RFI Solutions to work more DX, and keep your spouse and neighbors happy!

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Causing Neighborhood RFI?

IT'S ALL YOUR FAULT WITH THAT BIG ANTENNA!

Receiving RFI from Neighborhood?

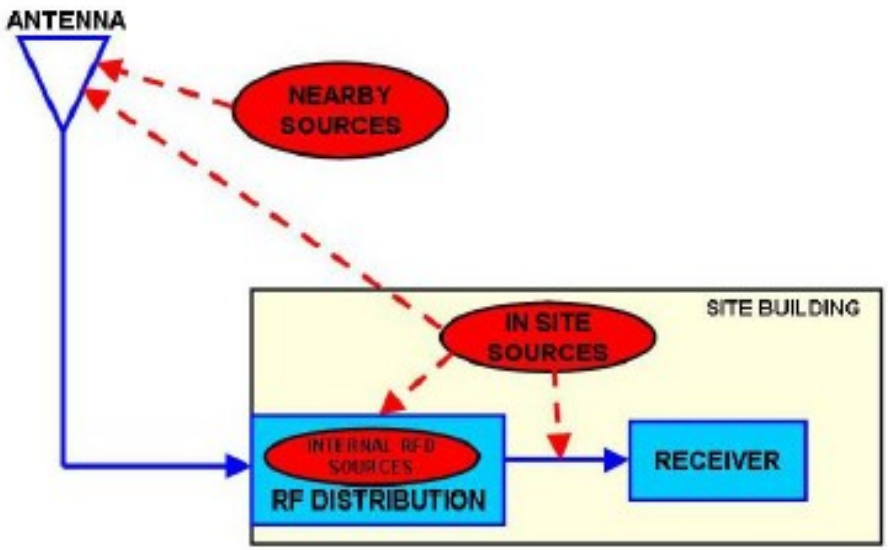


Figure 1 Block Diagram of On-Site Sources

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

RFI Workshop Objectives

- Learn fundamentals of RFI - symptoms, causes & cures
- What's a ferrite and how to pick the right one for your RFI
- How to use ferrites to solve the #1 RFI problem shared by all hams using HF radios
  - How to choose a feedline choke
  - RFI proof your indoor "antennas"
- How to solve transmitter RFI problems in your neighborhood

RFI 101

Symptoms, Causes and Cures to make ham radio more enjoyable

What is RFI?

- Radio Frequency Interference/Electromagnetic Interference (RFI/EMI) – at radio frequencies
  - A radio frequency disturbance that causes an unwanted interruption, degradation, or obstruction to an electrical circuit.
  - Common Sources
    - Radio Transmitters (Amateur, broadcast, consumer devices)
    - Natural: Sun, Cosmic noise, Lightning, atmospheric static
    - Electro-mechanical devices (motors), ignition systems
    - All sources cause rapidly changing electrical currents in the effected device which cause unintended operation(VICTIM)

Got RFI in your shack/home?

- 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 computer, TV, Stereo/Home Theater system, security system, garage door opener, microwave, telephone, DSL/cable modems/router, fax machine, touch on/off lamps, flickering lights, LED string lights, smoke/CO2 alarm, answering machine, sprinkler system
  - Degradation of computer data throughput or loss of data , computer/internet stops working

RFI Types that can be suppressed

- **TRANSMITTER RFI**

- An RFI symptom in your shack/home or your neighbor's home caused by your radio transmitter and/or antenna.

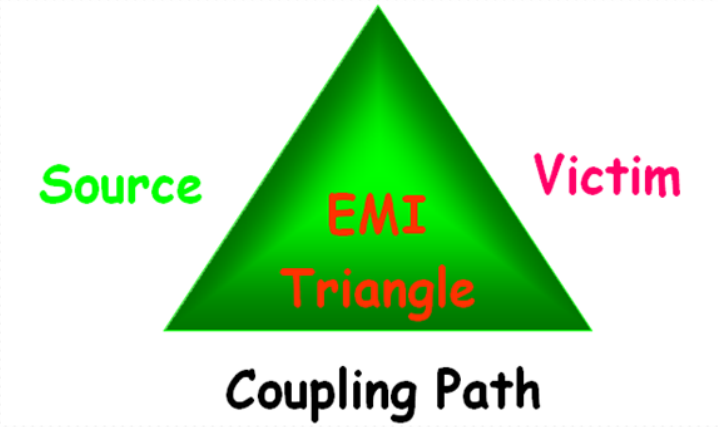
- **RECEIVER RFI**

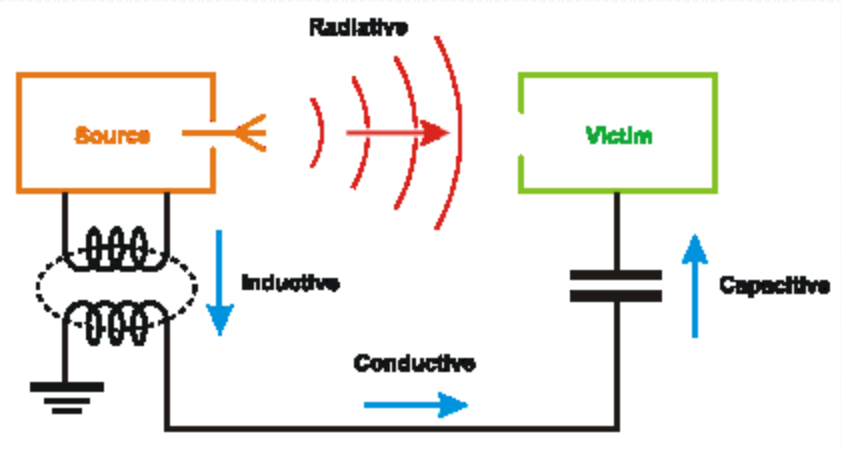
- An RFI problem caused by outside sources effecting your radio receiver (noise floor, periodic noise, etc)

RFI Contagious? How is it transferred?

How is RFI Transferred?

SOURCE – PATH - VICTIM





All three must be present to have an RFI problem.

Multiple paths are very common:

Radiative
Conductive
Inductive
Capacitive

Typical “Antenna" Paths for RFI

- 160-80-60-40 meter transmitting – “Long” - AC lines, Phone lines, satellite/cable coax, long CAT-5 cables, ham antennas coax shield, antenna control/rotor cables, 2nd story ground wires
- 20-6 meter transmitting – “Short” - speaker wires, device interconnect cables, mic cables, short Cat-5 cables
- AM Broadcast Receiver RFI – same as 160 – long “antennas”
- FM Broadcast Receiver RFI – short “antennas” – 3-6 feet long

- “Antennas” pick up RFI current on all conductors (called common mode current) from 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=E/R)

- Typical solutions: Resonant traps, <u>ferrites</u>, filters

Ferrites Are your Friend for RFI

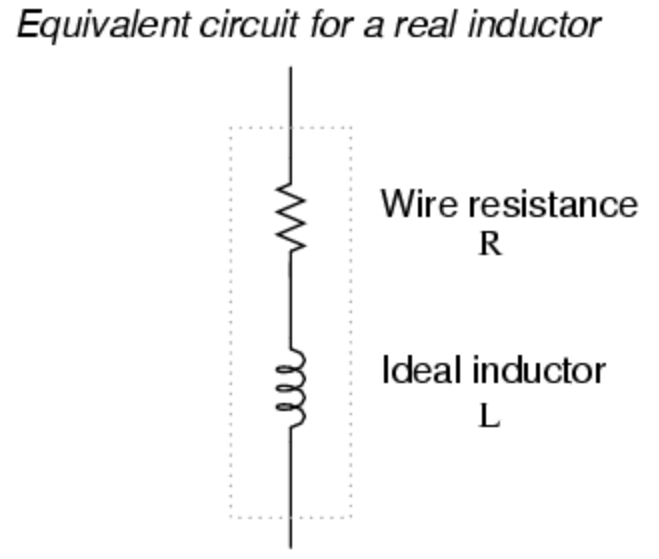
Slip On Bead

Snap On Bead

Toroid/Ring

- Cheap, easy to install, work on all ham frequencies
- Work on all paths (feed line, AC/DC, electronic devices)
- Lots of options in size, shape to fix most RFI path problems
- Can be installed by almost anybody who understands how to choose the correct ferrite for a particular RFI problem.

