Maximizing Performance from Simple Antennas

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Agenda

- Introduction
- Antennas: RF to EM waves
- Simple Antenna Types
  - Verticals
  - Dipoles
- Amplifier vs Better antenna
- Antenna Performance Secrets
- Case Study: Spanning the globe with a simple 160 meter antenna
- Conclusion

Introduction

Most important part of an amateur station is the antenna system

The antenna system can be the most expensive or least expensive part of the station.

Inexpensive Antennas

- Worldwide communications can be achieved with an inexpensive antenna
- Commercial dipole antenna kits can be purchased for as little $50 dollars
- Homebrew antennas can be made for under $25 dollars
- Most hams use simple antennas for economic or because of real estate restrictions

Expensive Antennas

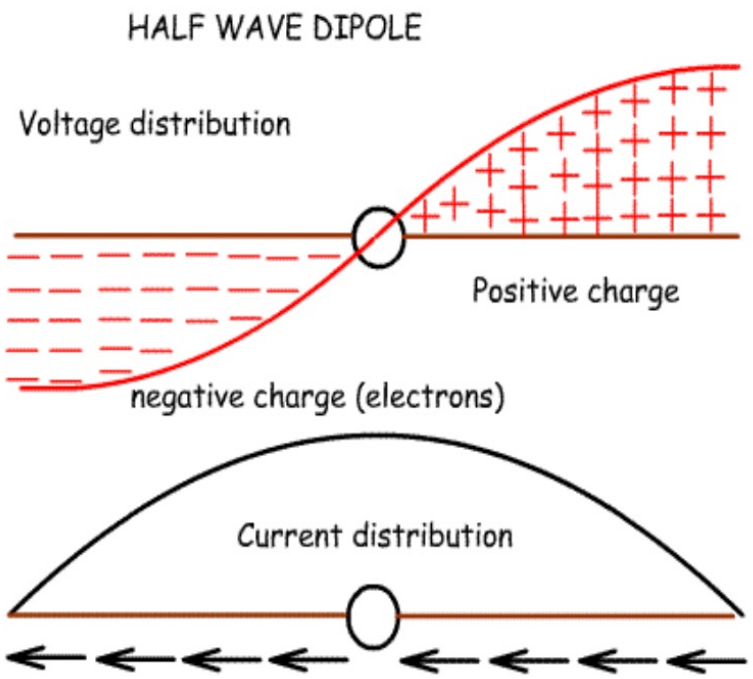
On the other end of the spectrum an elaborate antenna system can cost $10000+

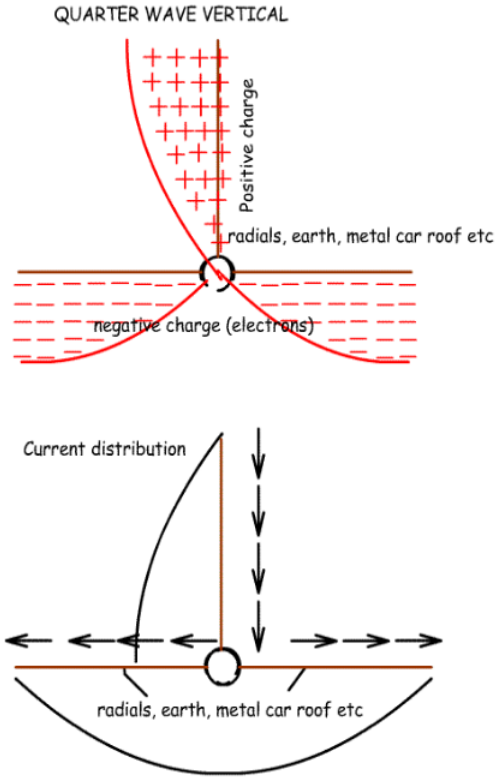
- High performance 7 element Yagi beam
- Rotator and control box
- Tower structure and installation
- More punch and geared toward for die-hard contesters

Antenna RF to EM wave

What is an antenna ?

- Antenna is device that converts RF energy (high frequency AC) into EM waves (i.e. photons)
- Antennas are bi-directional, same antenna will convert EM waves back into RF energy





Horizontals (Dipoles)

1) Horizontal antenna (i.e. dipole or Hertzian)

