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Analytical Study of Wireless LAN using MIMO with OSTBC

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Abstract*— The use of multiple antennas for wireless communication systems has gained overwhelming interest of research in wireless communication. This paper deals with the effect on Multiple Input Multiple Output transmission technique for multiple fading channels using Phase shift keying (PSK) of Modulation Order (M=2) and Quadrature Amplitude Modulation (QAM) , there are two transmitting (Tx1, Tx2) and Two Receiving antenna (Rx1,Rx2) are used for anticipation. In this paper, I also tried to show the effect on Frame Error Rate (FER) by increasing the signal to noise ratio (SNR) using OSTBC MIMO technique, Quadrature phase shift keying (QPSK) modulation technique is used for the modulation and there are two transmitting antenna (nTx1, nTx2) and one receiving antenna (nRx1) are used to simulate the Multiple Input Multiple Output (MIMO) for Quadarature Phase shift Keying (QPSK). The main concern of this paper is to show the specification and effect of 802.11ac protocol that deals with the QAM Modulation technique that leads MIMO transmission to higher level that can achieve milestone for wireless communication system.

***Index Terms*—PSK, QPSK, QAM, OSTBC**

I. INTRODUCTION

Enhancing the capacity of the communication system is one of the primary factors in wireless communication and by using multiple input and multiple output i.e. multiple transmit and multiple receive antenna technique, we enhance the capacity of the wireless communication system. The requirement of the multiple transmit multiple receive (MIMO) antenna is to provide fast data transfer, higher throughput and reliability in performance and with the help of this MIMO technique we are able to transmit video , voice at higher data rate because it allows higher transmission rate.

Multiple transmit/receive antenna technique (MIMO) is very important part of modern wireless communication system such as: Wifi, 4G, Wi-Max. It also overcome the effect of Inter Symbol Interference (ISI) because Multiple transmit/receive antenna (MIMO) achieves higher spectral efficiency and link reliability or diversity [1]. Multiple antenna technique are used to improve the robustness and performance of the wireless link which means MIMO simply refers to the use of an array of antenna for both transmitting and receiving. We can say, it is a full duplex technology with a higher data rate. This digital technology in wireless communication has become a very useful advancement for the users and MIMO made an extra advancement in the growth of wireless communication because of its improved capacity.

MIMO (multiple input multiple output) achieves the goal of spreading the same total transmit power over the antennas to achieve an array gain that improves the spectral efficiency (more bits per second per hertz of bandwidth) or to achieve a diversity gain that improves the link reliability (reduced fading).

II. MIMO TECHNIQUE

A. MIMO System

MIMO stands for multiple inputs and multiple output and it is the use of multiple antennas at both the transmitter and receiver to improve communication performance. With the help of diagram (figure 1), I tried to show the simple way of understanding this MIMO (multiple input multiple output) technique.

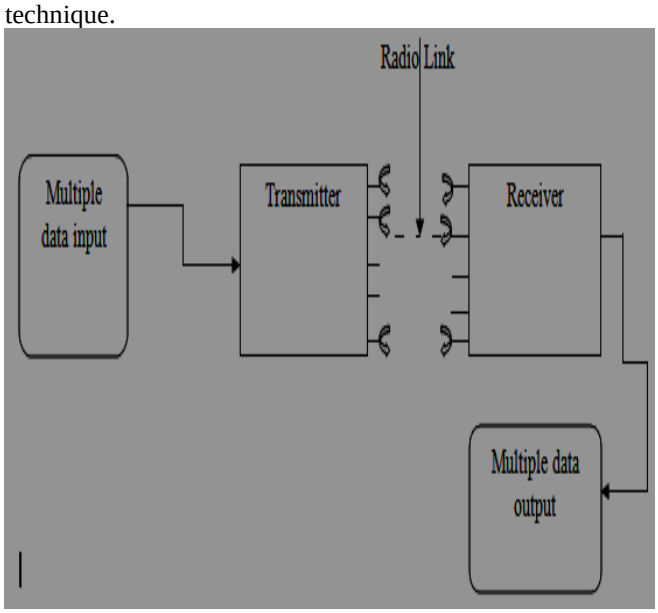

Figure 1: MIMO Technique in WLAN

As we see in the figure that, the multiple inputs are simultaneously transmitted and then it rejuvenate at the end of the receiver and we get the multiple outputs as well to the other end of the link. MIMO technique is also called as the Joint Transmit and receives technique or simply Joint Transmit/Receive because it includes the joint transmitting and receiving antenna array [2]. MIMO is one of the most popular research areas in wireless transmission as it offers more flexibility and reliability than single input/output technique.

