

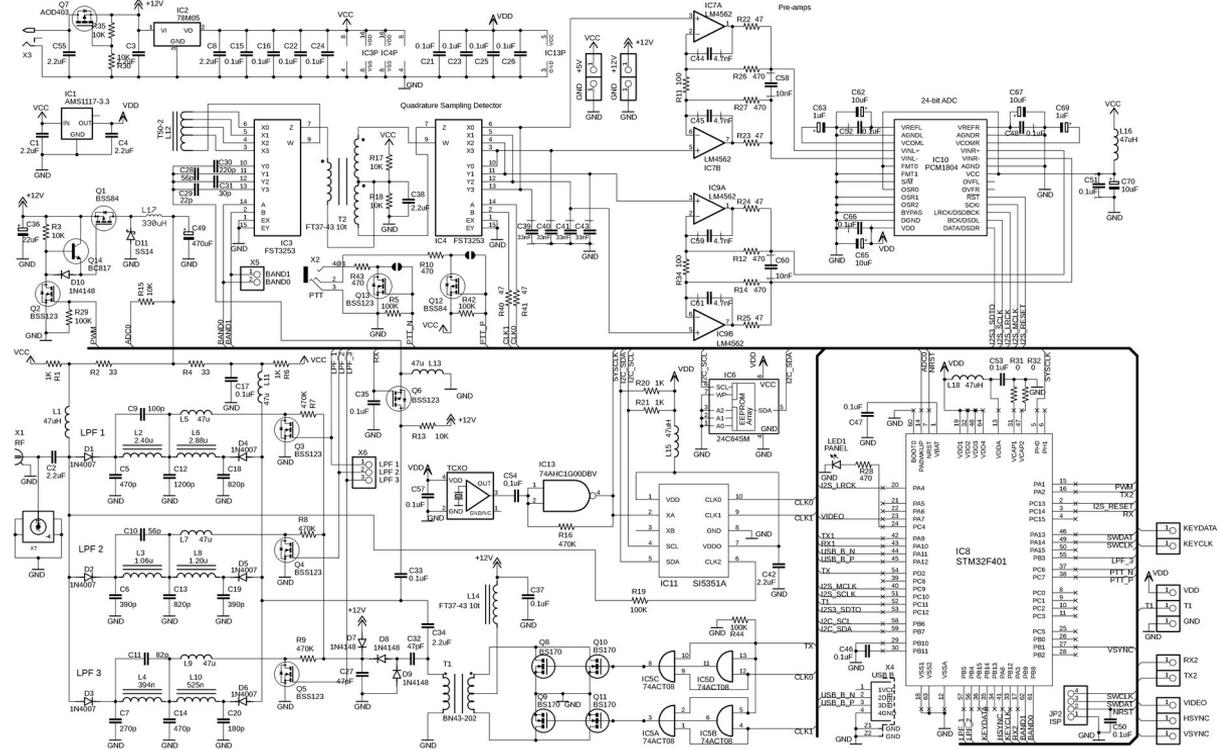
A Homebrew Digimode- Transceiver

Henning Paul DC4HP

10.10.2023

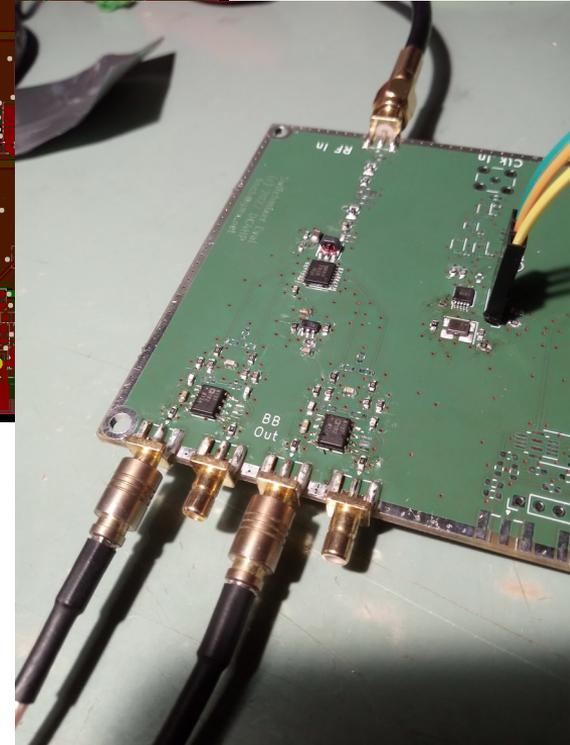
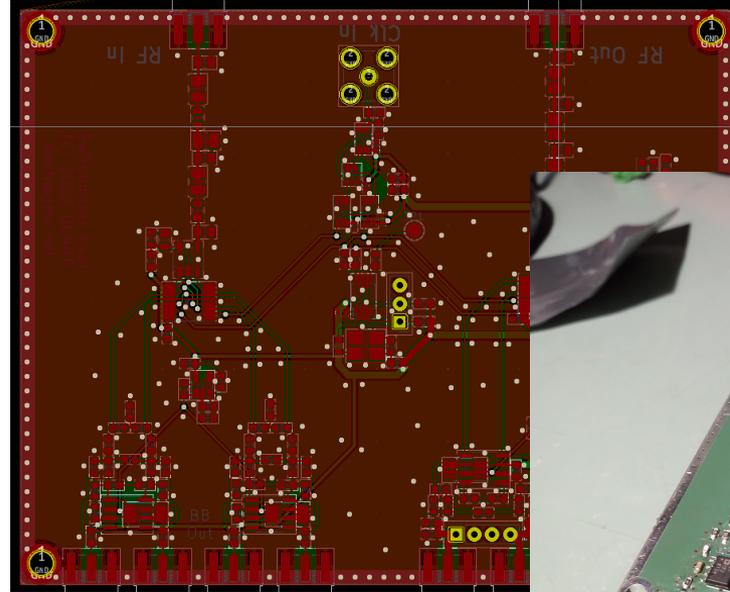
Motivation

