*Available online at http://www.journalcra.com*

*International Journal of Current Research*
*Vol. 7, Issue, 06, pp. 17297-17300, June 2015*

**INTERNATIONAL JOURNAL OF CURRENT RESEARCH**

**ISSN: 0975-833X**

## RESEARCH ARTICLE

# PERFORMANCE ANALYSIS OF MIMO-OF DM BY USING WIRELESS COMMUNICATION SYSTEM

***,[1]Ravinder, O. and [2]Ravinder, M.**

[1]Department of ECE, GNITC, Hyderabad
[2]Department of ECE, KCEA, Nizamabad

**ARTICLE INFO**

***Article History:***
Received 26th March, 2015
Received in revised form
12th April, 2015
Accepted 29th May, 2015
Published online 30th June, 2015

***Key words:***
MIMO, OFDM,
Optimal, Sub-optimal,
OSTBC, MAN, LANs.

**ABSTRACT**

Due to increasing in demand of faster data transmission speed in the future telecommunication systems, the multiple antenna systems have been actively investigated and successfully deployed for the emerging broadband wireless access networks. Multiple Input Multiple Outputs (MIMO) takes the advantage of multiplexing to increase wireless bandwidth efficiency and range. MIMO-OFDM is a technique to increase channel capacity without using additional transmit power or spectral bandwidth. MIMO-OFDM is an attractive air-interface solution for next generation wireless LAN's, Wireless MAN's & 4G mobile cellular wireless systems. The major drawback of MIMO is required higher amount of circuits. To avoid that drawback we use antenna selection technique. In this paper we are using three types of selection antennas. They are Optimal, ascending or descending and Orthogonal Space Time Block Code (OSTBC) antenna selection. Then we are investigating channel capacity with antenna selection. The channel capacity increases with the numbers of antennas added to the system due to the more diversity gain of alamouti code. Finally we evaluate BER performances of alamouti OSTBC scheme with antenna selection.

***Citation***: Ravinder, O. and Ravinder, M. 2015. "Performance analysis of mimo-of dm by using wireless communication system", *International Journal of Current Research*, 7, (6), 17297-17300.

## INTRODUCTION

The use of multiple antenna technique has gained overwhelming interest throughout the last decade. The idea of using multiple antenna configuration instead of a single one has proven to be successful in enhancing data transfer rate, coverage, security and overall the performance of radio networks. MIMO systems were described in the mid-to-late 1990s by Gerard Foschini and others (Gerard Joseph Foschini and Glenn David Golden, 2001). MIMO offers higher data rates as well as spectral efficiency. MIMO is the first radio technology that treats multipath propagation as a phenomenon to be exploited. MIMO multiplies the capacity of a radio link by transmitting multiple signals over multiple, co-located antennas. This is accomplished without the need for additional power or bandwidth. MIMO is also part of the 802.11n standard (Gerard Joseph Foschini and Glenn David Golden, 2001) used by our wireless router as well as 802.16 (Chakchai So-In *et al.*, 2009) for Mobile WiMax used by our cell phone. Multiple input, multiple output-orthogonal frequency division multiplexing (MIMO-OFDM) is the dominant air interface for 4G and 5G broadband wireless communications. It combines multiple input, multiple output (MIMO) technology, which multiplies capacity by transmitting different signals over multiple antennas, and orthogonal frequency division multiplexing (OFDM), which divides a radio channel into a large number of closely spaced sub channels to provide more reliable communications at high speeds

MIMO-OFDM is the foundation for most advanced wireless local area network (Wireless LAN) and mobile broadband network standards because it achieves the greatest spectral efficiency and, therefore, delivers the highest capacity and data throughput. The history of the MIMO technology is, in 1984 (Winters, 1984) Jack Winters of Bell laboratories explained the optimum signal combining for space diversity reception in cellular mobile radio systems. In 1993 Arogyaswami Paulraj and Thomas Kailath proposed the concept of spatial multiplexing (SM) using MIMO (Naguib *et al.*, 1994). In the year 1996 Gregory G. Raleigh and V.K. Jones claimed that multi-path channels can have a multiplicative capacity effect if the multi-path-signal propagation is used in an appropriate communications structure (Raleigh *et al.,* 1999).

