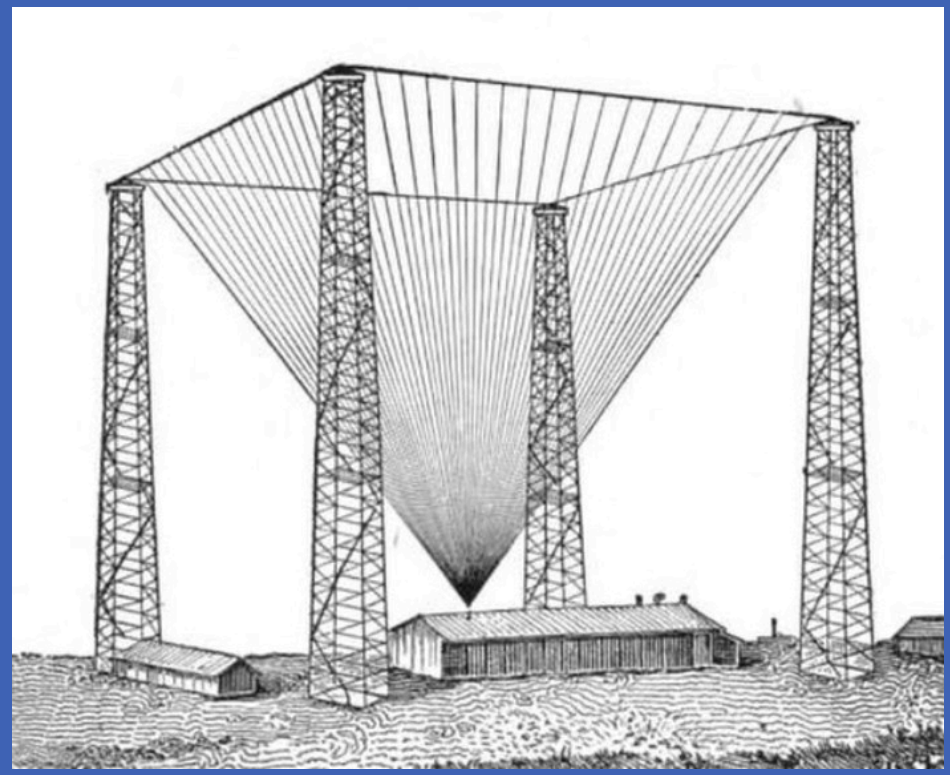
Antennas - Where the magic of radio begins

A brief summary of a number of popular antennas by David Okrent, W7DAO



Time for a Quick Review

$X_L = 2\pi fL$

$Z = R + X_L + X_C$

$X_C = 1/(2\pi fC)$

Feet = 486/MHz

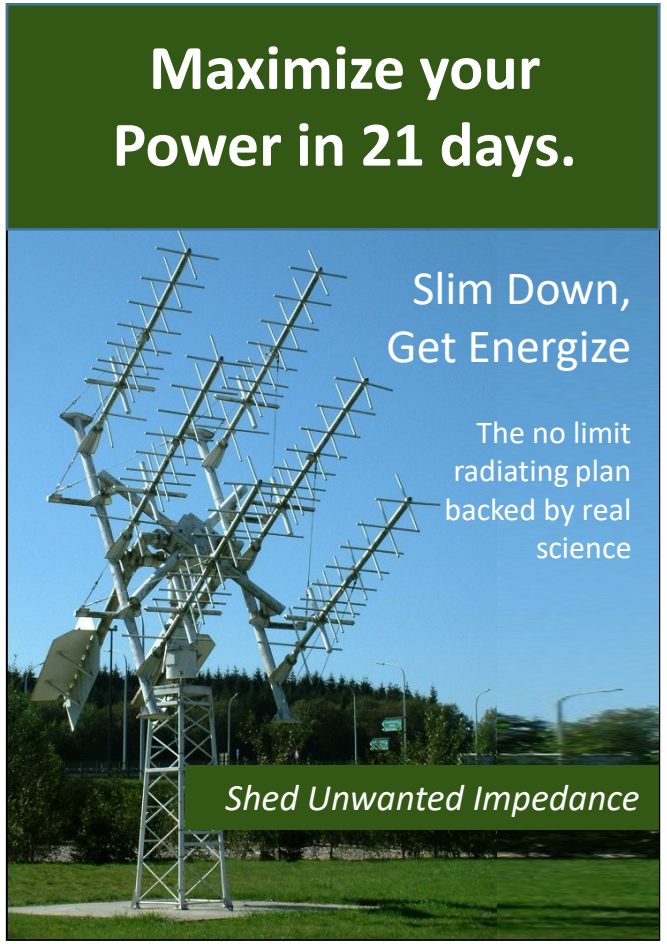
Keep in mind…

An antenna is one element of the circuit driven by an RF generator

The RF Generator, transmitter, feeds energy to all the items between it and the environment around the antenna.

Our objective is to maximize radiated power (radiation resistance).

Step 1: Maximize power transfer to the antenna by matching the transmitter and antenna impedances.

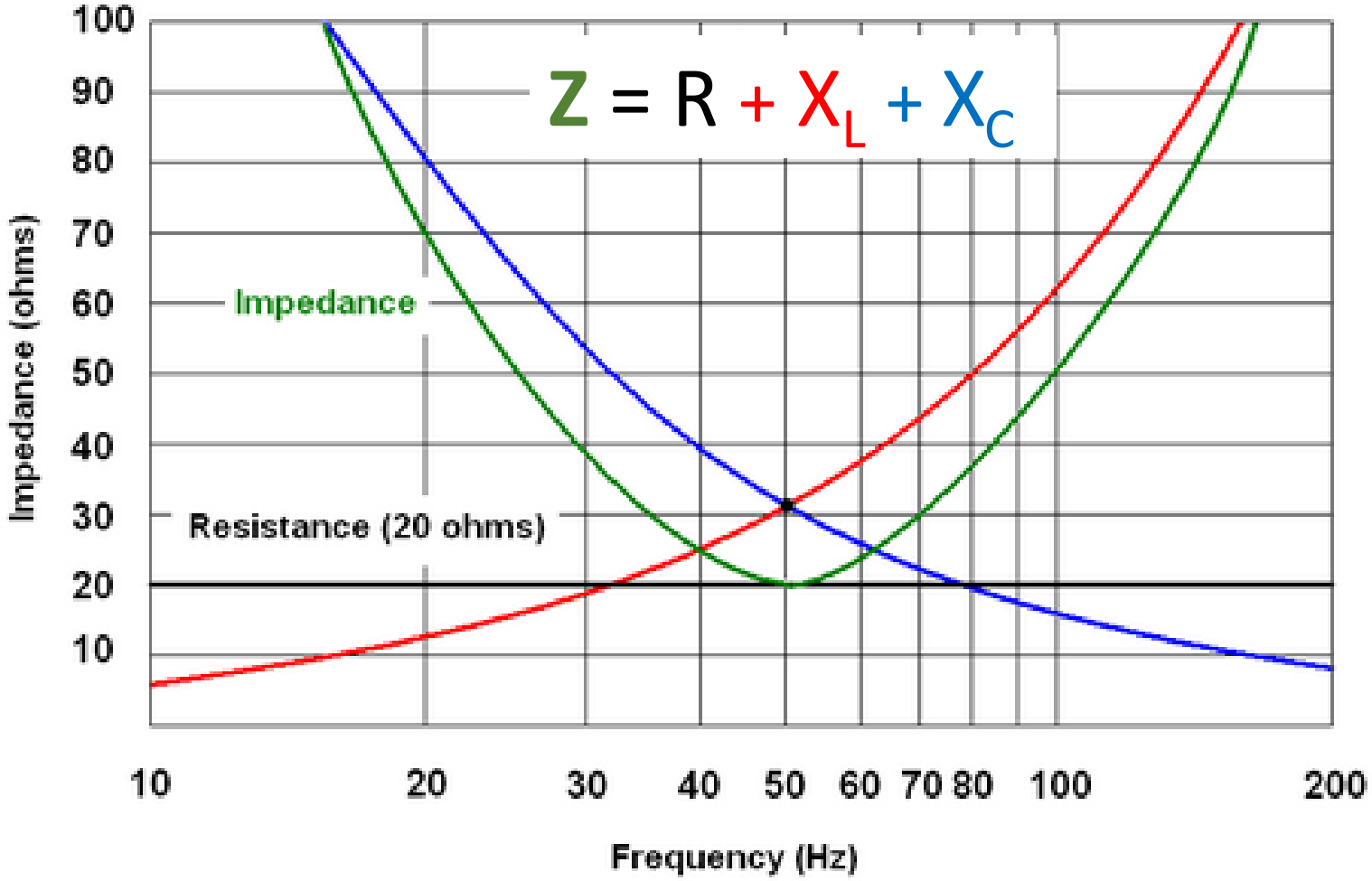


A quick review…

$X_L = 2\pi fL$

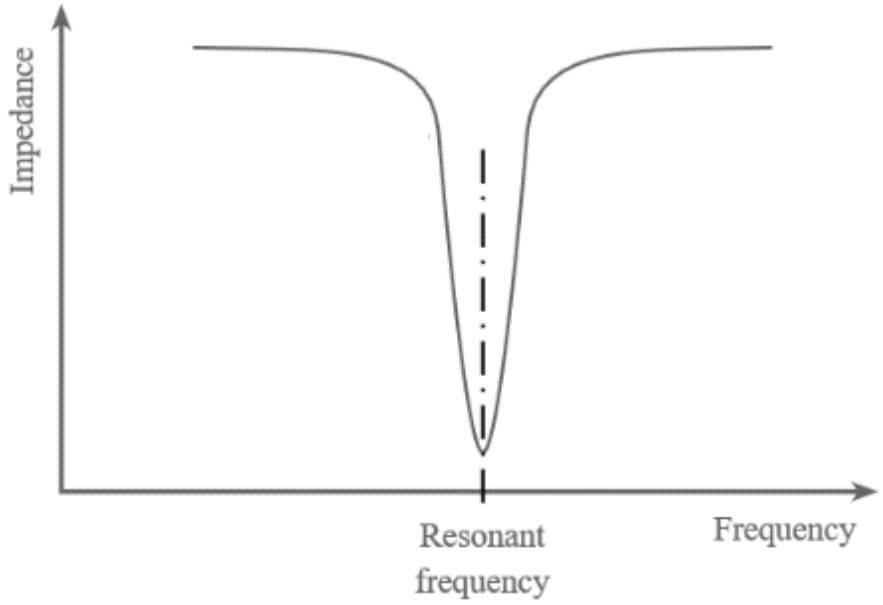
$X_C = 1/(2\pi fC)$

$$f_R = \frac{1}{2\pi\sqrt{LC}}$$

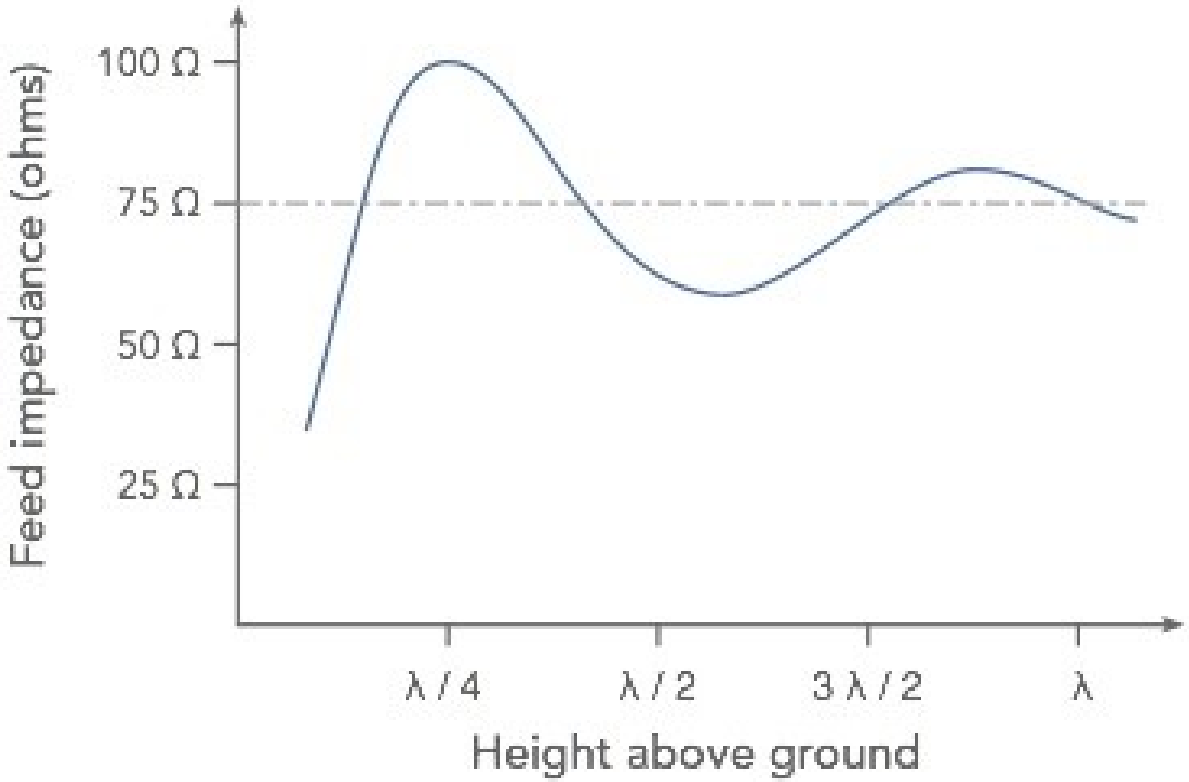


http://rsdacademy.net/textbooks/acelectronics/Part2/ResonantCircuits.html

Impedance varies with frequency and it changes with height.



