Amateur Radio

Amateur Radio has been around since the start of radio communication. It provides a good introduction and a good feed in to STEM subjects. Amateur Radio provides an area where new technologies can be developed and where they can feed into the wider community by being capitalised by businesses.

In the early days of radio communications the modulation method (mode) being used was AM - Amplitude Modulation. The frequency range being used was in the low MHz (Mega Hertz). Amateur Radio operators opened up the whole HF (High Frequency) spectrum and the advantages of using SSB (Single Side Band). Around this time FM (Frequency Modulation) was also opened up.

Amplitude Modulation is very inefficient power wise in that it uses a Lower Side Band (LSB) and a central carrier wave and an Upper Side Band (USB). It also uses double the bandwidth of a Single Side Band signal. Hence Amateur Radio operators mostly use LSB and USB, and commercial operators use USB, on HF frequencies.

Like any hobby there is a whole ecosystem in Amateur Radio, There are manufacturers from around the world. Many of them, especially the Japanese and Chinese manufacturers, supply equipment for both the Amateur Radio market and the commercial market. Often their development of Amateur Radio products feeds directly into their commercial product development. A good example is the Software Defined Radio (SDR) technology that initially came out in the Amateur Radio field where it could be tested and refined. It was then used in the other markets. SDR radios use a computer chip to encode and decode the signal. They are very sensitive, allow a spectrum to be displayed and can be easily reprogrammed for different transmission modes. They can extract digital signals from the noise. They are compact, simple in construction and are simple and flexible in operation.

Equipment like this, with a good antenna, allows Amateur Radio operators to communicate right around the World.

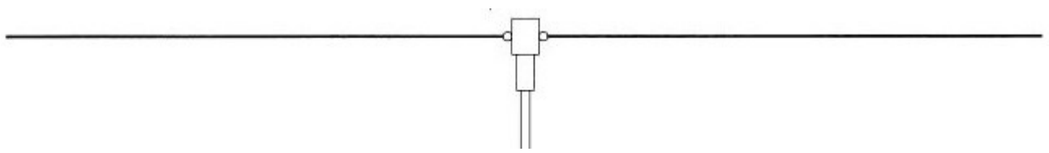
SSB, AM, FM, CW and digital modes such as FT8 and WSPR are used. APRS (Automatic Position Reporting System) and SSTV (Slow Scan TV) are also used.

The spectrum display on the ICOM shows amplitude versus frequency above the X axis and the historical amplitude in the waterfall below the X axis. The Yaesu shows the amplitude in a 3D format with the history going backwards along the Z axis. On the Audio Scope on the ICOM the left pane shows the amplitude versus frequency spectrum. The right pane shows the amplitude versus time spectrum.

Radio Communication

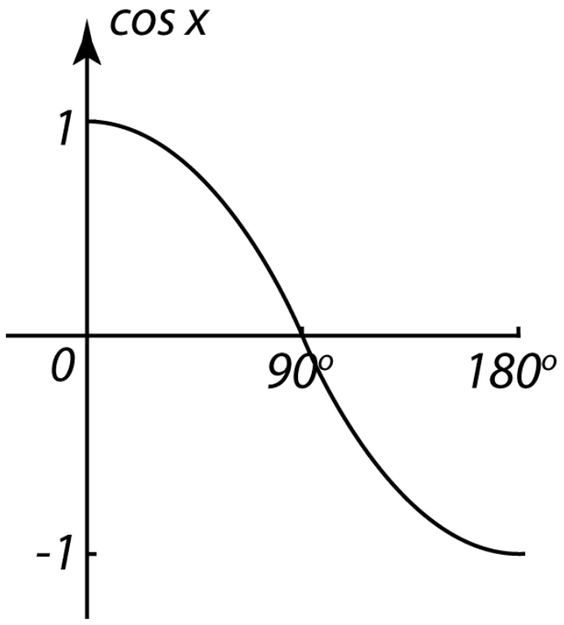
The best way to approach to describing how radio communication occurs is to look at how antennas operate.

The basic form of antenna is the 1/2 wave dipole.



This consists of 2 1/4 wave lengths of wire connected to the coaxial transmission line which is connected to the transmitter. One piece is connected to the ground terminal and the other piece is connected to the active terminal. When the radio signal is sent through to the antenna at the wave length of the antenna it produces the maximum voltage difference between the ends of the antenna.

