

RFI / EMI **and** **Amateur Radio**

Steve Frakes KAØSF

What it is.
How to locate the source.
How to identify the source.

Definition of RFI / EMI

- Radio Frequency Interference (RFI) refers to disruptive electromagnetic signals that interfere with the signal integrity and functionality of electronic devices. These signals can originate from various sources and affect a broad range of devices, from radios and televisions to computer networks and communication systems.
- Imagine settling down to enjoy your favorite television show, but suddenly, the picture becomes distorted, and the sound becomes unclear. Chances are you are experiencing RFI. It can manifest as buzzing, static, or distorted signals, leading to a degraded user experience.

Possible Sources

- RFI can be caused by a multitude of sources. Here are some common culprits:
- **Power Lines**: Overhead power lines can emit electromagnetic radiation which interferes with nearby electronic devices.
- **Equipment Malfunctions**: Faulty or poorly-designed electronic equipment can generate unwanted signals that disrupt other devices.
- **Wireless Devices**: Wi-Fi routers, cordless phones, and other wireless devices operate within specific frequency ranges. If one device operates on a frequency too close to another, interference can occur.
- **Lightning**: Thunderstorms can produce strong electromagnetic fields, causing temporary disruptions to electronic devices.

Bottom Line... ANYTHING that

- Generates electricity.
- Conducts electricity.
- Converts electricity.
- Uses electricity.
- Uses a microprocessor.

NUMBER ONE RULE of an RFI / EMI HUNT!

- **NEVER, EVER, EVER...**
- Have a pre-conceived notion of the **SOURCE** of your noise or interference!
- Let your equipment **LEAD** you to **WHERE** the noise **IS**.
- From THAT location, find the **SOURCE**.

NUMBER ONE RULE of an RFI / EMI HUNT!

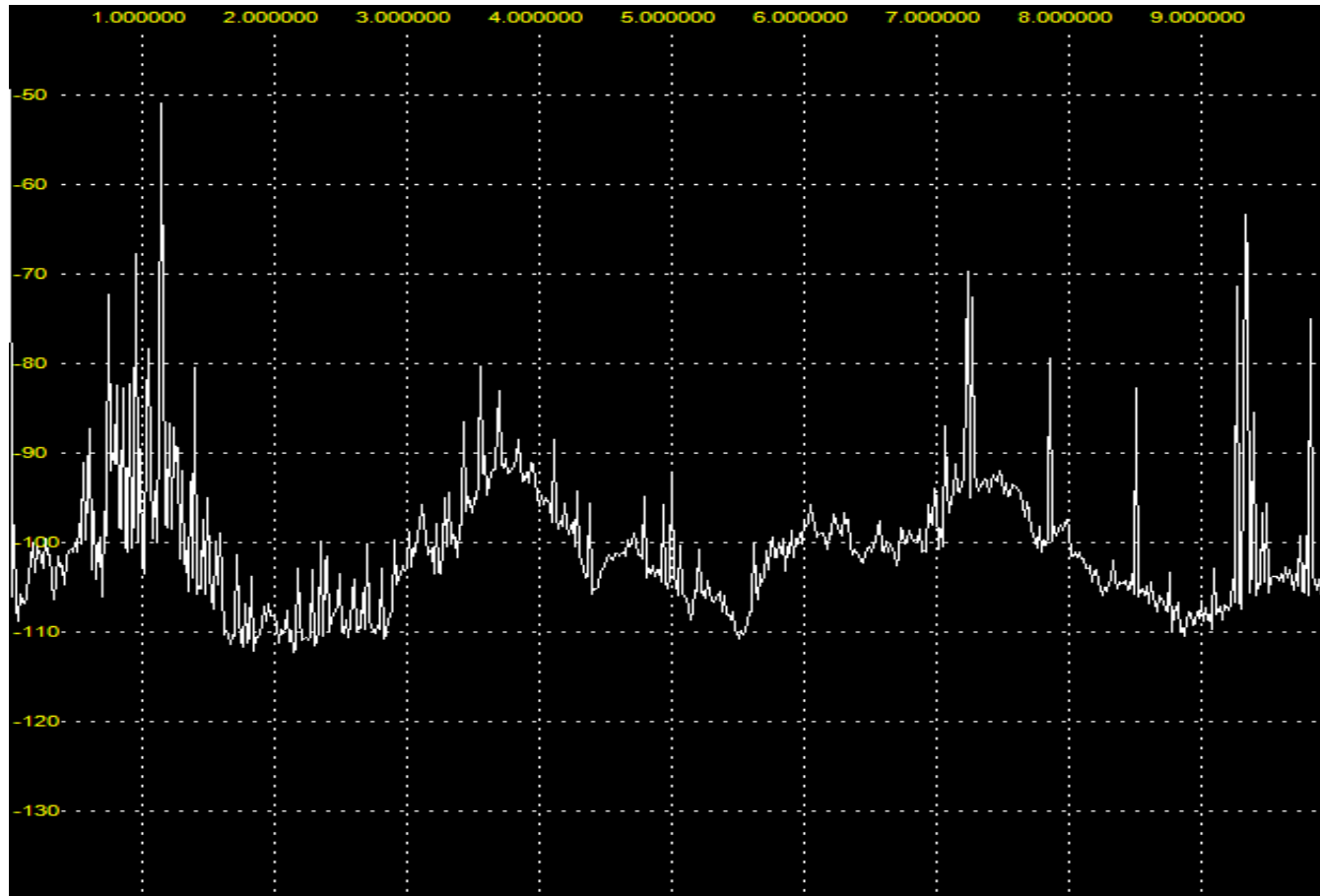
- Is there only **ONE SOURCE** of Interference?

- If you have a pre-conceived notion of the **SOURCE** of your noise or interference, you are likely to miss **ANOTHER SOURCE** and greatly lengthen the time to eliminate your problem.
- Many times, the source is a combination of signals (intermod).

Prime Candidates

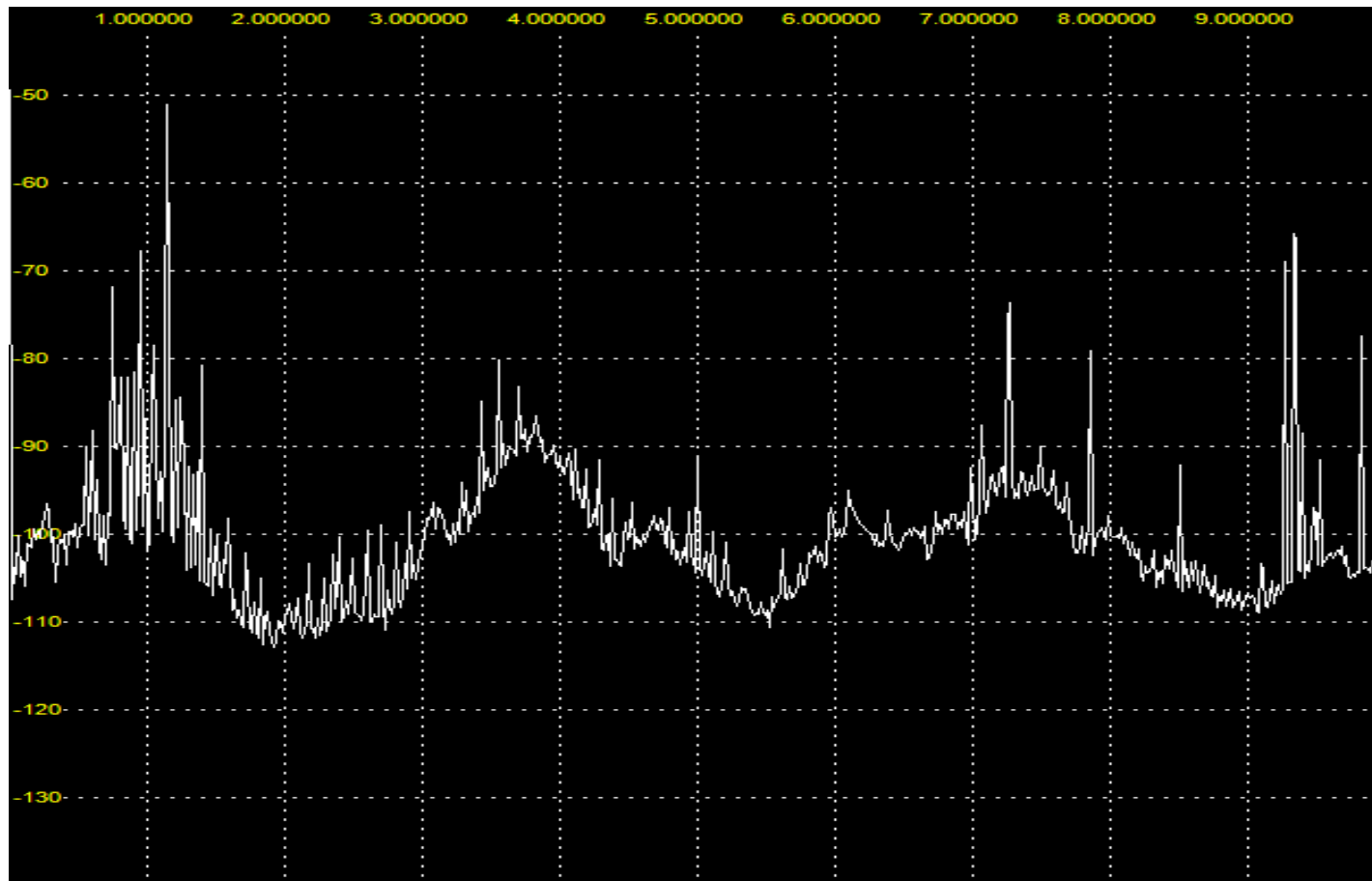
- **Switch Mode Power Supplies (SMPS) How many are in your station?**
- **•AKA “Wall Warts” Prevalent offenders these days**
- **•SMPS includes any charger for: cell phone, tablet, computer, battery, power tools**
- **•Plasma TV, LED TV, CRT TV, computers and monitors**
- **•Appliances such as high-tech washers and dryers, refrigerators**
- **•Any lights other than filament bulbs is suspect**
- **•LED bulbs (especially cheap ones), Compact Fluorescent Lamps**
- **•Fluorescent tubes, especially with new electronic ballast**
- **•Beware of Ballasts at DIY retailers: Residential versus Industrial (ARRL)**
- **•Grow lights (an emerging threat)**
- **•Sub-woofer internals with mode power supply (SMPS)**

What / Where is it?



* KAØSF 2023

What / Where is it?

