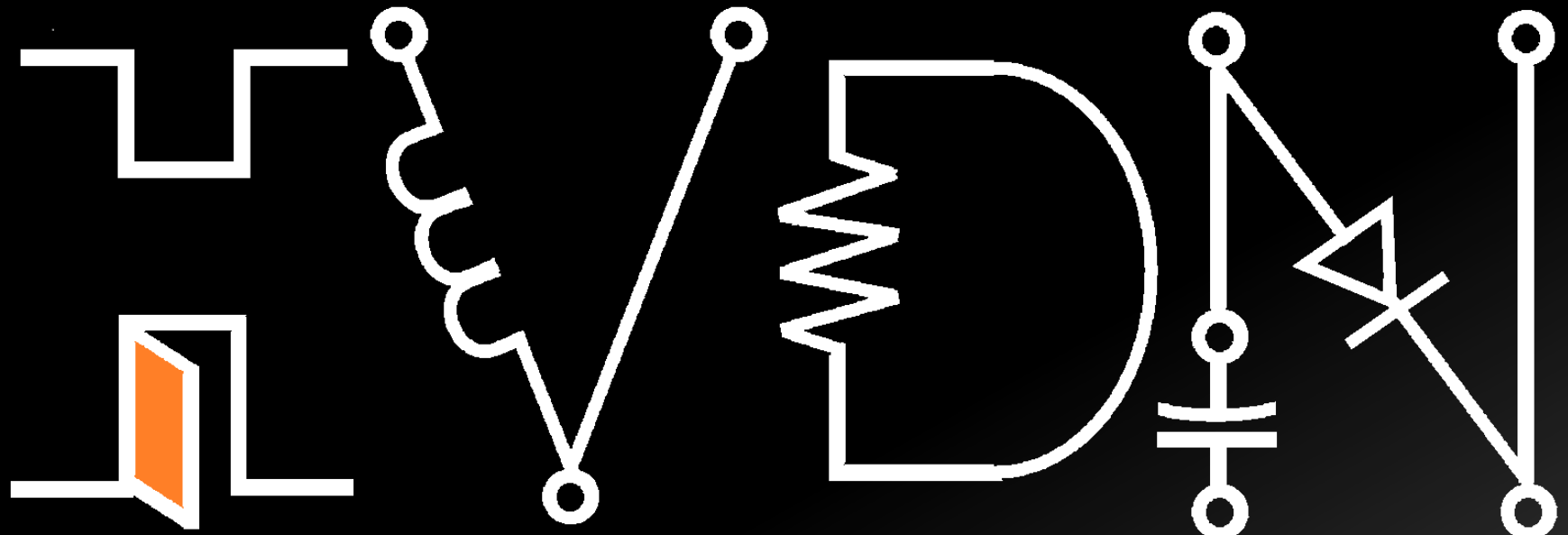

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SDR & IoT: Sensing the world around you with open source software

Presented at HV Open on November 6th 2019

About Hudson Valley Digital Network (HVDN)

Subpart A—General Provisions

§ 97.1 Basis and purpose.

The rules and regulations in this part are designed to provide an amateur radio service having a fundamental purpose as expressed in the following principles:

(a) Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications.

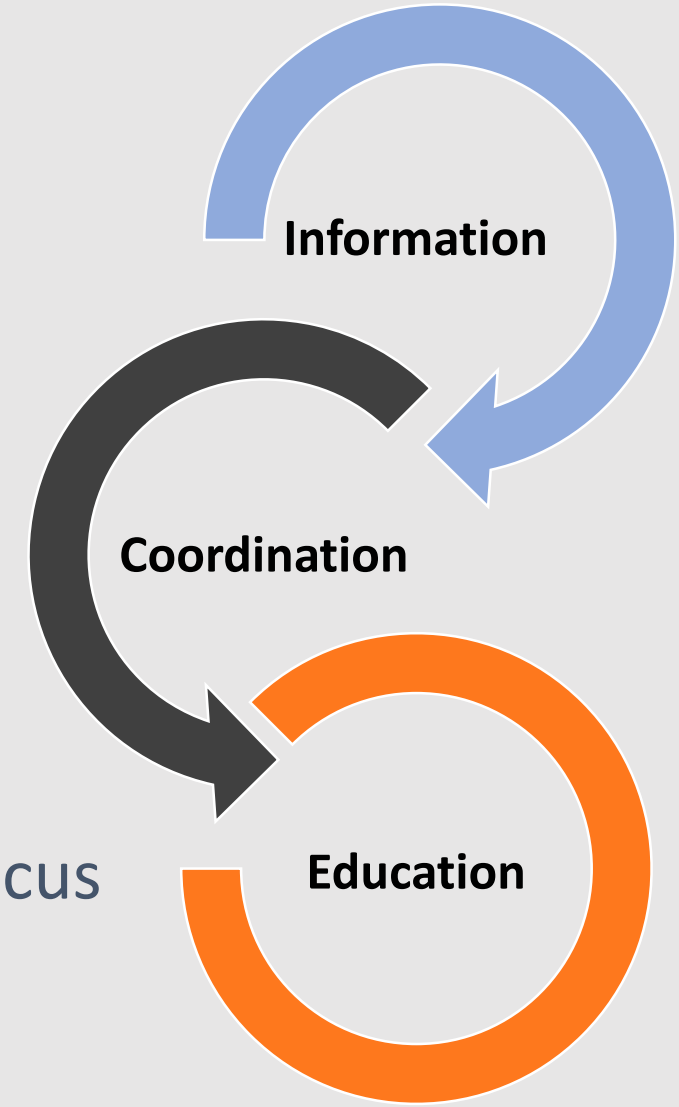
(b) Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.

(c) Encouragement and improvement of the amateur service through rules which provide for advancing skills in both the communication and technical phases of the art.

(d) Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.

(e) Continuation and extension of the amateur's unique ability to enhance international goodwill.

- HVDN founded 2017
- No, we are not "that" sort of network….
- Uphold FCC Part 97.1
- 3 pillar approach
- Deliberate modern & future focus
- Club call sign N2HVD



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The “Biography” Slide….

Steve Bossert
K2GOG, Co-Founder HVDN

Name:	Steve Bossert
First “Coding Experience”:	10 Years Old
Amateur Radio License Since:	1998 (21 Years Ago)
Hobby Funding Source:	Informa PLC
Top 3 Hobby Interests:	Hiking, Travel, Electronic Stuff
Fun Fact About Me:	Recently reviewed the Postal Service mailbox rules in detail

Presentation Overview

- What “really” is an SDR?
- SDR Basics
- SDR and IoT combined
- Open Source: SDR Software
- Found Signal/Use Case
- Doing Stuff: Replay, IFTTT and AI/ML

Presentation Goal

Demonstrate through the combined ethical use of software defined radio and open source software, illustrate converged ways different hobbies such as amateur radio, computers, makers, and electronics can be part of the "Internet of Things" by sensing the world around them.

