

My experiences with Software Defined Radios (SDRs) and active antennas for HF

by 9V1KG
Feb 2021

SDRs & Active Antennas

- Project Intentions & Preconditions
 - To [gather experience](#) with Software Defined Radios
 - To [monitor the HF bands for propagation](#) (WSPR, PSK reporter)
 - To be able to listen below on low bands 80 m and 160 m
- Conditions
 - [No transmit](#) capability required
 - Has to run under [MacOS](#) and [Linux](#), NO Windows!
 - Not to spend significantly more than \$ 200

SDR Hardware

- Essential parameter to look out for:
 - Frequency Range
 - Most SDR start above HF, some have Direct Sampling (DS) Mode to cover HF – but there are some limitations for DS.
 - Resolution (Bit)
 - Determines the dynamic range (and price!): from 8 Bit (50 dB) ... to 18 Bit (110 dB)
 - Important to be able to pick up weak signals
 - Bandwidth
 - For HF we need to cover at 500 KHz to have a full band in view (except 10 m), but a couple of MHz is not necessary

SDR Hardware

- SDR Hardware on the market (< \$ 200)
 - **RTL dongle:**
RTL-SDR V3 24-1766 (0.5-24 DS), 8 Bit, BW 2.4 MHz (\$ 25, \$ 35 set)
 - **Nooelec:** like RTL
 - **Airspy mini:**
24-1700, 12 bit, BW 6 MHz (\$ 99)
 - **SDRplay RSP1A:**
0.001-2000, 14 Bit, BW 10 MHz (\$ 109)
 - **Airspy+ Discovery:**
0.5-31,60-260, 18(16) Bit, BW 0.6 MHz (\$ 169)
 - **Spyverter** (or other): up converter from HF to VHF (\$ 49)



SDR Software

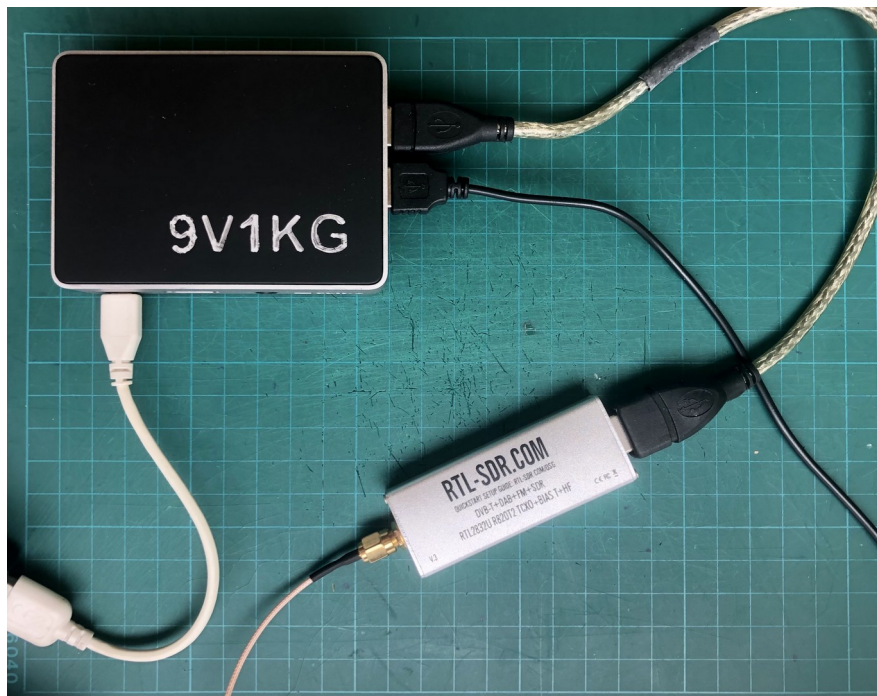
- SDR Receiver
 - SDR# (Windows only)
 - SDR Console (Windows only)
 - [GQRX](#) (Linux & MacOS)
 - [Cubic SDR](#) (Windows, Linux, MacOS)
- SDR Server
 - RTL_TCP
 - SpyServer
 - Soapy Remote
 - WebSDR

SDR Software

- SDR Server
 - SDR plugged into USB of Raspberry Pi 3B+
 - Server runs on Raspi
 - I/Q data sent via LAN
 - I/Q Data received and processed by Computer via LAN



SDR



- Direct Sampling Mode to cover HF
 - $f_s = 28.8 \text{ MHz}$
 - $f_{\text{max}} = f_s/2 = 14.4 \text{ MHz}$
 - Images above 14.4 Mhz!

SDR



- HF Up-converter
 - HF range is converted to $f + 120 \text{ MHz}$
 - 1 kHz – 60 MHz
 - Current consumption: $< 100 \text{ mA}$
 - DC via bias-tee Voltage (no additional cable required)

Active Antennas



Like many other OMs in SG,
I can setup my
antenna only temporarily.

5 m whip with loading coil on
the balcony

Active Antennas

- **Small size** – only a fractional of the wavelength
- Fixed installation possible
- Wide bandwidth!

BUT

- Receive only
- Need for (linear) preamplifier
- Intermodulation! – overload, images and spurious!
- Good Overview from G8JNJ: <https://www.g8jnj.net/activeantennas.htm>

Active Antennas

- Monopole or Whip
 - Very compact
 - Very difficult to prevent unwanted noise and interference from being picked up by the feed coax
- Dipole
 - Compact, balanced design, helps reject unwanted noise and interference
 - Needs very good balance in order to prevent unwanted common mode signals overriding the wanted differential mode signals
- Loop
 - Inherently balanced design, low value of feed point impedance helps reject unwanted noise and interference
 - Limited frequency range, loop conductor needs to be quite large in order to obtain the best results

Active Antennas

“Mini Whip”

- RA0SMS
- PA0RDT

\$ 11 ... \$ 25



0.1 ... 30 MHz

“Active Loop”

- MLA 30+
- Y-200A

\$ 35 ... \$ 40



Many cover 0.1 ... 180 (!) MHz,
No other specifications given

Active Antennas

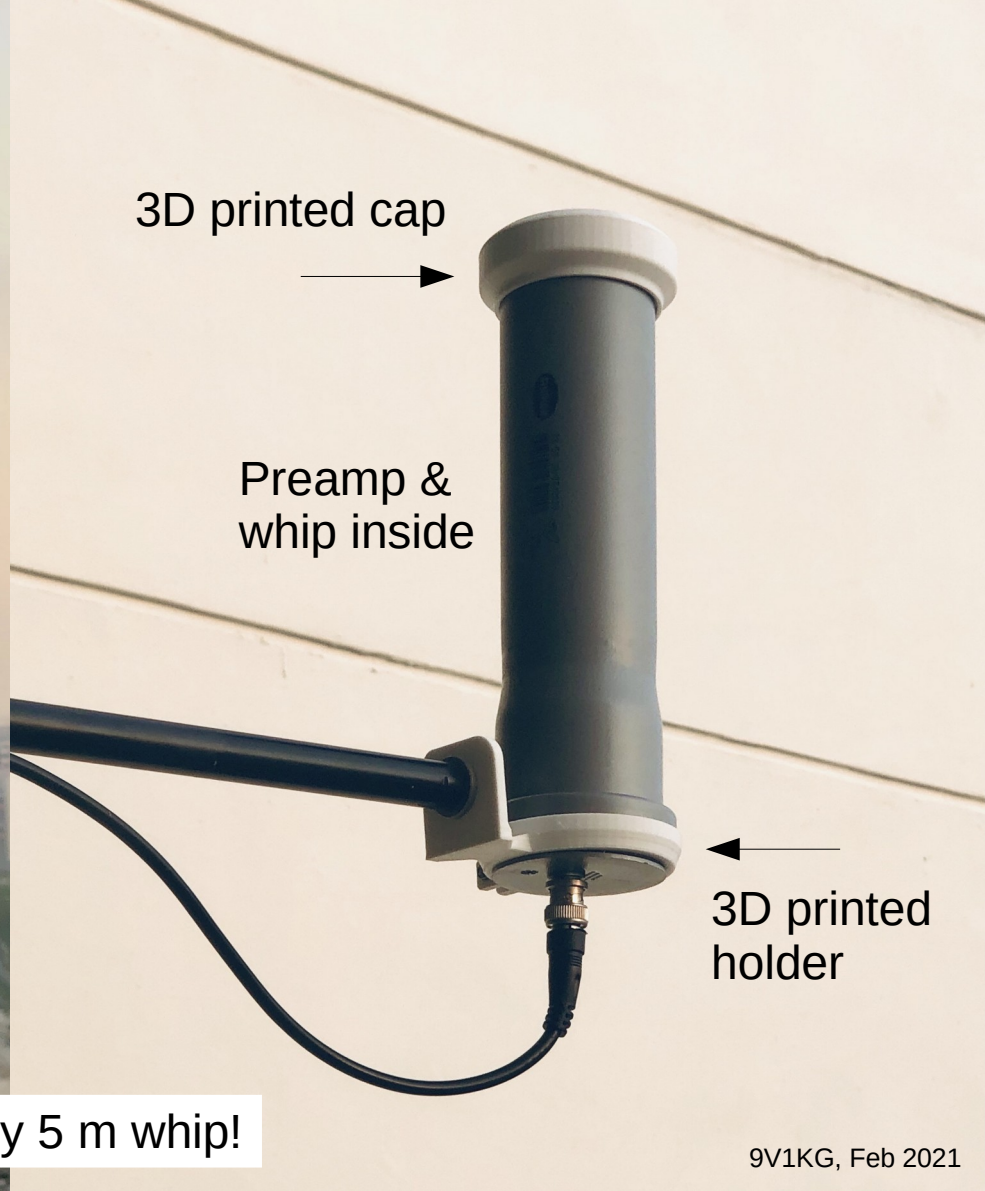
- Cross Country Wireless Loop Antenna Amplifier
 - **5 kHz to 30 Mhz**
(Option VLF)
 - OIP3: > **+37.5 dBm (20)**
 - Gain: **+26 dB** at 14 MHz
 - Noise figure: **0.8 dB (12)**
 - **\$ 75**
 - () MLA 30 values