https://www.electronics-notes.com/articles/antennas-propagation/antenna-theory/resonance-bandwidth.php



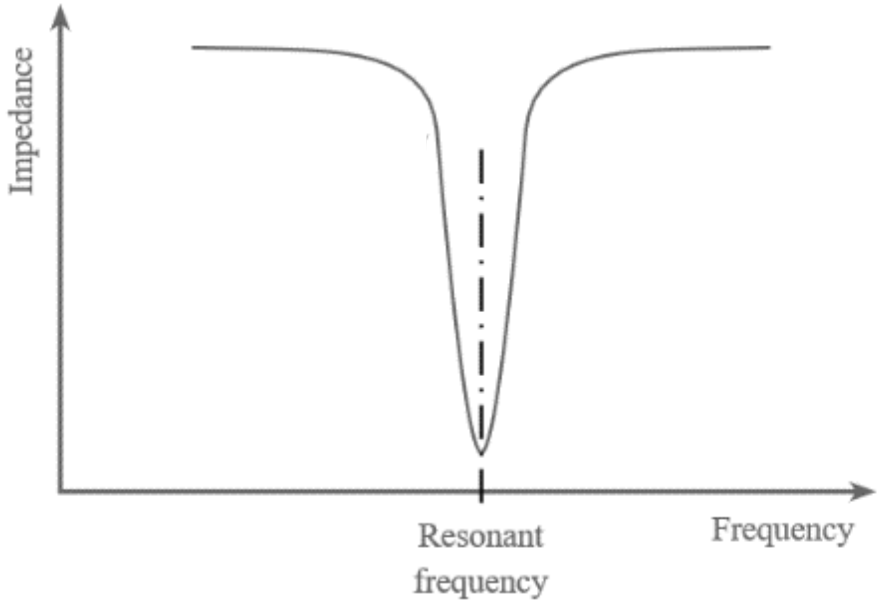
And much more…like quality of ground (earth) under the antenna and the buildings and trees nearby.

How is power transfer maximized if impedance (Z) changes as we adjust the frequency?

1. Accept the losses (heat) that occur as long as they are within the tolerances of your transmitter

2. Utilizes a fixed impedance transformation to bring the antenna system within the area of #1.

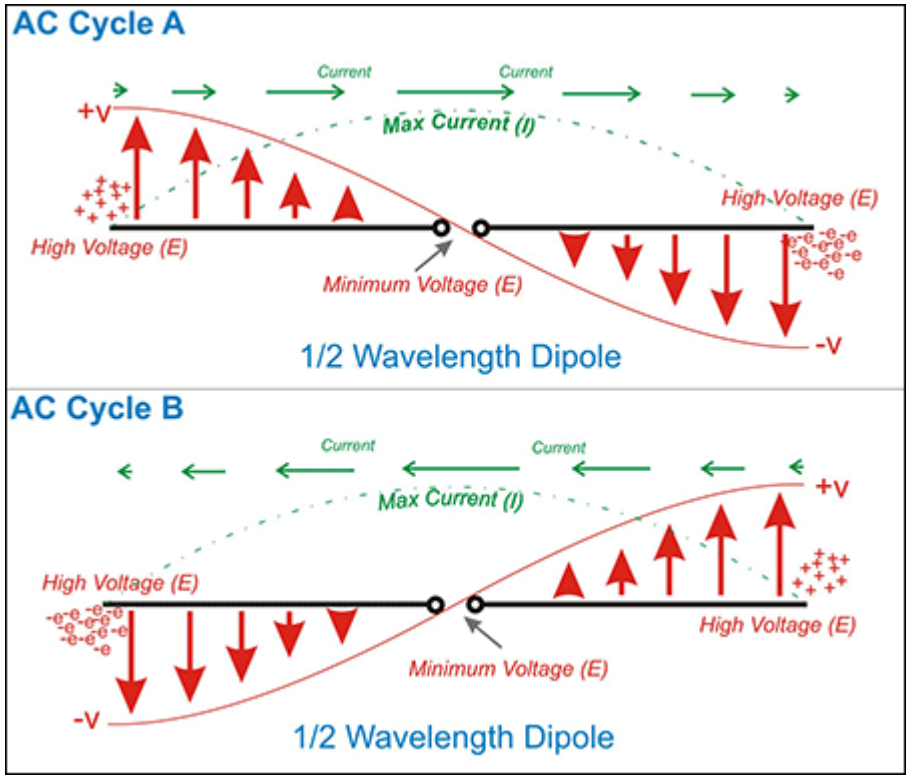
3. Attached an antenna tuner (transmatch), variable impedance transformational network between the transmitter and the antenna system (may still need #2).



https://www.electronics-notes.com/articles/antennas-propagation/antenna-theory/resonance-bandwidth.php

Keep in mind…

There are balanced and unbalanced antennas



A balanced antenna doesn't like being attached to an unbalanced line, coax; therefore you need a balun between the two.

The balun attempts to keep the current equal on both sides of the dipole.

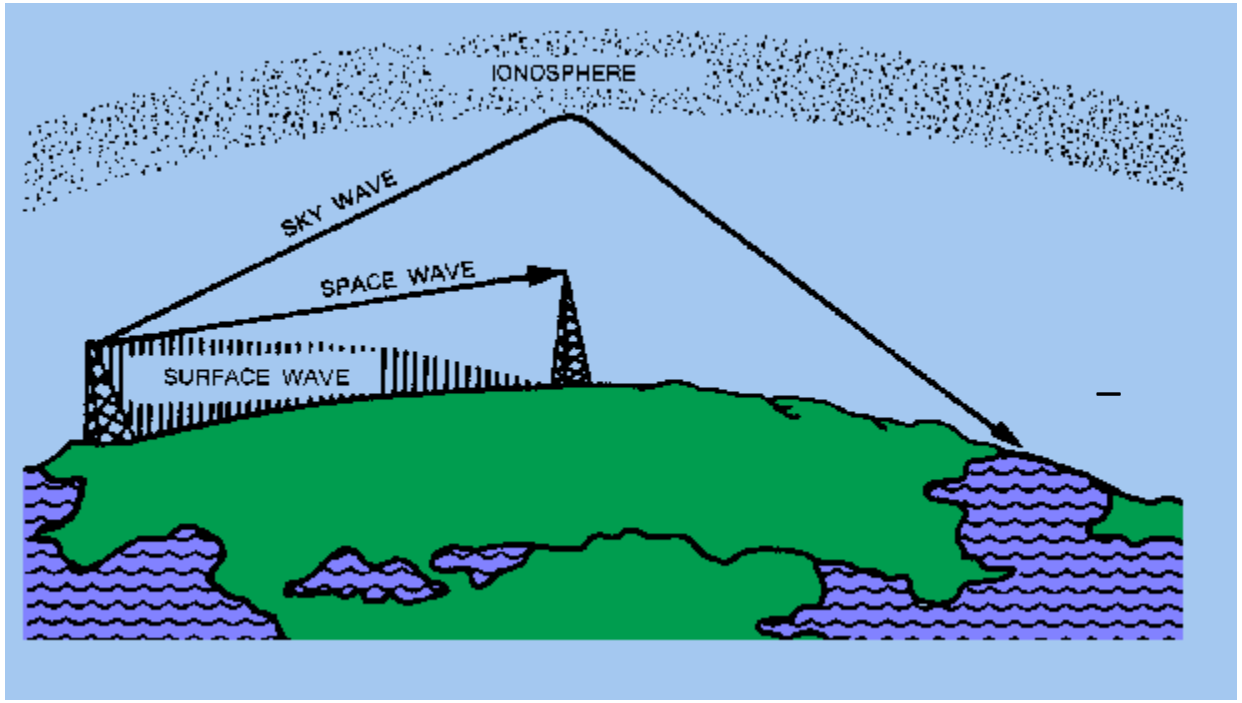
Baluns are not impedance transformers, when they are greater than 1:1 it means an impedance transformer is built in.

Unbalanced antennas, like random wire or end-feed half-wave dipoles use ununs to match to coax. These are only impedance transformers.

https://hamradioschool.com/general-question-of-the-week-g9b08-dipole-impedance/

Does polarization matter?

It depends…



For VHF, UHF and above, where we are more point-to-point terrestrial, i.e., where surface and space waves are dominant – **Yes**.

For DX, where we want skip, focusing on using sky waves – **No**.

Why no? The interaction with the ionosphere and refraction back causes the waveform to become elliptically polarized (right- or left-handed).

Other items that make this simple thing complex are…

Diameter of wire or tube conductors

Insulate or uninsulated wire

Type of material – copper or aluminum

Antenna coupling method

Length or overall dimensions of the antenna

Environment around it

Use of traps

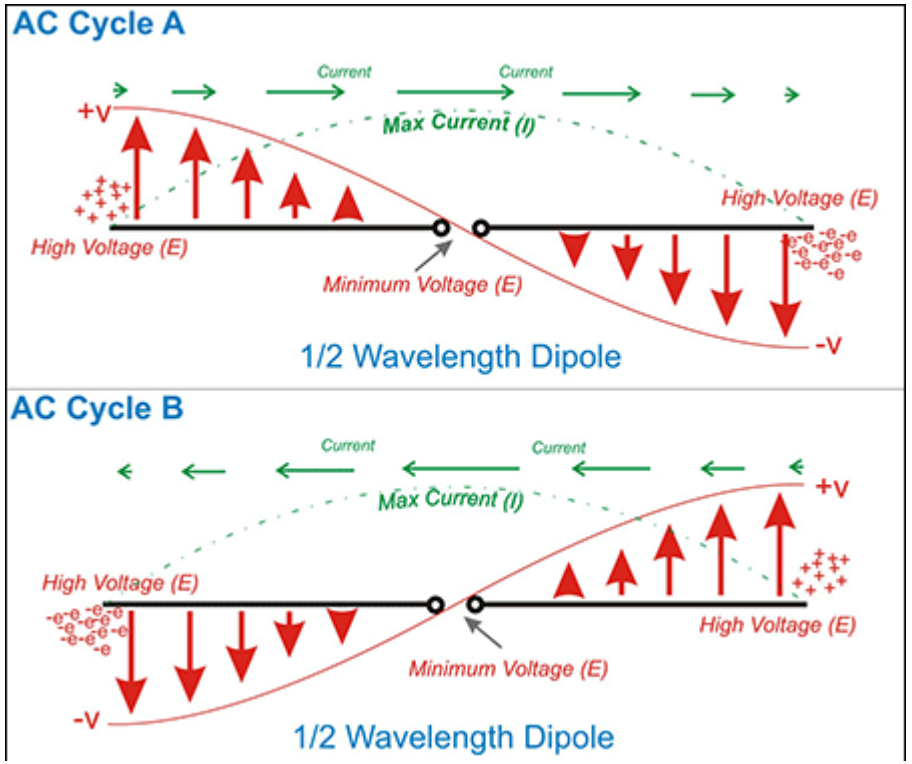
Use of mag-mounts – capacitive coupling to ground

