Interference and Electromagnetic Compatability.

Figure 6.4 Generation of a sine wave

6.5 Radio and sound waves

We have all seen the action of waves in liquids. These waves start at a point and travel outward. If, for example, we drop a stone into a still pond, the waves will radiate out from where the stone landed in the water to the edge of the pond. All waves behave in a similar manner, even those AC waves produced by a radio transmitter. That is, they radiate outward from their point of origin.

In electronics there are at least three waves that we have some interest in: radio waves, sound waves and light waves.

The medium through which a wave travels determines the speed at which it travels. Sound waves travel faster as the substance through which they are passing becomes denser; whereas radio waves travel slower through substances as they become denser. Sound is a convenient wave to consider when looking at the speed at which waves travel through materials of different density (see Table 6.1).

Radio waves consist of two parts: the electric component and the magnetic component. Combined, they form an electromagnetic wave. Radio waves are thus termed electromagnetic waves.

Radio waves travel through free space at about the speed of light which is 300,000,000 metres per second. Through all other mediums radio waves travel slightly slower.

Table 6.1 The speed of waves through different densities

Medium	*Speed*
Air	344 metres per second
Hydrogen	130 metres per second
Sea water	1540 metres per second

The distance a radio wave travels from the radiating point during one cycle is termed its wavelength and is directly related to the frequency of the signal and the speed at which it travels, i.e. the speed of light. The symbol for the speed of light in a vacuum is *c* which is approximately 300,000,000 metres per second.

The symbol for wavelength is the Greek letter lambda, λ. The unit for wavelength is the metre.

$$\lambda = \frac{300\,000\,000}{\text{frequency of radio signal (Hz)}}$$

This formula can be rearranged so that:

$$\lambda = \frac{300}{\textit{Radio frequency (MHz)}}$$

Those involved in radio often refer to groups of frequencies on which they operate as bands of various wavelengths. For example, the 3.5 megahertz band is often referred to by the 80 metre band. This is the approximate distance that a 3.5 megahertz signal would travel during one cycle (see table 6.5).

Some groups of frequencies are important to radio operators for various reasons. For example, they must know in which band they are allowed to operate and on what bands they may cause interference.

The regulation requirements for all radio operators as well as spectrum allocations are available from the Australian Communications and Media Authority or the Wireless Institute of Australia. The Licence Conditions Determination will specify the mode of operation and the exact frequency of the bands that each class of amateur licensee can operate. Table 6.2 gives a general outline of the frequency spectrum and their uses. Broadcast radio for domestic use is found in the MF band, the mode of operation called amplitude modulation (AM), between the frequencies of 525 kHz and 1606 kHz. The mode of operation called frequency modulation (FM) is found in the VHF band in the frequency range of 88 MHz to 108 MHz. The intermediate frequency for AM and FM are typically 455kHz and 10.7MHz.

Table 6.2 Frequency spectrum

Frequency	*Category*	*Remarks*
0Hz	Direct current	From battery
1 to 15 Hz	Sub-audible	Logic circuits sometimes generated mechanically
15 Hz to 30 kHz	Audio	Sound waves
300 Hz to 3 kHz	Voice	The bandwidth required to convey a message without loss of intelligence
30 kHz to 300 kHz	Low frequency	LF
300 kHz to 3 MHz	Medium frequency	160 m band MF
3 MHz to 30 MHz	High frequency	80 m band HF
		40 m band HF
		29 m band HF
		20 m band HF
		17 m band HF
		15 m band HF
		12 m band HF
		10 m band HF
30 MHz to 300 MHz	Very high frequency	6 m band VHF
		2 m band VHF
300 MHz to 3 GHz	Ultra high frequency	70 cm band UHF
		50 cm band UHF
		23 cm band UHF

Note: A number of frequency allocations have been made to amateurs in the super high frequency band 3 – 30 GHz and extremely high frequency band SHF 30 – 300 GHz

Domestic television in Australia is found in the VHF and UHF bands. Table 6.3 shows a list of television stations in Australia and their frequency of operation in the VHF band. Table 6.4 shows the Australian television station frequency of operation in the UHF band. There is an amateur frequency allocation in this band which is the output frequency of the amateur television repeaters. The radio frequency spectrum is a natural resource and as such it can be abused or destroyed through noise or interference. All users of this resource have a responsibility to ensure that they and others do nothing to damage or abuse it. This can be achieved by:

1. reporting illegal operators in any band;
2. avoiding generation of any interfering signal.

Table 6.3 Television stations and their frequency

Channel number	*Frequency limits*	*Vision carrier*
0	45 to 52 MHz	46.25 MHz
1	56 to 63 MHz	57.25 MHz
2	63 to 70 MHz	64.25 MHz
3	85 to 92 MHz	86.25 MHz
4	94 to 101 MHz	95.25 MHz
5	101 to 108 MHz	102.25 MHz
5a	137 to 144 MHz	138.25 MHz
6	174 to 181 MHz	175.25 MHz
7	181 to 188 MHz	182.25 MHz
8	188 to 195 MHz	189.25 MHz
9	195 to 202 MHz	196.25 MHz
9a	202 to 209 MHz	203.25 MHz
10	209 to 216 MHz	210.25 MHz
11	216 to 223 MHz	217.25 MHz
12	223 to 230 MHz	224.25 MHz

The intermediate frequency (IF) for television receivers is typically 33 to 40 MHz and video baseband is 0 to 5 MHz

Table 6.4 Television stations frequency in UHF

Channel number	*Frequency limits*	*Vision carrier*
28	526 to 534 MHz	527.25 MHz
29	534 to 542 MH2	535.25 MHz
30	542 to 550 MHz	543.25 MH2
31	550 to 558 MHz	551.25 MHz
32	558 to 566 MHz	559.25 MHz
33	566 to 574 MHz	567.25 MHz
34	574 to 582 MHz	575.25 MHz
39	614 to 622 MHz	615.25 MHz
40	622 to 630 MHz	623.25 MHz
41	630 to 638 MHz	631.25 MHz
42	638 to 646 MHz	639.25 MHz
43	646 to 654 MHz	647.25 MHz
44	654 to 662 MHz	655.25 MHz
45	662 to 670 MHz	663.25 MHz
46	670 to 678 MHz	671.25 MHz
47	678 to 686 MHz	679.25 MHz
48	686 to 694 MHz	687.25 MHz
49	694 to 702 MHz	695.25 MHz
50	702 to 710 MHz	703.25 MHz
51	710 to 718 MHz	711.25 MHz
52	718 to 726 MHz	719.25 MHz
53	726 to 734 MHz	727.25 MHz
54	734 to 742 MHz	735.25 MHz
55	742 to 750 MHz	743.25 MHz
56	750 to 758 MHz	751.25 MHz
57	758 to 766 MH2	759.25 MHz
58	766 to 774 MHz	767.25 MHz
59	774 to 782 MHz	775.25 MHz
60	782 to 790 MHz	783.25 MHz
61	790 to 798 MHz	791.25 MHz
63	798 to 806 MHz	799.25 MHz
64	806 to 816 MHz	807.25 MHz

Table 6.5 provides an overview of the amateur licences in Australia. The specific amateur radio frequency allocations, modes of operation and operating requirements are defined in the Australian Communications and Media Authority (ACMA) Licence Conditions Determination. This can be found on the ACMA web site www.acma.gov.au. It is a requirement to obtain an amateur licence that prospective amateurs have an understanding of the Licence Conditions Determination. The Licence Conditions Determination (LCD) is a component of the regulation Examination a copy should be downloaded from the ACMA web site and studied.