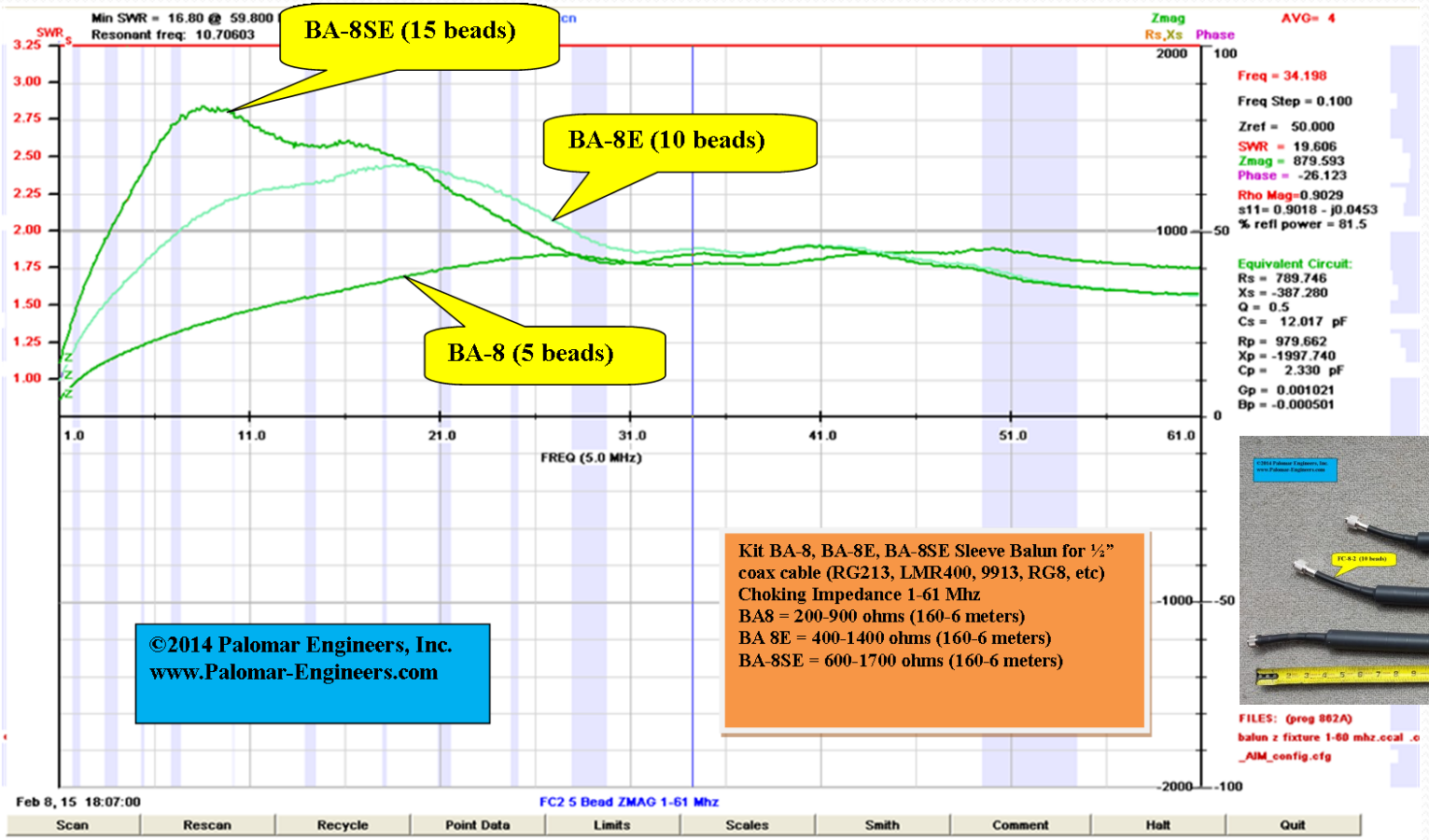
Ferrite Equivalent Circuit



Picture shows One Turn coil through a ferrite whose impedance varies with frequency (X_L=2∏*f*L) until resonance reached.

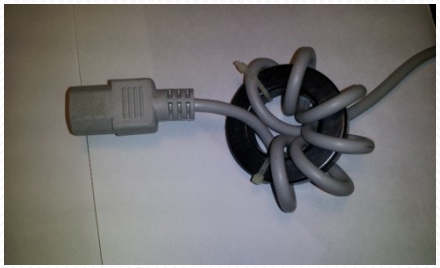
Impedance (Choking Z) can be increased several ways.....

Multiple beads increase Choking Z



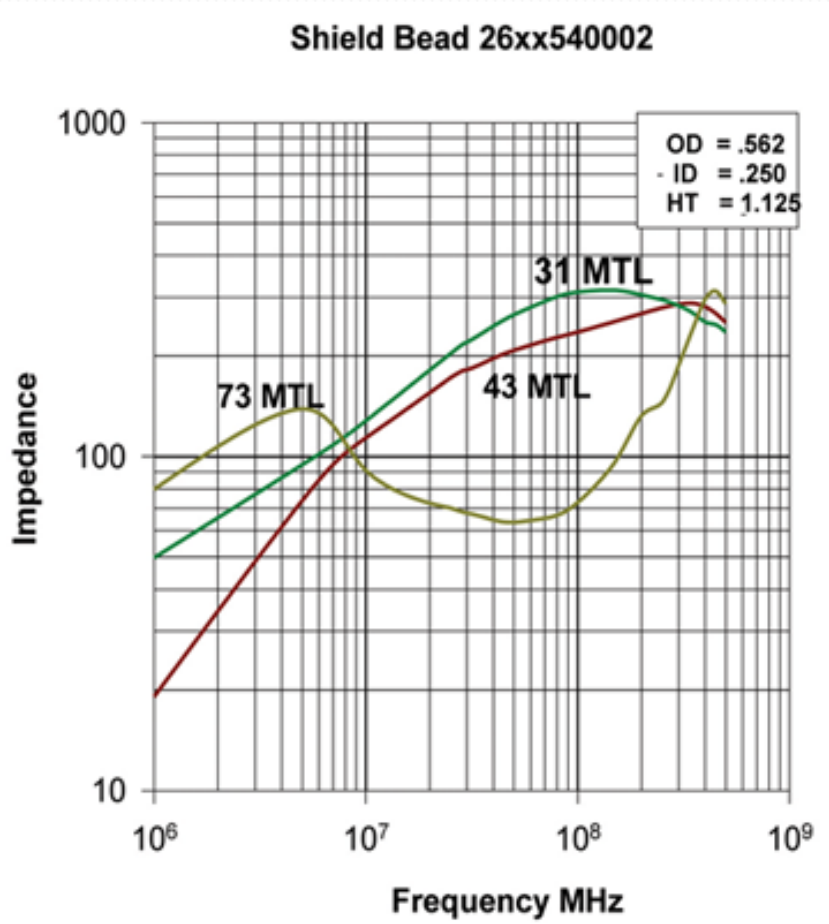
Choking Z Varies with $(\text{turns})^2$

