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Impact on BER of Different Detectors for 2*2 MIMO System under Rayleigh Channel

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Abstract- This paper is motivated by the potential of multi input multi output (MIMO) frameworks to accomplish high speed data rate demand of future generation wireless systems because these are capable of mitigating multipath fading effect without increased spectral bandwidth. This paper is generalized to the case of 2 antennas at both sides For separating spatially multiplexed information ZF and MMSE and ML detectors have been used so that goal of information gathering maximizes at receiver end. ZF and MMSE identifiers are used if system complexity is issue or ML is used if BER performance is to be considered. No feedback is required from receiver to transmitter in this methodology. In this paper BER execution of 2*2 MIMO framework with different detectors at the beneficiary side has been evaluated under Rayleigh blurring channel, which is usually a case of no line of sight. These frameworks are implemented by using MATLAB, which gives us performance comparison between 2*2 MIMO framework with different detectors and classical maximal ratio combining scheme.

Keywords- Multi input multi output (MIMO), Bit error rate (BER), Binary phase shift keying (BPSK), Maximum Likelihood (ML), Zero forcing (ZF), Minimum mean square error (MMSE), Signal to noise ratio (SNR), Rayleigh channel.

I. INTRODUCTION

In this cutting age time of wireless communication systems, mobile technology is the most progressive and fourth generation of versatile correspondence is the recent generation at present, where purpose of 4G is towards offering productive outcomes for the usefulness of future mobile generations. In the near future, beyond 4G (fourth generation), foremost intention is towards increase in capacity, improved data rate, decreased latency and better nature of administration [1]. Hence requirement for high information rate technologies is increasing which is not conceivable to accomplish by conventional means in light of the fact that with a specific end goal to achieve higher data rates we require to improve the capacity of transmission system and Shannon's capacity theorem for SISO system states that it is enhanced only by increasing bandwidth and SNR. Since bandwidth is a finite resource so we have to preserve it and SNR also not increased because for that we have to increase transmitter power which is against future wireless systems aspects because these aim to have low power transmitters.

There are several factors disrupting the execution of the correspondence framework such as interference, noise, propagation losses, limitation of bandwidth and fading caused by multipath [2]. So keeping in mind to eliminate all these issues and meet all requirements Space-Time Block Coding is used. It is MIMO technology which upgrades capacity of system by employing diversity concept because it is practical and effective approach used for reducing effect of multipath fades [3] so that goal of high information rate is fulfilled by modern communication systems. It mitigates the fading effect in wireless channels by introducing spatial and transient assorted variety [4-5]. This technique has no need of bandwidth expansion and due to potential of MIMO systems to provide numerous request of magnitude improvement without the need of additional spectrum [6]. In case of mobile communication various parameters provides few restriction such as size of antenna, selection of modulation technique, and signal processing chains in MIMO framework [7].

In MIMO technology, advantages of the capacity and diversity strongly rely upon which kind of fading the channel undergoes and whether the fades integrated with different sender and beneficiary antennas are correlated or not. Another pointing issue is that the sender side is having access to channel state data or not [8]. In this STBC technique we do not need to obtain channel state information (CSI) and generally it is considered that all the transmitting antennas are independent mutually i.e. no correlation. Space-time coding techniques is also having another types such as layered space-time coding (LSTC) and space-time trellis coding (STTC), in which LSTC is worst in performance [9] and STTC is drawing researchers attention because it provides both coding gain and decent variety pick up so it is up to STC design criteria[10]. In this proposal, we have plotted BER versus SNR (signal to noise ratio) graph of 2*2 MIMO system under Rayleigh channel (no observable pathway) and modulation scheme BPSK with different detectors at receiver.

In section II, 2*2 MIMO framework show is described. Section III consist of STBC encoder and detectors such as ZF, MMSE and ML. In section IV, modulation scheme is discussed. Section V, discusses Rayleigh blurring channel which is usually in case of no line of sight. In section VI, bit error rate and SNR is discussed. In section VII, results obtained by MATLAB is analyzed and the last section VIII gives the final conclusion.

II. RELATED WORK

Various efforts have been made by the researchers to improve BER performance of MIMO systems. Classic approach to improve it was to use multiple antennas at receiver side and then performing various function so that quality of received signal is improved. Other techniques were to use time and frequency diversity, space time trellis coding [4]. In 1998 Alamouti proposed a code called as space time coding in which he proposed use of multiple antennas at transmitter which is contrary to MRC scheme and he also showed that use of MIMO technology can improve BER performance of system up to a specific level. After that several efforts have been made to improve BER performance for future generation systems to meet demand of high speed of information rate.

