Space Time Block Coding Application for MIMO OFDM Broadband Wireless Solutions

Rajat Gupta, Vikas Soni
Electronics and Communication Engineering,
MIT, Kota, India
Rajat4747@gmail.com, vikassonieck@gmail.com

ABSTRACT:

Multiple transmit antennas employ space–time block coding usingdata transfer in fading networks. Data is broken down into 'n' streams of continuously broadcast strings over n transmit antennas after being encoded using a space–time block code. The receiving signal is a combination of the n broadcasts signals that have been corrupted by noise at the receiver end. Instead using joint detection, the probabilistic decoding approach is used to recover data via decoupling of signals delivered from various antennas. The maximum likelihood decoding system uses the space–time block code's (OSTBC) orthogonal structure to provide a maximum-likelihood decoding algorithm dependent on linear computation at receiver. In this research, a Matlab/Simulink model built on orthogonal space–time block codes is constructed to acquire highest dimension of variability for a specific number of broadcastsas well as receive antennas utilizing a simple decoding technique. With as well as without grey coding, the orthogonal space coding block containing space–time block coding is utilized in Simulink block. The OSTBC algorithms calculate the highest achievable transmission rate for every amount of transmit antennas in any constellations, including an M-PSK array. M- PSK space–time block codes are used for different complex constellations to achieve 1/2 as well as 3/4 of highest allowable transmission rate for MIMO transmit antennas utilizing multiple various constellations.

Keywords: Multipath channels, transmit diversity, multiple input multiple output, Wireless communication and OSTBC.

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1. Introduction

Fading in multipath wireless systems makes it difficult for reception antenna to distinguish transmitted signal unless receiver is set up with a few sort of variety that has a less-faded duplicate of signal broadcast by the transmitting ends antenna. Various uses exist now, Most common practical ways to achieve diversity is to double the number of antennas at transmitter as well as maybe likewise at the receiver. However, there is a desire for receivers to be modest in size. As a result of this issue, several detecting sides' antennas at the mobile remote location may not be viable. This supports thinking about transmit side diversity first.

In wireless fading systems, transmit diversity is used to eliminate data mistakes [2]. Because of its simplicity of construction as well as the durability of many antennas at the ground station, it is quite popular. Multiple transmit links at base can be implemented above many users in terms of price. [10] Space–time trellis coding is a revolutionary coding strategy which integrates signal analysis at receiver using various transmits antenna coding algorithms. In slow-fading situations (usual of interior transmission), certain space–time trellis codes proposed for 2–4 transmit antennas work exceedingly well and approach near to outage capability estimated by Telatar [3] as well as separately by Foschini and Gans [4]. Decoding difficulty of space–time trellis codes (assessed in respect of decoder trellis levels) rises exponentially with transmission rate whenever number of transmit antennas is constant. In the context of decoding complexities, a surprising technique for transmission employing only two transmit antennas has recently been developed. For two transmit antennas, this approach is simpler than space–time trellis coding, however there is a capacity penalty when compared to space–time trellis codes. Notwithstanding this loss of capacity, Alamouti's method [1] is widely used owing to its simplicity and effectiveness, as well as it has inspired scholars throughout the world to develop similar programs depending on over two transmit antennas or the equivalent.

2. OFDMA:

The Orthogonal Frequency Division Multiplexing (OFDM) system was designed to enable large data rates with multiple carrier signals. Its unique feature is that it may reduce Inter Symbol Interference (ISI) significantly more than additional multiplexing techniques. Improved Frequency Division Multiplexing (FDM) is more likely because FDM has a guard band to reduce interference among various frequencies that consumes a higher bandwidth, whereas OFDM does not have an inter-carrier guard band as well as may manage interference more effectively than FDM. As a result, this is an excellent solution for WiMAX since it can assist meet the goals of effective spectrum use and low transmission costs. Furthermore, OFDM compensates for multipath effects by transforming serial data into multiple parallel data streams utilizing the Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT).

2.1 OFDM Based Communication:

Because OFDM uses multicarrier modulation, data transfer is sufficient when compared to FDM. OFDM accomplishes this by dividing high data bits to low data bits as well as sending each sub-stream in many concurrent sub-channels, referred to as OFDM subcarriers. These subcarriers are opposite each other, and every subcarrier has a substantially smaller bandwidth than entire bandwidth. Inter Symbol Interference is decreased with the OFDM technology because every sub-symbol channel's time Ts is greater than just the channel delay dispersion.