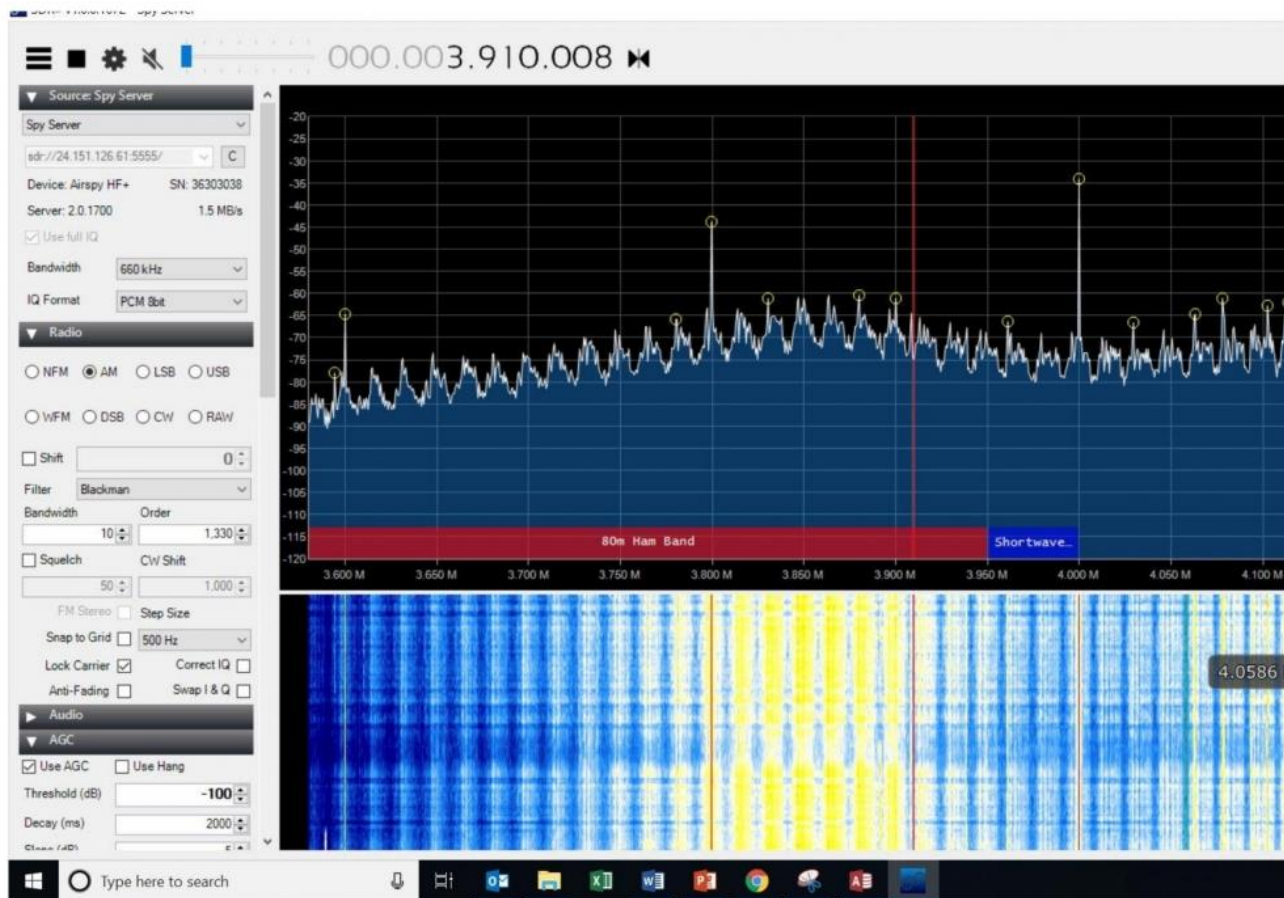


* KAØSF 2023

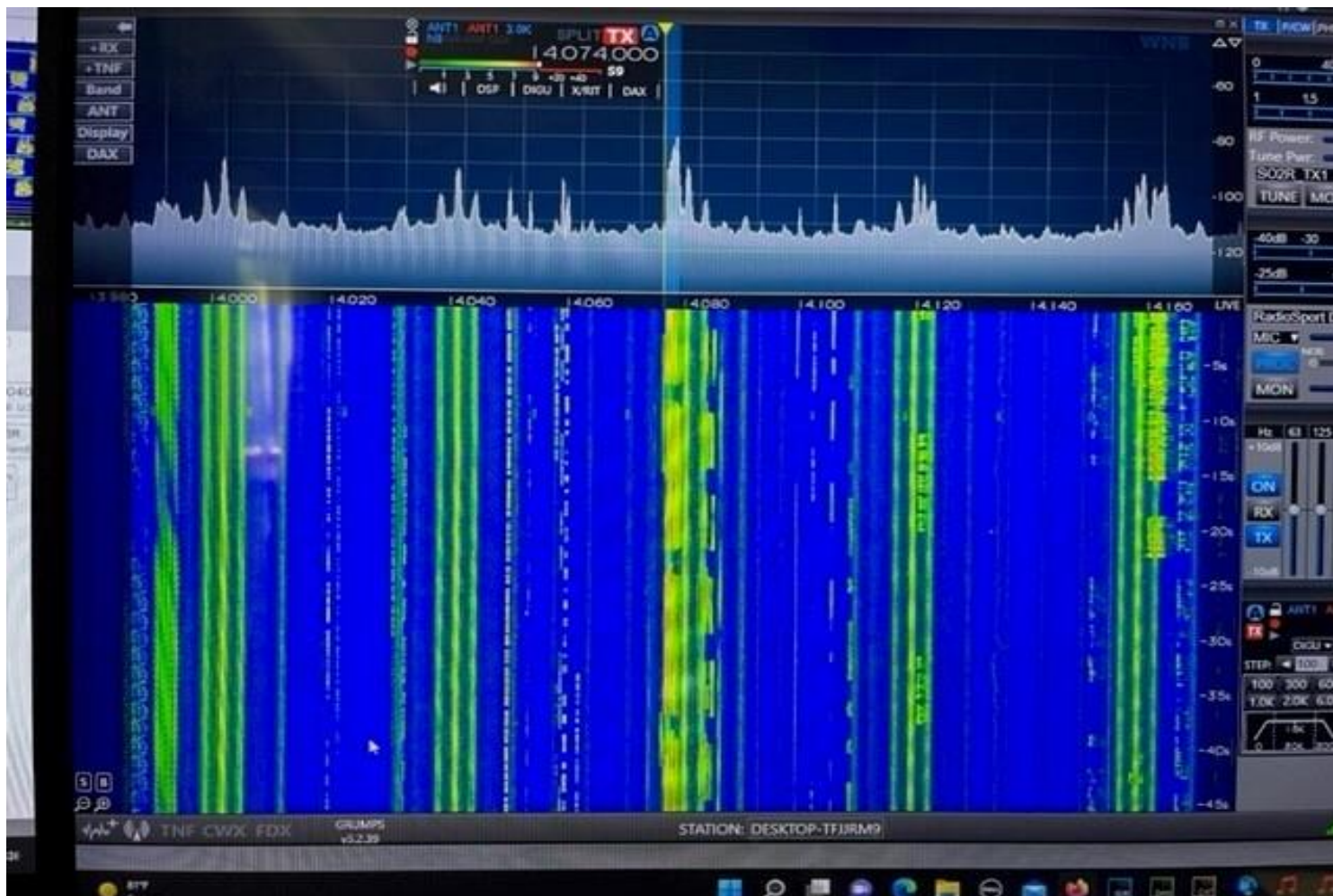
The Beginning!



Solar System Interference



Solar System Interference



Solar System Interference



Solar System Interference

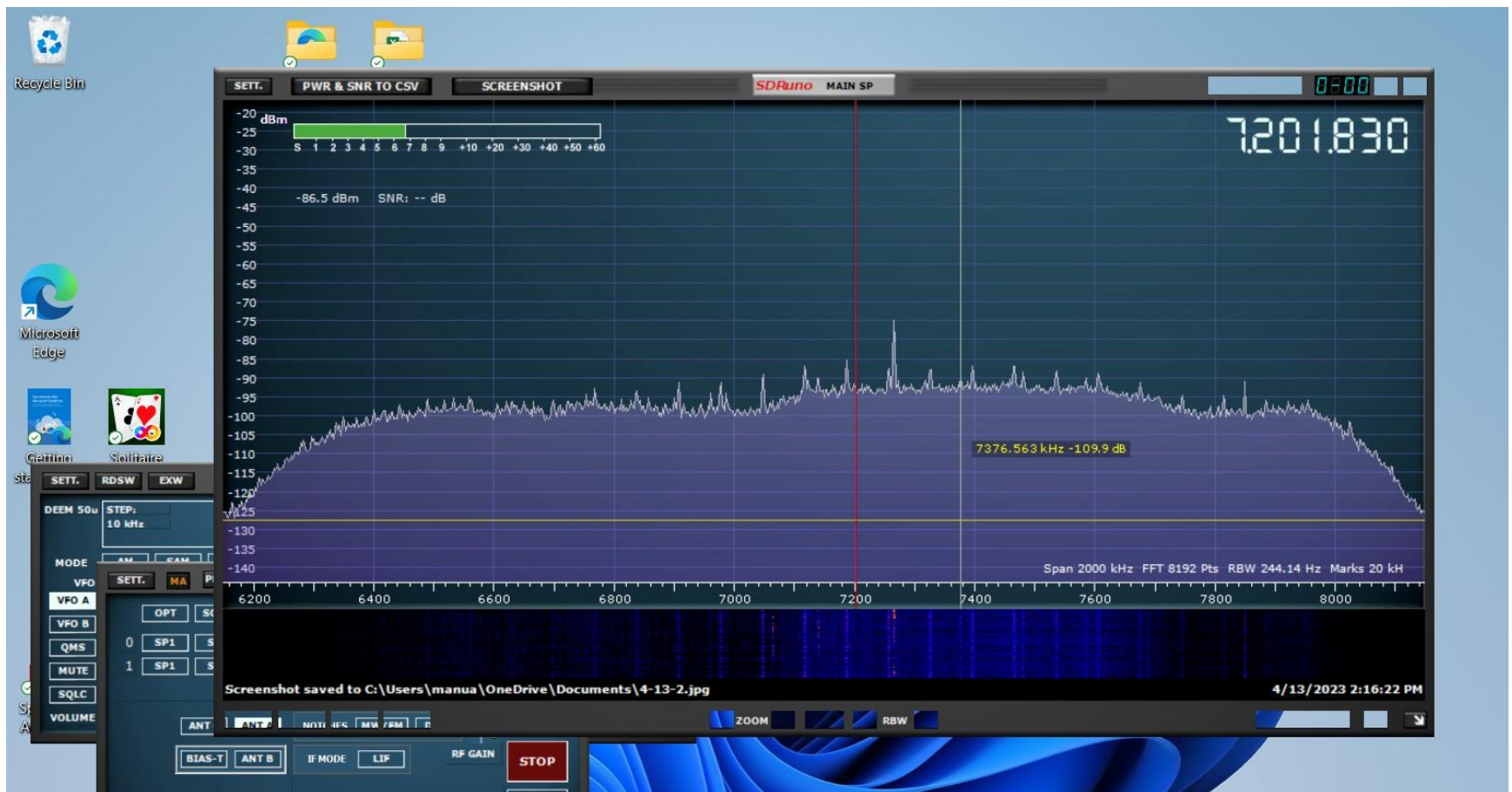


Solar System Interference

•**RFI from inverters.** These devices are responsible for switching the high voltage dc from the array to 60 Hz phase-synchronous ac, meaning ac power in-phase with the utility ac waveform. One or more inverters may be incorporated in a given array, depending on its size. Typically, RFI from these devices is radiated by the dc wiring to the PV panels with an 18 kHz to 60 kHz fundamental switching frequency. Harmonics can extend well into the HF bands and lower VHF bands.

RFI from power optimizers. Power optimizers might be installed at every PV panel, or there may be a single power optimizer for several PV panels, depending on the component manufacturer and system size. Under full sunlight, power optimizers can have fundamental operating frequencies ranging from 39 kHz to 200 kHz. As with inverters, there may be harmonics extending through HF and into the lower VHF bands. It should also be noted that when power optimizers are in the “off” or non-power generating mode, the PV array is disconnected from the ac wiring but may still generate RFI as there is still some part of the device powered by the sunlight. RFI may be reduced significantly but it can still be noticeable.

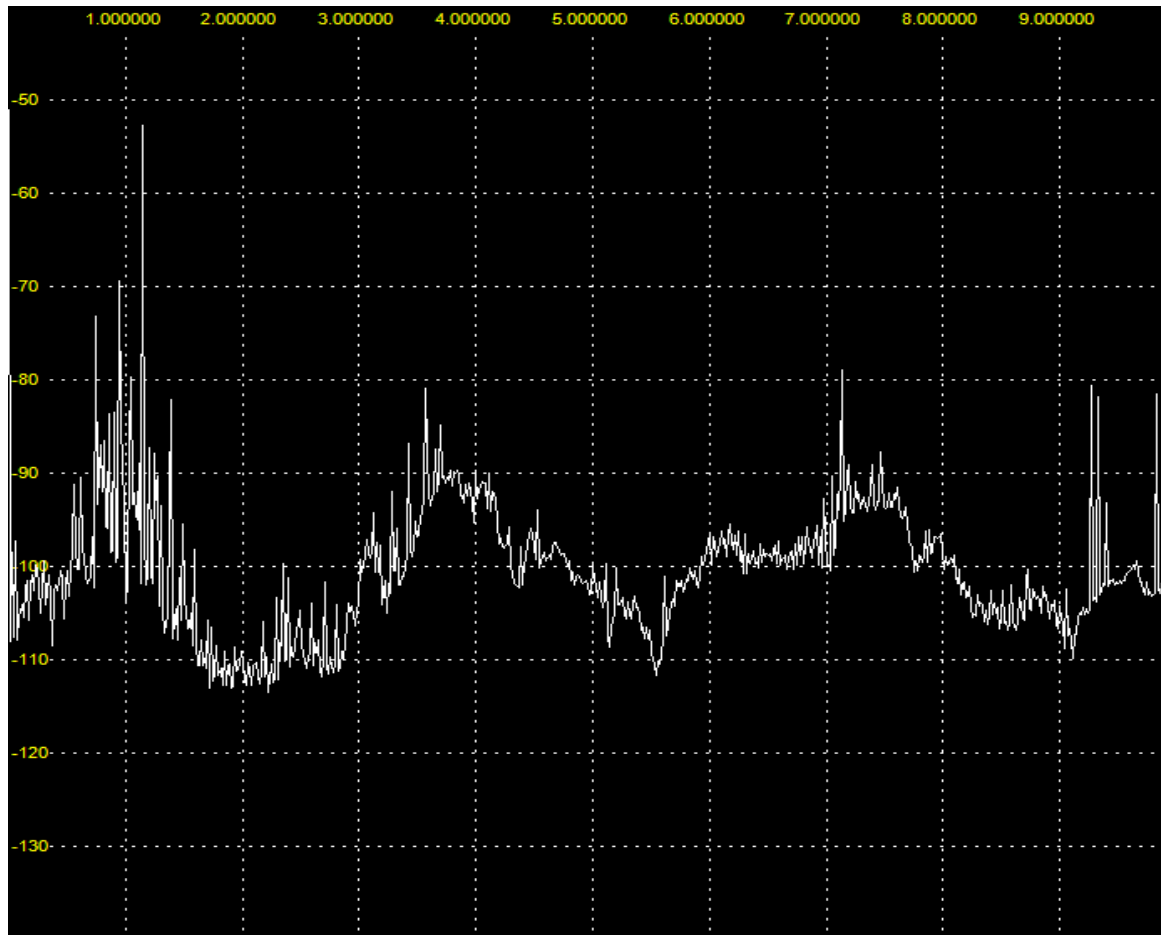
The beginning!



The Plot Thickens

- My sdr PlayDX has the ability to run in Spectrum Analyzer Mode via software.
- While not a laboratory measurement device, it DOES give you a rough visualization of what the spectrum looks like at your location with frequency defined representation.

The Plot Thickens!!



