WHERE THERE IS NO TELEPHONE

Chapter 2. AERIALS

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The purpose of an aerial is to launch the power from a radio transmitter into space in the form of radio waves. These waves then proceed, either by reflection from the ionosphere or along the surface of the earth, to the receiving location. Here the waves are captured by another aerial and steered to the receiver. So the aerial is a very important part of your radio system and it is essential that you use an aerial which is suitable for the particular frequency you intend to transmit. You may be told that all you require is a long piece of wire,the longer the better. Whilst such a wire could be suitable for reception an additional unit would be necessary to tune the wire before it was suitable for transmission.

2.1.Standing Wave Ratio

VSWR stands for Voltage Standing Wave Ratio and is often abbreviated to SWR. SWR is a measure of how suitable an aerial is for a particular transmitter at a particular frequency i.e. how well it is matched to the transmitter. The theoretical ideal value for SWR is 1. Some radio manufacturers specify that an aerial with a SWR of 1.5 or less should be used with their radios whilst others permit a maximum SWR of 2. The SWR of an aerial can be measured by connecting a SWR Meter between the transceiver and the aerial. The operating instructions for these meters varies according to the manufacturer. You must make sure you have the instructions and keep them with the meter and always follow them correctly, otherwise you may get inaccurate readings.

Although aerials are normally made to a length suitable for your specified frequency the SWR should be measured after the aerial has been erected. It is desirable to tune the aerial for a minimum SWR but it is essential to do it if the SWR exceeds the manufacturers permitted maximum e.g. 1.5 or 2.0. For instructions on tuning aerials see para. 6.2.4.6.

2.2. Dipole Aerials

The horizontal half-wave dipole aerial (see Fig 2.1) is the most commonly used HF aerial. Of the 188 aerials reported on the Questionaire 91% were dipoles. The dipole is electrically simple, cheap, requires no earth system or additional circuits and it is easy to erect. However it is normally only suitable for use with one frequency.

2.2.1. Dimensions

The total length of a dipole aerial is half a wavelength at the frequency of use. However it is permissible to use the aerial at frequencies up to 2% above and below this frequency. e.g. a 10 MHz dipole could be used for frequencies from 9.8 MHz to 10.2 MHz. The length of the aerial can be calculated from the following formulae:

$$\text{Total length in feet} = \frac{468}{\text{Frequency in MHz}}$$

$$\text{or Total length in metres} = \frac{142.6}{\text{Frequency in MHz}}$$

For example a frequency of 6 MHz would require an aerial of :

$$\frac{468}{6} = 78 \text{ feet} \quad \text{or} \quad \frac{142.6}{6} = 23.77 \text{ metres.}$$

2.2.2. Construction

The dipole consists of 2 pieces of wire each piece a quarter of a wavelength long: i.e. half of the total length. One piece of wire is connected to the centre conductor and the other piece of wire is connected to the outer conductor of a coaxial cable. The other end of each piece of wire is connected to its own insulator see Fig 2.1. Pre-stressed aerial wire is used to prevent streaching of the aerial. The resulting assembly is suspended horizontally at a certain height above the ground. The connections between the coaxial cable and the aerial wires must be both mechanically strong and waterproof. Ready-made small units can be bought for this purpose. These units can include a BALUN which it is claimed improves the aerial performance. However dipoles are usually purchased ready-made and cut for the specified frequency by your radio manufacturer.

2.2.3. Horizontal Directivity

A horizontal dipole transmits and receives most energy in a direction at 90 degrees; i.e. at right angles to the wire itself as shown in Fig 2.2. For example a dipole erected in a north-south line would be suitable for communicating with stations to the east and west but would be less effective for stations to the north and south.

2.2.4. Height

The height of a dipole above the ground will determine the vertical directivity i.e. the direction in which power is both transmitted and received. An indication of the vertical angles at which power is transmitted is shown in Figs 2.3. and 2.4. The height of the aerial is given in units of wavelength of the frequency for which the dipole is designed to operate. For short ranges e.g. up to 150 kms, power needs to be transmitted at a steep angle up to the ionosphere see Fig 2.3. So a dipole suspended 1/4 wavelength above the ground should be used. For distances of 1000 or 1500 kms a height of 1/2 wavelength would be more suitable see Fig 2.4. The ideal condition would be to have two dipoles one for short, one for long ranges but in practise this is not always possible. Take a frequency of 7 MHz : 1/4 wavelength is 10.7 metres and 1/2 wavelength is 21.4 metres. Erecting an aerial 21.4 metres above the ground would demand the construction of special supporting towers which would be a costly exercise even if the materials were available. Therefore in practise aerials are often suspended as high as possible between trees and poles or between a tree and the top of a building. The result is therefore a compromise between the theoretical ideal and that practically achievable but remember that for better communication at long distance your dipole should be as high as possible.

