Antennas

A good antenna works

A bad antenna is a waste of time & money

Antenna systems can be very inexpensive and simple

They can also be very, very expensive

Antenna Considerations

–The space available for an antenna

–The proximity to neighbours

–The operating frequencies you will use

–The output power

–Money

Antenna Types

High Frequency

1.6 - 30 Mhz + 50 Mhz

160 - 6 metres

An antenna's size/length depends on the frequency

It's functionality largely depends on the height above ground, as well as the polarity and it's configuration

Some Math

Velocity of propagation 300,000,000 m/sec

For 1 wavelength, above 30 MHz

Frequency (f) = 300 / wavelength
Wavelength (λ) = 300 / frequency

Frequency measured in megahertz
Wavelength measured in meters

Above 30 MHz, λ = 300/f metres or 984/f feet
For a half wave λ = 150/f metres or 492/f feet
Below 30 MHz λ = 286/f metres or 936/f feet (including the velocity factor 0f 0.95)
For a half wave λ = 143/f metres or 468/f feet

The length of a half wave dipole for 3.65 MHz

The length of a half wave dipole for 3.65 MHz

L = 143/f = 143/3.65 = 39.18 metres

The higher the frequency the shorter the antenna
The lower the frequency the longer the antenna

Types of Antennas

Simple wire

- Dipole
- Folded dipole
- Trap dipole
- Offset or Windom antenna
- Phased dipoles
- Vertical or horizontal (both)
- Beverage wave antenna

Types of Antennas

–Metal
–Vertical
–Yagi
–Trap Yagi
–Phased arrays
–Loops
–Vertical or Horizontal
–Horns for super ultra high frequencies
–Mobile antennas

Antenna Polarization

- Vertical or horizontal

- Electrical vs Magnetic radiation

(Diagram)

- Vertical waves travel @ 90° to the earths surface

- Horizontal waves travel parallel to the earth's surface

- Usually wire antennas are horizontal but an inverted 'V' dipole has a vertical component

- Yagi type antennas can be either vertical or horizontal

Circular antennas can be both

- Usually, horizontally polarized antennas hear less noise

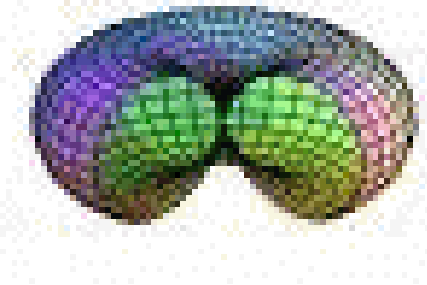
Isotropic Antenna

- The isotropic antenna is a hypothetical point source.

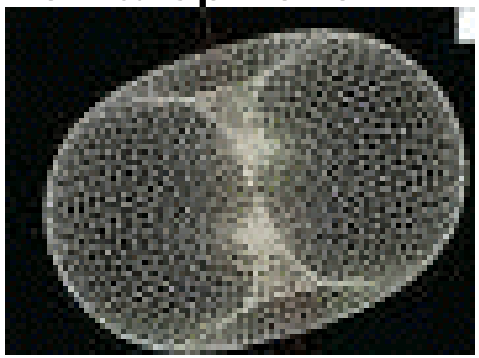
- It does not exist in reality but is considered as an important starting point considering different

- antennas from the theoretical to the practical

- The pattern is a Cardioid - a donut shape or a sphere



Dipole Radiation Pattern



Polarization - Practical

Antennas radiating a vertical polarization are best received by an antenna of like polarization

Cross polarization reduces reception by as much as 30 db

Bouncing DX signals probably have both polarizations

Designing antenna polarization usually depends on the frequency being used - at 70 cm in th eUHF band the elements are very short so either polarization is possible. Usually vertical is used as repeaters are vertically polarized.

