

ABC's of RFI for Hams

Symptoms, Causes & Cures



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This presentation available on website

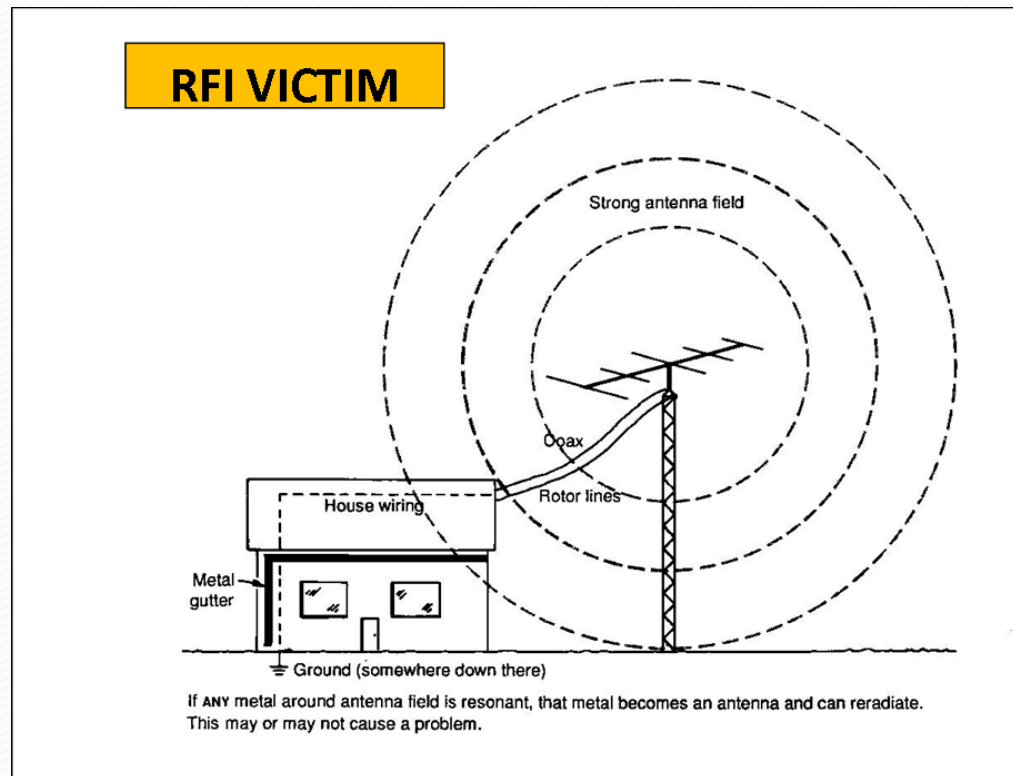
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Are you the **SOURCE** of RFI?



IT'S ALL YOUR FAULT WITH THAT BIG ANTENNA!

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



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



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 coax-fed HF antennas
- How to use ferrites to solve transmitter RFI problems, reduce your receiver noise floor, and keep your neighbor's and spouse happy!

Thinking cap time.....

RFI 101

For Contesters, DX'ers, Rag Chewers, Old
Timers and Beginners too!



What is RFI?

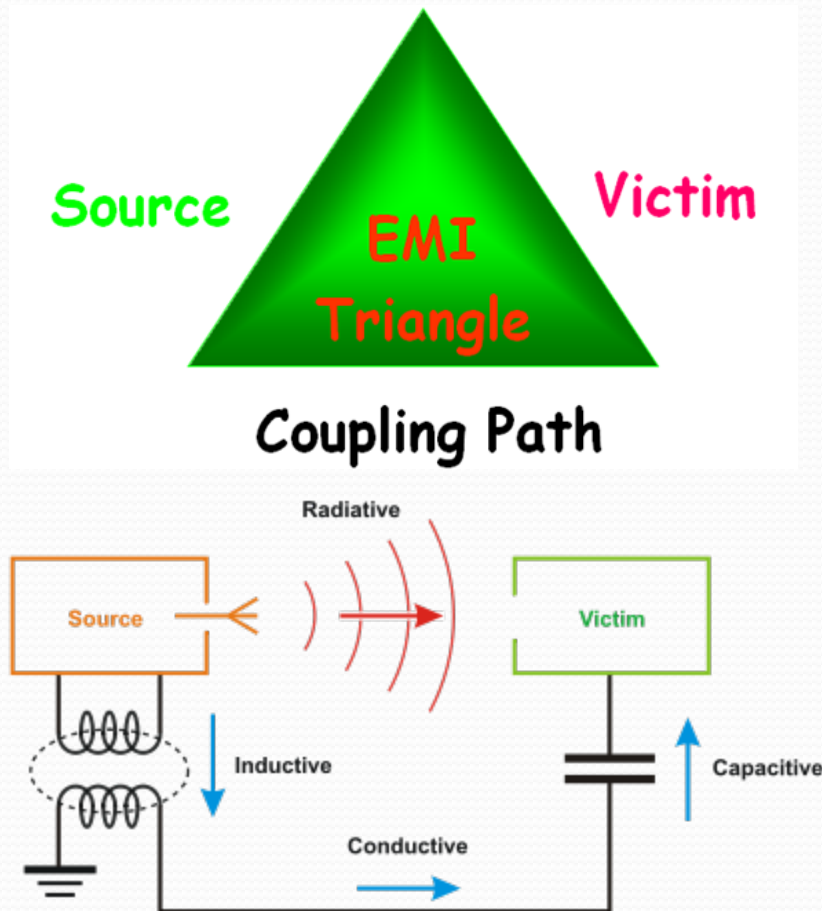
- Radio Frequency Interference/Electromagnetic Interference (RFI/EMI) – (100 KHz – 2 GHz)
 - A radio frequency disturbance that causes an unwanted interruption, degradation or unintended operation to an electrical circuit.
 - Common Sources
 - Natural: Sun, Cosmic noise, Lightning, atmospheric static
 - Radio Transmitters (Amateur, broadcast, consumer devices)
 - Motors, ignition systems, power lines, square wave generators
 - Common Victims
 - Any electronic device that malfunctions by acting as an unintended “receiver” of RFI

Got RFI in your shack/home?

- **TX Symptoms** – caused by your transmitter or antenna
 - Hot microphone – lip burns, distorted audio
 - Resonant length 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, sprinkler systems, etc.)
 - Wife Alarm goes off
- **RX Symptoms** – caused by sources outside your shack
 - High receive noise level not due to atmospheric conditions
 - Birdies, chirps, buzzes, clicks, broadband noise on receiver
 - Distorted receiver audio

How did you get RFI?

How is RFI Transferred?



