Dreiländereck Sysop Treffen 2023
Engen, February 11th 2023
Matthias Bopp DD1US
www.dd1us.de

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 for QO-100
- Receive chain for the NB transponder
- Transmit chain for the NB transponder
- Integration
- SDR based solutions
- Activities on QO-100

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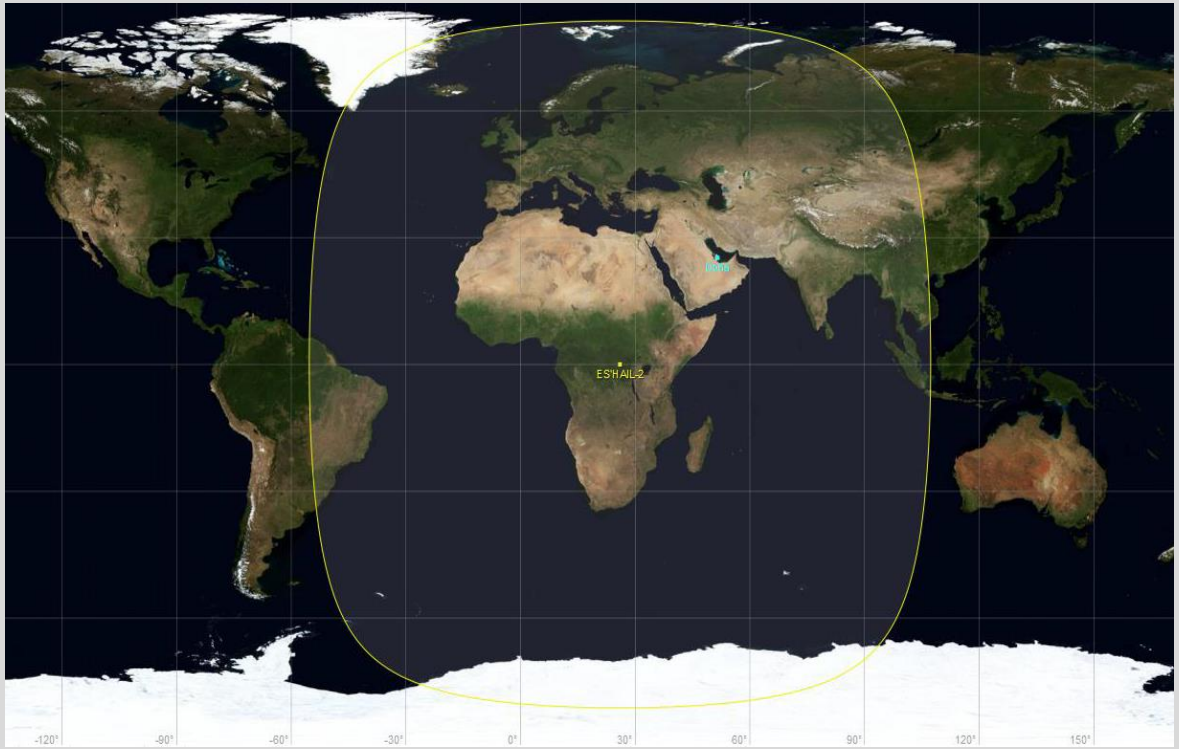
Qatar-OSCAR 100 (Es‘hail-2)

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). AMSAT-DL has specified the transponders which were built by MELCO in Japan. QO-100 is the first geostationary satellite (P4A).

http://www.amsat-dl.org

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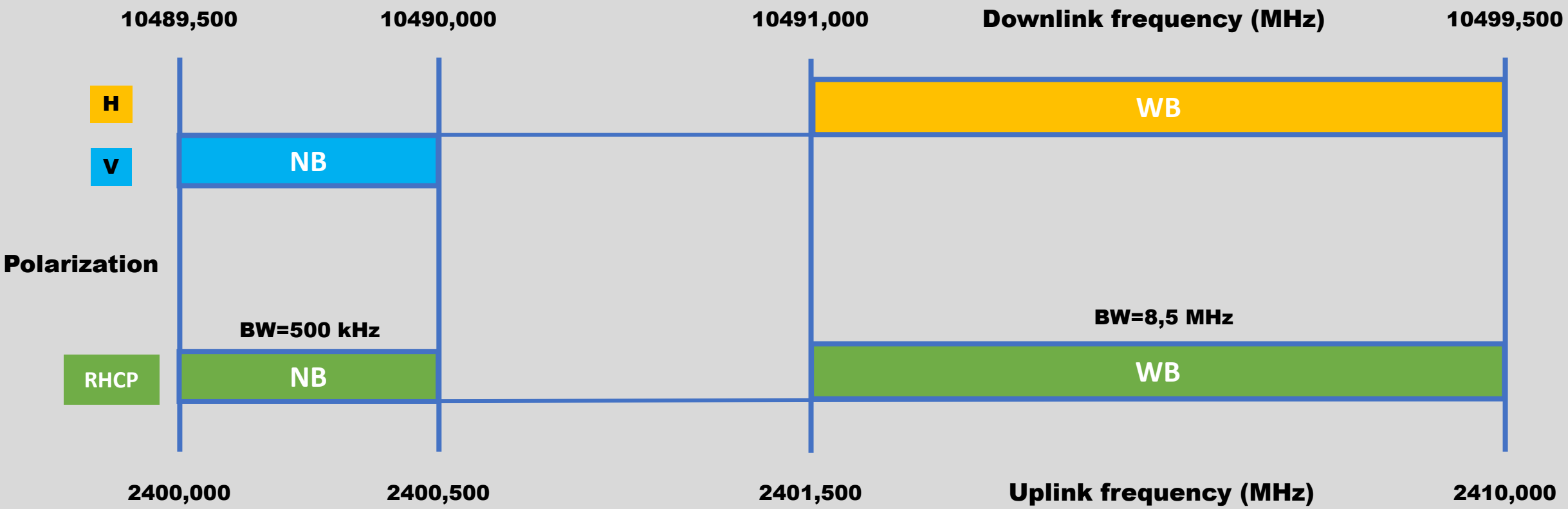
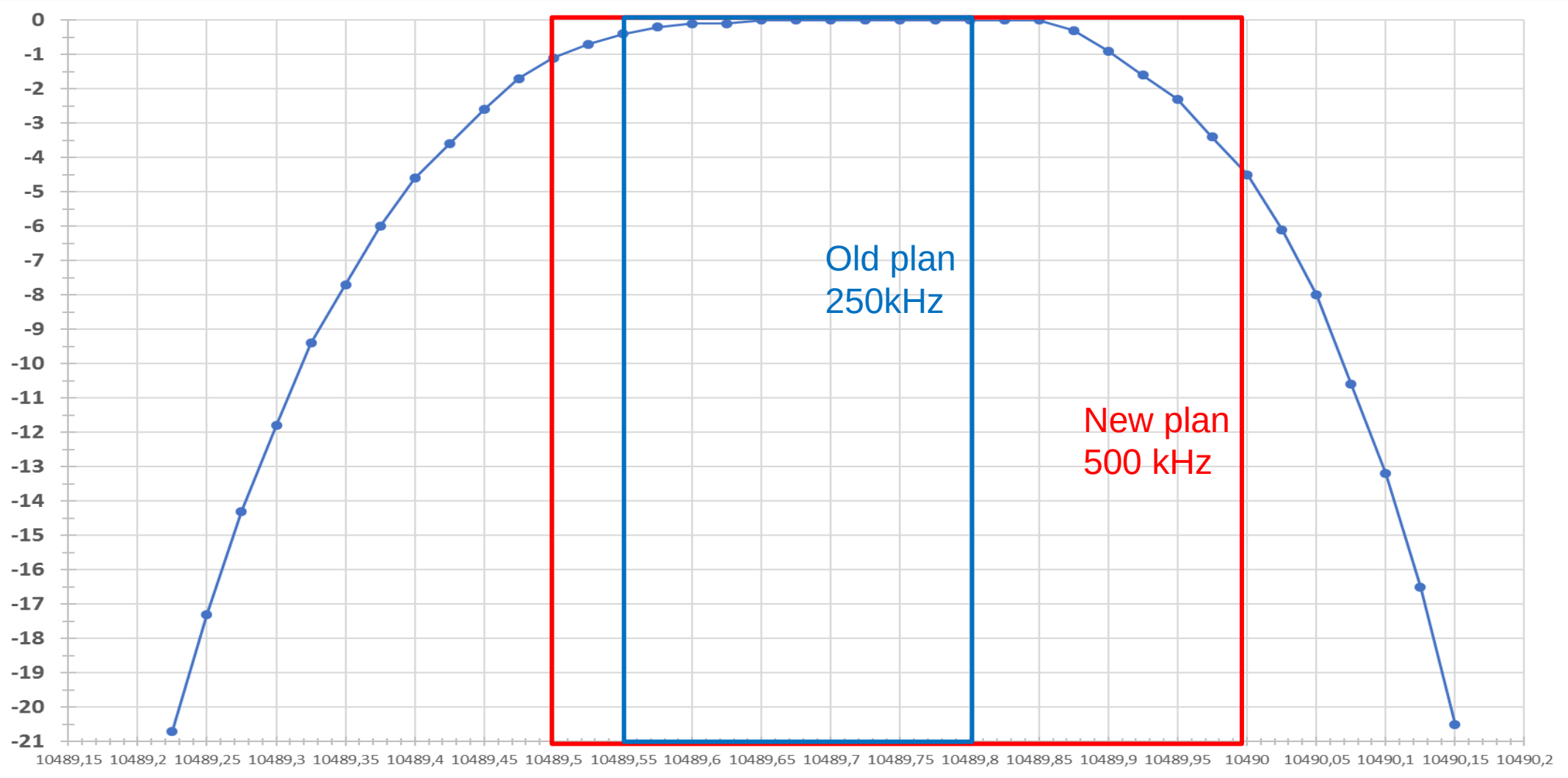
QO-100 transponders

http://www.amsat-dl.org



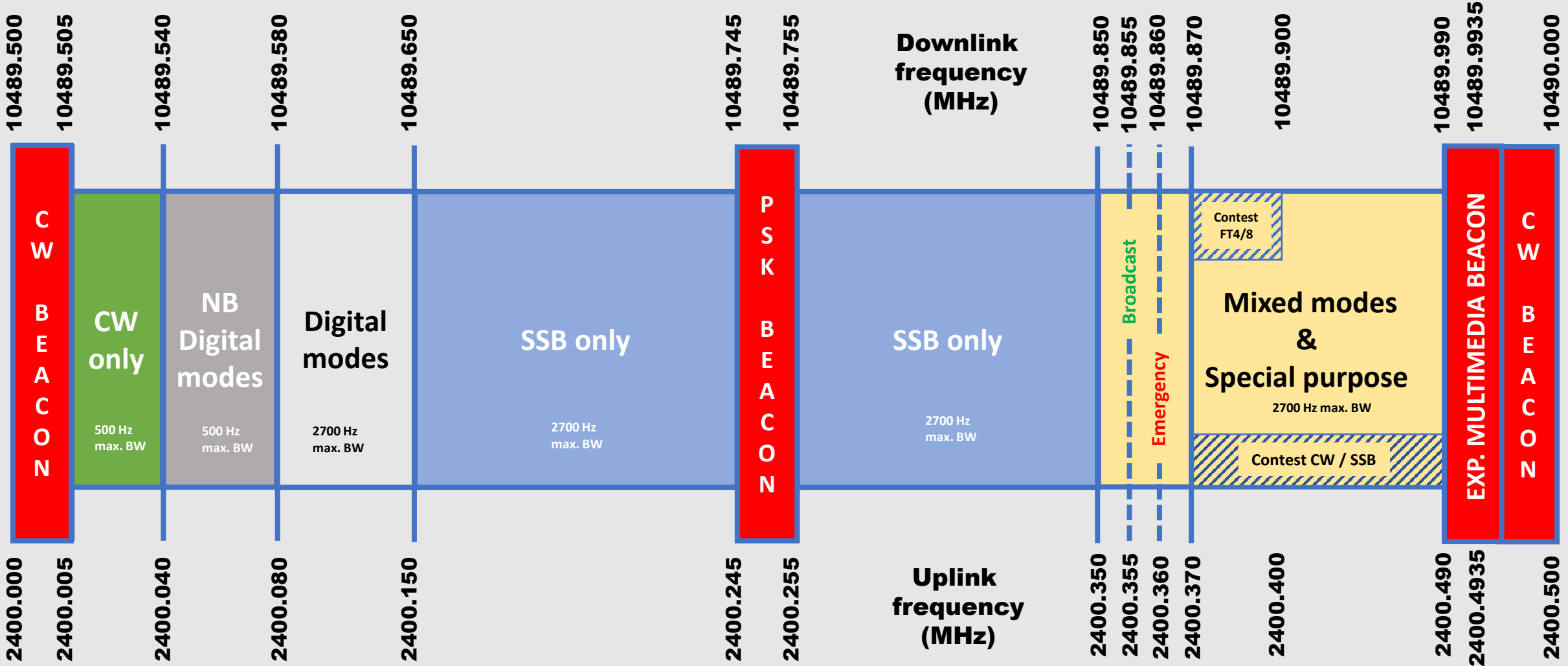
QO-100 NB transponder



NB-Transponder frequency response

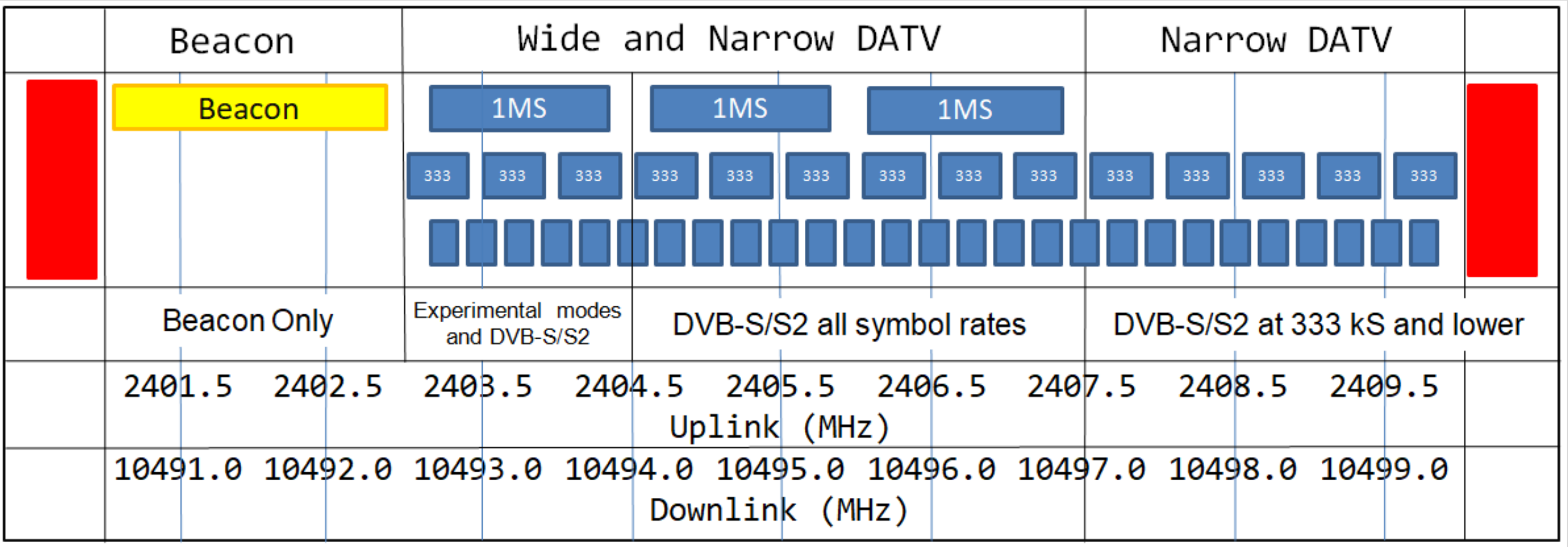
http://www.amsat-dl.org

QO-100 NB transponder



Status Feb. 2023

QO-100 WB transponder



Quelle: AMSAT-DL

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QO-100 NB modes

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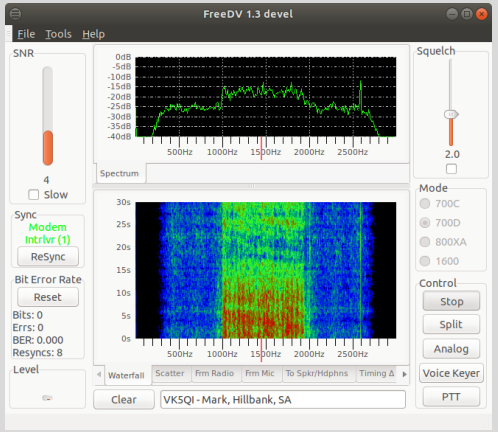
Basic rules for the NB transponder:

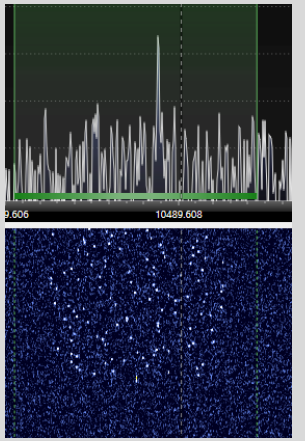
- Control your uplink power, so that your downlink signal is not stronger than any beacon (use fullduplex to monitor this and avoid collisions with others)
- No transmissions with a bandwidth higher than 2.7kHz
- No analog FM modes and no digital FM modes such as DSTAR, C4FM
- No transmissions outside the transponder passband
  (CW beacons mark the band edges)
- Comply with the bandplan published by AMSAT-DL
- Keep a guard band to the beacons

