RFI and The Impact On Your Ham Radio Operation

Paul Havlik – WD9IOK
WCARES March, 2023

Agenda

- Background
- What is RFI?
- Examples
  - Home, External, Neighbors & Diplomacy
- Understanding approaches to identifying and finding RFI
- Questions

Background

- Radio Frequency Interference (RFI) is something we will all deal with at some point in our ham radio hobby
- I've been personally dealing with RFI since my first months as a ham up until recently
- I've been a ham for over 45 years and as the hobby evolves, so does our ability to resolve RFI issues and our knowledge and capability to deal with it
- While I'm not an engineer, I'll highlight some practical considerations, experiences and tools you can use if you encounter RFI

What is RFI?

- RFI is actually part of EMI
  - Electromagnetic Interference (EMI) – a general term involving all types of interference in the electromagnetic spectrum
    - Electrostatic discharge (DC static)
    - Electromagnetic Fields (EMF) – near power lines
    - ELF – Extremely Low Frequency electromagnetic fields
- Three types of "interference"
  - **Noise** – generated by electronic devices
  - **Overload – (Fundamental Overload)** – where radio signals cause interference to consumer equipment. The inability of that equipment to REJECT the fundamental signal
  - **Spurious emissions** – radio signals inadvertently transmitting weak signals on a frequency not assigned to that transmitter (harmonics)

RFI Types

- **Noise**
  - You can receive these signals on all types of devices. Maybe you hear them tuning around the HF bands.
  - Typical examples of RFI Noise:
    - Neon signs
    - Power lines
    - Security systems
    - Computer systems
    - Switch mode power supplies
    - Grow lights
    - Thermostats
    - LED lighting power supplies
    - Solid state “wall wart” power supplies
    - Many, many others
  - Everyone hears them…you and your neighbors

RFI Types

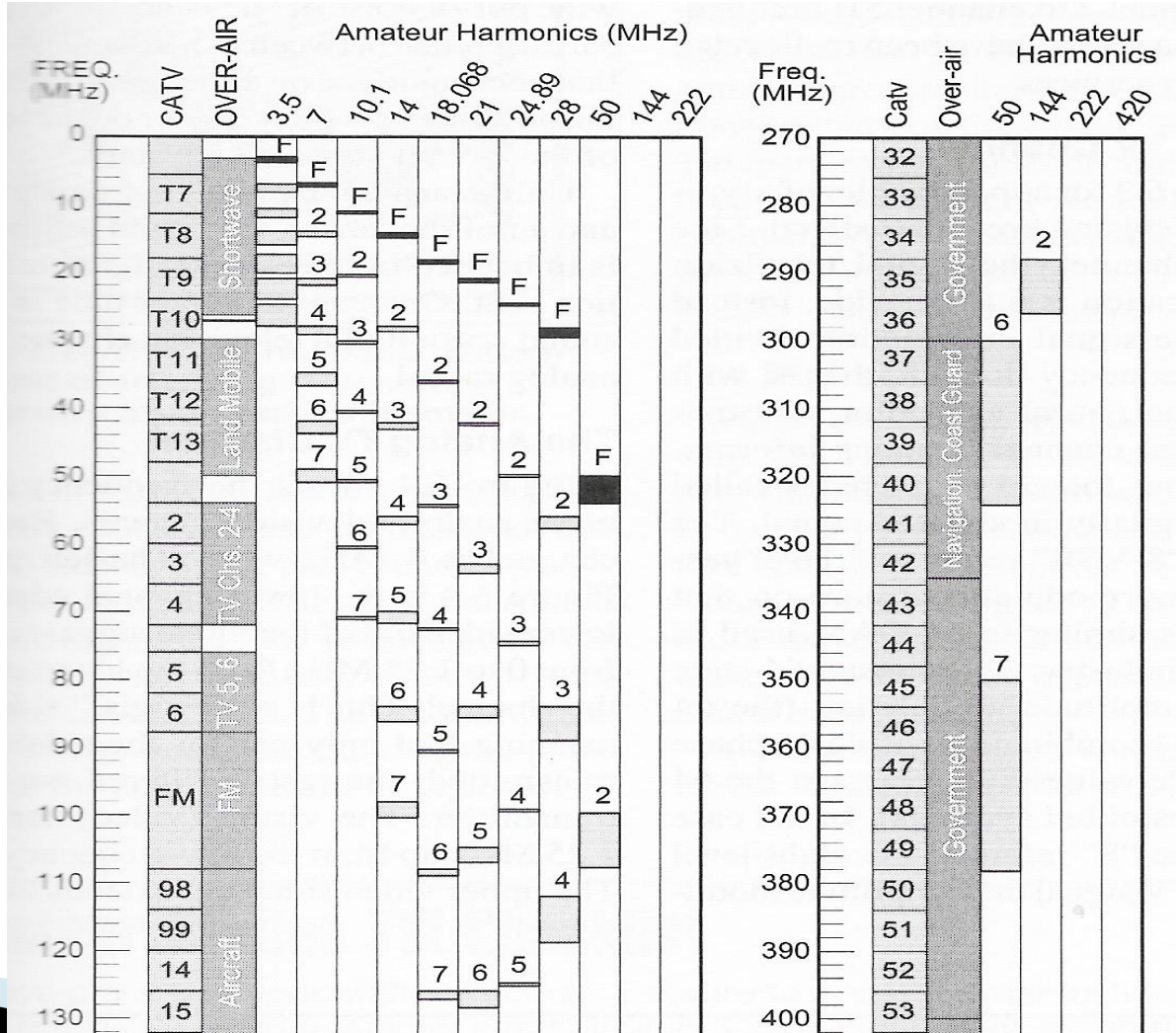
- **Overload** – Fundamental Overload
  - Instances where your transmitter fundamental signal on your assigned frequency is received by consumer equipment lacking protection
  - Consumer equipment cannot reject the strong nearby signal
  - Your running full power or QRO with the amplifier may be part of the issue.
  - Even filtering added to the equipment may not be able to eliminate the signal
  - While you may not be responsible for the neighbors equipment, it is the manufacturers responsibility to provide protection according to the FCC….but that doesn't solve the political issue (more later)

RFI Types

- **Spurious Emissions**
  - These are usually considered inadvertent emissions
  - You may not realize that you're transmitting there
  - The FCC requires YOU, as the operator, to correct the problem if you are interfering with other services.
  - Most newer equipment has protections built-in and designs tested.
  - May require you to add additional filtering, shielding or grounding to the transmitting equipment (importance of a good ground)

Harmonics

- These are spurious emissions from your fundamental operating frequency and possible interference causes
- Inteference YOU MAY CAUSE!!!

