WSPR

Weak Signal Propagation Reporter

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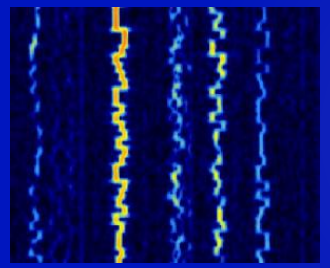
What is WSPR?

- WSPR is HAM telemetry system with an extremely narrowband transmission. It is a one-way transmission (beacon), designed to predict and show the propagation path to different geographical locations.



- WSPR utilizes:
  - Modulation: 4 FSK (4 frequency shit keying)
  - Total bandwidth of 6Hz, tones separated by 1.46Hz
  - 50 bits of payload packed in 162 bits with FEC (Forward Error Correction) (50+32-1) x2 and synchronization within 110,6 seconds:
    - 28 bits for callsign
    - 15 bits for locator
    - 7 bits for power level

  Theoretical SNR needed for a solid copy is –29dB (800 x below noise level!)
  For comparison CW (12wpm) needs –12dB and PSK-31 –10dB !!)

  • Transmitters use randomized frequencies, timeslots, repetition rates to reduce collisions. Every ~2min, beginning by even minutes (UTC).

Why do we need WSPR?

- WSPR was originally designed and implemented by Joe Taylor, K1JT, (HAM & noble price winner) for probing potential propagation paths with low-power transmissions.
  The protocol is nicely implemented in a computer program.
- WSPR can give insight into station performance without test equipment. Questions like…
  - Despite having good SWR, does an antenna work well?
  - What does its radiation pattern look like? directionality?
  - Talking to other hams, you might hear that a band is open, but then wonder how well your antenna works on that band?
  - How do you know when exactly from your specific location, the band is open to your exotic DX destination and its vicinity?
  - You can see seasonal, day/night, and hourly propagation, and also monitor reported paths to different receivers – all nicely displayed on a map.

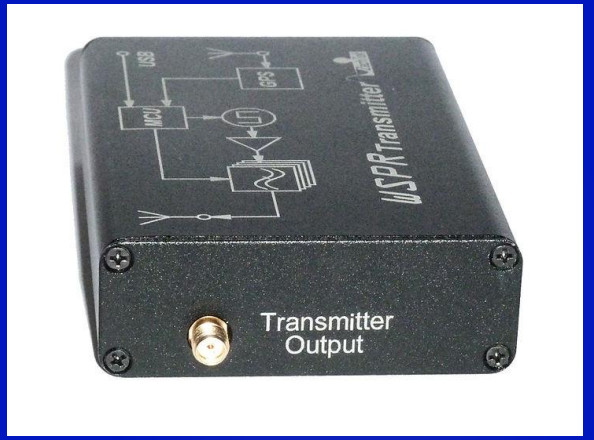
How to own a WSPR beacon?

- USB dial (MHz):

0.136
0.4742
1.8366
3.5686
5.2872
5.3647
7.0386
10.1387
13.5539
14.0956
18.1046
21.0946
24.9246
28.1246
50.293
70.091
144.489
432.300
1296.500

- Buying a beacon

~ $139



- Building a kit (LPF)

~ $100

What if you have an old Raspberry Pi?

