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NPR –VSAT
(Hamnet / IPv4 over QO-100)

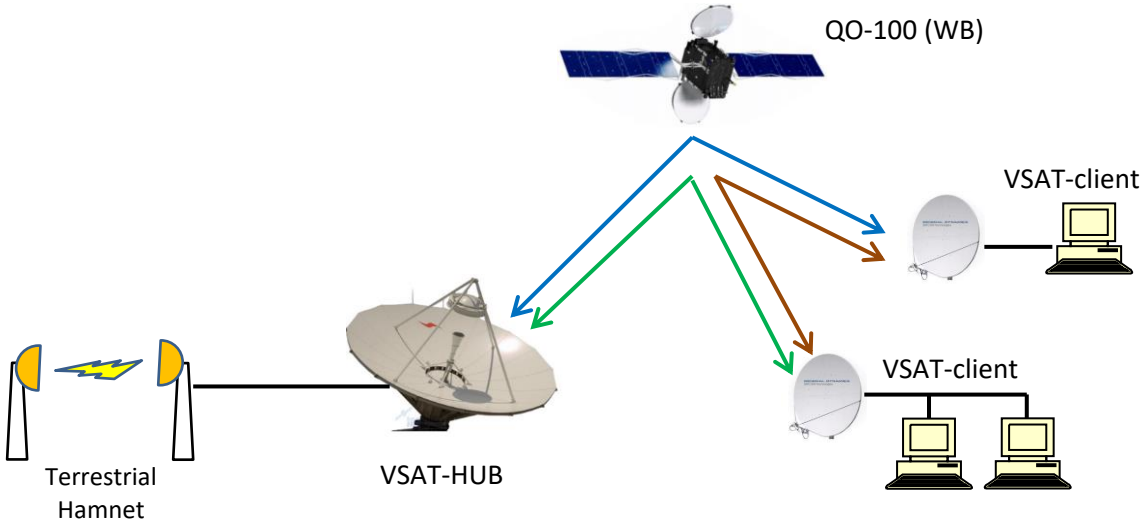
User guide

Version 0.4

Please read the document entirely

before attempting to connect to NPR-VSAT

1 General description



1.1 General description

The NPR-VSAT project enables IPv4 access over QO-100.
The goal is to

- Have access to the European-Hamnet with a QO-100 station, wherever inside the QO-100 coverage.
- Communicate via IPv4 between stations

It is low-datarate (dozens of kb/s mean for users, peak ~100kb/s).

It works over the QO-100 wide-band transponder, therefore requiring a quite powerful station.
It is an SDR-based solution, and it requires a PC (Linux or Windows), with a dedicated software NPR-VSAT.

NPR-VSAT means “New Packet Radio over VSAT”.
The protocol is inherited from NPR-70 project (https://hackaday.io/project/164092) with improvements and specific features for the QO-100.

The protocol is 100% custom, invented and designed by me (Guillaume F4HDK), an amateur-radio operator, intended for amateur-radio usage. Of course, only amateur-radio operators, with valid licence, can use a QO-100 station.

1.2 The Hub

The « NPR-VSAT Hub » (called “the Hub” here after) is the VSAT-Hub, the central QO-100 station which coordinates the network.

- It informs the members about the network characteristics (channels, their frequency, their symbol rate, timing characteristics, IPv4 configuration and routing)
- It gives a central clock / timing, in order to synchronize the network.
- It allocates RF resources (channels and timeslots) among clients, dynamically, depending on their needs, in real time.
- It manages the connection and disconnection of members (clients) to the network.
- It manages the allocation of IPv4 addresses
- It interconnects the IPv4 subnet with Hamnet

Even if we have a central station, 2 client-stations can communicate with each other directly, without the hub having to repeat the traffic.

1.3 MF-TDMA (Multi-Frequencies Time-Division-Multiplexing)

NPR-VSAT works with MF-TDMA.
The allocated radiofrequency spectrum dedicated to NPR-VSAT is split into a 2D matrix made of

- Several channels, each having a different frequency. Different channels can have different Symbol Rates (50kS/s or 100kS/s or 200kS/s)
- Several timeslots inside each channel, each one lasting ~24milliseconds.

Therefore, client stations only transmit bursts of traffic, they do not transmit continuously. It induces a more efficient Radiofrequency resource sharing among multiple clients (compared to stations sending continuous streams of data, like DVB-S).
Each station listens to all frequency-channels simultaneously, and demodulate/decode them all.
We can have one or several dozens of stations simultaneously connected, even if there are only 3, 4 or 5 frequency-channels.
NPR-VSAT is therefore well suited for “burst” kind of IPv4 traffic, like small file transfer, e-mail, tchat, light web-browsing. It is not well suited for continuous stream of data over IP, it would rapidly saturate the NPR-VSAT network.

1.4 Modulations

Two modulations are proposed: BPSK or QPSK. Both can cohabit together in the same channel, and this is decided on a frame per frame basis.

BPSK is more robust than QPSK, requires less RF power, but it carries less datarate.

NPRVSAT uses BPSK exclusively for all the traffic about network coordination: connection request, connection acknowledge, resource allocation, timing broadcast, and also the header of all the radio frames.

The IPv4 traffic can be BPSK or QPSK, depending on each station RF power. It is configured by the user of the transmit station via the setting “RF_TX_CAPABILITY”. You can refer to the paragraph “Transmit Power Considerations” for more details.

