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Analyzing the BER Performance of OFDM-System with QPSK and BPSK Modulation Technique

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Abstract: In this paper Bit Error Rate (BER) performance of different modulation techniques are analyzed. There are different modulation schemes such as Binary Phase Shit Keying (BPSK) and Quadrature Phase Shift Keying (QPSK). The performance in between these modulation techniques is analyzed and best suited with respect to low Bit Error Rate (BER) is transmitted. Orthogonal Frequency Division Multiplexing also reduce the inter-symbol Interference (ISI). Simulation is carried out on the software named MATLAB. Simulation is carried over both BPSK and QPSK to obtain the optimum value of BER and SNR.

Keywords: OFDM, BPSK, QPSK, PSK, BER, SNR.

I. INTRODUCTION

Previous networks area unit primarily comprised of electrical cables (telephone or co–axial) and area unit thus area unit restricted in terms of information turnout and transmission distance. The natural resolution to beat this 'last–mile bottleneck' is to require advantage of the massive bandwidths offered by optical fibres associated to maneuver the fibre network nearer to the client therefore on eventually produce an all optical communications network. This sort of all optical access network has been termed Fibre–To–The–Home and is seen as a protected term resolution to fulfill growing information measure demands. This presents the vital monetary and technical challenges so as to produce adequate information rates to every user of outer importance once planning the next generation access networks are the choice of extremely economical modulation format to produce most turnout on each optical channel. This has lead to the emergence of Orthogonal Frequency Division Multiplexing.OFDM are often utilized in future optical networks. OFDM may be a modulation technique that is wide utilized in each wired and wireless radio communications and so has been such that for in radio communications standards like WiMAX and ADSL. OFDM's high spectral potency is that the main reason behind its use in current radio standards. However, what makes OFDM significantly engaging to be used in optical communications is its inherent tolerance to chromatic dispersion.

II.OFDM

Orthogonal frequency division multiplexing (OFDM) is a parallel transmission scheme[1], where a high-rate serial data stream is split up into a set of low-rate sub-streams, each of which is modulated on a separate sub-carrier (SC) (frequency-division-multiplexing). Thus, the bandwidth of the sub-carriers becomes small compared with the coherence bandwidth of the channel, i.e., the individual sub-carriers experience flat fading, which allows for simple equalization. This implies that the symbol period of the sub-streams compared to the delay spread of time-dispersive radio channel.

OFDM could be a Multicarrier Transmission technique which divides the out there spectrum into several carrier every one being modulated by a single data rate stream.

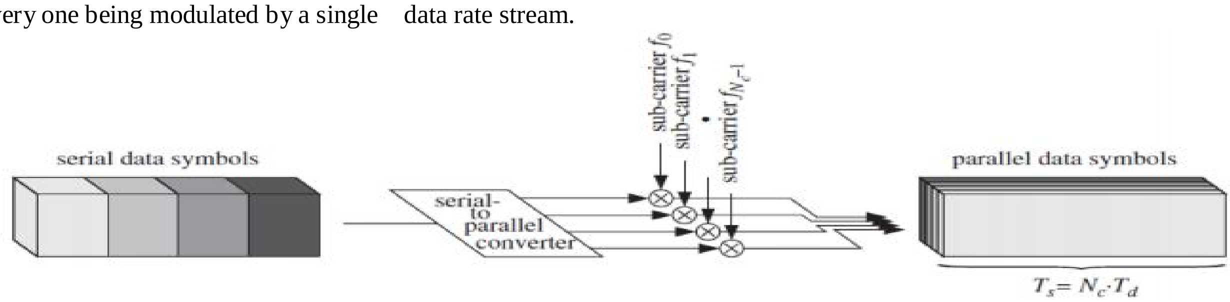

Fig. 1 Transmission of multicarrier

Selecting a special set of (orthogonal) carrier frequencies, high spectral efficiency is obtained, because the spectra of the sub-carriers overlap, while mutual influence among the sub-carriers can be avoided . By introducing a cyclic prefix (the so-called guard interval (GI)), the orthogonality can be maintained over a dispersive channel.. OFDM introduces inter-symbol interference (ISI) and inter-carrier interference(ICI).Intersymbol interference (ISI) is eliminated almost completely by introducing a guard time in every OFDM symbol.