All three parts 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

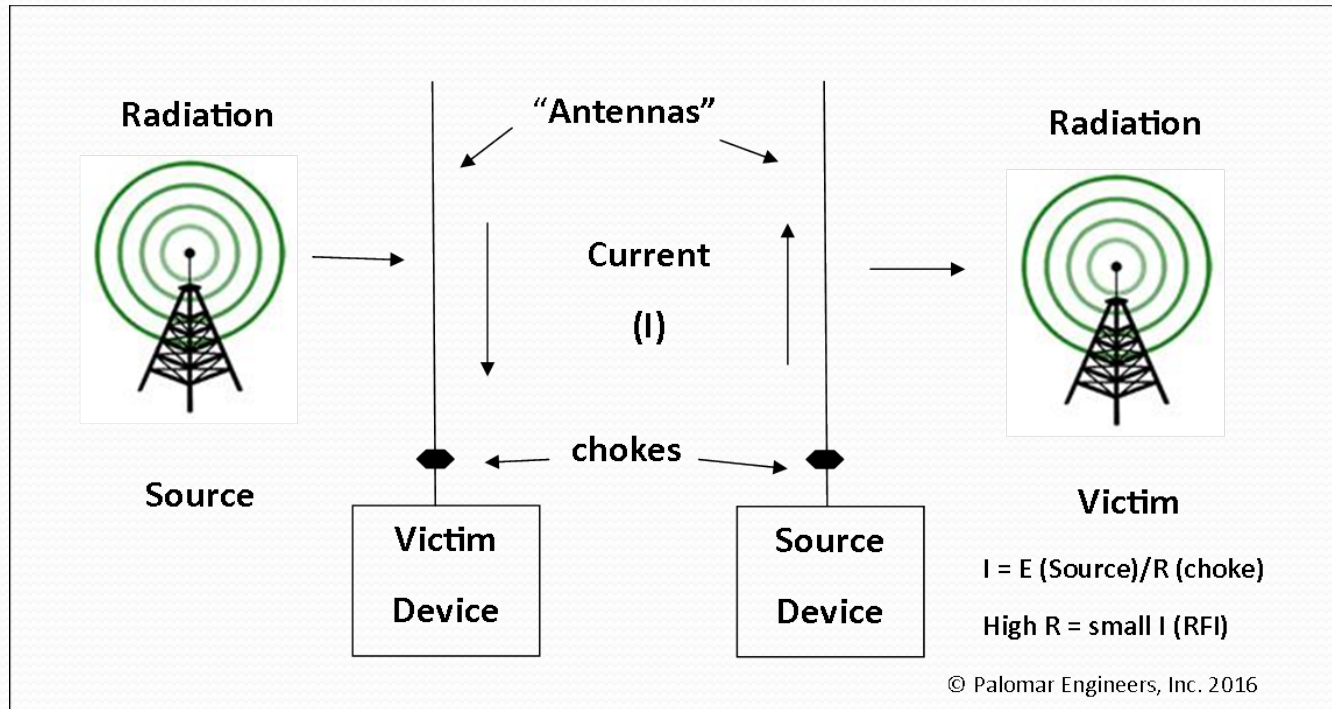
How to identify the path(s)

Typical RFI receiving “antennas”

- 160-80-60-40-30 meter transmitters – “Long” - AC power lines, telephone/DSL lines, satellite/cable coax, long Ethernet cables, antenna feed line coax shield, antenna control/rotor cables, 2nd story ground wires
- AM Broadcast Transmitter 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 – device interconnect cables
- “Antennas” pick up RFI radiation and a common mode current is induced on ALL conductors from an RFI SOURCE

How do we stop or reduce this current?

Reduce RFI current to reduce RFI



- 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!

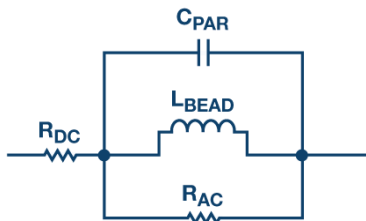
CHARACTERISTICS

- 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 to choose the correct ferrite and where to install the ferrite for a particular RFI problem

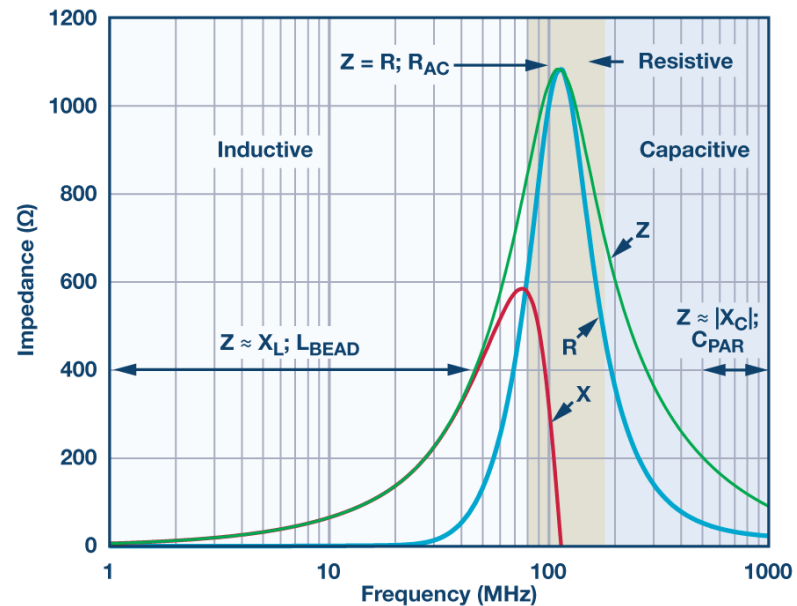
How do ferrites work?

How do Ferrites Work?

Simple Equivalent Circuit



(a)

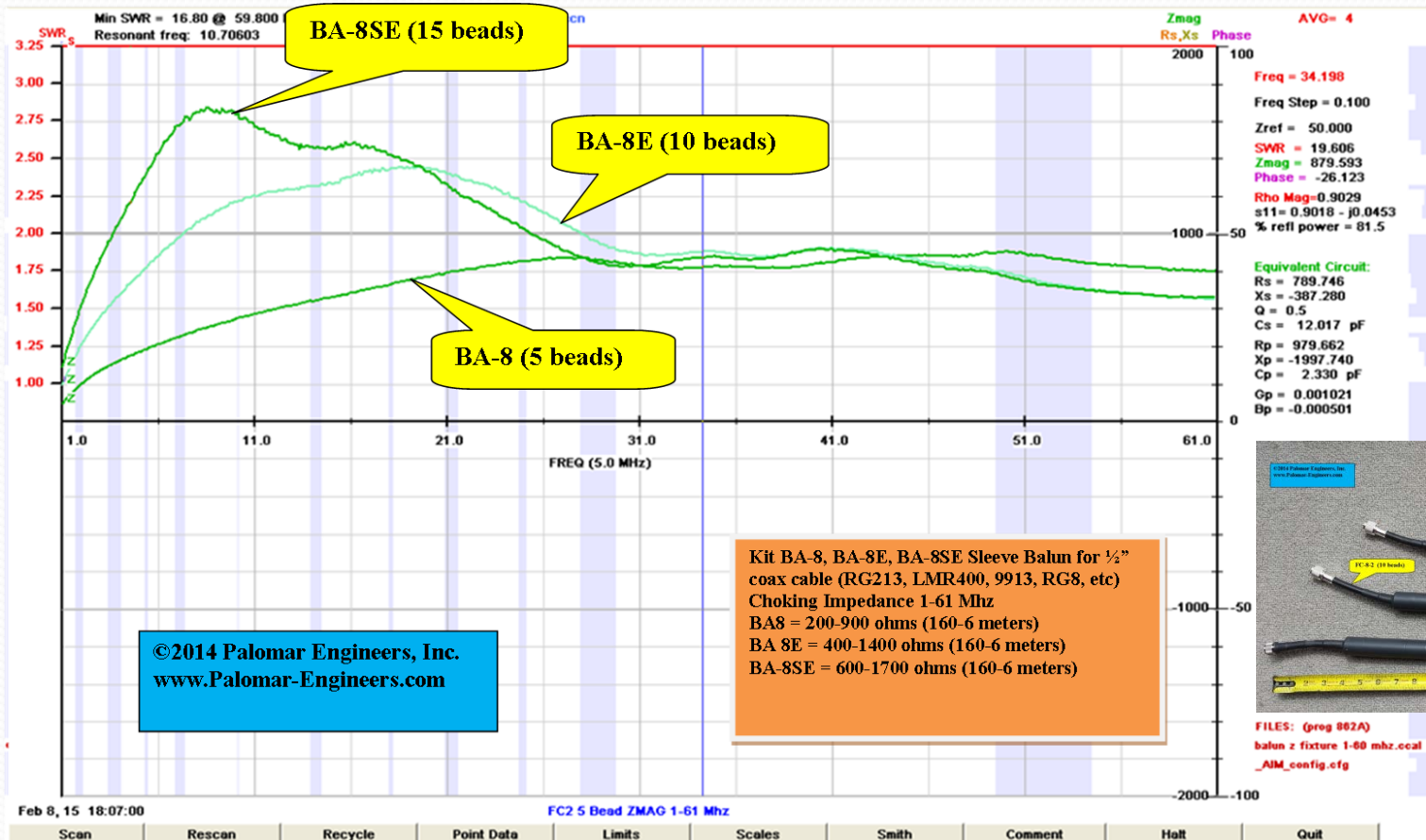


(b)

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 high frequency noise and dissipates it as heat.