- Was pointed at QDX by fellow ham
- Schematics available online



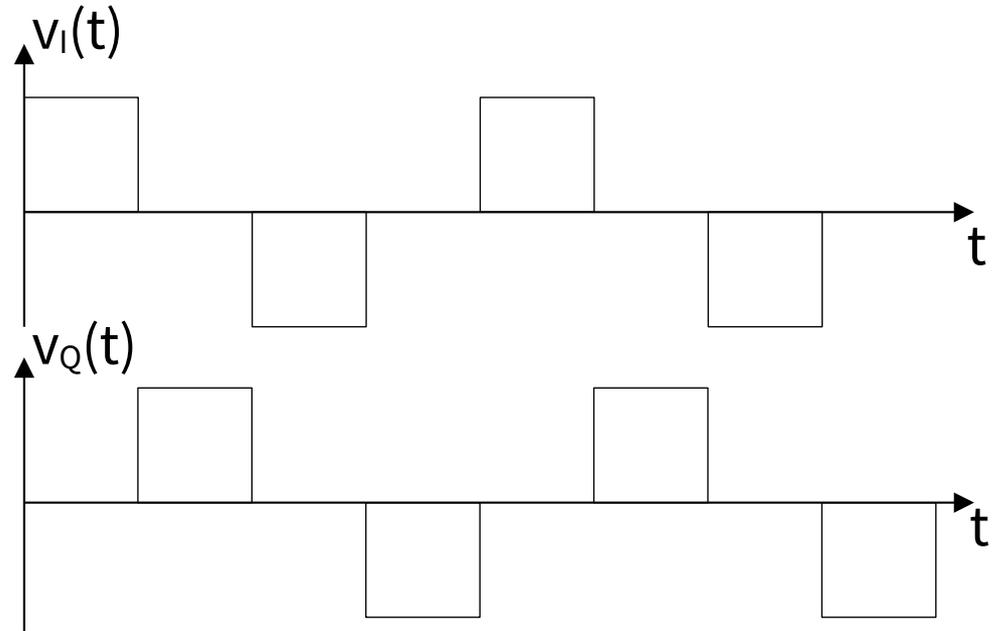
H-mode mixer

- Gained interest in workings of quadratur H-mode mixer
- Laid out experimenter board to study it



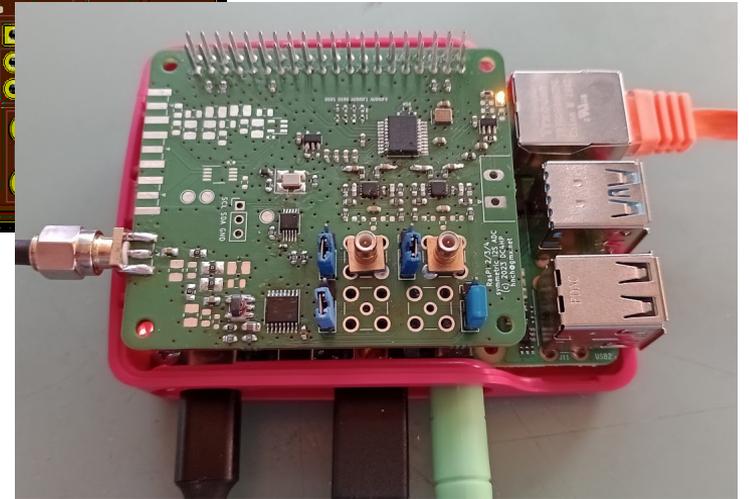
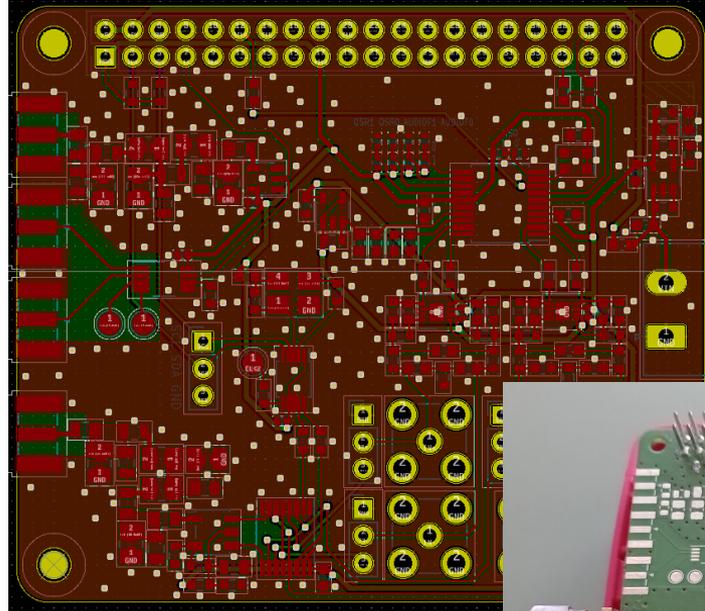
H-mode mixer

- Mode of operation:
 - Received HF is switched onto I and Q receive path with alternating sign in a round-robin fashion



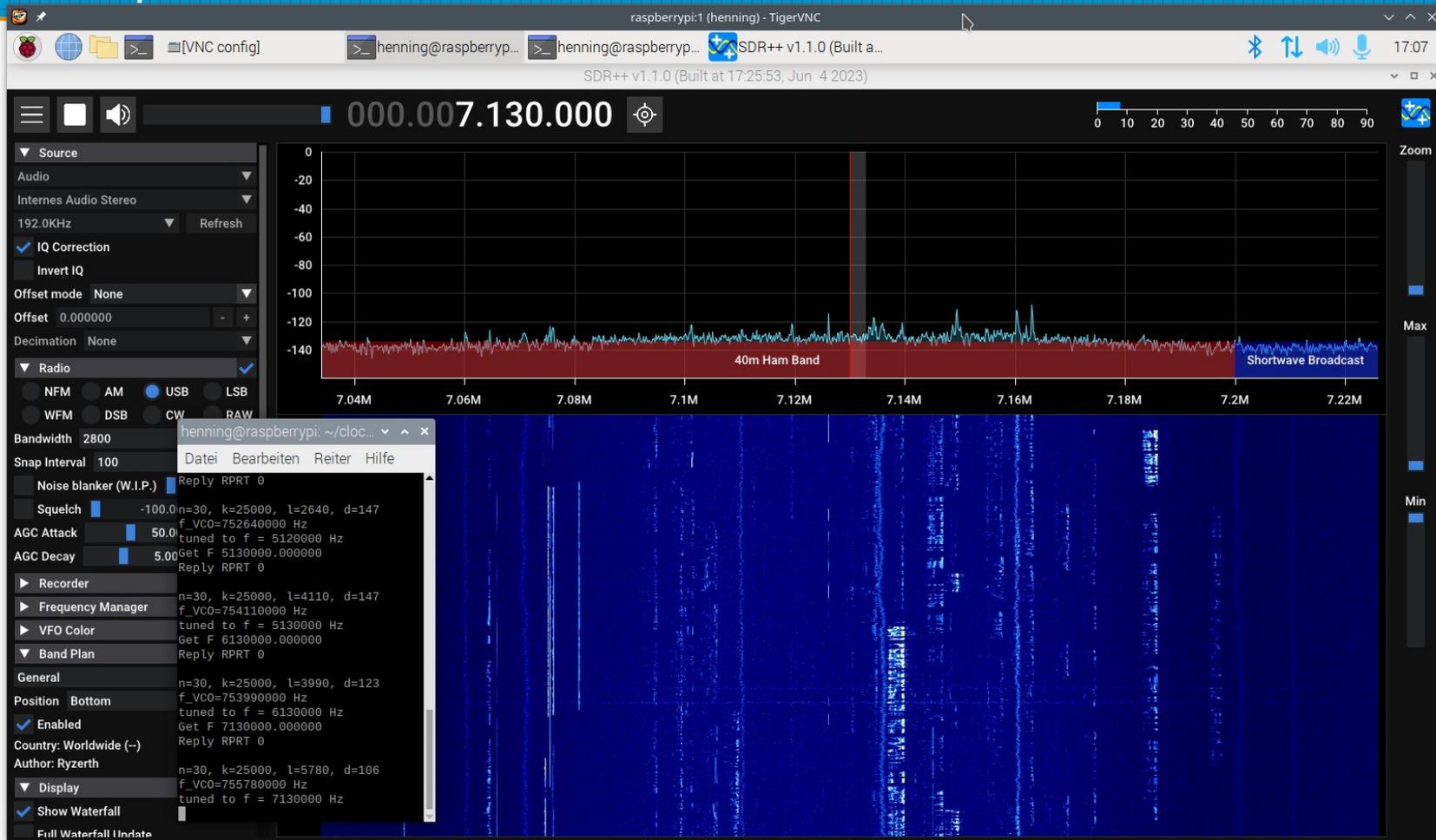
Raspberry Pi Hat

- After successful tests with a USB audio adapter I developed a hat for the Raspberry Pi using a 192kHz/24bit ADC