Channels can have symbol rate of 50kS/s (kilo Symbols per sec) or 100kS/s or 200kS/s. 50kS/s is not used currently.

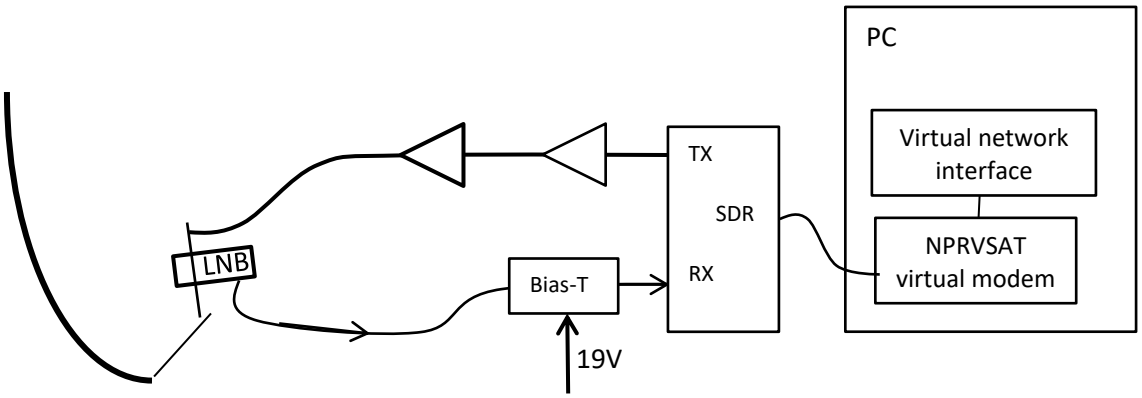
1.5 Compliance with amateur-radio regulation

Like for NPR70, we respect 2 mandatory rules

- Each station sends regularly, every ~30 seconds, its own characteristics including
  - its amateur-radio callsign,
  - its IPv4 addresses

  All station within the NPR-VSAT network (or spying the network) displays the characteristics of all the connected stations inside the terminal window
- The traffic is not encrypted, and the protocol is public, open-source. Everybody can demodulate and decode all the traffic with the NPR-VSAT software, and can “spy” all the IPv4 traffic.

2 A typical client station



2.1 SDR and Radio installation

You need to have a bi-directional / full-duplex SDR. The NPR-VSAT software is currently compatible with :

- Lime-SDR-Mini
- Adalm-Pluto-SDR

Warning, the compatibility with Lime-SDR-Mini is currently very poor

	Pluto-SDR	**Lime-SDR-Mini**
Windows	OK	Not optimal. Freq offset compensation not fully implemented
Linux	OK	Not implemented

I plan to provide soon compatible with all SDR hardware compatible with “Soapy SDR”.
You can use intermediate frequency converters or not inside your station. Of course, if you use, you will have to configure the software accordingly.
Your station must have full duplex capability over the QO-100 wide-band transponder (transmitting and receiving at the same time). Both sides (TX and RX) of your full-duplex SDR must be connected.

Your TX amplifier chain shall be always “PTT-ON” while using NPR-VSAT. Because of the “burst” kind of traffic, NPR-VSAT is not compatible with VOX features included in some up-converters or power-amplifiers (unless you implement your own VOX with ultra-fast switching time ~40µs maxi, everything considered inside your TX chain. 40µs, not 40ms, yes that’s challenging).

Warning, NPR-VSAT requires quite powerful station in terms of transmit power / dish size. You should refer to the paragraph *“Transmit power consideration”* for details about transmit power requirements. If you already transmit DVB-S with 200kS/s, it is OK.

2.2 Software virtual modem

The NPR-VSAT software provided is a virtual modem. It runs on either Windows (7, 10 or 11), or on Linux. A 64bits Windows or Linux is mandatory. 32-bits operating systems will not work.
The source code for a client is provided; you can also compile it by yourself.

For IPv4 traffic, the NPR-VSAT software interface to your operating system using a virtual Ethernet network interface (Tun/Tap).

The software handles the following features

- Interface with SDR
- Modulation and demodulation of the signal
- Packet management
- Dialog with the virtual network Ethernet interface (Tun/Tap)
- DHCP server

2.3 The PC

Warning, the NPR-VSAT software requires a quite powerful PC, in terms of CPU, because it is currently not optimised. (Optimization planned in future releases).

A rough estimation of the required CPU power (both criteria apply):

- Passmark “CPU-Mark” should be above 4500
- Passmark “Single-thread” should be above 1700

You can search the Passmark Values about your CPU here : https://www.cpubenchmark.net/

3 IPv4 addresses

3.1 IPv4 addresses – general considerations

Like for NPR-70, the NPR-VSAT distributes the IPv4 addresses dynamically to client-stations. There are 2 levels:

- The Hub allocates 1 or 2 IPv4 addresses to each client station, depending the setting "CLIENT_IP_SIZE".
- The NPR-VSAT software acts like a DHCP server, and allocate this (these 2) IPv4 addresses via the virtual network interface

The hub tries to keep the IPv4 to each client unchanged between 2 connections, but there is no guarantee, therefore the IPv4 address can change if a client disconnect and reconnects again later.
(I plan to implement soon a static IPv4 address feature).

Like for NPR-70, the IPv4 address of the "virtual modem" is the same for all client stations, in order to use less IPv4 addresses. This IPv4 address is used for DHCP server. It is only accessible locally, not remotely.