Advanced	The Advanced licensing option allows operation on all bands allocated to amateurs in Australia. This licence replaces the Unrestricted, Intermediate and Limited licences.
Standard	The Standard licensing option allows restricted operation on the 3.5, 7, 14, 21, 28, 52, 144, 430, 1240, 2400 and 5650 MHz amateur bands. This licence replaces the Novice and Novice Limited licences.
Foundation	The Foundation licensing option allows restricted operation on the 3.5, 7, 21, 28, 144 and 430 MHz amateur bands.
Repeater	The Amateur Repeater licensing option authorises the operation of stations that automatically re-transmit transmissions from other amateur stations. Amateur repeaters are used to improve the communications coverage of the amateur service. They are usually sited to take advantage of terrain characteristics that enhance coverage. They may employ either two-frequency (receive information transmitted from amateur stations on one frequency and re-transmit it on another) or single-frequency (receive and transmit on the same frequency using information storage and delayed transmission techniques) operating modes. The frequency channel assigned by ACMA will normally accord with channel arrangements developed by the Wireless Institute of Australia (WIA). Normally, all applications for proposed repeater services are expected to be endorsed by the WIA. Amateurs may only gain access to repeaters that have input and output frequencies within bands authorised under the amateur's own licence.
Beacon	Amateur Beacons are used by other amateur stations, principally for the purpose of identifying propagation conditions, that is, the effect the earth's atmospheric layers and space have on radiofrequency emissions.

Table 6.4 Summary of Amateur Licence Frequency Allocations

Table 6.5 shows the relationship between frequency and wavelength. In the example shown on the graph the band is 40 meters and the frequency is approximately 7.5 MHz.

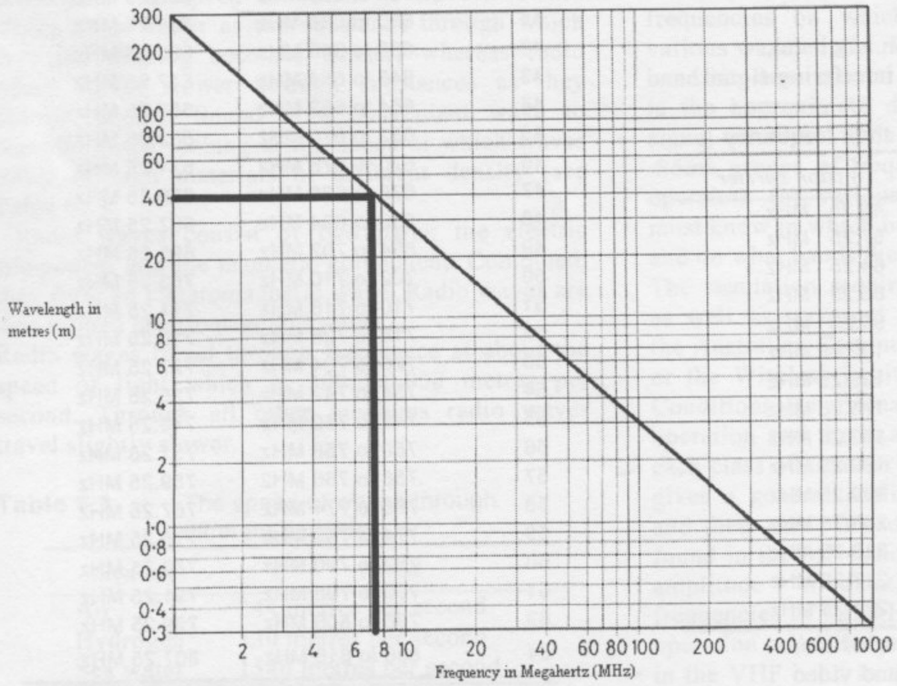

Table 6.5 Frequency to wavelength conversion graph

19 Interference and immunity

19.1 Problems of interference

Radio frequency interference (RFI) can be defined as interference caused to any device by an electromagnetic field. RFI can occur whenever an electronic or electrical device is surrounded by an electromagnetic field. The ability of a device to operate in a radio frequency field is described as Electromagnetic Compatibility (EMC).

At some stage, you, as an operator, may be accused of some form of interference. When this occurs, you must assist the people making the complaint in every way possible. Advice can be sought from the Wireless Institute of Australia or the Australian Communications and Media Authority.

Table 19.1 Some devices which can cause interference

Transmitters	*RF noise generators*
Amateurs	Power tools (any electric motor)
Citizen band	Fluorescent and neon lights
AM and FM broadcast	Computers
Television	Power feeds and transformers
Other commercial transmitters such as police, military, etc.	Automobile ignitions
	Arc welders
Other transmitters	*Victims of RFI*
Microwave ovens	Television and radio receivers
Radio-controlled models	Audio equipment
Remote door openers	Blasting devices
Diathermy and other medical apparatus	Electronic control equipment
Television and radio receiver oscillators.	Vehicle electronic equipment
Plastic welding machinery	Telephones

What to do when interference occurs

1. Discuss the problem with the person who is being troubled by the interference.
2. Impose a station shut-down on yourself until the problem is resolved.
3. Ask the complainant to note dates and times of interference.
4. Check this information against your logbook.
5. Try to discover the source of interference. To achieve this assistance may be sought from others.
6. If the problem is still evident beyond the scope of the amateur, or the person being interfered with is hostile, advise and or assist them to lodge a formal complaint with the Australian Communications Authority.

Table 19.1 is a list of some of the many devices which can cause interference and be interfered with.

19.2 Noise and Interference

The two types of noise we have particular interest in are internal and external noise. Receiver noise, generated within the receiver due to current-carrying components, has been discussed previously in Chapter 10.

Noise external to the receiver, which can interfere with the incoming signal, can be subdivided into two categories:

1. Man-made noise generated from sources such as:
   (a) machines;
   (b) automobile ignitions;
   (c) power lines;
   (d) computers.

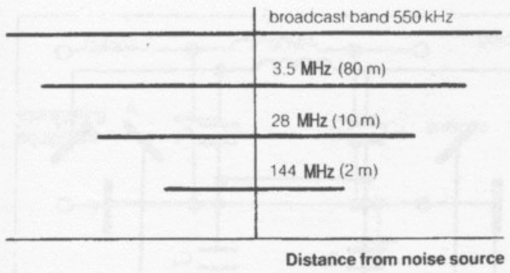

Figure 19.1 Relationships between noise, frequency and distance

2. natural noise generated from sources such as:
   a. lightning;
   b. electrostatic build-up.

Noise is generally attributed to stray electrostatic and electromagnetic fields. It has several interesting characteristics, one of which allows us to track down a noise source using simple receivers. The noise intensity is directly related to the frequency that is generated. The noise generated in the low frequency band will be of far greater intensity over a greater distance than the noise produced from the same source in the high frequency band.

