Performance Analysis of Different Modulation Schemes on Space Blocks Time Code (SBTC) For Multiple Antenna Systems.

Enaholo, E., Alli, K.S. & Akinola, S.O.
Department of Electrical/Electronics & Computer Engineering
Afe Babalola University
Ado-Ekiti, Nigeria
E-mail: alliks@abuad.edu.ng

ABSTRACT

Wireless networks are becoming part of everyday life. Wireless LANs, cell phone networks, and personal area networks are just a few examples of wireless networks widely used in our everyday lives. However, wireless devices are range and data rate limited. The research community has spent a great deal of effort on finding ways to overcome these limitations. One method is to use Multiple-Input Multiple-Output (MIMO) links. The multiple antennas allow MIMO systems to perform precoding (multi-layer beamforming), diversity coding (space-time coding), and spatial multiplexing. For the simulations, Simulink in MATLAB is used to show the simulation of two transmit antenna and one receive antenna. The Results and analysis for computing the Bit error rate (BER) for Binary Shift Keying (BSK) modulation in a Rayleigh fading channel with Alamouti space time block coding with two transmit and one receive antenna are shown. The constellation diagrams for various modulation techniques including Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK) 16 and 64 Quadrature Amplitude Modulations (QAM) are described. The result of the simulation shows that using multiple antennas during transmission reduces bit error rate when compared to single antenna systems.

Keywords: MIMO, Wireless, Modulation, Constellation, Simulation

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1. INTRODUCTION

There have been emerging demands for high data rate services and high spectral efficiency which are the key driving forces for the continued technology evolution in wireless communication. The adoption of smart antenna techniques and MIMO systems in future wireless systems are said to have a high impact on the efficient use of the spectrum, the reduction of the cost of establishing new wireless networks, on the optimization of the service quality provided by wireless networks and the realization of transparent operation across multi-technology wireless networks. This technology uses a number of antennas to send multiple signals as a way to significantly increase the speed and range of a wireless network. Multiple-Input / Multiple Output (MIMO) technology has emerged in the last decade as a powerful means of increasing the throughput and performance of wireless communication systems. Research on this technology has penetrated many fields, ranging from signal processing to information / communication theory to wireless propagation. MIMO technology has made its way into current and next generation communication standards and systems. The study of "realization of different diversity technique for MIMO based mobile ad hoc network using space time block codes" in [1]. Space time block codes are used to demonstrate different diversity technique for MIMO based mobile ad hoc network to display the superiority in performance quality of MIMO over single-antenna routing schemes, especially at high Signal to Noise Ratio (SNR). A study has been conducted on "Performance Comparison of MIMO Systems over Additive White Gaussian White Gaussian Noise (AWGN) and Rician channels with Zero Forcing Receivers" presented in [2]. In the paper, analyses were carried out on the performance of MIMO system over AWGN and Rician fading channels with Zero- Forcing (ZF) receiver using different antenna configurations. Also, a study was conducted on the bit error rate performance characteristics of Zero- Forcing (ZF) receiver for M-PSK (M-ary Phase Shift Keying) modulation technique using AWGN and Rician channels for the analysis purpose and their effect on BER (Bit Error Rate).

The "Performance Evaluation of Multiple Antenna Systems with Diversity Techniques Using Ber Analysis" has been investigated in [3]. The paper has examined the efficiency of multiple-antenna systems in signal interference mitigation. Wireless communication is constituted by multipath propagation resulting to signal degradation. The research introduced MATLAB Toolbox version 7.0 at R.F Processing to perform BER Raleigh fading environment for the various antenna systems including Single-Input Single-Output (SISO) is used for performance simulation specifically for reference purpose. The use of Zero-Forcing (ZF) Equalizer at the receiver is incorporated in the model.

Performance evaluation was carried out at receiver BER Threshold of 10^{-3} and 10^{-4}. Analysis were performed on the diversity methods employed by the multiple antennas by comparing their E_b/N_o (Energy per bit to noise power spectral density ratio). Multiple-Input Single-Output (MISO) with Transmit diversity technique was presented to have 3_ diversity gain over receive diversity approach resulting to a more robust transmission method.

Exploration of MIMO Systems with a Space-Diversity Technique for Combating Signal Fading in Radio Propagation has been conducted by [3]. The paper has presented a diversity technique in creating solution to the problem of signal fading and poor reception of radio signals. The previous studies results presented in the literature have space diversity as a powerful tool for solving signal fading in a radio broadcast station whose studio and transmitting stations are located in a various geographical location, by linking multiple antennas at both the transmit and the receive ends. The relationship between antenna heights and coverage distance in line of sight transmission was verified and exploited using MATLAB. The presented results were in total agreement with the attenuation square law which states that signal strength is inversely proportional to distance.

