Interference to Amateur Radio Reception

1 Purpose of this leaflet

The RSGB EMC Committee receives many enquiries from members about interference to reception of amateur radio signals. This information sheet gives advice to members about identifying and locating sources of Radio Frequency Interference (RFI) that affect reception of signals in amateur radio bands.

2 The Amateur Service

The amateur service is, like all other radio services, entitled to operate free of harmful interference from radio and non-radio electromagnetic emissions that are not supposed to be in our bands. However, as a non-professional service we have to accept that we come lower in Ofcom's priorities than resolution of interference to, say, safety of life services, or those who rely on radio for their business.

However, that is not the same as being a non-protected service. That term simply means that amateurs have to accept interference from other radio services that are entitled to share our bands, provided they are operating within their authorised conditions. See leaflet EMC 09 for a fuller explanation.

If a simple do-it-yourself approach does not work, the interference can be reported to OFCOM. Before doing so, make certain that the interference is not coming from something in your own premises and, if possible, identify the source or at least the location from which the interference is coming,

It is worth checking if the interference also affects analogue radio broadcasting, DAB or your terrestrial TV reception. However, interference to broadcast reception is now handled, in the first instance, by the BBC (see
https://faq.external.bbc.co.uk/templates/bbcfaqs/emailstatic/interferencePage).
If the interference is found to be due to an illegal source it will be referred to Ofcom for investigation

3 Interference characteristics

It is worth keeping a log of exactly when the RFI occurs as this can give a clue to the possible source. Tuning across the affected band or bands can also give some clues about the source of the interference which normally falls into one of the following categories:

Narrowband
Narrowband interference affects one or more spot frequencies in a band with little or no detectable interference in between these frequencies. On an SSB receiver, a true narrow band source would be heard as a tone, but in some cases it will be a rough burbling signal covering a few kHz.

Broadband with no peaks
If interference appears right across a band at about the same level with no peaks, it is classed as a broadband source.

Broadband with broad peaks
Some sources such as switch-mode power supplies and digital electronics produce broadband emissions with regularly spaced broad peaks. The spacing between the peaks indicates the fundamental frequency. The peaks may not be well defined so it is best to note the frequencies of 11 regularly spaced peaks and divide the difference between the highest and lowest by 10.

Broadband with narrow peaks
Some emissions are broadband but also contain narrowband signals as described above. This is characteristic of digital electronic circuitry.

3.1 Drift
The frequency of a narrowband emission may drift due to temperature changes. The times of these temperature changes can give some clues about the source. If it is crystal controlled, the drift may be very slight but if it uses a ceramic resonator, it may drift up to a few kHz at VHF or a few hundred Hz at HF.

3.2 Modulation
It is worth listening to the interference using FM, SSB and AM modes if possible. You may find one of the following characteristics:

No modulation
This may be a harmonic from a crystal oscillator.

50 or 100Hz buzz.
If the audio signal is viewed on an oscilloscope triggered on 'line' (mains), the trace stands perfectly still if the interference is synchronised to the mains.

White noise
A steady hiss like the background noise level on the band but at a considerably higher level.

Other modulation
Some sources are modulated with a characteristic sound (see below).

4 Some residential sources of RFI

4.1 Television Interference

The old TVs using cathode ray tubes have been almost completely replaced by flat screen sets. In the old CRT televisions the line timebase frequency of 625 line television systems is 15.625kHz. Harmonics may be heard on multiples of this frequency. The line frequency is 1MHz divided by 64, so harmonics were on multiples of 125kHz.

On the whole, flat screen TVs are much better from the RFI point of view, with one notable exception. Some of the larger flat screen TVs use “plasma” technology and these can generate broadband RFI, mainly on the lower end of the HF band. The problem arises from the use of high voltages in the plasma process in the screen. and the large dimensions mean that most of the interference is radiated directly from the screen itself. Measures such as a mains filters will, at best, only be partially effective. Fortunately, so far as domestic TV sets are concerned, other technologies have taken the place of plasma, but some large screen plasma TVs are still being sold. The RFI tends to get worse as the TV set ages so may not be noticed when the set is new.

