

# RFI 101

## Off-the-Shelf RFI Cures to keep your spouse and neighbors happy!



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# Got Neighborhood RFI?



IT'S ALL YOUR FAULT WITH THAT BIG ANTENNA!



# RFI Workshop Objectives

- Learn fundamentals of transmitter RFI causes & cures
- How ferrites work to suppress RFI
- How to use ferrite kits to solve specific RFI problems in your shack
  - RF feed lines, antenna control lines
  - AC/DC power lines, phone/DSL lines
- How to solve neighborhood RFI problems

# RFI 101

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 your transmitter or antenna
  - 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<sub>2</sub> 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**

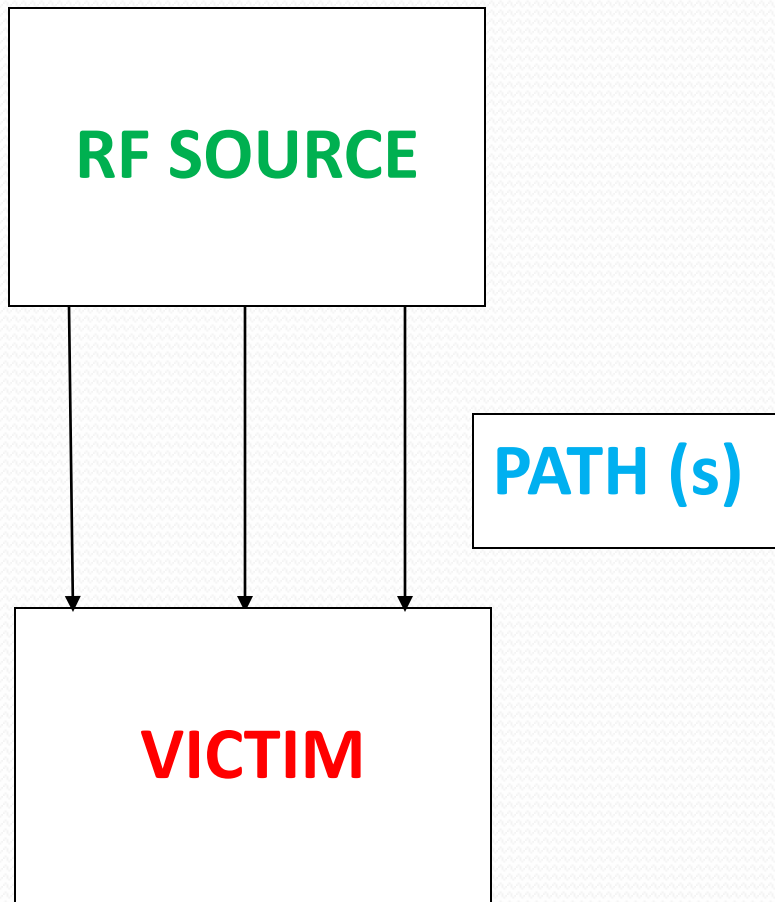
- An RFI problem caused by outside sources effecting their radio station



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, 2<sup>nd</sup> 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

# 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, an electromagnetic field exposed to a wire induces a current in the wire.
- Reducing the current through the wire, reduces the radiation from the wire.
- Without choking, the outside coax braid is an unwanted antenna

# Ferrites Are your Friend for RFI



Slip On Bead



Snap On Bead

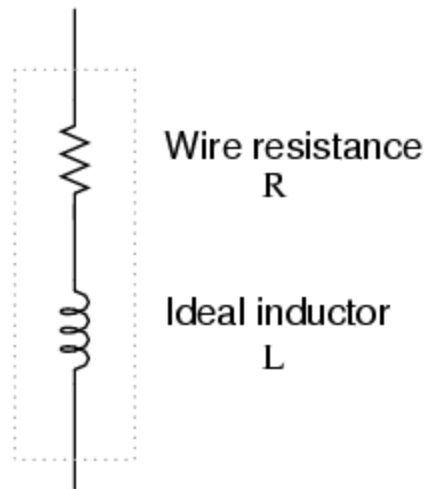


Toroid/Ring

- 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.

