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Reducing Bit Error Rate in MIMO-OFDM System through Space-Time Block Coding (STBC)

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ABSTRACT:-

In contemporary wireless communication systems, Orthogonal Frequency Division Multiplexing (OFDM) is widely employed to meet the increasing demands for high voice quality, elevated data rates, multimedia features, and lightweight communication devices. However, the wireless communication channel faces notable challenges, particularly fading induced by multiple propagation paths and the swift movement of mobile devices.

The MIMO-OFDM system, integrating Multiple-Input-Multiple-Output (MIMO) and OFDM technology, stands out as a solution capable of achieving high data transmission rates with reliability through diversity. Incorporating Space-Time Block Coding (STBC), MIMO-OFDM demonstrates exceptional performance against multi-path effects and frequency-selective fading, while maintaining a low Bit Error Rate (BER) and coding complexity.

This paper introduces MIMO systems, incorporating multiple antennas at both transmitter and receiver ends, with their adoption driven by the potential capacity gains achieved through multiple antennas. These antennas leverage spatial dimensions alongside time and frequency dimensions without altering the system's bandwidth requirements.

Building upon the flat-fading Rayleigh channel as a foundation, the paper explores the concept of Orthogonal Space-Time Block Coding, particularly relevant in scenarios involving multiple transmitter antennas. The analysis assumes independent fading between multiple transmit-receive antenna pairs. Additionally, the paper provides insights into the performance degradation when the channel is imperfectly estimated at the receiver, contrasting it with the scenario of perfect channel knowledge at the receiver.

In summary, this paper contributes to the understanding of advanced wireless communication systems, showcasing the effectiveness of MIMO-OFDM with STBC in overcoming channel impairments. The exploration of MIMO systems and Orthogonal Space-Time Block Coding enriches the discourse on enhancing the reliability and performance of contemporary wireless communication.

Keywords:- Wireless communication, Diversity, Gain, Space Time Block Coding, MIMO, OFDM.

1. INTRODUCTION

The MIMO-OFDM system, a fusion of MIMO and OFDM technologies, offers high data transmission rates and reliability through diversity. Employing Space Time Block Codes (STBC) enhances performance against multi-path effects and frequency-selective fading, while maintaining low Bit Error Rate (BER) and coding complexity. Spatially multiplexed MIMO boosts throughput, but in high-throughput scenarios, multipath characteristics make the MIMO channel frequency-selective. OFDM resolves this by transforming the channel into parallel frequency-flat MIMO channels, improving frequency efficiency. MIMO-OFDM is researched as the infrastructure for next-generation wireless networks.

As an alternative to Single Input Single Output (SISO) transmission, MIMO-OFDM, with multiple antennas in an OFDM system, becomes practical. However, channel estimation complexity increases due to the greater number of channels, especially when the channel is frequency-selective. In today's communication environment, the demand for high data rates and reliable high-speed communication presents challenges for parallel data transmission, alleviating issues faced by serial systems.

Orthogonal Frequency Division Multiplexing (OFDM), a wideband multicarrier wireless digital communication technique based on modulation, achieves required bit rates and high speeds, particularly in wireless multimedia applications. Fading may cause errors in received bits, but error-correcting codes, adding extra bits at the transmitter, correct many or all incorrectly received bits. Modulation schemes for high data rate transmissions may induce Inter-Symbol Interference (ISI) due to channel delay spread, necessitating high-performance equalizers. Multicarrier modulations (MCM), such as OFDM, divide high data rate serial streams into parallel streams with lower data rates. The number of sub-channels is chosen to increase symbol time compared to channel delay spread and reduce sub-stream bandwidth size relative to the channel coherence bandwidth, making ISI bearable. OFDM, an FFT-based MCM scheme, is a leading contender for next-generation communication systems. Space-time coding introduces redundancy in space and time through techniques like STBC and Space Time Trellis Codes (STTC). STBC ensures consistent coverage in all directions, addressing infrastructure complexity. STTC balances diversity and coding gain at the expense of higher decoding complexity. Concatenating STBC with an outer code, like Trellis Coded Modulation (TCM), provides coding gain. Concatenating STBC with Raucous Coded Replace with (TCM) creates bandwidth-efficient conventions with coding gain. In conclusion, the MIMO-OFDM system, enriched with STBC and other advanced techniques, stands as a robust solution for achieving high data rates, reliability, and efficient communication in the evolving landscape of wireless networks.