Most common antenna for new ham and old timers

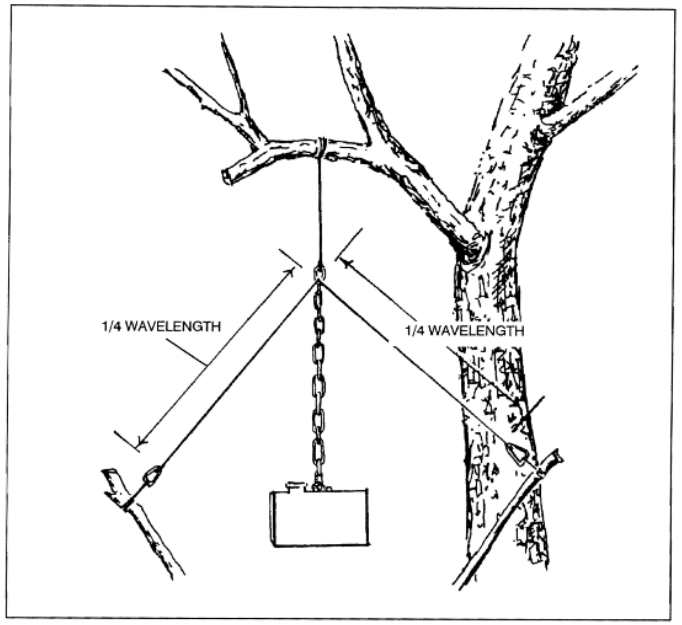


Figure D-10. Inverted Vee antenna.

Pros:

- Simple, cheap, no ground needed and easy to setup
- Good Rx and Tx gain

Cons:

- Requires real estate (e.g. 66 ft for 40 meters)
- Take off angle dependant on height (more on this later)

Variation #1: Inverted 'V' ➔ Improved real estate footprint and low take off angle

Variation #2: Sloper ➔ Improved real estate footprint and low take off angle

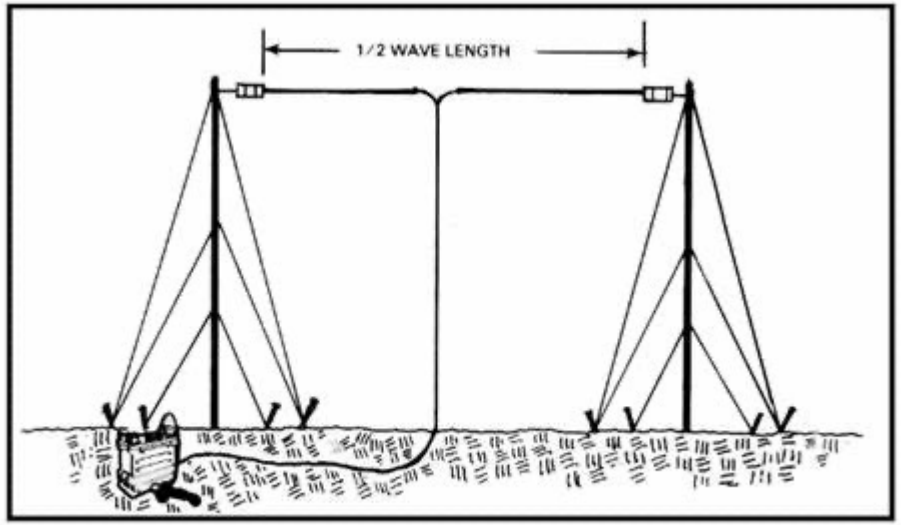
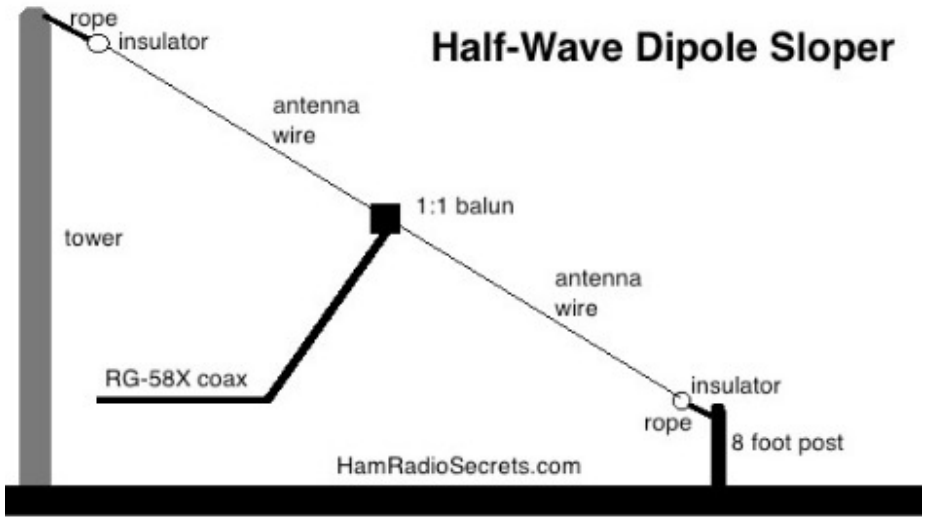


Figure 3-12. Center-fed Hertz antenna with two upright supports.



