Newcomers and Elmers Net: Antenna Theory (Lite)
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Antennas are by nature selective, or perhaps to be slightly more accurate, selectively receptive to the various RF signals racing through the atmosphere.
-- Electro-mechanical elements within your radio block some signals while passing others through a process of tuning and amplification.
-- This keeps us from hearing all the signals at once—which of course would make them unintelligible.
-- The antenna is the first step in this selection process, and so a basic understanding of how antennas work will increase our chances of using them effectively.

To understand antennas we have to understand radio waves, specifically several important characteristics of a radio wave.
-- The first important characteristic is that radio waves are *electromagnetic* waves, meaning that there is an electric component and a magnetic component.
-- The second important characteristic is that the waves have direction
-- The antenna's job is to transfer radio frequency electrical current to electromagnetic waves which then radiate from the antenna. The more efficient the antenna the better the quality of signal and the further the signal will travel.
-- A vertical antenna, like the one on a handheld radio, sends out waves parallel to the ground- think of a placing a donut over your index finger while pointing your finger straight up in the air
    - the radiation pattern of a vertical antenna (your finger) goes in the direction of the donut, perpendicular to your finger
    - for a horizontal antenna, think of the same donut/finger combination, but this time with your finger pointing at someone in front of you
    - like the donut ring, some of the signal would go up, some would go to the side, and some would go into the ground

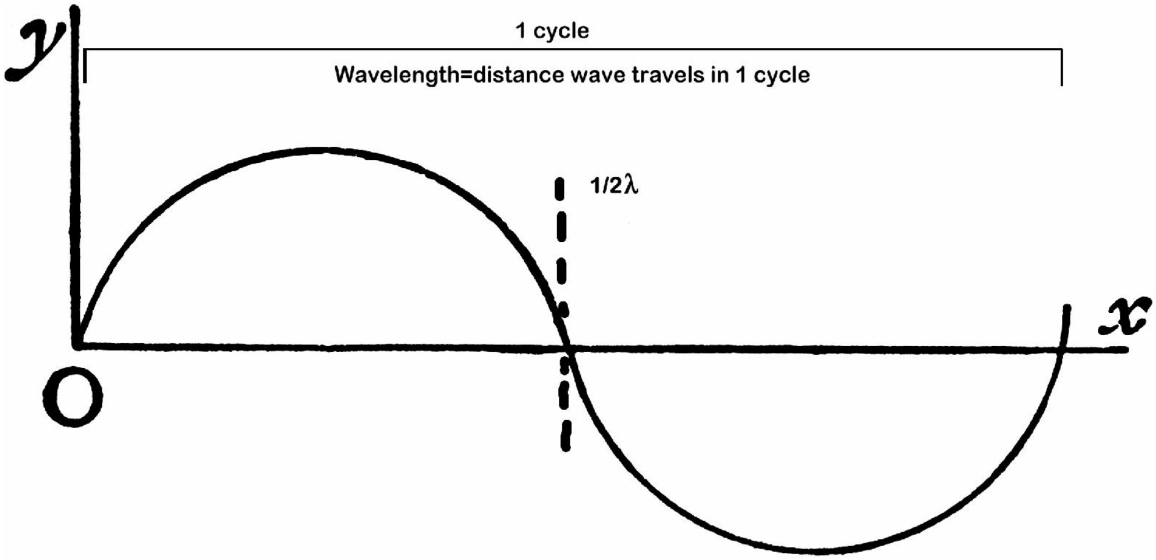
In a perfect world the signal source would be a point in space that radiated in all directions evenly without obstructions of any kind.
-- In reality the length of the antenna, its direction, surrounding objects, and the physical location of the antenna all factor in to interfere with perfect signal generation.
-- Theoretical perfection has its uses however, as it gives us an unbiased starting point from which to compare real-world antenna performance.

Another significant characteristic of a radio wave is its *frequency*, a term we all know from looking at our radio dials.
-- All radio waves travel through space at a specific frequency; this number indicates a mathematical representation of how rapidly a signal oscillates as it moves through the air.
-- Frequency is measured in so many cycles (Hertz) per second. Since radio waves travel at just below the speed of light, 1 cycle travels a distance of 300,000,000 meters per second (or 186,282 miles per second).

If we increase the frequency to 1,000, then each cycle travels 1/1,000 x 300,000,000m/s, or 300,000m/s. Okay—now lets make this practical.

An AM station whose frequency is 550 kHz has a signal that is oscillating 550,000 times per second. That means each cycle travels 1788 feet
-- (hence the “longwave” designation for signals in this band—each wave is almost 1/3 of a mile).
-- Shortwave signals are, in fact, much shorter: a 7.200 MHz signals oscillates 7,200,000 times per second, or 136.6 feet per cycle.
-- A 28.800MHz signal travels just 34 feet per cycle.
-- A common Civilian Aircraft frequency in the U.S. is 122.900MHz, and so one cycle travels a “mere” 8 feet.

