

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**

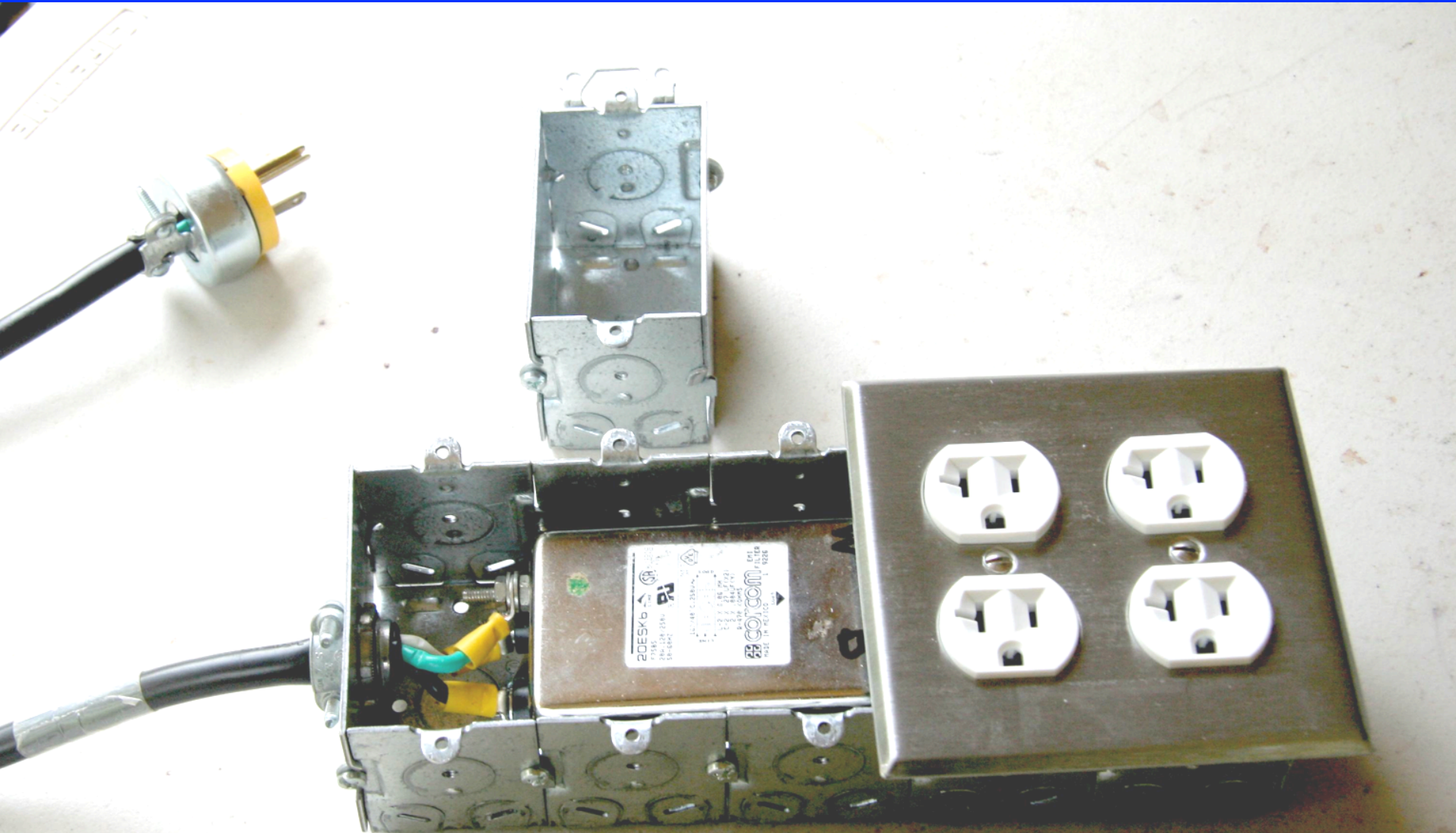
The Generator Filter

- **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**

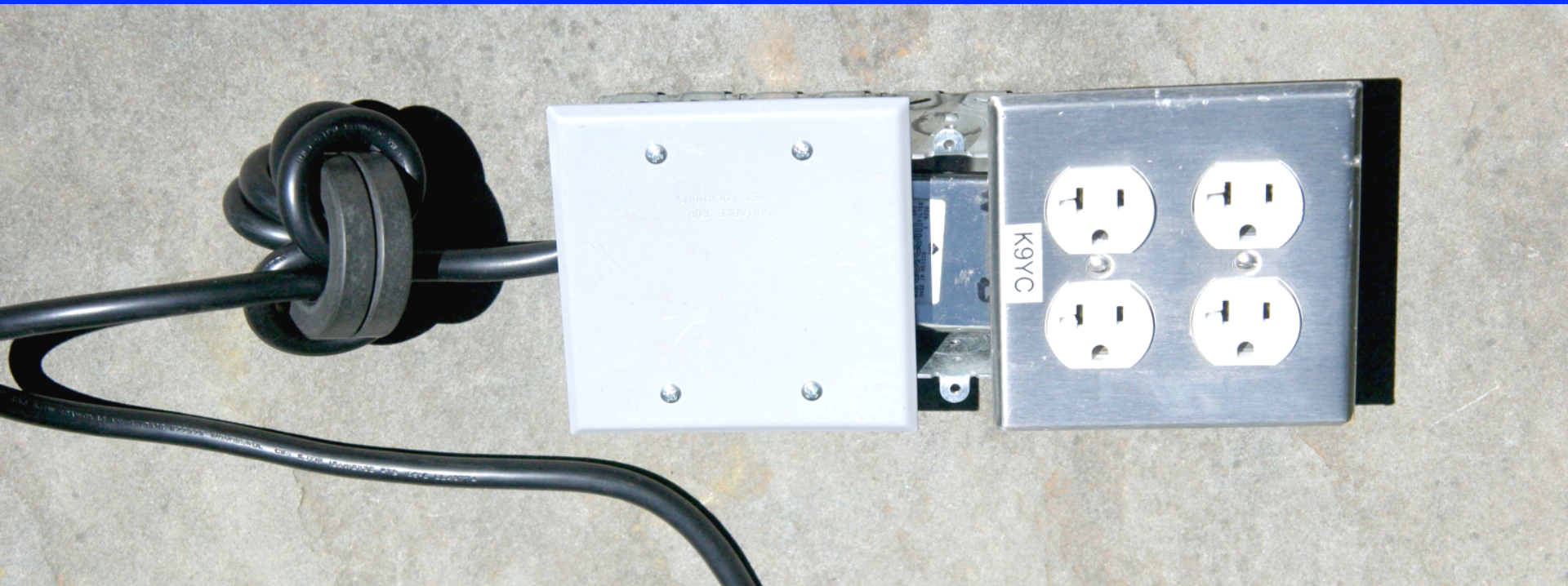
The Generator Filter