SDRPlay Device

\$214.95 @ Ham Radio Outlet



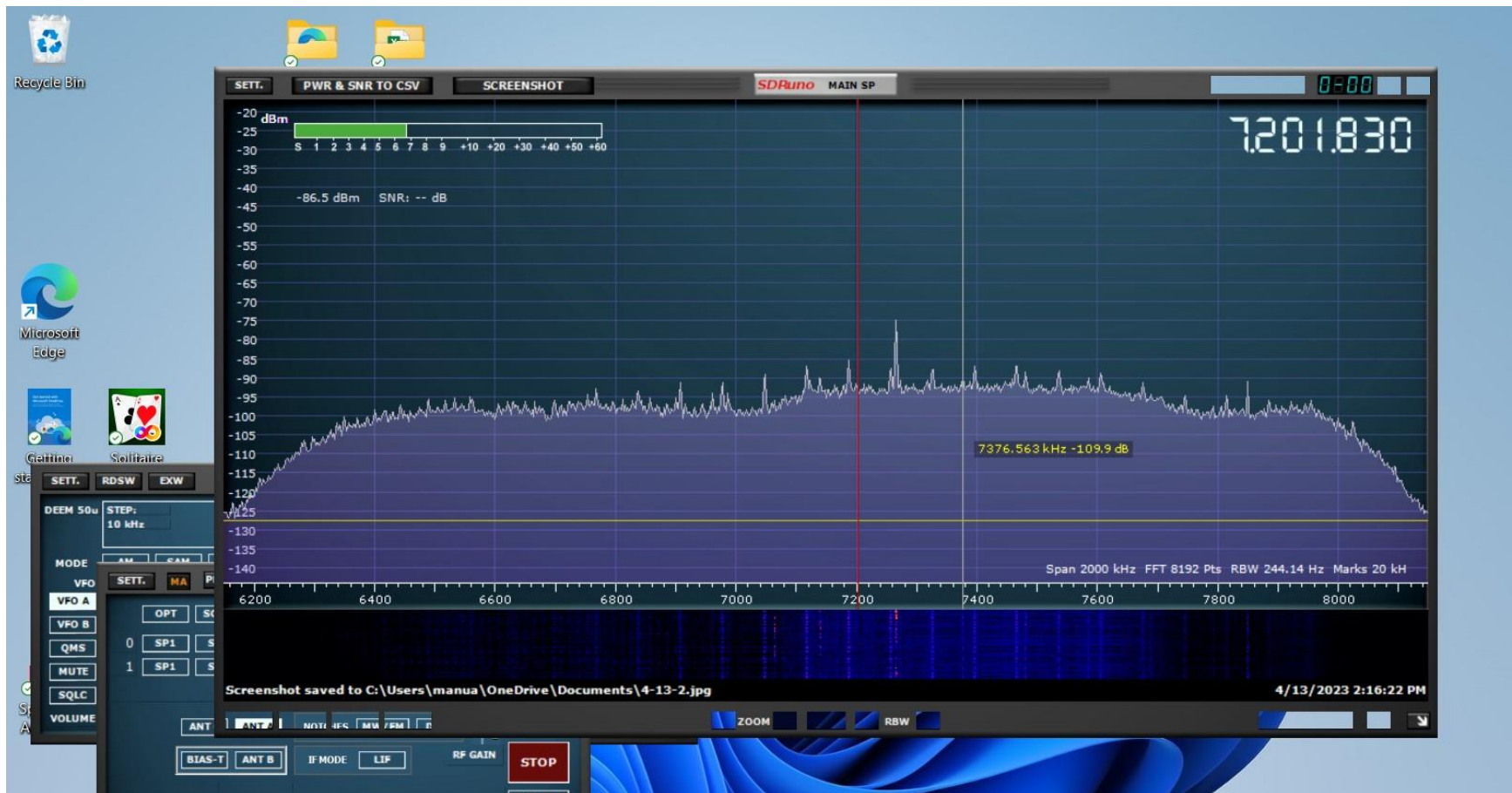
SdrPlay RSPDx

- The SDRplay RSPdx is a complete redesign of the popular RSP 2 and RSP 2 pro multi antenna receiver. It's a wideband full featured 14 bit SDR which covers the entire RF spectrum from 1 kHz to 2 GHz. Combined with the power of readily available SDR receiver software (including SDRUno supplied by SDRplay) you can monitor up to 10 MHz spectrum at a time. The RSPdx provides three software selectable antenna inputs, and an external clock input. All it needs is a computer and an antenna to provide excellent communications receiver functionality. A documented API allows developers to create new demodulators or applications around the platform.

SdrPlay RSPDx Features

- Covers all frequencies from 1kHz through VLF, LF, MW, HF, VHF, UHF and L band to 2GHz, with no gaps
- Receive, monitor and record up to 10MHz of spectrum at a time
- Performance below 2MHz substantially enhanced improved dynamic range and selectivity
- Software selectable choice of 3 antenna ports
- Enhanced ability to cope with extremely strong signals
- External clock input for synchronisation purposes, or connection to GPS reference clock for extra frequency accuracy
- Excellent dynamic range for challenging reception conditions
- Free use of windows based SDRUno software which provides an ever increasing feature set
- Strong and growing software support network
- Calibrated S meter/ RF power and SNR measurement with SDRUno (including data logging to .CSV file)
- Documented API provided to allow demodulator or application development on multiple platforms

Receiver Software Packages



SDRuno MAIN V1.42 1014 TCTR 0:00

Final SR: 2000000
IFBW: 1.536MHz (LIF)
Gain: 30.9dB

0 SP1 SP2 RX

1 SP1 SP2 RX

DECIMATION 1

ANT C ANT A NOTCHES MW/FM DAB

BIAS-T ANT B IF MODE LIF

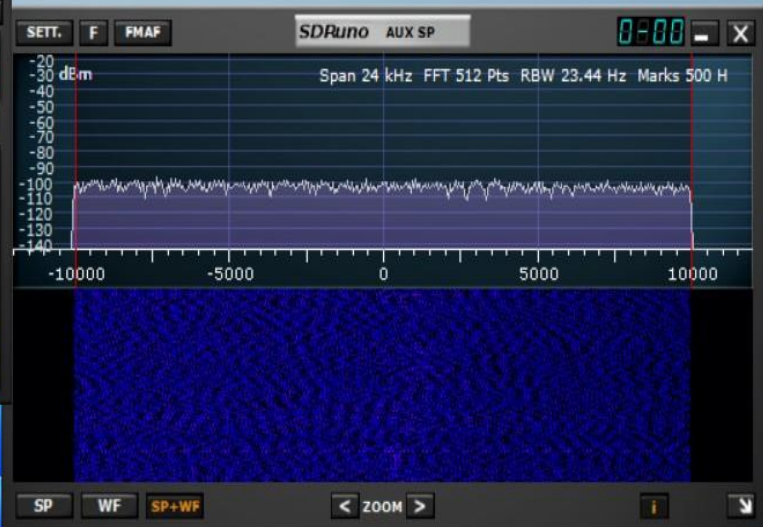
RF GAIN

ADD VRX
DEL VRX
LO LOCK
STOP
MEM PAN

Sdr: 4%
Sys: 14%
SAVE WS Default Workspace

1 3 5 7 +20 +40 +60

Bands MHz
2200 630 160
80 60 40
30 20 17
15 Clear Enter

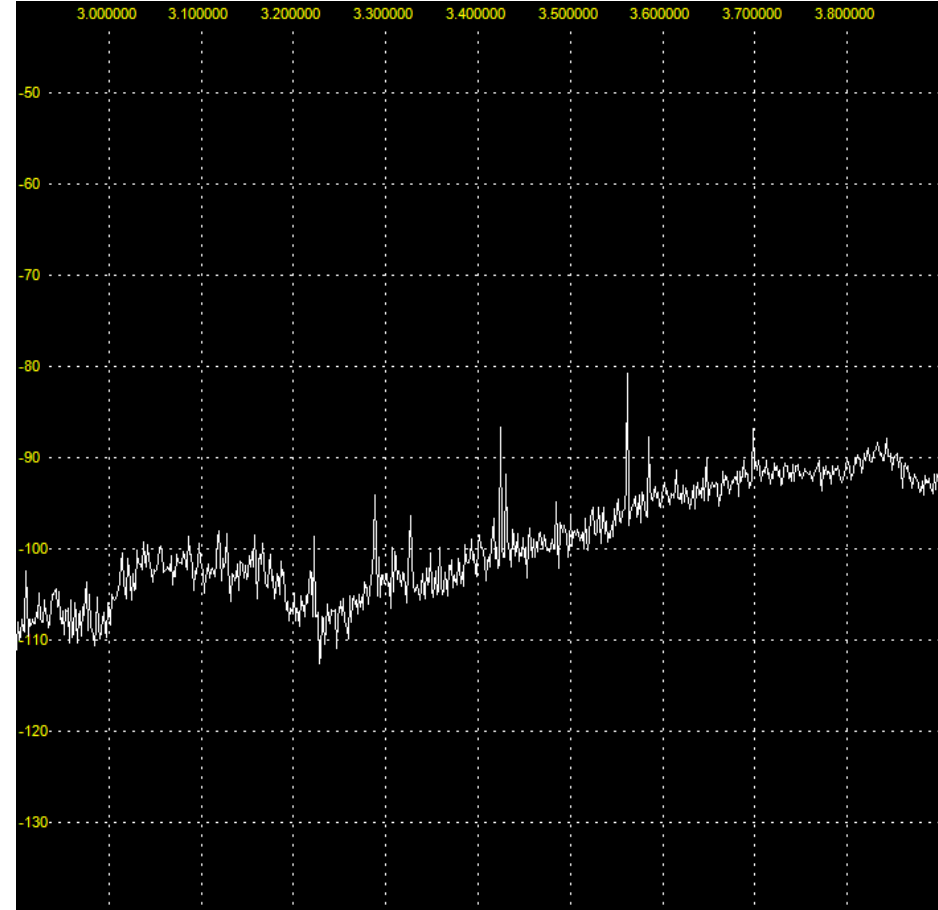
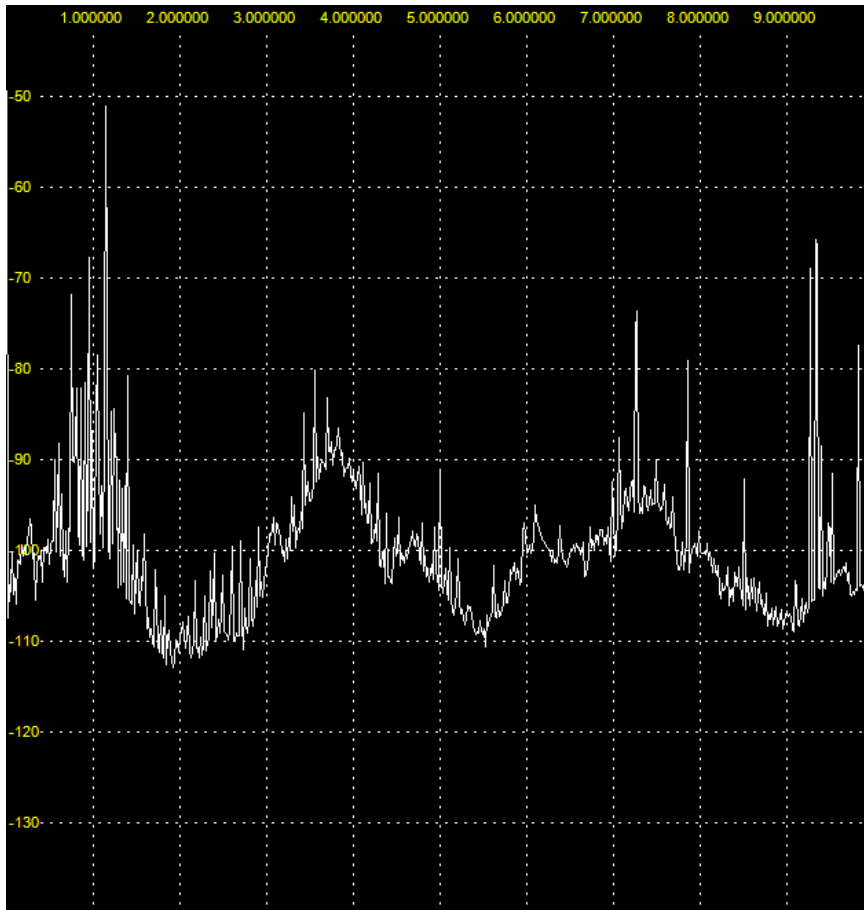


Microsoft Edge

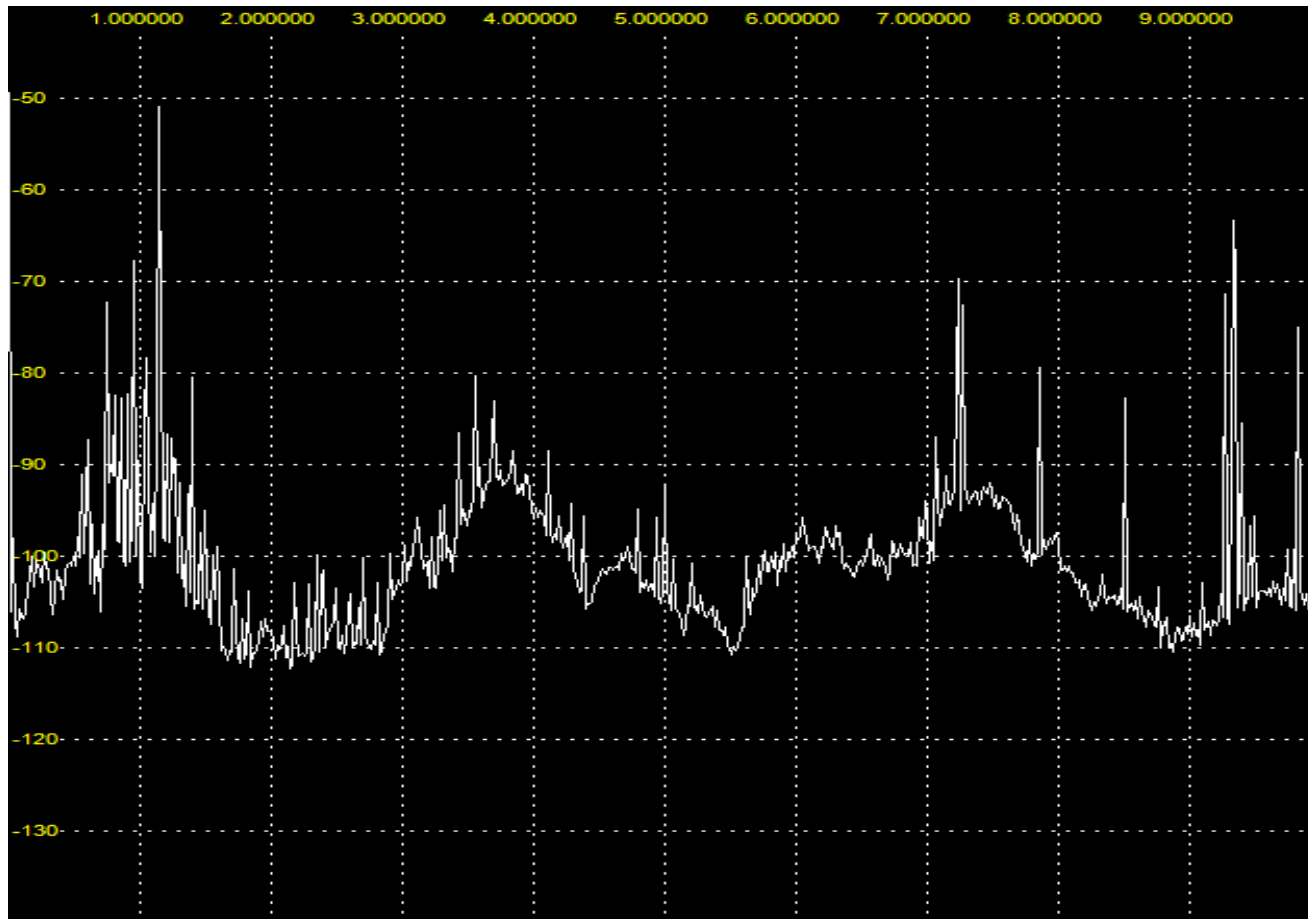
Get started

Spectrum Analyse...

