Locating and Killing Receiver Interference

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NA6O . COM

Agenda

- Types of noise and interference
- Typical noise sources
- Finding the noise
- Noise mitigation
- Your rights per the FCC
- References

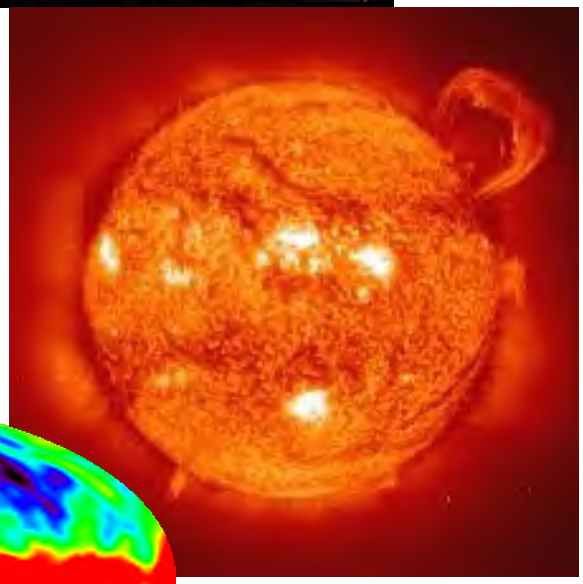
NOTE: While this talk focuses on noise arriving at your receiver, some of the mitigation techniques also apply where your transmitter is interfering with other equipment, e.g., getting into the stereo.

Types of noise and interference

- Natural
  - A case where all-natural isn't better!
- Intentional emitters
- Unintentional emitters

Nature gives us “baseline” RF noise that we can’t do much about

- Lightning
- Solar activity
- Cosmic background
- Thermal noise



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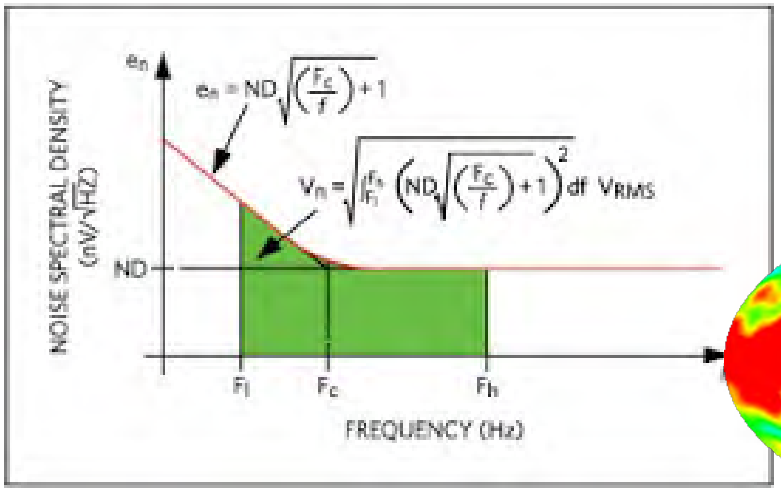
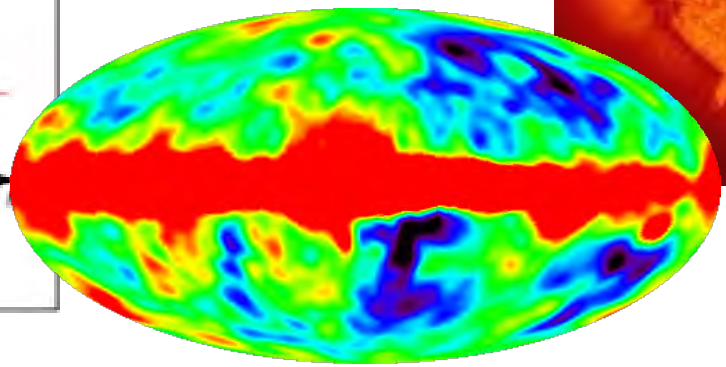




Intentional emitters are other legal transmitters, including other hams

- Strong signals may overload your receiver
- Multiple signals can mix (*intermodulate*) and appear at unexpected frequencies
- Licensed =
  - FCC regulated
  - Legal leverage
  - Negotiable

Unintentional emitters are almost always the problem… It gets worse every year!

Many electrical devices not designed to be transmitters may radiate interference

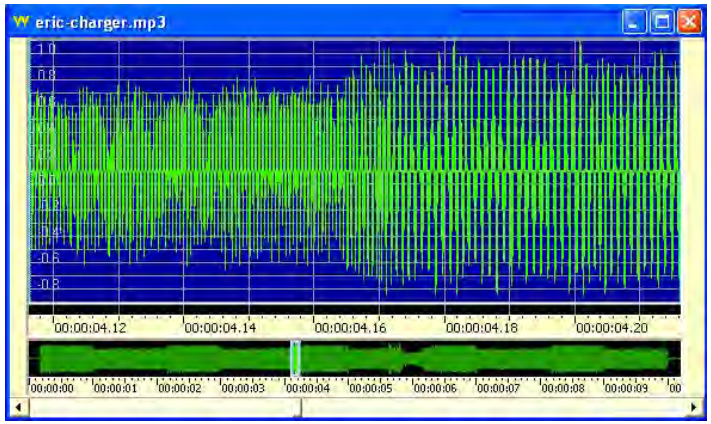
There are tools and techniques to help locate interference sources

- Spectral fingerprinting
- Power-down until it goes away
- Radio direction finding
- Ultrasonic detection (only for arcs)

