QO-100 Analog Transceiver for amateur radio

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Introduction

The availability of a B200mini sdr and a geostationary amateur satellite pushed me to afford the challenge of creating an amateur transceiver using what was available in the open source universe of Linux.

I am presenting here the result which is a full duplex transceiver covering the analog window of the satellite and with features tailored to make the use as ergonomic as possible on the satellite.

The B200_system was designed to use the Ettus Research B200mini SDR:

Hardware Prerequisites

No particular requirements , any modern PC will be good enough , due to the high frequency in use it is very important to provide a good frequency stability of the sdr.

The B200 has an sma input for a 10 Mhz reference signal , even if the sdr works also with the internal oscillator it is recommended to provide a GPS controlled 10Mhz to guarantee stability and precision.

Software Prerequisites

The current version is based on an Ubuntu Linux version 20.1

The application package contains all other dependencies except QT.

QT is a big development environment which allows it to be used as open source but where it is not possible to export the libraries. I used QT to build the graphic user interface but if anyone wants to try the application has to provide its own QT installation , the version used is QT 5.15.1

The QT site from where to start downloading:.

https://www.qt.io/download-open-source?hsCtaTracking=9f6a2170-a938-42df-a8e2-a9f0b 1d6cdce%7C6cb0de4f-9bb5-4778-ab02-bfb62735f3e5

Installation

The application is released as a single directory "QO-100sdr" in a compressed file, the installation consists simply by extracting the directory in a convenient place of the file system and making a few post install configurations.

Post Install

1)Make the installation directory visible in the environment PATH variable added to .bashrc:

   export PATH=$PATH:/home/"username"/QO-100sdr

2)Since the installation directory contains the Ettus software components necessary to make the B200mini to work properly the path to them must be exported as well as the QT installation place.

3) Suppose you are installing QO-100sdr and QT into your home directory, the following are the modifications to make in the .bashrc file:

LD_LIBRARY_PATH=:/home/"username"/QO-100sdr/Libs:/home/"username"/Qt/5.15.1:/usr/local/lib

