International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Volume 1 Issue 5 (June 2014) http://ijirae.com

Performance Analysis of 2x2 MIMO for OFDM-DSSS Based Wireless System

Mr. Bhavin Gamit*
Electronics, SVNIT

Prof. Shweta N. Shah
Electronics, SVNIT

Abstract— In today's 3G world moving to 4G requires high data rate support in applications like multimedia services, internet access and video streaming services. Such applications are always in need of very high speed data rate support which increases the requirement of efficient usage of spectrum and high capacity systems. Thus the major challenges to be taken care of in designing the next generation wireless communications system should provide or accommodate capacity, the spectral efficiency, improved link reliability and multimedia services. So we can establish a distributed system in terms of multi-carrier, multi-antenna and coded pulse. It gives rise to hybrid technology based on DSSS, OFDM, and MIMO system which can be the ultimate solution for wireless cellular communication systems. In this paper we analysis the performance of MIMO-OFDM-DSSS system. This paper also includes comparison of performances of MIMO-OFDM-DSSS system with ZF and MMSE equalizer on the basis of BER using different modulation techniques in a scattering environment.

Keywords— DSSS, OFDM, MIMO, ZF, MMSE, BER, BPSK, QPSK, 16-QAM, ISI, CCI.

I. INTRODUCTION

Wireless communication systems are pulling in popularity, specially with respect to mobile telephones and wireless data devices because of their easiness of function and mobility. Initially, wireless systems were mainly designed and developed to support voice. As multimedia applications gaining popularity, the need for high rate data services is growing. Hence they require higher data rate with quality of service (QoS). The major challenges in future wireless communication system will be increased capacity, spectral efficiency, link reliability and multimedia services [1][2].

Electromagnetic waves reflect, diffract, and scatter so they alleviating the demand for direct line of sight between sender and receiver and also creating the complicated multipath problem. Multipath is the virtually infinite number of ways that a signal can take from sender to receiver, reflecting off smooth objects, scattering off rough objects, and diffracting around sharp corners. Multipath problem can be resolved by the DSSS. Spread spectrum originated as a means of secure communication in the military provided spreading of signal in the frequency domain to give a very low peak power [3]. To observers, a spread spectrum signal looks similar to white noise, and hence has a Low Probability of Intercept (LPI). Recently, IEEE 802.11n Task Group (TGn) was organized with the goal of increasing the application throughput to at least 100Mbps by making modifications in the PHY and MAC layer. The major variety in the PHY layer is the uses of multiple transmit and receive antennas along with the Orthogonal Frequency Division Multiplexing (OFDM) system to support several parallel streams which is likewise known as multicarrier based technique. It can mitigating ISI by addition of cyclic prefix as one of the option in OFDM. It can also improve capacity in the wireless system with spectral efficiency (bps/Hz) and reduces receiver complexity in wireless broadband systems. It is rather tolerant of the ever present interference in the bands where it is used because it transmits hundreds of symbols simultaneously at a low rate per symbol [4]. There are many techniques for sustaining high data rate transmission, such as the Multiple Input Multiple Output (MIMO) system. Digital communication using MIMO processing comes forth as a breakthrough for revolutionary wireless systems. It solves two of the hardest problems facing any wireless technology today: speed and range. MIMO system promises to increase data rates, reliability and performance with acceptable BER without increasing the total transmission power and also without consuming extra radio frequency [5]. But this MIMO cannot achieve zero ISI and hence cannot be used alone. The MIMO signalling can easily be overlaid on an OFDM based system. The MIMO signalling treats each subcarrier in OFDM as an independent narrowband flat channel. It can be viewed as N parallel MIMO systems operating with flat fading channel coefficients. The use of MIMO technology in combination with OFDM seems to be an attractive solution for future fastest broadband wireless systems. MIMO-OFDM can support a higher data rate as well [2]. But MIMO suffer from co-channel interference problem [6]. It is the interference between users in different cells and using same frequency (known as frequency reuse), results in CCI [7].Solution to that is to apply DSSS techniques based on spread spectrum technology. The main advantage of applying DSSS is that it reduces power per signal, That may mitigate CCI problem in MIMO-OFDM based system. By considering problem solving capabilities of different technologies, Here, Hybrid system based on MIMO, OFDM and DSSS techniques is analysed.

