



Space Weather Station Project



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SDR Hardware Capabilities

- \$20 RTL-SDR not the best choice for HF
 - 8 bit analog-to-digital converter limits dynamic range
 - But can do >2 MHz bandwidth
 - Latest RTL-SDR.com v3 has TCXO, covers to <100 kHz
 - N1GP rtl_hpsdr on Raspberry Pi allows multiple dongles to appear on ethernet as a single HPSDR radio
- Hermes/Mercury/Anan have 14 or 16 bit ADC
 - Superb dynamic range
 - Multiple 384 kHz virtual receivers
 - Can't do wider sample rates due to firmware architecture



SDR Hardware Capabilities

- Red Pitaya has dual 14 bit ADC for <\$300
 - HPSSDR emulation with 8 virtual receivers
 - 2.5 MHz bandwidth with native driver
 - High-impedance antenna input is (fixable) challenge
 - External frequency reference, but at 125 MHz
 - Internal reference pretty wobbly
 - Possible digital noise issue (being explored)



Wideband Data Recording

- The Eclipse experiment proved (to me, at least) the value of recording RF data rather than trying to analyze it in real time.
 - It's neat to take multiple passes through the band to look at different aspects.
 - Much less stress when you don't have to get it right the first time!
- Storage capacity now only a minor issue.
 - 4TB USB3 drive now ~\$100
 - 384 kHz recording uses about 270 GB/day (96 kHz about 67.5)
 - Record continuously and replace oldest data with newest. Archive when something interesting happens.
 - (Data does **not** compress well)

