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BER Analysis Of MIMO-OFDM System Using QPSK Modulation Technique And ISI Reduction With Cyclic Prefix In Wireless Communication

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Abstract-*For high speed data transmission system quality is a big challenge. In case of multiple-input multiple output (MIMO) system, orthogonal frequency division multiplexing (OFDM) modulation technique is used to achieve this target. Inter Symbol Interference has been a great challenge in MIMO system, which is required to be reduced and it can be achieved by variation in cyclic prefix and modulation technique. Orthogonal Frequency Division Multiplexing (OFDM) has changing into a awfully fashionable multi-carrier modulation technique for transmission of signals over wireless channels. OFDM eliminate inter-Symbol-Interference (ISI) and permits the information measure of subcarriers to overlap while not Inter Carrier Interference (ICI). A MIMO-OFDM modulation technique an do reliable high rate transmission over broadband wireless channel and Also the result of the analysis suggest for the better technique in order to improve the BER characteristic of the MIMO-OFDM system.*

Keywords*-MIMO-OFDM, BER(Bit Error Rate), ISI(inter-Symbol-Interference), QPSK, AWGN(Additive White Gaussian Noise), CP(Cyclic Prefix).*

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is modulation and multiplexing technology, developed to meet the increasing demand for higher data rates in communication[1]. OFDM provides immunity to the frequency selective fading channels multipath, high spectral efficiency, and high power efficiency.Multi-carriers (MC) modulation is the key concept of OFDM technique. OFDM System used in Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), Digital subscriber Lines (DSL), and Wireless Local Area networks (WLANs), Wireless Metropolitan Area Networks (WMANs).An arrangement of combining OFDM with MIMO technology achieves high data rate and robust transmission. Therefore, MIMO-OFDM System takes advantage of multipath interference effect to increase user and data capacity. Multiple antennas at transmitter and receiver (MIMO) allow achieving high spectral efficiency high-quality service and high speed in the wireless communication system. Modulation and demodulation are accomplished by the use of Inverse Fast Fourier Transformation (IFFT) and Fast Fourier Transformation (FFT) respectively. The symbolduration time is the inverse of the carrier spacing, ensuring orthogonality between the carriers. In Quadrature Phase Shift Keying (QPSK) two sinusoids (sin and cos) are taken as basis functions for modulation. Modulation is achieved by varying the phase of the basis functions depending on the message symbols. In QPSK, modulation is symbol based, where one symbol contains 2 bits [2] [3]. Orthogonal Frequency Division Multiplexing (OFDM) is a widely used technique in wireless communication systems. It"s also the base for fourth generation mobile communication. OFDM provides high spectral efficiency and high data rates. In this paper bit error rate (BER) of QPSK and QPSK based OFDM is analyzed. Inter Symbol Interference (ISI) is the most prominent and disastrous phenomenon that cause huge data loss. This paper provides the information on how the ISI is caused and how it causes the data loss. A comparison is made between the presented estimation techniques, showing the advantages and disadvantages of each one. The main objective ofthis paper is to present an analysis for channel estimation & BER estimation against differentchallenges of wireless communication system. It also minimize transmission power required (translates to SNR), and minimize bandwidth (frequency spectrum) used. MIMO is an important part of modern wireless communication standards such as IEEE 802.11n (Wi-Fi), 4G, 3GPP Long Term Evolution, WiMAX and HSPA+ [3]

II. MIMO

Fig. 1 shows the MIMO communication system basic blocks. The information bits to be transmitted are encoded and interleaved. The spatial data streams are mapped to the transmit antennas by the space-time coding block with linear precoding block thus spreading the various parallel streams across the various antennas with the aid of appropriate weighting factors. The receiver collects the signals at the output of each receive antenna element and reverses the transmitter operations in order to decode the data:

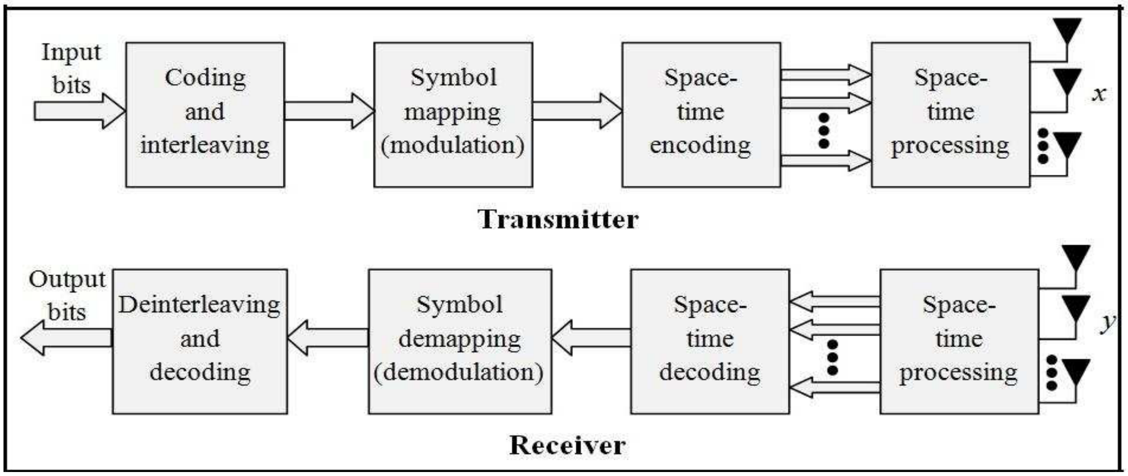

Figure 1. MIMO Transmit and Receive System Block Diagram.

III. OFDM

Fig. 2 shows the block diagram of a OFDM system. In this, baseband modulated symbols are passed through serial-to-parallel (S/P) converter which generates N size of complex vector *X*. *X* is then passed through the IFFT block, which convert X into OFDM time signal per block of symbols. OFDM time domain signals are then passes through the P/S converter and the serially data are transmitted through channel. Channel adds the effect of noise that can be eliminated. After passes through channel the received signal are splits data into parallel form and FFT converts time domain signal into frequency domain and then converts signal into parallel form and recovered original data.

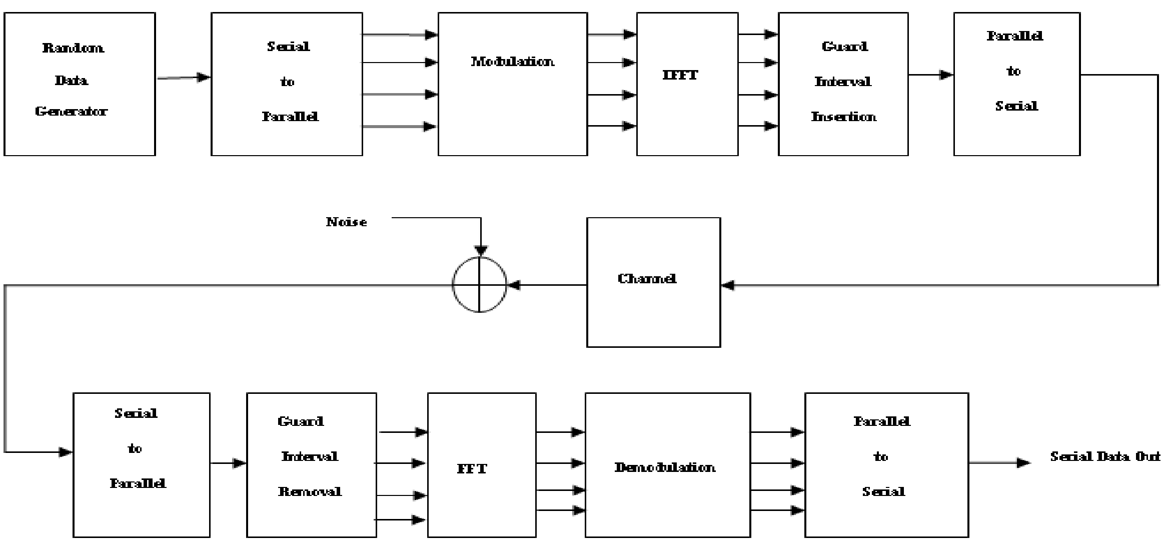

Figure 2 :- Block diagram of OFDM system.

IV. BER(Bit Error Rate)

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to bit synchronization errors, noise, interference and distortion. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval .BER is often expressed as a function of the normalized carrier-to-noise ratio measured denoted Eb/N0 that is energy permit to noise power spectral density ratio, or Es/N0 that is energy per modulation symbol to noise spectral density. As the name implies, a bit error rate is defined as the rate at which errors occur in a transmission system.bit error rate can be define as: BER = number of errors / total number of bits sent If the signal to noise ratio is high and medium between the transmitter and receiver is good 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,

The BER expression for M-ary QAM signalling for AWGN Channel is as given below[2]

$$P_e = \frac{M-1}{M\log_2 M}\, Q\left(\sqrt{\frac{6E_b \quad \log_2 M}{N_0(M^2-1)}}\right)$$

For Rayleigh channel[2]

$$P_e = \frac{M-1}{M\log_2 M}\left(1-\sqrt{\frac{3\gamma\log_2 M/(M^2-1)}{3\gamma\log_2 M/(M^2-1)+1}}\right)$$

Where $\gamma = E_b/N_0$ and M is the modulation order.