[4] has reported the "MIMO-Future Wireless Communication". The overview of new technology Multi-Input-Multi-Output (MIMO)-the Future Wireless system has been addressed in the paper which will be much more effective to meet the higher demand of Wireless communication in offered limited frequency resources. The channel of MIMO is frequency selective (multipath) and is recognized to boost channel capacity for high-data rate transmissions, low power operation, suitable signal processing algorithm. The FPGA based coding methods will reduce the size, complexity and improve the reliability of connectivity. "FPGA Based Design & Implementation of Alamouti MIMO Encoder for Wireless Transmitter" has been presented in [5]. The design and implementation of Alamouti Transmit Diversity Scheme using Field Programmable Gate Array (FPGA) for MIMO wireless communication transmitter has been addressed in the paper. The duty of the FPGA based MIMO Encoder is to process two digital signals (S1 & S1) having real (q) and imaginary (i) parts, are being transmitted using two transmitting antennas by making use of Alamouti transmitting scheme in Very High Descriptive Language (VHDL). The results reported used the FPGA devices of the Xilinx family. The effectiveness is examined for optimized device resource utilization, data link for two symbol period. The specific function of MIMO Encoder/transmitter is to handle the traffic of multi user through multiple channels, to make sure the quality signals at the receiver even in failure of any channel. "BER analysis of MIMO-OFDM system in different fading channel" has been presented in [6]. The Bit Error Rate (BER) analysis of BPSK signal in MIMO and Multiple Input Multiple Output Orthogonal Frequency Division multiplexing system (MIMO-OFDM) is discussed in the paper. MATLAB SIMULINK is used to perform BER analysis whereby various fading channel is examined. To achieve full diversity, MIMO System is considered using Orthogonal Space-Time Block Code (OSTBC) encoder, to overcome fading effect of channel. The ISI can be deduced with higher data rate and higher spectral efficiency by using OFDM.

"A Wideband H Shape Dielectric Resonator Antenna for Wireless MIMO Systems" has been developed by [7]. The paper presents the design of a wideband H- shaped Dielectric Resonator Antenna (DRA) used for wireless MIMO systems. The proposed antenna propagates at a dual band of 6.26 GHz and 15.2 GHz at a given impedance bandwidth of 119%. A 2×2 MIMO system is developed by using the proposed antenna propagating at a dual band of 6.35 GHz and 15.53 GHz with an impedance bandwidth of 119% and a mutual coupling of -21dB and -25 dB at the operating frequencies. The developed antenna system is widely used for the 4G and WiMAX applications.

[8] has presented an approach in performing simulation and effectiveness analysis of blast structure in MIMO environment called MIMO-VBLAST technique to provide array gain that is high data rate for modern wireless scenario. "Capacity Evaluation of a High Altitude Platform Diversity System Equipped with Compact MIMO Antennas" has been presented in [9]. In the paper, the potential gain of using compact MIMO antenna array configurations in conjunction with High Altitude Platforms (HAPs) diversity techniques in order to increase the capacity in HAP communication systems has been addressed. For this reason, a novel compact MIMO antenna which is denoted as the "MIMO Octahedron" and compares its performance with the vector element antenna was as well proposed. The presented simulation results show that the MIMO-Octahedron antenna achieves superior performance to the vector element antenna and the single HAP case. "WIMAX Performance Evaluation: OFDM (MIMO) Antenna for Base Station Applications with Space Diversity" has been reported in [10].

A new approach in the design of WIMAX base station antenna compatible with Space Diversity to examine multiple input multiple output (MIMO) antenna for base station applications was presented in the paper. MATLAB simulation was employed to measure transmitted, received and loosed signal in the work. The details of the theory and methods were also presented. The design modeling of the system is achieved for WIMAX IEEE 802.16 transceiver in MATLAB SIMULINK and the performances are examined using software MATLAB. A geometry based model which involves the propagation effects that are critical for MIMO performance has been proposed in [11]. In the paper, single scattering around the Base Station (BS) and Mobile Station (MS), scattering by far clusters, double-scattering, wave guiding, and diffraction by roof edges were presented. The details of the involved parameters for the complete definition of the model and typical parameter values in macro and microcellular environments are analyzed.

[12] has presented a new class approach called cooperative communication which allows single antenna mobiles in a multi-user environment to share their antennas and generate a virtual multiple- antenna transmitter that enables them to achieve transmit diversity. The overview of the developments in this burgeoning field is presented in this paper. Effective space-time codes have been reported in [13] that uses a large portion of the available capacity. In the work, the case of the partial transmission, but not perfect, information about the channel and how to enhance a predetermined code has been considered so that this fact is taken into consideration. A derived working criterion is performed for a frequency-nonselective fading channel and then used to optimize a linear transformation of the scheduled code. The optimization problem resulted into convex and can thus be efficiently solved using standard methods. In addition, a particularly efficient solution method is developed for the special case of independently fading channel coefficients. The proposed transmission scheme combines the benefits of conventional beam forming with those given by orthogonal space-time block coding. The simulation analyses presented for a narrow-band system with multiple transmit antennas and one or more receive antennas show significant gains over conventional approaches in a scenario with non-perfect channel knowledge.