Receiver Software Packages



Noise floor over range.

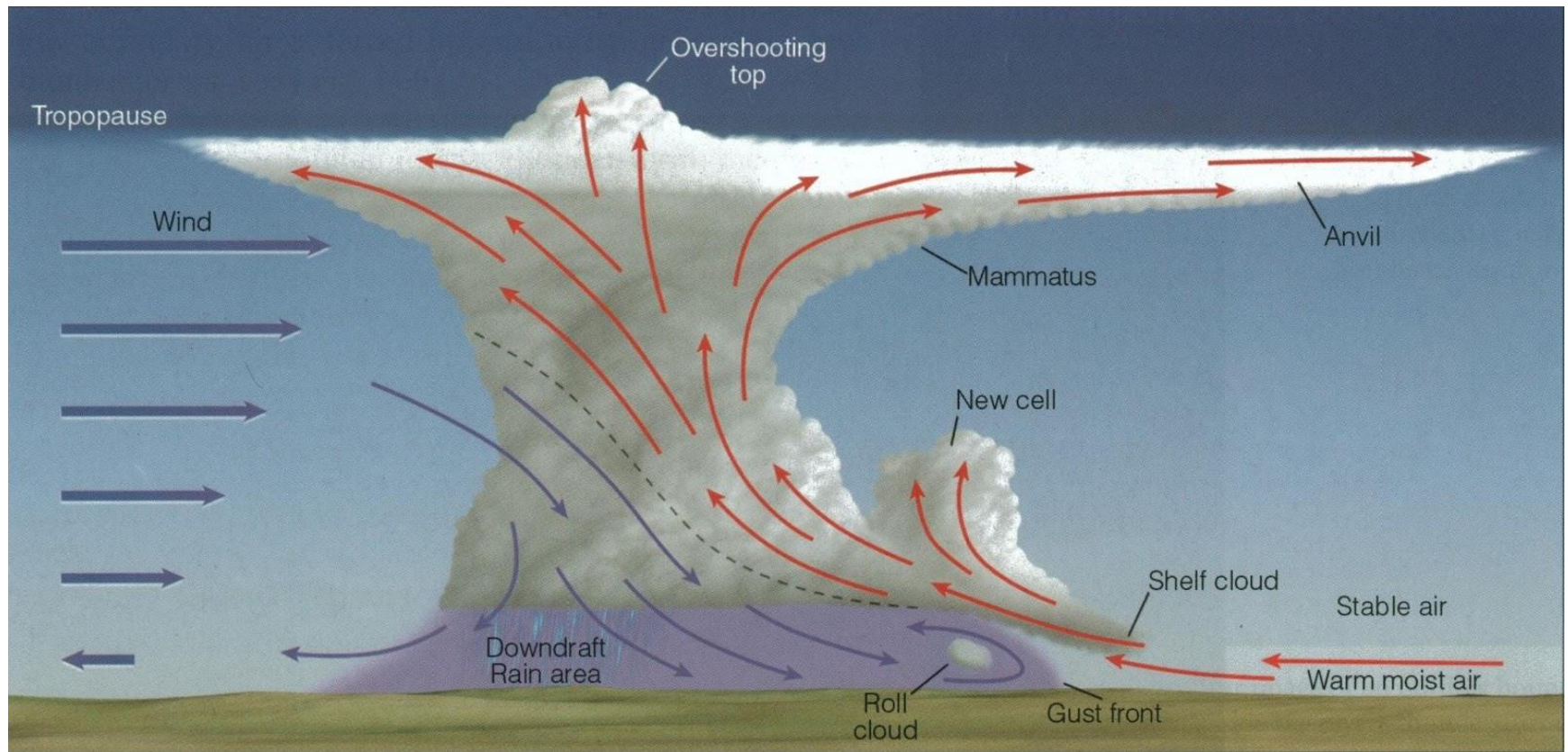


Prime Candidates

- **Cable TV Set Top Boxes (STB)(birdies, SMPS)**
- **Cable Modems (birdies, SMPS)**
- **Ceramic Heaters**
- **Electric Blankets**
- **Dimmers, touch control lighting (120Hz rasp)**
- **Electric Fences (horses, cattle)**
- **Invisible Dog Fences using buried wires and collar (broadband RFI producers)**
- **Furnace Control Circuits, HVAC**
- **Air Cleaning Machines (HV electrostatic)**
- **Photocell controlled outdoor lighting**
- **Door Bell transformers (faulty and hidden in attic)**

Examples

No. 1 Example



Examples



Examples



Examples



Examples



Examples



Examples



**Switch mode VS linear
Power Supplies.**

BIG IRON

Identifying sources at your QTH

- **Technique: Go to main Circuit Breaker (CB) panel with battery powered RX, AM mode, tuned to hear the offending noise**

Turn *OFF* Main breaker to premises, if noise stops, RFI is from within your own residence



Identifying sources at your QTH

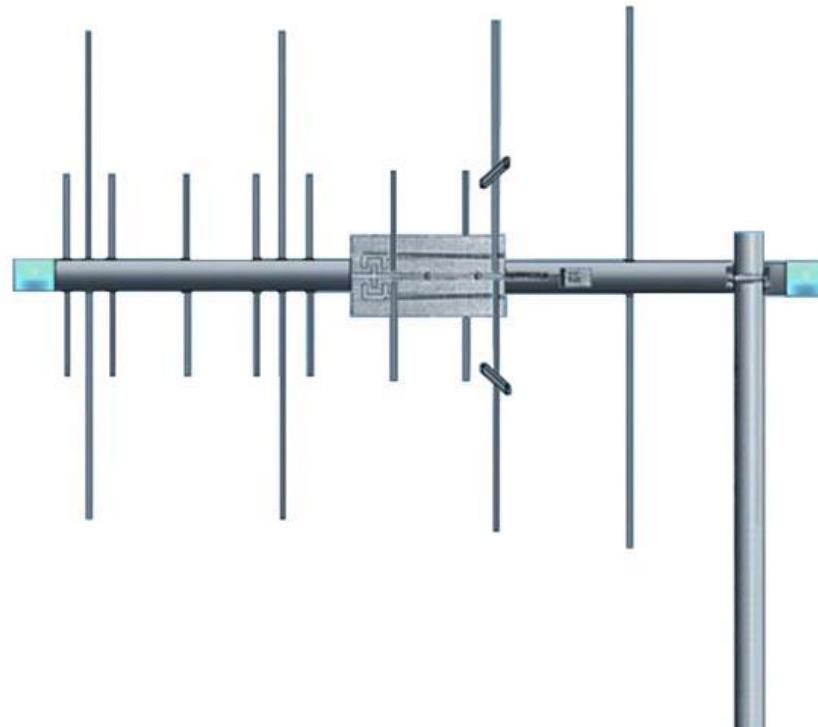
- Turn **ON Main** breaker
 - Turn **Off and ON individual** breakers until noise stops and starts again
 - Leave **OFF breaker** that stops the noise
-
- Determine what is turned off in the house, unplug all unpowered devices, turn **ON CB** that stopped the noise
 - Plug in devices one at a time until noise returns to locate the offender
 - You **FOUND IT!!!**



Not your house??

- **First impressions will make or break resolving *YOUR* RFI /EMI issue**
- **•Politeness, Diplomacy and Charm is imperative!**
- **•Use handheld portable HF RX and hold close to doorbell, porch light, outdoor light, electric meter panel, anything connected to AC mains to check for noise. If found, and with a cooperative neighbor, follow the same steps used at your QTH**

Where is it?



Power Line Noise

- Causes of powerline noise

- **Sparking/Arcing across some powerline related hardware, may or may not be visible**

- **A breakdown and ionization of air occurs, and current flows between two conductors in a gap**

- **Gap may be caused by broken, gapped, loose, or oxidized hardware, compromised insulator, etc.**

- **External Sparking/Arcing produces ultrasonic shockwaves which can normally be detected**

- **Internal Sparking/Arcing (lightning arrester) does NOT produce detectable ultrasonic shockwaves**

Power Line Noise

- **Characteristics of powerline noise:**

- Typically occurs near positive and negative peaks of 60Hz AC waveform

- Strong 120Hz noise component (2x60Hz line freq.)

- Fixed 120Hz freq. synced to AC line freq. no “wandering”

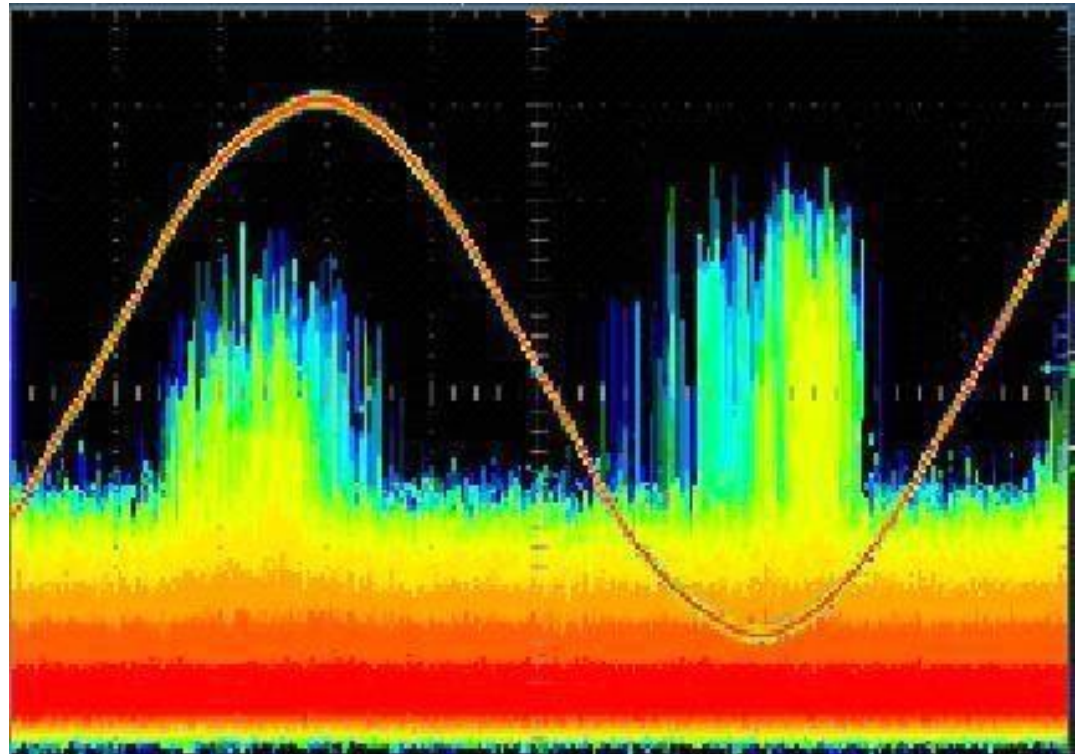
- 8.33 mS period (120Hz), RX audio observed on o’scope

- Usually occurs on distribution lines, 7.2kV, 16kV, 33kV, 66kV

- Rarely occurs on 120/240V, 4.2kV lines (legacy back yard lines), 115kV, or 220kV and higher transmission lines (on towers)

Visual (electronic clues)

- **Sparking/Arcing typically occurs near peak voltages, i.e., the positive and negative peaks of 60Hz AC waveform**
- **Sparking/Arcing typically occurs 2x /cycle, thus 120Hz buzz/rasp noise**
- **Group of multiple Sparks/Arcs occurs in each half cycle (a “Pulse Group”)**
- **A “Pulse Group Pair” typically occurs once each cycle**



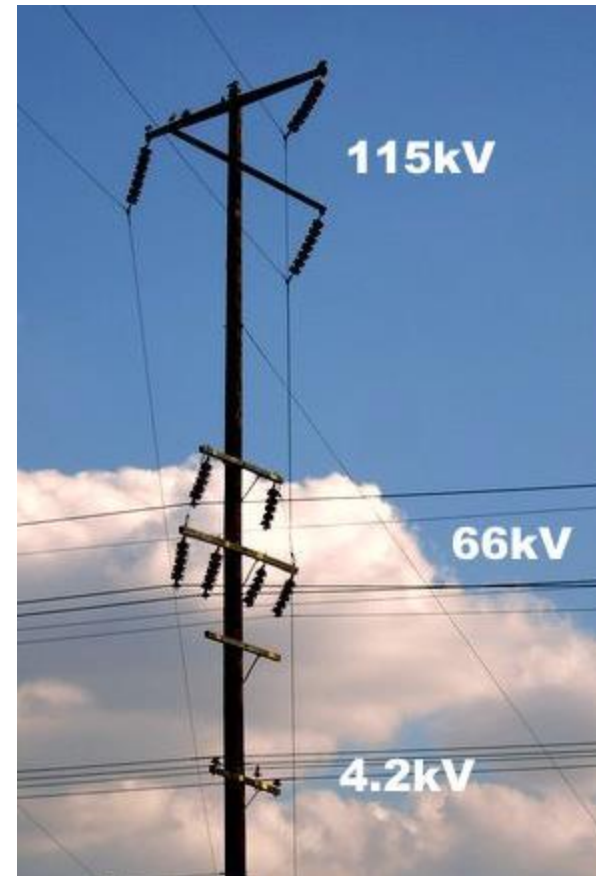
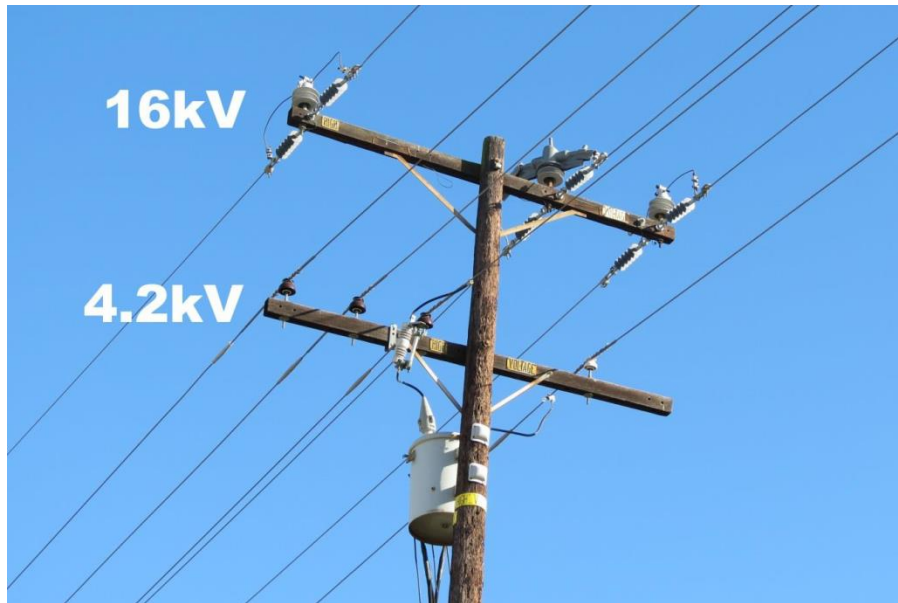
Power Line Noise