- 1 turn = Z
- 2 turns = 4Z
- 3 turns = 9 Z
- More Z = less wire current = less RFI radiated from wire or induced into wire



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

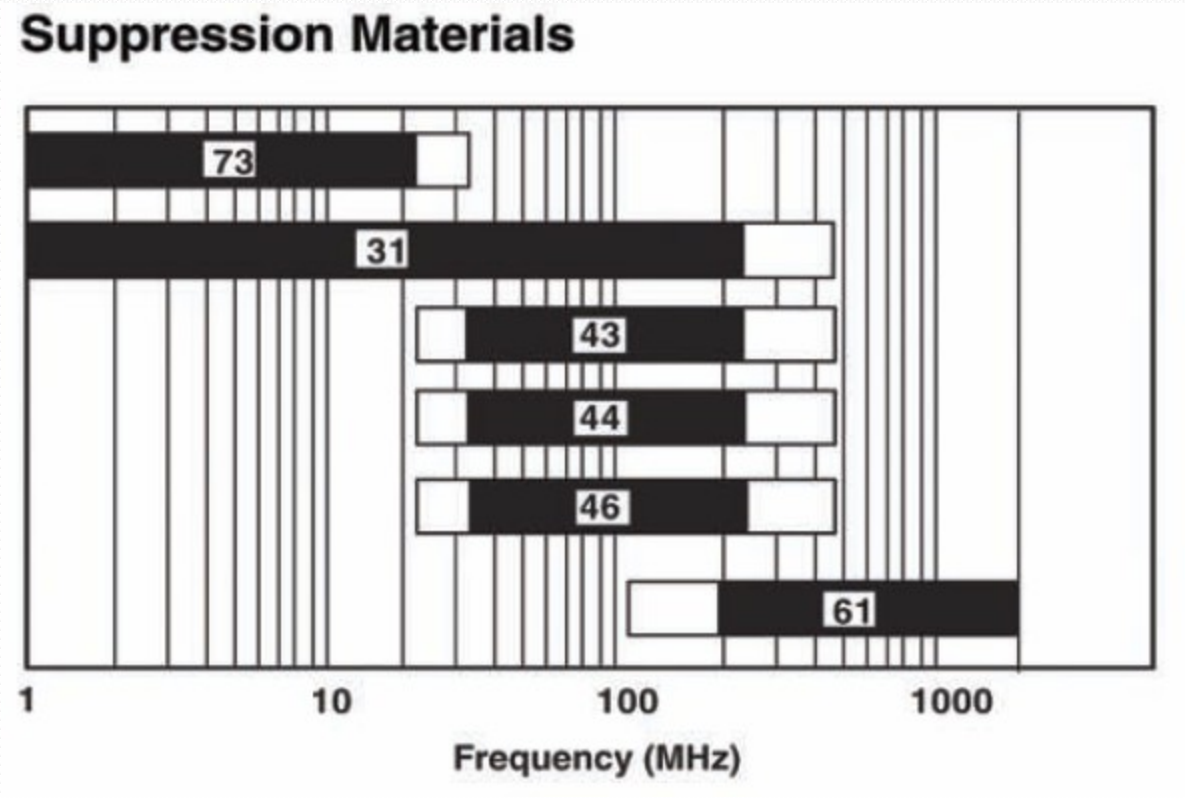
Ferrite Mixes



Different mixes for different frequency ranges of choking. Use at frequencies to the "left" of peak for chokes.

Most popular ham frequency mixes are 31, 43, 61, 77 – see website for ranges of each mix.

Ferrite Mix Selection - Chokes



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

Ferrite Use Recap

- Determine RFI interfering frequency
- Choose proper mix (31, 61, 77) to suppress RFI 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

How does this solution apply to your ham shack/home?

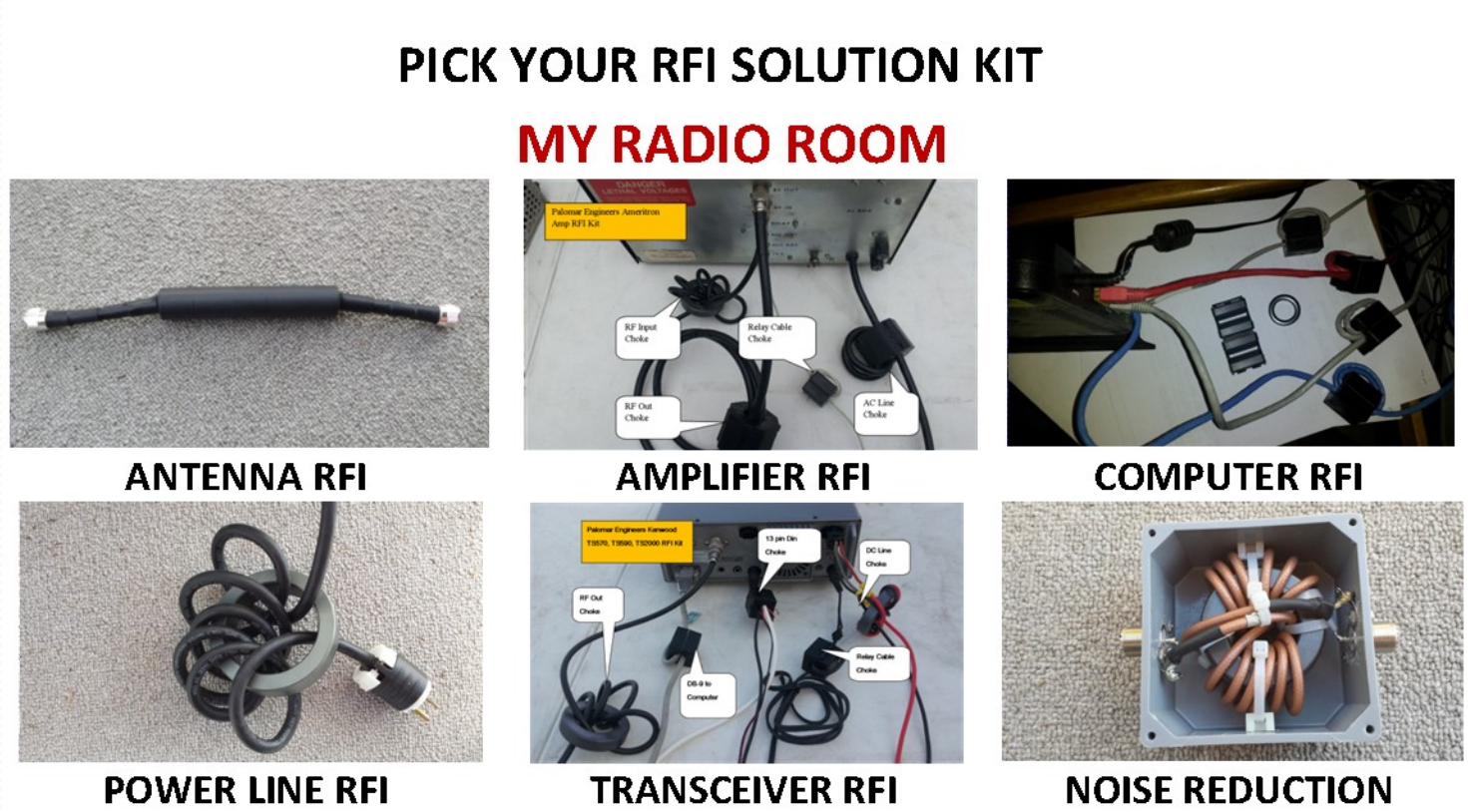
RFI Proof your Transmissions

Ham's RFI Strategy

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

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

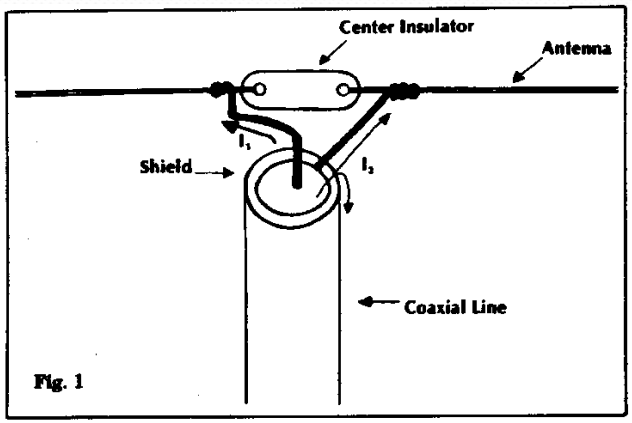
Ham Shack RFI Solutions – reduce radiation from the source