A multiple-input multiple-output OFDM wireless communication system, lab test results, and field test results obtained in San Jose, California has been reported in [14]. The MIMO system field tests were to establish the performance of MIMO communication systems. In the paper, increased size, coverage, and reliability are clearly evident from the test results. A space-time coded (STC) orthogonal frequency-division multiplexing (OFDM) system in frequency-selective fading channels was presented in [15]. The analyses of the pairwise error probability (PEP) show that STC-OFDM systems can likely give a diversity order as the product of the number of transmitter antennas, the number of receiver antennas and the frequency selectivity order. Also, the large efficient length and the ideal interleaving are two most important principles in designing STCs for OFDM systems. “An adaptive space time transmit diversity scheme with simple feedback” has been proposed in [19] for the future generation wireless communication systems. This new diversity scheme can efficiently exploit the diversity potential provided by multiple antenna arrays without introducing interference among the signals transmitted at different antennas by combining orthogonal space time block codes with adaptive sub-group antenna encoding technique. A new quadrant phase constraining method is introduced to formulate the feedback information so as to reduce the amount of feedback information as well as the computational complexity.

> “A simple two-branch transmit diversity scheme” has been reported in [20]. In the work, two transmit antennas and one receive antenna scheme were used to provide the same diversity order as maximal-ratio receiver combining (MRRC) with one transmit antenna, and two receive antennas. It was also reported that the scheme may easily be generalized to two transmit antennas and M receive antennas to provide a diversity order of 2M.

However, in a wireless communication system, sending and receiving messages simultaneously on the same channel node have been a serious challenge due to strong self-interference that exists in it and also noise cancellation are limited in analogue system. This paper has addressed the perform analysis of different modulation scheme using SBTC (Space Block Time Code). It also shows the results for computing the Bit error rate (BER) for different binary shift keying (BSK) modulation including Binary phase shift keying (BPSK), Quadrature phase shift keying (QPSK),16 and 64 Quadrature amplitude modulation baseband. showing the best modulation schemes in signal transmission, and also showing the different constellation diagrams for the different modulation techniques.

2. SIMULATION AND DESIGN

Space-time block coding (STBC) is a transmission method where the number of the transmitted code symbols per time slot is equal to the number of transmit antennas. These codes are a generalized version of Alamouti scheme, but have the same key features. The Alamouti code, remarkable for having an elegant linear receiver, is now a paradigm in space-time block coding. Space-Time Codes (STBCs) have been implemented in cellular communications as well as in wireless local area networks (WLAN). This coding technique is performed in both spatial and temporal domains by introducing redundancy between signals transmitted from various antennas at various time intervals. It can achieve transmit diversity and antenna gain over spatially encoded systems without sacrificing bandwidth. The research on STBC focuses on improving the system performance by employing extra transmits antennas. In general, the design of STBC amounts to finding transmits matrices that satisfy certain optimality criteria. STBC achieves a transmit diversity gain and can work with one receive antenna, often with simple processing and combining techniques. There are other various coding methods as space-time trellis codes (STTC), space-time block codes (STBC), space-time turbo trellis codes and layered space-time (LST) codes but here the space time block coding will be employed. Fig. 1 and 2 illustrate the system block diagram and different forms of antenna systems respectively.

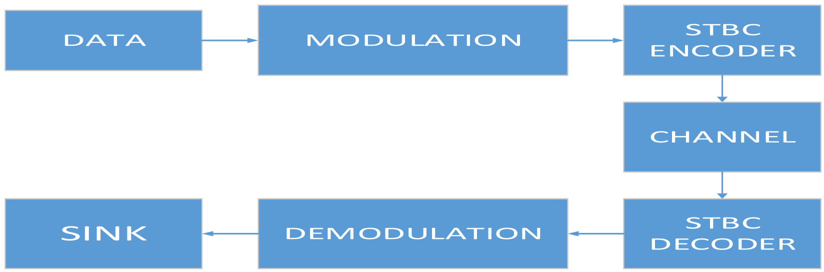

Fig. 1: System Block Diagram

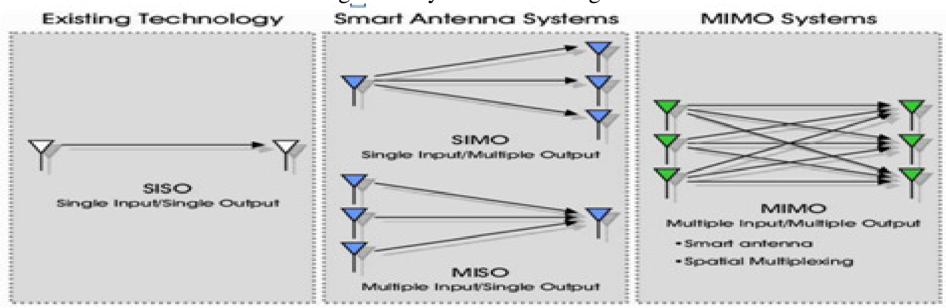

Fig. 2: Forms of MIMO Antenna Systems

2.1 Modulation Schemes Binary Phase Shift Keying:

This is also known as phase reversal keying (PRK), or 2PSK is the simplest form of phase shift keying (PSK). It uses two phases which are separated by 180°. It does not particularly matter exactly where the constellation points are positioned. This modulation is the most robust of all the PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision. It is however, only able to modulate at 1 bit/symbol and so is unsuitable for high data-rate applications.

