ANATOMY OF A WORKING TS-930S POWER AMPLIFIER

Revision 3: 10/25/2020

The purpose of this document is to help HAMs determine whether or not his/her TS-930S RF power amp is in working condition, and if tests indicate that it is not, to provide some guidance with how to find the problem and repair it. The only tools that are needed for the first part of this work are a soldering pen and a decent Digital Multimeter (DMM) with diode test. Other functions such as capacitance, inductance, and/or frequency are useful, but not necessary for repairing the PA. But if you are planning to buy a DMM, get one with frequency also. Most testing here was done with an Amprobe AM-570. The specs say it reads frequency to 20 MHz, but mine reads accurately to 29.500 MHz!

To make things easier, I've broken this down into tests of increasing complexity. **LEVEL 1** tests can be performed with basic tools like a DMM. **LEVEL 2** testing must be performed under signal and power with tools like oscilloscopes or a signal generator. It's for the truly curious or desperate.

Tests 1a & 1b can be performed with your PA securely mounted in your radio with only the top cover removed. Basically you will be testing the Collector-Emitter junctions of all five signal-processing transistors as a group using a DMM set to Diode test and just the PA power input cables. You should see a forward voltage similar to that of a silicon diode with the leads connected one way, and nothing when they are reversed. This is what I refer to throughout this document as a "Diode Relationship". If these tests reveal a short or readings that mimic a bad diode then it's time to remove the PA, warm up your soldering iron, and get to work.

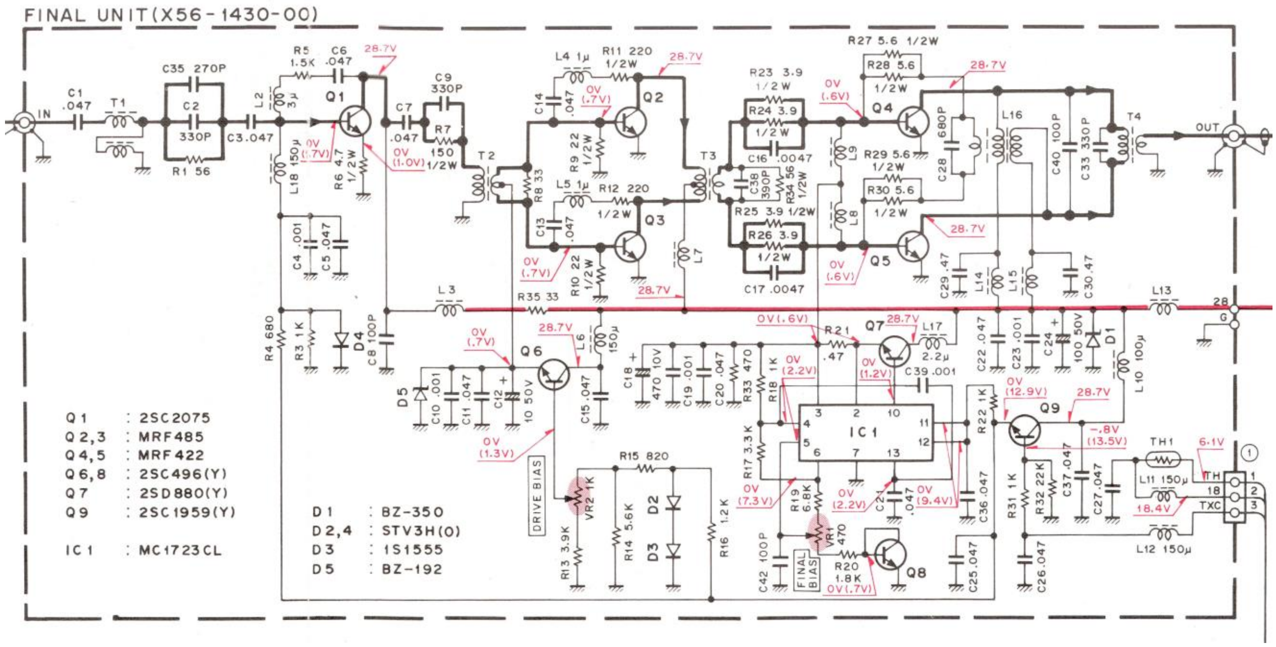
Tests 2a through 5b require removing your PA, but you can perform the tests with the circuit board still attached to the heatsink. These will let you test all five of the signal amplifying transistors Q1 through Q5. If you locate the problem, you can replace the defective part without removing the circuit board.

If after performing tests 1a through 5b your power leads still show a short or low resistance or other anomaly, then you will have to pull the circuit board so that you can isolate some of the transistors in that area that are connected to the main power bus. I've been there. After exhaustive testing on a PA, I still was reading a pure resistance of about 3,500 ohms in both directions across the PA power leads. I removed the board and began the task of removing one end of the RF chokes that feed power to Q6, Q7, and Q9. I didn't have to go far. As soon as I pulled one end of L10 to Q9, the "diode relationship" returned to the main power leads. I replaced Q9 and the PA worked perfectly.

The PA under study in this case will be the basic OEM PA shown below, since this is what most Ops will likely find when they open up their 930S rig and remove the PA.

The famous "Red Dot" Motorola MRF485 driver transistors that you've probably heard about are boxed in yellow. The red dot denotes low current gain, also known as Beta or hFe. These have not been manufactured for years, as they were a special "run" for these radios by Motorola. I'll explain the red circles and squares on the following pages.

Schematically, the 930S "Final Unit" has a 28 volt power bus running right down the middle, marked in red.



Kenwood conveniently arranged the schematic so that the SIGNAL amplification circuitry consisting of Q1, Q2 + Q3, and Q4 + Q5 and their associated components are located above the bus line, and the CONTROL circuitry consisting of Q6, Q7, Q8, Q9, and IC1 are below the bus line. However, it's NOT always arranged that way on the PA circuit board. I list Q2 + Q3 and Q4 + Q5 as pairs because they are arranged in a push-pull configuration.

If any of the major components that are fed from this bus are either shorted or open it will have a major impact on the bus. So, before we remove the PA or unsolder anything, let's run some tests.

LEVEL 1 TESTING (DMM)

1a. Connect the two heavy main power leads from your PA to your DMM so that the black negative PA lead is connected to the positive red DMM probe, and the red PA power lead is connected to the black DMM probe. Switch the DMM on and set it to DIODE TEST. The meter should display a reading that resembles what you would get if you were testing a silicon diode. The reading will vary from PA to PA and various DMM brands show significant differences also. Testing with my "red dot" MRF485 PA, my **JinHan 2012A** Scopemeter reads **0.522V,** my **Amprobe AM-570** DMM reads **0.566V**, my, my **Beckman 27XT** says it's **0.570V**, and my **AstroAI WH5000a** claims it's **0.583V**. The more expensive Amprobe and Beckman meters almost agree, which supports the industry claim that there's a correlation between cost and accuracy.

WHAT YOU ARE READING: You will notice from the schematic that all of the transistors are NPN, so what you are seeing is the aggregate forward voltage of the Collector-Emitter (C-E) junctions of Q1, and the Q2/Q3 and Q4/Q5 pairs. The meter is reading those through various inductors, but their impact is minor. Q6, Q7, and Q9 in the Control section will also have some impact.

1b. NOW, reverse your leads so that the black DMM lead is connected to the black PA lead, and the red goes to the red lead. Your meter should read either "OL" (Over Limit) or something high, like 2.8 – 3.0 volts.

WHAT YOU ARE READING: The reverse voltage through all those C-E transistor junctions. It should be infinity or "OL", but sometimes you will see a reading. One of my spare PA's reads 2.8V, which indicates either a leaky junction somewhere, or a leaky capacitor, yet that PA still works well.

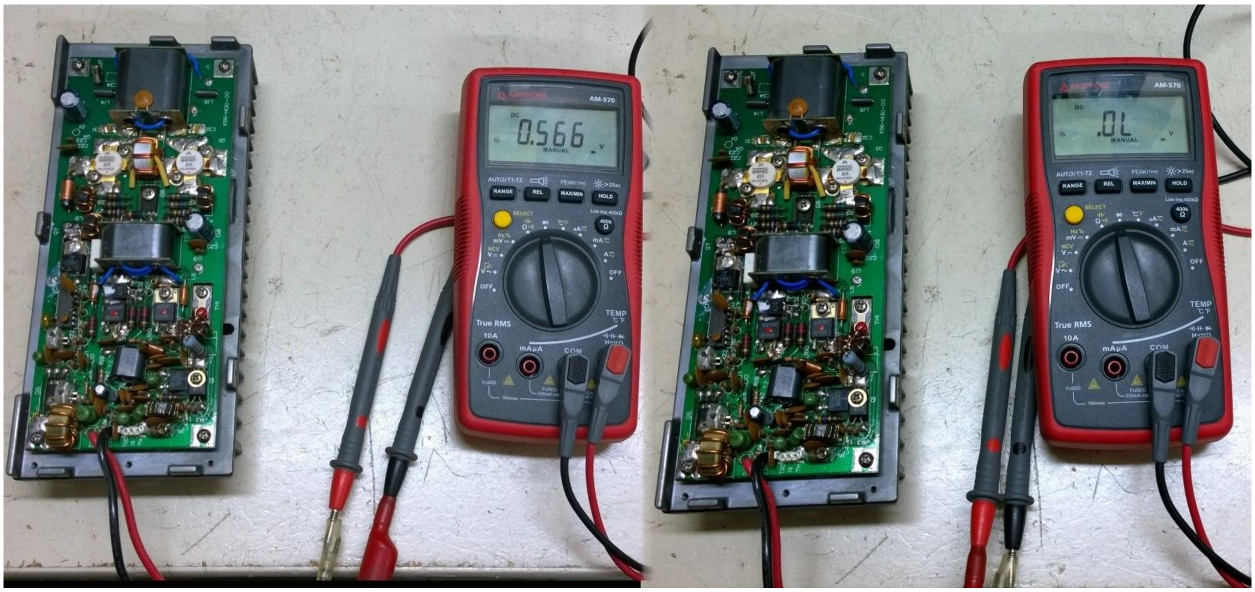
NOTE 1: If you've rebuilt your PA using Options 2 or 4, the reverse reading may differ due to the influence of the 12-volt MC78T12 voltage regulator, and/or the use of 2SC1969 drivers. I've conducted the above tests with Power Amps that I rebuilt using Options 2 and 4, and the readings are shown on the next page.

NOTE 2: I recently purchased an OEM "Red Dot" PA that showed a reverse voltage of 0.939 volts, yet that PA worked perfectly, with a clean waveform. More can be found in "Case Histories" at the end of this paper.

IF YOUR ABOVE READINGS SEEM REASONABLE, proceed to 2a through 2c. Or, if you are not sure if the problem is in your PA or your Signal Unit, go to the tests shown in the Appendix.

IF YOU GET A VERY LOW READING EITHER WAY, OR A DEAD SHORT, then Zener Diode **D1** may be shorted. Its location is shown in the photo on page 1 as the larger of the two red circles. If you're planning to replace your original power supply with a Quint or other modern power supply, you won't need D1. Cut it. It's possible to do this with the PA still in the radio, but it's easier to remove it. If the short disappears, but your readings are still off, your PA is probably damaged. I would also test Zener Diode **D5** (smaller red circle) because if an over-voltage causes D1 to short, D5 almost ALWAYS goes with it. If after cutting D1 your readings are still off, try cutting D5 also.

If your readings from 1a through 1c are still low or show a short after cutting D1 and D5, then you can skip directly to Steps 2a thru 2d. The pictures below show some of the testing described above.



MY READINGS FOR OPTIONS 2 AND 4: Here are the test readings from my Options 2 & 4 power amps.

