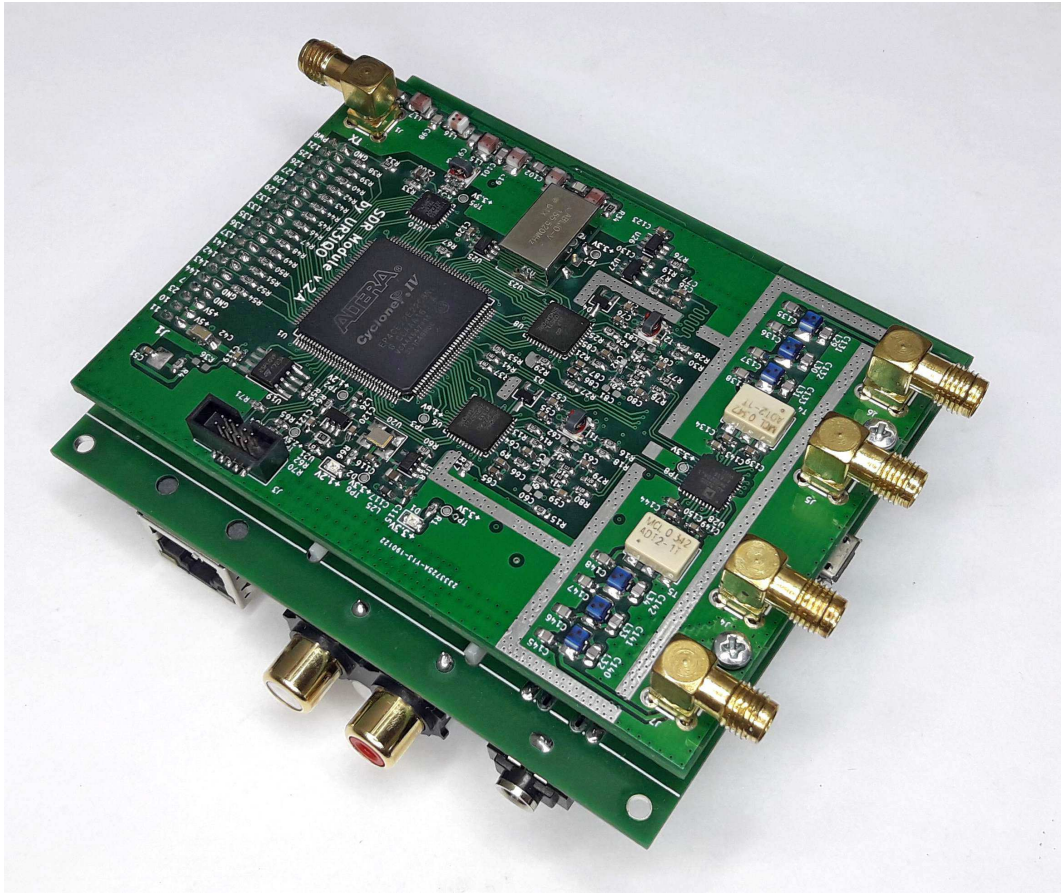
AngeliaLite - OpenHPSDR compatible transceiver

Oleg Skydan UR3IQO



Description

AngeliaLite is intended to be used as the base of the OpenHPSDR compatible transceiver. You need to add just some additional filtering for receiver and PA/LPFs for transmitter to make a full featured high performance HF SDR transceiver. A VHF/microwave transceiver can also be made by adding transverter to the **AngeliaLite**.

AngeliaLite consists of two boards - the SDR module and the interface board.

The SDR module has two RX inputs (with DVGA and 14bits AD9255 ADC) and one TX output (with 14bits AD9744 DAC). There are also Cyclone 4 FPGA EP4CE22E22, configuration memory and all necessary components for clocking and power it up. The ADCs are clocked at 77.76MHz and the DAC is clocked at 155.52MHz by the low noise ABLJO-155.52MHz VCXO.

The interface board contains Eternet PHY, standard ALEX, OC, keyer and PTT interfaces, four analog inputs, diagnostic LEDs, switching regulator (so it can be powered from the single 12V supply), microcontroller (used to interface SDR module to standard OpenHPSDR interfaces, IP and MAC addresses management) and power supply to power boards from the single 12V power supply.