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With the growth of application that demand better quality of service (QOS) , higher throughput and bandwidth, MIMO communication emerged as one of the most important and promising technology[3]. Multiple Antenna types are divided into different types and MIMO are of one of its type:

- ❖ SIMO : Single Input Multiple Output
- ❖ MISO : Multiple Input Single Output
- ❖ MIMO: Multiple Input Multiple Output

Multiple input Multiple Output system improves the capacity, range, and also the reliability of the wireless system. Because the transmitted electromagnetic waves the propagation environment, it is necessary to take into account the main propagation parameters for the design of the future communication system[4].

The functionality of the MIMO System can also be classified into three different categories, which helps to understand the working of this Multiple antenna technique. These three functions of the MIMO system are as:

Precoding: Proceeding is a beam forming method to support multilayer transmission in wireless communication. It is subdivided into two different categories

- ❖ Precoding for single user MIMO
- ❖ Precoding for multi user MIMO

B. Spatial Multiplexing

In spatial multiplexing, a high rate signal is split into multiple lower rate streams which are transmitted from a different transmit antenna. This technique increases the channel capacity of higher signal to noise ratio (SNR).

C. Diversity Coding Technique

Diversity coding technique exploits the independent fading in multiple antenna links to increase signal diversity. This technique is used when no channel knowledge at transmitter. MIMO systems provide a number of advantages over single input single output communication, Sensitivity to fading can be minimized by the spatial diversity provided by multiple spatial paths. Under certain environmental conditions, the power requirements linked with high spectral-efficiency communication can be significantly minimized by avoiding the compressive region of the information-theoretic capacity bound. Here, spectral efficiency is defined as the total number of information bits per second per Hertz transmitted from one array to the other [5].

D. MIMO Protocols

As we discussed earlier about the WLANs 802.11 protocols and its amendments, now the other amendments in the 802.11 series are 802.11n and 802.11ac which are used for the Multiple Input and Multiple Output (MIMO) transmission system that is the reason that I have given the name MIMO Protocols to these Wireless Protocols.

E. IEEE 802.11n standard

In July 2003, 802.11n task group was formed to create the new Wireless LAN standards with the goal to reach up to 100Mbps data rate. The proposal for the new standard included MIMO-OFDM, 20 and 40MHz channels, and packet aggregation techniques [6], the purpose of defining the 802.11n was to get higher throughput, better speed, reduced fading and improved range for Wireless Local Area Networks (WLANs) connection. These benefits are achieved through use of MIMO (Multiple-Input, Multiple-Output) technology. The latest draft for IEEE 802.11n describes rates up to 600Mbps, exceeding the maximum rate with the 11a/g standards by more than ten times, The process of developing the IEEE 802.11n amendment for the next generation of wireless local-area networks (WLAN) devices has encountered many hurdles, particularly in the initial stages, where the competing draft proposals from leading companies resulted in an overall inability to proceed with the standardization process. With the latest draft of IEEE 802.11n (Draft 3.0), throughputs beyond 200Mbps are possible, based on physical layer (PHY) data rates up to 600Mbps. Techniques employing multiple transmit and receive antennas, referred to as MIMO (multiple input, multiple output) are used to achieve these rates. These MIMO techniques include spatial division multiplexing (SDM), transmitter beam forming, and space-time block coding (STBC), used either to increase throughput over single antenna systems (by two to four times) or to improve range of reception, depending on the environment.

