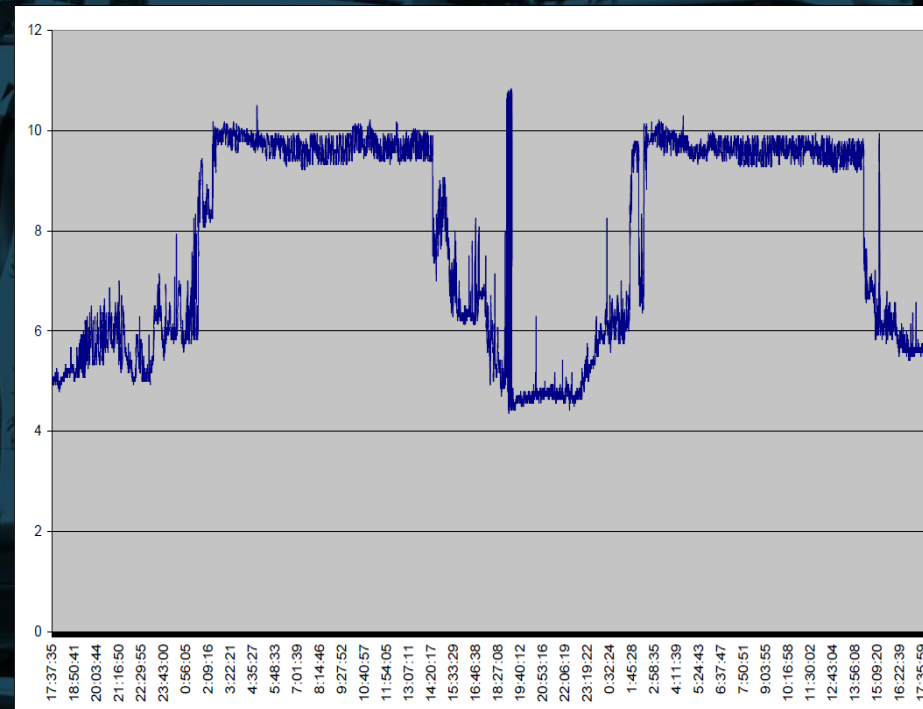
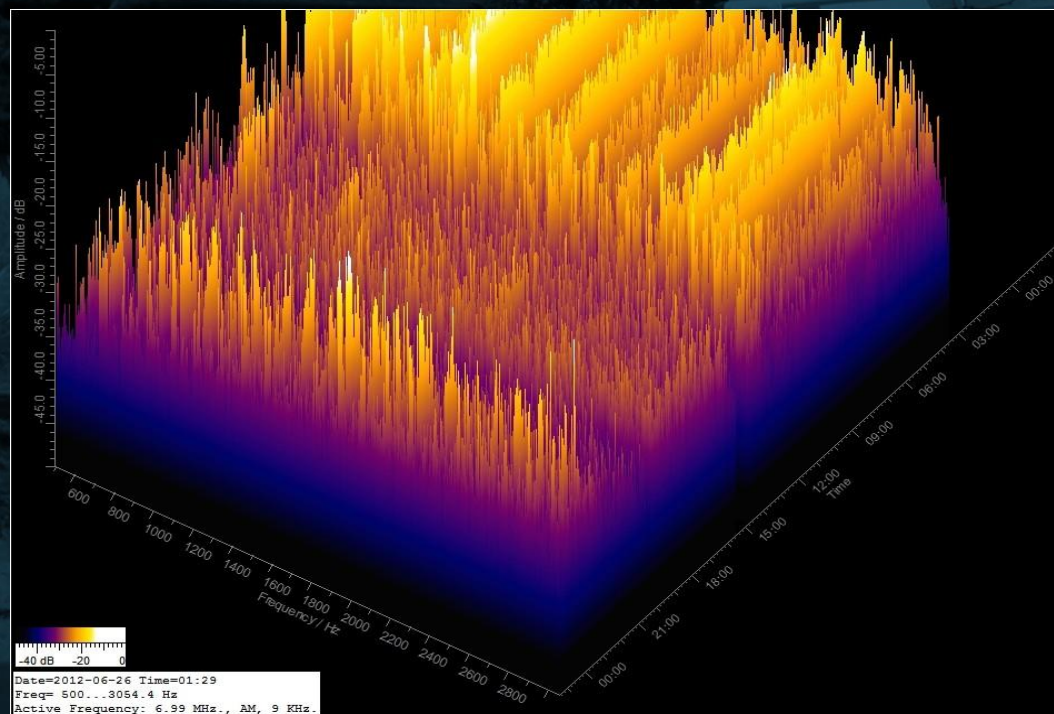


# Radio Frequency Interference

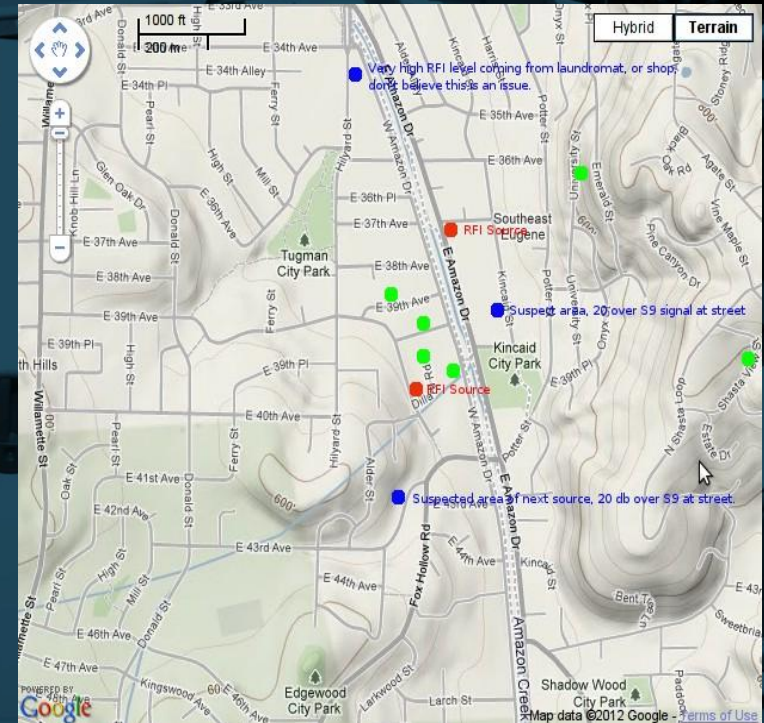


Presented by  
RON P MILIONE



# Introduction

- ARRL OOC for Oregon.
- Active in AFMARS, and SHARES.
- 40 Years of RF experience.
- Got tired of not having 40 Meters.
- Solved many RFI issues.
- Worked directly with FCC.
- Constructed many RFI hunting antenna.
- Won the last local Fox Hunt in under 5 minutes.
- Like hunting RFI sources.



