



How to become QRV on the NB Transponder
A05 Freiburg, March 24th 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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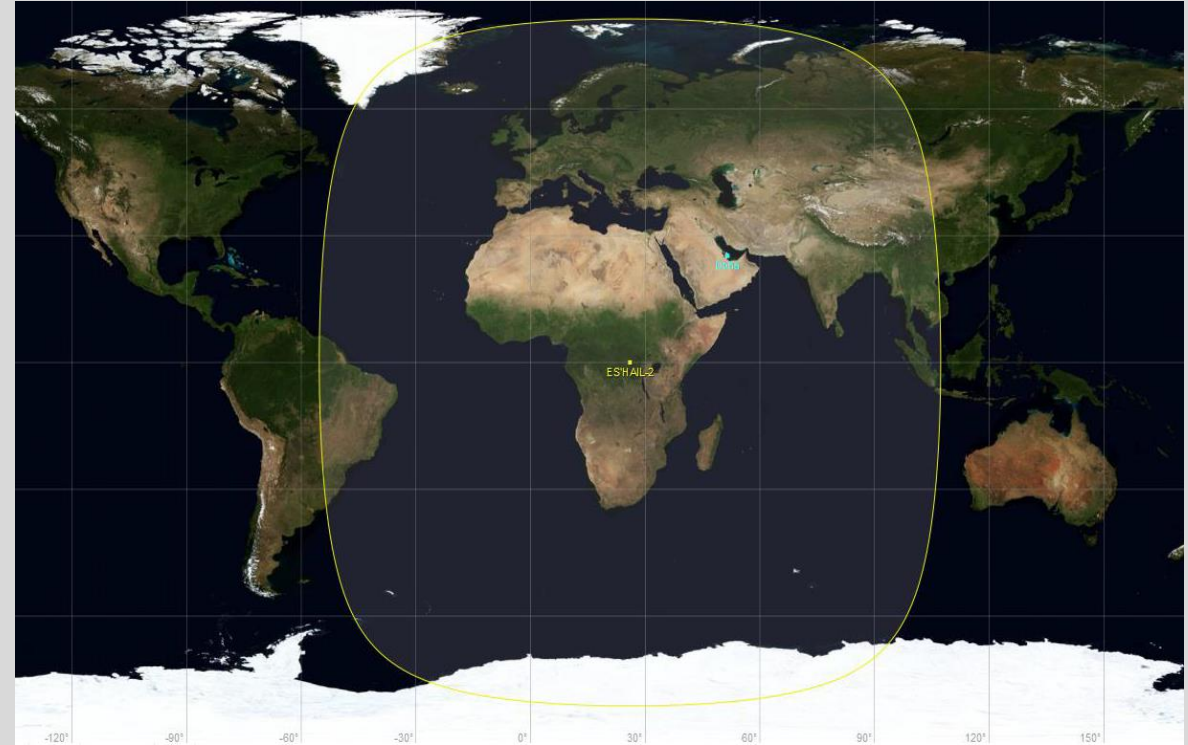
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Qatar-OSCAR 100 (Es'hail-2)

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).



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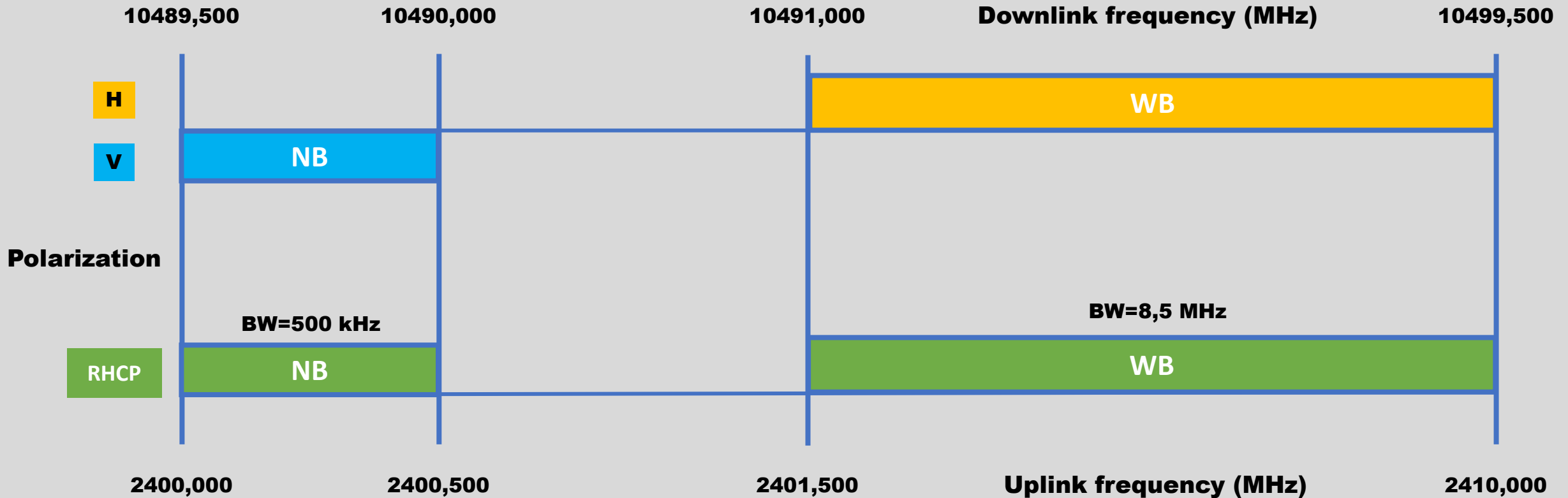
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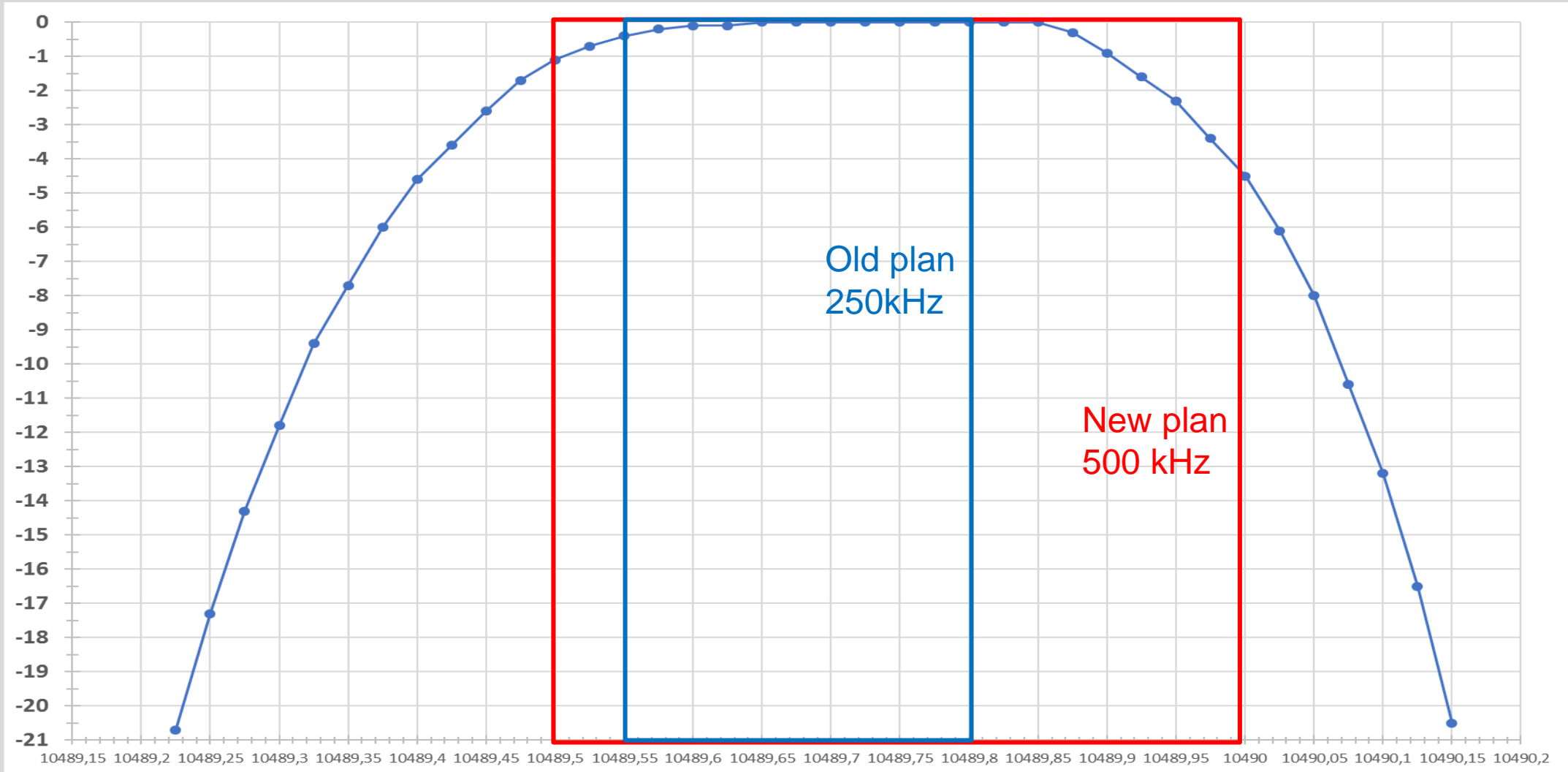
QO-100 transponders



<http://www.amsat-dl.org>

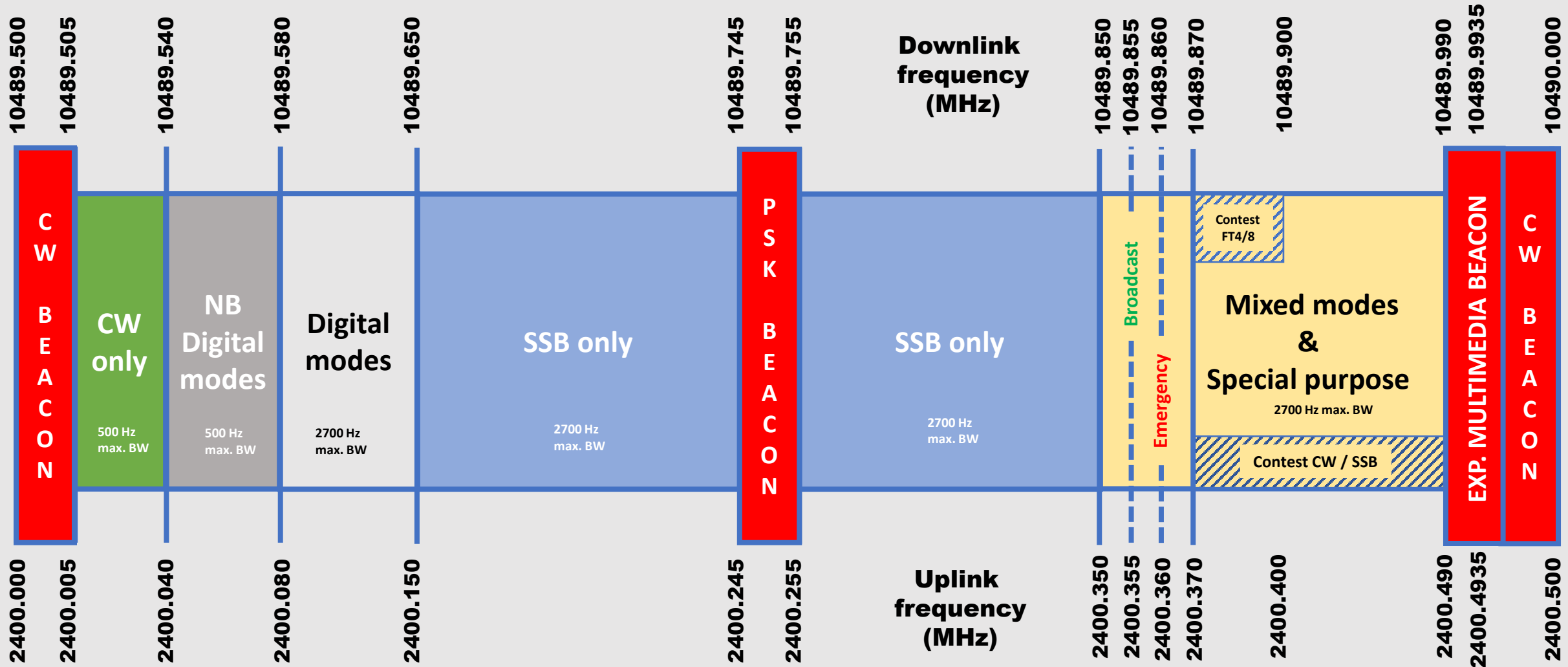


QO-100 NB transponder



NB-Transponder frequency response

QO-100 NB transponder



QO-100 WB transponder

	Beacon		Wide and Narrow DATV					Narrow DATV							
	Beacon		1MS		1MS		1MS								
			333	333	333	333	333	333	333	333	333	333	333	333	
	Beacon Only		Experimental modes and DVB-S/S2		DVB-S/S2 all symbol rates			DVB-S/S2 at 333 kS and lower							
	2401.5	2402.5	2403.5	2404.5	2405.5	2406.5	2407.5	2408.5	2409.5						
	Uplink (MHz)														
	10491.0	10492.0	10493.0	10494.0	10495.0	10496.0	10497.0	10498.0	10499.0						
	Downlink (MHz)														

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QO-100 NB modes

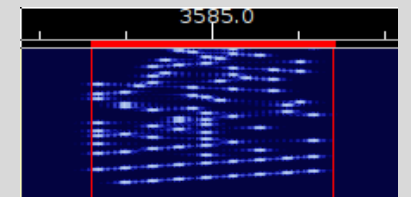
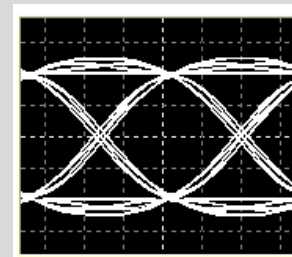
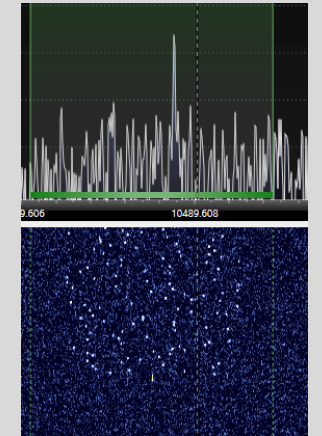
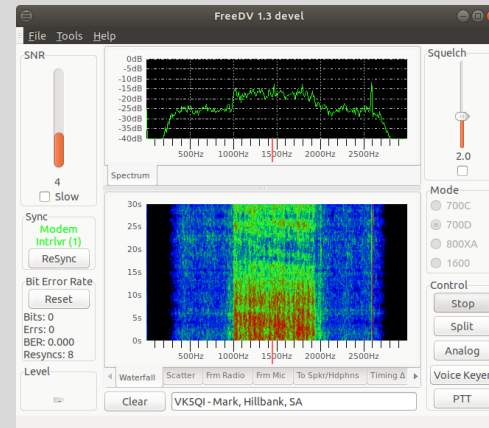
Basic rules for the NB transponder:

- 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:

