Cambridge and District Amateur Radio Club (CDARC)

Foundation Licence in Amateur Radio

Slide Pack for courses from September 2024

Welcome to our Foundation Course in Amateur Radio.

We hope that you find it enjoyable and informative.

This slide set complements the teaching material in the course book "Foundation Licence Manual".

There is no such thing as "a daft question". If you do not understand anything that we say or demonstrate during this course please ask us to explain the point again or in another way.

Course Structure

The course runs over two days – 09:00 hrs. to 17:00 hrs. each day.

- Please help yourselves to tea and coffee whenever you want.

- Roughly half of the course is practical and half theoretical. The practical aspects will allow you to become familiar with the equipment we use and, subsequently, to be able to use it properly and with increasing confidence.

- The theory will give you a basic understanding of the protocols, the legislation and what is going on inside the equipment. It will also provide a good basis for further study and advancement to the Intermediate Licence.

"Don't Panic!" You will sit the examination at the end of the course. We will give you plenty of practice in exam technique and the type of questions that you will be asked. It is very straightforward.

Syllabus And Topics

Our course supplements the book "Foundation Licence Manual". This book in its turn is based around the syllabus for the Foundation Licence. (You can download the syllabus from the RSGB website.)

This slide set is available as a pdf from the CDARC website. At the bottom of each slide is the syllabus reference number telling you to which part of the syllabus the slide refers. The topics we will cover are:

Licensing	Technical Aspects	Transmitters and Receivers
Feeders and Antennas	Propagation at HF and Above	Electromagnetic Compatibility (EMC)
Operating Practices and Procedures	Safety	Measurement and Construction
Practical Assessments	Questions and Answers	Examination Techniques and Likely Questions

My Maths Is A Bit Rusty.....

Addition, subtraction, multiplication, and division.

Simple fractions and their decimal equivalents.

Multiple and sub-multiple units from micro to Giga.

Conversion of numbers from 10^{-3} to 10^{9} to/from decimal.

Understanding of simple formulae *[eg I=V/R]* and how to rearrange them to make any parameter the subject of the formula *[eg V=I x R]* .

Rigging The Antenna
And
Building The Station

- We are now going to go outside and rig the antenna that we will be using today.

- We will then connect the station components together ready for the practical assessments. (You will all have an opportunity a little later on to do this individually as part of your practical assessments.)

Section 1

Licensing

Nature Of Amateur Radio

The amateur radio licence is solely for:

- Self Training in radio communications;
- Experimentation.
- The licence is not commercial and may not be used for business or advertising.
- You may not broadcast.

Nature of Amateur Radio

- Technical innovation.
- Recreational activity.
- Emergency communications. RAYNET

In addition the licence requires the amateur station to support the User Services upon request or during a civil emergency. (Fire, Police, Local Authority etc.)

- Promotion of international friendship.
- Repeaters, ATV, Data, Beacons, Satellite.
- Awards, QSL Cards, Special Event Stations, RSGB, RadCom, Local Clubs, Rallies, Contests.
- DX Expeditions.
- SOTA, IOTA.

Ouse Washes Event
Typical RAYNET Deployment



Types of Amateur Licence

There are three classes of Amateur Radio Licence:

- The Foundation Licence;
- The Intermediate Licence;
- The Full Licence.

Geographical Boundaries

The Licensee is authorised to:

(a) establish, install and use the Radio Equipment in and over the United Kingdom, the Channel Islands and the Isle of Man in each case including their territorial sea; and

(b) use the Radio Equipment aboard any ship or aircraft registered in the United Kingdom, the Channel Islands or the Isle of Man in international waters or airspace. *(With the permission of the master of the vessel.)*

Foundation Licence

Foundation Licencees:

- Are generally limited to a maximum of 25 Watts of RF output,
- Do not have access to all UK amateur frequencies,
- May not build or modify their own (active) equipment. (eg transmitters)

Intermediate Licence

Intermediate Licencees:

- Are generally limited to a maximum of 100 Watts of RF output,
- May construct or modify their own transmitters.

Full Licence

Full Licencees:

- Are generally limited to a maximum of 1000 Watts of RF output on primary bands,
- May construct or modify their own transmitters,
- May operate abroad in CEPT signatory countries.

You May Not Broadcast

You may not transmit for general reception. (This is what the BBC does for example.)

You must establish contact with another licensed amateur before passing any messages or information to that person.

A CQ call is not broadcasting as you have to do this before you can establish contact with an individual. It is an intent to establish contact.

When talking in a "net" with several other amateurs you are not broadcasting as each member of the net has established individual contact when joining the net.

Change of Address etc.

Your station is registered to your home address (usually) or some other fixed, permanent address. If you change your registered station address you must inform OFCOM immediately in writing.

Once every five years you must confirm that the details shown on your licence remain correct. (Revalidation)

OFCOM can revoke your licence if you are in breach of the licence conditions or if you fail to revalidate your licence within the five year period.

On-Air Station Identification

When transmitting you must clearly identify your station with its call sign:

- When you change frequency.
- When you change mode or the type of transmission. (eg from Morse to speech.)
- If there is a change of supervisor. (For example if you, as a Foundation Licence holder, are operating a club station under supervision.)
- If you move from one UK region to another.
- As often as is reasonably practical. (Generally at least once every fifteen minutes is a good rule of thumb.)

Whom May I Contact?

- You may only communicate with (send messages to) other, licenced amateurs.

Secret Codes

- You may not transmit encrypted messages.

This means that your messages must be either "en clair" (ordinary speech) or using some kind of publicly available code. (For example: Morse code, PSK31, etc.) The message must not be obscured.

Under very specific circumstances when operating on behalf of a user service you may be required to send an encrypted message.

Airborne Operation

This is limited to 0.5W on the primary bands only.

Who May Use The Equipment?

"The Radio Equipment may be used by the Licensee or by any person who has the permission of the licensee to do so and who is under the direct supervision of the Licensee."

and

"When the Radio Equipment is used by a person other than the Licensee, the Licensee: a) must ensure all users are made aware of and comply with the terms, conditions and limitations of the Licence; and b) remains responsible for the operation of the Radio Equipment and compliance with the terms, conditions and limitations of the Licence"

Format of UK Call Signs

Basic, UK amateur call signs follow a recognizable format:

G – # – number – letter – letter – (letter)

M – # – number – letter – letter – letter

2 – # – number – letter – letter - letter

"G" Call Signs

G – # – number – letter – letter – (letter)

The first UK call signs all started with a "G". These have all now been allocated. After the letter "G" there is a place holder [#]. This may be filled by a:

REGIONAL SECONDARY LOCATOR.

This regional secondary locator is a letter identifying from where in the UK the licencee is currently operating. It fits in the place holder.

The Regional Secondary Locator Letters are:

England:	E
Wales:	W
Scotland:	M
Northern Ireland:	I
Isle of Man:	D
Jersey:	J
Guernsey:	U

Very early G call signs may only have two letters following the number in the call sign. For example: G2XV

"G" Call Sign Example

All "G" call signs are full licence holders.

GE6KWA

G This indicates a UK, full licence holder;
E The E (optional) following the G shows that the licence holder is operating in England;
6 Full licence holder;
KWA Three, arbitrary letters in the range AAA to ZZZ (Excluding offensive combinations!)

“G” Call Sign Example (cont)

GE6KWA goes on holiday to Wales and transmits from his holiday cottage. Because he is now in Wales he adds the appropriate (optional), regional secondary locator – W.

His call sign whilst he is in Wales is now:

GW6KWA

Similarly, if he transmits from Scotland his call would become GM6KWA and so on with the other regions.

“M” Call Sign Example

M – # – number – letter – letter – letter

“M” call signs starting MEØ, ME1 or ME5, are full licence holders.

MEØDCV

M	This indicates a UK, full licence holder;
E	Operating from England;
Ø	Full licence;
DCV	Three, arbitrary letters in the range AAA to ZZZ (Excluding offensive combinations!)

M Call Sign Example (cont)

MEØDCV goes on holiday to Jersey and transmits from his holiday cottage. Because he is now in Jersey he changes to the appropriate, regional secondary locator – J.

His call sign whilst he is in Jersey is now:

MJØDCV

Similarly, if he transmits from Northern Ireland his call would become MIØDCV and so on with the other regions.

“2” Call Sign Example

2 – # – number – letter – letter - letter

Intermediate call signs are slightly different. The regional identifier is mandatory. The number in the call sign may be Ø or 1.

2EØABC

2E This indicates a UK, Intermediate licence holder operating in England;

Ø An intermediate licence

ABC Three, arbitrary letters in the range AAA to ZZZ (Excluding offensive combinations!)

“2” Call Sign Example (cont)

2E1XYZ goes on holiday to The Isle of Man and transmits from her holiday cottage. Because she is now in the Isle of Man she adds the appropriate, regional secondary locator – D.

Her call sign whilst she is in the Isle of Man is now:

2D1XYZ

Similarly, if she transmits from Guernsey her call would become 2U1XYZ and so on with the other regions.

OFCOM will not issue any further 2# licences.

Future Intermediate Licences will be in the series M8 and M9.

Foundation Call Signs

Foundation call signs start with an "M". They commence with either:

ME3, or

ME6, or

ME7.

They follow the same rules. For example:

ME3ABC, MM6XYZ, MD7RST, MI3KRT etc

Quick Test

MEØDCV uses this call sign when transmitting from which part of the UK?

MEØDCV goes to the Isle of Man. His call sign there would be?

MEØDCV travels from the Isle of Man to Aberdeen. What is his call sign there?

2JØABC is transmitting from where in the UK?

Just For Interest……

Very occasionally you may hear a valid UK call sign that does not comply with the foregoing.

These are generally "short-form" call signs used by contest groups.

For example:

M4A

You are unlikely to be examined on these (very few) odd call signs.

Typical Optional Suffixes

You can add these to the end of a call sign to indicate that you are somewhere else other than your registered address - or if you are operating from some sort of vessel or vehicle.

/P (Pronounced “Stroke Portable”)

/A (Pronounced “Stroke Alternative”)

/M (Pronounced “Stroke Mobile”)

/MM (Pronounced “Stroke Maritime Mobile”)

Typical Optional Suffixes (cont)

/P (Pronounced "Stroke Portable). This is where you are operating from a location without a postal address (Post Code). For example: on a mountain, or from a beach.

/A (Pronounced "Stroke Alternative"). This is where you are operating from a location with a postal address. For example: from Foxton Village Hall.

/M (Pronounced "Stroke Mobile"). This is where you are moving as you operate. For example: in a car, on a bicycle or on foot.

/MM (Pronounced "Stroke Maritime Mobile"). Operation from a vessel in tidal waters.

Optional Suffixes - Examples

GE2XV/A

GE2XV/P

GW2XV/M

MEØIPO/MM

Periodic Station Tests

The licencee must, from time to time, check that his/ her station is not causing undue interference to other users of the spectrum.

OFCOM has the right to send a duly authorised person to inspect the radio equipment. That person has the right to inspect, require the modification or closedown of the equipment.

As part of the investigation into any interference issues OFCOM may require the licencee to keep a log of all transmissions for a specified period of time.

Reciprocal Licencing

Other, overseas administrations do not routinely recognise the Foundation Licence.

At the time of writing you may only operate within the UK with a Foundation Licence.

The Schedule To The Licence

Your licence contains an important section known as *"The Schedule To The Licence"*. This is a legal document.

The schedule defines :

- The frequency bands that you may use;
- The power levels at which you may transmit;
- Geographic exceptions where you may not transmit.
- Acceptance of interference from other, primary users on some bands.

You will receive a copy of the schedule for the exam. You will need to know how to extract information from it.

The schedule is *really important* and you must observe its requirements.

Section 2

Technical Aspects

A Short Mathematical Detour

Maths Revision

Fractions and decimal equivalents:

To convert a fraction to its decimal equivalent use a calculator to divide the numerator by the denominator. *In other words simply divide the number on top of the line by the number under the line.*

For example:

¼ = 1 divided by 4 which equals 0.25
½ = 1 divided by 2 which equals 0.5
¾ = 3 divided by 4 which equals 0.75

13/64 = 13 divided by 64 which equals 0.203125

micro (μ) to Giga (G)

You need to know these:

micro	μ	one millionth	1/1,000,000
milli	m	one thousandth	1/1,000
kilo	k	a thousand times	x 1000
Mega	M	a million times	x 1,000,000
Giga	G	a thousand million times	x 1,000,000,000

10 microfarads	= 10/1,000,000 ths of a Farad	10μF
8 millihenries	= 8/1,000 ths of a Henry	8mH
3.3 kilohms	= 3,300Ω	3k3Ω
7.1 Megahertz	= 7,100,000 Hz	7.1MHz
1.2 GHz	= 1,200,000,000 Hz	1.2GHz

(One thousand two hundred million)

Powers of Ten

Large and small numbers are best expressed as powers of ten. This makes calculations easier when dealing with such numbers.

$10 \times 10 = 100$	Ten times itself twice
$10 \times 10 \times 10 = 1000$	Ten times itself three times
$10 \times 10 \times 10 \times 10 = 10{,}000$	Ten times itself four times

etc.

10×10 is written as 10^2
$10 \times 10 \times 10$ is written as 10^3
etc.

$1 / 10 = 0.1$	Written as 10^{-1}
$1 / 100 = 0.01$	Written as 10^{-2}
$1 / 1000 = 0.001$	Written as 10^{-3}

Powers of Ten

To multiply using powers of ten you simply add the indices.

$10^2 \times 10^3 = 10^5$ $100 \times 1000 = 100{,}000 = 10^5$ (3 + 2)

To divide using powers of ten you simply subtract the indices.

$10^4 / 10^2 = 10^2$ $10{,}000 / 100 = 100 = 10^2$ (4 – 2)

For example: 3k3 x 47µF

$(3.3 \times 10^3) \times (47 \times 10^{-6})$

155.1×10^{-3}

This may also be written as 0.551

Back To The Main Road!

The Charge Carrier

All matter is made up of atoms. Atoms comprise:

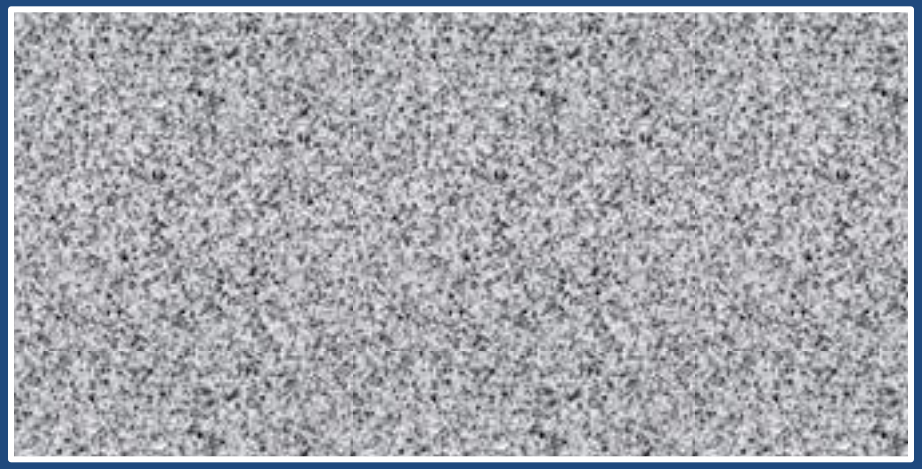
- Protons;
- Neutrons;
- Electrons

Electrons carry a unit negative charge. Protons carry a unit positive charge. Atoms have an equal number of electrons and protons. Overall they are electrically neutral.

Not all matter is the same. The universe comprises metals, non-metals, liquids, gases. They all contain Protons, Neutrons and Electrons. *Why do metals conduct electricity and non-metals do not?*

It's all due to the number of *free electrons* in the material that are not closely bound to a parent atom

Conductors and Insulators



CONDUCTOR:

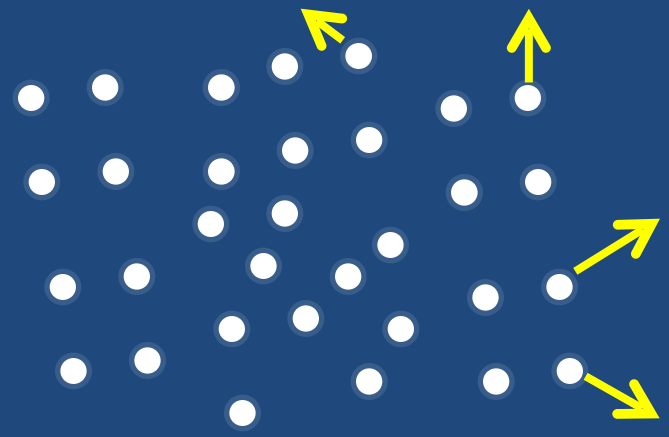
The conductor has lots of free electrons within the atomic lattice. These will move under an applied voltage and constitute a current.



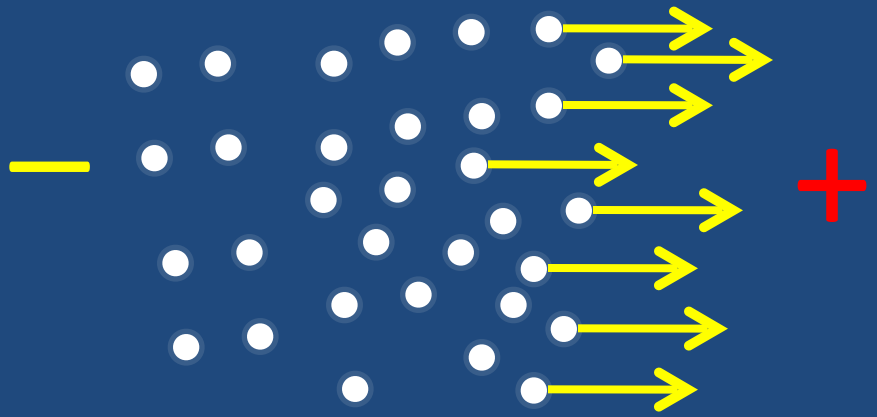
INSULATOR:

The insulator has hardly any free electrons within its lattice. There are thus no free charge carriers to move under an applied voltage. No current will flow.

Applying A Voltage



With no voltage applied to a conductor the free electrons just move randomly.
Their net motion is zero – hence no current flows



Applying a voltage across the conductor causes the electrons to move in the same direction – a flow of current.

The Circuit

Every electrical circuit has to form a closed-loop.

• For a current to flow in the conductors or components a source of electrical pressure (eg a battery) has to be applied across them.

• This source of electrical pressure causes the free electrons (charge carriers) in the conductors and the components to flow or move.

• The charge carriers move because there is an applied potential gradient across the conductor or component.

• The source of electrical pressure does not provide the charge carriers – they already exist in the circuit – but rather it causes them to circulate. (The battery is in effect a “charge pump”.)

• Thus to sustain operation you need a closed-loop or circuit to provide the charge carriers with a path around which the charge pump can circulate them.

The Ampère

The Ampère is the unit of current flow.

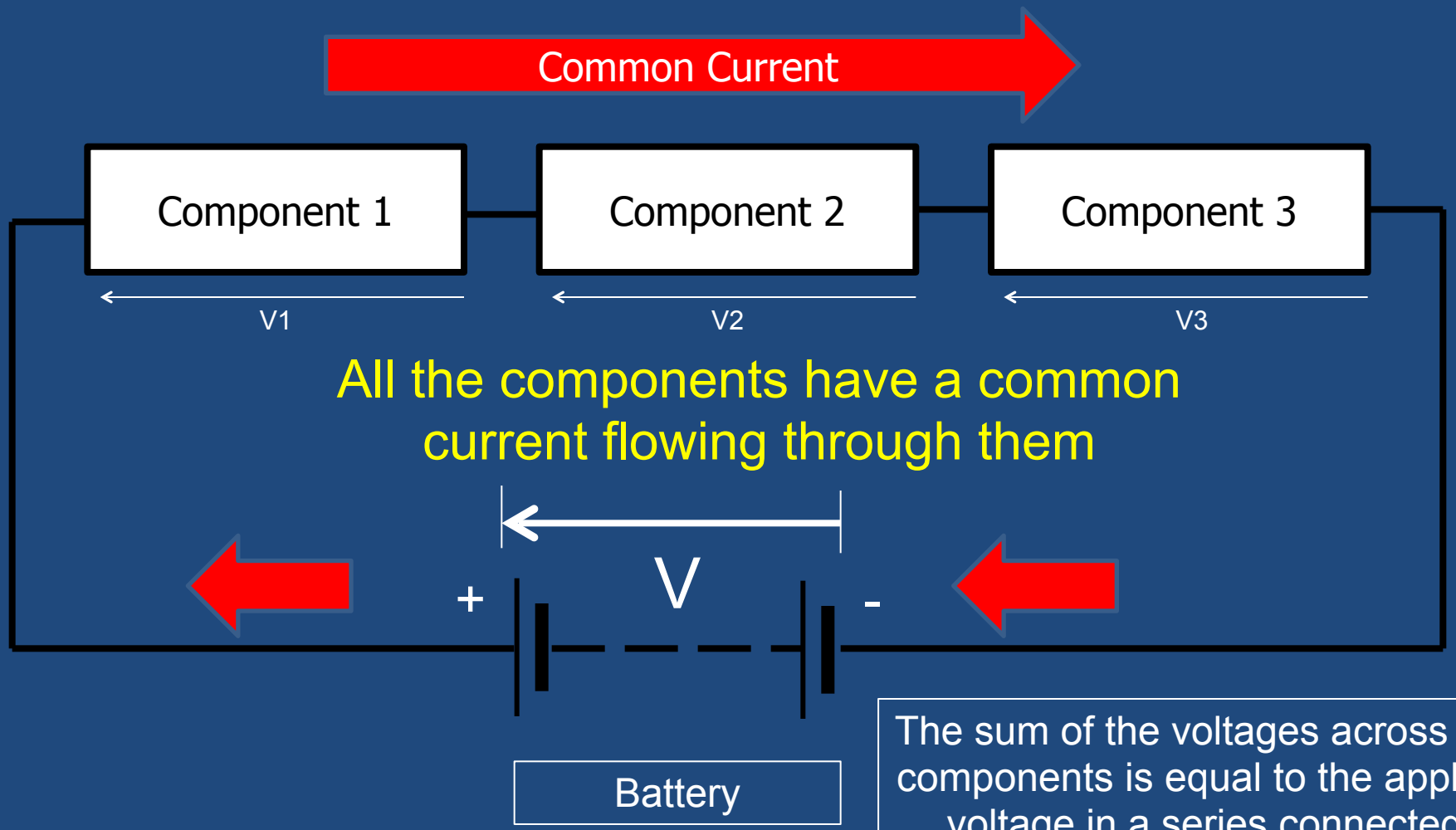
It is equal to a flow of one Coulomb of charge per second. In terms of electrons flowing past a boundary it is:

6.2415093×10^{18} elementary charges moving past a boundary in one second

The Volt

The Volt is the unit of electrical potential causing electrons (charge carriers) to all move coherently in a single direction.

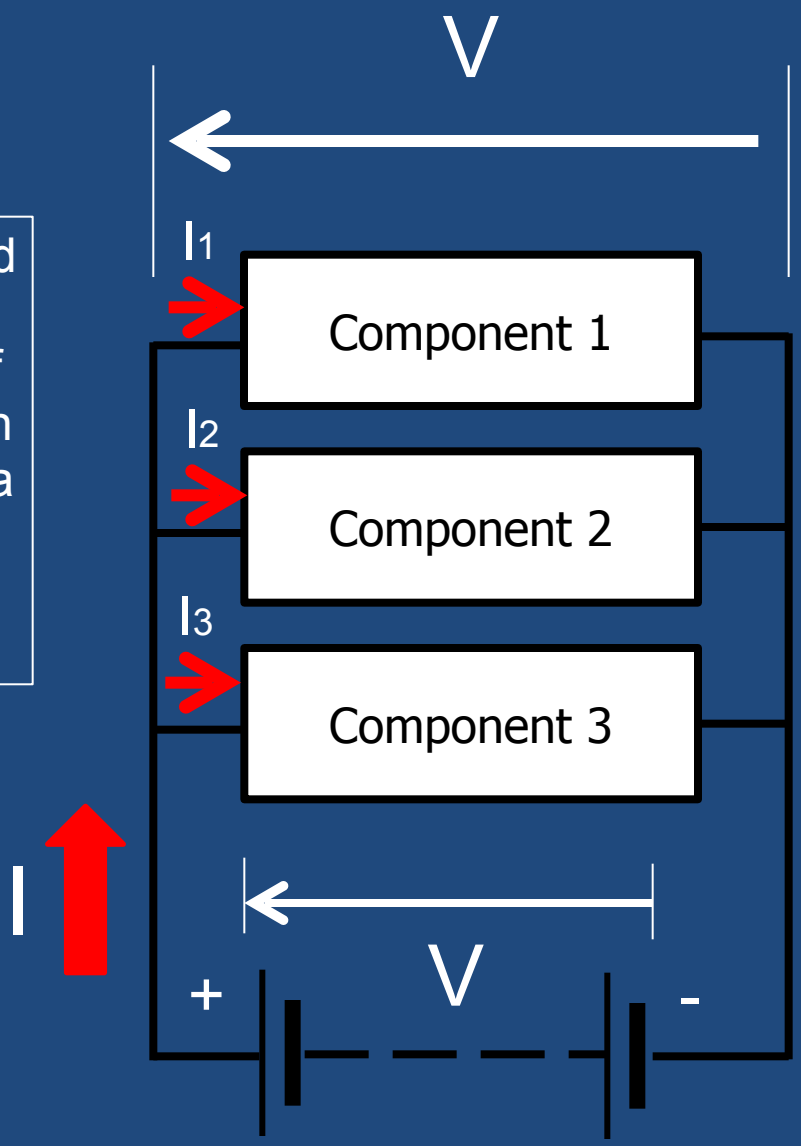
The Series Connected Circuit



The sum of the voltages across the components is equal to the applied voltage in a series connected circuit. ($v_1+v_2+v_3$) = V

The Parallel Connected Circuit

The current supplied by the battery is equal to the sum of the currents through the components in a parallel connected circuit.
$(I_1+I_2+I_3)=I$



All the components share a common voltage

Electrical Power (W)

- Power is the rate at which electrical energy is dissipated as heat in a load resistance.
- Power is measured in Watts.
- Electrical power is only dissipated by resistance.
- In a dc circuit the power being dissipated in a resistance (or circuit) is equal to the current through the resistance (or circuit) multiplied by the voltage across the resistance (or circuit).

