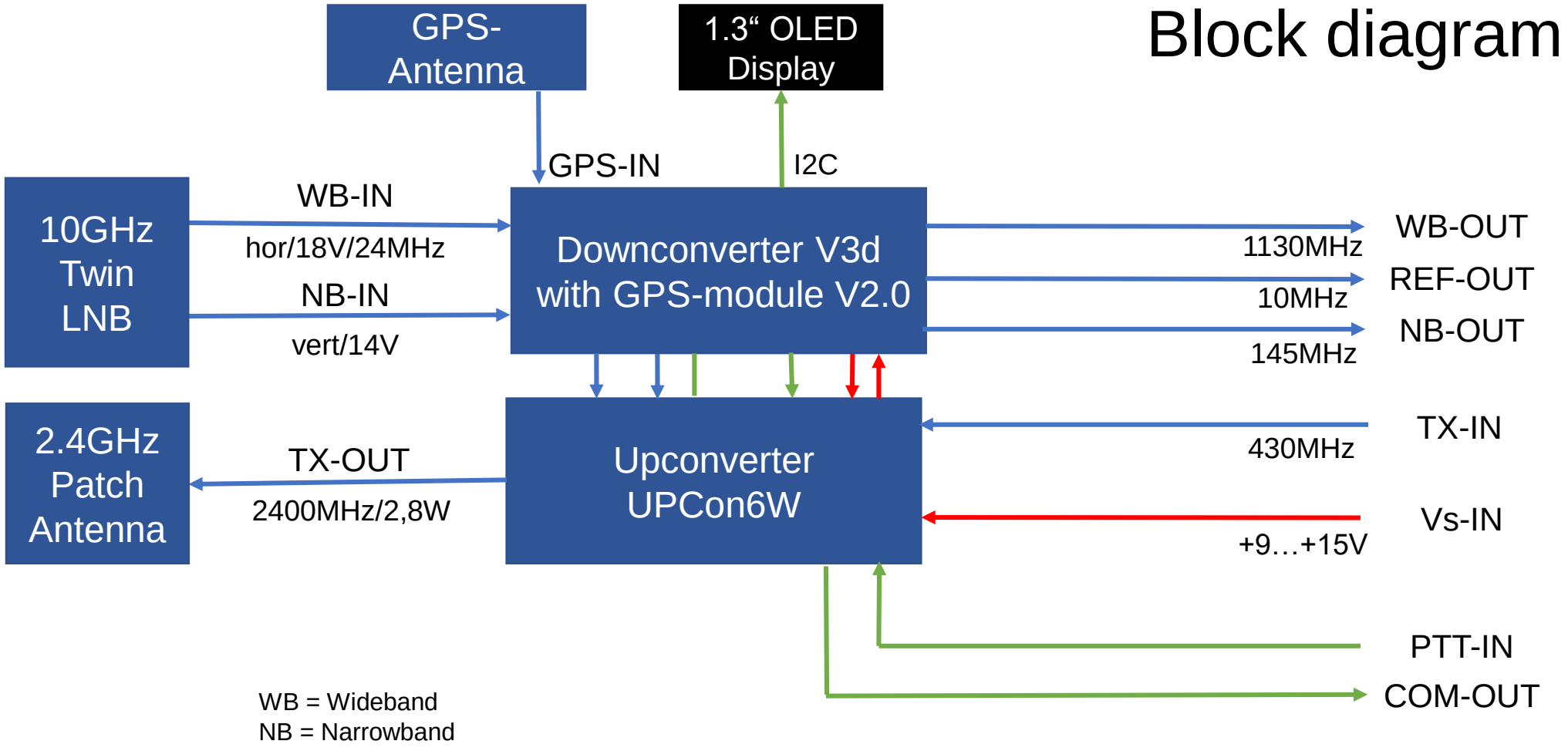
Portable station for QO-100 based on the modules of AMSAT-DL