The schematics for both boards, FPGA source code and FPGA/MCU compiled firmware are available on the GitHub (https://github.com/UR3IQO/AngeliaLite).

The FPGA firmware is based on the OpenHPSDR Angelia code, the NCO code is from the HermesLite2 project. There were many changes in the code to fit 4 DDCs into the relatively small and low pin count EP4CE22E22 FPGA, some changes were required because of the different ADC/DAC sample rates and different Ethernet PHY chip.

There are some limitations compared to the OpenHPSDR Angelia board:

- The maximum supported output samplerate is 192kSPS.
- There is no audio CODEC on the boards.
- The Ethernet connection has 100Mbit/s speed.
- The ADC operates on the second Nyquist zone on 50MHz band. The board has LPF filter with 60MHz cutoff frequency, so additional selectivity is needed to avoid image reception. It can be as simple as switchable 30MHz LPF and 50MHz bandpass filter.
- There is no TX power amplifier at the DAC output - just an LPF filter-diplexer. So, you will need some amplification/filtering in the TX path.
- Altera USBBlaster or similar JTAG adapter is needed for FPGA firmware update

The FPGA code implements OpenHPSDR protocol version 2. The **AngeliaLite** operates with the **SDR Console v3** and **Thetis**.

Specifications

General

Architecture	Direct Sampling DDC/DUC Transceiver
Interface	Ethernet (100Mb/s)
TCXO Stability	±0.5 ppm
RX ports	Two SMA connectors (each ADC has dedicated input)
TX ports	SMA connector

Electrical

Supply voltage	8..15V DC
Supply current	0.5A

Mechanical

Weight	100g (approx.)
Dimensions (two boards stacked)	100mm x 85mm x 35mm

Receiver

Receiver Architecture	Direct Sampling / Digital Down Conversion
ADC	Two 14 bit Phase Synchronous ADCs @ 77.76MSPS. Hardware supports 4 independent receivers assignable to either ADC
Frequency Coverage	1MHz to 35MHz (1st Nyquist zone) and 45MHz to 65MHz (2nd Nyquist zone), reception below 1MHz is possible with some RX parameters degradation
Input filtering	LPF with 65MHz cutoff frequency
Attenuator	0..31dB 1dB step attenuator

Transmitter

Transmitter Architecture	Digital Up Conversion
DAC	14 bit @ 155.52MSPS
RF Output Power	-3..-5dBm
Transmitter phase noise	-140dBc/Hz (at >1kHz offset and max. drive settings)

IO interfaces

RCA PTT in, PTT Out
3.5mm Jack CW Key
2.54mm pin headers for ALEX, 7 freely programmable open collector outputs, analog Inputs (4channel + power supply monitoring), two digital inputs
SMA connector for 10MHz reference input/output
SMA connector for 155.52MHz reference output
RJ45 Ethernet LAN Connector

Receiver measurements

The BDR/RMDR/IMD tests were made using two ultra low noise XTAL oscillators. The receiver bandwidth was 500Hz during these tests.

