# ABC's of RFI for Hams

## Symptoms, Causes & Cures


Bob Brehm, AK6R
Chief Engineer
Palomar-Engineers.com

Visalia DX Convention 2016

# Causing Neighborhood RFI?

IT'S ALL YOUR FAULT WITH THAT BIG ANTENNA!

# Receiving RFI from Neighborhood?

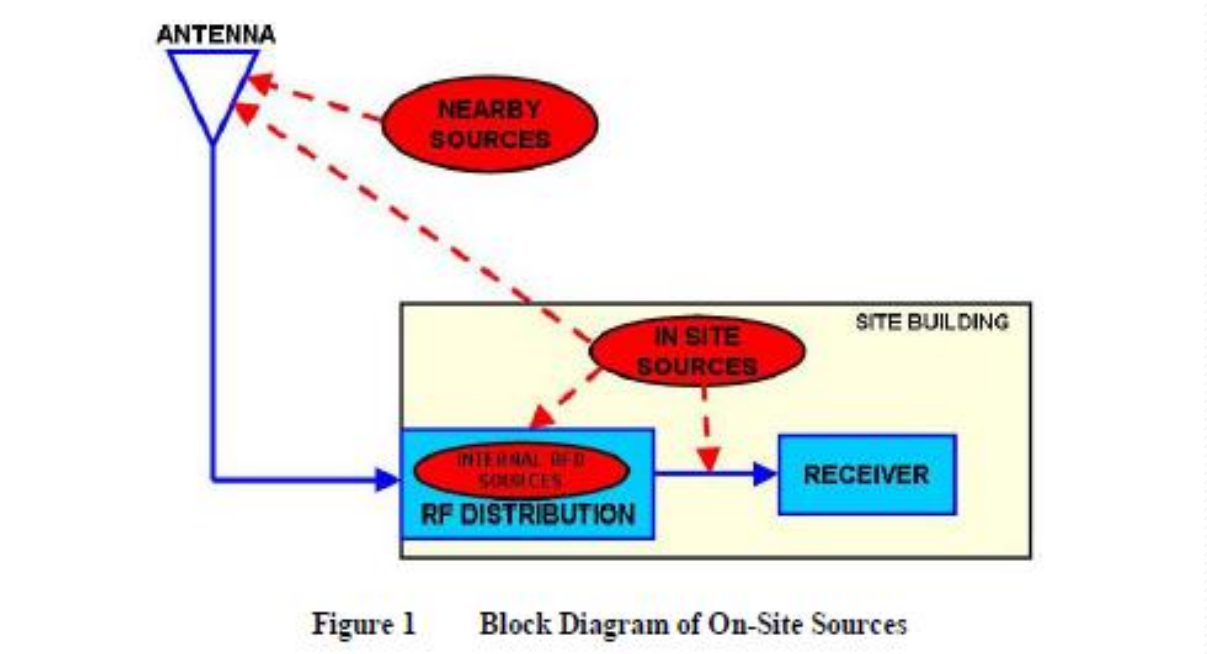



Figure 1 Block Diagram of On-Site Sources

QRN - High Noise Floor – Weak Signals – NO DX – So Sad!

# RFI Workshop Objectives


- Learn fundamentals of RFI - identify symptoms, pinpoint causes & apply simple cures
- What's a ferrite and how to choose & buy the right ferrite for your RFI issue
- How to use ferrites to solve the #1 RFI problem shared by all hams using HF radios
- How to use ferrites to solve transmitter RFI problems in your home or neighborhood

Thinking cap time……

# RFI 101

For hardcore DX’ers and beginners too!

# What is RFI?

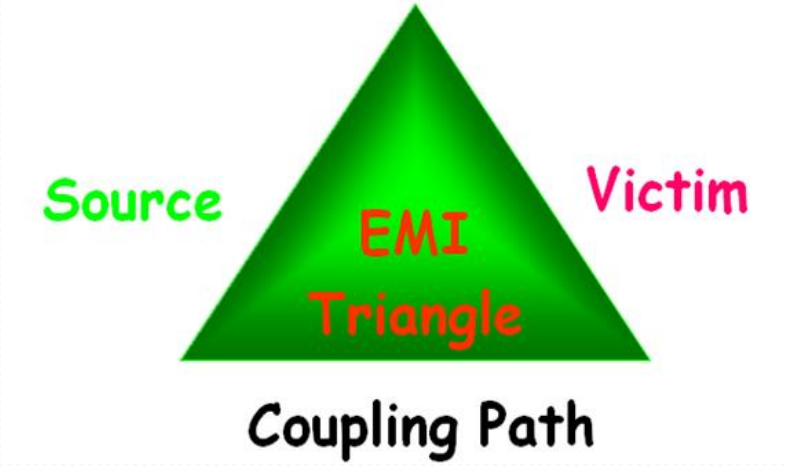
- Radio Frequency Interference/Electromagnetic Interference (RFI/EMI) – (100 KHz – 1 GHz)
  - A radio frequency disturbance that causes an unwanted interruption, degradation or unintended operation to an electrical circuit.
  - Common Sources
    - Radio Transmitters (Amateur, broadcast, consumer devices)
    - Natural: Sun, Cosmic noise, Lightning, atmospheric static
    - Motors, ignition systems, power lines, square wave generators
  - Common Victims
    - Any electronic device acting as a “receiver” of RFI

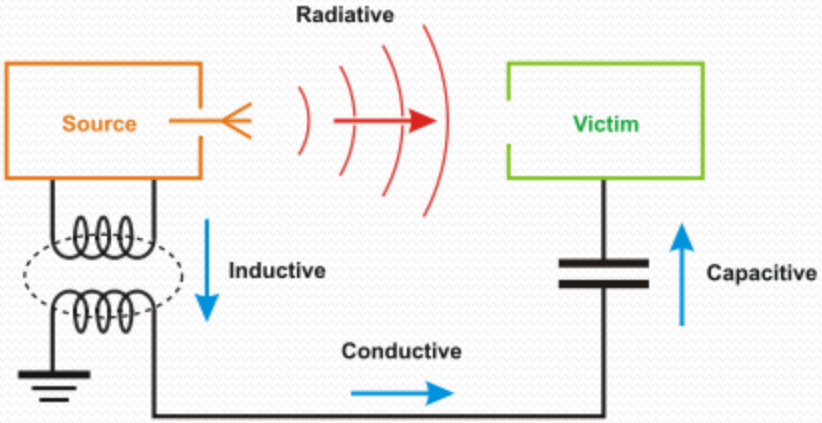
# Got RFI in your shack/home?

- **TX Symptoms** – caused by <u>your transmitter or antenna</u>
  - Hot microphone – lip burns, distorted audio
  - Resonant antennas don't tune correctly or high SWR
  - 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, etc.)
  - Wife Alarm goes off
- **RX Symptoms** – caused by <u>sources outside your radio room</u>
  - High receive noise level not due to atmospheric conditions
  - Birdies, chirps, buzzes, clicks, broadband noise on receiver
  - Distorted audio

How did you get RFI?

# How is RFI Transferred?




All three must be present 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)

# Typical RFI receiving “antennas"

- 160-80-60-40-30 meter transmitters – “Long” - AC power lines, telephone/DSL lines, satellite/cable coax, long Ethernet cables, ham antennas coax shield, antenna control/rotor cables, 2nd story ground wires
- AM Broadcast Receiver RFI – same as 160 – long “antennas”
- 20-6 meter transmitters – “Short” - speaker wires, device interconnect cables, mic cables, short Ethernet cables
- FM Broadcast Receiver RFI – short “antennas” – 3-6 feet long

- “Antennas” pick up RFI and a common mode current is induced on all conductors from an RFI SOURCE

How do we reduce this current?

