Antennas and Feed Lines

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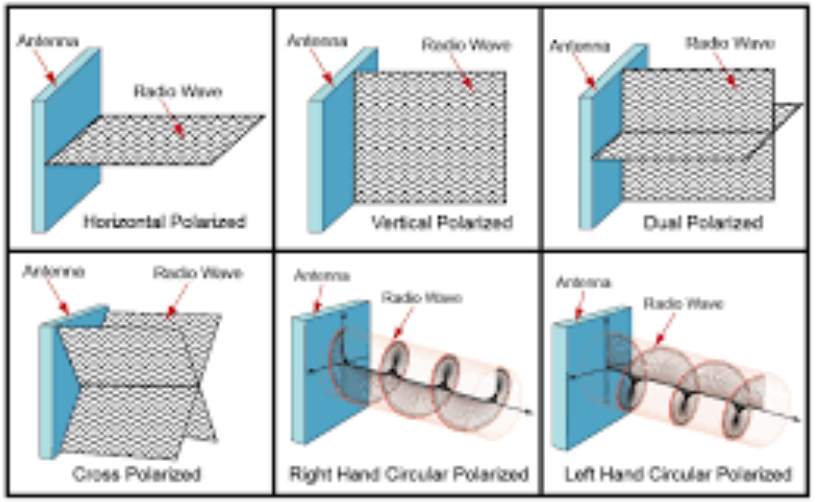
Polarization

- Radio waves have a polarization characteristic as they are emitted from the antenna.
- The orientation of the electrical field describes the signal's polarization.
- If the transmitted signal is vertically polarized and the receiving antenna is horizontally polarized, the received signal will be significantly attenuated.



When working long distances or with weak signals, a horizontal polarization generally works better because most interference (nature made and man made) has vertical polarization

T3B02

Antenna Polarization

- Antenna polarization is important at VHF and higher frequencies.
  - The position of the antenna determines the electrical polarization: vertical, horizontal, or circular
  - A signal from a horizontally polarized antenna will be significantly attenuated by a vertical receiving antenna
  - VHF and UHF FM radios are standardized around vertical polarization (including repeaters), so how you hold your HT makes a difference
  - VHF and higher SSB and Digital modes are generally horizontally polarized
- HF frequencies are usually unaffected by polarization and the ionosphere often reverses the polarization anyway

T3A03, T3A04, T3A09

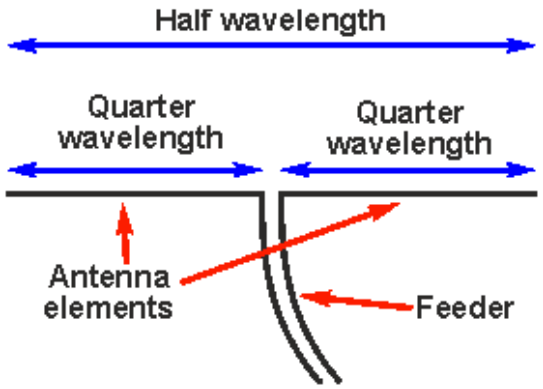
What About My HT?

- Most HT's come with an antenna … commonly called a "rubber duck" as these antennas usually are very inefficient
  - Cheap Chinese radios in particular have poor antennas
- Using an HT in a car can be problematic as the metal body of the car shields the emitted and received radio signals

T9A07, T9A04

Dipole Antennas

- Most common type of antenna
- Radiates well broadside to the antenna
- Length of the antenna wire determines the resonant frequency
  - Shorten to go higher
  - Lengthen to go lower
- Height above ground affects the radiation angle
  - Works best 1/2 wavelength or more above ground

