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BER Reduction in QPSK

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ABSTRACT

In this paper, a solution is presented to reduce the BER of a signal to obtain a high quality signal. The presented technique is actually the combination of two different digital modulation techniques, this gives two advantages that are very useful in reduction of BER. The first one is the increase in magnitude of a signal and the second one is the spreading of cancellation points. The BER performance of the presented method over AWGN is compared with BER performance of BPSK and QPSK. From comparison of BER graphs it is clear that the presented technique gives much better results in reducing BER of a signal as compared to other described modulation techniques.
KEYWORDS: *BER, BPSK, QPSK, AWGN.*

I. INTRODUCTION

The main objective of modulation is to transmit maximum amount of data in the available spectrum. To achieve this goal mostly digital modulation techniques are used. Here we define a term that is spectral efficiency, which is basically the ratio of maximum number of bits transmitted to the minimum available bandwidth. In case of MPSK, the spectral efficiency increases as M increases. As M increases more data is transmitted in the available bandwidth but the problem is that the system becomes complex and the BER increases [5,7 and 14]. To reduce BER of MPSK modulation schemes several methods have been developed[1, 2, 3, and 4]. Some authors have provides the comparison of MPSK techniques with respect to BER using different simulation tools [5,6]. In [22], authors have used the technique of OFDM (Orthogonal Frequency Division Multiplexing) to reduce the BER of a Wimax Modem. But this technique is limited, one cannot simply expand the technique to other areas. So its desirable to develop a universal technique that can be modified easily and can be expanded to use in other areas. In this paper, we have overcome this problem and develop the basic technique that can be expanded and can be used in other areas as well. The presented model have the ability to accumulate other blocks i.e. OFDM to become effective in other areas such as Wimax.

PSK is the most efficient modulation scheme and is widely in communication industries [8, 9]. Other digital modulation schemes are amplitude shift keying (ASK) and frequency shift keying (FSK).

ASK is a method in which the amplitude of a carrier wave is changed in accordance with digital data. This technique is one of the low quality techniques because it is highly affected by noise. So it is normally avoided to use this technique. FSK is a better technique than ASK. In FSK frequency of a carrier wave is changed in accordance with digital data, but the error performance of FSK is poorer than PSK, therefore PSK is most widely used digital modulation scheme[5].

In case of modulation when the signal passes through a channel several modifications are done. To study this modification normally we use additive white Gaussian noise channel (AWGN channel) [16]. In next section of the paper we will discuss additive white Gaussian noise channel (AWGN channel).

Noise is any unwanted electrical signal that corrupts the original signal. There are many categories of noise but the most important one that is present in all communication systems is thermal noise. Thermal noise is normally modeled as additive white Gaussian noise. Additive means the addition of noise values into the transmitted signal. White usually means that the power of noise is uniform while Gaussian implies that in time domain the noise amplitude values will follow the Gaussian probability distribution function [10, 11,12, and 13]. The AWGN channel basic purpose is to add a white Gaussian noise to a signal. AWGN is a simple mathematical model used for studying the behavior of system[16] .

Bit error is simply the error in the receiving bits i.e. the no. of received bits over a communication channel that are altered by the effect of distortion, noise, interference and bit synchronization errors. So the bit-error rate (BER) is the ratio of no. of bit errors to the total no. of transmitted bits in the studied time interval [20].

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$$\text{BER} = \frac{\text{number of bits in error}}{\text{total number of transmitted bits}}$$

BER is a factor that is used to study the performance of modulation techniques. BER is higher for higher PSK modulation but the one advantage of higher PSK modulation schemes is that the maximum data is transmitted in the available bandwidth. For BPSK the BER is given by mathematical formula [15, 21]

$$P_b = \frac{erfc}{2}\sqrt{\frac{E_b}{N_o}} \qquad (1)$$

Where $\frac{E_b}{N_o}$= ratio of signal energy per bit to noise spectral density.
Erfc is the complementary error function, mathematically defined as

$$erfc(x) = \frac{2}{\pi}\int_x^\infty e^{-t^2}\,dt$$

Complementary error function are frequently used in probability theory since the normalized gaussian curve represents the probability distribution with standard deviation σ relative to the average of a random distribution. The complementary error function represents the probability that the parameter of interest has outside the range between $\frac{x}{\sigma\sqrt{2}}$and $-\frac{x}{\sigma\sqrt{2}}$.