This technique has been adopted for a number of applications such as the standard for digital audio broadcasting (DAB), digital video broadcasting (DVB), HIPERLAN/2, Wireless LAN (IEEE802.11x) and WiMax, etc. This paper starts with a brief introduction to the OFDM transmission technique,based on the description of the system's block diagram

I-A **BLOCK DIAGRAM OF OFDM SYSTEM**

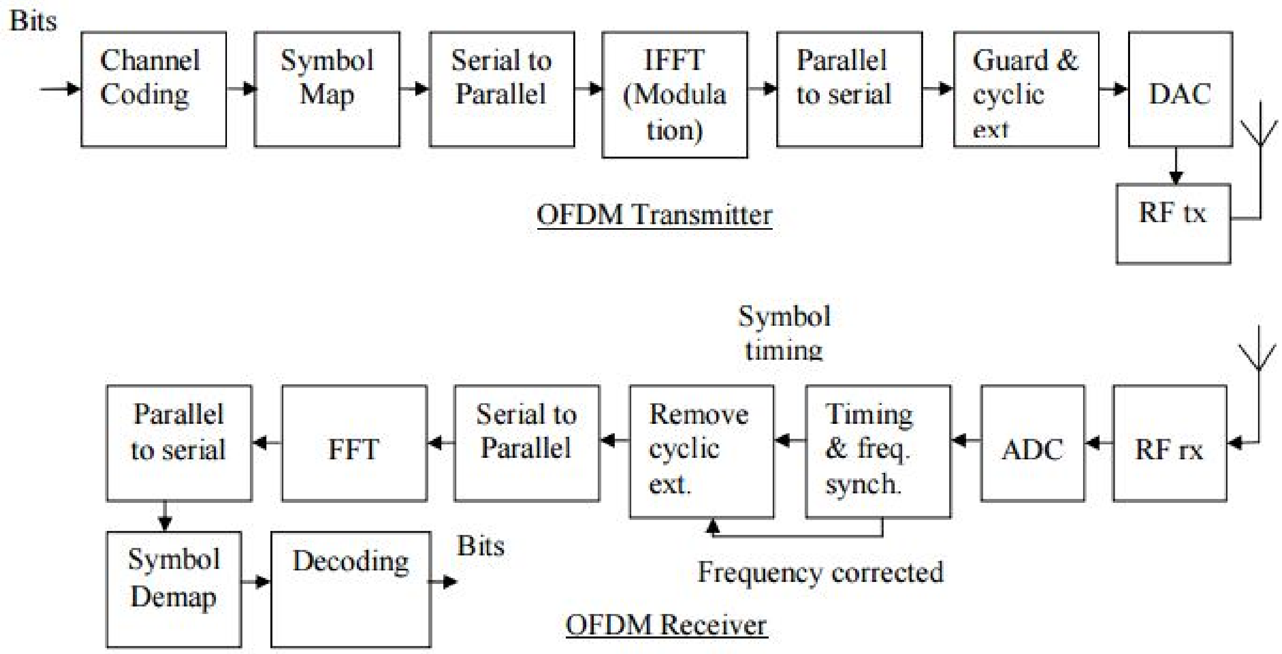

Fig. 2 Simple block diagram of OFDM

At the transmitter, the user information bit sequence is first subjected to channel encoding to reduce the probability of error at the receiver due to the channel effects. Usually, convolution encoding is preferred. Then the bits are mapped to symbols of either 16-QAM or QPSK. The symbol sequence is converted to parallel format and IFFT (OFDM modulation) is applied and the format. Guard time provided between the OFDM symbols and the guard time filled with the cyclic extension of the OFDM symbol. Windowing is applied to the OFDM symbols to make the fall-off rate of the spectrum steeper. The resulting sequence is converted to an analog signal using a DAC and passed on to the RF modulation stage. The resulting sequence is once again converted to the serial RF modulated signal is, then, transmitted to the receiver using the transmit antennas. Here, directional beam-forming can be achieved using antenna array, which allows for spectrum reuse by providing spatial diversity.

At the receiver, first RF demodulation is performed. Then, the signal is digitized using an ADC and timing and frequency synchronization are performed. The guard time is removed from each OFDM symbol and the sequence is converted to parallel forma tand FFT (OFDM demodulation) is applied. The output is then serialized and symbol demapping is done to get back the coded bit sequence. Channel decoding is, then, done to get the user bit sequence.

