



# RADIO FREQUENCY INTERFERENCE (RFI) INVESTIGATION AND RESOLUTION GUIDE

# CONTENTS

01	Purpose and scope	01
02	The interference location process	02
03	Interference location techniques for domestic interference	03
04	Interference location techniques for commercial interference	09
05	Interference at radio station sites	11
06	Suppression methods	14
07	Safety and compliance	16
08	Contacts/Bibliography	17

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# 01 PURPOSE AND SCOPE

**THIS RADIO FREQUENCY INTERFERENCE (RFI) AND RESOLUTION GUIDE IS DESIGNED FOR USERS WITH A MODERATE TO HIGH LEVEL OF ELECTRICAL, ELECTRONIC OR TELECOMMUNICATIONS KNOWLEDGE, SKILL AND EXPERIENCE.**

Radio Spectrum Management (RSM) has produced this self-help guide to locating and identifying RFI sources. The information outlines some common causes of interference and suggests a methodology to resolve them. The use of the term interference in this publication is in accordance with normal industry practice, but does not imply that any particular situation or example is necessarily interference as defined in the Radiocommunications Act 1989.

Changing technology means that the sources of interference are also continuously changing, and this will often mean adopting new technology and techniques. Nevertheless, well-established methodology that is systematically employed will normally serve practitioners well.

Although best practice in installation and maintenance is essential to preventing and minimising RFI, this Guide does not address such aspects. These requirements are generally covered in manufacturer instructions and in standards available from Standards New Zealand.

## BACKGROUND

Regulatory measures are in place to prevent unacceptable levels of RFI pollution to the New Zealand radio spectrum resource. These measures are provided for under the Radiocommunications Act 1989 and Radiocommunications Regulations 2001, and managed by RSM.

### RSM's responsibilities include:

- licensing of radio transmitters and
- managing compliance frameworks for electrical products and radio transmitters.

These frameworks are supported by random audits and inspections to ensure the integrity of New Zealand's self-regulatory system protecting the communication services essential to the New Zealand economy. Compliance requirements for electrical "noise," and the engineering of radio licences assume that radiocommunication services cannot be provided with a "radio-silent" background, and that the services should work satisfactorily in the presence of reasonable levels of unwanted signals.

## 02

# THE INTERFERENCE LOCATION PROCESS

### **1. Obtain detailed information from affected parties as to the nature of the interference such as:**

- what time does it occur?
- what frequencies are affected?
- when did it start?
- which geographical area is affected?
- what does it sound like or look like?
- does it happen in certain weather conditions?

We recommend you never prejudge a case as to the source of the interference.

### **2. Determine how the affected service is being impaired.**

Determine the way the affected service operates (system configuration) as this will assist in understanding how the interference is affecting the wanted service and hence the likely nature of the interference.

- eg for systems such as linked voting systems there may be several possible points of entry for the interference.

### **3. Check the receiving installation and where possible test or change the affected equipment to ensure the equipment or receiver settings is not the source of the interference.**

### **4. Determine if poor installation practices are causing or contributing to the interference.**

- eg for land mobile sites, is the configuration in accordance with industry standards such as AS 3516.2-1998 – Part 2: Guidelines for fixed, mobile and broadcasting services operating at frequencies above 30 MHz.

### **5. Conduct measurements of the incoming interference to determine:**

- levels
- modulation characteristics
- direction.

### **6. Review your original information and follow up on relevant information as required.**

Consult others in the industry as appropriate. If necessary, request further information from the affected parties so you can be certain to understand the affected system and the interference mechanism before proceeding.

# INTERFERENCE LOCATION TECHNIQUES FOR DOMESTIC INTERFERENCE

**THIS SECTION RELATES TO INTERFERENCE TO TV AND BROADCAST RECEPTION AND OTHER NON-COMMERCIAL SERVICES LIKE AMATEUR, DX LISTENING, CITIZEN BAND AND PUBLIC RADIO SERVICE.**

## 1. Check the equipment and installation.

Ensure the affected receiving installation is configured correctly, and working effectively. This, together with sufficient wanted signal is critical to ensure that it is as immune as possible to external interference.

- Faulty systems eg incorrect wiring, overloaded and/or mismatched amplifiers, faulty distribution equipment, etc may create their own interference.
- Installers tend to use amplifiers that have excessive gain, thinking that this will provide better system performance. High gain amplifiers are considerably more susceptible to interference. Use only the gain needed for the task – the lower the gain, the lower the system susceptibility.

## 2. Trace the signal along the wiring.

The diagram on the following page shows how interference travels to a typical domestic residence.

While unwanted signals will radiate directly from the RFI source they will also travel considerable distances along wiring. It is thus possible to trace the noise along the lines. It is likely that radiation from these lines will also occur at multiple points, hence a number of radiated signals will likely require attention.

Wiring attached to RFI sources frequently acts as an aerial. The nature of this wiring provides for a multiplicity of radiated and conducted patterns of RF energy which will vary widely from one frequency to another.

Urban situations with underground power will also behave in this way although radiation will

largely occur from wiring that emerges from the ground at street fuse boxes and at houses.

The signal level (see below) works best in this situation.

Watch for multiple interference noises and frequently check that you are following the correct one.