Resonance

Antenna length is dependant on frequency

The lower the frequency the longer the antenna elements

Examples

80 metres	3.750 Mhz	124 ft
40	7.055	66
10	28.5	16.4
6	52	9
2	145	3.2

Isotropic Source

An isotropic antenna is a: **hypothetical point source**

What is the antenna radiation pattern for an isotropic radiator? **A sphere**

Polarization of an antenna is determined by: **the electric field**

What does horizontal wave polarization mean? **The electric lines of force of a radio wave are parallel to the earth's surface**

What does vertical wave polarization mean? **The electric lines of force of a radio wave are perpendicular to the earth's surface**

Polarization by Element Orientation

Con't

What electromagnetic wave polarization does a Yagi antenna have when its elements are parallel to the earth's surface? **Horizontal**

What electromagnetic wave polarization does a half-wavelength antenna have when it is perpendicular to the earth's surface? **Vertical**

VHF signals from a mobile station using a vertical whip antenna will normally be best received using a: **vertical ground-plane antenna**

A dipole antenna will emit a vertically polarized wave if it is: **Parallel with the ground mounted vertically**

If an electromagnetic wave leaves an antenna vertically polarized, it will arrive at the receiving antenna, by ground wave: **vertically polarized**

Compared with a horizontal antenna, a vertical antenna will receive a vertically polarized radio wave: **at greater strength**

Wavelength vs Physical Length

The speed of a radio wave: **is the same as the speed of light**

The velocity of propagation of radio frequency energy in free space is: **300 000 kilometres per second**

If an antenna is made longer, what happens to its resonant frequency? **It decreases**

If an antenna is made shorter, what happens to its resonant frequency? **It increases**

The resonant frequency of an antenna may be increased by: **shortening the radiating element**

Wavelength vs Physical Length

Con't

To lower the resonant frequency of an antenna, the operator should: **lengthen it**

Adding a series inductance to an antenna would:

decrease the resonant frequency

Wavelength vs Physical Length

Con't

- The wavelength for a frequency of 25 MHz is:
  12 metres (39.4 ft)

- The wavelength corresponding to a frequency of 2 MHz is:
150 m (492 ft)

- At the end of suspended antenna wire, insulators are used.
These act to: **limit the electrical length of the antenna**

- One solution to multi-band operation with a shortened radiator is the "trap dipole" or trap vertical. These "traps" are actually: **a coil and capacitor in parallel**

Gain, Directivity, etc.

- What is meant by antenna gain? **The numerical ratio relating the radiated signal strength of an antenna to that of another antenna**

- The gain of an antenna, especially on VHF and above, is quoted in dBi. The "i" in this expression stands for: **isotropic**

- Approximately how much gain does a half-wave dipole have over an isotropic radiator? **2.1 dB**

- What is a parasitic beam antenna? **An antenna where some elements obtain their radio energy by induction or radiation from a driven element**

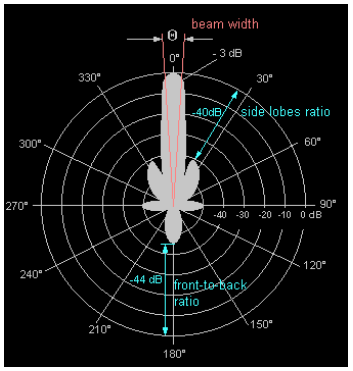
- If a slightly shorter parasitic element is placed 0.1 wavelength away from an HF dipole antenna, what effect will this have on the antenna's radiation pattern? **A major lobe will develop in the horizontal plane, toward the parasitic element**

- If a slightly longer parasitic element is placed 0.1 wavelength away from an HF dipole antenna, what effect will this have on the antenna's radiation pattern? **A major lobe will develop in the horizontal plane, away from the parasitic element, toward the dipole**

Gain, Directivity, etc.

