South Bristol Amateur Radio Club
Lesson 5 – Feeders, Antennas and SWR
Syllabus sections 5a.1 – 5a.2, 5b.1 – 5b.2, 5c.1 – 5c.5, 5d.1, 5e.1 – 5e.2, 5f.1

Feeders
(Syllabus section 5a.1 to 5a.2)

The cable that connects the radio to the antenna is called the feeder.

The most widely used type of feeder is coaxial cable due to its screening properties. Coaxial cable has an inner conductor that carries the signal and an outer conductor (the braid or shield) around it with a suitable insulator in-between.

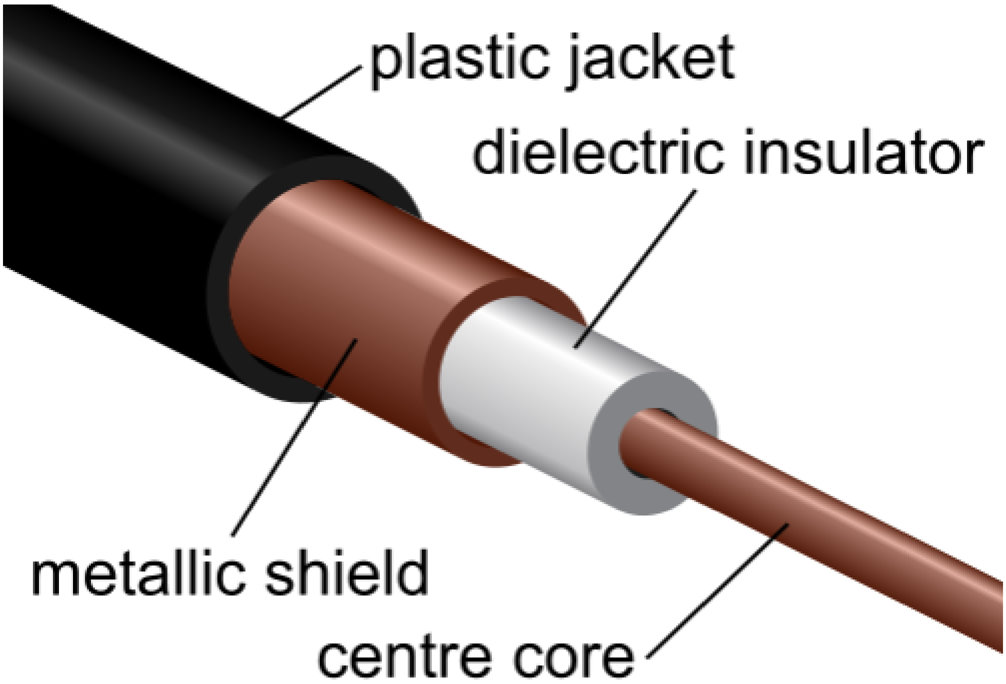

Figure 1 - Coaxial Cable

Figure 2 shows real coaxial cable to give an indication of how the various parts look in the real world. Note that the metallic shield in the real case is in fact copper braid over a thin foil blanket.

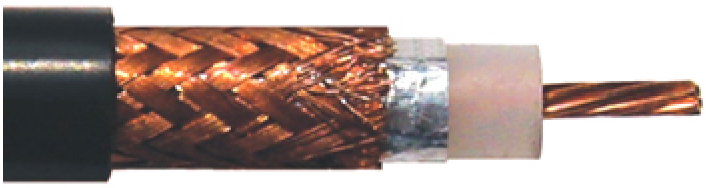

Figure 2 - Coaxial Cable

There are many types of connectors used for coaxial cable; the most common being PL259 and BNC connectors. Both of these types of connectors ensure that the screen as well as the signal carrying central core is continuous through the connector.

Figure 3 - BNC (left) and PL259 (right) connectors

To minimise signal loss it is always better to use the thickest type of coaxial cable possible with the highest quality braid. The braid (the outer part of the cable) is a screen that keeps the signals within the cable and must be continuous through all connectors used.

Antennas
(Syllabus section 5b.1 to 5d.1)

The purpose of the antenna is to:

1. radiate the RF signal generated by the transmitter and
2. pick up the radiated signals that will be passed to the receiver.

