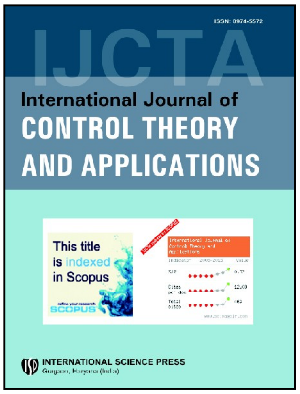

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Performance Analysis of MIMO OFDM System for Different Channel Lengths and Interference Cancellation Techniques

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Abstract: Orthogonal frequency division multiplexing (OFDM) accomplishes high data rate through simultaneous transmission of data on multiple orthogonal sub-carriers. In multiple input multiple output (MIMO) technology, multiple transmitter and receiver arrays are employed in order to increase spectral efficiency in wireless multipath environment. The OFDM technology is combined with MIMO to achieve highest spectral efficiency and deliver high data throughput in wireless local area network and mobile broadband network standards. In this paper, the performance of MIMO-OFDM system is evaluated for different channel lengths in wireless multipath environment. The performance of spatial multiplexing interference cancellation techniques such as ordered successive interference cancellation (OSIC) and parallel interference cancellation (PIC) in multipath Rayleigh fading environment is also investigated in this paper. Bit error rate (BER) is considered as a means to analyze the performance of the 2X2 and 4X4 antenna configurations using MATLAB simulation.

***Keywords*:** MIMO, OFDM, Channel Length, OSIC, PIC

1. INTRODUCTION

OFDM is multi-carrier digital communication technique in which the data is transmitted on large number of orthogonal sub-carriers. It is a popular method for high speed data transmission in multipath fading environment. In OFDM, frequency selective channel is transformed into a collection of parallel flat fading channels. In each OFDM symbol information symbols are transmitted on parallel sub-carriers and guard interval is placed between OFDM symbols in order to reduce the effect of inter symbol interference (ISI) [1].

MIMO technology employs transmit and receive antenna arrays to attain high spectral efficiency in wireless communication system. The two flavors of MIMO technique are spatial diversity and spatial multiplexing. The diversity gain indicates improvement in reliability of data whereas the multiplexing gain indicates improvement in data rate. In this work, MIMO spatial multiplexing configuration is used in order to improve data rate. In wireless multipath environment, high speed data transmission faces the problem of inter symbol interference. The BER of MIMO system is severely affected because of the ISI effect. Hence the MIMO technology can be combined with OFDM to combat the effect of ISI [2]-[3].

In MIMO spatial multiplexing configuration, the MIMO detection techniques aim at separating multiple data streams transmitted by cancelling multi-stream interference (MSI) or spatial multiplexing interference (SMI). The two popular linear MIMO detection algorithms are zero-forcing (ZF) and minimum mean square error (MMSE). Even though ZF receiver has low computational complexity, its drawback is noise enhancement. The MMSE detector suppresses noise and is superior to ZF detector. The non-linear MIMO detection techniques such as OSIC or PIC gives better performance than linear MIMO detection techniques such as ZF and MMSE [4].

When the channel length is more, the delay spread will be more and the interference between consecutive symbols will be more. In [5], the authors analyzed the effect of channel length on BER performance of OFDM system. In our work, the BER performance of MIMO-OFDM system is analyzed by varying channel length in multipath Rayleigh fading environment. In [6], performance of various MIMO detection techniques is analyzed for MIMO system. In our work, we simulated the BER performance of various detection techniques such as MMSE, MMSE-PIC and MMSE-OSIC for MIMO-OFDM system for both 2X2 and 4X4 antenna configurations in MATLAB.

The remainder of the paper is organized as follows. Section II gives the description of MIMO-OFDM system model. The analysis of simulation results is presented in Section III and the conclusion is given in Section IV.