For MPSK, BER is given by mathematical relation

$$P_b = \frac{2\,(erfc)}{M}\sqrt{\frac{M(E_b)}{2\,N_o}}\sin\left(\frac{\pi}{M}\right) \qquad (2)$$

For QPSK, M = 4 , so putting the value of M in above equation, we get

$$P_b = \frac{(erfc)}{2}\sqrt{\frac{2(E_b)}{N_o}}\sin\left(\frac{\pi}{4}\right) \qquad (3)$$

Putting different values of $\frac{E_b}{N_o}$ we will obtain BER graph. In section of simulation, we will show graph obtained by both theoretically and by simulation. The next section of the paper is related to digital modulation schemes.

II. RELATED WORK

Binary phase shift keying sometimes called as phase reversal keying is the most basic technique of phase shift keying. In this technique, binary 1 represents one phase while binary 0 represents another phase. These two points i.e. binary 1 and binary 0, that represents binary information are 180^{o} apart from each other [17]. The two signal elements S_0 and S_1 are mathematically represented by

$$S_i(t) = \sqrt{\frac{2E}{T}}\cos(2\pi f_c t + (1-n)\pi) \qquad (4)$$

n= 0, 1.
'E' represents the energy strength of signal per bit.
'T' is bit duration.
't' is in range $0 \leq t \leq T$.
For bit = 0, n = 0

$$S_0(t) = \sqrt{E}\,\Phi_0 \quad (5)$$

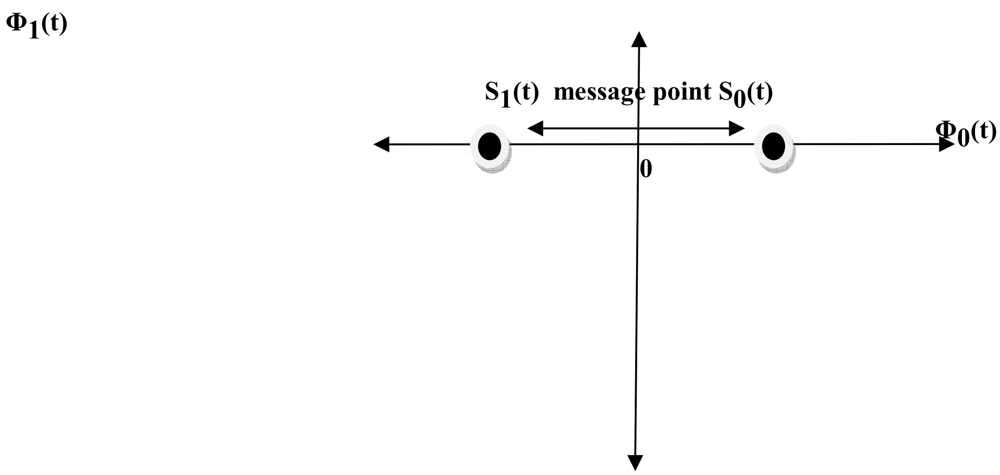
$$\Phi_0 = -\sqrt{\frac{2}{T}}\cos(2\pi f_c t) \quad (6)$$

For bit = 1, n = 1

$$S_1(t) = \sqrt{E}\,\Phi_1 \quad (7)$$

$$\Phi_1 = \sqrt{\frac{2}{T}}\cos(2\pi f_c t) \qquad (8)$$

So there are two message points S_0 and S_1.