- **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

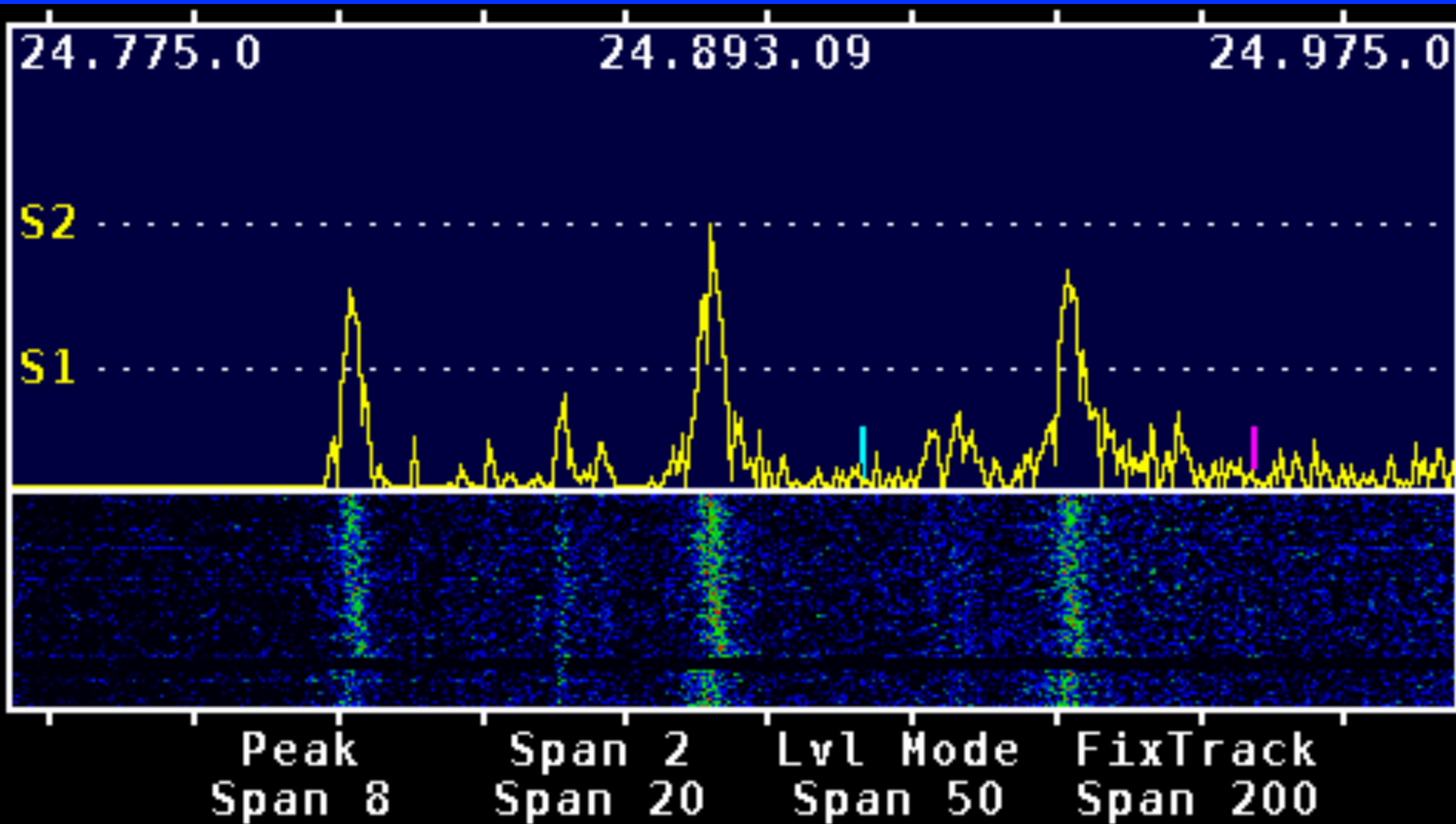
Sources of RF Noise

- **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**

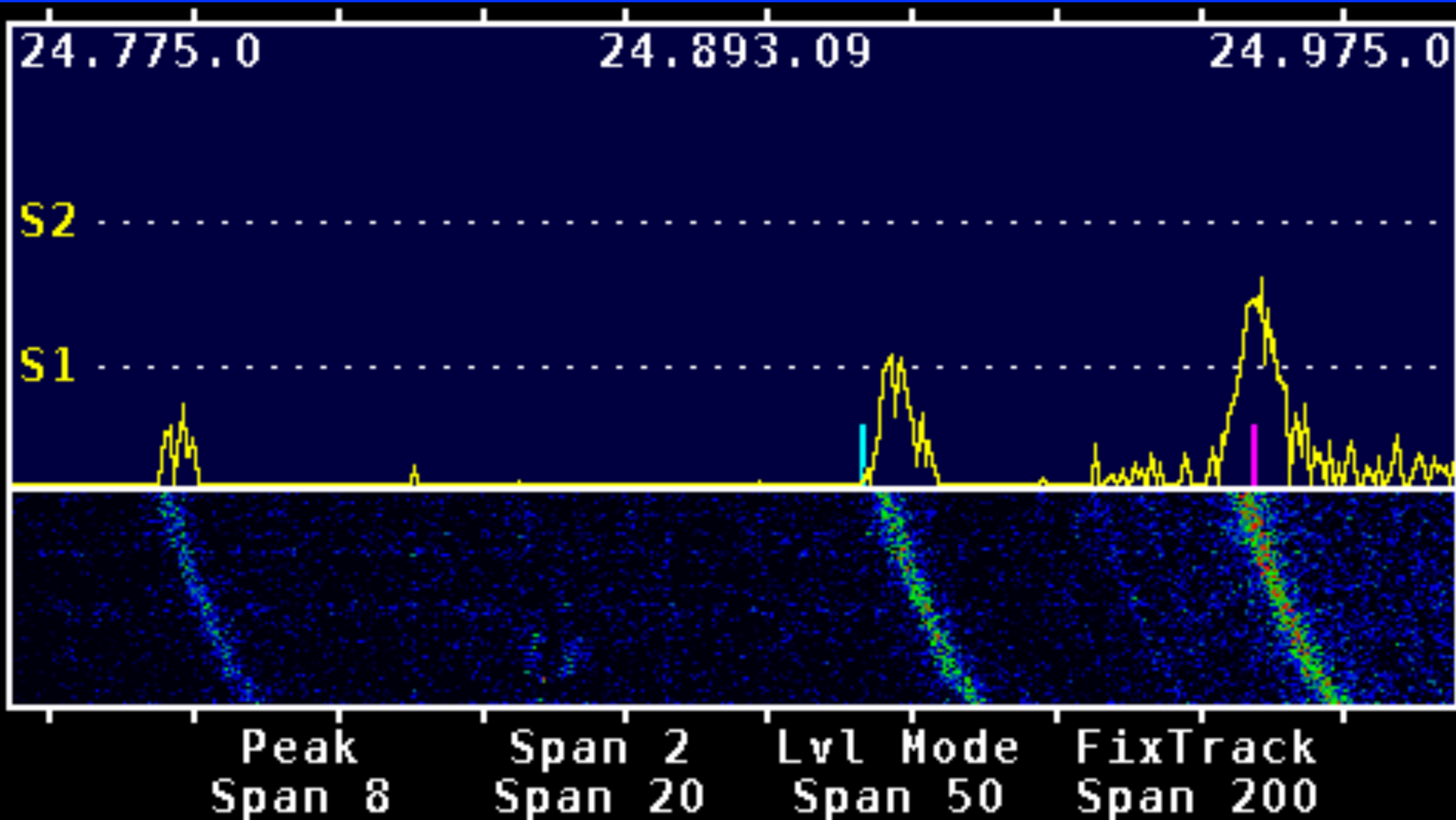
Typical noise signature of a switching power supply



