Implementation of BPSK/QPSK Transmitter and Receiver on NI USRP

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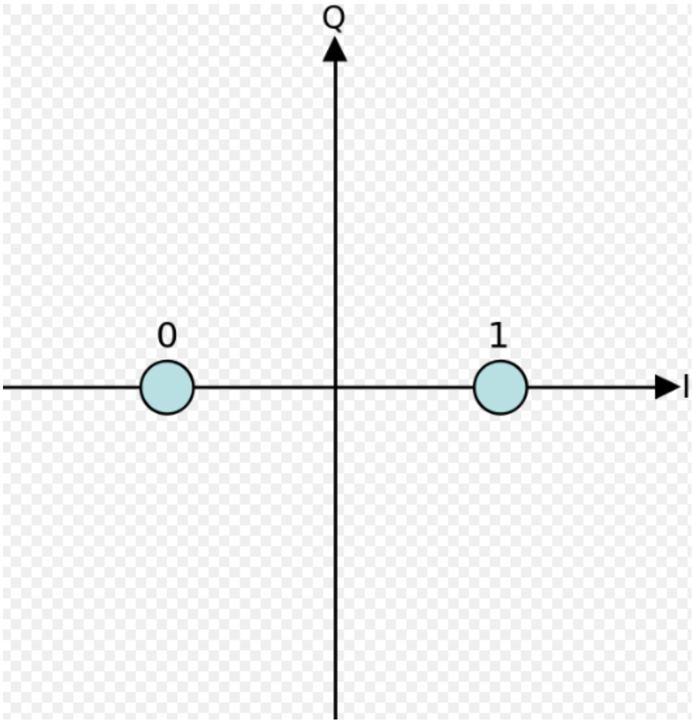
***Abstract*— Digital communication Systems are widely used in all fields of communication. We have different digital modulation schemes based on keying techniques that are used for implementation of digital communication systems. Some of the major techniques of keying that widely used are Frequency Shift Keying (FSK), Amplitude Shift Keying (ASK), Phase Shift Keying (PSK), etc. In this report, we are going to focus on BPSK (Binary Phase Shift Keying) and QPSK (Quadrature Phase Shift Keying). These are types of Phase shift keying. BPSK uses two points on the constellation diagram to represent the two phases and can encode one bit per phase and QPSK uses two points on the constellation diagram to represent the two phases and it can encode two bits per phase. We are going to use LABVIEW (Laboratory Virtual Instrumentation Engineering Workbench) for BPSK and QPSK simulation. LABVIEW provides good programming environment being graphical and also gives good visualization of the results.**

Keywords*— *Digital Communication Systems, Keying, PSK, QPSK, BPSK, Phase Shift Keying, Binary Phase Shift Keying, Quadrature Phase Shift Keying, LABVIEW, Bits.

I. INTRODUCTION

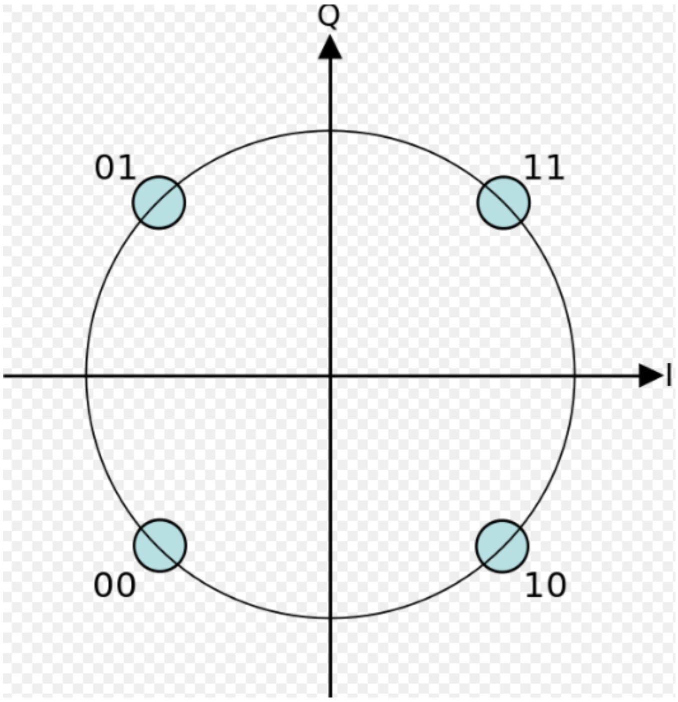
BPSK is the simplest form of PSK. It has 2 phases i.e., In the constellation diagram there are two constellation points - 0 and 1 which are represented by different carrier phases each is 180 degree apart from other. The Binary Phase shift keying (BPSK) uses two different phases to represent 0 and 1. While Quadrature Phase shift keying has four points on the constellation diagram to represent the four phases which are 90 degrees apart from each other and can encode two bits per symbol. Shifting Keying is the technique of modulation forms which is used to transmit digital signals and data over an analog channel. Modulation is the technique of casting a signal to send information. For expressing digital signals into analog waveform the keying technique can be used. The modulating signals have only restricted number of states to represent the corresponding digital states in keying. The main purpose of the modulation techniques is to increase the data rate transmitting efficiency. In wireless communication, QPSK has widely used modulation technique as it can transmit at twice of the data rate for a fixed bandwidth over BPSK. And for a given data rate the transmission bandwidth can be reduced by 2 by using QPSA.