---

****Corresponding author: Ravinder, O.***
*Department of ECE, GNITC, Hyderabad*

Greg Raleigh proposed that the practical solutions for modulation (MIMO-OFDM), coding, synchronization, and channel estimation (Michael A. Pollack *et al.,* 2001)

In this paper we are investigating channel capacity with antenna selection. We use three types of antenna selections they are optimal, sub optimal and OSTBC selection. The channel capacity increases with the numbers of antennas added to the system due to the more diversity gain of alamouti code. Finally we evaluate BER performances of alamouti OSTBC scheme with antenna selection. The organization of the paper is as follows, Section II will discuss about MIMO-OFDM System model, Section III will discuss about Antenna selection techniques. Section IV is about Simulation results and discussion and finally conclusion is given in section V. And References mentioned at last.

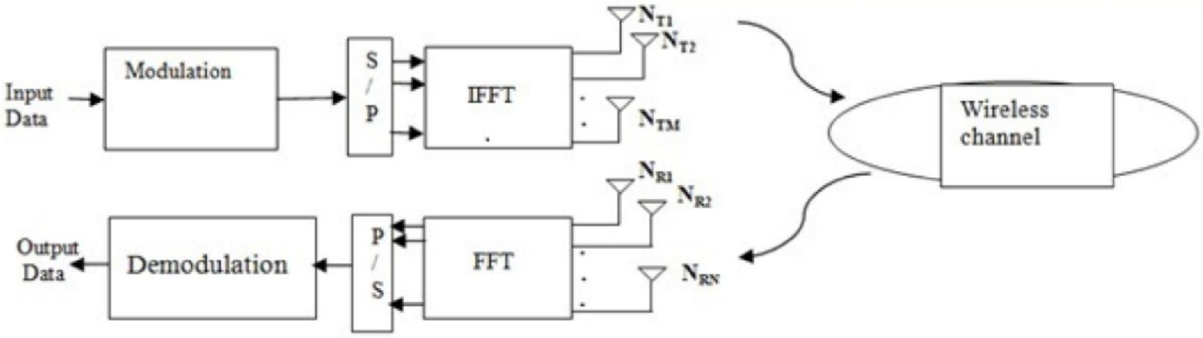

**Fig.1. MIMO-OFDM block diagram**

## II. Mimo-ofdm system

Fig.1 shows the system model for MIMO-OFDM. Here we consider $N_{TM}$ transmitting antennas and $N_{RN}$ receiving antennas. A multicarrier system such as OFDM implemented efficiently with inverse FFT (IFFT) as a modulator and an FFT as a demodulator. The samples at the output of the IFFT stage are "time" domain samples of the transmitted waveform.

For the analysis of antenna selection techniques, we consider the following assumptions. First one is Channel state changes from symbol to symbol, but it does not significantly change within one OFDM symbol period. Second is channel impulse response (CIR) length is shorter than cyclic prefix (CP). And last one is synchronization is perfectly achieved in the receiver side. The effect of intersymbol interference (ISI) and intercarrier interference (ICI) are neglected. Let $X = \{X_0, X_1, ..., X_{N-1}\}$ denote the length-*N* data symbol block. The IFFT of the data block is

$$x_n = IFFT_N\{X_k\}(n) \qquad \text{................ (1)}$$

To overcome the effects of channel delay spread, a guard interval is appended to transmit sequence. The received signal for the k$^{th}$ subcarrier of n$^{th}$ OFDM symbol is (Ye *et al*., 2002)

$$y_{n,k} = H_{n,k}x_{n,k} + w_{n,k} \qquad \text{........... (2)}$$

Where $H_{n,k}$ is the $N_{TM}$ x $N_{TR}$ complex matrix and $w_{n,k}$ is $N_{TR}$ x 1 noise vector with zero mean and variance $\sigma_n^2$. Each element in channel matrix $H_{i,j}$ is the channel gain between the $j$ $^{th}$ transmit and the $i^{th}$ receive antennas. The elements $H_{i,j}$ are assumed independent identically distributed (i.i.d) complex circularly symmetric normal RVs, with zero-mean and unity-variance.

## III. Antenna selection techniques

The advantage of MIMO systems is that better performance can be achieved without using additional transmits power. However, its drawback is it requires high-cost RF modules as multiple antennas are employed. To reduce this drawback, antenna selection techniques can be used. In the antenna selection we use only Q RF modules, they support $N_{TM}$ transmit antennas (Q < $N_{TM}$). Note that Q RF modules are selectively mapped to Q of $N_{TM}$ transmits antennas.