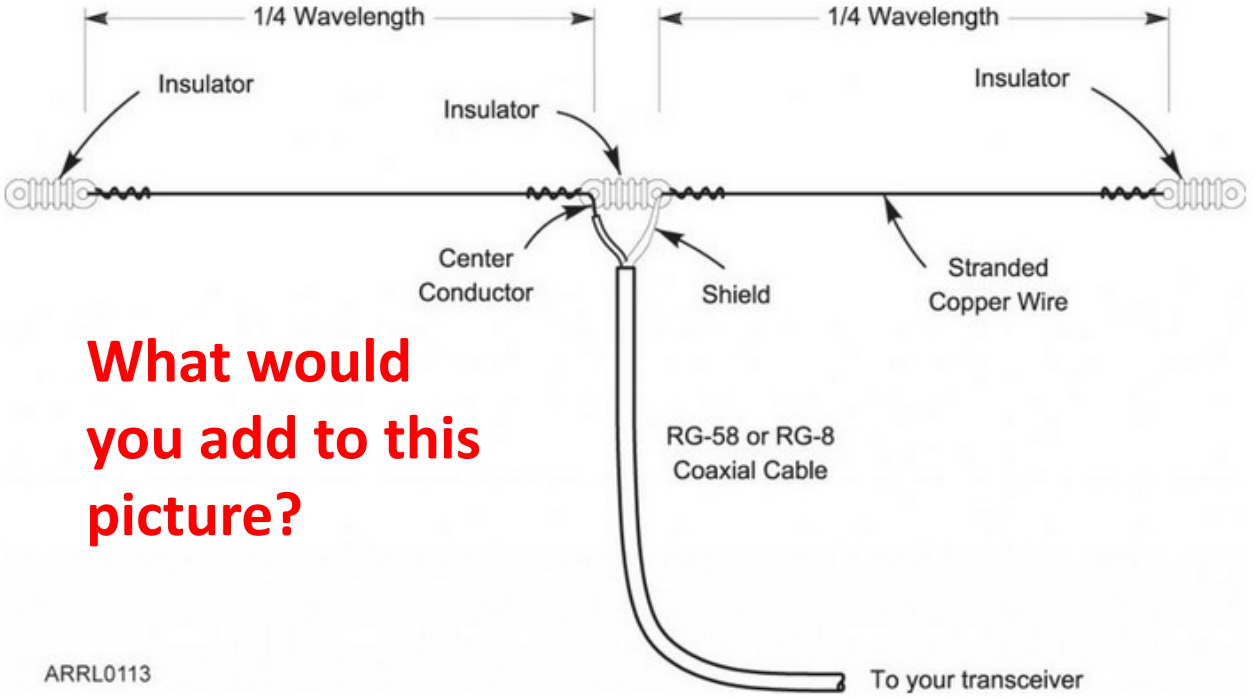
Elevated or ground radials

Feed point location

Dipoles – The reference antenna

There are dipoles, cousins of dipoles, and antennas that wish they were dipoles

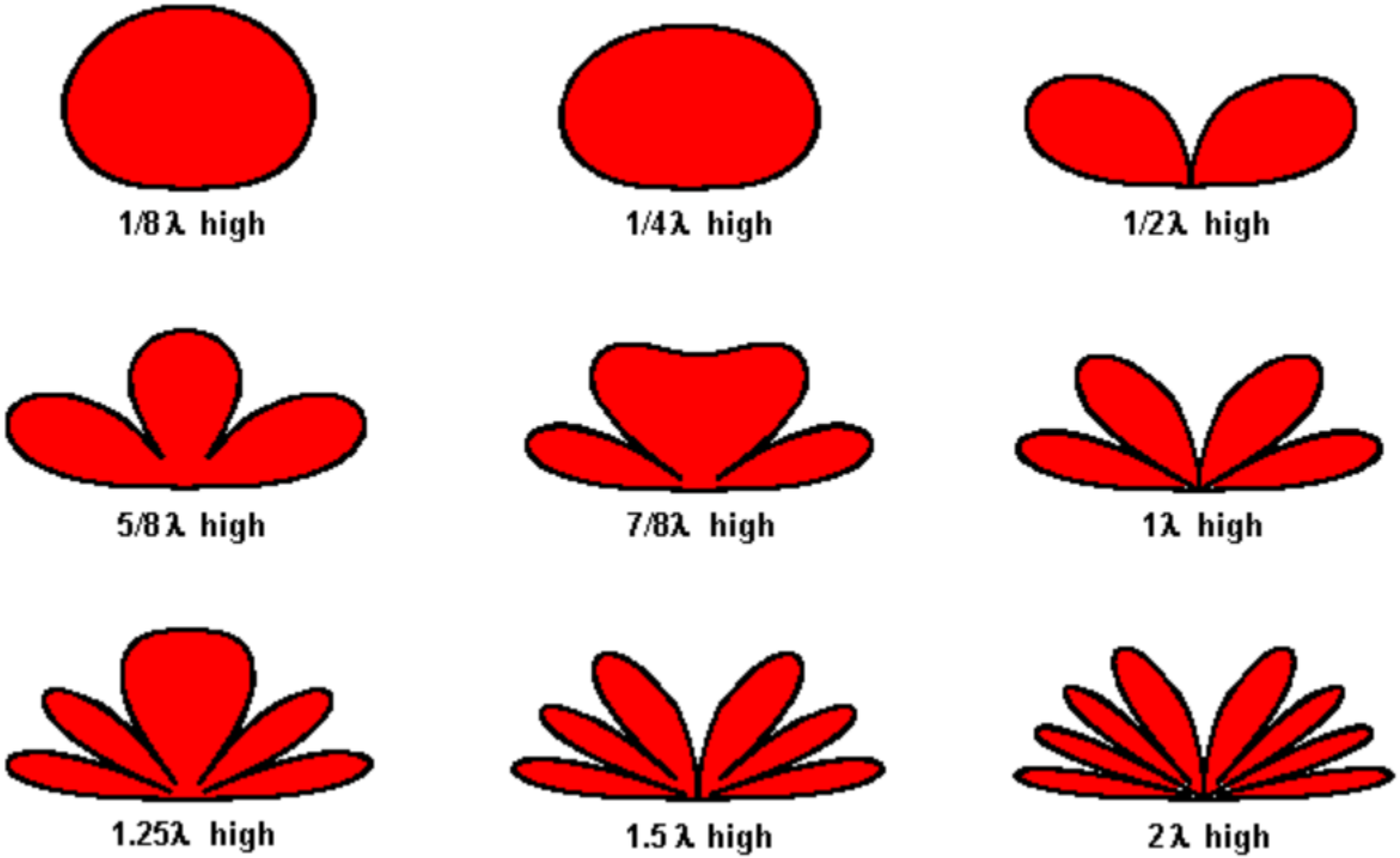




What would you add to this picture?

2.15 dB gain over an ideal isotropic radiator

Ideal dipole radiation pattern ce at different factions of a wavelength above ground at resonance

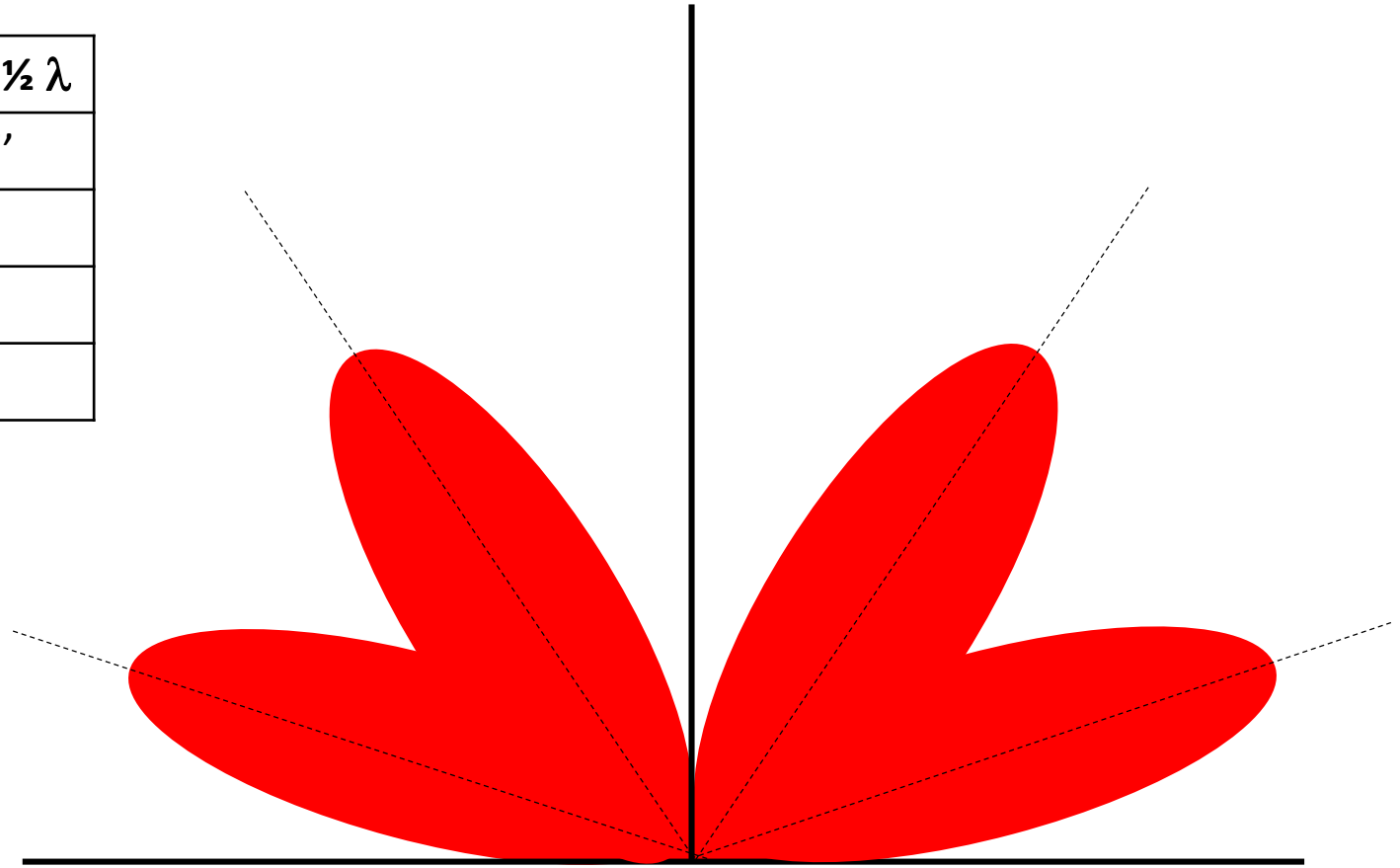


Dipoles are magic for DX when up 1λ high or more

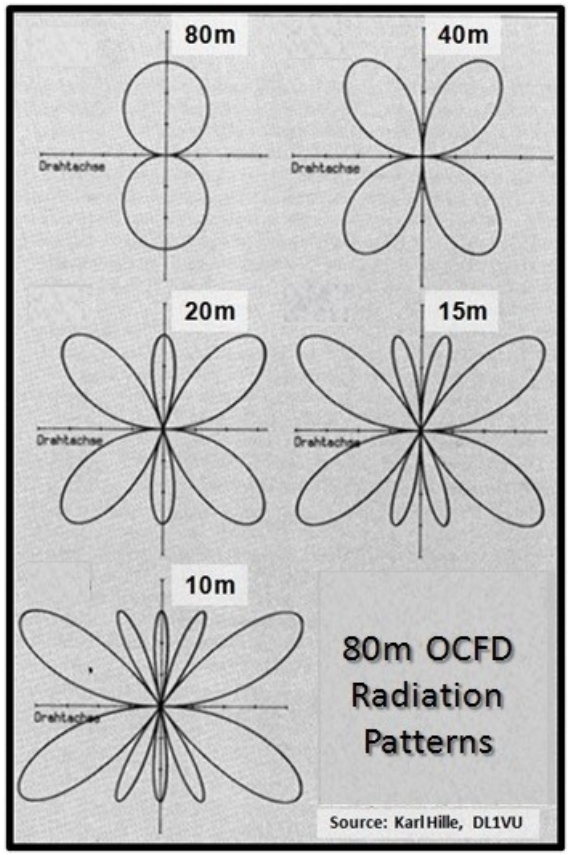
Lower angle to the ionosphere means longer skip

Frequency	Height 1λ	Height ½ λ
3.8 MHz	257’	129’’
7.2 MHz	135’	68’
14.2 MHz	69’	35’
28.4 MHZ	34’	17’

Got space?



OCF Dipole – Useful on multiple bands



66% / 34%

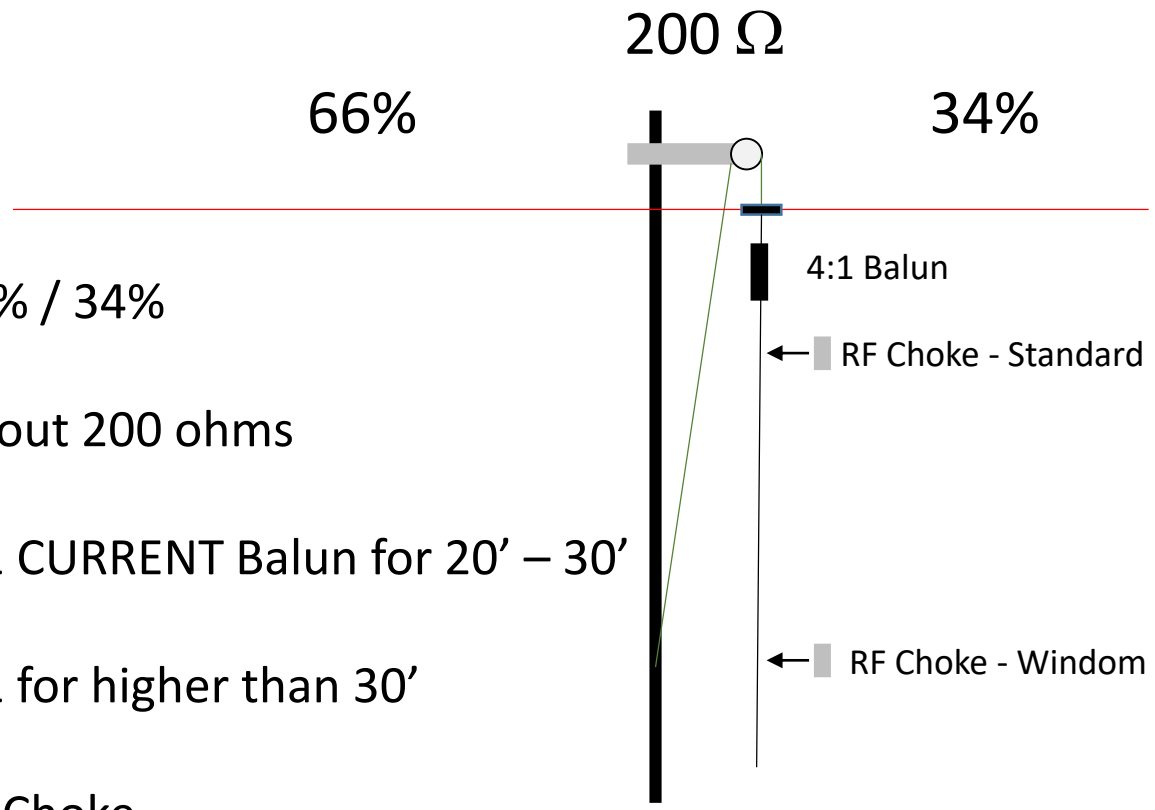
About 200 ohms

4:1 CURRENT Balun for 20’ – 30’