In the presence of an arbitrary phase-shift introduced by the communications channel, the demodulator is unable to tell which constellation point is which. As a result, the data is often differentially encoded prior to modulation. BPSK is functionally equivalent to 2-QAM modulation.

Quadrature Phase Shift Keying: This is known as quadriphase PSK, 4-PSK, or 4-QAM. The root concepts of QPSK and 4-QAM are different but the resulting modulated radio waves are exactly the same. QPSK uses four points on the constellation diagram, equispaced around a circle. With four phases, QPSK can encode two bits per symbol.

QPSK can be used either to double the data rate compared with a BPSK system while maintaining the same bandwidth of the signal, or to maintain the data-rate of BPSK but halving the bandwidth needed. The BER of QPSK is exactly the same as the BER of BPSK and deciding differently is a common confusion when considering or describing QPSK.

The advantage of QPSK over BPSK becomes evident: QPSK transmits twice the data rate in a given bandwidth compared to BPSK - at the same BER.

Quadrature Amplitude Modulation: This is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components. QAM is used extensively as a modulation scheme for digital telecommunication systems. A variety of forms of QAM are available and some of the more common forms include 16 QAM, 32 QAM, 64 QAM, 128 QAM, and 256 QAM.

Table 1: The summary of the bits rates of different forms of QAM and PSK

MODULATION	BITS PER SYMBOL	SYMBOL RATE
BPSK	1	1*bit rate
QPSK	2	½ bit rate
16QAM	4	¼ bit rate
32QAM	5	1/5 bit rate
64QAM	6	1/6 bit rate

2.2 Simulations in MATLAB
Simulations were carried out in MATLAB to show the various modulations technique.

For BPSK, the simulation was carried out in Simulink using three transmitters and two receivers as the OSTBC combiner and Binary Bernoulli modulation was used as well as BPSK modulation band.

The E_b/N_o (dB) was varied from 0 to 20. This was done in other to determine the various variations of signal and find out the signal with the lowest frequency bandgap. The E_b/N_o (dB) (dB) is varied by double clicking on the All White Gaussian Noise (AWGN). This will display a block shown below where the E_b/N_o (dB) (dB) is varied and run.