How can resistance be increased?

Ferrite resistors add in series



More beads =
higher choking R
(up to 30 MHz)

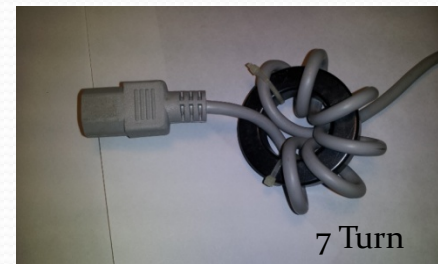
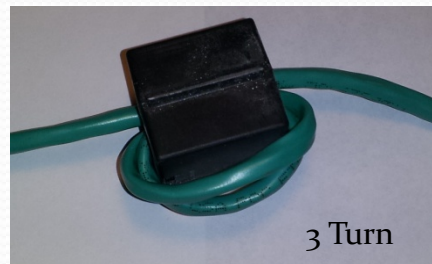
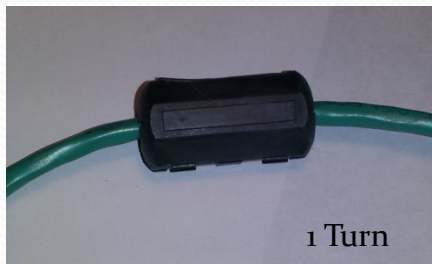


FILES: (prog 862A)
balun z fixture 1-60 mhz.ecal .o
_AIM_config.cfg

$$\text{Impedance (Z)} = \text{Resistance} + / - \text{Reactance}$$

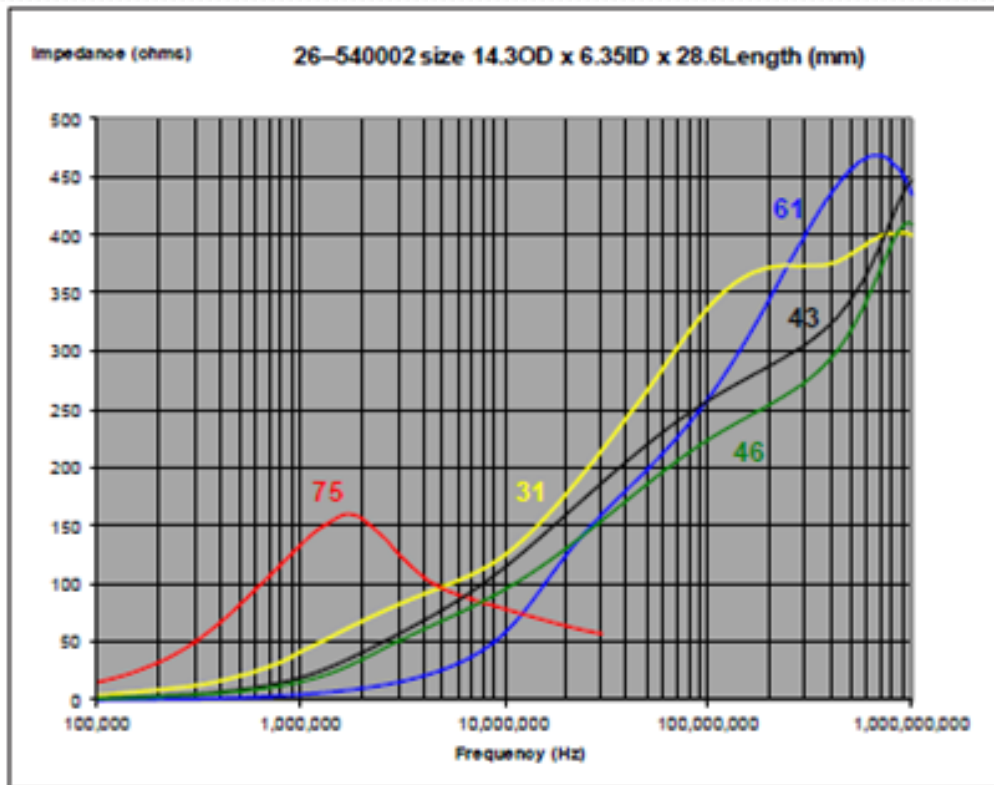
Choking Z Increases with (turns)²

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



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)

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

Example:

for 1-4 MHz us mix 75/77

for 30 MHz us mix 31 or 43

for 450 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 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

=

**BUY With
CONFIDENCE!!**

Part # FSB31-1/2-10

Palomar-Engineers.com

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

Question: How and where do you put the ferrite band aid?

Transmitter RFI Solutions



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)
 - or

3

- **Protect the VICTIM**
 - (filter inputs and/or reduce signal to victim)

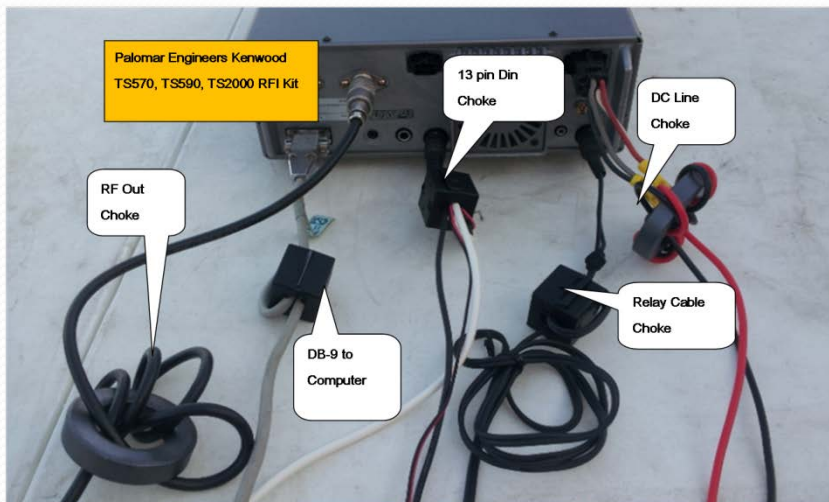
How does these steps apply to your ham shack?

RFI Chokes for Transmitters/Amps

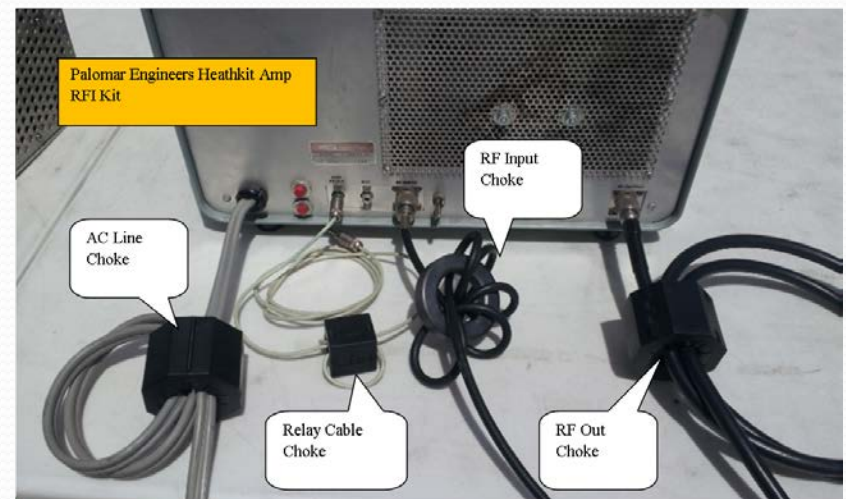
- Transmitter – Amplifier - Antenna RFI suppression
 - All cables into/out of radios, amplifier, antenna tuners
 - Includes
 - ALL Coax RF feed lines
 - Rotor/Antenna Control lines
 - AC/DC power Lines including wall warts!
 - Computer – radio interconnects
 - Examples on next slides
- Recommendation: Get the transceiver and amplifier RFI kits with mix, sizes, instructions already determined.