September 26th 2020

Matthias Bopp

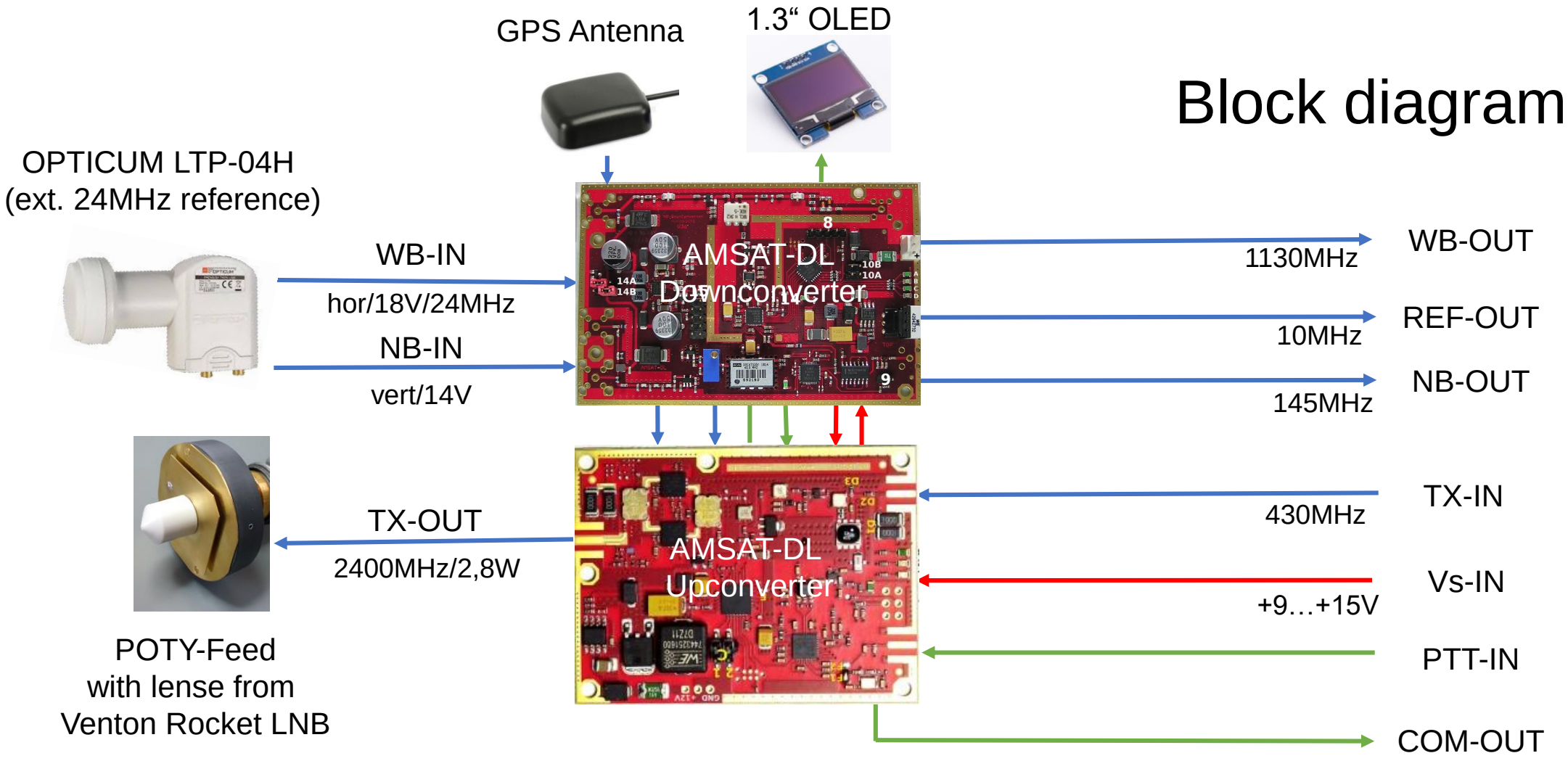
DD1US

Block diagram



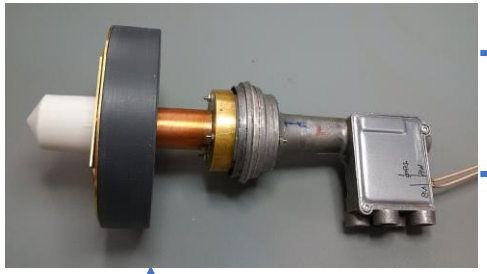
WB = Wideband
NB = Narrowband

Block diagram



QO-100 transverter

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

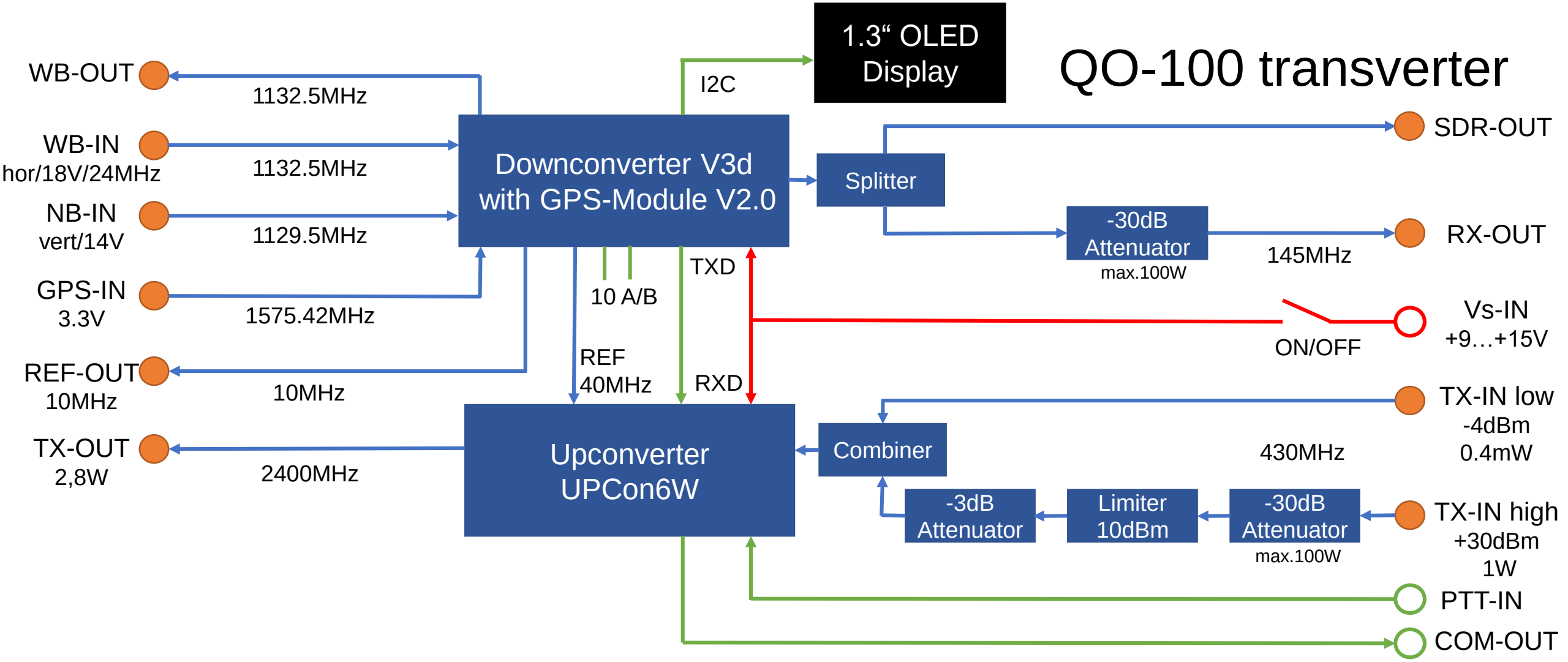
TX-IN

430MHz

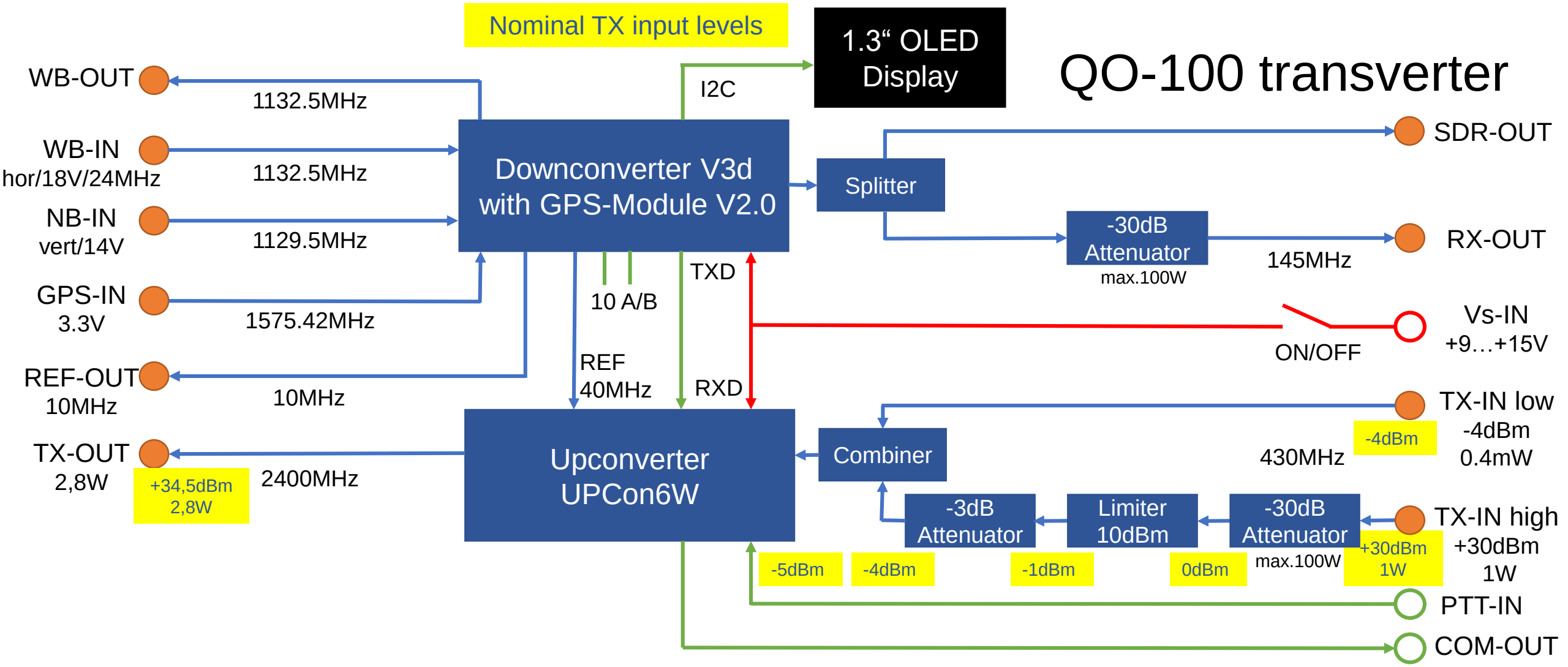
PTT-IN

COM-OUT

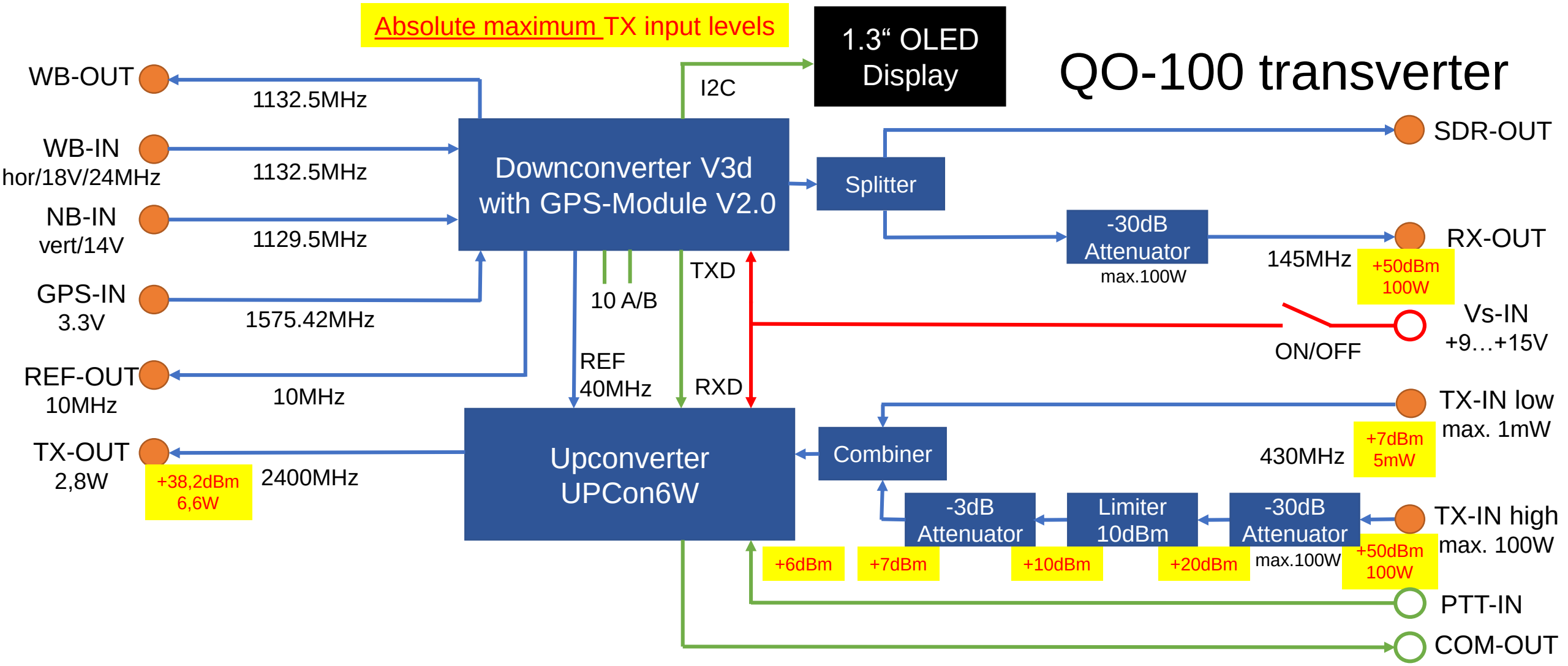
Portable Station for QO-100 based on the modules of AMSAT-DL

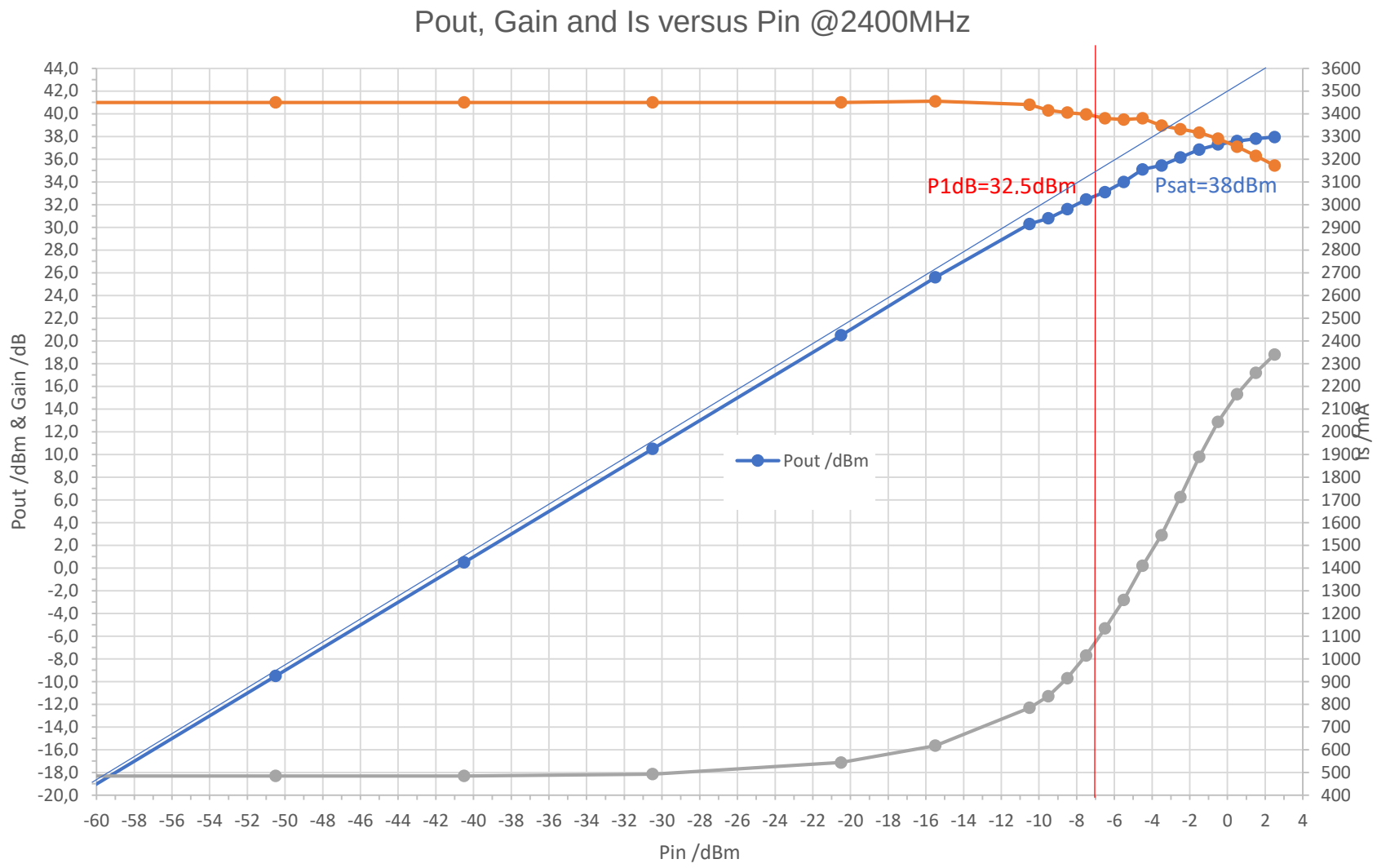


Portable Station for QO-100 based on the modules of AMSAT-DL



Portable Station for QO-100 based on the modules of AMSAT-DL





QO-100 upconverter

TX-path with modified input attenuator*:

P_{in} @f_{in} = 430MHz,TX-IN low

P_{out} @f_{out} = 2400MHz,TX-OUT

V_s = 12V
I_s = complete transverter

*** The original PI-type input attenuator in the upconverter with an attenuation of 25dB was replaced by 3 dB attenuator.**

Pin /dBm	Pout /dBm	Pout /mW	Gain /dB	Is /mA	Pdc /W	Efficiency η /%
-60,5	-19,5	0,01	41,0	485	5,8	0,000
-50,5	-9,5	0,11	41,0	485	5,8	0,002
-40,5	0,5	1,12	41,0	485	5,8	0,02
-30,5	10,5	11,22	41,0	493	5,9	0,19
-20,5	20,5	112	41,0	544	6,5	1,72
-15,5	25,6	363	41,1	618	7,4	4,90
-10,5	30,3	1072	40,8	785	9,4	11,4
-9,5	30,8	1202	40,3	836	10,0	12,0
-8,5	31,6	1445	40,1	915	11,0	13,2
-7,5	32,5	1758	40,0	1015	12,2	14,4
-6,5	33,1	2042	39,6	1134	15,1	13,5
-5,5	34,0	2512	39,5	1260	16,9	14,8
-4,5	35,1	3236	39,6	1410	18,5	17,5
-3,5	35,5	3508	39,0	1545	20,6	17,1
-2,5	36,2	4121	38,7	1713	22,7	18,2
-1,5	36,9	4842	38,4	1890	24,5	19,7
-0,5	37,3	5370	37,8	2044	26,0	20,7
0,5	37,6	5754	37,1	2165	26,0	22,1
1,5	37,8	6026	36,3	2260	27,1	22,2
2,5	38,0	6237	35,5	2340	28,1	22,2

QO-100 upconverter

TX-path with modified input attenuator*:

P_{in} @f_{in} = 430MHz,TX-IN low

P_{out} @f_{out} = 2400MHz,TX-OUT

V_s = 12V
I_s = complete transverter

*** The original PI-type input attenuator in the upconverter with an attenuation of 25dB was replaced by 3 dB attenuator.**

QO-100 transverter

Elements on the front panel:

TX-IN low: 70cm ZF input from a SDR (0,25mW)

TX-IN high: 70cm ZF input from a TRX (1W)

PTT in: Input transmitter keying

OLED display: display time in UTC, QTH locator from GPS data, IF-IF, reference frequency for LNB, number of GPS satellites currently received, QTH latitude and longitude

COM out: Serial output for displaying various operating parameters on a remote display

ON/OFF: On/Off switch

NB-IF out: 2m ZF output to (T)RX

Vs: +9...+15V DC voltage supply input

QO-100 transverter

Elements on the backside:

WB-IN: signal from LNB (~1132 MHz), wideband transponder, hor. polarized, also output of the 24MHz ref. signal for LNB and 18V LNB remote power supply voltage

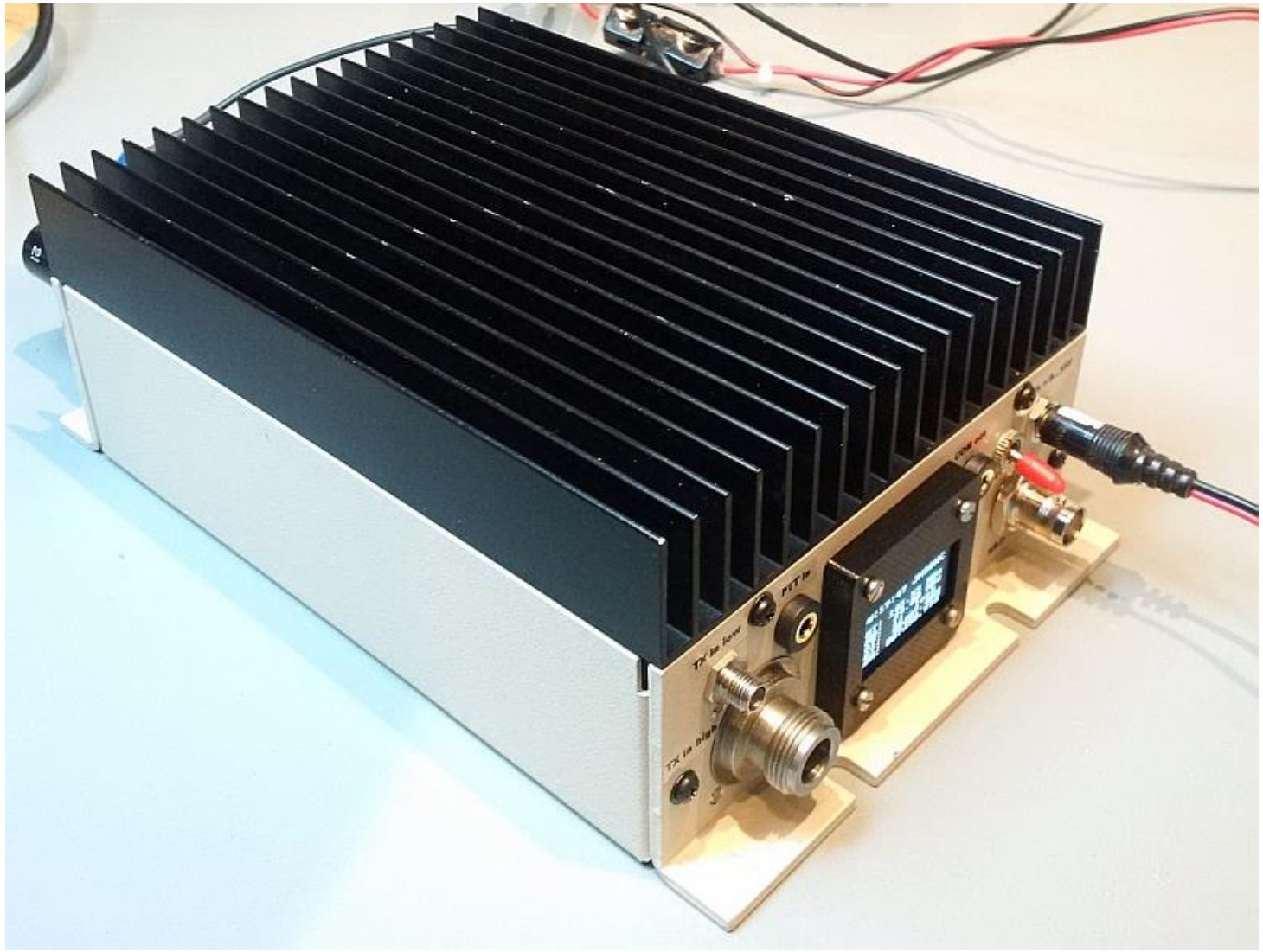
WB-IF out: signal of the wideband transponder (from WB-IN) looped through for DATV receiver

