Summerland Amateur Radio Club Foundation Module 3

for the AMC Foundation & Practical Syllabus V10

Transmission Lines and Antennas

Syllabus Assessment Objectives

5.1	Identify from a supplied diagram, photograph or physical examples, common co-axial and balanced transmission lines. Recall their typical characteristic impedance.
5.2	Identify from a supplied diagram, photograph or physical examples, co-axial connectors commonly used in radiocommunications.
5.3	Understand the reason for continuity and insulation testing a co-axial cable terminated with co-axial connectors. Recall the continuity and insulation testing procedure.
5.4	Recall that the purpose of an antenna is to convert electrical signals into radio waves, and vice versa.
5.5	Recall the relationship between the physical length of the antenna and the frequency of operation.
5.6	Identify, from supplied diagrams, a half-wave dipole, folded dipole, 1/4 wave vertical ground plane, Yagi, and end-fed half-wave antenna.
5.7	Recall that the on-air performance of an amateur station can be improved significantly by the correct choice of antenna. Identify, using supplied reference material, the symbol for an antenna.
5.8	Recall the meaning of the terms polarization, omni-directional, bi-directional, unidirectional and gain as they apply to antennas.
5.9	Recall that the polarisation and directivity of an antenna is determined by its physical construction and orientation.
5.10	Recall that ERP is the product of transmitter power and antenna gain. Recall that antenna gain is generally expressed in decibels.
5.11	Recall the need to match an antenna to a transmission line and to minimise the Voltage Standing Wave Ratio (VSWR).
5.12	Recall the uses, purposes and adjustment of a typical manual ATU.
5.13	Recall when feeding a balanced antenna with an unbalanced transmission line (co-axial cable), the preferred practice is to use a balun.
5.14	Recall the correct placement, use and adjustment of an VSWR Meter.
5.15	Recall that an VSWR equal to, or less than, 1.5 indicates a satisfactory antenna match.

Resources

CARS Foundation powerpoint slides – Feeders and Antennas, download at
http://www.g0mwt.org.uk/training/courses/foundation.htm

WIA Foundation Manual Chapter 3

SARCEd Module Content

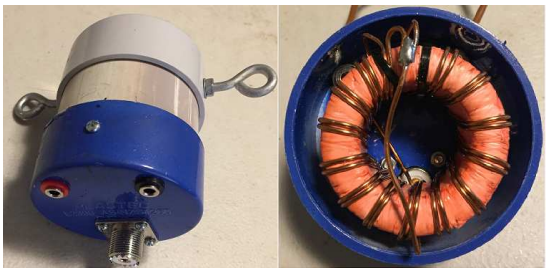
Antennas:

Antennas convert electrical signals to radio waves & vice versa
Antenna **gain** is measured in **decibels** (dB also dBi and dBd)
An antenna is **resonant** when its length is related to the wavelength of operation.
An antenna that radiates (or receives) better in some directions than others has **directivity**.

ERP = Effective Radiated Power. = Transmitter power times antenna gain (less losses)

VSWR = Standing Wave Ratio
It indicates how much of the transmitter output is reflected back from the antenna and transmission.

Less than 1.5:1	Considered acceptable
1.5:1 to 3:1	Needs adjustment of the antenna - (probably length) or compensate using an Antenna Tuning Unit (ATU)
Greater than 3:1	There is a problem. Look for short circuits, open circuits, antenna is for another band, or using an antenna with a very high or low impedance without a suitable balun.

