Improving STFBC MIMO OFDMA with channel estimation using DFT and DCT Technique

Lailatulmunira binti Abu Bakar
Faculty of Electrical Engineering ,Universiti Teknologi MARA Malaysia
404500 Shah Alam ,Selangor
lailatul_munira@yahoo.com

Abstracts- **Full speed transmission and high capacity data rate become everyone's needs nowadays. Higher demand in rapid data transmission makes the wireless technology become more popular in this new modern era. The ability of wireless technology in supporting high data signal with the capability of MIMO antenna system and OFDMA modulation scheme in providing high data capacity and excellent performances. Therefore these alliances become one of the best solution that can fulfill everybody's dream come right in time to serve the demand. These MIMO OFDMA system is based on the diversity coding and appropriate channel estimation in order to achieve maximum diversity order for each user and minimize the interference that have been generated during the transmission. Thus, in this paper in order to boost the overall system performances, another alternative in diversity coding techniques using Space Time Frequency Block Code (STFBC) and channel estimation technique involving Discrete Fourier Transform (DFT) and Discrete Cosine Transform (DCT) are going to be investigated and tested to compare each performances. The result states that by using STF block code and DCT channel estimation gain better performance in MIMO OFDMA system.**

Keywords – *MIMO (Multiple Input Multiple Output) OFMDA (Orthogonal Frequency Division Multiple Access), STFBC (Space Time Frequency Block Code), STBC (Space Time Block Code), SFBC (Space Frequency Block Code), DCT (Discrete Cosine Transform), DFT (Discrete Fourier Transform)*

I. INTRODUCTION

Over the last few decades, the world has been witnessing the sudden shift in mobile communication technology and reap a lot of benefits from it. The wired technology becomes aborted as all people are moving towards the wireless technology where everything is controlled within a touch. This new emerging technology becomes more demanding due to its outstanding capabilities in providing the best solution in connecting people and data transmission[1]. The invention of multipurpose antenna in transmitting and receiving multiple data at once has created a lot of advantages in wireless transmission technology and somehow the merges between two technologies also bring a greater impact towards the system.

Therefore in order to explore the goodness of these technologies this project will focuses on the combination of two technologies in wireless communication between MIMO smart antenna and the latest multiple access technique modulation called OFDMA. MIMO can be categorized as the advanced technology in transmitting the data signal and can be diversified in different spaces (antenna), time and frequency or in other words the signal can be sent simultaneously for a different user[2]. While OFDMA is a new modulation technique so called discrete multitone modulation where an enormous number of subcarrier are modulated by using digital modulation technique such QAM, BPSK ,QPSK and many more depend on its application[3].

However the system that promising in supporting higher data rate and performances somehow has been disturbed and affected from interference and losses [4]. Thus, it will influence it performances .In addition with different types of diversity coding such as Space Time Block Code(STBC) and Space Frequency Block Code (SFBC) that attached during the transmission it will also lead to the fast fading and frequency selective channel respectively[5] . Therefore in order to upgrade and fully utilize the maximum diversity order in MIMO system the Space Time Frequency Block Code (STFBC) will be investigated to see the effects on the system performance[6]. Simulation outcomes are given in comparing between the two systems. The remaining paper is organized as follows. In section II, system model with mimo antenna and diversity type are described. In section III, channel estimation methods are given and simulation results are given in section IV. The paper is concluded in section V.

II. SYSTEM MODEL

A. MIMO OFDMA SYSTEM

MIMO can be define as Multiple Input Multiple Output that consist of several transmission antennas and receiver antennas [7]. Whilst MIMO wireless

communication can be designated for transmitting the data over wireless links that been formed by multiple antennas equipped at the transmitter and receiver[8].

Meanwhile OFDMA that was induced from FDMA where the users are separated in distinct frequency bands or sub channels [9]. Thus by the execution of this new technology of wireless access the data rate can be decreased for each user or subscriber when the number of them is increasingly large. MIMO also able to be the next favorite choices in achieving high bandwidth efficiency and can be executed more in OFDMA framework [10].

The new merging technology are capable to exploit further in the spatial and time dimensions of the channel. In this systems the data signal have ben break into multiple unique streams and each of them are modulated and transmitted through a different radio antenna chain at the same time in the same frequency channel[11]. MIMO can be used in two types of modes which are in spatial multiplexing and spatial diversity. In Spatial multiplexing the independent signals is transmitted abruptly over the same frequency channel and it increase the spectral efficiency level [12]. While in spatial diversity the same information signal has been linearly decoded into transmitting stream to enhance the coverage of signal range.[1]. The main advantages of this MIMO wireless technology towards the networks by expanding more coverage range, increasing more throughput and the robustness of the data link layer [11].