Standard Q- function defined as[2]

$$Q(x) = \frac{1}{\sqrt{2\pi}}\int_x^\infty e^{-t^2/2}\,dt$$

V. ISI(Inter-Symbol Interferance)

Inter symbol Interference (ISI) is an unavoidable consequence of both wired and wireless communication systems. Morse first noticed it on the transatlantic cables transmitting message using dots and dashes and it has not gone way since. He handled it by just slowing down the transmission . Assume that the time span of the channel is Lc samples long. Instead of a single carrier with a data rate of R symbols/ second, an OFDM system has N subcarriers, each with a data rate of R/N symbols/second. Because the data rate is reduced by a factor of N, the OFDM symbol period is increased by a factor of N. By choosing an appropriate value for N, the length of the OFDM symbol becomes longer than the time span of the channel. Because of this configuration, the effect of intersymbol interference is the distortion of the first Lc samples of the received OFDM symbol. An example of this effect is shown in Figure 3.

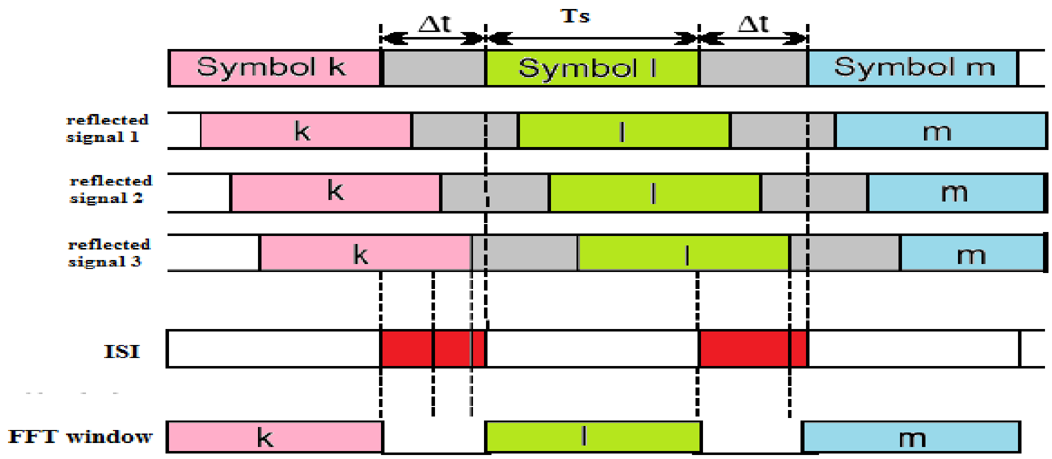

Figure 3 Combating ISI using a guard period

By noting that only the first few samples of the symbol are distorted, one can consider the use of a guard interval to remove the effect of inter symbol interference. The guard interval could be a section of all zero samples transmitted in front of each OFDM symbol since it does not contain any useful information, the guard interval would be discarded at the receiver. If the length of the guard interval is properly chosen such that it is longer than the time span of the channel, the OFDM symbol itself will not be distorted. Thus, by discarding the guard interval, the effects of intersymbol interference are thrown away as well.

VI. CP(Cyclic Prefix)

For a given system bandwidth the symbol rate for an OFDM signal is much lower than a single carrier transmission scheme. For example for a single carrier BPSK modulation, the symbol rate corresponds to the bit rate of the transmission. However for OFDM the system bandwidth is broken up into NC sub carriers, resulting in a symbol rate that is NC times lower than the single carrier transmission. This low symbol rate makes OFDM naturally resistant to effects of Inter-Symbol Interference (ISI) caused by multipath propagation. Multipath propagation is caused by the radio transmission signal reflecting off objects in the propagation environment, such as walls, buildings, mountains, etc.