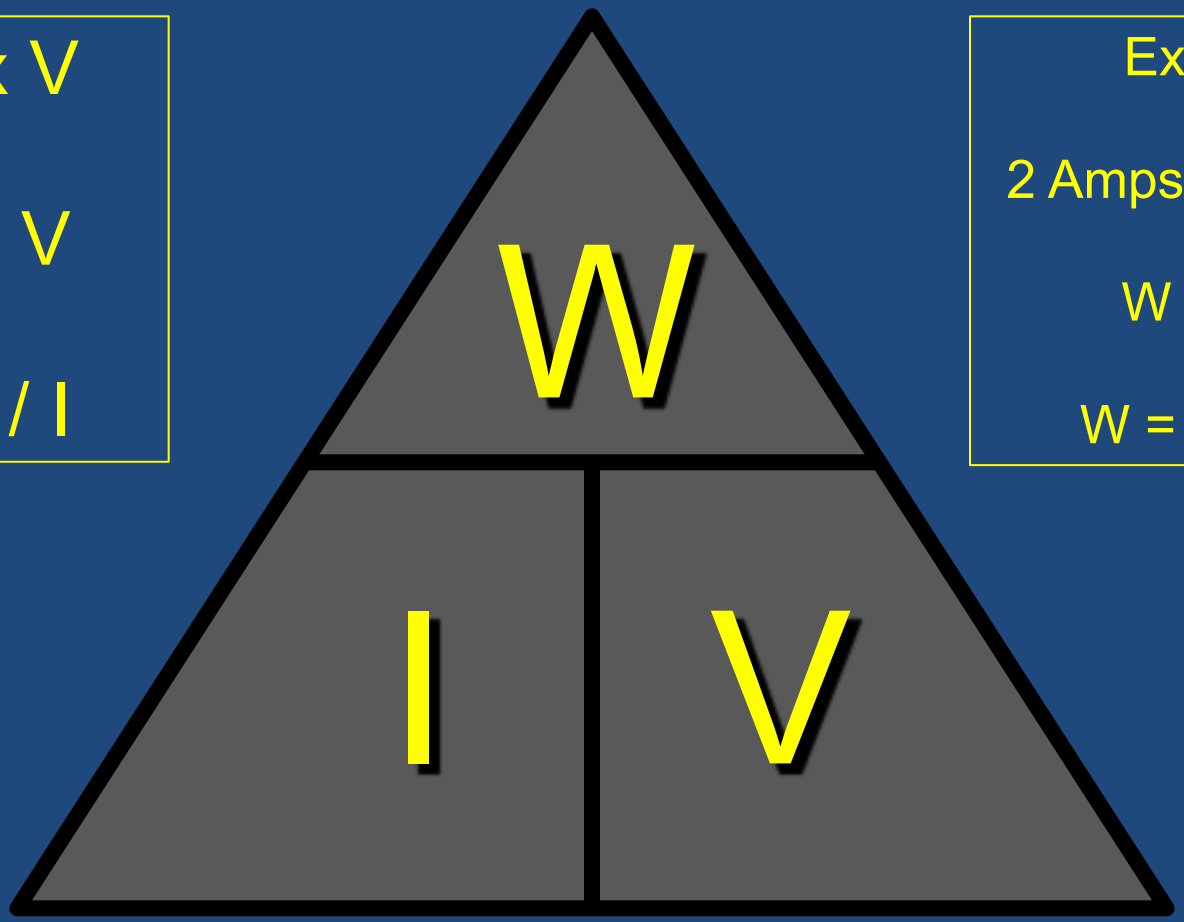
$$W = I \times V$$

“Power Triangle”

W = I x V

I = W / V

V = W / I



Example:

2 Amps and 5 Volts

W = 2 x 5

W = 10 watts

Ohm's Law

The Voltage (V), Current (I) and Resistance (R) are linked by a fundamental electrical engineering law.

This law is called:

Ohm's Law

Ohm's Law

Ohms Law states that:

The current flowing through a resistance is directly proportional to the applied voltage.

Ohm's Law

Ohms Law can best be written mathematically as:

$$V = I \times R$$

Where:

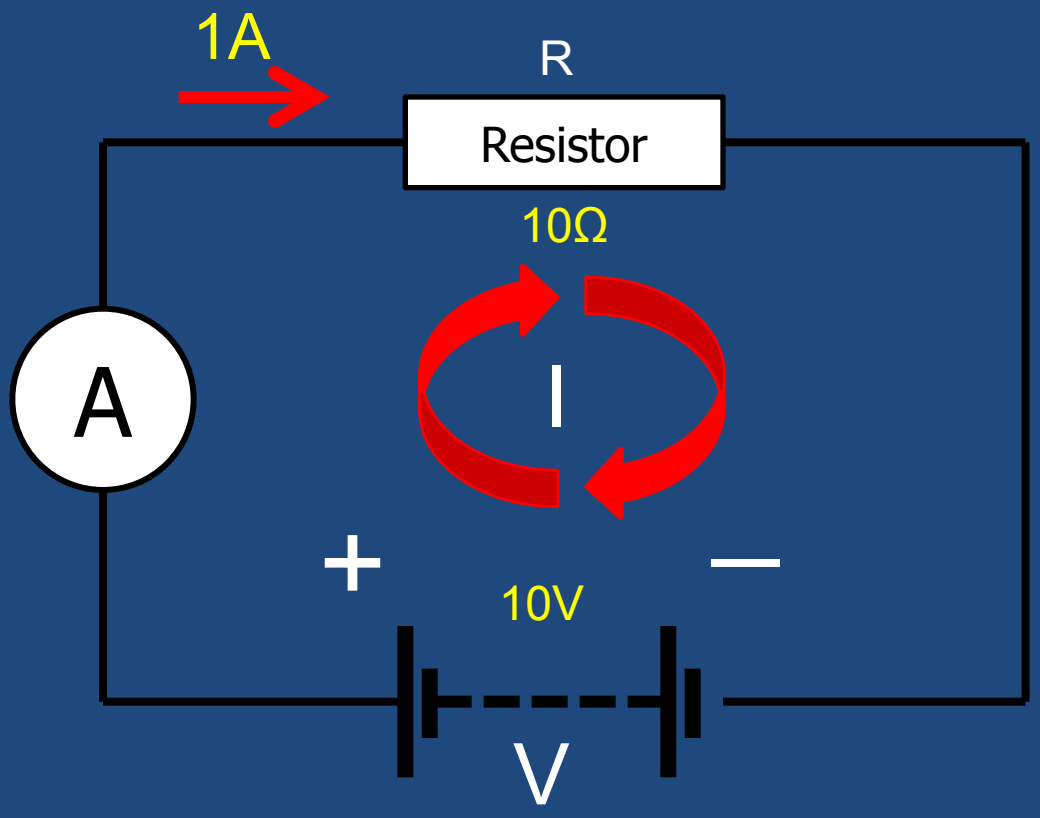
V is the voltage, (Expressed in Volts)

I is the current, (Expressed in Ampères)

R is the resistance. (Expressed in Ohms)

So – what does this mean…….?

This Means:



$$V = I \times R$$

A Battery with a voltage V is connected across a Resistor (R) in a simple circuit.

There is an Ammeter (A) in the circuit which will measure the current (I) which flows.

If the resistor is 10 Ohms and the battery voltage is 10 Volts then 1 Ampere of current will flow.

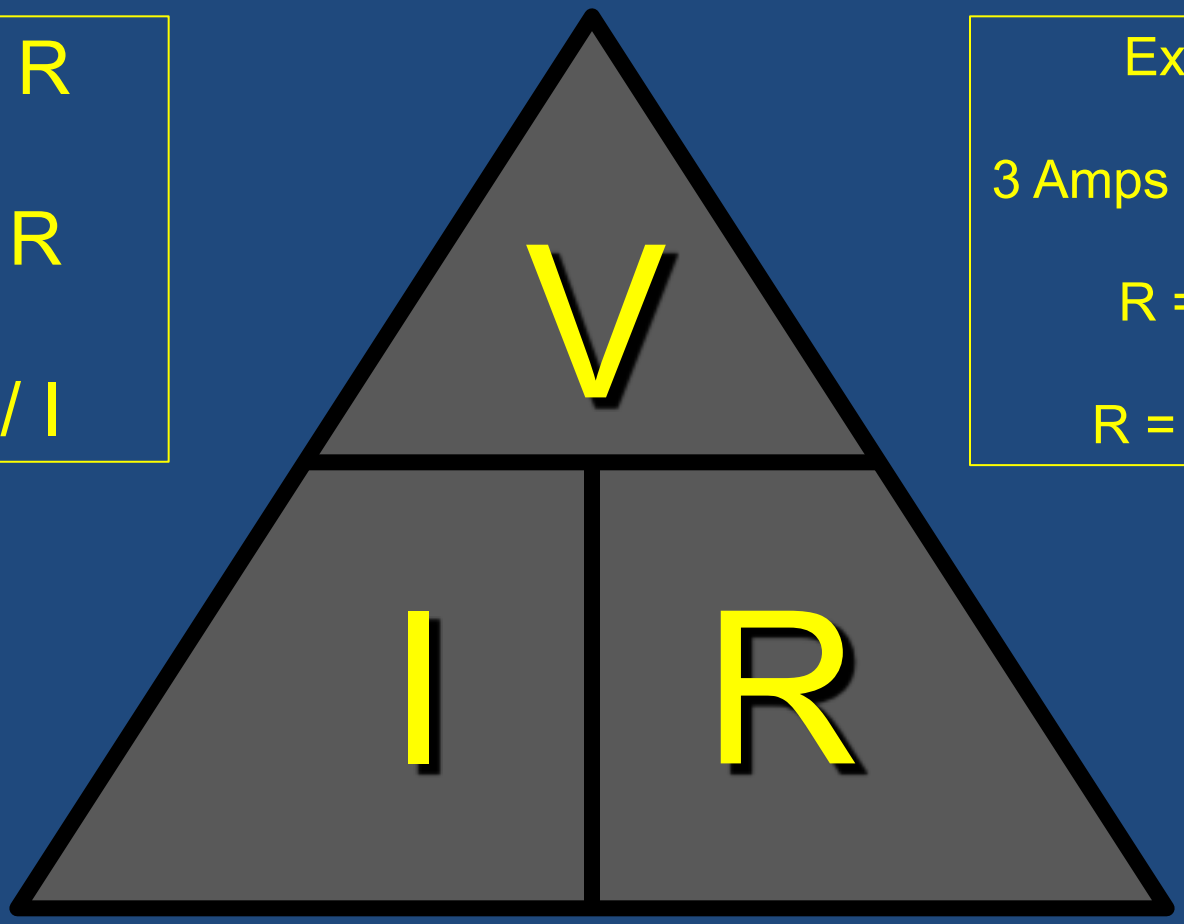
If the Battery voltage is increased to 20 Volts then 2 Amperes of current will flow.

“Ohm’s Law Triangle”

V = I x R

I = V / R

R = V / I



Example:

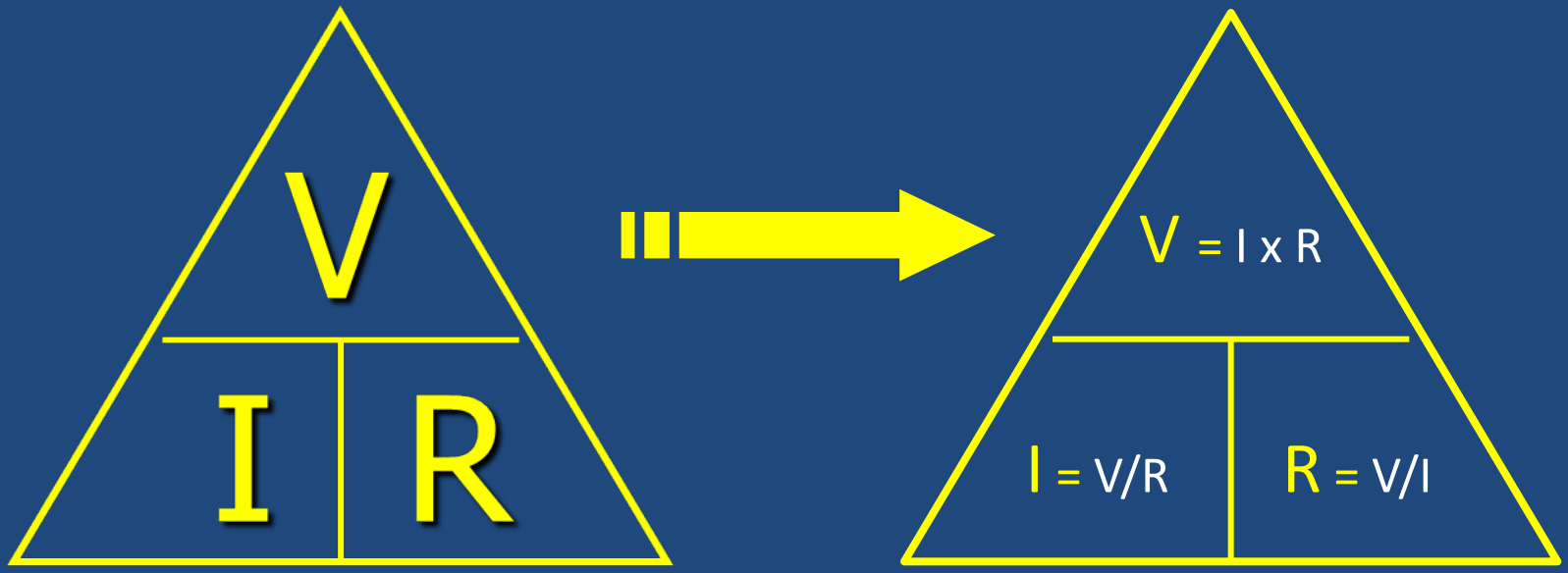
3 Amps and 15 Volts

R = 15 / 3

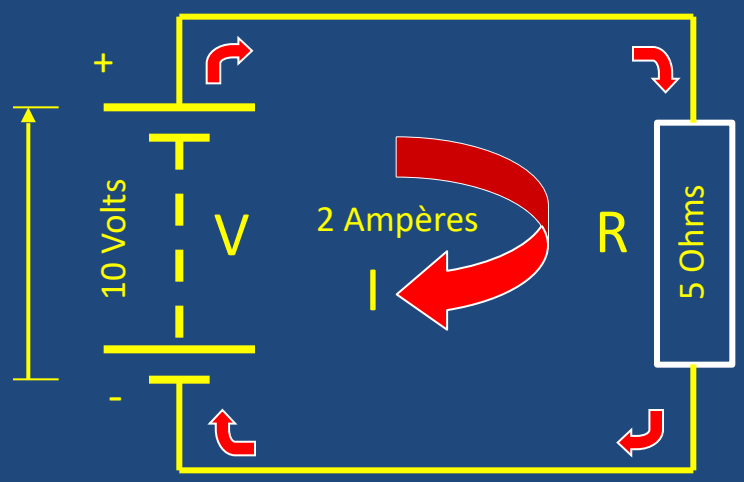
R = 5 Ohms

Manipulating The Equation

$$V = I \times R$$



Ohm's Law Example



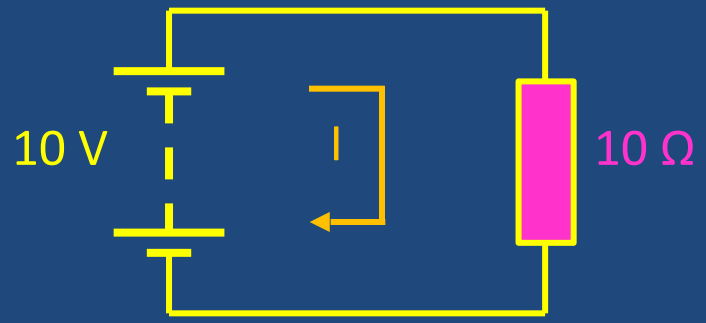
A 10 Volt battery when connected across a 5 Ohm resistor to form a circuit will cause a current of 2 Amps to flow from the battery, through the resistor and back to the battery.



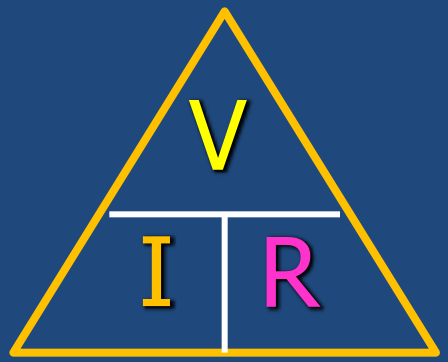
$V = I \times R$

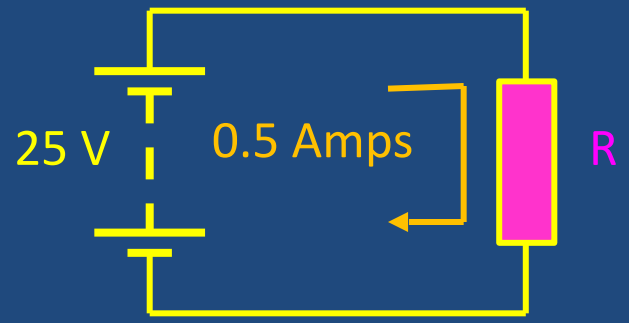
$10 = 2 \times 5$

Ohm's Law – Quick Examples

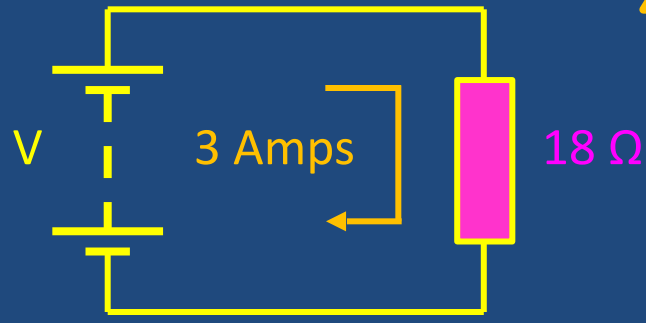


I = ?

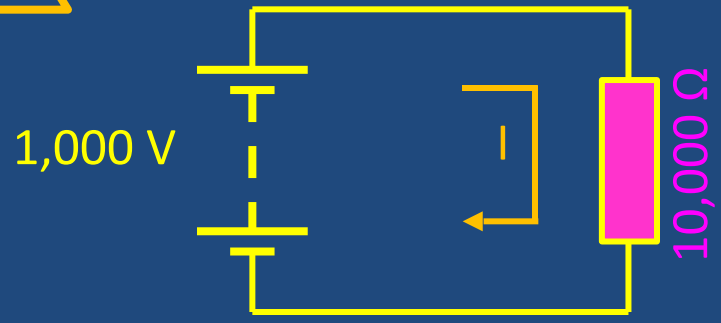




R = ?

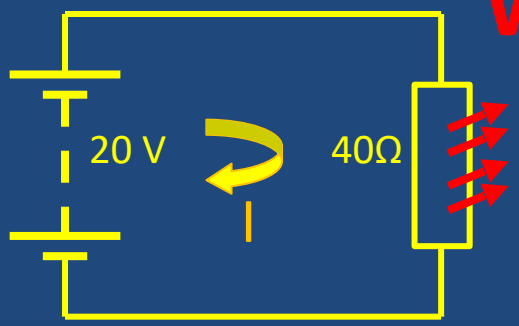


V = ?



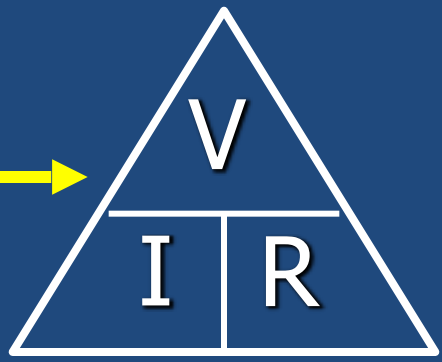
I = ?

Power - Quick Example



W = ?

Use Ohms Law to calculate the current I which the battery drives through the resistor



I = V/R

I = (20 / 40)

I = 0.5 Amperes

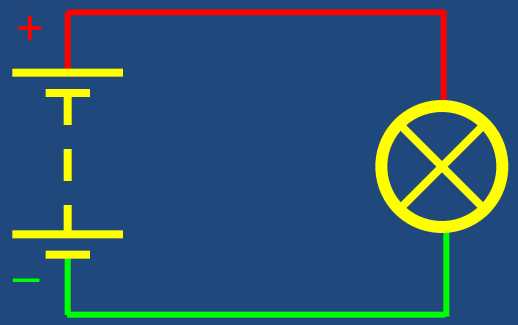
Now we know the current and voltage we can calculate the Power dissipated by the resistor

W = I x V

W = 0.5 x 20

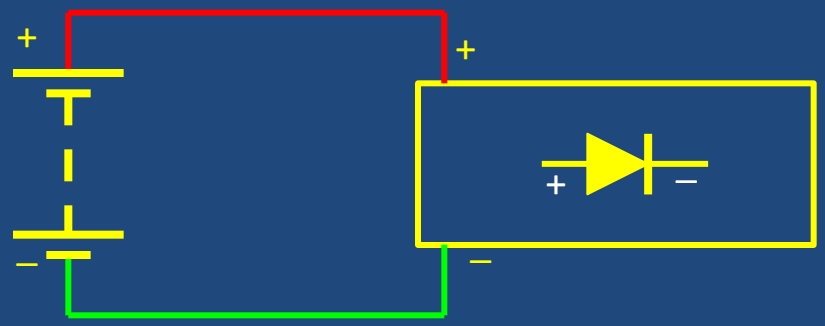
W = 10 Watts

Polarity



A battery has a positive and a negative terminal.

When connected to a purely resistive load – such as a filament lamp in a torch - it does not matter which way round you connect the load to the battery.



However, if you connect a dc supply to a device containing semiconductors (eg. Your radio) you must observe the correct connection polarity.

Semiconductor devices may be destroyed if you connect them with reverse polarity. (eg. Your radio.....!)

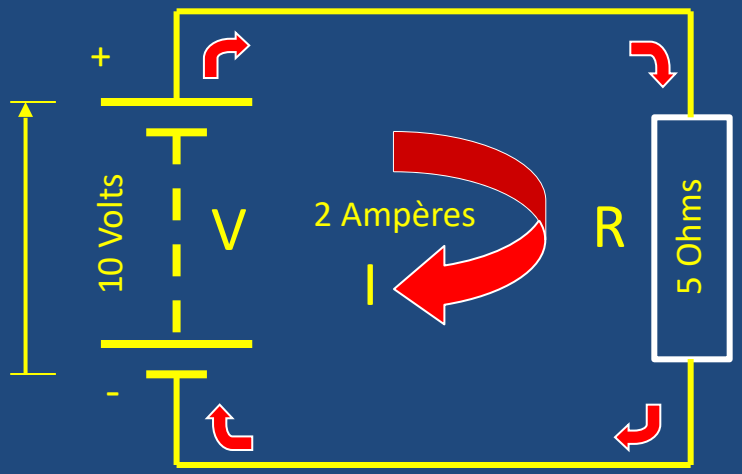
Direct Current (DC)

A Direct Current (DC) is a current which flows continuously in one direction only.

A battery provides a direct current – as does the DC Power Supply Unit (PSU) which powers the Tx/Rx.

In the circuit shown the current flows in one direction. It would flow clockwise around the circuit. (Conventionally).

In order to get it to flow counter-clockwise you must reverse the battery connexions.



Alternating Current (AC)

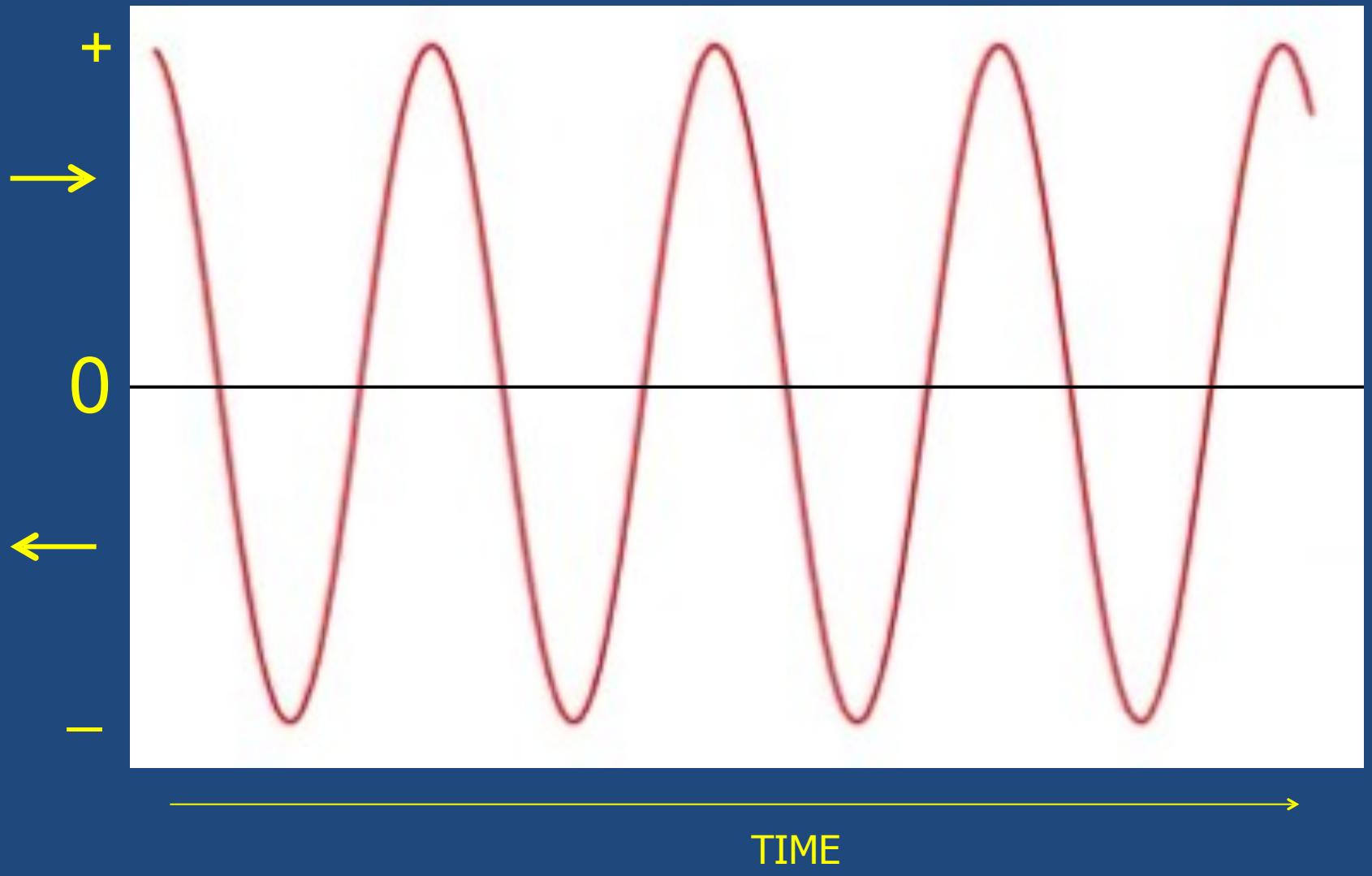
An Alternating current is a current that continually reverses direction. Usually, but not necessarily, an AC current is depicted as a sine wave shape.

