Repeater Duplexer Connection Cabling

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BACKGROUND:

In an ideal world, the Yaesu DR-2X repeater's RX and TX signal inputs will be a perfect 50+j0 Ohms. The duplexer terminals will also have and "see" a perfect 50+j0 Ohms. In such a configuration, the length of the cables is irrelevant. However, we do not live in a perfect world since Adam ate of the fruit while in the Garden of Eden.

When an impedance is a perfect 50+j0 Ohms, changing the connection cable lengths cannot introduce phase differences into the system which will change that perfect vector impedance. But if there is some other impedance, then cable length matters. Therefore, there are optimal cable lengths for the coax cabling that connects duplexer cavities between themselves, the receive input, the transmit input, and the antenna feed line. These optimal lengths can, in theory, be solved for analytically but in practical fact, can only be arrived at by trial and error.

While the repeater is specified by Yaesu to have vector input impedances of 50+j0 Ohms, the actual vector impedances of any one unit will be something slightly different.

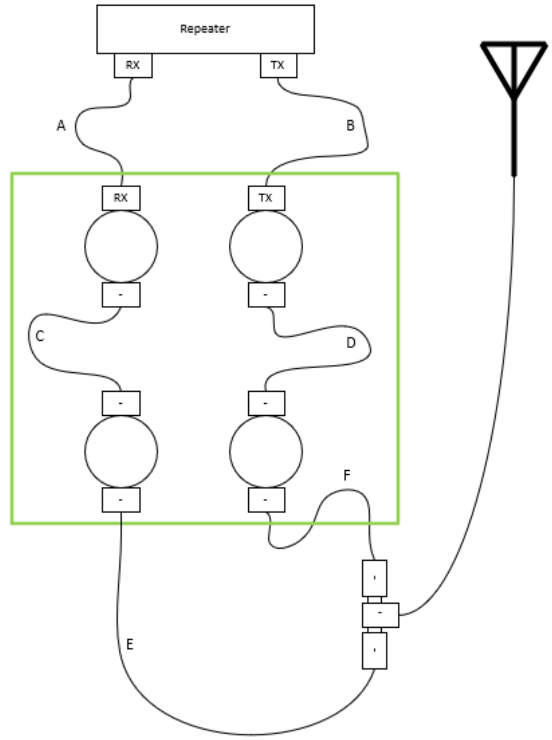

Figure 1 A typical repeater cabling configuration is shown in the illustration. For an initial installation, each cable should be a quarter-wave of the operating signal (in or out) or multiple of that. There are 6 RG-214 double-shielded cables in the configuration.

PREPARATIONS:

Prepare a set of RG-214 cables with type-N connectors having dimensions indicated below. It is critical to note that there can be no exceptions for equipment substitution. RG-214 cables are double-shielded and have a silver plated core. These **MUST BE USED** for duplexer connections. If you substitute with cheap stuff you will just end up getting the real thing later on. Likewise, the type-N connectors must be silver-plated and are very costly. Do not get cheap on this requirement.

RG-214 coax is assumed to have a velocity factor (vf) of 0.66 for purposes of this study. The measurements are based on a quarter-wavelength. The operational frequency is taken as the geometric mean of 144.85 MHz and 145.45 MHz—145.1497 MHz.

Each substitute cable is labeled X, Y, Z, etc.

$$electrical\ quarter-wavelength = \frac{299.79*0.66*100}{4*145.1497} = 34.08\ CM = 34\ CM \pm 1\ \text{CM}$$

1. X: 34 CM Actual length:_______________
2. Y: 34*0.9 = 30 CM Actual length: _______________
3. Z: 34*1.1 = 38 CM Actual length: _______________

4. T: 20 CM Actual length: _______________
5. U: 15 CM Actual length: _______________
6. One or two type-N barrel connectors

   Length added by barrel: 2.0 CM

HIGH-LEVEL DESCRIPTION OF THEORY BEHIND THE PROCEDURE:

If each cable were precisely a quarter wavelength of the transmit and receive frequencies (they are 0.6 MHz different but that is close enough to being the same for these purposes), we would at least not be introducing additional error into the system. The reason why we say that the input and output frequencies are close enough to have a common wavelength is that at 0.6 MHz for a fundamental of 145 MHz, there are only 0.2 CM difference between the two. Cutting coax to ±1.0 CM is all the accuracy we are capable of.

However, different cable lengths, optimized for that individual system, can almost always improve the power transfer of the system. But sadly, for practical reasons it can only be done by trial and error.

What we will do in step 1 is the following.

1. Record the ambient temperature where the duplexer is located.
   a. Ambient temperature duplexer environment:________ ±1°F
2. Shut off the repeater facility power.
3. Cable-by-duplexer-cables are identified and measured.
   a. record the length of each.
   b. Physically label each using the nomenclature of Figure 1.
      i. Length A:___________cm
      ii. Length B: ___________cm
      iii. Length C: ___________cm
      iv. Length D: ___________cm
      v. Length E: ___________cm
      vi. Length F: ___________cm
   c. Restore each cable before disconnecting the next.
4. Disconnect the antenna feedline as illustrated in Figure 2.
5. Place a 50 Ohm dummy load in its place.
6. Restore the repeater power.
7. Record the repeater power output setting: low, medium, or high.
   a. Repeater output power setting: ___________
8. Measure the forward power into the dummy load and record.
   a. Power out of duplexer into dummy load: ___________Watts
9. Shut off the supply power to the repeater.
10. Disconnect the dummy load and restore the feedline connection per Figure 1.