Time and frequency synchronization are very important for the OFDM based communication system. Without correct frequency synchronization the orthogonality will not exist among the carrier which leads to an increase in BER. Without correct timing synchronization it is not possible to identify start of frames.

III **MODULATION TECHNIQUES**

The technique of superimposing the message signal on the carrier is known as modulation. The process by which carrier wave is able to carry message or digital signal (series of ones and zeroes)is called modulation. Modulation is performed at the transmitter and the reverse operation of demodulation or detection is performed at the receiving end. Different classes of digital modulation techniques used for transmission of digitally represented data.

(a)Amplitude Shift Keying (ASK
(b)Frequency Shift Keying (FSK)
(c)Phase Shift Keying (PSK)

(a) **Amplitude Shift Keying (ASK)**

- Change in amplitude with respect to each symbol
- Frequency constant
- Low bandwidth requirements
- Very susceptible to interference

(b) **Frequency Shift Keying (FSK)**

- Change in frequency with respect to each symbol
- Needs larger bandwidth

(c) **Phase Shift Keying (PSK)**

- Change in phase with respect to each symbol
- More complex
- Robust against interference

III-A **BPSK**

BPSK (also sometimes called PRK, Phase Reversal Keying, or 2PSK) is the simplest form of phase shift keying (PSK)[5]. In binary phase shift keying (BPSK) the transmitted signal is a sinusoid of fixed amplitude. It uses two phases which are separated by 180° and so can also be termed 2-PSK. Binary Phase Shift Keying (BPSK) modulation, the simplest and most robust of all techniques, the signal shifts the phase of the waveform to one of the two states, either zero or 1. It is only able to transmit 1 bit/symbol in this case and so this is considered to be a disadvantage when using high data-rate systems with limited bandwidth. For transmission of '1'

$$S_1(t) = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t)$$

For transmission of '0'

$$S_2(t) = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t + \pi)$$

Where, Tb is bit duration, fc is carrier frequency, Eb is transmitted signal energy per bit. In another way, it can be understood as a binary level digital modulation scheme of phase variation that has two theoretical phase angles, +90° and -90°.It is immune to noise and interference therefore it improves BER performance. Each modulation symbol represents a single phase.

Constellation diagram:

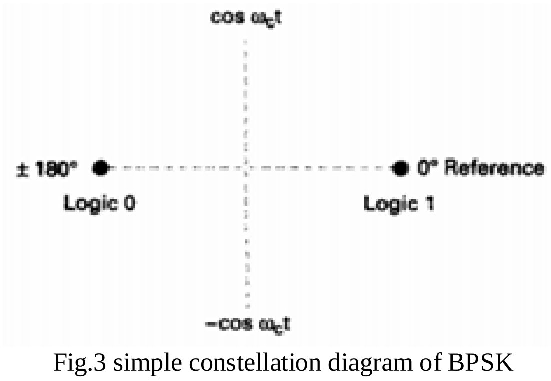

Fig.3 simple constellation diagram of BPSK

III-B **QPSK**

Quadrature Phase-shift Keying (QPSK) is a widely used method of transferring digital data by changing or modulating the phase of a carrier signal [1,2]. A four-level (4-ary) PSK is called Quaternary Phase Shift Keying (QPSK). The signal shifts the phase to one of four states and so QPSK can transmit 2 bits/symbol. When applying Gray coding each adjacent symbol only differs by one bit. It gives high spectral efficiency and it is more efficient than BPSK because it uses two symbols at a time for modulation. Both BPSK and QPSK are power efficient in same way but QPSK is more bandwidth efficient than BPSK.

In the modulator four phase generated((+45°,+135°, -45°, and -135°).During each symbol interval, the modulator shifts the carrier to one of four possible phases corresponding to the four possible values of the input symbol.
The two basis functions are:

$$\varphi_1(t)=\sqrt{\frac{2}{T}}.\cos 2\pi f_c t\ ;0\le t\le T\quad\text{and}\quad \varphi_2(t)=\sqrt{\frac{2}{T}}.\sin 2\pi f_c t\ ;0\le t\le T$$

Constellation diagram:

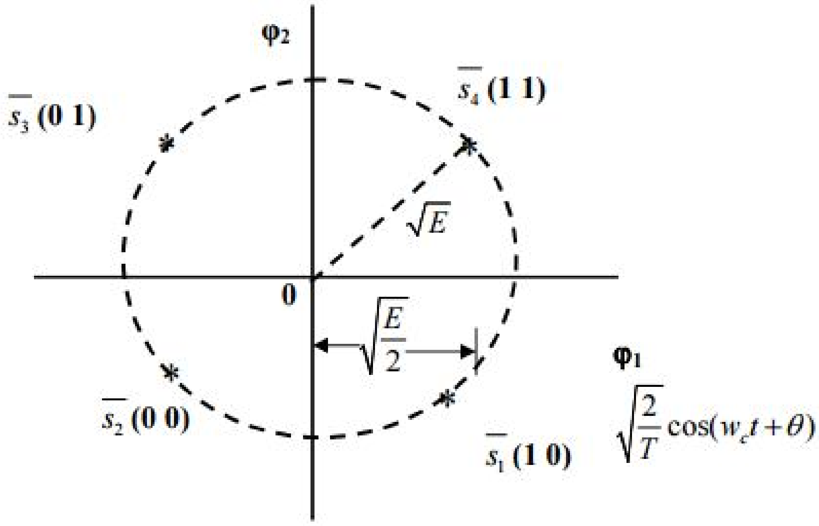

Fig. 4 constellation diagram of QPSK

III-C **PSK**

Phase-shift keying (PSK) is a method of modulation in digital communication in which the phase of a signal is varied to convey information. There are several methods that can be used to accomplish PSK. The simplest PSK technique is called binary phase-shift keying (BPSK). It uses two opposite signal phases (0 and 180 degrees). The digital signal is broken up timewise into individual bits (binary digits). The state of each bit is determined according to the state of the preceding bit. If the phase of the wave does not change, then the signal state stays the same (0 or 1). If the phase of the wave changes by 180 degrees that is, if the phase reverses then the signal state changes (from 0 to 1, or from 1 to 0). Because there are two possible wave phases, BPSK is sometimes called bi-phase modulation.

IV- **BER**

Bit error rate, BER is a key parameter that is used in assessing systems that transmit digital data[2][3] from one location to another. Systems for which bit error rate, BER is applicable include radio data links as well as fibre optic data systems, Ethernet, or any system that transmits data over a network of some form where noise, interference, and phase jitter may cause degradation of the digital signal. Although there are some differences in the way these systems work and the way in which bit error rate is affected, the basics of bit error rate itself are still the same.

When data is transmitted over a data link, there is a possibility of errors being introduced into the system. If errors are introduced into the data, then the integrity of the system may be compromised. As a result, it is necessary to assess the performance of the system, and bit error rate, BER, provides an ideal way in which this can be achieved. Unlike many other forms of assessment, bit error rate, BER assesses the full end to end performance of a system including the transmitter, receiver and the medium between the two. In this way, bit error rate, BER enables the actual performance of a system in operation to be tested, rather than testing the component parts and hoping that they will operate satisfactorily when in place.
Therefore Bit Error Rate can be defiend as:

BER= Number of errors/Total no.of bits sent

the medium between the transmitter and receiver is good and the signal to noise ratio is high, then the bit error rate will be very small - possibly insignificant and having no noticeable effect on the overall system However if noise can be detected, then there is chance that the bit error rate will need to be considered . The main reasons for the degradation of a data channel and the corresponding bit error rate, BER is noise and changes to the propagation path (where radio signal paths are used).

Both effects have a random element to them, the noise following a Gaussian probability function while the propagation model follows a Rayleigh model. This means that analysis of the channel characteristics are normally undertaken using statistical analysis techniques. It should be noted that each different type of modulation has its own value for the error function. This is because each type of modulation performs differently in the presence of noise. In particular, higher order modulation schemes (e.g. 64QAM, etc) that are able to carry higher data rates are not as robust in the presence of noise. Lower order modulation formats (e.g. BPSK, QPSK, etc.) offer lower data rates but are more robust.

IV-A **FACTOR AFFECTING BER**

There are dfifrent kinds of factor which can effect Bit Error Rate are as follows:

(a) - **Interfrence**

The interference levels present in a system are generally set by external factors and cannot be changed by the system design. However it is possible to set the bandwidth of the system. By reducing the bandwidth the level of interference can be reduced. However reducing the bandwidth limits the data throughput that can be achieved.

(b) - **Increase the power level**

It is possible to increase the power level of the system so that the power per bit is increased. This has to be balanced against factor including the interference levels to other users and the impact of increasing the power output on the size of the power amplifier and overall power consumption and battery life, etc.