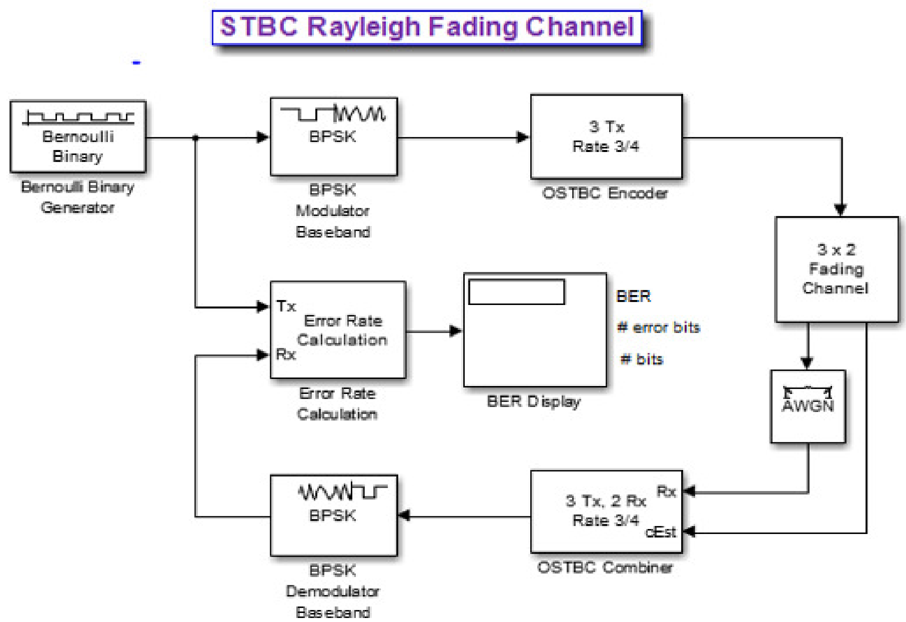

Fig. 3: Simulation of BPSK Modulator Baseband

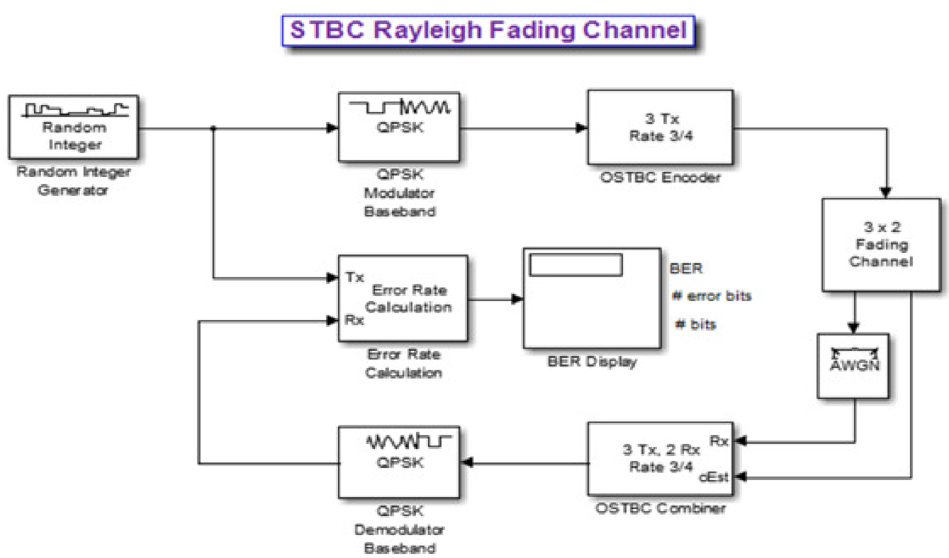

Fig. 4: QPSK Modulation Scheme

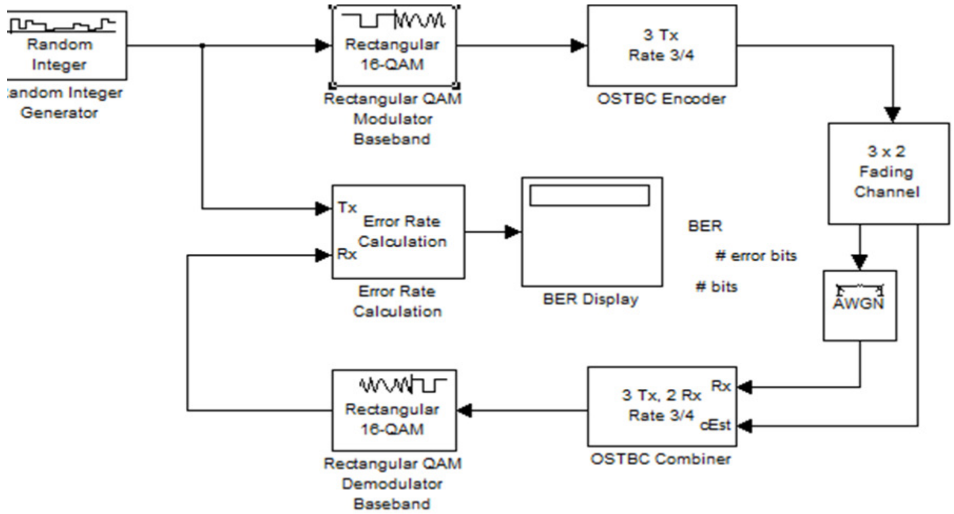

Fig. 5: Simulation for Rectangular 16 QAM

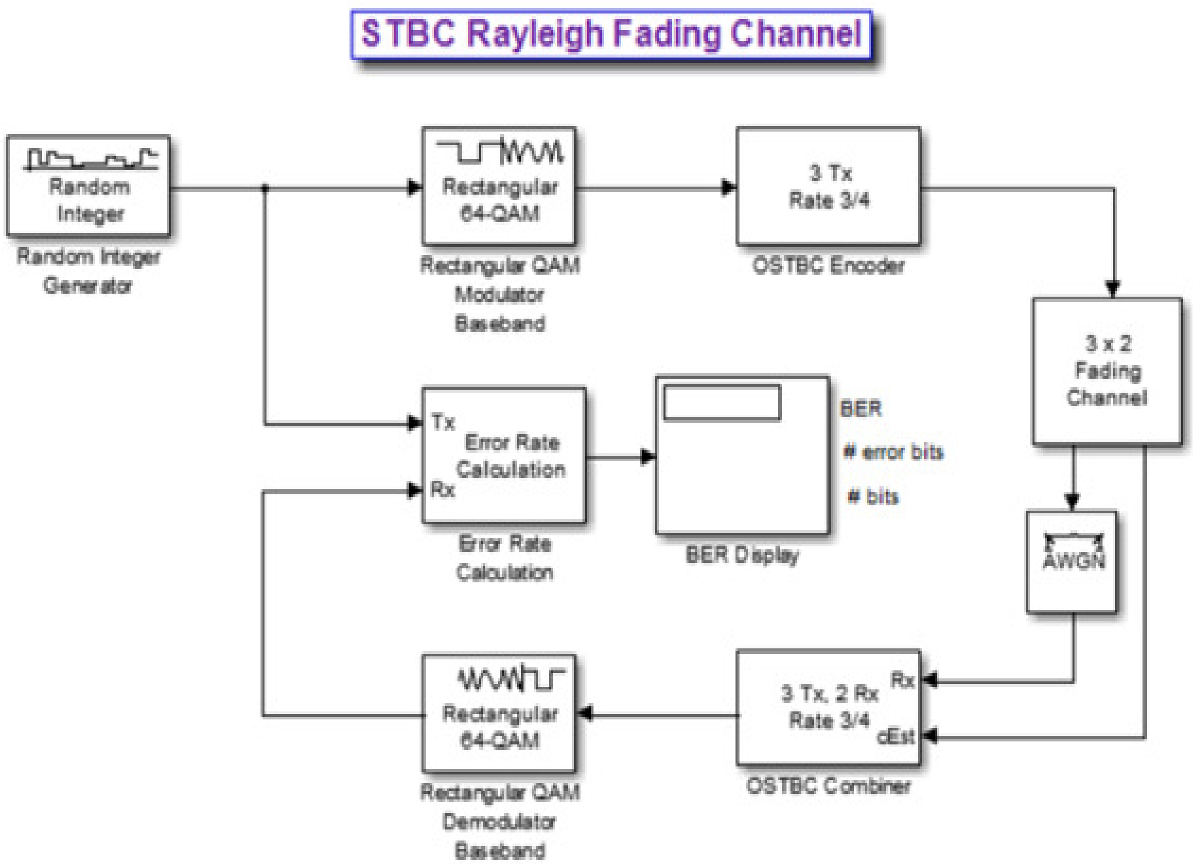

Fig. 6: Simulations for Rectangular 64 QAM

3. RESULTS AND ANALYSIS

Simulation results are presented to evaluate the performance of system with two transmit antennas and one receive antenna. The performance of the system is analyzed with various low SNR values ranging from 0 dB to 20 dB. Keeping all other variables the same, the result obtained for QPSK and BPSK are nearly identical. As expected, for each different code blocks, the performance degrades as more bits per symbol are transmitted.

Table 2: Showing the Relationship of Signal Noise Ratio (SNR) To Bit Error Rate (BER) In a Wireless Link

Signal noise ratio(SNR)	Bit error rate(BER)
0	0.01773
1	0.01191
2	0.008589
3	0.003426
4	0.00178
5	0.006782
6	0.0003371
7	0.0001581
8	$6.7e^{-05}$
9	$2.1e^{-06}$
10	$9e^{-06}$
11	$2.1e^{-05}$
12	$1e^{-06}$
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0

However, Fig.8 shows the various curves in the Alamouti Space time block code. The black curve shows an ideal curve for transmission using one transmit and two receive antenna which is the best for transmission. The red curve shows the simulated curve for two transmit and one receive antenna based on Alamouti scheme. The blue curve shows the transmission using one antenna at both the transmitter and the receiver. This shows that using multiple antennas during transmission reduces code error rate and improves the strength of the signals.