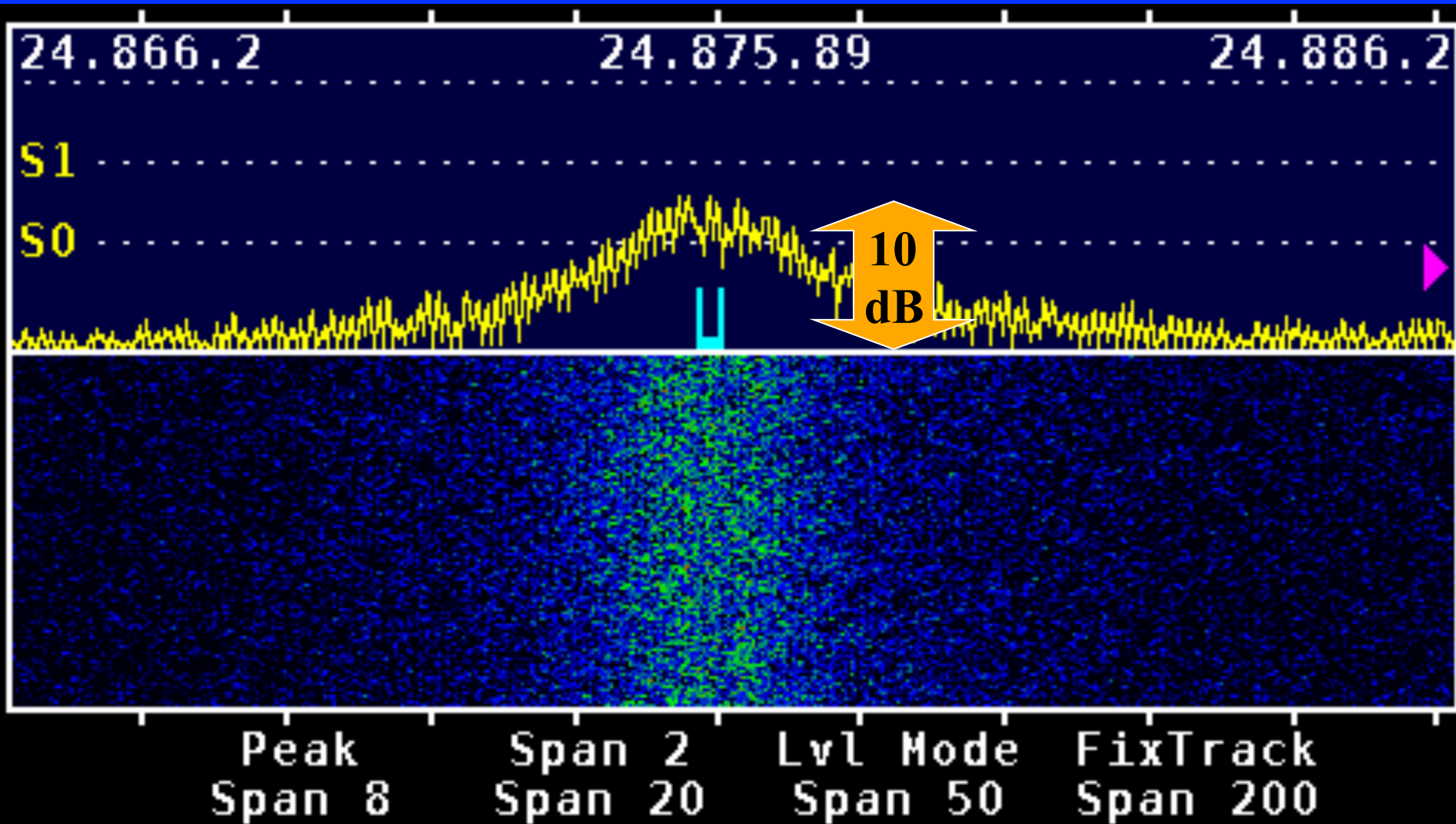
Why a Hump Instead of a Steady Carrier?