4.2 Switch-mode power supplies (SMPS)

A switch-mode power supply (SMPS) generates a square wave at a frequency of 30 - 90kHz or more. On the LF, MF and lower HF bands, harmonics from an SMPS can produce broad band RFI with broad peaks and 100Hz modulation. The peaks are spaced at multiples of the switching frequency. On the higher HF bands and at VHF, the peaks may merge together.

TV power supplies
When heard on an AM or SSB receiver, the sound from a TV switch-mode power supply usually changes with picture content but is broad band and may peak at a certain frequency such as 14-18 MHz. The switchmode power supply also runs when in standby mode and its characteristics may change so that interference is only noticeable in standby mode. Emissions in standby mode are normally continuous but in some sets sold since 1999, the noise is modulated at about 8 - 10Hz in standby mode. This produces a 'chuff-chuff' noise like a fast steam train. These are mainly 28 inch Bush models, although there are some other brands that use a similar chassis.

Video equipment power supplies
Video devices such as recorders and video players rarely cause problems but a number of cases have occurred where low-cost units have caused RFI.

TV 'set-top boxes'
There are various types of TV 'set-top box' for satellite TV, cable TV, digital terrestrial TV or video on demand. These normally have switch-mode power supplies that run continuously.

Lighting
Interference from lights can often be identified by observing when lights are on and off. RFI from modern energy efficient lights varies markedly with type and manufacturer.

Electronic transformers -
For lighting which uses 12 volt halogen spotlights, the transformers may be a conventional type but is more likely to be an 'electronic transformer' which is a switch-mode power supply with AC output. These can be a source of RFI.

Compact fluorescent lamps (Low energy lamps) – including LED lighting
Most types are electronic and contain, or are associated with, a small switch-mode power supply. The investigation of RFI from new low energy lamps is an ongoing activity. Latest information will be published in the EMC Column of RadCom as it becomes available.

Computer power supplies
In a desktop computer, the SMPS is normally in a screened box with a mains filter. Units fitted on computers supplied by reputable suppliers usually have good RFI suppression. There are replacement units on the market in which the suppression components have been left out to minimise cost. These generate severe interference. They often look almost identical to the genuine units and may be (illegally) CE marked. Laptop computers have an external mains power supply unit/charger which is normally an SMPS without screening but they rarely cause problems

Fax machines
The power supply runs 24 hours a day and is almost always a switch-mode type.

4.3 Electric Motors

RFI from an AC or DC electric motor with brushes and a commutator is broad band without peaks. Its pitch varies as the motor speed varies. The variations in speed and the pattern of use can give clues about the source. For example, this might be a washing machine or drier, sewing machine, electric lawn mower, food mixer, electric drill, hair dryer or even a model railway. It is not likely to be a refrigerator or freezer as these normally use induction motors which do not produce RFI.

4.4 Thermostats.
Faulty thermostats can arc for 1 to 30 seconds or more, producing broad band RFI with no peaks and 100Hz modulation. This may be heard on a number of HF and/or VHF bands. The most common source is a faulty gas central heating boiler thermostat and it is likely to be worse in winter. The arcing may occur every 5 - 20 minutes although in some cases it could be as often as two or three times per minute.

4.5 Other broad band sources.

Conventional fluorescent lights
RFI from fluorescent lights is broad band with no peaks and is modulated with a 100Hz buzz, mainly on the LF, MF and lower HF bands. Fluorescent lights have been required to include RFI suppression since 1978 although most met the relevant standard long before this date. If the tube is worn out and flickering at 50Hz, this can increase the level of RFI

Dimmer switches
RFI from dimmer switches is similar to that produced by fluorescent lights and is stronger when the lamp is dimmed than when on full brightness. Dimmer switches sold in the UK have been required to include RFI suppression since 1978 although most met the relevant standard long before this date. They seldom cause problems to amateur reception unless they are faulty or are a type not designed for the European market.

4.6 Computers

Various oscillators in a computer and its associated components, such as the keyboard and mouse, can produce narrow band radiated emissions. Some are crystal controlled and generally have no drift or modulation, while others use a ceramic resonator which drifts and may have slight frequency modulation which can be heard as a 'warbling' noise on an SSB or CW receiver. Such modulation may sound like someone typing on a keyboard or playing a game. Almost all PCs have a crystal oscillator at

or near 14.318MHz although this signal may not be particularly strong. Nevertheless, if it is present at the same time as other signals, this shows that the other signals are likely to come from a computer. In many cases in the past, computer monitors were a common source of interference to the amateur bands. This has largely gone away with the almost universal use of flat-screen monitors.