We present the performance analysis and simulation of a MIMO-OFDM-DSSS with ZF and MMSE equalizers using different modulation techniques in Rayleigh channel to reduce CCI and to improve performance. We present the MIMO-OFDM-DSSS based hybrid system model in section II. A short description of ZF and MMSE equalization techniques is given in section III. The simulation results and conclusion are presented and discussed in section IV and V respectively.

II. SYSTEM MODEL

Fig 1 shows the simple model of MIMO-OFDM-DSSS system. The input data are initially sent to scrambler block. Scrambler block scrambles the input data using linear feedback shift register whose configuration specifies using the scramble polynomial parameter. The signal is then sent to the convolution encoder having mother code rate of ½. The signal is then forwarded to an interleaver. The idea of interleaving is to disperse a block of data in frequency so that the entire block does not experience deep fade in the channel. This prevents burst errors at the receiver. Otherwise the convolution decoder will not perform very well in presence of burst errors. The interleaved data are grouped together to form symbols. The symbols are then modulated using any of the modulation schemes like, BPSK, QPSK, 16QAM. The Tx diversity block provides spatial diversity to modulated signal. In the figure we are considering 2x2 MIMO systems. The Tx diversity encoder splits the data into 2 orthogonal streams which are processed through individual OFDM blocks. The first stream will fed to the top IFFT modulator and second stream will be fed to the lower IFFT modulator. Here individual OFDM signals are generated by inserting pilot carriers and CP for channel estimation. Hence the information is transmitted in packets through the multiple transmitters. The Rx does exact reverse process of transmitter to retrieve the transmitted information back. Due to presence of MIMO technique, equalization is required at receiver side which is explained in next section.

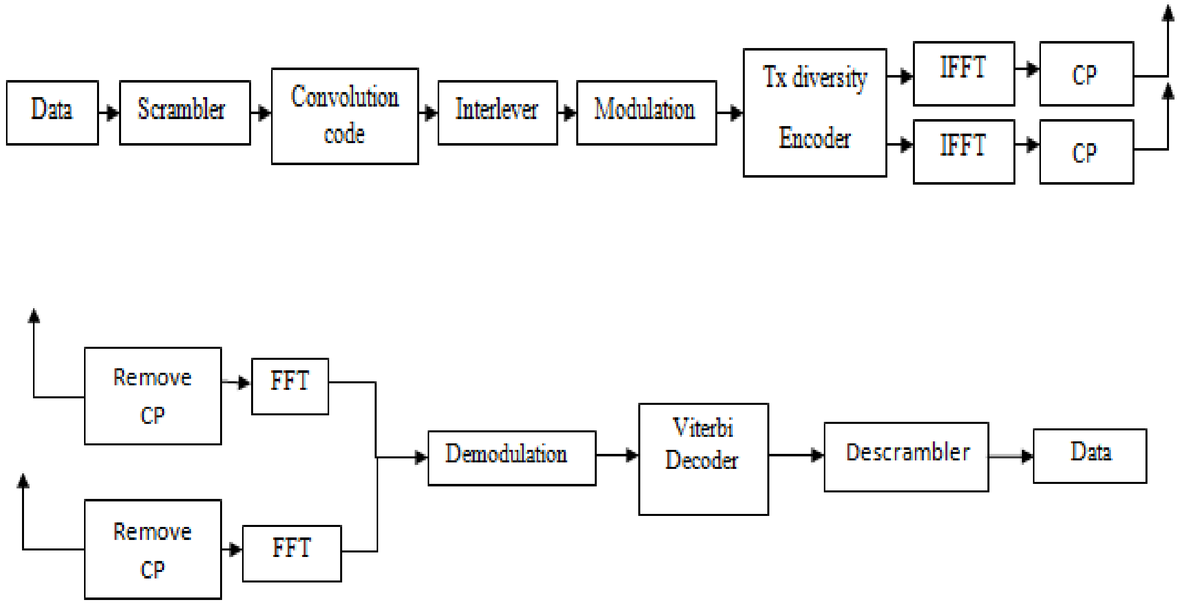


Fig. 1 system model of MIMO-OFDM-DSSS system

III. EQUALIZER

Equalization is to palliate the effects of ISI to decrease the probability of error that occurs without suppression of ISI, but this reduction of ISI effects has to be balanced with prevention of noise power enhancement. Here we present the most common detection techniques ZF and MMSE.