MDS / NF / FS level / BDR

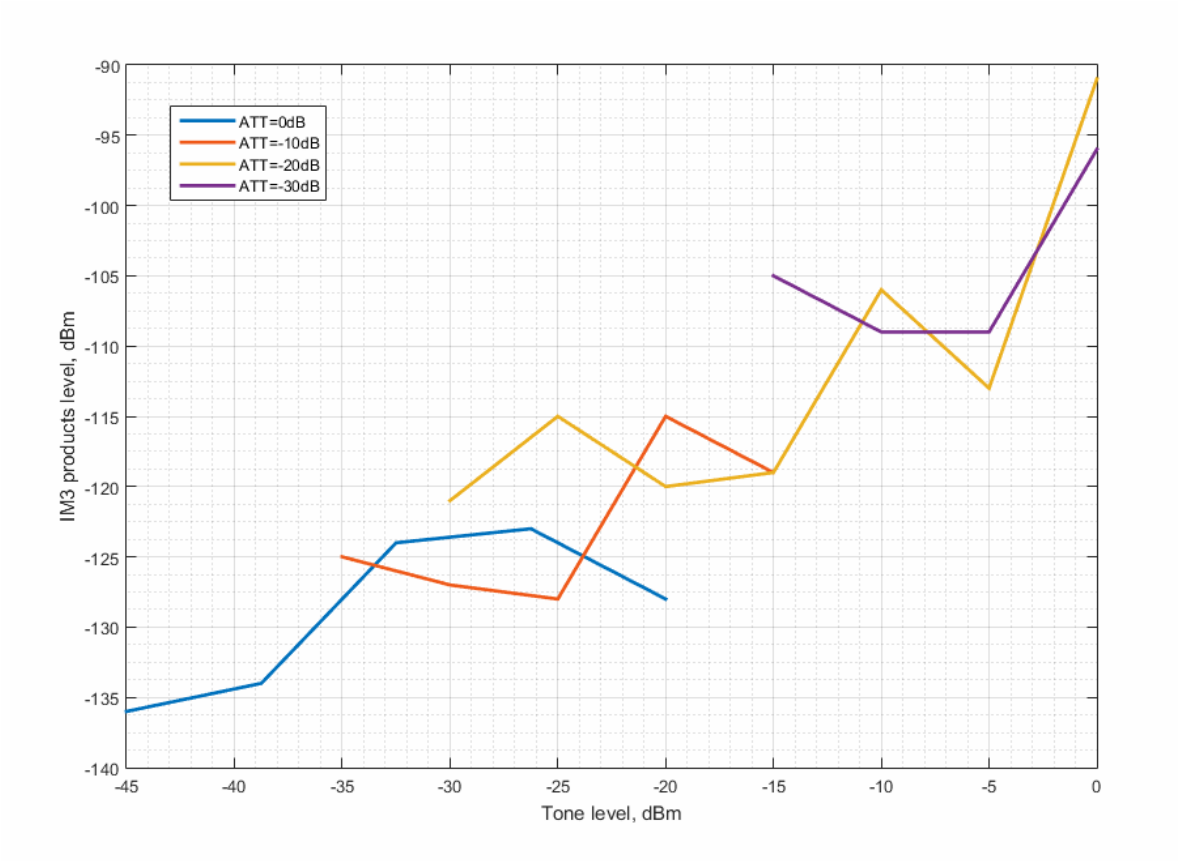
ATT	**MDS**	**NF**	**FS level**	**BDR**
0dB	-133dBm	14dB	-13dBm	120dB
-10dB	-127dBm	20dB	-2dBm	125dB
-20dB	-117dBm	30dB	+9dBm	126dB
-30dB	-107dBm	40dB	-	-

