RFI 102
Using baluns, ununs and ferrite chokes to work more DX!

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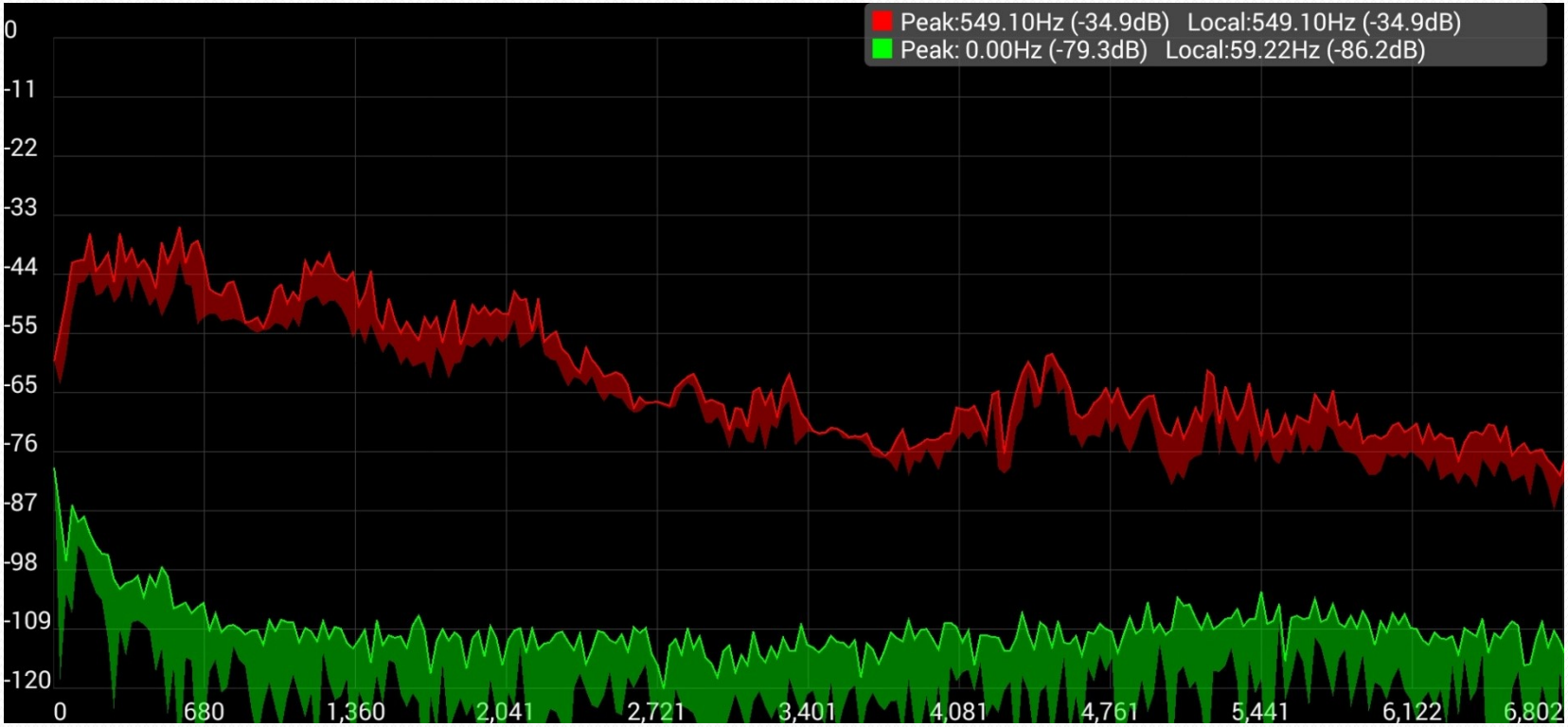
RFI Workshop Objectives

- Review fundamentals of Common Mode Noise
- How ferrites work to suppress Common Mode noise
- How to use ferrite kits to solve specific common mode noise problems in your shack
  - RF feed lines, rotor control lines
  - AC/DC power lines
  - “Noisy” devices – switching power supplies, wall warts, routers, plasma TV, etc.
- How to suppress neighborhood common mode noise problems
- Selecting baluns, ununs and chokes to increase signal level

Signal to noise ratio



Red = Signal + noise, Green = noise
Objective is to reduce noise

Got RFI Noise in your shack?

- Symptoms – receiver noise caused by <u>outside sources</u>
  - Clicks, buzzes, birdies, or chirps in your receiver on 1 or more bands
  - High noise level – periodic or varies by time of day
  - Receiver overload or desensing of front end with no signal present
  - Motor “noise” of varying/constant pitch – often caused by fans, heater/blower motors, heat pumps, fuel pumps
  - Florescent light crackle or buzzing or arcing sound
  - Switching power supplies, battery chargers, inverters, solar controllers, plasma TV, digital gear “GRUNGE"

Improve Signal/Noise Ratio

- Solutions
  - Common mode chokes at RECEIVING end (blocks common mode RFI into receiver) in addition to transmitting end (keeps RF on the antenna)
  - Use common mode chokes (1:1 ununs) to choke noise on signal path AT THE RADIO/ANTENNA TUNER
    - Cube baluns – have hi Z (2K-10K ohms)
    - Sleeve baluns – snap on or slip on (200-1500 ohms Z)
    - Super Chokers (1.5-3K ohms)

Testimonial Case

- WOW…
- I just tried one of your toroids on my modest antenna system. I have a Hamstick on top of an all aluminum manufactured home. Its the best ground plane one could hope for, and I've made contacts to Korea on 40m with it.
- Before… on 40m I had an AM background noise of 5S units. I wrapped about 10 turns into one of the toroids right by the radio and the noise floor dropped to below 1 S unit (not readable on my TS-480s).
- You know… when I got this from you yesterday, I figured maybe 2 S units if that and the price was right… I am truly amazed by the results!!!

Bob K2IU (2/25/2014)

Quick RFI Review

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 Common Mode Noise/RFI?

- Symptoms – caused by <u>your transmitter or antenna</u>
  - Periodic “birdies” or whistles in your band spectrum
  - Constant or time sequenced high noise level across the entire band
  - AM/FM broadcast signals picked up off frequency
  - Motor whine, buzzing noise, noise pops, directional noise, heater, AC line monitors, baby monitors, etc
  - Switching power supply whine

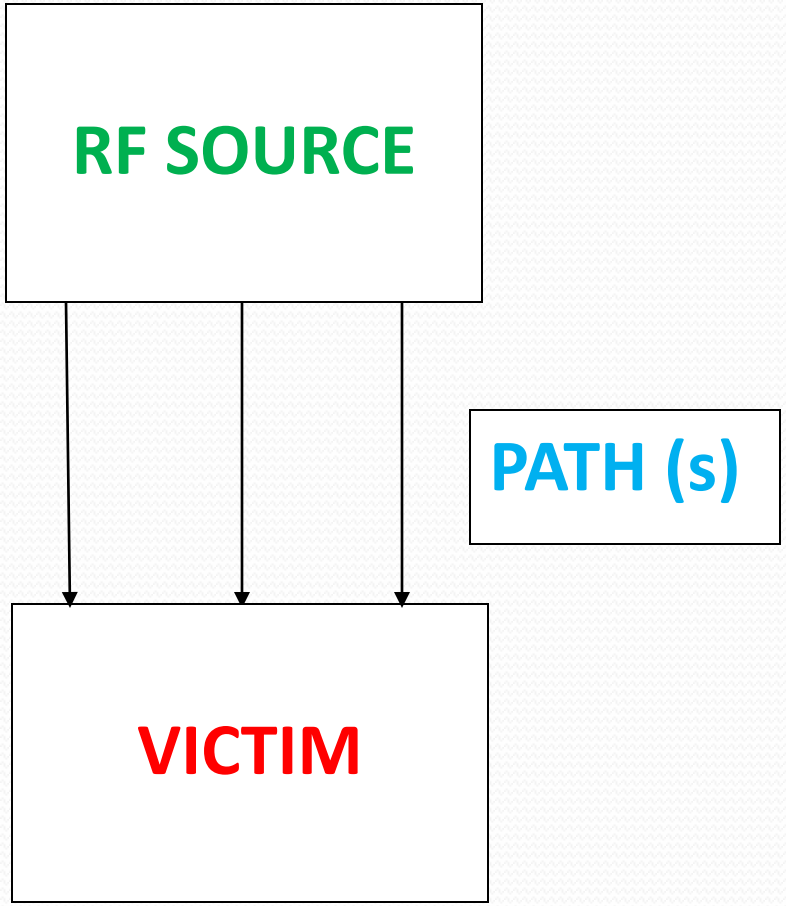
RFI Types that can be suppressed

- About 60% of customers call to REACT to an RFI symptom in their shack/home or their neighbor's home they think is caused by their radio transmitter and/or antenna.
  - **TRANSMITTER RFI**

- About 40% of customers call to CURE an RFI problem caused by outside sources effecting their radio station
  - **RECEIVER RFI**

How is RFI Transferred?