Receiver performance

- Fixed gain (20dB in ADC driver only)
- No HF filtering



Receiver performance

The image displays a software interface for a receiver, likely a software-defined radio (SDR) application. The interface is divided into several sections:

- Source:** A dropdown menu showing the selected source.
- Audio:** A dropdown menu showing the selected audio output.
- Internes Audio Stereo:** A dropdown menu showing the selected audio output.
- 192.0KHz:** A dropdown menu showing the selected sample rate.
- Refresh:** A button to refresh the data.
- IQ Correction:** A checked checkbox indicating that IQ correction is enabled.

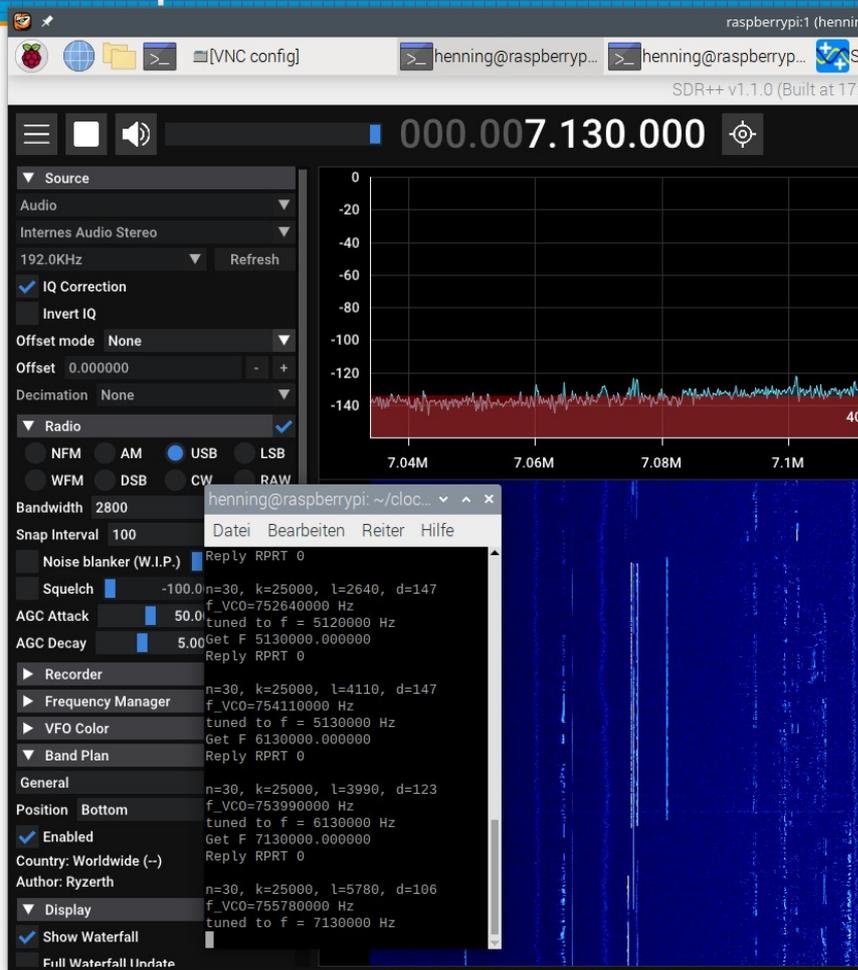
Below these settings, there is a window titled "henning@raspberrypi: ~/cloc..." showing a list of settings and their values:

Setting	Value
Bandwidth	2800
Snap Interval	100
Noise blanker (W.I.P.)	Reply RPRT 0
Squelch	-100.0 n=30, k=25000, l=2640, d=147
AGC Attack	50.0 f_VCO=752640000 Hz
AGC Decay	5.00 tuned to f = 5120000 Hz
Recorder	Get F 5130000.000000
Frequency Manager	Reply RPRT 0
VFO Color	n=30, k=25000, l=4110, d=147
Band Plan	f_VCO=754110000 Hz
General	tuned to f = 5130000 Hz
Position	Get F 6130000.000000
Enabled	Reply RPRT 0
Country	Worldwide (-)
Author	Ryzerth
Display	n=30, k=25000, l=5780, d=106
Show Waterfall	f_VCO=755780000 Hz
Full Waterfall Update	tuned to f = 7130000 Hz

On the right side, there is a waterfall plot showing the frequency spectrum. The plot is titled "m Ham Band" and "Shortwave Broadcast". The frequency range is from 7.12M to 7.22M. The plot shows a signal at approximately 7.13M Hz. The plot is zoomed in, with a zoom level of 90. The plot is titled "DR++ v1.1.0 (Built a...)" and "25:53, Jun 4 2023".

Receiver performance

- Python script emulating rigctld to control Si5351A synth

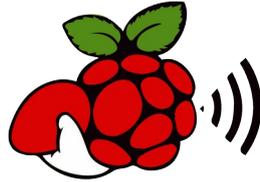


```
henning@raspberrypi: ~/cloc...
Datei Bearbeiten Reiter Hilfe

Reply RPRT 0
n=30, k=25000, l=2640, d=147
f_VCO=752640000 Hz
tuned to f = 5120000 Hz
Get F 5130000.000000
Reply RPRT 0
n=30, k=25000, l=4110, d=147
f_VCO=754110000 Hz
tuned to f = 5130000 Hz
Get F 6130000.000000
Reply RPRT 0
n=30, k=25000, l=3990, d=123
f_VCO=753990000 Hz
tuned to f = 6130000 Hz
Get F 7130000.000000
Reply RPRT 0
n=30, k=25000, l=5780, d=106
f_VCO=755780000 Hz
tuned to f = 7130000 Hz
```

Transmit signal generation

- rpitx by Evariste F5OEO



(<https://github.com/F5OEO/rpitx>)

- Clock synthesizer of Raspberry Pi is abused to generate arbitrary clock signals on Pin 7
- Originally only FM/FSK possible - but since RPi 2 also AM, SSB and OFDM

