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PSK Modulator Design Implementation using GNU Radio

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Abstract: There is a rise in the popularity of Internet of Things (IoT) and devices are becoming wireless in modern world. Modern Software Defined Radio (SDR) has become more accessible and easier to examine RF signals used by devices to communicate. In this paper we present software defined design of PSK modulation for cognitive radio systems using GNU radio tool.
Keywords: SDR, PSK modulation, GNU radio, Cognitive radio, USRP.

I. INTRODUCTION

GNU radio is an open source and free software development framework that allows the users to design, simulate and establish a highly capable Software Defined Radio (SDR) systems. Due to ever increasing demand of hassle free and fast communication systems Software Defined Radios have been employed in the world of digital communication. A SDR system is radio communication system in which hardware components eg. mixers, filters, modulators, amplifiers etc. are implemented by means of software.

The underlying principle of wireless communication is digital modulation. With the availability of limited spectrum and yet there are unused spectrum. Here comes the main goal of modulation to squeeze as much data into the amount of spectrum available. Cognitive Radio can be programmed and configured to use the best wireless channels in its environment to avoid user interference and congestion. The main function of Cognitive Radios is to detect and share unused spectrum with other systems without any harmful interferences.

A. Modulation

It the process of varying one or more properties of a carrier signal with a modulating signal, that typically contains the information to be transmitted.

The baseband signals are unreliable for direct transmission, for such signal to travel long distance; its strength has to be increased by modulating with high frequency carrier wave which doesn't affect the parameters of modulating signal.

B. Types of Modulation

There are many types of modulations, depending on the modulation type being used; modulation classification is shown in the following figure.

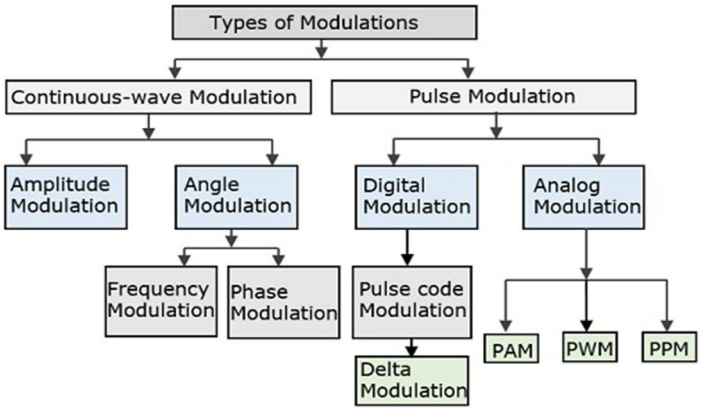

Figure 1: Hierarchy model for Modulation

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C. Phase Shift Keying (PSK) Modulation

The digital modulation is the technique of changing the phase of the carrier signal by varying the sine and cosine inputs at a particular time intervals.

D. Binary Phase Shift Keying (BPSK)

In BPSK the phase of the carrier sine wave reverses by 180° and 0°.

BPSK Modulator:

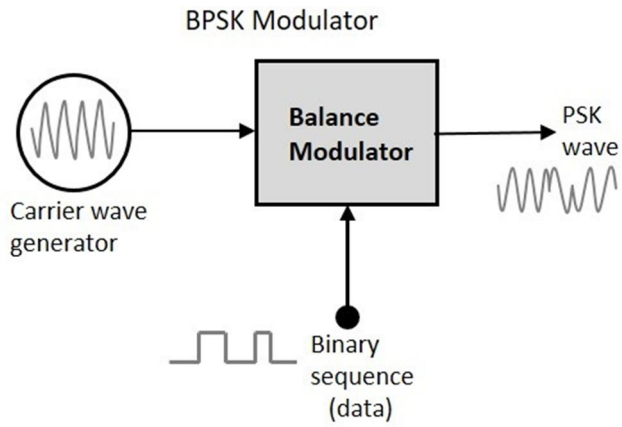

Figure 2: BPSK modulator

A BPSK modulator consists of a balance modulator, to which two inputs is given. One input is the carrier wave and other input is the binary sequence. The balance modulator multiplies the two signal applied at the input. For zero binary input the phase will be 0° and for high input the phase reversal will be of 180°.