- Indications of TRUE Power Line Noise

- **120Hz buzz or rasp, popping, burbling, ripping**
- **Wideband, although sometimes much stronger on certain bands due to resonances**
- **Sometimes audible on one band but inaudible on other bands**
- **Normally goes away with moderate rain (moisture may short out the arc, rain washes conducting contaminants from insulator sheds)**
- **Almost always varies with weather conditions, specifically *wind, humidity & temperature***

Power Line Noise (PLN)

- Anatomy



Power Line Noise (PLN)

- **Anatomy**

- **Porcelain Bell Insulators (oxidized clevis pins, slack spans)**
- **Loose hardware: bolts and nuts, staples, bonding wires, brackets and braces**
- **Tracking on insulators caused by carbon, salts, contaminants, or industrial pollution on insulator sheds**
- **Loose or oxidized tie wires (tie wires hold conductor to insulator)**
- **Lightning damaged insulators and damaged lightning/surge arresters**
- **Loose or broken wire clamps**
- **Guy wire touching neutral**
- **Loose cross arm brace, loose transformer mounts**
- **Cutouts (fuses)**
- **Construction defects, touching/rubbing wires, defective insulation**
- **Vegetation interference (vines and climbers)**
- ***RARELY* transformers**

Power Line Noise

- **Locating Tools**

- **RX MW/HF Bands AM and SW Receivers (AM Mode, wide IF BW 6kHz)**
 - **AM Band 530-1710kHz**
 - **SW Band 2-30MHz**
- **RX VHF/UHF Bands (AM Mode, wide IF BW 6kHz)**
 - **118-136MHz (Aviation band)**
 - **144MHz (2M)**
 - **440MHz (70 cm)**
- **RX Wideband**
 - **Radar Engineers Model 243 RFI/PLN receiver 0.5-1000MHz**

Power Line Noise

- **Locating Tools cont.**

- **ANT MW/HF Bands**

- **Active Whip or Magnetic Mount Omnidirectional (CB antenna)**
- **Small Loop ($\lambda/10$)**
- **Ferrite Rod**

- **ANT VHF/UHF Bands**

- **Magnetic Mount Omnidirectional Monopole**
- **Dipole**
- **Yagi-Uda “Beam” (VHF/UHF)**
- **Log Periodic (Wideband)**

TOOLS

TecMad ATS-25a Max AM FM Portable Radio,
Upgraded Version 5.2a
Max Full-Band Radio Receiver DSP Receiver,
with 2.4-inch Color Touch Screen,
3,000mAh Lithium Battery

\$131.95



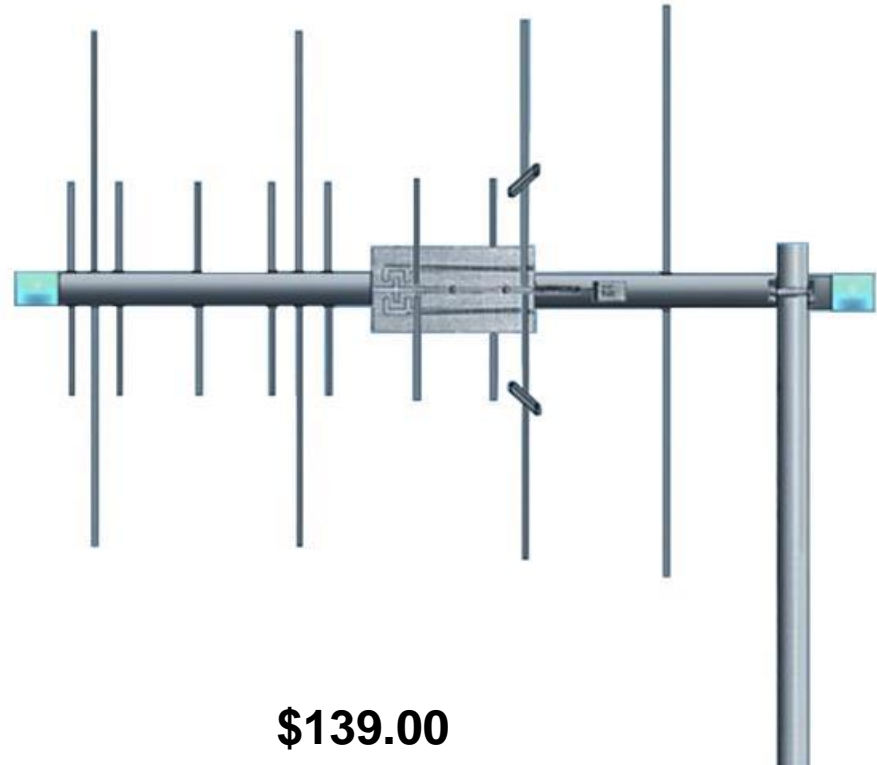
TOOLS

1.8 thru 30 Mhz



2x4 foot

\$119.00



\$139.00

SDRPlay Device

\$214.95 @ Ham Radio Outlet

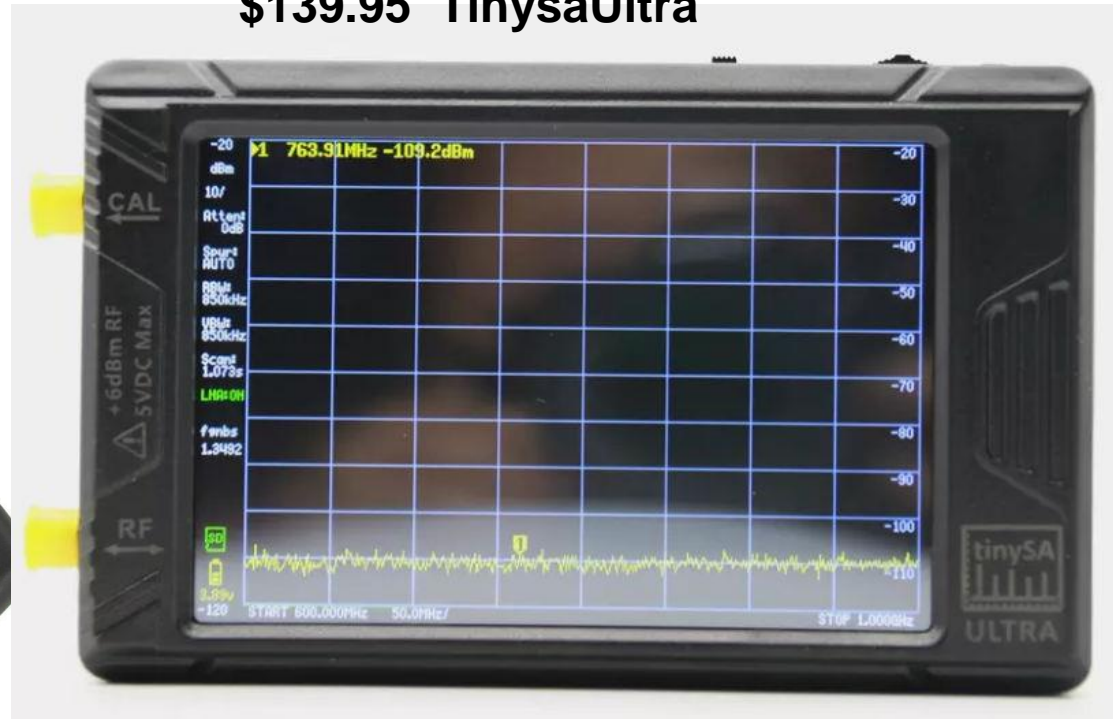


TOOLS



\$155.99

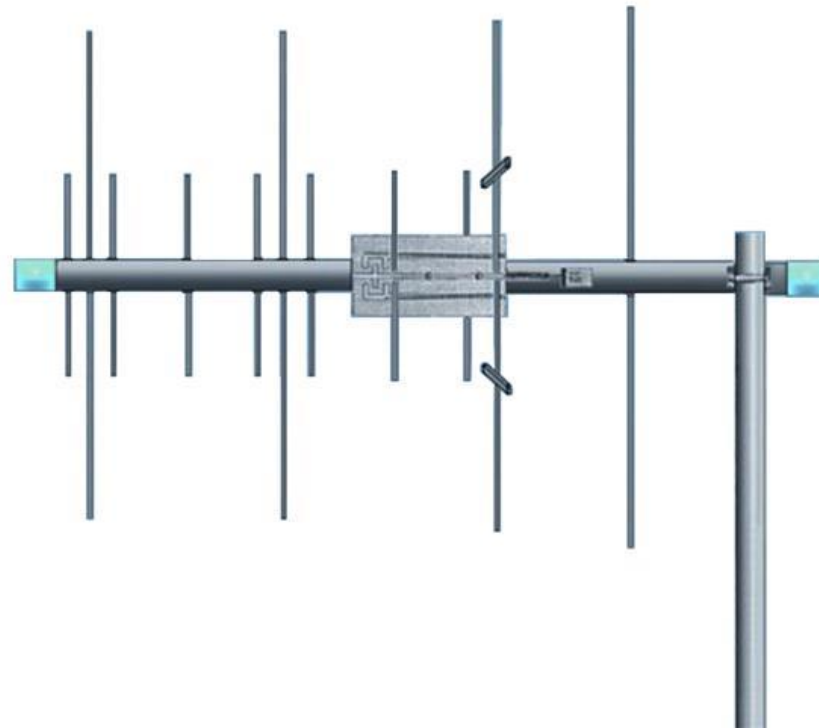
\$139.95 TinysaUltra



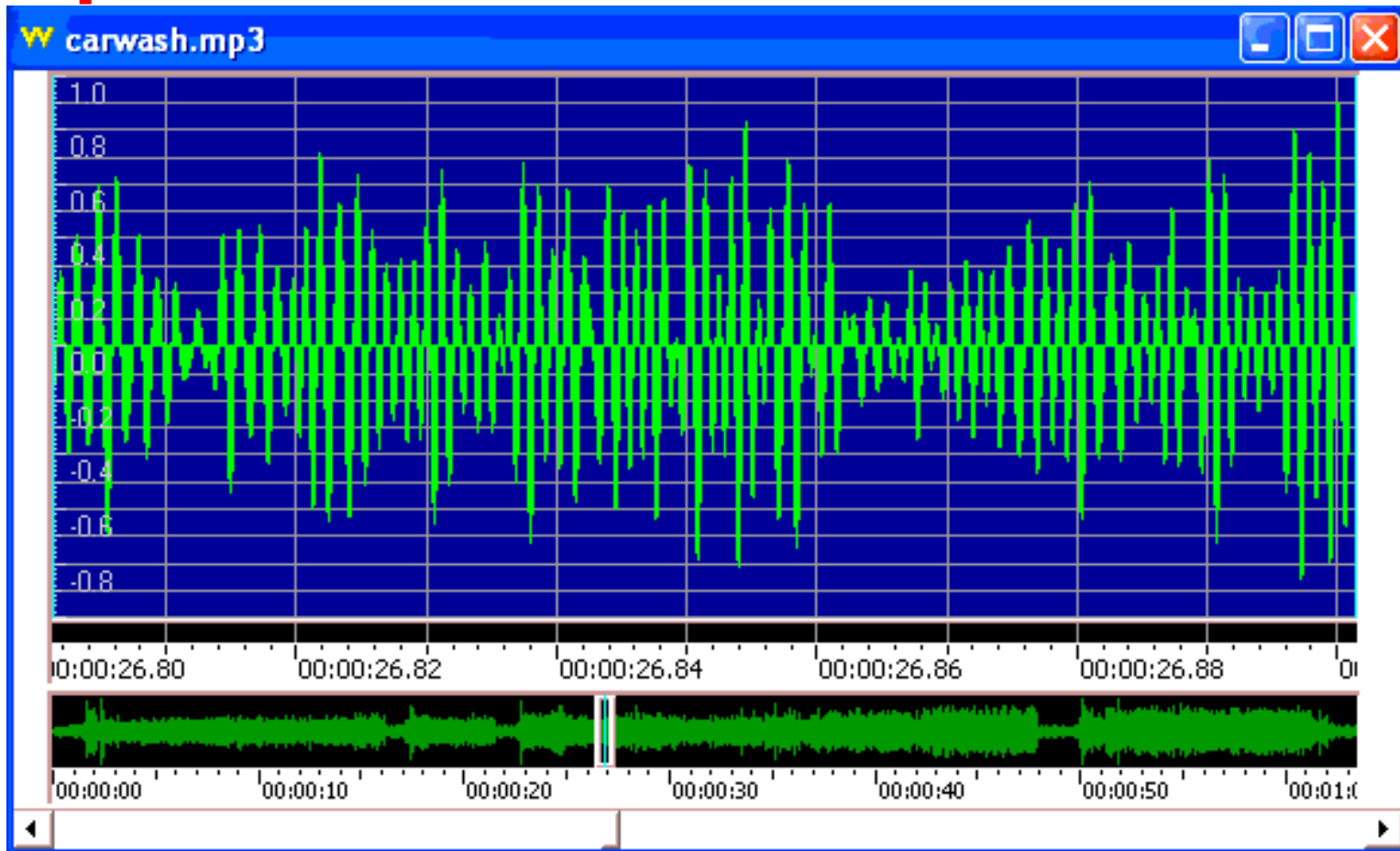
TOOLS



Time for Direction Finding (DF)