The simulink model of BPSK for calculating BER is shown below

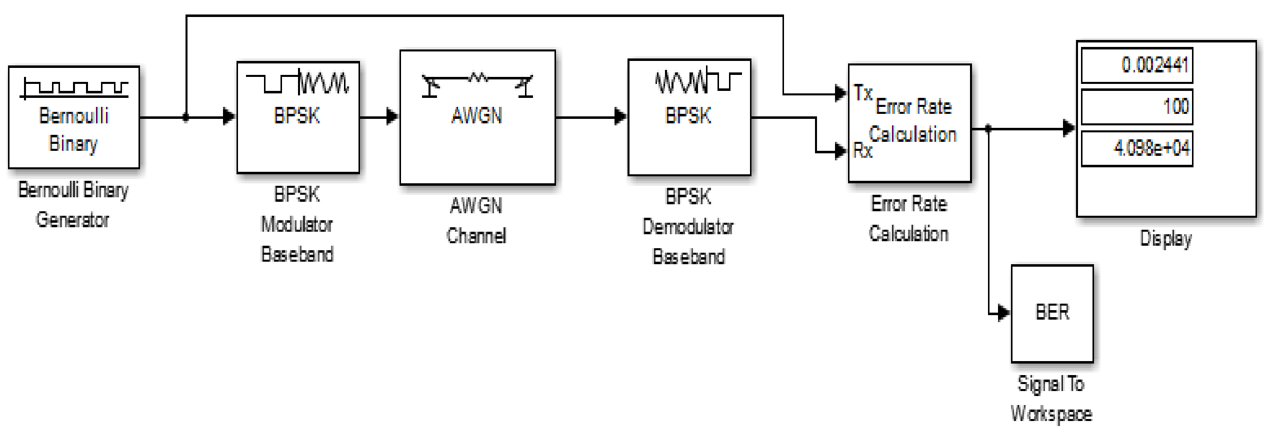


Fig. 1. Simulink model for BPSK

In quadrature phase shift keying (QPSK), instead of two phases like that in BPSK, four phase states are used, so there are four signal elements in QPSK and each are separated by 90^{o}. the general mathematical equation for QPSK is given by [18,19].

$$S_i(t) = \sqrt{\frac{2E}{T}}\cos(2\pi f_c t + \frac{(2n-1)\pi}{4})(9)$$

n = 1, 2, 3, 4.

So in this case we have four signal elements.
The simulink model of QPSK for calculating BER is shown below

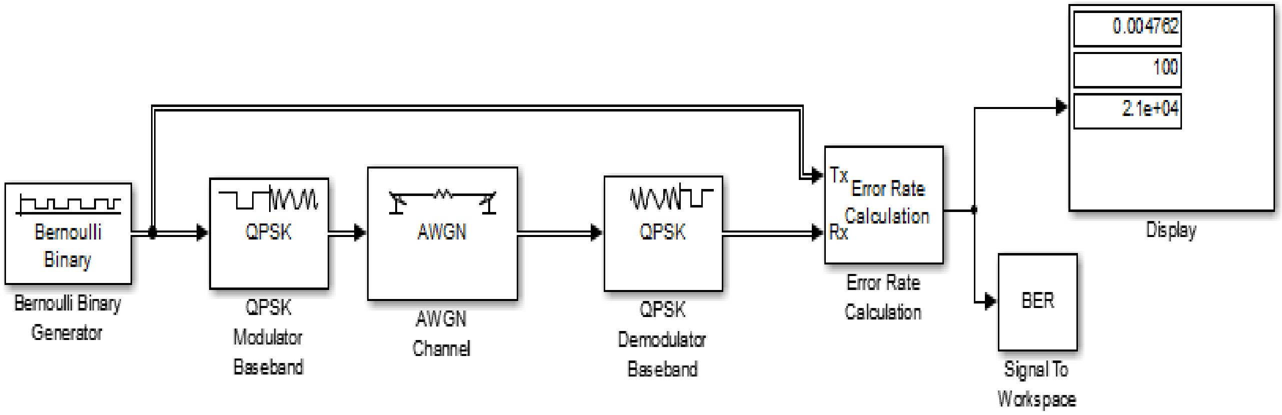


Fig. 2. Simulink model for QPSK

III. ANALYTICAL METHOD

The presented method is actually the combination of two techniques i.e. BPSK and QPSK. The basic purpose of the presented technique is to minimize the BER, to obtain a high quality signal. Now the question is how can we achieve this. The idea is that spread the concellation points as far apart as possible, this idea help in recognizing the coming bit easily. so our idea for minimizing BER of QPSK signal is that, mix two different kind of signals i.e. BPSK and QPSK.