OPTION 2: 12-volt regulator with medium-gain MRF485's. Diode: Forward = 0.572V Reverse = 2.712V

OPTION 4: 12-volt regulator with 2SC1969's: Diode: Forward = 0.542V Reverse = 1.610V

If your PA shows readings similar to those described in step 1, but the PA is still not producing power, then one or both of the drivers may be open, so we need to move on to that area of the PA. If the drivers are open instead of shorted, you might see a diode relationship, except the forward voltage will usually be higher – 0.625 or more.

One way to test a transistor is to test it with your DMM as a pair of back-to-back diodes. For the NPN transistors in this PA, that means placing the positive lead from your DMM on the BASE of each driver, and then placing the negative lead on the COLLECTOR tab. You should see a forward voltage for each test of 0.575 to 0.625 for each, and nothing in the opposite direction. If you get a high B-C reading on one of the drivers, then that driver is probably damaged.

Normally, you could also test the Base-Emitter junctions, but RF transformer T2 and resistor R6 present a near short from each BASE to the grounded EMITTERS. So, the only way to test the B-E junctions of the drivers is to carefully unsolder and lift one of the leads so that you can do the test.

Before you do that however, there's a simpler and easier test that you can perform to estimate the condition of your drivers by testing the C-E junctions.

Look at the photo of the PA on Page 1, and the Schematic on Page 2. Note that the drivers are fed by a line from the main 28V bus that passes through an RF choke, L7. That choke, and the solder joint that you will be unsoldering, is shown in the square red boxes in the photo of the PA.

The bus connection for L7 is just a wire that is soldered down to the square "pad" that feeds 28 volts to Q7. It's MUCH easier to melt that solder and lift the end of L7 up from that pad and test the drivers than to unsolder your bases. Yes, you will only be testing the C-E junctions of the drivers and not the B-E or B-C junctions. But if the C-E junction of either driver is shorted or leaky, this test will reveal that.

2a. Set your DMM to Diode Test and connect the positive lead to the ground. The heatsink will work, or you can use the black PA power lead. Then touch the negative DMM lead to wire end of L7. You should read a forward voltage, just like you would with a silicon diode. My red dot drivers showed a reading of 0.590.

2b. Now Reverse the leads. You should get nothing – an OL reading.

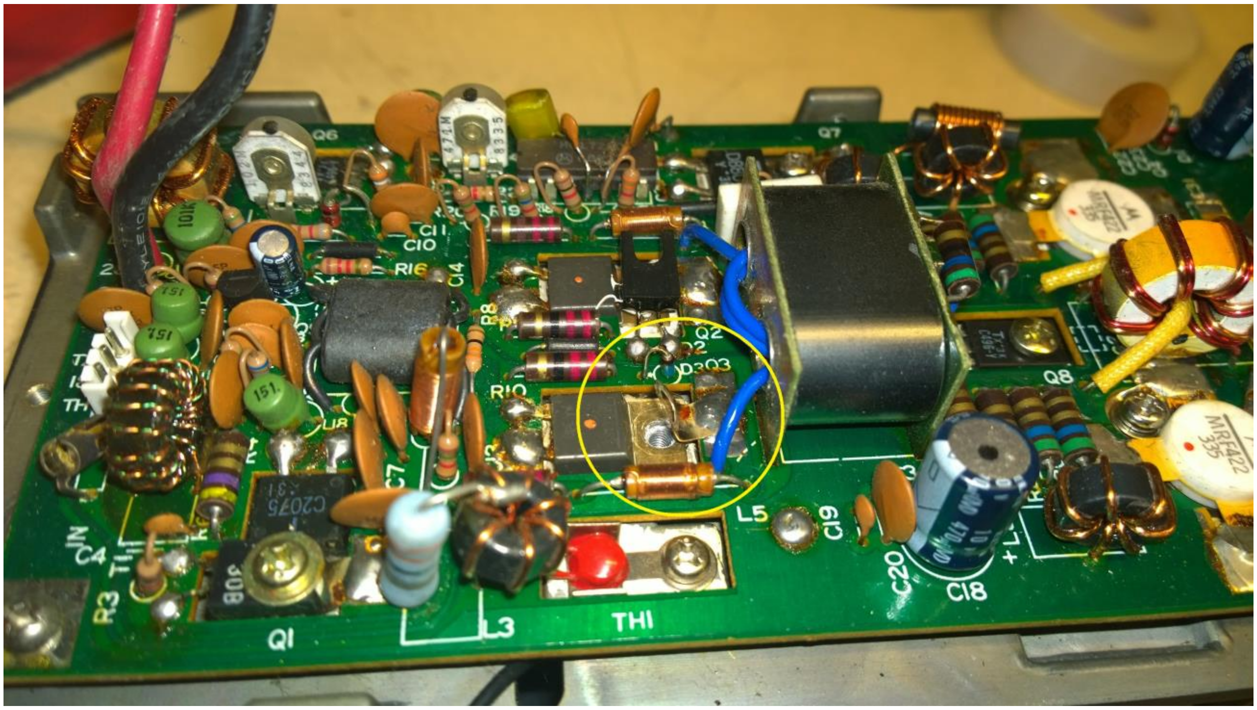
If you get something other than what you see, especially a reverse voltage (or a low resistance) then you have one or more bad drivers. I've NEVER seen a driver with just a bad Base-Emitter or Base-Collector junction. The Collector-Emitter is also bad – it either shows a low resistance in each direction, or it's completely open. Sometimes Q2 is open, while Q3 is good in the forward direction with leakage in the reverse.

An easy way to isolate the drivers individually is to remove the tab screw for Q3 and measure the C-E junction of Q3 alone. It easier to test Q3 because that tab isn't under a gob of thermal grease and a thermistor.

3a. Lift the metal contact of Q3 away from the tab. Put the red lead from your DMM (set to Diode test) on the base and the black lead to the Collector tab. Be sure to just touch the driver tab and not the metal contact shown on the next page (circled in yellow). Now reverse the leads. The readings should look like the ones seen in tests 2a and 2b.

3b. Now re-do the L7 test. With Q3 out of the circuit, you'll be testing Q2 by itself. Again, your readings should look like those seen in 2a and 2b. If you show a low voltage in both directions, Q2 is bad.

If both drivers test bad, then you might as well buy a matched pair of new drivers. The drivers you pick will be decided by which repair option you select.



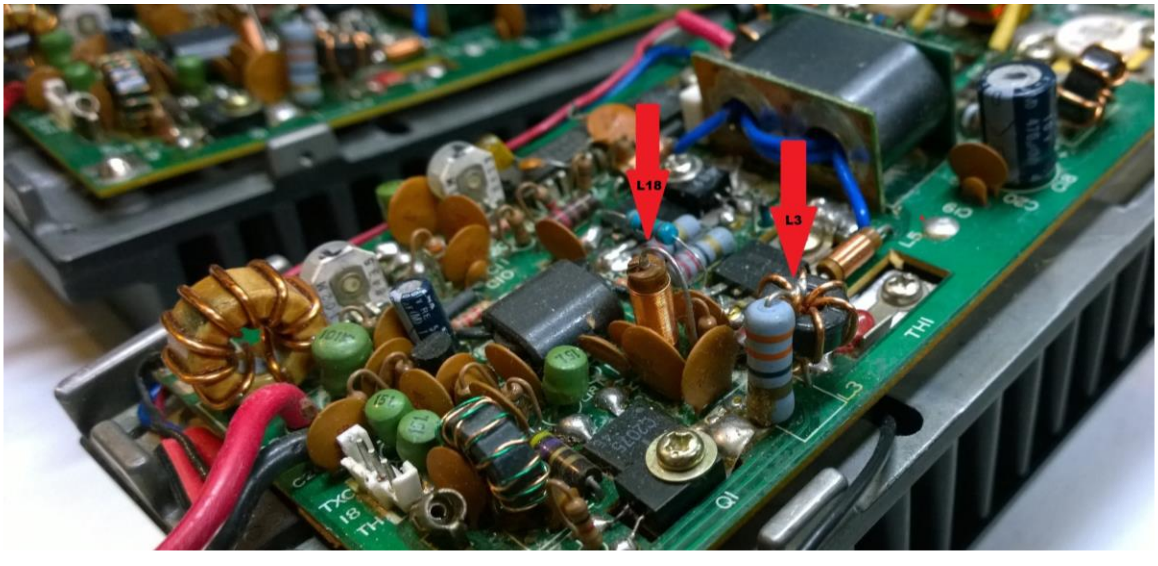
IMPORTANT: Even with the drivers removed, your PA should pass tests 1a and 1b, but with a higher forward voltage - around 0.630. The reverse will be still be zero, or OL. The reason for the higher forward voltage is that you will have one less pair of C-E junctions in the mix. If you remove your drivers, and this test shows a low resistance in either direction, or the same reading each way, then you have a problem elsewhere in the PA. You MUST find out why BEFORE you install new drivers.

If your PA appears to pass all of the above tests but it still does not produce output, then you may have an issue with one of the control circuits or your signal board. I would try the tests outlined in the Appendix before removing more parts from your PA.

FIRST AMPLIFIER - Q1 TESTS

I've never encountered a bad first amplifier transistor (Q1) but if your drivers don't appear to be the problem, it's best to test Q1 before you move on to the Finals or the bias control circuits.

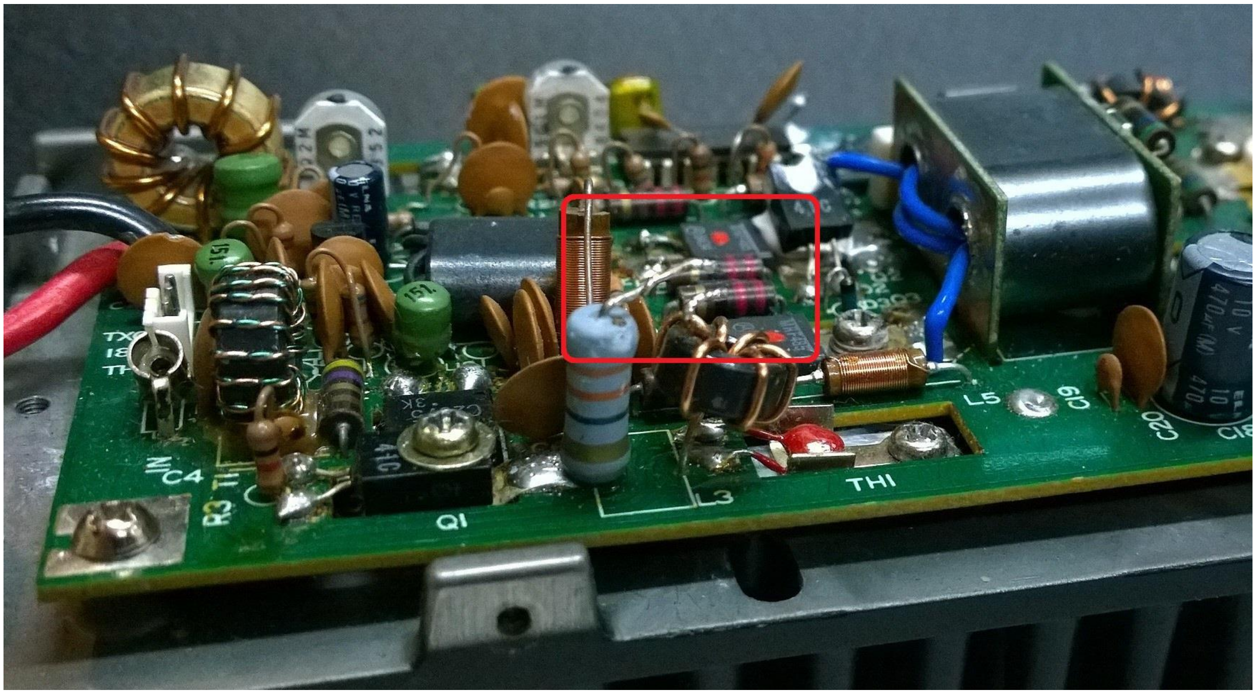
Q1 has a pair of convenient test points - the two RF choke "towers" that flank it. The towers are shown below. The one on the left is the top of L18 which is on the BASE side of Q1. The other is L3, which connects to the COLLECTOR. These are very convenient test points, especially if you decide to trace a signal through your PA with a Scope.



