Matthias Bopp DD1US

Bochum, November 9th 2019

AMSAT-DL
Satelliten für Kommunikation, Wissenschaft und Bildung
Satellites for Communication, Science and Education

Agenda

- QO-100 our first Phase-4 geostationary satellite (P4-A)
- QO-100 transponders
- QO-100 NB modes
- Antennas
- RX for the NB transponder
- TX and amplifiers
- SDR TRX
- Activities on QO-100

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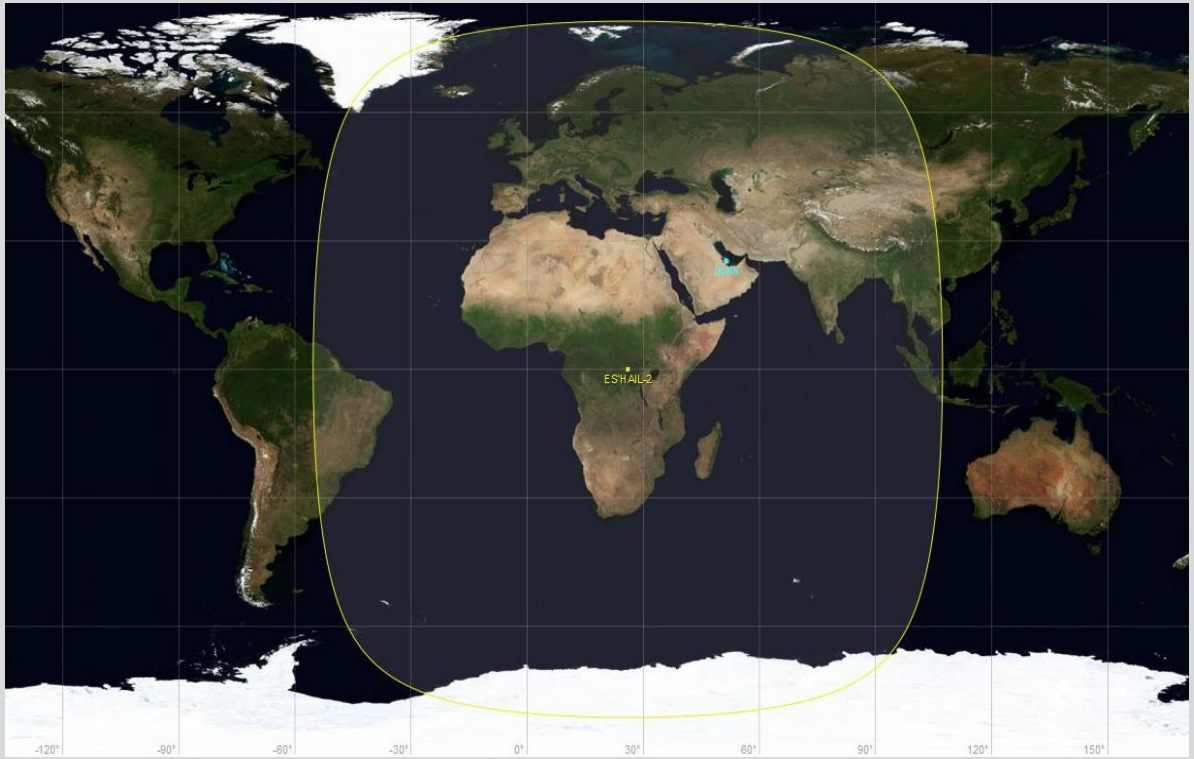
Qatar-OSCAR 100 (Es‘hail-2)

Es‘hail-2 was launched on November 15th 2018 on a Falcon 9 from SpaceX.



It is primarily a communication and TV-Broadcast satellite for the middle east.

Es‘Hail-2 is positioned on 26° East and covers Europe, Africa and most of Asia.

Peter DB2OS (chairman of AMSAT-DL) convinced the owners in Qatar to add 2 transponders for Ham Radio (↑13cm Uplink / ↓3cm Downlink).

http://www.amsat-dl.de

Qatar-OSCAR 100 (Es‘hail-2)

Peter DB2OS was recently awarded the Louis Varney Cup for Advances in Space Communications from RSGB. Achim DH2VA collected it on behalf of Peter.

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http://www.rsgb.org

Qatar-OSCAR 100 (Es‘hail-2)

Congratulations to Peter and his team!

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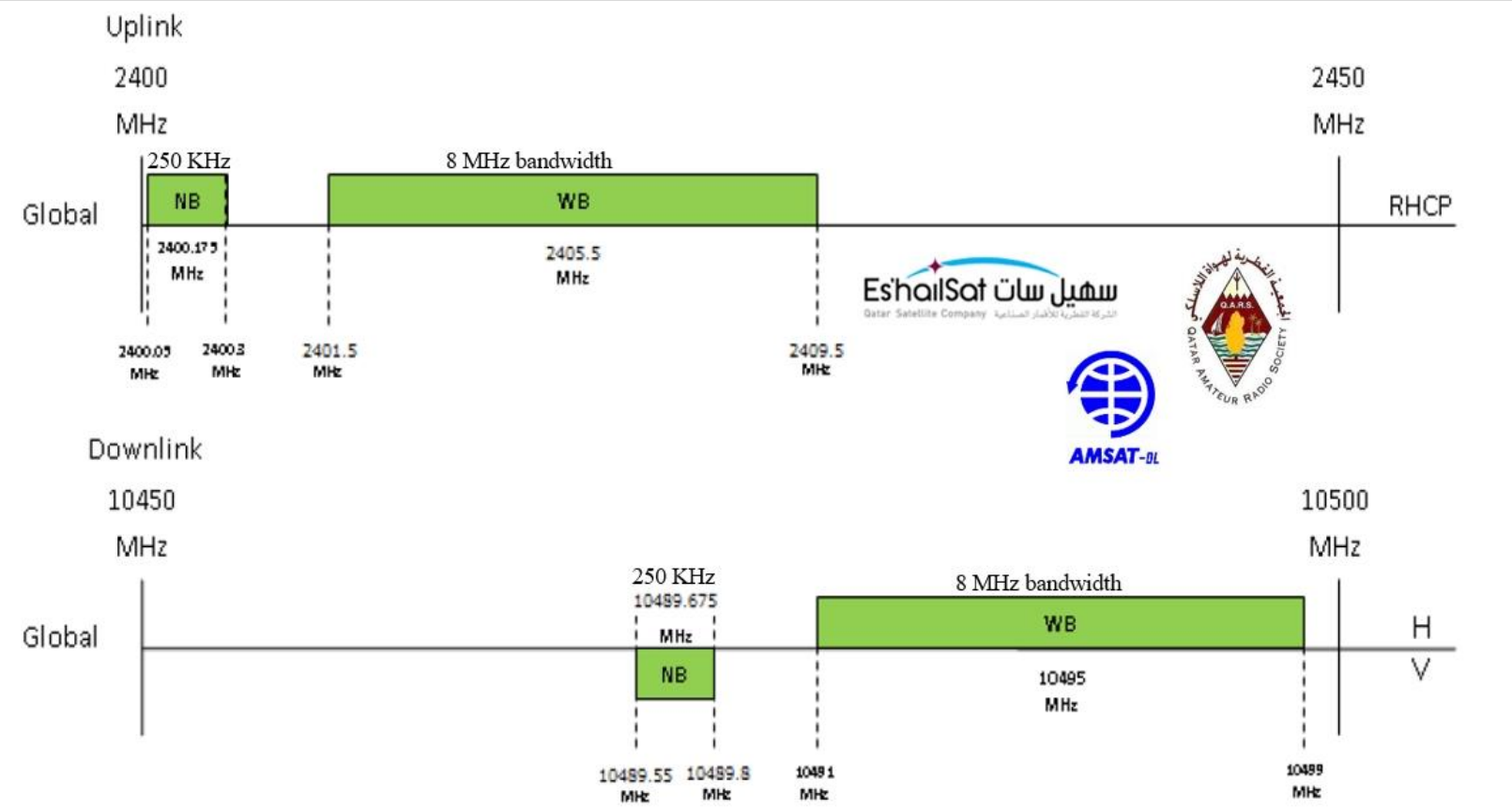
QO-100 transponders



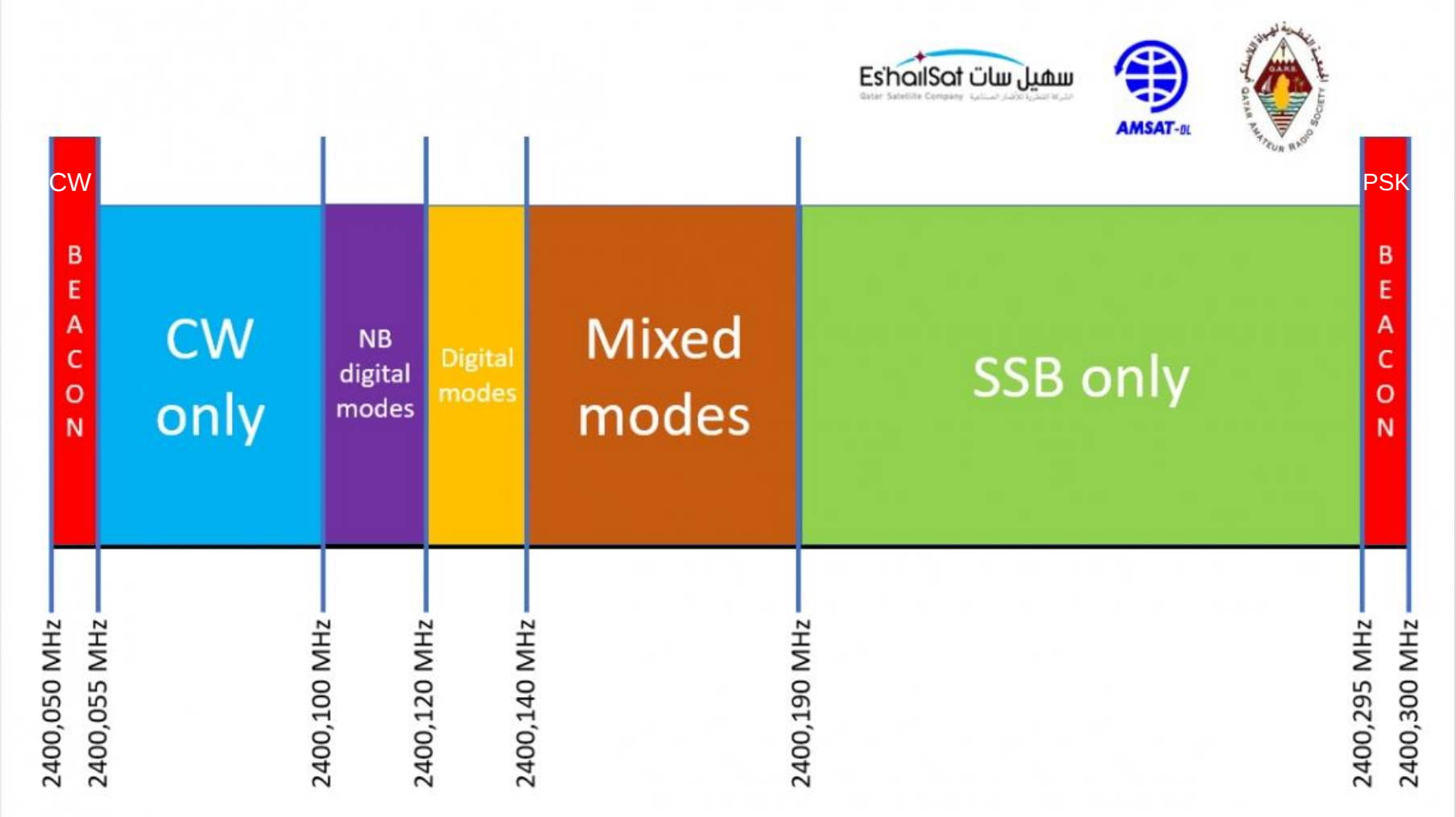
Xpdr	U/L FREQUENCY (MHz)				D/L FREQUENCY (MHz)				LO	BW
No	Pol	Begin	Center	End	Pol	Begin	Center	End	(MHz)	(MHz)
NB	RHCP	2400.05	2400.175	2400.3	V	10489.55	10489.675	10489.8	8089.5	0.25
WB	RHCP	2401.5	2405.5	2409.5	H	10491	10495	10499	8089.5	8

The WB-transponder was recently extended by 500kHz at its upper end!

http://www.amsat-dl.de

QO-100 NB transponder

Bandplan of the narrowband transponder:



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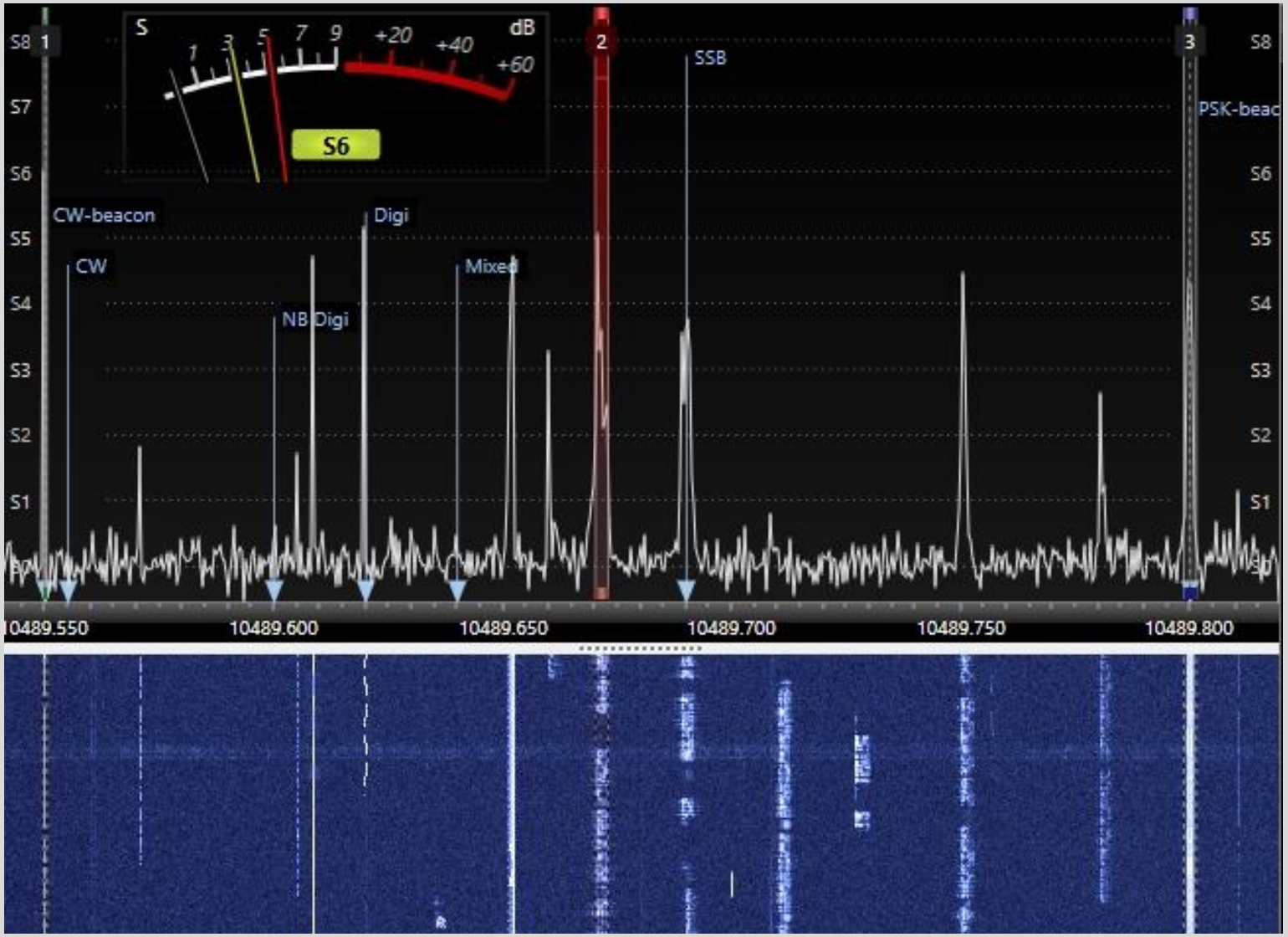
QO-100 NB transponder

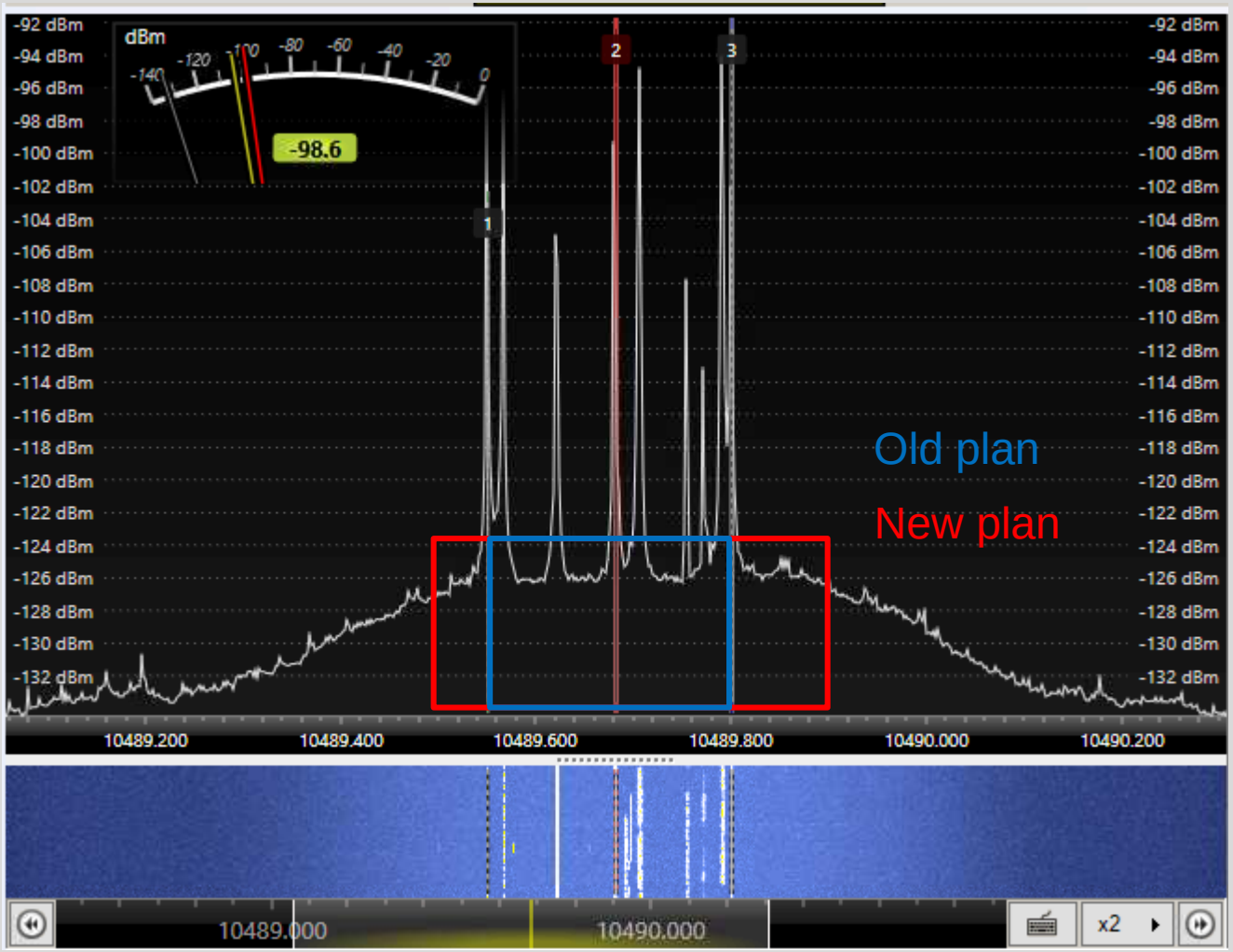


An extension of the narrowband transponder is presently under discussion.

The idea is to wide the transponder from presently 250 kHz to 500 kHz.

This is only a preliminary proposal subject to approval.