4.7 Intruder alarm systems.

Intruder alarm systems normally contain a microprocessor and can radiate signals from the wiring to the sensors on the HF and/or VHF bands. As they normally use a ceramic resonator, the harmonics drift slightly and may have slight modulation which can be heard on an SSB receiver. This modulation may change if the alarm ever goes off and may also change when the user presses keys on the control panel.

4.8 Other digital electronic devices.

Digital electronic circuitry can radiate narrow band signals on certain frequencies such as harmonics of the clock frequency and may also produce broad band signals. Such sources include NICAM decoders and other digital electronics in TV sets, video recorders and satellite receivers/decoders. Many of these devices are connected to long cables which can radiate RFI on HF bands as well as VHF.

4.9 Cable TV

Many modern cable television systems use vision carriers from 128MHz upwards on multiples of 8MHz although some frequencies such as 144.000MHz are not normally used. The street cabinets normally contain a switch-mode power supply which may produce detectable emissions on the HF bands due to common-mode signals conducted along the coaxial cables.

4.10 Telephone equipment

Fax machines contain a microprocessor which runs continuously. If a computer is connected to a modem, this can allow RFI from the computer to be radiated via the telephone line. If the modem can receive fax or voice calls, the owner may leave the computer running all the time. If a telephone subscriber has an ISDN (Integrated Services Digital Network) line, the line carries 90V DC which powers a switch-mode power supply in the customer's premises. Some types of ISDN equipment at the customer's premises can produce RFI when a call is in progress. Businesses and even some homes may have their own internal telephone exchange or PABX. Some types can produce RFI on the HF and VHF bands.

Emissions from overhead telephone lines
If the RFI is strongest under telephone lines or close to a telephone pole, the source could be one of the items mentioned above but in many cases, it is something completely unrelated to the telephone system. If anything feeds RFI onto the mains in a house, this can be coupled onto telephone wires via the mains transformer of any mains powered telephone equipment such as an answering machine or a cordless phone.

Broadband Internet Access on the Telephone Lines
The two common types of internet access via the telephone lines are ADSL (Asymetric Digital Subscriber Line) and VDSL (Very high speed Digital Subscriber Line). ADSL has been around for a

number of years and does not seem to give rise to any problems. VDSL is a newer technology using frequencies up to about 12MHz. Generally the VDSL does not cause RFI but in some services there is an upstream band around 10MHz. This involves relatively high signal levels being fed on to the phone lines at the customer's premises. In certain circumstances this might give rise to interference. This should be born in mind when looking for a source of white sounding noise around 10MHz. Switching off or unplugging the modem will cause the VDSL signal to go off the local telephone line.
Ancillary equipment such as hubs and routers will use switch-mode power supplies, usually in the form of plug-in units, and these could be a possible source of RFI.

4.11 Vehicles

Ignition systems
Although there have been regulations controlling ignition interference since 1952, this can be a problem for weak signal reception near a busy road. Many transceivers contain a noise blanker which is effective against the short impulses from vehicle ignition systems.

Remote keyless entry receivers
Some cars made since mid 1994 use radio keys operating on 433.92MHz. Radio key receivers in some cars contain a local oscillator which runs continuously somewhere in the range 433.275 - 433.475MHz. Other types use a super-regenerative receiver and some aftermarket alarms sold in 1994 and 1995 can emit broad band noise across the 430-440MHz band

4.12 Miscellaneous

Radio teleswitches
These are a type of electricity meter which may be used to control off-peak electricity. One type, the Schlumberger model RTA manufactured before 1992 radiates harmonics of 1.52MHz including 50.116, 144.400 and 145.920MHz. These frequencies are highly accurate as they are phase-locked to the carrier of BBC Radio 4 Long Wave on 198kHz. On an SSB receiver, it is possible to hear low rate data which sounds like continuous but very slow packet radio.