2. OVERVIEW

Simulation of wireless channels accurately is very significant for the design and performance evaluation of wireless communication systems and components. Fading or loss of signals is a very important phenomenon and must be well understood by all engineers related to the Wireless Communications Field. The fading models which try to explain the fading patterns in different environments and situation. Although no model can 'perfectly' explain an environment, they strive to get as much precision as possible. The enhanced a model can describe a fading environment, the enhanced can it be compensated with other signals, so that, on the receiving end, the signal is error free or at least close to being error free? This would mean higher precision of voice and higher accuracy of data transmitted over wireless medium.

Frequency bands utilized by wireless devices are strictly specified by responsible regulatory bodies, which set limits on the bandwidth available for communication. Therefore, a very

natural and important question is what the maximum data rate is (equivalently, information rate) at which reliable communication over a mobile channel of a given bandwidth is attainable. This quantity is known as the channel capacity. For AWGN channels of a given bandwidth, Shannon [1] has derived the well-known expression for the maximum data rate that can be achieved, for reliable communication. The average BER can be made randomly close to zero by use of channel coding, for transmissions up to the maximum reachable rate. For mobile channels, that are time-varying and dispersive in time and frequency however, the channel capability derivation is still an open research region. In this system, we point out the lack of equivalent vector channel models for realistic continuous-time single input single output and multiple input multiple output dispersive fading channels. Such models serve as the foundation upon which channel capacity results are derived.

The study of the achievable average error rate performance of communication systems is a natural complement to the study of channel capacity, since waveform fading channel models or their equivalent vector channel models are now used in the context of actual communication systems which include a transmitter and receiver. The average error rate performance, quantified via the minimal average symbol error probability, is a measure of communication reliability. Given a realistic fading channel model and a transmitter configuration, the study objective is to minimize the error rate performance by an appropriate choice of receiver design. An example of a common signaling scheme and a common received-signal discrimination technique is the use of Nyquist sampling of the received signal. This approach is neither optimal in the sense of minimizing the average error rate performance, nor have they been previously compared (in sense of the achievable error performance) to optimal communication systems that perform an ML detection of the received data symbols. Nyquist signal sampling doesn't maximize the SNR in the received signal observables when the received signal is not band limited. Additionally, it can be information-lossy when the number of samples is finite [2]. Also, the interference cancellation techniques, commonly used prior to symbol detection, diminish the positive effects of implicit channel diversity [3] ordered by time/frequency- selective fading channels.

3. PERFORMANCE MEASURES

Some key measures of performance related to practical communication system design are as follows:

Signal to noise Ratio (SNR) It is a vital performance measure of a communication system. This performance determine is usually measured at the output of the receiver and indicates the overall quality of the system. For wireless communication system due to the occurrence of fading, the instantaneous SNR is a random variable.

Outage Probability: It is another important measure of performance to calculate the quality of service provided by wireless systems over fading channels and is defined as the probability that SINR falls below a certain threshold.

Average Bit Error Probability (BEP): It is one of the most informative indicators about the performance of the system. This measure can be obtained by averaging the conditional (on the fading) BEP over fading statistics.

Bit Error Rate (BER): In digital modulation techniques, due to some noise, interference, and distortion the received bits are altered .So bit error rate is defined as the number of error bits divided by total number of transmitted.

$$\text{Bit Error Rate (BER)} = \frac{\text{No of bits in error}}{\text{Total no of transferred bits}}$$

The performance of modulation is calculated BER with assumption that system is operating with AWGN. Modulation schemes which are able of delivering more bits per symbol are more immune to errors caused by noise and interference in the channel. Moreover, errors can be easily formed as the number of users is increased and the mobile terminal is subjected to mobility. Thus, it has driven many researches into the purpose of higher order modulations.

4. Proposed Method

We introduce MIMO systems, which use multiple antennas at the transmitter and receiver ends of a wireless communication system in this work. MIMO systems are increasingly being adopted in communication systems for the potential gains in capability they understand when using multiple antennas. Multiple antennas use the spatial dimension in addition to the time and frequency ones, without varying the bandwidth need of the system.

For a generic communications link, this demo focuses on transmit diversity in lieu of conventional receive diversity. Using the flat-fading Rayleigh channel, it illustrates the concept of Orthogonal Space-Time Block Coding, which is employable when multiple transmitter antennas are used. It is assumed here that the channel undergoes free fading between the multiple transmit-receive antenna pairs.

