By Jan Skirrow

The Collins CU-168/FRR Antenna Multicoupler

Radio collectors often want to connect a number of receivers to a single antenna. Switches provide one solution, but can become cumbersome as the numbers increase. More problematic, serious shortwave listeners often want to operate more than one radio simultaneously from a single antenna.

Passive signal splitters, such as those used to connect two or more televisions to the same cable connection, are not satisfactory due to the substantial losses involved. Also, receivers operating simultaneously can interfere with each other if there isn't adequate isolation between their antenna connections.

Photo 1 - Front view of the Collins CU-168/FRR antenna multicoupler

There has been growing interest recently in active multicouplers. These can provide good isolation between receivers and minimize signal loss. Unfortunately, these devices seem rare on the surplus market. Most are solid-state, but I recently bought what was advertised as a government rebuilt Collins CU-168/FRR vacuum-tube antenna multicoupler in its original packaging. It was built for the US Navy and able to connect up to five receivers to one antenna. The seller claimed that this unit was used with the R-390/URR and R-390A/URR receivers. Although skeptical of both claims, I had to have one, if only because it was a vacuum-tube boatanchor in the grand tradition! I was also curious to see how Collins had tackled the design problems unique to this kind of equipment, and interested in comparing its performance to a solid-state multicoupler of more recent vintage.

The CU-168/FRR turned out to be pretty much as advertised. It was a rebuild but, unfortunately, at some point early on holes had been made in the protective wrapping and some kind of oily grit had settled on what was probably only partially cured paint. The unit was packed with its front panel down, so this sticky stuff settled largely on the rear. Most of it cleaned off, but the power transformer and choke were left with a bad rash!

Photo 2 - Rear view of the CU-168/FRR

The multicoupler consists of a main chassis that fits flat against a detachable front panel. The power supply is mounted on a separate plug-in sub-chassis. Five individual amplifier sub-chassis also plug into the main chassis, which has a power connector and two N connectors. One connector is the antenna input and the other an output that can either be terminated with a 70 ohm termination, or connected to additional multicouplers. Each amplifier module has its own output N connector.

Photo 3 shows the underside of the main chassis with the front panel removed. The power supply plugs into the socket in the upper center of the chassis. The large box beside the fuses is the line filter. The horizontal Bakelite strip contains the signal and power distribution circuitry as well as sockets for the individual amplifier sub-chassis.

The unbalanced antenna input is applied to the balun transformer on the right side of the Bakelite strip to drive a balanced distribution line. This line is terminated at the other end by a matching balun that connects to the output connector.

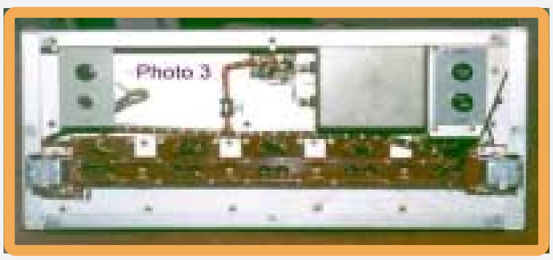


Photo 3 - The main chassis with the front cover removed

Photo 4 shows the underside of the power supply chassis. It is a conventional two-section, choke-input filter design using a 5U4G rectifier. It shows the Collins' touch, such as electrolytic capacitors that plug into very high quality ceramic sockets.

Each amplifier module draws about 80mA at 165vdc. The 5U4G thus operates somewhat beyond its maximum ratings for a choke input filter, making it an odd choice in an otherwise conservative design. Space is not an issue on this chassis, and a pair of 5U4GBs would seem to be a better choice.

Five identical amplifier modules plug into the main chassis. Each module contains two separate amplifiers, one for each side of the balanced input obtained from the main chassis. Each separate amplifier consists of two 12AU7 dual-triodes, a good choice for high frequency

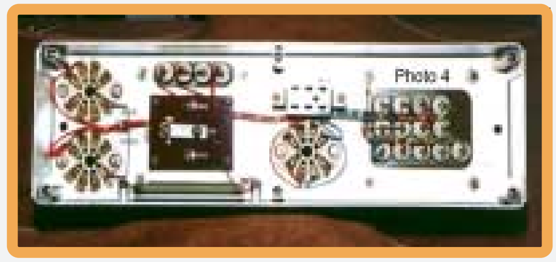


Photo 4 - Underside of the power supply chassis

amplifiers. A major challenge for the designers would have been to maintain the amplifier gain-bandwidth product for the range of frequencies the multicoupler had to cover. The gain-bandwidth product is inversely related to plate load resistance, thus requiring a low load resistance to achieve the needed bandwidth. But a low load resistance, coupled with the need to operate the tube so that it can handle both large and small signals, results in large plate currents. I suspect that the need to balance these factors resulted in each 12AU7 having its two triode sections connected in parallel.

