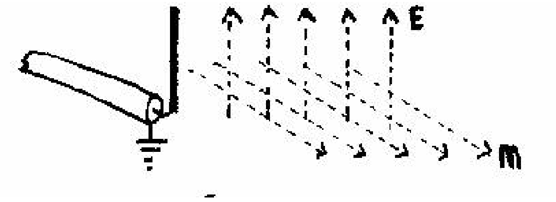
Electromagnetic Waves

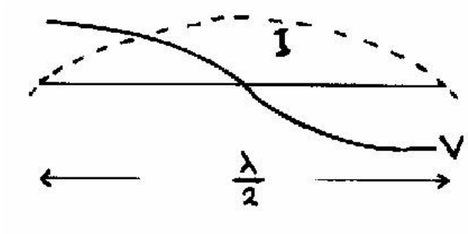
The *radio frequency power* from the transmitter, causes a *radio frequency current* to flow in the aerial. This will create an *electromagnetic wave* that comprises a *magnetic* and a *electric field.* These two fields are at right angles to each other.



A vertical aerial will create an electromagnetic wave that is said to be vertically polarised .The electric field will be vertical and the magnetic field will be horizontal.

Current and voltage distribution

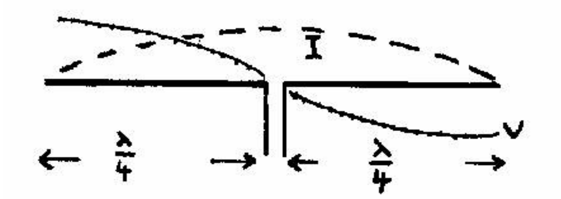
This shows a wire aerial that is half a wavelength long.
The current will be a *maximum* in the middle and zero at each end. (as there is nowhere for the current to flow at the ends)
The voltage will be zero in the middle and a maximum at the ends



If this *half wavelength wire* is cut in the middle and connected to a radio, it is called a "half wave dipole".

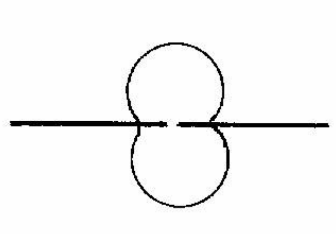
Half wave dipole aerial

The cable connecting the aerial to the radio is called the *feeder*. The feeder cable is connected to the centre of this cable. Therefore each half of this *half wave dipole* is *a quarter wave length* long.



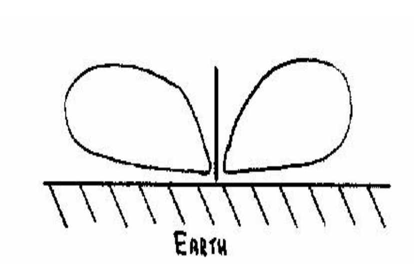
One advantage of this simple aerial is that it has a low impedance at the centre feed point, typically 70Ω or 80Ω. Thus a feeder of that impedance can be used to give a good match and transfer of power.

If the dipole is used as a transmitting aerial, the radiation pattern can be plotted. The field strengths are measured all around the aerial and a polar diagram can be drawn.
A polar diagram is drawn by joining together all the points of equal field strength.
(rather like contour lines on a map)

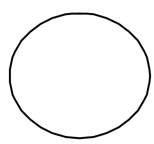


Ground Plane Aerial

This is a vertical aerial. A simple example is a vertical wire or rod that is λ/4 in length.
The feeder cable is connected to the lower end and earth.
The vertical aerial would normally be fed with coaxial cable from the radio. The *inner* is connected to the bottom of the aerial. The *outer screen* is connected to earth (or ground plane wires or plate).
This type of is suitable for "mobile operation".
The roof of the car is used as the 'ground'.



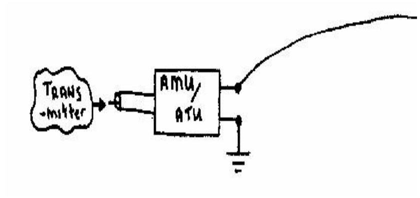
This is the *polar diagram* of a λ/4 vertical aerial, as viewed from the sky.. It shows that the signal is radiated equally in all directions, in the horizontal plane
– but *vertically polarised…..*



End Fed Aerials

In order that the impedance is not unmanageably high, the length of the wire should <u>not</u> be an *<u>even</u> number of quarter wavelengths.* An Aerial Matching Unit (sometimes referred to as a Aerial Tuning Unit) would normally be used at the feed point.

