

# CORC TECHNET - RFI INTERFERENCE

## **Radio Frequency Interference (RFI) *Into* Amateur Radio Receivers**

**By**

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**Version 2.0**

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**RFI can be grouped into two prominent categories**

- 1. Transmitter/ Receiver issues including harmonics, Intermodulation products, non-linearity amplifiers... etc.**
- 2. Noise Sources due to motors - generators, power supplies, lights, arcing insulators/contacts, gasoline engine ignitions, welders, etc.**

**This discussion will only concentrate on Noise Sources.**

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## Typical Noise Sources



# Introduction

- **Definition of RFI**
- **AC power lines**
- **Commercial and Residential devices**
- **How to determine the types with modest test equipment**

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Radio Frequency Interference (RFI) is unwanted **Noise** into radios, televisions, computers, audio systems, and medical devices, etc.

Most RFI Noise sources fall into two categories

## AC Power Line Noise

- Caused by arcing on the power lines and related hardware
- Noisy transformers
- The noise produces harsh raspy buzz across the radio spectrum

## Consumer & Commercial Noise

- Devices that are electronic and sometimes the electrical wiring in the home and homes/commercial businesses nearby.
- Most electronic consumer devices must meet FCC Part 15 and Part 18 of the FCC's rules
- Residential Devices are “Type B” devices. Business are “Type A” devices.

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**Common consumer radiated noise sources include:**

- **Switched mode power supplies including “Wall Warts”**
- **Solar Photovoltaic Systems (PV)**
- **Lighting devices, including LED lights (The Power supplies in the bulb package and not the LED make noise between 50 MHz to 400++ MHz)**
- **Electronic fencing**
- **Burglar alarm systems**
- **Proximity Detectors**

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## Consumer AC Power Line Noise NOT From the Power Company & Other Utilities

- **AFCI Breakers – arcing and/or RF radiation produced by the breaker**
- **Appliances – arcing and/or RF radiation**
- **Cable TV and/or Internet Leakage – RF Radiation**
- **Modems – RF Radiation**
- **Battery chargers (nonlinear) – RF Radiation**
- **Furnace blower power supplies – RF Radiation**
- **LED Lights working off the AC mains – RF Radiation**
- **Electric motors (bad brushes) – Arcing - RF Radiation**
- **PC power supplies (Switchers) – RF Radiation**
- **PC motherboards & Video cards– RF Radiation**

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## **The RF radiation from business or household items**

- **Are due to high frequency Oscillators**
- **Square wave generators**
- **Non-sine wave digital signals**
- **Poor shielding and RF bypassing**
- **Corrosion**

**The majority of these items are due to Switched Mode Power supplies.**

**Square waves are rich in harmonics. This is how switched mode power supplies work.**



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## Linear Power Supplies are usually RFI free.

Understanding Linear Power Supplies

### Advantages and disadvantages of linear power supplies

Advantages	Disadvantages
<ul style="list-style-type: none"><li>• Inexpensive</li><li>• Simple / durable</li><li>• Clean output</li><li>• Low levels of emissions</li></ul>	<ul style="list-style-type: none"><li>• Large</li><li>• Heavy</li><li>• Inflexible</li><li>• Inefficient</li></ul>

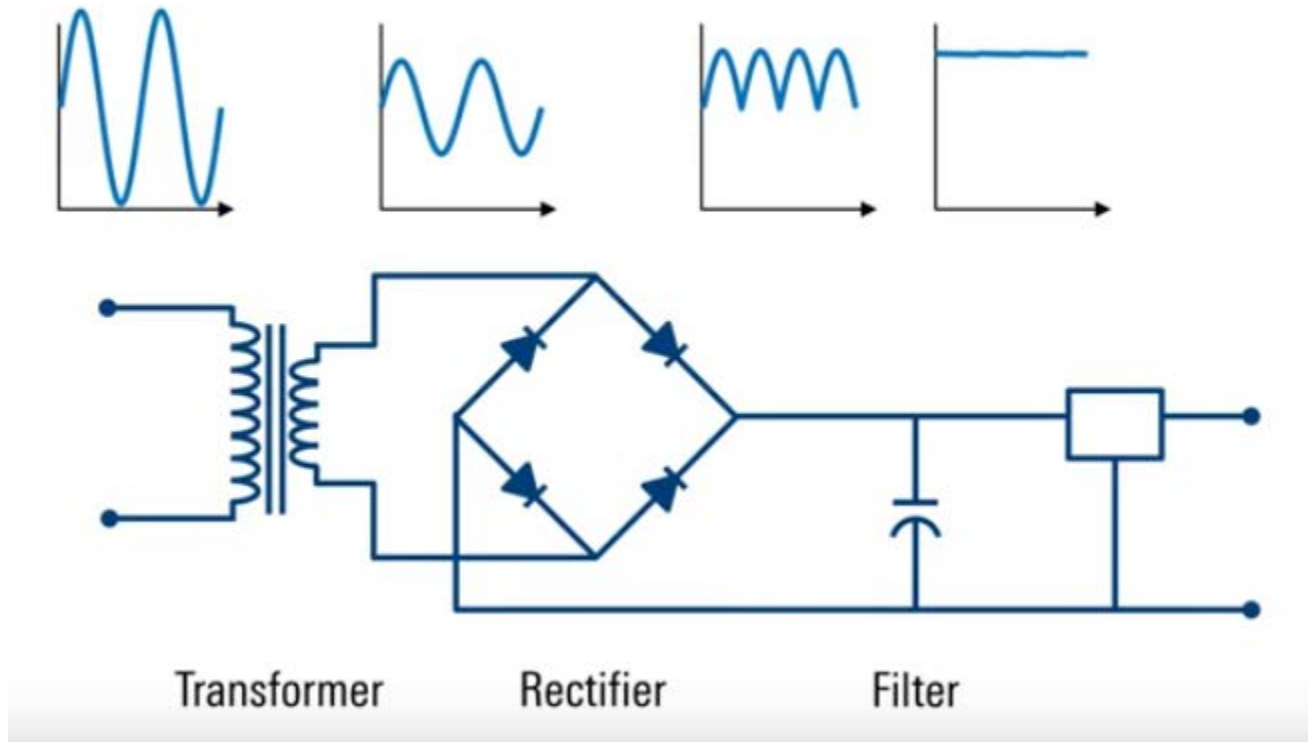
Switching mode power supplies (SMPS) address many of these disadvantages

