

South Florida



ANTENNAS: PART II

For the DX University
Presented by
Pete Rimmel N8PR

Antenna types:

Wire antennas

- Dipoles
- G5RV
- Zepp
- Off center fed

Horizontal arrays

- + Yagi
- + Quad
- + Wires
- + Commercial

Verticals

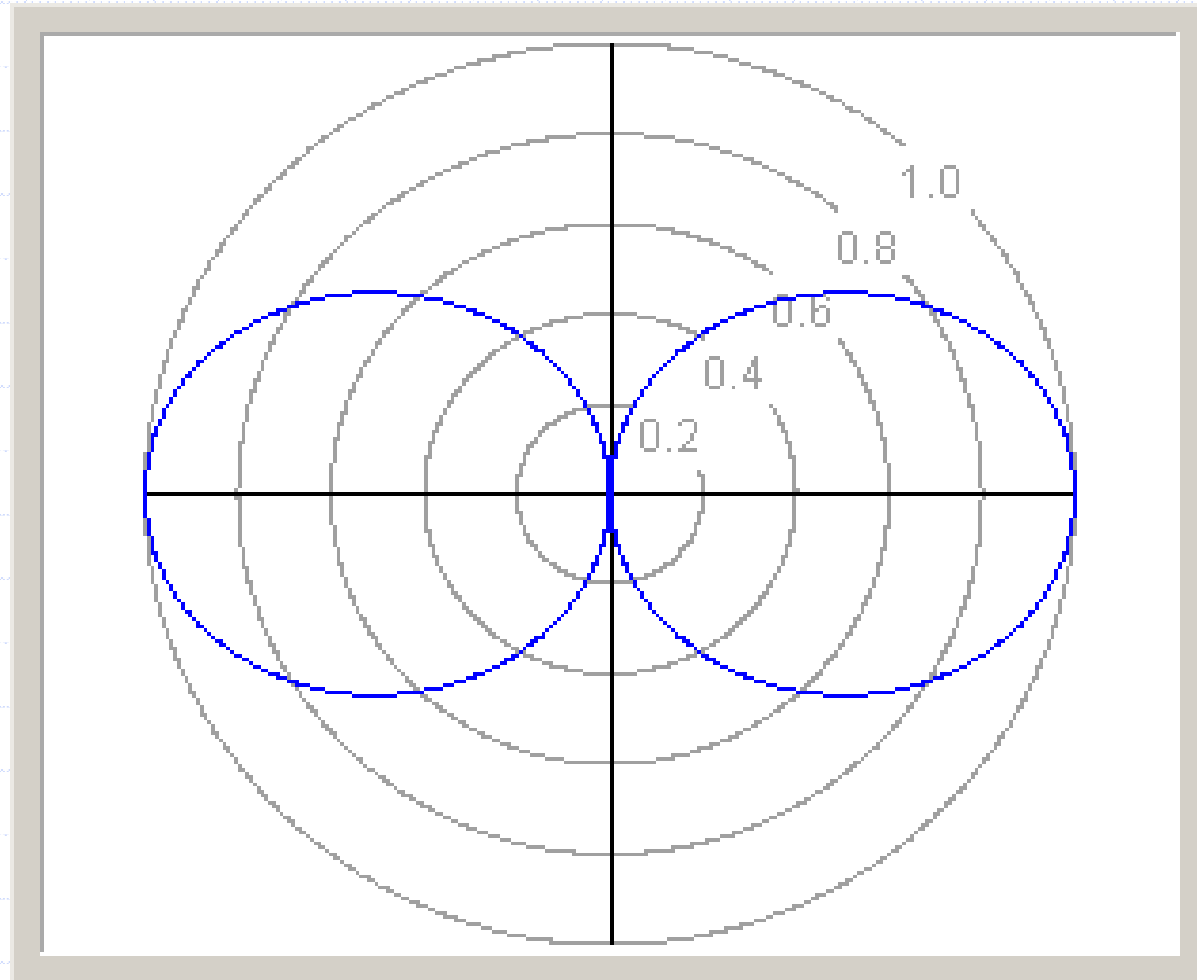
- $\frac{1}{4}$ wave
- Arrays
- Commercial

DIPOLES

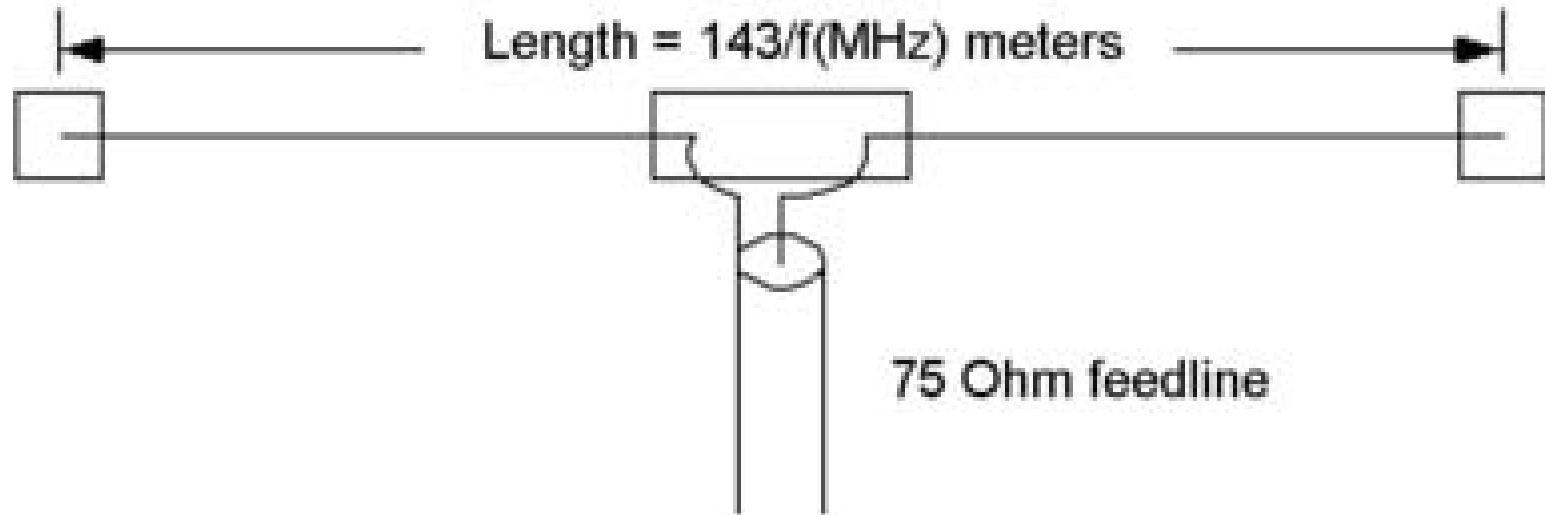
Almost all antennas are based on a variation of a Half Wave Dipole. Most antennas are compared to the radiation characteristics of a dipole.

A half wave dipole – $\frac{1}{2} \lambda$ Dipole – has a radiation pattern like a figure 8.

In this figure the antenna is in the vertical axis and radiation is maximal in the plane of the wire, and minimal off the ends of the antenna.



Calculating the length of a Half Wave Dipole (bare wire)
(for insulated wire deduct 2-3% for Vf)

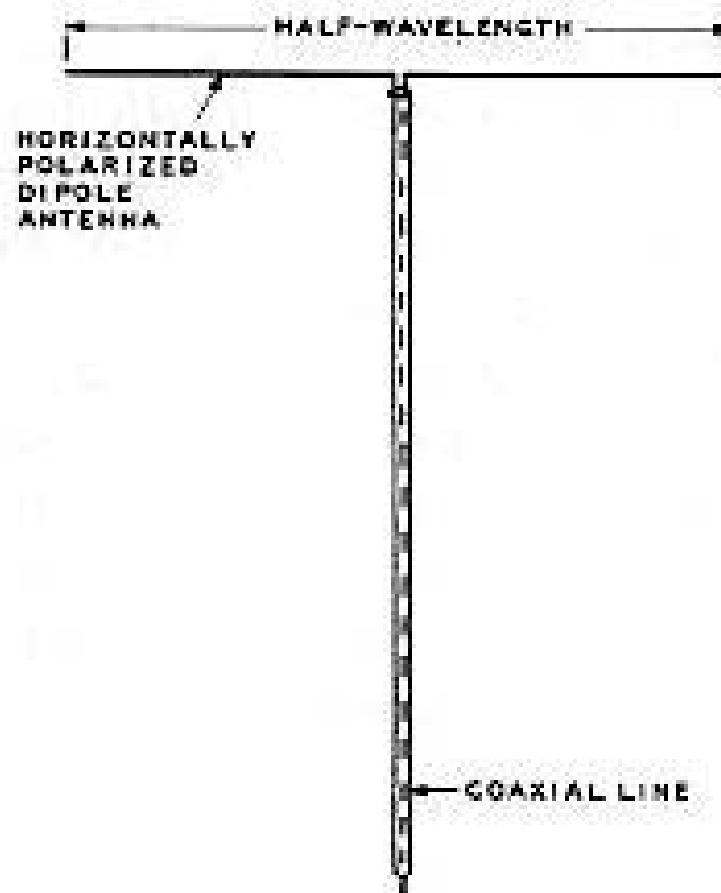


For a $\lambda/2$ Dipole:

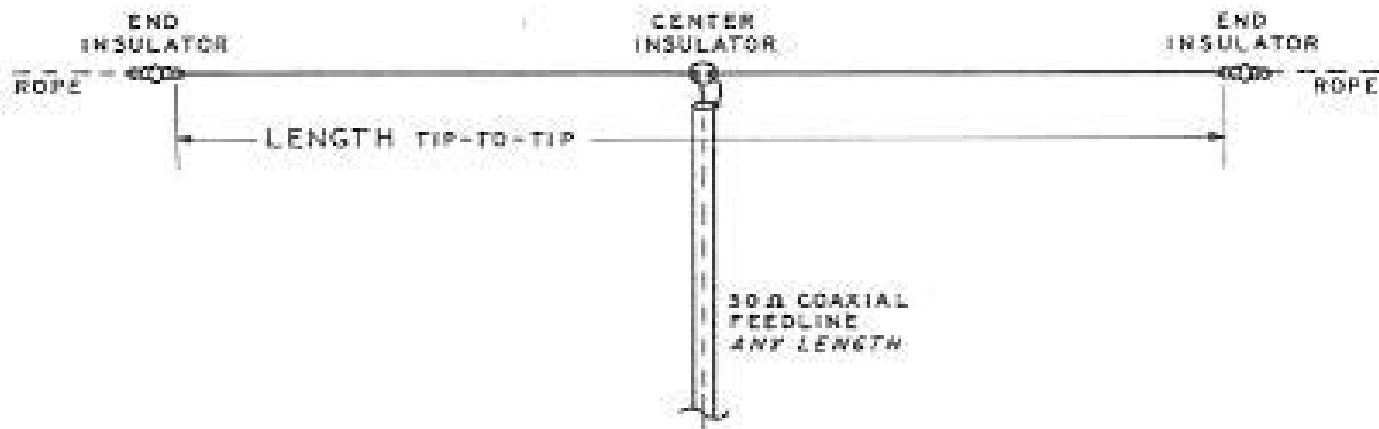
$$\text{Length (ft.)} = \frac{468}{f(\text{MHz})}$$

Example: A dipole resonant at 14.250 MHz

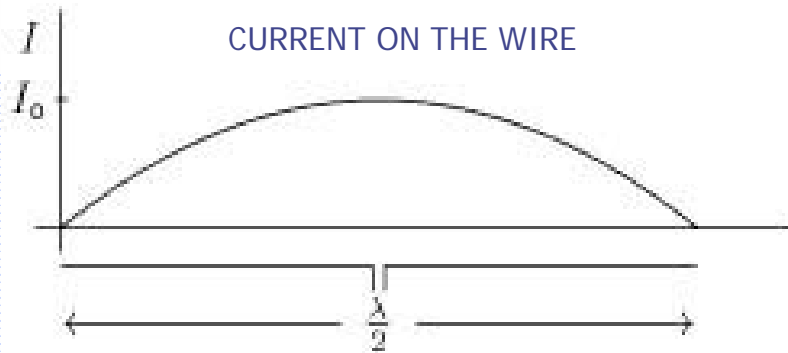
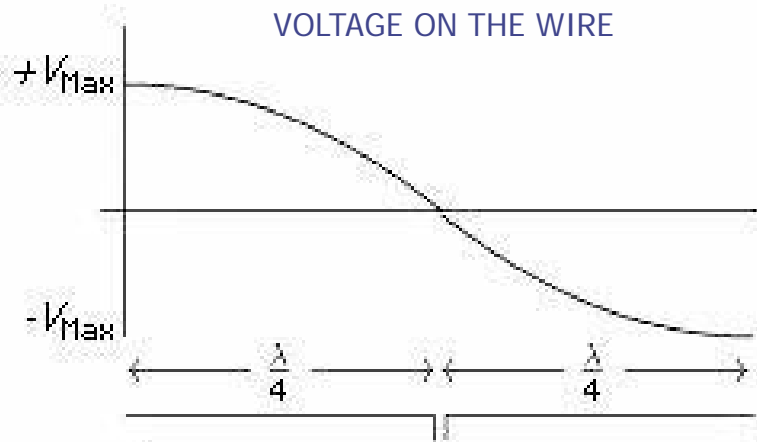
$$\frac{468}{14.250} = 32.84 \text{ ft.} = 32 \text{ ft. } 10 \text{ inches}$$



THE DIPOLE ANTENNA



BAND	CENTER FREQ. (MHz)	LENGTH TIP-TO-TIP	METRIC LENGTH
150	1.85	253' 0"	77.10
160	1.93	240' 0"	73.15
80	3.60	130' 0"	39.62
60	3.80	123' 2"	37.54
40	7.15	63' 6"	19.98
30	10.12	46' 3"	14.10
20	14.15	33' 1"	10.10
17	18.12	25' 10"	7.87
15	21.20	22' 1"	6.73
12	24.93	18' 9"	5.72
10	28.60	16' 3"	4.98
5	50.20	9' 2"	2.80
$\text{LENGTH (FT)} = \frac{468}{F \text{ (MHz)}}$			