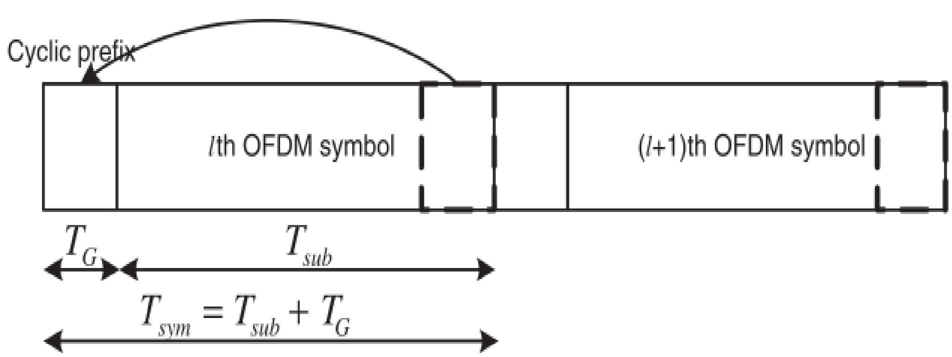

Figure 4 Inserting cyclic prefix (CP) to an OFDM symbol

These multiple signals arrive at the receiver at different times due to the transmission distances being different. This spreads the symbol boundaries, causing leakage between them. The effect of ISI on an OFDM signal can be further improved by the addition of a guard period to the start of each symbol. This guard period is a cyclic

copy that extends the length of the symbol waveform, known as cyclic prefix (CP). Each sub carrier, in the data section of the symbol, (i.e. the OFDM symbol with no CP added, which is equal to the length of the IFFT size used to generate the signal) has an integer number of cycles. By placing copies of the symbol end-to-end results in a continuous signal with no discontinuities at the joins. Thus by copying the end of a symbol and appending this to the start results in a longer symbol time. Fig 4 shows the insertion of a guard period.
The total length of the symbol is

$$T_s = T_G + T_{FFT}$$

Where T_s is the total length of the symbol in samples, T_G is the length of the CP in samples and T_{FFT} is the size of the IFFT used to generate the OFDM signal. In addition to protecting the OFDM from ISI, the guard period also provides protection against time-offset errors in the receiver.

VII. QPSK(Quadrature Phase-Shift Keying)

This is known as *quadriphase PSK or* 4-PSK.QPSK uses four points on the constellation diagram, equispaced around a circle. With four phases, QPSK can encode two bits per symbol, shown in the diagram with gray coding. QPSK transmits twice the data rate in a given bandwidth compared to BPSK - at the same BER.

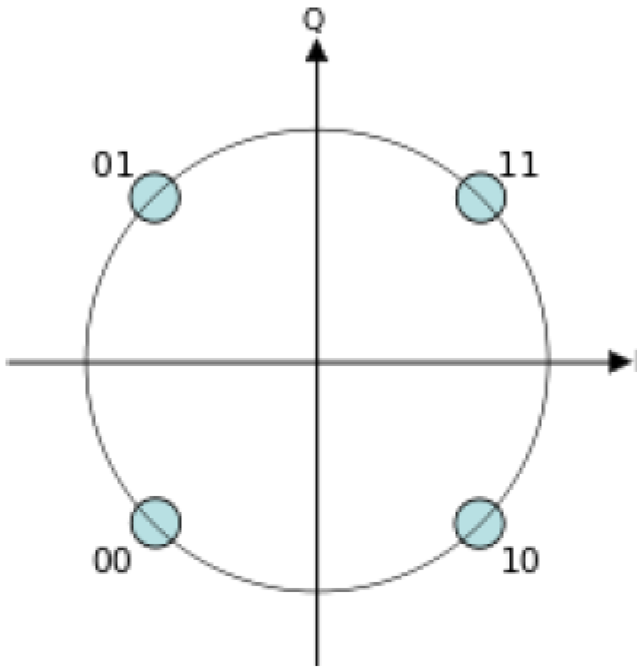

Figure 5. Constellation diagram for QPSK Implementation

The implementation of QPSK is more general than that of BPSK as given below:

$$S_n(t) = \sqrt{\frac{2E_s}{T_s}} \cos(2\prod f_c t + (2n-1)\frac{\prod}{4})$$

Where
n=1, 2, 3, 4.
This yields the four phase's π/4, 3π/4, 5π/4 and 7π/4 as needed.This results in a two-dimensional signal space with unit basis function. The first basis function is used as the in-phase component of the signal:

$$\phi_1(t) = \sqrt{\frac{2}{T_s}} \cos(2\prod f_c t)$$

And second basis function is used as the quadrature component of the signal.