9 7:04 / 8:38 • Advantages Disadvantages Understanding Linear Power Supplies

ROHDE & SCHWARZ

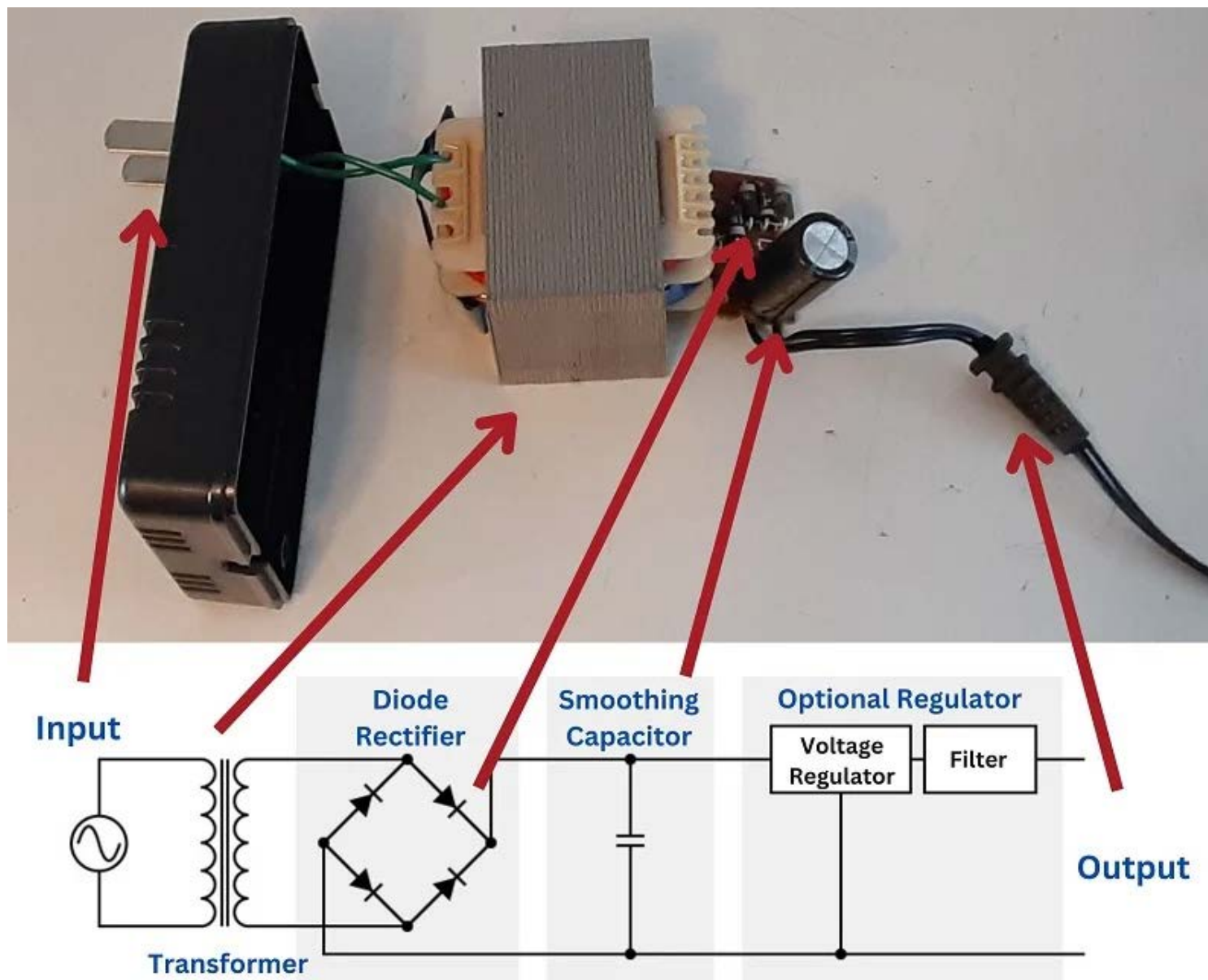
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## Typical AC to DC Analog Linear Power Supply