The first 12AU7 is a cathode follower connected to one side of the balanced input. This configuration provides high input impedance, thus allowing many such units to be connected to the antenna without substantial signal loss. The output is low impedance, which is advantageous in an amplifier that has to operate over a wide frequency range. However, the gain of a cathode follower cannot exceed unity. The cathode follower output is connected through a shunt-series compensating circuit (to broaden the frequency response) to the input of the second amplifier.

The second 12AU7 is a grounded grid amplifier, which is inherently stable at high frequencies and provides good isolation between input and output due to the grounded grid acting as a shield between plate and cathode. The input impedance is low, thus providing a good match to the preceding cathode follower stage. The circuit is configured to provide some voltage gain.

The unbalanced 70 ohm output is obtained from a center-tapped transformer. Each side of the primary is driven by one of the cathode-follower and grounded-grid amplifier pairs just described.

Photo 5 - Amplifier module - tube side

Photos 5 and 6 show a typical amplifier module. The output balun is at the N connector end of the amplifier. Figure 6 shows the underside, with the slide-on module cover.

It seems unlikely that the CU-168 / FRR was designed for use specifically with the R-390 / URR. The use of type N connectors throughout, and a 1952 manufacturing date on one of the power supply capacitors, suggests that it was designed for use with an earlier radio. Although the R-390 / URR has an unbalanced input (with a type C connector) to allow use of a whip antenna, the balanced input seems to have been the primary intended configuration. It certainly provides enhanced performance, and adds considerable complexity to the radio's construction. The CU-168 / FRR was clearly intended for use with unbalanced transmission lines.

I posted my puzzlement to the Internet's Milsurplus reflector. Wayne Hertel was kind enough to respond. He worked in a military installation in the mid-1960s that had several hundred R-390 / URR and R-390A / URR radios. There were also a few SP-600 SuperPros and other assorted receivers in use. The CU-168 / FRR was used to allow simultaneous use of a variety of antennas. The receiver inputs and the multicoupler outputs were connected to patch-panels that allowed the operator to connect a receiver to the antenna most appropriate for a given transmitter and direction. All of the R-390 / R-390A receivers used the unbalanced connector input.

The CU-168 / FRR was made for the Navy. Later versions of the R-390A / URR Navy technical manual provide a simple mod that allows the use of the unbalanced input connector with the balanced input circuitry, so that the advantages of that circuit are not lost. It seems likely that the receivers at Wayne's location had that mod.

Photo 6 - Amplifier module - component side and slide-on cover

Wayne also has a CU-168 / FRR manual dated 10 September 1952, which is consistent with the apparent age of my unit. However, the CU-168 / FRR that he has was made by Telectro Industries under contract NObsr 75293. Mine was made by Collins under contract NObsr 49175. Wayne's manual also suggests that there was a third contract NObrs 52727, but I could find no further information on this.

A multicoupler is simple in concept but difficult in practice. It must minimize degradation of signal to noise ratio, sensitivity, or the overload and cross-modulation characteristics of the radio. It must not allow receivers to interact, and connecting or disconnecting one or more radios should not alter the performance of the rest. It must operate over a broad frequency range with a reasonably flat frequency response. With modern designs and miniaturized devices, this is a fairly straightforward exercise, but not so simple half a century ago!