For a chosen system, it also provides a measure of the performance degradation when the channel is incorrectly estimated at the receiver, compared to the case of perfect channel knowledge at the receiver.

5. RESULTANALYSIS

The diversity reception is a well-known technique to mitigate the effects of fading over a communications link. But if we concentrate on the same thing then it can be overlay on the last end only. In this work we also propose diversity for the transmission which can employ and provides a better way of diversity gain when using n antennas or multiple antennas. So we can say that the more number of antennas, the higher space-time coding diversity gain and the better performance of system. So BER of the system with 4 antennas is lower than that with 2 antennas. We can apply receive and transmit diversity by applying coherent binary phase-shift keying (BPSK) modulation over flat- fading Rayleigh channels. For transmit diversity we can use 1*1, 1*2, 2*1, 2*2,4*1,4*2 etc. antenna combinations.

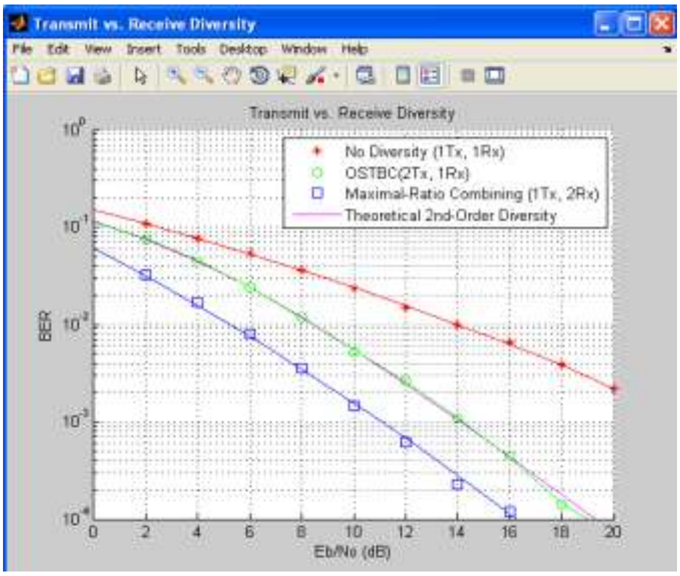

Figure 1: Output1.

After experimentation we also realize that transmit diversity has a disadvantage when compared to MRC receive diversity. Because the transmitted power in both in the transmitted and the receiving case is same. So the nature of performance is identical, because if we analyze the transmitted and receive power then the transmitted power such that the received power for these two cases is the same, then the performance would be identical. The theoretical performance of second-order diversity link matches the transmit diversity system as it normalizes the total power across all the diversity branches.

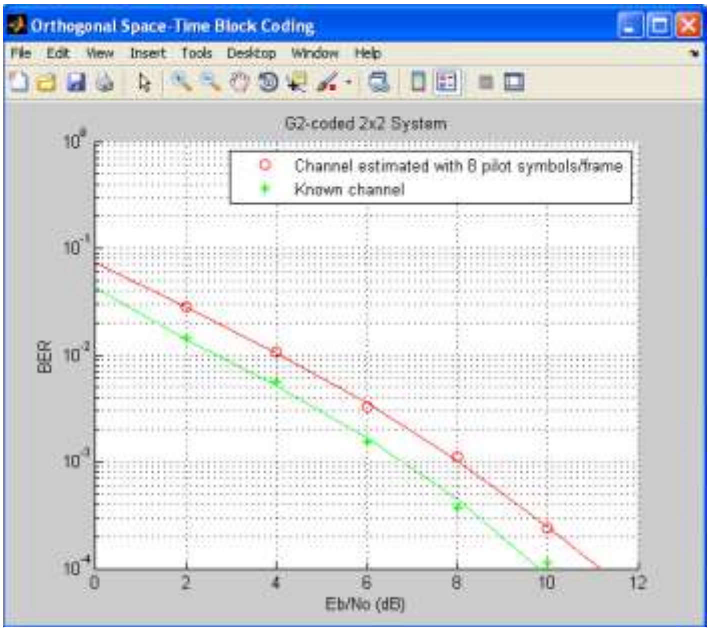

Figure 2: Output 2.

