PALOMAR ENGINEERS®

RFI Solutions from KHz to GHz

8 Hacks to Cure RFI Now

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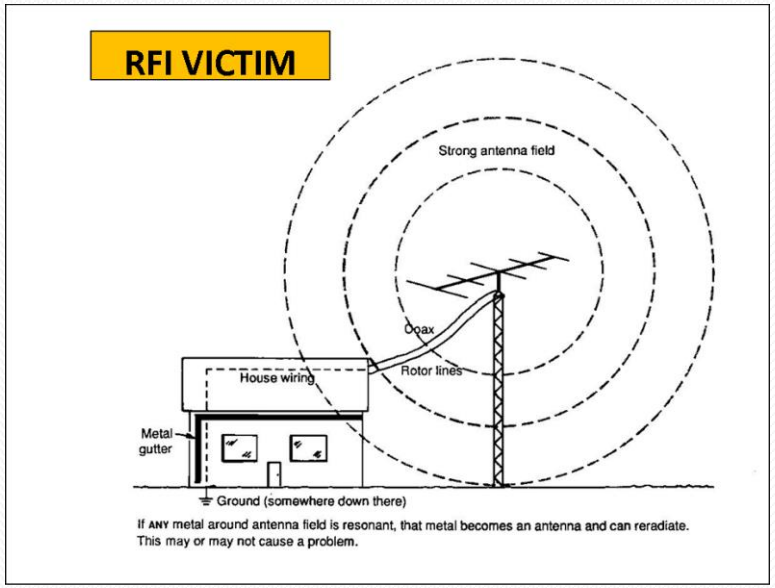
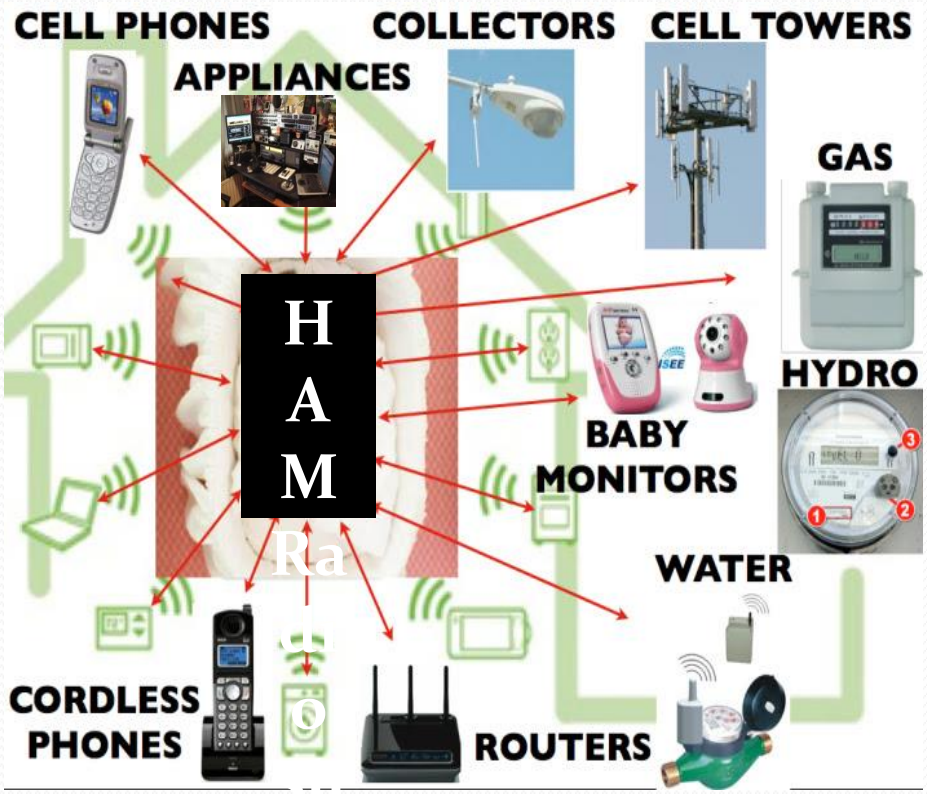
This presentation available on website

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 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

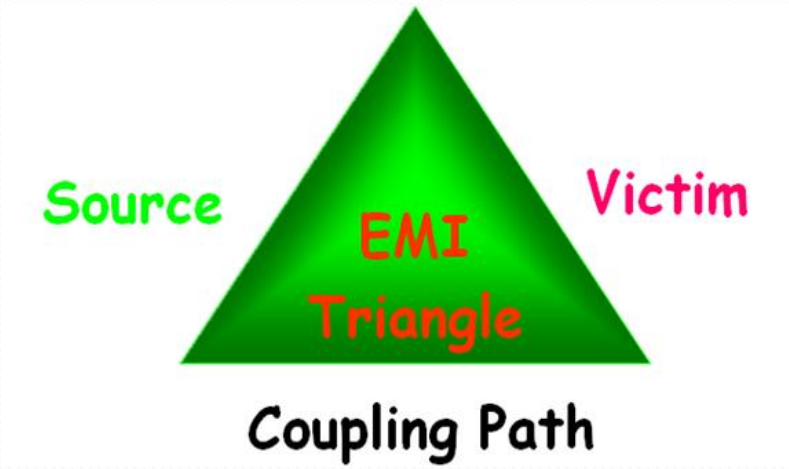
RFI “Antennas”

