Performance Measures of Adaptive Channel Estimation methods for Enhanced MIMO-OFDM

[1]Milendrakumar M. Solanki and J.M. Rathod[2]
[1]Assistant Professor, [2]Associate Professor
[1,2] Department of Electronics Engineering Department, Birla Vishvakarma Mahavidyalaya Engineering College,
Opposite Shastri Medan, Vallabh VidyaNagar, Gujarat, India.
[1,2]Orcid Id: 0000-0002-0276-1757, 0000-0001-6474-2386

Abstract

Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing(MIMO-OFDM) estimates the channel using one antenna at a time for sequence transmission and the other antenna has been kept idle. This paper present the enhanced adaptive channel estimation technique. Here the simulations are carried out for the performance measure of the adaptive channel estimation technique of the MIMO-OFDM system for wireless fading channel like Rayleigh channel, AWGN Channel etc. In this paper BER performance of the SISO-OFDM is compared with MIMO-OFDM by using adaptive channel estimation techniques for same number of message symbols. The SISO-OFDM modulation with various modulation techniques is applied on Rayleigh and AWGN channels . The simulation results shows the effectiveness of the proposed enhanced channel estimation using MIMO-OFDM algorithm.

Keywords: BER, OFDM, MIMO, Channel Estimation, Adaptive system.

INTRODUCTION

MIMO uses multiple antennas at transmitter and receiver side for improving communication performance. In limited bandwidth MIMO system provides higher spectral efficiency compare to SISO (single input single output), MISO (multiple input single-output), SIMO (single input multiple output). MIMO offers major advantage of increased data throughput and link range with the same available bandwidth and transmit power. To achieve this it distributes same total transmit power among antenna for improving spectral efficiency and link reliability. Requisition of high data speed can be achieved through MIMO channel [1].Mobility of the wireless communications has been increased by MIMO channel and hence next-generation wireless services like as WiMAX (worldwide interoperability for microwave access), WLANs (wireless local area networks), WiFi (wireless fidelity), 3GPP (3rd generation partnership project) , cognitive radio and LTE (long term evolution) use MIMO [2]. Incorporation of OFDM with MIMO, which is known as MIMO-OFDM systems Proves to be a sensitive toward synchronization errors. Co-channel interference caused by antennas because of simultaneous transmission of signal makes MIMO- OFDM more complex than a single antenna system, which challenges the need to develop the algorithm which can provide high accuracy for MIMO-OFDM system performance. The review of existing channel estimation methods has been done and the work has been proposed to enhance the performance of adaptive channel estimation technique of the MIMO-OFDM system. The proposed algorithm checks the BER performance of the system with various modulations scheme for MIMO-OFDM. The performance of the BER for SISO-OFDM has been compared with MIMO-OFDM using adaptive channel estimation techniques for same number message symbols and simulated with Rayleigh and AWGN channels.

CHANNEL ESTIMATION METHODS IN MIMO-OFDM SYSTEM

Different methods are available for channel estimation mainly pilot aided [2] and blind [7] approaches. Pilot assisted approach, a portion of the bandwidth is assigned to training symbols and in Blind approach, which can be implemented by using statistical properties. In pilot aided method, Equiv space pilots are inserted amongst subcarrier at transmitter side, which are known to the receiver end and has been extracted to estimating the channel, which is followed by interpolation for another subcarriers. Mainly pilots are inserted using Block type and comb type pilot arrangements. Every OFDM symbol consist of the pilot tones at periodically placed subcarriers in arrangement of comb type pilot. It has been used for a interpolation in frequency-domain to estimate the channel[1]. In block type all the subcarriers has been used as pilots. LS or MMSE has been used to estimate the channel. A statistical property of received signals has been used in Blind Channel Estimation by which without resorting to the preamble or pilot the channel will be estimated. The advantage of Blind channel estimation technique is that it cannot incur an overhead with training signals rather large amount of received symbols required to extract statistical properties.

PROPOSED ADAPTIVE CHANNEL ESTIMATION ALGORITHMS FOR MIMO-OFDM

Adaptive algorithms like RLS (Recursive Least Square), Kalman filter.LMS (Least Mean Square), which are used in major applications of Radar system. Estimation of Wireless channel etc. Among these LMS has been proved powerful due to simplicity in simultaneous channel estimation of all subcarriers at receiver side. Primarily, it uses LS (least square) method followed by linear interpolation for estimation purpose.