Touch Lamps'
These are table lamps with a touch-operated switch which turns the lamp on and off and selects several levels of brightness. They contain a sawtooth oscillator which operates continuously and produce emissions which are similar to an SMPS but with a fundamental frequency of around 190kHz. Some models sold before 1996 contain no RFI suppression.

Garage door openers
The super-regenerative receivers for some 173MHz remote-controlled garage door openers manufactured in the late 1980s radiate broad band noise on 430-440MHz. They can also receive VHF radio paging and rebroadcast it at a number of frequencies on the 430-440 MHz band!

Water conditioners
Electronic water conditioners are claimed to reduce deposition of lime scale. Some types use a sequence of audio frequency tones which have harmonics up to 28MHz in some cases. The radiated emissions have a very unusual characteristic as the a tone changes about once a second in a sequence which repeats every few minutes.

Electric fences
RFI from an electric fence is a regular clicking noise. The source is likely to be a sparking at a faulty insulator rather than the electric fence unit itself. Try looking for flashovers in the dark (with the landowner's permission).

Photo-Voltaic Cells and Wind Farms
These technologies rely on power invertors to convert generated DC to AC 50Hz. In some cases, these convertors can be a source of radio spectrum emissions. Fortunately, such installations are conspicuous and so using a portable receiver to confirm the source of the emissions is relatively easy, after which a reference should be made to Ofcom.

4.13 Overhead power cables

Overhead power cables can radiate broad band noise with 100Hz modulation. High voltage cables always produce a certain amount of RFI due to corona discharge from the cable itself but RFI can be greatly increased due to arcing at a faulty insulator, in which case, the level of RFI may reduce in dry weather.

4.14 Other radio services

Radio Paging
This sounds rather like packet radio but usually starts with a tone. Strong signals from nearby radio paging transmitters may be heard on the 2 metre band or other bands but in most cases, such breakthrough is caused by shortcomings in the amateur receiver. Transceivers with extended receive coverage are more likely to be affected than those which only cover amateur bands. Hand-held transceivers connected to an outdoor antenna can be particularly susceptible.

4.15 Powerline Adaptors (PLAs)

In recent years these have become a serious source of interference. They are sometimes used for networking computers but the most common use is for video distribution. Generally they minimise emissions in the amateur bands (known as notching) so that interference is most likely to be noticed on the HF broadcast bands. Further information on interference from PLAs and PLT can be found in Leaflet EMC14**.**

5 Searching for the source

First of all, don't forget to check everything in your own home! If you have a receiver which can run on battery power, switch off all the mains power at the fuse box. If the receiver needs mains power, unplug each item from the mains in turn. Don't forget to unplug appliances such as a video recorder, TV set or fax machine which may be in a 'standby' mode even when they appear to be switched off. It may not be possible to check an intruder alarm system by disconnecting the mains supply as this may cause the alarm to sound and in any case, some systems have a battery back-up. On the HF bands, interference can enter your home via the mains supply whether underground or overhead and can be radiated by your mains wiring. In such cases, switching off a double pole main switch at the fuse box will probably reduce it, although this depends on the exact layout of your mains wiring. Pickup of

mains-borne interference on the HF bands can often be reduced by moving your antenna further from mains wiring if possible, or by using a balanced antenna such as a dipole instead of an end-fed antenna. The information in section 4 above can give some clues about what might be the source but if it is not in your own home, the next step is to go out and search for it using a portable receiver
In the case of HF mains-borne interference, the source is likely to be on the same phase as your own mains supply. In a street of houses, every third house is normally on the same phase. On VHF, if you have an antenna on a rotator then it should be possible to get some indication of the direction of the source. RFI which occurs continuously or frequently can often be located without a directional antenna, simply by going around searching for the strongest signal. For RFI which only occurs intermittently such as an arcing thermostat, a portable directional antenna is very useful. In either case, the receiver should have an 'S' meter, preferably a moving coil type. It is also useful to have an attenuator to reduce the sensitivity when you get closer to the source. Further details of radio direction finding (D/F-ing) techniques are given in Reference 2. One possible problem is that RFI which is quite strong when using your main station antenna cannot be heard at ground level on a portable receiver. For a narrowband source, the maximum sensitivity is achieved by using CW mode with a narrow bandwidth. For broadband sources such as arcing, greater sensitivity is achieved by using a receiver with the widest possible bandwidth. The first thing to establish is whether the source of the RFI is nearby (within about one hundred metres for example) or further afield such as the next street or even the next town. Getting someone to drive you around the local roads in a car with a portable receiver connected to the car aerial may show a clear peak at a certain point which is not apparent when walking. If interference is being conducted along telephone wiring or mains wiring, there may be a number of peaks which coincide with telephone poles, overhead power lines or lamp posts.