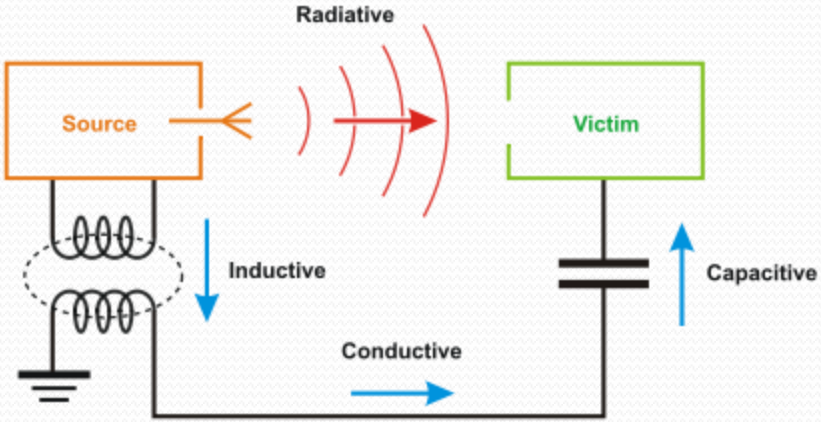
RFI Cures

What is RFI?

- ***A radio frequency disturbance that causes an electrical circuit to function improperly***
- Common <u>Sources</u>
  - Sunspots, Cosmic noise, Lightning, atmospheric static, AC power lines (no fix)
  - "Transmitters" -Ham, CB, AM/FM, electronic devices, motors and speed controllers, inverters, switching power supplies (can use filters to minimize)
- Common <u>Victims</u>
  - Any electronic device that malfunctions by acting as an unintended "receiver" of RFI

How is RFI Transferred?





<u>All three parts must be present</u> to have an RFI problem.

Multiple paths are very common:

1. Radiative - air
2. Conductive - wire
3. Inductive - wire
4. Capacitive - wire

How to identify the path(s)

Got RFI in your shack/home?

- **TX Symptoms** – caused by <u>your transmitter or antenna</u>
  - 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 <u>sources outside your radio</u>
  - High receive noise level <u>not due</u> to atmospheric conditions
  - Birdies, chirps, buzzes, clicks, broadband noise on receiver
  - Distorted receiver audio

How did you get RFI?

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 ¼ wavelength ground wires)
- FM broadcast, 20-6 meter transmitters,– short “antennas” - speaker wires, device interconnect cables, mic cables, short Ethernet cables

- “Antennas” pick up radiated or conducted RFI and a <u>common mode current is induced on ALL conductors</u> from an RFI SOURCE

How do we stop or reduce this current?

Curing RFI Issues

I (RFI Current) = E (constant)/R (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)

Using ferrites to cure RFI

Ferrite Fundamentals

How to select, configure and apply

Ferrite Topologies (Shapes)

Slip On Bead

Snap On Bead

Toroid or Ring

Fuzzy Ferret – not!