In LMS algorithm, parameters of Channel estimation can be obtained from each iteration, which is to be used for next iteration. The Step-size μ is to be considered very precisely as its very important parameter for the channel estimation through proposed method. Estimation of the channel coefficients can be done using LMS recurrence method. In this Proposed algorithm the convergence time will be decided by step size μ and must be selected properly to achieve the result close to that of LS method. The small value of μ results in long convergence time which will not serve the purpose of LMS algorithm at the same time too large value of μ results in failure in converge of algorithm.

Steps for Channel Estimation

(1) Initially the train of sample is passed through filter which yield

$y(n) = \hat{W}^H(n)u(n)$……(1)

(2) Error at iteration n is given by

$E(n) = d(n) - \hat{W}^H(n)u(n)$……..(2)

(3) Co-efficient of the FIR filter are updated by

$\hat{W}(n+1) = \hat{W}(n) + \mu \times u(n)E^*(n)$…….(3)

The coefficient has been updated iteratively by proposed algorithm and given it to the FIR filter which uses this coefficient $\hat{W}(n)$ and input reference signal $x(n)$ to produce the output $y(n)$, then subtract this output from the desired signal $d(n)$ to find an error. Using this error the coefficient can be computed by the algorithm.

Steps for the simulations in AWGN channel

1. First decide the number of bits and number of symbols to be modulated by OFDM. Here 52 numbers of bits and 7000 message symbol are taken.

2. After deciding FFT size and number of subcarriers Es/No (symbol to Noise Ratio) has been found.

3 Implement the SNR equation and then apply the QPSK,4-QAM, 8-PSK,BPSK modulation scheme.

4. Using QPSK modulation scheme, Generate the data to be modulated and to be transmitted.

5. After serial to parallel conversion insert the pilot data and then apply IFFT.

6.. Insert the cyclic prefix and then convert the data into serial to parallel.

7. Pass this data from the AWGN channel.

8. Then equalize the channel using LMS channel algorithm as below:

(a) Error at iteration n is given by,

$E(n) = d(n) - \hat{W}^H(n)u(n)$……(4)

(b) Co-efficient of the FIR filter are updated according to

$\hat{W}(n+1) = \hat{W}(n) + \mu \times u(n)E^{*}(n)$…………(5)

9. Estimate the received signal and demodulate the received signal.

10. Plot the bit error rate Vs Signal to noise ration on semi log axis.

Steps for the simulations in Rayleigh channel

1. First decide the number of bits and number of symbols to be modulated by OFDM. Here 52 numbers of bits and 7000 message symbols are taken.

2. After deciding FFT size and number of subcarriers implement the Es/No (symbol to Noise Ratio) equation.

3. Implement the SNR equation and then apply the QPSK,4-QAM,8-PSK,BPSK modulation scheme.

4. Generate the data to be modulated and to be transmitted.

5. After serial to parallel conversion insert the pilot data and then apply IFFT.

6. Insert the cyclic prefix and then convert the data into serial to parallel.

7. Pass this data from the Rayleigh channel.

8. Then equalize the channel using LMS channel algorithm as below:

(a) Error at iteration n is found using equation (4)

(b) Co-efficient of the FIR filter are updated using equation

Number (5)

9. Estimate the received signal and demodulate the received signal.

10. Plot the bit error rate Vs Signal to noise ration on semi log axis.

RESULTS AND DISCUSSION

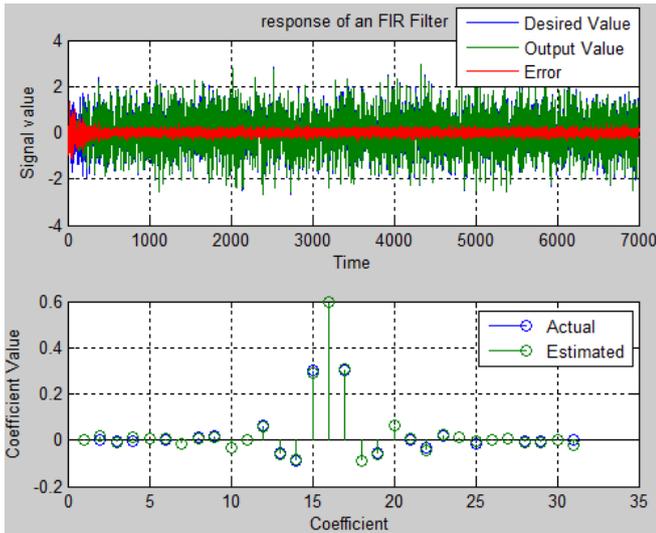The simulation results for the proposed algorithm has been shown.