4a. Set your DMM to the OHMS scale. Connect the black meter lead to the black ground lead to the PA, or the heatsink. Touch the red lead of your meter to the top of L18 and note the reading. It should read 800-900 ohms.

4b. Set your DMM to DIODE test. Put the red meter lead on the top of L18, and the black lead to the top of L3. You should get a diode reading of about 0.625 to 0.650V. Now reverse the leads. You should see what you read in step 2a, which should be "OL". In the case of my "leaky" PA, I get 2.80V.

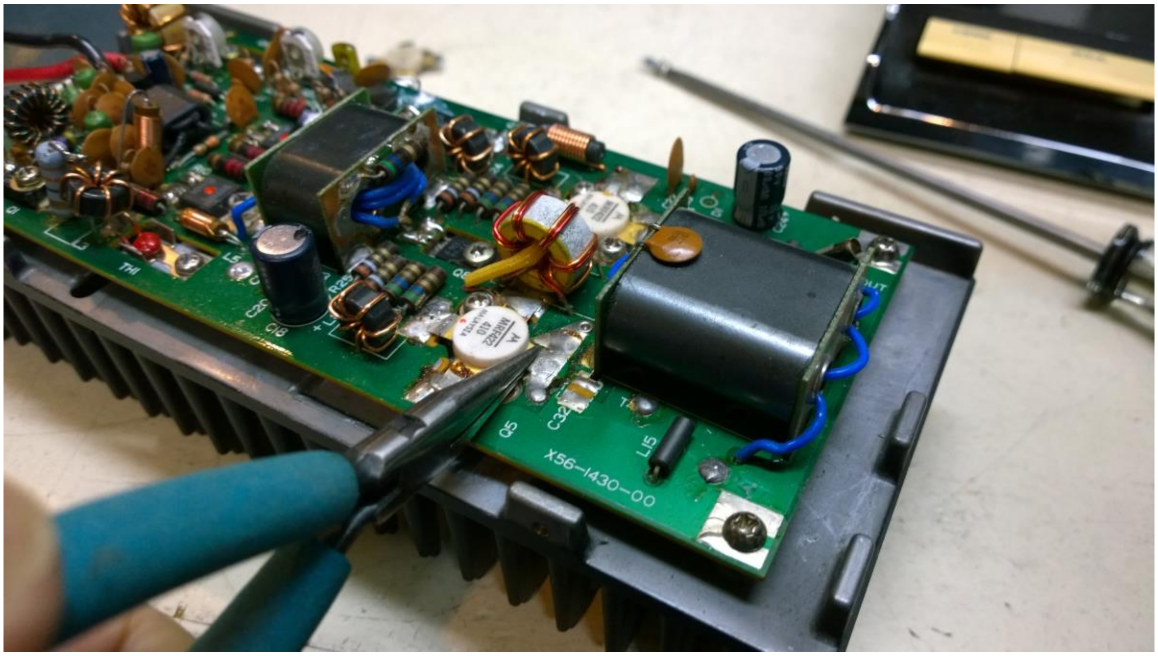
If your DMM shows a short or low resistance, it could be caused by a short elsewhere along the main bus. To be sure, disconnect L3 from the main bus. This will isolate the first RF amplifier Q1 from the bus. L3 is connected to 3-watt resistor R35 through a simple wrap and solder connection. The best way to undo it is to grip the end of the twisted section with a pair of pliers, heat the joint until the solder melts, and twist the wires in the opposite direction of the wrap so that you end up with what you see below. Solder wick helps here.



Now repeat 4a and 4b. If Q1 tests good, the problem must be either in the Final Output stage (Q4 & Q5), or the CONTROL circuitry. Reconnect L3 before putting your PA back in service.

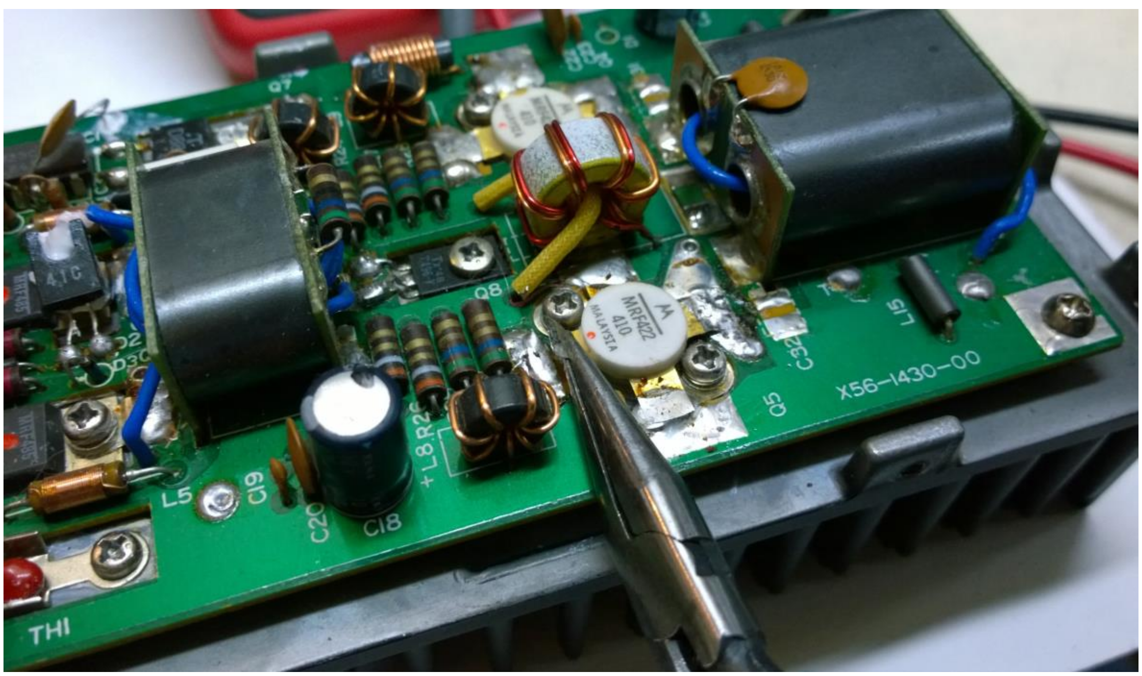
The Final Amplifier "pills"

The only way to isolate the MRF422 Collectors from the board is to unsolder one end of both L14 and L15, OR by lifting up both Collector tabs. Unsoldering L14 and L15 requires removing the PA board from the heatsink, whereas lifting the collector tabs does not. I like to use fine tip needle-nose pliers for this job. Removing the adjacent mounting screw makes this easier.



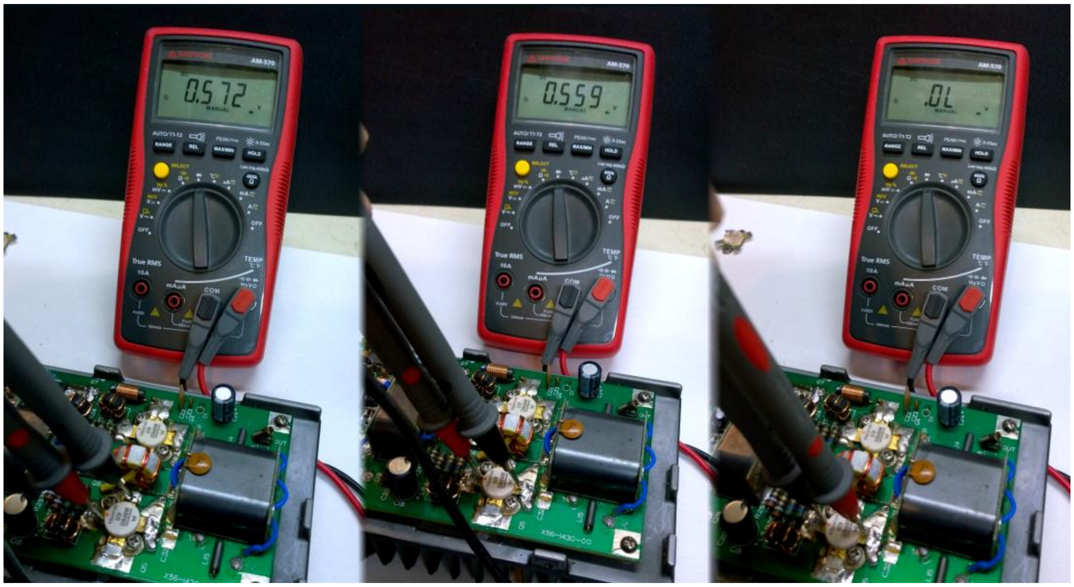
If lifting the Collector tabs causes the readings across the PA power leads to return to normal, then one or both of the Finals are leaky or shorted. If only one IS bad and you have a spare with the same color dot, then you might be able to replace just the bad final. I would use a transistor analyzer like a Peak DCA55 to make sure their gains are close. If they aren't, replace both as a pair.

If this test fails to identify the problem, then it's time to lift the Base tabs. Push on to 5a & 5b. Again, the needle-nose pliers are a big help as shown below, plus they protect the transistor from heat.



5a. Set your DMM to Diode Test. Put the red DMM lead on the Base tab, as shown below. Then touch the black meter lead to the Emitter and then the Collector tab. You should see a forward voltage for each, just like a diode. If you see nothing (OL), then that junction is open and that Final is bad.

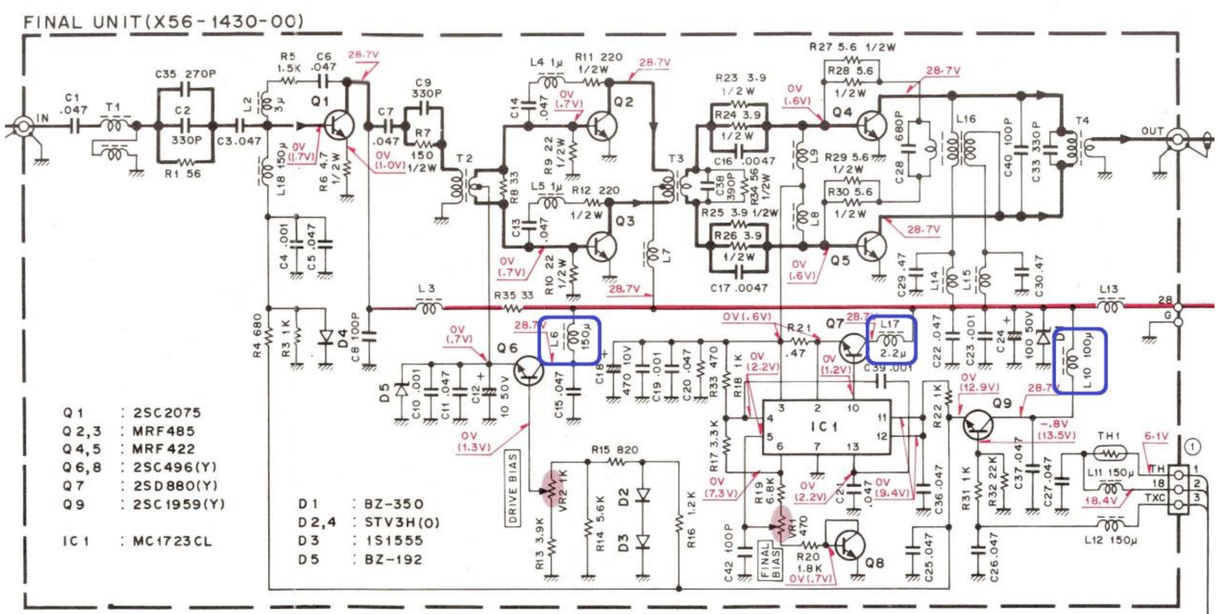
5b. Now reverse the leads so that the black lead is on the Base. You should see "Over Limit" when you touch the Emitter and/or the Collector. If you get a reading, that Final is bad.