3.2 DHCP server

By default, the NPR-VSAT software is configured to be a DHCP server.
If you want to deactivate it, you should set "DHCP_SERVER_ACTIVE:0. Then you have to set manually the IPv4 addresses within the IPv4 range provided by the Hub specifically to your station.

By default, the DHCP server sends the "route to Hamnet" information via "DHCP option 121" (Classless IPv4 static route). This is the preferred option. It allows a machine to be connected simultaneously to Hamnet via these "static routes" and to Internet (or another private network) via a "default route".

If your OS does not support this "DHCP option 121" properly (it should be rare), then you can set the option *"DEF_ROUTE_ACTIVE:1"* instead of *":2"* by default. In this case, a double connection (Internet + Hamnet over NPR-VSAT) will probably not work; please deactivate your internet connection.

3.3 DNS (DHCP)

By default, the DNS entry of the DHCP server is activated.
If you want a double connection with both on a single PC

- Internet access
- Hamnet access over NPR-VSAT

And if your "internet DNS" already provides you Hamnet DNS entries (which is highly probable), then you should deactivate the DNS-DHCP option, by setting DHCP_DNS_ACTIVE:0.

At the opposite, if your PC is only connected to Hamnet over NPR-VSAT, then you should let the default value DHCP_DNS_ACTIVE:1 (or nothing).

4 Software Installation on Windows

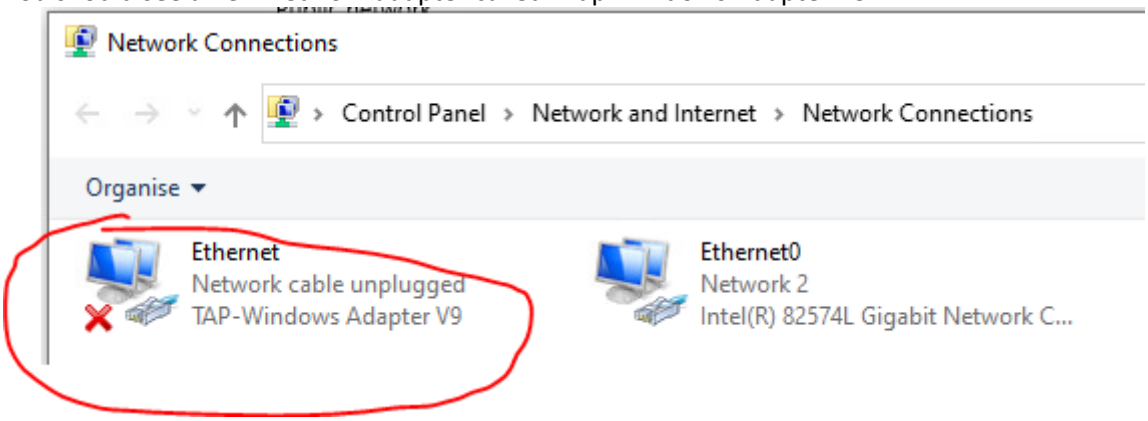
All the installation files are inside the ZIP "NPRVSAT_Windows_install.zip".

4.1 Virtual network interface

First, you need to install the virtual interface. Run one time the "tap-windows.exe" installer (provided inside the ZIP file "NPRVSAT_Windows_install.zip").
Run it one time only. It will install a virtual network interface.
You can check that the installation is OK by opening the network interface manager of windows:

Settings / Network-and-Internet / Change-adapter-options /

You should see a new network adapter called "Tap-Windows Adapter V9".



Remark: If a VPN software is already installed on your PC, you maybe already have this "Tap-Windows v9" network adapter. If the NPR-VSAT and your VPN software interfere with each-others, a solution would be to stop the VPN-software (totally) before running NPR-VSAT. If the interference between the 2 is worse, please let me know.

4.2 SDR driver

You should install your SDR drivers (probably already installed).
For Pluto-SDR: https://github.com/analogdevicesinc/plutosdr-m2k-drivers-win/releases

4.3 Optional : Visual Studio Redistributable package

With old Windows installation, you will perhaps need to install "Visual Studio Redistributable Package". Only install it if you have an error message when trying to run the NPR-VSAT software.
With an up-to-date windows-10 or windows-11, this should not be required.
https://aka.ms/vs/17/release/vc_redist.x64.exe

4.4 The software itself

From the ZIP file *"NPRVSAT_Windows_install.zip"*, you should extract the folder "NPRVSAT"; and put it this folder where you want in your user folder.
Warning: if you copy-paste from another existing installation, from another PC for example, please delete the file "`\prog_data\NPRVSAT.nvm`". It is a kind "non-volatile memory". It is automatically generated at the first start, and contains a random number which should be unique.

4.5 Software update

For newer versions of the NPR-VSAT software, you should only download the ZIP file *"NPRVSAT_windows_binary.zip"*, which is much smaller than the full.
Then you extract it, and copy the file NPRVSAT.exe inside the following folder

`NPRVSAT\bin\`

5 Software Installation on Linux

I am not a Linux expert; the instructions below are perhaps not optimal.

5.1 Virtual network interface

You have to create a TAP virtual interface by yourself. Not a TUN interface.

```
$ sudo ip tuntap add dev tap_01 mode tap user f4hdk
$ sudo ip link set tap_01 up
```

You should not assign an IP address, if you use the DHCP feature of the NPR-VSAT virtual modem.