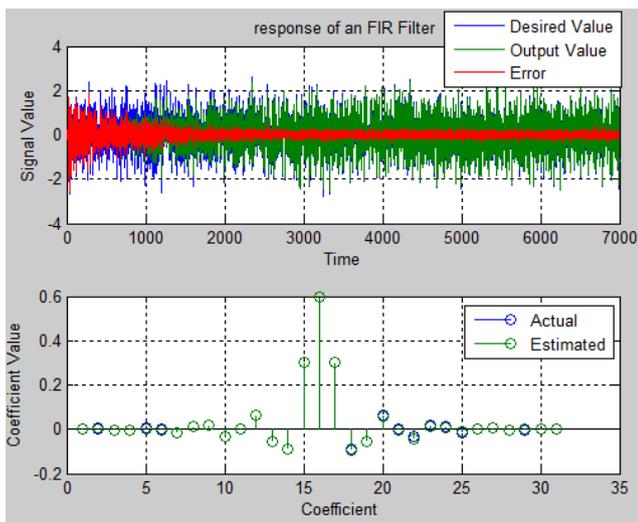**Figure 1:** Plot for response of an LMS filter for step size μ=0.01

Figure 2: Plot for response of an LMS filter for step size μ=0.001

The precision must be taken for selecting appropriate step size. A randomly selected high value results in large variation of an error. To compute the step size, it is required to consider the parameter such as channel properties, sampling rate, signal properties, etc. Experimental Simulations are carried out by varying the step size to get faster convergence.

This proposed methodology is having   following two drawbacks.

1. Selection of design parameters is an iterative and time-consuming process. It is discouraging to consider the number of trials needed for selecting the best combination of design parameters, without any other knowledge of the adaptive filter's behavior for simple just like the LMS adaptive filter.

2. It requires the large   amount of data for accurate

characterization of the behavior of the adaptive filter for all presented cases.

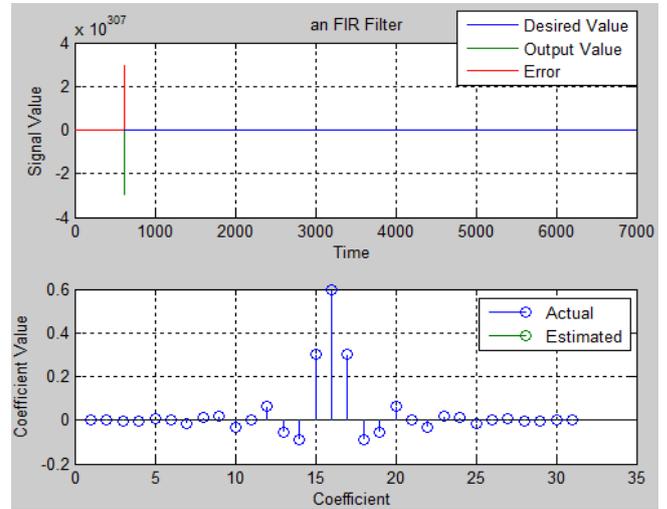Above disadvantages makes this algorithm a poor choice to characterize the performance of an adaptive filter:

Figure 3: Plot for response of an LMS filter for step size μ=0.8

The adjustment of adaptive filter parameters are directly proportional to the tap-input vector so LMS filter get a problem of gradient noise amplification problem for large values of μ.This problem has been solved in proposed algorithm by using N-LMS(Normalized LMS) filter. In this filter, the tap-weight vector is adjusted at iteration $n+1$ and is "normalized" with respect to the square Euclidian norm of the tap-input vector u(n) at iteration n.
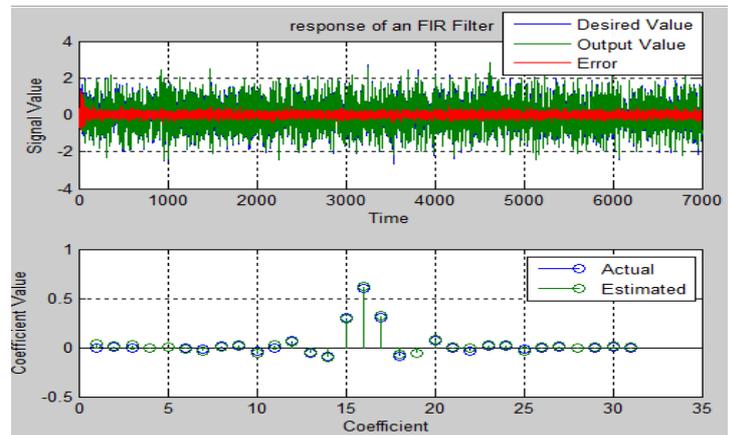

