The Radio Amateur Society of Australia

# Foundation Level Study Guide

## V3.1 December 2025


## Your Gateway to the World of Amateur Radio

Amateur Radio provides virtually unlimited opportunities for you to explore the technical, scientific and social aspects of this truly global hobby

## A Free Amateur Radio Learning Resource

**This multimedia learning resource has been developed by RASA and is provided free of charge.**

The Radio Amateur Society of Australia

# Foundation Study Guide ©

  Release 3.1  December 2025

**Contact: info@vkradioamateurs.org        Web: vkradioamateurs.org**

# Contents

# Welcome

Welcome to the wonderful world of Amateur Radio.

The **Radio Amateur Society of Australia Inc.** (RASA) is pleased to provide this Foundation Level resource to prospective Australian Amateurs.

The Amateur Radio Service is defined by the International Telecommunications Union as:

*A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorised persons interested in radio technique solely with a personal aim and without pecuniary interest.*

It permits operation on a vast range of frequencies, from Very Low Frequencies (VLF) all the way up to Super High Frequencies (SHF) - microwaves and beyond.

RASA is a strong proponent of self-training and experimentation and believes learning a little more than required will provide you with the knowledge and tools to get the most out of this fascinating hobby. We encourage you to have an enquiring mindset and to make ongoing learning a core component of your journey into Amateur Radio.

## How to use this resource

Like all RASA on-line resources, this is free of charge. It is published in two formats. The online version contains many hyperlinks which will direct the reader to another website for more information. Hyperlinks are also used to access our videos, providing a great multi-media approach to describing a topic or explaining how to perform a technical procedure.

If you have purchased the paper copy from Amazon, we encourage you to download the PDF version from our website so you can access the additional online resources such as:

- **QRM Guru** - our online resources to help you understand and resolve Radio Frequency Interference
- **RASA YouTube channel** - where you can access the videos associated with this resource

Some sections in this resource are embedded in a blue box. This indicates the material is important, but is **not** examinable. We also have links to external resources, such as QRM Guru.

Should you find any omissions, errors, or have suggestions for improvements, please send us an email. As this is an electronic resource we can make updates easily and at no-cost.


## Acknowledgements:

We would like to thank the people and associations who have contributed to this resource.

- Alan Cheshire VK6CQ
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- Radio Amateur Society of Australia Inc
- Australian Communications and Media Authority (ACMA - website)

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 Email us at info@vkradioamateurs.org

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# Chapter 1: **Nature of Amateur Radio**

Amateur (or “ham”) Radio is a diverse and engaging hobby. It promotes and encourages self-education and technical experimentation. Many amateur radio operators around the world form long-term friendships fostering international good will.

It permits operation on a vast range of frequencies, from Very Low Frequencies (VLF) all the way up to Super High Frequencies (SHF) - microwaves and beyond.

## Amateur Radio offers:

- Education in electronics and radio theory
- Construction of equipment & antennas
- Radio sport: contesting and awards
- World-wide (DX) communications
- Communication via satellites and even bouncing signals off the moon
- Sending and receiving pictures & video via radio
- Outdoor activities – radio contacts from mountain summits and parks
- Connecting radios to the internet
- Experimentation in many other radio related topics. eg. radio propagation

The Foundation Licence and this learning resource are your gateway to a life-time of fun and friendships the world over.

### Key Learning Outcomes

By the end of this chapter, you should be able to explain the following:

- The nature of Amateur Radio
- Types of radio licences
- Allocation of frequency bands

Amateur radio involves building and operating amateur radio stations, participating in contests, experimenting with new radio technologies, and providing emergency communication services during natural disasters or other crises.

Enthusiasts often enjoy the technical aspects of the hobby, as well as the opportunity to connect with people from different cultures and backgrounds.


*A HF Radio Station (Image courtesy of ieee.org)*

Amateur Radio operators hold an Amateur radio Class Licence, issued by the Australian Government Radio Regulator, the Australian Communications and Media Authority (ACMA). The Amateur Service operates on frequency bands set aside for their use, some of which are shared with other services on a non-interference basis. For the allocations we share with other users, we are referred to as Secondary Users. For the allocations dedicated to us, we are the Primary Users.

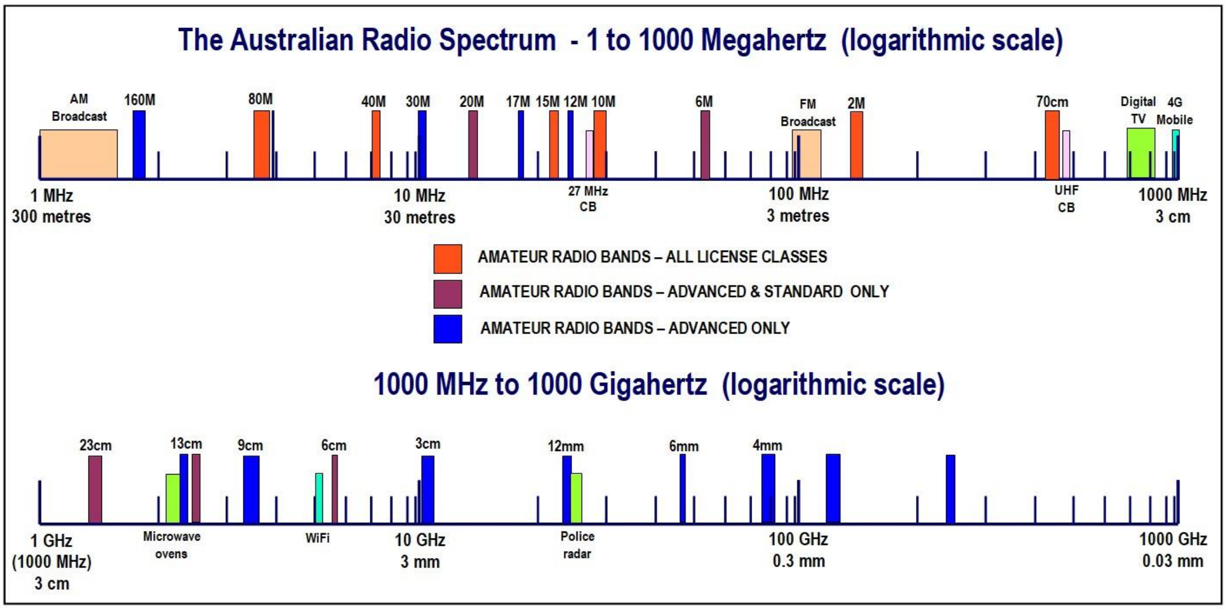
The Amateur Radio Service is defined by the International Telecommunications Union as:

*A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorised persons interested in radio technique solely with a personal aim and without pecuniary interest.*

It is important to note that different countries and regions may have slightly different amateur radio band allocations and other restrictions.
A copy of the Australian Band Plan has been included here in Appendix 3.  You can also download a wall chart version of the band plan from the Radio Amateur Society of Australia here.

Other non-amateur services such as broadcasting, aeronautical, and maritime services are also allocated frequency bands appropriate to their needs.

The chart below illustrates a segment of the radio frequency spectrum and Amateur Radio allocations.




*Australian Spectrum Plan with Amateur Radio bands*

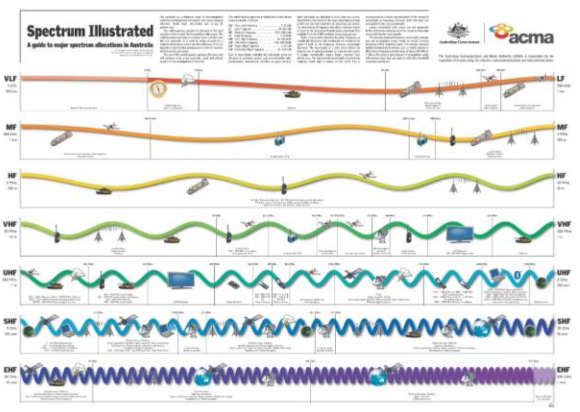
The Australian Communications and Media Authority is charged with the management and oversight of the Radio Frequency Spectrum in Australia. You can visit their website to learn more about their role in administering Amateur Radio.

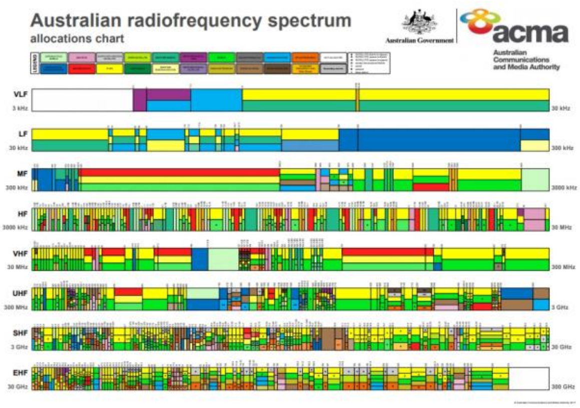
[Amateur radio | ACMA]

They also publish some informative charts to illustrate how the Spectrum is allocated.

[Australian Radiofrequency Spectrum Plan | ACMA]

[Spectrum illustrated - A guide to major spectrum allocations in Australia.png (acma.gov.au)] Left
[Australian radiofrequency spectrum allocations chart.pdf (acma.gov.au)] Right



# Chapter 2: Licence Conditions

REGULATIONS COMPLIANCE PRACTICE

Your Amateur Radio Licence is granted subject to certain conditions and rules, and understanding these will help you to make the most of your Amateur Radio journey.

## Key Learning Outcomes

By the end of this chapter, you should be able to recall the following:

- that operation under an Amateur Licence is subject to conditions in the Radiocommunications Act 1992, and related regulations and documents
- that an Amateur Licence primarily authorises operation for hobby and self-training purposes
- how to handle distress and urgent transmissions
- the use and allocation of callsigns
- power levels, modes and equipment that can be used
- the role of the ACMA and it's inspectors

## Licence Conditions

All radio activity in Australia is regulated under provisions of the Radiocommunications Act 1992. The Act is interpreted for Amateur Radio in the Radiocommunications Licence Conditions (Amateur Licence) Determination 2015 (The LCD), and the Radiocommunications (Amateur Stations) Class licence which came into effect on 19th February 2024. These two are the "***rule books***" describing how we must conduct ourselves. The Act and the Determinations are available for download from the ACMA website.

The Amateur LCD:

AUSTRALIA

**Radiocommunications Licence Conditions (Amateur Licence) Determination 2025**

The Australian Communications and Media Authority makes the following determination under subsection 110A(2) of the *Radiocommunications Act 1992*.

Dated: 11 September 2025

You can access this document https://www.legislation.gov.au/F2025L01087/latest/text

The Amateur Radio Class Licence

AUSTRALIA

**Radiocommunications (Amateur Stations) Class Licence 2023**

The Australian Communications and Media Authority makes the following class licence under section 132 of the *Radiocommunications Act 1992*.

Dated: 7 December 2023

You can access this document here
Radiocommunications (Amateur Stations) Class Licence 2023 (legislation.gov.au)

## Purpose of the Amateur Service

Amateur licences are intended for hobby radio and technical experimentation.
You can do this in many ways, including voice, Morse code and data.

Your Amateur Licence authorises you to operate an Amateur radio station for self-training and experimentation in radiocommunications, intercommunications between Amateurs and technical investigations into radiocommunications.

## Distress and Urgency Signals

In the event that you hear a distress call, you must give that call and subsequent communications priority over all other transmissions.

A distress signal indicates that a person is threatened by grave and imminent danger and requires immediate assistance.

The distress signal consists of the word MAYDAY. Anyone hearing a 'MAYDAY' communication is responsible for noting the nature and details of the emergency and for passing the information on to an appropriate authority.

Examples might include a sinking fishing boat in Port Phillip Bay, or a life threatening injury to a hiker in the bush.

PAN-PAN is used for urgent situations not requiring a MAYDAY.

Examples might include a fishing boat with a failed engine, not facing immediate danger, but requiring emergency services assistance, or a non-life threatening injury to a hiker in the bush, which may prevent them from returning to safety without assistance.

These communications must receive priority and must be reported to an appropriate authority. Follow this link for more information from the ACMA:
https://www.acma.gov.au/amateur-radio-operating-procedures#distress-and-safety-procedures

## Station identification

You are required to properly identify your station.
You must use your call sign and the callsign of the station you are in communications with: your identification is your callsign.

## Amateur Callsigns

Amateur callsigns consist of a prefix that includes a number, and a suffix. In Australia, the prefix is "**VK**", and the numeral designates the station's State or Territory at the time an Amateur is first allocated their callsign. This numeral may be from **0-9**, indicating the State or Territory in which the station is operating:

**0 = Antarctic & sub-Antarctic islands**
**1 = Australian Capital Territory**
**2 = New South Wales**
**3 = Victoria**
**4 = Queensland**
**5 = South Australia**
**6 = Western Australia**
**7 = Tasmania**
**8 = Northern Territory**
**9 = Australian External Territories**

The suffix can be two or three letters. Two letter suffixes are reserved for Advanced Licencees. The table shows the callsign template for Australia.

Note: The single letter suffix callsigns are for Advanced Amateur Operators and for Contest use only.

| Licence Type | Template |
|---|---|
| Advanced | VK$aa, VJ$a, VL$a, VK$a |
| Advanced, Standard & Foundation | VK$aaa to VK$zzz |

For further information see Amateur radio call signs | ACMA

## Encoded messages

The transmission of messages that are encoded for the purpose of obscuring their meaning is not permitted except for the purposes specified in the Amateur Licence Condition Determinations (LCD).

## Authorised frequency bands and emissions

Your Amateur Radio Licence authorises operation on certain frequency bands. The bands and blocks of frequency are specified in the LCD. Many people publish “Band Plans”, which are useful to you, however these are all derived from the bands described in the LCD. The LCD is the source document. A table showing Advanced, Standard and Foundation frequency allocations is in the following page.

## Permitted Power Output

Your Foundation Amateur Licence restricts the transmitter output power to a maximum of 10 (ten) watts peak (Px). This should be measured either by the power output meter of the radio, or an external measuring device connected to the output of the radio. Note: You may also hear the power expressed as 10 watts PEP instead of Px. These terms mean the same thing.

## Notification of change of address

You do not need to notify the ACMA of a change of address, but you should ensure they have a correct postal or email address on file at all times.

## Harmful interference

A licensee, (you), must not operate an Amateur station if operation causes harmful interference to other licenced services. If a neighbour, local radio station, or anyone else knocks on your door and tells you that you are causing interference to their licensed service, you must cease operation and seek to resolve the issue.

You can find helpful, experience based advice here: **QRM.GURU**

## Band Allocation Table

This table shows a summary of the accessible bands and frequencies for Advanced (**Green**) Standard (**Blue**) and Foundation (**Red**) operators

| Class | | | Band | Frequency | Necessary Bandwidth (note 1) |
|---|---|---|---|---|---|
| A | | | 2200m | 135.7-137.8 kHz | No greater than 2.1 kHz |
| A | | | 630m | 472-479 kHz | No greater than 2.1 kHz |
| A | | | 160m | 1800-1875 kHz | Where the necessary bandwidth exceeds 8 kHz, the maximum power spectral density from the transmitter must not exceed 1 watt per 100 kHz. |
| A | S | F | 80m | 3500-3700 kHz | As above |
| A | | | 80m | 3776-3800 kHz | No greater than 2.8 kHz (note 2) |
| A | S | F | 40m | 7000-7100 kHz | Where the necessary bandwidth exceeds 8 kHz, the maximum power spectral density from the transmitter must not exceed 1 watt per 100 kHz. |
| A | S | F | 40m | 7100-7300 kHz | No greater than 8 kHz |
| A | | | 30m | 10100-10150 kHz | No greater than 8 kHz |
| A | S | | 20m | 14000-14350 kHz | Where the necessary bandwidth exceeds 8 kHz, the maximum power spectral density from the transmitter must not exceed 1 watt per 100 kHz. |
| A | | | 17m | 18068-18168 kHz | As above |
| A | S | F | 15m | 21000-21450 kHz | As above |
| A | | | 12m | 24890-24990 kHz | As above |
| A | S | F | 10m | 28000-29700 kHz | Where the necessary bandwidth exceeds 16 kHz, the maximum power spectral density from the transmitter must not exceed 1 watt per 100 kHz. |
| A | S | | 6m | 50-52 MHz | No greater than 100 kHz |
| A | S | | 6m | 52-54 MHz | No restriction |
| A | S | F | 2m | 144-148 MHz | No restriction |
| A | S | F | 70cm | 430-450 MHz | No restriction (note 3) |
| A | | | 23cm | 1240-1300 MHz | No restriction |
| A | S | | 12cm | 2300-2302 MHz | No restriction |
| A | | | 13cm | 2400-2450 MHz | No restriction |
| A | S | | 9cm | 3.3-3.6 GHz | No restriction (note 4) |
| A | | | 6cm | 5.650-5.850 GHz | No restriction |
| A | | | 3cm | 10-10.5 GHz | No restriction |
| A | | | 12mm | 24-24.250 GHz | No restriction |
| A | | | 6mm | 47-47.2 GHz | No restriction |
| A | | | 4mm | 76-81 GHz | No restriction |
| A | | | | 122.250-123 GHz | No restriction |
| A | | | | 134-141 GHz | No restriction |
| A | | | | 241-250 GHz | No restriction |

## Use of Amateur stations

Amateurs may not use their Amateur Radio Station for financial gain.

The LCD states that transmission of any form of entertainment by Amateurs on Amateur Bands is **not** permitted.

## Inspection of Class Licence

ACMA Inspectors may require an Amateur to present their Letter of Confirmation issued by ACMA. It is unlikely an ACMA Inspector would demand you produce your licence.

## Restriction of operation to avoid interference

In order to avoid harmful interference, the ACMA has the right to restrict the operation of an Amateur station. If an ACMA inspector tells you to shut down the station, you must do so.

## Use of the Licence Condition Determinations & Class Licence

This is not a memory test. You will be asked to demonstrate that you have some familiarity with the documents.

## Station Security

You must ensure that your Amateur station is not accessible to unauthorised persons.
For further information and to learn more, visit these resources:

- Regulations: Vkregs.info
- Understanding and managing Interference: Qrm.guru

# Chapter 3: **Technical Basics**

## Units of Measure

In all facets of science, mathematics and physics, we need accurate measurements for very large and very small values. Amateur Radio is no exception. Amateur Radio requires the measurement of voltage, frequency, length and many other parameters. Such quantities and values must be recorded with accuracy.

Many units and scales of measurement are in common use. For example, the metre is the metric unit of length, but it is routinely expressed in kilometres and millimetres for large and small scales. These two examples use the prefix ‘kilo’ to represent ***thousands*** of metres and ‘milli’ to represent ***thousandths*** of a metre.

For Amateur Radio we need to be aware of a broader scale of units. The table below lists the most common units and scales in general use.

**Table 1: Units of Measure**

| TERM | No. OF UNITS | Abbreviation |
|---|---|---|
| 1 Giga | 1,000,000,000 | G |
| 1 Mega | 1,000,000 | M |
| 1 Kilo | 1,000 | K |
| Units | 1 | |
| 1 Milli | .001 | m |
| 1 Micro | .000,001 | µ or u |
| 1 Nano | .000,000,001 | n |
| 1 Pico | .000,000,000,001 | p |

Another example is measuring frequency in Hertz. One Hertz is one complete cycle per second. The abbreviation for Hertz is Hz. The base unit of Hertz is used for low frequencies such as sound. One hundred and twenty-three cycles in one second would be expressed in writing as 123 Hz.

We must also be able to express very large frequency values. For example, the output frequency of an Amateur repeater may be 438,425,000 Hz. This is a large and unwieldy number. The conventional approach is to express this large value in millions of Hertz, or Megahertz.

**438,425,000 Hz = 438.425 Megahertz or 438.425 MHz**

Most Amateur transceivers display their working frequency in Megahertz or kilohertz.


## Units used in Amateur Radio

There are many parameters that can be measured, however for the Foundation Level, we only need to know the basic units of measurement. The table below presents the six most common units.

## Table 2 Common Units

| Unit | Common Expression | Abbreviation |
|---|---|---|
| **Voltage** | Volts | V or E |
| **Current** | Amps | A or I |
| **Resistance** | Ohms | R or Ω |
| **Power** | Watts | W or P |
| **Frequency** | Hertz | Hz |
| **Wavelength** | Metres | M or λ |

**Voltage**

This is the electrical 'pressure', or potential difference between two points in any electrical circuit. Voltage is measured in Volts, abbreviated to V. Some formulas also use E to represent voltage, where E is the abbreviation for EMF (Electro-Motive Force)

This is expressed as a positive or negative potential with respect to Earth (or other common reference point within a circuit). Some voltage sources are constant, such as a 12V car battery, or a 1.5V AA battery in a LED torch.

Where polarity is fixed, for example on a battery, the voltage is termed DC. When a load is applied the resulting current is Direct Current.

Where the polarity changes or alternates at a high rate, for example on a mains power outlet, the voltage is described as AC or Alternating Current.

It is very important to check the polarity of a DC voltage source before connecting it to any electronic device. Positive connections are identified with a **'+'** sign and are usually coloured **red**. Negative connections are identified with a **'-'** sign and usually coloured **black** or **blue**.

Batteries always have positive and negative markings.

Failure to observe the correct polarity of a DC supply in an electronic circuit often results in permanent damage to the equipment.

## Current

Current has the potential to do physical work. For example, the flow of water in a river can be used to rotate a mill. Similarly, electrical current can cause a lamp to glow, a motor to spin or a heater element to warm up. In electronic circuits, these currents can be extremely small and may be measured in milliamps (mA) or even microamps (uA).

## Resistance

Resistance in an electrical circuit is the opposition to electron flow. The greater the resistance, the fewer electrons can flow between two points in a given time, so the lesser the current. Resistance is measured in ohms, abbreviated to Ω (the Greek letter 'Omega').

In general, all materials are either those capable of conveying electrical current (conductors) or those which are not (insulators). In general, most metals are conductors, whilst most other materials such as wood, plastics and ceramics are insulators.

In electronics, there is a large family of components called Resistors. Resistors are neither pure conductors nor pure insulators but are manufactured to have different resistances somewhere in between. A low value of resistor of say 10 ohms may represent the resistance of a short section of copper wire. A resistor with a value of millions of ohms or 'Megohms' would be closer to being an insulator than a conductor.

## Power

Whenever an electrical device is connected to a voltage source, it will consume Energy in order 'to do something'. For example that 'something' might be a light bulb glowing, an electric motor spinning or a heating element warming up. It could also be an Amateur Radio station transmitting a radio signal.

There is a mathematical relationship between Voltage, Current and Resistance from which Power can be calculated.

Similarly, for a given voltage, if the resistance between the voltage points *decreases*, the current always *increases* by the same proportion. Higher current means that more energy is consumed per second (in other words, Power increases as well).

Most electronic components have a Power Rating in watts. This is the maximum energy that the component can safely dissipate as heat before it overheats and becomes permanently damaged. In general, if an electronic device becomes too warm for a person to touch, it is a good sign that one or more of its internal components have been stressed beyond their designated power rating.

Power measurements can vary greatly. For example, the power of an FM broadcasting station would be measured in kilowatts. In contrast, the sound energy coming from a radio receiver's loudspeaker would only one or two Watts.

Power measurements can vary greatly. For example, the power of an FM broadcasting station would be measured in kilowatts. In contrast, the sound energy coming from a radio receiver's loudspeaker would only one or two Watts.

**The relationship between Voltage, Current & Resistance**

The relationship between these three is known as ohm's Law.

If any two values are known, then the third value can be calculated. ohm's Law can be transposed three ways to find a missing value:

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}} \qquad \text{Resistance} = \frac{\text{Voltage}}{\text{Current}} \qquad \text{Voltage} = \text{Current} \times \text{Resistance}$$

*Simplified as:*

$$I = V / R \quad \text{or} \quad R = V / I \quad \text{or} \quad V = I \times R$$

For example, a resistance of 250 ohms is placed across the terminals of a 12V car battery and we wish to calculate the current flow in Amps. **12 / 250 = 0.048 Amps** or **48 milliamps.**

## Calculating the relationship between Voltage, Current, Resistance and Power

Calculating the amount of power in a DC circuit is an extension of ohm's Law, viz:

- **When a current of** One Ampere exists through a resistance of One ohm, the resistance dissipates One watt of power.
- (the resistor dissipates the power as heat into the air).
- **Power can be calculated if any two factors are known**. For example, Voltage & Current, or Voltage & Resistance, or Current & Resistance.

$$\text{Power} = \frac{\text{Voltage (squared)}}{\text{Resistance}} \quad \text{or} \quad \text{Power} = \text{Voltage} \times \text{Current} \quad \text{or} \quad \text{Power} = \text{Current (squared)} \times \text{Resistance}$$

*Simplified as:*

$$P = V^2 / R \quad \text{or} \quad P = V \times I \quad \text{or} \quad P = I^2 \times R$$

**Remember…Some reference material uses symbol 'E' for Electro-Motive-Force, rather than 'V' for Voltage, but both symbols represent the same value.**

For example, a car headlamp of 25 ohms is placed across the terminals of a 12V car battery and we wish to calculate the amount of power delivered to the lamp in watts. We would use:

$$P = V^2 / R$$

**(12 x 12) / 25 = 5.76 Watts of Power**

Calculating the power delivered by AC circuits is rather more complex since factors such as impedance and reactance must be taken into consideration. These calculations are not addressed in this manual.