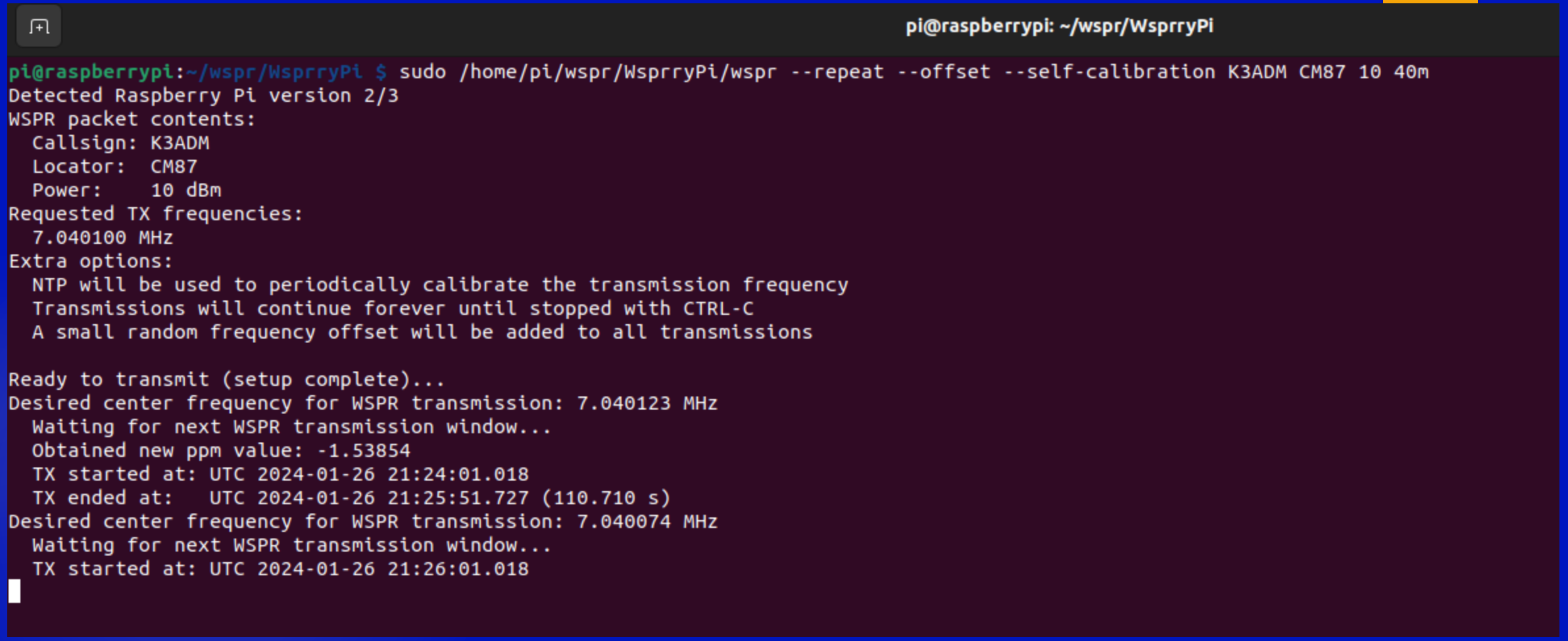
In this case you already have a transmitter!

The GPIOs and clock outputs of Rpi (3,4,5 or zero, …) can toggle up to 250MHz with max 15mA of current, so theoretically you can build a transmitter up to 222MHz HAM band!

What do you need?

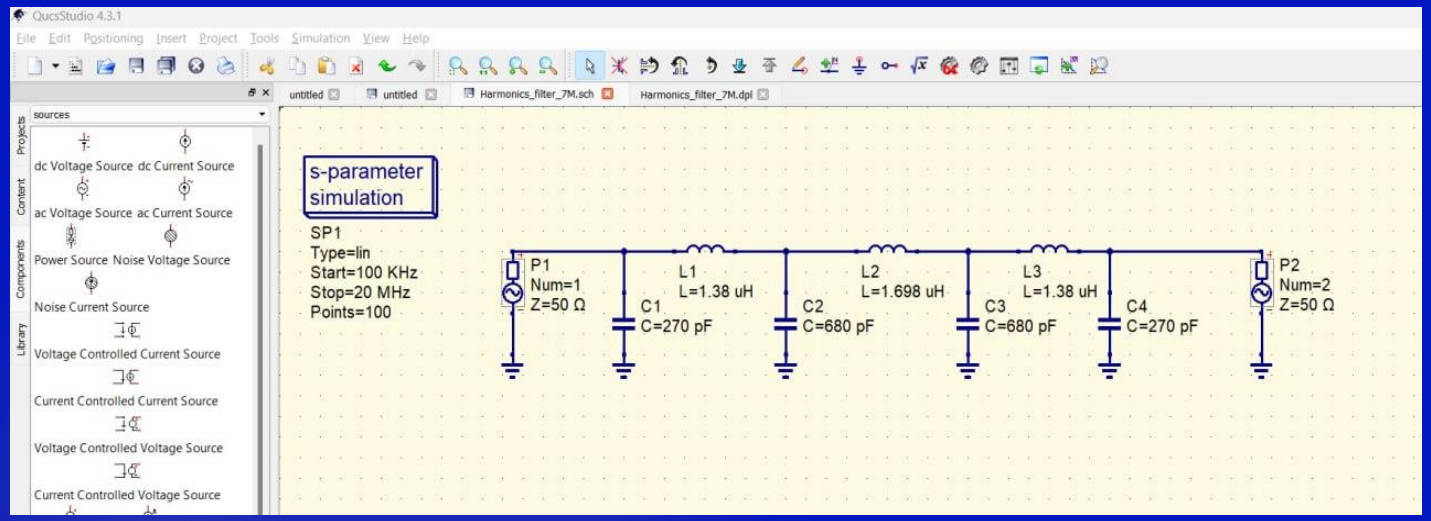
- A Raspberry pi (cost: 0 or $15 up to $60)
- Some software (from Github) (cost free)
- A low passfilter to clean up the harmonics (FCC, be a nice HAM!) (cost $5 max)
- Optional a USB GPS unit ($9)
  - Total costs ~$29 (and the fun of building)

