ABC's of RFI for HAMS

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RFI Workshop Objectives

- Learn fundamentals of RFI
- How ferrites work to suppress RFI
- How to use ferrite kits to solve specific RFI problems in your shack
  - RF feed lines
  - AC/DC power lines
- How to solve neighborhood RFI problems

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/CO_2 alarm, answering machine, sprinkler system
  - Degradation of computer data throughput or loss of data , computer/internet stops working

Got RFI Noise in your shack?

- Symptoms – receiver noise caused by outside sources
  - 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"

Got Neighborhood RFI?

IT'S ALL YOUR FAULT WITH THAT BIG ANTENNA!

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**

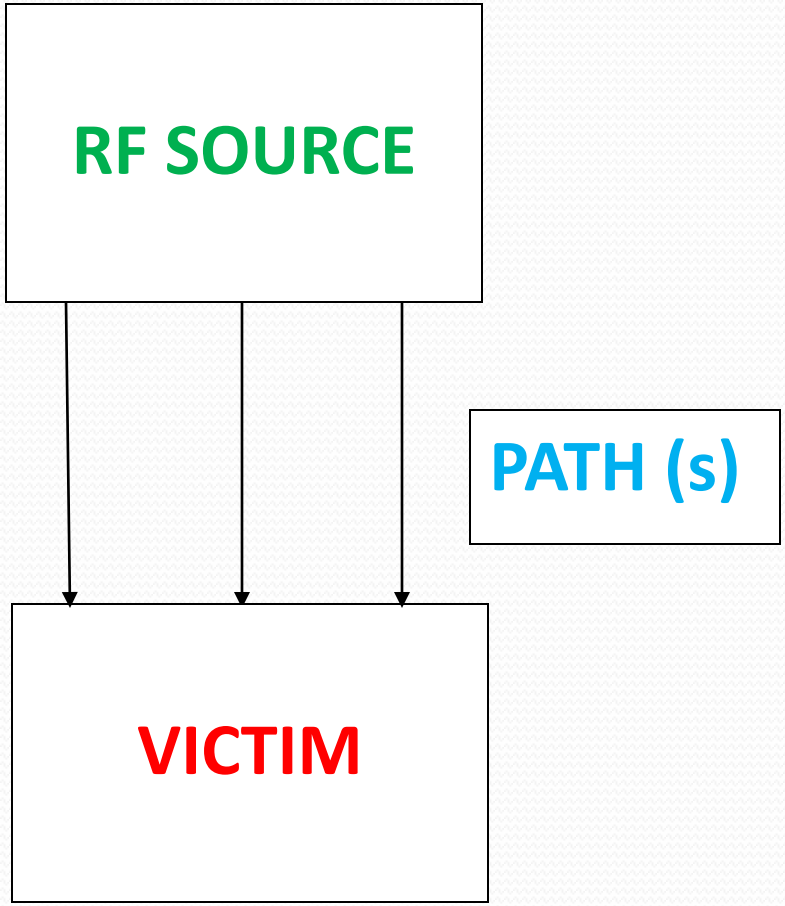
- About 40% of customers call to CURE an RFI problem caused by outside sources effecting their radio station
  - **RECEIVER RFI**

RFI 101

Causes and Cures to make ham radio more enjoyable

How is RFI Transferred?

RFI Transmission



RFI REQUIREMENTS

SOURCE of RF

Connecting PATH(s) – conducted or radiated

VICTIM of interference

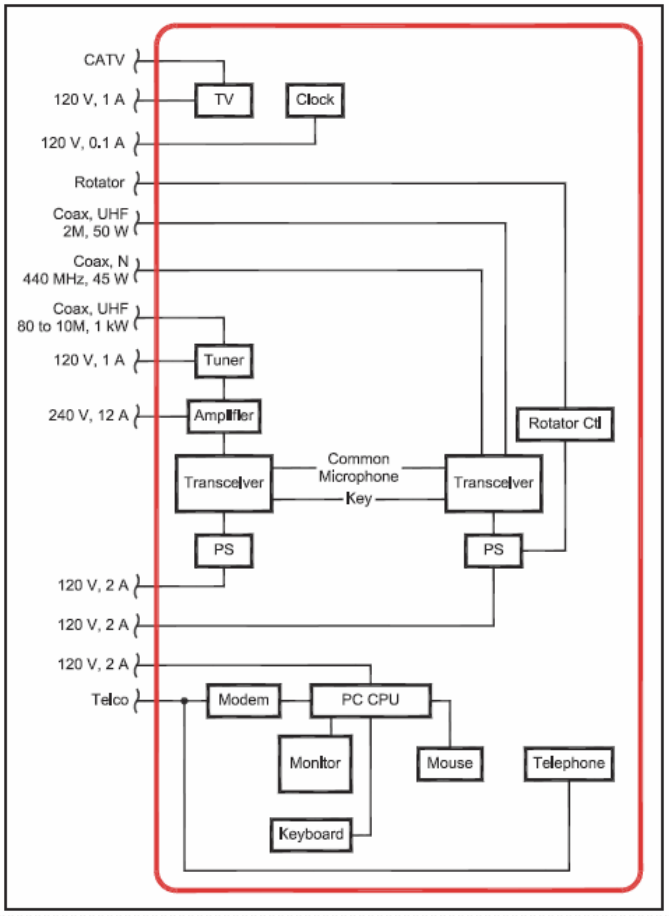
All three of the above must be present to have an RFI problem.