**Frequency**

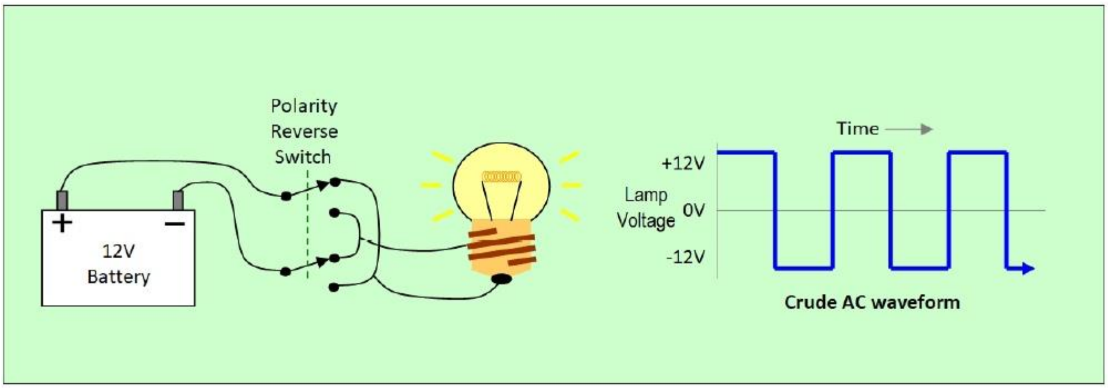
Frequency is the rate at which a voltage or current changes from positive to negative then back to positive again *per second*. It is expressed as a value in hertz, abbreviated to Hz.

Low frequencies are used in AC power systems. The 230 V power outlet in your home alternates in voltage and current between positive and negative fifty times per second, or 50 Hz. Therefore, one complete cycle takes one-fiftieth of a second, or 20 milliseconds to complete.

Audio comprises sound waves that travel through the air. Audio covers a range of frequencies between low (or 'bass') and high (or 'treble'). For the human ear, this range runs from about 20 Hz (very low) to about 20 kHz (very high), although our ability to hear the high-end frequencies decreases as we age. For speech, we only need to hear audio between about 300 Hz to 3000 Hz to understand what is being said.

Radio comprises *electromagnetic* waves that travel through free space at the speed of light. They cover a much wider range than sound waves. Radio waves begin at around 10 kHz and extend high into the Gigahertz range.

Consider the circuit below where a battery is connected to a light via a switch which can reverse the polarity of the battery. If we leave the switch in one position, we are feeding the light with



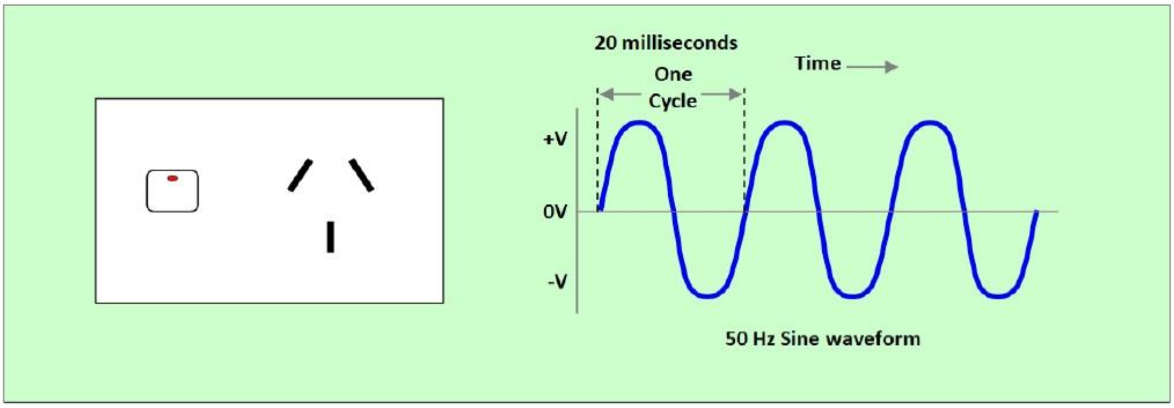

Direct Current (DC) and the lamp remains on. If we flip the switch back and forth rapidly at say ten times a second, as far as your eyes are concerned, the lamp keeps glowing at full brightness, but we are now feeding it with Alternating Current (AC) at 10 Hz.

The switch circuit here is a simple arrangement, producing what is known as a ‘Square Wave’. Regardless of the switch’s position, power is still being delivered; only the polarity is changing.

The voltage waveform on domestic power outlets also alternates between positive and negative in a similar manner, however the transition between positive and negative is much smoother, with a wave-like shape known as a ‘Sine Wave’.

Like measurements within a circle, one complete sine wave cycle is divided into 360 degrees. The first transition in the positive direction runs from $0^o$ to $180^o$ and the second transition in the negative direction takes up the remaining $180^o$ to $360^o$, after which the entire cycle repeats itself.

This process of swapping between voltage polarities at a high rate is called Oscillation. A device which produces such waveforms is called an Oscillator. An oscillator may be a stand-alone item of test equipment or a separate stage within a transmitter for the generation of radio frequencies. Frequency can be measured with a Frequency Meter. This is a device that counts the number of cycles that take place each second and displays the value as a figure in hertz, kilohertz or Megahertz on a digital readout.




Frequencies and voltages used in power systems vary around the world. In Australia, AC power is delivered at a nominal 230 V at 50 Hz. Historically this was 240 V. In practice, Australian mains power is 230 V within an acceptable tolerance range of -6% to +10%, which equates to between 216 V and 253 V AC.

By contrast, In the USA mains power is nominally 110 V AC at 60 Hz. Because the voltage is lower, the current drawn must be correspondingly higher in order to deliver the same power as the Australian standard.

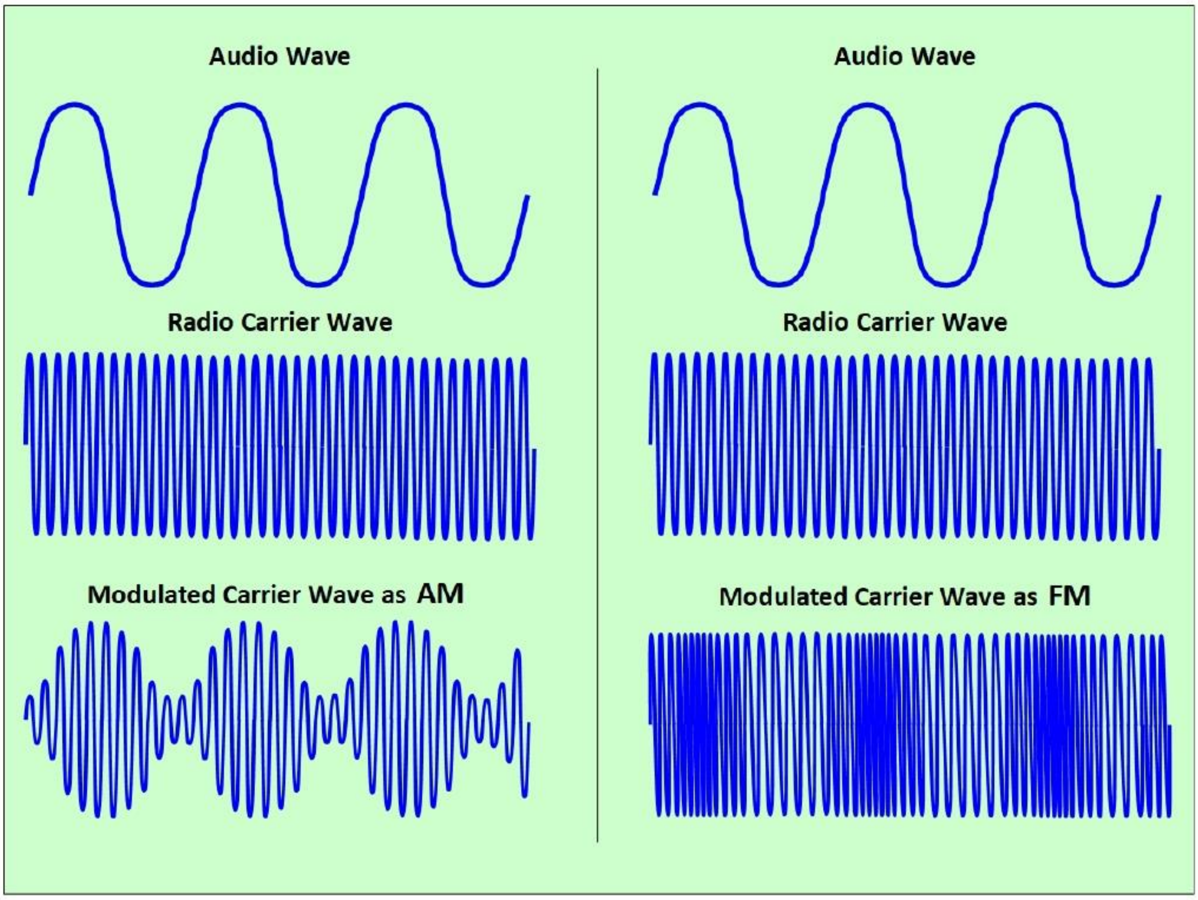
## Modulation

Radio waves can be modulated to convey speech, music and other types of information.
The simplest way to do this is to switch the radio wave on and off in specific patterns using an agreed code such as Morse Code.

Audio frequencies such as speech and music can also be 'piggy backed' onto a radio wave at a specific frequency (the Carrier frequency) by varying the intensity or *Amplitude* of the radio wave in a process known as Amplitude Modulation**.**

Another technique is to use audio frequencies to make small shifts in the radio wave's Carrier Frequency using a method called Frequency Modulation or FM. With this technique, the louder we speak into a microphone, the more the carrier frequency will shift. This effect is called Deviation.
FM has some advantages over AM because FM strips away noise from the carrier frequency, making FM clearer than AM at the receiving end of a contact.

There are more details about these modulation techniques in the Transmitter section of this manual.



## Speed of Electromagnetic Radiation, Wavelength

Radio waves propagate in free space at a constant speed known as the ‘speed of electromagnetic radiation’ (sometimes known as ‘the speed of light’).

For most practical purposes, this speed is 300,000 kilometres per second.
Wavelength is the distance in metres between the crests of a radio wave. It is fundamentally related to the radio wave’s frequency.

As a radio wave’s frequency increases, its wavelength decreases, therefore antennas used for higher frequencies become proportionately smaller.

Using this basic formula, it is possible to calculate approximate wavelength from a frequency, or approximate frequency from a wavelength.

$$\frac{300{,}000{,}000}{\text{Frequency in Hz}} = \text{Wavelength in metres}$$

$$\text{Example: } \frac{300}{146\ (\text{MHz})} = 2.05 \text{ metres}$$

In the above example we divide the frequency in the centre of the 2 metre amateur band and calculate 2.05 metres of wavelength for that band.

w

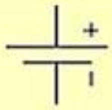
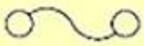
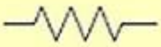
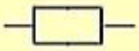
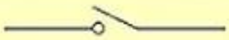
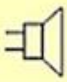
The speed of a radio wave does slow down slightly when flowing through a solid conductor rather than free space. This is the Velocity Factor and it has to be taken into consideration when calculating how long an antenna needs to be.

### Table 3 The Radio Spectrum

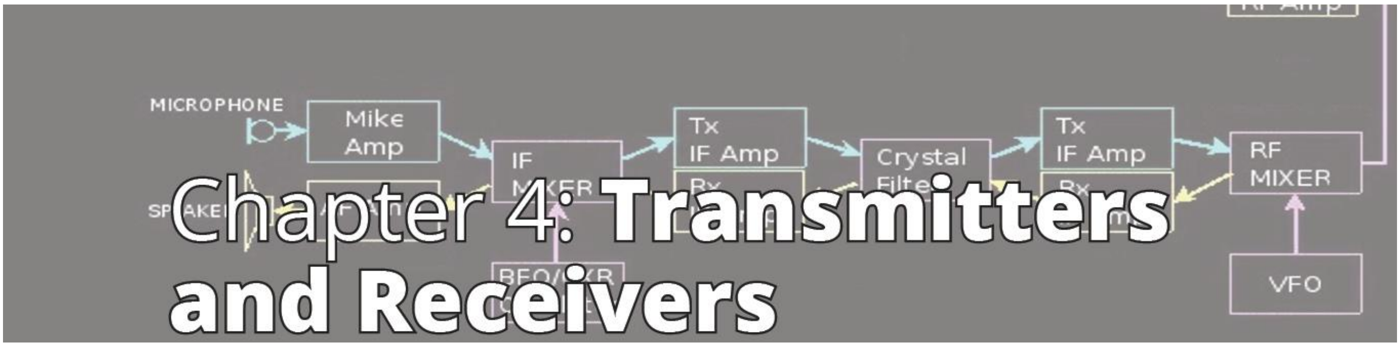
| Abbr. | Common Description | Frequency Range | Wavelength Range |
|---|---|---|---|
| LF | Low Frequency | 30KHz – 300KHz | 10 km – 1000 Metres |
| MF | Medium Frequency | 300KHz – 3 MHz | 1000 – 100 Metres |
| HF | High Frequency | 3MHz – 30 MHz | 100 – 10 Metres |
| VHF | Very High Frequency | 30 MHz – 300 MHz | 10 – 1 Metre |
| UHF | Ultra High Frequency | 300 MHz – 3 GHz | Metre – 100 cm |
| SHF | Super High Frequency | 3 GHz – 30 GHz | 100 cm – 10 cm |

## Basic Circuit Symbols

One of the requirements of the Foundation qualification is the recognition of some basic component and radio circuit symbols.  These are universal and will often appear within radio manuals.  Exam candidates should memorise these items.

| Description | Symbol |
|---|---|
| Cell |  |
| Battery |  |
| Fuse |  |
| Lamp |  |
| Resistor |   |
| Switch (SPST) |  |
| Antenna |  |
| Earth |  |
| Microphone |  |
| Loudspeaker |  |

# Chapter 4: Transmitters and Receivers




All facets of Amateur Radio use transmitters and receivers. The terms transmitter and receiver are used in this chapter, however it is more common for equipment to use a combined transmitter and receiver - called a transceiver.

## Key Learning Outcomes

By the end of this chapter, you should be able to recall the following:

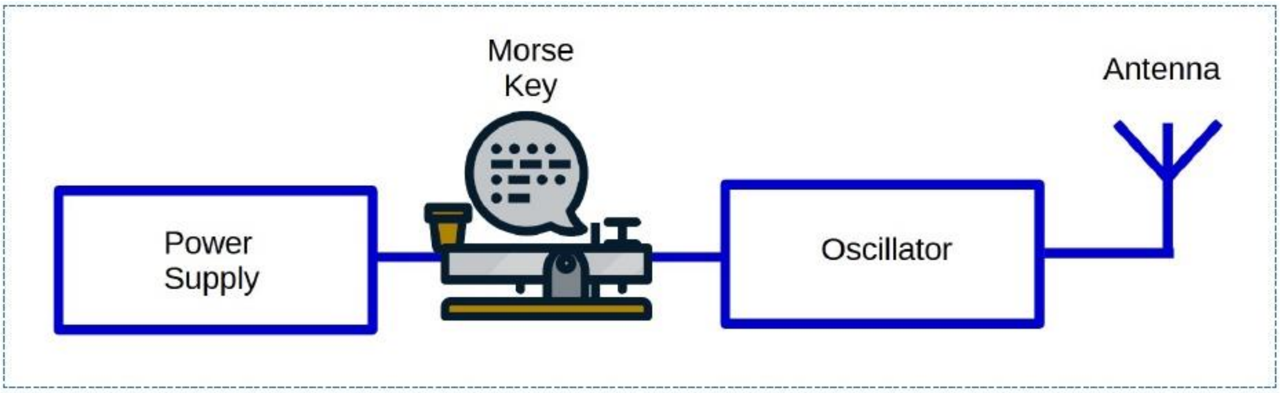
- At a block diagram level, basic knowledge of simple CW and AM transmitters
- At a block diagram level, basic knowledge of a simple receiver
- Understand the importance of proper transmitter adjustment and to keep transmissions within amateur radio frequency allocations
- Recognise the waveforms of audio, AM and FM modulation
- Understand that SSB is a form of AM
- Effect of AF gain control on output modulation
- Understand the terms Sensitivity, Selectivity and Stability in relation to receivers.

## Transmitters

A transmitter is a device that generates electrical energy in the Radio Frequency (RF) spectrum. This is then fed to an antenna which radiates this energy as electromagnetic (radio) waves.

In electronics, we often use simplified circuit diagrams in a format that looks like a flowchart, using boxes with the name of the circuit and lines to explain the operation of equipment. These are called Block Diagrams.

Below is the block diagram of a simple Continuous Wave (CW) transmitter capable of transmitting a short distance.




*A simple CW Transmitter Block Diagram*

The first block is the power supply. This could be a battery or even the mains supply with electronics converting the 240VAC mains supply to an appropriate voltage for the transmitter.

The next step is a Morse key, a switch operated by hand to send Morse Code, and the last block is an oscillator – an electronic circuit that generates electrical energy in the Radio Frequency (RF) spectrum.

This RF energy is then fed to an antenna represented here by the trident symbol. The antenna converts the oscillator's energy into electromagnetic waves and radiates these into space so that the CW signal can then be received by a radio receiver.

The oscillator produces what is called a **carrier signal**. We can send information using Morse Code by switching the carrier signal on and off with the Morse key.

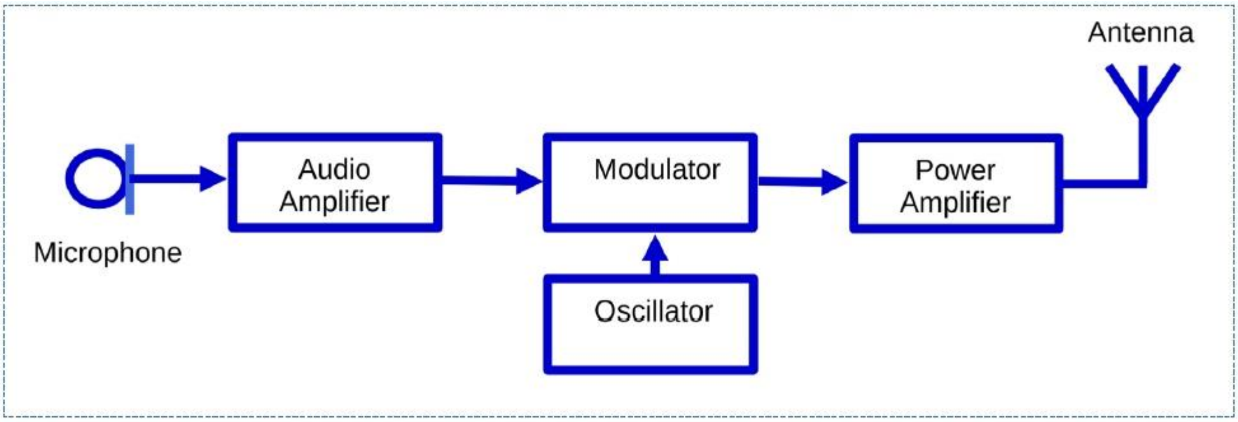
## Adding a Microphone

The next evolutionary step is to transmit the human voice by removing the Morse key and adding some additional circuits to our transmitter block diagram.

For voice signals to be intelligible, they need to be at least telephone quality. This requires audio frequencies between 300 Hz to 3000 Hz to be transmitted. To do this, we need to combine the voice from the microphone with the Radio Frequency (RF) carrier produced by the oscillator to produce a *modulated* RF output.

This method of voice transmission is known as Radio Telephony.

Below is the block diagram of a simple Amplitude Modulation (AM) transmitter:



A simple AM Transmitter Block Diagram

Let's look at what each of the blocks do.

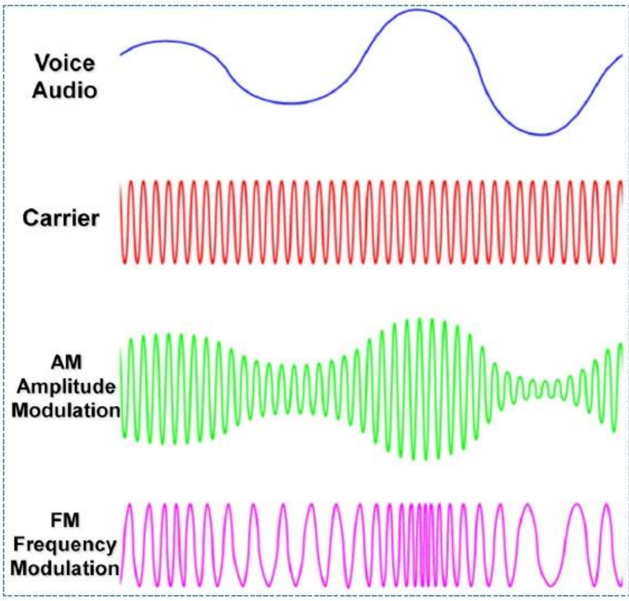
- **Microphone** - converts voice sound waves into a low level alternating electrical signal.
- **Audio Amplifier** – Amplifies the signal from the microphone.
- **Oscillator** – An electronic circuit that generates electrical energy in the Radio Frequency (RF) spectrum.
- **Modulator** - The circuitry in this block *modulates* (combines) the RF carrier waveform produced by the oscillator with the voice audio waveform from the audio amplifier. The modulator's output is now a modulated carrier. In this case the amplitude (intensity) varies in sympathy with the voice level. This is known as **Amplitude Modulation (AM)**.
- **The Power Amplifier** - The modulator output is a very low-strength signal. The power amplifier boosts (amplifies) it so the signal can be transmitted to air.

There are several modulation types:

**Amplitude Modulation (AM)** the one we have just described, where the amplitude (intensity) of the modulated wave varies in sympathy with the voice modulation. The frequency of the modulated carrier itself does not change.
It is the amplitude of the sidebands that varies with modulation (not the carrier).

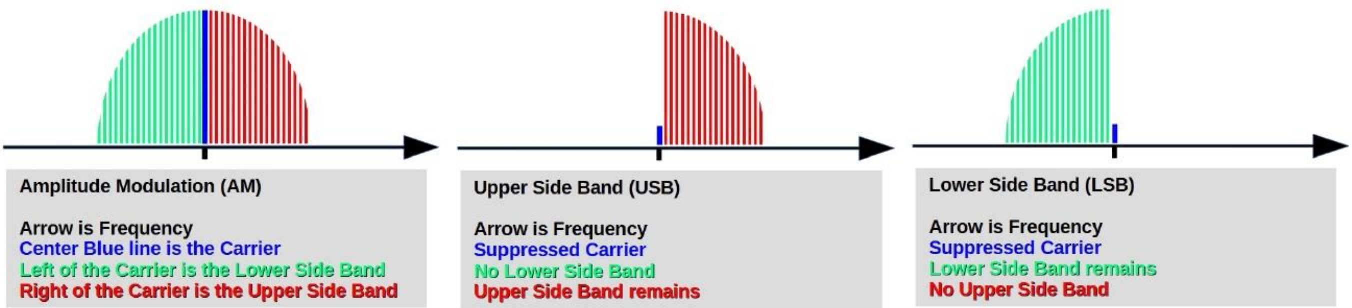
**Frequency Modulation (FM)** where the carrier's *frequency* varies either side of centre in sympathy with the voice. Modulation of an FM transmission is referred to as **deviation**. Unlike AM, the power of the transmitted signal remains constant.

Another term for AM is Double Sideband (DSB), Full Carrier. There is a carrier present whenever the transmitter is on and on either side of it, an upper and lower sideband containing the voice information. These sidebands are simply mirrors of each other, so they contain the same information - a lot of RF energy is wasted in this duplication. We can make the transmit signal stronger by removing these unnecessary components.




*AM and FM Modulation*

| | |
|---|---|
| Single Sideband (SSB) | ⇢ Is a form of AM where the unnecessary and duplicated parts of the RF modulated signal are removed (or not generated in the first place) before being transmitted. SSB does have a carrier, but it is suppressed, hence with no modulation the transmitter has no useful output.<br>⇢ SSB has either the lower sideband (LSB) or the upper sideband (USB) removed along with the carrier.<br>⇢ A simple AM receiver can then be used to receive an SSB signal by reinserting an artificial carrier before the detector by using a Beat Frequency Oscillator (BFO). More complex receivers use a Product Detector. |
| SSB has several advantages over AM | ⇢ SSB transmissions take up less bandwidth or 'space' on the Amateur bands. AM requires 6 kHz of bandwidth, whereas SSB only needs 3 kHz.<br>⇢ SSB effective power is higher than AM resulting in a more efficient use of energy. SSB is measured as Peak Envelope Power (PEP).<br>⇢ A receiver capable of handling SSB needs to be more complex and stable. |




*AM and SSB*

## Important things to know about transmitters

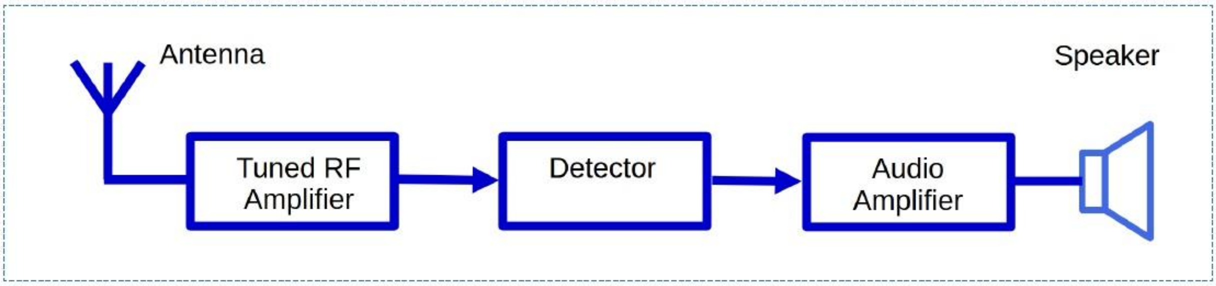
- A transmitter that is incorrectly adjusted can cause harmful interference to other stations.
- Excessive microphone gain will distort your transmitted signal, which can result in interference to other stations.
- Ensure that your transmitted signal is within the frequencies allocated for your licence.
- Ensure that the transmitter is correctly matched to the antenna system and its feedline. Failure to do so may result in interference to other stations and damage to the transmitter.

| Duty cycle | |
| --- | --- |
| | - The term duty cycle refers to the amount of time a transmitter is transmitting compared to the time that it is not.<br>- Modes with a carrier, such as AM and FM, have a high duty cycle, as the transmitter is operating at its full rated power when transmitting.<br>- For example, a 50,000W broadcast station transmitter has a 100% duty cycle – the transmitter is running at full power all the time.<br>- Similarly, a 50W amateur FM transmitter produces 50W whenever it transmits.<br>- On the other hand, a typical amateur 100W SSB transmitter has a relatively low duty cycle. The transmitter is not designed to transmit 100W continuously, as SSB does not drive a transmitter to continuous full power – the power output is proportional to the modulation (voice) input. The full 100W output power is only reached very occasionally on voice peaks. Typical Duty Cycle for SSB is around 25% and Morse Code is around 40%.<br>- However, digital modes, such as FT8 and RTTY, have a 100% duty cycle, as the digital tones can drive the transmitter to its full rated power. For this reason, it is very important that HF transceivers are not operated at full power when using digital modes. The power must be reduced, otherwise the transmitter will overheat and may produce spurious emissions which could cause interference. You could also damage your transmitter. |

## Receivers

Now that we have described the transmitter, we need to understand how a receiver can select the wanted transmission out of the many different radio signals an antenna receives.