### Optimal antenna selection technique

A set of Q transmit antennas must be selected out of $N_{TM}$ transmit antennas so as to maximize the channel capacity. When the total transmitted power P, then the channel capacity of the system is

$$C = \max_{R_{xx},\{p_1,p_2,...,p_Q\}} \log_2 \det\left(I_{N_{RM}} + \frac{E_x}{QN_o} H_{\{p_1,p_2,...p_Q\}} R_{xx} H^H_{\{p_1,p_2,...p_Q\}}\right) bps/Hz \qquad \text{....(3)}$$

Where $R_{xx}$ is $Q$ $x$ $Q$ covariance matrix. If same power is allocated to selected transmit antennas then $R_{xx}$ =I$_Q$

$$C_{\{p_1,p_2,...,p_Q\}} \cong \log_2 \det\left(I_{N_{RM}} + \frac{E_x}{QN_o} H_{\{p_1,p_2,...p_Q\}} H^H_{\{p_1,p_2,...p_Q\}}\right) bps/Hz$$
..(4)

To maximize the system capacity, one must choose the antenna with the highest capacity

$$\{p_1^{opt}, p_2^{opt}, ...p_Q^{opt}\} = \underset{\{p_1,p_2,...,p_Q\} \in A_Q}{\arg\max}\ C_{\{p_1,p_2,....,p_Q\}} \qquad \text{......(5)}$$

A$_Q$ represents a set of all possible antenna combinations, by considering this it involves large complexity when $N_{TM}$ is very large, so to reduce the complexity we go for other method i.e sub-optimal antenna selection

**Sub-optimal antenna selection**

To reduce the complexity of above method we selected sub-optimal method. In this additional antenna can be selected in ascending order of increasing the channel capacity, with the highest capacity is first selected

$$p_1^{sobopt} = \arg\max_{p_1} C_{\{p_1\}} = \arg\max_{p_1} \log_2 \det\left( I_{N_{RM}} + \frac{E_x}{QN_o} H_{\{p_1\}} H^H_{\{p_1\}} \right)$$

……….(6)

The second antenna is selected

$$p_2^{sobopt} = \arg\max_{p_2 \neq p_1^{subopt}} C_{\{p_1^{subopt}, p_2\}} = \arg\max_{p_2 \neq p_1^{subopt}} \log_2 \det\left( I_{N_{RM}} + \frac{E_x}{QN_o} H_{\{p_1^{subopt}, p_2\}} H^H_{\{p_1^{subopt}, p_2\}} \right)$$

……………… (7)

After the nth iteration which provides $\left\{ p_1^{subopt}, p_2^{subopt}, \ldots p_n^{subopt} \right\}$ the capacity with an additional antenna, say antenna l, can be updated as

$$C_l = \log_2 \det\left( I_{N_{RM}} + \frac{E_x}{QN_o} H_{\{p_1^{subopt}, \ldots p_n^{subopt}\}} H^H_{\{p_1^{subopt}, \ldots p_n^{subopt}\}} + H_{\{l\}} H^H_{\{l\}} \right)$$

…… (8)

This process continues until all Q antennas are selected

**Antenna selection for OSTBC**

In the previous method, channel capacity has been used as a design criterion for antenna selection. In other words, transmit antennas can be selected so as to minimize the error probability.

Let Pr (Ci→Cj |H {$p_1$, $p_2$…$p_Q$} denote the pair-wise error probability when a space-time codeword Ci is transmitted but Cj is decoded for the given channel H {$p_1$, $p_2$…$p_Q$}, j ≠ i. For an effective channel H {$p_1$, $p_2$…$p_Q$} with Q columns of H chosen, an upper bound for the pair-wise error probability for orthogonal STBC (OSTBC) is given as

$$P_r\left( C_i \rightarrow C_j \mid H_{\{p_1, p_2, .. p_Q\}} \right) = Q\left( \sqrt{ \frac{ \rho \left\| H_{\{p_1, p_2, .. p_Q\}} E_{i,j} \right\|_F^2 }{ 2N_{TM} } } \right) \leq \exp\left( - \frac{ \rho \left\| H_{\{p_1, p_2, .. p_Q\}} E_{i,j} \right\|_F^2 }{ 4N_{TM} } \right)$$