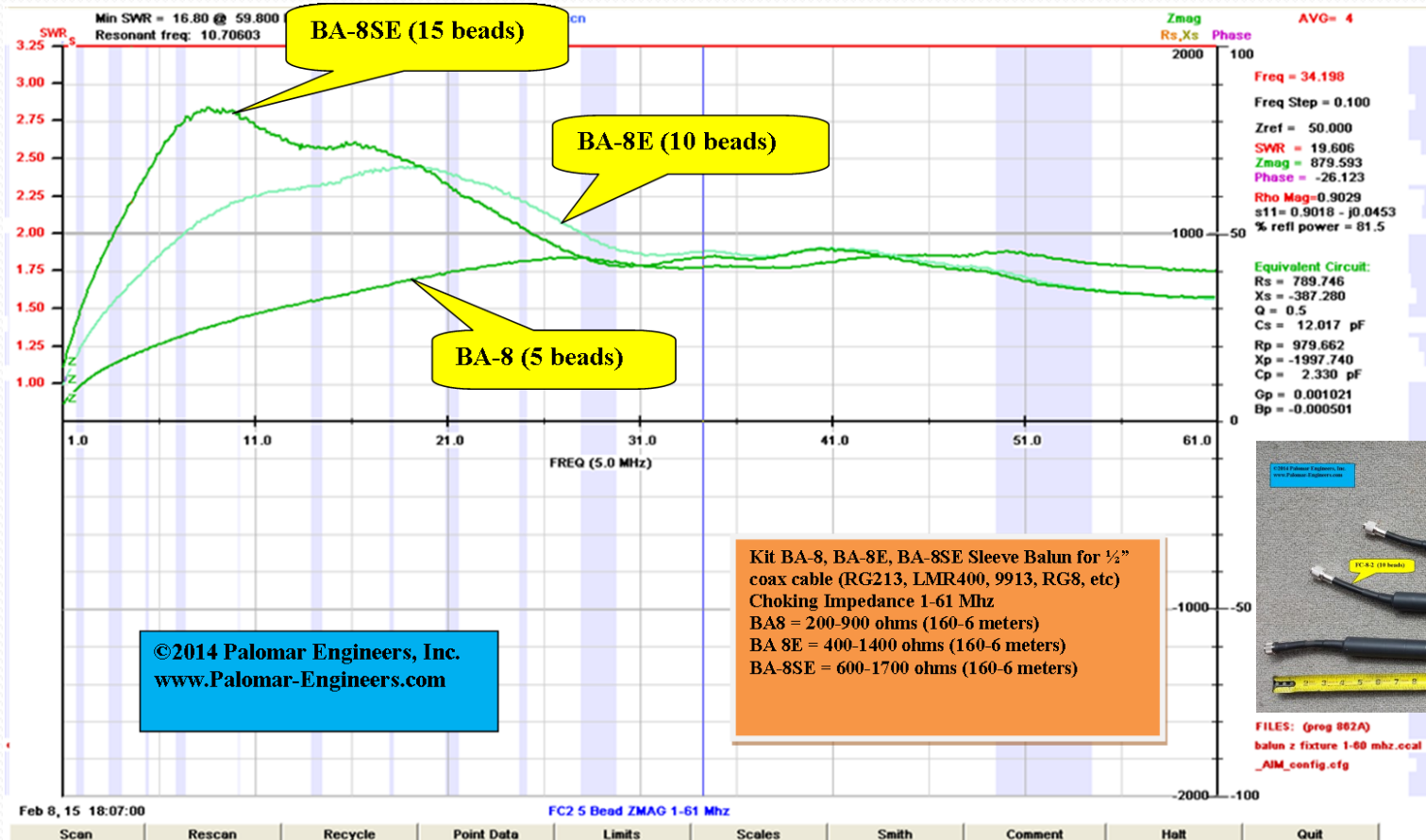
# Ferrite Equivalent Circuit

*Equivalent circuit for a real inductor*



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

# Multiple beads increase Choking Z



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Kit BA-8, BA-8E, BA-8SE Sleeve Balun for 1/2" coax cable (RG213, LMR400, 9913, RG8, etc)  
Choking Impedance 1-61 Mhz  
BA8 = 200-900 ohms (160-6 meters)  
BA 8E = 400-1400 ohms (160-6 meters)  
BA-8SE = 600-1700 ohms (160-6 meters)



FILES: (prog 882A)  
balun z fixture 1-60 mhz.ccal.o  
\_AIM\_config.cfg

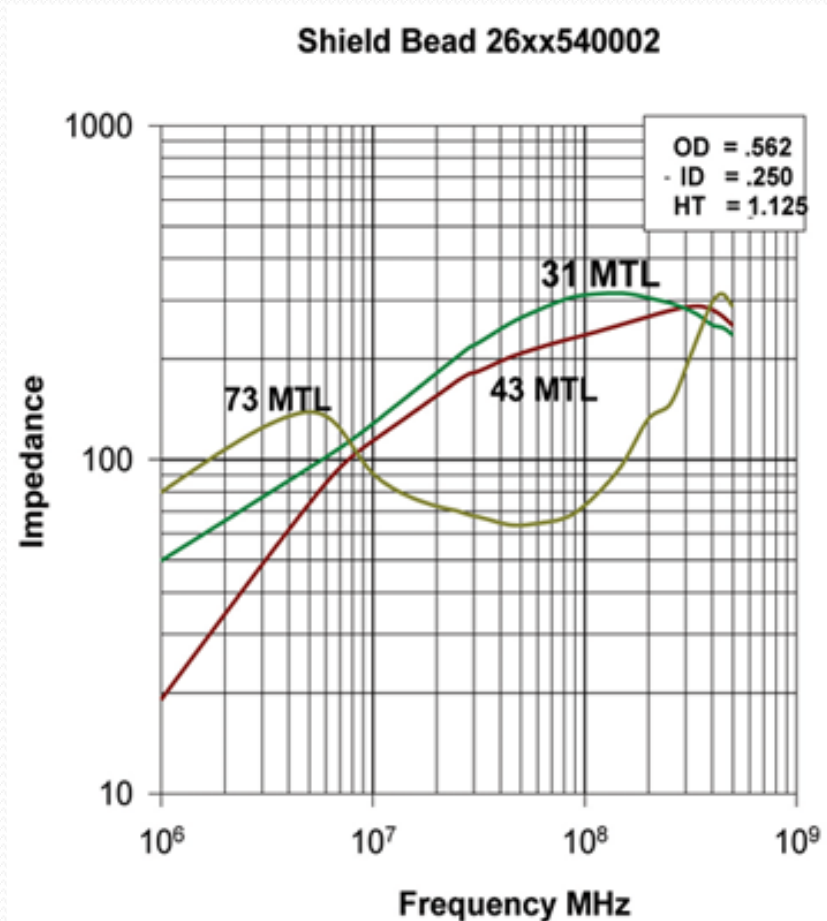
# Choking Z Varies with (turns)<sup>2</sup>