5.2 Installing prerequisite software

You have to install the following packages

- libsfml-dev : `$ sudo apt-get install libsfml-dev`
- SoapySDR : `$ sudo apt-get install libsoapysdr-dev`
- Libiio (for Pluto SDR): `$ sudo apt-get install libiio-dev`

5.3 Specific for SoapyPlutoSDR

The default version of SoapyPlutoSDR does not allow big transmit buffer. It allows only 4096 samples, instead of 32768 required for NPR-VSAT.
You should compile the new version that I provide, provided inside the ZIP *"NPRVSAT_Linux_install"*, with the following instructions

```
$ cd SoapyPlutoSDR
$ mkdir build
$ cd build
$ cmake ..
$ make
$ sudo make install
```

(Inherited from https://github.com/pothosware/SoapyPlutoSDR/wiki)

5.4 Compile NPR-VSAT

You have to compile your own version of NPR-VSAT.
The binary file will be generated with the right version of SFML and SoapySDR, which depend on your OS version.
Inside the "NPRVSAT_source" folder, you just type "make".
It should generate a binary file called "NPRVSAT".

5.5 Directory structure

- Extract the directory structure "NPRVSAT", provided inside the ZIP *"NPRVSAT_Linux_install",* where you want
- If you have copied this directory structure from another PC, please remove the file "`./prog_data/NPRVSAT.nvm`". It is a kind "non-volatile memory". It is automatically generated at the first start, and contains a random number which should be unique.
- If needed, copy-paste the binary-executable file that you have just compiled to the right directory: ./`NPRVSAT/bin/`.

6 Configuration file

You have to create and/or modify your own configuration file, **before** using NPR-VSAT.
It is located here:

```
config/NPRVSAT_glob_config.txt
```

THIS IS MANDATORY.

You can change some parameters "live", while the software is running, mostly for the frequency offsets, the RF-TX-Capability, and the TX-Gain. For all other parameters, please try to modify these when the software is not running.

If a parameter is not present inside the file, then it takes its default value, except for the callsign.

	Parameter	Mandatory or optional	Live update possible	Description
	CALLSIGN	**Mandatory!**	No	Your callsign. It must be unique in the NPR-VSAT network. 15 characters maxi.
SDR	SDR_HW	**Mandatory!**	No	SDR hardware 0: Adalm Pluto 1: Lime SDR Mini 9: custom (not yet implemented)
	PLUTO_IP	Cf comment	No	Mandatory for Pluto on Linux only. It is the IP address of the Pluto SDR. By default: 192.168.2.1
Frequencies and Symbol rate	CENTER_TX_FREQ	**Mandatory!**	Yes	Frequency of channel One.. Refer to the paragraph *"Frequency considerations"*. The right value is given by the admin/sysop of the Hub or by AMSAT.
	CENTER_RX_FREQ	**Mandatory!**	Yes	Frequency of channel One. Refer to the paragraph *"Frequency considerations"*. The right value is given by the admin/sysop of the Hub or by AMSAT.
	RX_LO_FREQ	**Mandatory!**	Yes	Refer to dedicated paragraph *"Frequency considerations"*
	TX_FREQ_OFFSET	Highly recommended	Yes	Refer to dedicated paragraph *"Frequency considerations"*
	SR_CHAN_1	**Mandatory!**	Yes	Symbol rate for channel 1. The right value is given by the admin/sysop of the Hub or by AMSAT. 0: 100kS/s 1: 50kS/s 2: 200kS/s (default value)

	Parameter	Mandatory or optional	Live update possible	Description
IPv4 config	TUNTAP_NAME	Cf comment	No	Name of the TUN/TAP virtual network interface. Mandatory for Linux. Currently useless for Windows.
	CLIENT_IP_SIZE	Optional	No	Number of IPv4 machines (PCs) that you want to connect to NPR-SAT network, with dedicated public IP addresses each. Let to value 1 unless you know precisely what you are doing. Refer to the dedicated paragraph “multiple IPv4 nodes”. Max allowed : 2.
	DHCP_SERVER_ACTIVE	Optional	No	0: DHCP server inactive 1: DHCP server active Refer to the paragraph *“IPv4 addresses”*
	DEF_ROUTE_ACTIVE	Optional	No	1: DHCP server with “default route” to the Hamnet router 2: DHCP server with “option 121” static route (recommended value) Refer to the paragraph *“DHCP server”*
	DHCP_DNS_ACTIVE	Optional	No	1(default val):DHCP servers sends DNS entry within Hamnet 0: DHCP DNS entry inhibited Refer to the paragraph *“DNS (DHCP)”*
	TX_MAX_GAIN	**Mandatory!**	Yes	Maximum TX-Gain allowed for SDR. Refer to paragraph *“Transmit power consideration”*
	RF_TX_CAPABILITY	**Mandatory!**	Yes	TX capability of your station. Refer to paragraph *“Transmit power consideration”*
DEBUG	DISPL_CONSTELLATION	Optional	No	Refer to dedicated paragraph *“Optional feature: display graphs”* 0: no display (default) 1: display I/Q constellation
	DISPL_EYE	Optional	No	Refer to paragraph *“Optional feature: graphs”* 0: no display (default) 1: display BPSK eye graph 3: display BPSK, I, Q eye graphs
	SDR_SAVE_TO_FILE	Optional	Yes	Refer to dedicated paragraph *“Optional feature: capture files”* Set to 1 in order save raw SDR IQ file 1MS/s.
	FRAME_SAVE_TO_FILE	Optional	No	Refer to dedicated paragraph *“Optional feature: capture files”* Set to 1 in order to safe debug text file
	IPV4_SPY	Optional	Yes	Refer to dedicated paragraph *“Optional feature: IPV4_SPY”* 0: normal operation (default) 1: normal + spy 2: spy only
	INHIB_TUNTAP	Optional	No	Set to 1 if you want to run the NPRVSAT software without IPv4 connection, even without a Tun/Tap interface. For debug only.