## LOCATING WIDEBAND INTERFERENCE

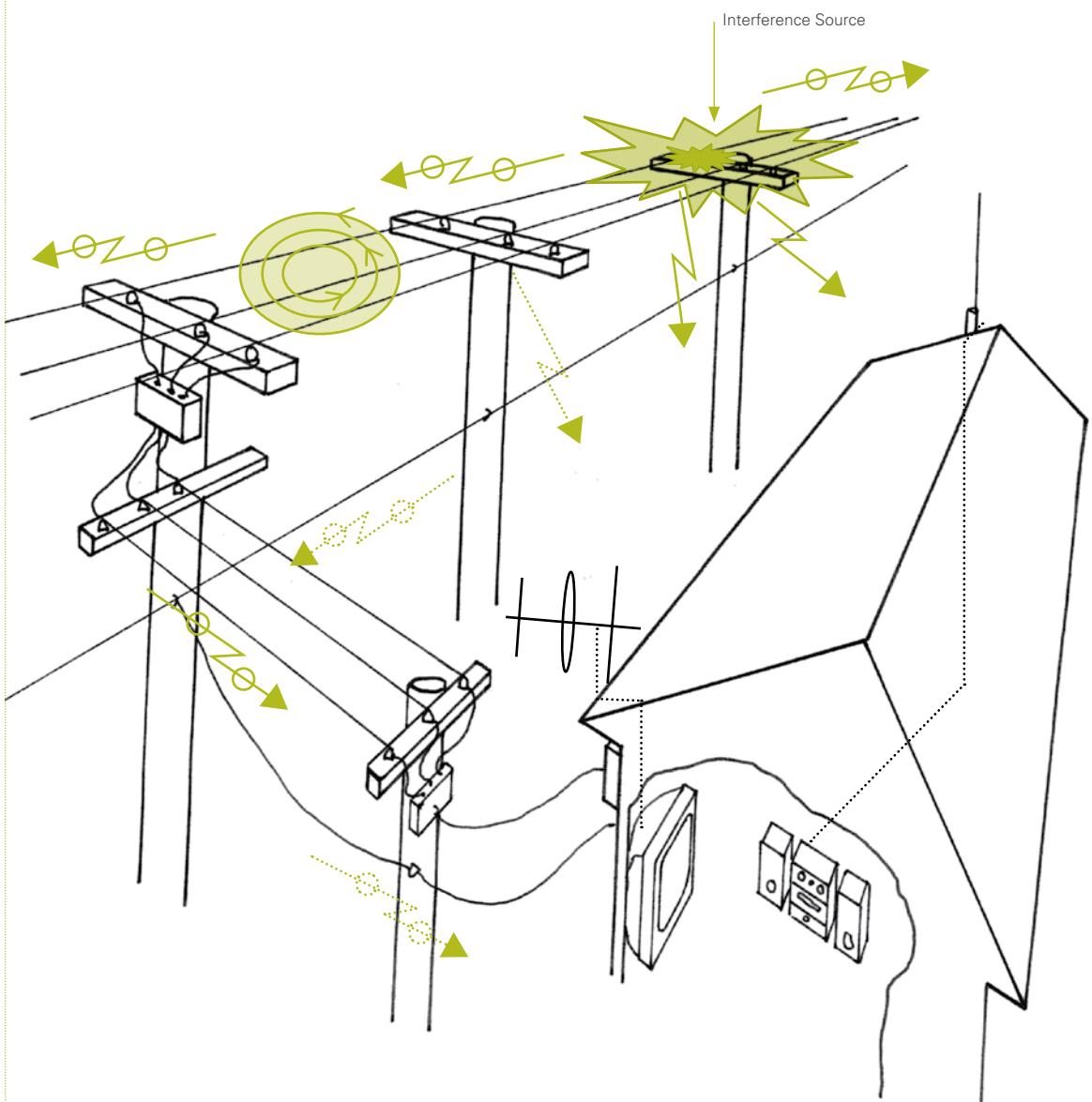
Techniques for locating the source of wideband interference are:

### 1. Measure interfering signal levels.

Normally the stronger the RFI level, the closer you are to the interference source.

- Lower frequencies eg AM broadcast (521 to 1612 kHz) wavelengths are long and standing waves will occur. They will likely occur a great distance away from the source, meaning the level may be strongest away from the source.
- It is easy to confuse direction when tracing signals in the low frequency (300 kHz) to high frequency (30 MHz) range. This is particularly so when the conducted component meets other powerlines or junction points. The measured level at the junction may exceed levels closer to the source.
- When following conducted noise along an uninterrupted power line, each standing wave peak will be a little lower than the previous. This is particularly noticeable at VHF and UHF frequencies. When close to the source, the standing wave pattern changes into a steady level of signal.

## Propagation of interference signals



### Legend

Conducted noise	Secondary radiated noise
Secondary conducted noise	
Radiated noise	Induced noise

## **2. Measure highest interference frequency.**

The closer you get to the source, the higher in frequency the interference will be detectable. Due to shorter wavelengths at higher frequencies, there is a tendency for more radiated signal closer to the source.

## **3. Direction of signal.**

Reflections from metallic surfaces will provide multiple signals and the reflections may be stronger. The screening/shielding effect of buildings and topography can help in determining the direction to an interference source.

## **4. Band fill (on spectrum analyser).**

A fuller band will likely mean you are closer to the interference source.

### **EQUIPMENT AND APPLIANCES THAT COMMONLY CAUSE INTERFERENCE INCLUDE:**

All electrically-powered equipment produces electromagnetic fields (radio waves). For most equipment this effect is unwanted (unintended radiation) and is limited by design to comply with mandatory standards. For other equipment (transmitters) the radiation is intentional and necessary for communication or material treatment.