NB-IN: signal from LNB (~1129 MHz), narrow band transponder, vertically polarized, also 14V LNB remote supply voltage

GPS Ant: Signal from active GPS antenna, also 3.3V remote power supply for GPS antenna

10MHz out: 10MHz reference frequency output for TRX (e.g. IC-9700 transceiver)

2.4GHz out: Output for transmission signal to POTY antenna



QO-100 transverter

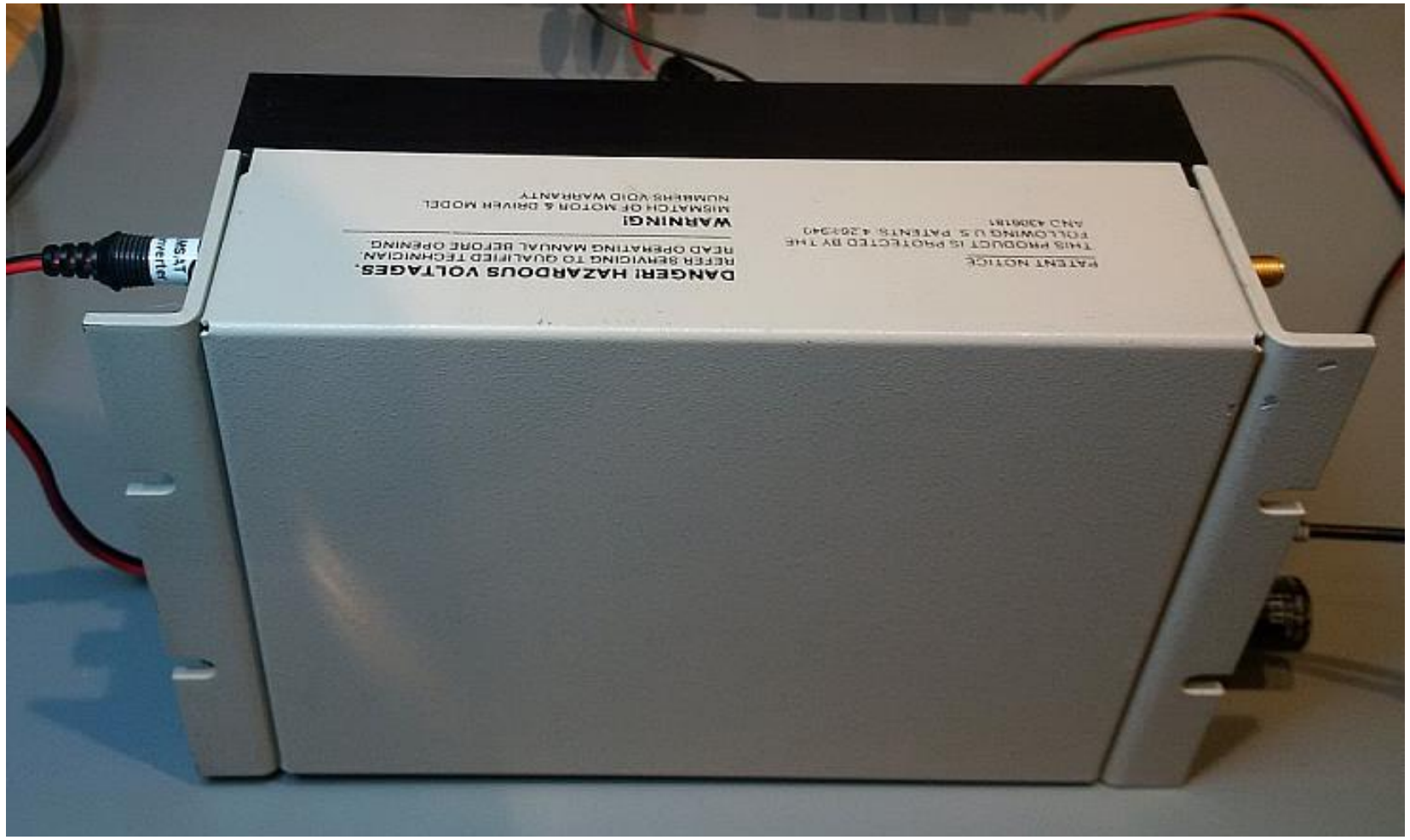
A rugged surplus housing with integrated heat sink is used.

The large heat sink allows the avoidance of active cooling (no fan needed).

QO-100 transverter

AMSAT-DL transverter ready mounted on the feed arm of the dish.

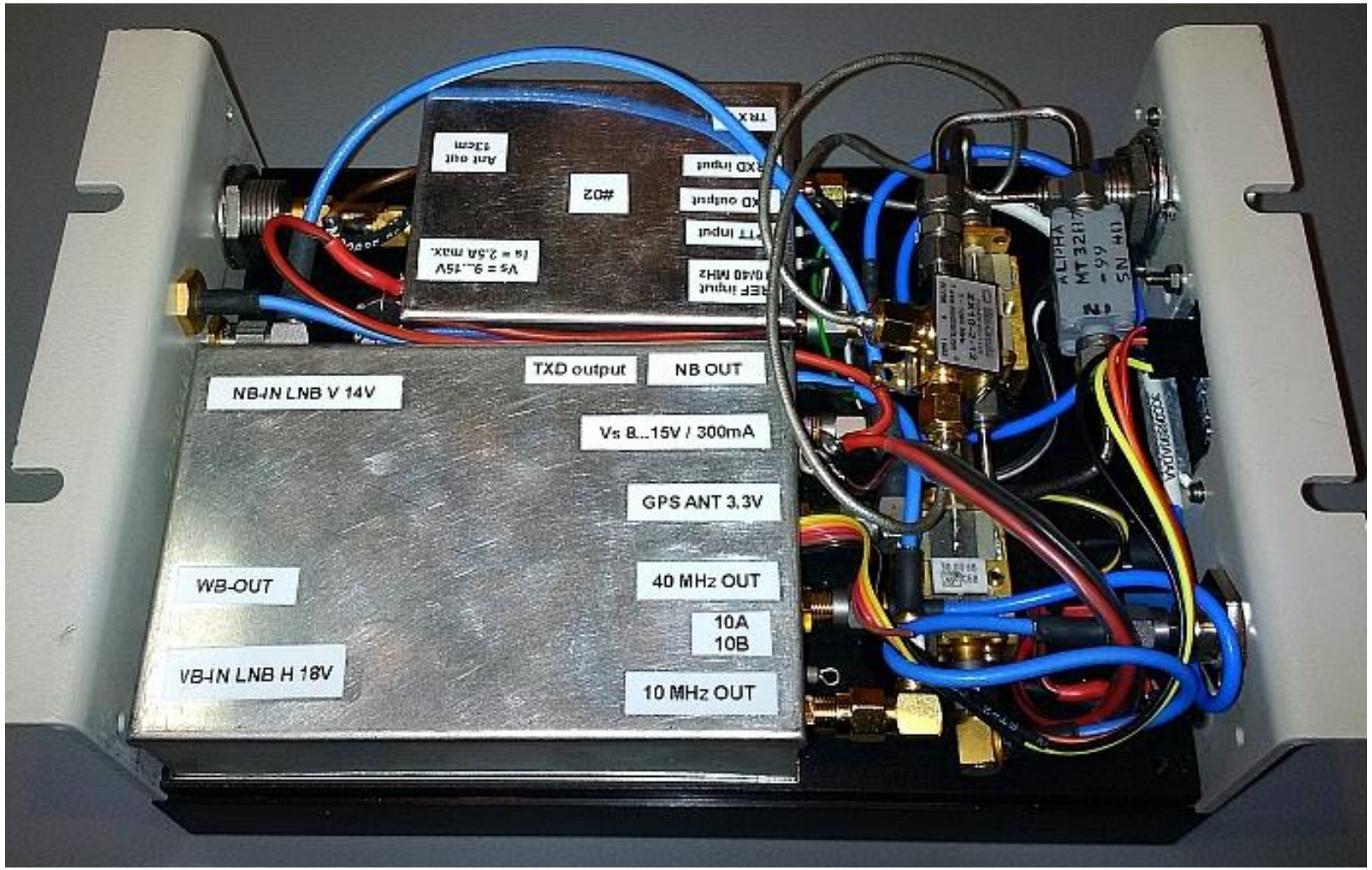
In this picture both inputs and both outputs (low power and higher power) are shown.



QO-100 transverter

The front and rear sides are screwed to the top heat sink.

The bottom part with the side panels can be easily removed to gain access to the assemblies.

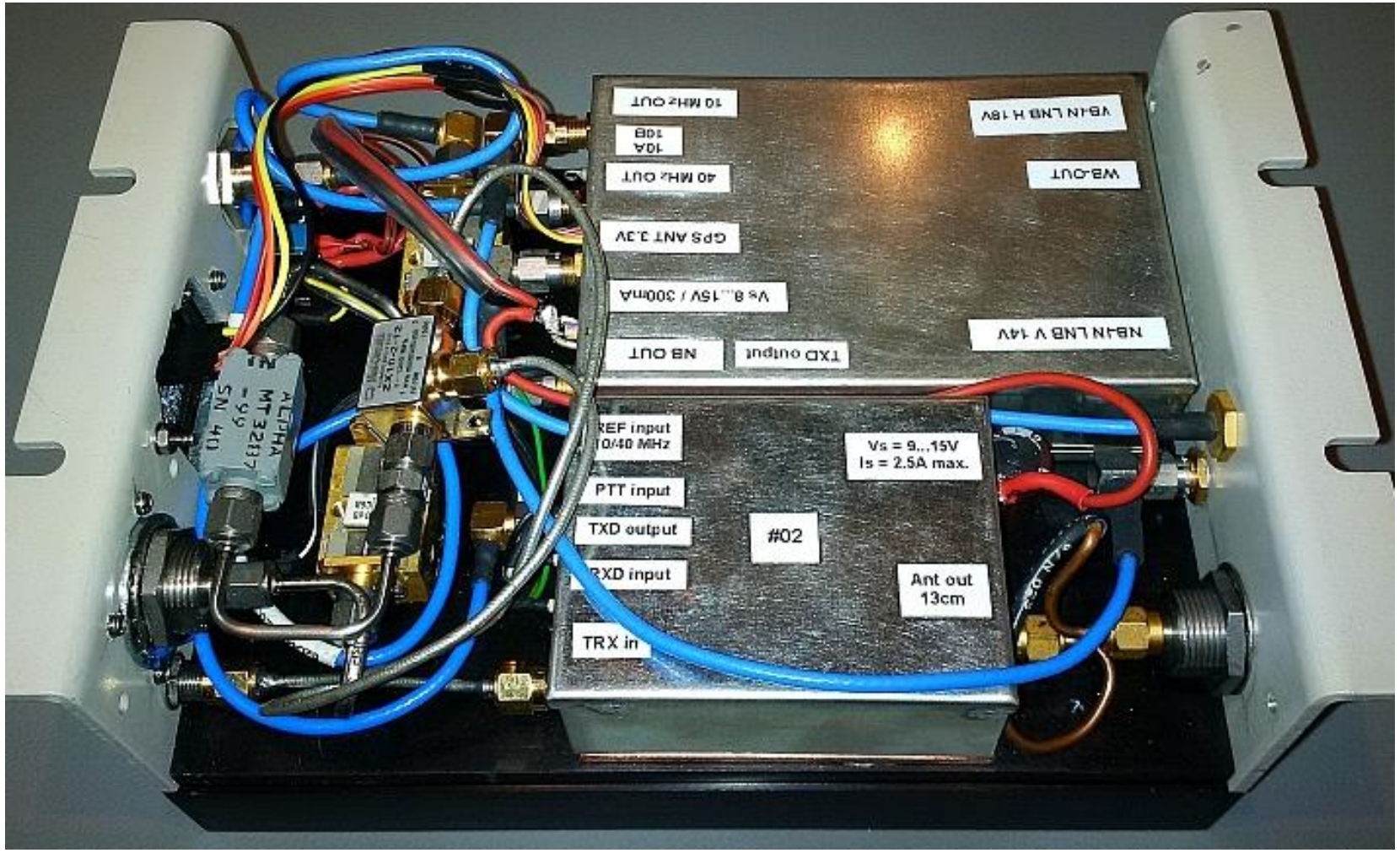


QO-100 transverter

The assemblies hang on the heat sink located at the top.

Upconverter (above) and downconverter (below) are shielded in tin plate housings.

On the right:
power attenuators, limiter, power splitters.

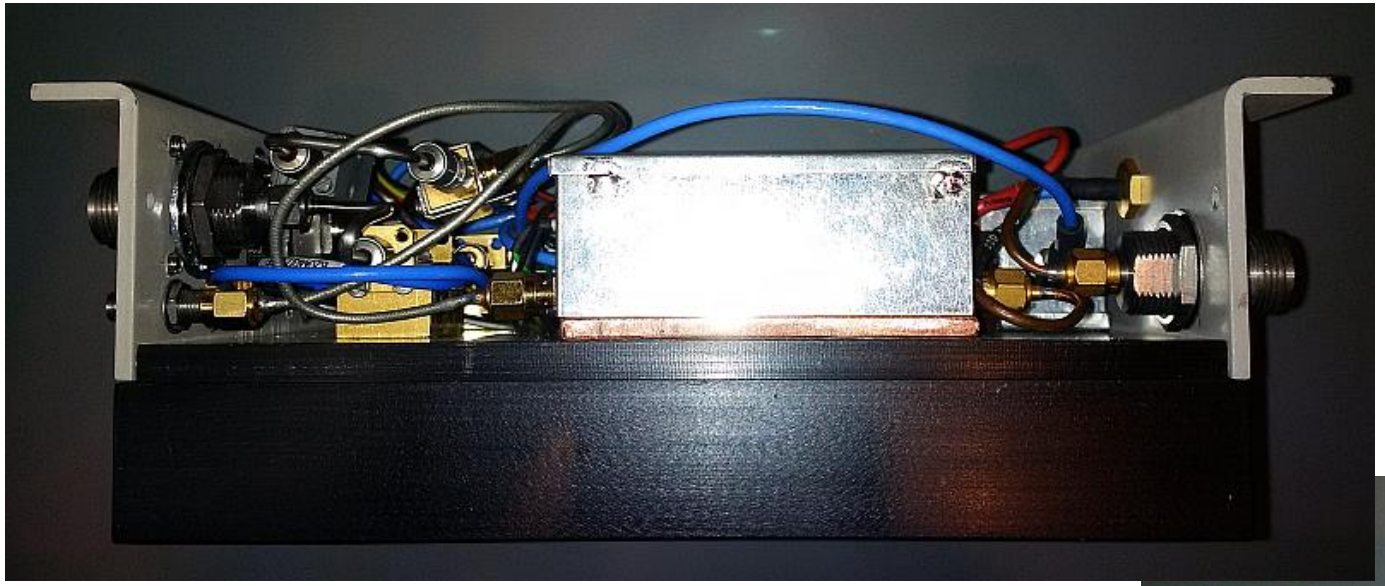


QO-100 transverter

The assemblies hang on the heat sink located at the top.

