



RFI Solutions from KHz to GHz

Quick & Easy RFI Solutions

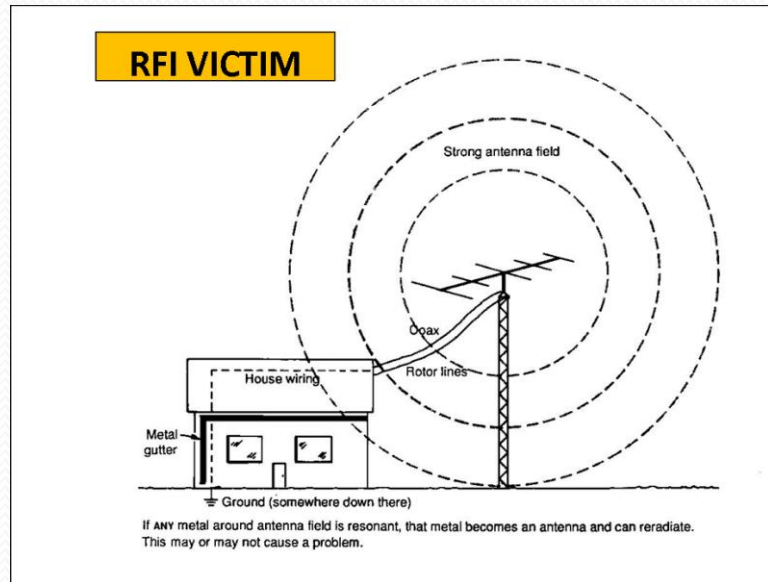


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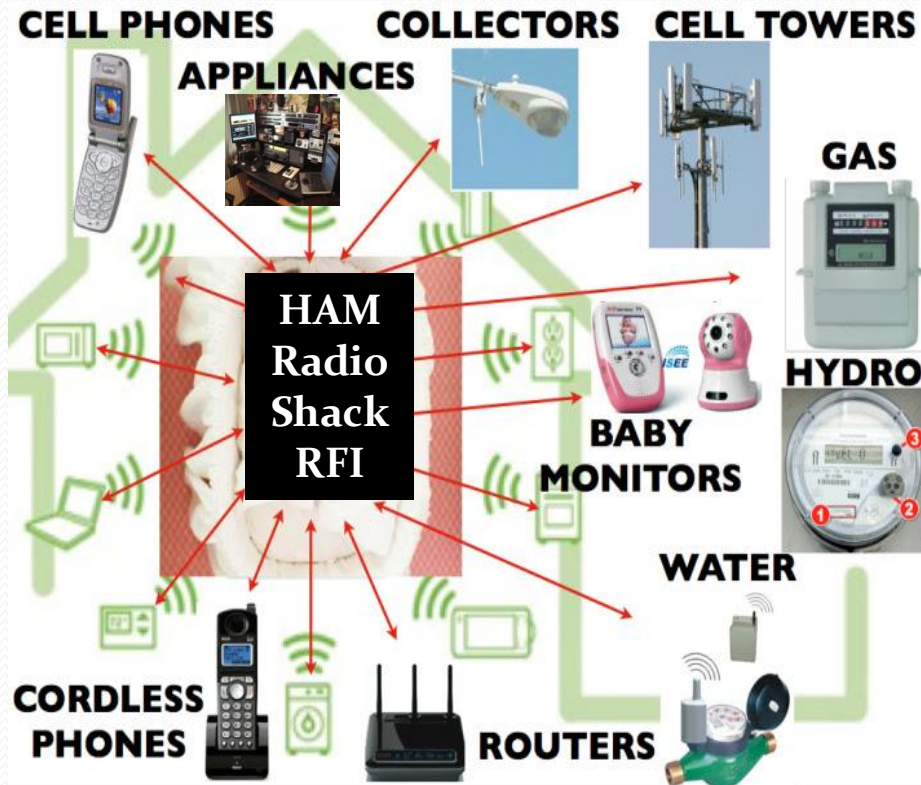
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Are you the **SOURCE** of RFI?



IT'S ALL YOUR FAULT WITH THAT BIG ANTENNA!

Are you a **VICTIM** of local RFI?



RFI Sources

- Ham Antenna
- Radiating Coax
- Electronic Devices
- Solar Systems
- Grow Lights
- HVAC motor
- Plasma TV
- DSL/Routers
- Switching power Supplies
- Washer/Dryer or other appliances

QRN - High Noise Floor – Weak Signals – NO DX – No fun!



RFI Workshop Objectives

- Understanding RFI - definition, symptoms, transmission paths, simple cures
- Ferrite Fundamentals - how to select, configure, and buy the right ferrite for your RFI issue
- How to suppress your transmitter RFI using ferrites
- How to reduce your receiver noise floor using ferrites
- Understand CONCEPTS with little or NO MATH required

Thinking cap time.....

RFI 101

What is RFI?

How is it transferred?

Typical Symptoms

RFI “Antennas”

RFI Cures

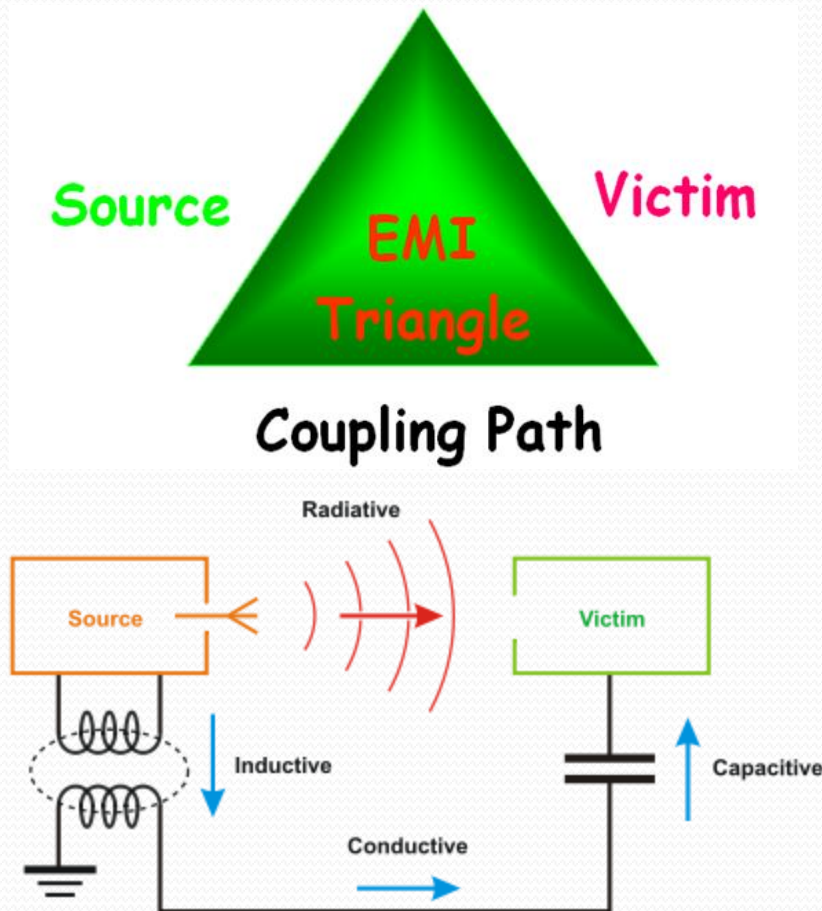


What is RFI?