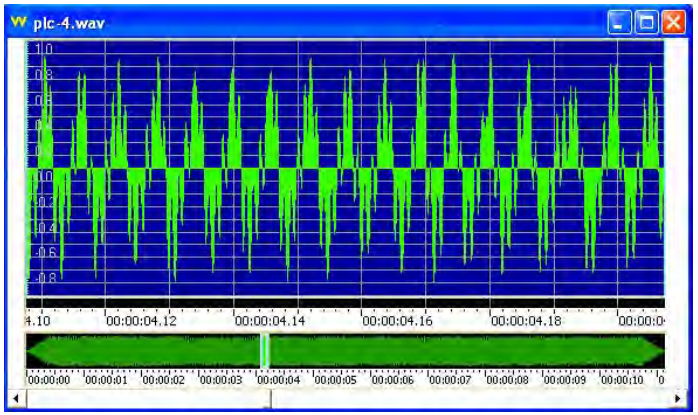
Fingerprints: What do you hear?

- Tune around. Note frequencies. Is the same signal periodic in time or freq? What interval?
- Listen. 60 Hz hum? Video? Pulses? Voice?
- Record audio, ask others for identification

http://www.arrl.org/sounds-of-rfi



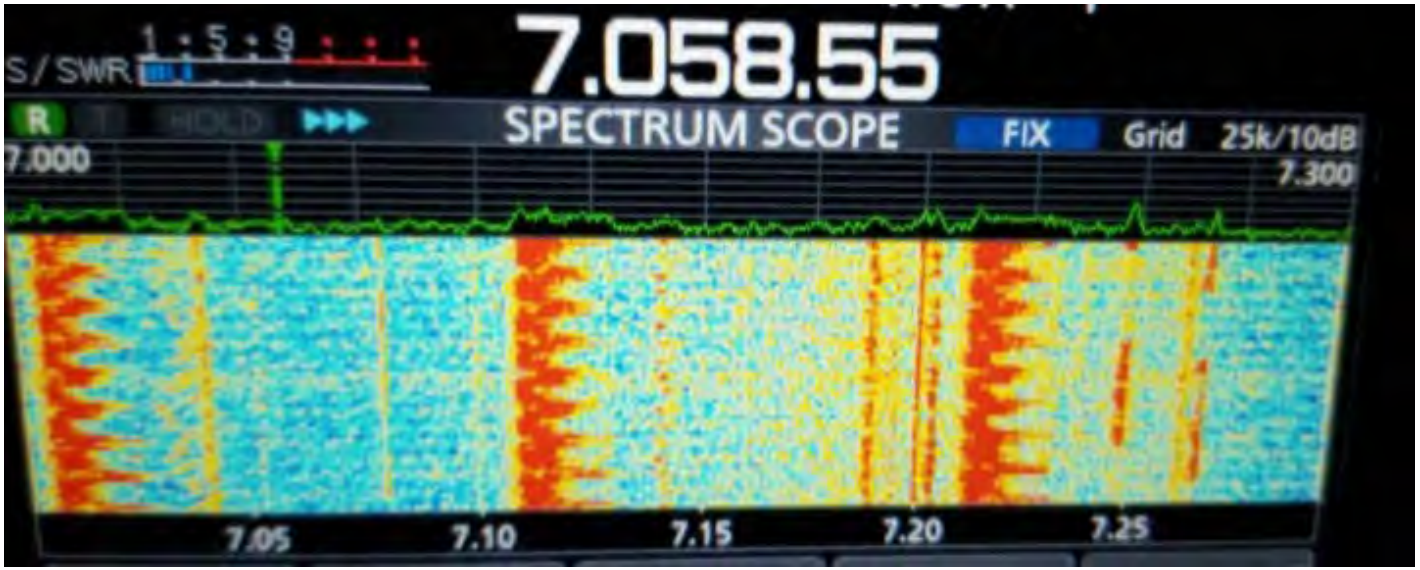
Phone charger



Power Line Control (PLC-4)

Fingerprints: SDR with panfall display

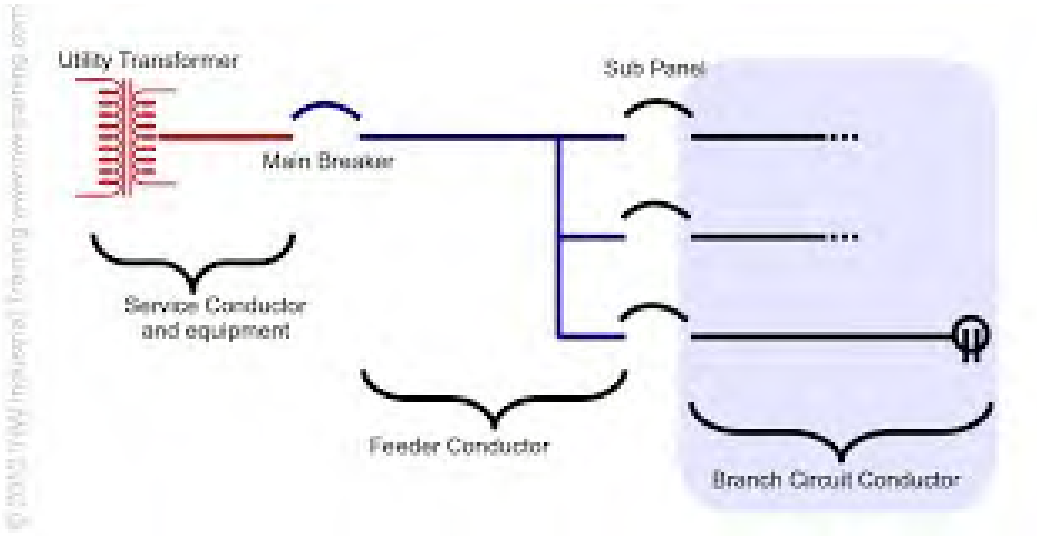
- Measure amplitude and frequency
- Track dynamic signals
- Compare before and after mitigation
- Don’t forget to **write down** everything



