Experiment No……. Date …….

Part C

Familiarization with Software Defined Radio (Hardware and Control Software)

Aim:

To

1. Familiarize with an SDR hardware for reception and transmission of RF signal.
2. Familiarize how it can be interfaced with computer.
3. Familiarize with GNU
4. Familiarize available blocks in GNU Radio. Study how signals can be generated and spectrum (or power spectral density) of signals can be analyzed.

Theory:

The term "software-defined radio" (SDR) describes a technology in which the functions of a radio system's hardware components are instead defined by software. SDR systems are more flexible than traditional radio systems. Software-defined radio is a type of radio communication in which the components that have traditionally been implemented in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented via software on a computer.

GNU Radio is a free & open-source software development toolkit that provides signal processing blocks to implement software radios. This can be used with readily-available low-cost external RF hardware to create software-defined radios, or without hardware in a simulation-like environment. It is widely used in research, industry, academia, government, and hobbyist environments to support both wireless communications research and real-world radio systems. It is a graphical user interface that comes with a comprehensive library of processing blocks that can be readily combined to make complex signal processing applications.

Hardware : consist of RTL SDR dongle. Antennas, USB port, connector wires, stands for Antennas.

Figure 1. SDR Hardware Part

Figure 1 shows the parts of RTL SDR Hardware set up.

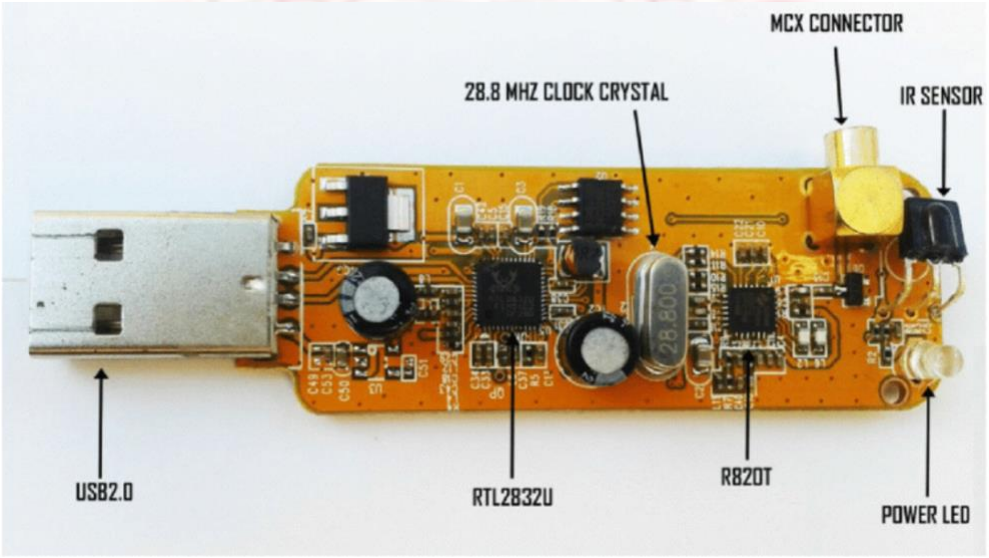

Figure 2. Inside the RTL SDR Dongle

Figure 2 shows the components inside an RTL dongle. The two important ICs are RTL 2832 which is a digital modulator and R820 T is a tuner.

Installing Software

First step is download and install Ubuntu Desktop

Go to terminal

Install the following software Gqrx, GNU radio

Gqrx is a graphical SDR receiver.

Update Ubuntu

```
sudo apt-get update
```

To install GNU radio at

```
sudo apt install gnuradio
```

To check whether RTL SDR is installed *type rtl tab* in command window and see the list.

To install Gqrx

```
sudo apt-get install gqrx-sdr
```

Go to terminal and type *lsusb* to check whether the system has recognized the dongle.

Please make sure that the system should recognize the dongle.

Can make sure this by typing the command *dmseg*

To receive a signal

Then type *"gqrx"* in terminal which will pop up a configurable menu

Configure the SDR – select the I/O device

Now configure the receiver. Three panes appear in the screen. One is the receiver pane which shows receiver frequency, waterfall diagram etc. Figure 3 shows configurable receiver frequency and figure 4 shows corresponding waterfall diagram.