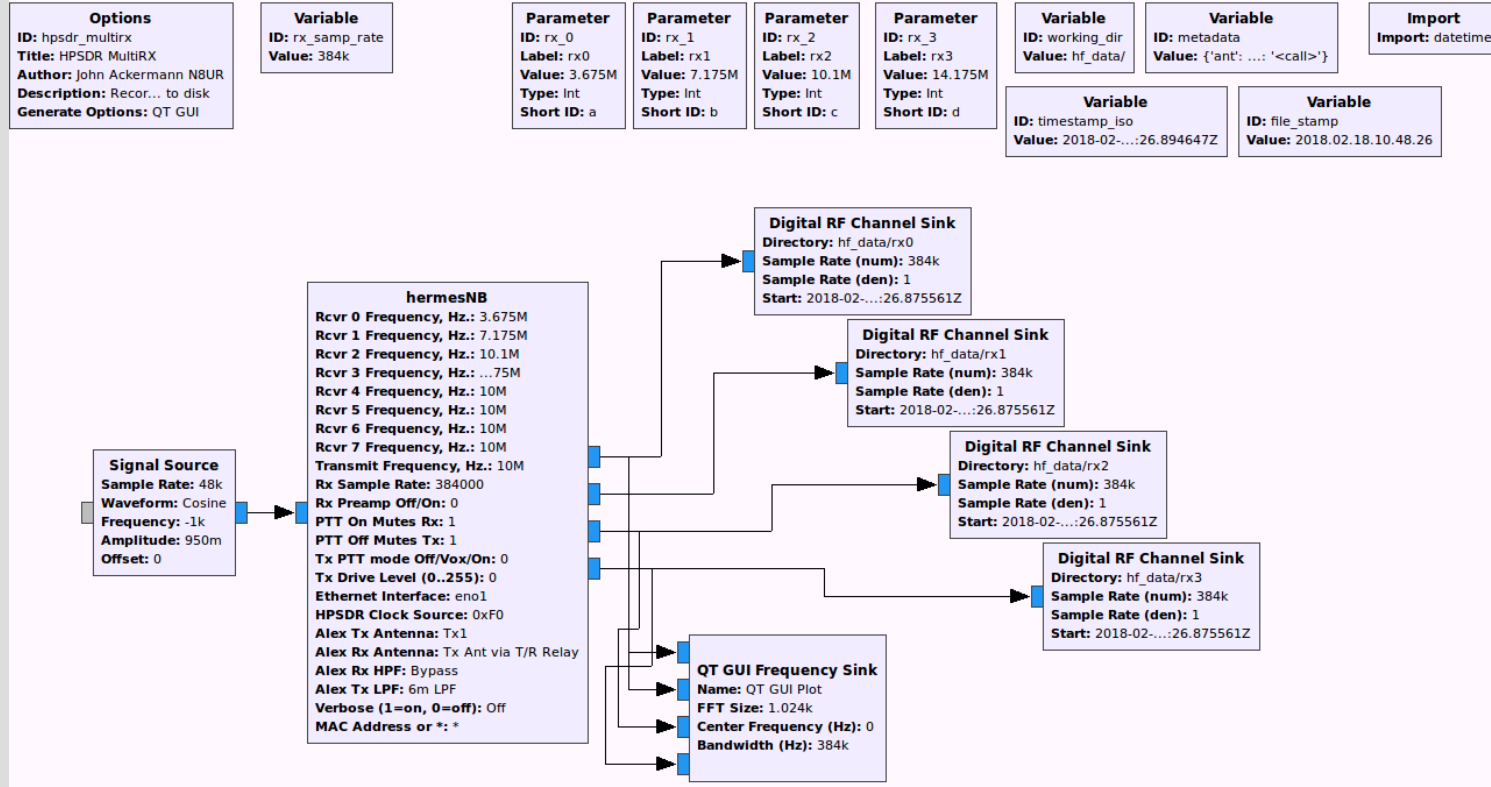


Hardware and Software

- I've focused on Gnu Radio for capture and analysis
 - Open Source
 - Multi-platform (Linux, Mac, and now Windows)
 - Gnu Radio Companion allows WYSIWIG radio building
- Gnu Radio provides broad hardware support:
 - N5EG “HermesNB” driver for HPSSDR compatible radios
 - Up to eight 384 kHz receiver streams, depending on radio
 - Red Pitaya emulates HPSSDR
 - Red Pitaya wideband driver
 - Up to 2.5 MHz bandwidth
 - UHD driver for Ettus Research USRP
 - RTL-SDR driver for “dongles”
 - And others...