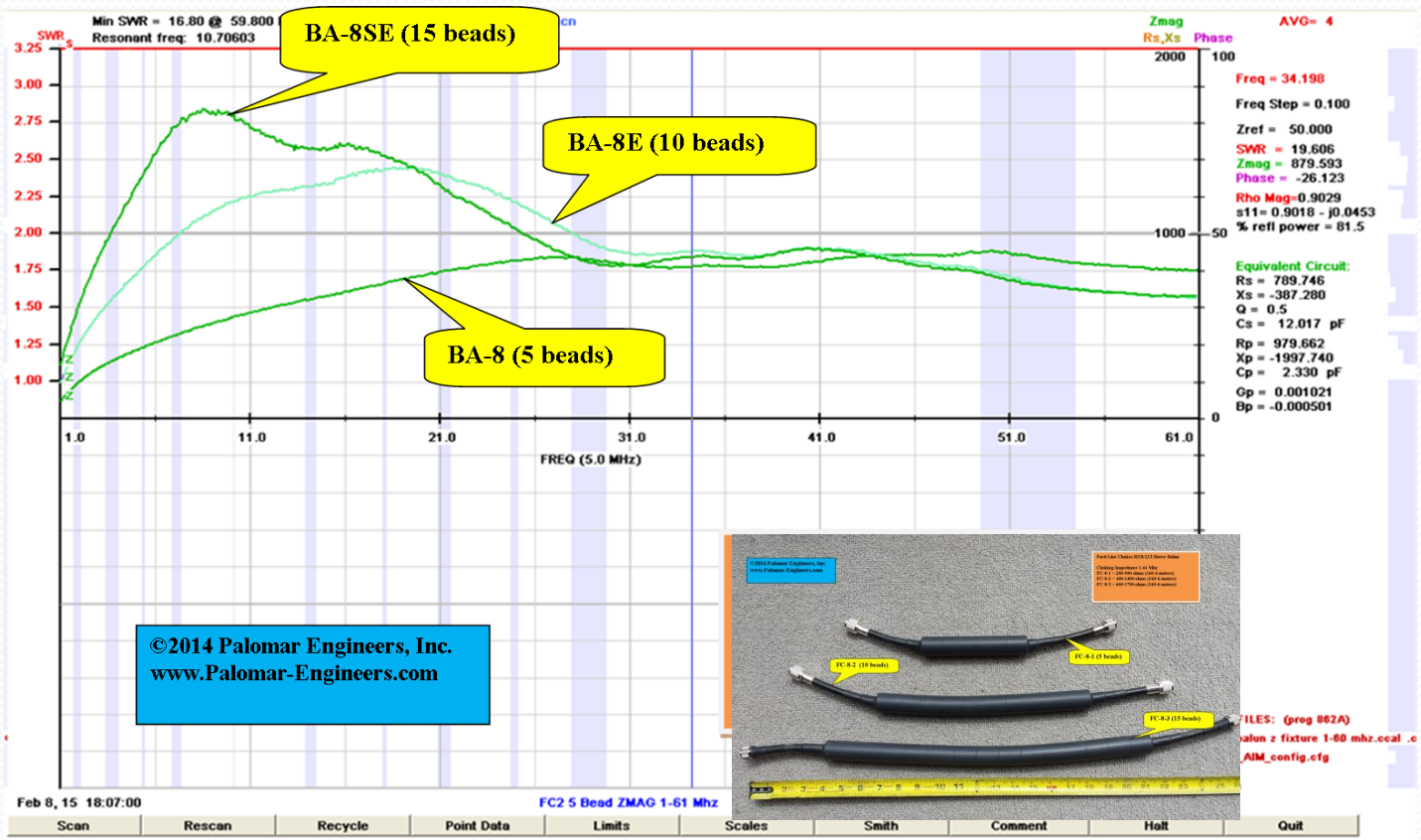
CHARACTERISTICS

- 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

How to increase choking resistance?

Ferrite resistors add in series

Impedance



More beads =

higher choking R (up to 30 MHz)

At 7 MHz:

5 beads = 400Ω

10 bead = 1000Ω

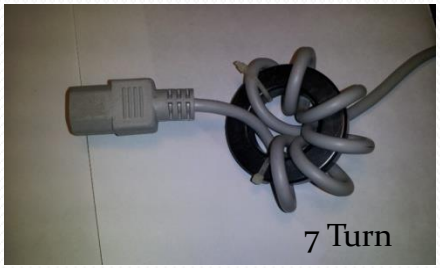
15 beads = 1600Ω

Frequency →

Impedance (Z) = Resistance +/- Reactance

Choking Z Increases with (turns)^2

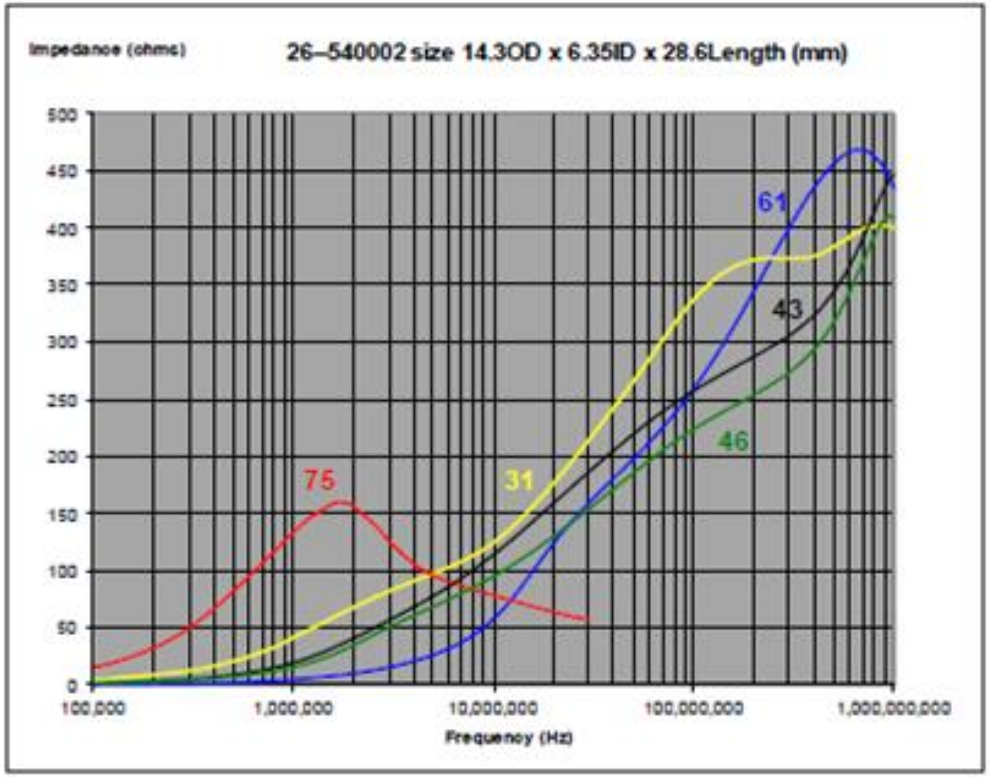
- If 1 turn = Z, 2 turns = 4Z, 3 turns = 9 Z
- More Z = less RFI wire current = less RFI radiated from wire or induced into wire. (I=E/Z)
- ***<u>General rule: choking Z > 10X line impedance</u>***
- (e.g. > 500 Ω for 50 Ω cable but 5000 Ω is 10x better)



7 MHz: 100Ω 900Ω 2500Ω

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

Ferrite Mixes



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

<u>Select mix for max Z at RFI fundamental frequency NOT frequency of receiver.</u>

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.

Know how to buy

How to buy ferrites the wrong way!

=

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

PALOMAR ENGINEERS ®

Ferrite Split Beads
10 Pack -1/2" ID
Common Mode Choke

Each Mix 31 bead provides:
71Ω/5 MHz
100Ω/10 MHz
156Ω/25 MHz
260Ω/100 MHz
260Ω/250 MHz

Part # FSB31-1/2-10

Palomar-Engineers.com

=

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 <u>fundamental</u> frequency
- Choose Topology(slip, snap, ring) to fit the Path
- Install ferrites – retest for RFI suppression
- Consider additional ferrites or Paths if RFI persists