The waveform representation of BPSK modulated output wave along with its given input is shown in the figure below:

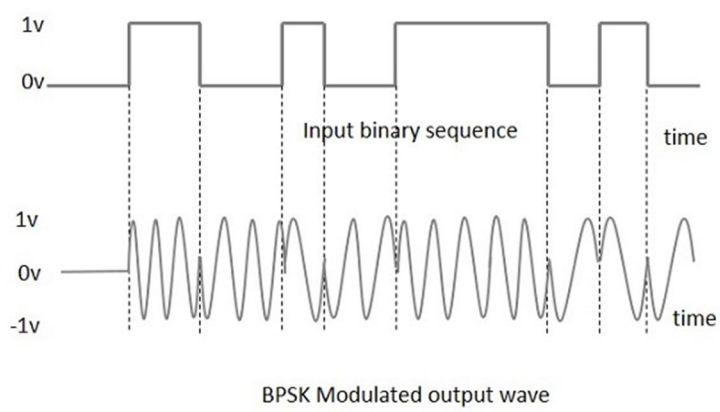

Figure 3: Modulated output for BPSK

E. SDR (Software Defined Radio)

Software Defined Radios (SDR) is a radio communication system in which the radio operating functions are implemented by means of software instead of typical hardware**.** Software Defined Radio technology provides flexibility, cost efficiency and power to extend communication forward.

SDR acts as a key for enabling technology for other reconfigurable radio equipments in wireless radio world.

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F. Cognitive Radio

SDR technology provides this type of radio with the flexibility necessary for them to acquire their full potential, this benefits to reduce cost and increase system efficiency.

Cognitive radio is a radio in which communication system have knowledge of their internal state and environment, such as location and utilization on RF frequency spectrum at that location.

Universal Software Radio Peripheral (USRP) is a range of software defined radio designed by Ettus Research and its parent company, National Instruments. The universal software radio peripheral is the most common hardware used with the GNU Radio to build a SDR system. It consists of two main sub devices, a mother board and a daughter boards which can convey and/or receive data at different frequencies. The daughter boards can be easily exchanged which provides more flexibility to the system. The mother board consists of FPGA and their main function is to convert analog signals into baseband digital signal and vice versa thus needing ADC and DAC. To solve the issue of data realisation by ADCs and DACs at very high speed the daughter boards are introduced in the USRP

G. GNU Radio

The implementation of SDR takes large amount of time, effort and cost as it has to process tremendous amount of data in real time. As MATLAB and other similar tools cannot process such huge amount of data in real time and inculcates large expense in acquiring licenses. Open source softwares have been developed to solve this problem. The most widely used and accepted software is GNU Radio [5]. It offers various building blocks for signal processing. It offers methods to manipulate data flow between the blocks. Moreover, it provides protection to the system from damage due to high speed reading and writing operations and implementing high sample rate devices via. “Throttle” block. The advantages of using GNU Radio are: 1. Inbuilt blocks, which are directly used for the designing of a system. 2. Provision for adding a self-constructed block 3. Any system as a whole can be implemented using the software.

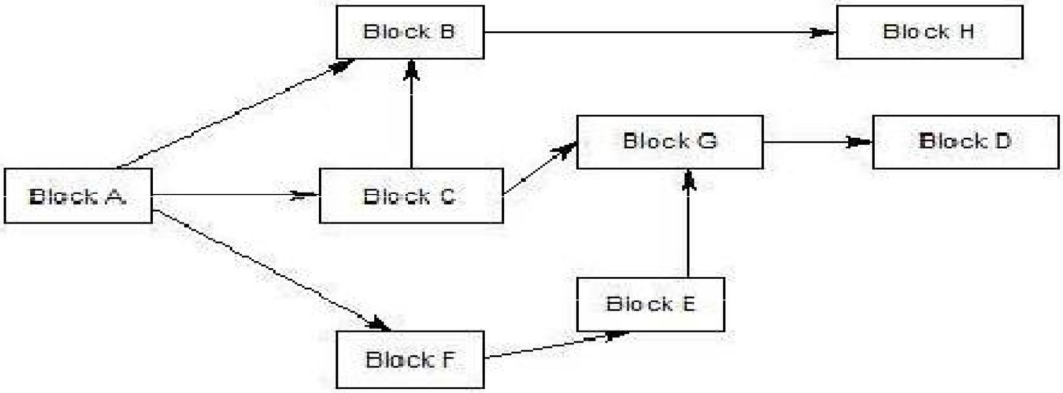

Figure 4: Data flow graph in GNU radio

GNU Radio offers various functions such as Mathematical Operations, logical Operations, FFT/IFFT Blocks, Filters, etc. It also offers Type Conversion such as Float to Short block, Integer 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 component blocks are designed using C++ and connected using python.