This is best illustrated by a cosine wave extending from 0° to 180°.



What happens is that the electrons are forced up and down the antenna in the same manner. As such they push and release space time thus creating a wave in space time that moves out at 90° to the dipole. If the dipole is horizontal the wave comes out polarised horizontally. And likewise if it is vertical the wave comes out polarised vertically. The receiver's antenna must be similarly polarised in order to maximise reception strength. However that is more important for UHF and higher signals than for HF signals as the lower frequency waves get twisted in their travels by atmospheric effects.

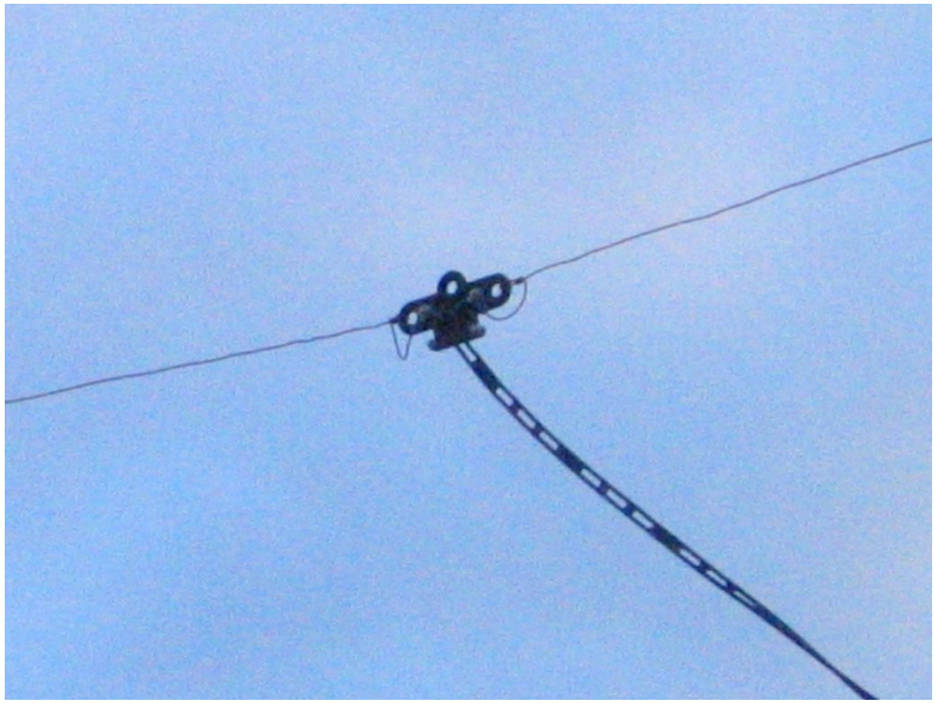
When the wave in space time arrives at the receive antenna the gravitational repulsion pushes the electrons up and down the antenna. This results in an electrical current being generated and a corresponding voltage appearing across the antenna's terminals. The receiver then amplifies this voltage and filters in - tunes to - the required frequency. The signal is then decoded from its modulation type, amplified further and then output to the speaker.

Light waves are a separate case in that they go in and out so are received correspondingly differently.

Antennas

Antennas are typically of the following basic types :-

Dipoles and Yagi Arrays - dipoles with reflectors and directors



Verticals and Helicals - verticals with the antenna wound around the post

Dishes

Transmission Lines, Antennas and Standing Wave Ratios (SWR)

When the 'Big Bang' occurred the universe expanded from a singularity of zero size to its current size. During this time the standard distance (eg 1m) expanded and the speed of time (eg 1s) increased. Within frames of reference - fixed standard distances and speed of times - the speed of light (and electromagnetic waves in general) remains constant. In order for time to occur there has to be a resistance within the frame. For moving objects - kinetic energy - this is described as inertia. For electromagnetic waves (ripples in space time) - this is described as impedance.

Impedance is expressed in terms of resistance. When an AC (alternating current) sine wave is passed electrically through a passive component such as a resistor, capacitor (2 plates closely spaced) or inductor (coil of wire) a voltage occurs across the component - and vice versa. With resistors the voltage and current waves are in phase - 0°. With a capacitor the current lags the voltage by 90°. With an inductor the current leads the voltage by 90°. Impedance is expressed as a complex number in terms of Resistance and Reactance.