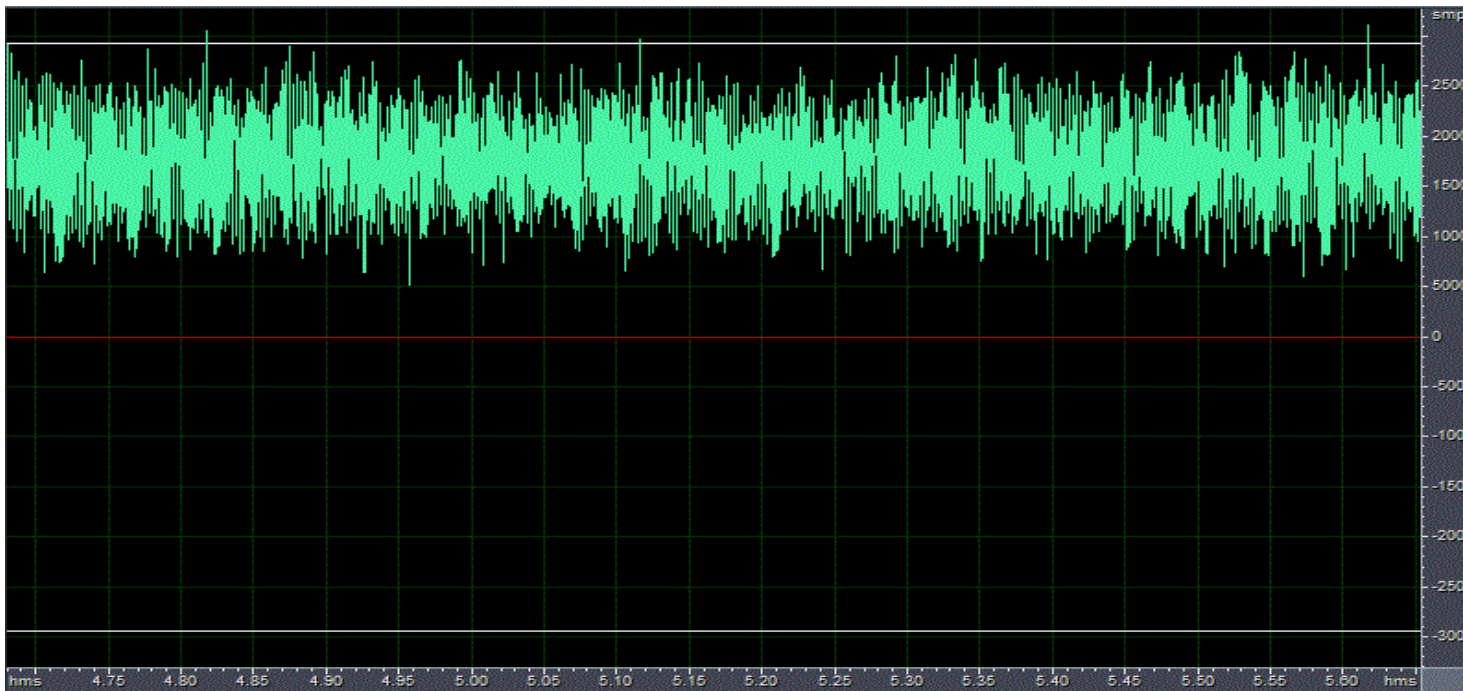
Specific Noises



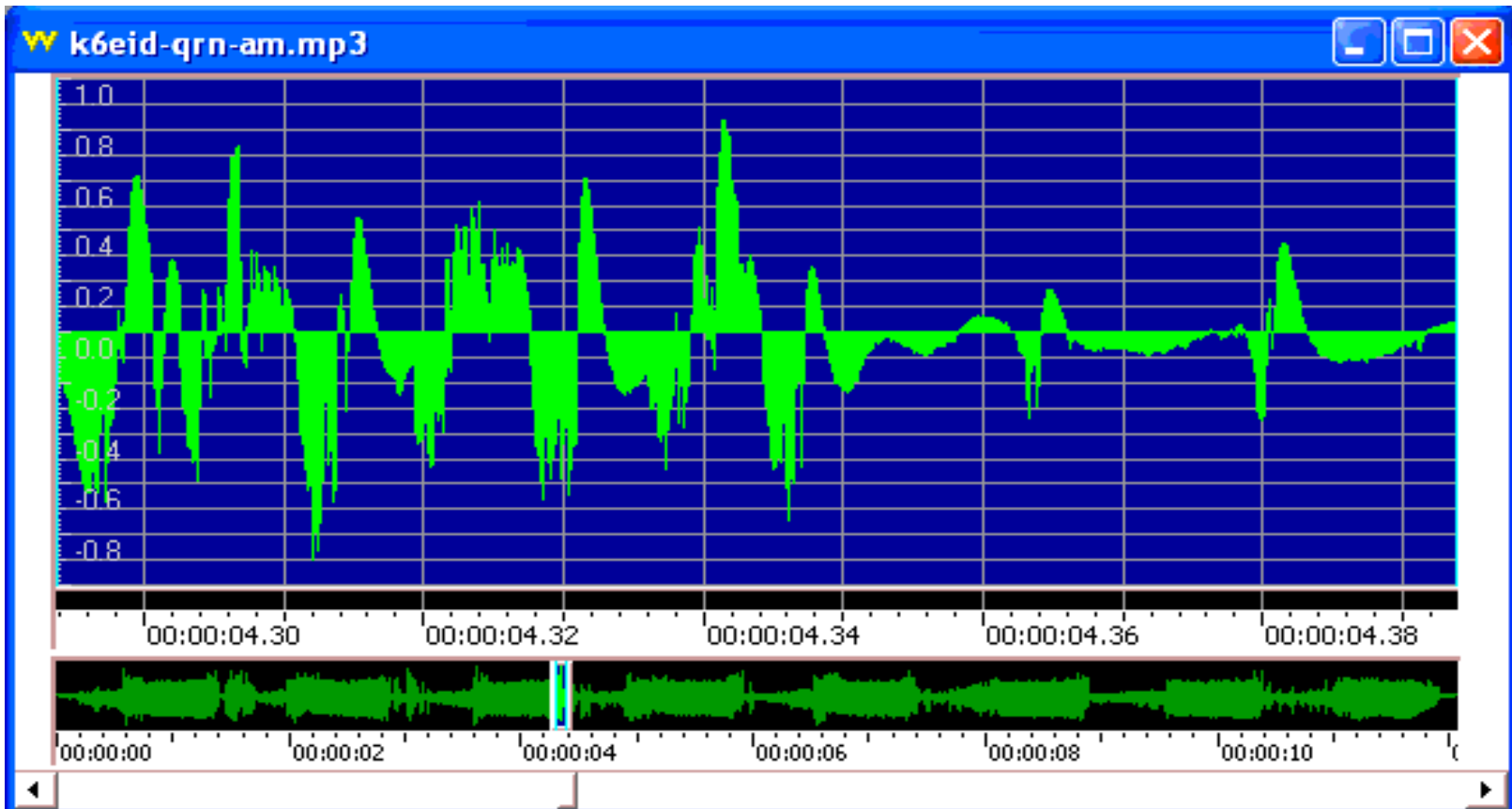
Specific Noises



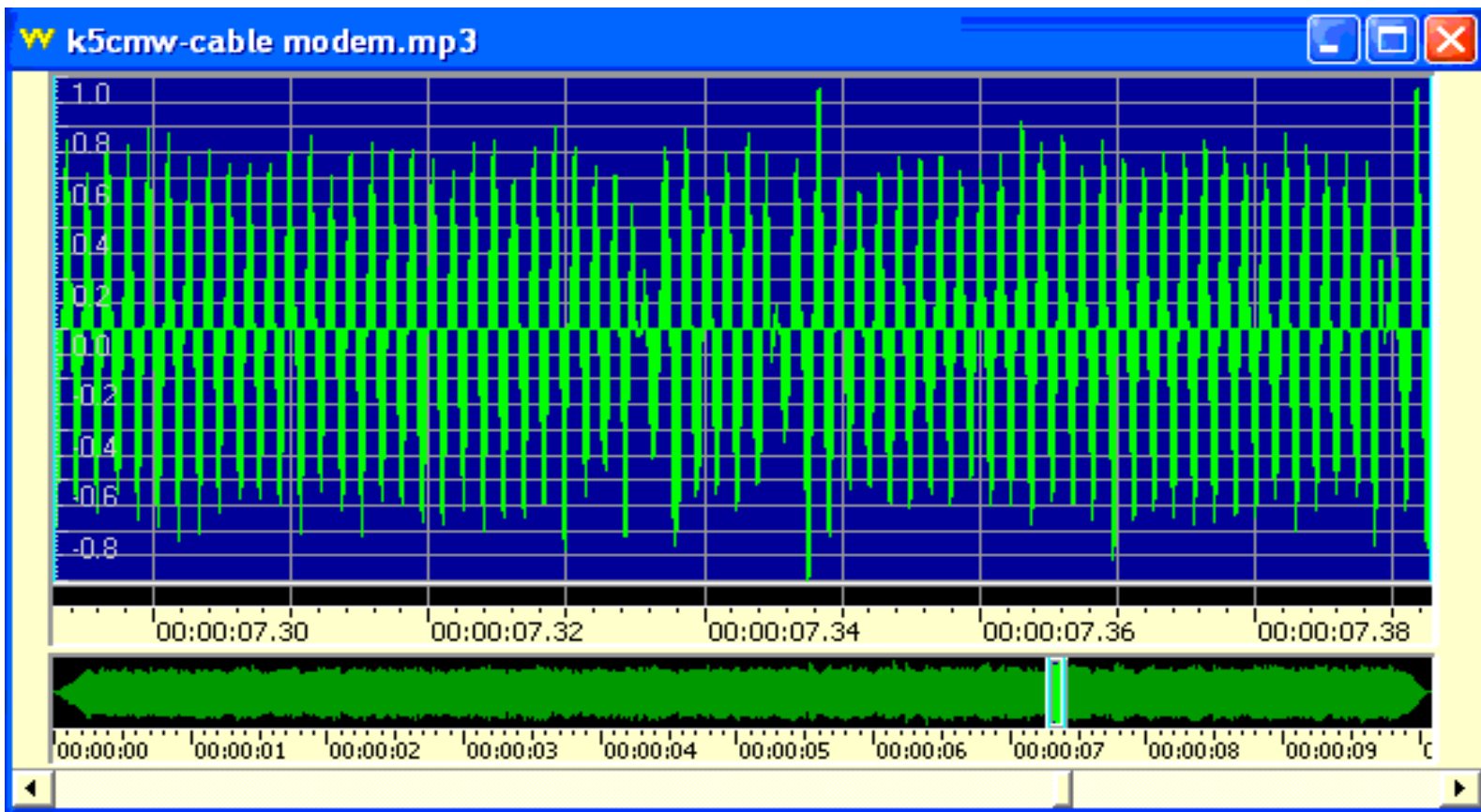
Router



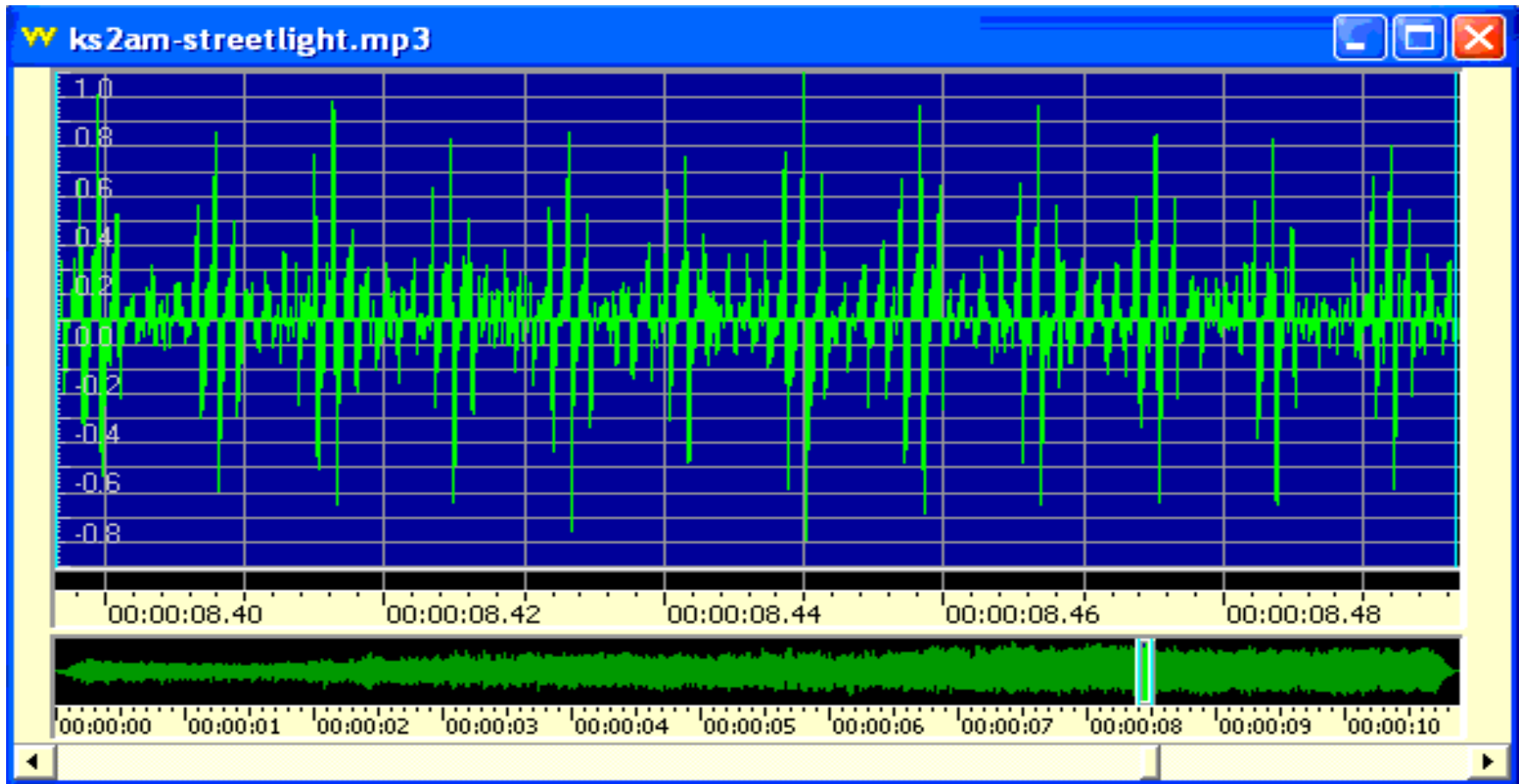
Specific Noises



Specific Noises

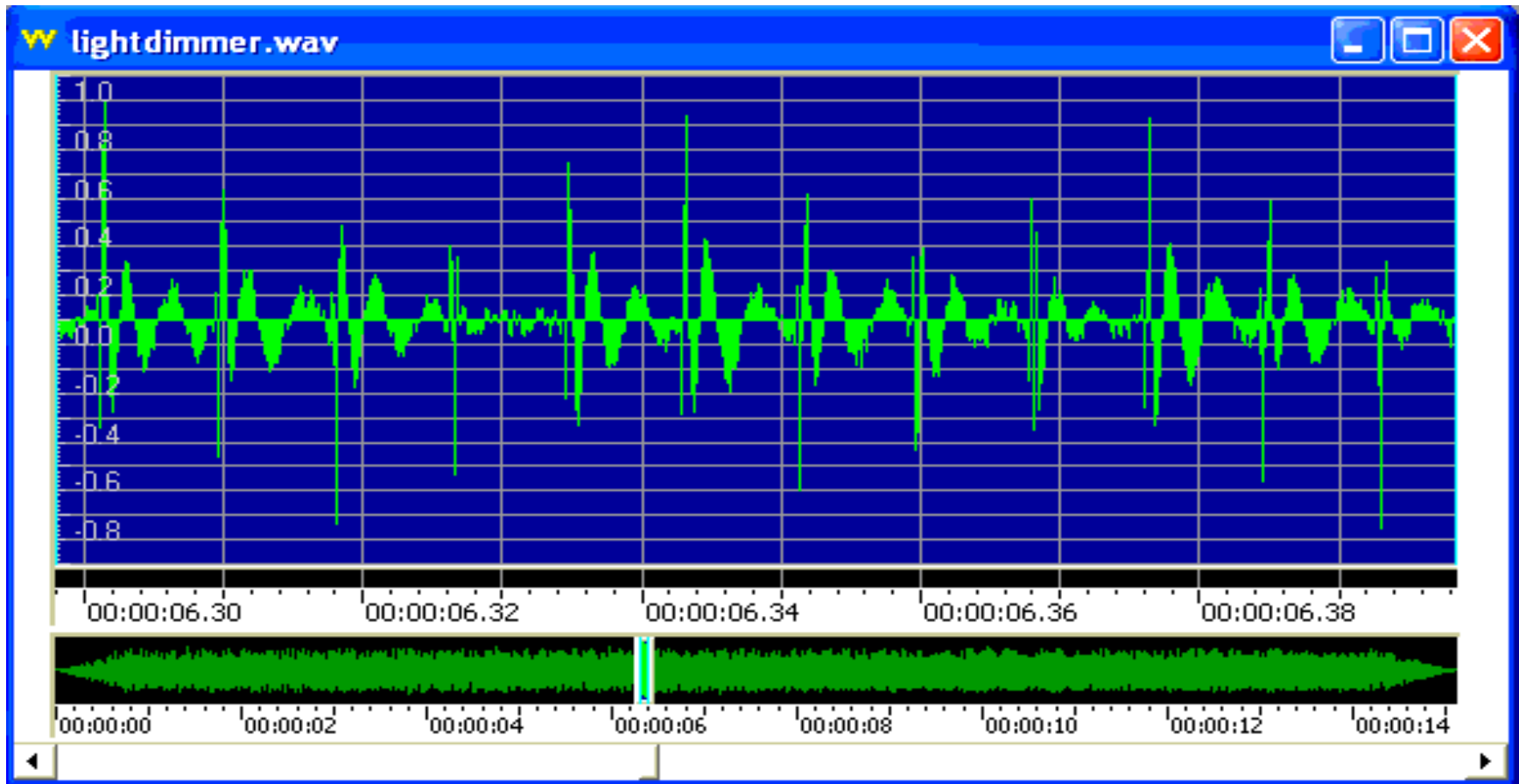