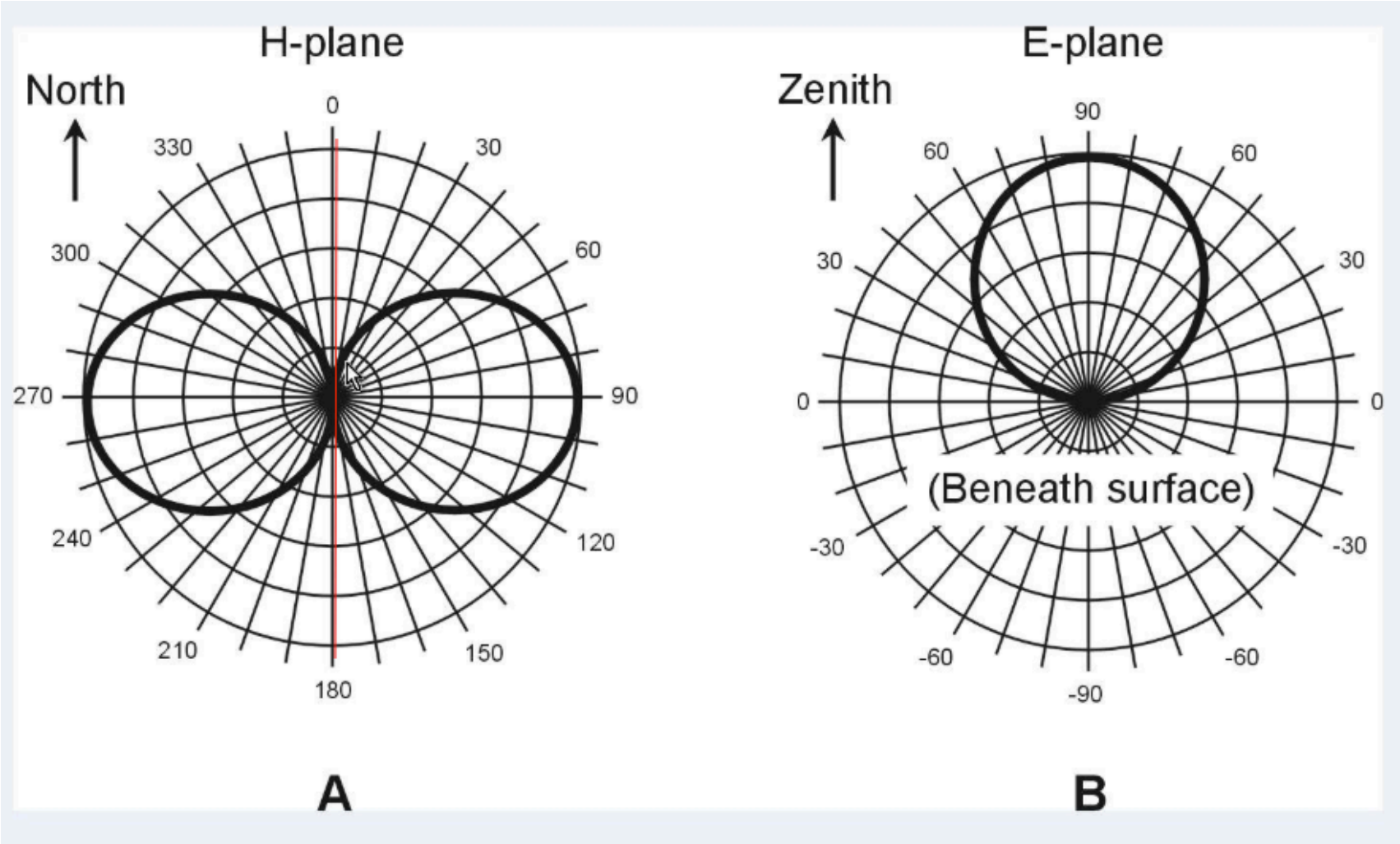


Half wave dipole antenna

Antennas horizontal to the ground are horizontally polarized.

T9A03, T9A05

Dipole Radiation Pattern



T9A10

How Long Should A Dipole Be?