BPSK Constellation Diagram



Reference: https://upload.wikimedia.org/wikipedia/commons/thumb/4/41/BPSK_Gray_Coded.svg/200px-BPSK_Gray_Coded.svg.png

QPSA Constellation Diagram

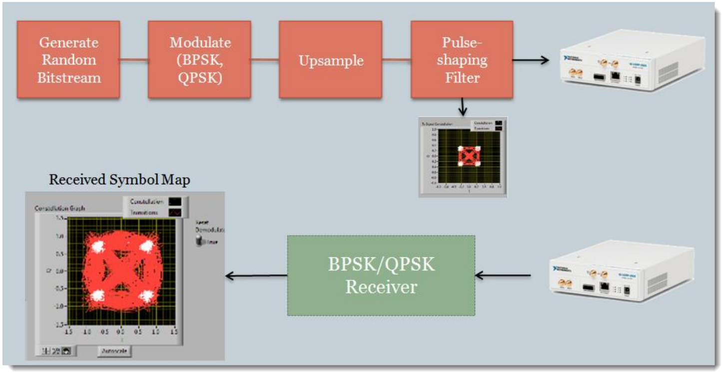


Reference:-
https://upload.wikimedia.org/wikipedia/commons/thumb/8/8f/QPSK_Gray_Coded.svg/200px-QPSK_Gray_Coded.svg.png

We will implement BPSK/QPSK communication system using the software LabVIEW. AWGN noise is added to the data and then the input signal is recovered at the output after removing the noise. LabVIEW i.e., Laboratory Virtual Instrumentation Engineering Workbench is a graphical programming language introduced by National Instruments. LabVIEW has many built-in functions, which is used as a tool for simulation and control. The main areas where this LabVIEW programming environment is used involves digital communication, industrial automation, controller design applications, etc. They can be implemented on many platforms including Windows and Linux.

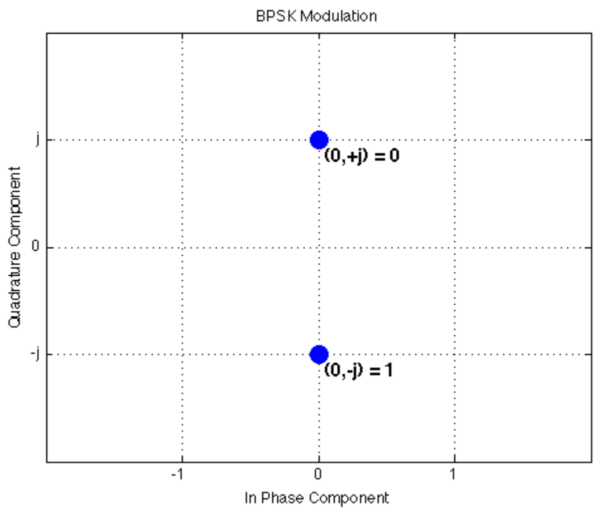
II. DESCRIPTION

Transmitter: On transmitter side we generate random bit stream then do modulation (BPSK, QPSK) and after that we apply pulse shaping filter (root raised cosine) to avoid ISI .The whole setup will look like as shown in figure.