7 Using NPR-VSAT software

7.1 Running the program

The instructions are the same for Linux or Windows.
You first open a terminal window / command prompt.
Set the current directory to the NPRVSAT one that you have installed. Do not try to run from the "bin" folder, the "path" will not be the good one.
And from there, execute the binary executable

- Windows: `> .\bin\NPRVSAT.exe`
- Linux: `$ ./bin/NPRVSAT`

Then the terminal window shows useful information about what is happening.
If the hub is active, and if all your settings are correct, and if your station is powerful enough, the NPR-VSAT software should:

- Connect automatically to the hub, after dozens of seconds (usually 30 to 60 sec), displaying "Status = connected".
- You can see connection attempts when "Frame TX count" increases by 1 or 2.
- Once it is connected to the hub, activate the virtual network interface.
- Assign an IP address to your PC via DHCP. If not, once connected, you can try to trigger a manual DHCP request
    - Windows : `> ipconfig /renew`
    - Linux : `> sudo dhclient tap_01` (where tap_01 is the name of your TAP interface)

In parallel, while the program is running, you can modify your configuration file live if needed (mostly about frequency offset, RF-TX-Capability and TX-max-gain), the modification will be immediately taken into account.

You probably have to enlarge the terminal window, in order to view all the text.
If you want to clean the terminal window, because of overlapping text, you can save the configuration file; it will trigger a terminal clean-up.

There are 2 command line options, which are detailed in dedicated paragraphs of this document

- TX_test (paragraph "Transmission test")
- Reset_TX_gain (paragraph "Transmit power consideration")

If you want to terminate the program, you just press `[ Ctrl + C ]`.

7.2 Reading and understanding the text status

```
                  +-------------+-------------+
                  |  from Hub   |   from ME   |
-----------------+-------------+-------------+
       SDR-Gain  |  RX: 60.1 dB|  TX: 87.0 dB|
   amplitude RX  |     310.1   |     334.7   |
  Timing-Advance |             |   418.221 ms|
 Freq Offset(MHz)| RX:1660.476 | TX:   0.047 |
-----------------+------+------+------+------+
                  | BPSK | QPSK | BPSK | QPSK |
-----------------+------+------+------+------+
   frame TX count|  --  |  --  |    17|    66|
   frame TX rate |  --  |  --  |   0/s|   3/s|
   frame RX count|   322|   541|    17|    66|
   frame RX rate |   5/s|  23/s|   0/s|   4/s|
-----------------+------+------+------+------+
 Word err rate(%)|  1.73| 19.77|  0.00| 13.00|
Frame err rate(%)|  0.00|  0.00|  --  |  0.00|

STATUS: CONNECTED

 DHCP ENTRIES*******
   0:stat:2 IP:44.168.30.22 MAC:D2:19:2E:3B:AC:B0 age:17sec

WHO:
ME 1 "F4HDK" IP: 44.168.30.22 to 44.168.30.23
  0 "F6KBF-Hub" IP: 44.168.30.17 to 44.168.30.19 Static:0
```

From-Hub / From-ME:

The column **"From Hub"** shows the decoding of frames received from the hub. It should be used for detecting problems about reception in your station.

The column **"From ME"** shows information about the reception by your station of its own transmitted frames. It should be used for detecting problems about the transmission part of your station (once the "from hub" part works reliably, of course).

frame-count / frame-rate

For the **"From Hub"** part, you should get minimum 30 frames per second (BPSK + QPSK).

For the **"from ME"**, the values should be almost the same between TX and RX. If not, there is a problem about the TX part of your station :

- TX frequency not tuned
- Or too weak RF power.
- Or big signal distortion (saturated amplifier)
- Or the CPU of your PC is too weak.

Frame error rate:

The Frame error **"from-Hub"** rate should be zero (or above zero very occasionally). If you don't receive frames "from hub" or if the frame error is above 1%, you should fix that before attempting to transmit and to connect to the NPR-VSAT network.

The frame-error-rate **"from-Me"** should always be Zero (or above zero very occasionally).
We distinguish errors between BPSK and QPSK.

If you see QPSK frame error rate always 100%, whereas BPSK frame error rate is 0%, there could be 2 root causes:

- The frequency (RX or TX) is not well tuned (most often)
- The signal is too weak (TX or RX)

What should you do if you have Frame-error-rate "from Me" too high?

- Maybe your RF power is too weak.
- You can try to lower the setting "RF_TX_CAPABILITY". Decrease the value by 1 and test again.
    - If you have QPSK errors, but not BPSK errors, one solution can be to force RF_TX_CAPABILITY to value 2 (BPSK 100kS/s). With this setting, your station will only transmit BPSK frames.
- Maybe you can increase the setting TX_MAX_GAIN (SDR gain), if the TX-Gain shown in the table is already at your max setting TX_MAX_GAIN, and only if your TX amplifier chain allows it.