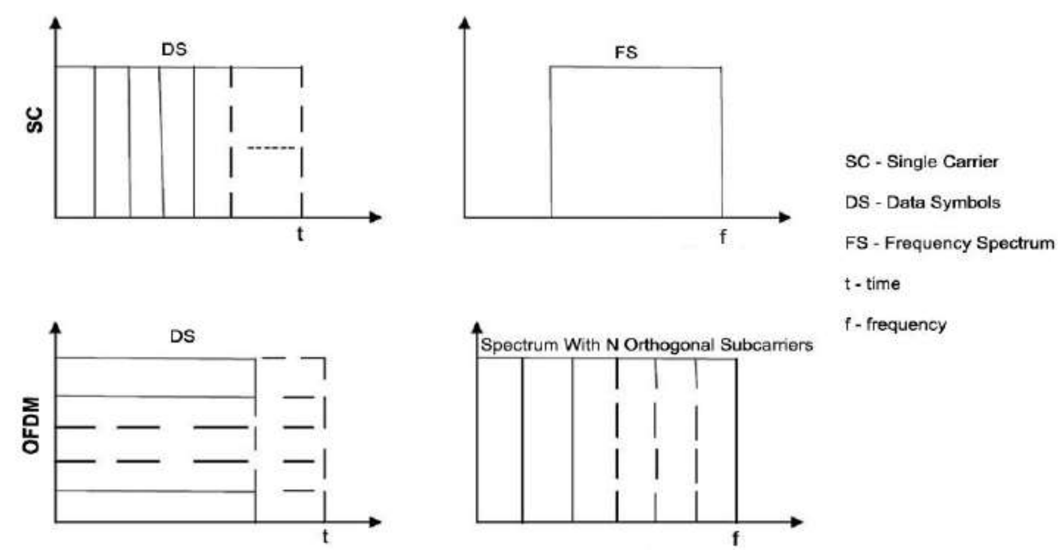

Fig 1: Time as well as Frequency diagram of single and Multi-carrier signals [7].

In the fig 1 OFDM clearly defies the multipath effects by using a lower frequency bandwidth as well as a longer period of time, resulting in higher spectral efficiency.

2.2 OFDM Architecture and Working:

Two variants of WiMAX have distinct implementations of the OFDM physical layer. The FFT size for OFDM-PHY is set at 256 bits for stationary WiMAX, whereas it can be 128, 512, 1024, as well as 2048 bits for mobile WiMAX [1]. This aids in the reduction of ISI as well as Doppler spread. Another distinction among OFDM-PHY with OFDMA-PHY is that OFDM separates an unique data stream with a large bit rate stream into numerous low bit rate data sub-streams in parallel, each of that is modulated utilizing IFFT, although OFDMA receives multiple users' data and multiplexes it into a downlink sub-channel. The uplink sub-channel provides several uplink accesses. The parameters of OFDM-PHY as well as OFDMA-PHY are briefly addressed in the next sections.

Physical Layer of OFDM:

In this case, the FFT size is set at 256 bits, with 192 data subcarriers, 8 pilot subcarriers for synchronization, estimate of channels, as well as 56 null subcarriers [23]. Fixed WiMAX channel bandwidth is 3.5 MHz, however it changes depending to subcarrier space. Subcarrier spacing increases as bandwidth increases, reducing symbol time and increasing delay range. OFDM-PHY assigns a considerable portion of guard space to minimize delay dispersion. The ideal symbol time for OFDM-PHY is 64 seconds, the symbol length is 72 seconds, as well as the guard time space is 15.625 kHz [23].

Physical Layer of OFDMA:

The FFT size in mobile WiMAX can vary within 128 to 2048, as well as the FFT length must be set to preserve the subcarrier spacing at 10.94 KHz, that helps to limit Doppler spreads. Because several channel bandwidths exist, such as 1.25, 5,10, plus 20 MHz, FFT sizes are 128, 512, 1024, as well as 2048. The appropriate symbol time for OFDMA-PHY is 91.4 seconds, duration of the symbol is 102.9 seconds, as well as the symbol length in 5 ms frames is 48.0 [23]..

2.3 Widening of Coverage Area:

WiMAXorganizes the existing subcarriers into groups and assigns them to various users based on channel circumstances and user requirements. Sub-channelization is the term for this technique. Sub-channeling divides the transmit power across smaller groups of subcarriers to boost system gain and extend coverage area while reducing absorption losses caused by buildings as well as other impediments. The connection budget would be unbalanced without sub-channelization; therefore bandwidth monitoring might be poor [7]. On just the uplink, fixed WiMAX-depending OFDM-PHY allows for a small extent of sub-channelization. Transmission can take occur in one, two, four, eight, or all of the 16 conventional sub-channels of the SS's uplink. SS adjustsamount of transferred power according on the available sub-channels. The transmission power level increases when the number of allowed sub-channels for uplink users grows, and it drops when the number of allotted sub-channels declines. The maximum level of transmitted power is never exceeded. Uplink sub-channelization allows the SS to transmit just a portion of bandwidth allotted by the BS in constant WiMAX to enhance link budget as well as the performance of the SS battery [24].