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





# Ferrite Mixes

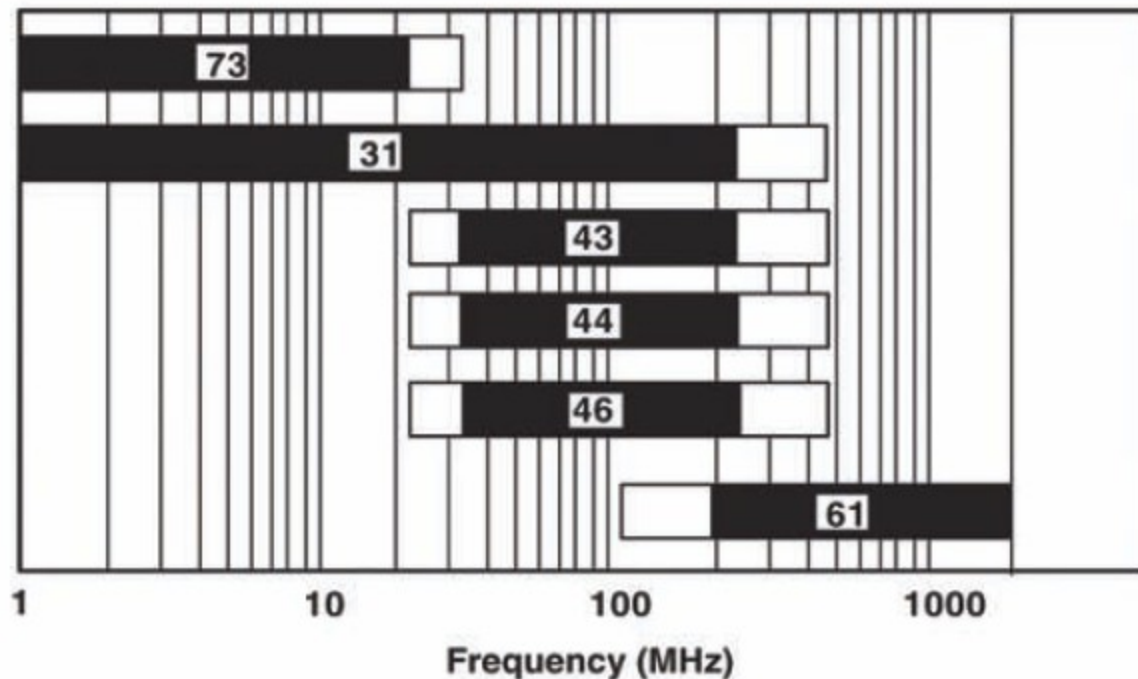


Different mixes for different frequency ranges of choking. Use at frequencies to the “left” of peak for chokes.

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

# Ferrite Mix Selection - Chokes

**Suppression Materials**



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

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
  - or
  - Choke the PATH
    - or
  - Protect the VICTIM

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

# Source-Path-Victim in the Ham Shack

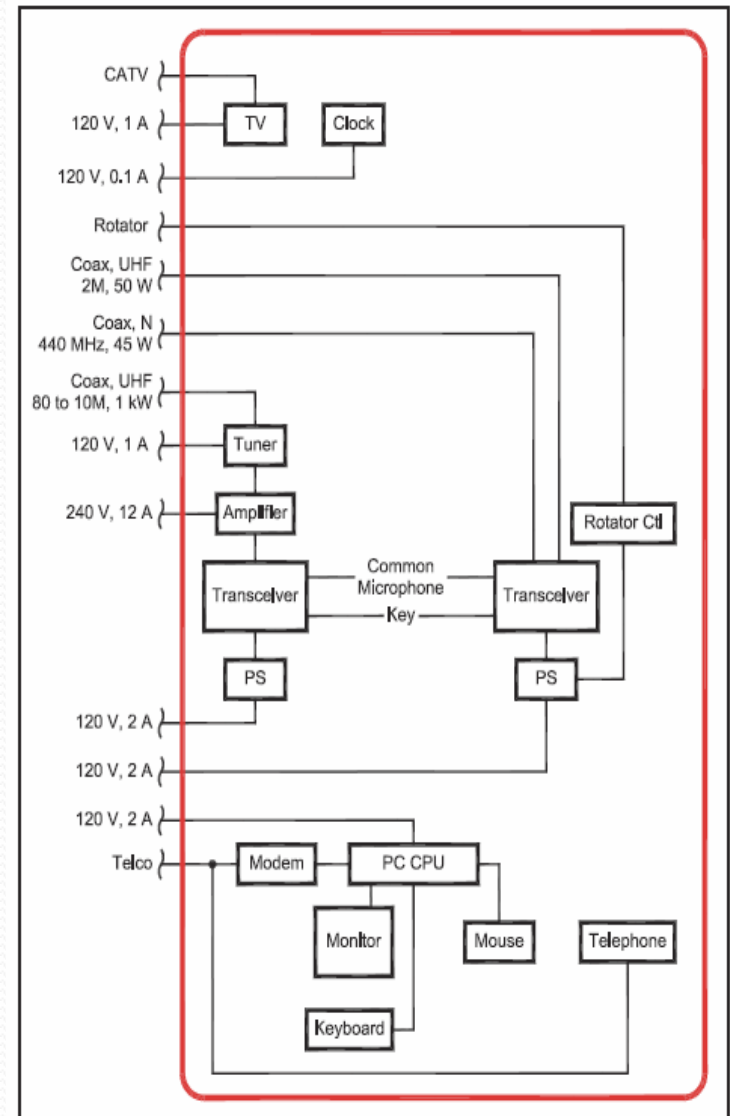
- **Source**
  - Transmitter or antenna or feedline
- **Path** (single or multiple wires in/out of equipment act as **TRANSMITTING** antennas)
  - Antenna (direct radiation)
  - Antenna Coax, rotator/antenna selector control lines
  - 120/240V AC wiring
  - Phone/DSL telephone service wires
  - Cable/Satellite coax
  - Device interconnect cables (mic, audio, speaker, video, power)
- **Victim** (Device receiving interference – I/O wires also 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 victim “antennas” as common mode current (same on all wires).