Is your head spinning from all the numbers yet? No? Good! What does all this have to do with antennas?
-- Well, as I mentioned earlier, an antenna is designed to selectively receive (or transmit) radio signals in a given range of wavelengths.
-- A *wavelength* is defined as the distance it takes for a radio wave to travel one cycle (see illustration below).



Fortunately there need not be a one-to-one relationship between the antenna and the specific wavelength of the signal received, or we would only be able to listen to one station per radio or TV.
-- A range of signals can be received through one antenna, but there are limits imposed by the size of the wavelength being received and the tuning sensitivity of the radio.
-- I'll save a discussion of tuning sensitivity and intermodulation of radio receivers for another day, however!

While there are many different types and sizes of antennas, I will assume the use of a half-wavelength (½λ) wire antenna, meaning the length of the antenna is half the length of a given frequency's wavelength.
-- A half-wavelength antenna allows a signal at a particular frequency to travel down the antenna and back again in one cycle.
-- For reasons I will explain later, this is the shortest length of antenna that will produce an efficient signal without additional manipulation through coils, traps, etc., and therefore the most useful when discussing how antennas work.

From the examples of various wavelengths above, if you wanted to use an efficient antenna for the 28.800MHz frequency, an antenna length of approximately 17' (34'/2) would work well.
-- If you wanted a good antenna to transmit on 7.200MHz, you would need an antenna slightly over 63' in length.
-- You can see that, depending on the desired frequency, even a half-wave antenna can get rather long!

A lot of the experimentation done with antennas in the Amateur Radio world involves finding ways to use shorter antennas on the lower bands with acceptable results.
-- Unless you live on a pretty good size piece of real estate, you have to figure out ways of shortening the necessary length of an antenna, especially for 40 or 80 meters.
-- The most common solution is going vertical with an antenna because the height can be cut in half or more, but again, that will be a topic for another day.

While the right antenna certainly aids reception, when transmitting a signal the proper antenna length becomes crucial to sending out a strong signal.
-- a 25' wire can receive all kinds of signals, from AM up to VHF/UHF signals, enough for you to hear over a large range of frequencies
-- transmitting signals is something quite different
-- An efficient antenna transfers almost all of the applied power to the radiating signal. An inefficient antenna tends to lose much of the applied power, and here's why.

Due to the nature of how an electrical current travels down the wire, a new wave of current begins its trek down the antenna just as the first wave gets to the end of our half-wave antenna on an efficient antenna.
-- When the wave reaches the end (or far) point of the antenna, it reverses direction and travels back to the source (or near) point (alternating current).
-- This process continues as long as power is applied to the antenna. If we could watch this process in (extremely!) slow motion, we would see current flowing back and forth along the wire antenna, with each new wave or "pulse" exactly matching the previous wave.
-- Admittedly, this whole process sort of boggles the mind, so if you have to study and restudy these things, don't feel bad. I still can't always wrap my mind around the process without a lot of thought!

This leads us into the *SWR*, or *Standing Wave Ratio*, more properly termed *VSWR*, *Voltage Standing Wave Ratio*.
-- If you now have something of a mental image of what is happening as an electromagnetic current travels back and forth along the antenna, you may have pictured a wave arcing from one end of the antenna to the other.
-- This wave remains constant as long as power is supplied, and it can be measured in terms of its efficiency by calculating the VSWR.
-- This is what your SWR meter is measuring as you transmit a signal.
-- A 1:1 reading means that, for all practical purposes, you are

sending out as much power as you are applying because the standing waves are virtually in sync.
-- A reading of 6:1 means that the standing waves are very much out of sync, and your antenna is fighting with itself to radiate the electromagnetic waves.

If you are still with me, you may be thinking "If I can't get at least close to 1:1, I am just wasting my time because my signal is not going anywhere." This is where things get a little weird.
-- Assuming your transmission line (feedline) is functioning properly, your feedline is sending full power to your antenna.
-- What this means is that despite a higher than desired VSWR, if your transmitter is matched properly to the transmission line, eventually your signal will end up radiating most of its power through the antenna system anyway.
-- Poor VSWR is more about giving your transmitter problems through reflected power (that is, power that gets sent back down the feedline toward your radio) than it is about signal loss.

Modern rigs tend to cut back power or shut down altogether when they sense current coming back into the system.
-- Feedline loss is a far more common culprit in robbing you of your station's power than a high VSWR reading.
-- If you can put a tuner in-line, your tuner will allow you to get close enough to a match that your rig will put out full power.
-- Assuming little feedline loss, your rig will send any reflected power back up the antenna as it continues to send out your signal.