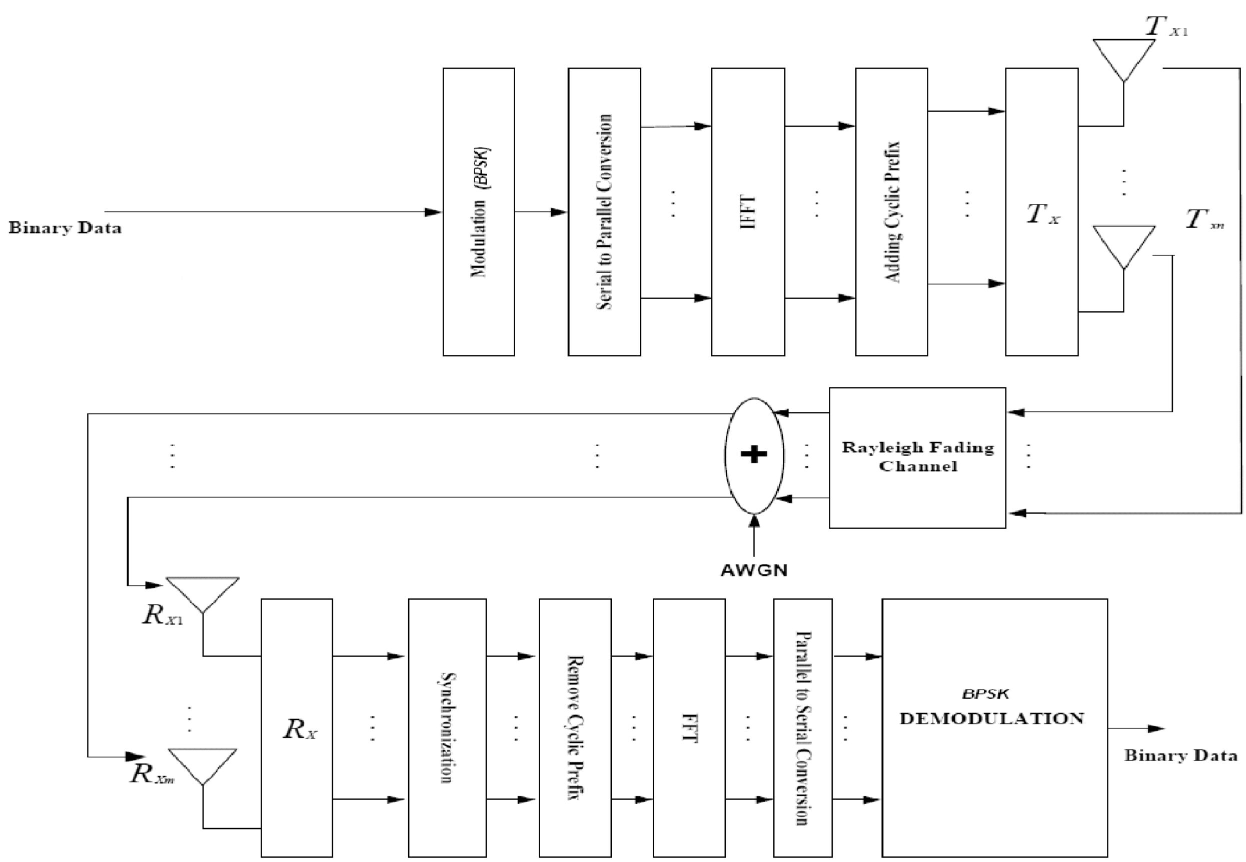

Figure 1: MIMO-OFDM System Model

2. SYSTEM MODEL

A MIMO-OFDM system with N_t transmitters and N_r receivers is considered, with a single OFDM modulator per each transmit antenna. Fig. 1 shows a simple block diagram of MIMO-OFDM system [7]. The block diagram consists of transmitter, Rayleigh fading channel and receiver. In our simulations, 2X2 and 4X4 antenna configurations are considered. We generate independent bit streams of binary data and each bit stream is modulated using BPSK modulation technique. OFDM modulation is applied on each sub-stream using N-point IFFT module. Cyclic prefix (CP), whose length is greater than that of channel impulse response, is inserted in between the consecutive OFDM symbols to avoid ISI. Rayleigh fading channel is considered as wireless channel in this work and the channel remains constant during the transmission of one OFDM block.

At the receiver side, FFT is applied after removing CP. Let the vector $x = [x_1, x_2, \ldots \ldots \ldots \ldots, x_{N_t}]$ contains symbols transmitted through N_t antennas on and the vector $y = [y_1, y_2, \ldots \ldots \ldots \ldots, y_{N_r}]$ contains the received signals through N_r antennas. Then,

$$y = Hx + n \tag{1}$$

where H is the channel matrix of size $N_r X N_t$ which is assumed to be perfectly known at receiver and $\boldsymbol{n}$ is additive white Gaussian noise with covariance matrix $\sigma_n^2 I_{N_r}$. In MIMO spatial multiplexing configuration, various detection algorithms are proposed in literature for recovering transmitted signal from received signal. In this work MMSE technique is used to estimate the transmitted symbols from received signal. The vector of estimated symbols can be given as [4],

$$\hat{x} = Wy \tag{2}$$

where

$$W = R_{xy} R_y^{-1} = (H^* H + \sigma_n^2 I)^{-1} H^* \tag{3}$$

In SIC, at each step (layer) of signal separation process, the signal transmitted from each antenna is detected using ZF or MMSE and then the contribution of detected symbol is subtracted from the received signal and the result is passed to the next layer. In OSIC, the detection process proceeds from most reliable symbol detection to less reliable symbol detection. In PIC, the symbol detection is performed in two stages as opposed to SIC. The first stage gives rough estimates of symbols of all data streams using ZF or MMSE. In the second stage, all symbols are simultaneously detected by subtracting interference from all the other symbols estimated in the first stage.