- *A radio frequency disturbance that causes an electrical circuit to function improperly*
- Common Sources
 - Sunspots, Cosmic noise, Lightning, atmospheric static, AC power lines (no fix)
 - “Transmitters” -Ham, CB, AM/FM, electronic devices, speed controllers, inverters, switching power supplies, computer electronics, Cable/DSL/Ethernet (can use filters to suppress)
- Common Victims
 - Any electronic device that malfunctions by acting as an unintended “receiver” of RFI

How do you get RFI?

How RFI is Transferred



Source (antenna) and **Victim** (antenna) coupled via **Path** (all must be present to have RFI)

Multiple paths are very common:

1. Radiative - air
2. Conductive – wire(s)
3. Inductive - wire
4. Capacitive - wire



How to find the source & path

Typical RFI in your shack/home

- **TX Symptoms** – caused by your transmitter or antenna
 - Hot microphone – lip burns, distorted audio
 - Antennas don't tune correctly, high SWR, radiating coax
 - Your voice/transmission causes interference with consumer electronic devices acting as ham radio frequency “receivers” (e.g. computers, TV/audio system, security system, garage door opener, telephone, sprinkler systems, lights, etc.)
 - Wife Alarm goes off
 - **RX Symptoms** – caused by sources outside your radio
 - High receive noise level not due to atmospheric conditions
 - Birdies, chirps, buzzes, clicks, broadband noise on receiver
 - Distorted receiver audio
- “Antennas” & paths

Typical RFI receiving “antennas”

- AM broadcast, 160-80-60-40-30 meter RFI – long “antennas” - AC power lines, telephone/DSL lines, satellite/cable coax, long Ethernet cables, antenna feed line coax shield, antenna control/rotor cables, 2nd story ground wires (avoid $\frac{1}{4}$ wavelength ground wires)
- FM broadcast, 20-2 meter transmitters, – short “antennas” - speaker wires, device interconnect cables, mic cables, short Ethernet cables
- “Antennas” pick up radiated or conducted RFI and a common mode current is induced on ALL antenna conductors from an RFI SOURCE

How do we reduce this current?

Curing RFI Issues



$I \text{ (RFI Current)} = E \text{ (constant)} / R \text{ (Choking resistance)}$

- Shut down the SOURCE (Set E to zero)
- Choke the PATH (minimize E, set R high)
- Protect the VICTIM (Set R very high)

Objective: Minimize RFI current, I

Using ferrites to cure RFI



Ferrite Fundamentals

How to select, buy, configure and apply



Ferrite Topologies (Shapes)



Slip On Bead



Snap On Bead



Toroid or Ring



Fuzzy Ferret – not!

CHARACTERISTICS

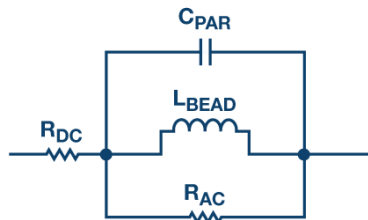
- Cheap, easy to install, suppress RFI from 100 KHz - 2 GHz
- Work on all conductive paths (antenna feed line, AC/DC, I/O cables)
- Lots of options in size, shape to suppress most RFI path currents
- Are effective if you understand how ferrites work, how to choose the correct ferrite and where to install the ferrite for a particular RFI problem

Ferrite characteristics can be used to reduce RFI common mode current

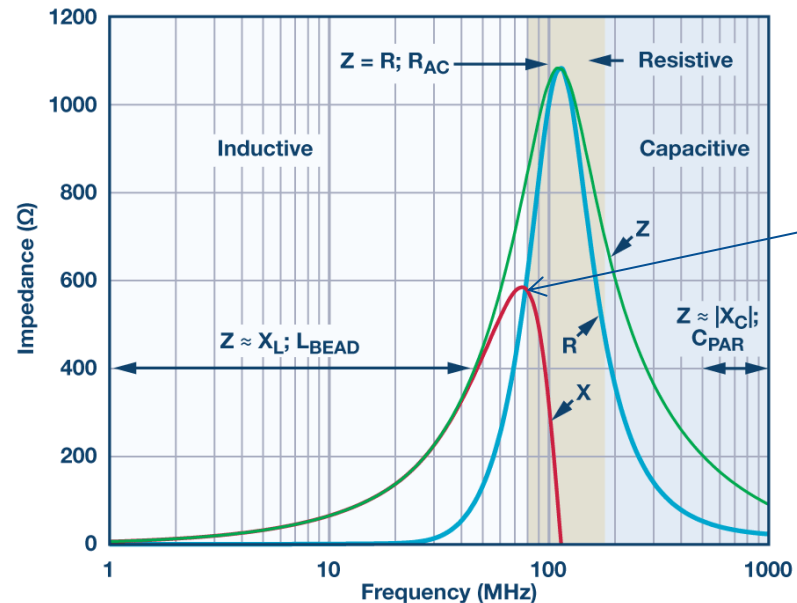
How do Ferrites Work?

Simple Equivalent Circuit – parallel tuned circuit with a high impedance resonance

Acts like a frequency dependent resistor to RFI



(a)



