Receiving and Spotting WSPR and FT8 on all bands at once, using GNU Radio and RTL SDRs

By Mark Smith, N6MTS

With *TONS* of advice from
Derek Kozel, MW0LNA

Introduction: Who am I?

- Mark Smith
- N6MTS as of February 2021, formerly KR6ZY
- Licensed in high school, 1991. Extra in 2001.

- SmittyHalibut on Twitter, YouTube, and GitHub
- Recurring guest on the Ham Radio Workbench podcast

What are we talking about today?

- The “What” and “Why”
- Overview of solution
- GNU Radio blocks
  - SSB Demodulator
  - Dual SSB Demodulator
  - Top Block
- Demonstration
- Q&A

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WSPR and PSKReporter Networks

- Digital modes provide a unique opportunity to collect real time propagation information:
  - Tx location and power
  - Rx location and SNR
- Requires transmitting and receiving stations.

WSPR and PSKReporter Networks: Transmitters

- Inexpensive WSPR beacons:
  - Ultimate 3S, QRP Labs
  - Can beacon on several bands (one at a time)
- Ubiquitous FT8 transmitters:
  - Everyone’s operating FT8!

WSPR and PSKReporter Networks: Receivers

- Receivers require more computation than a Microcontroller
- Conventional receivers, sound interfaces, and computers
  - Ties up whole radio and computer for one band, one mode, at a time.
- Full Spectrum SDRs and FPGAs:
  - Red Pitaya: Can receive and spot WSPR on 8 bands concurrently. No FT8.
  - http://pavel-demin.github.io/red-pitaya-notes/sdr-transceiver-wspr/

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- Can we do this cheaper?

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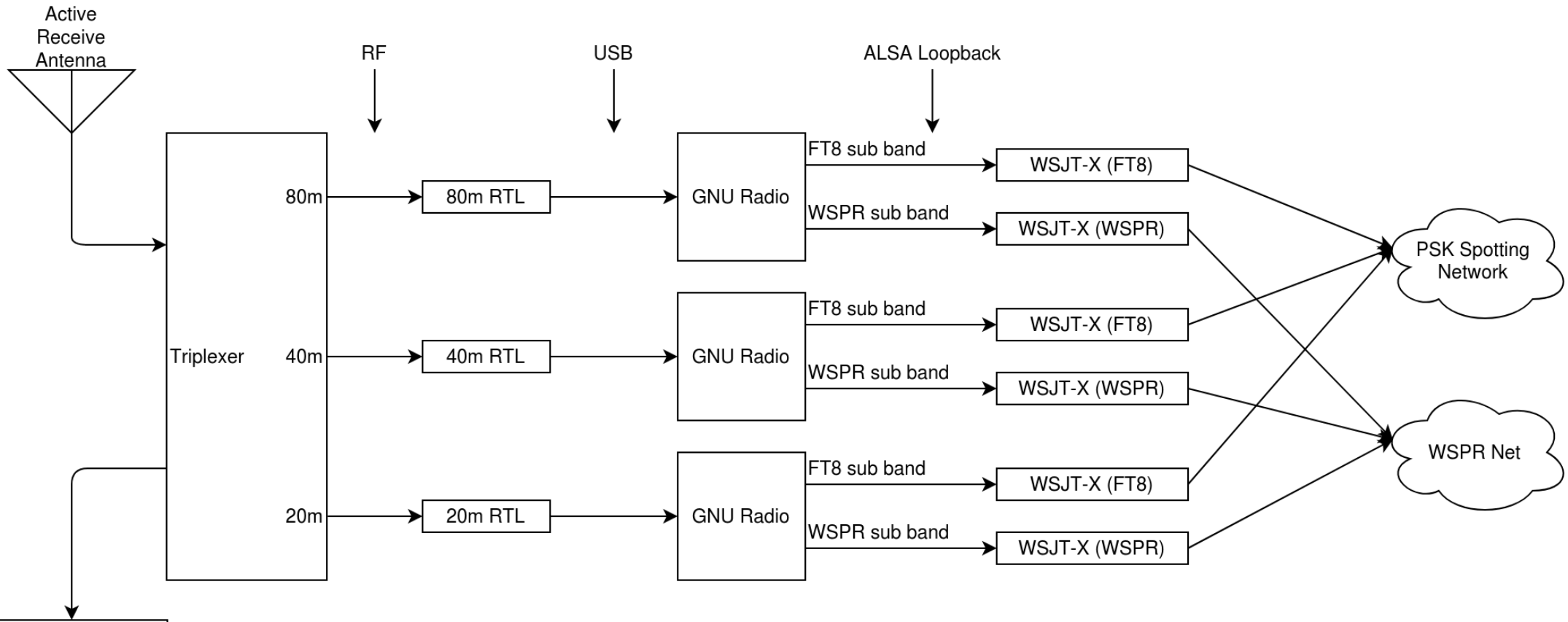
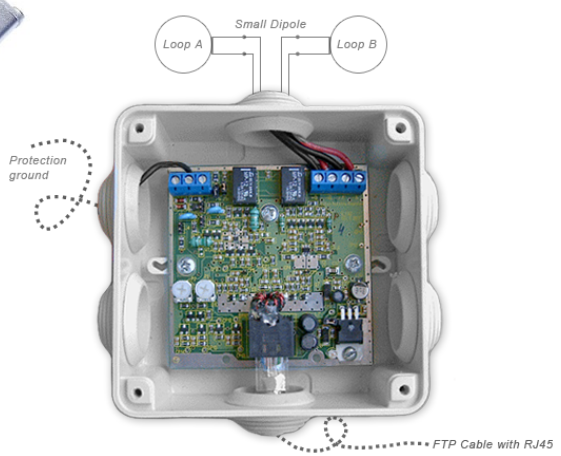
Architecture