Con't

- In free space, what is the radiation characteristic of a half-wave dipole? **Minimum radiation from the ends, maximum broadside**



- The front-to-back ratio of a beam antenna is: **the ratio of the maximum forward power in the major lobe to the maximum backward power radiation**

- The property of an antenna, which defines the range of frequencies to which it will respond, is called its: **bandwidth**

- What is meant by antenna bandwidth? **The frequency range over which the antenna may be expected to perform well**

- How can the bandwidth of a parasitic beam antenna be increased? **Use larger diameter elements**

Vertical Antennae

- To calculate the length in metres (feet) of a quarter wave vertical antenna you would : **Divide 71.5 (234) by the antenna's operating frequency (in MHz)**

- If you made a quarter-wavelength vertical antenna for 21.125 MHz, how long would it be? **3.6 metres (11.8 ft)**

- If you made a half-wavelength vertical antenna for 223 MHz, how long would it be? **64 cm (25.2 in)**

- If a magnetic-base whip antenna is placed on the roof of a car, in what direction does it send out radio energy? **It goes out equally well in all horizontal directions**

- What is an advantage of downward sloping radials on a ground plane antenna? **It brings the feed point impedance closer to 50 ohms**

Vertical Antennae

Con't

What happens to the feed point impedance of a ground-plane antenna when its radials are changed from horizontal to downward-sloping? **It increases**

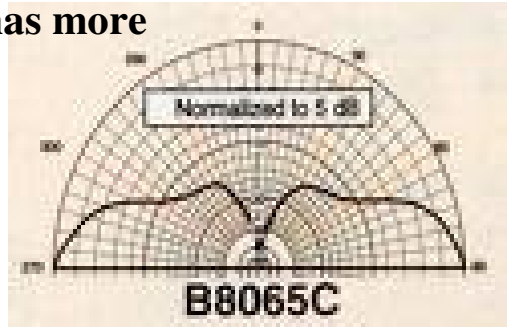
Which of the following transmission lines will give the best match to the base of a quarter-wave ground-plane antenna? **50 ohms coaxial cable**

The main characteristic of a vertical antenna is that it will: **receive signals equally well from all compass points around it**

Why is a loading coil often used with an HF mobile vertical antenna? **To tune out capacitive reactance**

What is the main reason why so many VHF base and mobile antennas are 5/8 of a wavelength? **The angle of radiation is low**

Why is a 5/8-wavelength vertical antenna better than a 1/4-wavelength vertical antenna for VHF or UHF mobile operations? **A 5/8-wavelength antenna has more gain**



Yagi Antennae

How many directly driven elements do most Yagi antennas have? **One**

Approximately how long is the driven element of a Yagi antenna for 14.0 MHz? **10.21 metres (33 feet and 6 inches)**

Approximately how long is the director element of a Yagi antenna for 21.1 MHz? **6.4 metres (21 feet)**

Approximately how long is the reflector element of a Yagi antenna for 28.1 MHz? **5.33 metres (17.5 feet long)**

The spacing between the elements on a three-element Yagi antenna, representing the best overall choice, is : **0.2 of a wavelength.**

What is one effect of increasing the boom length and adding directors to a Yagi antenna? **Gain increases**

What are some advantages of a Yagi with wide element spacing? **High gain, less critical tuning and wider bandwidth**

Yagi Antennae

Con't

What are some advantages of a Yagi with wide element spacing? **High gain, less critical tuning and wider bandwidth**

Why is a Yagi antenna often used for radiocommunications on the 20-metre band? **It helps reduce interference from other stations off to the side or behind**

What does "antenna front-to- back ratio" mean in reference to a Yagi antenna? **The power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction**

What is a good way to get maximum performance from a Yagi antenna? **Optimize the lengths and spacing of the elements**

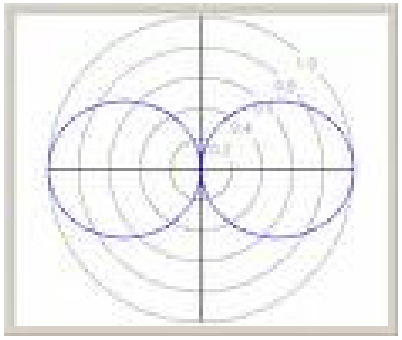
If the forward gain of a six- element Yagi is about 10 dB, what would the gain of two of these antennas be if they were "stacked"? **13 dB**