RFI Transmission



RFI REQUIREMENTS

SOURCE of RF

Connecting PATH(s) – conducted or radiated ("antennas")

VICTIM of interference

All three of the above must be present to have an RFI problem.

Cure
Eliminate the SOURCE, or
Block/Choke the PATH, or
Protect the VICTIM

Typical “Antenna" Paths for RFI

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

Antenna Lengths

Band	Freq Mhz	1/4 Wavelength (ft)	1/4 Wavelength (m)
160	1.9	129.42	39.45
80	3.75	65.57	19.99
80	3.52	69.86	21.29
40	7.15	34.39	10.48
30	10.1	24.35	7.42
20	14.2	17.32	5.28
17	18.1	13.59	4.14
15	21.3	11.54	3.52
12	24.8	9.92	3.02
11	27.2	9.04	2.76
10	28.5	8.63	2.63
6	50.25	4.89	1.49
2	146	1.68	0.51

wavelength (ft) = 983.6/freq (Mhz)

wavelength (m) = 299.7925/freq (Mhz)

RFI Frequency "Antennas"

160-30M – typically longer "antennas" like AC house wire, telephone system, CAT5, satellite/cable coax

20-2M – typically shorter "antennas" like device interconnect cables, speaker wire. Audio, microphone cables, USB computer cables

Ferrites Are your Friend for RFI

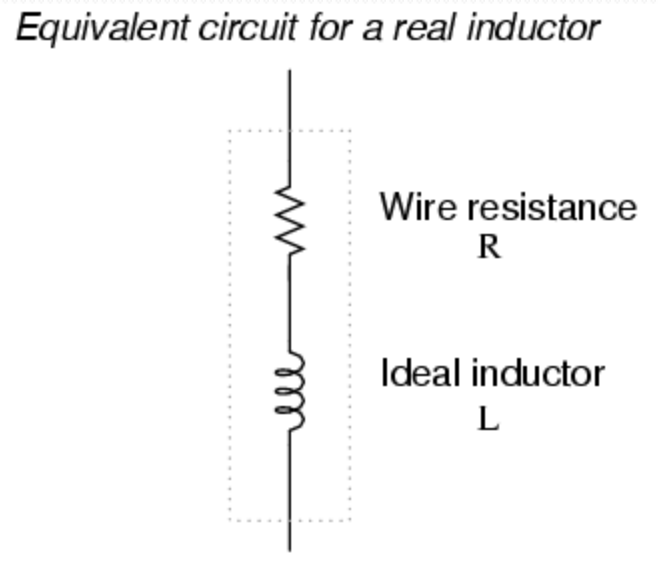
Slip On Bead

Snap On Bead

Toroid/Ring

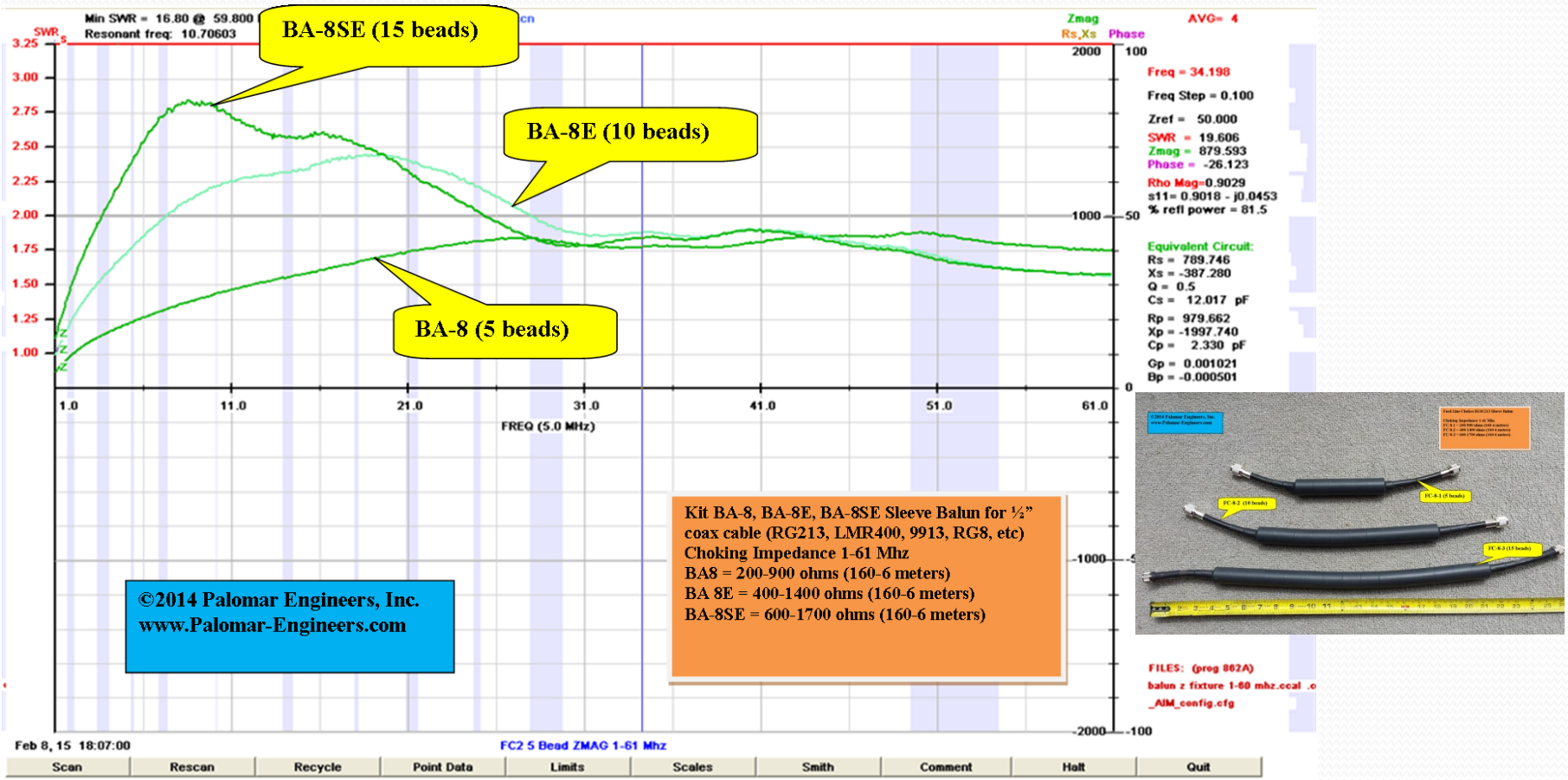
- Reduces common mode current to reduce RFI
- Cheap, easy to install, work on all ham frequencies
- Work on all paths (feed line, AC/DC, electronic devices)
- Lots of options in size, shape to fix most RFI path problems
- Can be installed by almost anybody who understands how to choose the correct ferrite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