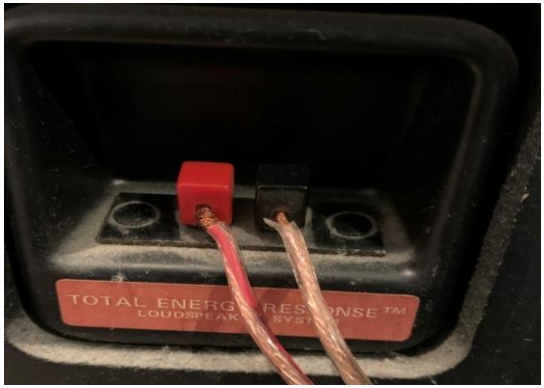


Early Ham examples of RFI (1) – Overload

- Problem
  - Transmitting on 10M SSB interfered with TV in-house on OTA CH2
- Solutions
  - Low Pass Filter at radio
  - High Pass Filter at TV
  - Change operating hours (parent's house)
  - Big Switch Story….

Early Ham examples of RFI (2) – Overload

- Problem
  - Interference to stereo speakers
  - Stereo system was OFF
  - Modulation was received on speaker wire and generating garbled audio in stereo speakers
  - Primarily a 10M operation issue (length of wire runs approximated 10M receive antenna
- Solution
  - .01 uF capacitors across speaker lines at speakers



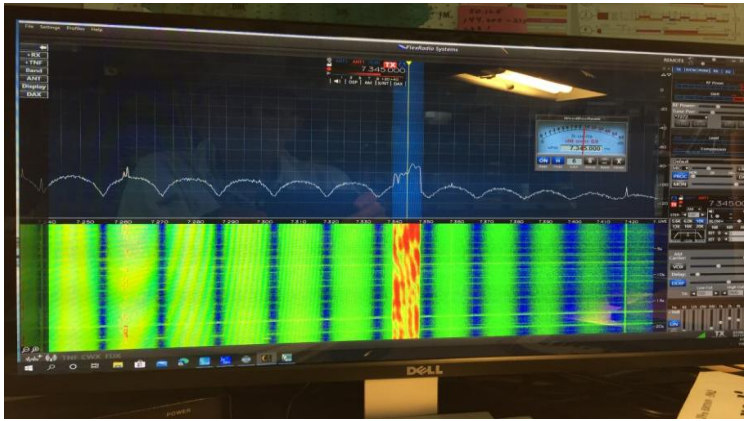
Early Ham Examples of RFI (3) – Overload

- Interfered with neighbors TV in close by bedroom
  - **Problem**:
    - TV was old and in a spare bedroom for “grandma to watch”
    - TV antenna was rabbit ears on the set
    - Radio operation caused interference at times I operated.
  - **Solution:**
    - Nice neighbor – good relations to problem solve
    - Installed hi-pass filter (my expense), mitigated but did not resolve
    - Neighbors son-in-law fed a new cable from master antenna on roof farther away from my antenna – problem resolved (lucky)
    - More on diplomacy later…

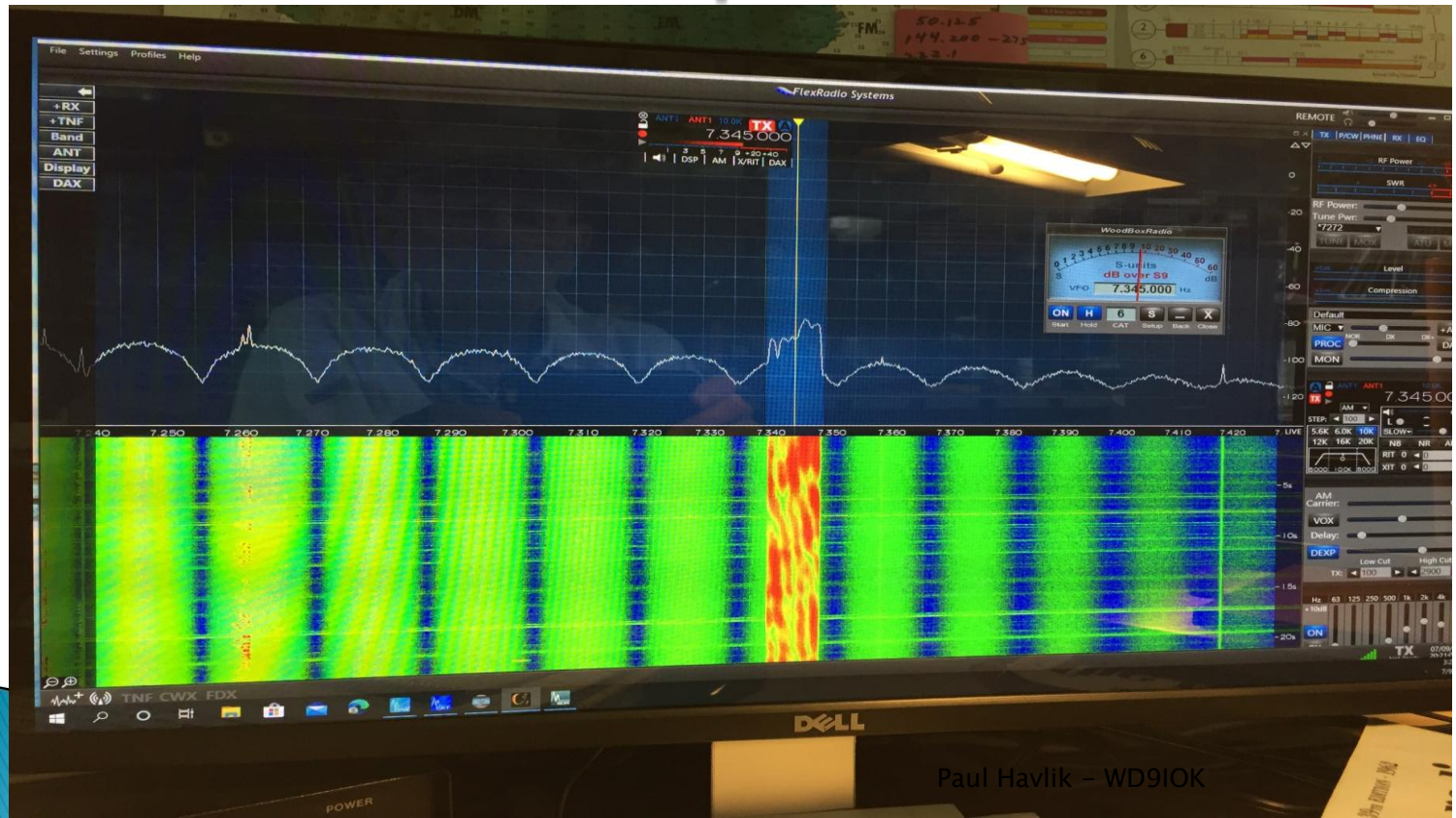
Hustler 5 BTV that I was using at the time

Power Line Noise – W4LWW QTH – 2018

- Bruce Kryder (W4LWW) was experiencing loud, intermittent noise at his QTH in Franklin, TN
- After monitoring for a bit, he noticed that it did not have any special timing other than it would pop up during his net activity wiping out signals making it impossible to copy stations
- He captured a visual for reference on his display



Peak on 40M just outside the band but broad in dispersion.



