Killing RF Noise for Field Day and CQP

Jim Brown, K9YC
The Fundamental Problem

• RF noise is generated inside equipment
• The wires inside equipment, and cables that interconnect equipment, are antennas, and can transmit that RF noise
• The same problems that let RF into the box also let it out of the box
  – Pin One Problems
  – Poor shielding and poor circuit layout
• Our antennas receive it like any other signal
General Strategy

• Don't bring problems with you – check out every piece of gear for RFI before you leave home

• Prepare for known common problems
  – Most generators are noisy
  – Switching power supplies for gear, battery chargers, wall warts
  – Noisy equipment
The Generator Filter

• Most of the noise is common mode, and power line filters don't work on RF common mode

• Power industry's definition of common mode is voltage between neutral and green

• The true definition of common mode is current flowing in the same direction on all conductors

• Common mode current radiates trash to our antennas
The Generator Filter

• Use the same cookbook guidelines for power line common mode chokes as for coax of the same diameter

• Make cable between choke and generator very short

• You can add a commercial line filter, but it is much less important than the choke
A Generator RF Noise Filter
Ferrite Choke More Important Than Line Filter Inside the Box

Very Short Cable to Generator
Sources of RF Noise

• Generators, including Hondas
• Switching Power Supplies, including Battery Chargers
• Equipment with digital circuitry
  – Computers, audio and video gear, ham gear
• Degraded Insulators in Power Systems
• Variable Speed Motors
What is Digital Noise?

- Most digital noise results from oscillators or clocks that produce square waves
- Square waves have lots of harmonics
- Faster rise times = stronger harmonics
Typical noise signature of a switching power supply
Why a Hump Instead of a Steady Carrier?

- Oscillators are *dithered* (modulated by random noise) to skirt FCC RFI rules.
- That noise causes them to wobble around in frequency or drift, and the modulation makes them broad.
- FCC rules limit the strength of carriers, so the noise modulation moves some of power from carrier to sidebands.
The same switching PSU drifting after being switched on
A closer look at one of the peaks
Same picture, a minute later
And another minute later
And another minute later
And another minute later
That’s the PSU for my SteppIR

- I’d already suppressed the noise by more than 20dB before I took these pictures!
- I’ve worked a lot of guys who don’t move my S-meter
- 10 dB of noise makes a 1kW signal seem like a 100W signal
- 20dB of noise makes 1kW seem like 1W
- You can’t work ‘em of you can’t hear ‘em!
- It’s really worth it to chase and kill RX noise
Finding Noise Sources

• Run your station on a battery and kill power to your home
  – Be sure to turn off any UPS units
• Listen on all bands
• Any noise that goes away is your noise
• Restore power, and turn off one breaker at a time until noise stops (or gets weaker)
Killing RF Noise

• **Noise must** be killed at the **source**
• So we **must** find the source
• Exception – use antenna location and directivity to **reduce** noise
  – Move antennas away from noise sources
  – Use serious chokes on your feedlines at the feedpoint (that is, up in the air)
When You Can't Attack the Source

• Use serious chokes on your feedlines at the feedpoint (that is, up in the air)

• Chokes prevent RF picked up on the feedline from filling in the nulls in your beam's pattern
  – Use antenna directivity to reject noise

• Follow guidelines in my Choke Cookbook

• Benefit typically 3-6 dB
Probing For Noise Sources

Ham talkie that receives HF

Low cost AM-FM- Short-wave receiver (this one has DSP IF, $45 at amazon)
Probing For Noise Sources

• Tune the portable receiver to the range where you hear RF noise
• Move antenna around suspected noisy equipment
  – For lower bands, antenna is a loopstick (in base of talkie)
  – For higher bands, it's the duck or rabbit ear of the Tecsun
CQP Sites Are Often Much Quieter

• S2-S3 is common at remote locations unless we screw it up with our own trash

• An S5 noise level at home may prevent your RX from hearing noisy equipment

• If your probe receivers hear trash, kill the trash or leave the noisy gear at home
Switching Power Supply Wall Warts

• Identifying a switcher
  – Much smaller and lighter for same power rating
  – Probe with the receiver
  – Most have hash below 3 MHz
  – Worst ones have noise extending to high HF bands
Is This Switcher a Problem?