F. IEEE 802.11ac standard

The next amendment to the wireless LANs Protocol is 802.11ac which is also used for the MIMO transmission with enhanced performance than 802.11n. In order to address the higher data rate throughput capacity require by the new technological growth in wireless applications, the IEE task group in 2008,developed an amendment to the IEEE802.11 PHY and MAC layer . IEEE802.11ac has an improving delivery capacity beyond its counterpart, IEEE802.11n.It is the next evolution of the Wi-Fi standard with the capacity to deliver multiple (High Definition) HD video streams simultaneously and provide improvements over 802.11n.It can cover 33m propagation distance by using 80MHz on the 5GHz band, This new technology proposed by IEEE802.11-VHT ,aims at higher throughput of 1Gbps and with the frequency band of 6GHz or below excluding 2.4GHz frequency bandwidth of 80MHz and 160MHz option building on the 40MHz available in 802.11n.For spectrum efficiency, MU-MIMO technology is employed in this standard to achieve the aimed target throughput of 1Gbps.An obvious technical problem is envisaged in this technology. Due to its huge frequency bandwidth which will only allow four frequency channels , will lead to severe inter cell interference due to frequency channel shortage among multiple basic service sets .TGac and TGad were established in Sep 2008 and Dec 2008 respectively, targeting completion of standardization late in 2012 and The final approval of the IEEE802.11ac standard amendment is expected in December 2013, though as the moment, initial products with basic feature of 802.11ac has started to emerge on the market[7].

G. Comparison between the 802.11n and 802.11ac [7]:

Table 1: Features Comparison between 802.11n/802.11ac

Parameters	IEEE802.11n	IEEE802.11ac
Channel Widths	20, 40 MHz	20,40,80MHz, 106MHz optional
Frequency Band	2.4 and 5 GHz	5GHz only
Single Stream (1x1) Maximum Client Data Rate	150Mbps	450Mbps

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Three Stream (3x3) Maximum Client Data Rate	450Mbps	1.3Gbps
Spatial Streams	1 to 4	1 to 8 total up to 4 per client
Multi- User MIMO	No	Yes

III. MIMO MULTIPATH FADING CHANNELS SIMULATION FOR PSK

The simulation for MIMO Multipath Fading channels are based on 802.11n channel models by using MATLAB. Two transmit and two receive antennas are used for the simulation with Phase Shift Keying (PSK) Modulation technique by Varying different Modulation Order (M), the simulation also uses the bell Doppler spectrum objects. Here are the simulations results for the above discussed models for Modulation Order M=2

A. Simulation parameters:

Modulation Technique (hmodem) = PSK
Modulation Order (M) = 2
Input Symbol Rate (Rsym) = 10e3
Input Bit Rate (Rbit) = Rsym*log2(M)
Over Sampling factor (NOS) = 4
Input Sample Period = (1/Rbit)/NOS