Verticals

2) Vertical antenna (i.e. Marconi)

<u>Pros:</u>

- Simple, cheap, and easy to setup
- Real estate efficient
- Low angle of radiation

<u>Cons:</u>

- Rx sensitivity for ¼ wave vertical is not optimal
- Not as efficient as dipole. Ground rod is not perfect counterpoise
- Secret to better performance, use ¼ wavelength counterpoise radials instead of ground rod

→ Self standing antenna can be made with fiberglass rod (i.e. fishing pole)

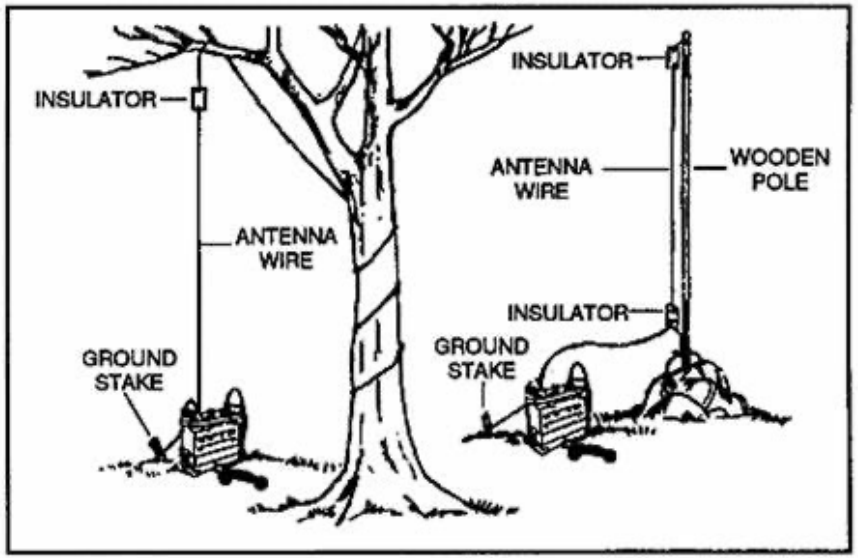
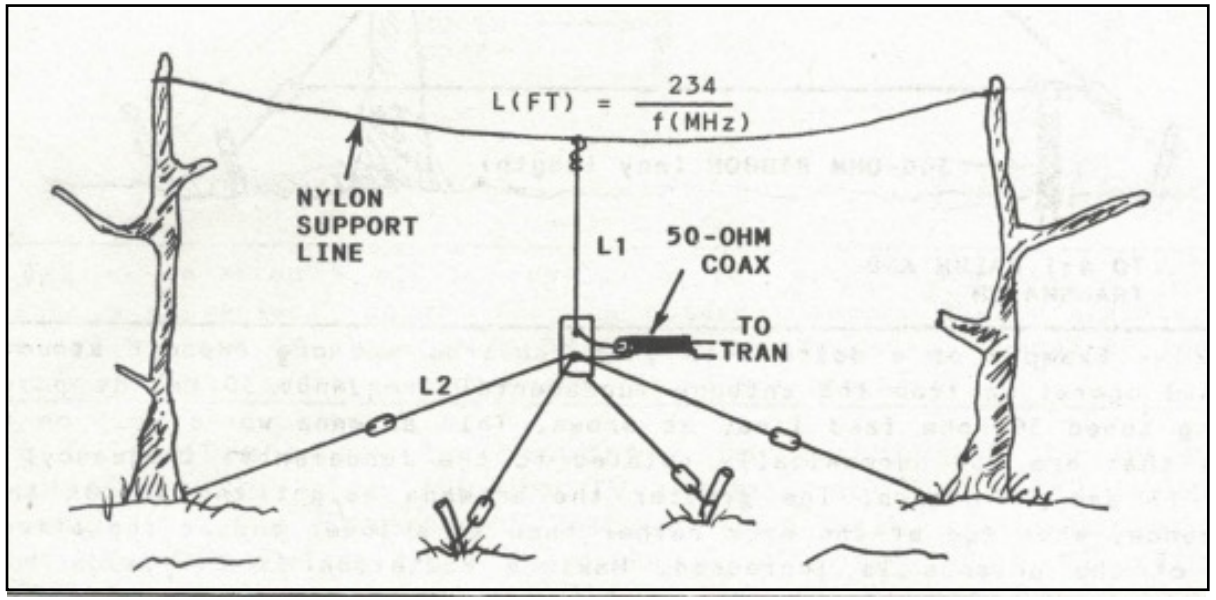


Figure 7-3. Field substitutes for support of vertical wire antennas.



Amplifier versus BetterAntenna

<u>Bigger Amplifier (better Tx)</u>

- Same stations will hear you louder
- Some stations who you can't hear, will hear you now

➔No more new contacts then before

<u>Better Antenna (better Tx and Rx)</u>

- Same stations will hear you louder
- You will hear new stations not possible before with inferior antenna

➔Better chances at winning contests and award hunting

Antenna Performance Secrets

1) Antenna Impedance Perfect Match

- Antenna and feedline must be matched
- At resonance antenna appear as resistor (e.g. 50 ohms)
- All power will be radiated (or absorbed in receive mode)
- SWR will 1:1

In most cases match is not perfect

- Simple antennas dipoles and vertical can be cut to match
- Loading coil helps TX match, but RX reception suffers
- Antenna tuner cancels out L or C components and maximizes power into feed line.