2.3. Inverted Vee Aerial

This is simply a dipole supported in the middle and having each side of the aerial sloping down to some 2 metres above the ground. It thus forms an inverted V, see Fig 2.5. This aerial transmits energy in most directions hence it is suitable for more all round coverage. Some of the transmitted power is vertically polarised and some is horizontally polarised making it suitable for communicating with fixed stations with horizontal dipoles as well as vehicles using vertical aerials.

2.4. Vertical Aerial

Another simple HF aerial is the 1/4 wavelength vertical. The name describes the aerial, a vertical conductor 1/4 wavelength high insulated from the ground at its base and connected to the inner conductor of a coaxial cable see Fig. 2.6.

2.4.1.Earthing of vertical aerials

It is necessary to provide a good earth for this aerial. This can be achieved by connecting 3 or more 1/4 wavelength long pieces of wire to the outer braid of the coaxial cable at the base of the aerial. These wires should be laid out radially and spaced an equal distance apart as in the plan view of Fig.2.7. and then buried some 25 cms underground.

2.4.2. Directivity

A vertical aerial will transmit power equally in all horizontal directions and at low vertical angles (below 45 degrees). It is therefore a good choice for a central station with a network which is spread out at various angles and long distances.

2.5. Mobile Aerials

Practical considerations dictate that most mobile HF aerials are vertical but not physically a full 1/4 wavelength long e.g. 1/4 wavelength at 5 MHz is 15 metres! So you will find vertical mobile aerials some 2 or 3 metres long. These can either be tuned to any frequency with an Aerial Tuning Unit (ATU) see para 2.6.3. or they will have been pre-tuned to a single frequency with a coil. The coil forms part of the aerial and will either be at the base of it or halfway up. The further the coil is away from the base the more efficient is the aerial. The tuning should be checked and adjusted after installation on the vehicle see para.6.4.3. Another form of mobile aerial is the helical whip. Here the aerial wire is twisted around and sealed into a fibreglass rod. If this is tuned to a specific frequency it may also be used at other frequencies by using a ATU.

2.6. Multi-frequency aerials

It has been stated that an individual dipole is only suitable for one frequency. However most transmitters will be operated at several frequencies hence requiring an aerial system suitable for all the frequencies. There are several aerial configurations that will satisfy this requirement.

2.6.1. Multi-dipoles

This aerial consists of several individual dipoles, each ones length being appropriate to its particular frequency. They are A-A', B-B' and C-C' and are all connected to one piece of coaxial cable as shown in Fig 2.8. The advantages of this type of aerial is that only one coaxial cable feeder is required and that the aerials can be accommodated in a smaller space than required by several individual ones. However the frequency of each dipole should differ from the others by at least 15%. A maximum of 4 dipoles can be connected to one piece of coaxial cable. The tuning of the dipoles can sometimes be difficult because of interaction between each other.

2.6.2. Broadband aerials

A single broadband aerial can cover all the frequencies in the range stated by its manufacturer for their particular aerial e.g. 3 to 30 MHz. They use special frequency compensating networks and matching circuits therefore need to be bought ready-made. One broadband aerial is some 30 metres long and has a single coaxial cable connecting it to the radio. It can be erected horizontally or in the inverted vee form. Its height above the ground should be at least 5 metres but 10 metres if possible.The SWR of these aerials can be less than 2.0 over a high percentage e.g. 90% to 95%, of their frequency range. However some manufacturers specify that an aerial with a SWR of 1.5 or less should be used with their transceivers. A broadband aerial will receive all transmissions i.e. wanted and unwanted, equally well. Hence strong transmissions, including SW broadcasts, can cause interference when the station you are listening to is weak.

2.6.3. Long wire aerials and Aerial Tuning Units

A long piece of wire e.g. longer than 10 metres, can be used as an aerial but it has to be tuned for each frequency with an Aerial Tuning Unit (ATU). The SWR of a long piece of wire could be high so the purpose of theATU is to match the wire to the transmitter and to give a low SWR. The ATU can be an integral part of the transceiver as in the case of some CODAN models. Here the tuning procedure is to adjust the controls of the ATU for the brightest light from a lamp. Separate ATUs can be purchased, some with meters as tuning indicators. You can buy ATUs which will automatically tune a long piece of wire to any frequency from 1.5 to 30 MHz. The most modern ATUs will reduce the SWR of the long wire aerial to 1.5 and also handle a transmitter output power of up to 1KW. Long wire aerials are often used for temporary or portable situations when it is easy to hang up a piece of wire. However the wire must be insulated from anything that supports it.

2.6.4. Single Dipole for Two Frequencies

It is possible to design a single dipole and its coaxial feeder cable to operate at two frequencies. The main reason for using this design is economy, that is to obtain "two aerials for the price of one". However, to understand the design you may require the aid of a radio communications engineer. The method is nevertheless a very useful one to use with aerials which do not have a balun transformer. The dipole is designed for use normally at one frequency, but at the second frequency there will be standing waves on the coaxial cable. So the length of cable has to be cut to present a low impedance at the transceiver. This is done by measuring the SWR at the transceiver output socket and by reducing or increasing the length of the coaxial cable until an acceptable SWR is achieved e.g. less than 2.

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