- Length in feet = 468 / frequency in MHz
  - Remember the formula to convert wavelength into frequency
- A 6 meter half-wave dipole?
  - 6 meters = 50 MHz (300/6)
  - length = 468 / 50 = 9.36 feet = 112.3 inches

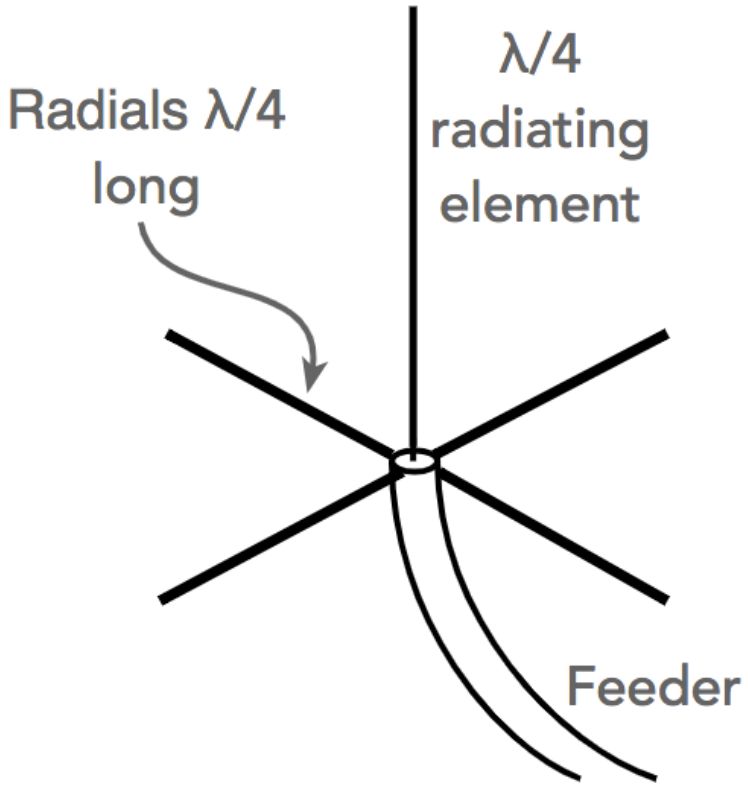
How to remember the formula? Think 2-4-6-8 …

Who do we appreciate?