Word error rate

It is normal to have a word error rate above zero (unlike frame-error rate which should always be zero). The FEC algorithm usually corrects these.
The "word error rate" is useful if you want to qualify the quality of signals, if you want to see if there are improvements or degradation when applying a modification.
Remark: even if your station only transmits QPSK frames, the Word-error-rate **"From-Me"** BPSK will still be filled, because the header of each frame is always transmitted with BPSK.

Timing-Advance

It is the time between decision of transmission, and reception of its own frame. It contains the TX-buffer duration, the RX-buffer duration, and more importantly the round trip from the station to the satellite. If this value varies during time of more than ~0.5 milli-seconds, it probably means that the CPU of your PC is too weak.

7.3 Optional feature: IPV4_SPY

You can collect all the IPv4 traffic which transits over the satellite, not only the one dedicated to your station. In this case, all the traffic which is not intended to your local IPv4 nodes is transferred to a virtual/dumb MAC address (4E:50:52:57:A3:B1), over the virtual network TAP interface.
There are 3 possible settings

- IPV4_SPY:0 Is the default value, the spy mode is inhibited.
- IPV4_SPY:1 Connects to the NPR-VSAT network, and in parallel collects all the traffic
- IPV4_SPY:2 Only listens to the NPR-VSAT network, do not attempt to connect to it

7.4 Optional feature: capture files

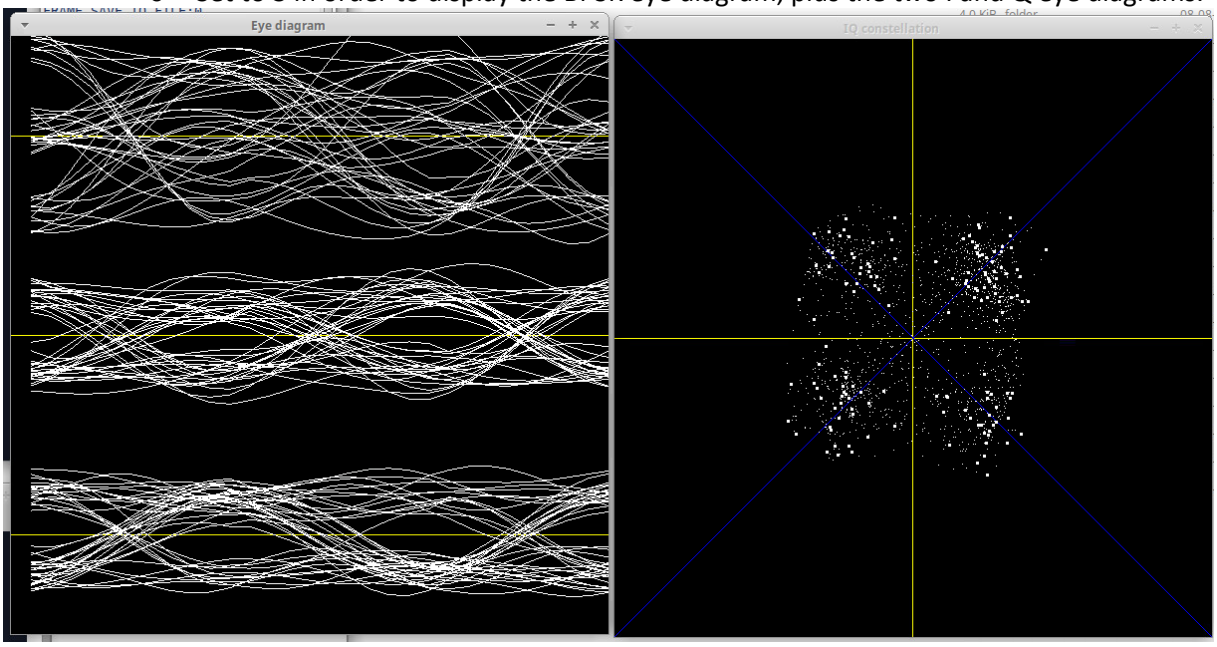
You can generate 2 types of capture files

Setting	Comment
SDR_SAVE_TO_FILE:1	Stores a raw IQ capture file inside the folder "user_data". Sample rate is 1MSample/s currently. You can open the file with the "inspectrum" software.
FRAME_SAVE_TO_FILE:1	Stores a text/csv file about characteristics of radio frames. Mostly for debug purpose.

7.5 Optional feature: display graphs

You can display live graphs for channel One.
Warning, it induces additional CPU usage. If your CPU is slow, I do not recommend it.

- DISPL_CONSTELLATION : set to 1 in order to display the I/Q constellation
- DISPL_EYE:
    - Set to 1 in order to display the BPSK eye diagram
    - Set to 3 in order to display the BPSK eye diagram, plus the two I and Q eye diagrams.



8 Transmission test

You can test the good behaviour of your installation (software, SDR, tuning, RF amplifier, LNB, etc…) without connecting to the Hub and to the NPR-VSAT network.

Warning: if you test over the satellite, the test shall be as short as possible. You should test transmit chain mostly with dummy load and local instruments (spectrum analyzer, frequency counter, etc…).

With a command prompt, at the root folder of your installation, you type:

Windows	`> bin\NPRVSAT.exe TX_test 2408.75`
Linux	`$ ./bin/ NPRVSAT TX_test 2408.75`

2408.75 is an example of frequency, you can chose the one you want.