Figure 4: Plot for response of an N-LMS filter for step size μ=0.8

Simulation result shows here that filter reaches steady state even though for very low value of step size. The variation in amplitude is also very low compared to the same step size in LMS filter. A positive real scaling factor ($\tilde{\mu}$) is introduced for regulating control over the tap-weight vector changes with every iteration by avoiding any changes in direction of the vector. The adaption constant $\tilde{\mu}$ for normalized LMS filter does not have any dimension but the adaption constant μ used

by the LMS algorithm has the dimension of inverse power. For both uncorrelated and correlated input data, the normalized LMS algorithm gives a rate of convergence much faster than the standard LMS algorithm. Also, it was experimentally found that N-LMS algorithm convergences faster than LMS for less number of samples. It will reaches steady state condition as soon as it convergences which will have some delay in LMS algorithm.
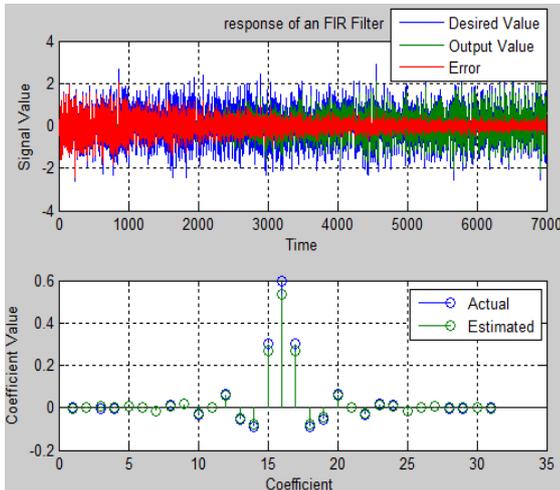
We see the results for the Alamouti's scheme where only 2x1 antennas are used. Here for the 2x2 MIMO with the OFDM modulation we get the improvement in the BER performance for the wireless fading channel like Rayleigh. We first simulated BER Vs SNR plot for SISO-OFDM
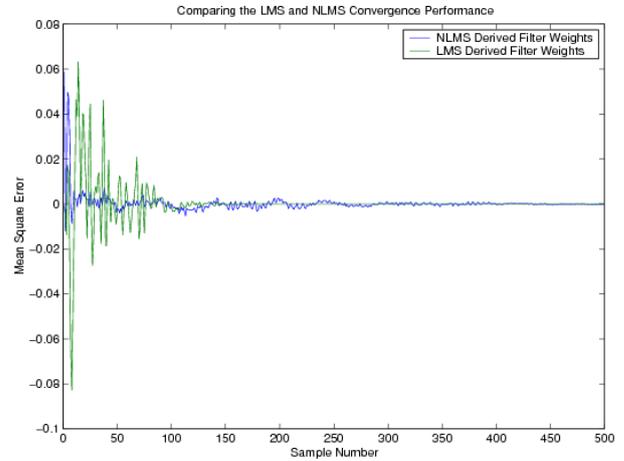

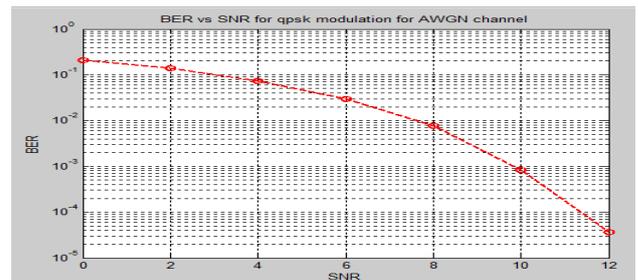**Figure 7 :** Comparison of convergence speed for NLMS and LMS weights

