FIXING AM POWER ISSUES IN THE KENWOOD TS-930S

SECTION 1: RESTORING AM IN A KENWOOD TS-930S TRANSCEIVER AFTER REPLACING AN EARLY MODEL SIGNAL UNIT (SU) WITH A LATE MODEL BOARD

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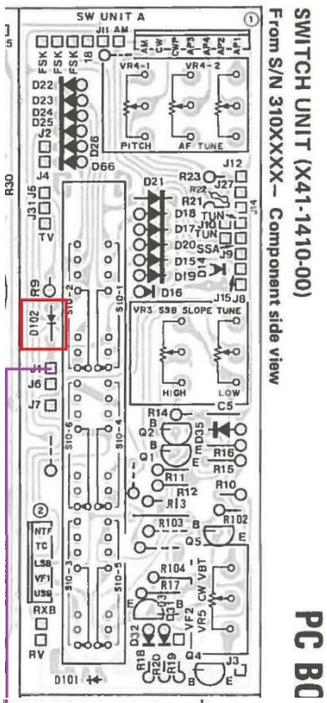
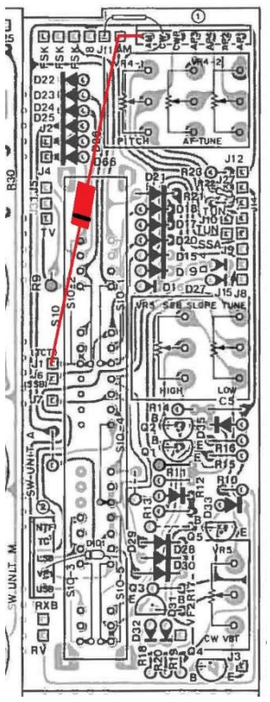
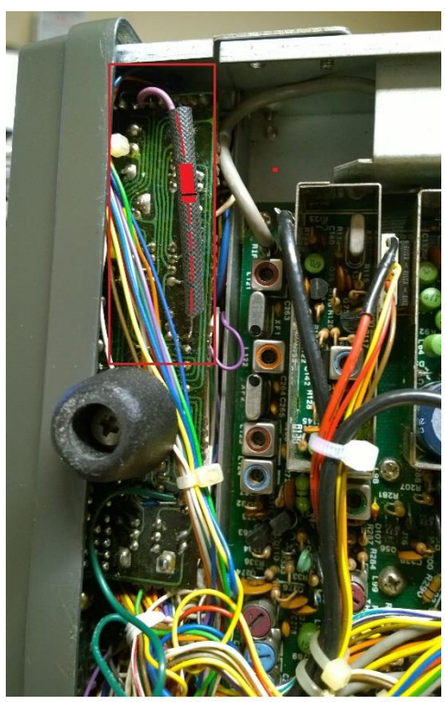
As parts become scarcer for your Kenwood TS-930S amateur transceiver, you may find yourself in a situation where installing a replacement Signal Unit (SU) circuit board becomes necessary. The procedure is not difficult, and in many cases, no special alignment is required except perhaps some basic tweaking. One issue, however, is that in the older TS-930S series, bias control for the AM mode is contained entirely on the SU and is set by potentiometer VR22. On the later Signal Units, AM carrier level is set by the front panel Carrier control. This presents a problem after the swap because there will be no AM carrier when the MODE switch is set to AM. Only modulation will be present, so what you will hear through a monitor and what other operators will hear will sound like SSB.

