Radio Noise

By Jerry Spring VE6TL – February, 2024

Outline

- What is radio noise (RFI) ?
- Identifying noise
  - Interior vs Exterior Sources
- Eliminating/Reducing Noise
  - Common Vs Differential Mode Currents

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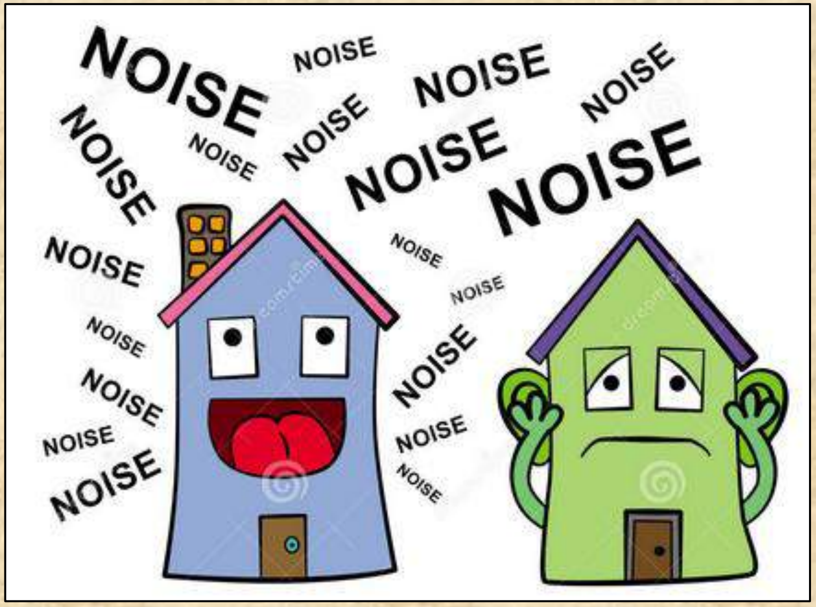


What is Radio Noise?

Radio Noise Definition: **"Unwanted random or coherent EM signals present in a radio receiver, in addition to the desired radio signal"**

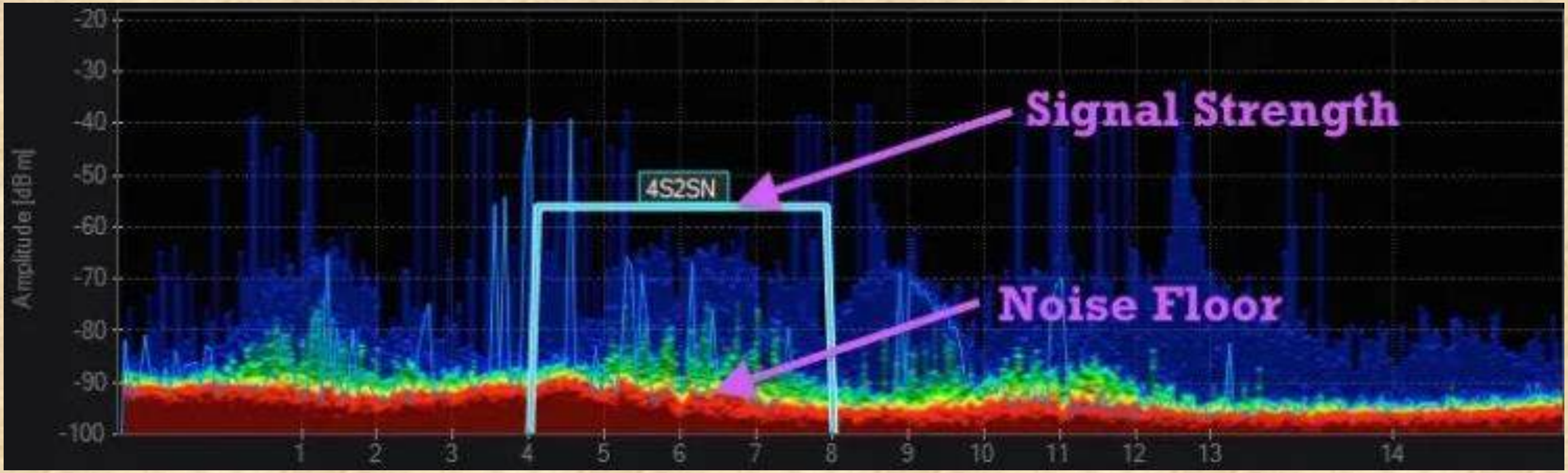
Radio noise may come from three separate sources:

1. Naturally generated signals (cosmic, atmospheric, etc.)
2. Manmade (RFI) from other electrical devices picked up by the receiver's antenna
3. Thermal noise present in the receiver, caused by random thermal motion of molecules

In order to receive a signal, it must be stronger than the noise surrounding it.

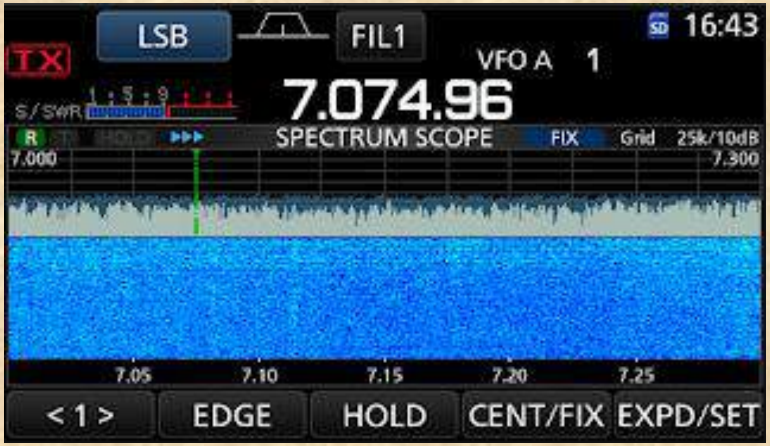
Noise Floor Definition: **"Total amount of noise surrounding a signal". If the signal is weaker (lower) than the noise floor, it's gone. Also referred to as "ambient noise floor".**

More on Noise Floor:



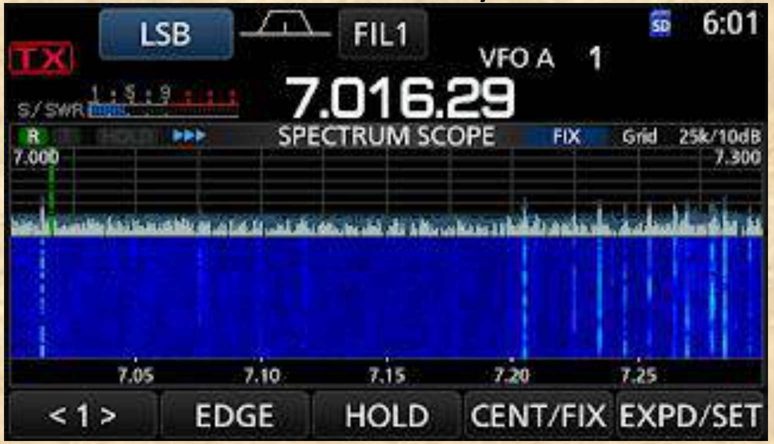
Courtesy John Fallows *play.fallows.ca*

Broadband S9 Noise



Courtesy Peter B Marks blog.marxy.org

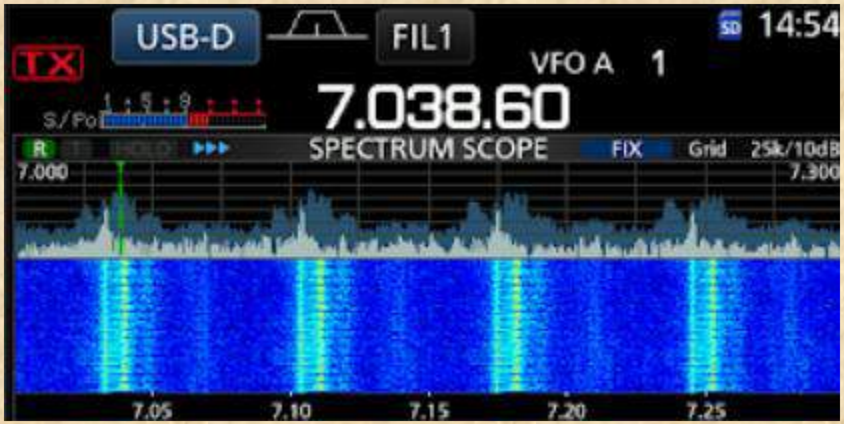
Other times – Very low noise

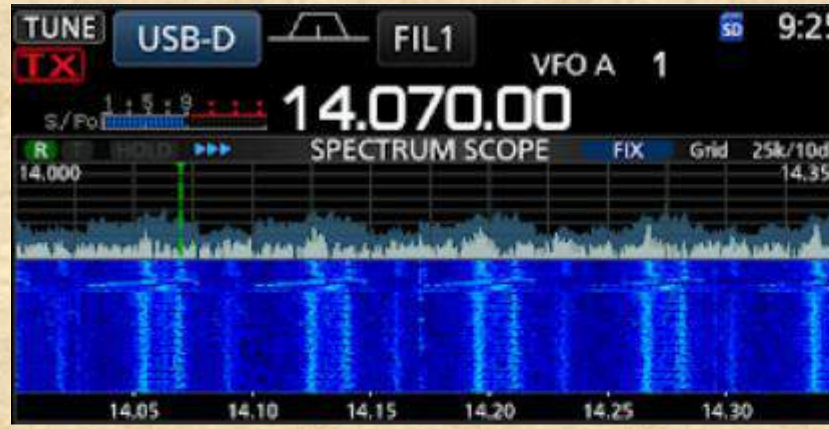


Courtesy Peter B Marks blog.marxy.org

Common Noises:

Switching Power Supply Noise – Across All Bands





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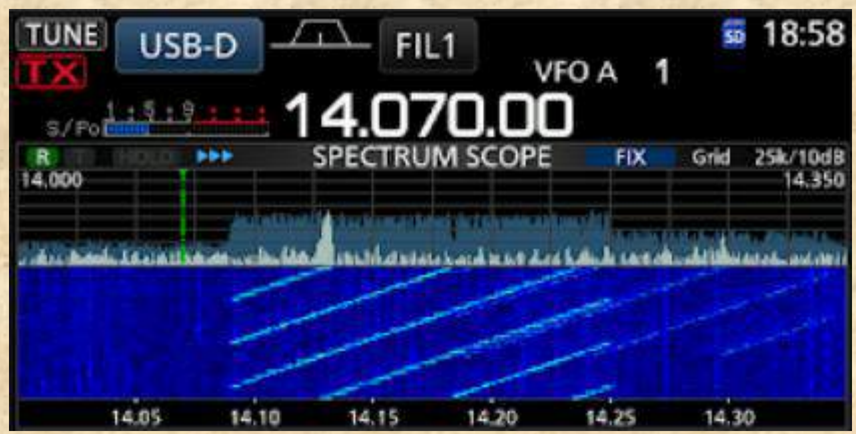
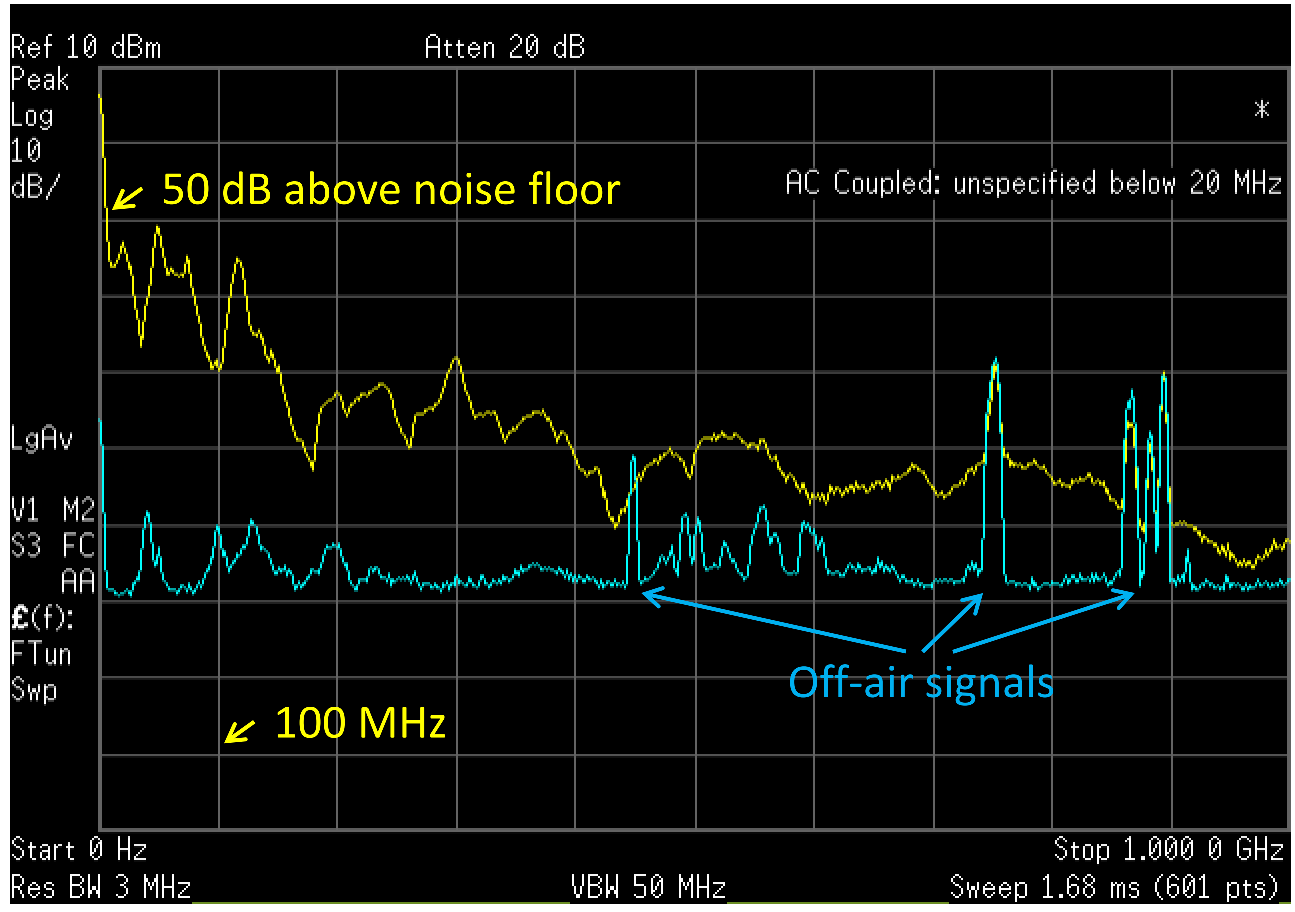
Over the Horizon Radar?



Courtesy Peter B Marks blog.marxy.org

LED Floodlight/Grow light:

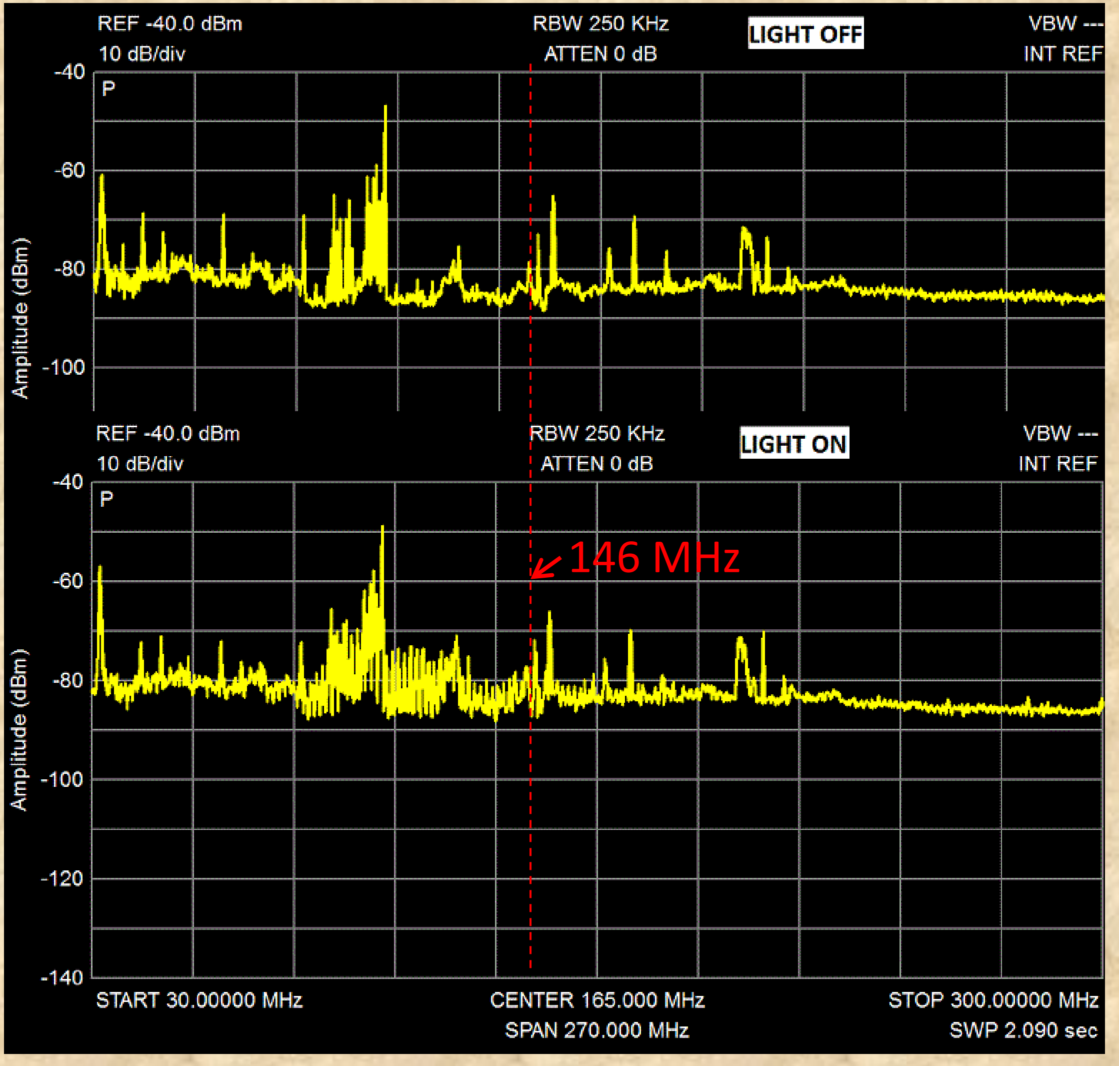


Yellow trace = LED ON, Blue trace = LED OFF

LED-generated noise decreases with frequency (in general)