# LEGAL DISCLAIMER

- ▣ The views discussed during this presentation are those of the presenter and no one else.
- ▣ Verify all information before acting upon it.
- ▣ By viewing this presentation, you agree to defend and hold harmless the presenter from any and all legal issues arising from your use of the information presented.

**IF YOU DO NOT AGREE TO THE ABOVE TERMS,  
PLEASE LEAVE NOW!**



# What will be covered tonight

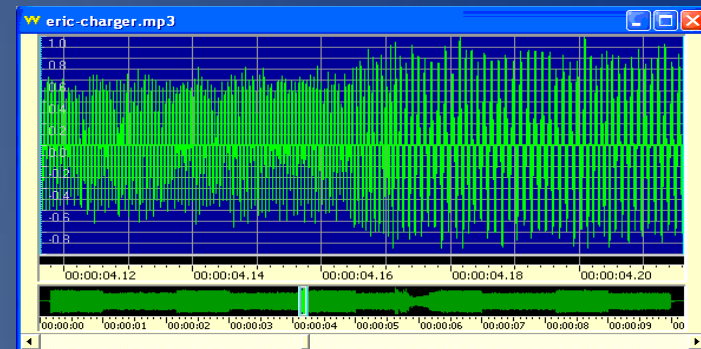
- What is RFI?
- Sources of RFI.
- Who is responsible for fixing RFI issues.
- How to deal with the responsible party.
- RFI Log.
- How to locate RFI.
- Some legal issues.
- Resources.

# What is RFI

- RFI is any man-made interference, that harms your enjoyment of Amateur Radio.
- RFI can be broadband in nature.
- RFI can be narrow band in nature.
- RFI can be 7 by 24, or only on for a moment.
- The most reported source of RFI is power line noise.
- The source causing the least RFI are power lines.

# Sources

- ▣ Many RFI sources can be confused with Power Line Noise, they are:
  - ▣ Florescent Lighting.
  - ▣ Lamp Dimmers.
  - ▣ Street Lamps.
  - ▣ Horticultural Lights.
  - ▣ Plasma TV.
  - ▣ Everything with a Microprocessor in it.
- ▣ Often located right in your own home
- ▣ Difficult to differentiate between these devices and Power Line Noise.



# Responsibilities

- ▢ Differentiation is important, it tells you who to contact.
- ▢ Power Company responsible only for their own equipment.
- ▢ Sources may be in your own home.
- ▢ Neighbors.
- ▢ Unlicensed device responsibilities.
  - ▢ Must meet FCC rules.
  - ▢ May need to meet emissions limits.
- ▢ Unlicensed operator responsibilities.
  - ▢ Ultimately most problems are the device operators problems.



# Power Company Responsibilities

- ▣ Responsible for RFI caused by their equipment.
  - ▤ Power companies MUST correct RFI caused by them to any licensed station.
- ▣ Not responsible for non power company RFI.
- ▣ May sometimes help locate the source for you.
  - ▤ Truck rolls cost money, and all companies have budgets.
  - ▤ Of late legal issues are in play regarding privacy.
- ▣ Not as well trained as most Hams in locating RFI.
  - ▤ In LI, we are lucky, the power company has a clue.
- ▣ They sometimes blame non power company equipment, in error.
  - ▤ Again in LI, we are lucky, the locator's are skilled.



# Devices the FCC Recognizes

- Incidental emitters.
- Unintentional emitters.
- What are Incidental emitters?

- Power Lines

- Motors

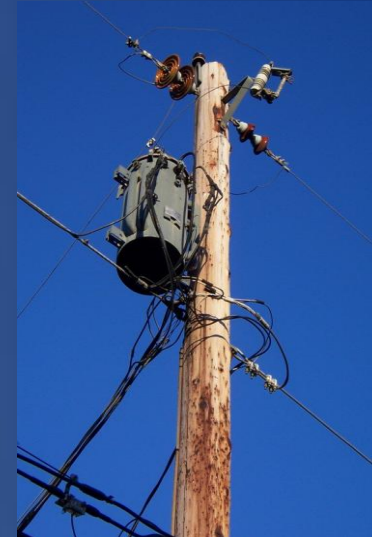
- Anything not generating RF intentionally, that is radiating RFI to a licensed station.

- What are Unintentional emitters?

- Computers.

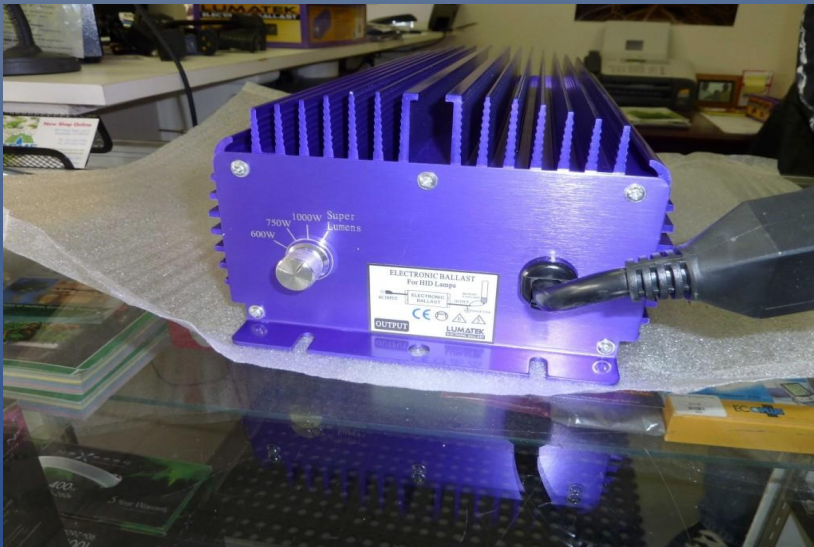
- Horticultural lighting systems.