“Mini Whip” RA0SMS



Disappointing compared to my 5 m whip!

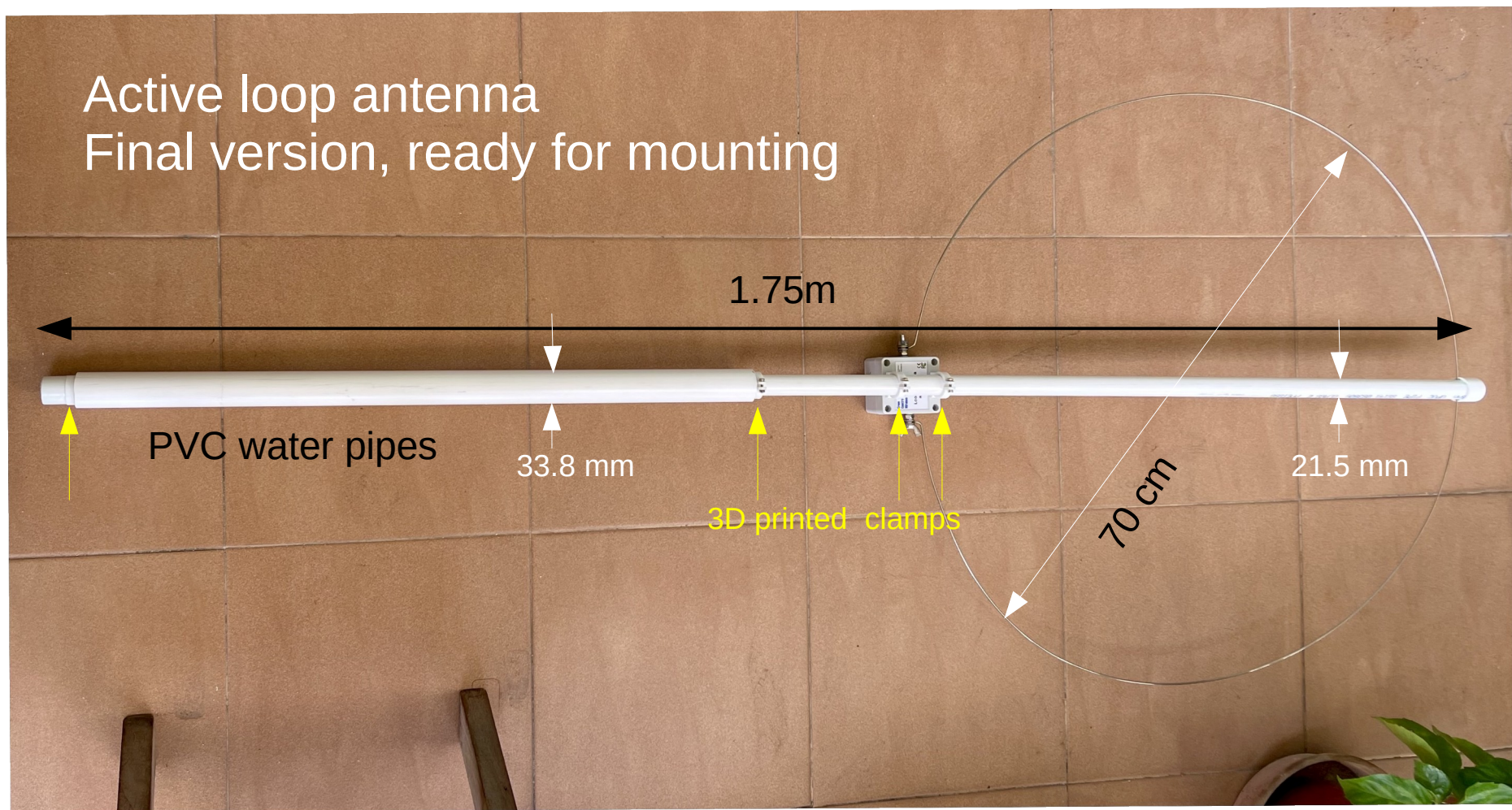


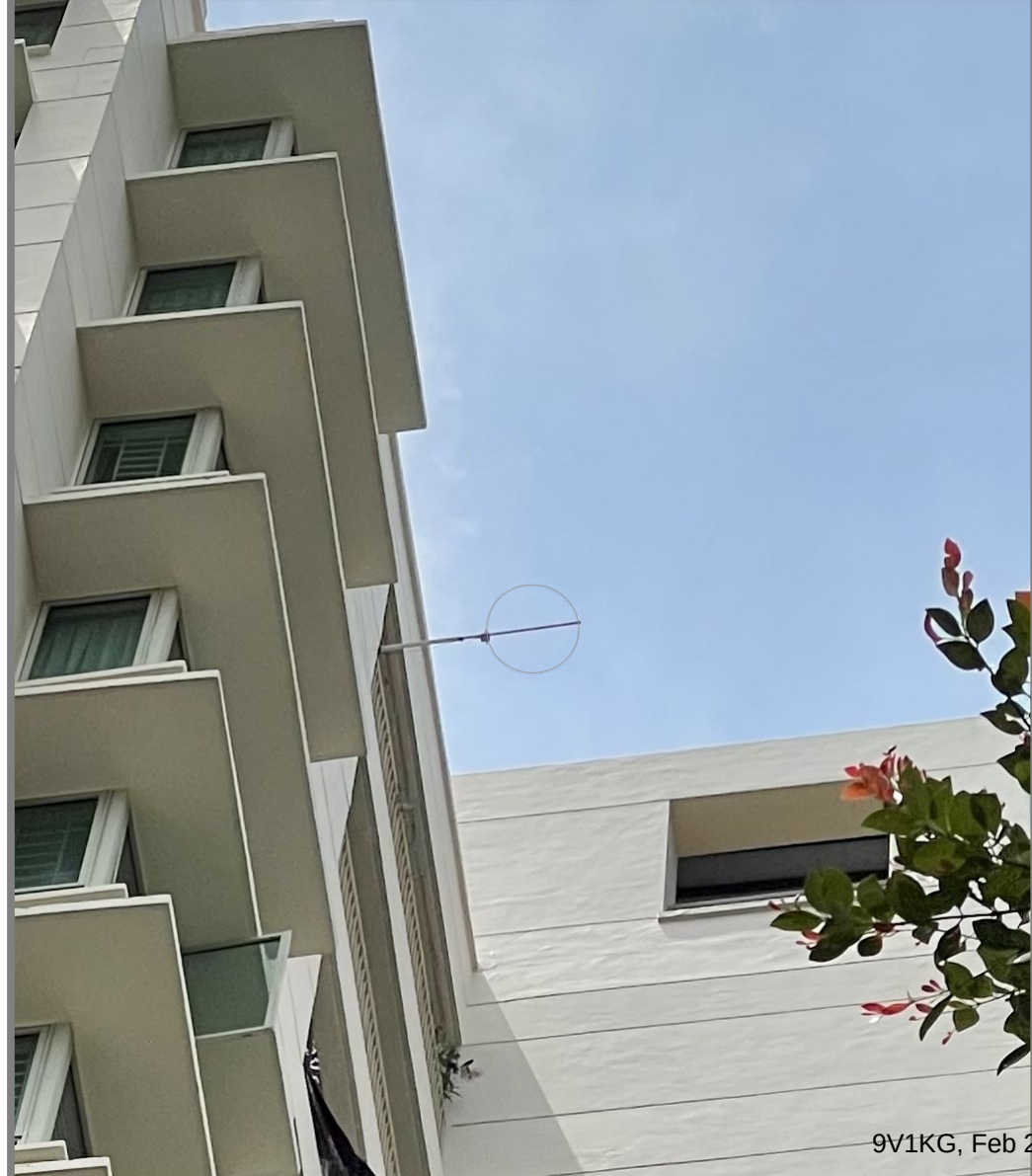
3D printed cap

Preamp &
whip inside

3D printed
