RF Transmission Lines and Antennas

Part Three

Overview:

This week we continue our discussion of transmission lines and antennas. Those discussions are available on the PPRAA website under Tech Talk. This week we are going to briefly review SWR levels from last week and why a higher number might not be such a disaster as you might have been led to believe. Following the review we are going to discuss several types of antennas and some of their good and bad points.

I. Antennas SWR Review

1. **The perfect antenna system is said to have a SWR of 1:1. This means that there is no energy being reflected from the antenna back down the transmission line to the transceiver. However, if our analyzer tells us the SWR is 2:1 we may not understand what that is actually telling us. Due to the complex nature of inductive and capacitive impedance's what we are actually seeing is about ten watts of power reflected back to our transceiver when it is sending 100 watts into the transmission line. Thus an antenna with an SWR of 2:1 is about 90 percent efficient or there is about one db of loss due to SWR.**
2. **If an SWR of 1.5:1 is measured, about 4 watts are reflected back to the transceiver and 96 watts are available to be radiated. This is less than a half db loss. A one db change is usually the smallest change in sound level perceivable to the human ear. It takes an SWR of about 1.8:1 to be discernable by your ear.**
3. **An SWR of 4:1 will reflect back about 35 watts leaving about 65 watts to be radiated. This is about a five db power loss. That is less than one "S" unit a receiver. Remember, an "S" unit normally considered equal to 6 db.**
4. **Most solid state transceivers are designed to reduce their output power when the SWR exceeds 1.5:1 or 2:1. This reduction is so they do not have to absorb the reflected RF power and potentially over heat or be damaged.**
5. **As can be seen all the worry you may hear or have about high SWR numbers is to protect your transceiver's final RF power amplifier not to produce a perceivable change in radiated signal level.**
6. **Vacuum tube final RF power amplifiers are much better able to absorb the reflected energy as they operate at high temperatures and the power reflected back does not significantly add to the burden of their cooling system. Another reason is they usually have a matching network that helps match impedance between the vacuum tube circuit and transmission line preventing the reflected RF from making it's way all the way back to the power amplifier.**

II. Operating a nonresonant antenna without stress to RF power amplifiers.

1. **A working knowledge of wavelength will help you better understand how antennas and their matching devices function. The flow of alternating current and, of course RF energy can be presented on a graph. To begin on the graph we start at the left side and draw a line thru the middle to the right margin. Let's call this zero voltage. Lets look to the left again. As RF begins to flow it will start at this line, that is zero volts, and rise and move toward the right until reaching some maximum value and begin to fall and pass thru the line and**

continue below the line. As it reaches an amount opposite the maximum reached above it will rise again back to the line which is zero volts. The RF energy we are describing has now completed one cycle which is equal to one wavelength. The up and down movement is called a wave. Thus from the end of one cycle to the beginning of the next cycle is a wavelength.

2. **The impedance along this cycle or wavelength is constantly as the RF energy rises and falls. When the voltage is near zero the impedance is low. When the voltage is at it's peak the impedance is very high. Thus along this cycle we have varying impedance and voltage. The voltage at it's highest point in a wavelength can be several hundred and even thousands of volts depending on the applied RF power. We will use the varying impedance property later to match impedance's.**
3. **Efficiently operating a nonresonant antenna can be done several different way. Remember that without physically changing the size of an antenna it's actual resonant frequency does not change. Therefore, these devices do not actually "tune" an antenna as their name implies but only act as an impedance matching device. The matching is done by presenting an impedance equal to an antenna or transmission line at its output and maintaining an impedance equal to the driving transceiver at it's input. When this matching is done correctly there will be minimum reflected energy loss in the matching device or transceiver's RF power amplifier.**
4. **Probably the most popular device to accomplish this matching is the "antenna tuner." As implied above this name is misleading as it does not tune your antenna. It is an impedance matching device. It simply has a fixed 50 ohm input impedance and a variable output impedance that is adjusted for minimum SWR at the tuner indicating it's output impedance is matched to the transmission line and ultimately to the antenna. When originally marketed 40 plus years ago they were called "transmatches." This is a better name than used today.**
5. **Another device to match impedance's is a balun or it's cousin the unum. The word balun is a contraction of the words balanced and unbalanced. A unum simply matches unbalanced to unbalanced coax transmission lines. A balanced line is usually at the output of the device and an unbalanced line is usually at the input. These are available with an impedance ratio between the output and input of 1:1, 4:1, 9:1 and probably other rations. This mean with a 1:1 ratio the output and input impedance is equal and is usually 50 ohms. A 4:1 ratio mean the output impedance most likely is 200 ohms and the input is 50 ohms. These used alone or in conjunction with an antenna tuner makes possible matching the 50 ohm output of our transceiver with 400 ohm ladder line for example.**
6. **Baluns and Unum's are of one of two different constructions. One type has two coils wound one on each other similar to a transformer. The turns ratio is selected to establish the ratios we mentioned a moment ago. Some people may refer to these as current baluns. The second type is simply coax wound on itself. They are wound either on a metalized rod or simply has an air core. These are referred to as a voltage balun or choke balun. They always have a 1:1 ratio.**
7. **Gamma, Delta, and hairpin devices are used as well to match impedance's. A detailed description of each is beyond the scope of this text. However, they present an impedance which combined with transmission line and antenna impedance's that match the respective impedance's of the transmission line and antenna. Thus, efficient transfer of energy can take place. They operate by**

being a fraction of a wavelength long. At that fraction of a wavelength there is an impedance that will match the parts of our antenna system.

8. **The major difficulty with these matching devices is they effectively compress the wavelength inside themselves to find a matching impedance along the wavelength. Remember we said the voltage varied along this wavelength and could be several hundred or even thousands of volts. This high voltage inside our matching device can exceed it's insulation's ability to contain it and can cause arcing. This can serious damage to the device.**

Next week we are going to look at the practical aspects of transmission lines and antennas. Why some may be better than others and problems associated with certain types.