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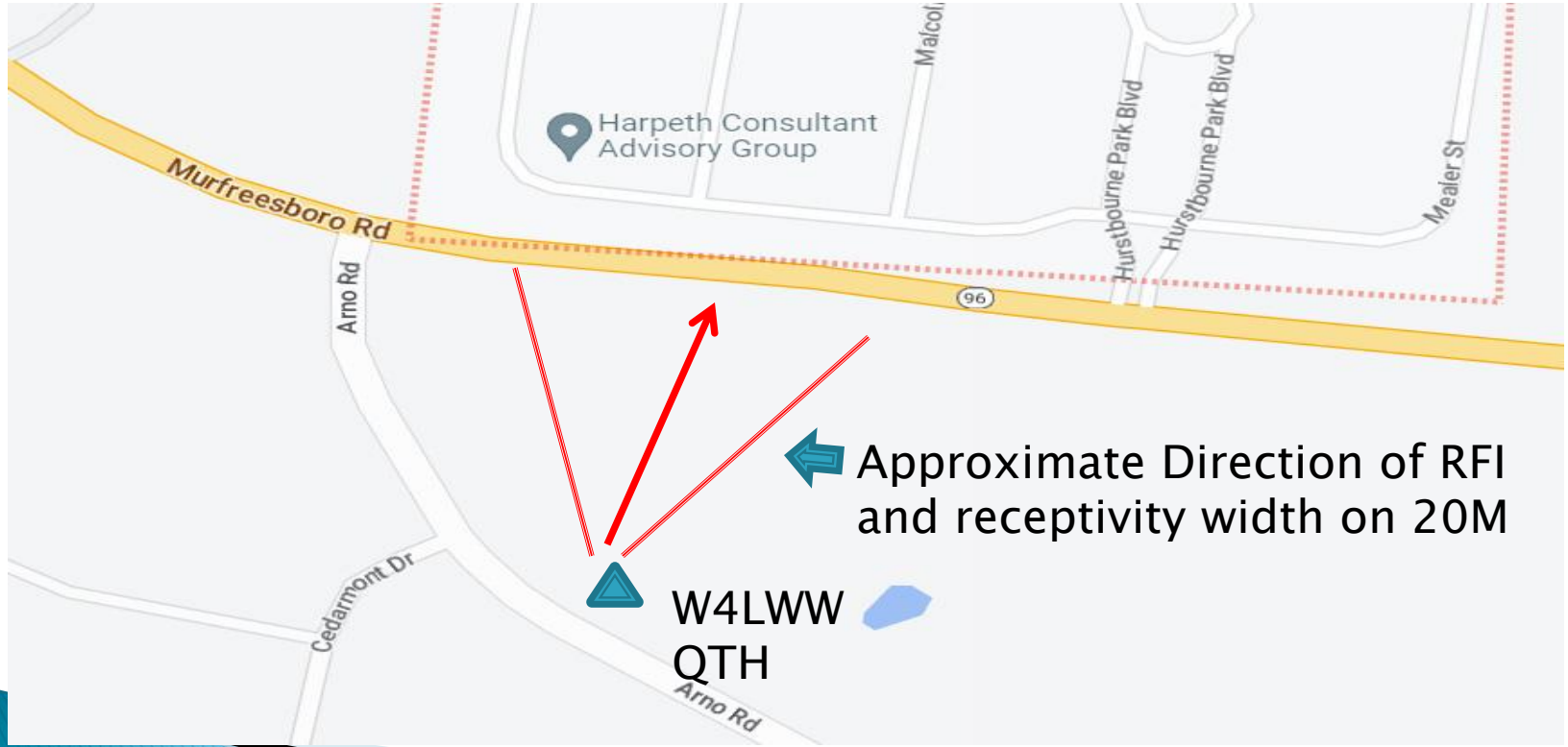
Tracking Down The Problem

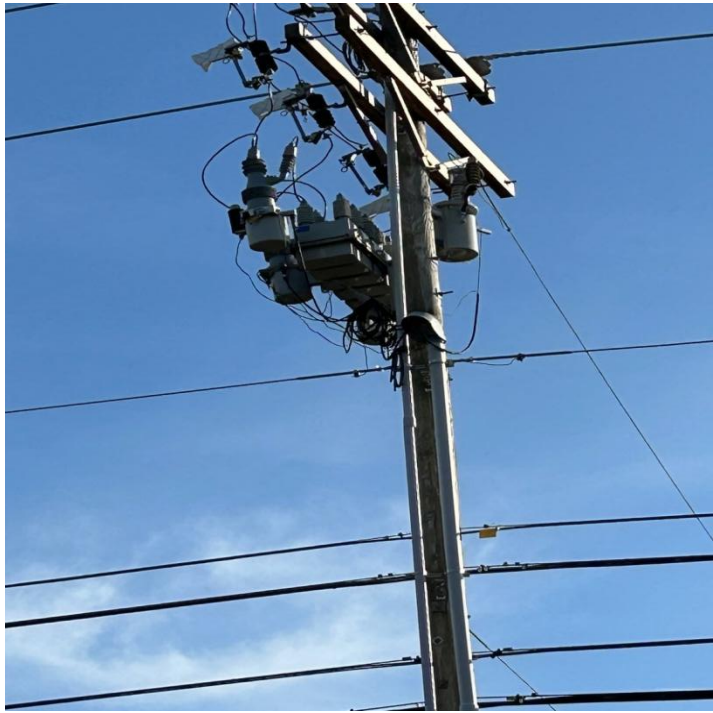
- Intermittent problem – no fixed time
- Was able to monitor on other bands
  - 20, 15 and 10M
- Used 3 Element beam to focus antenna on the approximate direction (northerly)
- Tried using a portable AM radio but could not easily isolate on Rt. 96 – just the stretch of highway could be confirmed
- Contacted me and I brought over my MFJ-852 and 3 Element 2M Beam
  - Receiver works in the 135 Mhz range and the beam allowed more directivity vs. dipole antenna