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

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 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 multiple paths

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

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)

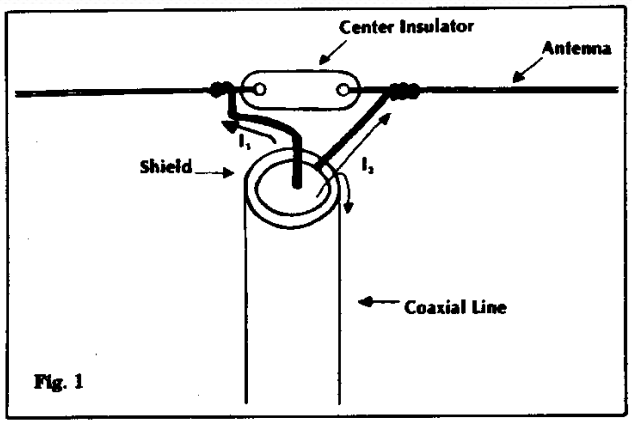
RFI Frequency "Antennas"

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

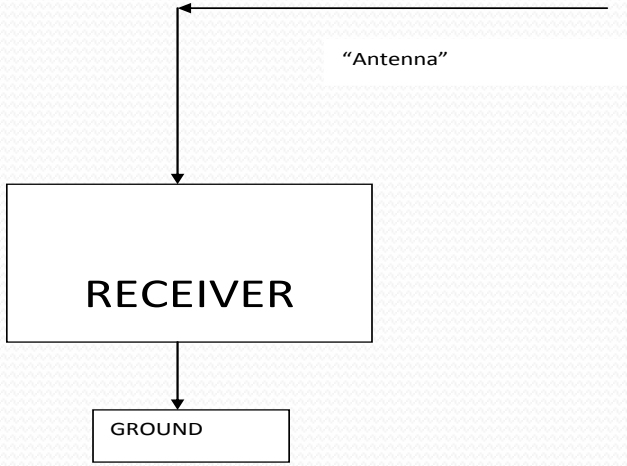
Is your Coax an “antenna”?

- 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

Measuring Coax Braid Current

- Common Mode Current (RF) meter – clamps on outside of coax cable, radials, device cables, AC/DC cables and measures current.
- With proper choking current will decrease

Reduce RFI current to reduce RFI

- I = E/R
- Where I = Common Mode Current - I_{RFI}
- E = voltage on coax
- R = Choking impedance (Z=R+j) to reduce I
- Higher Z means less I = less RFI because
- I_{RFI} = E/Z

- An “antenna” is a wire with alternating current going through it creating an electromagnetic field of radiation.
- Reducing the current through the wire, reduces the radiation.
- Without choking, the outside coax braid is an unwanted antenna

Ferrites Are your Friend for RFI

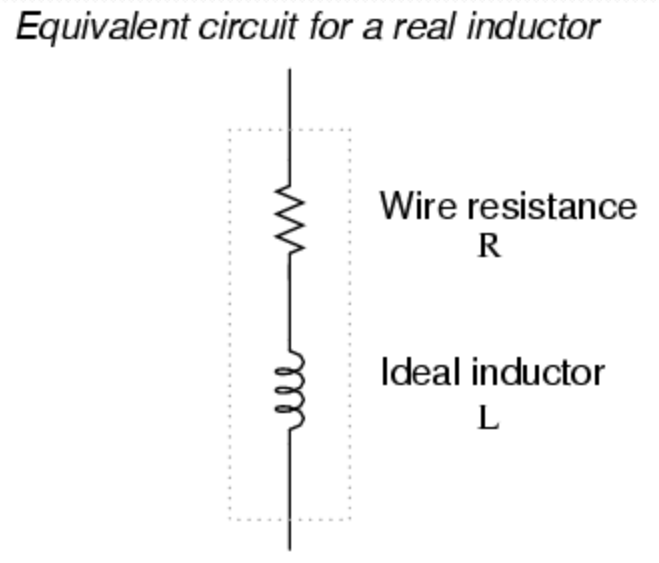
Slip On Bead

Snap On Bead

Toroid/Ring

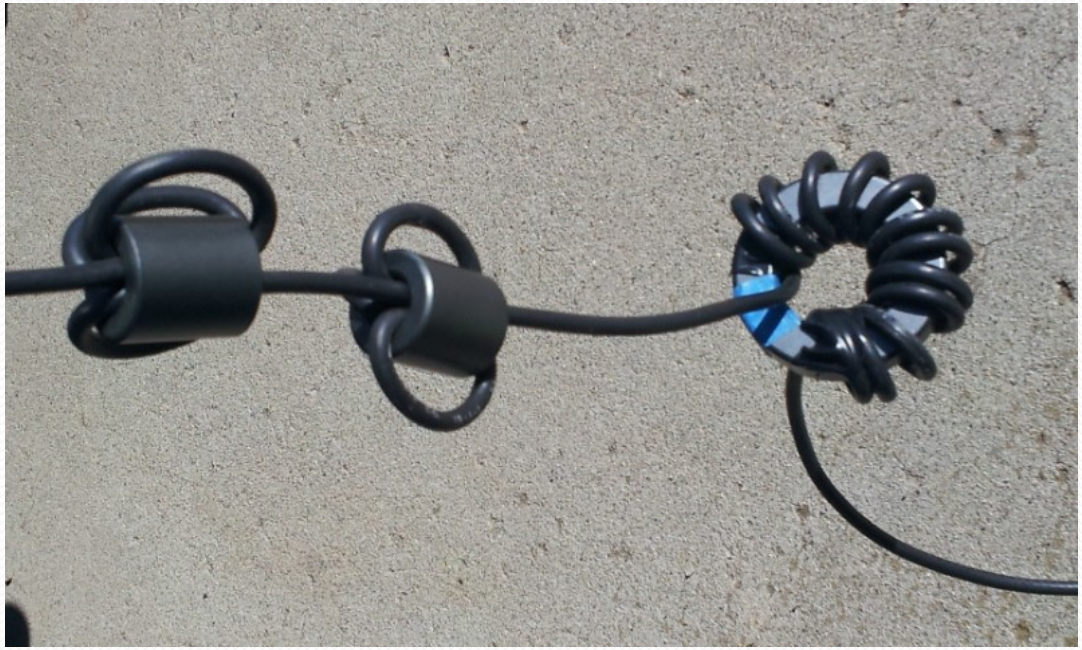
- Cheap, easy to install, work on all ham frequencies
- Work on all paths (feed line, AC/DC, electronic devices)
- Lots of options in size, shape to fix most RFI path problems
- Can be installed by almost anybody who understands how to choose the correct ferrite for a particular RFI problem.