Some examples of interfering equipment are listed below:

- Switch mode power supplies, TVs, stereos, DVD players, satellite receivers, videos, computers, 12 volt lighting, energy saver bulbs and other lighting equipment.
- Variable speed drives, water pumps, air conditioners, lifts.
- Motorised equipment, drills, food processors, model trains, vacuum cleaners, water blasters.
- Microprocessor controlled equipment, computers, sewing machines, alarms, TVs, DVD players, heat pumps.
- Unstable masthead or distribution amplifiers, incorrectly installed distribution hardware, and faulty receiving equipment.

■ Cordless phones, baby monitors, amateur radio, citizen band or wireless networks. Interference may occur because these are in close proximity or on the wrong frequency. A recording of the interference may be useful in determining the source. Beware of receiving installation deficiencies which may cause the appearance of interference even though the transmitter operation may comply with all requirements.

### **Additional tips to help you locate wideband interference:**

- Suitable equipment will be needed for this task, with a quality continuous tuning wideband receiver covering the range 550 kHz to 3 GHz with a signal strength meter and attenuator. Efficient wideband antennas will also be required.
- When tracing TV interference, a TV receiver is often useful if the interfering signal is contained within and thus masked by the TV signal.
- Understanding the propagation of signals at low frequencies (AM band) as opposed to high frequencies (TV bands) is useful.
- The "T" intersection of power lines and telephone lines act like half- or quarter-wavelength stubs (or multiples of, or parts of) and thus the noise will behave accordingly. These intersections are often the location of strong standing waves and radiation, and may be a long way from the interference source.
- An understanding of power reticulation is useful.
- Often it is not possible to differentiate the noise source among two or more houses. In this instance requesting help from the residents and turning off the mains will help identify the correct location.
- Turning off the power to a house may reduce the interference to your receiving equipment due to the proximity of your equipment to the house wiring. This may give you the incorrect impression that the source is located in that house. Always check back with the complainant at this point.

- Alarm systems and other backed up equipment (battery and uninterruptible power supplies) will keep associated equipment active, even with the house mains off. Check for the presence of such equipment before assuming the premises do not hold the interference source. An alarm technician may be needed to check security systems.

## POWER LINE INTERFERENCE

Power line interference usually comes from broadband noise.

It may be traced using the same techniques as tracing interference from an appliance. The interference is conducted along power lines and is also radiated in a similar manner. It is usually noticed only where power is reticulated via overhead power lines and receiving aerials are relatively close to the lines.

It is a complex task to trace power line interference and a number of techniques will likely be required but the final analysis may still not lead to the source. Patience and concentration over a period of time is often required.

- Power line interference tends to affect a wider area and is often moisture and wind dependent. Band one TV signals are more susceptible to this type of interference. The nature of the interference is largely determined by the voltage of the power lines. The majority of interference occurs with 11 KV, 22 KV, and 33 KV equipment.
- The location of interference on 22 KV and 33 KV equipment may be difficult where multiple sources are likely. They also tend to have a high level of ambient noise where wooden structures are used, due to loose hardware (caused by shrinkage) and tracking between metal hardware. Corona discharge may also add to the ambient noise.

## Consider the following during the location process:

- Equipment for measuring interference level, frequency and direction is effective in locating power line interference. In some instances the arc producing interference can be seen (particularly at night) or heard, but should not be confused with corona discharge.
- At times the exact source hardware may be determined with the use of an ultrasonic detector, but only where an arc is present which is exhibiting ultrasonic noise. Binoculars are helpful in looking for faulty equipment as is a wooden maul for vibrating the poles to determine the presence of loose hardware.
- It may be necessary to employ the assistance of power authority staff to test hardware to determine the exact source.

## AUDIO RECTIFICATION

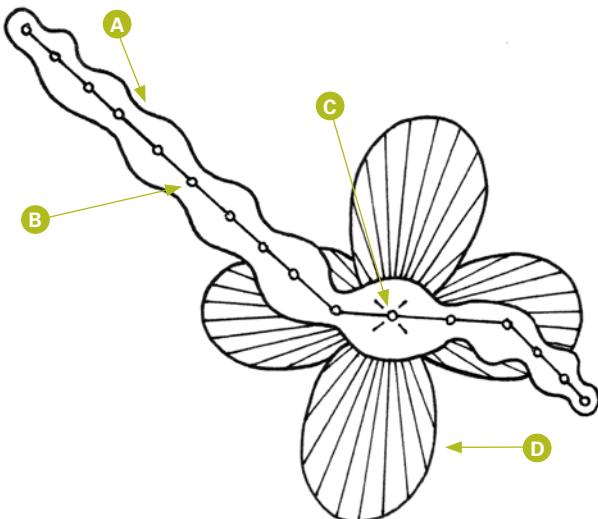
Audio rectification usually occurs in narrow band transmissions.

Strong RF signals are picked up by audio amplifying or computer equipment and are rectified by one or more of the many diodes and transistors in this equipment. This produces DC voltages that corrupt operation. At times these diodes and transistors will demodulate the RF signals and this may be heard over speakers attached to the system.

Please consult texts in the bibliography on page 17 for techniques to correct these cases.

## POWER LINE INTERFERENCE

### Radiation patterns



A Induction area

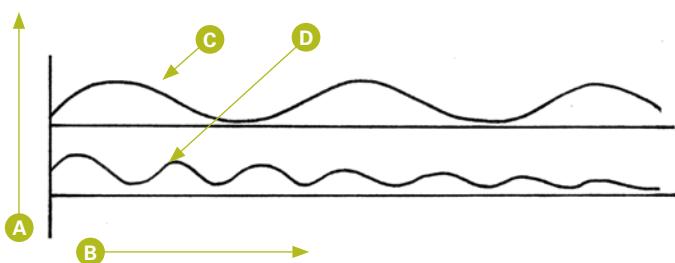
B Power line

C Source

D Radiation area

Typical single source, single line, power line radiation and conduction patterns.

