A Collins S-Line Troubleshooting and Repair Adventure

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In October 2011 I obtained a Collins S-Line station from a friend and fellow ham in San Antonio (K5JWK – Gary). It was a winged emblem 32S-1 transmitter, 75S-1 receiver, and a 516F-2 power supply. They are early serial number units, so they were likely built over 50+ years ago (probably in 1958-59). While in the USAF, I had the opportunity to operate many Collin KWM-2s and S-Line stations, but never owned or worked on any. This was an opportunity I had always wanted to pursue.

Gary let me take them for a few days to inspect them before I committed to the purchase. A very nice offer on his part and it only took me a few hours to decide I wanted to get these units back on the air and we finalized the sale/purchase.

An Adventure Begins Neither the transmitter, receiver, or the power supply was working properly when I got them but they were all marginally functional to some degree or another. They were also very clean from a cosmetic perspective. *(note: Gary disclosed all issues and I bought these units knowing some degree of repair would be required – **there is no buyer's remorse here nor should any be inferred** – also it should be noted, Gary had obtained these items from an estate and hadn't made any extensive effort to repair them – some of the problems described later were the result of the owner(s) previous to Gary)*

The following is a brief summary of the troubleshooting and repairs necessary to bring this equipment back into operations. Hopefully this will serve as encouragement for others to undertake a similar repair and/or restoration project.

75S-1 Receiver While the receiver came alive, the S-Meter was not reading anything except on very high power signals (such as the 100 kHz calibrator), the S-Meter was also erratic, and the receiver was somewhat anemic and noisy. I concluded that the repair of the receiver was going to be minimal. Setting the receiver aside for a bit, I turned my attention to the transmitter and power supply.

32S-1 Transmitter and 516F-2 Power Supply The transmitter would not develop any drive, except on 40 meters, and the output power, in tune, was only 10 Watts or so on 40 meters. Clearly the transmitter and its associated power supply had some issues.

After working with the transmitter for a few days trying all the usual things (checking voltages, changing tubes, cleaning switch contacts, etc.) it appeared that someone had attempted to align the transmitter in the past. This was evident by the different height of the slugs in the band switch rack and some different coloring on the threaded stems of these slugs. I broke out my oscilloscope and signal generator and started to go thru the manual's signal tracing procedure that injects calibrated signal levels into each stage to look for proper drive and output power.

This confirmed that I could tune the driver and finals and get upwards of 40 Watts on all bands. However, going back to the 455 KHz first IF stage and the 3055 kHz IF I could not get any drive by injecting a signal from my signal generator. This pointed to a bad second mixer.

Checking all of the resistances in the second mixer confirmed the operating point of the 2nd mixer should be within a normal operating range. However, the voltages on the 2nd mixer did not agree with the voltages in the manual (low 3055 kHz 2nd IF injection voltage).

At this point I broke one of my cardinal repair rules. I decided to align the 455 KHz and 3055 KHz intermediate frequency (IF) stages in an attempt to get sufficient 2nd mixer injection. It is generally not a good idea to attempt realignment unless absolutely necessary.

Both stages appeared to be aligned, however I still was not getting proper injection into the 2nd mixer. On 4 November, in utter frustration, I gave the 3055 KHz IF can (T1) slugs some arbitrary turns while monitoring the 3055 KHz signal at the input to the second mixer (V5). Initially the signal dropped but as I continued turning the slug the signal amplitude increased on the oscilloscope. *(Note: there was a false, but minor, peak in the 3055 KHz IF can that someone had evidently found previously and which I also found in my first alignment pass of the IF stages. I also later identified that this false peak occurs in the 75S-1 receiver (the receiver uses a similar IF scheme as the transmitter, but in the case of the receiver it was on the proper peak).* This was a major ***Ah-Ha!*** moment since from that point on I was able to complete the alignment properly and get drive and power (up to 50 Watts) on all bands. More on the low power problem later, but here are a few lessons learned:

- Ensure you have the latest manual – manuals can be downloaded for free from the Collins Collector Association (CCA) website: http://www.collinsradio.org/archives/Collins_Radio_Equipment_Manuals.aspx. In my case I had been using the original equipment manual. However, a later manual, along with all service bulletins provided better procedures for performing alignment and troubleshooting.
- Carefully inspect the radio for modifications and repairs. As part of this visual inspection it was obvious some slug twiddling had been done in the past. This was the nudge that allowed me to break a cardinal rule of repair (i.e., something that is broke usually doesn't benefit from a realignment and in fact can serve to mask a bad component making the repair even more difficult).
- Mixers are good check points for troubleshooting a heterodyne circuit – I'd suggest using a combination of verifying resistor values around the mixer and then ensuring that voltages (both DC and RF injection signals and RF output signals) are proper as a start. *(note: In this case it was easy to verify proper resistances, yet the DC and RF voltages (injection and output) were out of agreement with the manual – poor output from the mixer plus weak 2nd IF injection pointed to a problem in the IF stages prior to the 2nd mixer)*
- Ask for help. I received a lot of help from the CCA members. Notably pointing me away from my original manual to the latest one posted on the website.