Using this principle it is a relatively easy process to find the location of the noise by listening on a broadcast receiver. Using higher frequency receivers pinpoints the source to a specific area.

Figure 19.1 shows the relationship between a noise source and the frequency at which it would be heard.

One problem with tracking down noise source using a receiver is that the noise can be picked up by power lines, fences, etc., and fed for great distances, causing the search for a noise source to become confused.

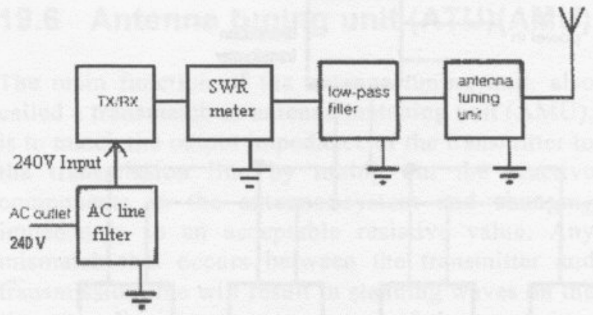

Figure 19.3 Typical amateur station setup

Noise generated by an electricity supply authority, which is fed via the power line cables, is usually difficult to find.

Noise generated in this form is also fairly common and is caused by faulty transformers, dirty insulators, etc. This noise can be so severe as to cause interference to television reception. If you suspect that you are receiving noise generated in the electricity supply system, then the reporting technique is the same as for any other interference, that is, through ACMA using the appropriate form.

Going directly to the electricity supply department will only cause confusion and delays in having the problem rectified.

Figure 19.2 shows how mains-generated interference can appear to be located in an area away from the source.

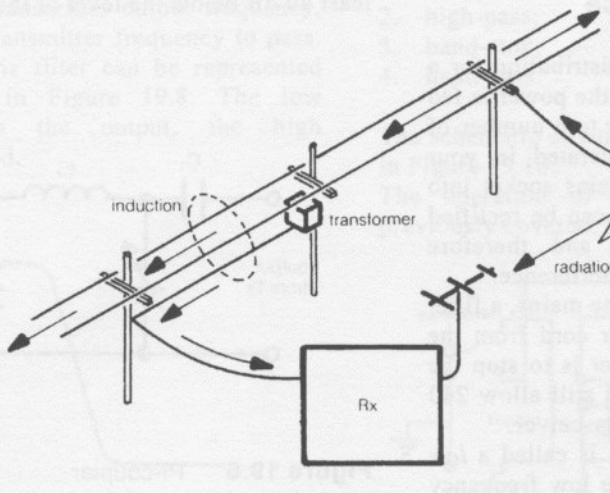

Figure 19.2 Power distribution interference

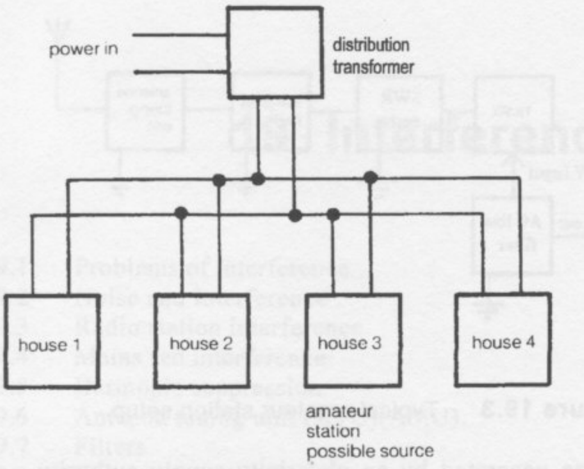

Figure 19.4 Mains fed interference

19.3 Radio station interference

Figure 19.3 is a block diagram of a typical radio station setup for HF, VHF, UHF and SHF transmitting and receiving. The two possible sources from an amateur transmitter that could cause interference are:

1. via the mains power connection;
2. via the antenna.

The greater the distance between the interference source and the affected equipment the less likelihood the interference will impact on the equipment that is the weaker the RF signal the less the impact. Keeping the radiated field strength to minimum will also reduce the likelihood of causing interference

19.4 Mains fed interference

Figure 19.4 is the 240 volt power distribution for a typical suburban neighbourhood. As the power is fed from a local distribution transformer to a number of houses, it is possible that RF generated in your transmitter can be fed out of the mains socket into other homes. RF fed in this manner can be rectified by various household appliances and therefore produce audio which is considered interference.

To stop RF from being fed out of the mains, a filter is included in series with the power cord from the transmitter. The function of this filter is to stop the RF from being fed to the mains and still allow 240 volt power to be fed into the radio transceiver.

This circuit, shown in Figure 19.5 is called a *low pass filter* because it has to pass the low frequency 50 Hz and stop the high frequency RF. The XC of the capacitors must be high for the 50 Hz and the XL of the RFC must be low.

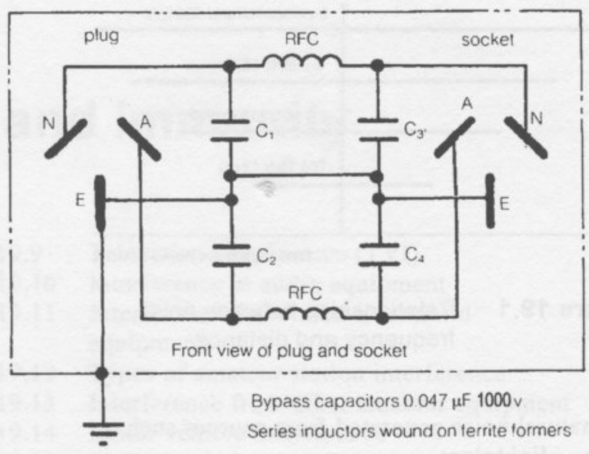

Figure 19.5 Mains filter

At RF the reverse condition applies. The XC of the capacitors in shunt with the mains is low and the XL of the inductance in series with the mains is high. The low XC in shunt effectively short-circuits any RF. The XL is in series and will be high impedance at RF, therefore attenuating the RF.

The capacitors in this filter would be approximately 0.047 microfarad RF bypass capacitors with a voltage rating of 1000 volts. The high voltage rating allows a safety margin when operating on the mains. The RFCs would be heavy gauge copper wire wound on a ferrite core.

19.5 Harmonic suppression

The RF output from every transmitter will contain some harmonic energy. The harmonic energy from a transmitter must be kept to a minimum and be at least 40 dB below the level of the transmitted carrier.