Battery tender observed at K6KM

Power down to quickly find the smoking gun: Start with your own house

- Unplug everything, then plug in one thing at a time
- Even better, turn off breakers
- See when the noise appears or disappears
- Same with (friendly) neighbors



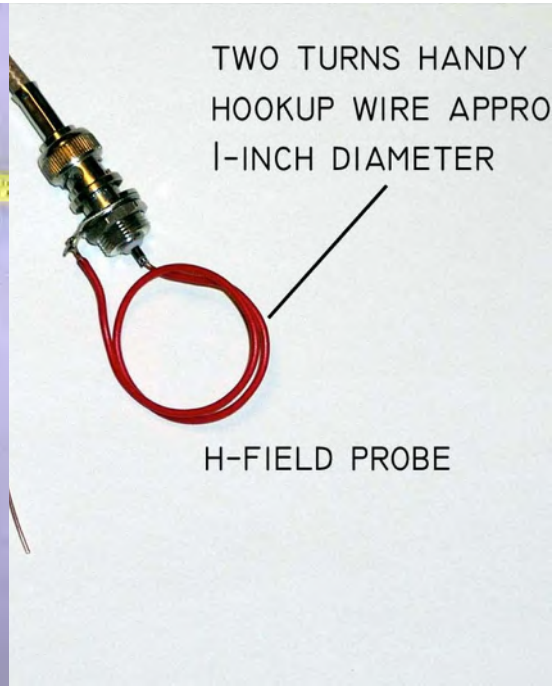
Not from your house? Head for the field: Radio direction finding

- All bands may be useful: MF, HF, VHF
- Directional antennas are most useful
- Walk around, tune around, triangulate

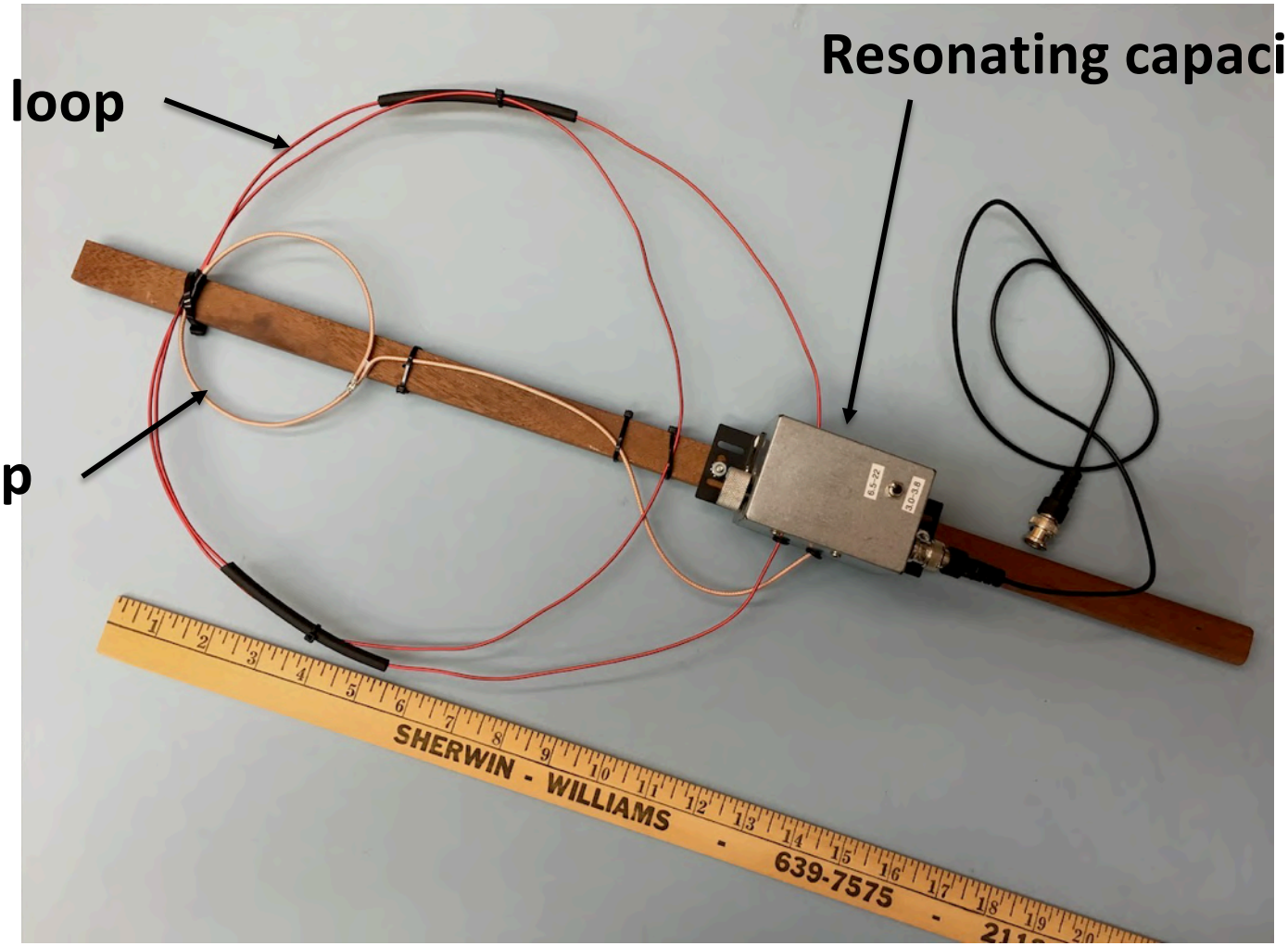
VHF Yagi

HF Loop

Sniffer Probe



Make a direction finding antenna!
Every club should have one. Easy to make.