Figure 5 : Plot for response of an NLMS filter for step size μ=0.001

Figure 8: Plot for BER Vs SNR for QPSK modulation AWGN channel μ=0.01

Figure 6: Plot for response of an NLMS filter for step size μ=0.001

The LMS algorithm is implemented for SISO-OFDM and MIMO-OFDM for AWGN and Rayleigh channel. The Number of symbols used is 7000. The FFT size is 52 which is equal to the number of bits per symbol. Since signal to noise ratio is continuously varying over the channel. We can see the drastic improvement in the BER and in the SNR. As we see the output for the AWGN channel is better than the Rayleigh channel.
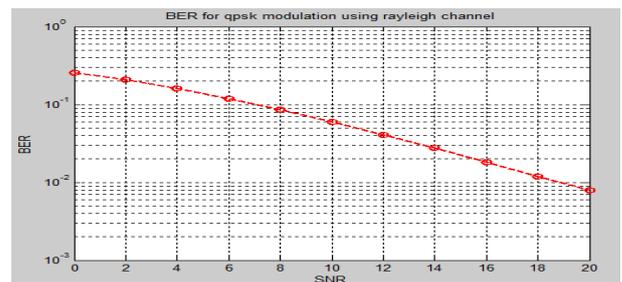

Figure 9 : Plot for BER Vs SNR for QPSK modulation Rayleigh channel μ=0.01

For the SISO-OFDM with QPSK modulation the BER performance is to be checked at different values of SNR. Here 7000 message symbols are considered and the BER is decreasing with increasing in SNR. Also the comparison of BER results of AWGN and Rayleigh channel shows that for higher values of SNR the BER of AWGN channel is high compared to Rayleigh channel.

Simulation result shows here that for lower values of the SNR the bit error rate performance is high but for higher values of SNR the BER performance of the system is good. But this is limit for bit error rate performance in 8-PSK which approximately archives performance closer to that of the 16-QAM. Then we should use other QAM techniques like 64-QAM, 128 QAM etc.
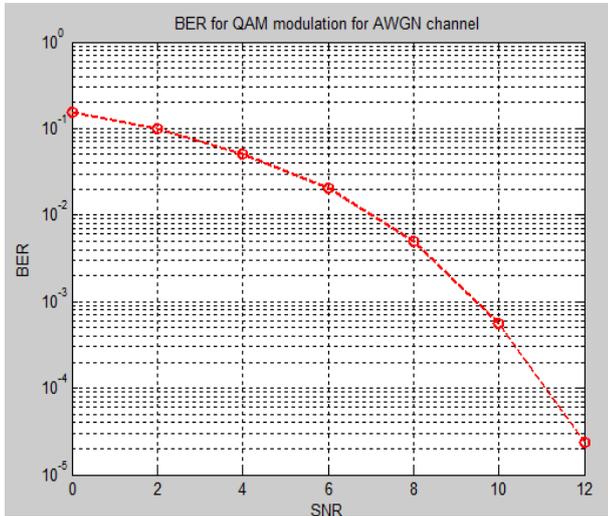

Figure 10: Plot for BER Vs SNR for 4-QAM modulation AWGN channel µ=0.01

for further reduction in bit error. If require data-rate is higher then offered by 8-PSK , then QAM is the better choice. In the I-Q plane, it achieves a greater distance between adjacent points by more evenly distributing the points.
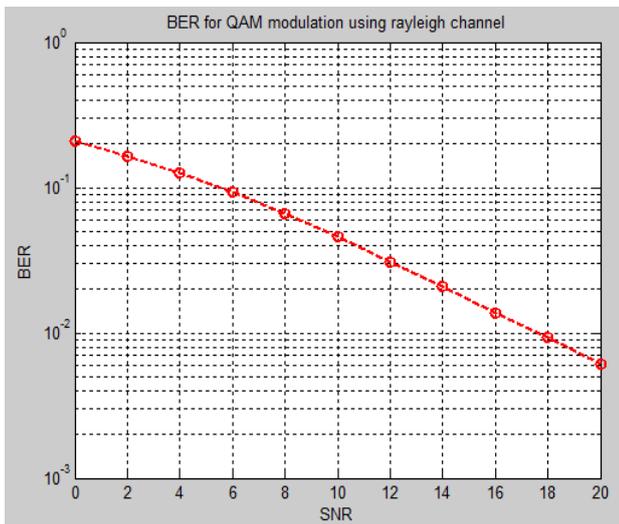