III. SYSTEM MODEL

System model is separated in to 2 sections where one is transmitter section consisting of information source through which meaningful information is generated. After that space-time encoder is managed for encoding purpose and then it is connected to 2 transmitter antennas. It can be understand by following-

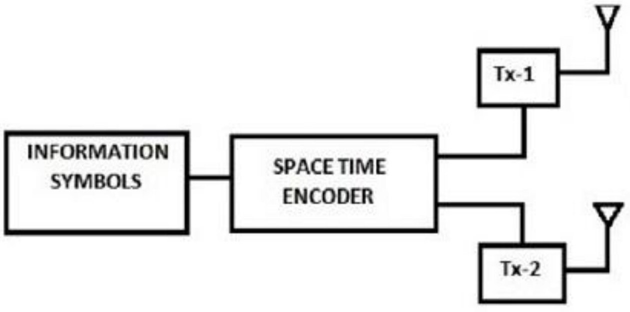

Figure 1 - 2*2 MIMO System Transmitter

While at the other side receiver section model which consist of channel estimator and combiner and then connected to detector used for decision rule. Here in this technique throughput of the framework also depends linearly on number of antennas used.

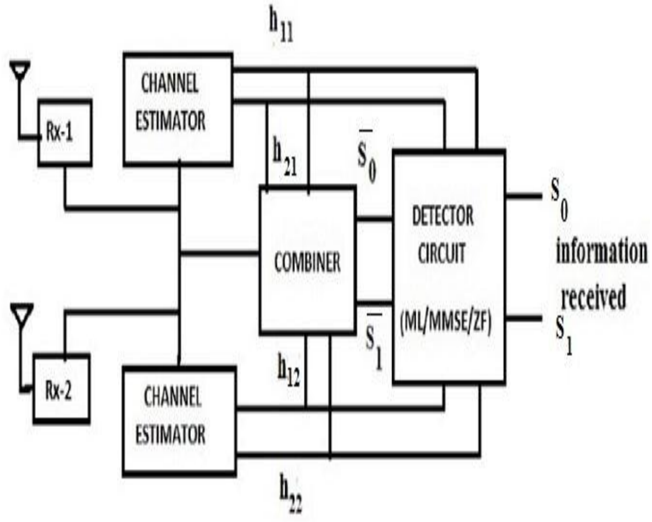

Figure 2 - 2*2 MIMO System Receiver

IV. ENCODER AND DECODER

A. 2*2 MIMO STBC

In a 2*2 MIMO STBC system there are two transmitter and 2 receiver antennas. Working principle of 2*2 MIMO is similar to 2*1 Alamouti STBC but it is having one additional receiving antenna. This combination of antennas provides better bit error rate performance when contrasted to 2*1 Alamouti STBC [4]. We have assumed that the channel parameter are not changing with time i.e. remains constant during the two time slots. Channel is thought to be flat fading.

$Y_{11} = h_{11}(X_1) + h_{12}(X_2) + n_{11}$ (first time slot receive data in R_{X1}) (1)

$Y_{12}= h_{21}(X_1) + h_{22}(X_2) + n_{12}$ (first time slot receive data in R_{X2}) (2)

$Y_{2\,1}= h_{11}(-X_2^*) + h_{12}(X_1^*) + n_{21}$ (second time slot receive data in R_{X1}) (3)

$Y_{2\,2}= h_{21}(-X_2^*) + h_{22}(X_1^*) + n_{22}$ (second time slot receive data in R_{X2}) (4)

Above equations are composed as in following form

$$\begin{bmatrix} Y_{11} \\ Y_{12} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} n_{11} \\ n_{12} \end{bmatrix} \quad (5)$$

The received vector in second time schedule is

$$\begin{bmatrix} Y_{21} \\ Y_{22} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} -X_2^* \\ X_1^* \end{bmatrix} + \begin{bmatrix} n_{21} \\ n_{22} \end{bmatrix} \quad (6)$$

In above mentioned equations X_1 and X_2 are modulated symbols,Y_{11} and Y_{12} are received vectors in first time slot,Y_{21} and Y_{22} are received vectors in second time schedule ,and h_{11}, h_{12} , h_{21} and h_{22} are impulse response of Rayleigh blurring channel.n_{11}, n_{12} added noise in first time slot ,n_{21} and n_{22} is added noise in second time slot.