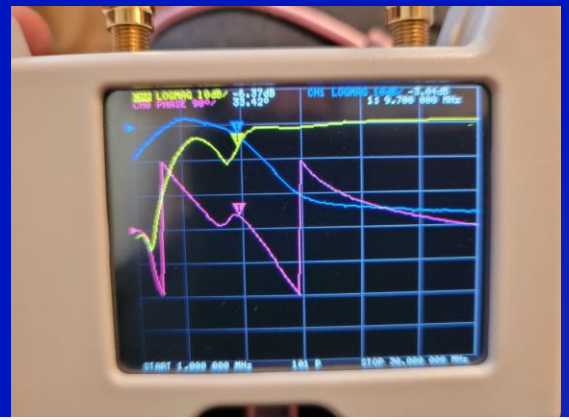
Raspberry Pi WSPR transmitter software

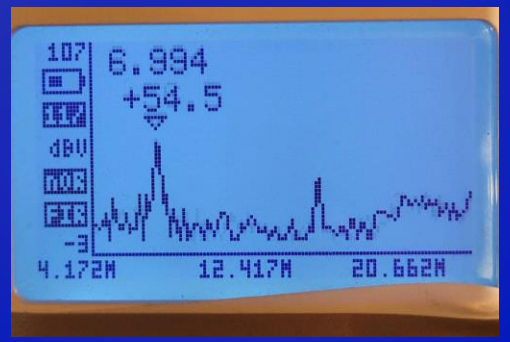


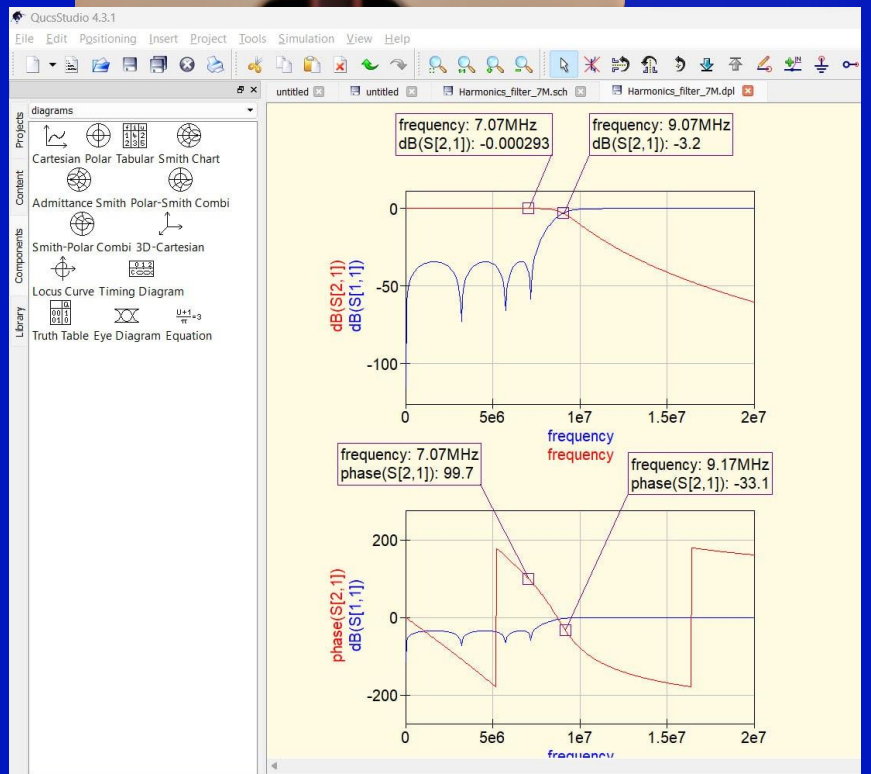
The wspr process was implemented in as a system service, which is started by every reboot of the Rpi.
Above the manual start of the wspr process