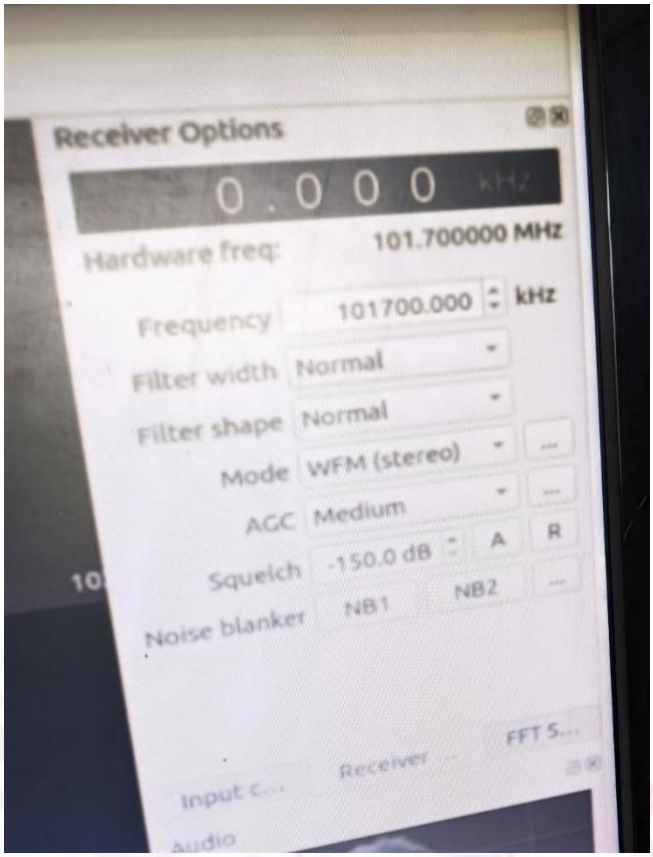

Figure 3. Frequency configuring window

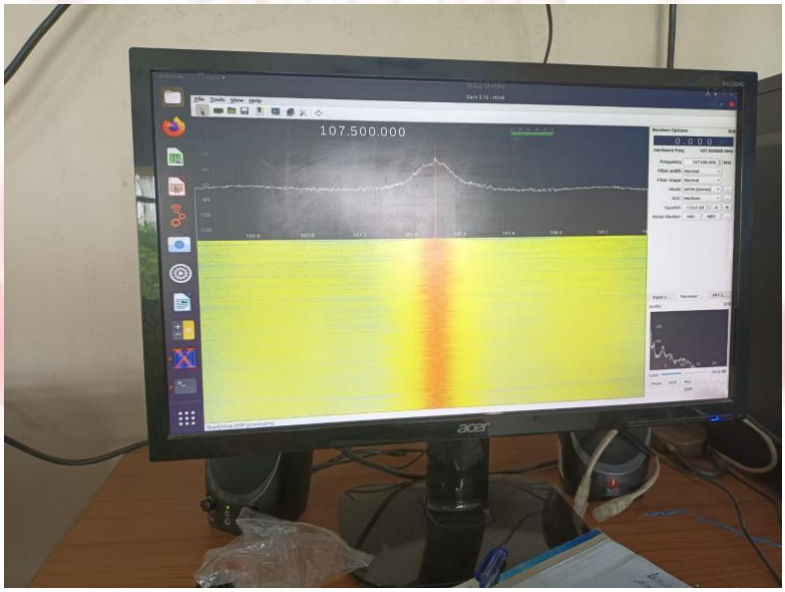

Figure 4 .Water fall diagram

You can set the frequency in receiver pane. The bottom pane shows how audio is processed.

Select frequency and mode as WFM (wideband FM)

Press the play button.

You can hear the corresponding radio station.

This part of the experiment helps you to verify your dongle and understand software defined radio.

You can try different radio stations

- Radio Mango 91.9 FM.
- Club 94.3 FM.
- All India Radio Air Akashvani 102.3 FM.
- Radio Mirchi 104 FM.
- Red 93.5 FM.
- Air Rainbow 102.3 FM.
- Radio Gyan Vani 105.6 FM.
- All India Radio AIR Kochi 107.5 FM.

Using GNU radio

To open GNU radio in Ubuntu :

Open a terminal window using: Applications > Accessories > Terminal.

At the prompt type: *gnuradio-companion*.