holder

Active loop antenna Final version, ready for mounting





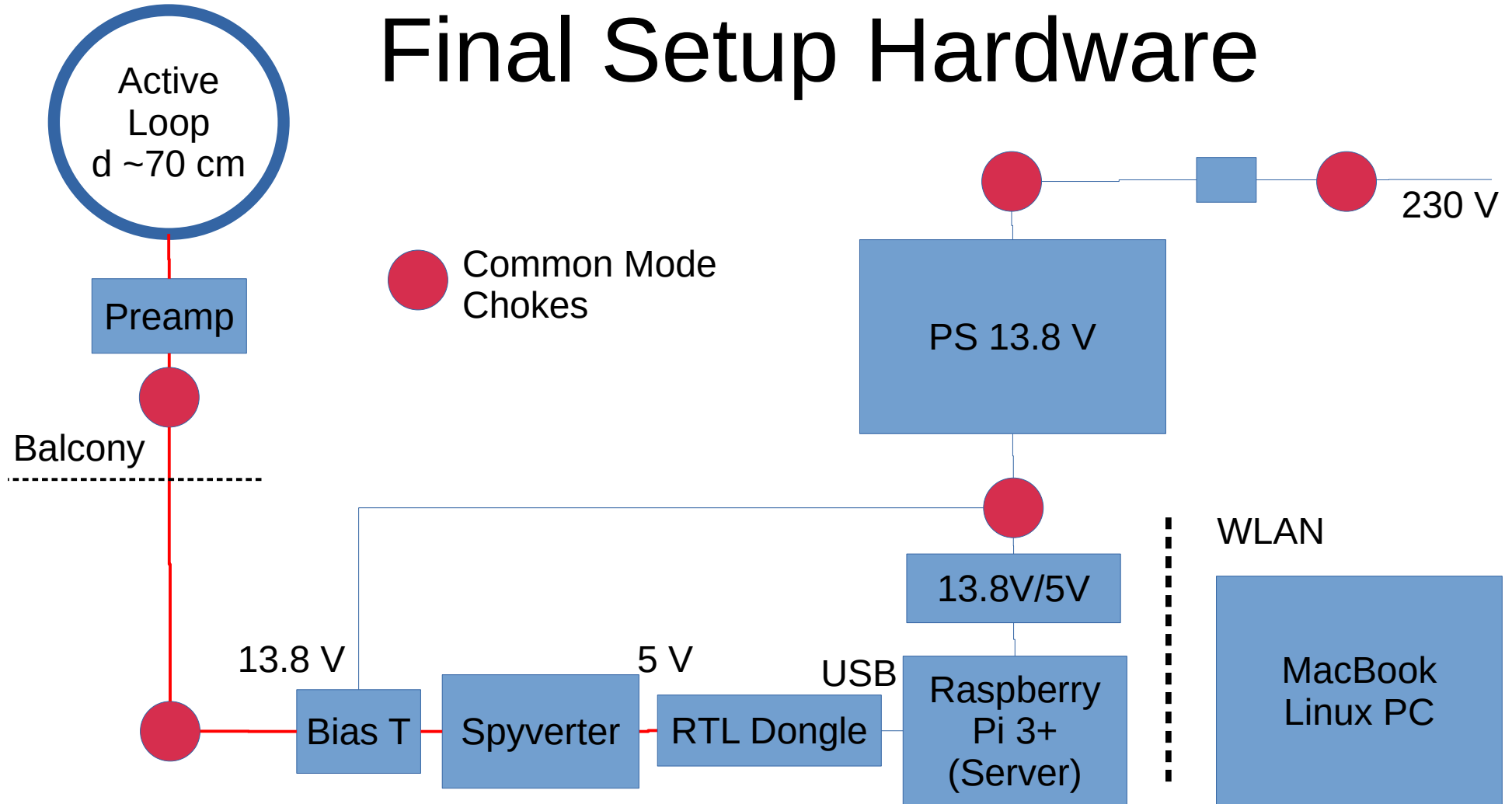
Loop
Antenna

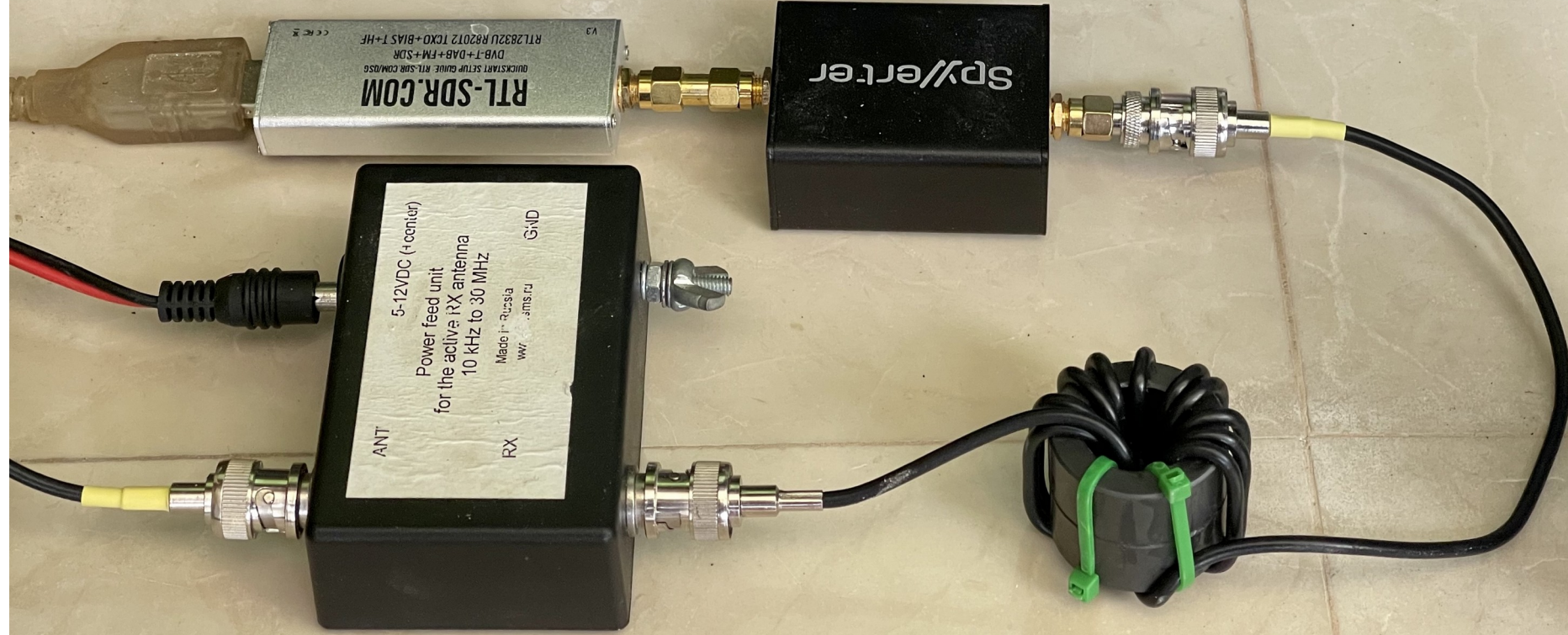
Fixed
Installation

Horizontal!