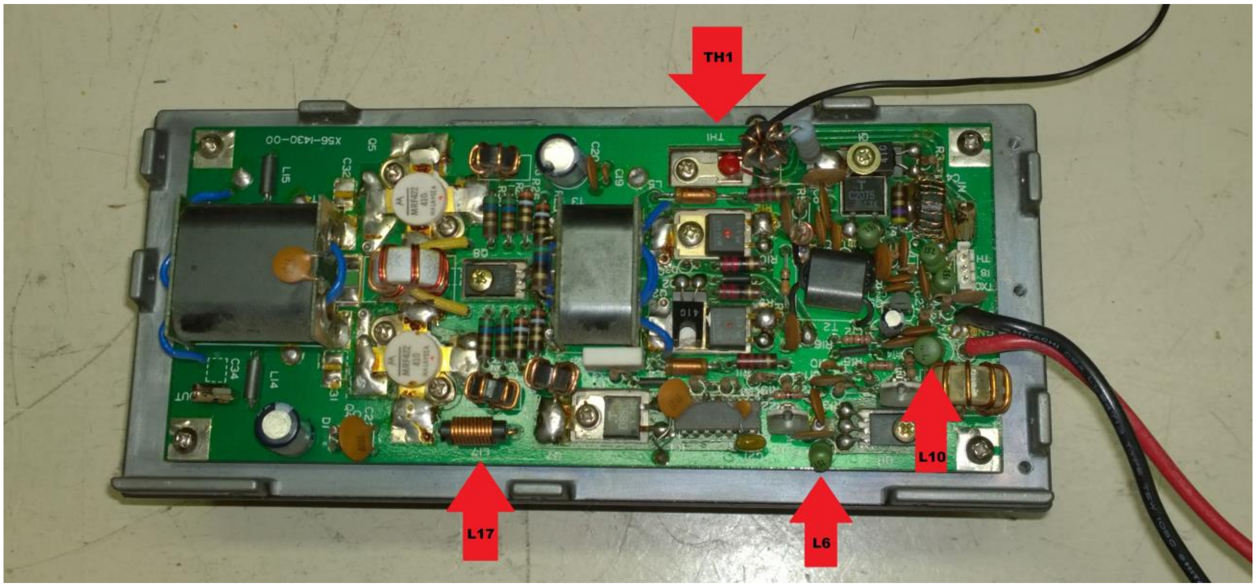
PA Drive and Bias Control Circuits

If all of the above tests don't identify the problem, then it's time to check the control circuits that constitute the "lower half" of the schematic. This will require removing the board from the heatsink. This isn't difficult; you just have to keep track of which screws went where, and where the mica insulators must go. I've taken photos that will help, and they are posted at the end of the APPENDIX.

The fastest way to isolate where the fault lies is to remove one end of each choke that connects each transistor stage to the PA bus. I've reinserted the PA schematic here with the pertinent chokes boxed in dark blue, along with a photo of the PA with the three chokes identified by red arrows.



The chokes are L6, L17, and L10. The only control circuit part that I've ever found to be bad while repairing PA's was Q9: A 2SC1959(Y). It was shorted, which dragged down the bus. Q9 is located right next to the PA main power leads. If you look at the schematic you will see that the base and collector of Q8 are shorted together, which essentially turns this transistor into a diode. TH1 is referenced in the Signal Unit control circuit tests in the Appendix.



If you still have a short or low resistance across along the main bus/power leads after testing all of the transistors in the PA, then you will have to perform what I refer to as a “board sweep”. I start at one end, usually near the power leads, and test each resistor and capacitor for a fault. Test electrolytic capacitors C24, C18, and C12 first. I’ve never actually seen a shorted capacitor in a 930S PA, but anything is possible. This is a tedious, last-ditch process.

I’ve never encountered a bad voltage regulator IC (IC1), but if yours proves to be bad, they are available online for about $5. The voltages are marked on the schematic above, but some owners may want pin-by-pin diode test readings, so I will include them here at a later date. If anyone needs them, please send an email to w3afc@aol.com

LEVEL 2 TESTING

If you have an oscilloscope at your disposal, then testing your PA is quick and easy. The photo below shows the PA with the test points identified by numbers, which correspond to Scope waveforms on the following pages.

Basically, there are 10 amplifier circuit signal test points:

1	Top of RF choke "tower" L18 – signal input to Q1 from the signal unit
2	Top of RF choke "tower" L3 – signal output from T1 to the drivers
3 & 4	The base tab of each driver
5 & 6	The collector tab of each driver
7 & 8	The base tabs to each final
9 & 10	The collector tab of each Final

Reading the waveform at the bases of Q2 & Q3 can be risky. If you're concerned about doing it (probe slip, short, etc), then go right to the collector tabs. If there's no signal there, but you see the appropriate RF volts at the top of L3, then you might want to test for the signal at the driver bases.

The chart below shows typical RF voltages that you will see with your scope with the rig set at 14.175 MHz, in TUNE mode, and with the Carrier control at or over position 5. These are VERY approximate. They depend on the output from your Signal Unit, differences in various PA components, and a whole host of other things including the waveform peak at the moment your camera fired.

TEST POINT(S)	SIGNAL	**EXPECTED P-P RF OUTPUT**
1	Input to Q1	**Between 0.2-0.3 RF volts (200-300 mV)**
2	Output from Q1	**Between 1 & 1.5 RF volts**
3 & 4	Bases of Q2/Q3	**Between 2 & 2.5 RF volts**
5 & 6	Collector tabs of Q2/Q3	**Between 5 & 8 RF volts**
7 & 8	Base tabs of Q4/Q5	**Between 2 & 4 RF volts**
9 & 10	**Collector tabs of Q4/Q5**	**Between 24.5 & 29.5 RF volts**

The lower RF voltages at the bases of each successive stage is caused by the inter-stage components, such as the Transformers and negative feedback loops.

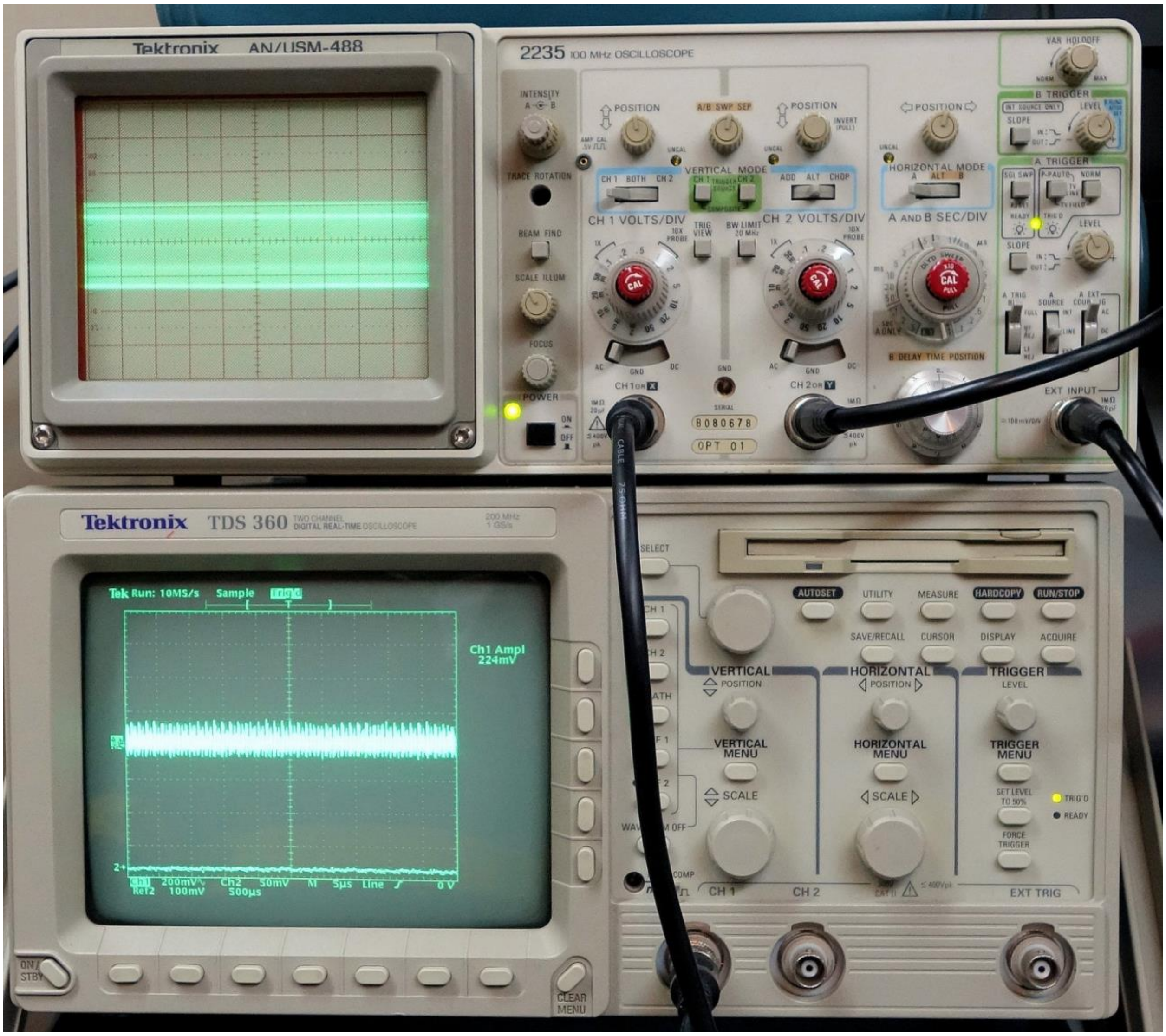
TYPICAL SCOPE PATTERNS

The Scope patterns on the following pages are typical of what you might see with an analog or digital scope. The digital scope on the bottom displays the peak voltage to the right of the display. Yours may look quite different depending on your scope, your PA, your probes, etc. Some pictures show significant harmonics, but at the output the waveform is smooth.

These were taken in TUNE mode with the Carrier control set at full. **Don't** leave the Send switch on continuously during testing or you may damage the Finals. During SSB voice mode, the RF peak values at the collectors of Q4 & Q5 can reach 40 volts or more.