6:1 for higher than 30’

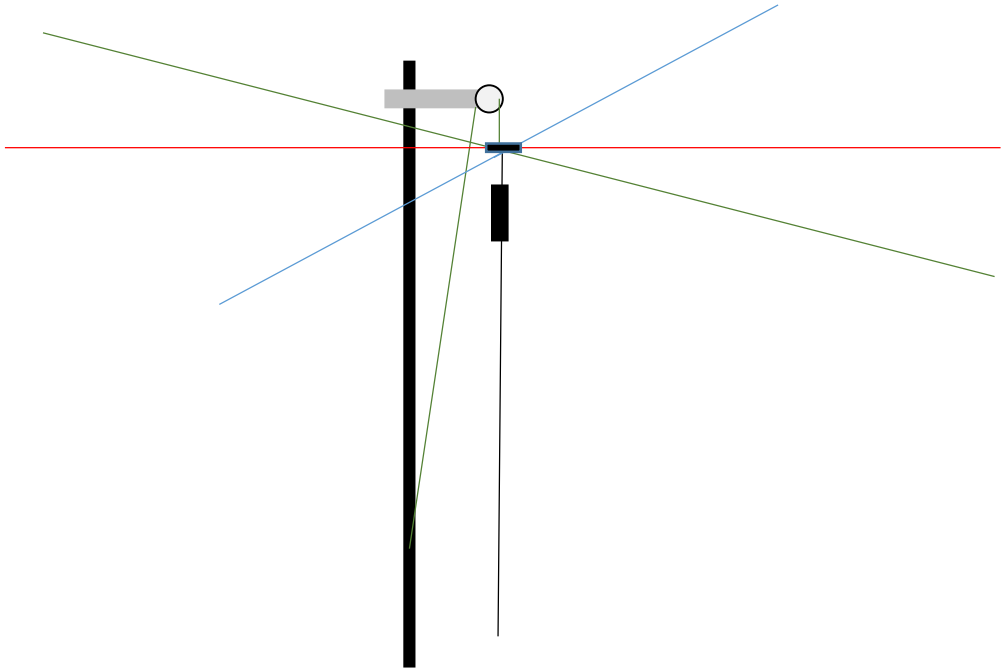
RF Choke

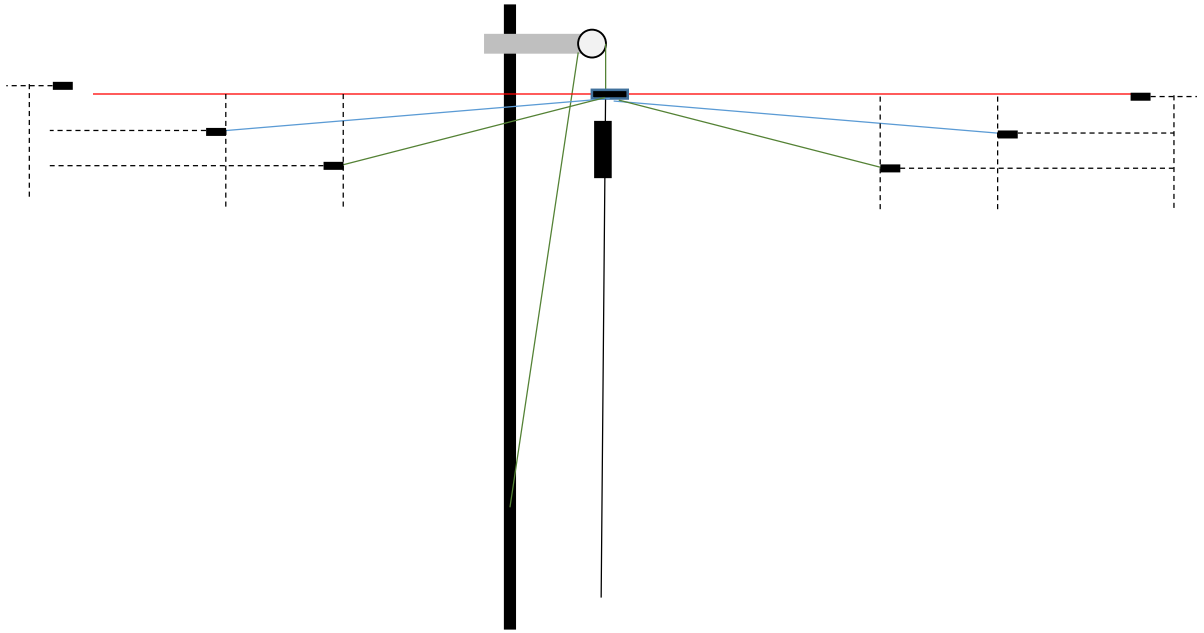
Tuner



Fan Dipole – Best if the elements are not in the same plane

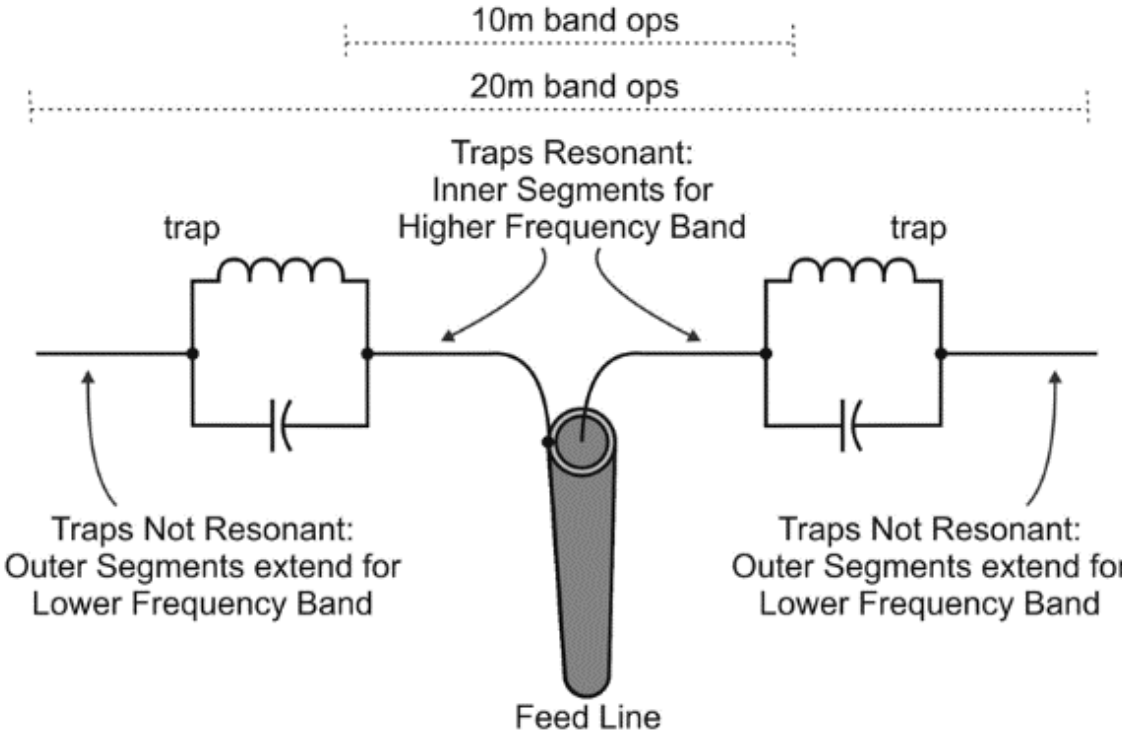
RF takes the path of least impedance. Tune highest band first.