- 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

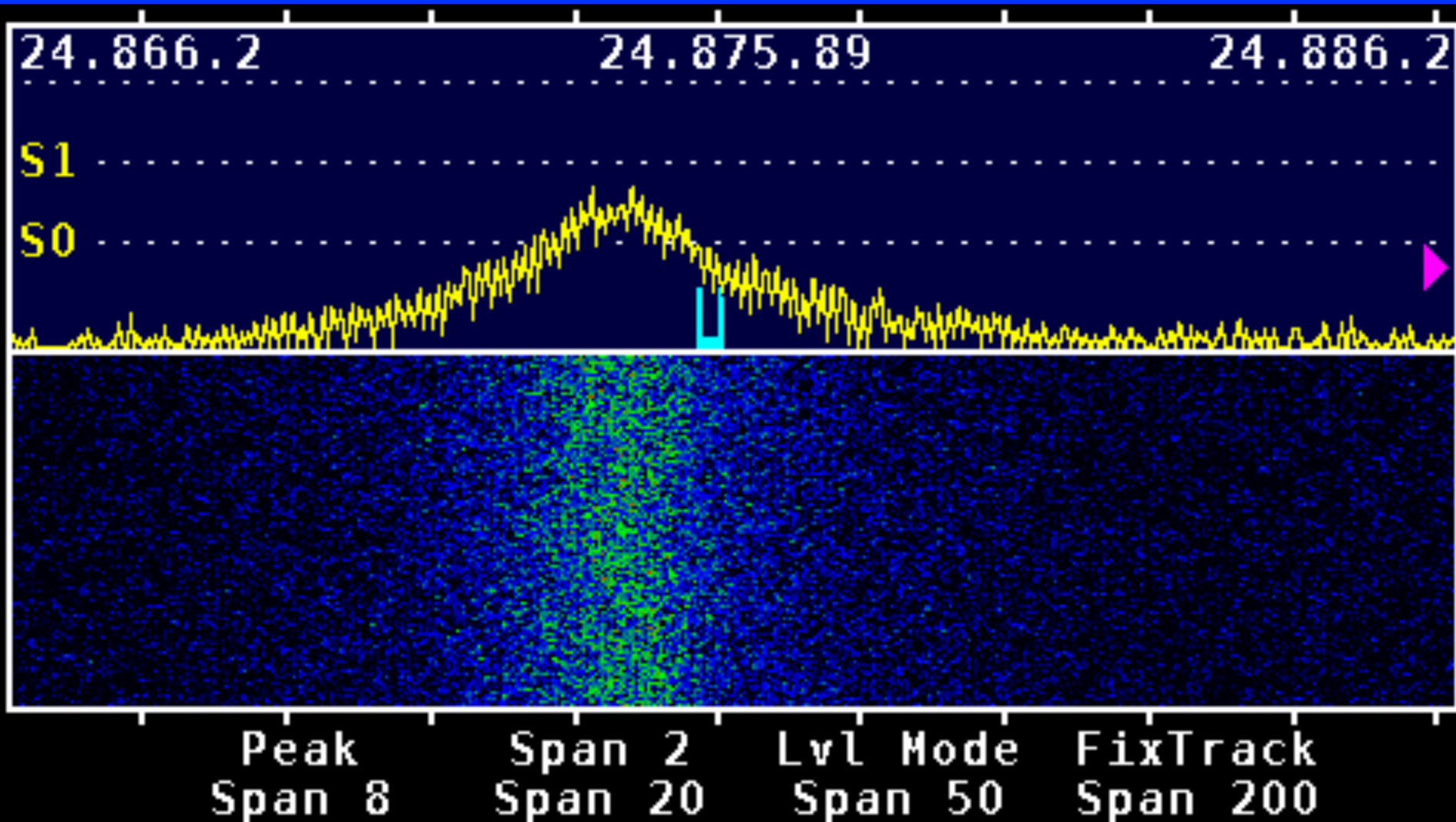
The same switching PSU drifting after being switched on