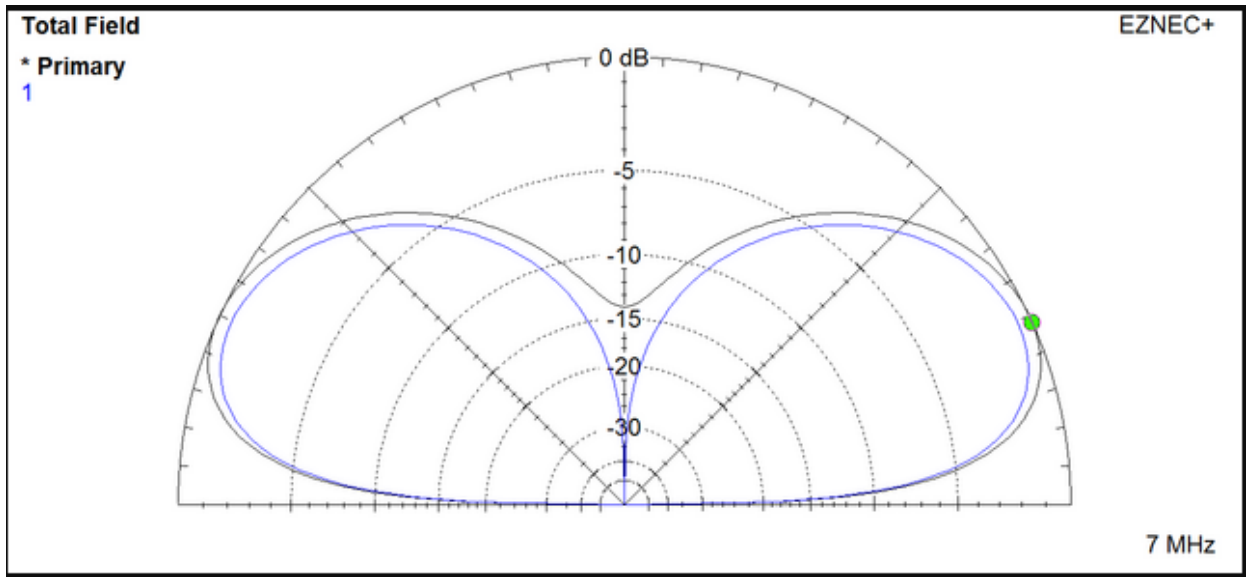
T9A08, T9A09

Vertical Antennas

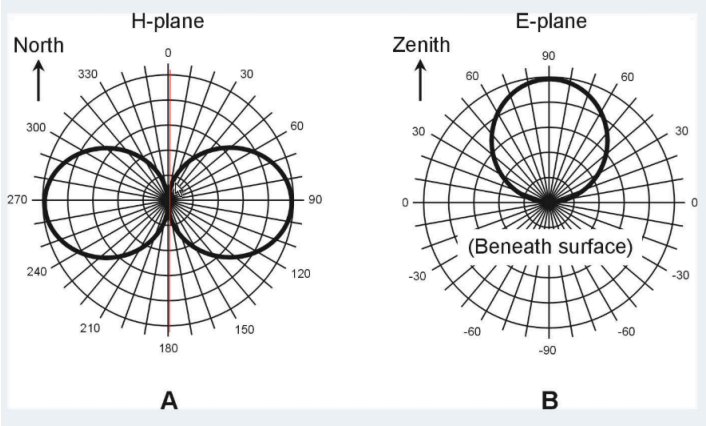
- Vertical antennas have a vertical element (1/4 wavelength) and several radials, also 1/4 wavelength, along the ground
- They have a very low takeoff angle (good for distant contacts)
- More susceptible to noise than horizontal dipoles
- The antenna on your hand-held radio is a vertical antenna with the body of the radio acting as the other half of the antenna

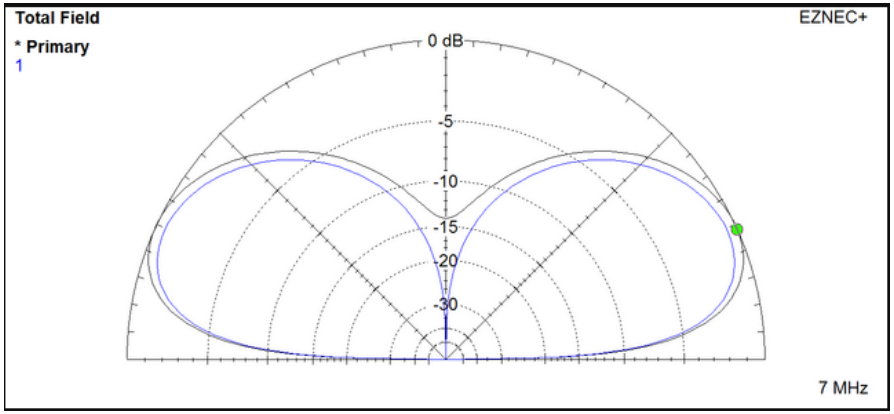


Vertical Antenna Radiation Pattern



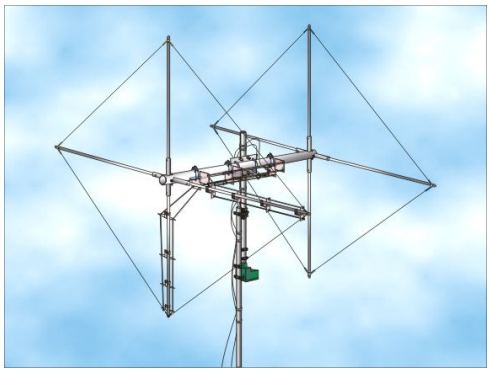
Horizontal vs Vertical Antennas





Directional Antennas

- Yagi, Quad, and Dish are all types of directional antennas
  - Directional means that the radiation pattern is more focused than a dipole or a vertical antenna
- Directional antennas have more “gain” and a higher “front to back ratio”