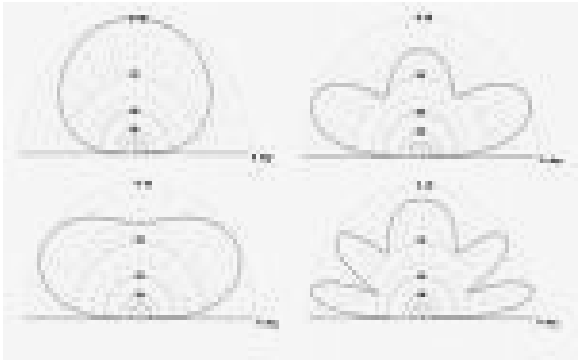
Wire Antennae

If you made a half-wavelength dipole antenna for 28.550 MHz, how long would it be? **5.08 metres (16.62 ft)**

What is the low angle radiation pattern of an ideal half-wavelength dipole HF antenna installed parallel to the earth? **It is a figure-eight, perpendicular to the antenna**

The impedances in ohms at the feed point of the dipole and folded dipole are, respectively: **73 and 300**





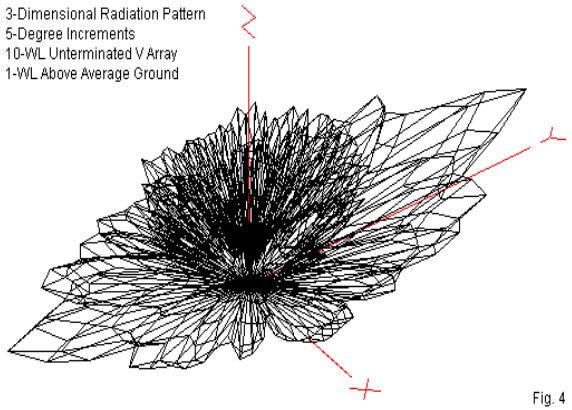


Fig. 4

Wire Antennae

Con't

A dipole transmitting antenna, placed so that the ends are pointing North/South, radiates: **mostly to the East and West**

How does the bandwidth of a folded dipole antenna compare with that of a simple dipole antenna? **It is greater**

What is a disadvantage of using an antenna equipped with traps? **It will radiate harmonics**

What is an advantage of using a trap antenna?

It may be used for multi- band operation

What is one disadvantage of a random wire antenna? **You may experience RF feedback in your station**

Quad / Loop antennae

What is a cubical quad antenna? **Two or more parallel four- sided wire loops, each approximately one-electrical wavelength long**

What is a delta loop antenna? **A type of cubical quad antenna, except with triangular elements rather than square**

The cubical "quad" or "quad" antenna consists of two or more square loops of wire. The driven element has an approximate overall length of: **one wavelength**

The delta loop antenna consists of two or more triangular structures mounted on a boom. The overall length of the driven element is approximately: **one wavelength**

Approximately how long is each side of a cubical quad antenna driven element for 21.4 MHz? **3.54 metres (11.7 feet)**

Approximately how long is each side of a cubical quad antenna driven element for 14.3 MHz? **5.36 metres (17.6 feet)**

Approximately how long is each leg of a symmetrical delta loop antenna driven element for 28.7 MHz? **3.5 metres (11.5 feet)**

Quad / Loops

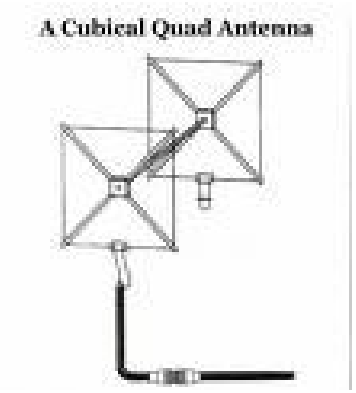
Con't

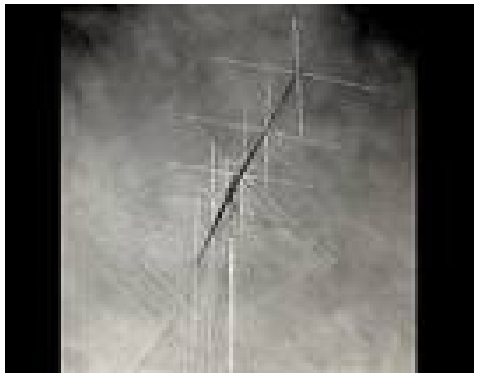
Which statement about two- element delta loops and quad antennas is true? **They compare favorably with a three element Yagi**