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

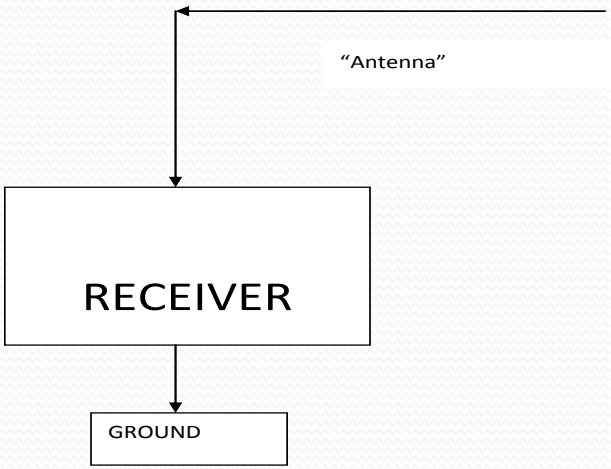
Is your Dipole a Tripole?

- Coax outside braid as a <u>transmitting</u> antenna



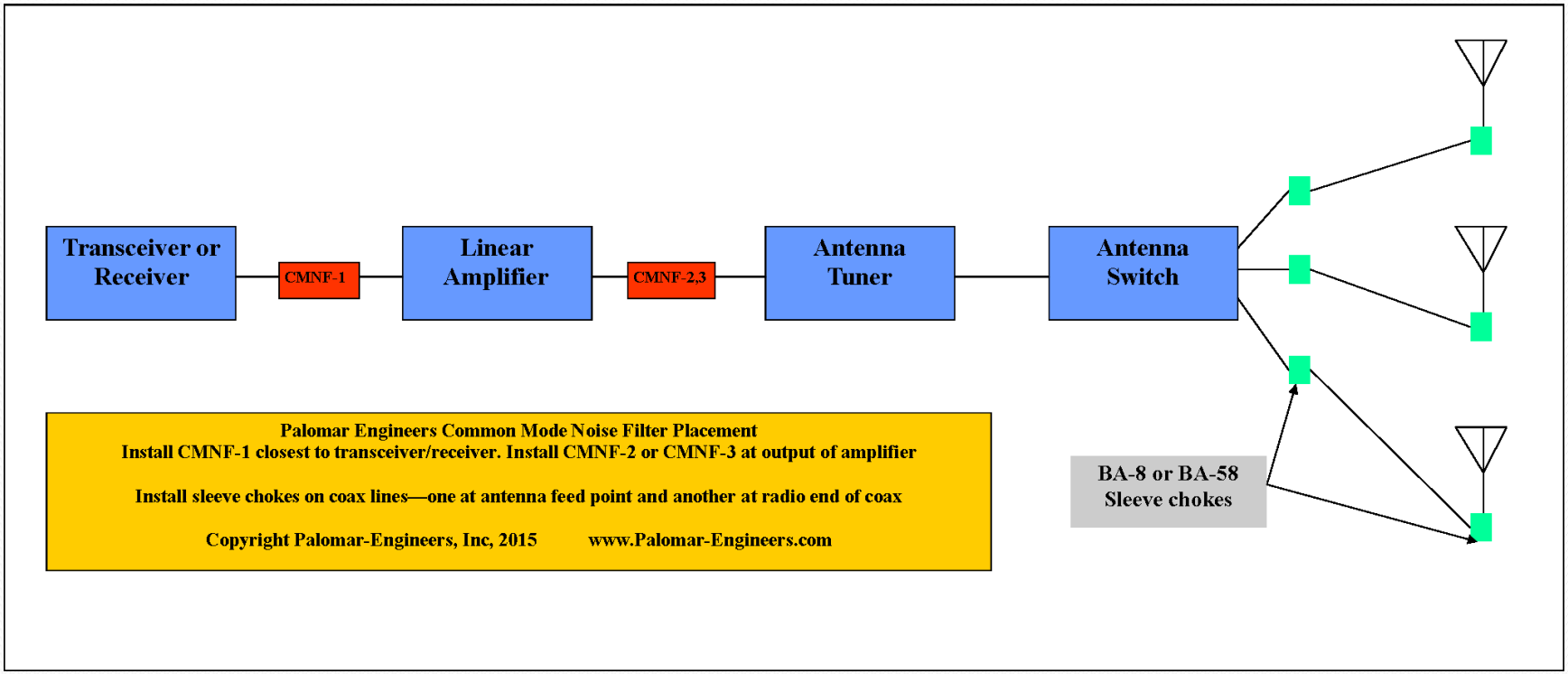
1% braid current = 2.75 watt radiation at 1500 watts input, or 1.6 watts at 500 watts input or .7 watts at 100 watts input

- Coax outside braid as a <u>receiving</u> antenna



From choked antenna feed point to receiver, outside braid receives "noise" radiation from antenna and neighborhood devices