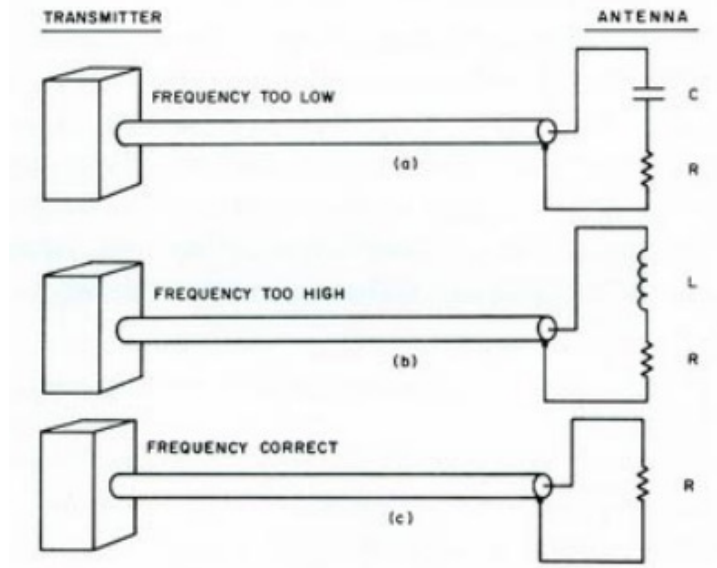
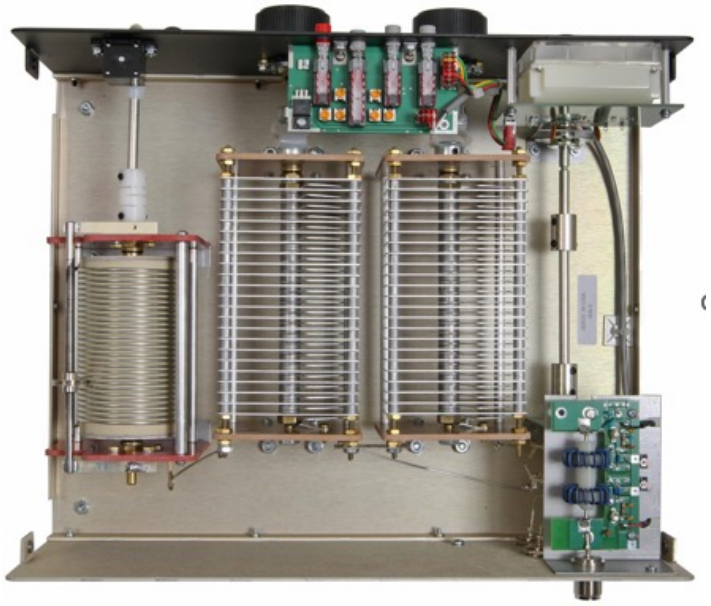


FIG. 11 EQUIVALENT CIRCUITS FOR ANTENNA BELOW, ABOVE, AND AT RESONANCE



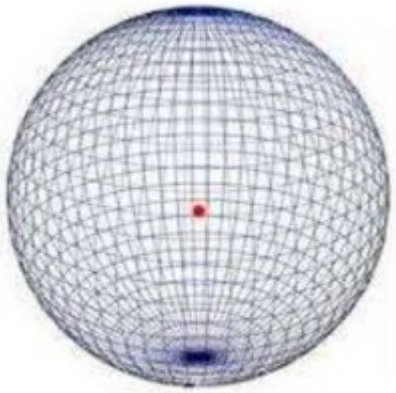
Antenna Performance Secrets

2) Antenna Directionality

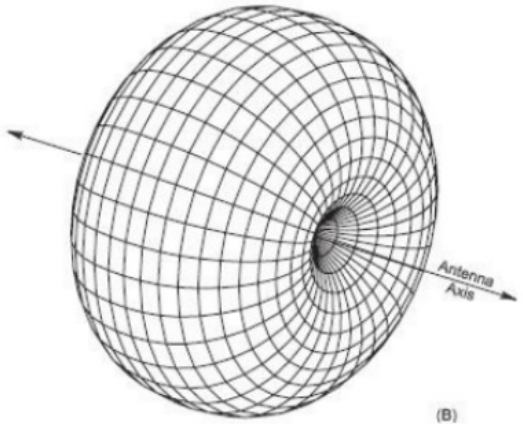
a) All antennas are referenced to theoretical **isotropic antenna (**using dBi units)
Radiates equally in all directions. Not possible to implement such an radio antenna in practice
The sun is an example of isotropic radiator of visible light, IR and UV. ➔ Radiation pattern is a ball or globe

b) Dipole has bi-directional radiation pattern
➔ Radiation pattern is “donut” around the horizontal radiators