For example the UK mains supply is:

230 Volts AC 50 Hertz. (230V ac 50Hz)

This means that it reverses its direction fifty times each second.

The Sine Wave



Radio Frequency (RF)

Radio frequency (RF) waves extend below 30kHz to well above 3000MHz (3GHz).

RF waves are electro-magnetic waves which travel at the speed of light which is very nearly:

300 million metres per second.

(300,000,000 m/s).

Audio Frequency (AF) waves are pressure waves in the atmosphere which travel at about 330 m/s

The Relationship Between Frequency, Wavelength and Velocity

Frequency is the number of oscillations that a wave makes each second.

Frequency is measured in Hertz (Hz)

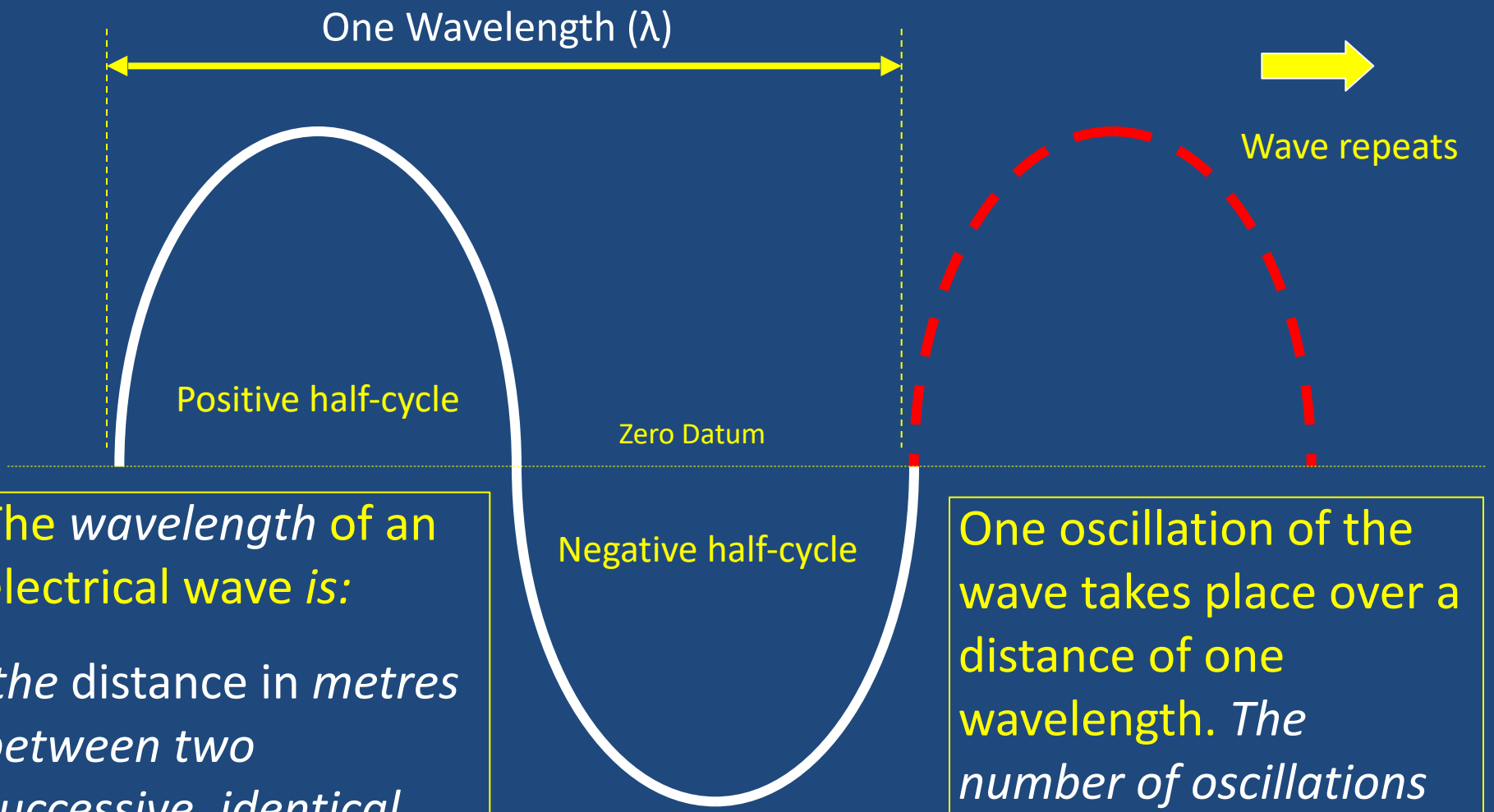
Wavelength is the distance in metres between successive identical points on a wave.

Wavelength is measured in metres (m)

Velocity is the rate at which a wave moves through free space.

Velocity is measured in metres per second (m/s)

Frequency and Wavelength



The *wavelength* of an electrical wave *is:*

the distance in *metres between two successive, identical points*.

One oscillation of the wave takes place over a distance of one wavelength. *The number of oscillations each second is the frequency (Hz)*

Velocity of Electro-Magnetic Waves

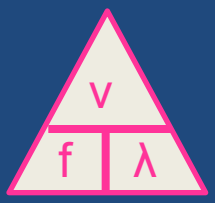
The velocity (v) of electro-magnetic waves in free space is the speed of light, or

300,000,000 metres per second

The three quantities: Frequency (f), Wavelength (λ) and Velocity (v) are related thus:

Velocity = Frequency x Wavelength

$$v = f \times \lambda$$



Classification of RF Waves

RF waves are grouped according to their frequency.

Very Low Frequency (VLF)	3kHz to 30kHz
Low Frequency (LF)	30kHz to 300kHz
Medium Frequency (MF)	300kHz to 3MHz
High Frequency (HF)	3MHz to 30MHz
Very High Frequency (VHF)	30MHz to 300MHz
Ultra High Frequency (UHF)	300MHz to 3GHz
Microwaves	3GHz and up.

Remember these

Sometimes microwaves are referred to as 1GHz and above.

Audio Frequency (AF)

The normal range of human hearing is conventionally between:

20Hz and 15kHz

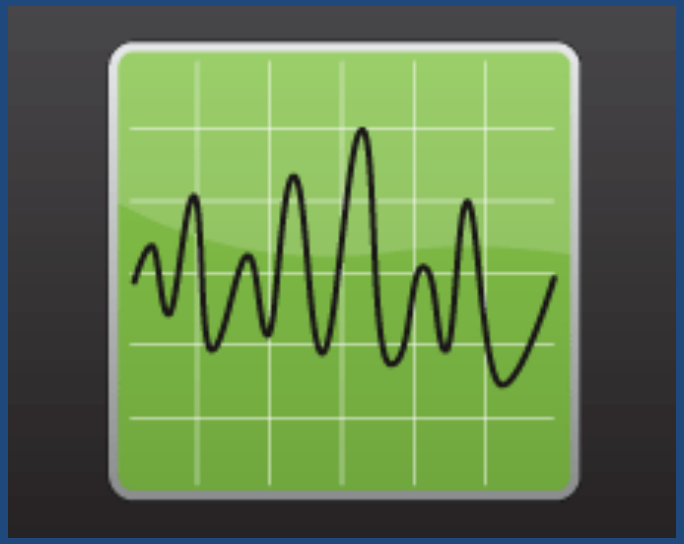
For effective audio communication we don't need this full range. We only need to transmit audio between:

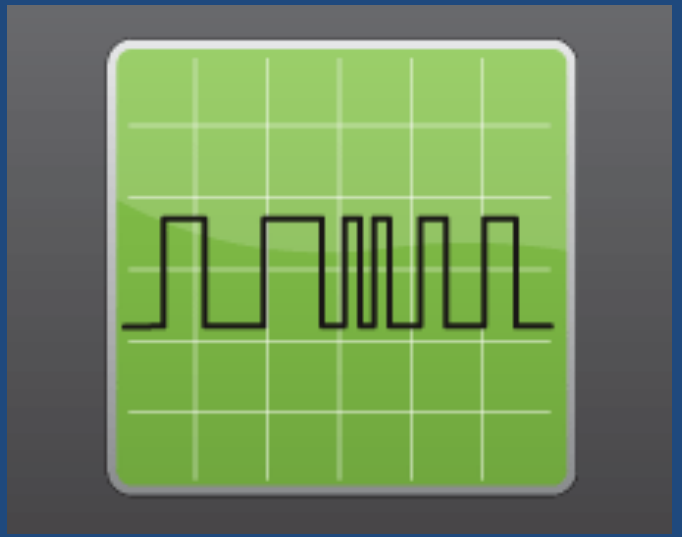
300Hz and 3kHz

Analogue and Digital Signals

Analogue signals are constantly changing in their frequency, amplitude or both.

Digital signals are a stream of finite values at a specific sampling rate.





Digital Signal Processing

With suitable software digital signals may be processed by a computing device.

Primary and Secondary Cells

Cells are either primary or secondary types.

Primary types cannot be recharged once their stored chemical energy has been converted to electrical energy.

Secondary cells – once depleted – can have their internal chemistry reversed. This is known as *"re-charging the battery"*

Once recharging is complete the cell can once again supply electrical energy.

Rechargeable cells can have several hundred charge-discharge cycles over their working life.

Do not leave re-chargeable cells in a discharged state for any lengthy period.

Batteries

Batteries convert stored *chemical energy* into electrical energy. A voltage exists between the terminals.

A *battery* comprises two or more *cells* in series or parallel. A fully charged lead-acid cell has a terminal voltage of 2.2 Volts. Six in series give 13.2 Volts.

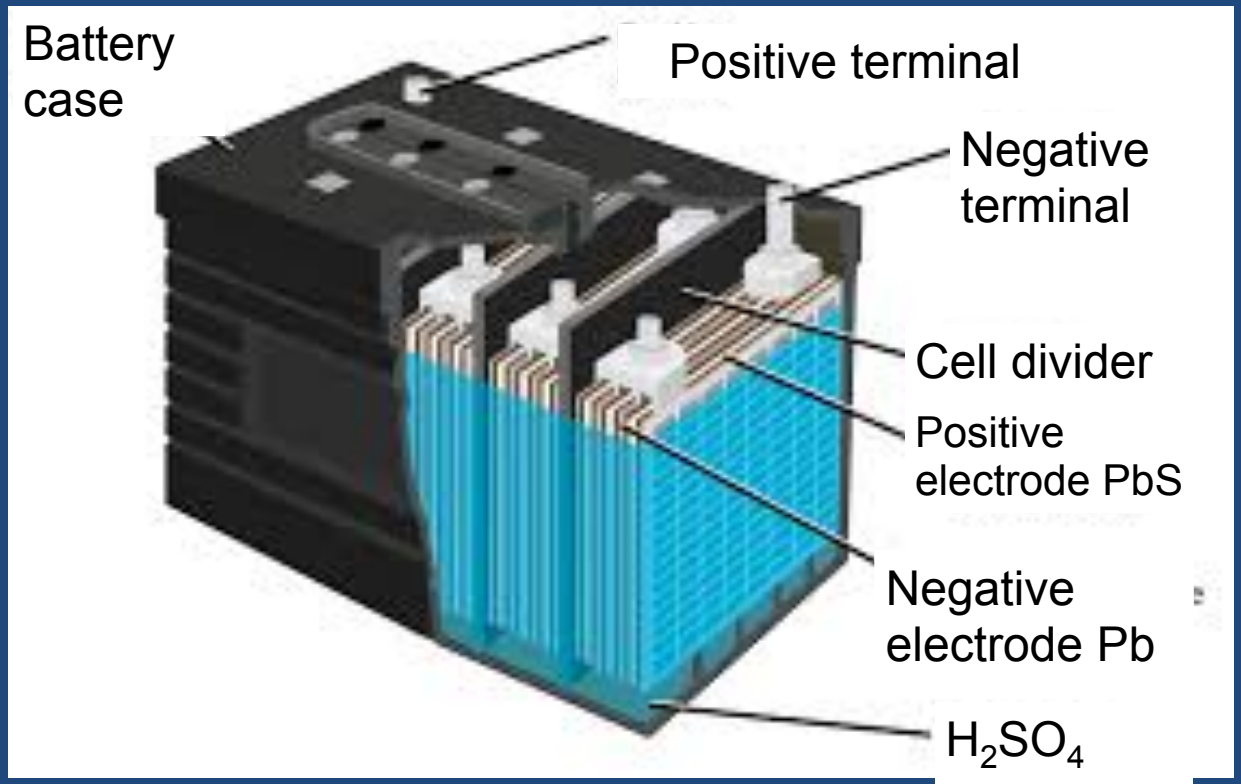
Batteries are usually connected in series to provide an increased output voltage.

Sealed Lead Acid and Lithium Ion batteries are commonly used. You may come across Nickel cadmium in older equipment.

Batteries


YUCEL
Y7-12
12V,7.0Ah C20
Valve regulated
lead-acid type
rechargeable battery
Pb


LG
Lithium Ion
Battery 3.7V


Battery case
Positive terminal
Negative terminal
Cell divider
Positive electrode PbS
Negative electrode Pb
H_2SO_4

Disposal and Safety

Cells and batteries are chemical devices. Dispose of them properly in accordance with your local authority regulations. Usually you have to dispose of them separately from other waste.

A sealed lead acid battery contains a substantial amount of energy. It also contains concentrated sulphuric acid.

Always use the correct charger for the battery in a well ventilated space and never short out the terminals.

For portable use always use a sealed lead acid battery. (Do not use the “wet” types with a liquid electrolyte.) Make sure that your battery is fused properly at the terminals.

Section 3

Transmitters and Receivers

(Plus Practical Assessments)

The Transmitter

The purpose of the transmitter is:

To convert *energy* from the DC power supply to *energy* at radio frequency.

To *impress information content* onto the radio frequency energy. (*Modulation*.)

To *transfer* the modulated information onto *an antenna* for radiation as electromagnetic waves from the transmitter site to a distant location.

Transmitter Block Diagram

RF Oscillator

This is the generator of the radio frequency (RF) which is to be transmitted and which will act as the carrier of the information such as the Morse, speech or television signal (video).

AF Amplifier

This is a simple audio frequency (AF) amplifier which raises the level of the signal from the microphone.

Modulator

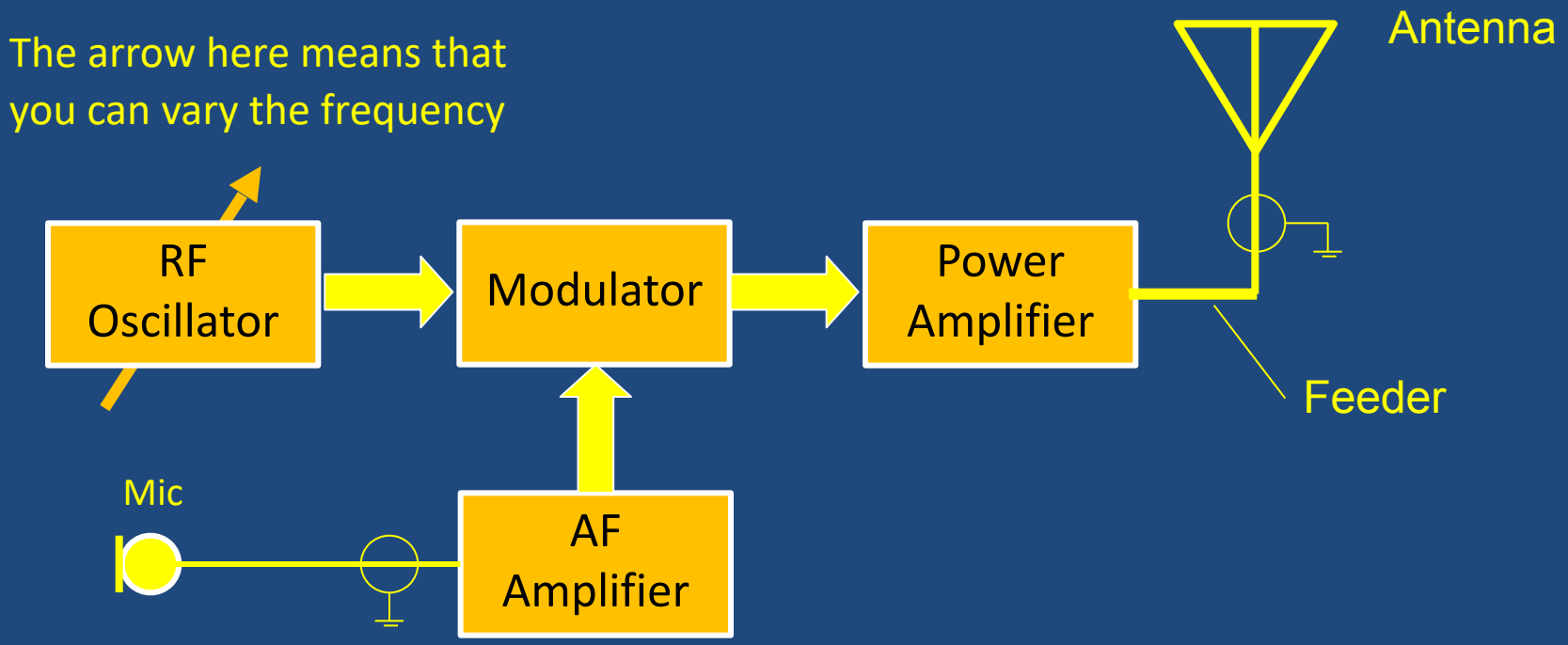
The output from the AF Amplifier is "mixed" with the output from the RF Oscillator in the Modulator. An effect called "heterodyning" takes place in the modulator and generates additional, new frequencies. The new frequencies are:

- the sum of the audio frequency and RF oscillator frequencies;
- the difference between the audio frequency and RF oscillator frequencies.

Power Amplifier

This is an RF amplifier with sufficient power gain to produce a good feed into the aerial to radiate the signal.

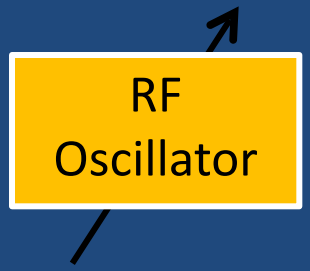
Transmitter Block Diagram



As a Foundation Licensee you are only allowed to use CE-approved, commercial equipment. This will avoid any chance of out-of-band interference.

Avoid over-driving the Power Amplifier or over-modulating as this will cause distortion and possible harmonics.

The Transmitter RF Oscillator



14.350 MHz

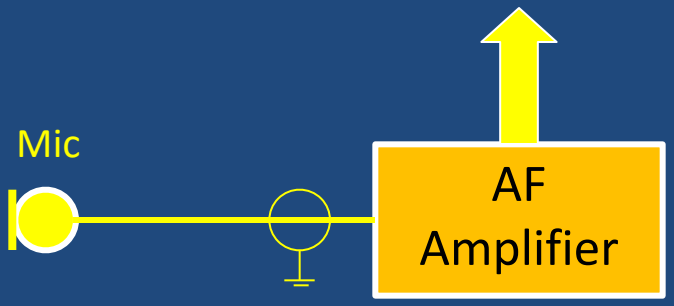
The RF oscillator in the transmitter sets the transmit frequency.

You need to take care – particularly near the band edges – as to what frequency you select. Also check the band plan for the correct portion of the band for the mode you wish to use.

If you are in usb mode at the upper band edge then your transmitted speech signals will lie above the oscillator frequency shown on the transmitter variable frequency oscillator (VFO).

If you are at the upper band edge (eg 14.350 MHz for the 20m Band) then your subsequent usb transmission will be out-of-band.

The Microphone Amplifier

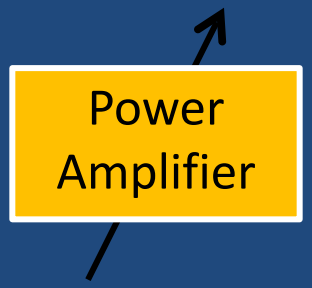


The microphone amplifier (Mic Gain) amplifies the tiny signal from the microphone to a level where it can drive the modulator.

However, if the Mic Gain control is advanced too much it will cause the modulator to be *over-driven*. This results in a distorted signal (splatter) and also in increased bandwidth of the radio signal. The amplifier also limits the AF bandwidth to around 3.5kHz.

Adjust the Mic Gain control carefully to give just the right amount of drive. You do this with a dummy load fitted and adjusting the Mic Gain to give three or four bars of ALC display when speaking normally. *(Practical refers.)*

RF Power Amplifier



The final stage in the transmitter is the RF Power Amplifier.
This amplifies the signal to a level where it can be delivered to the antenna at the chosen level.

You ***do not*** need to run at full, legal power all the time.
(Indeed the Schedule to your licence identifies frequencies where you might have to operate the transmitter at below the maximum Foundation licence power of 10W.)

You only need to run *sufficient power* for reliable communications. *Reducing your transmit power by a factor of four will only drop one S point (6db) at the distant end.*

Modulation

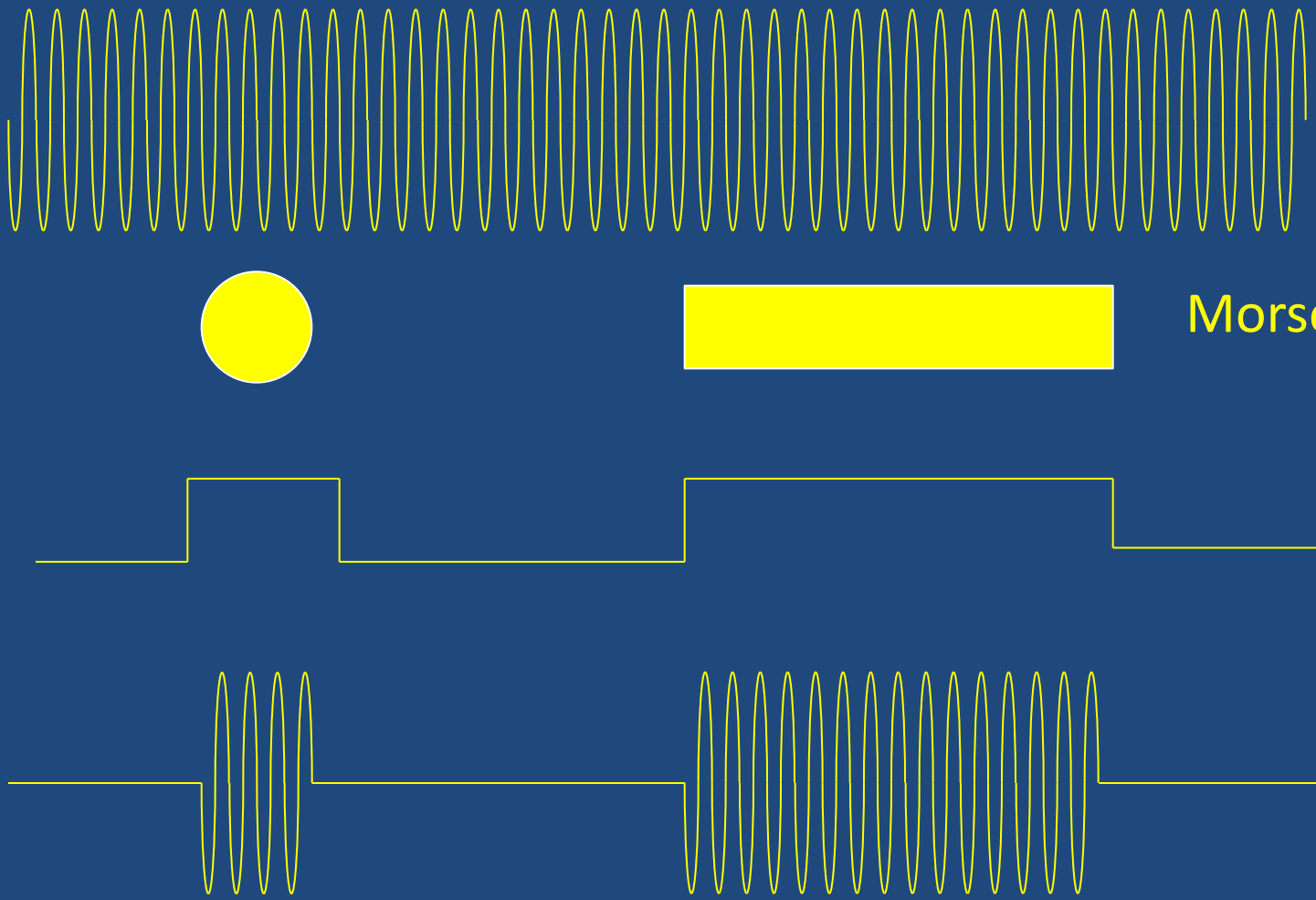
- Modulation is the term that describes how the RF carrier wave is manipulated in order to impress the information content upon it.
- We will consider three ways of modulating a carrier wave:

  - By turning it *on and off* (CW, Morse);

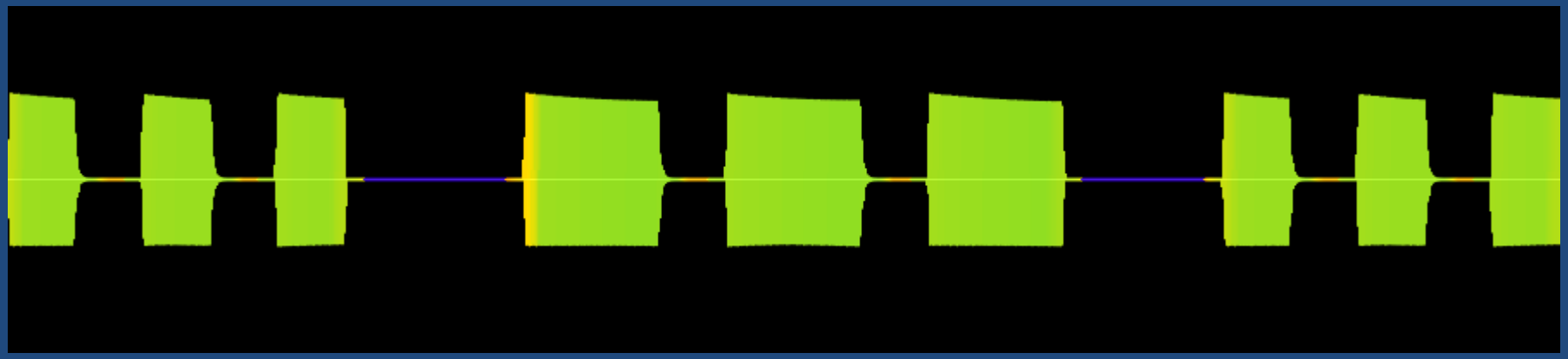
  - By varying its *amplitude* or height (AM and ssb);

  - By varying its *frequency* (FM).