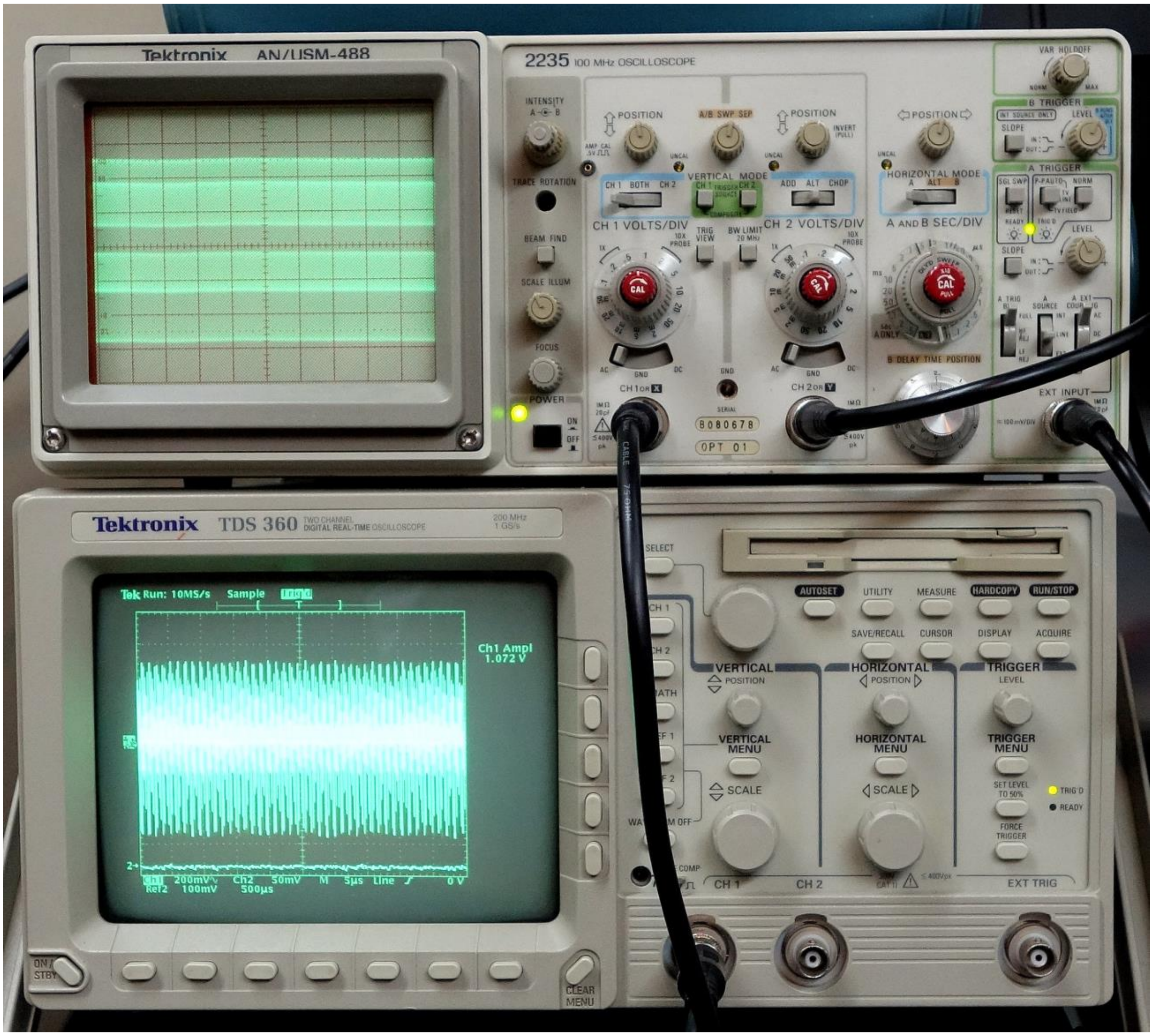
Base of Q1/Top of L18

SCOPE SETTINGS: VERTICAL: **200** Mv/Div (0.20V/div) HORIZONTAL: 5 *u*s/div



<u>Collector of Q1/Top of L3</u>

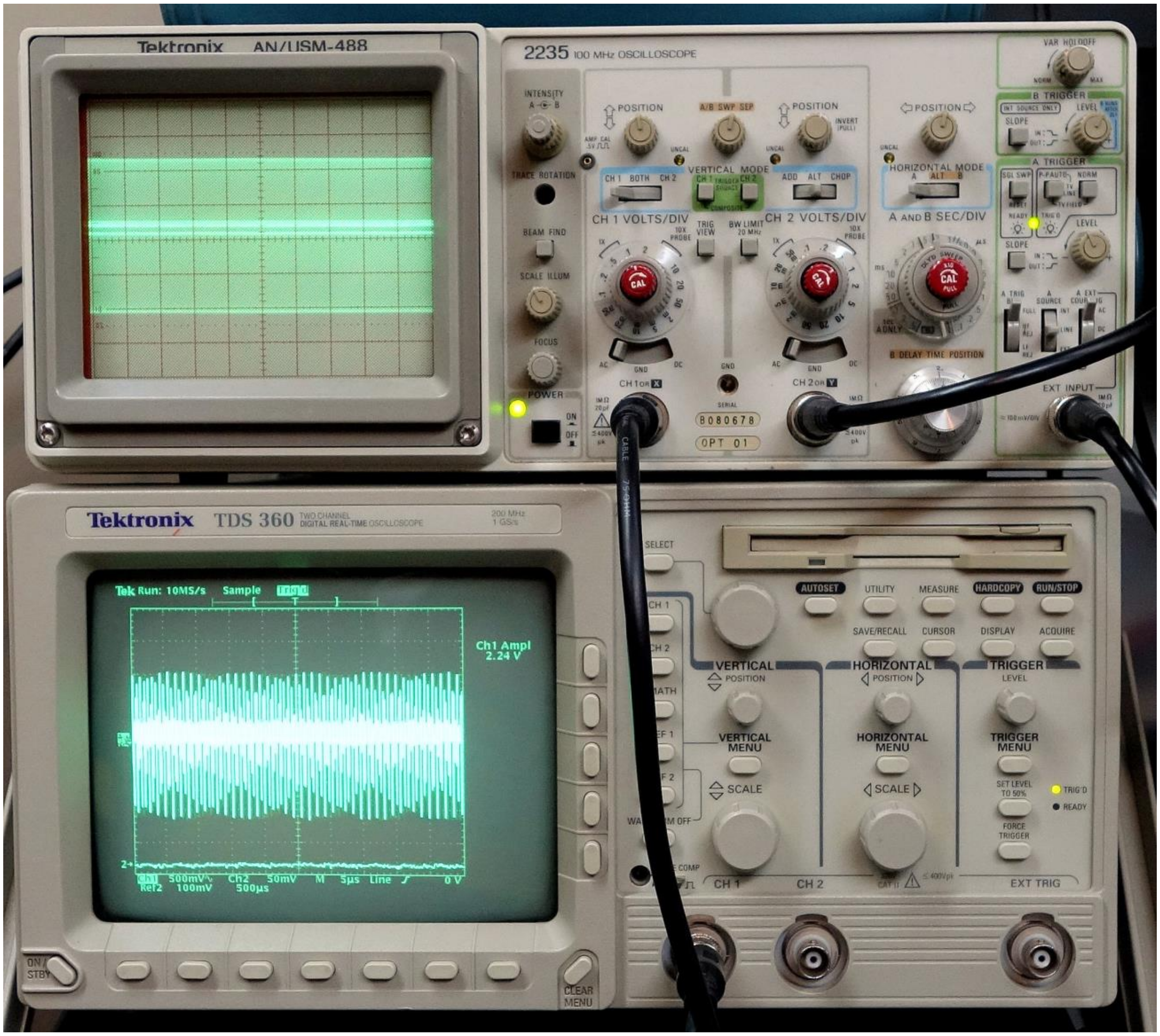
SCOPE SETTINGS: VERTICAL: **200** Mv/Div (0.20V/div) HORIZONTAL: 5 *u*s/div



Base of Q2

Be careful when testing the bases of Q2 & Q3. A probe slip can spell disaster. I turned the rig off, attached a scope J-clip probe, made sure the probe was not shorting to the heatsink, and then turned the rig back on.

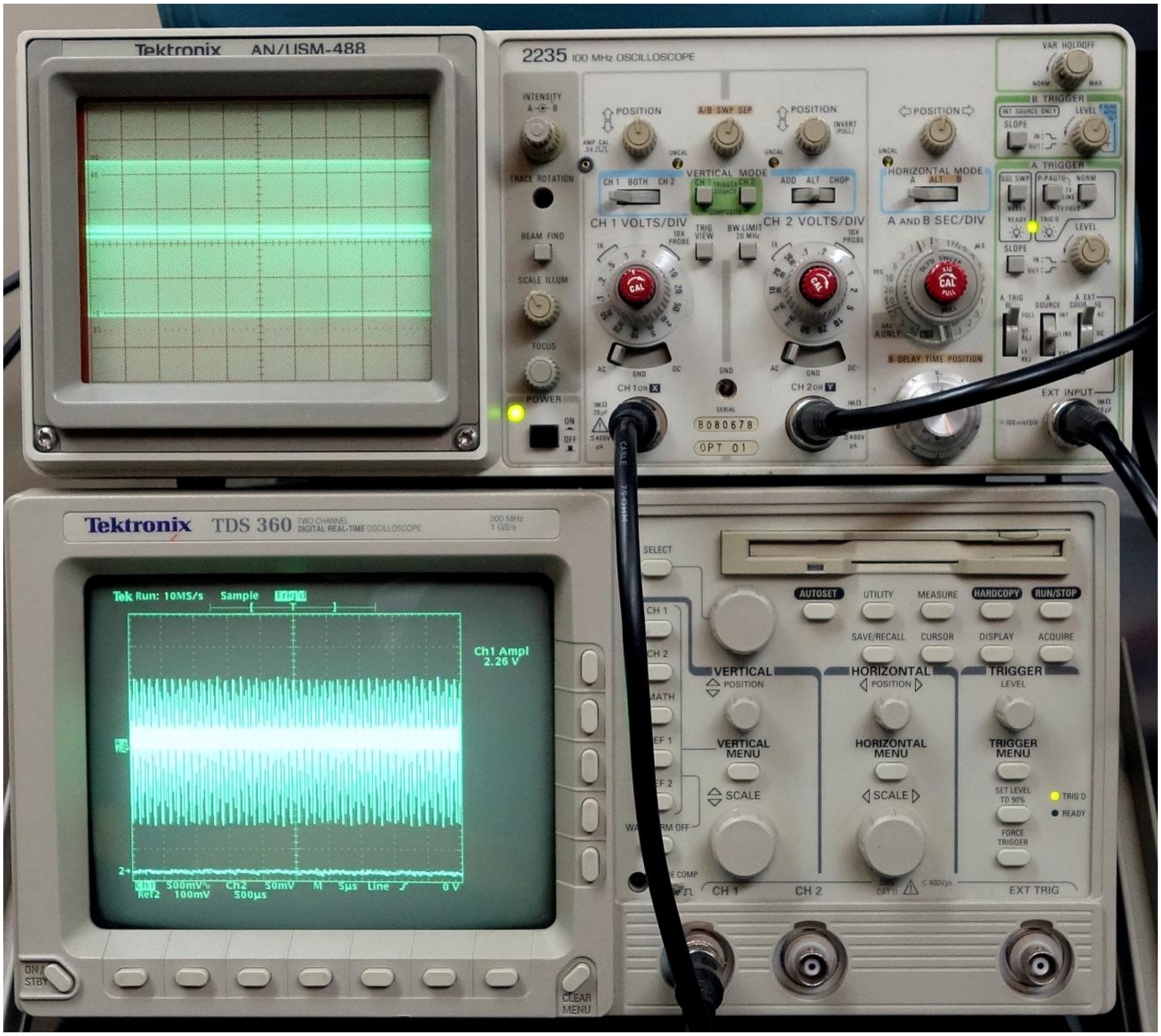
SCOPE SETTINGS: VERTICAL: **500** Mv/Div (0.500V/div) HORIZONTAL: 5 *u*s/div



Base of Q3

It's not uncommon for the amplitudes to be very different here, but these are very close. Note the difference in the digital waveforms.