Therefore through the combination of OFDMA that supporting each other in the physical layer and MIMO smart technology able to improve the effectiveness to the physical transmission layer with greater flexibility and efficiency can be achieved[13].

B. ANTENNA DIVERSITY

Diversity become crucial as it performed an important role in a process of transmitting the OFDM signal through the antenna. From the previous study Space time coding (STC) based on Alamouti Code become the pioneer in spatial diversity scheme as applied according to code rate-1 in getting full spatial diversity for two transmitting antennas with low decoding complexity[14]. Basically there are two types of sub-carrier mapping in applying Alamouti code in OFDMA system. Firstly, two modulation symbols is encode over two OFDM symbol at the equal sub carrier and over two antenna [4]. The code is known as Space Time Block Coding (STBC) while the other is done by encoding two modulation symbols over two sub-carriers of the same OFDM symbol and over two antennas, called Space Frequency Block Coding (SFBC)[15]. Both of the code STBC and SFBC have a significant drawback that not fully capable to mitigates the effect of flat fading and separating extra frequency of frequency selective fading channel respectively[14]. Therefore the Space Time Frequency (STFBC) to overcome the flaws by distributing transmitted symbols from the same space in frequency and time. It ability to separate spatial and frequency diversity by mapping the information symbol makes STFBC becoming a perfect methods to get low overhead , increase latency and achieving maximum efficiency during the transmission[16].

III. CHANNEL ESTIMATION

The suitable type of channel estimation technique is very crucial to increase and improve the received signal accuracy and quality [17]. Its important character in transmitting the radio signal through a multipath channel in recognizing the unknown parameter for amplitude and phase variation of the received signal [14]. The most suitable channel estimation technique will provide better performances to the system[18]. Even though there are a lot type for channel estimation techniques but it have the same goals but our main focus in this paper is to compare the system performances between DFT and DCT channel estimation techniques. The system are described as follows

i. DFT as a channel estimator

DFT channel estimation is a time domain time domain estimation technique. It is used to suppress noise in time domain because energy is concentrated in time domain [19]. The equations N-point of the finite length sequence x (n) of DFT is:

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-\frac{j2\pi kn}{N}}, \; k = 0,1, \ldots . N-1$$

While the inverse transform in frequency domain called inverse DFT or IDFT provide a way to recover the finite length sequence as:

$$x(n) = \frac{1}{N} \sum_{k=0}^{N-1} X(k) e^{j2\pi kn/N}, \; k = 0,1 \ldots . . N-1$$

ii. DCT as a channel estimator

DCT normally attempts to decorrelate the image data and then transform each coefficient that can be encoded independently without losing its compression efficiency[20]. Due to important properties, DCT has been widely deployed as a channel estimator to improve the performance in data transmission [6]. The time domain for DCT given as:

$$F(k) = \frac{2c(k)}{N} \sum_{j=0}^{N-1} f(j) \cos \frac{(2j+1)k\pi}{2N}$$

when $k = 0,1, \ldots . . N-1$ and $c(k) = \frac{1}{\sqrt{2}}$

Whereas the inverse of DCT or called IDCT sequences as:

$$f(j) = \sum_{k=0}^{N-1} c(k)F(k)cos\frac{(2j+1)k\pi}{2N}$$

when $i = 0,1 \ldots\ldots N-1$ and $c(k) = \frac{1}{\sqrt{2}}$

IV. SYSTEM DESCRIPTION

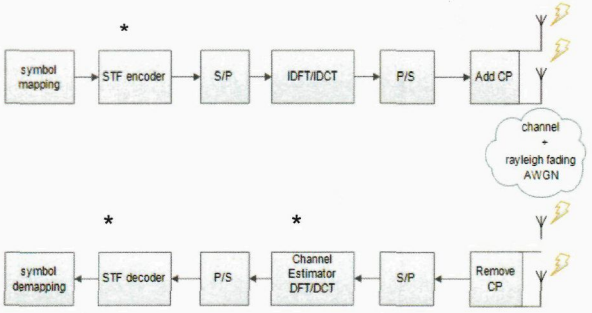

Figure 1: MIMO-OFDMA Transceiver Block Diagram with Channel Estimator

At the transmitter, all the input bit data stream in serial order is converted to serial to parallel using S/P converter after going through the STFBC encoder[21]. Then all the subcarriers is processed and modulated into OFDMA modulation segment by using IDFT/IDCT in frequency domain[13]. The frequency domain of the data set then will be transformed into the time domain. The waveform with multiple orthogonal frequency component will be formed and generated[22].