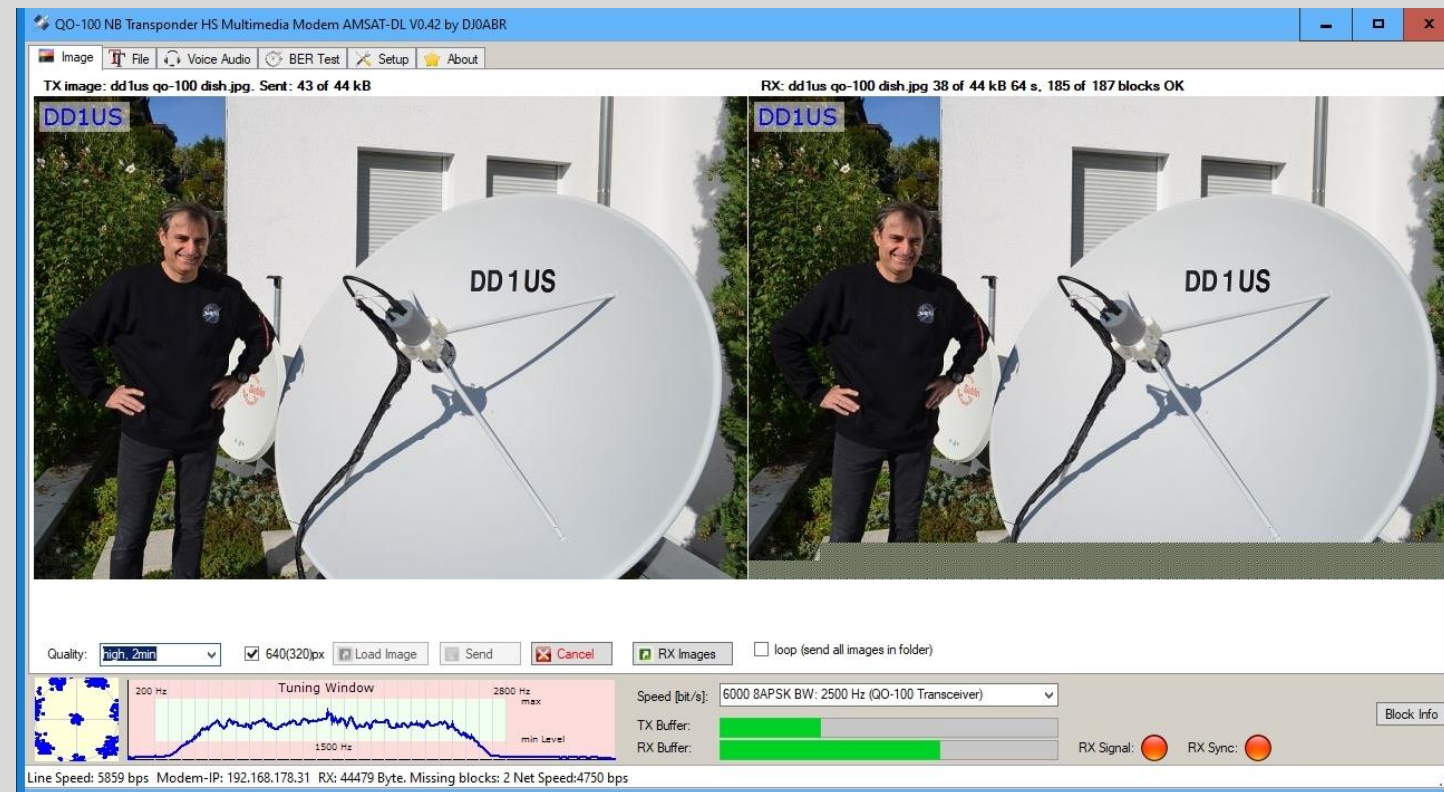
- SSB / CW
- FreeDV (incl. 2020)
- RTTY
- SSTV / KGSTV
- FAX
- Feldhell
- Digimodes such as PSK31, FT8, FT4, THOR8, ROS, QRA64D, JT65A, Robust Packet, VARA, Winlink, ...
- AMSAT-DL Highspeed Modem (up to 7200bps in 2.7kHz bandwidth)



QO-100 NB modes

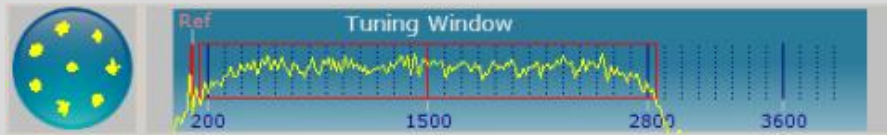
AMSAT-DL High Speed Multimedia Modem (developed by Kurt DJ0ABR)

- Sound card modem
- Open Source
- Supports full duplex
- 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 DJOABR

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QO-100 Experimental HTML Beacon
via HSmodem 7.2kbps 8APSK

Version 0.98 (p:DJ0ABR, DJ2ET / AMSAT-DL)
ALL information shown here are transferred via QO-100. Internet is not used anywhere
CONNECTED to local HSmodem

Narrow Band Transponder Activity | **Wide Band Transponder Activity**

DX-Cluster Messages | **CW Skimmer**

News | **QO-100 DX Club News** | **AMSAT Bulletin** (auto update)

NEWS SERVICE #1 #2 #3 #4 #5 #6 #7 #8 #9 #10
ANSAT NEWS SERVICE ANS-015

In this edition:

- * FalconSat-3 Nears Re-entry
- * More Amateur Radio Astronauts Head for the ISS
- * Changes to AMSAT-NA TLE Distribution
- * Why We Don't Call CQ on FM Birds
- * ARIS5 News
- * Upcoming Satellite Operations
- * Hamfests, Conventions, Maker Faires, and Other Events
- * Satellite Shorts From All Over

The AMSAT News Service bulletins are a free, weekly news and information service of AMSAT, The Radio Amateur Satellite Corporation. ANS publishes news related to Amateur Radio in Space

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Antennas for QO-100



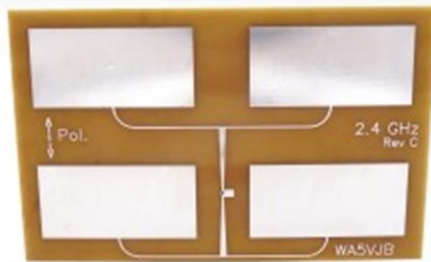
Dualband
Feed in
single dish



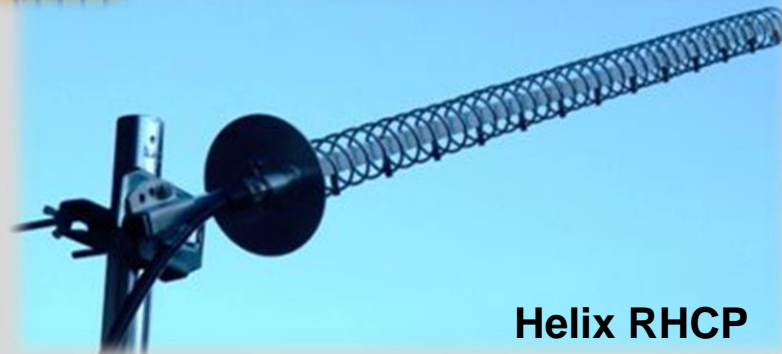
WiFi Grid
linear



Separate
Dish Antennas
for Up- and
Downlink



Patch Array WA5VJB



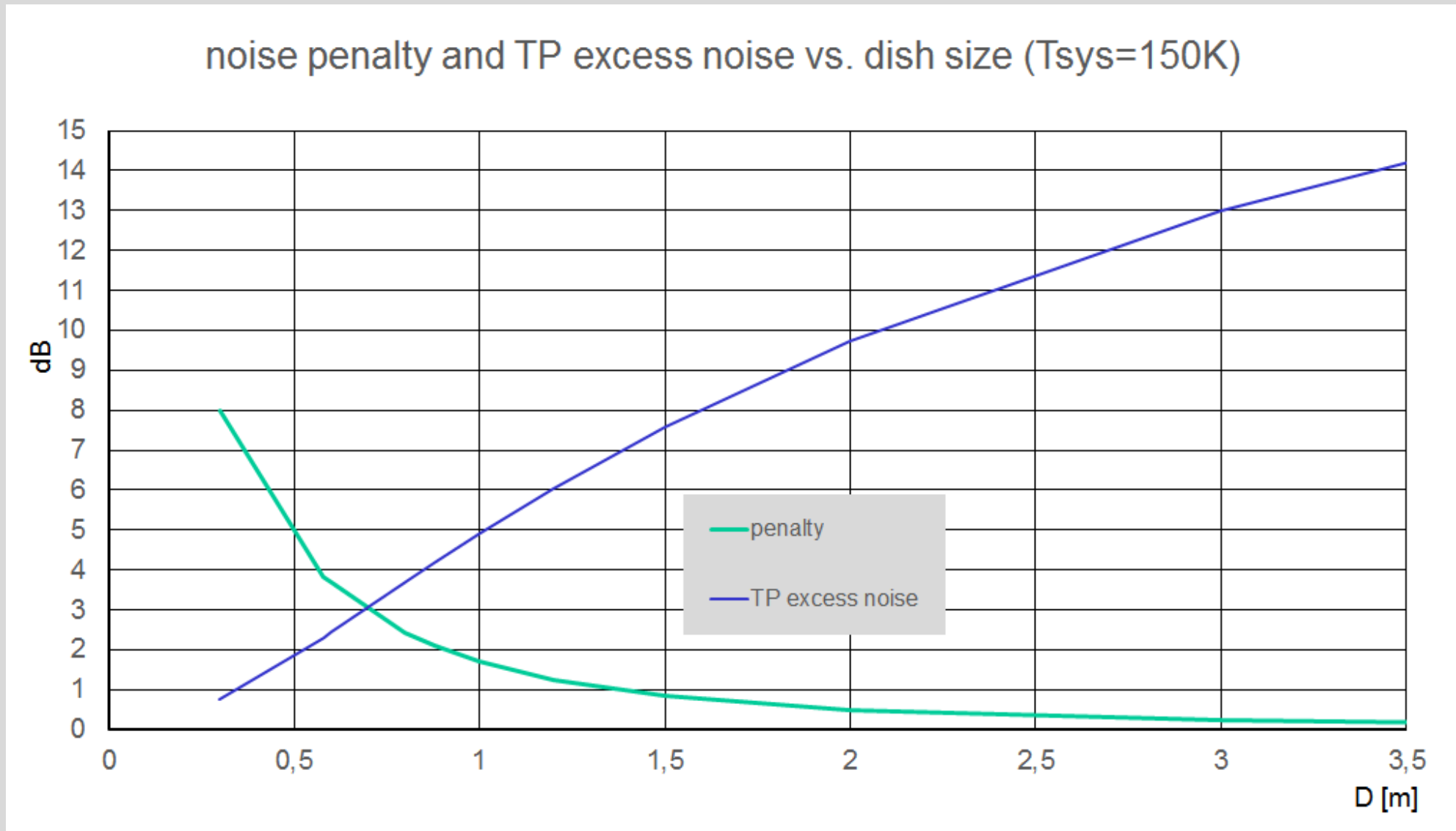
Helix RHCP

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)

Which diameter is needed for your dish?



Antennas for QO-100



Vintage solid Kathrein dish
($D=1.8\text{m}$, $f/D=0.29$)



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

RX:
NB transponder noise: 8dB
WB beacon MER: $\geq 10\text{dB}$

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

Antennas for QO-100



Gary ZS6YI



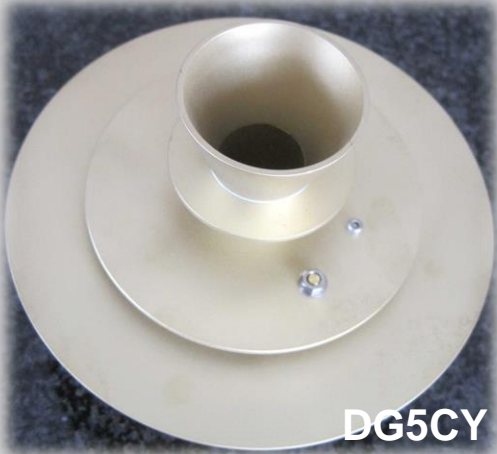
Jürgen DL8SDQ

Antennas for QO-100



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

Feeds for QO-100



DG5CY



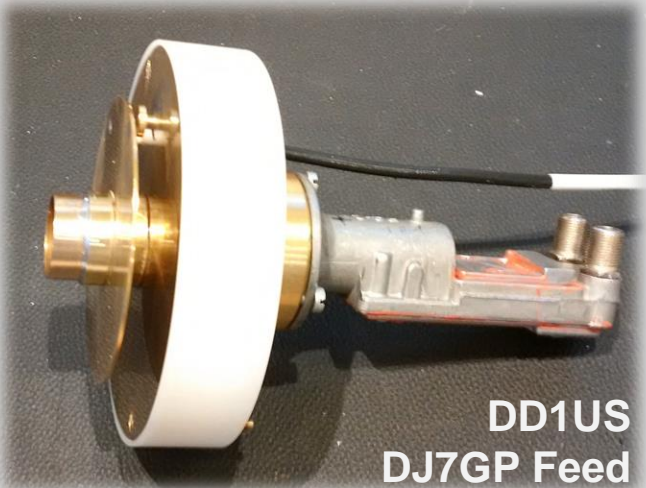
DD1US
POTY Feed



DF2GB
Helix Feed
with LNB



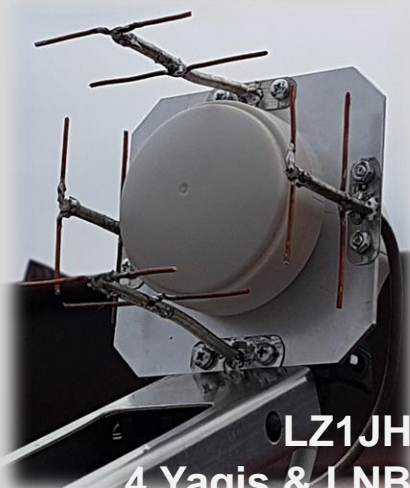
Vorserienmuster des
10/2,4 GHz Duoband-Feeds
nach DJ7GP