QO-100 NB transponder



Transponder noise floor and bandplan

QO-100 NB transponder

Uplink		Downlink				
Start [MHz]	End [MHz]	Start [MHz]	End [MHz]	Available [MHz]	NB-TPX-response /dB	Comment
		10489,500	10489,505	0,005	-1,1	Lower Beacon 10489,500 MHz, CW, + guard band
2400,005	2400,040	10489,505	10489,540	0,035	-1,0...-0,5	CW only
2400,040	2400,080	10489,540	10489,580	0,040	-0,5...-0,2	narrowband digimodes (500 Hz max. BW)
2400,080	2400,150	10489,580	10489,650	0,070	-0,2...0,0	digimodes (2700 Hz max. BW)
2400,150	2400,245	10489,650	10489,745	0,095	0,0	SSB only (2700 Hz max. BW)
		10489,745	10489,755	0,010	0,0	Center Beacon 10489,750 MHz, 400 Bit/s BPSK or CW + guard band
2400,255	2400,350	10489,755	10489,850	0,095	0,0	SSB only (2700 Hz max. BW)
2400,350	2400,495	10489,850	10489,995	0,145	0,0...-4,3	mixed modes (2700 Hz max. BW) & special purpose
		10489,995	10490,000	0,005	-4,5	Upper Beacon 10490,000 MHz DVB-S2X/CCSDS with FEC (extremly narrowband) + guard band

This is only a preliminary proposal subject to approval.

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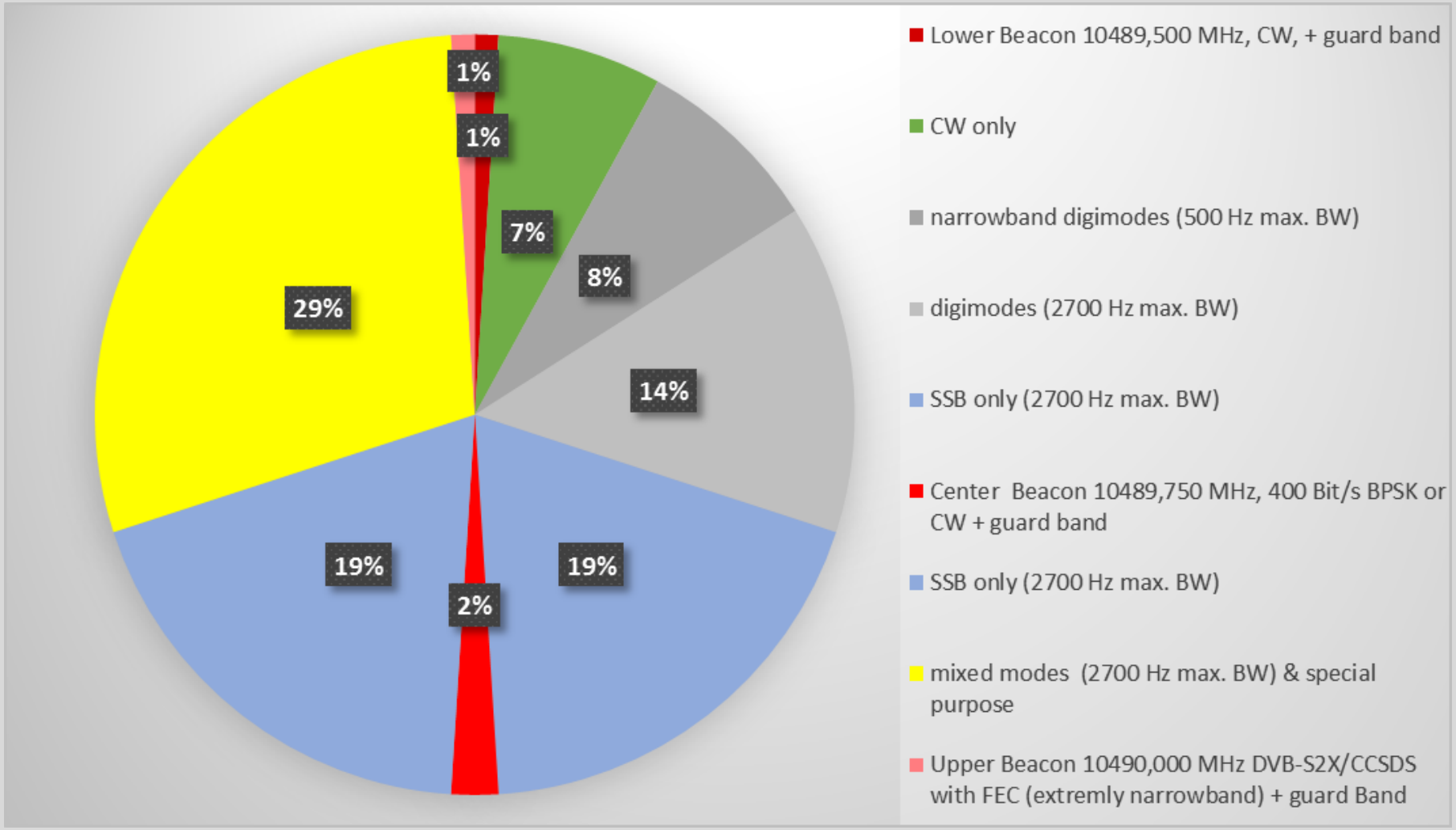
QO-100 NB transponder



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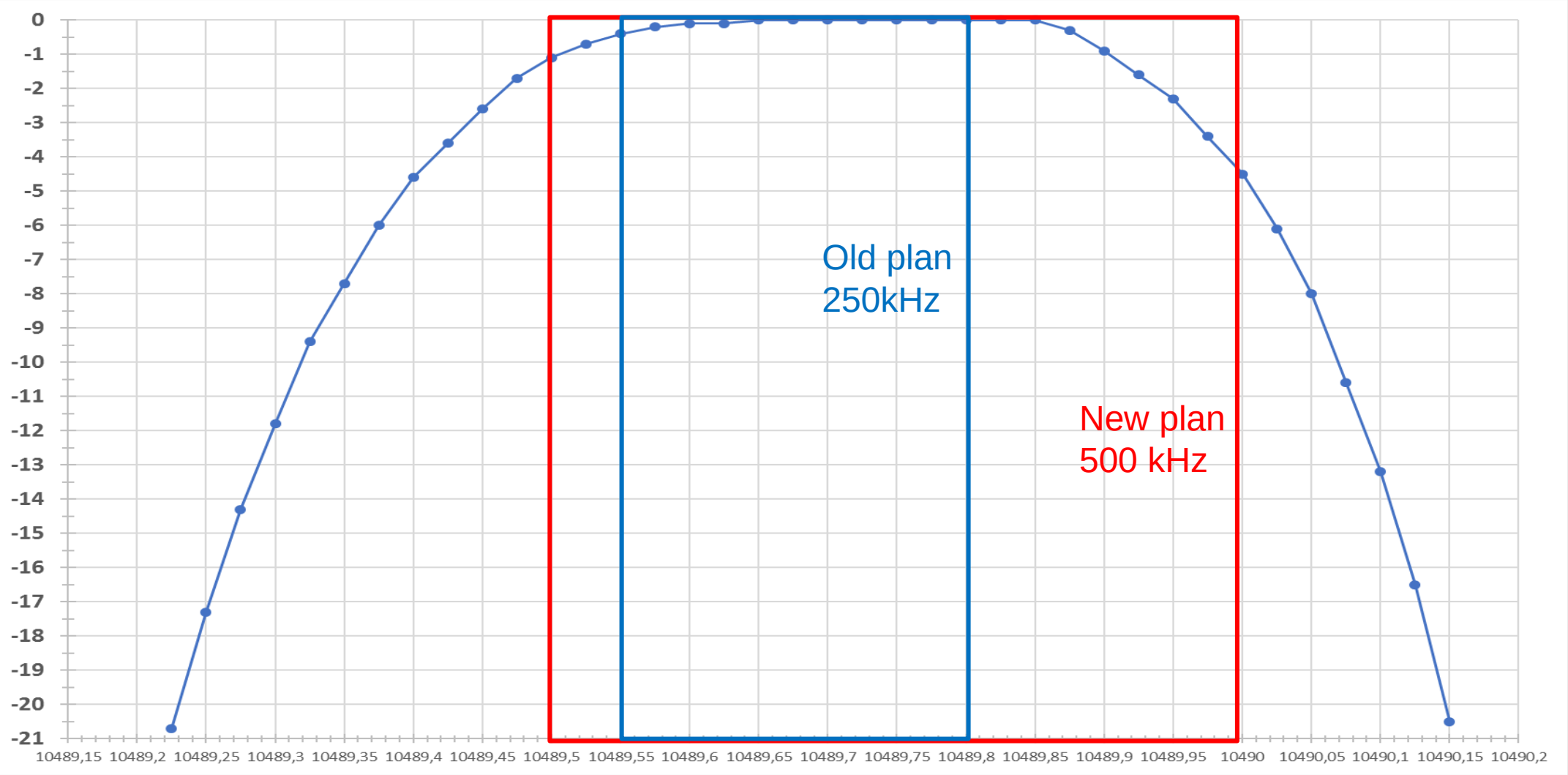
QO-100 NB transponder



NB-Transponder frequency response

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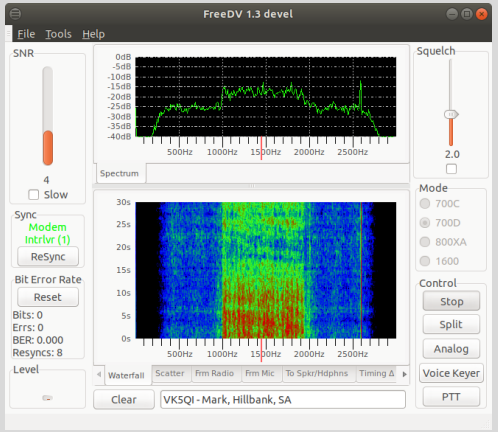
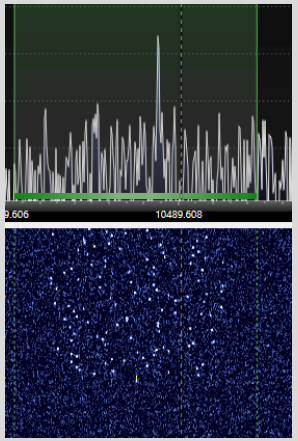
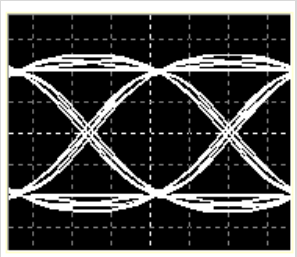
QO-100 NB modes

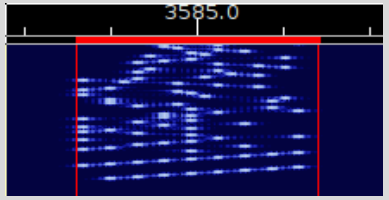
Operating modes on the narrowband transponder of QO-100:

- SSB / CW
- FreeDV
- RTTY
- SSTV / KGSTV
- FAX
- Feldhell
- Digimodes such as PSK31, FT8, FT4, THOR8, ROS etc.









QO-100 NB modes

<u>Basic rules for the NB transponder:</u>

- Control your uplink power, so that your downlink signal is not stronger than the beacons
- No transmissions with a bandwidth higher than 2.7kHz
- No analog FM modes and no digital FM modes such as DSTAR, C4FM
- No transmissions below the CW beacon and above the PSK beacon
- Keep a guard band to the beacons (especially 5 kHz to the PSK beacon because many users are locking their receiver to the PSK beacon

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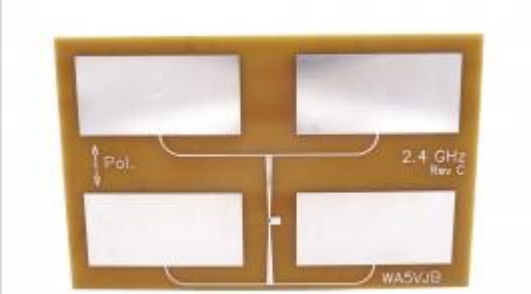
Antennas for QO-100

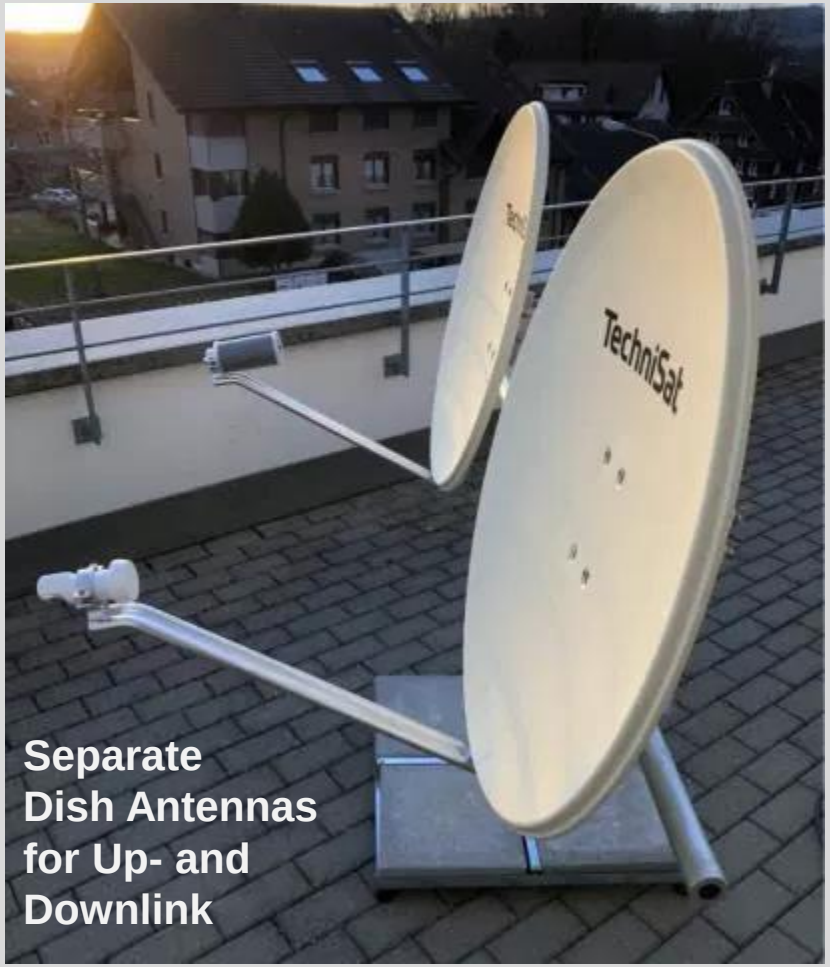
Dualband
Feed in
single dish

WIFI Grid
linear



Patch Array WA5VJB

Helix RHCP



Separate
Dish Antennas
for Up- and
Downlink

2.4 GHz uplink of NB and WB TPX is RHCP, 10 GHz downlink of NB TPX is vertical, WB TPX is horizontal.

2 Dishes or 1 Dish with Dual Feed?

2 Dishes	1 Dish with Dual-Feed
Each feed can be optimized for each dish independently:	Setup is more compact
Each feed optimized for f/D	Better for portable operations
Each feed optimized for frequency	‘off-the-shelf’ feed solutions available
Each feed position and thus proper phase center can be chosen independently	Possibly simplied wiring
Each dish can be adjusted independently in case a feed is squinting	Adjustment of antenna simpler (just optimize RX and TX should be ok)

Input from Achim DH2VA

Antennas for QO-100

1.9m fine mesh dish for C&KU-band
f/D=0.4, dual-band feed according to
to DJ7GP

>500 QSOs in 6 months using only
300mW at the feed

TX very good, RX not so great
(NB transponder noise 3-4 dB)

Antennas for QO-100

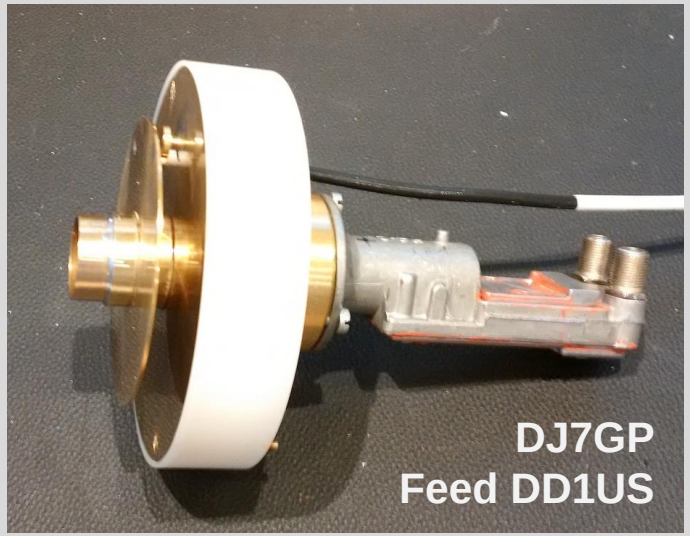
Vintage solid Kathrein dish
(D=1.8m, f/D=0.29)

TX with old feed about 2.5dB worse
(dish is under illuminated)

TX with POTY feed same as before because of good circular polarization

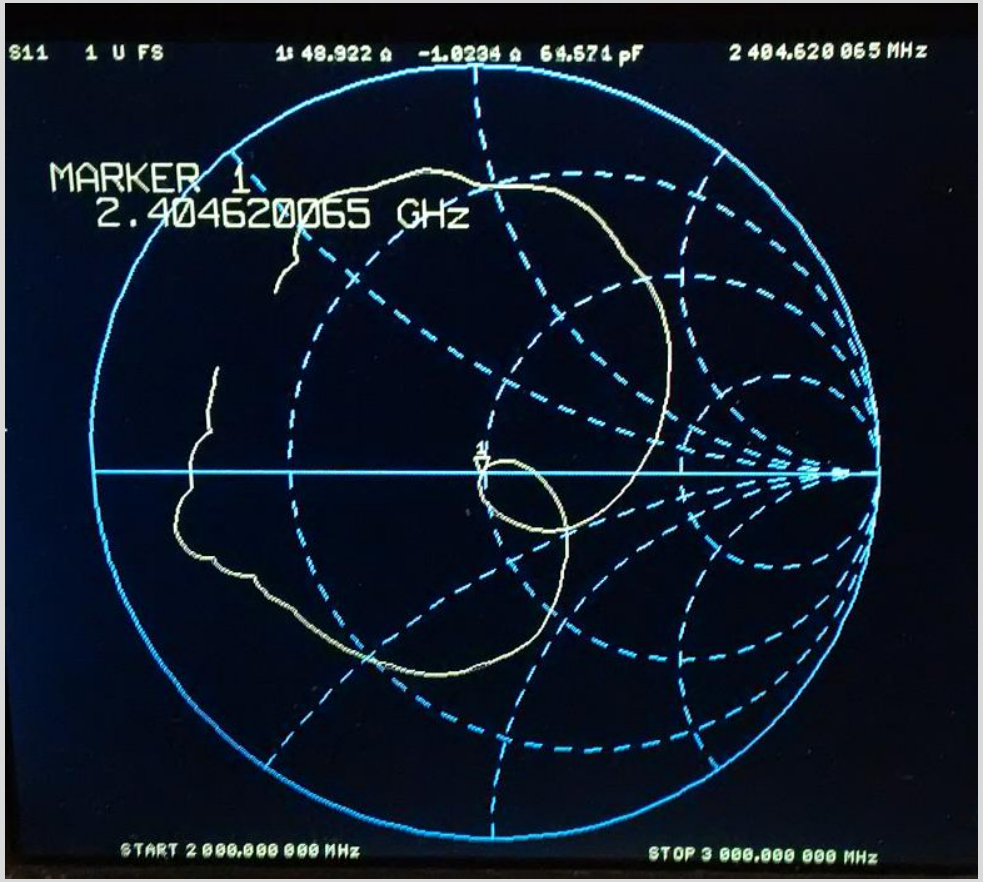
RX excellent G/T:
NB transponder noise: 8dB
WB beacon MER: >=10dB