Final Setup Hardware

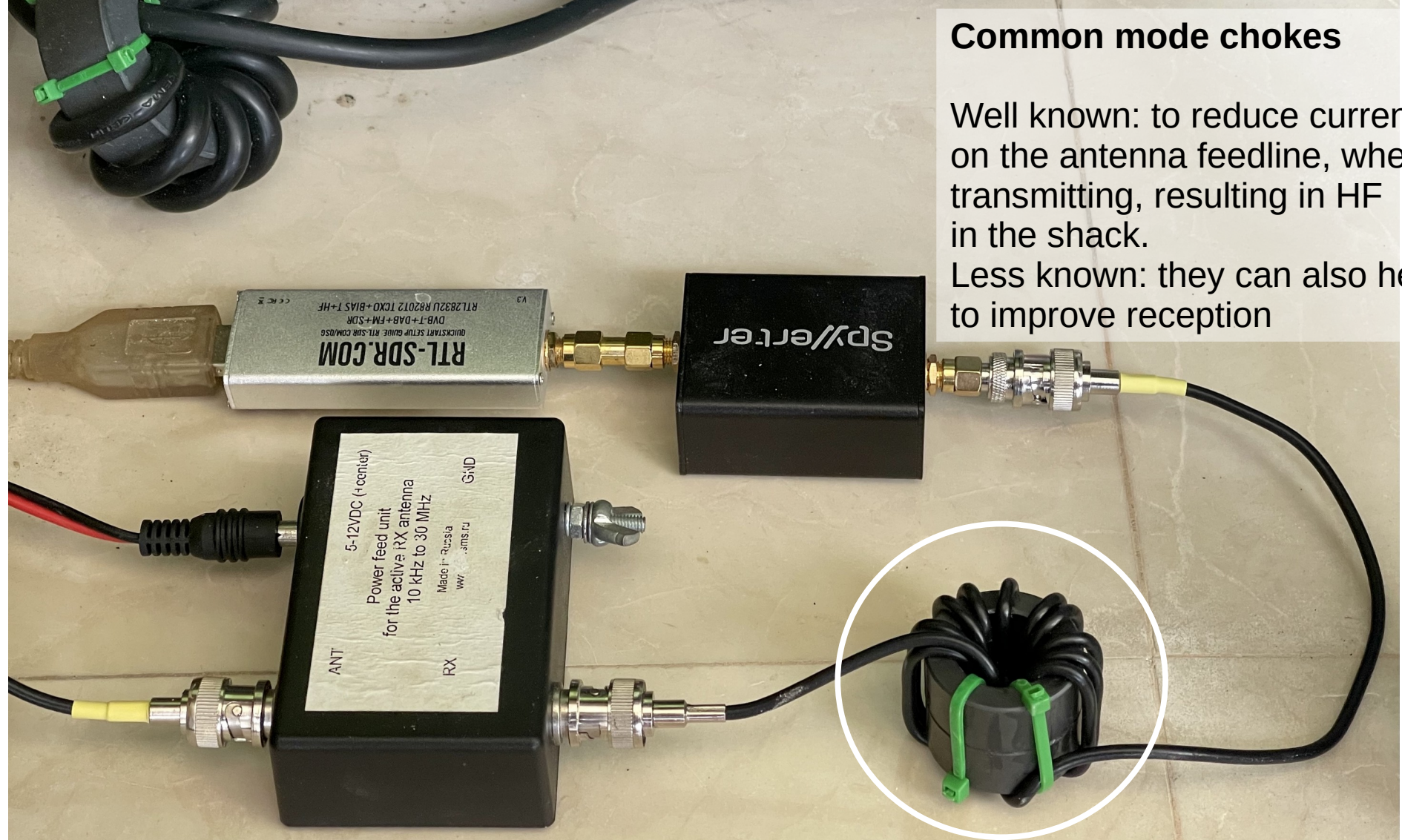




Common mode chokes

Well known: to reduce currents on the antenna feedline, when transmitting, resulting in HF in the shack.

Less known: they can also help to improve reception



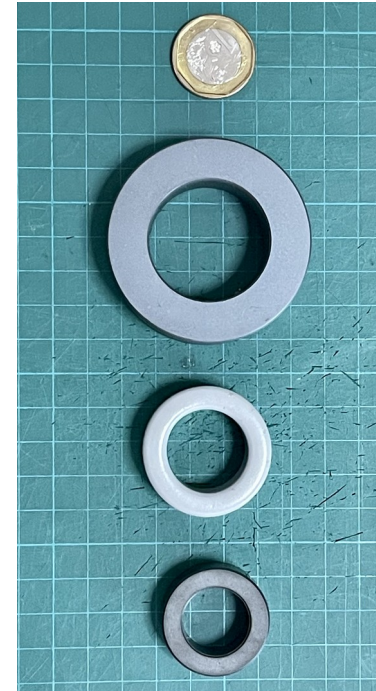
Common Mode Chokes

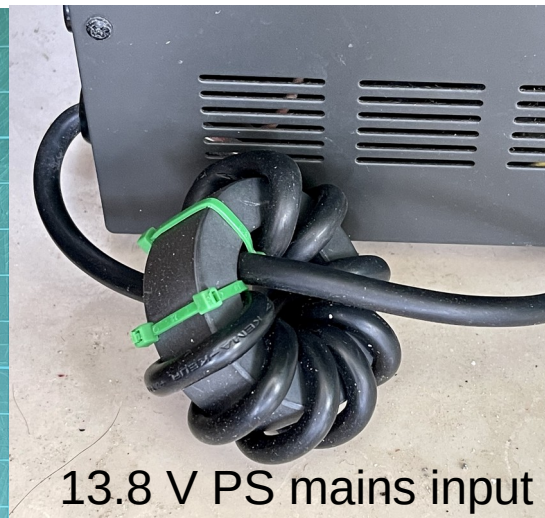
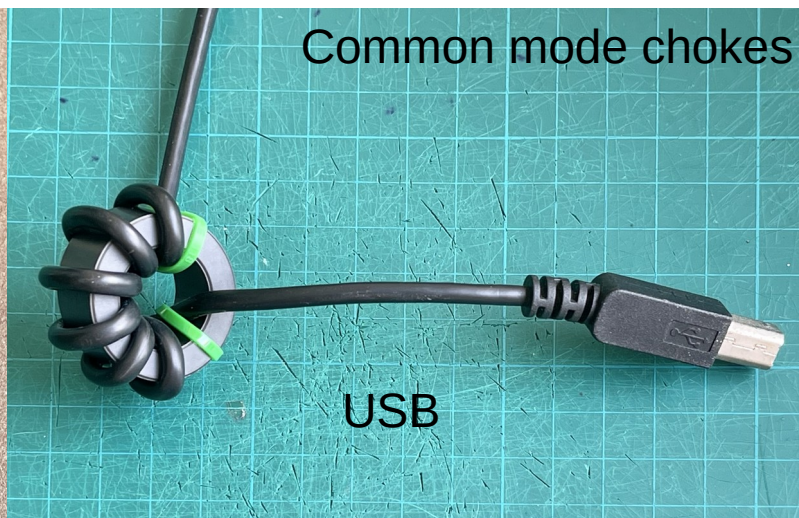
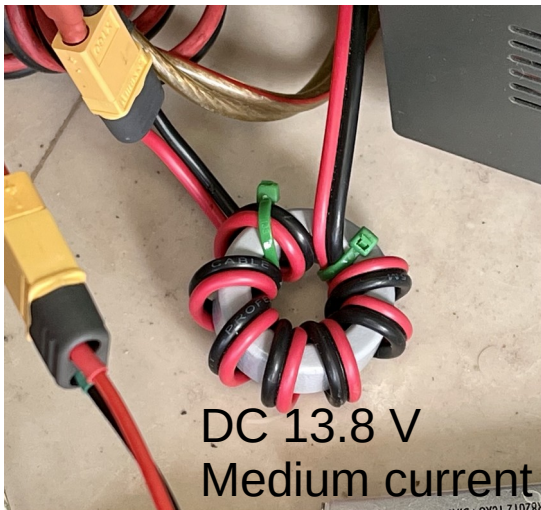
- All cables act as antennas and carry noise to the receiver
- Putting common-mode chokes on your feedline, power lines and other cables will substantially reduce your received noise level.
- A good choke has $\gg 1 \text{ k}\Omega$ impedance for all MF and HF bands