Transceiver/Amp RFI Kits

Transceiver RFI Kit



Linear Amplifier RFI Kit

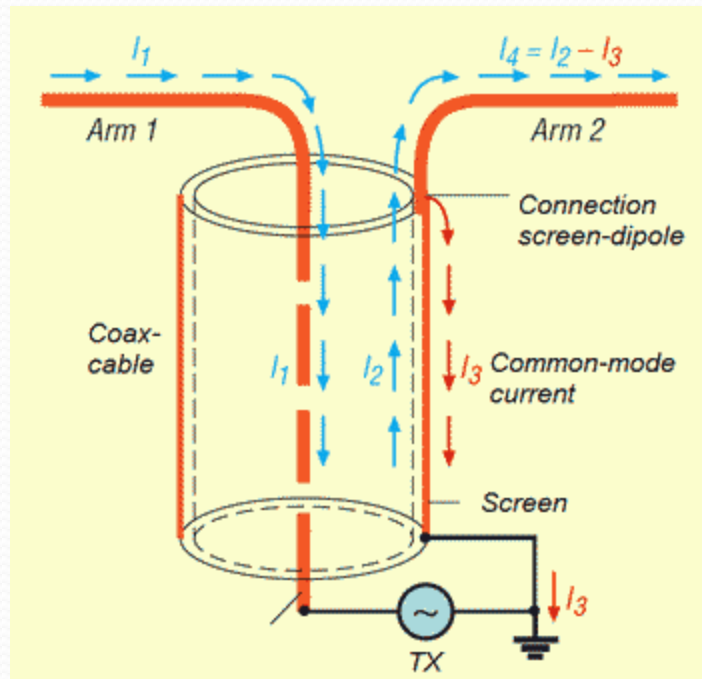


After Transmitter/Amp Source RFI Suppression

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

Is your Dipole a Tripole?

- Coax outside of braid acts as extension of transmitting 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 dipole into tripole!

Goal is to reduce common mode
current with a feed line choke to keep
all RF on antenna.

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

Antenna feed line choke options

Definition: Feed line choke: 1:1 (50Ω to 50Ω). Impedance transformer: $<1:1$ or $> 1:1$

EVERY coax fed antenna needs a common mode choke at the antenna feed point!

EVERY rotor control, remote antenna selector also needs a common mode choke!

Feedline chokes are made with several output options dependent on antenna type and the output option determines whether it is an UNUN or BALUN:

- Prefix (output) = Bal, Un, Suffix (input) = Un
- Ununs #1 (verticals, end fed antennas)
- Ununs #2 (coax in/coax out)
- Baluns (beams, dipoles, loops, log periodics, etc.)

Examples

UNUN #1 (+/- output, coax input)

Applications:

Verticals, end
fed antennas

Style
1

{UN}
{Unbalanced
Output}

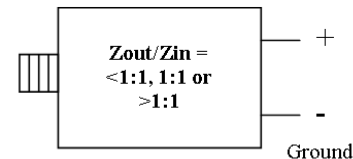
{UN}
{Unbalanced
Input}

Typical Use:
1:1 vertical feedline choke

1:2 Low Z antenna matcher
(25Ω to 50Ω coax)

4:1, 9:1 end fed antenna im-
pedance transformer

Coax In
(Unbalanced
Z in)

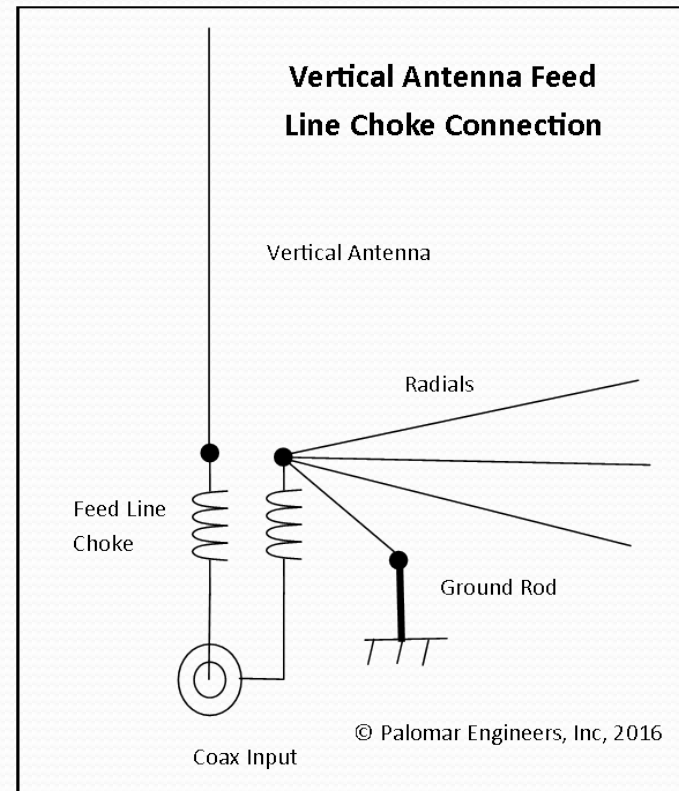
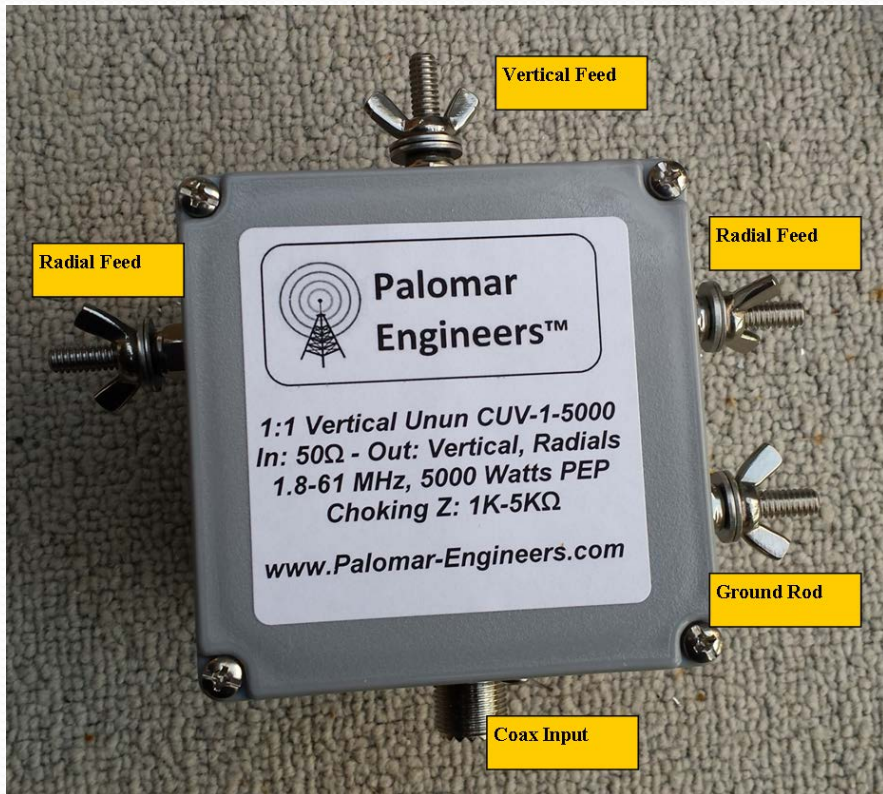


Antenna/Load Out
(Unbalanced Z out)
- vertical, end fed

Impedance Ratio = Output Impedance/Input Impedance = Z_{out}/Z_{in} normalized to 1 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)