It opens up as shown in figure 5

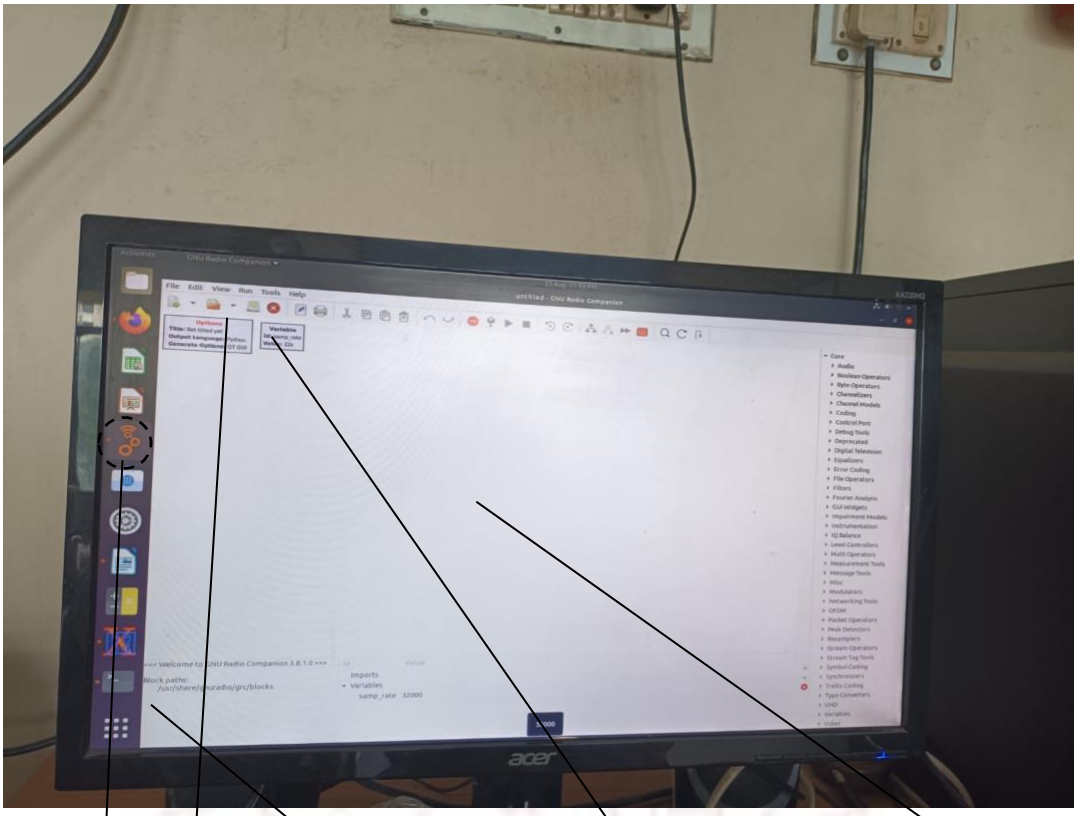

Figure 5. GNU radio

Message window

Work space

(You can also open GNU radio by pressing this icon.)

Options block

Variable window

The programs are developed in workspace.

GNU radio programs are called flow graphs. There are two blocks which you will find when you open GNU radio. They are Options block and Variable block

On opening Open Window as shown in figure 6, another window pops up.

In this window you can give title, id, copyright etc. There is a tab called output language. While compiling the flow graph ,a program can be generated either in Python or C language by selecting the corresponding output language tab. From generate options select *QT GUI.*

The next block is Variable block. On variable block by default *the id is sampling rate*. We can change the sampling rate to 1 or 2 MHz as we are setting up digital radio.