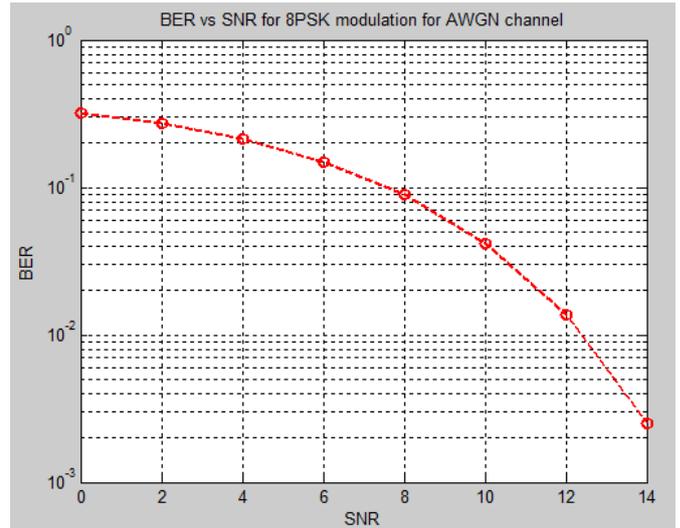**Figure 11:** Plot for BER Vs SNR for 4-QAM modulation Rayleigh channel µ=0.01

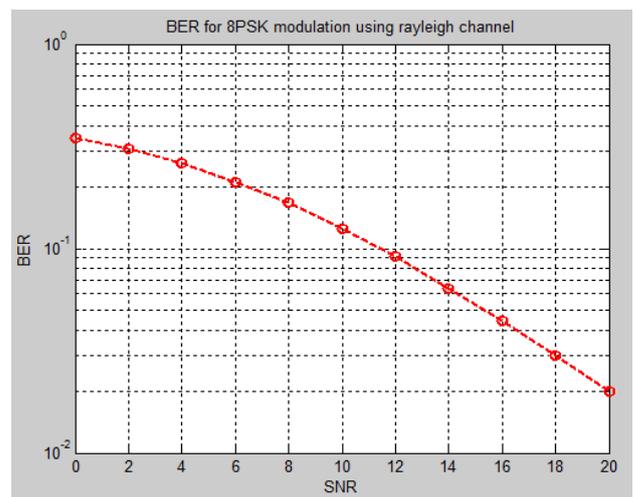**Figure 12:**Plot for BER Vs SNR for 8-PSK modulation AWGN channel µ=0.01

Figure 13: Plot for BER Vs SNR for 8-PSK modulation Rayleigh channel

For the SISO-OFDM with 8-PSK modulation the BER performance is to be checked at different values of SNR. In AWGN as SNR increases the BER has high values which can be further increased with increase in SNR. While in Rayleigh channel for low values of SNR the BER performance of the system is good, also at higher SNR the overall performance decreased. Also it was founded that 8-PSK has better performance in AWGN channel compared to Rayleigh channel for same values of bit error rate and signal to noise ratio.
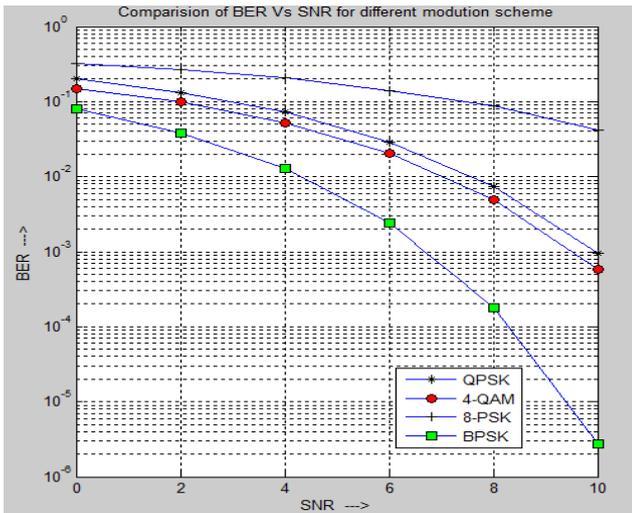
Figure 14: Plot for BER Vs SNR for different modulation techniques in (AWGN)