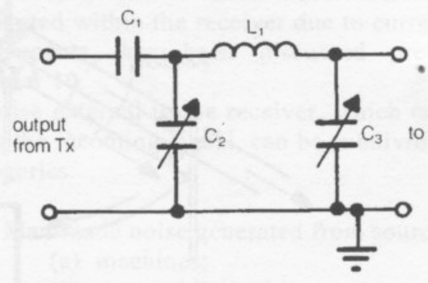

Figure 19.6 Pi-coupler

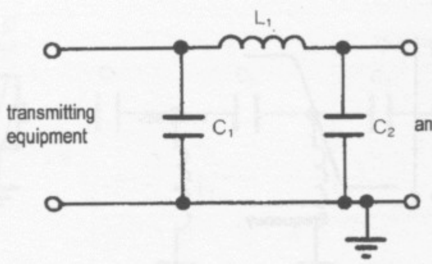

Figure 19.7 Low-pass filter

There is usually a pi coupler in the output of the transmitter. The function of this coupler is to match the output impedance of the transmitter to the transmission line and to suppress harmonics. In some instances the pi coupler may not attenuate the harmonic energy sufficiently, and a low-pass filter may be included in the output of the transmitter.

If harmonic energy is allowed to be transmitted to air, interference to other services may occur. Figure 19.6 is the circuit diagram of a pi coupler in the output of a transmitter.

Figure 19.7 is the circuit diagram of a low-pass filter. Note the similarity between the low-pass filter and the pi coupler. As the name implies this circuit will pass the low RF frequencies from the transmitter and block the higher harmonic frequencies.

Harmonic energy entering the filter, shown in Figure 19.7, will find a low impedance path to earth via the capacitors in shunt with the signal as they have low XC at the high harmonic frequency.

The inductor in series with the signal will offer a high impedance path for the harmonics. This will cause the harmonic energy to be attenuated by the high XL at the harmonic frequency.

The capacitors are selected to have a high XC at the transmitter output frequency and the inductor to have a low XL at the transmitter output frequency, therefore allowing the transmitter frequency to pass. The characteristic of this filter can be represented graphically as shown in Figure 19.8. The low frequencies appear in the output, the high frequencies are attenuated.

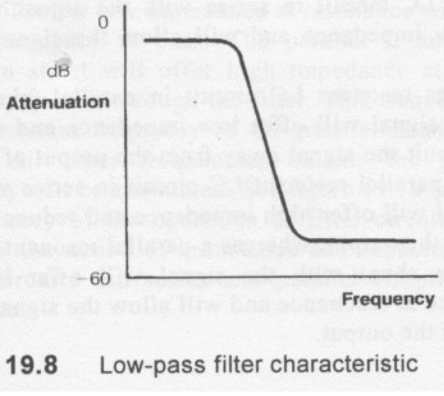

Figure 19.8 Low-pass filter characteristic

19.6 Antenna tuning unit (ATU)(AMU)

The main function of the antenna tuning unit, also called a transmatch or antenna matching unit (AMU), is to match the output impedance of the transmitter to the transmission line by tuning out the reactive components in the antenna system and changing impedances to an acceptable resistive value. Any mismatch that occurs between the transmitter and transmission line will result in standing waves on the line. Standing waves cause some of the transmitter power to be reflected back along the transmission line into the transmitter where it is dissipated in the form of heat.

Standing waves occurring on transmission lines can cause damage to the power output devices of the transmitter and can cause some of the power to be reflected away from the antenna back to the transmitter.

To reduce harmonic interference, the ATU can be designed to act as a low-pass or band-pass filter, therefore providing attenuation for harmonics as well as matching the transmitter to the transmission line. Figure 19.9 is the circuit diagram of an ATU. Note the similarity between this circuit, the low-pass filter and the pi coupler.

The ATU can be located either before or after the transmission line. When located at the transmitter the ATU cannot impact on the SWR between the ATU and the antenna but does match the output of the transmitter to the antenna system.

19.7 Filters

There are four filters of which we must have an understanding. These are:

1. low-pass;
2. high-pass;
3. band-stop;
4. band-pass.

The schematic circuits of these four filters are shown in Figure 19.10.

The operation of the low-pass filter has been previously covered. See figure 19.10 (a).