II. DESIGN OF BPSK MODULATOR

In digital modulation techniques, a set of basic functions are chosen for a particular modulation scheme. In BPSK, modulation is achieved by varying the phase of the sinusoid depending on the message bits. The data flow graph has been designed considering the following equations

$C(t) = A \times \cos(2\pi fc\, t)$, where, fc= 10 kHz and A=1

The modulation waveform of frequency fm and amplitude M is given by:

$m(t) = A \times \cos(2\pi f_m t+\pi)$ where, fm=1 kHz .

The modulated wave is obtained by considering the following equation

$y(t) = [1+m(t)] \times c(t)$

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III. DESIGN OF FLOW GRAPH

The blocks used in a bit transmitter flow graph of BPSK are shown if Fig. The predefined signal processing blocks are chosen from the library of GNU radio software and proper connections are made. Data flow graph is obtained accordingly.

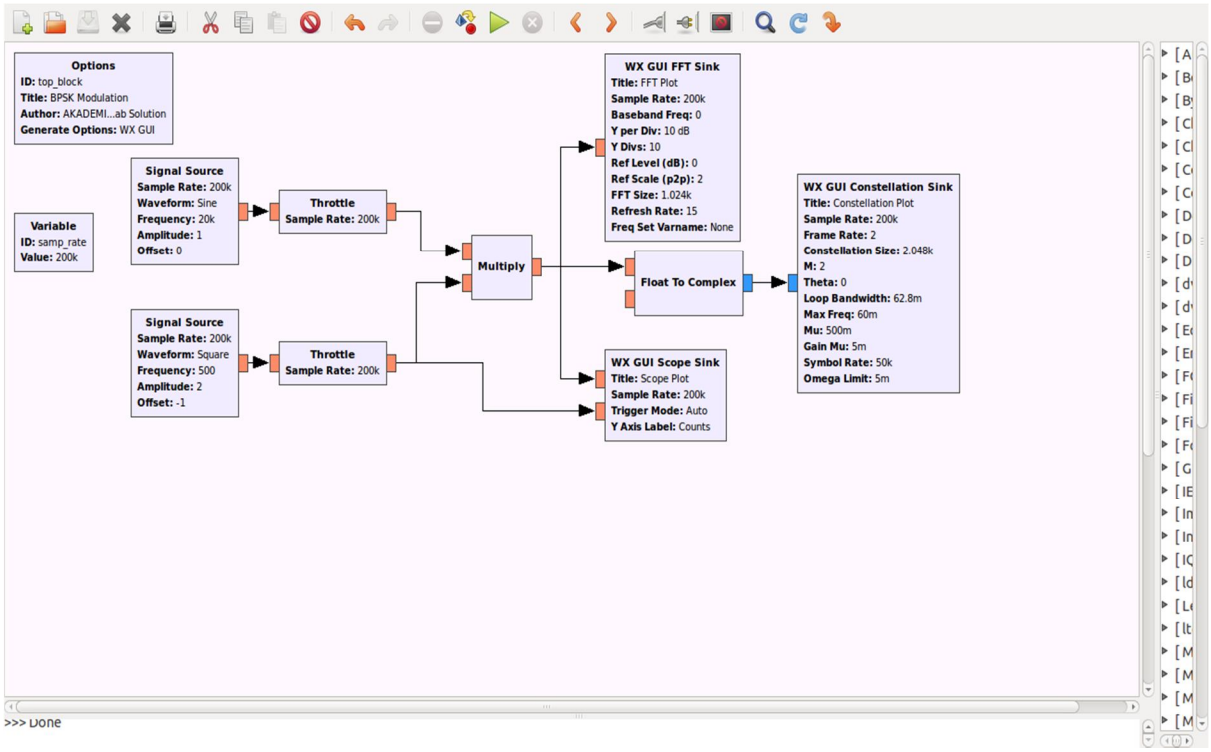

Figure 5: Data flow graph representation for BPSK modulator in GNU radio

The output waveform for the above data flow graph representation of BPSK modulator is given as follows.