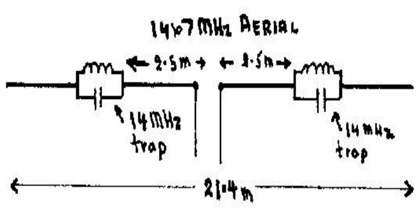
The AMU would be connected with 50Ω, 60Ω or 70Ω coaxial cable.



Multiband Aerials

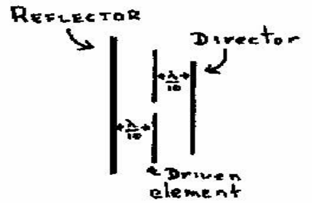
As mentioned earlier, a half-wave dipole (2 x λ/4) presents a good impedance match to a 70Ω feeder cable. For the aerial to function well on several Amateur Bands it would have to be able to change its length!
This can be electrically achieved if *tuned circuits* (called 'traps') are inserted into the aerial wires.

As an example, an aerial could be designed to be *half wave-length* at 7 MHz. If a trap (tuned to 14 MHz) is inserted into the wires, about 2.5 Metres from the feed point, then this aerial would also work well at 14 MHz. At 14 MHz the tuned circuits resonate and act as a very high impedance. This gives the electrical illusion that the ends of the wires, beyond the traps, have been removed.



Directional Aerials

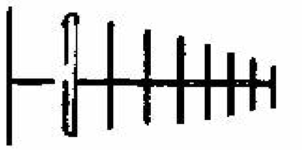
These are aerials that are designed to concentrate the transmitted RF energy (in the case of transmitting aerials) in one direction.
A dipole, as seen earlier, transmits *broadside.* If another wire, slightly longer than the dipole, is placed parallel to and about λ/4 away, then the aerial will have directional qualities.
This extra wire is called a *reflector.*



Adding a shorter wire (*director*) on the other side will further increase the directional qualities.

Yagi Aerials

If more directors are added the aerial called a *Yagi,* and is frequently used at VHF and UHF. The element spacing is typically 0.25λ. Most TV aerial Yagi designs.



Problem: Adding directors dramatically reduces the impedance of the feed point of the driven element.. In order to combat this, the dipole is replaced by a loop.

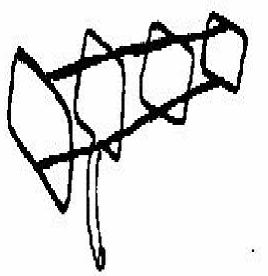
This loop steps up the feed impedance and brings it back to a suitable value.

Quad Aerials

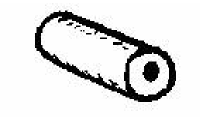
Quad aerials have rod or wire elements that are formed into square loops having λ/4 sides.

The *reflector loop* is slightly larger than the driven loop and the *director loops* are progressively smaller.
The element spacing is approx. λ/5.

The Quad Aerial is compact and prevents high angle radiation.



Feeder Cables
This is the cable that connects the radio to the aerial. It can be coaxial or ribbon cable. Coaxial cable has a centre conductor that is surrounded by insulation and a wire mesh screening. Typical impedance is 50Ω or 70Ω. The screen is usually earthed and this cable is know as a *unbalanced feeder.*



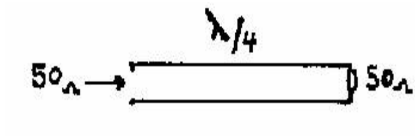
Coaxial cable (often just referred to as 'coax') has the advantage that it does not have to be installed clear of building and other structures. It is convenient to use as it can be directly fastened to walls etc.
However, it is not cheap and it has quite a high loss for the signals passing through it.

Ribbon cable feeder comprises of two parallel wires. Depending upon its size it can have a series of spacers, giving the appearance of a ladder or can have a continuous flat plastic spacing.

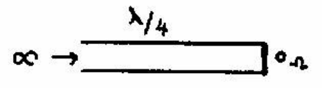
The wire spacing can range from 10mm to 100mm.
This gives impedance from about 70Ω to 600Ω. Ribbon cable is low loss and cheap but must be kept clear of walls and metal structures. This makes it less practical….

Feeders
A feeder, whether it is *balanced twin* or *unbalanced coaxial* cable has a *characteristic impedance* that is dictated mainly by its physical dimensions. If this is to be connected directly to the transmitter, it should match its output impedance A transmitter output impedance is usually 50Ω or 75Ω.