Ferrite Equivalent Circuit



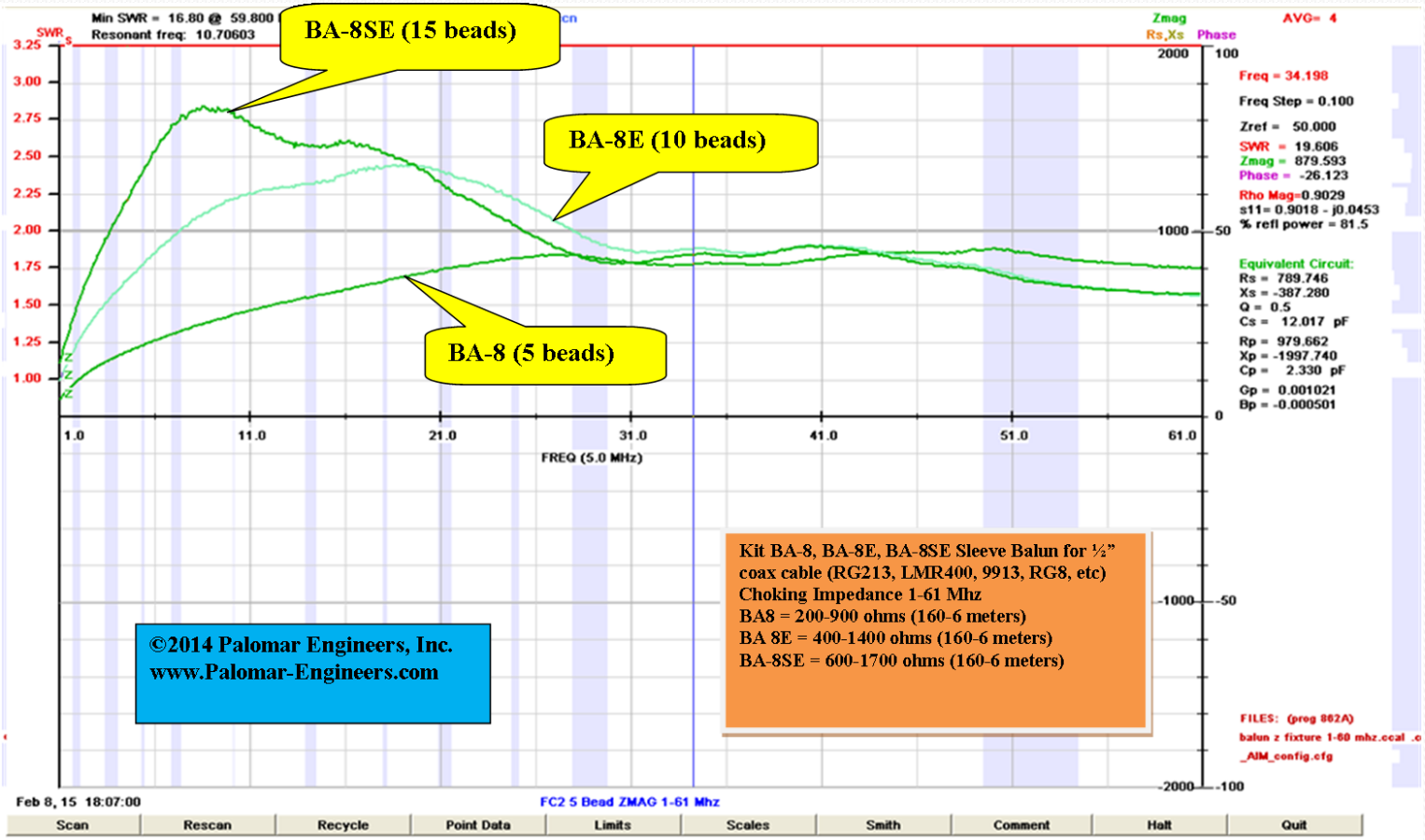
One Turn coil through a ferrite with reactance which varies with frequency ($X_L=2\prod*f*L$). Reactance goes up as the square of the number of turns, e.g. 2 turns = 4X, 3 turns = 9x, until resonance reached

Multiple Ferrites in Series add



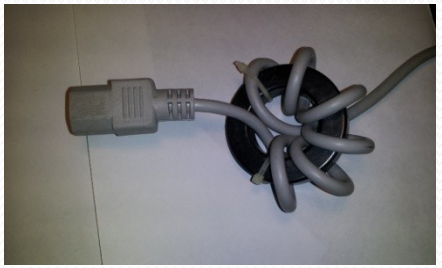
For additional choking impedance you can put chokes in series – use multiple mixes for broadband choking.