The guard interval, called CP (Cyclic Prefix) will be put in to lessen the inter symbol interference between the symbols that been transferred in the system [14]. The converter parallel to serial will create the orthogonal signal of OFDMA signal by outputting sample of time domain[23].

The channel model that have been considered in this transmission are fading channel and Additive White Gaussian Noise (AWGN) with a suitable Doppler Shift[24]. The converter serial to parallel going to use again at this stage to split the OFDMA data at the receiver part [2]. Then CP is discard from the received signal [16].

All the data will be going through the channel estimator in order to get the accurate amplitude and phase variation of the received signal that have been transmitted[17].

In this paper there are two different types of channel estimation technique that already being analyzed which are DFT and DCT method in order to compare their performances. Finally the converter parallel to serial will transformed the processed data back to its original data signal[25].

a. Simulation Parameter

All the results have been obtained through the simulation process have been tested using MATLAB Software. Table 1 shows the parameter that have been used for MIMO OFDMA based on IEEE 802.16 Mobile WiMAX. Three multipath had been considered in this simulation.

PARAMETERS	VALUES
IFFT size	128
Sampling Frequency (Mhz)	11.2
Number of Subcarrier	128
Channel	Multipath Rayleigh Fading Doppler Shift AWGN

Table 1: Simulation Parameter

V. RESULT AND DISCUSSIONS

In this section, some of the simulation result about the performances of MIMO OFDMA Diversity and Channel Estimator of interest which are DFT and DCT in terms of BER. This section have divided into two where the first part compare the BER performance of MIMO OFDMA with SF, ST and STF coding. While another section compare the MIMO OFDMA using STF coding with different type of channel estimator such as DFT and DCT.

A. BER Performance Comparison of SF,ST and STF for MIMO OFDMA

Figure 2 shows the simulation result that consist of three types of coding which are SF, SF and our proposed STF coding. The bit error rate (BER) for STF system is the best compare to ST and SF system. Thus from the result it can be conclude that from result depicted from MATLAB simulation, it can be summarize that the graph(signal to noise ratio)denoted as Eo/No in the graph is inversely proportional to BER (bit error rate). The value for SNR increases as the value of BER decreases. Therefore it indicate that ISI (inter symbol

interference) is slowly lessen. Therefore it shown that STFBC coding able to improve the system performance in MIMO OFDMA system as well provide the maximum diversity order.

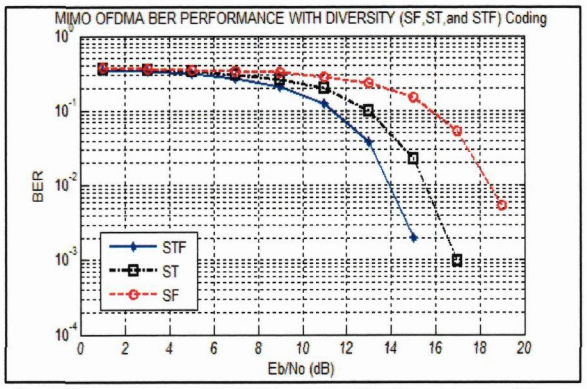

Figure 2: MIMO OFDMA BER Performance with Diversity (SF, ST and STF) Coding

B. BER Performance with DFT and DCT for MIMO OFDMA with STFBC coding

This second section present the result for Figure 3. The result shows that the bit error performance comparison between the system using different type of channel estimator. The graph shows that DCT channel estimator shows a very significant BER compare to DFT in minimizing losses during the transmission[20]. Therefore it can be conclude that DCT with MIMO OFDMA with STFBC coding as an alternative channel estimator to the system with very minimize BER.

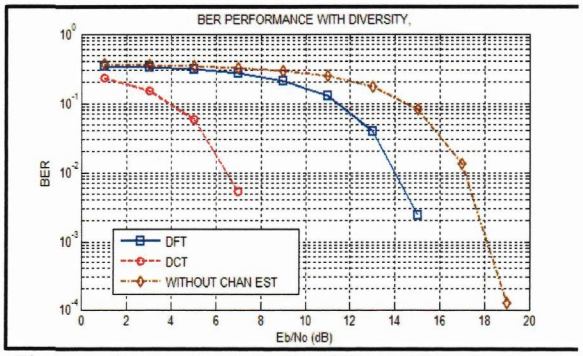

Figure 3: Comparison MIMO OFDMA STFBC with DFT and DCT Channel Estimation and without CE.