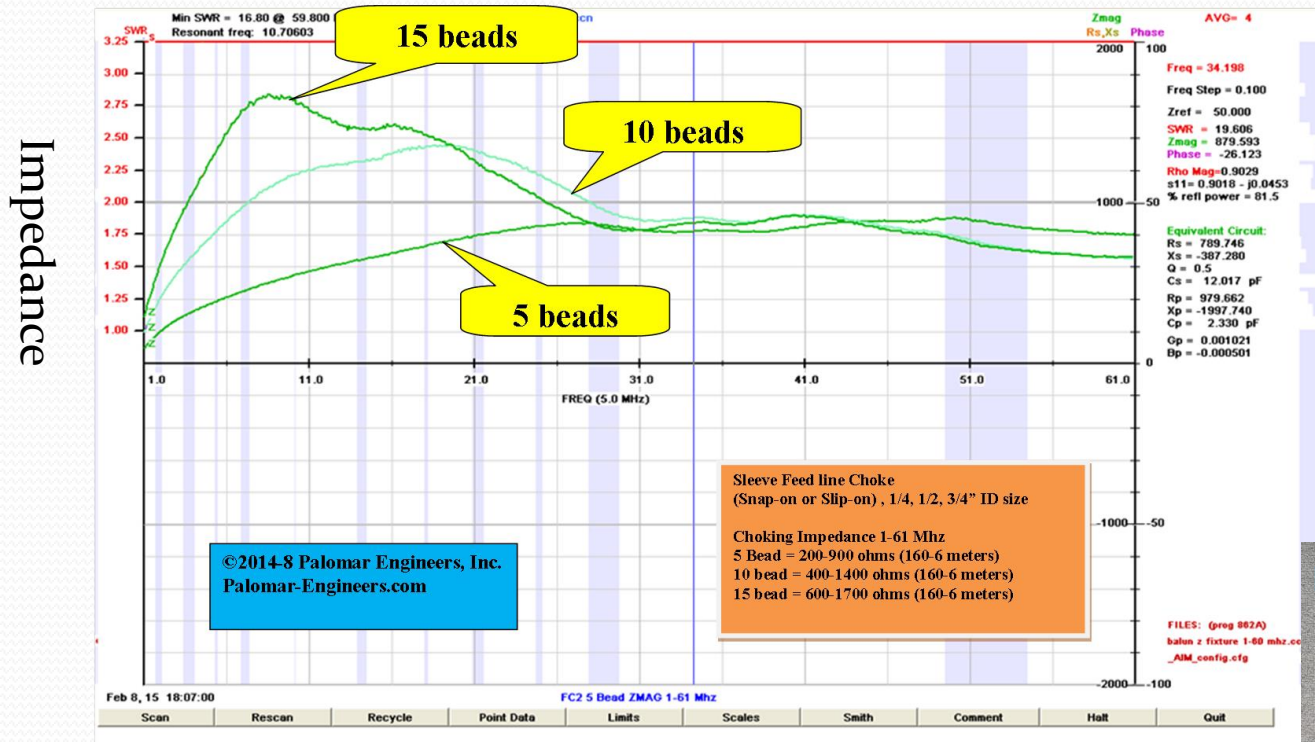
Resistive region starts here – 80 MHz to 300 MHz

(b)

Ferrite beads are categorized by three response regions: inductive, resistive, and capacitive. ***To reduce high frequency interference (noise), the bead must be used in the resistive region where it acts like a resistor, which impedes the common mode current (noise) and dissipates it as heat.***

Objective: reduce common mode current by increasing choking resistance

Ferrite resistors add in series



More beads =

higher choking R
(up to 30 MHz)

At 7 MHz:
5 beads = 400Ω

10 bead = 1000Ω

15 beads = 1600Ω



Frequency →

$$\text{Impedance (Z)} = \text{Resistance} \pm \text{Reactance}$$

Choking Z Increases with (turns)²

- If 1 turn = Z , 2 turns = $4 \times Z$, 3 turns = $9 \times Z$
- More Z = less RFI wire current = less RFI radiated from wire or induced into wire. ($I=E/Z$)
- **General rule: choking $Z > 10X$ line impedance**
- (e.g. $> 500 \Omega$ for 50Ω cable but 5000Ω is 10x better)



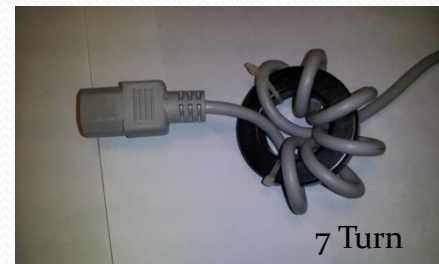
1 Turn

7 MHz: 100Ω



3 Turn

900Ω

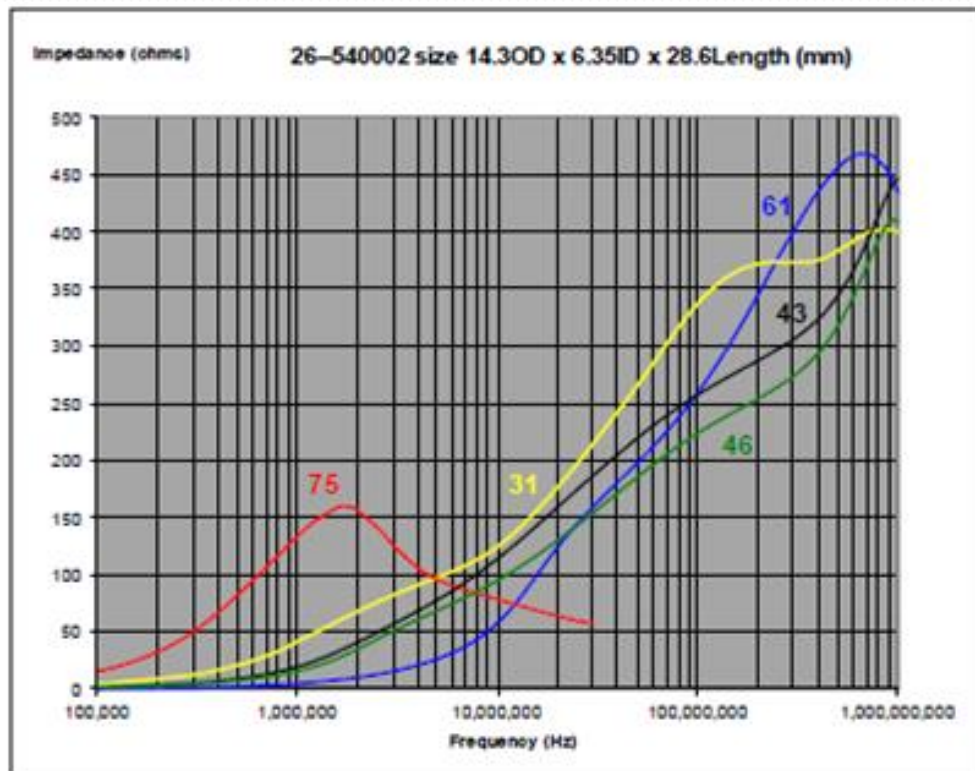


7 Turn

2500Ω

Question: How do we choose the correct ferrite for the RFI frequency?

Ferrite Mix determines frequency range of effectiveness



Mix = chemical formula of the iron oxide with manganese-zinc (31, 75) or nickel-zinc (43, 61)

Select mix for max Z at RFI fundamental frequency NOT frequency of receiver.

Example:

for .1-10 MHz use mix 75/77

for 1-300 MHz use mix 31

for 20-250 MHz use mix 43

for 200-2000 MHz use mix 61

Most popular ham frequency mixes are 31, 43, 61, 75, 77.

Wrong or unknown mix will probably not work so.....