# Reduce RFI current to reduce RFI

- An “antenna” is a wire with alternating current going through it creating an electromagnetic field of radiation, or conversely, a wire exposed to an electromagnetic field induces a current in the wire.
- Reducing the current through the wire, reduces the radiation from the wire or conducted through the wire
- High choking impedance (R) reduces RFI current, I (remember Ohm’s law: I=E/R)

- Typical solutions: Resonant traps, ferrites, filters with high choking impedance

Ferrites are your friend

# Ferrite Topologies (Shapes)

Slip On Bead

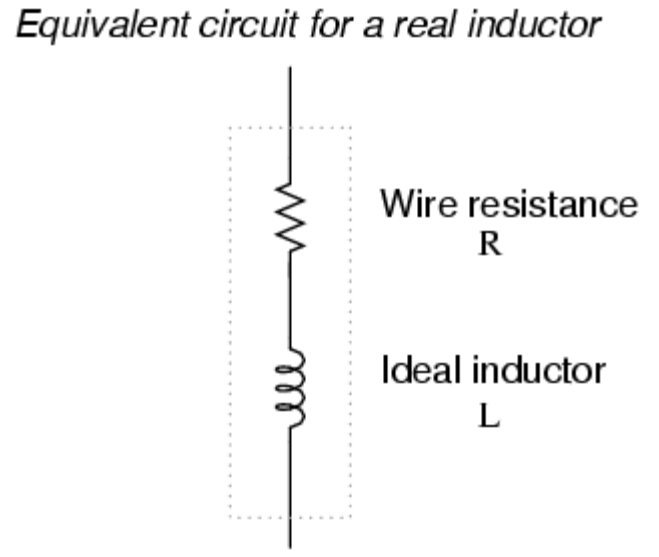
Snap On Bead

Toroid or Ring

Fuzzy Ferret – not!

- Cheap, easy to install, work on all ham frequencies under 1 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
- Can be installed by almost anybody who understands how to choose the correct ferrite for a particular RFI problem

# How do Ferrites Work?

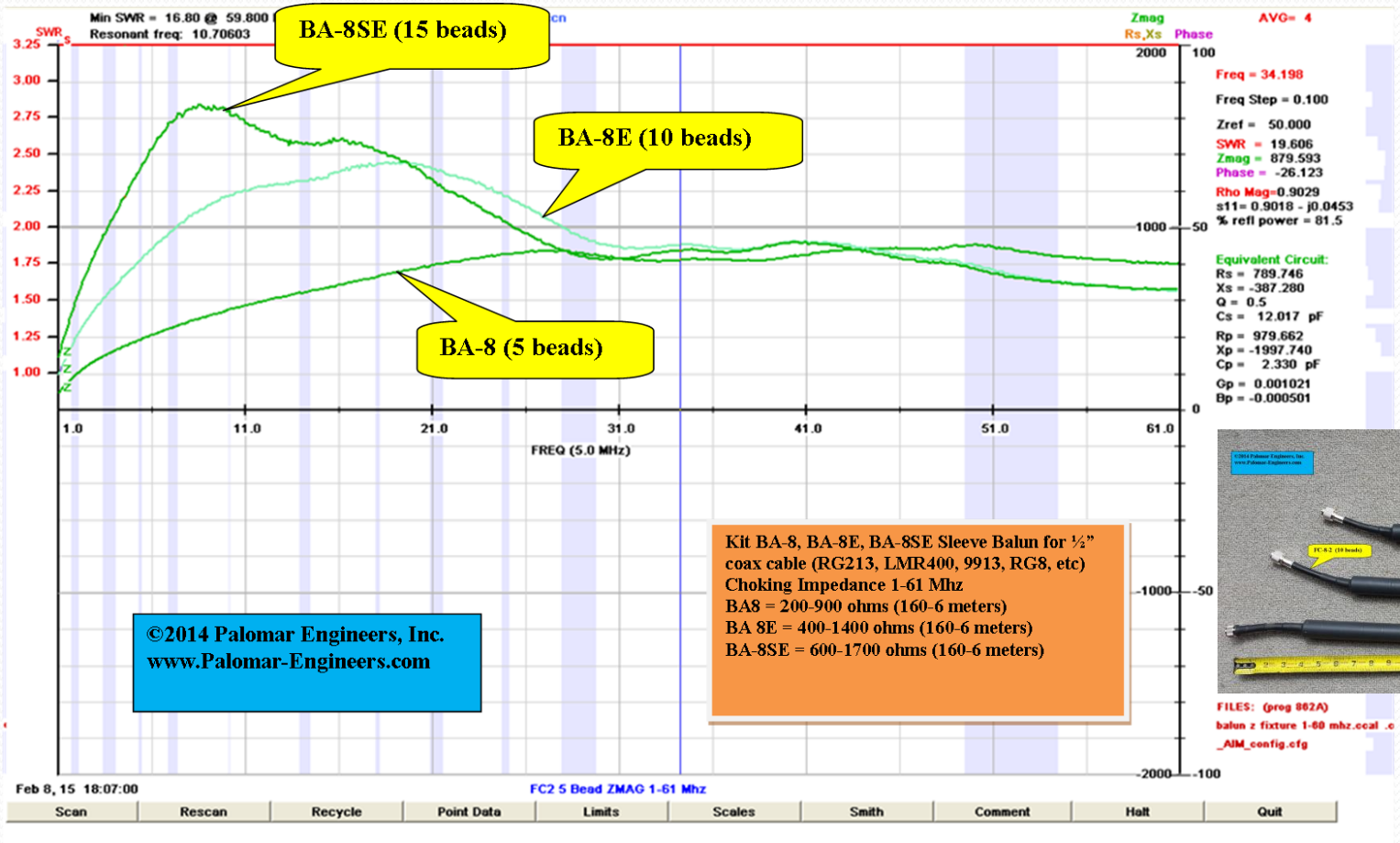



Picture shows One Turn coil through a snap on ferrite - typical bead with 1 turn has 50-300 ohms impedance depending of frequency

Inductive reactance varies with frequency ($X_L=2\prod*f*L$) until resonance reached. Increase reactance or impedance($Z=\sqrt{(X_L^2+R^2)}$ to decrease common mode current producing RFI

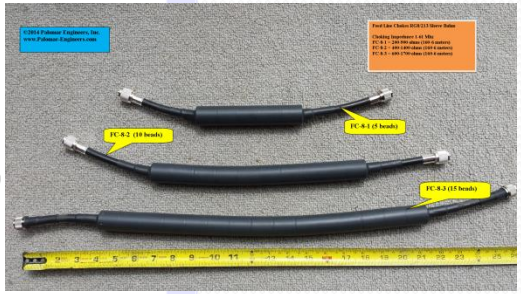
Impedance (Choking Z) can be increased several ways……..