VI. CONCLUSION

The paper was compared on different types of diversity used which consists of SFBC,STBC and STFBC in improving BER performances for the system [26]. The STFBC coding that have been introduced in this paper able to upgrade and boost more on the capabilities of MIMO antenna. The percentage of improvement for diversity is 20%. The system also portrays how the STFBC system utilizes the maximum diversity order compared to STBC and SFBC coding. The alliances between both system MIMO OFDMA with SFTBC coding and DCT channel estimation also proven that it can be able to be reduce BER and other losses. The percentage of improvement is 25%. As a conclusion MIMO STFBC OFDMA system with DCT channel estimation manage to improve the overall system performance in wireless data transmission. It also can be one of the choices to overcome the wireless problem in fulfilling the demand of multiuser for rapid data transmitting simultaneously [27].

VII. FUTURE WORK

In order to enhance further the capability of the system with DCT channel estimator future works need to done and test for MIMO system that used that more than two antennas.

ACKNOWLEDGEMENT

The author would like to thank Dr.Azlina binti Idris for her guidance and support. Also a special thanks to Dr.Noorazlan bin Othman and Dr.Norsalwa binti Damanhuri for all the advices and ideas.

REFERENCE

[1] H. Dong-Hyun and S. Hyoung-Kyu, "Cooperative diversity scheme using SPC in MIMO-OFDMA system," *Electronics Letters*, vol. 51, pp. 364-366, 2015.

[2] N. K. Chavali and B. K. Kumar, "A reduced complexity MIMO decoder," in *Signal Processing, Informatics, Communication and Energy Systems (SPICES), 2015 IEEE International Conference on*, 2015, pp. 1-5.

[3] K. Reethu and J. Jeevitha, "BER performance of OFDMA system based on DCT and phase modulation," in *Electronics and Communication Systems (ICECS), 2014 International Conference on*, 2014, pp. 1-5.

[4] S. Siyue, C. Chih-Wei, C. Shin-Wei, C. Hsiao-hwa, and M. Weixiao, "Multiuser-Interference-Free Space–Time Spreading MIMO Systems Based

on Three-Dimensional Complementary Codes," *Systems Journal, IEEE,* vol. 9, pp. 45-57, 2015.

[5] A. Idris, M. Sabry, N. I. Abdul Razak, and A. L. Yusof, "Fast time-varying channels in MIMO-OFDM system using different diversity technique," in *Wireless Technology and Applications (ISWTA), 2013 IEEE Symposium on*, 2013, pp. 138-141.

[6] R. Kehrle Miranda, J. P. C. Lustosa da Costa, M. A. M. Marinho, E. Pignaton de Freitas, R. Freitas De Ramos, L. Kefei, C. Hing, L. Baltar, and R. T. de Sousa, "Evaluation of Space-Time-Frequency (STF)-Coded MIMO-OFDM Systems in Realistic Channel Models," in *Advanced Information Networking and Applications Workshops (WAINA), 2014 28th International Conference on*, 2014, pp. 310-315.

[7] T. Mata, K. Naito, P. Boonsrimuang, K. Mori, and H. Kobayashi, "Proposal of STBC MIMO-OFDM for ITS systems," in *Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), 2013 10th International Conference on*, 2013, pp. 1-6.

[8] G. Femenias, F. Riera-Palou, and J. Thompson, "Robust Scheduling and Resource Allocation in the Downlink of Spatially Correlated MIMO-OFDMA Wireless Systems with Imperfect CSIT," *Vehicular Technology, IEEE Transactions on,* vol. PP, pp. 1-1, 2015.

[9] U. Oruthota and O. Tirkkonen, "Link Adaptation of Precoded MIMO-OFDMA System With I/Q Interference," *Communications, IEEE Transactions on,* vol. 63, pp. 780-790, 2015.

[10] X. Xiao, T. Xiaoming, and L. Jianhua, "Energy-Efficient Resource Allocation in LTE-Based MIMO-OFDMA Systems With User Rate Constraints," *Vehicular Technology, IEEE Transactions on,* vol. 64, pp. 185-197, 2015.

[11] M. S. Faridi, "Spatial Correlation Based MIMO Mode Switching in LTE Downlink System," in *Computational Intelligence & Communication Technology (CICT), 2015 IEEE International Conference on*, 2015, pp. 438-442.

[12] M. Moretti, L. Sanguinetti, and W. Xiaodong, "Resource Allocation for Power Minimization in the Downlink of THP-Based Spatial Multiplexing MIMO-OFDMA Systems," *Vehicular Technology, IEEE Transactions on,* vol. 64, pp. 405-411, 2015.