Know how to buy

How NOT to buy ferrites!



=

DON'T

BUY!!!

- NO Mix Designation
- NO Impedance Range
- NO Frequency Range = No No No!

Buying unknown ferrites is like buying a box of rocks - a waste of time and money!

How to buy Ferrites the right way



RFI Solutions from KHz to GHz



Ferrite Split Beads
10 Pack -1/2" ID
RFI Range: 1-300 MHz
Mix 31
Single turn, each bead provides:
71Ω/5 MHz, 100Ω/10 MHz
156Ω/25 MHz, 260Ω/100 MHz,
260Ω/250 MHz

For: AC/DC Power, Coax, Ethernet, Audio/Video Cables

Multiple turns for best results

Part # FSB31-1/2-10

=

**BUY With
CONFIDENCE!!**

Product Labeling (Mix, Frequency, Impedance) + Known Vendor = Winner!

So let's recap RFI 101

Ferrite Use Recap

- Determine RFI interfering frequency & suspected Path
- Choose proper mix (31, 43, 61, 75/77) to suppress RFI fundamental frequency
 - Choose Topology(slip, snap, ring) to fit the Path
 - Install ferrites – retest for RFI suppression
- Consider additional ferrites or Paths if RFI persists

Most popular Mix for HF is MIX 31 (1-300 MHz)
(Mix 75/77 for .1-10 MHz, Mix 61 for 200-2000 MHz)

How and where do you put the ferrite band aid - transmitters?

Transmitter RFI Solutions

Practical Tips to minimize transmitter source RFI



Tip #1 - Install Transceiver, Linear Amp RFI Filters

Our Goal: Minimize SOURCE RFI from radio and amplifier “antennas”



RFI Chokes for Transmitters/Amps

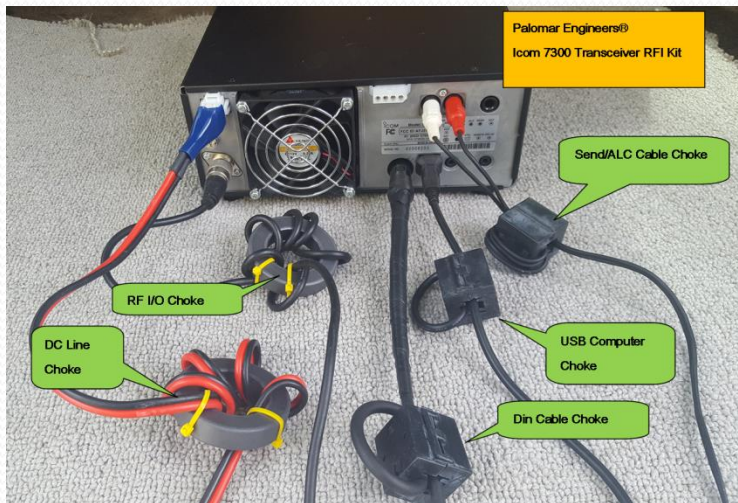
- Transmitter – Amplifier - Antenna RFI suppression
 - Choke all cables into/out of radios, amplifier, antenna tuners
 - Includes
 - ALL Coax RF feed lines or common line of coax switch
 - Rotor/Antenna Control lines
 - AC/DC power Lines including wall warts!
 - Computer – all radio interconnects, AC power
 - Examples on next slides
- Recommendation: Filter ALL power cables to equipment and buy Palomar transceiver, amplifier and computer RFI kits with mix, sizes, instructions already determined.

Transceiver/Amp Examples

Transceiver/Amp RFI Kits

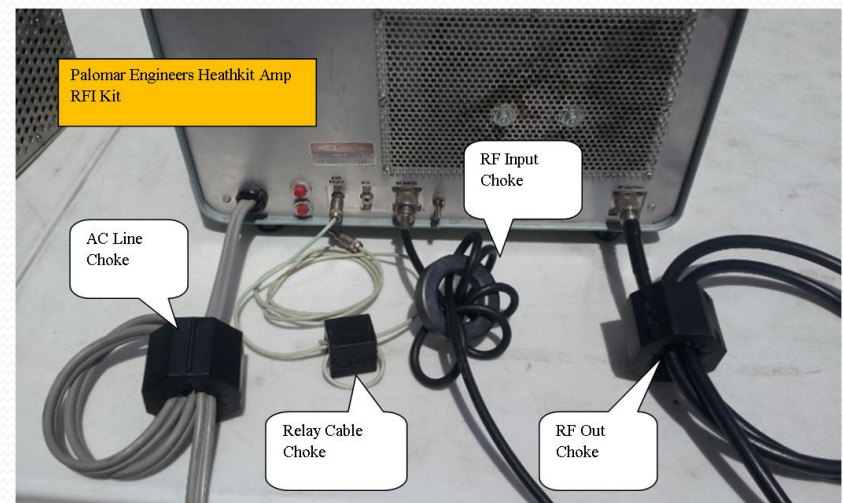
Palomar RFI kits for all brands of transceivers and amplifiers

Transceiver RFI Kit



ICOM 7300

Linear Amplifier RFI Kit



HEATHKIT SB220

Clean up the RFI **SOURCE** first – your radio and amp

Tip #2. Stop Transmit RFI on coax braid

ALL coax fed antennas need a feed line
choke at the antenna feed point!!!!

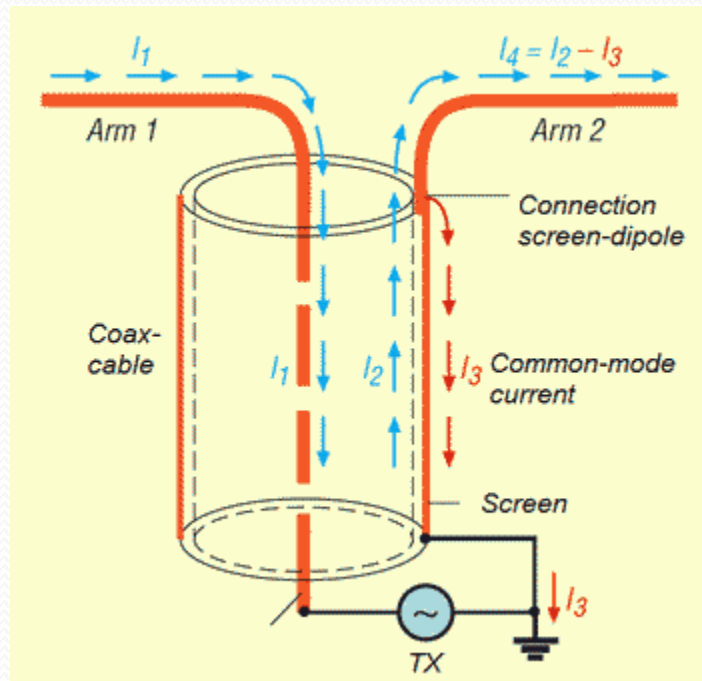
OR

Your dipole will become a tripole
Your unipole (vertical) will become a dipole



Is your Dipole a Tripole?

