GNU Radio based Implementation of Audio Transmission using Narrow-band Frequency Modulation

Jaskaran Singh Phull* and Narwant Singh Grewal**
*PG Student, GNDEC, Ludhiana
Email: phull_jaskaran@yahoo.co.in
**Assistant Professor, GNDEC, Ludhiana
Email: Narwant@gndec.ac.in

Abstract: GNU Radio is an open source software-defined radio project, whereas the Universal Software Radio Peripheral (USRP) is hardware which is used with GNU Radio. These two technologies have been used to implement very sophisticated and low cost software-defined radios. In this paper, Audio transmission using Narrow Band Frequency Modulation will be implemented on the Pre-stored audio file by utilizing the Software Define Radio (SDR) platform which consists of GNU radio and Universal Software Radio Peripheral (USRP). Audio Transmission using SDR approach is easy to implement as it is basically block diagram based and not requires any circuitry.

Keywords: Gnu is not Unix (GNU) Software Defined Radio (SDR), Universal Software Radio Peripheral (USRP).

Introduction

Wireless communication is one of the major areas of research at the moment. But the conventional hardware based wireless communication systems are not able to adapt with the advancements in the wireless field. There is a need to develop such systems that can use the voice transmission channels to transfer audio, data, images, videos etc., on the same medium. For this, there will be a need for an additional capacity for the existing systems and might require modifications in the infrastructure/hardware. There are some other challenges like scarcity of frequency resources, competitive standards [1][2][3]. The advent of SDR lead to the third revolution of wireless communication as it helped in providing greater flexibility because the changes are done at software level, instead at hardware [6][7][8]. It is a flexible, reliable, upgradable, low cost and reconfigurable and reusable platform [9] [10][11][12][13].

In this paper, the implementation of pre-stored audio transmission and streaming using an open source platform- GNU Radio is presented. Audio transmitted through USRP using Narrowband Frequency Modulation is the basic advancement in phase modulation which removes noise as in the case of Amplitude modulation [4][3][5] .Using this technique noise levels can be reduced to desired level.

Terminology

SDR

SDR technology used consists of software part running on a nonspecific hardware part. Hardware part basically consists of DSPs and general purpose microprocessors. It is used to implement radio functions such as generation of transmitted signal (modulation) at transmitter end and detection of received radio signal (demodulation) at receiver end.

GNU

GNU Radio is a free software development toolkit that provides the signal processing runtime and processing blocks to implement software radios using readily-available, low-cost external RF hardware and commodity processors. It is widely used in experimental, academic and commercial environments to support wireless communications research as well as to implement real-world radio systems [4].

USRP

The USRP is intended to be a comparatively inexpensive hardware device facilitating the building of a SDR system. The USRP is one of the most popular SDR platforms currently available and it provides the hardware platform for the GNU Radio project in the research and experimental [5].

Experimental Setup

In this setup we take two laptops in which we install gnu radio and link it with USRP (A) and USRP (B) which act as wireless device through which we can transfer audio signal.

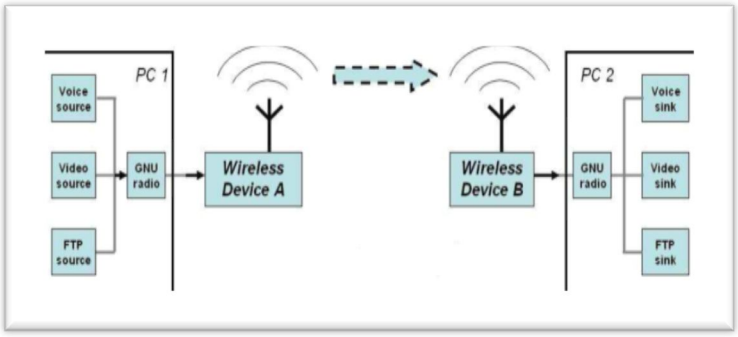

Figure 1 Overall Architecture

Narrowband Frequency Modulation

When a signal is frequency modulated, the carrier shifts in frequency in line with the modulation. This is called the deviation. In the same way that the modulation level can be varied for an amplitude modulated signal, the same is true for a frequency modulated one, although there is not a maximum or 100% modulation level as in the case of AM. The level of modulation is governed by a number of factors. The bandwidth that is available is one. It is also found that signals with a large deviation are able to support higher quality transmissions although they naturally occupy a greater bandwidth. As a result of these conflicting requirements different levels of deviation are used according to the application that is used.