11. Place the dummy load at the transmitter output as illustrated in Figure 3.
12. Restore the repeater supply power.
13. Measure the forward power into the dummy load and record.
    a. Power out of repeater into dummy load: ___________Watts
14. Shut off supply voltage to the repeater.
15. Record the lost power as the difference of readings taken in paragraphs #8 and #13 above.
    a. Pwr of 13.a ___________W – pwr of 8.a_________W = _________W.
16. Restore the transmitter cabling (see Figure 1) removing the dummy load.

WHAT THE ABOVE PROCEDURE HAS REVEALED:

When the repeater was connected to the dummy load, it was safe to assume that it was outputting all the power it was capable of since there would have been no reflected power back. Measuring the power delivered to the feedline through the duplexer revealed how much of that optimal power would have been given to a perfect antenna. There will have been some loss. That loss is what we hope to lower by replacing the duplexer cabling through our yet-to-come trial-and-error process.

STEP 2:

What we will do in step 2 is the following. This will attempt to optimize the transmitter output.

1. Facility power to the repeater is still shut off.
2. Disconnect the antenna feedline and put in its place put a 50 Ohm dummy load (see Figure 2).
3. Restore facility power to the repeater.
4. Power out if different from #8.a of procedure on page 2:___________Watts
5. Record ambient temperature:__________ºF
6. Swap cable B with an alternative from the list shown on page 2.
7. Measure the power out:
    a. Measured power out:___________Watts
8. Continue with alternative substitutions in an effort to find one that maximizes the power delivered to the dummy load. The original cable may be included in the investigation process augmented with barrel-connected fractional cables. When that configuration is found, label that cable/assembly as "B optimization" and leave it in that position.
9. Continue the swap-optimization process with Cable D in the same manner as paragraph #8 above. If possible, leave that configuration in place, labeling it as "D optimization."
10. Continue the swap-optimization process with Cable F in the same manner as paragraph #8 above. If possible, leave that configuration in place, labeling it as "F optimization."
11. Continue the swap-optimization process with Cable E in the same manner as paragraph #8 above. If possible, leave that configuration in place, labeling it as "E optimization." This begins an optimization process working backwards toward the repeater receive input.
12. Continue the swap-optimization process with Cable C in the same manner as paragraph #8 above. If possible, leave that configuration in place, labeling it as "C optimization."

13. Continue the swap-optimization process with Cable A in the same manner as paragraph #8 above. If possible, leave that configuration in place, labeling it as “A optimization.”
14. Remove facility power from the repeater.
15. Disconnect the dummy load and restore the duplexer connection to the feedline as illustrated in Figure 1.
16. Restore facility power to the repeater.
17. Go home.

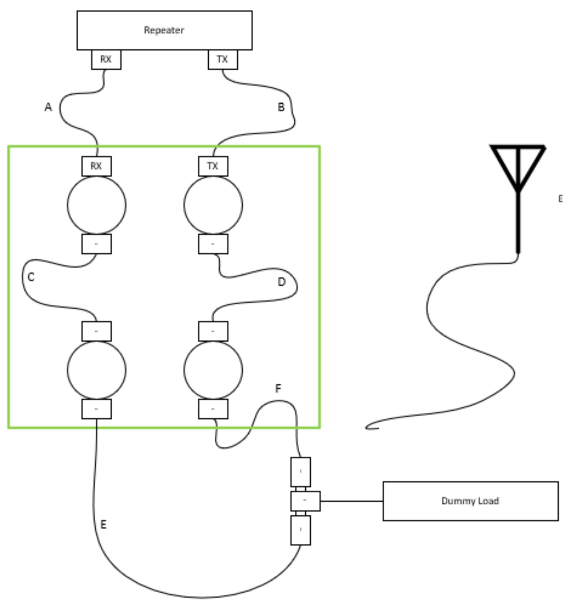

Figure 2 The antenna feedline is disconnected and in its place a dummy load is installed for the repeater transmitter to work into. The coax connecting to the dummy load does not need to be of RG-214 nature. It can be any coax such as RG-58.

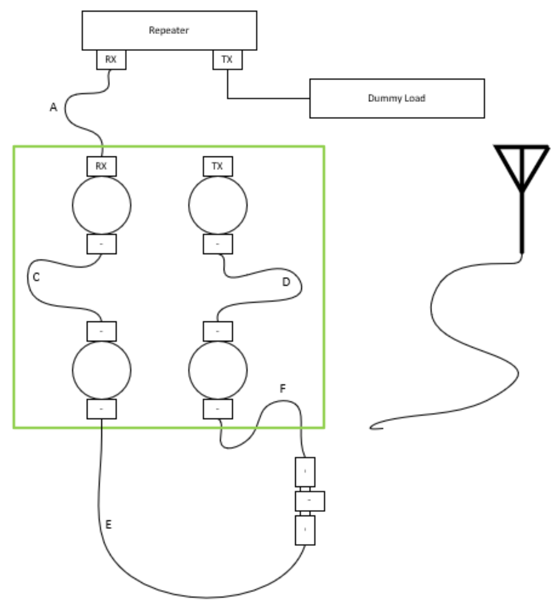

Figure 3 Both the antenna feedline and repeater TX output coax (B) cables are disconnected. The dummy load is installed where cable B used to be. The coax connecting to the dummy load does not need to be of RG-214 nature. It can be any coax such as RG-58.