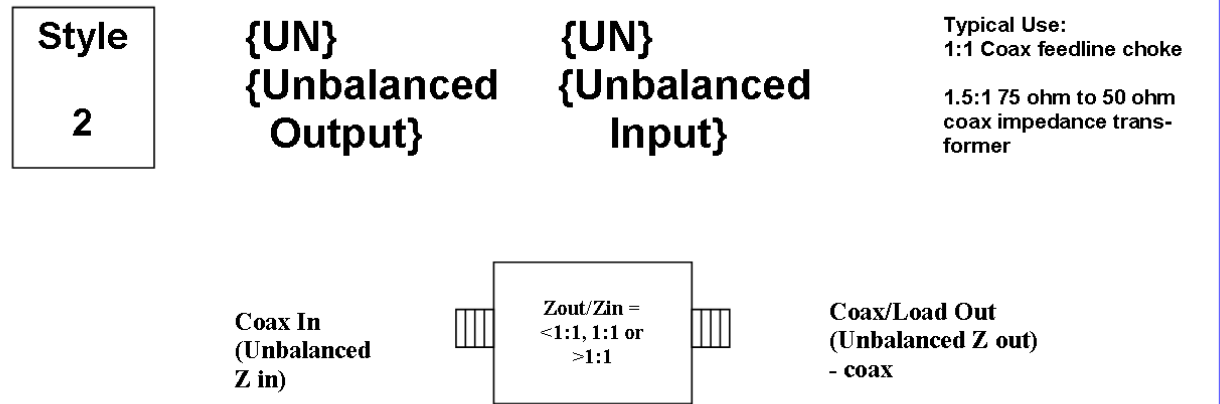
Vertical Unun Feedline Choke



UNUN #2 (coax out, coax in)

Applications:

Coax feedline
choke or line
isolator



Impedance Ratio = Output Impedance/Input Impedance = Z_{out}/Z_{in} normalized to 1 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)

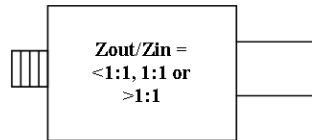


BALUN (balanced output, coax in)

**{BAL}
{Balanced
Output}**

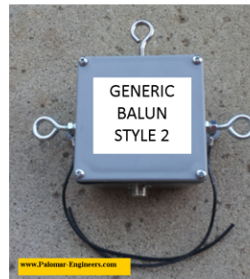
**{UN}
{Unbalanced
Input}**

**Coax In
(Unbalanced
Z in)**



**Antenna/Load Out
(Balanced Z out) -
Dipole**

Impedance Ratio = Output Impedance/Input Impedance = Z_{out}/Z_{in} normalized to 1 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)



Application:

Dipole, beam,
loop, symmetrical
antennas

Now some
practical
examples of feed
line chokes

Coax Choke (aka “Ugly” unun)



Picture: Ugly Unun (incorrectly called 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 high “Q” tuned choke using L and C of coax. $Z = 1\text{-}3\text{ K}\Omega$

Feedline Chokes for all antennas



Medium choking Z (500-2000 Ω) – 5KW for RG213

Snap On Chokes (Snap on)

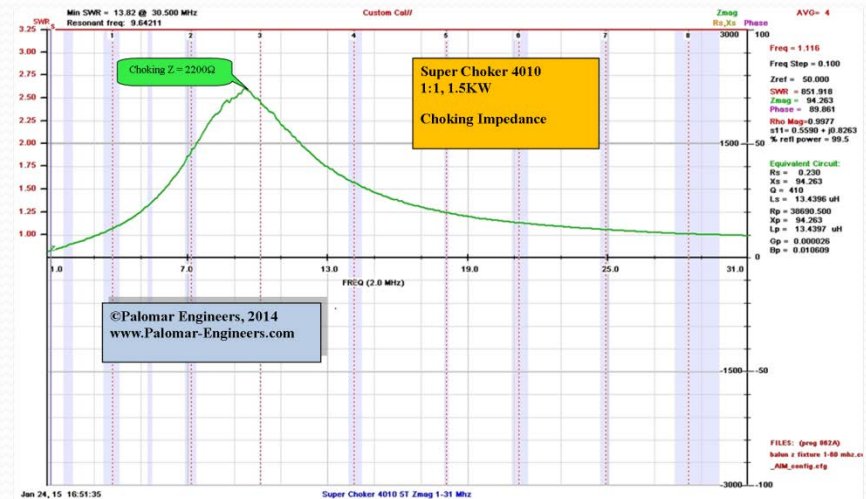


RG-8 (1/2" size) single turn
150-500 ohms



$3 \times 1K = 3K$ total ohms

Super Choker (40-10 Meters)



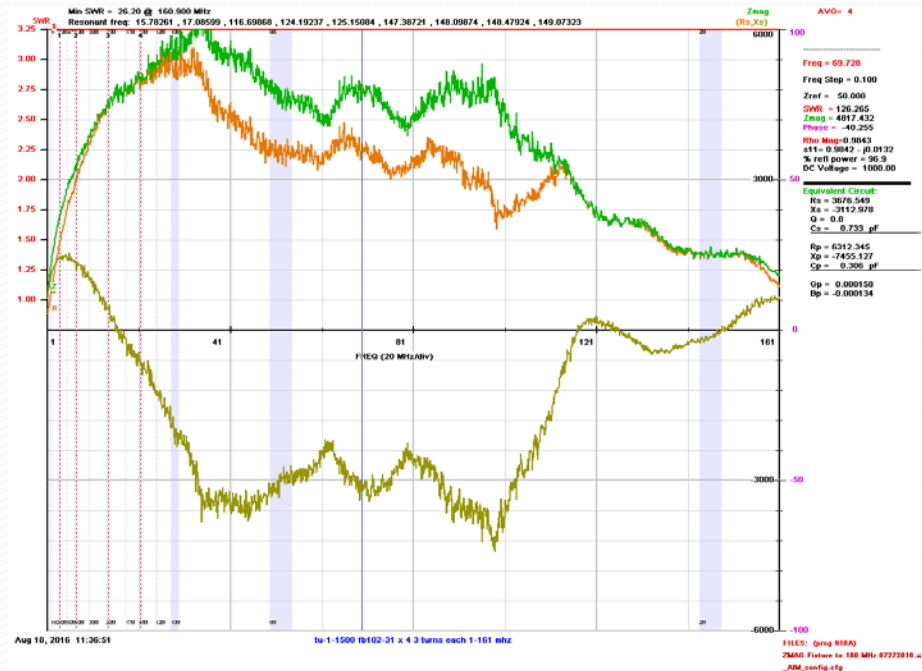
Medium (1K-3KΩ) Choking, High Power, Contesting,
Continuous modes (RTTY, AM, digital)

Available for 160-30 meters, 40-10 or 80-10 meters

Line Isolator (1-161 MHz)



Broadband (1-161 MHz), 1K-6K Ω choking for contesting, continuous modes (RTTY, AM, digital) with ground, static bleeder options



