# Portable station for QO-100 based on the AMSAT-DL transverter kit

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AMSAT-DL now offers in its web shop https://shop.amsat-dl.org all the necessary components to build a transmitting and receiving station for QO-100. The individual components such as the downconverter, its GPS module, the OLED display and the upconverter have been described in the last issues. In this concluding article the interaction of the individual modules will be described by means of an assembled portable station.

**Overall concept**

Here is a rough block diagram of all components (except the transceiver, which receives and demodulates the received signal on the 2m IF and generates the transmitted signal on the 70cm). As you can see in the following diagrams, the transmission branch is designed for a nominal output power of 2.8W (the maximum output power is 6.5W).

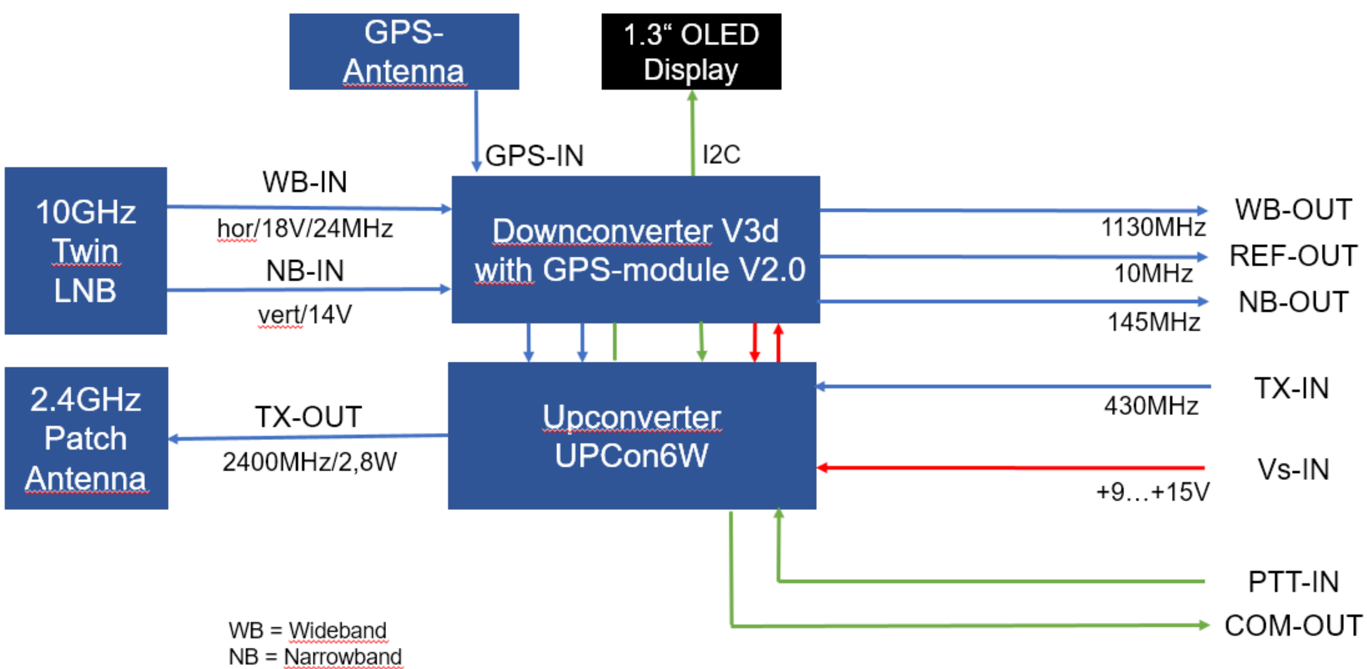


Figure 1: Coarse block diagram of the transverter

A POTY feed is used as the primary radiator in this design. This dual band feed consists of a left hand circular polarised patch feed for the 2.4 GHz uplink and an open circular waveguide for the 10 GHz downlink. A dual LNB is adapted at the rear output of the circular waveguide. The Opticum LTP-04H LNB used here has been converted to an external reference of 24 MHz and is available from the AMSAT-DL shop. The WB-IN connector of the downconverter receives the horizontally polarised signal of the broadband transponder, which is downmixed to 1132.5 MHz by the LNB, and supplies the 18 V supply voltage and the 24 MHz reference signal via the same coaxial line. The NB-IN connector receives the vertically polarised signal of the narrow band transponder downmixed to 1129.5 MHz and supplies the 14V supply voltage for the second part of this dual LNB.