DD1US
DJ7GP Feed



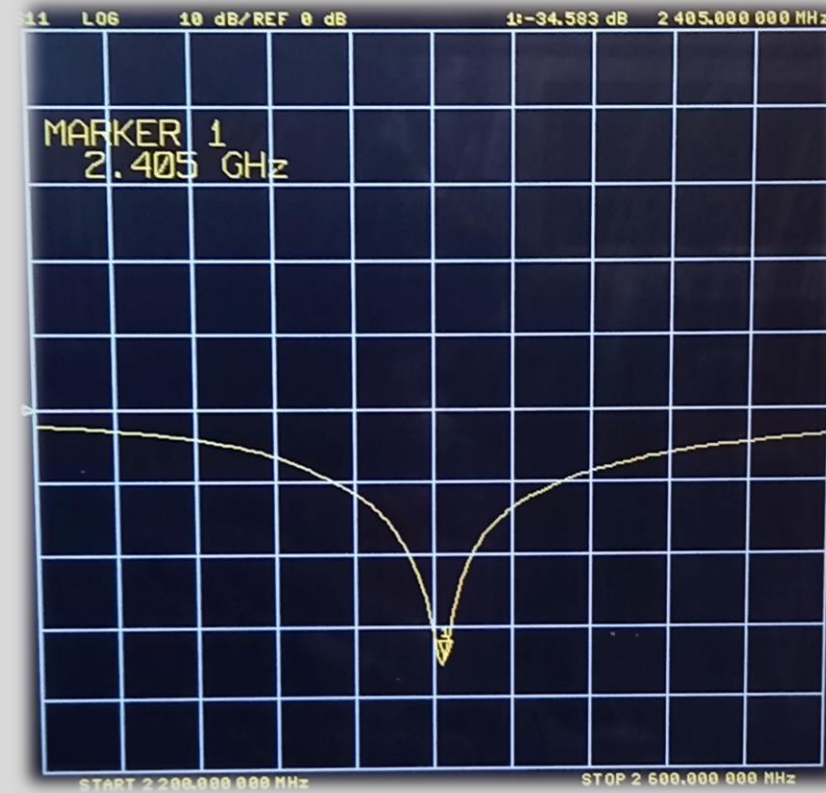
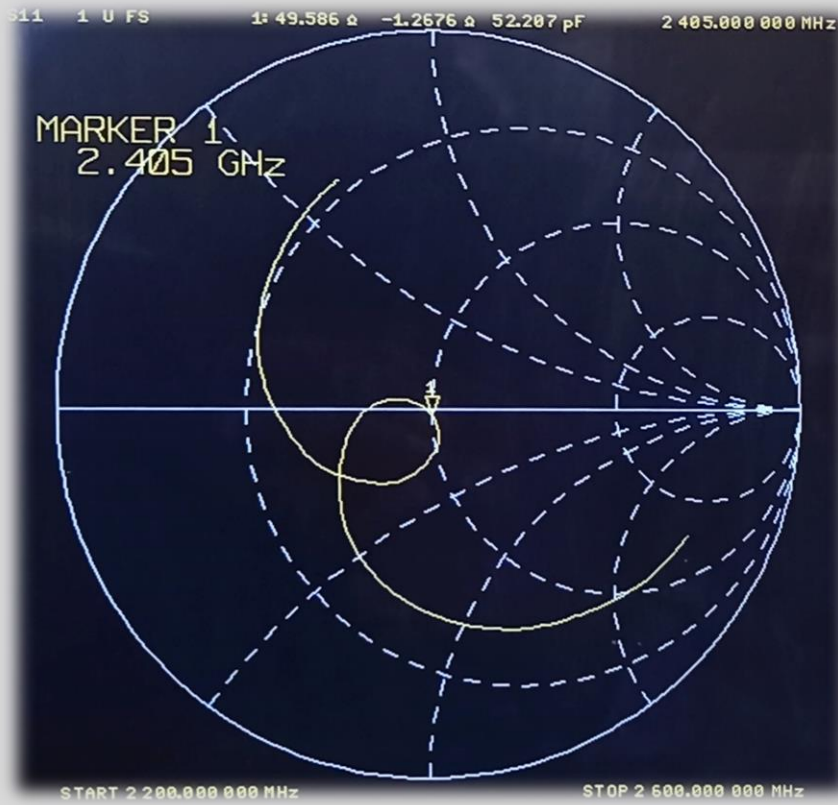
HB9PZK
Dipole Array
& Waveguide



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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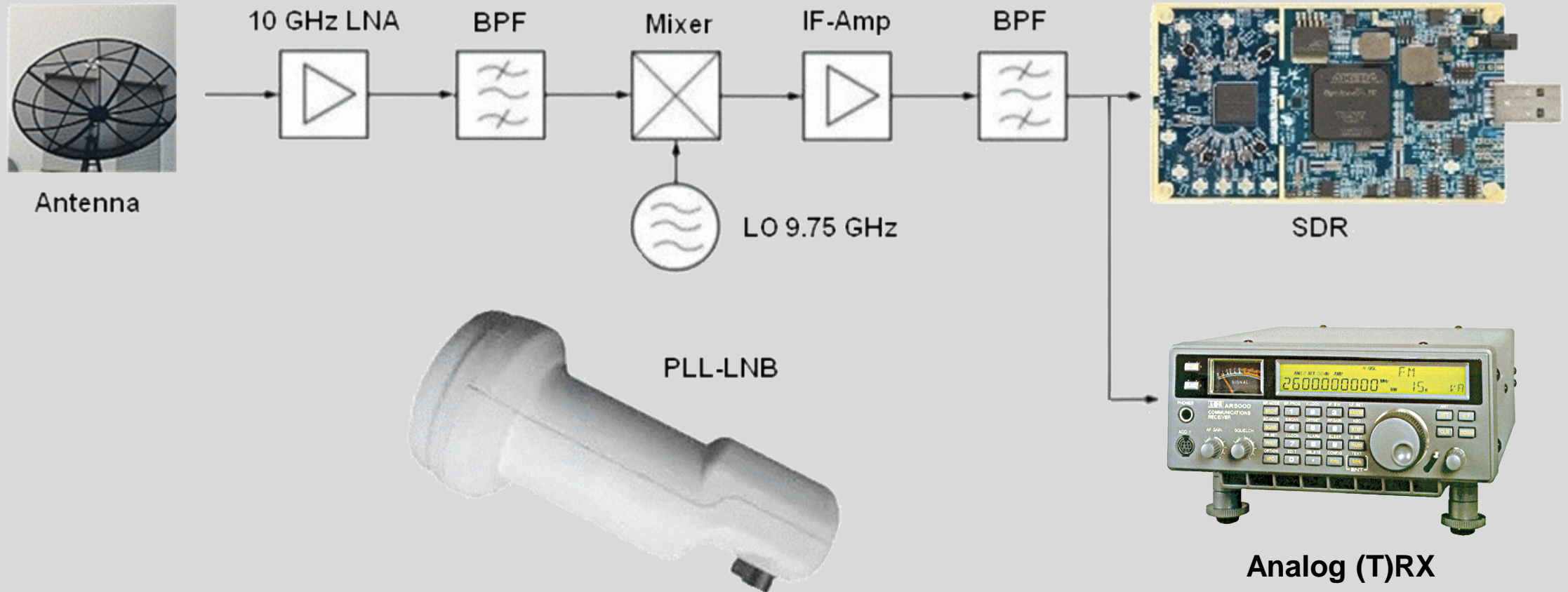
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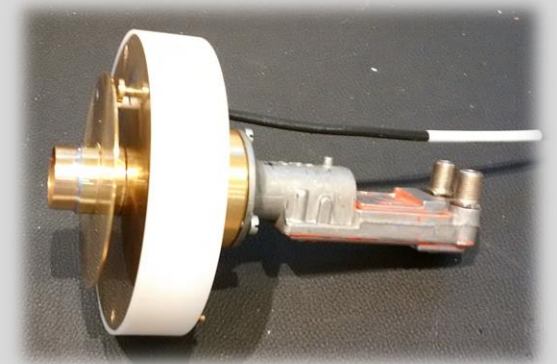
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RX-Setup for QO-100



PLL-LNBs for QO-100

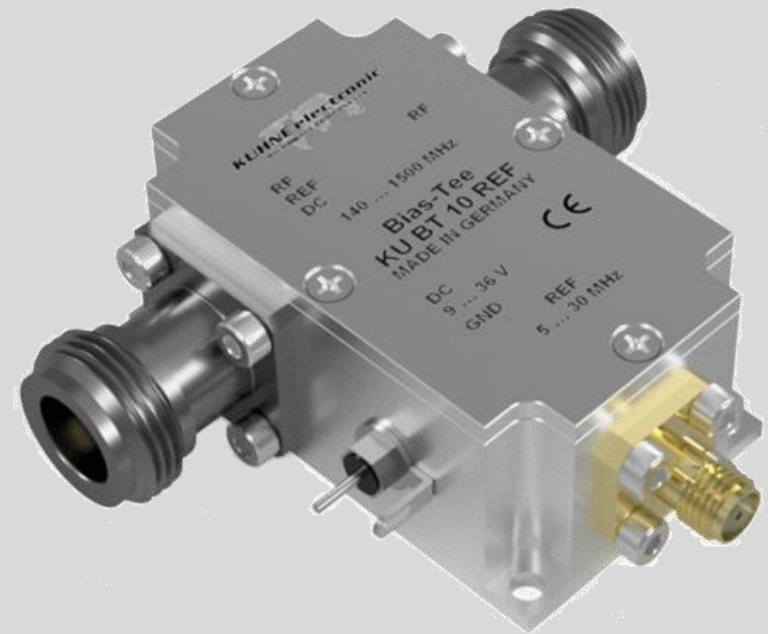
- There are many choices for PLL-LNB brands and models.
- The devices differentiate in temperature stability, phase noise, some show low frequency wobbling.
- As the models are rapidly changing, sometimes with the same part number, thus it is difficult to stay up-to-date. It is often a try-and-error 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

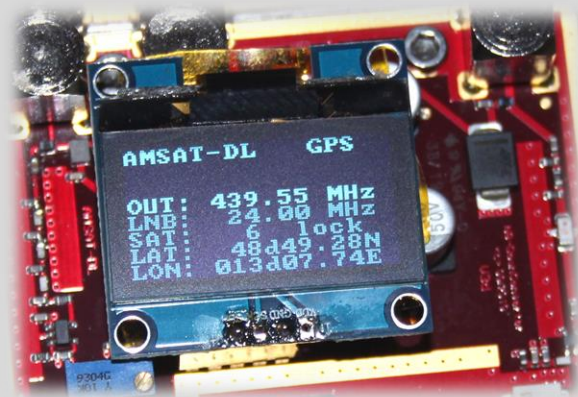
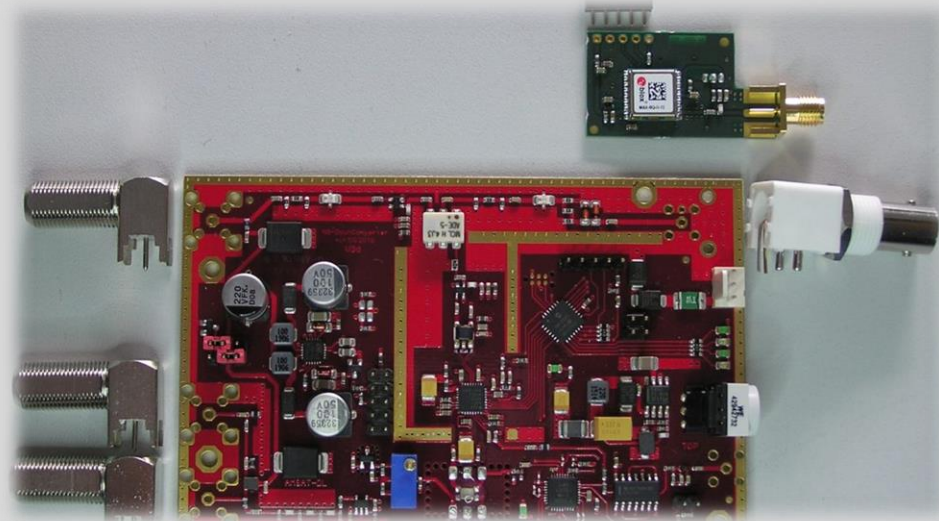


Kuhne 3cm Downconverter



**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€

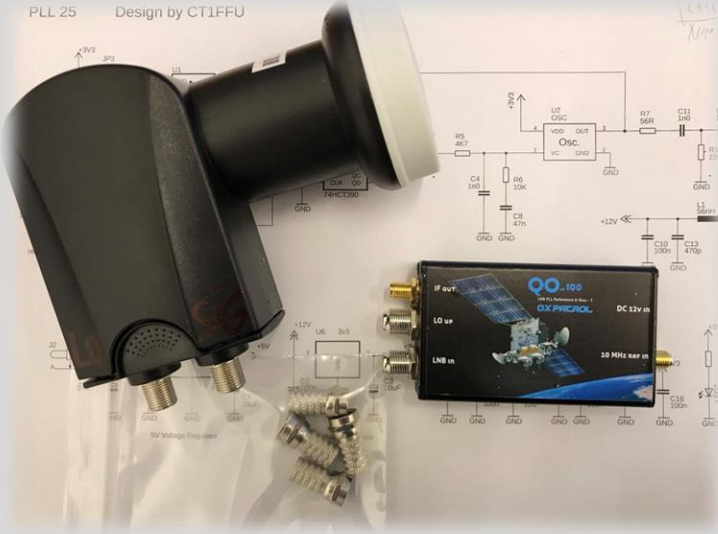


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Downconverters for QO-100



DX-Patrol QO-100 Downconverter

Features:

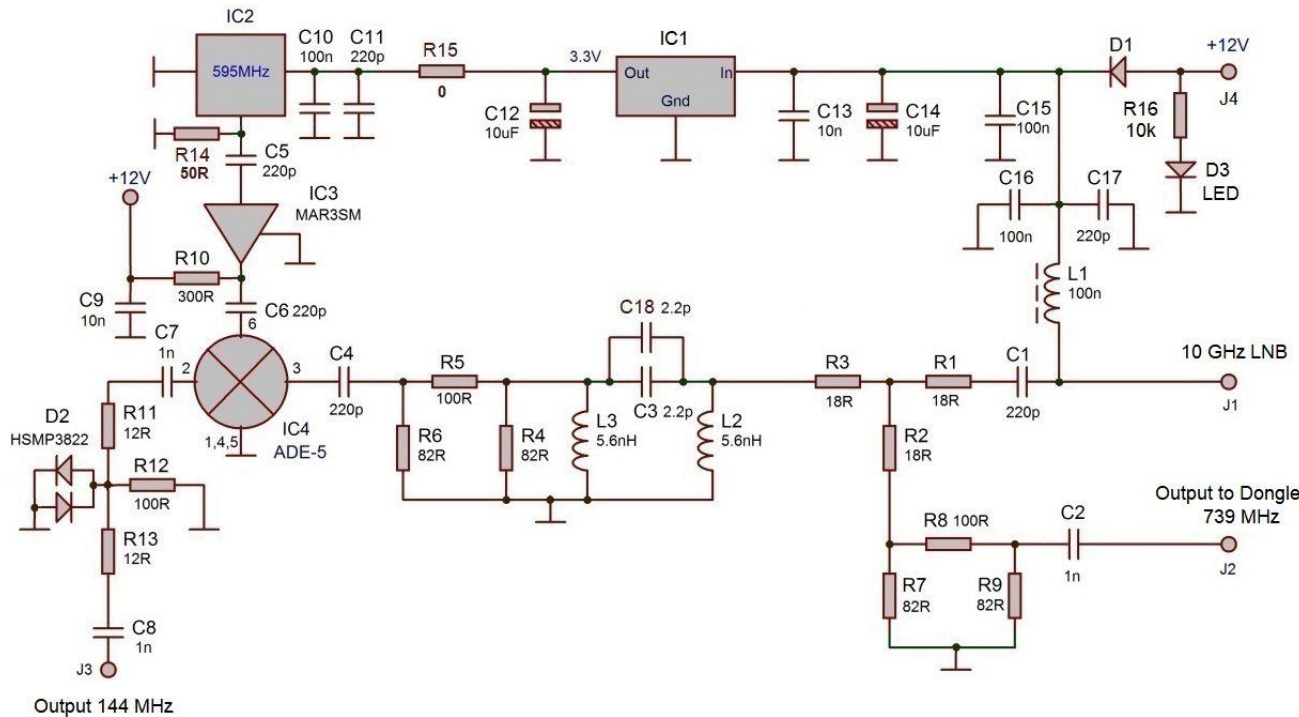
- Input voltage 12V to 18V (LBN polarization mode)
- Internal 10Mhz Reference TCXO 0,5PPM
- External 10MHz GPSDO input optional
- PLL lock LED indication
- Internal RX pre-amplifier 12dB gain
- RX gain adjust
- IF output: 10m, 2m, 70cm, 23cm
- Supplies 25MHz ref to LNB via 2nd cable
- Ready modified LNB included.