- Any device that generates RF by intent, and is not designed to radiate RF, but does, and interferes with a licensed station.



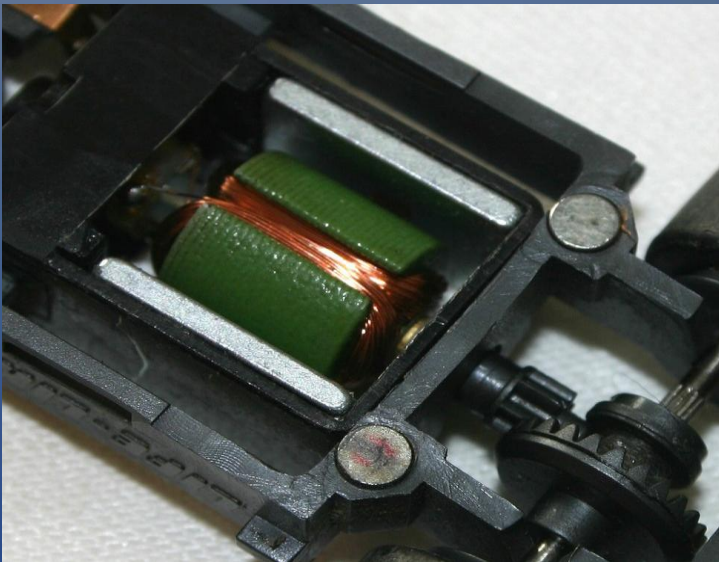
# Unintentional Emitters

- What are Unintentional emitters?
  - Computers.
  - Horticultural lighting systems.
  - Any device that generates RF by intent, and is not designed to radiate RF, but does, and interferes with a licensed station.



# Incidental Emitters

- Incidental Emitters, accidentally generates RF:
  - No limits on the amount of RFI generate and fed into power grid!
  - Must be constructed using good engineering practices.
  - Must not cause **harmful** interference to a licensed station.





# What is not Harmful Interference

- ▣ A few birdies on a few frequencies are not considered as harmful interference.
- An S-6 signal on one frequency is generally not going to be acted on by the FCC, unless it is on say the OEN frequency, then it “might” be acted on.
- ▣ A RFI source that radiates a 60 db over S9 signal across all the HF spectrum, wiping everything out for 60 seconds every day at the same time, then going quiet, will probably not be considered harmful interference, unless it is interfering with health and welfare traffic directly.
- ▣ A one or two S unit increase in your background above static levels... IE. If you had an S4 40 meter background, and now something is making it S5...

# What is Harmful Interference

- ▣ Defined as any disruption of emergency. communications or related services, Fire, Police, Power Company, etc.
- ▣ Defined as repeated disruption or serious degradation of other licensed services.
- ▣ In the eye of the beholder.
- ▣ A plasma TV spraying RFI all over the band, at S7 or above.
- ▣ Lighting systems that wipe out entire neighborhoods.
- ▣ Sparking power company hardware.
- ▣ Switching Power Supplies.

# More Examples

- ▣ If you live in a quiet area, and an S1 noise source comes up and stays there all day, every day, for years, it will probably not be considered harmful interference.
- ▣ A streetlight that comes on and generates RFI all day, across a broad spectrum probably will be considered harmful interference.
- ▣ An LED controlled intersection generating 60 db over S9 of RFI, where no ham is affected unless they drive through the intersection will probably not be considered as harmful interference, until someone is effected.
- ▣ A change in 1 or 2 S-units will probably not be considered harmful.



# Real World

## ▣ Incidental Emitters:

- No rules, only the harmful interference clause.

## ▣ Unintentional Emitters:

- Less than 30 MHz. 1000  $\mu$ V conducted into power lines over most of HF.

- Over 30 MHz., less than 150  $\mu$ V/M 3 meters from source can be radiated.

## ▣ Real World:

- About S7 from your neighbor, is on the line

- About S9 + from your home, is not OK

- If you are experiencing S9 or above RFI, and it is not you, then the offending device is more than likely exceeding FCC limits.

# So... It's harmful, now what?

- ▣ Must triage source between yourself and not yourself.
- ▣ Start at home
  - ▮ Battery operated radio
  - ▮ Kill the breakers, (shutdown computers first).
- ▣ Oh no! It's me!!
  - ▮ Best possible outcome, maybe...
  - ▮ Bring breakers up one at a time until you hear the RFI.
  - ▮ Now go unplug everything on that circuit, and when it stops, you have your device.

# It's my new \$3000 Plasma TV

Don't call the FCC, you are the operator of the device and hence the responsible party, you must stop using it, or put up with the RFI.

Back in the day, Riley Hollingsworth offered a Proposed fine to a ham who insisted the FCC fix just such a problem, the ham would not shut up about it, so Mr. Hollingsworth offered the Ham a fine of \$10,000 per day for operating the device...

The Ham decided to drop the matter...

Today the fine is \$22,000 per day for such violations.





# Why the best possible outcome?

- ▣ You control everything about the RFI source!
  - ▮ You can stop it.
  - ▮ You can start it.
  - ▮ You can filter it.
  - ▮ You can tell your wife that the \$3000 Plasma TV you just bought can't be used between the hours of 6 PM, and midnight!
- ▣ Interference in your own home is between you and the device operator, (your family), the FCC will not get involved.
- ▣ If you bought a \$3000 RFI generator, then you get to live with it.

# What is Power Line Noise

- Interference caused by arcing on power lines or related hardware.
- RF is generated by an arc, and is broadband in nature.
- Does not change as you tune around.
- Almost never caused by corona discharge, no matter what you hear!
- Can be affected by weather, better in the rain, worse on dry days.
- Symptoms include:
  - Harsh sounding buzz, (60 or 120 Hz), heard.
  - Draws straight vertical lines on waterfall displays.
  - Relatively constant across the spectrum as you tune.
  - Can be heard at VHF as you get close to source.