Courtesy KA7OEI's blog ka7oei.blogspot.com

LED EMI Issues: VHF



LED-generated noise can still be considerable at VHF

Other RFI Sources:

- Power line noise
- Touch control lamps
- Clean air machines
- Solar power systems (inverters)
- Improperly shielded microwave ovens
- Baby monitor
- Medical equipment
- Appliance chargers (toothbrush, shaver, etc.)
- Electric motors
- Battery chargers
- Switching power supplies (wall warts)
- Door bell transformers
- Electric blankets
- Heating pads
- Recessed lighting fixtures
- Furnace control circuits
- Refrigerators
- Light Dimmers
- Fluorescent lights
- Ethernet networking cables, switches, etc.

Steps to Solving Noise Problems

Step 1: Identify the type of noise
Step 2: Try to locate the noise emitter (source)
Step 3: Attempt to eliminate or minimize at the source

Practice Good RFI Elimination Design:

- Bonding
- Grounding
- Shielding
- Filtering

RF in the Shack?

- Shock from microphone
- Fuzzy/distorted audio modulation
- Electronic keyer sending wrong characters
- Crazy SWR readings
- PC goes crazy
- Desktop monitor jitters
- Unconnected LEDs on while transmitting
- Buzzing in headphones/speakers
- Disappears with low RF power output

All are symptoms of poor bonding

Bonding

- Keep all equipment at same potential
- Avoid ground loops and daisy chains using single point shack ground
- Install ground wire as far from main house wiring as possible
- Keep bonding wires short
- Use heavy duty copper wire

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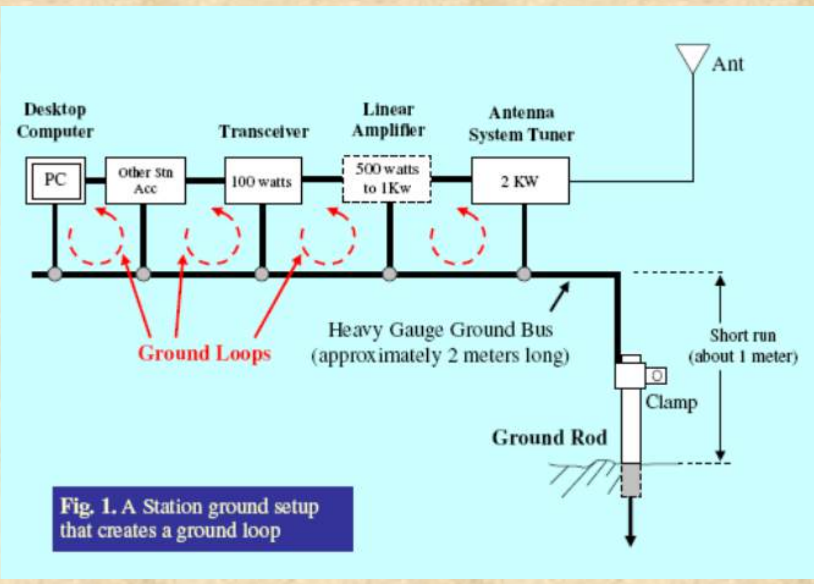


Fig. 1. A Station ground setup that creates a ground loop

Excellent DC ground system but very poor RF ground!