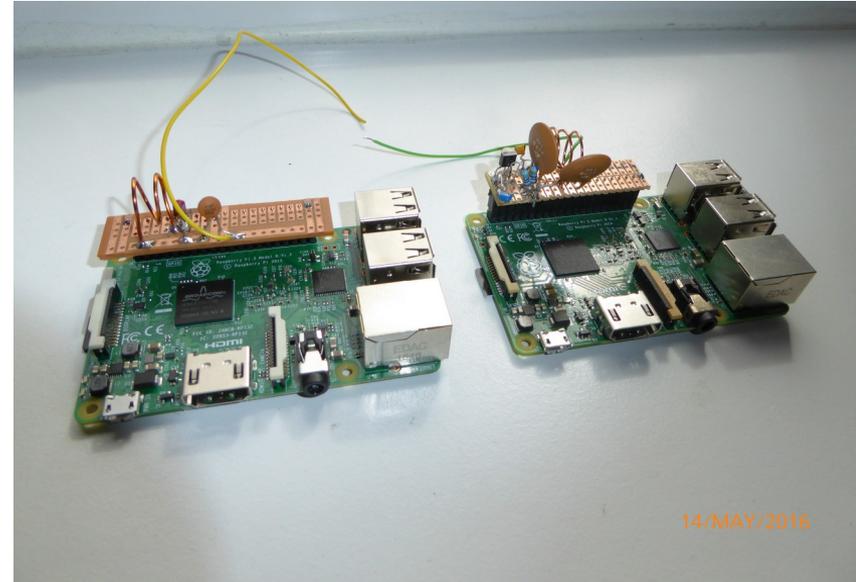
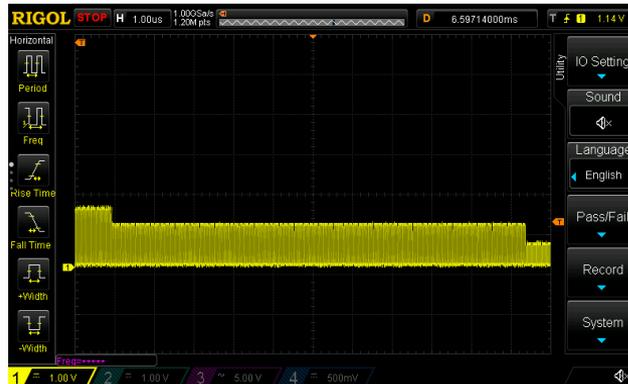
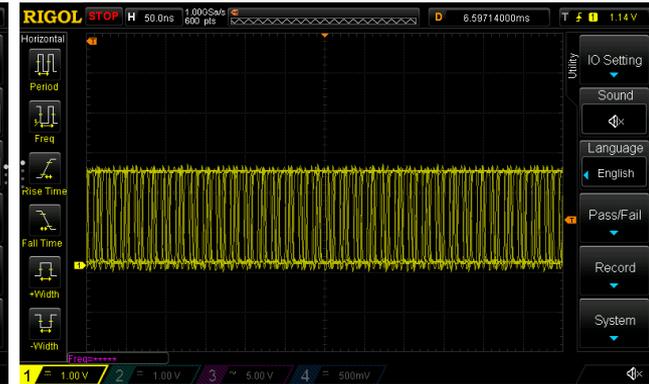
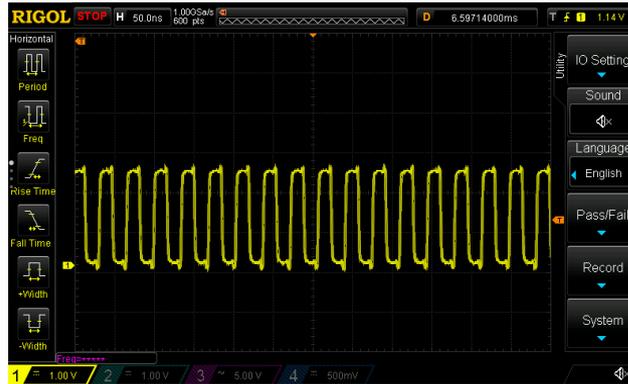


Photo: Gerald DL5BBN (TU Berlin), 2016

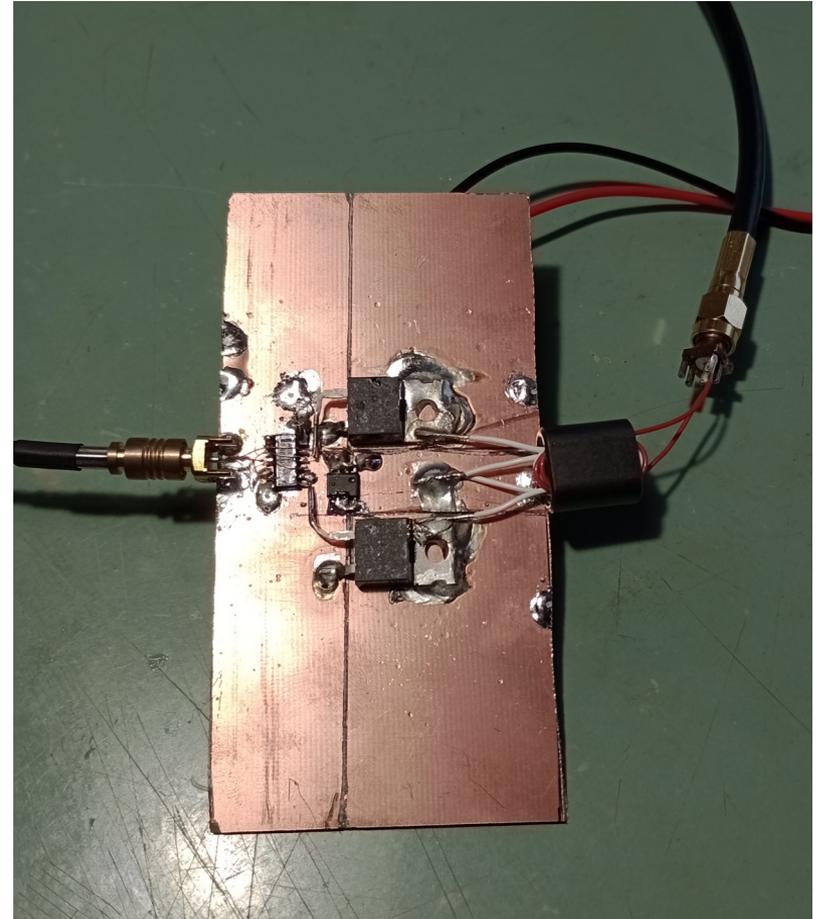
Transmit signal generation

- rpitx wave forms
- NBFM on 10m
- SSB on 10m:
 - Simultaneous FM and AM to create SSB



