

# RF Transmission Lines and Antennas

## Part Two

### Overview:

Last week we discussed Radio Frequency transmission lines. The discussion is available on the PPRAA website under Tech Talk. Obviously, your antenna is intended to radiate your voice or a digital signal that you may want to send. Antennas take many different shapes and sizes. Shapes and sizes are determined by their resonant frequency, available space, desired radiating pattern, method of mounting, cost and several other factors. Each factor contributes its own set of problems and hopefully viable solutions.

We said the following in our presentation on transmissions lines and it is worth repeating again. 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.

Again as was said in our prior presentation; 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.

### Antennas:

#### I. The basic antenna premise.

1. Every antenna, regardless of shape, size or RF frequency applied operates on one simple premise. The antenna has one and only one resonant frequency. The antenna operates most efficiency at this one frequency. If any other frequency is applied it operates less efficiently. This is regardless of antenna tuners, matching networks, baluns or any other device or circumstance. Any antenna operated at any frequency other than its resonant frequency is a compromise antenna. It will radiate less efficiently than if it were operated at resonant. Equal power applied, a resonant antenna will radiate more RF energy than an antenna operated at a frequency other than resonance.
2. Exactly what is resonance? It is the point in an AC circuit, in our case here, an antenna, that the inductive impedance and capacitive impedance is equal. This is usually achieved in an antenna system when the physical characteristics of the antenna are such that it's total reactive impedance is equal to that of the transmission line and equal to that of the transceiver. Other words all three have the same impedance. Then and only then do they operate at their highest efficiency.
3. Only one frequency will cause any antenna to have equal inductive and capacitive impedance. Thus an antenna, transmission line and transceiver will operate most efficiently at only one frequency. This is the main technical reason

that all commercial radio and television stations transmit only on one frequency. Their antenna, transmission line and transmitter are designed and maintained to operate on only one frequency.....and this is the frequency that is most efficient, that is resonant, frequency for their transmission system.

4. With amateur radio having something like fourteen different bands from near DC to daylight it would be highly undesirable to be limited to only one frequency. But, in order to operate on more than one frequency we must accept compromise in our antenna and that compromise is loss of efficiency.
5. As we implied earlier, regardless of antenna tuners, matching networks, baluns or any other device or circumstance we cannot change a nonresonant antenna to resonant antenna. These are matching devices only. They do not actually change the resonant frequency of an antenna. We will address this in more detail later.

## II. The pains of QSYing from resonant frequency.

1. So what happens and what are the penalties for operating at nonresonance? First and foremost, the antenna system radiates less power than if operated at resonance.
2. If that is only a small percent then we may not really care. However, if it is, say 50 percent we probably would be concerned.
3. Another consideration is the power not radiated is being dissipated elsewhere in the antenna system. Your rig probably is still sending that 100 watts into the transmission line when the antenna is operated at nonresonance.
4. All that power is not radiated but part is reflected back to the transmitter and the final power amplifier dissipates the reflected power as heat.

## III. How serious is this loss of efficiency?

1. The power we send down (or up) the transmission line from the transceiver is called incident power. As we mentioned above the power returning from the antenna when operated at nonresonance is called reflected power. These can be compared as a ratio. When compared in this manner we call the ratio standing wave ratio or simply SWR.
2. Equipment is readily available to the amateur operator to measure this SWR and we don't need to concern ourselves with actually calculating it. However, we do need to understand how to interpret the ratio. The instrument used to measure SWR is referred to as an antenna analyzer or SWR analyzer.
3. 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 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.
4. So if your antenna system has an SWR of 2:1 it is about 90 percent efficient. That is 90 watts are available to be radiated and 10 watts are reflected back to the transceiver to be dissipated as heat in the final RF power amplifier. This is about a one db loss.
5. 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.
6. 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.
  7. 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.
  8. As can be seen from above 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. Until the SWR reaches over 4:1 does the decrease in radiated power become significant as for as actual received signal strength at a distant receiver.

**Due to the weight and other complexities of reducing SWR on spacecraft antenna systems an SWR of 4:1 or greater is sometimes acceptable as the small loss in db level is of no consequence in interplanetary distances when losses can actually be in the hundreds of dbs due to distances of many trillions of miles.**