A. Zero Forcing Equalizer

The Zero-Forcing Equalizer applies the inverse of the channel to the received signal, to re-establish the signal before the channel. The name Zero forcing corresponds to taking down the Inter Symbol Interference (ISI) to zero in a noise free case [10]. This will be useful when ISI is more predominant when comparing to the noise. For a channel with frequency response F (f) the zero forcing equalizer C (f) is constructed by C (f) = 1 / F (f). So the combination of channel and equalizer gives a flat frequency response and linear phase F (f) C (f) = 1.

Take a 2x2 MIMO channel, the received signal on the first receive antenna is:

$$y_1 = h_{11}x_1 + h_{12}x_2 + n_1 \tag{1}$$

$$y_1 = \begin{bmatrix} h_{11} & h_{12} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + n_1 \tag{2}$$

The received signal on the Second receive antenna is:

$$y_2 = h_{21}x_1 + h_{22}x_2 + n_2 \tag{3}$$

$$y_2 = \begin{bmatrix} h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + n_2 \tag{4}$$

Where y_1 & y_2 are the received symbol on the foremost and second antenna respectively, and h_{ij} is the channel from i^{th} transmit antenna to j^{th} receive antenna. x_1 & x_2 are the transmitted symbols and n_1 & n_2 are the noise on 1^{st} and 2^{nd} receive antennas.

The equation can be represented in matrix notation as follows:

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} n_1 \\ n_2 \end{pmatrix} \quad (5)$$

Equivalently,

$$Y=HX+N \quad (6)$$

To solve for x, we need to see a matrix W which satisfies $WH = I$. The Zero Forcing (ZF) detector for meeting this constraint is made by:

$$W= (H^H H^{-1})\ H^H \quad (7)$$

Where W is the Equalization Matrix and H is Channel Matrix [11].

B. MMSE EQUALIZER

A Minimum Mean Square Error (MMSE) estimator describes the approach which minimizes the Mean Square Error (MSE), which is a coarse measure of estimator quality. The primary feature of MMSE equalizer is that it does not usually eliminate ISI completely, but, minimizes the full force of the noise and ISI components in the output. Let x and y be an unknown random variables [12]. An estimator *x*^(y) is any function of the measurement *y*, and its mean square error is given by:

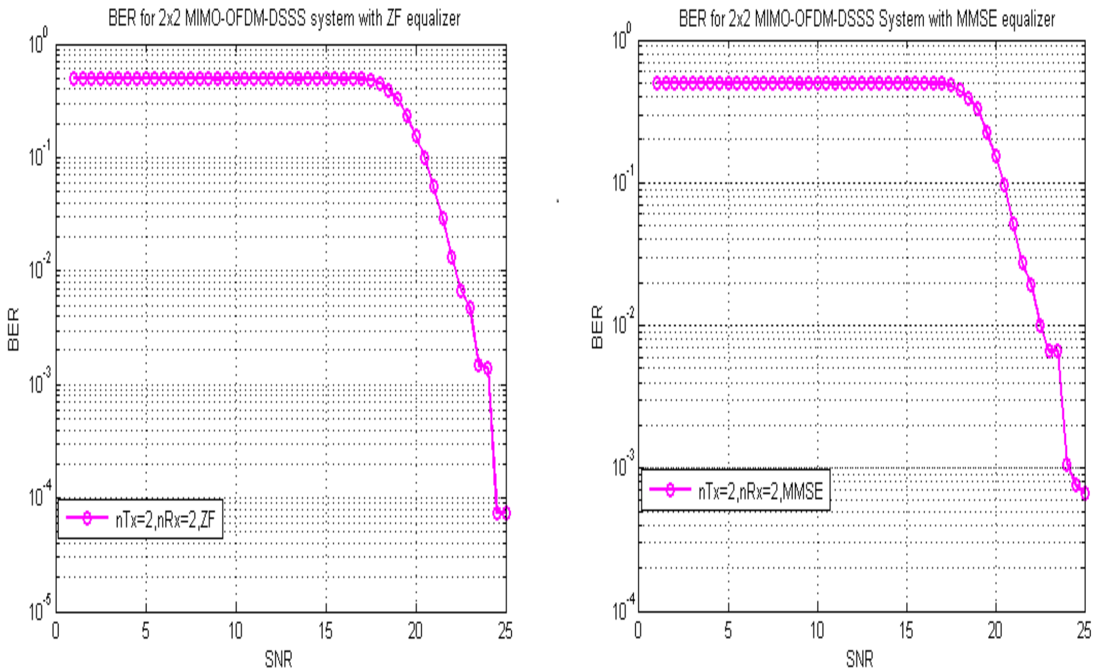
$$MSE=E\ \{(\hat{X} - X^2)\} \quad (8)$$