Transmitter

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 modulator, WAV file source and other blocks are connected to each other to complete the transmitting section of the NBFM modulator which is shown in Figure 2. In transmitting section we use a variable block to set sample rate value to 48kbps. After that Wav file source is also used which is also sampled to 48kbps.

After that Band Pass filter block is added to control the level and gain of the signal. In this block we select the desired band and undesired frequencies will be eliminated. In this modulation use of NBFM Transmit is used for audio transmission. In NBFM transmit block we have to set the sample rate to 48 kbps and quadrature rate to 240kbps. To select the particular band of frequencies we use the Band pass filter (BPF) after modulation. We need 48 kbps frequency, so we have to take same sample rate in BPF block. Multiply constant block is used to multiply the carrier with the modulated output and amplitude of samples input to SDR should be less than ± 1.

GUI Frequency sink block must be given same bandwidth of 240kbps. Similarly GUI Time sink block is used and bandwidth is set to again 240kbps.GUI tab widget and GUI Range link the carrier frequency with frequency sink block. Use amitec sink block to set the RF gain of channel. This sink frequency is the modulated frequency and using this frequency we can transmit our Audio signal to the other end. Similarly time sink is used to transmitting the Audio signal in proper time lapse and all these sinks are the primary need for any type of transmission whether it is audio, video or any other file.

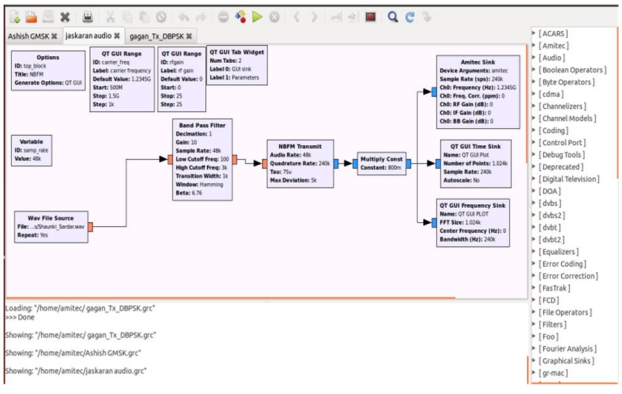

Figure 2 Transmitter Block for Audio Transmission using NBFM modulator

Receiver

Firstly, open the GRC window which is same as the transmitter side window. After this connect the low pass filter and NBFM demodulator to other blocks. The Figure 3 Show the complete flow graph of NBFM demodulator. The cut-off frequency of the low pass filter is 50 KHZ and it used the hamming window. The Amitec source which is USRP device used 1.2345 GHZ frequency. In receiver side sampling rate must be 240kbps using variable block in flow graph and GUI range must be linked to carrier frequency. Use of LPF for filtering the low frequencies and removing high frequencies is then given to NBFM receiver. In the last section audio, frequency and time sink is used for sinking the Audio source. Low pass filter here used to convert that high frequency to low. GUI Frequency sink block must be given same bandwidth of 240kbps. Similarly GUI Time sink block is used and bandwidth is set to again 240kbps.GUI tab widget and GUI Range link the carrier frequency with frequency sink block. Use Amitec sink block to set the RF gain of channel. This sink frequency is the modulated frequency and using this frequency we can transmit our Audio signal to the other end. Similarly time sink is used to transmit the Audio signal in proper time lapse and all these sinks are the primary need for any type of transmission whether it is audio, video or any other file.