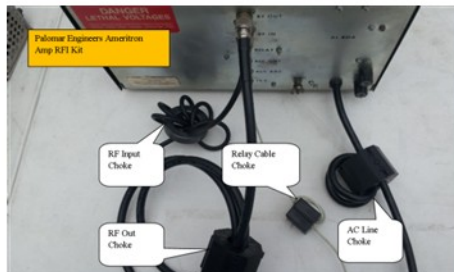
# Ham Shack RFI Solutions – reduce radiation from the source

**PICK YOUR RFI SOLUTION KIT**

## **MY RADIO ROOM**



**ANTENNA RFI**



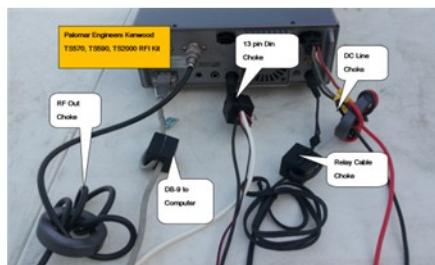
**AMPLIFIER RFI**



**COMPUTER RFI**



**POWER LINE RFI**



**TRANSCEIVER RFI**

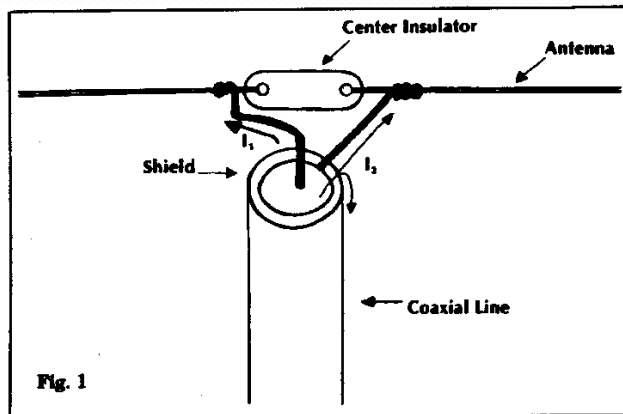


**NOISE REDUCTION**



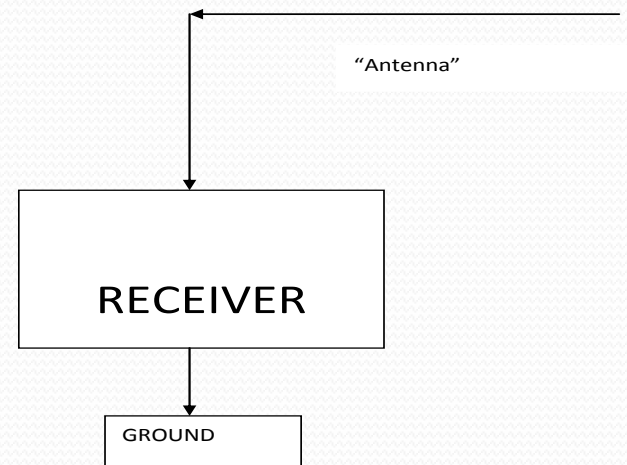
# Is your Dipole a Tripole?