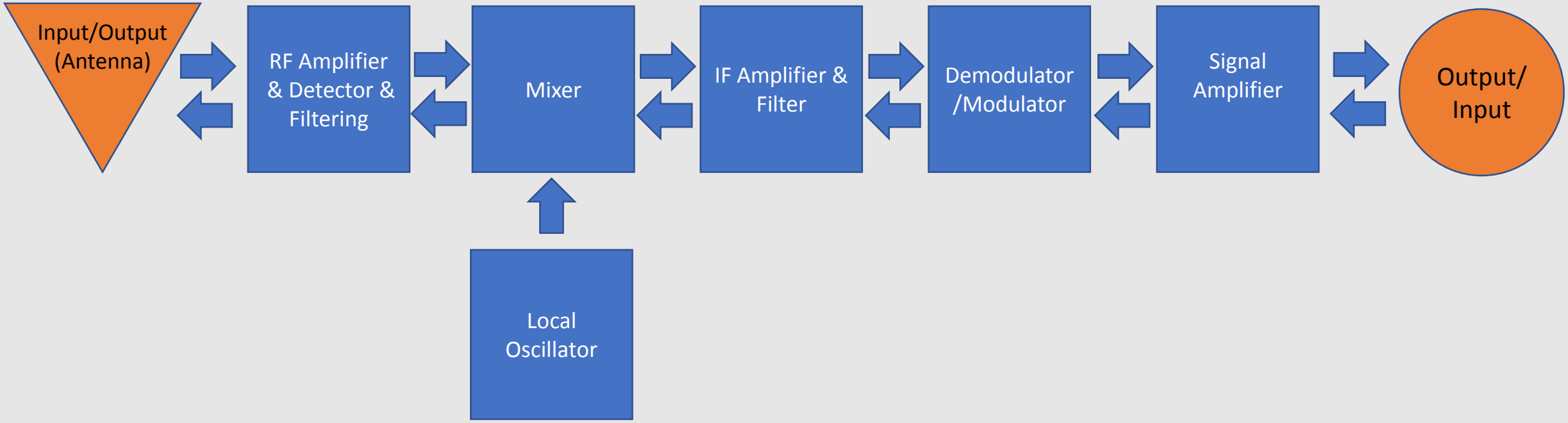
Note: At the HV Open meeting, a customized video was used in lieu of the above statement for better audience engagement

What really is an SDR?

Sound Card	Wi-Fi Card	USB Oscilloscope	USB TV Tuner	Raspberry Pi	Smartphone	Lab Transceivers
						
0 Hz to 500 kHz+	2.3 GHz to 6 GHz	0 Hz to 60 MHz+	0 Hz to 1.9 GHz+	0 Hz to 1.5 GHz+	0 Hz to ?? GHz	0 Hz to 6.0 GHz+

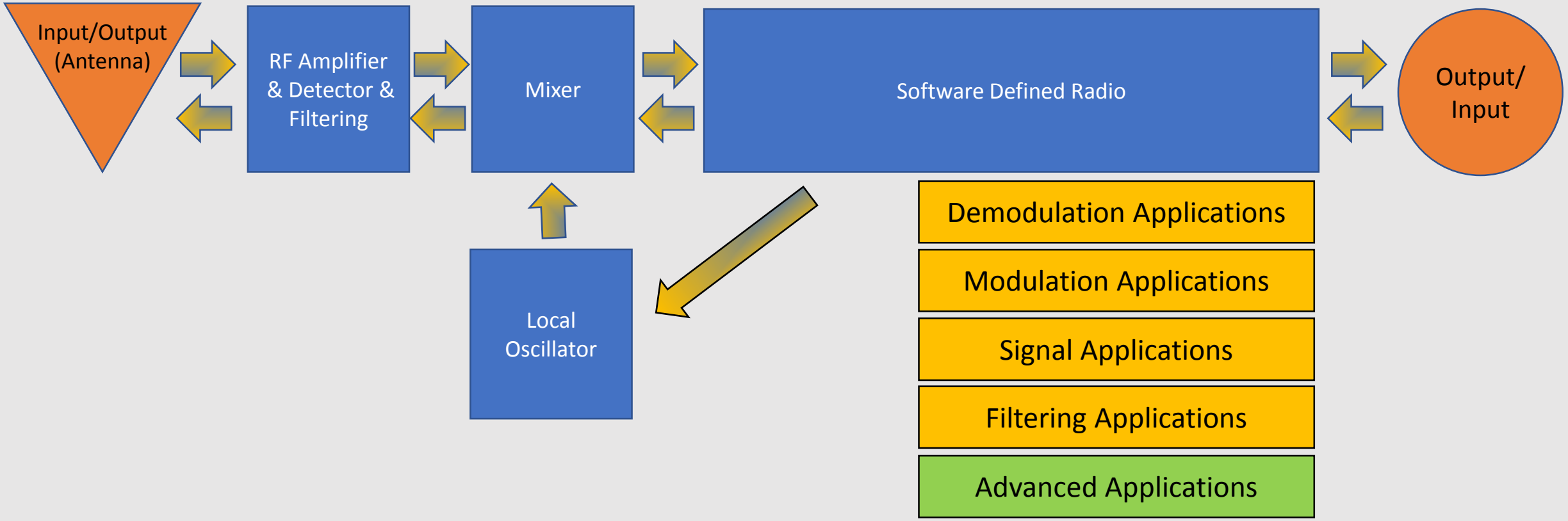
+ many more specialized and odd options too

SDR Basics: Traditional Radio Theory



Traditional Radio Systems are limited to hardware features and functionality (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) There are applications where this still have benefits when very narrow needs are required.

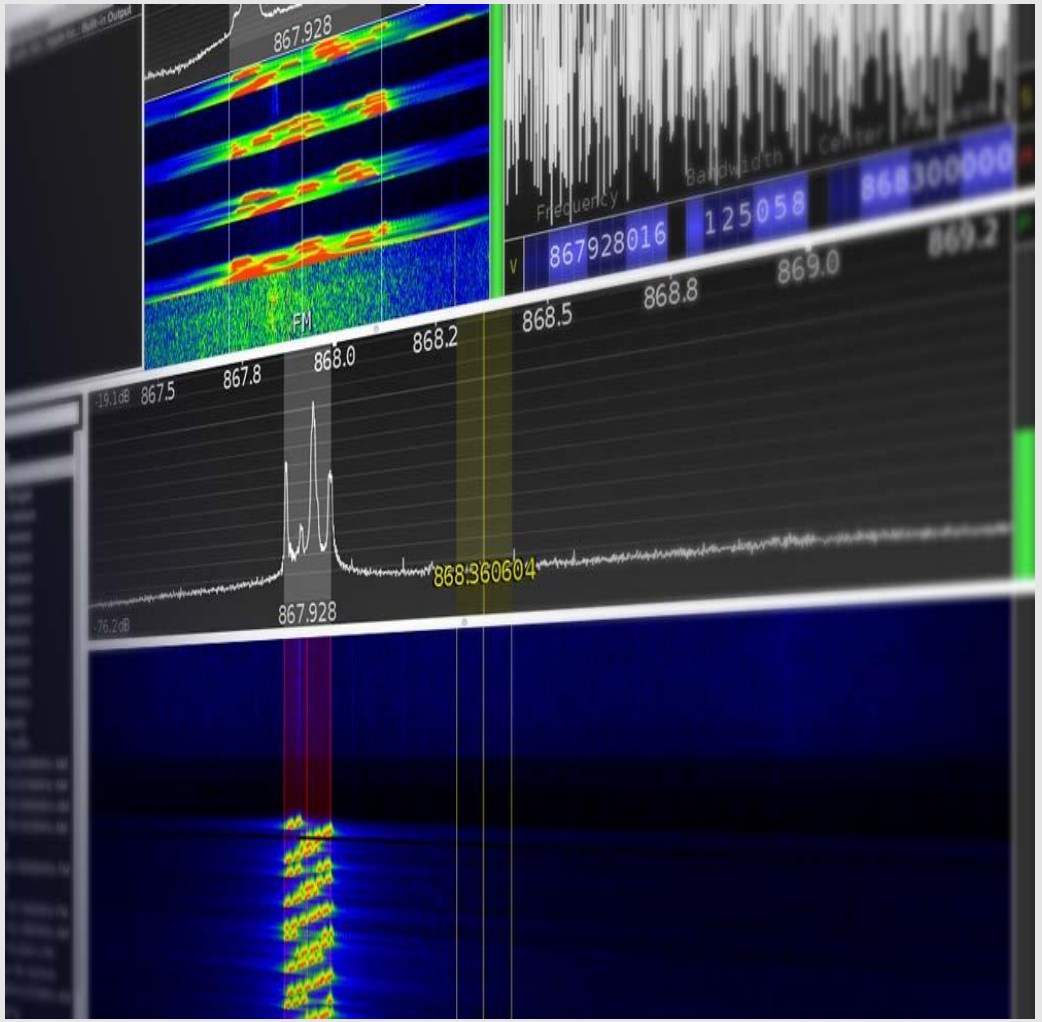
SDR Basics: New Radio Theory



Software-defined radio (**SDR**) is a radio communication system where components that have been traditionally implemented in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented by means of software on a personal computer or embedded system.