Low Power – Power Creep – Plate Meter Accuracy After getting drive and power on all bands, the three remaining problems in the 32S-1were:

1. a slow rise in transmitter power,
2. only 50 Watts output instead of a nominal 95 – 120 Watts (band dependent), and
3. almost 300 ma of indicated plate current to get anywhere close to 50 Watts of output power.

This last problem was suspected to be a plate current metering issue, and, while it was an issue I wanted to correct, it was temporarily set aside to troubleshoot the first two problems. Suspecting the choke in the power supply, a substitution was made with a known good 516F-2 power supply from my friend Skip, W5BMK. That substitution confirmed normal power output could be achieved.

Back to the 75S-1 Receiver There were three micro-phonic tubes, a bad S-Meter pot as well as some bad electrolytic and paper capacitors. These were all quickly replaced and after confirming nominal performance, the receiver was realigned. This was close to the middle of November, and because Thanksgiving Holiday season was looming, not a lot of effort was put on the 516F-2 power supply which was determined to be the unit causing the low power and power creep problems.

Power Supply Revisited In early Dec 2011 some time was spent looking at the low and creeping power. It eventually turned out these were two independent problems.

The Low Power Problem Carefully (safely) measuring the HV, I discovered that the no-load to load high voltage (HV) voltage dropped considerably (from about 800 VDC to 400 VDC). I was back suspecting the choke in the power supply. *(note: the voltages in this power supply are lethal – I always used a 'chicken stick' to ensure the capacitors were discharged and used clip-on test leads to my voltmeter so my hands would not accidentally come in contact with these lethal voltages)*

One day, after reconnecting the choke leads (disconnected to do testing on the choke), one of the plate leads to the 5R4 was found not to be connected. The lead was held in place to the sockets terminal by the wire's plastic covering, but the stranded conductors underneath the covering had broken at some point in the past. This caused the power supply to only be getting half cycle rectification instead of full wave rectification. Once fixed, the power from the 32S-1 transmitter developed full power, although it continued to display power creep (it would take 3-5 seconds to develop full power). (*note: I had observed power creep of this nature in other transmitters with defective tubes in the finals – I had previously pulled a set of known good 6146s from another transmitter and confirmed to myself that the 6146s were not the cause of this problem)*

The Power Creep Problem Continuing to suspect a bad choke, I engaged a few CCA members and bought another power supply along with a matching speaker cabinet. My logic was it would be cheaper that way than trying to just acquire a new choke and the old power supply would be a good source of parts. *(note: the Collins 516F-2 power supply uses a resonant choke and capacitor in the HV circuit that has been extensively described elsewhere – since my symptoms were in alignment with this known*

systemic 516F-2 failure mode, it certainly shaped my thinking and resulted in a lot of wasted troubleshooting time)

When the second power supply arrived its 5R4 HV rectifier would arc internally and blow the fuse. *(note: This arcing is another known systemic problem with the 516F-2 power supply and has been discussed in a Collins service bulletin along with a recommendation to replace the 5R4 with a solid state rectifier. I elected to keep the 5R4 as I wanted my Collins S-Line to be in as close a condition as possible to that as when it came off the assembly line.*)

Replacing the arcing HV rectifier with other 5R4s I had on hand resulted in the same problem; except with one tube, the one from the initial power supply. With power established at 100 + Watts, it was further discovered under testing that the power creep was intermittent regardless of which power supply I used. It would manifest itself at times (maybe 80% of the time, but not always).

About this time I did more research on the power supply and obtained specified load and no-load voltage levels. My measured voltages agreed with information obtained from the internet. I now felt that the filter chokes (L1) and resonant capacitors (C1) in both power supplies were functioning properly. I was now beginning to suspect a component in the 32S-1 driver or final section and turned my attention away from the power supplies. This was a bad mistake on my part. (*note: since it had worked properly on Skip's power supply I should have continued to focus on the power supply as being a source of the creeping power*)

Plate Current Measurement Accuracy Between 2 to 8 January 2012 several hours were spent testing the components in the final section to try to identify the power creep problem.

All this time was not a wasted effort as the cause of the plate current inaccuracy in the meter readings was identified. The six 12 Ohm resistors (R44-46 and R49-51) in the final cathode circuit had aged to between 16-23 Ohms causing a high plate current reading when in reality the plate current was much less. All resistors were replaced with 10 Ohm new old stock (NOS) resistors that had aged to between 11.5 to 12 Ohms. With ~4 ma of grid drive and 200 ma plate current I obtained ~115 Watts output into dummy load on 7.1 MHz. Loading and tuning seemed normal except for the lingering power creep gremlin.