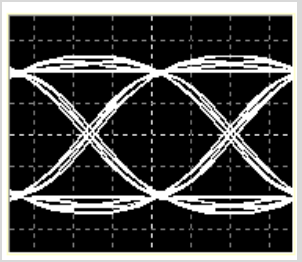
QO-100 NB modes

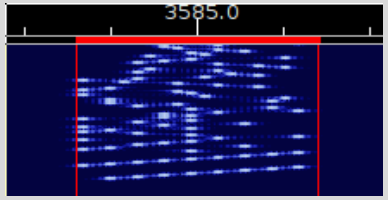
Operating modes on the narrowband transponder of QO-100:

- SSB / CW
- FreeDV (incl. 2020)
- RTTY
- SSTV / KGSTV
- FAX
- Feldhell
- Digimodes such as
  PSK31, FT8, FT4, THOR8, ROS, QRA64D,
  JT65A, Robust Packet, VARA, Winlink, …
- AMSAT-DL Highspeed Modem (up to 7200bps in 2.7kHz bandwidth)





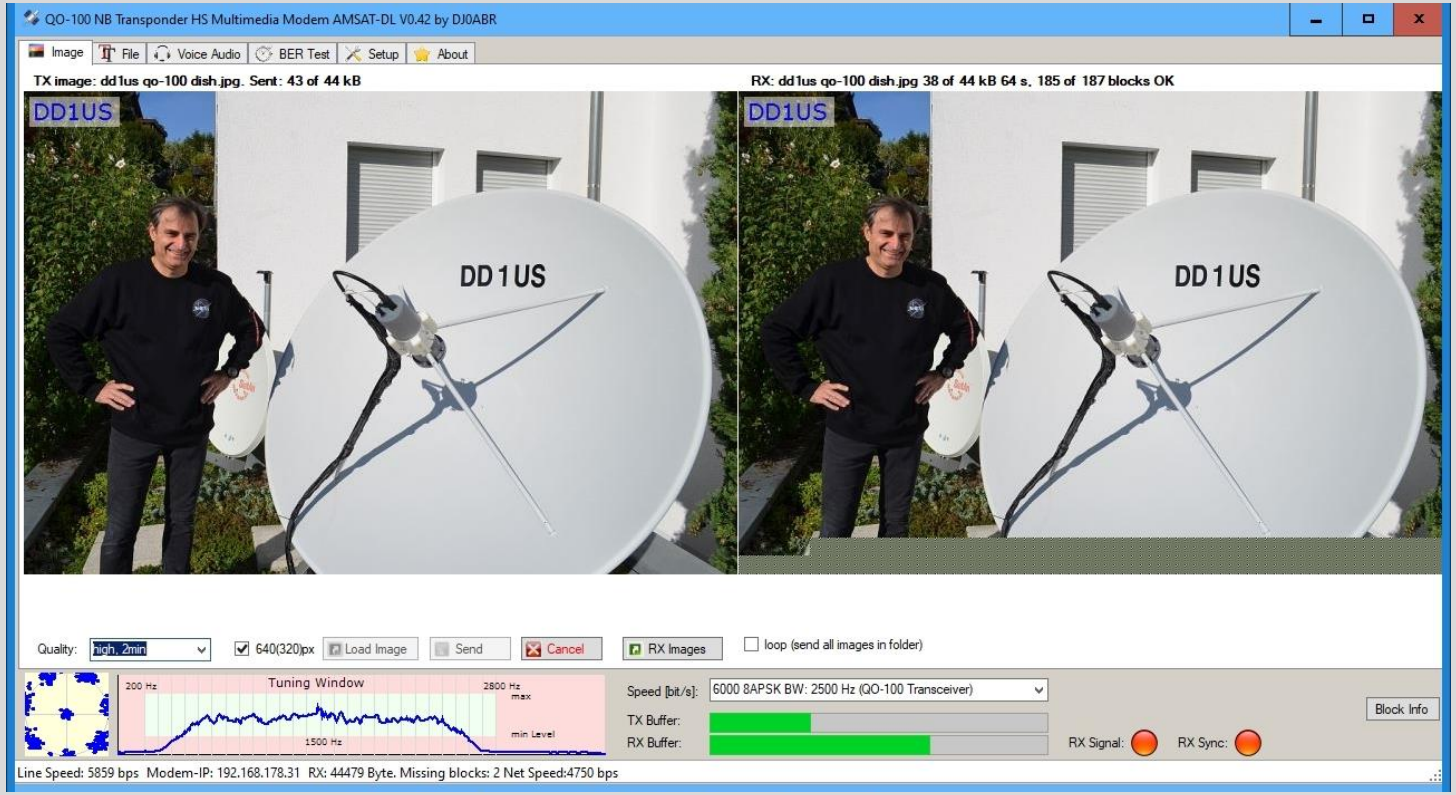




QO-100 NB modes

AMSAT-DL High Speed Multimedia Modem (developed by Kurt DJ0ABR)

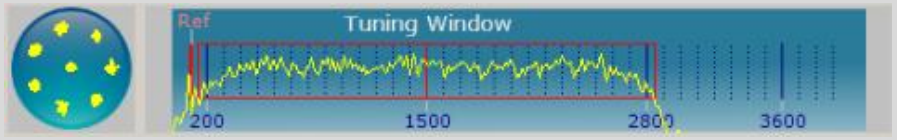
- Sound card modem
- Open Source
- Supports fullduplex
- Optimized modes for QO-100
- Maximum BW 2.7kHz
- Datarates up to 7200bps
- Different modulation schemes
- Transfer of Images
- File Transfer
- Website transfer
- Digital Voice
- RTTY



AMSAT-DL Multimedia Beacon

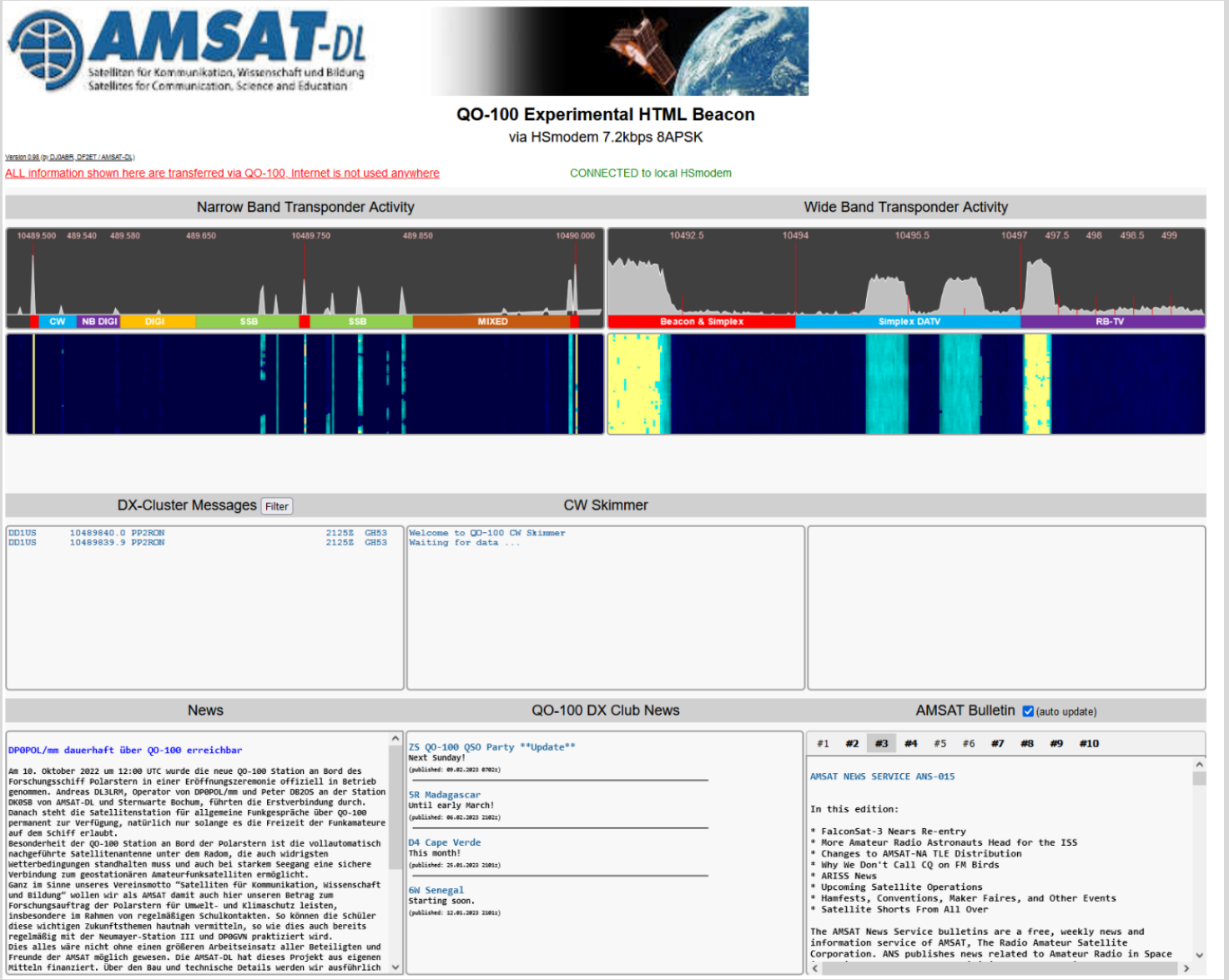
Transmitted by AMSAT-DL in Bochum

on 10489.995 MHz in 8APSK/7200bps



Content:

- Live Spectrum & Waterfall NB TPX
- Live Spectrum & Waterfall WB TPX
- Newsticker
- DX-Cluster Messages
- CW-Skimmer
- News
- QO-100 DX Club News
- AMSAT Bulletins



Based on High Speed Multimedia Modem developed by DJ0ABR

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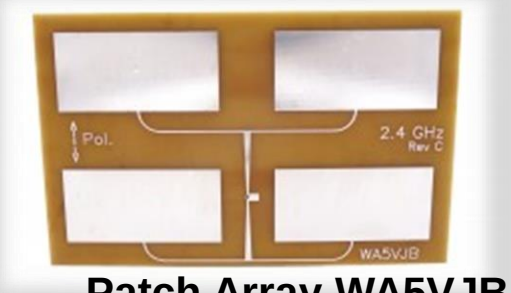
Antennas for QO-100

Dualband
Feed in
single dish


WIFI Grid
linear

Separate
Dish Antennas
for Up- and
Downlink



Patch Array WA5VJB


Helix RHCP

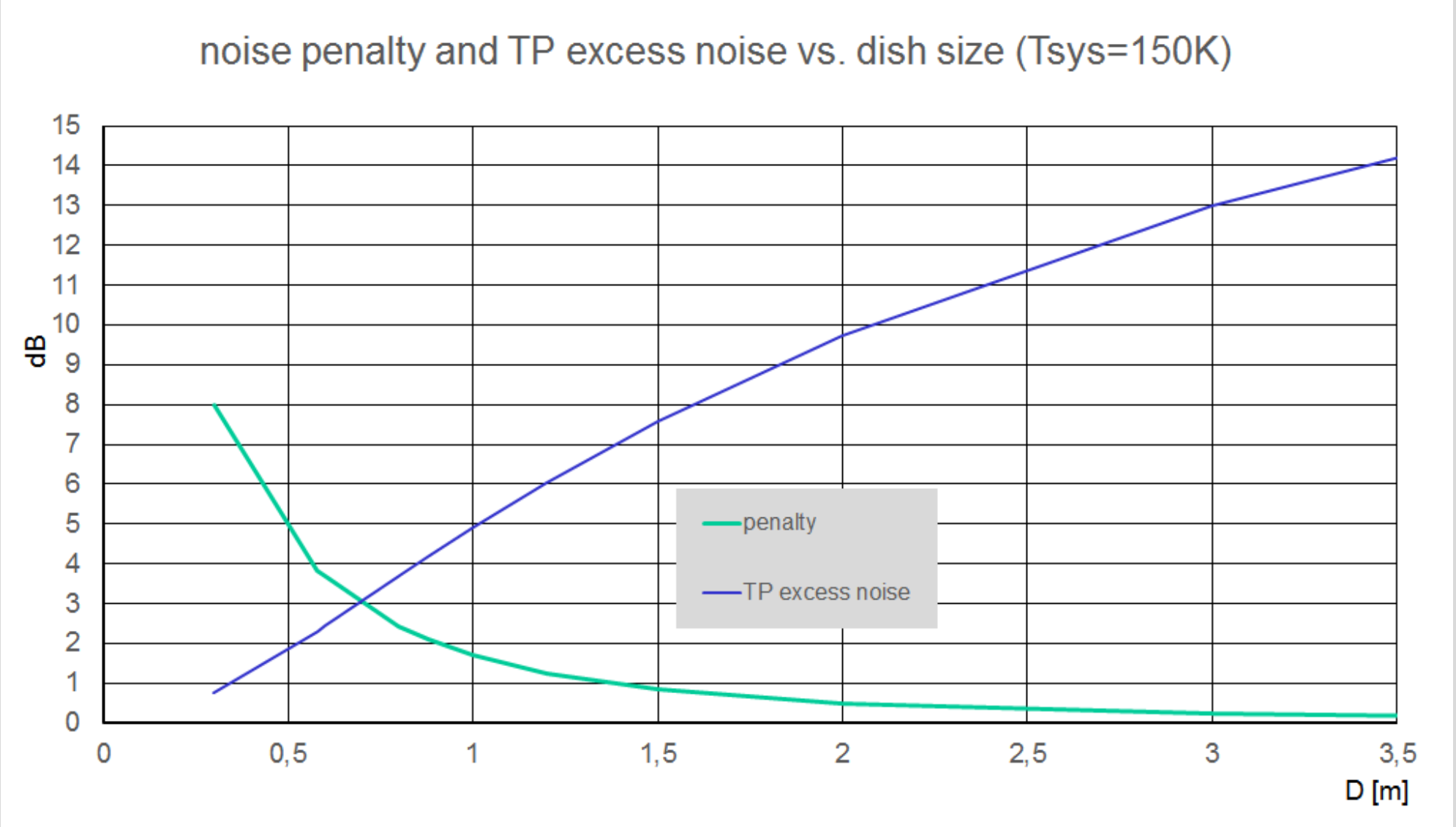
2.4 GHz uplink of NB and WB TPX is RHCP, 10 GHz downlink of NB TPX is vertical, WB TPX is horizontal.

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 band	‘off-the-shelf’ feed solutions available
Each feed position and thus proper phase center can be chosen independently	Possibly simplified 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

Which diameter is needed for your dish?



Source: Achim DH2VA

Antennas for QO-100

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

POTY dual band feed
(circular polarization for uplink, horizontal and vertical polarization for downlink)

RX:
NB transponder noise: 8dB
WB beacon MER: >=10dB

TX:
400mW for SSB
30W for 1MSps DATV

Antennas for QO-100

Gary ZS6YI

Jürgen DL8SDQ

Antennas for QO-100

Portable operations on the research vessel Polarstern by Felix DL5XL and Theresa DC1TH on their trip to Antarctica