# Ferrite Z adds in series




More beads =

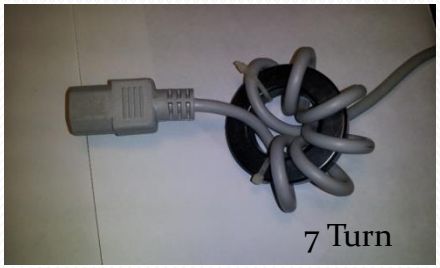
higher choking Z (up to 30 MHz)



# Choking Z Increases with (turns)$^2$

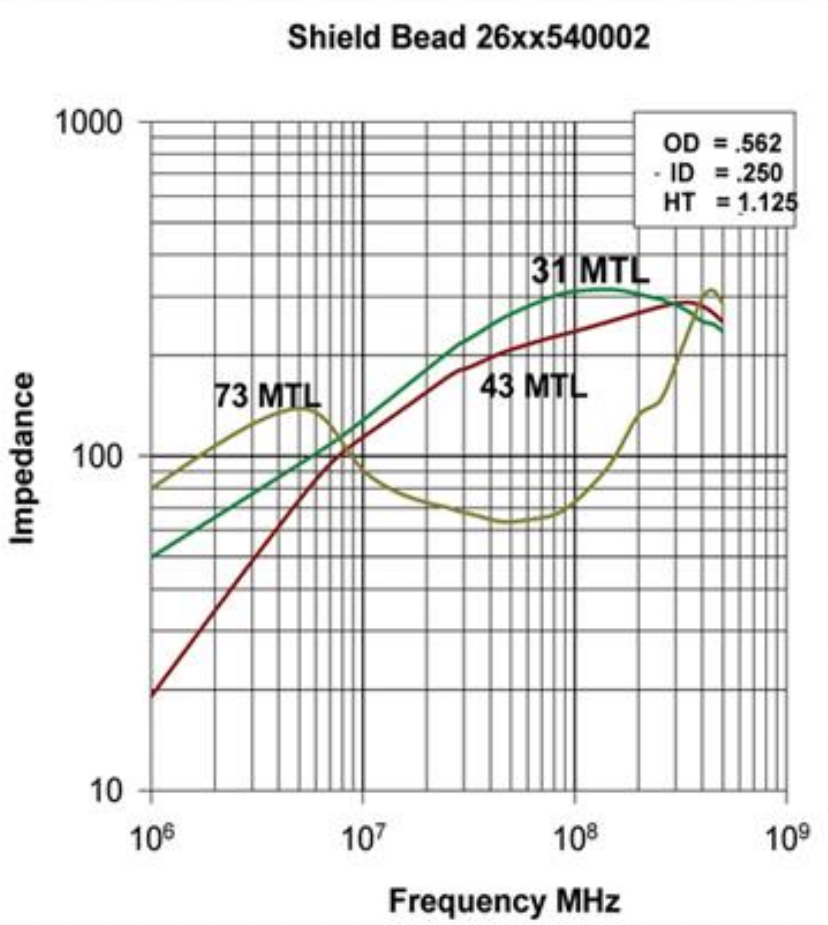
- If 1 turn = Z, 2 turns = 4Z, 3 turns = 9 Z
- More Z = less wire current = less RFI radiated from wire or induced into wire.
- General rule is to have choking Z > 10X line impedance
- (e.g. > 500 Ω for 50 Ω cable but 5000 Ω is better)






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

# Ferrite Mixes



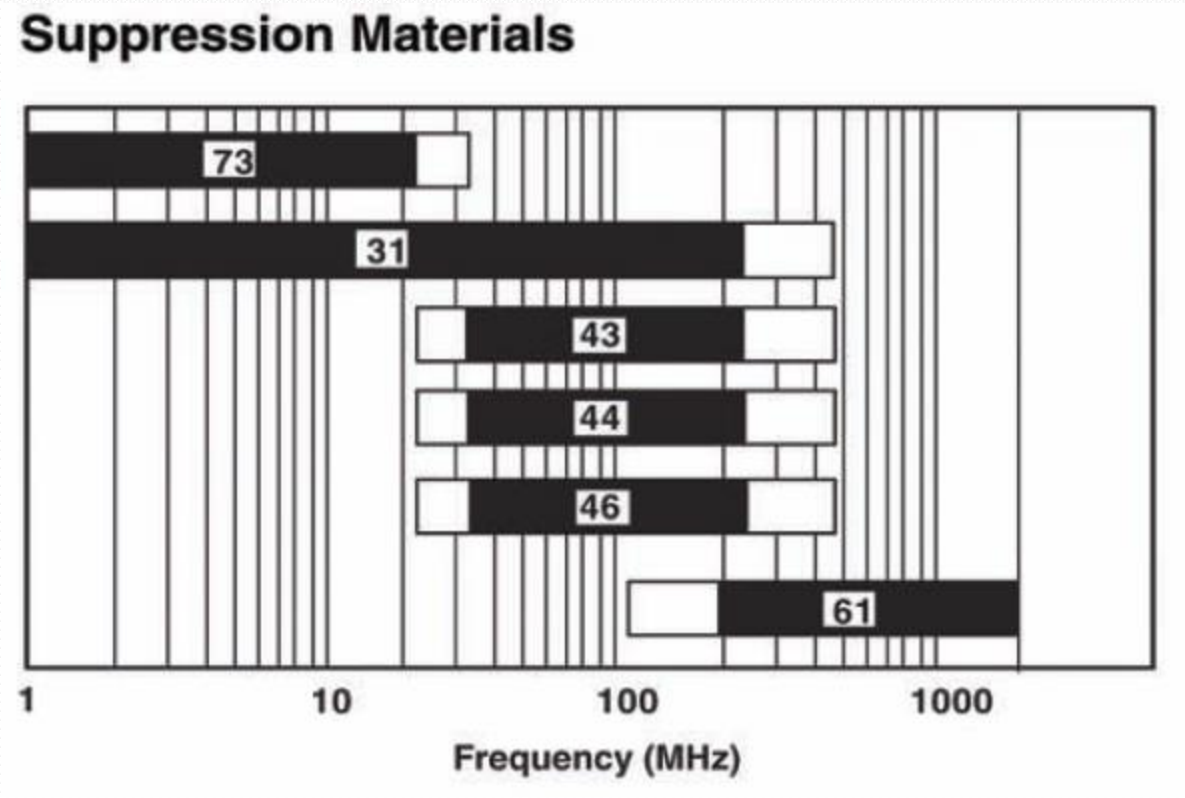

Mix = chemical formula of the iron oxide with manganese-zinc (31, 73/77) or nickel-zinc (43, 61)

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

(e.g. for 2 MHz us mix 73/77, for 30 MHz us mix 31 or 43)

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

# Ferrite Mix Selection - Chokes




How to buy?

# How to buy ferrites the wrong way!

- No MIX Designation
- No Impedance Range
- No Frequency Range

=

**DON'T**

**BUY!!!**

**Buying unknown ferrites is a waste of time and money!**

# How to buy Ferrites the right way

**PALOMAR ENGINEERS ®**

**Ferrite Split Beads**
**25 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 # FSB31-1/2-25**

www.Palomar-Engineers.com

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**BUY With CONFIDENCE!!**

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

# Ferrite Use Recap

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

Most popular Mix for HF is MIX 31

(Mix 77 for < 10 MHz, Mix 61 for 200-2000 MHz)

How can you use ferrites for RFI issues in your ham shack/home or your neighbor's home?