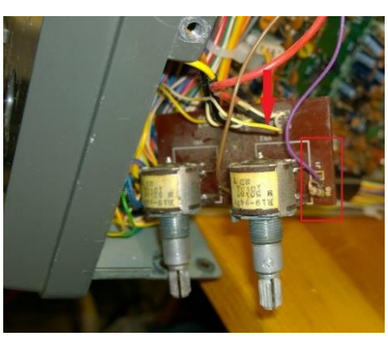
After studying the AM circuits and switching systems for both early and late model radios, Dave Phillips identified the missing link: a diode, D102, was absent from Switch Unit "A" in the early 930S chassis. That diode wasn't needed because the carrier level was already set by VR22. D102 provides voltage and isolation between the AM terminals on Switch Unit A and J1 on Switch Unit D via a purple wire as shown below. That voltage is then fed to the Carrier control via a foil trace. The resulting variable voltage appears on the CV terminal on unit D. All that is needed on the older switch unit is a diode between the AM terminals at the top of Switch Unit A and the top terminal (TCT) at J1, as shown below. I spanned both AM terminals since they are small. NOTE: The two graphics from the service manual on the left are shown from the *Component* side, so they are mirror images of the photo of the foil side on the far right. The purple wire that connects J1 on Switch Unit A and J1 on Switch Unit D can be seen in the photo on the far right.

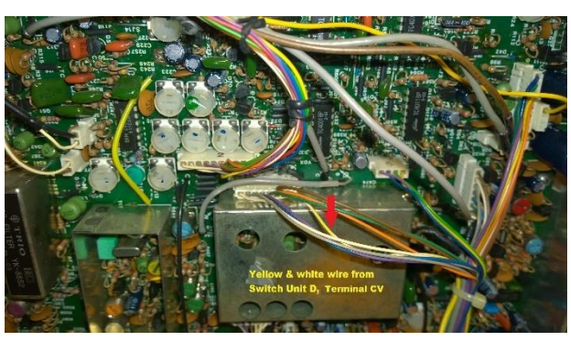
LATER UNITS (D102 is already there)	EARLY UNITS (A diode must be added)	DIODE ADDED (Inside insulation)