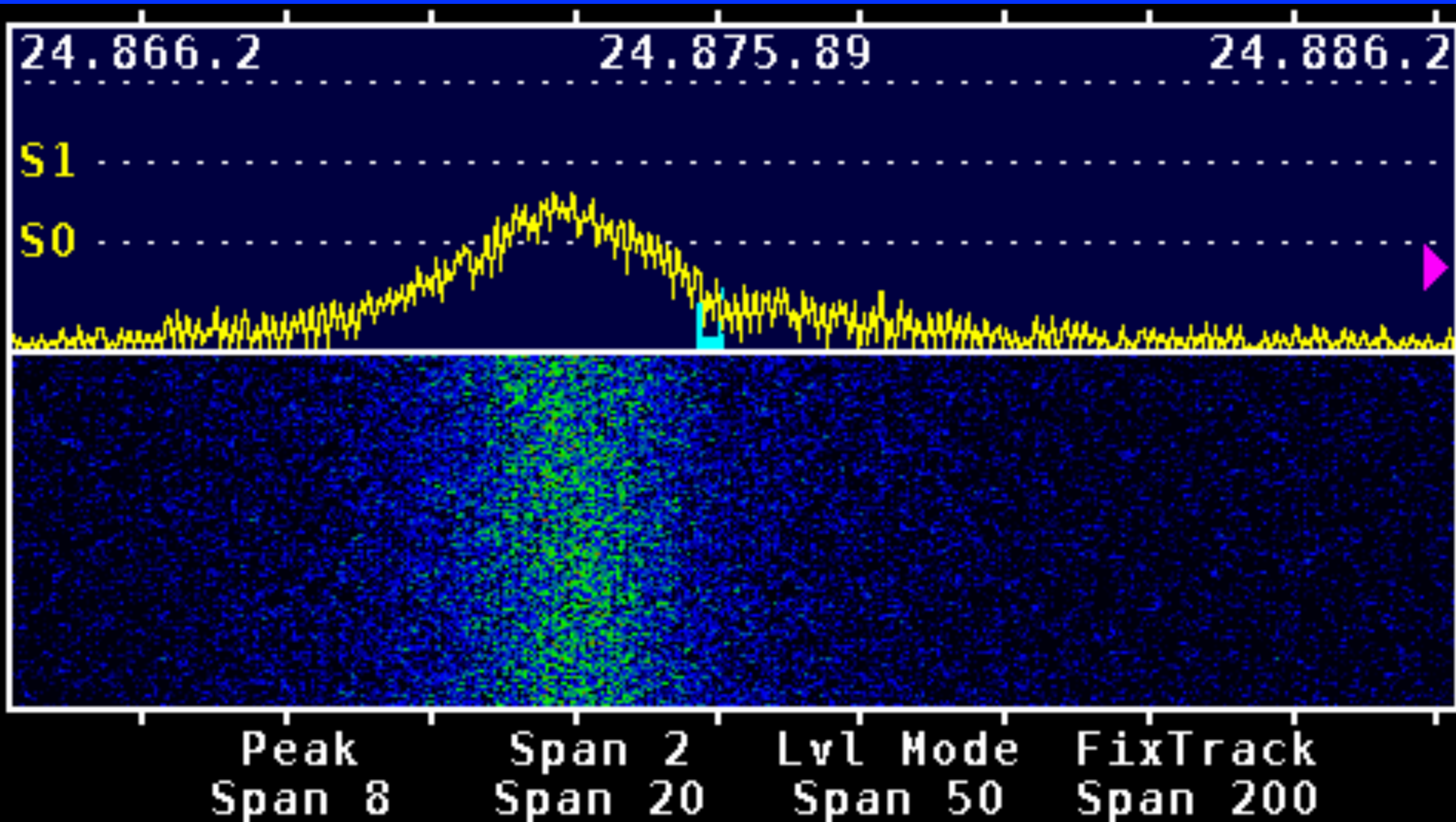
A closer look at one of the peaks



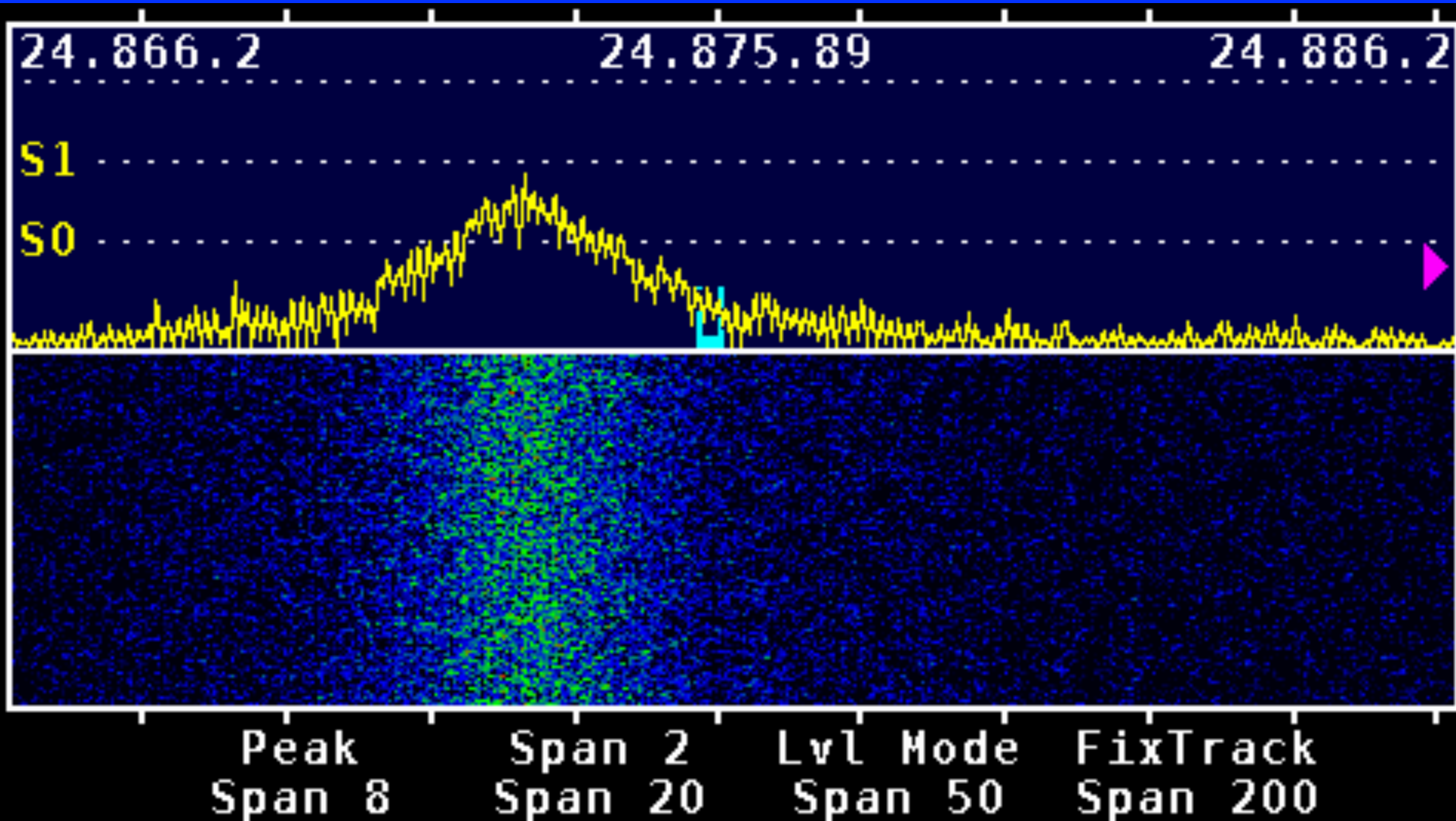
And another minute later



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 if 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**
 - **<http://k9yc.com/RFI-Ham.pdf>**
- **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**