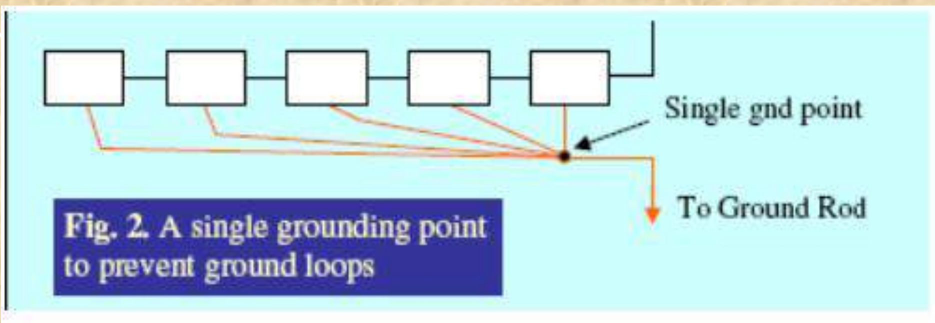


Fig. 2. A single grounding point to prevent ground loops

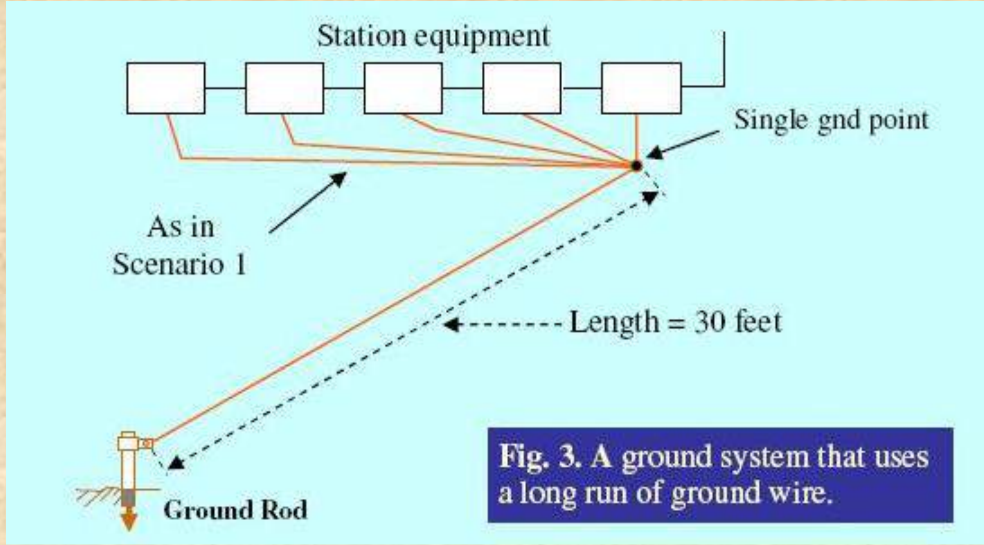
Better Bonding

* https://wd7ale.wordpress.com/grounding-and-bonding/

Grounding

- Locate ground rod as near to shack as possible (< ¼ wavelength for operating)
- Locate ground rod as far away as possible from nearest neighbour's house
- Can use hot/cold water pipe for grounding (controversial)
- Install ground wire as far from main house wiring as possible
- Use heavy duty copper wire (Min 8 AWG)

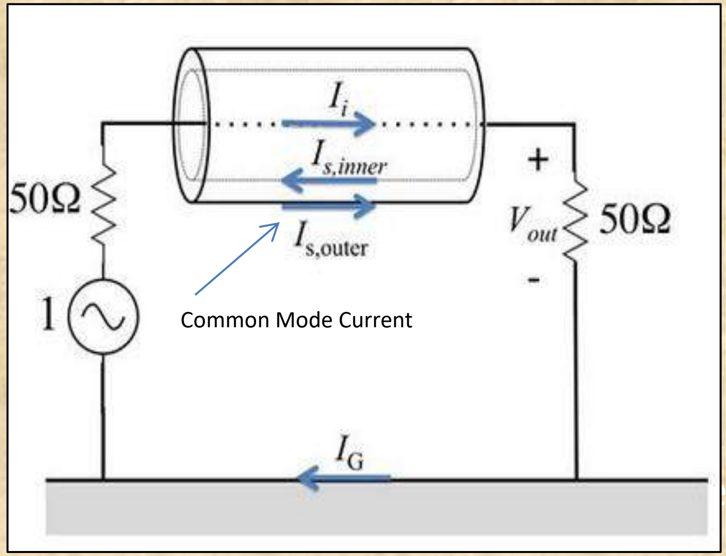
*



RF Ungrounded Ground System

* https://wd7ale.wordpress.com/grounding-and-bonding/

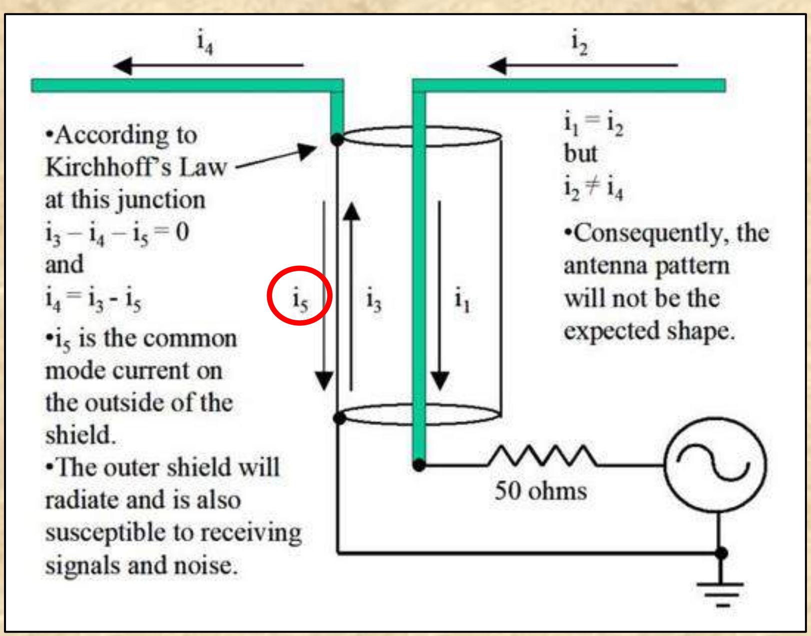
I'm still getting RF in the shack…



Unbalanced Coaxial Transmission Line

- RF travels near the surface of a conductor (Skin Effect)
- The conductor "depth" that the RF uses for propagation along the conductor decreases as frequency increases
- Coaxial cable, for RF, has 3 conductors: center wire, inside and outside of shield
- The RF currents in the center wire and inside of shield travel in opposite directions (differential mode)
- Common mode current runs on the outside of the shield, induced by a noise source or from near-field antenna radiation
- Common mode current can generate noise in your receiver, make your mic "hot" (voltage-wise), give erroneous SWR readings, hang your PC, etc.

More on Common Mode Currents



- One side of our dipole antenna is connected to the shield
- But the current traveling in the shield may split between the antenna and outside of the shield
- With current in the center and outside of the shield flowing in the same direction, the coax acts like a single wire transmission line, with the outer shield radiating and receiving power quite nicely in common mode
- Currents on the antenna halves are assymetric, corrupting the radiation pattern
- Current on the outer shield may be returned to the chassis of the transmitter (ouch)

Remedy for Common Mode Currents

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- **Convert unbalanced coaxial line to a balanced line where it feeds the antenna and provide a means of suppressing current i5.**
- **The choke balun effectively disconnects the inner shield from the outer shield so most of the current will no longer flow on the outer shield**
- **May not completely block the common mode currents, so may still require another choke at another current maximum on the coax outer shield close to the entrance to the shack (found using a clip-on antenna probe – like MFJ 854)**
- **Burying some of the coax may also help**