- Coax outside of braid acts as extension of transmitting antenna and extra receive antenna



Coax cable has 3 conductors!

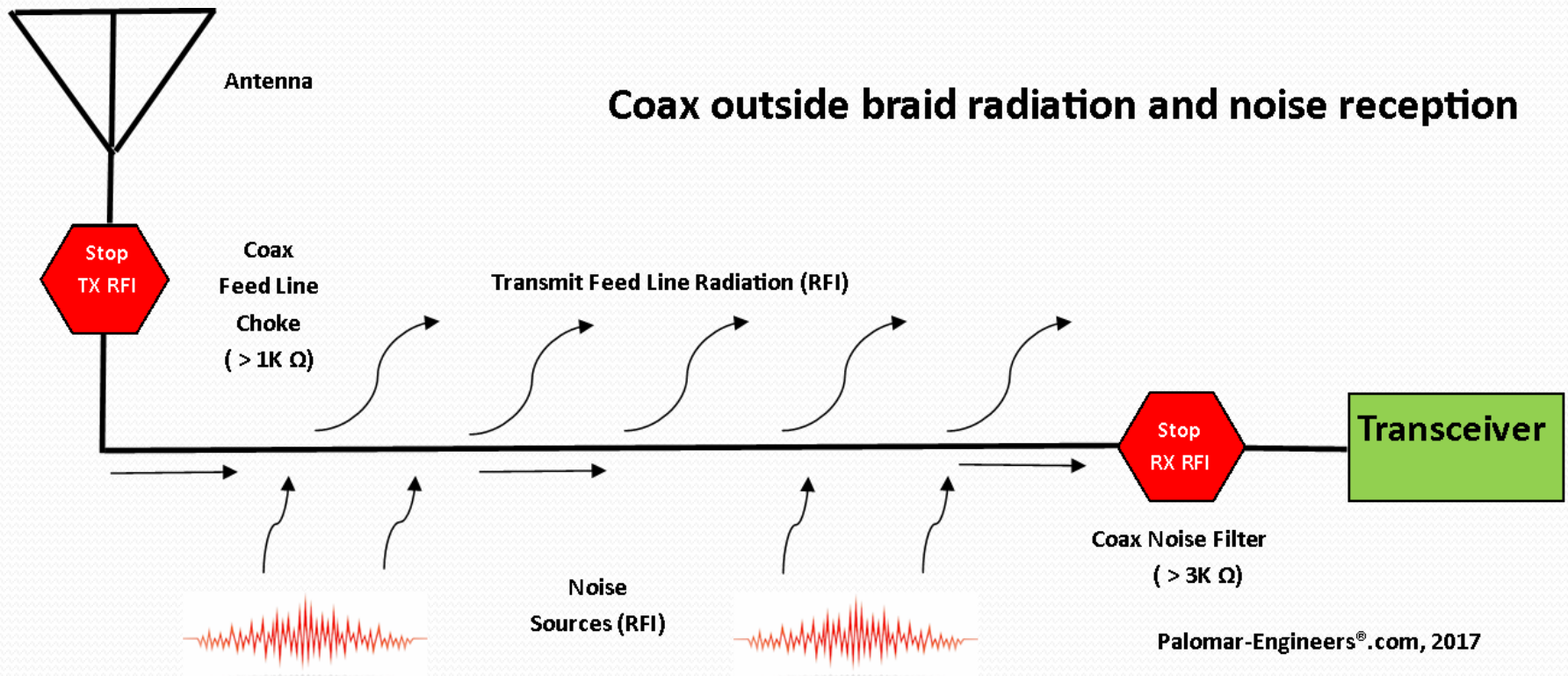
Coax braid is actually 2 conductors :
1 on the inside (normal RF signal), and
1 on the outside (common mode current)
that turns a dipole into tripole on transmit
or a second antenna on receive!

Goal is to reduce common mode current
with a feed line choke to keep all transmit
RF on antenna and use a coax noise filter to
minimize noise into receiver.

FYI: 1% common mode braid current = 2.75 watt radiation at 1500 watts input,
or 1.6 watts at 500 watts input or .7 watts at 100 watts input

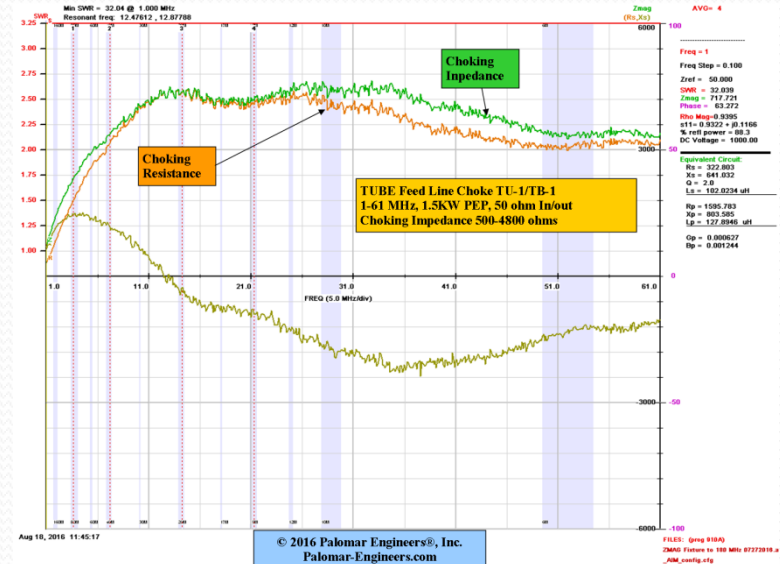
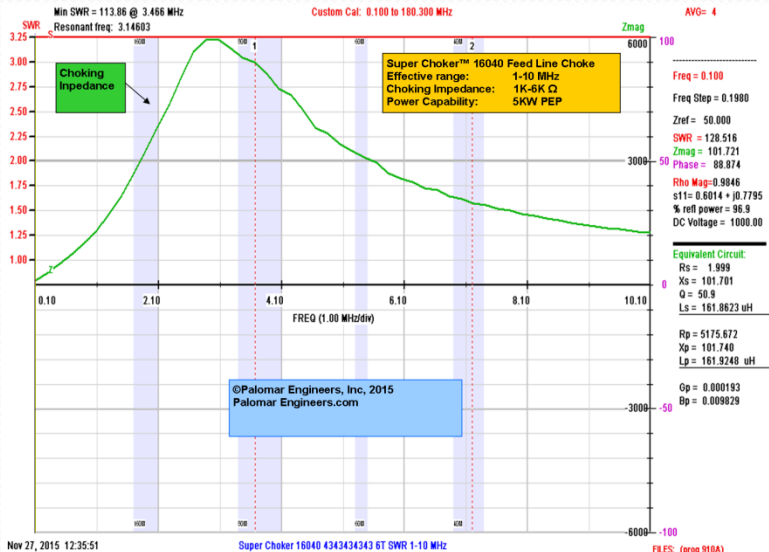
Typical Coax Antenna