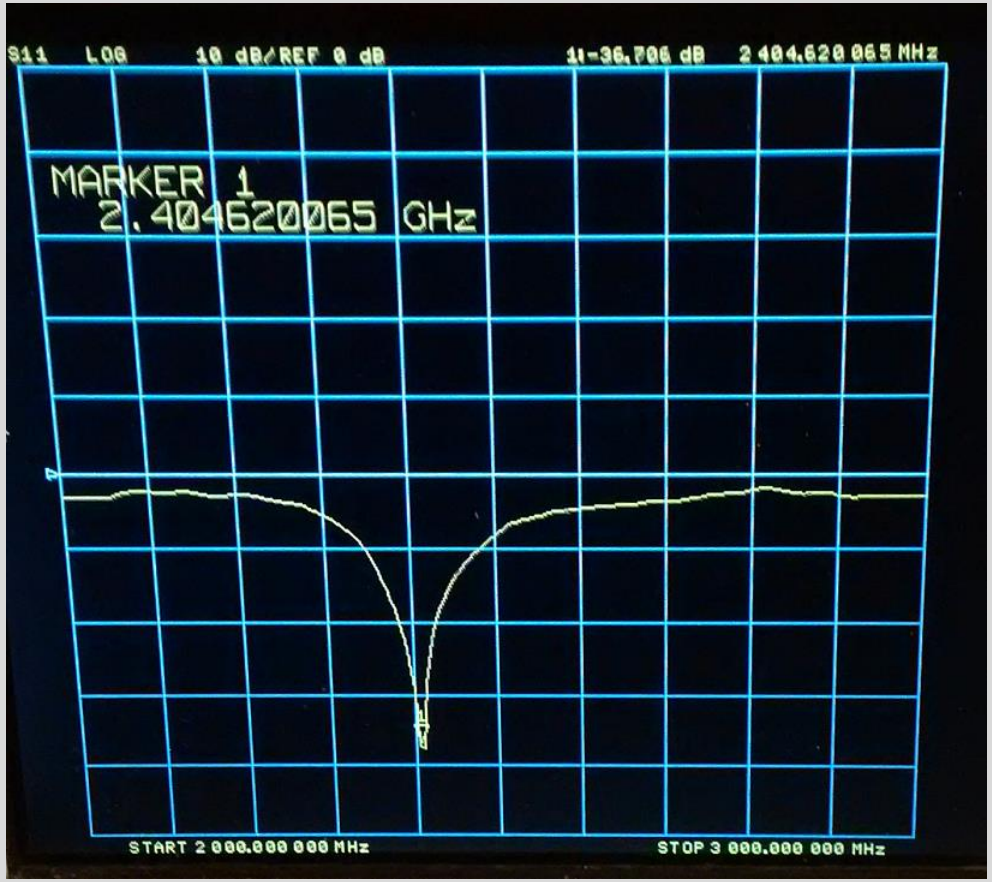
Feeds for QO-100



POTY Feed for QO-100

Developed by Mike G0MJW, Remco PA3FYM and Paul M0EYT

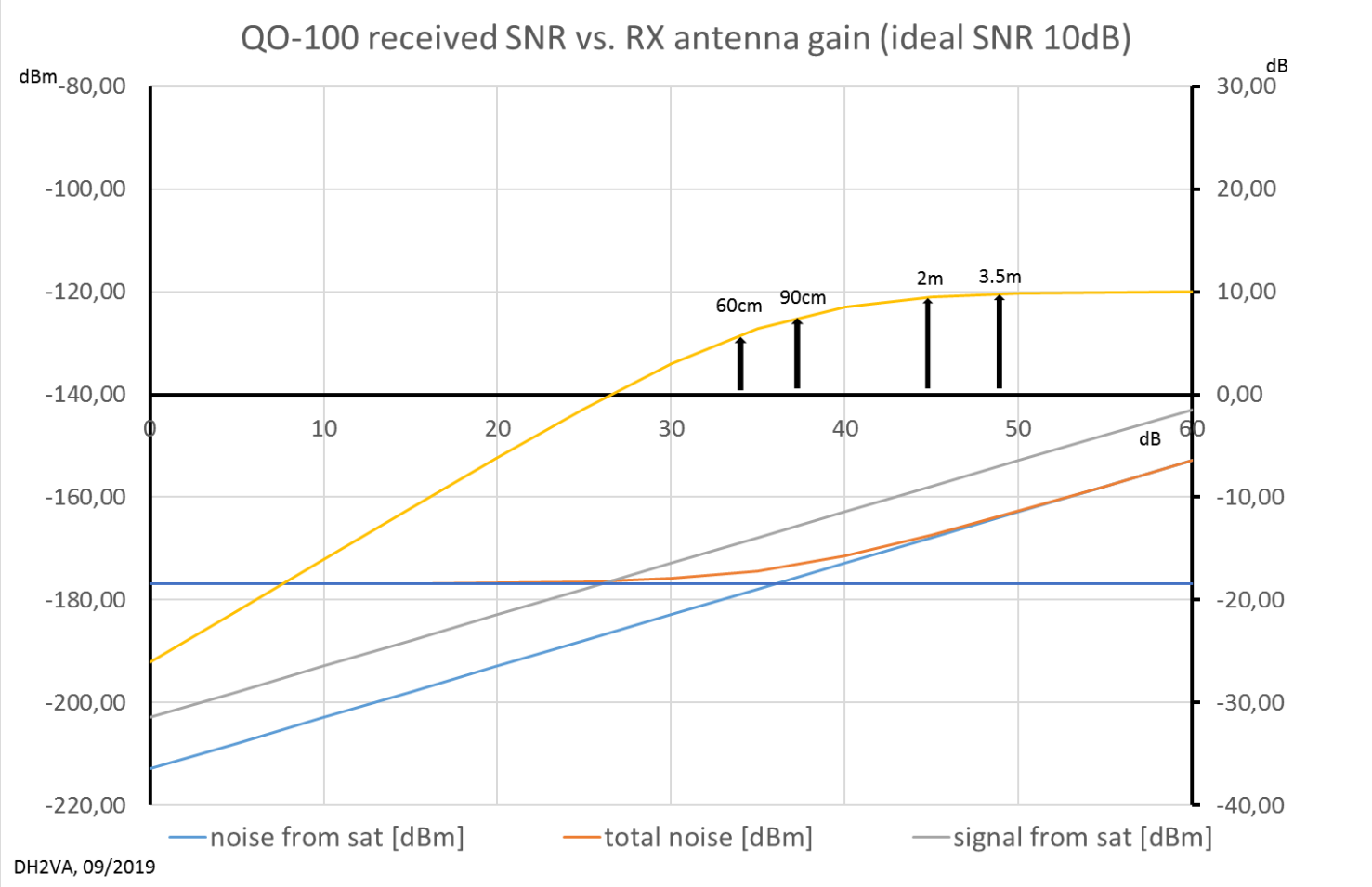




POTY feed needs to be carefully tuned to achieve very good circular polarization

Which diameter is needed for your dish?

“The larger the better!” *“Yes but …”*



Source: Achim DH2VA

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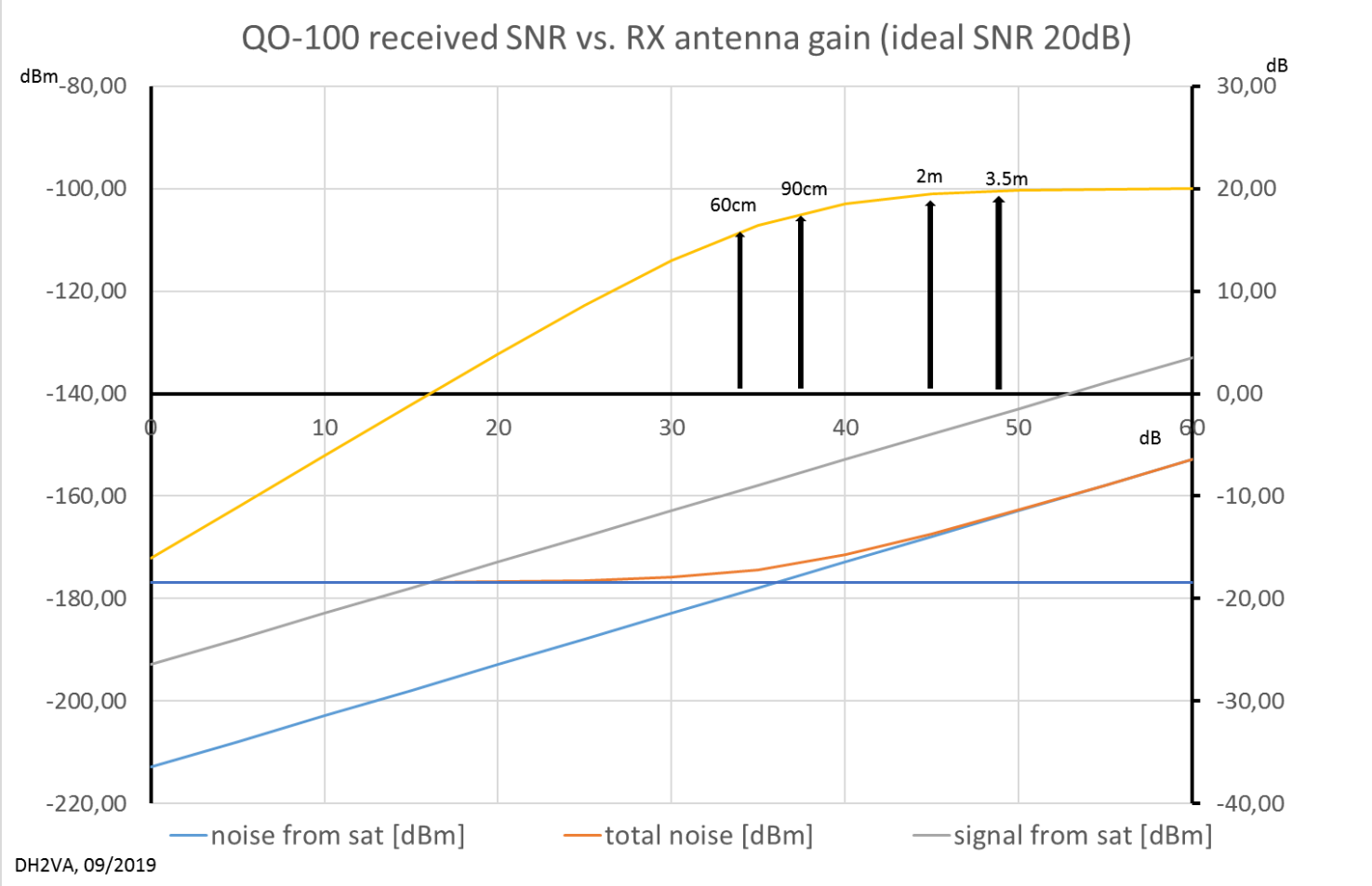
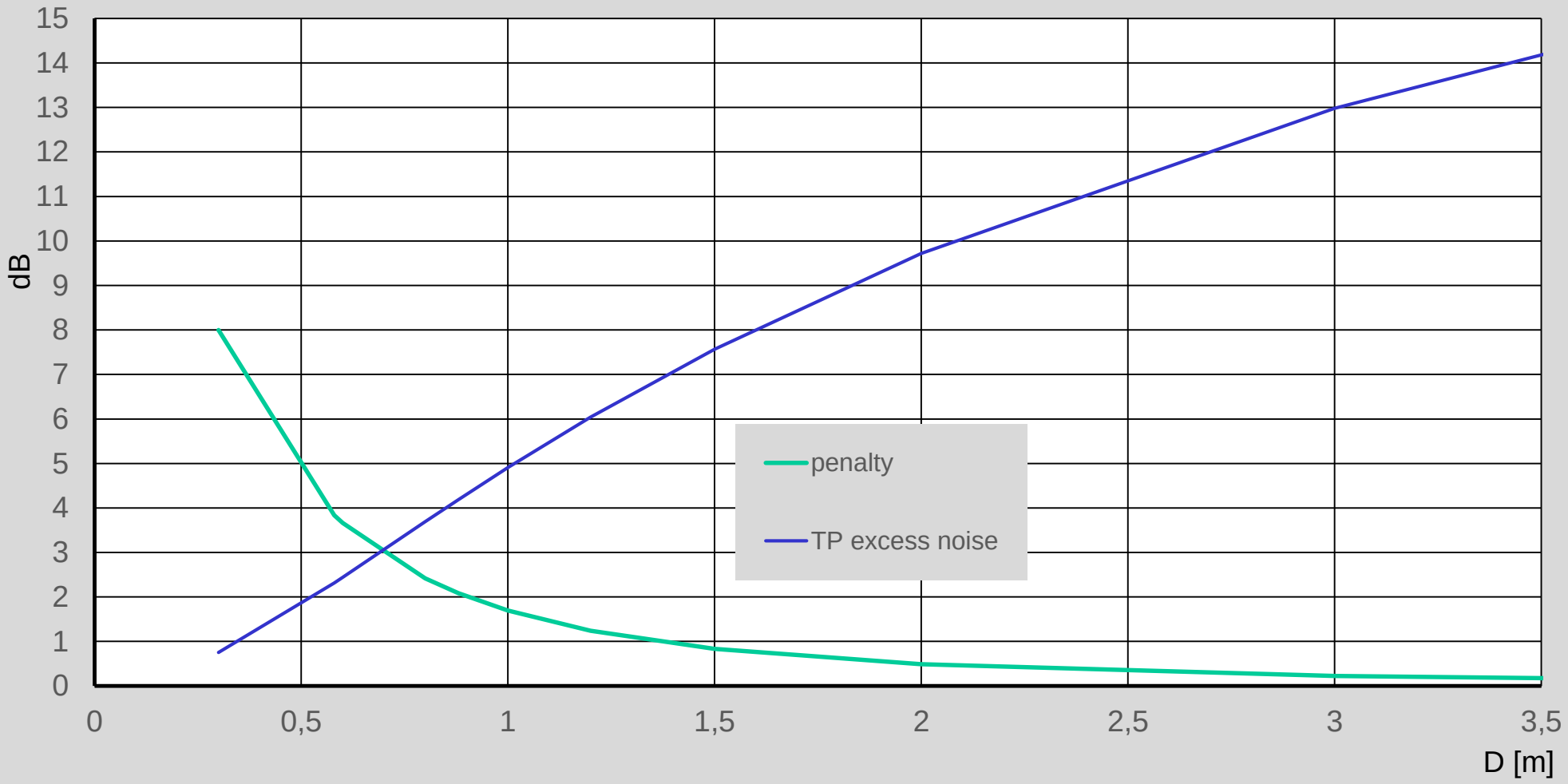


Source: Achim DH2VA

Which diameter is needed for your dish?

noise penalty and TP excess noise vs. dish size (Tsys=150K)



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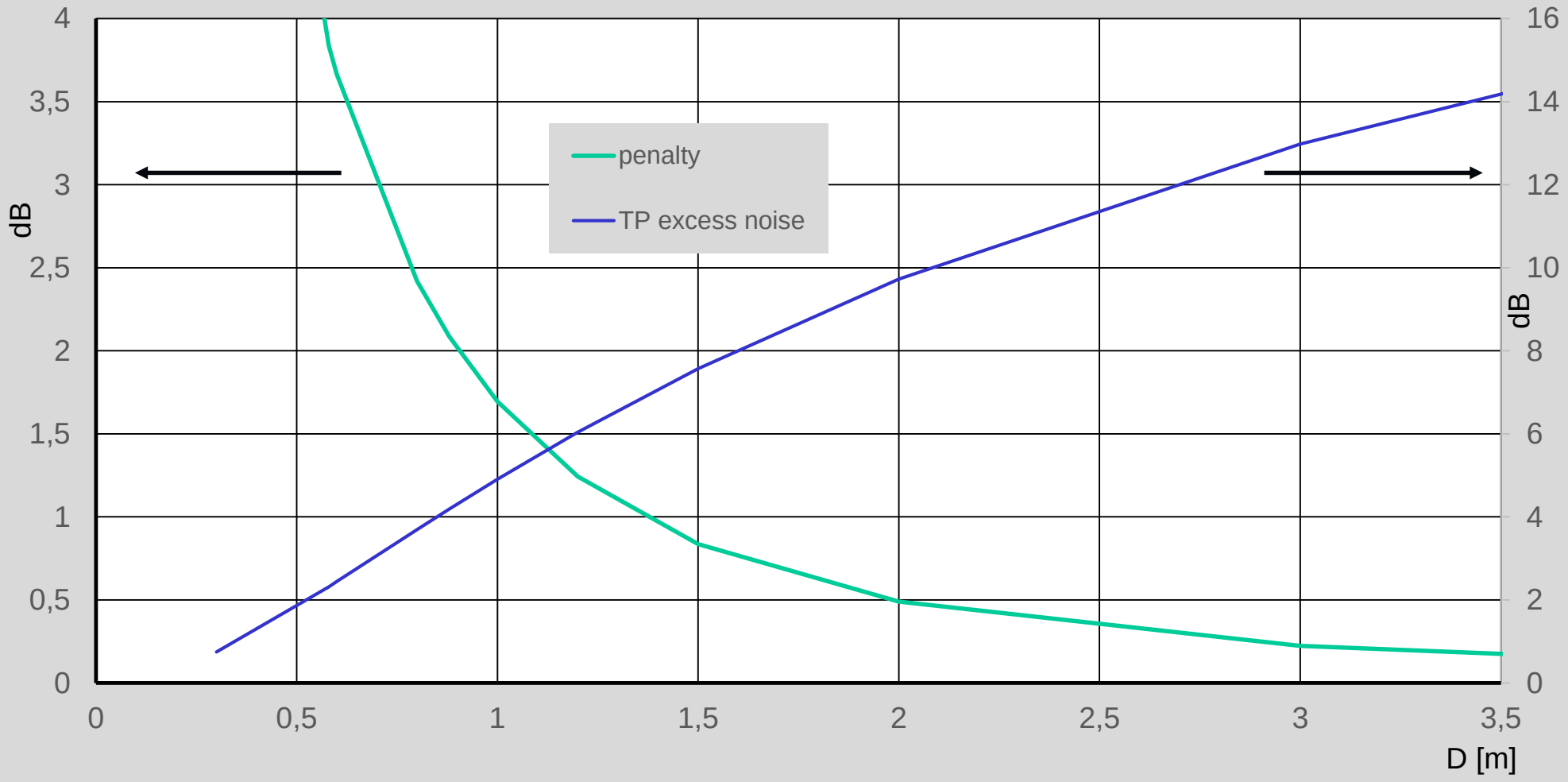