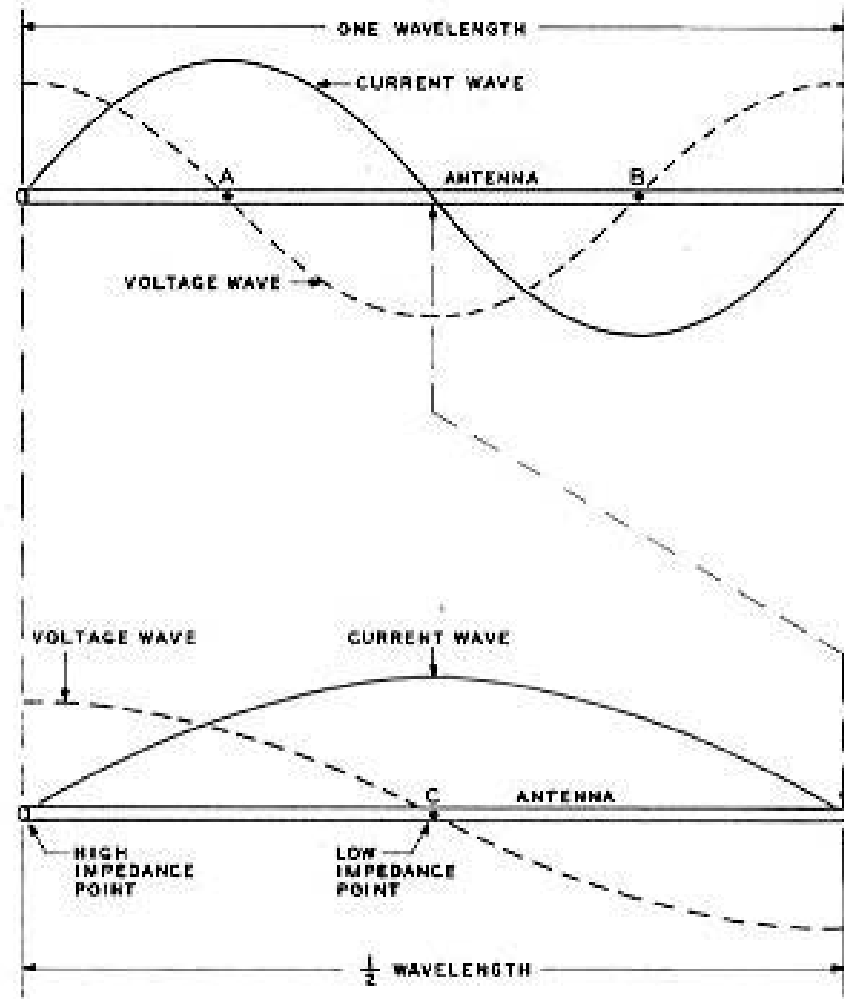


On a Half Wave Dipole the voltage at the feed point is at a minimum, and at a maximum but 180 degrees out of phase at the ends of the wire.

On the same wire, the current is at a maximum at the feed point and a minimum at the ends.

Here is why we do not try to feed full wave antennas at the middle, or half wave verticals at the bottom.

We cannot feed an antenna (generally) at a high voltage point. We must feed it at a voltage null which is also a high current point A or B in the top part of the drawing.



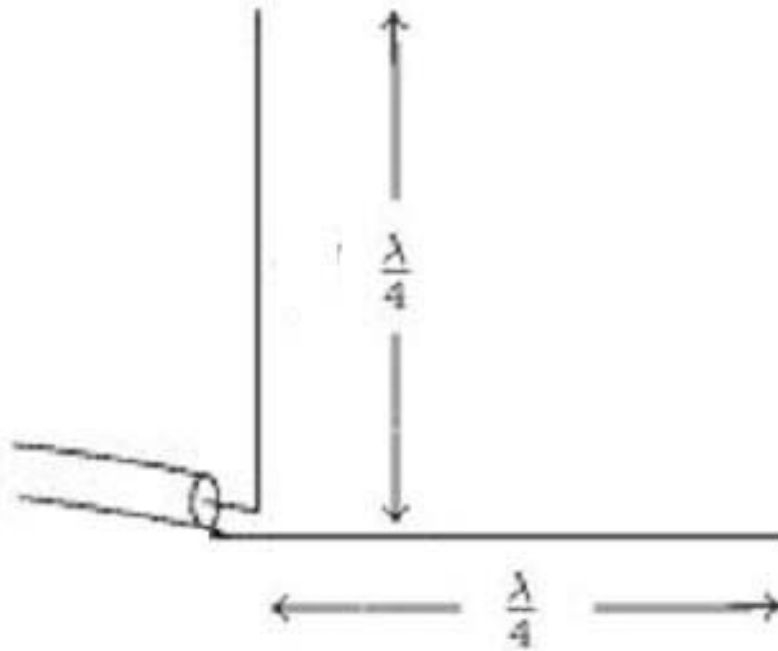
Until we got privileges on the WARC bands it was relatively simple to build harmonic antennas which would work reasonably well on the original ham bands.

1.8 MHz x2	=	3.6 MHz	\	
3.6 MHz x2	=	7.2 MHz	\	
7.1 MHz x2	=	14.2 MHz		- all harmonically
7.1 MHz x3	=	21.3 MHz	/	related
14.2 MHz x2	=	28.4 MHz	/	

Unfortunately, the WARC bands do not fit into that nice, neat mathematical relationship.

VERTICALS

Let's take that dipole and turn one of the horizontal wires 90 degrees and make it into a vertical element.

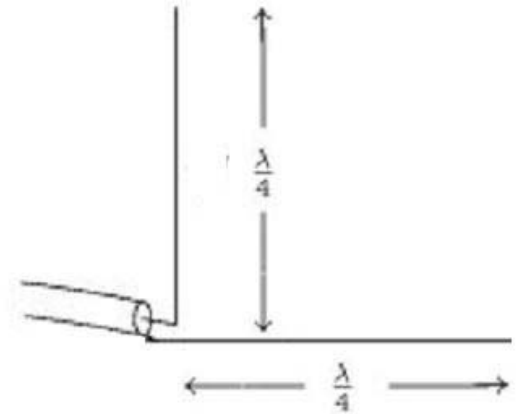


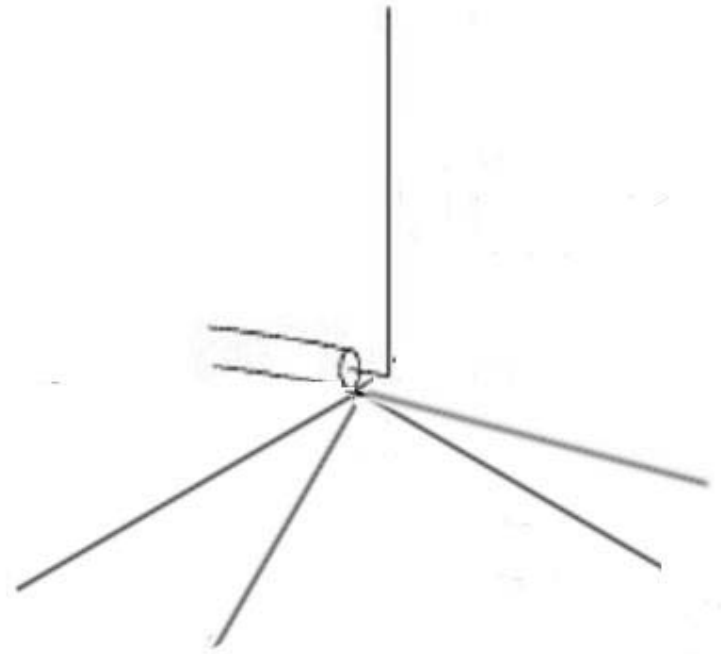
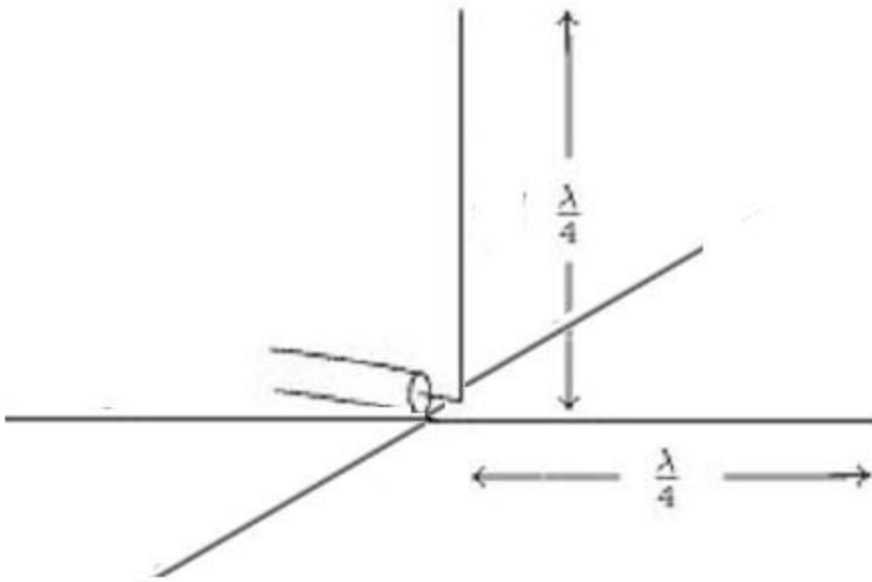
We still have a half wave antenna, but one element is in the vertical plane, and the other one is in the horizontal plane.

This is a basic $\lambda/4$ vertical.

Currents and voltages are the same as they are in a half wave dipole.

Now we can replace the horizontal element with A counterpoise, radial system or ground.

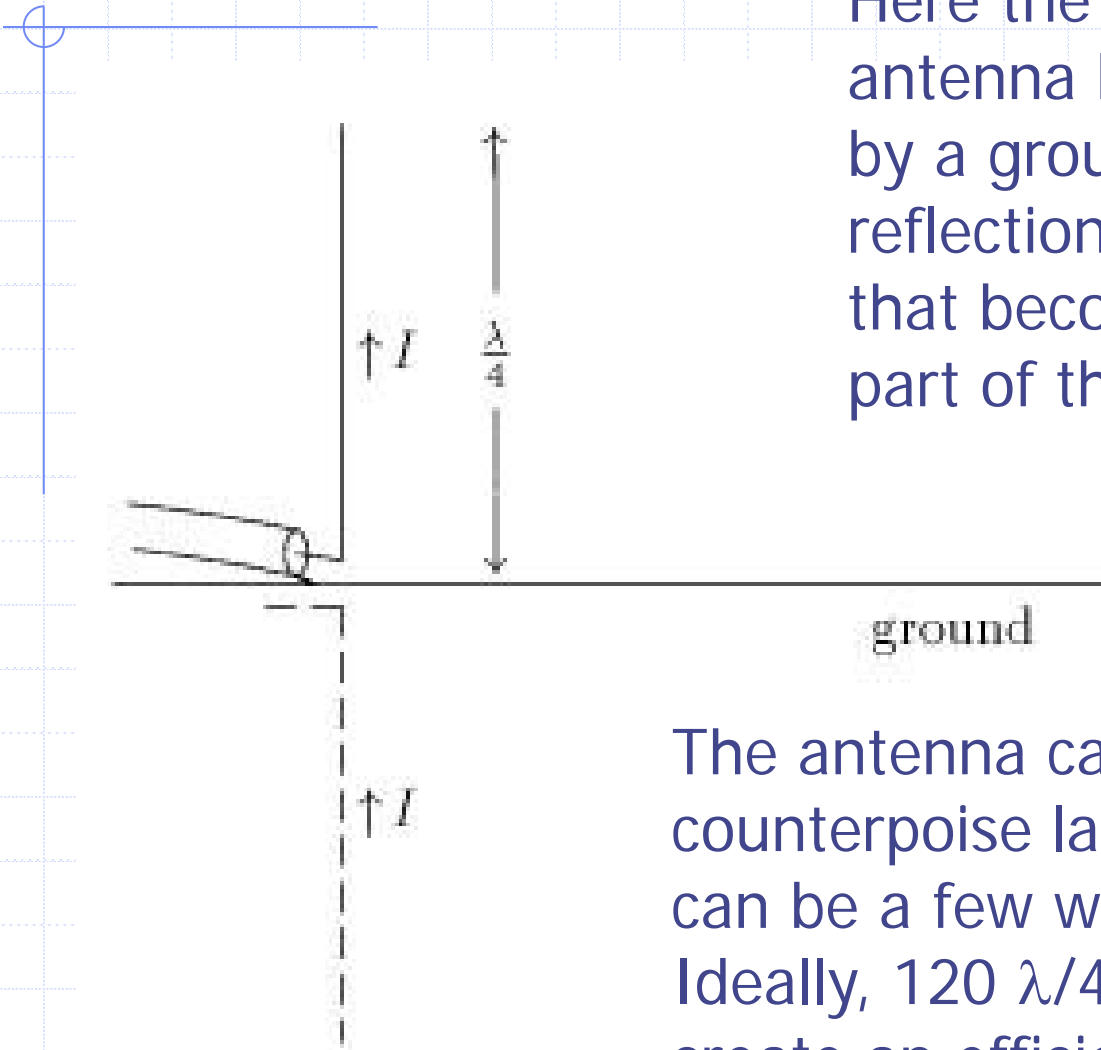




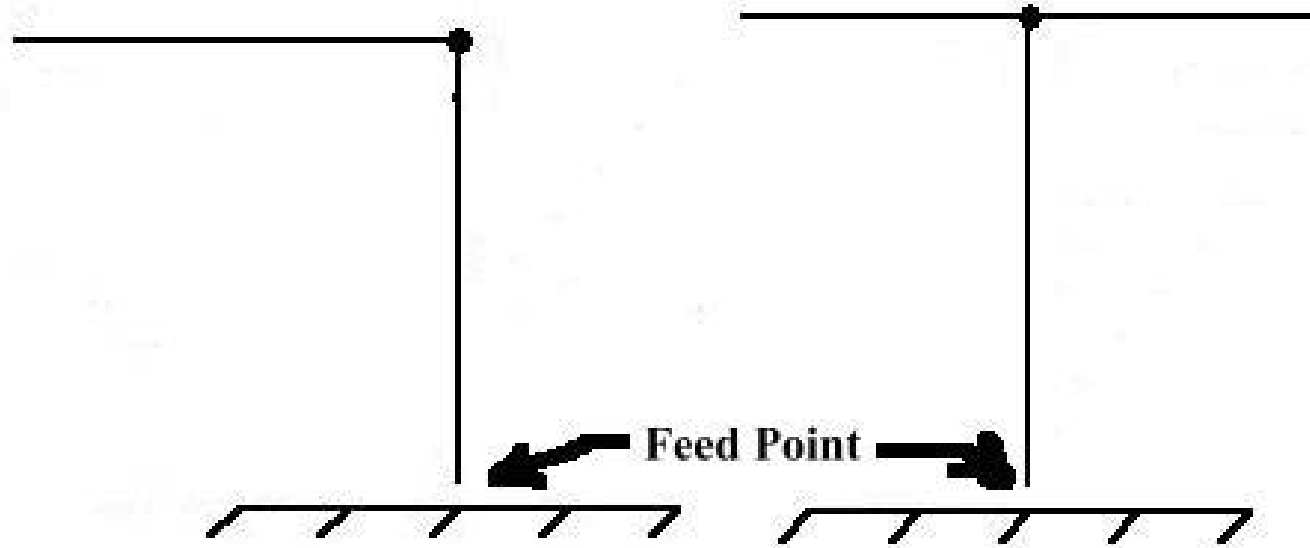
Add three more $\lambda/4$ radials and you have made a ground plane antenna. It can be a few feet above the ground or elevated high above ground.