Specific Noises

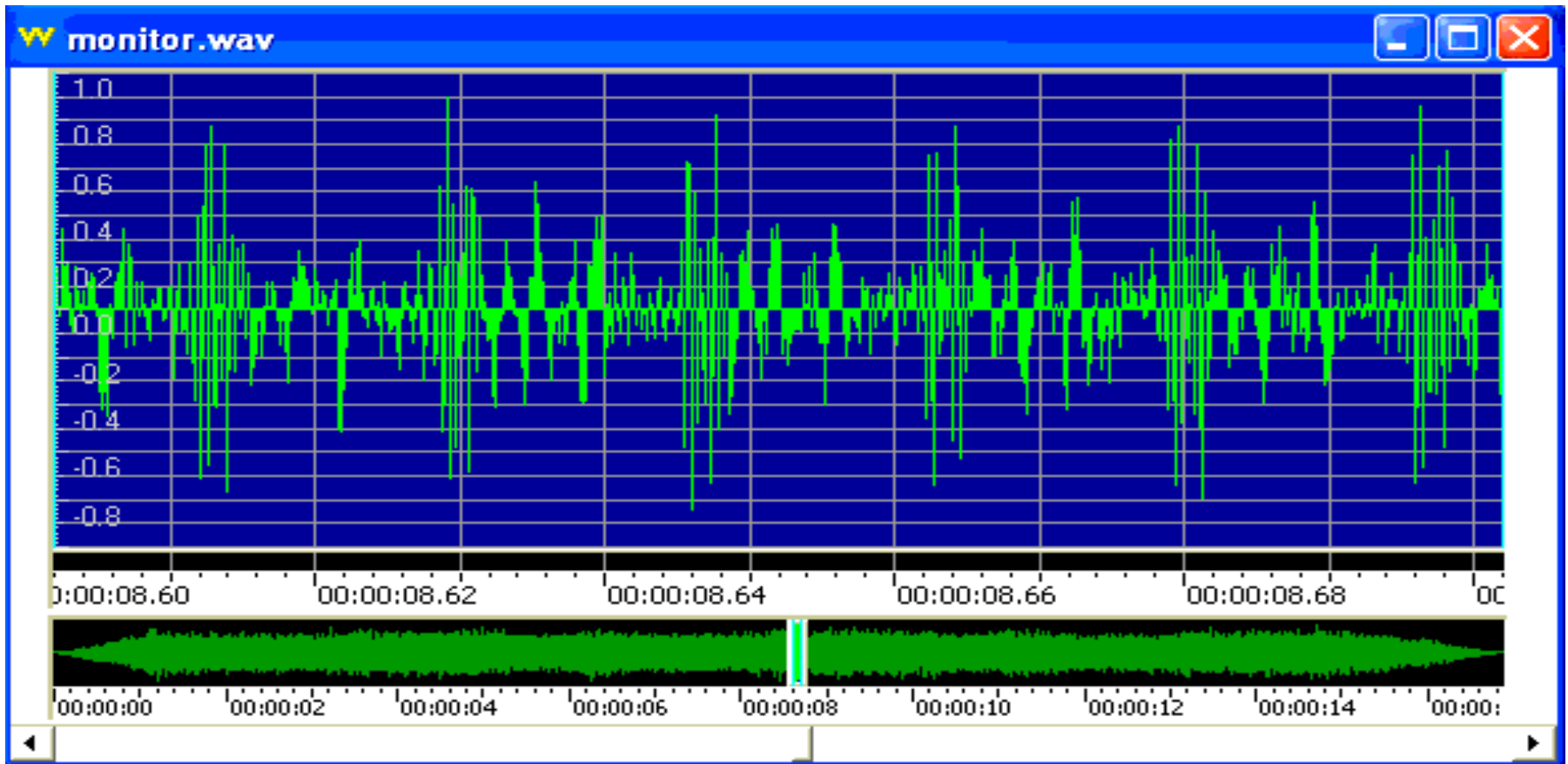




Specific Noises

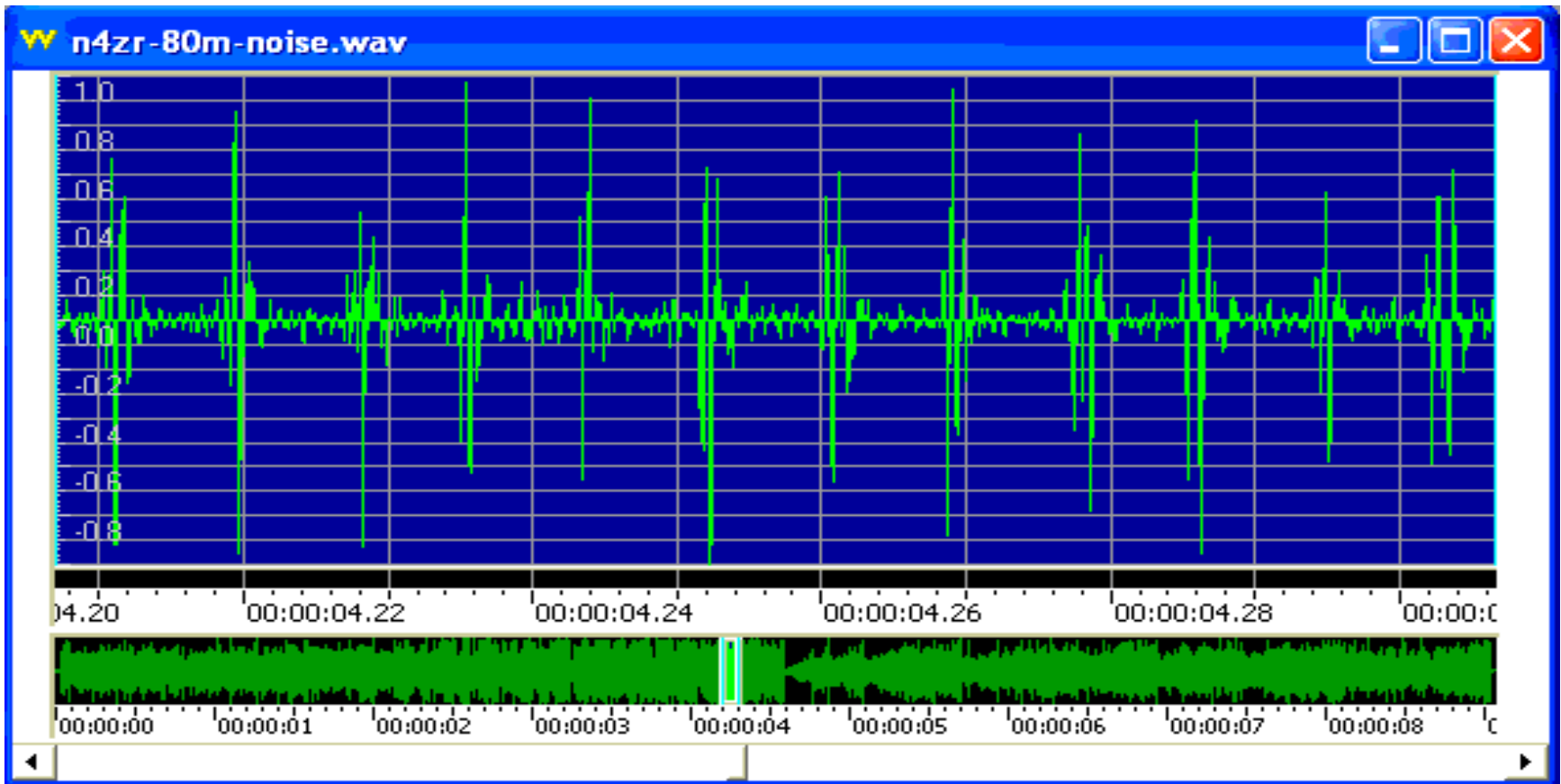


Specific Noises

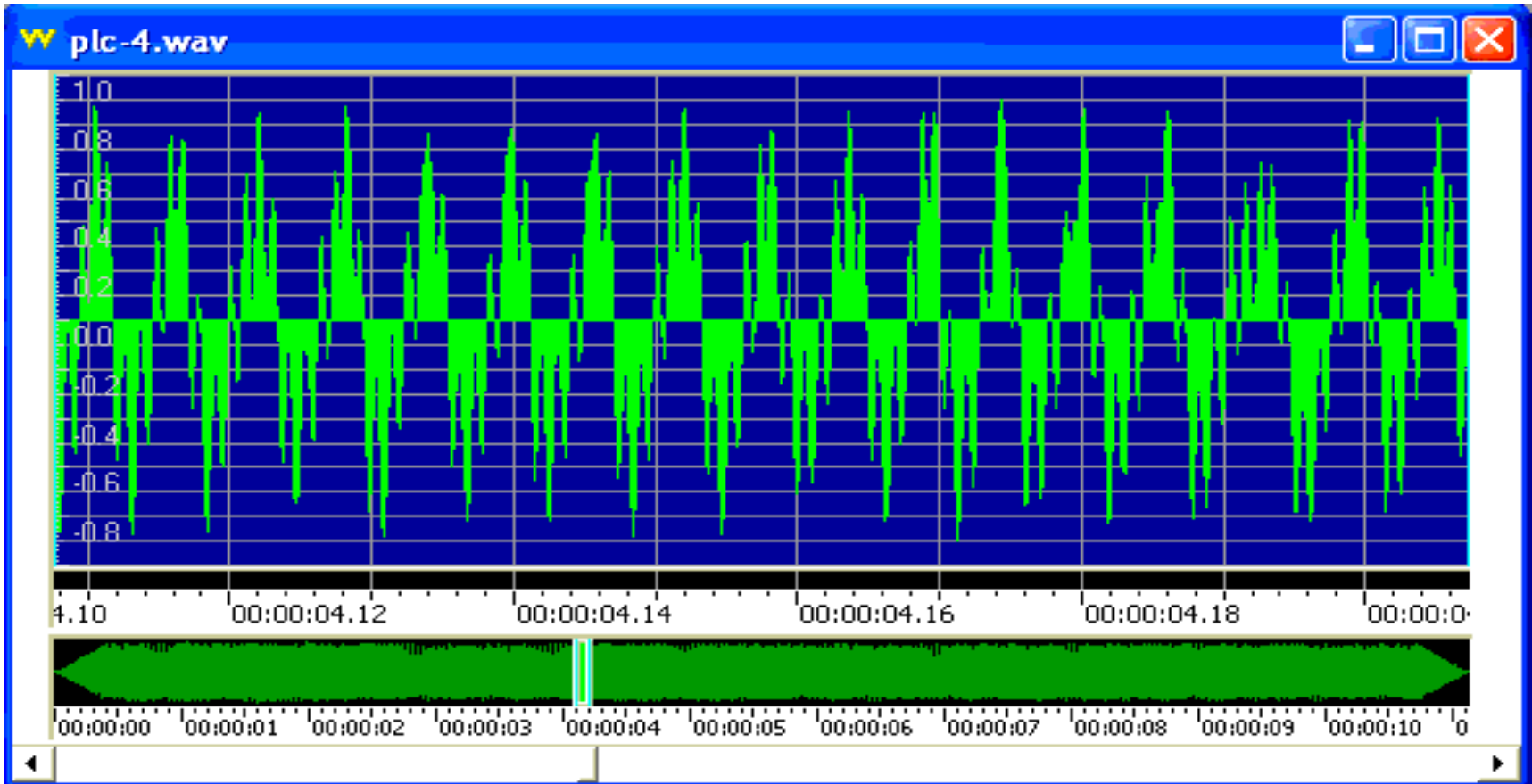




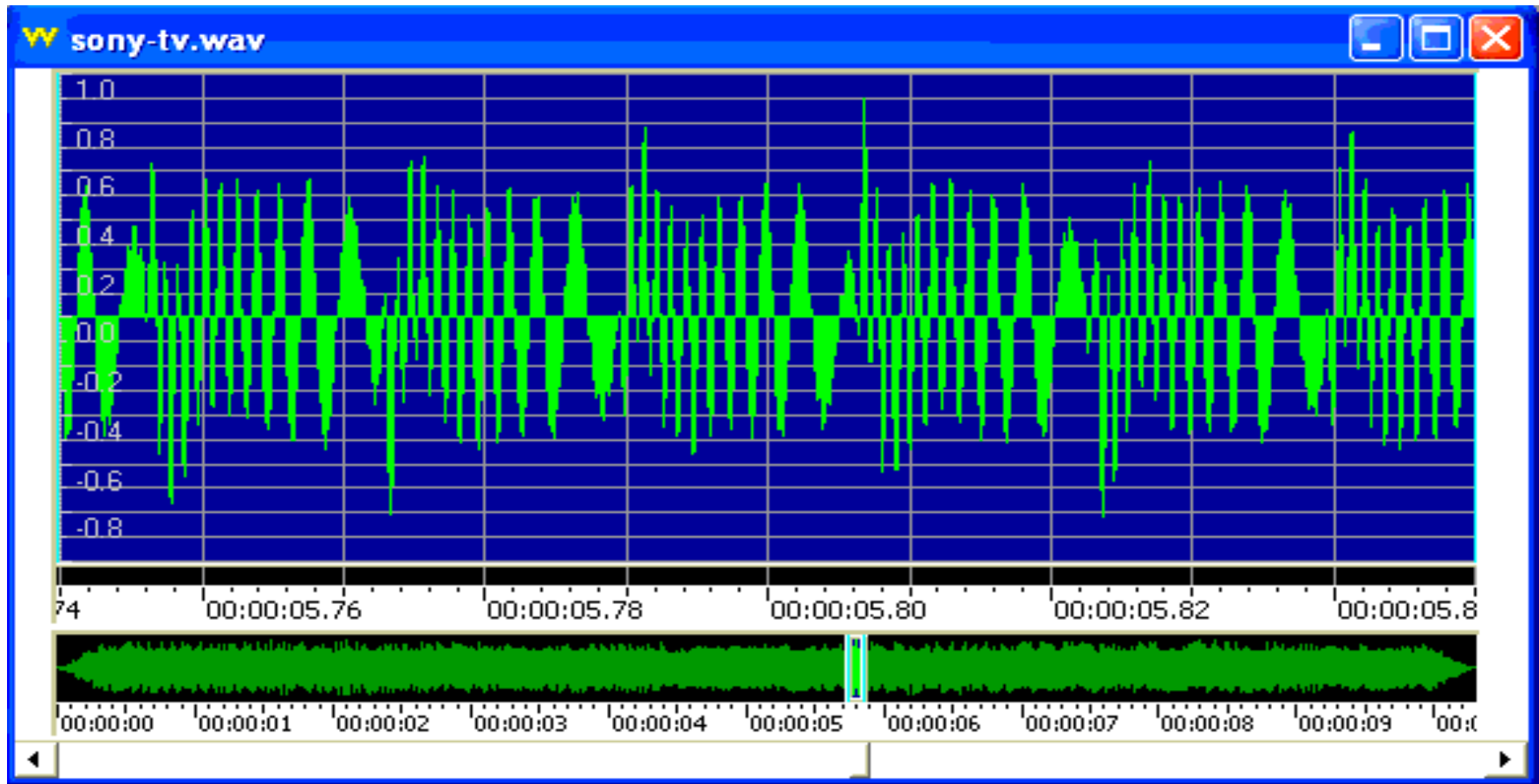
Specific Noises



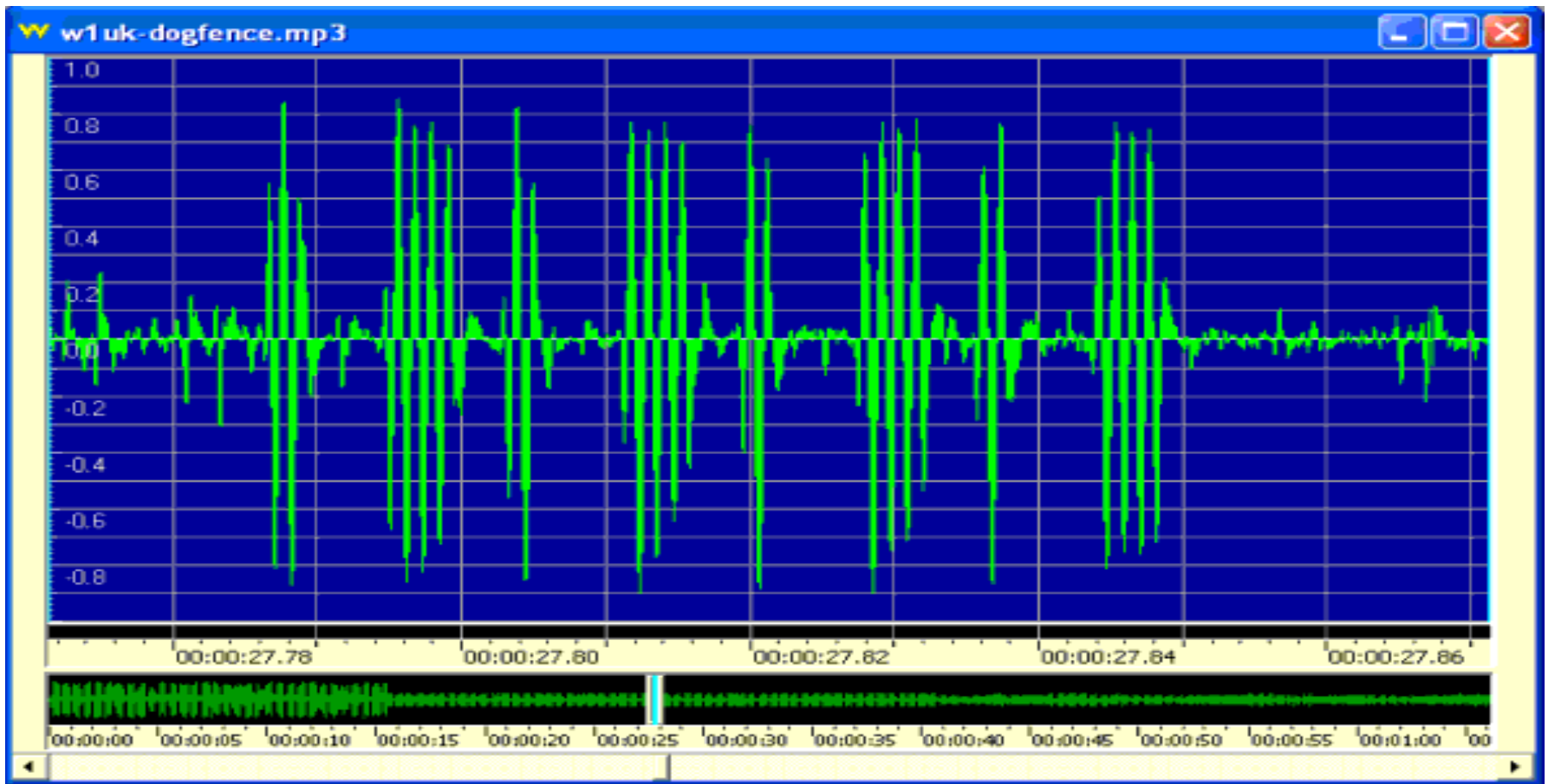
Specific Noises