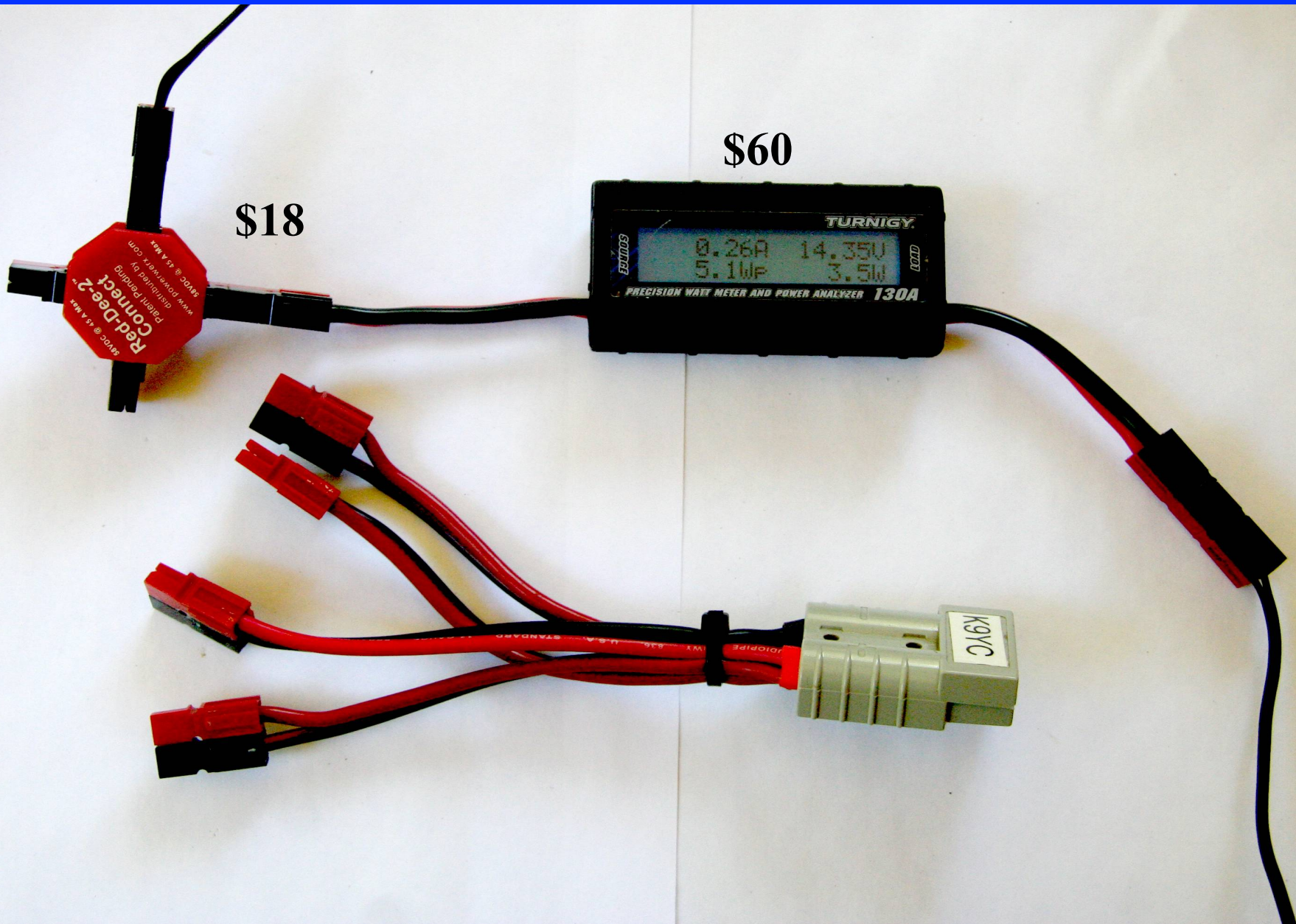
Buying Power Pole Stuff

Individual Housings, Contacts & Parts



- 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



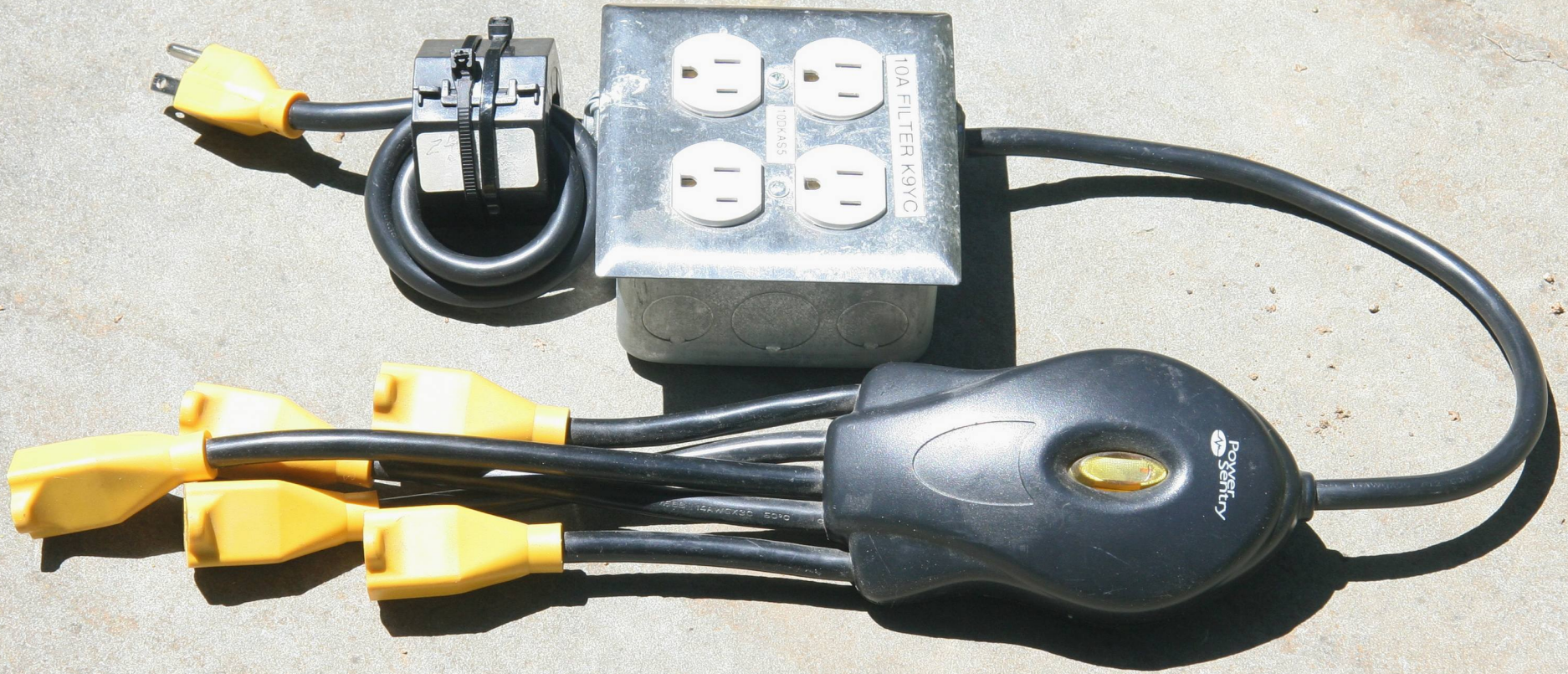
\$18

\$60