Gnuradio Data Recorder



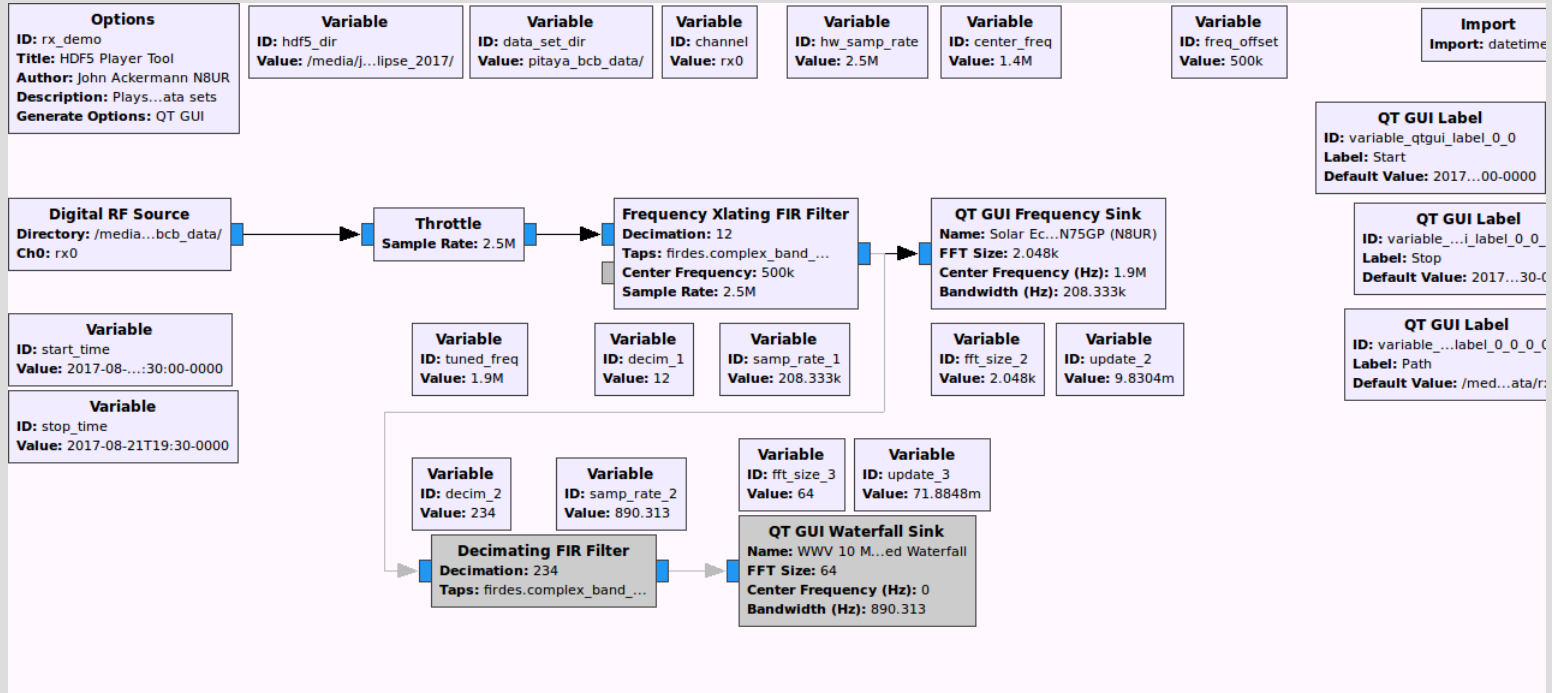


Recorder Wish List

- Current recorder requires parameters to be set in Gnu Radio Companion, and GRC has some limits on functionality (can't change some values "on the fly").
- Would like a cross-platform GUI front-end to make it easy for anyone to use
- Current wish-list on my blog:
<http://blog.febo.com/wp/?p=293>
- I'm not a GUI guy, so looking for a volunteer. Any takers?



Gnuradio Playback Script





Playback Tool Wish List

- imilarly, GUI front-end to Gnu Radio Companion:
 - Source file sample rate and center frequency
 - Destination file sample rate and center frequency
 - Output format (HDF5, Complex64, WAV)
 - Channelizer with multiple outputs?
 - Etc.



VHF/UHF Reverse Beacon Network

The Question

From Bob, K8TQK:

“Can we come up with a way to automatically monitor VHF/UHF beacons and report on propagation?”

Is there a wheel that's already been invented???

An Answer

Yes.

1. Leverage Existing Reverse Beacon Network and Cluster Tools (DXMap, etc.) to display VHF/UHF spots from beacons and other users.
2. There's a way to leverage low-cost hardware to feed multiple VHF/UHF bands into CW Skimmer.

CW Skimmer and the Reverse Beacon Network

- CW Skimmer by Alex, VE3NEA
 - Magic software that decodes all CW signals in the bandpass
 - Can listen to 8 192kHz chunks simultaneously
 - Generates “Spots” showing time, call, freq, speed, SNR
 - Runs on Windows; \$75 license fee
- Reverse Beacon Network
 - www.reversebeacon.net
 - Receives spots from many skimmers – usually 150+ on line
 - Feeds info to DX Cluster and to places like www.dxmaps.com
 - However, almost **no** VHF+ spots from the US!!!
 - This morning (2 Feb 2018) three VHF+ skimmers shown, all on 6M

RBN Spot Page

W8KSE is
only US station
reporting above
6M!