$$\phi_2(t) = \sqrt{\frac{2}{T_s}} \sin(2\prod f_c t)$$

VIII. RESULT

QPSK for AWGN without OFDM

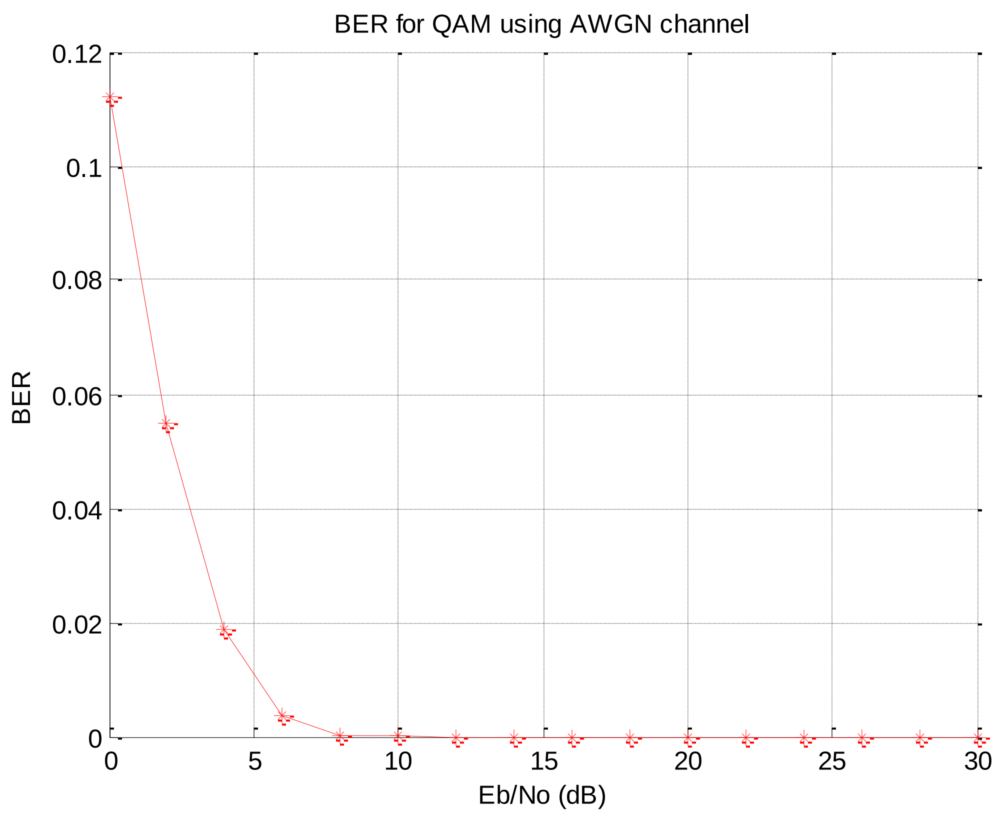

Fig.6 Bit error probability curve for QPSK Without OFDM

fig.6 shows ber performance of qpsk modulation scheme in awgn channel.

as bit energy/noise is increasing ber is decreasing.