Source: DL5XL, DC1TH

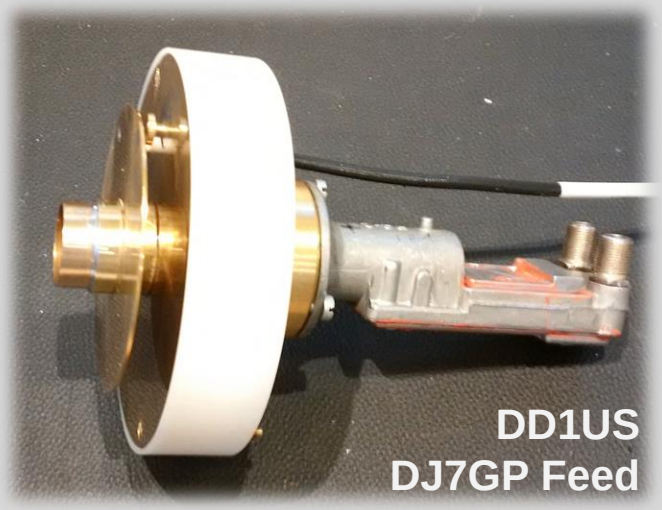
Feeds for QO-100

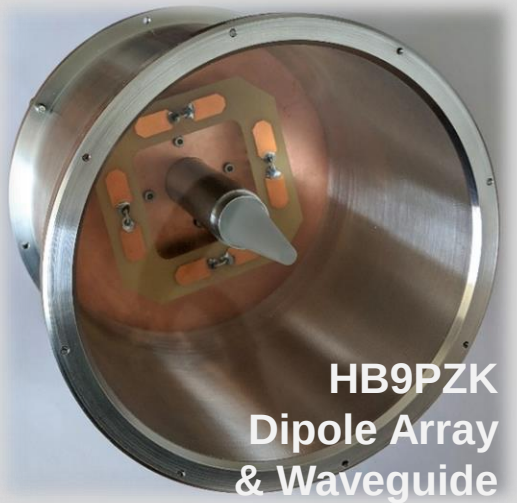

DG5CY


DD1US
POTY Feed


DF2GB
Helix Feed
with LNB


Vorserienmuster des
10/2,4 GHz Duoband-Feeds
nach DJ7GP

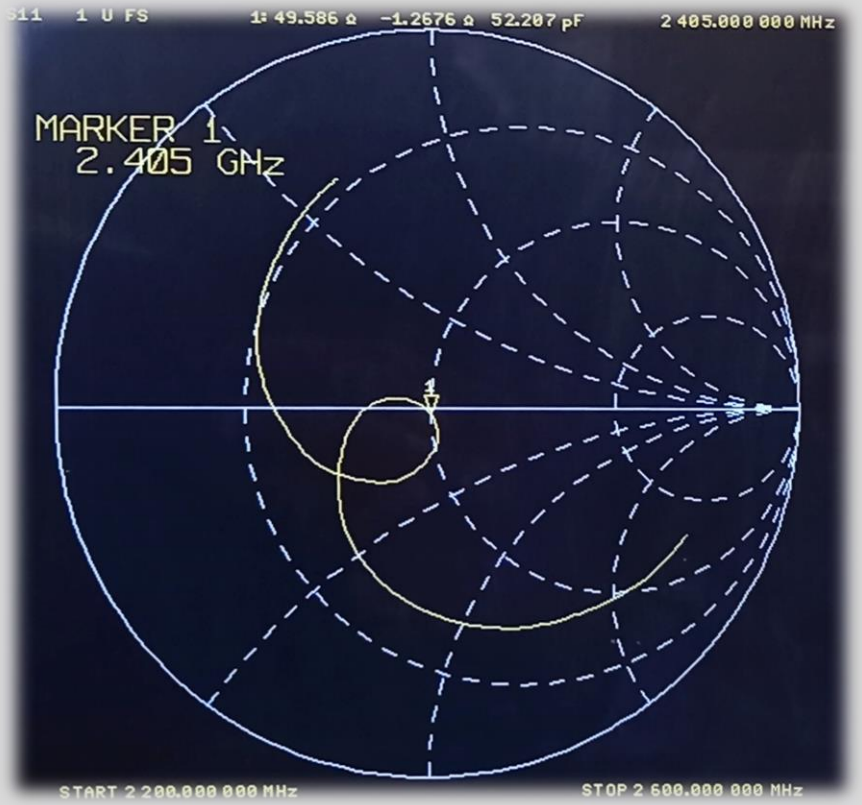

DD1US
DJ7GP Feed

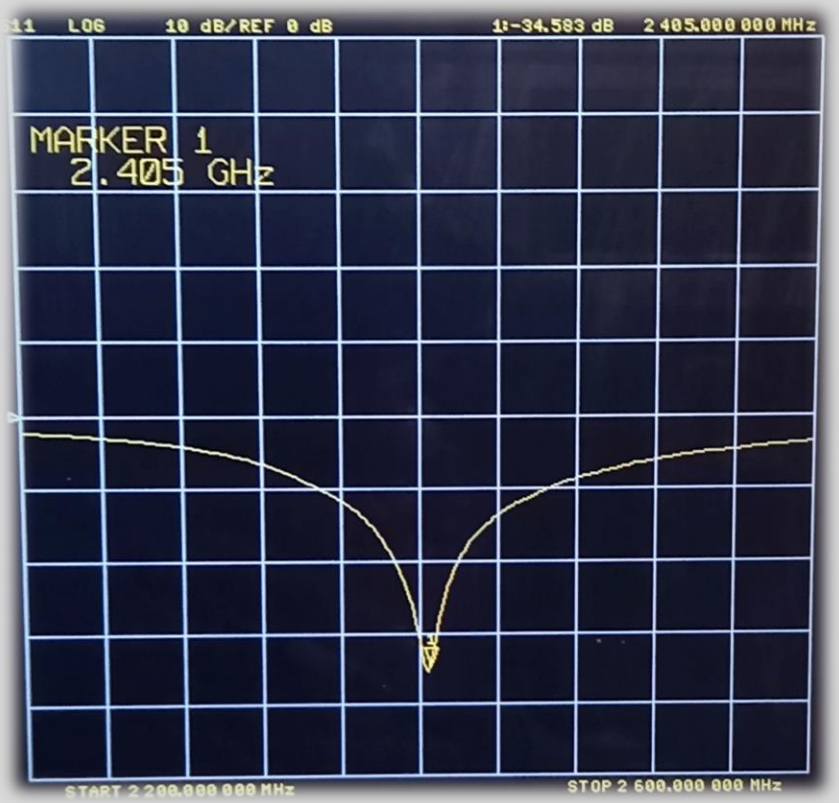

HB9PZK
Dipole Array
& Waveguide


LZ1JH
4 Yagis & LNB

POTY Feed for QO-100

Developed by Mike G0MJW, Remco PA3FYM and Paul M0EYT





POTY feed needs to be carefully tuned to achieve proper circular polarization

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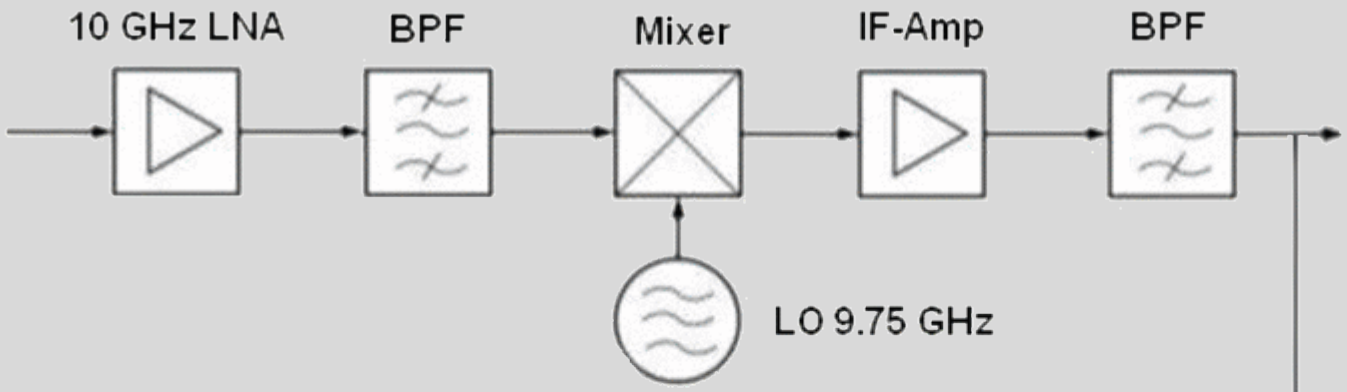
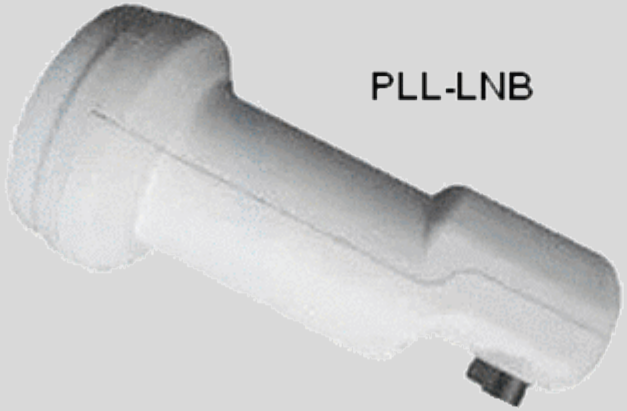
RX-Setup for QO-100

Antenna



SDR

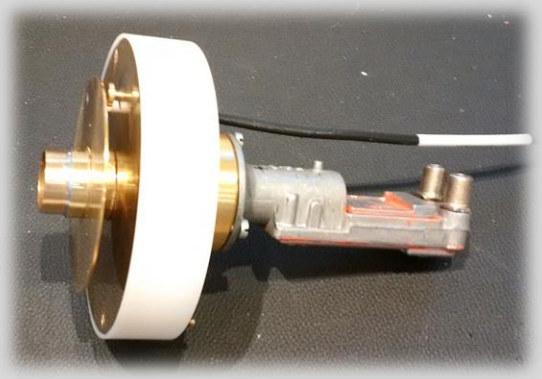


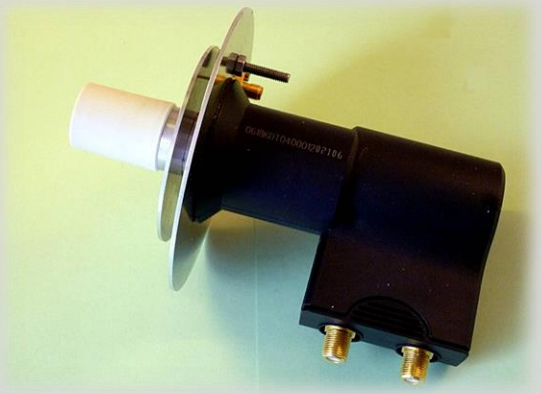
PLL-LNB

Analog (T)RX

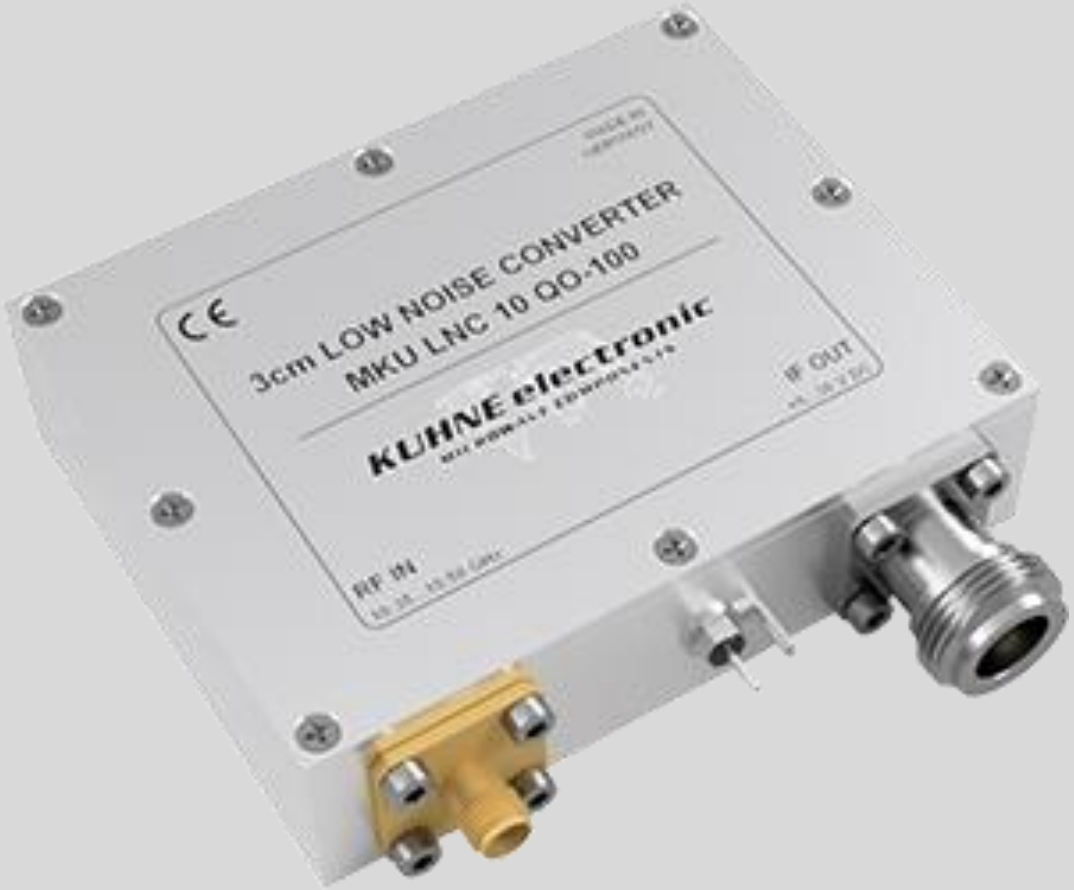
PLL-LNBs for QO-100

- 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

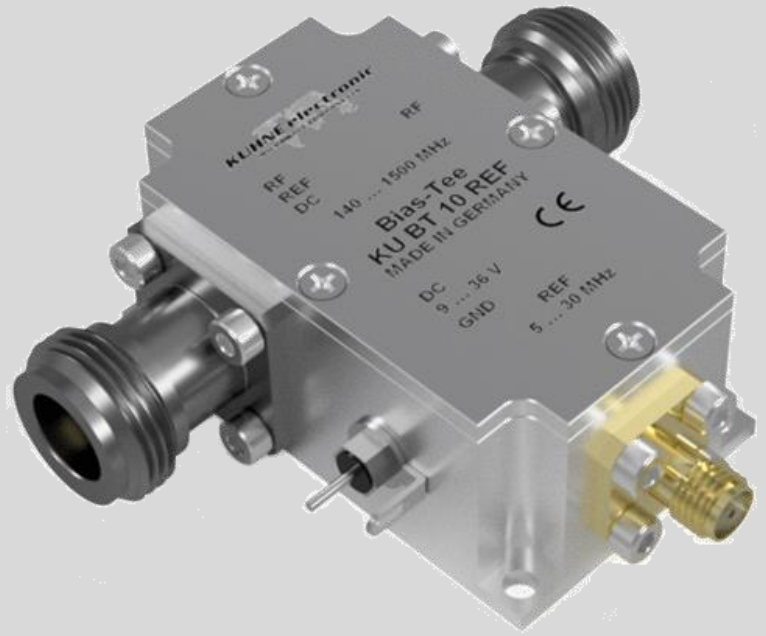




Downconverter for QO-100

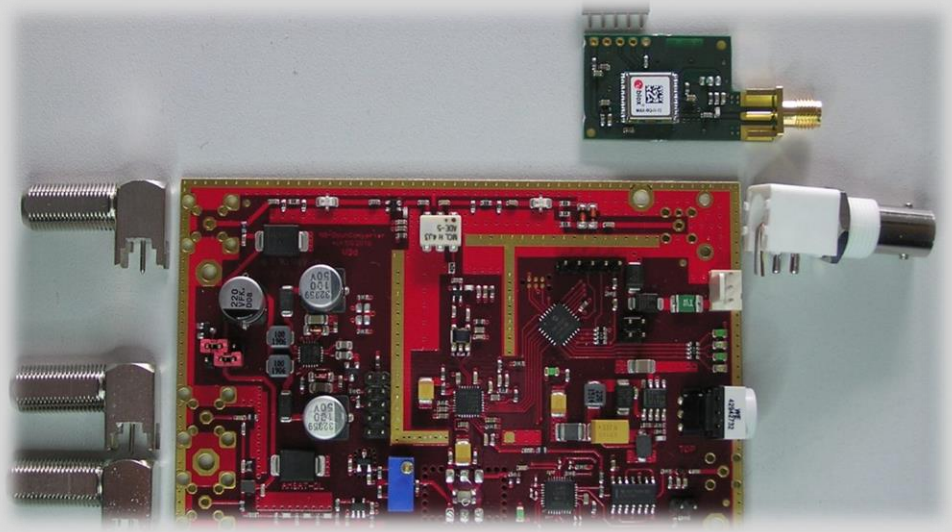


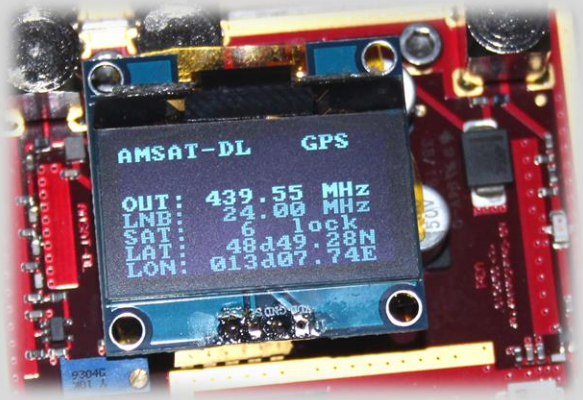
Kuhne 3cm Downconverter



Kuhne BIAS-T mit Referenzfrequenzeinspeisung

Downconverters for QO-100





AMSAT-DL Downconverter V3d

SOLD OUT

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
- Price: 289€

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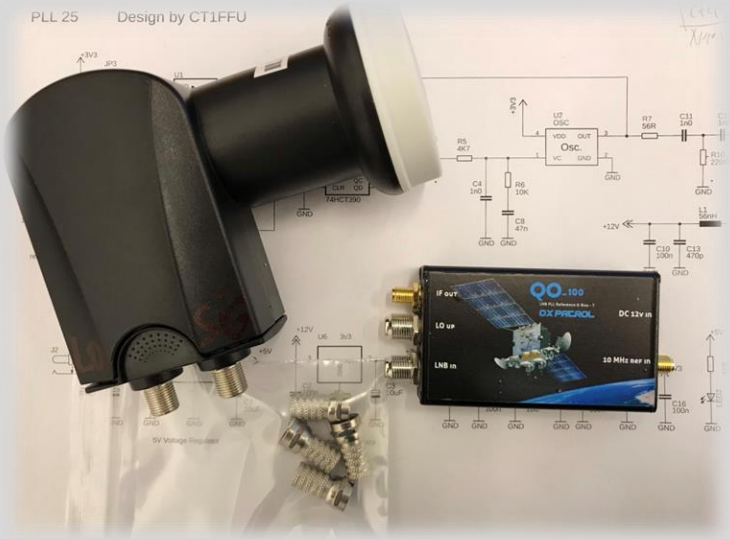
Downconverters for QO-100



DX-Patrol QO-100 Downconverter

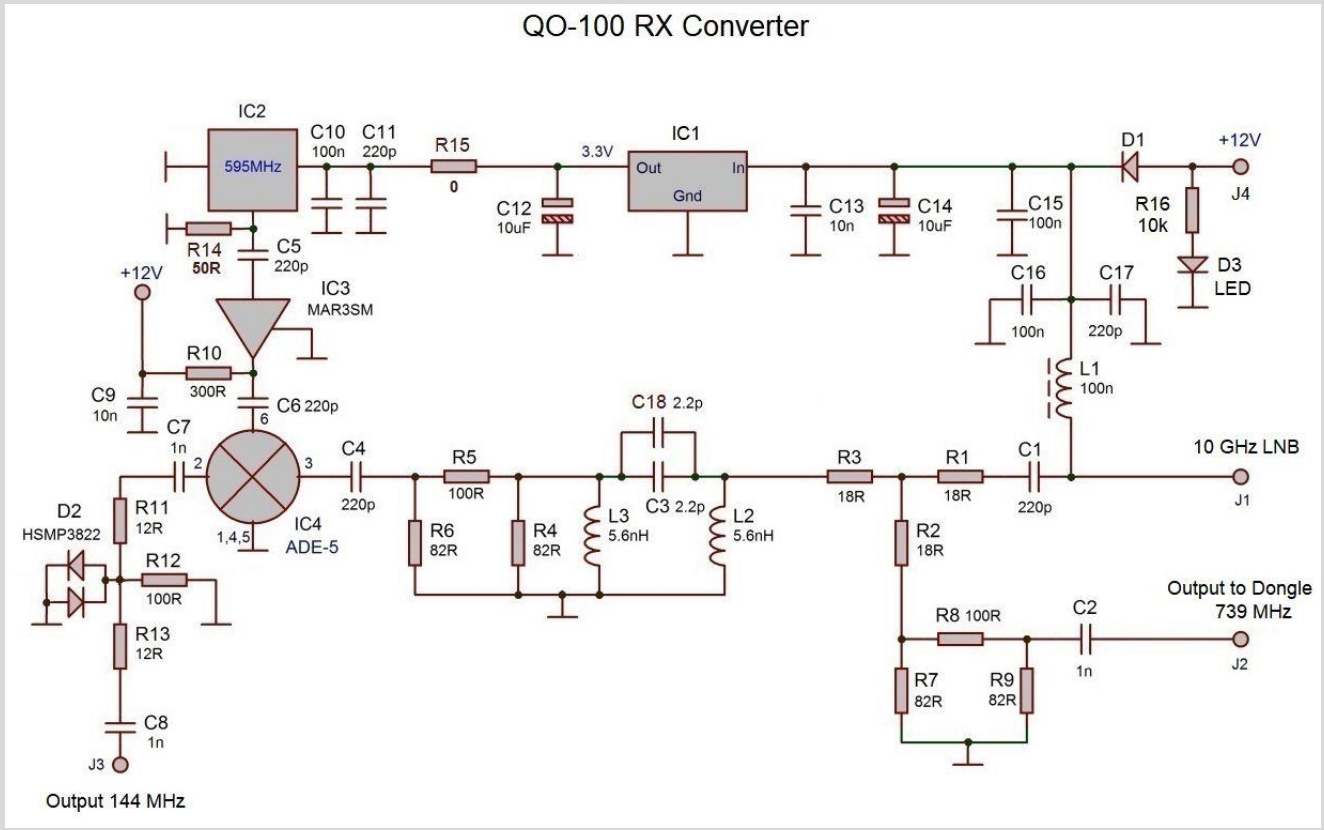
<u>Features:</u>

- 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
- IF output: 10m, 2m, 70cm, 23cm
- Supplies 25MHz ref to LNB via 2nd cable
- Ready modified LNB included.