OFDMA-PHY in mobile WiMAX allows sub-channelization including both uplink as well as downlink channels. Analysis of multiple access approach, the BS assigns the minimum frequency as well as sub-channels to distinct users. It seems this type of OFDM is known as OFDMA (Orthogonal Frequency Division Multiple Access). Generation of dispersed subcarriers provides frequency diversity across mobile applications. Numerous distributed carrier dependent sub-channelization methods are available for mobile WiMAX. Partial Sub-Carrier Usage is the one that is required (PUSC). Adaptive Modulation and Coding (AMC) is another sub-channelization system based on unbroken subcarriers that prioritizes multiuser variety. Users are assigned sub-channels depending on their frequency response in this case. Although continuous sub-channels are especially suitable for constant as well as low mobility applications, they can provide a small increase in total systems capabilities [24].

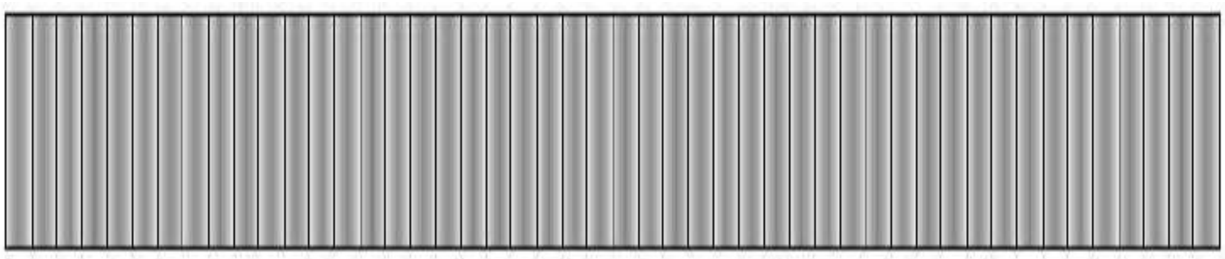

Fig 2: Downstream transmission of OFDM spectrum [7]

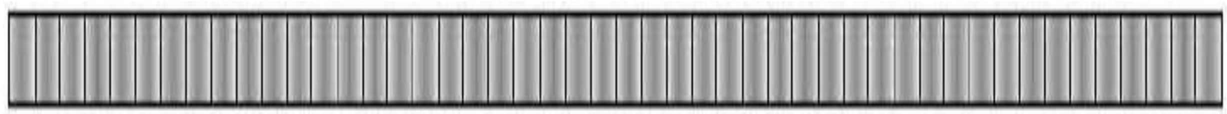

Fig 3: Upstream transmission of OFDM spectrum [7]

Figure 3 depicts upstream transmission of OFDM spectrum through a CPE with carriers that are fourth the length of those in Figure 2 [7].

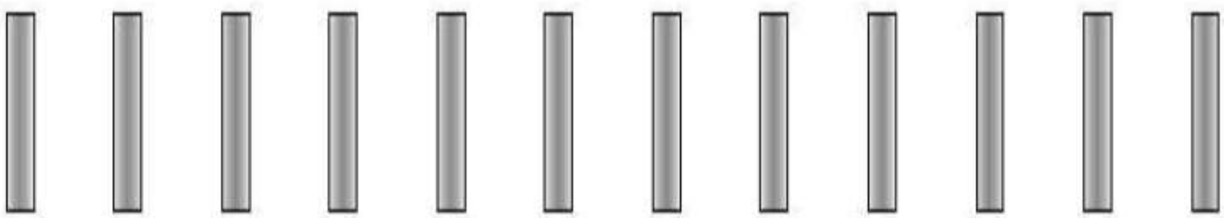

Fig 4: Upstream transmission of OFDM spectrum from the CPE [7]

Figure 4 shows transmitted upstream OFDM spectrum through a CPE using carriers that have the identical size as well as range as BS but have a lower capacity [7].