Ferrite Equivalent Circuit



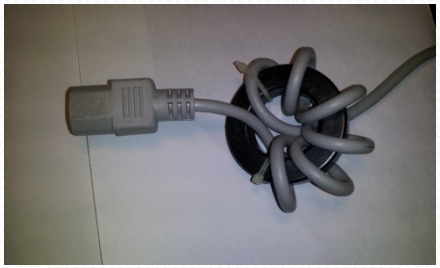
One Turn coil through a ferrite with reactance which varies with frequency (X_L=2∏*f*L). Reactance goes up as the square of the number of turns, e.g. 2 turns = 4X, 3 turns = 9x, until resonance reached

Multi-Bead Choking Z

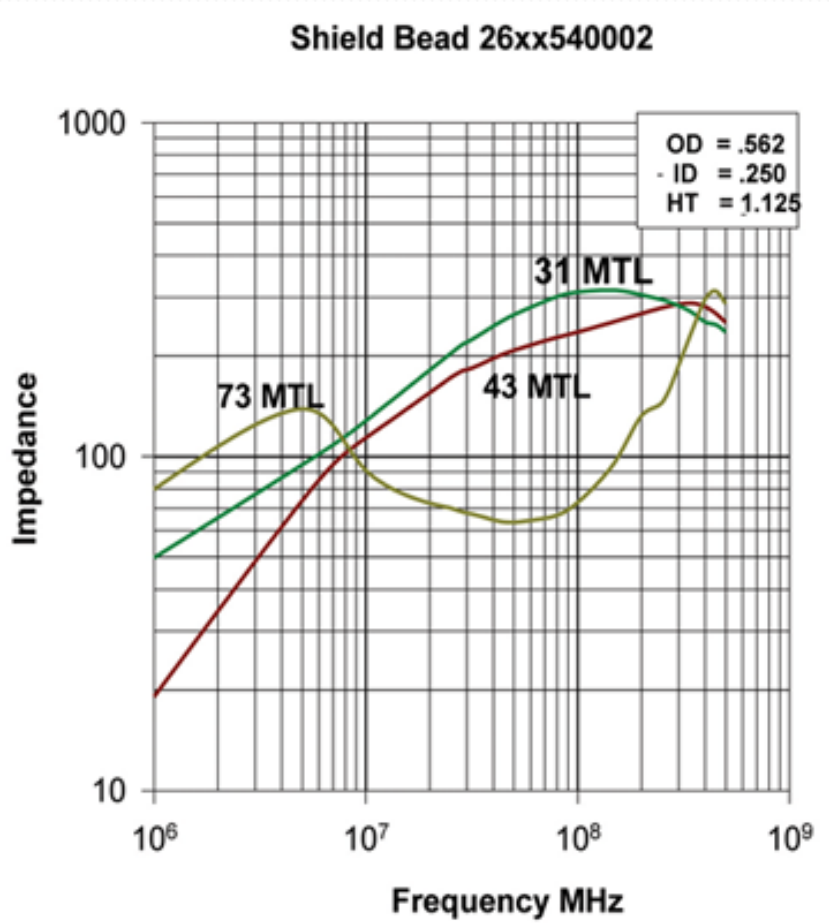


Z Varies with $(\text{turns})^2$

- 1 turn = Z
- 2 turn = 4Z
- 3 turn = 9 Z
- More Z = less current = less RFI



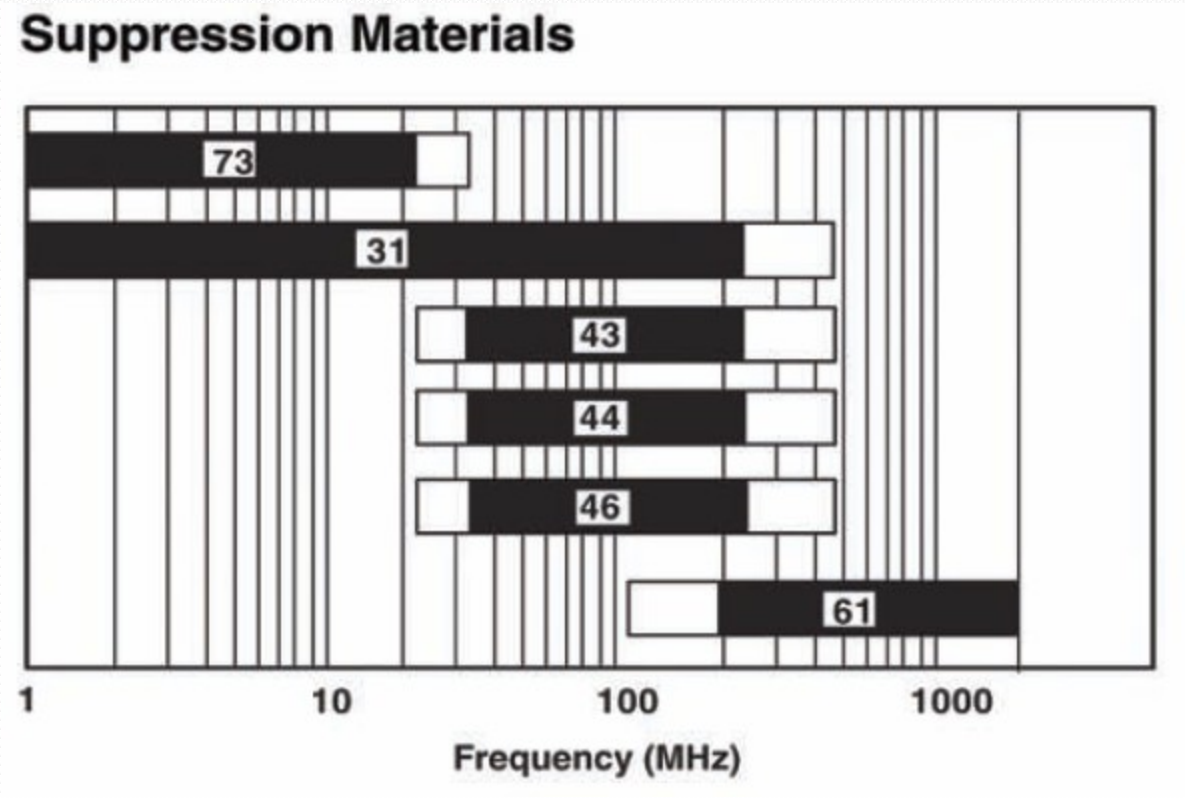
Ferrite Mixes



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 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

Reduce Common Mode Current Noise in your Receiving System

=

Higher
Signal/Noise Ratio

=

MORE DX!