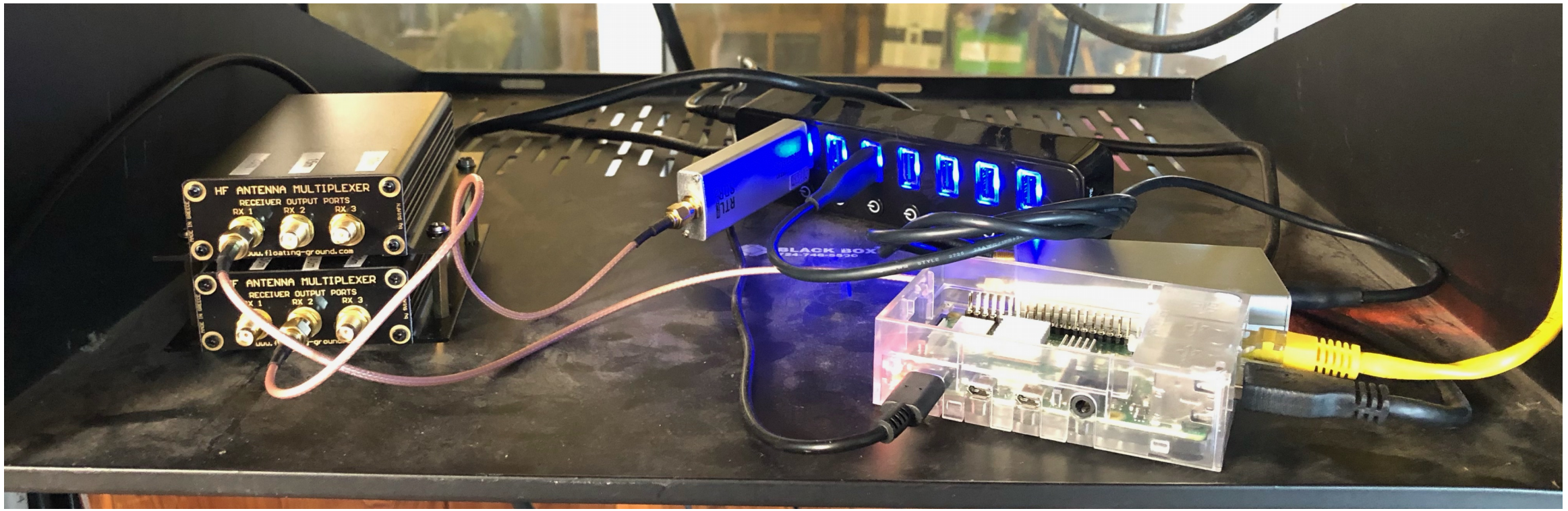


Parts

- RTL-SDR receivers:
  - Inexpensive, $25 each for rtl-sdr.com V3.
  - Receives 1 entire HF band, no up-converter.
- Wideband active receive antennas:
  - active-antenna.eu by LZ1AQ, €105 plus materials
  - One antenna for all bands, good sensitivity
