

Experimenting with Software Defined Radio

Dr.Sunil T T
College of Engineering
Attingal

Hardware Required

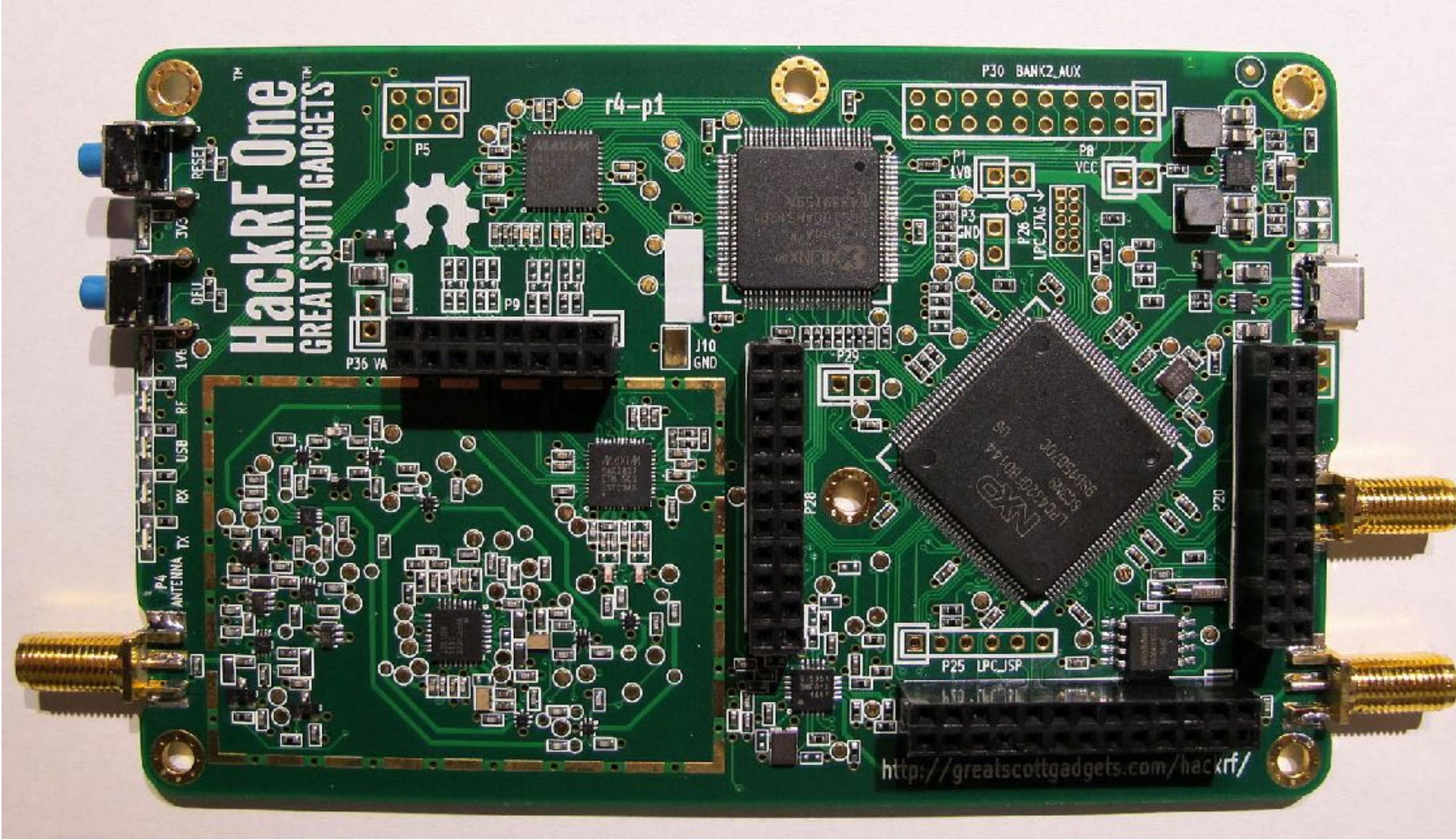
- RTL SDR dongle
- Hack RF one (if you want to transmit)
- FM Transmitter or some other RF signal source. (Be careful)
(Raspberry pi can be used)

RTL SDR Dongle



- You can buy a cheap RTL dongle from amazon or RS components

Hack RF one



- Chinese clones for original hack rf one are available online at about Rs 8.5 k
- Another possibility is Adalam Pluto board from Analog devices.

Software Required

It is advised to do all the experiments on ubuntu 20.04 LTS

- GqrX
- Gnu Radio
- Cubic SDR (if you want to transmit)
- There are plenty of other software available

Download Ubuntu Desktop

Ubuntu 20.04.4 LTS

Download the latest [LTS](#) version of Ubuntu, for desktop PCs and laptops. LTS stands for long-term support — which means five years, until April 2025, of free security and maintenance updates, guaranteed.