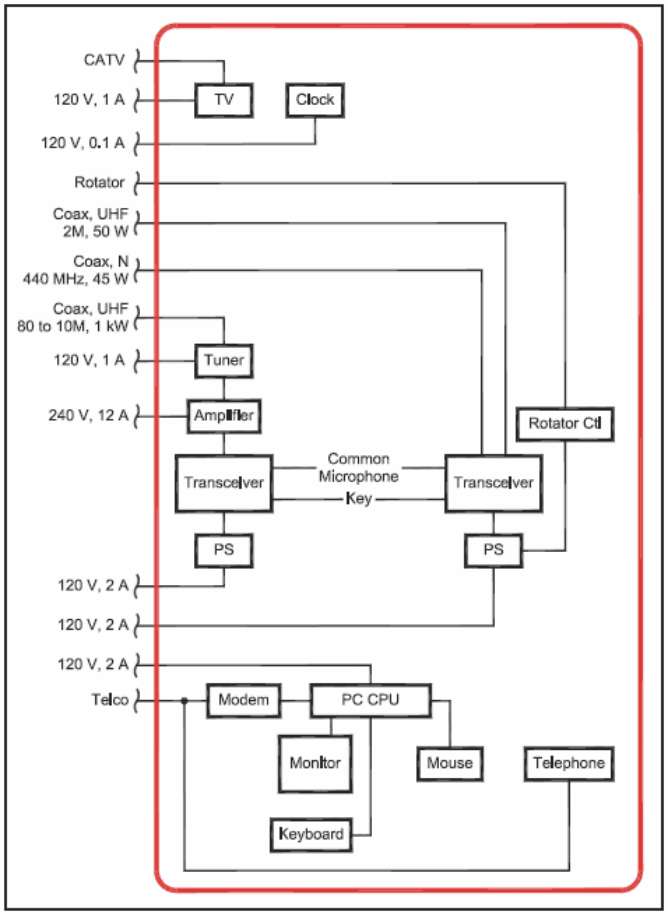
RFI Strategy

- Eliminate/reduce RFI SOURCE
- or
- Choke the PATH
- or
- Protect the VICTIM

Source-Path-Victim in the Ham Shack

- ***Source***
  - Transmitter or antenna or feedline
- ***Path*** (single or multiple wires in/out of equipment act as TRANSMITTING and RECEIVING antennas)
  - Antenna (direct radiation)
  - Antenna Coax, rotator/antenna selector control lines
  - 120/240V AC wiring
  - Phone/DSL telephone service wires
  - Cable/Satellite coax
  - Device interconnect cables (mic, audio, speaker, video, power)
- ***Victim*** (Device receiving interference – I/O wires <u>also</u> act as RECEIVING antennas)

Typical Ham Shack



"ANTENNAS"

- Multiple AC Connections
- Multiple Antennas/Coax lines
- Telephone/DSL line
- Antenna Control Lines
- Satellite/Cable Coax feed
- RFI can take <u>multiple</u> paths

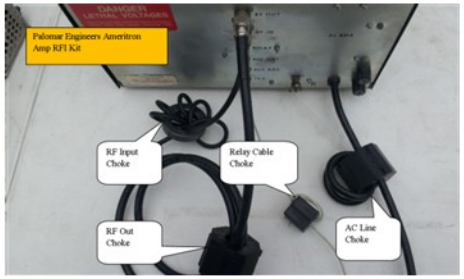
Antennas can transmit <u>and</u> receive common mode current at radio frequencies (RFI). Your antenna(s) radiate energy that is induced into shack "antennas" as common mode current

Ham Shack RFI Solutions

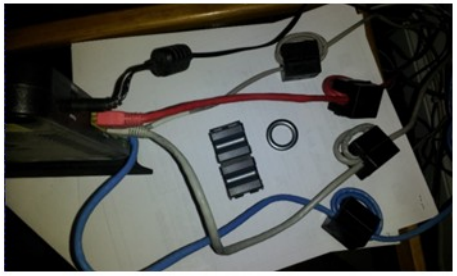
PICK YOUR RFI SOLUTION KIT

MY RADIO ROOM

ANTENNA RFI

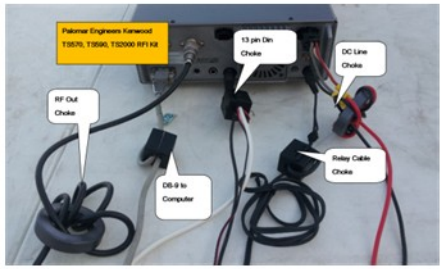


AMPLIFIER RFI



COMPUTER RFI

POWER LINE RFI

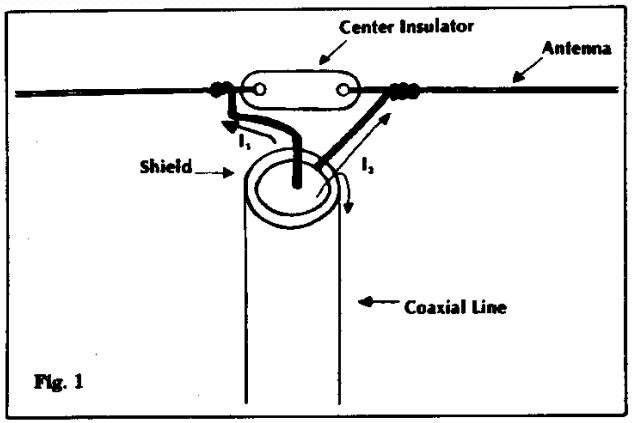


TRANSCEIVER RFI

NOISE REDUCTION

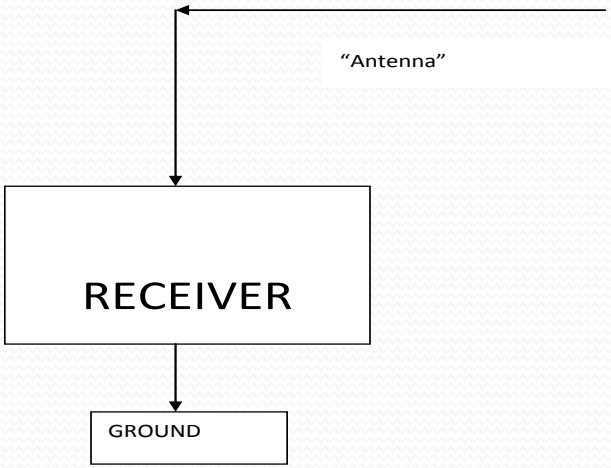
Is your Dipole a Tripole?

- Coax outside braid as a 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

- Coax outside braid as a receiving antenna



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

RFI Chokes for feed line path

- Path
  - Antenna feed line choke (aka 1:1 balun, 1:1 unun, line isolator, line choke, sleeve baluns)
    - Coax Air Wound – frequency dictates # turns for Z (5-10 turns at VHF, small diameter, 15-30 turns large diameter at HF)
    - In line (ferrite – toroids, split beads, sleeve beads)
      - 1:1 balun (voltage (DC grounded) or current)
      - Line isolators (w or w/o ground lug)
      - Examples

Coax Balun (aka “Ugly” balun)

Picture: Ugly balun at 7 Mhz, 16 turns,
4.5” diameter = 3,000 Z – 20 feet of coax

Sleeve Baluns (Snap on)

RG-8X (1/4” size)
150-500 ohms

RG-213 (1/2” size)
150-500 ohms

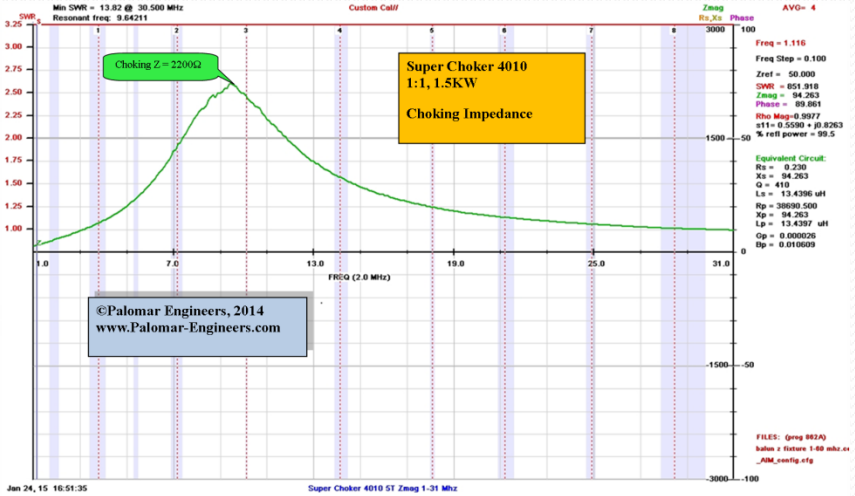
Large Clamp On (FSB-1) = 1” ID

3 turns =
1K ohms

Sleeve Baluns (Slip on)

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

Super Choker (40-10 Meters)