Modulation



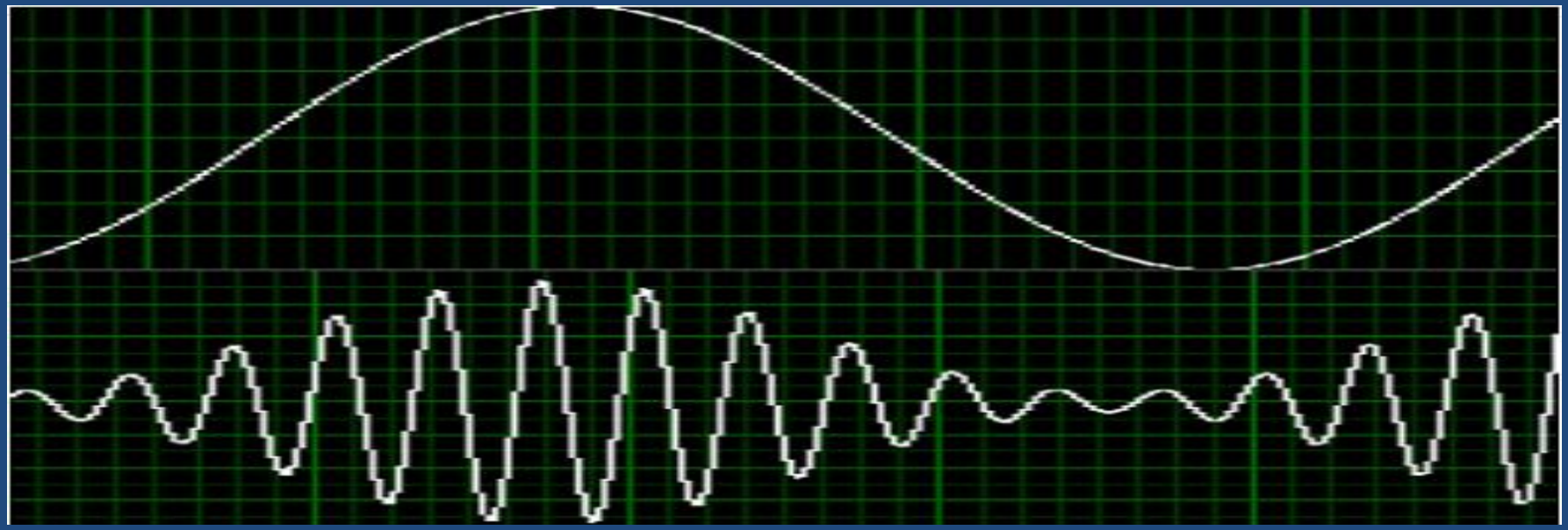
SOS Keyed in Carrier Wave (CW)



di di dit dah dah dah di di dit

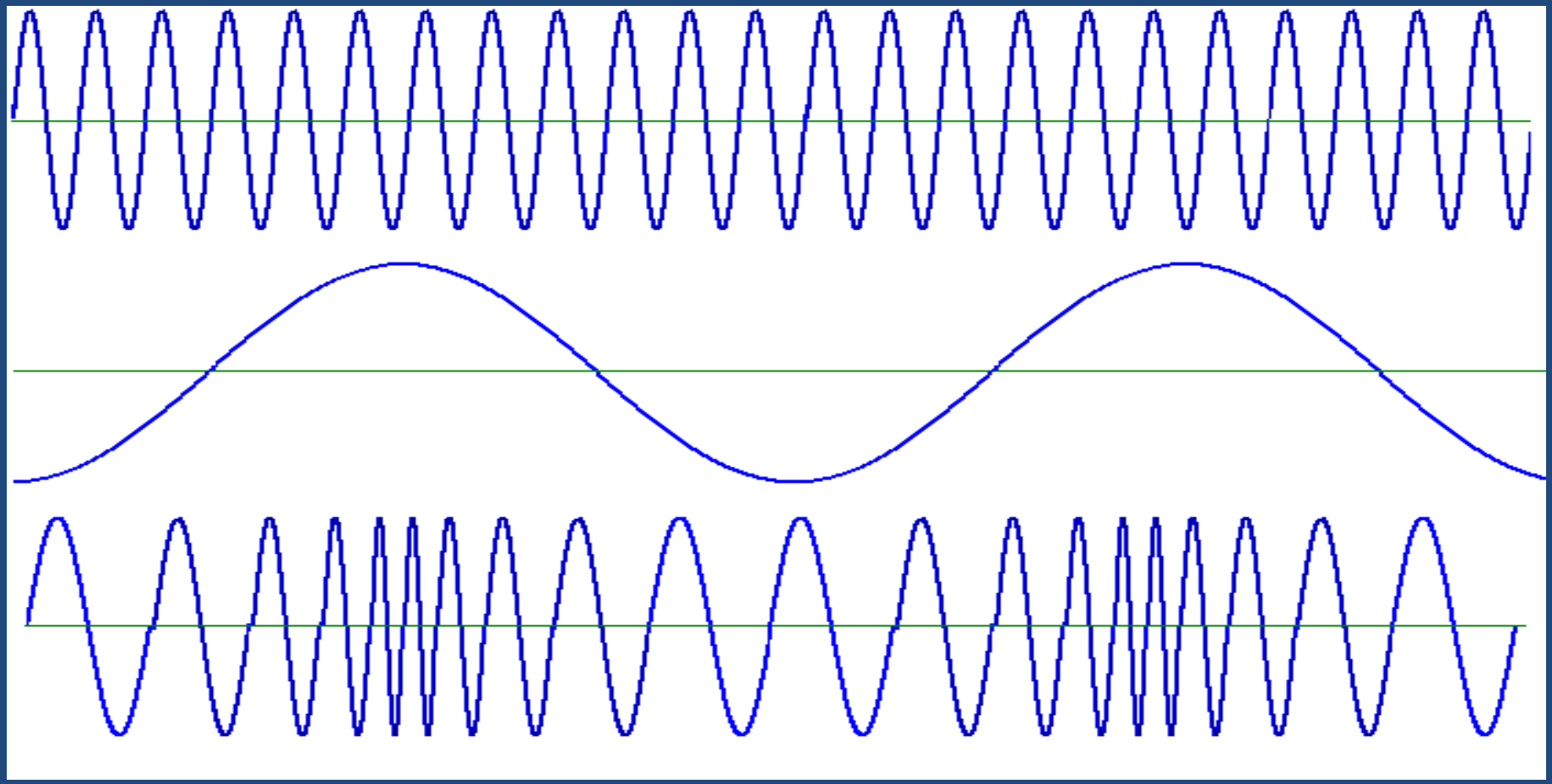
S O S

Amplitude Modulation (AM)

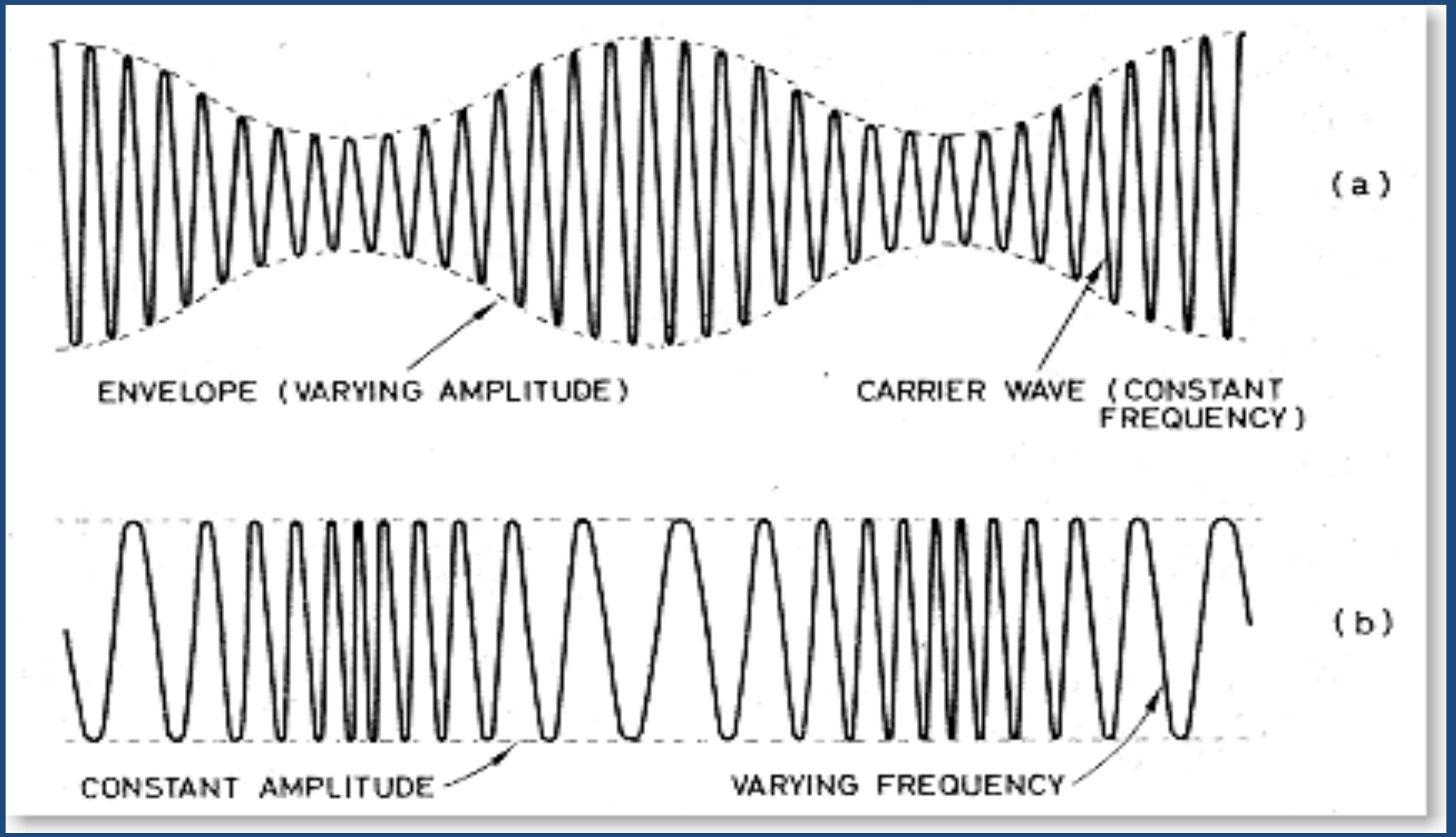




Frequency Modulation (FM)



Comparison of AM With FM



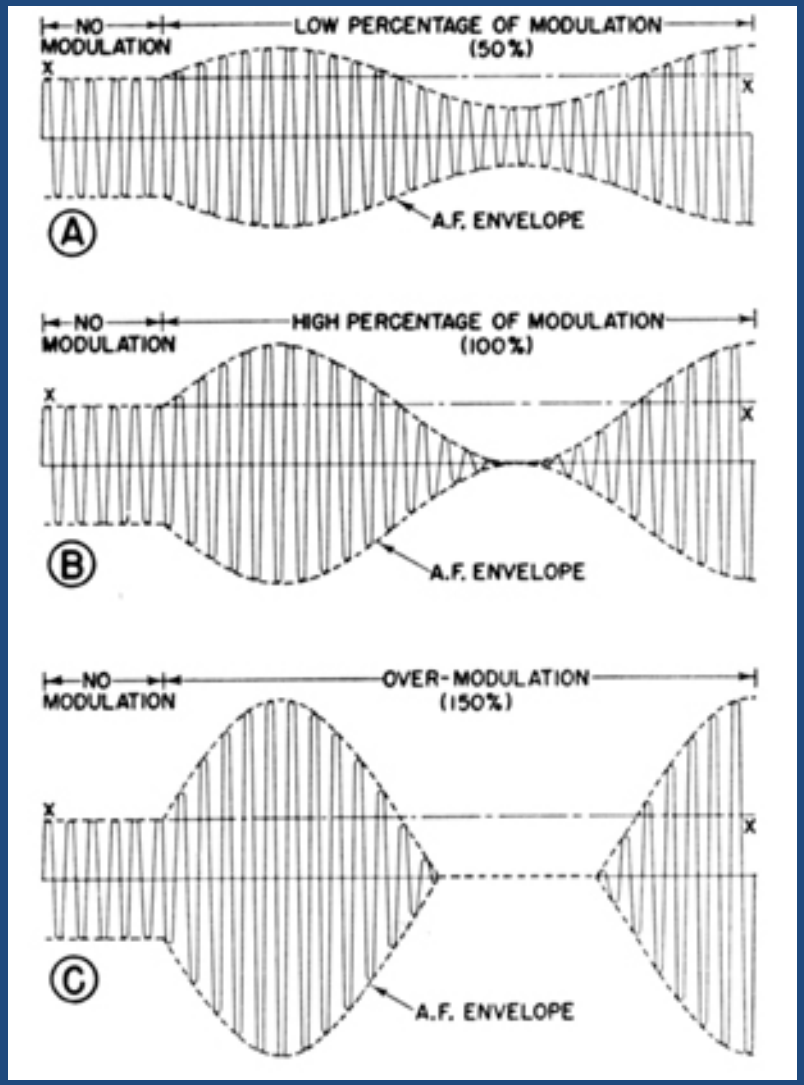
Over Modulation / Deviation

If you overly amplitude modulate an RF carrier it will cause a distorted output and interference to adjacent channels.

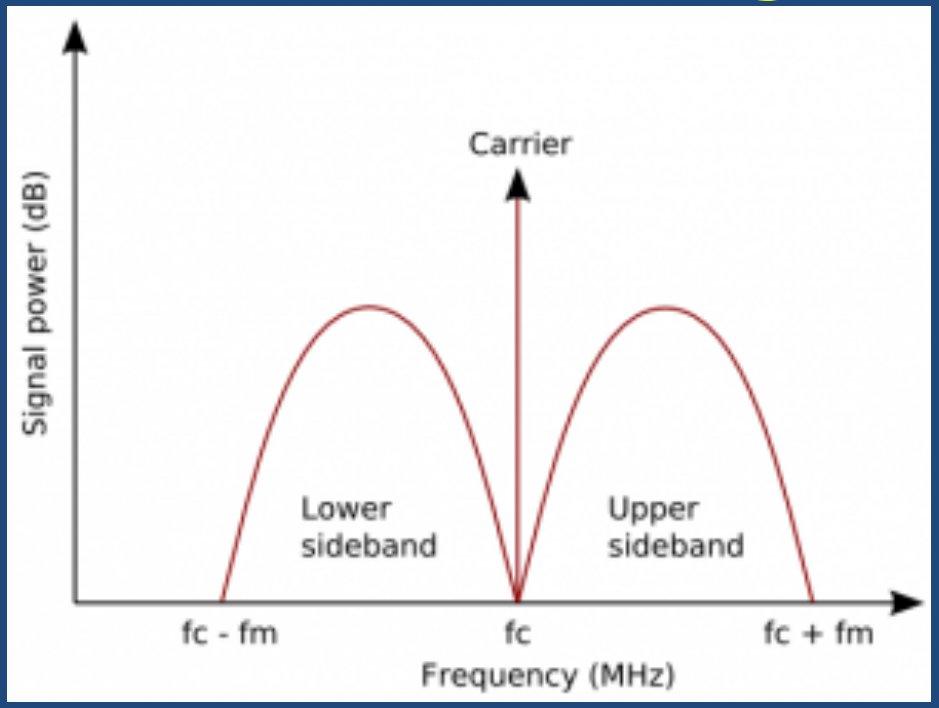
Similarly if the frequency deviation of an FM carrier is excessive the bandwidth of the signal will also be excessive. This will in turn cause interference to adjacent channels.

DO NOT OVER MODULATE

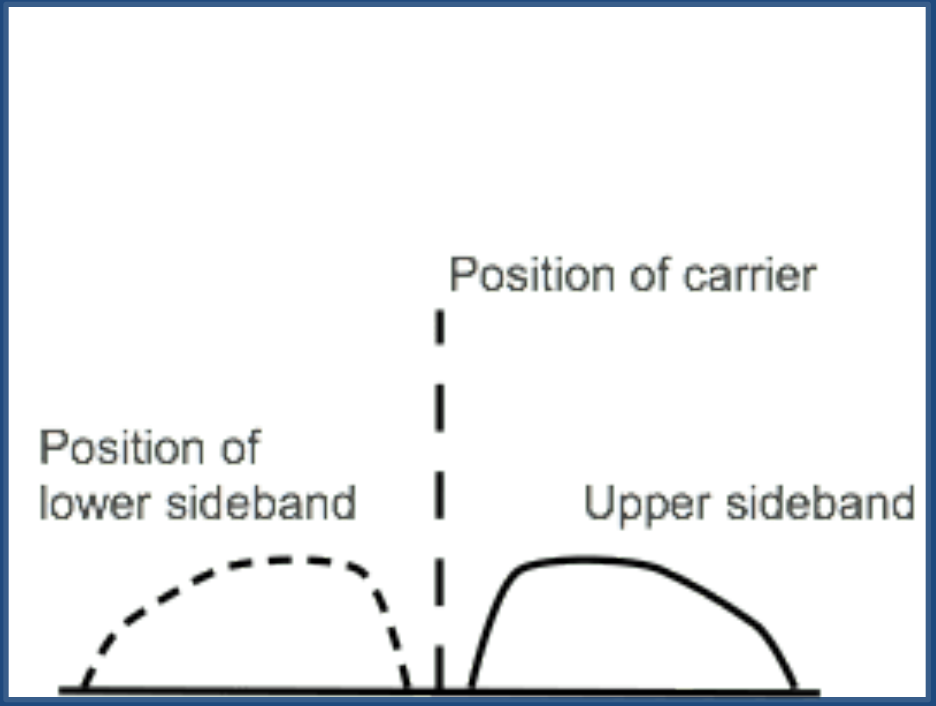
Overmodulation of an AM Signal



AM And Single Side Band (ssb)



Amplitude Modulation Double Side Band

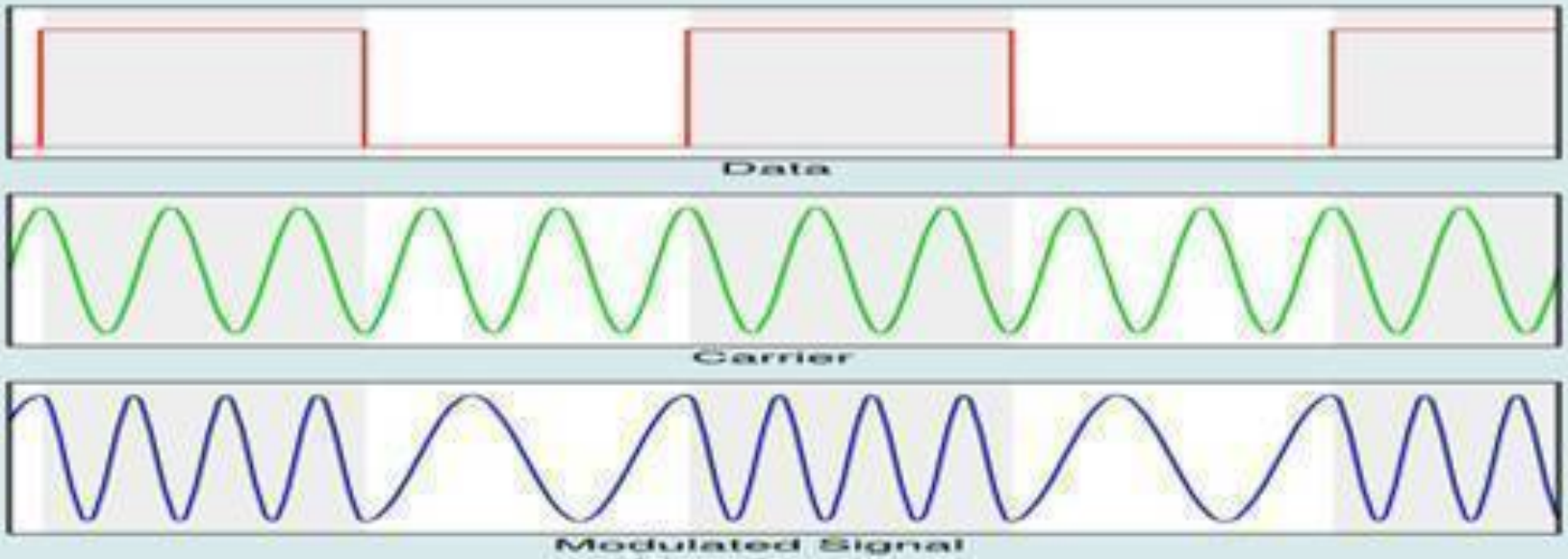


Amplitude Modulation Single Side Band

When the RF and AF signals are mixed in the modulator two sidebands – an upper and a lower - and a residual carrier are produced..

For ssb transmission the carrier and one of the sidebands is suppressed.

Frequency Shift Keying (FSK)



By using two frequencies or tones it is possible to send binary data. One frequency represents ”0” and the other “1”.

It is decoded / encoded by an audio interface (eg a sound card) in the computer and the data recovered or the tones generated for transmission. Data signals often have a warbling sound when you hear them on the receiver.

Transmitter-Antenna Matching

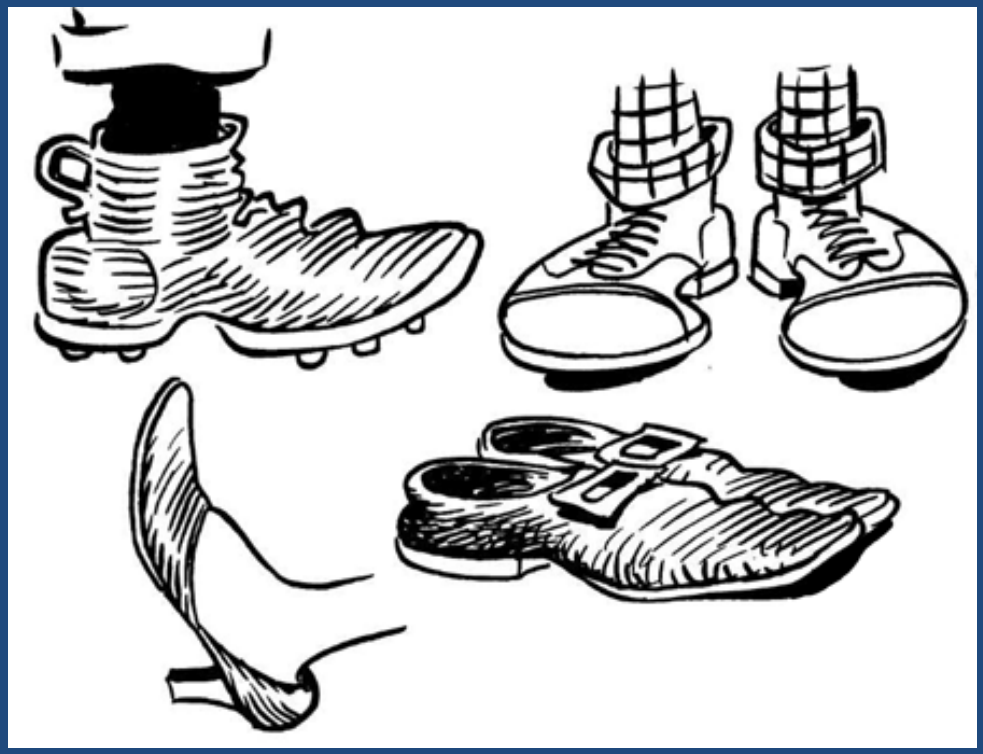


The transmitter generates the RF energy and the feeder takes it to the antenna.

The transmitter has an output impedance of 50Ω and the characteristic impedance of the feeder cable is also 50Ω. Under practical conditions the radiation resistance of your resonant (but not very high above the ground) dipole will also be around 50Ω at resonance. This would be a well-matched state of affairs (50Ω+50Ω+50Ω) and you could be confident that the majority of the transmitter power was indeed being radiated.

BUT, as you will shortly see from the "VARIABLE DIPOLE" practical as you change frequency away from the antenna's resonant frequency your antenna no longer presents 50Ω as the load. This leads to a mis-match and power is not radiated efficiently by the antenna - some is reflected back towards the transmitter.

How To Think Of Matching….



Ideally if you are a size 8 you will feel most comfortable in size 8 shoes.

A size 8 will match *your foot size.*

You *could* squeeze into a size 7 or slop around in a size 9 – but your mobility would be impaired.

When everything in the RF transmission chain is a characteristic 50Ω impedance then the system is matched and operating to best efficiency.

The Variable Dipole Demonstration

These are the key points to bear in mind:

- The output impedance of the transmitter is 50Ω
- The characteristic impedance of the coaxial feeder is 50Ω
- The ideal transmitter load is a resistance of 50Ω

- A dipole, when it is half a wavelength long is said to be "resonant at that frequency". (ie it accepts and radiates the RF power optimally.)
- Practically speaking a resonant dipole is somewhere between 50Ω and 70Ω at resonance. (Don't get hung about the exact number. 50Ω is a good figure.)

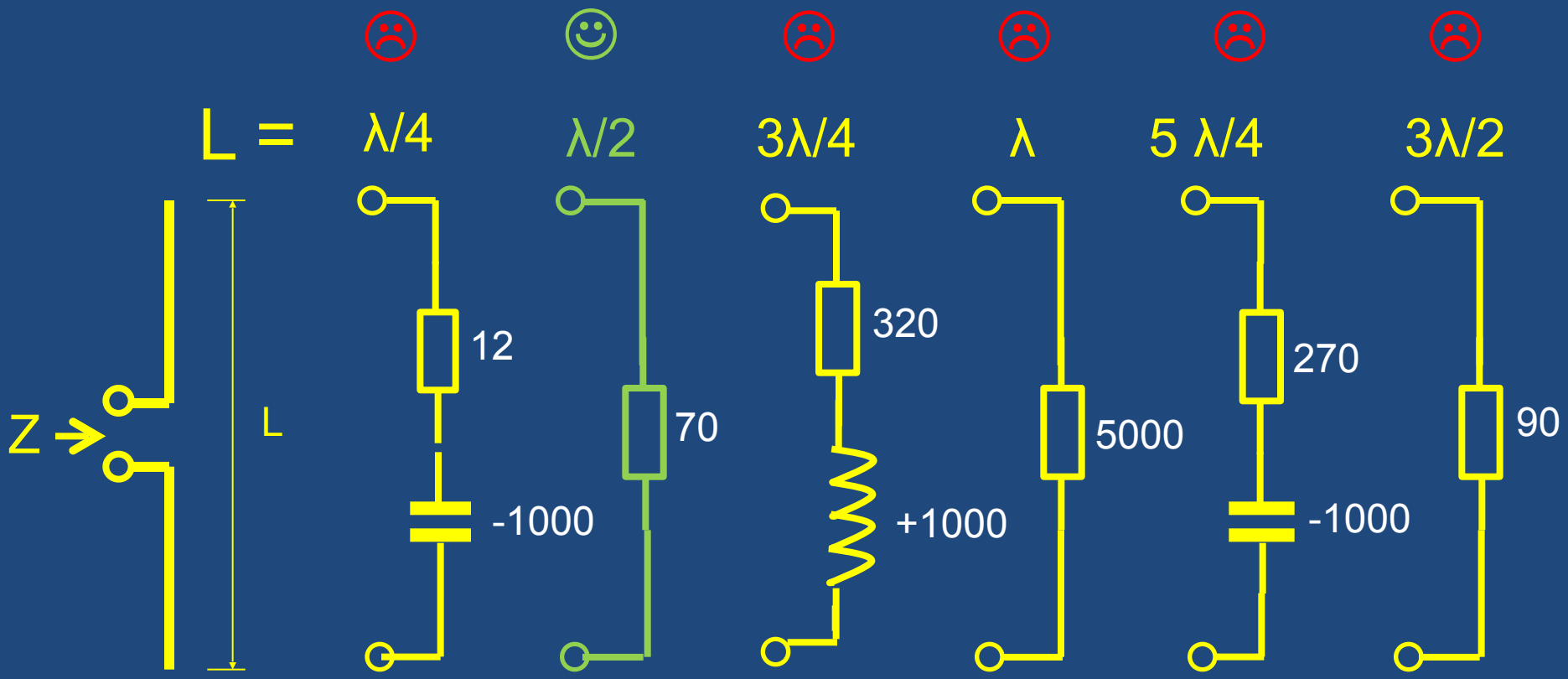
- A resonant antenna (50Ω) looks like a 50Ω resistor and will radiate optimally

- At frequencies above or below the resonant frequency the impedance of the antenna will not be 50Ω

- This means that power will be reflected back to the transmitter. This can damage the transmitter. Having the correct load presented to the transmitter is critical. The "wrong" antenna won't match and will reflect power back to the transmitter.