Trapped Dipoles – Multi-band on one wire

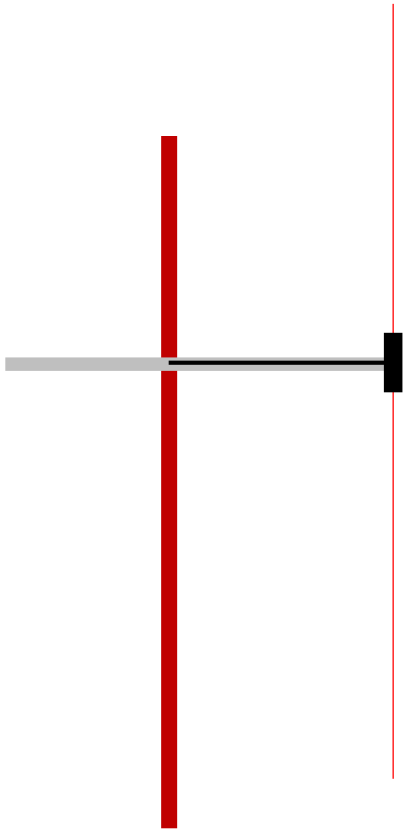
Automatic band switching

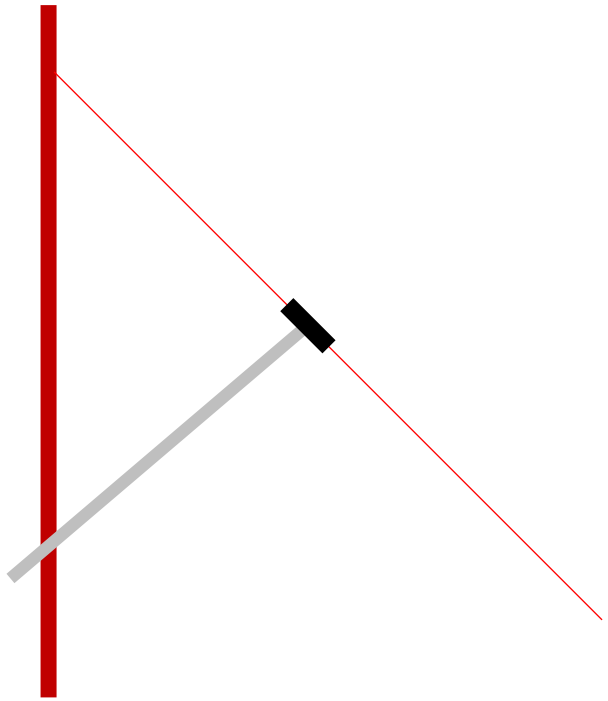


Coils – Adding inductance can electrically shorten an antenna

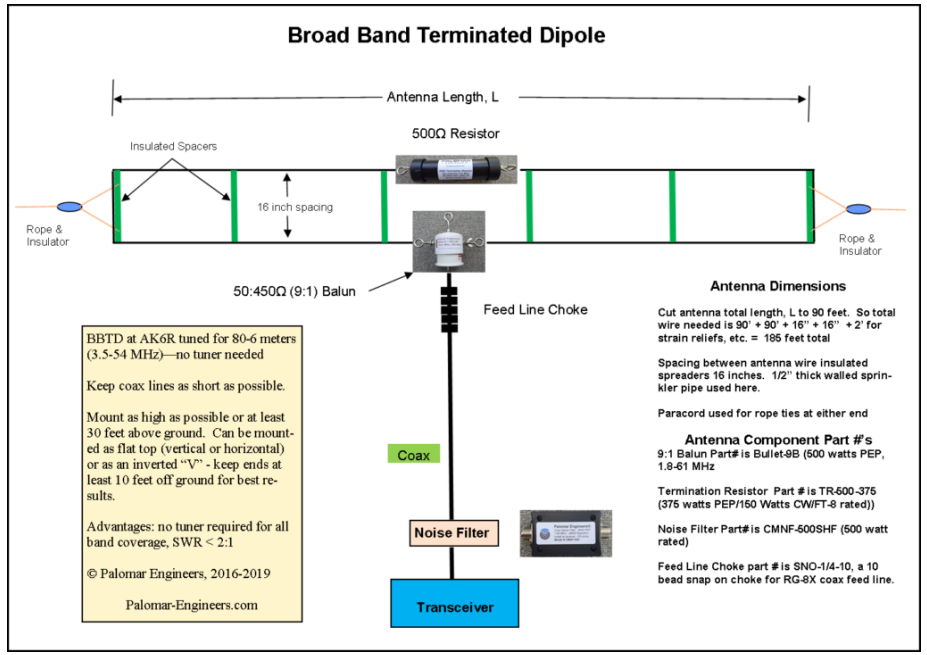
Slope to vertical dipole

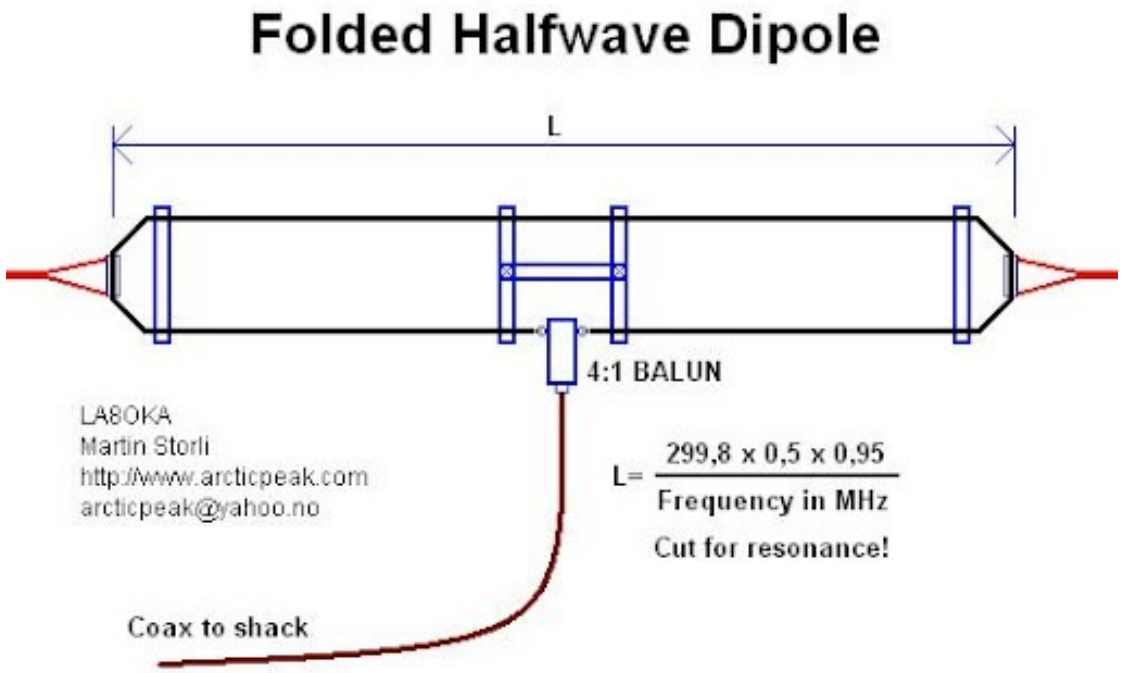
Coax must come off at a right angle to the dipole



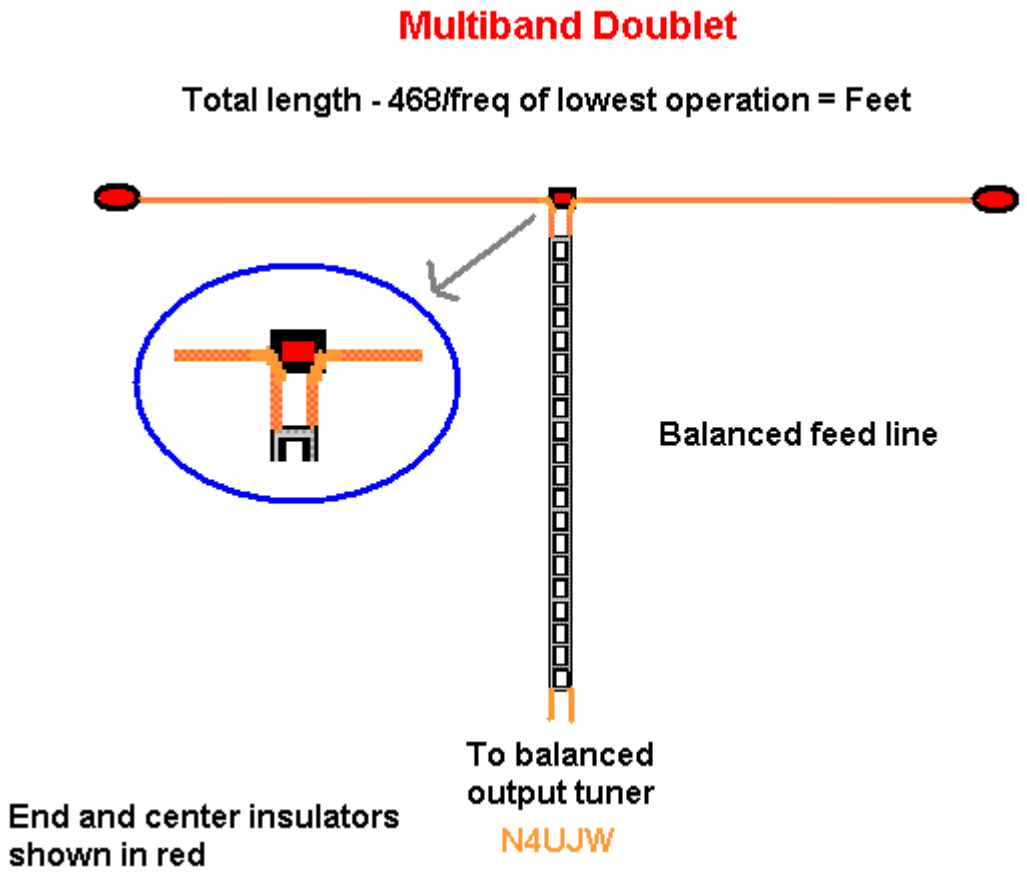


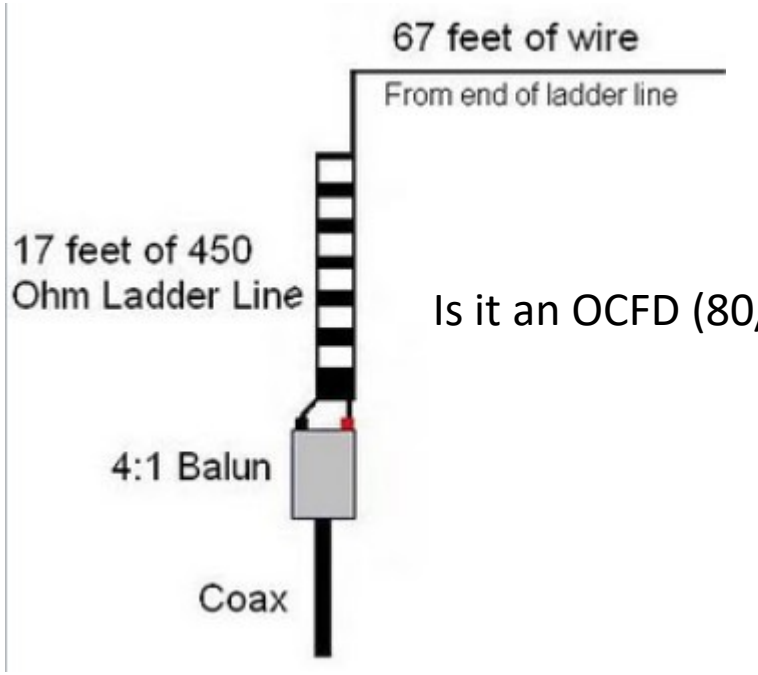
Folded Dipole





Doublet and Zep

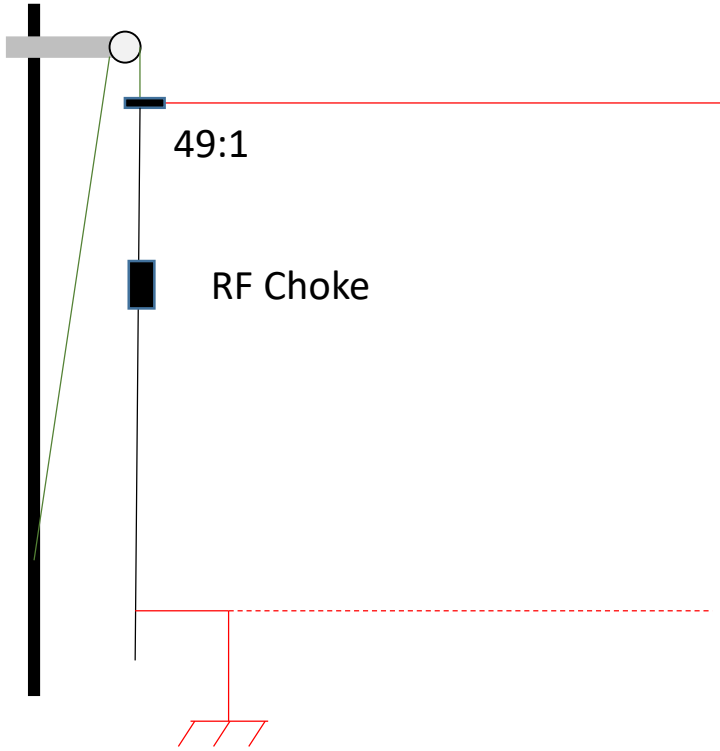




Is it an OCFD (80/20)?

End-Feed Half-Wave Dipole

Popular – needs an 49:1 Unun

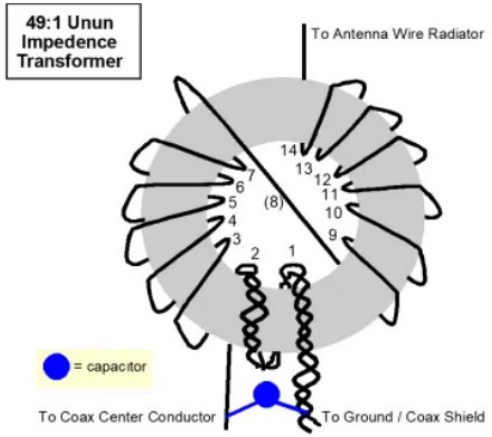


One or two ground rods

Some call for counterpoise (OCFD?)

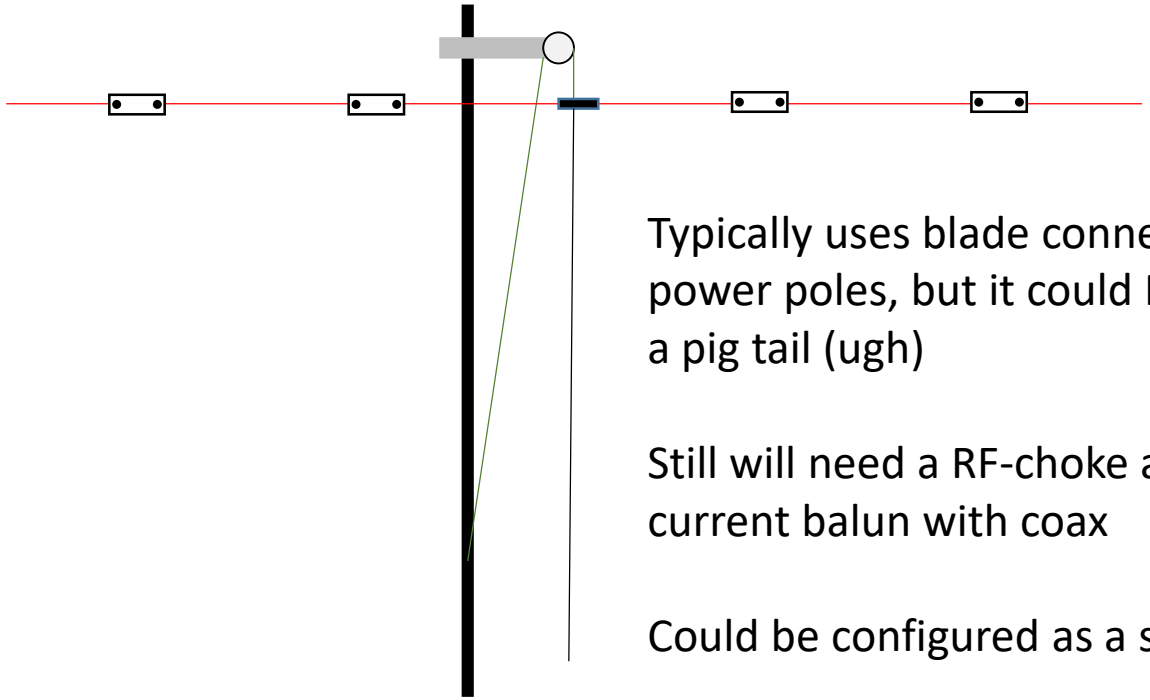
Works on primary band and harmonics

Can be feed from either side and often used in a slopper configuration



Linked Dipole – Variable length resonant antenna

Clip in/out the band you want to work

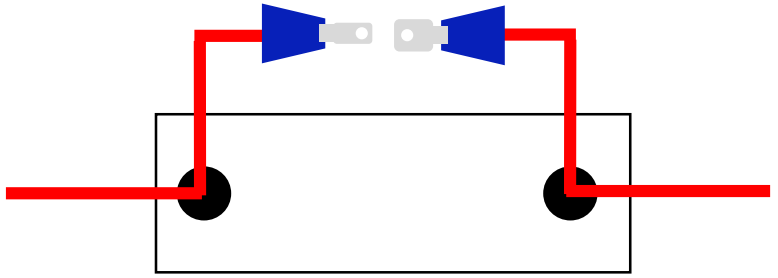


Typically uses blade connectors, power poles, but it could Molex, even a pig tail (ugh)

Still will need a RF-choke and 1:1 current balun with coax

Could be configured as a sloper

Calculator:
https://www.sotamaps.org/extras



Strain relief the wire using a loop or cable tie

Fun with Verticals

A vertical antenna is like half a dipole, or is it?