A feeder is correctly matched when it is terminated in its own value impedance.

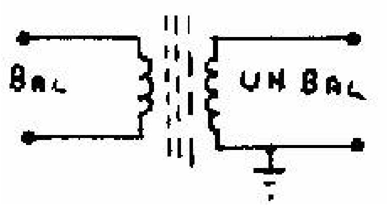


However, if *incorrectly terminated*, The impedance as seen from the other end will depend on the length of the feeder cable. For example, quarter wavelength of cable .will 'reverse' the impedance.



A *short circuit* at one end of a λ/4 cable (or odd number of λ/40) will appear to be *an infinite impedance* as seen form the other end.

Balanced/Unbalanced
The aerial socket on a radio is usually a *coaxial* socket and is therefore *unbalanced.*
The feed-point of a dipole aerial is *balanced.*
Coaxial cable is *unbalanced;* twin feeder is *balanced.*
It is often necessary to 'convert' from balanced to unbalanced.
This is done by a "balun".
A *balun* can also be constructed to change the impedance.

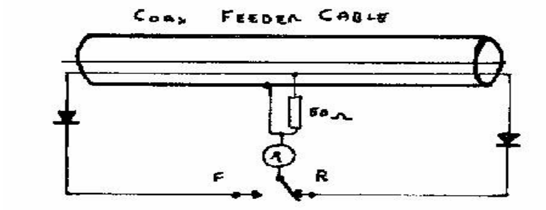


Thus a 2:1 Balun could be used to match a balanced aerial, that has a feed impedance of 100Ω, to a coaxial feeder cable of 50Ω impedance.

Standing waves

If a feeder is incorrectly matched then some of the transmitted power will be *reflected*. The presence of both forward and reverse voltages & currents will result in the formation of *standing waves*.

Standing wave ratio meters (SWR meter or bridge)

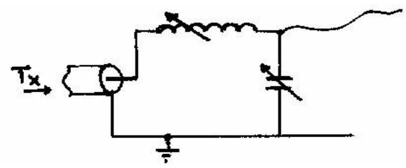


This meter will determine the ratio between the forward between the *forward* and the *reverse* powers within the feeder cable and can indicate if, for example, the aerial is correctly matched to the feeder.

An SWR meter can also be used to check the condition of a feeder cable. A *terminating resistor*, equal to the *characteristic impedance* of the cable, is connected across the far end of the cable. A SWR meter is connected between the transmitter and the feeder cable.. Low power (radio frequency) is then transmitted and if the cable is "good" the SWR meter will indicate a *low SWR reading.*
A *high SWR reading* would indicate that there was likely to be a fault in the feeder cable. The actual problem is usually then found by *visual inspection*. IE Having a look!

Aerial Matching unit

The impedance at the feed point of an aerial often does not match the impedance of the of the feeder cable. An AMU can improve this matching and can also (where necessary) perform the function of a *balun*.



This circuit shows a simple AMU that is being used to match "an end fed wire" to a feeder cable.
This AMU can be adjusted to enable the same end fed wire to be used on several Amateur Bands.

And now read the RAE manual covering aerials and feeder etc before attempting these questions.

8C1. The balun, at the centre of a $\lambda/2$ dipole, is connected to the transceiver by:
a) 300Ω ribbon cable feeder b) 600Ω ladder type feeder
c) 3Ω low loss coaxial cable feeder d) 75Ω coaxial cable feeder

8C2 A 50Ω carbon resistor is connected between the inner and outer of a $\lambda/4$ length of 50Ω coaxial cable. The impedance at the other end of the coaxial cable will be :
a) 12.5Ω b) 50Ω c) 100Ω d) 200Ω

8C3 An aerial is radiating a radio wave whose magnetic component is vertically polarised.
This would have been generated by an aerial that is said to be:
a) vertically polarized b) horizontally polarized
c) slant polarized d) circularly polarized

8C4 A $\lambda/4$ (quarter wavelength) vertical aerial is mounted at ground level is best fed with :
a) 600Ω open wire feeder wire b) 300Ω ribbon cable feeder cable
c) 70Ω coaxial cable feeder d) 7.5Ω coaxial feeder cable

8C5 The Radio Frequency *voltage* at the centre of a half wave dipole is approximately:
a) 0 Volts b) 50 Volts c) 75 Volts d) 600 Volts