- Price incl. LNB 185€

Downconverters for QO-100



QO-100 RX Converter



Transverters-Store QO-100 Downconverter

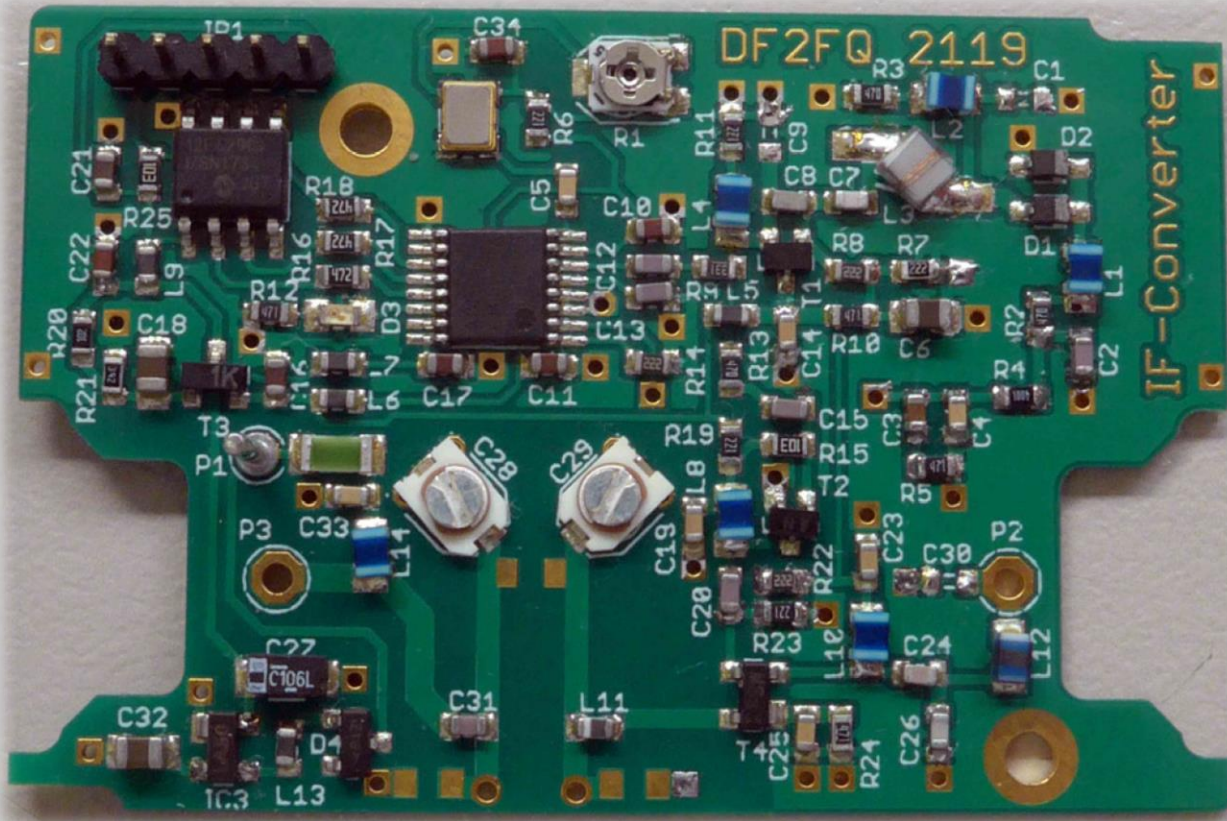
Features:

- Input voltage 12V
- Only for NB operations

TEMPORARILY CLOSED

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

Downconverters for QO-100



DF2FQ IF-Converter IFC

Features:

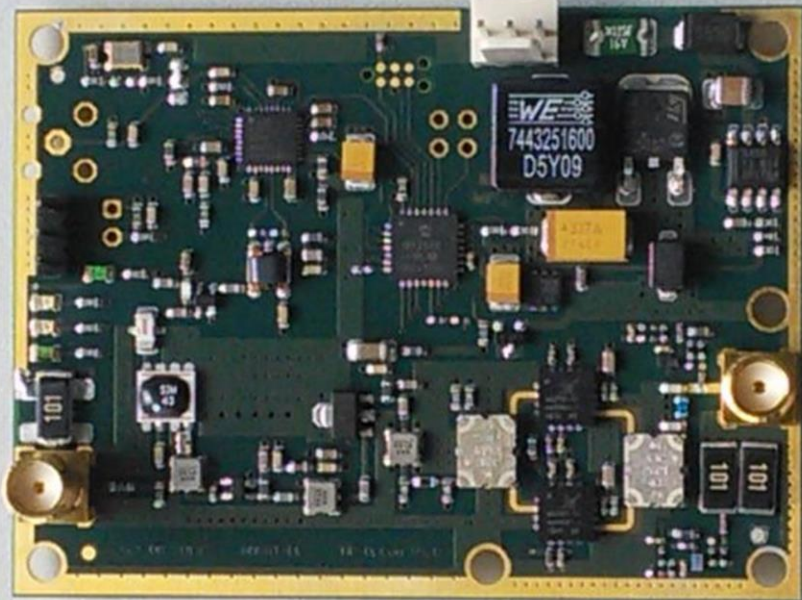
- Input voltage 12....18V, 40mA
(plus opt. LNB phantom feed supply)
- IF out: 2m or 10m
- Price: 65 Euro

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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€



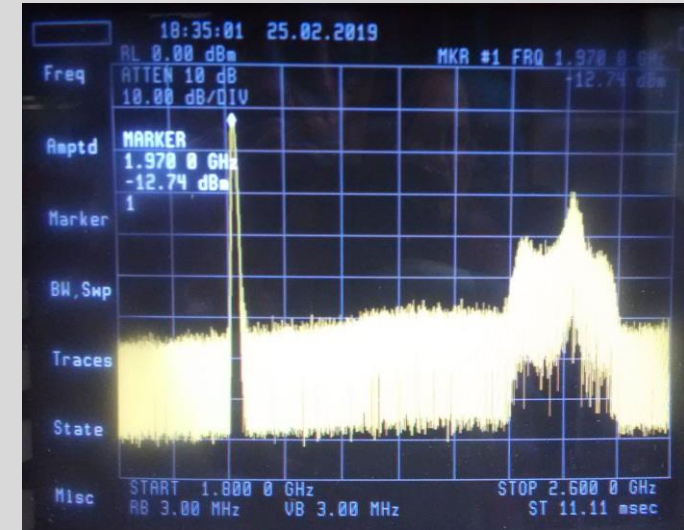
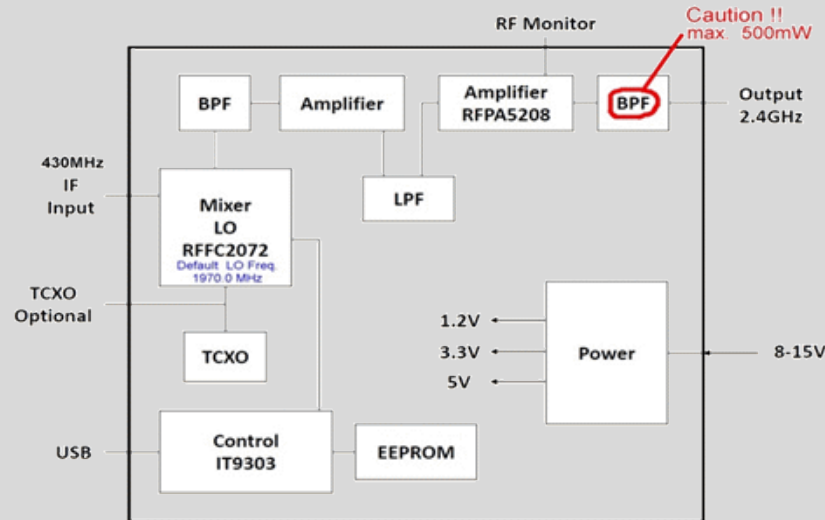
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<http://www.amsat-dl.org>

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\$

NB TX for QO-100



DX-Patrol Upconverter MK4

IF-input: 10m/2m/70cm/23cm (max. 3W)

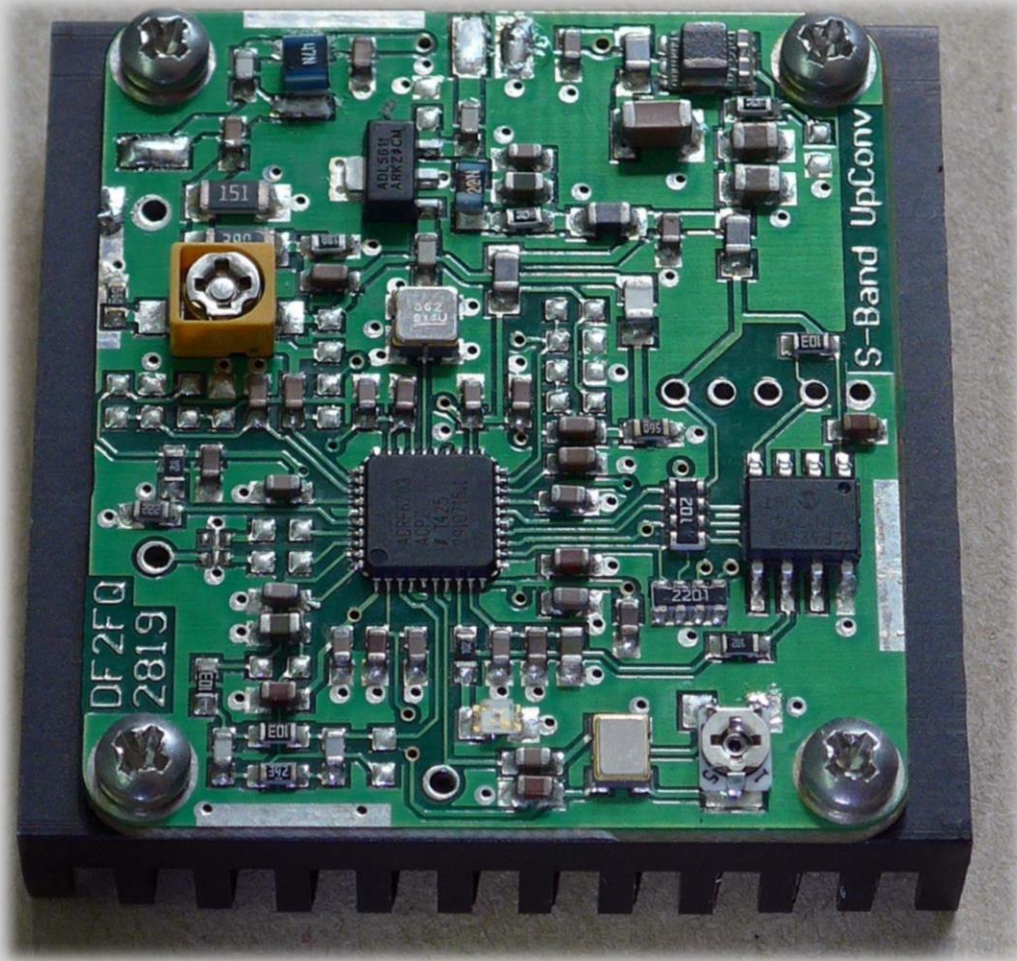
RF-output: 13cm (Pout=200mW)

Internal or external 10 MHz reference

Price: 135€



NB TX for QO-100



DF2FQ 2.4GHz Upconverter UPC-11/2G4

IF-input: 144..145 MHz (typ. 10mW)

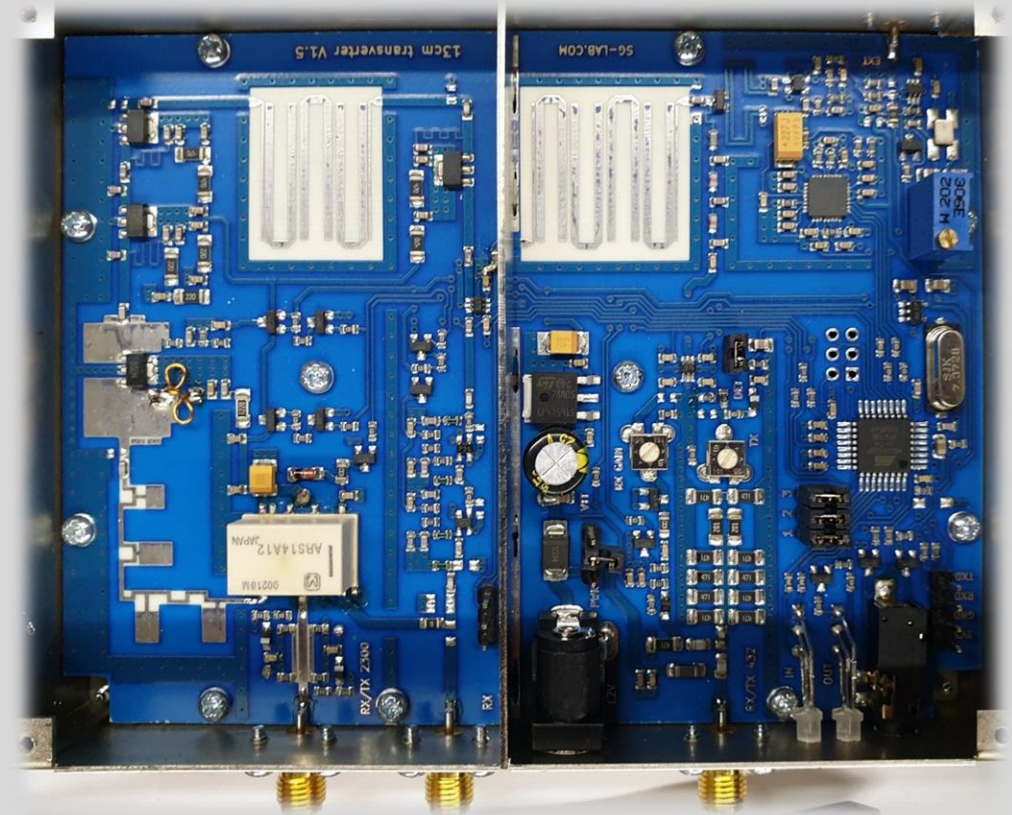
RF-output: 2320...2406MHz (Pout=50mW)