B. Simulation Results:

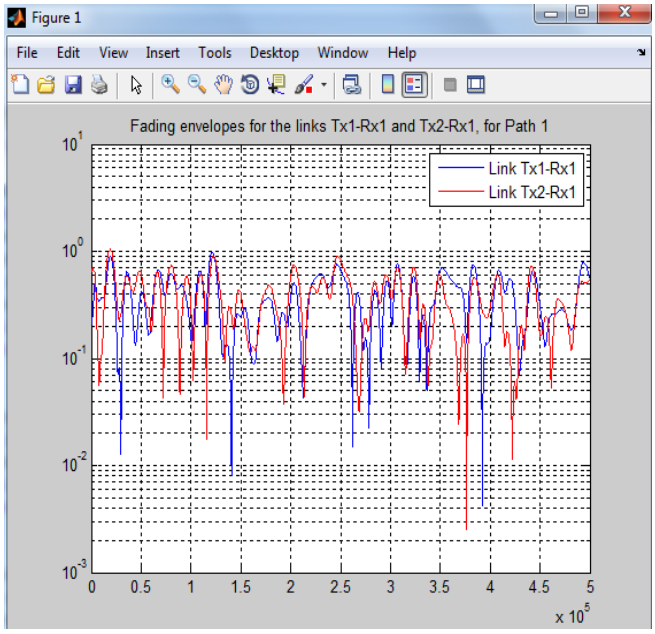

Figure 2: Fading Envelope for the links Tx1-Rx1 and Tx2-Rx1, for path 1

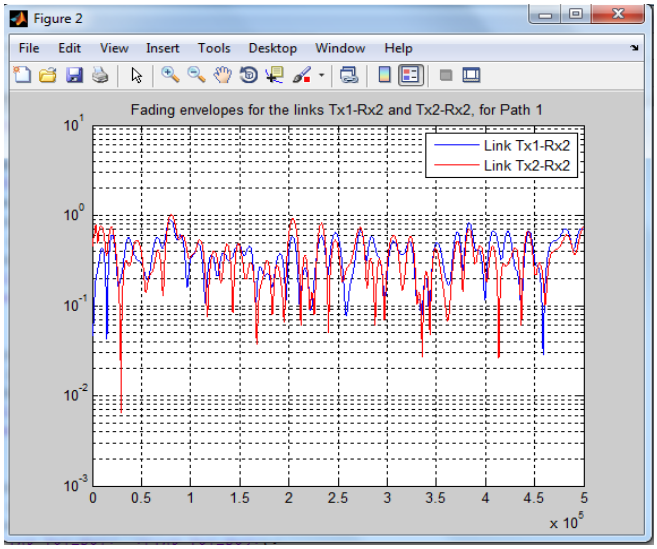

Figure 3: Fading Envelope for the links Tx1-Rx2 and Tx2-Rx2, for path 1

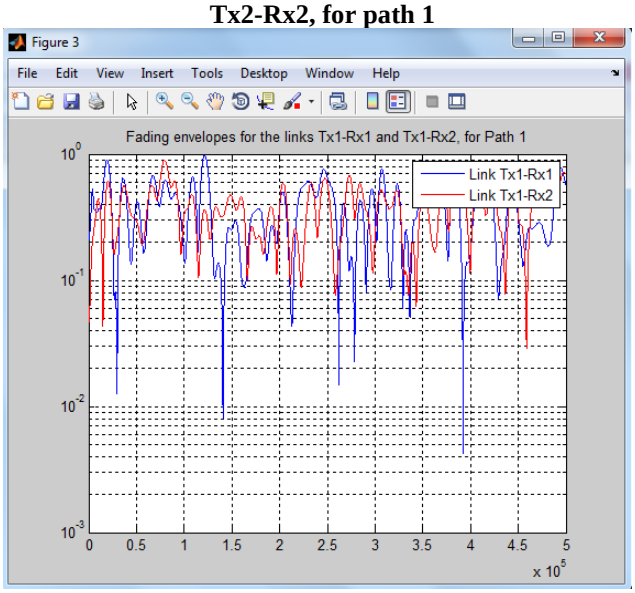

Figure 4: Fading Envelope for the links Tx1-Rx1 and Tx1-Rx2, for path 1

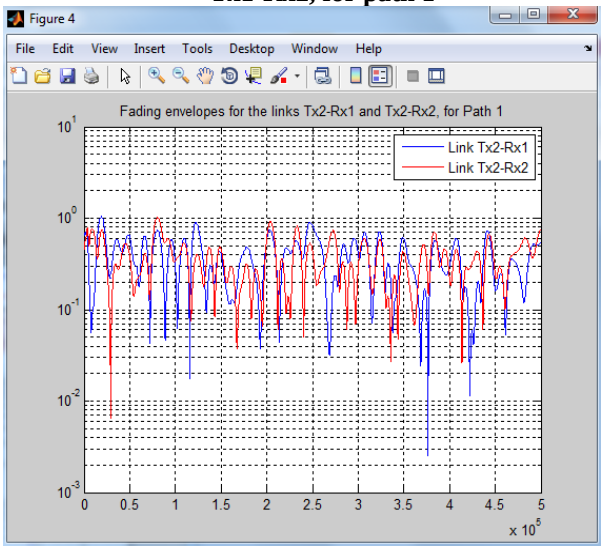

Figure 5: Fading Envelope for the links Tx2-Rx1 and Tx2-Rx2, for path 1

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IV. MIMO MULTIPATH FADING CHANNELS SIMULATION FOR QAM

MIMO Multipath Fading channels Simulation for QAM: Here I tried to simulate MIMO Multipath Fading channels are based on 802.11n channel models using QAM. Two transmit and two receive antennas are used for the simulation with Quadrature Amplitude Modulation (QAM) Modulation technique by Varying different Modulation Order (M), the simulation also uses the bell Doppler spectrum objects. Here are the simulations results for the above discussed models for Modulation Order M=64;

A. Simulation parameters:

Modulation Technique (hmodem) = QAM
Modulation Order(M) = 64
Input Symbol Rate (Rsym) = 10e3
Input Bit Rate (Rbit) = Rsym*log2(M)
Over Sampling factor (NOS) = 4
Input Sample Period = (1/Rbit)/NOS