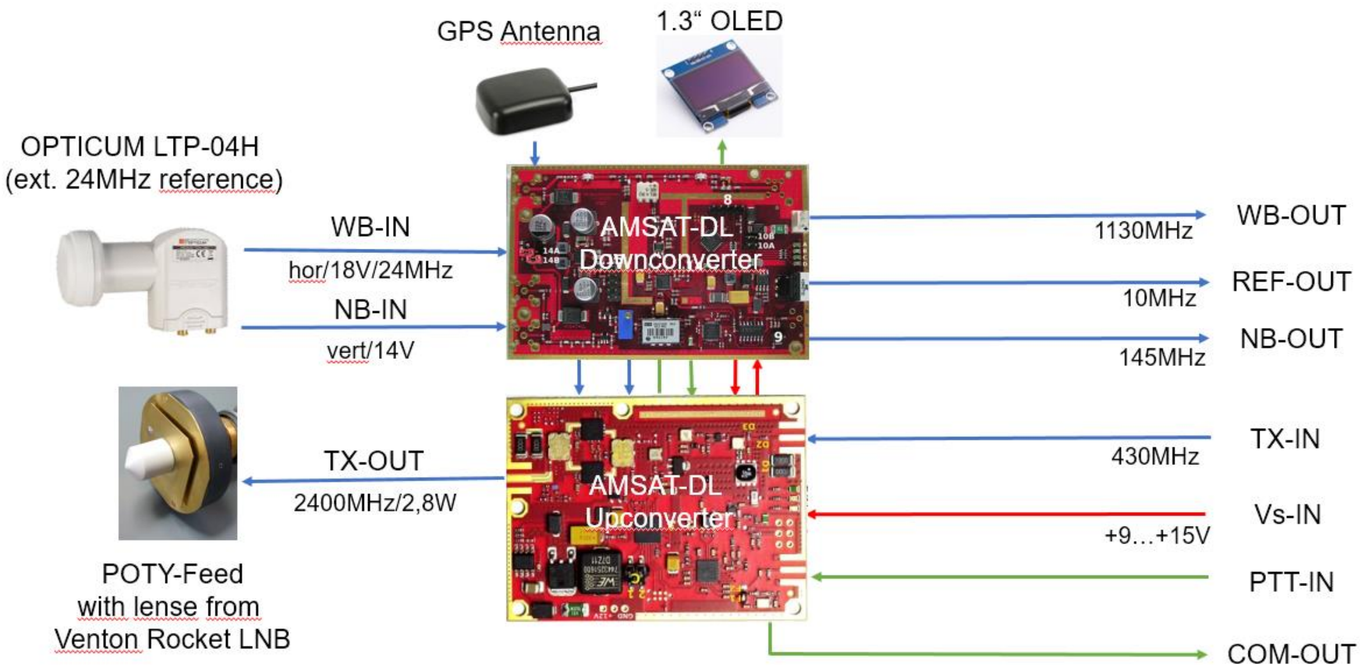


Figure 2: Individual components of the transverter setup

Up- and downconverters including the OLED display were installed in an existing surplus housing. In order to minimise the cabling effort, the signals REF-OUT (10 MHz), NB-OUT (145 MHz) and TX-IN (435 MHz) are combined at the transverter via a Diamond MX-2000N triplexer and split again with the same type of triplexer at the ICOM IC-9700. This means that only a single coaxial cable is required between the antenna and the transceiver. The IC-9700 is synchronised by means of the GPSDO from the downconverter. In addition, a Minitiouner V2 is mounted on the feed arm to receive DATV parallel to the narrow band operation.