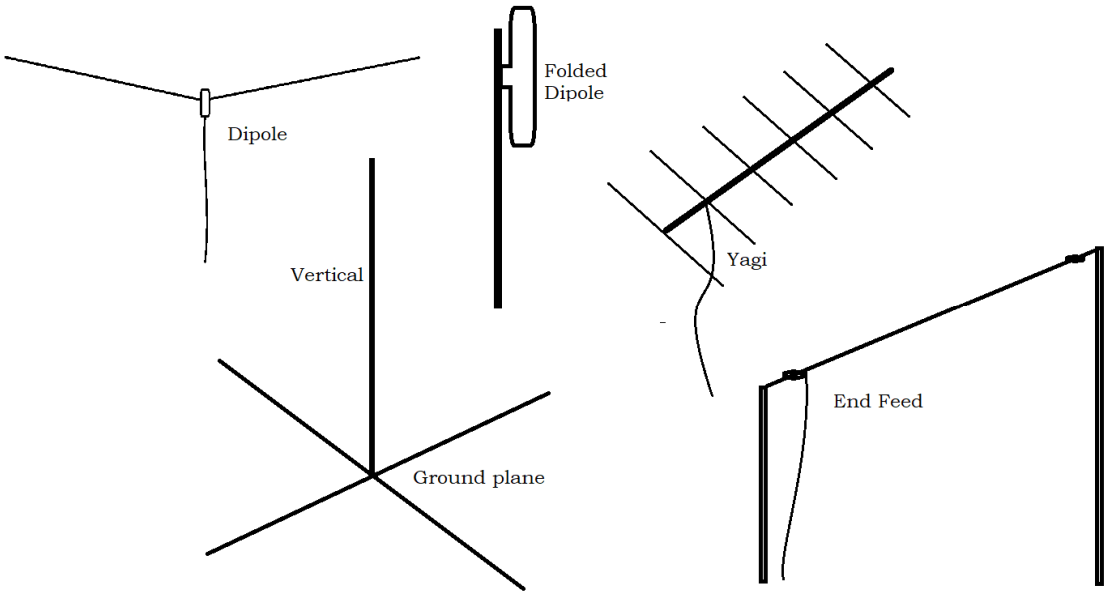


A **Balun** (Balanced to Unbalanced) is used to match coaxial cable (un-balanced feeder) to a dipole (balanced antenna) to prevent currents flowing down the outside of the coaxial cable. These currents can cause unwanted radiation (eg interference).

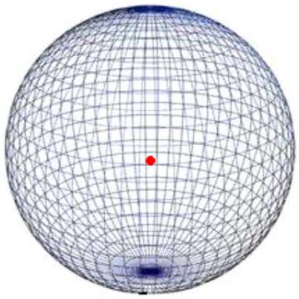
Baluns can also be made that include impedance matching – these are 'transformer baluns'.

Types of antennas

There are a wide variety of antennas, usually constructed from copper wire or aluminium tubing.



A dummy load is used for transmitter testing, without sending out a signal. It is fitted in place of the antenna. These are made with an impedance of about 50 ohms to give an SWR of 1:1. The power handling of a dummy load depends on its design.



The **Isotropic antenna** is a theoretical antenna that radiates uniformly in all directions, with the same intensity regardless of the direction of measurement. They are never realised in practice (the red dot represents the antenna, with equal radiation all around the surrounding sphere).

ATU – Antenna Tuning Unit

or antenna matching unit – can be used to modify the impedance of the antenna and feed line so that the impedance presented to the transmitter is closer to its output impedance.

The correct placement, use and adjustment of a VSWR Meter will be covered in the practical module of the Foundation Course.

Antenna terms

Directivity	If an antenna receives or transmits better in one direction than others then it has directivity. An antenna may be omni-directional, bidirectional or unidirectional.
Polarisation	This is the orientation of the electric wave in electromagnetic radiation. Polarisation is usually vertical or horizontal, but there are others.
Gain	In a transmitting antenna, the gain describes how well the antenna converts input power into radio waves headed in a specified direction. In a receiving antenna, the gain describes how well the antenna converts radio waves arriving from a specified direction into electrical power.
ERP – Effective Radiated Power	ERP is the output power of the transmitter, multiplied by the gain of the antenna, minus the attenuation and losses incurred by cable runs and connectors' in-between the transmitter and antenna. Measured in decibels.

Transmission lines (also called Feedlines)

Balanced = parallel line – symmetrical – two wires with fixed spacing.
Unbalanced = Coaxial cable – round with an outer shield and an inner conductor.

Balanced

Typical impedance 450Ω

Unbalanced

Typical impedance 50Ω

Co-axial connectors commonly used in radiocommunications.

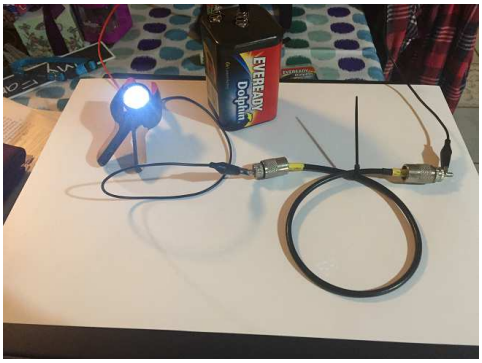
N type connector (male and female)

BNC Bayonet connector (male & female)

UHF / PL type (male)

Continuity and Insulation Testing

The simple reason for continuity and insulation testing is to ensure that what should be connected is and what should not be connected isn't.
This can be achieved with a simple set of wires connected to a battery and a globe, but would be better using a multimeter with a continuity testing feature. The procedure is basically the same.
The centre of the connector should be connected so when the probes are held on each end centres, the light globe should illuminate, good so far. If not, they are not connected, time to investigate. Next hold one probe on the centre and the other on the shield, this should not be connected so the light should not shine indicating no connection, as it should be.
Test all possible combinations of centre and shield, then retest.