Power Creep Solved On 8 January 2012 I reviewed all of my troubleshooting and repair notes and discovered a common thread among the testing and troubleshooting I had overlooked before. A 5R4 that didn't exhibit any arcing had been used (shared back and forth) between the two power supplies. Another search of all of my available 5R4s uncovered one that wouldn't arc. When this 5R4 was used, the power creep gremlin went away. This was proved by fairly extensive bench testing into a dummy load on 8 and 9 January. Finally – closure on my last major problem.

Cleanup Neutralization, carrier balance, ALC adjustment, etc. were accomplished in short order as well as a good cleaning of the cabinets and chassis of the transmitter and the receiver.

Some More Lessons Learned This might be a time to recap some other lessons learned along the way:

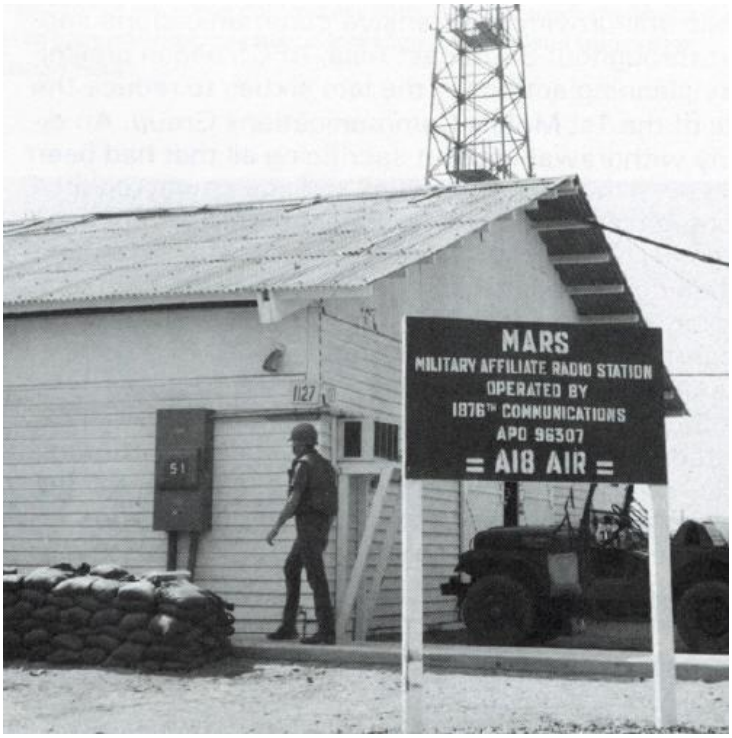
- Don't trust your tube tester – the defective 5R4 that caused the power creep tested good – certainly well enough to be within expectations of previous readings on other 5R4s I had tested
- Trust your tube tester – the defective 5R4 had some different readings for the two tube sections. It also seemed to have some erratic behavior that I had discounted as a dirty pin which cleared up when I reseated the tube in the socket
- Don't let known failure modes and associated symptoms adversely color your thinking. I made the mistake of letting the resonant choke/capacitor failure mode shape my thinking, even though testing of these components in both power supplies indicated they were ok.
- Keep good notes during the repair process – the review of my notes finally got me on track to try another 5R4 to eventually crack the power creep issue.
- Take more voltage readings – a lot of my problems might have been solved faster if I'd taken more and better voltage readings earlier in the troubleshooting process of the power supply. HV load and no-load voltage readings and their comparison with power supply specifications on the internet (http://www.wa3key.com/516f2.html) enabled me to confirm the resonant filtering circuits in both power supplies were operating properly.

Epilogue On 9 January 2012 cables were fabricated from RG-58 to allow the 32S-1 and 75S-1 to work together as a transceiver. On 10 January 2012 contacts were made on 40 Meters LSB. The first contact was with a local station (W5ALI – Bruce). Two other contacts were soon made with stations in Arkansas: (KA5RHK – Ken (who I chat with frequently on AM), and WX5J – Nick). Good audio reports were obtained and the S-Line performed flawlessly producing about 125 Watts of peak output power as measured on my Palstar antenna tuner's peak power meter.

As I gain experience with my S-Line I'm sure there will be other tweaks and adjustments to be made, but that is the nature of operating equipment that is over 50 years old. Following is a picture of my handsome S-Line station made shortly after my second contact was finished.

I'm extremely happy with my S-Line station and look forward to using it. I'd again like to thank Gary (K5JWK) for his parting with it and providing me with this opportunity to bring it back to an operational status and for his words of encouragement along this journey. The troubleshooting and repair of this S-Line has been an adventure that has had many twists and turns. But the result was certainly worth the effort and along the way I've gained a much better appreciation for how these units work.

As I use my S-Line station I'll be thinking of past amateur radio operators such as Senator Barry Goldwater (K7UGA-SK), Gen Curtis LeMay (K0GRL-SK), Art Collins (W0CXX-SK), and the many others for whom the Collins equipment was in their station line-up. I'll also remember the phone patches made from Vietnam to my wife in Austin, TX made using a Collins S-Line from the MARS station at the Tan Son Nhut AFB, Saigon, RVN in 1969 to 1970.



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