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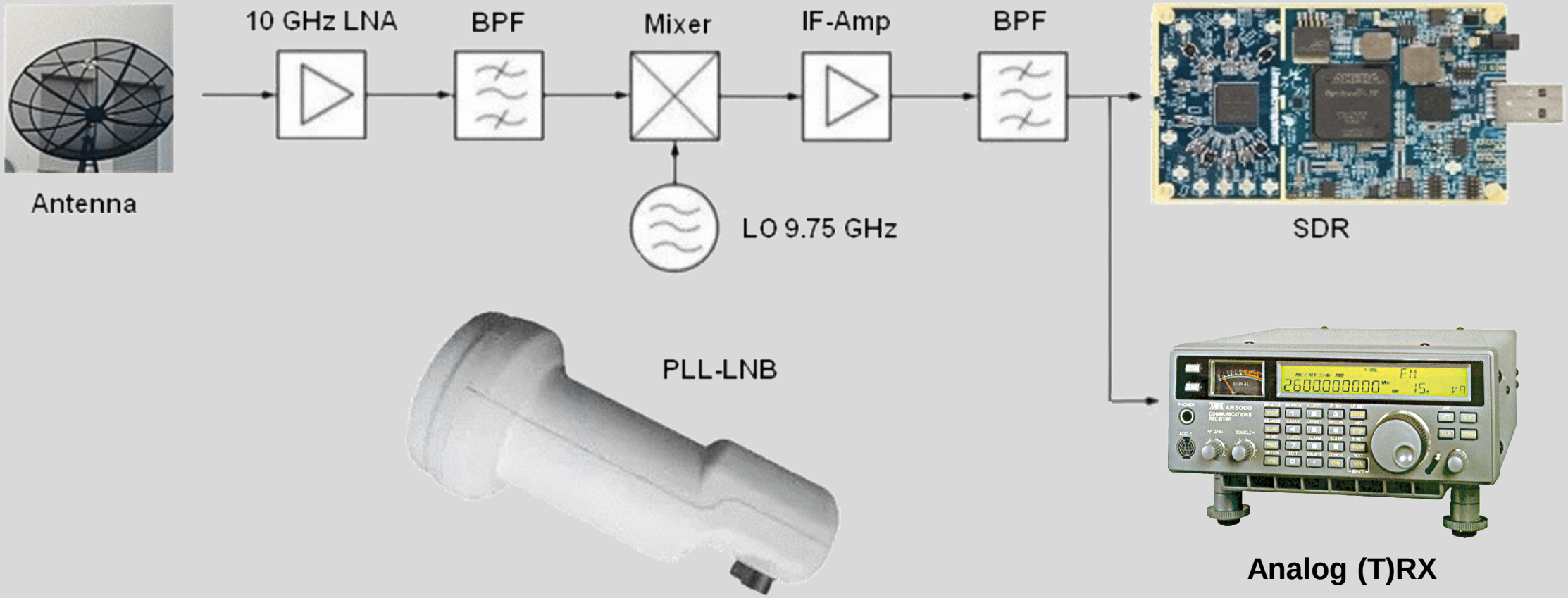
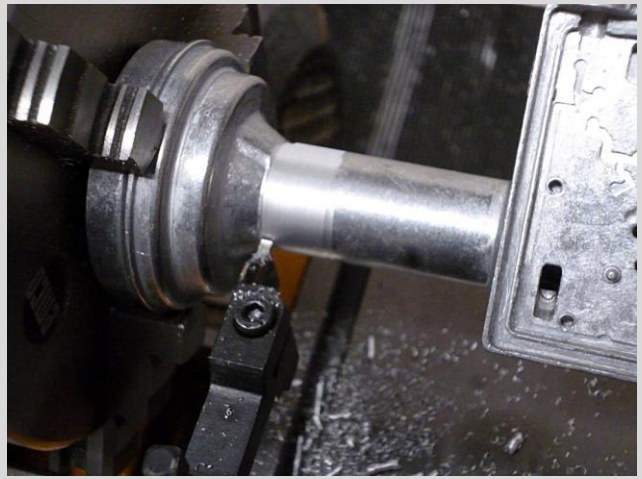
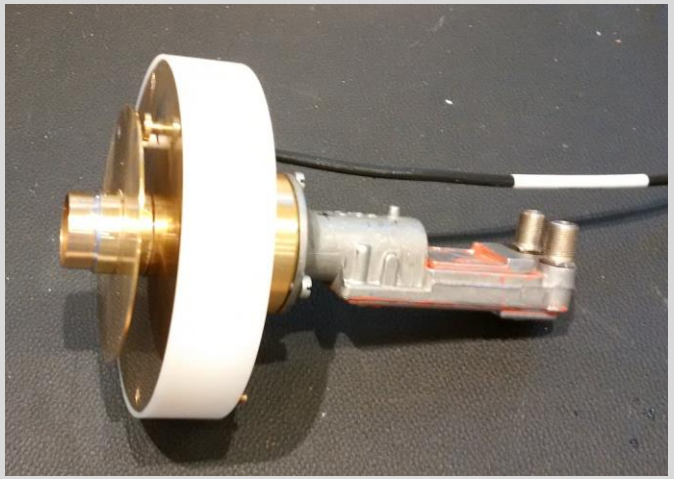
RX-Setup for QO-100



PLL-LNBs for QO-100





Megasat Diavolo

Octagon Dual OTSLO

PLL-LNBs for QO-100

- There are many choices for PLL-LNB brands and models.
- The devices differentiate in temperature stability, phase noise, some show low frequency wobbling.
- As the models are rapidly changing, sometimes with the same part number, thus it is difficult to stay up-to-date. It is often a try-and-error method but fortunately the LNBs are very cheap (typ. 2 - 10€).
- A good overview can be found here:
- http://www.pabr.org/radio/lnblineup/lnblineup.en.html
- https://uhf-satcom.com/blog/ku-band-pll-lnb-s
- https://wiki.batc.org.uk/Es%27hail-2_LNBs_and_Antennaes

SDRs for RX of NB TPX

RTL-SDR

Funcube Pro

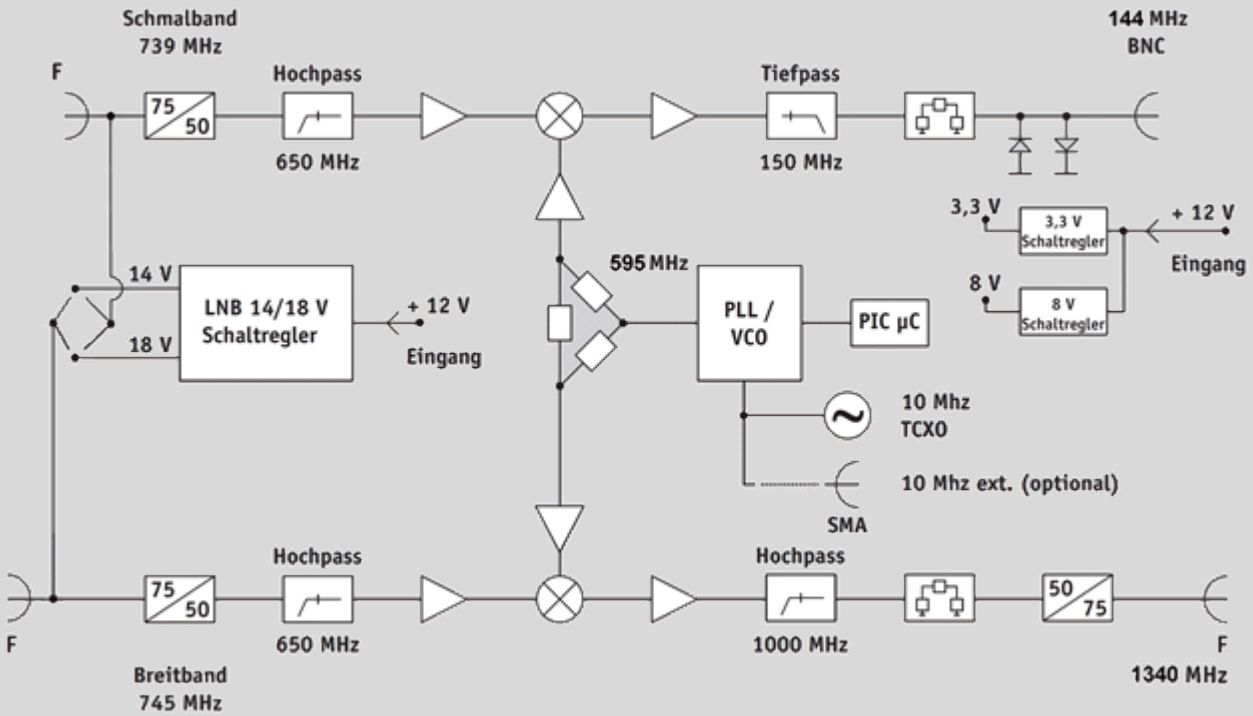
Airspy mini

DX-Patrol MK4

SDRplay

Airspy 2

Downconverters for QO-100



Downconverter AMSAT-DL
Price: 178,50€

Converts the IF of both polarizations
to convenient bands:
- 1340 MHz for WB TPX to use Sat-RX
- 144 MHz for NB TPX to use 2m (T)RX

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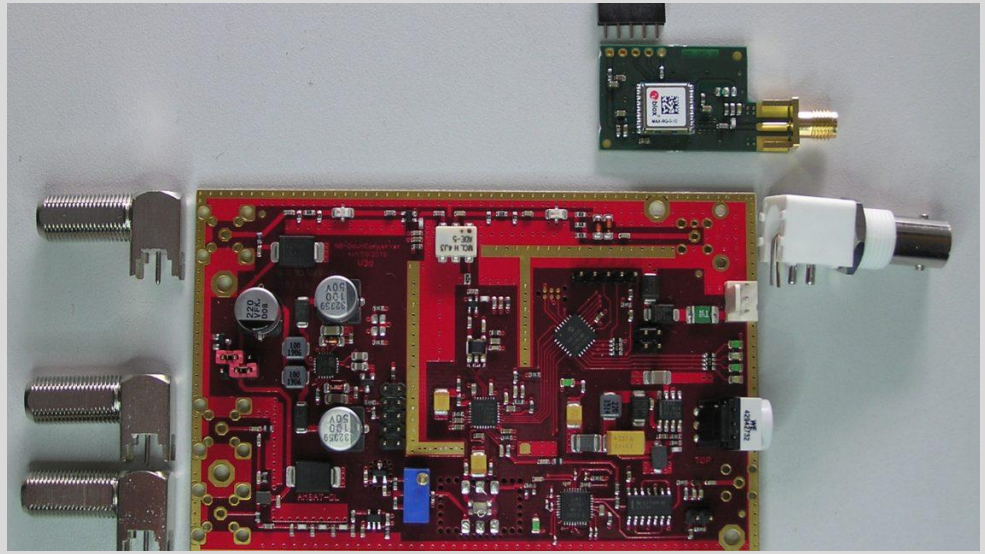

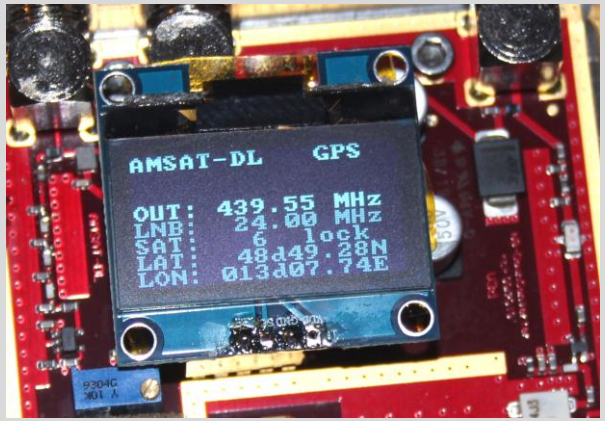

New AMSAT-DL Downconverter V3d

Features:

- Central clock generation with OCXO or GPS
- Reference clock for the PLL in the LNB
- Reference clock for a transmitter mixer
- Reference clock for an SDR
- Short-circuit-proof LNB phantom feed
- Connection for a dual LNB (for simultaneous NB and WB reception)
- Downward mixing of the NB transponder into a ham radio band (UHF/VHF or KW)
- Optional OLED display for indication of operating status and station coordinates

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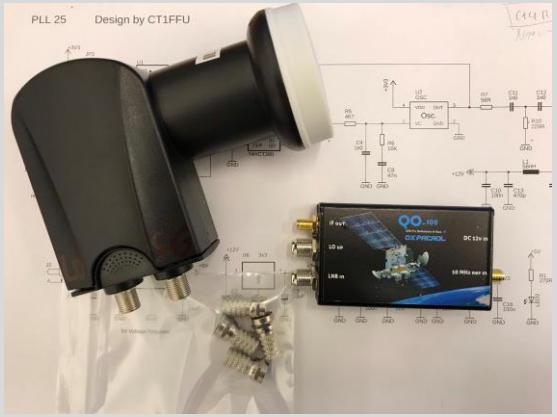

DX-Patrol QO-100 Downconverter

<u>Features:</u>

- Input voltage 12V to 18V (LBN polarization mode)
- Internal 10Mhz Reference TCXO 0,5PPM
- External 10MHz GPSDO input optional
- PLL lock LED indication
- Internal RX pre-amplifier 12dB gain
- RX gain adjust
- Four possible IF reception conversion selectable
- Ready modified LNB included.

- Price incl. LNB 180€

http://www.dxpatrol.pt

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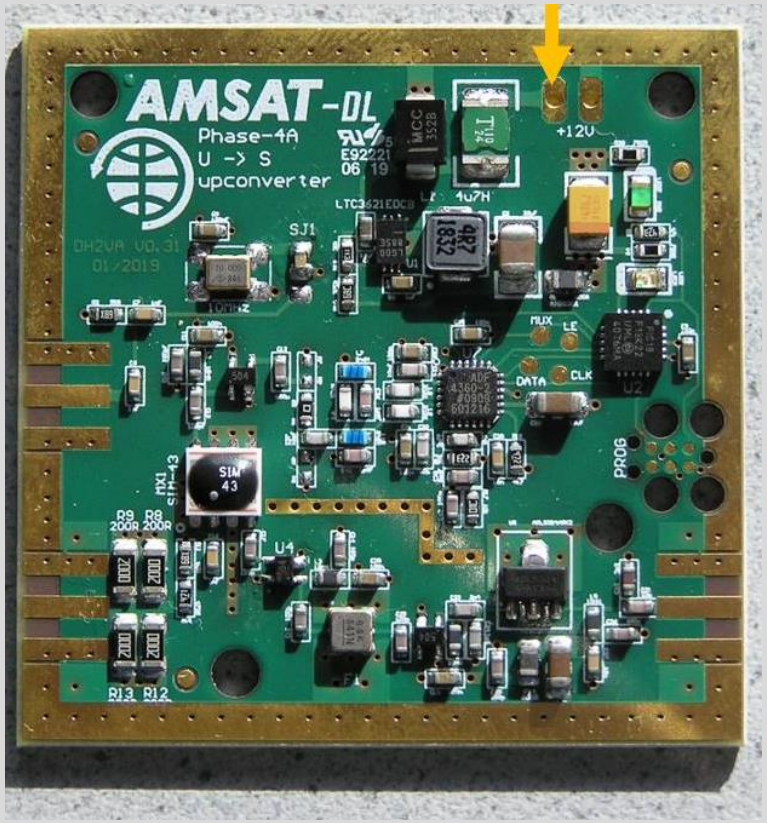
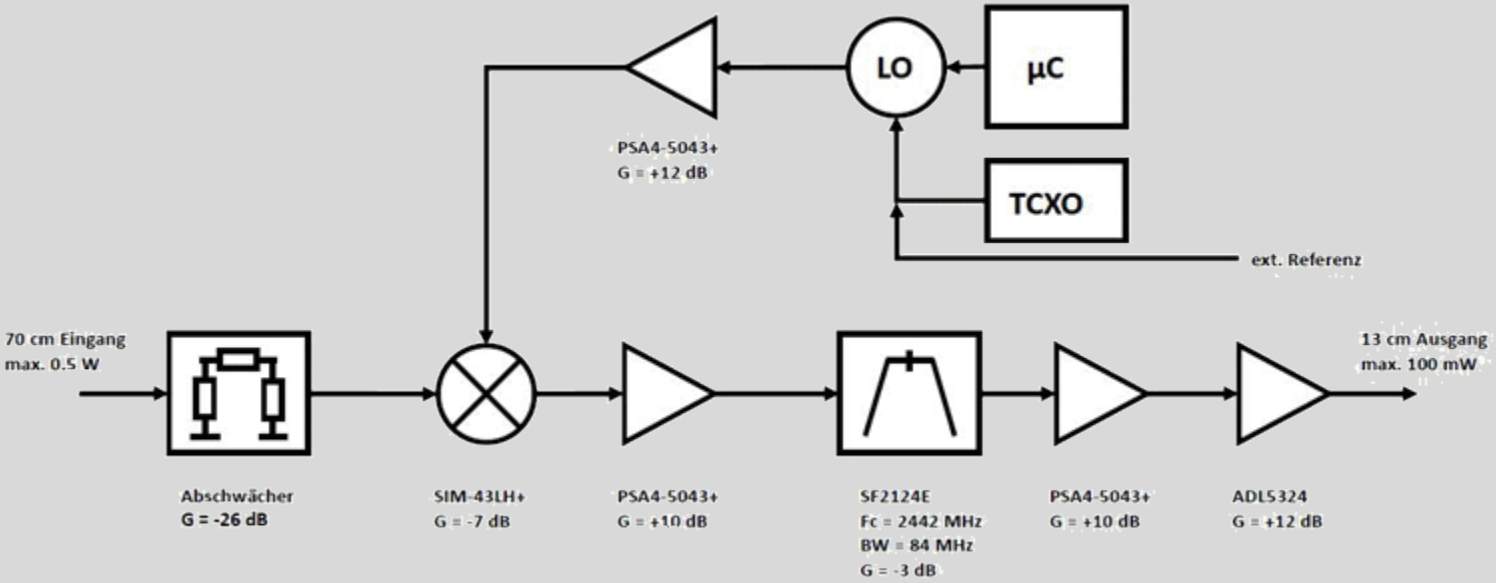
NB TX for QO-100





Upconverter AMSAT-DL V1
70cm input (max 500mW)
13cm output (max. 100mW)
99€

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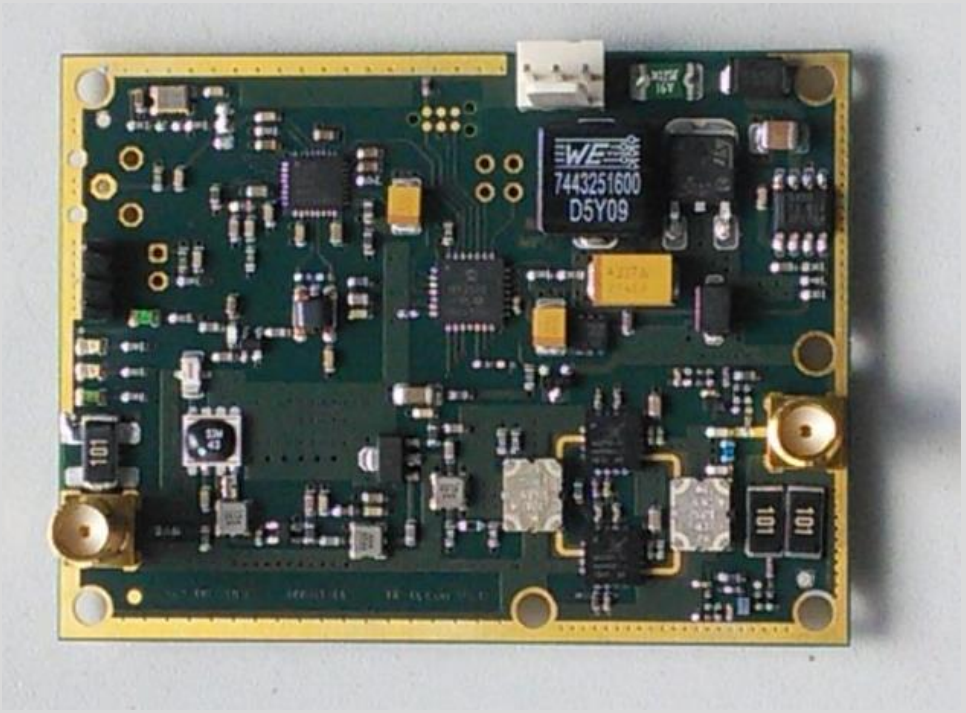
NB TX for QO-100



Coming soon in the AMSAT-DL store:

Upconverter AMSAT-DL V2

IF-input: 70cm (max 500mW)
RF-output: 13cm (max. 8W)
Reference clock can be supplied from the AMSAT-DL downconverter V2