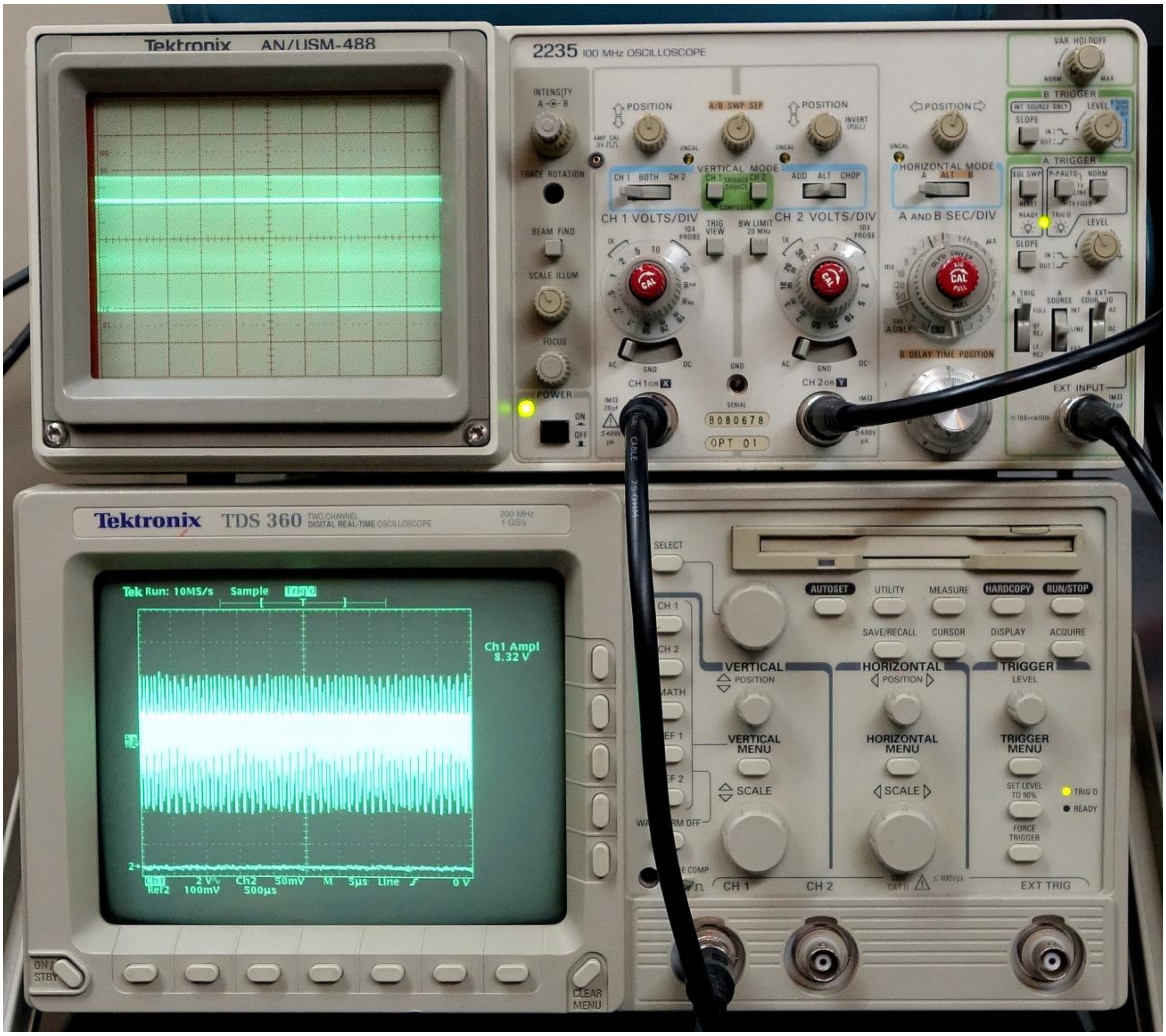
SCOPE SETTINGS: VERTICAL: **500** Mv/Div (0.500V/div) HORIZONTAL: 5 *u*s/div



Collector of Q2

Note the change of scale here. The signal level increases dramatically.

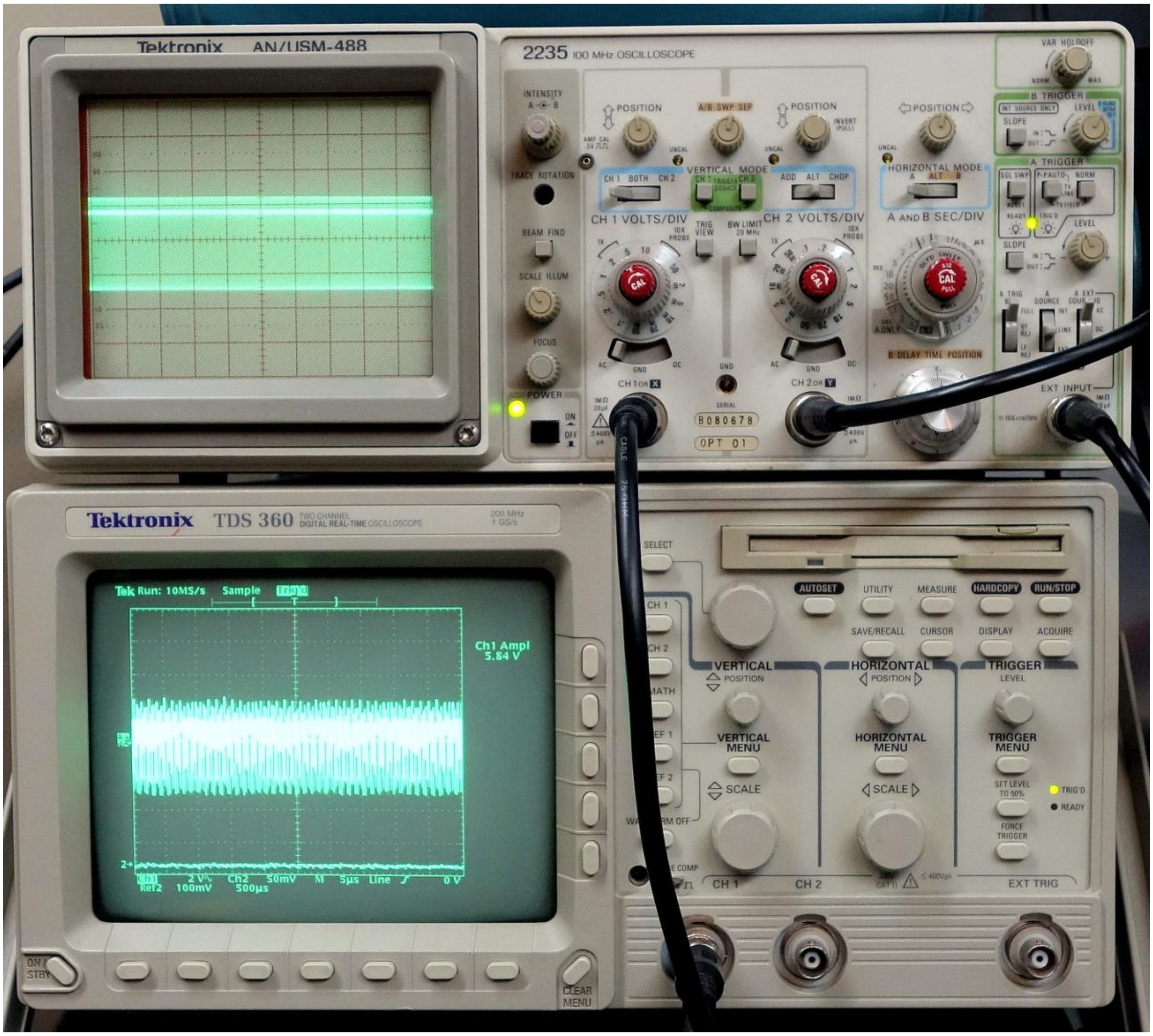
SCOPE SETTINGS: VERTICAL: **2volts**/Div HORIZONTAL: 5 *us*/div



Collector of Q3

Note the difference from Q2. This is common. Sometimes Q2 is smaller, and sometimes they are reversed.

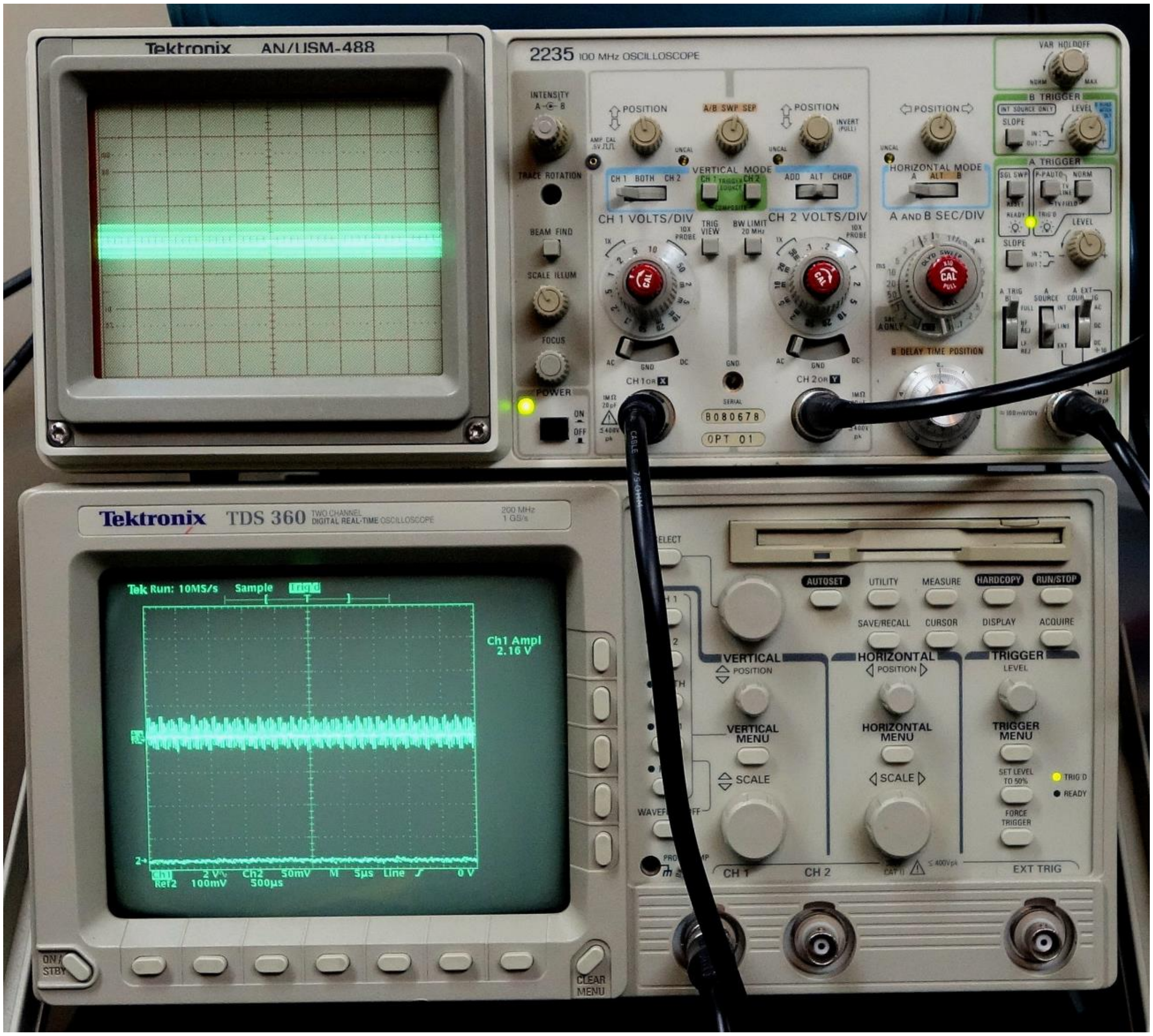
SCOPE SETTINGS: VERTICAL: **2volts**/Div HORIZONTAL: 5 *us*/div



<u>**Base of Q4**</u>

The signal level to the bases of Q4 & Q5 is lower due to transformer T3, negative feedback, and circuitry designed to balance the upper and lower wave halves. I retained the 2V/div scale to show the increase when we test the collectors.