5.1 Lower HF bands

If interference affects the 1.8MHz amateur band, it may also be audible on an MW broadcast receiver. Alternatively, a ferrite rod aerial with an MW coil can be tuned to the 1.8 MHz amateur band and connected to a portable HF receiver using a 2 turn coupling winding to match into a 50 Ohm receiver input. For 3.5MHz, the main winding on the ferrite rod should be about 20 turns tuned with a 200 pF variable capacitor. A 1 or 2 turn coupling winding should be used. A ferrite rod aerial is recommended for D/F-ing RFI on the 1.8 and 3.5MHz bands because it can be held right down on the ground to detect the magnetic field from RFI propagating along underground cables as a common mode signal (that is, on all conductors together relative to earth). If properly balanced, a ferrite rod aerial gives a minimum signal when the rod is pointing towards or away from the source but this direction finding property can give misleading results in built-up areas or near overhead cables because MF/HF interference can travel for hundreds or thousands of metres along mains wiring or telephone wiring (particularly if overhead). Standing waves can cause the signal strength to rise and fall at intervals along the line. With any RFI from overhead cables, it is best to search for it on the highest frequency possible, moving higher as you get closer. If you want to follow overhead power cables across land without a public right of way, permission should be obtained from the landowner before entering. If you can identify which pole is responsible, make a note of its number and report it to the electricity company.

5.2 Higher HF bands

The tendency for interference to travel along wiring decreases as frequency increases so it is better to search for interference on the highest frequency on which it can be heard. In practice, it will probably be necessary to listen on a frequency above the MUF where the HF bands are quiet. The 28MHz band is a good band to use and a direction finding loop can be made as shown in References. [2] or [3]. When you get closer to the source, try to find it on a VHF band but check that the VHF signals have the same characteristics as the HF signals and are not coming from a completely different source!

5.3 VHF bands

On 144MHz, it is possible to use a horizontal half wavelength dipole with a balun for direction finding. This gives a minimum signal when pointing towards or away from the source although it can give misleading results if the source is vertically polarised. It is also possible to use a yagi antenna which gives an unambiguous direction bearing. If the source appears to be vertically polarised, the yagi can be used vertically, otherwise horizontal polarisation is preferable because the antenna has a narrower beamwidth when used horizontally. A 4 or 5 element yagi is about the largest which is reasonably portable at 144MHz. An HB9CV is of some use but the main lobe is very wide and the directional bearings can 'squint' due to the unbalanced feed. To correct for 'squint', turn the antenna over, take another bearing then average the two.

It is important to remember that at 144MHz, direction finding in a built up area can give misleading results due to reflected signals from buildings, lamp posts, cars, etc. It is therefore necessary to take a number of bearings from different locations as no single direction bearing can be regarded as reliable. If D/F-ing from a car, remove any 144MHz mobile antenna before taking a directional bearing as this can reflect signals. It should be noted that Time Difference Of Arrival (TDOA) and ring Doppler direction finding techniques are only suitable for D/F-ing a coherent carrier and cannot be used on random noise from motors or thermostats. The 50MHz band is less prone to reflections than 144MHz but the only reasonably portable direction finding antenna is likely to be a loop. Another possibility is to use an 88-108MHz FM broadcast receiver, tuned between stations, with a 3 element FM aerial.

5.4 UHF bands

If RFI can be heard up to the 70cm band, a 10 element 70cm band yagi makes a good direction finding antenna but at UHF, more care is required to avoid misleading results due to reflected signals.