Approximate RFI Direction



Fox Hunting for RFI

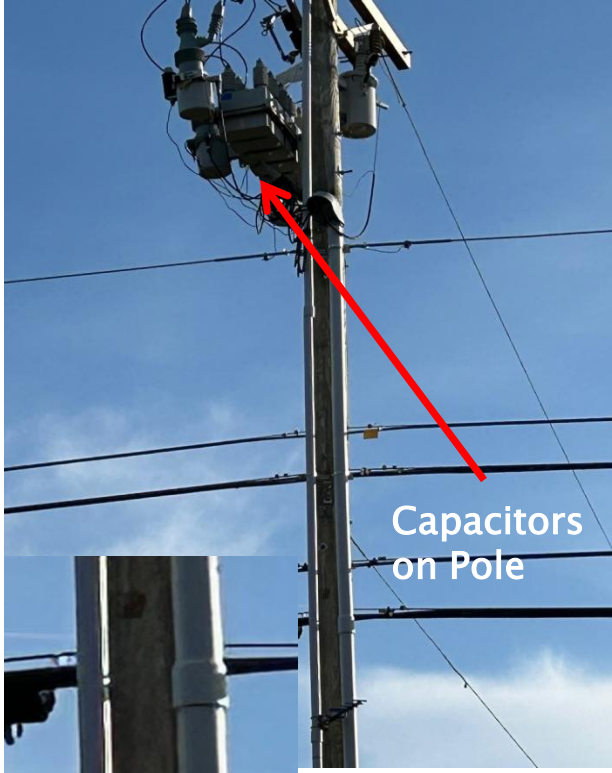
- We stopped in spots along a neighborhood to his north.
  - Checking for the noise along Hwy 96
  - My HF mobile confirmed the 20M noise along a neighborhood
- Walked along several poles with MFJ unit and beam pointing at poles. Located a suspect pole
- Verified against other poles and captured the pole information (pole #, date, time, etc. and methodology)
- Bruce Contacted Middle Tennessee Electric (MTE) customer service and entered a ticket on the problem



Utility pole with
noise radiating from it

W4LWW Issue Resolved

- MTE called back
- Issue was MTE equipment
  - A remote controlled capacitor used to help correct power factor in their lines along HWY 96 had malfunctioned
  - Unit was radiating as it was turned on. Once powered down, the interference stopped.
- Replacement unit installed by MTE – Problem gone



Affecting systems in the home

- **Inducing interference with operating**
  - Tripping AFCI Circuit Breakers in new home
  - HOA wouldn't allow outside antennas so set up dipoles in the attic along with beams and wires
  - First time on 40M I tripped 5 Eaton AFCI Circuit Breakers!!!
  - XYL was not happy and neither was I
  - Read about Eaton susceptibility to RF online/ARRL work and needed to replace with different breakers
  - Opted to switch out panel to Square D and the problem went away

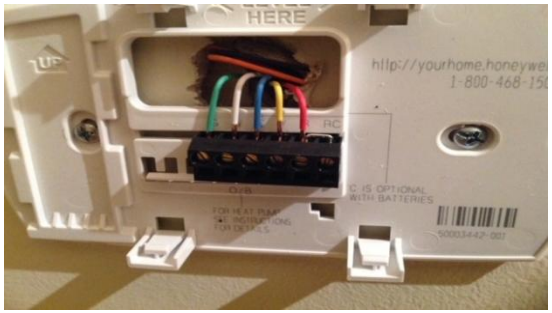
Affecting systems in the home

- **Setting off smoke alarms**
  - **Problem**: Set up short 2M beams for FM and SSB in the attic.
  - Normal operation was fine but once I fired up high power and the amps, the smoke alarms were overloaded with RF and went off. They quit screaming shortly after I quit transmitting
  - **Solution** – Small chokes on the power feed wires. I could run 50W but not the amp.
  - Alternative solution from WA9JSI *(do not block air sampling area with foil)*

WA9JSI Solution

Affecting systems in the home

- **Wiping out thermostat memories**
  - **Problem**: HF operation (40M) wiped out upstairs HVAC control unit memories
  - Inside of unit had wire access for small chokes only
  - **Solution** – Wire ran up into attic above and had enough length to wrap around toroid coil.
  - Memories no longer erased with HF Operation



TV/Stereo Interference Inside The Home

- RF from your transmitter can overload TV's and stereos/radios
- Good news for TV…much is streamed or via cable – less chance for issues
- OTA antennas a potential source, but digital signals now reduce that threat due to frequency changes
- Points of RFI entry to systems include: AC Line, outside RF antenna amplifiers, inside distribution amps & standard FM stereo antennas

External Interference – When you bother your neighbors

- This is one of the toughest problems to resolve
- Most of the issues are due to their equipment not being protected adequately and not your transmitter
- Operative word is *DIPLOMACY* and good public relations

External Interference – When you bother your neighbors

- I've discovered living in various residences that some neighbors would complain of interference. Some was real and some not.
- **Diplomacy is HARD.** It takes patience and understanding
- Neighbors perspective: *They didn't have any issues until they spotted your antenna or had actual interference they think you created*
- ***Your goal…to try to resolve the issue – real or not***

Some diplomacy tips

- Always stay patient and polite
- Try to pinpoint the issue
  - When did the “interference start”?
  - Do you have a specific time?
  - If you “log” your transmissions, especially HF, that is a clue to whether you may be part of the problem
  - If you were not on the air at that time, then it might be something else
  - Politely describe that you are an FCC Licensed Station operating within your licensed frequencies. Sometimes manufacturers of electronics skimp on interference protection and do not add the appropriate filtering
- Do not offer to go into their house and fix things! Once you do that, you‘re liable!

Some diplomacy tips

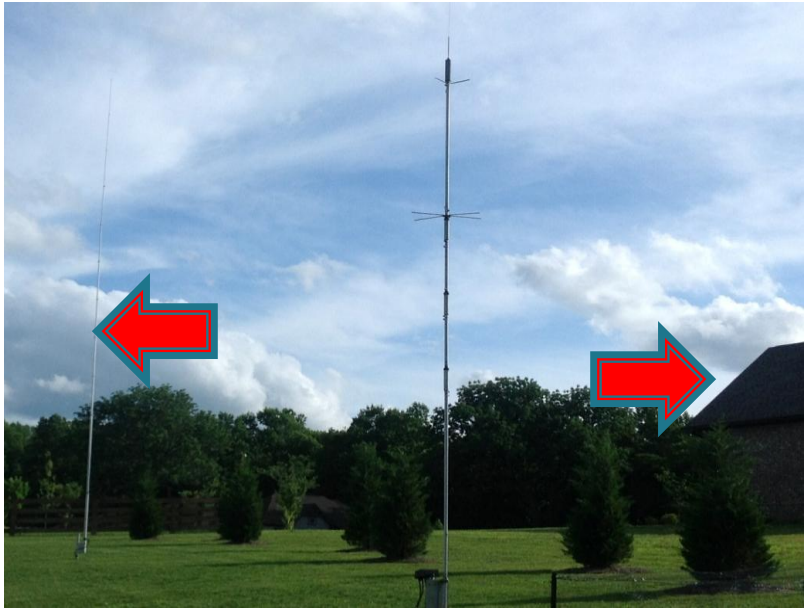
- **Try to assess the specifics of the problem**
  - Time of day it was experienced
  - When did it start happening?
  - If they can't be specific, ask them to write down dates/time
  - Type of interference?
    - Audio only? Video only? Both? From what device? TV? Stereo? Portable Radio? Computer speakers?
    - Are you on cable or streaming? OTA Antenna?
- **Gather all the facts that you can**
  - Advise that you'll check your operating logs and get back to them
  - Tell them that there are many sources of interference from the power lines to other transmission towers in the area (if there are any) and you'll try to assess

So what do you do?