SDR and IoT combined

- “Internet of Things” devices can be found across the entire 1 to 6000+ MHz spectrum
- SDR Ethics: Not all of them are encrypted
- Many of them use proprietary software and hardware. Most are “hackable”.
- Using an SDR lets you sense, analyze and interact with the IoT world around you
- Explore simple “If this, than that” uses.



Open Source: SDR Software Summary (GUI)

GUI friendly open source options

- Many open source options currently available
- Most users start with SDR#, HDSDR and SDRuno which are not open source
- SDRangel, GNUradio and even SDR# offer much more....

Software Defined Radio Receiver Software

Application Name	Windows	Linux
	Easy Scale (Less ★ is harder)	
SDR#	★★★★★	★★
SDRangel	★★★★	★★★
HDSDR	★★★	★★
GQRX	★	★★★★
GNUradio	★	★
SDRconsole	★★★★	★★
CubicSDR	★★★	★★
SDRuno	★★★★	★★
Linrad	★★	★★
ShinySDR	★★	★★
Sodira	★★	★★★
Qtradio	★	★★

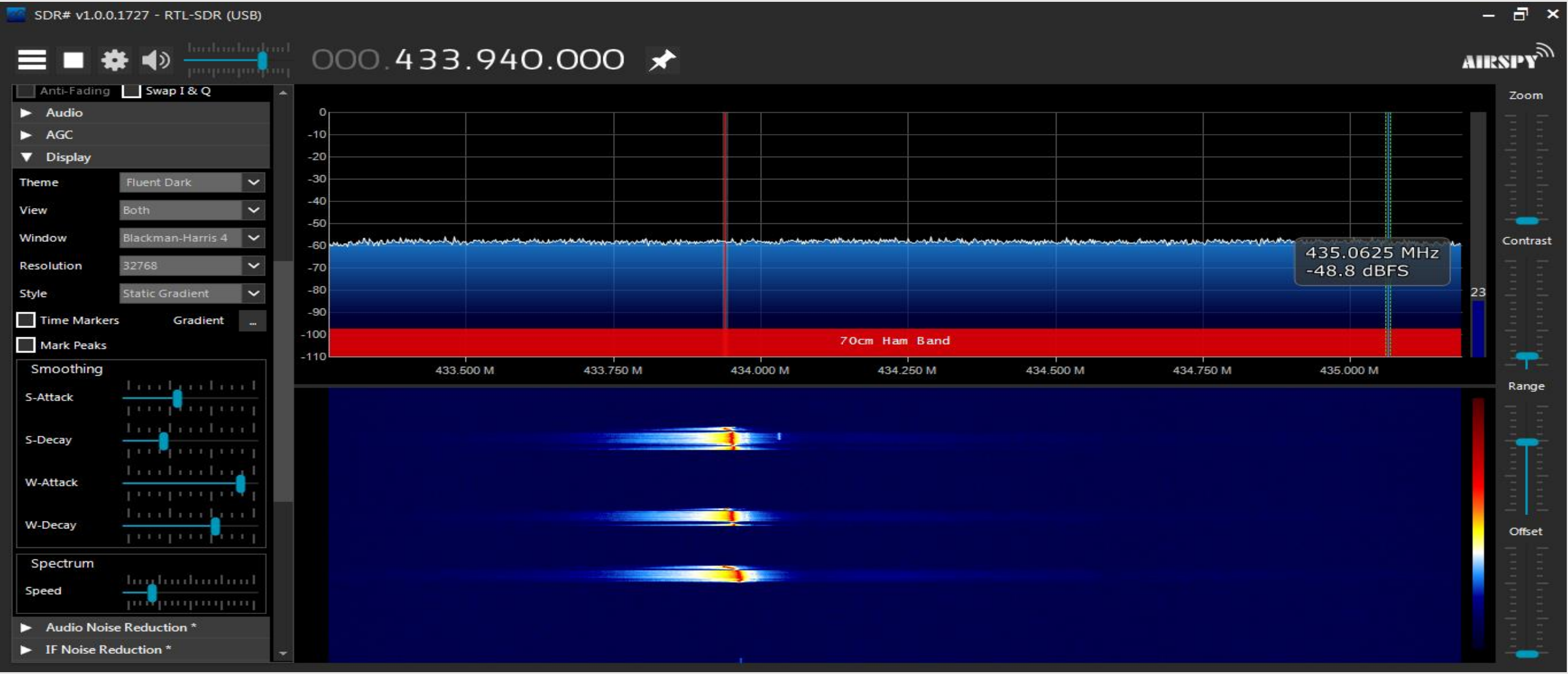
Courtesy of : hvdn.org/notebook

SDR Software: GUI Overview

The following 7 slides are photos of popular SDR software highlighted on slide 11.

These were further described/presented in the live discussion.

SDR Software: SDR# (Closed, but open plugins..)



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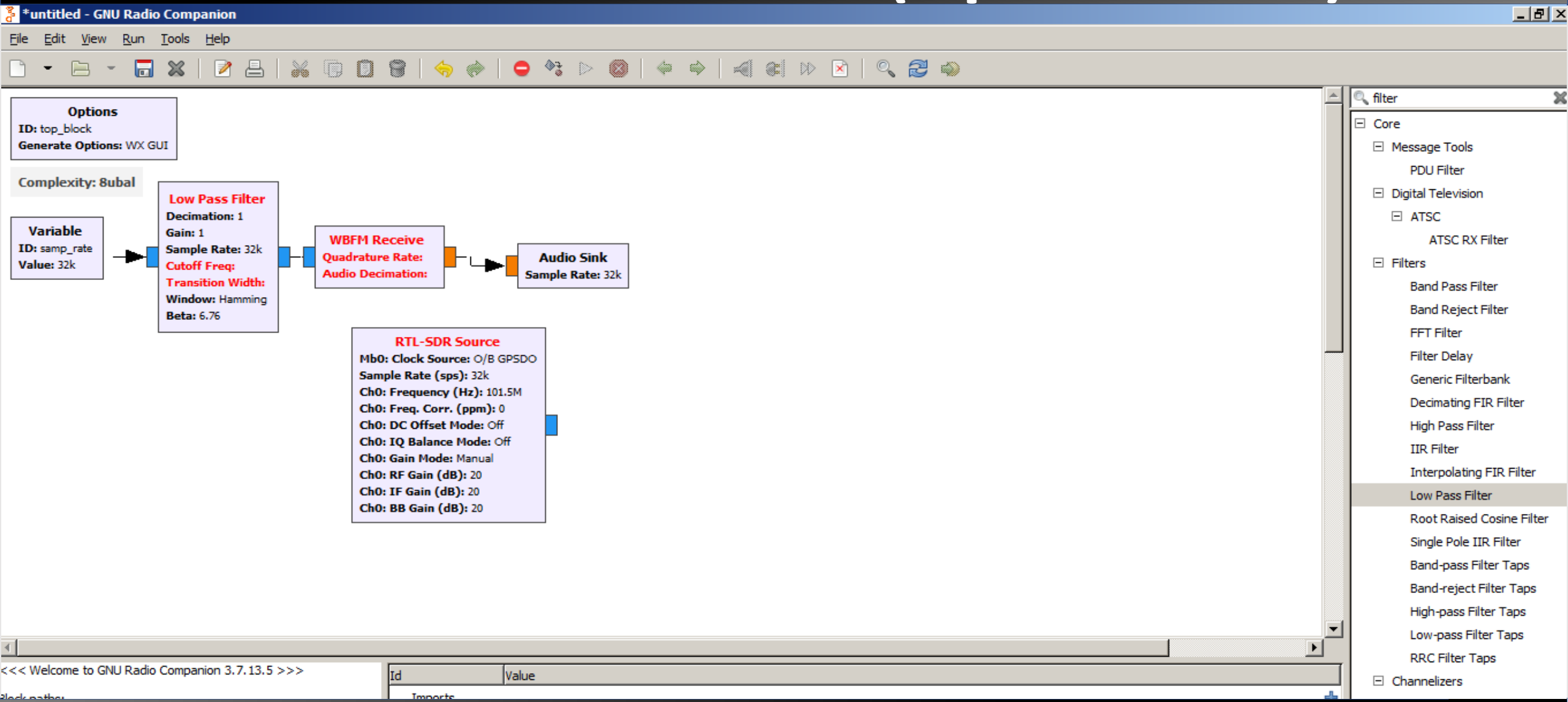
SDR Software: GNU Radio (Open Source)