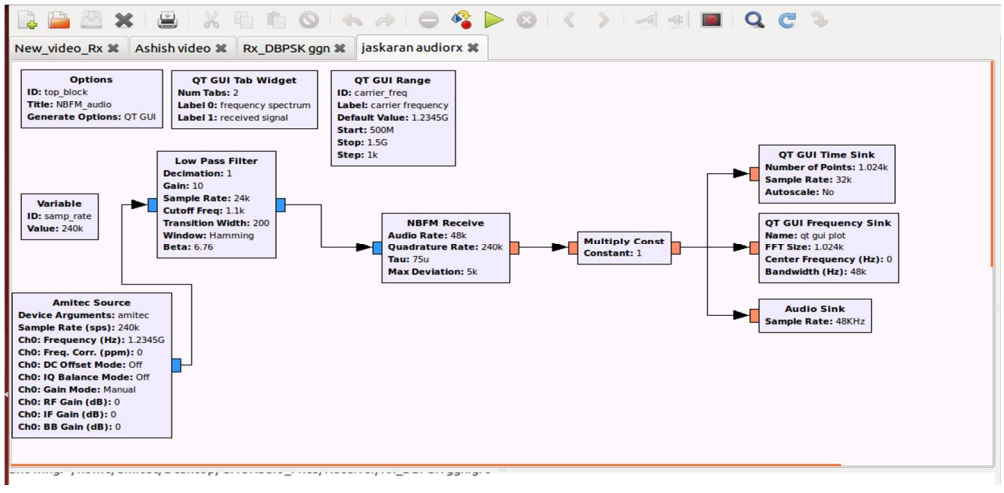

Figure 3 Reciever Block for Audio Reception using NBFM Demodulator

Results

In this paper NBFM modulation is used to transmit Pre-stored Audio file signal via GNU Radio and USRP. The figure 4 shows the transmitted file signal from GNU Radio. From the above plot, we see that spectrum efficiency is maximum at sampling frequency. This sampling frequency is Nyquist sampling rate which also prevent aliasing so that interference with neighboring bands is neglected. From spectrum we can calculate the bandwidth at which maximum transmission takes place.

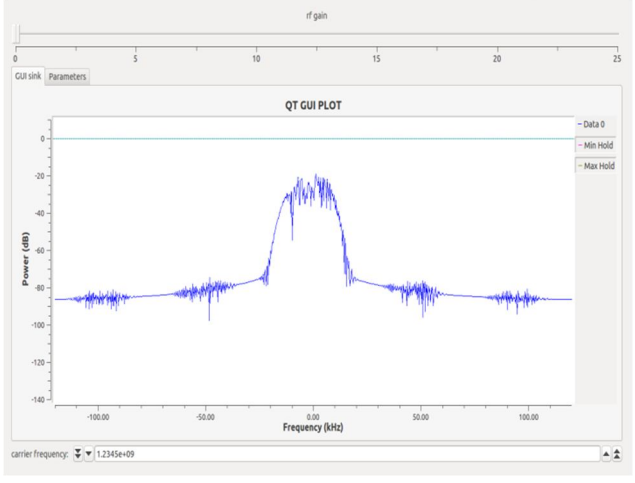

Figure 4 Spectrum of NBFM modulator

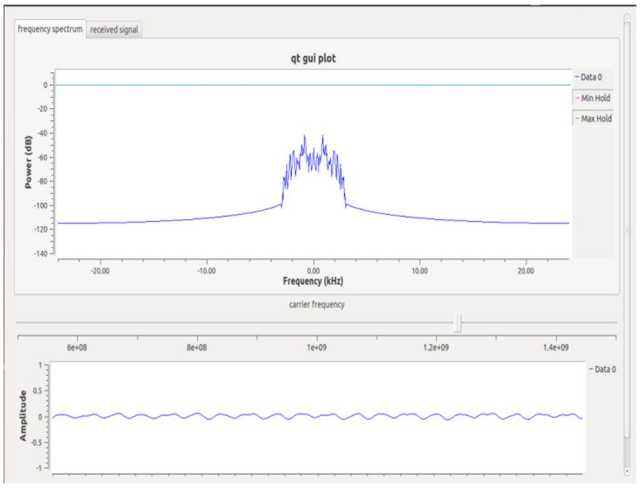

Figure 5 Spectrum of NBFM Demodulator

In Figure 5 spectrum of NBFM demodulator shows that there is maximum efficiency at sampling frequency but there are amplitude variations. These variations can be reduced by using various other modulation techniques. Power received is less as compared to input power. Using bit error rate block variations in the output noise can be estimated. From the spectrum of amplitude variations are very less. Audio transmission reception and transmission are nearly like a matched filter.