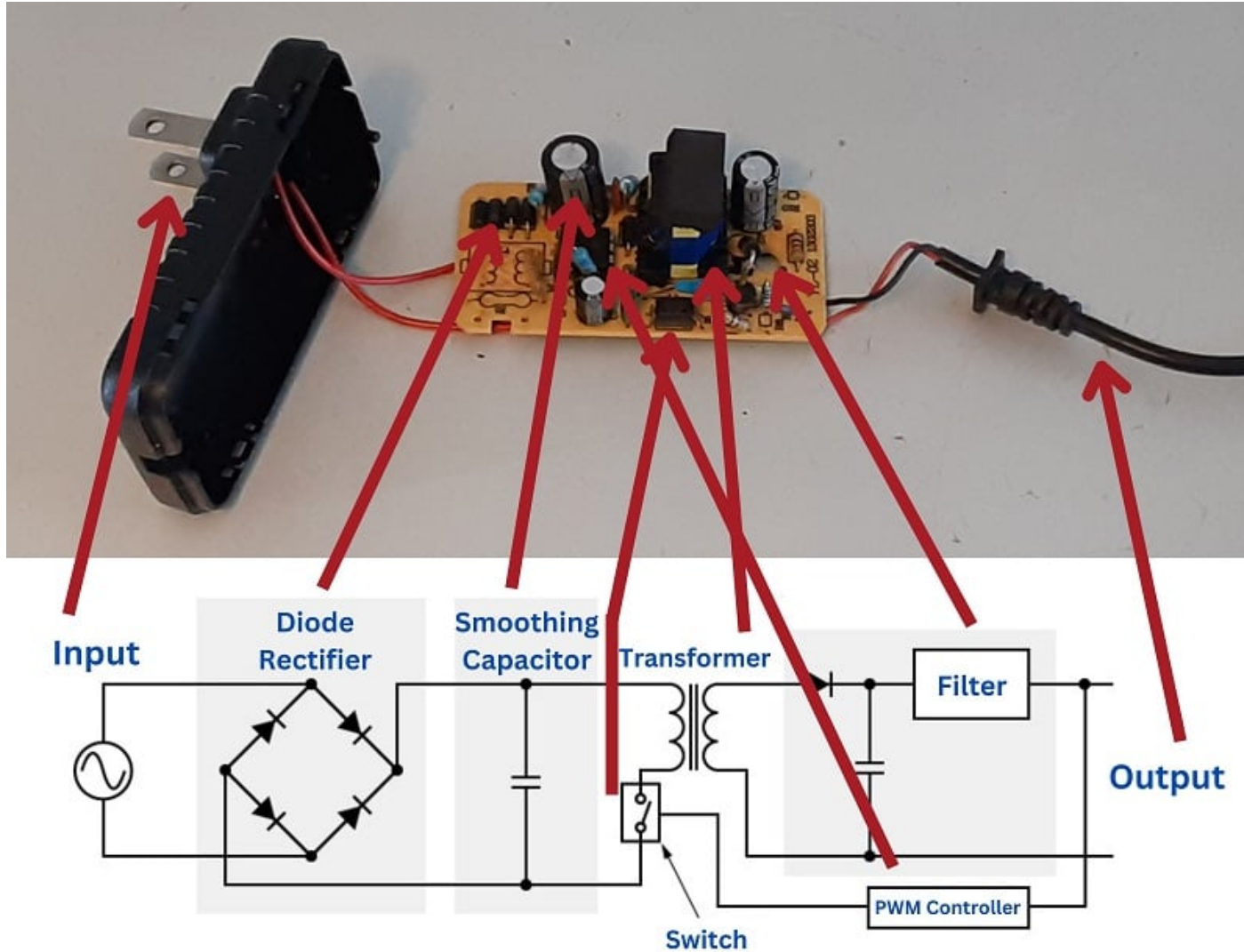
<https://www.youtube.com/watch?v=Wlh20roJiZU>

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## Stages in a Switched Mode Power Supply

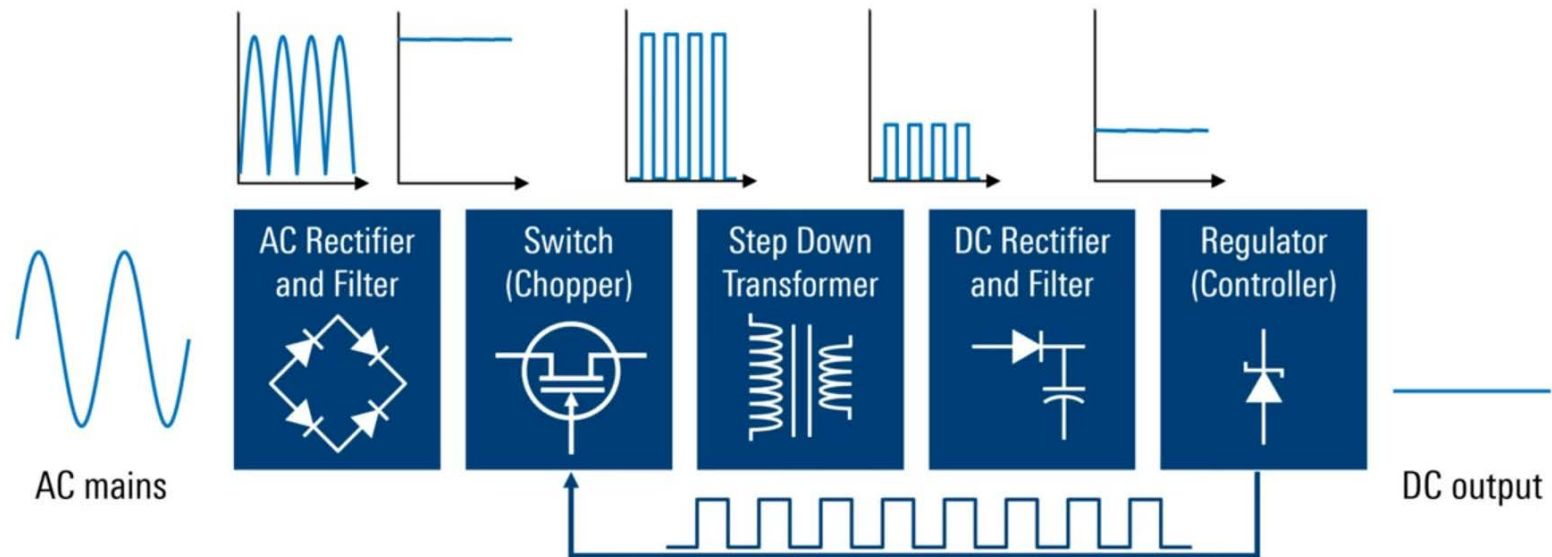


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Understanding Switching Mode Power Supplies