Some concellation points of both signals are same and some are different. The addition of concellation points will results in the spreading of the concellation points.

Mathematically

For BPSK

$$S_i(t) = \sqrt{\frac{2E}{T}}\cos(2\pi f_c t + (1-n)\pi) \qquad (10)$$

For QPSK,

$$S_i(t) = \sqrt{\frac{2E}{T}}\cos(2\pi f_c t + \frac{(2n-1)\pi}{4}) \qquad (11)$$

By adding the two signals we get.

$$S(t) = [\sqrt{\frac{2E}{T}}\cos(2\pi f_c t + \frac{(2n-1)\pi}{4})] + [\sqrt{\frac{2E}{T}}\cos(2\pi f_c t + (1-n)\pi)] \qquad (12)$$

For n=1.

$$S(t) = (1+\sqrt{2})\sqrt{\frac{2E}{T}}\cos(2\pi f_c t) - \sqrt{\frac{E}{T}}\sin(2\pi f_c t) \qquad (13)$$

In BPSK , $s(t) = \sqrt{\frac{2E}{T}}\cos(2\pi f_c t)$. while for QPSK $s(t) = \sqrt{\frac{2E}{T}}\cos(2\pi f_c t + \frac{\pi}{4})$.

Now look at the signal obtained by the presented technique. $(1+\sqrt{2})$ this term results in the increase in the magnitude of signal. So it is the first advantage of the presented method, that the signal is now powerful. After addition of signals the concellation points becomes far apart from each other so it becomes easy to recognize the coming bit.

The simulation is performed on simulink. The parameter used in the block are shown in table below

Block Names	Parameter Names	BPSK / QPSK
Bernoulli Binary Generator	1. Probability of a Zero 2.Initial Seed 3.Frame Based Output 4.Samples per frame 5.Output Data Type	1. 0.5 2. 61 3. Checked 4. 1000 5. double
Modulator baseband	1. phase offset 2.concellation ordering 3.input type 4.output data type.	1. (π/2) / (π/4) 2.binary 3.integer 4.double
Demodulator baseband	1. M-ary number 2.phase offset 3.concellation ordering 4.output data type.	1. 2 / 4 2. (π/2) / (π/4) 3. binary. 4.double
AWGN channel	1.Initial Seed 2.Mode 3.Eb/No (dB) 4.No. Of Bits per Symbol 5.Input Signal Power(watts) 6.Symbol period (s)	1.67 2.SNR(Eb/No) 3. Eb/No 4. 1 / 2 5. 1 6. 1
Error rate calculation	1.Receive Delay 2.Computation Delay 3.Computation Mode 4.Output Data 5.Reset Port 6.Stop simulation 7.Target No. of Errors 8. Maximum number of symbols	1.0 2. 0 3.Entire Frame 4.Port 5.Unchecked 6. Checked 7.maxNumErrs 8.maxNumBits
Display	1.Format 2.Decimation 3.Floating display	1. Short 2. 1 3. Unchecked
Signal to workspace	1.Variable Name 2.Limit data point to last 3.Decimation 4.Save Format 5.Save 2d signal as 6.Log Fixed point data as a fi object	1.BER 2. 1 3. 1 4.Array 5. 2-D array (Concatenate along first dimension) 6. Unchecked

TABLE 1. PARAMETER SETTINGS FOR BPSK, QPSK.

3.1. Simulink model of presented technique:

We have given a name BQPSK to the model that we have presented in this paper. BQPSK, the presented technique is same as QPSK but the advantage of this technique is that the BER is better than QPSK. The simulink model is given below