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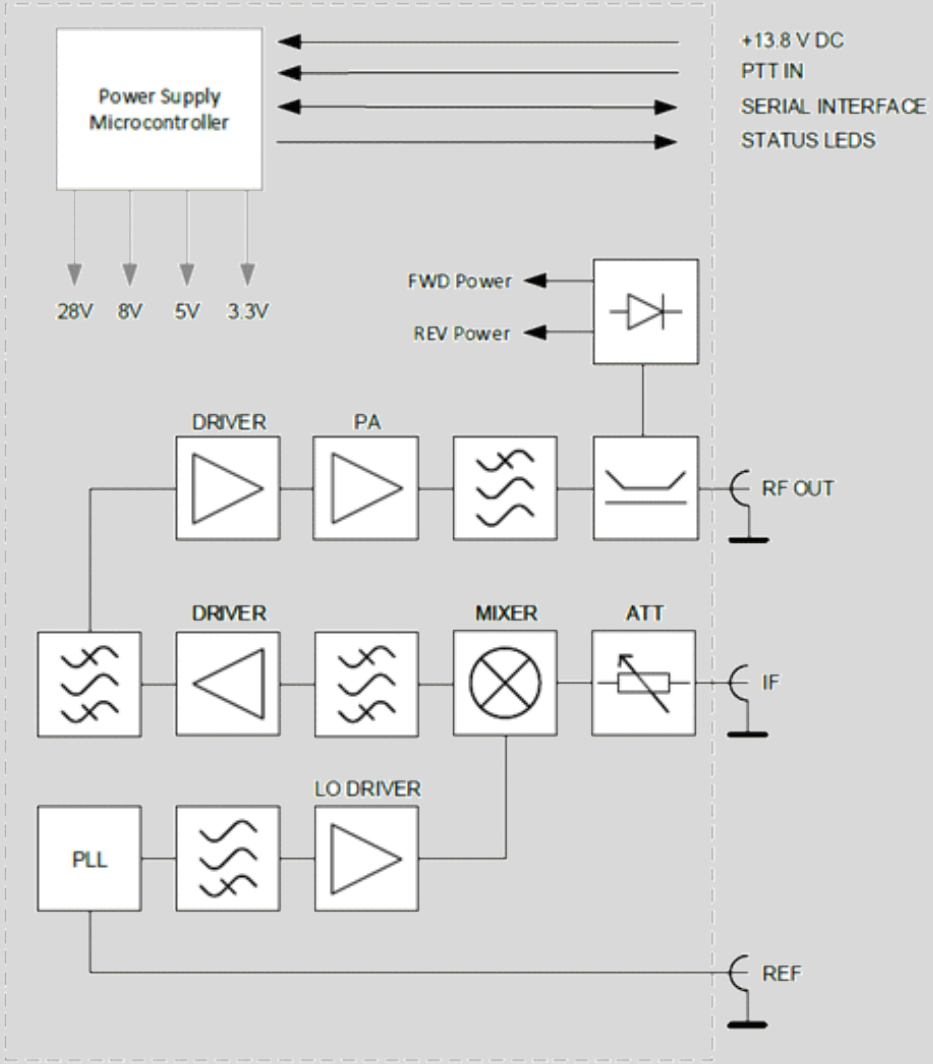
http://www.amsat-dl.de

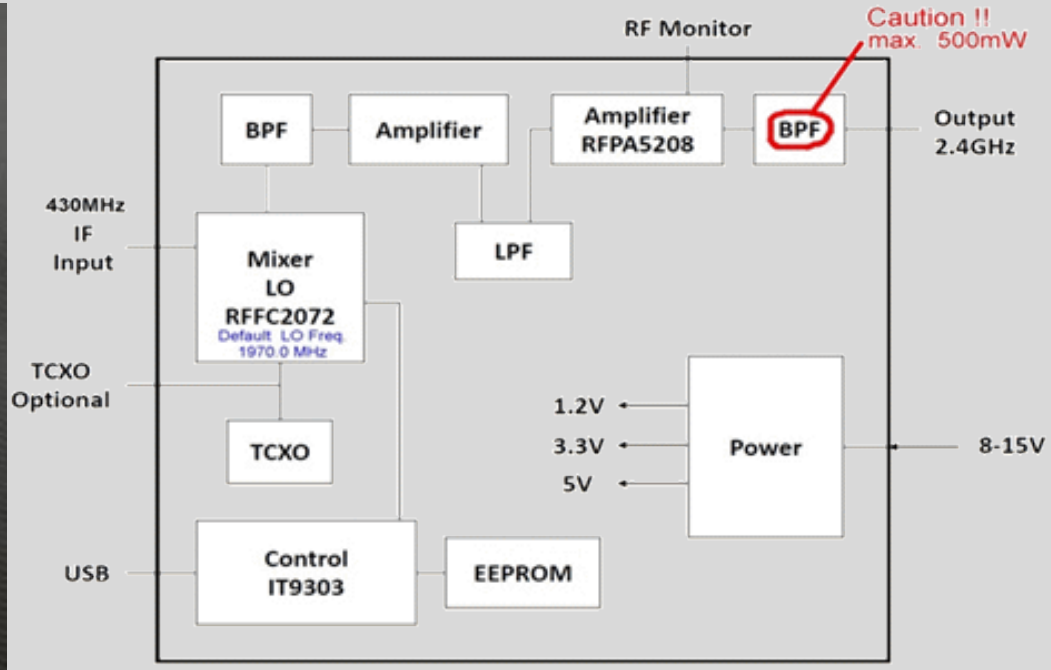
NB TX for QO-100

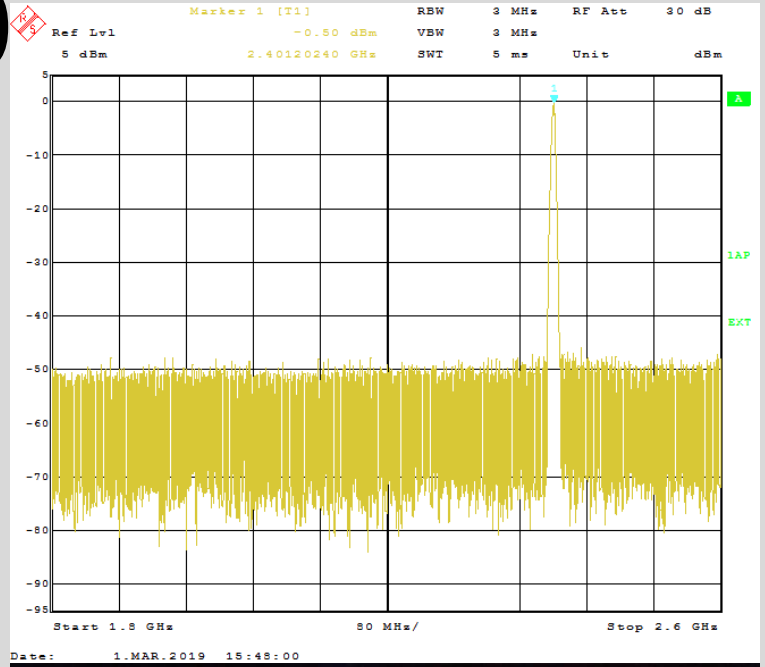


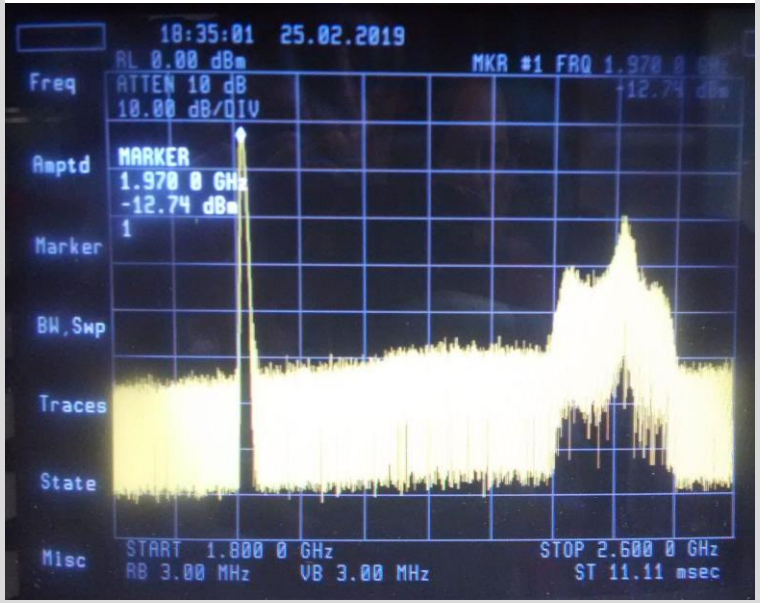
Upconverter Kuhne MKU UP 2424 B
IF-input: 2m/70cm (max 5W)
RF-output: 13cm (20W)
10 MHz ref. freq. input
949 €

https://shop.kuhne-electronic.de/kuhne/de/shop/eshail-2/

NB TX for QO-100



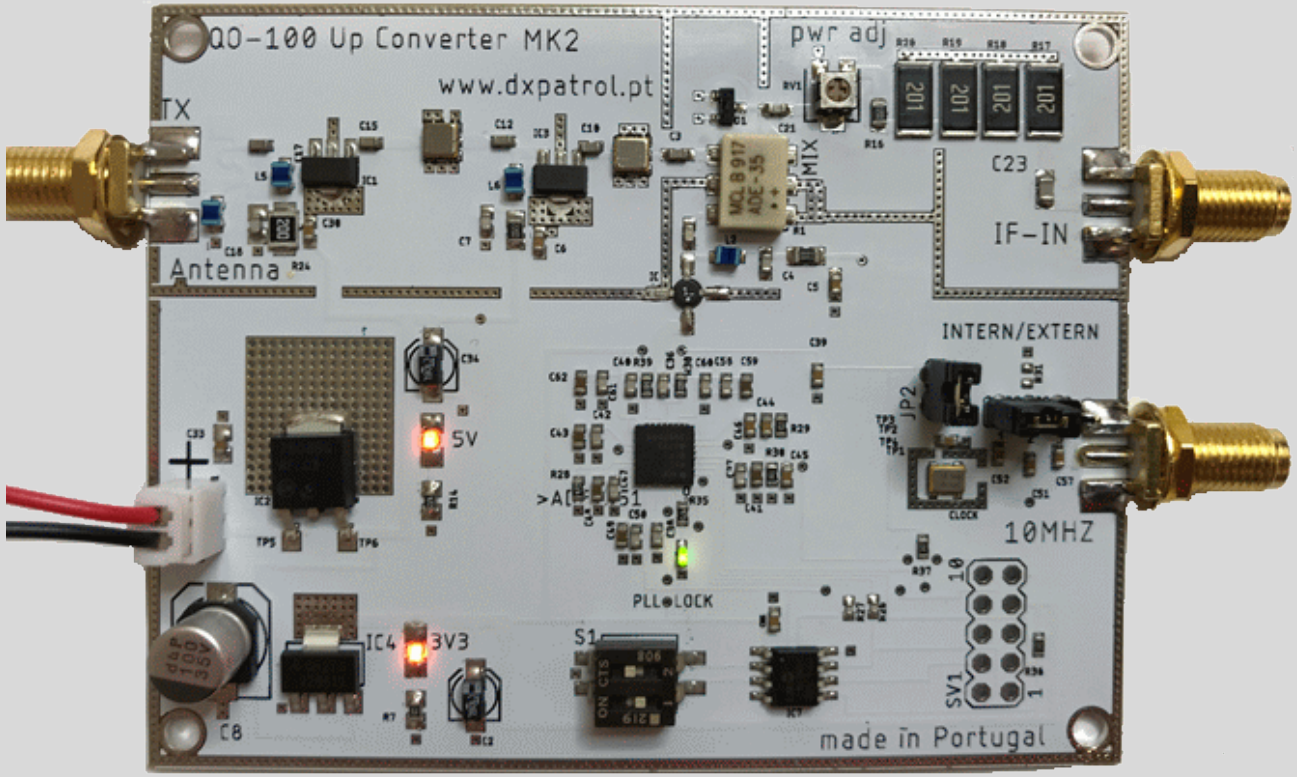




HIDES BU-500 Upconverter
IF-input: 2m/70cm (max. 10mW)
RF-output: 13cm (max. 500mW)
169 US$ / 135€

2nd generation is improved !

NB TX for QO-100



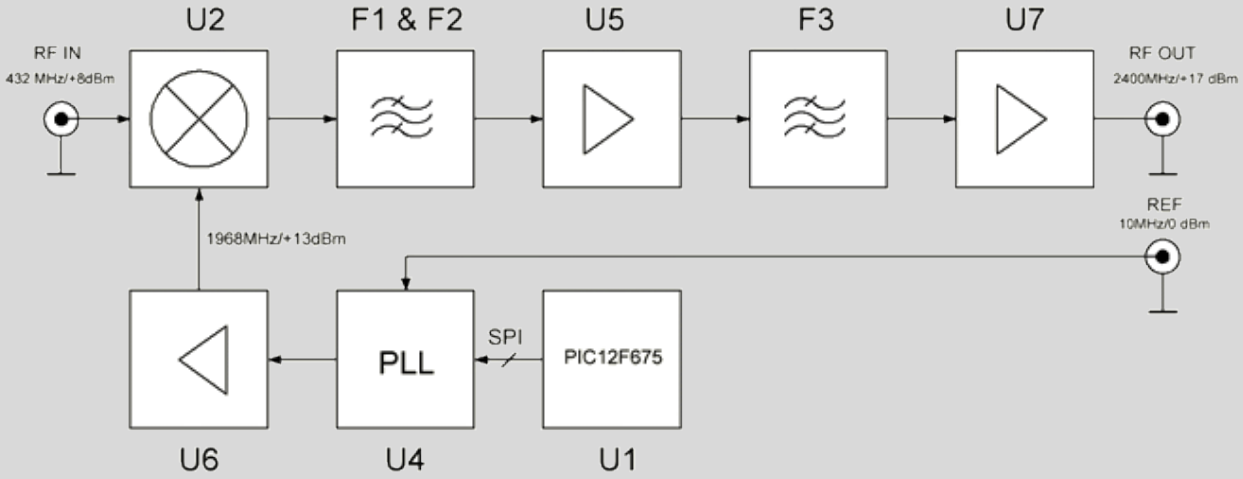
DX-Patrol Upconverter MK2

IF-input: 10m/2m/70cm/23cm (max. 3W)
RF-output: 13cm (Pout=100mW)
Internal or external 10 MHz reference

120€

http://www.dxpatrol.pt

NB TX for QO-100



Transverter STC-7013 from RA3APW

IF-input/output: 70cm (max. 3W)
RF-input/output: 13cm (Pout=50mW, opt. 12W)
PA based on MW7IC2725 PA module
Ext. 10 MHz ref. input

ca. 210€

http://www.ra3apw.ru

NB TX for QO-100

SG-Labs Transverter TR2300 from LZ5HP

IF-input/output: 70cm (max. 5W)
RF-input/output: 13cm(NF=1.5dB typ.,
Pout=2W typ.)
Switchable LO supporting also terrestrial operation / EME / split mode

200€

http://www.sg-labs.com

How much power for SSB via QO-100

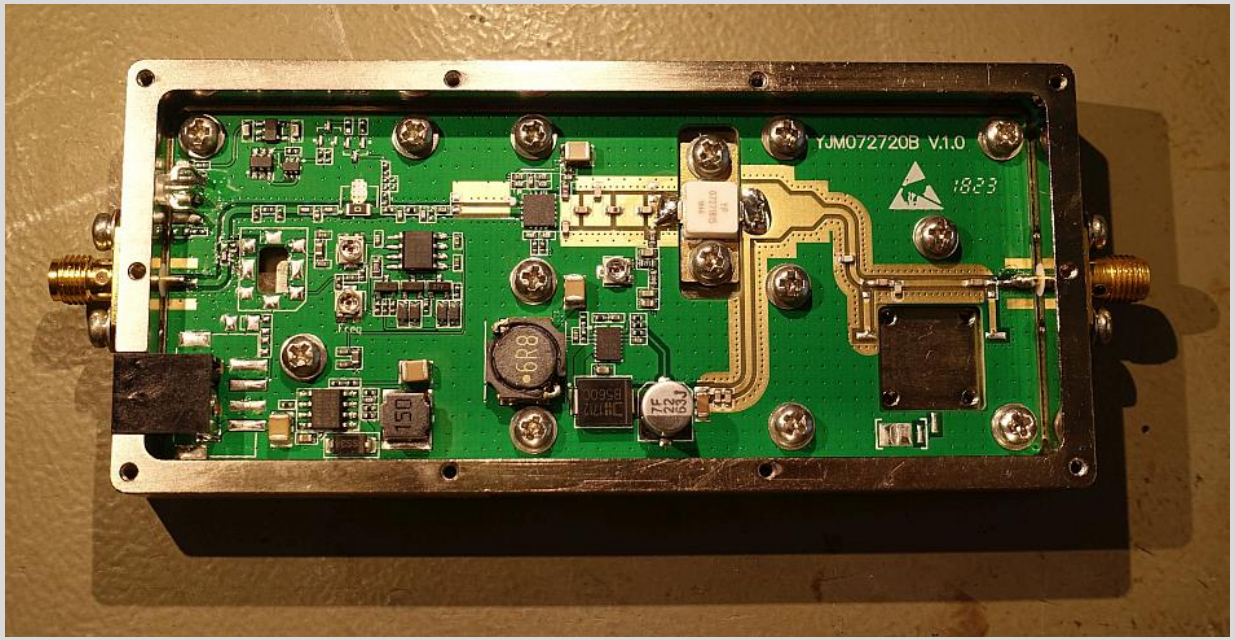
I am using a 1.8m dish with a POTY feed and approx. 300-600mW

Many are using a 80cm dish and approx. 2-4 Watt

Some are using a helix-antenna (20-40 turns) and approx. 10-20 W

In any case:
Be careful with high power at 2.4 GHz (narrow beam helps to be safe)
No uplink signal should result in a downlink signal stronger than the beacons

PAs for QO-100



20W WiFi Booster from AliExpress
testet and described in AMSAT-DL Journal 1/2019
16W P1dBm, OIP3 49.5 dBm, Gain ~34 dB
5A max. @12V

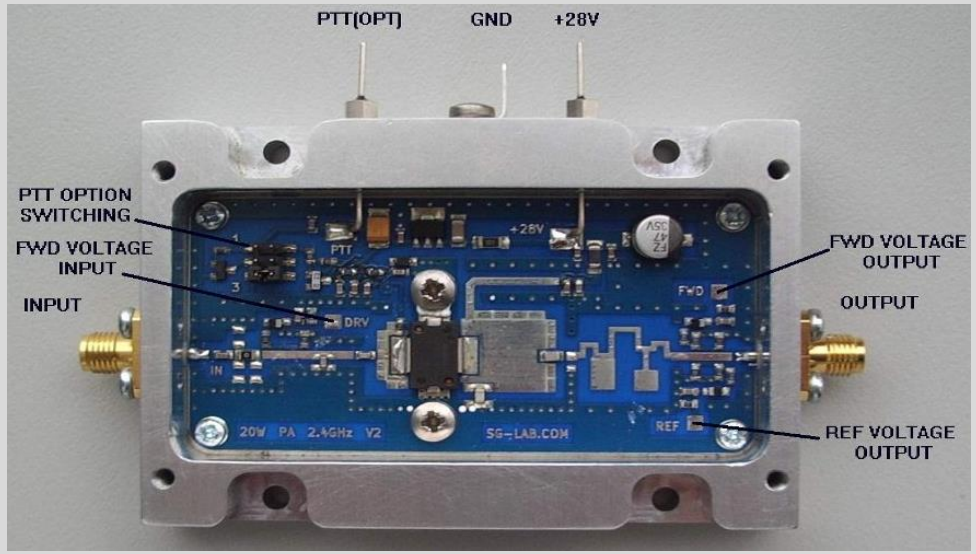
230$

4W < 50$

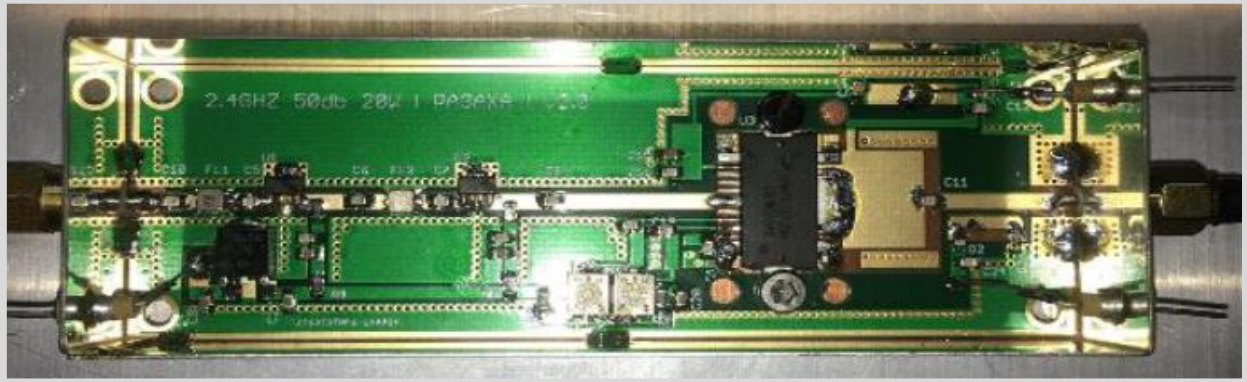
WIFI amplifiers for 2.4 GHz
Pout typ. 3dB under spec
but useable