See my RFI pages at NA6O.COM

Use a portable shortwave radio, HT or spectrum analyzer with your DFing antenna

Tecsun PL-660 or 880

Whatever radio you use, put it in AM mode for most noise sources

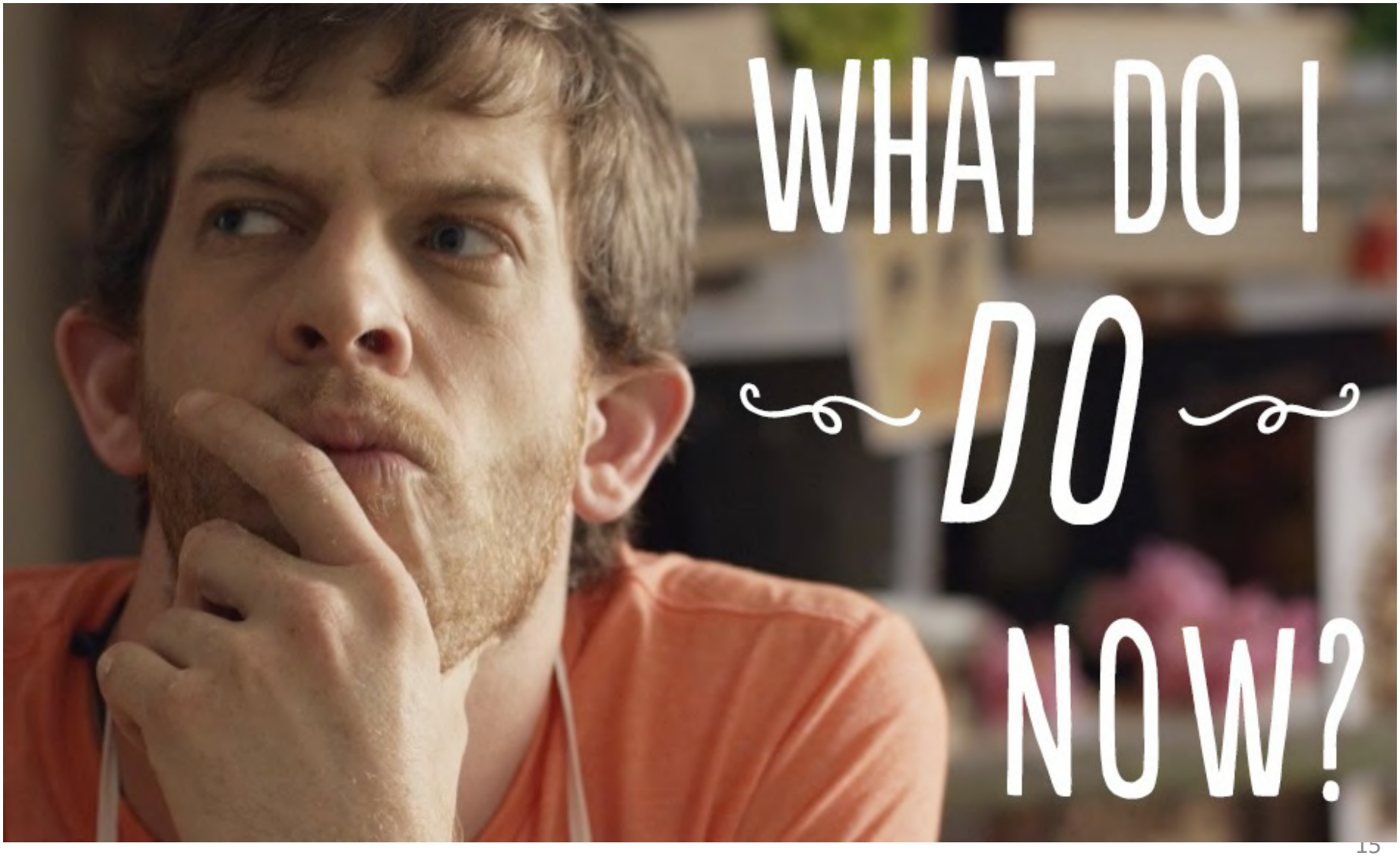
TinySA Spectrum Analyzer: Fantastic for noise finding!