### Standing waves



A Voltage level

C Low frequency

B Distance from source

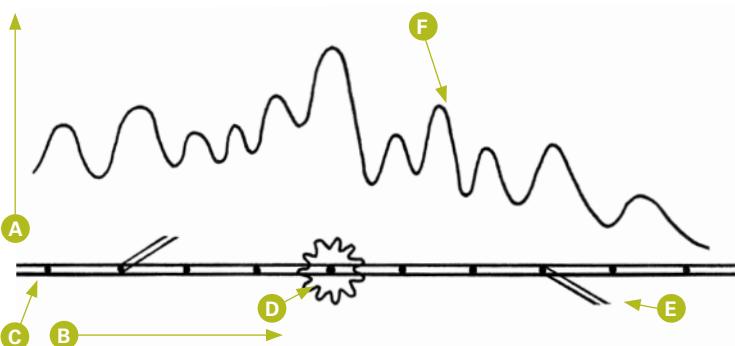
D High frequency

Standing waves (a series of noise peaks and troughs) appear along the line. Note the noise between peaks lessens as they approach the source. Likewise, the distance between a peak and a trough lessens as the source is neared.

Variations in noise levels along the line may be due to secondary line radiation, down leads, ground wires, and nearby metallic objects.

Usually, the higher the frequency, the less the distance between peaks and troughs eg the standing waves become shorter.

### Noise voltage levels



A Voltage level

D Noise source

B Distance

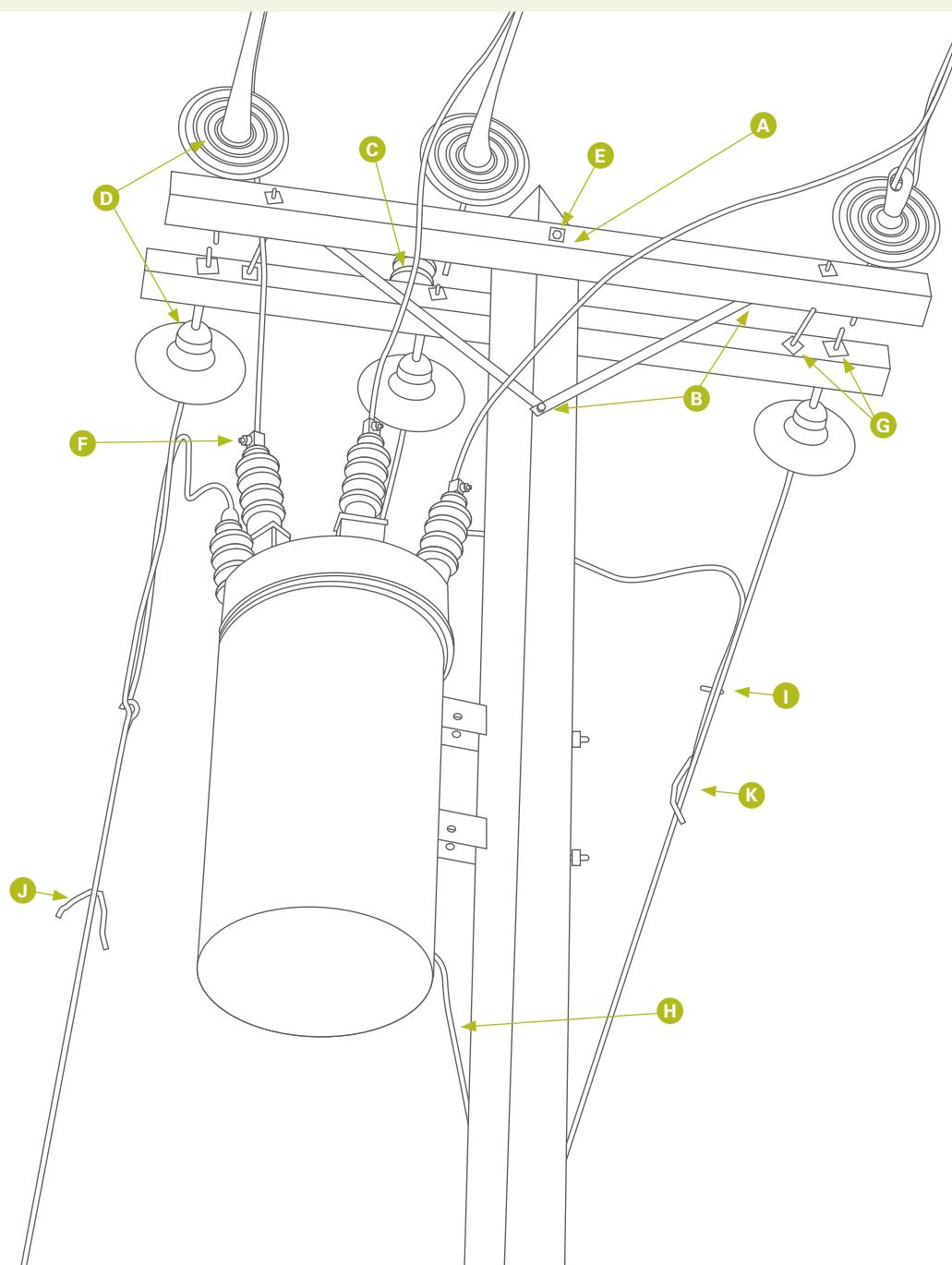
E Secondary lines

C Main line

F Standing waves

Affect on standing waves of secondary power lines joining the main line.