Supply voltage 9..36V

Internal or external 10 MHz reference

78€

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

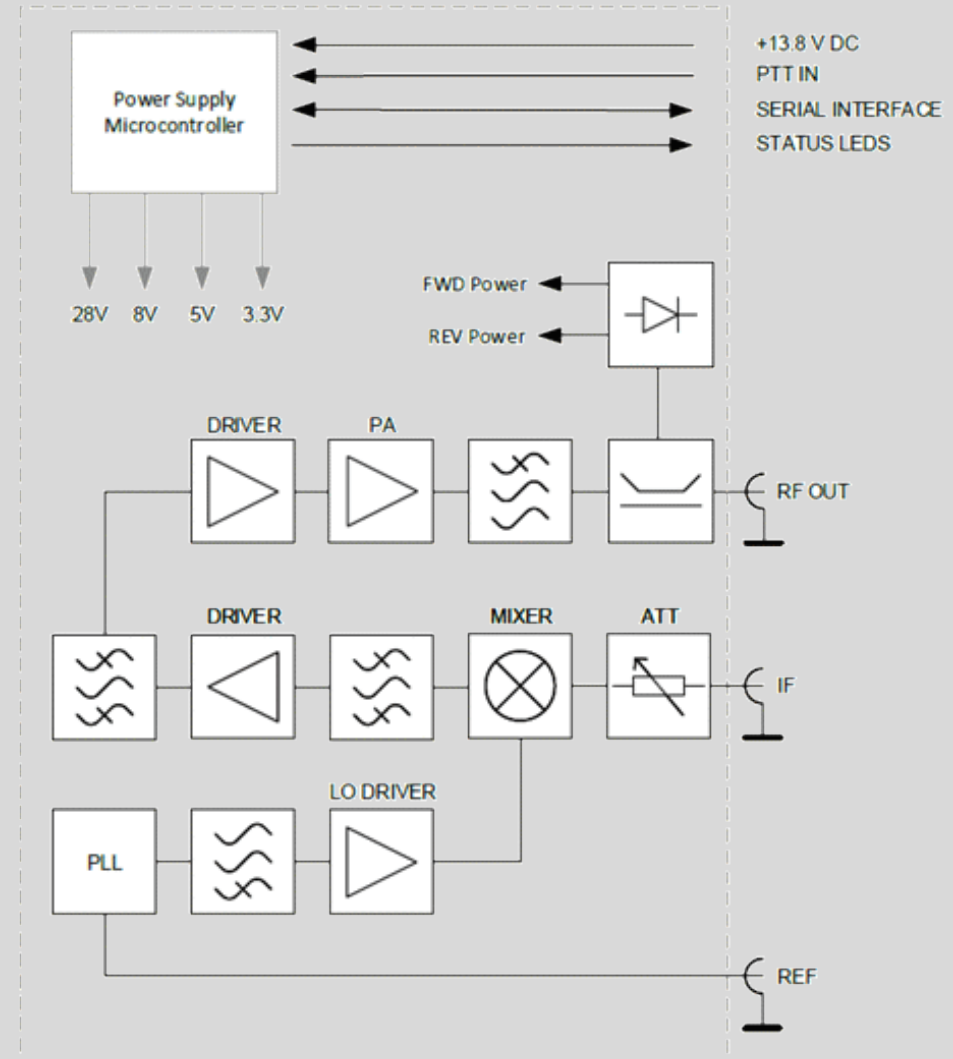
200€

<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 €



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

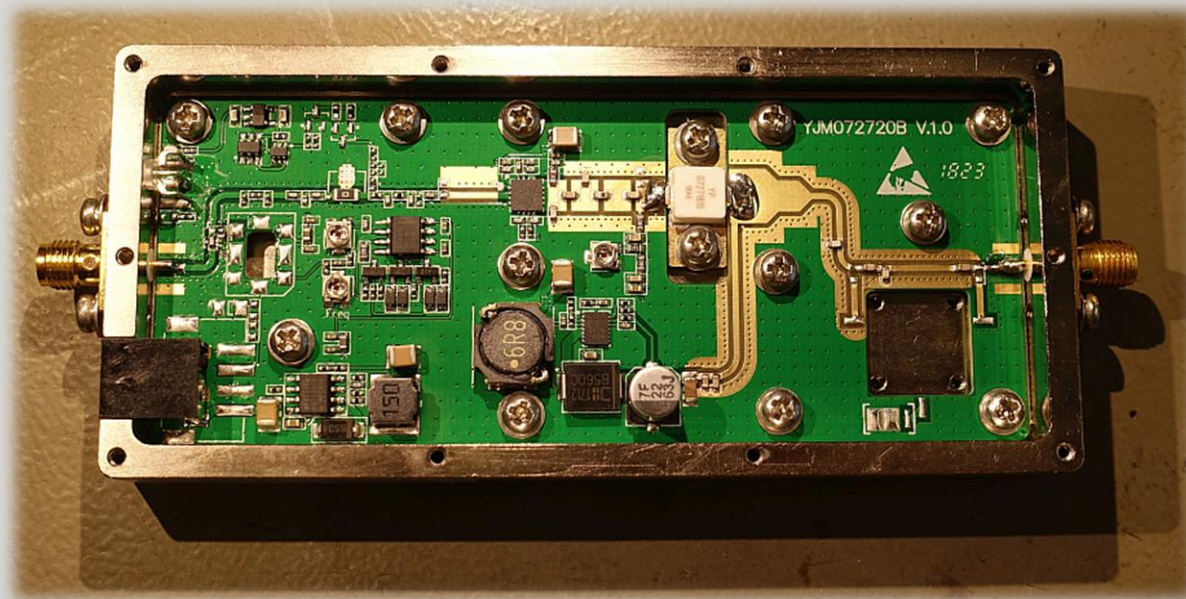
PAs for QO-100



4W < 50\$

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

2W < 30\$



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

230\$ (not sure whether still available)

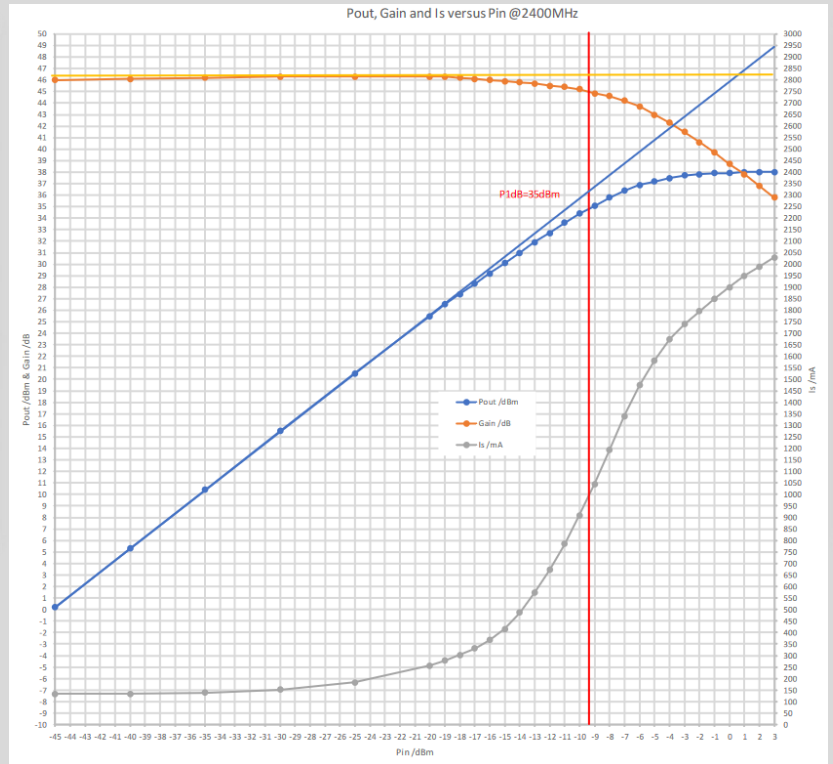
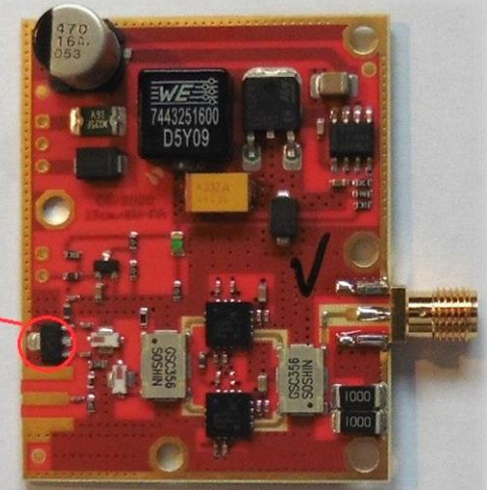
SOLD OUT

PAs for QO-100

SOLD OUT

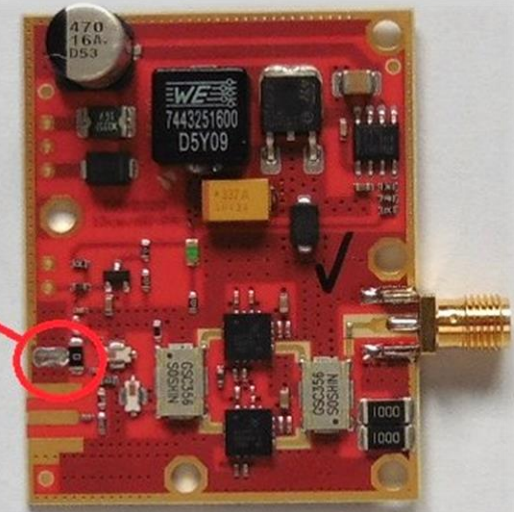
für Betrieb mit Pluto

Amp VV GVA



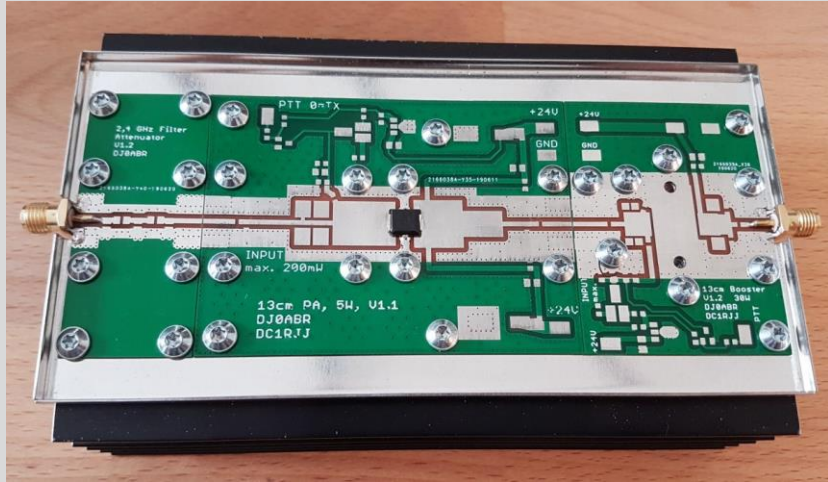
AMSAT-DL for SDR-TRX
 Gp=46dB
 P1dB=35dBm (3W)
 Psat=38dBm (6W)
 Vs=6-15V
 Price 129,50€
<https://shop.amsat-dl.org>

ohne VV GVA



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>

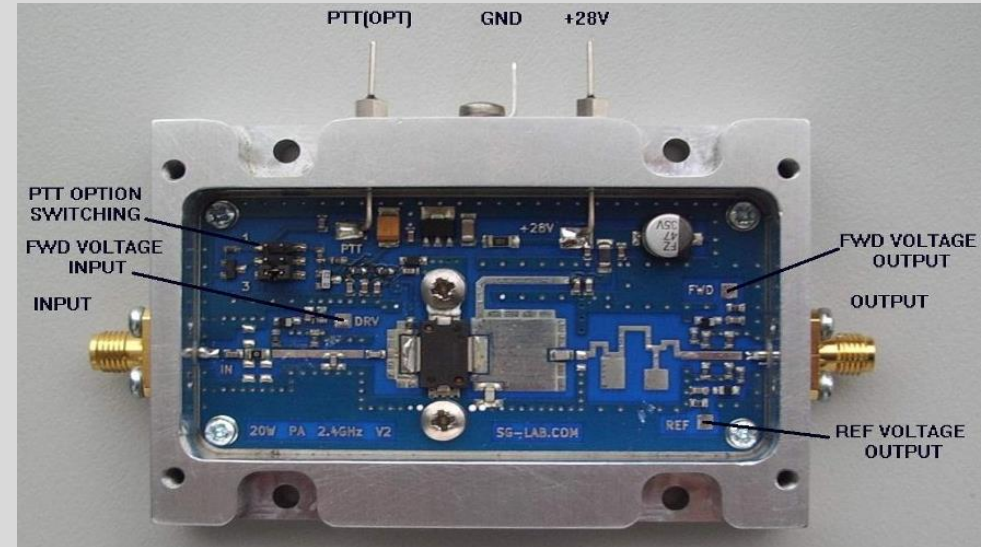
PAs for QO-100



DJ0ABR 13cm PA with MHT1008N
Pout=10W @24V (2W recommended for SSB)
Gp=17dB
Price PCB & components < 40€ (no kit available)

Optional second stage with 25W @24V
(6W recommended for SSB)

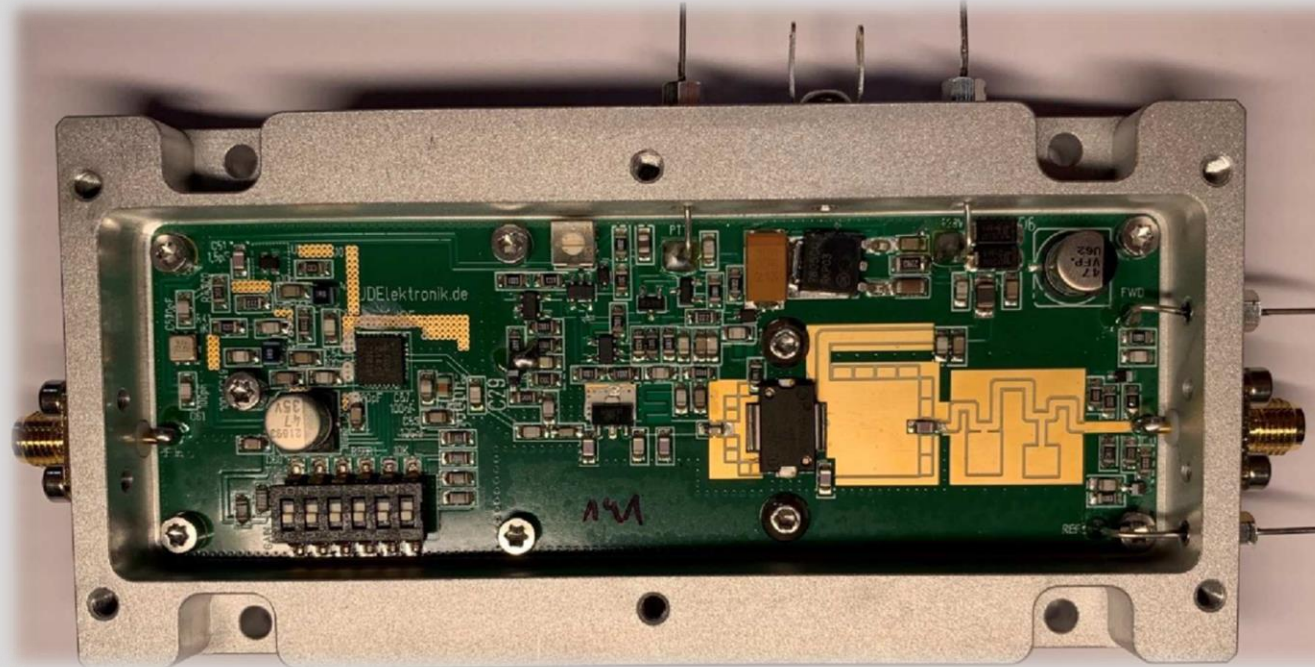
www.helitron.de/dj0abr/



SG-Labs 13cm PA LZ5HP
Pout=21W @28V / 17W @24V
Gp=16dB
Price 126 €
www.sg-labs.com