If the antenna is orientated horizontally it will have horizontal polarisation and similarly if mounted vertically it will have vertical polarisation. In VHF/UHF systems it is important that both transmitting and receiving stations use the same polarisation to minimise signal loss.

There are five types of antenna that we need to look at for this course:

- Half-wave dipole.
- Quarter-wave ground plane.
- Five-eighths wave ground plane.
- Yagi.
- End-fed wire.

The official diagrams of these antennas are shown in the 'Foundation Now!' text book, however the images and diagrams that follow are typical examples of the type.

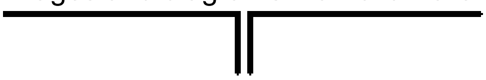

Figure 4 - Half Wave Dipole

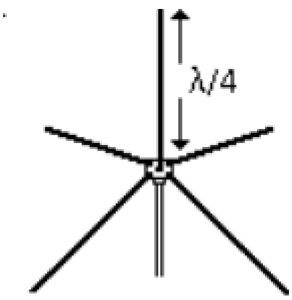

Figure 5 - Quarter Wave Ground Plane

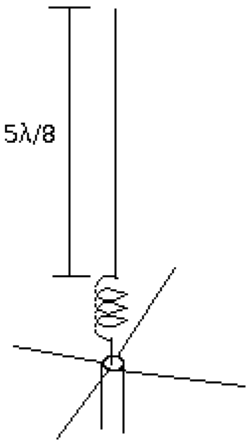

Figure 6 - Five Eighths Wave Ground Plane

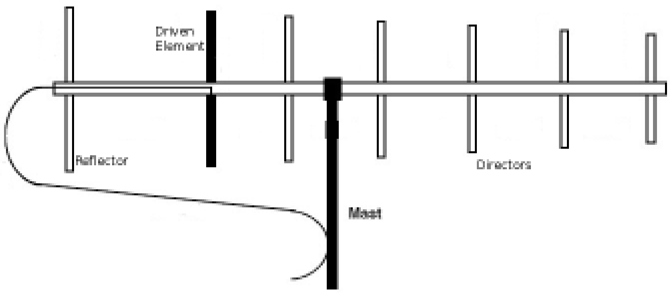

Figure 7 - Yagi

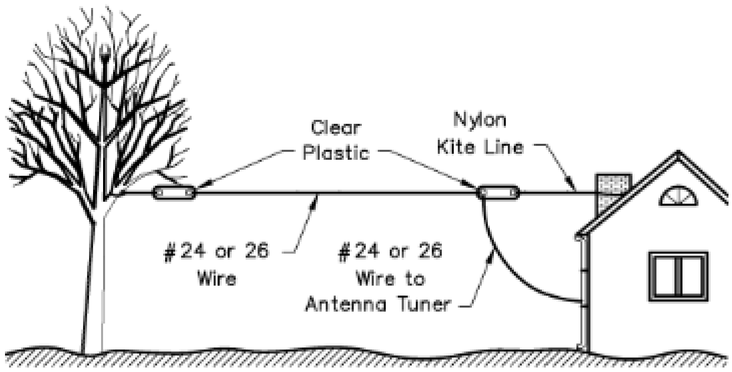

Figure 8 - End Fed Wire

Note that the Greek letter lambda (λ) is the symbol used for wavelength. So a quarter-wave ground plane may be described as a λ/4 ground-plane.

The sizes of HF and VHF antennas are different because they are related to the wavelength, though they operate on the same basic principles.

The λ/2 dipole has a length approximately equal to a half wavelength at the operating frequency.

The λ/4 ground-plane, 5λ/8 ground-plane and a vertically mounted λ/2 dipole are omni-directional with a vertical polarisation pattern. This means they radiate and pick up signals from all directions.

Note that if an antenna is not correctly designed or tuned for the frequency it will not work effectively. To use an antenna not designed for the frequency an antenna tuning unit (**ATU**) sometimes referred to as an Antenna Matching Unit should be used so the transmitter will feed the antenna with the least amount of loss (lowest SWR).