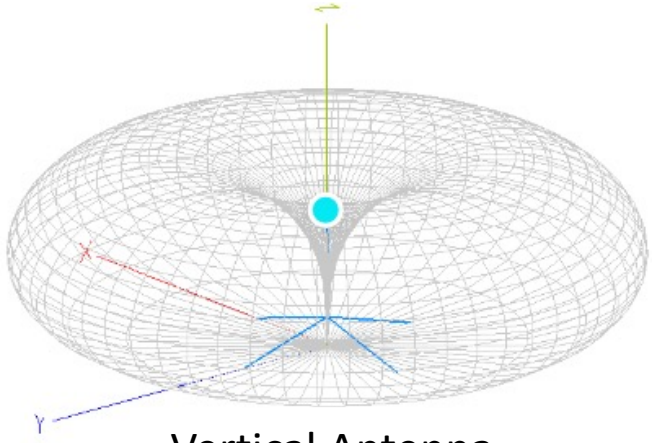
c) Vertical antenna has omnidirectional radiation pattern
➔ Radiation pattern is a “donut” around the vertical radiator



Isotropic Antenna



Horizontal Antenna



Vertical Antenna

Antenna Performance Secrets

3) Take Off Angle

Lower take angle (TA) ➔ farther reach

The polarity of antenna determines takeoff angle

a) Vertical antennas produce low TA even when directly on ground

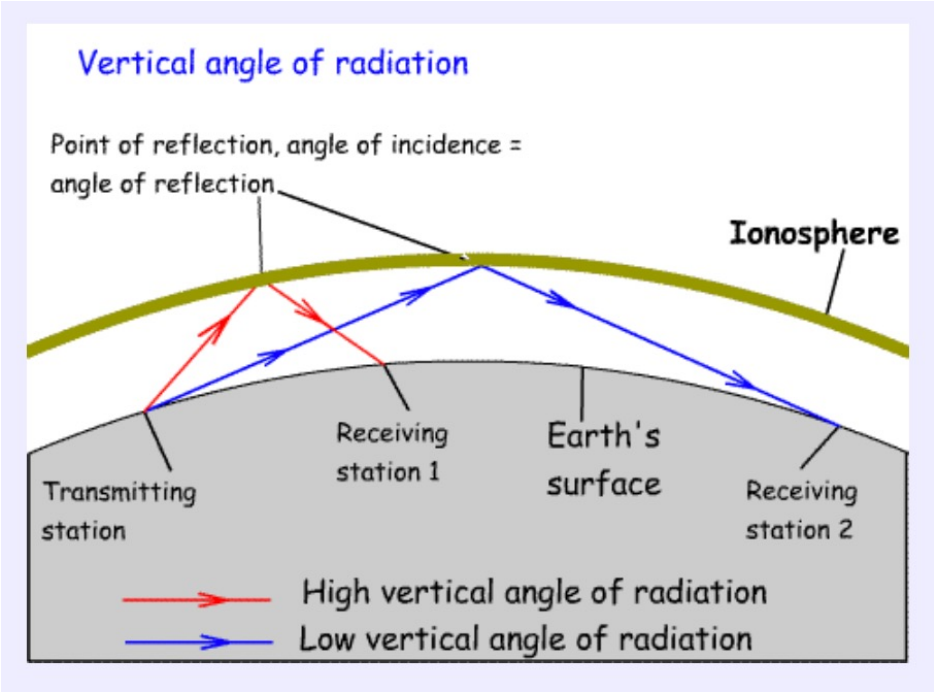
b) Horizontal antennas ➔ height (λ above ground) determines TA

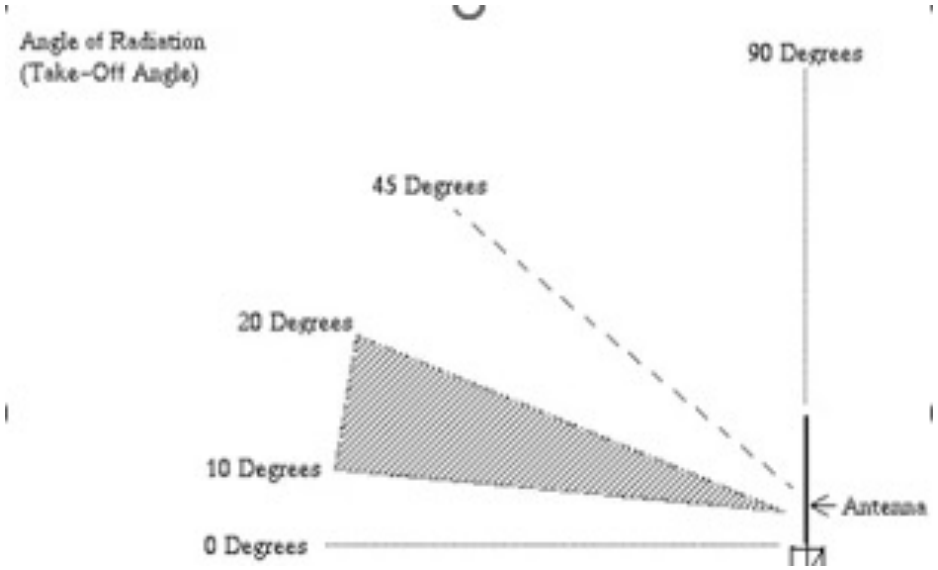
Magic TA angle for DXing is between 10 and 20 degrees