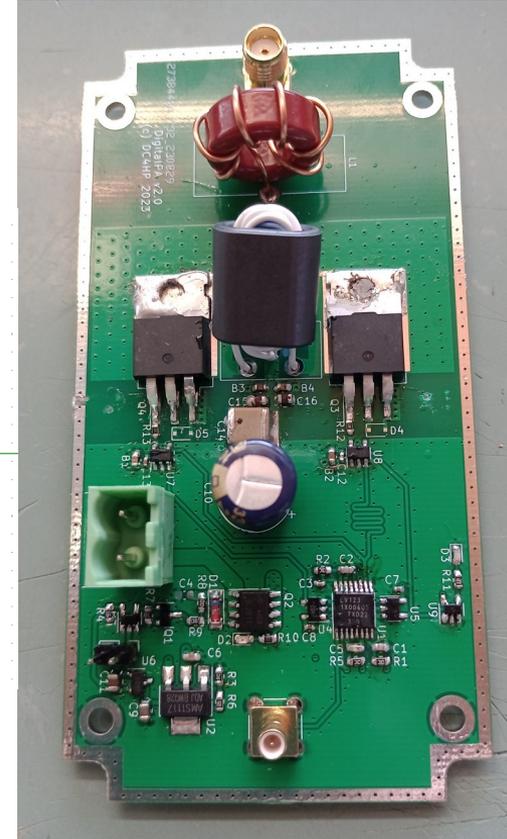
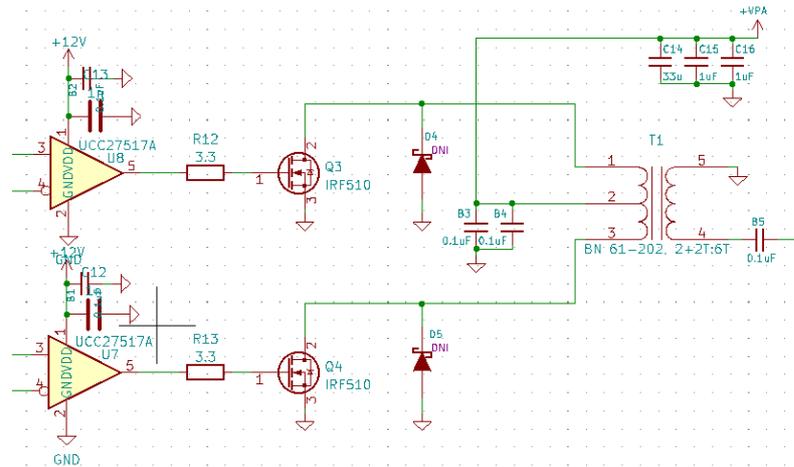
Power amplifier

- Output signal of Raspberry Pi is 3.3V logic level (at least for FSK):
- Option 1: Filter and feed into (linear) HF PA
- Option 2: Use digital (switching) PA
- Experiments using circuit derived from QDX (but with stronger MOSFETs)



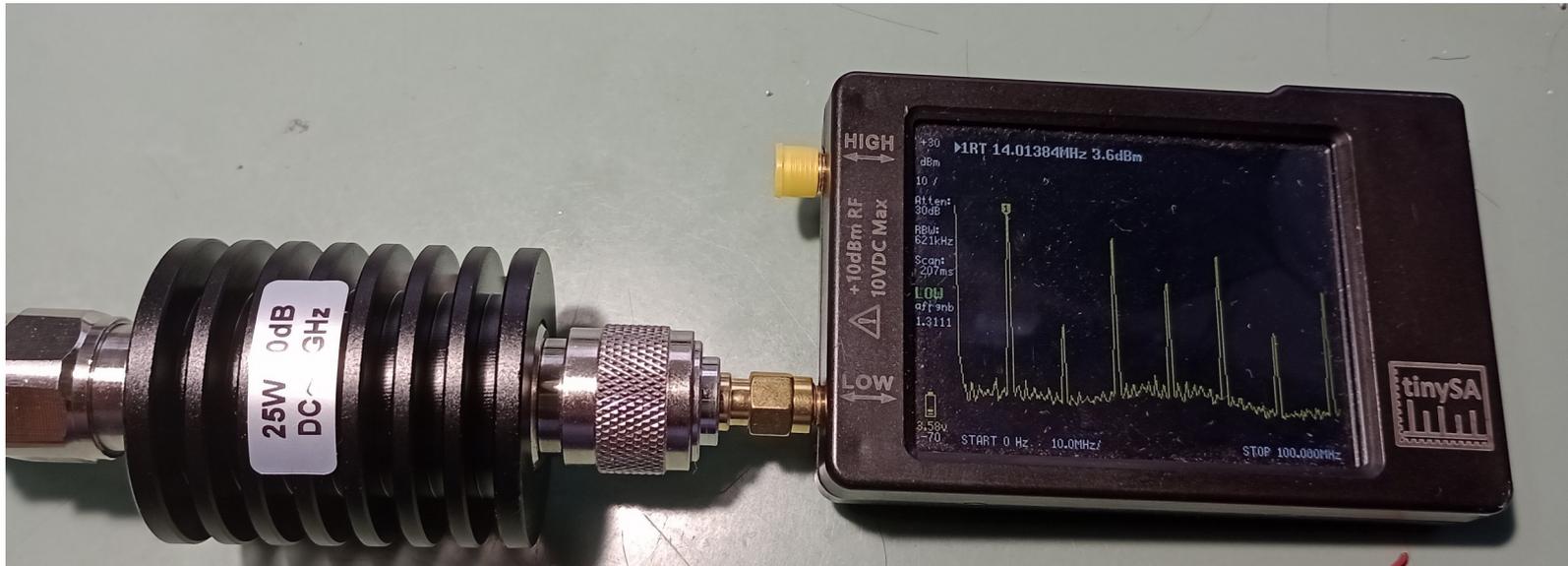
Power amplifier

- Final circuit:
 - 4A gate driver
 - High side PMOS to switch on PA
 - Under frequency lockout (500kHz) to avoid destruction of transistors by DC levels