# Why 120 Bursts per second?

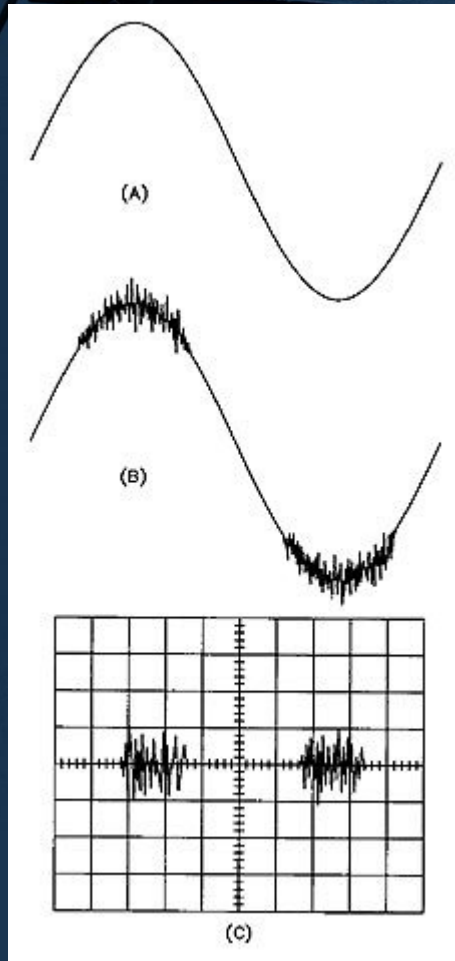


Figure A, 60 Hz signal on a clean line

- Almost a pure sine wave.
- No noise.

Figure B, 60 Hz signal on a dirty line

- If a line or device, which is arcing is connected to a power line, you may see the noise. Typically at the positive and negative excursions of the sine wave.

Figure C, if the radiated noise is observed on a scope

- The noise will be present during the positive and negative excursions.

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# Burst Rate is a clue!

- ▣ Noise not at 60, or 120 Hz., is almost never Power Line Noise.
  - ▣ Power Line noise is almost always locked to the 60 cycle rate.
- ▣ On a oscilloscope the burst rate can be observer and timed. It should occur every 8 and 1/3rd or 16 and 2/3rd milliseconds
  - ▣ That corresponds to 120, or 60 Hz.
- ▣ Ocillograph images can infer that an arc is involved from the noise on the positive and negative excursions of the waveform.
- ▣ So you think it is Power Line Noise
  - ▣ Now what?

# Your RFI log

- ▣ What should my RFI log contain?
  - ▣ Power off test info for yours, and any other houses you tested.
  - ▣ Date/times you were unable to use your radio.
  - ▣ Pretty much anything you said to anyone, or anything anyone said to you, about this RFI issue.
- ▣ Remember, your log might become part of a legal proceeding.
  - ▣ Keep it simple.
  - ▣ Keep it clean.
  - ▣ Keep it accurate.
  - ▣ Keep times/dates.
  - ▣ Keep it unemotional.



# Your RFI log

## ■ Why so much detail:

- You may have to prove you actually have a problem.
- You may be building a document for use in court.
- You must appear competent. The RFI log serves to infer to anyone involved, that you are serious, competent, able to keep notes, and in general a careful person.
- Your notes will help the Utility, the ARRL, the FCC, you, and if things get out of hand the court system in solving your RFI case.
- So keep notes carefully, and remember at all times, anyone involved in solving this case, should be able to ask for your notes and get them from you with no delay.
- See the sample RFI log.



# Your RFI log

## ▣ Lets talk about Privacy:

- ▣ The Utility may not tell you where they located the RFI source. Given the recent change in laws dealing with Marijuana growing, this is completely understandable.
- ▣ If you believe you have located an RFI source, keep that data to yourself. Log it, but DO NOT tell, or give that log data to uninvolved people.
- ▣ If you share your log with anyone, review it first, and ask yourself if the data in it is appropriate for sharing?
- ▣ If it's not appropriate then rethink what you are keeping in your log. It might get called into court sometime, even if you did not request it be used. Remember, you are creating a legal document.

# Learn some location techniques

- ▣ Learn some RFI location techniques or get help:
  - ▣ Next time there is a Fox Hunt, hang out with the winner of the last one to get some tips.
    - ▣ Ask questions
    - ▣ Ask to join his/her team.
  - ▣ Buy or build the needed equipment.
  - ▣ Use that equipment.
  - ▣ Build a loop
  - ▣ Use that loop.
  - ▣ Practice

# Why do I have to locate the RFI?

- ▣ Why am I having to find the RFI, not the Utility?
  - ▣ It might not be the utilities issue, and you will need to locate the source yourself in order to contact the offender, Utility or otherwise.
    - ▣ Remember, if the Utility is not the cause, they have no requirement to assist you in any way.
  - ▣ It helps the Utility if you can tell them where you believe the source is, and why.
  - ▣ You understand the problem better, and can better understand why it takes so long to fix.
  - ▣ It lets the Utility know that you are a competent RFI locator
  - ▣ It's fun!



# Who do I call at the Utility?

- ▢ Start with customer service.
  - ▢ Explain the short version of your problem:
    - ▢ I'm a ham radio operator
    - ▢ I believe I am getting interference from your equipment.
    - ▢ Be brief, be succinct, be quick, but nice.
    - ▢ Write down the persons name you are speaking to in.
    - ▢ Establish a single point of contact, (SPOC), by asking who you should contact to correct this possible problem.
  - ▢ Write everything you say, who you said it to, (by name), and what they said to you down in your RFI log.

# First Contact

- Once you get the SPOC, If you get the person, or voice mail:
  - Understand these people are busy.
  - Remember, YOU need them, they don't need you.
  - Speak slowly.
  - Speak clearly.
  - Don't tell them they have to fix it or else.
  - Don't tell them they have a problem, tell them you have a problem.
  - No threats of calling FCC, or the ARRL.
  - Treat them as you would like to be treated.
  - Remember, you have a won position here... Don't destroy it!