export LD_LIBRARY_PATH

export UHD_IMAGES_DIR=/home/"username"/QO-100sdr/Images

4) Enable the usb access by opening a terminal on QO-100sdr/Usb and execute ./sudo enable
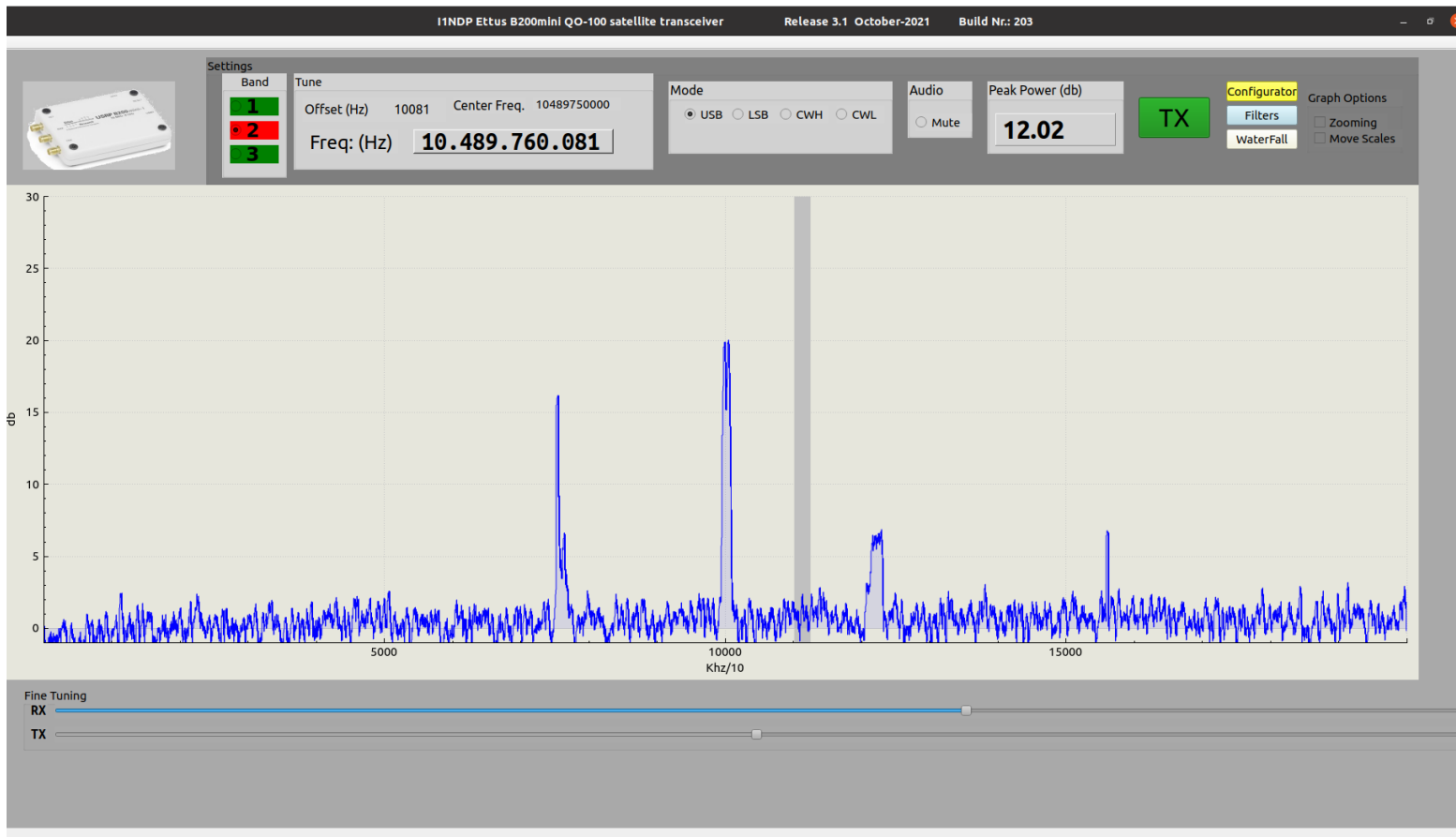
5) Enable the real time execution by:

sudo gedit /etc/security/limits.conf and adding the following line

@username - rtprio 99

Description

Main Transceiver Interface

Most of the display area is dedicated to the monitor , the QO-100 analog window is divided in 3 sub bands of 200 Khz each , the following is the middle sub band mainly dedicated to

SSB (shot taken with low activity)

Tuning

The receiver tuning can be done with mouse by left clicking on any position of the monitor

The RX tuning can be refined by moving the RX slider

The Tx can be used in case of no GPS locking to adjust the isofrequency

A vertical grey bar shows the current tuned position, the wideness corresponds to the current filter shape

Sub Windows

Band

To select the sub band , in the above sub band 2 is current selection

Tune

Read only window reporting receiver frequency in hertz

Mode

Receive and transmit mode selection , SSB & CW only used with QO-100
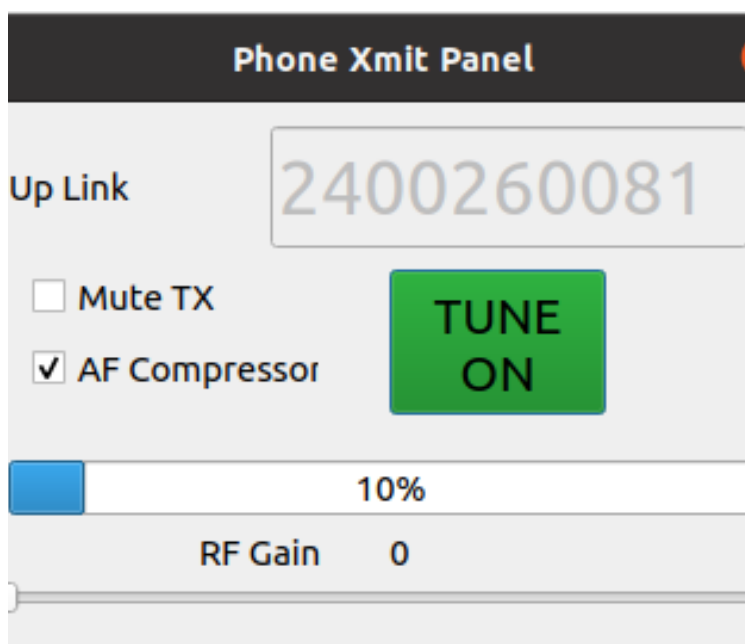
Audio