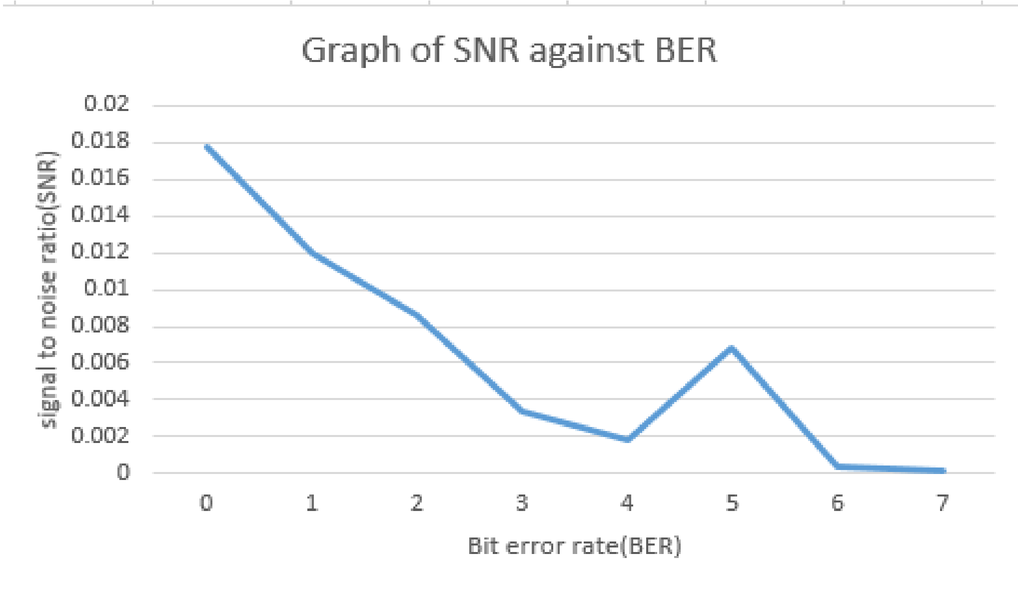

Fig. 7: Graph of SNR to BER

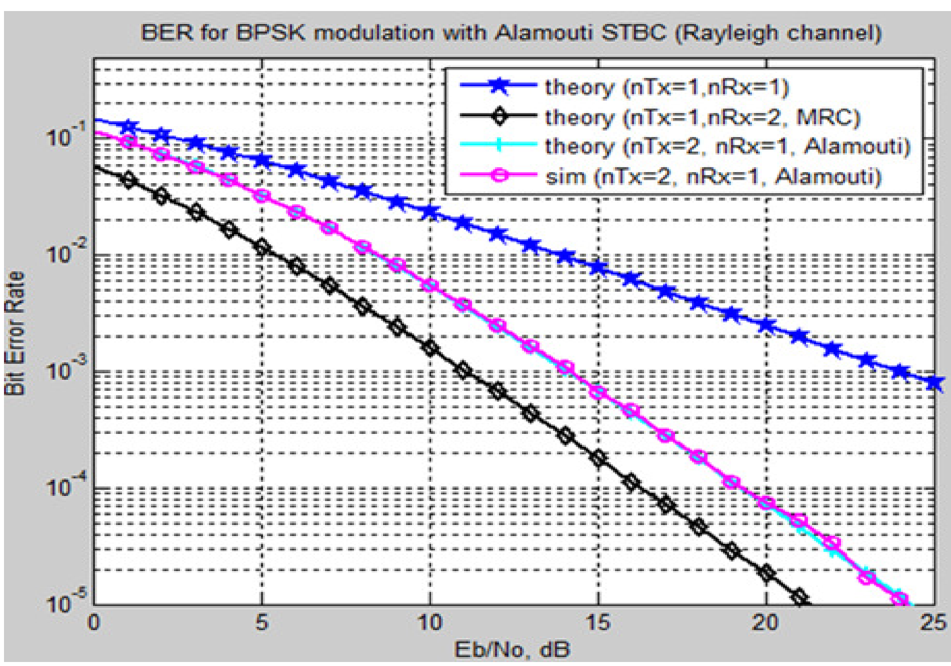

Fig. 8: Bit error rate (BER) modulation with Alamouti STBC (Rayleigh channel)

4. CONSTELLATION

A constellation diagram is a representation of a signal modulated by a digital modulation scheme such as quadrature amplitude modulation or phase – shift keying. It displays the signal as a two- dimensional scatter diagram in the complex plane at symbol sampling instants. It represents the possible symbols that may be selected by the given modulation scheme as the points in the complex plane. This helps to recognize the type of interference and distortion in a signal. Plotting several symbols in a scatter diagram produces the constellation diagram. The points on a constellation diagram are called constellation points. There are set of modulation symbols which comprise the modulation alphabet. As the order of the modulation increases, so does the number of points on the constellation diagram.

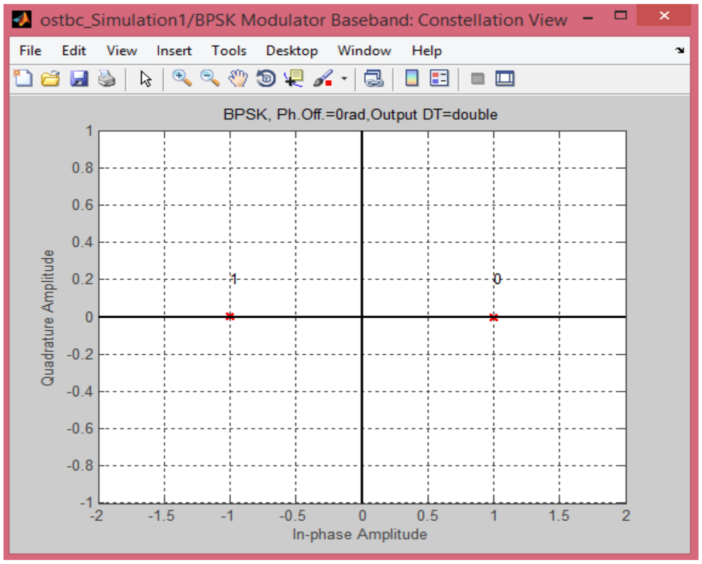

Fig. 9: Constellation view of OSTBC simulation BPSK modulator baseband

From the constellation diagram in Fig. 9 above, the signals are far apart so the interference and distortion is very low. BPSKs is the best modulation scheme since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision.

