Audio Transmission through NBFM using GNU Radio

Raj Sekhar Goswami
ECE Department,
BGIET Sangrur, Punjab

Sushil Kakkar
ECE Department,
BGIET Sangrur, Punjab

Shweta Rani
ECE Department
GZSCCET, Bathinda, Punjab

ABSTRACT
This paper analyzes the transmission of Audio File using NBFM modulation technique on the GNU Radio software platform. The NBFM modulation techniques are used broadly in audio communication and data transfer. The key concept around Software Defined Radio (SDR) is also described. Nowadays SDR has the attributes of remodel the system parameters without actually changing the hardware part. The employment is done on the GNU Radio Companion. In case of spectrum efficiency Narrowband FM (NBFM) is used but when better signal quality is considered Wideband FM (WBFM) is used for greater spectrum usage. The Audio signal reception and transmission is achieved by USRP (Universal software radio peripheral) and designed by GNU Radio 3.7.5.1 in the laboratory ambiance.

Keywords
SDR, USRP, GNU Radio, NBFM.

1. INTRODUCTION
In the present era, all the communication processes are done on hardware but the combination of the proper hardware can creates errors in various signal processing. The cost of the hardware is very high and also not easily portable. So SDR is the effective solution for the high cost and hardware based radios that are less flexible. The modulation schemes are implemented to show the effectiveness of SDR based on mathematical models [1]. Good performance has been achieved in wireless communication through the combination of USRP and GNU Radio. Many researchers are also widely implementing digital communications using GNU Radio and USRP [2]. The modulation and demodulation techniques in digital signal processing have been the key technology of the SDR implementation [3].

In this paper, the transmission of Audio signals using modulation techniques are analyzed using the GNU Radio software. We successfully transmit the audio file from source to destination. In addition, we also implement the same communication system using NBFM modulation scheme and we successfully get desire result.

The whole paper is arranged as follows. First, a description of SDR and GNU Radio is given. Then the proposed modulation technique, that is, NBFM is discussed in detail. Second, the implementations of these modulation techniques are performed on the GNU Radio Companion (GRC). Third, the results of the experiment are examined and parameters are analyzed. Lastly, the conclusion of the experiment is explained.

2. SOFTWARE DEFINED RADIO
In SDR there are certain stages in receiving and transmission chain where signal is digitized and using software techniques computation is done on digital radio signal. The main aim of this SDR is to convert almost all hardware system problems into digital domain problems so it can be easily modified and problems can be solved easily. In general, SDR consist of Antennas, an ADC and subsystem defined in software domain.

Thus, there are certain conditions to be followed to implement software define radios which are as follows:

1. Antennas which are used for any specific system should be capable for all radio signal of interest that to be operated.

2. So design for ADC and DAC would be such that its sampling rate must be grated than twice the frequency than that for signal of interest.

3. Thus, the unit which does task for processing should be capable of enough processing power to process signal of interest.[5]

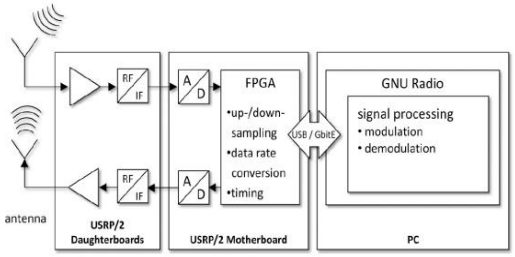

Fig. 1 Software Defined Radio Block Diagram

2.1 Universal Software Radio Peripheral (Usrp)
USRP was designed by the Ettus Research and released in 2005. USRP is mainly a hardware device involved in developing of SDR platform form general purpose computers. It is comparatively inexpensive device.[4] Daughter boards which are implementing the signal processing blocks of GNU Radio are supported by the motherboard of USRP. The USRP we use here knows as USRP 1 in which motherboard consist of four ADCs/DACs which are capable for fast and effective performance these are connected to radio front end daughterboard. There is programmable FPGA Chip on motherboard which is connected to PC through USB. The connectivity of the USRP is with the host computer through a high speed link. The host computer consists of software which controls the Transmit/Receive signals through USRP. Figure 2 show USRP's motherboard and daughterboard, also there are other list of daughterboard that are used for different frequency band.[5]