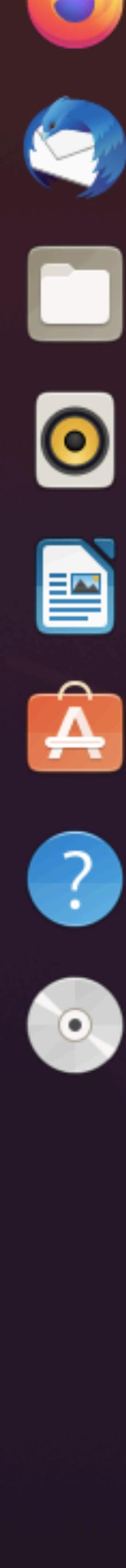
[Ubuntu 20.04 LTS release notes](#)

Recommended system requirements:

- ✓ 2 GHz dual core processor or better
- ✓ 4 GB system memory
- ✓ 25 GB of free hard drive space
- ✓ Internet access is helpful
- ✓ Either a DVD drive or a USB port for the installer media

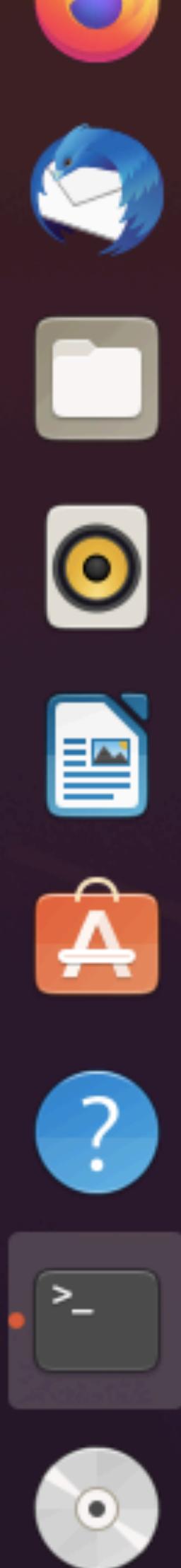
[Download](#)

For other versions of Ubuntu Desktop including torrents, the network installer, a list of local mirrors, and past releases [see our alternative downloads](#).

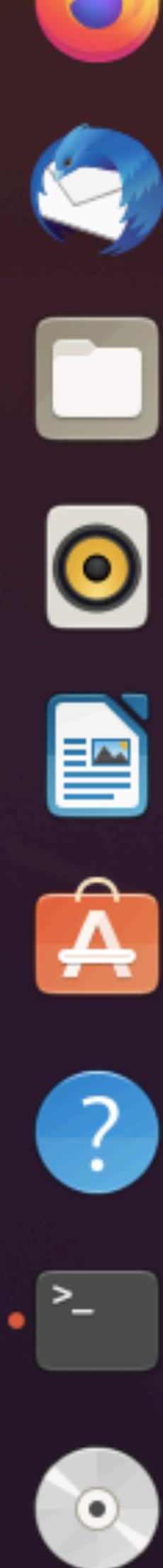


sunil@sunil-VirtualBox: ~

```
sunil@sunil-VirtualBox:~$  
sunil@sunil-VirtualBox:~$  
sunil@sunil-VirtualBox:~$  
sunil@sunil-VirtualBox:~$ sudo apt update
```

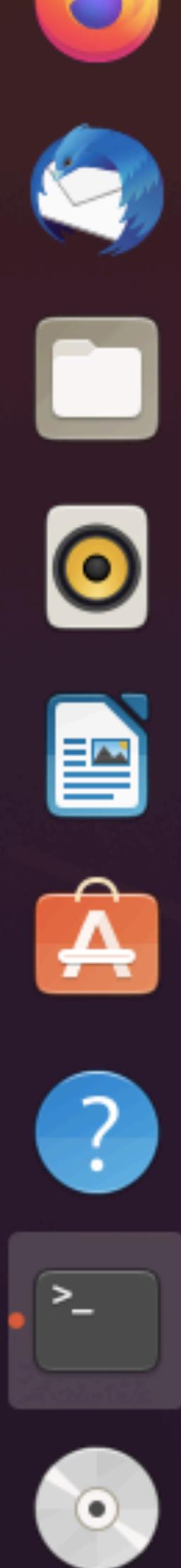


```
sunil@sunil-VirtualBox:~$  
sunil@sunil-VirtualBox:~$  
sunil@sunil-VirtualBox:~$  
sunil@sunil-VirtualBox:~$ sudo apt update  
[sudo] password for sunil:  
Hit:1 http://in.archive.ubuntu.com/ubuntu focal InRelease  
Hit:2 http://in.archive.ubuntu.com/ubuntu focal-updates InRelease  
Hit:3 http://in.archive.ubuntu.com/ubuntu focal-backports InRelease  
Hit:4 http://security.ubuntu.com/ubuntu focal-security InRelease  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
108 packages can be upgraded. Run 'apt list --upgradable' to see them.  
sunil@sunil-VirtualBox:~$
```