The feed point impedance of this antenna is approximately 37 Ohms. By tipping the four radials down about 45 degrees you can get a good 50 Ohm match to coax cable

Here the $\lambda/4$ radials of the antenna have been replaced by a ground. The ground reflection creates an image that becomes the other part of the half wave antenna.



The antenna can be fed against a counterpoise laid on the ground. This can be a few wires of random length. Ideally, 120 $\lambda/4$ to $\lambda/2$ radials will create an efficient counterpoise



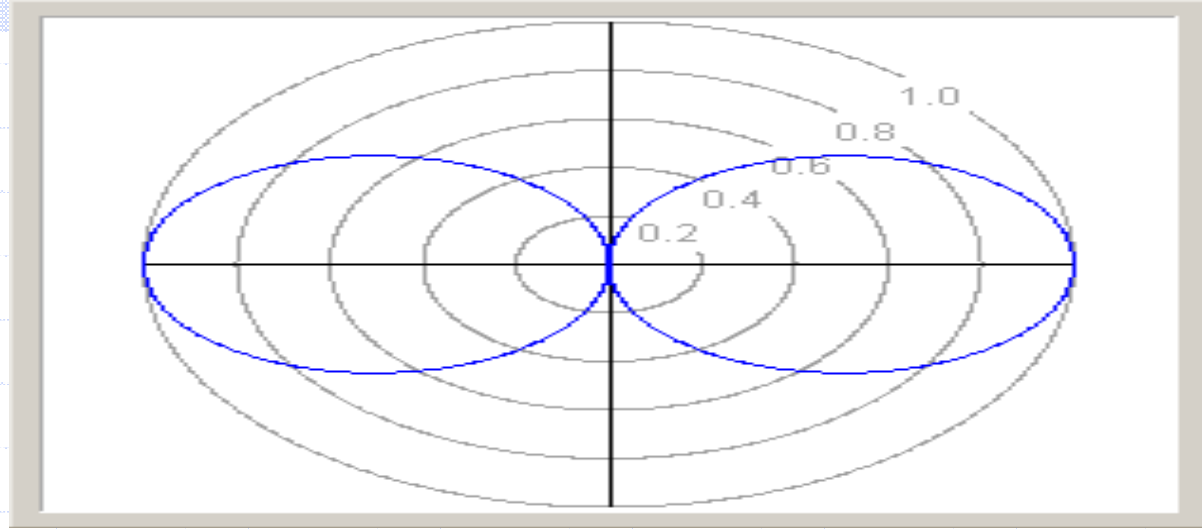
Inverted L

**Top Loaded
Short Vertical**

Loop antennas

Loop antennas share one common factor. The ends of a dipole antenna are connected together to form a closed antenna. This antenna has more gain broadside to it than a dipole, if in the vertical plane. It is usually $1\lambda + 5\%$ long on the desired band.

Loop antennas are usually quieter than long wire antennas. ie. They are less susceptible to man made noise and static.

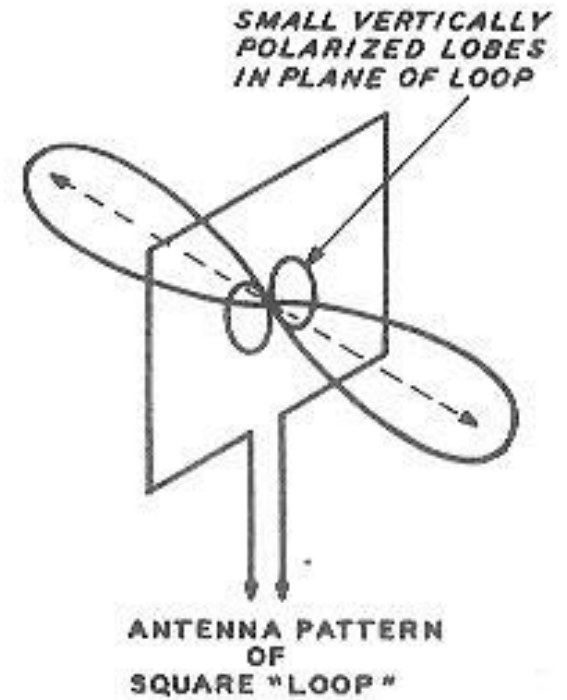
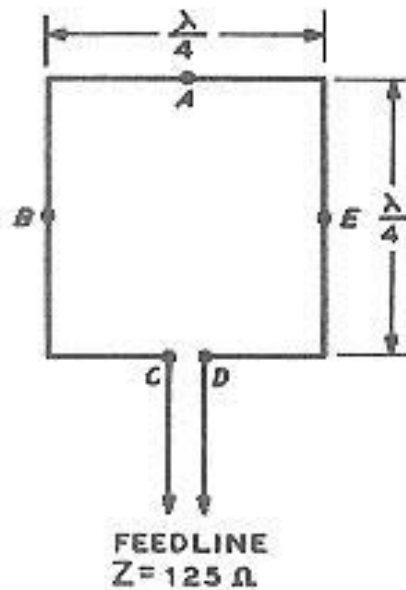
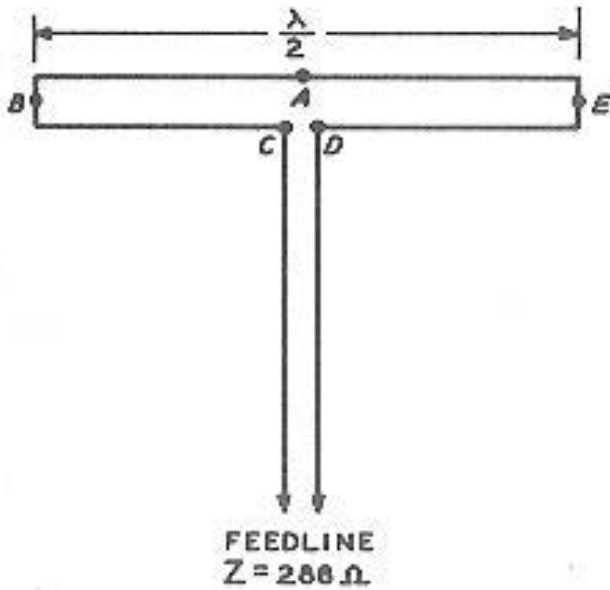


The large loop antenna is similar to a dipole, except that the ends of the dipole are connected to form a circle, triangle or square. Typically such a loop is some multiple of a half or full wavelength in circumference. Good results can be had with a 1λ loop.

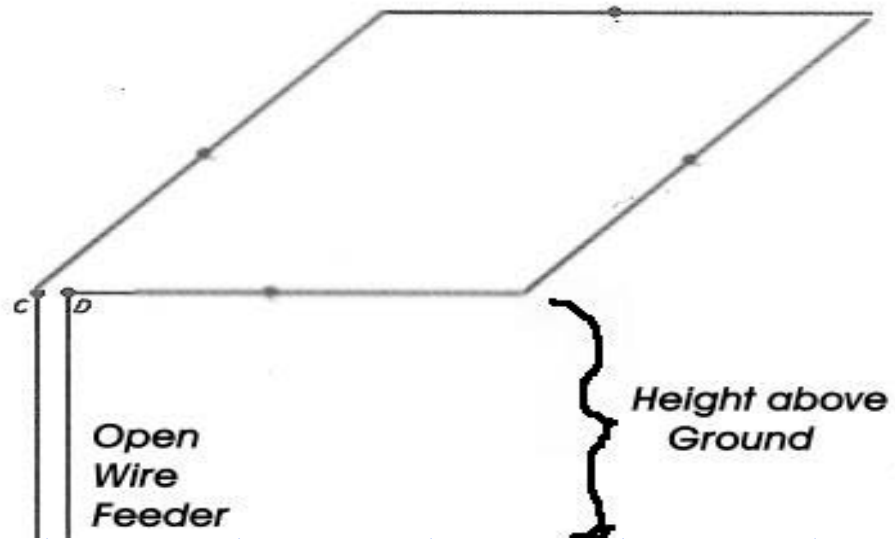
A loop has a pattern similar to a dipole with the maximum radiation broadside to the plane of the loop. The minimum is in the plane of the loop.

A single full wave loop has about 3 dB gain over a dipole

TWO WIRE FOLDED DIPOLE



*The Folded Dipole is a special case of a closed loop antenna.
It is $1/2\lambda$ long and only a few inches high.*

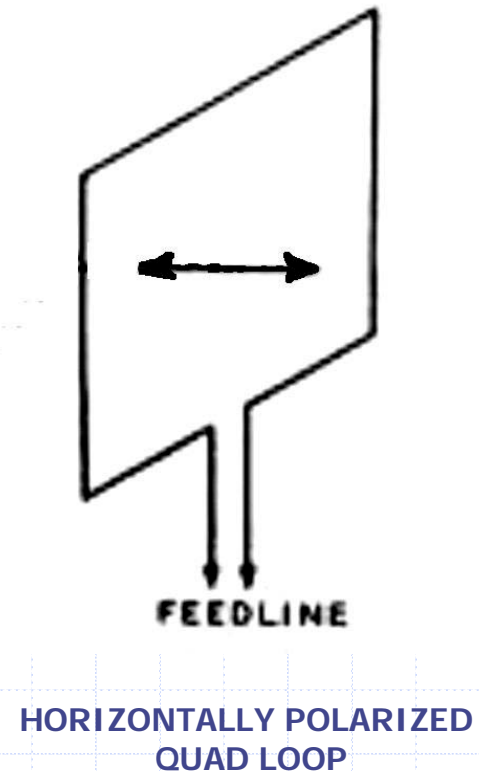
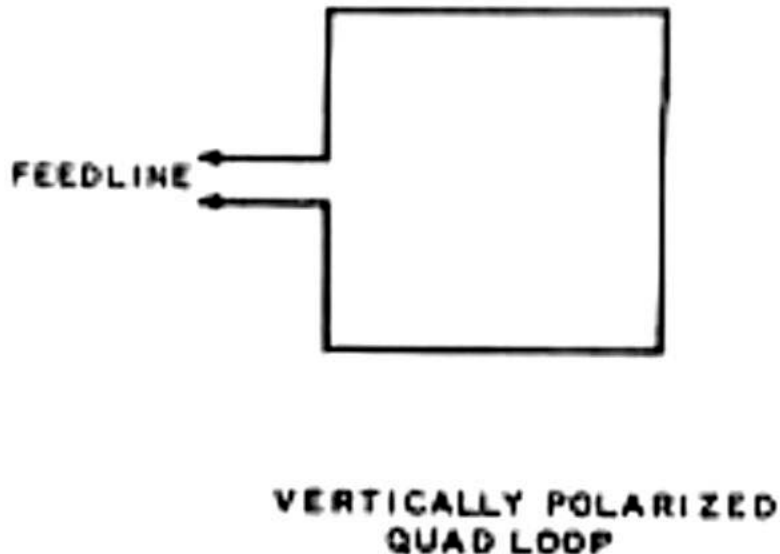


A horizontal loop held up equally high at 4 corners and fed with ladder line or a balun will perform well on a number of bands. Its height above ground will determine its vertical take off pattern. Usually, on the low bands, it is used as a cloud warmer to talk to near in stations.

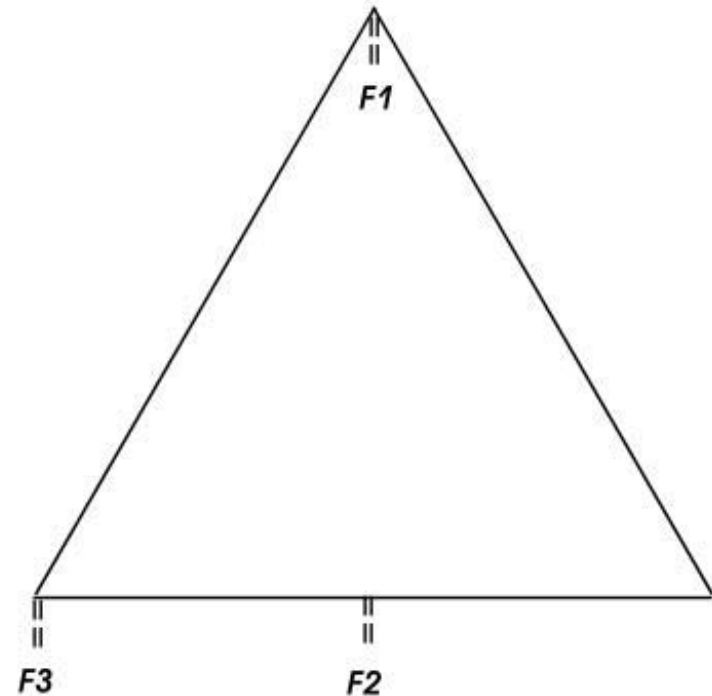
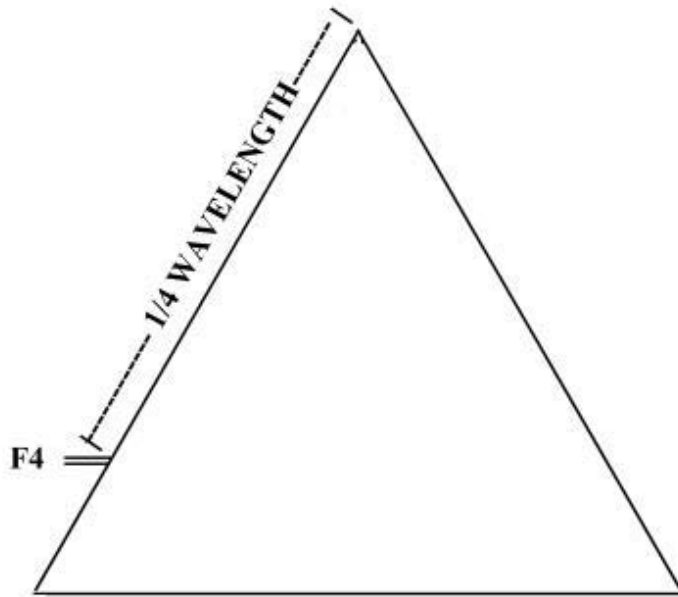
It can be 1λ or longer on desired bands. It must be at least 1λ long on the lowest band used.