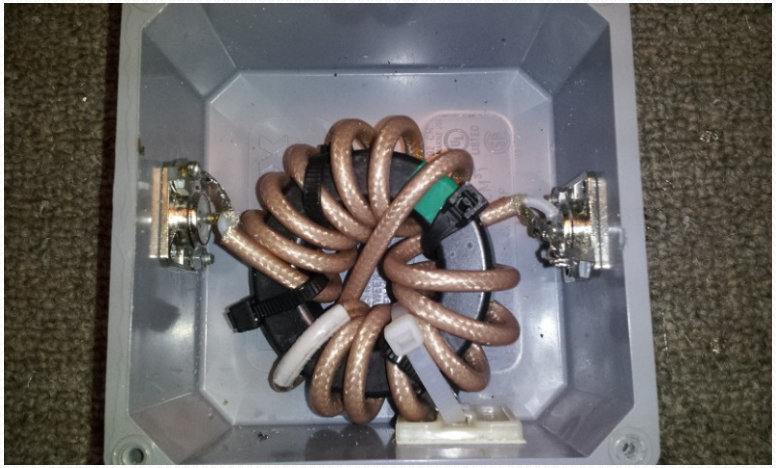


Z = 1,500 at 7Mhz , 2.2K at 10 Mhz, 1K at 14 Mhz, 300 at 28 Mhz – 5 Turns, 3 cores

CUBE Baluns

BA-1-1500 (1:1, 1500w)
Z = 2k-10k
Feedline choke and
noise filter

Do It Yourself KIT



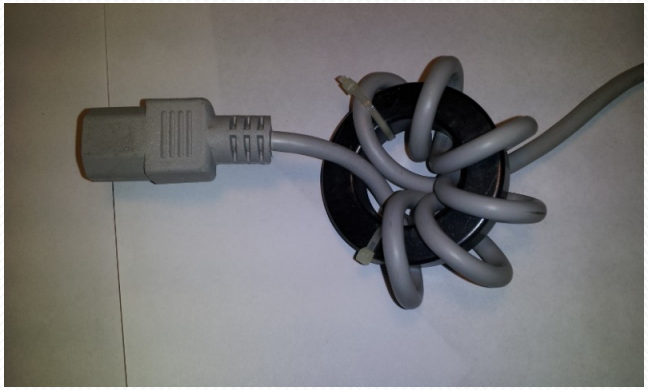
CB-1-5000 (1:1, 5000w)
Z = 3k-12k
Feedline choke and
noise filter

ASSEMBLED

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

Reducing Common Mode Noise 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 ferrite chokes on ALL antenna feed lines and control lines at antenna end and receiver end – retest for RFI suppression
- Install ferrite chokes on all victim devices and sources
- Consider additional Paths if RFI persists
- Have a low impedance common ground for all radio/computer equipment

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

DC Power Line Chokes

- Wall power plug
- DC power - transceiver

Palomar F140 (1.4OD), Z=1K, 5 turn

Palomar F240 (1.4OD), Z=2K, 5 turn

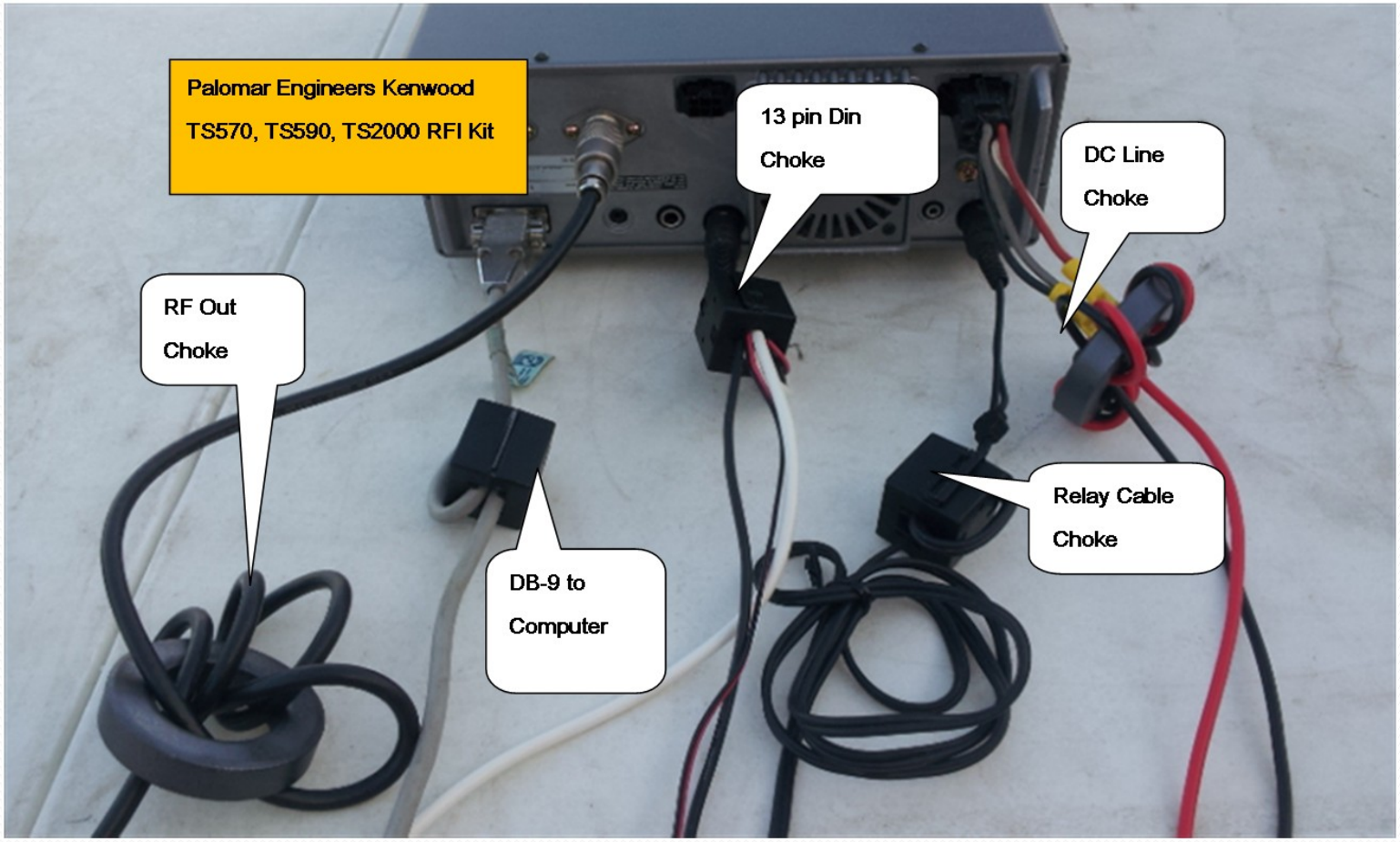
Device Cable Chokes

- Toroids
- Snap On
- All Input/Output Cables on device
- Longer cables more important to choke because they are better receiving antennas