Take Off Angle = Sin^{-1} (0.25/h) where h = height/wavelength

Example, 40 meters operation

- Height = 10 meters ➔ TA= **90 degrees** (h = 10/40)
- Height = 20 meters ➔ TA= **30 degrees** (h = 20/40)
- Height = 40 meters ➔ TA= **15 degrees** (h = 40/40)

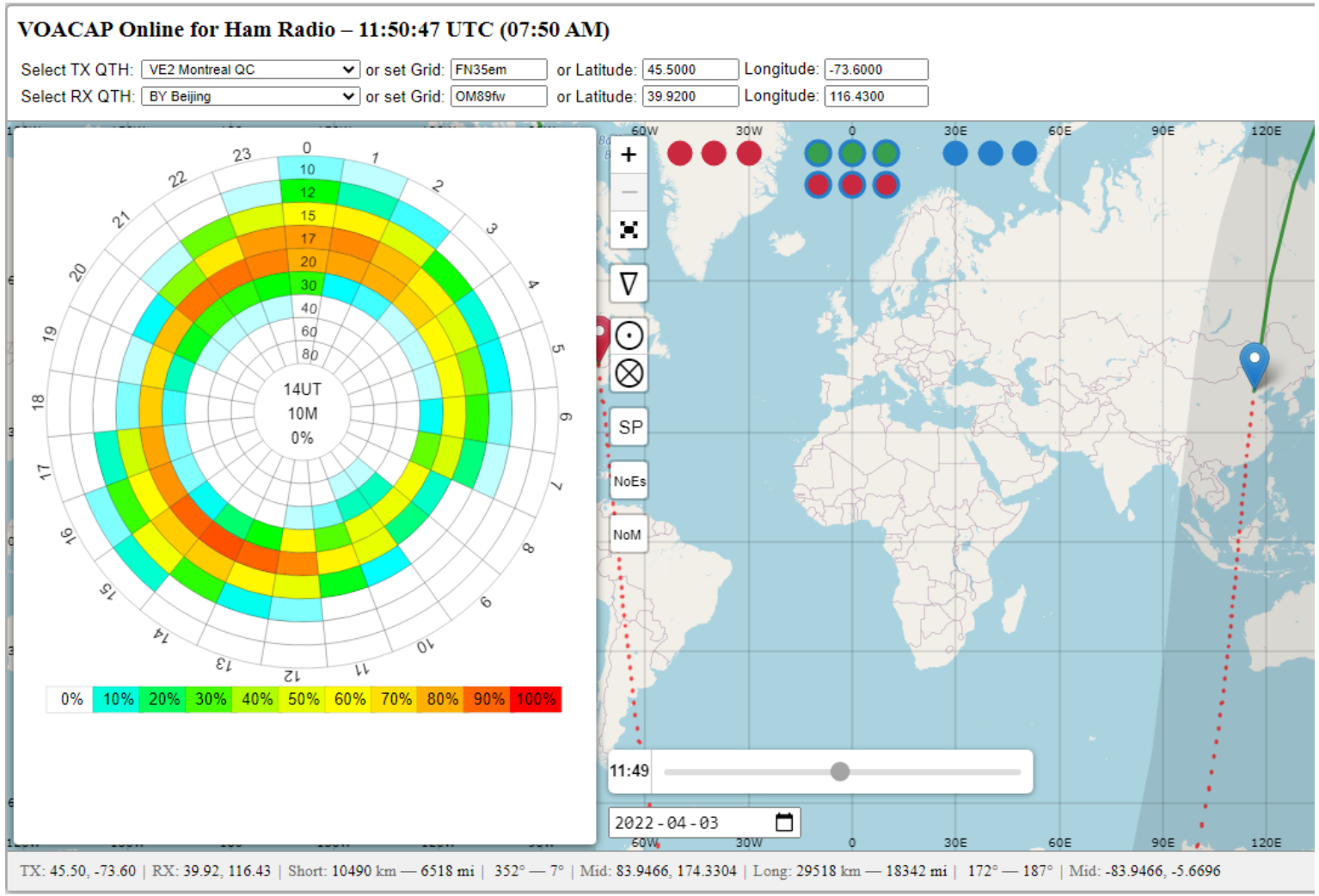




Antenna Performance Secrets

4) Propagation Conditions

- Despite perfect antenna setup and positioning, DX contacts are not possible due to weak propagation
- VOA (Voice of America) CAP website useful to identify most opportune bands and times between two points



160 meter Inverted L Antenna

This antenna was built using concepts previous described.