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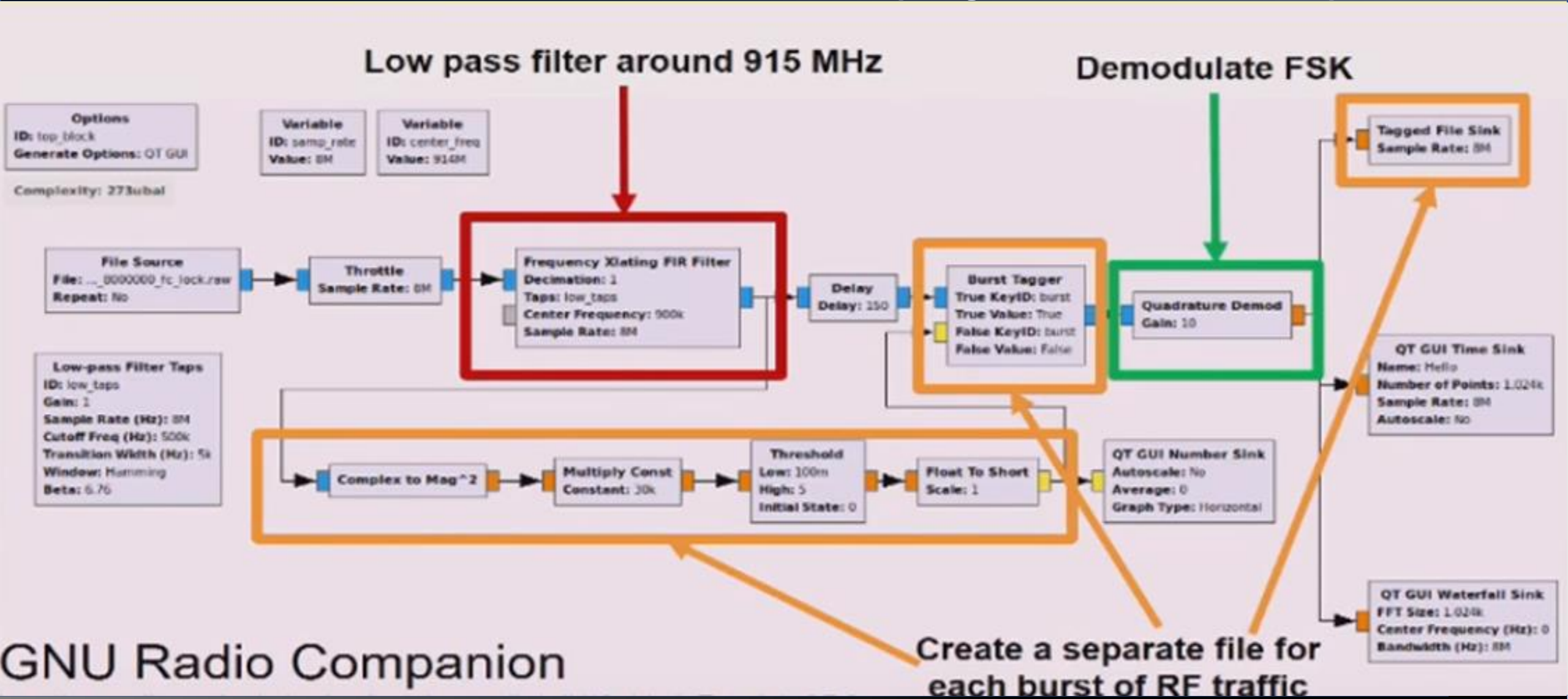
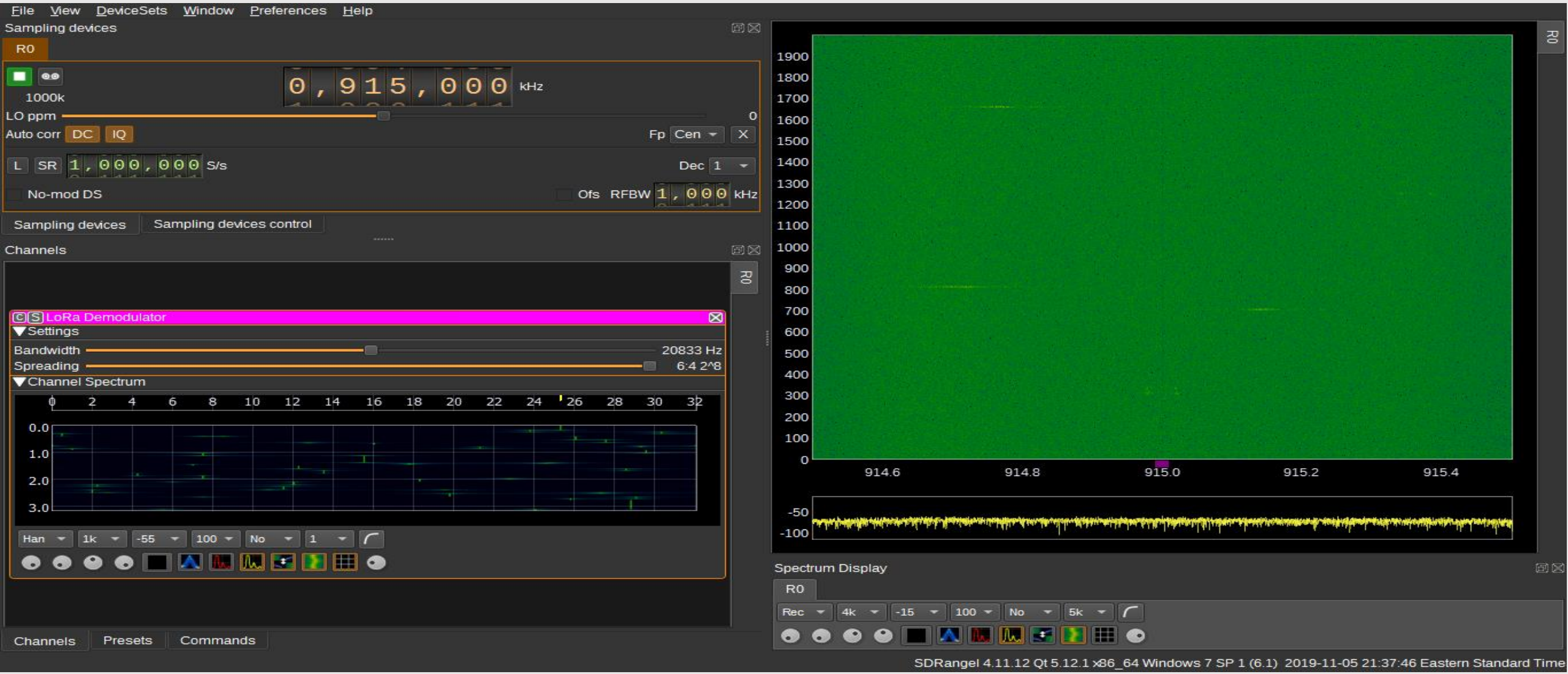
SDR Software: GNU Radio (Open Source)



SDR Software: SDRangel (Open Source)