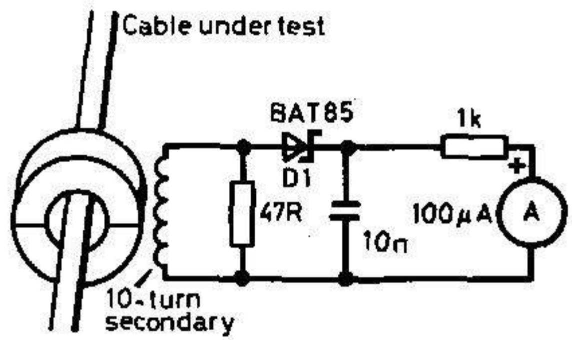
MFJ Clip-On RF Current Meter

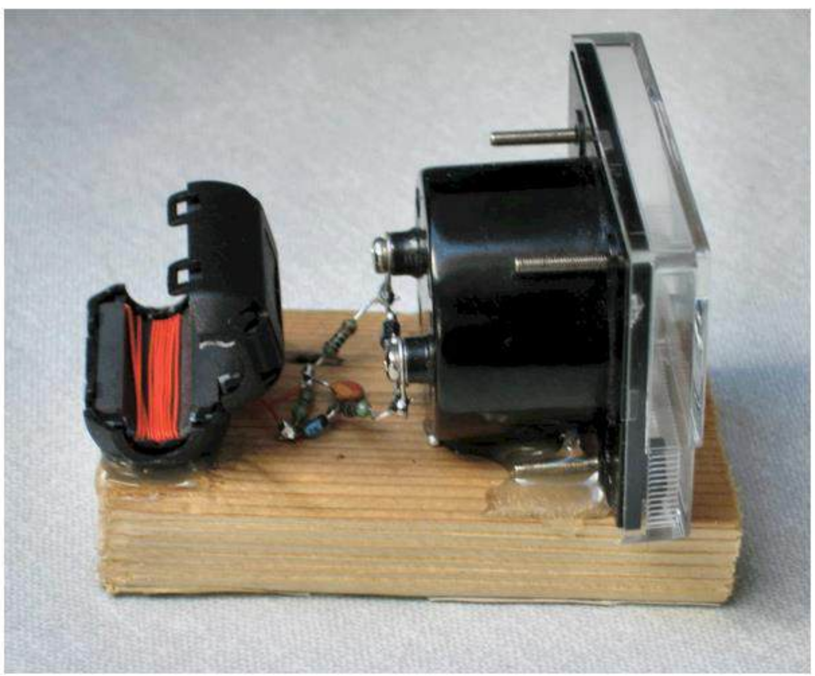
US$159.95

The MFJ-854 RF Current Meter reads true RF current!
It can accurately measure actual RF currents flowing in antenna elements, radials, ground wires and on the outside of coax feedlines. Study and optimize your antenna for peak performance.
Its also great for tracking down RFI causing currents on household wiring and cables.
MFJ-854s sense coil simply snaps over wires and cables for fast measurements on its easy to red meter.
You can select from five ranges to measure actual RF current from 30 mA to 3 amps full scale.
A sixth range has a variable sensitivity control quick, fast checks. At maximum sensitivity, RF currents of 1 mA or less will yield a usable meter deflection. This function is especially useful for tracking RFI pickup on household wiring and cables.
The MFJ-854 is sensitive enough to use an MFJ SWR Analyzer as the source to drive you antennas.

Home-brew Clip-On RF Current Meter

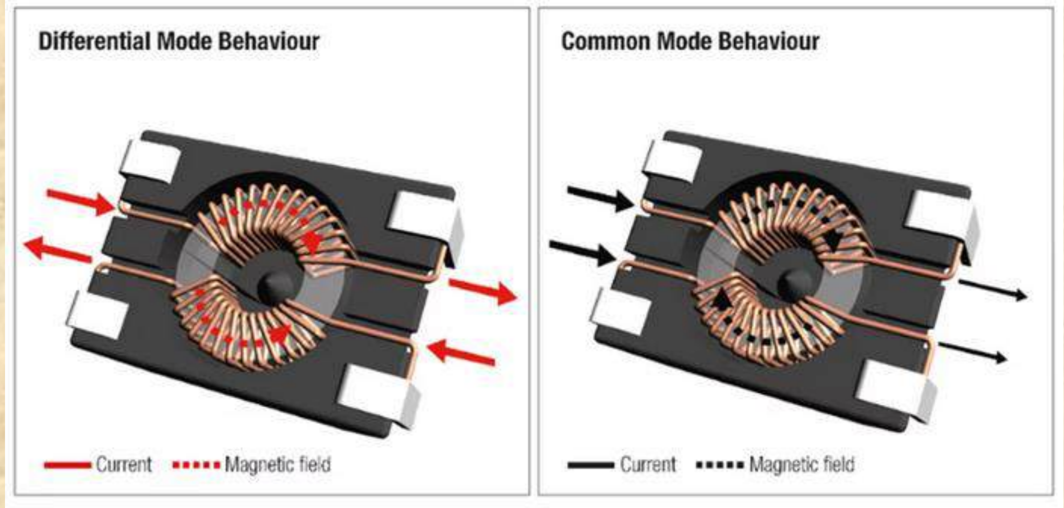
IFWTECH.CO.UK





- Assembled in half an hour
- The physical construction is ugly, but the RF construction isn't.
- The scrap wood wasn't entirely a joke. The base does need to be some kind of insulating material.
- D1 can be any small Schottky detector diode
- Make sure the core will still snap closed with the secondary winding in place. Thin enameled wire might be better than the wire-wrap wire that I used. If necessary, cut or melt away the inside of the plastic moulding to make space for the wire.
- Twist the wires from the core to the load resistor/detector, and keep the component leads very short as shown above.

How does a Common Mode Choke work?



