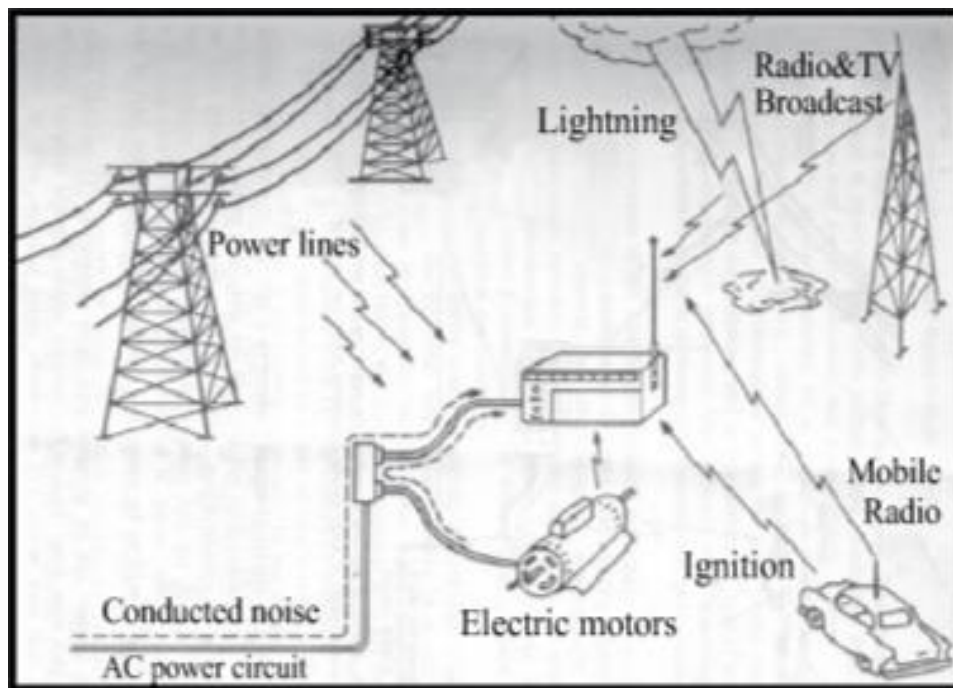
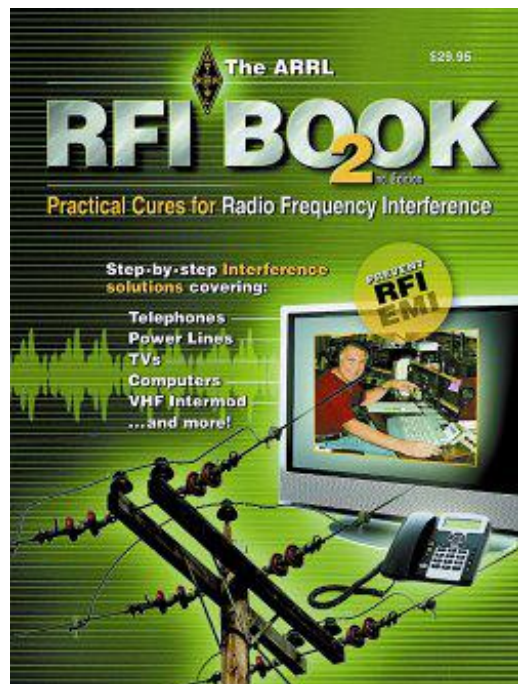


# Radio Frequency Interference



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Revision 1.00

# Article from ECN Magazine

Electronic Component News, an engineering magazine

## EMI is everywhere!

- Mother Nature provides many sources of electromagnetic interference and our own sun is a source of RF radiation on a daily basis.
- For electrical equipment we usually only have to deal with man made sources of radiation.
- These can be intentional such as radio, TV, telephony and RF
- They can be unintentional like switching power supplies, automobile ignition, or any other device where there is high  $dv/dt$  or  $di/dt$ .