Antenna Impedance Values

Note: λ is the wavelength of the frequency applied to the antenna . A resonant wire dipole antenna for 3.5MHz will be 42.5m long overall (λ/2 or half a wavelength at 3.5MHz). As the applied frequency varies the antenna length measured in terms of wavelengths at the applied frequency will also vary. The antenna becomes electrically longer or shorter.



The Radio Receiver

The function of the radio receiver is:

to recover the information carried on an electro-magnetic wave (modulated carrier) sent from a distant transmitter.

Recovering the information is a process known as **Demodulation**.

The Basic Receiver

RF Amplifier

The antenna provides miniscule voltages from incoming signals. These signals will be in the order of 1µV or less. The RF amplifier amplifies these signals and passes them on to the detector.

Detector

The detector recovers (demodulates) the audio (information) from the modulated RF carrier.

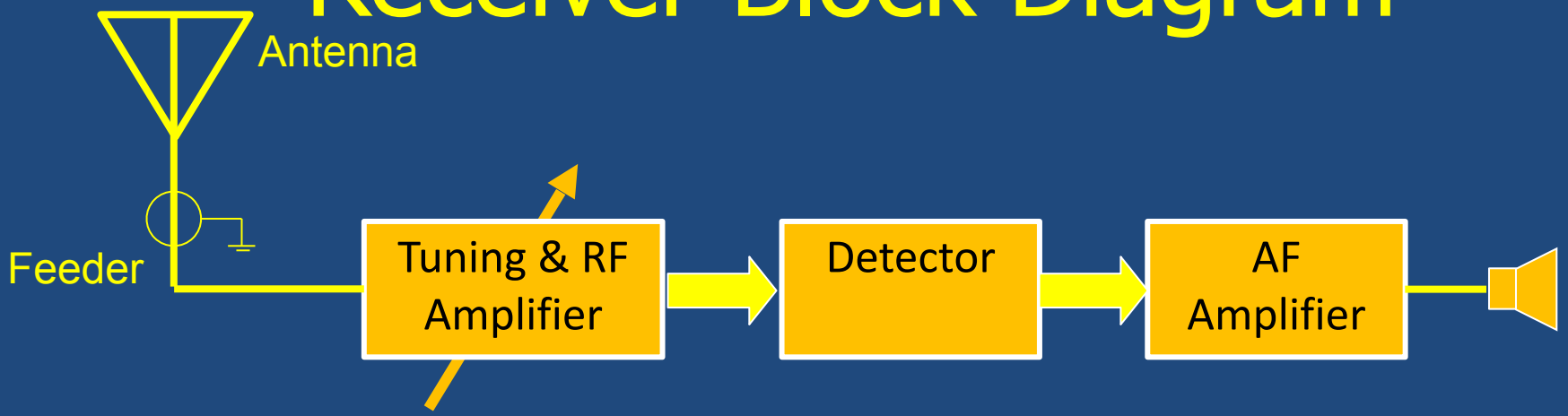
AF Amplifier

The AF Amplifier amplifies the recovered audio to a level suitable for driving headphones or a loudspeaker.



The Loudspeaker converts the electrical output from the AF Amplifier into analogue pressure waves in the air that you can then hear.

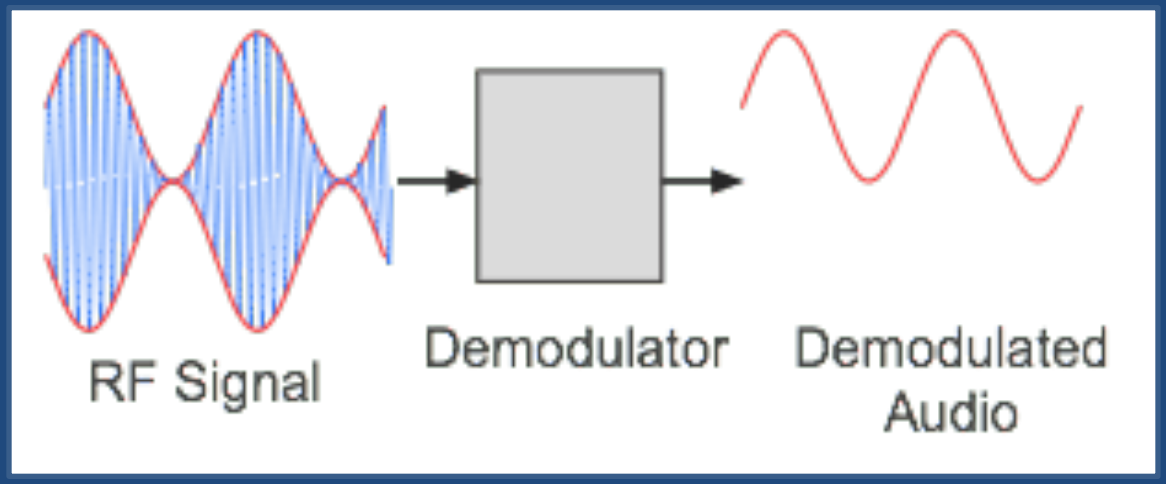
Receiver Block Diagram



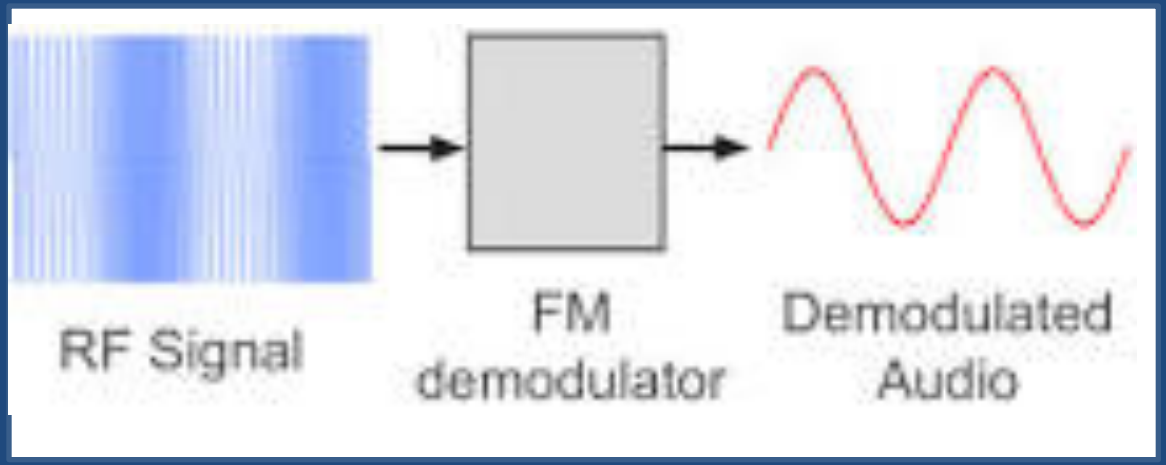
The RF front end deals with the tuning and RF amplification. It contains *tuned circuits* which *select* the wanted signal frequency from all of the frequencies presented to it by the antenna. It then amplifies this signal and passes it to the Detector. The quality of the RF circuit determines the noise performance of the Rx.

The Detector *demodulates* the information on the *RF carrier* to recover, say, the speech. Different circuits are used to decode AM, ssb, FM, FSK etc. The AF amplifier drives the loudspeaker or headphones..

Detection / Demodulation



To recover the transmitted information the receiver uses a detector (demodulator).



You need a different demodulator for AM and FM

Software Defined Radio - Rx

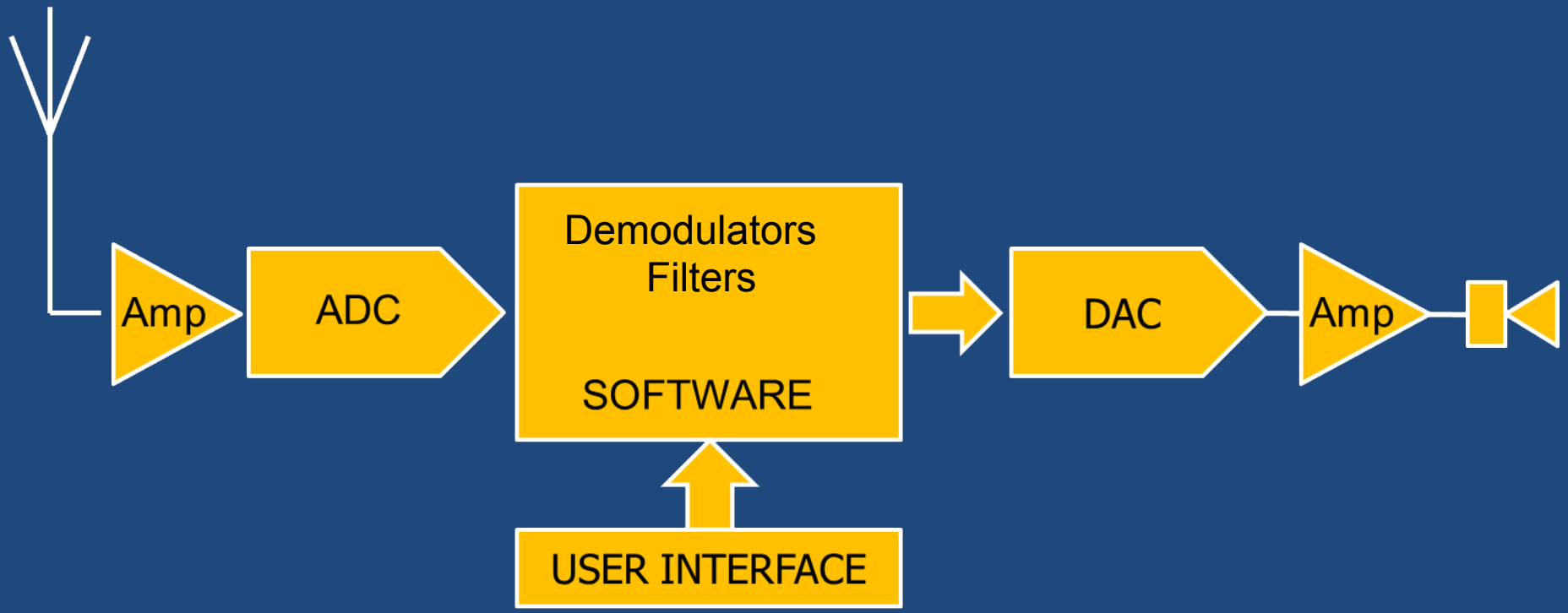
A software defined radio (SDR) is one in which the majority of the signal processing is performed digitally. The radio can be a stand-alone device or involve the use of a lap-top (or similar) computer and specialised hardware.

In an SDR receiver all of the signals appearing on the antenna are filtered and amplified to bring them up to a useable level. They are then digitised in an ADC (Analogue-to-Digital Converter). At this point the incoming signal is now entirely digital.

Software in the receiver then mathematically selects the required signal or signals. This signal may then be processed further to remove noise and interference as well as to demodulate it.

The processed signal passes through a DAC (Digital-to-Analogue Converter) before being amplified for the loudspeaker or headphones.

SDR Rx Block Diagram



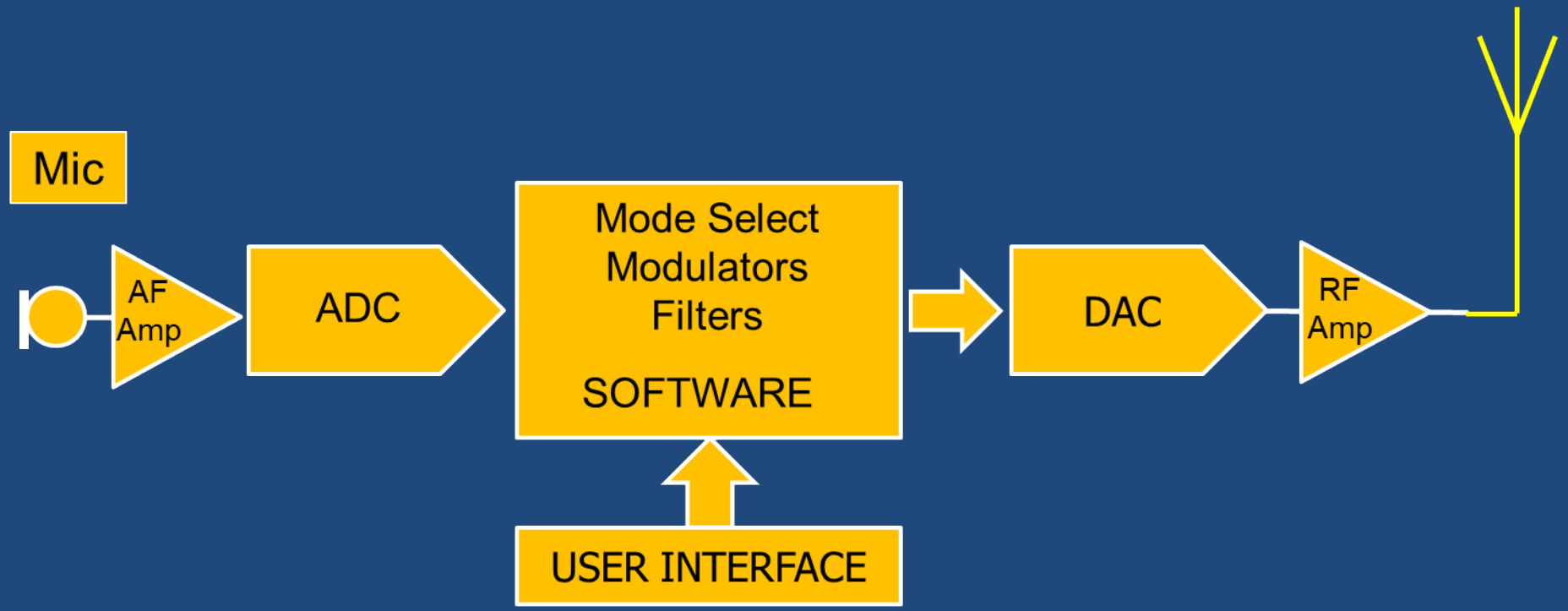
Software Defined Radio Tx

In an SDR transmitter the analogue audio signal from the microphone is digitised in an A-to-D converter.

Modulation and frequency selection are all performed mathematically within the software.

The digital signal is then converted by a D-to-A converter to analogue RF. The RF power amplifier then raises the level to the required power at the antenna.

SDR Tx Block Diagram



Section 4

Operating Practices and Procedures

Readability, Strength, Tone, Code

READABILITY (R)	STRENGTH (S)	TONE (T)
1. Unreadable	1. Faint signals barely perceptible	1. Sixty cycle a.c or less, very rough and broad
2. Barely readable	2. Very weak signals	2. Very rough a.c., very harsh and broad
3. Readable with considerable difficulty	3. Weak signals	3. Rough a.c. tone, rectified but not filtered
4. Readable with practically no difficulty	4. Fair signals	4. Rough note, some trace of filtering
5. Perfectly readable	5. Fairly good signals	5. Filtered rectified a.c. but strongly ripple-modulated
	6. Good signals	6. Filtered tone, definite trace of ripple modulation
	7. Moderately strong signals	7. Near pure tone, trace of ripple modulation
	8. Strong signals	8. Near perfect tone, slight trace of modulation
	9. Very strong signals	9. Perfect tone, no trace of ripple or modulation of any kind

Good Operating Practice

This we cover mostly during the on-air practicals. There are additional points:

- Repeaters;
- Keeping a log – generally and for contests;
- Beacon and Satellite frequencies;
- Correct signal levels of connected devices;
- Digital Voice (DV) and Digital Data (DD);

Repeaters

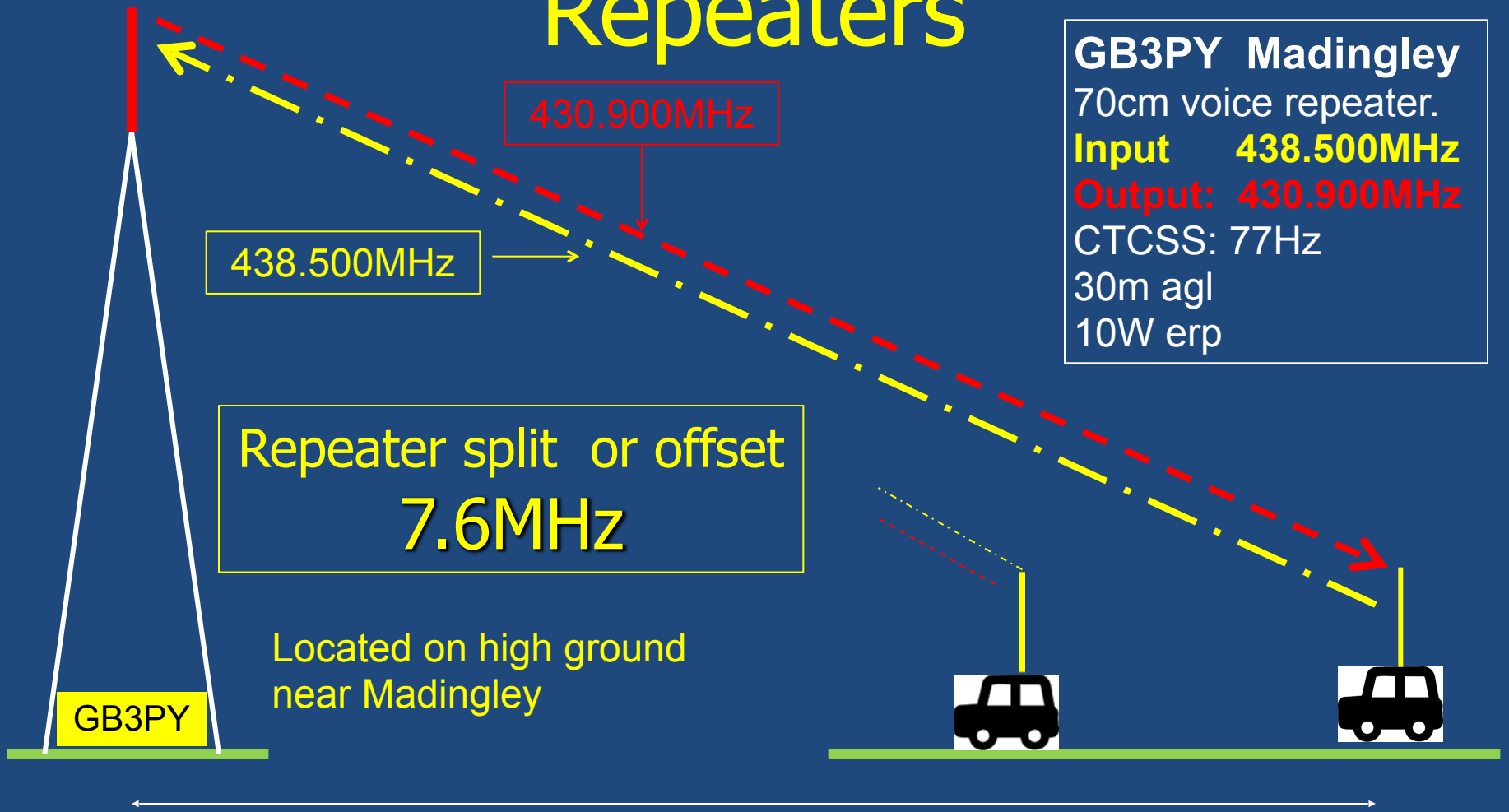
Repeaters are mainly intended for (low-power) mobile stations to enable them to work over a wider area.

The repeater listens on one frequency and re-radiates the signal on another frequency at a relatively high power.

Repeater antennas are often located on tall buildings, water towers or co-located with other commercial services on a radio mast.

Do not hold simplex QSOs on repeater frequencies!

Repeaters



GB3PY Madingley
70cm voice repeater.
Input 438.500MHz
Output: 430.900MHz
CTCSS: 77Hz
30m agl
10W erp

Repeater split or offset
7.6MHz

Located on high ground near Madingley

Range can be greater than 80 km depending upon conditions
Thus two mobile stations could be more than, say, 120km apart and yet be able to work each other easily through the repeater.

Satellite Bands

Satellite operations occur on designated frequencies within some of the bands.

Do not operate on these frequencies unless you are using the satellite.

Non-Microphone Connexions

Sometimes you may want to connect a peripheral device to your transceiver which is not a microphone. For example: the interface for PSK31 which uses a sound card.

You must ensure that you set the audio levels correctly for the device and that the PTT is correctly connected. The new level will almost certainly be different from the previously set microphone audio level.

Digital Voice (DV) and Data (DD)

These digital modes are available. There are different systems and they may not be compatible.

Appropriate transceivers are needed for these modes.

Digital voice radios may have embedded call signs. If you borrow equipment you will need to take account of this.

If using Digital Voice check that the channel is not in use by other modes. (This also applies to FM modes.)

Be aware that such checks are not necessarily 100% reliable.

Section 5

Feeders and Antennas

(Plus Practical Assessments)

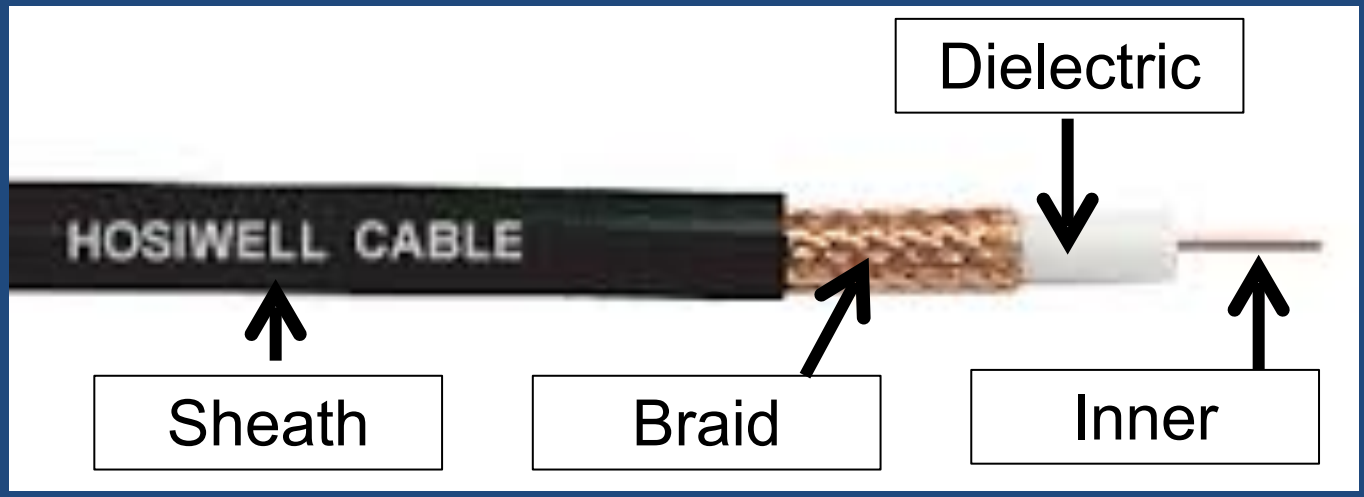
Antenna Feeders

Generally you cannot attach the antenna straight into the back of the radio. You have to use a feeder to attach the transceiver to the antenna. The feeder is the cable that carries RF signals to and from the antenna. It must do this with the minimum of loss.

The feeder most definitely is not just any old length of wire!

There are three, common types of feeder:
-coaxial or co-ax;
-parallel wire;
-ladder line.

Co-axial Feeder

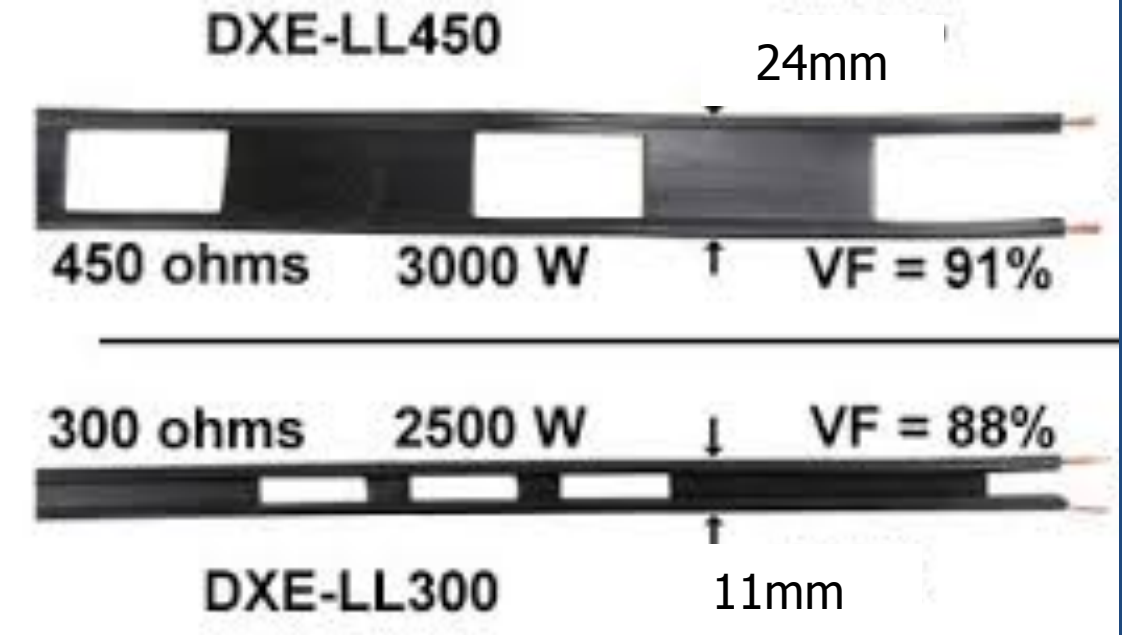


Co-axial feeder is very common. It is the feeder that you use at VHF and UHF. The braid gives it a screening property.