We also study the performance of such a scheme with different receive antenna and analysis with different respects. In the practical situation the data will be extracted from the receiver side knowing the visible states of all other system status. We consider the orthogonal signal which is send with the every packet data transmitted to the receiver for the channel estimators. It is assumed that the channel remains unchanged for the length of the packet, because of the slow fading. A similar experimentation is also adopted which leads us to estimate the BER performance for a space-time block coded system using two transmit and two receive antennas.

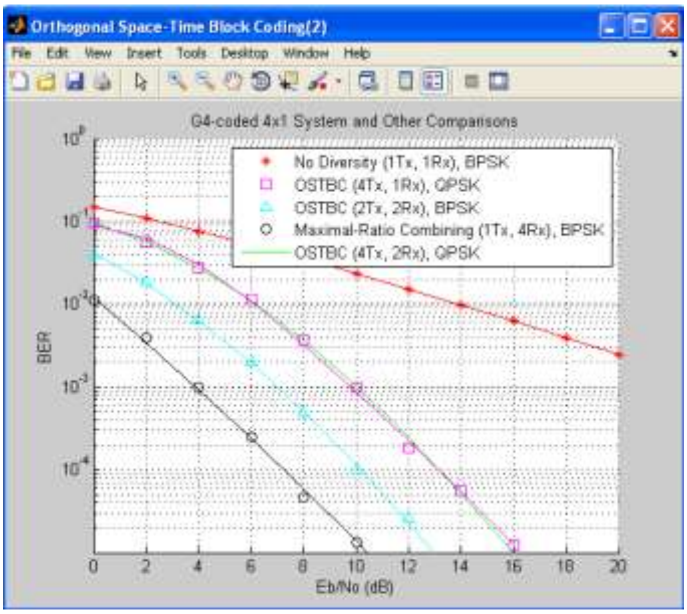

Figure 3: Output 3.

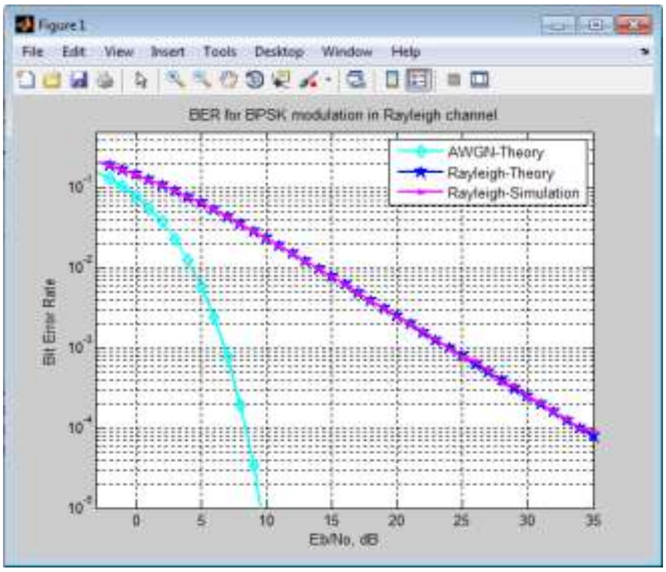

Figure 4: BER for BPSK modulation in Rayleigh Channel.

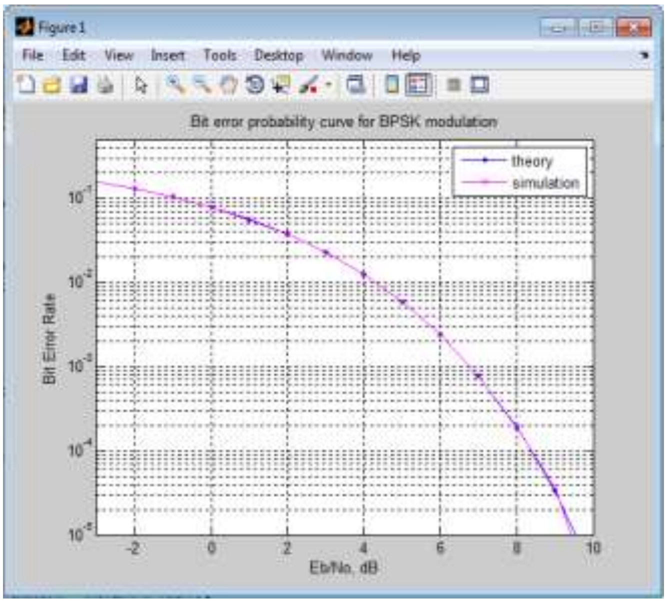

Figure 5: BER probabilities Curve for BPSK Modulation.