## A Simple AM Receiver




*A simple Receiver Block Diagram*

## What do the blocks do?

- **Antenna.** Captures electromagnetic radio waves on many frequencies and converts them into signals for processing by the receiver.
- **Tuned RF Amplifier.** Really two blocks in one. The first block is a tuned circuit, which is a type of filter that selects the specific frequency you want to receive. The narrower or sharper this filter, the better the **selectivity** (*i.e.* the better you can ignore all other frequencies and "zoom in" on the frequency you want to receive).

  The second is a Radio Frequency Amplifier which improves receiver sensitivity and makes the signal stronger for the next stage. This amplifier is also designed to introduce as little additional noise as possible.
- **Detector.** It combines (mixes) the carrier with the sidebands to reproduce the microphone audio from the transmitter.
- The carrier is filtered out and only the audio is passed on to the next stage.
- **Audio Amplifier.** Amplifies the audio signal output from the detector sufficiently to drive headphones and/or a loudspeaker. It includes a potentiometer (volume control) to adjust the volume level.

## Important Terms used to describe a Receiver's performance

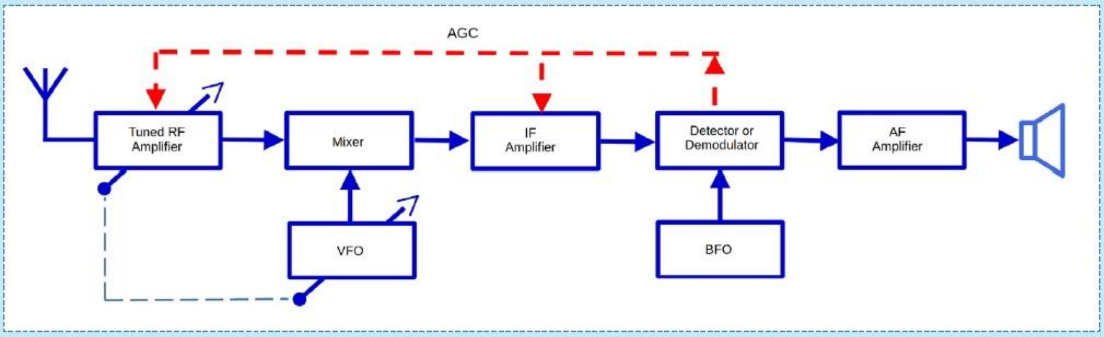
A list of desirable receiver attributes:

- **Sensitivity:**. The ability of a receiver to receive very weak signals.
- **Selectivity:** A receiver with good selectivity will be able to separate the desired signal from other signals on nearby frequencies. More complex receivers use specialised filters and audio processing techniques to improve selectivity when the bands are busy, or conditions are bad.
- **Stability:** A receiver with good stability does not drift in frequency. It will remain tuned to the same frequency over time and is not impacted by temperature change or mechanical vibration. Frequency stability is achieved by good oscillator design and good mechanical construction.

The receiver example on the previous page is known as Tuned Radio Frequency (TRF) Receiver and has limitations on its selectivity and sensitivity.

Improved sensitivity, selectivity and stability are generally found in designs such as the Superheterodyne Receiver and in modern Software-defined Radio (SDR).

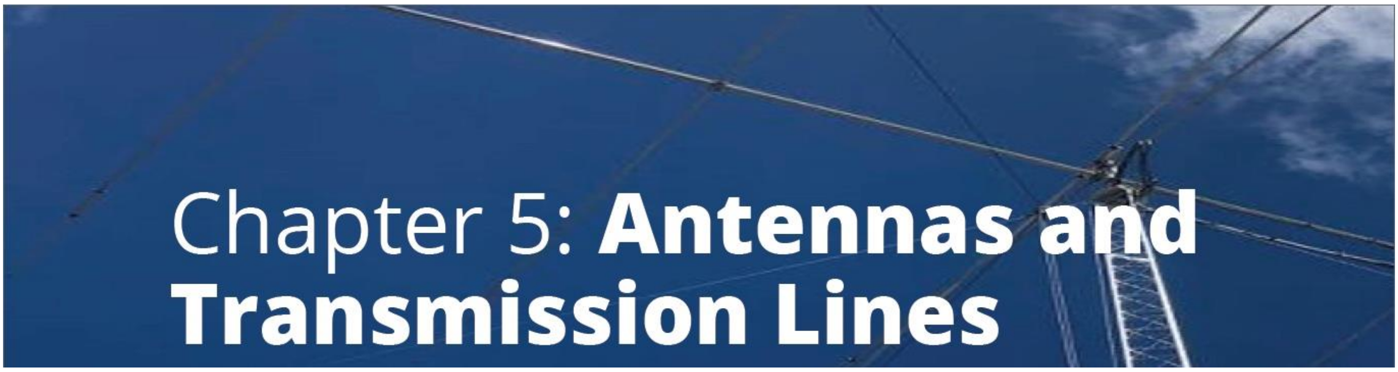
## A simple Superheterodyne Receiver




*A Simple Superheterodyne Receiver*

| | |
|---|---|
| What do the Blocks do? | ⇢ For example, the receiver is tuned to a Lower Sideband (LSB) signal on 7.150 kHz. |
| Tuned RF Amplifier | ⇢ two functions - Functions as per the previous example. |
| Variable Frequency Oscillator (VFO) | ⇢ A tuneable oscillator that generates an RF signal for use in the mixer. This oscillator must produce a clean and stable signal to the mixer circuit. Note the blue dotted line between the arrows on the Tuned RF Amplifier and VFO; this indicates that both are 'tied together' and are tuned in tandem. |
| The Mixer | ⇢ The original signal (7.150 kHz) mixes with the VFO signal (7,605 kHz) to produce 'sum and difference' frequencies of 14.755MHz and 455 kHz. The sum frequency is not required, so this is discarded by a Band Pass Filter, a kind of door that only lets the difference frequency through.<br>⇢ Since the Tuned RF Amplifier and VFO tunings are 'tied together' and tuned in tandem, this difference frequency is always the same.<br>⇢ This difference frequency then becomes the Intermediate Frequency of 455 kHz. |

| | |
|---|---|
| Intermediate Frequency (IF) Amplifier | ⇢ RF amplifiers are much easier to design at lower frequencies and a single frequency makes the design even simpler. The IF amplifier can now be optimised to perform at its best on this single frequency, which greatly improves the receiver's overall performance. |
| Beat Frequency Oscillator (BFO) | ⇢ The BFO is used to add a 'substitute' carrier on an SSB signal allowing the AM product detector to detect the audio signal. A BFO also provides a beat frequency for listening to CW Morse Code. |
| Product Detector | ⇢ Combines the sidebands with the signal from the BFO to convert the sidebands back to the audio that was fed into the microphone at the transmitter.<br>⇢ The carrier frequency gets filtered out and only the audio is passed on to the next stage. |
| Audio Amplifier | ⇢ Amplifies the weak audio signal output from the detector sufficiently to drive headphones and/or a loudspeaker. Includes a potentiometer to adjust the volume level. |
| Automatic Gain Control (AGC) | ⇢ Fading is a common phenomenon, especially on the HF bands. To help combat this, an AGC system is normally used to ensure the IF signal level remains as constant as possible. This means that the received audio in the headphones or loudspeaker remains at around the same level irrespective of how strong or weak the incoming radio signals are.<br>⇢ Note the red dotted line from the detector to the IF and RF amplifiers which controls the gains of those stages.<br>⇢ The AGC line can also be used to indicate received signal strength on a Signal Strength Meter. |



# Chapter 5: **Antennas and Transmission Lines**

## Key Learning Outcomes

By the end of this chapter, you should be able to explain the following:

- Antennas convert radio signals into radio waves and radiate them out into space and vice versa.
- Antenna resonance.
- Common types of antenna.
- The two types of Transmission Line
- Standing Waves
- Connectors
- Testing transmission lines

| | |
|---|---|
| | Polarisation |
| | Effective Radiated Power (ERP) |
| | Impedance matching & Antenna Tuning Units |
| | Baluns |
| | Voltage Standing Wave Ratio (VSWR) & acceptable limits |
| | Dummy loads and transmitter testing |

## Antennas

A transducer is any device that converts one type of energy into another type of energy. There are many examples in everyday life; e.g. loudspeakers convert electrical signals into sound waves, light bulbs convert electrical power into light, car engines convert the energy stored in fossil fuels into motion and so on.

A radio antenna is a type of transducer that converts electrical signals into electromagnetic waves which then radiate out into space and vice versa.

Your transmitter generates a stream of electrical signals at Radio Frequencies which are conveyed along the transmission line to the antenna which then converts these signals into electromagnetic waves and radiates them. Similarly, an antenna receives miniscule electromagnetic waves generated by faraway transmitters and converts them back into radio signals for the receiver to amplify and convert into something intelligible that you can copy e.g. Voice, data, Morse code.

## Antenna Resonance

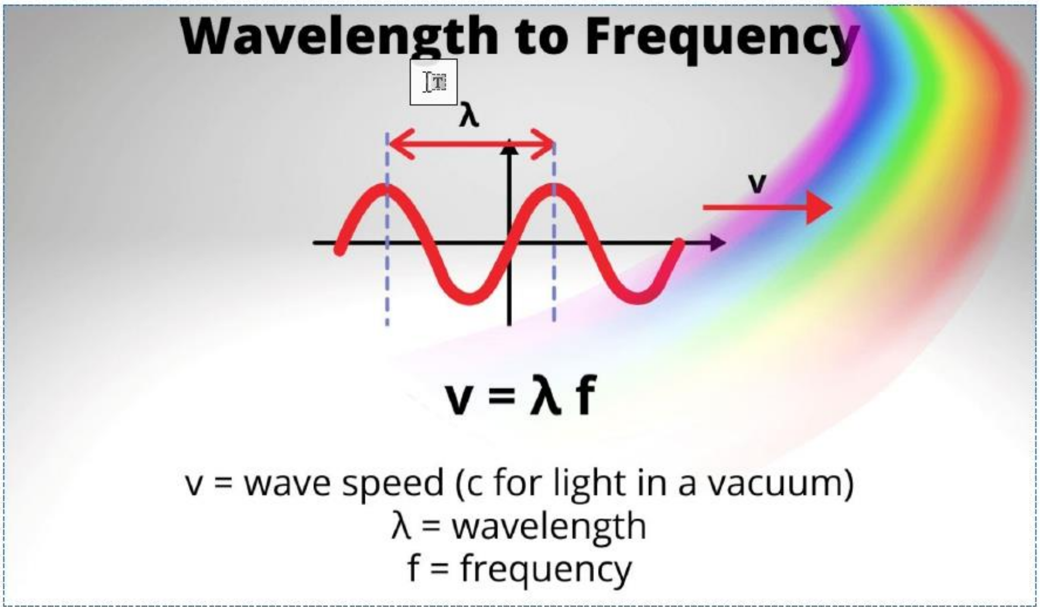
There are many factors that influence the efficiency of an antenna and how well it transmits or receives signals. However, for peak performance, the antenna must be *resonant* at the frequency you want to operate on. This simply means that the antenna is ‘tuned’ to that particular frequency, which makes it ‘super sensitive’ at that frequency.

This is because when an antenna is resonant at a particular frequency, the maximum amount of RF energy gets transferred to/from the transmission line and converted into electromagnetic waves at that frequency.

As mentioned earlier, the frequency and wavelength of radio waves are closely related to each other by the speed at which the radio waves travel. This connection between frequency **f** and wavelength **λ**, (the Greek letter 'Lambda' is used to denote wavelength) is described by the equation:

$$c = f \times \lambda$$

where **c** is the speed of electromagnetic radiation (300,000 kilometres per second).
Since this speed is always constant, if you increase the frequency, then the wavelength must decrease to maintain this equation and *vice versa*. In practical terms this means that as a radio frequency **increases**, the corresponding antenna size **decreases**.




For example, if **f** is **3.650 MHz** and **λ** = **c ÷ f**, then **λ = 300,000/3650 = 82.19 metres**.
This relationship for some of the common amateur bands is tabulated below:

| Frequency | Wavelength (nominal and used for convenience) |
|---|---|
| 1.8 MHz | 160 metres |
| 3.5 MHz | 80 metres |
| 7 MHz | 40 metres |
| 14 MHz | 20 metres |
| 21 MHz | 15 metres |
| 28 MHz | 10 metres |
| 144 MHz | 2 metres |
| 432 MHz | 70 centimetres |

You can try out a simple online calculator to illustrate the relationship between frequency and antenna length.

https://www.omnicalculator.com/physics/dipole

There are several types of antenna that are commonly used in Amateur Radio.
These include:

## The Monopole

This is often referred to as a 'quarter-wave' and is the most basic type of antenna you can make, as it is simply a wire or metal rod that is a quarter of a wavelength long at the required operating frequency.

It is most often used as a vertical radiator with the feed point at the bottom and needs a ***counterpoise*** underneath it in order to radiate efficiently. A counterpoise acts as a kind of reflector and is often simply the ground below, however ground losses are usually very high at Radio Frequencies, so an artificial counterpoise or ***ground plane*** consisting of several wire conductors is usually laid out at various angles along the ground to improve things.

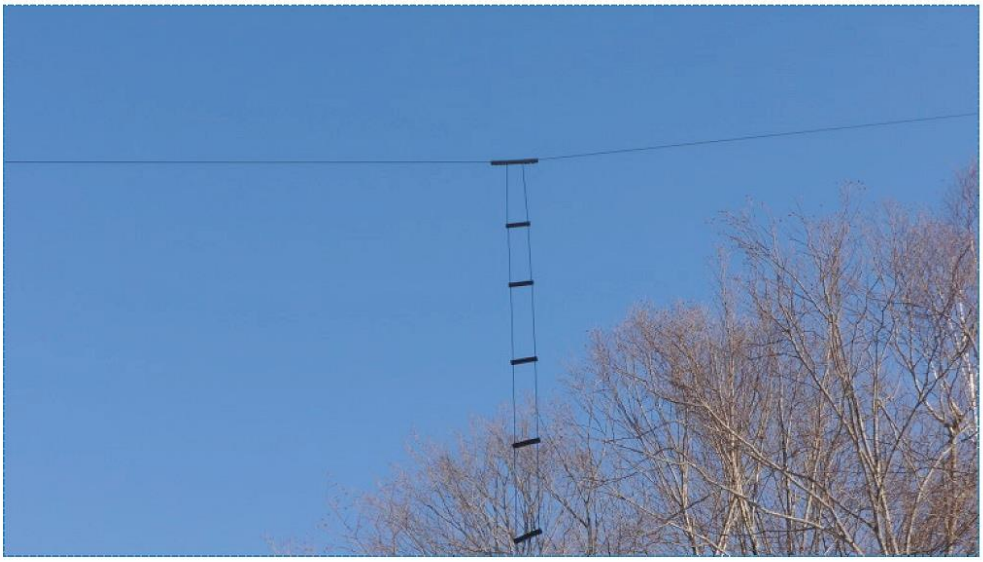
At VHF and UHF frequencies, a quarter wavelength is much shorter, so an effective counterpoise can be made from three or four aluminium tubes or steel rods (the classic 'coat-hanger antenna'). When used as a vertical, monopoles are omni-directional so it is a good all-rounder.

This is a basic antenna which is very easy to construct for many different frequencies.

## The Dipole

This is simply two quarter-wave monopoles strung together and insulated from each other, forming a half-wave dipole. The feed point is in the middle, where the two monopoles meet.

A dipole radiates well in most directions, except for along its axis.



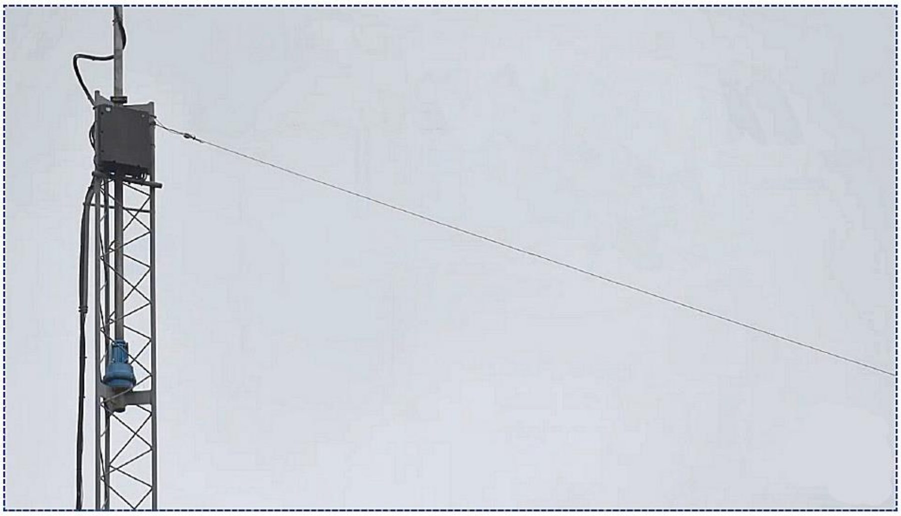
## Folded Dipole

The folded dipole is an extension of the basic dipole design, whereby the two ends of each dipole arm are folded back on themselves and joined together at some distance above the feed point. This has the effect of increasing the antenna's useable bandwidth: i.e. the frequency range over which the antenna will exhibit resonance.

Again, this antenna is relatively easy to construct and install across a range of frequency bands.

## End Fed Long Wire (EFLW) Antenna

This is another simple wire antenna that is fed from one end, rather than in the middle.



## Yagi-Uda Antenna

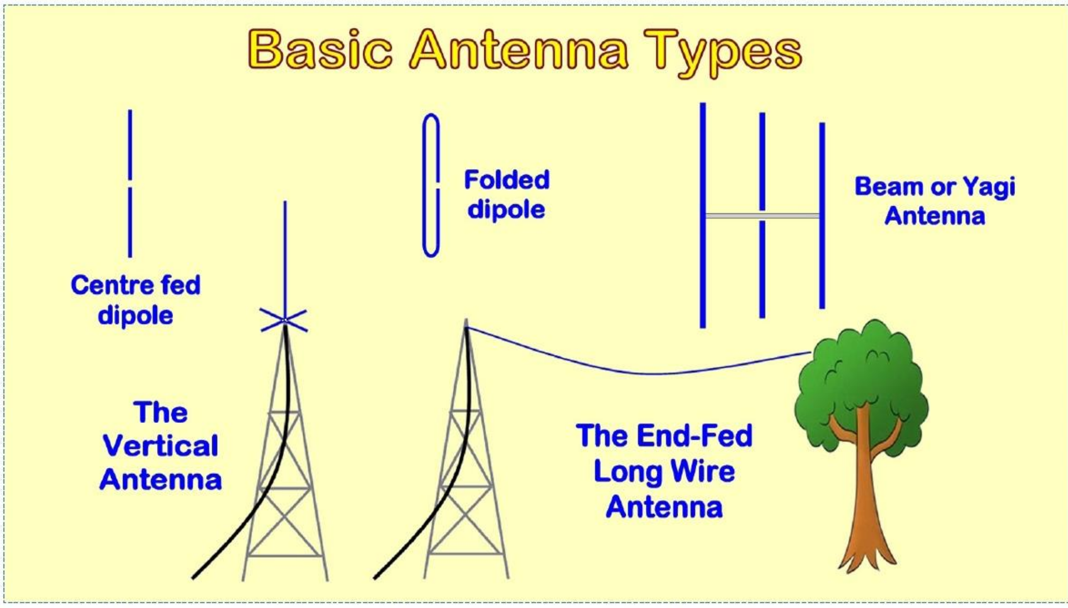
This is a directional antenna developed by two Japanese researchers in the 1920s, hence the somewhat unusual name. It is sometimes referred to as a 'beam' or a 'parasitic array', but most people just call them Yagi's.

A typical Yagi comprises a dipole or folded dipole as the active radiator with other similarly sized passive elements fixed nearby which act to reflect and direct the radio waves generated by the active radiator in a specific direction.   This directional gain effect can boost both transmission and reception of radio signals in the target direction.

Note that Yagi's do not radiate any more power than other antennas do. Instead, they focus the available RF energy into a 'beam' that's much stronger in one particular direction.

Yagi's are commonly used as domestic TV antennas, so you might already have one on your roof!

This short video provides a good overview of the basic antenna types we have described here.




Antenna types – YouTube

## Transmission Lines

The transmission line connects the transceiver to the antenna. Its role is to transfer the Radio Frequency (RF) signal generated by the transceiver to the antenna and *vice versa* as efficiently as possible.
Transmission lines can be either balanced or unbalanced and are defined by their ***Characteristic Impedance.***

The actual Impedance of any length of transmission line depends on what the line's dimensions and construction materials are. However, the Characteristic Impedance is the theoretical value of what this Impedance would be if the transmission line were infinitely long. This might seem of little practical value, but it is actually a very useful thing to know.

Unlike Reactance and Impedance that you will have perhaps touched upon elsewhere in this course, Characteristic Impedance does *not* depend on frequency; it is a fixed value that describes a transmission line's overall characteristics and behaviour at *any* frequency.

Transmission lines are manufactured to agreed Characteristic Impedances such as 50 Ohm, 75 Ohm, 300 Ohm *etc.* This is because using standard values such as these makes matching transmission lines to antennas, transmitters and other radio equipment much easier.

## Types of Transmission Lines

### Coaxial Cable (Unbalanced)

Coaxial cable (commonly referred to as 'coax') is a special type of cable that has an inner conductor surrounded by a tubular insulating layer known as a *dielectric*. This is then surrounded by an outer tubular conductor shield covered by an insulating sheath. The term "coaxial" refers to the various conductors and layers all sharing the same geometric axis. The inner conductor is often a single Copper plated solid wire and the outer is usually a Copper braid, whilst various plastics such as Polythylene or plastic foams are used for the dielectric.

Most coaxial cables used in Amateur Radio are manufactured to have a Characteristic Impedance of 50 ohm because this is the same as the input/output impedance of most modern Amateur Radio transmitters and receivers. 50 ohm is also close to the feed impedances of many common types of antenna at their resonant frequencies, so it makes sense to use it as a 'standard value'.

RF energy is conveyed from one end of the coax to the other as an electromagnetic field that gets generated within the dielectric by the alternating currents travelling one way along the inner conductor (the centre conductor) and then the other way along the inside surface layer of the outer conductor.

Since the outer conductor is metallic, its outside surface layer also acts as a very effective shield that prevents the RF signal from 'leaking' out whilst at the same time, it also minimises 'pickup' of unwanted electrical noise from the outside.

Probably the easiest way to picture how coaxial cable works is to think of it as a flexible metal 'pipe' that carries RF energy in a manner similar to how a domestic hosepipe carries water.

You will have no doubt come across coax before because it's also used for domestic TV antennas and it's by far the most common type of transmission line you will encounter in a typical Amateur Radio station because it is so very convenient to use.

However, coaxial cable does have one major drawback; losses.
All dielectrics have some losses associated with them and some of RF energy inevitably gets 'used up' in overcoming these losses along the cable.

It is important to minimize these losses where possible and in general, the thicker the coax the better the overall cable quality and the lower the losses.

RG58 is a common coaxial cable used for HF for distances of up to 30 metres. It is also suitable for short cable runs at VHF and UHF, such as a mobile installation in a vehicle.


If you are considering very long cable runs on HF, especially at the higher end of the spectrum (say 14 MHz and up), consider using a lower loss coaxial cable such as RG8 or RG213.

At VHF and UHF frequencies you should always use higher quality, lower loss cables such as RG213 or even LMR400 for long runs.

Try entering some values into this handy online calculator to give you a sense of losses for various frequencies and lengths of cable.
[https://www.qsl.net/co8tw/Coax_Calculator.htm](https://www.qsl.net/co8tw/Coax_Calculator.htm)

## Open Line (Balanced)

As the name suggests, the dielectric is air. Open line has far fewer losses than coaxial cable. It also makes for a great homebrew project, saving you money.

Open line conveys RF energy along its length in a manner similar to coax cable. However, it doesn't radiate any energy itself because at all points along the line the electromagnetic field generated around one conductor is always equal and opposite to the electromagnetic field generated around the other conductor, so they balance each other and there is no radiation from the transmission line itself.

Balanced transmission lines are also commonly known as twin feeder, ribbon feeder, open wire line, ladder line etc.