- HF Bandpass Filters / Triplexer
  - sv1afn.com: €95 for 3 bands, two for 6 bands.
  - Bonus: Triplexer provides pre-selection on RTL-SDR!



My Setup



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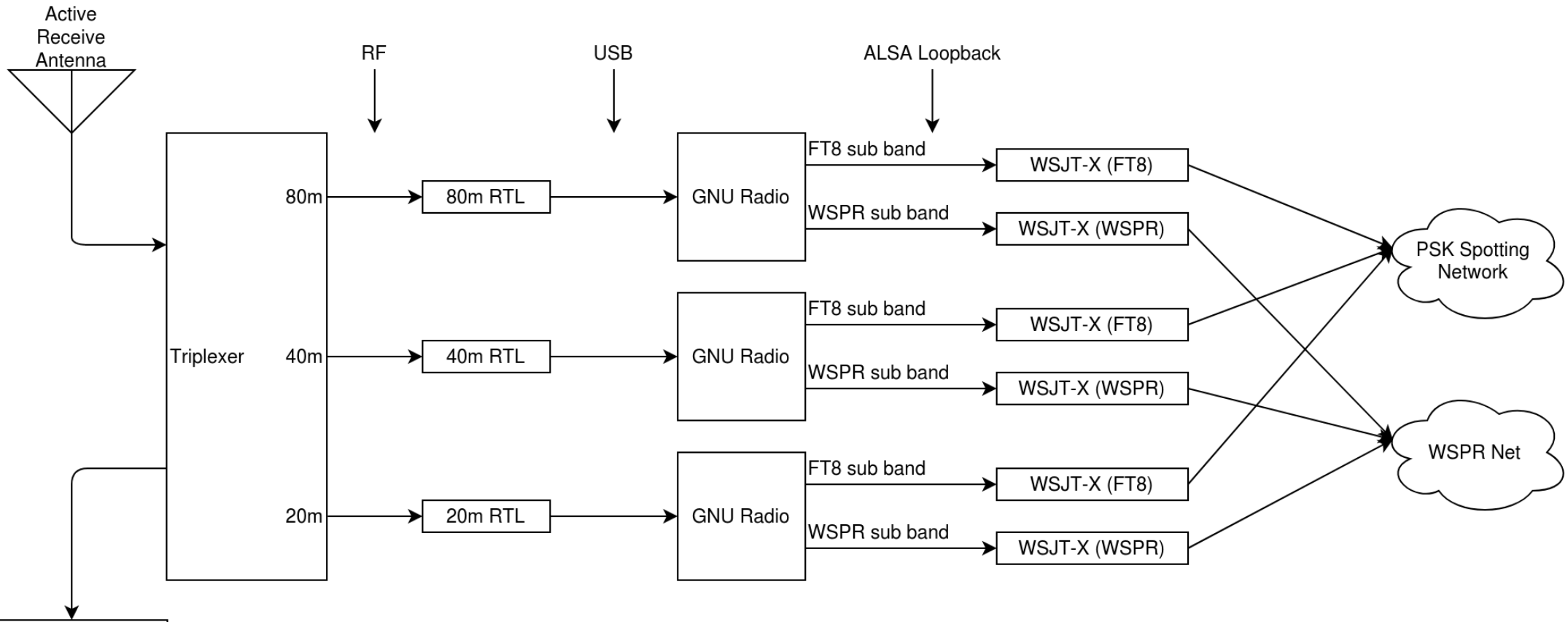
Architecture