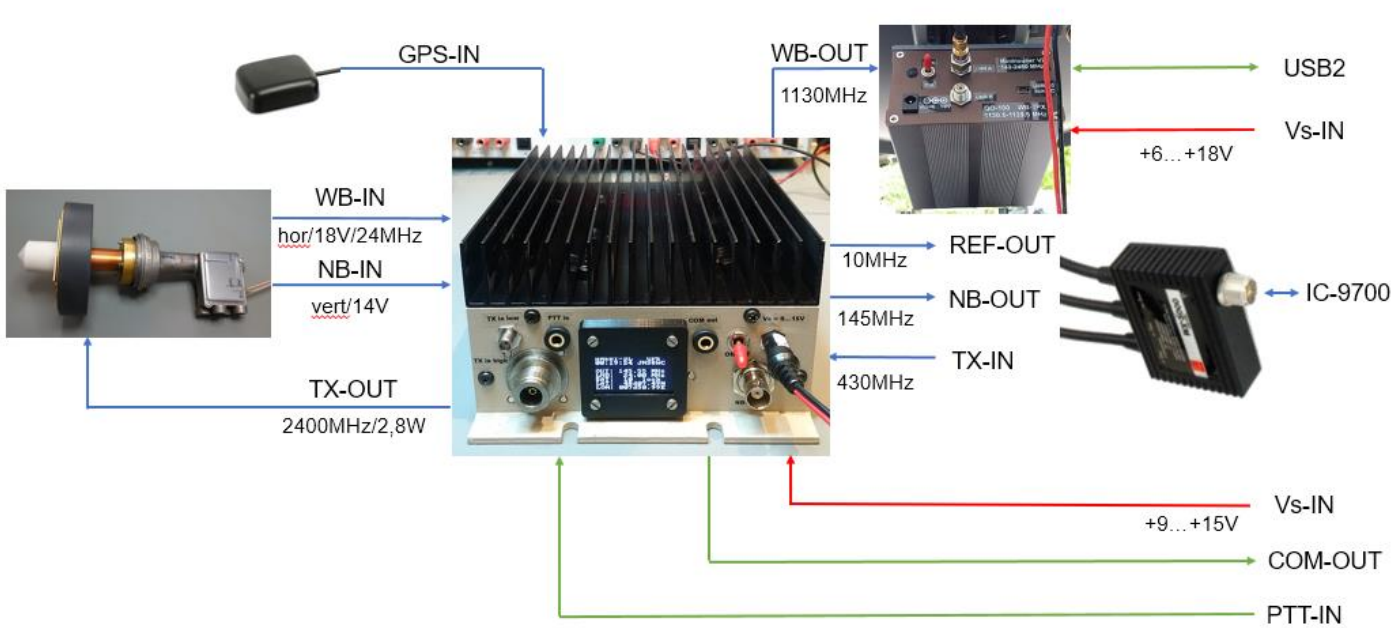


Figure 3: Individual components of the transverter setup

Figure 4: Triplexer on the ICOM IC-9700 transceiver

**Frequency and level plan**

Here are the detailed frequencies as they are used in the transverter. To protect the transverter against accidental triggering of the transverter with too high transmission power (at TX-IN high) as well as accidental transmission into the RX IF output (RX-OUT), protective circuits consisting of power attenuators and a limiter are built in. This protects the TX input and RX output up to a power of 100W. These protection circuits can be bypassed when using an SDRs during operation. The receiving IF is then tapped on SDR-OUT or the transmitting IF is fed into TX-IN low with low drive power.

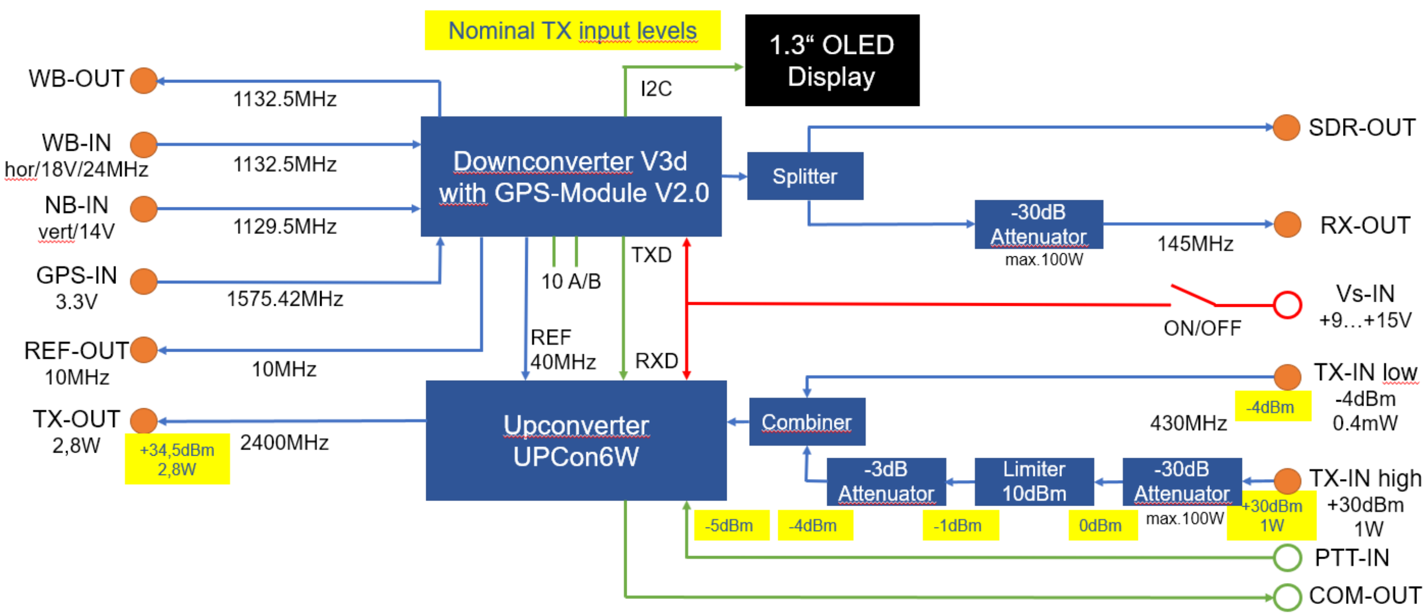

Figure 5: Frequency and level plan of the setup

The integrated PI attenuator at the input of the upconverter has an attenuation of 25dB at delivery. This was replaced by a 3dB attenuator. Thus, the necessary driving power of the SDR (at TX-IN low) is only -4dBm respectively the nominal driving power of the transceiver (at TX-IN high) is +30dBm.