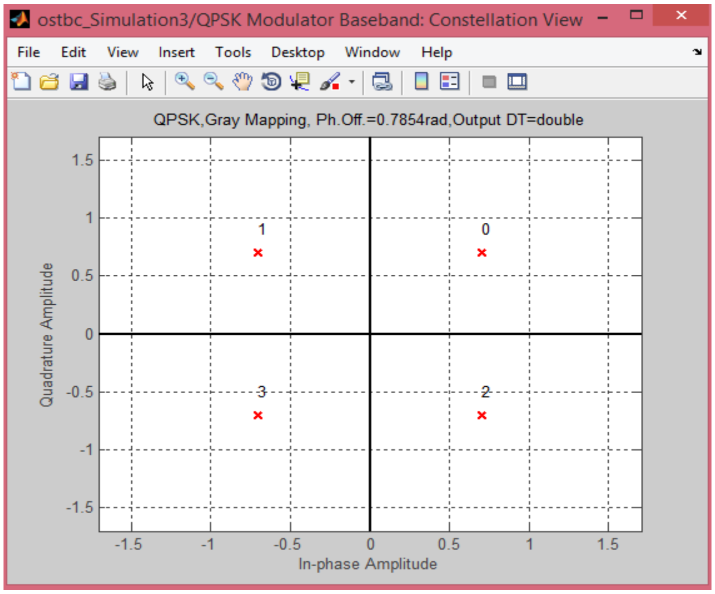

Fig. 10: Constellation view: OSTB simulation/BPSK modulator baseband

Here, there are four signals but the interference and distortion of signal is minimal presented in Fig. 10. The distortion is high when compared to the constellation diagram of BPSK modulator.

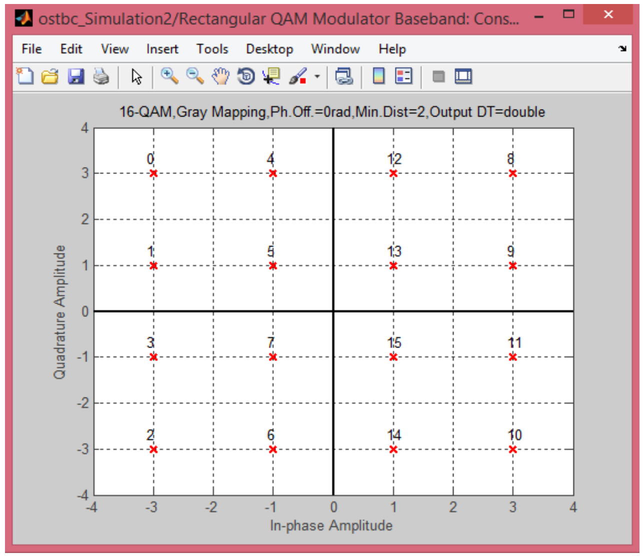

Fig. 11: Constellation view: OSTBC simulation/ Rectangular Modulator baseband

From the constellation diagram in Fig. 11, there are 16 signals. There will be distortion and interference signal when compared to the constellation diagram of QPSK modulator baseband.

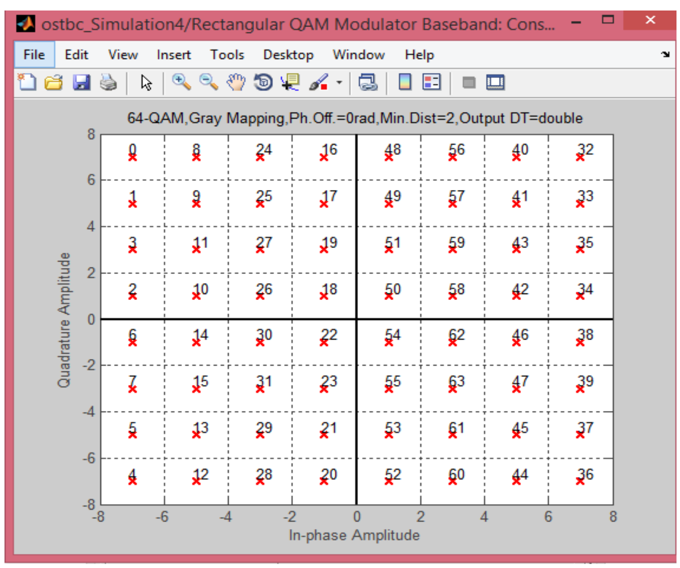

Fig. 12: Constellation view of rectangular 64 QAM modulator.

In Fig. 12, the signals have the highest signal interference and distortion as the signals are closed to one another. This is the baseband with the highest distortion.

5. CONCLUSION

This paper presents a basic overview of MIMO systems and basic introduction to Space- Block Time Coding technique was also presented in this report showing several performance analysis of different modulation scheme on STBC with results for computing the Bit error ratio (BER) for BSK modulation in a Rayleigh fading channel with Alamouti space time block coding for two transmit antenna one receive antenna. The Alamouti scheme has been simulated for BPSK modulation in Rayleigh channel. From the results and analysis, it is clear that employing multiple inputs multiple outputs (MIMO) is more efficient than single antennas as the bit error rate is greatly minimized when employing multiple antennas at both the transmitter and the receiver.

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