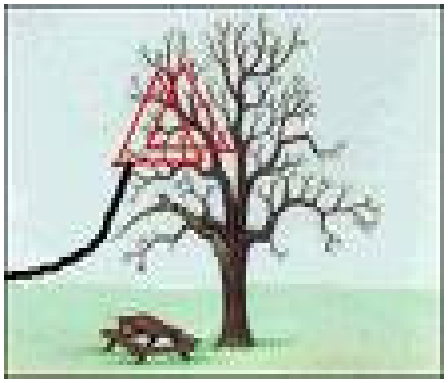
Compared to a dipole antenna, what are the directional radiation characteristics of a cubical quad antenna? **The quad has more directivity in both horizontal and vertical planes**

Moving the feed point of a multi-element quad antenna from a side parallel to the ground to a side perpendicular to the ground will have what effect? **It will change the antenna polarization from horizontal to vertical**

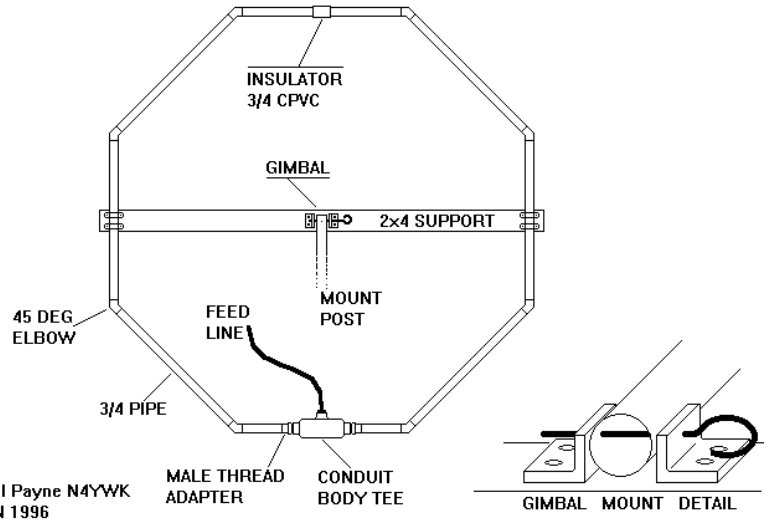
What does the term "antenna front-to back ratio" mean in reference to a delta loop antenna? **The power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction**