B. Simulation Results:

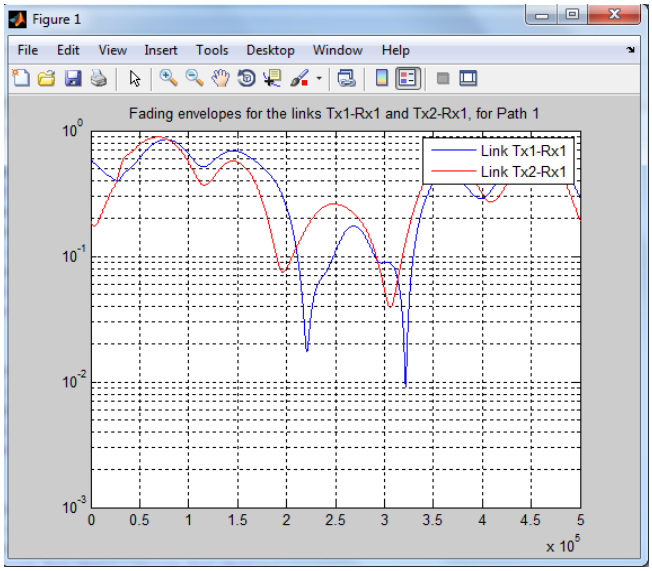

Figure 6: Fading Envelope for the links Tx1-Rx1 and Tx2-Rx1, for path 1

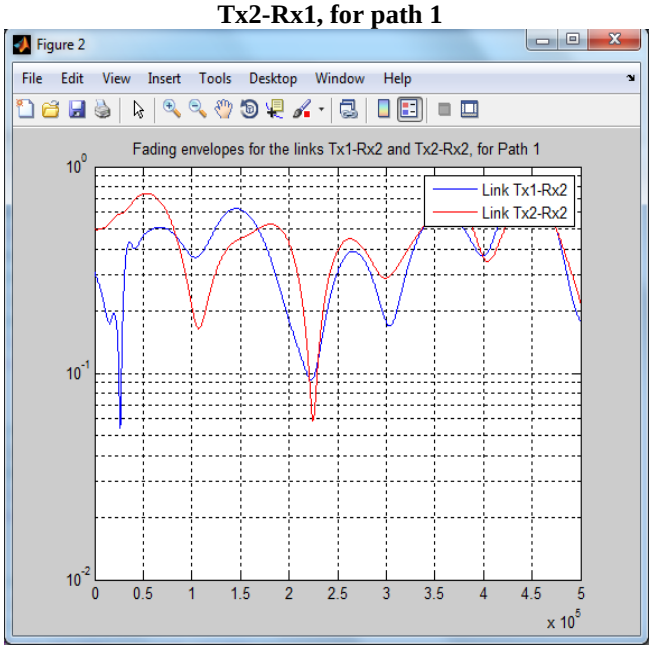

Figure 7: Fading Envelope for the links Tx1-Rx2 and Tx2-Rx2, for path 1

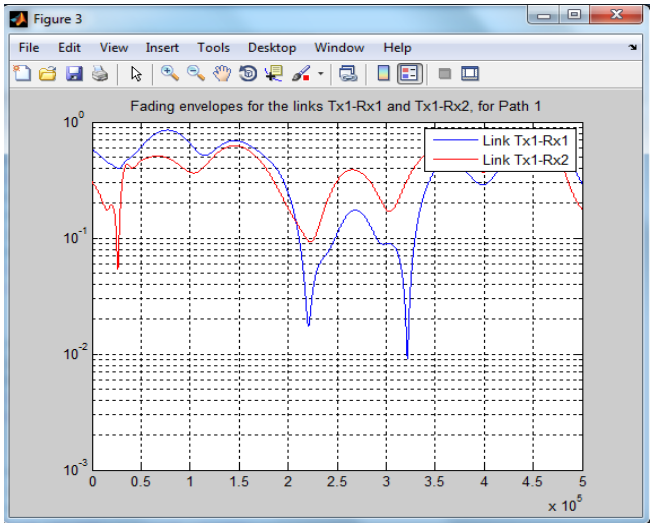

Figure 8: Fading Envelope for the links Tx1-Rx1 and Tx1-Rx2, for path 1

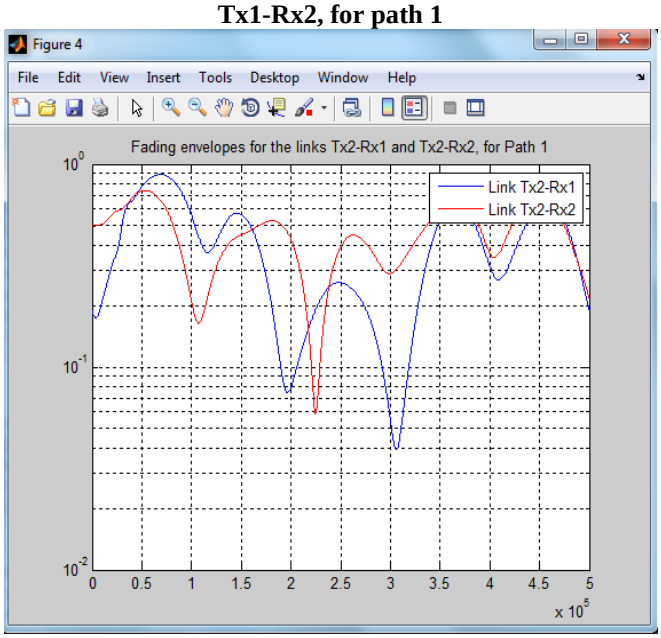

Figure 9: Fading Envelope for the links Tx2-Rx1 and Tx2-Rx2, for path 1

V. ADAPTIVE MIMO SYSTEM WITH OSTBC

This section illustrates an adaptive orthogonal space-time block code (OSTBC) transceiver system over a multiple-input multiple-output (MIMO) channel, the system uses a variable number of transmit and receive antennas. In any frame, the system operates with one; two, three or four transmit or receive antennas. MIMO system has already been discussed in the previous chapter, so let's have some brief idea about the OSTBC.

A. OSTBC

OSTBC[8][9] is orthogonal space-time block code , it is a multiple input multiple output (MIMO) wireless technique which allows multiple transmitting and receiving antenna to work simultaneously, basically it is a space-time block code with orthogonal codes that provide diversity in the multiple input and multiple output system[10].

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The basics functions performed in the orthogonal space-time coding are done with two main blocks of orthogonal space-time coding (OSTBC).

- ❖ OSTBC Encoder : Encode of the signal which is transmitted by the transmitter
- ❖ OSTBC Combiner : Combine the signal at the end of the receiver.

The OSTBC Encoder block encodes the information symbols from the QPSK Modulator by using either the Alamouti code for two transmit antennas or other generalized complex orthogonal codes [11] for three or four transmit antennas. The number of transmit antenna is given to this block as an input.