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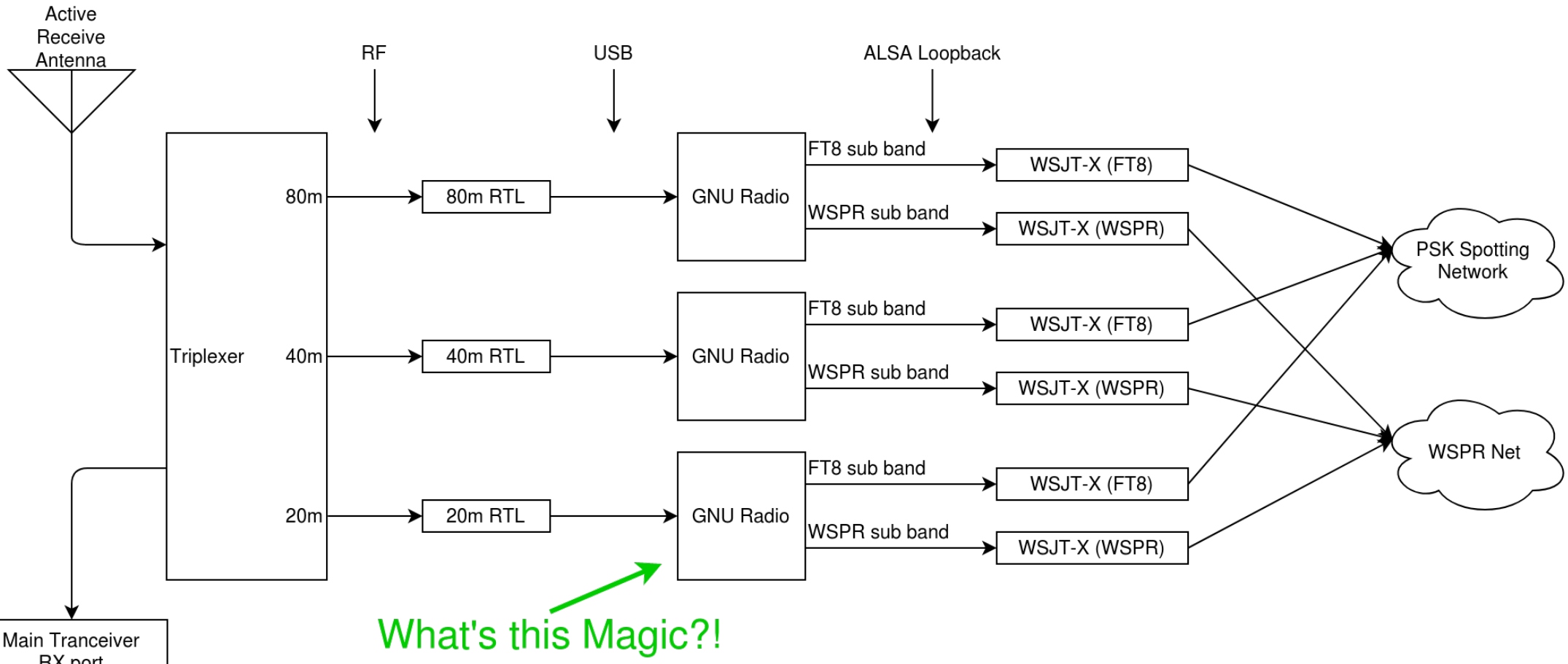