- Price incl. LNB 185€

http://www.dxpatrol.pt

Downconverters for QO-100



Transverters-Store QO-100 Downconverter

TEMPORARILY CLOSED

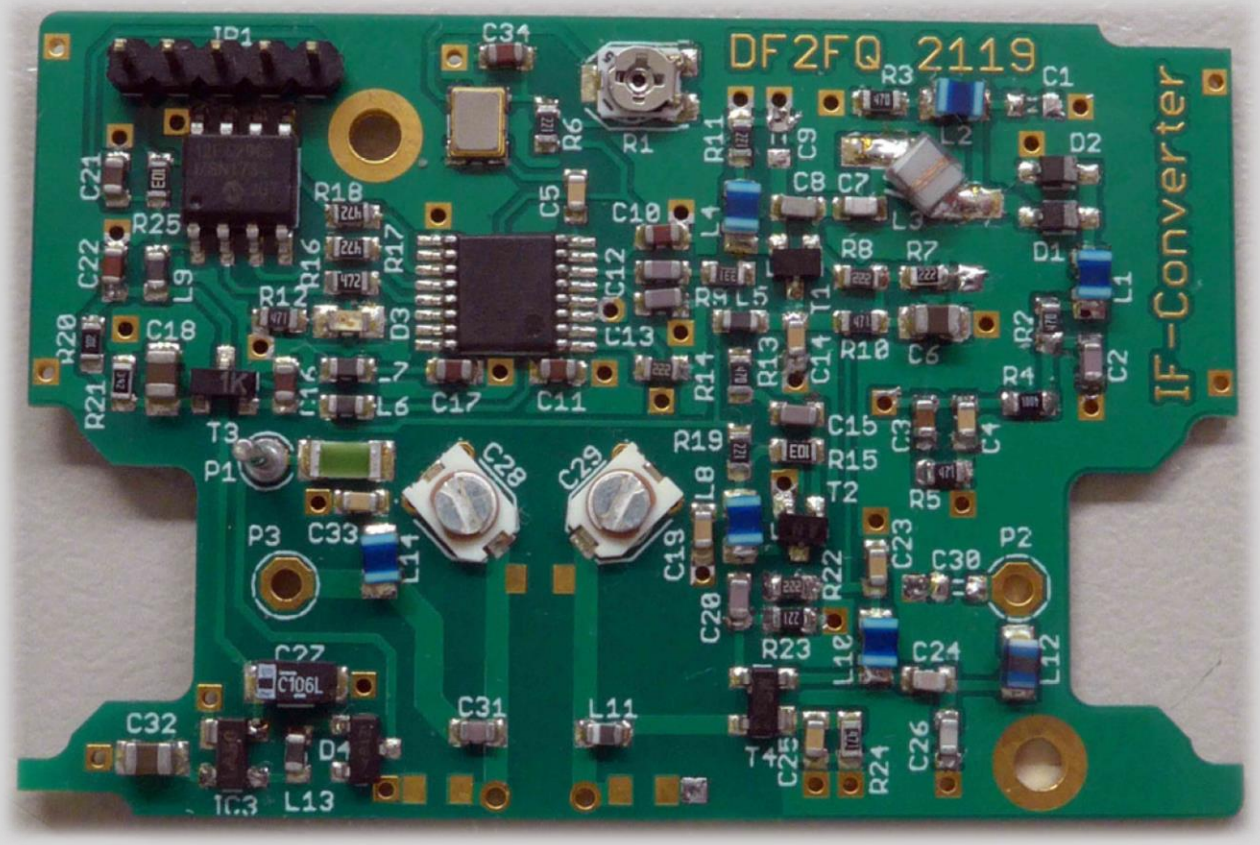
Features:

- Input voltage 12V
- Only for NB operations

- Prices: 85 USD (in encasing)
  67 USD (assembled PCB)
  45 USD (modificed LNB)

http://www.transverters-store.com

Downconverters for QO-100



DF2FQ IF-Converter IFC

Features:

- Input voltage 12….18V, 40mA
  (plus opt. LNB phantom feed supply)
- IF out: 2m or 10m

- Price: 65 Euro

http://www.df2fq.de

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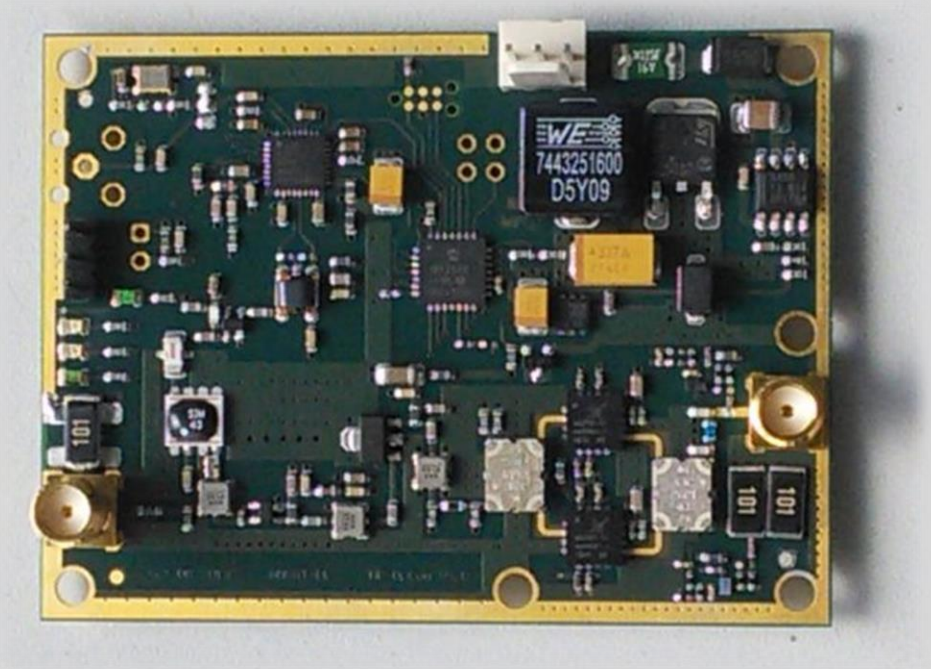
NB TX for QO-100

SOLD OUT



Upconverter AMSAT-DL V2 with PA

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

Price: 189€

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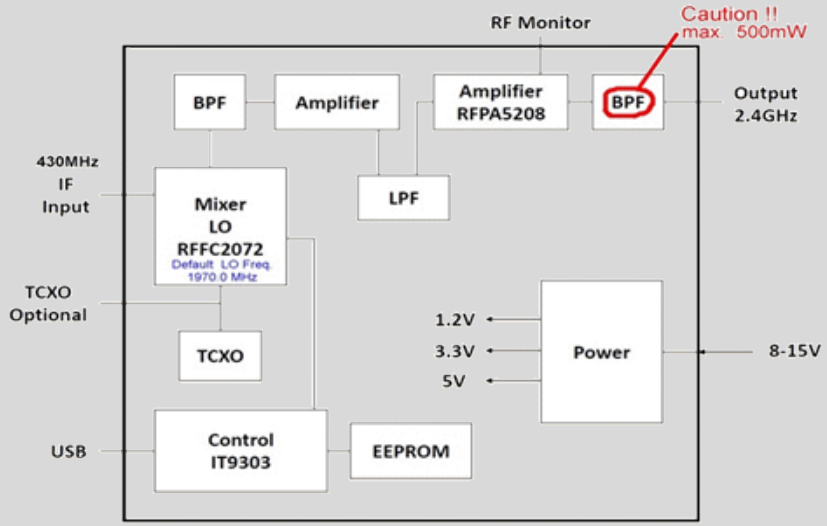
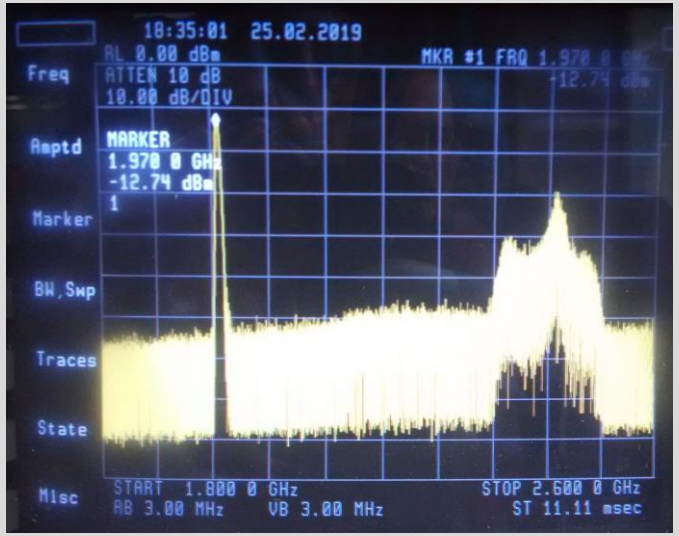
http://www.amsat-dl.org

NB TX for QO-100

Make sure not to buy 1st gen !





2nd generation apparently improved !

HIDES BU-500 Upconverter
IF-input: 100..1300MHz (max. 10mW)
RF-output: 2365..2500MHz (max. 1.7W SSB)
Price: 186 US$

http://www.hides.com.tw

NB TX for QO-100

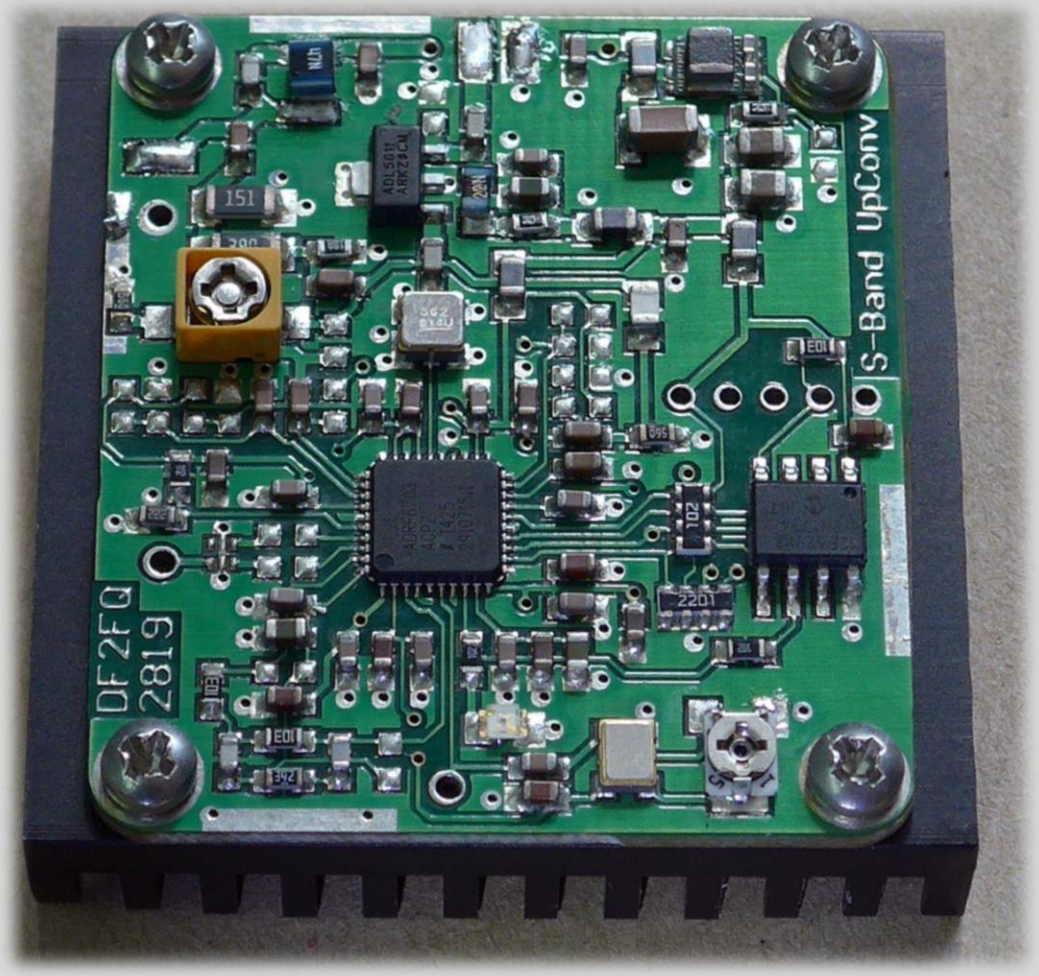
DX-Patrol Upconverter MK4

IF-input: 10m/2m/70cm/23cm (max. 3W)
RF-output: 13cm (Pout=200mW)
Internal or external 10 MHz reference

Price: 135€

http://www.dxpatrol.pt

NB TX for QO-100



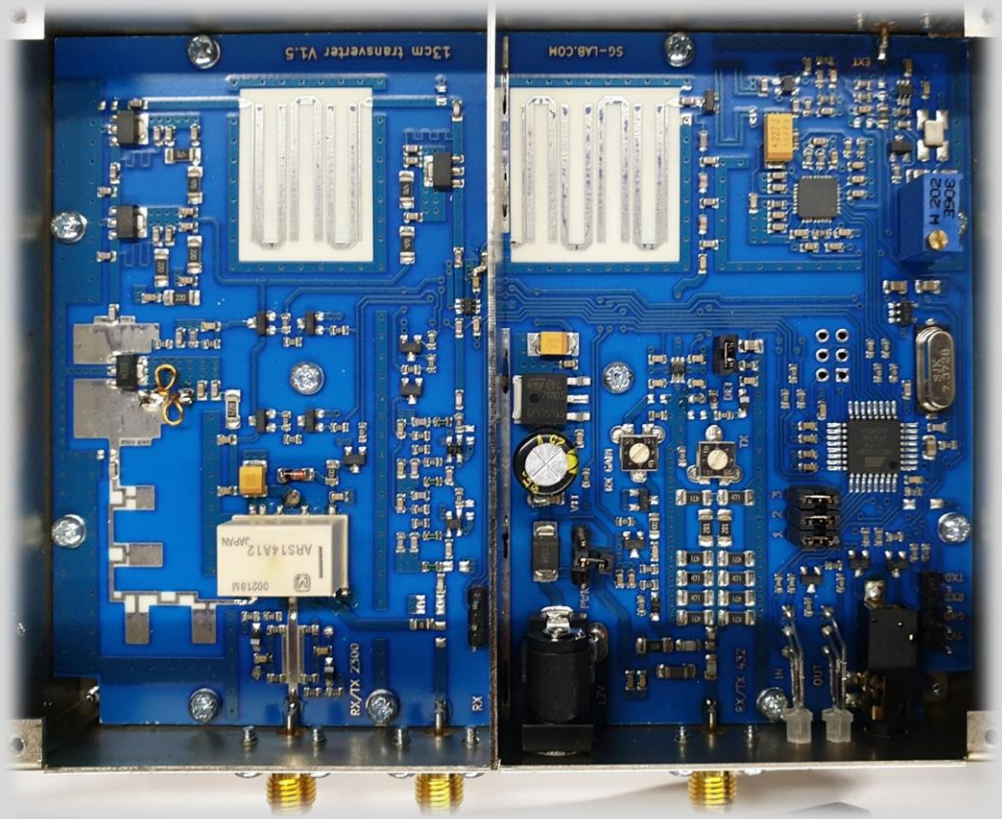
DF2FQ 2.4GHz Upconverter UPC-11/2G4

IF-input: 144..145 MHz (typ. 10mW)
RF-output: 2320…2406MHz (Pout=50mW)
Supply voltage 9..36V
Internal or external 10 MHz reference