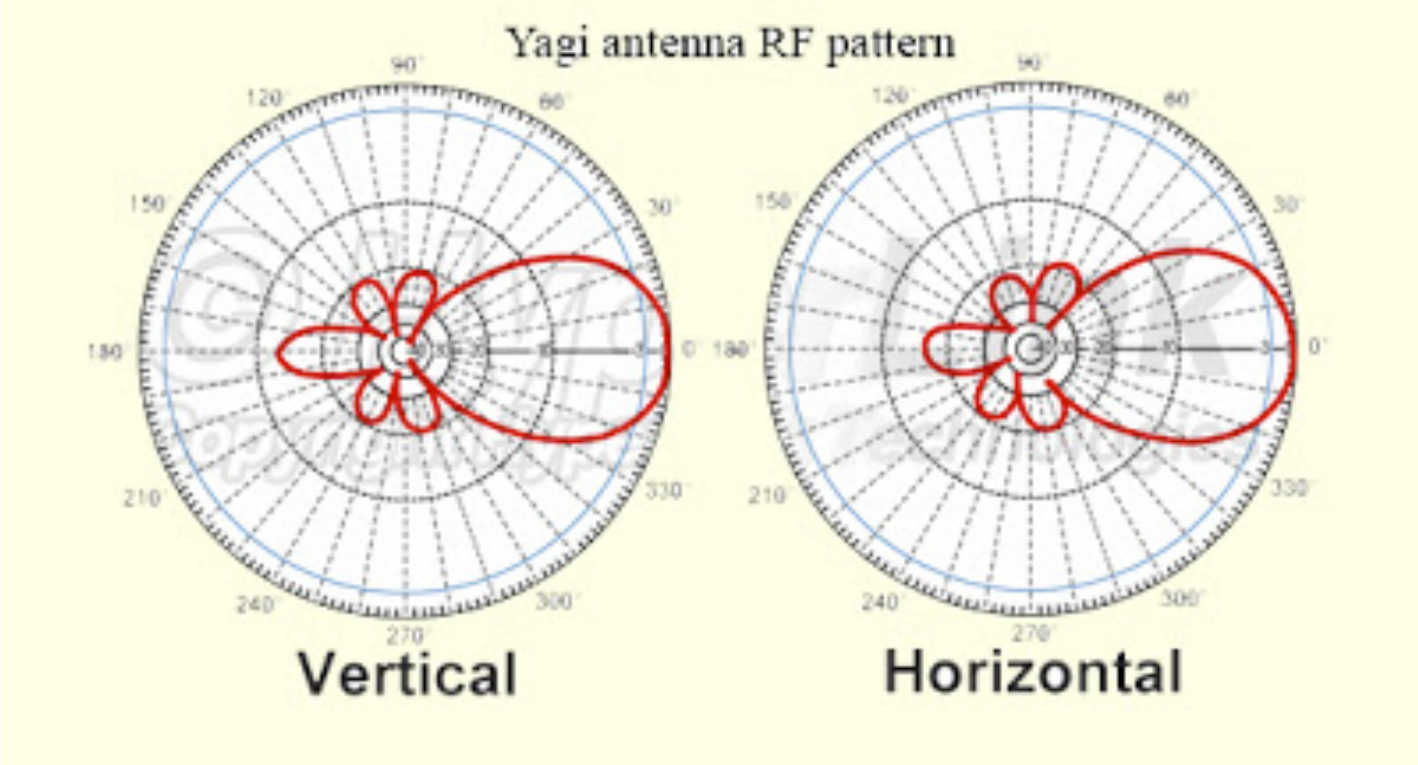


T9A01, T9A06, T9A11

Definitions

- **Gain**: a process of taking RF energy and focusing it in an intended direction. An antenna cannot “amplify” a signal, it can only “shape” a signal thus focusing the radiation
- **Front to Back Ratio**: The relative signal strength at the front of the antenna vs the relative signal strength at the back of the antenna
- Directional antennas a very useful for radio direction finding