B. ZF Detector

The ZF is a linear estimation method, which reverses the frequency response of received signal; the reciprocal is taken for the reconstruction of signal later the channel. The estimation of strongest transmitted signal is created by nulling the weak transmitted signal. After that strongest signal is eliminated from recipient signals for decoding strong signal leftover transmitted signal. ZF equalizer avoids the added substance commotion so application of it may result in amplification of noise for channel. The major advantage ZF linear equalizer is that it easily removes the ISI by forcing the overall pulse, which is the convolution of the channel and equalizer is provide a unit-impulse response. The ZF equalizer is represented mathematically by the pseudo inverse of H

$$W_{ZF} = (H^H H)^{-1} H^H \qquad (7)$$

W_{ZF} is equalization matrix and H channel matrix. ZF detector will give approving result only if W_{ZF}*H=1 condition is satisfied and corner to corner elements of pseudo inverse matrix should not be zero. The result of zero constraining equalization before quantization can be composed as

$$Y_{ZF} = (H^H H)^{-1} H^H y \qquad (8)$$

If we compare ZFE and MMSE detectors, initially MMSE outperforms ZFE, but as number of cycles increases, or SNR increases, both ZFE and MMSE converge with each other [11].

C. MMSE Detector

This detector limits the mean square mistake between the transferred symbol and the output of the detector. Previous work on different kind of detectors with MIMO system shows that MMSE is less complex when contrasted to ML detector, so as system complexity is to be considered than it is preferred [12-13]. As compared to a ZF detector, MMSE detector increases the signal-to- distortion ratio by punishing leftover ISI and enhancement of noise. After the cancellation of ISI totally, an MMSE detector provides some leftover ISI to decrease the overall distortion. As we compare between an MMSE and a ZF detector, an MMSE detector is much stronger in respect to deepest channel null and noise. The MMSE detector is expressed as following equation

$$W_{MMSE} = \arg_G{}^{MIN} E_{x,\,n}[x\text{-}x^\wedge]^2 \qquad (9)$$

By using orthogonality principle W_{MMSE} the is composed as

$$W_{MMSE} = H^H (H^H H + n_0 I_n)^{-1} \qquad (10)$$

In above W_{MMSE} is equalization matrix, H is correlated channel and n is the channel noise. Then the output vector can be written as equation

$$Y_{MMSE} = H^H (H^H H + n_0 I_n)^{-1} y \qquad (11)$$

D. Maximum Likelihood Decoder.

The ML space-time decoder is the excellent decoder but at the amount of enhanced complication in system model. It chooses the code word, which is the well on the way to be transmitted given the received signals. In the ML equalizer receiver tries to find $\hat{X}$ which minimizes J =$|Y-H\hat{X}|^2$ for the BPSK modulation. The possible value of X_1 is +1 and -1 and X_2 is also lies between 1 and -1. So find the minimum estimate of J from all four possible combinations in the ML decoder for below equation

$$J = \left| \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} - \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} \widehat{X_1} \\ \hat{X}_2 \end{bmatrix} \right|^2 \qquad (12)$$

The possibility of the transferred symbol is picked ideally on the base of an incentive from 4 quantities If the lowest is $J_{+1,\,+1}$= [1 1], If the lowest is $J_{+1,-1}$= [1 0], If the lowest is $J_{-1,\,+1}$ = [0 1] and If the lowest is $J_{-1,-1}$= [0,0].

V. MODULATION TECHNIQUE

In this proposal we have used BPSK modulation scheme. If the digital modulation BPSK is used then for encoding of M message bits, single pulse transmit 2M possible time shifts. It is additionally called as phase inversion keying. In it there are 2 phases which are isolated by 180° so it is considered as 2-PSK.

VI. COMMUNICATION CHANNEL

In a communication process channel is the medium to transmit the information. It can be delegated as two types in which first is wired and second is wireless. In the event of wired channel physical association exist amongst source and goal however in remote channel there is no physical association from source to goal. Based on blurring remote channels are of 2 writes as moderate and quick blurring channel.

Where impulse reaction is varying quickly in case of quick fade channel and in case of moderate fade channel impulse display remains constant from many symbols [14]. Rayleigh channel model is a valid model in case of plenty disturbances in the environment and when viewable pathway between sender and desired user is absent.