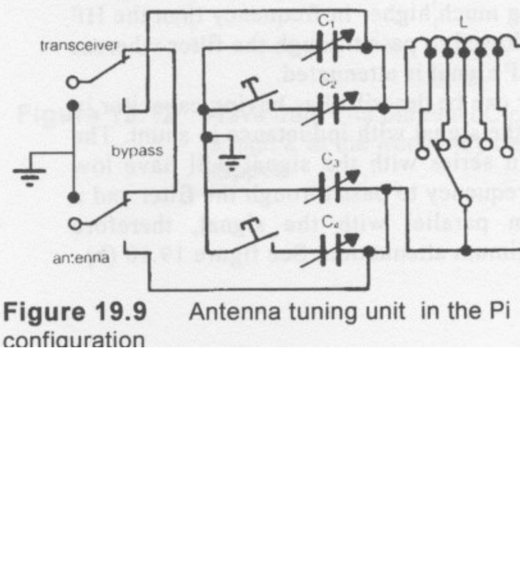

Figure 19.9 Antenna tuning unit in the Pi configuration

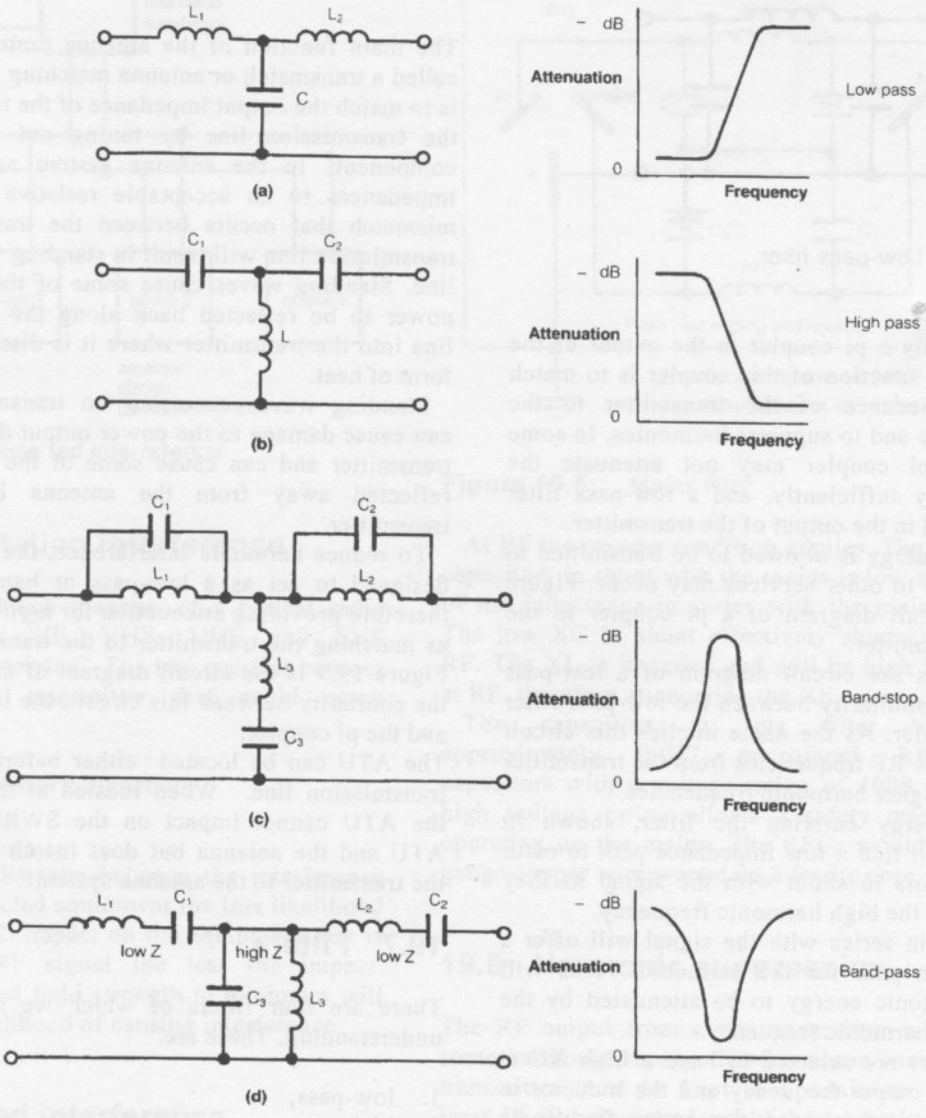

Figure 19.10 Filter configurations: (a) low-pass, (b) high-pass, (c) band-stop, (d) band-pass

High-pass filter

The high-pass filter allows the high frequencies to pass and blocks the lower frequencies. This filter is commonly used to stop HF transmissions from interfering with television signals. The television signal, being much higher in frequency than the HF signal, is allowed to pass through the filter whereas the lower HF signal is attenuated.

This filter can be described as having capacitor in series with the signal with inductance in shunt. The capacitors in series with the signal will have low XC at the frequency to pass through the filter and a high XL in parallel with the signal, therefore causing minimum attenuation. See figure 19.10 (b).

Band-stop and band-pass filters

Band-stop and band-pass filters are made up of series and parallel resonant LC circuits. A series resonant LC circuit in series with the signal will offer low impedance and will allow the signal to pass.

A series resonant LC circuit in parallel (shunt) with the signal will offer low impedance and will short-circuit the signal away from the output of the filter. A parallel resonant LC circuit in series with the signal will offer high impedance and reduce the signal in the output, whereas a parallel resonant LC circuit in shunt with the signal will offer high impedance at resonance and will allow the signal to appear in the output.

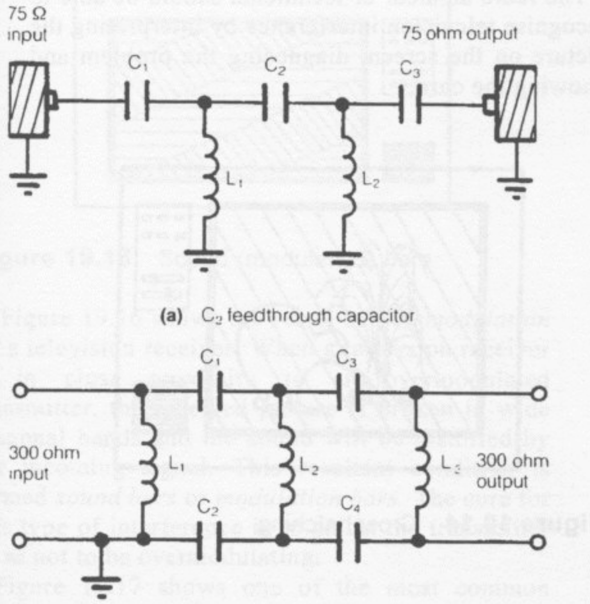

Figure 19.11 High-pass filters: (a) with 75 ohm coaxial cable, (b) with 300 ohm ribbon

Filter circuits are described as having resonant circuits in series with the signal and resonant circuits in shunt with the signal.

The band-stop filter can be described as having L and C in parallel, in series with the signal, with L and C in series, in shunt with the signal.

The parallel L and C circuit in series with the signal will have high impedance at the frequency to be stopped due to the resonance of the parallel circuit. The L and C in series, in shunt with the signal will have low impedance at resonance which will be at the frequency to be stopped, therefore effectively short-circuiting the signal.

The frequencies above and below the ones to be stopped are allowed to pass through the filter and appear in the output. See figure 19.10 (C)

The band pass filter can be described as L and C in series, with the signal with L and C in parallel, in shunt with the signal.

The series L and C circuit in series with the signal will offer low impedance at resonance which is the frequency to pass. The parallel L and C circuit in shunt will offer high impedance at the frequency to pass through the filter. This frequency is the resonant frequency of the parallel L and C circuit. All other frequencies outside the pass frequency will be attenuated. See figure 19.10 (d)

The theory of the operation of filter circuits is based on the action of inductance and capacitance in AC circuits and series and parallel circuits at resonance.

High-pass filter for TV overload

Interference to television reception from radio transmissions is a relatively common occurrence. The main reason for this interference is the close proximity of the radio antenna system and the television aerial.

Signals from the transmitter are sufficiently strong to cause the RF amplifiers in the television to become overloaded, thus forcing a signal through the RF amplifier and in doing so completely disrupting the television picture. This type of interference is termed *television set front-end overload.*

There are several ways to overcome this problem, depending on the type of interference that is occurring. If the interference is present on all HF bands, that is, from 160 metres to 10 metres, a high-pass filter in the television receiver feedline at the television set will most likely cure the problem. Figure 19.11 is the circuit diagram of such filters.

Figure 19.11(a) is a high-pass filter used where the television receiver feedline is 75 ohm coaxial cable and Figure 19.11(b) is a filter used where the transmission line is 300 ohm ribbon.

The VHF and UHF television signals are allowed to pass to the receiver with minimum attenuation due to the low XC of the series capacitors and the high XL of the shunt inductance. At the lower HF signals, the XC of the capacitors is relatively high and the XL of the shunt inductors low, therefore attenuating the HF signal.

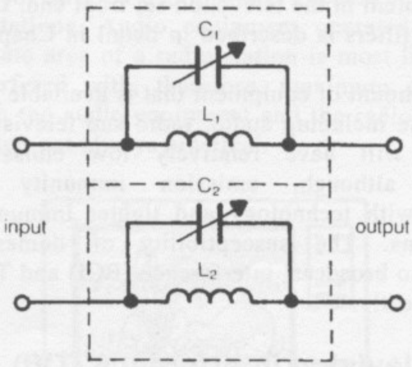

Figure 19.12 Wave trap. The parallel LC circuit is high Z at the frequency being trapped

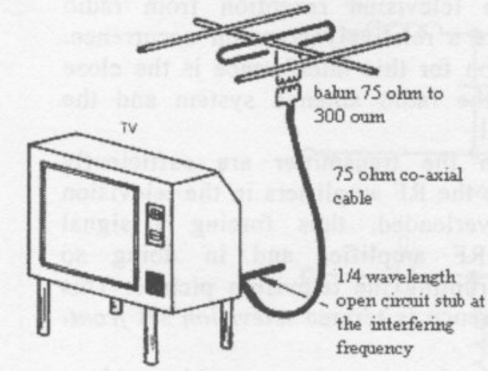

Figure 19.13 Stub as a filter

19.8 Wave trap and stub

The wave trap can be used to stop the effect of front-end overload on television receivers when there is a single radio band that is causing the interference. The wave trap can be in the form of a parallel LC circuit as shown in Figure 19.12 or in the form of a stub, Figure 19.13. The function of the wave trap is to provide low impedance for the television and high impedance at a specific band of frequencies. This type of wave trap can be described as a *band stop filter*. The parallel resonant circuit provides the band stop characteristic.

