No. 15 Coax: The Short Story

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One good way to think about antennas is as a system: the antenna system. The antenna system consists of all components that get power from the rig (or, on reception, to the rig) into the transducer (that is the antenna proper) that converts the electrical energy (the energy that shocks) into electro-magnetic radiation (the energy form that lets your signal bounce off the ionosphere to all that good DX). Some of those components are inside your rig: the filtering and impedance matching components that establish a 50-ohm impedance at the coax connector.

The remainder of the components are external: the antenna proper, the transmission line, the transmatch or antenna tuning unit (2 names for the same item, and it may also be in your rig's case), and any matching components at the antenna terminals (such as a beta or gamma match for a Yagi). All of these have to be working well to ensure maximum efficiency of energy conversion into RF radiation.

The weak link in the system is often the transmission line, and just because it is a simple, no-adjustment component. It does not start off as the weak link: it just gets that way because we ignore it. Most 10-10ers use coax to feed their antennas, so let's confine our discussion to coaxial cables as transmission lines.

Some Coax Basics

Everyone knows what coax looks like. There is a center wire, which may be solid or stranded. Surrounding the center wire is some insulating material: it may be a solid, translucent plastic or a white softer foam. Around the insulation is a layer of conductors: these may be a mesh or braid of copper, or in recent cables, the conductor may consist of a foil with a mesh around it. Over these layers is a coating--usually a black jacket on ham wires, but sometimes gray or even white for special purpose cables.

For the moment, forget the outer cover. The center wire, the insulating material, and the wire mesh that determine the characteristics of the cable as a transmission line. We can be a little more precise by remembering that alternating currents at HF frequencies travel at the surface of the wires. Hence, we are concerned with the outer surface of the center wire and the inner surface of the wire mesh: these two surfaces determine what the characteristic impedance of the cable will be. Of course, most of us use 50-ohm cables. Since getting a 50-ohm impedance depends on the ratio of the diameter of the center wire and the circle made by the wire mesh, we can make many different sizes of 50-ohm coax.

Here is a table of the most common 50-ohm coaxial cables we hams use:

Cable #	Outer Diameter*	50 MHz Loss**	Maximum Voltage***	Velocity Factor****
RG-174	0.1"	5.7 dB	1100	.66
RG-58	0.195"	3.1 dB	1400	.66
RG-58 Foam	0.195"	3.3 dB	1400	.79
RG-8X Foam	0.242"	2.1 dB	2000	.75
RG-213	0.405"	1.3 dB	3700	.66

* Outer diameter includes insulating jacket.
** Losses at 10 meters will be about 2/3rds this figure; losses are approximate and vary somewhat from one listing to another.

*** Maximum operating voltages (rms) also vary from one list to another.
**** Velocity factors on foam cables vary from one listing to another.

What can we learn from the table? Actually, several things.

1. The fatter the cable, the lower the losses in the cable. So, use the fattest cable you can afford and handle in your situation.

2. The fatter the cable, the higher the power handling capability (as roughly indicated by the operating voltage). So if you use an amplifier, use RG-213 or better.

3. The outer diameter of the cable determines what coax connectors to use. RG-213 requires regular PL-259 plugs. RG-8X, being the same size as RG-59 (a 70-ohm cable) requires UG-176 adapters. RG-58 requires a UG-175 adaptor. Do NOT forget the adapters for the smaller cables: they relieve stress on the wires for longer-lasting connections.

4. The velocity factors tell us how long a cable wavelength is relative to that same wavelength in free space. The cables with solid insulation will be an electrical wavelength long at only 2/3rds the length of the wave in free space. Notice that the foam insulations have higher velocity factors than the solid insulation types. For all foam and for cables with new numbers, be sure to check the velocity factor just in case you have to make up a cable that is a specific fraction of a wavelength long.

In addition to these basic cables, there are a number of new cables. Beldon and others make a very low-loss version of RG-213 under company stock numbers. It is for VHF or for very long (100' +) runs of coax. And it costs more. There are also marine cables with jackets that resist sun, salt water, acids in the air, and almost any other contaminant. They also cost more.

What Cable to Use

Determining the best cable for an application is a combination of cable characteristics and practical realities. While no absolute rules are possible, here are some scenarios and recommendations.

1. Mobile or portable: Since power with likely be no more than 100 watts and cable runs will be under 35' in most cases, RG-58 should do the job.

2. High power contesting: Use RG-213 or better cable to handle the power and the longer cable runs to permanent antennas. One of the low loss cables may be in order if you use very high towers or antenna supports.