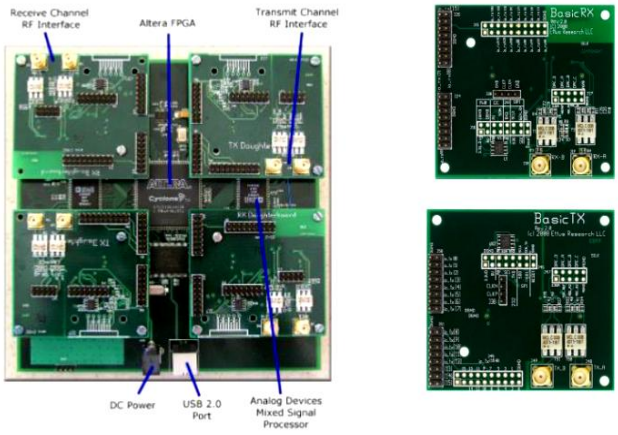

Fig. 2 USRP Main Board and Basic TX and Basic RX Daughterboard 1-250 MHz TX/Rx[5]

Following are list of Daughterboard with its band range

1. Basic TX and Basic RX Daughterboard 1-250 MHz Tx/Rx

2. LFTX -- DC-30 MHz Transmitter and Receiver

3. TVRX2 50-860 MHz Rx x 2

4. DBSRX -- 800 MHz to 2.4 GHz Receiver

5. RFX400 -- 400-500 MHz Transceiver

6. RFX900 -- 800-1000MHz Transceiver

7. RFX1200 -- 1150 MHz - 1450 MHz Transceiver

8. RFX1600-- 0.4-4 GHz Transceiver

8. RFX1800 -- 1.5-2.1 GHz Transceiver

9. RFX2400 -- 2.3-2.9 GHz Transceiver, 20+mW output

In this paper we considered the RFX1600 0.4-4 GHz Transceiver Daughterboard.

2.2 GNU Radio

GNU radio provide software environment for developing and which is open source and free of cost software and also has inbuilt signal processing blocks for implementation of software radios. For creating SDR it provides less cost RF hardware and it also provides stimulation like user interface which does not required physical hardware. It is widely used in real radio systems and for research related work for wireless communication.

For implementation in GNU Radio their certain blocks which are pre-defined in gr library, this blocks are been created in C++ as low level programming while python is used to build graphs as high level programming and as interface between them (Simplified Wrapper and Implemented Generator) SWIG is used.[5]

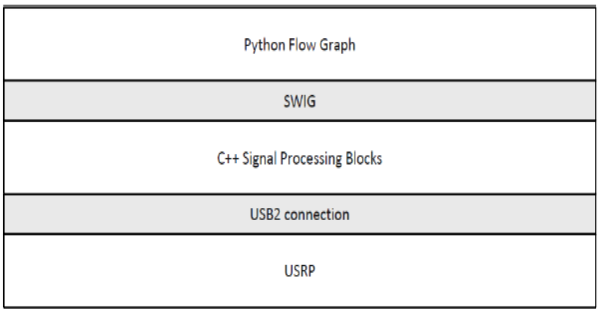

Fig. 3 GNU radio framework structure

3. NARROW BAND FREQUENCY MODULATION

NBFM has a small bandwidth when correlated to wideband FM. The modulation index β is small, i.e., less than 1. The upper sideband, the lower and the carrier of the signal contains spectrum of the signal. This can be utilize in mobile communications such as, ambulances, police wireless, taxicabs, etc. [6] NBFM is what we observe on our scanner; Fire, Police, City Services etc. [7] NBFM consists of a single pair of meaningful sidebands. The Deviation Ratio (DR) is bounded between 0.5 and 1.0 for NBFM. Only the carrier and the first sideband are of powerful amplitude by keeping the DR to small values. The NBFM signal engrosses the same bandwidth as an AM signal, when only the carrier and one sideband are transmitted. This defeated the faults of WBFM, the bandwidth requirement is large. The Federal Communications Commission (FCC) give permissions to the bandwidth of NBFM signals from 10 to 30 KHz, count on the type of operation recognized and allowed carrier frequency. [8]

In NBFM Modulation Index (β) << 1, therefore s(t) reduces as follows:

$$s(t) = A_c\, cos(2\pi f_c t + \beta \sin(2\pi f_m t))$$

$$= A_c \cos(2\pi f_c t) \cos(\beta \sin(2\pi f_m t)) - A_c \sin(2\pi f_c t) \sin(\beta \sin(2\pi f_m t))$$

Since, β is very small, the above equation reduces to

$$s(t) = A_c cos(2\pi f_c t) - A_c \beta \sin(2\pi f_m t) \sin(2\pi f_c t)$$

The above equation is similar to AM. Hence, for NBFM the bandwidth is same as that of AM i.e., 2 × message bandwidth (2 × B).

4. EXPERIMENTAL SET-UPs

System model of this experiment is divided into two parts. First part is about the transmitter side implementation and second part is the receiver side implementation of the GNU Radio software. The input of the system is a audio signal which is processed by the GNU Radio software. The code is written in the python language which is behinds the blocks of GNU Radio. The signal is transmitted wirelessly using dipole antennas. These antennas are connected to the USRP device at both transmitter and receiver side.