- Check to see if you were operating at those times
- Try going dark on that antenna for a few days to see and then check back. Ask them if they've had any interference…don't let them know if you operated or not…just find out
- Continue your research into the problem
- Get a hold of resources to help assess if you think you are the cause and try to fix

Example of External Interference

- **Franklin Vertical**
  - Erected my 40M vertical
  - Placed antenna way in the back of the property toward my neighbors garage
  - Was waved down about 2 weeks after it was erected by the neighbor.
  -



Example of External Interference

- **Franklin Vertical**
  - **Problem**: His computer speakers were being affected by some interference. No date or time noted. Sent him off to try and log and I'd double check my operating time against anything he came up with.
  - High probability it was me as I was using it and he worked from home
  - Consulted with N9APK – I had not made the installation permanent (pipe in ground).
  - Suggested I relocate the antenna farther from his house if possible. The Inverse Square Law!

Inverse Square Law

- ***The intensity of a source changes in inverse proportion to the square of the distance from the source.***
- For antenna radiation – As you move away from the energy source (antenna), the strength of the radiation decreases and is directly related to the distance from the source.
- Intensity and distance are **INVERSELY** related!
- ***Example: Double the distance and you have 4X less power at the receive point!***

Franklin Vertical Fix

- Relocated Antenna 120’ farther away from the original location
- Problem went away! No issue of overload in the neighbor’s computer speakers on 40M
- Checked with neighbor to see if he had further issues and it was fine!!!

Interference to my station

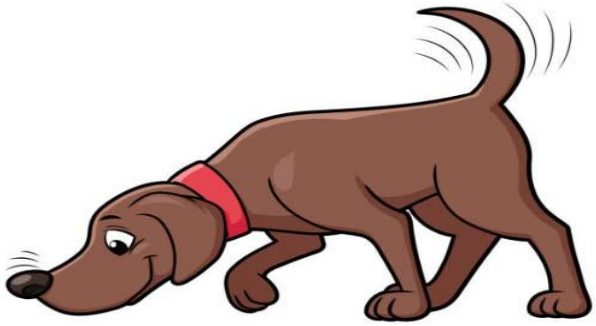
- In late 2010, a new interference source appeared on the 40/80 bands at my QTH
- It was sporadic at first, but became more pronounced and frequent with time.
- S-9!!! - Impacted my DXCC Hunt!!
- It was not the usual power line noise that I heard in foggy weather (arcing of insulators).
- It also was across the entire spectrum after further research

Interference to my station

- I also had a mobile HF set-up so started monitoring in the car.
- It was not on full-time and would run for a few hours and then shut off. Sometimes it would run for days and then stop.
- Frustrating issue.

Efforts at identifying

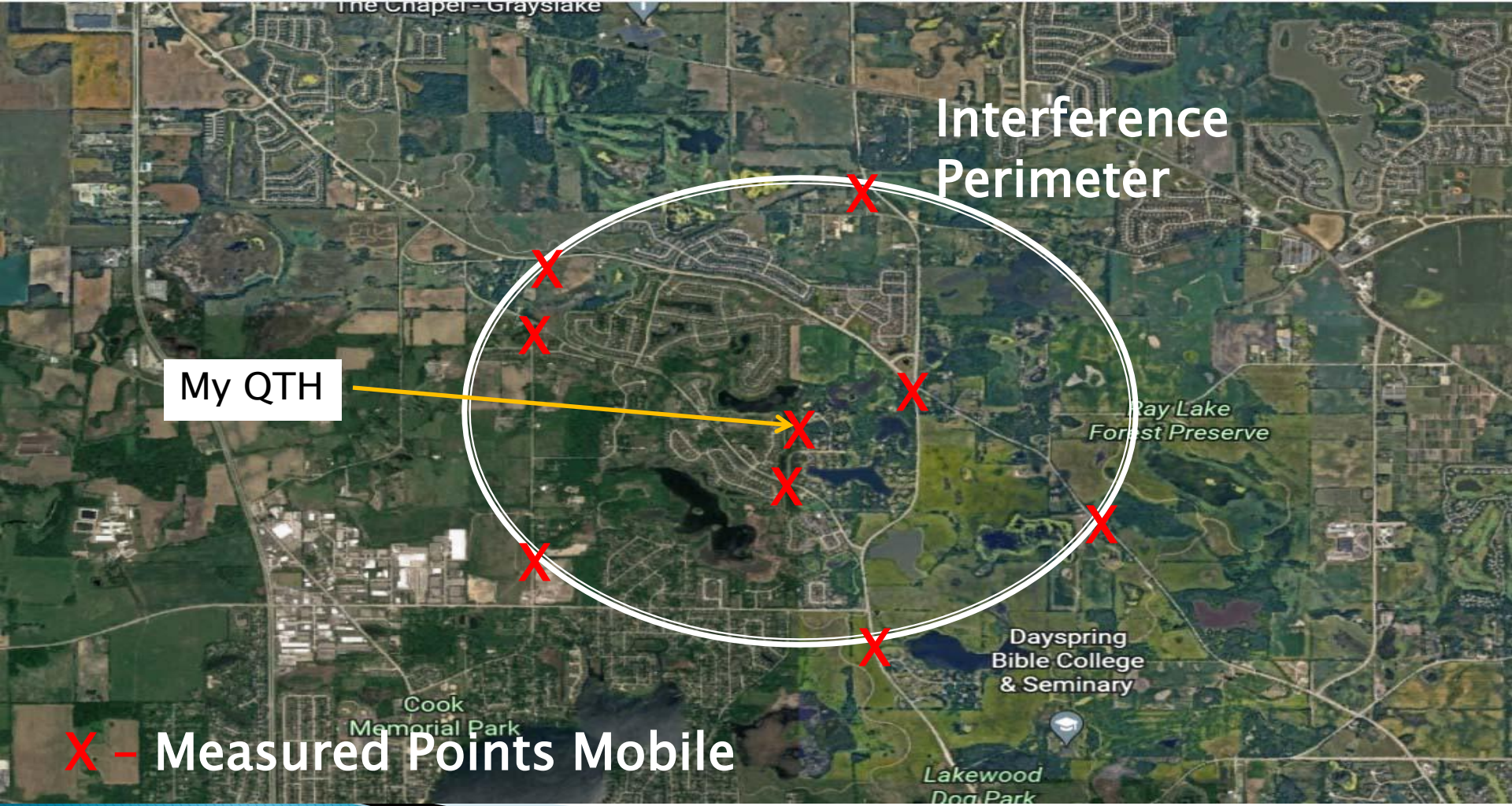
- RFI hunting can be a difficult process
  - Don't give up – solicit help and ideas from fellow hams
- Step 1 – Map out the impacted frequencies from the home QTH
  - Take signal strength readings BY BAND and note all dates/times
  - Record audio