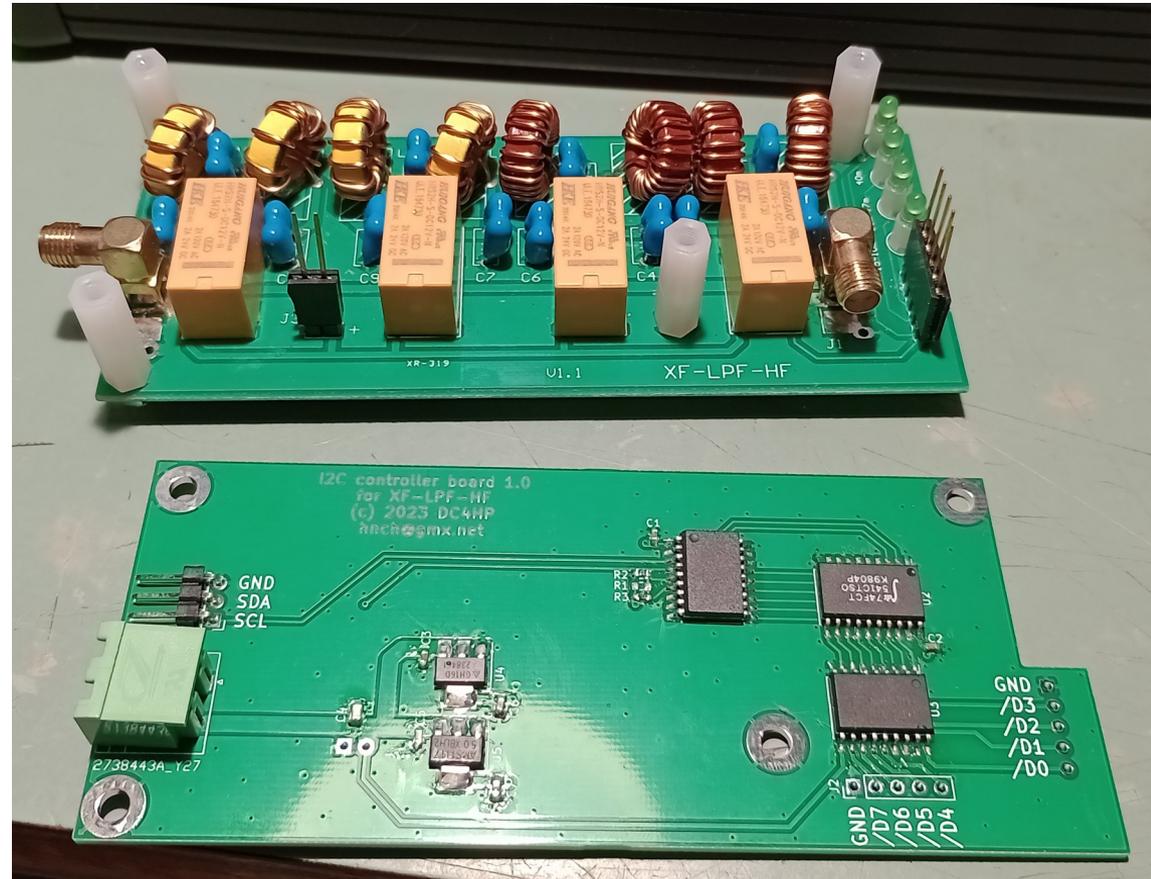
Power amplifier

- 43.6dBm (~22W) in the fundamental on 20m with 14V supply voltage (measured before low pass)



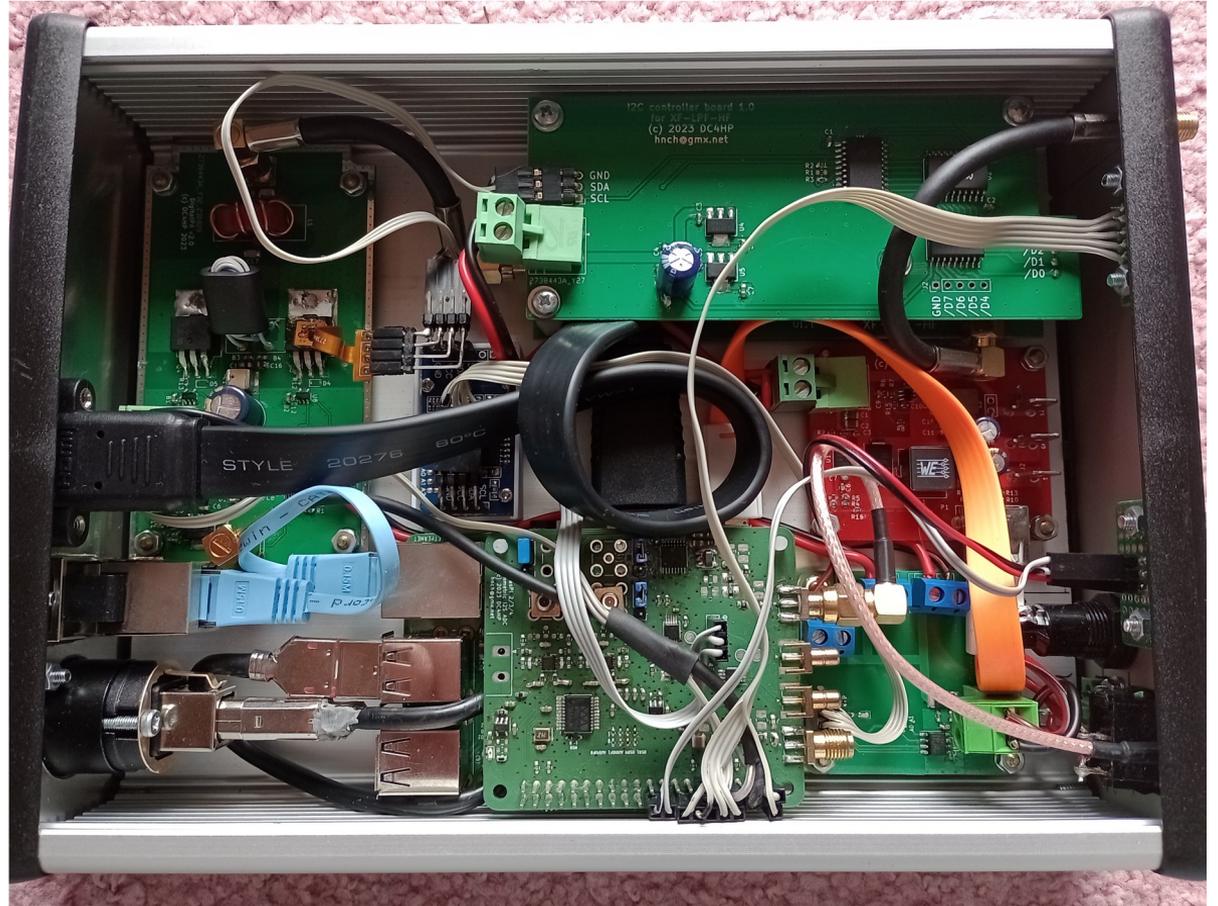
Power amplifier

- Filtering using XF-LPF-HF from AliExpress
- Controlled via I2C using self-designed controller board