## Basic AC-DC SMPS block diagram



▶ 6 ▶ 3:48 / 11:38 • AC rectifier and filter > Understanding SMPS

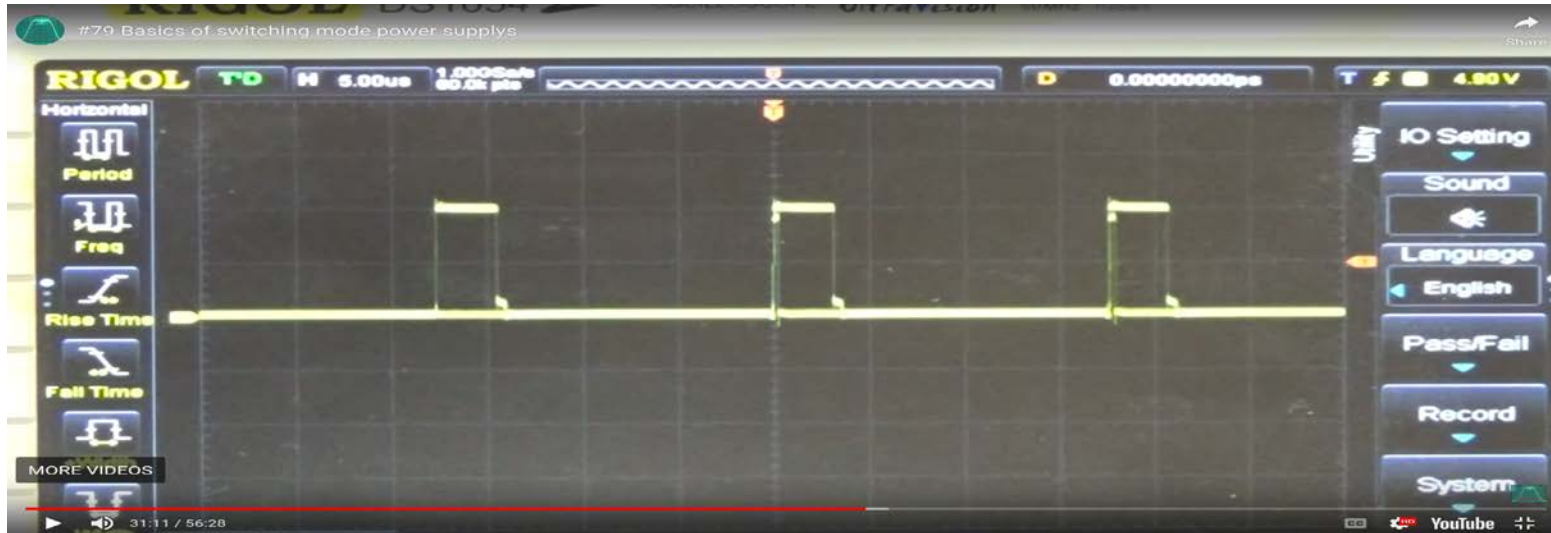
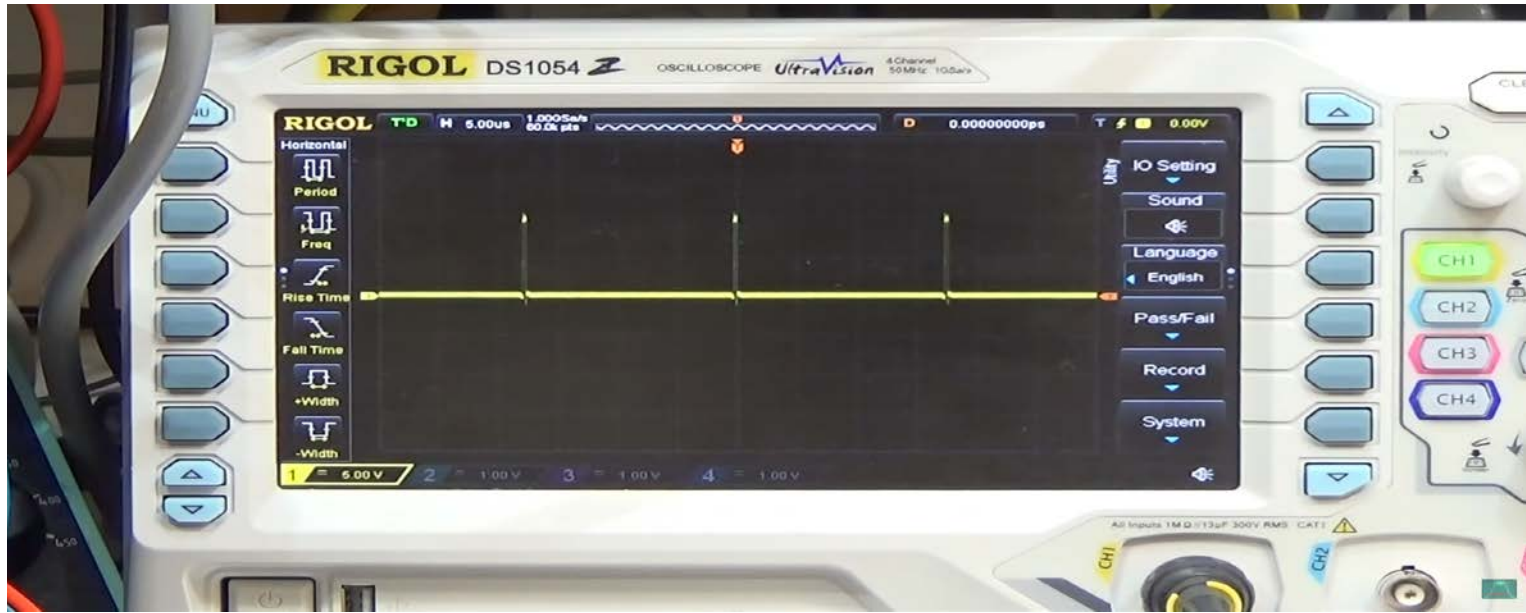
Scroll for details

