Antenna Basics

By KE7ZIW, March 12, 2010

Antenna Basics is undoubtedly one of the most difficult concepts of Radio Wave transmission that confronts new, as well as tenured, Radio enthusiasts. My hope here is to clarify some of the basic issues and help to steer thoughts in the right direction.

"You could have the most awesome, powerful, featured Radio transmitter in the world but without an efficiently functioning antenna, it would only be an expensive paperweight."

There are TWO concepts that must be accepted, learned or understood before any clarity in Radio Wave transmission will be achieved:

1. The relationship between Frequency and Distance (ex: 150mhz is 2 meters).
2. A basic knowledge of resistance, capacitance, inductance and impedance.

When a signal at a specific Frequency is generated by electronics equipment, it is sent via circuitry and cable/coax to an antenna. If the feed point (where the conductor is attached to the antenna) is an electrical "open" circuit, the antenna does not radiate any energy and this energy will be dissipated as heat or current back into the equipment.

If this feed point is an electrical "short" circuit, no energy is radiated and the generation equipment will see this as an infinite "current" drain on the transmitting circuitry. This usually results in damage to the Radio/Transmitter.

If your equipment is designed to operate on 50 ohms impedance and the coax is 50 ohm coax (notice how the impedance is equal), then when a transmitted signal sees 50 ohms of impedance on the antenna, a signal will resonate. This is called resonance. This is when your transmitted signal will actually radiate through the air.

In Summary of the TWO concepts we can say that "when an antenna length is determined by the frequency desired, and the impedance is matched at the antenna, radiation of energy at that frequency should be optimal."

Before we move forward, let's revisit some basic electronic terms.

<u>Resistance</u> = found in an AC or DC circuit, a component or device that restricts electron flow. A resistor has NO polarity in either AC or DC circuits.

<u>Capacitance</u> = a storage of electrons on one pole while AC signal travels in one direction, reversing when electron flow changes direction. A Capacitor can be polarized or non-polarized. (note: air is capacitive in effect)

<u>Inductance</u> = Inductors are coils of wire where the number of turns, the size of the core and the length of the windings determine "Henrys" of inductance. Electron flow is affected by the altered phase between voltage and current. Has NO effect in a DC circuit however, in an AC circuit, the current flow will follow the Voltage by 90 degrees in phase through a coil.

<u>Impedance</u> = measurement of resistance in an AC circuit; can be affected by capacitance/capacitive reactance, resistance and inductance/inductive reactance.

Radio waves travel at the speed of light. The speed of light is 186,282.397 <u>miles per second</u>. Frequency is usually stated in <u>cycles per second</u>. We must convert miles to feet so our antenna length will be noted in feet and NOT miles!

A 2 meter (2 meters in distance is 6.5618 feet) frequency of 146.000 million cycles per second (mhz) would have a full-wavelength of:
(speed of light x 5280) / 146,000,000 equals = 6ft, 8.84 inches or 80.84 inches. See Figure 1.
Determining fractional wavelengths (1/4, ½, 5/8, etc.) is simple arithmetic relative to the full-wave calculation.

Why are wavelengths important? Generally speaking, the length of the radiated wave will determine the angle of radiation relative to Earth/ground. A full-wave radiator will propagate a signal of lowest angle; ¼-wave will propagate a higher angle. For our Earth based transmissions, relative to a Vertical radiator, we usually want to have the best combination of lowest angle and/or shortest radiator.

This is where Engineering and ingenuity begin to be challenged. For example, a wavelength of a 160 meter signal is 517 feet long. You would need a lot of money and special permits to install an antenna that high. To address these challenges, we can use coils, inductors, and antenna shapes to produce positive effects on antenna systems that allow them to be shorter and yet efficiently radiating at the same time.

When these creative implementations are utilized they could require Baluns (impedance matching transformers) at the feed points of the antennas to provide for matched impedances between the transmission line and the antenna "circuit".

If we have an antenna system that is close to resonance but not perfect, we will have "standing wave" present on the transmission line while transmitting. This means that not all of the transmitted signal is radiating efficiently and that some of it is being dissipated as "reflected wave" or energy coming back toward the transmitter. We measure this effect with instruments to determine <u>"Standing Wave Ratio" or SWR</u>. A perfect, desired match is 1:1 ratio. Newer transmitters will actually begin to automatically reduce power on any SWR present of 2:1 or more. The closer we can set our "match" to 1.0:1, the more efficient our power radiation will be. This should always be the goal.

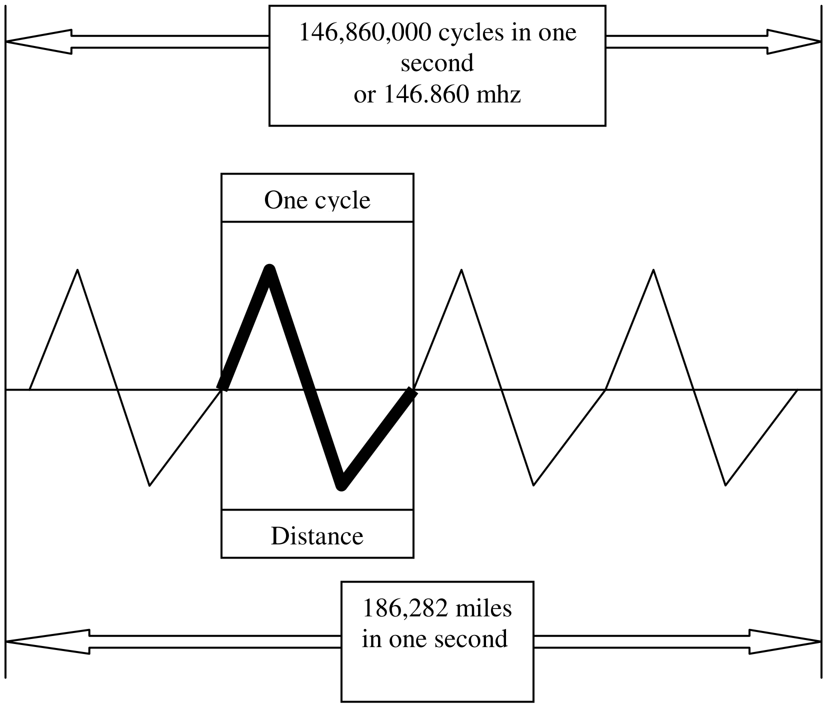

Figure 1

This drawing shows the visual relationship between Frequency and Distance.

The height of the depicted sine wave is irrelevant to Frequency and Distance. The only significant points relative to wavelength are the beginning and ending points of a complete cycle. The height is just the amplitude or power, usually measured in watts.

The horizontal line represents the total distance that Light travels in one second (186,282 miles) and the sine waves as 146.86 mhz in frequency (cycles per second). At the speed of light, X cycles per second have traveled 186,282 miles. If we use a Higher Frequency, we need to "pack" more cycles into the same time so the distance from the start of the cycle to the end of one cycle is shorter. This shows us visually that the higher the Frequency, the shorter the wavelength and inversely, the lower the Frequency, the longer the wavelength.