FileEditViewHistoryBookmarksToolsHelp

DE dxcc: K - United States X

www.reversebeacon.net/dxsd1/dxsd1.php?f=5296

170%

Search

SSN:16 SFI:70 A:7 K:4 callsign lookup:

REVERSE BEACON NETWORK

welcome | main | dx spots | nodes | downloads | about | contact us

show/hide my last filters

DE dxcc: K - United States / band: 2m,70cm

cancel filter selection / search spot by callsign

rows to show: 100

de	dx	freq	cq/dx	snr	speed	time
W8KSE	K5SW	144200.9	CW DX	19 dB	16 wpm	1510z 27 Feb
W8KSE	K8TQK	144200.7	CW CQ	19 dB	17 wpm	1425z 27 Feb
W8KSE	N1GC	144190.7	CW DX [LoTW]	23 dB	13 wpm	1422z 27 Feb
W8KSE	K5SW	144200.7	CW DX	21 dB	17 wpm	1422z 27 Feb
W8KSE	K8TQK	144274.3	CW DX	5 dB	21 wpm	1327z 27 Feb
W8KSE	W1VD	144180.8	CW DX	26 dB	21 wpm	1325z 27 Feb
W8KSE	WC4N	144205.6	CW DX	7 dB	21 wpm	1320z 27 Feb
W8KSE	W9ZIH	144205.8	CW DX	11 dB	19 wpm	1314z 27 Feb
W8KSE	KC4AAW	144180.8	CW DX	30 dB	17 wpm	1136z 27 Feb
W8KSE	KC4AAW	144274.5	CW DX	14 dB	18 wpm	1134z 27 Feb
W8KSE	K8TQ	144149.5	CW DX	11 dB	18 wpm	1130z 27 Feb
W8KSE	N4ASF	144180.8	CW DX [LoTW]	24 dB	17 wpm	1038z 27 Feb
W8KSE	W1VD	144252.8	CW DX	17 dB	20 wpm	0144z 27 Feb
W8KSE	KE8FD	144205.8	CW DX [LoTW]	13 dB	20 wpm	1525z 26 Feb
W8KSE	K5VH	144200.9	CW DX	14 dB	18 wpm	1519z 26 Feb

options:

show/hide

Do you enjoy the RBN?
Please consider supporting us!

Donate

we have 162 skimmers online

skimmers online:

3B8CW - 40m, 30m, 20m, 17m, 15m
3V/KF5EYY - no spot last 15min
7L4IOU - no spot last 15min
9A1CIG - 160m, 80m, 40m, 30m, 20m, 17m
9M2CNC - 40m, 30m, 20m
9V1RM - 40m, 20m
AA4VV - 80m, 40m, 30m, 20m, 17m
AC0C - no spot last 15min
BD2FW - no spot last 15min
BD4WN - no spot last 15min

V+RBN Configuration

- The magic bit is N1GP's rtl_hpsdr software:
 - Presents up to 8 RTL-SDR “dongles” on USB side as a single multi-receiver HPSDR device on the Ethernet side
 - Open Source and runs on Raspberry Pi 3
 - Source available from <https://github.com/n1gp/librtlsdr>, and an Rpi image is at http://febo.com/pages/os_images/
- Dongles have good sensitivity, but limited dynamic range. Suitable for use in many locations, but some may require filtering.
- **Dongles plus rtl_hpsdr create a low cost RF deck covering many VHF/UHF bands**