(c) - **Lower order modulation**

Lower order modulation schemes can be used, but this is at the expense of data throughput.

(d) - **Reduced Bandwidth**

Another approach that can be adopted to reduce the bit error rate is to reduce the bandwidth. Lower levels of noise will be received and therefore the signal to noise ratio will improve. Again this results in a reduction of the data throughput attainable.

V- **RELATED WORK**

Sutanu ghosh et.al[1] provides a comparitiveanalysis on the basis of this bit error rate.the author concluded the BER of different subcarriers of BPSK modulation. During this he will reach at lowest level of BER of BPSK modulation.there are 2048 number of subcaririers .

Dixit dutt bohra and Avinash bohra et.al[2] concluded the Bit Erroe Rate (BER),for different modulation techniques such as Binary Shift Keying(BPSK) and Quadrature Phase Shift Keying(QPSK) .In this different modulation techniques comaperd on the basis of BER and best modulation technique determined ,which can help to choose appropriate technique which suit the channel quality.

Mr. Sivanagaraju and Dr. Siddaiah. et. al[3] concluded that there is lot of stress in power limitation and quality of service provided by OFDM system in mobile networks.To improve OFDM system performance BER and SNR plays very vital role.for this different modulation techniques used.

Mr. Sumit Dalal /M.Tech Scholar and Mr Pulkit Berwal et.al [4]concluded the BER
performance over Rayleigh fading channel by using MMSE (minimum mean square error equalization) and MLSE (maximum- likelihood sequence estimation) equalization techniques with BPSK, QPSK, 4 and 16-QAM. BER for all modulations using CP (cyclic prefix) is calculated to reduce Inter symbol Interference (ISI), therefore to reduce the effect of ISI equalization is done at receiver, but it cannot be dimnished completely in MMSE and MLSE equalizer and results are calculated with equalization and without equalization. Results obtained are average value of BER of around 0.4 in BPSK QPSK, 4-QAM, 16-QAM without and BER reduced by using MLSE equalization and become constant at value of 0.0015 in BPSK and 0.02 in QPSK, 0.12 in 16QAM, 0.0003 in 4QAM.

M. Divya et.al [5] concluded the performance of BPSK with OFDM over AWGN and Rayleigh fading. The results show the improved results in BPSK over Rayleigh fading channel compared over AWGN channel. It is analyzed that the graphical results of simulated BER of BPSK is same as theoretical BER of BPSK and can further reduced by using channel estimation. The results are calculated over input parameters are number of subcarriers are 52 with sampling frequency of 20 MHz. The CP used is of 0.8us with symbol duration of 4us. FFT and IFFT window size is 64.

Irfan ali et.al [6] concluded that bit error rate is key parameter to transmit data from one place to another. BER is basically found in radio data links as well as in otptical fibre, Ethernet or any other system which can transmit data over networks. MATLAB is an ideal tool for simulation, which can provide better result one of the most frequent simulation tasks in the field of digital communications is bit-error-rate testing of modems. The bit-error-rate performance of a receiver is a figure of merit that allows different designs to be compared in a fair manner. Performing bit-error-rate testing with Mat lab is very simple, but does require some pre requisite.

Jonathan M. Buset, Student Member, Ziad A. El-Sahn, and David V. Plant IEEE et.al [7] concluded a 10 Gb/s bidirectional subcarrier multiplexed (SCM) wavelength-division multiplexed PON. In this square-root raised cosine pulse shaping techniques and digital signal processing is used to generate M-QAM for downlink and BPSK for uplink transmissions. Then as a result 10 Gb/s transmission over a 20 km single feeder PON with powers from 1 to 9 dBm is obtained.

Megha Gupta, Prof. Rajesh Nema, Dr. Ravi Shankar Mishra, Dr. Puran Gour et.al [8] concluded that MLSE (maximum likelihood sequence estimation) can reduce inter symbol interference (ISI) over Rayleigh fading. In this work the comparison of the performance of un- equalized systems with the equalized system is done. Hence the BER is improved by using modulations are BPSK, QPSK, 4-QAM, 16-QAM. The input parameters are sub carriers = 52, IFFT/FFT size=64 with CP=16us. The channel is Rayleigh channel with subcarrier frequency = 20MHz and symbol rate= 52/3.2 usec or 16 Mb. Results in improved BER with equalized system and represented graphically