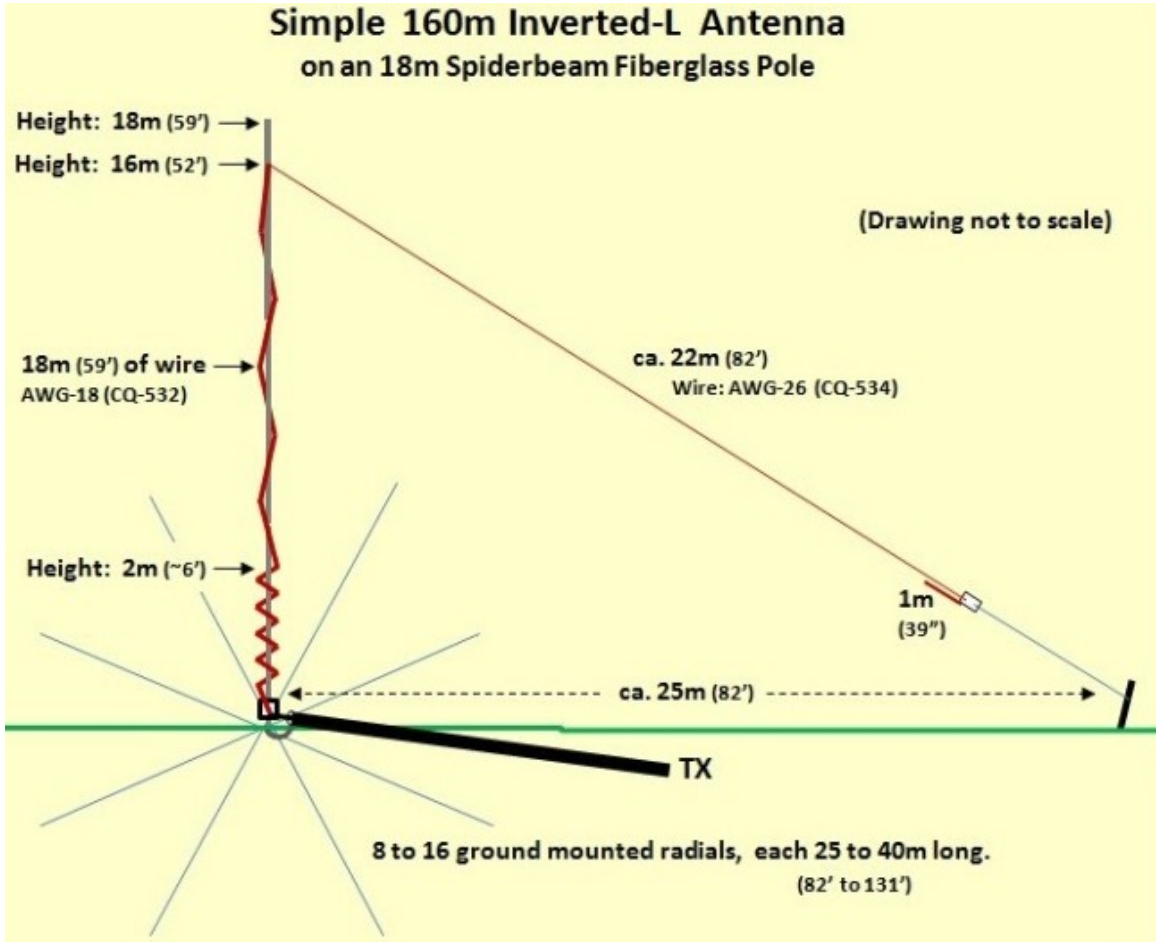
- Counterpoise system (40 m)
- Antenna has vertical radiator (15 m)
- Antenna has sloper element (22 m) at 45%
- Real estate friendly: (max height 15m + footprint 25m)

DJ0IP Richard Westerman design (shown in figure)

➔ Vertical + 45% sloper element

VE2DPE Claude Jollet design

➔ Vertical + 90% sloper (perpendicular to vertical element)



160 meter Inverted L Antenna

My antenna is simplified version with no copper wire.

- One counterpoise (40 m of insulated steel wire) floating on ground
- Westerman used 8-16 counterpoise elements, his performance will be better

The radiating section consisted of the two sections of “aircraft cable”

- 15 meter vertical from ground to tree top
- 25 meter sloper from tree top to 8 ft above ground.

Both sections provided good RX gain and good TX take off angle.