Design a harmonics filter for 40m (7MHz) in Qucs Studio









Raspberry Pi WSPR transmitter 40m

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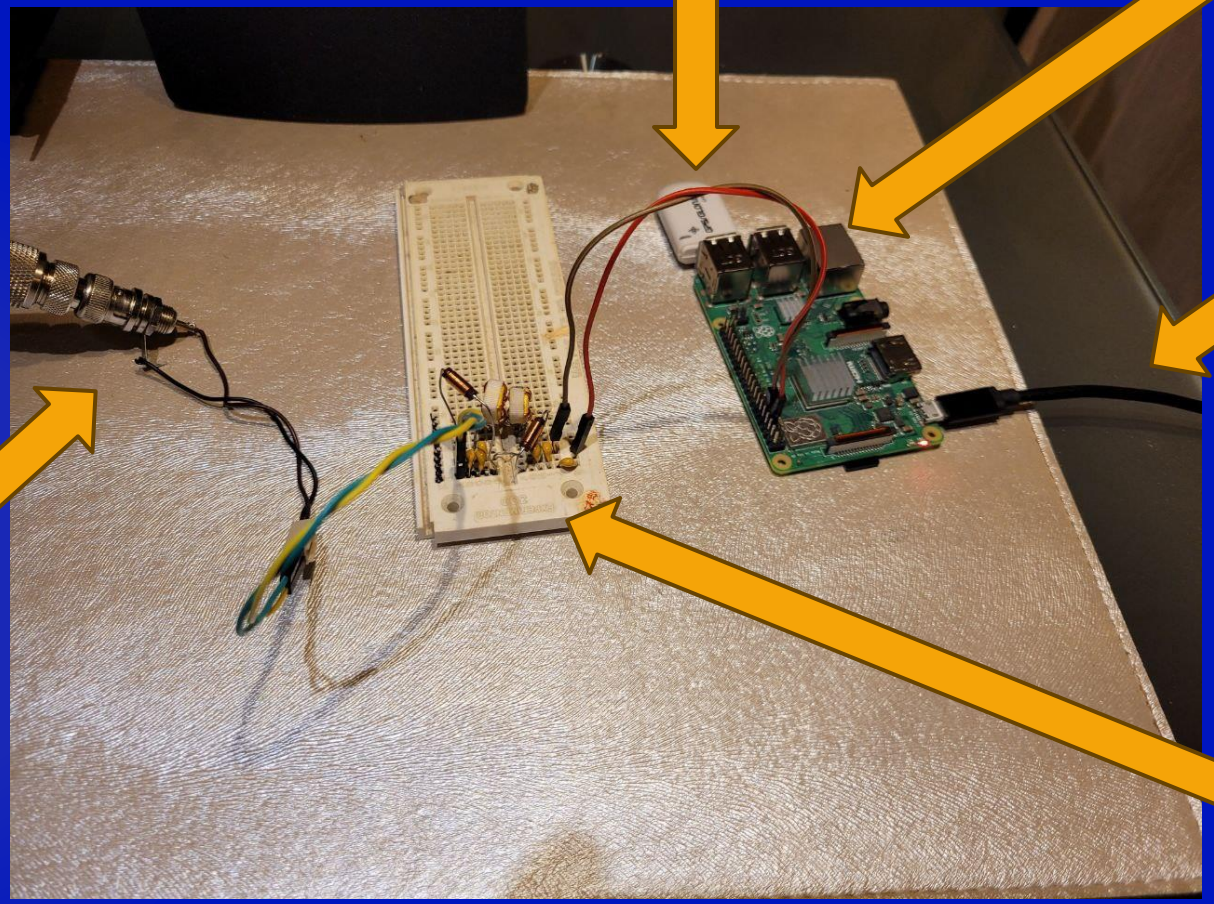
GPS Unit