### Some of the sources of interference found on a power pole



#### Legend

- A. Retaining nut and bolt head on cross arm
- B. Cross arm brace bolt head and over lap joint
- C. Insulator mounting post, loose insulator binder (tie) wire, and loose insulator
- D. Loose shackles on bell type insulators (disc strain type shown)
- E. Loose hardware eg bolt head to associated washer
- F. Loose clamps on insulator tops
- G. Tracking between non-associated hardware eg possibly too close
- H. Earth wire lightly touching pole stay wire (stay wire not shown)
- I. Dissimilar metals in contact causing corrosion
- J. Wire over line
- K. Long tail on line connection

# INTERFERENCE LOCATION TECHNIQUES FOR COMMERCIAL INTERFERENCE

**THIS SECTION RELATES TO COMMERCIAL INTERFERENCE FROM UNINTENDED RADIATORS, OR FROM INTENDED RADIATORS.**

## UNINTENDED RADIATORS

Some electrical equipment operates at high voltage or with high loads giving the potential to cause severe interference.

### Preventing interference from unintended radiators.

To prevent RFI from occurring, all electrical equipment must meet an appropriate standard or specification as described in the relevant notices on [www.rsm.govt.nz](http://www.rsm.govt.nz).

Products must not be marketed or used in New Zealand unless the equipment meets the designated specification:

- Suppliers must hold a Supplier Code Number and mark their equipment with compliance labelling.
- Equipment must be installed in accordance with the required (usually manufacturer's) installation specifications.

### Locating interference from unintended radiators.

Techniques for tracing the interfering noise are similar to that for domestic interference but there is often a higher radiated component and levels of interference tend to be higher.

Location in the urban environment presents additional challenges, particularly in respect of reflected signals. Reflections and multiple standing waves may require detailed analysis before meaningful results are obtained. If the interference is especially difficult to locate, it may be helpful for the tracing to be conducted concurrently on several different frequencies.

### Typical interfering equipment:

- Motor controlled equipment, motor commutator brushes, associated variable speed drives (thyristor noise).
- Microprocessor controlled equipment, computers and other devices, air-conditioning, conveyor control.
- RF equipment, radio frequency welders, sealing equipment, medical equipment.
- Switch mode power supplies, lighting, battery chargers.

## INTENTIONAL RADIATORS (TRANSMITTERS)

Interference from transmitters is primarily managed through the licensing system by separation in frequency, location or time. This management process can fail where equipment becomes faulty (spurious radiation) or where separation is insufficient (co-channel).

### Identifying spurious radiation or co-channel signals.

The determination will be made from several observed factors.

Spurious radiation interference usually occurs where a fault condition exists while co-channel usually occurs when the equipment is installed on the wrong frequency. A suitable directional aerial (correct band) and a good receiver is normally used to direction-find these sources.

### **Suggested steps in the location process:**

- Use RSM's online SMART spectrum search utility (area search in particular) to help locate or eliminate suspect transmitters.
- Use open reflection-free sites to conduct the direction finding process where possible.  
Watch for reflections and discard these readings.  
Watch for receiver overload in areas of high radio usage.
- Weak signals may initially require a visit to the affected site and the use of sensitive but robust receiving equipment. Filters may be needed to prevent receiver overloading.
- A good spectrum analyser may help to determine the nature of the signal. A small resolution bandwidth and narrow span is required for weak signals.
- Listening to the modulation may indicate the nature of the offending transmitter where you may be able to match it to the primary transmission.
- Narrow the area by triangulation and focus in on the triangle. In urban areas, portable equipment will be required and reflections will likely be a major problem.
- Use buildings as "RF shelters" if they will help to determine the direction of the signal.
- The direction and level of signals are the best tools to locate RFI, but there will be many false readings to discard.
- Helicopters with fixed aerials are often the most efficient way to track transmissions, especially in remote areas.
- Spectrum analysis may allow signal repetition rates and modulation characteristics to be determined which can help narrow the type of offending transmitters.

### **Co-channel signals.**

These are same-channel transmissions which may occur when transmitters are incorrectly programmed, mobiles are operating outside of their normal operating area or where they are located in geographically high positions.

Check SMART online for cancelled licences that may be still in use on the affected channel. A check with the previous licensee may identify this source.

This type of RFI may also occur during periods of stable weather where a high pressure weather system may be located across the country resulting in long range transmission of VHF and to a lesser extent UHF signals. This is called anomalous propagation. It will usually last for the duration of the high pressure system (may be several days) and normally occurs in mid- to late-summer. Often, trans-Tasman signals may be heard at the same time where interference is often received from high power FM broadcasting and TV stations.

Co-channel interference should not be confused with the normal shared channel arrangements prevailing in simplex services. Where channel sharing is in use, selective calling or tone squelch systems may be used to provide user privacy. Improper operation of those systems may be confused by users as being co-channel interference.

### **Adjacent channel signals.**

All receivers have limited ability to reject adjacent channel transmissions when in close proximity to a transmitter on an adjacent channel. The ability of receivers to reject adjacent channel transmissions varies among equipment makes and models.

If several channels are used in the same band simultaneously, like at port company premises while unloading a ship, careful planning of frequency usage will help reduce the occurrence of interference.