VI- **Results And Simulations**

Input parameters for BPSK, QPSK and PSK are listed in TABLE I and according to them graphical results of BER is obtained

TABLE I
Input bit to noise ratio

Eb/N0	**BPSK**	**QPSK**	**PSK**
VALUES	0:5	0:5	0:20

The graphical results obtained when following input parameters are taken and when implemented on MATLAB

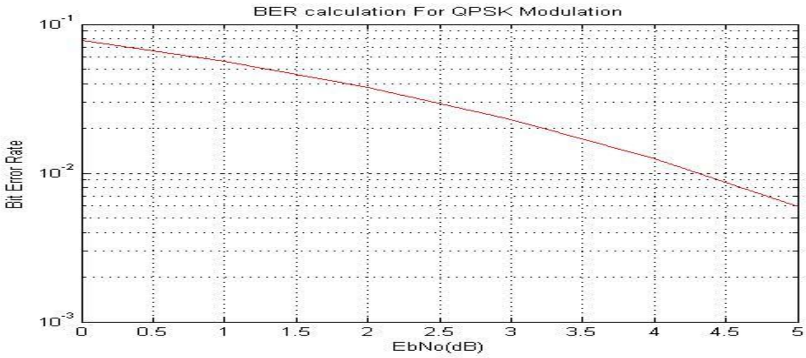

Fig.5 BER With Respect To QPSK

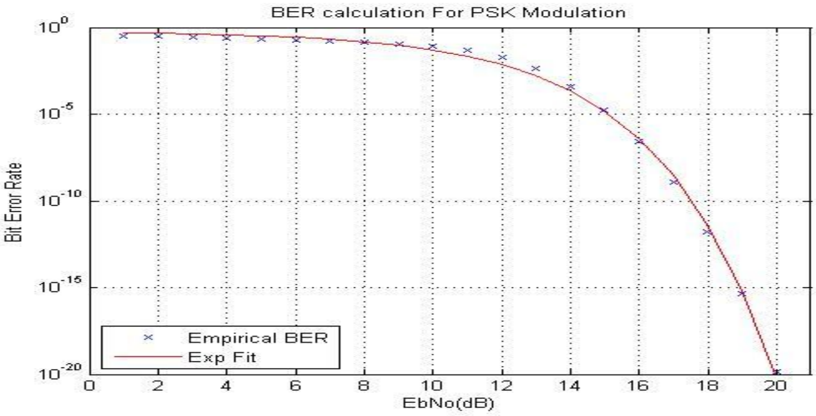

Fig-6 BER With Respect To PSK

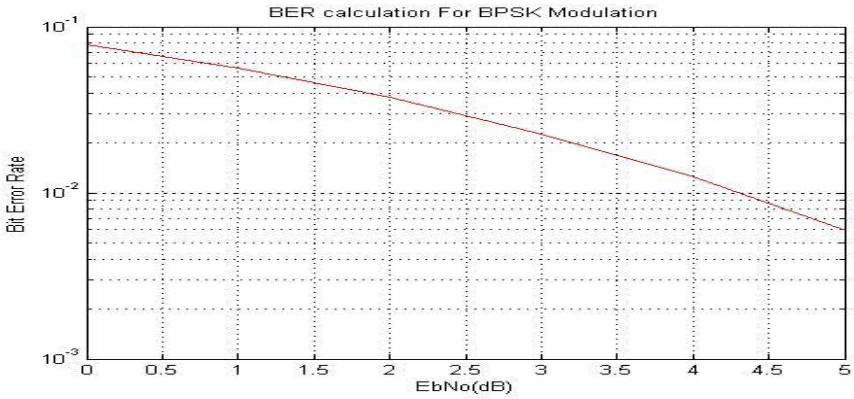

Fig -7 BER with Respect To BPSK

VI-A **CONCLUSION**

After simulation in MATLAB for different modulation QPSK is best modulation technique with good result to Bit Error Rate (BER).Simulation on different modulation in MATLAB can reduce BER to an adequate level .

VI –B **FUTURE SCOPE**

In future we can use some another modulation technique such as M-QAM. Because after 8-PSK (which is the maximum order PSK) BER get abruptly increased therefore by using QAM BER is reduced and it can handle more bits simultaneously.we can use different order of M-QAM(8-QAM order,16-QAM order,32-QAM order)to get better result than other modulation techniques.

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