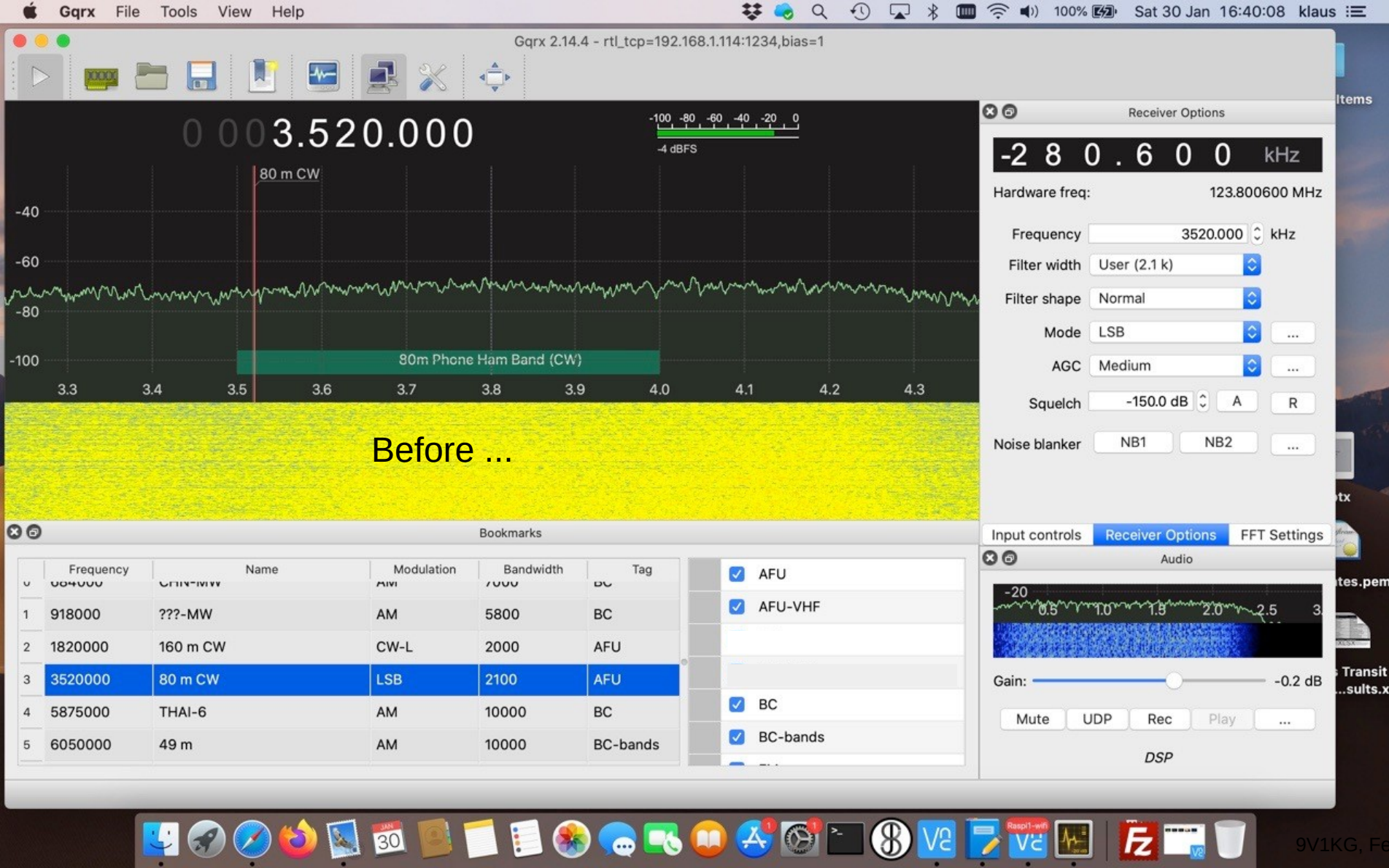


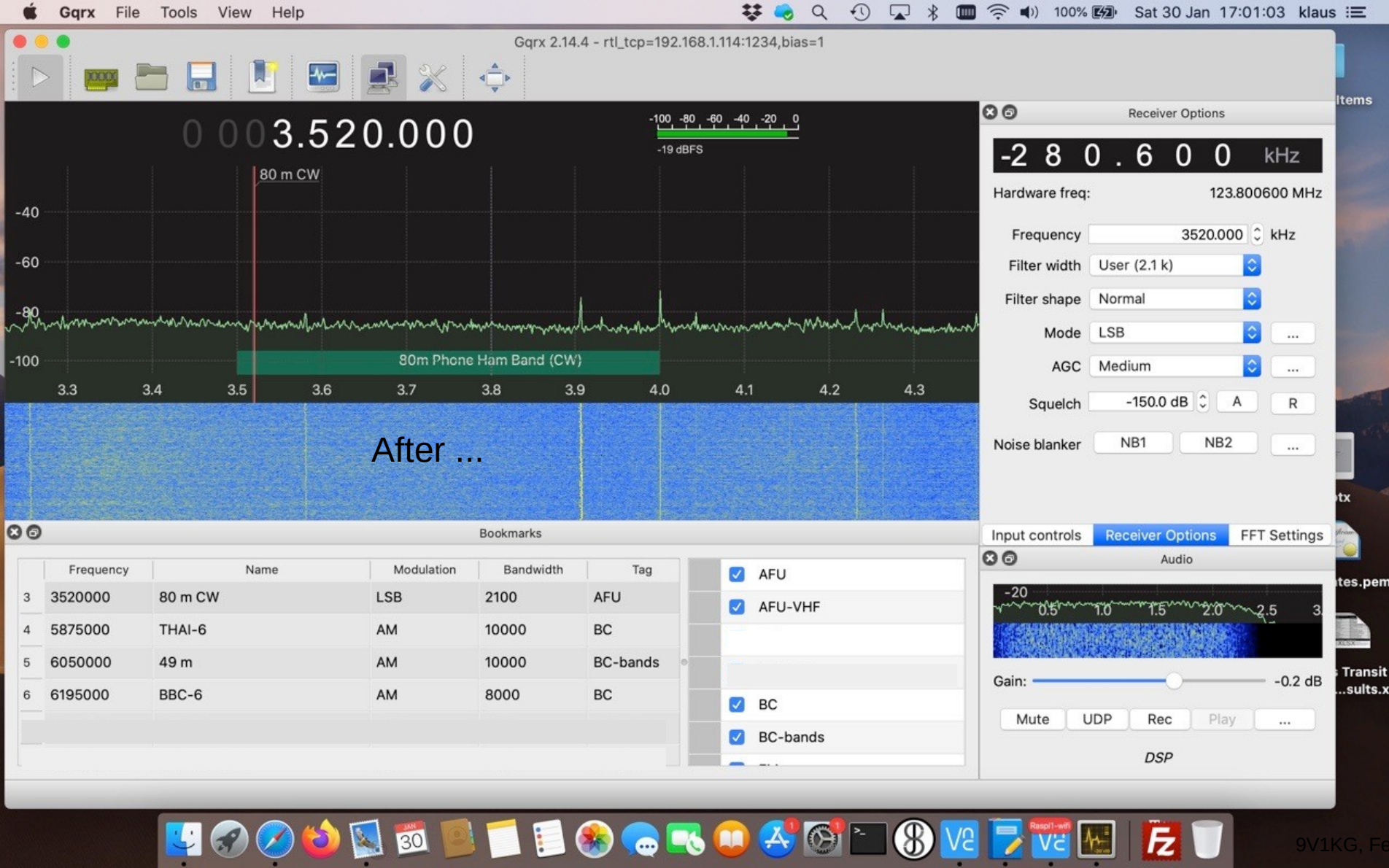
Common Mode Chokes

- XXL: Wurth Electronic Material AW 620 (\$ 11)
 - Size 61 x 35.5 x 20 mm (FT-240) for cables approx. 8 mm dia; 45 Ohm @ 3 MHz: 5 turns min
- XL: RS Pro Material K4000 (\$ 9)
 - Size 36 x 23 x 16 mm (FT-140) for cables approx. 5 mm dia; 100 Ohm @ 3 MHz: 3 turns min
- L: TDK Material HF 70 (\$ 2.50)
 - Size 31 x 13 x 19 mm (FT-120) for RG174 approx. 2.5 mm dia; 25 Ohm @ 3 MHz: 6 turns min









