

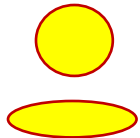

Ham 83 – Electrical, so Antenna basics

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- Recall the intro classes on Ham Radio. How many passive electrical components are there? What are they?
 - Hint: Passive means they exist, function, and operate without any power supply, which gets us to natural law.
 - Any electrical circuit consists of 3 and only 3 electrical components.
 - Resistor (R) is friction like opposition to current flow, converts electrical to mechanical energy, and creates heat.
 - Inductor (L) is the result of bends or turns in wire and converts between electrical and magnetic energy.
 - Capacitor (C) is the result of electrical conductors being adjacent and stores electrical energy.
- Without motors, energized components, and semi-conductors, an antenna is the definition of passive electrical device.
 - Then, an antenna consists of resistance, inductance, and capacitance. Nothing more or less.
 - Resistance is seldom intentionally added, because it converts to heat, which is lost.
 - Since the days of Marconi, most antennas have been designed around an inductor, consisting of turns and long lengths of wire.
 - The hidden part of the design is necessarily a capacitor.
- Natural frequency** is the relationship between capacitance and inductance.

$f = 1 / 2\pi \sqrt{LC}$

 - For an antenna to operate effectively, it must be tuned to the frequency, by changing the inductance and capacitance.
 - As observed above, these change by manipulating their shape.
 - Besides the radiator of the antenna, the other two necessary ingredients are counterpoise and relationship to earth or other metal. These change the capacitance and inductance.
- A fundamental problem with an inductor antenna design is the massive size and the necessity to wind coils.
 - Modern antennas, particularly those on circuit boards, are primarily capacitive design.
 - It is considerably easier to print a metal sheet for a capacitor than to wind a spool of very fine wire for an inductor.
- Traditional ham antennas still harken to Marconi and his long wires. These are simple, although huge.
 - The primary thing considered is wavelength (λ).
 - Modern modelling shows that is often improperly or unnecessarily long.

$\lambda f = c = 300,000,000$
- A much smaller and equally effective approach is capacitive, using sheets or grids of metal, rather than long wires.
 - Cellphones, which are just radios, do not trail lengths of wire. They use designed sheets of metal surface.
 - Sheets rather than wire allow more creative designs, polarization, and noise handling.
 - An effective 80-meter antennas uses 24"-wide fencing with 1/2"-grid, in a roll 10"- across, layers not touching.
 - Tweaking and using dielectric other than air would make it smaller.
- Gain** is an outcome of the First Law of thermodynamics: there is no free lunch.
 - Electromagnetic energy goes into an antenna, like a balloon.
 - To obtain gain, the energy must be squeezed from one direction to another. Gain has direction.
 - Squeeze the balloon on one side to get a bigger bulge (gain) on the other.
 - A 3dB gain in one direction is taken from another, generally by pushing from the sides or top to the front.
- Elevation** is the third ingredient of an effective antenna. The top of the antenna elevation determines its effectiveness.
 - The receive antenna must 'see' the transmit antenna, either directly, by reflection, or refraction.
 - An antenna across the horizon may be skipped over by radio waves.
 - Shorter wavelength and higher frequency are predominantly line of sight (LOS).
 - At a recent Storm Spotter class, the NWS instructor made a repeated point. Their radar cannot see low over the horizon. At a distance, it is only looking at the upper reaches of clouds. Since spin-ups are relatively low altitude, radar cannot see them at a distance.
 - That is why Spotters away from the radar site are so critical.
 - The same thing applies to ham antennas.
- If a station is not visible, you need additional stations (repeaters) or digital nodes to send the signal to a remote radio.
- Power into the antenna comes from the radio. This is not passive and has little to do with antenna design.
- Recap of antenna design:
 - Frequency is determined by the capacitance and inductance of the components, nothing else.
 - Gain is determined by the direction of the antenna, there is no free lunch.
 - Effective range is determined by the elevation of the top of the antenna.
- Life is good. Enjoy!