PA's for QO-100

NEW

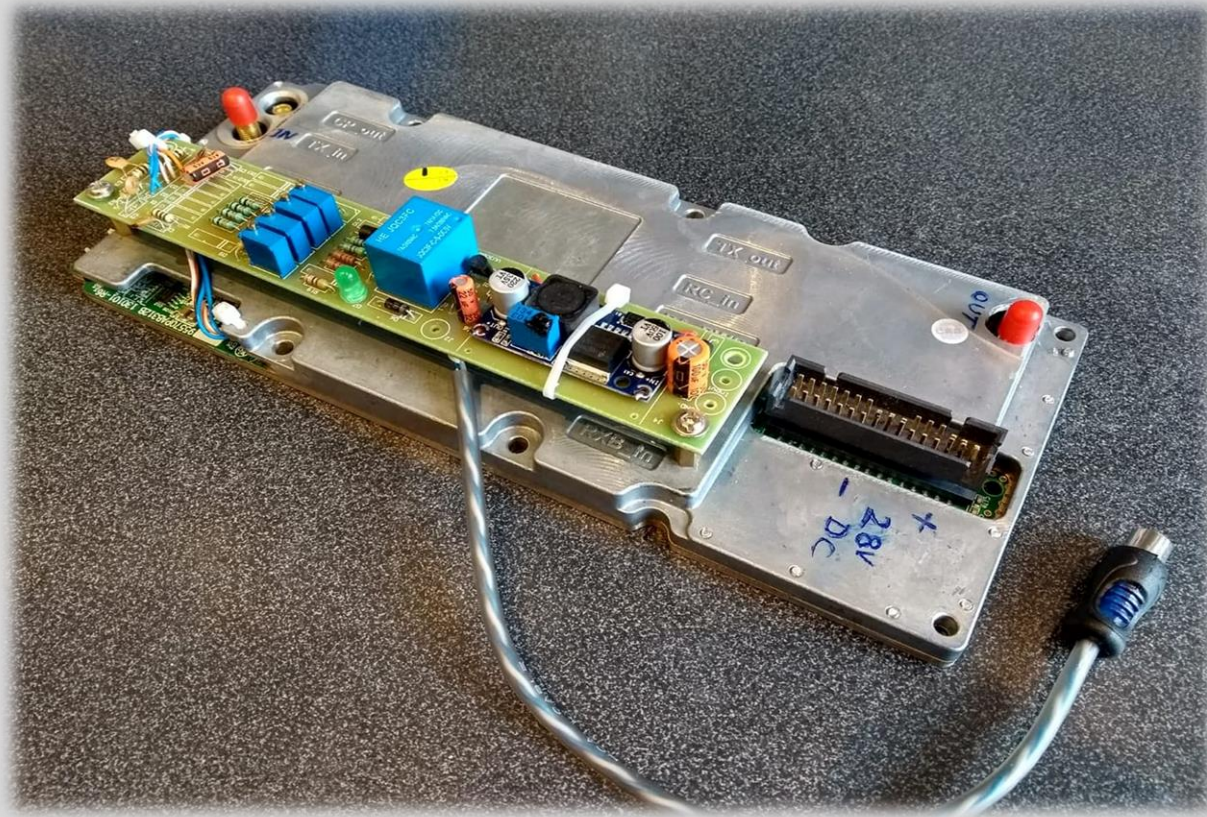


JDElektronik 2.4GHz PA 20W
Pout = 20W@24V / 10W@12V
Gp > 50dB – programmable attenuator
Pin = -20dBm ... +10dBm
Integrated SAW-Filter
RF-Vox & PTT-Input
Integrated detectors for FWD & REF Power

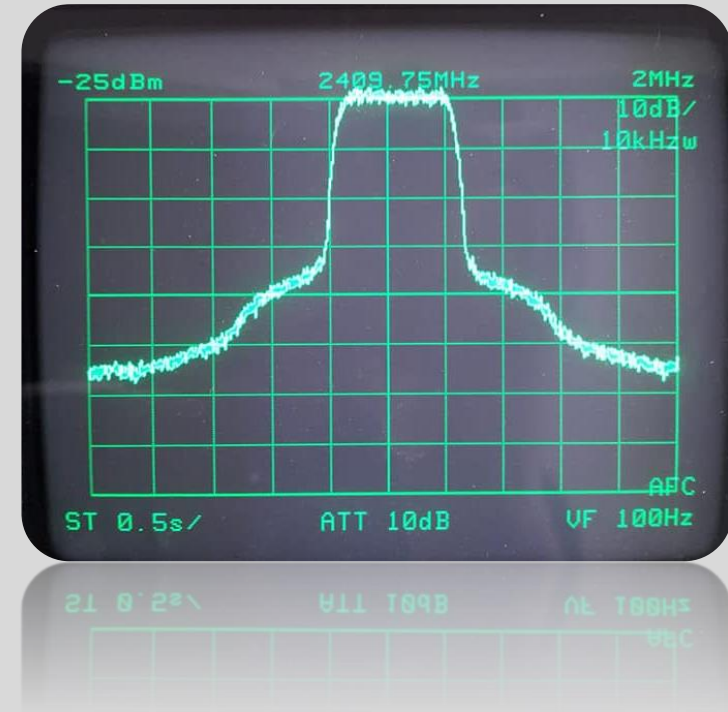
Price 200€

JDEelektronik Inh. J. Delvos
Müdenerstr. 59b
29345 Unterlüß
info@jdelektronik.de
Tel. +49 (0) 5827 416 9 309

PAs for QO-100



Surplus UMTS amplifier modified by ZS6YI

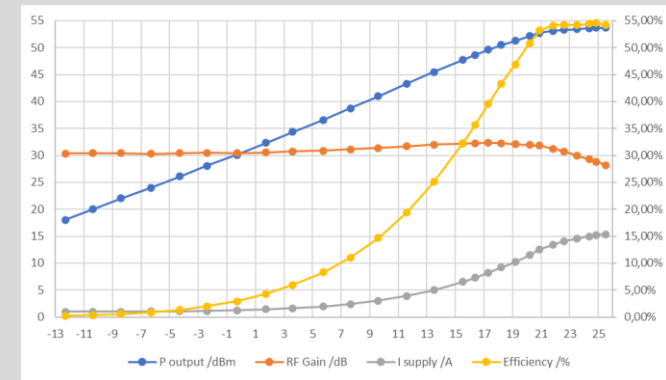
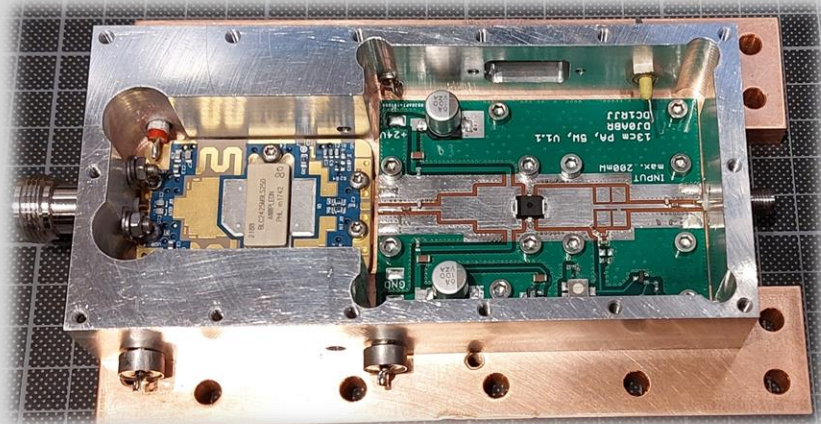


For DATV you need to backoff the PA typ. by 6dB to get good linearity (shoulders should be down -35dBc)

PAs for QO-100



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



Agenda

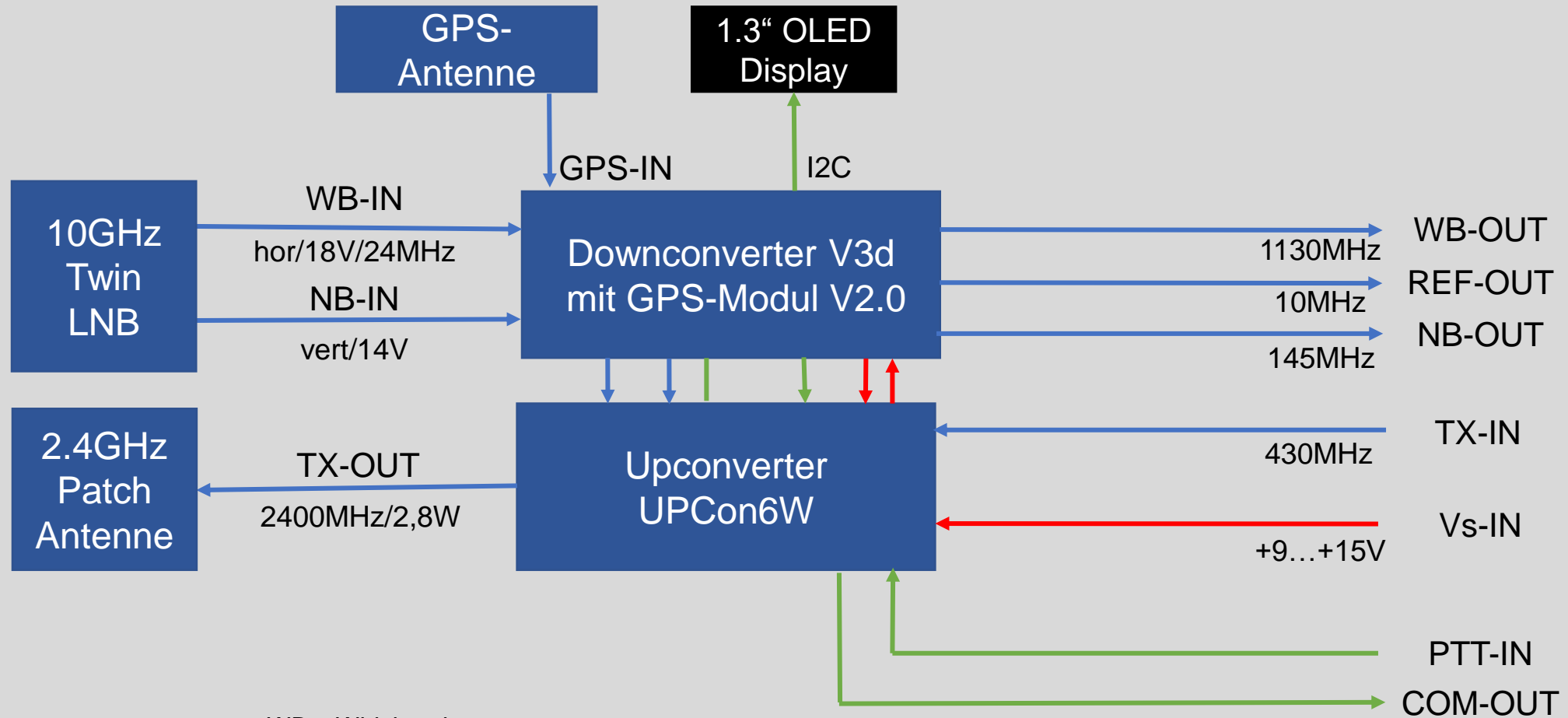
- QO-100 our first Phase-4 geostationary satellite (P4-A)
- QO-100 transponders
- QO-100 NB modes
- Antennas for QO-100
- Receive chain for the NB transponder
- Transmit chain for the NB transponder
- **Integration**
- SDR based solutions
- Activities on QO-100



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QO-100 transverter



WB = Wideband
NB = Narrowband

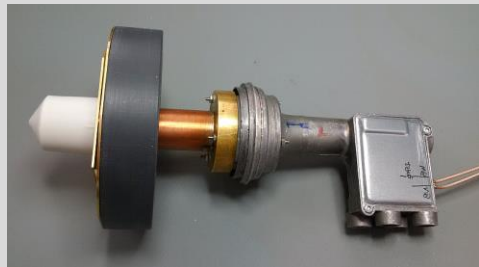
QO-100 portable station



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GPS-IN



WB-IN

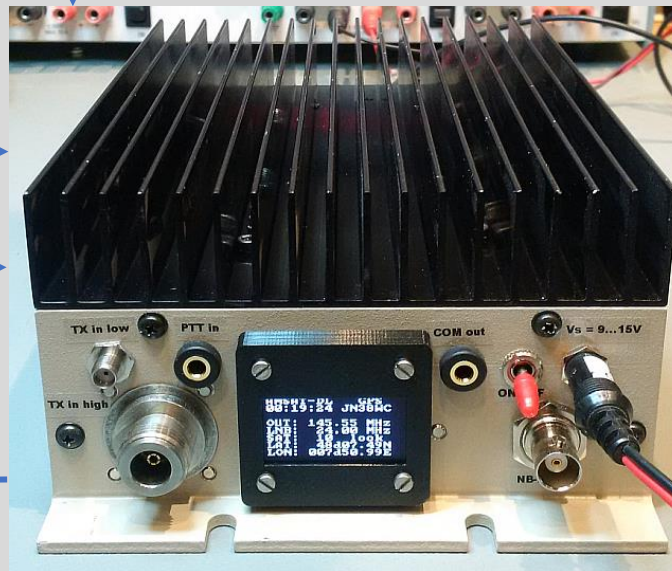
hor/18V/24MHz

NB-IN

vert/14V

TX-OUT

2400MHz/2,8W



1130MHz

WB-OUT

10MHz

REF-OUT

145MHz

NB-OUT

+9...+15V

Vs-IN

430MHz

TX-IN

PTT-IN

COM-OUT

QO-100 portable station



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60cm Kathrein offsetdish with AMSAT-DL transverter on feedarm

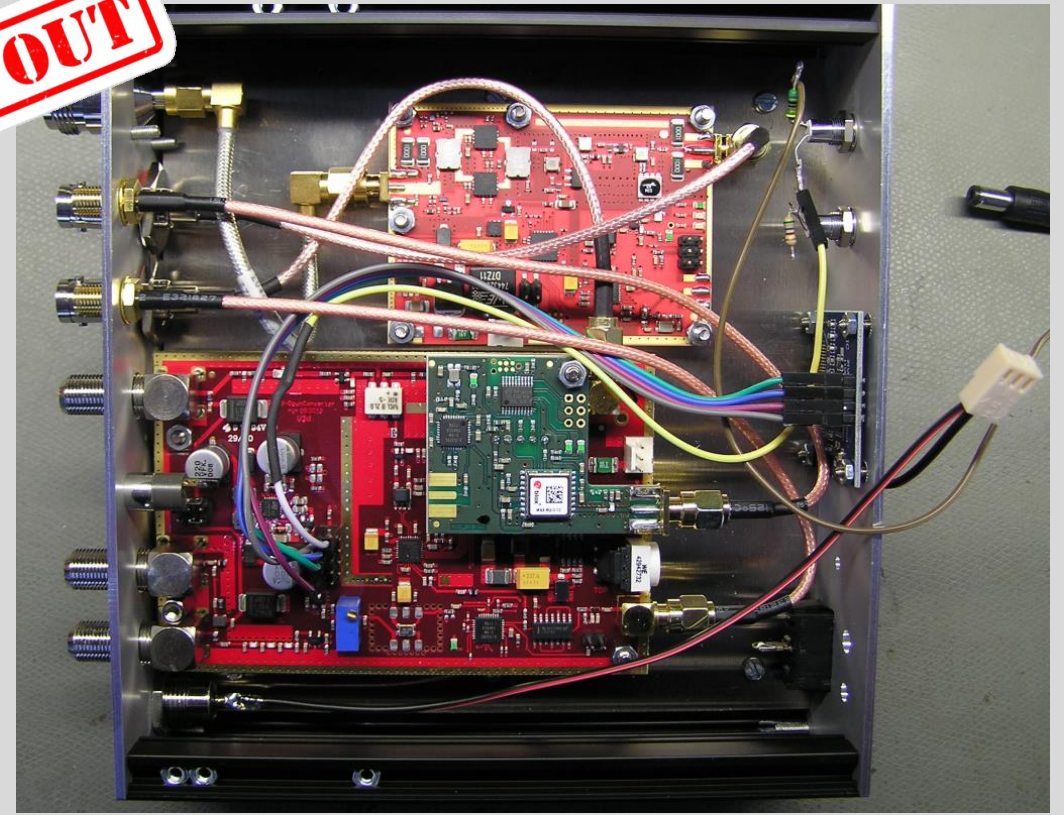
REF-IN → 10MHz
RX-IN → 145MHz
TX-OUT ← 430MHz



ICOM IC-9700 full duplex Allmode-TRX

← Vs-IN
+11,5...+15,0V
NF-OUT →
MIC-IN ←

QO-100 transverter



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

QO-100 transverter



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



QO-100 transverter



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



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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