In the next diagram you can see the measured output power of the complete transverter as a function of the input power at TX-IN low:

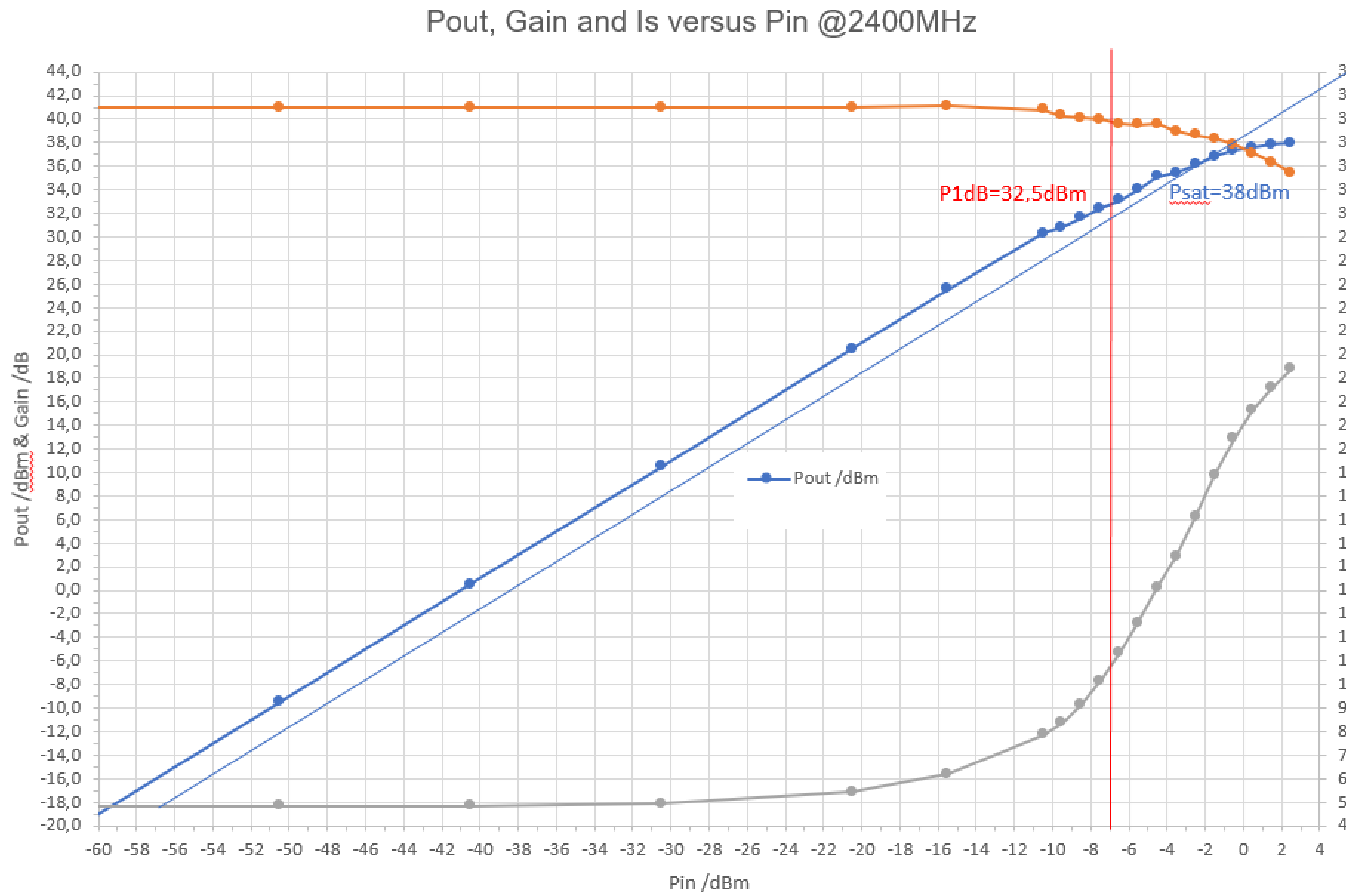


Figure 6: Output power as a function of input power

The current consumption of the complete transverter (!) is approx. 1.1A at an output power of 2W. With the used supply voltage of 12V the overall efficiency is 14%. At an output power of 6W the current consumption is 2.3A and the efficiency increases to 22%.

**Integration**

The following items are located on the front panel of the housing:

- TX-IN low: 70cm IF input from a SDR (0,4mW)
- TX-IN high: 70cm IF input from a TRX (1W)
- PTT in: input to key the transverter (transverter on when input is connected to ground)
- OLED display: time in UTC, QTH locator from GPS data, RX-IF, reference frequency for LNB, number of currently received GPS satellites, 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 IF output to (T)RX
- SDR-OUT: RX-output to an SDR (missing on the picture below because it was installed later)
- Vs:   +9...+15V DC power supply input

Figure 7: Front panel of the complete transverter

The following sockets are located on the back of the housing:

- WB-IN: wideband transponder signal from the LNB (~1132 MHz), horizontally polarised, also output of the 24MHz reference signal to the LNB and 18V LNB remote supply voltage
- WB-IF out: signal of the wideband transponder (from WB-IN) looped through for a DATV receiver
- NB-IN: narrowband transponder signal from LNB (~1129 MHz), vertically polarised, also 14V LNB remote supply voltage
- GPS Ant: Signal from an active GPS antenna and 3.3V remote power supply for it
- 10MHz out: 10MHz reference frequency output for TRX (here to IC-9700 transceiver)
- 2.4GHz out: transmit signal output to the antenna (here to the POTY feed)