2.4 OFDMA Application in Wireless Connection:

Method of Access The mobile WiMAXaccessibility technique is according to OFDMA, additionally known as Multiuser-OFDM, which was developed specifically for 4th generation wireless networks. This is a mix of Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), with Code Division Multiple Access (CDMA) since this divides possible size to accommodate multiple users in same way that these access techniques do. OFDMA is a CDMA alternative in which each user receives a variable amount of spreading codes with varied data speeds. Minimal data rate consumers can transfer data throughsmall transmission power as well as an uniform and shorter latency, similar to an alternate TDMA. It may also be thought of as a hybrid of time domain as well as frequency domain multiple accesses, including resources separated into time-frequency spaces and slots, as well as an OFDM subcarrier index. To keep the data rate as well as error probability for every user, different numbers of subcarriers can be assigned to varying numbers of users. In a nutshell, OFDMA is the most efficient multi-user access technique [25].

3. MIMO System:

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Digital communication via a wireless link with multiple inputs and outputs (MIMO) is now popular prevalent technological applications in contemporary communication. Such strategy is mostly focused on a list of current technological advancements that have the potential to solve traffic capacity challenges for future Internet-connected wireless networks. It appears that this technology has infiltrated large-scale standards-driven commercial wireless devices as well assystems such as wireless LAN, third-generation networks,broadband wireless systems, as well asoutside in the early years following its inception.

MIMO systems are described as any wireless communication method with such a connection in which both the transmitter as well as receiver sides are configured using multiple antenna devices (Fig. 1). Its signals on transmit (TX) antennas with single terminal as well as receive (RX) antennas from another side are "combined" in MIMO to improve the communication efficiency (bit-error rate or BER) or data rate (bits/sec) for every MIMO user. Such benefits are utilized to dramatically increase for both network's reliability of the service as well as the operator's income. In MIMO systems, the key process is space–time signal processing, that combines time (information about natural dimension of digital communication) through spatial dimension introduced by use of many geographically spread antennas. In this approach, MIMO systems may be thought of as extensions of smart antennas, a prominent technology that uses antenna arrays to improve wireless transmission that has been around for decades.

We built our simulation model with multiple antenna setups in view (Fig. 1). A transmitting unit comprising the functions of error control coding as well as (potentially united with) mapping to complex modulation symbols (M phase-shift keying (MPSK), M-QAM, etc.) receives digital basis information in shape of a binary stream. This results in a number of distinct symbol streams, ranging from impartial to partially redundant to entirely redundant. After then, every symbol stream is assigned to among many TX antennas. Either linear spatial weighting of antenna components or linear antenna space–time pre coding are used in mapping. The signals are released through into wireless channel following upward frequency conversions, filtering, with amplification. Signals are collected by several antennas at the receiver, where demodulation as well as demapping processes is conducted to retrieve message. Depending on the requirements, the amount of intelligence, difficulty, as well as a priori channel information employed in choosing coding as well as antenna mapping techniques might vary greatly. This defines the class as well as quality of the developed multiantenna system.

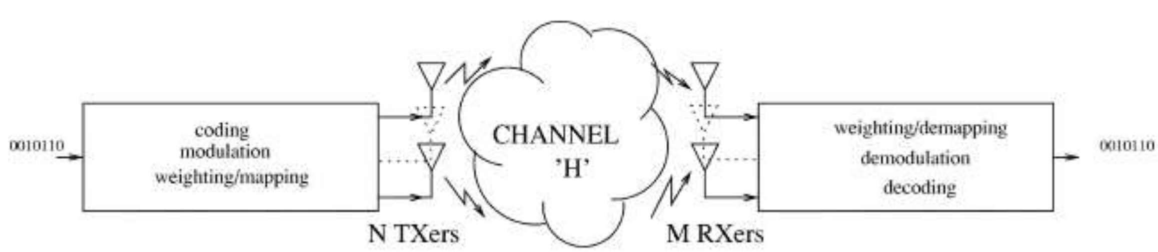

Fig 5: MIMO wireless transmission method having multiple antenna components for transmitter and the receiver.

Only transmitter and receiver are really designed by several components. in standard smart antenna nomenclature, which is often the base station (BTS), in which the extra cost & space have so far been viewed as more easily accessible than on a mobile phone device. Even though introduction of space–time codes (STCs) is changing this notion, the expertise of multi antenna system is traditionally found in weight selection method instead of the coding side.

In the case of poor propagation circumstances like as multipath fading with interference, simple linear antenna array merging can provide a better robust communication path. Beam shaping, that boosts the overall signal-to-noise ratio (SNR) by directing energy in desirable direction in either transmit or receive, is an important aspect in smart antennas. Indeed, by estimating the response within each antenna array to a particular intended signal, as well as any interference signal(s), one may combine the components optimally using weights determined by the response of each element. The average target signal level may thus be maximized while additional elements like as noise and co-channel interference are minimized.