RMDR / SSB noise

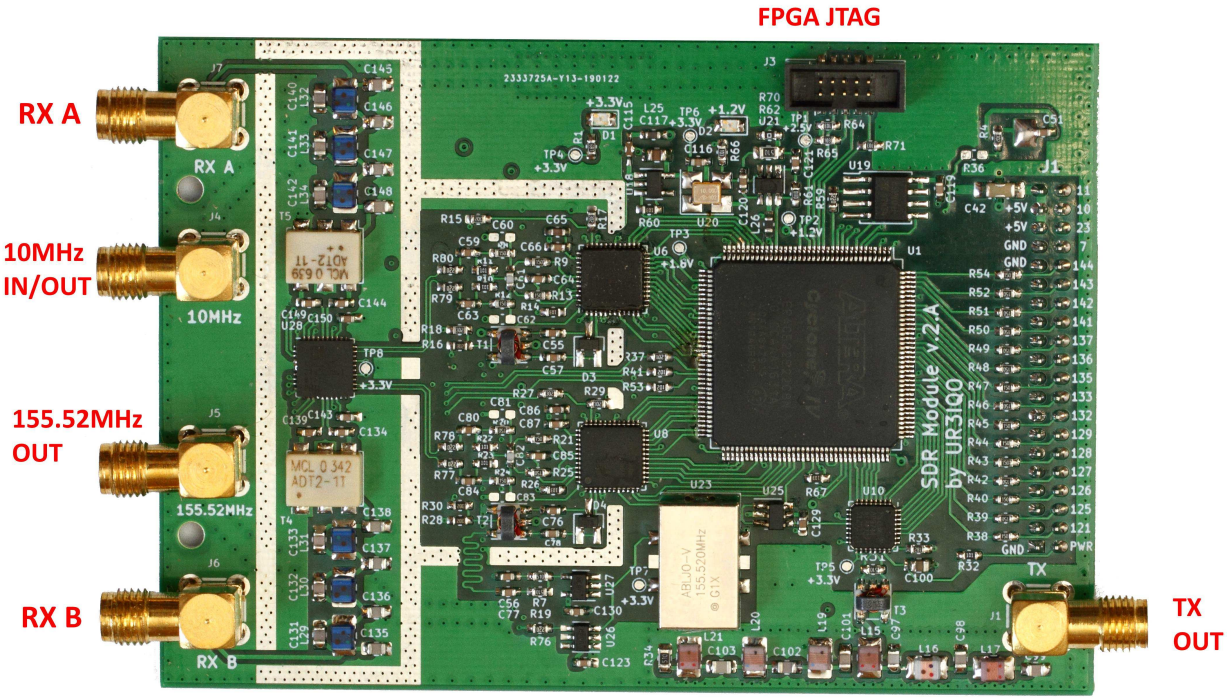
Offset	**RMDR**	**SSB noise**
1kHz	111dB	-138dBc/Hz
2kHz	113dB	-140dBc/Hz
5kHz	117dB	-144dBc/Hz
10kHz	121dB	-148dBc/Hz
20kHz	124dB	-151dBc/Hz