# Article from ECN Magazine

Electronic Component News, an engineering magazine

## **EMI is everywhere!** (continued)

- For example a power supply switching FET going from 0 to 200 volts in 40ns equates to a  $dv/dt$  of 5 million volts per second. This is the equivalent of a fast rise time 25 KHz pulse that is rich in harmonics.
- Any fast rising voltage or current transition will produce RF energy over a broad spectrum of frequencies.

# Radio Frequency Interference

- Interference **we cause** to other spectrum users.
- Interference **to us** from other non amateur radio spectrum users.
- Interference **to fellow amateur** operators.
  - Unintentional
  - Intentional

# Radio Frequency Interference

- External interference generating problems.
  - Maintenance related
  - Design related
  - Receiver overload
  - Receiver de-sense
- Systematic problems
  - Intermodulation
- Antenna problems
- Parasitic Resonance

# Your Antenna Makes You a Target

- If someone in your neighborhood is experiencing problems the first place they look at as the problem is the place with the large antenna in the back yard. You are the target they blame.
- Keeping a station log of your transmissions is one way to see if the interference reports or complaints correlate with your radio activity.



# Interference Caused By Our Hobby

- RF signals can cause interference to a number of devices. This is a partial list of the more common interference problems:
  - Television (not as common with Cable and Digital today)
  - Telephone (Land line not cellular)
  - Stereo Systems
  - Computers
  - Video Cameras
  - Alarm Systems

# What Causes Interference

- Rectified RF in the interfered with device.
- Harmonic & Spurious signals caused by poor connections & multiband antennas.
- Intermodulation distortion when two or more signals mix to create an interfering signal.
- Harmonics and Spurious signals from your transmitter.
- Resonant ground leads.



# What Causes Interference (continued)

- Parasitic resonance to nearby conductors.
- Coupling between conductors.
- Antennas with multiple resonant frequencies.
- Out of channel signals mixing externally to create an in channel interfering signal.
  - Rusty mounting hardware on antenna and tower
  - Rusted/oxidized guy wire joints
  - Oxidized/poor RF connectors
  - Rusted/oxidized open feed line connections

# What Causes Interference (continued)

- Out of channel signals mixing in the receiver front end to create an in channel Intermodulation product.
  - Frequently happens with wide frequency range VHF/UHF Transceivers.
- Receiver overload from desired and undesired signals (De-Sense).

# Interference in or near your home

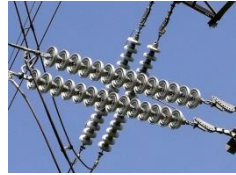


- Part 15 devices
- Motors and machinery (power tools, garage door openers, etc).
- SCR lamp Dimmers.
- Touch controlled lamps.
- Florescent lighting.
- CB Radios.
- Door bells and door bell transformers.
- Toasters and toaster ovens

# Interference in or near your home

(continued)

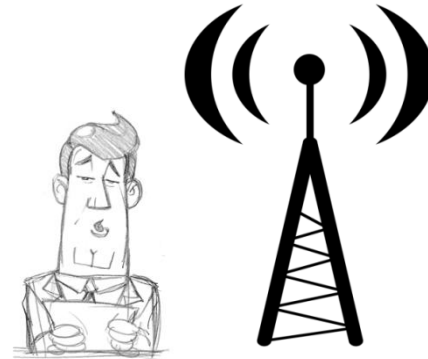
- Electric blankets.
- Aquarium and water bed heaters.
- Furnace controls.
- Computers and video games.
- Defective circuit breakers.
- Electrical toys (model train sets, slot car race tracks).
- Computers and calculators
- Scanners

# Interference in your neighborhood

- Nearby above ground power lines that can carry interference for miles from the source.
- Arcing high voltage insulators on electrical lines. 
- Nearby Hospital and medical facilities. 
- Nearby industrial plants. 
- Lightning storms.
- Electric fences.

# Interference in the neighborhood

- Commercial AM/FM radio transmission



- Commercial radios operating nearby (police, business, aircraft/airport).



- Neon signs.