The idea of spatial diversity is another major impact of smart antennas. Probability of discarding signal diminishes exponentially through extent of decorrelated antenna components deployed in the context of random fading induced by multipath propagation. Diversity order, that is determined byextent of decorrelated spatial branches accessible at transmitter or receiver, is a fundamental notion here. Smart antennas have been demonstrated to increase coverage range vs quality tradeoff supplied to wireless users when used together [6].

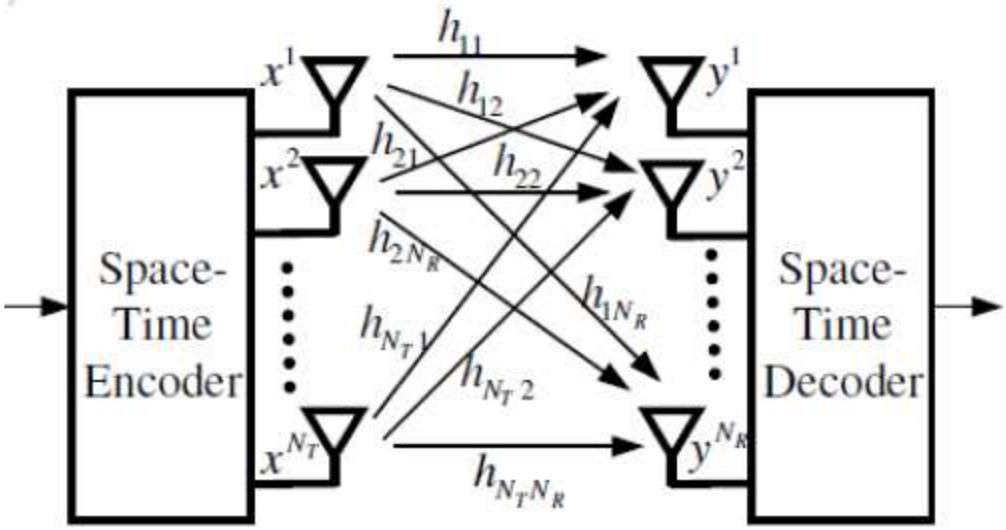

Fig 6: MIMO Structure Model.

The stringent size as well as complexity limits is getting less restrictive as subscriber units (SU) evolve into robust wireless Internet connection devices rather than simple pocket cellphones. Even while transferring most of computation as well as expense to network's side (i.e., BTS) generally provides engineering logic, it makes numerous antenna element transceivers a possibility on both parts of the link. However, the advantages of traditional smart antennas are preserved in a MIMO link because the multi antenna signals are optimized in a greater space, allowing for more degrees - of - freedom. MIMO systems, in particular, may give a combined transmit-receive diversity gain and an array gain by integrating the antenna elements in a coherent manner (assuming prior channel estimation). In truth, MIMO's benefits are significantly more basic. Beyond the extra diversity or array gain benefits, the fundamental mathematical architecture of MIMO, wherein data is carried via a matrix instead of a vector channel, provides novelas well as huge capabilities.

4. Result and Discussion:

In this part, we'll go through how to use MATLAB SIMULINK to create simulation data for effectiveness study of SISO as well as MIMO systems. In terms of scatter plot as well as bit error rate, there are three design styles that describe the model design and reactions (BER). Three alternative models are designed for step-by-step analysis: (1) SISO model, (2) MIMO 12 - 3 Txplus 2 Rx model at rate 1/2, as well as (3) MIMO 3/4 - 3 Tx as well as 2 Rx model at rate 3/4. We used four distinct modulation techniques for each model: BPSK, QPSK, 8PSK, and 16PSK. We employed data transmission without and with grey coding for every modulation technique. The data is broadcast via a Rayleigh fading channel with a maximum Doppler shift of 3 Hz. We utilized an AWGN channel simulink blocks to estimate BER at various SNRs with specific configuration that utilized condensation of distinct modulation coding methods.

At varied SNRs ranging from 1 to 25db, the response is expressed as a scatter plot and bit error rate. Because the signal strength increases with the SNR, the dispersion of the signal constellations reduces. The BER is a parameter which is equivalent to the channel noise, meaning that the higher the noise, the higher the BER. BER is determined by number of error bits divided byoverall number of bits. We acquired BER values by executing every simulation model for 10 seconds in simulink environment as well as recording BER results for various SNR levels. In the following sections, BER will describe our simulation model outcomes one by one.

