

RF Transmission Lines and Antennas

Part One

Overview:

For the next few weeks we are going to be taking a look at Radio Frequency transmission lines and antennas. Obviously, a transmission line is designed to transfer RF energy from your rig to your antenna when transmitting and from your antenna to rig when receiving. And, following that an antenna is the device that is on the opposite end of your transmission line from your rig. Its purpose is to radiate RF energy or to receive RF energy that has been radiated. The efficient transfer of energy, with it's superimposed intelligence, from your rig to a distant rig and the reverse for someone you are attempting to communicate with makes amateur radio possible.

As has been frequently said any antenna is better than no antenna. It is better to get an antenna and transmission line up and working than to try and spend days, weeks and maybe months trying to find and install the perfect system. Every system has compromises, some can be mitigated with little effort and some are impossible to overcome. Most fall somewhere in between. This somewhere in between makes antenna systems fun and challenging to deal with.

One fundamental fact about transmission lines and antennas that seems to be forgotten from time to time is that a complete circuit back to it's source is required for radiation of RF energy. If that return path is not provided as you learned in electronic fundamentals the result is that your antenna system will not function as intended. RF as opposed to direct current most likely will make it's own path if one is not provided. When that happens some grotesque things can and do happen to your signal and perhaps to your equipment or to you. We will discuss this in more detail later.

Transmission lines:

I. Types of transmissions: Over the years, transmission lines and antennas have taken many different shapes and sizes. Today transmission lines are composed of three different types.

1. Coax cables. These are the most common today and are the round cable that most of us are familiar with that goes from our rig to our antenna. These have one conductor in the middle surrounded by an insulator which is surrounded by an outer braid which is surrounded by outside insulation. Coax cables are considered to be unbalanced as the outer conductor is intended to be held at ground potential and the inner conductor carries the RF energy. Of course, the inner conductor is at a potential other than ground.
2. Parallel wire lines. These are usually flat cables with two wires running parallel to each other from your rig to your antenna. These are less common than coax cables but due to their efficiency they are popular with some users. Parallel wire lines are balanced because both conductors have the same voltage and current relationships with respect to ground.
3. Waveguides. These are hollow and flat metal transmission devices that RF energy simply radiates through from one end to the other. These are used primarily for the upper end of the UHF band and for super high frequencies such as microwaves. These are used by hams when operating on frequencies near one Giga hertz and higher. For our series of discussions here we will not address waveguides as those using them are normally well versed in their use and theory.

II. Characteristics of transmission lines:

- 1. Regardless of their lengths, all transmission lines have resistance, inductance and capacitance. These can be combined and are called impedance. Resistance is simply the DC resistance of wire. Inductance is resistance to an AC voltage. Capacitance is resistance to AC current. These definitions are not all inclusive but will suffice for our discussion. Impedance may also be known as attenuation. Impedance increases as RF frequency increases. Thus as frequency is increased a point is reached for a given transmission line that the attenuation causes unacceptable losses in both transmitted and received RF energy.**
- 2. When we speak of a 50 ohm (a measure of resistance) coax cable we are speaking of 50 ohms of impedance; that is resistance, inductance and capacitance combined is 50 ohms. Impedance is always measured in ohms.**
- 3. When we speak of a 300 ohm parallel wire line we are again speaking of 300 ohms of impedance which again is a combination of resistance, inductance and capacitance.**
- 4. The characteristic impedance of transmission lines is determined by several factors that influence resistance, inductance and capacitance. These include diameter of wires, and insulation inside the coax, distance between wires to include inner and outer conductor in coax lines and types of insulation. Coaxes tend to be in the 50-75 ohm impedance range and parallel wire lines tend to be 300-450 ohm impedance range. Parallel wire has higher resistance because the parallel wires are farther apart than coax inner conductor and outer shield.**
- 5. Transmission lines also have a characteristic known as “velocity factor.” This simply means it takes more time for RF energy to travel the same distance through a transmission line than it does through the atmosphere or space. Why is that? Their characteristic impedance as we mentioned is composed of resistance, inductance and capacitance. It takes more time for RF energy to travel through these than it does through space. This is due to the fact that their impedance opposes RF energy more than the impedance of space.**
- 6. The velocity factor of each type of transmission line is well documented and should be used when determining the electrical length of a section of transmission line. Velocity factor is expressed as a percentage. That is a direct comparison of the velocity of RF in a transmission line when compared to the velocity of RF in space. For example the velocity of RF in free space is 300,000 meters per second. That same RF in a coax might have a velocity of only 210,000 meters per second. Thus the velocity factor would be 70 percent. Other words the distance traveled in space would be 300,000 meters in a second and in our coax it would travel only 210,000 meters per second.**
- 7. The velocity factor of coax is usually near 70 percent and in parallel lines it is usually near 90 percent. A document such as the ARRL Antenna Handbook should always be consulted for the correct velocity factor for the specific transmission line being used.**
- 8. The type of insulation and the spacing between the inner and outer conductors of coax and between the two wires of parallel lines determines the maximum amount of power that can be applied to a transmission line. The frequency of RF energy also plays a major role in power handling capability. The higher the frequency the less power a transmission line can handle. An abnormally high standing wave ratio can also adversely affect the amount of power that can be handled. We will discuss SWR in more detail later.**

Next week we will turn our attention to antenna basics. Once we learn some of the basic properties of transmission lines and antennas we will combine that knowledge and talk about SWR, radiation patterns and other factors affecting signal levels and quality.