QPSK for AWGN with OFDM

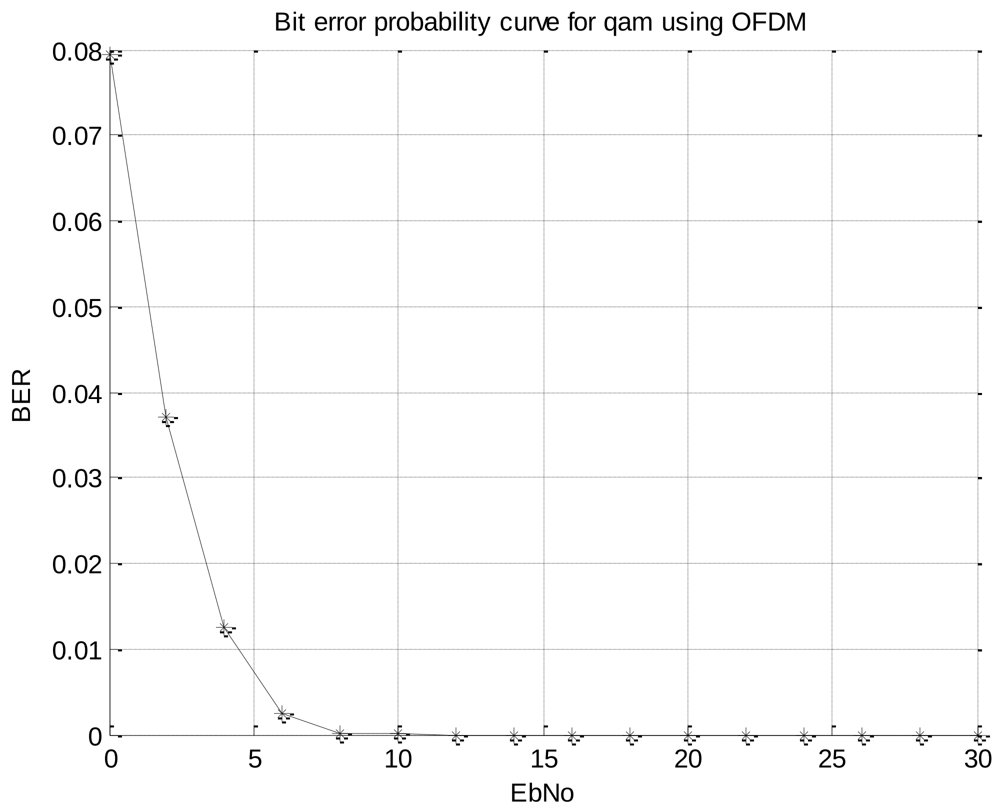

Fig.7 Bit error probability curve for QPSK With OFDM

In system with OFDM BER performance is improved (BER is decreased) as compared to system without OFDM.

COMPARISON

QPSK for AWGN with and without OFDM

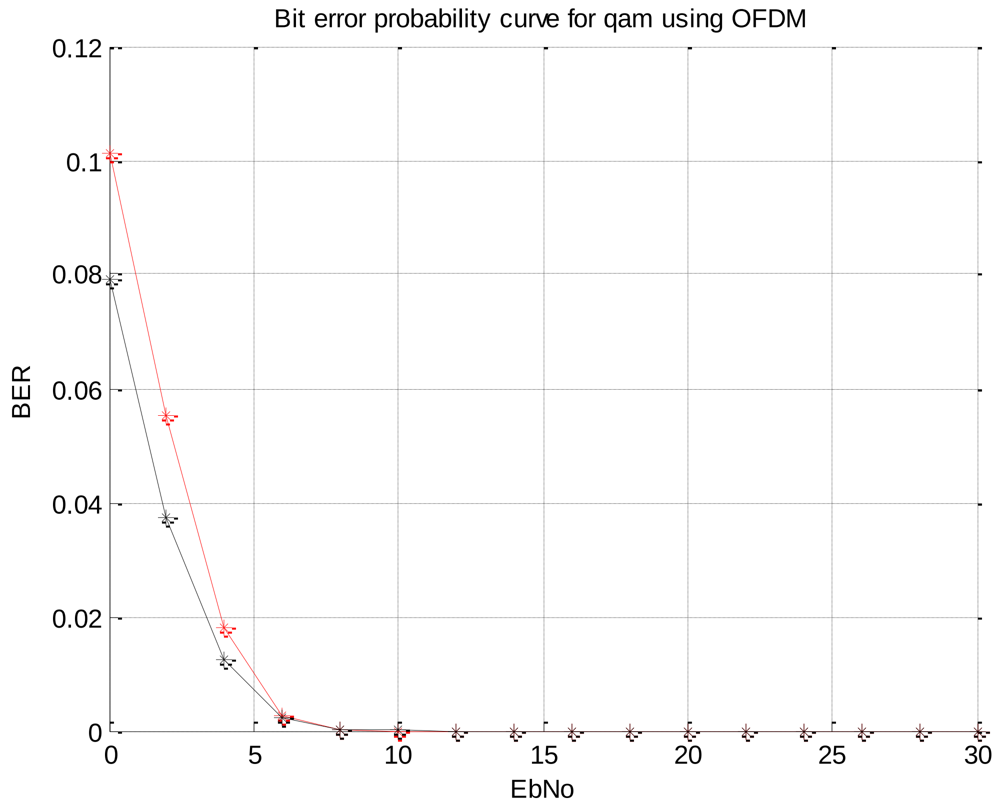

Fig.8 Bit error probability curve for QPSK With and Without OFDM

Fig.8 shows comparison of QPSK modulation scheme under AWGN channel with and without OFDM.

In system with OFDM BER performance is improved (BER is decreased) as compared to system without OFDM.

IX. CONCLUSION

The BER Performance of MIMO OFDM system has been analyzed for two scenarios, one is with Guard period inclusion and the other one without Guard period inclusion. The comparison shows that the performance with guard period is better than without guard period.

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