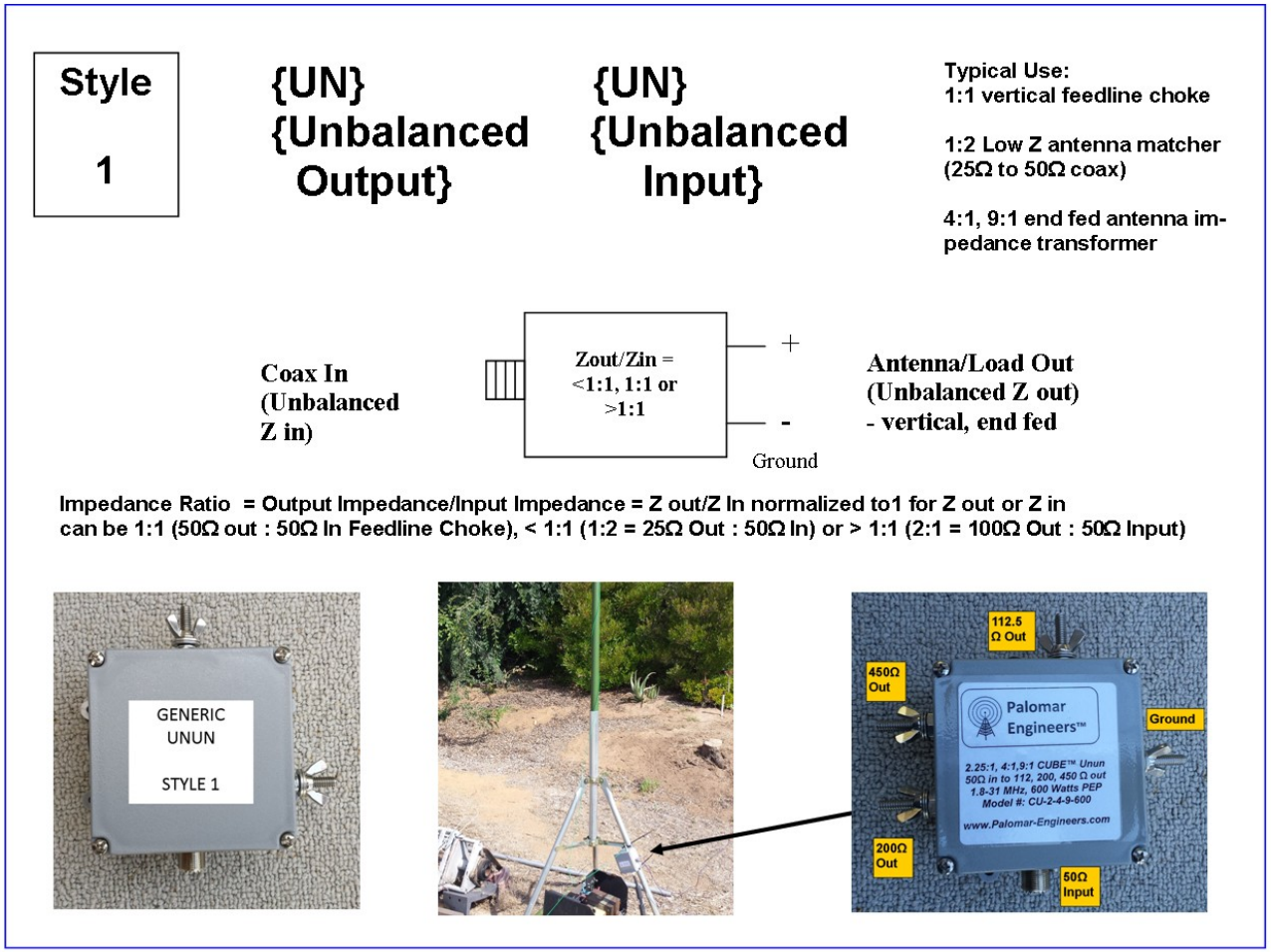
RFI chokes/filters for feed line path



EVERY coax feedline needs an RFI choke tuned for antenna frequency! Every rotor control, antenna selector needs an RFI choke! – How to choose – unun/balun?……

UNUN #1 (verticals, end feds)

Use 4:1 or 9:1 impedance transformer and feed line choke below.



UNUN #2 (coax in, coax out)

Style 2

{UN} {Unbalanced Output}

{UN} {Unbalanced Input}

Typical Use:
1:1 Coax feedline choke

1.5:1 75 ohm to 50 ohm coax impedance trans-former

Coax In (Unbalanced Z in)

Zout/Zin = <1:1, 1:1 or >1:1

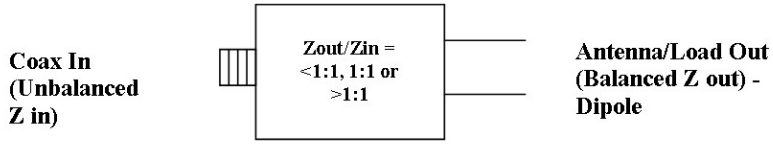
Coax/Load Out (Unbalanced Z out) - coax

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)

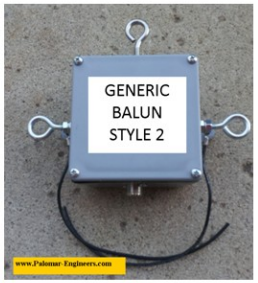
BALUN (dipole, beam, loop)

{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

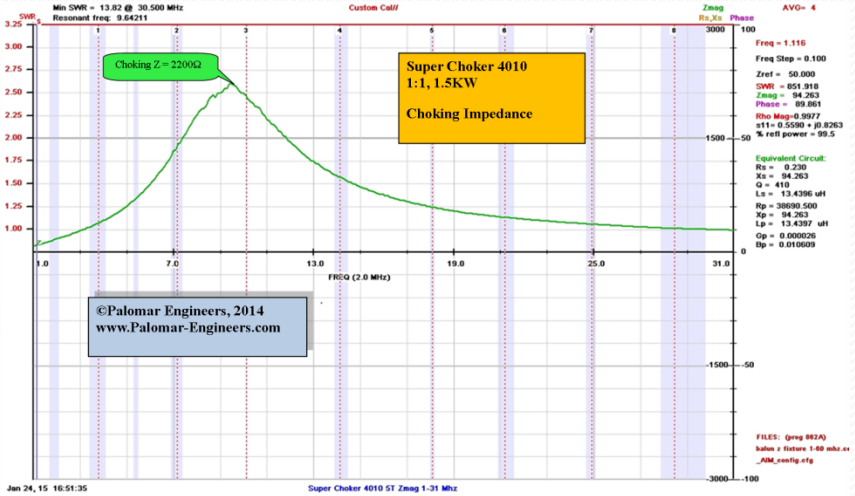
3 turns =
1K ohms

Sleeve Choke (Slip on)

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

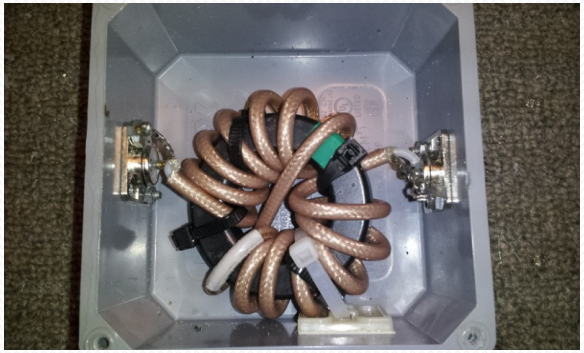
Palomar BA-8 Balun on Beam Antenna (RG-213)

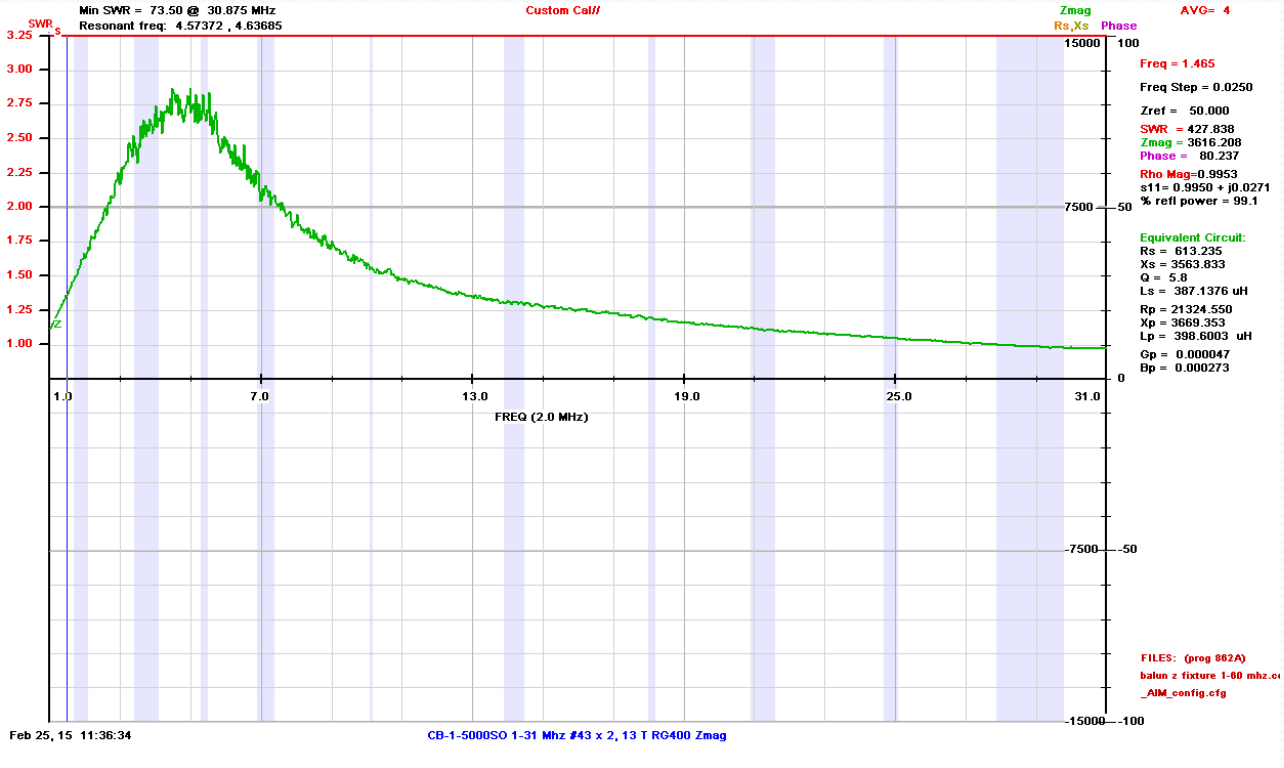
Super Choker (40-10 Meters)