The stub used as a wave trap is tuned in such a way as to provide a low impedance path for the radio transmission while appearing as high impedance to the television signal. This short-circuits the radio signal and does not allow it to cause a problem in the television set front end. Use of stubs as filters is described in detail in Chapter 20.

A large amount of equipment that is available for domestic use including audio, radio and television equipment will have relatively low emission immunity, although, emission immunity is improving with technology and tighter immunity specifications. The susceptibility of domestic equipment to broadcast interference (BCI) and TVI will vary greatly.

19.9 Television interference (TVI)

Domestic radio and television receivers are generally superheterodyne receivers. Television interference can be caused by the interfering signal being picked up by the television IF as well as via the antenna and RF system

The radio amateur or technician should be able to recognise television interference by interpreting the picture on the screen, diagnosing the problem and knowing the cure.

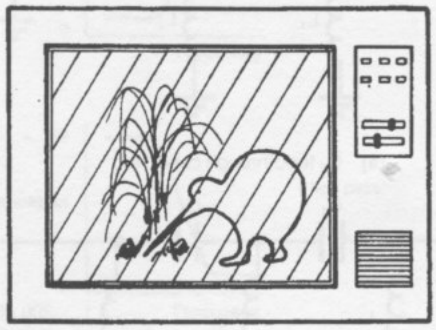

Figure 19.14 Crosshatching

Cross-hatching is diagonal lines on the television picture. It is caused by the beating together of the television carrier and the carrier of the amateur transmission. Cross-hatching is mainly caused when the interfering signal is AM, or FM unmodulated carrier.

The cure for this problem, if it occurs when transmitting on all bands, is to install a high pass filter at the television set. If it occurs on one band only, a wave trap at the television set will remove the problem. Figure 19.14 is a representation of crosshatching as it occurs on a television receiver.

A *herringbone pattern,* as shown in Figure 19.15, is mainly caused by frequency modulated transmissions. The herringbone pattern is produced by a beating together of the FM carrier and the IF of the television receiver and is usually worse on one particular channel. Herringbone is produced if the interfering signal is particularly strong. As the interfering FM signal is generally in the same band as the television signal, this problem is often difficult to cure and a reduction of FM transmitter power may be the only solution.

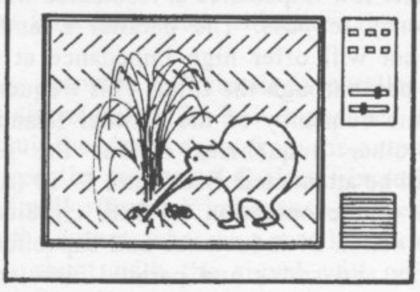

Figure I9.15 Herringbone

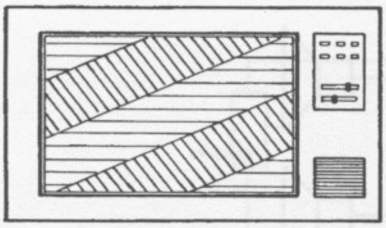

Figure 19.16 Sound (modulation) bars

Figure 19.16 shows the result of *overmodulation* on a television receiver. When a television receiver is in close proximity to an overmodulated transmitter, the received picture is broken in wide diagonal bands and the sound will be distorted by the incoming signal. This resultant condition is termed *sound bars* or *modulation bars.* The cure for this type of interference is to adjust the transmitter so as not to be overmodulating.

Figure 19.17 shows one of the most common forms of television receiver interference. This type of interference, termed *electrical interference,* is caused by a number of conditions that occur in the electricity distribution system. The result of this type of interference is bands of small spots that appear on the screen; in extreme cases, the sound may also be distorted by the interfering signal. Motor vehicle ignitions can also cause a similar problem to TV reception. To cure this problem the interference should be reported to the Australian Communications Authority.

Ghosting

Television receivers are susceptible to the reception of a false image in addition to the required image. The false image is caused by the reflection of the signal from some object prior to reaching the antenna. The ghost appears in a different position to the required signal due to the delay in propagation between the required and ghost signal.

Ghosting can often be rectified by repositioning the antenna but in some cases ghosts are difficult to eliminate without removal of the obstacle causing the reflection, which may be impractical.

Braid Breakers

Braid breaking filters are designed to provide high impedance to RF voltage and current that may be present on the braid of coaxial transmission lines. The braid breaker can be designed to operate in a similar fashion to a high pass filter where series capacitance and shunt inductance is used to provide the desired characteristic. Figure 19.19 shows the typical circuit diagram and characteristic of a braid breaker filter.

The resistor R_1 in the braid breaker provides a leakage path for static charges which can build up on the antenna system. The inductance L_1 is wound in such a way as to act as a 1 to 1 transformer to pass the required signal along the transmission line.

Co-axial choke

The television coaxial feeder can be made to act as an RF choke, common mode choke, to all but the required signal received at the antenna by winding the 5 to 15 turns of coaxial feedline around a high magnetic permeability toroid. The toroid will allow the television signal to pass the differential signal, and block the common mode signal, the RFI.

Mast Head Amplifiers

There are many locations in both rural and metropolitan areas where mast head amplifiers are used to improve domestic television reception. These amplifiers are broad band to allow reception of a wide range of television frequencies. Most mast head amplifiers are susceptible to radio transmitter interference and can suffer from the effects of cross-modulation or overload if the radio transmission is in close proximity

19.10 Interference to audio equipment

In our homes we have many items of audio equipment. To list a few: stereo or public address amplifiers; electronic organs; reel-to-reel or cassette-taping equipment. All these items of equipment are susceptible to interference from radio stations. Audio equipment operated in the immediate area of a radio station is most likely to be interfered with; therefore, maximum distance between the audio equipment and the radio station is best but not always practical.