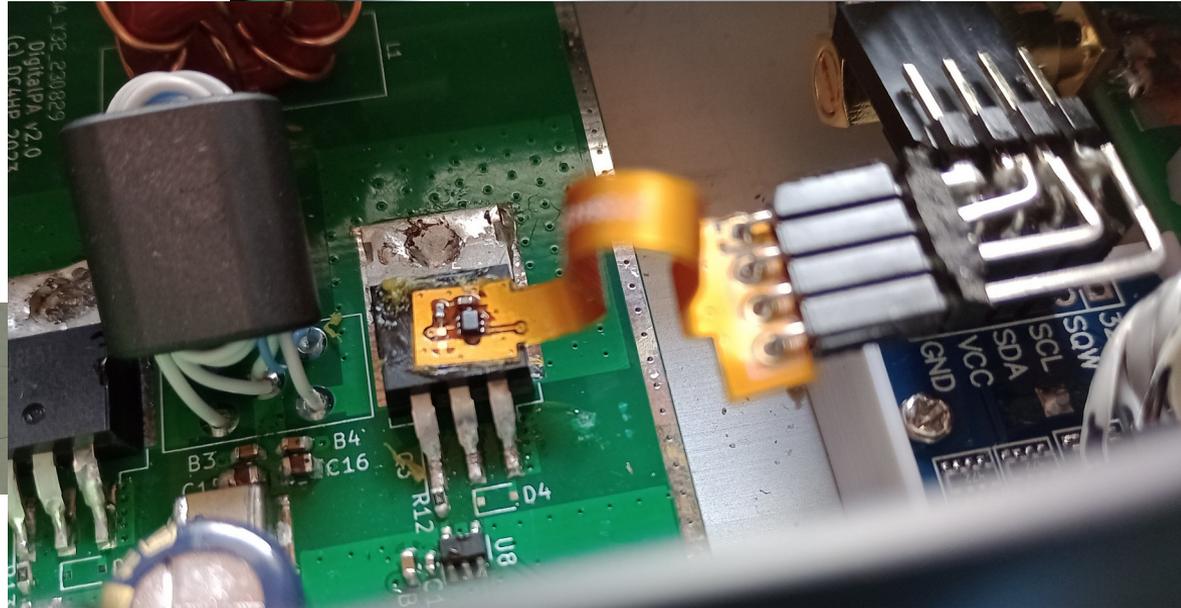
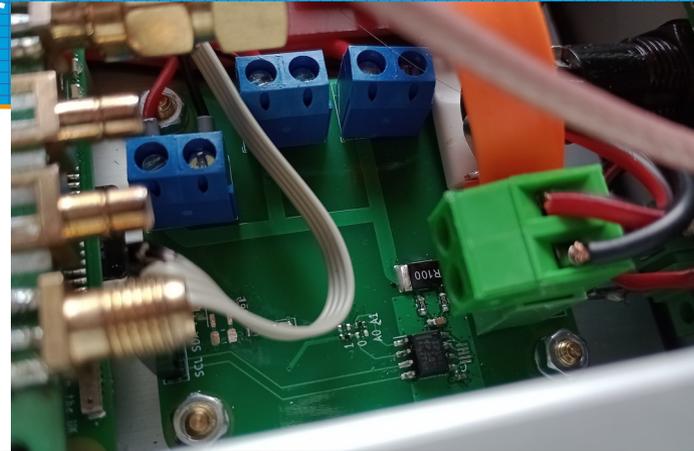
Putting it all together

- LAN, USB and HDMI routed to front panel
- I2C RTC and serial port für GPS receiver
- 5V for RPi generated by self layouted DC/DC board



Putting it all together

- Measurement of input current and voltage using self-designed board
- Measurement of PA temperature using self-designed flex board



Putting it all together

- ATU-100 antenna tuner and Rx/Tx switch externally
- Supplied from SLA or LiFePo4 battery

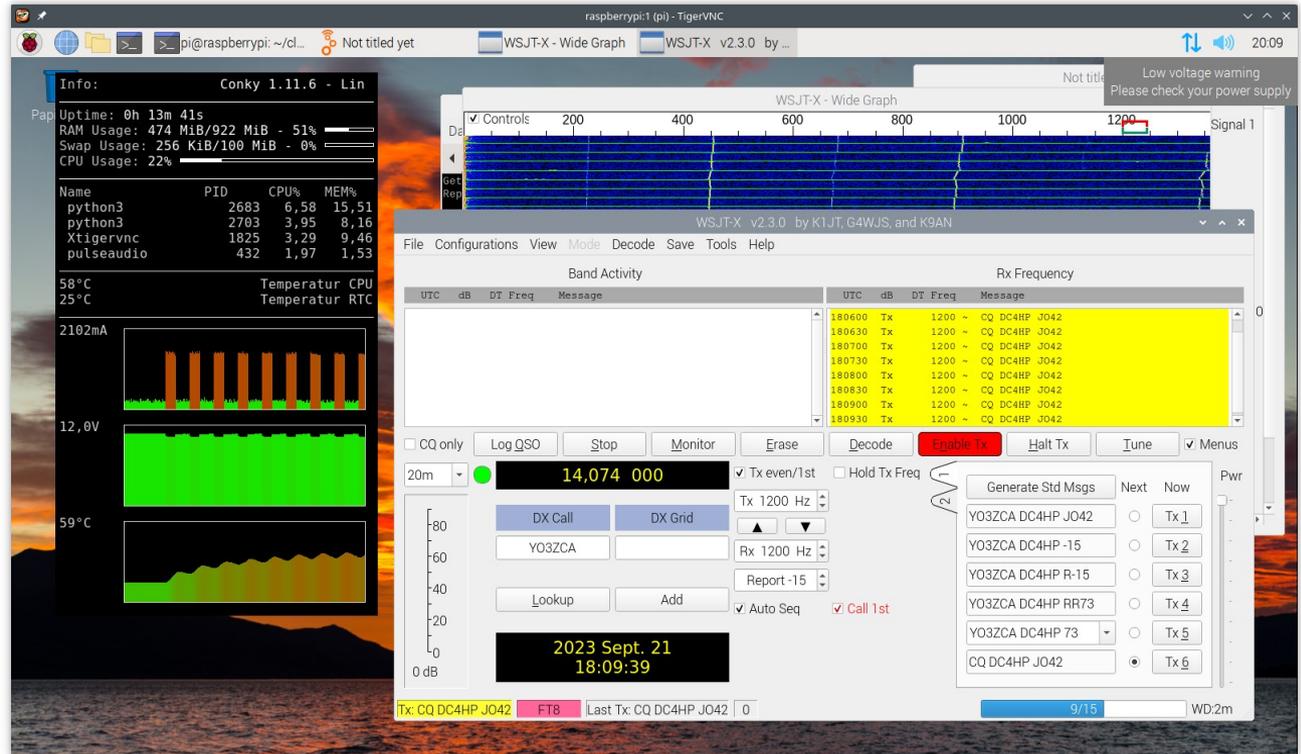


The software

- Python / GNU Radio under Linux on the Raspberry Pi
- GNU Radio Flowgraph for Rx:
 - Capture from I2S ADC; LPF at 2.9kHz; Output to virtual sound card
- GNU Radio Flowgraph for Tx:
 - Capture from virtual sound card; SSB modulation; Output to rpitx-Block (<https://github.com/jmfriedt/gr-rpitx>)
- Python script emulated rigctld
 - Controls Rx mixer's Si5351A via I2C
 - Parametrizes Tx flow graph via ZMQ
 - Controls output LPF via I2C

The software

- Current, voltage and temperature sensors available via standard Linux sensors API → use any tool you like for display