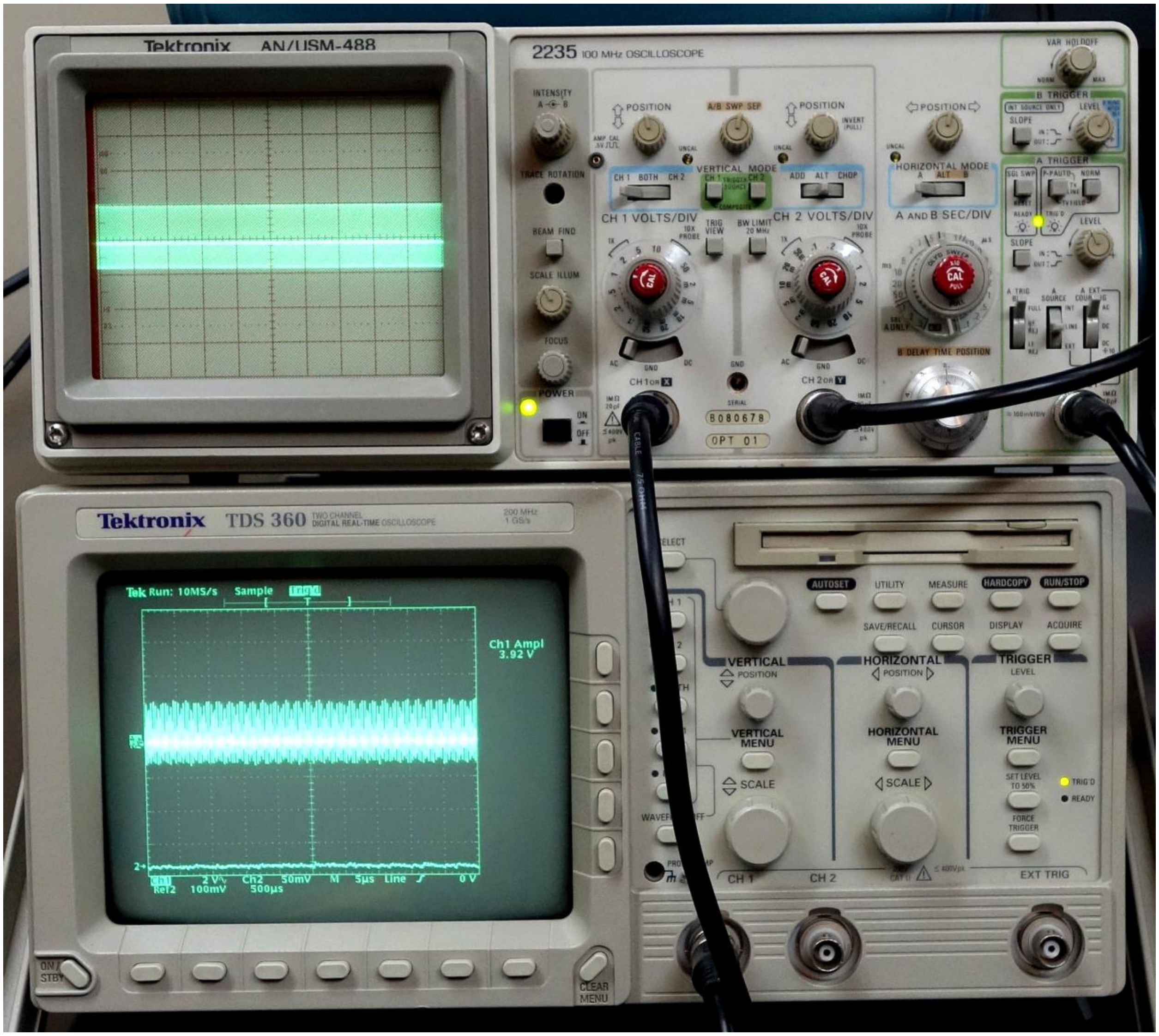
SCOPE SETTINGS: VERTICAL: **2volts**/Div HORIZONTAL: 5 *us*/div



Base of Q5

Note the difference in voltage between Q4 & Q5. This is not abnormal.

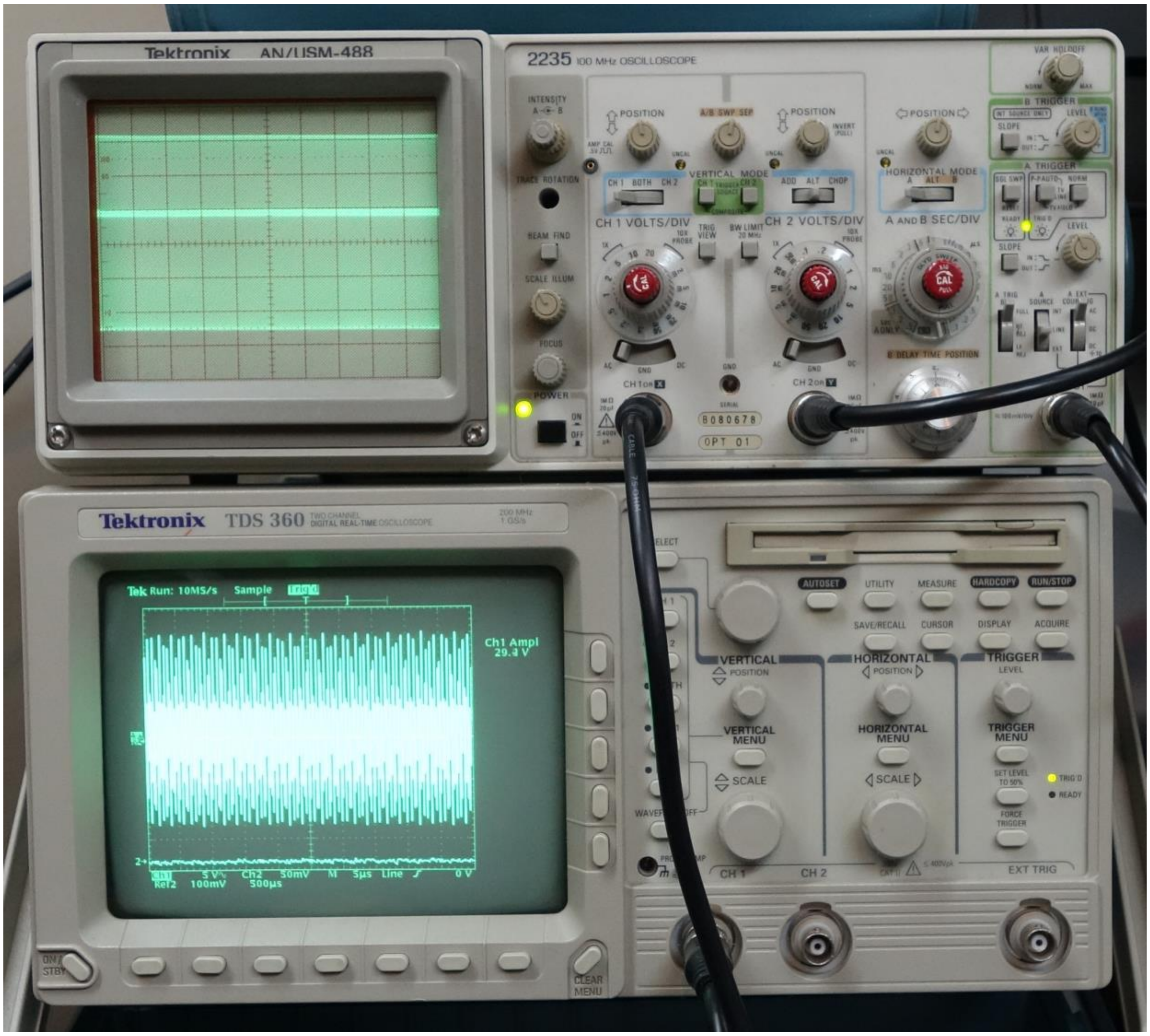
SCOPE SETTINGS: VERTICAL: **2volts**/Div HORIZONTAL: 5 *us*/div



Collector of Q4

A dramatic increase in output. Note the increase in the vertical scale. 28-29.5V is typical here.

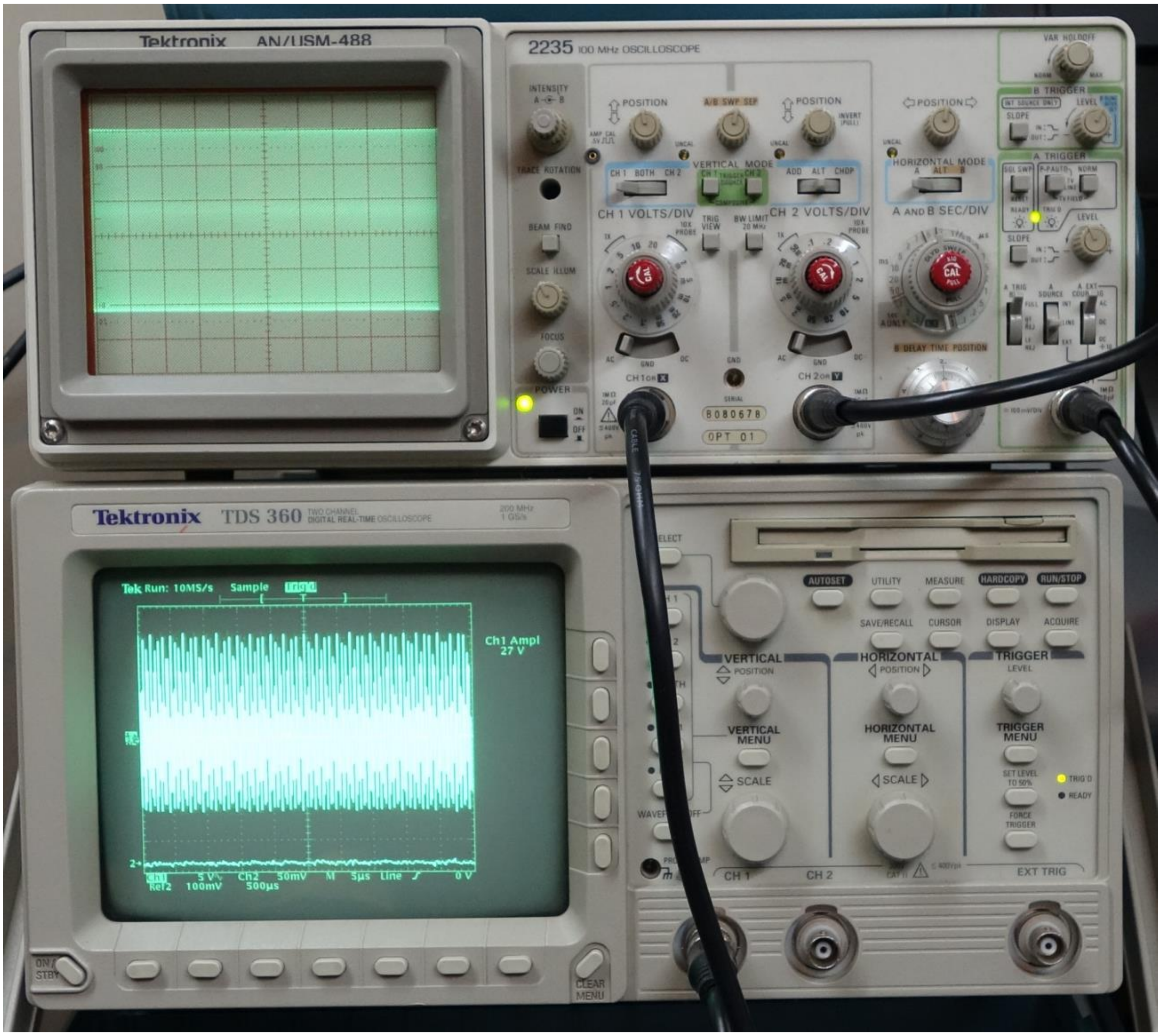
SCOPE SETTINGS: VERTICAL: **5volts**/Div HORIZONTAL: 5 *u*s/div



Collector of Q5

A dramatic increase in output. Note the increase in the vertical scale. 26-29.5V is typical here for TUNE mode. Your PA might show a higher output here than on the collector of Q4. I haven't noticed any set pattern. The important thing is that your PA shows a large signal on both collectors. If one is very low (5 RF volts, etc) then you have a bad final.