Typical Coax Fed Antenna System



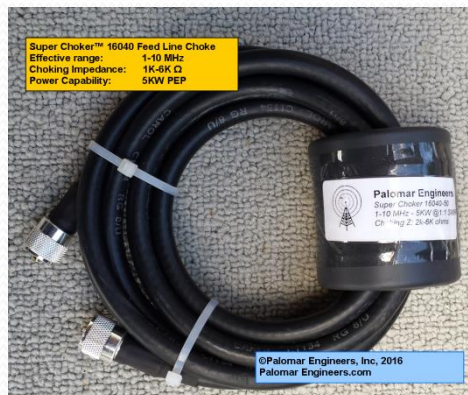
How many chokes do you need?

Choose choking impedance > 500Ω at frequency of use



Super Choker

1-10 MHz >2K
5KW PEP
1K-6K Z
3 pounds
Verticals
AM/RTTY
Contesting

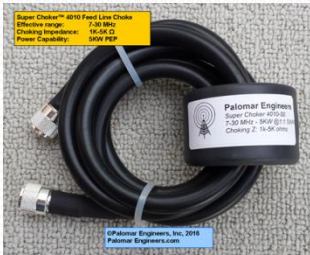


Line isolator

1-160 MHz >2K
1.5KW PEP
1K-6K Z
1 pound
All coax lines
Optional
ground, static
bleeder



Choosing a Feed Line Choke

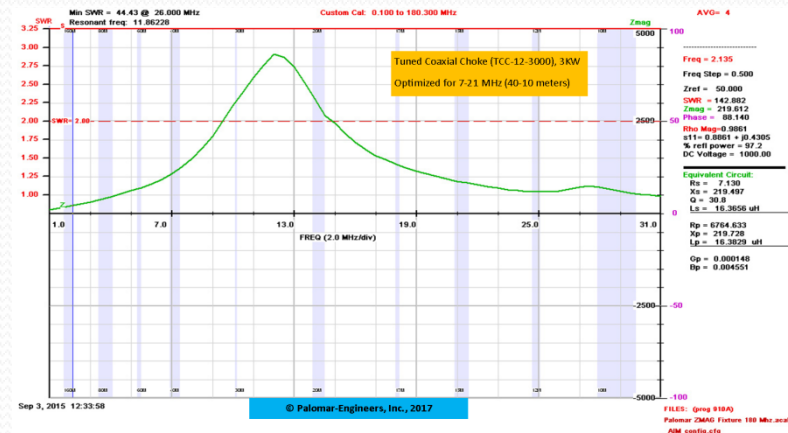


Criteria to Consider

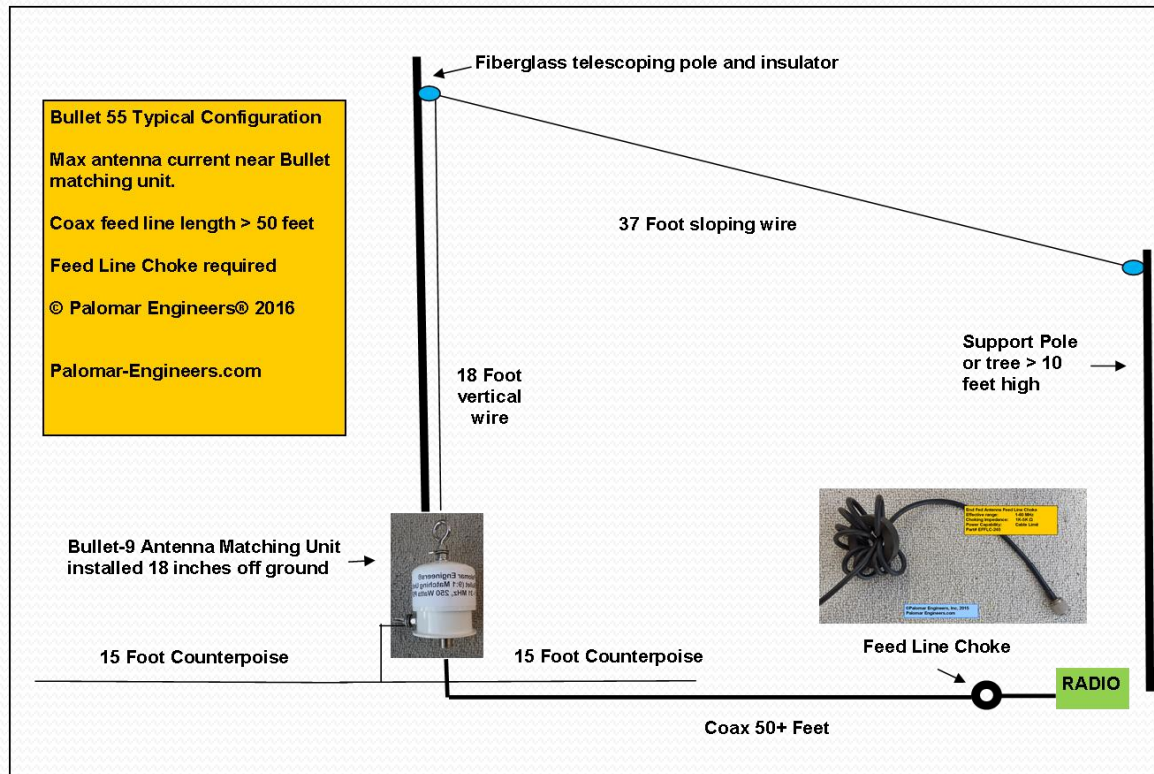
- Effective Frequency Range
- Adequate Choking Impedance > 500Ω
- Sufficient Power Rating
- Physical Size/weight
- Balun or unun output