# INTERFERENCE AT RADIO STATION SITES

**DETERMINING AND LOCATING THE SOURCE OF UNWANTED INCOMING RADIO SIGNALS AT A RADIO STATION SITE IS LARGELY A PROCESS OF ELIMINATION. REMOTE SITES MAY WELL PROVE A CHALLENGE WHEN THE SIGNALS ARE INFREQUENT AND INTERMITTENT IN NATURE.**

**Key steps in the process are:**

## DETERMINE IF THE INTERFERENCE IS CREATED ON-SITE OR REMOTE FROM THE SITE

1. Use our online SMART spectrum search utility to create an area search both wide ranging (eg 80 kms), and local (eg 1.5 kms). This information is useful for comparison purposes, for Approved Radio Engineers (AREs) and Approved Radio Certifiers (ARCs).
2. Determine if the signals are coming from the radio station site or from off-site. This may require connecting the radio site aerial to a separate receiver or, if the signals are strong enough, setting up a temporary receiving system on-site with directional capabilities.
3. Try another receiver or other equipment as necessary to eliminate equipment faults.
4. A sensitive spectrum analyser is a very useful tool for analysis of the parameters of the incoming signal. Watch for possible overloading of your receiving equipment.
5. Observe the nature of the interfering modulation and its amplitude/time/frequency characteristics.
6. If garbled or mixed modulation is heard it may be an intermodulation product created on-site. This is more likely at multi-transmitter sites. If no audible noise is heard the problem may well be receiver de-sensitising (see receiver de-sensitising on page 12).
7. Note any other transmitters that may be active when the interference comes on or goes off.

8. If on-site interference is determined, locate the transmitters causing the problem. An intermodulation calculation may help. Otherwise, note which transmitters are on during the presence of the interference. Narrow the search by observing the problem over a period of time sufficient to give confidence in the results.
9. Check the proximity of the transmit aerials to the receive aerials. Aerial isolation is critical even between widely spaced bands (eg UHF to VHF land mobile bands).

## LOCATING THE SOURCE OF THE INTERMODULATION PRODUCT

This source will likely be a transmitter not fitted with a circulator and filter, or a corroded joint enabling rectification and mixing of two or more transmissions to occur. Generally the contributing transmitters will be two or more on-site transmissions though a strong off-site transmission has been known to contribute.

Site operators have been known to replace entire masts with a type that does not use bolted joints as the most efficient way to solve ongoing problems.

### Useful advice

1. All transmitters must be fitted with filters and circulators to prevent intermodulation being formed in the final stages of transmitters and retransmitted. This is a primary source of interference.
2. It is possible to direction-find the source of the faulty joint in many circumstances. The use of sensitive receivers at multi-transmitter sites requires the use of filters.

3. Look for any bolts or screws that may have become corroded. Lattice towers where joints are secured by bolts are often a major source of rectification. Similarly, gridpack type antennas that are held together with screws often cause intermodulation.
4. A connector or cable may have suffered water entry causing internal corrosion.

### RECEIVER DE-SENSITISING

FM noise is a major contributor to receiver de-sensitising. It often occurs at sites where there are high-power FM broadcast transmitter aerials close to sensitive land mobile receive aerials.

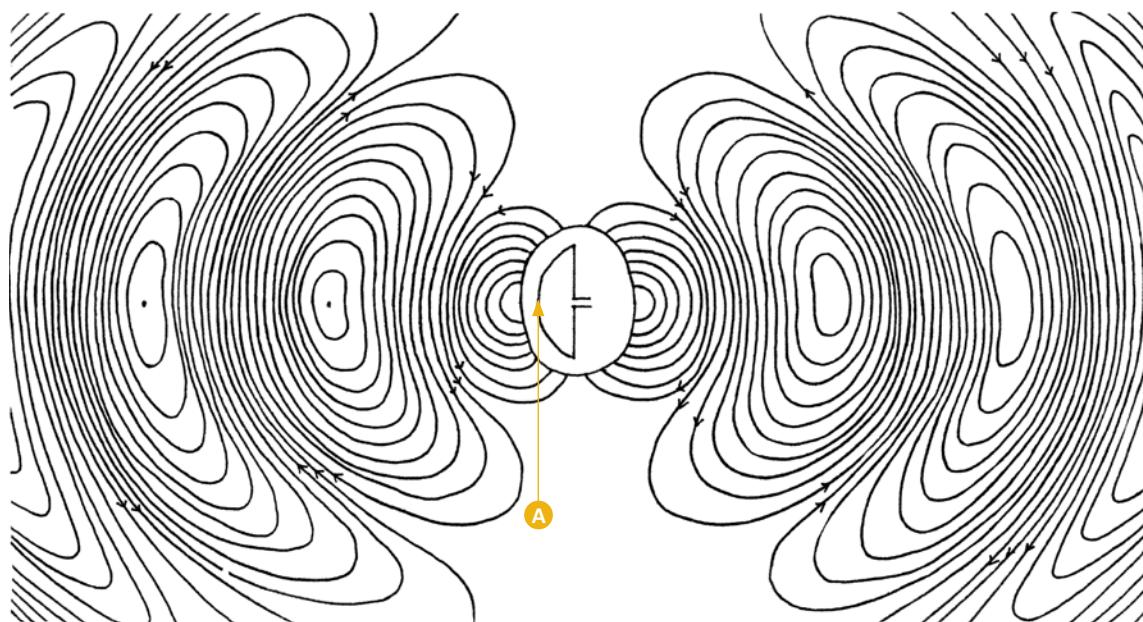
The white noise created in high power linear amplifiers raises the noise floor often over a wide range of spectrum and affects sensitive narrow band FM receivers by reducing their ability to

receive signals. The affected receivers may suffer a reduced sensitivity by 10 to 30 dB. It is not possible to audibly hear this noise and the receiver outwardly appears to be fine (receiver "hiss" is apparent and appears normal). It is possible to determine receiver de-sensitising by testing the signal to noise ratio through the use of a noise bridge and signal generator.