2W < 30$

PAs for QO-100

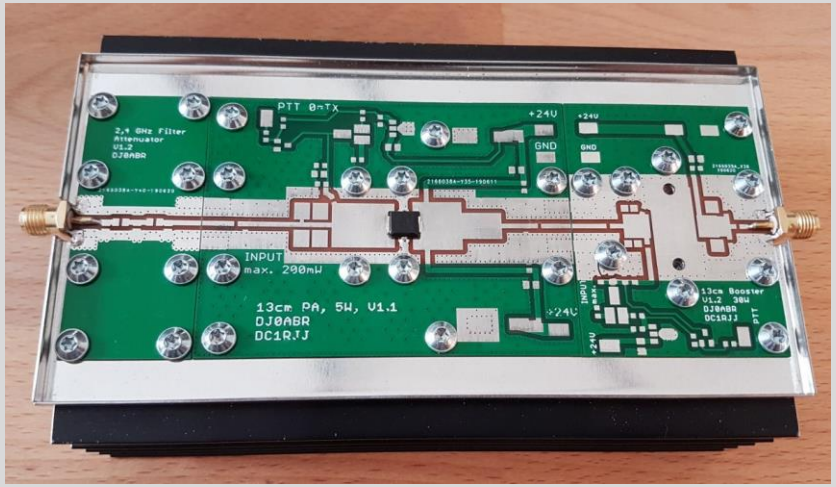


SG-Labs 13cm PA LZ5HP
Pout=20W @28V, Gp=16dB
126 €
www.sg-labs.com

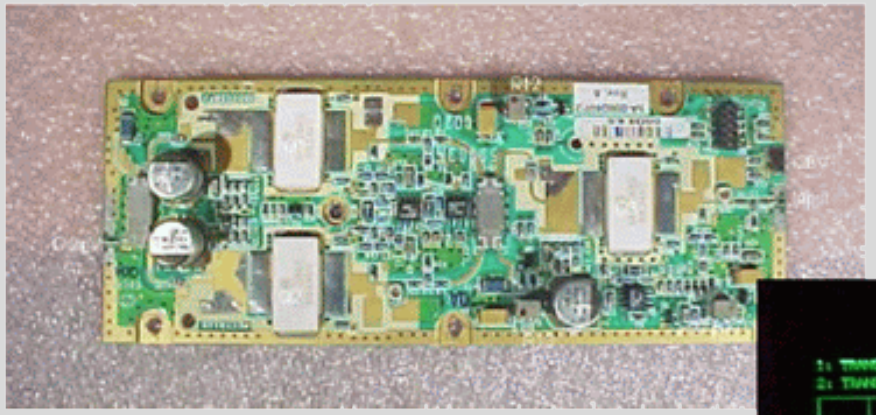


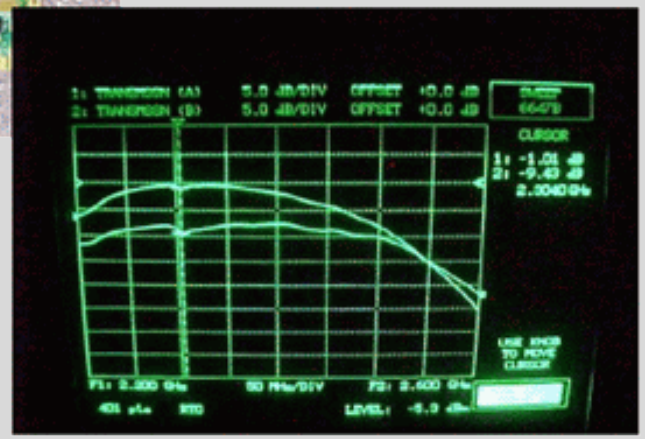
PA3AXA 13cm PA with MW7IC2725N
Pout=20W @12V+26V, GP=50dB
<70€
www.hybridpretender.nl

PAs for QO-100



DJ0ABR 13cm PA with MHT1008N
Pout=2.5W(10W) @24V
Gp=17dB, price <40€
Opt. second stage with 6W (25W) @24V
www.helitron.de/dj0abr/





- http://www.ebay.com/bhp/spectrian
- 75W Spectrian Linear RF Amplifier Board
- 2.3-2.35 GHz, gain 18dB 24/26V
- 1.25 Watt Input Power

- Price: 99 $US on eBay

Surplus amplifiers (e.g. Ebay), mostly ex UMTS with lower gain & power @2.4 GHz but still useable with low efficiency

Agenda

- QO-100 our first Phase-4 geostationary satellite (P4-A)
- QO-100 transponders
- QO-100 NB modes
- Antennas
- RX for the NB transponder
- TX and amplifiers
- **SDR TRX**
- Activities on QO-100

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Satellites for Communication, Science and Education

SDRs for QO-100

Besides traditional upconverter schemes as described before, modern SDR TRX provide a cost efficient solution for RX and TX for both, the NB and WB TPX

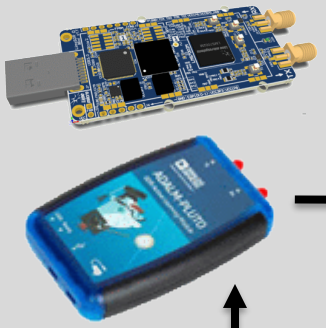
Only drawback is that always a PC is needed

Especially the Lime-SDRs and ADALM Pluto can be used to transmit NB and DATV signals directly at 2.4 GHz

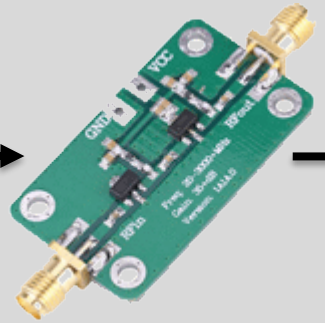
They support full duplex operation as mandatory for satellite communications

Adalm Pluto or Lime-SDR setup

SDR



35-40dB LNA
ca. 100mW



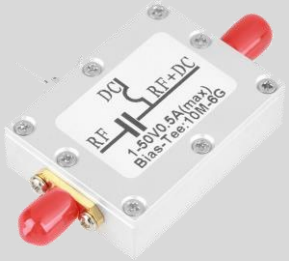
4W EDUP wi-fi
ca. 1.5W

RGC213/LMR400
coax cable - 15m

8W EDUP wi-fi
ca. 3W

1.2m dish
1.5turn helix
25MHz PLL LNB

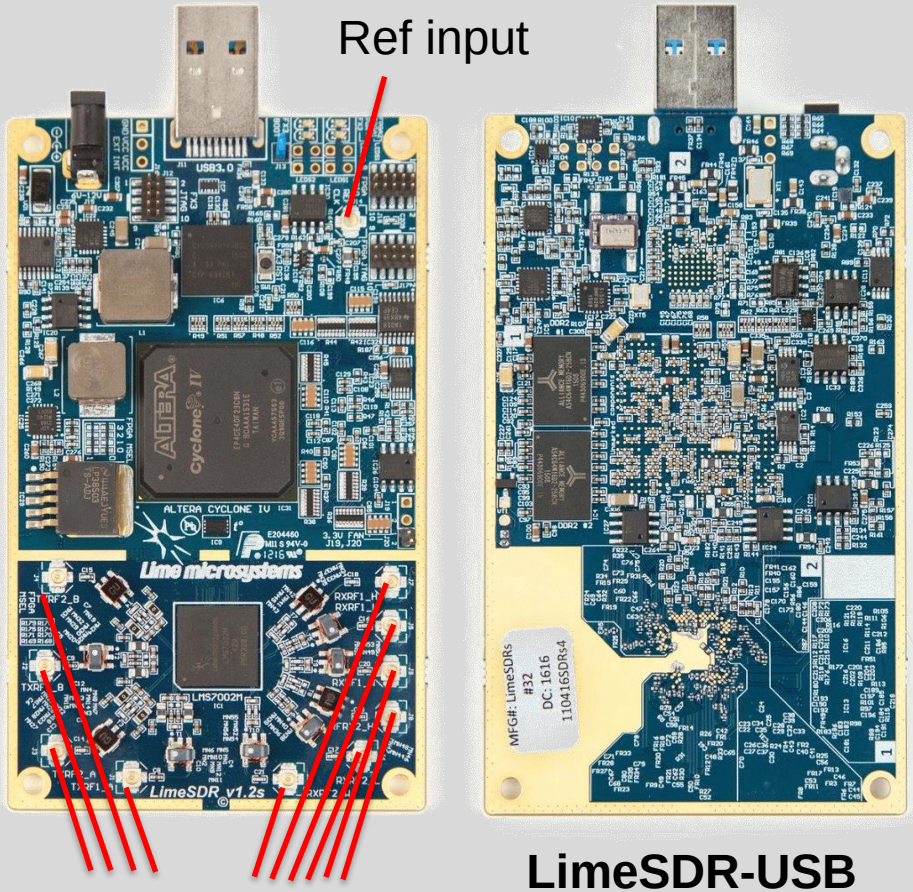
Bias Tee
12Vdc



75 Ohm – RG6
coax cable

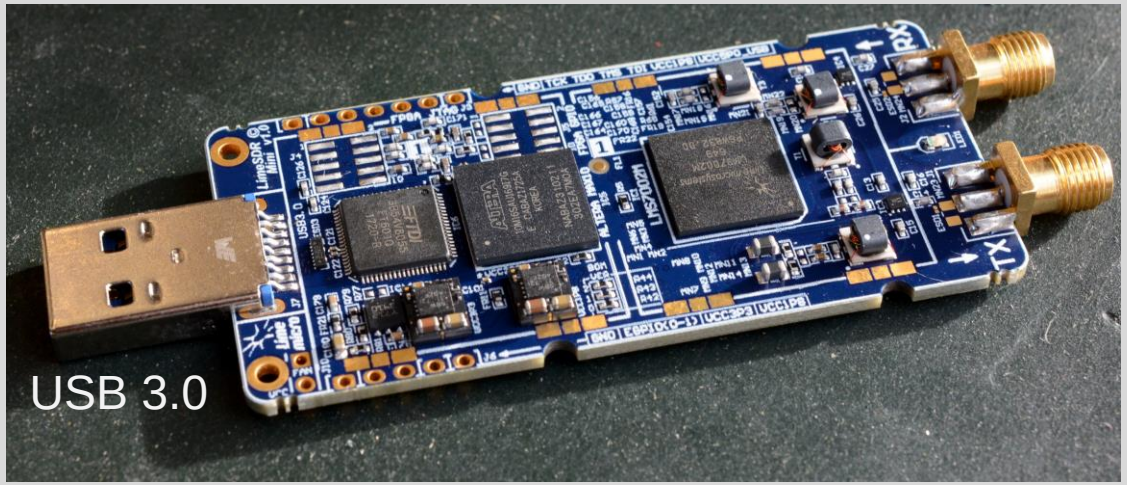
based on https://www.qrz.com/db/PY2RN

LimeSDR



LimeSDR-USB

The LimeSDR USB and mini can be used up to 3.6 GHz for RX and TX



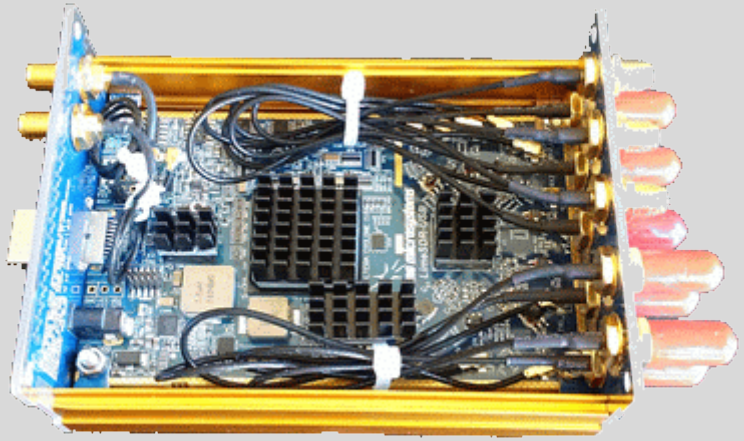
1x RX

1x TX

LimeSDR-mini

LimeSDR in metal case

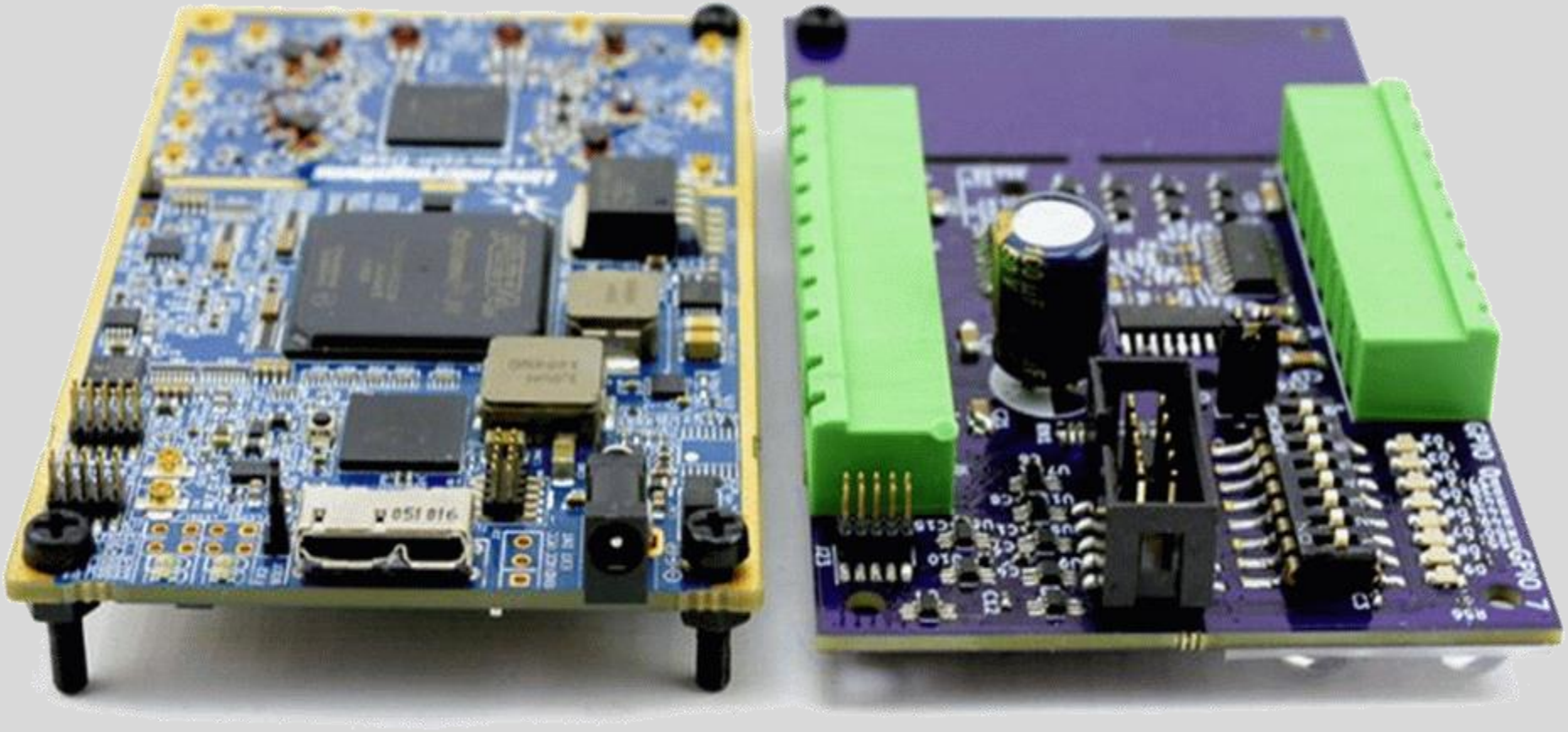
Ready made encasings are available supporting 6 RX inputs and 4 TX outputs



Adding heatsinks on the ICs is recommended

10 MHz Reference Input and Output available

LimeSDR with GPIO-board

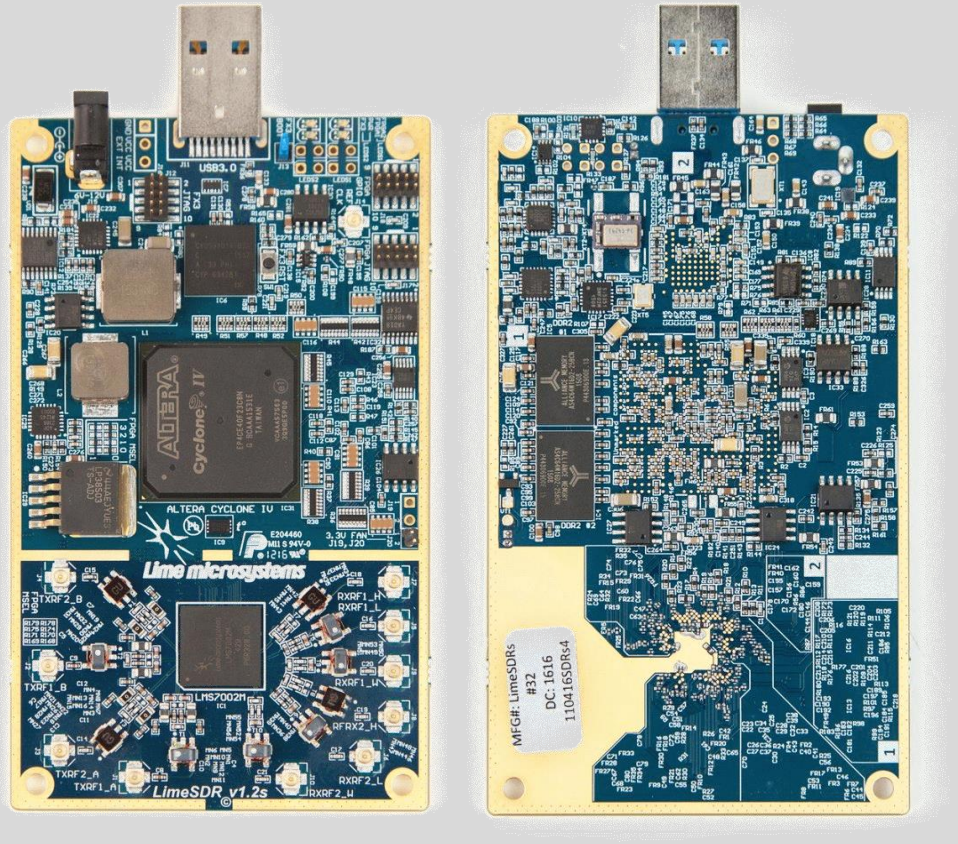


LimeSDR-USB

LimeSDR-GPIO board
supported by SDR-Radio software

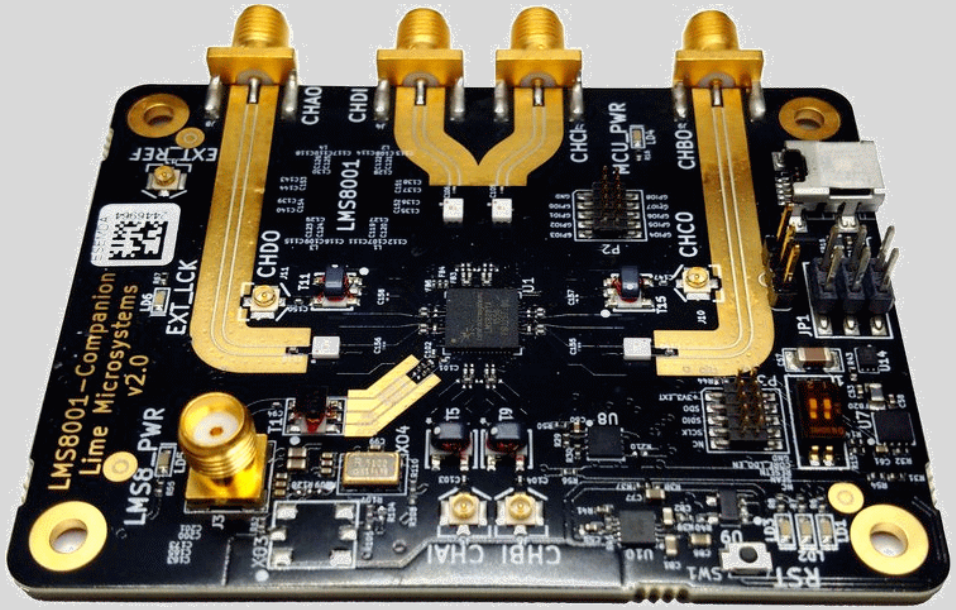
LimeSDR with LMS8001 companion board

USB 3.0



LimeSDR-USB
HF – 3.6 GHz

The LimeSDR companion board supports frequencies from 5-10 GHz
but no software supports it yet