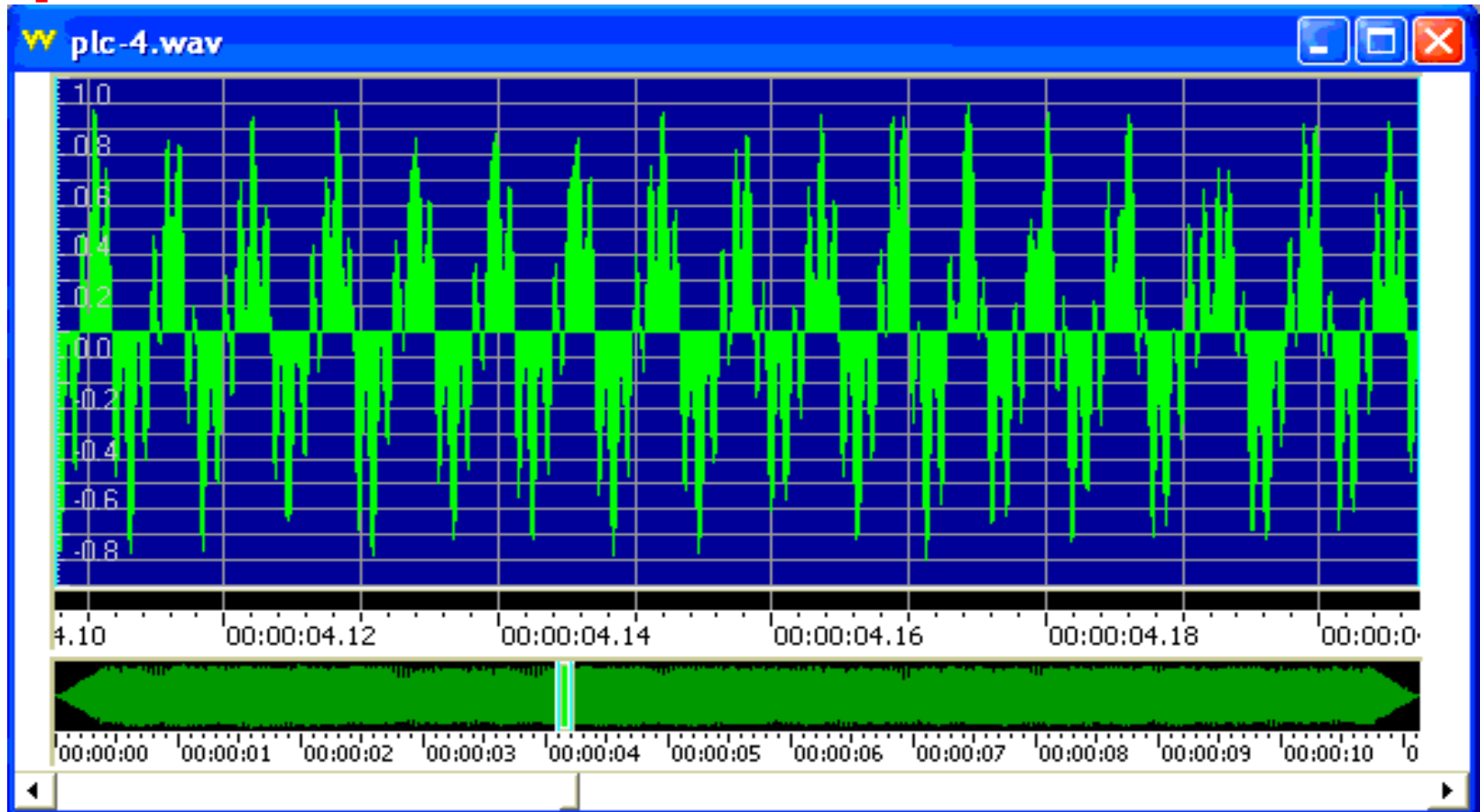
Specific Noises



Specific Noises



Specific Noises



TOOLS Noise Cancellers



MFJ 1026

\$259.99 Amazon



Timewave ANC-4 +

\$259.99 HRO

What do Noise Cancellers DO?



QUESTIONS ???

Steven W. Frakes KAØSF
frakessteve@yahoo.com
309-678-0796