…… (9)

Where $E_{i,j}$ is error matrixthe Q transmit antennas can be selected to minimize the upper bound in eq (9)

$$\left\{ p_1^{opt}, p_2^{opt}, .. p_Q^{opt} \right\} = \arg\max_{p_1, p_2, .. p_Q \in A_Q} \left\| H_{\{p_1, p_2, .. p_Q\}} E_{i,j} \right\|_F^2$$

…. (10)

In deriving Equation (10), we use the property $\mathbf{E}_{\mathbf{i,j}} \mathbf{E}^{H}_{\mathbf{i,j}} = \mathbf{aI}$ with constant a. From Equation (10), high column norms are selected for minimizing the error rate. The average SNR on the receiver side with Q selected antenna 1 is given as

$$\eta_{\{p_1, p_2, .., p_Q\}} = \frac{\rho}{Q} \left\| H_{\{p_1, p_2, .. p_Q\}} E_{i,j} \right\|_F^2 \qquad …….. (11)$$

We can see that the upper and lower bounds of the average received SNR are functions of $\|H\|_F^2$

## IV. SIMULATION RESULTS

To avoid high complexity of MIMO-OFDM and high RF modules requirement we are using antenna selection methods. This can increase the capacity of the system and reduce the complexity of the system at the same it less RF modules. From Fig.2 we evaluated the capacity of the optimal antenna selection method. Because of complexity of the algorithm we moved to complexity reduced antenna selection method

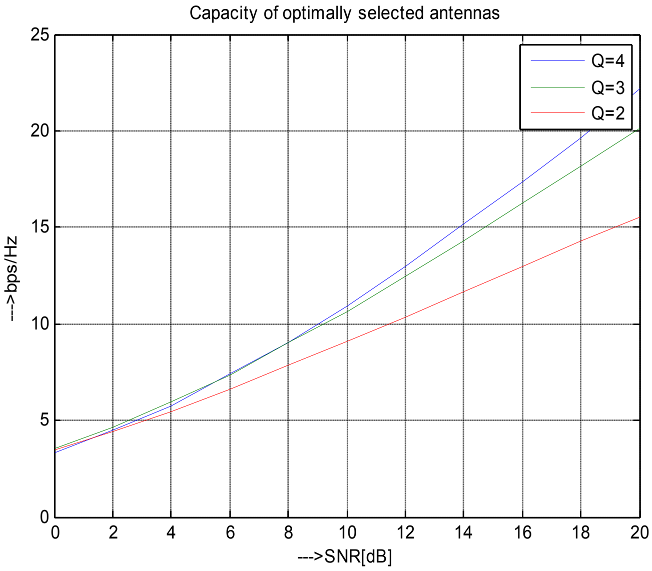

**Fig.2. Capacity of optimally selected Antennas**

Fig.3. shows sub optimal antenna selection, complexity of selection of antenna is very less comparing to optimal antenna

selection method. And one more thing upto SNR=10db capacity of the system for 3 antenna selection are equal to 4 antenna selection. So to reduce the complexity, better to select 3antennas

