South Bristol Amateur Radio Club
Lesson 6 – Propagation and EMC
Syllabus sections 6a.1 – 6a.5, 6b.1 – 6b.2, 7a.1 – 7a.4, 7b.1 – 7b.2, 7c.1 – 7c.3, 7d.1

Propagation
(Syllabus section 6)

Propagation concerns itself with how radio waves travel once they have left the transmitting antenna. It is a vast subject and one many amateurs have devoted a considerable amount of time and study to understanding. For the purposes of the foundation course this section of the course serves as an introduction to some of the more fundamental principles of propagation so that you will be aware of what to expect and understand how things work.

The first thing to remember is that **radio waves**, like light waves, **travel in straight lines**. However, they can be **deflected by obstacles** through **reflection** or **diffraction**. Sometimes these effects are beneficial, at other times they are not. Different radio frequencies are affected by different obstacles.

It is important to remember that **radio waves get weaker as they travel**, like throwing a stone into a pond; the ripples get weaker as the travel outwards. This is why a radio receiver close to a transmitting antenna will pick up a strong signal but as the receiver moves further away then the received signal becomes weaker. This is like shining a torch onto a wall. If the torch is held close to the wall the area lit up is small and as a result the intensity of the light is bright, whereas if the same torch shines on the wall from a larger distance the area illuminated is greater and therefore the intensity of the light is reduced.

The behaviour of HF and VHF/UHF signals is markedly different. Exactly where the transition occurs can vary from day to day and season to season as we will see later, and this is why some of the bands on the limits of HF and VHF (such as 28MHz and 50MHz) can exhibit very different characteristics at different times.

Under normal conditions **VHF/UHF** waves are limited more or less to **"line of sight"**, that is to say that a clear path must exist between the transmitting and receiving stations, and as the **operating frequency increases the effective range reduces**. Topographic features such as hills cause shadows, just like passing an object in a beam of light from a torch.

Clearly then at these frequencies **higher antennas are preferable to higher power**, as this improves both the transmit and receive performance. Outdoor antennas perform much better than indoor antennas. It is possible to work good distances at VHF/UHF under the right circumstances of location and antenna, and even moderate stations can, for example, contact orbiting amateur radio satellites due to the direct and clear line of sight that exists between satellite and ground station.

Radio waves get weaker when penetrating buildings but glass windows are more transparent to radio waves.

Between **70km and 400km** above the earth's surface there is a conductive layer of gas called the **ionosphere**. When parts of this layer become charged it is capable of reflecting radio waves back to earth, which can allow global radio communication to take place.

Different layers in the ionosphere affect different radio frequencies. Almost all communications on HF relies on waves being reflected by the ionosphere. HF can provide world-wide propagation depending on how well the ionosphere reflects radio waves back to earth. World-wide coverage requires several reflections. All this varies with frequency, time of day, and the season.

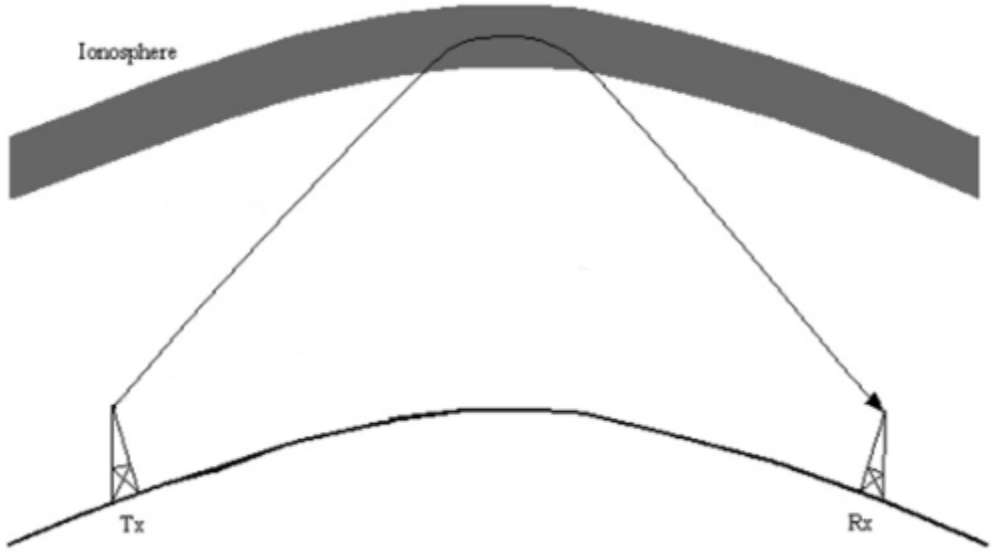

Figure 1 - HF Propagation

As mentioned the performance of the ionosphere varies according to the time of the day, the weather, solar activity, the season and to some extent the location of the transmitting and receiving stations.

If the ionosphere is highly ionised then it will bend higher frequencies back to earth than when the level of ionisation is low. For example during the day frequencies up to 30MHz may be returned to earth, whilst at night only those frequencies below 3MHz will be reflected. During the summer the variation between high and low is less pronounced, whilst during the winter it may be more extreme.

The highest frequency that is returned to earth is known as the **Maximum Usable Frequency (MUF)** and there are methods to predict what this value might be on any given day a few days in advance. Frequencies below the MUF will be reflected back to earth whilst those above the MUF will pass through the ionosphere without being reflected.

Electromagnetic Compatibility (EMC)
(Syllabus section 7)

Electromagnetic compatibility is concerned with the **avoidance of interference between various pieces of electronic equipment operating in the same environment**. It is not limited to radio equipment.

As amateur radio involves the use of radio transmitters there is the potential to cause interference to nearby equipment (e.g. TVs, Hi-Fi equipment, telephones, nearby emergency services).