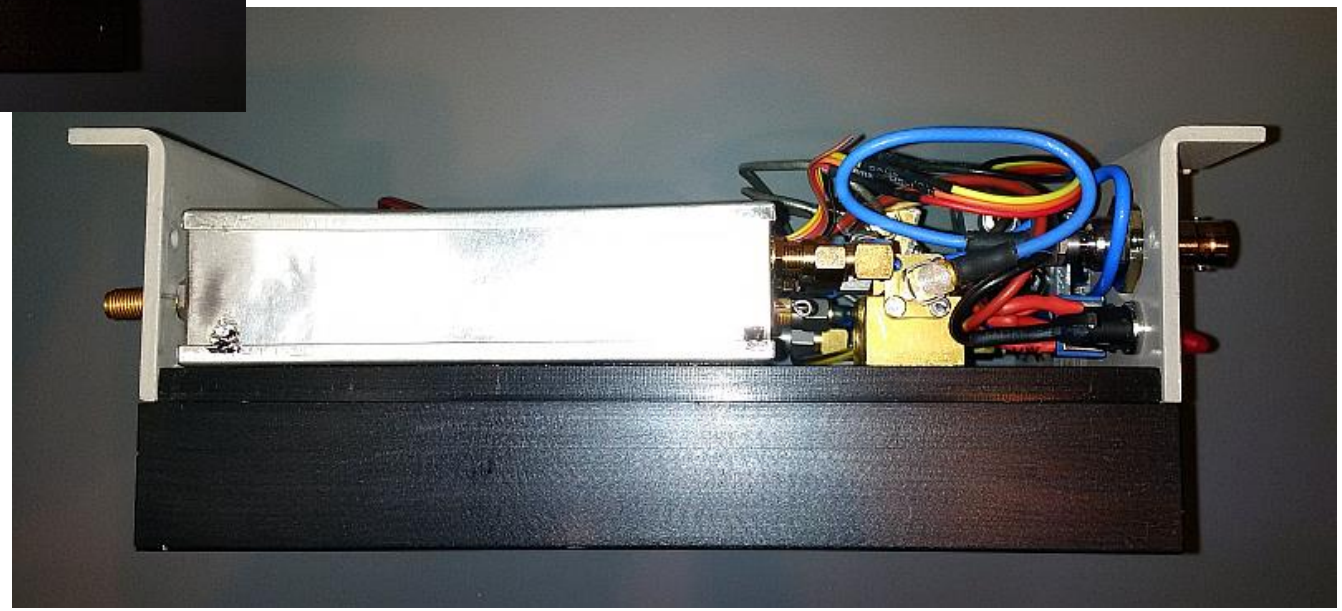
Downconverter (above) and upconverter (below) are shielded in tin plate housings.

On the left:
power attenuators, limiter, power splitters.

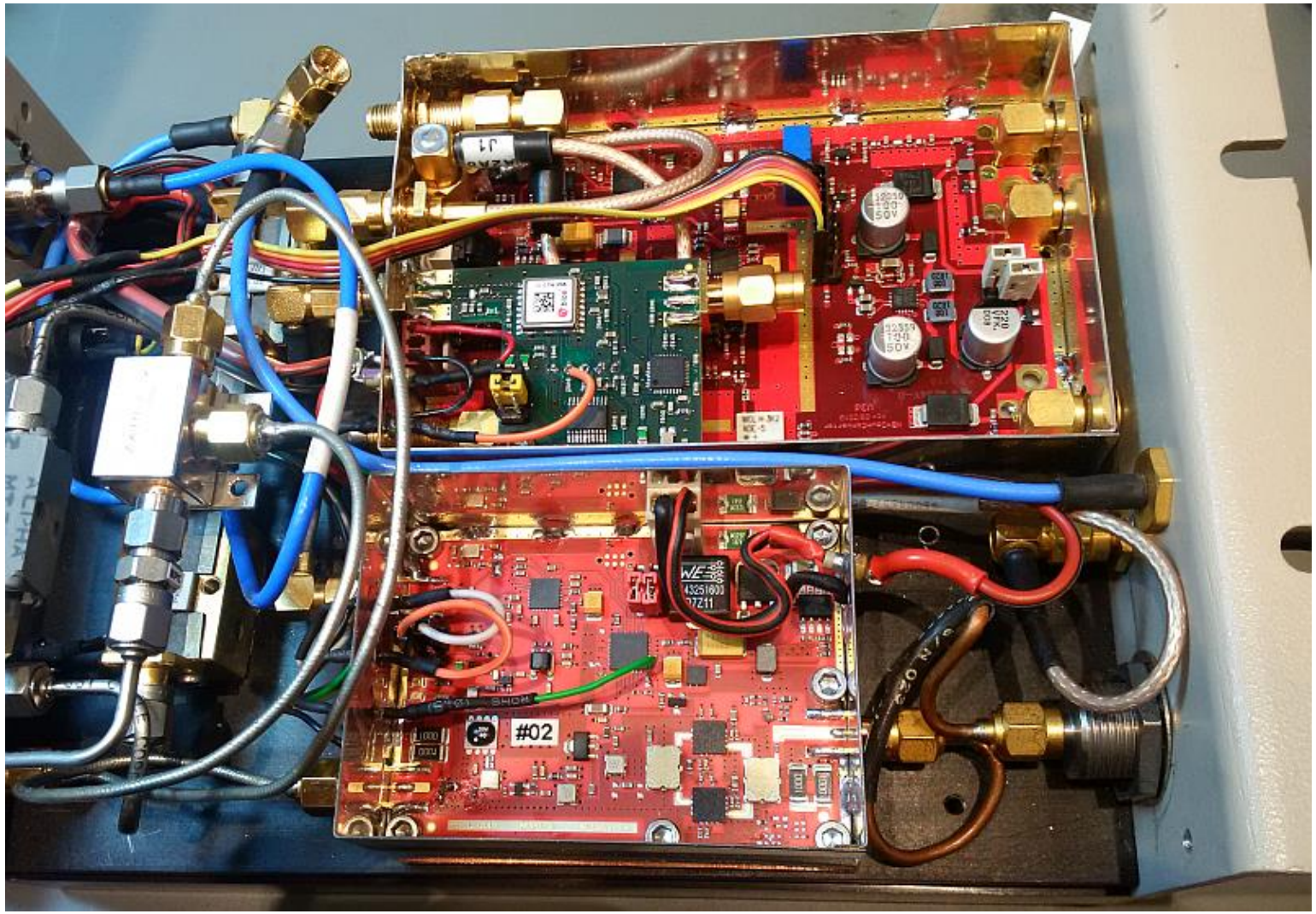


QO-100 transverter

The upconverter is mounted on a copper plate for optimised heat dissipation, which in turn is screwed to the aluminium heat sink.



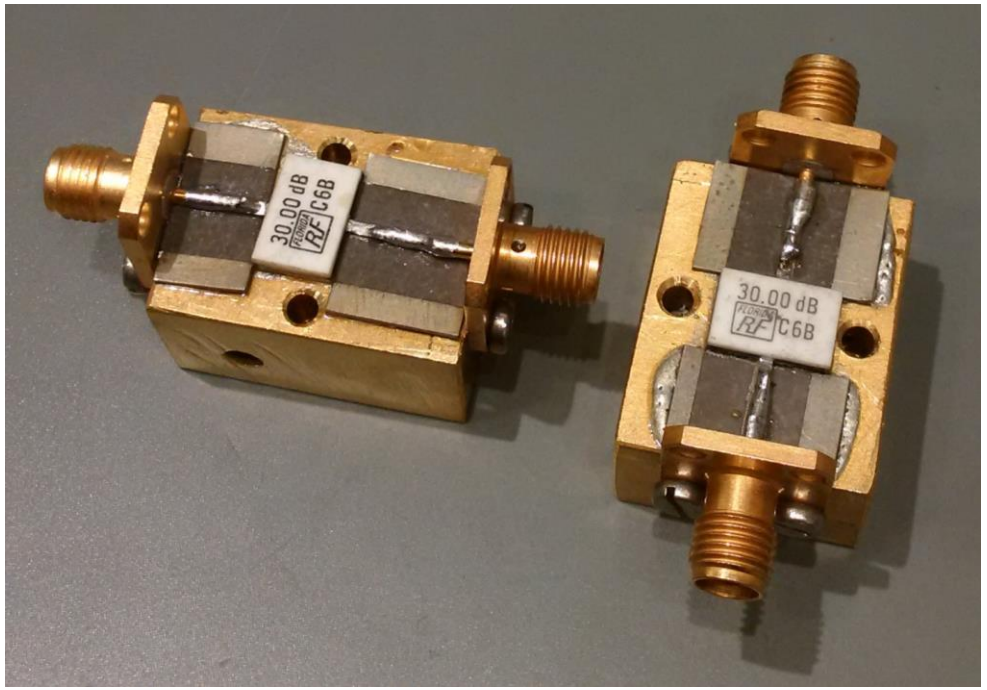
The downconverter sits in a tinplate housing including lid and base, which is screwed to the aluminium heat sink.

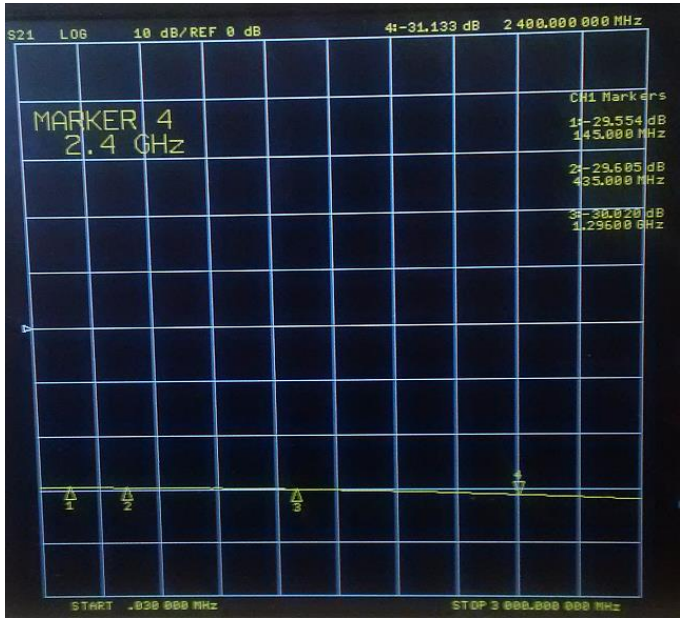


QO-100 transverter

Downconverter with attached GPS receiver (above) and upconverter (below) are shielded in tin plate housings.

The two TCXOs on the GPS board as well as on the downconverter board were thermally insulated with foam before the tinplate covers were put on to increase the thermal stability.

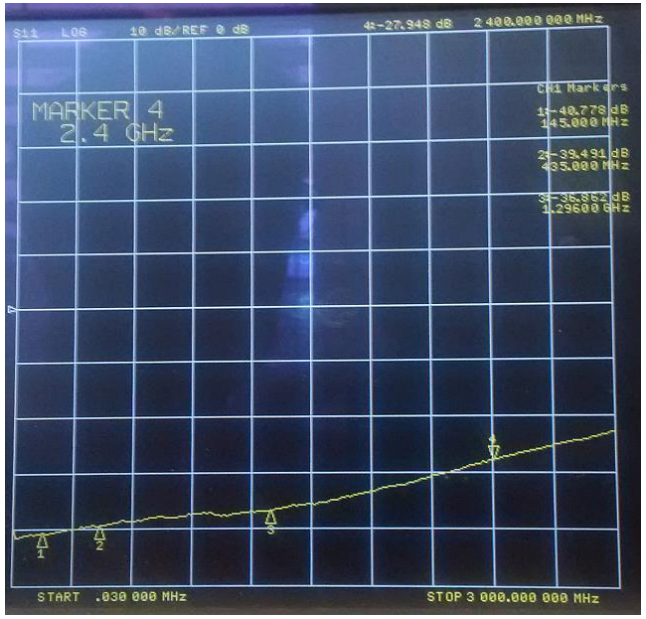




QO-100 transverter

Insertion loss S21

2m	**29.6dB**
70cm	**29.6dB**
23cm	**30.0dB**
13cm	**31.1dB**



30dB chip power attenuators to protect the TX IF input (70cm) from excessive transmit power from the downstream transceiver respectively the RX IF output (2m) from accidental transmission into this converter output. P_{max} approx.100W

Manufacturer Florida RF Labs (an EMC company)

Input return loss S11

2m	**40.8dB**
70cm	**39.5dB**
23cm	**36.9dB**
13cm	**27.9dB**

QO-100 transverter

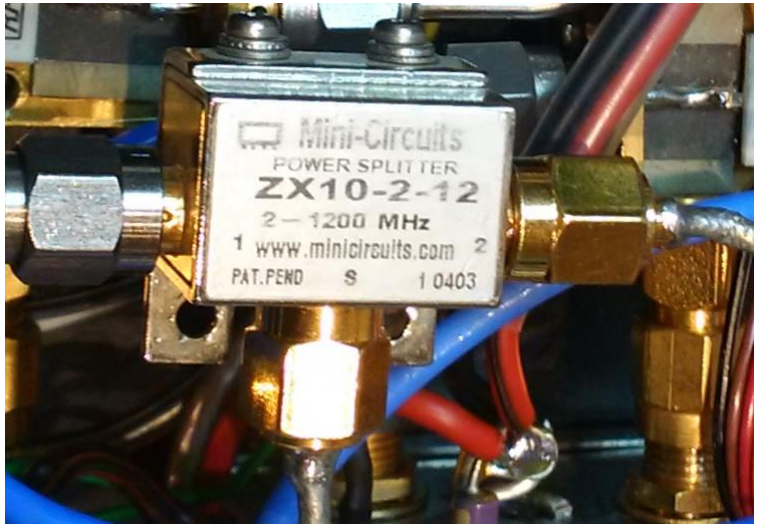
RF-Limiter from Alpha Type MT3287-99

This limiter limits an RF signal to approx. +10dBm. It is suitable for a frequency range from 100MHz to 3GHz.