A round or square loop that is fed at the top or center of the bottom leg will be horizontally polarized.

A round or square loop that is fed in the middle of the side will be vertically polarized.



A delta loop that is fed $\lambda/4$ down from the top will be vertically polarized. If it is fed at the top or the middle of the bottom, or bottom corner, it will be horizontally polarized



Before we talk about parasitic antennas and arrays, let's talk about various wire antennas that we can build and some general characteristics of some antennas:

Dipoles-- flat, sloping, inverted Vee

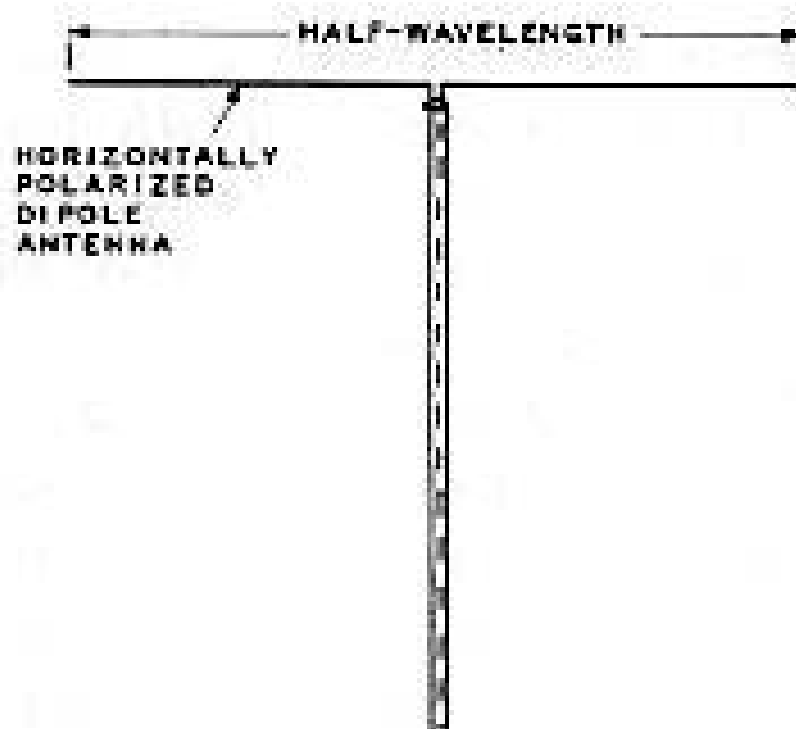
G5RV-- a special multiband dipole

Zepp-- end fed wire

Windom -- off center fed wire

Loops -- Square, Delta, Rectangle

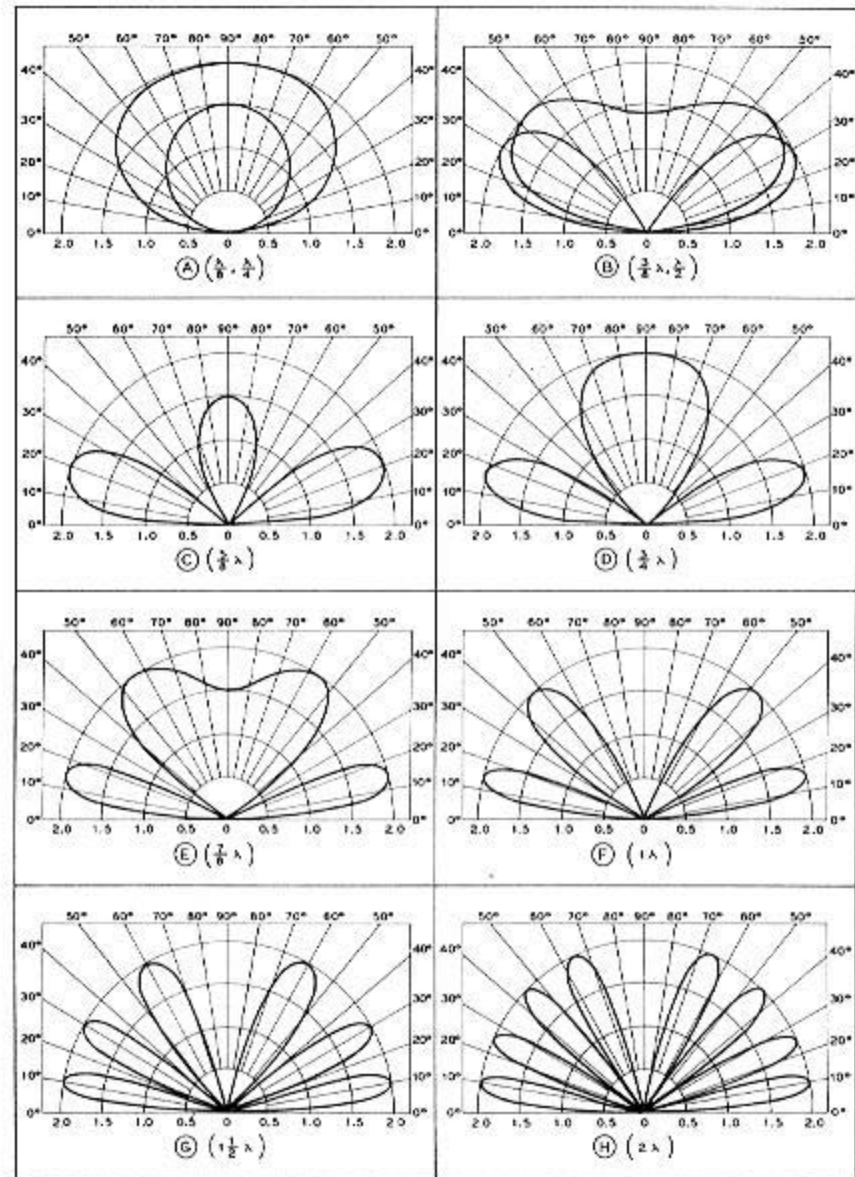
Dipole antennas work best when horizontal. They also work well when operated on odd multiples of a half wavelength.



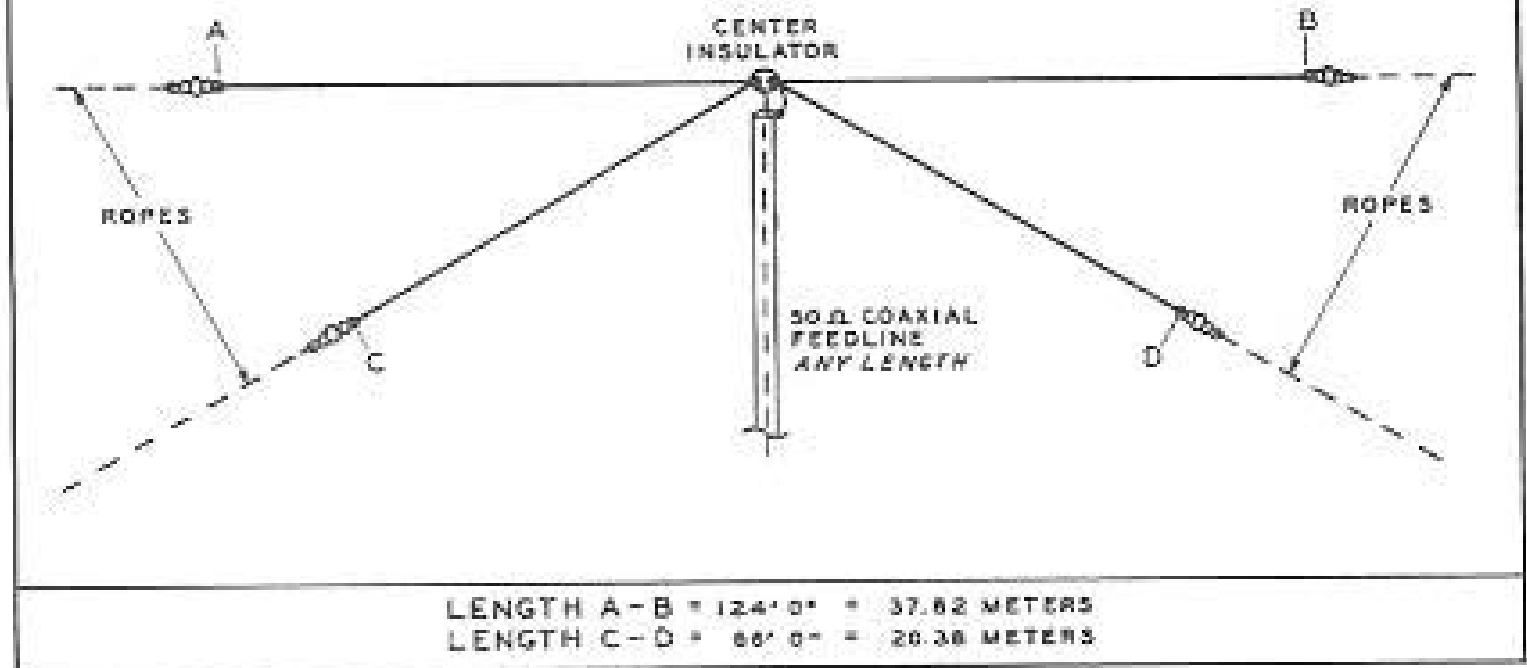
The take off angle of a dipole or any horizontal antenna is dependent on its height above ground.

To the right are patterns of a half wave dipole from 1/8 wave above ground to 2 wavelengths above ground. This holds for all HF Frequencies.

These patterns occur and vary due to the ground reinforcement and reflection of the RF.



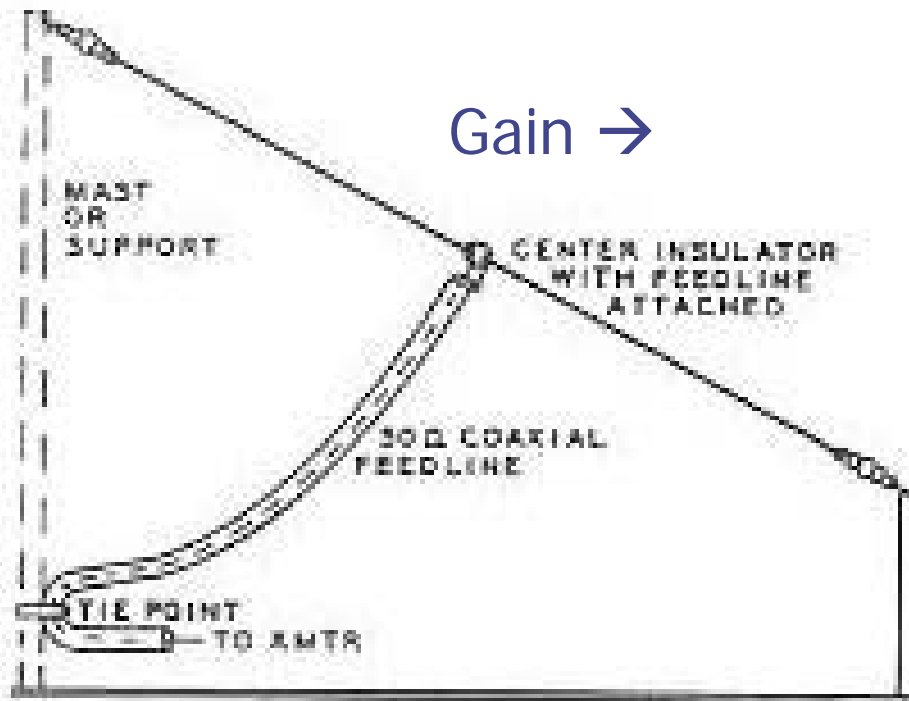
MULTI-BAND DIPOLE FOR 80-40-15 METERS



You can feed more than one dipole with the same feed line, but you must keep the wires somewhat separated to be effective, otherwise they interact and detune each other and nothing works.

Sloping Dipoles must be resonant, and can be held up by supporting one end higher than the other.

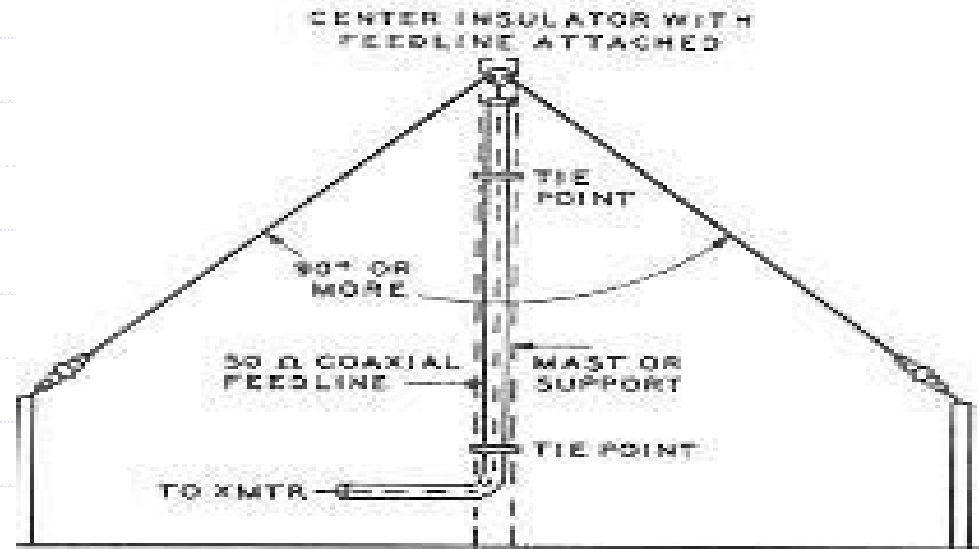
The feed line should be led away at right angles to the wires. It will show a small gain in the direction that the wire slopes.



Inverted Vee antennas are easy to erect because they can be held up by only one support.