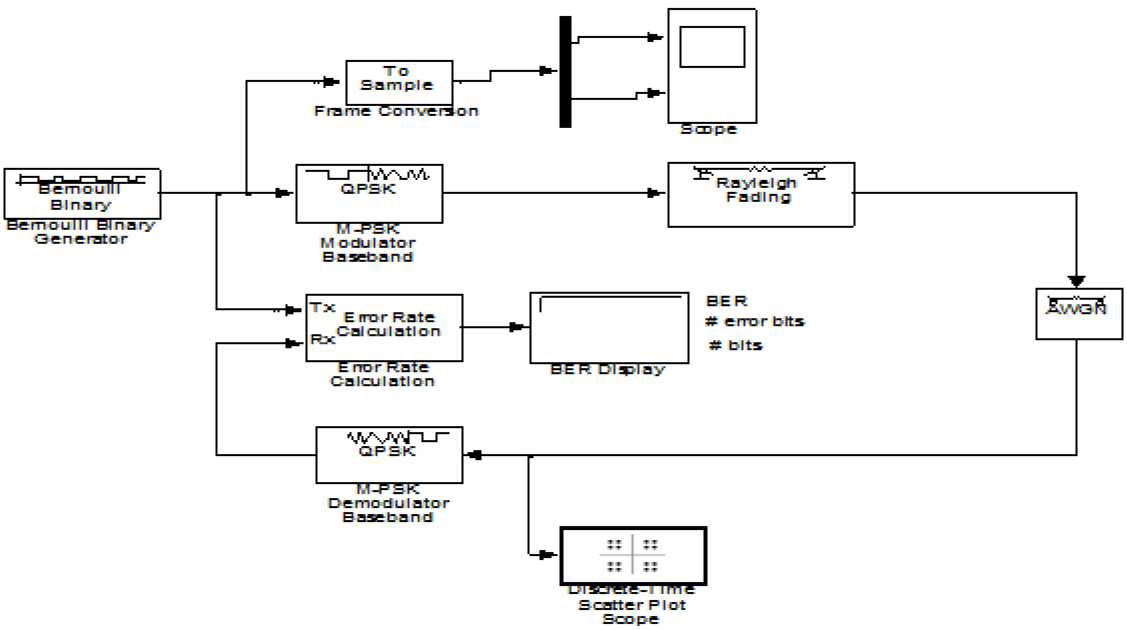

Fig 7: Simulink Model of SISO Structure

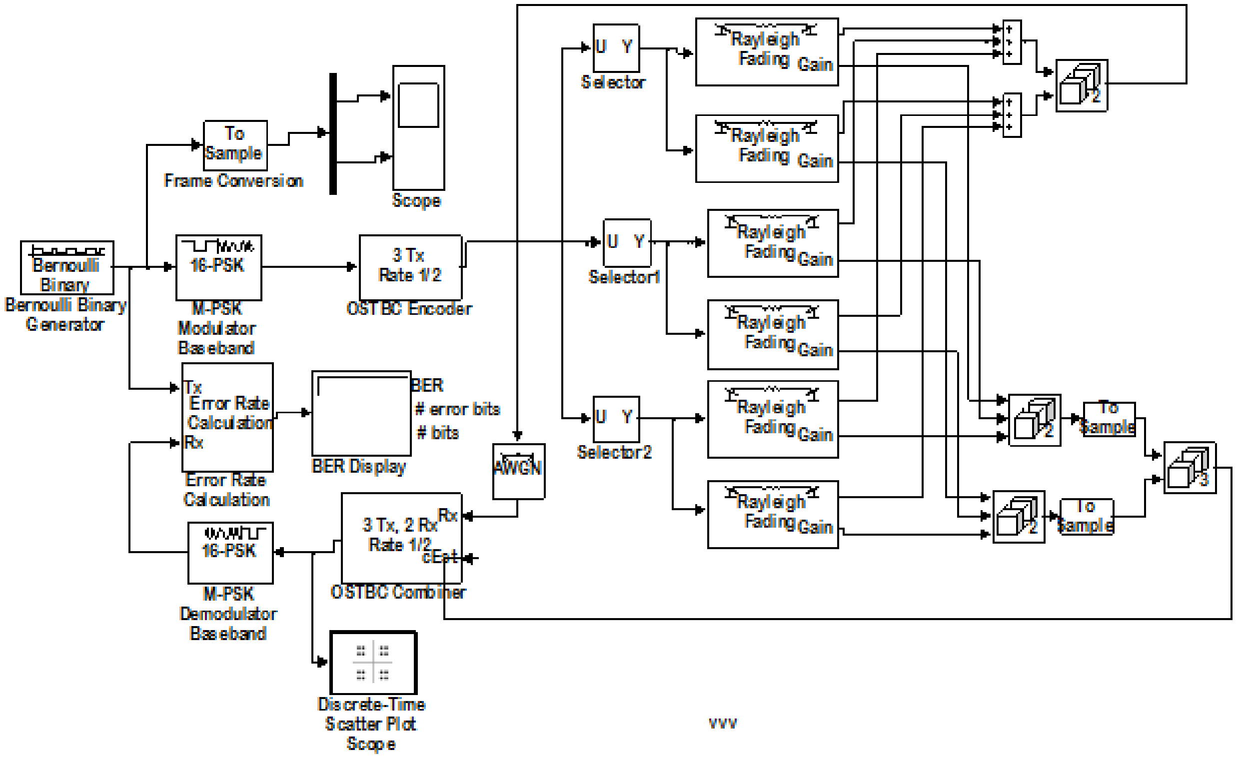

Fig 8: Simulink Model of MIMO1/2 Structure

Table 1: Performance results of SISO model scheme.

SNR	Bpsk(B)	Bpsk(G)	Qpsk(B)	Qpsk(G)	8psk(B)	8psk(G)	16psk(B)	16psk(G)
1	0.504	0.504	0.492	0.4958	0.4955	0.4946	0.4965	0.4918
5	0.4993	0.4993	0.4852	0.4953	0.4862	0.4876	0.4963	0.4928
10	0.497	0.497	0.471	0.4903	0.4878	0.4782	0.4927	0.488
15	0.502	0.502	0.4603	0.4846	0.4894	0.4748	0.4858	0.4893
20	0.5003	0.5003	0.4574	0.4862	0.4883	0.4737	0.4870	0.4887
25	0.5006	0.5006	0.4563	0.4875	0.486	0.4743	0.4828	0.489

Tables 1, 2, as well as 3 show BER values for our SISO model (figure 7), MIMO1/2 (figure 8) as well as MIMO3/4 designs, respectively, where B denotes binary coding plus G denotes grey coding for every row in table. Each column displays the bit error rate for various SNR levels in decibels. Table 1 show that the BER value varies from 0.48 to 0.505 depending on the coding and modulation technique used. As a result, this table shows that utilizing alternative coding as well as modulation techniques has no effect on BER in the SISO model.