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**

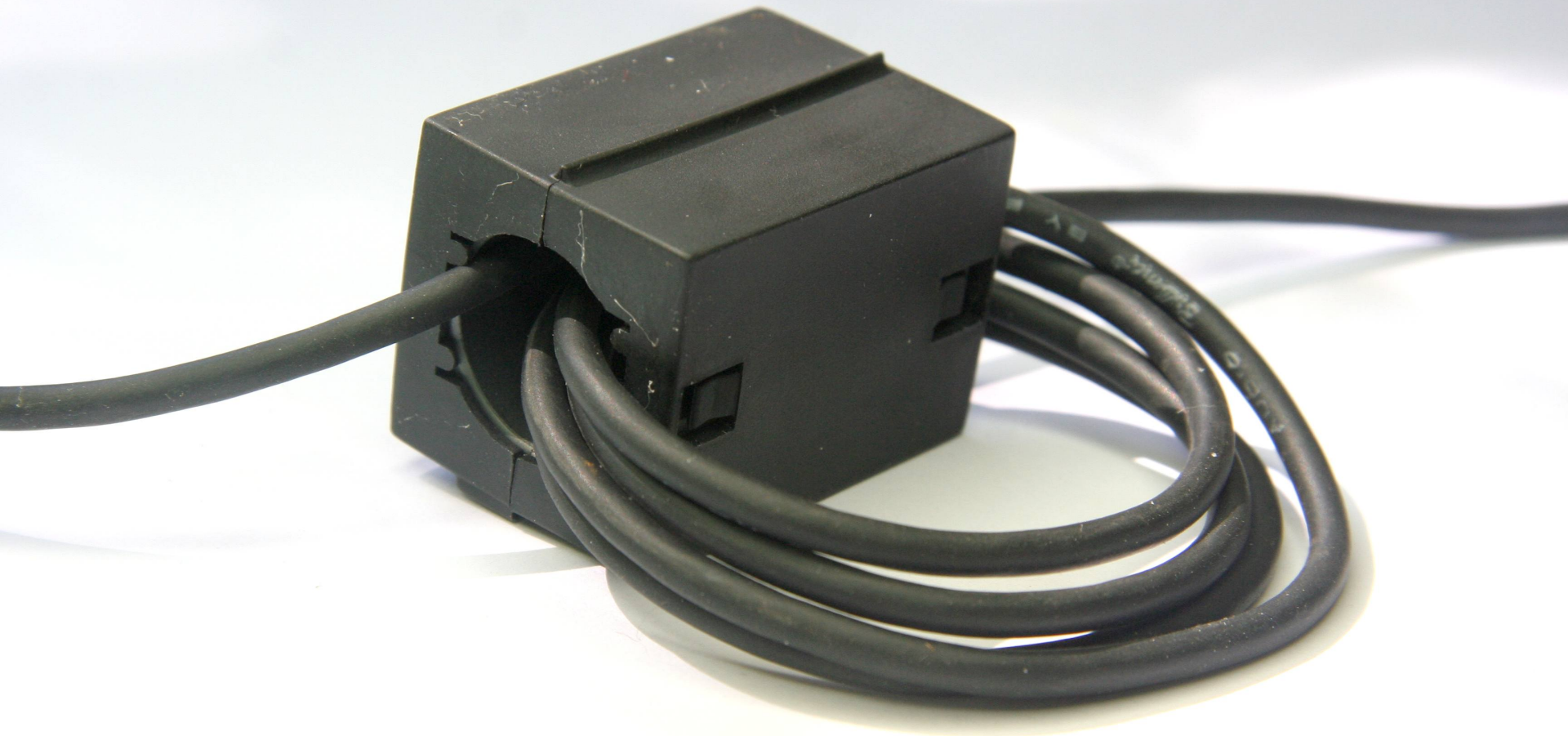
RFI From Digital Equipment

- **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**

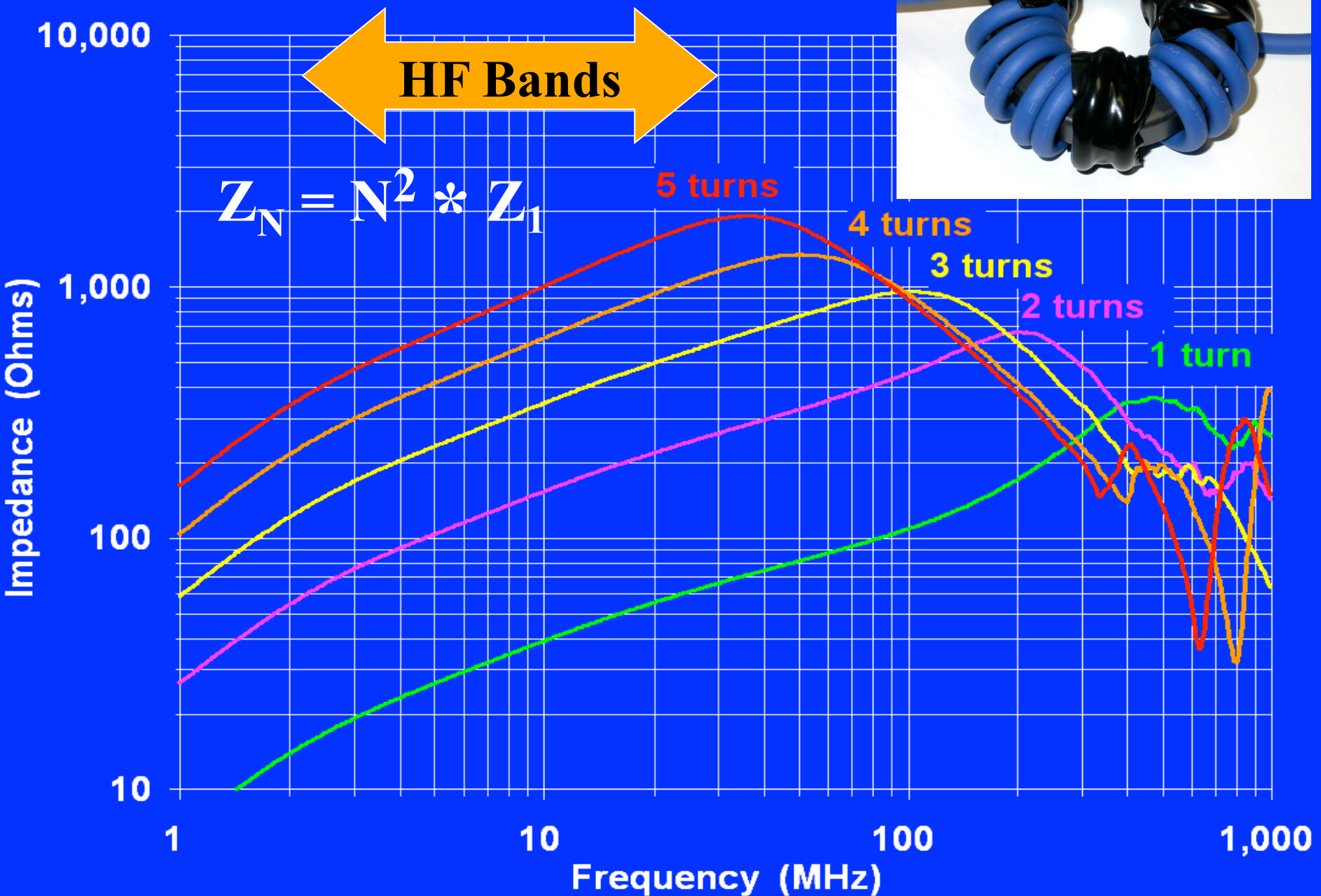