sunil@sunil-VirtualBox: ~

```
sunil@sunil-VirtualBox:~$  
sunil@sunil-VirtualBox:~$  
sunil@sunil-VirtualBox:~$  
sunil@sunil-VirtualBox:~$ sudo apt install gnuradio
```



```
libexpat1-dev libfftw3-bin libfftw3-dev libfftw3-double3 libfftw3-long3
libfftw3-quad3 libgcc-9-dev libgfortran5 libgmp-dev libgmpxx4ldbl
libgnuradio-analog3.8.1 libgnuradio-audio3.8.1 libgnuradio-blocks3.8.1
libgnuradio-channels3.8.1 libgnuradio-digital3.8.1 libgnuradio-dtv3.8.1
libgnuradio-fec3.8.1 libgnuradio-fft3.8.1 libgnuradio-filter3.8.1
libgnuradio-pmt3.8.1 libgnuradio-qtgui3.8.1 libgnuradio-runtime3.8.1
libgnuradio-trellis3.8.1 libgnuradio-uhd3.8.1 libgnuradio-video-sdl3.8.1
libgnuradio-vocoder3.8.1 libgnuradio-wavelet3.8.1 libgnuradio-zeromq3.8.1 libgsl23
libgslcblas0 libgsm1 libgsm1-dev libicu-dev libitm1 libjs-jquery libjs-jquery-ui
liblapack3 liblblfgsb0 liblog4cpp5-dev liblog4cpp5v5 liblsan0 libnorm1 libpcre2-16-0
libpgm-5.2-0 libportaudio2 libpython2-stdlib libpython2.7-minimal
libpython2.7-stdlib libpython3-dev libpython3.8-dev libqt5core5a libqt5dbus5
libqt5designer5 libqt5gui5 libqt5help5 libqt5network5 libqt5opengl5
libqt5printsupport5 libqt5sql5 libqt5sql5-sqlite libqt5svg5 libqt5test5
libqt5widgets5 libqt5xml5 libquadmath0 libqwt-qt5-6 librtlsdr0 libsdl1.2debian
libstdc++-9-dev libtcl8.6 libtk8.6 libtsan0 libubsan1 libuhd3.15.0 libvolk2-bin
libvolk2-dev libvolk2.2 libxcb-xinerama0 libxcb-xinput0 libzmq5 linux-libc-dev
manpages-dev python-matplotlib-data python2 python2-minimal python2.7
python2.7-minimal python3-bs4 python3-click-plugins python3-cycler
python3-decorator python3-dev python3-distutils python3-html5lib python3-kiwisolver
python3-lxml python3-matplotlib python3-networkx python3-numpy python3-opengl
python3-pyparsing python3-pyqt5 python3-pyqt5.qtopengl python3-pyqtgraph
python3-scipy python3-sip python3-soupsieve python3-tk python3-webencodings
python3-zmq python3.8-dev qt5-gtk-platformtheme qttranslations5-l10n rtl-sdr
tk8.6-blt2.5 ttf-bitstream-vera uhd-host zlib1g-dev
```

The following packages will be upgraded:

```
cpp-9 gcc-9-base libc6 libc6-dbg libexpat1 libpython3.8 libpython3.8-minimal
libpython3.8-stdlib python3.8 python3.8-minimal zlib1g
11 upgraded, 173 newly installed, 0 to remove and 97 not upgraded
```



sunil@sunil-VirtualBox: ~



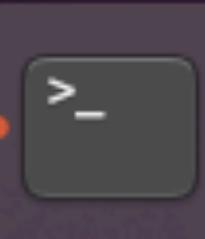
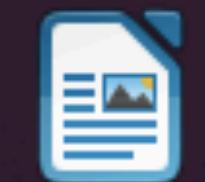
```
Unpacking libcanberra-gtk0:amd64 (0.30-7ubuntu1) ...
Selecting previously unselected package libcanberra-gtk-module:amd64.
Preparing to unpack .../034-libcanberra-gtk-module_0.30-7ubuntu1_amd64.deb ...
Unpacking libcanberra-gtk-module:amd64 (0.30-7ubuntu1) ...
Selecting previously unselected package libvolk2.2:amd64.
Preparing to unpack .../035-libvolk2.2_2.2.1-1_amd64.deb ...
Unpacking libvolk2.2:amd64 (2.2.1-1) ...
Selecting previously unselected package libvolk2-bin.
Preparing to unpack .../036-libvolk2-bin_2.2.1-1_amd64.deb ...
Unpacking libvolk2-bin (2.2.1-1) ...
Selecting previously unselected package python3-click-plugins.
Preparing to unpack .../037-python3-click-plugins_1.1.1-2_all.deb ...
Unpacking python3-click-plugins (1.1.1-2) ...
Selecting previously unselected package python3-lxml:amd64.
Preparing to unpack .../038-python3-lxml_4.5.0-1ubuntu0.5_amd64.deb ...
Unpacking python3-lxml:amd64 (4.5.0-1ubuntu0.5) ...
Selecting previously unselected package libblas3:amd64.
Preparing to unpack .../039-libblas3_3.9.0-1build1_amd64.deb ...
Unpacking libblas3:amd64 (3.9.0-1build1) ...
Selecting previously unselected package libgfortran5:amd64.
Preparing to unpack .../040-libgfortran5_10.3.0-1ubuntul~20.04_amd64.deb ...
Unpacking libgfortran5:amd64 (10.3.0-1ubuntul~20.04) ...
Selecting previously unselected package liblapack3:amd64.
Preparing to unpack .../041-liblapack3_3.9.0-1build1_amd64.deb ...
Unpacking liblapack3:amd64 (3.9.0-1build1) ...
Selecting previously unselected package python3-numpy.
Preparing to unpack .../042-python3-numpy_1%3a1.17.4-5ubuntu3_amd64.deb ...
Unpacking python3-numpy (1:1.17.4-5ubuntu3) ...
Selecting previously unselected package python3-openal.
```



sunil@sunil-VirtualBox: ~



```
sunil@sunil-VirtualBox:~$ rt
rtacct      rtkitctl    rtl.biast   rtl.fm       rtl.sdr      rtl.test    rtstat
rtcwake     rtl.adsb    rtl.eeprom  rtl.power    rtl.tcp      rtmon
sunil@sunil-VirtualBox:~$
```