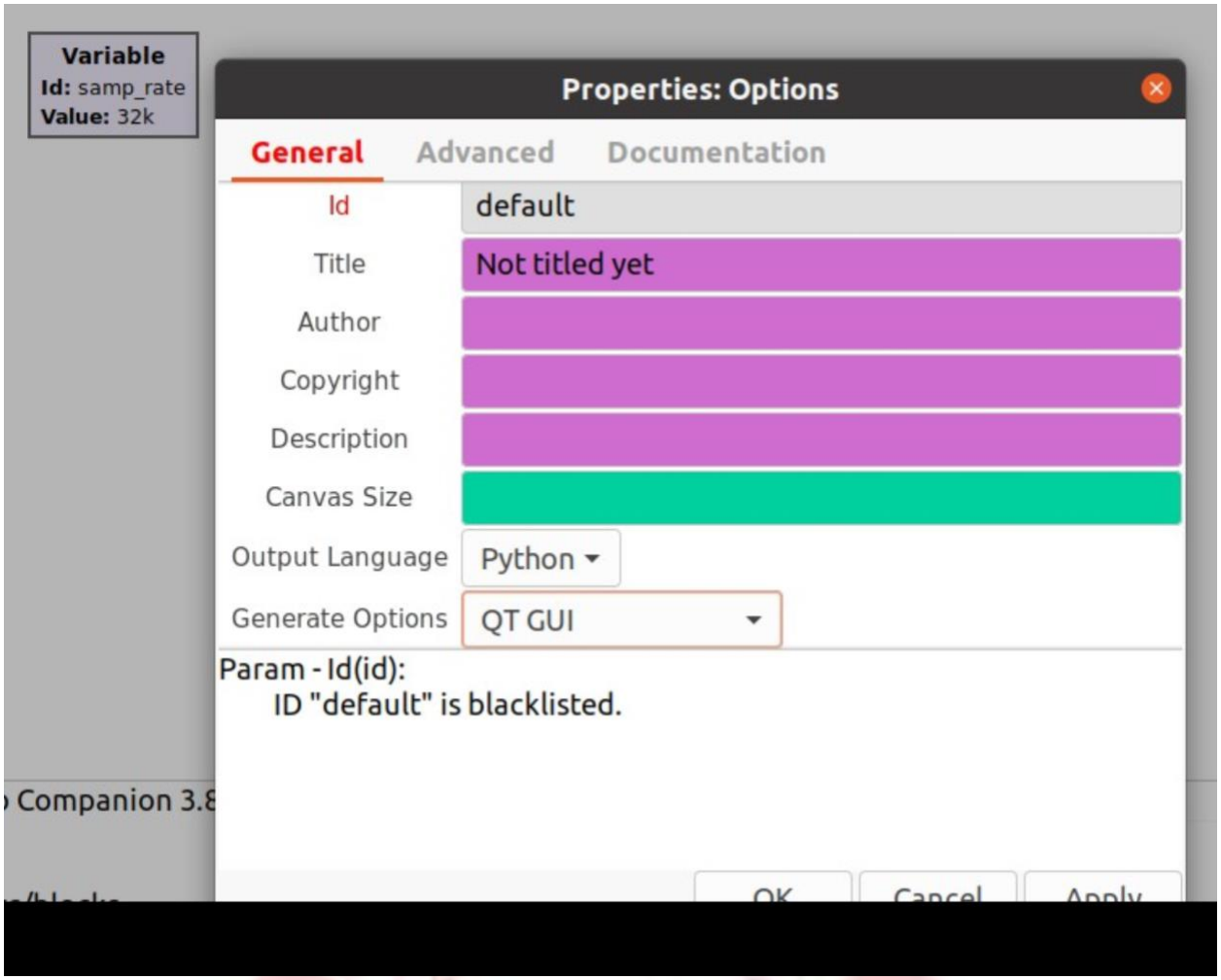

Figure 6. Options window

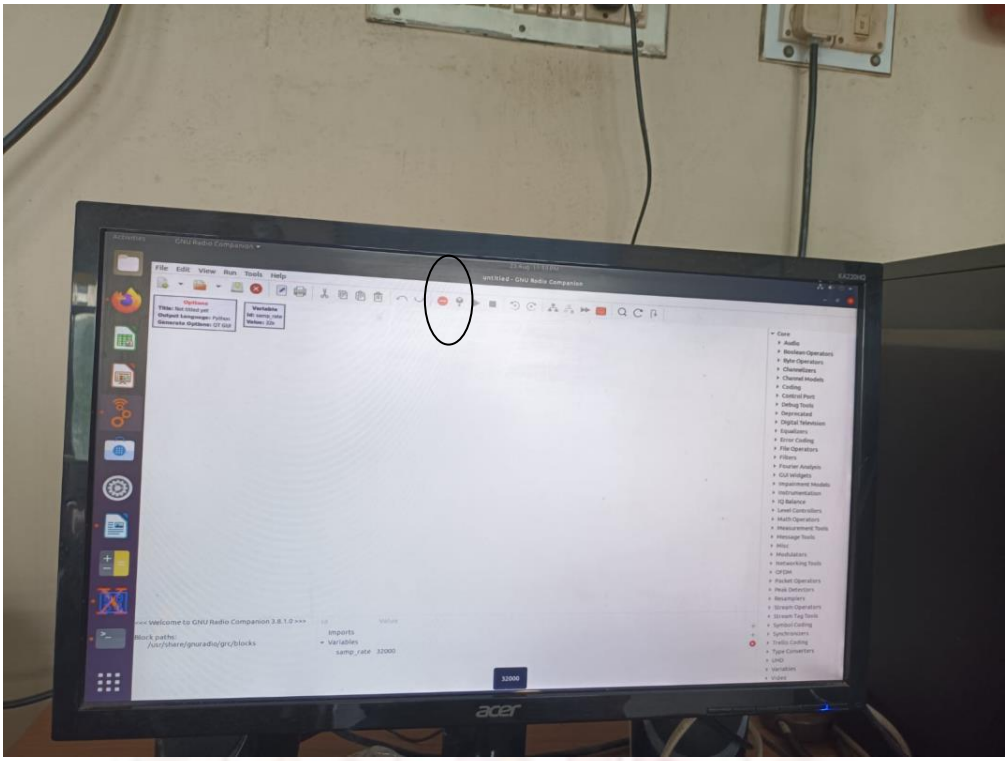

Figure 7

If there is an error in the code, the button marked in figure 7 is active. On clicking this button we will get errors. Then errors have to be rectified, and then only we can compile the program. Press the *RUN* button. There is an option called *GENERATE*, on pressing this, it will save as *.grc file.*

On the right side of the window is a list of the blocks that are available. By expanding any of the categories (click on triangle to the left) you can see the blocks available. Explore each of the categories so that you have an idea of what is available.

From the right side options, open the Waveform generators category and double click on the Signal Source. A Signal Source block will now appear in the main window. Double click on the block and the properties window will open. Adjust the settings as set to output a real valued 1 KHz sinusoid with amplitude of .5. Change the output type t float. Refer figure 8.

Result:

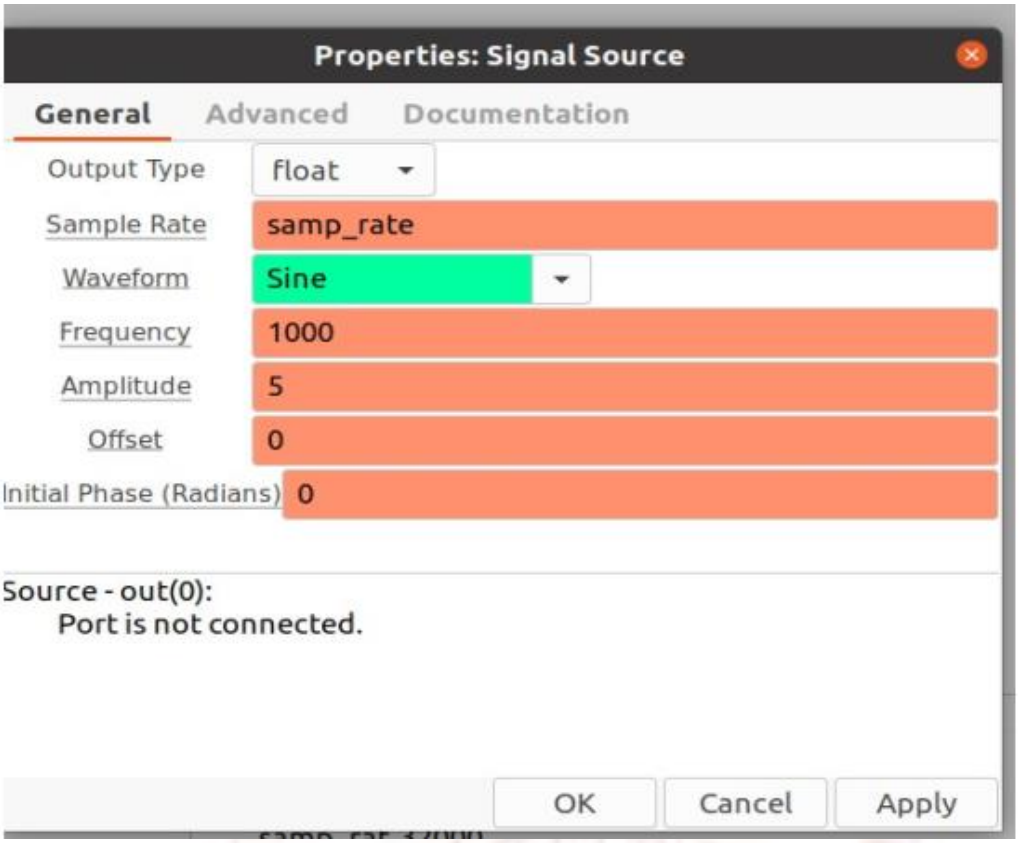

Figure 8 Setting Signal source

To view this wave we need one of the graphical sinks. Choose Core→Instrumentation→ QT →QT GUI Time sink as shown in figure 9 and then double click on it

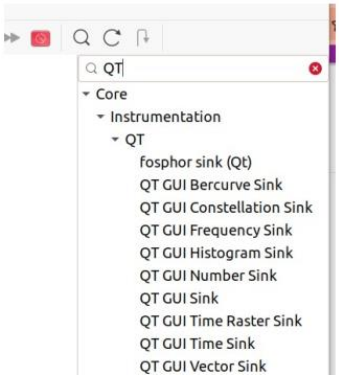

Figure 9 QT sink

A box will appear. Make connections between them as shown in figure

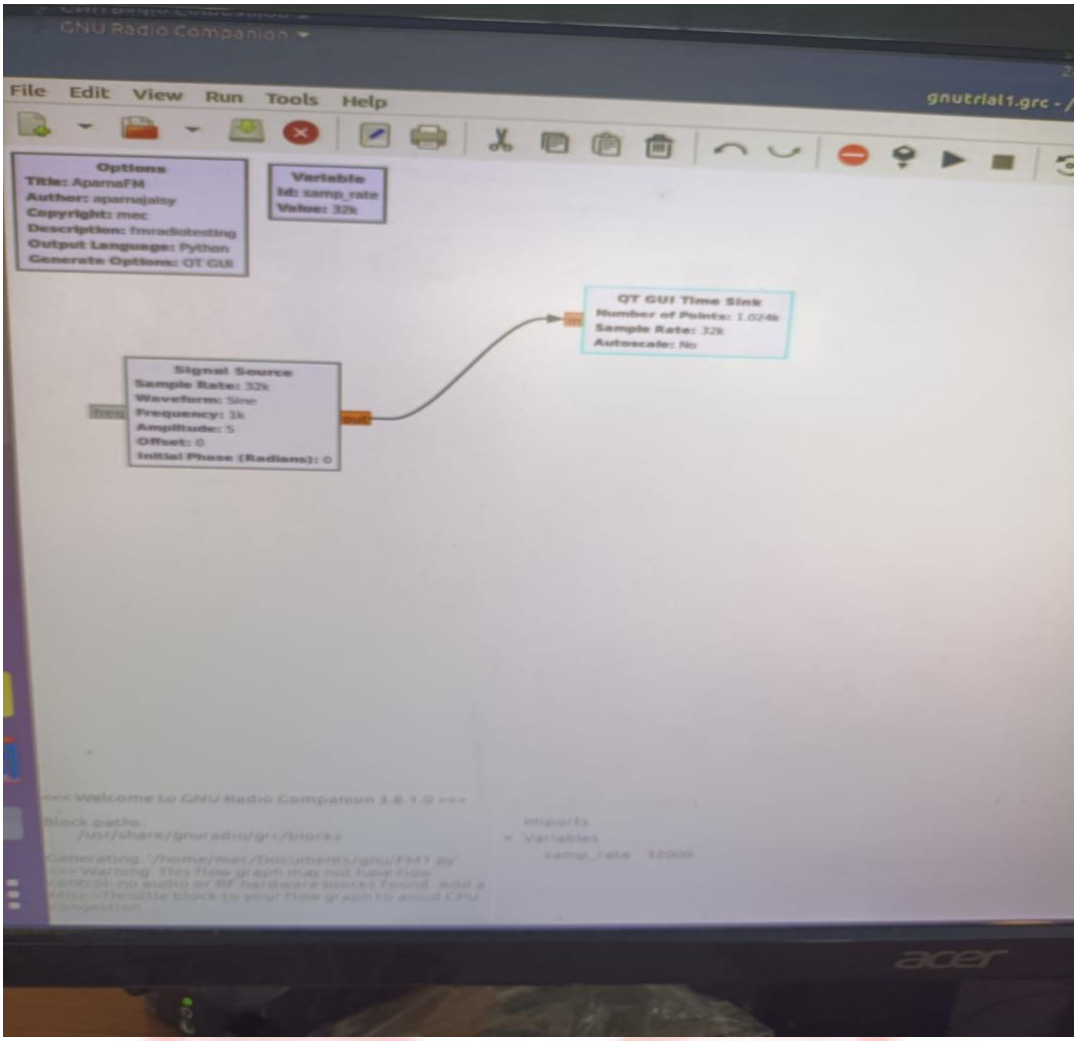

Figure 10.