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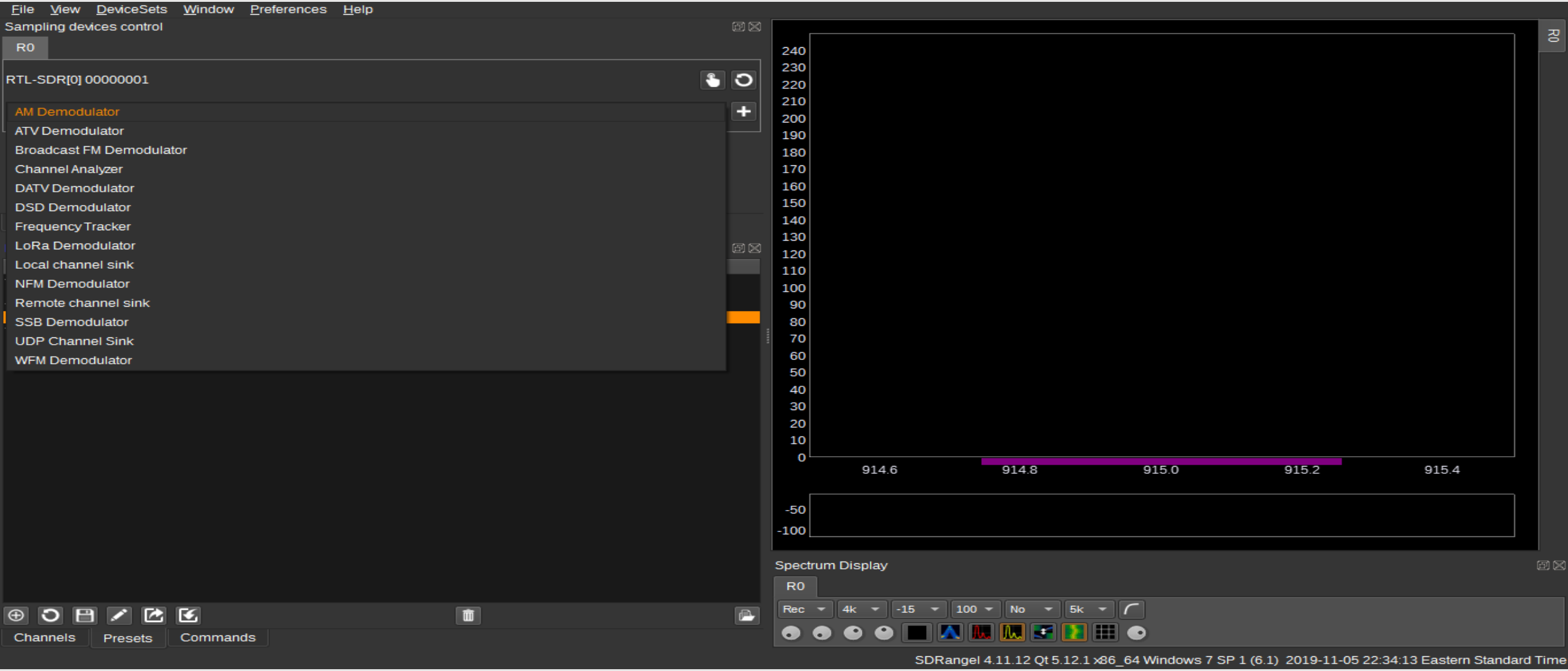
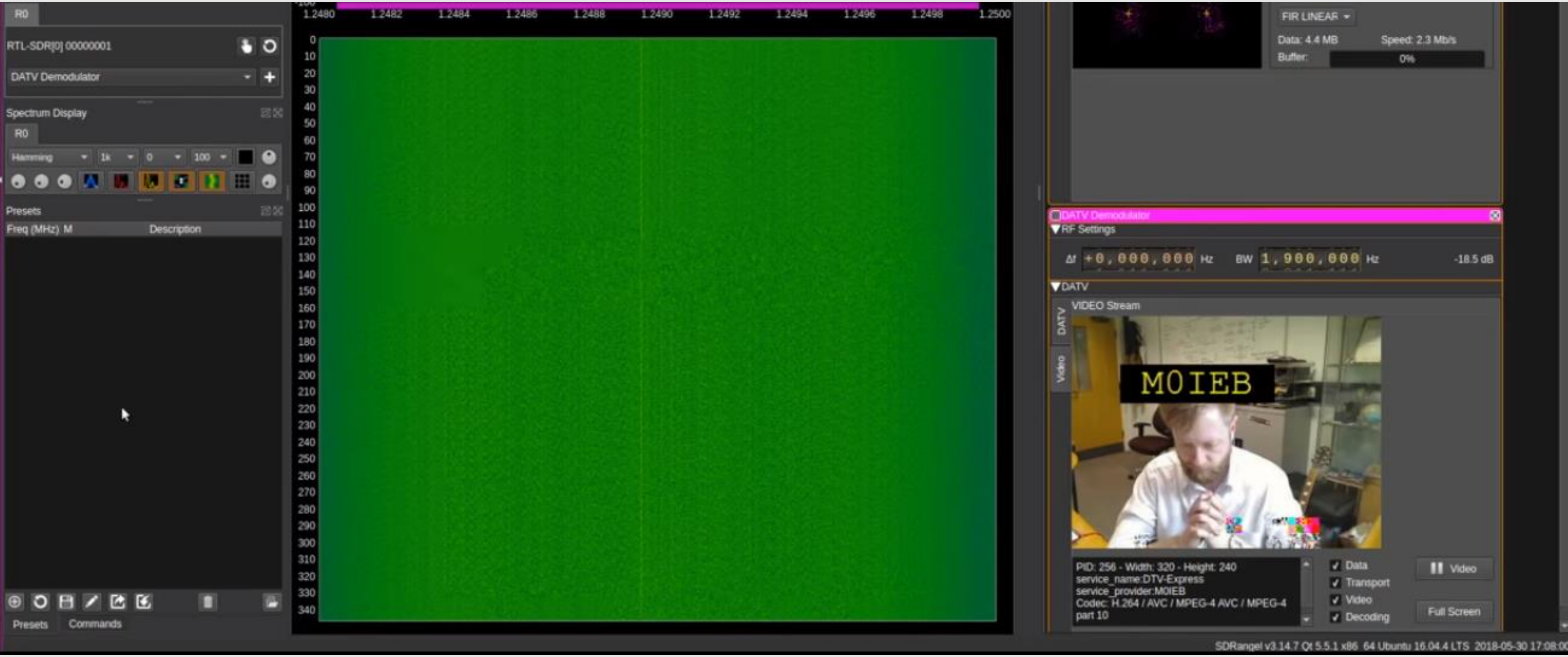
SDR Software: SDRangel (Open Source)