The mathematical expression for the MMSE equalizer for the received signal on the foremost and second antenna is same as in the case of ZF equalizer. The only deviation in this instance is the noise added to the equalization matrix.

$$W= [H^H \mathrm{H} + N_0 \mathrm{I}]^{-1} H^H \quad (9)$$

IV. SIMULATION RESULTS

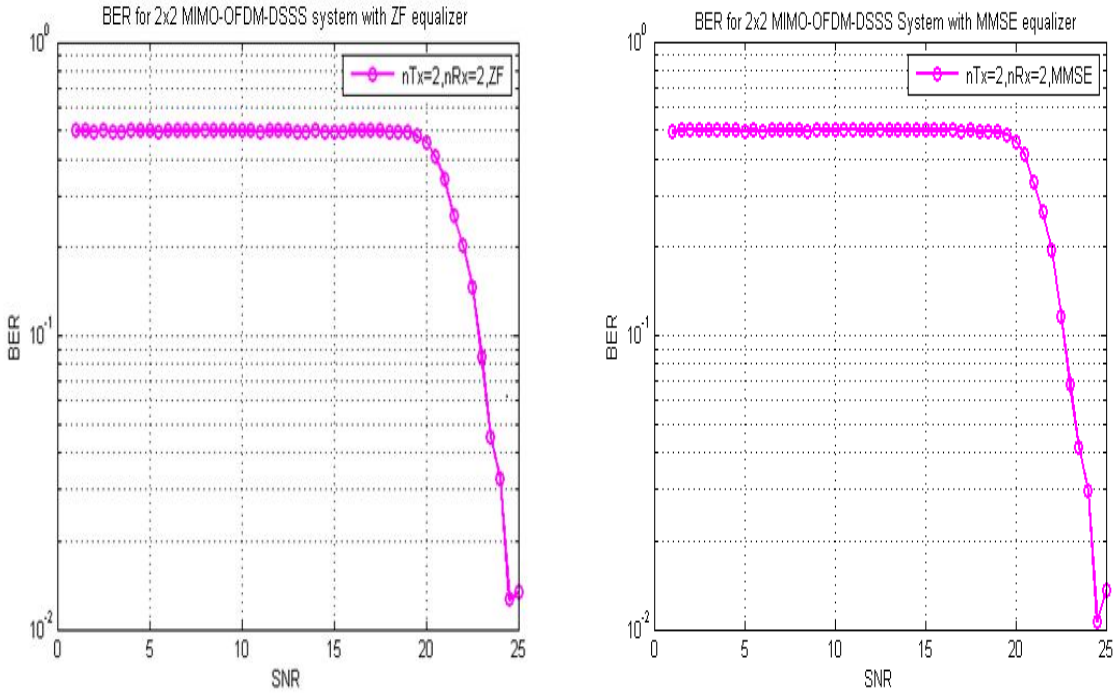
Fig 2 (a) and (b) shows the BER vs SNR curves for 2x2 MIMO-OFDM-DSSS system with BPSK modulation using ZF and MMSE equalization techniques. We can show in fig 2(a) that to achieve 10^{-5} BER we need 25 SNR using ZF. Fig 2(b) shows that to achieve 10^{-4} BER we need 25 SNR using MMSE. In the fig 2 (a) and (b) for BPSK modulation technique the minimum values of bit error rate are: for ZF equalizer min. BER is 0.029375. Similarly for MMSE equalizer min BER is 0.02715 at SNR 22.