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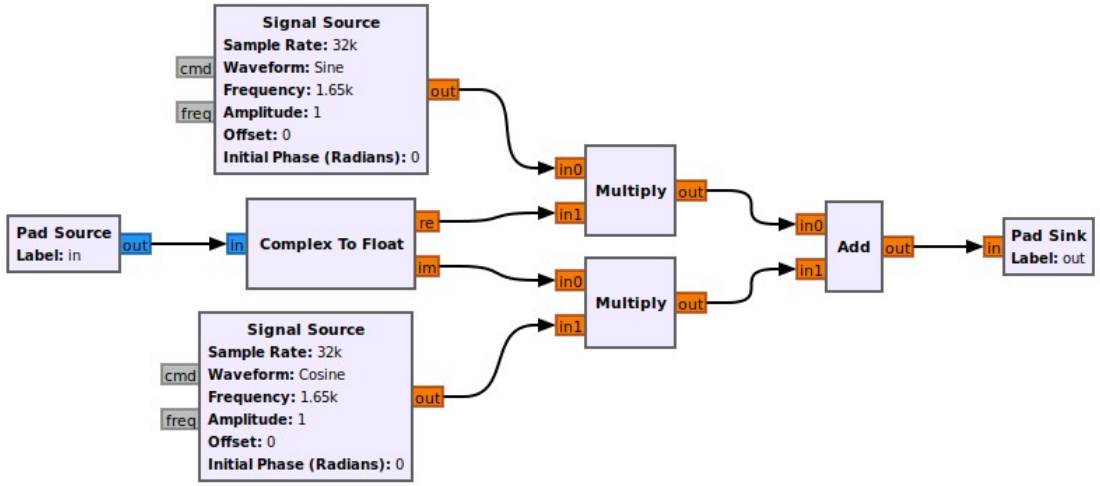
GNU Radio: SSB Demodulator

- An almost direct copy of the SSB Demodulator example on the GNU Radio wiki:
  - Baseband RF in, “dial frequency” at 0Hz
  - Weaver Method SSB demodulator
  - USB or LSB audio out
- Made into a GNU Radio “Hierarchical” Block to use elsewhere



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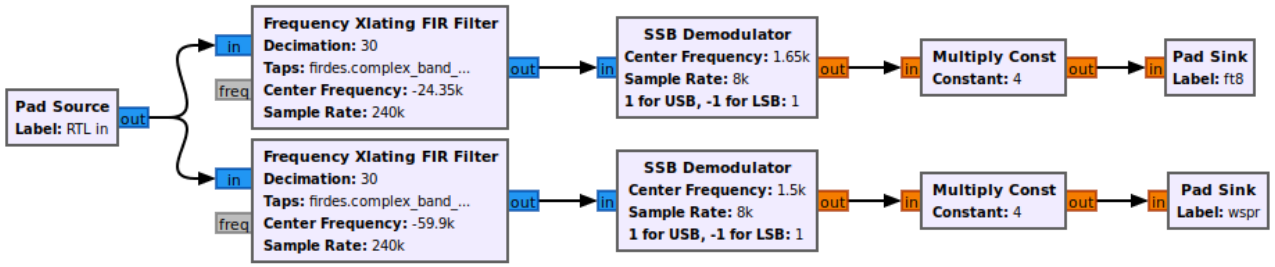
GNU Radio: Dual SSB Demodulator

- Frequency Translating FIR Filter selects sub-bands:
  - Wide band RF input
  - Bandpass filter to just the signal of interest
  - Translates signal to center, 0Hz
  - Decimates to lower sample rate
  - Filtered baseband RF output



- Passes sub-band to SSB Demodulator from previous slide
- Made into a Hierarchical Block to use later