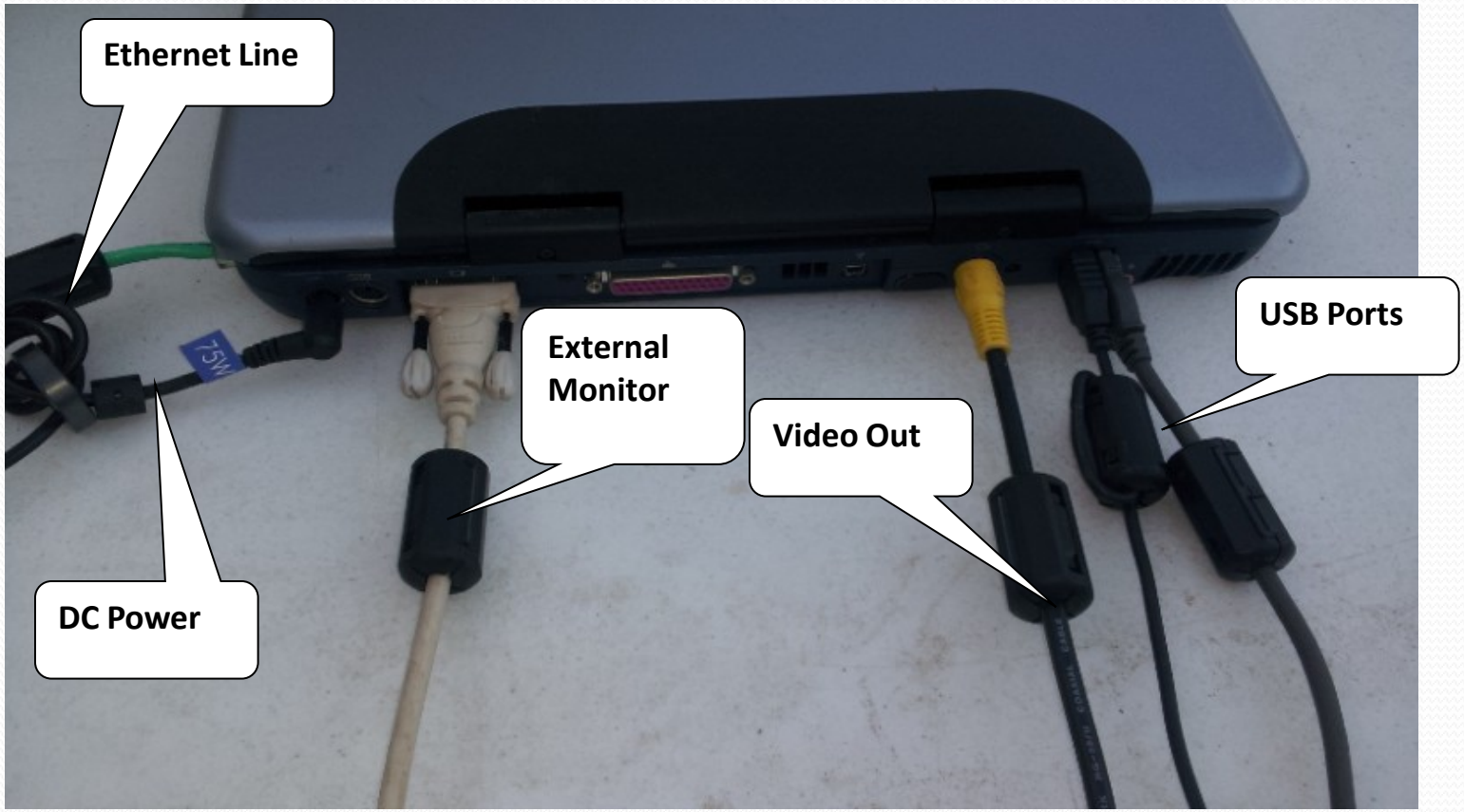
RFI Kits for specific problems – use most effective mixes, ferrite forms

- Transmitter/Transceiver Kits
- Linear Amplifier Kits
- Computer Device Kits
  - Lap tops
  - Desktops
  - DSL Router
  - Network boxes