Complete V+RBN Station

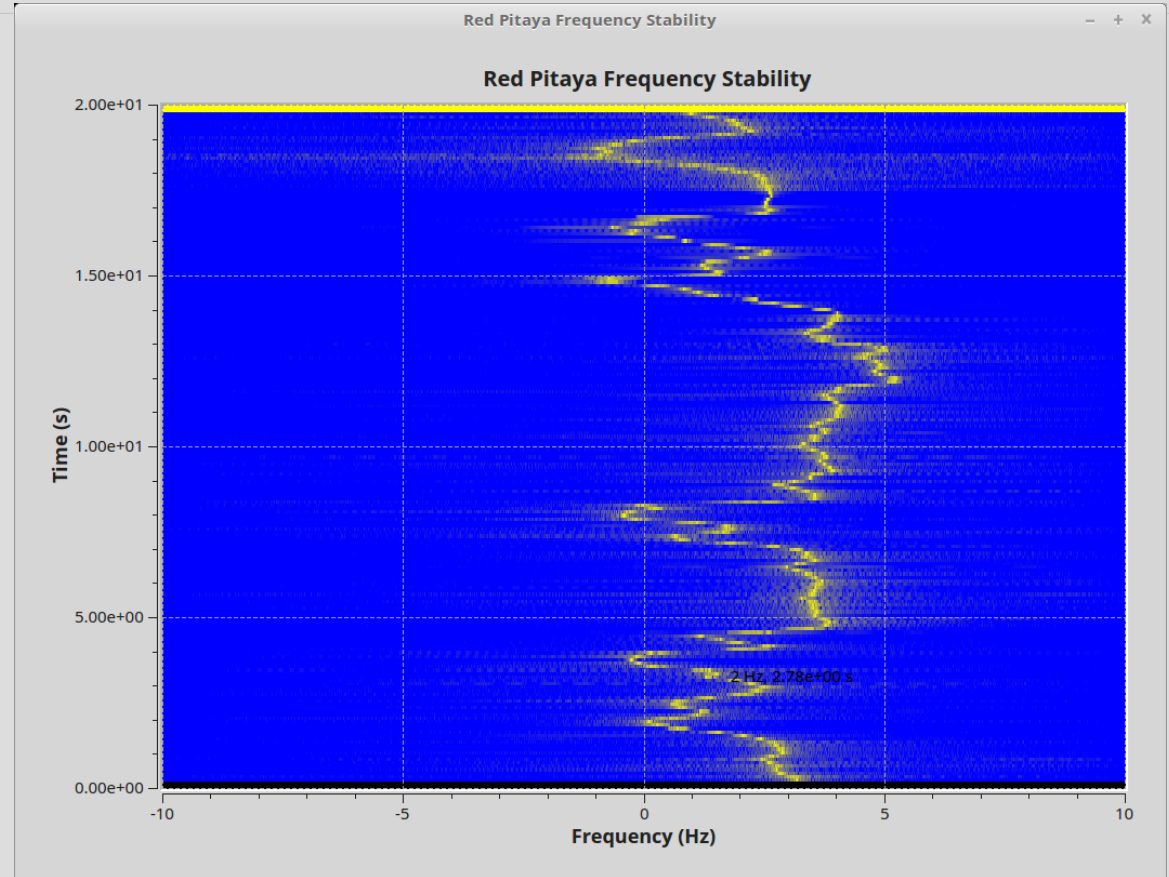
- Windows computer (i5 class is fine)
 - CW Skimmer Server (\$75 license fee)
 - RBN Aggregator software (free)
 - Low-rate Internet connection; DHCP OK
- Raspberry Pi 3 with rtl_hpsdr image
- Several RTL-SDR.com dongles (1 per 192 kHz segment)
- Powered USB Hub (Dongles draw some juice)
- Antennas:
 - Ideally horizontal polarization, some gain, up 40+ feet
 - Stacked halos seem a good choice
 - Consider LNA at antenna followed by RG6 coax to shack



Red Pitaya Frequency Control



Environmental Test Chamber



Stabilizing the Red Pitaya

- 125 MHz onboard crystal oscillator; specs not known
 - Clearly has poor temperature compensation
- Pads available to install external oscillator
- Goal is to develop synthesizer that allows Pitaya (and other devices) to be locked to quality 10 MHz reference (like GPSDO)
- Does RP have digital noise issues?
 - W1PJE and N8UR exploring