<u>Most popular Mix for HF is MIX 31 (1-300 MHz)</u>

<u>(Mix 75/77 for .1-10 MHz, Mix 61 for 200-2000 MHz)</u>

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

Transmitter RFI Solutions

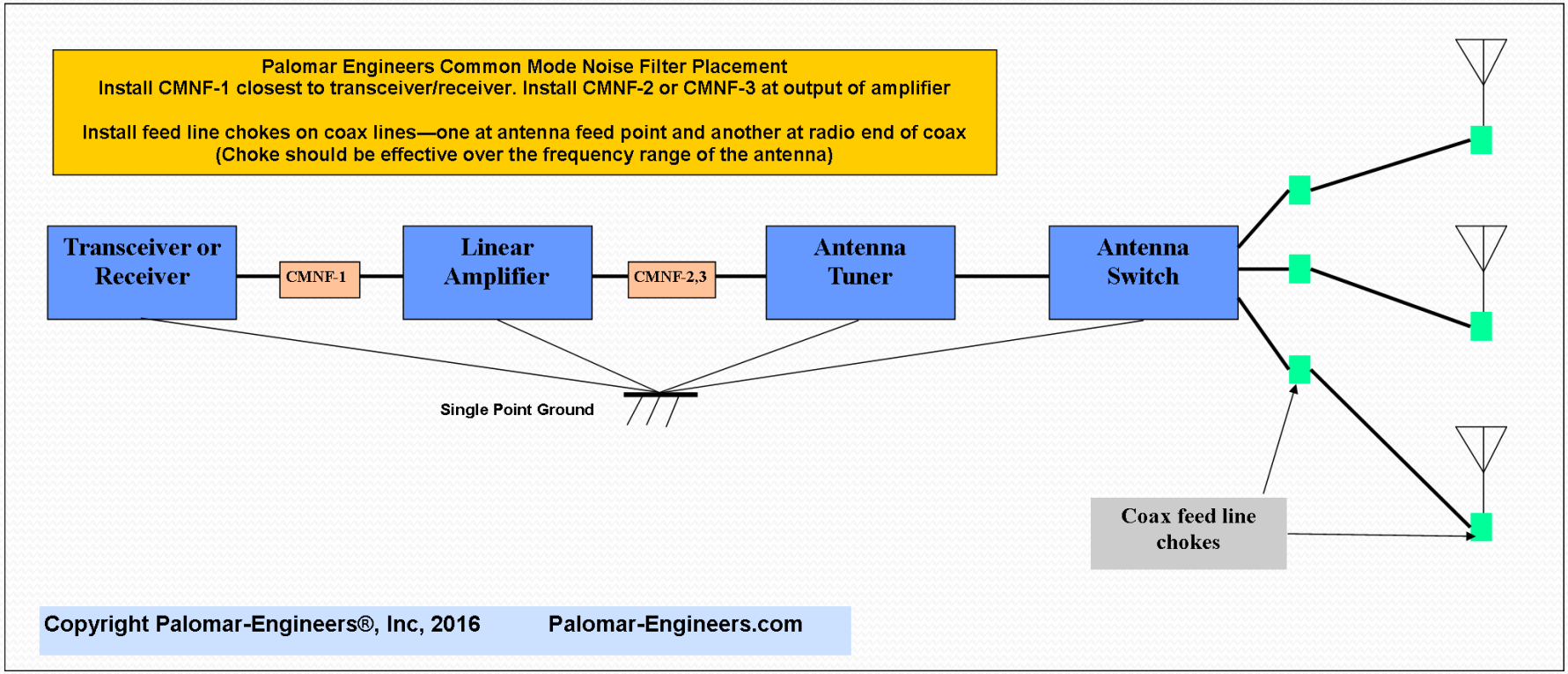
Transmit RFI Solution

Hack #1. Provide Common Ground System

Our Goal: Reduce RFI ground loops from connected equipment

Transmit RFI Problem

- Typical Transmitter Signal Chain



Hack #2. Install Transceiver, Amp, and Computer RFI Filters

Transmit RFI Solution

Our Goal: Minimize SOURCE RFI from radio and amplifier Cables

RFI Chokes for Transmitters/Amps

- Transmitter – Amplifier - Antenna RFI suppression
  - 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

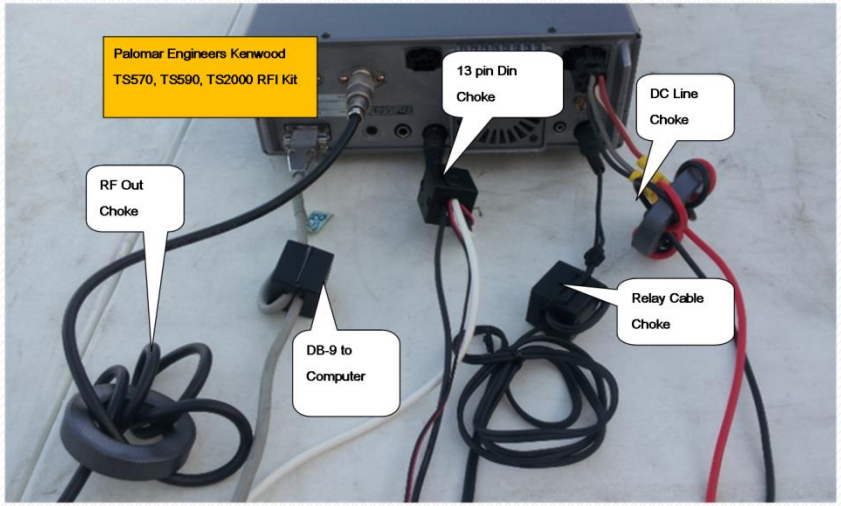
  - Recommendation: Filter ALL power cables to equipment and buy Palomar transceiver, amplifier and computer RFI kits with mix, sizes, instructions already determined.