HOWEVER, it has its limitations and is not always the best solution. This is particularly true where you are feeding a multi-band HF antenna.

Co-axial is an "UNBALANCED FEEDER"

Parallel Wire Feeder



This is often called "window line". It is a good feeder for multiband, HF dipoles.

Parallel wire feeder is a "BALANCED FEEDER"

Ladder Line or Open Wire Feeder



Open wire feeder has two, parallel conductors that are about 100mm apart. It is the ideal feeder for a multiband, wire, HF antenna. It is virtually lossless.

Open wire feeder is a:

"BALANCED FEEDER"

Feeder and Antenna Impedance

If the antenna feed-point impedance is different from the feeder impedance then power will be reflected back down the feeder from the load.

This is generally true right across the HF band with a doublet antenna used on multiple frequencies. The bigger the mismatch the more power is reflected. Coaxial feeder doesn't cope well with the effects of this reflected power. Parallel wire feeder is fine.

Antenna Physical Size

The physical size of an antenna is related to the wavelength – which is itself a function of frequency.

There are half wave dipoles, quarter wave vertical antennas and five-eighth wavelength verticals.

The higher the frequency the shorter the wavelength and thus the smaller physical size of a resonant antenna.

If you try and use the wrong antenna for the chosen frequency you will have a mismatch and therefore reflected power and standing waves on the feeder.

Balanced and Unbalanced

The terms "balanced" and "unbalanced" describe the voltages on the feeder measured with respect to ground.

Co-axial cable has its braid connected to ground. This means that only the voltage on the inner varies with respect to ground. Unbalanced feeder can radiate.

A balanced feeder has neither conductor connected to ground. Thus equal and opposite voltages appear on both conductors. Balanced feeder does not radiate.

Feeder Loss

The metal conductor forming the feeder has resistance. This resistance will cause some loss of the RF signal by converting it into heat.

Co-axial cable also has loss via the capacitance formed by the dielectric and the braid. As the frequency increases this loss gets bigger.

The loss occurs both on transmit and receive. The longer the feeder the greater the loss.

Choose the best quality feeder and the one with the lowest loss (dB/m) for the frequencies that you use.

Always use low loss coaxial feeder at VHF and UHF where the loss is greatest.

Balanced and Unbalanced Antennas

A balanced antenna is one where neither side is connected to ground. A dipole is such an antenna. It should be fed with a balanced feeder.

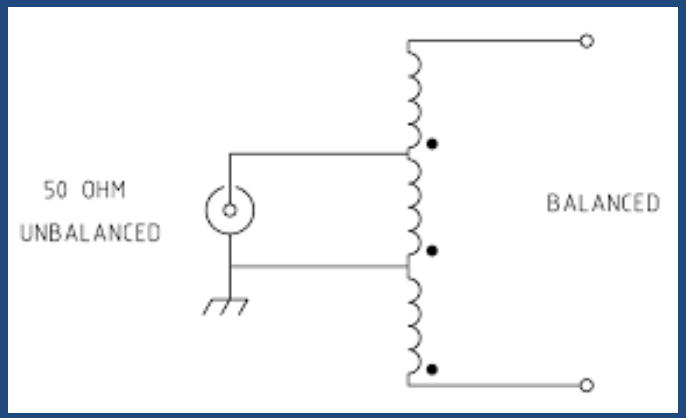
An unbalanced antenna is one which is worked against ground such as a long wire.

If you feed a balanced antenna with an unbalanced feeder you are connecting one side of the antenna to ground.

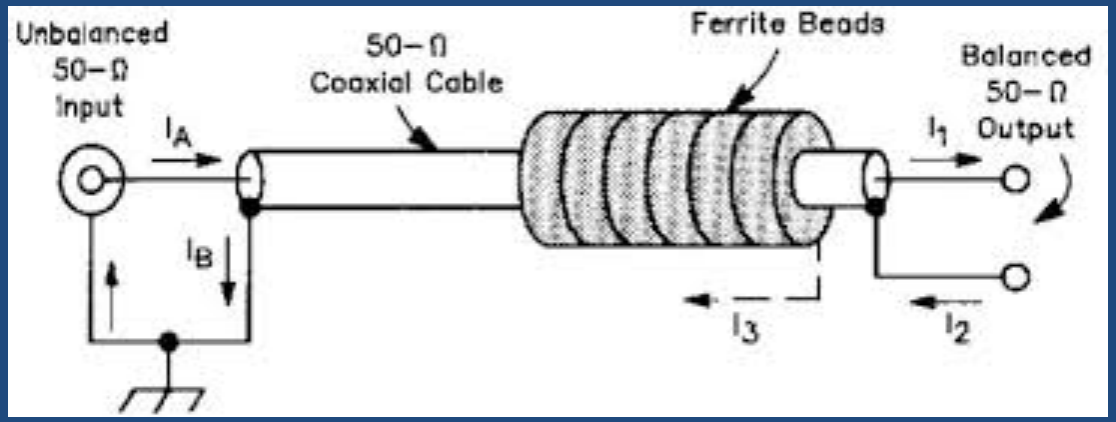
To avoid this you need to insert a "BALUN" (Balanced to Unbalanced) device at the point where the coaxial cable attaches to the antenna terminals.

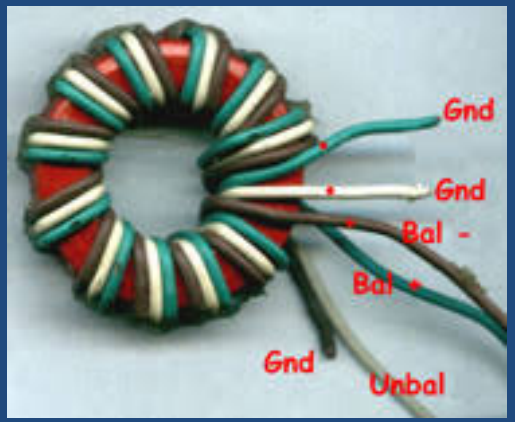
The balun "isolates" the antenna from the earthed braid of the coaxial feeder.

The Balun


50 OHM
UNBALANCED
BALANCED




Unbalanced
50–Ω
Input
50–Ω
Coaxial Cable
Ferrite Beads
Balanced
50–Ω
Output
I_A
I_B
I_1
I_2
I_3


Gnd
Gnd
Bal -
Bal
Gnd
Unbal

Antenna Polarisation

The antenna is a transducer. It converts electrical energy into RF (electro-magnetic) energy – and vice-versa.

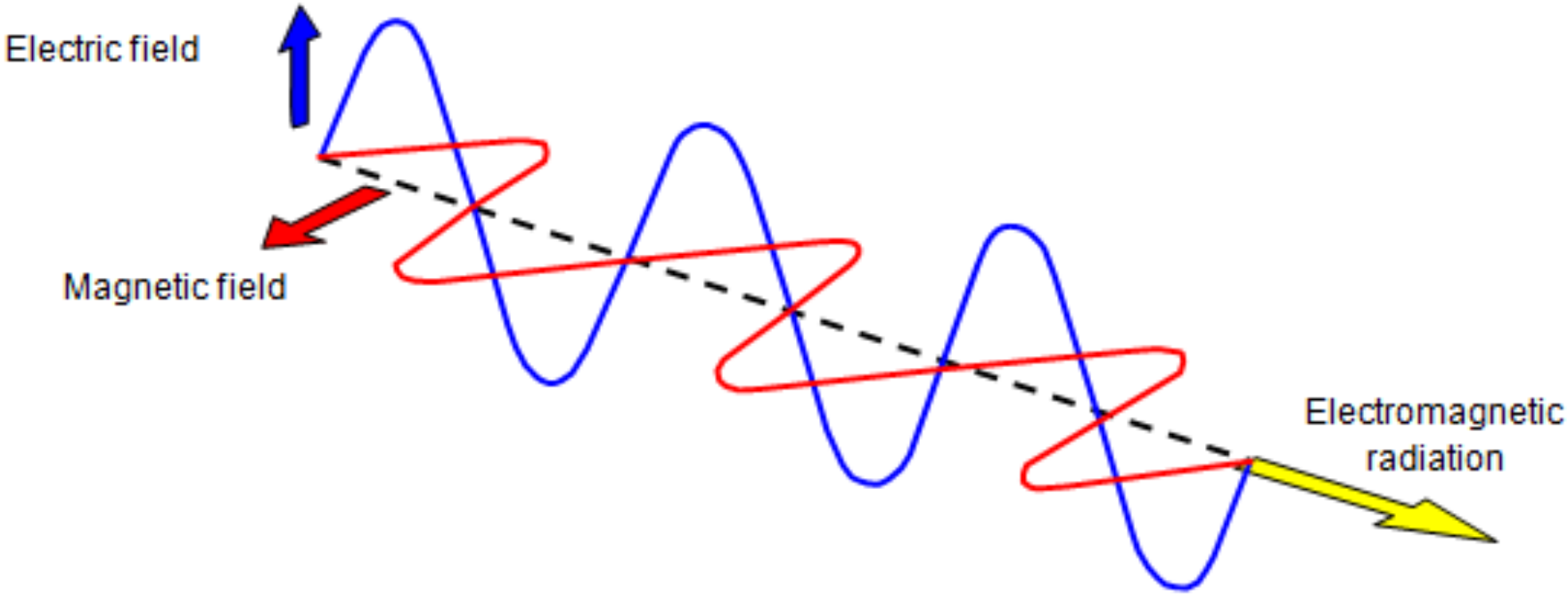
Depending upon the orientation of the antenna it will produce either:

- horizontally polarised waves;

- vertically polarised waves.

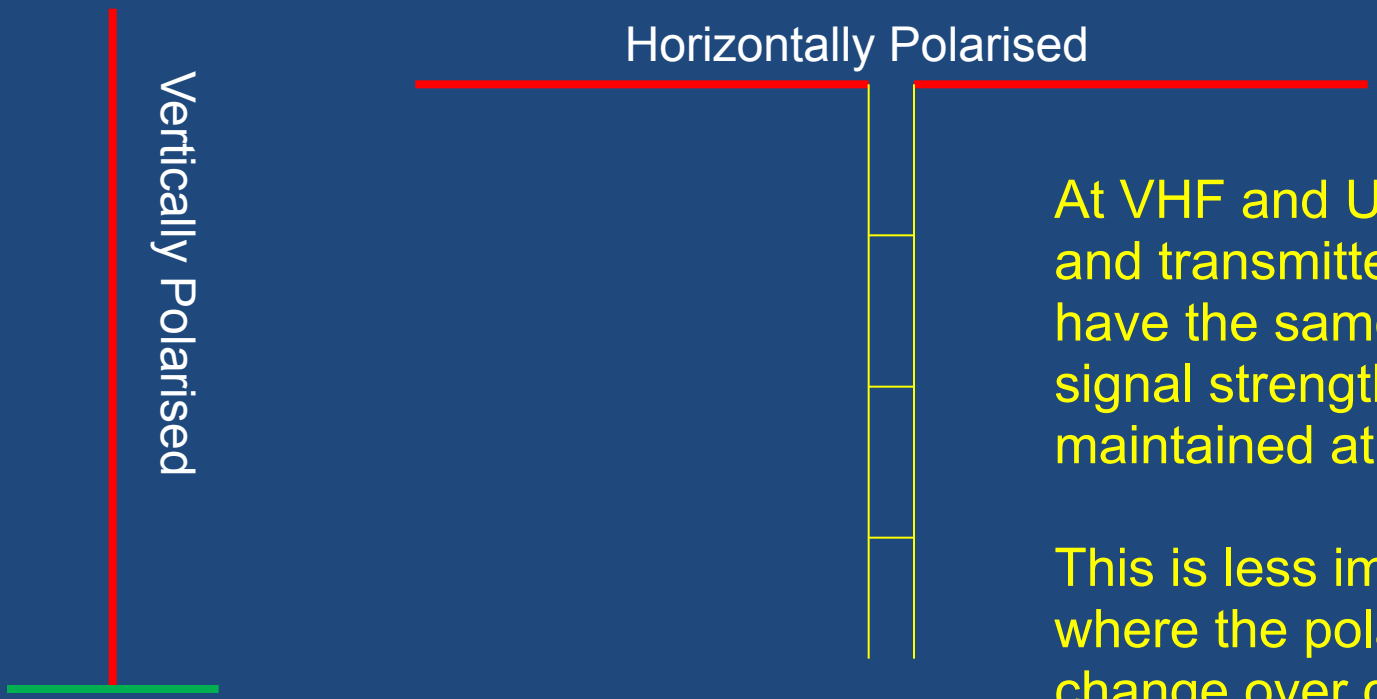
The polarisation refers to the orientation of the electric field in the wave.

Polarisation



The orientation of the electric field determines the polarisation of the wave.

Antenna Polarisation

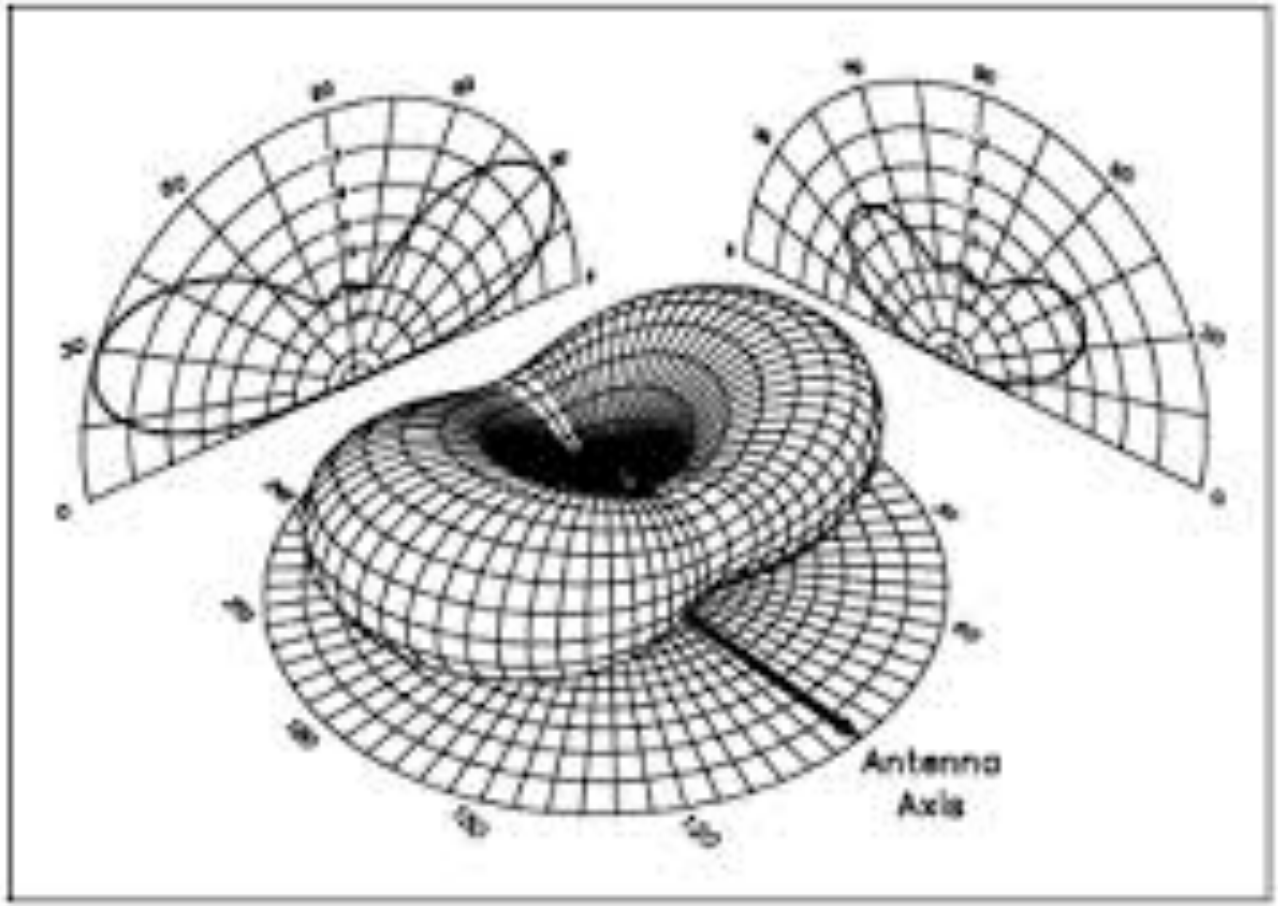


At VHF and UHF the receiver and transmitter antenna should have the same polarisation if signal strength is to be maintained at a distance.

This is less important at HF where the polarisation can change over distance.

A vertical antenna produces vertically polarised waves and a horizontal antenna produces horizontally polarised waves.

Antenna Radiation Pattern: Dipole

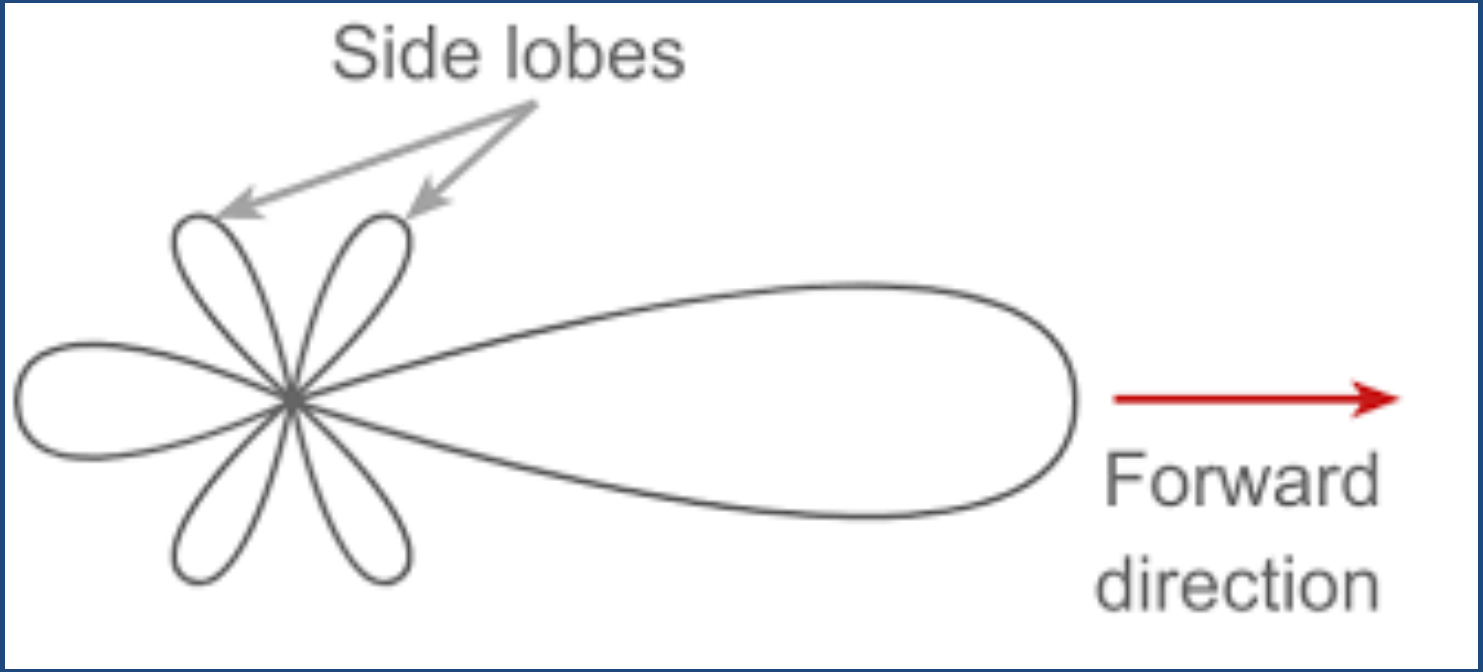


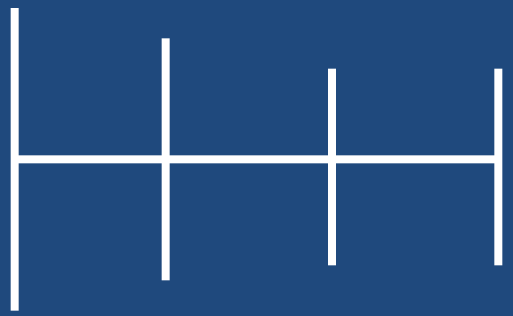
Three-dimensional representation of the radiation patterns of a half-wave dipole. 0.5 λ above ground.

Antennas receive (radiate) better in some directions than others.

The diagram showing this preference is called the radiation pattern of the antenna.

Antenna Radiation Pattern: Yagi



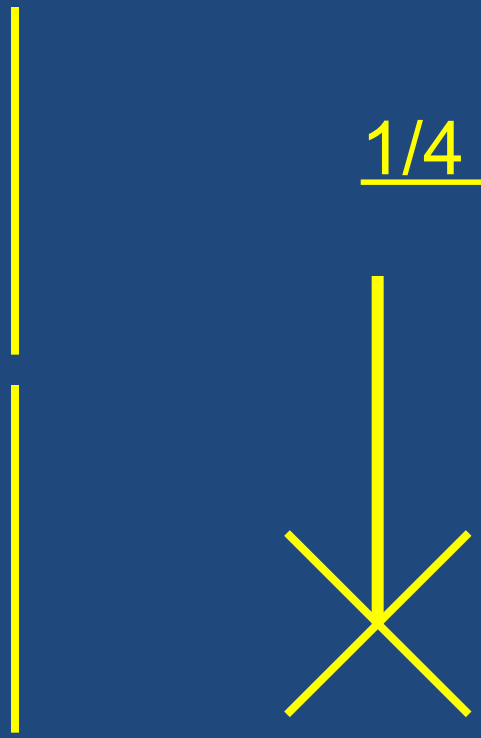


Yagi Antenna

Orientation Is Key

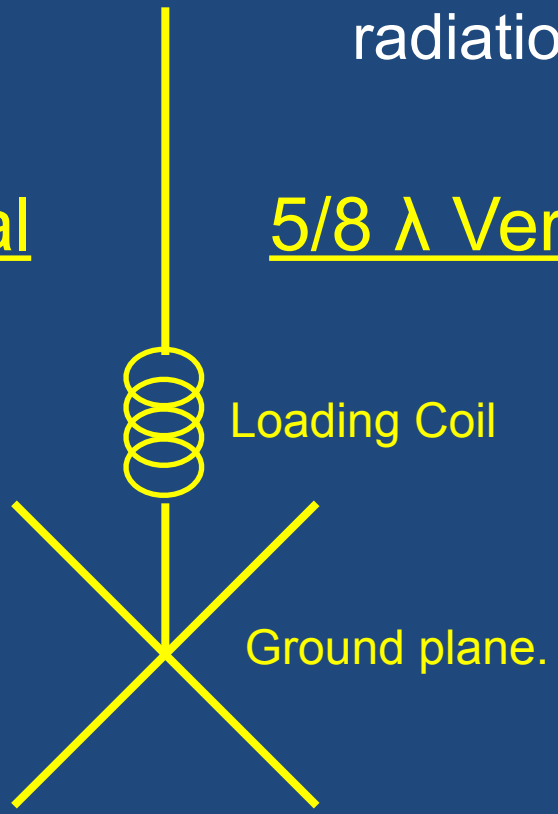
All these antennas give an omni-directional radiation pattern.

Vertical Dipole



1/4 λ Vertical

5/8 λ Vertical



Antenna Gain

Antenna gain is produced by focussing some of the radiated energy in a particular direction. *(This is similar to the reflector in a torch.)*

Gain is expressed relative to a half-wave dipole.

Gain is usually expressed in decibels (dB). The higher the dB value the greater the gain.

Directional power is known as Effective Radiated Power (ERP)

The apparent power increase is known as gain.

ERP is calculated by multiplying the power applied to the antenna by the gain.

The Decibel (dB)

Decibels refer to power ratios. The ratio in dB of two power levels is:

$$10 \log_{10} (Power_2 / Power_1)$$

You need to know these common power ratios in dB:

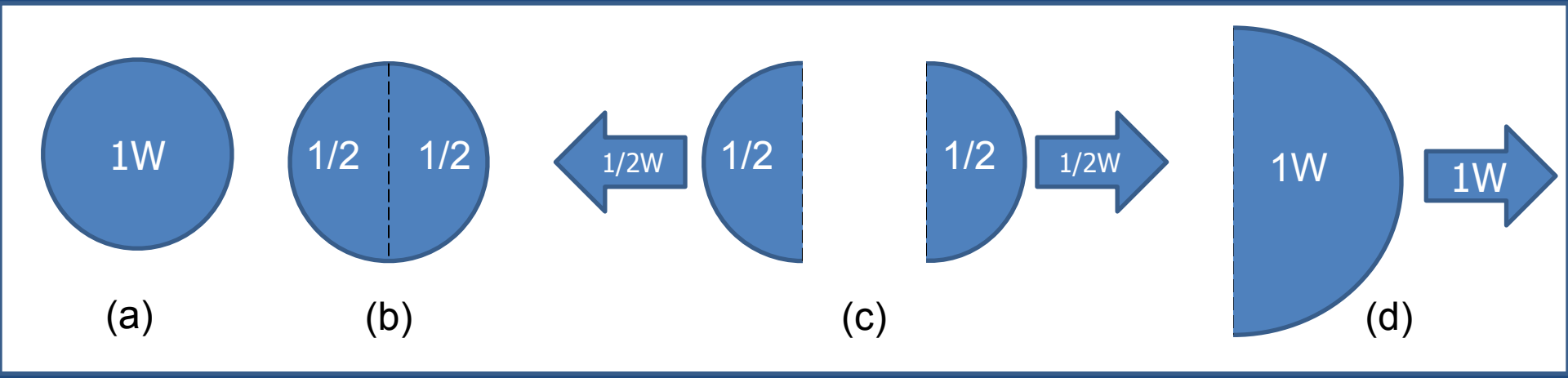
3dB = x2
6dB = x4
9db = x8
10db = x10

In the schedule to the licence power levels are referenced to 1W. This is written as dBw.
The 1W refers to $Power_1$ in the formula above. So if you transmit at 8W this is eight times greater than 1W so in dBw you would write "9dBw". Similarly if you transmit at 2W you would write "3dBw".

Antenna gain

(a). Isotropic radiator – radiates equally in all directions
(b). Divide this into two parts.
(c). Separate the two halves.
(d). Add one half to the other.
(e). This antenna now seems to radiate at twice the power of the original antenna. It is said to have:

a gain of two over an isotropic antenna.