6. CONCLUSION

This work is devoted to space-time coding for multiple- input/multiple-output (MIMO) systems. The enhance of space-time codes for wireless multiple-antenna systems with and without channel state information (CSI) at the transmitter has been also studied. In this work, the different properties of an MIMO System are analyzed and we also analyzed the effect of noise within frequency selective fading channel of this system. Multi input Multi output is a very attractive technique for multicarrier transmission and become one of the standard choices for high speed data transmission over a communication channel. It has various advantages, but also has one main drawback i.e. Effect of noise within frequency selective fading channel In this paper we present BER Analysis for MIMO OFDM System using Different Modulation Schemes. In this paper we present a comparative study with in phase component to show the better noise reduction parameters.

Its performance is analyzed with the help of powerful simulation tool MATLAB. Our Simulation result shows that the performance in term of bit error rate is increased by our proposed methodology. One common aspect of STBC design is that it is assumed that no channel information is available at the transmitter. However, the performance of multiple antennas can be improved if channel state information obtained at the receiver is fed back to the transmitter. Exploiting partial channel knowledge at the transmitter, two simple channel adaptive transmission schemes, namely, channel adaptive code selection and channel adaptive transmit antenna selection have been proposed.

REFERENCES

[1] Mr. S.S. Pandagale*1, Prof. Mrs. V.C. Maindargi*2 " BER Analysis of MIMO-OFDM System Using V-BLAST And STBC" ,International Research Journal of Modernization in Engineering Technology and Science (Peer-Reviewed, Open Access, Fully Refereed International Journal) Volume:05/Issue:08/August-2023

[2] Younes Djemamar* , Saida Ibnyaich, and Abdelouhab Zeroual," Space-Time Block Coding Techniques for MIMO 2×2 System using Walsh-Hadamard Codes"J. lnf. Commun. Converg. Eng. 20(1): 1-7, Mar. 2022

[3] Mranali Joshi Amar Nath Dubey Debendra Kumar Panda, *"Analysing various Fading channels using different Modulation Techniques under IEEE 802.16 Standard"*, IEEE Sponsored 2nd International Conference On Electronics And Communication System (ICECS 2015).

[4] Mohd. Abuzer Khan1, Sonu Pal2, Ankita Jose3, *"BER Performance of BPSK, QPSK & 16 QAMwith and without using OFDM over AWGN,Rayleigh and Rician Fading Channel",* International Journal of Advanced Research in Computer and Communication Engineering Vol. 4, Issue 7, July 2015.

[5] Pratima Manhas, M.K Soni, *"Performance Analysis of DWT-OFDM and FFT-OFDM using Various Digital Modulation Techniques and Channel Coding",* International Journal of Computer Applications (0975 – 8887) Volume 128 – No.11, October 2015.

[6] Deepak K. Chy1, Md. Khaliluzzaman, *"Evaluation of SNR for AWGN, Rayleigh and Rician Fading Channels Under DPSK Modulation Scheme with Constant BER"*, International Journal of Wireless Communications and Mobile Computing 2015; 3(1): 7-12 Published online February 6, 2015.

[7] Deepak Bactor , Rajbir Kaur and Pankaj Bactor, *"Diversity Techniques using BPSK and QPSK Modulation in MIMO system under fading environment",* International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE) Volume 4, Issue 5, May 2015.

[8] S.Sowndeswari, Dr.C.V.Ravishankar, *"Performance analysis of mobile & cellular communication system using M-ary modulation techniques by using PSK",* International Journal of Application or Innovation in Engineering & Management (IJAIEM) Web Site: www.ijaiem.org Email: editor@ijaiem.org Volume 4, Issue 11, November 2015 ISSN 2319 – 4847.

[9] Sachin Natasha Chandni, *"Analyzing the BER Performance of OFDM-System with QPSK and BPSK Modulation Technique",* International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 Issue 6, Volume 2 (June 2015).

[10] Karanpreet Kaur, Ankush Kansal, *"Performance Analysis of Convolutional Interleaved DWT based OFDM system",* International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 5, May 2014.

[11] Sutanu Ghosh, *"Performance Analysis On The Basis of A Comparative Study Between Multipath Rayleigh Fading And AWGN Channel in the Presence Of Various Interference",* International journal of Mobile Network Communications & Telematics (IJMNCT) Vol. 4, No.1, February 2014.