3. SIMULATION RESULTS

In this section, the BER performance of MIMO-OFDM system is analyzed by considering different channel lengths and various MIMO detection techniques such as MMSE, PIC and OSIC in Rayleigh fading multipath environment. The system parameters are shown in Table I.

Table 1
System Parameters

FFT size	*1024*
Digital Modulation	BPSK
Bandwidth	10 MHz
Antenna Configurations	2X2,4X4
Channel	AWGN, Rayleigh Fading
Channel Length	10,20,30 taps
Power Delay Profile	Exponential

The performance of the system for different channel lengths is shown in Fig. 2 and Fig. 3 for 2X2 and 4X4 antenna configurations respectively. It can be observed that as channel length increases, the performance of the system gets deteriorated. In Rayleigh fading multipath environment the performance of the system for different interference cancellation techniques is shown in Fig. 4 and Fig. 5 for 2X2 and 4X4 antenna configurations respectively. The performance is improved when interference cancellation techniques such as OSIC and PIC are used along with MMSE detection technique for both 2X2 and 4X4 antenna configurations.

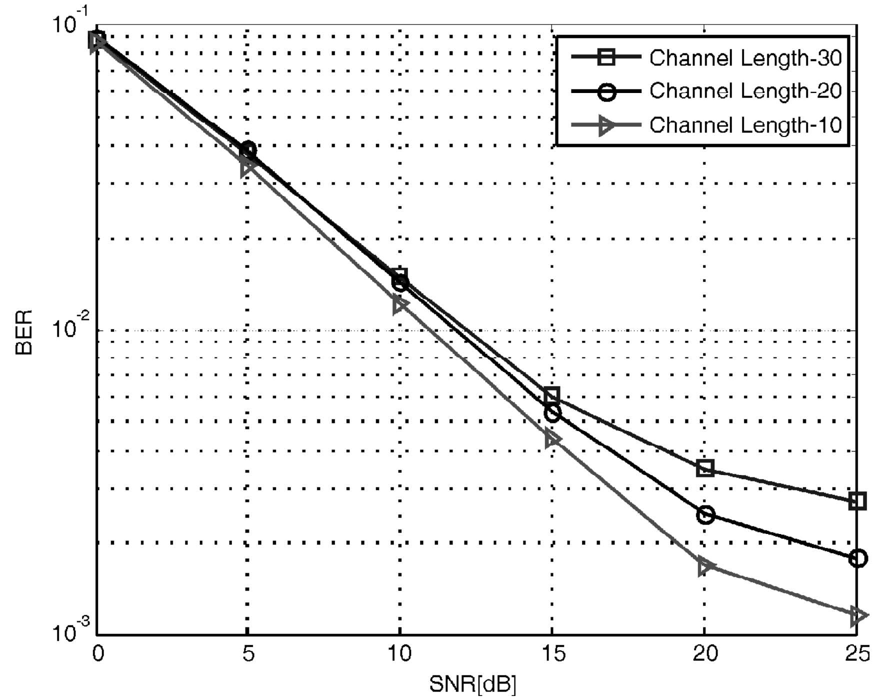

Figure 2: BER performance the system for different channel lengths for 2X2 antenna configuration