R_F > Rs (In case of fast fading)
R_F < Rs (In case of slow fading)

A. Rayleigh Communication Channel

3 mechanisms of EM wave propagation are reflection, diffraction and scattering [15-16].The Rayleigh fading channel display is a combination of scattered and reflected signals and generally used for modulation of the signals of the troposphere and ionosphere. Case approximation of attenuation caused by multi path fading remote channel can be done by Rayleigh fading channel if viewable pathway communication is not present between sender and desired receiver. It assumes that the signal that has gone through such a transmission medium that will vary randomly or start to fade as according to Rayleigh distribution. For obtaining Rayleigh distribution we take two identically distributed zero mean Gaussian random variables as real and imaginary part of a complex number and then its magnitude is taken. MIMO helps in improving link reliability [17].

VII. SIMULATION RESULTS AND DISCUSSIONS

Here bit error rate analysis of 2*2 MIMO system is done with ZF, MMSE, ML detectors at the receiver.
From figure 3 we observe that there is no improvement in SNR for same values of bit error rate.

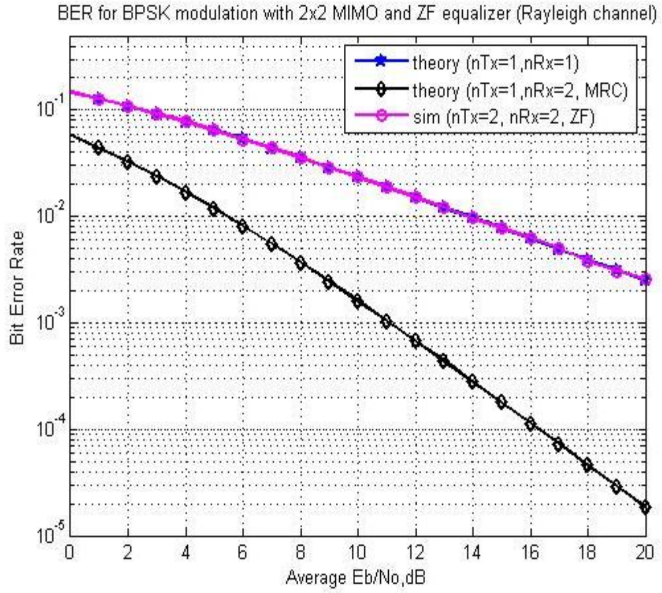

Figure 3- 2*2 MIMO with ZF equalizer

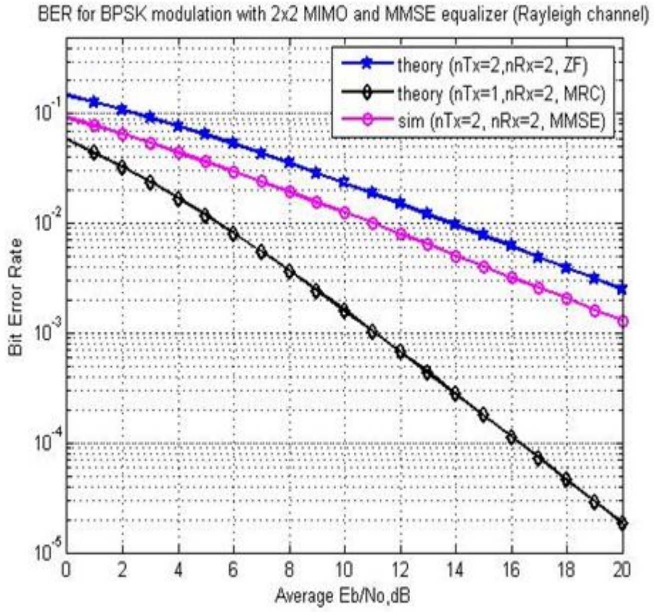

Figure 4- 2*2 MIMO with MMSE equalizer

Figure 4 demonstrates the bit error rate performance of 2*2 MIMO system with MMSE equalizers. Performance of MMSE system is better than that of ZF equalizer. At 10^{-2} BER MMSE detection shows 2 dB improvement in SNR.