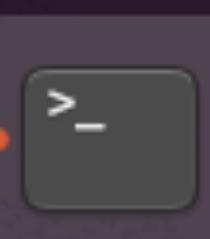
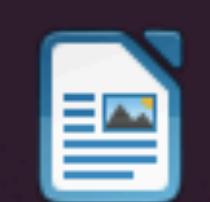




sunil@sunil-VirtualBox: ~

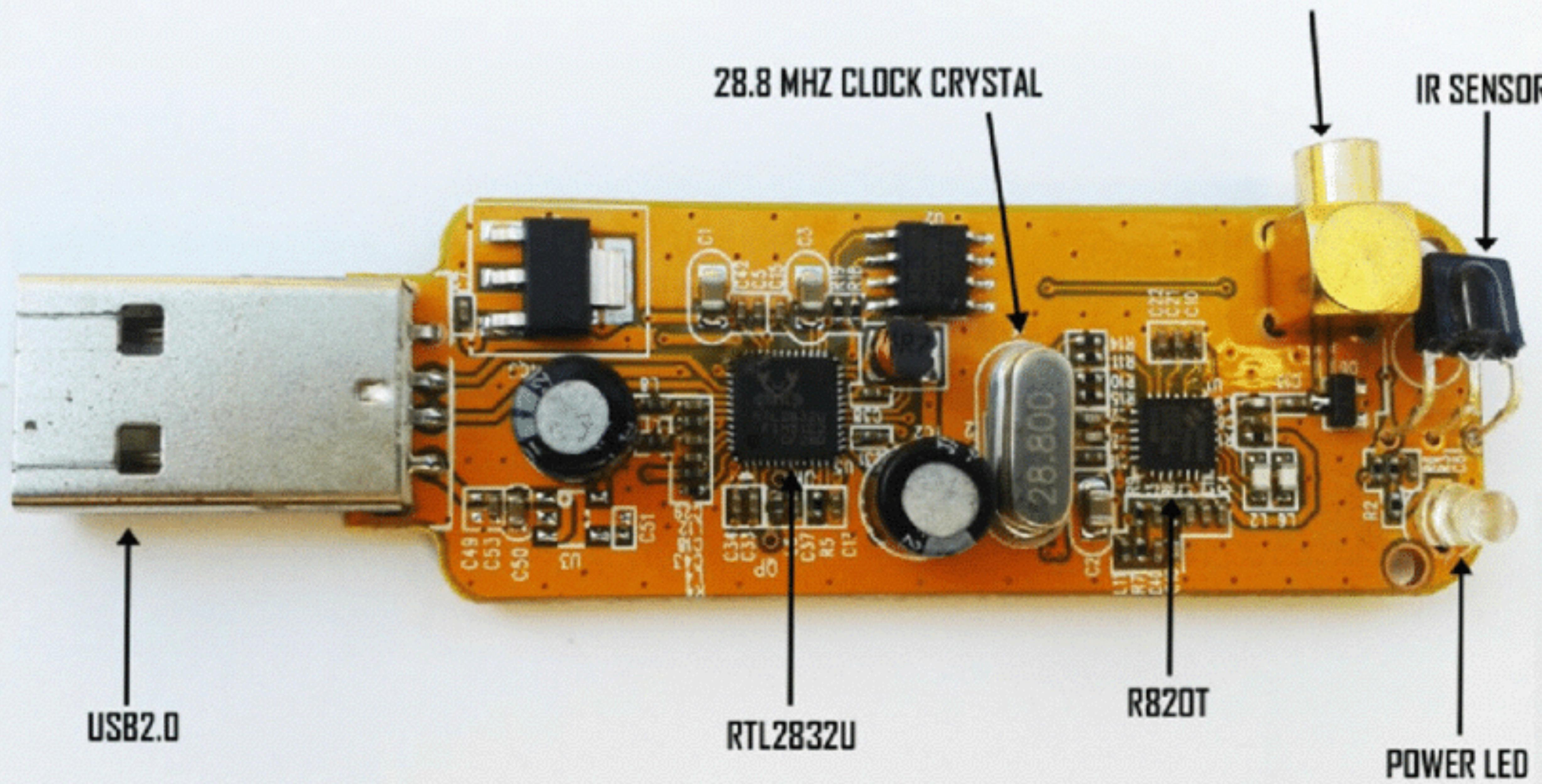


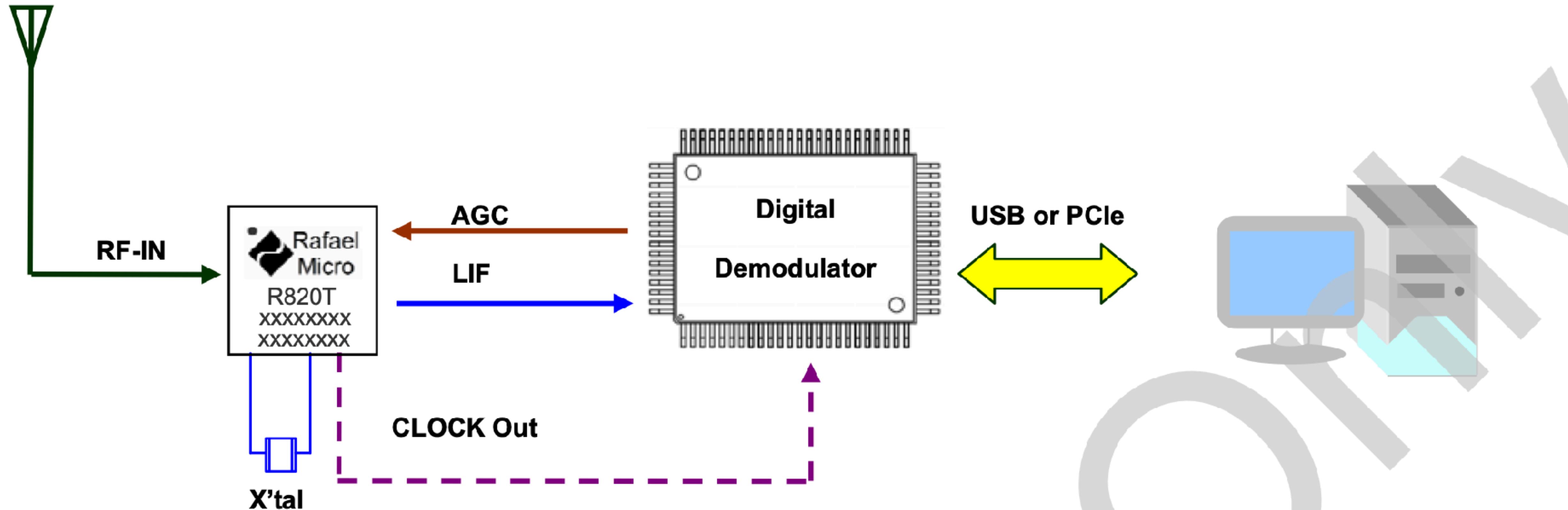
```
sunil@sunil-VirtualBox:~$ sudo apt install gqrx-sdr
```