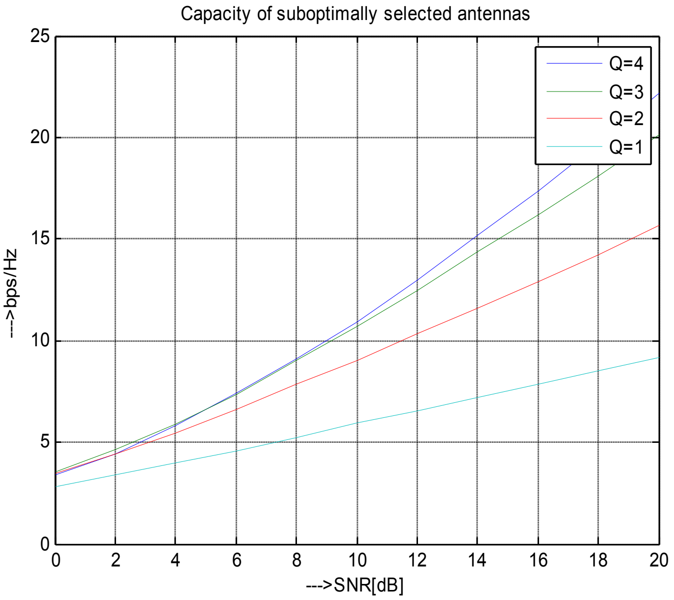

**Fig.3. Capacity of Sub-optimally selected Antennas**

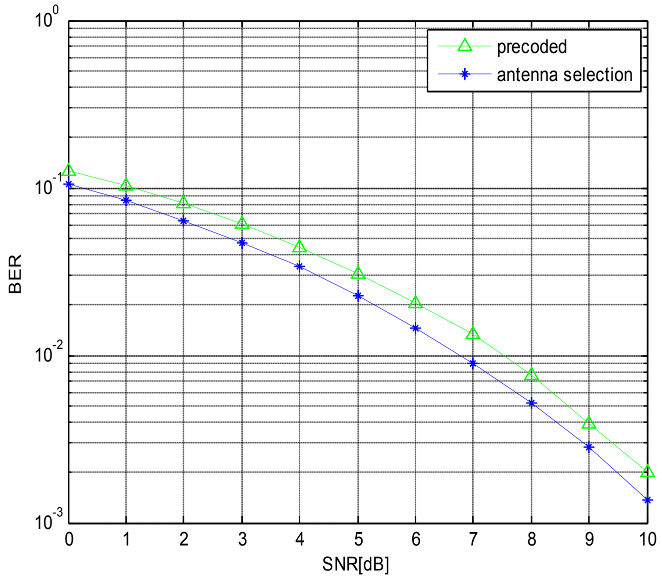

**Fig.4. Comparision of Precoded OSTBC and Antenna selection OSTBC**

In Fig.4. We evaluated the performance of the system by using BER for general precoded OSTBC and antenna selection method OSTBC. Antenna selection OSTBC providing less BER (Bit Error Rate).

## V. Conclusion

We considered the performance analysis of multiple-input multiple-output (MIMO) orthogonal frequency-division multiplexing (OFDM) systems for high data rate wireless transmission. In this paper we used three types of selection antennas. They are Optimal, ascending or descending and Orthogonal Space Time Block Code (OSTBC) antenna selection. Then we are investigated channel capacity with antenna selection. And we have shown that the channel capacity increases with the numbers of antennas added to the system due to the more diversity gain of alamouti code. Finally we evaluated BER performances of alamouti OSTBC scheme with antenna selection.

## REFERENCES

Chakchai So-In, Jain, R., Tamimi, A.K. “Scheduling in IEEE 802.16e mobile WiMAX networks: key issues and a survey” *Communications, IEEE Journal on,* Vol 27 Iss 2, February 2009 pp 156 – 171.

Gerard Joseph Foschini, Glenn David Golden “Wireless communications system having a space-time architecture employing multi-element antennas at both the transmitter and receiver” *Lucent Technologies Inc.*, US6317466 B1, Nov 13, 2001.

Michael A. Pollack, Vincent K. Jones,Gregory G. Raleigh “Medium access control protocol for OFDM wireless networks” *Cisco Systems, Inc.* US6192026 B1 Feb 20, 2001

Naguib, A.F. ; Paulraj, A. ; Kailath, T. “Capacity improvement with base-station antenna arrays in cellular CDMA” *Vehicular Technology, IEEE Transactions on* , Vol 43, Iss 3 Aug 1994 pp 691 – 698.

Raleigh, G.C., Cisco Syst., San Jose, CA, USA; Jones, V.K. “Multivariate modulation and coding for wireless communication” *Communications, IEEE Journal on*, Vol 17 , Issu 5 May 1999 pp 851 – 866.

Richard Van Nee, V.K. Jones, Geert Awater, Allert Van Zelst, James Gardner and Greg Steele “The 802.11n MIMO-OFDM Standard for Wireless LAN and Beyond” *Wireless Personal Communications* (2006) 37: pp 445–453, Springer 2006.

Winters, J.H. “Optimum Combining in Digital Mobile Radio with Cochannel Interference” *Communications, IEEE Journal on,* Vol2, Iss 4 July 1984 pp 528 – 539.

Ye (Geoffrey) Li, Jack H. Winters, and Nelson R. Sollenberger “MIMO-OFDM for Wireless Communications Signal Detection with Enhanced Channel Estimation” *IEEE Transactions on Communications,* Vol. 50, No. 9, SEP 2002 pp 1471-77.

*******