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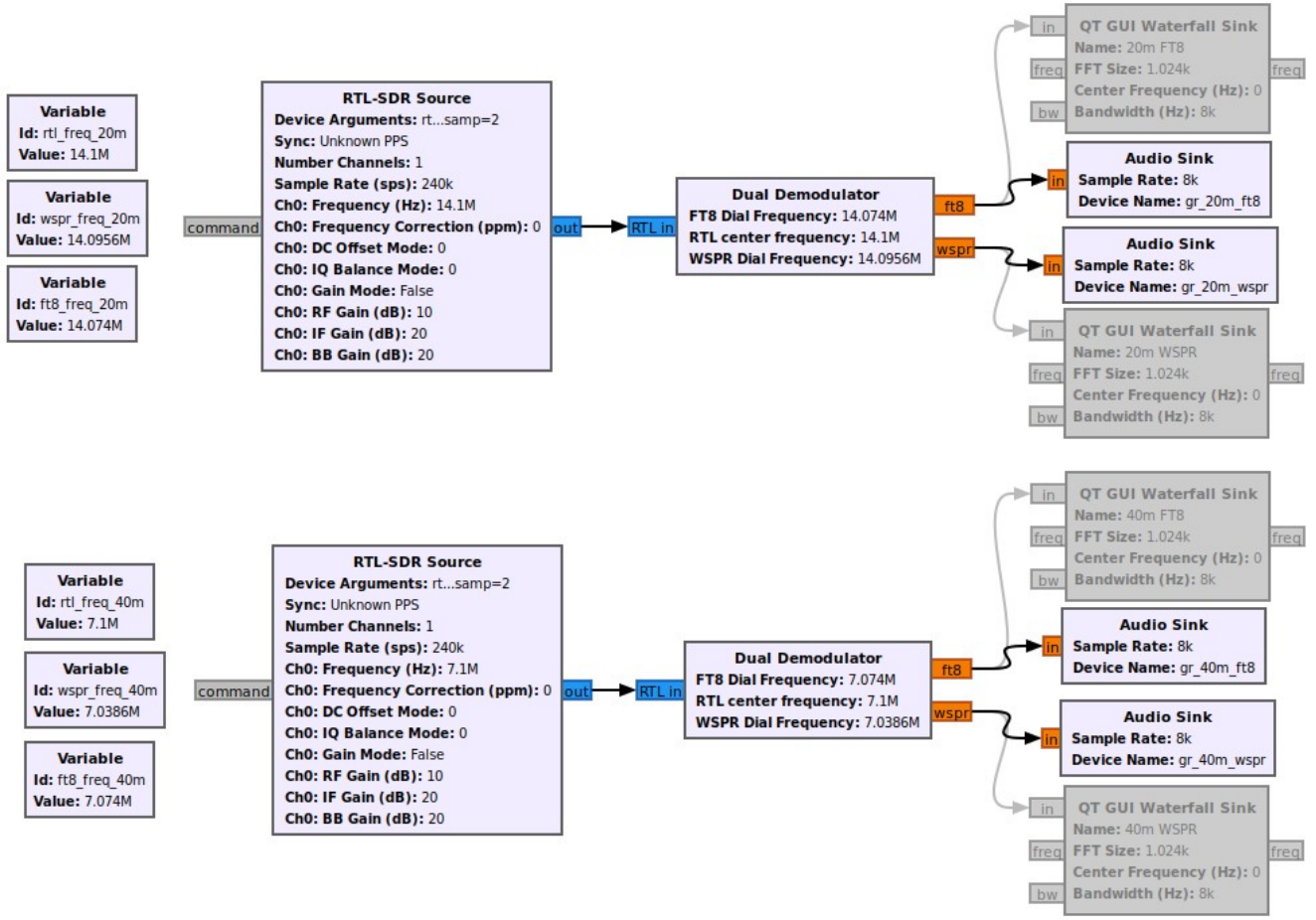
GNU Radio: The “Top Block”