In TX_test mode, there is only one frequency setting, the same for TX and RX, therefore your "RX_LO_FREQ" setting must be correctly chosen.

The "center frequency" is (of course) not inherited from the "config file", in order not to disturb the real NPR-VSAT frequency.
Warning: If you test over QO-100, you have to select an unoccupied frequency, usually dedicated to DATV/DVB-S, different from the NPRVSAT real network frequencies.

Warning, the RX frequency auto tuning is (currently) not implemented in the TX_test mode. You have to tune the frequency offsets precisely inside your config file, more precisely than over the NPR-VSAT network, if you want to decode your own signals, especially at low symbol-rates.
Refer to the dedicated paragraph.

While the test is running, you can modify some parameters live, mostly the following :

- RF_TX_CAPABILITY:
  - 1 or 2 means SR=50kS/s
  - 3 means SR=100kS/s
  - 4 means SR=200kS/s
- RX_LO_FREQ
- TX_FREQ_OFFSET
- TX_MAX_GAIN : during the test, the SDR transmit gain takes this "MAX" value.

The test transmits 50% of BPSK frames and 50% of QPSK frames. You can check the error rate of your own BPSK and QPSK frames over the satellite, in order to determine your "transmit capability". Refer to next paragraph for details.

9 Transmit power consideration

NPR-VSAT allows several stations to have different transmit power capabilities from each other's.
A less capable station will transmit with lower data-rate.
You have to choose the right transmit power capability via the setting RF_TX_CAPABILITY, depending on max TX RF power that you have at the antenna, and your TX antenna gain (TX dish antenna size).
Warning, if you select a too high value for RF_TX_CAPABILITY, compared to the real capability of your station, then your connection will be poor, unusable, with lots of transmission errors. It could also disturb all the network.

RF_TX_CAPABILITY value	Meaning		Comment
	Over the real NPR-VSAT network	With TX_test	
1	~~1 x BPSK 50kS/s~~	1 x 50kS/s (1)	50kS/s not yet implemented! (only for TX-test) Do not use this value, except for tests!
2	~~1 x QPSK 50kS/s~~ Or 1 x BPSK 100kS/s	1 x 50kS/s (1)	50kS/s not yet implemented! (only for TX-test) Currently restricted to BPSK 100kS.
3	1 x QPSK 100kS/s	1 x 100kS/s (1)	
4	2 x QPSK 100kS/s simultaneous (or 1 x QPSK 200kS/s)	1 x 200kS/s (1)	200kS/s currently only implemented for Hub TX. Clients will automatically use 2x100kS/s.
5	3 x QPSK 100kS/s simultaneous	1 x 200kS/s (1)	Currently no representative TX-test available.

(1) : with a mix of QPSK and BPSK frames

For setting 4 or above, the station can transmit on several channels simultaneously. Your RF TX amplifier chain (preamp plus power-amplifier) must be highly linear because the "peak to average power ratio" is higher in this configuration than with a single channel transmission.
The Hub is informed about your setting, and if it is set to 4 or above, the Hub will allow your station to transmit over several channels simultaneously if there are enough RF resources available.

You can determine the TX capability of your station via a transmission test over QO-100 Wide-band, either with the NPR-VSAT software, or with a DVB transmission for the same Symbol-Rate. On the BATC Web-SDR, you should see the peak spectral power that you achieve, with a chosen Symbol-Rate

- In order to transmit NPR-VSAT BPSK reliably, you should achieve 6.5dB above noise
- In order to transmit NPR-VSAT QPSK reliably, you should achieve 9.5dB above noise

The NPR-VSAT software incorporates an automatic compensation of the TX gain. It tries to tune the SDR transmit gain in order to achieve the same "spectral power density" as the Hub, if it is possible. But it cannot go above the setting TX_MAX_GAIN.

The setting TX_MAX_GAIN, inside the config file, is used 2 times in the software

- It is the maximum SDR transmit gain allowed for the auto-TX gain compensation
- It is the SDR transmit gain used during "TX_test"

You can change TX_MAX_GAIN live, it will be applied immediately.

You should tune this value TX_MAX_GAIN with 2 constraints in mind:

- Enough power in order to have a reliable transmission. You can check that with 2 ways
    - With TX-test or with a DVB transmission, Try to achieve the SNR mentioned above (6.5dB or 9.5dB), and slightly higher; I recommend ~1dB higher if possible.
    - With TX-test or with a real NPR-VSAT connection, get frame error rate "from me" = Zero.
- Keep value low enough in order not to saturate your RF amplifier chain

For example, if a TX_test with CAPABILITY=3 shows, with the max achievable TX power of your station

- Zero frame-error rate on BPSK frames
- Big frame-error rate on QPSK frames

Then you should select CAPABILITY=2 at the end (BPSK 100kS), over the real NPR-VSAT network.
Always try to reach frame error rate of Zero.
(I remind you: it is normal to have word-error rate above zero).

Warning:
Each time you start the NPR-VSAT software, it triggers an SDR-TX calibration test, which transmits a short burst of RF signal, outside of the QO-100 wide-band transponder, 30MHz above, with full SDR TX gain, even if above TX_MAX_GAIN. If your RF-TX chain (preamp and power-amplifier) cannot handle this, you should start your amplifier or preamplifier a few seconds after the software itself. Of course, it would be easier to insert RF attenuators before your amplifier if you have this constraint.