- 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

# 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

# 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



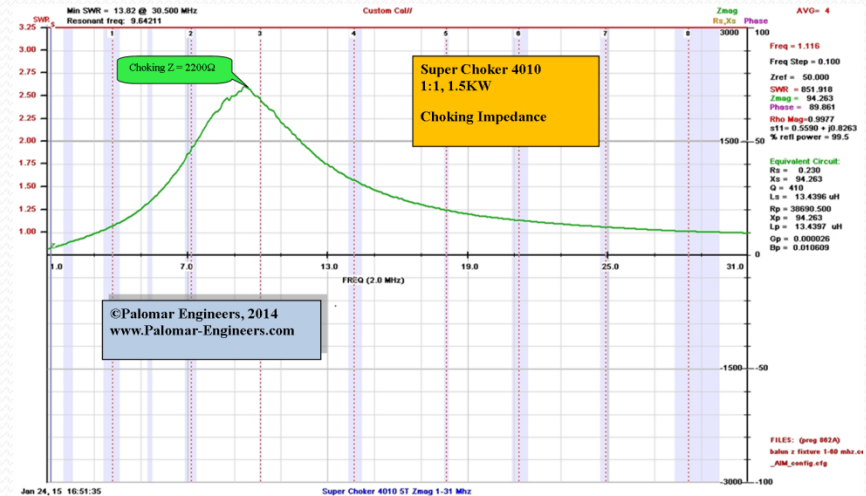
3 turns =  
1K ohms

# 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

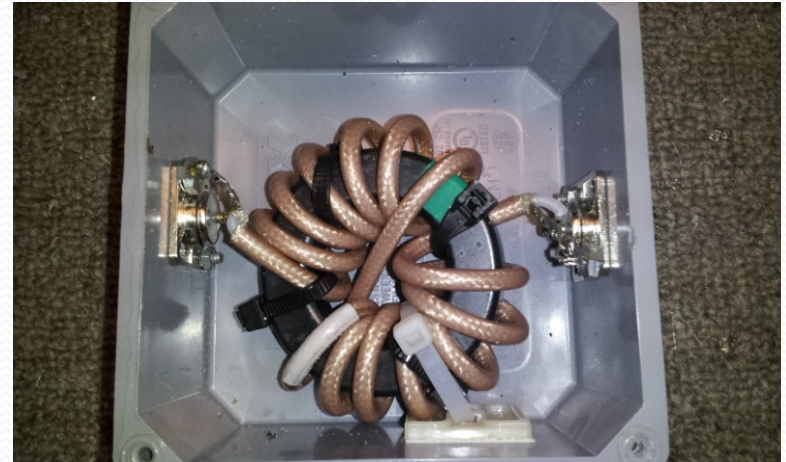


# CUBE Baluns



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

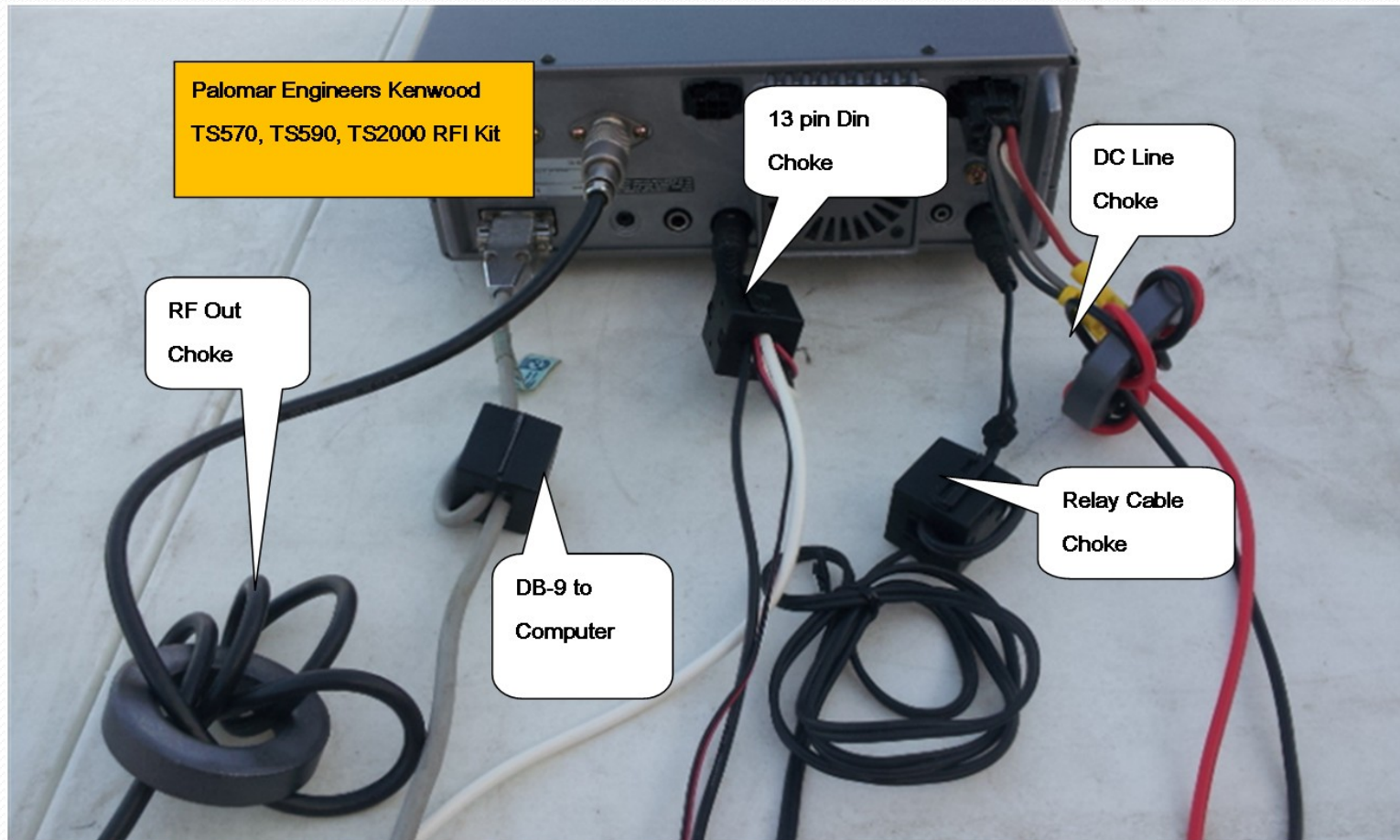
Do It Yourself KIT