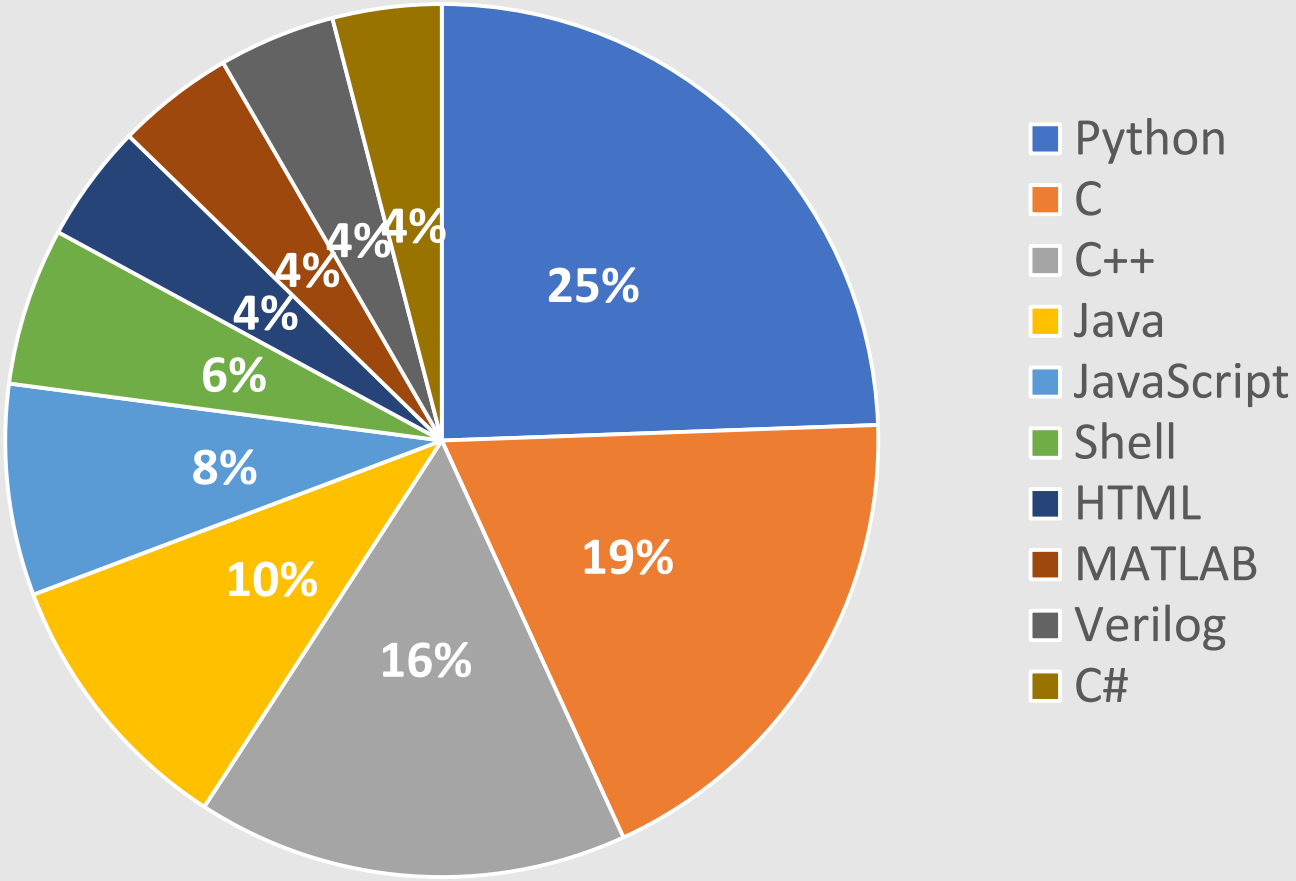


SDR Software: SDRangel (Open Source)



SDR Software Overview

By Language SDR projects on Git
(Updated - November 4th 2019)



3,600+ repositories involving SDR

Needed to receive signals + antenna

Open Source: SDR Software Summary (../)

Command line & other open source options

- Search for “SDR” on Git. Be amazed!
- Some for data, others for voice or video signals.
- rtl-sdr, RTL_433, dump1090 = 3 examples for IFTTT applications

GUI Analysis Tool Notable Mentions

- Inspectrum (Mike Walters)
- Kismet (Mike Kershaw)
- Audacity (Dominic Mazzoni/Roger Dannenberg)

SDR Software: Non-GUI Overview

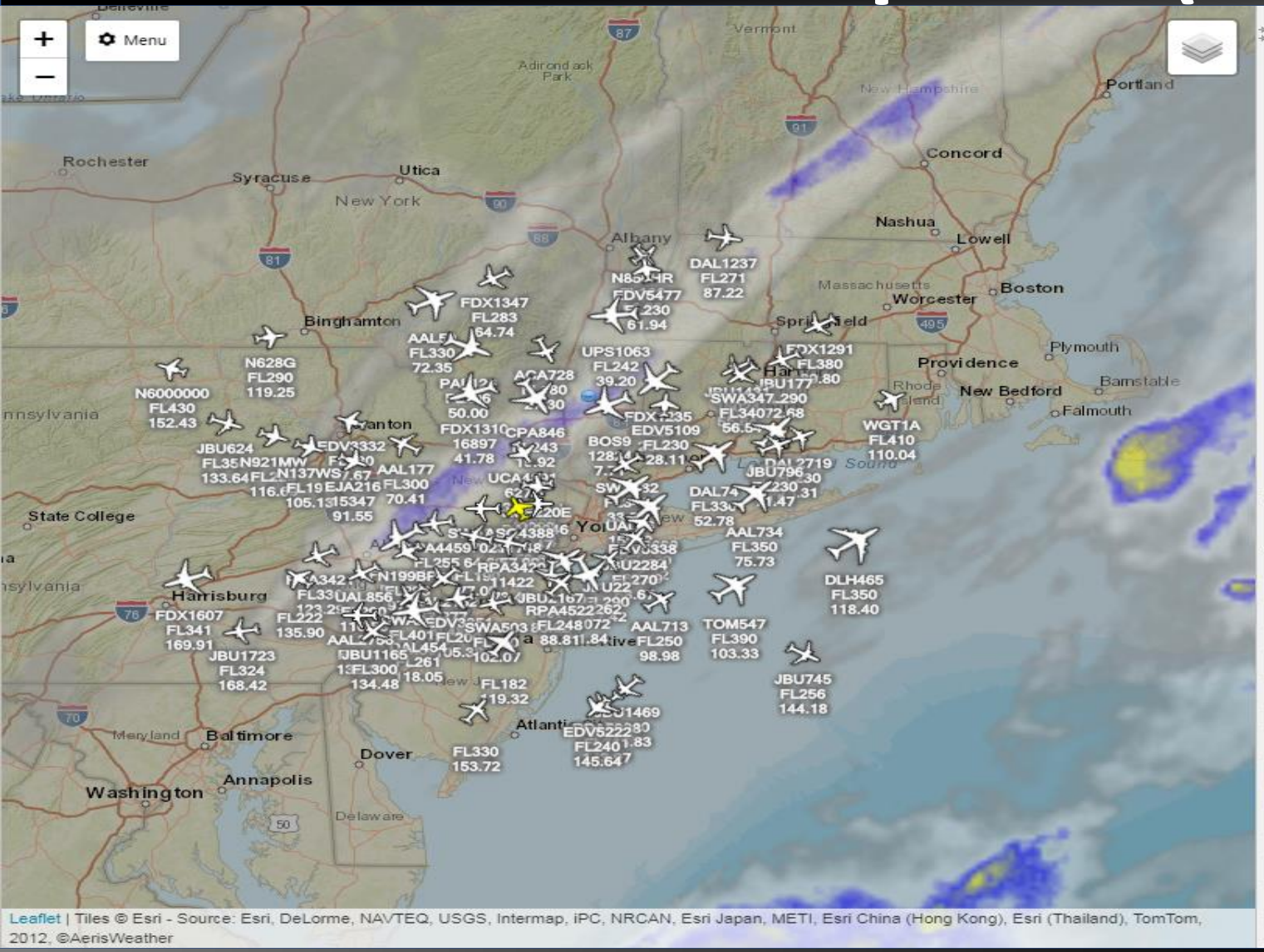
The following 6 slides are photos of popular additional SDR related software highlighted on slide 19.

These were further described/presented in the live discussion.