ROHDE & SCHWARTZ CC Z HD



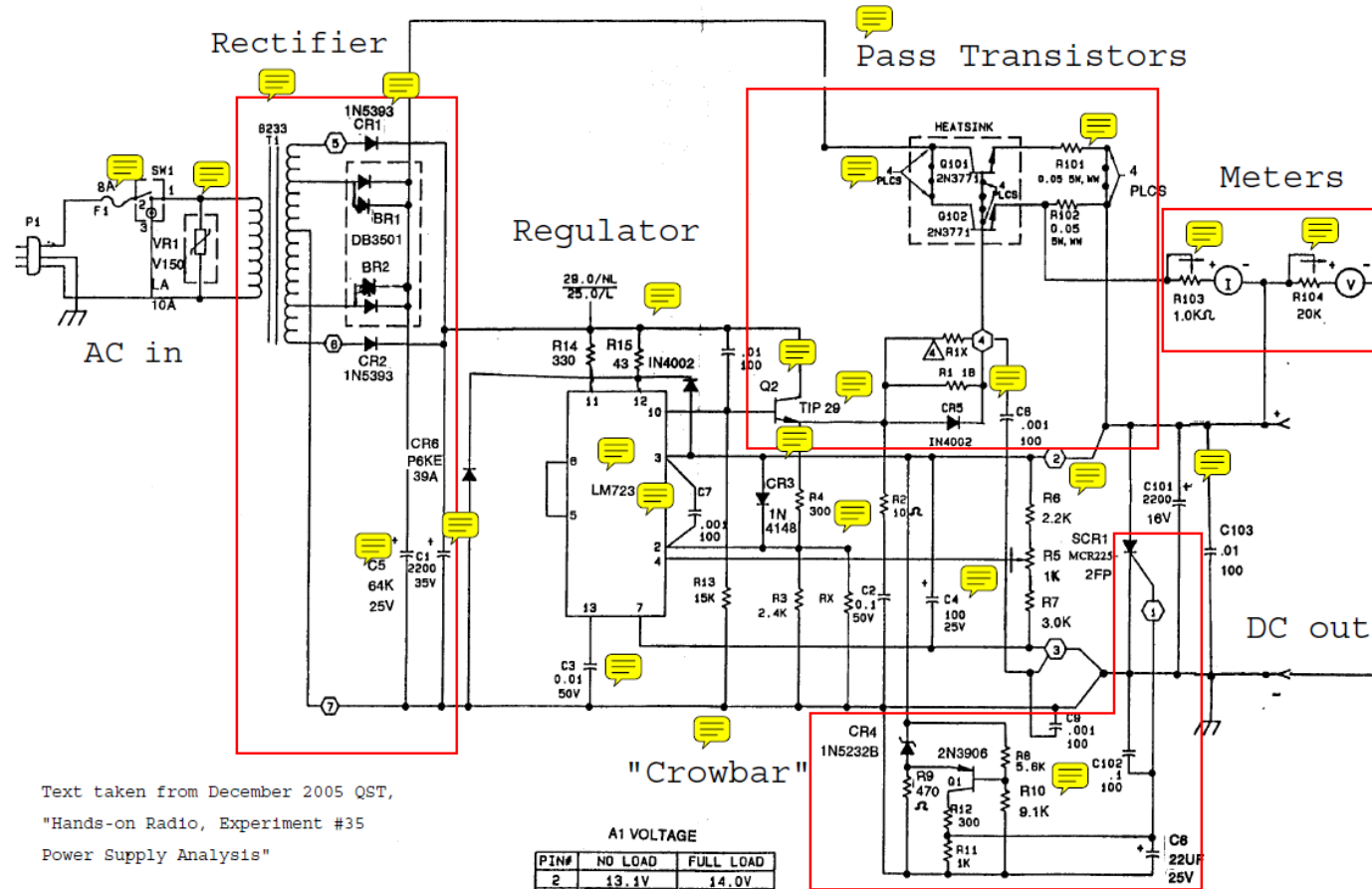
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## Loaded Switched Mode Power Supply Pulses



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## Typical Linear Power Supply (Astron RS-35M)



<b>ASTRON CORPORATION</b>	
IRVINE, CALIFORNIA	
DATE: 5-15-95	APPROVED: <i>[Signature]</i>
RS-35M/RS-35A	

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## Typical Switched Mode Power Supply (Astron SS-25M)