Yagi Antenna Radiation Patten

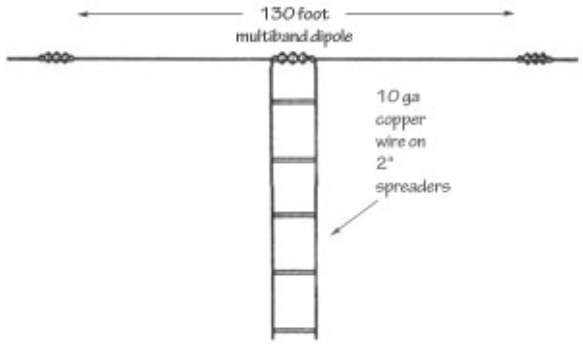


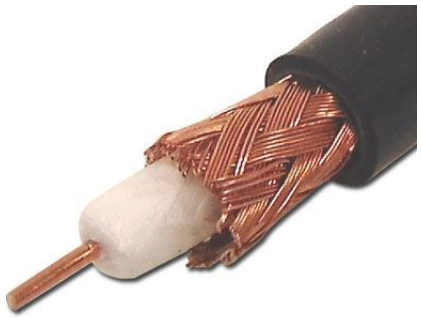
To focus the beam in the vertical: add elements to the beam

To focus the beam in the horizontal: stack another yagi

Feed Lines

- Two main types: ladder line (aka window line) and coax
  - Coax is used most often because of ease of use and no stand-off need
  - Ladder line has the lowest loss
- Each type of feed line has differing characteristic impedance





T7C10, T9B02, T9B03

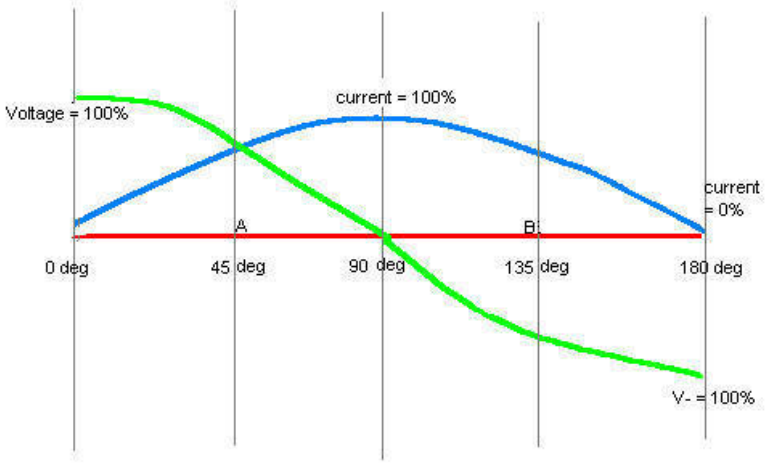
Coax Cable

- The antenna connector on the back of the transmitter / receiver expects to see an impedance (resistance) of 50 ohms
- Coax generally has either 50 ohms or 75 ohms of impedance (50 ohms … amateur; 75 ohms … TV)
- Coax used outdoors needs to have a weather and ultraviolet resistant outer jacket.