$140 at R&L Electronics

Direction Finding

DEMONSTRATION

Now that you found it…



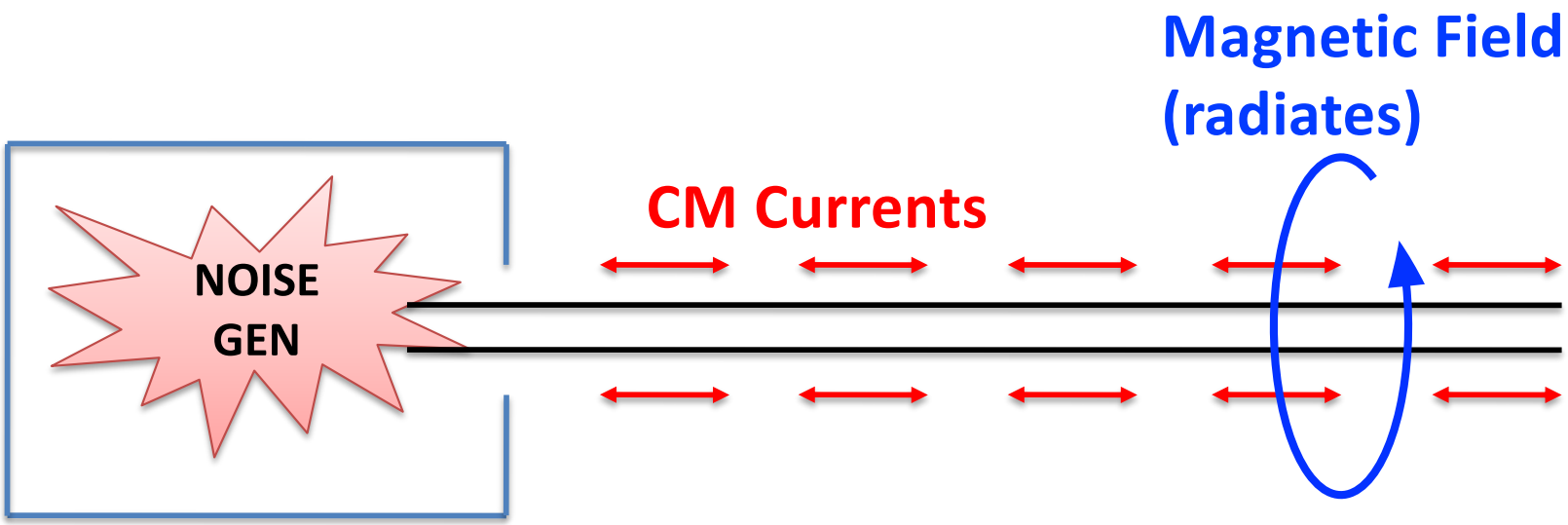
Well, you can do several things

- Remove the offending device
- Turn it off when you're operating
- Replace it with something less noisy
- Choke, filter, or shield it to reduce radiation
- Make your station more resistant to that interference

Here are some examples

Most noise is coupled through Common-Mode currents

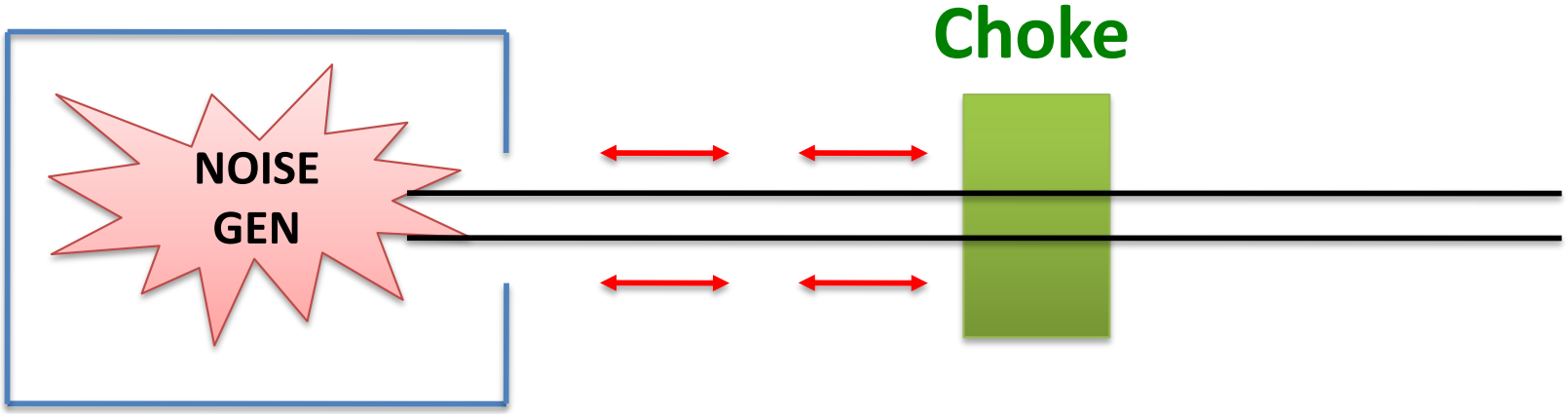
- Current that is common to all conductors
  - As opposed to normal-mode or differential signals
- Current on the lines gets **out of** or **into** equipment



- **Current in a wire <=> electromagnetic radiation**
- **Longer wire = better antenna**

Common-mode chokes (or transformers) can stop most of these currents

- Insert a high impedance in series with all conductors
- Reduces CM current while passing normal-mode (differential) current



- **Less current = less radiation**
- **Choke close to device = shorter antenna**
- **Twisting wires also helps cancel magnetic field**

Most common-mode chokes are made of ferrite… high impedance and lossy

High-power choke (balun) for antennas

See K9YC.COM

Arch-nemesis: Wall-warts and other switching-type AC adapters

- Replace switching supplies with linear supplies (find them on ebay); run off your station's 12 VDC.
- Apply common-mode chokes and/or filters to AC line and DC line
- Plug them into a choked outlet strip

Not all are defective but always be skeptical

LED lights contain switching power supplies
Some are HORRID for RFI. Fixtures are the worst.