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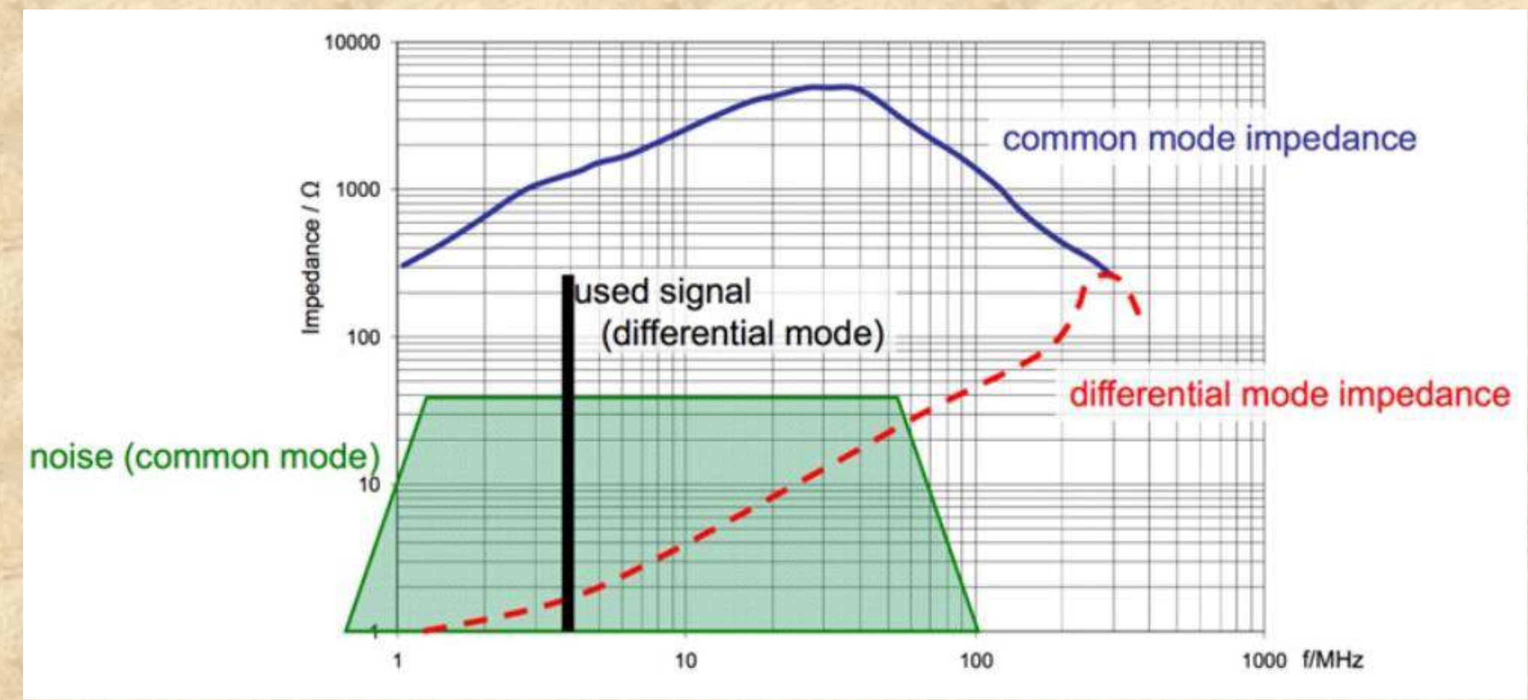
- A useful differential signal is input (red arrows) and creates a magnetic field inside the core.
- The differential signal returns to the source, creating a cancelling magnetic field in the core.
- Common mode noise also creates a magnetic flux inside the core but since both currents are in the same direction, the fields add together. The core responds with a high impedance to the unwanted noise.
- Filter chokes are designed to pass certain frequencies and reject others and are characterized by impedance vs frequency
- The best solution is to filter the noise close to the signal frequency

*** https://community.element14.com/products/manufacturers/wuerth-elektronik/b/blog/posts/emc-basics-common-mode-vs-differential-noise**

Common Mode Choke Example



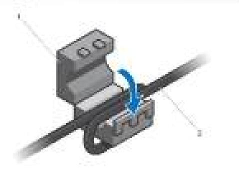
- The desired signal is centered around 4 MHz (black vertical line)
- The choke being used here has a high *common mode* impedance at 4 MHz and a low differential mode impedance at this frequency. The attenuation of the signal is minimal, while the attenuation of the common mode noise is high.
- When reading datasheets, it is important to check both impedances for your desired signal

*** https://community.element14.com/products/manufacturers/wuerth-elektronik/b/blog/posts/emc-basics-common-mode-vs-differential-noise**

Filtering – Ferrite Cores

- Most RFI problems are solved with a Common Mode core configuration





- Differential Mode core configurations are usually used only in DC applications
  - 12V DC inputs to transceivers
  - Ferrites will saturate – use iron powder or Molypermalloy
- Winding techniques:

<u>Coax</u>

<u>Bifilar</u>

<u>Segmented</u>

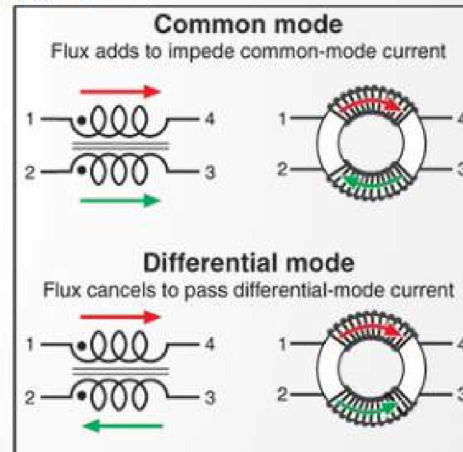
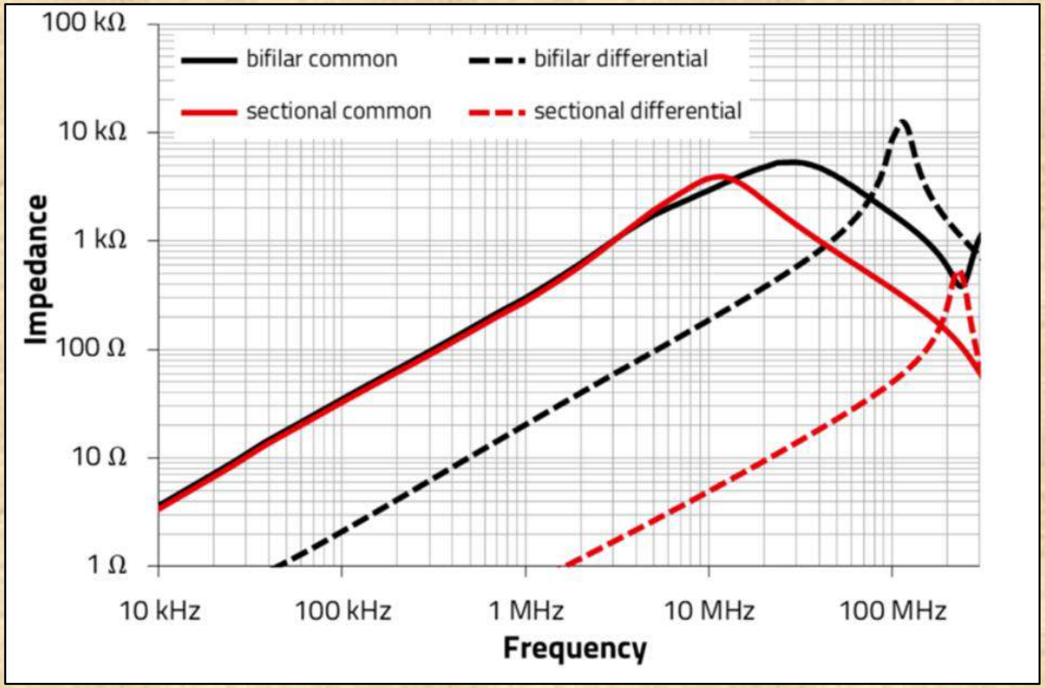