# Transmitter RFI Solutions

# Ham's RFI Strategy

- **Eliminate/reduce RFI SOURCE**
- (transmitter, amplifier, or antenna location)
- or
- **Choke the PATH**
- (coax feedline, AC/DC power line)
- or
- **Protect the VICTIM**
- (filter inputs to victim)

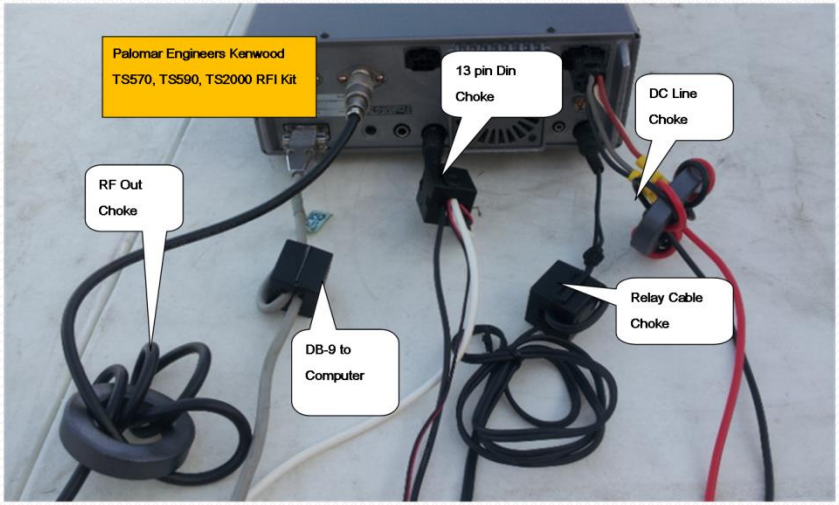
How does that apply to your ham shack/home/neighbor?

# RFI Chokes for Transmitters/AMP

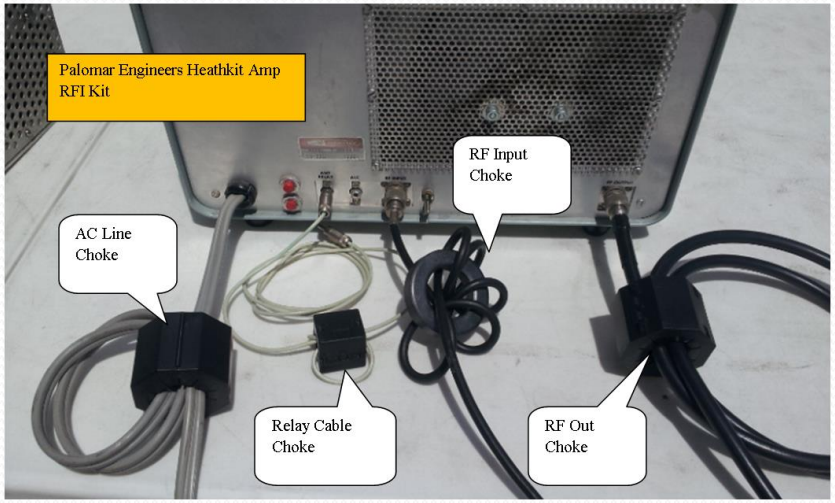
- Transmitter – Amplifier  RFI suppression
  - All cables into/out of radios, amplifier, antenna tuners
  - Includes
    - AC power Lines
    - DC Power lines
    - RF connections
    - Computer interconnects
    - Examples on next slides
  - Recommendation: Get the transceiver and amplifier kits with mix, sizes, instructions already determined.

# Transceiver/Amp RFI Kits

Transceiver RFI Kit




Linear Amplifier RFI Kit

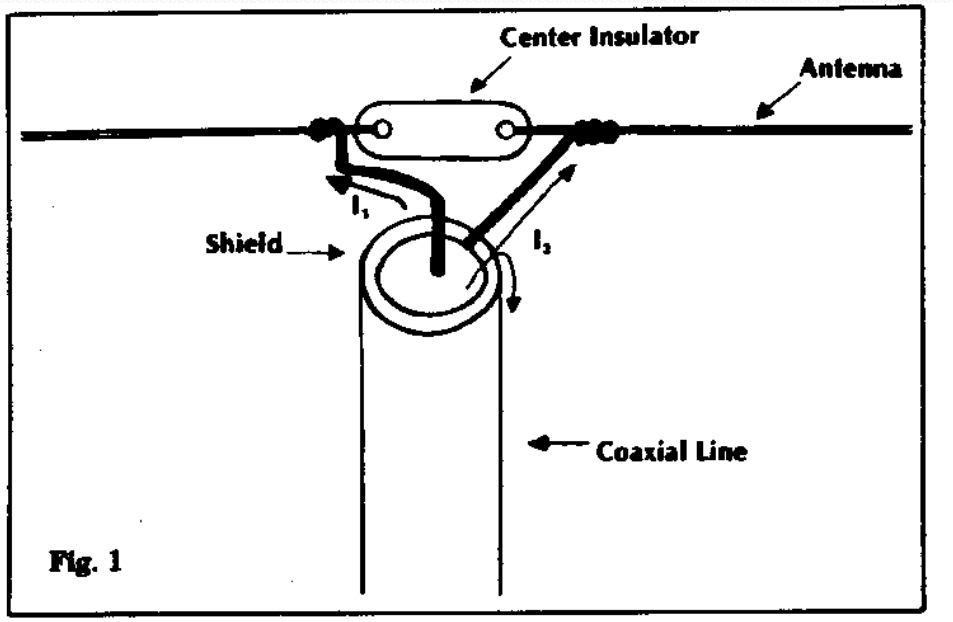



After Source RFI Suppression

#1 RFI problem is antenna feed line radiation –why?

# Is your Dipole a Tripole?

- Coax outside braid acts as extension of transmitting antenna




1% 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

# Antenna feed line choke options

EVERY coax feedline needs an RFI choke tuned to the antenna frequency!

EVERY rotor control, antenna selector needs an RFI choke!

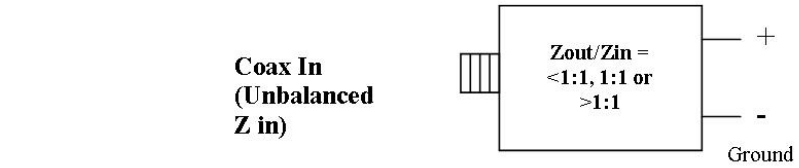
RFI chokes are made with several output options dependent on antenna type:

- Ununs #1 (verticals, end fed antennas)
- Ununs #2 (coax in/coax out)
- Baluns (beams, dipoles, loops)

# UNUN #1 (verticals, end feds)

Use 4:1 or 9:1 impedance transformer to antenna and a feed line choke

| Style | {UN} {Unbalanced Output} | {UN} {Unbalanced Input} | Typical Use: |
|---|---|---|---|
| 1 | | | 1:1 vertical feedline choke<br>1:2 Low Z antenna matcher (25Ω to 50Ω coax)<br>4:1, 9:1 end fed antenna impedance transformer |

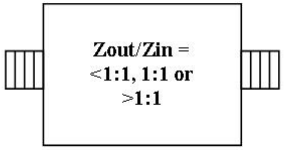



Impedance Ratio = Output Impedance/Input Impedance = Z out/Z In normalized to1 for Z out or Z in can be 1:1 (50Ω out : 50Ω In Feedline Choke), < 1:1 (1:2 = 25Ω Out : 50Ω In) or > 1:1 (2:1 = 100Ω Out : 50Ω Input)