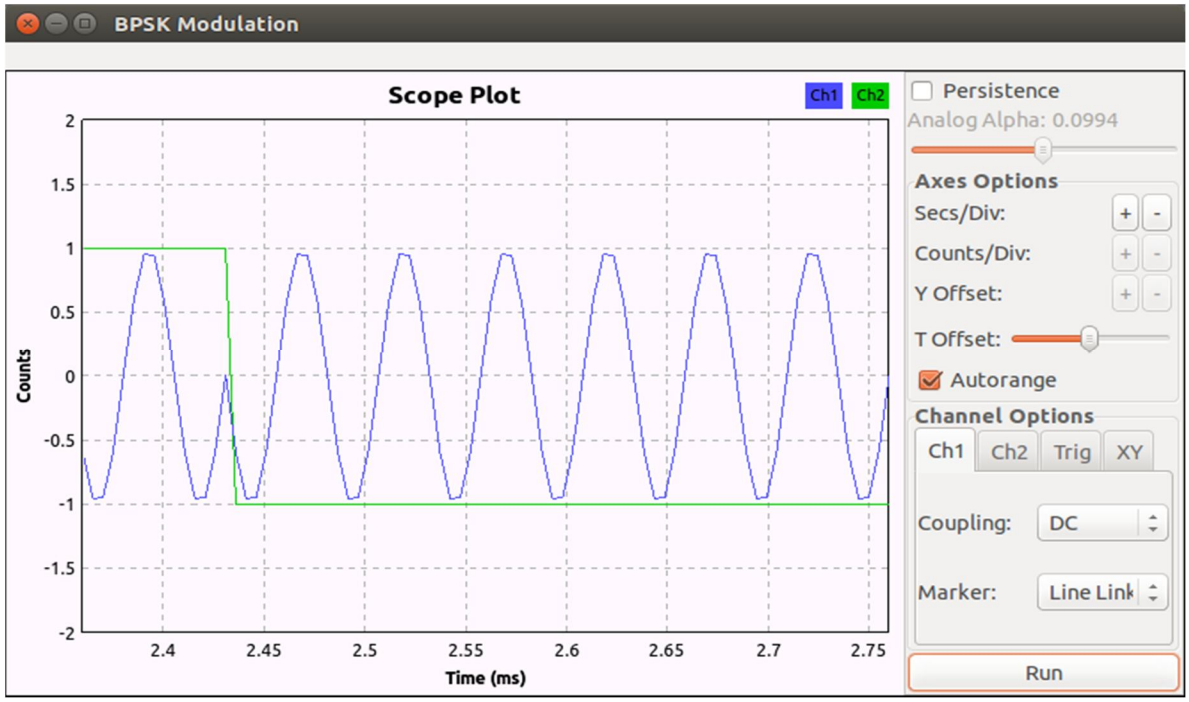

Figure 6: Output waveform of BPSK modulator using GNU radio

The output waveform obtained for Demodulation of USRP generated .DAT file using GNU Radio for modulator is shown in Fig.

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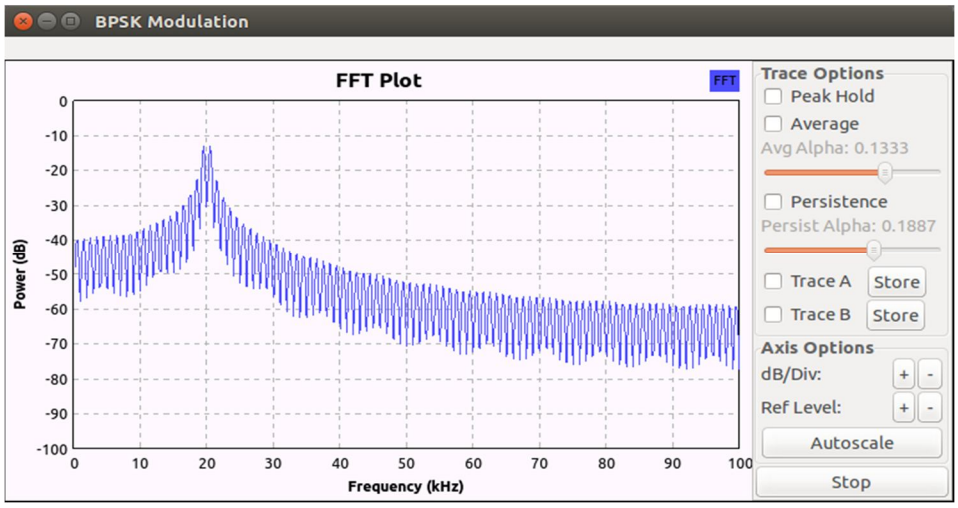

Figure 7: Demodulation of USRP generated .DAT file using GNU radio

IV. CONCLUSION

In this paper, BPSK modulator and demodulation of USRP generated .DAT file are studied and successfully implemented with the help of GNU radio software. The GNU radio tool consists of inbuilt predefined signal processing blocks , which are used to design the modulator in the form of data flow graphs. It has been observed that GNU Radio provides high flexibility and ease in designing signal processing blocks with it's main feature that allows to process real time data with high sampling rate and fast computation over other signal processing software. All of the above modulator and demodulation designs will help in understanding and improving the performance parameters of SDR.