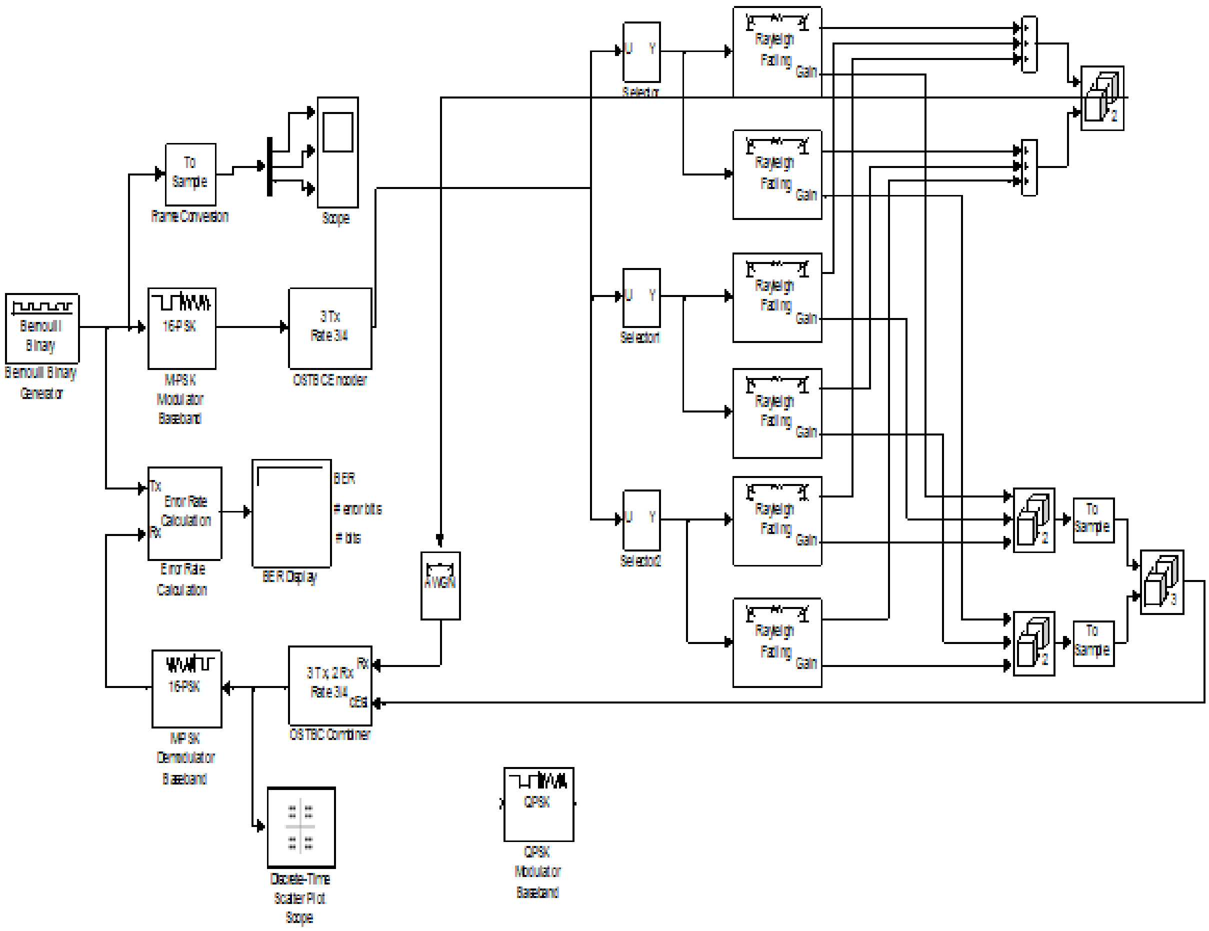

Fig 9: Simulink Model of MIMO3/4 Structure.

Table 2: Mimo Model ¾ Design Result

SNR	Bpsk(B)	BPSK(G)	Qpsk(B)	Qpsk(G)	8psk(B)	8psk(G)	16psk(B)	16psk(G)
1	**0.01075**	**0.01075**	0.5165	0.04464	**0.1809**	0.1126	0.3607	**0.2155**
5	**0.0002**	**0.0002**	0.01012	0.006197	0.7154	0.04467	0.2777	0.1167
10	0	0	0	0	**0.006898**	**0.004598**	0.09027	**0.03787**
15	0	0	0	0	0	0	**0.0113**	**0.006094**
20	0	0	0	0	0	0	0.000399	**0.0002**
25	0	0	0	0	0	0	0	0

Table 3: MIMO Model 1/2 Design Result

SNR	Bpsk(B)	BPSK(G)	Qpsk(B)	Qpsk(G)	8psk(B)	8psk(G)	16psk(B)	16psk(G)
1	0.01191	0.01191	0.04337	0.03754	0.1916	0.1111	0.2551	0.2315
5	0.000799	0.0007998	0.008258	0.005998	0.00535	0.03667	0.1977	0.11ter26
10	0	0	0.0003332	0.000288	0.007164	0.005199	0.0546	0.03791

15	0	0	0	0	0.0003999	0.0003333	0.01562	0.007985
20	0	0	0	0	0	0	0.001132	0.0007327
25	0	0	0	0	0	0	0.0001332	0

5. Conclusion:

The Multiple input multiple output (MIMO) technology demonstrates its potential to meet demands by boosting spectrum efficiency through the use of spatial multiple route gain and improving resiliency via the use of antenna diversity gain in our design methodology. We looked into and studied a number of issues in the field of MIMO wireless communication that were described in the literature from both a theoretical and a practical standpoint. It has been noted that MIMO technology has progressed to the point where it can be used to actual systems. We studied the problem with the MIMO system, which