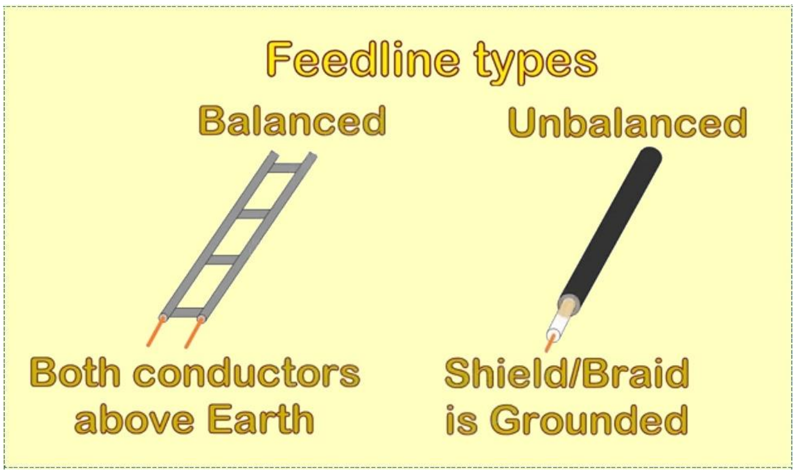
The characteristic impedance of open line typically lies in the range 300-600 ohm which is much higher than the typical transceiver impedance of 50 ohm, so a BALanced to Unbalanced transformer (balun) is usually required to match it to the transceiver.

Unlike coaxial cable, you'll need to exercise more care when installing open line and ensure that it runs clear of any objects between the transceiver and antenna, especially large, metallic objects. This is to avoid upsetting the balanced nature of the feedline. Coaxial cable doesn't suffer from this limitation and is well suited to lying on the ground, running up poles, around corners, along walls *etc.*

In summary, no matter what type of transmission line, the most important thing is that the transmitter, transmission line and antenna impedances must all be equal for maximum transfer of RF energy to/from the antenna.

In other words, the transmitter, transmission line and antenna impedances must all *match*.

This short video provides a good overview of these two basic feedline types.

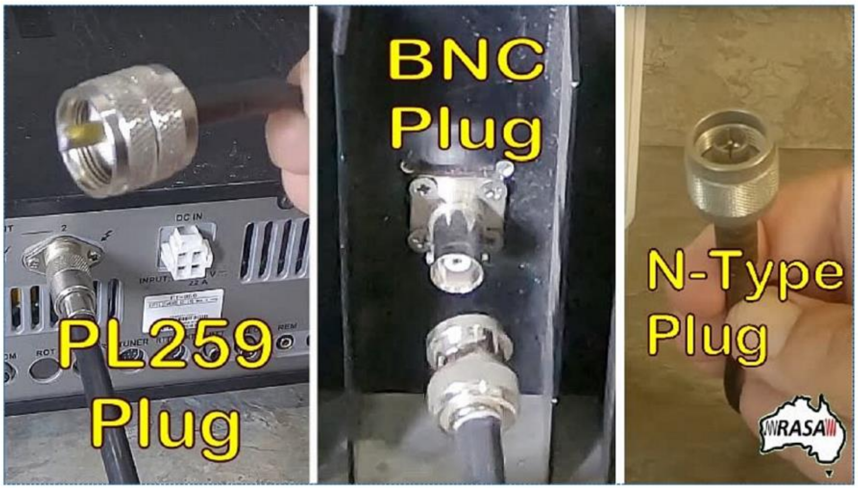



Feedline types – YouTube

## Connectors

Coaxial cables require specific types of connectors. You must use the correct connectors and the choice will depend on your application. Typically, most HF (and some VHF) radios use BNC or PL-259 type connectors. At VHF, UHF and above N-Type is the preferred standard.

This short video provides a good overview of these basic connector types.




[Connector types – YouTube]

## Testing Cable Connections

Before connecting coaxial cables to antennas, transceivers and other equipment, you should check them for continuity of both the centre core and the braided shield, then the insulation between these conductors.

Most multimeters have a continuity test function built into the meter Ohms range where the meter will beep when the probes are shorted together. This can be used to test the integrity of any connector or patch cable.

This brief video provides an overview of this process:


[Coax connector Continuity testing – YouTube]

## Impedance Matching and Antenna Tuning

This is a rather complex topic, so only the very basics will be introduced here. The most important aspect is that for your station to perform at its best, the transmitter, receiver, transmission line and antenna impedances must all be equal (or as close to being equal as you can make them).

This applies no matter what frequency you might want to operate on, so tuning your radio to a desired frequency and then adjusting things so that all the impedances match one another *at that frequency* is very important.

‘Tuning’ and ’matching’ are terms that many operators use interchangeably and often get very confused about, however there is a subtle but important difference between the two: ‘Tuning’ refers to frequency, whilst ‘matching’ refers to impedance.

Tuning an antenna to a particular frequency means changing its physical and/or electrical dimensions so that it resonates on that frequency.

Matching an antenna at a particular frequency means transforming its feed impedance *at that frequency* so that it comes as close as possible to the impedance of the transmission line. This might require the use of a balun or some kind of adjustable matching unit.

## Standing Waves

When *all* impedances are correctly matched, *all* the RF power generated by the transmitter travels forwards into the antenna and all of it gets radiated; *none* gets reflected back.

Whenever the impedances are not equal, some of the RF power generated by the transmitter ‘bounces back’ from the antenna and gets reflected back along the transmission line towards the transmitter (which means the antenna can’t radiate it). These reflections interfere with the RF power that’s travelling forwards, causing *Standing Waves* to appear along the transmission line.

Standing Waves are undesirable, but they are actually also very useful because they are easy to measure and can be used to indicate how near or how far the antenna is from resonance and how well the impedances are matched.

A Voltage Standing Wave Meter (VSWR Meter) is a very useful piece of test equipment for measuring the Voltage Standing Wave Ratio.

## How to Use a SWR Meter

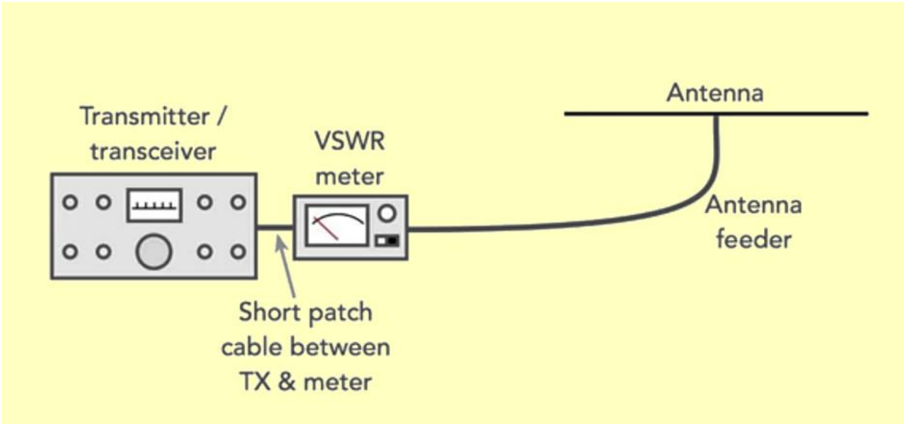

The various SWR meters above show the same information.  The amount of power going Forwards towards the antenna and the amount of power being reflected back from the antenna (if any)

The relationship between the wanted 'Forward Power' and the unwanted 'Reflected Power' can be expressed as the Voltage Standing Wave Ratio (VSWR). Ideally the VSWR should be a very low value (1.5:1 or less) on your operating frequency.

**Interpreting the Readings:**

| | |
|---|---|
| **VSWR of 1:1** | is ideal (although not often achieved). |
| **VSWR of 1.5:1** | is good in practice. |
| **VSWR of 2:1** | should be lower. |
| **VSWR of 3:1 to 4:1** | indicates the antenna is far from resonance or there is a large impedance mismatch. |
| **VSWR of 5:1** | or above indicates an antenna fault. |
| **VSWR of 10:1** | or above indicates a short or open circuit in the antenna or transmission line. |

This brief video provides an overview of how to use an SWR meter:




[Using an SWR Meter – YouTube]

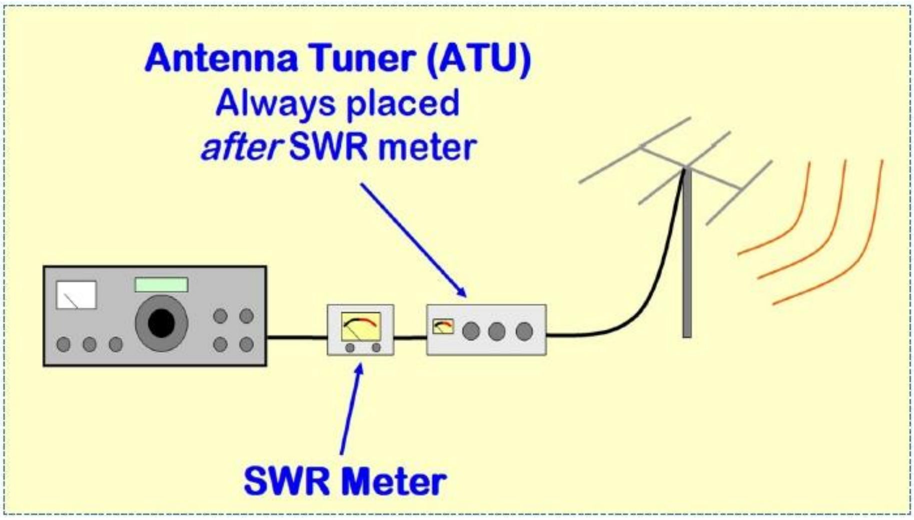
## Antenna Tuning Unit

(ATU, also known as a Coupling Unit or Matching Unit)
An Antenna Tuning Unit (ATU) can be used to match a 50 ohm transceiver to an antenna which is not 50 ohms. The two are usually connected by a 50 ohm coaxial transmission line, such as RG58.

Unfortunately, the term 'Antenna Tuning Unit' is somewhat of a misnomer – what you're really doing is *matching* the antenna's feed impedance (which varies over a wide range depending on how near or far the antenna is from its resonant frequency) to the Characteristic Impedance of your transmission line & radio (which are both fixed, no matter what frequency the radio is tuned to). However, the term 'ATU' has stuck.

An ATU is useful when your antenna system is not resonant at the desired operating frequency and makes it possible to use a single antenna on more than one frequency (and often on two or more entire frequency bands).

An ATU does *not* make your antenna perform or radiate more efficiently. However, it *does* make your antenna system far more versatile because it allows you to operate across several frequency bands at somewhat reduced efficiency without having to change antenna.




In this instance, we're trading-in a bit of performance efficiency on just one frequency for versatility across many frequencies, which is a worthwhile trade-off for most Amateur stations.

ATUs come in all shapes and sizes, including automatic models that use micro-processors and switches to find the best match for your antenna system.

Typically, a manual ATU will have two or three switches and knobs, depending on the design. These adjustments add or subtract inductive and/or capacitive reactances inside the ATU allowing a suitable match to be found for most antenna systems.

It is worth noting that many transceivers will have a VSWR meter built-in and more recent models even include an internal ATU. However, in most cases, internal ATUs have a limited range and will not be able to cope with an VSWR much greater than 3:1.

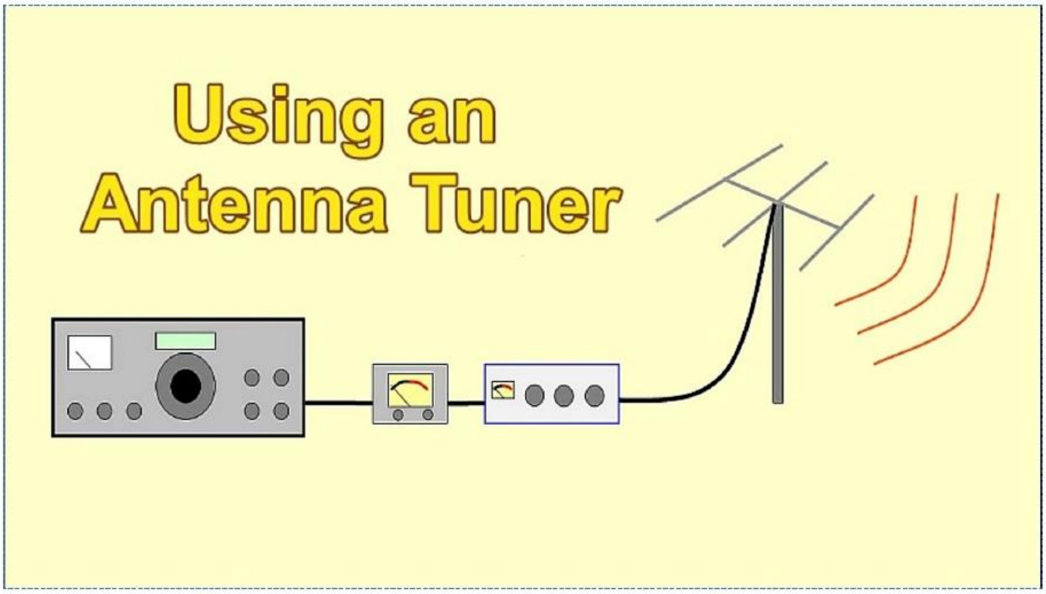
## How to Use an Antenna Tuning Unit

- Connect the ATU between the VSWR meter and the feedline to the antenna.
- Locate a clear frequency.
- Select the AM, FM or CW mode on your transceiver.
- Select low power (say no more than 10 W)
- Switch the VSWR meter to Cal (or on some meters it may be Fwd)
- Set ATU controls to mid-scale. Some ATUs will have a band selection knob, so set this to the appropriate band.
- On receive, adjust the ATU controls to peak receive noise. Repeat this procedure a number of times, noting that each control will interact with the others. Once you tune to peak receive noise you should be close to a suitable match.

- Announce your callsign and that you are testing
- Transmit a CW, FM or AM signal and measure the SWR; use the procedures described earlier in this chapter.
- Whilst transmitting, carefully adjust the ATU controls for minimum SWR. Each control will interact with the other, so you may need to repeat this procedure a number of times.
- Repeat the previous step until you "find a match" with a SWR of 1.5:1 or less.

Note the settings for future reference when returning to this frequency.
It is good practice to keep the SWR meter in-line. In the case of an internal meter, ensure this is the default meter setting on your transceiver. This enables you to monitor your station's performance and be aware of any potential problems.

The following video demonstrates how to use a typical Antenna Tuning Unit (also called an Antenna Matching Unit). ATUs come in a variety of designs and configurations.   For the correct tuning procedure, refer to your manual & model.




Using an Antenna Tuner – YouTube

## Antenna Characteristics: Polarisation

Antenna polarisation is an important concept. In essence it means that the transmit and receive antennas should have matching orientation. Vertical antennas will perform best when in contact with other vertical antennas. Horizontal antennas will perform best with other horizontal antennas.

If one antenna is vertical and the other horizontal, the signal losses between the two antennas can be significant. However, it is worth noting that long distance signals that skip around the world can change polarisation with each reflection/refraction.

For this reason, some stations use both horizontal and vertical antennas, switching between them to find the best signal for a given path, particularly at VHF/UHF.

## Directivity and Gain

Directivity describes the ability of an antenna to focus power in a specific direction, a bit like a torch (*e.g.* Yagi). A directional antenna will focus power in one direction. A Bi-directional antenna will focus the power in two directions (e.g. Dipole) and an omni-directional antenna will focus power equally in all directions. (e.g. Vertical).

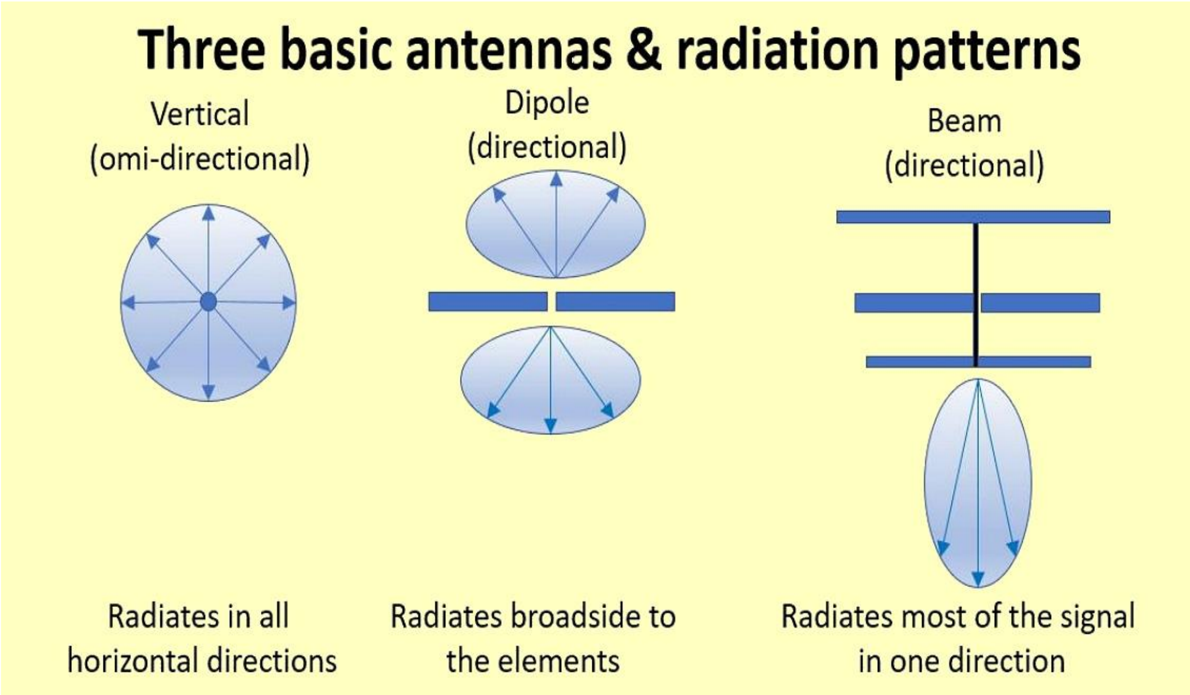
Gain describes the increase in power output when the power is focused in a particular direction. As a Foundation Licensee you are permitted to transmit up to 10 watts PEP.

If you are using a beam antenna that effectively doubles your power in a certain direction, it is said to have three decibels (3dB) gain.

A good example is the Yagi antenna. A three-element Yagi antenna should have a gain of approximately seven decibels (7 dB) over a dipole antenna. 7 dB is roughly the equivalent of doubling your power output twice. Your 10 W PEP will become an ERP of 40 W.

It is important to note that you'll get a similar benefit with the received signal strength, when compared to the reference antenna.

Decibels allow us to compare the ratio of power, voltage, or current. An antenna that radiates it's power in a single direction can have its gain expressed in decibels.




## Testing Transmitters

When testing a transmitter, it is good practice and common courtesy to use a *dummy load* to prevent your test signals from being radiated and annoying or causing interference to other users on the bands.

A dummy load is a useful piece of test equipment that mimics an antenna, except that it dissipates the applied RF energy from a transmitter as heat, instead of radio waves. It's usually a large 50 ohm Carbon-film resistor that's fixed into some kind of heat sink housing.

Alternatively, a variety of smaller resistors in different series/parallel combinations that sum to 50 ohms may be housed in a ventilated container.   Larger dummy loads are often immersed in oil, enabling them to dissipate higher power levels.


If you need to test a transmitter you should always do so into a dummy load for the following reasons:

You know for certain that you're connected to the correct impedance (50 ohms), no matter what frequency the transmitter might be tuned to.

Any measurements you make, such as transmitter output power, will be more accurate because you're transmitting into a known load impedance. You avoid causing on-air interference to other operators and earning yourself a reputation as a 'poor operator'.

# Chapter 6: **Propagation**

Radio waves are a type of electromagnetic radiation that can travel through space, air, and to a lesser extent, other materials.

Electromagnetic radiation itself is a combination of interacting electric and magnetic fields that are continually exchanging energy between each other. This constant exchange causes the two fields to expand outwards in unison as a wave.

Radio propagation refers to the behaviour and characteristics of radio waves as they travel through the atmosphere or other media.

**Key Learning Outcomes**

By the end of this chapter, you should be able to recall the following:

- Radio waves travel in straight lines, unless diffracted, reflected or refracted
- Radio waves become weaker with distance
- VHF/UHF propagation is essentially 'Line of Sight' and for terrestrial users is dependent on both antenna height and a clear, unobstructed path.
- Atmospheric conditions may at times provide extended range
- The ionosphere comprises layers of ionised gas at varying heights above ground
- Long distance HF communication relies on propagation by ionospheric refraction.

## Radio Wave Characteristics

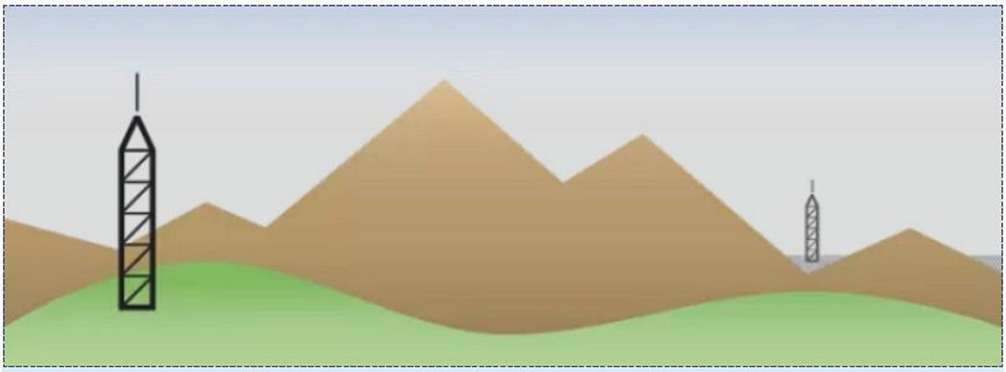
In free space, radio waves travel in a straight line, however, on earth they can be reflected, refracted, diffracted, or blocked.

A good analogy is light, which generally travels in a straight line, but can be impacted by buildings, lights or clouds.

Radio wave propagation is affected by numerous factors, including: frequency, distance, atmospheric conditions, solar conditions, the terrain, obstacles they encounter, and the weather conditions in the area.

At lower frequencies, radio waves tend to travel farther and penetrate obstacles better, while at higher frequencies, they tend to be absorbed or scattered more easily. Radio waves can also be reflected, refracted, or diffracted by various objects in their path, changing the direction and intensity of the signal.

The terrain and obstacles in the path of the radio waves can also affect propagation. Mountains, buildings, even large trees, and other structures can block or reflect the waves, while open spaces and bodies of water can allow them to travel farther.



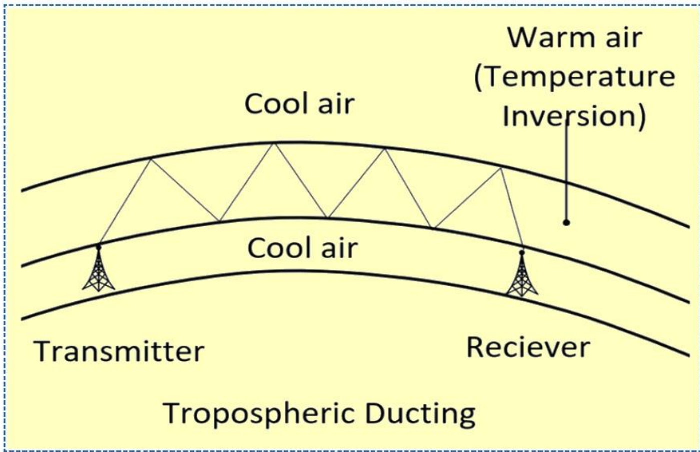
*Obstacles can block or impact radio signals*

Weather conditions can affect radio propagation, particularly at higher frequencies. Rain, snow, and other precipitation can absorb or scatter radio waves, while atmospheric conditions like ionisation and temperature inversions can cause them to bend or refract.

Radio propagation is a complex phenomenon influenced by a variety of factors, and a fundamental understanding is important for designing and operating radio communication systems.

## Atmospheric Conditions Can Enhance Propagation

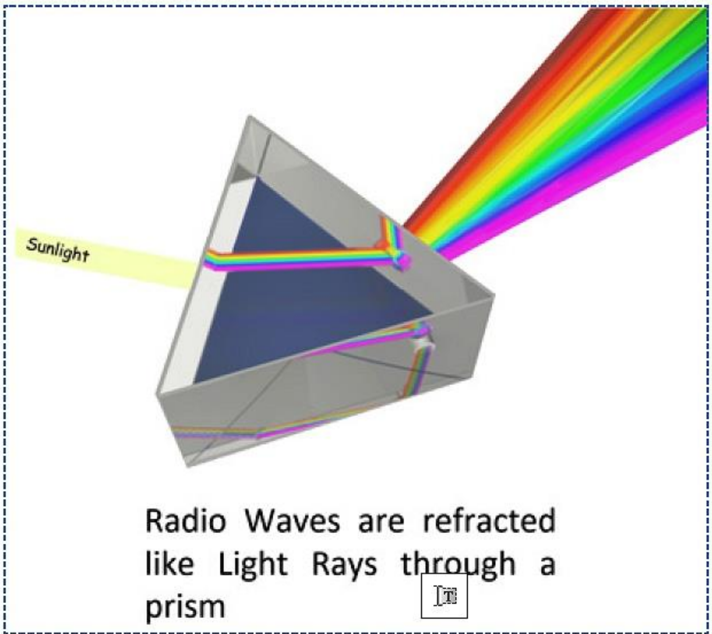
Long Distance Communication on VHF and UHF is sometimes possible due to atmospheric conditions, usually called tropospheric propagation or ducting. Under certain conditions, VHF and UHF signals will travel through the troposphere, causing the signals to travel beyond line of sight.