Transceiver/Amp Examples

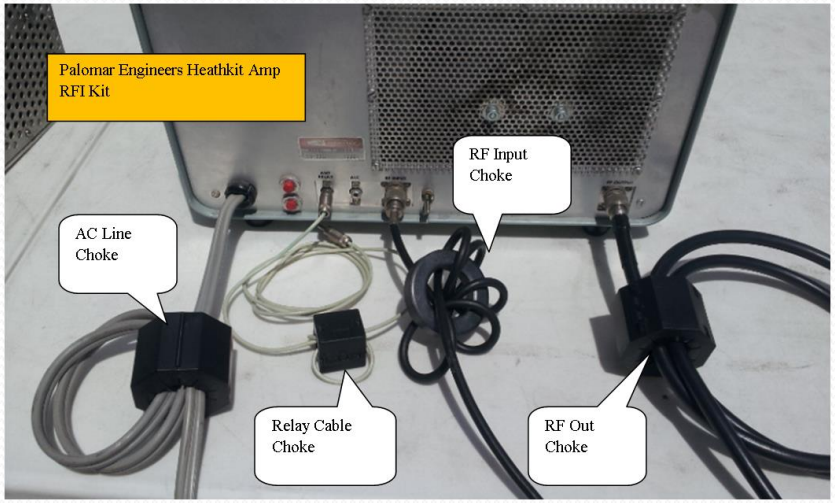
Transceiver/Amp RFI Kits

Palomar RFI kits for all brands of transceivers and amplifiers

Transceiver RFI Kit



Linear Amplifier RFI Kit



Clean up the RFI **SOURCE** first – <u>your radio and amp</u>

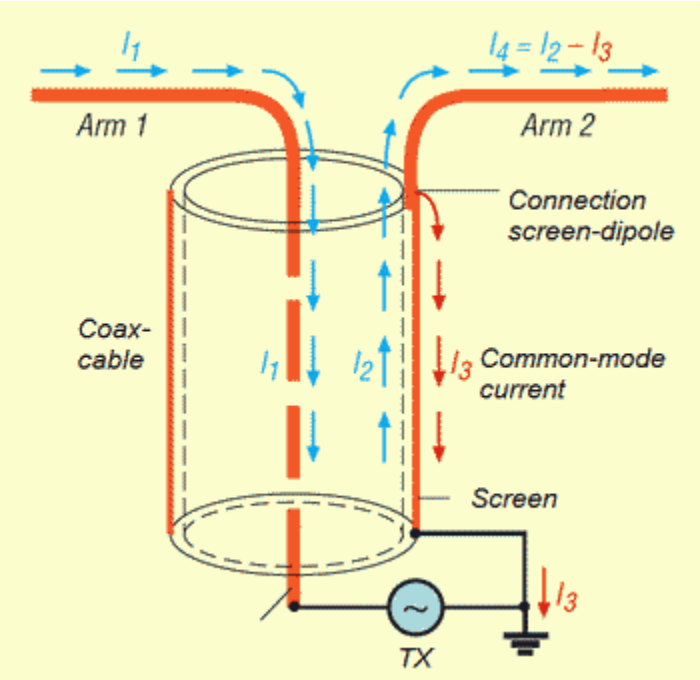
Hack #3. Stop Transmit RFI on coax

If your dipole acts like a tripole you need a feed line choke!

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

Is your Dipole a Tripole?

- Coax <u>outside</u> of braid acts as extension of <u>transmitting</u> antenna and extra <u>receive</u> antenna



<u>Coax cable has 3 conductors</u>!

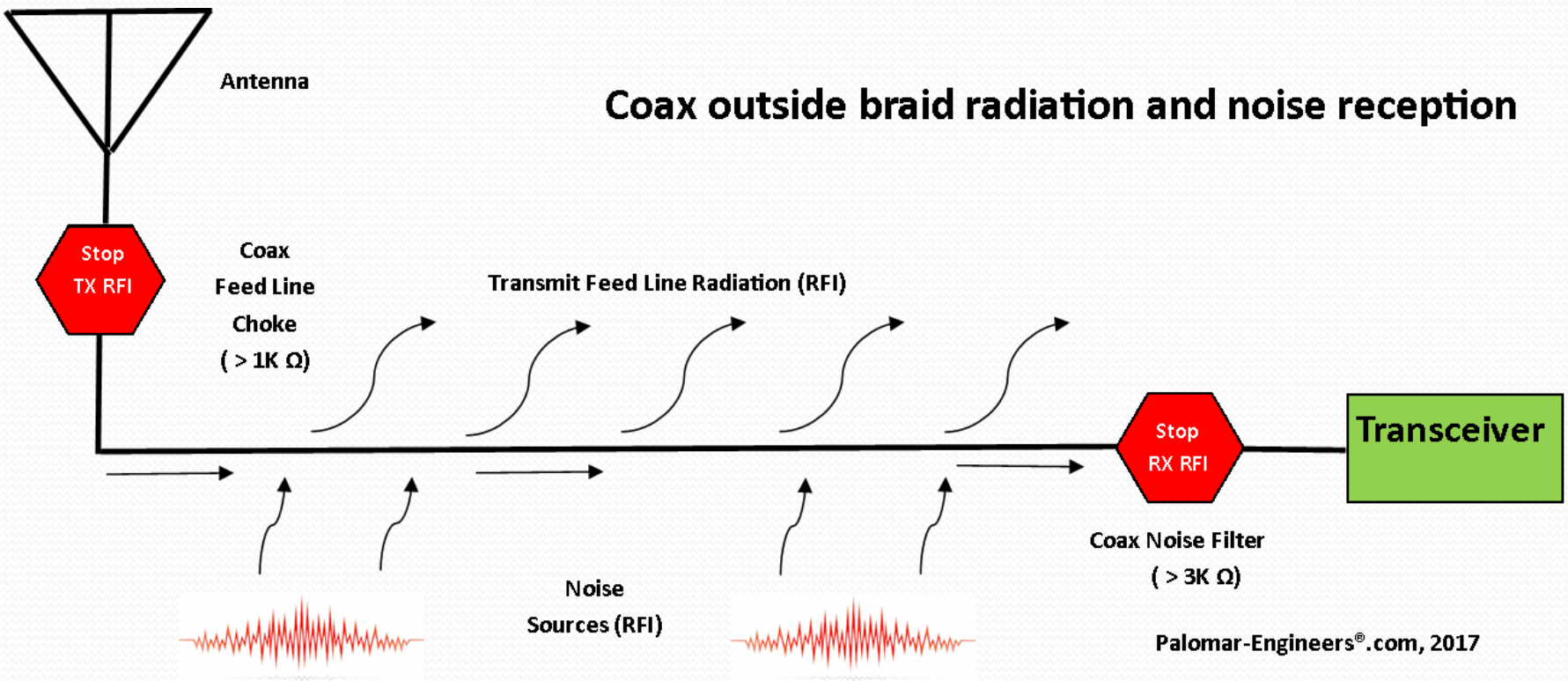
Coax <u>braid</u> is actually 2 conductors :
1 on the inside (normal RF signal), and
1 on the outside (common mode current)
that turns a dipole into tripole on transmit or a second antenna on receive!

