Electromagnetic Compatibility (EMC)

EMC Concepts

6A1

Recall that electromagnetic compatibility (EMC) is the avoidance of interference between various pieces of electronic equipment.

EMC is an important topic. It has the most potential to disrupt the enjoyment of the hobby.

In today's modern world the number of electronic devices in our households and day-to-day lives are numerous and increasing all the time. Some of these devices rely on wireless signals such as mobile phones, radios, hi-fi, TV, baby monitors, wi-fi cameras, Bluetooth smart speakers, tablets and laptops. Others are stand-alone or hardwired devices that nonetheless are susceptible to interference such as landline 'phones' and mains intercoms.

EMC is the capability of all of these devices to co-exist in a single environment (such as your house) without interfering with each other so that each device can be used to fulfil its intended function at the same time.

6A2

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

Immunity is the ability of a particular electronic device to continue to operate in the presence of other radio signals. Immunity has to be designed into a device such as a TV although there are some measures that can be adopted to make localised improvements to a susceptible device's immunity. The less affected a device is, the stronger or better is its immunity.

6A3

Recall that radio transmitters can cause interference to nearby electronic and radio equipment.

Immunity of equipment has improved over the years, the competing sources of signals becoming greater has led to all manufacturers having to improve their equipment and designs. Many countries or regions have established standards that commercial electronics must achieve in terms of immunity, in Europe the European EMC Directive sets these standards.

So the presence of these standards means that there is nothing to worry about?

Sadly no.

As Amateurs, we still have the ability to cause interference if our station is badly set up because we can produce local signal strengths that are beyond the levels that equipment is required to be immune to. This aspect is one of the primary reasons why Radio Amateurs have to undertake an exam to demonstrate that they understand their potential to cause interference and know how to react to it.

6A4

Recall that radio receivers can also suffer from interference from local and other sources.

It is also possible that our equipment, particularly our receivers can also be the recipient of interference. This is often because our equipment is necessarily more sensitive than commercial electronics due to our need to be able to detect and resolve weak signals.

Common sources of interference to our receivers are:

- Broadband VDSL boxes
- Plasma TVs
- Low-quality chargers for devices such as mobile 'phones', tablets, laptops etc.

Sources of interference and their effects

6B1

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 AM and SSB modes are the most likely to cause problems, FM and some of the HF data modes are least likely to cause problems.

The more power that a station uses the higher is the risk of interference. Essentially more power equates to stronger fields and a higher possibility that the field strength will exceed the affected devices immunity.

For this reason, when operating it is best practice to reduce the amount of power in use to the minimum required to maintain reliable communication.

Power levels permitted at the Foundation level are kept generally to 10W, this produces field strengths significantly less than can be achieved by a Full licensee using 400W. In fact, the field strength from a dipole antenna is over 6 times greater when using 400W than when using 10W and almost 9 times greater than when using 5W.

Clearly, the risk of interference when operating within the limits of the Foundation Licence is much less than when operating at higher powers, but the possibility cannot be ruled out.

The different modes of transmission at your disposal have different likelihoods of causing interference to nearby electronic devices. Modes that rely on amplitude modulation such as AM and SSB have a greater potential to cause interference than signals such as FM or FM based data modes where the amplitude of the transmitted signal is constant. CW has a low potential to cause interference as long as it is well-formed with smooth changes from "on" to "off".

Routes of entry

6C1

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.

There are many ways that "stray" or "unwanted" RF can find its way into affected equipment. Metalwork, wiring and pipes can all pick up RF signals just as an antenna does and convey this to the affected equipment.

Consider a typical Hi-Fi separates (tuner, amplifier, record deck, cd player etc) system. The units themselves might very well be immune to interference but there are plenty of sources outside of the units themselves that can provide a route into the equipment. These include:

- **Direct pickup** where the signal is picked up on internal wiring within one or more of the units. At particularly high frequencies in the UHF range, this might also include copper tracks on circuit boards. Direct pickup is usually only viable as a route of entry when the signals are at VHF or UHF.
- **Mains Cables** where RF is being picked up on house wiring and being conducted into the affected equipment.
- **Interconnecting Cables** can act as antennas, these cables can be speaker cables, antenna downleads or even the cables connecting the units together.
- **Earth Feedback** where RF is fed back into the mains earth wiring

Other equipment can be affected by different methods. An antenna sited close to overhead telephone lines might result in a radio operators voice being heard on the telephone and might prevent an electronic telephone from using features like stored number recall whilst the station is transmitting.

There are a large number of potential scenarios which makes it impossible to predict what the cause of the problem might be.

Filtering and remedial measures

6D1

Recall that the immunity of most types of equipment can be increased by fitting suitable external chokes and filters in mains or antenna leads.

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

In many cases, the best course of action once the entry route has been determined is to fit filters or chokes on the cables connected to the affected equipment.