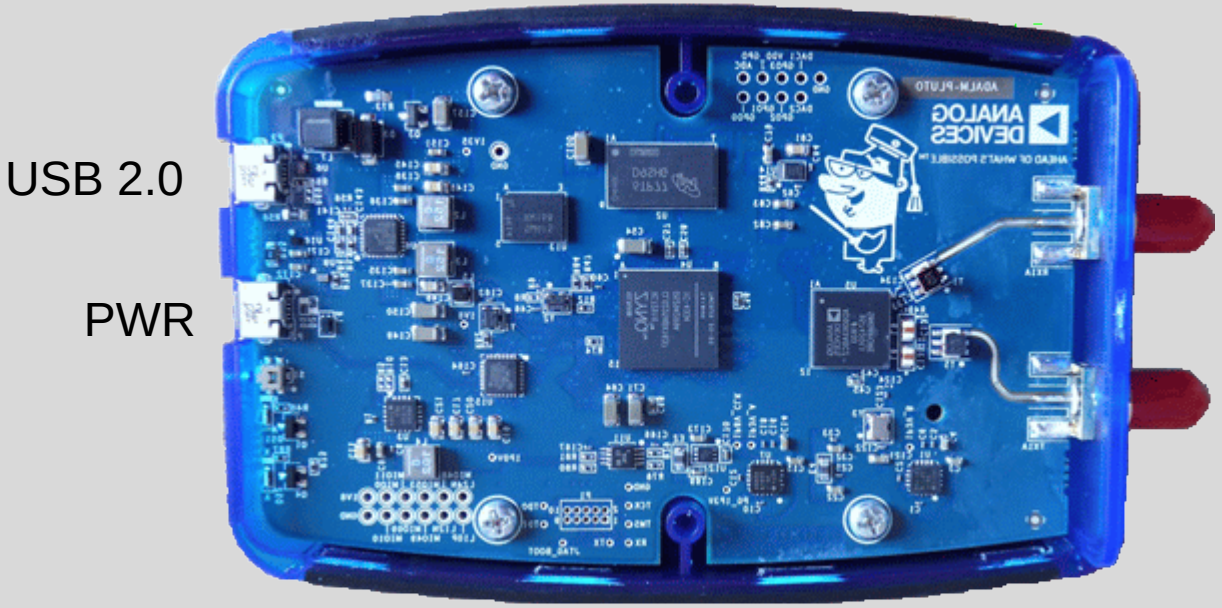


LMS8001 Companion board
5-10 GHz

Adalm Pluto

The Pluto SDR can be used up to 6 GHz for RX and TX

ADALM Pluto

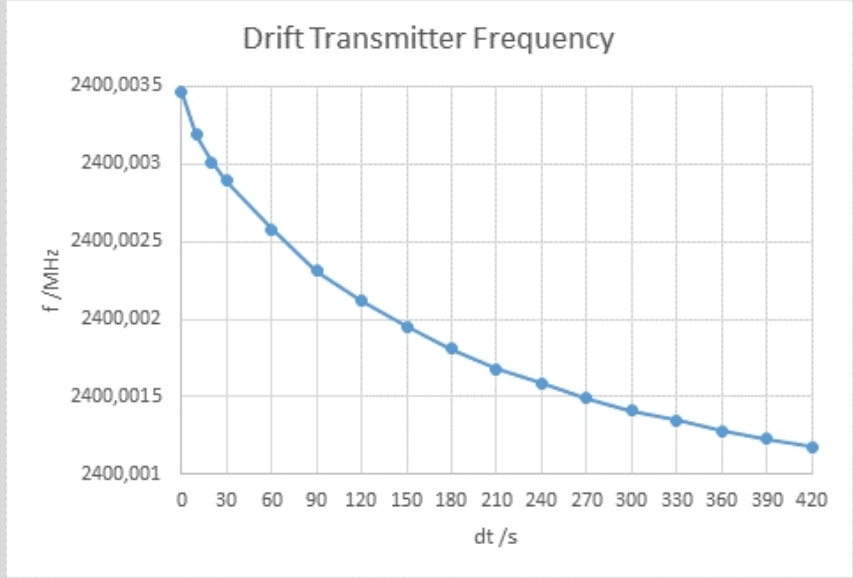


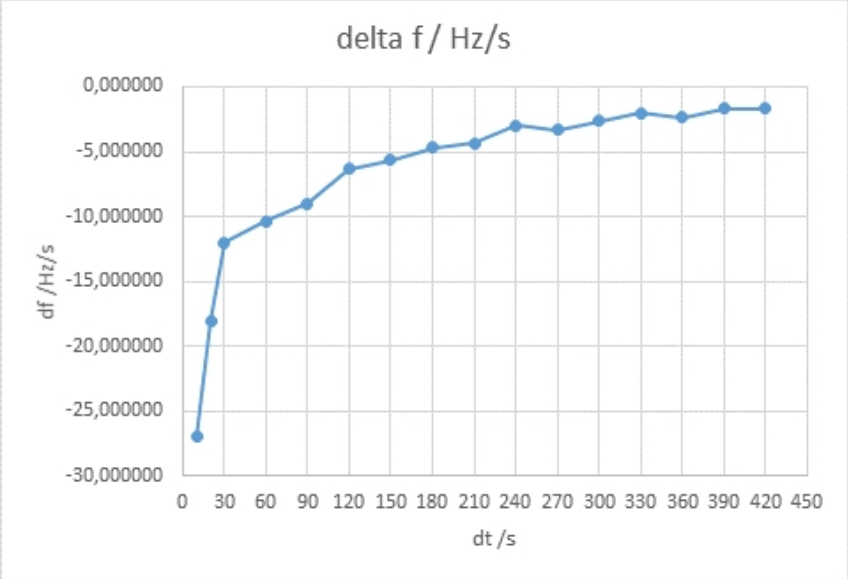
ADALM Pluto open

Adalm Pluto

Adding a simple USB-Ethernet adapter makes the ADALM Pluto to a full network controlled SDR TRX

Nice, but:



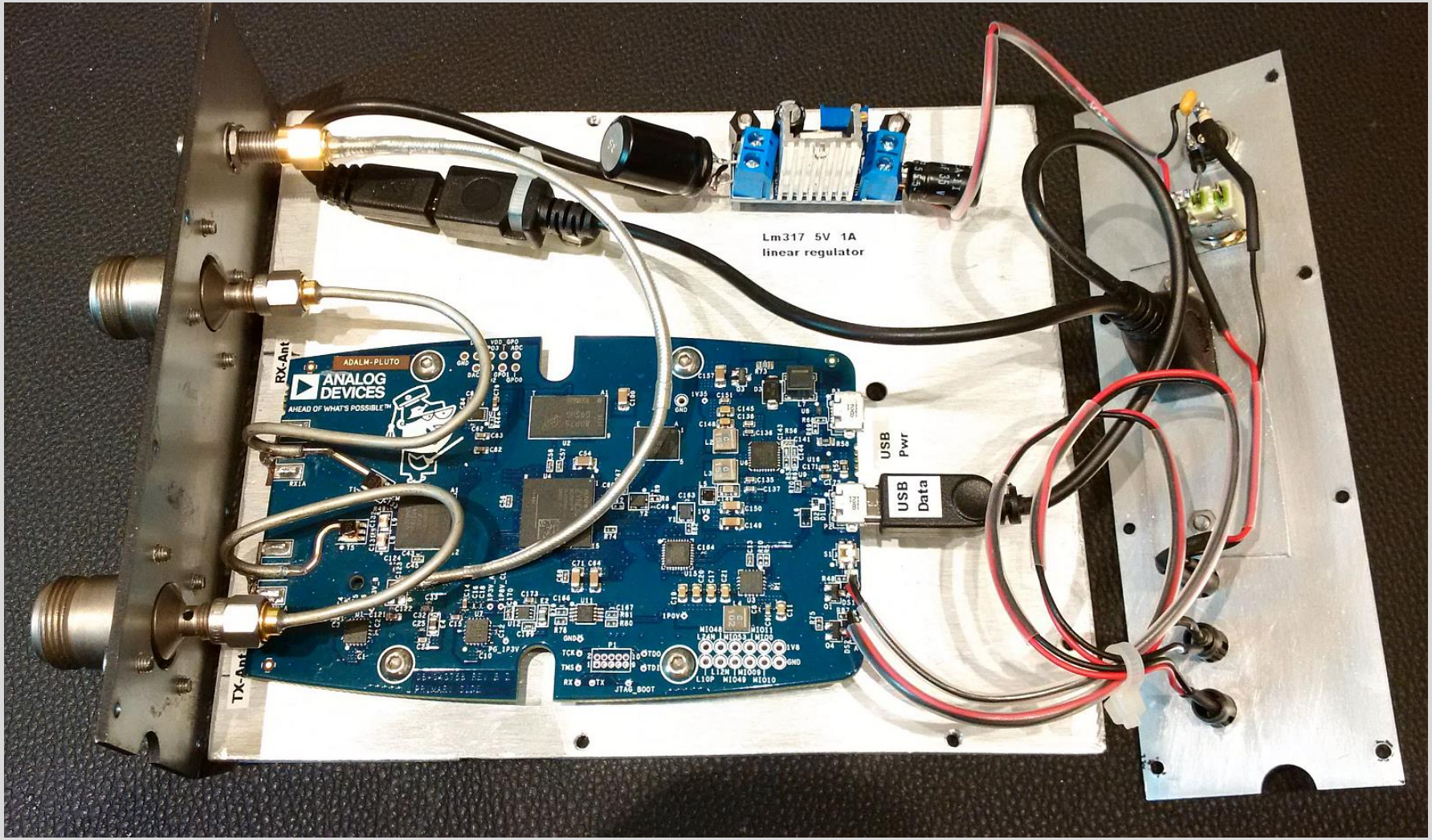


Internal 40 MHz TCXO needs to be replaced by a better TCXO or by an external reference

Adalm Pluto

ADALM Pluto in shielded encasing with external 40 MHz reference input

Adalm Pluto

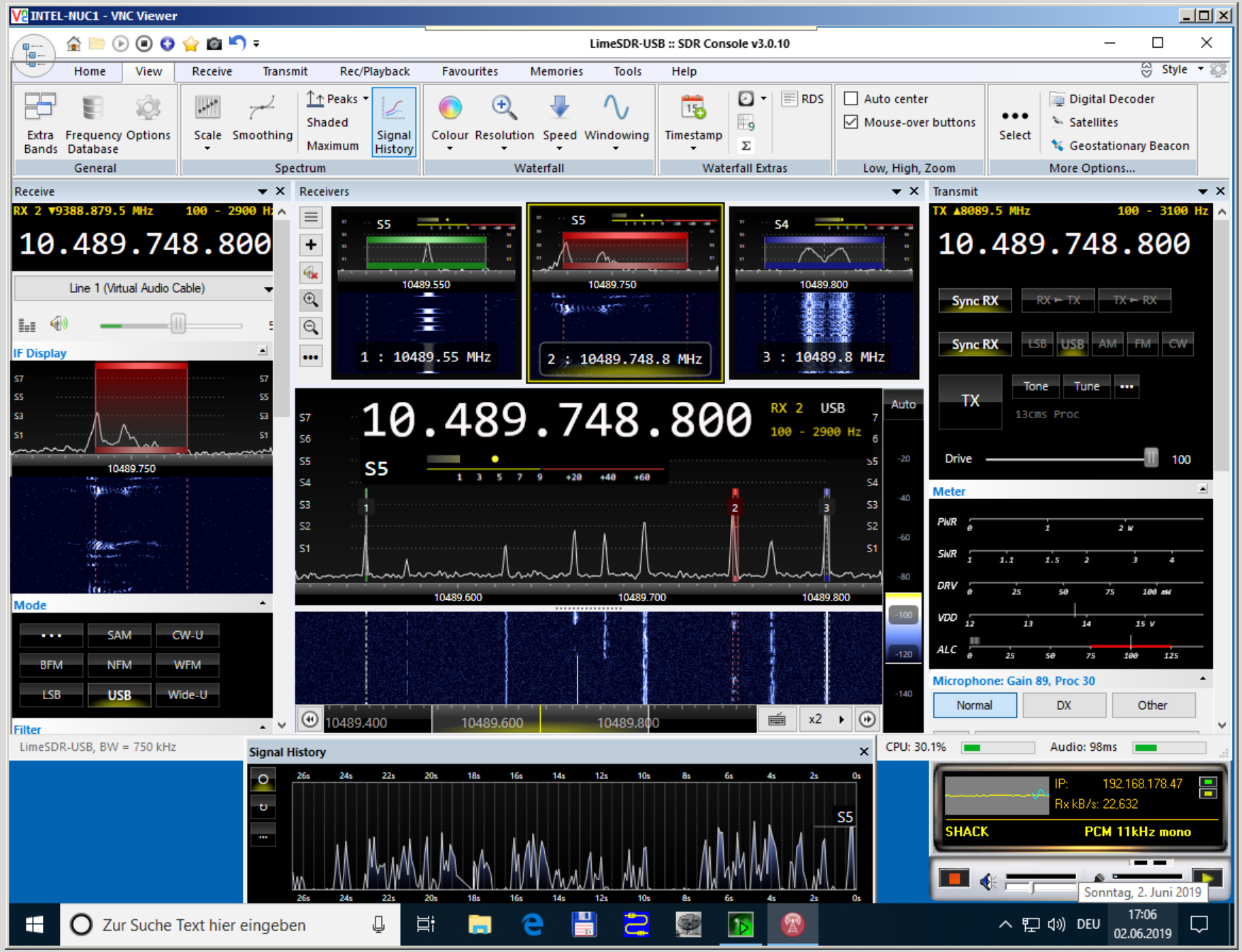


ADALM Pluto in shielded encasing with external 40 MHz reference input

SDR-Radio

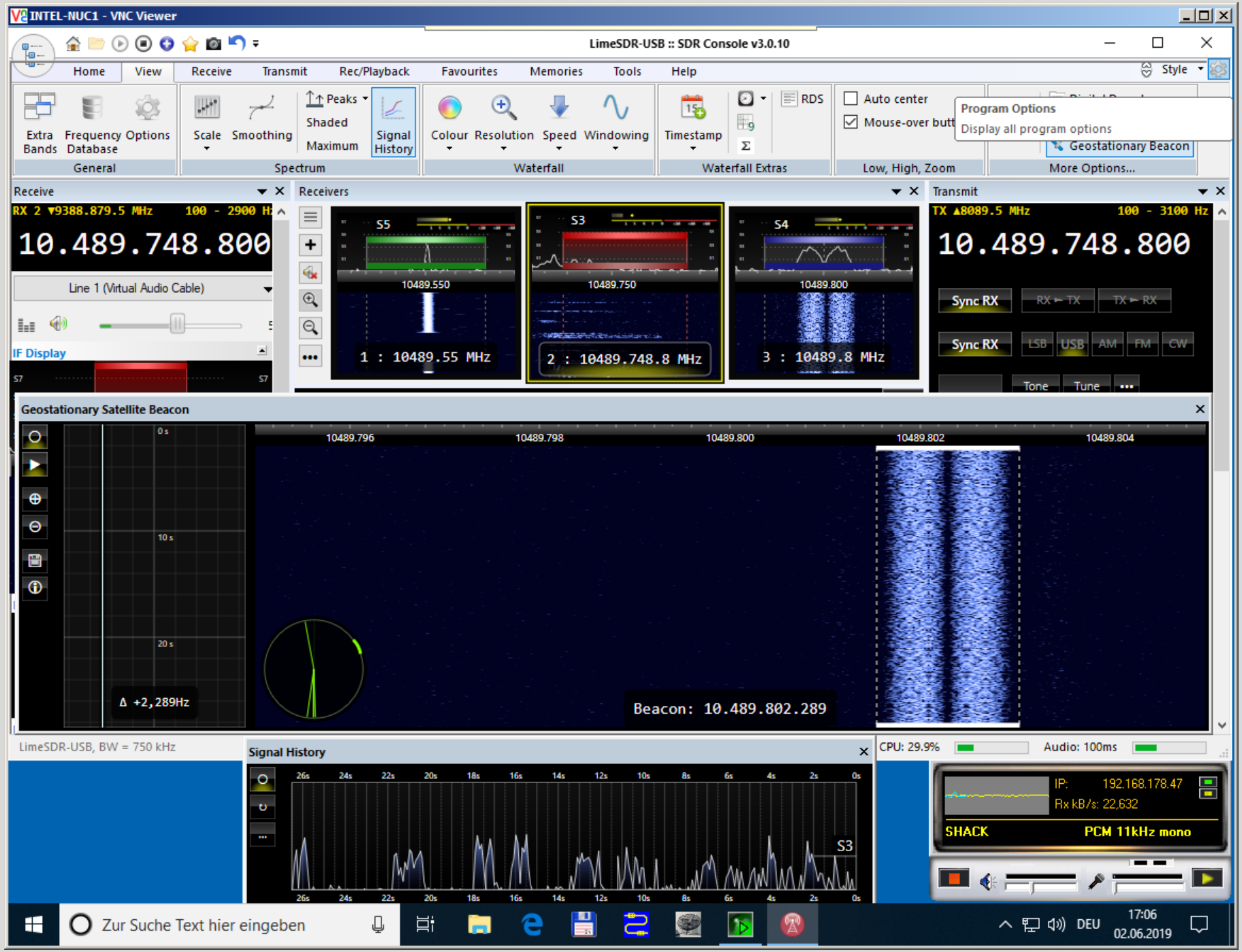
Full-Duplex with automatic tracking of RX and TX frequency and mode.

The latest version supports also traditional radios with up- and downconverters.



SDR-Radio

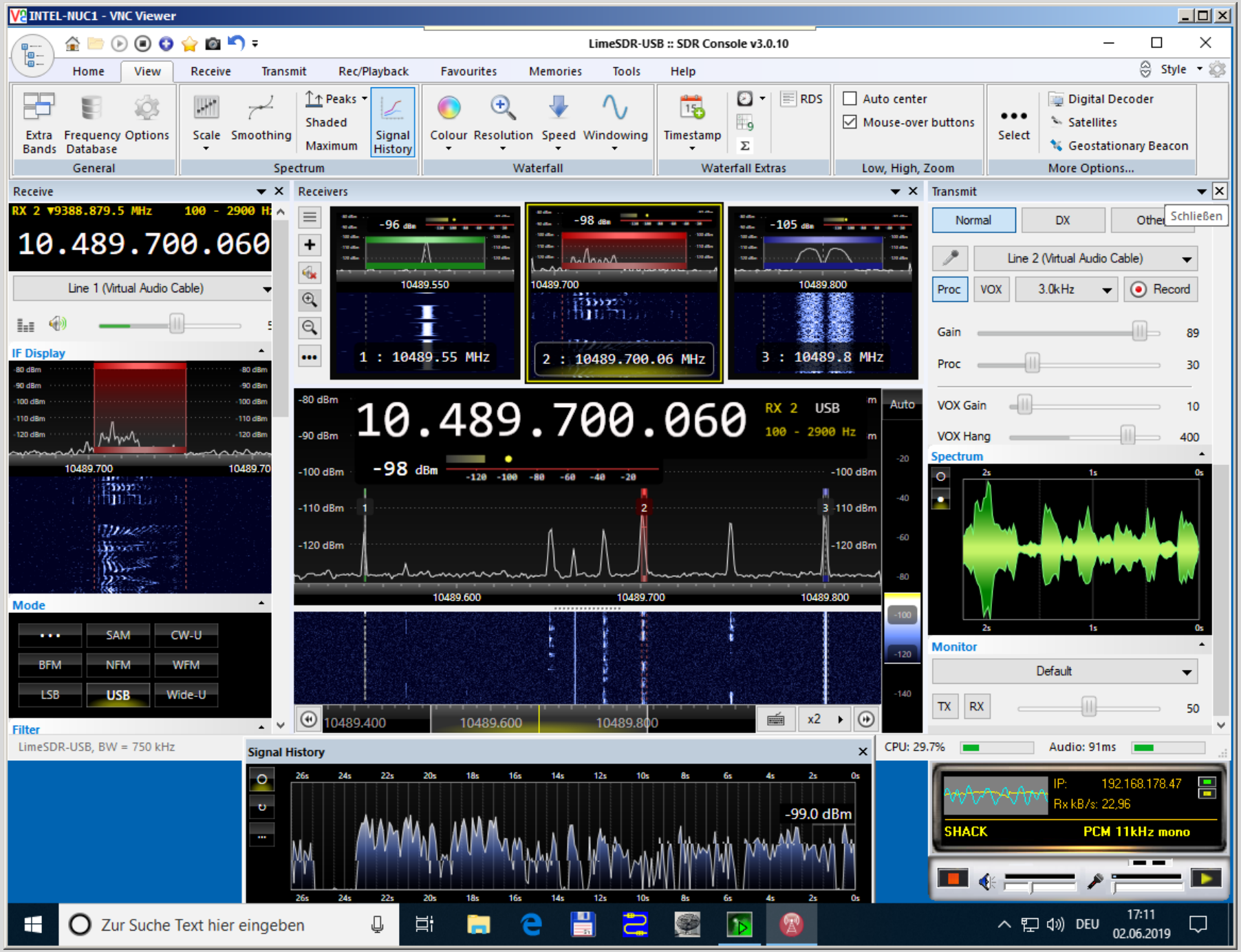
Locking the receiver to the PSK beacon eliminates the drift of the LNB.
The latest versions also support a variable frequency of the PSK beacon.