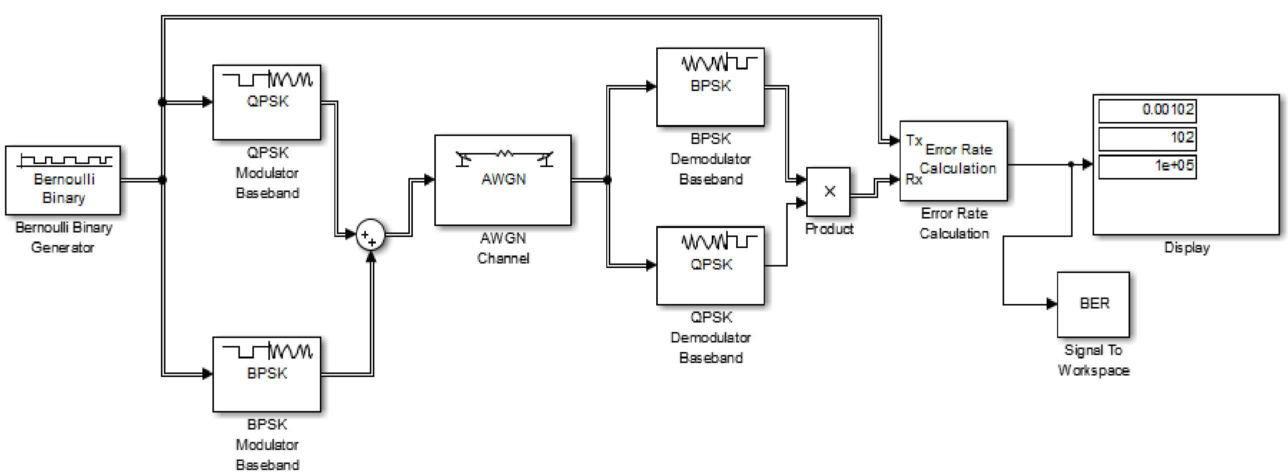


Fig. 3. Simulink model for BQPSK

IV. SIMULATION RESULTS:

In this section we have presented both theoretical and simulated BER performance of BPSK, QPSK and BQPSK. The simulation is performed by using Simulink. At the end of this section we have presented a combined graph of BPSK, QPSK and BQPSK, which clearly shows the performance of the presented model. The obtained results shows that the presented (BQPSK) model has better BER than any other digital modulation scheme.

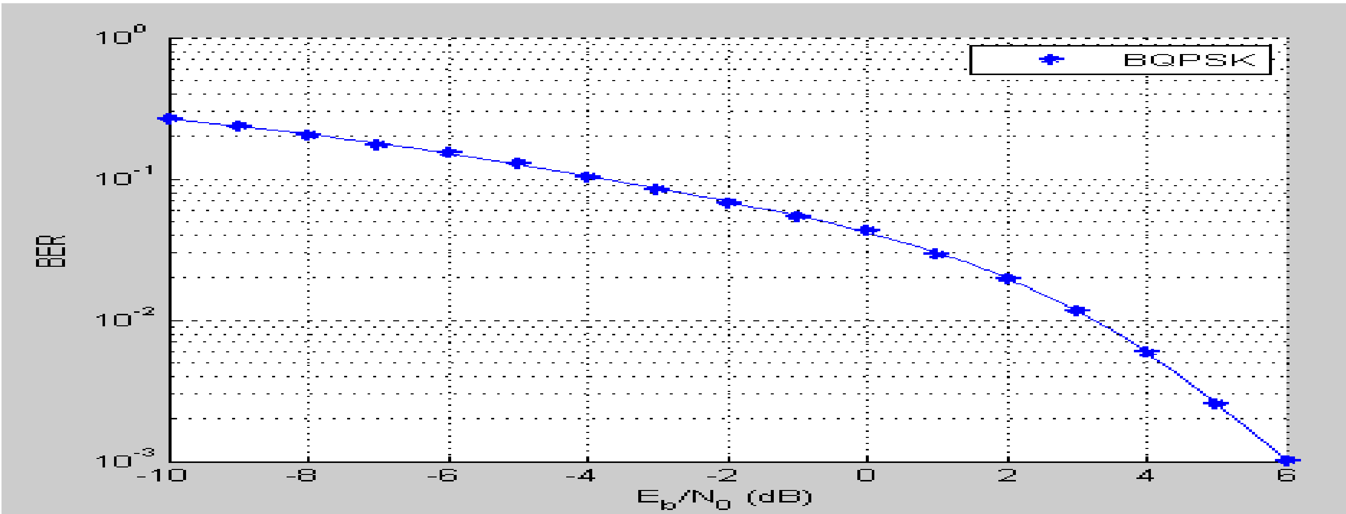


Fig. 4.BER VS$\frac{E_b}{N_o}$graph of BQPSK using Simulink.