5.5 Finding thermostats

A thermostat which arcs for perhaps 20 seconds every 10 minutes can be most annoying but difficult to find. If it is very close (less than about 30 metres), it may be possible to detect it using an old analogue UHF portable TV set with a 10 element UHF TV aerial. The wide TV IF bandwidth is an advantage when searching for a broad band source. The TV set should be tuned to a channel where there is no signal. It is important to make sure that the channel is free of any digital television signals as these look like noise on the screen but with a coarser 'snow' than true white noise. As arcing thermostats are modulated at 100Hz, they produce two darker bands of noise on the TV screen which are darkest when the aerial is pointing at the source. If a portable TV receiver or video recorder has a video output via a SCART or phono connector, it can be used for locating broad band UHF sources of

RFI by tuning it to a channel where there is no signal and listening to the video output via an audio amplifier or crystal earphone. An arcing thermostat produces a distinctive rasping sound which is clearly distinguishable from the background noise. If a suspect gas boiler has a flue which is near the street or near your property, it should be possible to hear when it lights up and switches off, particularly with a fan-assisted boiler. If you listen on a portable receiver at the same time, an arcing thermostat will produce a burst of RFI lasting for a few seconds or more each time the boiler turns off and possibly when it turns on. In such cases, it is worth obtaining a copy of Ofcom leaflet RA 272 on interference from thermostats.

6 Contacting the owner of the equipment which is causing RFI

6.1 Residential property

If you decide to approach the occupier of a house or flat where you think the source of the interference is, bear in mind that the occupier will probably want to be sure of your identity and your motive before letting you in. It is a good idea to write or telephone first to gain their confidence and arrange a convenient time for a visit. Remember that the source may not actually be where you think it is so you should say that there may be something in the house or flat which is causing interference. In most cases, the only way to prove what is causing the RFI is to ask the owner to switch off various electrical equipment until the source is found. In most cases, there is no fault in the equipment in question and only amateur bands are affected. A diplomatic approach is therefore essential as the owner of the equipment is under no obligation to do anything about the RFI so it can only be reduced with their cooperation. Any RFI reduction should be restricted to measures which can be fitted by the owner without the need for you to touch or dismantle the equipment in question. In some cases, for example a faulty thermostat, the RFI is likely to interfere with the owner's broadcast radio or TV reception and may affect neighbours. In such cases, if the owner is unwilling to take any action, the matter can be reported to Ofcom.

6.2 Commercial or industrial premises

If RFI appears to be coming from an office, shop, factory or other commercial premises, some effort may be required to make contact with the right person. In the case of a large company, there is probably an office services manager, building services manager or technical manager whom you could contact. If you are lucky, there may be a licensed radio amateur working on the site somewhere and he or she could be a very useful contact. In any case, it is best to write or telephone first and ask to make an appointment to see the appropriate person. With luck and a diplomatic approach, they may be prepared to take you around the site to look for the source. You will need to take a portable receiver as it probably won't be possible for equipment to be turned off.

7 Reducing the RFI

7.1 Contacting manufacturers

If you prove conclusively that a certain piece of equipment is producing RFI, it is worth trying to find out full details of the make, model number and date of purchase so that a complaint can be made directly to the manufacturer or importer. A polite and technically well-informed approach is recommended when dealing with manufacturers. The equipment probably met all necessary standards at the date of manufacture so the only way forward is on a good will basis. The best

approach when dealing with manufacturers is usually to phone first and find out the name of the person responsible for EMC then follow up the phone call with a letter, fax or e-mail. It is also worth finding out whether a newer model is available with reduced RFI. In some cases, the manufacturer may be prepared to provide a filter or exchange the equipment in question for a newer model at a reduced price.

7.2 Reducing RFI

Information on reducing RFI and interference cancellation techniques can be found in Reference 1. RSGB members can seek advice from an EMC Advisor. A list of EMC Advisors can be found in the EMC Section of the RSGB Yearbook and also on the RSGB EMCC web pages.

8 References

1 The RSGB Guide to EMC, Published by RSGB. This is now put of print but relevant extracts can be found in the Reference section on the RSGB EMCC web site.

2 Transmitter Hunting, Joseph Moell, K0OV and Thomas Curlee, WB6UZZ, First Edition 1987, Published by Tab Books, ISBN 0-8306-2701-4.

3 ARRL Handbook, any recent edition. Published by ARRL; See sections on Direction Finding

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