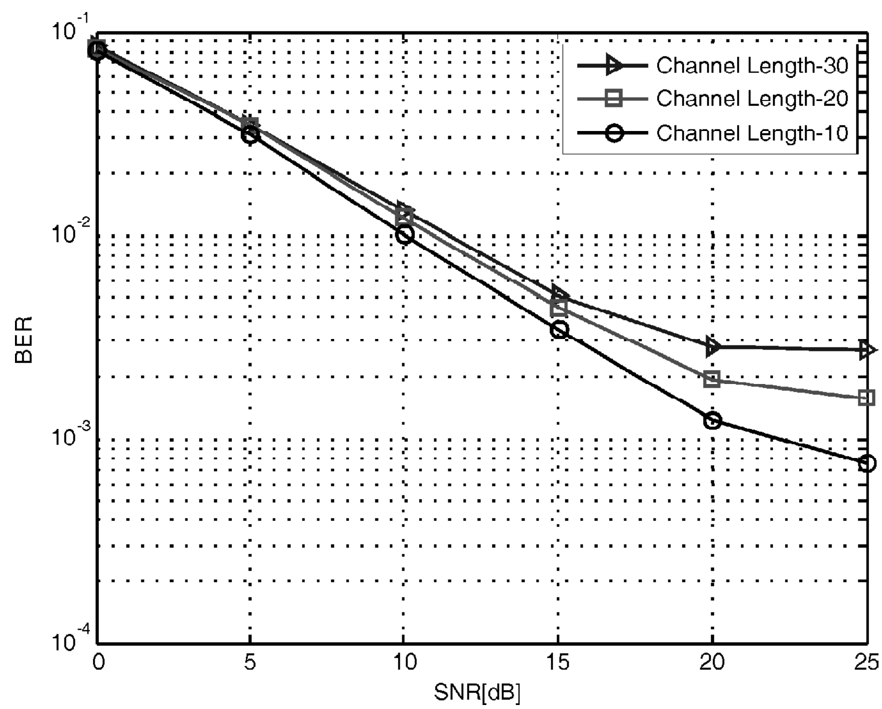

Figure 3: BER performance of the system for different channel lengths for 4X4 antenna configuration

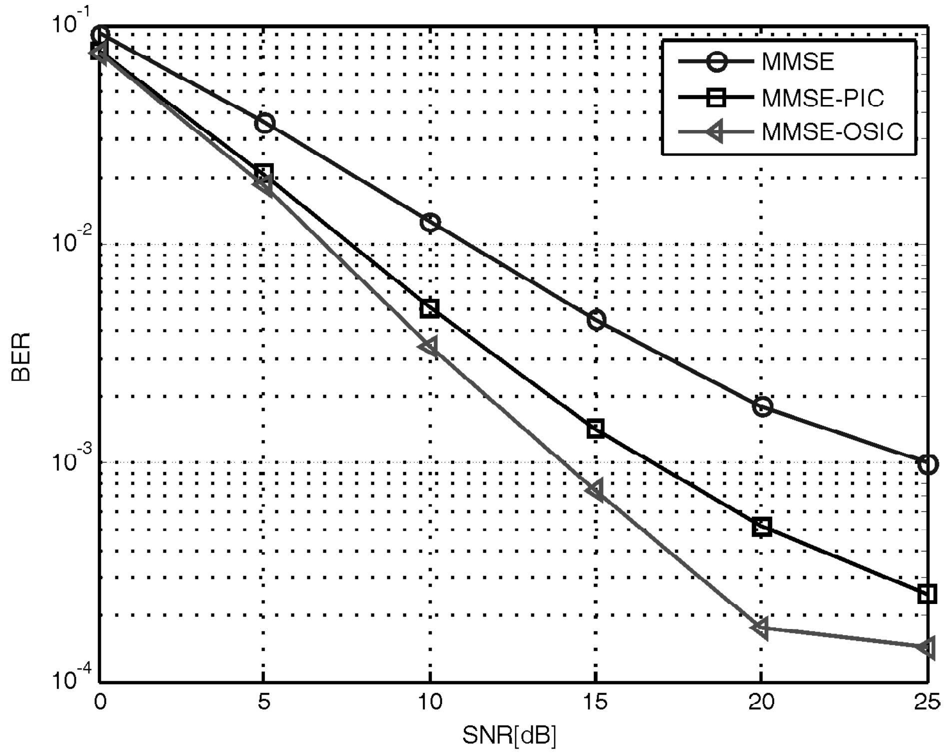

Figure 4: BER performance of the system for different detection techniques for 2X2 antenna configuration