The bit error rates of the four modulation schemes BPSK, QPSK, 4-QAM and 8-PSK are shown in the figure 14 for AWGN channel. Gray coding is used by above all modulation schemes which offers a few dB of margin in the BER performance. As we seen in simulation result for different modulation techniques 8-PSK provides the bit error rate in close approximation to the 16-QAM but bit carryon capacity is third order of the 16-QAM.The simulation result for four modulation techniques in Rayleigh channel is shown in fig.15. Here also all modulation schemes use Gray coding. In this simulation result the BPSK modulation has lowest bit error for lower values of SNR. In further simulation higher modulation scheme is applied, in which bit error rate at higher SNR increases
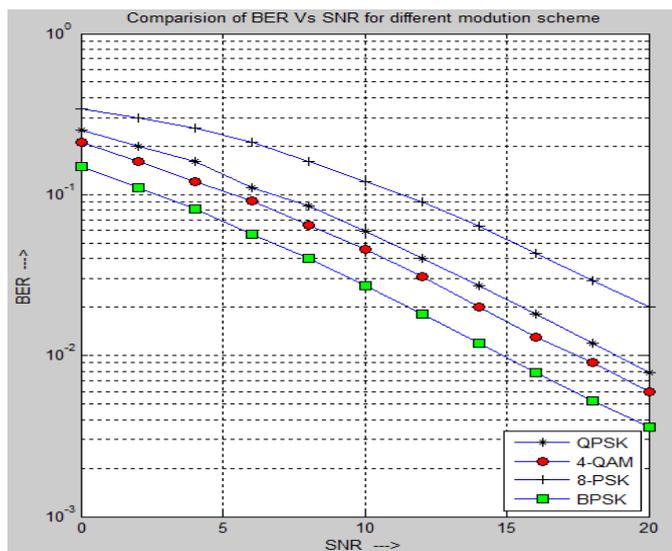

Figure 15 : Plot for BER Vs SNR for different modulation techniques in (Rayleigh)

Table 1: Comparison of BER Vs SNR for Rayleigh channel

SNR	BER (BPSK)	BER (QPSK)	BER (4-QAM)	BER (8-PSK)
0	0.15	0.25	0.21	0.34
2	0.11	0.20	0.16	0.30
4	0.082	0.16	0.12	0.26
6	0.057	0.11	0.092	0.21
8	0.040	0.085	0.065	0.16
10	0.027	0.059	0.046	0.12

The comparison in Table 1 shows that for SNR of 10 db BPSK modulation has very low bit error rate but at higher SNR the BER of the BPSK, QPSK, 4-QAM are approximate same. But for 8-PSK at higher SNR values bit BER is high which is not desirable.

The simulation result for 2x1 Alamouti scheme is shown in fig 16. The bit error rate Vs SNR graph shows that even though at higher SNR values it has low bit error rate compared to achieve with M-QAM techniques. Also by increasing number of antenna we can further reduced bit error rate. But this work is reserved for future expansion of MIMO-OFDM technique.
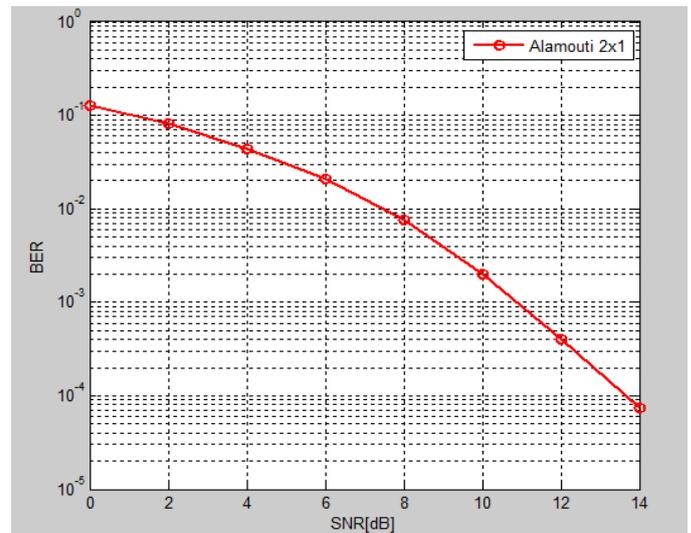

Figure 16 : Plot of BER Vs SNR for Alamouti scheme in AWGN channel

CONCLUSION

Using the OFDM and MIMO concept, the High Bit Rate and Link Reliability both achieved in wireless communication system. Here, in starting phase only OFDM system is consider and modulation techniques for all the subcarrier of the OFDM system are used like BPSK, QPSK and DPSK. The BER performance is analyzed for the AWGN and Rayleigh Fading. channels. Because of the Non Line of Site (N-LOS) for the