# UNUN #2 (coax in, coax out)

| Style | {UN} {Unbalanced Output} | {UN} {Unbalanced Input} | Typical Use: |
|---|---|---|---|
| 2 | | | 1:1 Coax feedline choke<br><br>1.5:1 75 ohm to 50 ohm coax impedance trans-former |

Coax In (Unbalanced Z in)



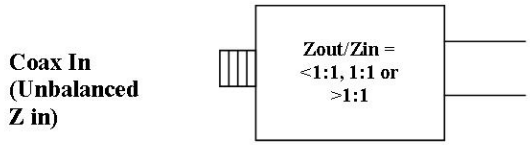

Coax/Load Out (Unbalanced Z out) - coax

Impedance Ratio = Output Impedance/Input Impedance = Z out/Z In normalized to1 for Z out or Z in can be 1:1 (50Ω out : 50Ω In Feedline Choke), < 1:1 (1:2 = 25Ω Out : 50Ω In) or > 1:1 (2:1 = 100Ω Out : 50Ω Input)

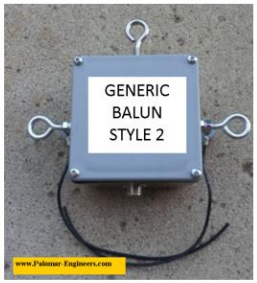

# BALUN (dipole, beam, loop)

**{BAL}**
**{Balanced Output}**

**{UN}**
**{Unbalanced Input}**




Impedance Ratio = Output Impedance/Input Impedance = Z out/Z In normalized to1 for Z out or Z in can be 1:1 (50Ω out : 50Ω In Feedline Choke), < 1:1 (1:2 = 25Ω Out : 50Ω In) or > 1:1 (2:1 = 100Ω Out : 50Ω Input)



Now some practical examples of feed line chokes

# Coax Choke (aka “Ugly” balun)


Picture: Ugly balun at 7 Mhz, 16 turns, 4.5” diameter = 3,000 Z – 20 feet of coax – ONLY effective for 1-2 ham bands since acts as a tuned choke using L and C of coax

# Sleeve Chokes (Snap on)


RG-8X (1/4” size)
150-500 ohms

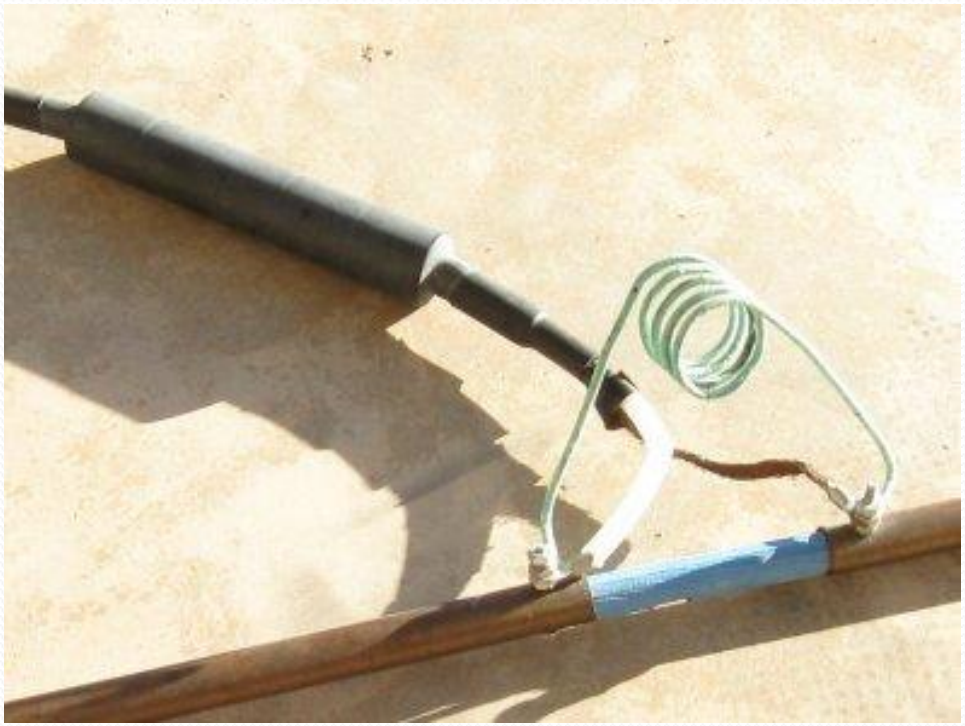
RG-213 (1/2” size)
150-500 ohms

# Clamp On Choke (FSB-1) = 1” ID

3 turns =
1K ohms

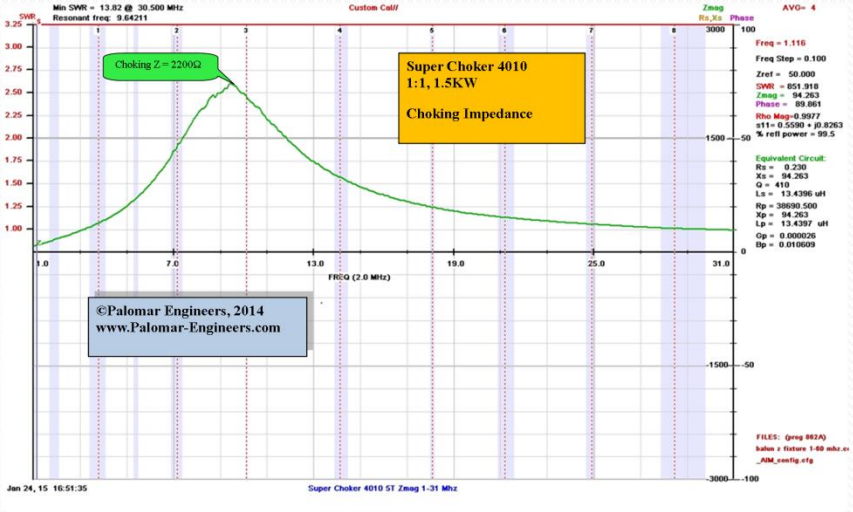
# Sleeve Choke (Slip on)

Small Size for dipole, beam, inline chokes of 500-1000 ohm choking Z



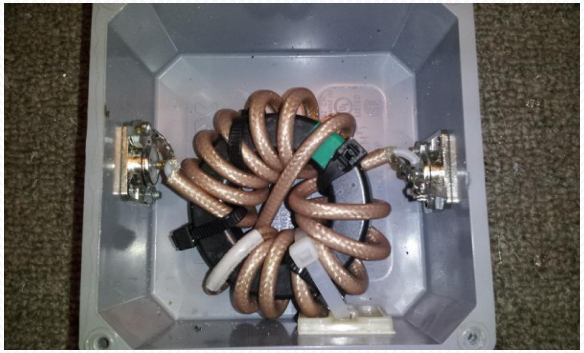
Palomar BA-8 Balun on Beam Antenna (RG-213)