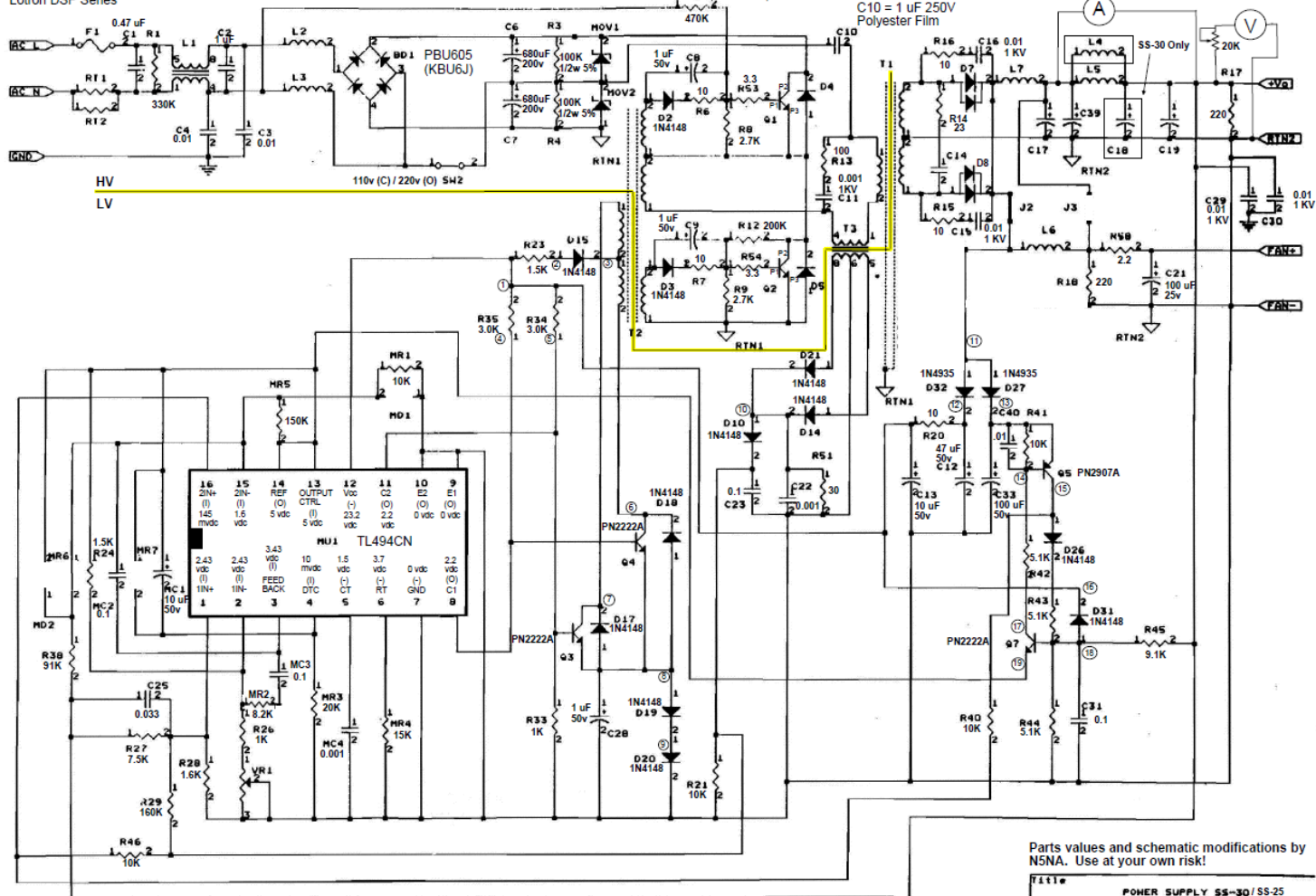
RT1 & RT2 = 5 ohm 4 amp NTC  
Thermistor Inrush Current Limiter  
Lotron DSP Series

MOV1, MOV2 = Z151-03UL

Q1, Q2 = 2SC2625  
D4, D5 = 1N4936

D7, D8 = FEP30DP  
C17, C18, C19, C39 = 3300uF, 16v

C10 = 1 uF 250V  
Polyester Film



Parts values and schematic modifications by  
N5NA. Use at your own risk!

File	POWER SUPPLY SS-30/SS-25
Size	Document Number
A3	SS30-001
Date	September 25, 2000 Sheet 1 of 1

Circled numbers correspond to the test points shown on page 2.



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**These schematics as well as other power supply schematics are from the “Repeater Builders Web” site**

<https://www.repeater-builder.com/rbtip/index.html>

**Additional Reference Papers on Switched mode power supplies:**

[https://en.wikipedia.org/wiki/Switched-mode\\_power\\_supply](https://en.wikipedia.org/wiki/Switched-mode_power_supply)

<https://www.monolithicpower.com/en/switching-power-supply>

<https://www.analog.com/en/resources/technical-articles/switch-mode-power-supply-basics.html>

<https://www.analog.com/en/resources/technical-articles/switch-mode-power-supply-basics.html>

<http://www.arrl.org/news/switching-power-supplies-a-more-common-noise-source-than-power-lines-arrl-lab-manager-says>

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## Examples of RFI

**The following is a case study at my location caused by something at my next-door neighbor's house ~60 feet from my antenna. He wouldn't help determine the noise.**

- **Broad Band RFI Scope Pictures**
- **Switched Mode Power Supply Scope Pictures**