The best way to imagine how transmission lines and antennas operate is to look at how waves going down springs operate. If the spring is excited the wave will travel down to the end of the spring and then will be reflected at the end. It will then hit the next cycle coming down the spring and constructively or destructively construct. This is dependent on the frequency of the wave and the corresponding impedance of the spring (which determines the speed of the wave travelling down the spring).

When an electrical wave is sent down a transmission line to the antenna the aim is to get the maximum amount of energy out of that antenna in the form of the corresponding radio wave. The standard impedance used for amateur radio communications is 50Ω. The output of the transmitter, the transmission cable and the antenna all have to have an impedance of 50Ω. If they are all matched this, theoretically, produces a SWR of 1:1 where the all of the forward power is emitted - where there is no reflected power that reduces the amount of emitted (transmitted) power.

The antenna has to be matched to the impedance of free space (space time) - 377Ω. This is done in the practicalities of the antenna construction.

Propagation

The success of propagating radio waves depends on their frequency and the proximity of the devices that are communicating.

VLF	3kHz - 30kHz		Ground and water penetrating.
LF - LW	30kHz - 300kHz	30kHz to 530kHz	Long distance regional communication - Ground Wave based - follows the curvature of the Earth.
MF - MW	300khz - 3MHz	530kHz to 1.610MHz	Medium to long distance regional communication.
HF - SW	3MHz - 30MHz	1.610MHz to 30MHz	Long distance communication - national and international.
VHF	30MHz - 300MHz		Local communication.
UHF	300MHz - 3GHz		Local and line-of-sight communication.
SHF	3GHz - 30GHz		Line-of-sight communication.

HF Propagation

HF Propagation is largely dependent on the characteristics of the ionosphere which is dependent on ionisation caused by solar particles. These are typically created by CMEs - Coronal Mass Ejections - and these are dependent on the number of Sunspots. The radio waves bounce off the Ionosphere or go straight through it depending on their frequency. The Sun goes through an 11 year Sunspot cycle. At the moment it's at its maximum so the upper HF bands are good for international communication.

HF Amateur Band Propagation

3.5MHz	80mb	Local and regional communication.
7MHz	40mb	Regional communication.
14MHz	20mb	National and international communication.
21MHz	15mb	National and international communication.
28MHz	10mb	Low Sun Spot activity: Local communication. High Sun Spot activity: International communication.

VHF and UHF Amateur Band Propagation

144MHz	2mb	Regional communication - usually line of sight but there is some bending. If conditions are good long distance E layer ducting can occur.
430MHz	70cmb	Line of sight.

VHF & UHF Repeaters

Amateur Radio operators have established an extensive set of VHF 144MHz - 148MHz 2mb - and UHF 430MHz to 450MHz 70cmb FM analog repeaters. These provide for regional communications.

Amateur Radio operators have also established digital repeaters and an extensive Internet based backbone linking the repeaters, gateways and hotspots. And linkages have been established into existing analogue repeaters.

Protocols and systems include D-STAR, DMR, C4FM, Fusion, IRLP, Allstar, Echolink.

Emergency Communications

The Amateur Radio service provides emergency communications in times of natural disasters and wars. Many Amateur Radio operators have Go Boxes into which all the equipment for a quickly assembled station has been placed. A Go Box will typically consist of :-

- An HF Transceiver
- A VHF \ UHF Transceiver
- Everything fixed in place - secured so that the box can be picked up and carried easily.
- A HF antenna tuner. A voltage meter. Optional current and power meters.
- Facilities for local non amateur radio communication - CB, emergency services etc.
- All cabling and sockets in place - everything connected and ready to operate.

Ham Radio 'Shacks'

Ham radio shacks consist of many different sizes and varying layouts but usually have the same basic configuration :-

SWR & Power Meter - SX-100

Scanner - AOR AR8600

VHF \ UHF Transceiver - ICOM IC-9700

Antenna Switches

Power Amplifier - ACOM1000

HF Transceiver - ICOM IC-7300

General Receiver - ICOM IC-R8600

For More Information

For more information scan this QR code :-