The Yagi antenna is directional and has gain because of its focusing ability. A Yagi may be mounted vertically or horizontally.

The gain of an antenna is measured in dBs (decibels). See table below for some examples.

dB	Gain
0	1x
3	2x
6	4x (3dB + 3dB = x2x2 = x4)
9	8x (3dB + 3dB + 3dB = x2x2x2 = x8)
10	10x
13	20x (10dB + 3dB = x10x2 = x20)

As an example, a 5W transmitter feeding a Yagi with 6dB of gain would have the same effect, in the given direction, as transmitting 20W into a λ/2 dipole (which has 0dB of gain). The gain would also be more helpful on receive than the equivalent increase in power is on transmit only.

The antenna gain therefore gives an apparent increase in power in the given direction. In general the greater the number of elements, the greater the gain.

The effective radiated power (**ERP**) is the power fed to the antenna multiplied by antenna gain. In the example above the power is 5W the gain is 6dB (4x) giving 20W ERP.

The dipole is an example of a balanced antenna. This type of antenna is fed in the middle and requires two feed connections, one to each half of the dipole. Coaxial cable, as we have seen, has one conductor and is unbalanced, which makes it unsuitable to connect directly to a balanced antenna. A device called a **balun** is required that converts the **bal**anced antenna feed to the **un**balanced coaxial cable.

Antennas such as the ground plane, where only one feed connection is required, are unbalanced and can be fed directly with co-axial cable.

Ground plane antennas are effectively half of a dipole. The “missing” half of the antenna is created by the ground plane. For this type of antenna to be effective it is usual to augment the natural ground plane with radials. For a ground mounted antenna these radials can be simple lengths of wire laid on or just beneath the ground. For antennas mounted above the ground, such as on a building, then the wires are often replaced with rigid rods at the feed point of the antenna. The length of the radials is usually related to the frequencies the antenna is designed to operate on.

Standing Wave Ratio (SWR)
(Syllabus section 5e.1 to 5f.1)

With an ideal station, all the power generated by the transmitter will pass up the co-axial cable (feeder) into the antenna and be radiated away. The antenna, feeder and transmitter will all be perfectly matched. However, this is usually not the case! In most stations, the antenna is not a perfect match and this causes some of the power to be reflected down the feeder into the transmitter.

The waves travelling up the feeder mix with reflected waves coming down the feeder and form standing waves. A Standing Wave Ratio (SWR) meter can measure this and allow the operator to adjust the antenna or ATU for the minimum reflected power. The illustration below shows the correct setup for this.