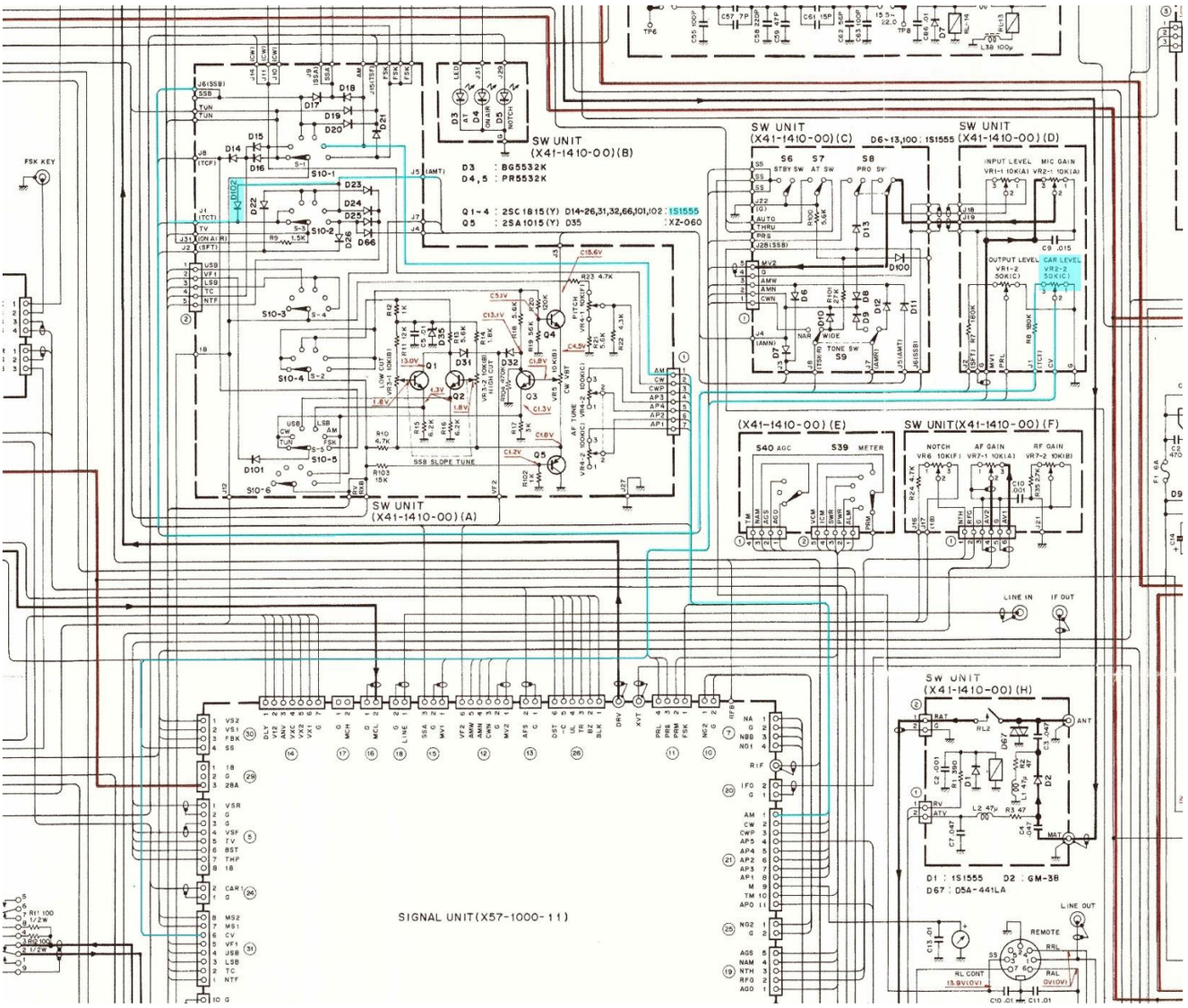








After making the diode connection above, check with a DMM for a variable voltage in AM mode at Pin 6 on connector 31 (Yellow & white wire). You do not need to hit SEND. The voltage will be there in standby. You should see about 4 volts when you rotate the Carrier control from 0 to 10. Mine reads 4.25V. The diagram, traced in blue, is on the next page.



If the carrier level is low, adjust coil L175 on the AM board to see if that increases the output. On one of Dave's 930S rigs, 2 volts was enough to provide 100 watts carrier. On my hybrid 930S, which is an older 930S with a later model Signal Unit in it, the 4 volts on my terminal only drives the board to an AM carrier of 45 watts on 20M and above, and only 25 watts on 40M and below. Your radio will no doubt show a slightly different level due to parts aging.

SECTION 2: ADDING FRONT PANEL AM CARRIER CONTROL TO AN EARLY MODEL KENWOOD TS-930S

If you have an older TS-930S radio and SU, and you want to move the AM carrier control from VR22 on the Signal Unit to the front panel Carrier control, it's not hard. Three options are presented below, but there are probably many others:

1. Leave VR22 in place and connect the variable carrier output from the CV terminal on switch unit D to the "top" of VR22 with a wire and a switch. This option uses the Switch Unit A diode system from Section 1. You will also want to cut jumper J129. The reason for cutting J129 and the switch is discussed in the section below.

2. Remove or simply "destroy" VR22 and connect the CV line to the wiper terminal post or circuit trace that connects to the base of Q86 via a direct-connect wire. I recommend adding a diode, a series of diodes, or some other non-resistive means in series with that wire to reduce the voltage that reaches Q86 to something less than the 3.5-4.0 volts that emanates from the CV terminal as explained below.

3. Creating a resistive voltage divider ahead of the diode on Switch Unit A, which if you use the values I used, should give you just under a volt at the base of Q86. The CV line can be connected directly the wiper terminal that was part of VR22. This gives a super smooth AM Carrier progression from 0 to 100 watts, except on the 10 meter band. That comment is explained in the appropriate section.