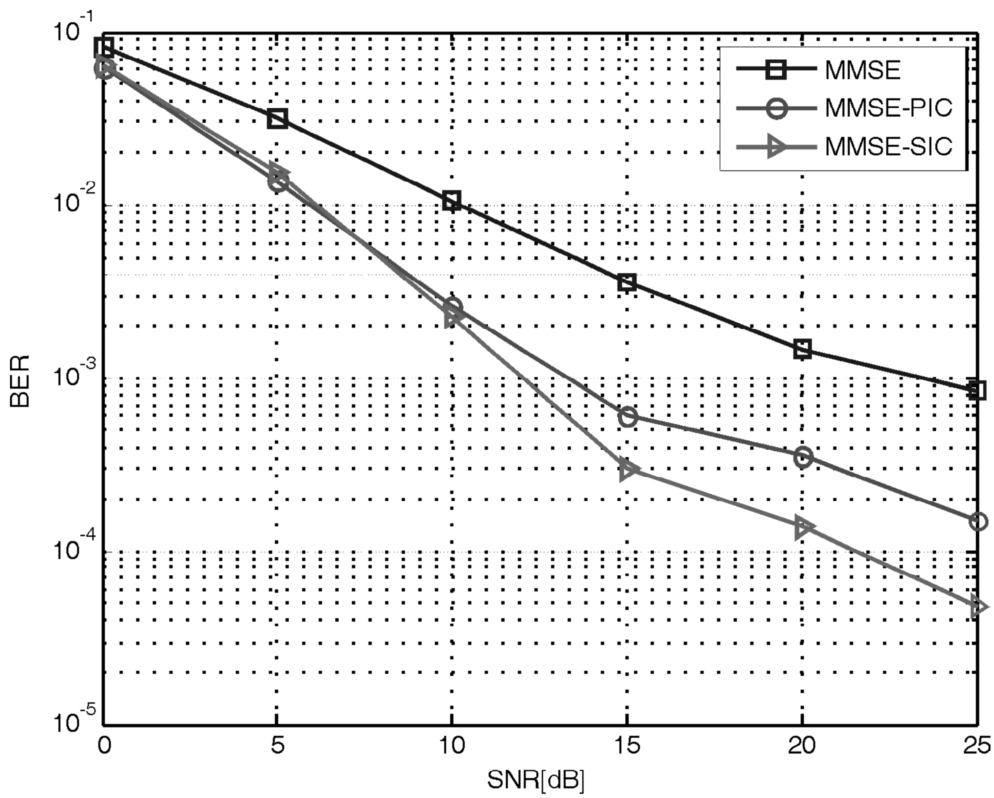

Figure 5: BER performance of the system for different detection techniques for 4X4 antenna configuration

4. CONCLUSION

In this paper, the effect of channel length on BER performance of MIMO-OFDM system is studied. It is observed that as channel length increases, performance of the system is degraded in terms of BER. The effect of channel length on BER performance is more prominent at higher values of SNR. At an SNR of 25dB, the BER is degraded by three times approximately when channel length is increased from 10 to 30. The performance of various MIMO detection techniques is also analyzed in this work. The interference cancellation techniques OSIC and PIC combined with MMSE give better performance than MMSE alone for both 2X2 and 4X4 MIMO-OFDM systems. At 25dB SNR, the BER of MMSE-OSIC is about half of that of MMSE-PIC.

REFERENCES

[1] Stuber, G.L., Barry, J.R., Mclaughlin, S.W., Li, Y., Ingram, M.A. and Pratt, T.G., 2004. Broadband MIMO-OFDM wireless communications. *Proceedings of the IEEE*, *92*(2), pp. 271-294.

[2] Misra, Jaya, and Rakesh Mandal. “A Review on Various Approaches to Reduce Intersymbol Interference in MIMO-OFDM System.” *International Journal for Innovative Research in Science and Technology* 1.8 (2015): 74-78.

[3] Abolade, Robert O., et al. “Hybridization of MIMO-OFDM Wireless System with Different Antenna Configurations over Rayleigh Channel.” *Journal of Wireless Networking and Communications* 5.2 (2015): 67-74.

[4] Wang, Jingming, and BabakDaneshrad, “A comparative study of MIMO detection algorithms for wideband spatial multiplexing systems,” *Wireless Communications and Networking Conference, 2005 IEEE*. Vol. 1, IEEE, 2005

[5] Ahmed, E., et al. “Performance Analysis of OFDM System for Different Channel Lengths and Multipath Channel Taps.” *Advances in Electrical Engineering Systems* 1.2 (2012): 124-128.

[6] Joshi, Shreedhar A., T. S. Rukmini, and H. M. Mahesh. “Performance analysis of MIMO technology using V-BLAST technique for different linear detectors in a slow fading channel.” *Computational Intelligence and Computing Research (ICCIC), 2010 IEEE International Conference on*. IEEE, 2010.

[7] Kaur, Navjot, and Lavish Kansal. “Performance Comparison of MIMO Systems over AWGN and Rician Channels with Zero Forcing Receivers.” *International Journal of Wireless & Mobile Networks* 5.1 (2013): 73.