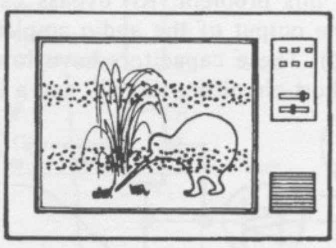

Figure 19.17 Electrical interference

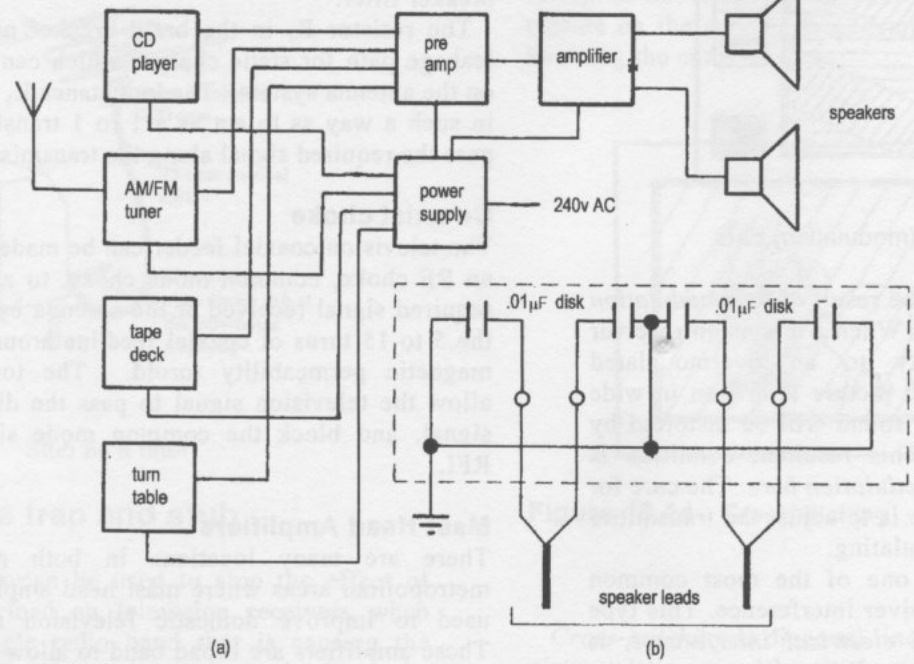

Figure 19.18 Typical hi-fi setup

To remove interference from audio equipment, the same general principles are followed whatever the type of audio equipment. To overcome audio interference, it is generally necessary to make modifications to the equipment.

Figure 19.18 (a) is the layout of a typical audio system used in the home to listen to stereo music. RF from the radio transmission can be picked up in any of the wiring leads between the items of equipment and cause a form of interference termed *audio rectification*. Audio rectification occurs when RF from a transmission is picked up by the leads, particularly the speaker leads as they are long, and fed into the amplifier output transistor. The transistor, being a non-linear device, causes the RF to be rectified or detected and then fed out to the speakers in the form of audio.

To overcome this problem, RF bypass capacitors are placed at the output of the audio amplifier (see Figure 19.18(b)). These capacitors have low XC at RF, therefore short-circuiting the RF, and a high XC at audio and therefore not affecting the audio.

The value of these capacitors is in the range from 0.01 to 0.047 microfarad. Bypass capacitors can be located on any of the leads that are picking up RF.

__Warning:__ Some modern solid state audio equipment may go into destructive, full power, possibly ultrasonic oscillation if connected to a capacitive load which by-pass capacitors would provide. Extreme care must be taken.

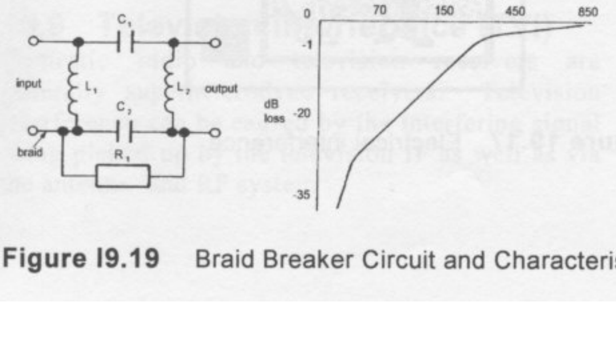

Figure I9.19 Braid Breaker Circuit and Characteristic

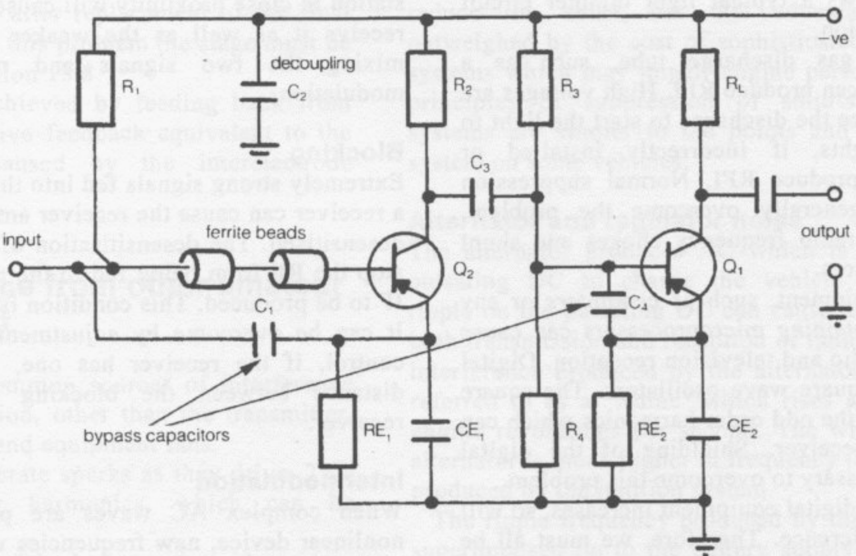

Figure 19.20 Ferrite bands and bypass capacitors

Ferrite beads and bypass capacitors, as shown in Figure 19.20, can be included in audio amplifiers to stop RF from passing through the audio circuit. Ferrite beads placed on the base legs of the transistors act as radio frequency chokes providing a high XL at RF and a low XL at audio. These ferrite beads being in series with the audio signal effectively act as a low pass filter.

RF bypass capacitors can be placed around the base emitter junctions to provide a low XC at RF, short-circuiting the RF away from the audio amplifier without affecting the audio signal.

19.11 Interference from other household equipment

There are many items of household equipment that can generate interference for which the radio amateur can be blamed. Suppression techniques applied to these devices can generally overcome the problem. Care must be taken when inserting RF suppression components to ensure that:

1. the safety of the device is in no way compromised;
2. the voltage and current rating of the component is adequate for the circuit;
3. the circuit, once modified, still functions as it was originally intended.

If you are in doubt seek professional advice.

Of the items of equipment that may cause problems in the home, six commonly used are:

1. light dimmers;
2. fluorescent lights;
3. computers;
4. thermostats;
5. motors;
6. switching circuits

The *light dimmer* allows the lights in your home to be reduced in intensity. This effect is achieved by electronically modifying the AC sine wave. Part of the wave is removed using a diac-triac combination. This often results in the sine wave being cut off during some part of the cycle. The cutting off of the sine wave tends to square it, producing large amounts of odd order harmonics which can be radiated as radio frequency interference (RFI) or TVI.

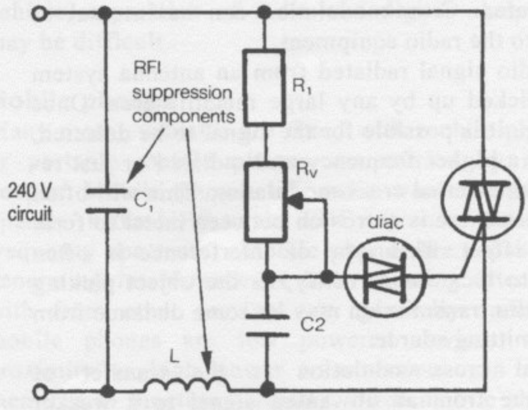

Figure 19.21 Light dimmer. CI and L are suppression components

Figure 19.21 shows a typical light dimmer circuit with RFI suppression.