Multi-Bead Choking Z

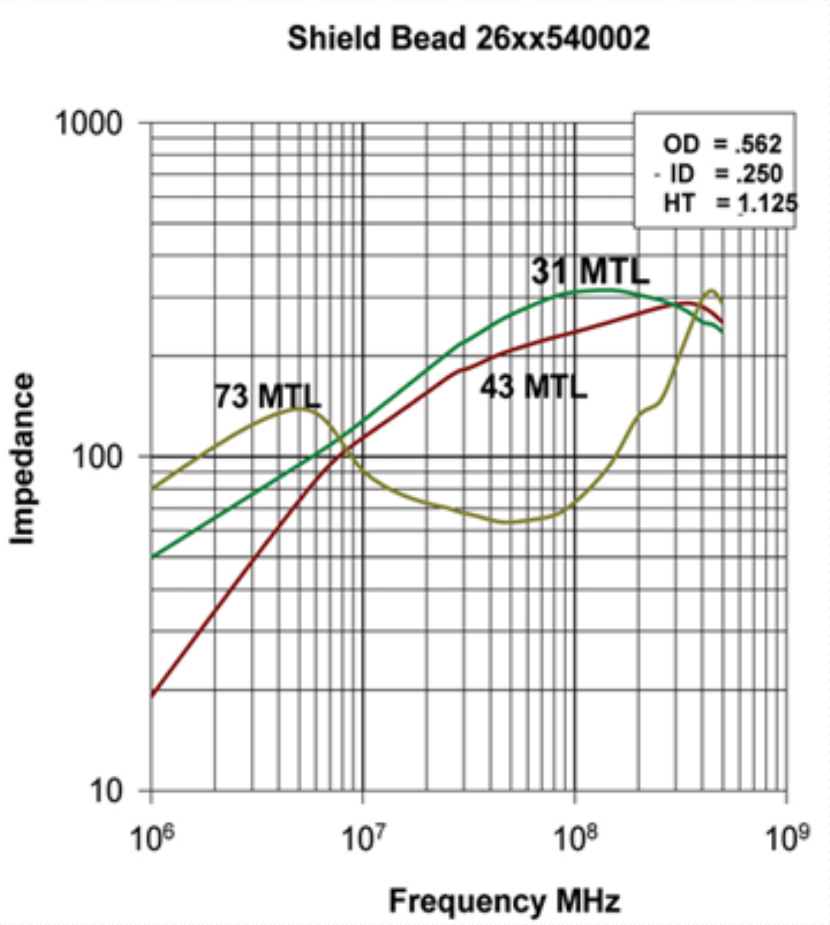


Z Varies with $(\text{turns})^2$

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



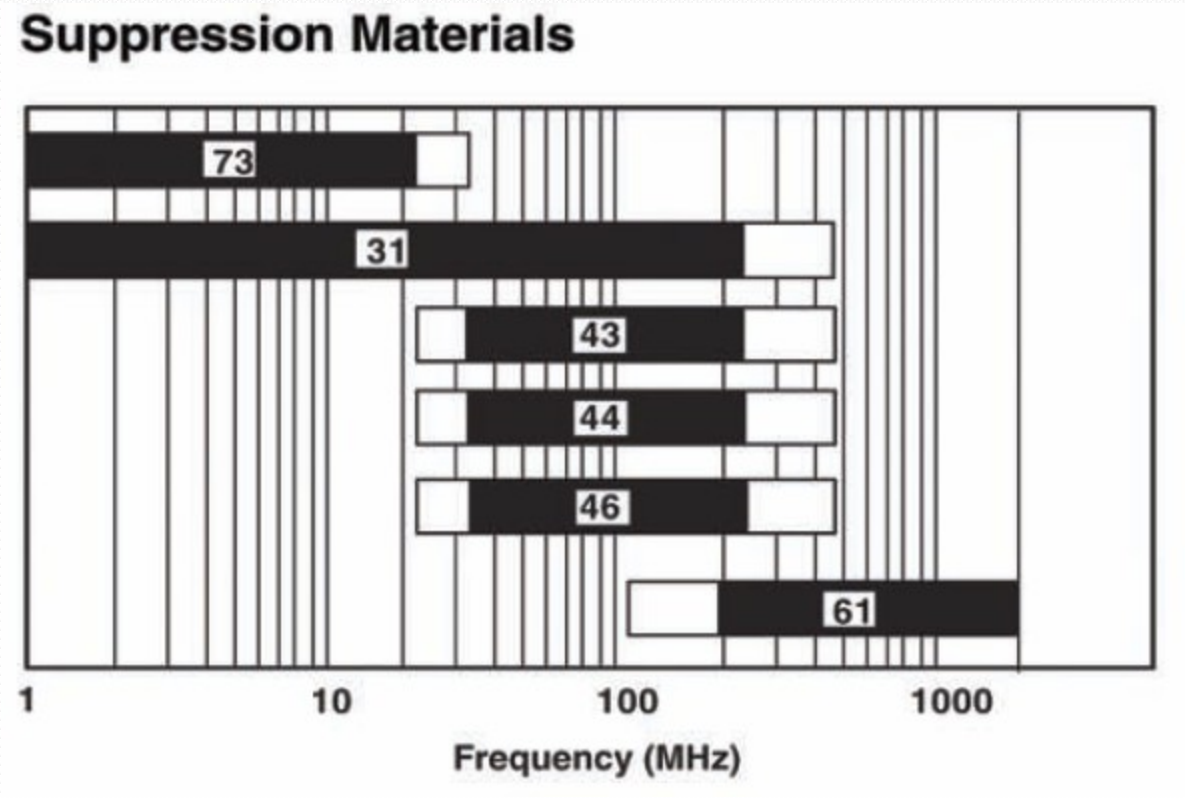
Ferrite Mixes



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

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

RFI Proof Your Shack

Suppress TRANSMITTER RFI, reduce RECEIVER RFI/NOISE

RFI Strategy

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

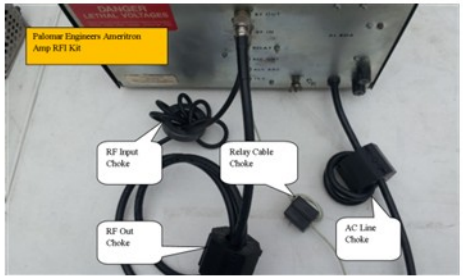
How does that apply to your ham shack/home?

