Implementation of OFDM based wireless Communication System on GNU-Radio Platform-An Overview

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Abstract—As communication technology continues its rapid transition, more functions of radio systems are being implemented in software, rather than in hardware and this leads to software defined radio architecture. As result of rapid increase in wireless communication systems it becomes essential to make appropriate use of the available spectrum since the spectrum is limited and day by day number of users is increasing to a great extent. Also transmitting data at high rate is the need for the day. These issues can be solved by changing the access techniques. OFDM provides high data rate transmission than single carrier transmission techniques. It is easy and cost-efficient technique to check the performance of any system on software rather than actually implementing it and verifying for certain parameters. This paper aims at implementation of OFDM based wireless communication system on GNU Radio platform which will evaluate the systems overall performance.

Index Terms—Access Techniques, GNU Radio, OFDM, SDR

I. INTRODUCTION

One of the most interesting areas in Communication Field today is Wireless communication. It is used to transmit the information over air without use of guided medium but it isnot as reliable as that of the guided medium due to various propagation effects and fading effects [1].Various numerous applications are being introduced which works on wireless medium but all of these requires specific spectrum for its usage. But the Federal Communications Commission (FCC) spectrum allocation policies [2] only allow spectrum access to primary users, various spectrum measurement campaigns have proven that, the spectrum usage across time and frequency is inefficient. VariousTechniques have been proposed to enhance the performance and thus reduce the interference in wireless communication by properly utilizing the available spectrum. A common technique is OFDM (Orthogonal Frequency Division Multiplexing)

II. OFDM

OFDM represents for Orthogonal Frequency Division Multiplexing, and it is the modulation technique used for the data transmission in the system. The aim of the OFDM is to convert a wide channel which is frequency selective channel into a flat-fading channel by removing the effect of ISI (Inter- Symbol Interference).This technique allows the data to be transmitted in parallel by modulating the data over the sub-carriers which are orthogonal.

The mobile radio channel is affected by multipath fading as the transmitted signal is reflected by various sources and multiple reflected signals arrive at the receiver at different times. These reflected and or delayed versions of the signal interfere with direct line of signal (LOS) wave and cause inter symbol interfernce which results in significant degradation of system performance. Though adaptive equalizers can be utilized at the receiver end to decrease the effects of ISI when the transmission data rate is of the order of kilobits per second, such a setup would become complex and expensive when the transmission bit rate is high (megabits per second). To overcome the effects of multipath fading, a parallel data transmission scheme needs to be used which reduces the effect of multipath fading and effects of ISI.

The principal problem has been investigated regarding the coexistence of the licensed and the secondary users. OFDM has established to be the prime candidate for spectrum pooling based mostly wireless transmission systems because it is able to do high rate communications, by together utilizing variety of orthogonally spaced frequency bands that are modulated by several slower information streams, and this division of the spectrum into variety of orthogonal sub-carriers makes the transmission strong to multipath channel attenuation. Moreover, it's attainable to show off the sub-carriers within the neighborhood of the first user transmissions, and therefore the spectral area will be filled up efficiently. In a classical parallel data transmission system that uses frequency division multiplexing (FDM), the carriers are spaced apart in frequency such that the signal carried by each carrier can be demodulated. This is done by using guard bands to avoid the spectral overlap of the channels, and hence, there is a huge waste of the spectrum, resulting in inefficient use of the spectrum. This situation is depicted in Figure 1.1. However, it is possible to allow the

overlap of the subcarriers without leaving spectral guard bands, and still be able to avoid the adjacent sub-carrier interference. This is the case, when the subcarriers center frequencies are orthogonal which is the case in OFDM.

It is a multicarrier modulation (MCM) scheme in which many parallel data streams are transmitted at the same time over a channel.It is method of encoding digital data on multiple carrier frequencies.Idea behind OFDM is to split the data stream to be transmitted into N parallel streams of reduced data rate and to transmit each of them on a separate sub-carrier. This means bits are transmitted in parallel over large number of frequency selective channels. There is saving of bandwidth by using Multicarrier modulation with orthogonal frequency division multiplexing. So the bandwidth for multicarrier system is less in comparison with single carrier system and hence bandwidth efficiency of multicarrier system is larger than single carrier system.