*Tropospheric Ducting can enhance signals*

## Effect of Ionospheric Refraction on HF Signals

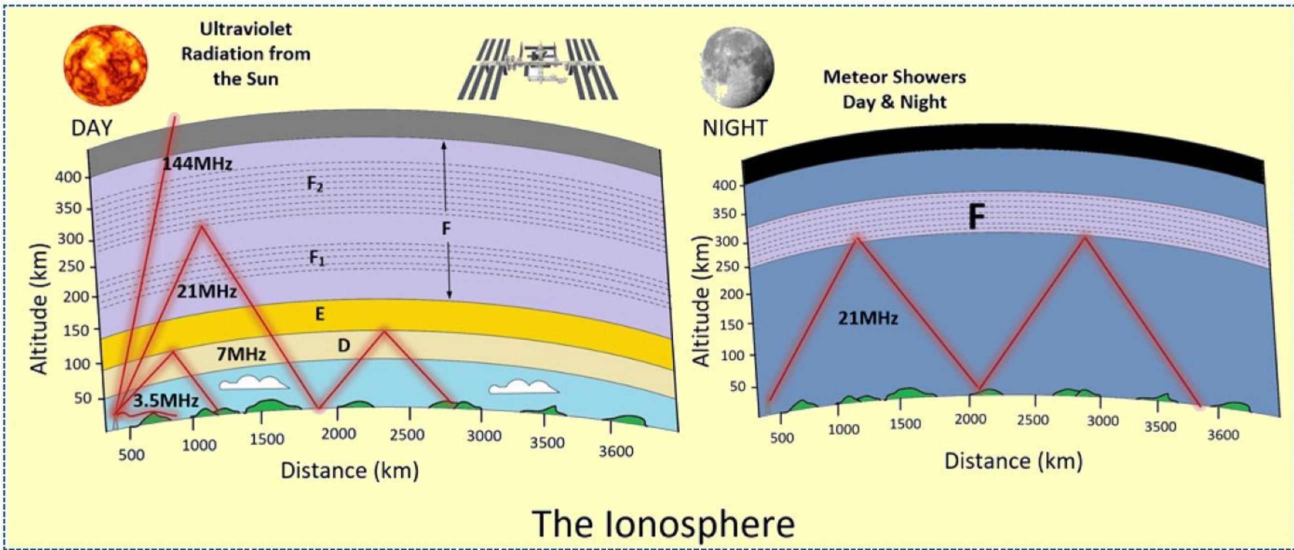
The Ionosphere, consisting of layers of ionised gas, can assist HF signals to reach more distant stations because the signals refract as they enter the various layers, and may return back towards Earth.




Refraction

The Ionosphere is located within the atmosphere and extends from fifty to five-hundred kilometres above the Earth's surface. It is divided into three regions, or layers: the F-Layer, E-Layer, and D-Layer. During the daytime, the F-Layer may split into two layers, then recombines at night.  Images labeled correctly to follow shortly.

The Ionosphere, consisting of layers of ionised gas, can assist HF signals to reach more distant stations because the signals refract as they enter the various layers, and may return back towards Earth.




Ionospheric Propagation can enhance HF signals

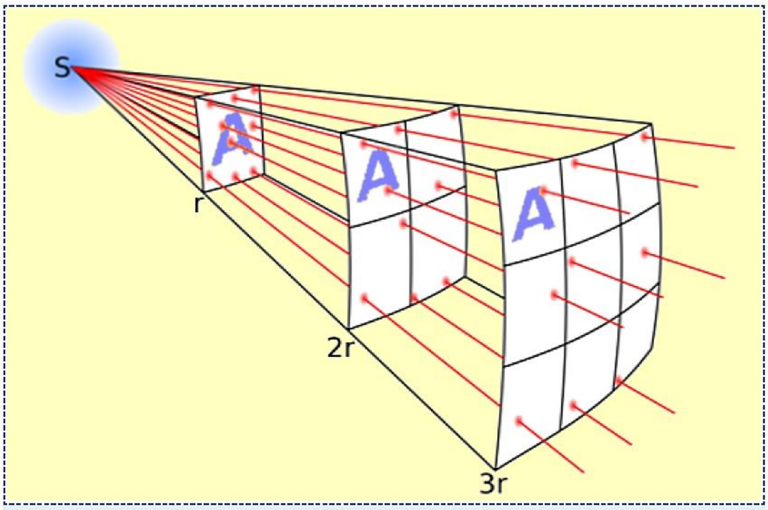
Propagation via the ionosphere varies with the seasons, time of day, frequency, and solar activity.

## Distance Affects Signal Strength

The intensity of radio waves over distance obeys the inverse-square law, which states that intensity is inversely proportional to the square of the distance from a source. Think of it this way:

| | |
|---|---|
| Double the distance, | and you get four times less power. |
| Quadruple the distance | and get sixteen times less power. |
| At ten times the distance | you get one hundred times less power. |

The radio wave's energy is "diluted" as it travels farther from its source because it spreads out over an ever-larger area.



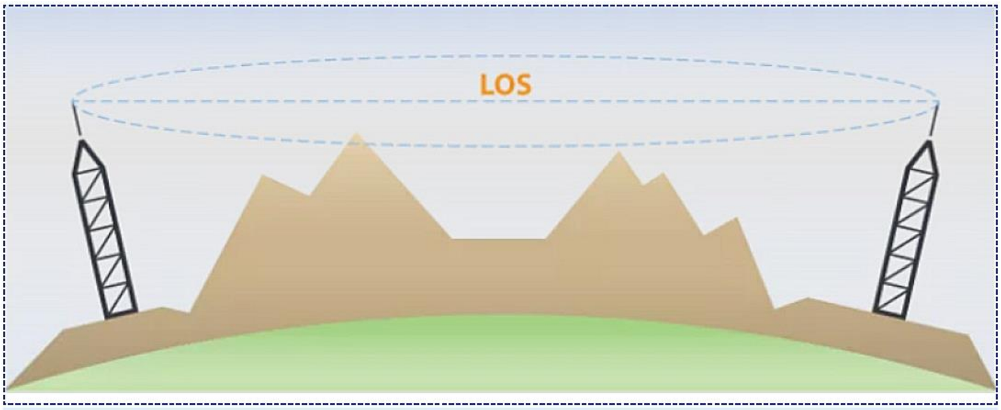

*Inverse square law – signals get weaker as they travel further from the source*

## Communication Range

Communication range at VHF/UHF is dependent on antenna height, a clear path, transmitter power, and receiver sensitivity. At these frequencies and higher, effective communication relies on line of sight ( there are exceptions). The antennas must "see" each other, and any obstacles between them will diminish the received signals.

## Obstacles Can Block Radio Signals

Obstacles can be hills and large structures.

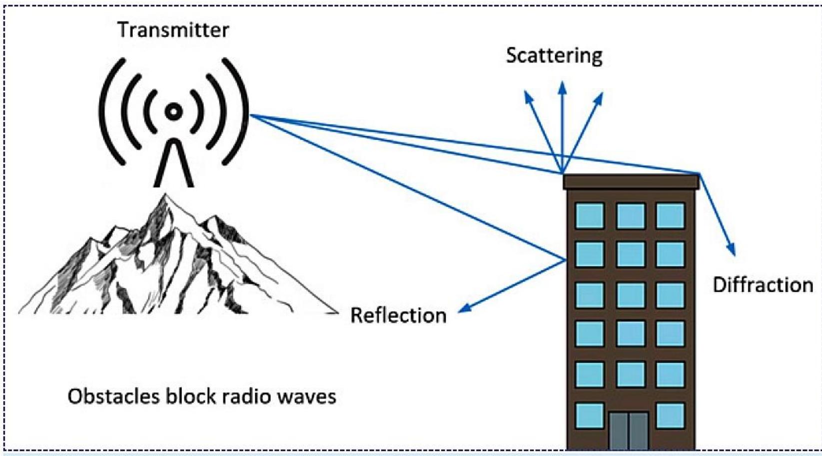



*Line of Sight*

One way to overcome obstacles is to raise the height of one or more of the antennas.

You can see this principle in practice with antennas mounted on house roofs, tops of taller buildings, or on masts.

Good examples of this are television or broadcast radio stations.



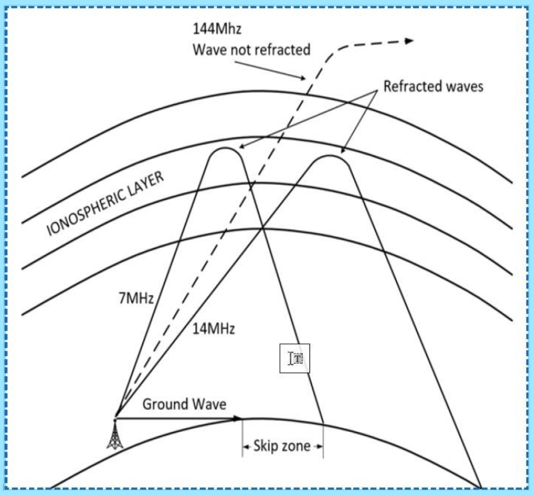
*Obstacles can block radio signals*

## Ground Waves and Sky Waves

Radio waves will radiate from an antenna as: ground waves; and sky waves.

- *Ground waves* travel over the Earth's surface. The distance over which they travel is determined by their radio frequency.
- *Medium Frequency (MF)* ground waves travel hundreds of kilometres while Ultra High Frequency (UHF) ground waves are limited to the line of sight.
- *Sky waves* are radiated upwards at all angles from the antenna, until they reach the Ionosphere.

The Ionosphere is a layer of ionised particles that lies between 50 and 500 kilometres above the earth's surface.




At High Frequencies (HF) the radio wave is refracted by the ionosphere and returns to the earth's surface, having travelled over thousands of kilometres. Long distance communications are conducted using HF radio in this way.

Lower frequencies are used at night, and higher frequencies used during the day to achieve the same communications range – that is; for a fixed distance between two stations, a 7 MHz channel would be used during daylight, and a 3.5 MHz channel at night.
To communicate with stations at greater distances during the day, higher frequencies are required – for example, to communicate from Melbourne to Townsville during the day, a 10 or a 14 MHz channel would be used. At night, a 7 MHz channel would be used.

The Ionosphere does not normally absorb sky waves at Very High Frequencies (VHF) and Ultra High Frequencies (UHF) – they travel straight through the Ionosphere into space.
HF ground and sky waves are illustrated in the image above.

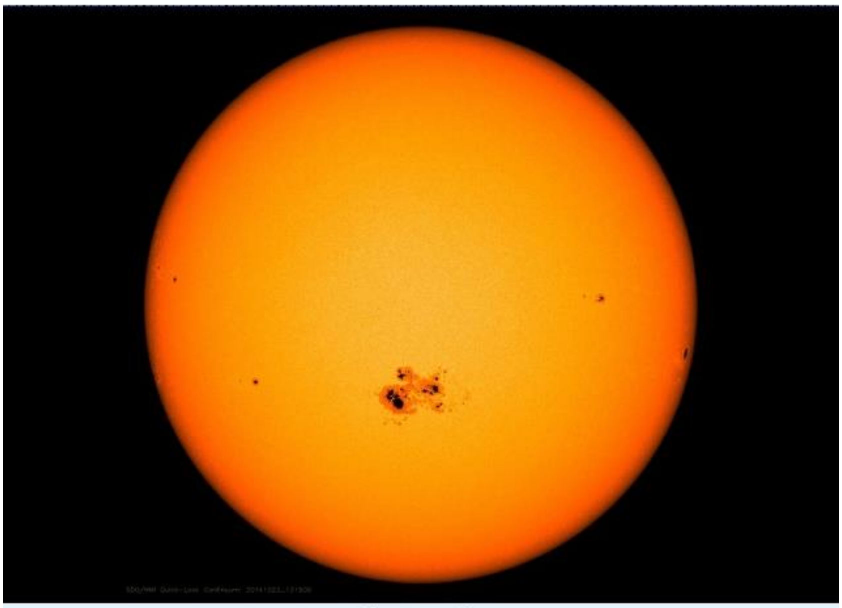
**Skip zone**

The area which lies between the end of the ground wave and the first set down of the reflected sky wave is known as the "skip zone".

Signals will not be heard in the skip zone. The signals "skip" straight over the top of the other station

## Sunspot Activity

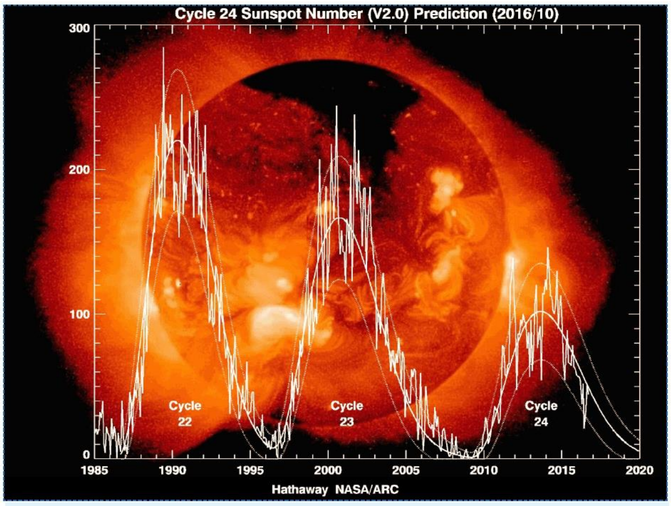
The sun radiates particles which energise the earth's ionosphere, enabling radio signals to be refracted and reflected back to earth. Sunspots influence the intensity and duration of this radiation, and sunspot activity rotates through an eleven year cycle. This is called the 'solar cycle'.



Sunspots

## Solar Activity

The sun radiates particles which energise the earth's ionosphere, enabling radio signals to be refracted and reflected back to earth. Sunspots influence the intensity and duration of this radiation, and sunspot activity rotates through an eleven year cycle. This is called the **Solar Cycle**.
During the peak of the cycle, the ionosphere is extremely active and higher frequencies become more reliable (in the HF Spectrum) for long distance communication. This is referred to as the **Sunspot Maximum**.
During the solar minimum, there is less ionisation, and the higher bands in the HF Spectrum will be less reliable. This is referred to as the **Sunspot Minimum**.
You will hear two common terms that define the level of solar radiation. The first is the **Sunspot Number** (SN), and the second is the **Solar Flux Index** (SFI). You do not need to know the details of these measurements for the Foundation Licence. However, it is good to know that during the Sunspot Minimum, the SFI can be as low as 55-60 and during a Solar Maximum as high as 300.




The Solar Cycle

**Image credit**: David Hathaway, NASA, Marshall Space Flight Center –

http://solarscience.msfc.nasa.gov/predict.shtml, Public Domain,

https://commons.wikimedia.org/w/index.php?curid=28557779

# Chapter 7: Interference

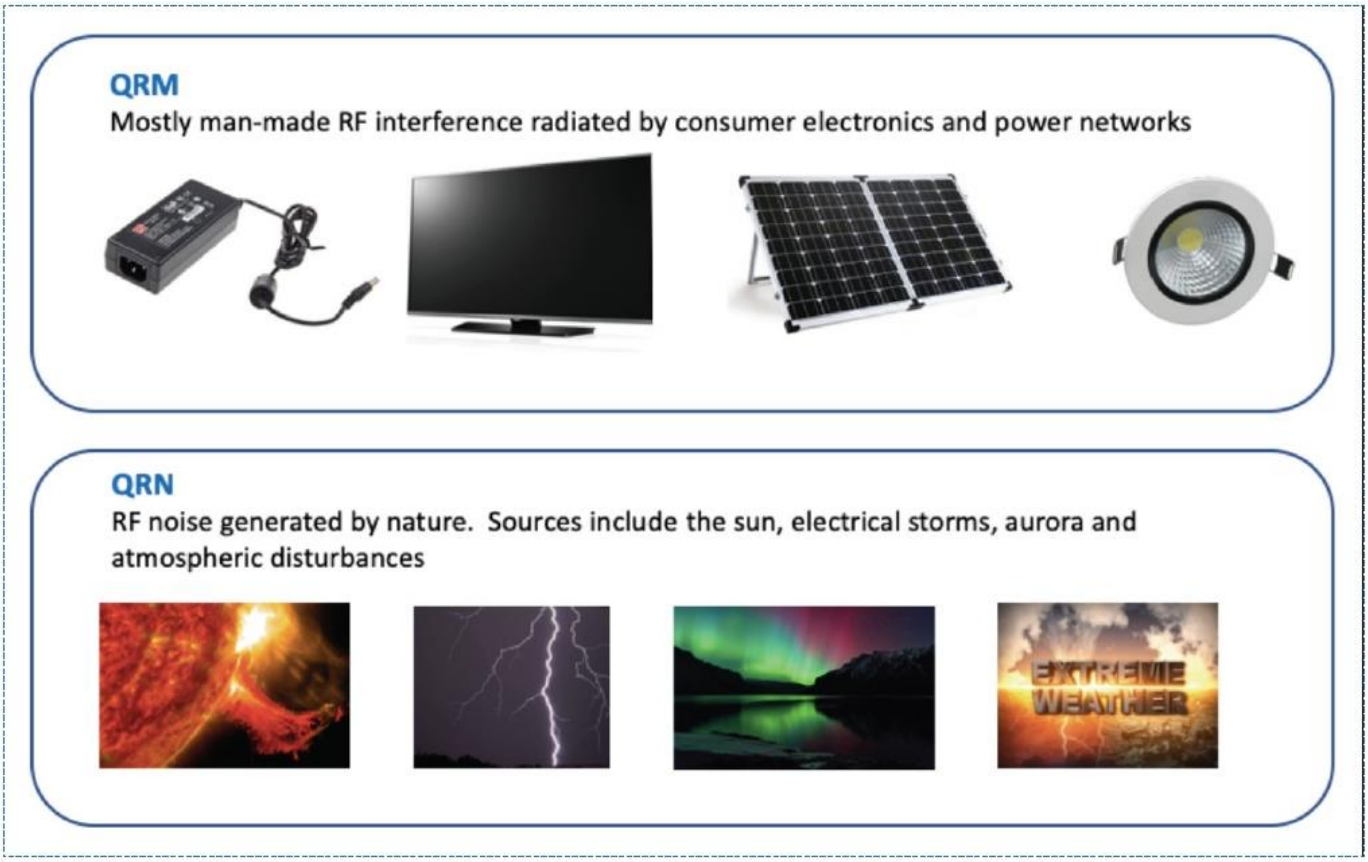
Understanding the basics of Radio Frequency Interference (RFI) and Electromagnetic Compatibility (EMC) are important aspects of amateur radio.

## Key Learning Outcomes

By the end of this chapter, you should be able to explain the following:

- Sources of radio interference
- Interference and Electromagnetic Compatibility (EMC)
- Interference pathways
- Amateur transmissions and EMC
- Antenna location and EMC
- Transmission mode and interference
- Filters
- RF earthing
- Diplomacy and EMC
- Harmful interference

There are two broad categories of interference you need to understand.




**Natural Noise - QRN:** this is atmospheric noise, usually characterised by natural phenomena such as space weather, geomagnetic storms, electrical storms and rain static. QRN is created by nature. You should unplug all antennas when electrical storms are nearby.

**Man-made Noise - QRM:** this is man made noise, usually characterised by a regular sound, such as the clicking noise every 2 seconds from an electric fence. Constant “hash” noise over many HF bands may be a power supply or other consumer device nearby (generally within 300-400m). Other man made transmissions that interfere with signals are also referred to as QRM.

**Sources of radio interference**

Your amateur radio station can be a cause of interference to broadcast radio and television if your equipment is not operated correctly, or is suffering a fault.
However, interference to broadcast radio and television can also be caused by many other sources, including faulty or poorly designed electrical appliances, as well as mains power infrastructure.

Radio signals may be induced into nearby electronic or radio equipment through conduction along electrical mains wiring or direct pickup by the equipment. In many cases, technical or operational solutions can resolve the interference.

The other major source of interference is from natural phenomena. Electrical storms are the most obvious; you will hear the static crashes when you turn on your radio.

If you believe an electrical storm is nearby, you should unplug your antennas, connect them to ground and disconnect your equipment from its power source.

It is important to note that your amateur radio station will almost certainly be impacted by unwanted RFI. Our society is surrounded by electronic appliances (LED lights, power supplies, home appliances, garage door openers, battery chargers, TV pre-amplifiers; the list is endless), much of which emits low levels of unwanted interference. A basic knowledge of RFI and how to identify and resolve it will assist you in getting the most from your Foundation Licence.
To view a video about this topic click this link:


R001 An introduction to Interference (youtube.com)

## Electromagnetic Compatibility (EMC)

Electromagnetic Compatibility (EMC) describes the ability of electrical equipment to function correctly in close proximity to other electrical equipment.
Electrical and electronic equipment should be designed and manufactured to international standards ensuring interference is non-existent or at acceptable levels.
EMC considers three elements:

- *Emissions*, which describe the generation and radiation of electromagnetic energy.
- *Susceptibility*, which describes the ability of electrical equipment to break down or function incorrectly in the presence of RFI
- *Immunity*, which describes the ability of electrical equipment to operate to specification in the presence of RFI

## Amateur Transmissions and EMC

Interference resulting from EMC problems may be dependent on the power, frequency and type of emission of the radiocommunications transmitter and its distance from the affected equipment.

> There are some good examples of interference and their effects here. You do not need to know these details for the examination, but it makes an excellent reference source once you have your licence.
>
> QRM Guru provides other links to interesting web-based resources to help you better appreciate the different types of signals you might hear on-air. These are not examinable, but it is fascinating to listen to a selection, as you will invariably come across a wide variety of strange sounding signals as you listen across the bands. Click this link for more information.

## Antenna location and EMC

Your antenna location can have a huge impact on interference; both from your transmissions as well as from unwanted signals. Your best strategy is to place your antennas high and clear of any surrounding structures. This includes: buildings, power lines, trees, lamp posts, garages, etc.

## Filters

Filters act as attenuators to unwanted signals. Your radio will have internal filters to assist in rejecting or suppressing unwanted interference. You can also place filters between your transmitter and antenna to reduce unwanted signals that may cause interference to other services.

Filters can also be installed close to the antenna socket of TV or radio receivers that are affected by interference. Filters or chokes can greatly reduce interference to electronic appliances. A choke can be constructed by winding the coax feedline through a ferrite ring four or five times. This video illustrates the components and methods for implementing simple filtering designed to suppress or pass unwanted signals.


[Creating a Filter – YouTube]

## RF Earthing

Electrical devices have a safety earth, and this topic is covered in more detail in the Safety Chapter of this manual.

RF earthing addresses unwanted RF currents that may be present when you transmit. Why do you need an effective RF earth?

- Minimise unwanted currents in your shack
- Reduce unwanted interference
- Improve the efficiency and effectiveness of your antenna
- Reduce likelihood of receiving RF shocks
- Reduce unwanted interference to your radio, computer and electrical appliances

You can read more about RF earthing here.

## Diplomacy and EMC

EMC problems have the potential to cause neighbourhood disputes. It is important to understand the need for diplomacy, the sources of advice available, and the role of the ACMA.

There is also the possibility of your neighbours taking a dislike to the visual impacts of your antennas. Whilst this matter is outside the scope of this manual, it is worth noting and reviewing the reference materials for guidance.

You need to get along with your neighbours, not just today, but for many years to come.
This section is about people skills, diplomacy, empathy and communication. Always maintain a friendly and cooperative stance when dealing with neighbours. When you own your home, a pleasant and cooperative neighbour will make your life so much more bearable.

Irrespective of the legalities, regulations or otherwise, our hobby is largely regarded as out-dated by many within our community. It is your job to be a good ambassador and project a positive image.

You can read more about dealing with neighbours here and a useful step-by-step guide here. ACMA offers some limited information here.

The Radio Amateur Society of Australia sponsors a dedicated online resource for helping you deal with interference here.

## Harmful Interference

You must not operate an Amateur station if its operation causes harmful interference to radiocommunication services.

Even if your station is operating in a Primary amateur radio band and transmitting a clean signal, it is good practice to shut down and investigate the interference. The first step is to confirm your station is the source of interference.

### Strategies to reduce interference

Start by conducting some basic investigative analysis; see if you can identify a pattern or certain condition under which the interference occurs. An understanding of the cause of the interference will assist in resolving the problem.

Once you've completed the first step you can consider options including:

- Relocating your antenna
- Reducing power
- Installing filters
- Applying ferrite cores or clips to feedlines and power cords
- Testing your transmitter
- Visit www.qrm.guru for more guidance.

# CHAPTER 8: Operating Practice and Procedures

Operating Practices and Procedures cover all the protocols associated with operating your amateur radio station. This chapter presents the basics you will need to know to get on-air.

**Key Learning Outcomes**

By the end of this chapter, you should be able to explain the following:

| | |
|---|---|
| | Demonstrate how to setup a radio station |
| | Know what bands and modes you are permitted to use |
| | How to avoid causing interference to other stations |
| | Basis on-air procedures and giving signal reports |
| | How to use a repeater |
| | Adjusting your transmitter to provide a clean signal |

## Setting up a radio station

During practical demonstrations and learning sessions, you will be shown the basic components of a radio station and how to connect them together.

## Basic Station

A basic HF station will comprise a radio, power supply, microphone, and depending on your radio's options, an external VSWR meter and Antenna Tuning Unit (if required).

Of course, there will also be power cords and feedlines connecting the components together. VHF and UHF stations will use resonant antennas, so an ATU is not required.

A video clip demonstrates the process of correctly hooking up a power supply, radio antenna tuner (ATU) and antenna


[Assembling a Station – YouTube](Assembling a Station – YouTube)

The RASA Publication Welcome to Amateur Radio provides guidelines in helping establish your radio station. You can download a free copy here.

## How to correctly configure your radio transceiver

During practical demonstrations and learning sessions, you will be shown the basic controls on a radio and how to use them correctly. Every radio's control panel will be different. Some have more knobs, dials, and buttons, whilst others utilise stacked menus or touch screens.