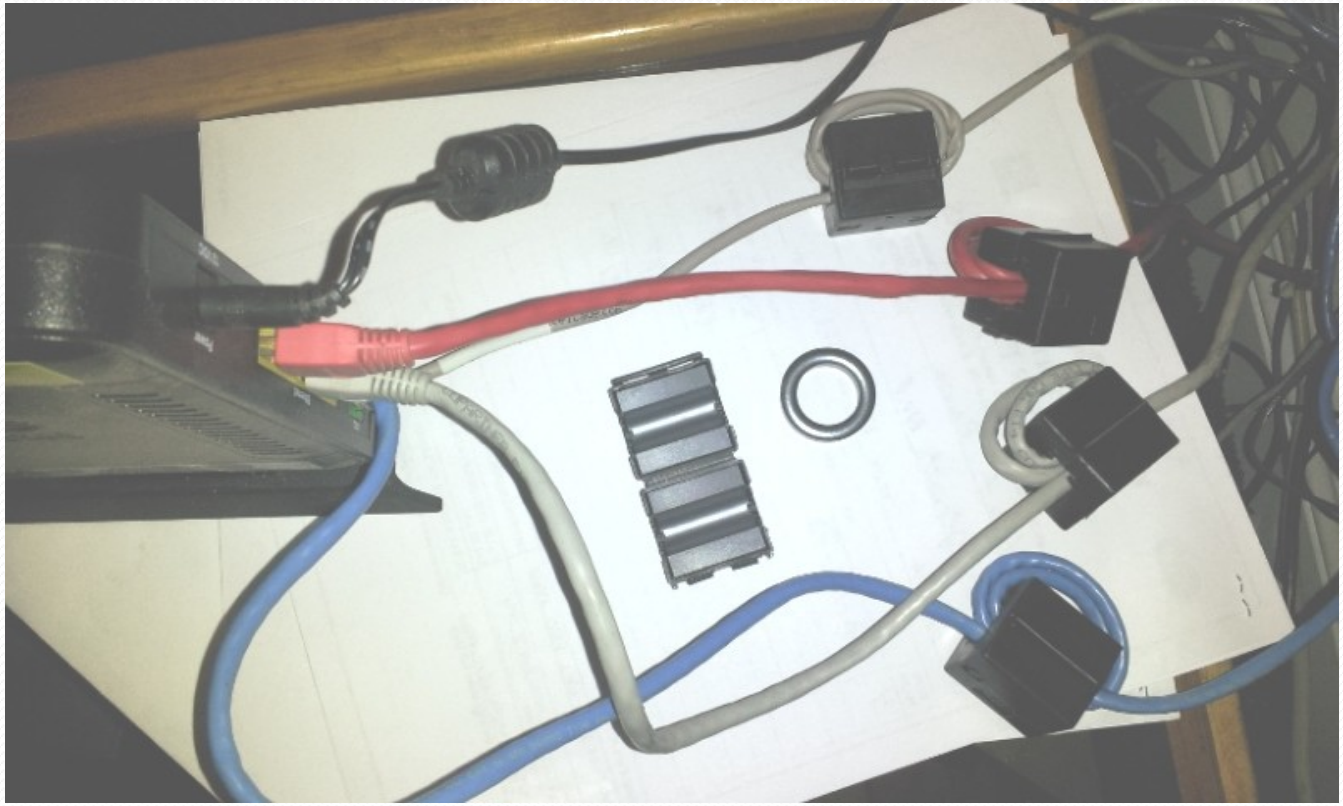
RFI Kit - Transceivers



Laptop RFI Kit

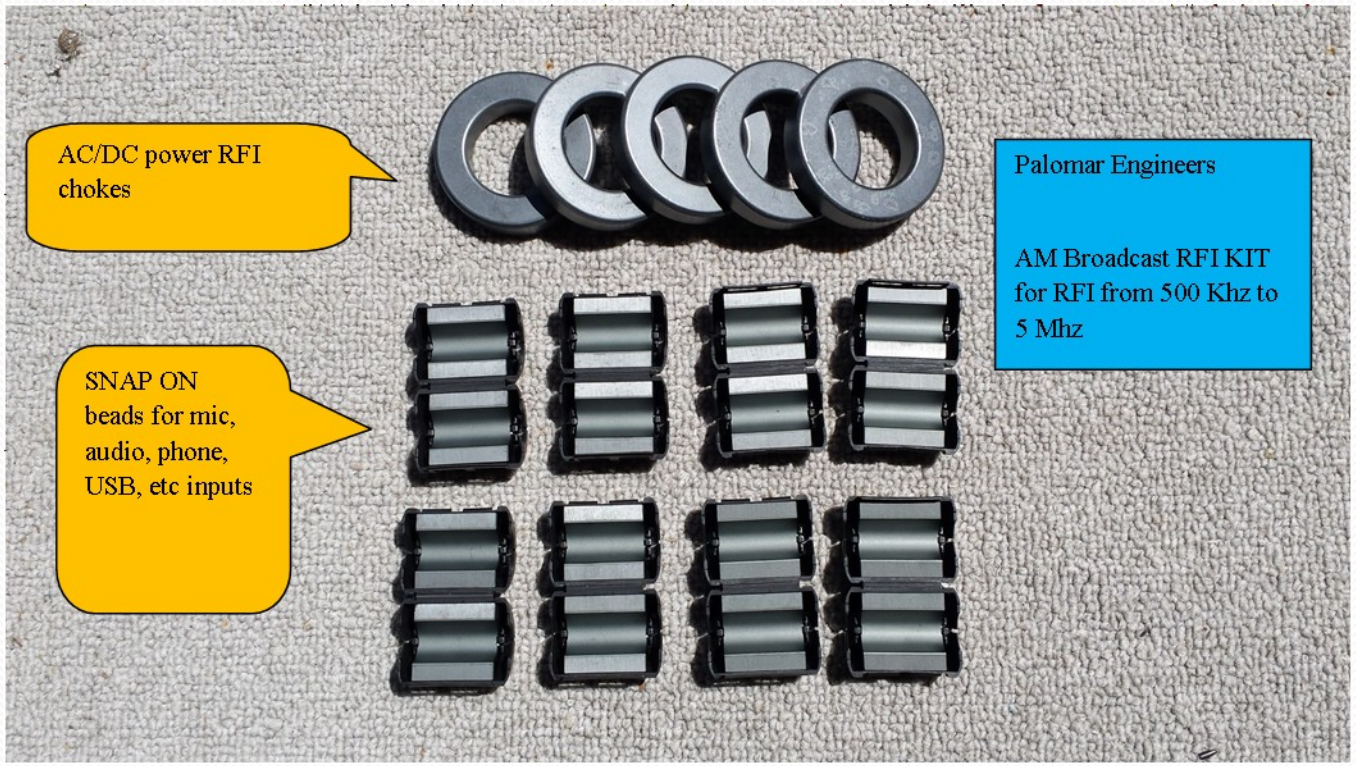


RFI Kits – Computer Devices



Palomar RFI-1A DSL Modem/Router RFI Kit

RFI Kits – AM Broadcast



Palomar RFI-AM Broadcast RFI Kit

RFI Proof Your Shack Summary

- RFI needs SOURCE-PATH-VICTIM (S-P-V)
- Define S-P-V for your shack
- Clean up SOURCE, Choke PATH, Protect VICTIM
- Choke all antennas, control lines on antenna end
- Common ground for all radio/computer equipment
- Choke all "Antenna" PATH(s) using individual ferrites and RFI kits at VICTIM
- Call Palomar Engineers if you get stuck or need help

Using Baluns and Ununs in your Receiving System

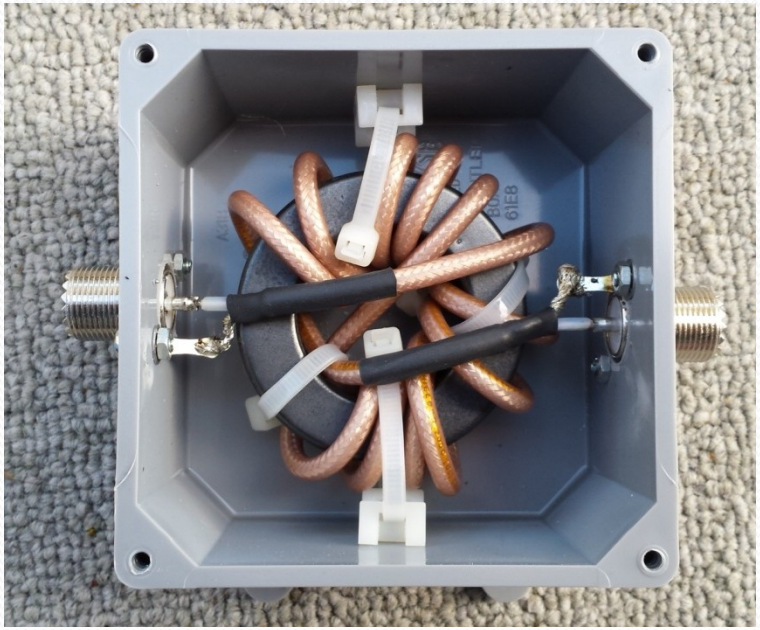
=

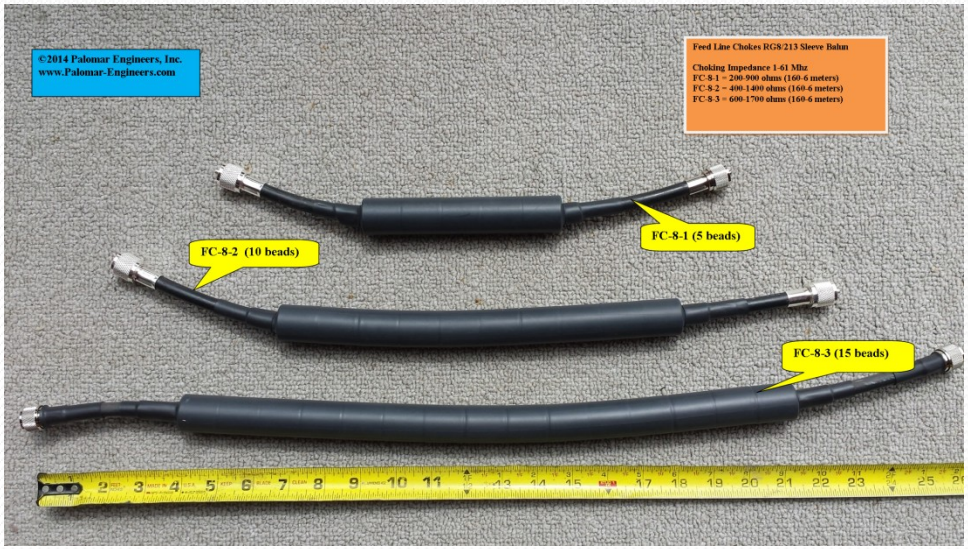
Higher
Signal/Noise Ratio
=
MORE DX!

Choose Baluns/Ununs for best impedance match to receiver

- Match feedline impedance to impedance seen at feed point (50:25, 50:50, 50:100, 50:200, 50:450 etc) – the transmission line impedance may not be the same as the feed point impedance so a matching device such as a transmission line transformer may be needed.
- Use Baluns for balanced loads (dipoles, center fed beams, log periodics, etc).
- Use Ununs for unbalanced loads (vertical, end fed, beverage, etc)
- Use feedline chokes with transmission line transformers to keep RF current on antenna and off the feedline.
- Call Palomar Engineers if you get stuck or need help