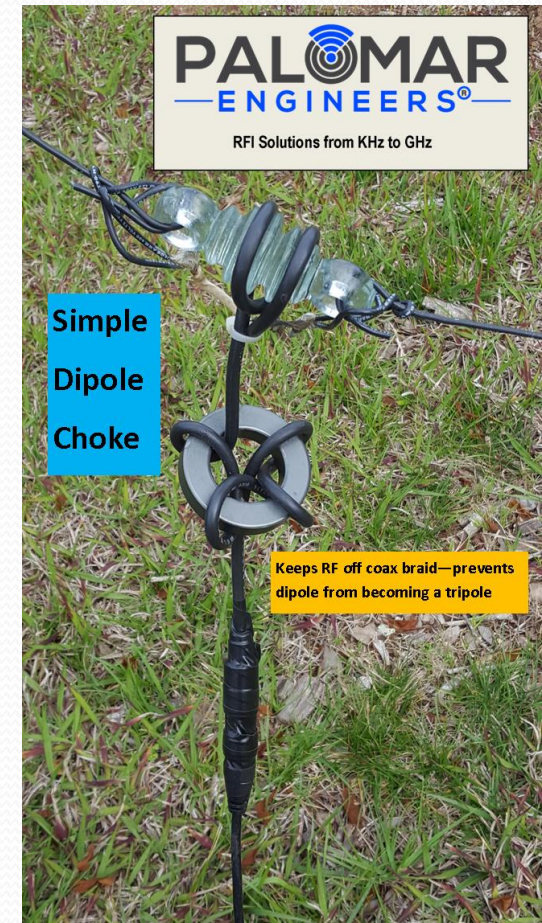
1-2 bands only



Simple DIY Feed Line Chokes



Use 1.4" ID Ring with multiple turns



Ham's Transmitter RFI Strategy

1

- **Eliminate/reduce RFI SOURCE**

- (transmitter, amplifier, or antenna location)

- or

2

- **Choke the PATH**

- (coax feedline, AC/DC power line)

Now Receiver RFI?

Receiver RFI Solutions

Our Goal: Lower Noise Floor = Higher SNR = More DX!



Tip #3. Install Coax Noise Filters

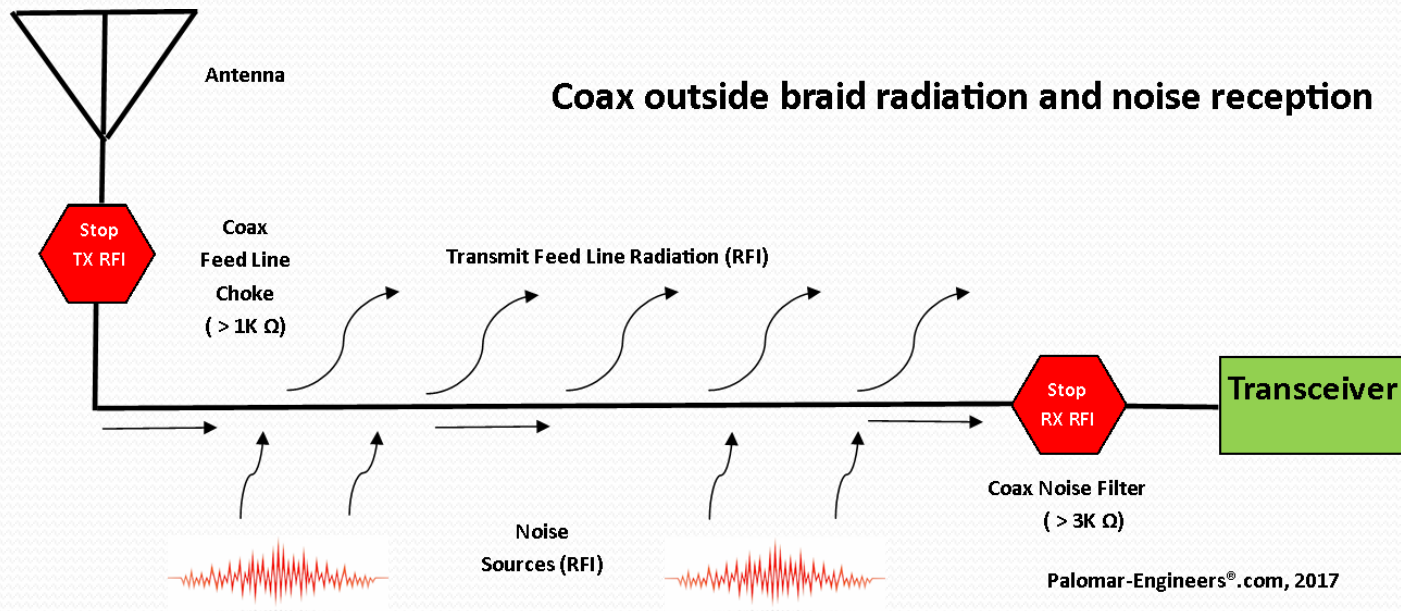
Less common mode noise current (RFI) = More DX!
How to select and install filters for maximum effect



Receive RFI Problem

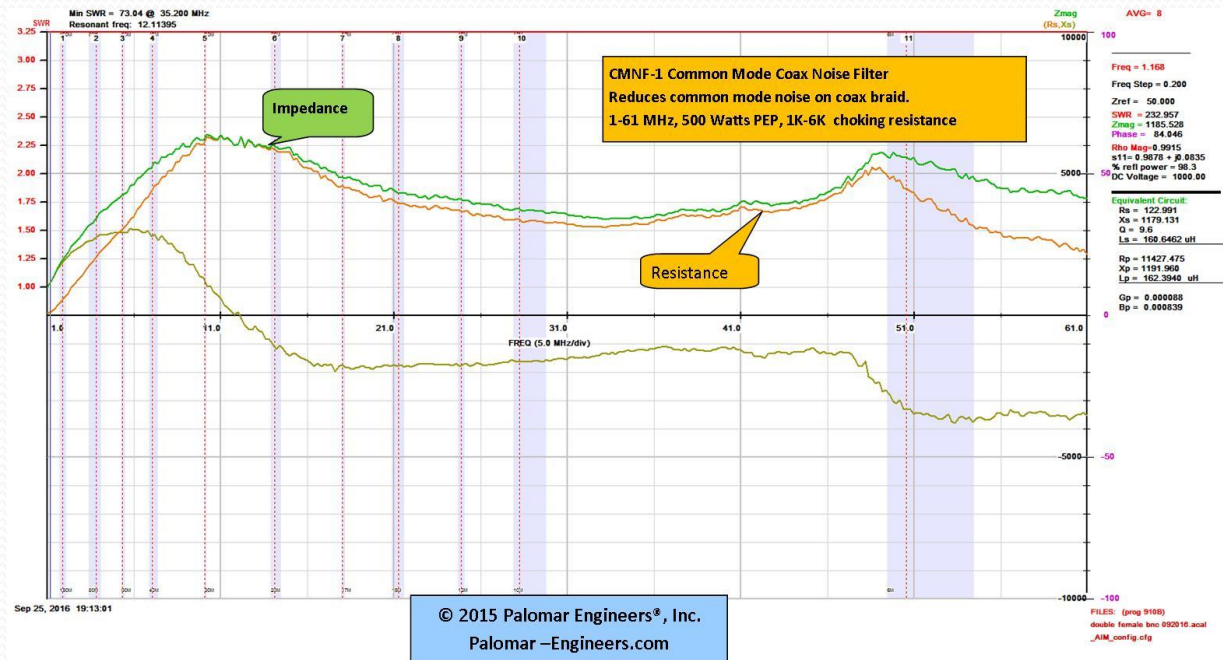
- Symptoms: High noise levels, spurs, buzzes, periodic signals across bands