In order to observe the operation of this simple system we must generate the flow graph and then execute it. Click first on the “Generate the flow graph” icon. A box will come up in which you enter the name of the file. Name this file: test1.grc and save. Click the “Execute the flow graph” icon. A scope plot will open and several cycles of the sine wave are displayed as shown in figure 11.

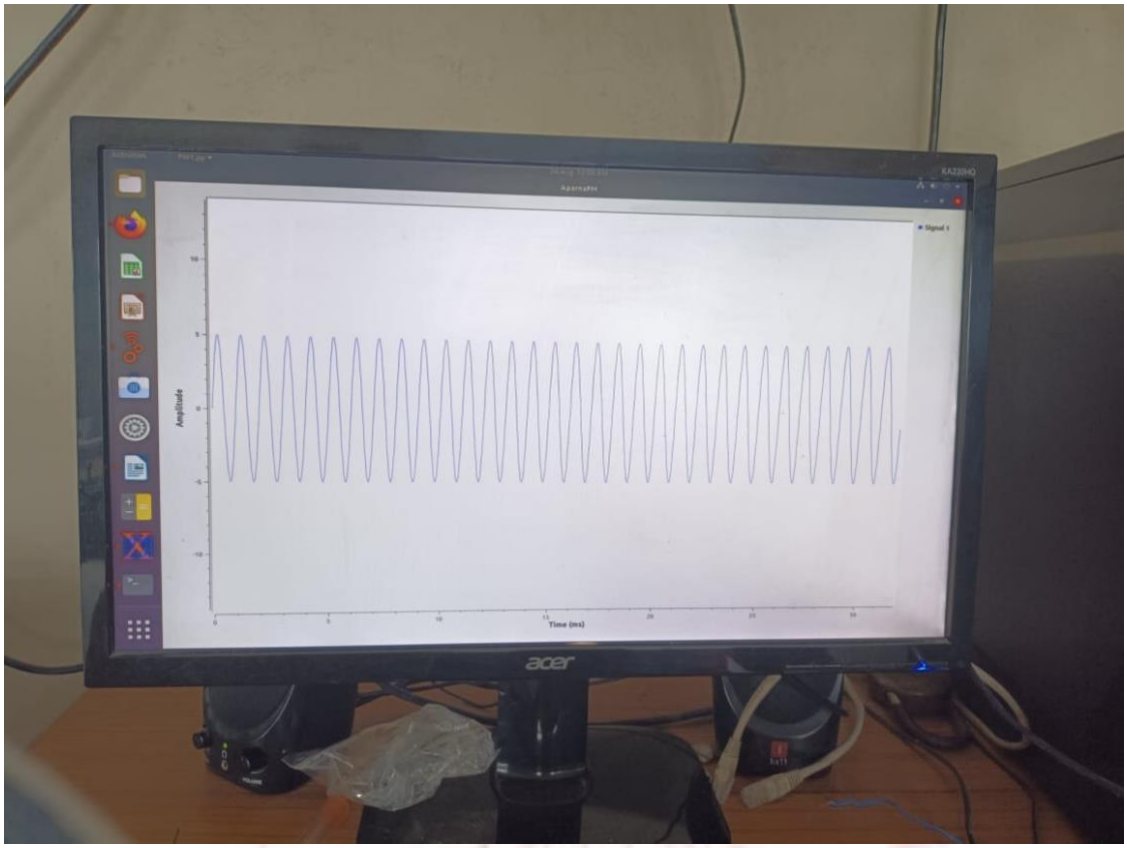

Figure 11.Waveform display

You can also display the frequency spectrum using QTGUI Frequency Sink, Audio sink waterfall Sink etc. The comnnections are as shown in figure 12 and results in figure 13