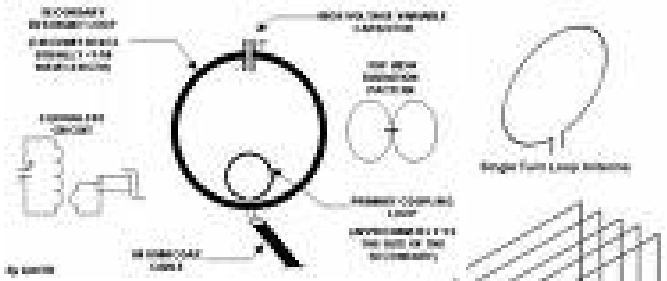


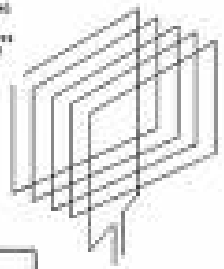


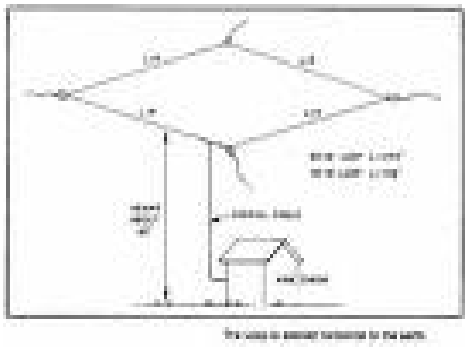


OCTOLOOP ANTENNA CONSTRUCTION







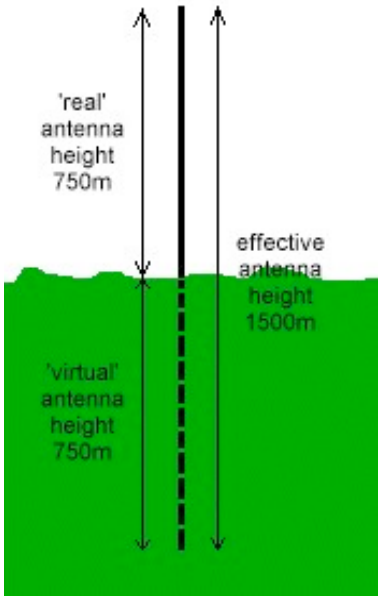


Basic Antenna Theory

Radio waves are generated by electrons accelerating in the antenna.

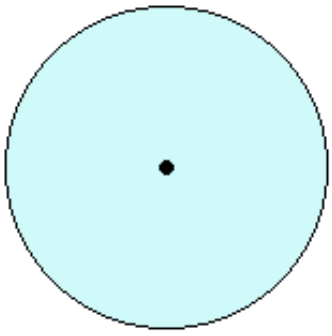
Consider a transmitter perpendicular to the ground. The electrons in the antenna, when a signal is applied, are changing their velocities continuously (i.e. moving up and down very quickly) in response to the applied signal.

For a station which broadcasts at a wavelength of 1500m, the antenna needs to be 750m long. This is because there is a 'virtual antenna' caused by the aerial being earthed in the ground:



The transmitting aerial (and the recieving aerial) need only be half-the-wavelength tall.

Now if this transmitter has no directional properties (i.e. it radiates in all directions equally), it has a coverage area, assuming completely flat ground, that is a perfect circle:



(View from above - antenna in centre; blue is coverage area)

Broadcasters rarely use a non-directional aerial though. It is possible to force the energy radiated by the transmitter into particular directions - the aerial becomes *directional*. Directional aerials are used to great effect near the coasts of the UK, where the broadcasters do not want their signal to be easily picked up on the continent.

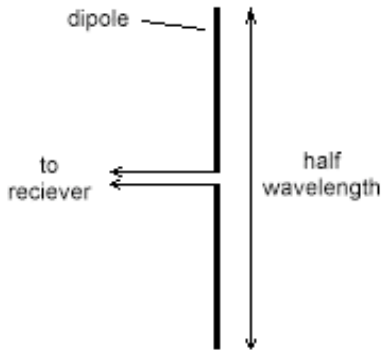
It is important that signal doesn't leak onto the continent since *i)* continental stations use the same frequencies and leaking signal would cause interference and *ii)* some programme broadcast rights apply to the UK only.

Under unusual weather conditions, despite the best efforts of broadcasters both in this country and abroad, signals travel much further than they normally would and interfere with reception of stations using the same channel, causing *co-channel intereference*.

Let's switch the emphasis from the transmitting aerial to the receiving aerial. Similar principles apply for receiving aerials as for transmitters as above.

The Half-Wave Dipole

There is only one part of a recieving aerial that is *active*, i.e. does the recieving and is connected to the TV/radio set. This active element is called the *dipole*. The simplest design of antenna would consist of a dipole only:

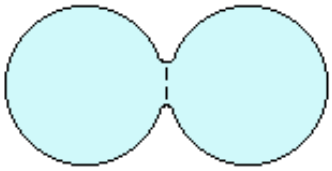


A half-wave dipole

In the diagram above, there are two wires marked 'to reciever.' For UHF and VHF, one wire will be the copper-core and the other the copper braiding of a co-axial cable.