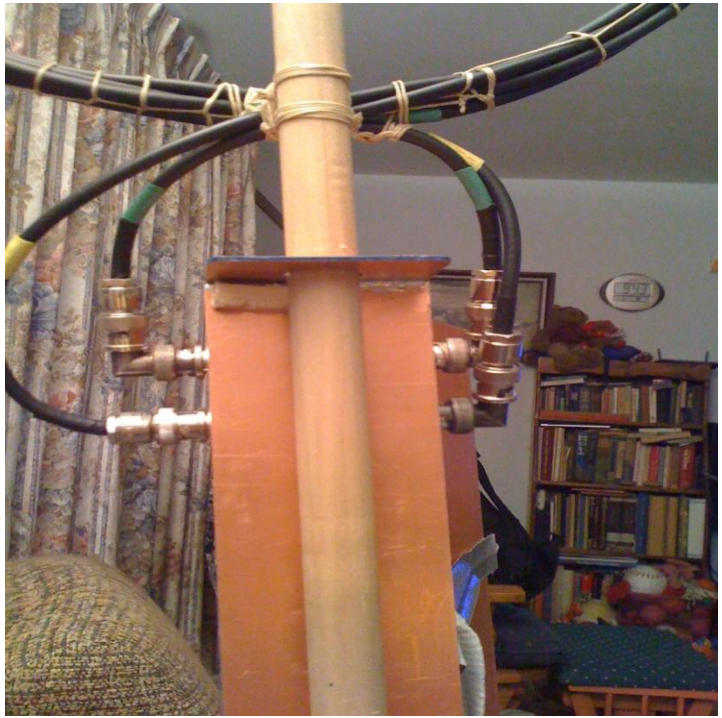
emi_noise.aif

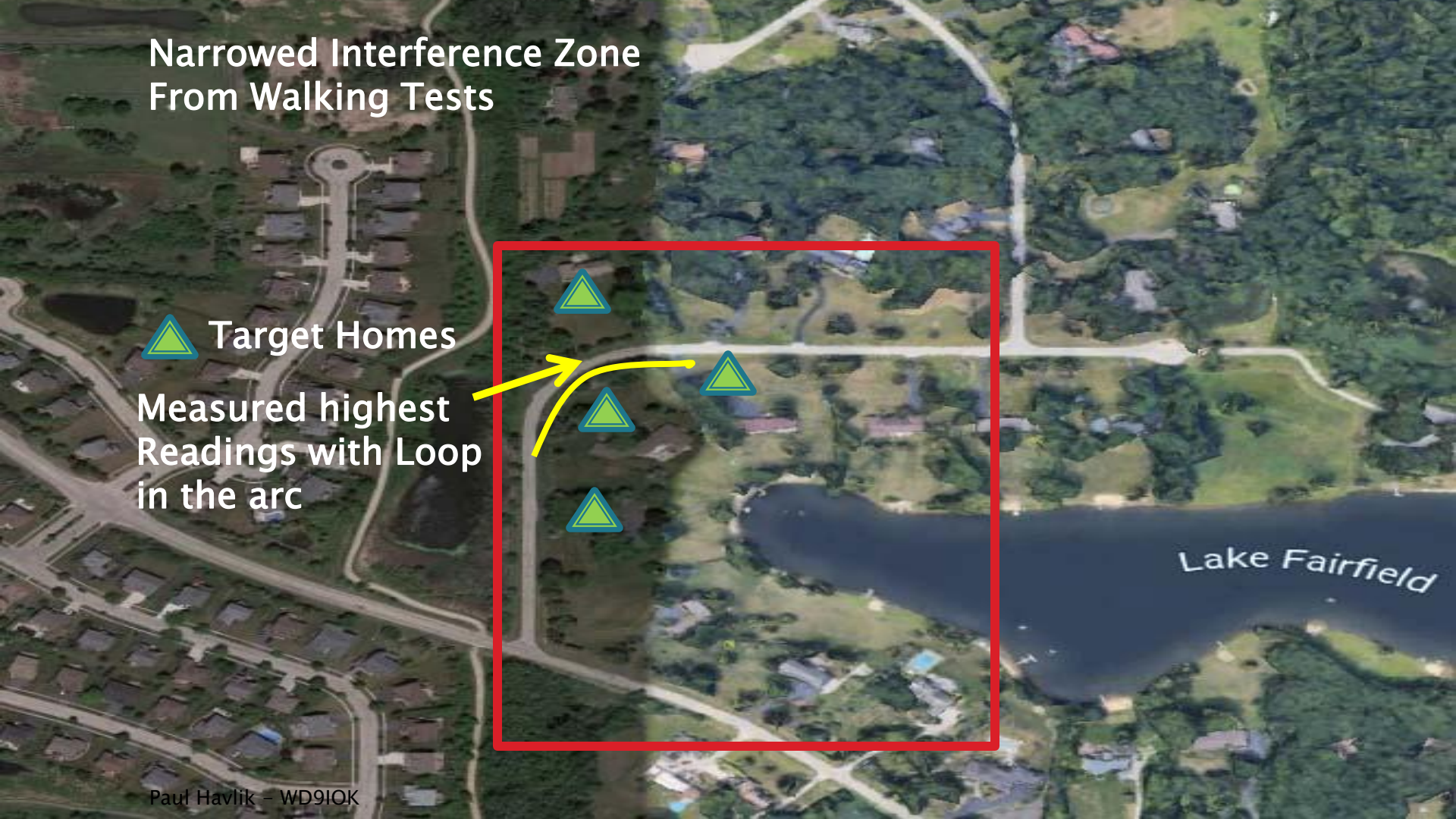
Map out affected areas

- Tried to measure the interference distance from my home when in the mobile
  - Took readings to and from work on HF/VHF/UHF
  - Drive roads in area to measure impact
- Perimeter of the radiation was well over 1 mile from my home QTH!
- So somewhere in my area was a strong radiator interfering with operation at home or mobile in the area
- Interference fall off was closer to source with VHF measurements


Interference Perimeter
My QTH
Ray Lake Forest Preserve
Dayspring Bible College & Seminary
Cook Memorial Park
Lakewood Dog Park
X – Measured Points Mobile

N9APK Portable RFI Loop




Narrowed Interference Zone
From Walking Tests
Target Homes
Measured highest
Readings with Loop
in the arc
Lake Fairfield
Paul Havlik – WD9IOK

Interference Location Could Not Be Identified

- Walked area several times with both 2M beam and with N9APK Loop
- The noise was spread throughout that area and possibly via underground electrical wiring
- Talked with home owner on NW Corner and noise appeared just as strong as elsewhere with antenna.
- Checked his cable TV box and noise was present
- Contacted cable company – their check did not note any radiation coming from their equipment (no leaks)

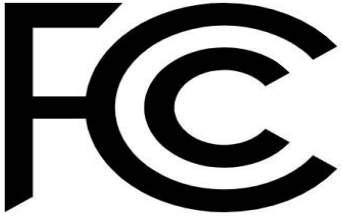
Time Elapses and No Changes

- Frustration builds as it's been over 6 months living with the noise
- N9APK suggests reaching out to the FCC (Federal Communications Commission)
  - Serious concerns…
  - What will I need to do?
  - Will they even bother with my situation?
  - Will my request be lost in the FCC system?
- Went to the FCC website and found a site to notify the FCC of an issue

“Hey Big Brother”

- In the spring of 2011, I filled out the online application for a noise complaint
  - Went to extreme detail
  - Months of tracking, frequencies assessed, signal readings, disruption of operation and potential interference to other services (small airport nearby and VHF interference).
  - Detailed months of working at problem but cannot locate beyond the potential street
  - Hit send and hoped to hear…..