Measured values at 430MHz:

- **The insertion loss is less than 0.5dB.**
- **Up to 0dBm input level (this is at the nominal control power of 1W) the harmonics are reduced > 60dB.**
- **From an input level of +3dBm the harmonics rise steeply because the diodes in the limiter start to conduct.**
- **At +16dBm input level the output level is approx. +9dBm, this confirms the specified +10dBm.**

QO-100 transverter



Coaxial

Power Splitter/Combiner

2 Way-0° 50Ω 2 to 1200 MHz

Maximum Ratings

Operating Temperature	-40°C to 85°C
Storage Temperature	-55°C to 100°C
Power Input (as a splitter)	0.5W max.
Internal Dissipation (as a combiner)	0.125W max.

Coaxial Connections

SUM PORT	3
PORT 1	1
PORT 2	2

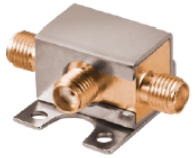
Features

- low insertion loss, 0.5 dB typ.
- excellent amplitude unbalance
- very good phase unbalance
- small size
- low cost
- protected under U.S. Patent 6,790,049 & 6,963,255

Applications

- cellular
- VHF/UHF receivers/transmitters
- radio
- defense

ZX10-2-12+



CASE STYLE: FL905

Connectors	Model	Price	Qty.
SMA	ZX10-2-12-S+	$24.95	(1-24)

+ RoHS compliant in accordance with EU Directive (2002/95/EC)

The +Suffix has been added in order to identify RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications.

Electrical Specifications (T_{AMB}=25°C)

ISOLATION (dB)		INSERTION LOSS (dB) ABOVE 3.0 dB		PHASE UNBALANCE (Degrees)	AMPLITUDE UNBALANCE (dB)
Typ.	Min	Typ.	Max.	Max.	Max.
21	**16**	**0.5**	**1.5**	**3.0**	**0.5**
29	21	0.3	0.7	3.0	0.5
25	18	0.3	0.8	2.0	0.4
21	18	0.5	1.0	2.0	0.5

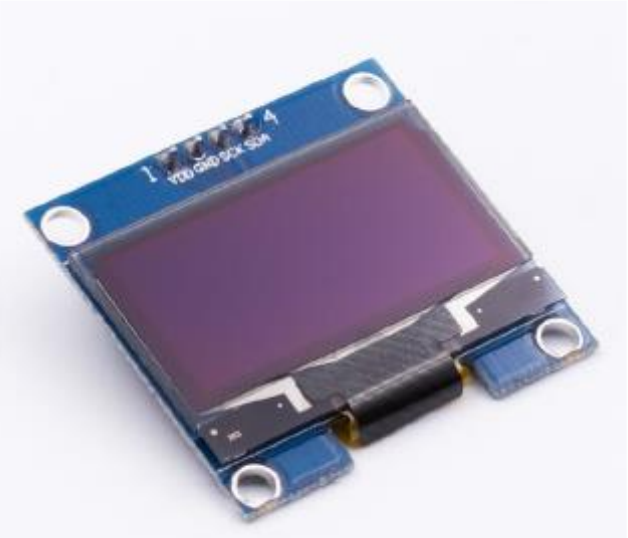
Two such combiners/splitters are used:

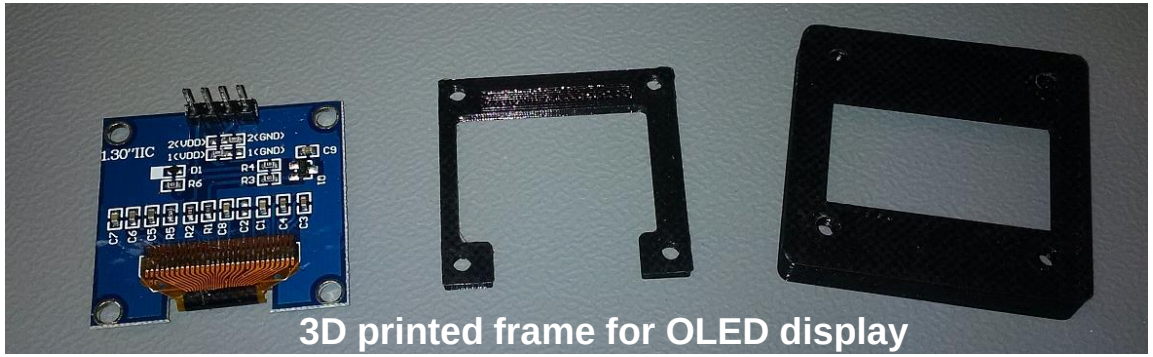
- **The two inputs TX-IN high and TX-IN low are combined before the 70cm signal is fed into the IF input of the upconverter.**

- **The 2m IF output signal from the downconverter is split and made available directly at the SDR-OUT connector or via a power attenuator at the RX-OUT connector.**

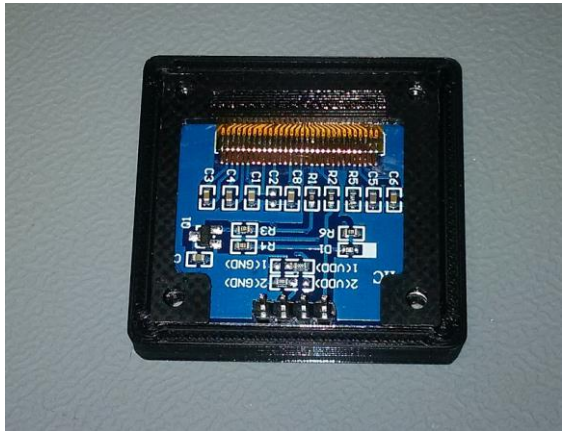
The insertion loss in the 2m and 70cm band is very low (about 0.3dB).

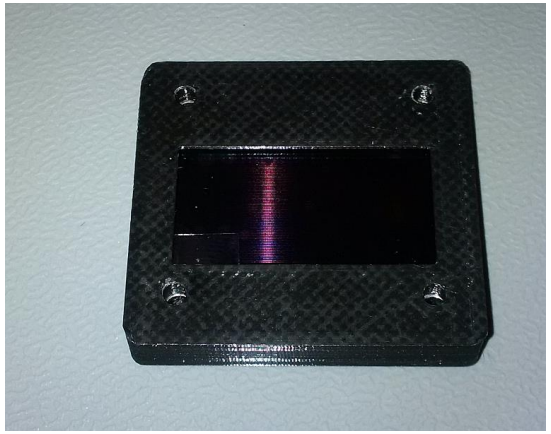
QO-100 transverter





3D printed frame for OLED display





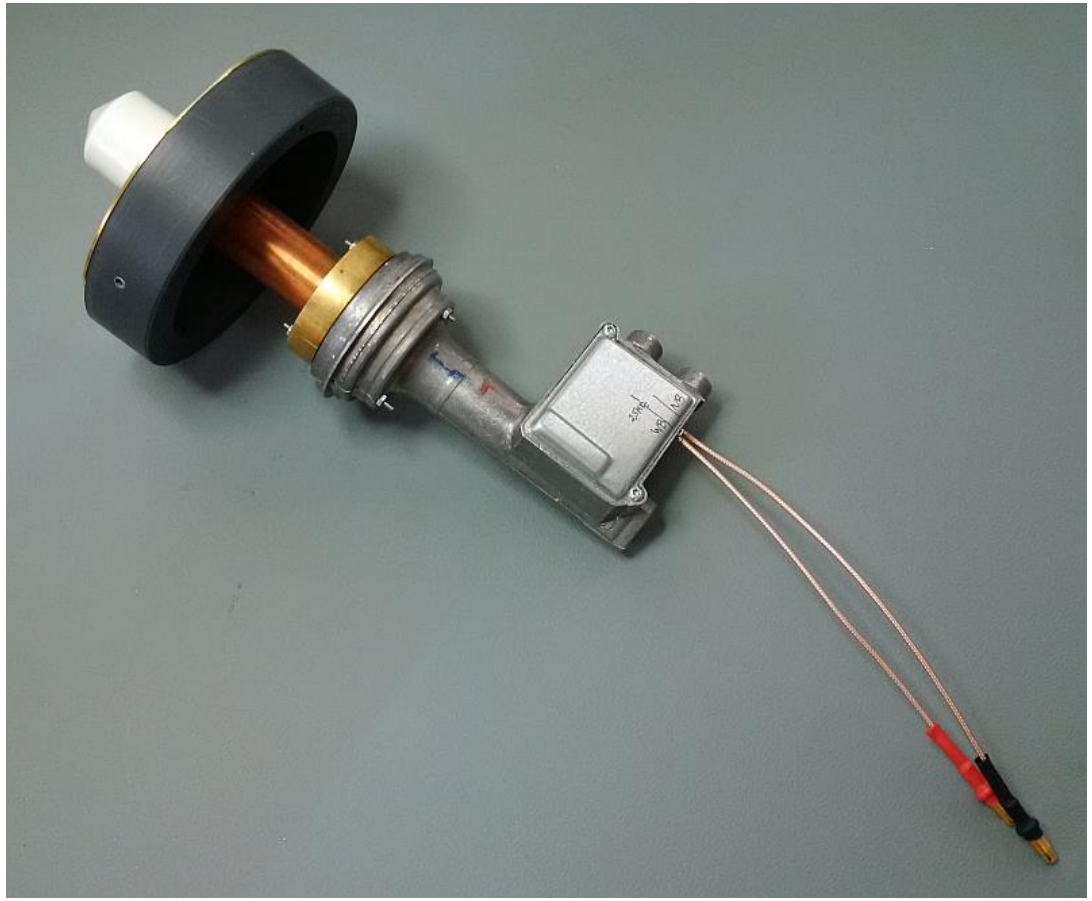
1.3" OLED display with a resolution of 128x64 pixels and a high contrast.

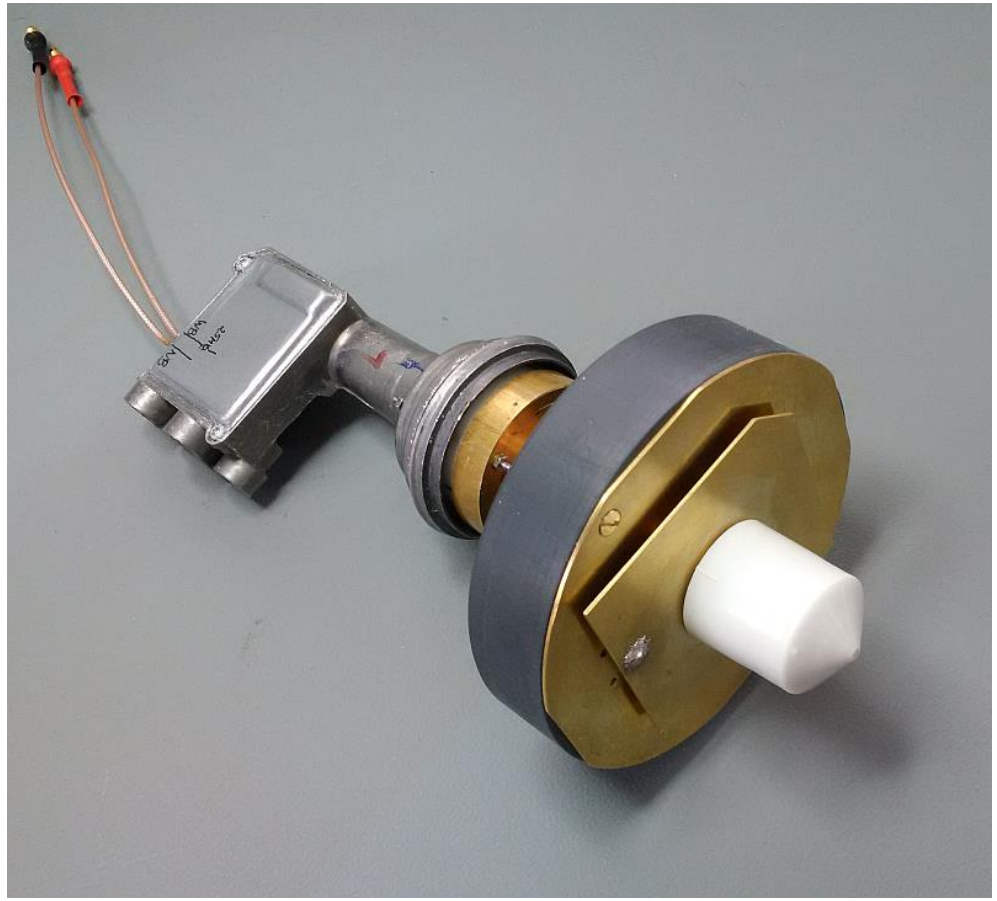
Controlled via I2C interface.

Design: Thorsten Godau DL9SEC
3D printing: Alfred Pertler DL3MX

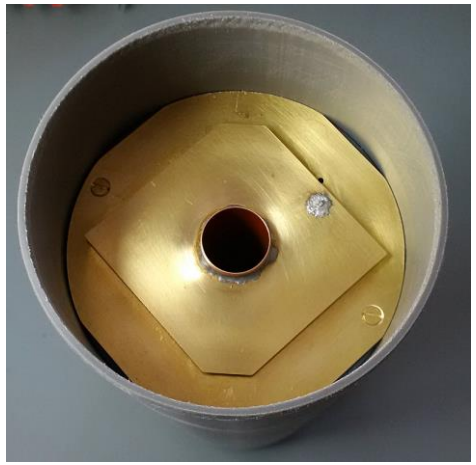
POTY-Feed (Patch Of The Year) adapted to OPTICUM LTP-04H. IF outputs for WB and NB are led out of LNB with thin Teflon cable at the bottom so that the assembly fits into the HT-pipe DN110.