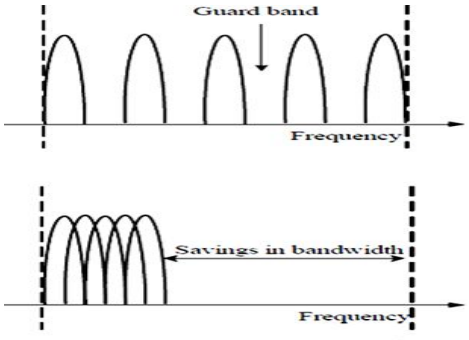

Figure 1.1The conventional and orthogonal FDM techniques or the spectrum for FDM and OFDM

The reason for the motivation of implementation is that OFDM is widely used in digital communication system such as DAV/DVB-T, WLANS, BRANs, and HIPERLAN-II [3,4] while SDR is a promising technique for multi-type, high speed wireless operations with low requirement of hardwaredevice, development cost. And hence we could easily evaluate performance of OFDM system. The conventional OFDM system is depicted in Figure1.2

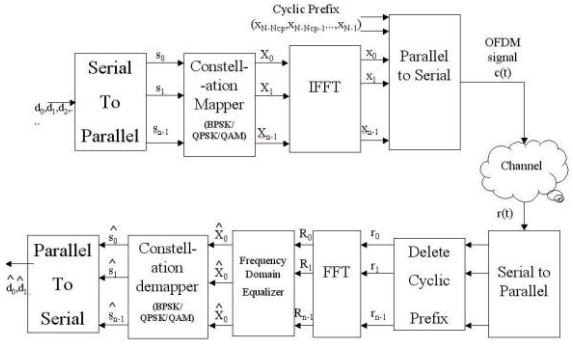

Figure 1.2 The conventional OFDM System Block diagram

These blocks can be designed in GNU-Radio by using Python Scripting language and this system can be implemented on SDR.

III. GNU RADIO

To enhance the wireless communication performance various techniques have been proposed. However implementation of these techniques on hardware is much more difficult as its implementation takes large amount of time, efforts and cost. Presently, Software defined Radio (SDR) could help to reduce time, effort and cost to implement a wireless system. And therefore it has become more and more prevalent in wireless networks. It is a very important tool to test the functionality of the overall system through software.It offers various building blocks for signal processing.Offers methods to manipulate data flow between the blocks.

The basic advantages of using GNU Radio is

- Add your own blocks(by programming in Python)
- Inbuilt blocks are present which can be directly used for the designing of the circuit or system.
- Any system as a whole can be implemented on the software.

GNU Radio can perform all the signal processing operations. It can write application to receive data from the digital streams or to load the data into the digital stream which can be considered as the input stream for certain operations which are then transmitted using the hardware. GNU Radio has filters, synchronisation elements, arithmetic operators, modulators, demodulators, equalizers, vocoders, channel codes and many other elements. These are called as elements blocks in GNU Radio. It also offers Type Conversion such as Float to Short block, Int to float block and complex to real block. Different Sources and sinks are also offered which thus makes it easy to build any system.

GNU Architecture includes 2 Components

- 1st is C++ Block(for various DSP Operations)
- Python Scripts(easy Reconfiguration and Manipulation)

GNU Radio applications are generally known as Flow-graphs.These Flow-graphs can be written in:

- C++
- Python Programming language

An example of such abstracted Flow graph is shown in Fig1.3 which shows data flow in between various blocks.

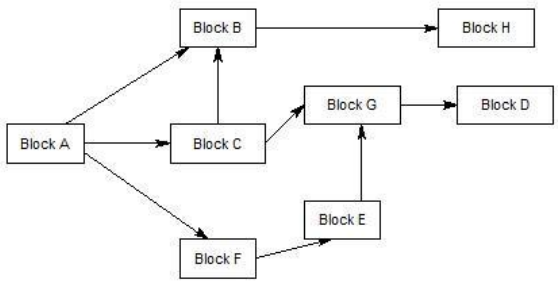

Fig. 1.3 Data Flow Graph for GNU Radio [10].