[12] Prajoy Podder, T Zaman Khan, Mamdudul Haque Khan, M. Muktadir Rahman , *"BER Performance Analysis of OFDM-BPSK, QPSK, QAM Over Rayleigh Fading Channel & AWGN Channel",* International Journal of Industrial Electronics and Electrical Engineering, ISSN: 2347-6982 Volume-2, Issue-7, July-2014.

[13] Pratima Sharma, Bhaskar Singh and Pushpraj Singh Tanwar, *"A Review in Multiple Modulation Techniques 16 and 64 QAM MIMO-OFDM BPSK-QPSK-PSK system",* International Journal of Electrical, Electronics ISSN No. (Online): 2277-2626 and Computer Engineering 3(1): 196-200(2014).

[14] E kwe O. A., 2Abioye, A. E., 3Oluwe, M. O., 4Okoro, K.C, *"Effective Fading Reduction Techniques in Wireless Communication System",* IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 9, Issue 4, Ver. II (Jul - Aug. 2014), PP 35-43,w ww.iosrjournals.org

[15] Anurag Pandey , Sandeep Sharma, *"BER Performance of OFDM System in AWGN and Rayleigh Fading Channel",* International Journal of Engineering Trends and Technology (IJETT) – Volume 13 Number 3 – Jul 2014.

[16] Mrityunjay Prasad Tripathi, Dr.Soni Changlani, Prof.Saiyed Tazin Ali, *"Performance Comparison of M-PSK and M-QAM Modulations for WiMAX OFDM system under the Rayleigh Fading Channel",* International Journal of Technological Exploration and Learning (IJTEL) , ISSN: 2319-2135, vol.3, no.2, April 2014.

[17] R. Asif, R. A. Abd-Alhameed, O.O. Anoh and Y.A.S. Dama, *"Performance Evaluation of DWT-FDM and FFT-OFDM for Multicarrier Communications Systems using Time Domain Zero Forcing Equalization"*, Communications on Applied Electronics (CAE) Foundation of Computer Science FCS Volume 1– No.1, December 2014.

[18] Abdul Haq N , Rajani Katiyar and Padmaja K V, *"BER performance of BPSK and QPSK over rayleigh channel and AWGN channel",* ISSN 2319 – 2518 www.ijeetc.com Vol. 3, No. 2, April 2014 © 2014 IJEETC.

[19] Arpita Mishra1, Stuti Rastogi , Ritu Saxena , Pankaj Sharma , Sachin Kumar *"Performance analysis of MB-OFDM system with QPSK AND QAM for wireless communication",* International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 2, February 2013.

[20] G.Tharakanatha1, SK. Mahaboob kamal basha, Vijay Bhaskar chanda, I.Hemalatha, *"Implementation and Bit Error Rate analysis of BPSK Modulation and Demodulation Technique using MATLAB",* International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 9- Sep 2013.

[21] Md. Mejbaul Haque, Mohammad Shaifur Rahman and Ki-Doo Kim, *"Performance Analysis of MIMO-OFDM for 4G Wireless Systems under Rayleigh Fading Channel",* International Journal of Multimedia and Ubiquitous Engineering Vol. 8, No. 1, January, 2013.

[22] G. Mahesh Naidu, O. Sudhakar, V. Sailaja, *"Simulation of BPSK Modulation and Demodulation on System Generator",* International Journal of Scientific Engineering and Research (IJSER) www.ijser.in ISSN (Online): 2347-3878 Volume 1 Issue 2, October 2013.

[23] Mr. Anshul Soni1, Mr. S.J. Basha, Mr. Ashok Chandra Tiwari, *"Comparative Analysis of OFDM under FFT and DWT Based Image Transmission",* International Journal of Innovative Research in Computer and Communication Engineering Vol. 1, Issue 2, April 2013.

[24] M. Mirahmadi, Member, IEEE, A.Al-Dweik, Senior Member, IEEE, and A.Shami, Senior Member, IEEE, *"BER Reduction of OFDM Based Broadband Communication Systems over Multipath Channels with Impulsive Noise",* IEEE Transactions on Communications, vol.61, No.11, November 2013.