Ham Shack RFI Solutions

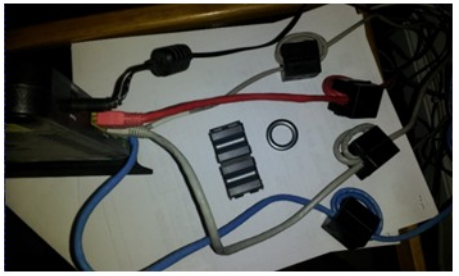
PICK YOUR RFI SOLUTION KIT

MY RADIO ROOM

ANTENNA RFI

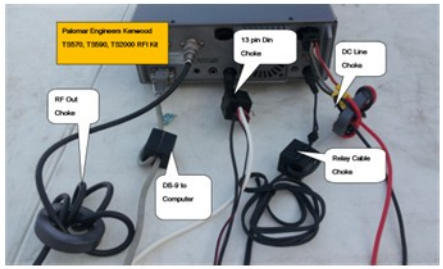


AMPLIFIER RFI



COMPUTER RFI

POWER LINE RFI



TRANSCEIVER RFI

NOISE REDUCTION

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

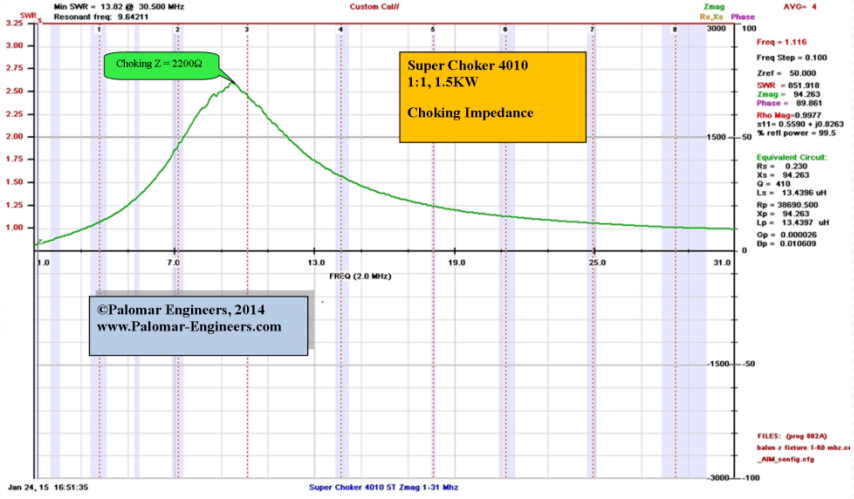
Large Clamp On (FSB-1) = 1” ID

3 turns =
1K ohms

Sleeve Baluns (Slip on)

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

Super Choker (40-10 Meters)

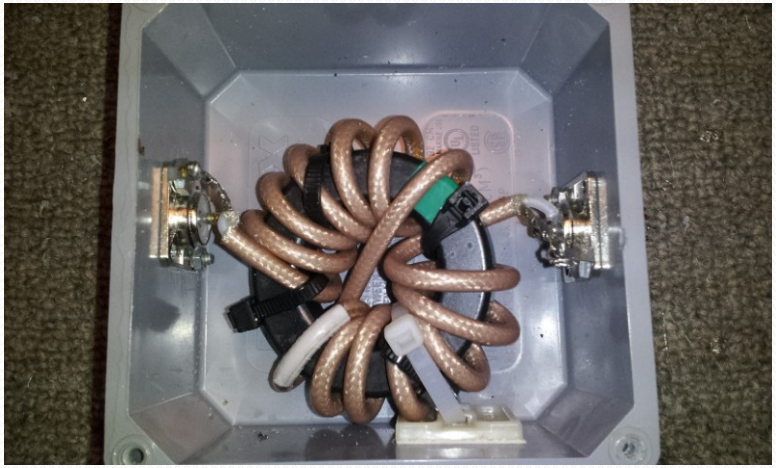


Z = 1,500 at 7Mhz , 2.2K at 10 Mhz, 1K at 14 Mhz,
300 at 28 Mhz – 5 Turns, 3 cores

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

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

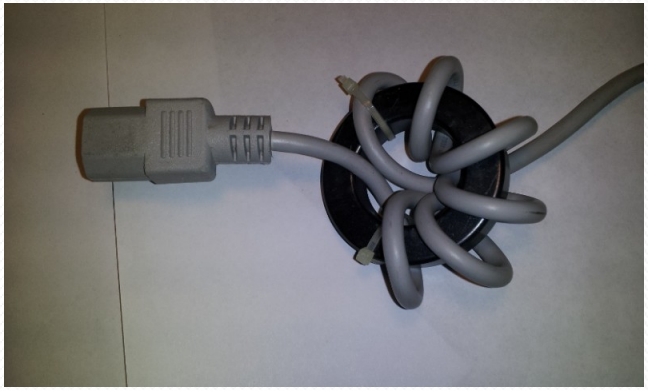
- WOW…
- I just tried one of your toroids on my modest antenna system. I have a Hamstick on top of an all aluminum manufactured home. Its the best ground plane one could hope for, and I've made contacts to Korea on 40m with it.
- Before… on 40m I had an AM background noise of 5S units. I wrapped about 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)