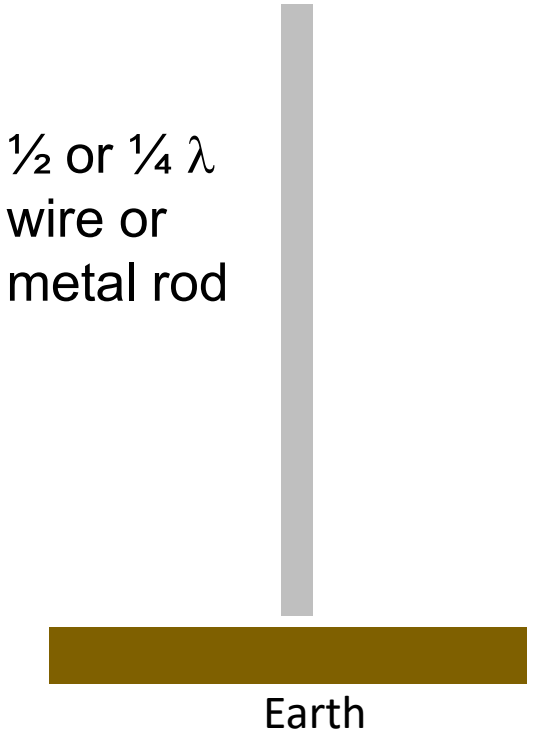
The system will try to find a way to create the other leg, if it can.

One leg

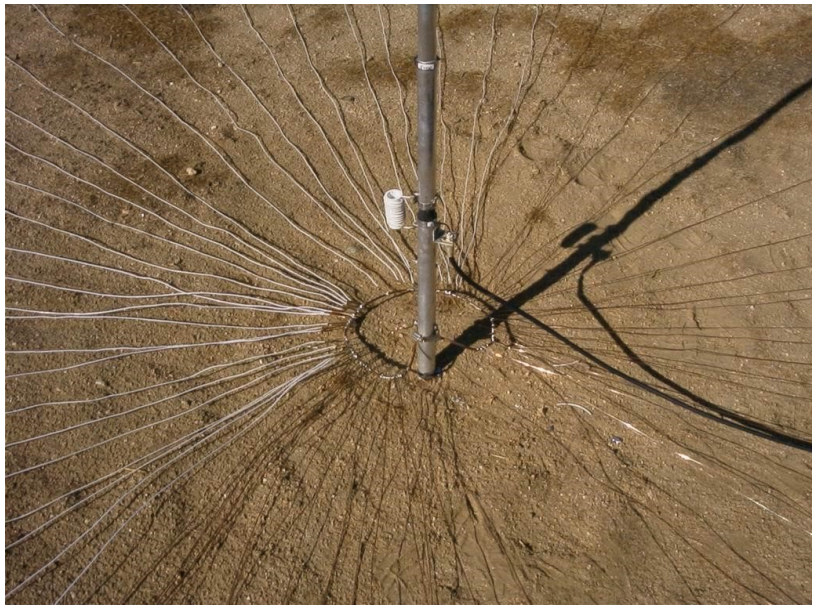
Where is the other leg?

- The case, if its metal may be part of the antenna.
- You can be the other part.
- Is this efficient?
  - No, but for VHF/UHF line of site short haul, it may be fine.
  - A rat-tail (counterpoise) can be added to improve efficiency – range
  - Inefficient means some power is lost to heat

The radial, ground plane, or counterpoise, conceptually creates a vertical dipole



"**A radial field enhances the ability of the ground around the vertical to conduct RF energy.** The radials "collect" the return current required for efficient antenna operation. Some hams complain that radials narrow the bandwidth of the antenna. This occurs because the radial system raises the "Q" of the antenna system. The higher the "Q" value, the more efficient the antenna will be. With a good radial field, radiation resistance will decrease, RF current will increase and bandwidth will narrow." - www.onallbands.com/radials-101-why-should-i-use-radials-with-my-ground-mounted-vertical-antenna/



Radial field. Yes, 120 would be wonderful, but past 30 and definitely past 64 not much added value.

How long should a radial be? Ground or elevated?

"One of the observations in that article was that the use of a small number of ¼ wavelength (free space) radials, lying on the ground surface, could lead to much higher losses than expected, and that shortening the radials could actually reduce ground loss. [Jack Belrose, VE2CV]

The classic analysis, however, does not take into account the possibility of resonances in the radial screen that might amplify the radial current, increasing ground loss."

www.antennasbyn6lf.com/arrl_antenna_articles/ Rudy Severns N

Some state radials of 0.35 λ and others 1/8 λ, to avoid resonances, but they all agree that shorter means more radials – just below ¼ λ is fine.

Elevated radials actually work better than ground ones, such that, you can use less of them for a given number on the ground.

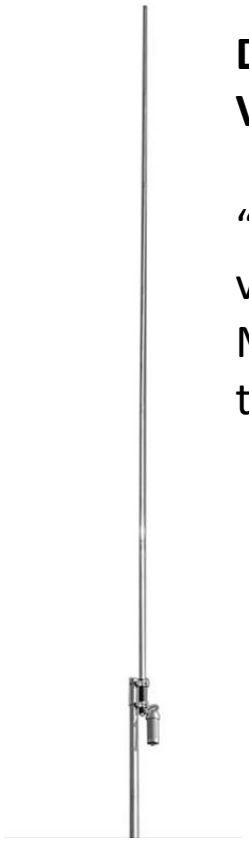
Ground systems will have a higher Q then elevated.

Some state the 4 elevated per band is adequate others go with 8, and 12 seem to be the upper limit.

Elevated radials can be safety hazard, need tuning, and effected by the environment..

Are there “no radial” vertical antennas?

Yes, but the question is how efficient are they?



Diamond Antenna BB7V Multi-Band Vertical Antennas

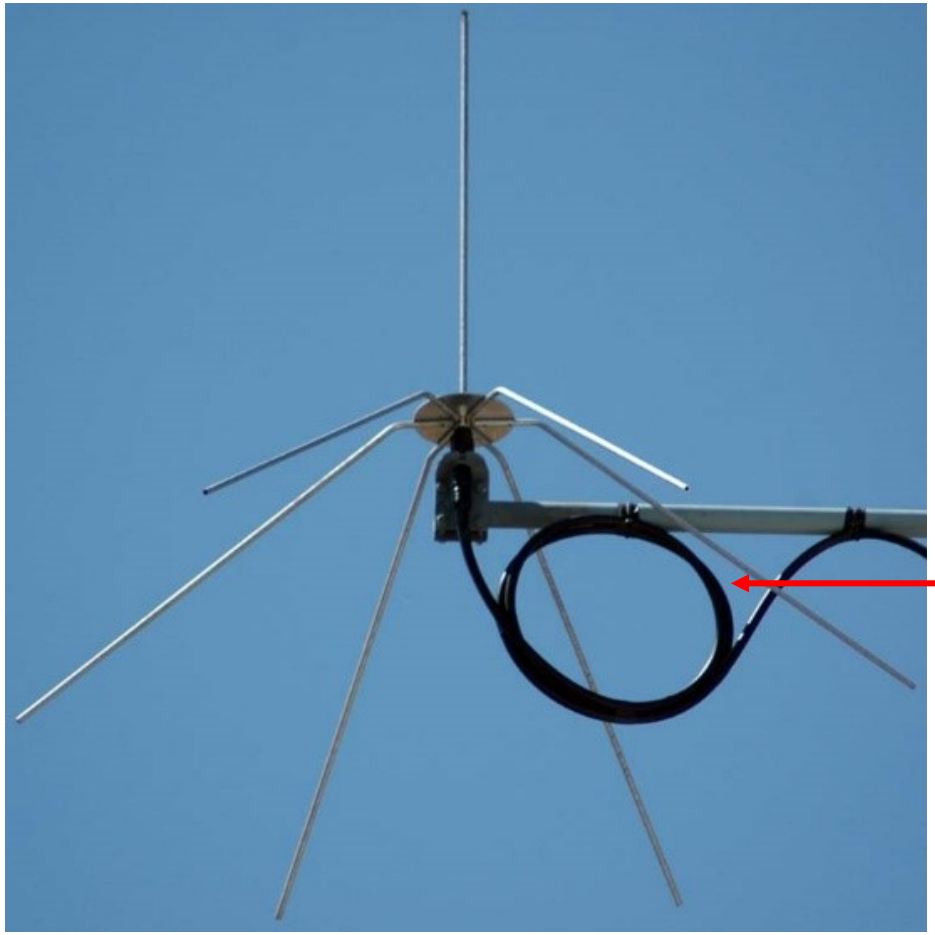
“Diamond Antenna BB7V broadband vertical antennas provide coverage from 2 MHz to 30 MHz **without radials.** Typically a tuner is required for most frequencies.”

“Without radials, a vertical antenna can still radiate, but not very well. Steer clear of any vertical antenna that claims great performance without radials.”

But a 1:1 SWR does not mean that an antenna is efficient, and efficiency is what really counts.

ARRL website

Typical 2m Ground Plane Antenna



Drooping the radials changes the impedance

When the radials are vertical you get 50 ohms

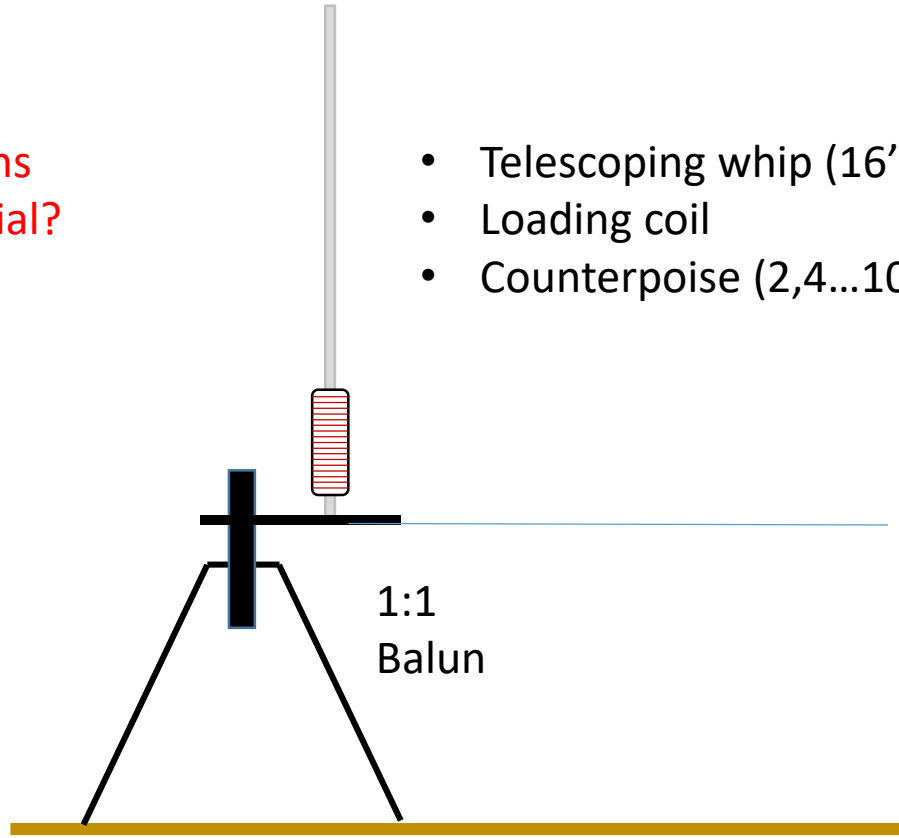
What's this?

Vertical antennas can be with and without a loading coil

On a tripod, mounted on a insulated pipe on the ground, or on a car

What happens with one radial?