The chokes should be fitted as close to the affected apparatus as possible.

Interference Method	Possible Cure
Direct pickup where the signal is picked up on internal wiring within one or more of the units. At particularly high frequencies in the UHF range, this might also include copper tracks on circuit boards. Direct pickup is usually only viable as a route of entry when the signals are at VHF or UHF.	Reduce the strength of the signal by relocating the antenna further away from affected equipment. It can also help if the antenna can be raised above house wiring and TV antennas
Mains Cables where RF is being picked up on house wiring and being conducted into the affected equipment.	Prevent RF signals leaving the shack along cables by fitting suitable filters on the power leads to the transmitter. This might involve fitting filters on both the DC lines and the AC line to the PSU
Interconnecting Cables can act as antennas, these cables can be speaker cables, antenna downleads or even the cables connecting the units together.	Reposition the antenna further away from the affected equipment and fit filters on the leads into the affected device
Earth Feedback where RF is fed back into the mains earth wiring	Sort out the earthing arrangements in the shack. If the RF earth is connected to the mains safety earth the connection may need filtering in the same way as the power leads.

6D4

Recall that transmitting into a dummy load is a good test for any unwanted RF being conducted out of the transmitter along its power supply leads and any connected interface leads and into the mains.

Recall that a dummy load is a screened resistor of the correct value and a suitable power rating connected instead of an antenna to allow the transmitter to be operated without radiating a signal.

A dummy load is a screened resistor capable of handling the full transmit power of the transmitter. Its purpose is to allow the transmitter to be operated whilst reducing the emitted signal to the lowest possible level.

In the case of interference investigation if the interference remains when a dummy load is used in place of the normal antenna then the problem is almost certainly the result of mains borne interference. If on the other hand the interference is removed once the dummy load is employed then the route of entry is more than likely via pickup from the antenna.

Station design and antenna placement - general principles

6E1

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 can present significant EMC problems.

Recall that information on avoiding interference can be obtained from the RSGB's EMC team and experienced local amateur radio club members.

Field strength is inversely proportional to the distance from the antenna. The field strength at 1m from an antenna is 10 times greater than the field strength at 10m from an antenna. It follows therefore that one of the best ways of reducing the potential for interference is to site the antenna as far away from potential recipients of interference as possible. This distance can be maximised by using height as well as lateral displacement.

The choice of antenna is also a factor in the potential for interference, at HF horizontal balanced antennas such as a dipole have a lower chance of causing interference than other types of antennas.

End-fed long wires are particularly prone to cause interference due to the high voltages or currents at the feed point. They need a particularly effective earth path but even with this in place, the potential for the feed point current or voltage to be picked up on other wiring remains high. If an end-fed wire is the only option then using coax to feed the antenna at the far end, away from the shack is preferable.

The RSGB provides a lot of useful information about avoiding or addressing interference through its EMC Committee, and has a dedicated section on the RSGB website with downloadable resources:

https://rsgb.org/main/technical/emc/

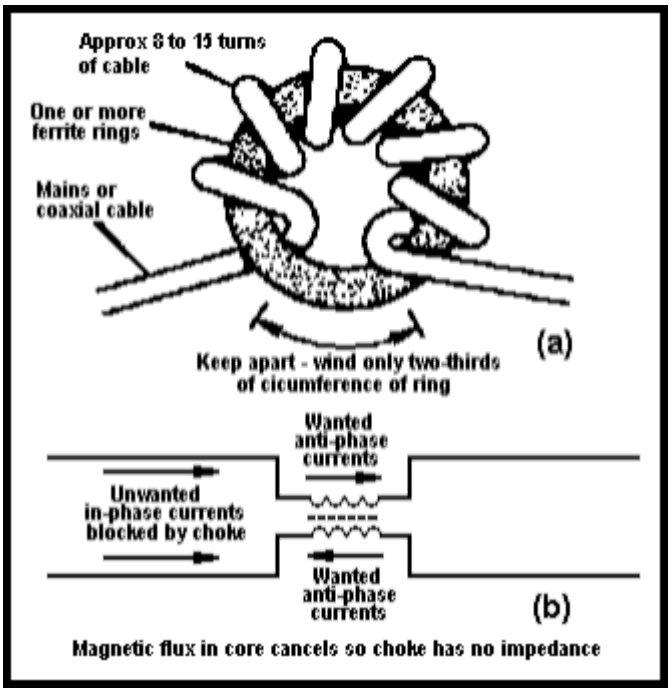
6E2

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

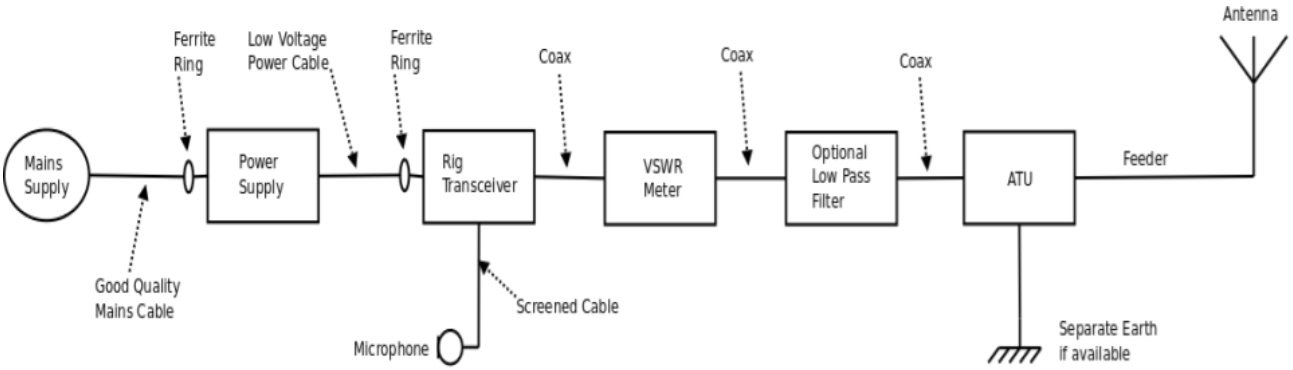
There are two types of earth that should be present in any permanent radio shack, these are:

1. **A Safety Earth**, unless equipment is "double insulated" which most amateur radio equipment isn't then a mains earth is needed for safety reasons and should not be removed.
2. **An RF Earth** for antennas that are fed with only a single wire feed (the centre of coax cable) there needs to be a return path for current and this is usually taken to earth. If this earth is linked to the mains earth the RF return current will flow into the mains earth and via house wiring to other mains powered equipment around the house and potentially neighbouring properties. This can be minimised by providing an RF earth in addition to the mains earth by driving a metal spike into the ground close to the point where feeders enter the house and connecting this using heavy gauge wire directly to the transmitter.

To further limit RF getting into the mains all 3 mains lead (live, neutral and earth) should be filtered. This is best done using a ferrite ring with about 20 turns of mains wrapped around it. Getting 20 turns on a single ferrite is not easy and it may have to be 4 rings each with 5 turns.



Good housekeeping within the permanent shack will go a long way to reducing the risk of causing interference.



Station design and antenna placement - mobile installation

6F1

Recall that it is the vehicle owner's responsibility to ensure that any radio installation is compatible with the vehicle's electrical and management systems and does not affect vehicle safety.

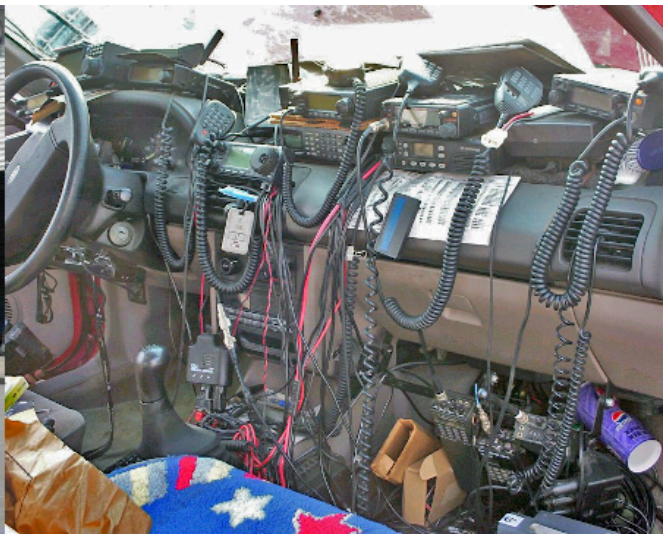
Recall that the fact of the installation may have to be disclosed to the vehicle insurers.

Recall that professional advice should be sought for all vehicle installations.

Modern motor vehicles are becoming increasingly complex. Even the most mundane vehicles now have complex engine management systems, in-car data buses, sensors, safety systems such as ABS, traction control, airbags and complex wiring looms hidden behind seemingly innocent pieces of trim around the cabin.

Safely and securely fitting Amateur Radio equipment, even the modern small mobile transceivers with detachable heads, is no simple matter. Before fitting anything consult the vehicle handbook thoroughly. As an example, there is an instruction buried about 126 pages into an owners manual stating that aftermarket radio transmitters shouldn't exceed 10W output and should be mated to an antenna outside the cabin of the vehicle to avoid potential interference with the cars on-board systems.

Anything added to a motor vehicle must not compromise the safe operation of the vehicle at all and it is the responsibility of the owner to ensure that this is the case. If there is any doubt consult a specialist to ensure that the equipment has not compromised the manufacturer’s systems and where necessary inform the vehicle’s insurers. Below is how not to do it.