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

ASSEMBLED

# RFI Kit - Transceivers



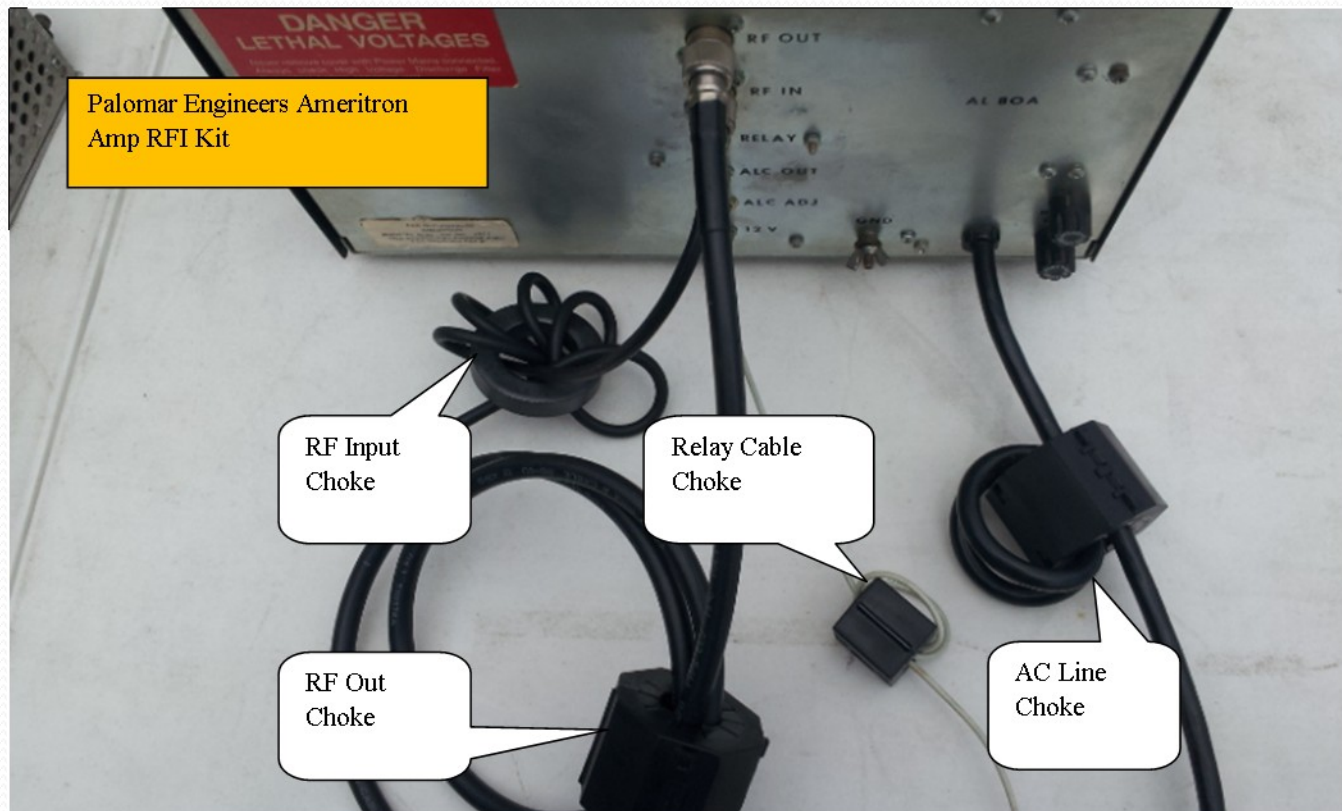
# Amplifier RFI Kits – all brands



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



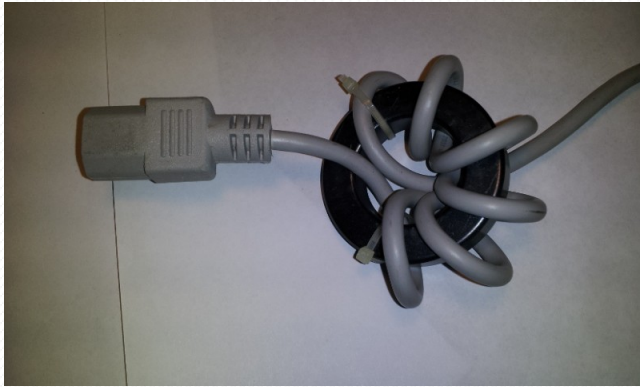
# RFI Kits - Amplifiers



# 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](http://www.Palomar-Engineers.com)

# Keep Your Neighbors Happy!



OR





# Got Neighborhood RFI?



IT'S ALL YOUR FAULT WITH THAT BIG ANTENNA!