- Telescoping whip (16’)
- Loading coil
- Counterpoise (2,4…10)

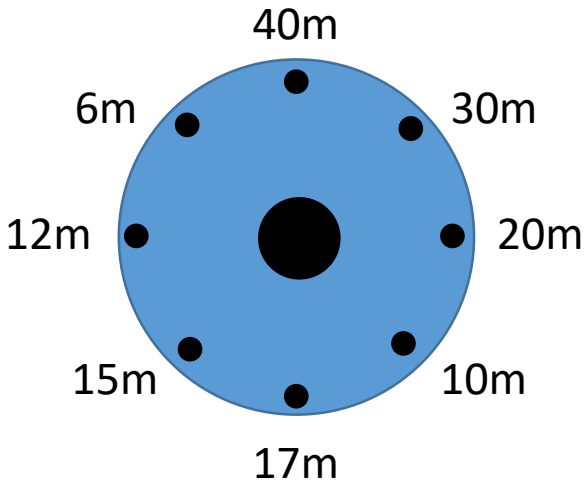


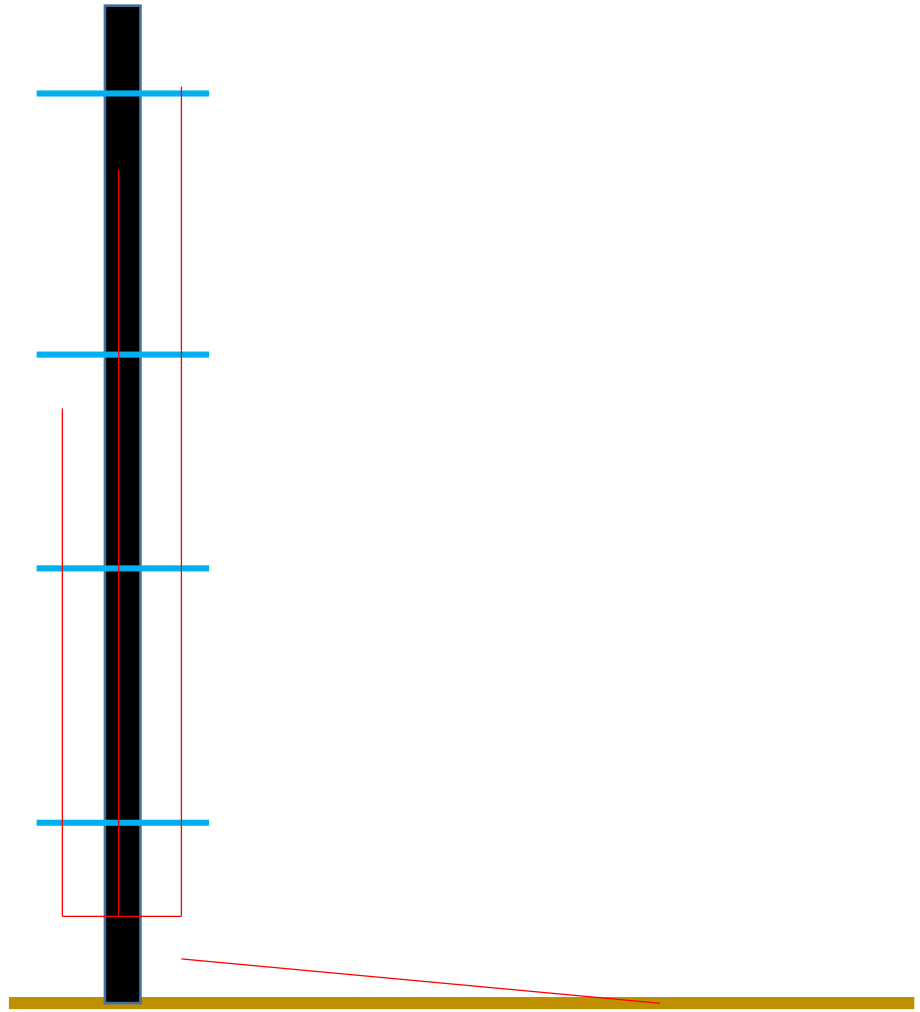
Your car can be an antenna platform

1. Make sure you create a good ground plane
2. Consider stresses when moving and during high winds when stationary
3. Match the impedances – generally low impedance, but expect less than optimal efficiency
4. Can one attached a set of radials to this? Sure, assuming driving isn't an option.

Multi-band vertical quarter-wave

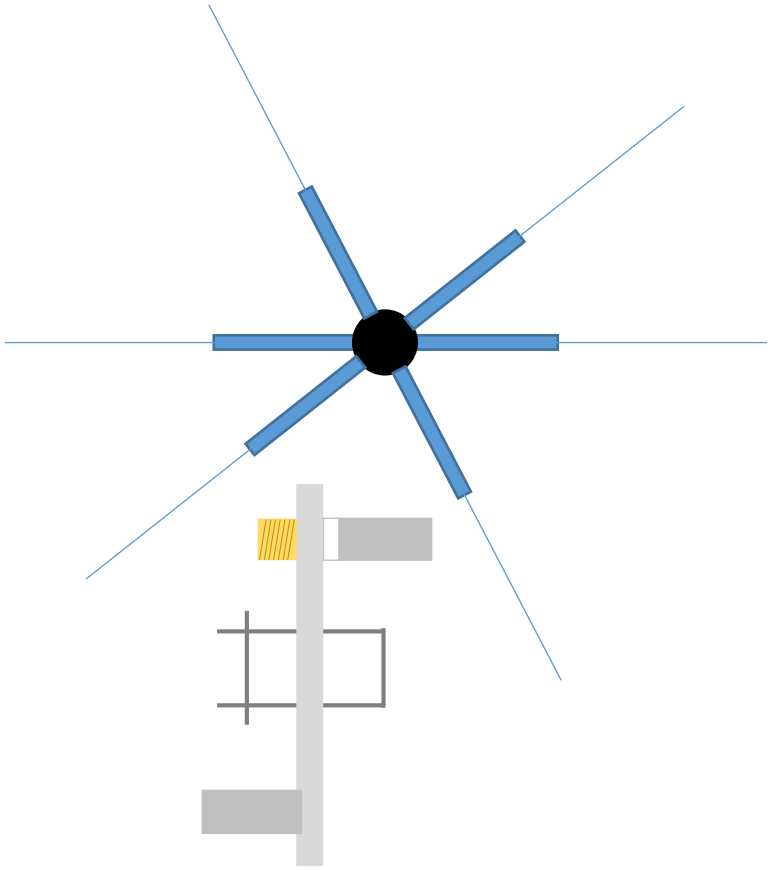
Love the counterpoise





Ham Stick fan and vertical Dipole

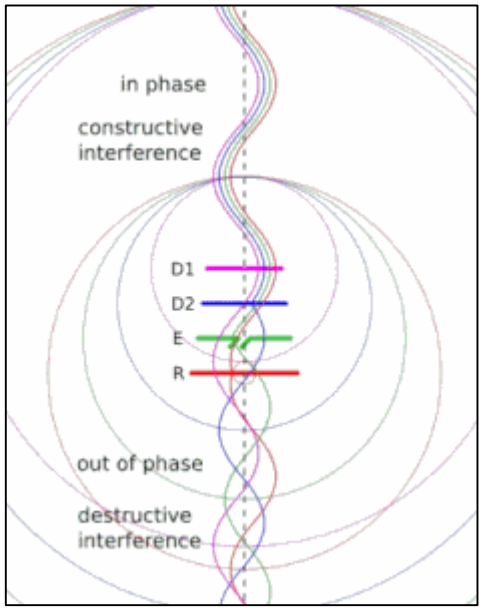
Will need a balun, band switching based on path of least impedance, low radiation efficiency



Beams

Yagi–Uda antenna –

Invented in 1926, Uda was the principle, but Yagi patented it first



Directors are shorter than the driven element to create a slight phase difference.

Consult the online calculators for lengths and spacing

Every wonder why you can use a metal boom with a yagi – its about the dipole (driven element). The voltage at the center is zero if designed correctly.

Is that a folded dipole?

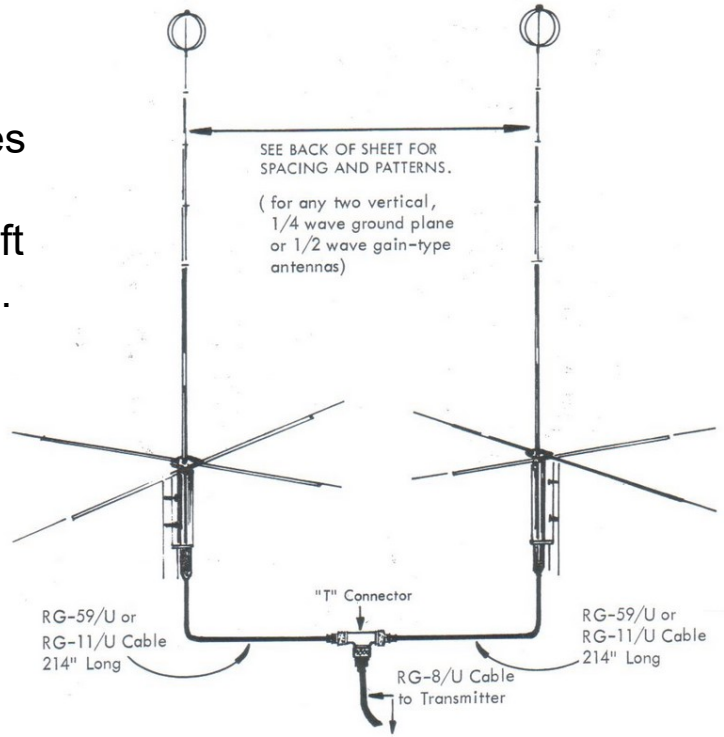
https://en.wikipedia.org/wiki/Yagi%E2%80%93Uda_antenna

Vertical Phased Array Antenna

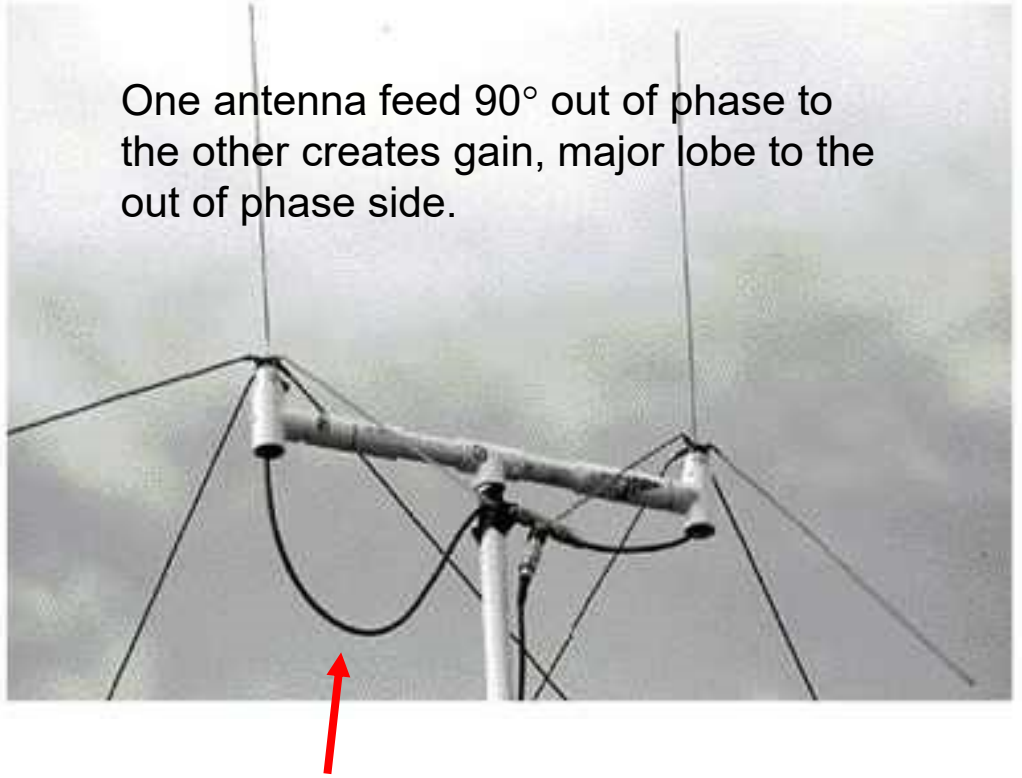
Co-Phased Antenna

Equal feed lines creates larger lobes on the left and right sides.

Yagi can be stacked this way too.

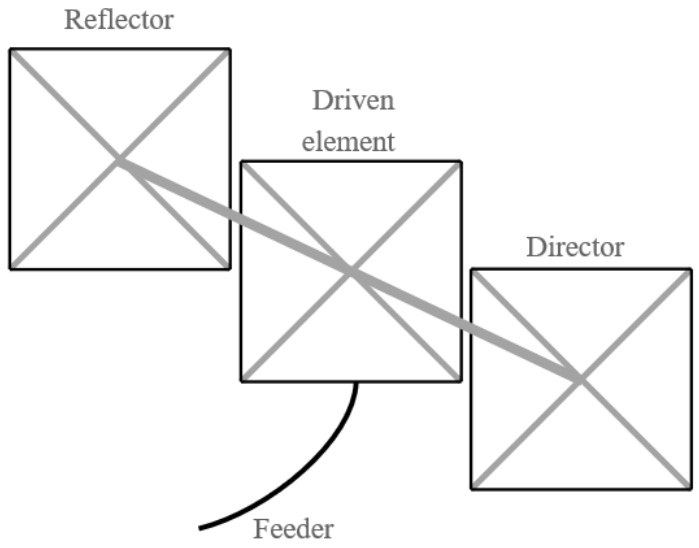


Broadside Array



The 90° phase change is done by delaying the signal to one side.