Equally radio receivers can suffer from interference from nearby equipment, examples of equipment that is best known to cause interference to radio equipment: cordless telephones, mobile phones, and personal computers.

Radio transmitters can cause interference by the following means:

- Pick up in house wiring.
- TV antenna down-leads (TV coax, Video cable, power cable etc.)
- Telephone wiring.
- Direct pickup by internal circuits of affected equipment (particularly at VHF/UHF).
- Speaker cables.

Situating antennas as far away from houses and as high as possible (within local legal height limits) is a good way of minimising EMC problems. The use of horizontal dipoles at HF is less likely to be a problem whereas end-fed wires can cause significant EMC problems. If using a balanced antenna, such as a dipole, make sure you use a balun if feeding with coaxial cable.

There are several sources of information on avoidance of EMC problems, e.g. Ofcom and the RSGB.

A high transmitting power is more likely to cause interference than a lower power, therefore always try to use lower power where possible.

Some modes of transmission are more likely to cause interference than others. AM and SSB are more likely to cause interference than FM, CW and data modes (such as PSK31).

The ability of a piece of equipment to function correctly in the presence of strong RF signals is known as **immunity**. All modern equipment should conform to immunity standards. You can increase the immunity of most types of equipment by fitting filters and RF chokes to down-leads (TV antenna, mains lead etc.).

Fitting filters to mains leads (other than ferrite rings) can be potentially dangerous, if in doubt seek advice from more experienced amateurs. Again Ofcom and the RSGB provide good advice should you need it. It is much better to purchase a pre-assembled filter instead of trying to make you own at Foundation level.

The RF earth connection on amateur equipment will provide a ground and minimise RF currents entering the mains earth system and causing interference to other electronic equipment.

Note that some modern houses are fitted with an earth system called **PME (Protected Multiple Earthing)** where the earth is connected to neutral at the main fuse box. In these set ups extreme caution must be applied when fitting external earths, as the potential difference between the two earth systems can cause the chassis of the amateur equipment to become live.

If you are unsure what earth system you have the consult your electricity supplier and/or, a qualified electrician for advice. **DON'T TAKE RISKS!**

EMC problems have the potential for causing neighbourhood disputes. In many cases it is found that the neighbours equipment is at fault, having poor immunity or old corroded antenna leads not screening properly. It can be extremely difficult to explain this to a neighbour therefore good diplomacy is essential.

Always be polite and willing to assist in solving the problem. Suggest to the neighbour that you carry out tests to determine which operating band / mode / power is causing problems. It may not even be you causing the problem! At times like these keeping an accurate and complete log of your operation can be an asset in determining what equipment is at fault or what combination of mode/power/antenna/beam heading is causing the problem.

Until the problem is solved, it is a good idea to agree not to operate when your neighbour is watching TV or using the affected item.

In the event that the problem cannot be solved Ofcom and the RSGB can assist.

Next Lesson
Operating Practices and Procedures

Lesson 6 – Summary

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

- Recall that radio waves travel in straight lines, unless diffracted or reflected
- Recall that radio waves get weaker as they spread out
- Recall that at VHF and UHF hills cause “shadows” and that waves get weaker in penetrating buildings but glass windows are more transparent to radio waves
- Recall that the range achieved at VHF/UHF is dependent on antenna height and a clear path and transmitter power. Understand that higher antennas are preferable to higher power as they improve both transmit and receive performance. Recall that outdoor antennas will perform better than indoor antennas
- Recall that at VHF/UHF range decreases as frequency increases and that in general VHF/UHF waves have a range not much beyond “line of sight”
- Recall that the ionosphere comprises layers of conductive gases at heights between 70 and 400km above the earth
- Recall that on HF most communication relies on the waves being reflected by the ionosphere
- Recall that HF can provide world-wide propagation depending on how well the ionosphere bends the waves back to the earth
- Recall that this varies with frequency, time of day and season
- Recall that electromagnetic compatibility (EMC) is the avoidance of interference between various pieces of electronic equipment
- Recall that radio transmitters can cause interfersence to nearby electronic and radio equipment
- Recall that radio receivers can also suffer from interference from local sources
- Recall that interference occurs through local radio transmissions being conveyed to the affected equipment through pick up in house wiring, TV antenna down-leads, telephone wiring etc., and (particularly at VHF/UHF) by direct pick-up in the internal circuits of the affected equipment

- Recall that EMC problems can be minimised by siting antennas as far away from houses as possible, as high as possible, and using balanced antennas at HF
- Recall that at HF (horizontal) dipoles are less likely to be a problem and that end-fed wires present significant EMC problems
- Recall that information on the avoidance of interference by the correct choice and siting of antennas and suitable operating procedures is readily available from several sources
- Recall that the more power a station runs the more likely it is to cause interference
- Recall that some types of transmission are more likely to cause interference to TV, radio and telephones than others
- Recall that SSB is one of the poorest in this respect. FM, CW (Morse) and some of the HF data modes (such as PSK31) are much better
- Recall that the ability of any piece of electronic or radio equipment to function correctly in the presence of strong RF signals is known as “immunity”
- Recall that the immunity of most types of equipment can be increased by fitting suitable external chokes and filters in the mains or TV antenna leads
- Recall that the filters should be fitted as close to the affected device as possible
- Recall that anything fitted to the mains wiring must be properly made for the purpose
- Understand that home-made filters (other than ferrite rings) are potentially dangerous
- Recall that information about the purchasing, making and fitting of chokes and filters is readily available from several sources
- Recall that the function of the RF earth connection in an HF 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
- Recall that EMC problems have the potential for causing neighbour disputes
- Understand the need for diplomacy, the sources of advice available and the role of the local office of Ofcom