Two Mode of Operation

- Listening (SWL)
 - RTL_TCP server runs on Raspi
 - Computer (Linux and Mac) with GQRX
- Reporting (PSK reporter)
 - GQRX runs on Raspi
 - Virtual Audio
 - WSJT-X runs on Raspi and sends reports to PSK reporter via WLAN
 - VNC (remote desktop) to connect Linux PC or Mac

Mode of Operation

- Audio Examples

40 m

DU Net

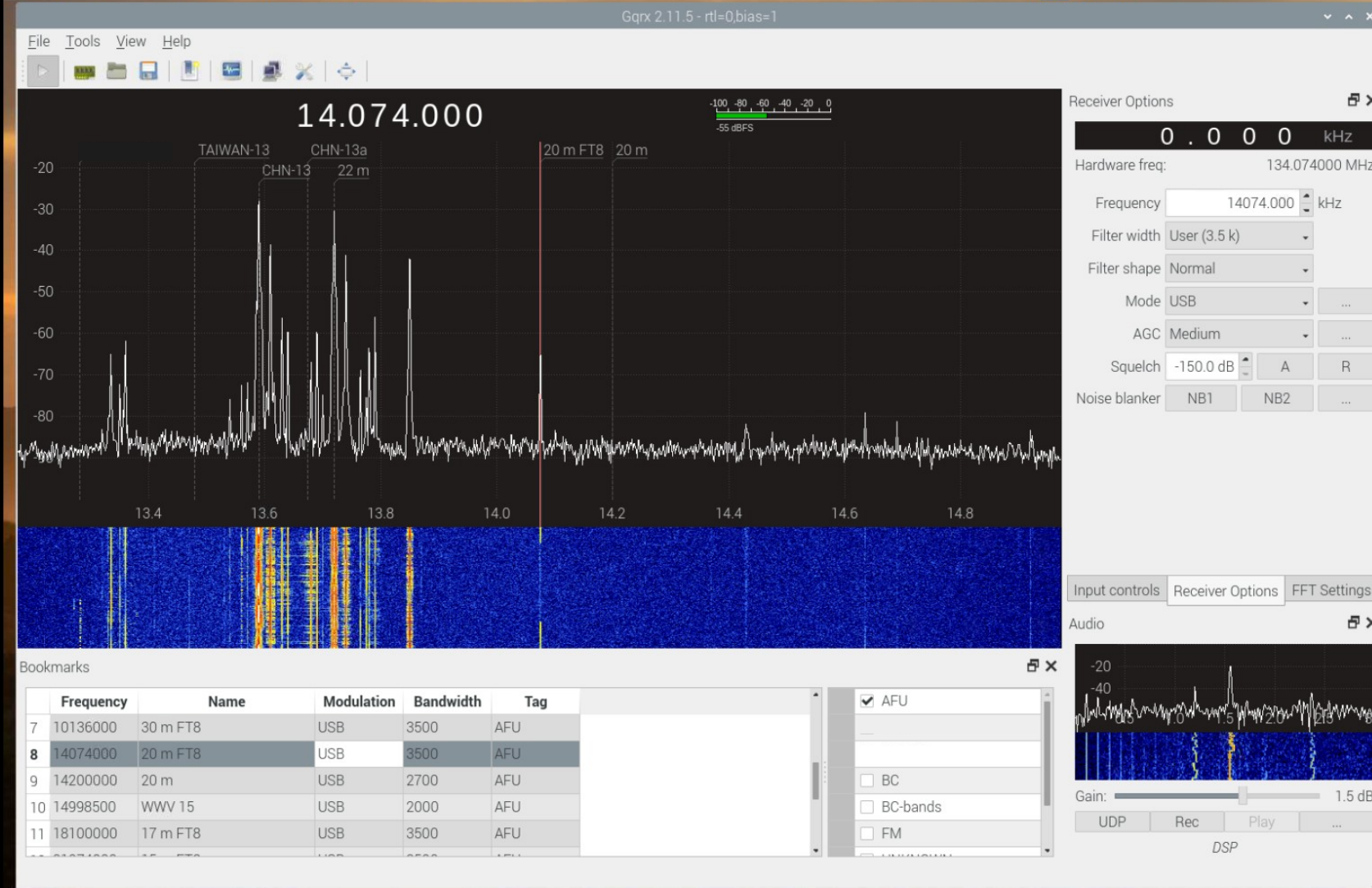
160 m

- 1) YC1COZ
- 2) BD7OB
- 3) 7C1B
- 4) E2X

80 m

- Comparison ICOM 7300 vs SDR
- a) Icom with 5 m vertical w loading coil
 - b) RTL SDR with active loop

- Live Demo



9V1KG

Gridsquare NO GPS

SFI: 71 A: 4

Sunspots: 0 K: 2

LOCAL UTC

18:48:51 10:48:51

21-02-15 21-02-15

SYSTEM

Frequency 1.40Ghz

Uptime 2d 5h 50m

Temp: 60.1 C

CPU 95%

MEM 418MiB / 924MiB 45%

SWAP 7.75MiB / 100MiB 7%

HDD 8.95GiB / 28.9GiB 63%

NETWORK/HOTSPOT

Wireless IP address 192.168.1.114

Wired IP address No Address

DHCP ADDRESSES FOR HOTSPOT

10.10.10.178 ApplesMcBook147

RADIO TOOLS

ARDOP OFF RIGCTL ACTIVE

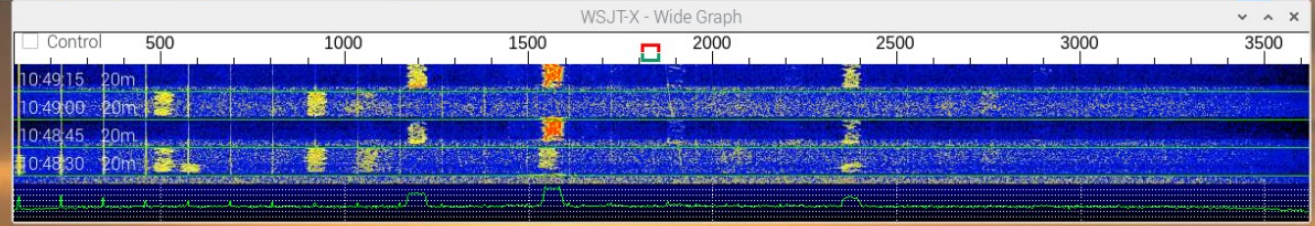
KISSATCH OFF DIREWOLF OFF

DIGITAL APPS

JSB OFF FLRIG OFF

WSJTXX ACTIVE FLDIGI OFF

PULSE ACTIVE PAT OFF



WSJT-X v2.2.2 by K1JT, G4WJS, and K9AN

1 to 1.5 sec delay due to SDR processing

Time	Delay	Call	Mode	Power	Location
104700	1.5	485	~ RU3QR YB0KXO OI33		
104700	1.3	884	~ IOINU E25MTT -20		
104700	1.3	558	~ LB5HI DU7EYG RR73		
104700	1.2	902	~ YC1BQF R2AUH RR73		
104730	1.5	903	~ CQ HS2KYA OK12		Thailand
104730	1.5	559	~ LB5HI DU7EYG RR73		
104730	1.7	487	~ RU3QR YB0KXO OI33		
104730	1.5	361	~ YC3YOG UR5EH R-17		
104730	1.4	356	~ CQ BH4BNQ PM01		China
104845	1.3	356	~ RA3VGS BH4BNQ PM01		
104845	1.4	176	~ RA9AIF YC3YOG -19		
104845	1.2	979	~ CQ BG7PHA OL72		China
104845	1.3	042	~ E25MTT BX2ADE RR73		
104900	1.6	487	~ RU3QR YB0KXO OI33		
104900	1.3	903	~ CQ HS2KYA OK12		Thailand
104900	1.4	034	~ CQ ERSDX AN46		Moldova
104900	1.3	903	~ IV3KKW R2AUH RR73		
104915	1.3	356	~ RA3VGS BH4BNQ PM01		
104915	1.3	176	~ RA9AIF YC3YOG -20		
104915	2.0	546	~ CQ BI6IVB OK48		China