Option 1 produces the smoothest AM carrier control. Once the parts are in place but with the case still off, set the front panel Carrier control to maximum, and then adjust VR22 to yield an AM carrier at 14.175 MHz of 60 or 70 watts. With the radio back together, you will be amazed at how easy it is to set the AM with the front panel carrier control to the 35-watt level recommended by Kenwood. The problem is that interaction between the three circuits that are controlled from the CV terminal will become obvious when you try to use TUNE or CW mode. The voltages needed for TUNE and CW mode are on the order of 3 to 4 volts, while the voltage needed for a full 100 watts on AM is less than 1 volt. VR22 is a 10K pot with one end grounded, so without a switch or some other means of switching out VR22, the higher voltage needed for TUNE and CW will be shunted to ground through that 10K resistance. Those two modes will be lost, which most operators will find unacceptable.

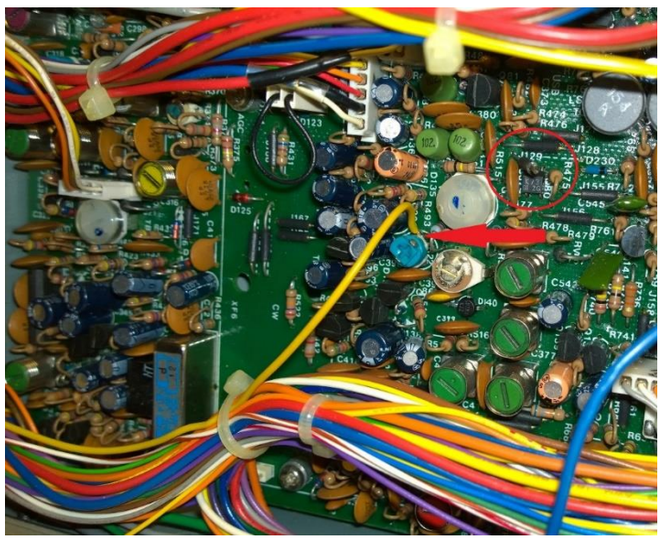
Since I seldom use AM, I seriously considered Option 1. The switch can be mounted using double-sided tape up next to the VOX controls and left in the "open" position until AM is needed. The wires can easily be run between the SU and the front panel. With this system, if you ever decide to restore your radio to its original state, all you need to do is remove the switch and wiring, and the line to VR22 and then resolder jumper J129. The diode from the AM switch terminals to the TCT terminal can be left in place. But I wanted to investigate options that would more accurately emulate the operation of a late model 930S, so I decided to test Options 2 and 3.

The picture below shows how I connected the line to VR22 in Option 1. I simply cut J129. I would cut yours in the middle in case you ever decide to put things back the way they were from the factory. It's just an insulated wire. The reason it should be cut is that the supply voltage to VR22 came from other circuits in the radio via J129.

Option 1 connections. If you use this system, use a switch to break the line from the CV terminal to VR22. I used a yellow wire. The diode, hidden inside that wire sheath, can be just a silicon diode, like the 1N4004 that I used.

Diode from AM to TCT terminal

Wire from CV to VR22 The switch is not shown here.



Advantages to Option 1:

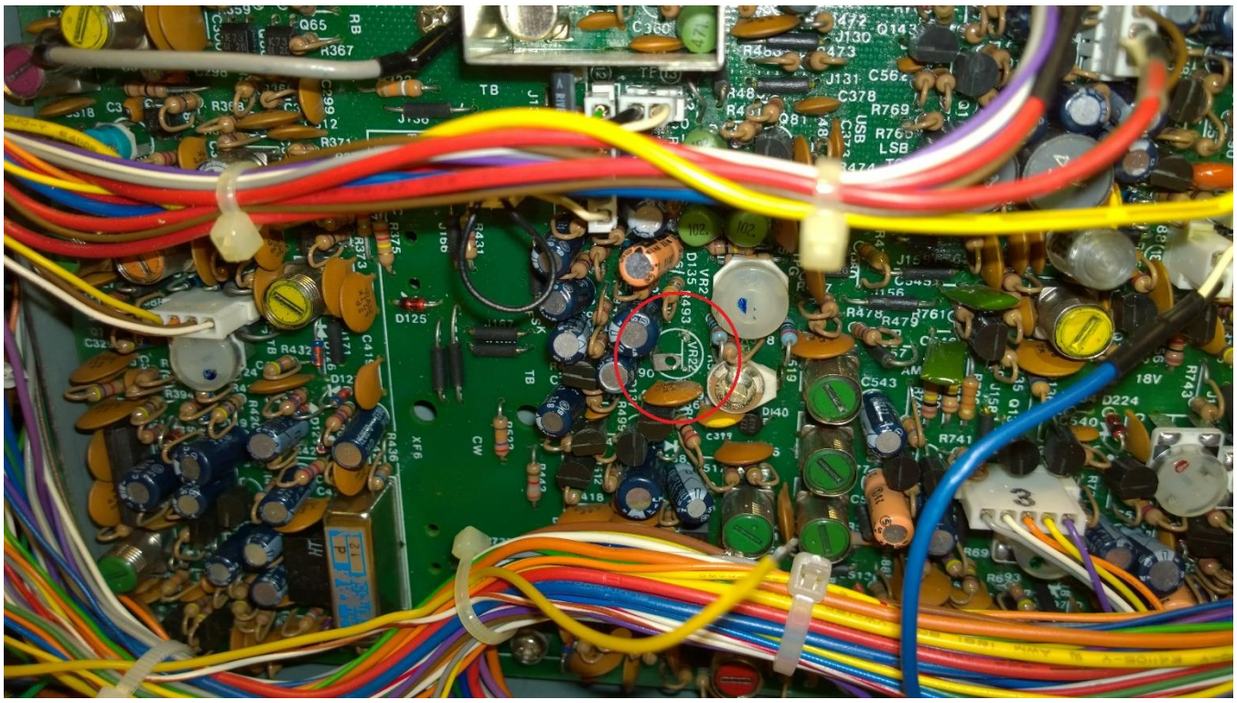
- Very smooth AM carrier operation
- Easy to return the radio to the "stock" configuration

Disadvantages:

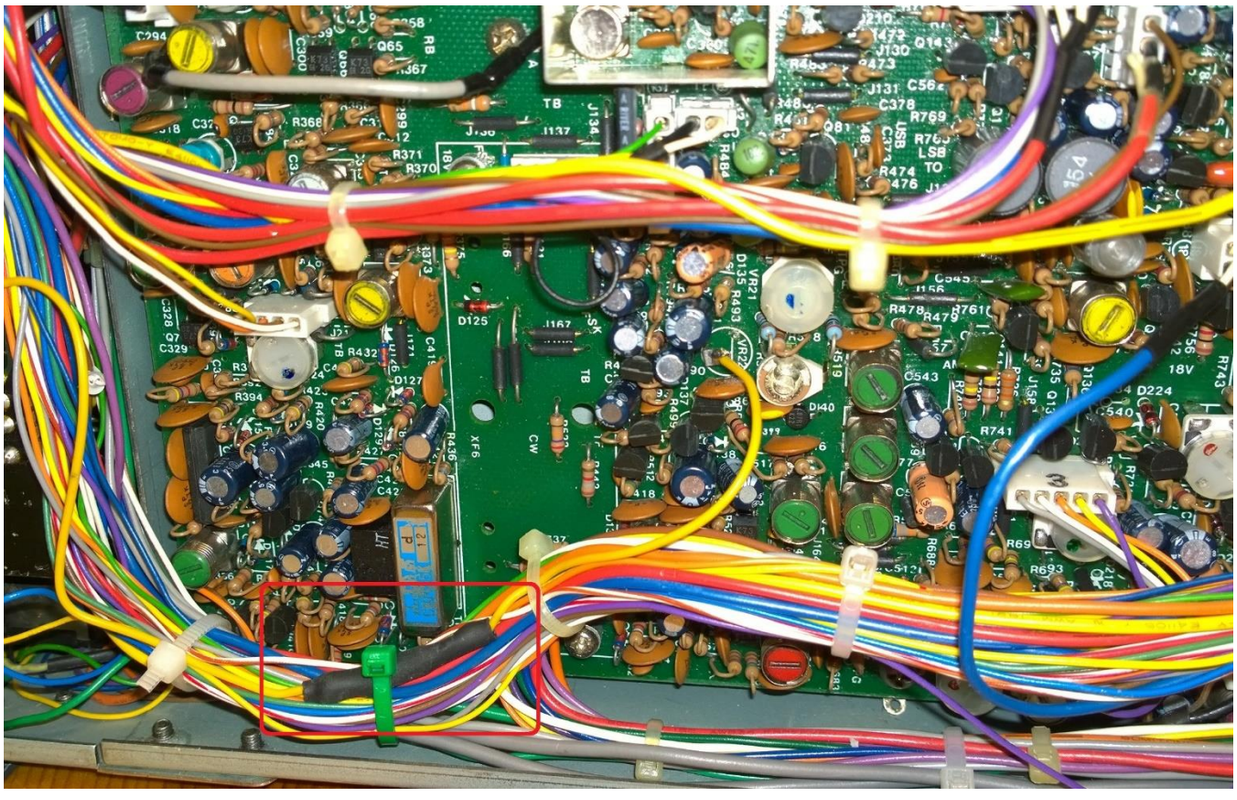
- A switch is required, or TUNE and CW modes will be lost
- The AM levels on 40 meters and below will be half as much as they are on 20M. If you use AM on 40, 75, or 80 meters, VR22 must be set higher on 20 meters, assuming VR22's range will allow that.