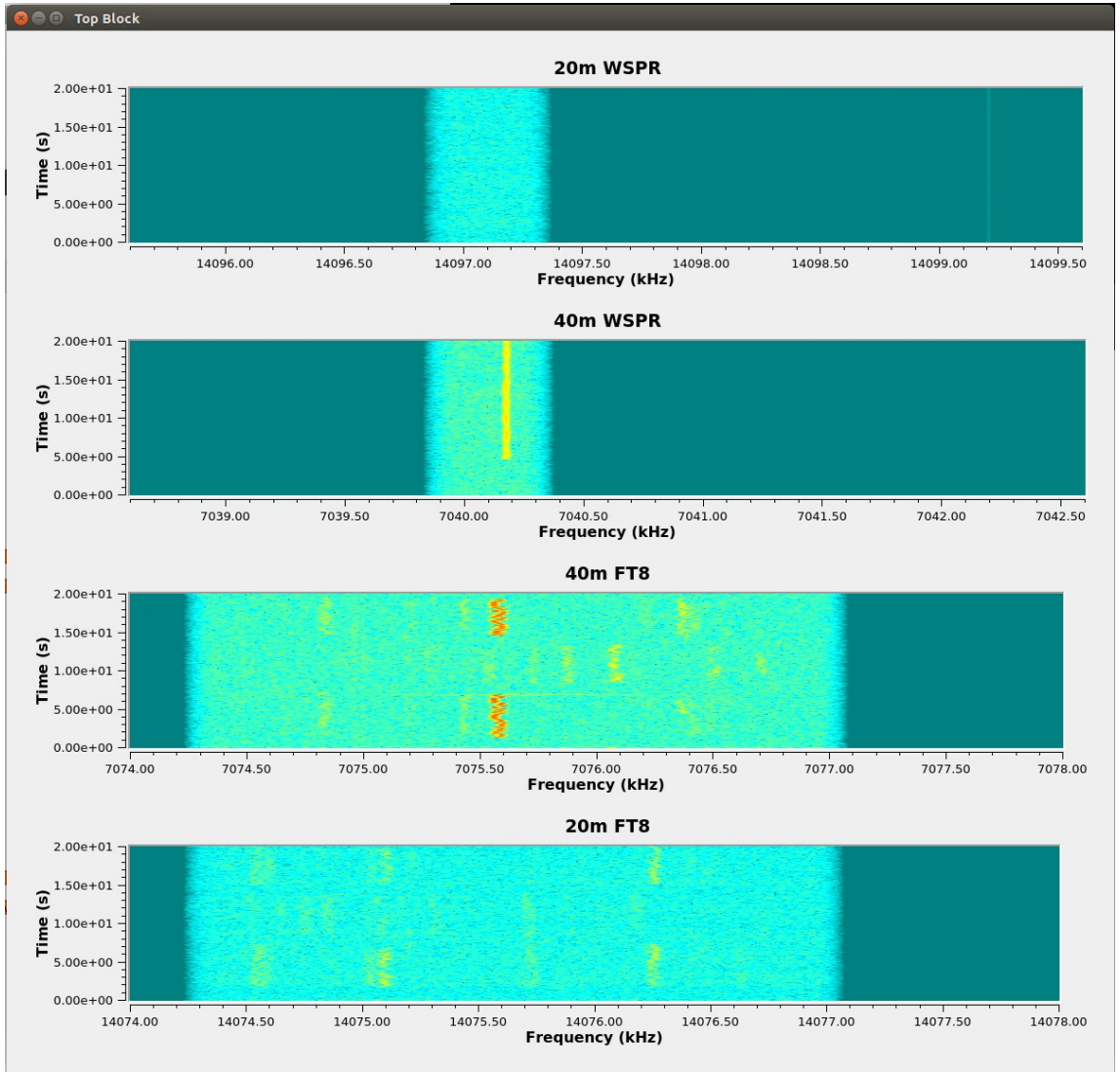
- Two paths: RTL to Audio
  - One for each: 20m and 40m
- RTL-SDR Source
  - Receives 240kHz of spectrum
- Dual Demodulator:
  - From previous slide
- Audio Sinks:
  - Sends demodulated audio to ALSA loopback interfaces
- Waterfalls for debugging
  - Disabled for normal operations



GNU Radio: What does it look like?

- Waterfalls enabled
- Notice:
  - The Filtered sub-bands
  - The 15 second period in the FT8 waterfalls
  - The end of a 120 second period in the 40m WSPR waterfall