4.1 Transmitter Side Implementations

Open the terminal window using keyboards inputs ctrl + alt + T. After this at the terminal prompt type: GNU radio-companion. An untitled GRC window is appearing. NBFM transmit, Audio source and other blocks are connected to each

other to complete the transmitting section which is shown in fig.4

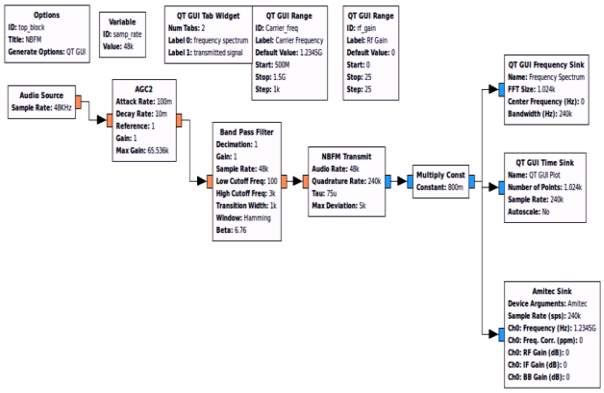

Fig. 4 Flow Graph of NBFM Transmitter

The BW=240k which is the bandwidth and the duration of bit period of NBFM signal. Amitec sink (USRP) used 1.2345 GHZ channel frequency.

4.2 Receiver Side Implementations

Firstly, opens the GRC window which is same as the transmitter side window. After this connects the low pass Gaussian filter and NBFM receive to other blocks. The following figure Show the complete flow graph of receiver.

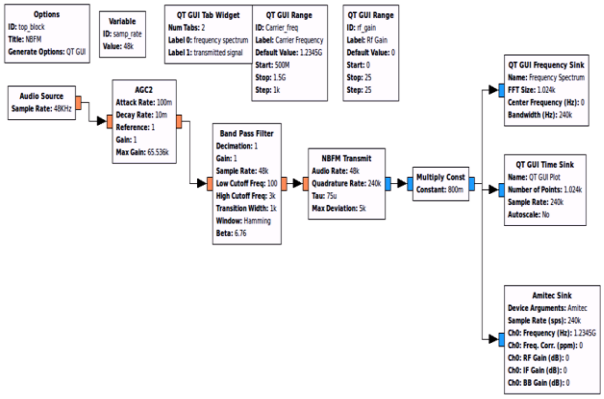

Fig. 5 Flow Graph of NBFM Receiver

The cut-off frequency of the low pass filter is 1.1KHZ and it used the hamming window. The Amitec source which is USRP device used 1.2345 GHZ frequency.

5. RESULTS

In this experiment Narrow Band Frequency Modulation is used to transmit Audio signal via GNU Radio and USRP. The audio signal is received from microphone connected in the laptop in the laboratory environment. The following figure shows the frequency spectrum of the modulated signal from GNU Radio.

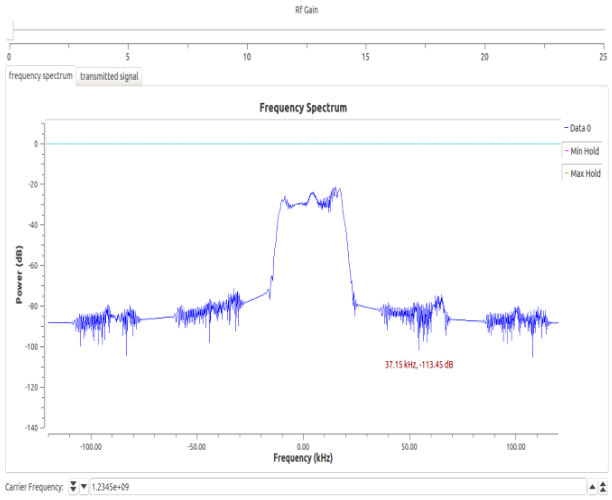

Fig. 6 Frequency Spectrum of the Transmitted NBFM Signal

The following figure shows the transmitted audio signal from GNU Radio.

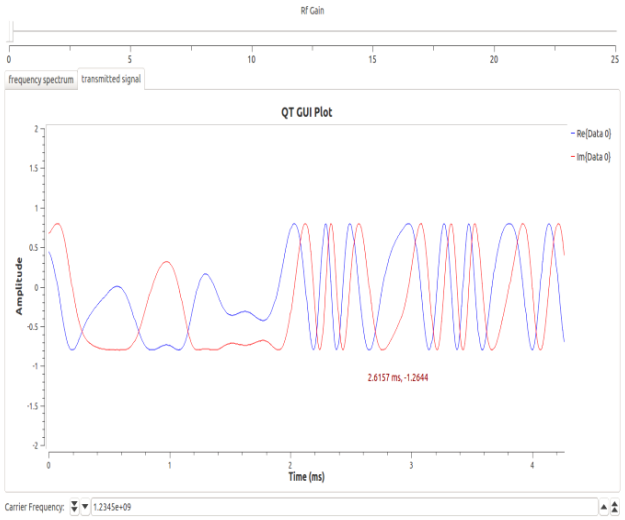

Fig. 7 Transmitted Audio signal from GNU Radio

The audio signal is received by the receiving antenna which is connected to the USRP. The parameter window of the received signal is shows in figure.