Option 2 uses the same D102 diode link used in Option1. With VR22 removed, the interaction problem between AM, TUNE, and CW modes is gone, but it introduces a different problem – too much voltage for the AM drive. The voltage coming from the CV line is almost 4 volts (3.88 in my radio), and the voltage at the base of Q86 needed for 100 watts out on AM on the older SU is approximately one-half (0.5) volt. Without VR22 in the circuit the full CV voltage will appear on the base of Q86 when the Carrier control is fully clockwise. Achieving the recommended 35 watts output will be very difficult. On my OEM early-production 930S, 35 watts is reached with a Carrier setting of about 1. A slight touch or bump of the control drives it up over 110 watts, which will overheat the PA during a long AM ragchew.

The correct way to wire this is option is to pull the signal unit and remove VR22, but with an old radio that involves some risk. Connectors, wires, or foil traces can break, etc. If your early serial number board works perfectly, you might consider carefully destroying VR22 with your SU in place. You can leave J129 alone because removing VR22 will isolate the new drive system to Q86's base from the rest of the radio. A picture of my SU after I did that work is below. Once you do this, there's no going back. I worked slowly and used a precision wire cutter. My yellow wire to CV is hanging free in this picture. A tiny screw from VR22's wiper will fall out when you do this so watch out for it.