### NEAR AND FAR FIELDS

Radio wave propagation close to antennas should be understood. Signals behave differently close to radiating antennas, where inductive principles predominate rather than the electromagnetic and electrostatic principles of radiation as you move away from the antenna. This may affect the measurement techniques needed to determine signal strength and direction for interference location.

#### Dipole near field diagram



A Current curve shown with  $I_{\max}$  at top of the curve

The way an RF field develops as it moves away from its transmission source is depicted in this drawing.

## ENGINEERING PRACTICES AT MULTI-USER SITES

Frequencies are engineered at sites on the basis of sound radio frequency engineering practices being employed. Where these practices are observed the chance of on-site interference is minimised.

RSM recommends that multi-user sites comply with specification AS 3516.2-1998 and that all contracts let for site construction contain this specification as part of the requirements.

## CROSS MODULATION

Cross modulation is a form of intermodulation where the mixing occurs in the front end of a receiver. Re-radiation does not normally occur from the receiver. It is commonly noticed where mobile equipment is not protected with circulators and/or filters.

At base stations, filters and circulators are normally fitted and this prevents this type of interference.

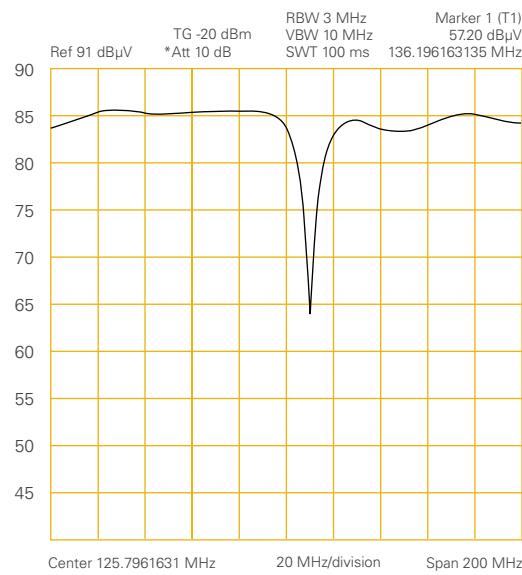
This is likely to be the primary problem when investigating interference sources. So a wise first step is to try to eliminate the effect with filters.

Remember to use only the minimum required gain in any broadband amplifiers, as overload and mixing will likely occur in the presence of a strong signal.

## Notch filter



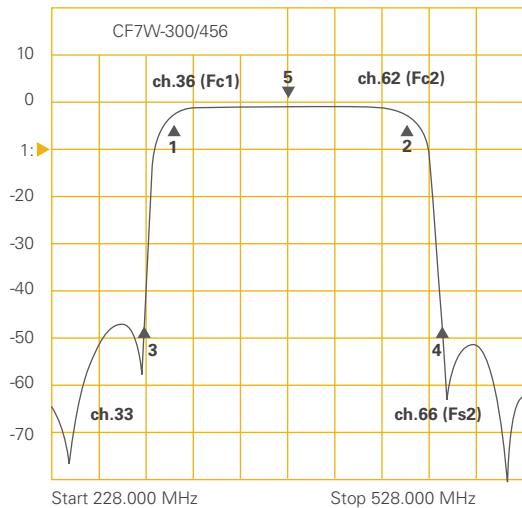
## Notch filter plot



Small indoor and outdoor commercial filters are available to prevent interference to TV and FM receivers.

Consult your Master Antenna TV equipment supplier.

## Typical UHF passband plot



# 06 SUPPRESSION METHODS

**ALL ELECTRICAL EQUIPMENT PRODUCES ELECTROMAGNETIC NOISE. ACCORDINGLY, AWARENESS OF THE NEED FOR DESIGN AND INSTALLATION PROCEDURES THAT MINIMISE THE NOISE IS IMPORTANT. WHERE THESE PROCEDURES ARE INADEQUATE TO ENSURE EQUIPMENT COMPATIBILITY AND COMPLIANCE, SUPPRESSION BECOMES NECESSARY.**

## INTENDED RADIATORS

For intended radiators, good engineering practices will prevent and eliminate sources of interference. Even radio frequency ‘intentional radiators’ like ISM (industrial, scientific and medical) equipment are required to be installed correctly and used in the appropriate spectrum.

## UNINTENDED RADIATORS

**The following process and considerations should be noted when suppressing these devices.**

- Before fitting filters determine that the installation has not developed a fault condition, and that it has been installed correctly. Instability often occurs where correct practices are not followed, eg RF distribution systems act like random transmitting aerials where correct matching is not employed consistently.
- Check with the supplier/manufacturer as they may have custom suppression components available or have the fix already.
- In the majority of RFI product cases a filter made from RF-rated inductive and capacitive components may be employed. Select the components of the correct value and performance and fit them in the correct place, eg for brush feed commutator motors the components should be attached directly to the brushes with short wires.
- Fitting filters away from the exact source of the noise is usually ineffective due to radiation from the wiring between the interference source and the filter.
- Low frequency interference will require higher value inductors and capacitors. Note that these components will likely be ineffective at high frequencies due to capacitive and inductive reactance which is as a result of their size.
- Some products are difficult to suppress, eg thyristor-controlled devices and microprocessor-controlled devices, as it is often difficult to get close to the sources of the interference. Suppression may also affect the operation of the device so check with the supplier before proceeding. **Caution! Electrical safety and operational performance may be adversely affected by suppression components. Ensure that the addition of suppression components does not cause the device to become electrically or operationally unsafe.**
- Special attention to earthing and screening when considering suppression of devices capable of being contained in a metal housing is recommended. See the diagram on page 15 in relation to the current paths that have to be considered. All these paths must be blocked and will require a combination of both inductors and capacitors. The use of screened cabling may also be an essential part of suppression for equipment using mains frequency conversion (inverters and variable speed drives etc).
- RF sources often have a low impedance thus any filtering must be designed with this characteristic in mind. A capacitor alone will not usually be sufficient.