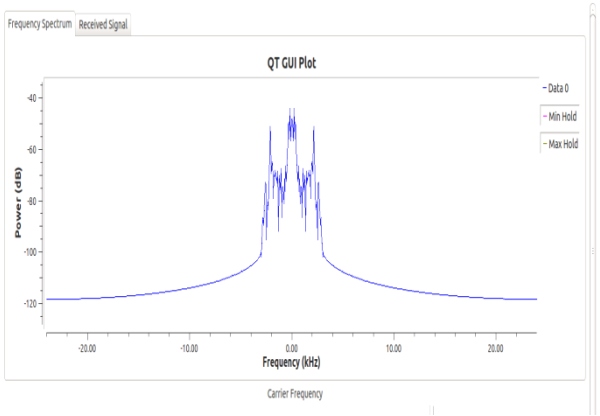

Fig. 8 Frequency Spectrum Of The Received NBFM Signal

Distance between the transmitter and receiver antenna is 1 meter and the audio rate is 48 kHz. The RF gain of the received signal is 25db and carrier frequency is 1.2345 GHZ.

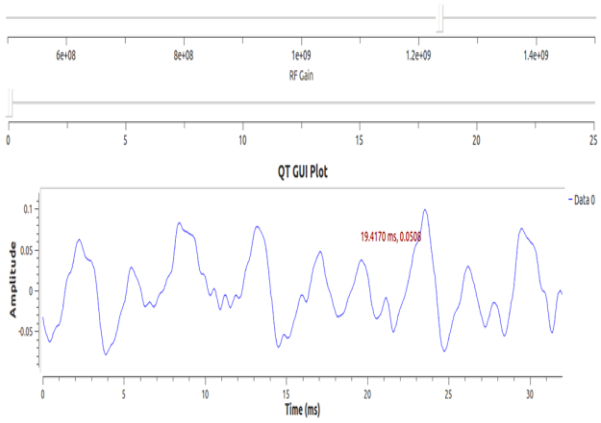

Fig. 9 Received Audio signal from GNU Radio

Table 1. Parameters set up for Audio Transmission

Parameter	**Transmitter**	**Receiver**
Frequency	0.4-4 GHz	0.4-4 GHz
Audio Rate	48000 Hz	48000 Hz
Filter used	Band Pass Filter	Low Pass Filter
Modulation	NBFM	NBFM

6. CONCLUSIONS

In this paper, the target is to transmit and received the Audio signal by using Narrow Band frequency Modulation scheme. GNU Radio is adjustable and effective platform to apply the Audio transmission. This experiment show how can be a audio signal transmit/receive by using python blocks of GNU Radio software. It can be achieved by using high audio rates at large band of frequencies. It can also find the RF frequency of received signal and try to reduce the noise by reconfiguration of transmission gain. In conclusion, SDR system gives adjustability to improvement of audio transmission using GNU Radio software and USRP hardware. The future scope of this experiment is about the improvement of the audio quality and extends the audio rate. Large band of frequencies is also used for long distance communication. GNU Radio also helpful in development of other wireless communication techniques likes 4G, 5G etc in future.

It should be noted that there should not be any error in the terminal window. Something speaks to be heard at the receiver side. A tone will also hear in the speaker.

7. REFERENCES

[1] Jay Kumar Lunagariya, Kenil Gokhruwala, Khyati Vachhani, Design Analysis of Digital Modulation Schemes with GNU Radio, (2015).

[2] Ahmad Zainudin, Amang Sudarsono, I Gede Puja Astawa, Reliability Analysis of Digital Communication for Various Data Types Transmission using GNU Radio and USRP, (2013).

[3] Rao Farhat Masood, Adaptive Modulation (QPSK, QAM).

[4] Pala Trinadh "Emergence of soft defined radio", March (2009).

[5] Raag Kharadi, Harshil Mehta "8d-Audio File Transmission using GNU RADIO and USRP", (2016).

[6] https://www.tutorialspoint.com/analog_communication/analog_communication_angle_modulation.htm.

[7] http://forums.radioreference.com/tennessee-radio-discussion-forum/106787-narrow-band-vs-wide-band.html.

[8] http://iitg.vlab.co.in/?sub=59&brch=163&sim=261&cnt=1.

[9] Amitec Manual for GNU Radio.