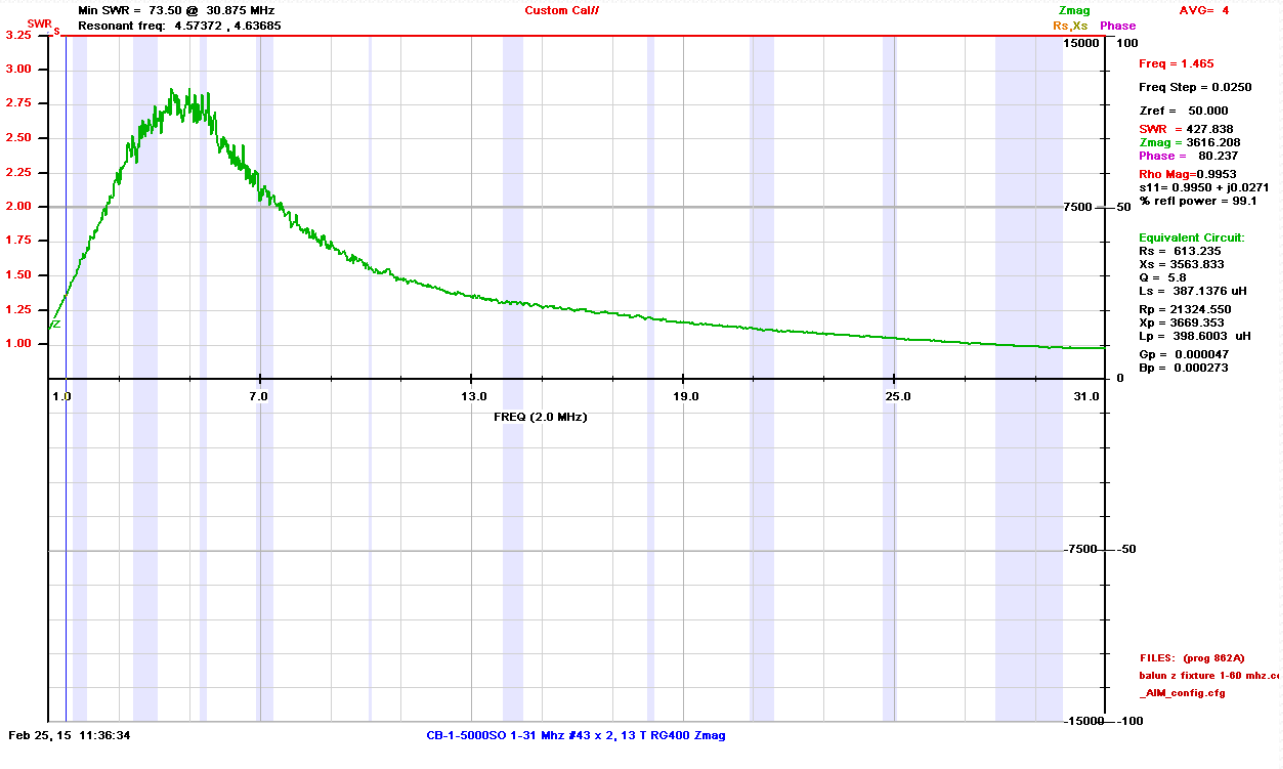
# Super Choker (40-10 Meters)


Medium Choking, High Power, Contesting,
Continuous modes (RTTY, AM, digital)

# CUBE Chokes



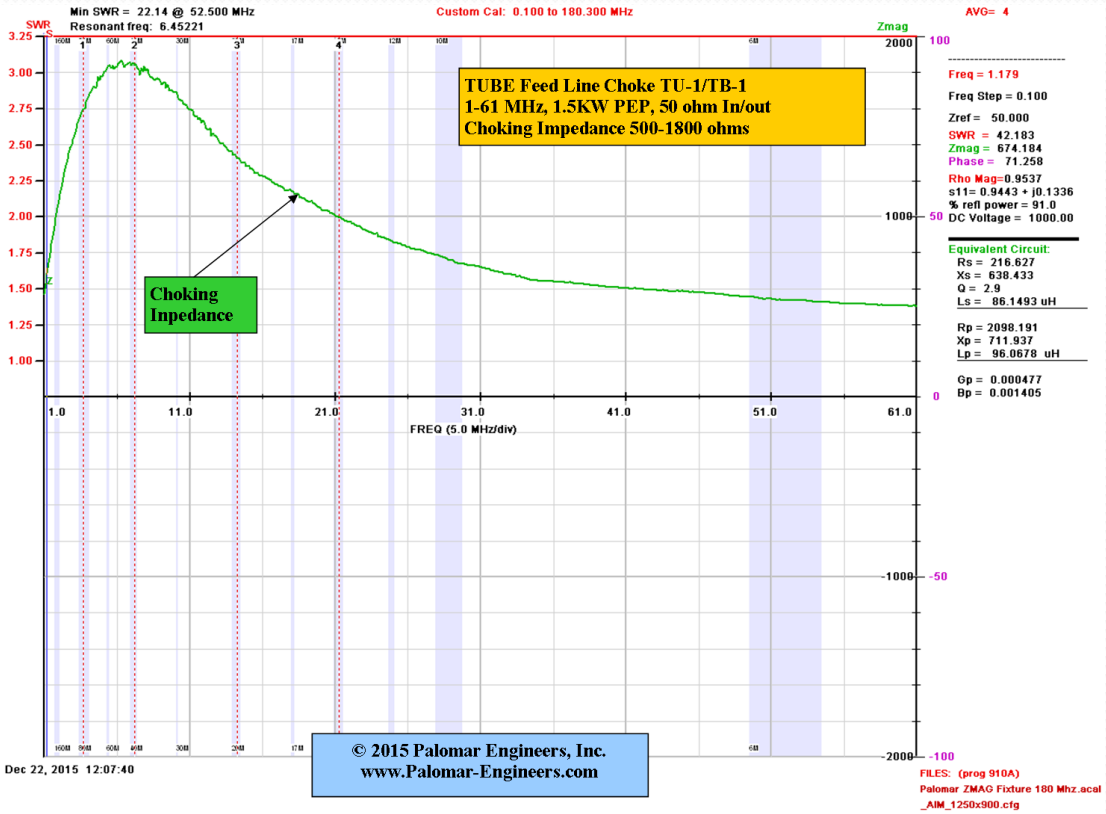



Highest Choking (5-15K ohms)

Power to 10KW PEP

Use: Inline choke, beam, dipole

# TUBE Chokes

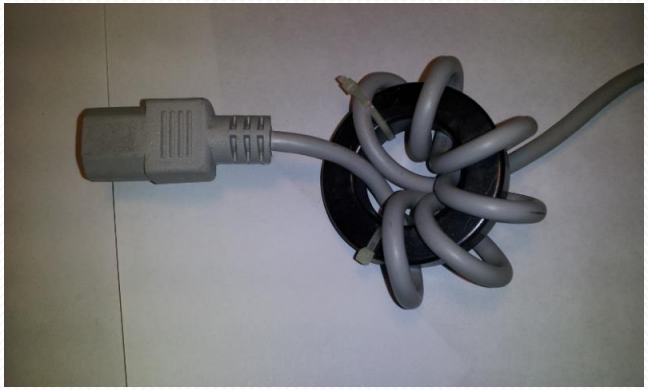

Medium Choking – up to 5KW PEP

Use: Inline choke with ground – long coax line isolator

# RFI Chokes – 120/240V AC Path

- Ring Toroids – most effective – usually 3-10 turns
- Snap Ons – convenient to use, usually 1-2 turns
  - Big Clamp On's – multiple turns, easy to install
  - Example pictures

# AC Line Chokes




Palomar F240 (1.4”ID/2.4”OD) Choke – 80-10 meters, Z = 2-5K range depending on frequency