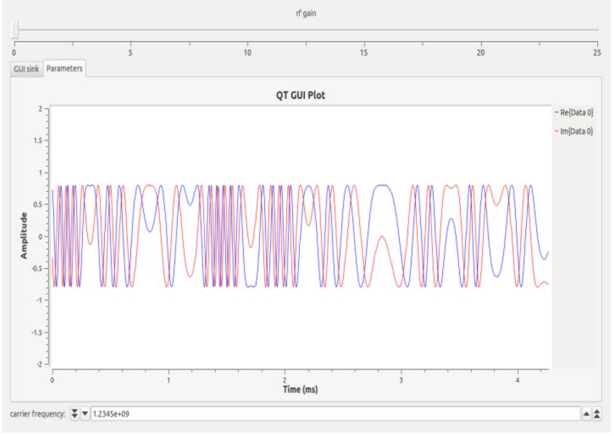

Figure 6 Amplitude variations on real and imaginary axis

Conclusion And Future Scope

Audio Transmission is mostly Hardware defined but with the help of Software defined radio hardware and as well as cost can be reduced. Since GNU is free open Source software and user friendly, audio can be transmitted with any of the modulation technique. Cognitive radio also removes the scarcity of spectrum access by converting it into Dynamic Spectrum Access (DSA). In this paper pre stored audio transmission using NBFM gives better result than using FM. This technique will revolutionize the wireless communication transmission not only in audio but also in video. An interesting aspect of using open source tools and datasets is that it has been found that reproducible research results cause greater impact. However, this requires the availability of low cost hardware and software and public databases. The GNU Radio and the USRP surely allow students to further research and effectively apply the theory of important and difficult areas such as digital signal processing and telecommunications. In the future work, measure of audio quality, audio synchronization and audio size research on audio transmission via SDR systems should be further enhanced using Digital modulation and MIMO based techniques. Using MIMO quantization error and noise can be reduced to minute levels.

References

[1] Verduin, “GNU Radio: Wireless protocol analysis approach,” Master Thesis, Universiteit Van Amsterdam, 2008
[2] J. Mitola, “The software radio architecture,” IEEE Communications Magazine, vol. 33 Issue 5, pp 26 – 38, 2002
[3] H. Mujahid, “Dynamic Spectrum Access for Multimedia Application,” IEEE Malaysia International Conference 2013.
[4] Kaddoum, J. Olivain, G. B. Samson, P. Giard and F. Gagnon, “Implementation of a Differential Chaos Shift Keying Communication system in GNU Radio,” International Symposium on Wireless Communication Systems, 2012
[5] GNU Radio. http://gnuradio.org, Accessed on Nov. 2, 2010.
[6] Raquel and Alexander, “Software-Defined Radio: Bridging the Analog–Digital Divide,” IEEE Journal, vol. 103 Issue 3, pp 409 – 423, 2015.
[7] Mujahid, S. K. Syed-Yus, N. Muazzah. A. Latiff, H. Hosseini and W. Xing, “Dynamic Spectrum Access (DSA) for Multimedia Application,” IEEE 11th Malaysia International Conference on Communications, 2013.
[8] R. Bano and R. Ramzan “COTS based Mutichannel FM receiver and Recorder using SDR concept” IEEE 20th International Conference on Electronics and Communication Systems, 2013.
[9] X. Li Weihong, H. Homayoun and A. Qureshi, “A Case Study Of MIMO SDR implementation ” IEEE Military Communication Conference, 2008.
[10] S. Ahmed, S. M. Navid, N. Sakib and R. Islam “Design and implementation of Data strings using GNU radio”, IEEE 7th International Conference on Electronics and Communication Systems, 2012.
[11] S. W. Xing, “Real Time Audio Transmission using USRP and GNU radio,” Master thesis University of Malaysia, 2012.
[12] E. Dobre, A. Martian and C. Vladeau, “USRP based experimental Platform for Energy detection in Cognitive Radio System,” International Conference on Communications, 2016.
[13] J. Muslimin, A. L. Asnawi, A. F. Ismail, H. A. Mohd Ramli, A. Z. Jusoh and S. Noorjannah, “Basic Study of OFDM with Multipath.