78€

http://www.df2fq.de

NB TX for QO-100



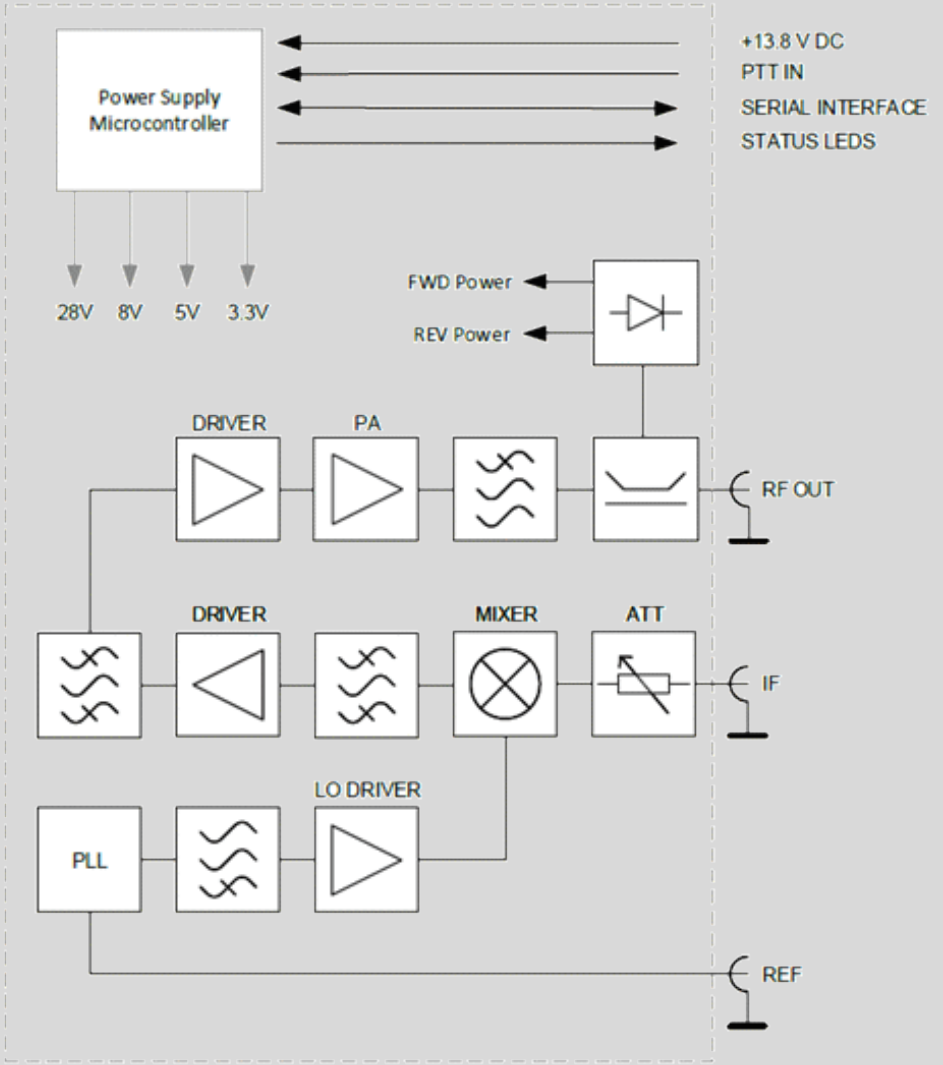
SG-Labs Transverter TR2300 from LZ5HP

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

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/

How much power for SSB via QO-100

I am using a 1.8m dish with a POTY feed and approx. 400mW

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

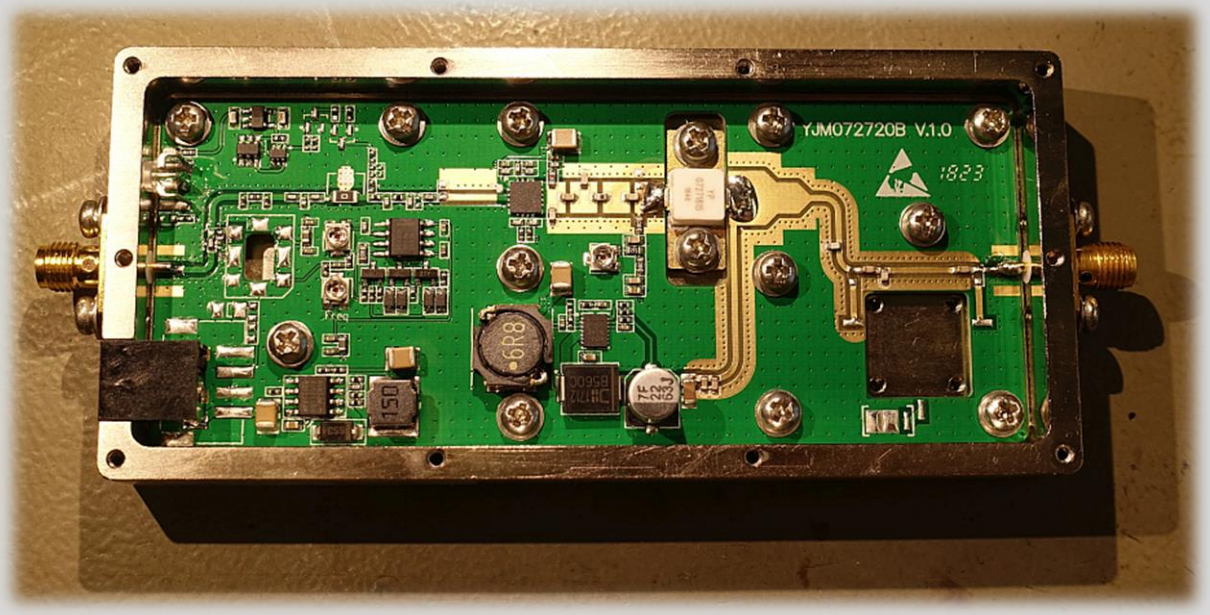
In any case:
Be careful with high power at 2.4 GHz (narrow beam helps to be safe)
No uplink signal should result in a downlink signal stronger than the beacons

PAs for QO-100

4W < 50$

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

2W < 30$

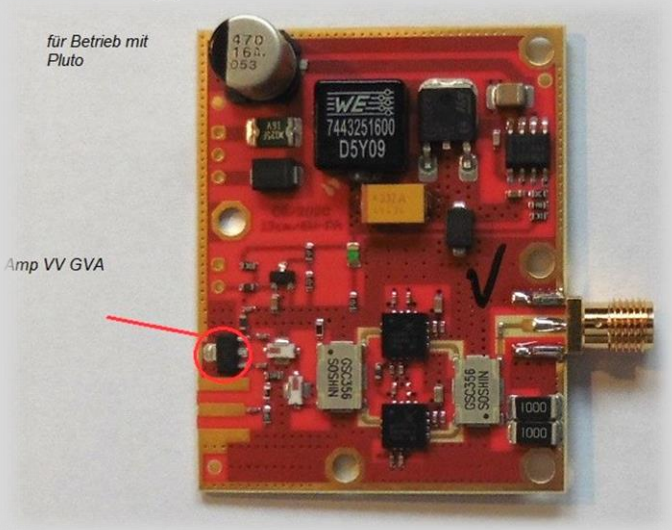


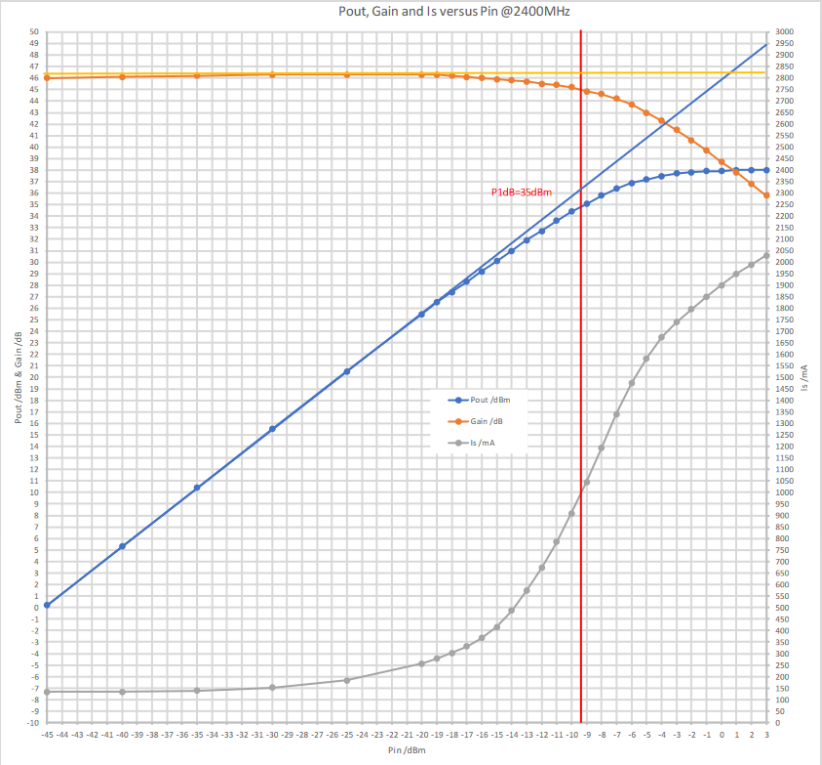
20W WiFi Booster from AliExpress
testet and described in AMSAT-DL
Journal 1/2019
16W P1dBm, OIP3 49.5 dBm,
Gain ~34 dB, 5A max. @12V

230$

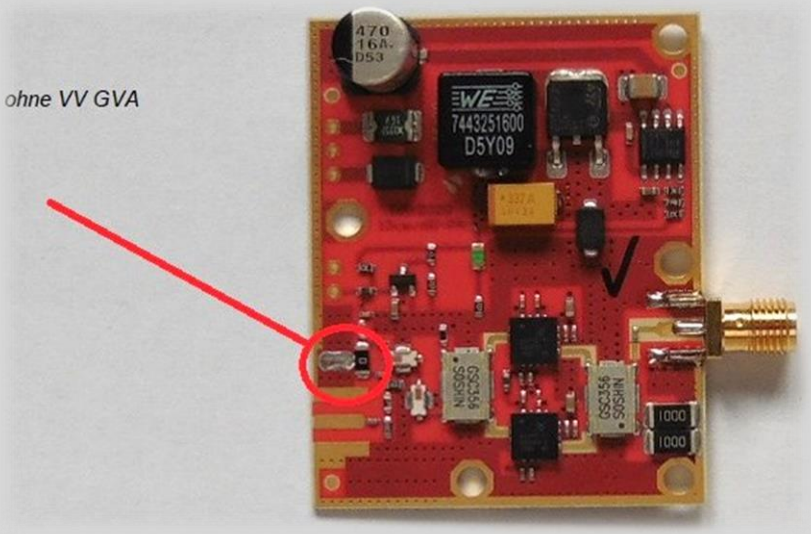
PAs for QO-100

SOLD OUT





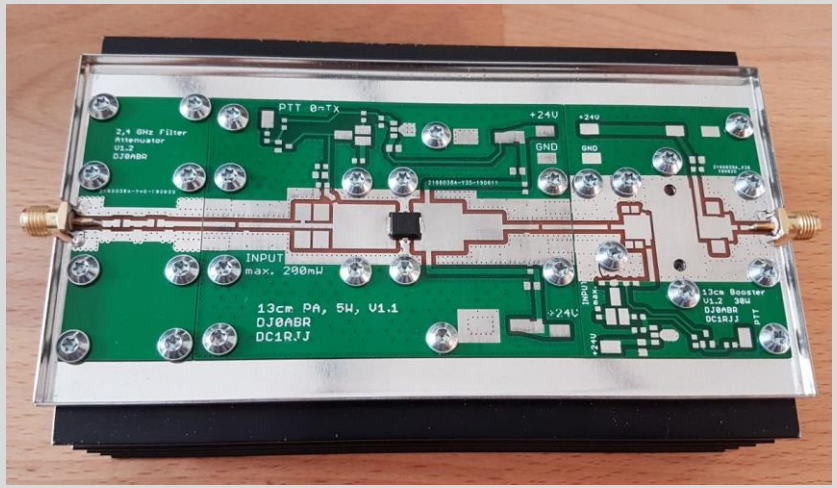
SOLD OUT



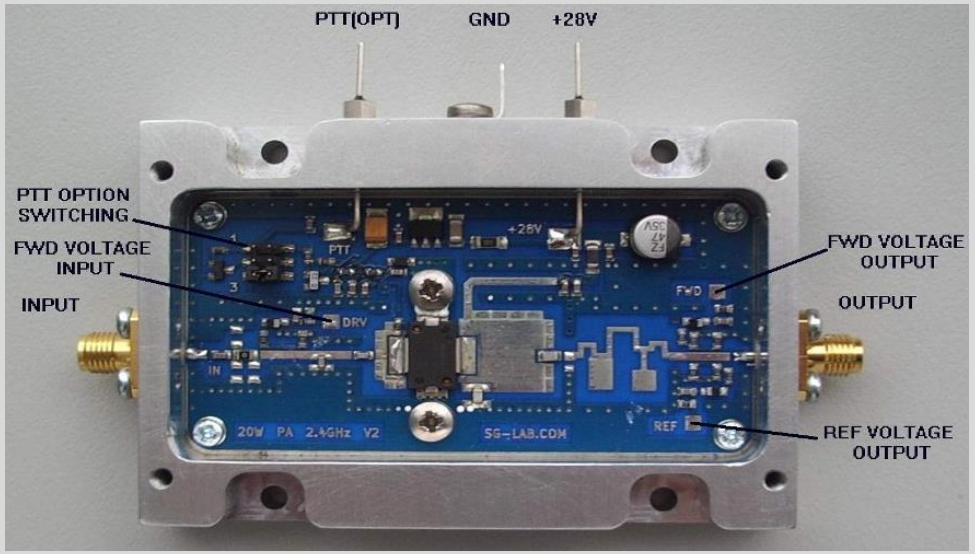
AMSAT-DL for SDR-TRX
Gp=46dB
P1dB=35dBm (3W)
Psat=38dBm (6W)
Vs=6-15V
Price 129,50€
https://shop.amsat-dl.org

AMSAT-DL for TRX with high drive power
Gp=20dB
P1dB=35dBm
Psat=6W @6-15V
Vs=6-15V
Price 119,50€
https://shop.amsat-dl.org

PAs for QO-100

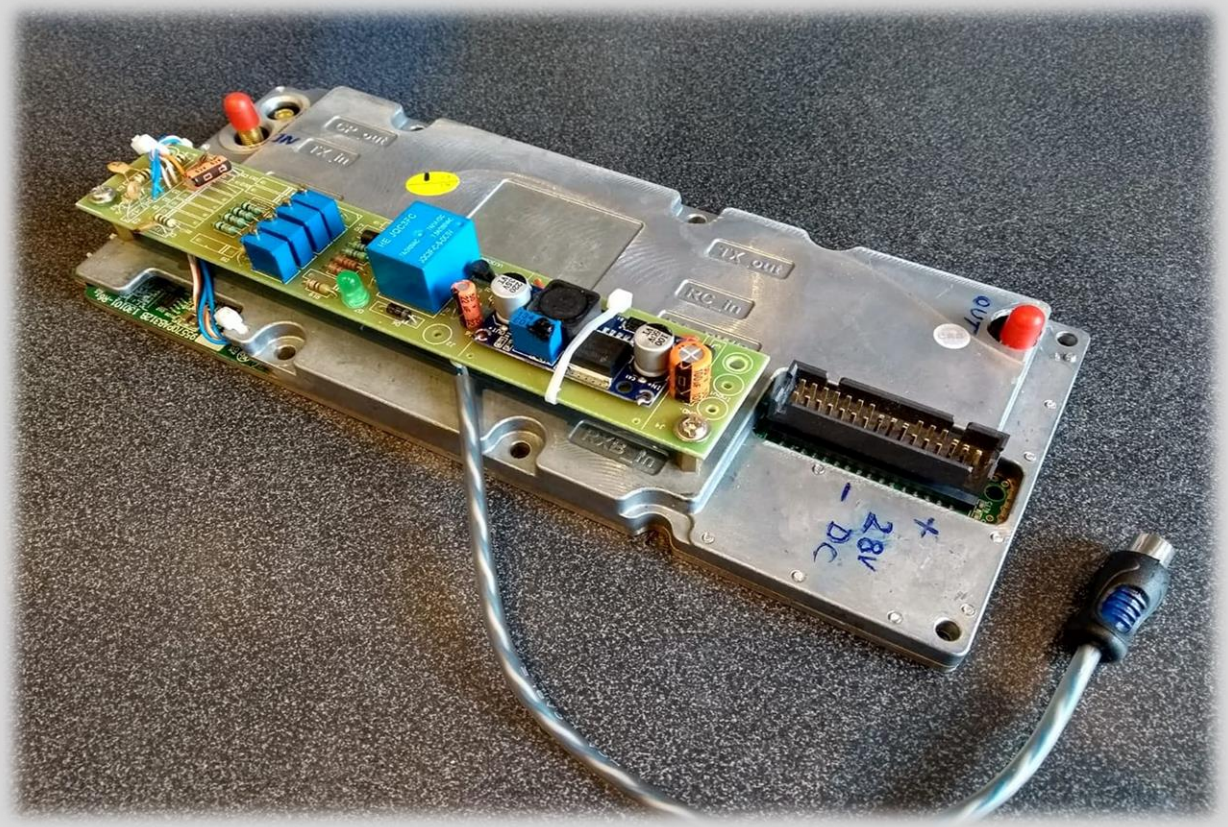


DJ0ABR 13cm PA with MHT1008N
Pout=2.5W(10W) @24V
Gp=17dB, price <40€
Opt. second stage with 6W (25W) @24V
www.helitron.de/dj0abr/