QO-100 feed



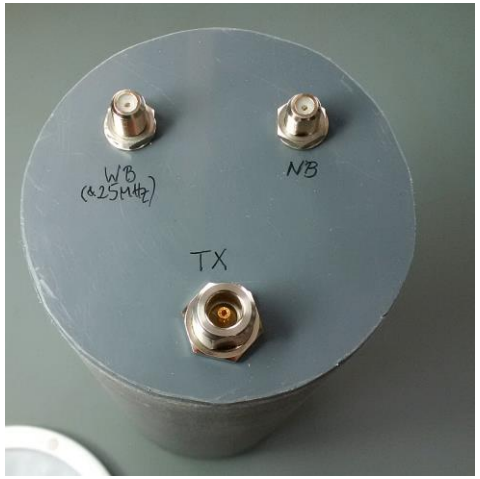


QO-100 feed

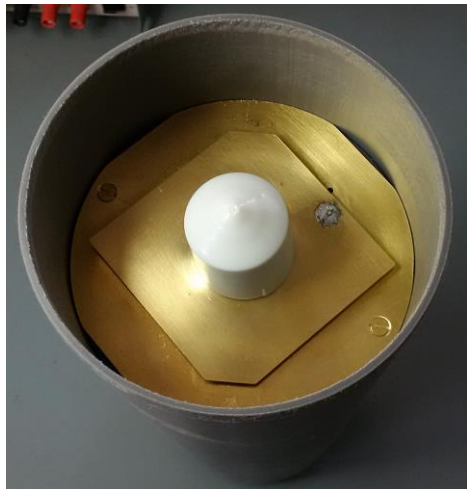


POTY-Feed in HT-pipe

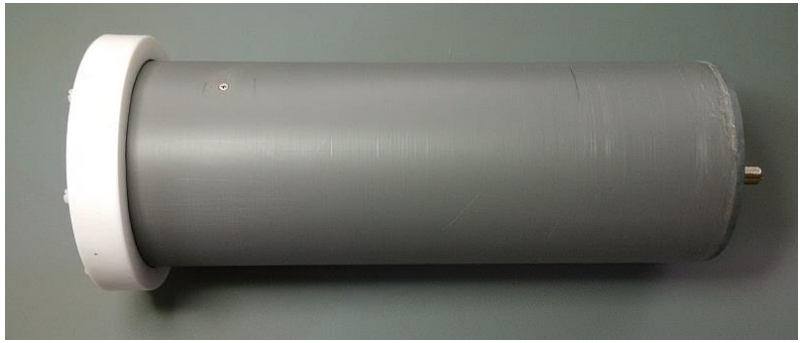
HT tube with glued bottom, Teflon cover, lens



Sockets WB-OUT, NB-OUT, TX-IN



Venton Rocket LNB lens on POTY

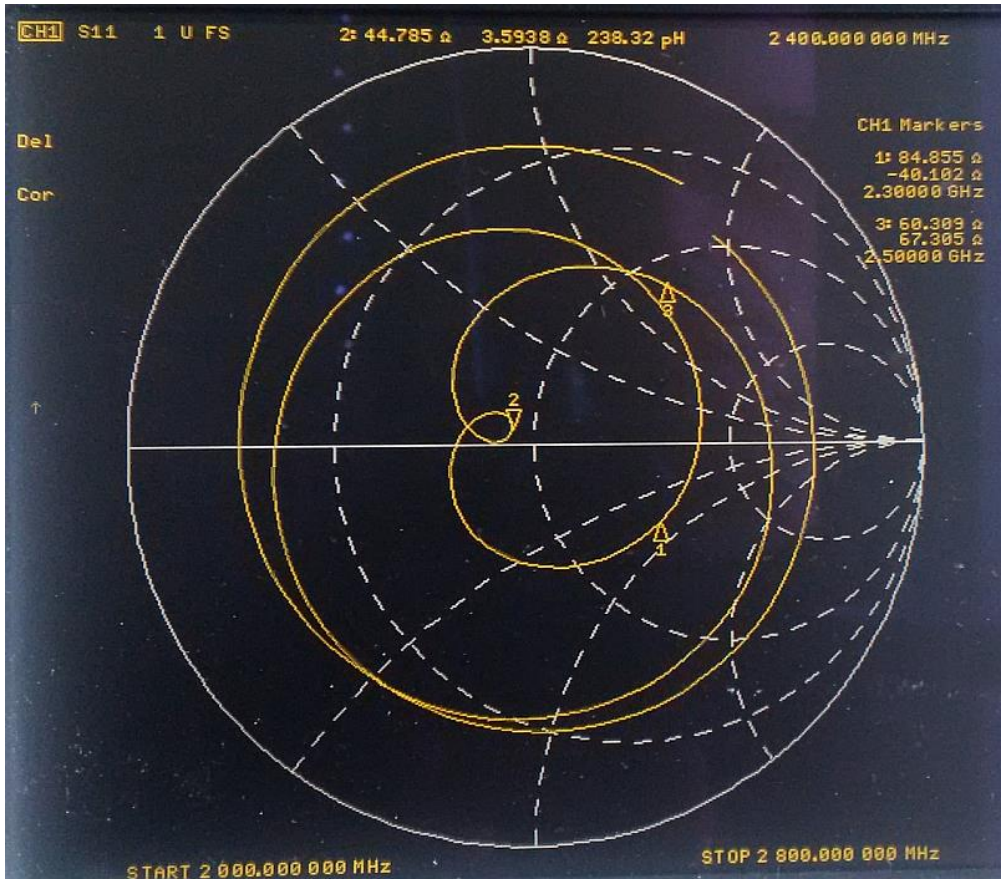


Teflon-Cover mounted

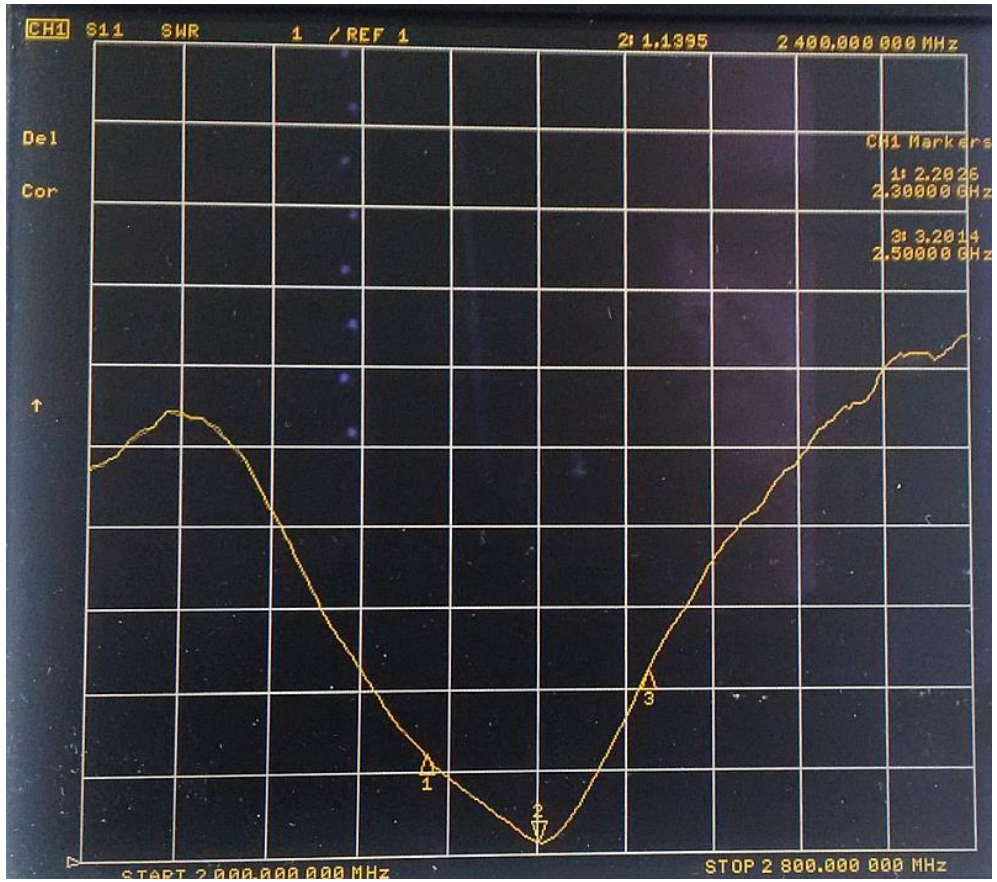
Connection cables for feed

QO-100 feed

S11 of the tuned TX patch antenna of the POTY feed: -24dB



VSWR of the tuned TX patch antenna of the POTY feed: 1:1.14



Portable Station for QO-100 based on the modules of AMSAT-DL

QO-100 portable station

60cm Kathrein offset mirror with feed in radome on tripod.

Feed holder made of aluminium tube allows flexible adjustment.

Transverter mounted on feed arm.

12V battery with solar cell.

On the table: ICOM IC-9700 transceiver with stand microphone.

QO-100 portable station

60cm Kathrein offset dish with feed arm mounted upside down

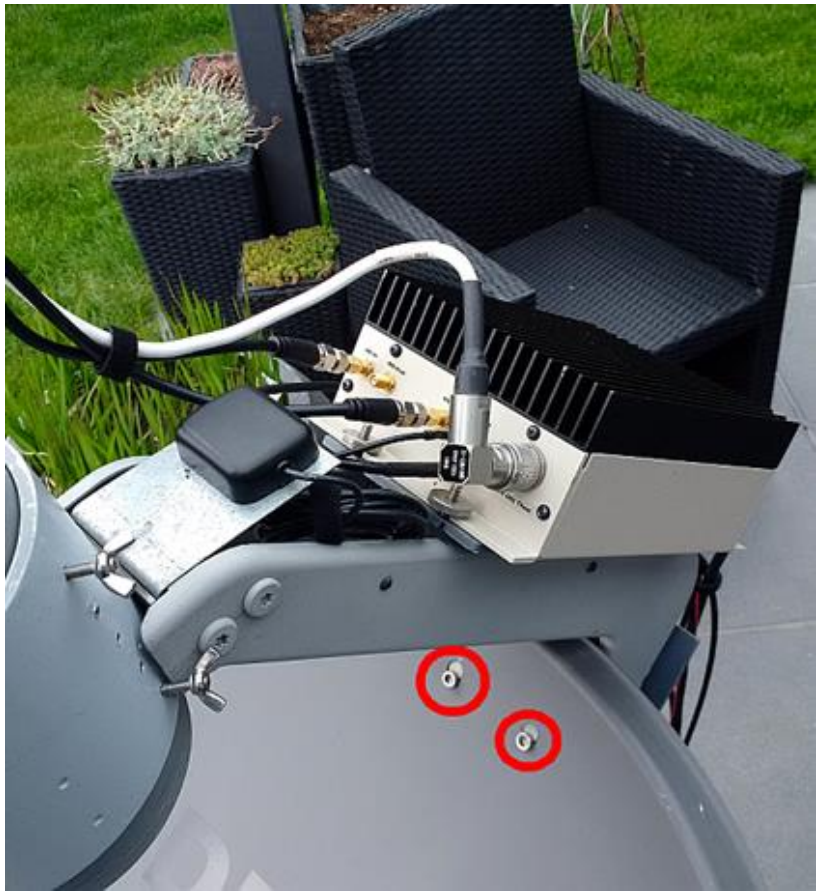
⇒ **feed is well protected from rain**

⇒ **weight well balanced**

GPS - antenna mounted on small bracket on feed arm

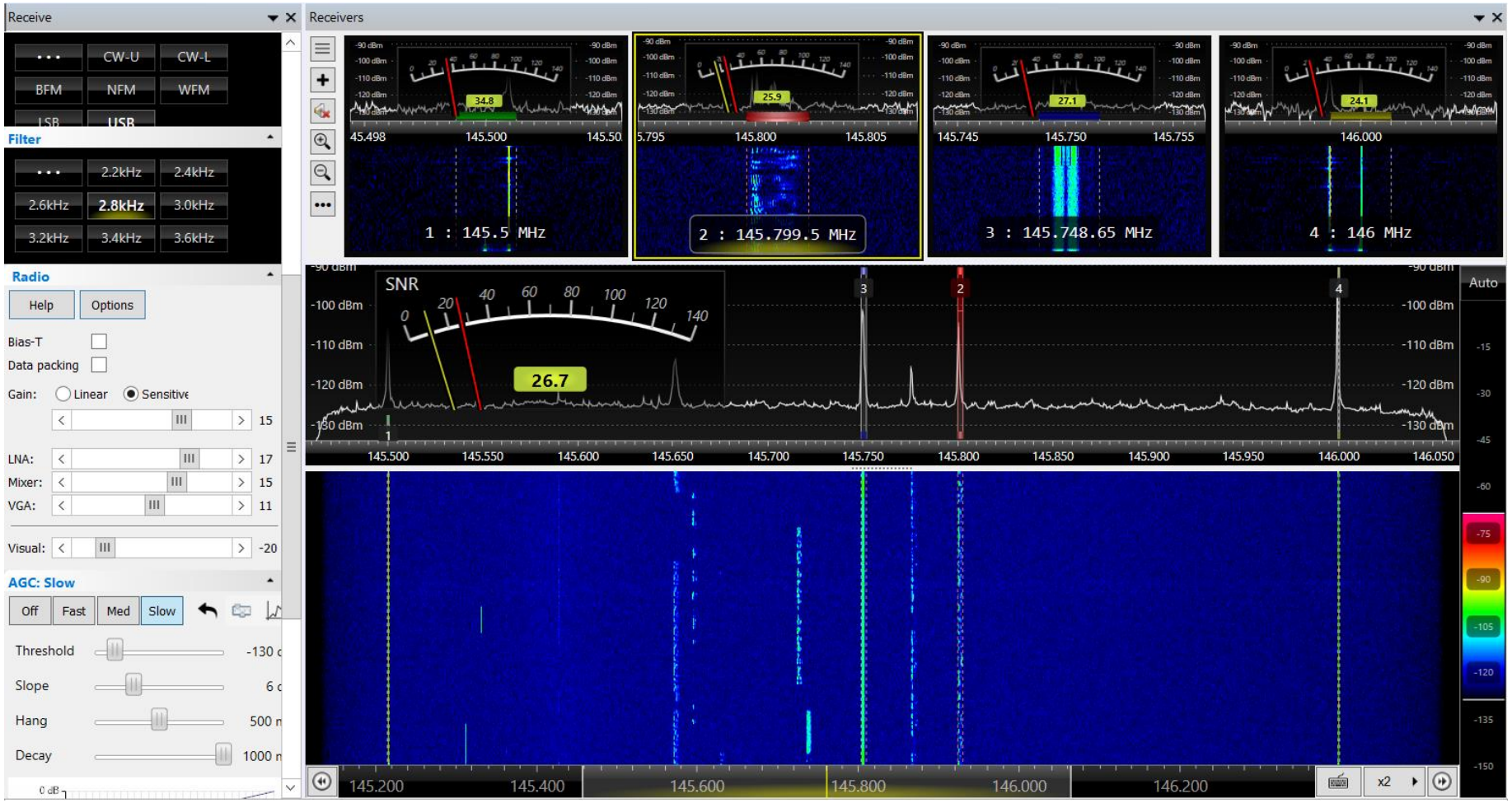
⇒ **no GPS interference also while Txing**

Portable Station for QO-100 based on the modules of AMSAT-DL



QO-100
portable station

For transport and storage, the 4 screws in the dish are slightly loosened and the dish can be removed using the oblong holes. This way the rest of the setup is very flat and the feed, GPS antenna and transverter do not have to be disassembled. The mount including the dish holder can be quickly removed from the tripod with 3 knurled screws.