# RFI proof your transmissions recap

- Determine frequency range of RFI
- Choose proper mix (31, 61, 77) to suppress RFI
- Choose Topology(slip, snap, ring) to fit the Path
- Install ferrites – retest for RFI suppression
- Consider additional Paths if RFI persists

If you need help

Call Palomar Engineers or view specific solutions at

www.Palomar-Engineers.com

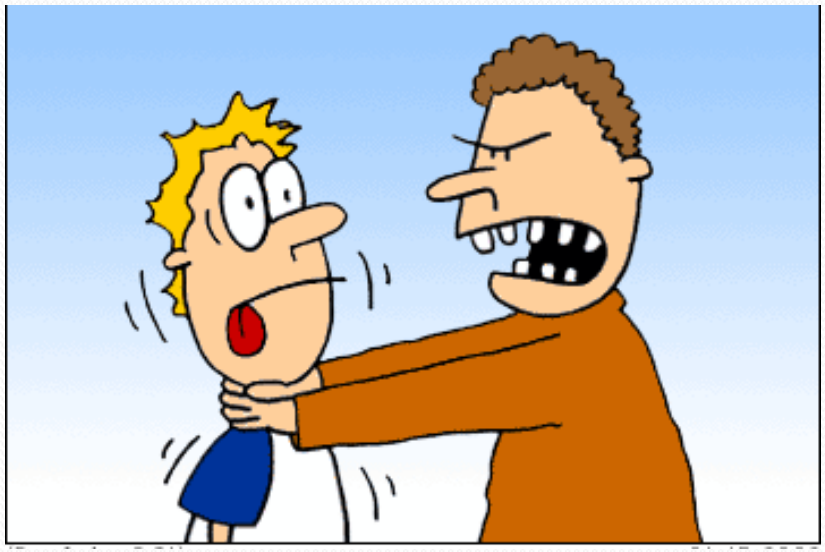
What about →→

# Keep Your Neighbors Happy!


OR

# Neighbor's RFI Strategy

- Choke RFI SOURCE



# Ham's Solution to Neighbor's RFI

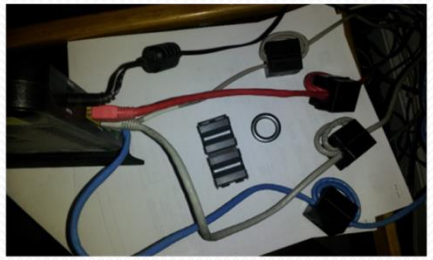
- Source (transmitter or antenna") – Path – Victim
  - Clean up your transmitter/shack first using techniques already discussed
- Assess Neighbor's Problem
  - Faulty device (device acting as receiver when not designed to be a radio receiver – e.g. Telephone)
  - Determine frequency of "transmitter" that is causing the problem (may not be on all bands – may not be you!)
  - Find the path (or paths) to the Victim (Receiver)
  - Choose the RFI choke/Kit for the frequency and path
  - Choke the path, protect the device (externally)!

# Neighborhood RFI Solutions

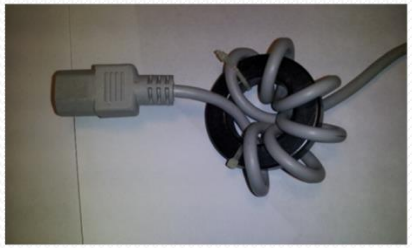
**MY HOME or NEIGHBOR'S HOME**

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.

# Neighborhood RFI Summary

- Assess S-P-V for the RFI – You or someone else?
- If ham transmitter is the source:
  - Use Palomar RFI solution kits for neighbor to install
  - Clean up SOURCE, Choke PATH, Protect VICTIM
  - Test RFI solutions for success
- If non-ham source of RFI:
  - Refer neighbor to Palomar Engineers for RFI solution kits
- Call Palomar Engineers if you get stuck or need help

Want to work more DX?

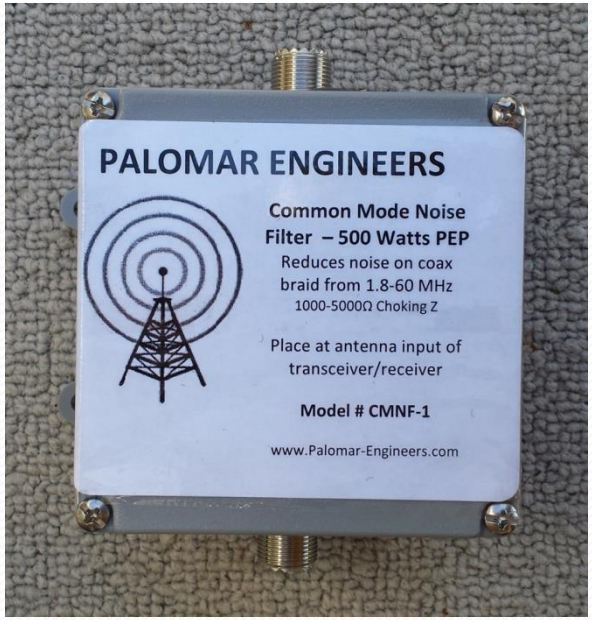
# Reduce Received RFI to work more DX

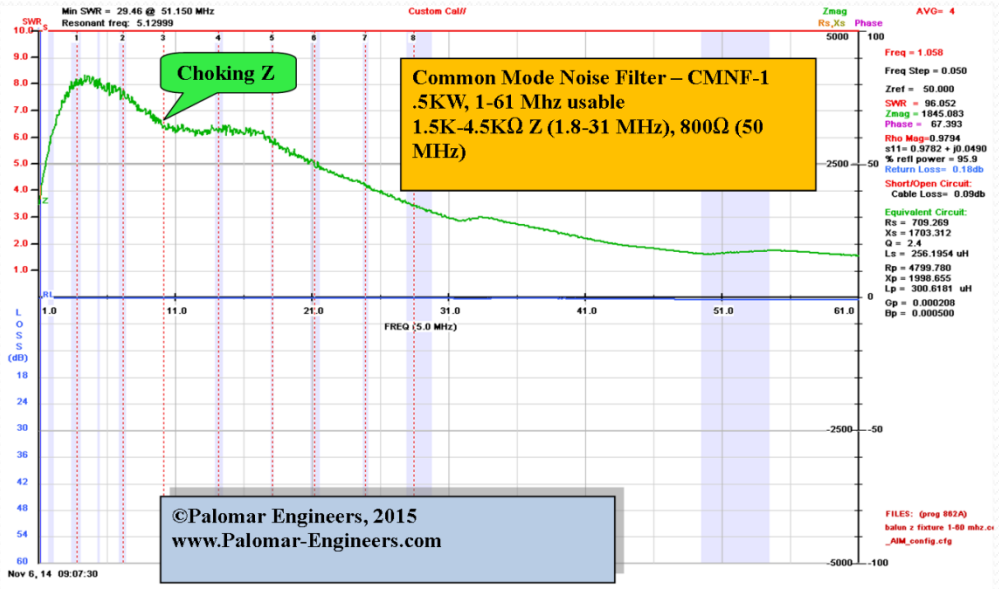
LESS NOISE = MORE DX!