[25] R. Asif, R. A. Abd-Alhameed, O.O. Anoh and Y.A.S. Dama, *"Performance Evaluation of DWT-FDM and FFT-OFDM for Multicarrier Communications Systems using Time Domain Zero Forcing Equalization",* International Journal of Computer Applications (0975 – 8887) Volume 51– No.4, August 2012.

[26] Umesh Sharma, *"Comparative Study of Digital Modulation Techniques in WIMAX",* International Journal of Engineering and Innovative Technology (IJEIT), vol.2, No.2, August 2012.

[27] Achala Deshmukh1 and Shrikant Bodhe, *"Comparison of DCT and Wavelet Based OFDM System Working in 60 GHz Band"* , International Journal of Advancements in Technology, Vol. 3 No.2 (April 2012) © IJAT.

[28] Anuradha.R.Kondelwar, and Dr.K.D.Kulat, *"BER Analysis of Proposed Wimax System in different channel Environments",* International Journal of Emerging Technology and Advanced Engineering (IJETAE), vol.2, No.9, September 2012.

[29] Khairi Ashour Hamdi, Senior Member, IEEE, *"Analysis of OFDM over Nakagami-m Fading with Nonuniform Phase Distributions",* IEEE Transactions on Wireless Communications, vol.11, No.2, February 2012.

[30] Brian Krongold, Timo Pfau, Noriaki Kaneda and Sian Chong Jeffrey, *"Comparison between PS-QPSK and PDM-QPSK with equal rate and bandwidth",* IEEE photonics technology letters, vol.24, no. 3, February 1, pp 203-205 ,2012.

[31] Suchita Varade, Kishore Kulat, *"BER Comparison of Rayleigh Fading, Rician Fading and AWGN Channel using Chaotic Communication based MIMO-OFDM System",* International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-1, Issue-6, January 2012.

[32] Md. Sipon Miah, M. Mahbubur Rahman, T. K Godder, Bikash Chandra Singh and M. Tania Parvin, *"Performance Comparison of AWGN, Flat Fading and Frequency Selective Fading Channel for Wireless Communication System using 4QPSK",* Copyright © 2011 Ijcit, Issn 2078-5828 (Print), Issn 2218-5224 (Online), Volume 01, Issue 02, Manuscript Code: 110125.

[33] A. Sudhir Babu Dr. K.V Sambasiva Rao, *"Evaluation of BER for AWGN, Rayleigh and Rician Fading Channels under Various Modulation Schemes",* International Journal of Computer Applications (0975 – 8887) Volume 26– No.9, July 2011

[34] A. Omri and R. Bouallegue, *"New Transmission Scheme for MIMO- OFDM System",* International Journal of Next Generation Networks (IJNGN) Vol.3, No.1, March 2011.

[35] Swati Sharma and Sanjeev Kumar, *"BER Performance Evaluation of FFT-OFDM and DWT-OFDM",* International Journal of Network and Mobile Technologies ISSN 2229-9114 Electronic Version VOL 2 / ISSUE 2 / MAY 2011.

[36] Min, G., Yusheng, J., Han, H., and Xiaokang, L., *"Tow-Dimensional Demodulation for 64-DAPSK Modulated OFDM Signal",* IEEE CCNC, proceedings (2010).

[37] Jiang, Y., *"New companding transform PAPR reduction in OFDM",* IEEE Transaction on communications 14(4), 282-284(2010).

[38] Xiaolong Li, *"Simulink-based Simulation of Quadrature Amplitude Modulation (QAM) System",* Indiana State University, Proceedings of The 2008 IAJC-IJME International Conference ISBN 978-1-60643-379-9.

[39] Abdullah, K., and Hussain, Z. M., *"Performance of Fourier-Based andnWavelet-Based OFDM for DVB-T Systems",* Australasian Telecommunication Networks and Applications Conference, 475-479 (2007).

[40] Y. Byungwook, H. L. Kyu and L. Chungyong, *"Implementation of IEEE 802.16e MIMO-OFDMA Systems with K-BEST Lattice Decoding Algorithm",* International Conference on Consumer Electronics. Las Vegas, NV, USA, 2007.

[41] Mr. S.S. Pandagale*1, Prof. Mrs. V.C. Maindargi*2 " BER Analysis of MIMO-OFDM System Using V-BLAST And STBC" , International Research Journal of Modernization in Engineering Technology and Science (Peer-Reviewed, Open Access, Fully Refereed International Journal) Volume:05/Issue:08/August-2023