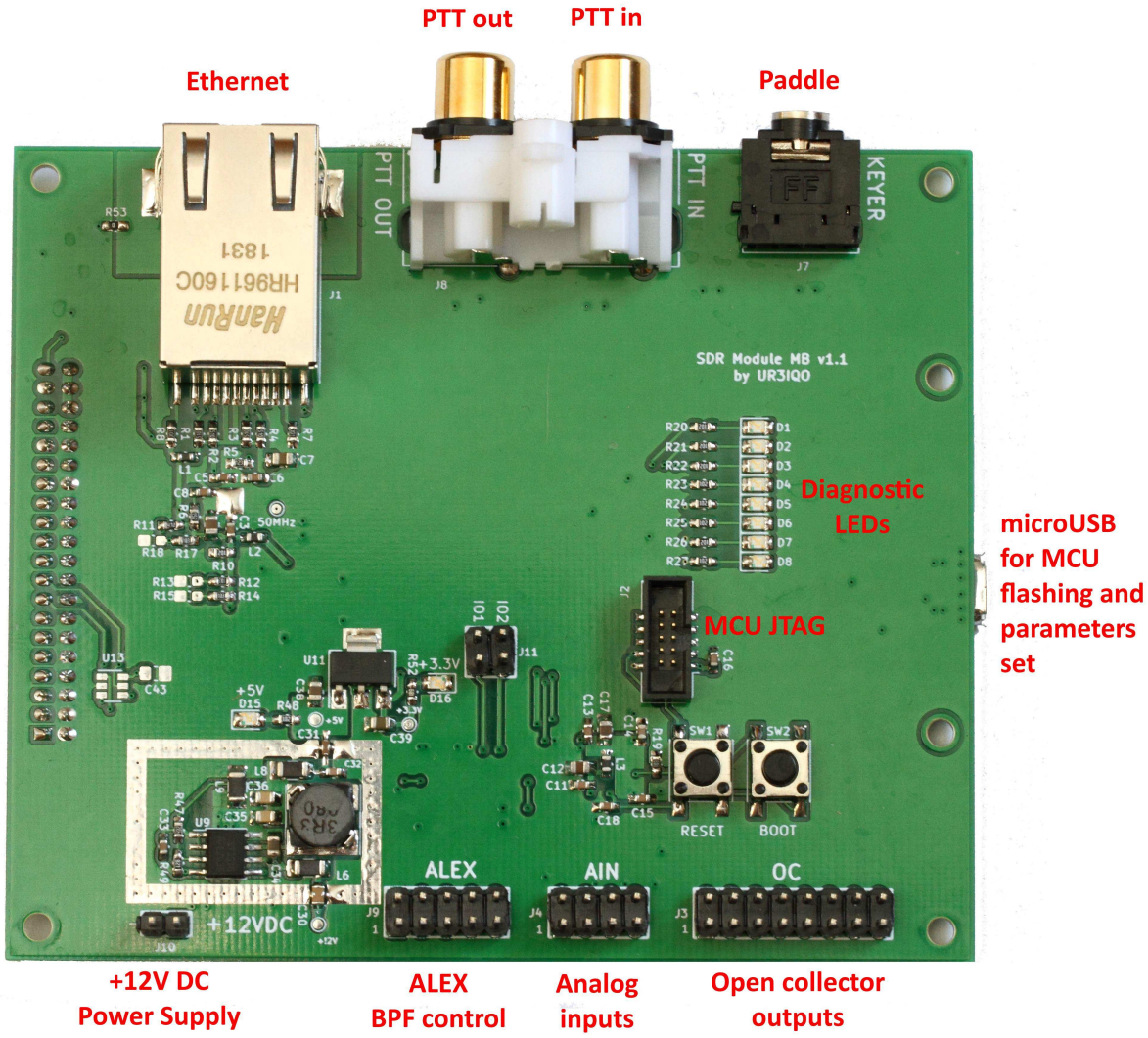
IMD3 Performance

The usual method of determining IMD3 receiver performance does not give useful data when testing direct sampling receiver (because of IMD products does not follow cubical law). So, the IMD3 performance data presented in graphical form showing IM3 levels depending of the test tones levels for the different attenuator settings.



Board Connections





Using the USB port on the interface board

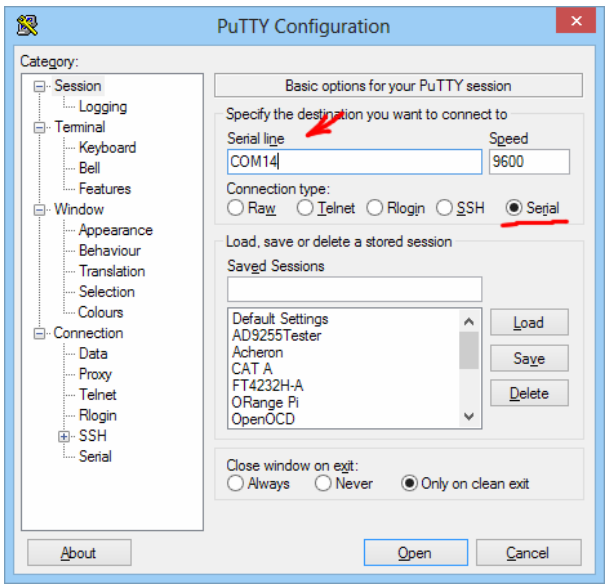
Using the USB port on the interface board you can:

- update MCU firmware
- selecting IP address assignment and set static IP address
- check the board MAC address and serial number
- check MCU firmware version
- set ADC dither override options

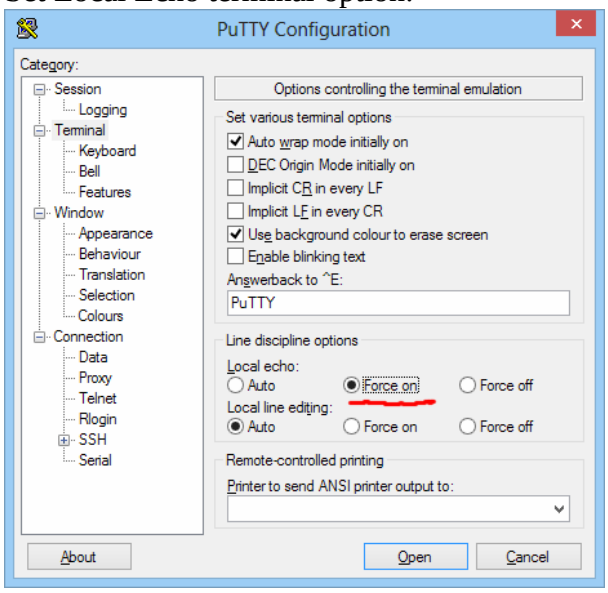
Connecting to the AngeliaLite service console