In above figure BER graph of a presented technique is presented which shows that as SNR increases, the BER start decreasing. The next figure shows the BER graph of BPSK and QPSK (both theoretical and simulation graphs, combined in a figure).

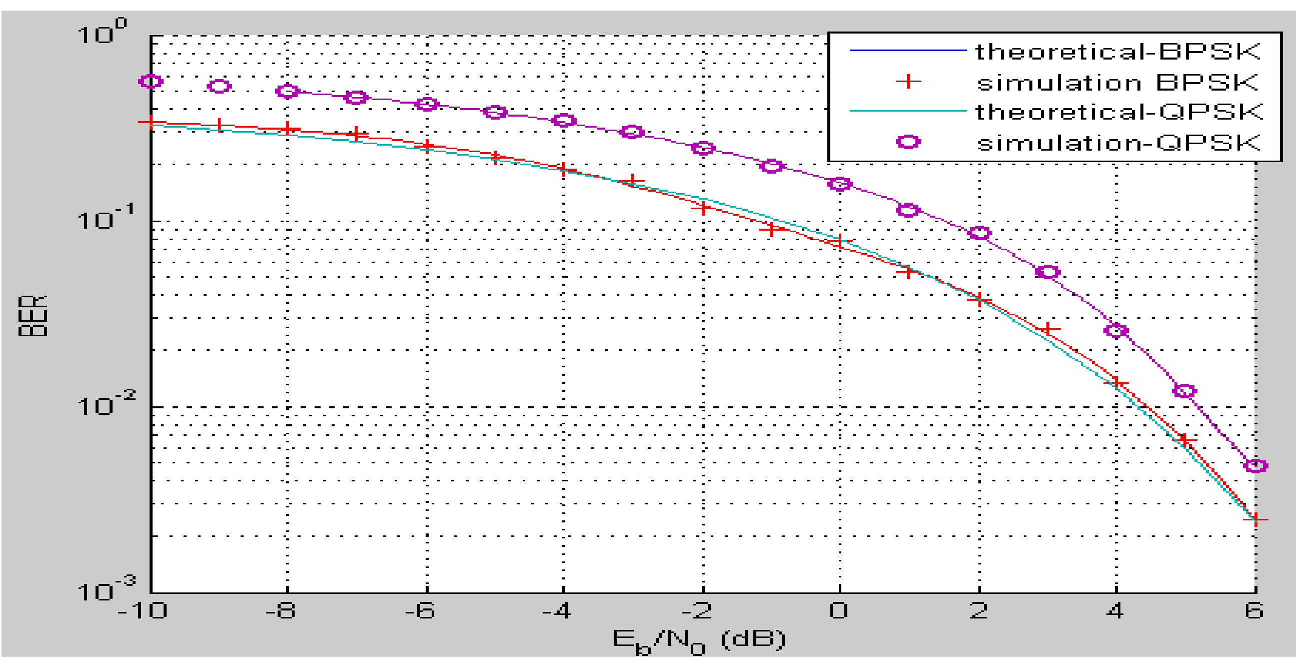


Fig. 5.BER VS$\frac{E_b}{N_o}$graph of BPSK and QPSK using Simulink.

From graphs it is difficult to find the exact difference between simulation and theoretical values, so at the end of the graphs, we have presented a table to clearly understand the difference between simulation and theoretical values. The next BER graph is the comparison of BPSK and QPSK with the presented technique [] . Normally it is difficult to achieve the theoretical value, but if we look at the comparison graphs, we will see that the presented method has beaten the theoretical values. This shows the success of the presented method in minimizing the BER.