Whilst the physical controls and interface may differ from radio to radio, their fundamental purpose is the same. Two examples are illustrated below: the YaesuFT-950 from 2007 and the ICOM IC-7300 from 2015.


Yaesu FT950

Image courtesy www.radiomasterlist.com


Icom IC7300

## Power On/Off

This will usually be located in a top corner of the radio; it is used to turn the radio on and off.

## Audio Frequency (AF) Gain

This is the volume control.
You should be careful when wearing headphones not to set the AF gain too high as this may lead to long term hearing loss.

## Radio Frequency (RF) Gain

The RF Gain controls the sensitivity of the receiver. When you have strong noise levels (ie. static) or strong signals from nearby stations, reducing the RF gain may assist in copying your preferred signal.

## Squelch or Mute

The squelch control on a radio silences background noise when no signal is being received. It works by setting an audio muting level inside the radio circuitry which limits noise or unwanted interference.

## Receiver Incremental Tuning (RIT) or Clarifier

The RIT (or Clarifier) allows you to adjust the receiver frequency without changing your transmit frequency. This feature is generally limited to no more than +/-5kHz from your main frequency. It may assist if the other station is slightly off frequency. Refer to your radio's manual for more information.

## Noise Blanker (NB)

The NB is designed to eliminate unwanted pulse type noises, such as hash from car ignitions or electric fences. More complex receivers may offer a variable depth of NB.

## Noise Reduction (NR) or Noise Blanking

The NR is very effective at eliminating unwanted random noise sources
More complex receivers may offer a variable depth of NR.

## Attenuator

The attenuator helps stop extremely strong signals from becoming distorted on or close to your operating frequency.  An Attenuator control usually provides a fixed level of signal reduction and performs a similar function as an RF Gain control, which is an adjustable method of receiver sensitivity.

## Band Switch

This is typically a button, or buttons, allowing you to select your band of operation. Some radios will have one button for each band whilst others will have BAND UP and BAND DOWN buttons.

## VFO Knob

The Variable Frequency Oscillator (VFO) Knob is placed on the front of the radio. This knob is used to navigate your way up and down the band. The frequency is displayed on a digital readout on the radio.

## Power Output/Carrier

On most radios this will be a knob and is used to set the power level of the radio's transmitter. Most radios are fitted with a power meter, whilst others will require you to attach an external power meter. Being able to measure your power output is important – keep in mind the Foundation Licensee is limited to 10 Watts PEP.

## Microphone Gain (mic gain)

Mic gain will adjust how much audio is applied to your RF signal for amplification and transmission. If you set the Mic Gain too high, you will overdrive the audio amplifier and transmit a distorted signal. At best, your audio may sound quite distorted or unclear to other stations; at worst you will create unwanted interference (splatter) to other services; perhaps even your own TV or home appliances.

Typically, set the mic gain between 30-50% of maximum. Conduct on-air tests with a friend who can provide feedback, or maybe even record your signals so you can hear first-hand what happens when you set the mic gain too high or too low. Do not assume that "all dials to the right" will result in the most powerful signal. Your signal will be distorted and may cause interference.

## Transmitter Measurements

As a Foundation Licensee you are limited to 10 Watts Peak Envelope Power (PEP). It is important that you know how to measure your transmit power, and are also able to measure the VSWR.

Most modern radios have inbuilt power and VSWR meters. If not, you will need an external meter. On single sideband, use the RF power control to set your power output so it does not exceed 10 Watts on peak meter readings. On FM, set the power to 10 Watts.

Before each operating session, check if your SWR is within an acceptable range (> 1.8:1). Antennas may develop tuning problems whilst you are away; be it a broken wire, faulty coax connection or some other antenna system malfunction.

You may need to demonstrate how to measure power output and SWR in the examination, so review the relevant sections in this manual.

## Correcting simple equipment maladjustments

You have learnt how to measure power output and VSWR. If you find you are transmitting too much power, wind back the RF Power until your power meter's readings do not exceed 10 watts.

Should you find your VSWR is too high (say above 1.8:1) you have few options depending on your circumstances. Chapter 5 explains and demonstrates the use of an antenna tuning unit (ATU).

You may need to make fine adjustments to the ATU settings to lower the VSWR.
To view a video about this topic click this link
How to measure VSWR?

Alternatively, you may have a fault in your antenna system that requires remediation. Examples include: a break in antenna wire, damaged coax cable, poor solder joint or coax connector not secured tightly or weatherproofed properly.

## How to avoid causing interference to other stations

There are some simple steps you can take to minimise interference to other stations.

- Listen, listen, listen. Check the frequency (and just above and below) is free from other transmissions.
- Make a short transmission "***This is VKxxxx, is this frequency in use?***" Consider transmitting this short message at least twice.
- If the frequency is clear of other transmissions you are free to use it.

> Be aware that you might not be able to hear other stations due to local noise at your location, or changing propagation conditions. In these cases, another station may advise you that the frequency is already in use... even though you got no response to your initial transmissions. In these scenarios, find a new frequency.

If you have not configured or constructed your station correctly, you may inadvertently cause interference to other stations, or other users of the radio spectrum. Chapter 7 talks more about this type of interference.

## What bands and modes are you permitted to use

As a Foundation Licensee you are permitted to operate on the following bands:

| | |
|---|---|
| 80 metres | 3.500-3.700MHz |
| 40 metres | 7.000-7.300Mhz |
| 15 metres | 21.000-21.450Mhz |
| 10 metres | 28.000-29.700Mhz |
| 2 metres | 144-148Mhz |
| 70 centimetres | 430-450Mhz |

Foundation Level operators are permitted to use all modes: AM, SSB, CW, FM, Digital modes

## On-air procedures and giving signal reports

### Before you start

It is good practice to work through a check-list before you get on-air. Even the most seasoned operators make mistakes.

- Are all my power cables connected?
- Is my feedline connected and have I selected the correct antenna for my band of operation?
- If I unplugged my feedline due to storm activity yesterday, have I plugged it back in?
- Are all radio controls set correctly? eg. Power level, Mic gain, Mode switch
- Is my VSWR acceptable?

Any tests prior to calling CQ should ideally be performed with a dummy load or on a clear frequency.

## The Phonetic Alphabet

The Phonetic Alphabet is an internationally recognised set of words used to help communicate when language differences or band conditions are inhibiting effective communication. A typical example might be:

"***My name is Harry, Hotel, Alpha, Romeo, Romeo, Yankee***". This would help clarify where the other station might think your name is Barry, or is simply having troubles copying your signal. You are not required to know the Phonetic Alphabet for the examination, but **a complete list of the Phonetic Alphabet is provided in Appendix #2.**

Note that you use the phonetic alphabet to spell your call sign and name completely. Do not use a mixture of plain language and the phonetic alphabet, as that will lead to confusion.

## Q-Codes

Q-Codes are three letter codes beginning with the letter Q. They were originally used for Morse Code but have made their way into voice communications.
Typical examples will include:

"***My QTH is Sydney***" (QTH means location and may be used as a statement or a question)

"***There is QRN affecting your signal***" (there is storm static affecting your signal)

You are not required to know the Q-Codes for the examination, but a list of commonly used Q-Codes is provided in **Appendix #2** at the end of this study guide.

## Calling CQ and making contacts

There are two ways to initiate a contact. When starting out it may be easier to respond to another station calling CQ.

Let us work through an example:

You are tuning on 40 metres and you hear: "*CQ CQ CQ this is **K0XXX** calling CQ and listening*".

You respond: "***K0XXX** this is **VK1ABC VK1ABC** over*".

If conditions are poor you may need to use Phonetics
"***Victor Kilo wun Alpha Bravo Charlie***"; repeat twice.

K0XXX responds: "***VK1ABC** this is **K0XXX** thanks for the call, My name is Bob, Bob and your signal is five, nine. Five and nine, over*".

Alternatively you want to call CQ. You have already listened and confirmed the frequency is clear.

You call: "*CQ CQ CQ this is **VK1ABC VK1ABC VK1ABC** calling CQ and listening*".

Depending on propagation conditions you may need to call a number of times before you get a response.

If you are operating on a calling frequency (a frequency reserved for calling CQ – normally on VHF and UHF bands) you should move to another frequency once you have established a contact.

> "***VK9ABC** this is **VK1ABC** thanks for coming back to my CQ, shall we move frequency? 146.550 is clear. I'll see you there. QSL?*"

to which the other station would respond:

> "***VK1ABC** this is **VK9ABC**, QSL, see you on 146.550, this is **VK9ABC** clear*".

## Third Party Operation

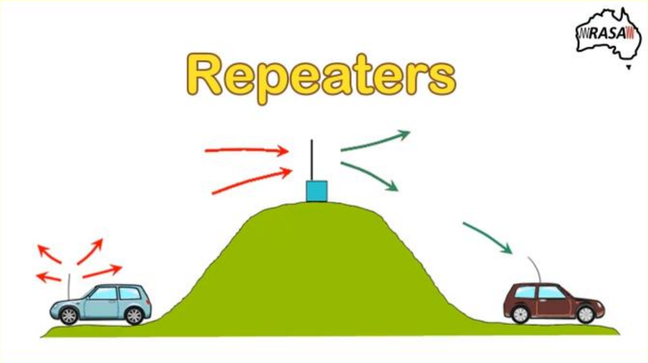
Note that it is acceptable for messages to be passed-on on behalf of third parties as long as they are not used for financial gain or reward. Unlicenced/unqualified operators may be permitted to use an Amateur station if a qualified operator is present at all times.

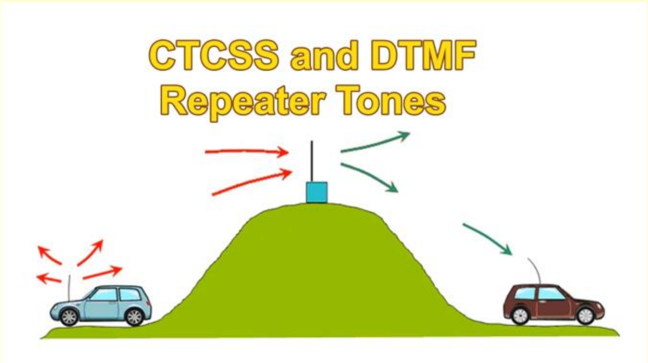
## Operating through a repeater

You will be required to demonstrate the correct use of voice repeaters. This including the use of **Continuous Tone Coded Squelch System (CTCSS)** and **Dual Tone Multiple Frequency (DTMF)** access control methods.

- As with any frequency, always listen first to ensure the repeater is not already in use.
- When operating through a repeater leave adequate breaks between transmissions. This will allow other users to access the repeater if required.
- If you are likely to have an extended contact and the other station is within range, you should move to a simplex frequency and leave the repeater available for other users.
- You normally do not call CQ on a repeater – just announce that you are listening – i.e. "***VK2ABC** listening*"

There are two useful videos on the topics of Repeater usage and access tones




Using Repeaters – YouTube | Using CTCSS & DTMF Tones – You Tube

**Note: All Australian Repeaters and Beacons have the letter R in the suffix. For example: VK3RAA**

## Signal Reports

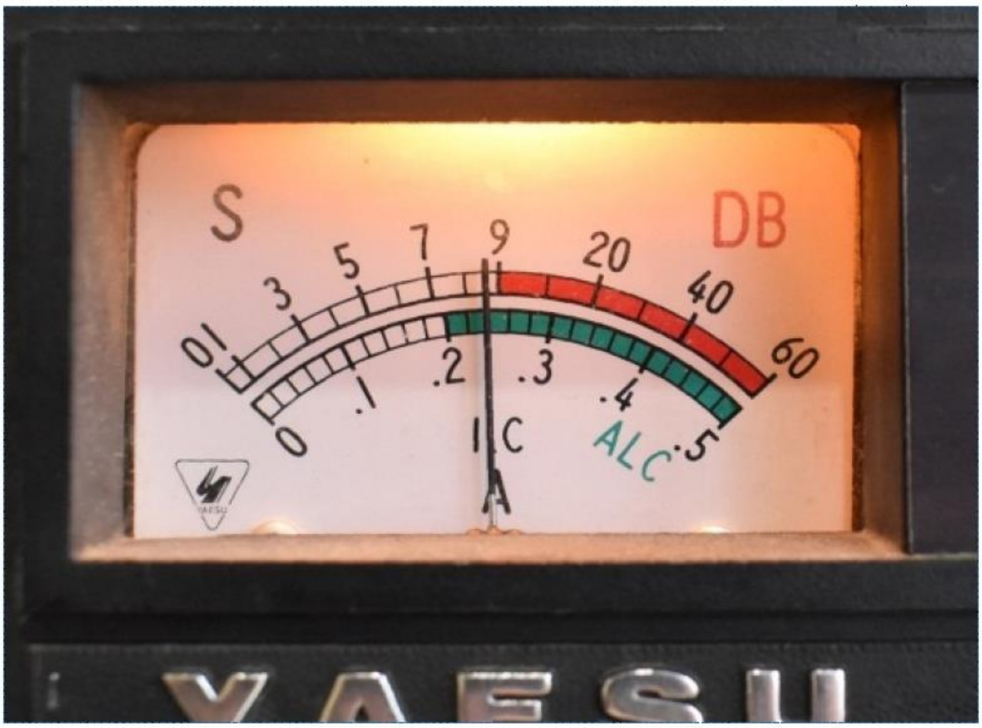
Signal reports are a standard protocol for reporting **Signal Strength** and **Readability**. Generally, each station will inform the other of their signal report. A signal report comprises two numbers, the first being readability, the second being signal strength.

Readability is a subjective measure and rates the readability on a scale of **one** to **five**. The agreed protocol for readability is described below:

1. **Unreadable**
2. **Barely readable, occasional words distinguishable**
3. **Readable with considerable difficulty**
4. **Readable with practically no difficulty**
5. **Perfectly readable**

The signal strength is read from your radio's signal meter, commonly referred to as an S-Meter. This number will be between **one** and **nine**.

- There is no such thing as a signal strength of zero
- The numbers 10, 20, 40, 60 are NOT Strength 10 etc. These values represent dB orders of magnitude above Strength 9. A value of **10 = 10 x S9**, **20 = 100 x S9**




*Above S-9 meters have a decibel scale indicating the number of decibels over S-9.*

When on air and providing signal reports you will need to apply a level of subjectivity, and over time you will become proficient at determining how to best provide the other station with a meaningful signal report.

A weak station which is perfectly readable might get a signal report:

"*you are five and two. Five, two, over*"

A strong station suffering a some interference with some difficulty might get:

"*you are three and nine. Three, nine, thirty-nine. Over*"

Operators will also want to know how their audio sounds:

"*you are five and seven and your audio sounds great*"

Or "*you are four and seven and your audio sounds distorted*".

If a station has bad audio you should do your best to describe what you are hearing, even if you cannot offer a solution.

## Language and Decorum

Amateur Radio is a hobby with a long and well respected tradition. When any of us are on-air, we are representing all of us. The LCD prohibits any offensive language as well as any commercial advertising or messages for personal financial gain.

In addition, the amateur code discourages controversial topics, so stay away from religion, sex and politics. You won't always be aware who is listening, and sometimes your humour may not translate well to other cultures. What you and your friends find funny or unoffensive may not be the case in other cultures, or even with other local listeners.

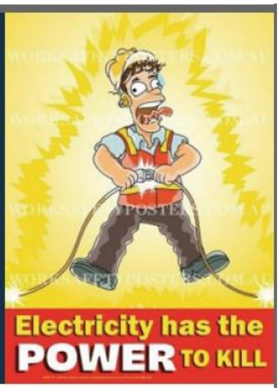
When speaking with international stations, be aware that English may not be their first language, so keep your conversations brief and try to avoid colloquialisms or Australian slang; chances are the other station will not understand what you are trying to say.

## Dealing with Abusive Stations

Amateur Radio is a reflection of society. You may experience inappropriate behaviour such as jamming or even outright abuse from other stations. Such behaviour is very rare, but not unknown.

In all cases, ignore the jamming or abusive station. This is often not easy to do, however it is the best strategy for defusing the situation. Never, ever "bite", as this just gives the abuser what he/she craves – attention.

# CHAPTER 9: **Safety**




**Amateur Radio has** elements of risk, and it is important to identify and mitigate these risks. Once you understand the risks, you can apply simple preventative measures and Amateur Radio will be a safe and enjoyable hobby.

### Key Learning Outcomes

By the end of this chapter, you should be able to understand and answer questions on the following:

| |
|---|
| Risk identification |
| Dangers associated with high voltages and currents. |
| Requirement for equipment to be approved by an Electrical Authority |
| Electrical Earthing |
| Fuses and Safety Switches |
| Station layout for physical safety |
| Power lead safety |
| What to do in the event of electric shock (Electrocution) |
| Battery safety |
| Antenna Safety and Electromagnetic radiation (EMR) |

## Identifying Risks

Risks range from exposure to electromagnetic radiation, high voltages, high currents, loud noises and injuries from constructing equipment.
Do not work alone when attempting work where there is a high risk.

## High Voltages

Electrical voltages flowing through the body may cause one or more of the following;

- burns
- temporary or permanent disruption of cell function
- involuntary muscle contractions
- heart failure causing death
- permanent injuries

**Do not work on equipment powered from the 230 V mains (i.e. a power point).**
Older equipment that use valves have internal voltages that are much higher than those found in modern solid state equipment. These voltages are *lethal*.

**If you are unsure of what you are doing, seek assistance from those who are suitably qualified or experienced.**

## High Currents

**High currents can cause serious burns. Even a low current exceeding the current capacity of a wire can cause extreme heat and even ignition!**
Amateur radio equipment uses power sources capable of supplying high currents. Examples include modern transceivers which can draw 20 Amps at 12 Volts.

Be aware of faults that may result in dangerously high currents.
High currents may cause the following:

- excessive heat, resulting in serious burns.
- electrical fires

Observing safe practices such as keeping the work area tidy, using suitable tools, covering exposed terminals, and the use of fuses or circuit breakers, will help to mitigate the risk.

## Safe practices when dealing with electricity

When working on equipment, remove any jewellery you are wearing to reduce the likelihood of electrocution or burns.

Make measurements using appropriately rated test equipment and work with one hand in your pocket. This will reduce the risk of receiving an electric shock across your chest!

## Electrical Equipment Approval

All electrical equipment purchased or used in Australia must have appropriate local compliance approval **with the Product Testing Approval logo**. Always use commercially manufactured and approved power supplies (wall wart, external power supply, battery, etc).

## Local Electricity Authority Requirements

An Amateur Radio qualification does not qualify you to perform the activities of an electrician. Only suitably qualified people are permitted to work on 230 VAC mains operated equipment and mains leads plugs and sockets.

**DO NOT PERFORM ANY WORK ON MAINS POWER SYSTEMS, POWER POINTS OR LEADS.**

## Power lead safety

Only use suitably rated, commercially sourced power leads and extension cords when using 230 V AC. Inspect power leads and extension cords for any damage paying special attention to worn sections or cuts in the insulation, heat stress to insulation and any damage to the plugs or sockets. Repairing with electrical tape is not safe!

If the lead is faulty, cut off the plugs/sockets and throw it all out. Purchase a new lead.

## Electrical Earthing

The Australian 230 VAC mains uses a safety earth to protect users from electrical shock. All equipment using a three pin mains plug connects to the safety earth of the household electrical system via the plug's bottom pin.

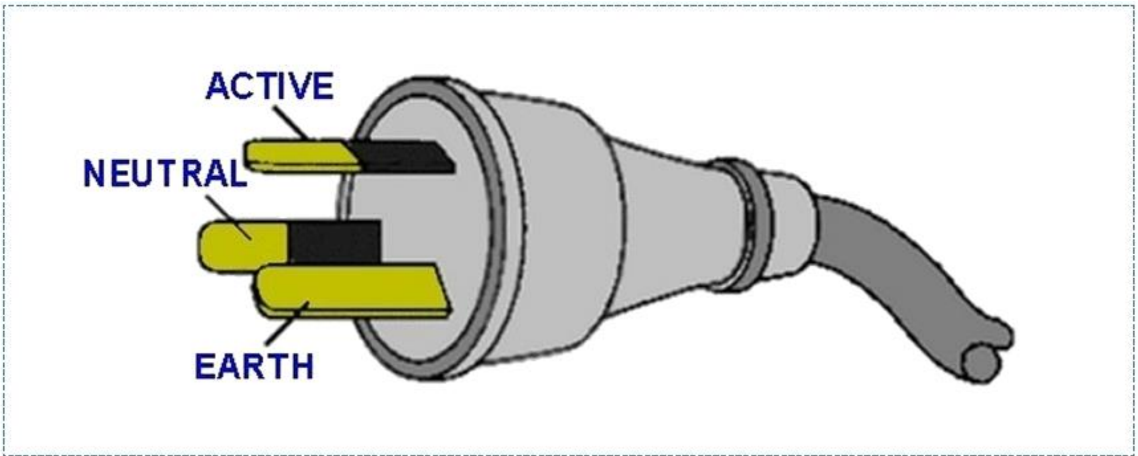



*Illustration of Australian 230VAC showing earth pin*

This pin is connected to the Yellow/Green striped wire (In older equipment it may be just green) of the equipment's power cable and is then connected to the metal case. When plugged in, the enclosure is at earth potential protecting the user. If the equipment fails and 230 VAC active makes contact with the case, it will cause the equipment's fuse to blow or safety switch to trip and the user will be protected from electric shock.

Your home's mains power switch box also has circuit breakers which will isolate the circuit in the event of an electrical appliance generating a fault.

**Note**: Not all equipment requires a mains earth connection, when doubly insulated - equipment which has two layers of insulation. An example is a mobile phone charger which does not have an earth pin.

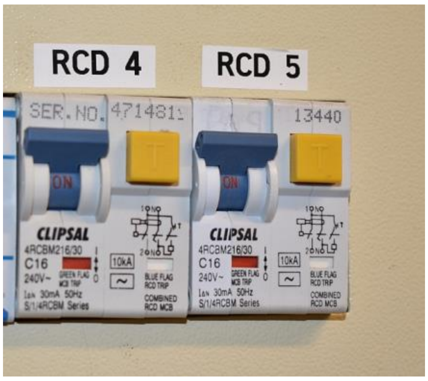
When equipment fails ensure that it is unplugged. Do not attempt to repair any equipment directly powered from the 230 VAC mains supply. Always seek assistance from those who are suitably qualified and experienced.

**Never remove the earth connection on equipment under any circumstances!**

**Note**: Be careful around equipment, especially older equipment, which may not be manufactured to the safety standards required in Australia.

## Electrical Safety Switch

The majority of home and commercial electrical installations are now fitted with one or more **Residual Current Devices** (RCD). Some older homes may not have an RCD fitted and this can be resolved by contacting an electrician.




An RCD works by precisely measuring the active and neutral currents and tripping if these differ by as little as 30 mA. Although a highly effective way of protecting people from electrocution, there are situations where an RCD will not trip. Do not depend on an RCD for your safety.

Always exercise safe practices around live circuits.

## Fuses

A Fuse is an electrical component designed to fail (*blow*) when the current flowing through it exceeds its current rating.

Fuses are wired in series with the power being supplied to the equipment.

Low DC voltage equipment may have a fuse in the positive supply cable, in both the positive and negative in the supply cable or a fuse holder fitted on the rear panel of the equipment.240VAC mains powered equipment is fused in the active supply and the fuses may be on the rear panel or be internal to the appliance.  An incorrectly fitted fuse will not provide protection!

Most fuses are of the Fast Blow variety, however where there may be a brief current spike in the equipment's operation, Slow Blow type fuses are then used.

## Replacing Fuses

Ensure that the equipment is disconnected from its power source before removing and replacing fuses. A fuse can be tested by using a multimeter on Ohms or continuity setting.

Never replace a fuse with a higher value or different type than the one specified by the equipment manufacturer. Fitting the wrong fuse may result in damage to your equipment or an electrical fire.
When equipment repeatedly blows fuses, ensure that equipment is unplugged from its power source.

Do not attempt to repair equipment that is directly powered from the 240VAC mains supply. Seek assistance from those who are suitably qualified or experienced.

## Station layout for physical safety

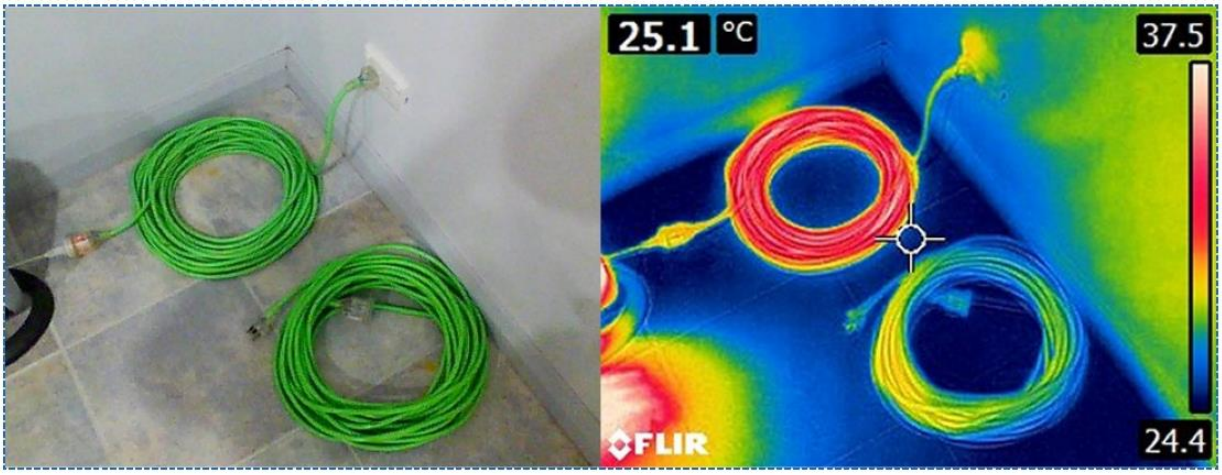
When designing an amateur radio station, and even when setting up for a portable field day, look carefully and assess potential hazards.