<u>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.</u>

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?

How many chokes do I need?

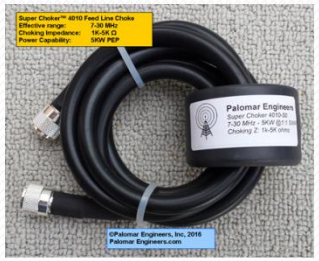
- Each coax line, antenna control line needs own choke – type used depends on frequency (>500 ohms or better)

Choking Impedance vs Attenuation

- Palomar Engineers specify RFI/EMI chokes in terms of impedance (in/out), but often the customer needs to know the attenuation to choose which product best suits the application. (1 “S” unit = 6db)

Choke Impedance (Z_{sc})	Attenuation (dB)
200	-9.5
500	-15.6
1000	-20.8
1500	-24.0
3000	-29.8
5000	-34.2
10000	-40.0

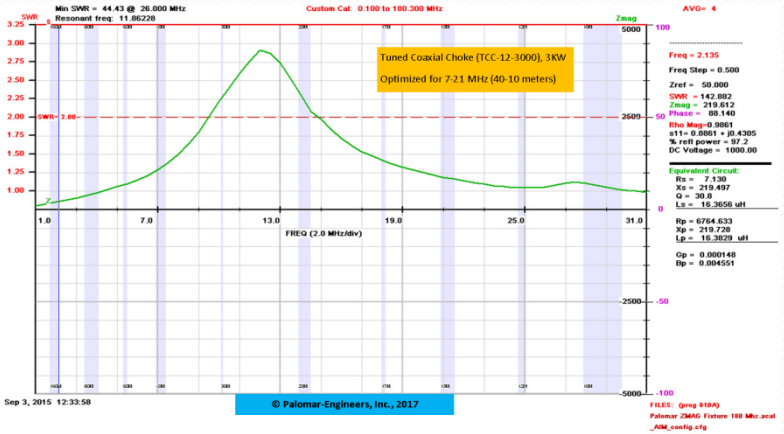
Choosing a Feed Line Choke



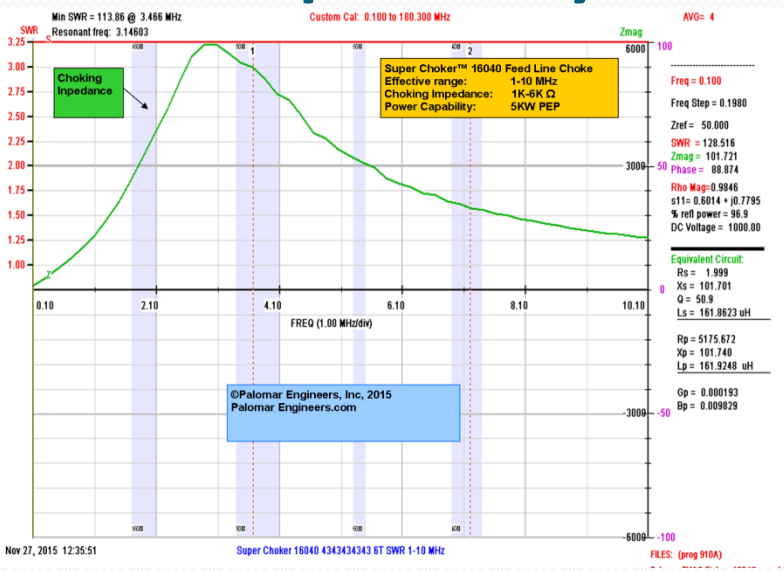
Criteria to Consider

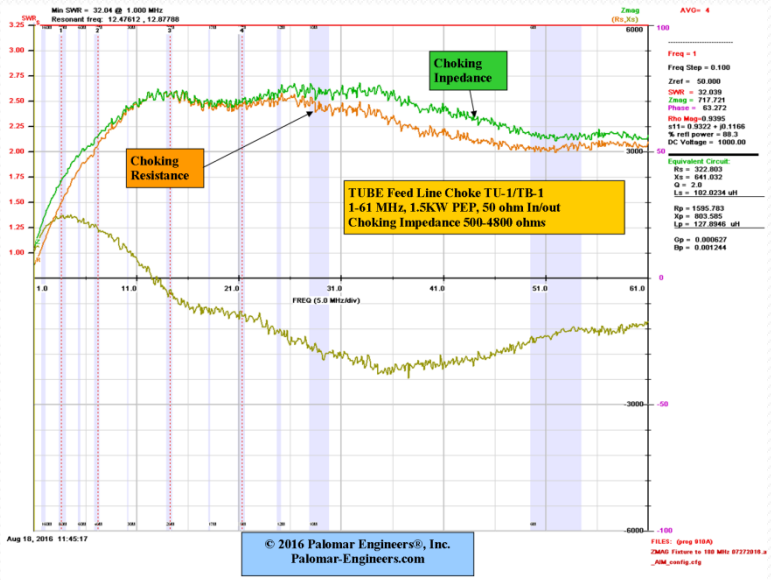
- Effective Frequency Range
- Adequate Choking Impedance > 500Ω
- Sufficient Power Rating
- Physical Size/weight
- Balun or unun output

←

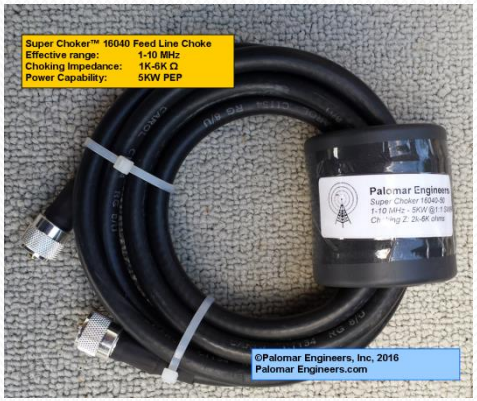


Choose choking impedance > 500Ω at frequency of use





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

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!

Hack #4. Install Coax Noise Filters

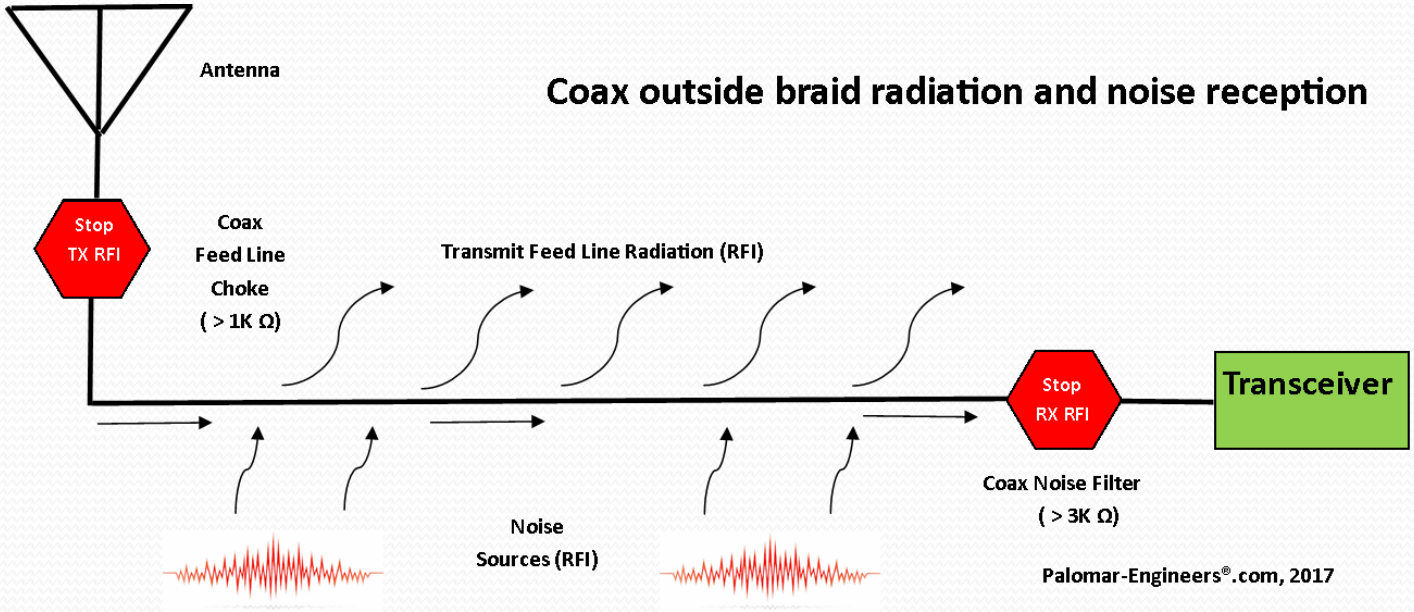
Less common mode noise current = More DX!