**The following two pictures are screen captures of an ICOM IC-7610.**

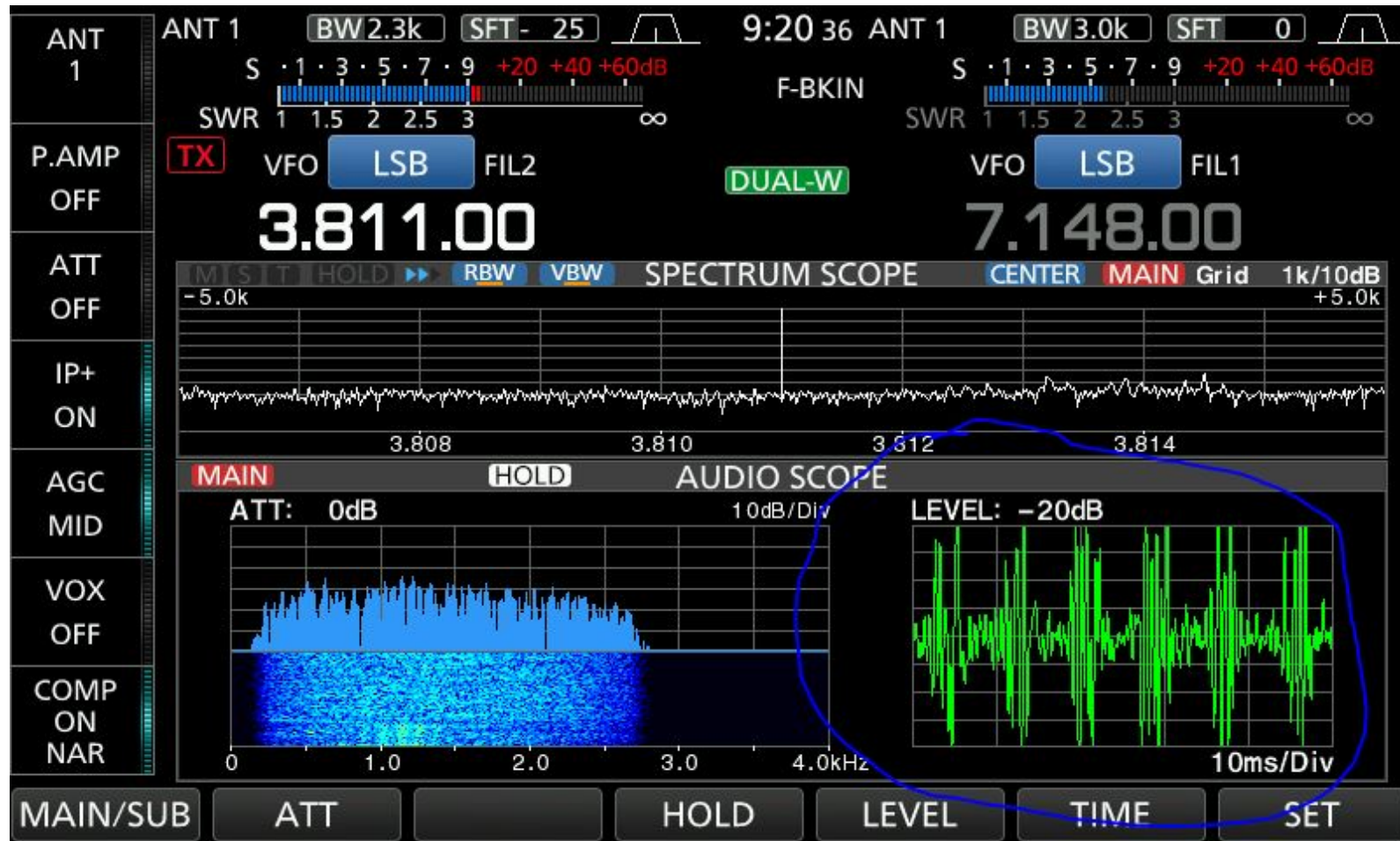
**There are three oscilloscope pictures contained within each screen capture.**

**The top scope is the RF spectrum. The bottom left is the audio spectrum waterfall of the demodulated audio. The bottom right is the demodulated real time audio signal. The bottom right is the visual picture of what you are hearing.**