SDR-Radio

Multiple receiver windows are convenient to check the own signal and compare it to the beacon level.

Transmit Audio Scope and spectrum available.

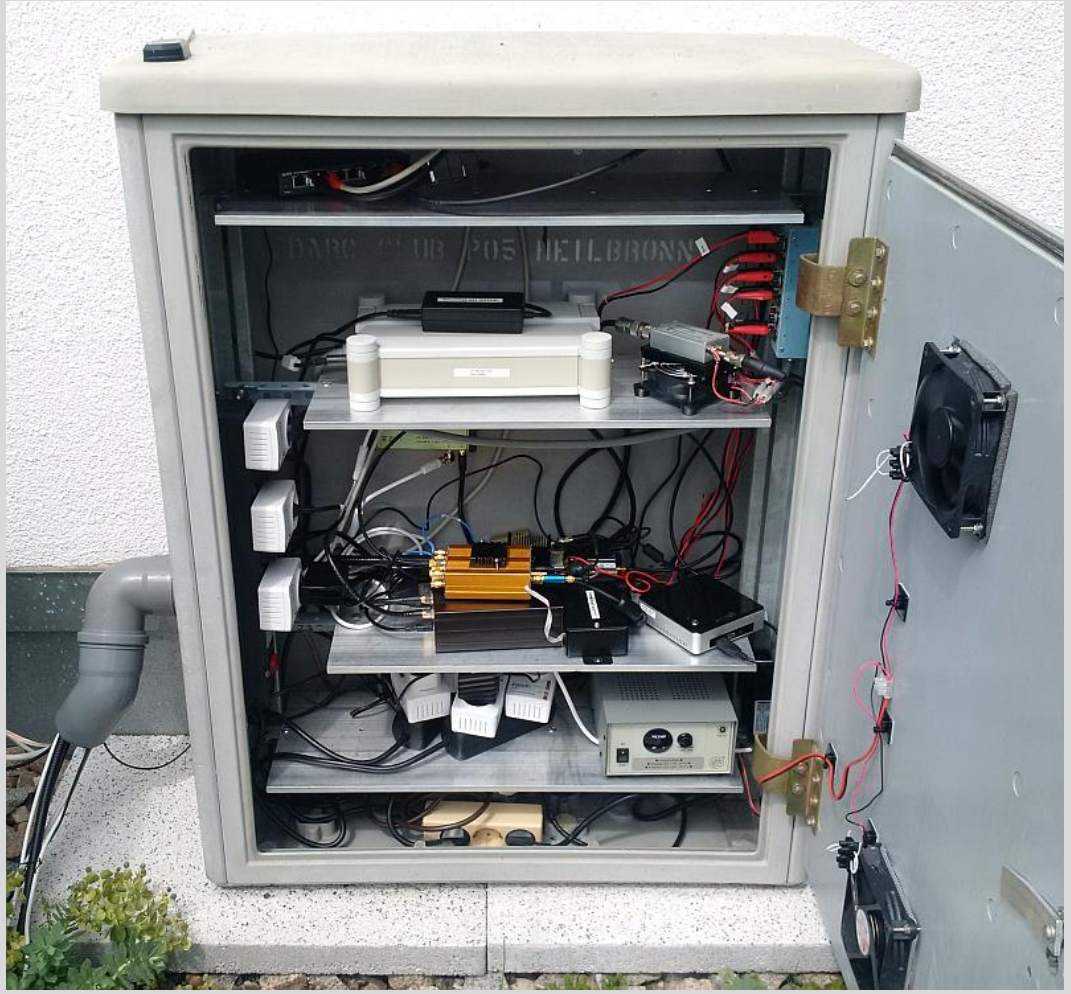


Out-Door-Unit DD1US

Vintage Kathrein 1.8m dish with dualband POTY feed, <1W enough for a SSB signal at beacon level

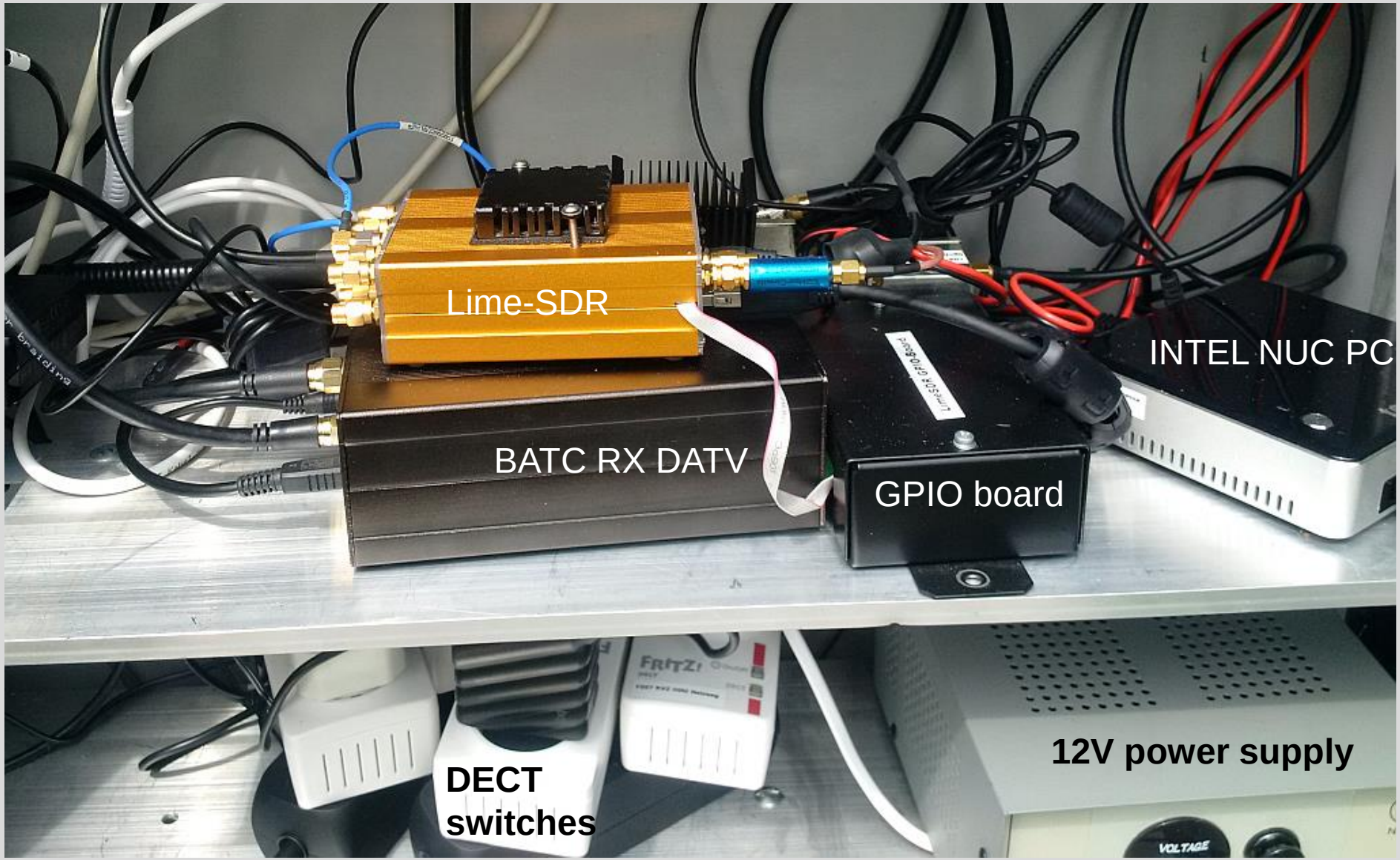
Adjustable feed holder and weather proof encasing with PTFE window for the dual-band feed and LNB

Out-Door-Unit DD1US



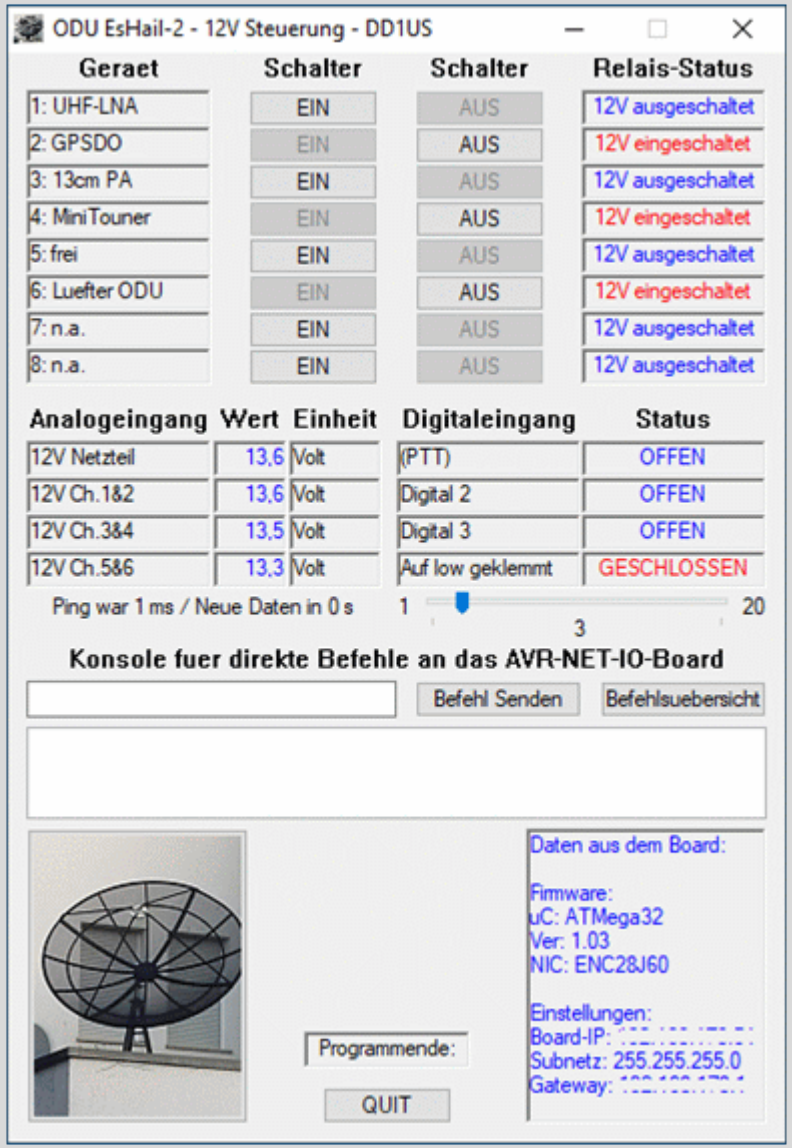
All Hardware except the LNB is in the ODU, only 230V and Ethernet cable to the house, allows remote operation

Out-Door-Unit DD1US



Out-Door-Unit DD1US

AVR Net-IO Unit
(Pollin)



Control Software
(DD1US)

Agenda

- QO-100 our first Phase-4 geostationary satellite (P4-A)
- QO-100 transponders
- QO-100 NB modes
- Antennas
- RX for the NB transponder
- TX and amplifiers
- SDR TRX
- **Activities on QO-100**

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QO-100 Logbook DD1US

DXCC	Country	Pfx
165	Mauritius	3B8
336	Israel	4Z
215	Cyprus	5B
438	Madagascar	5R
497	Croatia	9A
257	Malta	9H
299	West Malaysia	9M2
046	East Malaysia	9M6
402	Botswana	A2
370	Oman	A4
376	Qatar	A7
304	Bahrain	A9
318	China	BY
203	Andorra	C3
422	The Gambia	C5
272	Portugal	CT
256	Madeira Is.	CT3
149	Azores	CU
409	Cape Verde	D4
230	Fed. Republic of Germany	DL
281	Spain	EA
021	Balearic Is.	EA6
029	Canary Is.	EA8
245	Ireland	EI
330	Iran	EP

DXCC	Country	Pfx
052	Estonia	ES
027	Belarus	EU
227	France	F
453	Reunion Is.	FR
063	French Guiana	FY
223	England	G
114	Isle of Man	GD
265	Northern Ireland	GI
279	Scotland	GM
106	Guernsey	GU
294	Wales	GW
239	Hungary	HA
287	Switzerland	HB9
387	Thailand	HS
378	Saudi Arabia	HZ
248	Italy	I
225	Sardinia	IS
266	Norway	LA
254	Luxembourg	LX
146	Lithuania	LY
212	Bulgaria	LZ
206	Austria	OE
224	Finland	OH
503	Czech Republic	OK
504	Slovak Republic	OM

DXCC	Country	Pfx
209	Belgium	ON
221	Denmark	OZ
263	Netherlands	PA
108	Brazil	PY
302	Western Sahara	S0
499	Slovenia	S5
284	Sweden	SM
269	Poland	SP
466	Sudan	ST
236	Greece	SV
501	Bosnia-Herzegovina	T9
390	Turkey	TA
242	Iceland	TF
214	Corsica	TK
420	Gabon	TR
054	European Russia	UA3
015	Asiatic Russia	UA9
324	India	VU
333	Iraq	YI
275	Romania	YO
462	Republic of South Africa	ZS

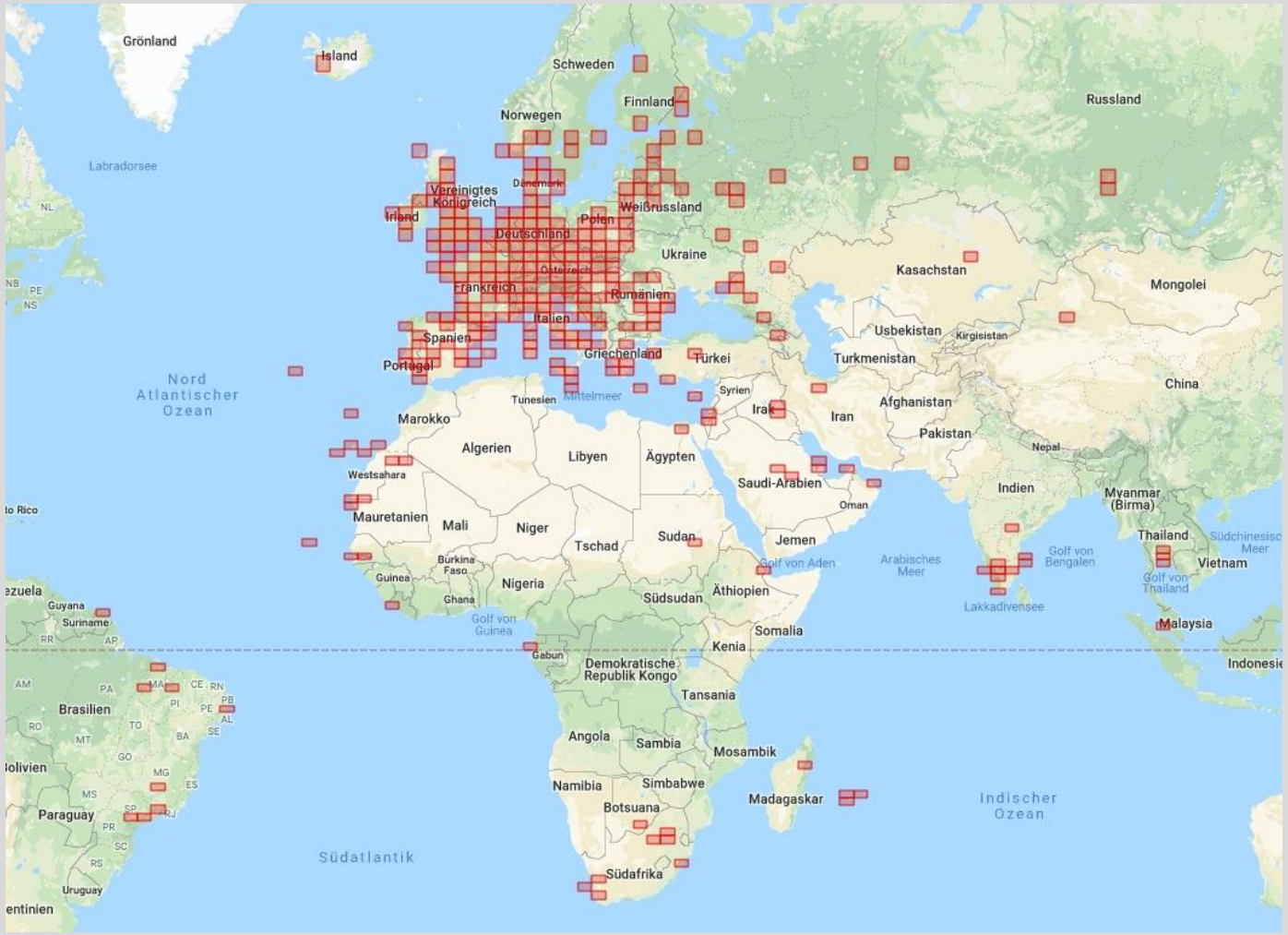
As of November 4th 2019
I worked 72 DXCCs in
> 750 SSB-QSOs via QO-100

Remco PA3FYM

As of November 4th 2019 Remco PA3FYM worked 80 DXCCs in > 800 QSOs via QO-100.

He worked >320 different grid squares.

As of that date 82 DXCCs were active on QO-100. He only missed only 4U1ITU and ZA (activated by DL2RMC)



Thank you very much for your attention !

Some of the slides / information were kindly provided by Achim DH2VA, who was not able to come to Bochum this time due to other obligations.

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Satellites for Communication, Science and Education

Thank you very much for your attention !

You will find this presentation and more information about my setup on my website www.dd1us.de

You can find there also a section called „Sounds from Space“ with more than 1500 recordings of various satellites and other space objects.

	Apollo 12 (crew: Charles "Pete" Conrad, Richard "Dick" F. Gordon, Alan L. "Al" Bean) CSM-108 #04225 1969-099A	This was the 2nd mission of Apollo with a landing on the moon. The rocket was struck twice (36 seconds and 52 seconds after launch) by a lightning. You can hear the launch campaign including the conversation about the lightning strikes in the first audio recording. The second audio files documents communication between LM (the lunar module with the nickname "Intrepid") and Houston ground control during the final descent phase (last 3 minutes) and the touch down on the moon (110 h, 32 min and 36 sec mission elapsed time). The crew returned safely on November 24th 1969. I extracted the recordings from the NASA audio collection. Alan L. Bean was the 4th man on the moon. After he left NASA he became an artist and started painting beautiful scenes of the moon. Enclosed a picture of himself which he named "A New Frontier".	Nov 14th 1969
	Apollo 13 aborted third manned mission to the moon (crew: James A. Lovell, Jr., John L. Swigert, Jr., Fred W. Haise, Jr.) CSM-109 #04371 1970-029A	This aborted 3rd manned mission to moon ended almost fatal. Due to an explosion of the oxygen tank in the service module the mission had to be aborted and luckily the crew returned safely on April 17th 1970. See here a short movie of the damaged service module when clicking on the picture to the right. Listen to the famous words of J. Swigert after the explosion of the tank: "Houston, we've had a problem here."	Apr 11th 1970