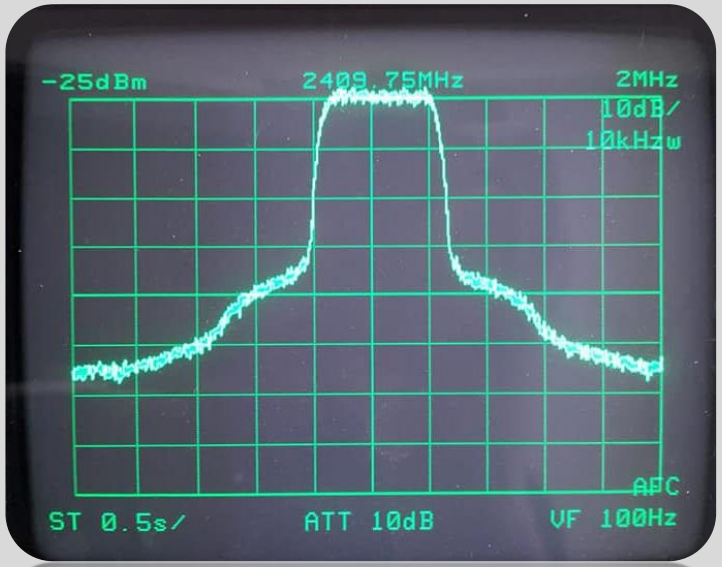


SG-Labs 13cm PA LZ5HP
Pout=20W @28V, Gp=16dB
126 €
www.sg-labs.com

PAs for QO-100

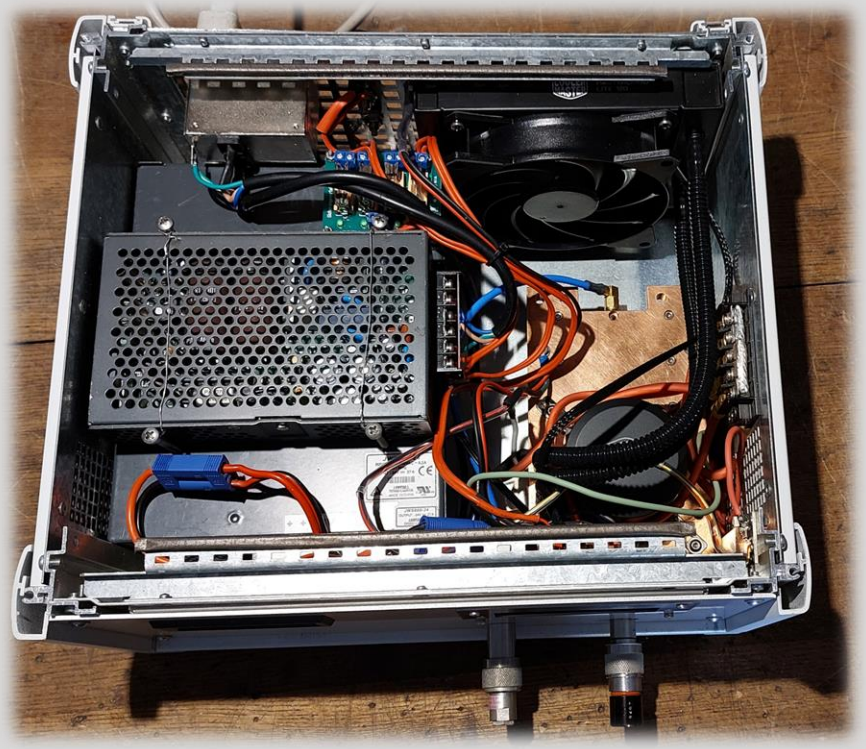


Surplus UMTS amplifier modified by ZS6YI

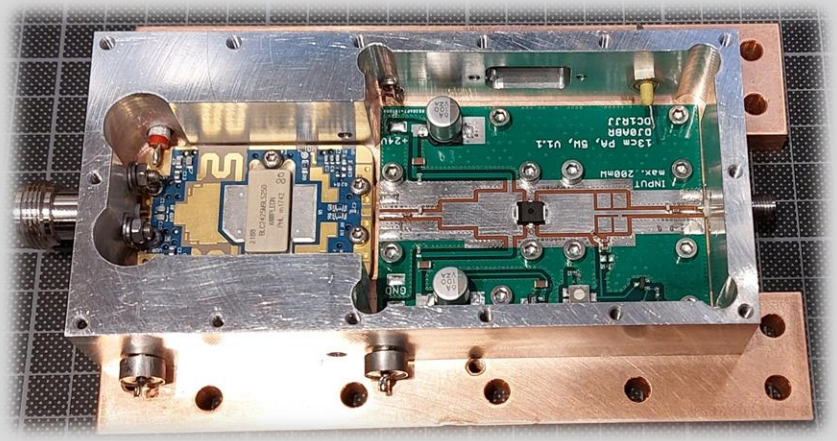


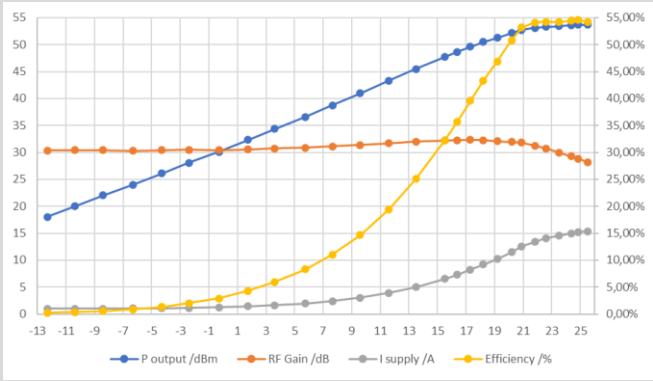
For DATV you need to backoff the PA typ. by 6dB to get good linearity (shoulders should be down -35dBc)

PAs for QO-100



Watercooled
230W PA based on
an Ampleon module
with controller by
AMSAT-DL





Agenda

- QO-100 our first Phase-4 geostationary satellite (P4-A)
- QO-100 transponders
- QO-100 NB modes
- Antennas for QO-100
- Receive chain for the NB transponder
- Transmit chain for the NB transponder
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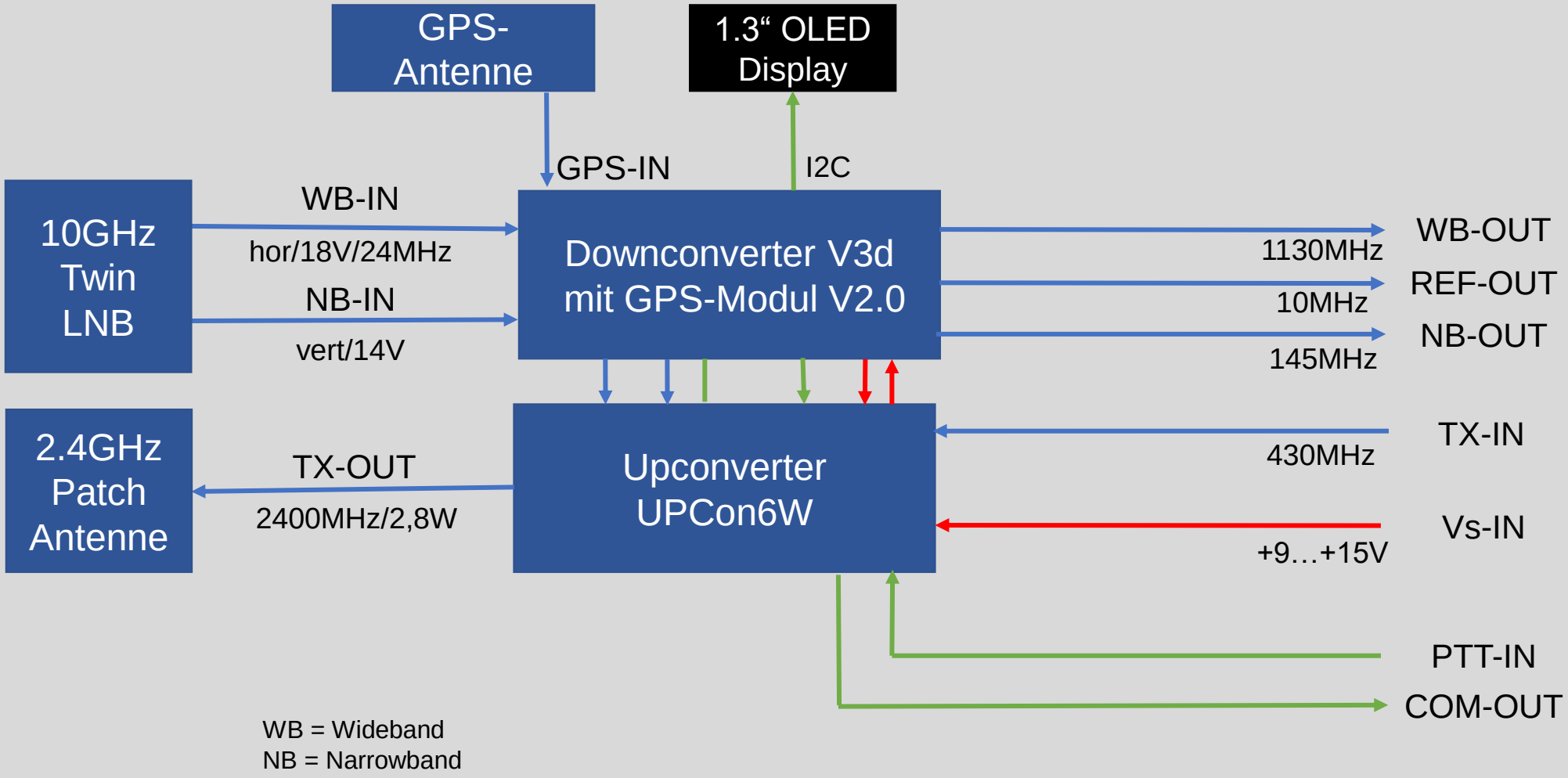
- Activities on QO-100

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

QO-100 transverter

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



WB = Wideband
NB = Narrowband

Source: DD1US

QO-100 portable station

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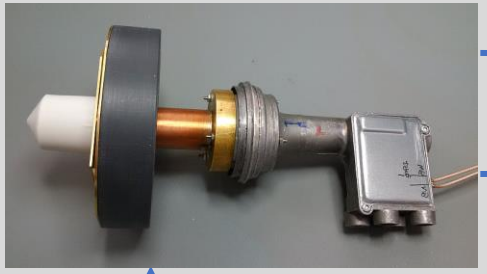
Satelliten für Kommunikation, Wissenschaft und Bildung
Satellites for Communication, Science and Education

GPS-IN



WB-IN

hor/18V/24MHz

NB-IN

vert/14V

TX-OUT

2400MHz/2,8W

WB-OUT

1130MHz

REF-OUT

10MHz

NB-OUT

145MHz

Vs-IN

+9…+15V

TX-IN

430MHz

PTT-IN

COM-OUT

Source: DD1US

QO-100 portable station

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Satellites for Communication, Science and Education

60cm Kathrein offsetdish with
AMSAT-DL transverter on feedarm

ICOM IC-9700 fullduplex Allmode-TRX

Source: DD1US

QO-100 transverter

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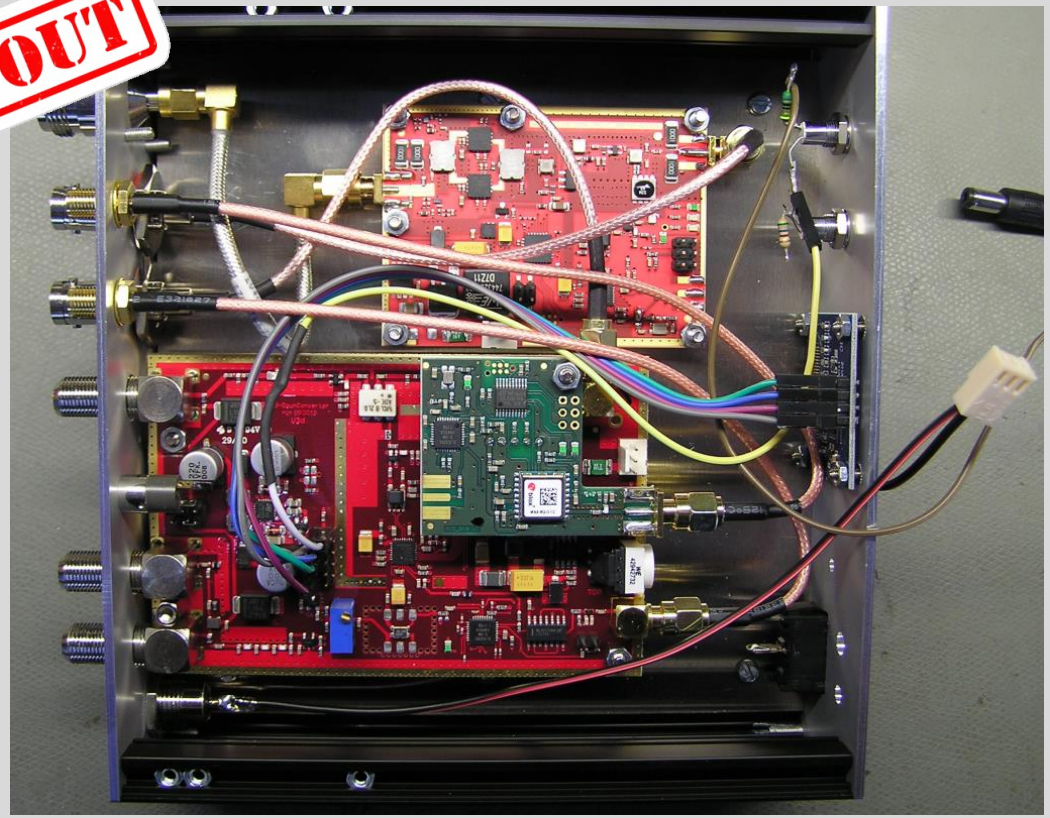
Satellites for Communication, Science and Education



Nice encasing to fit in the AMSAT-DL Up- aund downconverter incl. OLED-display

Source: AMSAT-DL

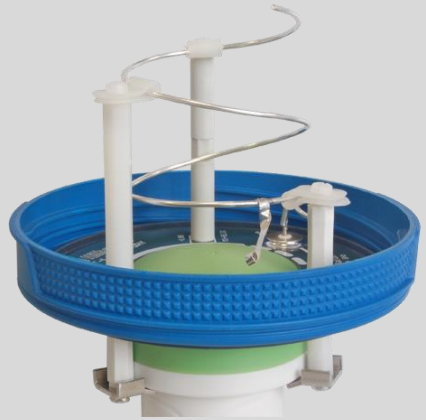
QO-100 transverter

DX-Patrol Groundstation FD
fullduplex
IF-input: 10m..23cm (max 5W)
RF-output: 13cm (10W)
with GPSDO and 10 MHz output
999 €

Source: DX-Patrol

QO-100 transverter

Hilberling UDL-16
fullduplex operation
IF-input: 6m..23cm (max 10W)
RF-output: 13cm (20W)
with GPSDO and 10 MHz output
No DATV supported
2190 € (incl. feed)



Source: Hilberling

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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