Impressions from the practical use

raspberrypi:1 (pi) - TigerVNC

WSJT-X - Wide Graph

WSJT-X v2.3.0 by K1JT, G4WJS, and K9AN

File Configurations View Mode Decode Save Tools Help

Band Activity				Rx Frequency					
UTC	dB	DT	Freq	Message	UTC	dB	DT	Freq	Message
170115	4	0.6	1035	~ K3RAW US5ZAL KN57	165830	-1	0.3	413	~ CQ EA4GA IN63
170115	-5	0.4	832	~ <8H78I> EA3NA JN01	165845	Tx		413	~ EA4GA DC4HP JO34
170115	5	-0.5	549	~ UT3UW <I8/ON8SGA> R-05	165915	Tx		413	~ EA4GA DC4HP JO34
170115	-11	0.2	892	~ <8H78I> RX5D -12	165930	1	0.3	415	~ DC4HP EA4GA -15
170115	-5	0.4	1170	~ CQ S59G JN65	165945	Tx		413	~ EA4GA DC4HP R+01
170115	-3	0.8	1338	~ CQ HA1BF JN86	170000	1	0.4	416	~ DC4HP EA4GA RR73
170115	-10	0.5	1194	~ <8I78N> F4VTG JN12	170015	Tx		413	~ EA4GA DC4HP 73
170115	-11	0.4	809	~ OZ1CWM R6FX LN14	170030	2	0.4	415	~ CQ EA4GA IN63
170115	-11	0.9	1016	~ R7TO F5PZ 73	170045	12	0.3	685	~ CQ IK1VHR JN44
170115	-14	0.5	776	~ VK3VM RM9WU LO74	170101	Tx		685	~ IK1VHR DC4HP JO34
170145	12	0.4	686	~ DC4HP IK1VHR RR73	170115	8	0.4	686	~ DC4HP IK1VHR -01
170145	13	-0.4	550	~ <UT3UW> I8/ON8SGA 73	170130	Tx		685	~ IK1VHR DC4HP R+08
170145	-6	0.5	1257	~ <8H78I> UB1CCL KO48	170145	12	0.4	686	~ DC4HP IK1VHR RR73
170145	0	0.3	475	~ CQ EI4JFB IO63	170200	Tx		685	~ IK1VHR DC4HP 73
170145	-2	0.4	832	~ <8H78I> EA3NA JN01					

Amplitude

Time (ms)

Relative Gain (dB)

Frequency (kHz)

20m

14,074 000

Tx even/1st

Hold Tx Freq

Tx 685 Hz

DX Call DX Grid

IK1VHR JN44

Rx 686 Hz

Az: 171 1073 km

Report 12

Lookup Add

Auto Seq

Call 1st

2023 Aug. 13 17:02:01

Generate Std Msgs

Next Now

IK1VHR DC4HP JO3

IK1VHR DC4HP +12

IK1VHR DC4HP R+1

IK1VHR DC4HP RRF

IK1VHR DC4HP 7

CQ DC4HP JO34

Tx 1

Tx 2

Tx 3

Tx 4

Tx 5

Tx 6

Pwr

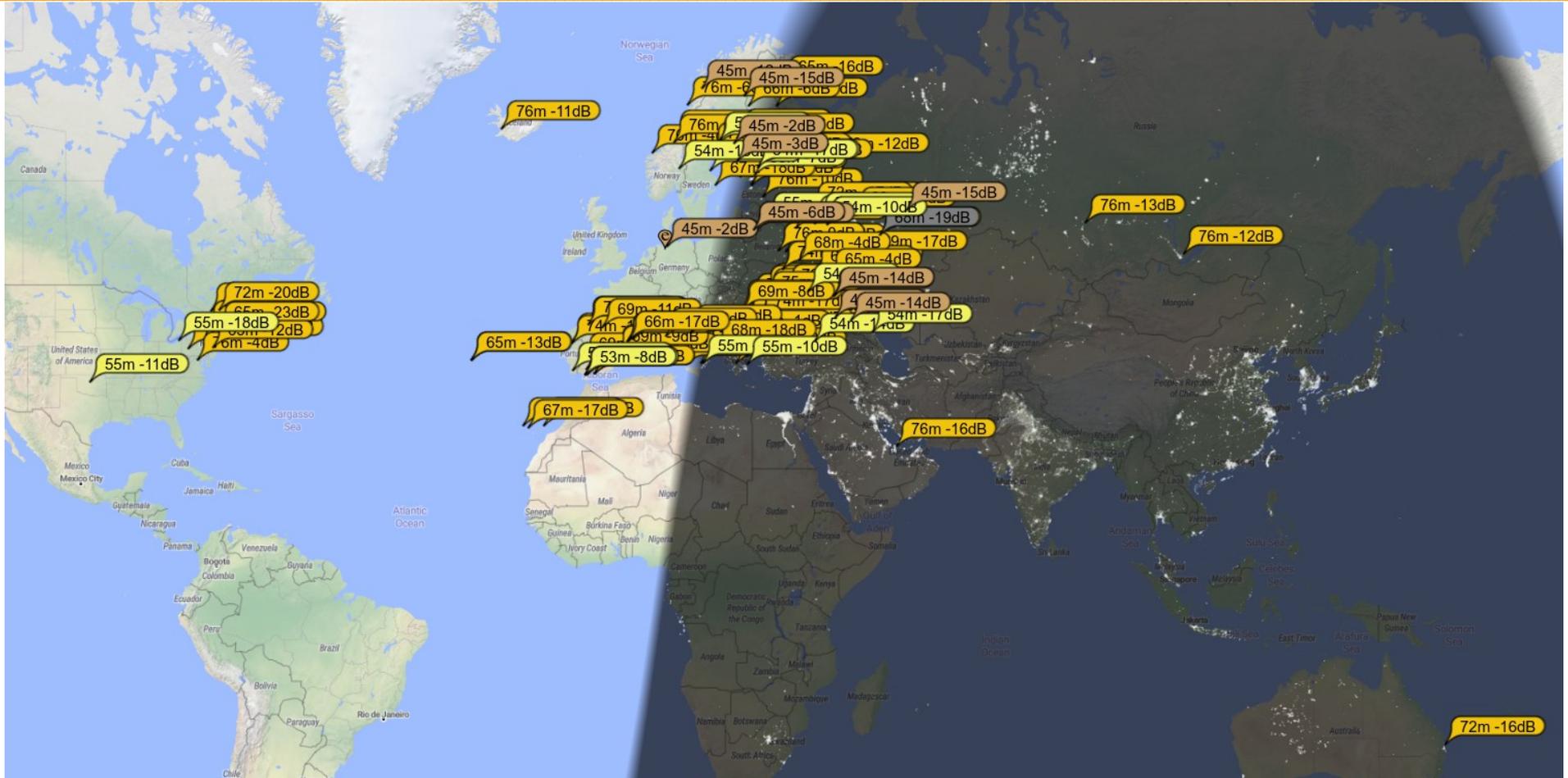
1/15

WD:6m

Tx: IK1VHR DC4HP 73 FT8 Last Tx: IK1VHR DC4HP R+08 5

```
pi@raspberrypi:~$ ./setpot.sh 180
pi@raspberrypi:~$ ./setpot.sh 192
pi@raspberrypi:~$
```

Impressions from the practical use



Thank you very much!