6F2

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

Obviously, any installation should be tested to confirm that it operates as expected and does not cause any adverse reactions in the vehicle's systems. Such tests should be carried out with all systems turned on but with the vehicle static. It's too late if you're moving and activate your new transceiver only to find that the engine cuts out, the ABS is disabled or one of the more aggressive safety systems such as lane departure warning, sidewind correction or active cruise control are accidentally activated or deactivated. If the static tests show everything to be in order, proceed to on-road tests in quiet areas such as industrial estates on a Sunday morning before using the Radio Equipment on a motorway.

Always remember that if you are driving a vehicle, no matter how interesting the QSO is, your primary duty and function is the safe operation of the vehicle and nothing, not even your enjoyment of Amateur Radio, should take precedence over that function.

6F3

Recall that vehicle ignition and battery charging systems can cause electrical interference to reception on mobile radio equipment.

While vehicles have the ability to get you to less RF polluted areas, away from Plasma TVs and noisy power supplies they also have their own potential sources of interference particularly from ignition systems, and charging systems. Modern electric vehicles also have inverters and other noise-generating systems.

Some radios, particularly those designed for mobile installation will come with "noise blankers" and other features that can reduce or eliminate typical types of automotive generated interference.

Social aspects and testing

6G1

Recall that EMC problems have the potential for causing neighbour disputes.

Recall the RSGB produce EMC and interference information leaflets.

Recall that advice is available from the RSGB EMC Committee and recall the role Ofcom in dealing with cases of interference.

Interference can bring us into conflict with neighbours. Rightly or wrongly people will see your antennas and assume you are the culprit even if the fault lies with their equipment or installation or the source of interference isn't you.

You have to be prepared for this and try to convince people that you want to work with them to solve the problem. Telling them "I have a radio licence and you can't stop me using it" or "the problem is your TV is plugged into an antenna and feeder as old as your house so it's bound to be your problem" isn't going to win you any friends and is far more likely to escalate rather than diffuse the situation.

If you are faced with this sort of problem stay calm and appear understanding. Offer to help resolve it constructively, point to sources of advice and be prepared to add filters to the affected equipment.

Do not offer to shut down your station but be prepared to temper its use avoiding critical TV programs or the worst offending frequencies/modes.

6G2

Understand that the station log will be of considerable assistance in dealing with complaints of interference, and that this is a good reason to keep a log of all transmissions.

Understand the merits of both the amateur and the complainant keeping a log of the instances of interference.

Understand the merit of conducting tests in cooperation with the complainant in instances of interference.

If you can't immediately identify the problem, and this is quite likely, then log keeping can help determine if there is a problem and what it is related to. If you keep a log as a matter of course then you already have a head start, if you don't keep a log then this is the time to start and remember to log every operation. Typical things to record would be:

- Date
- Start Time
- End Time
- Frequency
- Mode
- Beam Heading (if applicable)
- Power used

This is only part of the problem. The affected neighbour should also keep a log of when interference occurs. After a period of time, the two logs can be compared and patterns searched for. The logs might show that it isn't you. They might show that it's only certain bands or mods that are the problem. Once the problem band/modes have been identified then tests to determine the route of entry into the affected equipment can begin.

Some of the leaflets available from the RSGB (see earlier link) are written to be understood and presented to non-Amateurs so these may be useful. RSGB members can seek specific advice from the EMC Committee.

Should your own efforts and those of the RSGB fail to resolve the problem then there is recourse to Ofcom if the interference is to domestic radio or television. If Ofcom becomes involved then they will probably conduct the technical investigation themselves. The call must come from the party suffering from interference. If Ofcom can see that you and the neighbour have been trying to resolve the issue amicably then they will probably start with an inspection of your station. This isn't to catch you out or confiscate your equipment and they understand that particularly at Foundation level you are not going to be an expert but they will have expected you to have followed the advice from your training.

If you haven't been able to start working on the problem before Ofcom became involved then they are most likely going to request that both parties keep a log of their activities and when interference occurs.

If Ofcom's inspection identifies deficiencies with your station then they will usually give you advice as to what to do to improve the situation. If your station is not found to be deficient then their attention will turn to the affected equipment if the neighbour requests it. It is probably best if Ofcom informs the neighbour of their findings to avoid any suggestion of inaccurate reporting on your part.

You are required to perform tests on your station to ensure that it isn't causing unwanted interference. Whilst there are some specific tests the simplest way to handle this is from time to time to:

- Ask another amateur to listen a few kHz away from your transmitted signal to see how wide your signal is
- Listen on multiples of your transmitted frequency, i.e, if you are transmitting on 7.1MHz, listen on 14.2MHz, 21.3MHz and 28.4MHz to see if your signal can be heard. If not then all is good
- If you have access to a second receiver, transmit into a dummy load and listen for your own signal