Rayleigh Channel the signal received from the multipath at the receiver. Obviously the BER is good for the AWGN channel compare to Rayleigh fading channel and that is observed in comparison of results. Using the 2x1 MIMO-OFDM combine, the system performance is better compare to OFDM system. Here, Only BPSK modulation technique is used for the modulation of all orthogonal subcarriers of the OFDM. The 2 transmitter antennas and 1 receiver antennas are used for the design of the MIMO. The BER performance is improved by combining the MIMO with OFDM. The different modulation techniques like BPSK, QPSK, 8-PSK and 4-QAM is applied for AWGN and Rayleigh channel using SISO-OFDM scheme. The important parameter in LMS technique is step size μ. By varying the step size had precise effect on bit error of the MIMO-OFDM system, which is proven in simulation. Also the number of iteration and convergence speed is an issue for this technique. Here simulation of NLMS techniques for same number of iteration and compare the result in both cases. The bit error rate performance of the system in AWGN and Rayleigh channel is different for various modulation techniques which is compared in tabular form

REFERENCES

[1] Ashish Kakadiya, S K Hadia, M M Solanki, J M Rathod, "Analysis of adaptive channel estimation techniques in MIMO-OFDM system", International journal of advancement in Resarch and Technology, IJoART (USA), Volume 2, issue 3, April2013.

[2] He Zhongqiu, Xing Yanan "Pilot aided channel estimation of MIMO-OFDM system", Vehicular Technology Conference (VTC Spring), 2013 IEEE Xplore: 06 January 2014

[3] Yongming Liangt, Hanwen Luot, Jianguo Huangtt "Adaptive RLS channel estimation in MIMO-OFDM system", Communications and Information Technology, 2005. ISCIT 2005. IEEE International Symposium , IEEE Xplore: 16 January 2006

[4] Navid daryasafar, Aboozar lashkari, Babak ehyaee "Channel estimation in MIMO- OFDM System based on Comparative methods by LMS algorithm", IJCSI,Vol. 9, Issue 3, No 3, May 2012.

[5] Titus Eneh, Predrag Rapajic, Kwashie Anang, "Information Capacity of Adaptive MIMO OFDM Wireless Communication Systems", Adaptive Science and Technology (ICAST), 2011 3rd IEEE International Conferenc, IEEE Xplore: 02 February 2012.

[6] M. Moghaddari H, Zamiri-Jafarian, "Algorithms of Channel SVD Estimation in MIMO-OFDM Systems: Evaluation and Comparison", Telecommunications, 2008. IST 2008. International Symposium, IEEE Xplore: 14 October 2008

[7] Tan Yun*, Xu Wenbo, He Zhiqiang, "MIMO-OFDM Channel Estimation Based on Distributed Compressed Sensing and Kalman Filter", Signal Processing,

[8] Ashish N, A,tul Srivatsan K.R, R. Ramanathan "A novel channel estimation technique for MIMO-OFDM system for frequency selective Rayleigh channel", Devices and Communications (ICDeCom), 2011 International Conference on, IEEE Xplore: 24 March 2011.

[9] Mona Nasseri and, Hamidreza Bakhshi, "Iterative Channel Estimation Algorithm in Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing Systems", Journal of Computer Science, , 2010.

[10] Zheng Xiang Zhou Zhi-Jie Zhang Wen-Qiang "An Adaptinal Channel Tracking Algorithm Combined LMS and KALMAN, Filter"2008 IEEE.

[11] Navid daryasafar and Babak ehyaee, "Evaluation of Channel Estimation Algorithms in MIMO-OFDMSystems with Considering the Carrier Frequency Offset", IJSCT, Volume 3, Issue 5, May 2012.

[12] Scott C. Douglas, Markus Rupp , "Convergence Issues in the LMS Adaptive Filter" article .

[13] G. J. Foschini, "Layered space–time architecture for wireless communication in a fading environment when using multiple antennas," Bell Labs Syst. Tech. J., vol. 1, p.41–59, autumn 1996.

[14] G. D. Golden, G. J. Foschini, R. A. Valenzuela, and P. W. Wolniansky, "Detection algorithm and initial laboratory results using V-BLAST space–time communication architecture," Electron. Lett., vol. 35, pp.~14–16, Jan. 1999.

[15] C.Poongodi, P.Ramya, A. Shanmugam. "BER Analysis of MIMO OFDM System using M-QAM over Rayleigh Fading Channel",(Proceedings of the International Conference on Communication and Computational Intelligence – 2010).

[16] P. Li W. Hamouda "Performance of multiple-input and multipleoutput orthogonal frequency and code division multiplexing systems in fading channels" IET Commun., 2011.

[17] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[18] Jiun Siew, Robert Piechocki, Andrew Nix, and Simon Armour "A Channel Estimation Method for MIMO-OFDM Systems"