Raspberry pi 4

Power 5VUSB, consuming 4.3W on 120V



Antenna

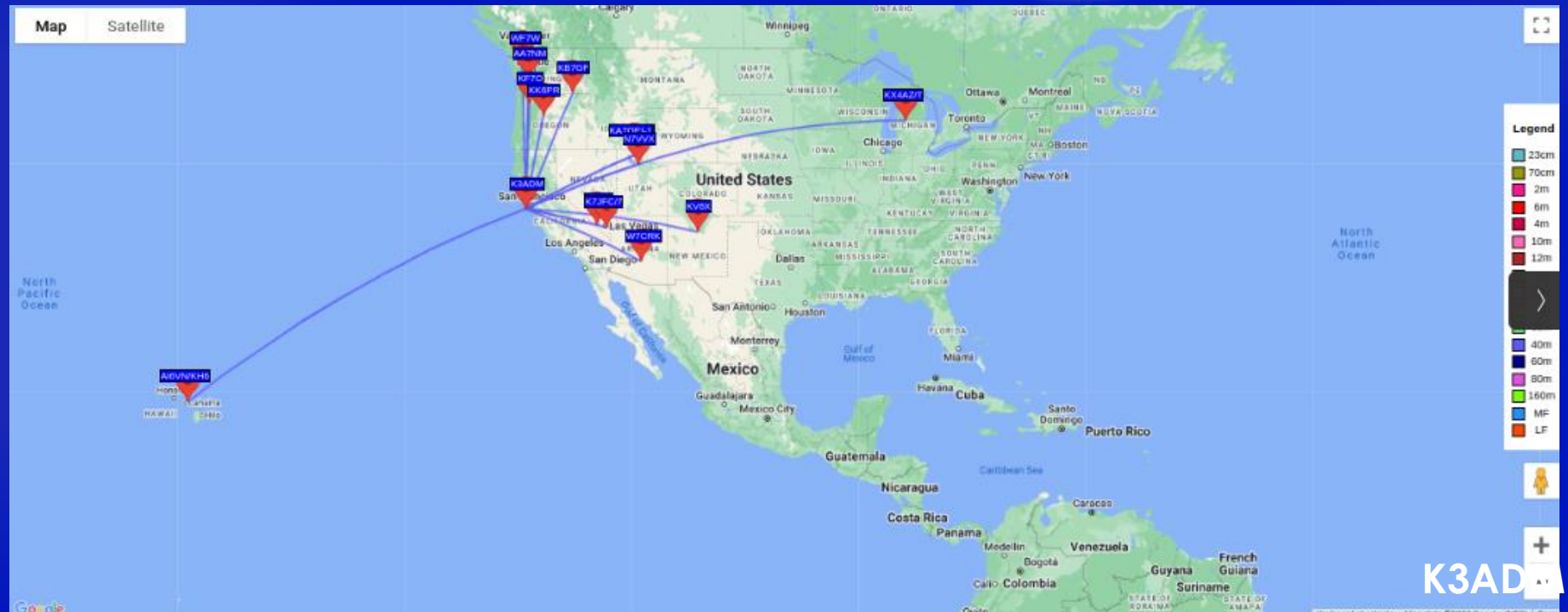
Low pass filter

K3ADM / FARS

On WSPR, what now? who is listening?

- Now we are sending WSPR packets. Who is listening?

More than 1,500 HAM radio stations!