Common hazards include:

- Trip hazards where power or antenna cables are running over walking areas
- Unsecured equipment and poorly fitted covers.
- Faulty mains cables
- Failure to provide an electrical earth where appropriate.
- A tidy and clean environment.
- Bundled up or tightly coiled mains cabling as this may cause a fire; best to have mains cables of the correct length.
- Power circuits not capable of delivering the power required and overloaded power boards. Get an electrician to fit additional power points fitted if required.

- If you have an area set up for your Amateur Radio station, it is preferable to have a dedicated mains switch for safety or use in an emergency.

**The image below** shows two power cords coiled up tightly.  Only one is in use, running a small radiator.  To the observer they appear identical, but under infrared imaging, the cable in use has risen to 35 deg after a short interval.   In the extreme, coiled cables under load can heat up to a point where the insulation can melt and become a fire hazard.   Extension cables should not be coiled up while under load.




*Normal view* *Infrared vision*

## Electric Shock

Immediate actions to be taken in the event of an accident involving electricity

- **If you are responding to an electric shock (*Electrocution*) patient, remember to switch off and disconnect all power. If not possible, use an insulated item to physically remove the patient from the power source.**

**DO NOT BECOME THE SECOND VICTIM!**

- **Call for help!** Get someone to call **000** whilst you are preparing to perform CPR

- **CPR (short for cardiopulmonary resuscitation)** can be used if someone is not breathing properly or if their heart has stopped.

- CPR is a first aid skill that everyone can learn and may save a person’s life.

***Do you know first aid and CPR?***
***It is a good idea to attend a local training course.***
***You never know when you may need to be a first aider***

https://www.healthdirect.gov.au/how-to-perform-cpr

# CPR chart

Cardio Pulmonary Resuscitation

NSW Ambulance

## D Check for danger

**Check for danger** e.g. electrical cords, petrol or other hazards

## R Response

**Check for response**

**If no signs of life:**

> Unconscious
> Unresponsive
> Not breathing normally

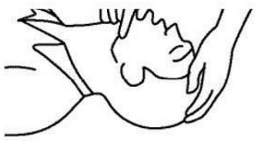
## SEND FOR HELP!

> Get someone to **dial Triple Zero (000) immediately**
> Ask for **AMBULANCE**

000 EMERGENCY

## A Clear airway

> Tilt head back (not for infants)
> Remove foreign matter from mouth (and nose of baby)
> Place on side if there is a lot of foreign matter



## B Check breathing

> Look, listen and feel for breathing
> **If normal breathing is present** leave or place patient on their side
> **If normal breathing is absent, commence CPR 30 compressions to 2 breaths at 100 compressions/min**

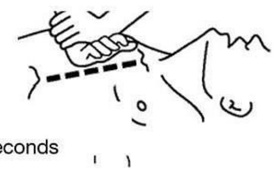
– Place patient on their back
– Tilt head back (not for infants)
– Lift jaw and pinch nostrils

## C Circulation

(at 100 compressions/min)

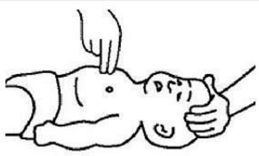
**CHILD & ADULT:**

> Place hands over the centre of the chest (sternum).
> Compress sternum one third the depth of the chest **30 times**
> **Continue with 30 compressions to 2 breaths**
> Do not interrupt compressions for more than 10 seconds



**INFANT:**

> Position 2 fingers on lower half of the sternum
> Depress sternum approximately **one third the depth of the chest**
> **Continue with 30 compressions to 2 breaths**



## D Defibrillation

If Automated External Defibrillator (AED) is available

**CONTINUE CPR UNTIL PARAMEDICS ARRIVE OR SIGNS OF LIFE RETURN**

**Beware of rescuer fatigue, if help is available swap rescuers every few minutes**

This chart is not a substitute for attending a first aid course. LEARN CPR NOW!

This CPR chart is provided free of charge and must not be sold. The chart is available to download from the Ambulance website at: www.ambulance.nsw.gov.au.

For enquiries about this chart: NSW Ambulance Locked Bag 105 Rozelle, NSW 2039 Tel: (02) 9320 7796

This chart conforms to the Australian Resuscitation Council's guidelines on effective CPR as at September 2015. For more information visit: www.resus.org.au

## Battery safety

Batteries are a safe way of powering equipment when you need to be portable. Just follow some simple rules.
When misused, batteries can explode, catch fire, cause burns, and emit toxic chemicals, gasses, and smoke.

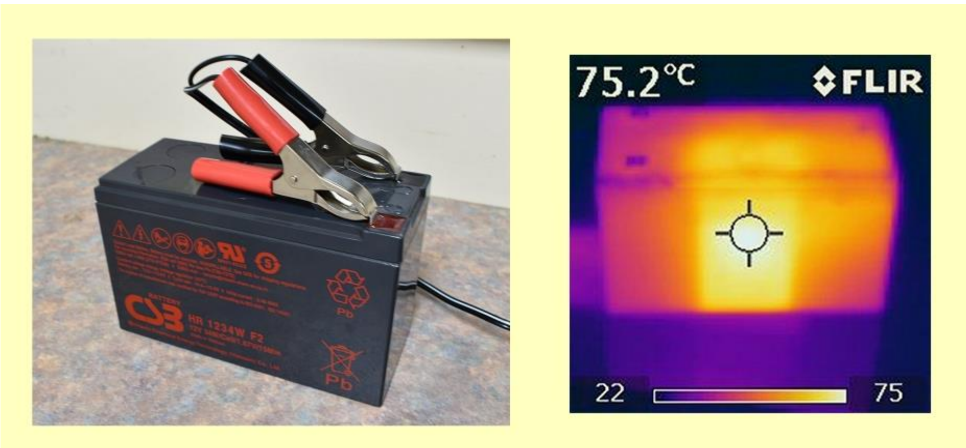
### Do's and don'ts with batteries

- Do not short circuit or dismantle any battery as this may result in a fire or explosion. Do not throw spent batteries in a fire as they are likely to explode.
- Use appropriate batteries to perform the required task. Note the voltage and amp-hour discharge rate. Manufacturer's data sheets are a good reference.
- Do remove replaceable batteries, spent or otherwise, in equipment when not in use for extended periods, to prevent corrosion or leakage.
- Do follow the manufacturer or your council's process for disposal of used, depleted or unwanted batteries. Putting batteries into general waste has caused fires at waste disposal centers and releases toxic chemicals into the environment
- Ensure that your electrical connections and cable size to batteries are secure and appropriate. Under-rated cabling or poor connections may cause a fire.

When working around batteries capable of delivering high current make sure that jewellery and tools are kept clear of powered circuits as these may inadvertently cause a short circuit resulting in serious burns.

## Charging Batteries

Only charge batteries that are rechargeable using the appropriate charger.
Follow the manufacturer's instructions and monitor for excessive heat, swelling, or leakage.
Besides the chemical danger, lead acid batteries require ventilation as charging may release hydrogen gas which can be explosive.




In this image a defective battery overheated while being charged and reached a dangerous 75 deg. before the charger was shut down.

Amateurs should be aware that Lithium based battery packs have a susceptibility to developing shorts and catching fire during charging processes.  Lithium packs should be charged in areas that would limit the damaged caused by a battery failure.

## Button Cells

Despite their size, button batteries are a serious safety hazard to children. If swallowed, they can cause significant injuries including internal burns, or choking which could be fatal. Do not underestimate the danger they pose: keep them out of reach of children.

*Button batteries look like confections and should be kept away from small children*

## Antennas and Safety

Before erecting an antenna you will need to assess the potential risks. You should also ensure you have the appropriate safety equipment.

Working on towers requires specialised skills and is best performed by professional riggers with working at height qualifications and experience. Call on help from an experienced friend or your local club for assistance. Never undertake working at heights alone.

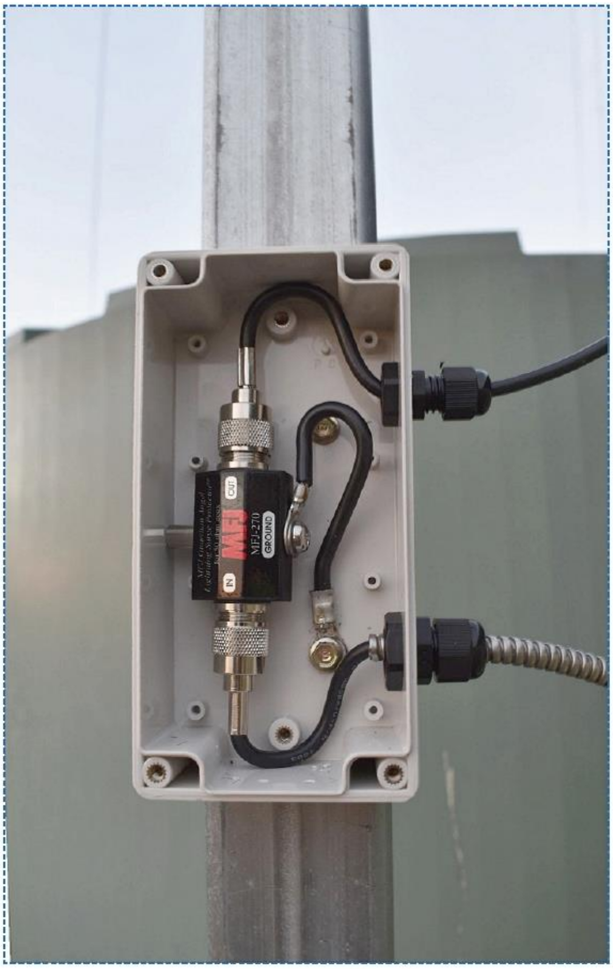
## Some hazards to consider

- ***What would happen if your tower, mast, or antenna fell down?*** Consider the risks to people and property if any components of your antenna structures were to break or fall?
- ***Ensure that your antenna is clear of power lines*.** In normal operation or if the antenna and its supporting structure were to fail, ensure there would be no contact with power lines - **Look up and Live!**
- **Working at heights.** Risks include falling, dropping tools and equipment on people below, etc. Use the correct climbing equipment such as a climbing harness, hard hat, gloves, and a secured ladder. Use lanyards on tools and on any heavy loose equipment you are installing or removing. Do not work alone - a second set of eyes may prevent an accident.
- ***Lifting and lowering large antennas and other equipment*** - can require specialised equipment and skills.
- ***Before working on any existing antennas***, disconnect these from any transmitting equipment. **Perform regular inspections** of supporting structures, feedlines, and the antenna itself for signs of failure such as corrosion, weathering, loose hardware etc.

Note: The above information is general advice only and does not replace the services of a professional rigger. As discussed previously, working at height is best performed by professional riggers.

## Lightning

Never use your station when there is an electrical storm nearby. Due to their height antennas can easily be hit by lightning.  The use of lightning arrestors may reduce the risks and will discharge any high voltages induced by lightning nearby. Lightning arrestors will not provide protection from a direct strike. If you are using a tower ensure that it is adequately earthed as this will minimise damage.




The above photograph is of a lightning arrestor.   A good practice is to disconnect and earth antennas when not in use. Do not leave your feedline 'floating', as this may lead to a build-up in static electricity.

To experience the effects of lightning on HF radio, view the video clip [Here:]

## Station Earth

Besides the mains electrical earth, it is good practice to have a separate station earth. This is a separate ground connection and does not replace the electrical earth. A station earth or ground can consist of an electrical earth stake, driven 1 metre or more into the ground or as a series of wires or conductive mesh buried under the soil.

Most equipment has an earth point and these are connected to the station earth. A station earth may also help with noise reduction and will improve the performance of some antennas (such as End Fed antennas) and may give better results with Antenna Tuning Units (ATUs).

*It is also beneficial to dab a little paint over the joint to minimise corrosion.*

## Radio waves can be dangerous

Electromagnetic Radiation (EMR) is all around us. We use it to cook our food in a microwave oven, to communicate on our mobile phone, open our garage doors, and for entertainment.

High levels of EMR can be dangerous. With careful management we can control the risks associated with EMR. The Foundation Licence power limit of ten watts is considered to be safe and with some simple controls, manageable.

The transmitting antenna is the source of EMR. The higher the power, and the higher the frequency, the greater the hazard.

Antennas that direct their power into a narrow beam of energy (eg. a Yagi Antenna), even at low power, can be dangerous in close proximity.

This beam of EMR is measured in Watts of Effective Radiated Power (W ERP) and can be several times more that the power being fed to the antenna due to the antenna gain.

If you plan to use such an antenna you should seek advice from those who are suitably qualified or experienced.

## Things to know and consider with EMR

- **Do not touch a transmitting antenna.** Above 5 watts, antennas can cause what is known as "RF Burns" which are caused by EMR current penetration and can be severe.
- **EMR Risk falls rapidly with distance.** This is why transmitting antennas are mounted high and out of reach and range of humans and animals.
- **Exposure time is another factor.** If you spend a lot of time using a hand held transceiver, you may consider using an external microphone and keep the radio and antenna further away from your body.

## Safe use of headphones

When engaged in any activity that uses headphones, be aware of excessive volume levels and ensure your ears are protected from permanent damage.

Start with the volume control (often labeled as AF Gain) at its lowest setting and adjust to a comfortable level.

Acoustic shock is by an unexpected loud noise. When acoustic shocks occur repeatedly, it can cause hearing damage, hypersensitivity to sounds, vertigo, or nausea.

To prevent this, be aware of the activity on air, keep your hand near the volume control and set the Automatic Gain Control (AGC) on to an appropriate setting.

Do not use headphones whenever there is electrical storm activity nearby.

### Summary

- **Be observant** - Be vigilant. Identify and understand the risks and put in place controls to manage those risks. Where necessary, call on others who are suitably qualified or experienced for advice and support
- **High voltages** - Can cause electric shock (Electrocution)
- **High current** - Can cause burns and fire
- **Fuses** - Always replace with the same type and current rating
- **Electromagnetic Radiation** - Can cause radio frequency burns and other health issues. Keep people and animals away from transmitting antennas
- **Batteries** - When mishandled may result in explosion, acid burns, high current
- **Towers, Masts,** and **Antennas** - Be aware of nearby power lines and the dangers of falling down. Manage your personal safety when working on antennas. Disconnect antennas during thunderstorms
- **Feed Lines, Power cables etc** - Can cause trip hazards
- **Headphones/Speakers** - Be aware of acoustic shock and hearing damage.

# Chapter 10. **Foundation Level Syllabus**

# ACMA recognition certificate (Foundation) Syllabus and examination information

FEBRUARY 2024

**The syllabus here is an extract from the ACMA website and is subject to change by the ACMA. To access the original and most up-to-date Amateur Radio Syllabus documents follow this link:**
https://www.acma.gov.au/amateur-radio-resources#documents

**The ACMA recognition certificate (Foundation) is the entry-level qualification for amateur radio in Australia. It allows people to operate an amateur station on a limited set of frequencies (foundation frequencies).**

The syllabus and related examination for the ACMA Foundation recognition certificate reflects the minimum level of knowledge, skills and experience required to:

- safely assemble an amateur station
- operate it safely on the foundation frequencies
- not cause interference to other users and services.

**Follow the operating conditions set out in:**

- The Radiocommunications (Amateur Stations) Class Licence 2023 (known as the Amateur Class Licence)
- The Determination 2015 (known as the Amateur LCD) – for beacon or repeater station operation.
- The Radiocommunications Act 1992.

**Examination Notes:**

- Examination candidates will be supplied with reference materials to facilitate some of the assessment requirements. Materials may include look-up tables, formulas, diagrams, photographs, relevant class licences or licence condition determinations, and physical examples.
- Under the column 'Assessment objective', the syllabus uses the following words to denote the differing levels of answer required:
- Recall indicates the requirement to recall a fact and apply it directly to the assessment question or situation. This may include using the supplied reference material.

- Understand indicates the need for more detailed knowledge of the subject.
- Demonstrate indicates that the candidate is required to carry out a physical task.
- Identify indicates that the candidate is required to identify particular objects, diagrams or other matters from a supplied set.
- Reference to a 'transceiver' means a combined transmitter and receiver.
- The transmitting antenna is the source of EMR. The higher the power, and the higher the frequency, the greater the hazard.
- Reference to 'harmful interference' means as defined in the Australian Radiofrequency Spectrum Plan.

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**The Syllabus in Detail**

**1.1 Nature of Amateur Radio**

Recall that amateur radio is intended to facilitate the hobby of radiocommunications

**1.2 Types of Licences**

Recall that amateur radio activities are authorised under the Amateur Class Licence and the Amateur LCD for beacon and repeater stations. Other forms of licences authorise different types of radiocommunications, such as citizens band (CB), land mobile, point-to-point links and broadcasting.

Recall that the amateur service operates on frequency bands allocated for amateur use. Recall that the amateur service shares some frequency bands with other services.

**1.3 Allocation of Frequency Bands**

Recall that services, such as broadcasting, aeronautical and maritime services, are allocated frequency bands appropriate to their purpose.

**2.1 Permitted Power Output**

Recall the maximum transmitter output power permitted under the Amateur Class Licence.

**2.1 Amateur conditions**

Recall that operation of an amateur station is subject to conditions in the Radiocommunications Act 1992, the Amateur Class Licence and the Amateur LCD for beacon and repeater stations.

**2.2 Purpose of the amateur service**

Recall that the Amateur Class Licence primarily authorises the operation of an amateur station for self-training in radiocommunications, intercommunication between amateurs and technical investigations into radiocommunications.

**2.3 Communications by amateur stations**

Recall that, except in relation to a distress or emergency situation, or participating in emergency services operations or training exercises, the Amateur Class Licence only authorises amateur-to-amateur communications.

**2.4 Third Party Operation**

Recall that messages may be passed-on on behalf of third parties as long as they are not used for financial gain or reward.

**2.5 Distress and urgency signals**

Recall that distress communications are signalled by the use of 'MAYDAY' and that these communications have priority over all other communications.

Recall that anyone hearing a 'MAYDAY' communication is responsible for passing the information on to an appropriate authority.

Recall that some urgent situations not warranting the use of 'MAYDAY' are signalled by the use of 'PAN-PAN'.
Recall that these communications should receive priority and should be reported to an appropriate authority.

### 2.6 Station identification

Recall that correct station identification is required at the beginning and end of a transmission and at least every 10 minutes during transmissions.
Recall that any transmission, even a test transmission, must contain station identification.

### 2.7 Amateur call signs

Identify from supplied reference material, the categories of call signs used in the Australian amateur service.
Recall all sign suffixes applicable to each licence category, prefixes and state designators

### 2.8 Encoded messages

Recall that the transmission of messages that are encoded to obscure their meaning is not permitted except for the purposes specified in the Amateur Class Licence

### 2.9 Authorised frequency bands and emissions

Recall the Amateur Class Licence authorises operation on certain frequency bands. Recall in which document the bands are specified.

### 2.10 Permitted power output

Recall the maximum transmitter output power permitted under the Amateur Class Licence.

### 2.11 Notification of change of contact details

Recall that an operator is no longer required notify the Australian Communications and Media Authority (ACMA) of any change of contact details.

### 2.12 Harmful interference

Recall that a person must not operate an amateur station if operation causes harmful interference to other licenced services.

### 2.13 Use of amateur stations

Recall that an amateur station cannot be used for financial gain.

### 2.14 Who may operate a Station

Recall that only people with suitable qualifications may operate a station

### 2.15 Use of a station by non-qualified persons

Recall that a person without amateur qualifications may communicate via an amateur station, provided the station is always under the full control of a qualified person.

### 2.16 The ACMA may obtain information or documents

Recall that the ACMA has the power to request information from an amateur, including evidence of their qualification.

### 2.17 Restriction of operation to avoid interference

Recall that the ACMA has the right to restrict the operation of an amateur station to avoid harmful interference

### 2.18 Use of the Amateur Class Licence and Amateur Class LCD

Identify the specific amateur conditions in the Amateur Class Licence/Amateur LCD for operating an amateur station on foundation frequencies.

### 2.19 Station security

Recall that an operable amateur station must not be accessible to unauthorised people.

### 3.1 Units of measurement, abbreviations and multiple/sub-multiple prefixes

Recall the units of, and abbreviations for voltage, current, resistance and power.
Recall the engineering prefixes milli, kilo and mega.

### 3.2 Meaning of DC and AC
Recall what is meant by the abbreviations DC and AC.
### 3.3 Audio and radio frequencies
Recall, using supplied reference material, the range of frequencies described as audio frequency (AF) and radio frequency (RF).
### 3.4 Meaning of AM and FM
Recall what is meant by the abbreviations AM and FM.
Recall how the radio frequency carrier is modified for AM and FM.
### 3.5 Meaning of Voltage, Current, Resistance and Power
Recall the meaning of voltage, current, resistance and power.
### 3.6 Simple Calculations
Recall, using supplied reference material, the relationship between voltage, current, resistance and power. Calculate an unknown value given the value of the remaining components.
### 3.7 Excessive and incorrect polarity
Recall that electronic circuits can be damaged by applying an excessive voltage or voltage of wrong polarity
### 3.8 Unit of Frequency
Recall the unit of frequency.
### 3.9 The Sine Wave
Recall the graphic representation of a sine wave and that sine waves are produced by oscillators.
### 3.10 Mains Electricity Supply
Recall the voltage and frequency of the mains electricity supply used in Australia.
### 3.11 Range of Human Hearing
Identify, from supplied reference material, the range of frequencies for normal human hearing.
### 3.12 Audio Frequencies used in radiotelephony
Identify, from supplied reference material, the range of audio frequencies commonly used in radiotelephony.
### 3.13 Frequency ranges for HF VHF and UHF
Identify, from supplied reference material, the frequency bands for HF, VHF and UHF.
### 3.14 The relationship between Frequency and Wavelength
Recall the relationship between frequency and wavelength.
Convert from one to the other using supplied reference material.
### 4.1 Block or Concept diagrams of simple Transmitters and Receivers
Identify, using supplied block diagrams, the names of the stages in a simple transmitter and receiver.
### 4.2 Importance of proper transmitter adjustment
Recall that improper adjustment of a transmitter can cause harmful interference to other radiocommunications services, both inside and outside the frequency bands allocated to amateurs.
### 4.3 Emissions within Band limits
Recall that all components of transmitter emissions must be contained within the radiofrequency bands allocated to amateurs.
### 4.4 Identification of Waveforms
Identify, with the aid of supplied diagrams, a radio frequency carrier waveform, an audio frequency waveform and a modulated waveform

**4.5 Waveform Generation**
Identify, using supplied block diagrams, where the carrier, audio and modulated waveforms occur in a simple transmitter.

**4.6 Types of Amplitude Modulation**
Recall that single sideband (SSB) is a form of amplitude modulation (AM).

**4.7 Transmitter Output Matching**
Recall that the final power amplifier stage of a transmitter must be connected to a correctly matched transmission line and antenna to avoid possible damage to the transmitter and/or cause interference to other radiocommunications services

**4.8 Effect of AF gain control on output modulation**
Recall the need to ensure microphone gain, where fitted, is correctly adjusted to avoid over-modulation of AM or FM transmitters.

**4.9 Effects of Over Modulation**
Recall that excessive modulation of transmitters may cause distorted output and interference to adjacent frequencies.

**4.10 Transceiver Controls**
Recall the purpose of the following controls: AF Gain, RF Gain, Squelch, Mode, VFO, RIT, Band and Carrier control.

**5.1 Types of Transmission Lines**
Identify from a supplied diagram, photograph or physical examples, common co-axial and balanced transmission lines. Recall their typical characteristic impedance.

**5.2 Coaxial Connectors**
Identify, from a supplied diagram, photograph or physical examples, co-axial connectors commonly used in radiocommunications.

**5.3 Testing of Transmission Lines**
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 Antenna purpose**
Recall that the purpose of an antenna is to convert electrical signals into radio waves, and vice versa.

**5.5 Antenna Length to Frequency relationship**
Recall the relationship between the physical length of the antenna and the frequency of operation.

**5.6 Identification of Common Antennas**
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 Choice of Antenna**
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 Antenna Directional Characteristics**
Recall the meaning of the terms: polarization, omni-directional, bi-directional, unidirectional and gain as they apply to antennas.

**5.9 Polarisation**
Recall that the polarisation and directivity of an antenna is determined by its physical construction and orientation.

**5.10 Effective Radiated Power (ERP)**
Recall that ERP is the product of transmitter power and antenna gain.
Recall that antenna gain is generally expressed in decibels.

**5.11 Antenna Matching**
Recall the need to match an antenna to a transmission line and to minimise the Voltage Standing Wave Ratio (VSWR).

**5.12 Antenna Tuning Unit**
Recall the uses, purposes and adjustment of a typical manual ATU.

**5.13 Baluns**
Recall that when feeding a balanced antenna with an unbalanced transmission line (co-axial cable), the preferred practice is to use a balun.

**5.14 Voltage Standing Wave Ratio (VSWR)**
Recall the correct placement, use and adjustment of an VSWR meter.

**5.15 Acceptable VSWR**
Recall that when testing a transmitter, a non-radiating load (dummy load) is commonly used to prevent a signal from being radiated.

**5.16 Testing Transmitters**
Recall that when testing a transmitter, a non-radiating load (dummy load) is commonly used to prevent a signal from being radiated

**6.1 Propagation Basics**
Recall that radio waves travel in straight lines, unless diffracted, reflected or refracted.

**6.2 Effect of Distance on Radio Waves**
Recall that radio waves get weaker with distance as they propagate from the antenna.

**6.3 Communication range**
Recall that communication range at VHF/UHF is dependent on antenna height, a clear path, transmitter power and receiver sensitivity

**6.4 Effects of Obstacles**
Effect of obstacles and structures on VHF and UHF signals

**6.5 Long distance communications on VHF and UHF**
Recall that unusual atmospheric conditions may at times provide extended range.