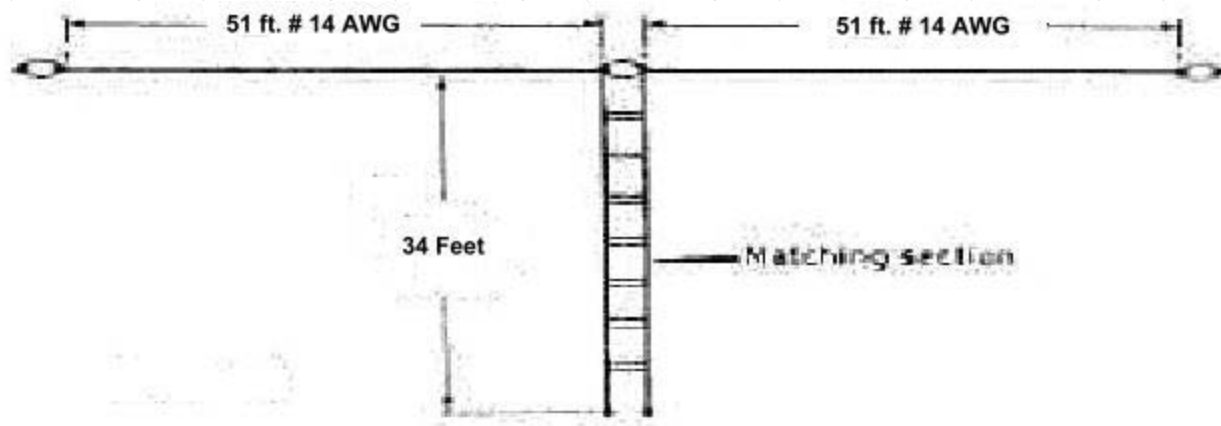
It is imperative that the included angle between the two wires is greater than 90 degrees, otherwise canceling will occur and the antenna will not radiate.

The inverted vee has horizontal polarization broadside to the antenna and vertical components off the ends.

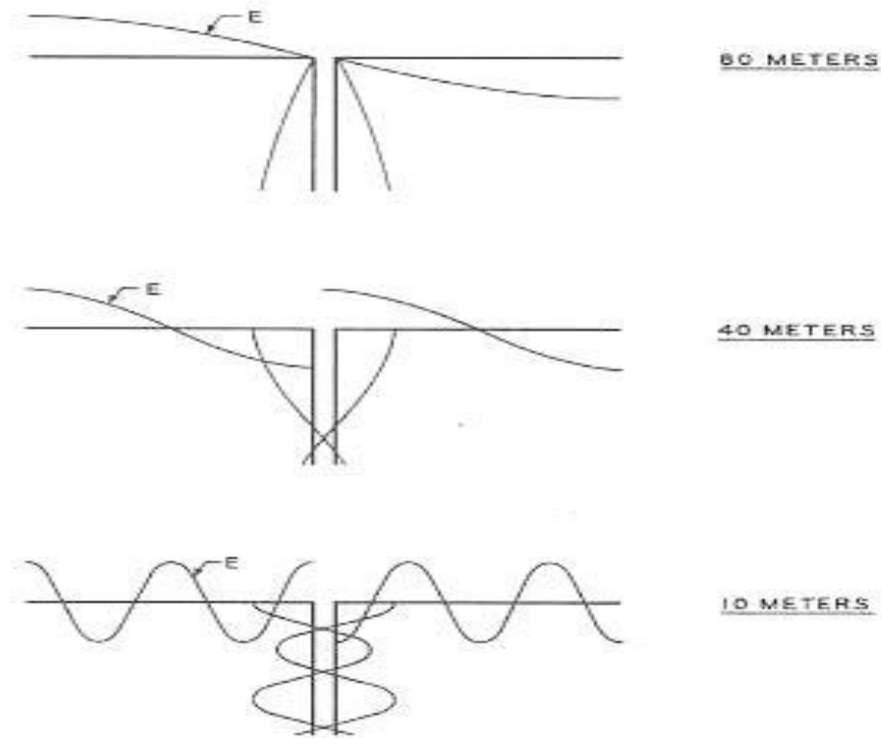


The G5RV antenna is a special dipole that by design (or accident of properties) allows a dipole that is fed with a special length of ladder line, a balun and coax cable to radiate fairly well on the HF bands.

This antenna is usually 102 feet long. The ladder line to it is 34 feet long. The two lengths added together in one instance create two $\sim\lambda/4$ wires on 80 Meters, and other resonant lengths for the higher bands from 40 through 10 meters. It must be fed with a Balun, to match a coax feed line.



**Connect 4:1 Balun and Coax from
Here to the Shack**

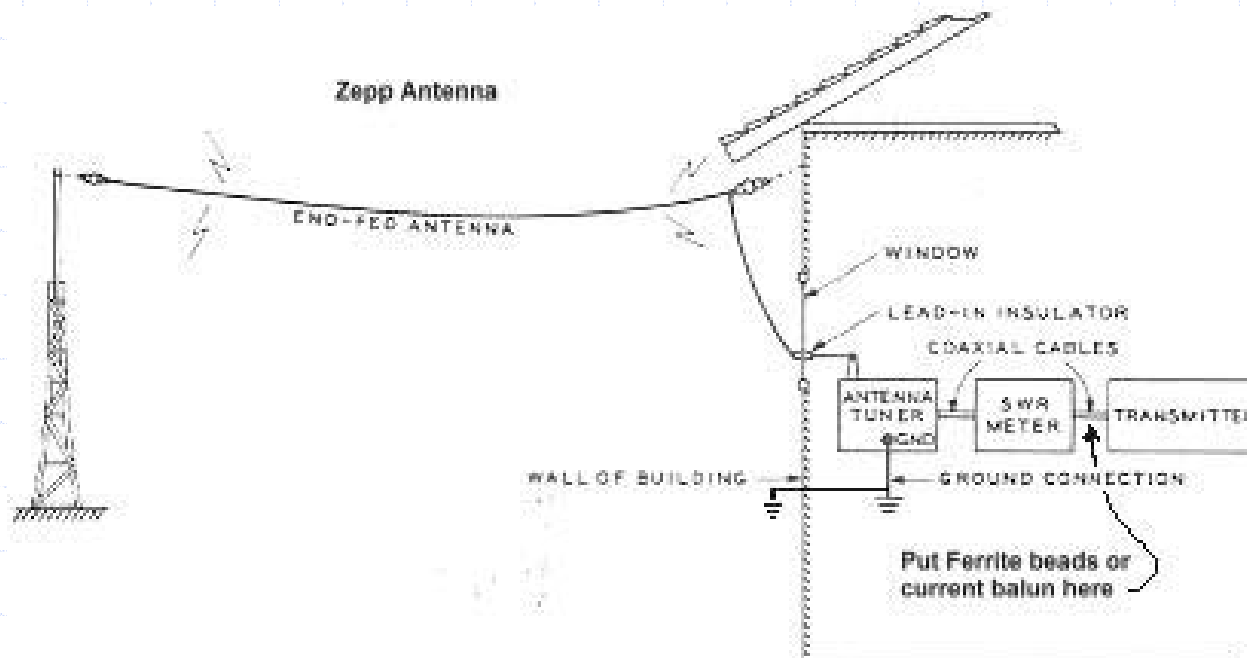


A variant of this antenna can be fed with ladder line all the way to a tuner in the ham shack.

It is best that this antenna be as horizontal as possible, but sloping the ends down a bit will not affect the antenna radiation patterns too much.

The Zepp antenna derives from the end fed wires that trailed the zeppelin airship. It was end fed, and unless it is an odd multiple of half wavelengths on the band desired, it will be difficult to feed.

The longer this antenna is in wavelengths, the more the pattern is skewed away from broadside radiation toward a more end fire pattern.



Question:

How do you use an antenna tuner to tune an antenna?

?

?

?

Question:

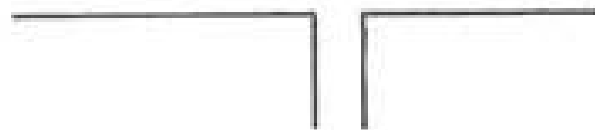
How do you use an antenna tuner to tune an antenna?

Answer: You don't tune the antenna with a tuner.

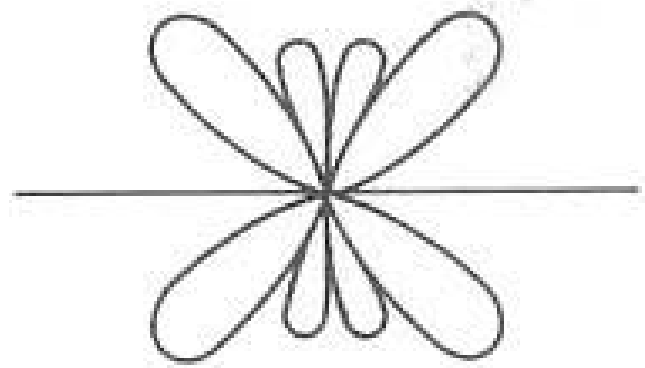
You create a match between the transmitter and the transmission line with a tuner. This allows the transmitter to put out its maximum power. If there is a poor match, the protection circuits for the solid state finals will cut back on the output power of your rig.

NOTE: A pi-network final in a tube rig is a "built in" tuner.

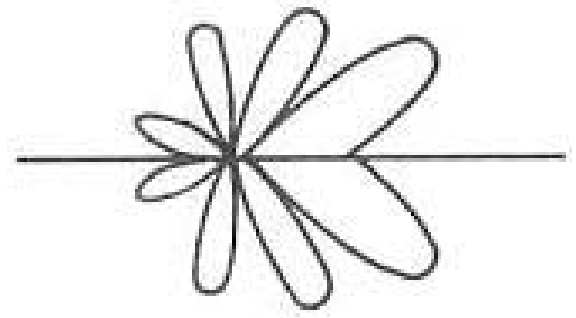
Only by altering the antenna do you "tune" it or make it resonant.



CENTER FED

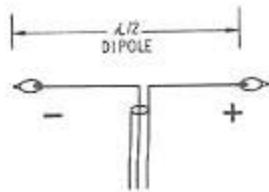


WINDOW

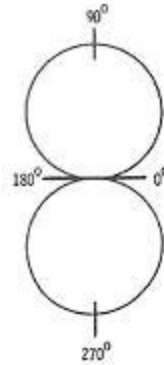


A Window antenna is a wire antenna that must be resonant. It is off center fed, which allows multi-band operation if fed with ladder line. Ideally, the feed point is placed at a $\lambda/4$ away from one end on the favorite band to be used. Hopefully, the other bands will still find an acceptable match relative to that feed point. It can be fed with ladder line or a single wire feed.

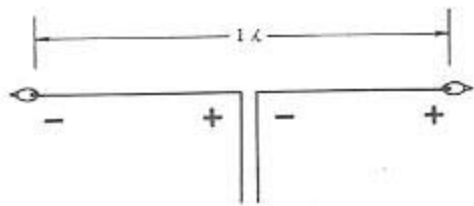
Harmonically fed dipole antennas



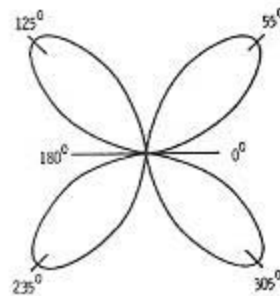
(A) Half-wave dipole.



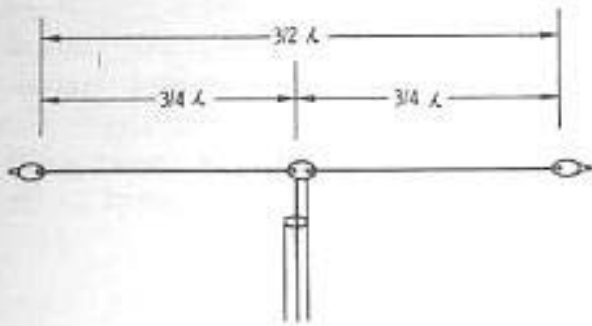
We know the typical pattern of a half wave dipole... a figure 8



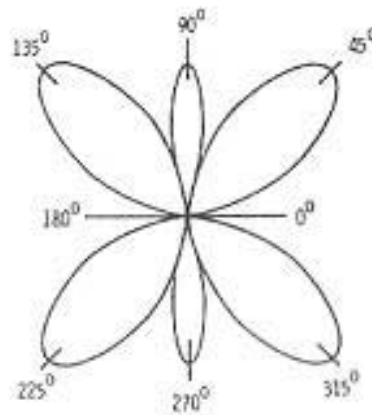
(B) Full-wave dipole.



Here is the radiation pattern when that same wire is fed as a full wave antenna... the pattern is now like a 4 leaf clover

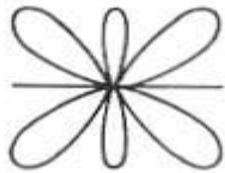


(A) Basic construction.

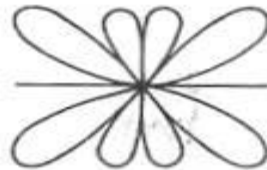


(B) Radiation pattern.

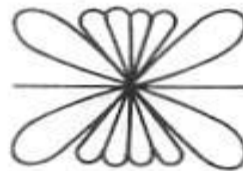
At Left is a $3/2\lambda$ Antenna



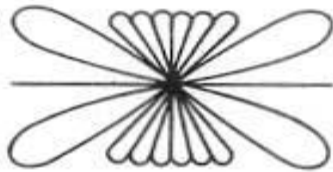
$3/2\lambda$



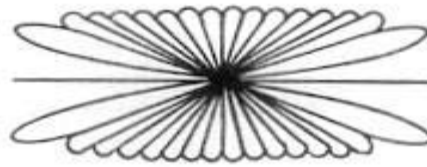
2λ



$5/2\lambda$



4λ



8λ

Influence of long-wire length on horizontal pattern.

These are higher multiple patterns.

You can see how the patterns skew toward the ends as the wire gets longer.