Figure 8: Back of the complete transverter

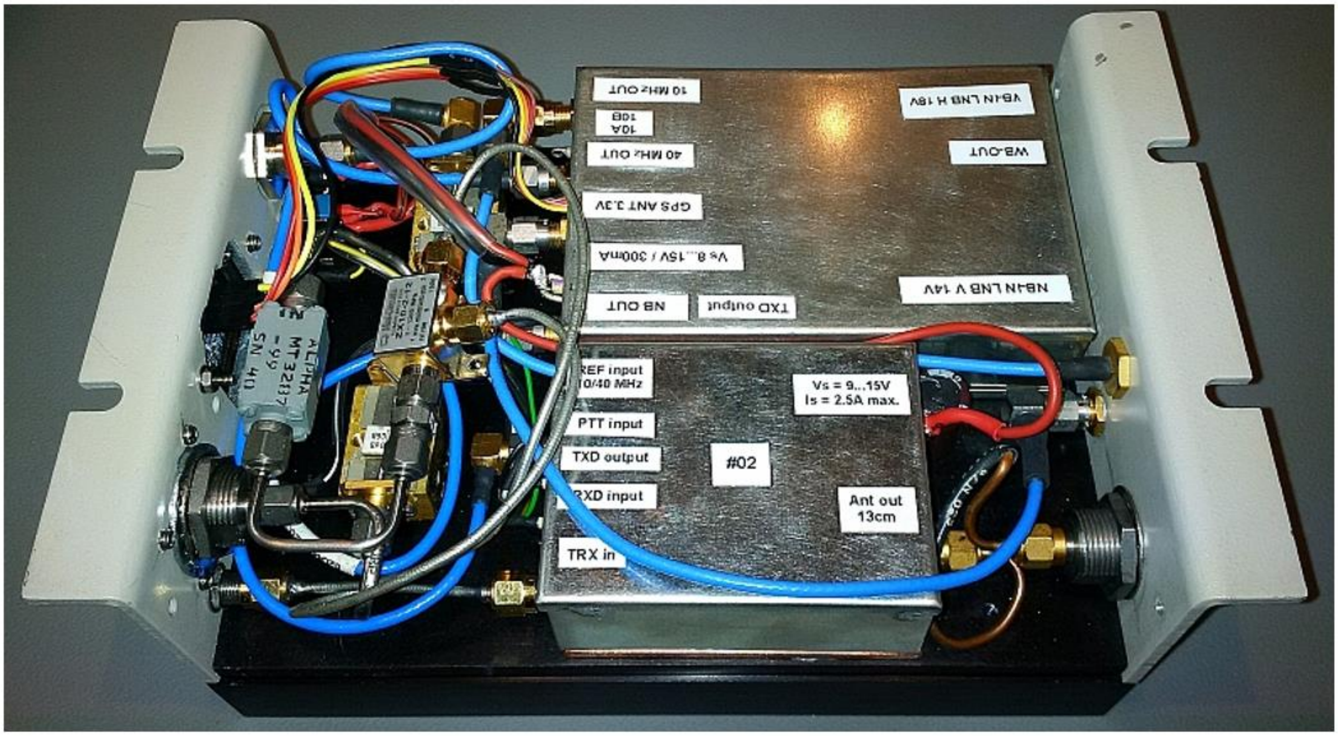


Figure 9: Downconverter with GPS module and upconverter are each built into a tinplate housing for better shielding. Left: Power attenuators, limiter and power splitters