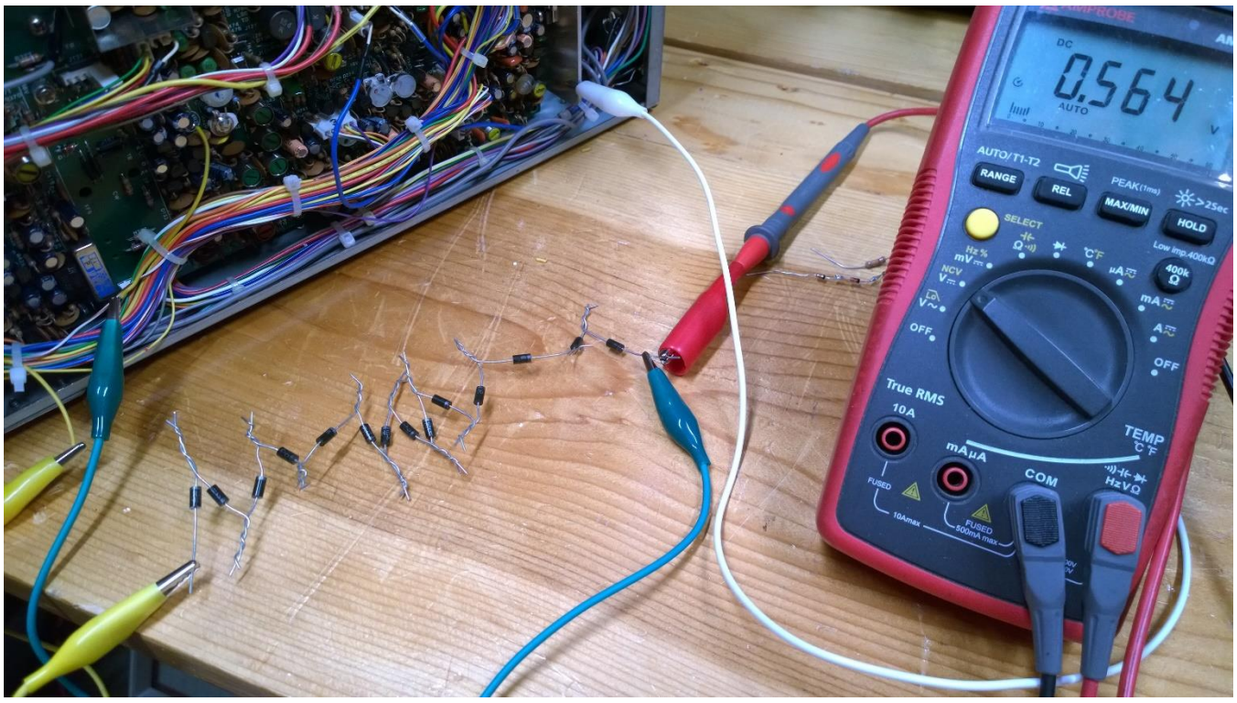


In the picture below, I've connected the line to what was the wiper of VR22 through a resistor inside heat shrink tubing. Work quickly when soldering the wire to that wiper so the heat doesn't loosen it. Because resistor J8 on Switch Unit D is 1 megohm, this resistor value must be high, around 22 megs. That worked until I applied modulation. Then the voltage on Q86's base dropped to almost zero. Worse yet, the AM audio quality was distorted.



I decided to use a solid-state solution to reduce the voltage to Q86. That would provide isolation for the TUNE and CW modes without the voltage drop and poor audio problem caused by the high series resistance.

One way to do that is to string silicon diodes end-to end. In theory, the voltage drop across a series of diodes will be equal to the sum of their individual values. To drop the 3.88 volts down to a volt or less, I could simply create a series string of six 1N4004 silicon diodes, each with a forward voltage drop of 0.507 volts. That works on paper but not in practice. The AM carrier was still 110 watts at carrier position 5 or less. The problem was that the voltage drop across each diode went DOWN as I added more diodes. In the end, I had to create a chain of fourteen 1N4004 diodes to achieve the desired 0.5 to 0.6 volt level shown in the picture below.



That solution worked *PERFECTLY*. The AM power glided up smoothly to 100 watts at Carrier setting 9. A carrier level of 35-40 watts came up at position 6 or 7. But it was too cumbersome.

As a final test, I used twelve 1N4004's in series, wrapped in shrink-wrap tubing, and zip tied to the wire harness. This solution resulted in 100 watts or more AM on all bands, and 35-40 watts came up at position 5 or 6. And the progression was super smooth.

A series string of 2-volt Zener diodes also worked. With a forward voltage of about 0.726 volts, not as many were required, plus they were smaller. Likewise, a single blue LED which had a forward voltage drop of 2.8 volts worked. Unfortunately, neither the Zener diodes nor the LED provided the smooth AM carrier rise that the silicon diodes did. All the above solutions provided the isolation needed so that TUNE and CW modes worked properly. The LED did not light in the above application because the current was too low.