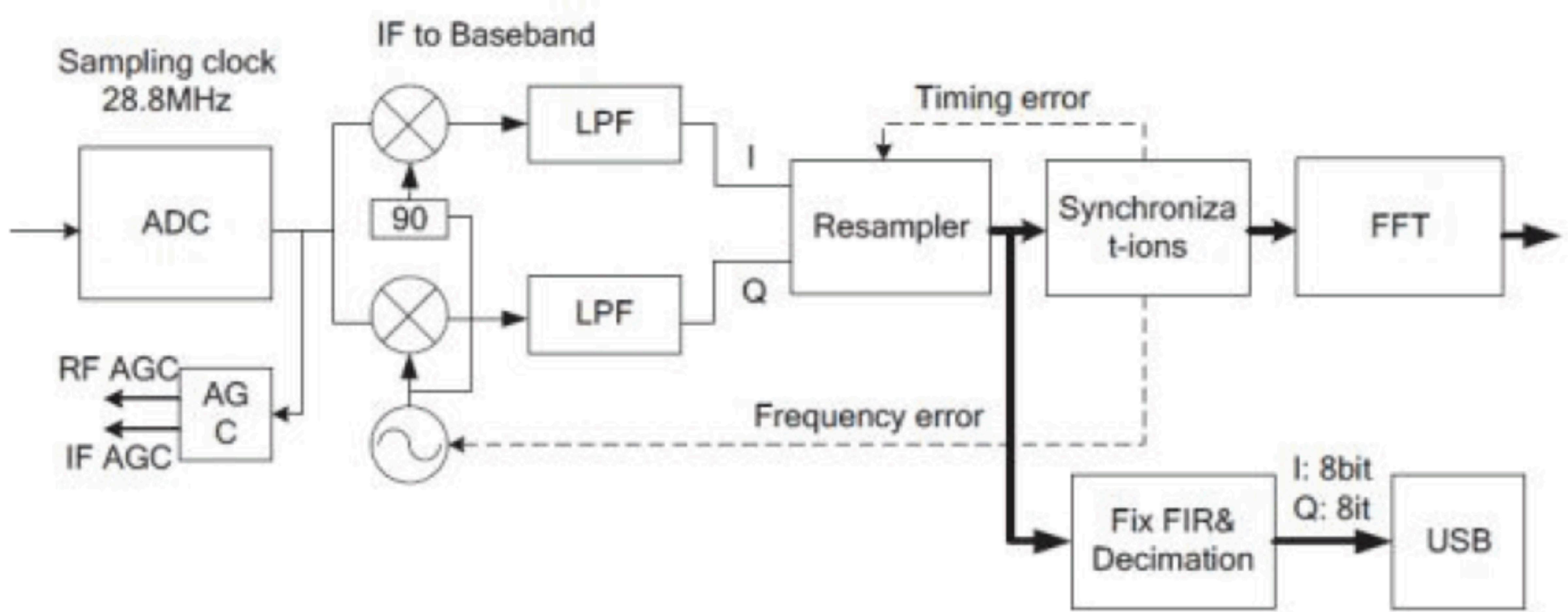
```
Setting up librtaudio6:amd64 (5.0.0~ds-3build1) ...
Setting up soapyosmo-common0.7:amd64 (0.2.5-3build2) ...
Setting up bladerf (0.2019.07-4build1) ...
Setting up libsoapsdr0.7:amd64 (0.7.2-1) ...
Setting up soapysdr0.7-module-airspy:amd64 (0.1.2-2build1) ...
Setting up soapysdr0.7-module-osmosdr:amd64 (0.2.5-3build2) ...
Setting up gr-iqbal (0.38-4build3) ...
Setting up libgnuradio-fcdproplus3.8.0 (3.8~20190817-3build3) ...
Setting up soapysdr0.7-module-bladerf:amd64 (0.4.1-2build1) ...
Setting up soapysdr0.7-module-audio:amd64 (0.1.1-2build1) ...
Setting up libgnuradio-fosphor3.8.0:amd64 (3.8~2.2d4fe78-1build3) ...
Setting up soapysdr0.7-module-rtlsdr:amd64 (0.3.0-2build1) ...
Setting up soapysdr0.7-module-uhd:amd64 (0.3.6-2build2) ...
Setting up soapysdr0.7-module-hackrf:amd64 (0.3.3-3build1) ...
Setting up libgnuradio-osmosdr0.2.0:amd64 (0.2.0-2) ...
Setting up soapysdr0.7-module-remote:amd64 (0.5.1-2build1) ...
Setting up soapysdr0.7-module-redpitaya:amd64 (0.1.1-2build1) ...
Setting up soapysdr0.7-module-lms7:amd64 (20.01.0+dfsg-2) ...
Setting up gqrx-sdr (2.12.1-1build2) ...
Setting up gr-fcdproplus (3.8~20190817-3build3) ...
Setting up gr-fosphor (3.8~2.2d4fe78-1build3) ...
Setting up gr-osmosdr (0.2.0-2) ...
Setting up soapysdr0.7-module-all:amd64 (0.7.2-1) ...
Processing triggers for mime-support (3.64ubuntu1) ...
Processing triggers for hicolor-icon-theme (0.17-2) ...
Processing triggers for gnome-menus (3.36.0-1ubuntu1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.2) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for desktop-file-utils (0.24-1ubuntu3)
```