Reset TX Gain
The TX gain, which is automatically determined by the "automatic TX Gain compensation" strategy inside the software, is saved (inside the NVRAM file) and recovered at the next execution of the software.

Sometimes, the previous "TX Gain" value is not relevant anymore. For example if you apply modification to your hardware TX transmission chain (changing a coax cable).

If the saved value of "TX Gain" is way too low, the "automatic TX gain compensation" strategy could take ages (dozens of minutes) in order to reach the required value, in order for your TX signals to be decodable.

In such situations, you can use the following command-line option at startup.

```
> .\bin\NPRVSAT.exe reset_TX_gain
```

It will force the "TX Gain" to the value "TX_MAX_GAIN" immediately.

10 Frequency consideration

The setting “center frequency” corresponds to the frequency of “channel 1”, the channel dedicated to the hub transmission. When the Hub is active, it should transmit continuously over this channel.
The right frequency is given by the admin of NPR-VSAT Hub or by AMSAT.
You do not have to set the frequencies and Symbol Rates for the other channels (channel 2 and above), their characteristics are automatically transmitted from the Hub to each client. The goal is to allow the NPR-VSAT Hub admin to make live modification to the configuration of channels.

You have to understand the meaning of frequency configuration.
I have chosen to work with uplink=TX frequencies (in 2400MHz range).

```
CENTER_RX_FREQ:2407.75
CENTER_TX_FREQ:2407.75
RX_LO_FREQ:1660.446
TX_FREQ_OFFSET:0.049
```

RX_LO_FREQ:

The “RX_LO_FREQ” setting is the combination of both

- The satellite frequency offset, which is very precise, and constant : 8089.5MHz
- Your LNB LO frequency. For a standard LNB, it should be around 9750MHz, with probably an error (unless you use a GPS-disciplined LO for your LNB).

Therefore, the real RX_LO_FREQ shall be equal to

```
RX_LO_FREQ = your_real_LNB_LO_Freq - 8089.5MHz (=~1660.5MHz)
```

The software will tune your RX-SDR frequency at

```
SDR_Freq_RX = CENTER_RX_FREQ – RX_LO_FREQ
```

You can determine the right setting for RX_LO_FREQ with the help of an SDR software which enables a “delta frequency” or “offset freq” or “transverter config”. You chose/tune the right offset frequency in order to observe the QO-100 narrow band beacons at their exact frequencies in the 2400MHz range:
2400MHz, 2400.250MHz, 2400.500MHz.

TX_FREQ_OFFSET:

The `TX_FREQ_OFFSET` setting compensates the error of your transmission chain. It is the difference:

```
TX_FREQ_OFFSET = frequency_setting (CENTER_TX_FREQ) – real_TX_freq
```

The software will tune your TX-SDR frequency at:

```
SDR_Freq_TX = CENTER_TX_FREQ + TX_FREQ_OFFSET
```

Unlike for traffic on the narrow band transponder, a GPS-disciplined installation is not required.
I strongly recommend to measure and adjust the real LNB LO-Frequency, even for PLL-LNB. You can do it by viewing the narrow band spectrum for example.

The virtual modem automatically compensates the frequency drift, on both sides:

- Reception: it relies on the hub frames, which are sent with precise frequency.
- Transmission: the virtual modem reads its own frames, and computes the frequency offset.

But you have to give an initial frequency offset value, and the precision depends on the Symbol Rate

- 200kS/s (the channel 1): requested accuracy +/-60kHz
- 100kS/s : requested accuracy +/-30kHz
- 50kS/s : requested accuracy +/-15kHz

Because the initial network connection starts with reception of the channel 1 (200kS/s), the reception chain can have a +/-60kHz error, which is a large value, easy to achieve.

11 Multiple IPv4 nodes (optional feature)

You can connect several IPv4 nodes/machine, connected locally, behind a single NPR-VSAT virtual modem.
One of these IPv4 nodes is usually the machine carrying the NPR-VSAT software, but it is not mandatory.
In order to connect several machines, you have to configure an Ethernet bridge between

- The virtual network interface used by the NPR-VSAT
- The network interface (virtual or physical) which connects to your others IPv4 nodes

The Bridge must be an Ethernet-mode bridge, a transparent “layer 2” bridge.
You have to configure your network interface (virtual or physical) in order not to filter MAC Ethernet in any direction; for example: enable promiscuous mode, allow MAC address change, allow Forged Transmits. This is required, because the virtual network interface has its own MAC address.

12 Future planned evolutions

You can give me your opinion about which feature you mostly expect, in order for me to determine the priority.

- Publish the protocol specification
- Static IP Address: it will be implemented with high priority. Client stations will have to request individually a static IP allocation to the admin/sysop of the NPR-VSAT Hub.
- Allowing IPv4 subnet to be statically routed over the network. One station could host its own IPv4 subnet (no dynamic routing protocol allowed, we have way too small datarate).
- Compatibility with other SDR hardware
- A semi-graphic status interface
- Automatic detection of too weak CPU
- Automatic detection of too weak TX power / bad capability setting
- Demodulator optimisation in order to lower the CPU usage
- Channels with lower SR 50kS/s, in order to allow less powerful stations to connect
- Channels with higher SR (400 or 500kS/s), or more channels
- Downstream DVB-S2 from the Hub