QO-100 portable station

SDR console shows good reception results.

RX windows from left to right:
lower CW beacon,
SSB signal,
PSK beacon,
upper CW beacon.

Side emission of the Leila at 10489.560MHz = 145.560MHz is just about visible.

Own uplink signal approx. 6dB below the beacon level and therefore sufficiently strong.

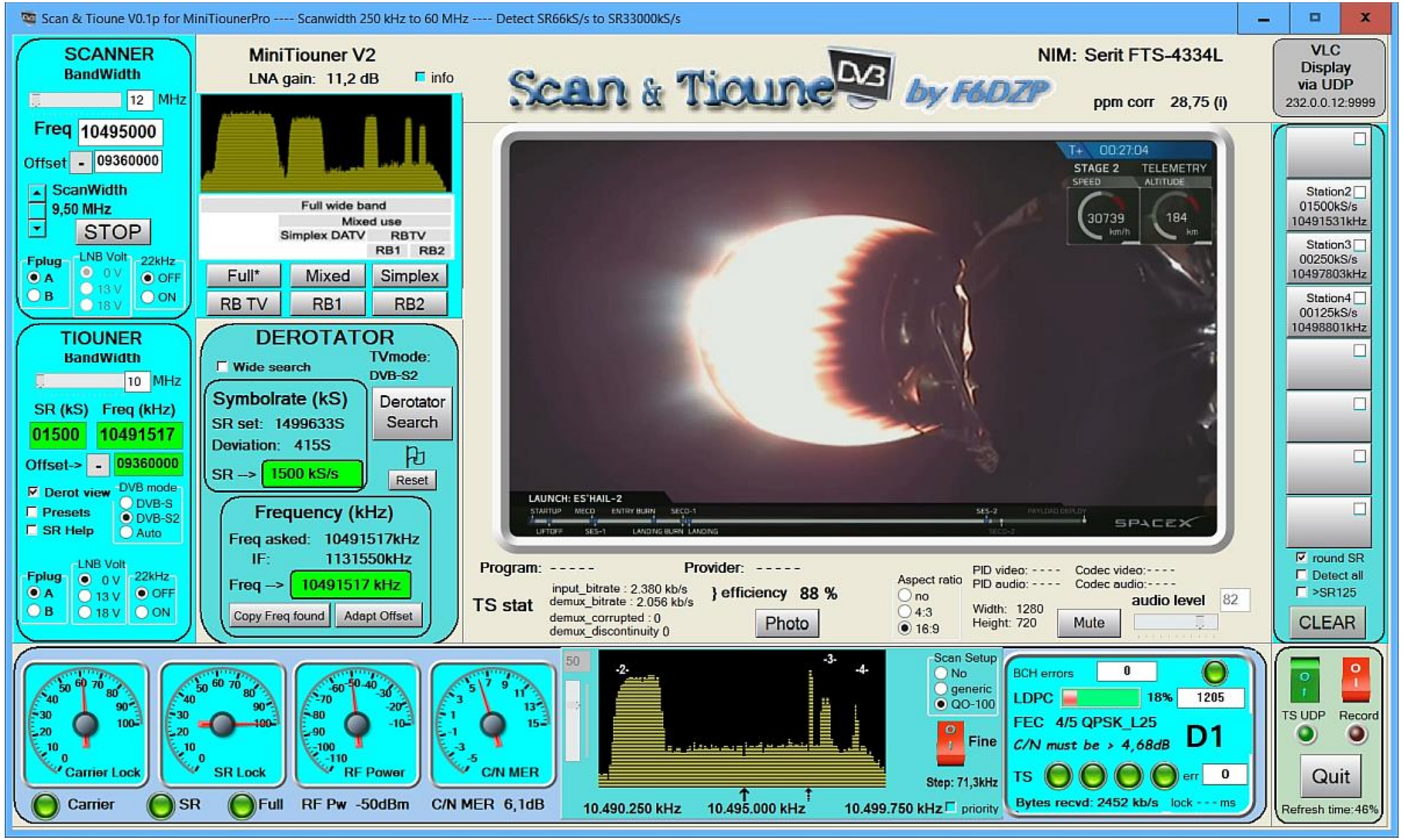
QO-100 DATV reception

In a further step I integrated a Minitiouner V2 into the system.

The Minitiouner is connected to the WB-OUT socket of the downconverter.

I can now see DATV on the PC parallel to the operation on the NB transponder.

Please note that the reception is possible but the levels have little margin.