- Usually can't fix this. Must replace them.
- Best bet: Only buy trusted name brands that actually pass FCC certification
  Bulbs by GE and Feit are proven good

Real data and recommendations on my RFI website:

https://www.na6o.com/main/RFI.html

Mobile: Inverters can be very noisy

This is what it took for K9YC to fix his Samlex 120V 1A inverter

Uninterruptible power supplies... Some are ok, others not so good

Cyberpower 1500 VA models are proven quiet

This is the just one of 5 chokes we needed to clean up a very expensive Tripp-Lite UPS

Defective power strips: Can generate noise, intermodulate like crazy

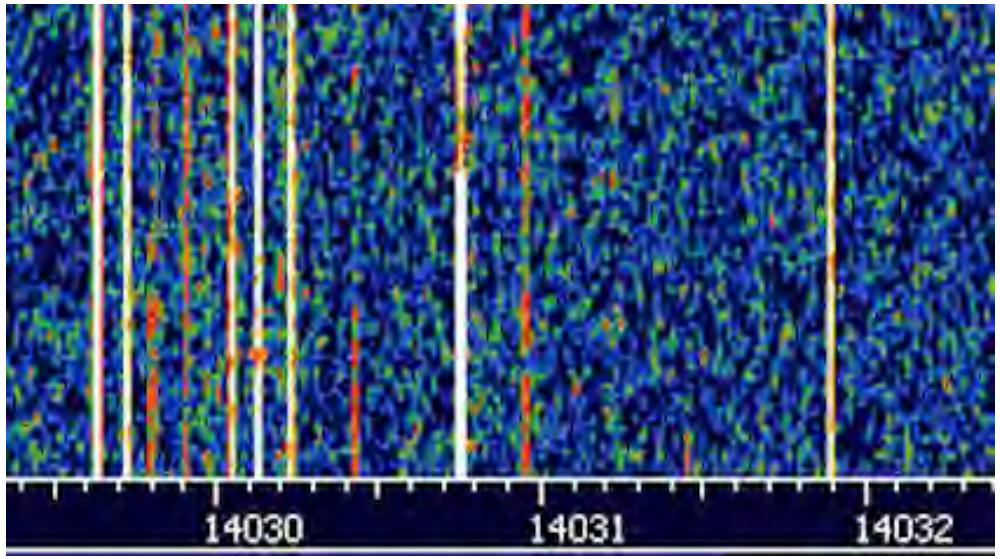
- 90% of these are total crap!!!!
  - Besides being likely noise generators, many are poorly made and just plain unsafe
- *Surge suppressor* types are the worst
  - Many active components, MOVs

A safe choice: Waber

- All metal enclosure
- Quality outlets
- No electronics

Ethernet cables can radiate groups of birdies all over the HF bands

- 10/100 is worse than GigE
- Upgrade all equipment to GigE or go WiFi
- Apply chokes near each end of long cables



Typical 20m birdies

13 turns, 2.4" type 31

Plasma TV… Thankfully they are falling out of favor

- Video-modulated interference with wide bandwidth on multiple HF bands
- Radiates from the screen!
- Only solution: Get rid of it.

Failing electrical equipment can be tracked and fixed

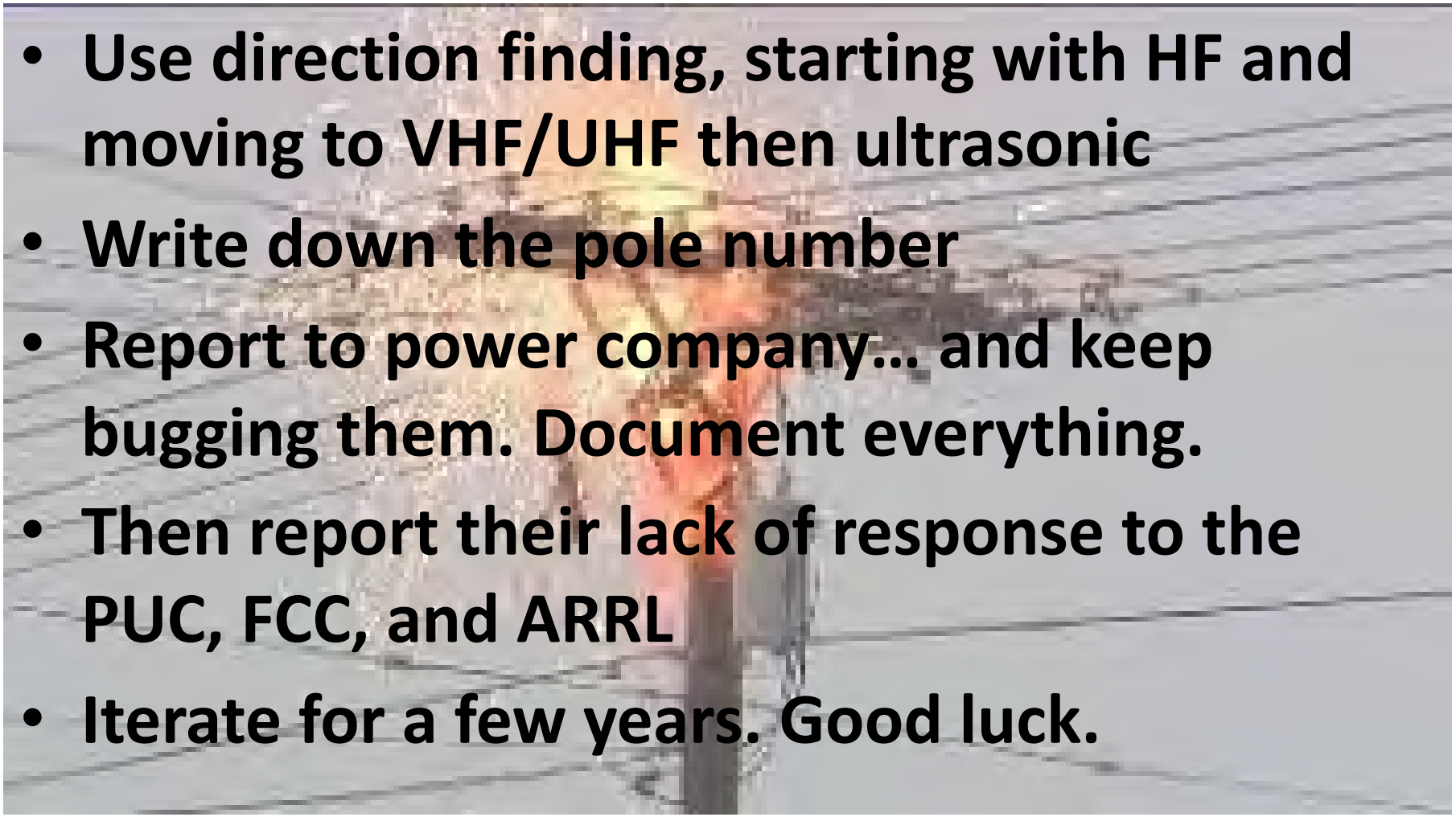
- Fluorescent lamps—replace the bulb
  - **FCC Class A (non-consumer)** switching ballasts are also well-known for generating RFI
- Flickering street lights—call the city
- Bad capacitor on an A/C compressor