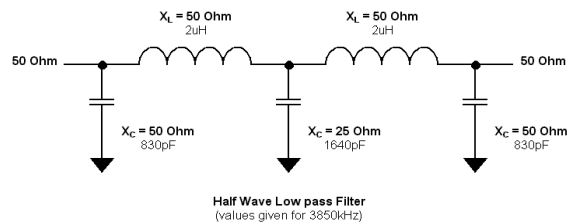


# Grounding is important

- Use short low inductance leads to avoid radiation and resonance.
- Always use a single ground point, never have multiple ground points or daisy chain your equipment to the ground point.
- Long ground leads at VHF and UHF may be much worse than no ground at all.

# Preventing conducted RFI

- Use low pass filters



- Use ferrite common mode chokes on leads



- Use toroidal cores with multi turns of wire





# Preventing conducted RFI (continued)

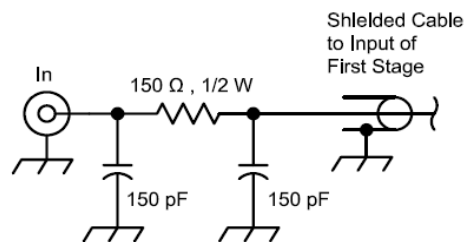
- When using ferrite materials be sure the use the correct mix for the frequency you are trying to block. The choice of the material matters.
- For more information and a source of ferrite materials go to:
  - [www.amidoncorp.com](http://www.amidoncorp.com)
  - [www.palomar-engineers.com](http://www.palomar-engineers.com)
- It is okay to try unknown junk box ferrites if they work use them, if not it may be the wrong mix for the frequency.

# Preventing conducted RFI (continued)

- Use bypass/feed thru capacitors on all non RF leads



- Low pass filtering & Power line filtering



**Do not install bypass capacitors across speaker leads on Solid State amplifiers. Today's Solid State amplifiers do not like operating into a capacitive load and may self destruct!!**

# Preventing conducted RFI (continued)

- Wrap excess lead length into a coil from;
  - WALL-WARTS
  - Telephone leads
  - Audio and video cables



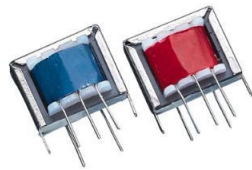
- Again use single point grounding systems, do not daisy chain ground connections to avoid ground loops.

- Twist conductor pairs

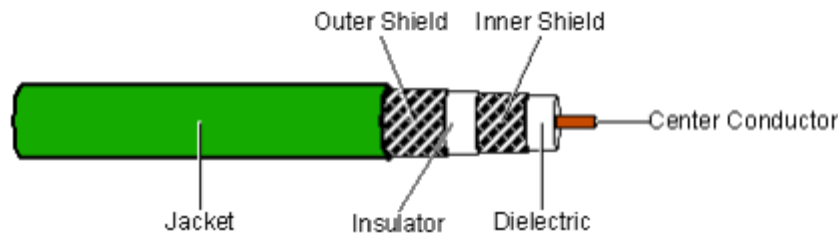


# Preventing conducted RFI (continued)

- Use transformers to break up audio ground loops.



- Use a guard as cable ground for floating microphone inputs.



- Consider only grounding one end of shielded cables to prevent ground loops.

# Identify the problem (be a Detective)



- Is it an RF problem?
- Were you on the air when the problem occurred?
- Does turning off other gear in the shack cause it to go away?
- Does it go away if you operate on battery power and turn off the AC power main to your home?
- Is it always present when you transmit?
- Is it only present only sometimes when you transmit?



# Identify the problem (be a Detective)

- Does turning off other gear in the shack cause it to go away?
- Does turning off other appliances make it go away?
- Is it an single frequency RF problem or broadband problem ?
- Is there RF riding on the power line, interconnect cables, ground leads, etc. in the shack.

# Identify the problem (be a Detective)

- Does turning off other gear in the shack cause it to go away? 
- is it only present at certain times during the day or night? 