How to select and install filters for maximum effect

Receive RFI Problem

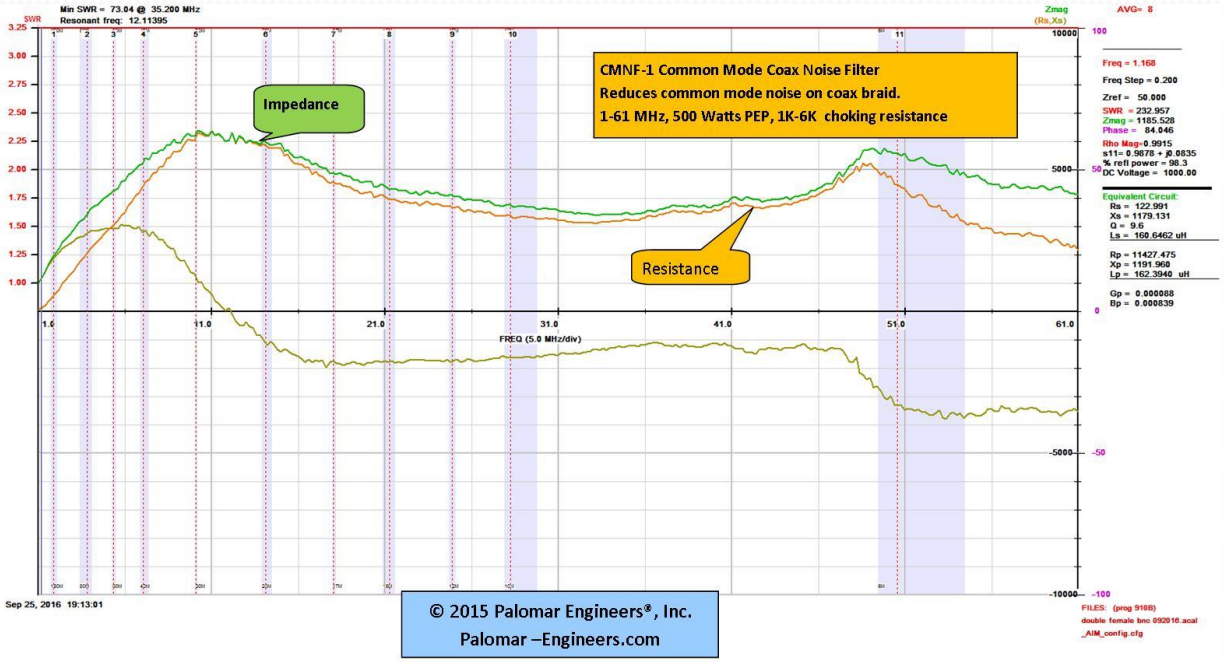
- Symptoms: High noise levels, spurs, buzzes, periodic signals across bands

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

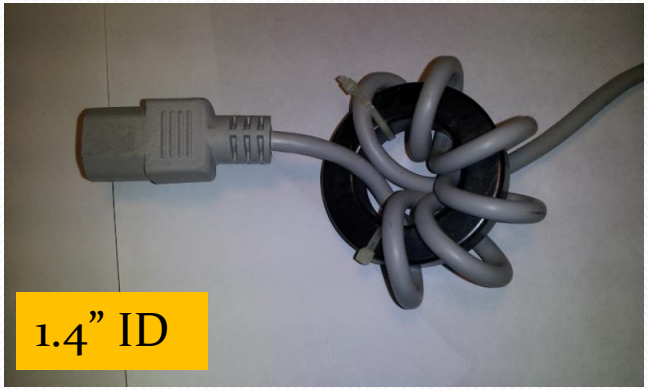
Hack #5. Install AC/DC Noise Filters

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 Warts

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

Hack #6. Use A/V RFI Filters

Our Goal: Stop transmitter interference to A/V systems and stop A/V system RFI to receiver.

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.

Transmit RFI Solution

Receive RFI Solution

Hack #7. Install Specific RFI Kits for electronics

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

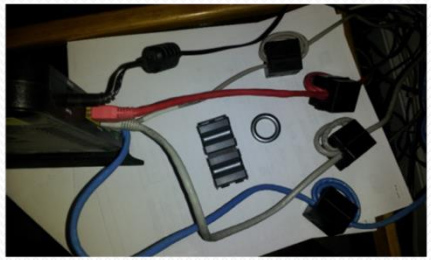
Garage Door Opener RFI Kit
Washer/Dryer/Refrigerator RFI Kits
Home Alarm RFI Kit
Computer Desktop, laptop, router RFI Kits

Neighborhood RFI Solutions

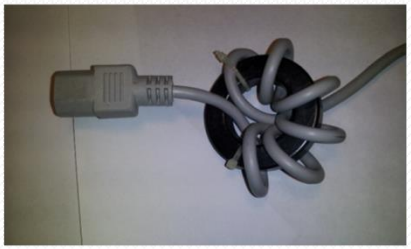
MY HOME or NEIGHBOR'S HOME

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.

Test Time – Win a prize!

Receive RFI Solution

Transmit RFI Solution

Hack #8. Use Combo RFI Kits for Newbies

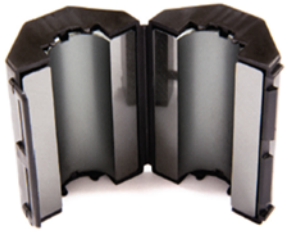
Ferrite Combo Kits for Troubleshooting Multiple RFI Issues

Combo pack of rings and split beads

Multi Ring + Snap On

Combo Pack—Mix 31

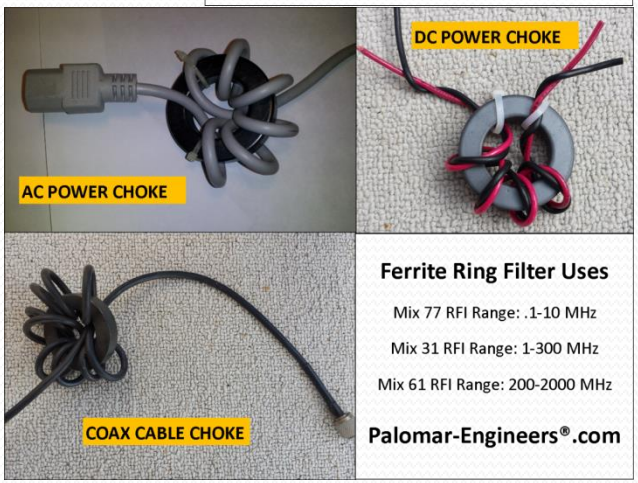
+



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 impedance of a ferrite filter choke?

A) Use high resistance wire and multiple turns on bead
B) Use multiple beads and dual core braided wire
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

- 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

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?

PALOMAR ENGINEERS®

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.