☐ CQ only ☐ Log QSO ☐ Stop ☐ Menus

20m ☒ 14.074 000

☒ Tx even/1st ☒ Hold Tx Freq

DX Call: 9V1KG DX Grid: OJ11

Az: 280 104 km

Report 16 ☒ Auto Seq ☐ Call 1st

2021 Feb 15 10:49:29

Receiving 9V1KG-RTL FT8 Last Tx: 9V1KG 9V1KG +17 3

14/15 WD:60m

9V1KG

Gridsquare NO GPS
SFI: 71 A: 4
Sunspots: 0 K: 2

LOCAL UTC
18:49:29 10:49:29
21-02-15 21-02-15

SYSTEM
Frequency 1.40Ghz
Uptime 2d 5h 51m
Temp: 60.1 C
CPU 66%
MEM 423MiB / 924MiB 45%
SWAP 7.75MiB / 100MiB 7%
HDD 8.95GiB / 28.9GiB 63%

NETWORK/HOTSPOT
Wireless IP address 192.168.1.114
Wired IP address No Address
DHCP ADDRESSES FOR HOTSPOT
10.10.10.178 ApplesMcBook147

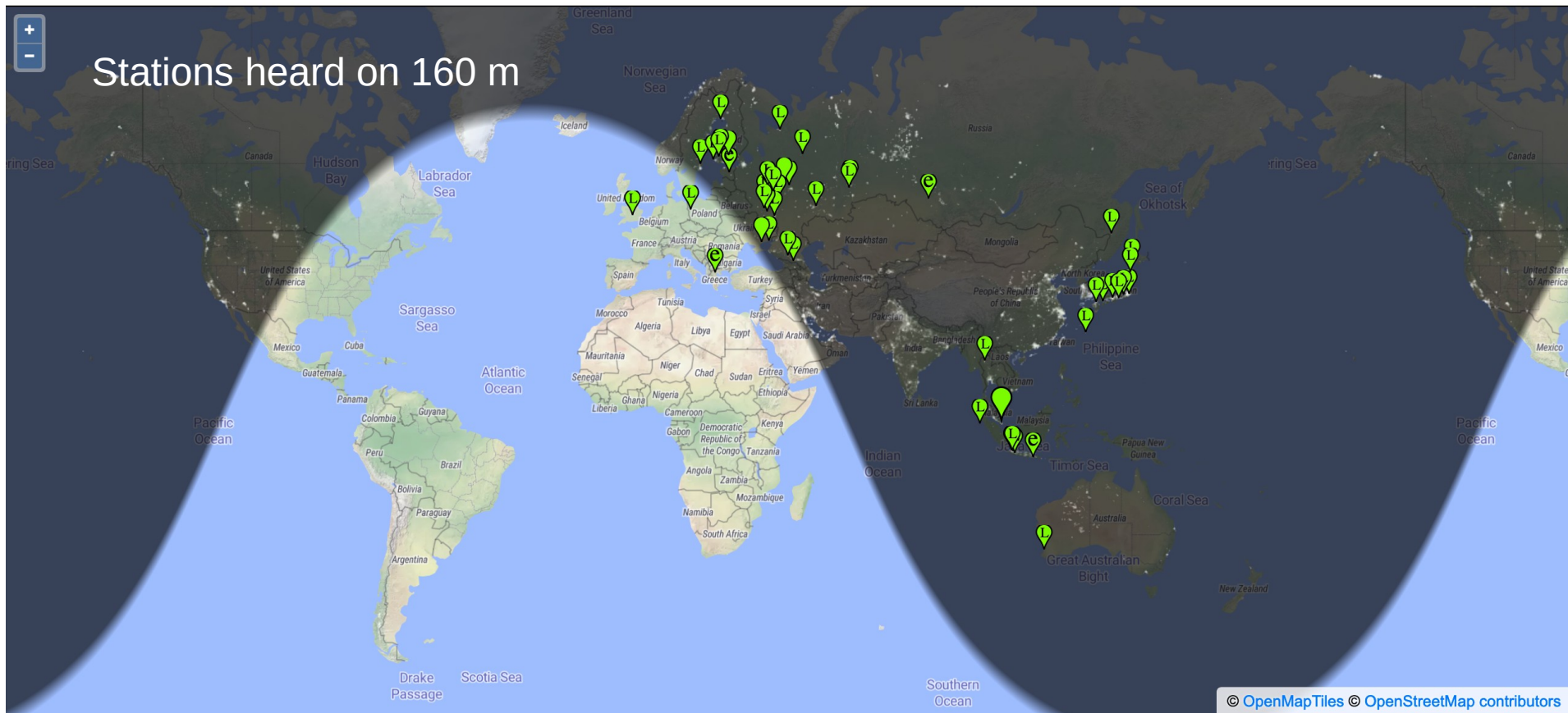
RADIO TOOLS
ARDOP OFF RIGCTL ACTIVE
KISSATCH OFF DIREWOLF OFF

DIGITAL APPS
JS8 OFF FLRIG OFF
WSJT-X ACTIVE FLDIGI OFF
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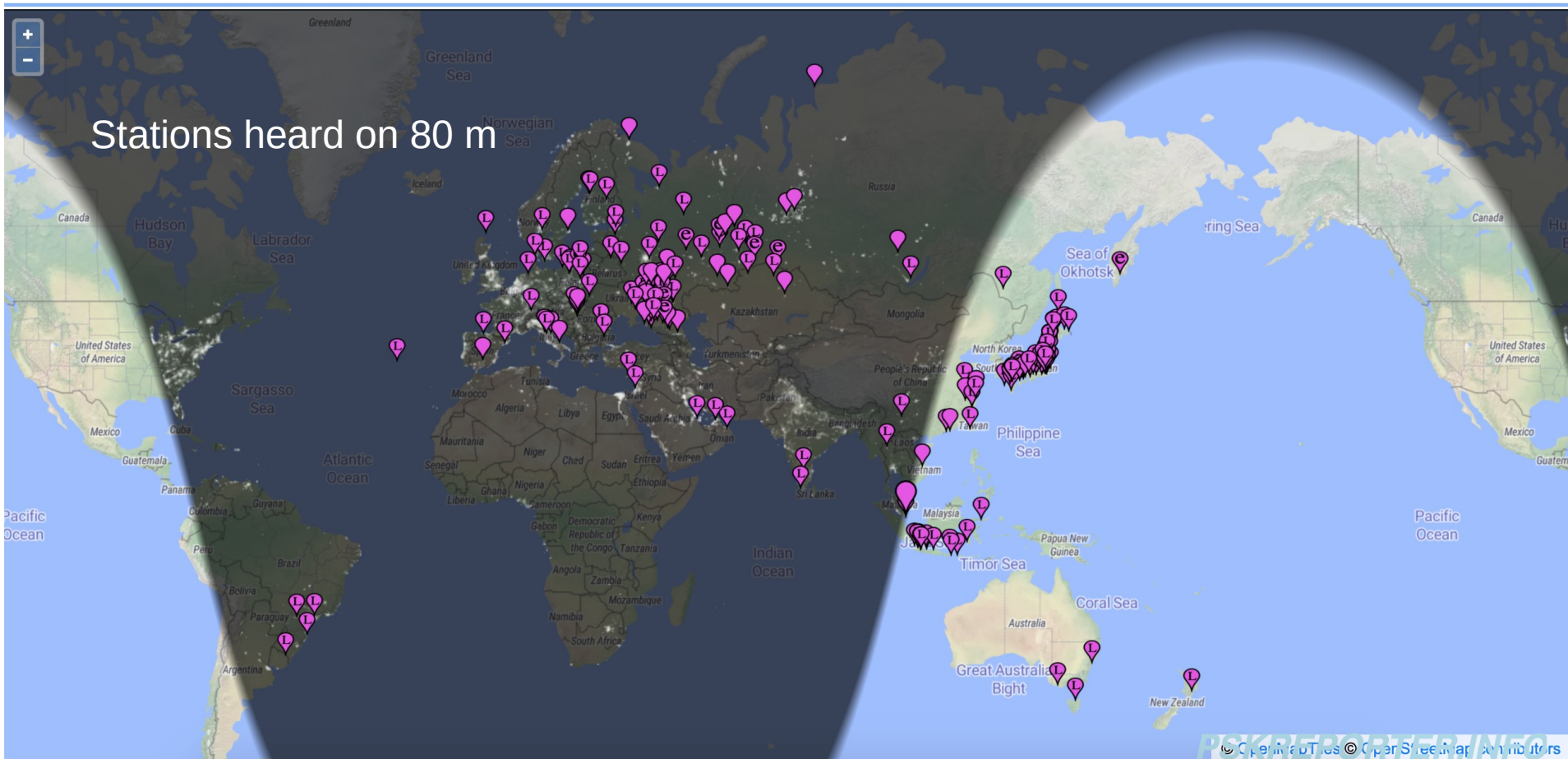
On 160m, show signals sent/rcvd by the callsign 9V1KG using all modes over the last 24 hours Go! [Display options](#) [Permalink](#)

Monitoring 9V1KG (last heard 8 days ago). Automatic refresh in 5 minutes. Small markers are the 49 transmitters ([show logbook](#)) heard ([distance chart](#)) at 9V1KG (2028 reports, 61 countries last 24 hours; 16266 reports, [74 countries](#) last week).