# What should happen?

- ▣ Your SPOC should arrange a meeting at your QTH, with an RFI Investigator, so they can see, and hear the RFI for themselves.
- ▣ Be prepared to give them a connection to your antenna.
- ▣ Clean up your shack.
  - If your shack is a mess, your credibility goes out the window.
  - Dust behind the rigs, they may want to see back there!
- ▣ Have your RFI log ready.
  - Be ready to share it with the RFI Investigator.
  - This shows them that you are serious, and careful about your RFI issue. It also makes them serious and careful, as they see you are taking notes.



# First Visit

- ▣ He or she will discuss the RFI with you and ask to hear it on your rig.
- ▣ The Investigator may ask to connect his/her receiver to your antenna.
  - ▣ He/she will snapshot the RFI as a data capture for later use.
- ▣ The Investigator will go out to where your antenna is and start listening with his/her rig, taking more data snapshots.
- ▣ The Investigator will then discuss with you if the RFI they are seeing, is the RFI you are seeing.
  - ▣ Be careful here to be as correct as possible.
  - ▣ This is where they decide what source to investigate.
  - ▣ If you mislead them, they waste money, and time
    - ▣ Not good for the cause of removing your RFI.

# Before they leave...

- ▣ You should ask the RFI Investigator that the Utility contact you with the results of this visit.
  - ▣ Provide your contact info.
    - ▣ Phone
    - ▣ Email
- ▣ Ask what the expected time-frame might be for that report.
- ▣ After they leave, log everything to your RFI log.
  - ▣ Who you talked to by name.
  - ▣ What they found.
  - ▣ What they did.

# After they leave...

- ▣ The Investigator will then drive around looking for your RFI.
- ▣ The Investigator will keep careful notes of what you said, what they think about you, what they observed RFI wise at your QTH, and what they found during the drive around.
- ▣ They will note anything they see that matches the data snapshots they find.
- ▣ They will start an RFI log of their own, you will be in it.
- ▣ You should continue to keep logging your RFI, and any actions you take to try and mitigate it.
- ▣ You should continue to look for the source...
  - ▣ Log your results.



# What if it's the Utility's fault?

- Under the FCC rules:
  - The Power Company MUST fix the problem, no matter what they say, no matter what the cost, and they must do it within a reasonable time-frame.
- You have a won position, don't blow it:
  - Don't threaten.
  - Don't tell them they are working too slowly
  - Don't tell them they have to fix anything.
  - Don't over call them for status reports.
  - This WILL take time.

# What if it's the Utility's fault?

- ▢ What the Utility should do:
  - ▢ The RFI Investigator will have spent some time looking for your RFI issue, and probably will have located it.
    - ▢ If it is a Utility device, they will then set up to fix it.
    - ▢ If it is not they will more than likely contact the device owner and let them know that they are generating RFI.
- ▢ If it is a Utility device:
  - They will fix something, perhaps replace and insulator, tighten a bolt, replace a pole.
  - They will then contact you asking if this solved the issue.
  - Hopefully it did, and you are done.

# If you do it right...



# What if the first visit failed?

- ▣ What if it did not fix the problem
  - ▣ Then everyone is disappointed, and the budget people for RFI start to worry...
- ▣ The locate process starts again.
- ▣ Remember, this costs the Utility real money, so it is in your best interests to do as much as reasonable to help them locate the issue.
  - ▣ If you get uppity and tell them it is their problem, things won't go well for anyone.
- ▣ There is are a limited number of loops possible, each loop costs the Utility hundreds of dollars.
  - ▣ Each loop proves that the Utility is trying to help you...
  - ▣ Use your loops wisely.



# What if this is taking too long?

- ▣ OK, you have tried to resolve the issue yourself:
  - ▮ You have kept your log
  - ▮ You have used your equipment to try and locate things.
  - ▮ You and perhaps others have reported the issue to the Utility.
  - ▮ You have been patient
  - ▮ You are fed up with the waiting...
- ▣ Be calm always:
  - ▮ Ask if the Utility has a time-line for correcting this problem.
  - ▮ Never get in their face, you only hurt your cause, and weaken your position if things get ugly later.

# Enough is Enough, who do I call?

- You are still not happy with the Utility's time-line.
  - You should call the ARRL first.
    - The ARRL has a history of working with the FCC and Utilities.
    - That history goes back as far as Riley Hollingsworth.
  - In order to get the ARRL's attention:
    - You should, by this time, have a large RFI log, filled with data, showing how reasonable you have been, and how long this has taken. This is your won position. You get support.
  - Now what?
    - The ARRL will drive the process from here. Assist them in every way possible. They have done this many times before.

# What if it's not the Utility's fault?

- ▣ Remember the Utility is your friend.
  - If it is a device, not owned by the Utility, inducing RFI on to the power grid, it is NOT the utility's issue anymore, even though the Utilities are carrying the RFI along the power lines. It is yours, and the device operators issue.
  - The Utility can still help you by locating the problem, but they no longer are required to help you.
  - They may, or not, be able to tell you who it is generating RFI due to privacy concerns.
  - They should be able to tell you if they believe they located the issue, and what they said to the person(s) involved.
  - Remember, once it is established that the source is not the utility, the utility has zero obligation to help you.

# Time to hunt...

- ▣ An RFI Investigator must be able to hear the source.
  - ▣ If it is not active you are done, go home!
- ▣ RFI Investigators use Radio Direction Finding, (RDF), techniques.
  - ▣ Remember your practice with FOX hunts?
- ▣ The upper frequency of the RFI can provide a very important clue:
  - ▣ The closer to the source, the higher in frequency you will hear the RFI at.
  - ▣ If you hear the noise on 400 MHz., it is within walking distance of you.
  - ▣ If you only hear it on 75 Meters, it is probably miles from you.
- ▣ Use your beam if you have one.