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

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

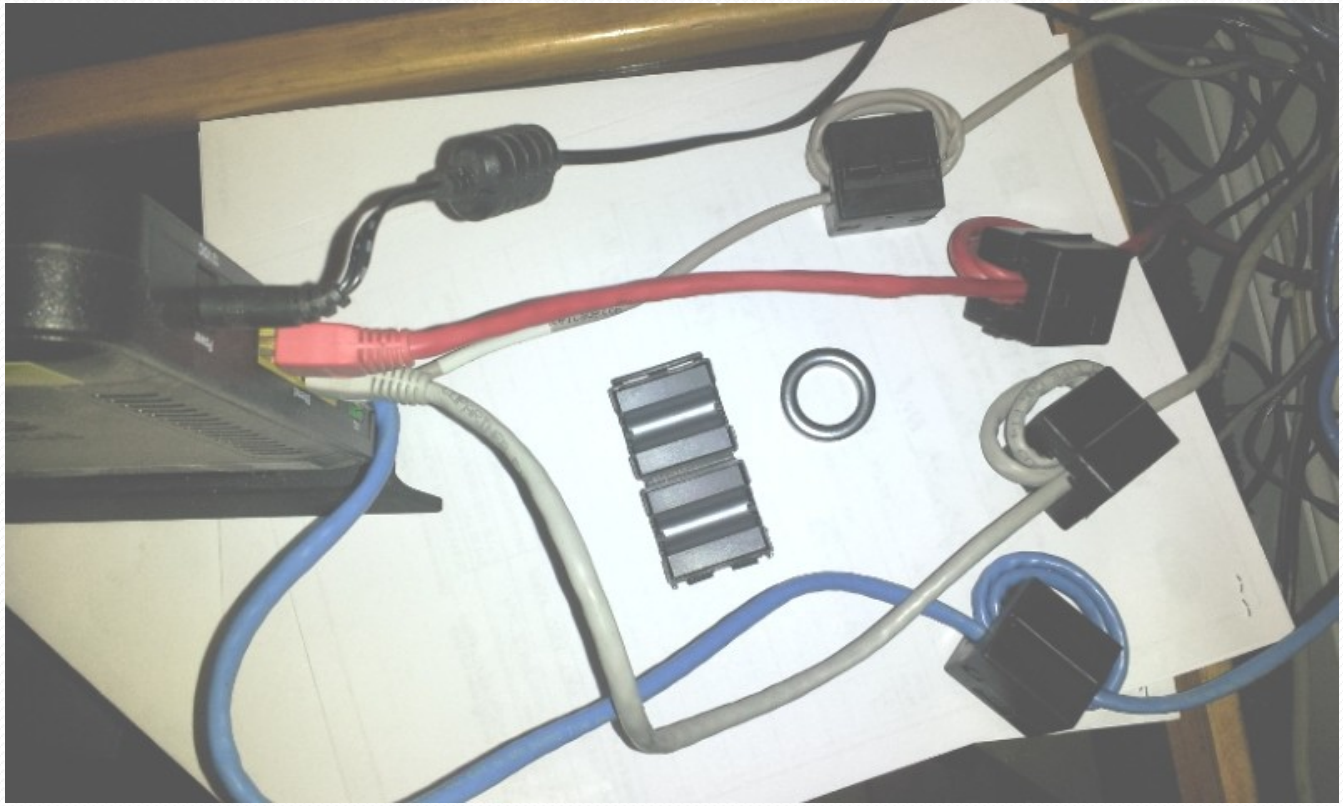
Device Cable Chokes

- 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

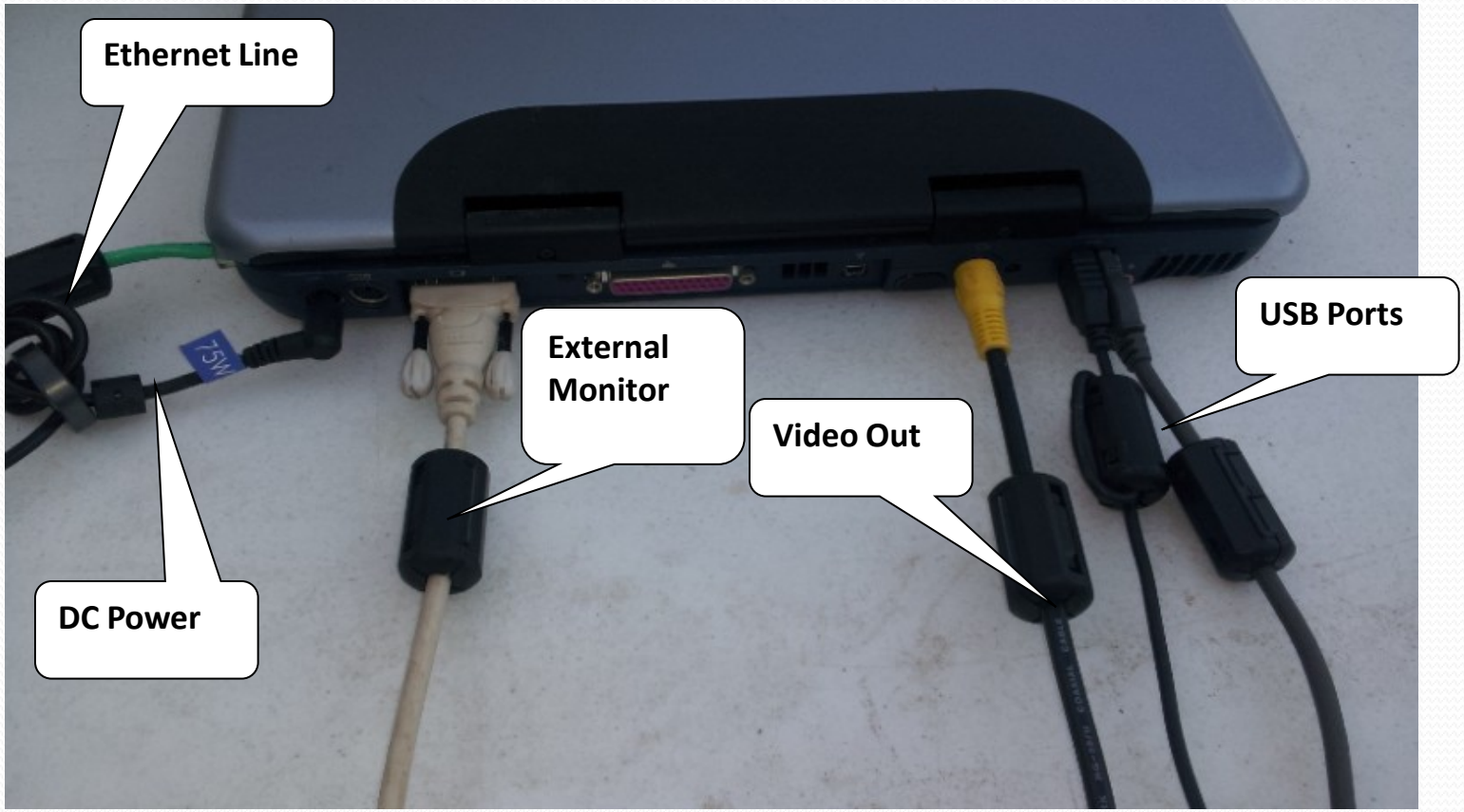
- Transmitter/Transceiver Kits
- Linear Amplifier Kits
- Computer Device Kits
  - Lap tops
  - Desktops
  - DSL Router
  - Network boxes