Audio Mute ON-OFF

Peak Power

Peak Power, shows the real time difference between the signal in the selected frequency and the noise floor in db

TX

To enable TX and show the tx popup according to the current mode (phone or CW)

There is no need to move tune the transmitting frequency being automatically linked to the current receiving window.

Tx phone:

Up-Link. - Transmit frequency on 13cm (read Only) , for small retuning (+-3Khz) the XIT bar can be used

Mute TX - To mute audio when transmitting and avoiding echoes or larsen effect

TuneON/TuneOFF - disable the microphone and transmit/remove a carrier at selected power
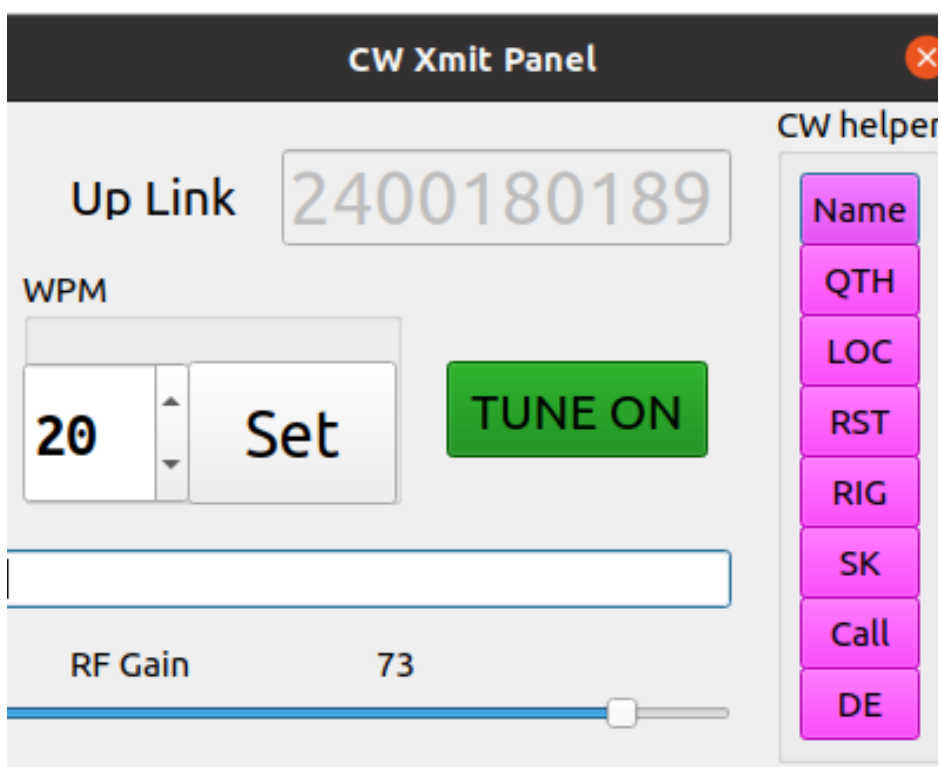
AF Compressor - to enable a BF compressor

RF Gain - output power regulation

Tx CW:

I first tried to connect via USB a CW keyer made with Arduino and connected via USB to PC but the delay of a few milliseconds in the monitor was confusing me, so I decided to remove the paddle and use the keyboard.