ARRAYS

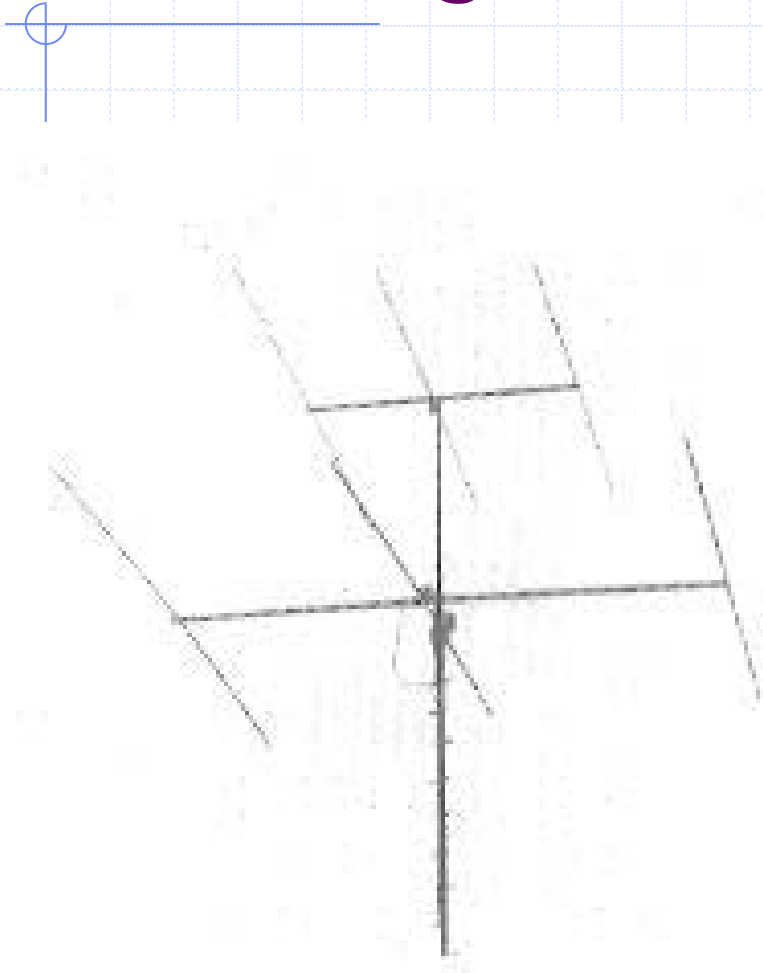
Take the antennas we have just discussed and we can create arrays of them to force the RF to be focused in one or two directions. This creates gain in those antennas relative to a dipole, loop or vertical antenna.

These antennas are Yagis, Quads and phased vertical arrays. The more elements, the more gain in a given direction. This can be good and bad.

Good: We have more ERP in a given direction.

Bad: We can't hear or be heard in other directions.

The Yagi – Uda Antenna

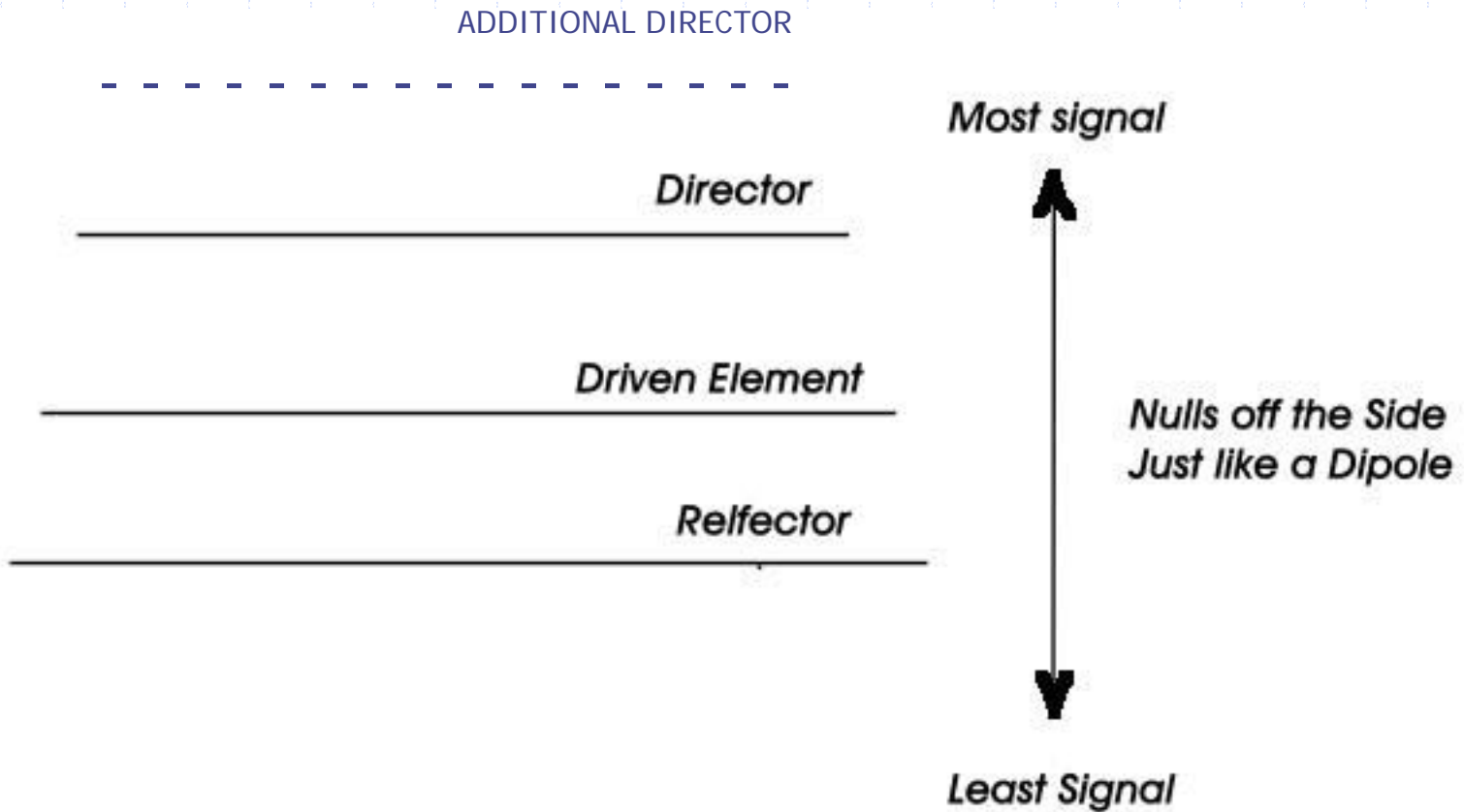


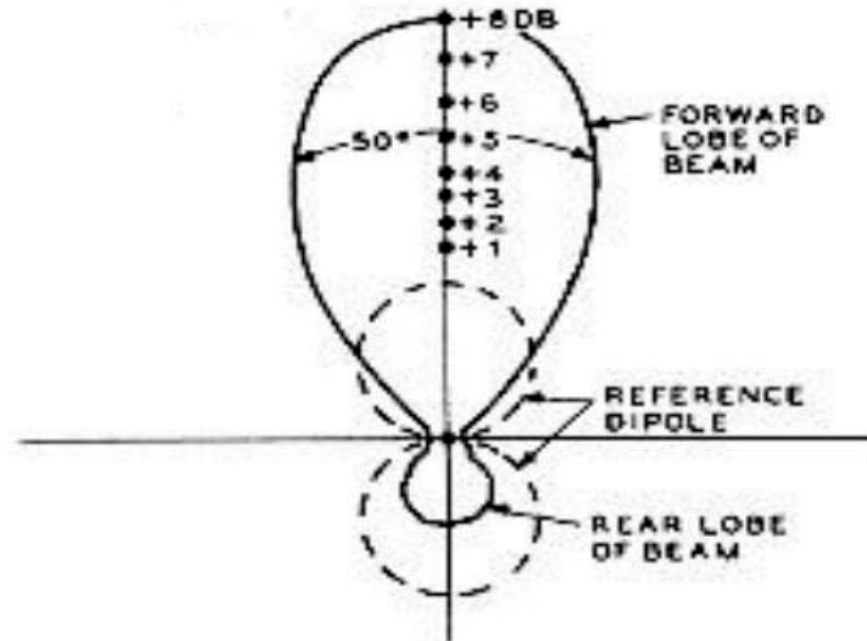
The Yagi antenna consists of two or more elements.

The driven element is a dipole and the directors and reflector are called parasitic elements.

They are resonant elements and will cause the RF to be reflected or directed in a specific direction giving the antenna gain in that direction.

The yagi antenna

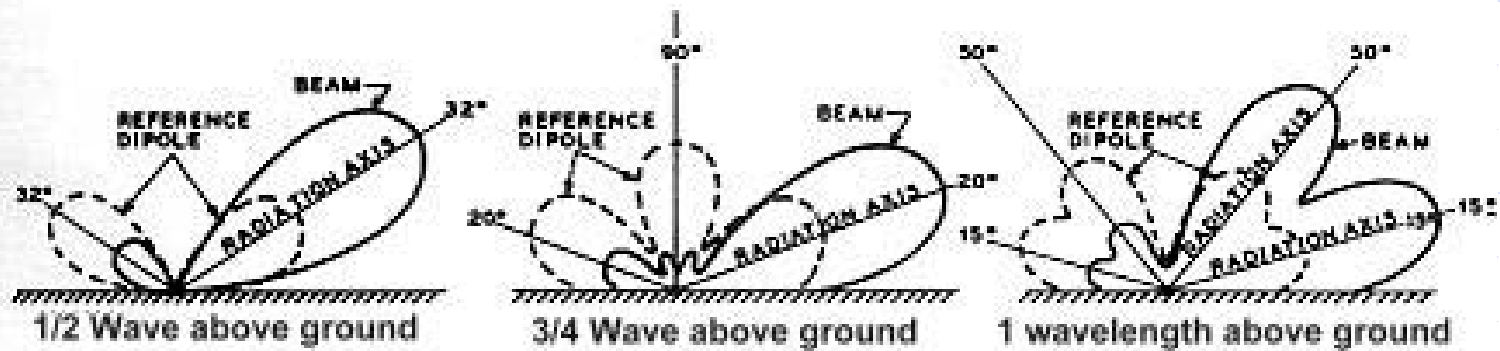




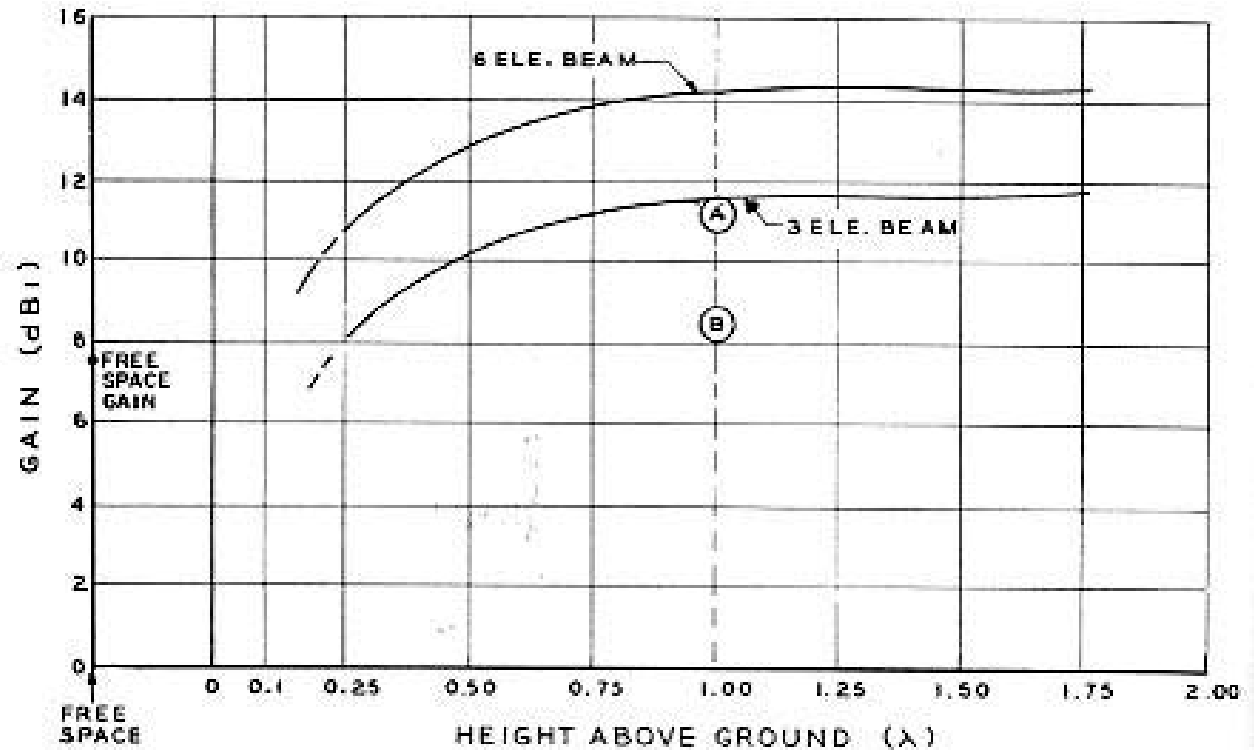
A 4 element Yagi polar plot shows that the Half Power Beamwidth (3 dB down points) is about 50 degrees.

The antenna has about 8 dB gain over a dipole (dotted line) and a front-to-back ratio of about 18 dB.

Since the pattern is broad, precise aiming is not necessary.



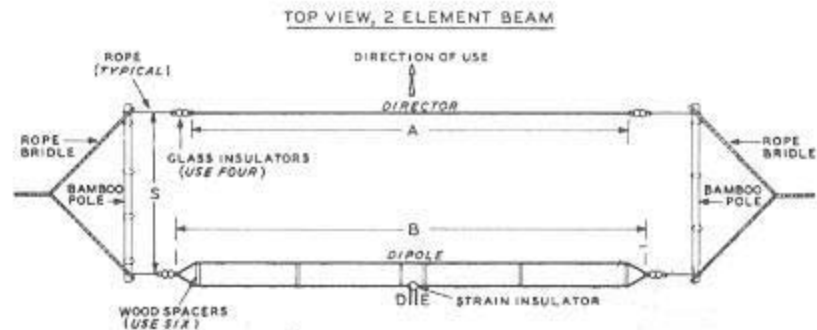
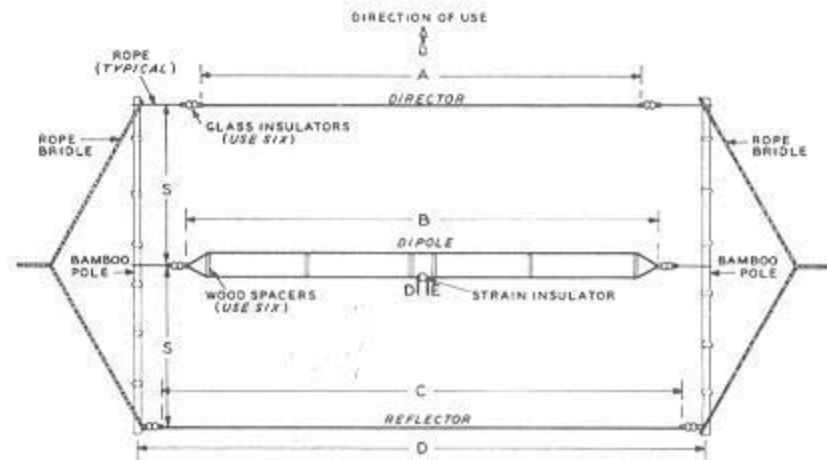
A 3 element Yagi, at various heights is compared to a dipole at similar heights. The same amount of radiated energy is seen by the area of both curves being equal. Only the Yagi concentrates the energy more in one direction.