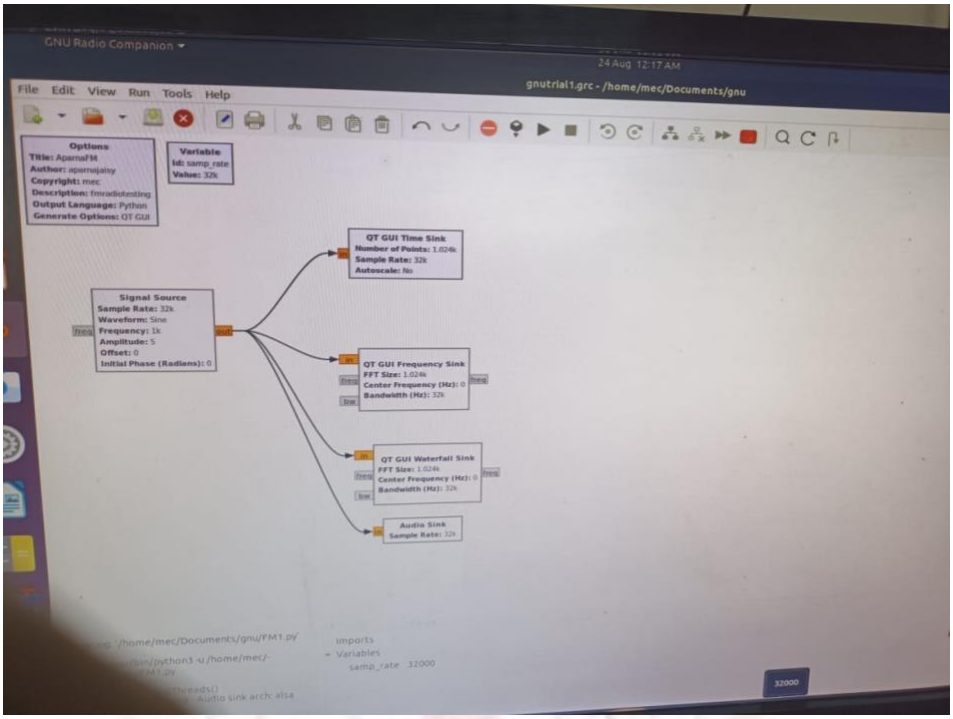

Figure 12

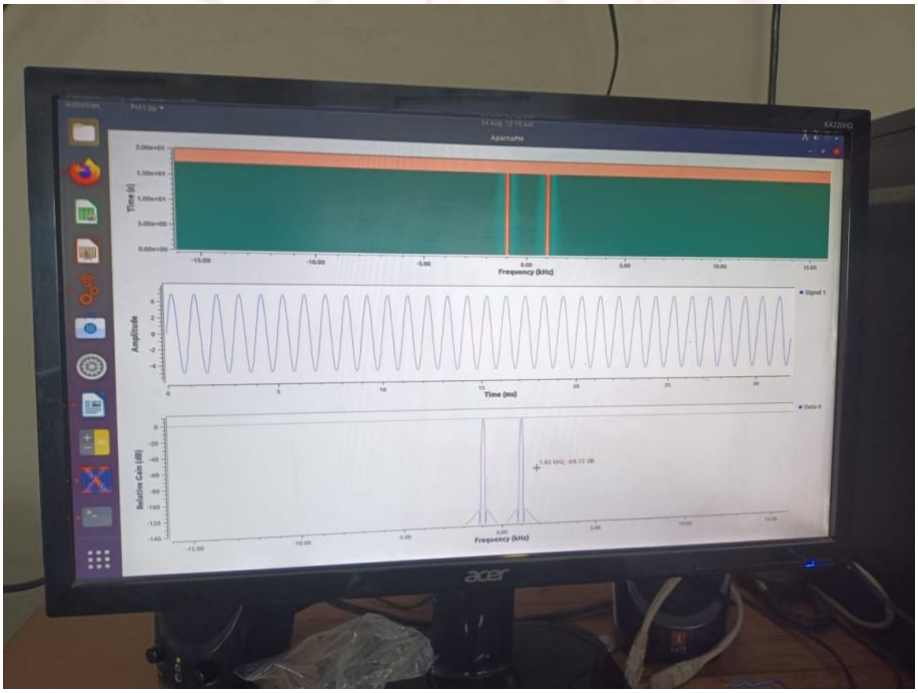

Figure 13

Similarly you can add multiply two different signals and display the results.

In addition to saving a ".grc" file with your flow graph, note that there is also a file titled "xxx. py". Double click on this block. You will be given the option to Run or Display this file. Select Display. This is the Python file that is generated by GRC.

Result :

Software Defined Radio is familiarized.

Experiment No..... Date : .....

FM RECEPTION

Aim:

To

1. Receive digitized FM signal (for the clearest channel in the lab) using the SDR board.
2. Set up an LPF and FM receiver using GNU Radio.
3. Use appropriate sink in GNU Radio to display the spectrum of signal.
4. Resample the voice to make it suitable for playing on computer speaker.

Procedure:

Start GNU radio. Set the Options and Variable windows. For Interfacing RTL SDR dongle, insert RTL SDR Source block as shown in Figure 1

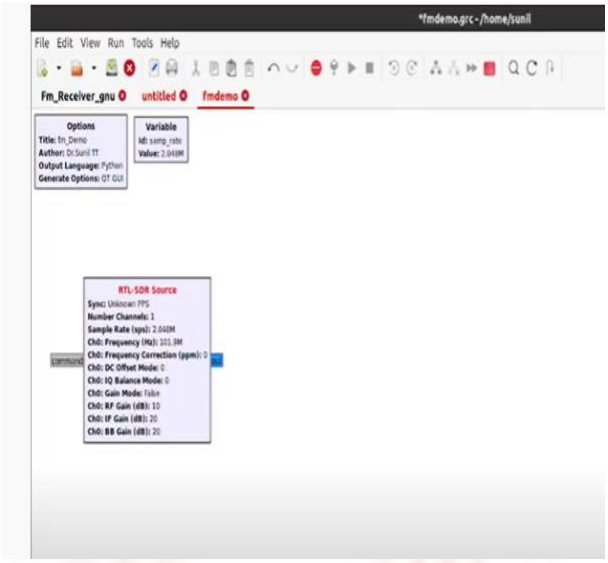

Figure 1

The simplest FM radio consists of few other elements like

Rational resampler

- low pass filter
- WBFM demodulator
- audio output - your PC's sound card

The setup for FM receiver is shown in Figure 2.