Connect microUSB port on the board to the computer and turn on the AngeliLite power supply. The computer will install the virtual COM port driver. Open Device Manager to check the port number assigned to the board. Run terminal program (the PuTTY will be used in examples).

Set the COM port number assigned to the board:



Set Local Echo terminal option:



Now press the Connect button, the terminal window with AngeliaLite service console will open.

The command you can issue in the AngeliaLite service console starts with the command (one letter) following by optional command parameter, each command ends with the semicolon.

Print help message

Type **H;** to print AngeliaLite conole commands list:

```
>H;

Commands list:
 H; - this message
 I; - show IP address
 I xxx.xxx.xxx.xxx; - set static IP address
 I DHCP; - obtain IP address from DHCP server or use APIPA address if DHCP fails
 P; - show 10MHz PLL status
 P xxx; - set reference mode:
          xxx = ON - normal operation.
          xxx = OFF - disable 10MHz PLL.
 D; - show dither override status
 D x; - set dither override:
          x = 0 - disable dither override.
          x = 1 - dither override on ADC1.
          x = 2 - dither override on ADC2.
          x = 3 - dither override on both ADCs.
 M; - show MAC address
 V; - show firmware version and serial
OK;
>
```

Check the MCU firmware version and serial number

Type **V;** to print MCU firmware version and board serial number

```
>V;
AngeliaLite service console. Designed by Oleg Skydan UR3IQO.
v0.64.209  from 16092020.
S/N 0000003F0000000000000042
Type h; for help
OK;
>
```

Check the board MAC address

Type **M**; to print AngeliaLite ethernet MAC address:

```
>M;
M [redacted];
OK;
>
```

Check/Set the board IP address

Type **I;** to print the current board IP address:

```
>I;
I DHCP;
OK;
>
```

Type **I xxx.xxx.xxx.xxx;** to assign static IP address xxx.xxx.xxx.xxx:

```
>I 192.168.100.1;
I 192.168.100.1;
OK;
>
```

Type **I DHCP;** to use DHCP to assign IP addres or APIPA address if DHCP will fail

```
I DHCP;
OK;
>
```

NOTE: you should cycle the power of the AngeliaLite to use the new IP address.

Check/Set ADC dithering override

It is recommended to keep ADC dithering enabled for the AngeliaLite, but the SDR software may not allow user to control ADC dithering. So there is ADC dithering override option that can be controlled using the AngeliaLite service console. If the dithering override bit is set the ADC dithering will be turned on independently of the SDR software settings.

Type **D;** to check the ADC dithering override status:

```
>D;
D 3;
OK;
>
```

Type **D x;** to change ADC dithering override flags:

```
>D 0;
D 0;
OK;
>
```

See the table below for the **x** parameter description:

Parameter value	Description
0	ADC dithering override is OFF, the SDR software will control dithering
1	ADC dithering override is ON for the ADC1 only
2	ADC dithering override is ON for the ADC2 only
3	ADC dithering override is ON for both ADCs

Close the terminal program and disconnect USB cable when you done with the AngeliaLite service console.

Updating MCU firmware

You will need DfuSe Demo software available at the ST web site:
https://www.st.com/en/development-tools/stsw-stm32080.html

Connect board to the computer USB port, turn the board power on when holding the BOOT button on the interface board. Alternatively you can hold the BOOT button and press the RESET button. Then release the BOOT button. The MCU will start the internal DFU bootloader and you will be able to flash it using the DFU image from the AngeliaLite GitHub: https://github.com/UR3IQO/AngeliaLite/tree/master/Firmware/MCU

Please see DfuSe Demo documentation how to load the image into the MCU flash memory.