- Even the most unlikely devices may be a major source of interference. For example, RSM dealt with an interfering 121.5 MHz signal, blocking the 121.5 Emergency Locator beacon receivers aboard satellites some 850 to 1000 kms above the earth.

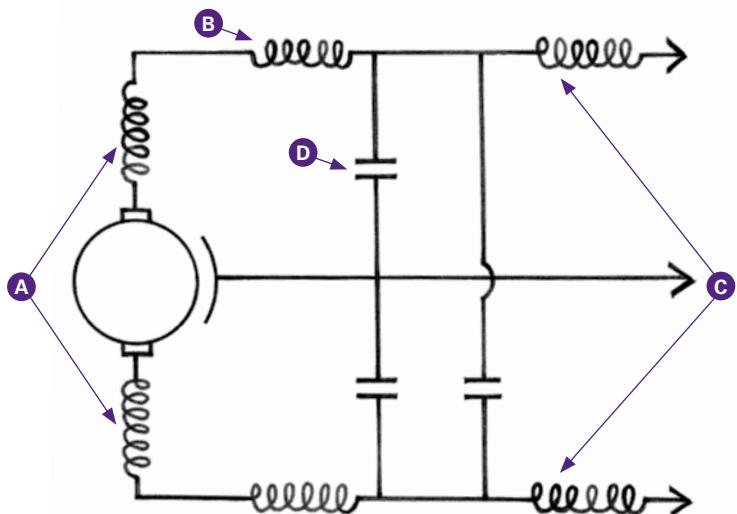
The source was a cumulative one, traced to tens of thousands of satellite receivers used in New Zealand which have a 121.5 MHz oscillator on the mother board.

### AC mains suppressor



This Schaffner suppression socket is effective at suppressing conducted noise from switch mode power supplies such as in satellite receivers and similar devices. When fitted in a complete metal housing that the supply is contained in it also removes the radiated component.

### Suppression of a commutator motor



A High frequency chokes

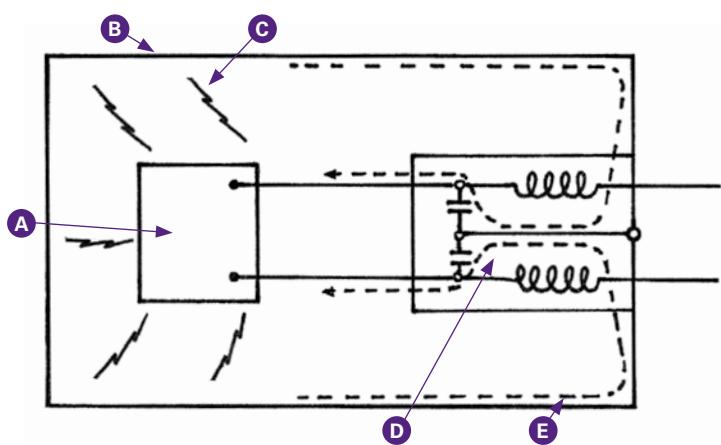
B Field windings

C Low frequency chokes

D Suppression capacitors

Suppression of a brush motor. Note the TVI chokes will be the most effective suppression device when fitted right on the brushes. They will also considerably reduce commutator sparking.

### Combined screening and suppression principles



A Interference source

B Electromagnetic screen

C Radiation is intercepted by screen

D RF filter or suppressor to prevent currents from propagating along supply leads

E RF currents returned to source via capacitors

Method works for almost all devices capable of having a screen placed around them and filtering placed on all leads entering the enclosure.

## 07 SAFETY AND COMPLIANCE

**NEW ZEALAND HAS PRESCRIBED REGULATORY REQUIREMENTS INTENDED TO PROTECT PEOPLE AND PROPERTY (THE ELECTRICITY ACT 1992), THE RADIO COMMUNICATIONS ENVIRONMENT (THE RADIOTRANSMISSIONS ACT 1989) AND OUR ENERGY RESOURCES (THE ENERGY EFFICIENCY AND CONSERVATION ACT 2000).**

**THE FOLLOWING ADVICE RELATES TO OTHER PERSONAL SAFETY ISSUES WHICH MAY ARISE DURING INTERFERENCE INVESTIGATION.**

The fitting of suppression components or modification of equipment to reduce interference may cause non-compliance with those requirements. Always check that proposed changes will not cause non-compliance before commencing suppression or modification. Check with the manufacturer or supplier if uncertain.

When working at radio station sites you will be exposed to radiation. Radiation causes heating of the organs of the human body and thus the level and duration of exposure should be minimised.

Determine the magnitude of this radiation before entering the site and seek advice on areas within the site where access is not permitted due to high levels of RF energy. It is recommended that persons

working at such sites have taken part in a suitable training course and wear RF radiation badges.

The climbing of structures is not normally permitted unless it has been prearranged with the site operator and the task is conducted by a qualified rigger.

Access to sites often requires appropriate training in site procedures and safety requirements, and the use of access tracks requires four wheel drive skills and experience. Site owner permission should always be arranged first, to ensure that any necessary safety information is obtained.

# CONTACTS/BIBLIOGRAPHY

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