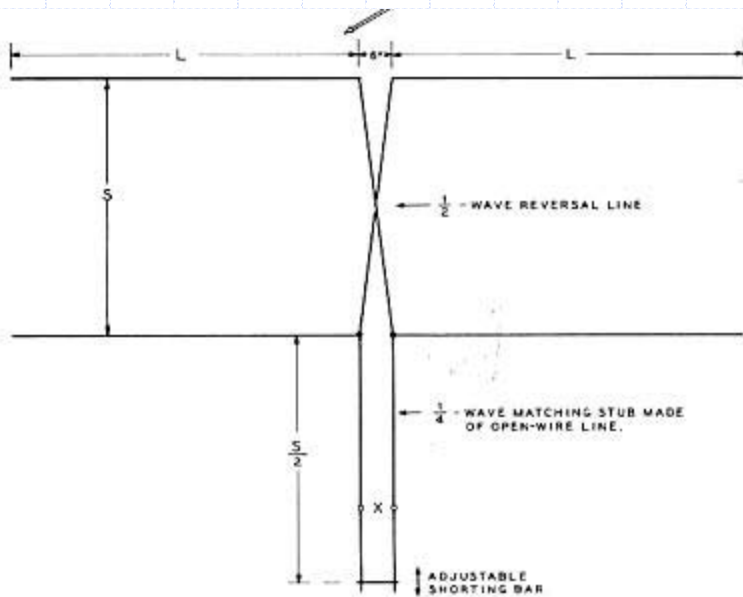


As the number of elements increase, so does the forward gain of the Yagi. Once it is 1λ above ground, the ground effects are lessened and the antenna gain is as if it were in free space. Subtract 2.3 dB for reference to a dipole antenna.

In the early days of Ham Radio, when aluminum tubing was not readily available, Yagis were made of wire and suspended between bamboo poles.

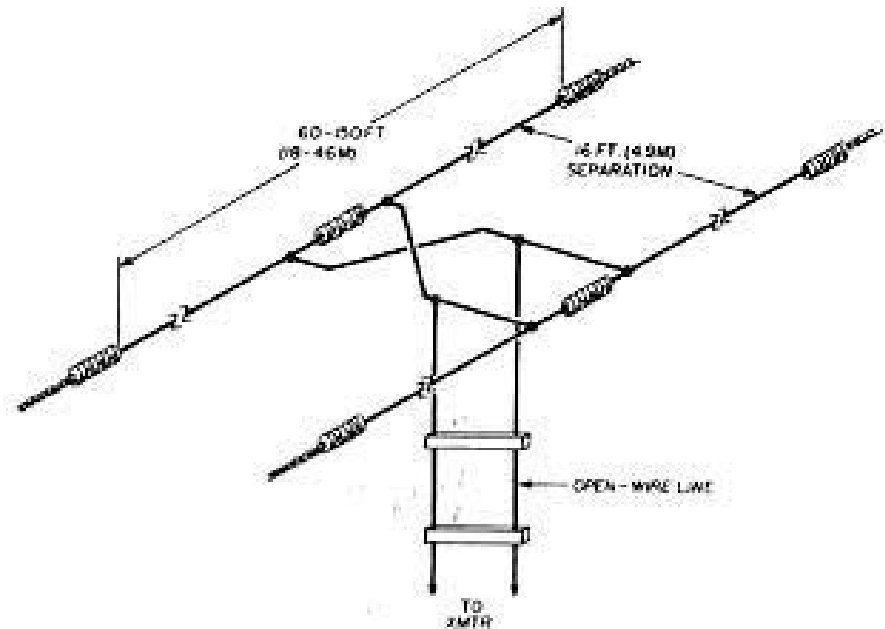
You could still make a very effective antenna this way, but rotating it would be tough !!





LAZY-H DIMENSIONS

BAND	LENGTH - L		SPACING - S	
	FEET	METERS	FEET	METERS
40	65' 7"	20.00	68' 9"	20.97
30	46' 4"	14.12	48' 7"	14.82
20	33' 0"	10.10	34' 8"	10.58
17	25' 10"	7.89	27' 2"	8.28
15	22' 1"	6.74	23' 1"	7.07
12	18' 9"	5.73	19' 8"	6.01
10	16' 4"	4.98	17' 1"	5.22
6	9' 4"	2.85	9' 9"	3.00



The Lazy H antenna (left) and the W8JK antenna (above) are examples of wire arrays that were widely used on the low bands where size makes it quite difficult to put up an aluminum Yagi antenna.



The Hy Gain TH-11 covers 20, 17, 15, 12, and 10 Meters
With good results. It weighs 88 pounds. Forward gain is in
The area of 7.5 to 9.2 dBi depending on the band.

\$1039.00



The Force 12 XR-5 antenna covers 5 bands 10/20M
It weighs 56 # and has gain figures approximately
4.5 dBd (6.7 dBi) on each band. It has two
active elements on each band. \$1664.00



The Cushcraft MA5B 5 band trap yagi shows gain in the 3.5 to 5 dBd range for 10, 15, and 20M and unity with the resonant dipoles on 12 and 17 M. It weighs 26 # and will handle 1200 W PEP. \$489.95

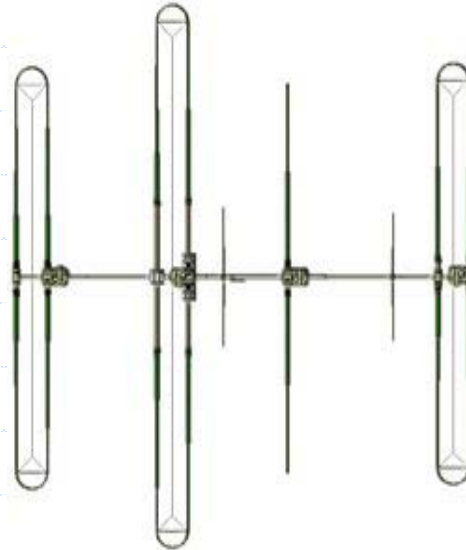
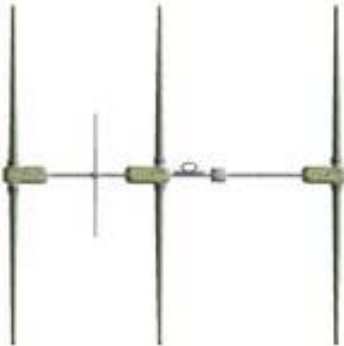
There are many "tribanders" that are 2 to 6 element trapped antennas. They cover the 10-15-20 Meter Bands but not the WARC bands 12 & 17 M.

The reason that there are so many is that they have been around much longer, since they were designed before the WARC bands were created.

Also, they are in demand by contesters where only the non-WARC bands are used.

To compliment them, there are duo-band trap yagis available for 12 & 17 meters that can be added to a stack.

Also, Single band yagi antennas are available for those who prefer only one band, or want to stack them in a "Christmas tree" array, or on several different towers.

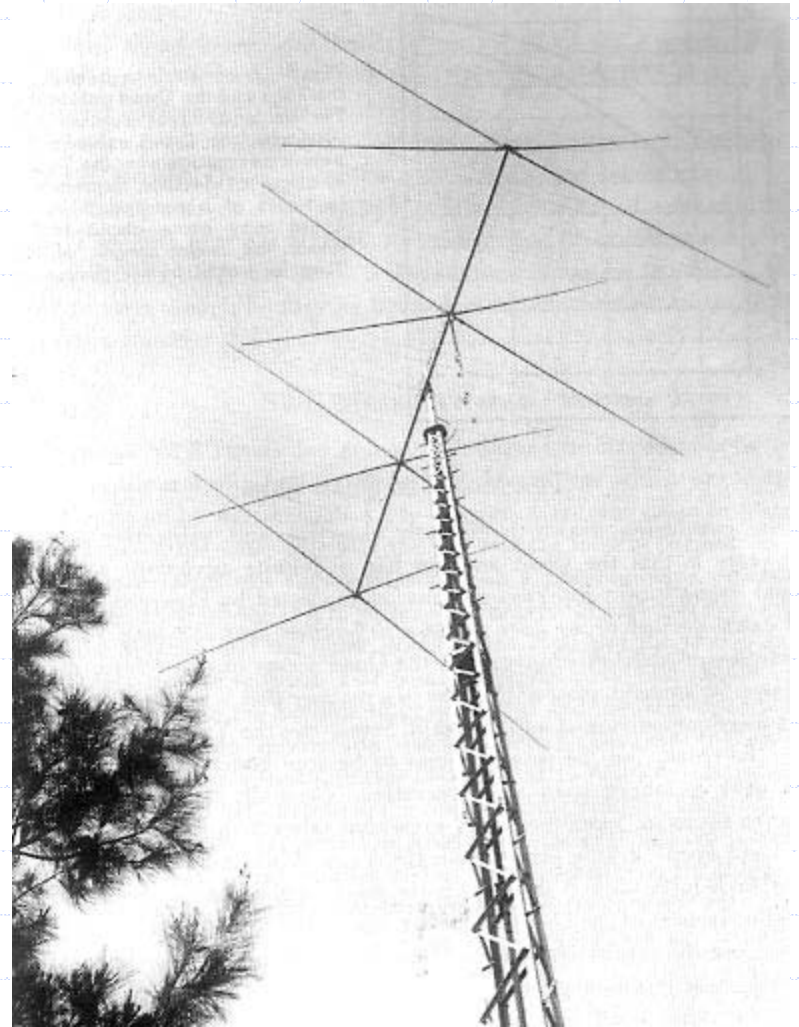


The SteppIR series of antennas are the new generation of technology. Each element in the Yagi or vertical antenna slides inside a hollow fiberglass housing. Each element length is continuously adjustable using a stepper motor (thus the name) to make each element the proper length for the operating frequency chosen. The adjustments can be made manually or automatically. You can have your rig or logging program tell the antenna the frequency.

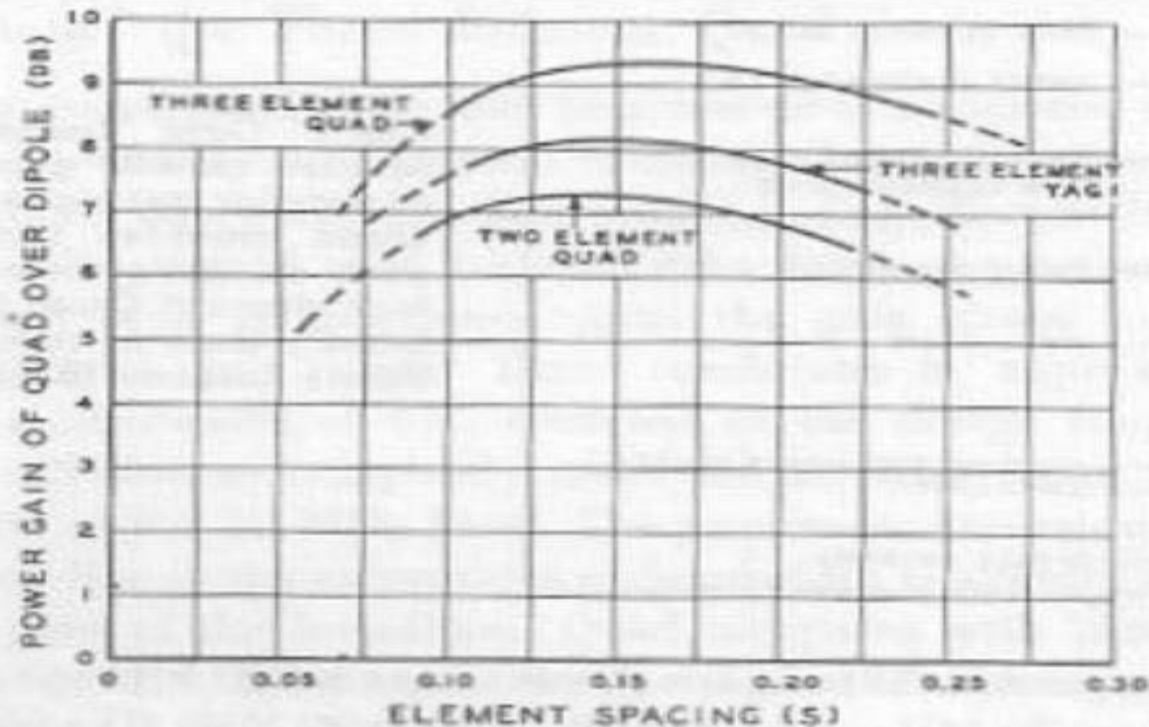
Quad antennas

Quad antennas are similar to the Yagi antenna in that they use a driven element and a reflector and/or directors to focus the RF in a desired direction.