RFI Kits – Computer Devices

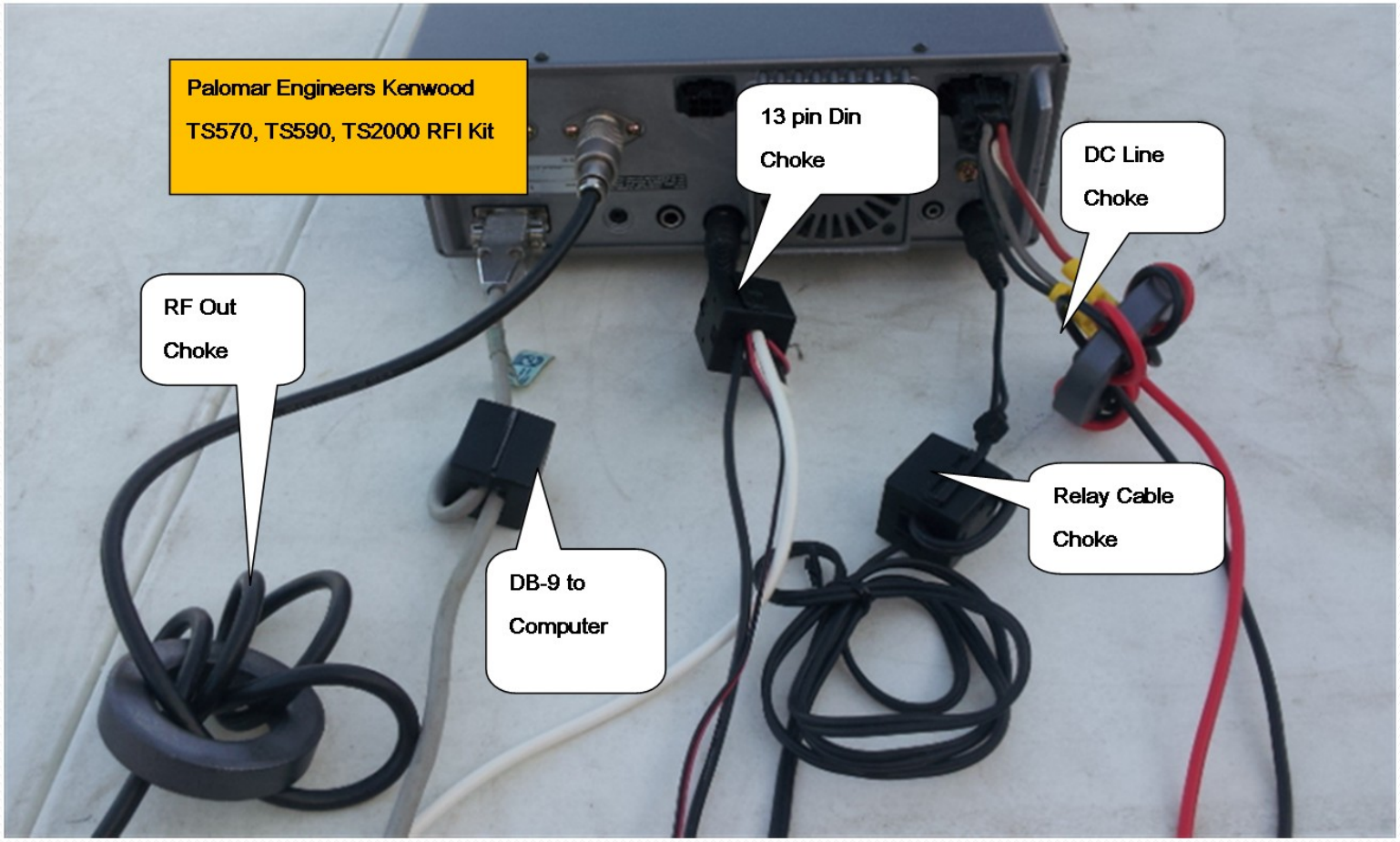


Palomar RFI-1A DSL Modem/Router RFI Kit

Laptop RFI Kit



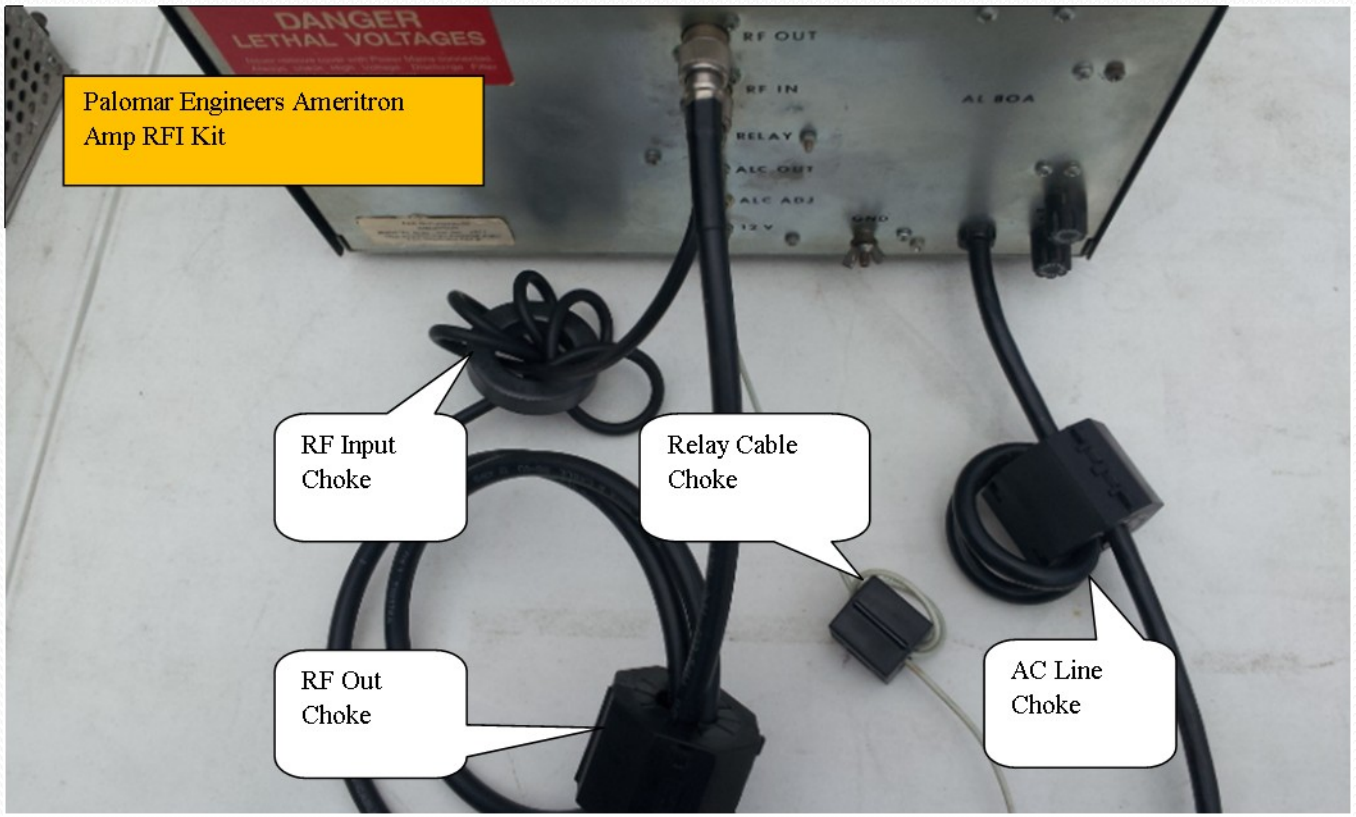
RFI Kit - Transceivers



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 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

Keep Your Neighbors Happy!

OR

Problem Isolation

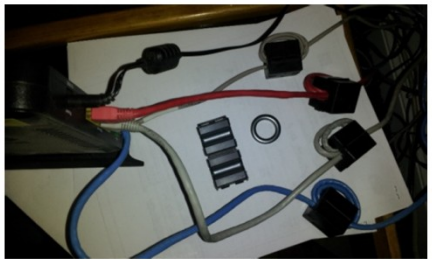
- Source (transmitter or antenna") – Path – Victim
  - Clean up your transmitter/shack first using techniques already discussed
- Assess Neighbor's Problem
  - Faulty device (device acting as receiver when not designed to be a radio receiver – e.g. Telephone)
  - Determine frequency of "transmitter" 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

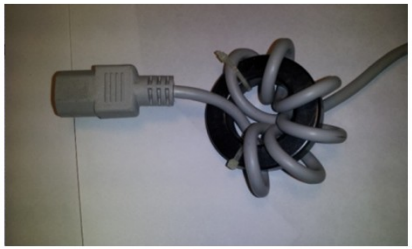
MY HOME or NEIGHBOR'S HOME

ALARM SYSTEM RFI

HOME THEATER RFI



COMPUTER RFI



MISCELLANEOUS RFI

GARAGE DOOR

TELEPHONE/DSL RFI

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

Contact Info

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