Any type of gas discharge tube, such as a *fluorescent light,* can produce RFI. High voltages are required to produce the discharge to start the light to glow. These lights, if incorrectly installed or maintained, can produce RFI. Normal suppression techniques can generally overcome the problem. These are series radio frequency chokes and shunt RF bypass capacitors.

Any digital equipment, such as *computers* or any other devices containing microprocessors can cause interference to radio and television reception. Digital equipment uses square wave oscillators. The square wave contains all the odd order harmonics which can be heard in a receiver. Shielding of the digital equipment is necessary to overcome this problem.
As the amount of digital equipment increases, so will this type of interference. Therefore, we must all be aware of digital interference becoming a common source of RFI and TVI.

Thermostats are used to control the temperature of hot water services, waterbeds, etc. The thermostat is a set of contacts connected to a bimetal strip which opens and closes depending on the temperature required. When the contacts close, a current is passed through a heating element to cause the temperature of the water to rise. As the contacts wear, become dirty or corrode, arcing across the contacts will occur. As the spark is rich in harmonics, interference is often generated. This interference can interfere with radio and television reception.

19.12 Types of amateur station interference

Cross-modulation

Cross-modulation occurs when a mixing process across a non-linear device causes new frequencies to be generated. Cross-modulation can be internal or external to the radio equipment.

The radio signal radiated from an antenna system can be picked up by any large metallic area. Once picked up, it is possible for the signal to be detected, mixed to a higher frequency and radiated or just re-radiated as external cross-modulation. This will often occur when there is corrosion between metal to form a diode effect. This type of interference is often difficult to locate and rectify, as the object picking up the radio transmission may be some distance from the transmitting source.

Internal cross-modulation is the transfer of intelligence from an unwanted signal to a weaker required signal. This occurs when two signals are mixed in the RF stages of a receiver to produce unwanted signals in the IF. For example, a broadcast station in close proximity will cause your receiver to receive it as well as the weaker required station, mixing the two signals and producing cross-modulation.

Blocking

Extremely strong signals fed into the RF amplifier of a receiver can cause the receiver amplifier to become desensitised. The desensitisation of the receiver will stop the RF from being fed to the mixer, causing no IF to be produced. This condition is termed *blocking.* It can be overcome by adjustment of the RF gain control, if the receiver has one, or placing some distance between the blocking station and the receiver.

Intermodulation

When complex AC waves are passed through a nonlinear device, new frequencies will be generated. These new frequencies are termed *intermodulation products.* Refer section 16.8.

Parasite frequencies

Parasite frequencies, not related to the transmitting frequencies, can be generated in radio transmitters due to stray and interelectrode capacitance, in conjunction with stray inductance, forming unwanted resonances in the circuit. These parasites are usually higher in frequency than the transmitted frequency. Parasites are usually eliminated by careful transmitter design. A parasitic suppressor is often included in the output anode (collector) circuit of the transmitter. Refer section 13.9.

Another accepted method of removing parasites is to place the output signal through a ferrite bead. This technique is often used in VHF and UHF transmitters as a parasitic suppression technique. The ferrite bead will be of a fairly low inductive reactance (XL) at the frequency of operation. However, as the parasites are higher than the operating frequency, the ferrite bead will offer a higher impedance.

Transmitter tuning

There are many transceivers available on the market and each has its own tuning technique. It is important to note that the radio transmitter must be tuned correctly to obtain:

1. an impedance match between the output of the transmitter and the transmission line;
2. maximum output power;
3. minimum interference.

An incorrectly tuned transmitter can oscillate at the transmitting frequency due to interelectrode capacitance.

This will often occur after replacement of the final devices. To overcome this problem the stage must be neutralised. Refer section 13.8.

Neutralisation is achieved by feeding back from output to input negative feedback equivalent to the positive feedback caused by the interelectrode capacitance.

19.13 Interference from other amateur equipment

Some of the most common sources of interference from an amateur station, other than the transmitter, are the antenna rotor and equipment fans.

Motors tend to generate sparks as they drive. This produces odd order harmonics, which can be radiated.

All manufacturers of both domestic and amateur equipment specify installation, operation, adjustment and servicing requirements of the equipment. Failure to adhere to these recommendations can result in interference in other services as well as danger to the operator or other persons. Particular consideration of the earthing requirements of radio stations as well as domestic appliances must be given. Earthing requirements assist in providing safety but also provide circuits for shielding and other interference reduction.

19.14 Motor vehicle interference

Motor vehicles can cause interference to radio receiving and transmitting equipment and, as amateur operators are likely to install equipment in a vehicle for portable or mobile operation, the possibility of interference is increased.

Ignition system

The ignition system of a vehicle requires high voltages to be switched on and off to produce the spark necessary to ignite the fuel. The high voltage and the spark can radiate energy over distances of 30 metres or more. The energy that is radiated from the high voltage and spark can be picked up by sensitive radio receiving equipment and clicks will be heard as audio in the speaker. The number of clicks will rise and fall with the revolutions per second of the engine. Suppression techniques often used to reduce ignition noise are resistors in high voltage cables, resistance spark plugs, spark plug covers and coaxial suppressors. Coaxial suppressors are especially designed capacitors which are used to pass the noise spikes produced by the ignition system away from the radio equipment. Ignition noise suppression will reduce the noise, but this advantage may be outweighed by the cost of sophisticated suppression systems which may impair engine performance. The principles of suppression of solid-state ignition systems are similar to the points and coil ignition system on some vehicles.

Alternator and regulator noise

The alternator produces AC which is converted to pulsating DC to charge the vehicle battery. The ripple on the pulsating DC can cause interference to both transmission and reception of radio signals. The interference produced by the alternator is generally referred to as a 'whine' which rises and falls with engine revolutions per second. The whine from the alternator is much higher in frequency than the clicks produced by the ignition system.

The ripple frequency produced by the alternator is superimposed on to the battery supply which is the same supply operating the radio equipment. The ripple frequency may be transmitted along with the intelligence when the operator is operating the equipment. Bypass capacitors in the vehicle battery-charging circuit will reduce alternator whine.

Electronic noise

Modern motor vehicles have electronic instruments, electronic voltage regulation, fans and other motors as well as other electronic (or electrical) devices installed in them. These devices are often digital and may be microprocessor controlled. The square wave used to make a digital system work can cause interference to radio reception, particularly on the HF band. In addition, the RF transmitted by the operator may interfere with the instruments. Interference to or from digital equipment is difficult to suppress.

The greater the distance between the transmitting equipment and the digital equipment, the less likely the interference and in the confined space of a vehicle, separation of radio and digital equipment may be difficult.

Mobile phones

Many motor vehicles are fitted with mobile phones or portable mobile phones are carried by many people. Mobile phones are radio transceivers that operate in the UHF to the EHF region of the radio frequency spectrum. Mobile phones are capable of generating interference as well as being interfered with from other services. As generally speaking, mobile phones are low powered devices, close proximity to high power transmissions can cause them not to function correctly. Often mobile phones will generate BCI in a motor vehicle by interfering with the vehicles domestic car-radio.