There are lots of other semiconductor devices that could work in this application. The desired forward voltage drop should be 2.8 to 3 volts. If anyone finds a neat solution, send an email to me at w3afc@aol.com and I'll add it to this document, along with the appropriate credit.

Advantages to Option 2:

- Very smooth AM carrier operation
- Provides complete isolation from TUNE and CW modes, so those work perfectly without a switch.
- The voltage at Q86 doesn't drop with modulation, so AM audio quality is excellent for an SSB rig.

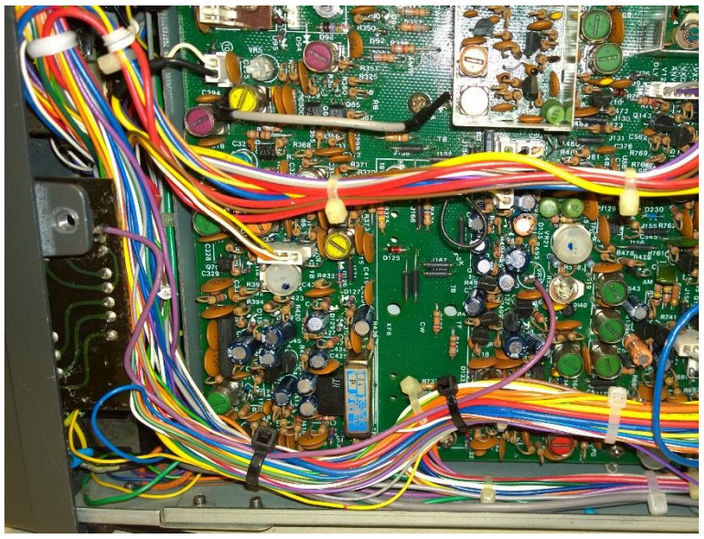
Disadvantages: If you use a string of diodes to drop the voltage to Q86, it can be cumbersome.

Option 3. This concept came from Dave. It departs from the previous two in that the voltage to terminal J1 on Switch Unit D is reduced at Switch Unit A via a pair of resistors, ahead of the diode. I soldered a 100K ohm ½ watt resistor to the AM terminals first. When connected to the diode, that reduced the 18V from the AM Mode terminals to approximately 12 volts at terminal CV. Then I soldered a 22K resistor from the junction of the 100K resistor and the diode to ground. That created a voltage divider that dropped the voltage at CV to about 0.6 volts. Since there was no convenient ground for the 22K resistor on Switch Unit A, I dropped a line down to the VFO board, which doesn't show in the photos below.

STEP 1 – install a 100k Resistor and diode.

STEP 2 – Add a 22K Divider resistor to gnd.

STEP 3: Run a line from the CV terminal on Switch Unit D over to the wiper terminal at the VR22 location, and you're done.



I used a purple wire for the last link since the line from Unit A to D is purple. It's important that the voltage divider is installed ahead of the diode or else TUNE and CW will once again be affected.

This solution provides extremely smooth carrier control all the way up to 95-100 watts on 20M and higher, and about 65 watts on 40M and lower. The recommended level of 35 watts is easy to set. However, in my rig, I found an anomaly. The carrier control on 10 meters is poor. At a Carrier control position of just under 2, the AM output is about 10 watts. At 2, it shoots up to 110 watts. This is probably a quirk with my radio, but I would be interested to know if anyone else has this problem.

Advantages to Option 3:

- Very smooth AM carrier operation
- Provides complete isolation from TUNE and CW modes, so those work perfectly without a switch.
- The voltage at Q86 doesn't change with modulation, so AM audio quality is excellent for an SSB rig.

Disadvantages: The carrier regulation on 10 meters may be poor, but this could be an isolated case with my radio.