# Multiple Sources



## Think Onion:

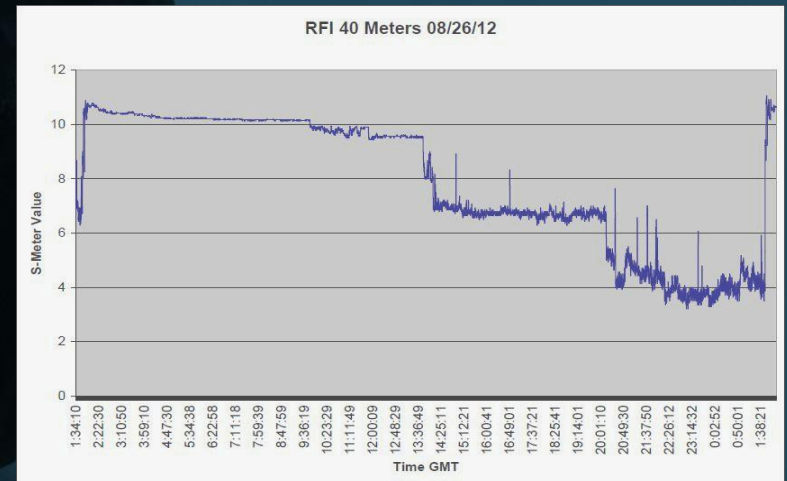
- Each layer of RFI covers the next layer...

- Each layer may be devastating to your receiver
- You peel the onion by locating the loudest layer first.
- Remove that layer of RFI.
- Am I happy with the results?
  - If no, go to peel step above.
  - If yes, jump to RFI Hunt ends below.
- Your RFI hunt ends.