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

CUBE Chokes



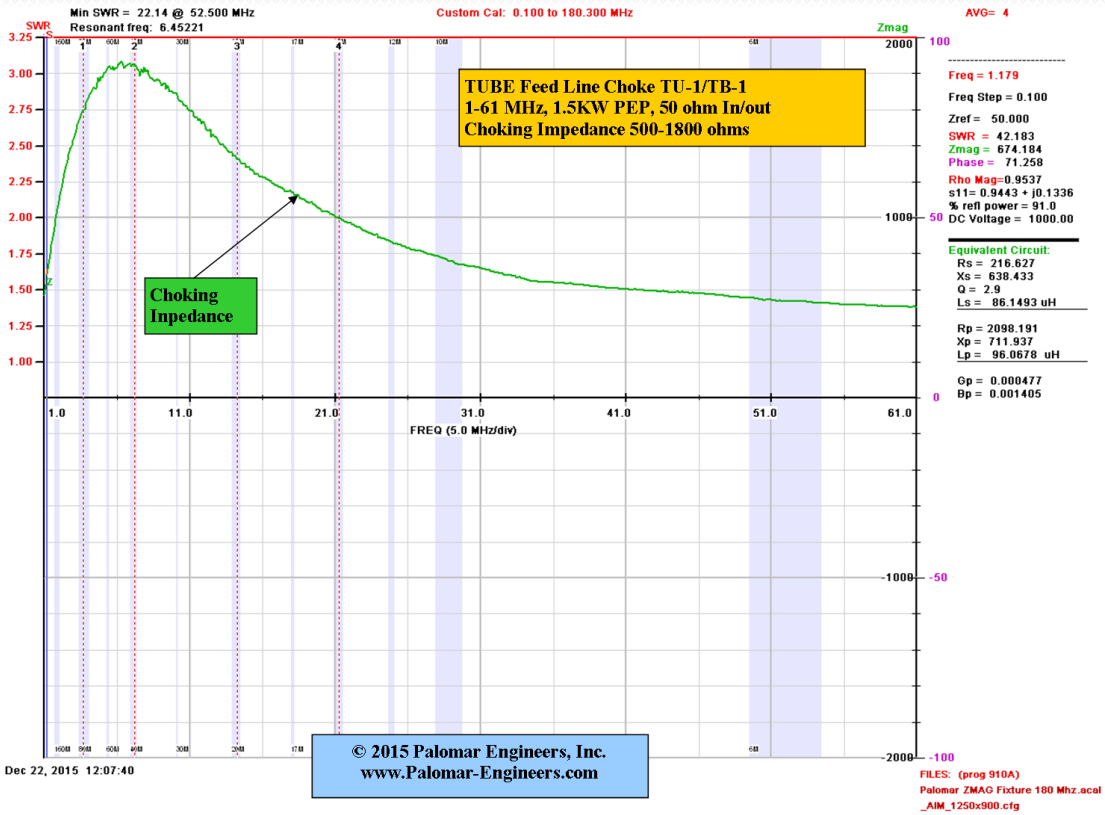


Highest Choking (5-15K ohms)

Power to 10KW PEP

Use: Inline choke, beam, dipole

TUBE Chokes



Medium Choking – up to 3KW PEP

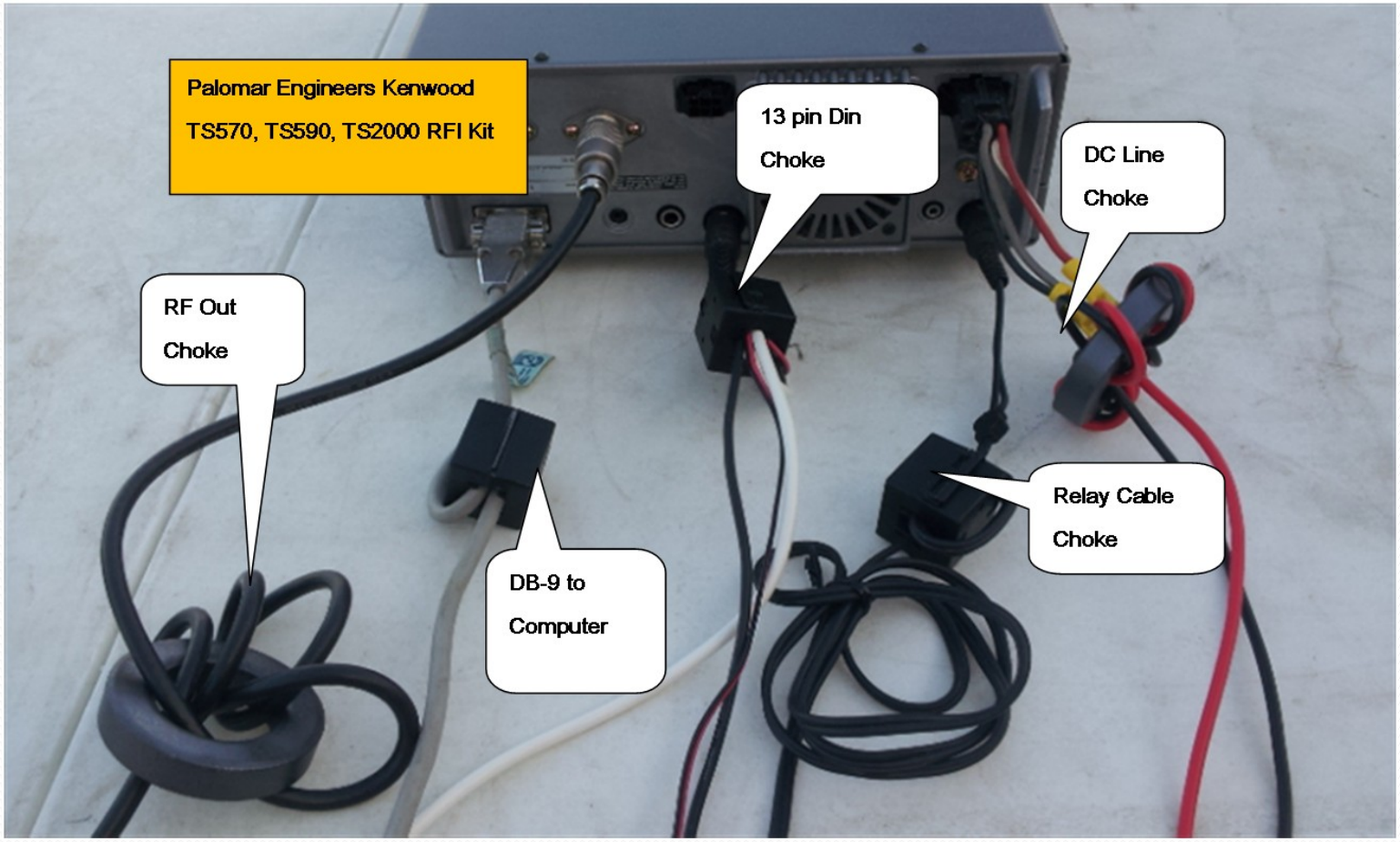
Use: Inline choke, beam

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.