# Cure the problem

- Reduce spurious emissions with low-pass or band pass filters.
- Insure all mechanical connections in the antenna, antenna mounting hardware and nearby structures are clean and tight.
- Fix all problems in your home before tackling your neighbor.
- Once you know how to solve your problems it will be easier to solve the neighbors.



# Locating RFI Sources

- Use an AM portable Broadcast band radio with a Ferrite rod antenna.

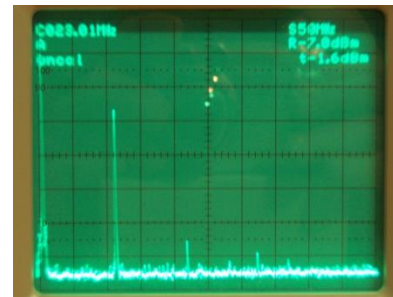


- Use a receiver type field strength meter with a directional antenna.



# Locating RFI Sources

- Use a spectrum analyzer with a directional antenna to locate:
  - Interfering signal source
  - Transmitter harmonics
  - Transmitter spurious emissions
  - Other signals causing intermodulation products
  - With a sniffer coil you can locate specific leakage points.



# Intermodulation Distortion (IM)

- Intermodulation interference occurs when two or more transmitters, transmitting at different frequencies, are coupled, resulting in the mixing of signals.
- This results in the presence of additional frequencies (intermodulation products) that are either sum or difference of the transmitted frequencies.

# Intermodulation Distortion (IM)

- If intermodulation products fall within the bandwidth of a receiver, intermodulation interference may occur.
- Due to the collocation of multiple transmitters at the same radio site, intermodulation is a common problem, but is easily prevented with careful site design.
- The use of Intermodulation calculation software (Available on the web) will easily let you determine where intermodulation products might occur, allowing appropriate action to be taken early in the site design stage.

# Intermodulation Analysis

- When two or more antennas operating at different frequencies are installed on the same platform – i.e. rooftop, mountain top, antenna tower, or water tower, transmitter coupling can occur resulting in intermodulation interference.
- Wherever antennas will be placed in close proximity to other antennas, intermodulation analysis should be performed. This analysis can determine the potential for intermodulation distortion before new antennas are installed.

# Intermodulation Analysis

- Once the potential for intermodulation has been identified by calculation, intermodulation interference can be prevented at the design stage.
- Appropriate selection of frequencies, adequate antenna spacing, transmitter shielding, or filtering at the transmitter or receiver are a few methods for preventing intermodulation interference.

# Calculating Intermodulation Products

IM Form	Order	# Freq. Involved	Total # IM Products
$2 * A - B$	3	2	$N * (N - 1)$
$A + B - C$	3	3	$N * (N - 1) * (N - 2) / 2$
$3 * A - B - C$	5	3	$N * (N - 1) * (N - 2) / 2$
$A + 2 * B - 2 * C$	5	3	$N * (N - 1) * (N - 2)$
$A + B + C - D - E$	5	5	$N * (N - 1) * (N - 2) * (N - 3) * (N - 3) * (N - 4) / 2$

IM Calculation software on the web:

<http://www.tcstx.com/software/intermod/intermodulation.htm>

<http://www.softpedia.com/get/Science-CAD/Intermond-Product-Calculations.shtml>

<http://www3.telus.net/PassiveRF/>

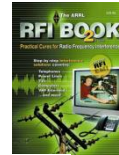
# Troubleshooting Intermodulation

- Locate all the frequencies on the air when you experience the problem, or locate all the frequencies near enough to cause a problem.
- Calculate all the possible combinations of these frequencies to determine if any fall in your receiver band pass range.
- Experiment with those frequencies that could generate an IM product to see if they really do.
- Determine the best method to isolate the offending transmitter(s). If they can not be isolated then a new frequency may be the best solution.



# For More Information

- ARRL RFI Handbook



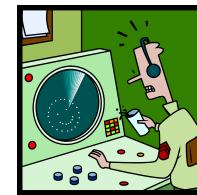
- ARRL Handbook



- Your local ARRL Technical Specialist



- An Experienced operator (Elmer)



# Any Questions?