CUBE Chokes for all antennas

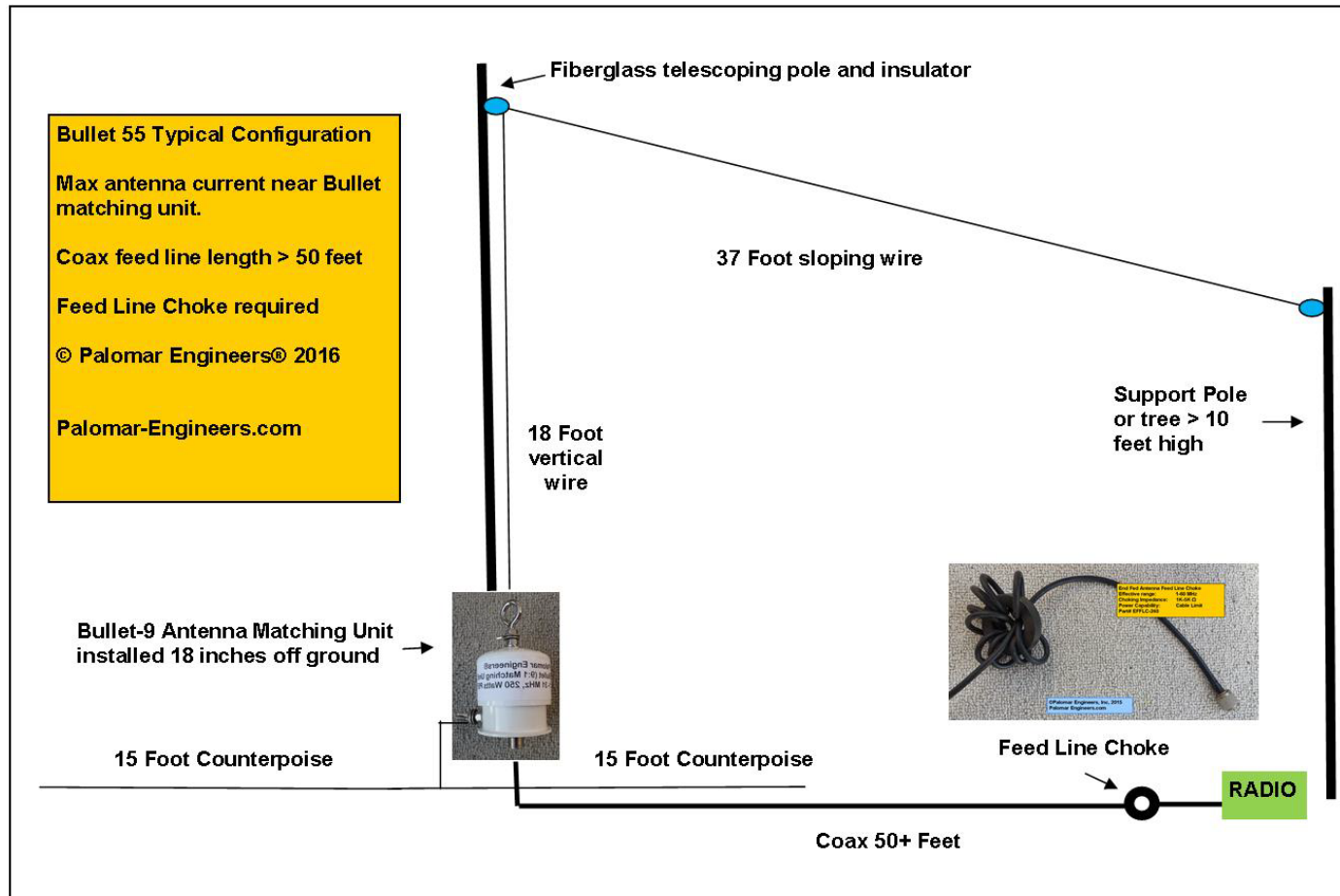


Highest Choking (5-15K ohms)

Power to 10KW PEP

Use: Inline choke,
beam, dipole, loop,
vertical

End Fed Antenna Choke Example



A \$10 DIY Feed Line Choke



+

C
o
a
x

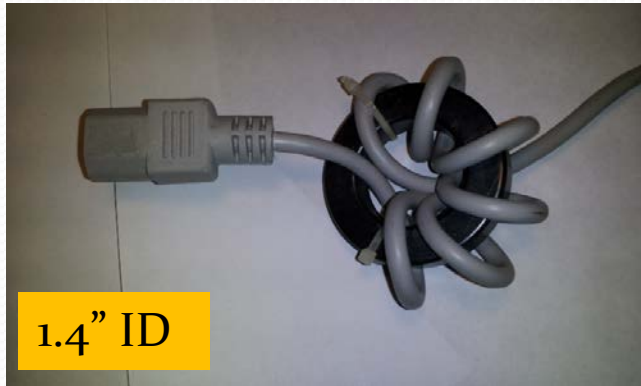
=



- Ring Ferrite + $\frac{1}{4}$ " Coax Cable = feed line choke – 2-5K ohms
- Use at antenna feed point to keep RFI off coax
- Use at radio end of coax to reduce RFI “Noise”
- Use RG-8X/58 for low power, RG303/400 for high power

Now RFI chokes for AC/DC power lines

RFI – AC/DC Line Chokes



Palomar F240 (1.4"ID/2.4"OD) Choke -160-6 meters, $Z = 2-5K$ range depending on frequency

RFI proof your transmissions recap

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

If you need help
Call Palomar Engineers or view specific solutions at
Palomar-Engineers.com

What about receiver noise? →→

Receiver RFI Solutions

Less noise = Higher SNR = More DX!

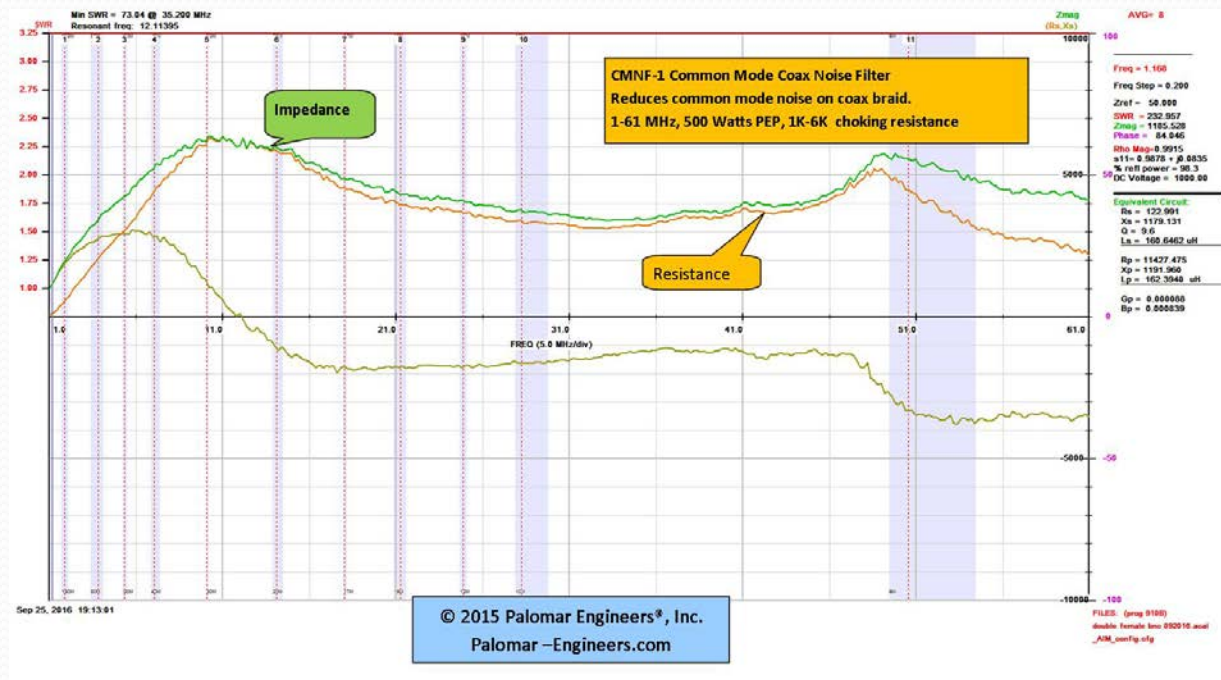


Receiver RFI Noise (man made)

- **SOURCES:** plasma TV, Uverse/DSL, Cable Boxes, HVAC, appliances with variable speed motors –square wave generators, LED lights, wireless metering systems, wall warts, switching power supplies, battery chargers, fluorescent lights, fish tank heaters, exercise equipment, computer “hash”, solar system inverters
- **PATH:** antenna coax braid, AC/DC power lines, phone/DSL line, computer to radio interconnects
- **VICTIM:** radio receiver – high noise level symptom
- **SOLUTION:** eliminate SOURCE, choke PATH, protect VICTIM