The Standing Wave Ratio

The power reflected from the antenna mismatch causes standing waves of voltage on the feeder. The ratio of the standing wave voltage (reflected power) to the voltage of the forward power wave is called the:

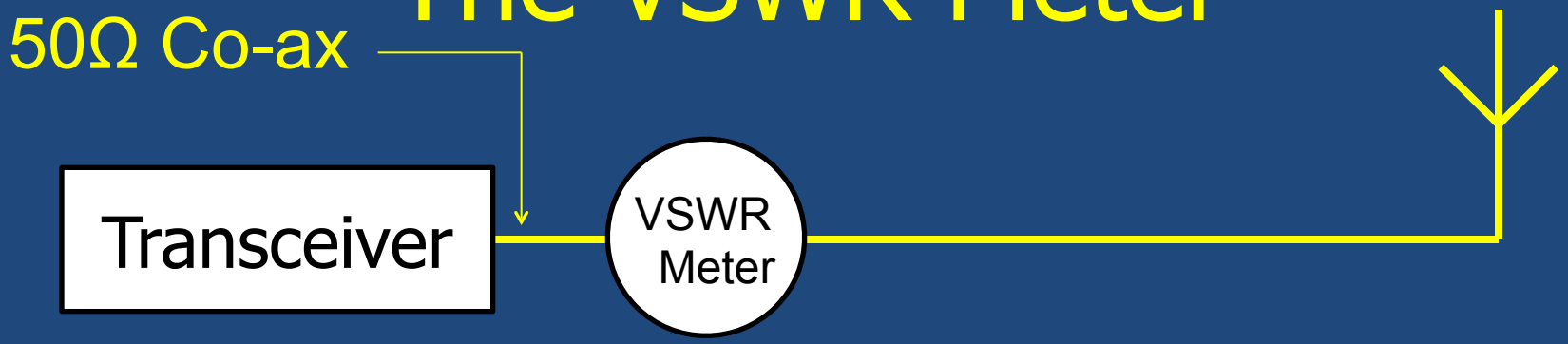
Voltage Standing Wave Ratio (VSWR).

Where there is no mismatch the VSWR is 1:1.

As the mismatch increases so does the VSWR.

You risk damage to the transmitter if it tries to operate into a load where the VSWR is greater than 2:1.

The VSWR Meter





The vswr meter displays the level of the forward and reflected powers using a meter with two needles..

Where the needles cross there is a third scale from which you can estimate the VSWR.

A high vswr indicates an antenna or feeder problem – not a fault with the transmitter.

The Antenna Matching Unit

A multiband HF antenna has to operate over a range of frequencies from 3.5MHz to 30MHz.

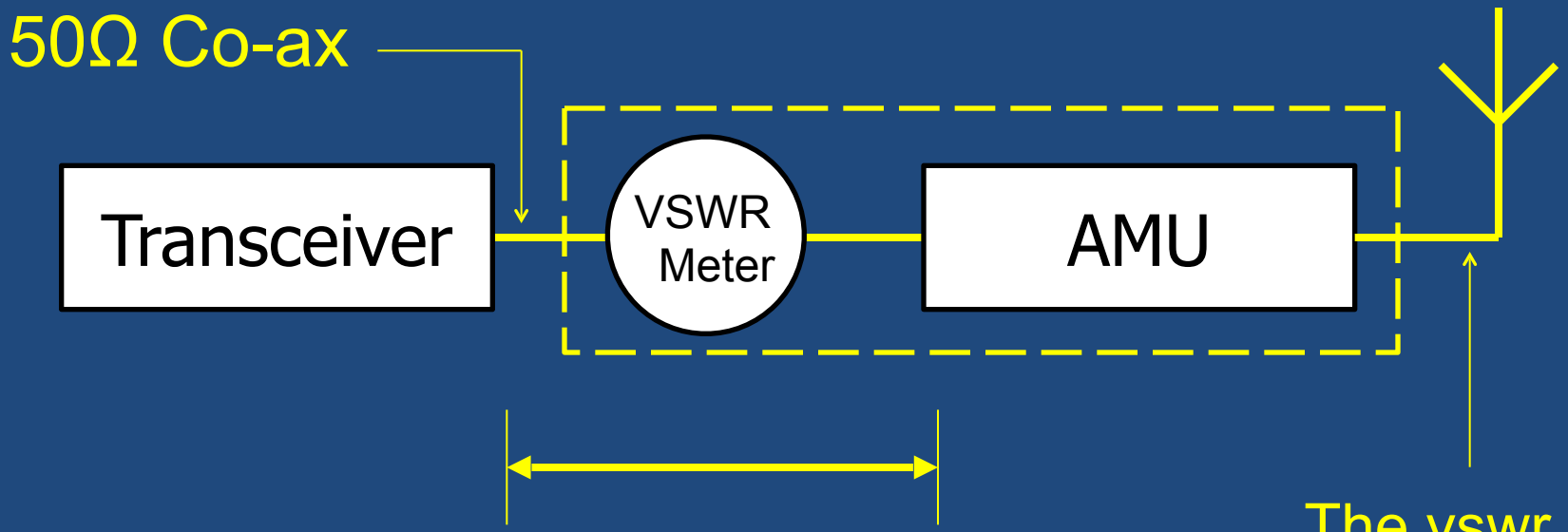
To accommodate the changes in feed impedance this creates you use an:

Antenna Matching Unit (AMU)



The AMU – sometimes called an Antenna Tuning Unit (ATU) – fits between the transmitter and the antenna. It is adjusted to present a 1:1 match to the transmitter..

The AMU

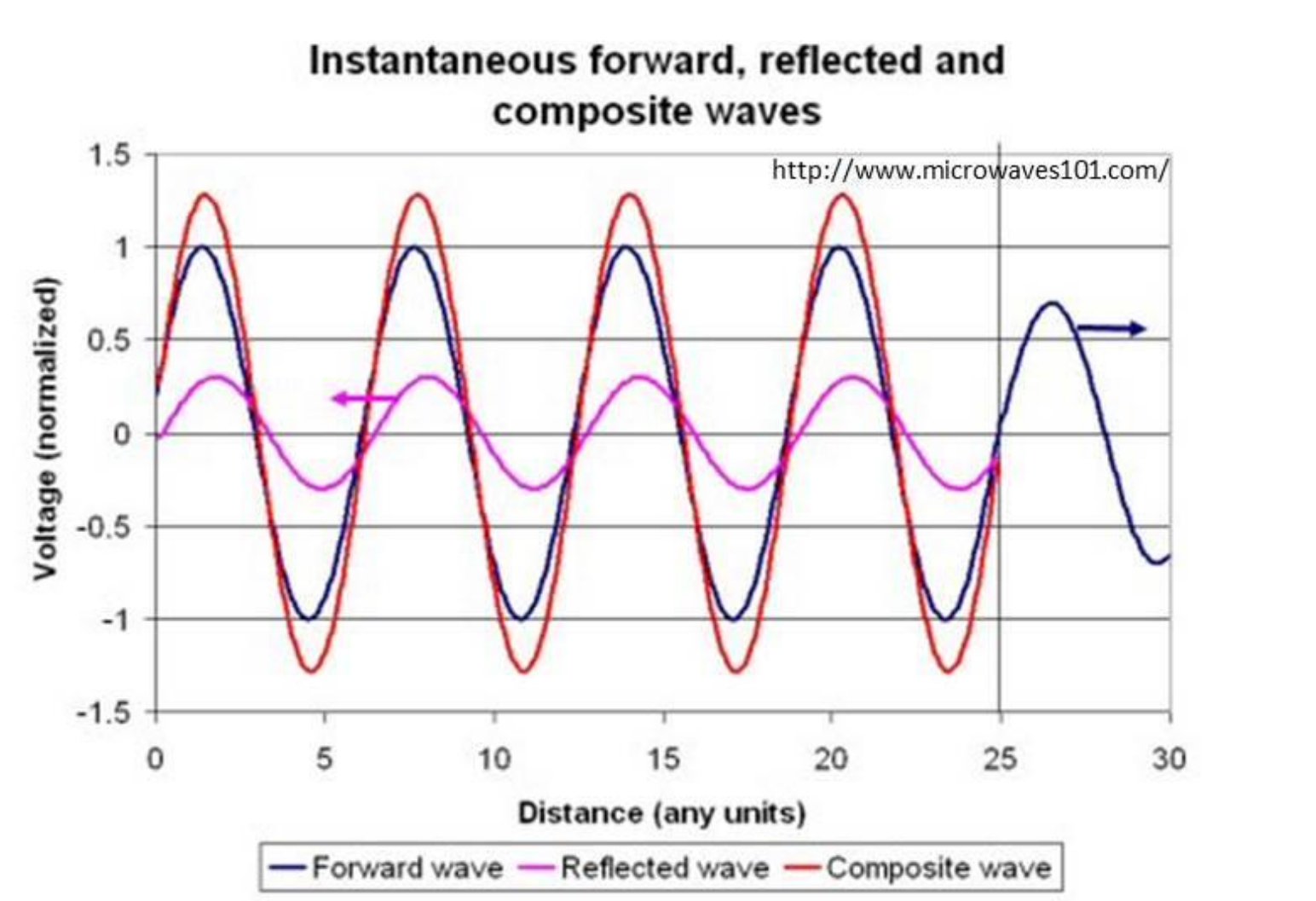


The Antenna Matching Unit (AMU) is used to present a 1:1 vswr to the transmitter

Only the section between the transceiver and the AMU has a vswr of 1:1

The vswr on the feeder between the AMU and the antenna may be very high

VSWR


Instantaneous forward, reflected and composite waves
http://www.microwaves101.com/
Voltage (normalized)
1.5
1
0.5
0
-0.5
-1
-1.5
0
5
10
15
20
25
30
Distance (any units)
Forward wave
Reflected wave
Composite wave

The Dummy Load

The dummy load is a screened 50Ω resistor. It absorbs the transmitter output with no reflected power. Because it is screened it does not radiate significantly.



You use the dummy load to set up the microphone gain without having to transmit a signal.

RF Plugs and Sockets


BNC Plugs & Sockets







PL259 are the standard connectors for HF.

N connectors and BNC connectors are excellent connectors for HF, VHF and UHF.

SMA connectors are often found on hand-held transceivers and for connecting pcbs within equipment.

There must be no leakage of signal from the plug.

Section 6

Propagation

Basic Propagation

Radio waves travel in straight lines (radially) outwards from the antenna.

- They can be:
  - Reflected;
  - Refracted;
  - Diffracted.

- Radio waves get weaker as they spread outwards.

(They follow an inverse square law. If the distance is doubled the wave is a quarter as strong. If the distance is trebled the wave is a ninth as strong and so on.)

VHF & UHF Propagation

At VHF and UHF propagation is “line of sight”. The higher above ground level the transmitter is situated the further the signals will travel.

VHF and UHF signals are blocked by hills, mountains etc.

At VHF and above signals pass through the Ionosphere. Propagation is mainly in the troposphere.

As the frequency climbs above UHF rain and snow will progressively absorb more of the RF energy.

The Ionosphere

In the thin upper regions of the Earth's atmosphere, between about 70kms and 400kms above the surface, ultra-violet radiation from the Sun can ionise the gases.

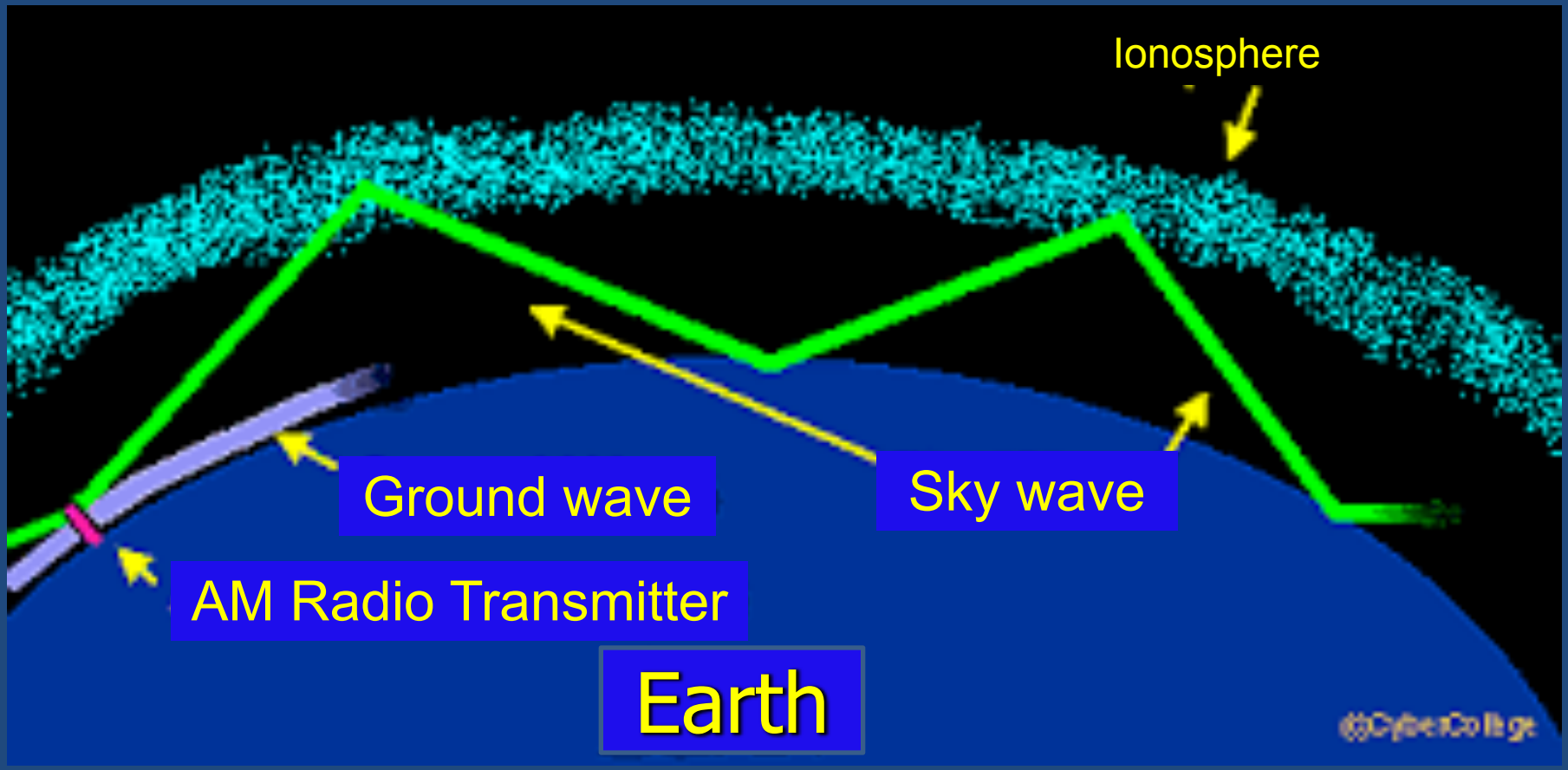
At frequencies below about 70MHz these layers can bend or refract radio waves.

At HF the ionosphere is relied upon to give world-wide propagation by refracting the wave back to the ground thousands of kilometres from the transmitter.

How well the ionosphere does this is affected by the time of day, the season and the level of solar activity as well as the chosen frequency.

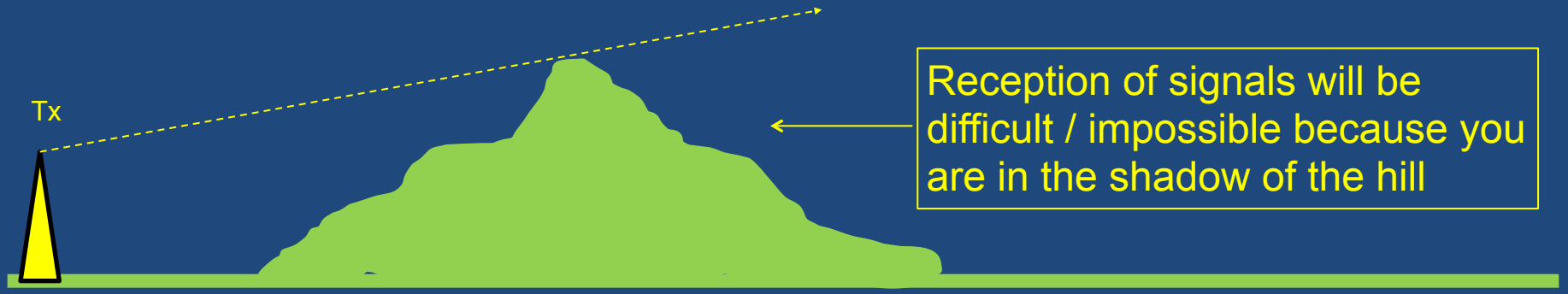
A "band" is said to be open when the Ionosphere supports skywave propagation.

Ionosphere

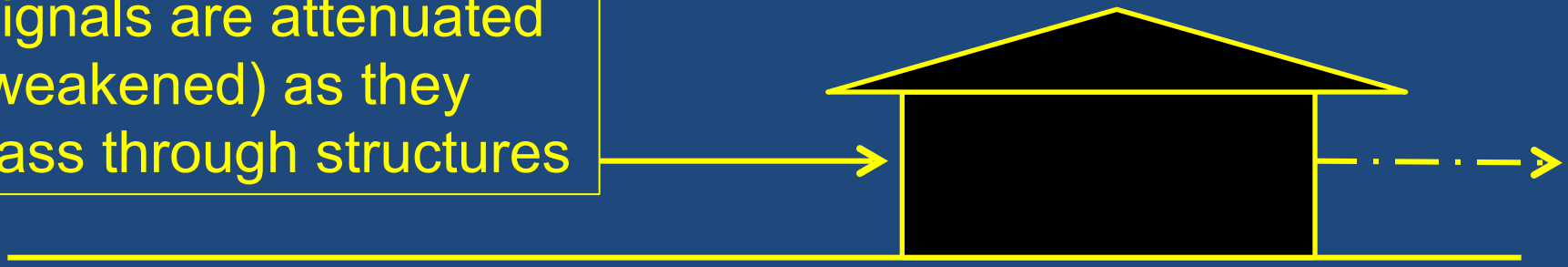


The refracted wave is reflected from the surface of the Earth – generally from the sea – to return upwards to the Ionosphere again. A series of hops gets it world-wide.

Strength & Range



Signals are attenuated (weakened) as they pass through structures



Range and Frequency

As the frequency increases the range decreases. In general VHF and UHF signals have a range similar to that of light. They do not travel much beyond “line of sight”.

However, certain atmospheric conditions ,such as sporadic E and ducting, can cause VHF and UHF signals to travel significantly further. (eg Spain to the UK).

At UHF and microwaves heavy rain, snow and ice can severely limit the range of signals through absorbtion and scatter.

Range and Antenna Height

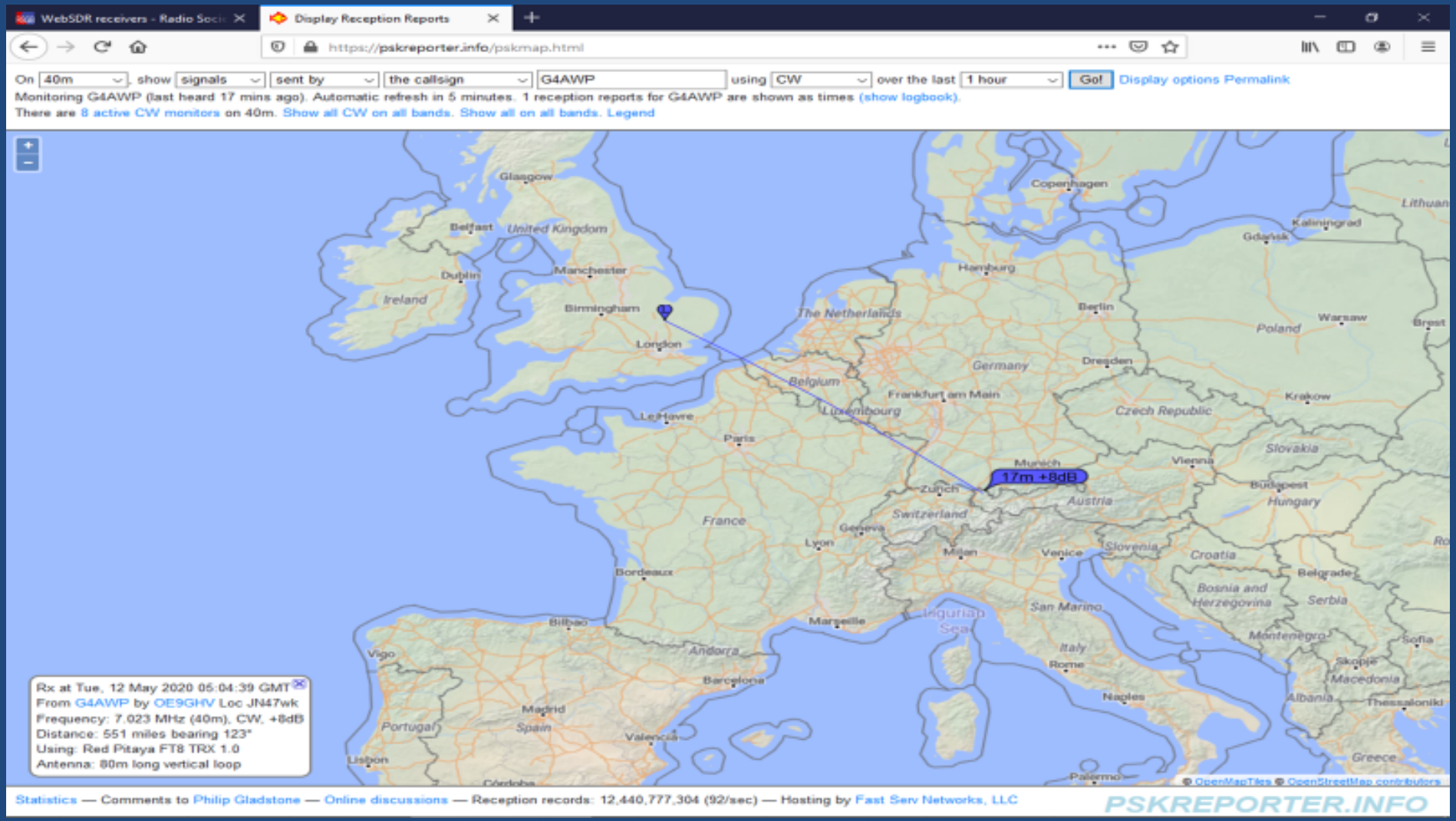
At VHF and UHF the range is increased by increasing the height of the antenna above ground. (ie you can see further from the top of a tall building than from ground level.)

In addition using an antenna with gain, having a clear signal path and the level of transmit power are also significant.

A high antenna is better than higher power as it will improve both the transmit and reception performance.

An outdoor antenna will perform better than an indoor antenna.

CW at 0.25W (G4AWP)



Section 7

Electromagnetic Compatibility

Electromagnetic Compatibility

Electromagnetic compatibility is the avoidance of interference between various pieces of electronic equipment.

The ability of a piece of equipment to function correctly in the presence of a strong, interfering , RF signal is known as its:

Immunity

Transmitters are a source of interference to other electronic equipment.

Radio receivers can also suffer interference from other equipment radiating an interfering signal.

Causes of Interference

The more power a station runs the more chance there is of causing interference.

Some modes of transmission are more likely to cause interference to TV, radio reception, hi-fi, telephones etc.

AM and ssb signals are poor in this respect;

CW (Morse), FM and some HF data modes such as PSK31 are much better.

Pick Up of Interference

Interference occurs by signals from a nearby radio transmission being conveyed to the affected equipment through pick up in the house wiring, TV antenna down leads, telephone wiring, speaker leads etc.

At VHF and UHF signals can be directly picked up in the internal wiring of the circuits.

(If the equipment has a cable or wire connected to it then this will act like an antenna.)

Improving Immunity

The immunity of most types of equipment can be improved by fitting suitable external chokes and filters in mains leads and antenna leads.

You need to fit the filter as close to the affected device as you can.

Antenna Position & Type

EMC problems can be minimised by positioning your antennas as far as possible away from houses, as high as possible and by using balanced antennas at HF.

At HF horizontal dipoles are likely to be less of a problem.

End-fed wires can present significant EMC problems.

There are several sources available to help with the correct siting of antennas. (eg RSGB publications, your local club, etc.)

Station RF Earth Connection

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.

Transmitting into a dummy load is a good test to see if unwanted signals are being conveyed by the mains wires or other leads.

Mobile Installations

The vehicle owner is responsible to ensure that any radio installation is compatible with the vehicle's electrical and engine management systems and does not affect vehicle safety.

The fact of the installation may have to be disclosed to the vehicle insurers.

Seek professional advice for all vehicle installations. Battery charging and ignition circuits can cause interference on receive.

Any tests following mobile radio equipment installation should be done static with all vehicle electronic systems operating before any on-road tests are carried out.

EMC & Diplomacy

EMC problems have the potential for causing disputes with neighbours. Be diplomatic and seek help in solving the problems.

The RSGB can offer advice and solutions via their EMC leaflets. OFCOM also have a role.

The station log book is invaluable in dealing with any complaints of interference. This is a good reason for always keeping a log of your transmissions.

There is much merit in both parties keeping a log of the instances of interference.

Additionally conducting joint tests co-operatively can speedily locate the issue and its solution.

Section 8

Safety

Safety

We will now examine some of the safety aspects of amateur radio.

Amateur radio does not present particular risks to health if you treat the hazards with respect and follow the correct working practices.

Electrical Safety

There are two hazards associated with the mains supply.

These are:

1. The risk of electrocution.
2. Fire arising from an unprotected overload.

When treated with respect the danger arising from these electrical supply hazards will be minimal.

The 230V 50Hz AC Mains Supply

In the UK the average, domestic property is supplied with electrical power from an alternating current mains supply.

Typically the power to the property is supplied at 230V / 50Hz and will have a capacity of about 12kW.

Normally the entire installation will be protected against overload by a 60A (or 80A) fuse installed by the electricity supply utility company.

Other sub-circuits in the consumer unit will have individual protection according to their function.

Electrocution

• Any voltage applied to the human body has the potential to harm you. The current that flows when your body forms the external circuit can affect you in two ways:

–By interfering with your nervous system and causing muscular spasm and heart irregularities (fibrillation);
–By causing burns.

• If you are wet or perspiring the current which will flow will be correspondingly higher because your skin resistance will be lower. (Ohm's law)

Electrocution

- There is *obviously* no "safe" lower limit of voltage. However, voltages above about 50V are *definitely* hazardous.

- Currents as low as 10mA *(ten thousandths of an Amp.)* can cause heart failure.

- The *worst case* is where the current passes across your chest and heart.

ie. Holding the positive wire of the supply in your right hand and the negative wire in your left hand. In other words:

"putting oneself across the supply"

Electrocution

The old adage of:

"It's volts what jolts but mils what kills"

- expresses the effect of electrocution well.