SDR Software: dump1090 (Open Source)

Hex	Mode	Sqwk	Flight	Alt	Spd	Hdg	Lat	Long	Sig	Msgs	Ti/
AB3D41	S			33000					7	2	0
A3D75C	S			34675					8	6	1
AB30F2	S			23000	451	349			8	4	1
A301F3	S								4	3	1
A0F869	S			7775	242	198			8	12	1
780A89	S	7404	CPA846	28650	486	113	41.953	-74.691	10	65	0
A368C2	S		FDX1310	6825	249	318			9	16	4
A1E6B9	S	3536	SWA782	34000	350	234			9	85	1

SDR Software: dump1090 (output into VRS)



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SDR Software: dump1090 (output to MilSpot)

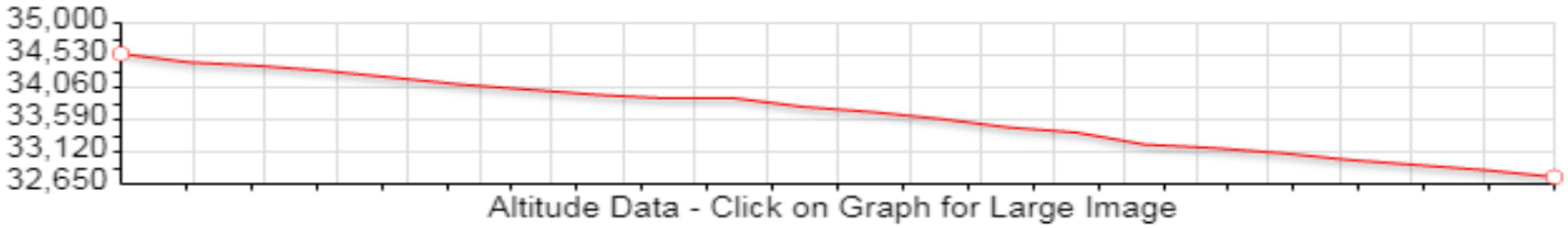
Telemetry for Aircraft Currently Being Received

Details

Hex Code: AE1172
Call Sign:
Altitude: 32750
Type: C-17A - C17
BuNos: 02-1100
First Seen: 21:38:02
Home Base: MEMPHIS INTL - MEMPHIS - TN

Receiver Location:
POUGHKEEPSIE, NY
Updated: 7 secs. ago
User: TN ANG 164AW
155AS [KMEM]

Altitude Profile



Last Seen (UTC)	HEXCODE	Altitude	Call Sign	Squawk	Aircraft BuNos	Aircraft Type & Operator	Receiver Location	Msgs Rcvd
11/06/19 21:39:27 (First Seen: 21:38:02)	AE1172	32750 ▼			02-1100	C-17A - C17 - TN ANG 164AW 155AS [KMEM] Home Base: MEMPHIS INTL - MEMPHIS - TN	POUGHKEEPSIE, NY	23
11/03/19 03:08:33 (First Seen: 02:49:55)	AE08CF	28650 ▼	RCH417	5613	00-0185	C-17A - C17 - USAF 3WG 517AS [PAED] Home Base: RED DOG - RED DOG AK -	POUGHKEEPSIE, NY	352
11/03/19 02:39:22 (First Seen: 02:23:51)	AE1457	34000	RCH527		05-5153	C-17A - C17 - USAF 15WG 535AS [PHIK] Home Base: HICKAM AFB BASE OPS - HONOLULU - HI	POUGHKEEPSIE, NY	89
11/03/19 02:32:36 (First Seen: 02:19:19)	AE0425	36975	BLUE21	6516	60-0342	KC-135T - K35R - USAF 92ARW [KSKA] Home Base: FAIRCHILD AFB - SPOKANE - WA	POUGHKEEPSIE, NY	163
10/21/19 00:52:01 (First Seen: 00:27:35)	AE0580	35000	RCH614	1020	87-0035	C-5M - C5 - USAF 436AW 9AS [KDOV] Home Base: DOVER AFB - DOVER - DE	POUGHKEEPSIE, NY	148
10/20/19 23:28:08 (First Seen: 23:05:49)	AE20C7	13650 ▼	RCH803		07-7186	C-17A - C17 - USAF 437AW [KCHS] Home Base: CHARLESTON AFB/INTL - CHARLESTON - SC	POUGHKEEPSIE, NY	
						KC-10A - DC10 - USAF 305AMW [KWRI]		

Top

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SDR Software: rtl_433 (Open Source)

```
Using device 0: Generic RTL2832U OEM
Found Rafael Micro R820T tuner
Exact sample rate is: 250000.000414 Hz
Sample rate set to 250000.
Bit detection level set to 0 (Auto).
Tuner gain set to Auto.
Reading samples in async mode...
Tuned to 433920000 Hz.
2019-11-05 22:36:19 :    Nexus Temperature/Humidity
        House Code:       147
        Battery:          OK
        Channel:          1
        Temperature:      8.80 C
        Humidity:         17 %
2019-11-05 22:36:37 :    Generic Remote
        House Code:       45523
        Command:          25
        Tri-State:        !10F1F010F!F
2019-11-05 22:36:37 :    Generic Remote
        House Code:       45523
        Command:          25
        Tri-State:        !10F1F010F!F
2019-11-05 22:36:37 :    Generic Remote
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2019-11-05 22:36:37 :    Generic Remote
        House Code:       45523
        Command:          25
        Tri-State:        !10F1F010F!F
2019-11-05 22:36:37 :    Generic Remote
```

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SDR Software: rtl433_influx + Grafana (Open Source)