Antenna Impedance

- The impedance at the feed point varies across the length of the antenna
- If the impedance of the antenna at the feed point varies much from the impedance of the feed line, some of the energy is reflected back towards the transmitter rather than going into the antenna
- If the mismatch is greater than 3:1 (150 ohms at the feed point and 50 ohms at the transmitter), then the transmitter may “fold back” the power to reduce chance of damage to the final amplifier

T9B04

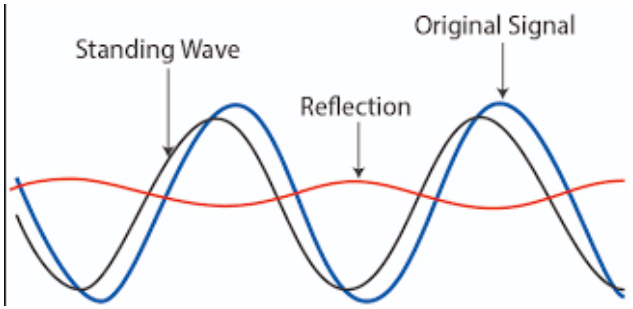


The method to address the mismatch is to insert a “transmatch” (short for transformer match) between the feed line and the antenna

Another name for a transmatch is an “antenna tuner”

Standing Waves

- The amount of power reflected back to the transmitter varies with the mismatch
- The returning wave combines with the transmitted wave to cause a “standing wave” on the feed line. The ratio between the transmitted wave and the reflected wave is called the “Standing Wave Ratio”
- Eventually the energy not getting into the antenna goes up in heat in the coax. The greater the SWR, the more heat



Reflected power from a mismatch comes back down the feed line on the outer jacket of the coax. This reflected RF power can “bite” the operator and may result in reports of garbled, distorted, or unintelligible voice transmissions

T7B11, T7C03, T7C07, T9B01

Antenna / Feed Line Factoids

- A 5/8 wave vertical antenna has higher gain and a “squashed” signal pattern vs a 1/4 wave antenna
  - Often used for mobile antennas
- Inductance coils are used to electrically lengthen shorter antennas. These coils are often located in the center of the vertical antenna
- All feed lines have loss. The longer the feed line, the more loss. Coax has significantly more loss than window line but is easier to use
  - The difference between RG-8 and RG-58 is the latter has more loss than the former
- Coax must be protected against moisture incursion. The copper braid will disintegrate
- Air-insulated hardline: lowest loss, hardest to use, install, and maintain

T7C11, T9A02, T9A12, T9B08, T9B09, T9B10, T9B11

Coax Cable Loss per 100 Feet

Coax Type	Size	Loss at HF 100 MHz	Loss at UHF 400 MHz
RG-58U	Small	61% (39 W)	90% (10 W)
RG-8X	Medium	66% (34 W)	61% (39 W)
RG-8U	Large	20% (80 W)	48% (52 W)
RG-213	Large	20% (80 W)	40% (60 W)
Hardline	Large, Rigid	6% (94 W)	16% (84 W)

Note that as the frequency increases, the amount of loss increases

T9B05

Coax Connectors

- PL-259 (top image) connectors, also called UHF connectors (a misnomer), fit on the ends of the coax.
- SO-239 (middle image) connectors are commonly found on transmitters / receivers as the coax connector.
- PL-259 and SO-239 tend to be lossy, particularly at frequencies above 50 MHz and are not waterproof.
- Type N (bottom image) connectors are waterproof and work well up into the high gigahertz ranges.

T9B06, T0B07

A Few More Factoids

- An antenna analyzer can be used to measure the SWR of an antenna system. Directional watt meters (aka SWR meter) can be placed in line with the feed line to measure SWR while transmitting
- A perfect impedance match (1:1) is achievable (??). A match of 1.5:1 and lower is considered a good match. Higher than 3:1 is a problematic match and likely will cause the transmitter to “fold back” to protect the final amplifier
- Loose connections (at the transmitter, the trans match, or the feed point) will cause erratic SWR readings
  - Deteriorating coax due to water damage will also exhibit strange SWR readings
- A “dummy load” is very useful when testing a radio but don’t want anything to be transmitted
  - A dummy load is simply a set of resistors giving an impedance of 50 ohms to the transmitter but sized large enough to handle the heat produced as the resistors use up the transmitted energy

T4A05, T7C01, T7C02, T7C04, T7C05, T7C06, T7C08, T7C09, T7C12

Jot down any questions you may have to ask during the online meeting