Most of the commands are the same as above

WPM – to set the speed

The edit line - to enter the characters to be sent

CW Helper to choose and send a message

Configurator

The sdr needs some parameters depending on environment and user choice, they can be entered and written as a "B200sdr.xml file on the B200sdr folder. The file can be edited with any text editor.To show a panel where to enter the possible configuration parameters:

Center Frequency RX & TX not to be touched unless changes in OA-100

LNB Osc Freq. The LNB converter oscillator frequency , used to set the receiving frequency and calculate the TX offset

RX gain to set the RX sdr gain

Max TX Gain, the max possible TX Gain, with B200mini max possible is 89db corresponding to 13-15 dbm output power (depends on frequency)

TX Gain to set current sdr TX Gain

CW Pitch , to set the CW tone

Zoomin & Resizable scale to enable disable the monitor scale change with mouse

Min V scale starting of y scale in db on the monitor , the signal strength is handled by the application in such a way to be referred to 0 db regardless to gain in RX chain

Max V scale top value in the y scale

Default band 1 to 3

TX Offset to eventually correct TX frequency

CQ call message to enter the desired string

Muted TX set starting mode

AF Compressor set starting mode
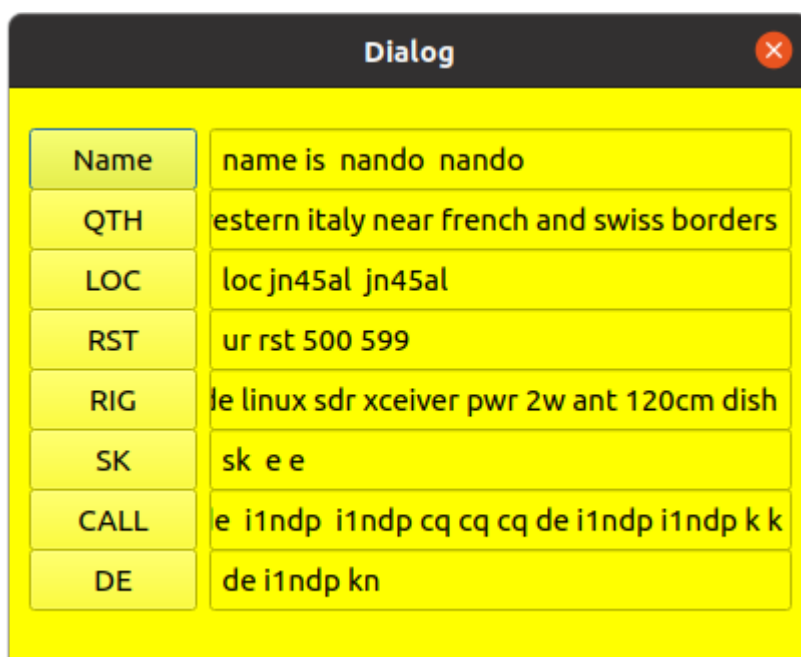
UPDATE to write it to disk

CW Message to configure predefined CW messages

CW Messages

Unused to CW keyboard keying i tried to add
a table of pre prepared messages and give
a chance to change them.
Not sure yet if it's of any help:

Dialog	
Name	name is nando nando
QTH	estern italy near french and swiss borders
LOC	loc jn45al jn45al
RST	ur rst 500 599
RIG	le linux sdr xceiver pwr 2w ant 120cm dish
SK	sk e e
CALL	e i1ndp i1ndp cq cq cq de i1ndp i1ndp k k
DE	de i1ndp kn

Note:

The .xml file must be compatible with the current application release, if not the following popup may appear on screen:

B200sdr

Configuration File not compatible
The file will be recreated with default values

✓ OK
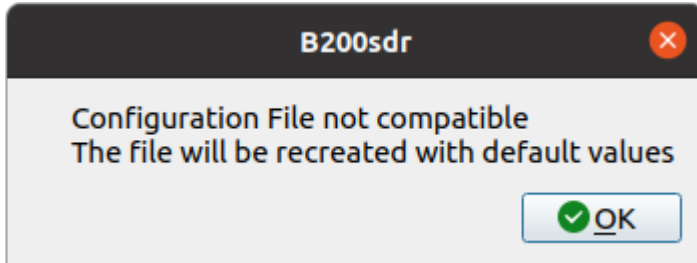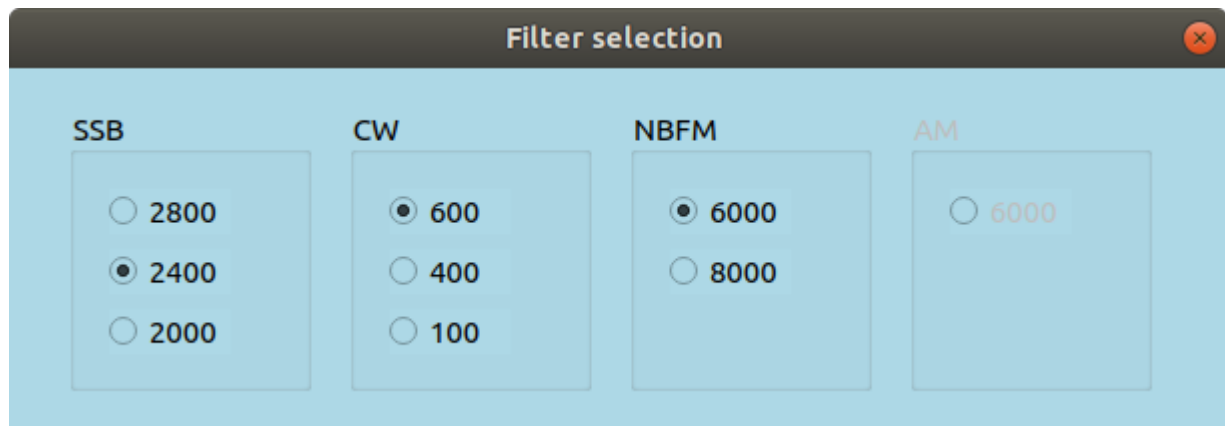
Filters

To choose among several options for SSB,CW NBFM :

For AM there is a fixed filter with 6000 Khz bandwidth ,WBFM has also a fixed filter of 15 Khz.

WaterFall

An additional feature:

RX Block diagram

From antenna 740 Mhz •

RX via USB 3.0

Time domain path

```
┌──────────────┐      ┌──────────────┐      ┌──────────────┐      ┌──────────────┐      ┌──────────────┐
│ B200sdr      │ ───> │ 48000 samples│ ───> │ Tuning time  │ ───> │ AGC control  │ ───> │ decimation   │
│ 480 Khz      │      │ I/Q blocks   │      │ shift        │      │              │      │ 480 to 48 Khz│
│ sample rate  │      │              │      │              │      │              │      │              │
└──────────────┘      └──────────────┘      └──────────────┘      └──────────────┘      └──────────────┘
```
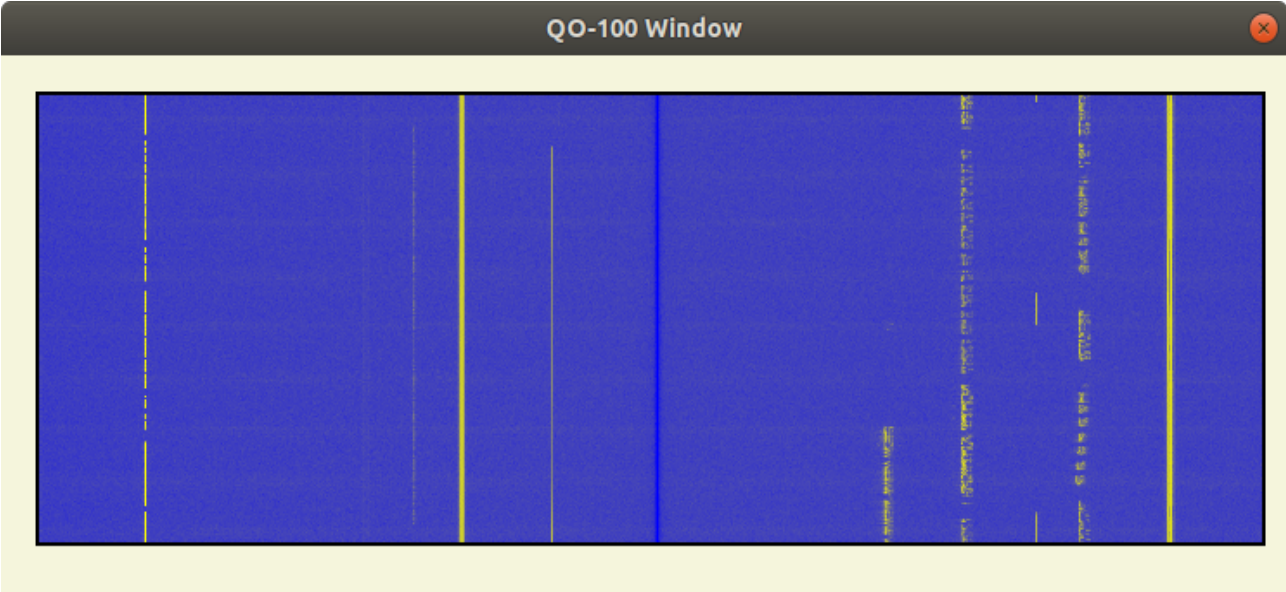
```
┌──────────────┐
│ FFT          │
└──────────────┘

┌──────────────┐
│ Convert I/Q  │
│ To Power     │
└──────────────┘

┌──────────────┐
│ 200 Khz      │
│ band monitor │
└──────────────┘
```

Frequency domain path

```
┌──────────────┐
│ anti alias   │
│ filter       │
└──────────────┘

┌──────────────┐
│ Hilbert      │
│ Transform    │
│ (CW/SSB      │
│ decode)      │
└──────────────┘
```

Output to Ubuntu
Audio Handling
Alsa mono at 48Khz

```
┌──────────────┐      ┌──────────────┐
│ I/Q to power │ <─── │ FFT based    │
│              │      │ Band pass    │
│              │      │ filters      │
└──────────────┘      └──────────────┘
```

TX Block diagram

Audio Blocks 48Khz from Ubuntu audio input

B200sdr TX chain

```
AF Compressor
        ↓
Hilbert transform
SSB Modulator
        ↓
Band Pass
Filter
(300-2800
        ↓
Interpolate      →    sdr TX            →    To amplification
48 to 480 Khz         480 sample/sec         chain (4mw to 2w)
                      13cm                   13 cm patch
                                             antenna
```

Availability

The software is in a good state of testing but not released, being still subject to last minute modifications.

The last checked version is in any case available upon request; an official download place might be provided depending on interest.

Change Log

Version 1.0 released on December 2020

The first version removed from the B200_system package and handled on its own , Version 2.0 released on October 2021can be considered the first release

Version 2.0 released on October 2021

Very minor modifications :

Added the peak power meter

Modified the audio handling,it seems to be more stable

Changed some filter parameters a better output quality

Version 2.1 released on October 2021

No need anymore to tune the transmitter being linked to the current receiving frequency

Removed unusable modes on QO-100 (NBFM-WBFM

Version 2.3 released on January 2022

Added CW predefined messages some add on to the documentation

References

[1] ETTUS : *https://www.ettus.com/*
[2] SODARADIO https://kb1vc.github.io/SoDaRadio/ Solving many of my doubts on how to build an sdr transceiver