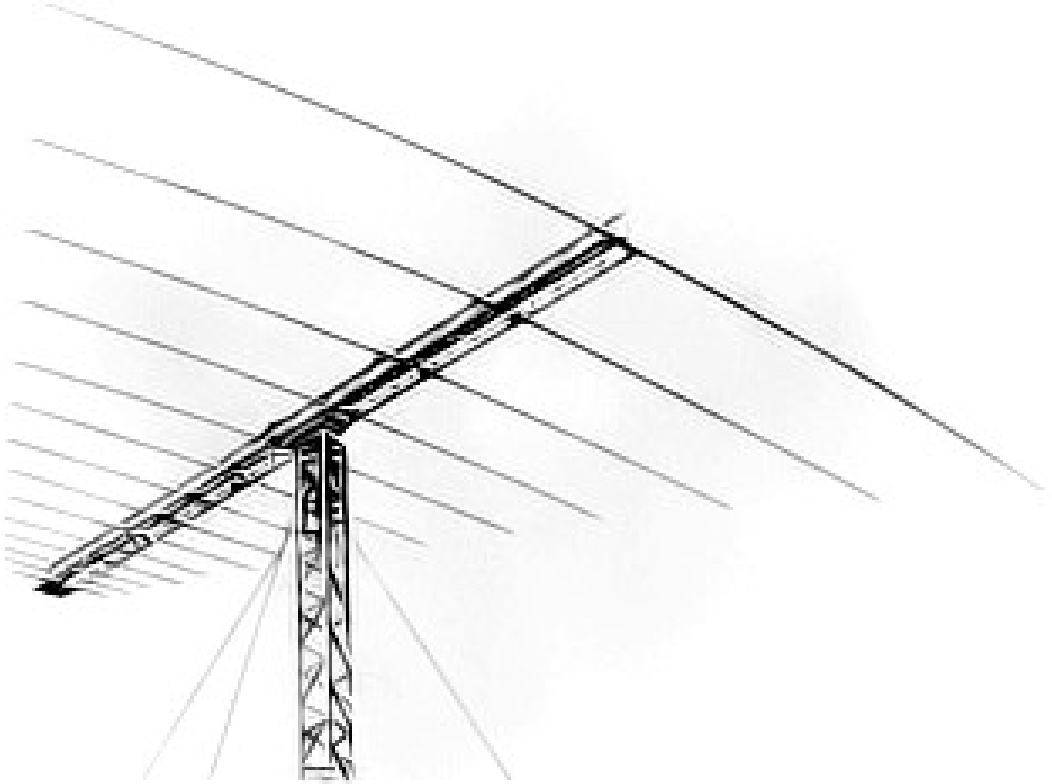
Cubical Quad – Higher gain and better pattern than a yagi and quieter too.

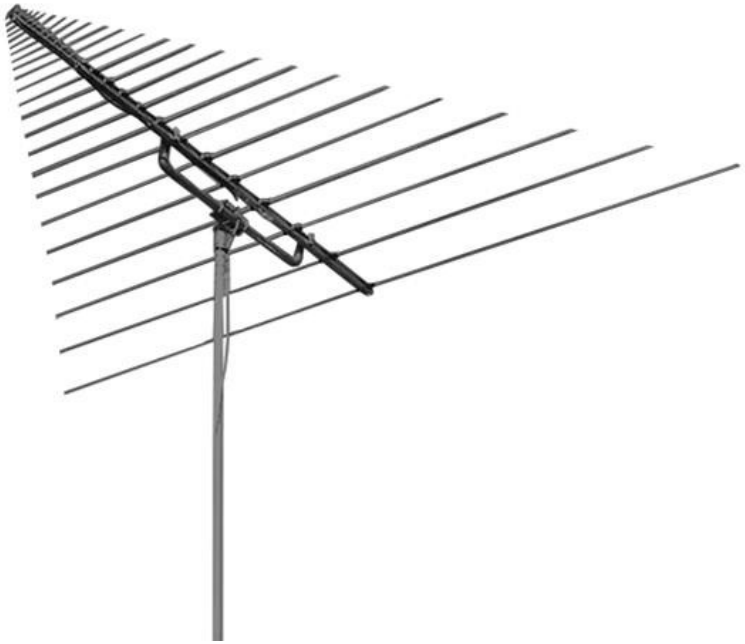


Basic cubical quad antenna

2m/70cm Cubical Quad

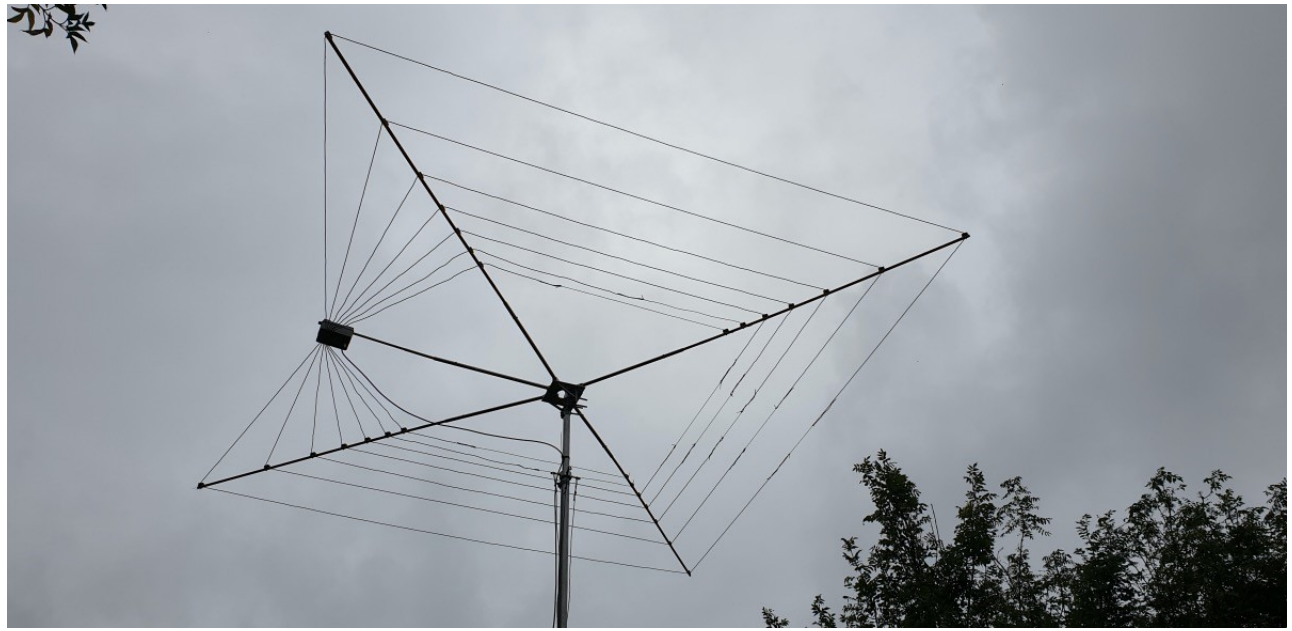
Did I forget the log periodic?

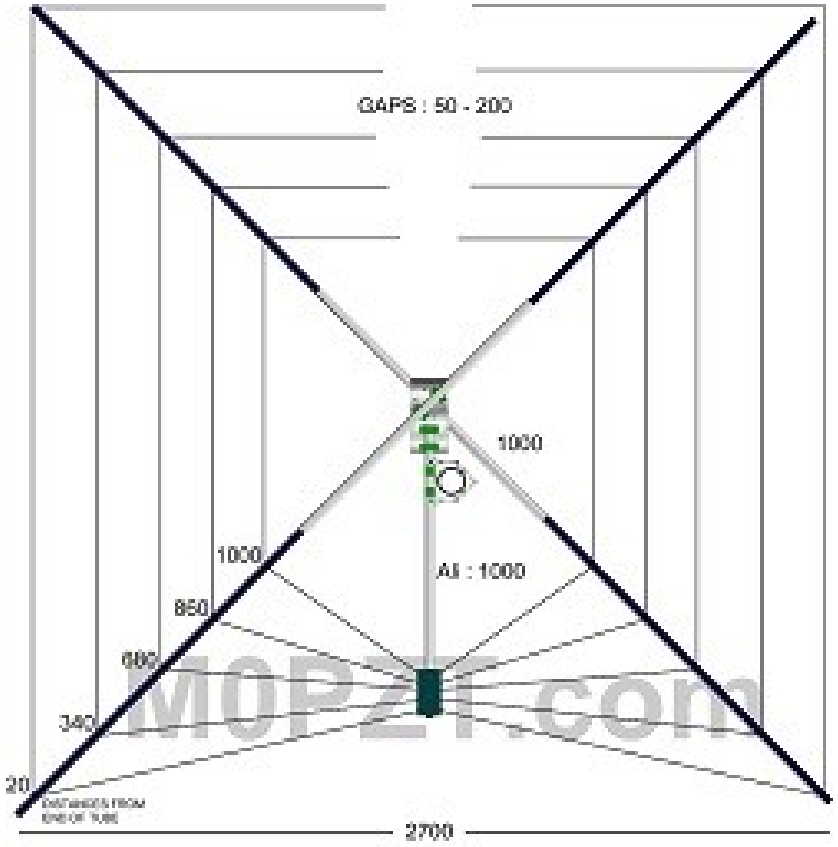




A handful of other types

Cobweb – Another folded dipole

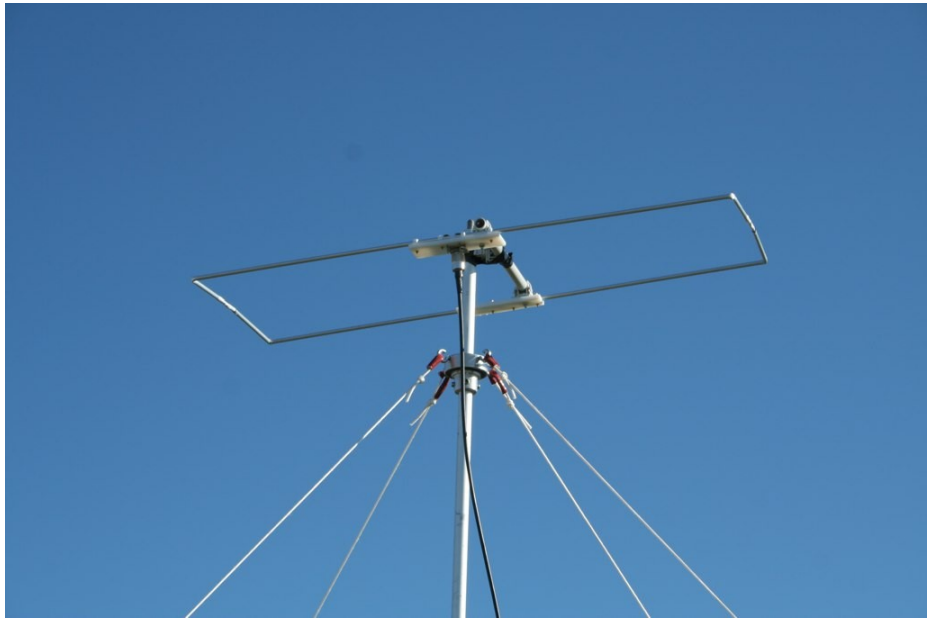




Did you just say you're bicycle mobile with a Hex Beam?

Hex Beam

A hex beam is a more folded version of a Moxon antenna.



Moxon

Take your magnetic loop anywhere you wish

Not generally efficient at hiking dimensions

Save weight with manual tuning

Weight/size okay for QRP

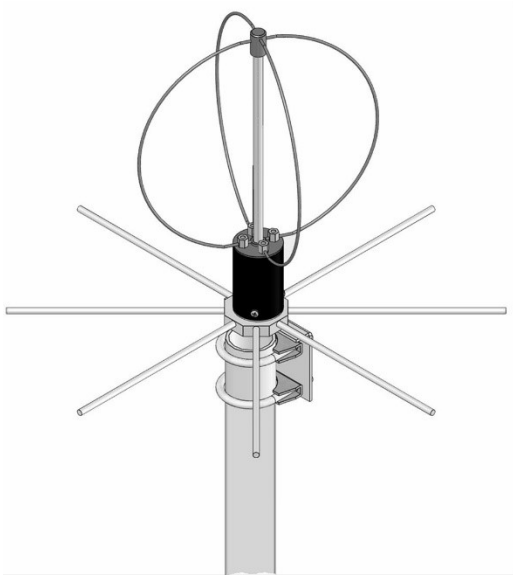
Can be made from coax

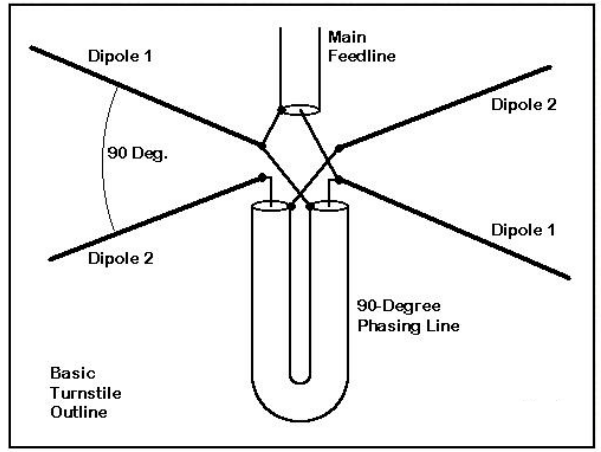
Not as good as one with tubing, but it will work.

With full size and 1” tubing the efficiencies are very good.

Eggbeaters and turnstile antennas – satellite comms

- Two full waves loops, mounted at right angles to each other.
- 90 degrees out of phase over a horizontal circular reflector.
- Omni directional and circularly polarized.





Turnstile: Single- two dipoles feed 90 degrees out and can be stacked.

Helical Antennas

- Consists of conducting wires wound in the form of a helix
- Made from one wire it's called *monofilar*
- *Two or four wires* are called *bifilar*, or *quadrifilar*
- *Circular polarization*

And more

Sleeve dipoles

Slot antennas

Meandering antennas

Spiral antennas

Log periodic

Huge list of antennas:
https://tristatesarc.com/club/wp-content/uploads/2018/12/287WireAntennasForHamRadio.pdf

Thank you

TU de W7DAO BTU K

W7DAO@arrl.net