Safety Imperatives

Never, ever work on live equipment.
Always isolate the equipment by removing the plug from the socket before removing any protective covers.
Never, ever assume equipment is dead – check first.
Never use electrical equipment which is damaged.
Always unplug all equipment and antennas if thunderstorms are in your area.
Never, ever operate during thunderstorms or if they are detectable anywhere in the vicinity.
(If there is less than 30 seconds between seeing lightning and hearing the thunder then the storm is local.)

Take no chances with lightning

Always fit the correct sized fuse for the cable.

Electrocution: Protective Devices

If you put yourself across the mains supply (live and neutral) then there is no circuit protective device that will stop you from getting an electric shock. *(Because the supply will see <u>you</u> as a <u>normal</u> load!)*

You should fit a *residual current device (rcd)* to protect against faults between the positive supply and earth. These will typically trip and disconnect the supply if they detect a leakage current from live to earth in excess of 30mA.

A fuse is fitted to protect the supply cable - not the equipment. It disconnects the supply if there is a short circuit between it and the load which would otherwise cause overheating of the cable and a fire.

Electrocution: System Isolation

- Your shack should have a single point of isolation which will disconnect the supply to all of your equipment.
- Indicate this point of disconnection clearly and prominently.
- Make sure members of your family know where this point of isolation is and how to operate it.

Equipment DC Power Supplies

- Your equipment will probably be powered from a mains power supply unit (psu).

- The psu will transform, rectify and condition the ac mains input to give a dc output of around 13.2V to operate your rig.

- Typically a psu will be able to deliver at least 25A in order to run a 100W Transmitter.

Equipment Power Supplies

There exists the danger of the 230V ac mains supply to the psu which we covered in the previous section. Although the dc side of the psu is at 13.2V it has the capability of delivering a *substantial current* – and the potential for *burns*.

- Always fit the correct line fuse(s) specified by the manufacturer.
- Keep the psu dry and never short out the dc supply.
- Check regularly for damage and any signs of overheating.
- Switched-Mode power supplies may also contain high internal voltages. Keep the covers securely attached.

Battery Power Supplies

When operating mobile a high-capacity, rechargeable battery is often used as the power supply. You must be careful and remember that *there is a lot of stored energy in a battery*. Typically this may be a sealed, or valve-regulated, lead-acid type or a Lithium Ion type.

The lead-acid battery is heavy, contains sulphuric acid and liberates the explosive gas hydrogen when recharging. It has a very low internal resistance and will produce a short-circuit current in the hundreds of amperes. (*ie the potential for burns and explosions.)*

• *Never recharge* a lead-acid battery in a confined space or with anything other than a properly designed charger for the particular battery.
• Treat all batteries with the *utmost care and respect.*
• Dispose of old batteries in accordance with environmental legislation applying to hazardous waste.

Battery Charging

Different battery technologies require a different charging process.

Always use the correct charger for the battery technology in question.

Always follow the manufacturer's instructions.

Lithium batteries in particular are an explosion and fire risk if not treated correctly.

Action In Case of an Accident

If you are first on the scene of a suspected electrocution. Then:

DO NOT TOUCH THE CASUALTY

- Find the supply isolator and turn off the current.
- Summon medical assistance.
- When you are CERTAIN that the supply is ISOLATED then check if the casualty is breathing.
- If the casualty has stopped breathing then apply CPR (Cardio-Pulmonary Resuscitation). Continue this until qualified medical help arrives.

Action In Case of an Accident

In most amateur (domestic) situations any electrocution is likely to be from 230V ac mains – with perhaps the exception of HV supplies within a piece of equipment.

Where higher, power-transmission voltages are involved (eg overhead pole routes at 11kV and above) you risk becoming a casualty yourself if you try to help without the certainty of the supply being isolated before anyone touches the casualty.



Cambridge News

Thursday, July 26, 2012 cambridge-news.co.uk UK Regional Newspaper of the Year 50p

FOLK FESTIVAL SPECIAL
• The Proclaimers tell all
• The weekend's best acts
PLUS Meet Tom Jones in our EXCLUSIVE competition
12-page pull-out What's On

I popped to the supe – and got diverted

104-PAGE HOMES GUIDE IN YOUR GREAT VALUE P

Jogger killed by 11,000 volt cable

Respected scientist, 41, dies in freak accident while out with running club

ADAM LUKE

A SCIENTIST died from severe burns while out jogging after running into a fallen electricity cable.

Dr James Kew, who studied neuroscience at Cambridge University before rising to be a director at pharmaceutical giant Glaxo-SmithKline, was jogging with his running club on Tuesday evening when the incident happened.

Dr Kew was killed after coming into contact with an 11,000 volt cable, which was hanging from a pylon, at 8.40pm in fields off Debden Road, near Newport in Essex. It started a blaze in the surrounding area. He was pronounced dead at the scene by the emergency services, who treated two other runners for minor electric shocks.

Dr Kew, of Radwinter Road, Ashdon, who was married with children, was a keen member of Saffron Walden-based running group Saffron Striders, who he was out with on Tuesday – just days before his 42nd birthday.

He regularly competed in races across the local area and this year took part in his first London marathon.

Turn to page 5

TRAGIC: Dr James Kew. Left, an officer at the scene of the incident

Shepre animal cool of

INSIDE ROSIE

The C stude kept flam

ARREST AFTER SUSPECTED ARSON ATTACK NEAR SCHO

Do you need a lawyer who is a specialist in employment law (including compromise agreements), litigation and disputes, immigration matters (including student visas) and business issues?

We are friendly solicitors at Wellington House, East Road, Cambridge. Call Nick Timmings or Dawn Kiddy on 01223 451010 or email us at enquiries@petersfields.com www.petersfields.com

PETERSFIELDS

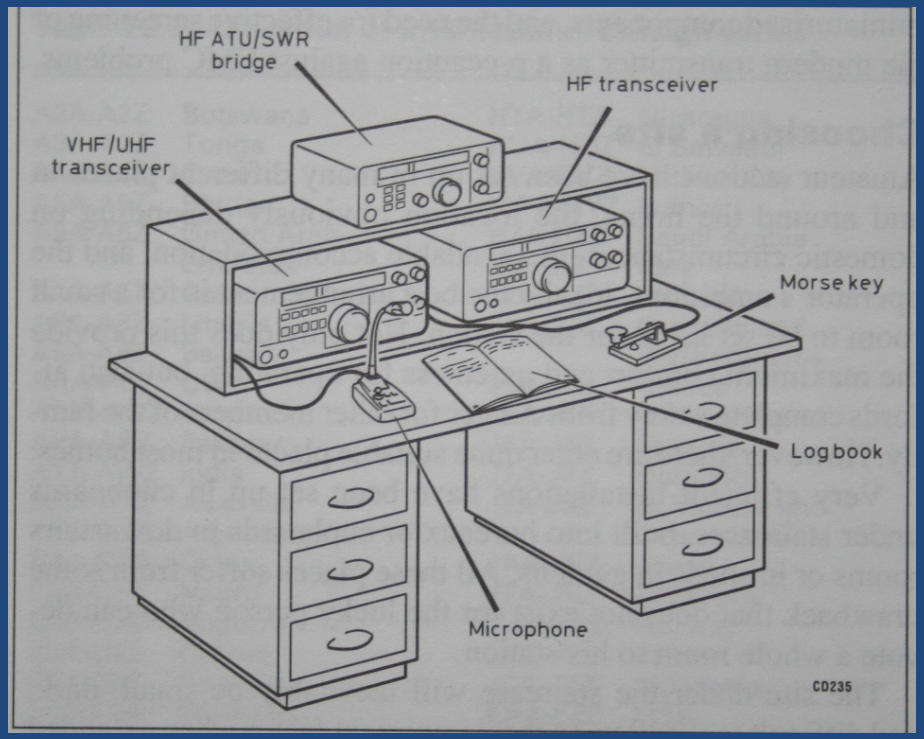
In addition you should never rig antennas or erect towers or ladders anywhere near to overhead electric cables.

Contact with the cables can be lethal.

It does happen……

Station Tidyness

The picture below shows how a typical amateur station could be arranged. (Taken from the RSGB Radio Communication Handbook, 7th Edition, Page 22.8)



In addition you need to make certain that there are no trip hazards from trailing leads. The mains wiring needs to be in good order and properly protected. For long operating periods you will suffer less fatigue if the lighting is adequate and the working height of the equipment is sensible and that controls are within easy reach.

Safe Use of Headphones

Occasionally you may find the use of headphones an advantage in copying weak stations. However, you risk damage to your hearing if the audio gain is too high.

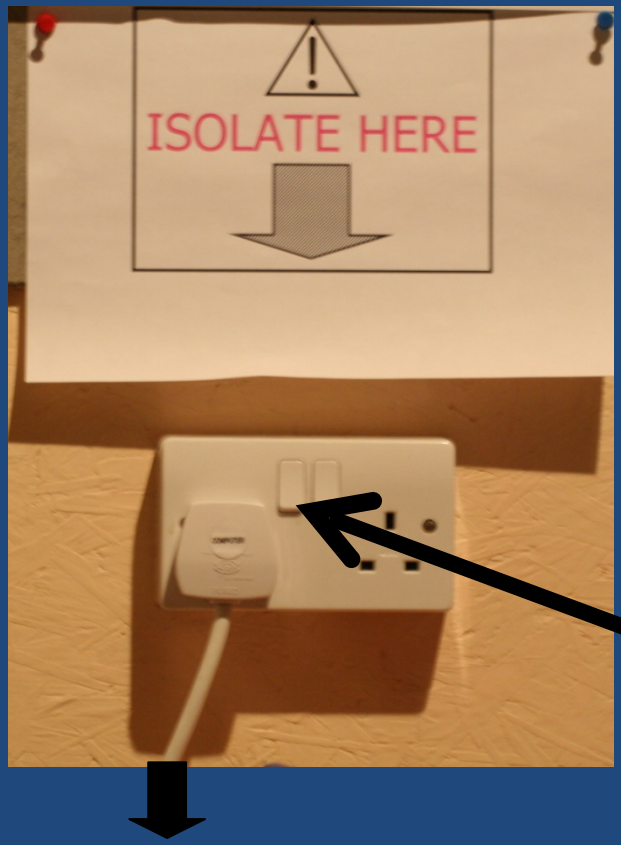
Always turn the gain to minimum each time you use headphones and then increase it to a comfortable level for copying the weak station.

The danger to your hearing comes from prolonged exposure to high audio levels very close to your ear. This can cause *"noise induced deafness"* over time. A sudden unexpected noise (static crash) can also exceed the safe power level at your eardrum.

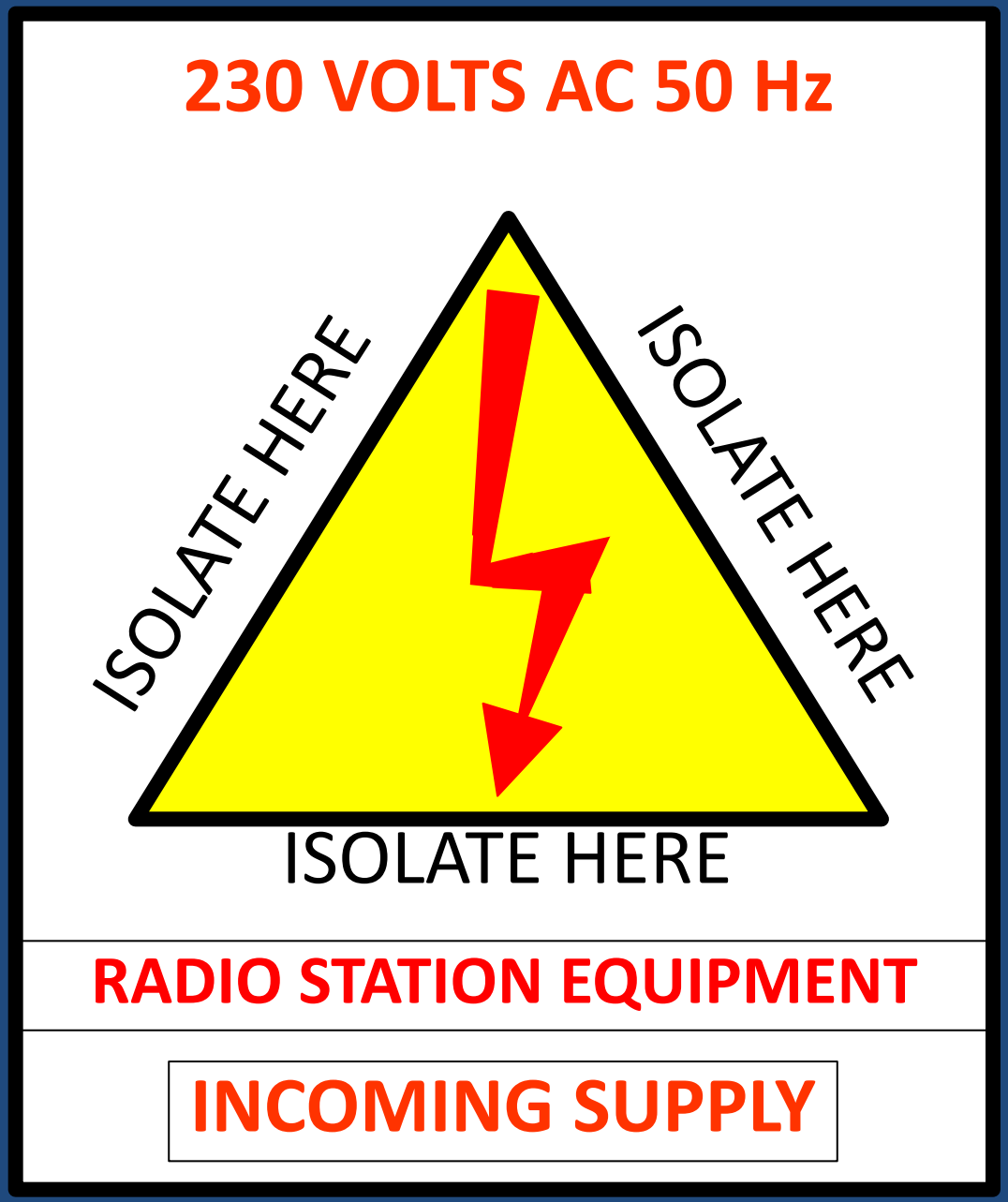
Don't wander around the shack with the headphone cable dangling down.

Don't work on equipment with the headphones on. An unexpected contact with the jack plug and the equipment wiring could cause a very loud noise in the earpiece. A startled response to this could put you in contact with live parts etc.

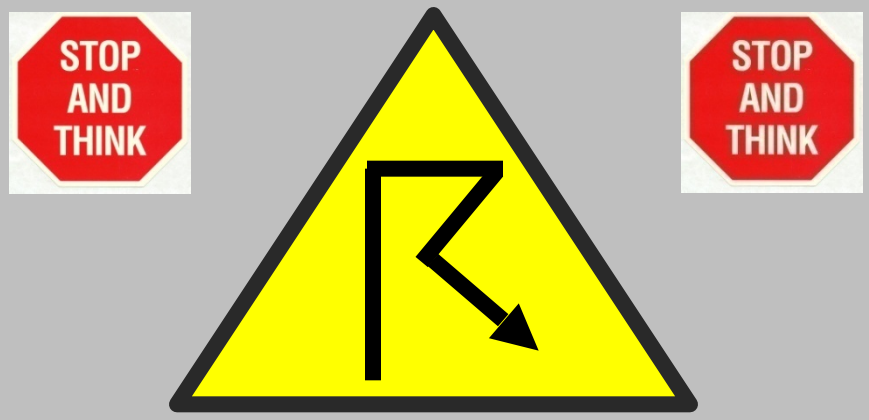
Isolation of the Supply



You can effectively make a single point of isolation for the shack equipment by feeding it from a 4-way trailing lead. The wall switch then becomes the single station isolator.


230 VOLTS AC 50 Hz
ISOLATE HERE
ISOLATE HERE
ISOLATE HERE
RADIO STATION EQUIPMENT
INCOMING SUPPLY

ANTENNAS



DO NOT

OPERATE RADIO STATION

DURING ELECTRICAL STORMS

DISCONNECTED

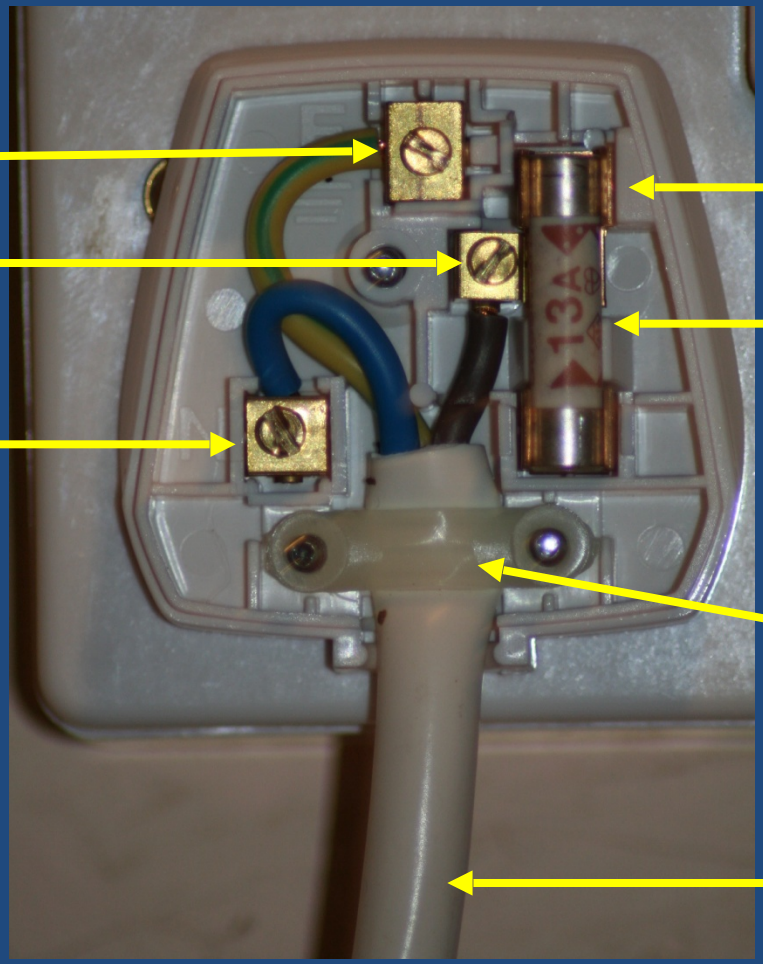
Plug Top Terminations

No broken strands:

No loose strands:

No clamped insulation:

No damaged cables.



Earth Terminal

"Live" Terminal

Neutral Terminal

Fuse Cradle

Fuse: Not ALWAYS a 13 Amp type. Size the fuse to properly protect the cable.

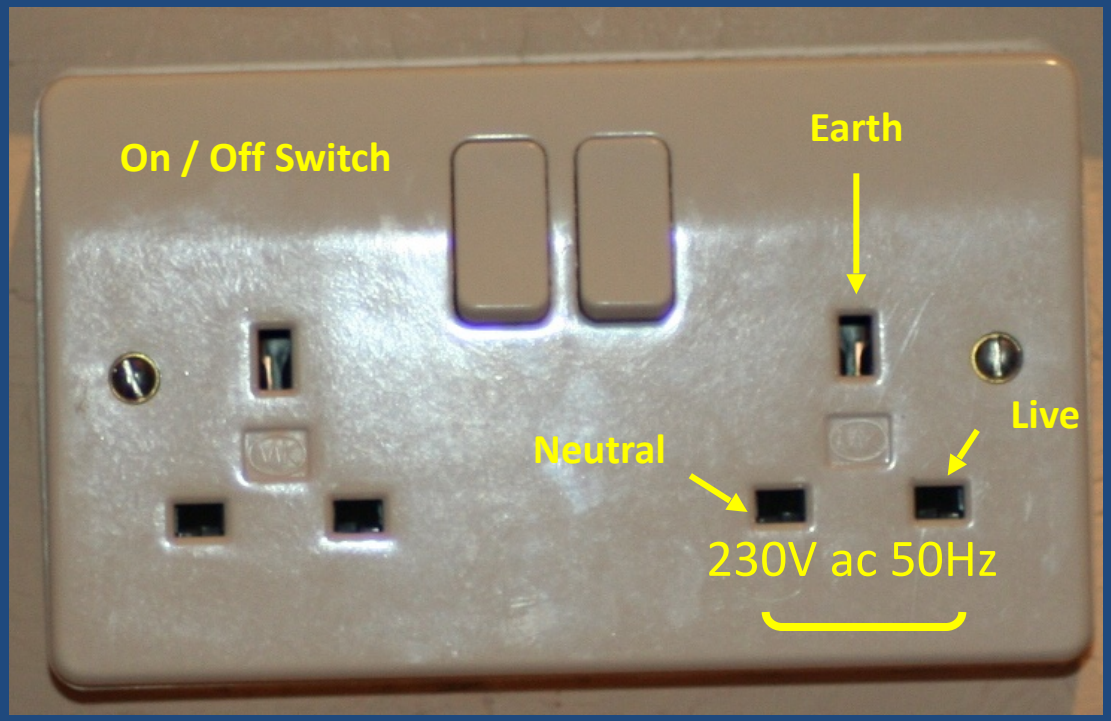
Cable Clamp

Cable Sheath

If it isn't perfect

then start again!

Socket Outlets



NEVER interfere with the earthing arrangements to your electrical supply.

NEVER use the electrical supply earth as a station RF earth. Under fault conditions there is the possibility of applying a high voltage to your equipment – and to you!

Keep your RF earth separate from the protective earth.

Get advice from your distribution network operator before installing any RF earths. This is particularly so where Protective Multiple Earth (PME) supplies are involved.

Ladders and Towers

Unless you are accustomed to working from a ladder at heights then don't start now merely to fix an antenna!

You need to be confident and have the correct equipment. Above all you need to know what you are doing.

If you must fix an antenna support on the roof then call in an aerial erection firm (TV antennas) and get the job done safely.

By using telescopic masts or aluminium poles you can erect a satisfactory antenna from ground level. You may be able to sling a rope over a tree branch and hoist up a wire.

Ladders and Towers

Keep well away from overhead power lines. Remember that the energy in HV cables can arc or flash over onto a metal ladder or anything with an elevated earth.

Do not rig an antenna underneath power cables.

Do not rig an antenna where a broken power cable and/or wind-blown antenna wire can come into mutual contact.

Tower / mast climbing requires specific safety equipment such as fall arresters. The tower, if an extendable one, must also be de-extended and “scotched” (or locked) to prevent any movement.

Lightning Protection

High towers may require lightning protection.

The local authority buildings department can advise.

Ladders and Towers

If you really must……

- 1-out-4-up gives a correct ladder angle of about 75 degrees.
- Tie the ladder to the building or have it footed by a companion.
- *Never work alone.*
- When climbing wear proper working boots with a definite heel and instep to locate on the rungs.
- Always keep one hand on the ladder and don't lean sideways.
- Plan the job beforehand and stop if the weather turns or you get tired.

Preferably get any antenna work at heights done by professional aerial erectors to your design.

Use The Correct equipment

The correct equipment is essential when working at heights.

Use a tool belt to help reduce the risk of you dropping heavy tools.

You and your assistants should wear “hard hats” when anyone is working at height.

Exposure to RF Fields

The main health risk from exposure to high levels of RF radiation is tissue heating in the body. The eyes are particularly sensitive to this.

Guidance on safe levels of RF radiation is available from government and international bodies, Public Health England and The International Commission on Non-Ionising Radiation Protection (ICNIRP)

Never look down the waveguide feeding a microwave antenna.

Do not stand in front of high gain VHF / UHF antennas – you don't know if they are in use.

Antenna Elements

Do not touch antenna elements when the antenna is in use. High voltages appear across antennas under certain conditions.

Mount antennas where they cannot be touched.

Low power hand-held devices are safe.

Temporary Premises

If you operate from a temporary premises be aware that there may be additional risks and hazards.

These include:

Trailing leads,
Guy wires;
Portable generators and overhead live wires;
Temporary supplies;
Trailing leads;
Damp ground;

Use RCBOs (rcd) and route cables sensibly. Fuse all supplies correctly and don't work live on any equipment.

Tell the appropriate person if you discover anything unsafe.

RESPECT YOUR SAFETY AND THE SAFETY OF OTHERS AT ALL TIMES.

Eye Protection etc.

When soldering you should wear eye protection to avoid injury from solder splashes.

When using side cutters to trim component leads the ends can “ping” off and cause damage to your eyes. Wear eye protection for this and similar activities.

The fumes from the flux used in solder is an irritant. Do any soldering in a well-ventilated area and avoid breathing the fumes.

Use lead-free solder and wash your hands thoroughly when finished.

Tools

Be careful when using any form of tooling.

Keep hands behind all cutting tools.

Power tools should be in good condition and the supply cable undamaged. The correct size fuse for the supply cable must be fitted.

Keep the supply cable to a soldering iron clear of the hot soldering bit. Always use a soldering iron stand in which to park the iron when not in use.

Section 9

Practical Assessments

Practical Assessments

We will undertake the practical assessments throughout the course to reinforce and illustrate the learning points. The assessments include:

- Sending and receiving a message in hand-sent Morse.

- Demonstrate the ability to make a contact using SSB. The contact must be made on air and include as a minimum:

- Tuning the radio to the correct frequency, or section of the band;
- Selecting the correct mode;
- Setting the radio microphone gain to the correct level;
- Check if the frequency is in use and make a CQ call;
- Vacate the calling frequency if appropriate after establishing the initial contact;

- The two-way exchange must include call sign, signal report and location;
- Ending the contact;
- Recording all details of the contact in a log.

Practical Assessments

• Demonstrate the ability to make a contact using FM simplex. The contact must be made on air and include as a minimum:

• Setting the radio to the correct calling frequency;
• Selecting the correct mode;
• Correct setting of the squelch control;
• Make a CQ call;
• Vacate the calling frequency after establishing the initial contact;
• Check if the new (working) frequency is in use;
• The two-way exchange must include call sign, signal report and location;
• Ending the contact;
• Recording all the details of the contact in a log.

Practical Assessments

- Adjust the physical length of an antenna for lowest SWR.

- Match an antenna system for lowest SWR in at least two bands using a transmitter or transceiver and a (manual) antenna matching unit.

- Correctly connect up a station. To include as a minimum, mains PSU, amateur radio transmitter/receiver or transceiver, microphone or PC interface, external item (e.g. VSWR/Power meter, AMU, filter), feeder and antenna.

- Connect a battery, resistor and LED to show the LED lights when connected with the correct polarity and measure the current flowing.

- Calculate the values of resistor required given the battery voltage and specified LED current.

- Demonstrate that connecting another resistor of the same value in parallel with the existing resistor results in a doubling of the current in the LED. Explain the reason to the tutor.

END