(a) (b)

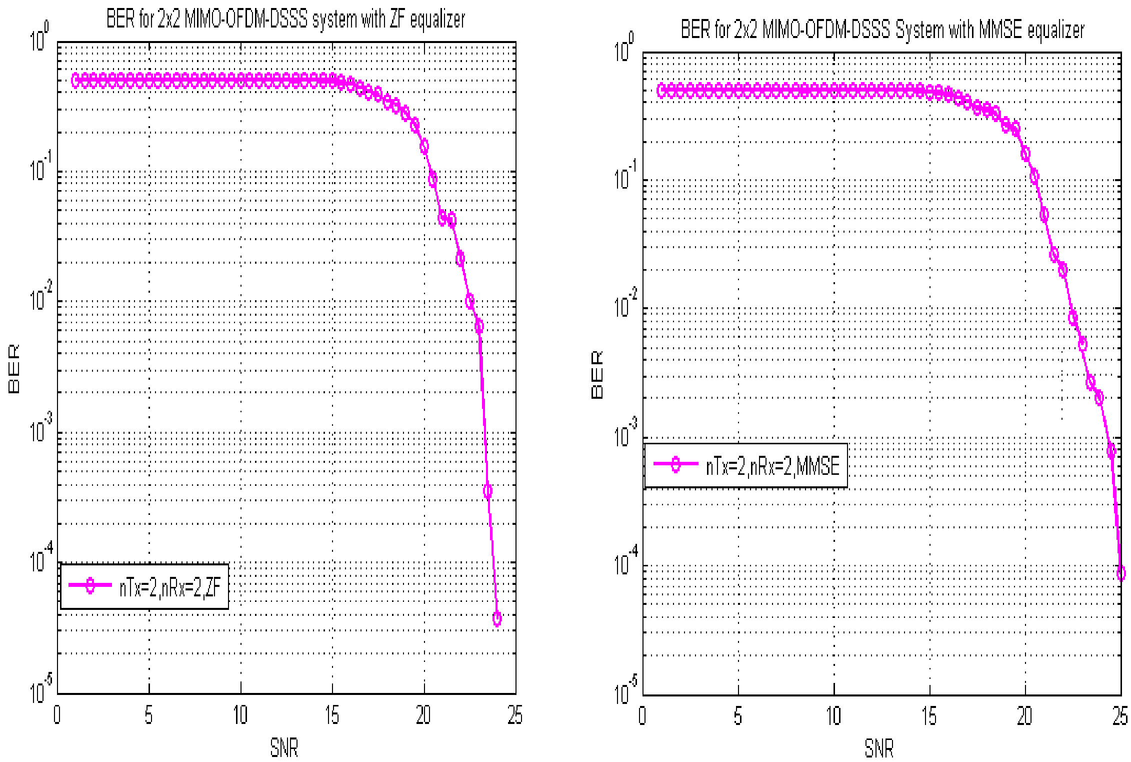
Fig. 2 BER vs SNR with BPSK for (a) ZF and (b) MMSE

Fig 3(a) and (b) shows the BER vs SNR curves for 2x2 MIMO-OFDM-DSSS system with QPSK modulation.



(a) (b)
Fig. 3 BER vs SNR with QPSK for (a) ZF and (b) MMSE

We can show in figure 3(a) that to achieve 10^{-2} BER we need 25 SNR using ZF. We can also show that to achieve 10^{-2} BER we need 25 SNR using MMSE in fig 3(b). In the fig 3 (a) and (b) for QPSK modulation technique the minimum values of bit error rate are: for ZF equalizer min. BER is 0.025825. Similarly for MMSE equalizer min BER is 0.026311 at SNR 22.