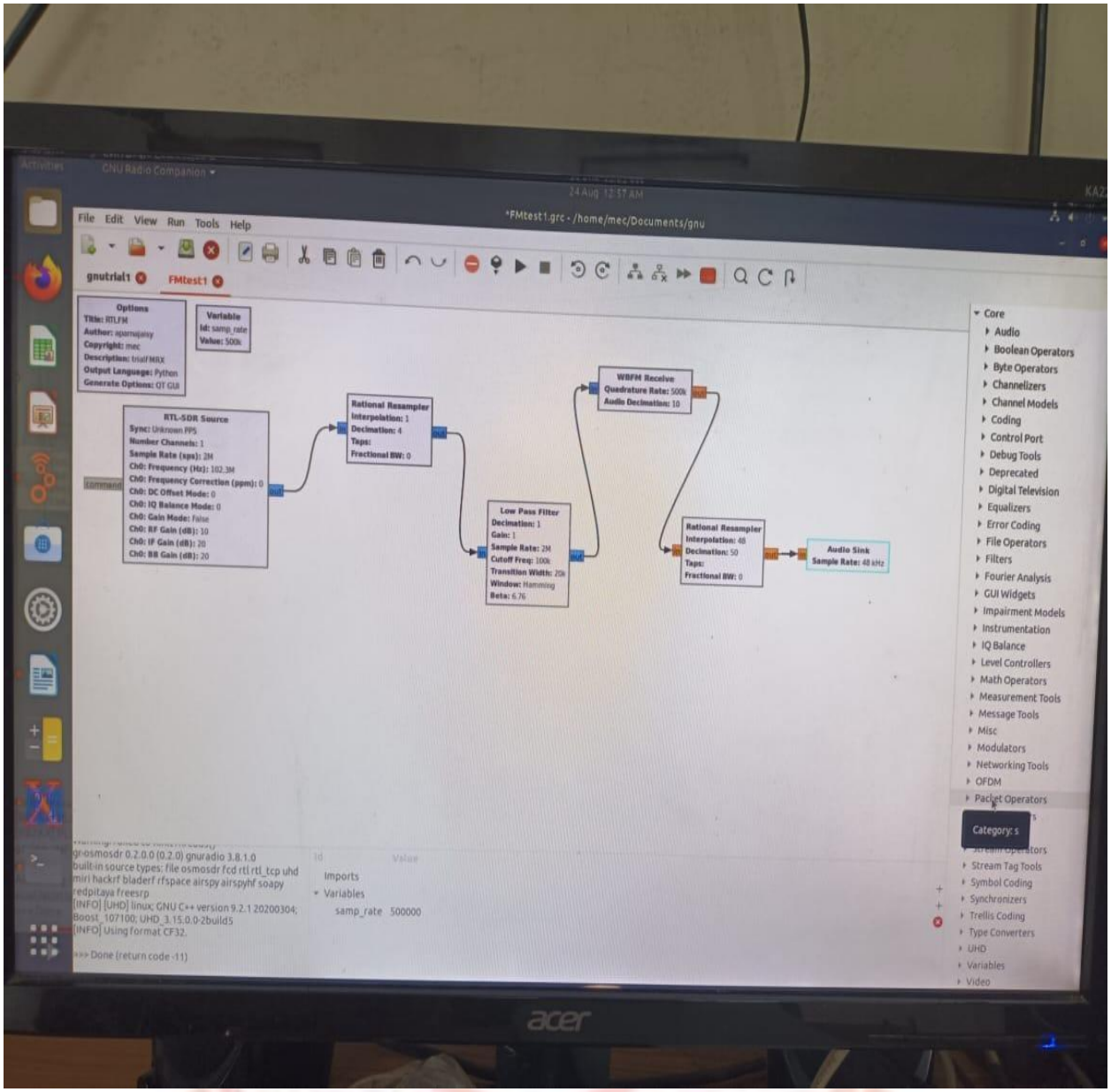

Figure 2

For the first rational resampler, set interpolation factor 1, decimation factor 4.

For Low pass filter, set decimation factor -1 Sample rate -2.04 MHz, Gain -1, Cut off frequency -100 KHz, Transition Width- 20 K, Window – Hamming, Beta – 6.76.

For WBFM Receive block, set the quadrature rate as 500 KHz and audio decimation as 10.

For Second rational resampler, set interpolation factor 48 and decimation factor 50.

Audio sink sample is at 48KHz.

Now run the program. You can hear FM radio station you have set.

We can add slider and water fall diagram to view the spectrum. We can set FM range by QT GUI Range.

Result :

FM receiver using Software Defined Radio is set up.