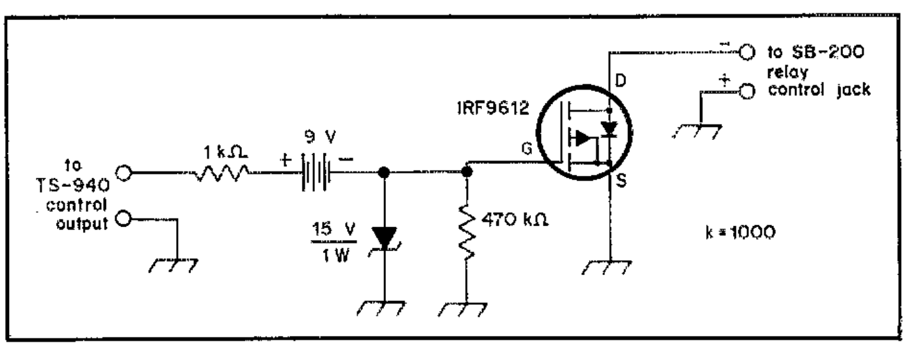


Fig 2—Richard Jaeger's solid-state transceiver-to-amplifier interface uses a power MOSFET instead of a relay for amplifier control. For amplifiers that use a *positive* relay-control voltage, reverse the polarity of the Zener diode and battery, and use an IRF612 N-channel MOSFET instead of the IRF9612.