The only difference is that the elements are loops and not dipoles or linear elements

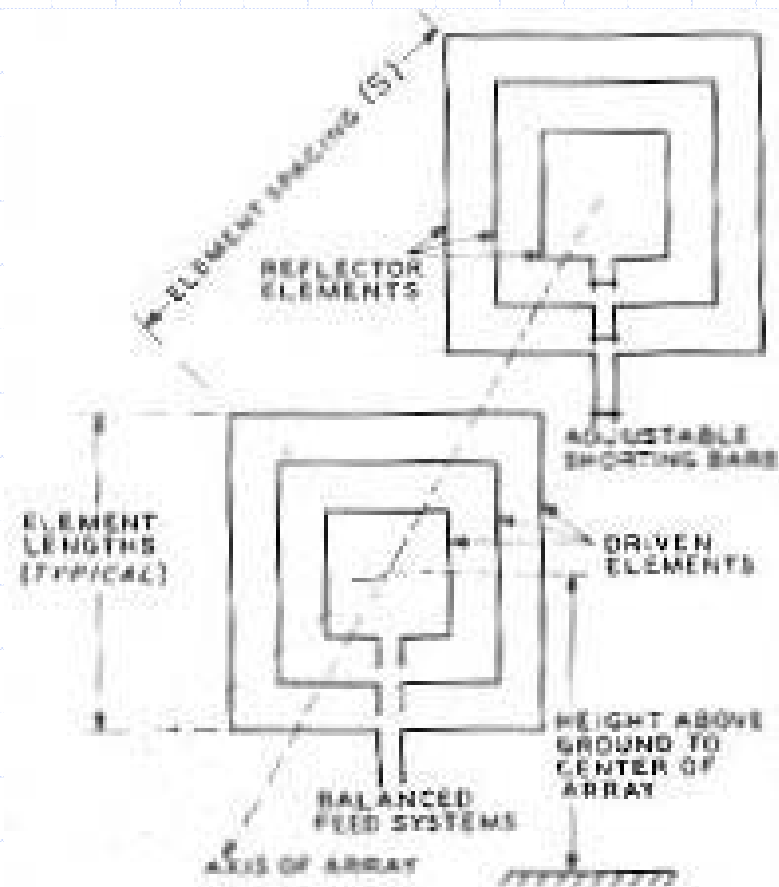


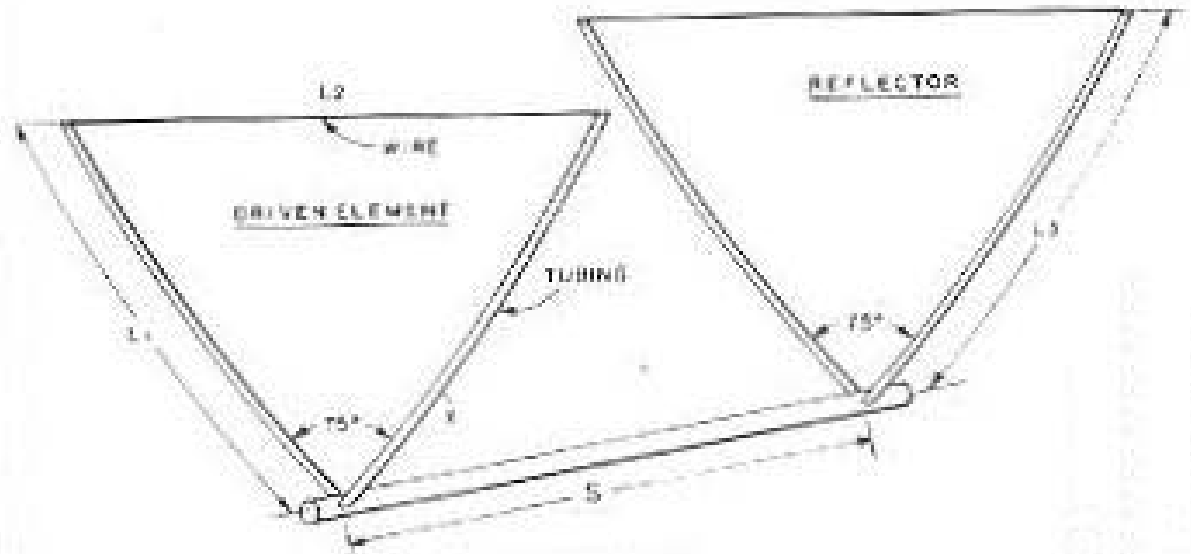
Being a loop antenna, the quad is a quieter receive antenna. It has a gain figure per element a bit higher than a Yagi. Remember— a full wave loop has a gain figure of 3 dB over a dipole to start with.



The quad is easily placed on multiple bands by interlacing resonant elements on each set of spreaders. The driven elements can be driven in parallel or individually.

Sometimes smaller spreaders are used to mount intermediate elements for the higher frequencies. This creates a better spacing between those elements and adds gain.





The Delta loop quad is easy to build, but not really suited to windy South Florida. It radiates equivalent to a diamond or square shaped 2 element quad.

Vertical Arrays

Just like Yagi or Quad arrays of elements, the vertical antenna is suited to creating gain in a given direction. By arranging the elements in a specific orientation and phasing how the RF is delivered to the antennas, all elements are usually active and radiating.

When the signals from the various elements meet, they reinforce or cancel similar to waves in a pond when several stones are thrown into it simultaneously or in succession.

The radiation patterns are determined by element spacing and phase lag or lead of the RF

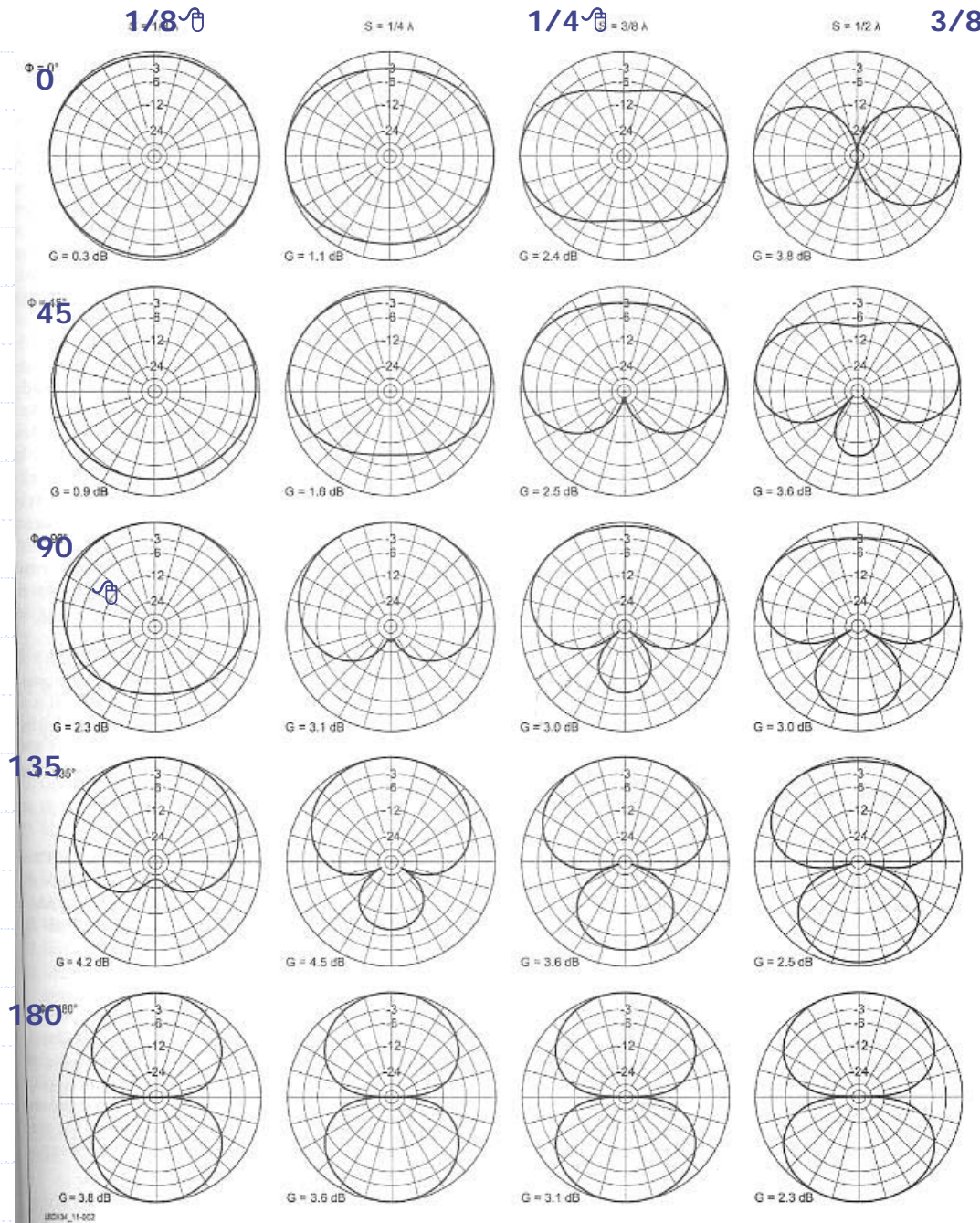
Except for the ground plane verticals discussed earlier, vertical antennas are usually best suited for the low bands, 160, 80 and sometimes 40 Meters.

They can be $\lambda/4$ tall or trap/coil loaded to shorten them.

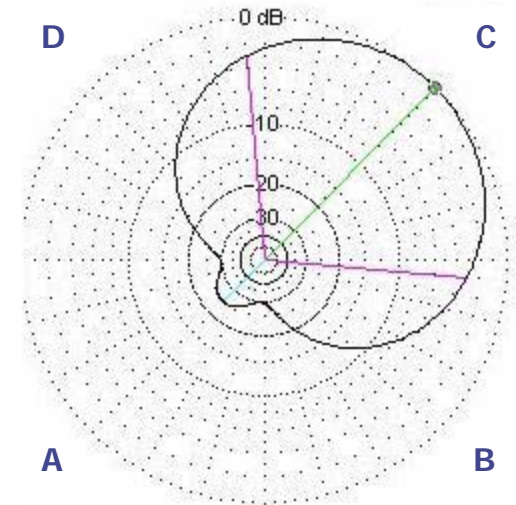
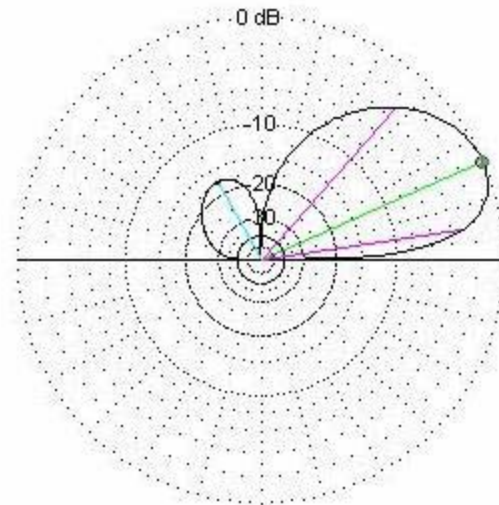
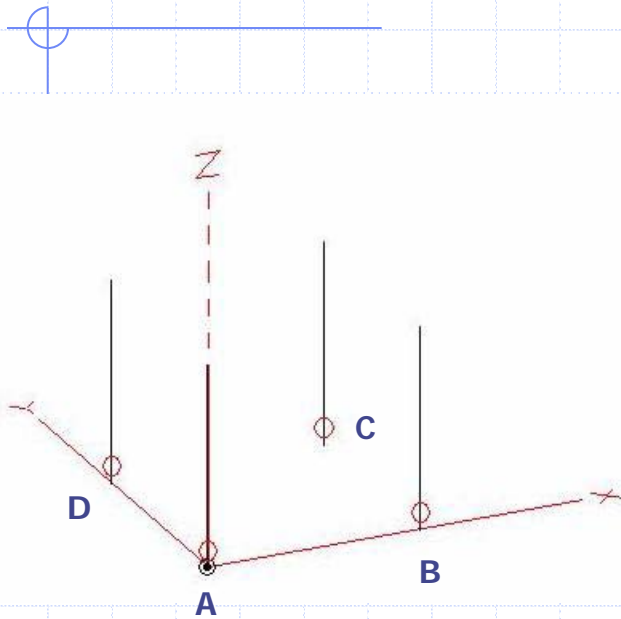
If you have a large area, the verticals can be put up in various configurations to give gain, just like Yagi antennas.

2, 3, 4 or more verticals can be fed in or partially out of phase to produce gain in a desired direction. This is a topic that could consume several nights.

The plots shown here are for a pair of phased verticals fed with equal current each, with spacing and phase lag between the two verticals as shown



4 - $\frac{1}{4}$ wave verticals – phased:



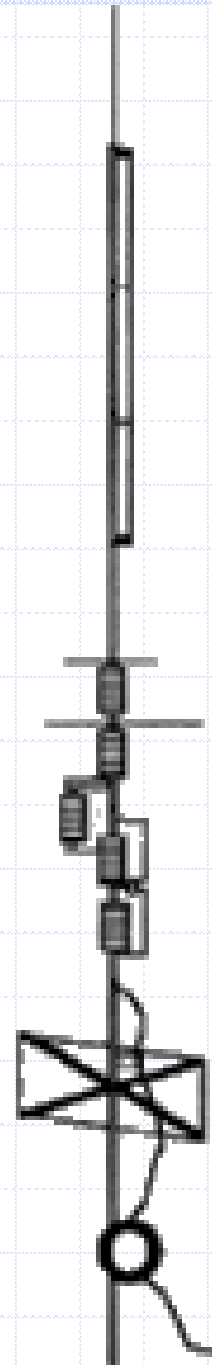
All 4 verticals are fed diagonally with two in phase and the leading and lagging corners fed 90 degrees leading or lagging to produce gain as shown above. A = +90deg.; B&D = 0deg.; C = -90 degrees phase.

Commercial, trapped verticals can be made to perform well on many of the HF bands. They must be fed against a counterpoise or ground system.

(Right) Butternut HF9V 80-6M

Vertical.

\$449.00



Exceptions to the need for radials or a counterpoise are the R5, R6, R8 and MFJ verticals.

The R series are end fed half wave antennas with a high impedance matching system for a feed.

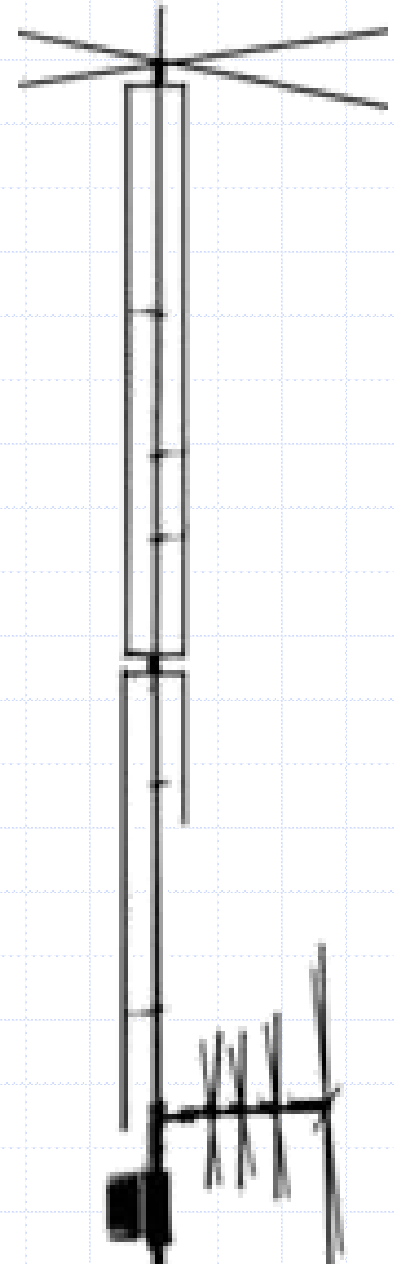
(Right) Cushcraft R8 40-6M
Vertical \$529.00



The MFJ is an off-center fed vertical dipole with the trapped lower resonant parts of the antenna rotated 90 degrees.

(Right) MFJ 1798 80-2M Vertical

\$279.00





This extendable vertical can be used at home or on an RV or at field day.

It contains a flexible wire and extends to 32 feet. When nested it is 4 feet long.

Here an antenna tuner feeds the vertical against the chassis of the RV as a counterpoise

Under \$100.00

Thank you for your attention

Any Questions???