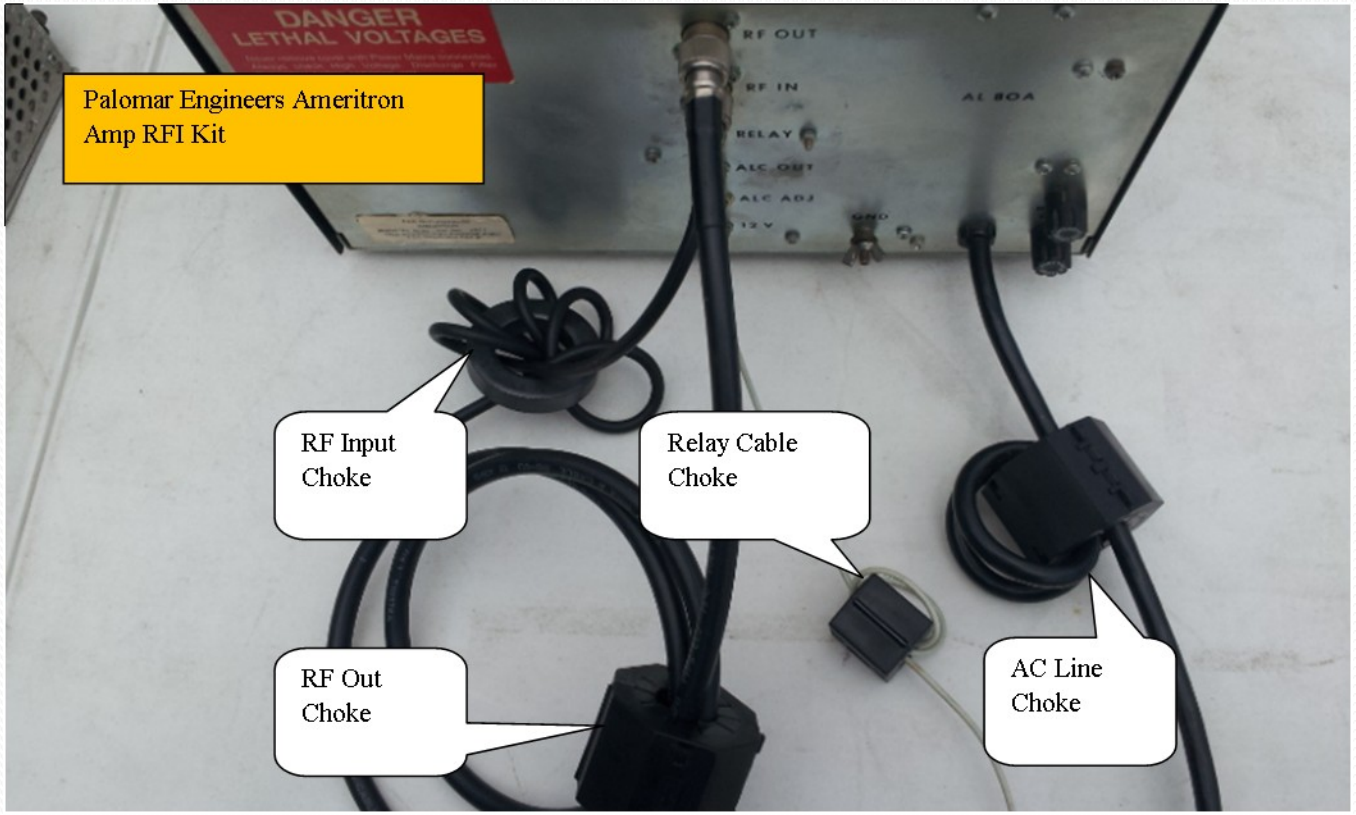
RFI Kit - Transceivers



Amplifier RFI Kits – all brands

Alpha, Ameritron, Amp Supply, B&W, Collins, Command, Drake, Gonset, Hallicrafters, Hammarlund, Heathkit, Henry, Hunter, Icom, Kenwood, Palomar, Palstar, QRO, SBE, SWAN, Ten Tec, Tokyo-Hy-Power, Yaesu