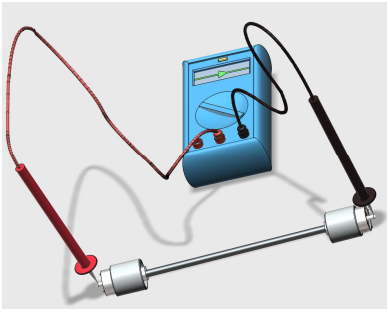


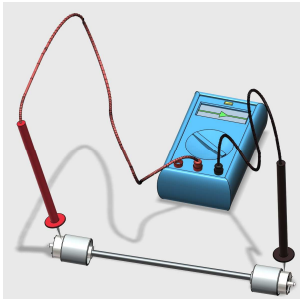
Current flows along central conductor. (note position of clips)

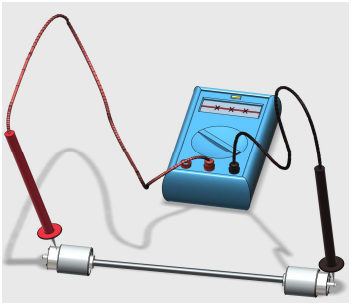
Outer sheath insulated from central wire. (Note clips)

The preferred method is to use a multimeter with a continuity test feature.
The meter probes are applied to each end and it will beep if there is continuity.
Otherwise, use the lowest resistance range (ohms) and if there is continuity, the meter will read zero ohms or very close to it. If there is no continuity, the meter should show either an extremely high resistance (many megohms) or an 'over-range' indication.

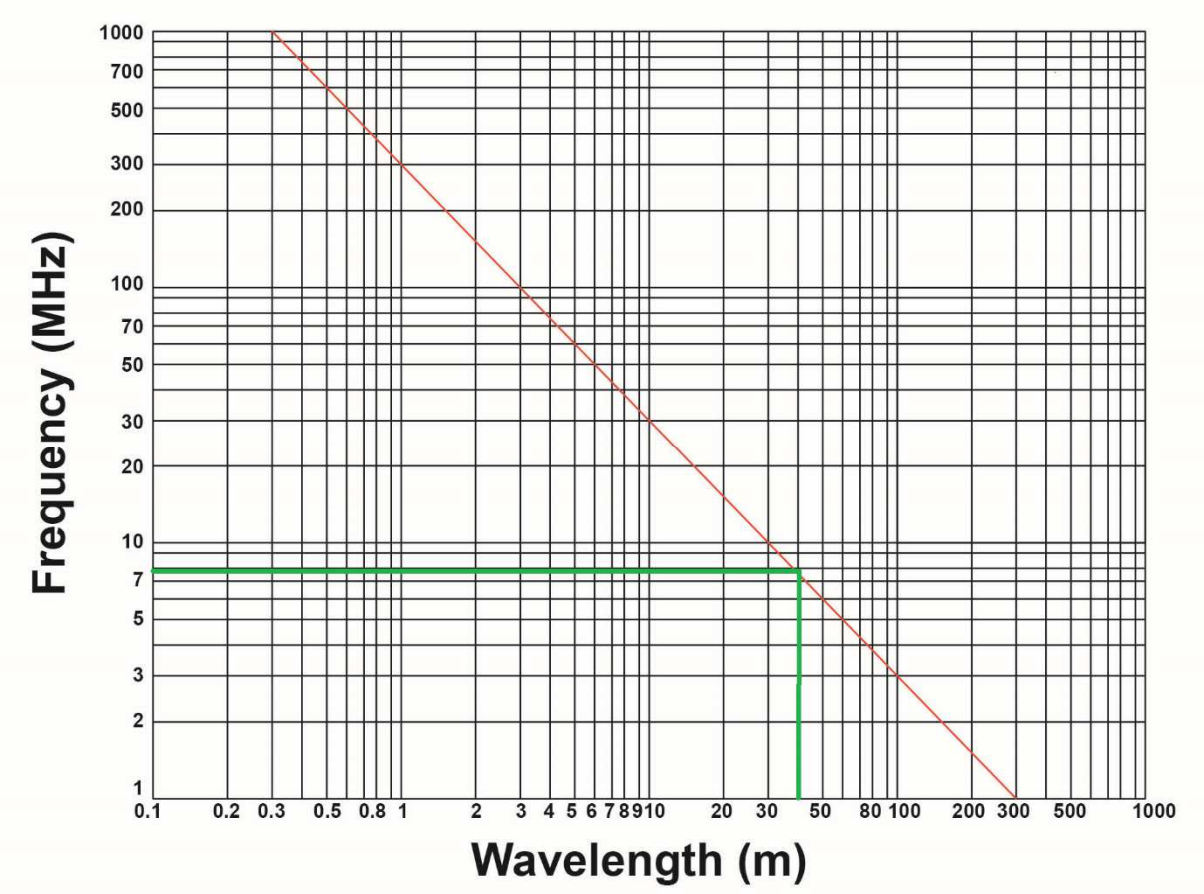
Currents and voltages in unwanted places can be deadly to both persons and equipment.
Read and follow all instructions and check all feedline coax cables before put to use.