**(See notes at the end of the presentation about using other equipment to determine what you are hearing.)**

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## Broadband RFI Noise

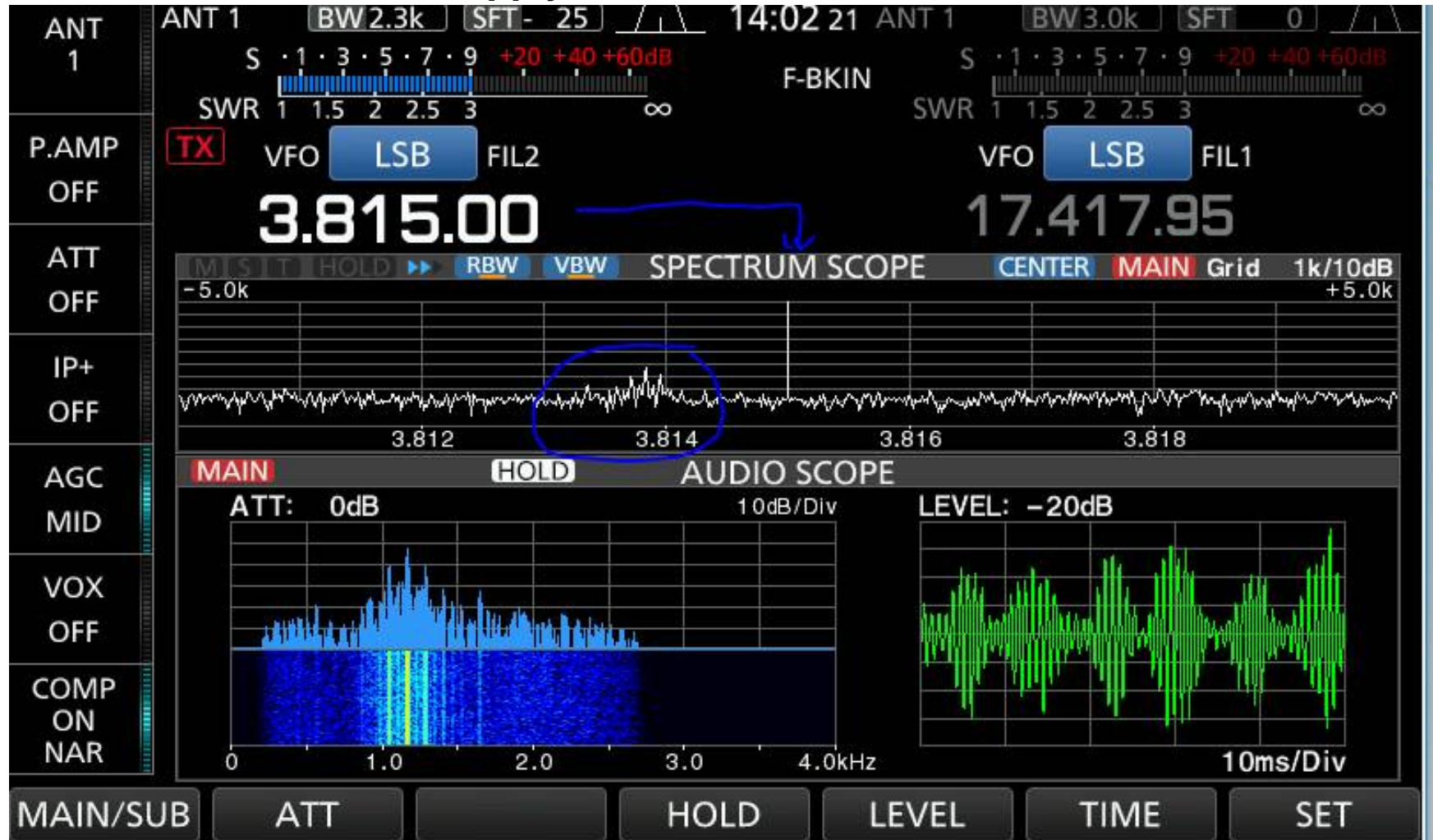


The Vertical and Horizontal scales per division are shown for each scope picture

The Broadband signal is an S9+. The real time scope (blue circle) shows 120 Hz spikes. Distance between spikes is ~8 ms = 120 Hz.

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## Switched Mode Power Supply Noise



The RF spectrum plot shows a switched mode power supply (Blue Circle).

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This noise hump repeats itself every 10 KHz (not shown) between ~3 MHz to ~21 MHz. This indicates the PWM oscillator is also at ~10 KHz.

The six spikes out of the noise are the pulse width modulator spectrum garbage.

They are probably microprocessor controlled. The controller is controlling the duty cycle of the square wave pulses, which in turn regulates the voltage and current out of the power supply.

The real time scope shows the six spikes AM modulating each other in some fashion.

### Wave File

Attached to this presentation (in the ZIP file) is the WAV formatted audio recording of the Switched mode supply you see shown in the scope pictures.

You will need an audio program to hear the WAV file.

Most PCs have at least one sound file player that will decode WAV files

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Other SDR receivers may be used to view similar scope pictures shown by the IC-7610. The IC-7300 shows the same data but it takes two screen captures.

I assume the Yaesu SDR transceivers allow viewing the same data similar screen captures.

Likewise, for the various Kenwood SDR transceivers.

Flex, Anan, Elad, Hermes, and USB SDRs should also work.

Non SDR receivers can be made to work with a SDR USB receiver. This will provide a spectrum scope picture when connected to the IF strip in a superheterodyne receiver.

To see the real time demodulated signals, use an oscilloscope across the speaker leads.

If you cannot view the RF spectrum, not all is lost. Alternative techniques must be used.

1. If this S Meter stays constantly at the same level as you tune across the band, you probably have broadband noise. Place an Oscilloscope across the speaker leads. If you see 60 Hz or 120 Hz spikes as shown in the IC-7610 pictures, you probably have a power issue or a noisy motor, etc...
2. If you run into a noise burst every 10 KHz, 20 KHz, 30 KHz, etc. ...you probably have a switched mode power supply problem. Placing an Oscilloscope across the speaker leads. You will see something similar to what the IC-7610 real time scope shows.



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3. Using a portable shortwave receiver to find the source is useful. More details later.



<https://www.amazon.com/Tecsun-PL880-Conversion-Shortwave-Reception/dp/B00GJ51NVA>

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## 4. Pocket Oscilloscope (example)



<https://www.adafruit.com/product/468>

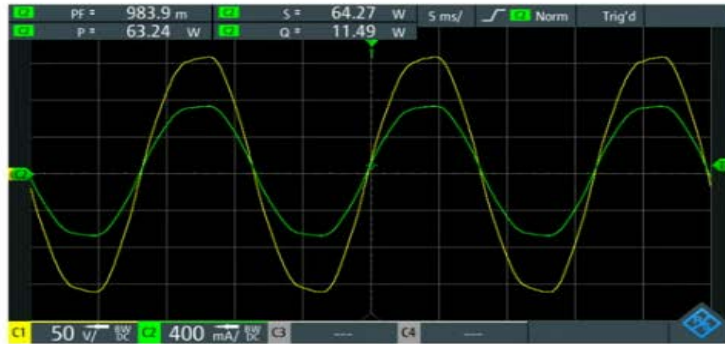
5.



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## 6. Voltage and current plot of a LED & incandescent light bulb.

### Example: incandescent vs. LED bulbs



60W incandescent bulb  
high PF (0.98), high active power (63 W)



LED bulb (60W equivalent)  
lower PF (0.56), lower active power (9 W)

The current wave form in the LED bulb show the sharp square waves (rich in harmonics) that is being drawn from the power line. In some cases, these square waves are being radiated down the power line. To avoid this radiation, filtering is require on the AC line input in the power supply within the light bulb.

A lot of the LED bulbs radiate between 50 MHz and 150+++ MHz. Transceivers with S Meters will show a rise in the noise floor when the bulbs are turned on.

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## Playing Noise Detective

1. Determine what type of noise you have. Arcing or Power Supply
2. Determine if the noise is coming from your location
  - Pull the main breaker while using a receiver on battery
  - If the noise is local, start turning off breakers to isolate the noise
3. Start roaming the neighborhood with a portable receiver
  - Using a directional antenna if possible
  - Start using a 135 MHz AM (Aircraft receiver) if necessary
  - A bad noise is more easily detectable at higher frequencies
4. Get to know your neighbors. See if they have added any new devices.
5. If you find the device elsewhere, ***Definitely DO NOT FIX IT YOURSELF!!!!!!!***
6. *Never repair someone else's equipment. It's a liability issue*