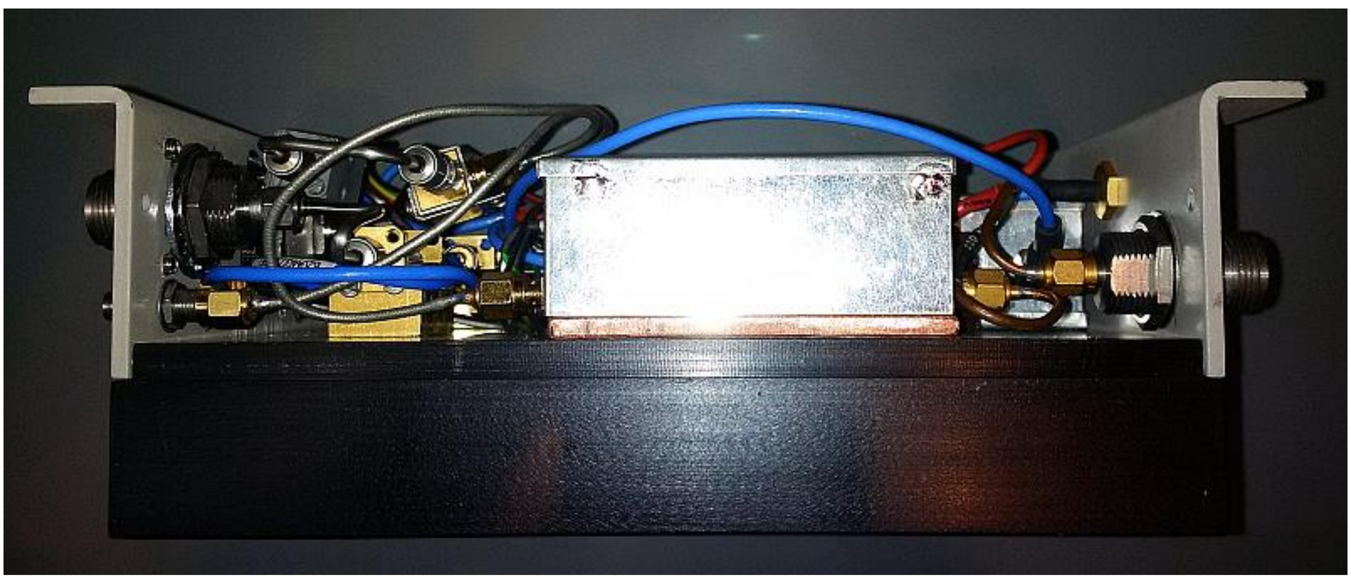

Figure 10: The upconverter is mounted on a copper plate for optimum heat dissipation, which in turn is screwed to the aluminium heat sink

For those radio enthusiasts who shy away from the mechanical work involved in setting up the transverter, a fully drilled and labelled housing kit will be available in the AMSAT-DL shop from autumn onwards. A presentation of this housing kit is planned for the AMSAT-DL Journal Q4/2020.

**Power attenuators**

To protect the TX IF input (70cm) from excessive transmission power from the downstream transceiver or the RX IF output (2m) from accidental transmission into this converter output, 30dB chip power attenuators from Florida RF Labs are used. These chip power attenuators are designed for a maximum power of 100W. They are soldered onto a brass block for cooling and optimal ground connection. The connection to the SMA sockets is done with 50 Ohm striplines. The insertion loss on 2m and 70cm is 30dB and the matching is very good with a return loss of about about 40dB.

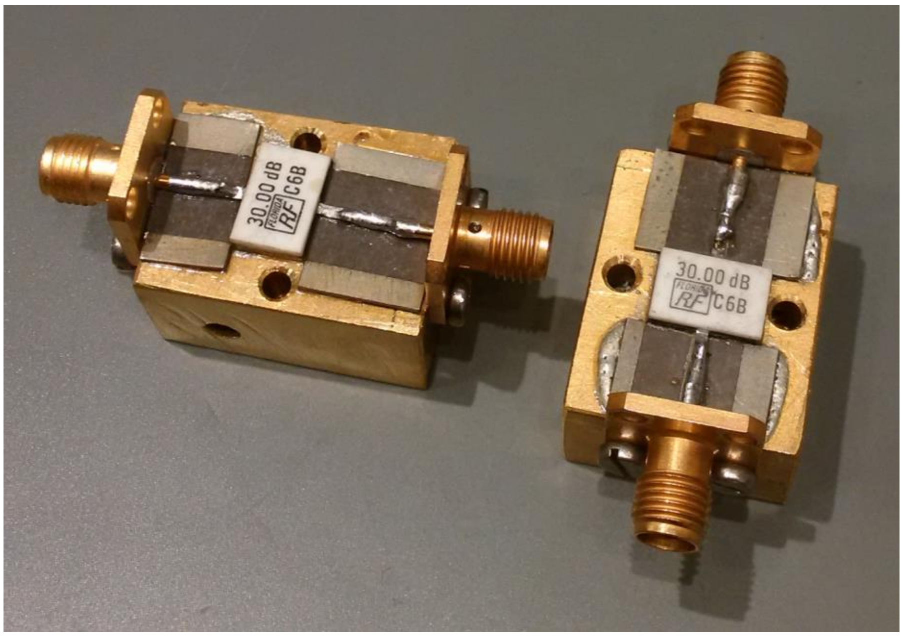

Figure 11: Power attenuation elements for protection against excessive drive power

**RF-Limiter**

In the transmission branch, an Alpha RF limiter type MT3287-99 is used after the power attenuator. This limiter limits an RF signal to about +10dBm. It is suitable for a frequency range from 100MHz to 3GHz. At 430MHz the insertion loss at low levels is less than 0.5dB. Up to 0dBm input level (this is at the nominal control power of 1W) the harmonics are below -60dBc. Above 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 max. +10dBm of the limiter. At the output of the limiter a small 3dB SMA attenuator is inserted to adjust the level at the splitter/combiner to the desired -4dBm.

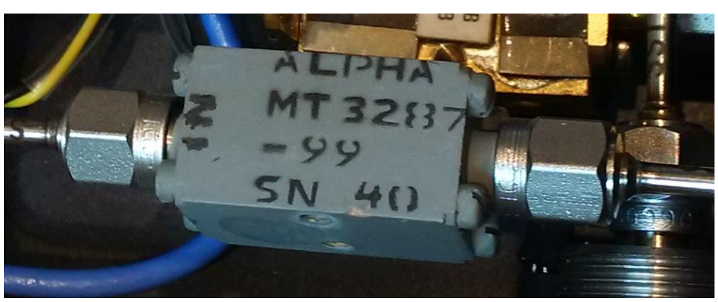


Figure 12: RF limiter for the transmission branch

**RF-Combiner/RF-Splitter**

Finally, the transverter contains two combiners/splitters of the company Mini-Circuits of the type ZX10-2-12, whose insertion loss is very low in the 2m and 70cm band with about 0.3dB.
On the one hand, 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. In addition, the 2m IF output signal is split in the downconverter and made available directly at the SDR-OUT connector or via the power attenuator at the RX-OUT connector.