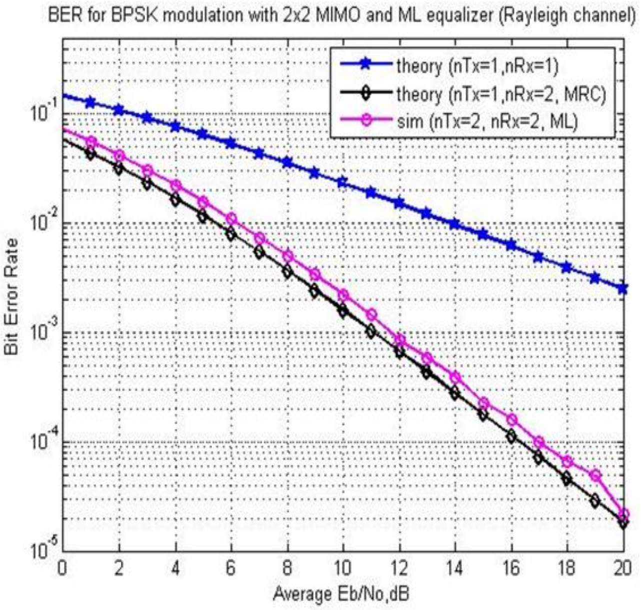

Figure 5- 2*2 MIMO with ML equalize**r**

Figure 5 is showing ML detector performance, from which we conclude that performance of system is improved up to a significant extent when contrasted to ZF, MMSE detector system. At 10^{-2} value of BER, SNR for ML detector is improved by 8 dB as compared to SISO system, ML detector system is also comparable to MRC scheme.

VIII. CONCLUSIONS

From simulation analysis we observe that use of ZF and MMSE detectors is not improving BER performance for 2*2 framework. But Maximum likelihood detector performs up to MRC scheme without requiring channel state information so this makes its execution easy.

Execution of bit error rate can be improved by increasing the number of transmit and receive antennas. Performance of this MIMO system can also be checked with other modulation schemes such as PAM, M-PSK, and QAM etc.

REFERENCES

[1] A. Gupta, and R. K. Jha, "A survey of 5G Network: Architecture and E- merging Technologies", 2169-3536(c) 2015 IEEE.
[2] V. Tarokh, A. Naguib, A. R. Calderbank, and N. Seshadri, "Combined Array Processing and Space-Time Coding", IEEE Trans. on Info. Theory, vol. 45, no. 4, 1999.
[3] W. Jakes, "Microwave Mobile Communications", New-York: Wiley, 1974.
[4] V. Tarokh, H. Jafarkhani, and A.R. Calderbank, "Space-Time Block Codes from Orthogonal designs", IEEE Trans. on Info. Theory, vol. 45, no. 5, July 1999.
[5] S. M. Alamouti, "A Simple Transmit Diversity Technique for Wireless Communications", IEEE Journal VOL. 16, NO. 8, OCTOBER 1998.

[6] D. Gesbert, M. Shafi, D. Shiu, P.J. Smith, and A. Naguib, "From theory to practice: An Overview of MIMO Space–time coded wireless Systems", IEEE Journal on Selected Areas in Communications, vol. 21, no. 3: 281- 302, 2003.

[7] A.S. Mindaudu, A.M. Miyim, "BER performance of MPSK and MQAM in 2*2 Alamouti MIMO system'', IJIST, vol. 2, No.5 September.

[8] A.K. Jaiswal, A. Kumar, and A. Prakash Singh, "Performance Analysis of MIMO-OFDM System in Rayleigh fading channel", IJSRP, vol. 2, I- ssue 5, May 2012.

[9] Xiang bin Yu, and Guang guo Bi, "Power control scheme for multiple antenna systems with Space-time coding in Rayleigh fading channels", Journal of systems Engineering and Electronics volume 22, No. 5, pp. 730–738 October 2011.

[10] B. Vasic, and E. M. Kurtas, "Coding and signal processing for maguet- ie recording systems", CRC Press LLC, 2005.

[11] B. Gupta, G. Gupta, and D. S. Saini, "BER performance improvement in OFDM system with ZFE and MMSE equalizers", IEEE 2011.

[12] M. Myllyl¨a, J.-M. Hintikka, J. R. Cavallaro, M. Juntti, M. Limingoja, and A. Byman, "Complexity analysis of MMSE detector Architectures for MIMO-OFDM systems", in Proceedings of 39th asilomar conference on Signal system and computers, pp. 75–81, Pacific Grove, Calif, USA , October- November 2005.

[13] R. B¨ohnke, D. W¨ubben, V. K¨uhn, and K.D. Kammeyer, "Reduced complexity MMSE detection for BLAST architectures", in Proceedings of IEEE Global Telecomm. conference, vol. 4, pp. 2258–2262, San F- Francisco, Calif, USA, December 2003.

[14] Satvir Singh, Md. Umar, and Shalini, "Channel Analysis in OFDM System,", WJRR 2016.

[15] Sklar B., "Digital Communications: Fundamentals and Applications", 2/E, Prentice Hall.

[16] Rappaport, "Wireless Communications: Principles and Practice", 2/E , Prentice Hall.

[17] S.M.Nimmagadda, "Full Code Rate Complex Non-Orthogonal STBCS for Eleven Transmit Antennas", IJSRCSE, 2017.

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