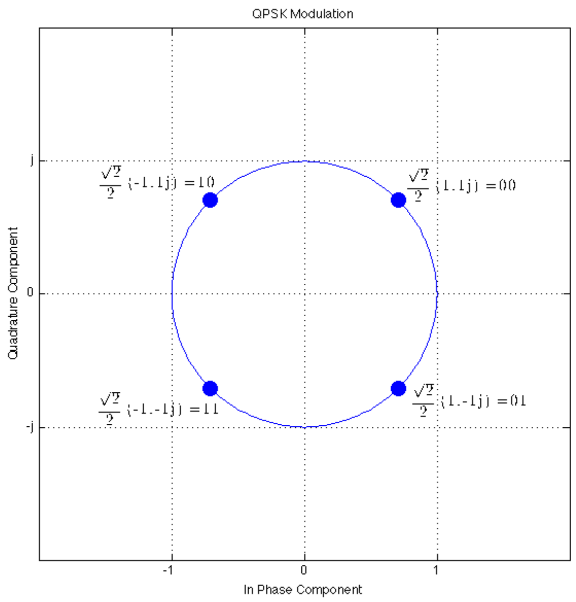
Modulation:

Binary Phase Shift Keying (BPSK): In BPSK each symbol carries single bit, So, we need to transmits two possible phases corresponding to the bit value. 0 is mapped to a phase offset of $\pi/2$. Binary 1 is mapped to a phase offset of $3\pi/2$. This symbol mapping is shown in below figure.



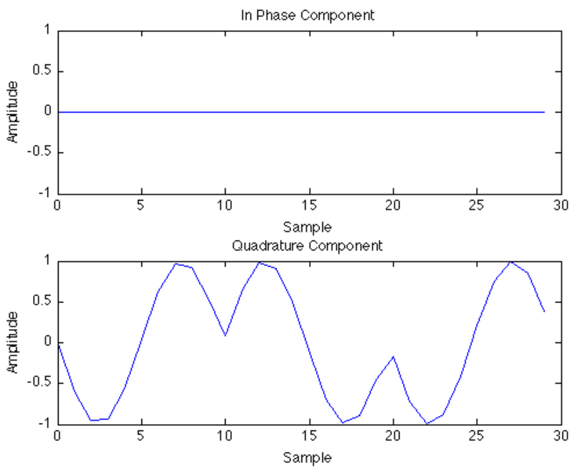
Quadrature Phase Shift Keying (QPSK) similarly, in QPSK 2 bits are packed in a symbol. Thus, there are four possible phases that a QPSK transmitter wili transmit that are $\pi/4$, $3\pi/4$, $5\pi/4$, $7\pi/4$. In I-Q notation, these points are $0.707 + 0.707i$, $-0.707 + 0.707i$, $0.707 - 0.707i$, $-0.707 - 0.707i$, respectively. This symbol map is shown in figure 3. In Gray coding, we map the bits such that the nearest neighboring symbols differ by only one bit. Because in gray coding successive symbols are flipped maximum by one bit. Our gray code mapping is as follows:

- 00 goes to 0.707 + 0.707i
- 01 goes to 0.707 − 0.707i
- 10 goes to −0.707 + 0.707i
- 11 goes to −0.707 − 0.707i



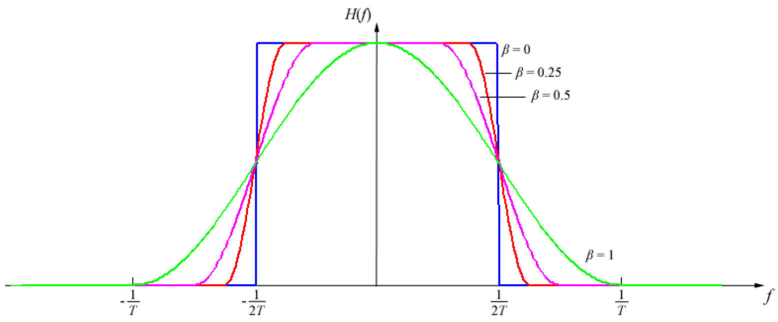
And the final modulated signal is shown in this figure.