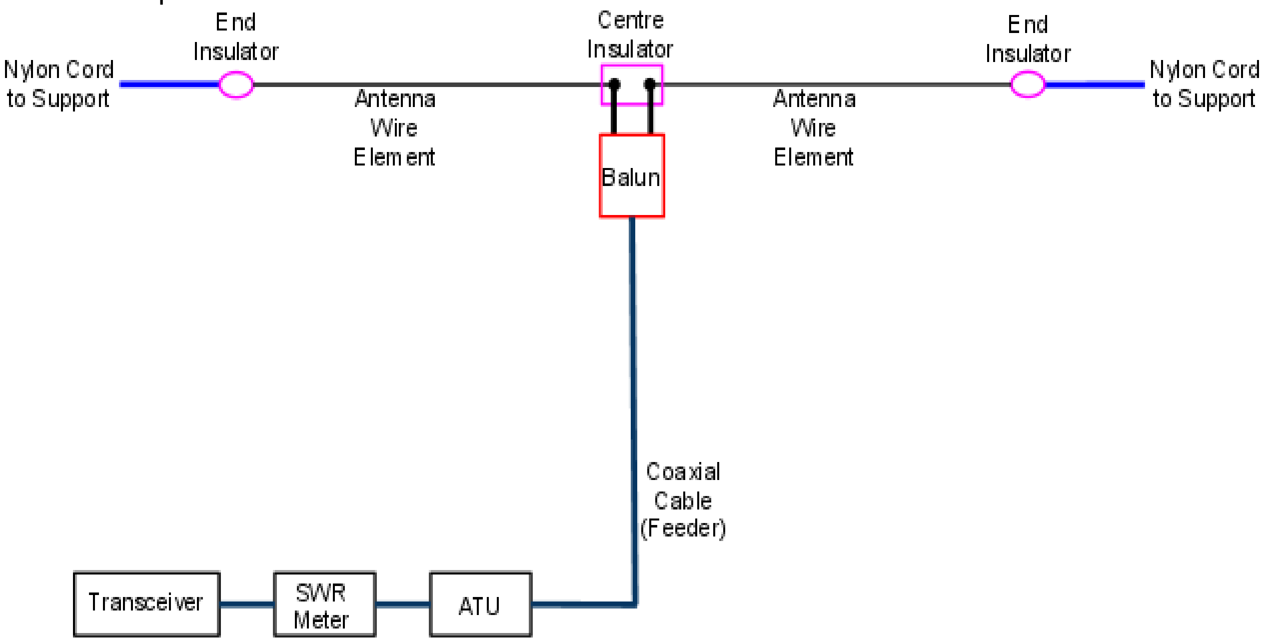

Figure 9 - Connection of Transmitter, SWR Meter, ATU and Antenna

A perfect match (with no reflected power) will give an SWR of 1:1. As more power is reflected back the SWR will increase. At an SWR of 2:1 about 10% of the power is reflected back. At 3:1 about 25% is reflected back.

A high SWR reading can be caused by a fault in the antenna or the feeder but **not** the transmitter.

A high SWR can damage the transmitter so it is advisable to have the **lowest** SWR possible.

In order to carry out checks on the feeder or transmitter it may be necessary to operate the transmitter without radiating a significant signal. Instead of feeding an antenna we can use a **dummy load**. A dummy load is a screened resistor that will provide a very good match (low SWR) to the transmitter whilst radiating very little RF power.

Next Lesson
Propagation and EMC

Lesson 5 – Summary

At the end of this lesson you should be able to:

- Recall the correct cable to use for RF signals and that coaxial cable is most widely used because of its screening properties.
- Recall that the plugs and sockets for RF should be of the correct type and that the braid of coaxial cable must be correctly connected to minimise RF signals getting into or out of the cable.
- Identify BNC and PL259 plugs.
- Recall that the purpose of an antenna is to convert electrical signals into radio waves (and vice-versa) and that these are polarised according to the orientation of the antenna e.g. a horizontally oriented antenna will radiate horizontally polarised waves.
- Identify the half-wave dipole, /4 ground plane, Yagi, end-fed wire and 5/8 antennas.
- Understand that the sizes of HF and VHF antennas are different because they are related to wavelength, though they operate on the same basic principles.
- Understand that the /2 dipole has a physical length approximately equal to a half wavelength of the correct signal.
- Understand that half-wave dipoles (mounted vertically), ground planes and 5/8 antennas are omni-directional.
- Understand that a Yagi antenna is directional and has gain because of its focussing ability.
- Recall that the ERP is the product of the power to the antenna and its gain.
- Recall that the antenna system must be suitable for the frequency of the transmitted signal.
- Recall that if an antenna is not correctly designed for the frequency it will not match the transmitter and will not work effectively.
- Recall that at HF, where an antenna has not been designed for the particular frequency, an ATU (Antenna Tuning Unit) improves the ability of the antenna to accept power from the transmitter.
- Recall that, when an antenna is not well matched to a transmitter, a matching unit, commonly known as an ATU (Antenna Tuning Unit), is used to ensure that the transmitter can supply energy to the antenna without damage to the transmitter.
- Understand the difference between balanced and unbalanced antennas and that a balun should be used when feeding a HF dipole with coaxial cable (which is unbalanced).
- Recall that a SWR meter shows whether an antenna presents the correct match to the transmitter and is reflecting minimum power back to the transmitter.
- Recall that a high SWR (measured at the transmitter) is an indication of a fault in the antenna or feeder (and not the transmitter). Relate this back to the transmitter block diagram from lesson 4.
- Recall that a “dummy load” is a screened resistor connected instead of an antenna to allow the transmitter to be operated without radiating a signal.