Both support full duplex operation as mandatory for satellite communications

SDRs for RX of NB TPX

RTL-SDR

Funcube Pro

Airspy mini

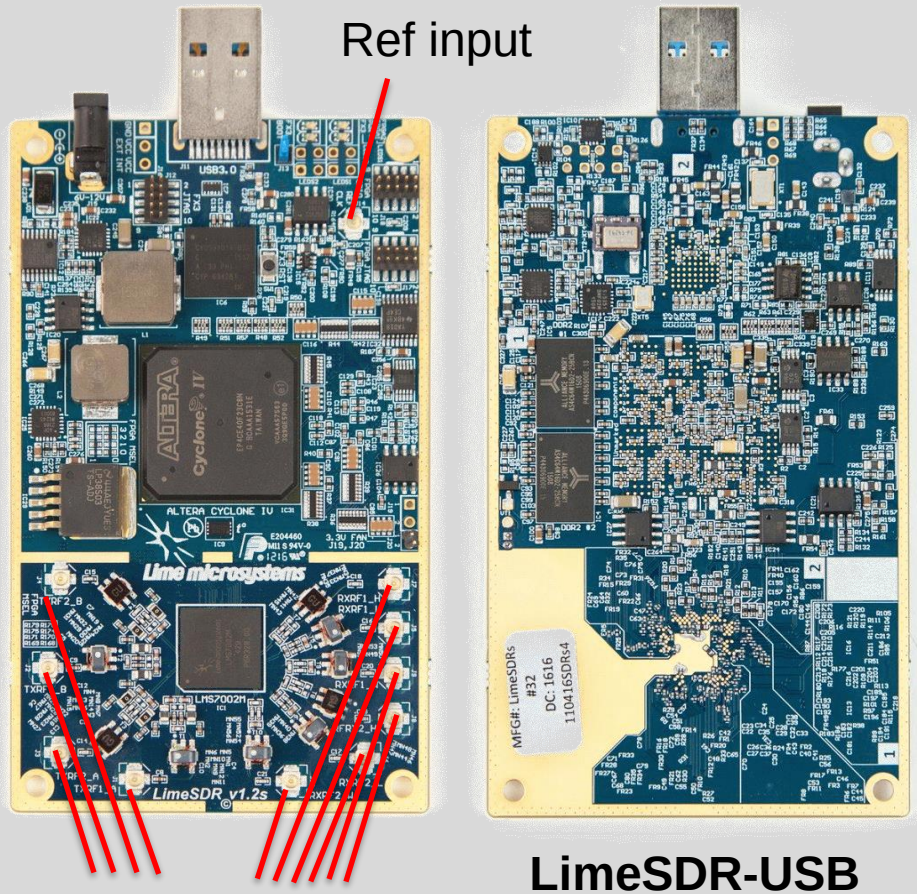
DX-Patrol MK4

SDRplay

Airspy 2

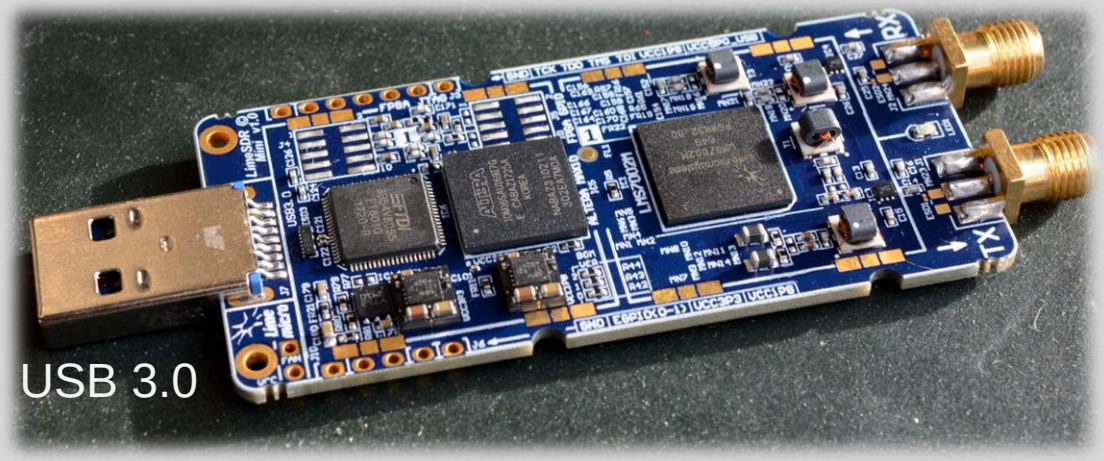
LimeSDR TRX

SOLD OUT



LimeSDR-USB

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

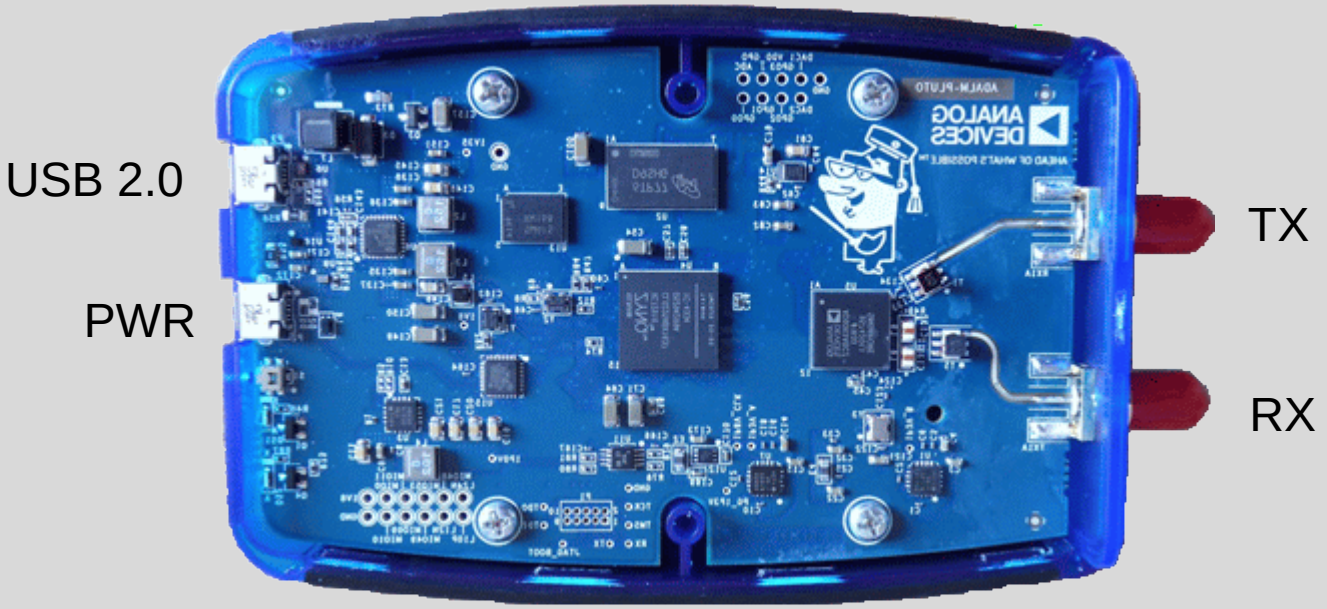


LimeSDR-mini

Adalm Pluto SDR TRX

ADALM Pluto

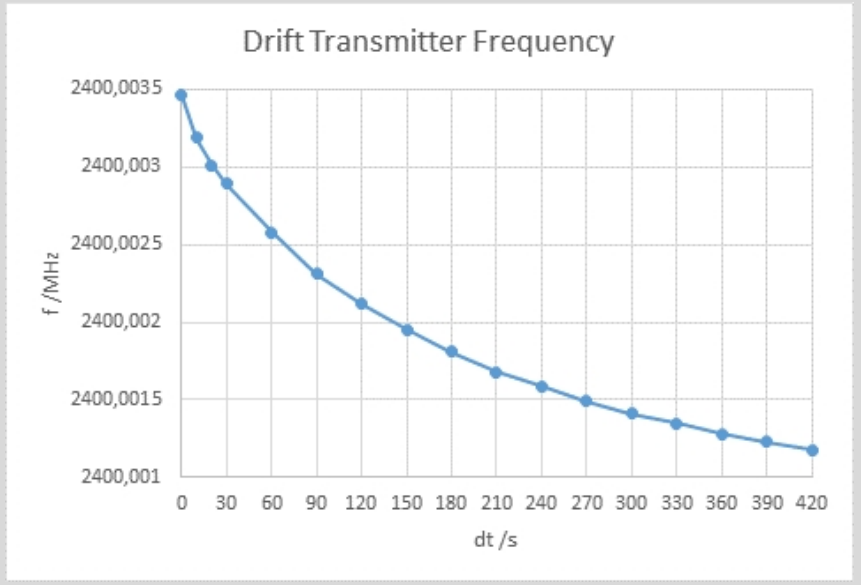
The Pluto SDR can be used up to 6 GHz for RX and TX



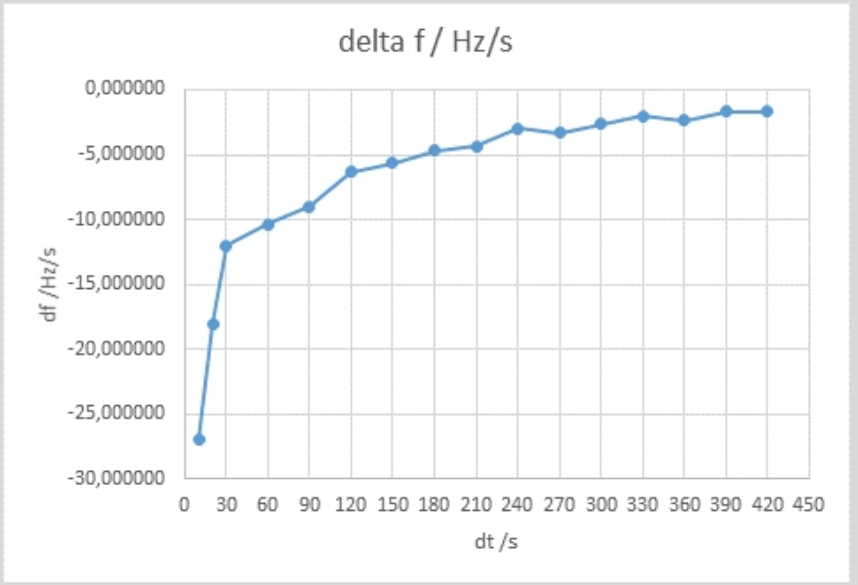
ADALM Pluto open

Adalm Pluto

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



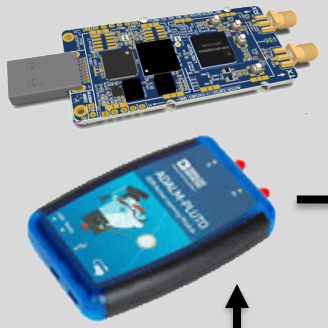
Nice, but:



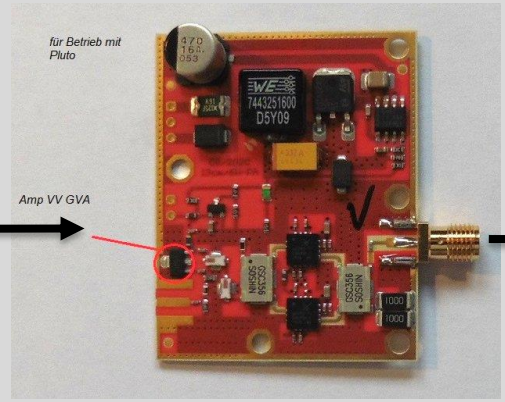
Internal 40 MHz TCXO needs to be replaced by a better TCXO or by an external reference

Adalm Pluto or Lime-SDR setup

SDR



50 Ohm low loss
coaxial cable

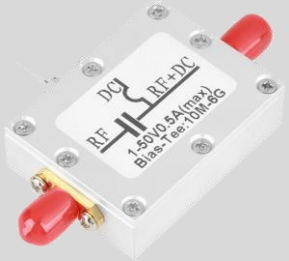


AMSAT-DL PA for SDR-TRX
Gp=46dB
P1dB=35dBm (3W)
Psat=38dBm (6W)

1.2m dish
1.5turn helix
25MHz PLL LNB

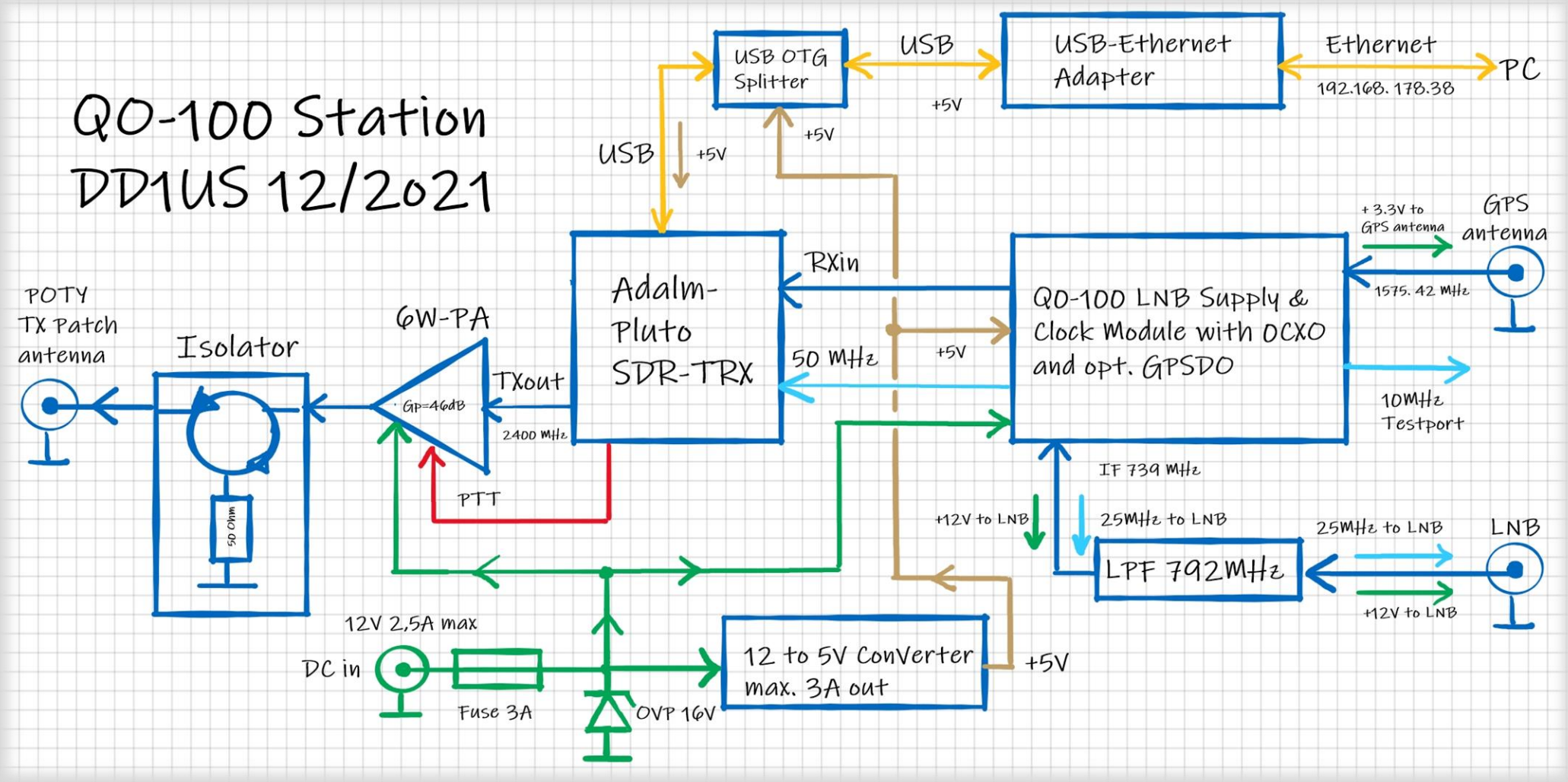
75 Ohm
coaxial cable

Bias Tee
12Vdc



Source: https://www.qrz.com/db/PY2RN

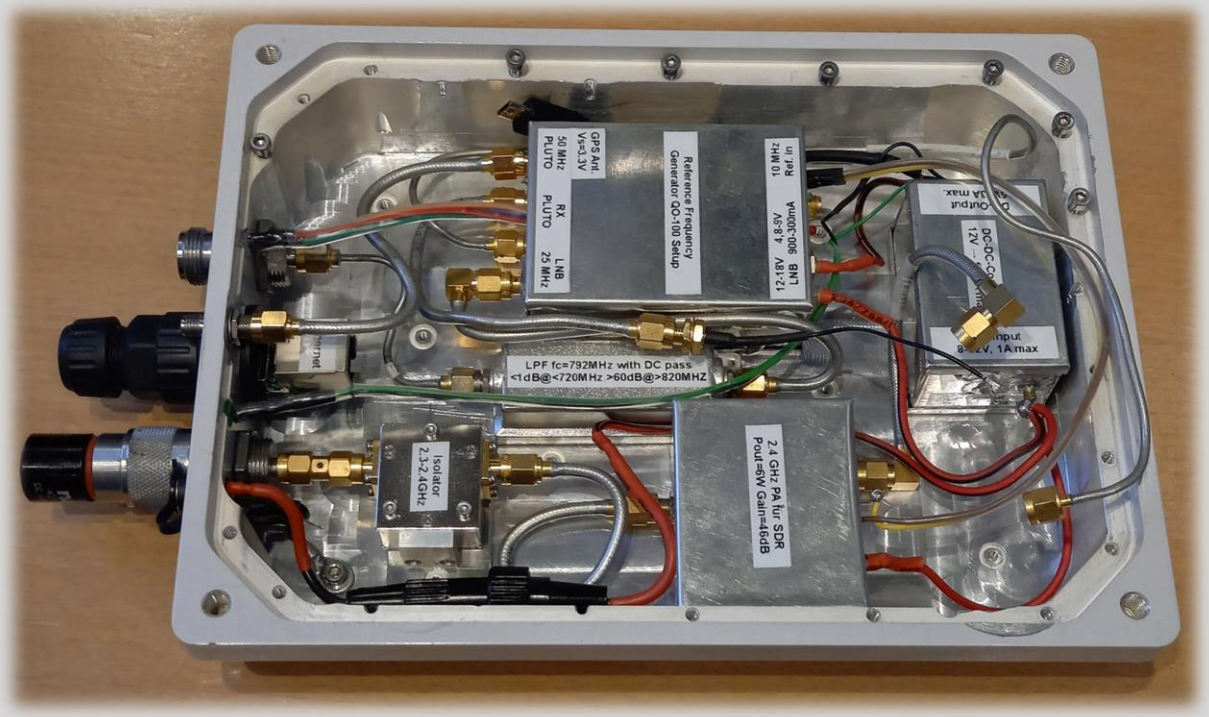
Pluto based QO-100 portable station



„ADALM-PLUTO SDR“ with „AMSAT-DL 6W PA“ and
„QO-100 LNB Supply & Clock Module“ from Kurt DJ0ABR.