Heaven forbid that it's a neighbor's solar panel system

- Can be difficult and expensive to fix
- See *QST* article, April 2016
- SolarEdge "Power optimizer" modules are worst offenders but not often installed
- Some are ok, particularly Enphase, Fronius, and SMA inverters

Every system generates *some* noise…
Death by 1000 cuts

HV power line interference is often challenging to locate and fix



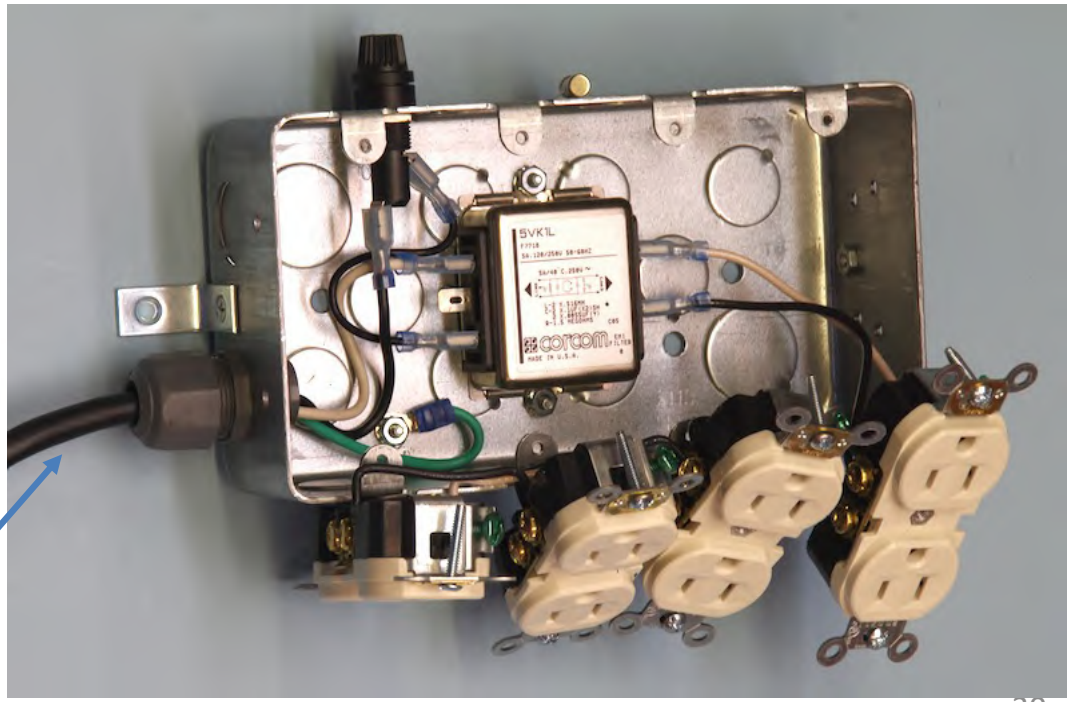
- Use direction finding, starting with HF and moving to VHF/UHF then ultrasonic
- Write down the pole number
- Report to power company… and keep bugging them. Document everything.
- Then report their lack of response to the PUC, FCC, and ARRL
- Iterate for a few years. Good luck.