Alternative websites, upload by RX

K3ADM CM87 10

K3ADM CM87 10

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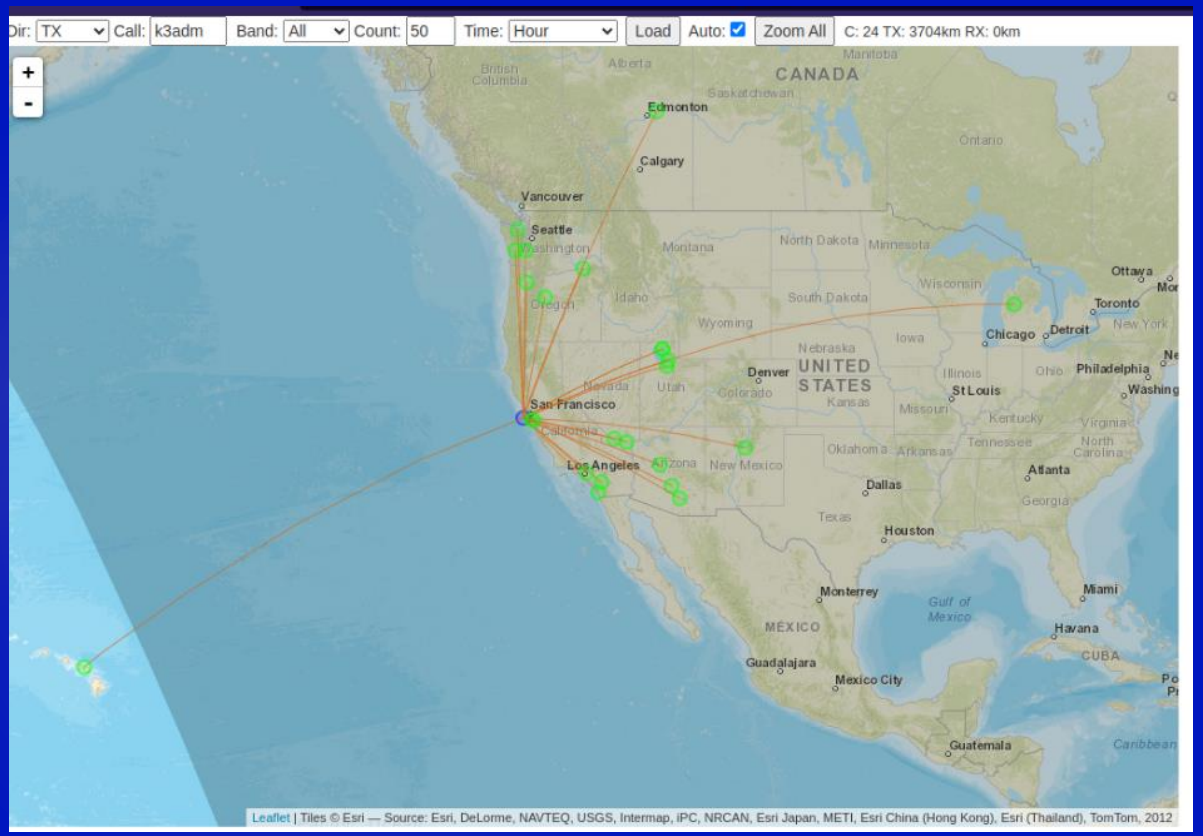