RTL2832 schematic (A/D converter, digital processor, USB slave interface)



```
sunil@sunil-VirtualBox: ~$ lsusb
Bus 001 Device 002: ID 80ee:0021 VirtualBox USB Tablet
Bus 001 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
sunil@sunil-VirtualBox: ~$
```

```
Bus 001 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
sunil@sunil-VirtualBox:~$ 
sunil@sunil-VirtualBox:~$ lsusb
Bus 001 Device 004: ID 0bda:2838 Realtek Semiconductor Corp. RTL2838 DVB-T
Bus 001 Device 002: ID 80ee:0021 VirtualBox USB Tablet
Bus 001 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
sunil@sunil-VirtualBox:~$ █
```

A screenshot of a terminal window titled "sunil@sunil-VirtualBox: ~". The window contains the command "dmesg" followed by a blank line. The background of the terminal is dark, and the text is white. The window has a standard Linux-style title bar with icons for search, minimize, maximize, and close.

```
sunil@sunil-VirtualBox:~$ dmesg
```



sunil@sunil-VirtualBox: ~

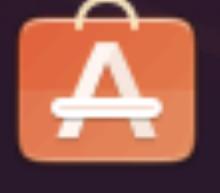
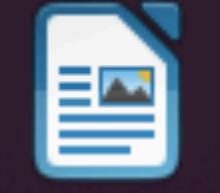


```
[ 1866.002347] rtl2832_sdr rtl2832_sdr.1.auto: Registered as swradio0
[ 1866.002351] rtl2832_sdr rtl2832_sdr.1.auto: Realtek RTL2832 SDR attached
[ 1866.002352] rtl2832_sdr rtl2832_sdr.1.auto: SDR API is still slightly experimental a
nd functionality changes may follow
[ 1866.025445] Registered IR keymap rc-empty
[ 1866.025523] rc rc0: Realtek RTL2832U reference design as /devices/pci0000:00/0000:00
:06.0/usb1/1-2/rc/rc0
[ 1866.025726] rc rc0: lirc_dev: driver dvb_usb_rtl28xxu registered at minor = 0, raw I
R receiver, no transmitter
[ 1866.027299] input: Realtek RTL2832U reference design as /devices/pci0000:00/0000:00
:06.0/usb1/1-2/rc/rc0/input8
[ 1866.027839] usb 1-2: dvb_usb_v2: schedule remote query interval to 200 msecs
[ 1866.055961] usb 1-2: dvb_usb_v2: 'Realtek RTL2832U reference design' successfully in
itialized and connected
[ 1866.056519] usbcore: registered new interface driver dvb_usb_rtl28xxu
[ 1905.662487] usb 1-2: USB disconnect, device number 3
[ 1905.668218] r820t 2-001a: destroying instance
[ 1905.668606] dvb_usb_v2: 'Realtek RTL2832U reference design:1-2' successfully deiniti
alized and disconnected
[ 2153.321301] usb 1-2: new full-speed USB device number 4 using ohci-pci
[ 2153.627624] usb 1-2: config 1 interface 0 altsetting 0 endpoint 0x81 has invalid max
packet 512, setting to 64
[ 2153.646832] usb 1-2: New USB device found, idVendor=0bda, idProduct=2838, bcdDevice=
1.00
[ 2153.646837] usb 1-2: New USB device strings: Mfr=1, Product=2, SerialNumber=3
[ 2153.646839] usb 1-2: Product: RTL2838UHIDIR
[ 2153.646841] usb 1-2: Manufacturer: Realtek
[ 2153.646842] usb 1-2: SerialNumber: 00000001
[ 2153.670173] usb 1-2: dvb_usb_v2: found a 'Realtek RTL2832U reference design' in warm
state
[ 2154.795168] dvb_usb_rtl28xxu: probe of 1-2:1.0 failed with error -32
sunil@sunil-VirtualBox:~$
```

Activities

Terminal ▾

Apr 11 13:23



sunil@sunil-VirtualBox:~\$ gqrx

sunil@sunil-VirtualBox: ~



Files

Configure I/O devices

I/Q input

Device Complex Sampled (IQ)

Device string epeat=true,throttle=true

Input rate

Decimation None

Sample rate 0 Msps

Bandwidth 0.000000 MHz

LNB LO 0.000000 MHz

Audio output

Device Default

Sample rate 48 kHz

Cancel

OK

Trash

sunil@sunil-VirtualBox: ~

```
Received "LibreOffice Writer"
d-01AA-ICH,0
01AA-ICH,1"
AEM :: 00000001"
trum Server"
raiever Server"
led (IQ) File"
ation from: "default.conf"
> /home/sunil/.config/gqrx/default.conf"
ut device:
```