There are [295 active monitors](#) on 160m. [Show all on all bands.](#) [Legend](#)



On 80m show signals rcvd by the callsign 9V1kg using all modes over the last 6 hours Go! [Display options](#) [Permalink](#)



>100 countries in 24 h, 121 countries in one week

China	BG2DIH	2021-2-15 14:08:05	Belgium	OO5Z	2021-2-15 10:04:49	Hungary	HA1BF	2021-2-14 20:02:34	Hawaii	K2GT	2021-2-14 02:44:27
East Malaysia	9W8MAD	2021-2-15 14:03:31	Moldova	ER5DX	2021-2-15 10:49:17	Kaliningrad	RA2FCL	2021-2-14 19:48:28	Sicily	IT9OPJ	2021-2-13 17:45:34
Indonesia	YD1CZL	2021-2-15 14:07:19	Netherlands	PA3CPS	2021-2-15 10:54:35	Latvia	YL2EA	2021-2-14 18:34:33	Kyrgyzstan	EX8ABA	2021-2-13 18:39:50
Japan	JK1XMP	2021-2-15 14:07:24	New Caledonia	FK8CE	2021-2-15 09:36:49	Lithuania	LY5O	2021-2-15 00:18:19	Laos	XW0LP	2021-2-14 01:31:12
Asiatic Russia	RA0QD	2021-2-15 14:03:32	Sweden	SM4DHT	2021-2-15 09:53:35	North Macedonia	Z34K	2021-2-14 18:10:28	Namibia	V51WW	2021-2-13 22:11:43
Republic of Korea	DS1TET	2021-2-15 14:06:42	Switzerland	HB9CUZ	2021-2-15 10:30:19	Mexico	XE1AQY	2021-2-15 00:27:34	Northern Ireland	MI0OBC	2021-2-13 19:05:47
United States	K7KE	2021-2-15 14:06:28	United Arab Emirates	A61QQ	2021-2-15 09:51:06	Norway	LA4DFA	2021-2-14 17:11:20	Puerto Rico	NP4G	2021-2-13 23:28:19
West Malaysia	9M2TO	2021-2-15 14:05:01	Italy	IK6DLK	2021-2-15 09:11:04	Oman	A45XR	2021-2-14 21:00:57	Samoa	5W1SA	2021-2-13 10:20:42
Australia	VK4PWG	2021-2-15 13:42:24	Czech Republic	OK1NI	2021-2-15 07:09:31	Portugal	CT1APN	2021-2-14 17:52:21	Saudi Arabia	HZ1WRD	2021-2-13 09:30:28
Austria	OE1EQW	2021-2-15 11:07:12	Guam	KH2ZZ	2021-2-15 07:19:20	Romania	YO3JR	2021-2-15 00:29:20	Serbia	YU9MBA	2021-2-14 01:19:13
Colombia	HK4L	2021-2-15 12:14:43	Israel	4X1PF	2021-2-15 06:49:58	Scotland	MM0EAX	2021-2-14 17:49:42	Venezuela	YV7WGA	2021-2-14 00:38:51
Fed. Rep. of Germany	DL6CNG	2021-2-15 11:14:03	New Zealand	ZL3RJ	2021-2-15 06:43:28	Singapore	9V1KB	2021-2-14 17:59:02	Zambia	9J2BS	2021-2-13 20:58:57
Hong Kong	VR2YQU	2021-2-15 14:01:21	Qatar	A71EM	2021-2-15 04:25:20	Slovak Republic	OM5XX	2021-2-15 00:12:57	Bonaire	PJ4NX	2021-2-14 00:21:08
India	VU3OBP	2021-2-15 13:50:36	Argentina	LU1JAO	2021-2-14 22:55:17	Slovenia	S57U	2021-2-14 11:15:28	Bahrain	A92GE	2021-2-13 06:05:39
Kazakhstan	UN7ECA	2021-2-15 12:59:47	Belarus	EW6FL	2021-2-14 19:36:57	South Africa	ZS6DPL	2021-2-14 19:41:28	Vanuatu	YJ8RN	2021-2-13 06:42:19
Pakistan	AP2HA	2021-2-15 13:49:52	Bosnia-Herzegovina	E72AD	2021-2-14 11:15:20	Spain	EA2FBG	2021-2-15 00:25:05	Azores	CU2AP	2021-2-11 19:15:43
Philippines	DU3JH	2021-2-15 13:46:29	Brazil	PP5JR	2021-2-14 22:31:31	Uzbekistan	UK8FAV	2021-2-14 17:38:57	Barbados	8P6EX	2021-2-13 00:09:07
Poland	SP3AMZ	2021-2-15 11:52:42	Bulgaria	LZ3CB	2021-2-15 00:21:04	Asiatic Turkey	TA2ANK	2021-2-14 11:34:05	Ireland	EI4DQ	2021-2-12 00:14:12
European Russia	R2RA	2021-2-15 14:02:35	Croatia	9A1AD	2021-2-14 11:47:58	Estonia	ES2AJ	2021-2-14 07:00:35	Luxembourg	LX1JX	2021-2-13 01:02:12
Seychelles	S79KW	2021-2-15 11:18:51	Denmark	OZ8ABE	2021-2-15 00:33:18	Armenia	EK1KE	2021-2-13 20:17:49	Maldives	8Q7PR	2021-2-13 01:20:12
Sri Lanka	4S6RSP	2021-2-15 12:11:28	England	M0DHO	2021-2-14 11:33:27	Balearic Islands	EA6FB	2021-2-13 18:24:21	St. Lucia	J69DS	2021-2-13 01:04:27
Taiwan	BV4WU	2021-2-15 13:48:23	Finland	OH1FOL	2021-2-14 19:19:13	Canada	VA7QI	2021-2-14 00:18:58	Uruguay	CX6VM	2021-2-11 22:27:58
Thailand	HS2AQG	2021-2-15 13:54:33	France	F4UJU	2021-2-15 00:23:19	Fiji	3D2TS	2021-2-13 11:04:42	Afghanistan	T6AA	2021-2-11 13:25:42
Ukraine	UT4UO	2021-2-15 13:59:36	Georgia	4L6QL	2021-2-14 13:54:22	Cyprus	5B4AHL	2021-2-14 05:33:49	Alaska	KL7ILA	2021-2-10 00:36:37
Vietnam	XV9HEU	2021-2-15 11:21:17	Greece	SV7BVM	2021-2-15 00:20:27	Ecuador	HC2FG	2021-2-13 23:50:27	Canary Islands	EA8CDG	2021-2-11 00:09:28
									Ghana	9G5FI	2021-2-10 00:13:46

Summary

- RTL dongle with up-converter is suitable for HF, total costs approx \$75
- Disappointed with Mini Whip
- Active loop was a big success; be sure to build or buy a good preamp, limited to HF frequencies (to avoid overload)
- I never expected such dramatic effect from good common mode chokes; now I am able to listen to 80 m & 160 m with SDR (and also IC7300) (Forget about clamp-on ferrites, they are useless on HF frequencies!)
- My SDR is now usually running 24/7 on FT8 reporting to PSK reporter
- To come: [Airspy+ Discovery with 18 bit](#) – expecting even better performance

Thank You!

9V1KG