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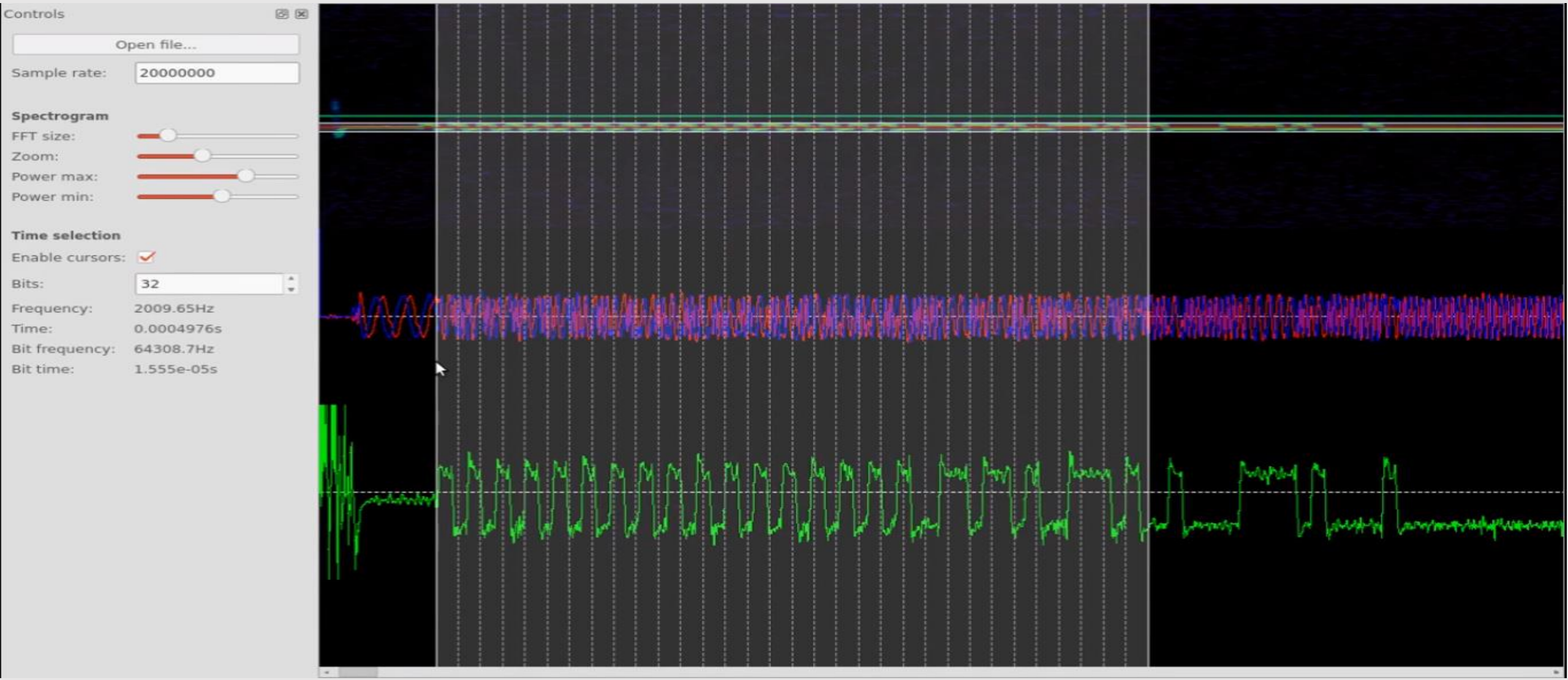
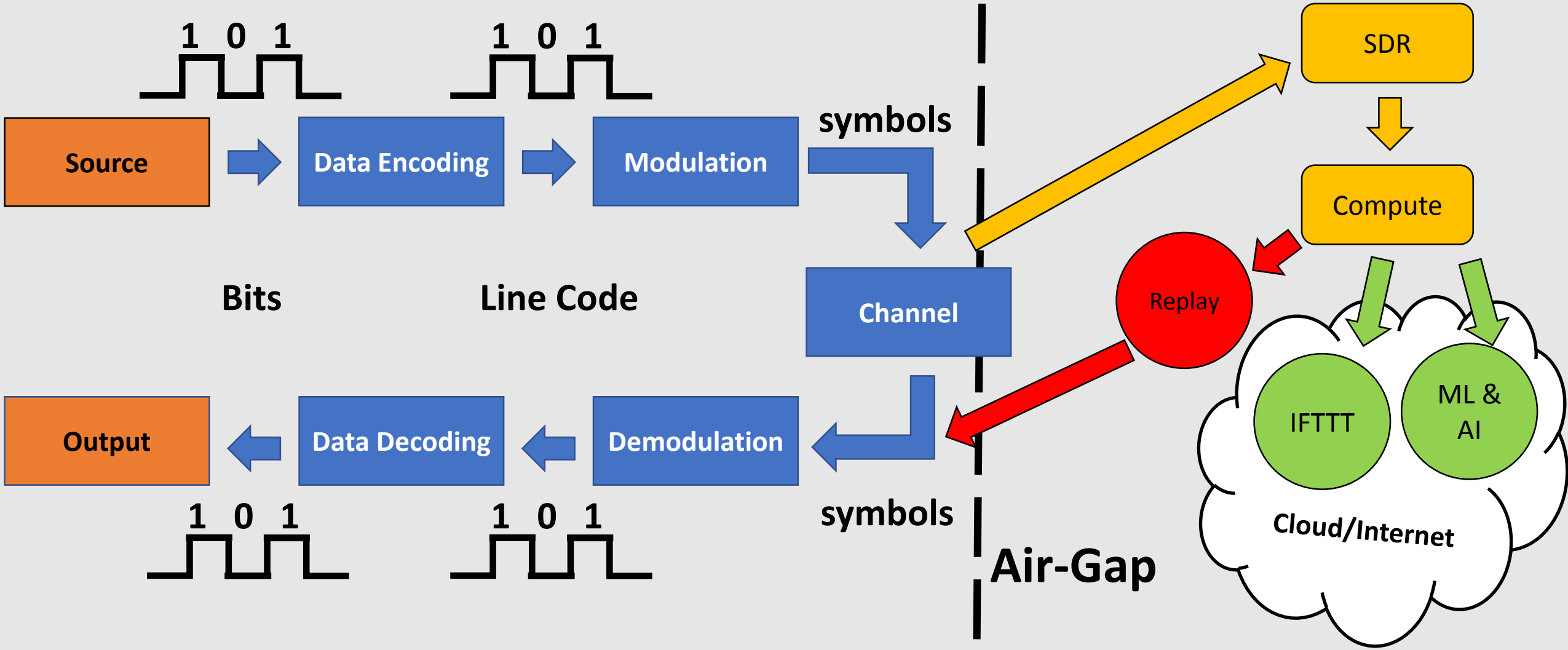
SDR Software: Inspectrum (Open Source)



Doing Stuff: First Understand Signals & Bits



Found Signal/Use Case: Review

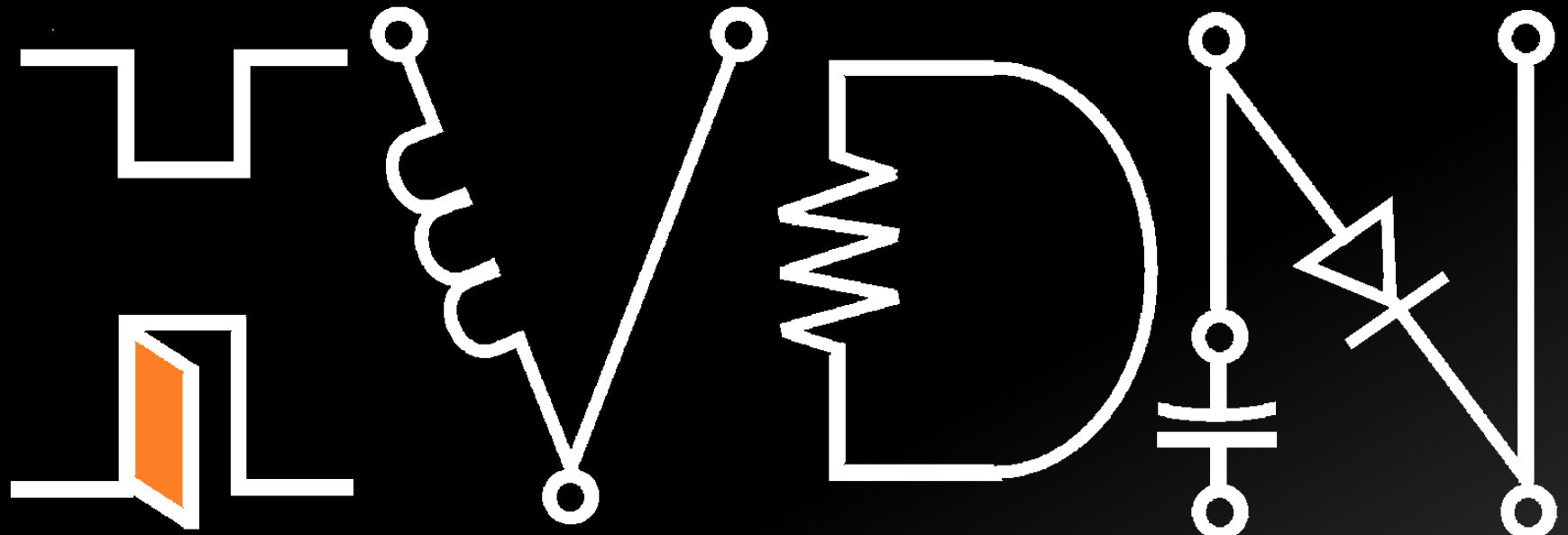
- Step 1: Capture
  - Baseband, Audio or IQ Recording
  - Examples: SDR# & SDRangel
- Step 2: Analyze
- Step 3: Research Source
- Step 4: Research Signal
  - Center Frequency & Modulation Method
  - FSK Deviation & Bit Timing
  - Data encoding method (Manchester, etc.)
  - Symbol Rate & Symbol Time
  - Examples: Inspectrum, Audacity, SDRangel
- Step5: Replay, IFTTT, ML/AI
  - GNU Radio, MQTT/Mosquito, etc
  - Observe ethics in your next steps

Found Signal/Use Case: Examples

Car remotes
Temperature sensors
Amateur radio hotspots
Pagers
Weather stations
Door alarms
RFID
Loss Prevention Devices
Industrial Control
Water spill alarm
Tire Pressure (TPMS)
Water meters
Smoke alarms
Toys
Security devices
Aircraft
Satellites
Environmental sensors

SDR Software: Capture & Playback (RX)

A live demonstration of a remote SDR connected to an OpenWRT router using rtl_tcp was demonstrated. Examples included receiving an FM broadcast, decoding RDS information, sensing and decoding433 MHz IoT sensors and recording IQ files and playing them back for later analysis



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