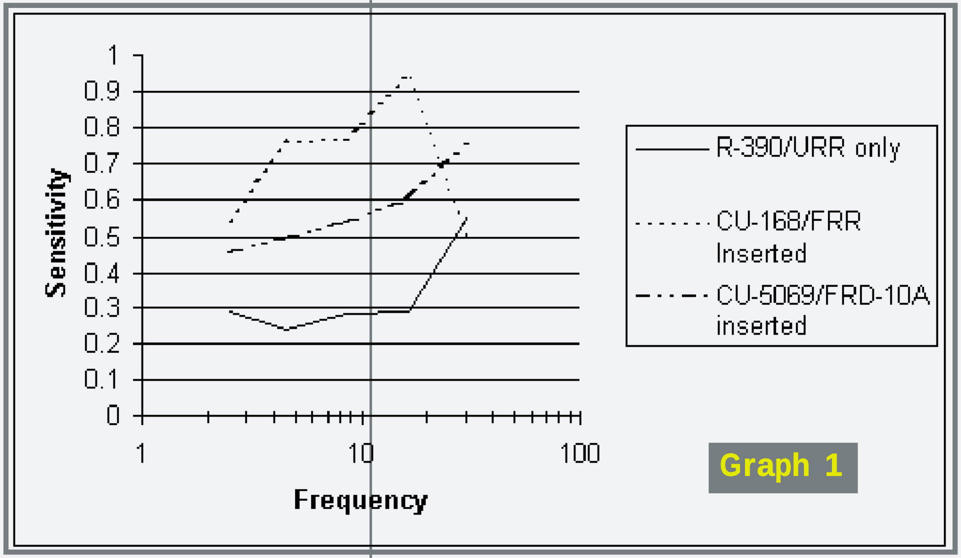
I wanted a few "quick and dirty" performance measurements for the CU-168 / FRR, and I wanted to compare these to a more modern multicoupler. First, however, I thought it would be interesting to know how well the unit was supposed to work when fresh from the factory. Unfortunately, Wayne Hertel's manual did not provide much help. With the output terminated by 70 ohms, the CU-168 / FRR was not to give a voltage loss of more than 4 db over the 2 to 32 MHz designated operating range, suggesting that the designers were prepared to accept some signal degradation in return for the broad operating range.

I also have an RCA CU-5069 / FRD-10A multicoupler manufactured by Technical Materiel Corporation under contract to RCA. It allows up to 32 receivers to be connected to a single antenna. It is solid-state and covers the same frequency range as the CU-168 / FRR. I repeated the tests on the RCA unit for comparison.

I did two tests. First, I measured the S / N ratio at several frequencies for an R-390A / URR connected directly to my signal generator, and then with each multicoupler connected between the signal generator and receiver. Second, I measured the gain of both multicouplers at several frequencies.

Test 1: Signal Loss

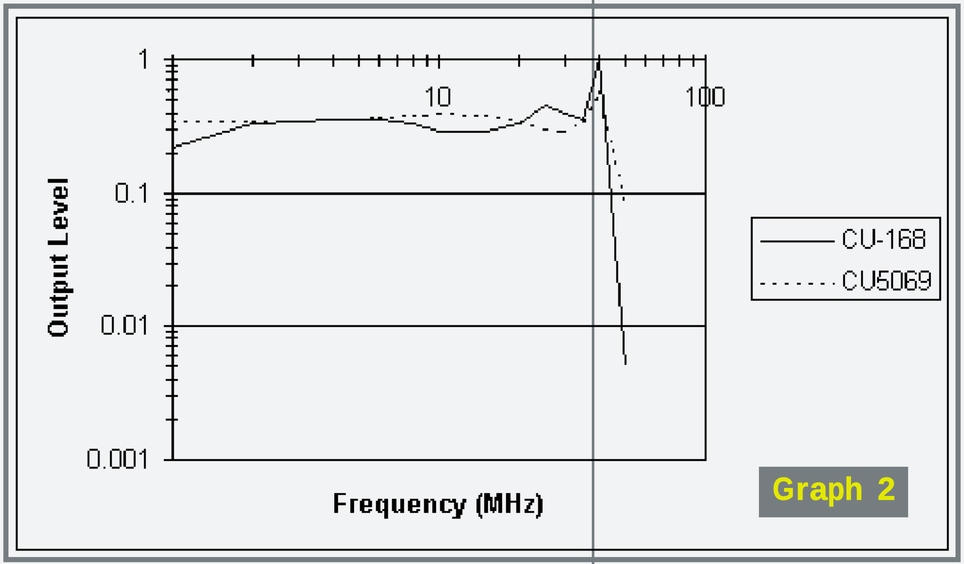
An HP8640B signal generator was connected to an R-390A / URR (8kHz filter setting and balanced input with the Navy mod) and the output measured across the receiver's line output, terminated with a 600 ohm resistor, using an HP3400A RMS voltmeter. The HP8640B used



Graph 1

50% modulation at 1 kHz. The tests were repeated with each of the multicouplers connected between the signal generator and receiver. The receiver's antenna trimmer was adjusted for maximum signal prior to each measurement. The results are shown below. The figures given are in microvolts for a S+N rise of 10db over N. No attempt was made to correct any of these figures to account for possible impedance mismatches. However, I believe that they are comparable for purposes of this article. Also, this is the way these units would probably be used in real life! Graph 1 shows the results.