Coax Feed Line Noise Filters

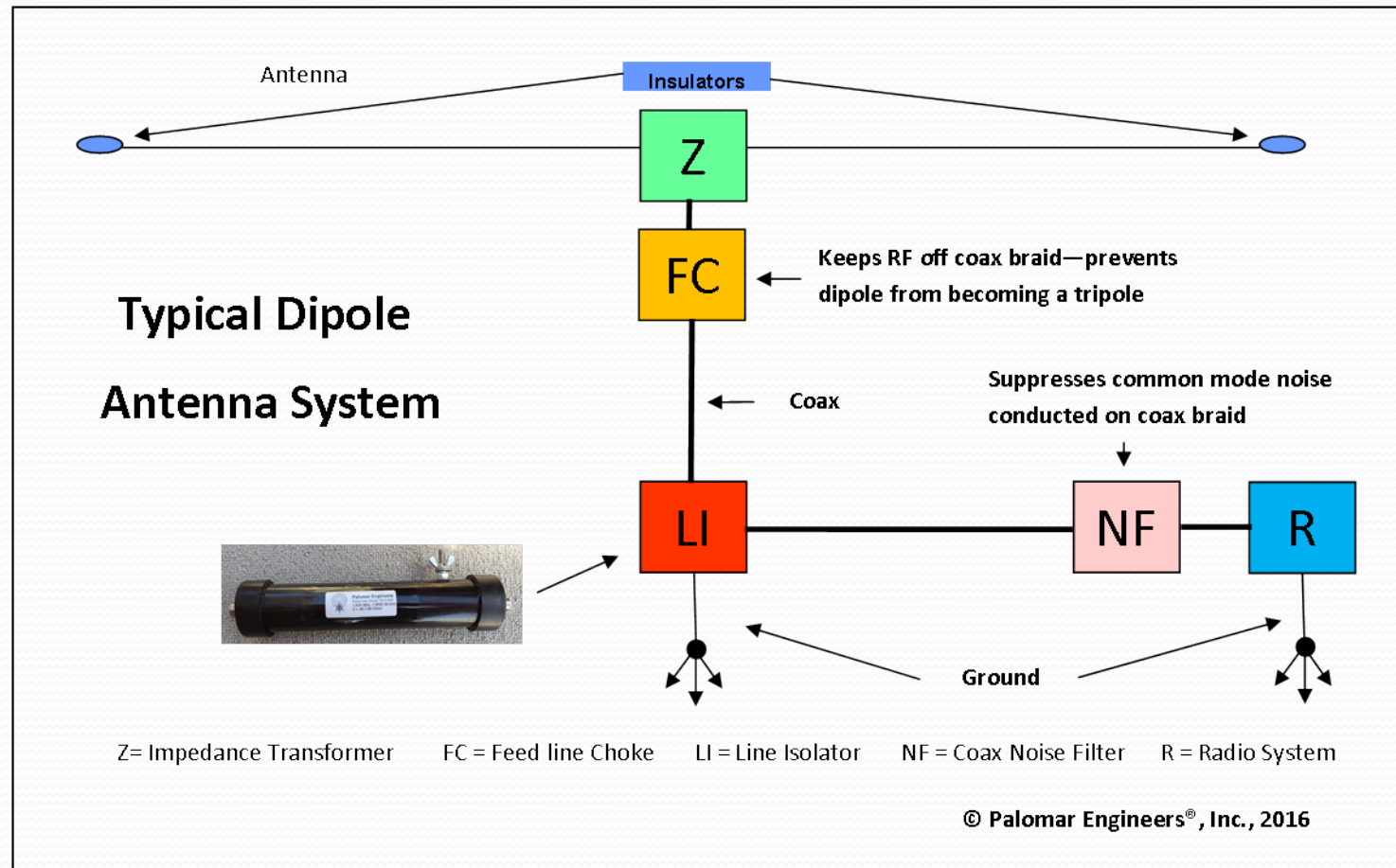
>>> One of the best kept secrets in ham radio!!! <<<



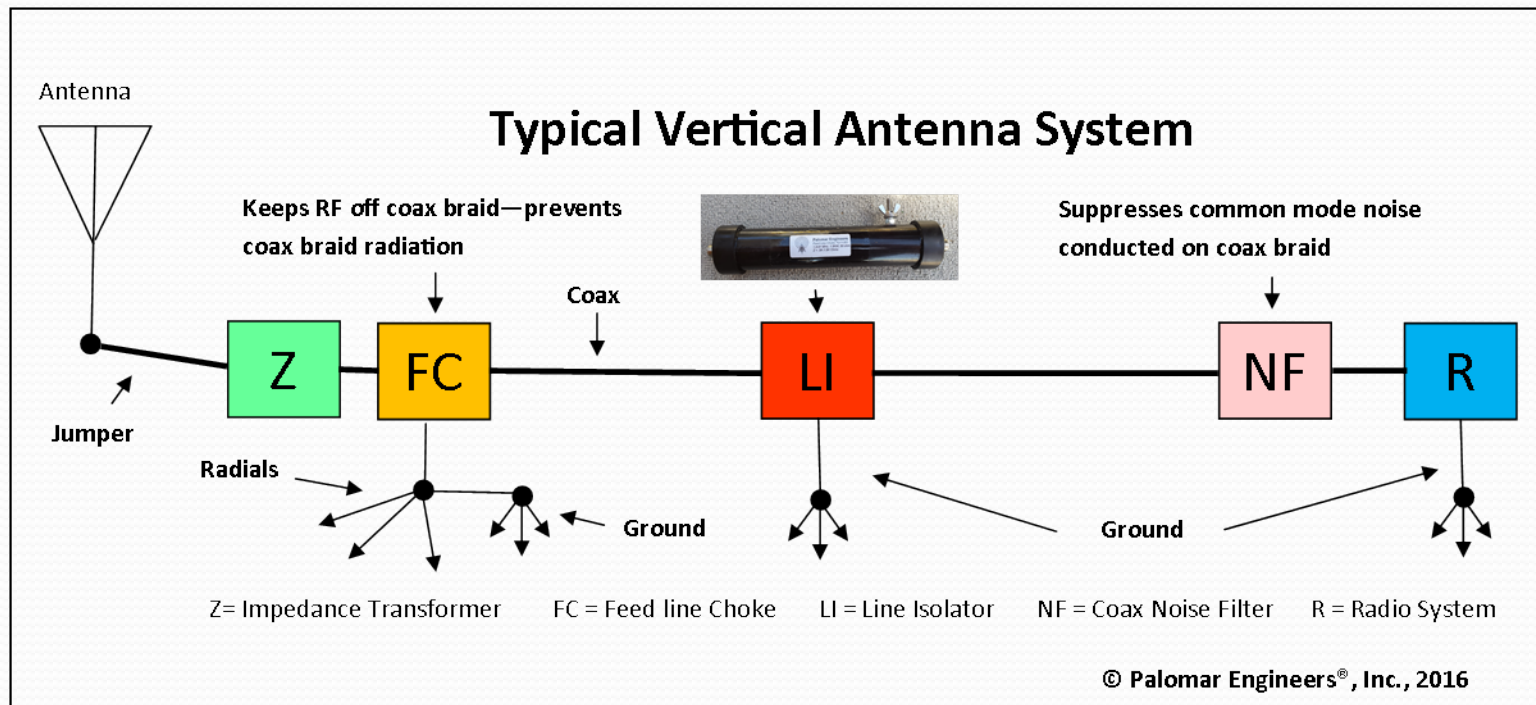
Placed at RADIO END of coax feed line to suppress common mode current on coax braid between antenna feed point choke and radio

Choke location

Dipole Antenna “Systems”

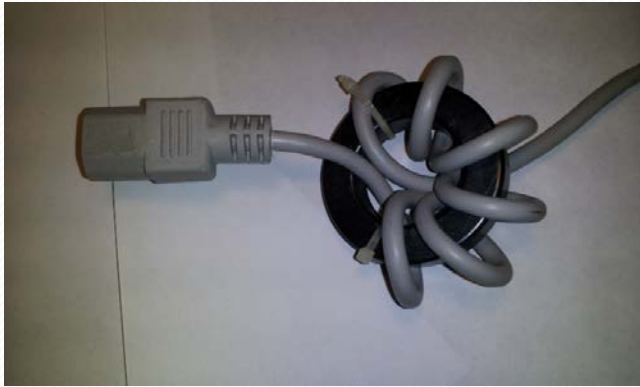


Vertical Antenna Systems



Power Line RFI Noise

AC Line/DC Power Filters



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.