Checking inner to inner for continuity.


Checking outer to outer for continuity.


Checking outer to inner for NO continuity.

The relationship between the physical length of the antenna and the frequency of operation.

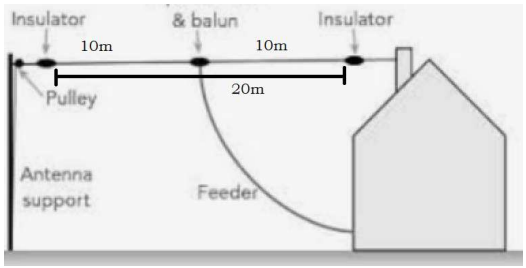


Most antennas are made with the length of the radiating part being close to a fraction or a multiple of the wavelength.

Any point on the red line corresponds to a particular frequency and wavelength.
The green line on the graph shows an example of how to read the graph – 40 metres wavelength is a bit above 7 MHz.

Important antenna types to know about are -

the half-wave dipole, which is a 1/2 wavelength long in total. For example, if made for the 7 MHz band, this is 40m wavelength, and the antenna will be approximately 20m long.



the quarter wave antenna - this is commonly used for vertical orientation, using a 'ground plane' as one half of the antenna. This may consist of a set or 'radial' wires or tubing, or a connection to the earth under the antenna. For a frequency of 144 MHz, the wavelength is approximately 2 metres, so a 1/4 wave is half a metre or 500mm.

There are also 'random wire' antennas which can be any length, and use a balun and/or an ATU to provide a proper impedance match to the transceiver.

On-air performance of an amateur station can be improved significantly by the correct choice of antenna.

From the previous sheet we know that antennas can vary in their directedness. Omni-directional antenna will radiate in all directions equally. This is useful for general calling for anybody to communicate. It usually comes with a smaller reach. A directional antenna, such as a Yagi will concentrate your signal in one direction. These are better for communicating over greater distances or copying weak signals.

This is the accepted symbol for an antenna

Antenna Polarisation

An antenna is said to be ‘polarised’ according to the orientation of the part that radiates the signal. Dipole antennas made from wire are usually suspended parallel to the ground and so are horizontally polarised. 1/4 wave antennas as often used on vehicles are usually vertically polarised. The electromagnetic wave from a transmitting antenna will have the same polarisation as the antenna.

Question 1:
If an antenna receives its strongest signals in two opposite directions, it is said to be:

A) omni-directional B) bidirectional C) unidirectional D) isotropic

Question 2:
Antenna gain is measured in these units:

A) decibels (dB) B) Amps (A) C) Power (P) D) Volts (V)

Question 3:
If you measured the SWR of an antenna as 1.4:1, What would you do?

A) carefully lower the transmitting power and use infrequently
B) ask an expert to help you look for problems with the antenna
C) leave it alone and use it
D) throw it away and get a better one

Question 4:
To test your feedline you should attach which of the following to the end:

A) a small Yagi antenna B) a dummy load C) a random piece of wire D) nothing

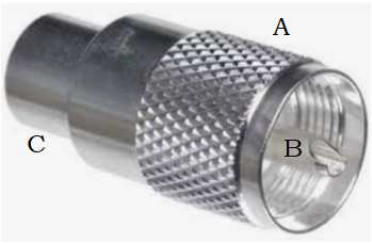
Question 5:
Which feed line is considered balanced?

A) coaxial cable B) ladder line

Question 6:
The usual impedance of a joiner used with coaxial cable is:

A) 50dB B) 50A C) 50Ω D) 12V

Question 7:
To check the continuity of the central wire you would attach the tester to?



A) A at one end and A at the other
B) C at one end and A at the other
C) B at one end and C at the other
D) B at one end and B at the other