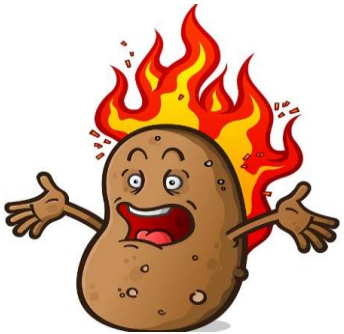
A "Response"!!!!!!



- On June 3, 2011, I received a telephone call from the FCC Field Engineer-In-Charge, Jim Roop, Chicago Field Office.
- *"We shouldn't have interference to licensed services."*
- They sent out the "sniffing van" and located a residence and would advise further.
- They validated the interference and would double check the harmonics too. No one was home at the time of their visit.
- Not Comcast, Not the electric utility equipment.

FCC Follow-up Visit

- Connected with homeowner
- FCC agent traced the interference
  - Strongest at their load center – labeled new addition
  - Interference was detected at all outlets in new addition
- Field office gave me the homeowners contact information
  - *I was to go over as a licensed service and work with the homeowner to find the source!!!!*
  - *OMG!! NOW WHAT?????*



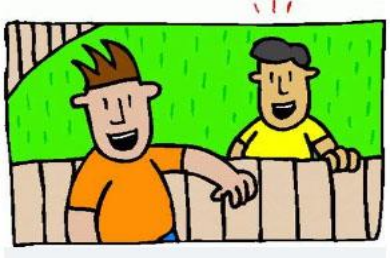
Preparing for the visit

- Did not know homeowner
- Drove by his house on the way home
- Called him on the phone and used my best PR as a representative of the FCC. Referenced the FCC agent meetings and wanted to help him locate the inteference
- Set up a weekend meeting in the afternoon in late August 2011 to hopefully solve this problem

What did I bring?

- Equipment that would work independent of his house power
  - Portable power pack (Car jumper pack)
  - Kenwood TS140S
  - Mag mount antenna as I'd be close to the source
  - Portable radio receiver (GE 10-Band)
  - IDEAL circuit analyzer to check power
  - Volt/Ohm Meter
  - Assorted tools just in case and extra fuses for the radio

Meet the Neighbors….



- I arrived at the appointed time
- Introduced myself and had my best PR hat on representing Amateur Radio
- Appreciated his time to try and solve this for the FCC
- He complained right at the start that he wanted to know how the FCC got a hold of his wife's unlisted number to contact him
  - "***Really***"???????

Into the realm of RFI sniffing

- Homeowner explained the efforts at mitigation since the FCC visit…
  - Replaced the circuit breaker in the panel
  - Thought that ought to fix it
- I politely commended him on his effort, but the noise was still there
- Got down to business and asked to set up the gear in the “addition” where the FCC indicated the problem was possibly emanating

Assess the Area

- The addition was a large multi-purpose room with a TV, DVD, VCR cabinet and a large work desk with multiple computers
  - Turned on the radio and began capturing the sound so we both could hear it
  - Very strong readings (59+20)
  - Asked permission to start by shutting off the room circuit breaker
    - The noise immediately stopped
  - Had him turn the circuit breaker back on to begin evaluating each piece of equipment in the room

What did I find?

- Through the process of elimination – once device at a time – unplugged each
- TV cabinet was clean
- Work desk had two PC's and monitors
  - All devices were in a surge protection power strip
    - Killed power on strip – noise stopped
    - Repowered strip and noise returned
  - Explained to the homeowner that we're close, it's something on the strip
  - Unplugged each device until we identified the culprit as an old Dell 486 generation Desktop computer. Noise would shift up and down 10-15 kC's each power cycle.

What next?

- The computer was below his desk always plugged in and with power to the supply awaiting “turn on”
- I turned on the old computer and the noise stopped! Powered down the computer and the noise returned! BINGO
- I turned down my radio audio and listened closely to the computer cabinet and when the computer was off you could hear low level arcing within the cabinet!!!!!! Bzzt sound.
- It was about to be a fire hazard some time in the future as it would burn through the cabinet or carbon path out in some way….
- Device was radiating through the new addition wiring and into the load center using the house wire as the transmitting antenna. Being so broad it was hard for us to locate.
- FCC has superior equipment to do the detection…

Homeowner Response

- Option to replace PS was unrealistic
- He needed to get old information off the computer and promised to retire ASAP
- Explained the potential fire hazard and to not leave plugged in until he was able to copy off the contents and then unplug
- He agreed and I packed up and left thanking him for his time and assistance

Happy endings….

- Upon returning home, compiled a summary of the visit, identified problem and conclusion in an email to Jim Roop at the FCC FO thanking him for locating it. 80M was all quiet after that problem was solved….on to my DXCC hunt.
- Also sent a very nice Letter to the Editor at QST as we need to let the world know that they do some great investigative work.
- Joel Kleinman, NIBKE, former Managing Editor of QST, thanked me for sharing the good experience with the FCC and published it later in the year

Takeaways/Guidance

- Don’t always think of the FCC as “Big Brother”
- The Enforcement Bureau does really have our spectrum protection in mind
- They might not always be able to help, but are there in tough cases
- Like all other work associates, do your homework before writing and you might be pleasantly surprised
- Have patience!!!! The wheels move slowly as they’re understaffed…but they’re engineers who get it

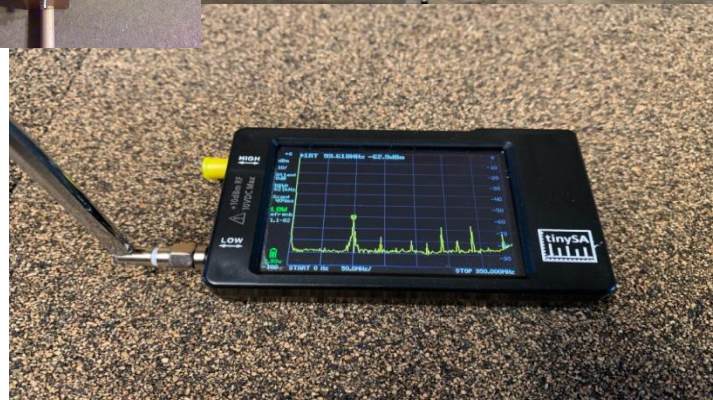
Use Systemic Approaches

- Don't try to solve for everything at once!
- Use the process of elimination
  - Think about potential sources of the interference
  - Do one thing at a time and see if it resolves the problem
  - Be patient…problem solving can take a lot of time
    - Time is precious, but solutions do not always jump out at you
  - Start with your station and home first!
    - Try turning off single circuits in your home to see if something in your home is the radiator
  - You'd be surprised how some electrical devices in your home can be RFI generators!