Now before anyone starts pulling out their hair and running for the hills screaming because I said VSWR isn't as important as we often assume it is, I do believe you should always produce the best signal possible whenever you transmit.
-- Doing so will ensure the best chance for success. Put the best coax or ladder-line you can on your antennas. Cut your antennas to the proper length for the frequencies you want to use.
-- Always try to make the best use of your locale by avoiding things that will interfere with your transmission and reception of RF signals.
-- Just keep in mind that there are worse things than a 3:1 VSWR reading from your antenna!

Radio Waves
For our purposes here, radio wavelengths are significant because differing frequencies have differing antenna needs and different

propagation patterns to them (*propagation* refers to how signals get from one place to another).
-- Antennas need to be suited to the signals they are going to send or receive, and this is where the above calculations come into play.
-- An antenna designed to work efficiently at the 14.25 MHz frequency needs to be equal to either one whole wavelength (λ) in size, or a length which is divisible by 2, 4, 8 etc.
-- In practical terms antennas are usually either 1λ, ½ λ, or ¼ λ. The ratios can get smaller, but there is usually too great a signal loss much below 1/8 or 1/16 λ.
-- When this ½ λ is achieved, the wave pattern (if you could see it) matches perfectly with itself every time, giving you an SWR of 1:1. This match produces an even and consistent radiation pattern from the antenna. This is called resonance.
-- If an antenna is something other than ½ wavelength, then as one wave travels down the antenna and back again, it runs into the next wave out of sync – the signals sort of fight each other and efficiency is reduced
--The more inefficient, the greater the standing wave ratio – 3:,4:,5:, even 10:1 or greater.

Gain
Antennas can exhibit something called gain, sometimes mistakenly thought of as an antenna adding power to a signal.
-- Unless the antenna has some form of mechanical amplifier, gain actually refers to how well an antenna performs compared to a given standard.
-- The standard used to measure gain is an important one, and it is not always the same from one manufacturer to another!
-- The old "buyer beware" adage applies here: when an antenna is claimed to have a "gain" of 3 dB over a dipole, the question is which kind of dipole?
-- Is it an isotropic antenna (dBi) or a real world dipole (dBd)?
-- When an antenna is measured in dBd, it is assuming a more real-world antenna which starts with the dBi number built in.
-- dBd measurements assume an antenna does not radiate perfectly in all directions, but does exhibit directional gain over an isotropic antenna.
-- Real gain is directional, meaning it favors one direction over another.
-- Think of an omni-directional mike versus a directional mike—the omni-directional mike covers more area but with less sensitivity in any one direction.

Antenna Efficiency
One way an antenna is considered efficient is if it radiates the same amount of power given out by the transceiver. Ideally you want 100 watts out for 100 watts in.
-- Even under the best of circumstances you will not get a full 100 watts out (assuming your transceiver is really putting out a true 100 watts!); there will be unavoidably slight losses from radio to antenna, but if everything is working properly these losses are negligible.
-- Your goal, of course, is to make everything work as well as you can, including the transmitter, the feedline, and the antenna.
-- Assuming proper antenna design, more often than not the feedline poses the biggest obstacle to antenna efficiency by interjecting losses to the signal before it ever reaches the antenna.
-- let me underscore here the importance of using high quality, low-loss coax (assuming coax is your feedline choice).
-- Don't get cheap here! I would rather have good coax and a less-capable rig than the other way around. You can't work stations if they can't hear you!
-- A second measure of antenna efficiency is more subjective: does the signal go where it is supposed to go? In other words, given the antenna's design, location, and bandwidth, is it doing what it is supposed to do?

Ground
Ground conditions have a significant impact on how well some antennas radiate.

A horizontal dipole strung between posts at a height of ½ λ typically has good range for medium and long distance communications on HF because ground effects are minimized.

Lower that same antenna to ¼ λ or less and ground conditions become significant. Generally the higher the frequency the greater effect ground conditions have on a signal, to the point where VHF and UHF signals are considered "line of sight" since there is almost no reflection off the ground or from the atmosphere.
-- The reflectivity of ground is dependent on the ground composition.
-- While you can estimate the effects of ground close in, the further you get away from your antenna the more difficult it becomes to determine how your signal will react.
-- We may have hills or valleys or cities surrounding us, which will unavoidably affect our signals, so we just try to do the best we can.
-- Keep in mind when I am discussing antenna theory the point is not to overwhelm you with problems, calculations, or hopeless analysis paralysis!

First and foremost, get on the air! The theory is here to help you build upon your initial experiences and to develop an innate sense of how antennas work in order to slowly but surely improve your station.

Whatever you do, don't get lost in the details! This hobby is about having fun while you learn!