Before we proceed, a quick word about *gain*. Although having a technical definition, for us 'gain' can mean "the effectiveness with which a recieving aerial recieves a signal."

The diagram below shows the reception pattern of a half-wave dipole. The blue area is where the gain is higher than a certain value; the dipole is in the centre:

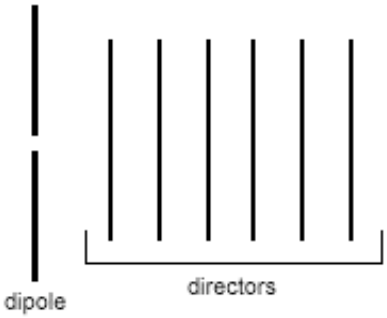


We can change the directivity of the aerial by adding other *elements*. Any other elements that we add to the basic half-wave dipole are called *passive* elements and are not connected electrically to the dipole.

There are two types of passive elements:

Directors

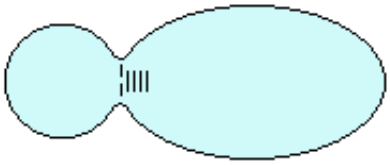
Directors alter the directivity of the aerial so that the aerial's gain is improved in front of the dipole. Most aerials have more than one director, and the more directors the aerial has the better the aerial is at picking out the signal from the required source and rejecting signals from other angles.



These diagrams do not show the cross-bar that holds all the elements in place as it does not affect the characteristics of the aerial.

The spacing between the directors, diameter of the tubing used and the spacing between the first director and the dipole are important in practice but will be disregarded here. The length of the directors governs the bandwidth of the aerial (over which channels it is effective), but suffice it to say that it is about 75% the length of the dipole.

The gain of the dipole with directors in place looks like this:



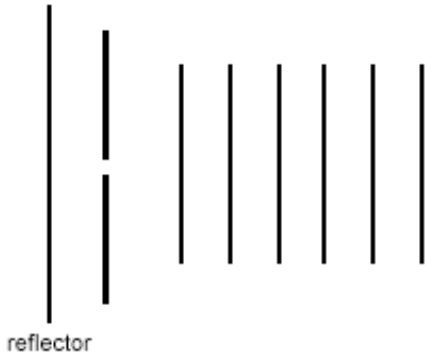
Notice how the gain is now more focused in the direction of the directors.

As stated earlier, the more directors an aerial has the more focused the gain is in the direction of the directors. Every new director added becomes less effective though, and in practice it is only worth adding 18-20 directors to the aerial, as any more than this wouldn't increase the gain very much.

On the diagram above, the aerial still has some gain at the rear - in other words, it can still recieve signals from behind. This is known as a *low front-to-back ratio*.

The Reflector

To improve the front-to-back ratio we can add the second type of passive element, a reflector. The reflector reflects signal coming in from the back of the aerial whilst improving the forward gain.

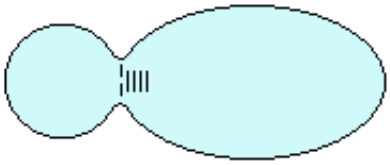


This design is called a Yagi-Uda array, after its creators.

Again, the length, size and position of the reflector affect the aerial's properties, but we won't go into that here.

The reflector can take the shape of a metal plate (with holes in it, making the aerial more impervious to wind) or several rods spaced equidistant from the centre of the dipole.

The result is that there is less gain behind the aerial and more, where we want it to be, in front:



Folded Dipoles

In order to minimise signal loss it is important that the impedance (a sort of resistance for AC) of the dipole matches that of the feeder cable and the recieving set.

The impedance for the type of dipole discussed above is about 75 ohms. More often than not though the impedance needs to be altered to match the cable and recieving set characteristics.

This change of impedance is acheived by folding a rod over so that its folded length is still half-a-wavelength:

Now we know what each constituent part of an aerial is called and what its function is.