# Neighborhood Noise Sources

- **SOURCES**: plasma TV, Uverse/DSL, Cable Boxes, Appliances with motors, HVAC systems (variable speed motors-square waves), home automation systems, electric fences, LED lights, wireless metering systems, wall warts, switching power supplies, battery chargers, fluorescent lights, fish tank heaters, exercise equipment, computer "hash", solar system inverters, optimizers
- **PATH**: generally receiving antenna coax braid, AC/DC power lines, computer to radio interconnects

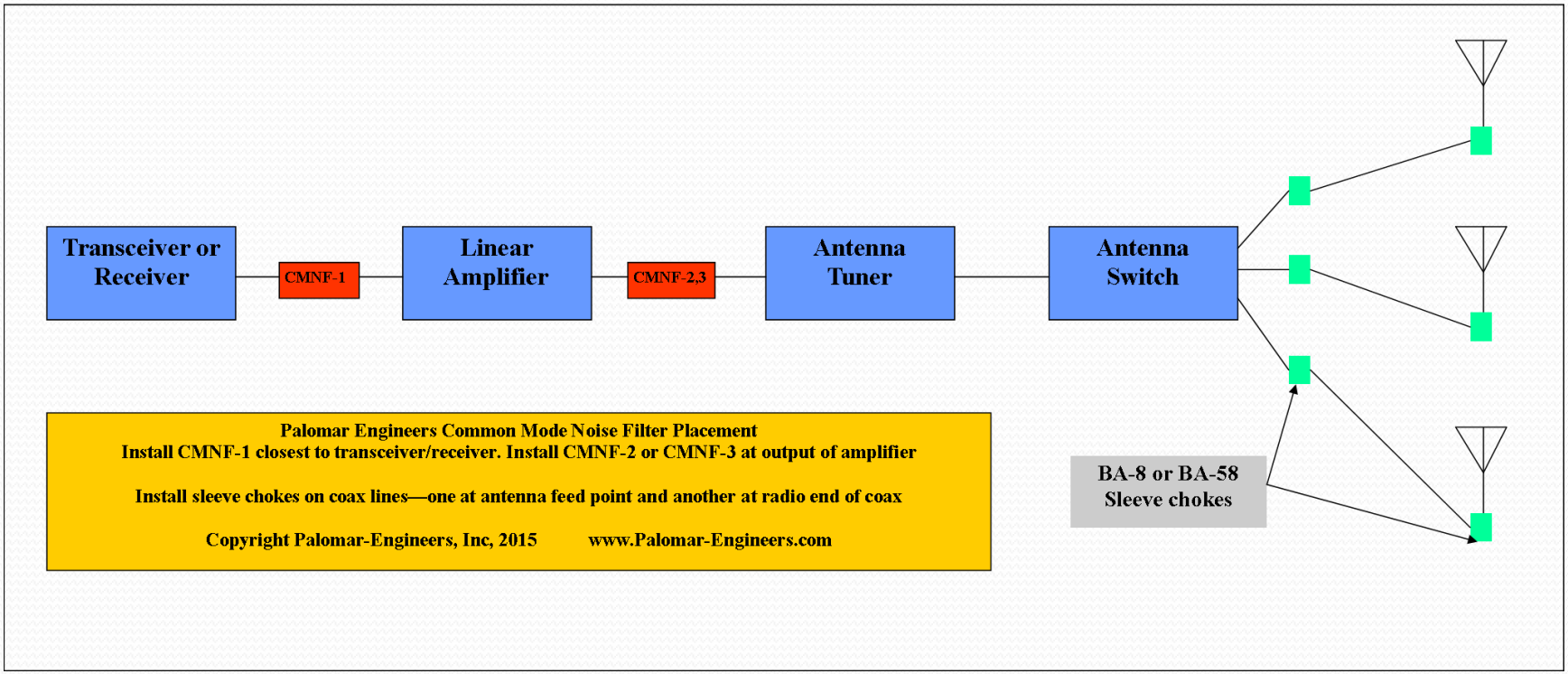
# Coax Feed Line Noise Filters




Placed at RADIO END of coax feed line

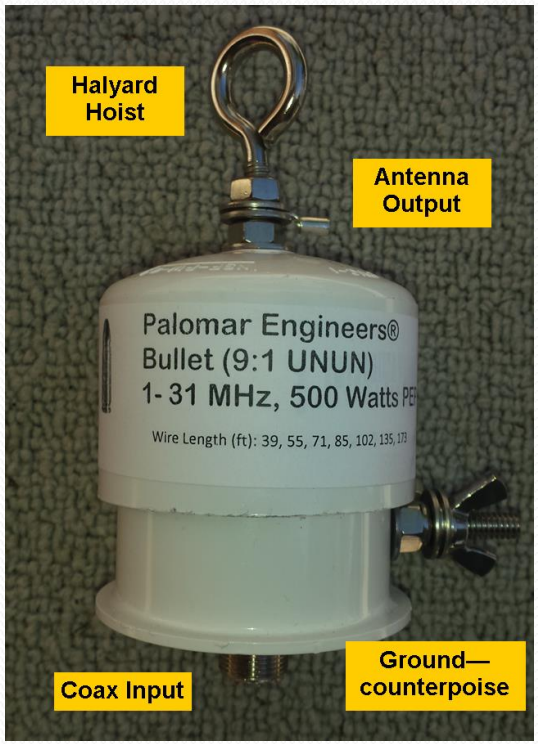
# Coax Noise Filter Placement




Filter ALL coax lines, rotor, antenna control lines (STEPPIR)

# End fed antenna chokes

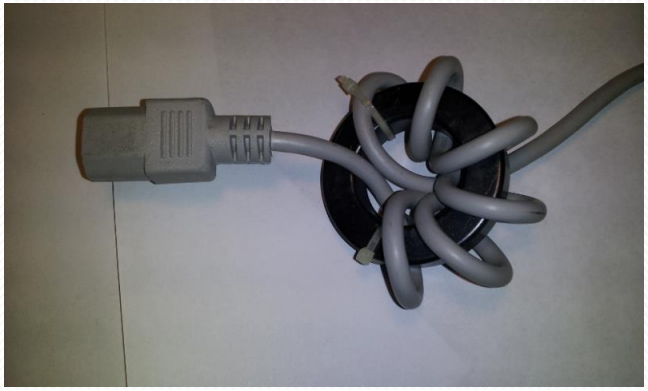
Antenna uses coax braid for counterpoise and you need feedline choke at radio end of coax to stop RFI from transmission and also RFI received on braid from all sources.




**BULLET Matcher (9:1)**


**Snap On Feed line choke at radio end**

# AC Line/DC Power Chokes



Palomar F240 (1.4”ID/2.4”OD) Choke – 80-10 meters, Z = 2-5K range depending on frequency

# 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

# Neighborhood Noise Strategy

- Assess S-P-V for the RFI – You or someone else?
- PROTECT the VICTIM (Your receiver)
  - Coax noise filters on antenna feed lines
  - Chokes on AC/DC cords, Wall Warts – ring or snap on ferrites
  - Chokes on radio-computer interconnect cables
  - Test RFI solutions for success
- ELIMINATE/ISOLATE the SOURCE
  - Chokes AC/DC power to source, snap on ferrites for all I/O
- All RFI solutions also apply to mobile, portable operations
- Call Palomar Engineers if you get stuck or need help

Test Time – Win a prize!

# Prize Question #1

- Name 2 ways to increase the choking impedance of a ferrite choke?

# Prize Question #2

- Name three ferrite mix numbers used by hams to suppress RFI

# Contact Info

- 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.