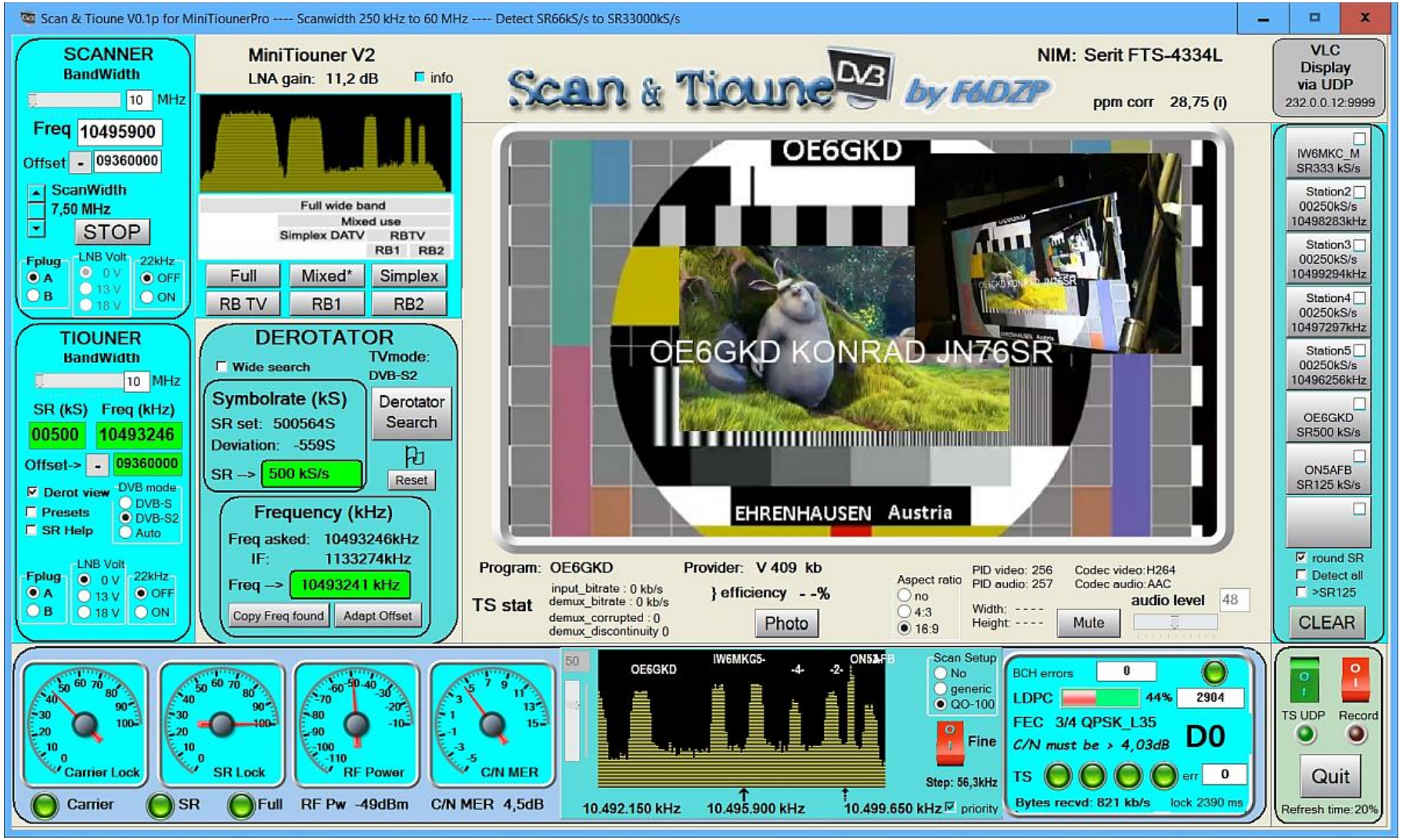


QO-100 DATV reception

DATV Beacon A71A

SR	**1.5MSPS**
Mod	**QPSK**
FEC	**4/5**
MER	**6,1dB**
Margin	**1,4dB**

Portable Station for QO-100 based on the modules of AMSAT-DL

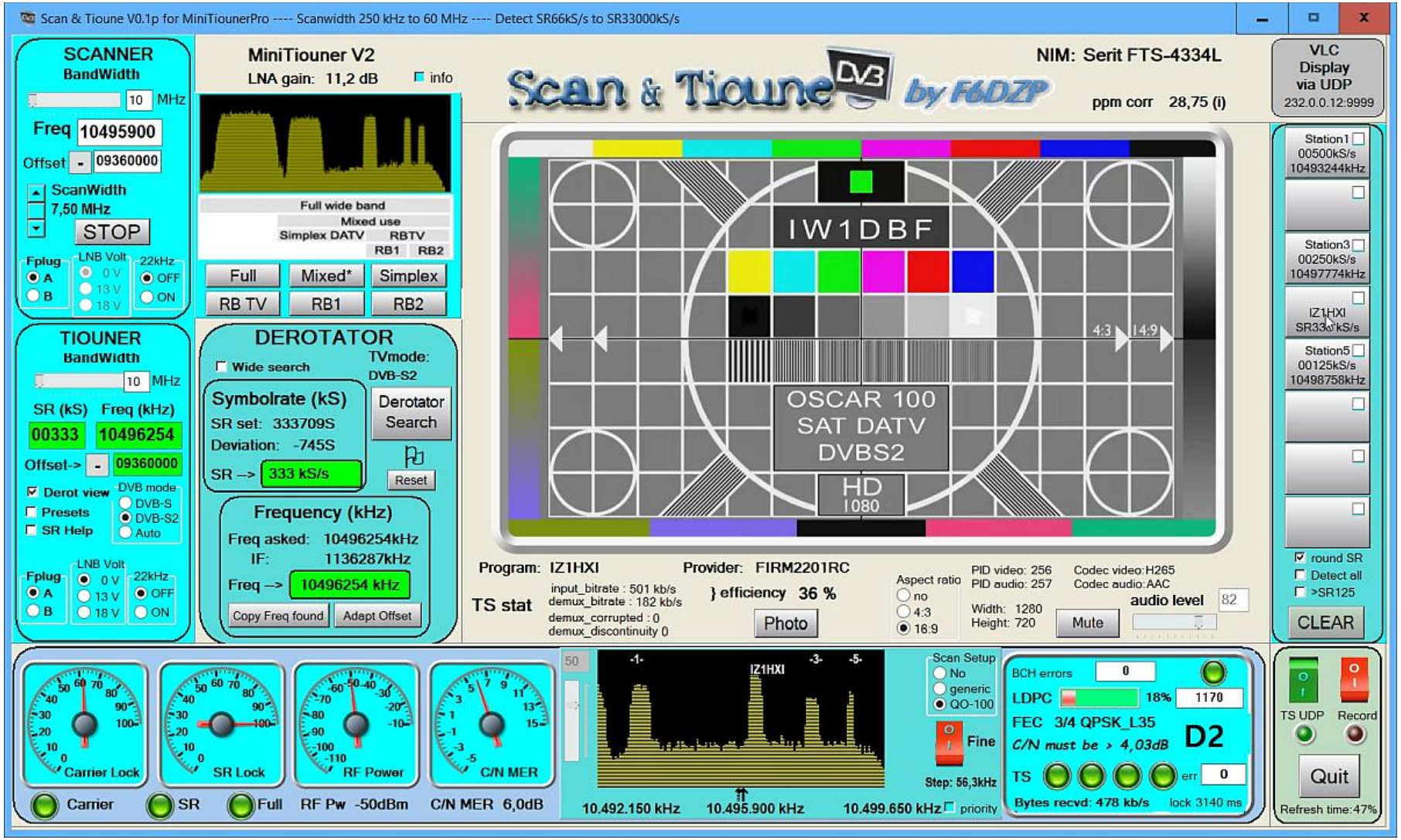


QO-100 DATV reception

DATV OE6GKD

SR	**500kSPS**
Mod	**QPSK**
FEC	**3/4**
MER	**4,5dB**
Margin	**0,5dB**

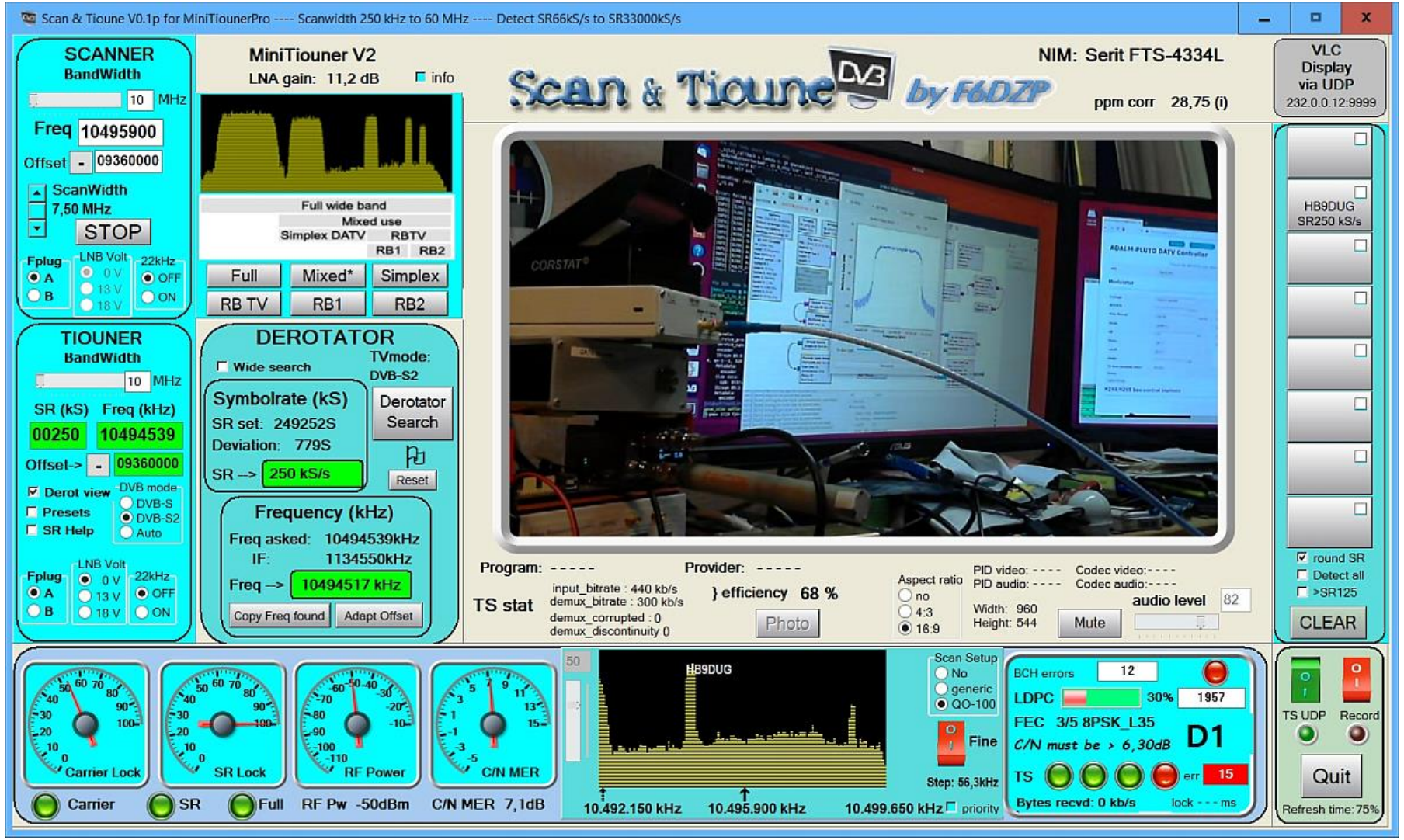
Portable Station for QO-100 based on the modules of AMSAT-DL



QO-100 DATV reception

DATV IW1DBF

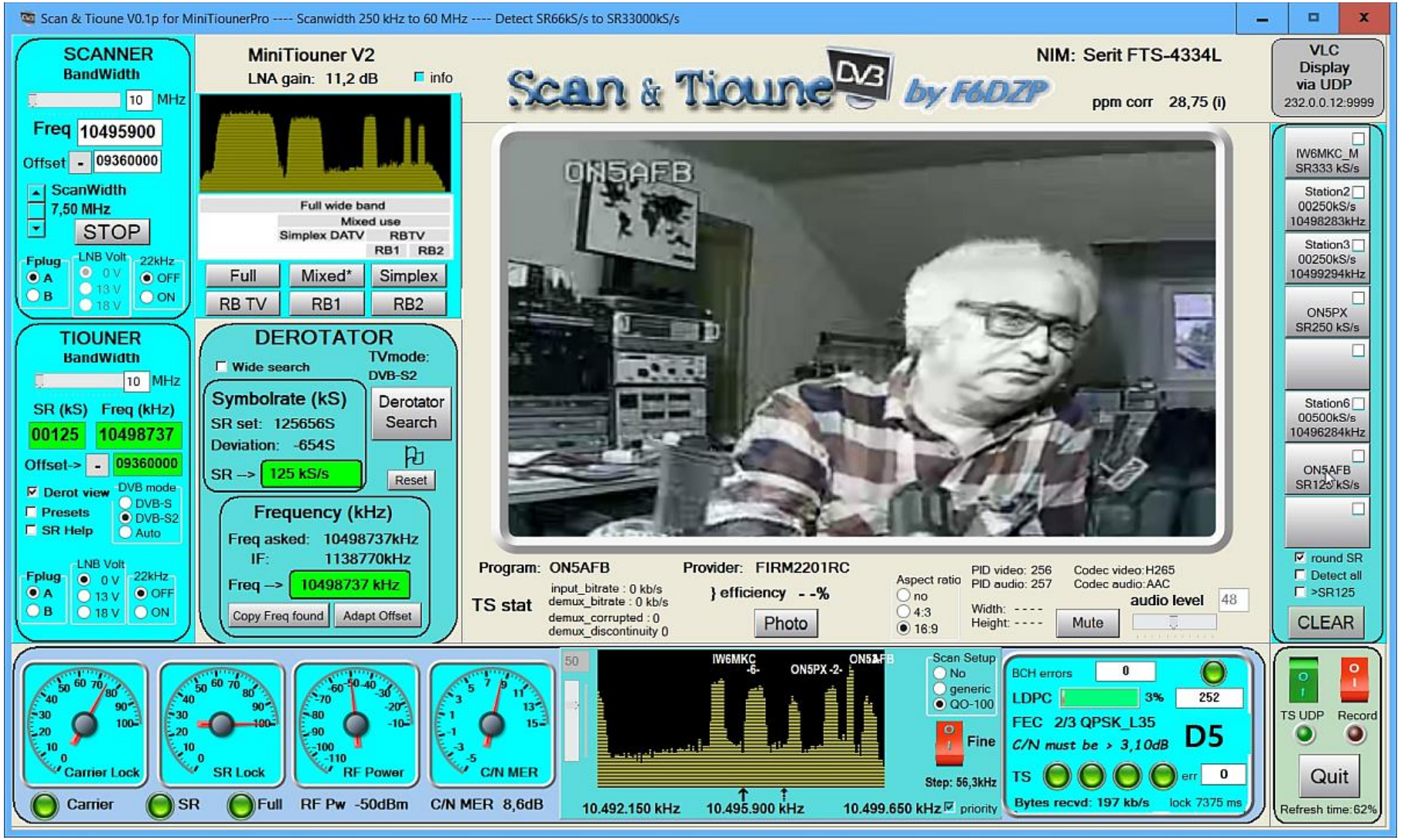
SR	**330kSPS**
Mod	**QPSK**
FEC	**3/4**
MER	**6,0dB**
Margin	**2,0dB**



QO-100 DATV reception

DATV HB9DUG

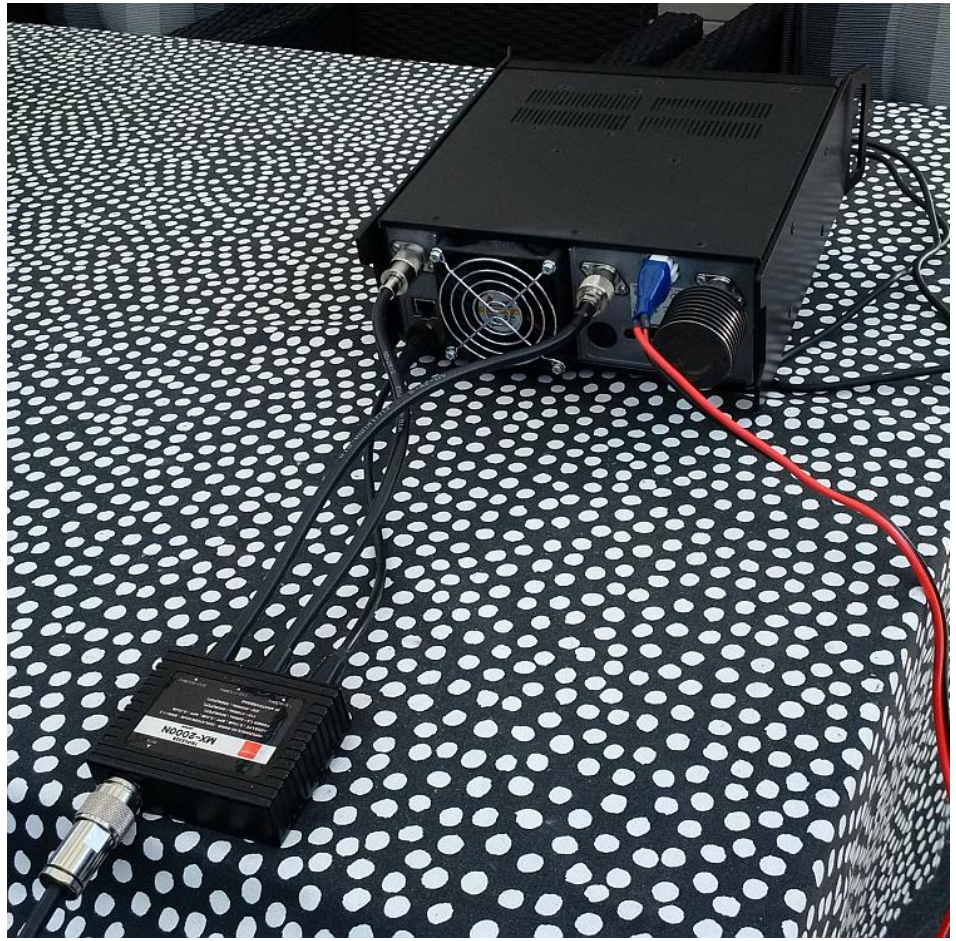
SR	**250kSPS**
Mod	**8PSK**
FEC	**3/5**
MER	**7,1dB**
Margin	**1,8dB**



QO-100 DATV reception

DATV ON5AFB

SR	**125kSPS**
Mod	**QPSK**
FEC	**2/3**
MER	**8,6dB**
Margin	**5,5dB**

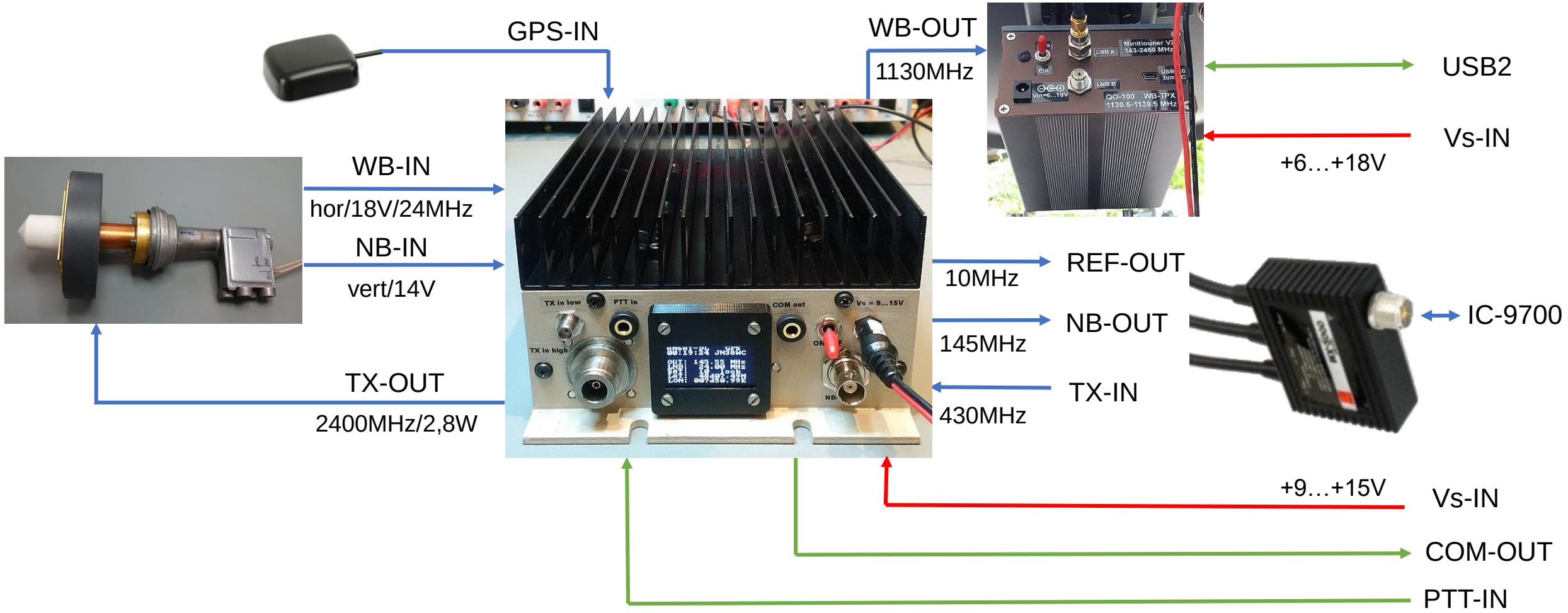


Minimize wiring

Finally I added two modified Diamond MX-2000N triplexers to both the transverter and the IC-9700 transceiver.

This reduces the cabling to a single coaxial cable, on which 3 signals are combined:
- the receive signal on 2m,
- the transmit signal on 70cm
- the 10 MHz reference frequency from the transverter to the TRX.

Complete setup



Complete setup

In order to transport the portable station safely and to store it dust-proof, I made a wooden box from light poplar plywood. The parabolic dish can be easily attached with 2 screws.

Transport box

Transport box

The inside of the box is lined with foam.

The box is divided so that various accessories such as tools, cables, power supply and the IC-9700 transceiver can be safely stored.

The feed arm of the dish is stored completely mounted:
I only have to put it on the tripod and fix it with 3 screws.

The dish is mounted as described before:
by using the 4 oblong holes in the dish and screwed tight to the feed arm.

Thus the whole system is assembled and ready for operation in less than 10 minutes.

Portable Station for QO-100 based on the modules of AMSAT-DL

The kits can be ordered at the AMSAT-DL webshop
https://shop.amsat-dl.org/

QO-100 Downconverter TCXO + GPS Module V2
https://shop.amsat-dl.org/produkt/qo-100-downconverter-tcxogps/

285,60€

UpCon6W – 6 Watt UpConverter for QO-100
https://shop.amsat-dl.org/produkt/upcon6w-6-watt-upconverter/

189,50€

QO-100 modified LNB
https://shop.amsat-dl.org/produkt/qo-100-modifizierter-lnb/

25,00€

Special thanks to
Stefan DG8FAC and Kurt DJ0ABR
for developing this excellent transverter

Thank you very much for your attention!