Simplified Wrapper and Interface Generator (SWIG) is used as the interface compiler which allows the integration between C++ and Python language. Fig.1.4 shows the structure of GNU Radio and USRP SDR. The USRP will digitize the inflow data from the air and passing it to the GNU Radio through the USB interface. GNU Radio will then further process the signal by demodulating and filtering until the signal is translated to a packet or a stream of data.

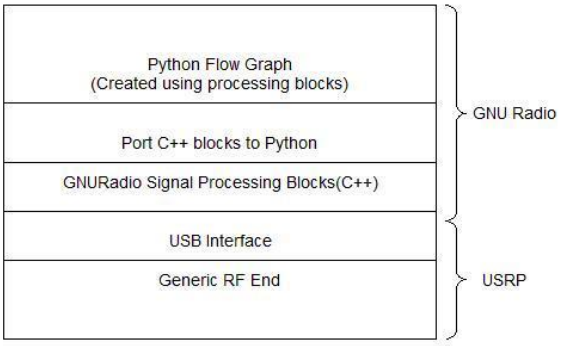

Fig. 1.4GNU Radio Components

A. AM Using GNU Radio

Amplitude modulation has been used since early days of radio technology. Amplitude modulation is used in variety of applications. But now-a-days this technique is not widely used due to recent trends in radio communications.

Implementation of Amplitude modulation is shown in Fig1.5.

The data flow graph is designed by considering the equation

$$A_m = E_c(1 + m \sin\omega_m t) \qquad (1.a)$$

And the modulation index can be calculated from

$$m = \frac{A_m}{A_c} \quad (1.b)$$

The data flow graph in Figure1.4shows the amplitude modulation of a signal source sampled at 256 KHz.

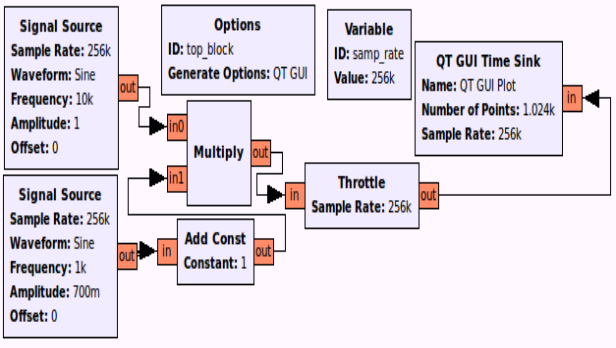

Fig. 1.5 Data Flow Representation of AM

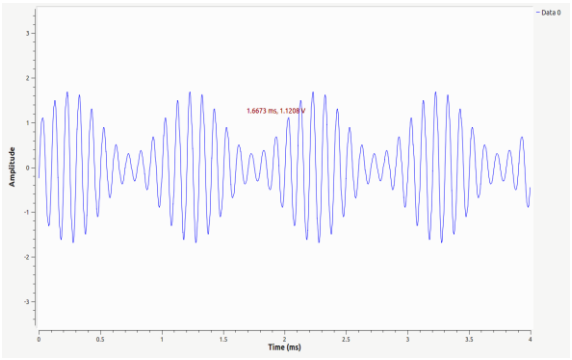

Fig.1.6. Output waveform obtained from the simulation of Fig 1.5

From the theoretical calculation for modulation index and from the practical observation the practical value if modulation index nearly matches the theoretical value calculated from Equation (1.b)

B. DSB Modulation using GNU Radio

Double Sideband suppressed-carrier transmission in which frequency produced by Amplitude Modulation (AM) are symmetrically spaced above and below the carrier frequency and the carrier level is reduced to lowest practical level, ideally being completely suppressed. DSB-SC transmission is the special case of double sideband reduced carrier transmission. DSB-SD is generally used for radio data system.The equation used for the DSB in this paper is that of equation (2.a).The equation represents that by multiplying the modulated signal by the carrier signal, the output obtained is the scaled version of the original message signal.

$$V_m \cos(\omega_m t) + V_c \cos(\omega_c t) = \frac{V_m V_c}{2}[\cos((\omega_m + \omega_c)t + \cos((\omega_m - \omega_c)t] \qquad (2.a)$$