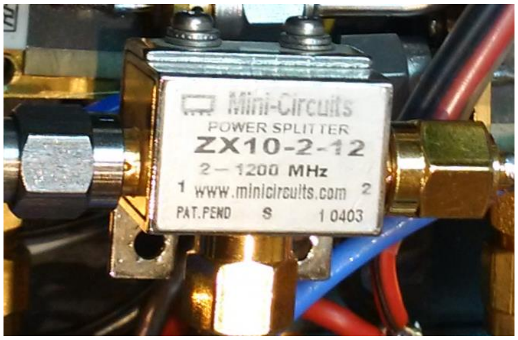


Figure 13: RF-Combiner/Splitter

**Feed and LNB**

The feed used in this setup is a POTY feed (Patch Of The Year) with a lens from a Venton Rocket LNB. The POTY-Feed is adapted to the modified OPTICUM LTP-04H LNB using a brass adapter. The two IF outputs WB and NB are led out of the LNB with a thin Teflon cable at the bottom so that the assembly fits into a standard HT pipe DN110. A plastic circular blank is glued to the back of the HT pipe. Two feed-throughs for the receiving signals (WB = horizontally polarised and NB = vertically polarised) and one feed-through for the transmitting signal are screwed into this and sealed with Spinner Plast 2000.