is a high bit error rate owing to channel fadings, in this study. We developed several MIMO models based on 1/2 as well as 34 MIMO transmitter receiver antennas, as well as we integrated influence of grey coding in signal trial to the modulation. Even at the tiny noise power mirror, the BER in the SISO system mode is quite substantial for any form of modulation scheme. BER is never less than 0.4 due to the fading channel. However, for any sort of modulation scheme, BER has achieved zero for 12 and 34 designing outcomes at SNR greater than 25. The BER for BPSK modulation is negeable in the MIMO 12 architecture, and it is about the same for binary and grey coding. The BER after grey coding is found to be lower than BER after binary coding in BPSK, QPSK, 8PSK, and 16PSK. Similarly, the BER of the MIMO 34 model is lowered due to the grey coding modulation strategy. We may infer that grey coding improves data transmission efficiencymutually 12 as well as 34 MIMO systems in this way.

We also evaluated our MIMO 12 and 34 systems as well as discovered that the 12 model has reduced BER for BPSK modulation at all SNR levels. In the case of QPSK, 34 MIMO design is better than 12, however in case of 8 as well as 16PSK schemes, our MIMO 12 design has a lower bit error rate than 34 MIMO design, especially at SNRs greater than or equal to 10db. As a result, in the majority of the scenarios we looked at, MIMO 12 channel design outperformed MIMO 34 channel design.

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