Figure 1. Magnetic flux paths

- Using ferrite makes a “low pass filter” on the cable it is applied to
- The ferrite dissipates the RF energy as heat in the core
  - Cores must be large enough to handle the dissipation caused by magnetic flux in the core when used as baluns or transmit feedline common mode chokes to prevent core saturation
- Turns on a core are counted by the <u>number of times the wire passes through the inside</u> of the core

*** https://community.element14.com/products/manufacturers/wuerth-elektronik/b/blog/posts/emc-basics-common-mode-vs-differential-noise**

Filtering – Ferrite Cores Cont'd



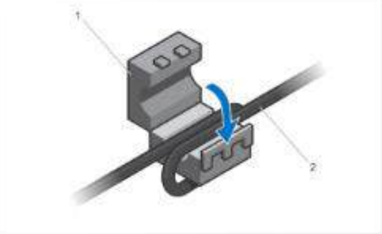
- Bifilar-wound parts are typically used for low voltage signal lines because we don't want to attenuate the differential mode signal
- Sectional/Segmented-wound components are most useful in power supplies because high voltage lines need to be separated a minimum distance. They can also be used as inductors to attenuate differential mode noise

*** https://community.element14.com/products/manufacturers/wuerth-elektronik/b/blog/posts/emc-basics-common-mode-vs-differential-noise**

Filtering – Ferrite Cores

- Toroid
- Bead
- Clamp on
- Ribbon cable
- Can be wound with a single or multiple turns
- Cores are made of various material 'mixes'
  - Mix will determine effective attenuation at various frequencies
    - Refer to data sheets



* https://wd7ale.wordpress.com/grounding-and-bonding/

Mixtures – Palomar Engineers

Mix #	Material	Initial Permeability	RFI/EMI Common Mode Suppression Range	Tuned Circuits – Coil	Wide Band Transformer
31 (1)	MnZn	1500	1-300 MHz	–	1:1 only, <300 MHz
43 (2)	NiZn	800	25-300 MHz	< 10 MHz	3-60 MHz
52 (6)	NiZn	250	200-1000 MHz	< 20 MHz	1-60 MHz
61 (3)	NiZn	125	200-1000 MHz	<100 MHz	1-300 MHz
73 (7)	MnzN	2500	< 50 MHz	< 2 MHz	<10 MHz
75/J (4)	MnZn	5000	150 KHz – 10 MHz	< .75 MHz	.1-10 MHz

Notes

(1) Mix 31 excellent for 1-10 MHz common mode suppression, then about same as 43 up to 250 MHz, NOT recommended for multi-ratio impedance transformers (baluns/ununs) due to material characteristics and power handling capability – ok for ham radio 1:1 feed line choke applications. Curie temperature >130 C. Mix 31 is available in **TOROIDS**, **SLIP ON BEADS**, and **SNAP ON SPLIT BEADS**

(2) Mix 43 excellent for common mode chokes from 25-300 MHz, Use Mix 31 below 10 MHz for higher choking impedance. Curie temperature >130 C.. Mix 43 is available in **TOROIDS**, and **SLIP ON BEADS**

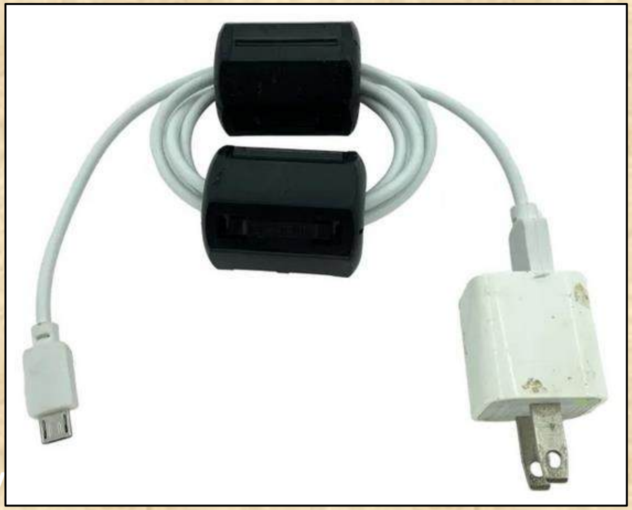
You want a mixture that covers the frequency range you are using (typically Mix #31)

Improving Results

When you go through the same bead or toroid more than once (loops), it multiplies the impedance, with each loop delivering better choking results.

When you use more than one core or bead, you multiply the amount of impedance by the number of cores/beads. Going through a set of beads or cores several times will multiply the amount of impedance of all the loops by the amount of cores/beads.

Improving Results Cont'd



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Ferrite beads in series – Often helps on antenna coax

Multiple ferrite beads and loops – You are only limited to the amount of beads you can install on the loop

The End

References

Standke, Randy E, “Identify and Track Down RFI”, QST, May 2019:
https://www.arrl.org/files/file/QST/This%20Month%20in%20QST/May2019/Standke2a.pdf

Jerry(The