It appears that both multicouplers degrade ultimate receiver sensitivity to some degree. Part of this may be due to insertion loss, and part may be due to noise added by the multicoupler. By the "ear" test, the older Collins unit definitely contributed more excess noise than did the solid-state RCA unit. The degradation due to the solid-state unit was fairly constant across the full frequency range, whereas the vacuum-tube design showed rapid falloff at the top end.



Test 2: Bandwidth

The HP8640B was used to provide a constant input to the two multicouplers at various frequencies and the output level measured to determine the frequency response characteristics of both units. The HP8640B output level is not flat enough across its range to assume that variations would be too small to matter. Thus various ways of measuring both input and output levels were tried. The method that seemed to give the most consistent and comparable results involved using a Tektronix 454A scope to simultaneously monitor both the HP8640B output and the multicoupler output. In each case the multicoupler was terminated with a resistive load. No attempt was made to correct the readings for impedance mismatches, or for the loading effect of the scope. This test was intended as a comparison, and the measurements for both multicouplers were made in the same way. Because of the method used, the input signal level used was much higher than a typical received signal. But both multicouplers would have been intended to operate in both strong and weak signal environments. The results are shown in Graph 2.

The CU-5069 / FRD-10A was remarkably flat across its operating range. The low frequency response of this unit is better than that of the CU-168 / FRR. According to the information I have found on the CU-5069 / FRD-10A, it was apparently intended to work down to VLF frequencies.

However, the CU-168 / FRR was also surprisingly flat within its 2 to 32 MHz design range. This is a considerable achievement, given the inherent difficulties of broadband designs using vacuum tubes, and the complexity of its multiple baluns and the internal RF distribution line.

Both multicouplers are quite old. A random check of component values in both revealed the kind of drift in value expected with age, and in the case of the CU-5069 / FRD-10A, with 7-24 operation for many years. Thus it is possible that simple aging effects would adversely affect performance over time.

These tests were not done with great precision, but hopefully do give a sense of the capability of the Collins CU-168 / FRR in comparison to a later solid-state design. What I find most interesting is just how good the vacuum-tube design is, even though later technology may have made the task simpler. Still, the inevitable reality is that to duplicate the capability of the 32-output CU-5069 / FRD-10A using the earlier technology would require about five feet of rack space, compared to the actual 3.5".

It was also interesting to conclude that the performance of a receiver connected through either multicoupler was degraded somewhat. So the bad news for my SWL friends, straining to hear the unhearable? Stick with one receiver and a good antenna! The good news for everyone else? A multicoupler is a great addition to the well-equipped collector's shack!

Want More?

See the Next Page!

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I received an email from John Bunting, W4NET. He has a CU-168/FRR that was made by the Hugh H. Eby Co under Contract NObsr 64811. There seems to have been quite a few of these made, so it is curious that they are apparently rare.

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John emailed that he had obtained a copy of a manual NAVSHIPS 91697A , dated 10 Sept. 1952. Possibly the same manual Wayne mentioned, but John's copy lists two manufacturers - Collins and Decitron. So we seem to have four manufacturers and five contract numbers: Eby - 64811; Telectro -75293; Collins- 49175 & 52727; Decitron - 81160.

Want Parts, Information, Pictures??

- Boatanchor Dreams - information on collecting and resurrecting fine old radios. Military, ham & broadcast.
- Classic Technology - military connectors, semiconductors, lamps, manuals etc. Small quantities, no minimum order for the collector, hobbyist & rebuilder.
- Tech Talk 1 - The R-390A RF deck is the radio's heart. There is a safe and relatively easy way to thoroughly clean it.
- Tech Talk 2 - The R-390A often comes without meters. Read why! Originals are hard to find and pricey. But there are other meters available that can be adapted!
- Tech Talk 3 - Turn on your precious tube radio and tubes, transformers and other pricey bits may blow. Learn how to protect from In-Rush Current Surges!
- Tech Talk 4 - Want to Improve your R-390A Audio? Read this first!
- Tech Talk 6 - Another multicoupler - the RCA CU-5069 and the problem with heat.
- Tech Talk 7 - and speaking of heat - solving the excess heat problem with the Collins HF-2050 Receiver.
- eMail Jan Skirrow