Typical Receive Chain Connections



Coax Feed Line Noise Filters

>>> One of the best kept secrets in ham radio!!! <<<



Placed at RADIO END of coax feed line to suppress common mode current on coax braid between antenna feed point choke and radio

Now AC/DC Filters

Tip #4. Install AC/DC Noise Filters

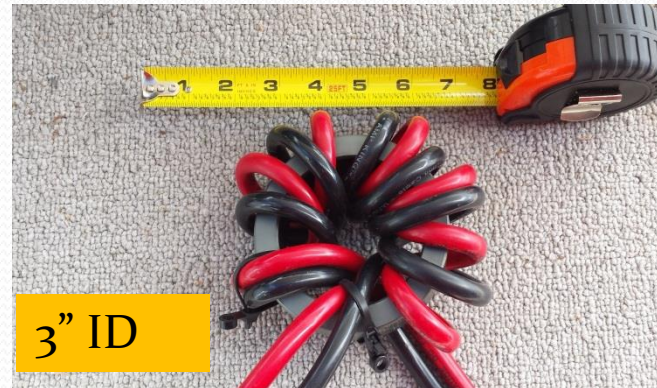
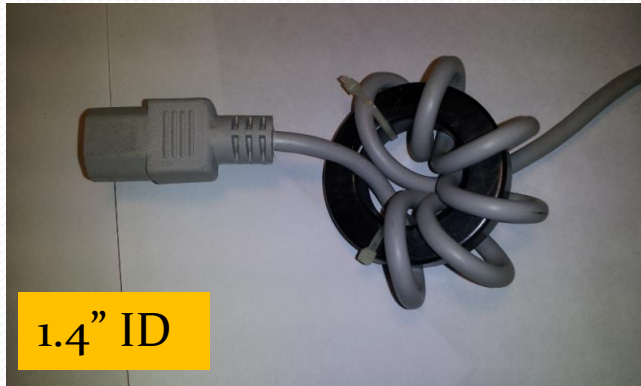
Lower Noise Floor = Higher SNR = More DX!

How to select and install filters for maximum effect

Goal is to reduce common mode RFI current INTO “receiver”



RFI – AC/DC Line Chokes



Choose mix frequency range and size to fit cable – use multiple turns

Wall Wart RFI Kit

Wall Wart switching DC power supplies that plug into the AC power line plug and provide DC power to laptops, routers, battery chargers, cell phone chargers, etc are a known source of broadband RFI

A simple ferrite ring filter on the DC power line can help suppress the RFI noise affecting the device or keep the DC power cord from acting as an antenna and radiating RFI from the powered device.



RFI Filter on DC Cord



Economy 10 ring kit

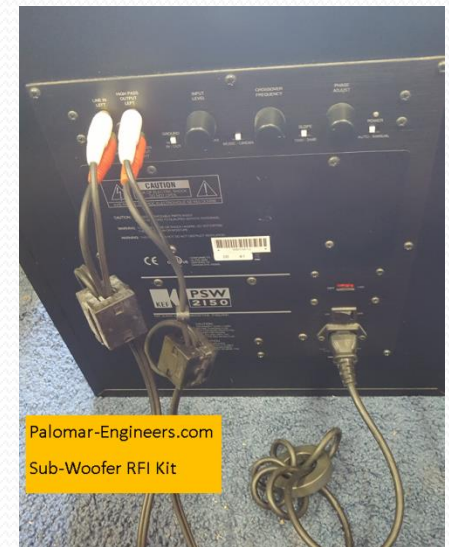
Tip #5. Install Specific RFI Kits for electronics

Our Goal: Minimize Transmit RFI to Home Electronics and Home Electronics RFI to receiver

Garage Door Opener RFI Kit
Washer/Dryer/Refrigerator RFI Kits
Home Alarm RFI Kit
Computer Desktop, laptop, router RFI Kits
Home Theater A/V Systems



Audio/Video RFI Solutions



Recommendation: Use RFI kits for specific problems, have neighbor purchase and install – do not make mods to neighbors equipment! MOST problems are RFI picked up by AC power/phone lines so ferrite filters work well.

Neighborhood RFI Solutions

MY HOME or NEIGHBOR'S HOME



ALARM SYSTEM RFI



HOME THEATER RFI



COMPUTER RFI



MISCELLANEOUS RFI



GARAGE DOOR



TELEPHONE/DSL RFI

Recommendation: Use RFI kits for specific problems, have neighbor purchase and install – do not make mods to neighbors equipment! MOST problems are RFI picked up by AC power/phone lines so ferrite filters work well.

Tip #6. Use Ferrite Combo RFI Kits for Newbies

Ferrite Combo Kits for Troubleshooting Multiple RFI Issues include multiple ferrite shapes and sizes covering multiple frequency ranges

½” snap on and 1.4” ID ring are the most popular and can be used to solve most RFI problems



Combo pack of rings and split beads

Multi Ring + Snap On Combo Pack—Mix 31



Ring: F240-31(6) 1.4" ID
Snap On: 3/8"(6), 1/2"(5)
RFI Range 1-300 MHz

- Use Multiple turns for best results



Prize Question #1

- What are 2 ways to increase the choking resistance of a ferrite filter choke?
 - A) Use high resistance wire and multiple turns on bead
 - B) Use multiple turns and double shield coax
 - C) Use multiple beads in series with multiple turns
 - D) Use mix 31 and mix 77 beads in series with a single turn

Prize Question #2

Mix 77 is used in which frequency range to suppress RFI common mode current?

- A) 1-300 MHz
- B) 200-2000 MHz
- C) .1-10 MHz
- D) 1-2000 MHz
- E) CB Band Only

Prize Question #3

TOP SECRET

- What is one of the best kept secrets in ham radio?
 - a) Ladder line has more loss than coax
 - b) A coax wound choke can cover all frequencies from 160-6 meters if the coax is long enough
 - c) All ferrites work on all frequencies, so buy the cheapest
 - d) Coax noise filters reduce common mode noise level in your receiver
 - e) All extra class hams go to heaven

Bonus Prize Question #4

- Which company is your best source for RFI solutions?



RFI Solutions from KHz to GHz

- Website: www.Palomar-Engineers.com
- Email: Sales@Palomar-Engineers.com
- Phone: 760-747-3343
- Bob Brehm, AK6R – Chief Engineer
- This presentation available on the website.