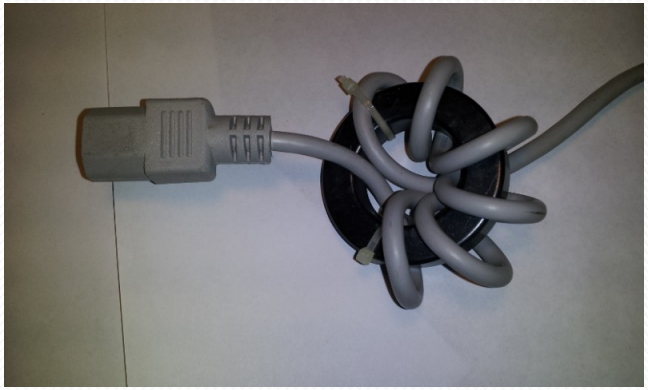
RFI Kits - Amplifiers



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

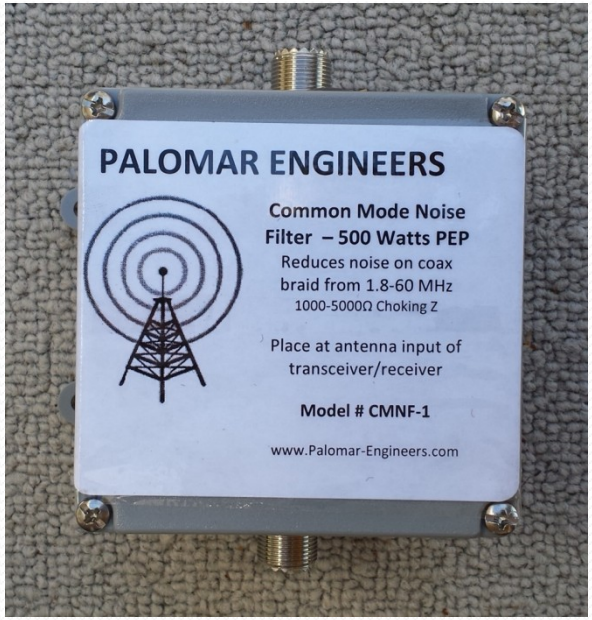
Reduce Received RFI to work more DX

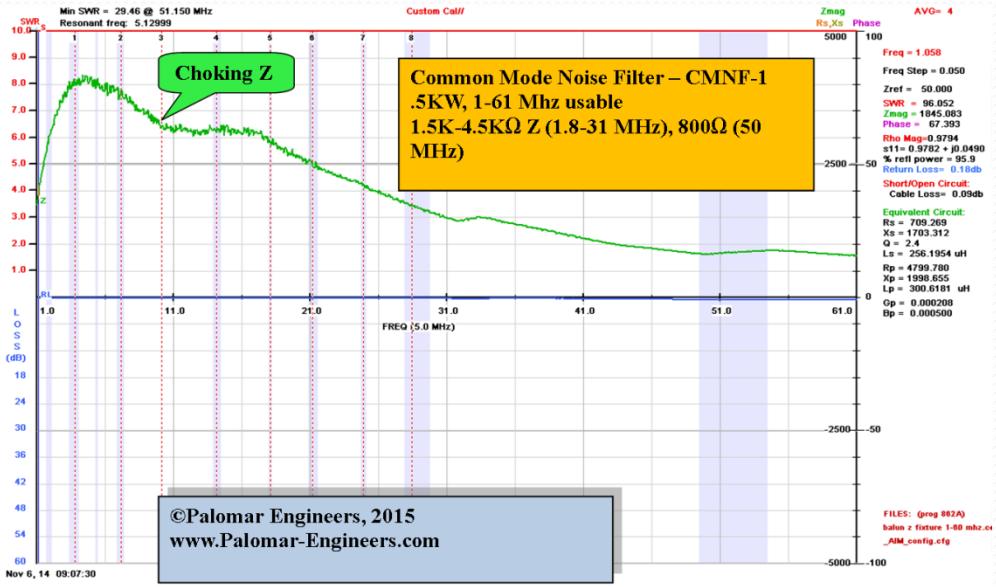
LESS NOISE = MORE DX!

Neighborhood Noise Sources

- **SOURCES**: plasma TV, Uverse/DSL, Cable Boxes, Appliances with motors, HVAC systems (variable speed motors), 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

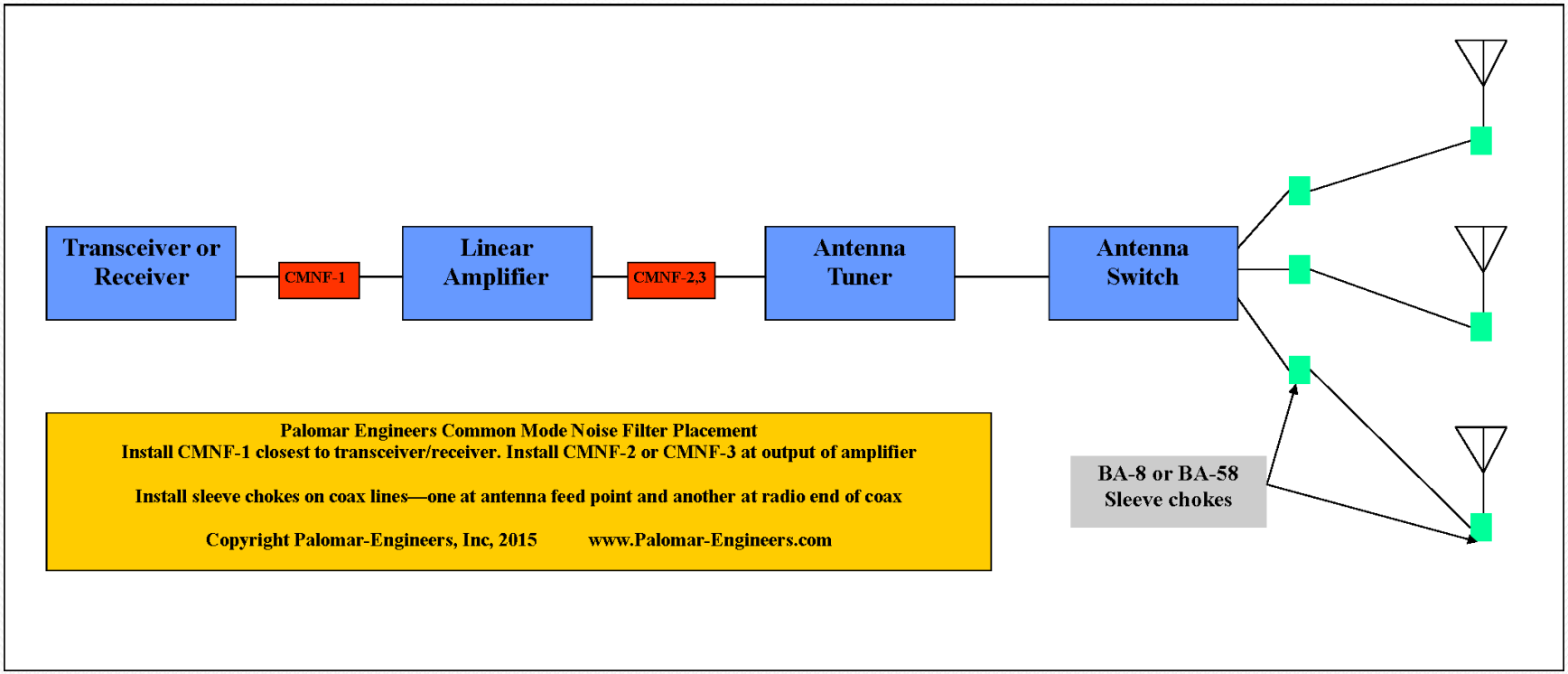
Coax Feed Line Noise Filters





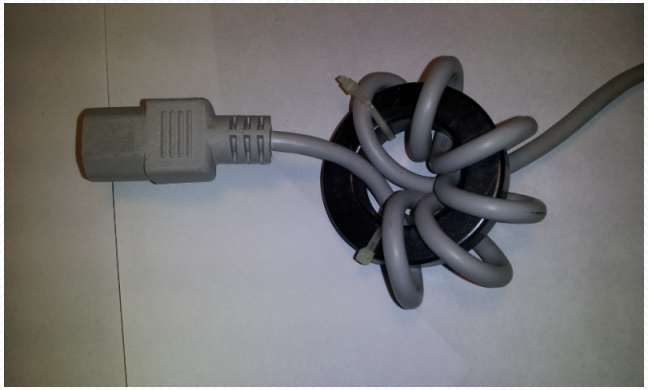
Placed at RADIO END of coax feed line

Coax Noise Filter Placement



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

AC Line/DC Power Chokes



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

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 – 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

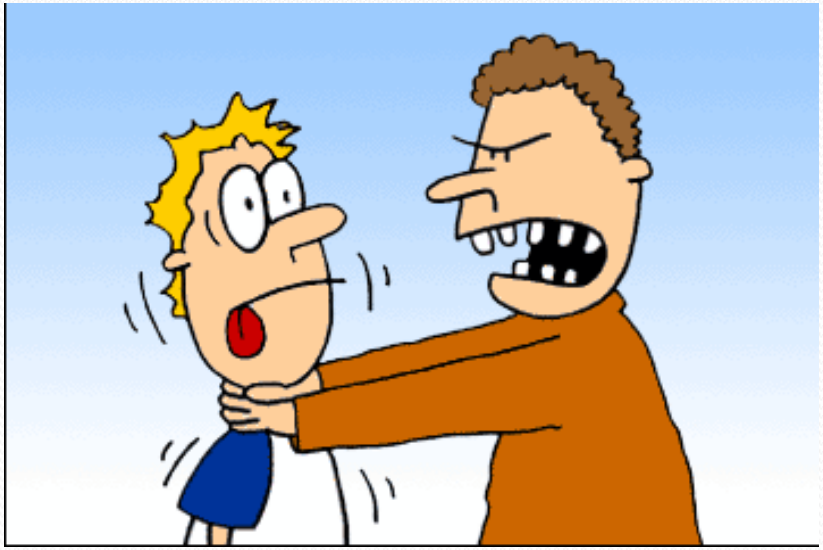
- Call Palomar Engineers if you get stuck or need help

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

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

TEST TIME! WIN A PRIZE

Prize Question #1

- How do you increase the choking impedance of a ferrite choke?

Prize Question #2

- Name two ferrite mix numbers used by hams

Contact Info

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- Bob Brehm, AK6R – Chief Engineer
- This presentation available on the website.