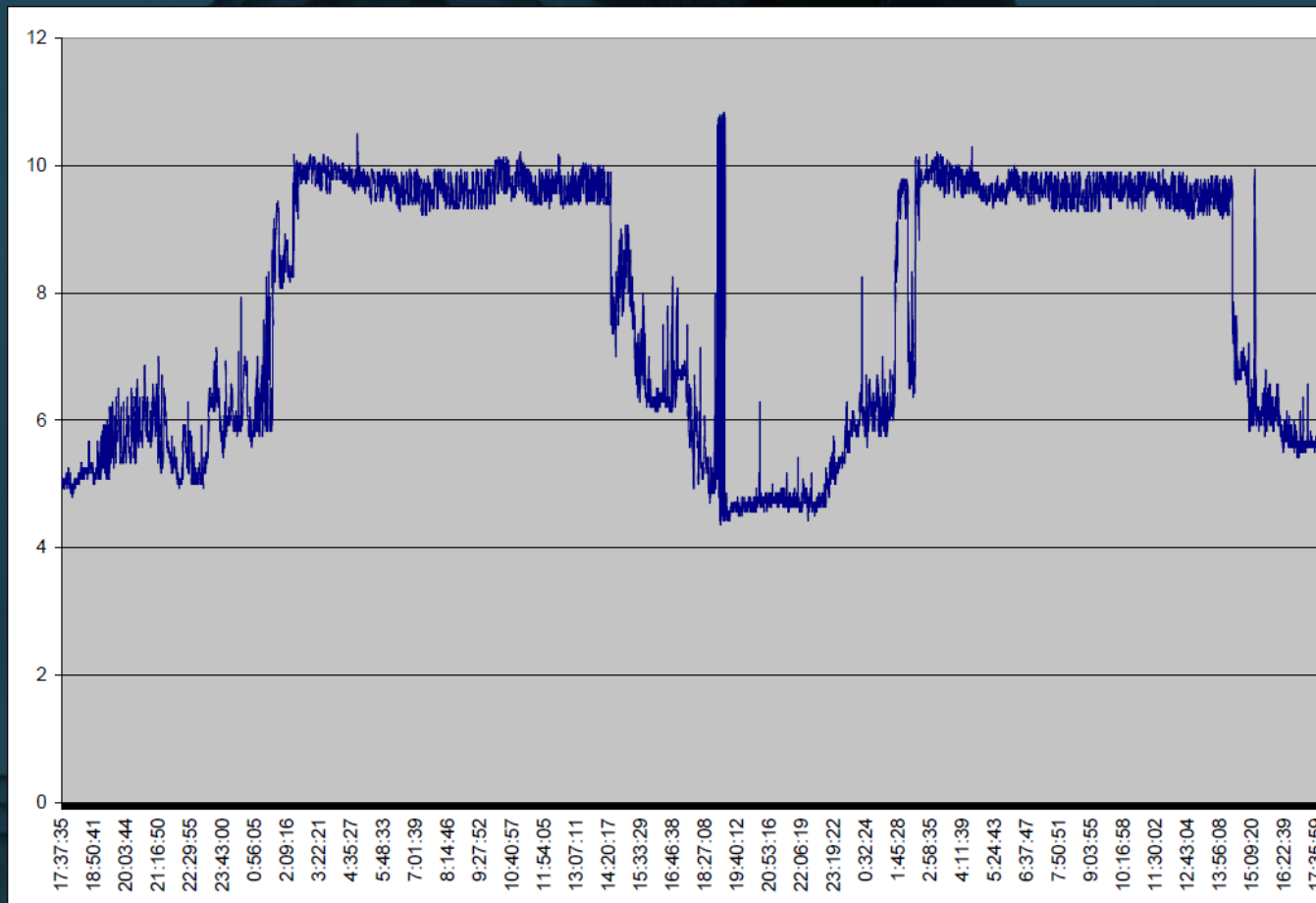
# Characterize your RFI

## Download and install S-Meter Lite:

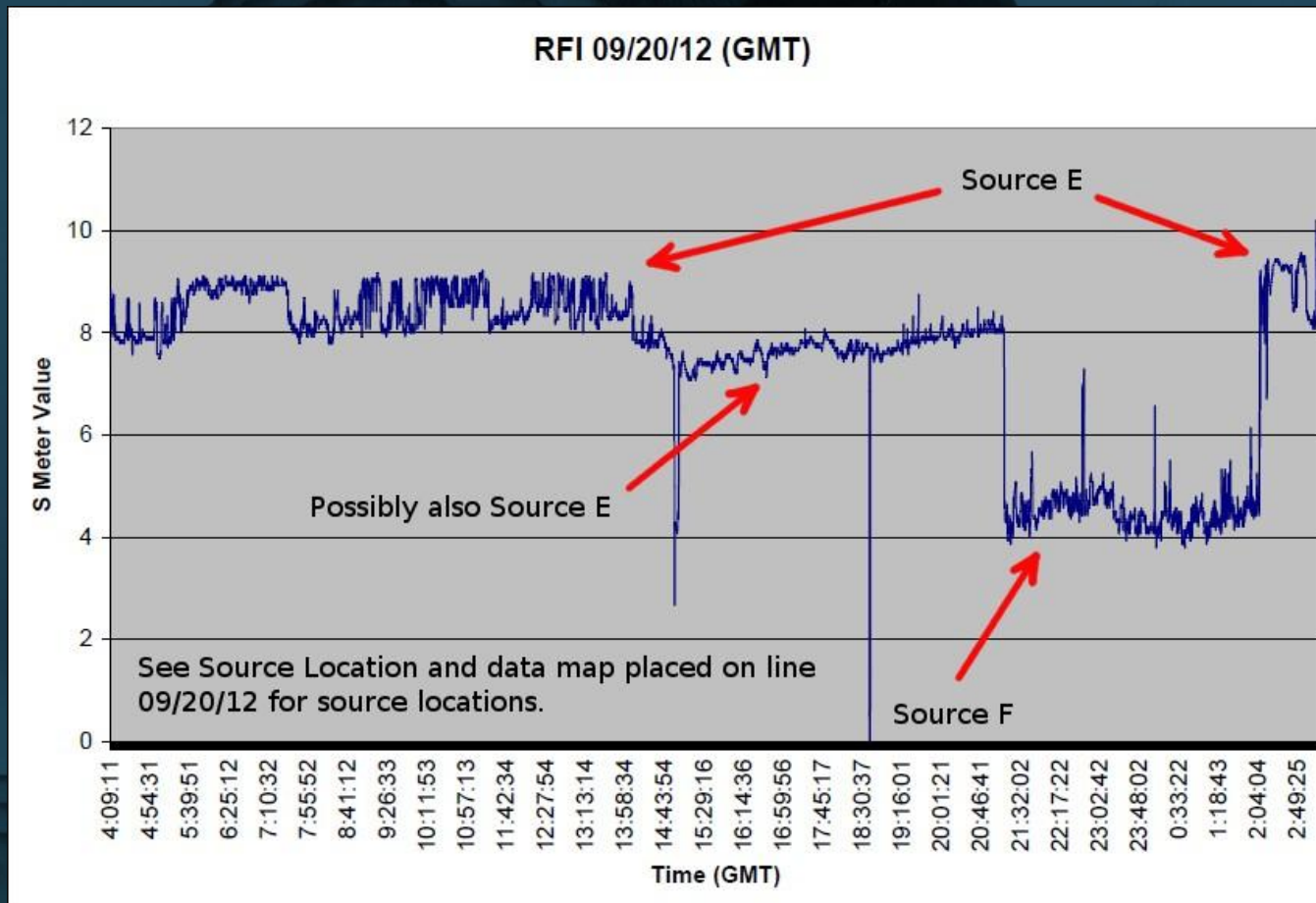
- ▮ Play with it for a day to get used to it.
- ▮ Configure it to save data.
- ▮ Make a test run of a few hours.
  - If good move on below.
  - If not fix.
- ▮ Run it for two days, 24 hours a day.
- ▮ Capture data every 30 seconds.
- ▮ Save data to it's own directory, and name it with the date.
- ▮ Make an entry to your RFI log of what you did.



# S-Meter Lite



# What you can learn





# Equipment for the hunt...

- ▣ Equipment:
  - ▮ Minimum needed is a hand held short wave radio.
  - ▮ Maximum is like everything else, whatever you want to afford.
- ▣ A Decent setup:
  - ▮ A mobile rig, or small portable, hand held short wave radio.
  - ▮ A set of small magnetic loops for RDF work. Fits all radios.
  - ▮ MFJ-856 RFI detecting Yagi antenna.
  - ▮ An HT that will do AM mode. Kenwood TH-F6A
  - ▮ Handheld 144/450 beam for the HT.
  - ▮ Google Maps
  - ▮ A Computer

# The Hunt begins, an overview...

- Now that you know what you are looking for, start at your antenna.

- Use your loop, or station beam to get headings.

- If you have no loop or beam, spiral out from your antenna.

- Continue this until you start to hear your RFI at VHF frequencies.

- Take heading measurements, use the null, not the peak.

- Walk towards the RFI.

- If it gets weaker, use the OTHER heading if looped.

- Walk towards the RFI, it should be getting stronger.

- Move up in frequency as you approach the source:

- Move from 40 Meters, to 10, meters, to 2 Meters.



# The Hunt begins, an overview...

Now that you are at VHF/UHF

If you are still hearing your RFI you are very close, perhaps within a stones throw at 450 MHz.

Look around you

Near by power pole

Underground transformer

Houses

Use the MFJ Beam:

Point it at homes, see if you can get a reading.

Minimize the RF gain.

Most times you will find the source this way.



# The Hunt begins, hints...

Don't get fooled by pole noise:

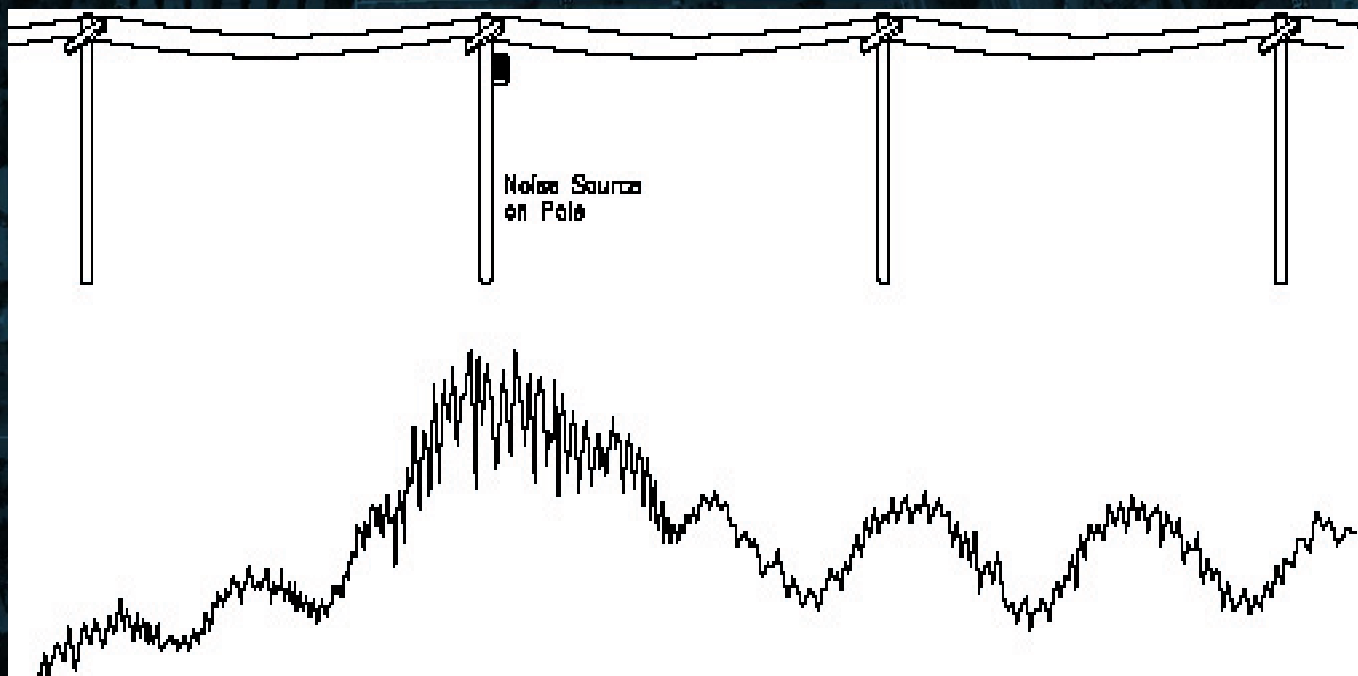


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# The Hunt begins, hints...

Now you think you have the pole:

Don't

DO NOT CLIMB THE POLE.

DO NOT SHAKE THE POLE.

DO NOT TOUCH THE POLES SUPPORT WIRES.

DO NOT TOUCH THE GROUND ON THE POLE

DON'T BECOME A FUSE.

DO NOT TOUCH ANYTHING AT ALL.

DO NOT STAND UNDER THE POLE.

DO NOT STAND IN THE STREET.

USE YOUR HEAD!

YOU COULD BE KILLED!



# The Hunt begins, hints...

Now you think you have the pole:

Do:

- Use your Ultrasonic Pinpointer.

- You may be able to pin the RFI source down to an item on the pole.

- Look at the pole with Binoculars.

- You may see burned, or loose parts.

- Use your 440 beam and point it at the top of the pole.

- Do you hear RFI? If so go to one GHz. and listen.

- Log all results to your RFI log.

- This will help the power company later.



# The Hunt begins, hints...

Does the suspect pole have a service feeding a home on it?

If so, point the MFJ antenna at the home it is feeding.

Does the RFI get louder?

If so, then it is probably from that house.

If not, then it is probably from the pole.

If from the house:

Walk on the sidewalk in front of the house, and use the MFJ antenna to see if you can triangulate on the house. Most times this works.

If you feel comfortable, contact the owner and ask if you may perform a power off test on the house.



# Legal Disclaimer

- THE FOLLOWING IS HOW I WOULD DEAL WITH AN RFI PROBLEM, AND IS NOT INTENDED AS A GUIDE FOR YOU.
- I AM NOT RECOMMENDING YOU PERFORM ANY OF THESE TASKS, ONLY TELLING YOU HOW I DO IT.
- YOU ARE RESPONSIBLE FOR YOUR OWN ACTIONS.
- YOU AGREE TO DEFEND AND HOLD HARMLESS THE PRESENTER, HIS FAMILY, AND ALL OTHERS INVOLVED IN THIS PRESENTATION BY CONTINUING TO VIEW IT.

**IF YOU DO NOT AGREE TO THE ABOVE TERMS,  
PLEASE LEAVE NOW!**



# Safety Issues

- ▣ I always work with another Amateur Operator.
  - ▣ If I am accused of something I have a witness.
- ▣ I never enter a home alone.
  - ▣ That would leave wide open to anything.
- ▣ I perform all tests from outside the home.
  - ▣ The power off test will locate to the home.
    - ▣ If it is the house, then I ask the owner to power things down one at a time, and I listen outside.
- ▣ If something does not feel right I leave.
  - ▣ I never stick around anywhere I don't feel safe.

# Legal Issues

- ▣ I never offer advice on how to correct the problem:
  - ▣ If the resident takes my advice, and his/her house burns down, I could be sued.
  - ▣ If the resident asks me for advice, I tell him/her why I can't suggest fixes, I don't want to be sued if the house burns down.
- ▣ I never say the RFI is fixed.
  - ▣ I may be wrong, it is always only fixed for me.
    - ▣ If I tell someone the RFI is fixed, and another ham reports to them to the FCC later for a band I did not check, and they get fined, I told them it was fixed, when it was not. RFI is never fixed, I either hear it or you don't hear it. Nothing more.

# Problem resolution

- ▣ I use the handout my club created, and had reviewed by a Lawyer to reduce legal exposure:
  - ▮ I send mail, or leave the hand out on the door of a suspected RFI generating location.
  - ▮ If the location is a rental house, I may send a copy to the home owner.
  - ▮ I keep my RFI log updated as to when I delivered a handout.
  - ▮ I wait a month, and if I hear nothing, and the RFI is still present I contact the ARRL.
  - ▮ That starts the ball rolling on getting the FCC involved.
  - ▮ The handout is available email, [w2tap@arrrl.net](mailto:w2tap@arrrl.net)

# Resources

This presentation:

email: [w2tap@arrl.net](mailto:w2tap@arrl.net) for a copy

- Resources:

- THE ARRL RFI Book:
- <http://www.arrl.org/shop/The-ARRL-RFI-Book-3rd-Edition/>
- ARRL RFI Web Page
- <http://www.arrl.org/radio-frequency-interference-rfi>
- AC Power Interference Handbook by Loftness
- Mike Gruber at the ARRL, (860) 594-0392

Email: [w1mg@arrl.org](mailto:w1mg@arrl.org)



# Credits

- Thanks to Ed Hare Ed Hare of the ARRL.
- Produced using Linux, and LibreOffice Presentation software.
- Some diagrams by ARRL staff, PSEG-LI.
- Most diagrams and photos-- by me...