**6.6 The Ionosphere**
Recall, using supplied reference material, that the ionosphere comprises layers of ionised gas at varying heights above ground.

**6.7 Factors affecting HF propagation**
Recall that ionospheric propagation is dependent on time of day, season, frequency and solar activity.

**6.8 Ionospheric refraction**
Recall that long-distance HF communication relies on propagation by ionospheric refraction.

**7.1 Sources of Radio Interference**
Recall that broadcast radio and television receivers can suffer interference from local sources, including electrical and electronic equipment and high voltage electricity supply lines, as well as from than radiocommunications transmitters.

**7.2 Interference to Other Services**
Recall that interference to other radiocommunications services, including broadcast radio and television reception, can be caused by the faulty operation of radiocommunications transmitters.

**7.3 Nearby Transmitters**

Recall that radiocommunications transmitters can be the source (but not necessarily the cause) of interference to nearby electronic and radio equipment.

Recall that technical solutions can generally resolve the interference.

**7.4 Interference and electromagnetic compatibility (EMC)**

Recall that the ability of electronic or radio equipment to operate properly, without interference, in the presence of electromagnetic radiation, such as radiocommunications transmissions, refers to the EMC of the equipment. This is also known as the equipment's radiofrequency immunity.

**7.5 Interference Pathways**

Recall that radiocommunications transmissions that are the source of interference, may be induced into nearby electronic or radio equipment through conduction along electrical mains wiring or from direct pickup by the equipment.

**7.6 Amateur Transmissions and EMC**

Recall that interference resulting from EMC problems may be dependent on the power, frequency and type of emission of the radiocommunications transmitter and its distance from the affected equipment.

**7.7 Antenna Location and EMC**

Recall that interference resulting from EMC problems can be minimised by careful selection and siting of antennas.

**7.8 Transmission Modes and Interference**

Recall that some transmission modes are more likely than others to cause objectionable interference to broadcast radio and television reception and to telephones.

**7.9 Filters**

Recall that the immunity of most types of equipment can be increased by fitting suitable filters in external cabling, such as antenna, power supply or interconnections between equipment.

Recall that the filters should be fitted as close to the affected devices as possible.

**7.10 Simple Choke Filter**

Recall how to construct a simple RF 'choke' filter using a ferrite rod or toroid.

**7.11 RF Earthing**

Recall that the function of the RF earth connection in an amateur station is to provide a path to ground to minimise RF currents entering the mains earth system and causing interference to other electronic equipment.

Identify, from supplied diagrams, the symbol representing an earth connection.

**7.12 Diplomacy and EMC**

Recall that EMC problems have the potential for causing neighbourhood disputes. Understand the need for diplomacy, the sources of advice available and the role of the ACMA.

**7.13 Harmful interference**

Recall that a licensee must not operate an amateur station if its operation causes harmful interference to radiocommunication services.

**8.1 Equipment Practices**

Demonstrate connecting a transceiver safely to a power supply, microphone, VSWR meter, antenna matching unit, transmission line and antenna.

**8.2 Knowledge of the frequencies and emissions that may be used under an ACMA recognition** certificate (Foundation)
Recall the relevant band plans, frequencies and emissions that may be used by the holder of an ACMA recognition certificate (Foundation) under the Amateur Class Licence.
Recall that amateur band plans, by agreement, play an important part in managing interference between amateur stations.
Relevant reference material will be supplied.

**8.3 Requirement not to transmit on Frequencies In Use**

Recall and demonstrate the requirement to listen on a frequency before transmitting to ensure that interference will not be caused to other stations using the frequency.

**8.4 Operating Practises**

Demonstrate, by making on-air contacts using appropriate calling procedures, the correct operation of HF and VHF/UHF transmitter/receivers.
Demonstrate the use of a signal strength meter to make meaningful signal reports.

**8.5 Operating through a Repeater**

Recall and demonstrate, using supplied reference material, the correct use of voice repeaters, including the use of continuous tone-coded squelch system (CTCSS) and dual tone multiple frequency (DTMF) access control systems.

**8.6 Leaving Breaks when using a Repeater**

Recall and demonstrate the need to leave adequate breaks between transmissions when using voice repeaters.

**8.8 Abbreviations**

Recall that there are internationally recognised abbreviations commonly used in communications.

**8.9 Transmitter Measurements**

Recall and demonstrate the measurement of the output power of a transmitter.
Measure the VSWR using a suitable measuring device.

**8.10 Correcting simple Equipment Maladjustments**

Recall and demonstrate the correction of simple problems such as high VSWR, excessive modulation, and excessive RF output power.

**9.1 Dangerous Voltages**

Recall that high voltages and high currents are dangerous.

**9.3 Awareness of state electricity authority requirements**

Recall that it is necessary to check relevant requirements regarding unqualified people wiring and testing mains-operated equipment. This includes leads, plugs and sockets connected to the household mains supply.

**9.4 Electrical Earthing**

Recall why most mains-operated equipment should have a safety earth connection.

**9.5 Fuses**

Recall that fuses prevent excessive currents that may cause heat damage or fires.

**9.6 Correct fuse to be used**

Recall that a correct fuse must be fitted to all electrical equipment.

**9.7 Replacing Fuses**

Recall the precautions to be taken when replacing faulty fuses including the selection of a fuse rated in accordance with an equipment manufacturer's specifications or the requirements of an electricity supply authority

**9.8 Station Layout for physical safety**

Recall that the layout of an amateur station should take account of physical safety issues.
Recall that trailing cables are trip hazards and dangerous.

**9.9 Power Lead Safety**

Recall that frayed or damaged power leads are dangerous and should be replaced or repaired by an authorised person.

**9.10 Know location and desirability of a Mains OFF switch**

Recall the desirability for a clearly marked switch to turn off all station equipment in an emergency.

**9.11 Actions to be taken in the event of an accident involving electricity**

Recall that, in the event of an accident involving electricity, the first action is to safely switch off the power.

**9.12 Electric Shocks**

Recall that a casualty of electric shock must not be touched unless the power has been switched off.

**9.13 Call for help – use of resuscitation techniques**

Recall that emergency services need to be called immediately and that cardiopulmonary resuscitation (CPR) may need to be administered.

**9.14 Battery safety**

Recall that batteries contain chemicals and emit fumes and may explode if punctured or exposed to flames or sparks

**9.15 Antennas and Safety**

Recall that it is important for all people (and animals) to be kept at a safe distance from antennas.

**9.16 Radio waves can be dangerous**

Recall that electromagnetic radiation (EMR) can be dangerous and higher frequencies and power levels and proximity to the source increase the danger.

**9.17 Safe Distances**

Recall that a safe distance from an antenna depends on the ERP, operating frequency, antenna type and orientation.

**9.18 Antenna Erection**

Recall that antenna erection is potentially dangerous and should be carried out by suitably qualified people.

**9.19 Securing and Siting antennas**

Recall that antennas and their fittings must be suitably located and secured and must never be connected to, or sited close to, mains poles and lines.

**9.20 Lightning protection**

Recall that it is good practice to install lightning protection on antennas, disconnect antennas from any radio equipment before a thunderstorm and never operate an amateur radio during a thunderstorm.

**9.21 Safe Use of Headphones**

Recall that excessive volume when wearing headphones can cause damage to human hearing.

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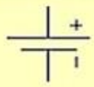
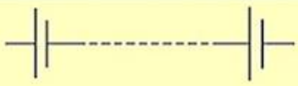
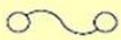
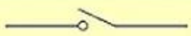
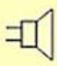
**The Examination Process**

1. The examination comprises:
   (a) A multi-choice question paper: 25 Questions covering theory and regulations questions may be drawn from all parts of the syllabus except for section 8.
   (b) A practical component to demonstrate operating knowledge and skills: Assessment will be based primarily on section 8 of the syllabus, and may also address matters in sections 2 and 9 of the syllabus.
2. Where possible, the practical component will be carried out under actual operating conditions.
3. Candidates will be supplied with reference materials to facilitate some of the assessment requirements.
4. The examination may be undertaken in one session or as part of a course of training.
5. Thirty (30) minutes is allowed for the multi-choice paper when the examination is undertaken at one session.
6. An ACMA recognition certificate will be issued to candidates who correctly answer 70% (18/20) or more of the multi-choice questions and demonstrate competence in all elements of the practical component of the examination.
7. The following symbols may be used in the examination:

| Description | Symbol |
|---|---|
| Cell |  |
| Battery |  |
| Fuse |  |
| Lamp |  |
| Resistor |  |
| Switch (SPST) |  |
| Antenna |  |
| Earth |  |
| Microphone |  |
| Loudspeaker |  |


## The Amateur Radio Practical Assessment

Anyone currently attempting to acquire an Amateur Operator qualification must submit to and pass the Practical Assessment. There is no getting around this. The candidate will be asked a series of questions, of which they must provide an adequate answer. They must be able to physically demonstrate knowledge of basic skills. **Candidates must achieve a 100% proof of competency to pass**. The process will take around 30 minutes.

This is not as scary as it sounds. The tests are simple. Often it is simply a matter of pointing at the right item, or saying a key word that the assessor is looking for. A few hours of reading and observation is usually sufficient to achieve a pass – but nonetheless, it must still be done. As with all Amateur assessments, remember to bring along a form of photo I.D. to the exam .

On this page we break down the steps involved in a practical assessment and link to the specific sources of information that provide clear answers. Candidates who follows these 11 steps, view the linked content and watch the embedded video clips, should have little difficulty in passing their Amateur Radio Practical Assessment.
However, it is important to understand **All the steps** and not just some of them.

**Step 1 Antenna Connections**
Candidates need to identify the differences between shielded (Coax) cables and open wire balanced feedlines. This is described on **Pages 38 - 40** of this guide.
Also, visit: https://thisisamateurradio.com/p61-identifying-antenna-cables/

Candidates need to identify common coax connector types and must be able to use a meter to check the integrity of a coaxial patch cable with continuity testing. This is described on **Page 41** of this guide.

**Step 2 Antenna identification**
Candidates must be able to recognise at least for of the five basic antenna types by name. Centre-fed dipole, Folded Dipole, Beam/Yagi antenna, Vertical antennas and end-fed long wire antennas. This is described on **Page 38** of this guide.

Visit Page 44: https://thisisamateurradio.com/p44-identifying-common-antennas/

**Step 3 Make a simple RF Choke**

Using a short section of cable, candidates must be able to demonstrate how it may be wrapped around a ferrite ring to form an RF Choke device as a method of reducing radio interference. This topic is covered on Page 59 of this guide.
Also visit : https://thisisamateurradio.com/p59-constructing-an-rf-filter-choke/

**Step 4 Identify basic circuit symbols**

Candidates will be presented with a series of symbols on a sheet, of which they must be able to correctly identify. This includes the symbols for Earth and Antenna. A summary of these symbols appears on Page 90 of this guide.

**Step 5 Setting up a radio**

Candidates must be able to demonstrate how to connect up a radio to a power supply and antenna, in the correct order. Visit Page 60 of this guide for a description of these procedures
Also visit : https://thisisamateurradio.com/p73-assembling-an-amateur-station/

**Step 6 Recognise the Frequency ranges of Amateur Bands**

Candidates are supplied with a chart and have to be able to show that they understand where the edges of each band allocation start and finish for Foundation, Standard and Advanced.
Become familiar with the band access table on Page 13 of this guide.

**Step 7 Correct on-air operating procedures**

Candidates must demonstrate the steps taken leading up to transmitting on-air, then show the procedures for calling another station. Leaving a suitable pause between transmissions and on-air arrangements to swap to a different frequency (QSY). Visit Page 60 of this guide for a description of these procedures.

This process also includes the correct way to provide a Signal Strength report, as described on Page 67 of this guide.

**Step 8 Understanding Repeater tones**

There are two conventions for using audio tones on repeaters. One is the Repeater Access Tones (CTCSS) and the other is repeater control tones (DTMF). These methods are described on page 66 of this guide.

**Step 9 Q codes and the Phonetic Alphabet**

Candidates need to be familiar with the use of common abbreviations and codes used on the air. This does not mean that they all need to be memorised, but candidates do need to understand that these abbreviations are in common use. A summary of these procedures appears on Page 65 of this guide, with additional information in Appendix #1 and #2 of this guide.

**Step 10 Measuring transmitted power and SWR**

Candidates must show some familiarity with the steps to measure how much power is being transmitted and the differences between satisfactory and unsatisfactory antenna SWR. They should also be aware that Antenna Tuner devices have a role to improve an antenna match, but an actual antenna tune-up is not needed. These steps are described on Page 63 of this guide

**Step 11 An awareness of the dangers of high voltages and current**
Candidates will be asked about what voltages are considered to be dangerous voltages and how high current flow through a human can cause burns. These issues are described on Page 70 of this guide

**ACMA Requirements**
There is a lot of information available for the steps required to attain an Amateur Radio qualification. Where there is any doubt, the legislative detail from the ACMA website should be followed, as this will always contain the most current information.

A good place to start is here:
https://www.acma.gov.au/qualifications-operate-amateur-radio

## Appendix #1 - The Phonetic Alphabet

The Phonetic Alphabet is an important adjunct to long-range communications. It is an internationally recognised set of words used to help communicate when language differences or band conditions are inhibiting effective communication.
A typical example might be:
"***My name is Harry, Hotel, Alpha, Romeo, Romeo, Yankee***".

This would help clarify where the other station might think your name is Barry, or is simply having difficulty copying your signal.

You are not required to know the Phonetic Alphabet for the examination, but it is important to be aware of this word-set as it remains in common usage around the world.

Note that you use the phonetic alphabet to spell your call sign and name completely. Do not use a mixture of plain language and the phonetic alphabet, as that will lead to confusion.

Unless signals are very poor in readability, it is not normal practice to use the Phonetic Alphabet on VHF/UHF FM transmissions, direct or via repeater.

Historically, there have been several variants of this alphabet. For clarity, Amateur operators should use the official NATO version (below)

**Alphabetic code words**

| | |
|---|---|
| Alfa | November |
| Bravo | Oscar |
| Charlie | Papa |
| Delta | Quebec |
| Echo | Romeo |
| Foxtrot | Sierra |
| Golf | Tango |
| Hotel | Uniform |
| India | Victor |
| Juliett | Whiskey |
| Kilo | Xray |
| Lima | Yankee |
| Mike | Zulu |

## Appendix #2 - The Q-code

Q-Codes are three letter codes beginning with the letter Q. They were originally used for Morse Code but have made their way into voice communications.

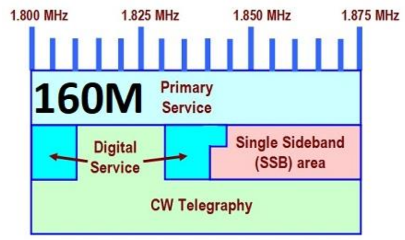
Typical examples are:

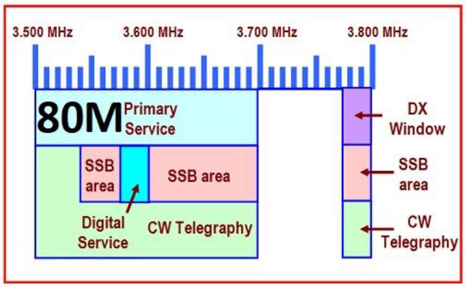
"***My QTH is Sydney***" (QTH means location and may be used as a statement or a question)

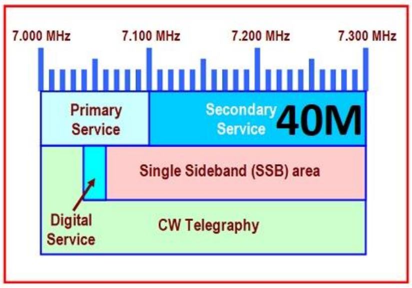
"***There is QRN affecting your signal***" (there is storm static affecting your signal)

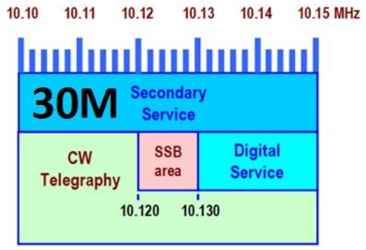
| | |
|---|---|
| **QRL** | Busy |
| **QRM** | Interference |
| **QRN** | Noise |
| **QRO** | High power |
| **QRP** | Low power |
| **QRS** | Low speed CW |
| **QRT** | Shut down the station |
| **QRX** | Stand by |
| **QRZ?** | Who is calling me? |
| **QSB** | Fading |
| **QSL** | Confirmation *or* card to confirm contact |
| **QSO** | Radio contact |
| **QSY** | Change frequency |
| **QTC** | Message |
| **QTH** | Location |
| **QTR** | Time |

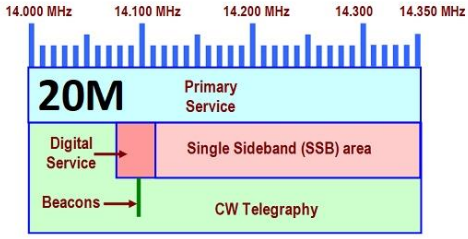
# Appendix #3 - AUSTRALIAN AMATEUR BAND PLAN (for main bands)



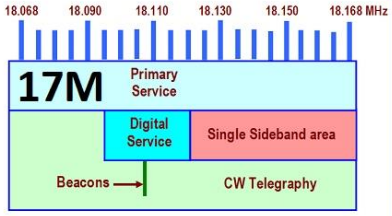



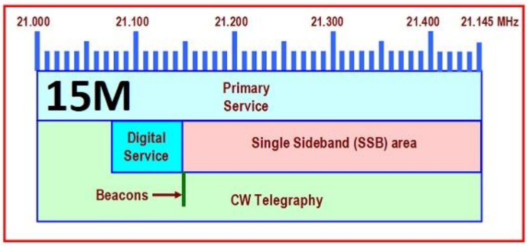



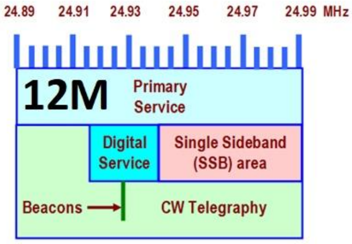

- Bands circled in Red are Foundation Qualification bands 10W max
- For brevity, bands below 160M and above 23cm are excluded here.

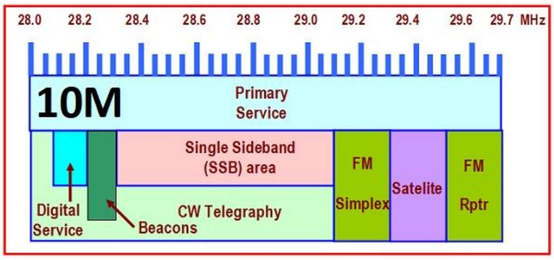
**FT8 Frequencies**

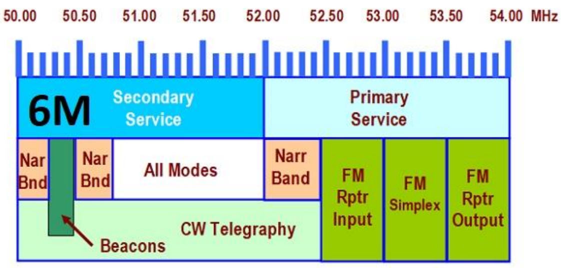
| | |
|---|---|
| 160 | 1.840 MHz |
| 80 | 3.573 MHz |
| 40 | 7.074 MHz |
| 30 | 10.136 MHz |
| 20 | 14.074 MHz |
| 17 | 18.100 MHz |
| 15 | 21.074 MHz |
| 12 | 24.915 MHz |
| 10 | 28074 MHz |
| 6 | 50.313 MHz |

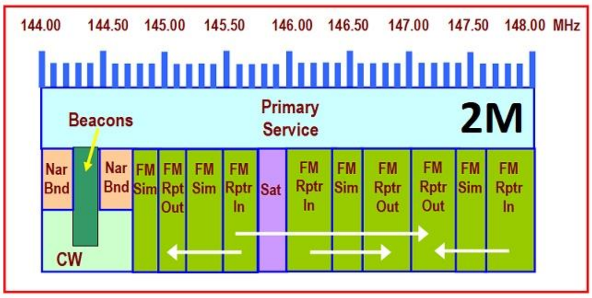


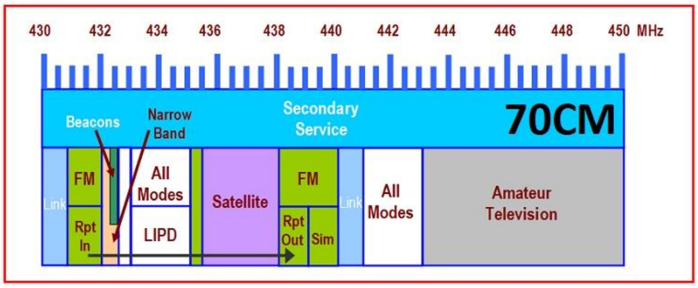



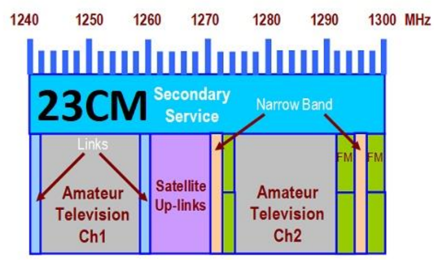



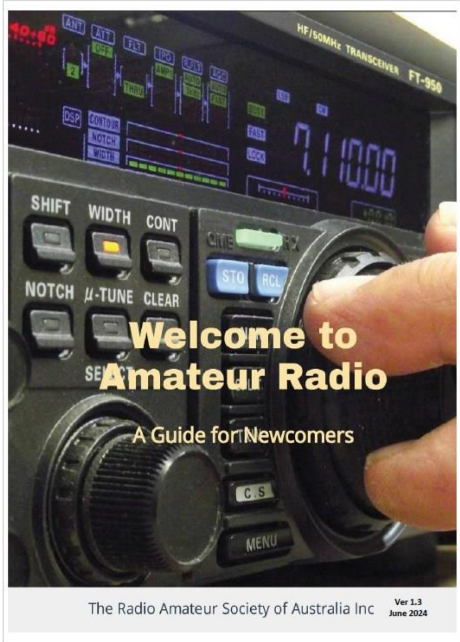



# Other free resources from the Radio Amateur Society of Australia

**These digital books in PDF form are available to members and non-members alike.**

## Welcome to Amateur Radio

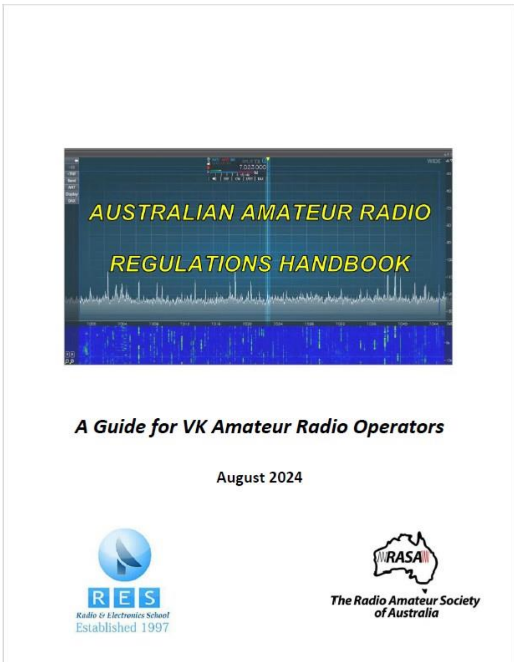
The Welcome to Amateur Radio book is a downloadable digital book aimed at the new Amateur operator faced with many questions on the practical aspects of getting on the air. It is the logical follow-on from successful Foundation exam candidates. Click **Here** to download




## VKReg Info Book

The ACMA website contains all of the regulations and procedures which govern our hobby. However, some of it is very rich with legal jargon and other details are scattered across multiple ACMA pages and documents. The VK Regs book details all of the latest rules and regulations on Amateur Radio, written in a friendly, readable form.

This book was updated in August 2024 to reflect the latest changes brought about from the transition to a Class Licence. Click **Here** to download

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# Free Networking page for Clubs & Groups conducting Amateur Radio Classes and Exams

**If your club or group is conducting training and exam sessions, you can have your contact details placed on this page for free. To advise about a service, or update details that appear here, send an email to info@vkradioamateurs.org**

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## VICTORIA

**Southern Peninsula Amateur Radio Club (SPARC)**
Down the Mornington Peninsula SPARC conducts regular classes at their clubrooms in the Vern Wright Reserve, Elizabeth Avenue, Capel Sound, on Saturdays from 12 noon until 2:00pm. Assessments for all levels of licence are also conducted at the clubrooms at mutually convenient times. For details regarding any of these activities, send an email to: **training@sparc.org.au**

**Frankston and Mornington Peninsula Amateur Radio Club (FAMPARC)**
In the South-Eastern suburbs of Melbourne FAMPARC conducts classes and exams from time to time. Follow this link for details: **https://www.vk3frc.org.au/foundation-license**

**Eastern Mountain District Radio Club (EMDRC)**
To Melbourne's North-East the EMDRC group conducts regular classes and assessments
Follow this link for details: **https://www.emdrc.com.au/foundation-licence-courses/**

**Amateur Radio Exam Service for Gippsland (DWExams)**
Free exam events are conducted at Drouin West on the 3rd Saturday of each month at 10:00 am.
7 days notice is required. Email: **dwexams@gmail.com** **Phone (03) 5644 3118**

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## WESTERN AUSTRALIA

**Western Australian Ham Radio Education (Ham College inc.)**
Ham College welcomes contact from everyone interested in training courses and exams. Training and assessments are carried out at regular intervals.
Follow this link for details: **https://www.hamcollege.org.au/contact-ham-college/**