Modulated signal



Filtering:

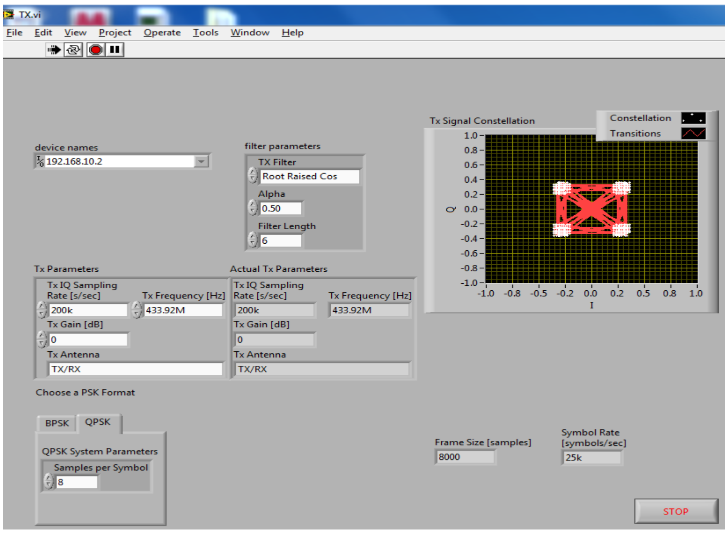
Our transmitting signal is baseband because we have a limited amount of frequency spectrum. Modulated signal have generally sharp "edges" due to the sudden phase shifts, which causes generation of higher frequency components. To avoid the aliasing outside transmitted symbols are filtered to smooth the transitions and minimize the harmonic content. We used “Root Raised Cosine Filter" as shown in figure 5 for removing of higher frequency components and make the spectrum smooth.



Root Raised cosine filter

LABVIEW:

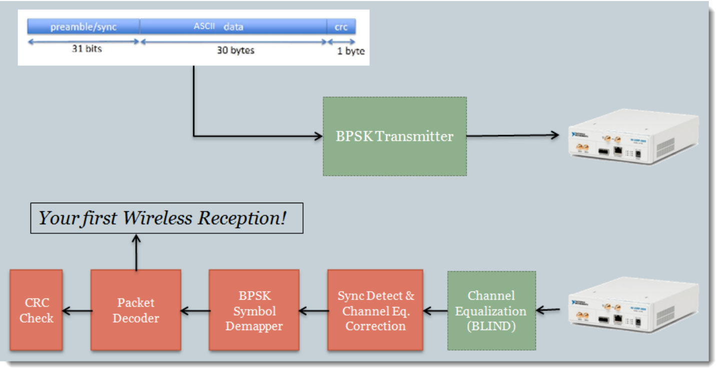
Front panel of transmitter in the labview will look like as shown in below figure.



Transmitter front panel in labview

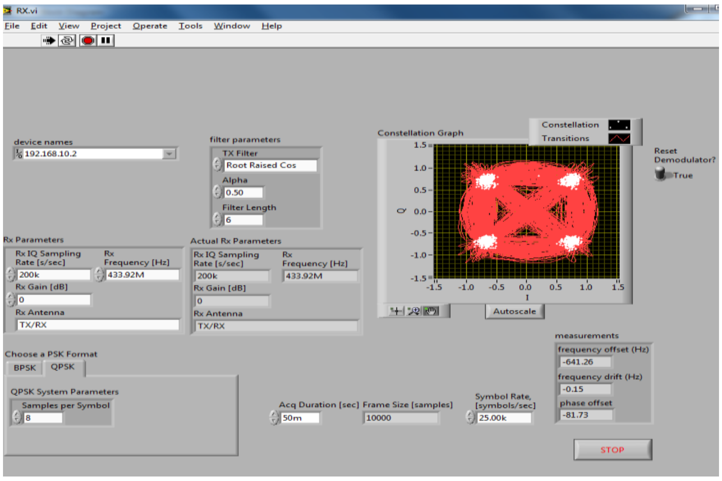
Receiver:

The setup of receiver side will look like as shown in figure 7. Where we first do synchronize detection then demodulation and symbol detection and then error checking to check whether the bits detected are received correctly or not.



LABVIEW :

Front panel of labview for receiver is shown in below figure.



III. CONCLUSION

We implemented QPSK and BPSK using LabVIEW. Experimental results are shown which are generated by LabVIEW program. The graphical environment of LABVIEW is easy to learn and simple to transform a concept to a working program. And with the help of LABVIEW graphical environment it is possible to continuously vary the input parameters in front panel and to observe the corresponding results.

IV. REFERENCES

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