(a) (b)
Fig. 4 BER vs SNR with 16-QAM for (a) ZF and (b) MMSE

Fig 4(a) and (b) shows the BER vs SNR curves for 2x2 MIMO-OFDM-DSSS system with 16-QAM modulation using ZF nad MMSE equalization techniques. We can show in fig 4(a) that to achieve 10^{-5} BER we need 24 SNR using ZF. We can show that to achieve 10^{-4} BER we need 25 SNR. In the fig 4 (a) and (b) for 16-QAM modulation technique the minimum values of bit error rate are: for ZF equalizer min. BER is 0.041875. Similarly for MMSE equalizer min BER is 0.00865 at SNR 22.

V. CONCLUSIONS

In this paper the concept of MIMO-OFDM-DSSS based hybrid system using different equalizer over a multipath Rayleigh fading channel is presented. The idea of hybrid technology is implement and analyse by plotting the SNR v/s BER performance for MIMO-OFDM-DSSS system. The MIMO-OFDM-DSSS system is implemented using different equalization techniques like ZF and MMSE. The MMSE gives best performance for all three modulation techniques BPSK, QPSK and 16-QAM. ZF is a gives fairer performance compare to MMSE for lower order modulation techniques. MMSE can give best performance for high order modulation techniques. 16-QAM gives best result among all three modulation techniques.

REFERENCES

[1] G. J. Foschini, M. J. Gans. “On limits of wireless communications in a fading environment when using multiple antennas”. Wireless Pers. Communication, vol. 6, pp.311-335, March 1998.
[2] Jiang Xuehua , Chen Peijiang, ”Study and Implementation of MIMO OFDM In matlab Simulation”, in International Conference on Information Technology and Computer Science, 26th July 2009.
[3] Yao Liu, Peng Ning, Huaiyu Dai, An Liu “Randomized Differential DSSS: Jamming-Resistant Wireless Broadcast Communication” at IEEE INFOCOM, ISBN 978-1-4244-5836-3, pp.1-9, 2010.
[4] Ramjee Prasad “OFDM for Wireless Communications Systems, Artech House Universal Personal Communications series”, proceedings of the IEEE, 2004.
[5] Q. H. Spencer, C. B. Peel and A.lee, “An Introduction to the Multi-User MIMO Downlink,” IEEE Commun. Mag., vol. 42, no. 10, pp. 60-67, Oct. 2004.
[6] Muhammad Imadur Rahman, Elisabeth de Carvalho, Ramjee Prasad “Mitigation of MIMO Co-Channel Interference using Robust Interference Cancellation Receiver”, IEEE 66th Vehicular Technology Conference, pp.531-535, 2007.
[7] Anas M. Salhab And Ghandi F. Manasra “Performance Analysis of A Beyond 3G Mobile Communication System in the Presence of Co-channel Interference”, Wseas Transactions On Electronics Manuscript, Issue 6, Volume 4, June 2007.
[8] Nirmalendu Bikas Sinha, R.Bera, S.Manna, Shashank Gupta, “ Hybrid Technology for Next Generation Broad band Mobile Radio Communications”, IEEE conference on wireless and optical communication network,, pp. 1-5, April 2009.
[9] N. Tamilarasan L. Nithyanandan “Performance of the MIMO MC-CDMA System with Beamforming”, 4th ICCCNT 2013 in Tiruchengode, India IEEE – 31661, pp.1-5 July 2013.
[10] Abdessalem Trimeche, Nesrine Boukid, Anis Sakly, Abdellatif Mtibaa “Performance Analysis of ZF and MMSE Equalizers for MIMO Systems”, IEEE International Conference on Design & Technology of Integrated Systems in Nanoscale Era, pp.1-6, 2012.
[11] Bhasker Gupta and Davinder S.Saini “BER Performance Improvement in MIMO Systems Using Various Equalization Techniques”, 2nd IEEE International Conference on Parallel, Distributed and Grid Computing Waknaghat, pp.90-194, Dec 2012.
[12] Manish Kumar and Jasmeet Kaur “Performance analysis of BPSK system with ZF & MMSE equalization”, International Journal of Latest Trends in Engineering and Technology (IJLTET), Vol. 1 Issue 3 September 2012.