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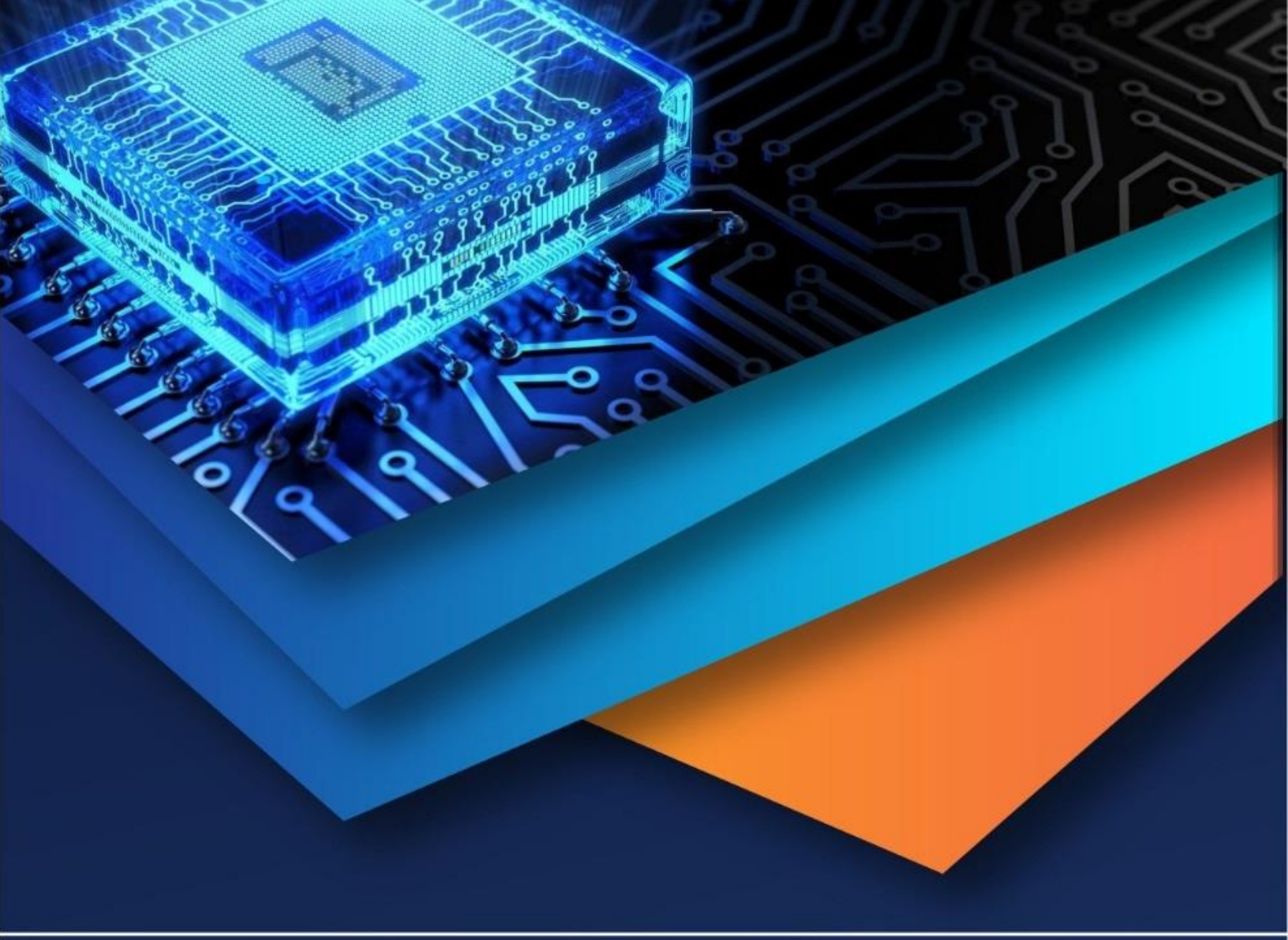

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