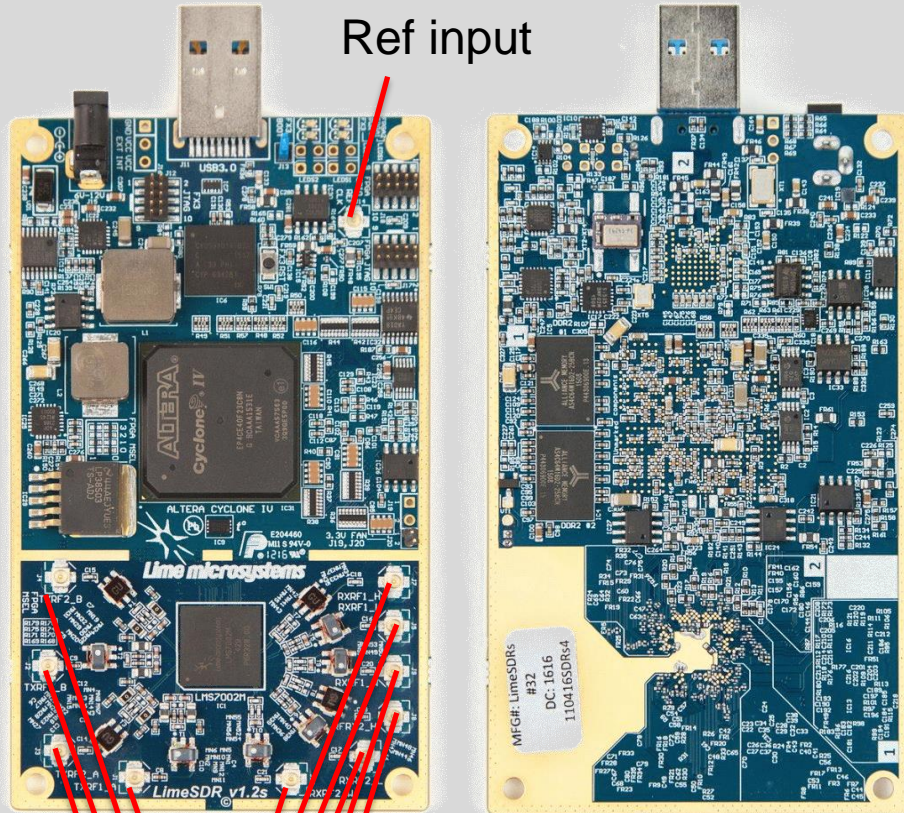
SDRplay



Airspy 2

LimeSDR TRX

SOLD OUT



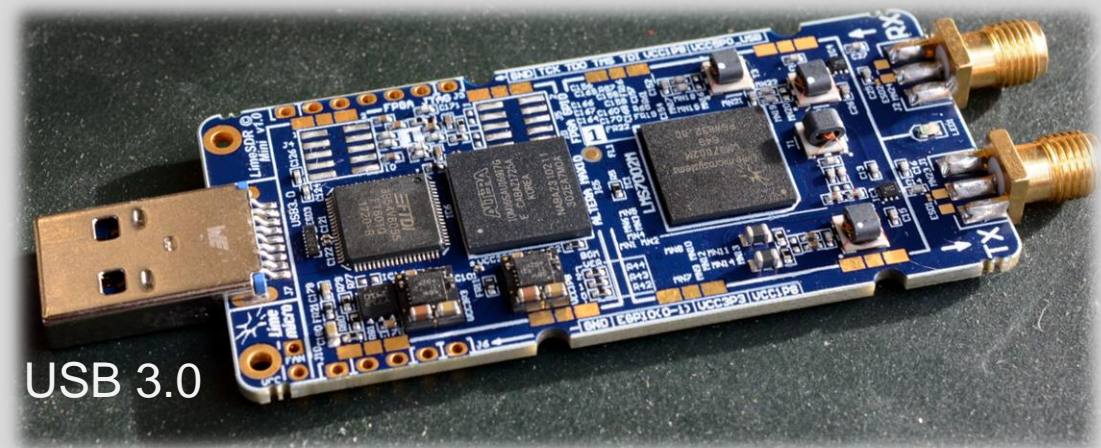
Ref input

USB 3.0

4x TX outputs
6x RX inputs

LimeSDR-USB

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



USB 3.0

1x RX

1x TX

LimeSDR-mini

Adalm Pluto SDR TRX

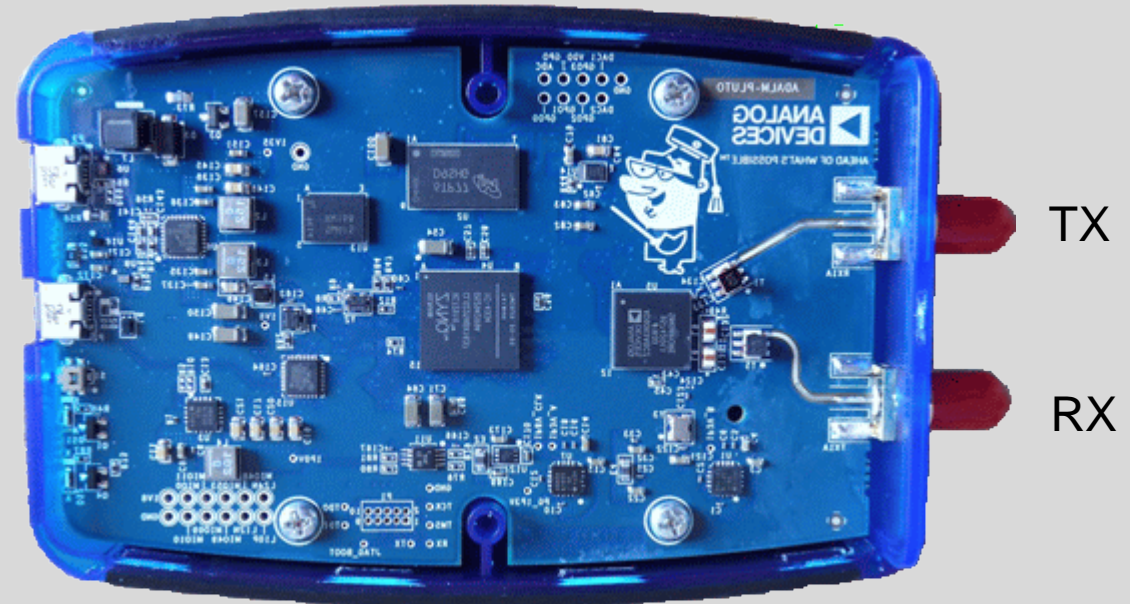
The Pluto SDR can be used up to 6 GHz for RX and TX



ADALM Pluto

USB 2.0

PWR



ADALM Pluto open

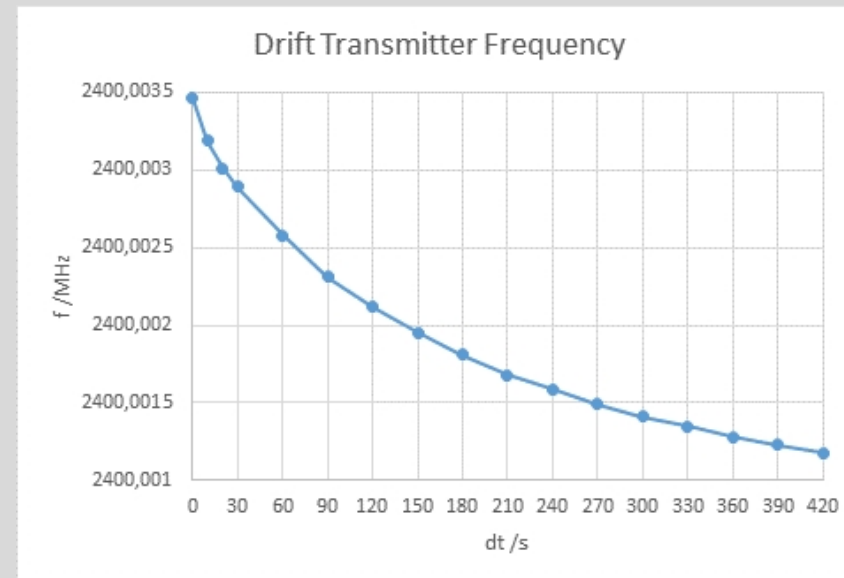
TX

RX

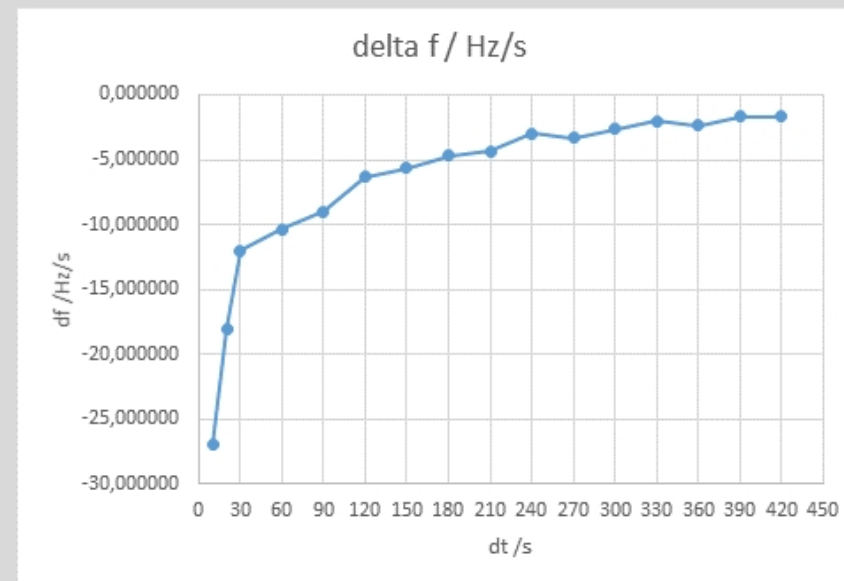
Adalm Pluto



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

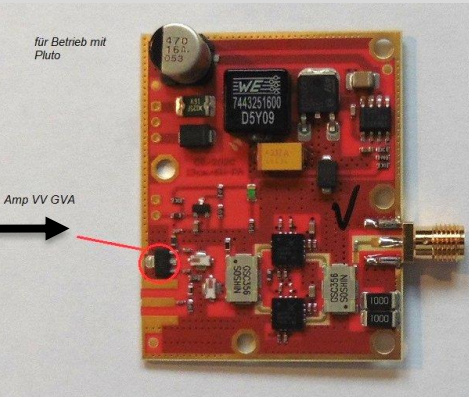
SDR

50 Ohm low loss
coaxial cable

1.2m dish
1.5turn helix
25MHz PLL LNB

Bias Tee
12Vdc

75 Ohm
coaxial cable



AMSAT-DL PA for SDR-TRX

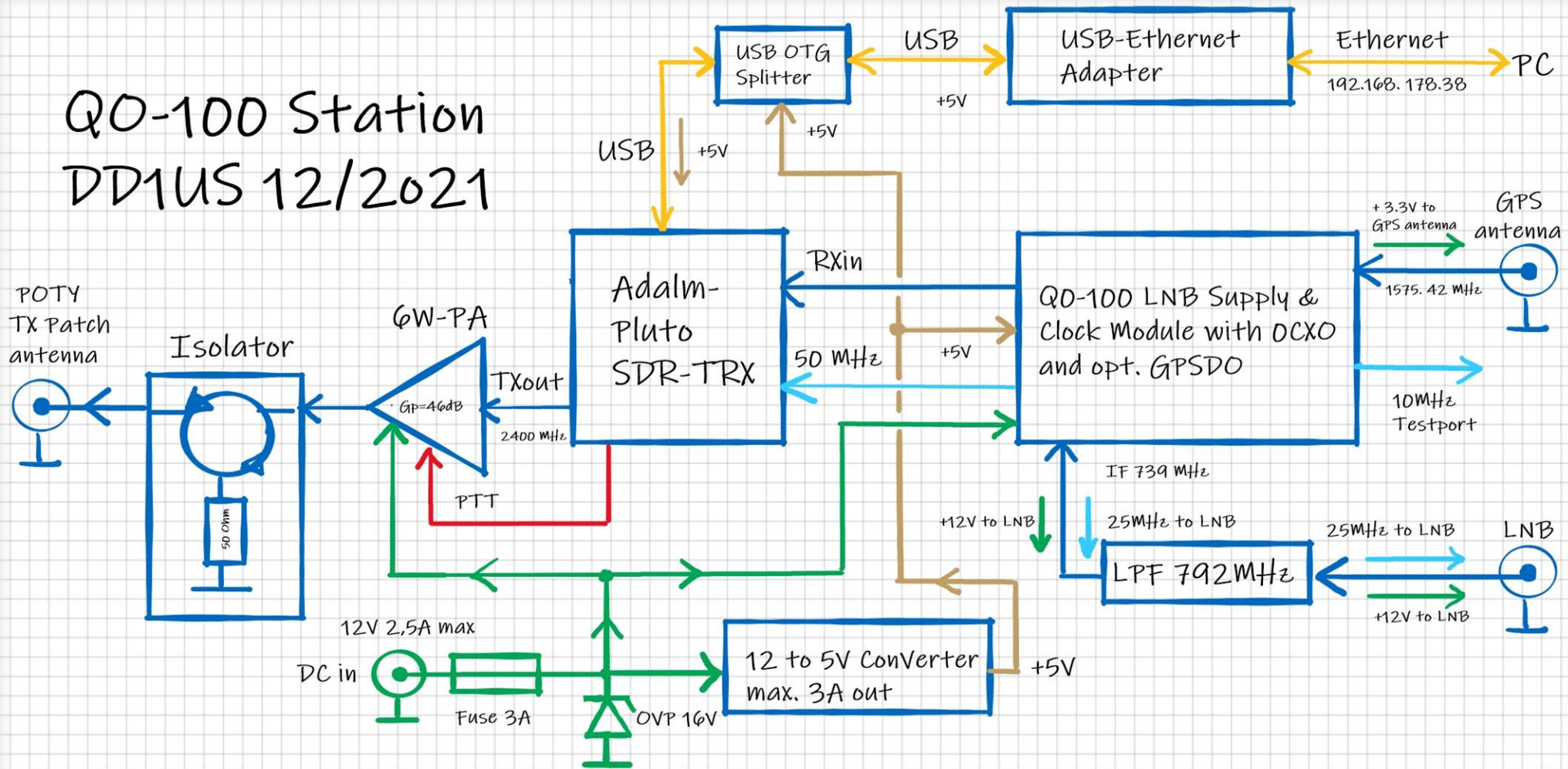
$G_p=46\text{dB}$

$P_{1\text{dB}}=35\text{dBm}$ (3W)

$P_{\text{sat}}=38\text{dBm}$ (6W)