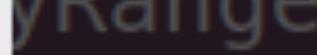
Hz



Hz



Hz



failed fetching new hardware frequency range

Configure I/O devices

I/Q input

- | | |
|---------------|------------------------------------|
| Device | Complex Sampled (IQ) File |
| Device string | Generic RTL2832U OEM :: 00000001 |
| Input rate | RFSPACE Cloud-IQ Receiver |
| Decimation | RFSPACE NetSDR Receiver |
| Sample rate | RFSPACE SDR-IP Receiver |
| Bandwidth | RFSPACE SDR-IQ Receiver |
| LNB LO | RTL-SDR Spectrum Server |
| | Realtek RTL2838UHIDIR SN: 00000001 |
| | Red Pitaya Transceiver Server |
| | default |
| Audio output | hw:Intel 82801AA-ICH,0 |
| | hw:Intel 82801AA-ICH,1 |
| | Other... |

Cancel

OK

sunil@sunil-VirtualBox: ~

```
d- "Receiver"
01 ICH,0"
01AA- ICH,1"
8320 OEM :: 00000001"
trum Server"
raiver Server"
led (IQ) File"
ation from: "default.conf"
> - /home/sunil/.config/gqrx/default.conf"
ut device:
Hz
dt
0 Hz
0 Hz
ppm
yRange failed fetching new hardware frequency range
```

Configure I/O devices



I/Q input

Device Realtek RTL2838UHID

Device string rtl=0

Input rate 1800000

Decimation None

Sample rate 1.800 Msps

Bandwidth 0.000000 MHz

LNB LO 0.000000 MHz

Audio output

Device Default

Sample rate 48 kHz

Cancel

OK

Gqrx 2.12 - rtl=0

File Tools View Help



0 871.000.000

-100 -80 -60 -40 -20 0
-100 dBFS

-50

-100

870.5

871.0

871.5

Receiver Options

0 0 0 . 0 0 kHz

Hardware freq: 871.000000 MHz

Frequency 871000.000 kHz

Filter width Normal

Filter shape Normal

Mode AM

AGC Medium

Squelch -150.0 dB

Noise blower NB1 NB2

Input c...

Receiver ...

FFT S...

Audio



Gain: -20.0 dB

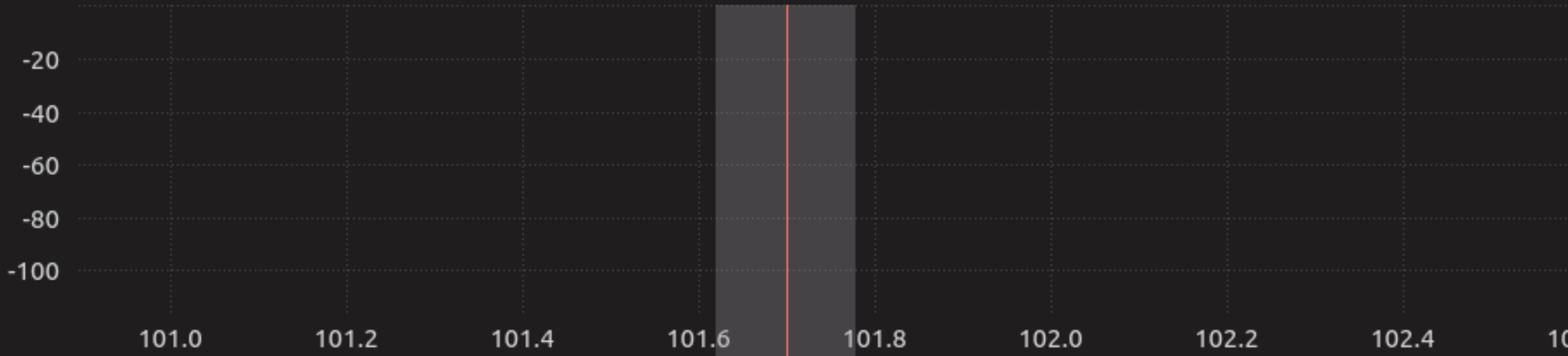
Mute UDP Rec Play ...

DSP

File Tools View Help



0 101.700.000



Receiver Options

0 0 0 . 0 0 0 kHz

Hardware freq: 101.700000 MHz

Frequency 101700.000 kHz

Filter width Normal

Filter shape Normal

Mode WFM (stereo) ...

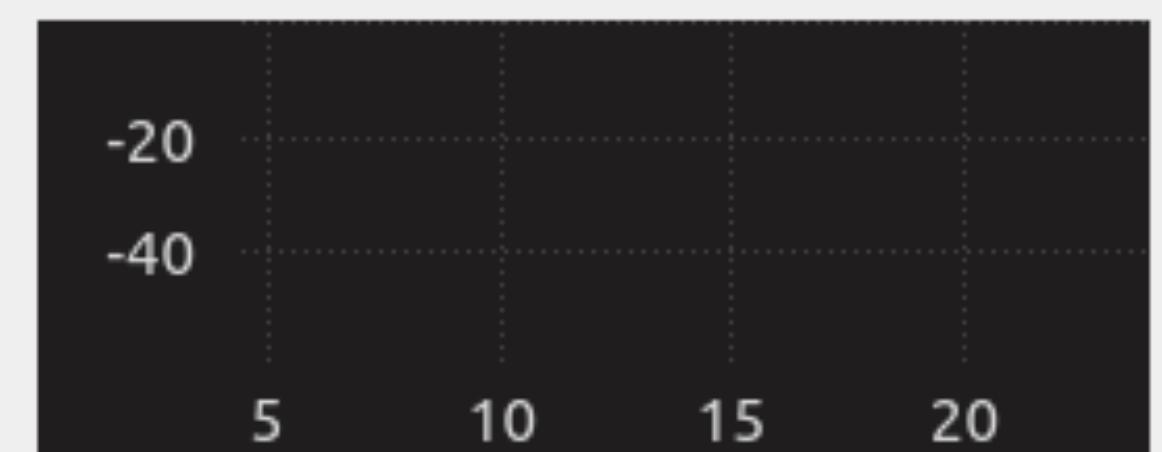
AGC Medium ...