Stabilizing the Red Pitaya

- Silicon Labs has a bewildering variety of clock generator chips
 - Si5351A
 - Three outputs up to 160 MHz
 - Moderate jitter/phase noise
 - Seems to want 25 MHz reference
 - Si5340/5342/5348 family
 - Frequency resolution to fractional Hz
 - 4 or 10 independent outputs to 1 GHz
 - Extremely good jitter/phase noise possible
 - QFN44 package
- I'm working on a couple of “chip carrier” designs
 - Will require motherboard with MCU and signal conditioning

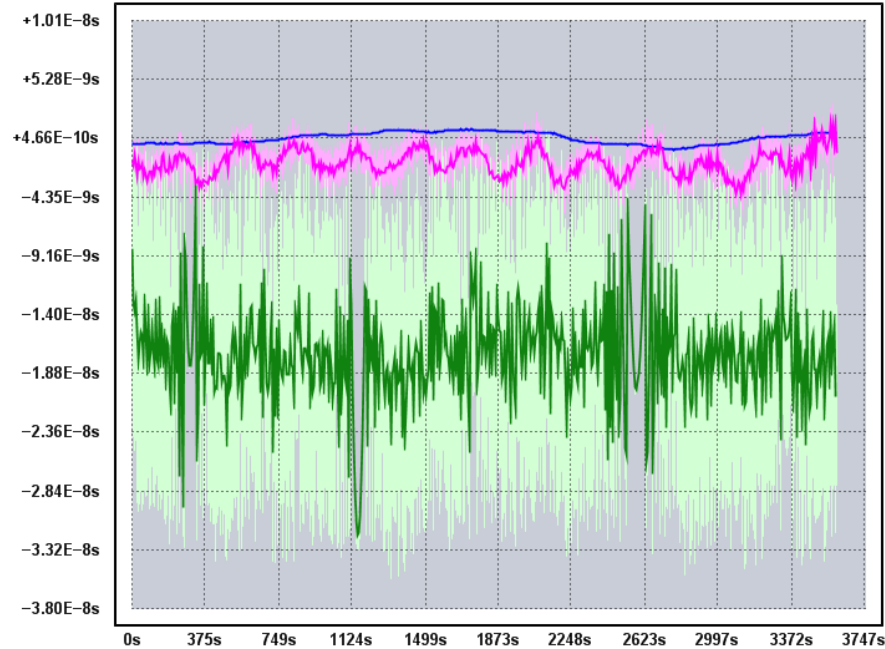
Wideband Data Timestamping

- Ethernet Stream Timestamper?
 - FPGA with 2 Ethernet and 1 PPS input
 - Adds timestamp to HPSDR data stream
 - Would require new receive block in software
- Pulse Stamper
 - Inject sharp pulse edge at antenna input; creates pulse visible across HF spectrum
 - Also interferes with desired signal
 - If you inject pulse per minute (or per 100 seconds), reduces interference and still maintains phase assuming GPSDO frequency control
 - Testing this method begins soon

GPS PPS Jitter

Original Phase Difference (Zero-based)

Averaging window: Per-pixel



Origin	Slope (sec/sec)
$+4.71\text{E-}10$	$-1.01\text{E-}24$
$-1.50\text{E-}9$	$+1.29\text{E-}23$
$-1.73\text{E-}8$	$-8.21\text{E-}24$

Trace	Notes	Input Freq	Sample Interval	Acquired	Instrument
Z3801A vs. HP5065A	PPS	1 Hz	1.00 s	3600 pts	StanfordResearchSystems,SR620,02281,1.48
CNS2 vs. HP5065A	PPS	1 Hz	1.00 s	3600 pts	StanfordResearchSystems,SR620,02281,1.48
TAC2 vs. HP5065A	PPS	1 Hz	1.00 s	3600 pts	StanfordResearchSystems,SR620,02281,1.48