[13] D. Molteni, M. Nicoli, and U. Spagnolini, "Performance of MIMO-OFDMA Systems in Correlated Fading Channels and Non-Stationary Interference," *Wireless Communications, IEEE Transactions on,* vol. 10, pp. 1480-1494, 2011.

[14] T. Mata, K. Mori, H. Kobayashi, and P. Boonsrimuang, "Channel estimation method for SFBC MIMO-OFDM based wireless two-way relay system in time-varying fading channel," in *Communications and Electronics (ICCE), 2014 IEEE Fifth International Conference on*, 2014, pp. 71-76.

[15] K. M. Tanairat Mata, Hideo Kobayashi, "Channel Estimation Method for SFBC MIMO-OFDM Based Wireless Two Way Relay System in Time Varying Fading Channel," *IEEE Transactions on Wireless Communication,* 2014.

[16] B. Gupta and D. S. Saini, "A low complexity decoding scheme of STFBC MIMO-OFDM system," in *Wireless Advanced (WiAd), 2012*, 2012, pp. 176-180.

[17] A. Q. Kiayani, L. Anttila, Y. Zou, and M. Valkama, "Channel Estimation and Equalization in Multi-User Uplink OFDMA and SC-FDMA Systems Under Transmitter RF Impairments," *Vehicular Technology, IEEE Transactions on,* vol. PP, pp. 1-1, 2015.

[18] W. Y. Zhang Jiangxin "Complexity Analysis of Channel Estimation Algorithm in MIMO-OFDMA System," *Information Technology Journal 11,* 2012.

[19] S. Szu-Lin, L. Yung-Chuan, H. Chieh-Chih, and G. C. H. Chuang, "A DFT-based channel estimation scheme for IEEE 802.16e OFDMA systems," in *Advanced Communication Technology (ICACT), 2010 The 12th International Conference on*, 2010, pp. 775-779.

[20] L. C. R. Syed Mohammaed Sajid, "DCT Based Improved OFDM Communication," *International Journal of Engineering and Innovative Technology (IJEIT),* vol. 2, June 2013 2013.

[21] S. Das, I. Chakrabarti, and S. S. Das, "Hardware implementation of Frequency Domain Link Adaptation for OFDMA based systems," in *Communications (NCC), 2015 Twenty First National Conference on*, 2015, pp. 1-6.

[22] B. Kamali, R. A. Bennett, and D. C. Cox, "Understanding WiMAX: An IEEE-802.16 Standard-Based Wireless Technology," *Potentials, IEEE,* vol. 31, pp. 23-27, 2012.

[23] M. F. Rabbi, "Basis Expansion Model (BEM) based MIMO-OFDMA channel capacity and estimation," in *Electrical Information and Communication Technology (EICT), 2013 International Conference on*, 2014, pp. 1-5.

[24] H. Sahlin and A. Persson, "Aspects of MIMO Channel Estimation for LTE Uplink," in *Vehicular Technology Conference (VTC Fall), 2011 IEEE*, 2011, pp. 1-5.

[25] V. Jumba, S. Parsaeefard, M. Derakhshani, and T. Le-Ngoc, "Resource Provisioning in Wireless Virtualized Networks via Massive-MIMO," *Wireless Communications Letters, IEEE,* vol. PP, pp. 1-1, 2015.

[26] L. Mang, Z. Youguang, and X. Zixiang, "Diversity analysis for space-time-frequency (STF) coded MIMO system with a general correlation model," in *Wireless Communications and Networking Conference (WCNC), 2013 IEEE*, 2013, pp. 2661-2666.

[27] L. Yingshan, L. Jun-Seo, L. Kang-Me, and R. Heung-Gyoon, "STFBC method for the ICI reduction in OFDM communication system," in *Communications, 2004 and the 5th International Symposium on Multi-Dimensional Mobile Communications Proceedings. The 2004 Joint Conference of the 10th Asia-Pacific Conference on*, 2004, pp. 927-931 vol.2.

thesis 2015

ORIGINALITY REPORT

24%	15%	10%	21%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universiti Teknologi MARA Student Paper	8%
2	ency.cl Internet Source	3%
3	Submitted to American Public University System Student Paper	2%
4	Submitted to University of Louisiana, Lafayette Student Paper	1%
5	web2.uwindsor.ca Internet Source	1%
6	Submitted to Lovely Professional University Student Paper	1%
7	Submitted to Khalifa University of Science Technology and Research Student Paper	1%
8	www.hhi.fraunhofer.de Internet Source	1%