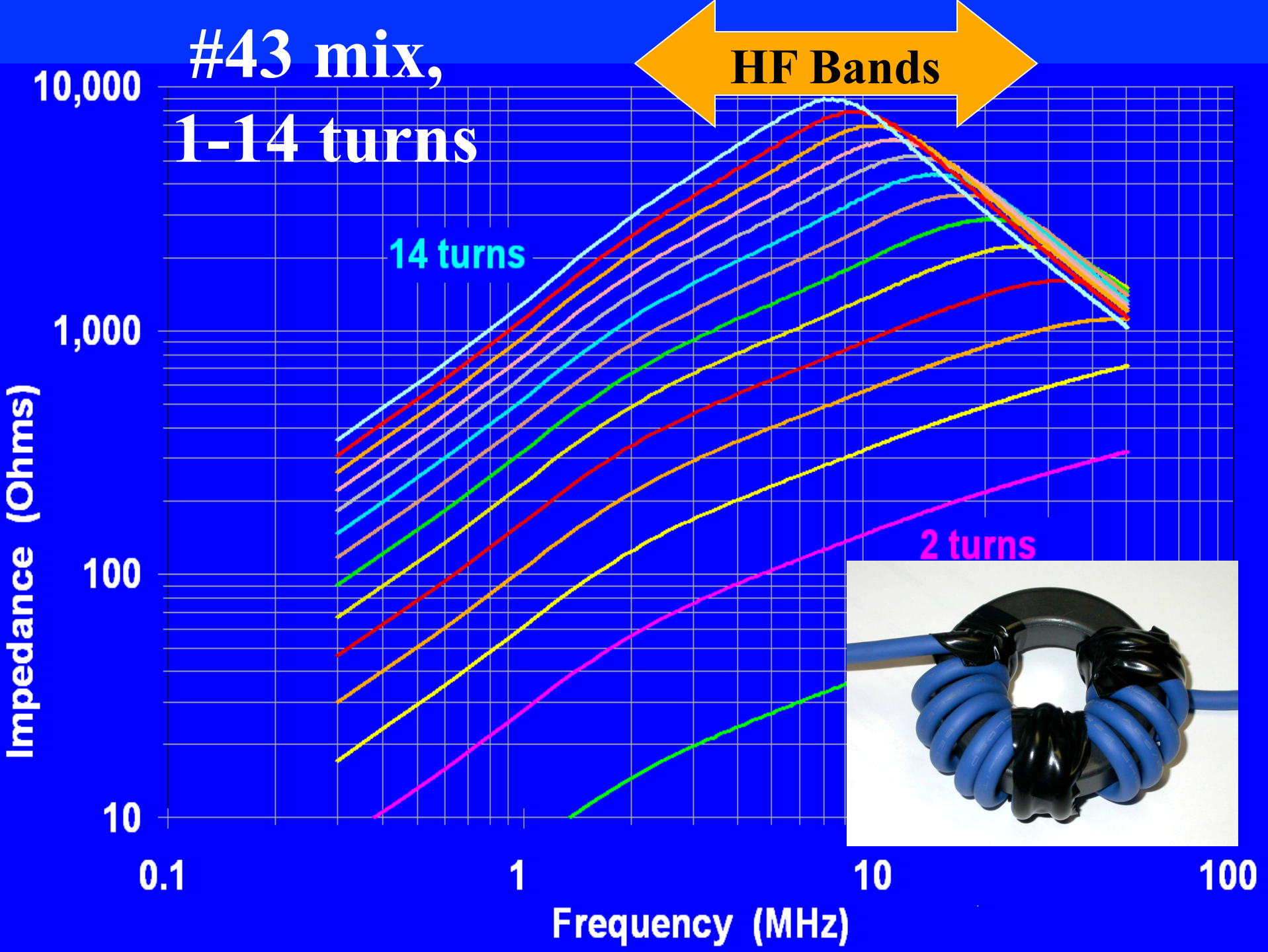
An Effective Choke for 2-10 MHz



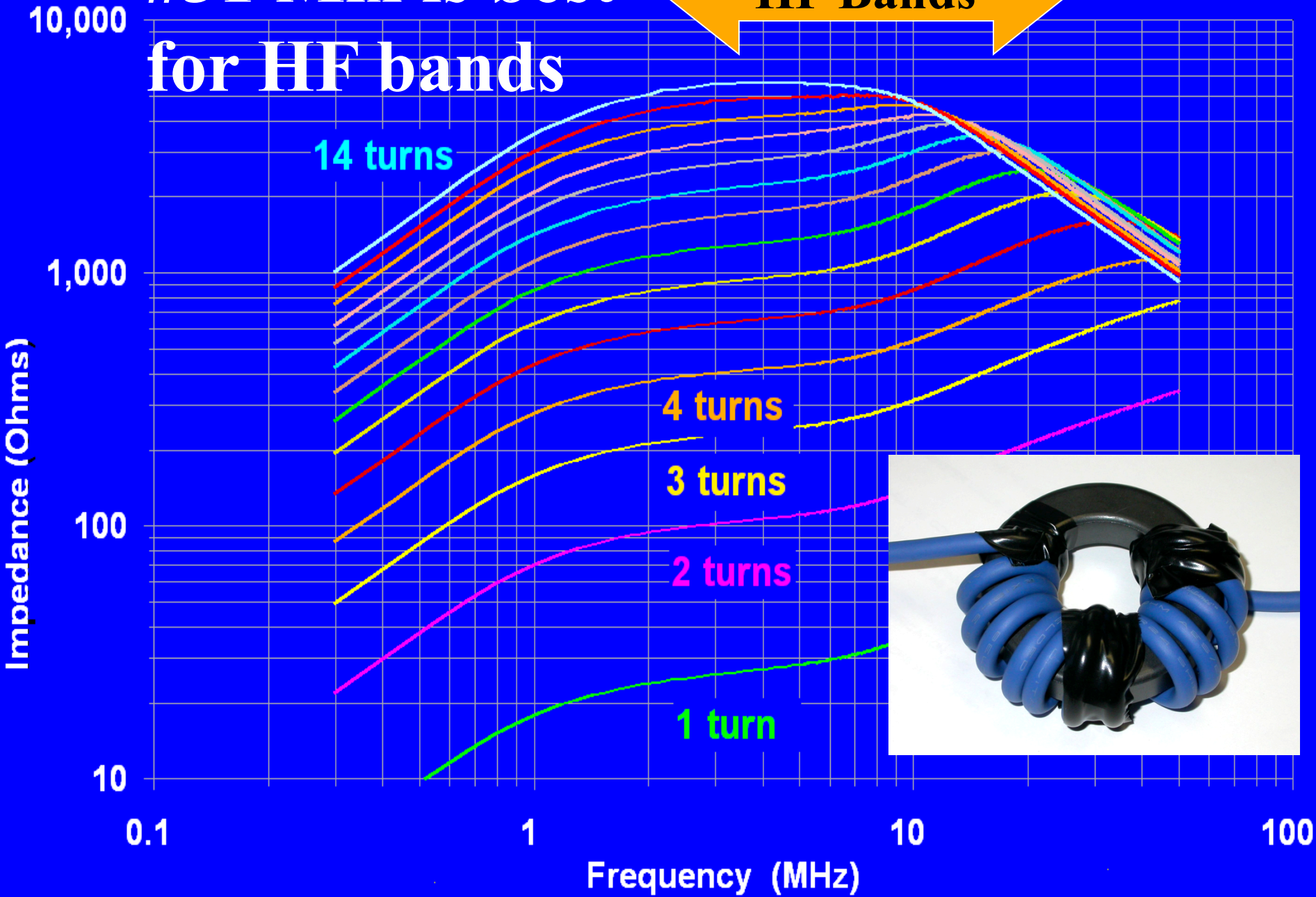
14 turns around a #31 core

#43 mix, 1-5 turns





#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.