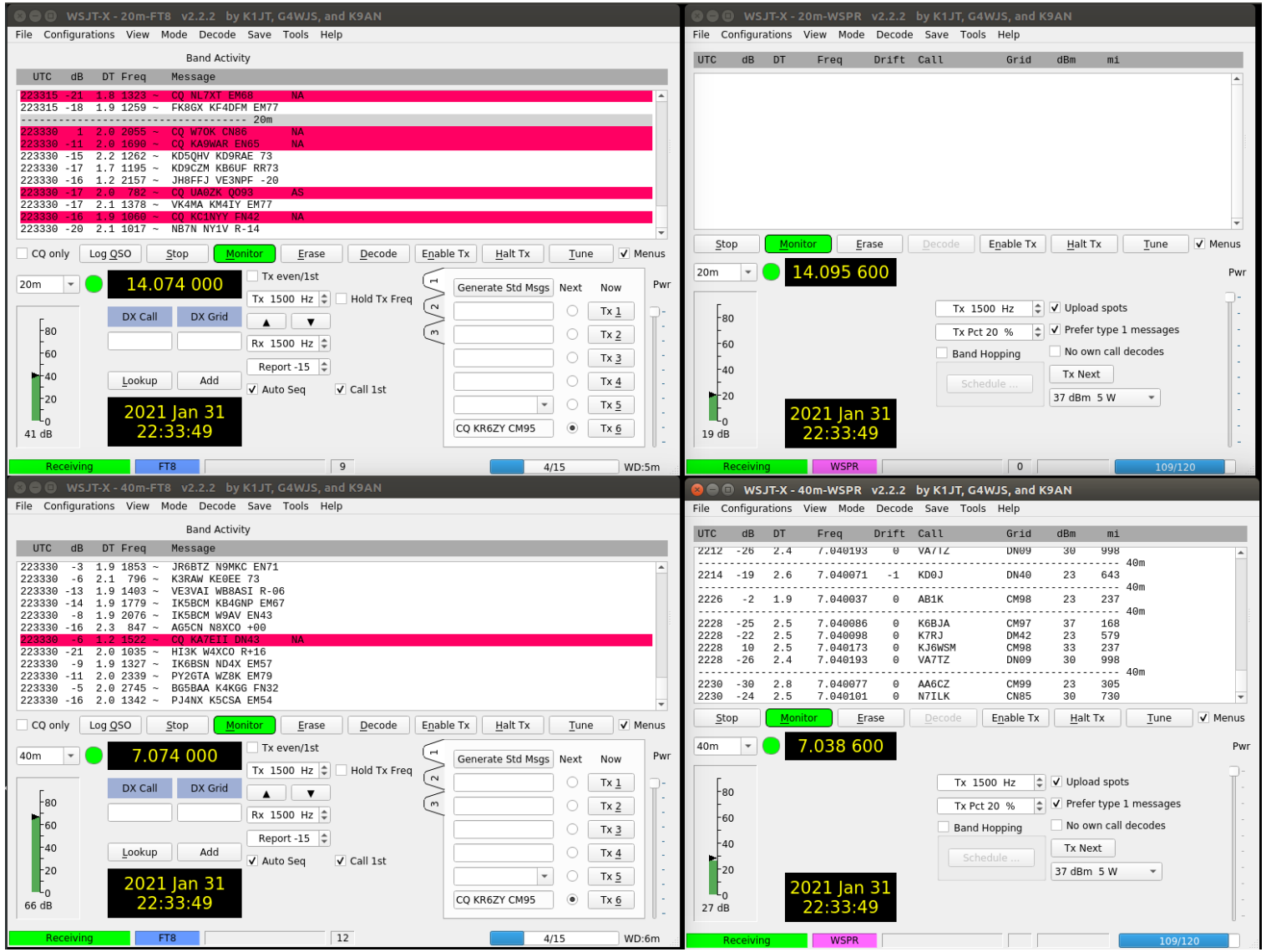
My 20m Receiver is very insensitive. :-(



WSJT-X: What does it look like?

- Waterfalls disabled
- Rows are bands
  - Top: 20m, Bottom: 40m
- Columns are mode
  - Left: FT8, Right: WSPR

I told you my 20m RTL was deaf...



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Live Demonstration!

...I see no way this will end poorly...

What are the problems with this?

- CPU Intensive:
  - Raspberry Pi 4 is BARELY able to keep up with two modes, two bands. Still gets behind.
  - My laptop (2017 Dell XPS 15) does two modes, two bands, about 50% CPU.
  - Disable waterfalls in GR and WSJT-X, setting to “Normal” decode, helps.
- Latency:
  - Even when it’s not behind, it still adds about 2 seconds of latency. WSJT-X reports “DT” (Delta Time) of 1.8 at best, 2.0 is typical.
- It’s not truely “headless”:
  - WSJT-X requires a GUI. I was hoping to do it all at the command line, or in a start-up script.

Q&A

https://github.com/SmittyHalibut/GR-MultipleReceivers

https://twitter.com/SmittyHalibut

https://youtube.com/SmittyHalibut

Foo Bar

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