Squelch -150.0 dB A R

Noise blanker NB1 NB2 ...

[Input c...](#) [Receiver ...](#) [FFT S...](#)

Audio



Gain: -20.0 dB

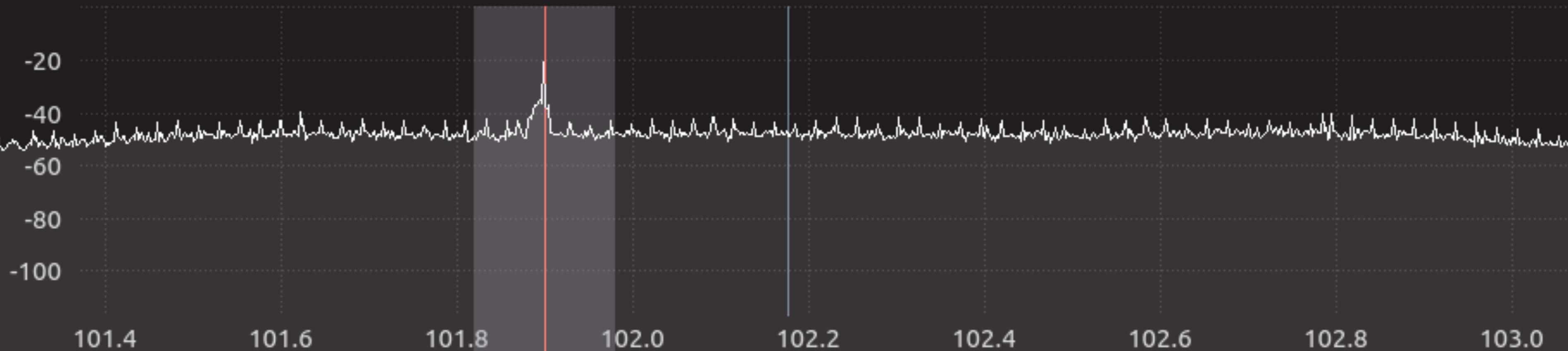
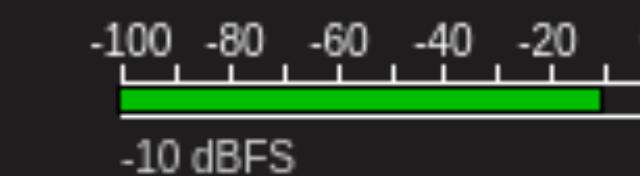
Mute UDP Rec Play ...

DSP

File Tools View Help



0 101.900.000



Receiver Options

-2 7 6 . 0 0 0 kHz

Hardware freq: 102.176000 MHz

Frequency 101900.000 kHz

Filter width Normal

Filter shape Normal

Mode WFM (stereo)

AGC Medium

Squelch -150.0 dB A R

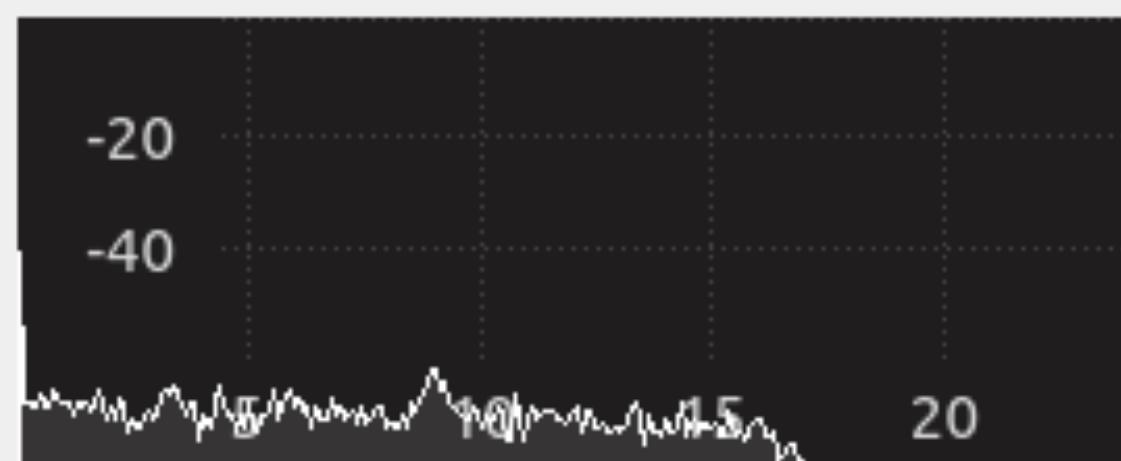
Noise blower NB1 NB2

Input c...

Receiver ...

FFT S...

Audio



Gain: -20.0 dB

Mute UDP Rec Play ...

DSP