• Set it up with the equipment it powers, turn that equipment on, with all cables attached

• Probe all cables (including both AC and low voltage power) with the RX

• If the cables are noisy, they are carrying RF current that can radiate to our antennas (it's normal for noise to vary along length of cable)
Noisy Switching Power Supplies

- Try to replace with a linear supply
- Most switchers are regulated
- Most linears are not regulated, just a transformer, rectifier, and filter cap
  - No load voltage will be 30-40% greater than rated voltage, will drop under load
  - Some gear may not turn on at higher voltage (internal protection circuit)
Finding Linear Power Supplies

- Your junk box (you don't save stuff?)
- Cheap ($ .25- .50) at second hand stores
  - Goodwill, Salvation Army, etc.
- Electronic Flea Markets
  - I see hundreds of them laying on the ground at DeAnza Swap
Replace a noisy switching power supply with a vintage linear supply
Replacing Switching Power Supplies

• Buy a bunch of Power Pole Connectors
• Cut cables of both supplies
• Put Power Poles on linear supplies, and on the plugs that fit the gear
• Make a Power Pole Y-cable so you can measure voltage under load
Buying Power Pole Stuff

- Powerwerx is cheapest by far if you buy individual housings and contacts
- They're easy to install
- I've never used a crimper for this stuff
Some Useful Power Accessories

$60

$18
RFI From Switching Power Supplies

- If you cannot replace one with a linear supply:
  - Wind turns of the DC cable through a ferrite core to form a choke
  and
  - Plug supplies into choked multi-outlet boxes or wind AC power cable through a toroid to form a choke
Plug Noisy Power Supplies and Gear Into Filtered Power Outlets
RFI From Digital Equipment

• Noise must be radiated for us to hear it

• What are the antennas?
  – Every interconnecting cable
  – The power cable

• With the portable RX, probe the gear, and along each cable

• If you hear lots of trash on a cable, it needs a choke
RFI From Digital Equipment

- Wind multiple turns of AC cable through a ferrite core to form a choke
- Wind every interconnect cable through a ferrite core to form a choke
This 4-turn choke is about right for 15-30 MHz
This 5-turn choke is about right for 10-30 MHz
An Effective Choke for 2-10 MHz

14 turns around a #31 core
$Z_N = N^2 \times Z_1$

#43 mix, 1-5 turns

HF Bands

Impedance (Ohms)

Frequency (MHz)
#43 mix, 1-14 turns

HF Bands

Impedance (Ohms)

Frequency (MHz)
#31 Mix is best for HF bands.
If you can’t easily remove the connector
Biggest Clamp-On, #31

Sometimes you can’t remove the connector.
Other Noisy Gear

- Video Monitors
  - Don't bring it if it's noisy – find one that isn't noisy
  - If you must use it, choke both video and power cables
  - Chokes can't kill trash radiated by internal wiring – if that's the problem, leave it at home!
Solar Systems Can Be Noisy

• Most charge regulators use pulse-width-modulated square waves
• Most DC to 120VAC converters are square wave generators that are filtered and shaped to approximate a sine wave
• Nearly all are very noisy unless the designer has worked on making them quiet – and, quiet ones are expensive
A Quiet Solar Charge Controller for Small Systems

- $ 17 at amazon
- Hysteresis regulator is a simple switch – no pulses
- Charges until battery hits 14.2V, starts charging when voltage drops below 13V
- Max panel open ckt 24V
- Thanks, AB6VU
RFI From Battery Chargers

• What are the antennas?
  – The AC power line
  – The DC cable, if there is one

• Treat it like any other switching power supply – replace it with a linear supply, or choke the antennas!
Ethernet Birdies

- Identifying Ethernet birdies
  - Crystal controlled, wide tolerance, modulated
  - Around 14,030 kHz, 21,052 kHz, low end of 10M CW, low end of 6M
  - Often multiple signals – we hear our neighbors too, each on a slightly different frequency
  - Kill power to your router to see if birdies go away, work on those carriers
  - Many other frequencies, but these will tell you if you have a problem and if you're fixing it
Killing Ethernet Birdies

- Wind each cable around a toroid
  - 6-8 turns usually about right
  - Don’t forget power supply cable
  - Choke both ends of cables > 0.2\(\lambda\)

- Use shortest cables practical
  - Longer cable is better antenna

- There is no fix for trash radiated from a badly shielded box
  - Leave those boxes at home
Try Wireless Networking

• The short cable to internet modem, and a poorly shielded box are only causes of RFI
  – No QRM from our rigs to wireless
  – Modern WiFi good for 200 ft or more

• The downside of wireless networking
  – Configuration conflicts between wireless routers and an ad hoc collection of computers are all too common, and can be very difficult to solve
The Biggest Myths

Myth: “I need a better ground”
Fact: A connection to earth almost never reduces noise or RFI, and it will often make it worse, because the “ground wire” can act as an antenna.

Fact: A connection to earth is very important for lightning protection.