➔ Contacted Australia with this antenna in early October 2023 via FT8

Conclusion

Worldwide communication possible on regular basis with simple antennas

- Dipole
- Vertical

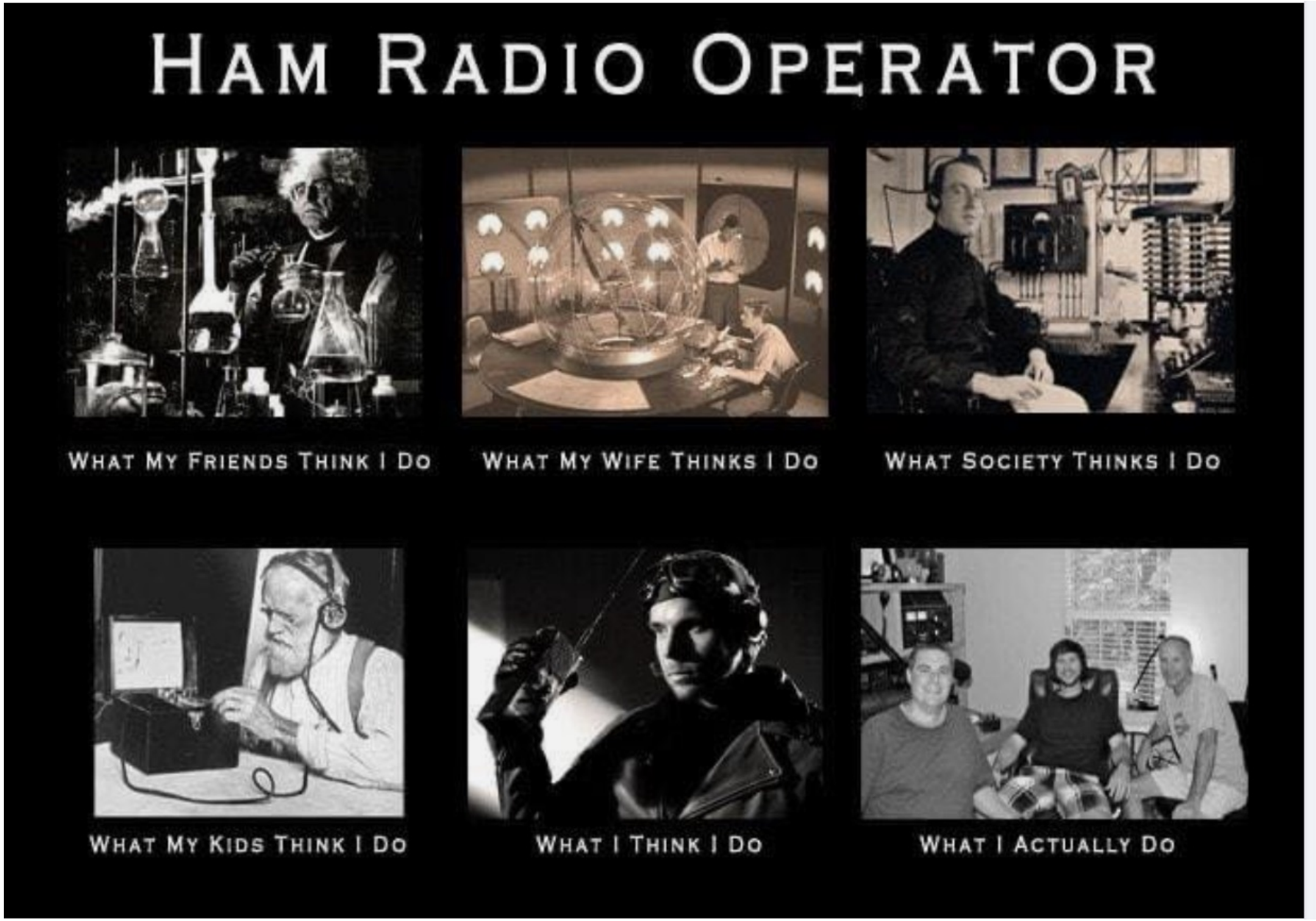
Optimization includes the following

- Match transmitter impedance to antenna
- Aim antenna in desired direction
- For horizontal antennas, ensure height is at least ½ wavelength for low TA
- Check propagation with VOACAP

Westerman 160 meter antenna uses the following tricks:

- Several counterpoise(s) ¼ wavelength elements
- Vertical radiator (15m) combined with sloper radiator (22m) for ¼ wavelength for low take off angle
- Impedance match with ½ wavelength of total loaded elements

Questions ?


HAM RADIO OPERATOR
WHAT MY FRIENDS THINK I DO
WHAT MY WIFE THINKS I DO
WHAT SOCIETY THINKS I DO
WHAT MY KIDS THINK I DO
WHAT I THINK I DO
WHAT I ACTUALLY DO