# 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

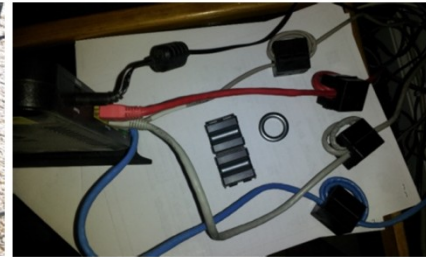
## MY HOME or NEIGHBOR'S HOME



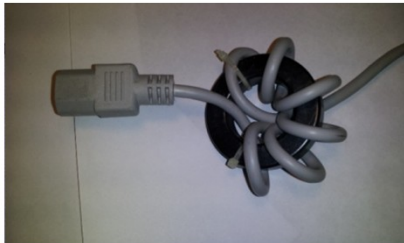
**ALARM SYSTEM RFI**



**HOME THEATER RFI**



**COMPUTER RFI**



**MISCELLANEOUS RFI**

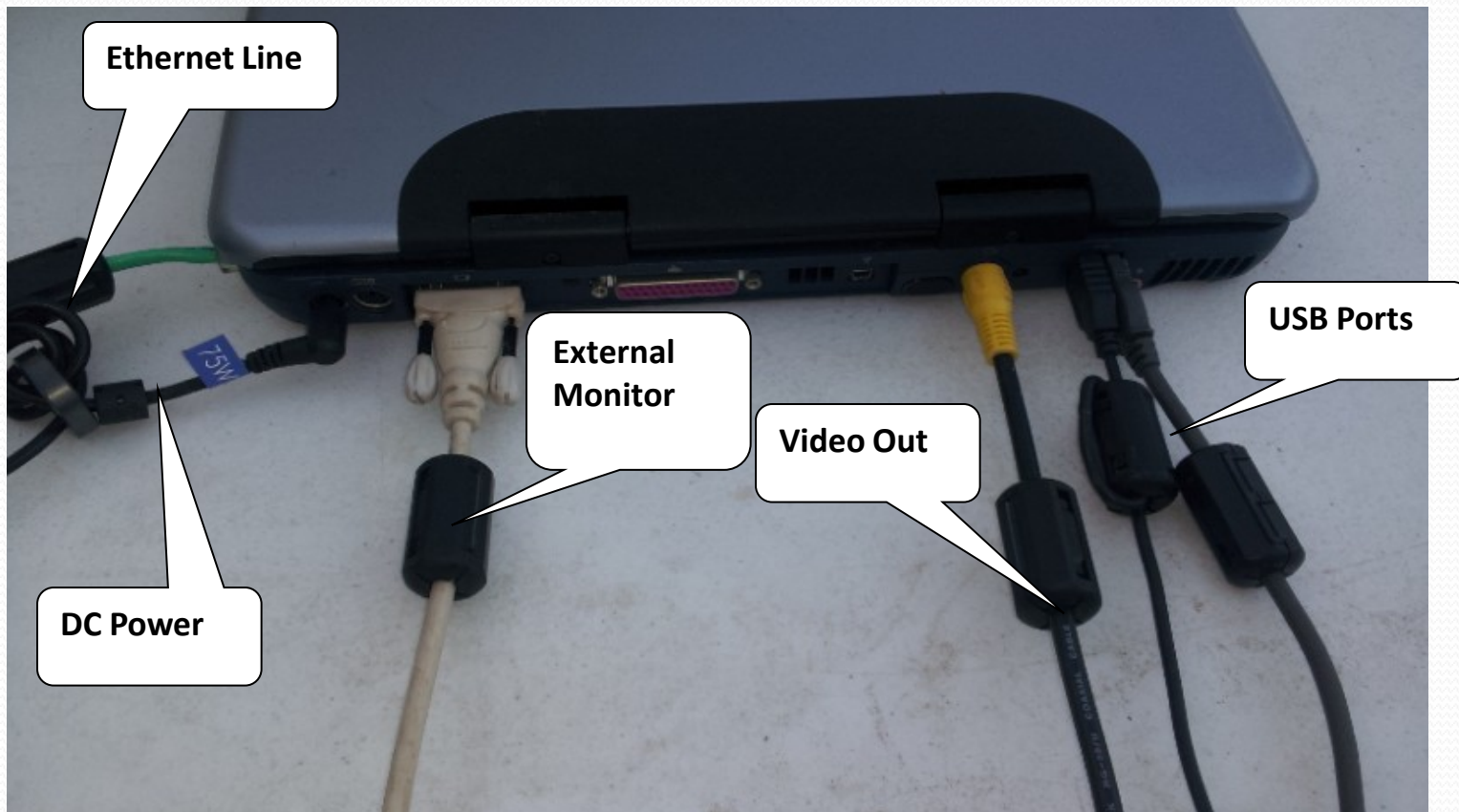


**GARAGE DOOR**

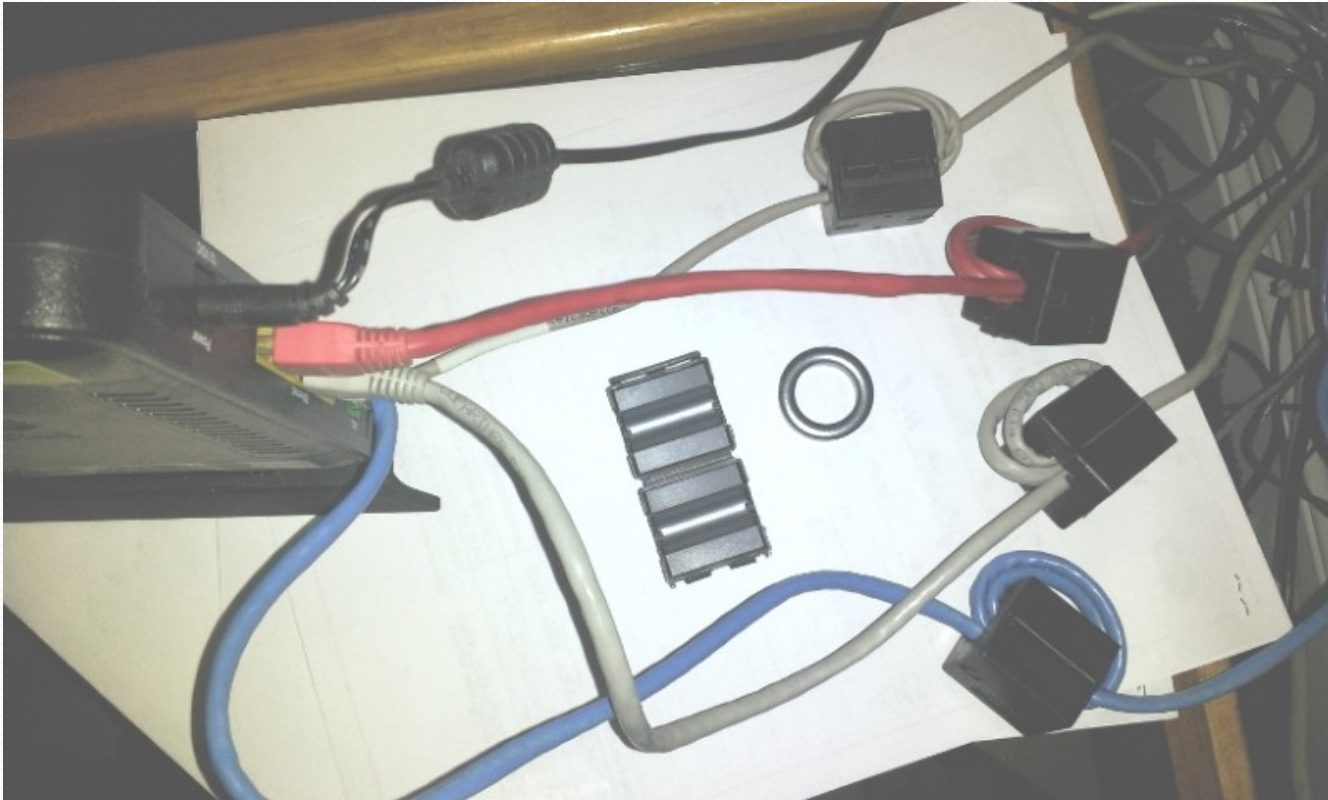


**TELEPHONE/DSL RFI**

# Laptop RFI Kit



# RFI Kits – Computer Devices



Palomar RFI-1A DSL Modem/Router RFI Kit



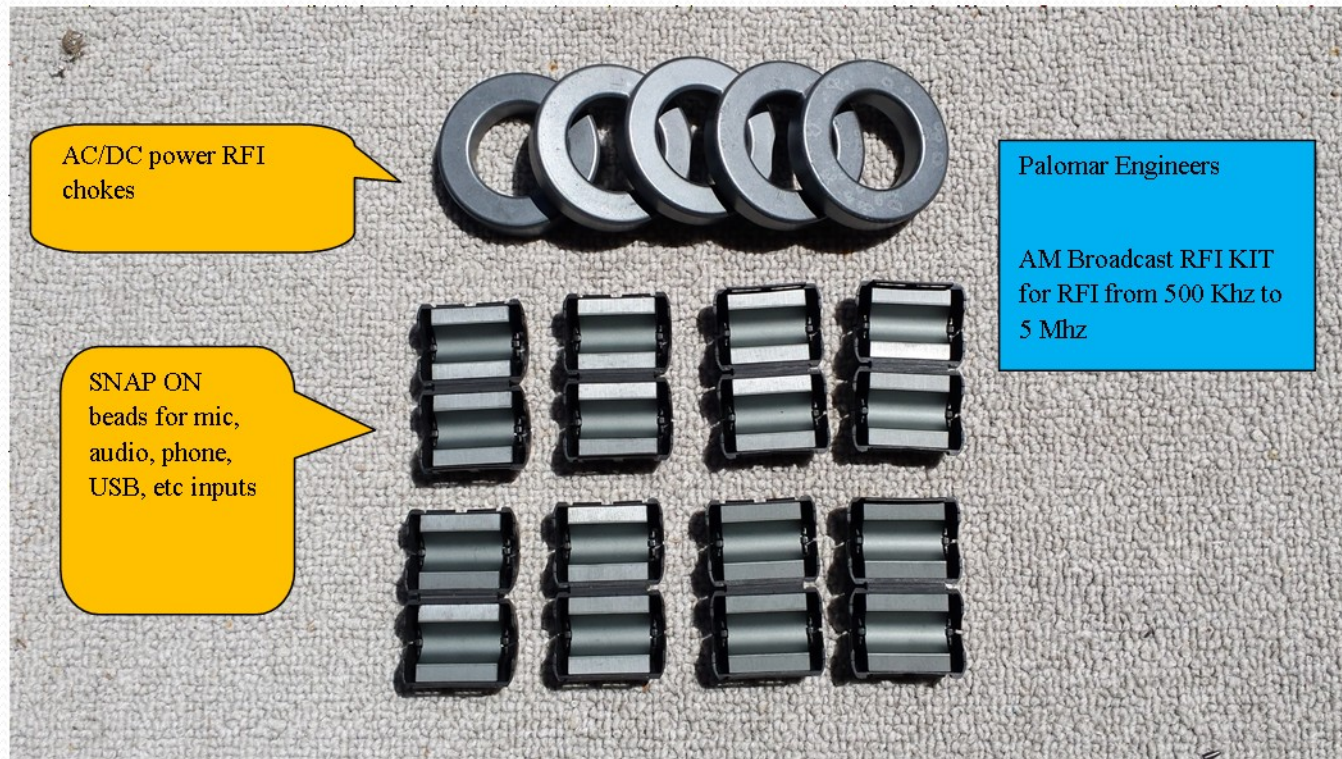
# RFI Kits – Home Theater



Palomar RFI-HTS Home Theater RFI Kit

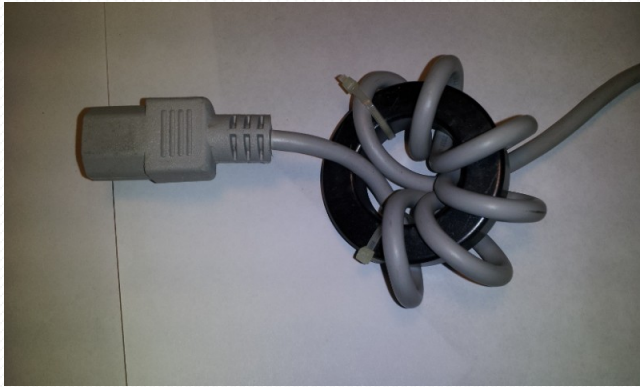


# RFI Kits – AM Broadcast



Palomar RFI-AM Broadcast RFI Kit

# AC Line Chokes



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



# RFI Kits – Garage Door Opener



Palomar RFI-GDO Garage Door Opener RFI Kit

# 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

# 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

## Prize Question #3

- Your 80 meter signal is coming through your neighbor's subwoofer every time you call CQ Contest – what should you do to solve this problem?



# Contact Info

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