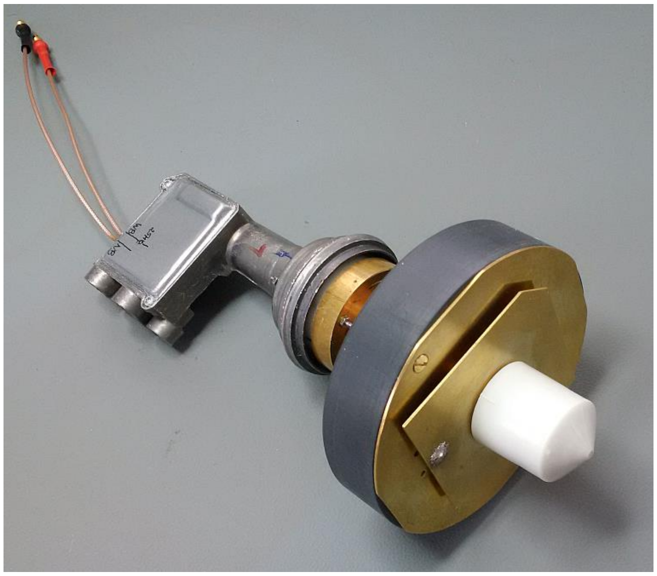

Figure 14: POTY-Feed with adapted LNB

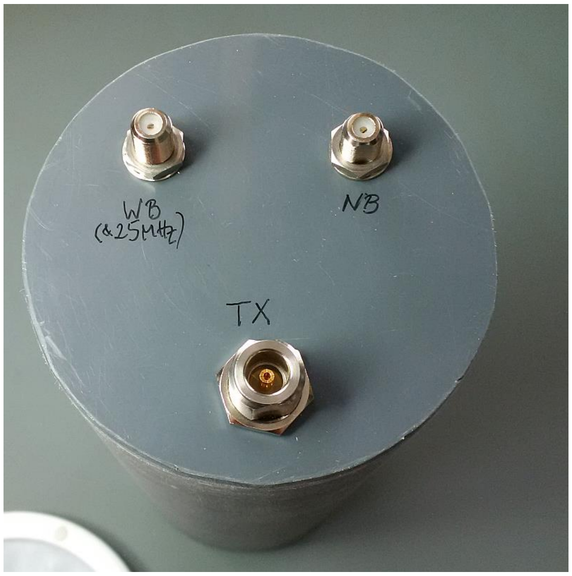


Figure 15: Sockets on the back of the HT-tube

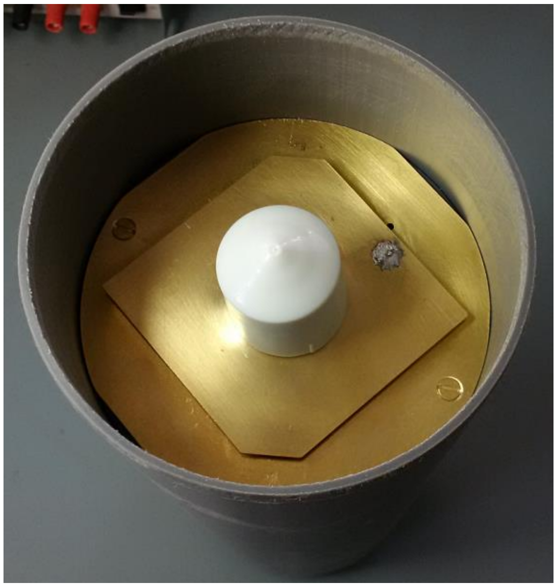
Figure 16: POTY-Feed with lens


Figure 17: Patch cable to LNB and Feed

**Overall structure**

An old Kathrein 60cm offset dish, which was rescued from the scrap container of the local recycling centre, is used as a parabolic antenna. This antenna has a very stable feed arm. The actual dish has 4 oblong holes and can be removed from the feed arm for transport in a few seconds by loosening 4 screws. The parabolic antenna is mounted "upside down", i.e. with the feed arm on top. Thus, the opening of the HT tube points almost vertically downwards and does not have to be sealed with a Teflon foil or similar. The complete transverter is mounted on the feed arm and therefore the connecting cables to the POTY-Feed are only about 50cm long. Especially on the transmission side due to the use of a short and very low-loss coaxial cable the line losses are very low.

The dish is mounted on a tripod by means of a bracket adjustable in azimuth and elevation.


Figure 18: Complete assembly including 12V battery with solar cell and ICOM IC-9700

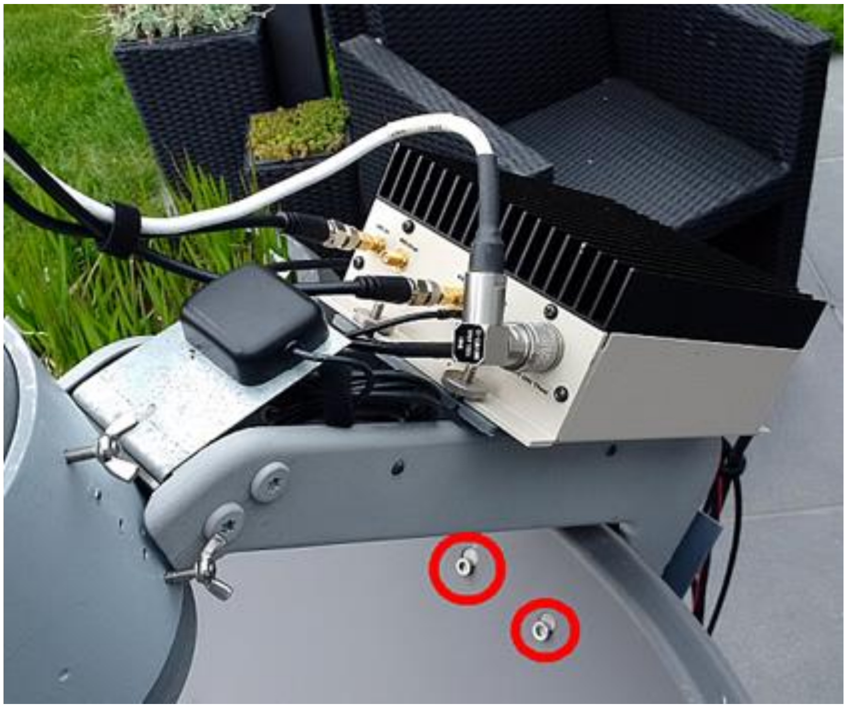

Figure 19: Thanks to the 4 oblong holes, the dish can be dismantled very quickly.
The GPS antenna is mounted on a small metal bracket beside the feed

Narrow-band operation with the setup works perfectly. The own uplink of this station using an output power of 2W is approx. 6dB below the beacon level and therefore sufficiently strong. On the receiving side the weak secondary emission of the Leila unit in the control station in Bochum at 10489.560MHz (IF= 145.560MHz) is just barely visible.

So far, all stations which were recognisable on the WEB-SDR could be received and worked well with this setup in SSB.


Figure 20: Above AMSAT-DL Transverter, below BATC Minitiouner V2

In order to be able to receive DATV on a laptop at the same time as narrowband operation, a BATC Minitiouner V2 is connected to the WB-OUT socket of the transverter

However, the 60cm dish offers hardly any reserves with regard to receiving DATV. The 1.5MSPS beacon can be received with a MER of 6.1dB under clear skies, at least 4.7dB are required. Also, numerous user signals with 500kSPS, 333kSPS, 250kSPS and 125kSPS can be received if they are transmitted sufficiently strong. Weaker user signals can no longer be decoded with this setup, and even the beacon disappears in the noise when there are thick clouds.

In order to transport and store the portable system safely, a suitable wooden box was made from light plywood (poplar). On the outside the dish can easily be hung up with 2 screws. The inside of the box is lined with foam and subdivided so that various accessories such as tools, cables, power supply, triplexer and also the transceiver ICOM IC-9700 including microphone can be safely stored inside.

The feed arm of the dish remains completely mounted, so when setting up the station, it only needs to be placed on the stand and fixed with 3 screws. The dish is mounted as described above using the 4 slots in the feed arm and screwed tight. Thus, the whole system is assembled and ready for operation in less than 10 minutes.

Figure 21 & 22: Transport box made of light plywood

We hope that this description and the short field report will motivate some of you to try out portable operation with the AMSAT-DL transverter kits. Outdoor operation (only with a transceiver, without a PC) is a lot of fun and a few days ago, during a local fieldday, this setup enabled some other OMs to make first contacts via QO-100.