Tools for the RFI Toolbox

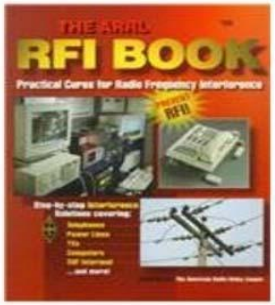
- Some essential tools….
  - **Portable radio**
  - **RFI antennas and portable receivers**
    - *Power Line Noise Tracer*
    - I use an ICOM R20 *broadband receiver* when sniffing
    - *Small beam*
    - *Portable Loop*
    - *Spectrum Analyzer* (Nice to have) – Tiny SA is a great, cost effective, alternative*

*Note when using Tiny SA use an attenuator start somewhere around 20 db and work from there



Tools for the RFI Toolbox

- Some essential tools cont….
  - **Cascade switchable attenuating filter** for narrowing down gain (Like fox hunting)
  - Low Pass/High Pass Filters/Chokes
  - RFI Book from the ARRL
  - Experienced hams who've encountered RFI to be guides and provide encouragement
  - PATIENCE!!!! It's a process to locate RFI!!!!



Equipment for the shack

- MFJ Noise Cancellation Filter
  - Use multiple antenna's to phase out interference
  - Works in many cases, but not all
  - Enclosed whip antenna not that effective
  - Phasing can work…requires retuning as you change frequencies
  - Other brands available

Final Tips

- **Implied Interference: Some neighbors don't appreciate the beauty of our ham antennas…**
  - **Operating Tip:**
    - **When you erect a new antenna, don't use it for a week or two (Yes this is hard) if you have sensitive neighbors**
    - Wait to see if anyone complains about anything
    - I've practiced this for years
      - New roof mounted antennas that can be seen from the street
      - New tower/antennas
        - Leave them disconnected and give it time. If you receive a complaint and you were not active….it's something else
      - CB operators nearby? Illegal amplifiers

Final Tips

- When encountering interference that you're possibly causing to others
  - Be understanding,
  - Appreciate their concerns regardless of whether it's their equipment or not
  - Be patient and try to resolve
  - DON'T GO INTO THEIR HOME OR ADD FILTERS TO THEIR EQUIPMENT
    - Suggest what they can buy to try
    - Do your best to make sure your station is running clean
      - Don't overpower/overdrive amplifiers, splatter, etc
      - Look at your antenna….are you choking off return RFI path's? Radiating cleanly and not through the coax or feed line?
      - Look for the interference yourself with the help of other hams

Final Tips

- When RFI occurs, remember that there are many possible sources out there
- Don't be discouraged as it may take time
- Consider that it may not be resolved as one possibility – something outside of your control or the generator
- When working with neighbors or utilities…remember that YOU REPRESENT AMATEUR RADIO!! Put on your best face as it reflects on all of us!!! PR FIRST!

Loop Construction

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Carl's Post

Carl Lavoie ▶ DIY MAGNETIC LOOP
4 hrs ·

Start your magnetic loop with the following:

1 - What frequencies do you want to cover? Usually it will be 10M to 40M. To cover 10M to 40M the loop radiator should be about 30" to 36" in diameter.

2 - If you do not care about 10M and 12M but instead you want to have better performance on 15M to 40M then you can increase the loop diameter to 40" to 48" in diameter. It's important to mention that wider a loop radiator is and harder it would be to move it around. Wide magnetic antenna radiator made of LMR-400 will start to show their mechanical limits as they'll start sagging and get deformed under their own weight thus changing radiation patterns and efficiency.

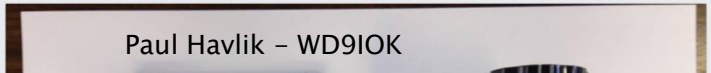
3 - The coupling loop diameter will be about 1/5 to 1/7 of the loop radiator diameter. So if you want a loop of 36" in diameter then start with a coupling loop of 7.2" wide (1/5) and use 114" long of coax to make your radiator. It's easier to trim the radiator than trimming the coupling loop. Use the following website to calculate your diameter: http://www.onlineconversion.com/circlesolve.htm

4 - Make your coupling as the following: https://www.nonstopsystems.com/radio/img-ant/antenna-mag-loop-coupling-unshielded.jpg
You do not need to use a coax cable to do so. You can use anything that can be formed into a circle easily. A higher gauge of solid wire will do the job.

5 - The capacitor is the MOST important part of the magnetic loop antenna unit. It needs to cover enough pF like 5pF to 500pF. No need to go higher than that. The capacitor that we're providing in our kit covers 12.5 pF MIN - 432.5 pF MAX PER SECTION and it had two sections. They're the EXACT same capacitors that are used in the Chameleon Antenna CHA F-LOOP and CHA P-LOOP.

16 8 Comments

Like Comment



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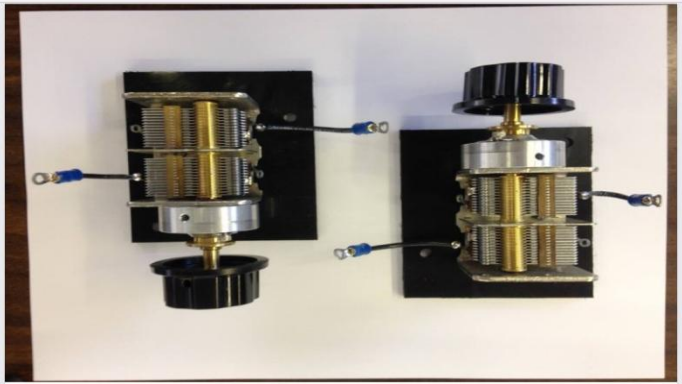
Carl's Post



Like Comment

Appreciate the help of these individuals/resources

- ARRL RFI Book
- N9APK – Clark Sell – RFI hunter/Engineer/RFI Loop & tracking assistance
- WA9JSI – Rich Galitz – Engineer – Assistant with ideas for RFI tracing
- W4LWW – Bruce Kryder – RFI Example
- Google Earth
- Yahoo Graphics

Questions????

- Thank you for your attention

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