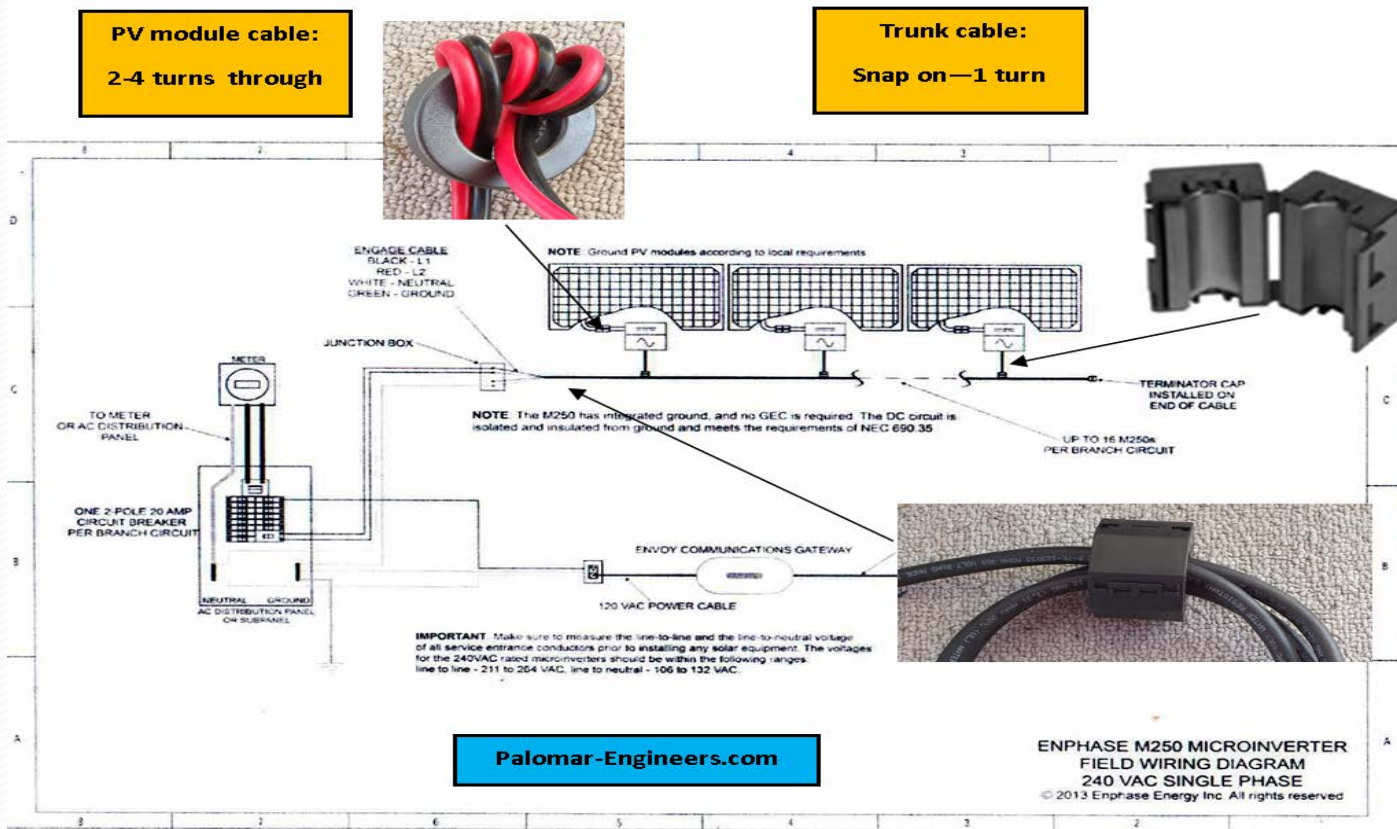


RFI Filter on DC Cord



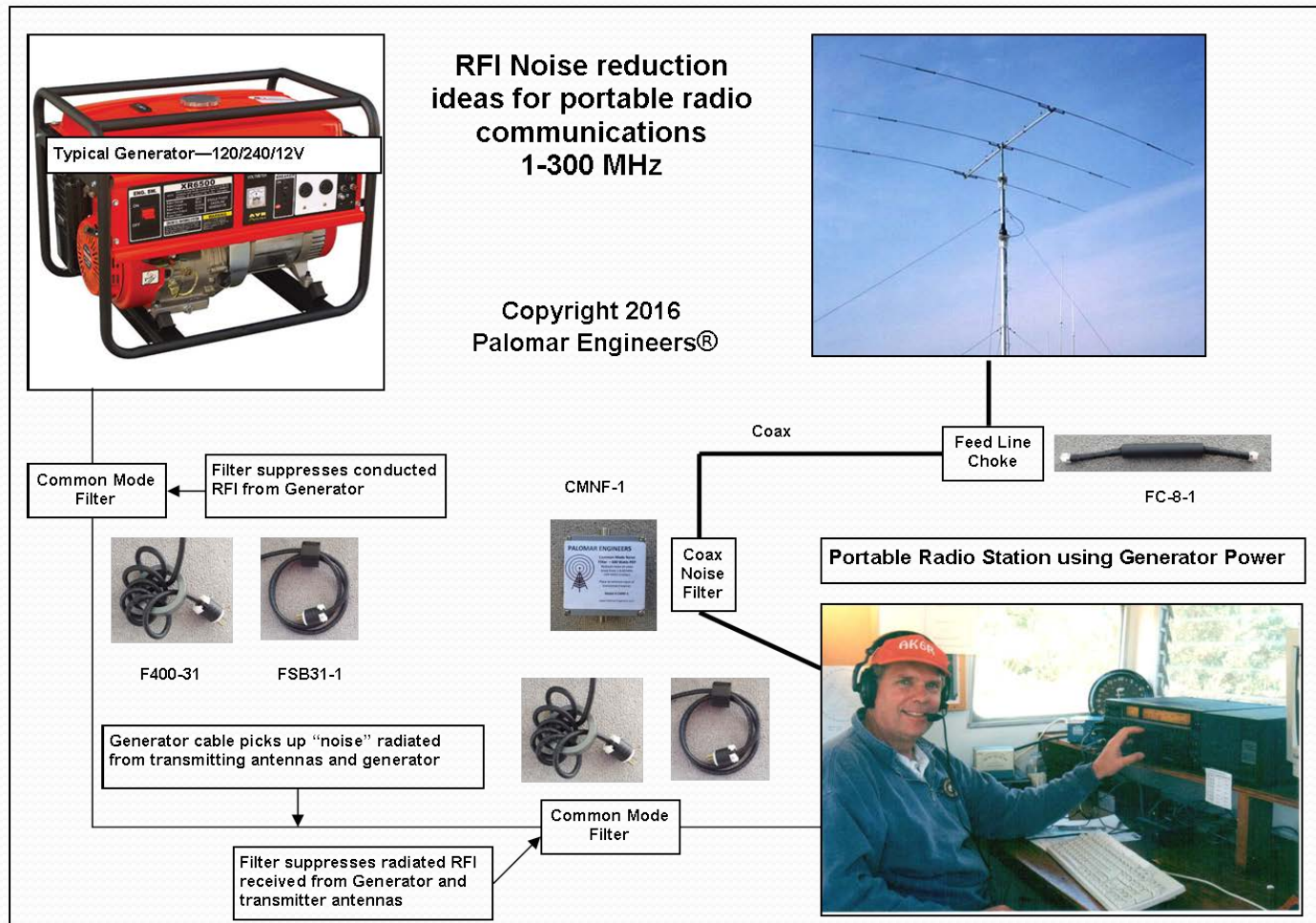
Economy 10 ring kit

Solar System RFI Kit



RFI Chokes for “Antennas” connecting arrays, controllers, inverters, and breakers

Portable Operation RFI Kits



Mobile Operation RFI Kits



Reduce RFI to car electronics +
car electronics RFI to radio

Coax Noise
Filter

DC Power
Noise Filter



Receiver RFI 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 rotor lines
 - Chokes on AC/DC cords, Wall Warts – ring or snap on ferrites
 - Chokes on radio-computer interconnect cables
- 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

What about →→



Keep Your Neighbors Happy!



OR



Neighbor's RFI Strategy

- Choke RFI SOURCE



Ham's Strategy is different

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, HDTV)
 - 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.

Test Time – Win a prize!

Prize Question #1

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

Prize Question #2

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

Prize Question #3

- What is one of the best kept secrets in ham radio?

Bonus Prize Question #4

- Why don't cannibals eat comedians?

Which vendor do you call when you have an RFI problem?

- Palomar Engineers

- 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.