Pluto based QO-100 portable station

QO-100 Station
DD1US 12/2021



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

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



Pluto based QO-100 portable station



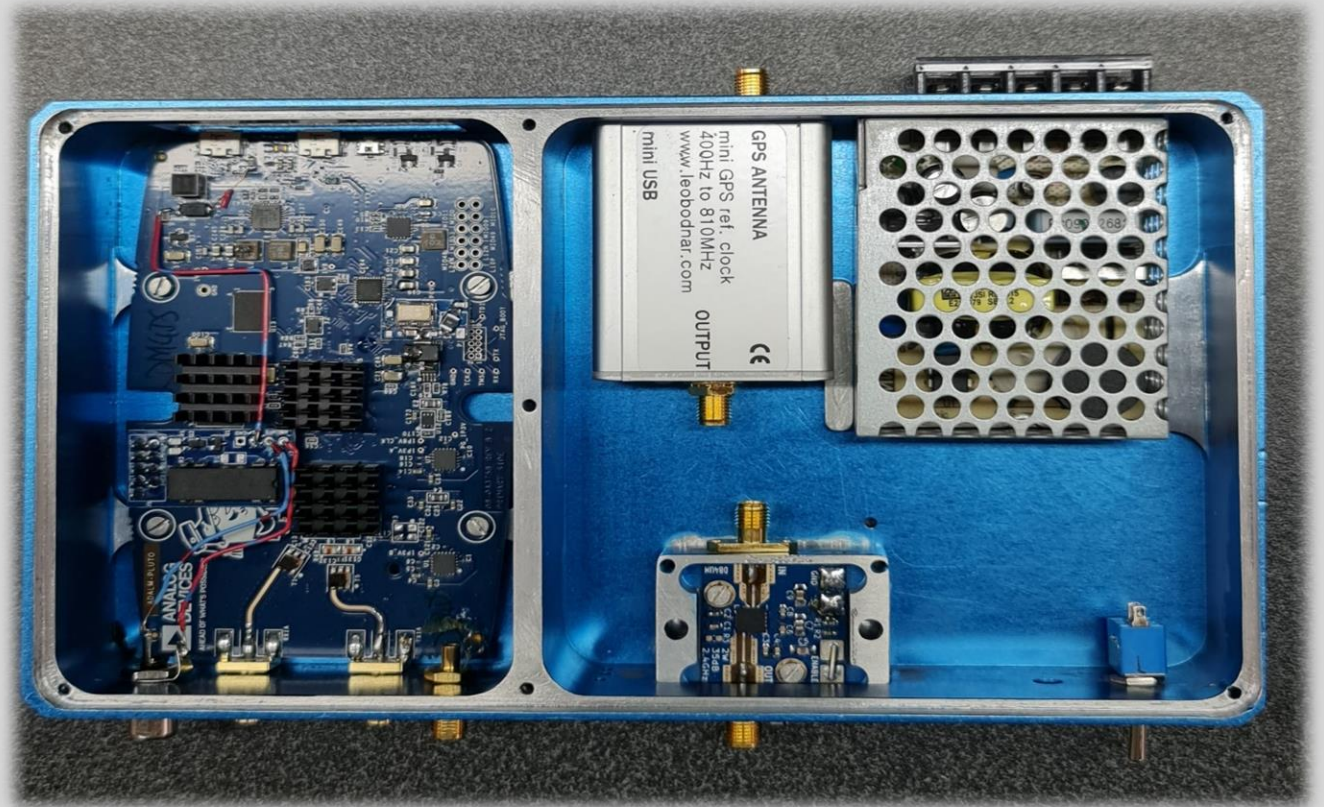
Source: DD1US

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



SDR-Console

The screenshot displays the SDR-Console v3.3 interface. At the top, a menu bar includes Home, View, Receive, Transmit, Rec/Playback, Favourites, Memories, Tools, and Help. Below the menu is a toolbar with various icons for radio control and utility functions. The main window is divided into several sections:

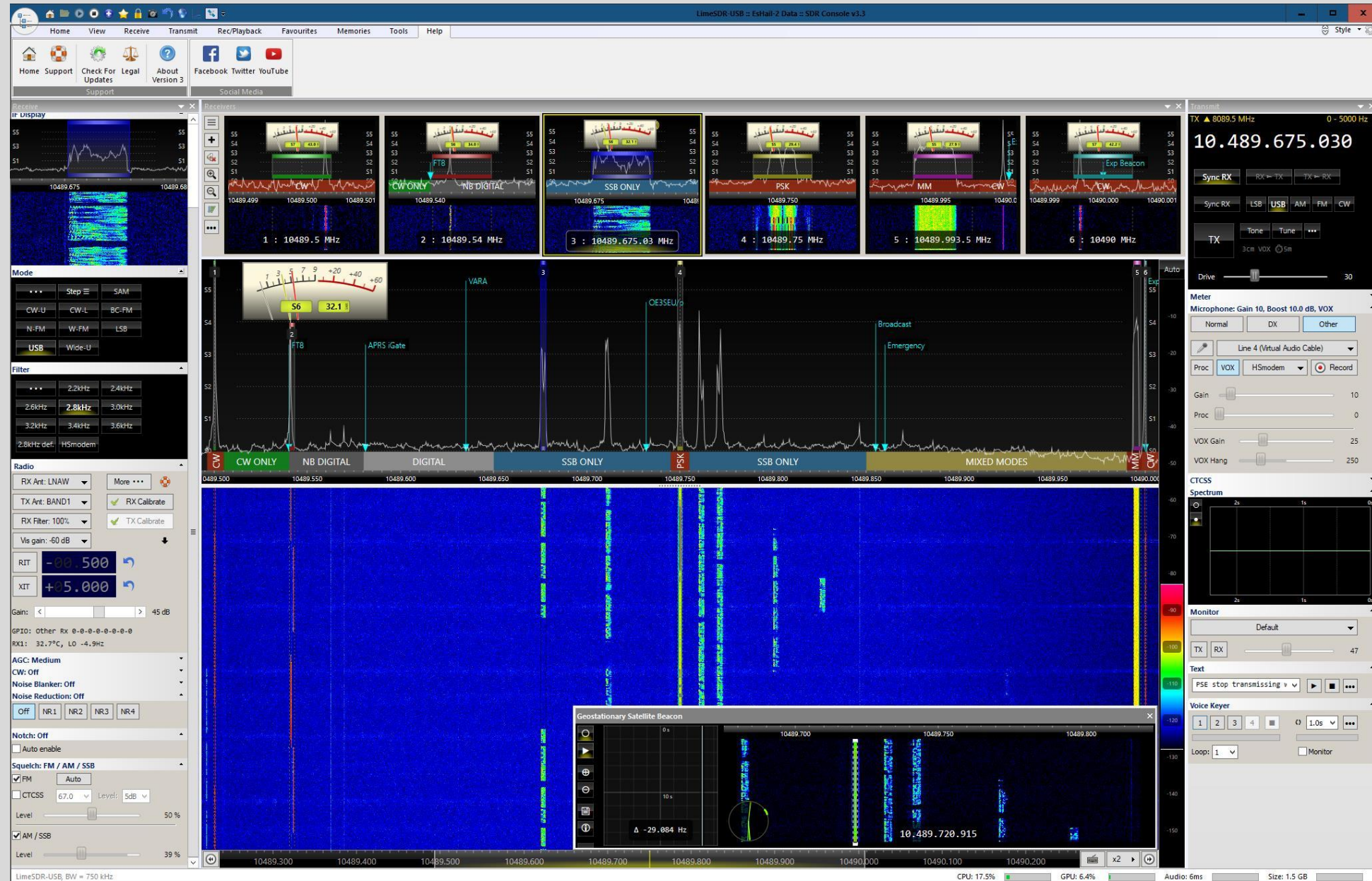
- Receivers:** A row of six receiver windows, each showing a frequency display and a spectrum plot. The frequencies are: 1: 10489.5 MHz, 2: 10489.54 MHz, 3: 10489.674.97 MHz (highlighted), 4: 10489.75 MHz, 5: 10489.993.5 MHz, and 6: 10490 MHz.
- Main Spectrum:** A large central spectrum display showing a wide range of frequencies from 10489.500 to 10490.000 MHz. It features a waterfall view with color-coded signal strength and various callouts for stations like FT8, APRS iGate, VARA, OE3SEU, and Emergency. A mode indicator at the bottom identifies different signal types: CW ONLY, NB DIGITAL, DIGITAL, SSB ONLY, and MIXED MODES.
- Transmit Panel:** Located on the right, it shows the TX frequency (10.489.674.970 MHz) and mode (USB). It includes controls for Sync RX, TX, and TX-RX, as well as a Drive level slider set to 86.
- Meter and Settings:** A section on the right side contains a microphone gain control (34), a processor (Proc 10), and various other settings like VOX Gain (30) and VOX Hang (820).
- Monitor:** A small window at the bottom right shows a spectrum plot with a 2s scale.

At the bottom of the interface, system status information is displayed: CPU: 9.1%, GPU: 5.6%, Audio: 0ms, and Size: 1.5 GB.

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

Also supports analog radios with up- and downconverters.

SDR-Console

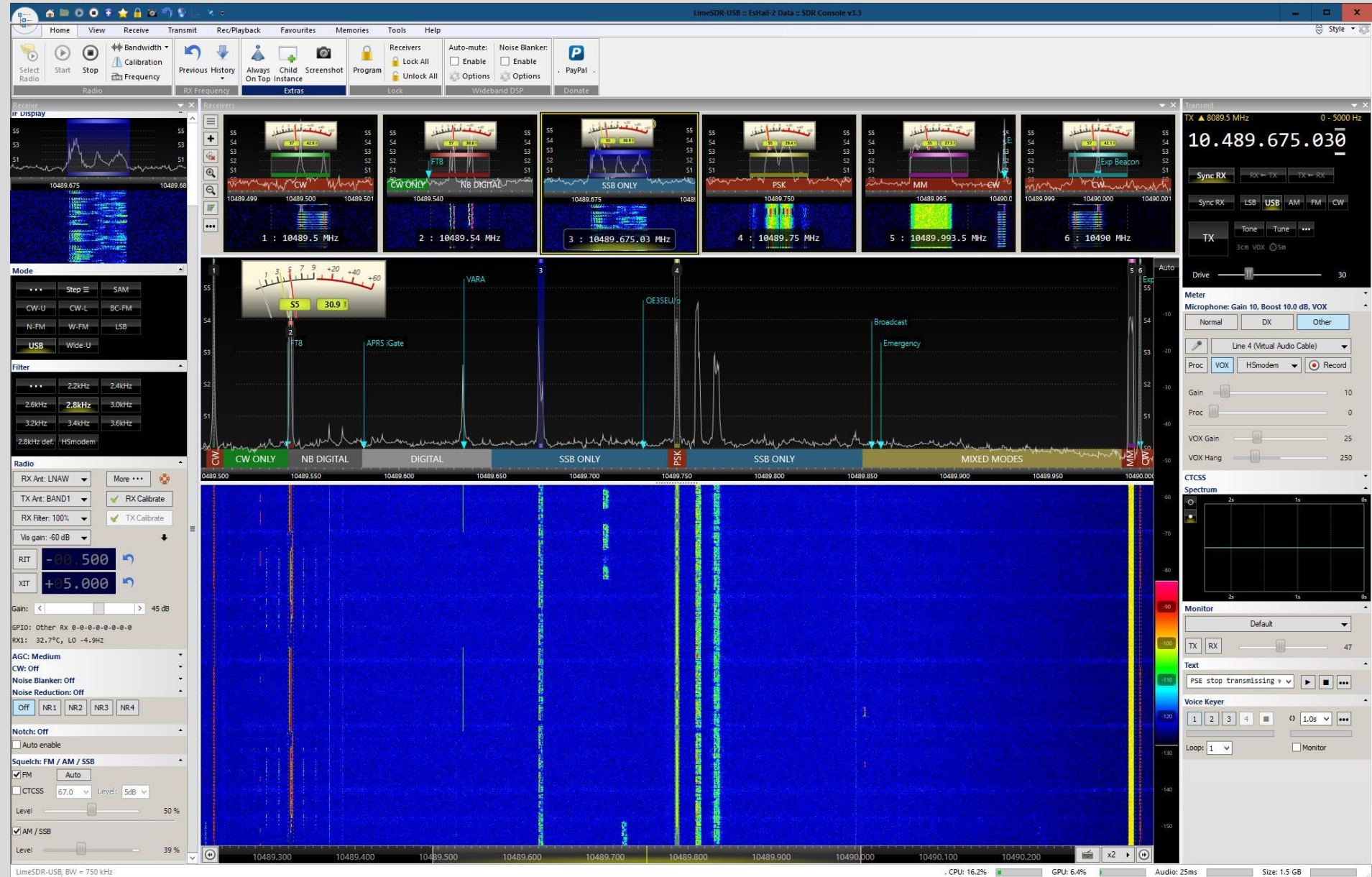


Locking the receiver to the PSK beacon eliminates the drift of a unmodified PLL-LNB.

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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QO-100 activities



EA2AA **149 DXCCs** (of activated 150)

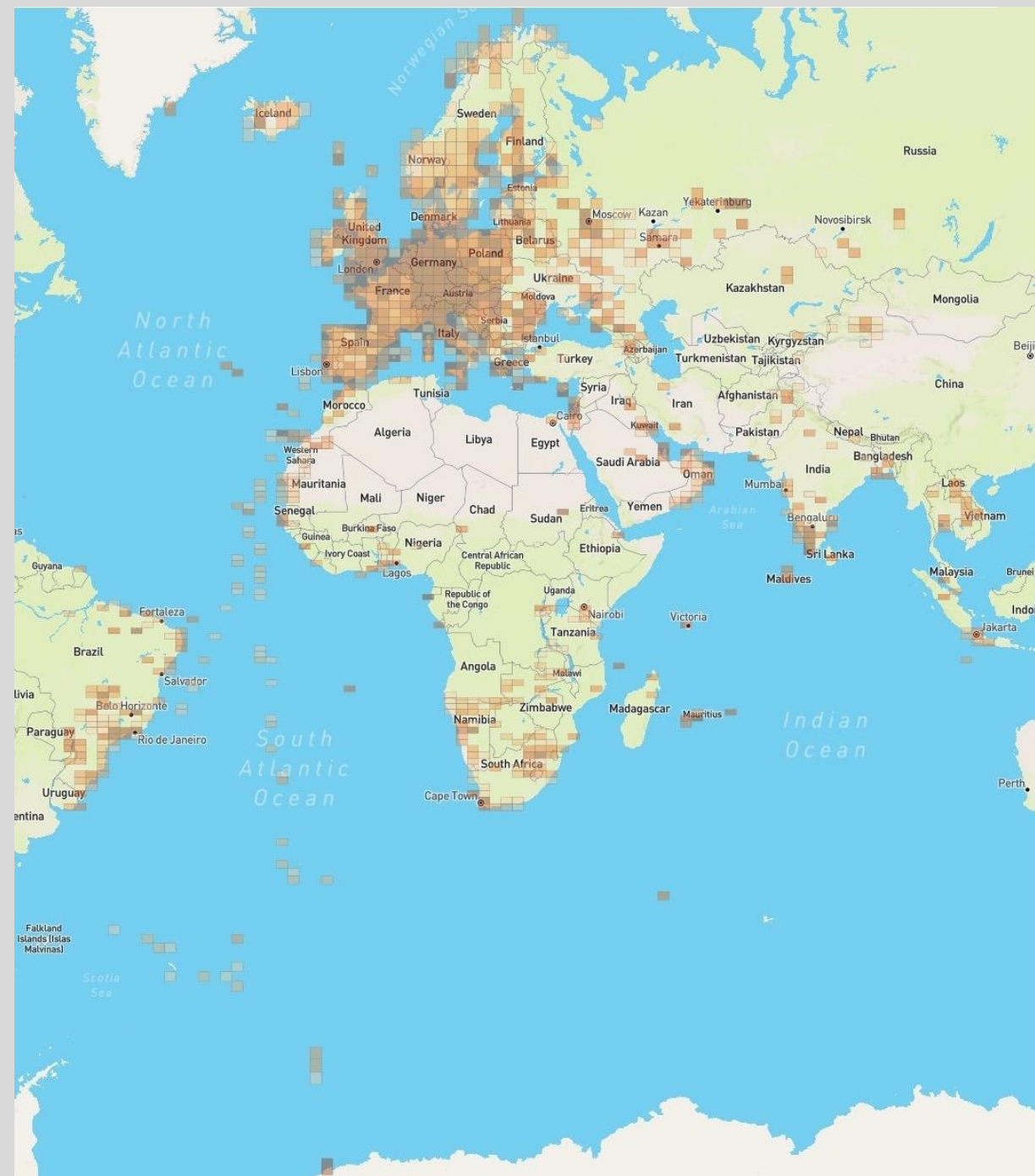
PE1CMO **865 VUCC-Grids**

DL2GRC **1st WAC**

PP2RON **2932 initials**

OE5VLL **10125 QSOs**

Status: March 21st 2023





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

www.dd1us.de



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