3. Moderate power, but over 65 years old: Consider RG-8X. It is lighter and easier to handle than RG-213, but has more power handling ability and lower loss than RG-58. (For every tens years of age over 40, also consider lowering your tower by 10' to a height you can climb.)

4. Coast-line or industrial area installations: consider some of the marine cables with their extra protection.

5. Buried cable installation: RG-213 (an improved version of the old RG-8) should work fine, but for minimum maintenance, consider one of the cables with greater resistance to chemical and abrasive wear.

Check at hamfests: sometimes a dealer will run a special on one of the marine or low-loss cables, bringing the price down to nearly the same as RG-213. I tend to avoid preassembled cables, since the crimped connectors are not as well-connected to the cables as carefully assembled regular connectors. However, I do use them for quick tests and for portable work. After a while, I end up replacing the connectors with soldered versions.

The UG series of connectors was made to be taken on and off with ease, and to some degree, they depend on the abrasive effects of connecting and disconnecting to keep the center pin and the threads clean. If you use them at the antenna terminals, be prepared to disassemble and clean the connectors at least once a year, even if you use plenty of coax sealant to weather protect the connection.

Coax Problems

There are two types of coax problems: mechanical and electrical.

Mechanical problems and maintenance: Nothing lasts forever (except love). Inspect your coax and connectors at least once per year or whenever you have any signal strength problems. Clean the connections and reseal them, if outdoors. Wipe down the coax to remove dirt and chemical build- up. Try to install your coax as much in the shade as possible to reduce the rate of sun deterioration of the outer jacket. For buried installations, check for standing water around the cable and improve drainage if necessary. Be certain that you use plenty of support on vertical runs (for example, up the leg of a tower). Avoid long, unsupported horizontal runs: use a support rope to which the coax is taped at small intervals. Coax was not made even to support its own weight. Avoid tight corners: the fatter the coax, the larger the radius of a corner. (This also prevents deformation of the cable, which can change its electrical characteristics.)

After five years of outdoor use, replace your coax. It may have some good life in it, but the odds are that your signal strength on both transmission and reception have dropped as the aging cable ate more of the signal power. If you want to use the old cable, cut away and discard a few feet from each end, along with any segments with visible jacket damage. Then use the remaining cable for those shorter noncritical indoor runs of a few feet each. Or remove the jacket and extract the braid as a grounding strap. But keep your outdoor coax fresh.

Electrical problems and maintenance: Remember that the transmission line characteristics of the coax involved only the outer surface of the center wire and the inner surface of the wire mesh. The wire mesh also has an outer surface perfectly capable of conducting HF electrical energy. In fact, it can act just like an antenna in parallel with your "real" antenna. That phenomenon can ruin the performance of your system (unless it is designed into the system, as in some wire antenna schemes). Hence, you need something to isolate the outer surface of the coax from the antenna currents. Many beam manufacturers already provide a "balun" or "line isolator" to take care of that potential problem. If your system does not have one, consider purchasing a 1:1 current balun or W2DU-type choke balun to install between the antenna terminals and the coax run.

I also take one other precaution. Instead of running one piece of coax from the antenna terminals to the rig, I use several. The first goes from the beam terminals (actually, the choke balun) to the mast, around the rotator with a large strain-relief loop, and down abut 8 feet along a tower leg. I have grounded my tower legs as best I can, and I have a plate on the leg with a bulkhead (double female) coax connector. The first length of coax ends here and the second begins. electrically, the tower and the outer coax braid surface are at the same potential. The second coax length goes to another plate installed where the coax enters my home. At this weather protected point, when weather threatens, I can move the coax from the house run to a plate with coax connectors and a long pipe into the soil. Keeping heavy charges outdoors is my goal, especially when I am on vacation. This measure protects my home. A third run goes from the home- entry plate to a plate at the edge of my operating table. Routinely, whenever I am not on the air, the coax, ground strap, computer connector, and AC cord to the station are all completely disconnected, so that the station is isolated from any electrical dangers. This measure protects my rig. Finally, short lengths from the plate to my antenna tuners and rigs complete the connections.

Do I get some losses from having so many coax connectors? Probably a little. But so far, in 40+ years of operating, I have had no problem with static charge build-up on the antenna, power line surges, ground surges, or other weather- and thunderstorm-related problems.

Coax makes a very effective transmission line, but its effectiveness depends on sensible selection, thoughtful installation, regular maintenance, and timely replacement. You might want to check out your transmission lines before the sunspots numbers take your mind off everything except operating.

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