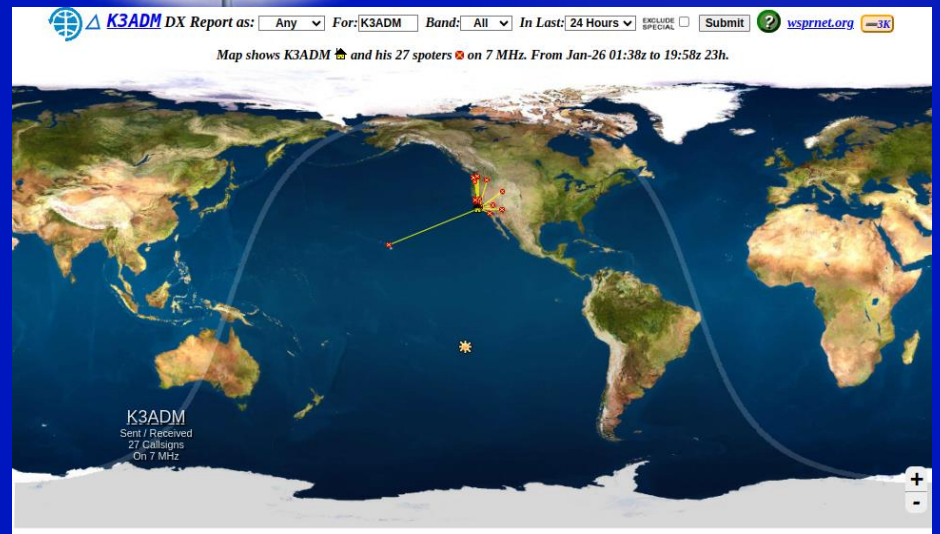

Timestamp	Call	MHz	SNR	Drift	Grid	Pwr	Reporter	RGrid	km	az	Mode
2024-01-26 19:58	K3ADM	7.040075	-4	0	CM84	501	KFS	CM87tj	330	10	W-2
2024-01-26 19:58	K3ADM	7.040074	-5	0	CM87xi	0.01	KPH/Q	CM88mc	116	316	W-2
2024-01-26 19:58	K3ADM	7.040071	-6	0	CM87xi	0.01	KPH/K	CM88mc	116	316	W-2
2024-01-26 19:58	K3ADM	7.040074	-6	0	CM87xi	0.01	KPH	CM88mc	116	316	W-2
2024-01-26 19:56	K3ADM	7.040075	-5	0	CM87xi	0.01	KFS	CM87tj	30	279	W-2
2024-01-26 19:56	K3ADM	7.040075	-21	0	CM87xi	0.01	WB7ABP/K	CM88dk	137	332	W-2
2024-01-26 19:56	K3ADM	7.040075	-18	0	CM87xi	0.01	KP4MD	CM98iq	162	24	W-2
2024-01-26 19:54	K3ADM	7.040075	-22	0	CM87xi	0.01	KJ6MKI/Q	CM88oi	129	330	W-2
2024-01-26 19:54	K3ADM	7.040075	-22	0	CM87xi	0.01	KJ6MKI	CM88oi	129	330	W-2
2024-01-26 19:54	K3ADM	7.040075	-1	0	CM87xi	0.01	KPH/Q	CM88mc	116	316	W-2
2024-01-26 19:54	K3ADM	7.040075	-2	0	CM84	501	KFS	CM87tj	330	10	W-2
2024-01-26 19:54	K3ADM	7.040075	-15	0	CM87xi	0.01	KP4MD	[illegible]	162	24	W
2024-01-26 19:54	K3ADM	7.040071	-1	0	CM87xi	0.01	KPH/K	[illegible]	16	3[illegible]	[illegible]
2024-01-26 19:52	K3ADM	7.040075	-21	0	CM87xi	0.01	KJ6MKI	[illegible]	129	330	W-2
2024-01-26 19:52	K3ADM	7.040075	-19	0	CM87xi	0.01	KJ6MKI/Q	CM88oi	129	330	W-2
2024-01-26 19:52	K3ADM	7.040075	-15	0	CM87xi	0.01	KP4MD	CM98iq	162	24	W-2

But wait, what do we do with time synchronization?

WSPR needs to start the transmission on an even minute UTC time.
As long as the Raspberry Pi is connected to the Internet it can use the NTP servers and synchronize the time.

If left standalone with a 100ppm clock on board, worst case it can have 10s deviation per day. This would result in out of sync transmission latest after 6 days.

Solution ?

A GPS receiver. ($9-$12 amazon)
Not only the GPS can synchronize the time, but it can automatically determine the location and gridsquare.

Lost in space!

You need min 3-4 GPS satellites to acquire a 3D location. Indoors w/o external antenna, this is very challenging.

But you need only one to acquire a highly accurate time:. And it always works indoor:

```
pi@raspberrypi:/dev $ cat ttyACM0 |grep GPGLL
$GPGLL,[redacted],W,220519.00,A,A*73
$GPGLL,[redacted],W,220520.00,A,A*79
$GPGLL,[redacted],W,220521.00,A,A*74
$GPGLL,[redacted],W,220522.00,A,A*70
$GPGLL,[redacted],W,220523.00,A,A*77
$GPGLL,[redacted],W,220524.00,A,A*74
```

```
pi@raspberrypi:~ $ ./sync_time.sh
Acquiring GPS time ...223414.00
GPS time read and set the local time
pi@raspberrypi:~ $
```

I simply wrote a script on the cron job to sync the Raspberry Pi time every few hours with the GPS UTC.

Summary

WSPR

- Can help optimizing the antenna performance and direction.
- Shows the open path to the different destinations in REAL TIME.
- Can alarm you in case you want that special exotic DX in your logbook.
- Can teach your about cycles, seasonality and other factors, which affect the performance of your station/antenna.

The reports are tailored exactly to your antenna and your location.

A very quick and fun project for a Saturday afternoon.

Simulation, measurements, hardware & software!

What else does a HAM need??

WSPR

Questions?