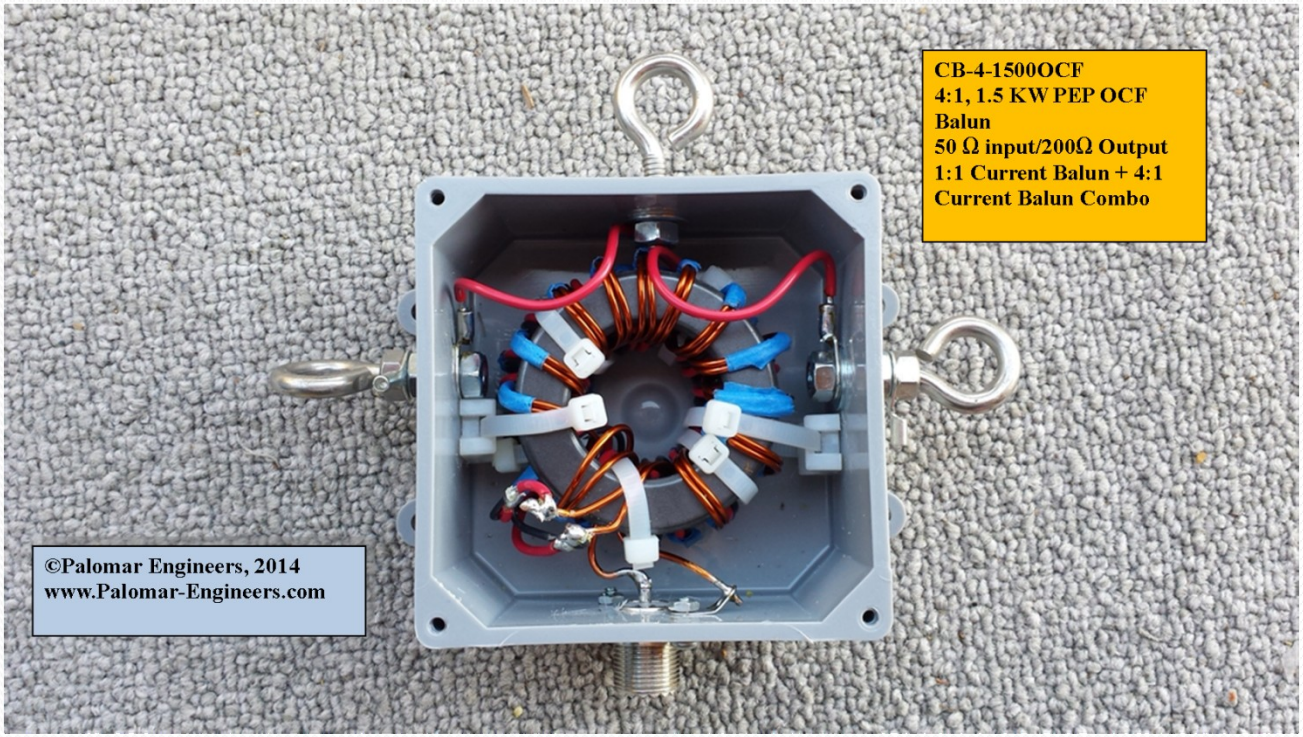
Simple Feedline chokes 1:1





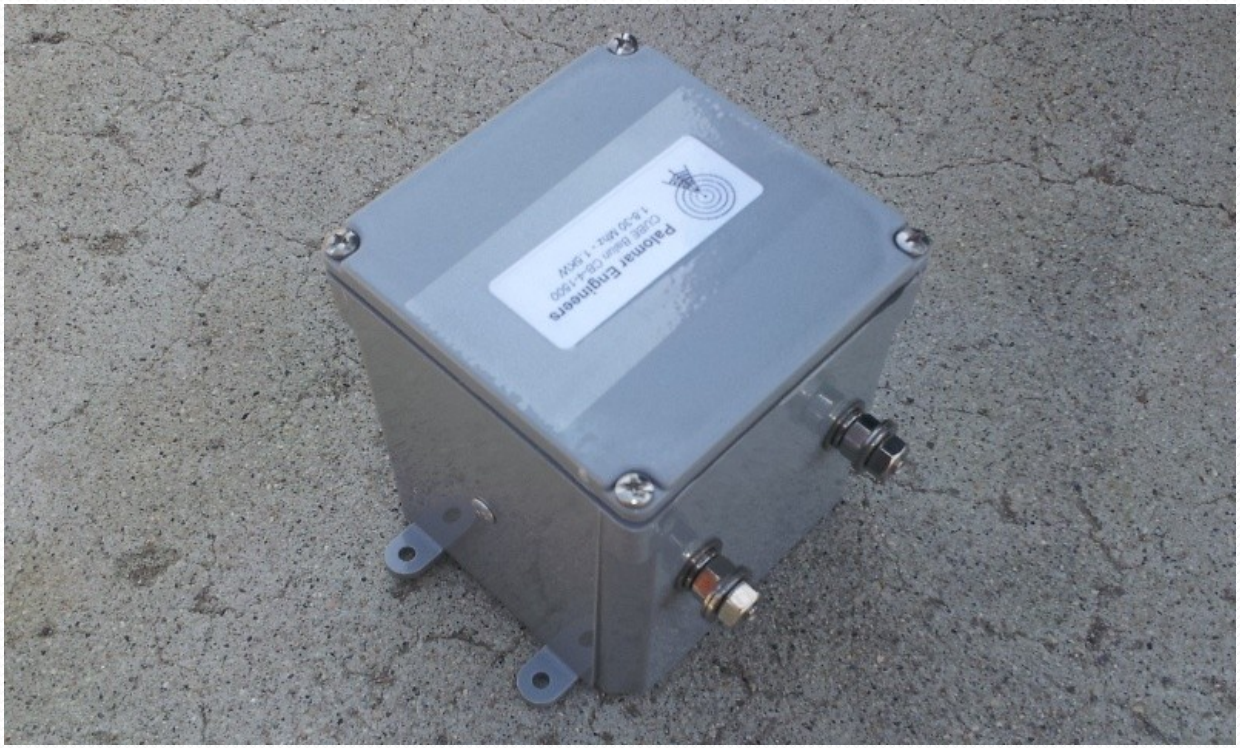
Palomar 1:1 feedline choke/common mode noise filters – toroid choking Z > Bead Z choking

OCF Antenna 4:1 Balun + Choke



Palomar CB-4-1500OCF Balun + Common mode choke in single enclosure

Ladder Line Baluns 4:1



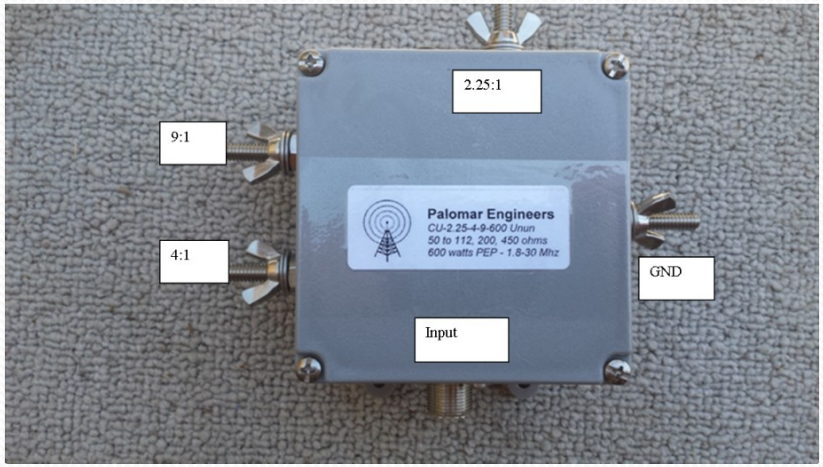
Palomar CB-4-1500AT – special design for large impedance matching to 50 ohms

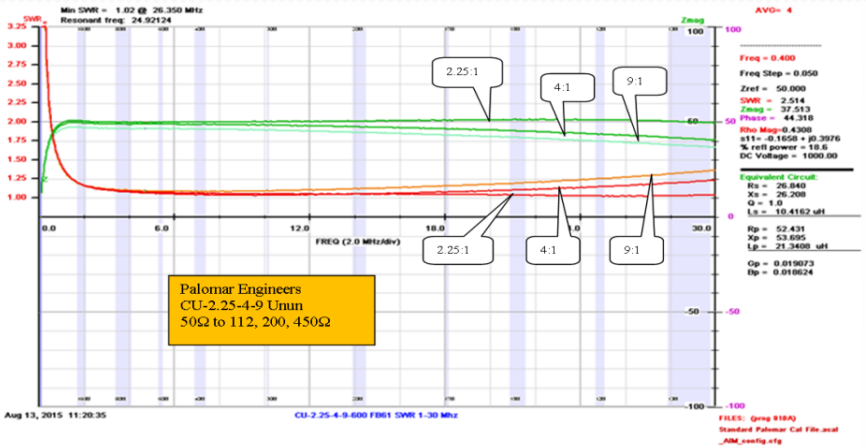
Palomar Engineers Porta-Pole™

Palomar Porta-Pole™ - 27 feet tall – Special unun
for 40-10 meters vertical operation

Palomar Engineers Porta-Pole™

- Special Unun for impedance matching for higher signal strength





Palomar Porta-Pole™ with CU-2-4-9-600 unun

Prize Question?

- Who is the youngest ham who remembers the most popular mix of ferrite to use on HF frequencies?

Contact Info

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