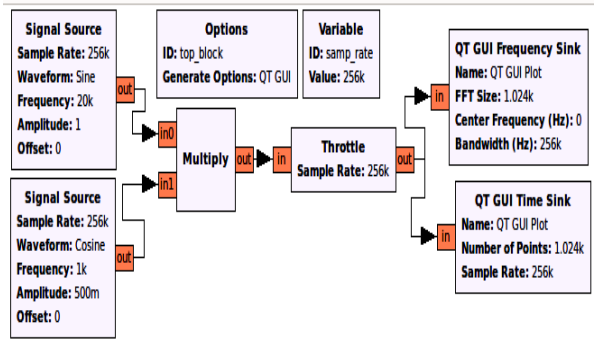

Fig. 1.7 Data Flow Representation of DSB-SC

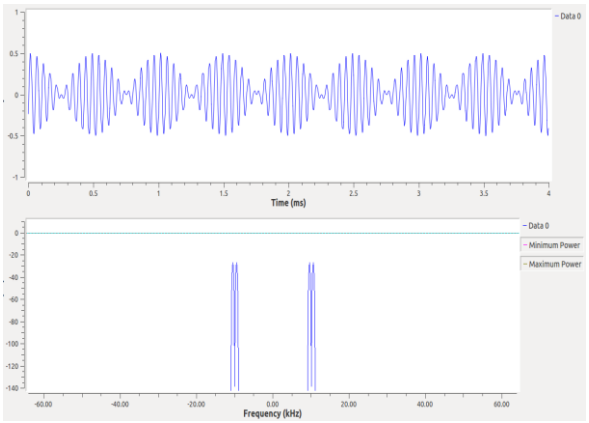

Fig.1.8. Output waveform obtained from the simulation of Fig 1.7

Double Side band Modulation Technique is similar to that of amplitude modulation. In double sideband carrier suppression the frequency spectrum is divided along both the sides. Figure 1.8 thus verifies the DSB-SC spectrum using GNU-Radio platform.

IV. CONCLUSION

In this paper we have simulated AM and DSB-SC systems using GNU-Radio platform. The experimental design matches the output.GNU Radio offers the simulations of the Real time systems and thus is more efficient as compared to that of the SIMULINK. This thus proves that GNU-Radio is a powerful open source which can be usedfurther for the simulations of the entire system as a whole.

REFERENCES

[1] D. Tse and P. Vishwanath, Fundamentals of wireless Communication Cambridge University Press 2005.

[2] Federal Communications Commission, "Notice of proposed rulemaking and order: Facilitating opportunities for flexible, efficient, and reliable spectrum use employing cognitive radio technologies," ET Docket No. 03-108, Feb. 2005.

[3] Federal Communications Commission, "Spectrum policy task force report." EE Docket No. 02-135, 2002.

[4] JusnainiMuslimin, A.Z. Jusoh, Basic Study of OFDM with Multipath Propagation Model in GNU Platform 2015 IEEE Conference.

[5]. J. Mitola and G. Q. Maguire Jr., "Cognitive radio: making software radios more personal," IEEE Personal Commun., vol. 6, no. 4, pp. 13–18, Aug.1999.

[6]. J. Mitola III, "Software Radio Architecture: A Mathematical Perspective," in Proc. IEEE Journal on selected areas in Commn., vol. 17, 1999.

[7]. M.C.Jeruchim, P. Balaban and K.S. Shanmugan, Simulation of Commmunication Systems, 2nd edition, Kluwer Academic/Plenum publishers, New york 2000.

[8] S.B.Pokle ,K.D.Kulat, "Performance Improvement of 2X2 MIMO-OFDM based wireless commincation system using channel estimation."International Journal for Engineering Research and Industrial Application(IJERIA),ISSN 0974-1518,vol.1, NoII(2008)

[9] S. Haykin and M. Moher, Modern Wireless Communication, Patience Hall, 2005.

[9] Taewon Hwang,OFDM and Its Wireless Applications, IEEE 2009.

[10] DucToan Nguyen, "Thesis of Implementation of OFDM using GNU and USRP " University of Wollongong,2013.

[11] Driss Aboutajdine, Throughput Optimization For Wireless OFDM System in Downlink Transmission Using Adaptive Techniques, IEEE Transaction 2006

[12] S.B.Pokle ,K.D.Kulat, MATLAB Simulation Of a wireless Communication system Using OFDM Principle, IETE Technical Review Journal,Vol.23,No.3,May-June2006,ppl187-189