The OSTBC Combiner block combines the received input signal with the channel state information (CSI), the input signal, to output the estimates of the modulated symbols. The Frame Error Rate (FER) in MIMO system can be calculated by using Adaptive MIMO system with OSTBC Model corresponding signal to Noise Ratio (SNR). The discussed model is as follows:

B. Adaptive MIMO system with OSTBC Model

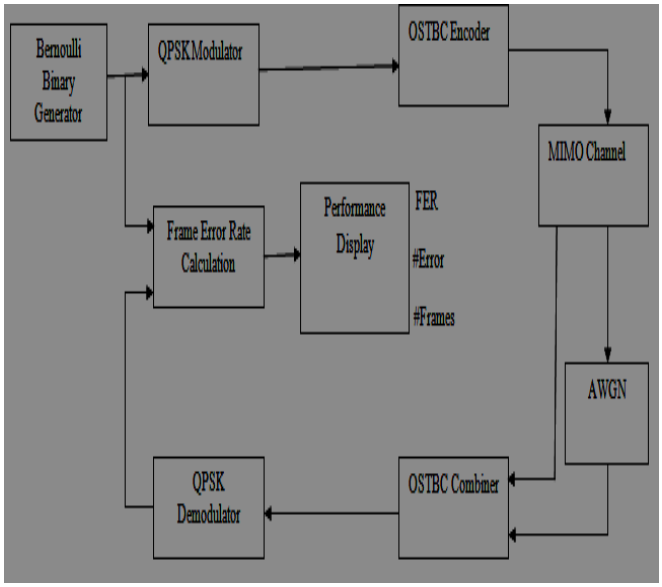

Figure 10: Adaptive MIMO system with OSTBC Model

Simulation graph: Simulations are done using Matlab software, the results for the calculation of frame Error Rate (FER) corresponding Signal to Noise Ratio (SNR) is checked in the simulink and then graph is plotted to show the effect of the same.

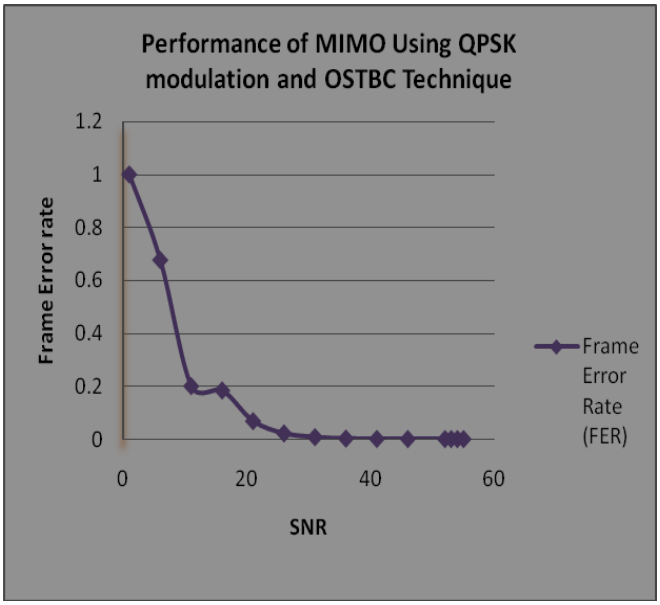

Figure 11: Frame Error Rate (FER) performance of QPSK modulation using OSTBC Technique

VI. CONCLUSION & FUTURE SCOPE

This paper is all about the specification of multiple input Multiple Output (MIMO) in Wireless Local Area Network (WLAN) and it shows the multipath fading effect on MIMO transmission using two different Modulation technique Phase shift keying (PSK) and Quadrature Amplitude Modulation (QAM) by changing its modulation order in the simulation results. On the other hand I also show the effect on Frame Error Rate (FER) in the MIMO system with Orthogonal Space Time Coding (OSTBC) corresponding Signal to noise ratio (SNR) where QPSK Modulation technique is used. In future, if we extend this work using different modulation technique in place of QPSK with OSTBC.

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