Source: DD1US

Pluto based QO-100 portable station



All modules fully shielded and connected with semi-rigid cables: TX-Isolator, 792MHz RX-lowpassfilter, AMSAT-DL 6W PA, QO-100 LNB Supply & Clock module, DC-DC-Converter, on top of a shielding plate ADALM-Pluto

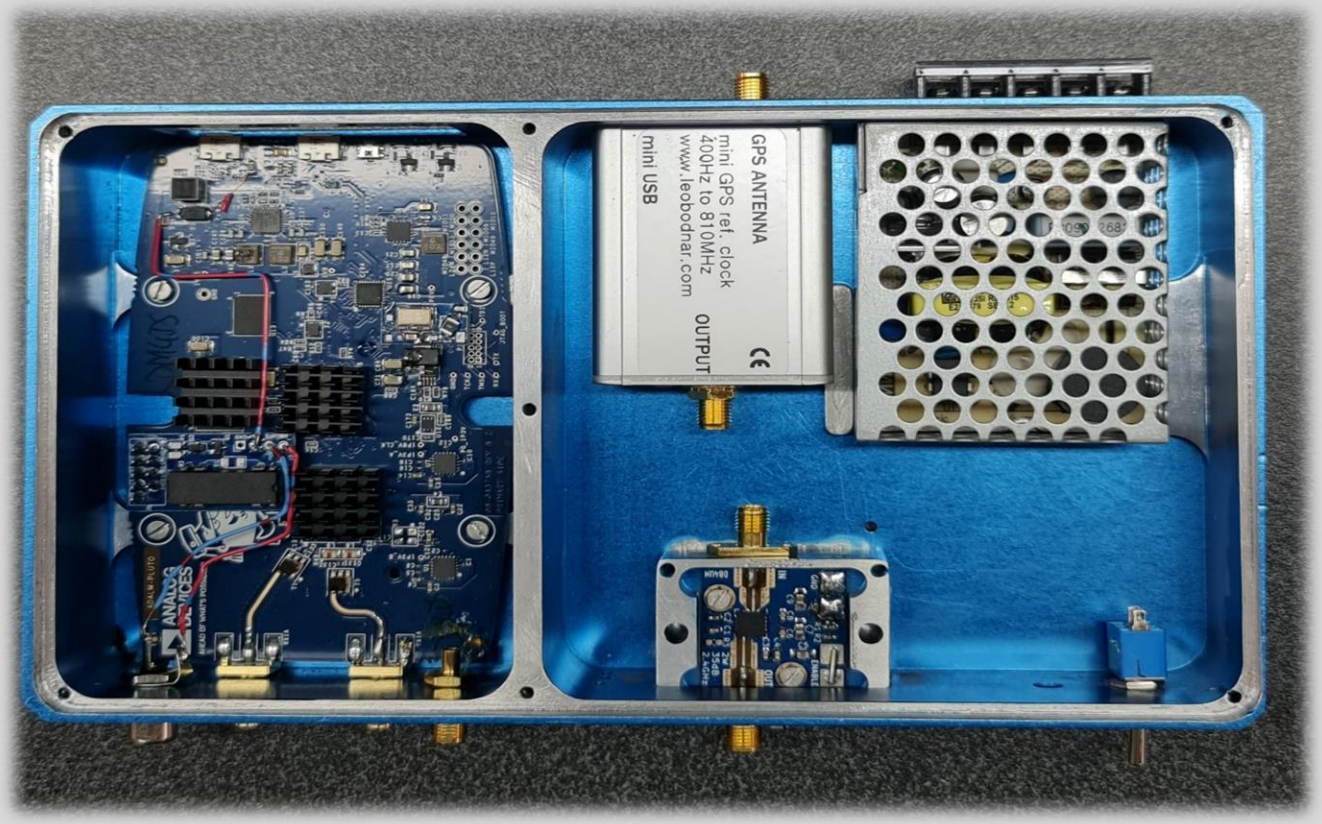
Source: DD1US

Pluto based QO-100 portable station

Source: DD1US

60cm Kathrein offsetdish: mounted upside down for better balance point and protection of feed for rain

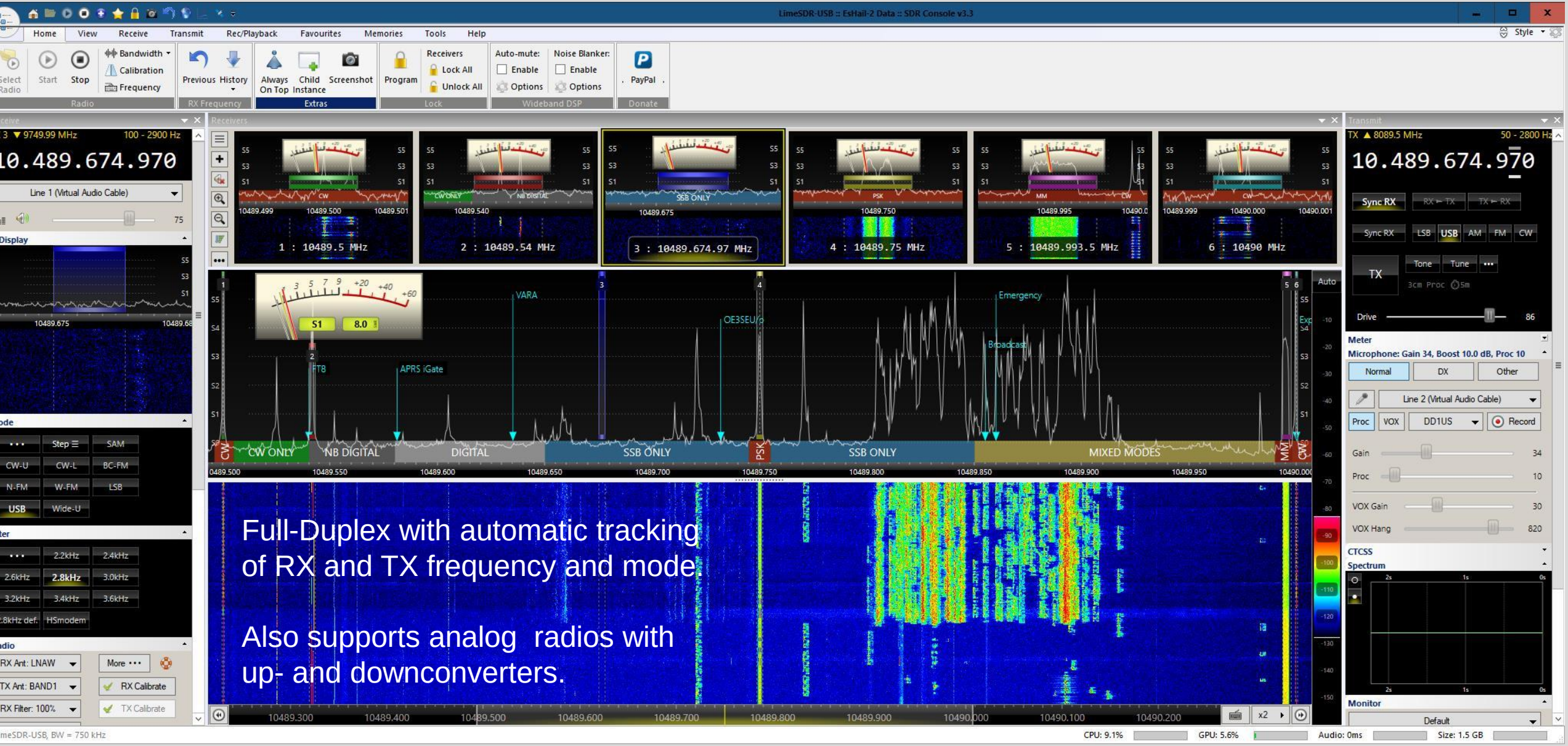
Adalm Pluto



ADALM Pluto in shielded encasing with GPSDO for external 40 MHz reference, power supply and TX driver stage

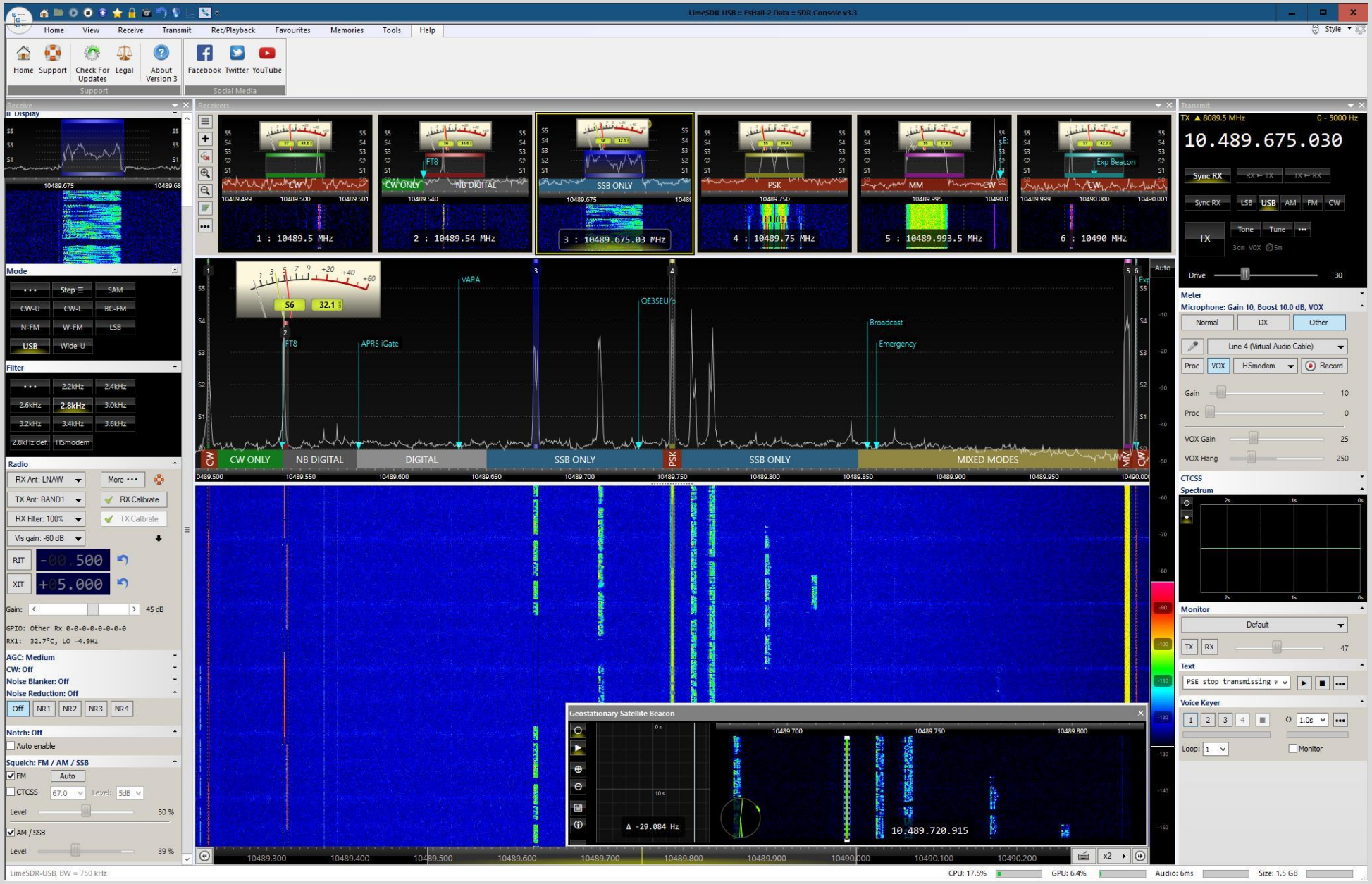
Source: ZS6YI

SDR-Console


LimeSDR-USB :: EsHail-2 Data :: SDR Console v3.3
Full-Duplex with automatic tracking of RX and TX frequency and mode
Also supports analog radios with up- and downconverters.

SDR-Console

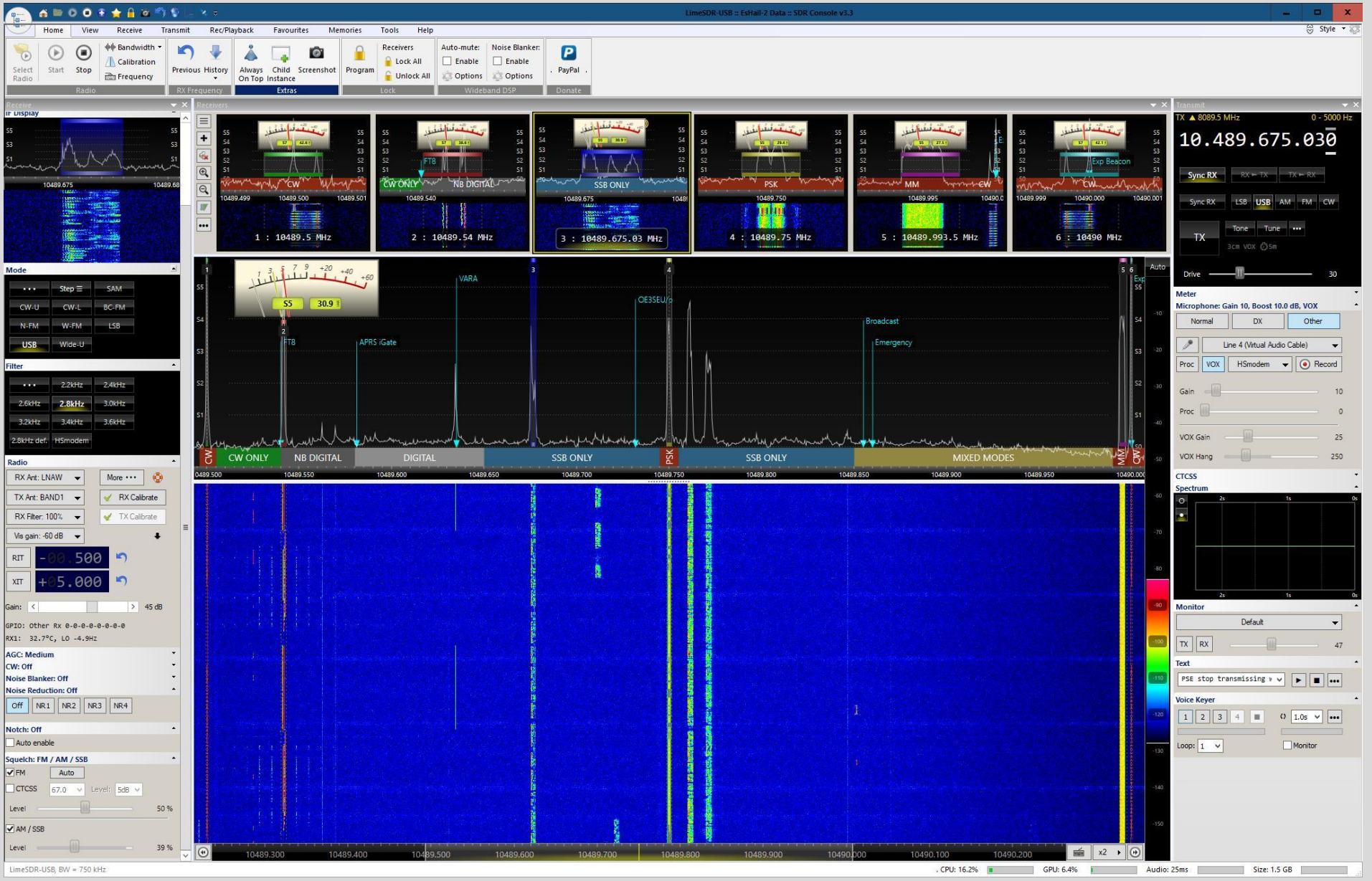
Locking the receiver to the PSK beacon eliminates the drift of a unmodified PLL-LNB.



SDR-Console

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

Transmit Audio Scope and spectrum available.



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Satellites for Communication, Science and Education

QO-100 activities

PY2RN all activated **146 DXCCs**

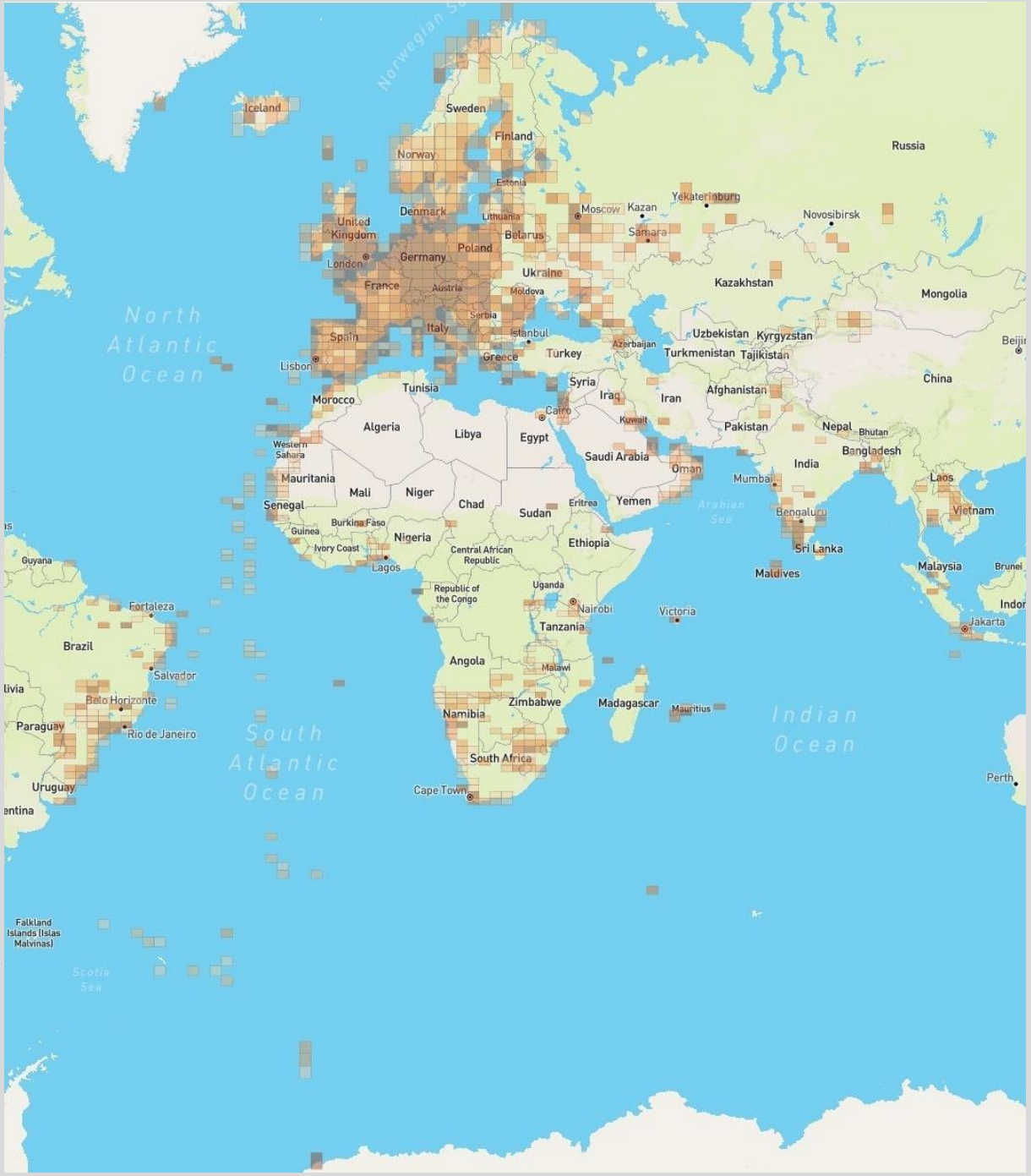
PE1CMO **860 VUCC-Grids**

DL2GRC 1st **WAC**

PP2RON **2831 initials**

OE5VLL >**10000 QSOs**

Status: February 10th 2023



Thank you very much for your attention!
I will be happy to answer your questions.

www.dd1us.de

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