Filtering AC lines can be effective, but more difficult and expensive to install

- Requires fabrication of a **safe** 120 VAC enclosure, or embed the filter inside of equipment

Corcom, Schurter, Delta

Wall Wart "Island"



Also add a big CM choke on the line cord

Reduce your station's susceptibility to noise

- Common-mode chokes on transmission lines and other conductors
  - Prevent radiated noise from getting to your RX
- Low-noise receiving antennas
  - As a rule, horizontal is better than vertical polarization for local QRM rejection
  - A low dipole can be a good/cheap RX antenna
- Use your rig's Noise Blanker (NB) and Noise Reduction (NR) features

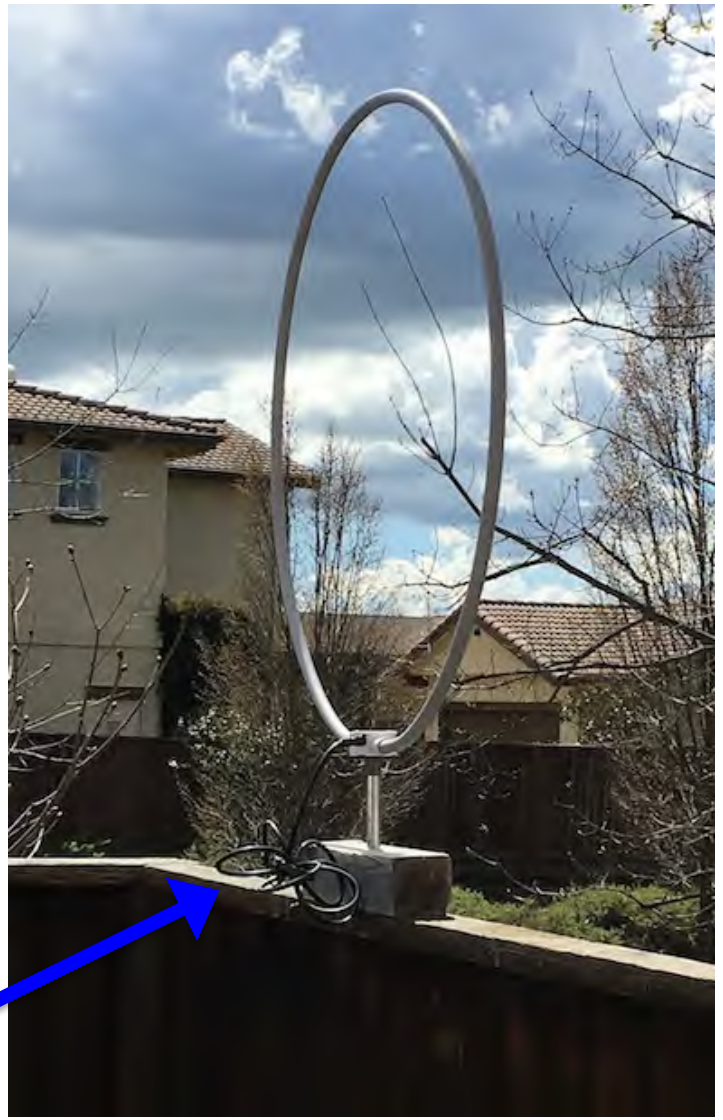
Ferrite common-mode chokes can benefit nearly any antenna

- Noise on the outside of coax shield is conducted to the antenna then to your RX
- An EFFECTIVE choke (balun) is required at the antenna feedpoint

K9YC.COM Article "RFI, Ferrites, and Common Mode Chokes For Hams"

Low-noise receiving loop rejects near-field RFI (less than one wavelength away)

- Covers all HF bands
- No tuning required
- Orient to null out QRM
- Some makers:
  - Wellbrook
  - Pixel Technologies (DXE)
- Resonant loops are also very good



Myth: "I need a better RF ground to reduce my noise"

- **Fact:** There is no such thing as an RF ground, due to wavelength, inductance, skin effect.
- **Fact:** A connection to Earth almost never reduces noise or RFI, and it will often make it worse, because the "ground wire" can act as an antenna.
- **Fact:** A connection to Earth is very important for lightning protection.

See: ARRL, *Grounding and Bonding for the Radio Amateur*

As a licensed ham, the FCC grants you legal rights (and responsibilities)

- Devices that **cause** harmful interference are at fault and the operator (owner) is legally responsible for fixing it
- Devices that **cannot accept** interference from licensed and legally-operated services are handled the same way
  - So make sure your transmitter is clean

- **As a goodwill gesture, you should always help.**
- **ARRL is your best resource for serious RFI.**

References

- ARRL: *The ARRL RFI Handbook*
- ARRL RFI pages http://www.arrl.org/rfi
- ARRL: *Grounding and Bonding for the Radio Amateur*
- Jim Brown, K9YC
  - http://k9yc.com/publish.htm
  - RFI, Ferrites, and Common Mode Chokes For Hams. Also his **choke cookbooks**.
- Dave Cole, NK7Z
  - https://www.nk7z.net "I Have RIF" pages
- Gary Johnson, NA6O
  - https://www.na6o.com/main/RFI.html

Part numbers and sources for type 31 ferrite

1.1 inch, Fair-Rite 2631801202 ($1.50)

2.4 inch, Fair-Rite 2631803802 (about $6)

4 inch, Fair-Rite 2631814002 (about $21)

Large clamp-on (1” ID) Fair-Rite 0431177081 (about $12)

mouser.com, proaudioeng.com, KF7P.com, arrow.com, newark.com Consider group buy!

Avoid: Palomar Eng., Amidon, DX Eng.... way too expensive!

Epilogue: My own RFI disaster

- 23 LED fixtures installed next door
- Worked with ARRL, FCC, tried to fix
- New neighbor added even more stuff…..
  - Home station is now QRT
- See my RFI page for the full story


My final solution: Go remote!
@W6SRR