SCOPE SETTINGS: VERTICAL: **5volts**/Div HORIZONTAL: 5 *u*s/div



APPENDIX

TRANSMITTER CONTROL CIRCUIT TESTS

If your PA seems to test "good", you might want to check some of the PA control circuits to make sure one of those isn't the source of the problem before you tear the PA apart. Any one of these can make your rig appear lifeless.

Transceiver Control Circuit (TXC)

The three-pin connector next to the PA power cables is for the transceiver control line. The center pin is 18 volts in, and it feeds that voltage through thermistor TH1 on the PA back to the Low Pass Filter (LPF) via the TH line. You can test this circuit with the 3-pin connector unplugged from the PA, which will prevent any output. Also, you can leave the carrier control at zero, but all voltages must be measured in SEND mode. The thermistor can be measured with the radio powered off.

1. If that thermistor fails, the LPF will shut down the PA. The cold resistance of the thermistor can be read with a simple ohmmeter. <u>You should see 14,000 to 15,000 ohms across the center pin and the one marked TH.</u>
2. The center pin should have 17.5-18 volts to ground on it with the rig in SEND mode. If it doesn't, the PA will appear to be dead.
3. The TXC line supplies 16 volts to the base of Q9 in the PA. Measure the voltage between that TXC pin and ground at the 3-pin cable to the PA. If you don't have 15.5-16 volts on that pin (red wire) when you hit "send" the PA won't work.

VSF/VSR ALC Control Line

The VSF/VSR ALC line comes from the far right side of the LPF when viewed from the rear. It's a 4-pin plug with only two wires. The LPF board has the letters VSF VSR silkscreened on it. This line controls the gain or output of the PA. A fault in this line or a problem in the LPF can shut down the signal unit's drive to your PA completely.

1. With your rig powered off, pull that plug.
2. Put the radio in TUNE mode and SLOWLY bring in some carrier. If the LPF is the source of your "no output" problem, the power will shoot right up. Be careful because the power can go up to 150 watts without that plug connected, which could damage your PA.

Current Control (ICA/ICB) Circuit

The other system that can shut off your PA is the Current Control (ICA/ICB) circuit. There are two wires from those two small green inductors on your AVR board that run down to a circuit on the signal board. If that circuit senses excessive current draw (whether it's really happening or not), it kills the signal drive to your PA. If one of those green inductors goes bad, the PA may appear dead. The white and brown wires from that connector carry two slightly different voltages down to the signal unit to a plug marked ICA/ICB.

1. Again with the power off, unplug the 3-pin connector from the side of the AVR board (grey-white-brown wires). As an alternate, you can unplug the two-pin connector from the signal board instead.
2. Put the radio in TUNE mode and SLOWLY bring in some carrier. If this circuit is the culprit, your power should be restored.

SIGNAL UNIT OUTPUT TESTS

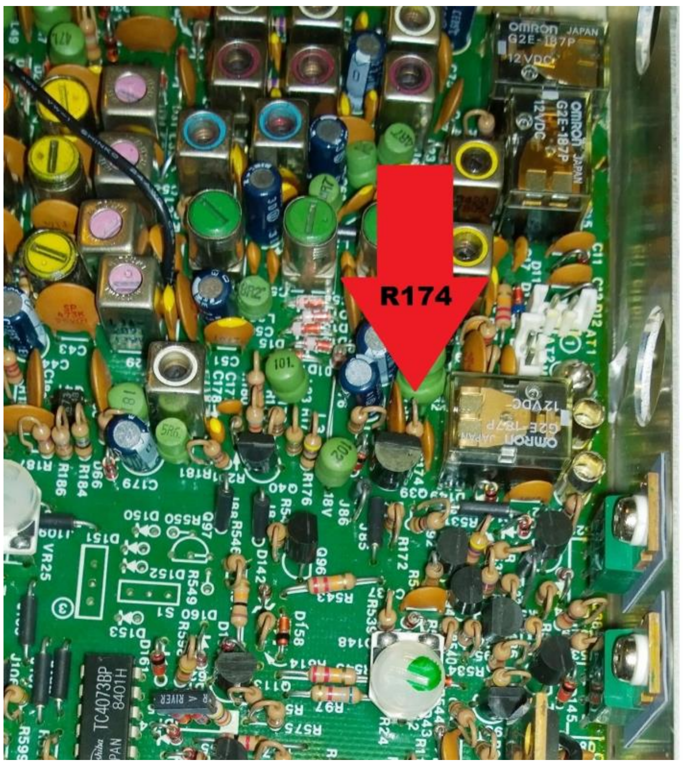
If you lack test equipment like an oscilloscope, frequency counter, or RF probe, you can still see if your Signal Unit is putting out RF using a couple tricks. One is with a DMM that has the ability to measure frequency. The other is to make a "quick & dirty" One-Minute RF probe, using only a diode and a capacitor.

DMM: A meter that measures up to 20MHz is ideal, but if yours only reads to 5 or 10 MHz you can still use it. You just have to use a lower band. If yours measures to 10MHz, then use 40M, maybe around 7.2 MHz.

<u>Basically you have two options</u>: You can connect the leads from your meter to the cable that feeds RF into the PA, or you can put the rig up on its side and connect to the wire part of resistor R174, which is just to the left of relay RL-3 next to the DRV/XTR output terminals. I would try the RF cable first. If you don't get a signal there, then check at R174 to make sure RL-3 hasn't failed.

Connect your leads to the end of the RF cable to the PA input as shown below. Just don't bend the little center pin. The cable shown below is black instead of gray because I replaced the original with a longer one that I made.

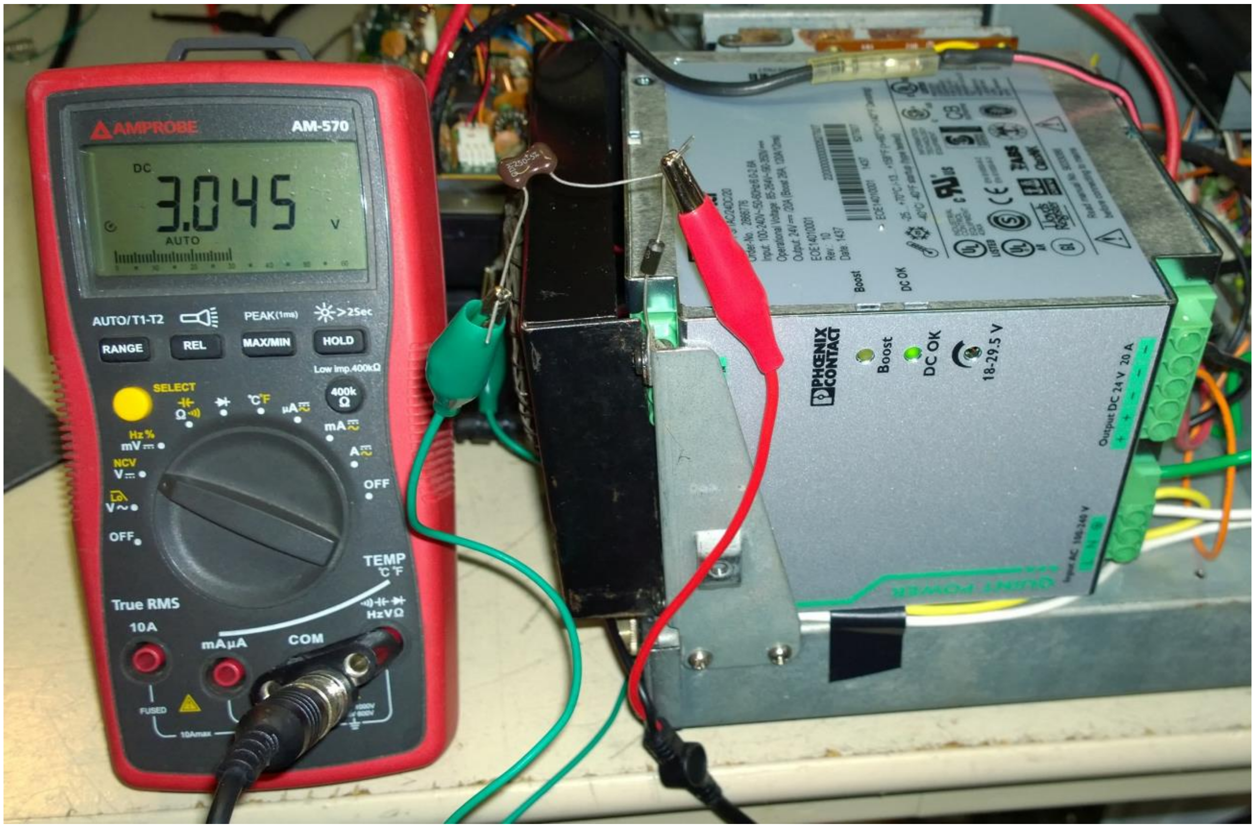
The same test is shown below, but using R174 with my rig set at 14.200 MHz. I've connected a scope probe here, but a J-hook works too. To use the resistor, you will have to scrape some paint from the wire lead shown above (arrow).



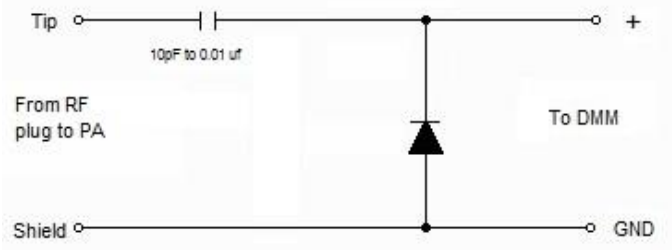
Be careful not to rock R174 back and forth as you remove the paint or you may loosen it. I would use an Exacto knife or something similar and work slowly, shaving in the direction of the wire.

TEST: Set your rig to TUNE with the CARRIER control at zero. Push the SEND button and slowly turn the CARRIER control clockwise. If your Signal Unit is working properly your meter should display the frequency by the time your control is at the 4 or 5 position. Before you are fully clockwise, it certainly should be. If it's not, carefully check your connections. Try it both ways if necessary. Most DMMs require between 0.250 and 0.400 RF volts to produce a frequency reading, which will produce a power output from a working PA of 35-55 watts.

One-Minute RF probe: If you have some diodes lying around your shack and a non-electrolytic capacitor, you can literally make a “one-minute” RF probe. I won’t be as accurate as a commercially-made one, but it will do in a pinch.



The little apparatus shown above is just a silicon diode, combined with a non-polarized capacitor. I used a 250pF. A germanium diode works well too if you have that. The anode end of the diode is simply pinned between the fan housing and the rig’s frame, and the capacitor is hooked to the center pin of the RF plug with a jumper cable. The red alligator clip lead goes to the meter plus terminal, and the black is clipped to the RF cable barrel just like it was in the previous test. Set your DMM to DC volts. At full TUNE, the meter shows a little over 3 RF volts. By contrast, my meter with a Fluke 85 RF probe shows 2.6 RF volts, but the Fluke 85 uses Germanium diodes and it’s calibrated. As you back down the Carrier control, you will see the voltage drop down all the way to zero. Here’s the schematic:



It’s crude, but it gets the job done. If you see nothing with this little setup, the problem is probably in your signal unit.

The mica insulator and screw locations.

The driver mounting screws have nylon shoulder washers on them like Q7. They're not shown in the photos.