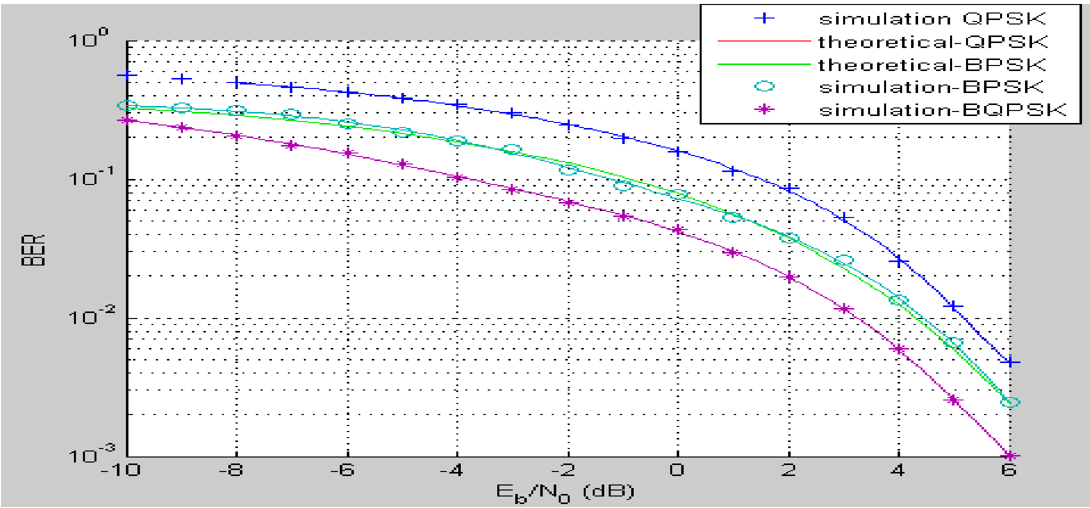


Fig. 6.BER VS$\frac{E_b}{N_o}$graph of QPSK, BPSK, BQPSK using Simulink.

Now we have shown a table to compare the BER results of presented method with the other modulation techniques. The table is helpful in understanding the differences between the BER values of all the discussed modulation techniques.

Eb/No	BER of Simulated BPSK	BER of Simulated QPSK	BER of Theoretical BPSK	BER of Theoretical QPSK	BER of BQPSK (Proposed)
-10	0.337	0.557	0.327	0.327	0.267
-9	0.323	0.528	0.307	0.307	0.236
-8	0.313	0.495	0.286	0.286	0.204
-7	0.294	0.461	0.263	0.263	0.176
-6	0.251	0.420	0.239	0.239	0.153
-5	0.218	0.382	0.213	0.213	0.13
-4	0.187	0.345	0.186	0.186	0.104
-3	0.165	0.302	0.158	0.158	0.084
-2	0.116	0.245	0.130	0.130	0.067
-1	0.090	0.198	0.103	0.103	0.054
0	0.077	0.158	0.078	0.078	0.043
1	0.052	0.114	0.056	0.056	0.029
2	0.037	0.086	0.037	0.037	0.019
3	0.025	0.052	0.022	0.022	0.011
4	0.013	0.025	0.012	0.012	0.005
5	0.006	0.012	0.005	0.005	0.002
6	0.002	0.004	0.002	0.002	0.001

Table2: Result comparison of proposed technique with existing techniques

V. CONCLUSION

The simulations using Simulink and the mathematical analysis shows that the BER for all MPSK modulation techniques decreases monotonically with increasing values of $\frac{E_b}{N_o}$ .BER rate in case of MPSK techniques is better for BPSK, but less data is transmitted in the available bandwidth in case of BPSK. In practice QPSK is mostly used because more data is transmitted in the available bandwidth as compared to BPSK and the theoretically

BER for QPSK is same as for BPSK. In this paper the obtained result shows the performance of the presented model. The presented model shows much better BER than BPSK & QPSK.

VI. FUTURE WORK

Future work is, to present a technique that is universally valid i.e. It is applicable to all types of digital modulation techniques i.e. for all MPSK, QAM and MFSK. In our research, We have developed a technique that is applicable to all MPSK techniques, the next step of our research is to extend the method to QAM and MFSK. In next paper we will present the universally valid technique to minimize the BER to obtain a high quality signal.

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