MIMO OFDM CHANNEL MODELING FOR UWB COMMUNICATION SYSTEMS USING SINGULAR VALUE DECOMPOSITION (SVD)

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Abstract

The emerging (Ultra Wide Band) UWB system offers a great potential for a design of high speed short range wireless communications which fully support high data streaming capacity. This can be achieved by exploiting both spatial and multipath diversity via the use of MIMO OFDM system and proper coding techniques. In this paper, MIMO-OFDM channel modeling for UWB communication system is proposed by applying the concept of decomposition of frequency selective fading channel into parallel flat fading channel in the frequency domain. The concept of decoupling of frequency selective channel into spatial domain by presenting SVD based approach is developed to decouple flat fading MIMO channels to orthogonal spatial channels. The SVD is combined with FFT based frequency domain decoupling to obtain UWB MIMO OFDM parallel channel model. The theoretical analysis can be implemented in high speed short range UWB communication systems by applying a rate selection technique based on channel condition. The channel capacity and BER are evaluated for diffrent modulation technique environments. The results show that the system capacity and BER of MIMO-OFDM for UWB communication system can be achieved by using ECC compared to without ECC..

1. Introduction

The development of wireless telecommunication technology lead to fulfilled high capacity needs, using efficiently of bandwidth and ability to protect data from noise and minimizing error. OFDM is multicarrier modulation that have ability to work in multipath fading condition and give a solution of real time high speed access needs[1]. Combination of MIMO OFDM have ability to support high speed communication access, reliable, flexible and also using efficiently of bandwidth[2]-[5]. MIMO antenna system that proposed in this undergraduate thesis using Spatial Multiplexing technique for data transmission and Singular Value Decomposition channel modelling.

In an important paper, Deerwester et al. examined the dimensionality reduction problem in the context of information retrieval [2]. They were trying to compare documents using the words they contained, and they proposed the idea of creating features representing multiple words and then comparing those. To accomplish this, they made use of a mathematical technique known as Singular Value Decomposition. More recently, Sarwar et al. made use of this technique for recommender systems [3].

Coexisting with many concurrent narrowband services, the performance of UWB systems will be affected considerably by them. Specifically, IEEE 802.11a systems which operate around 5 GHz and overlap the band of UWB signals will interfere with UWB systems significantly. In this paper, a novel narrow-band interferences (NBI) suppression technique based on singular value decomposition (SVD) algorithm for different mudulation technique environment is presented. SVD is used to approximate the interferences which then are subtracted from the received signals. The proposed technique is simple and robust. Simulation of spatial multiplexing MIMO OFDM using three type of modulation, that are QPSK, 16-QAM and 64-QAM and also three different code rate for Error Control Coding (ECC) are proposed. Simulation results show that the proposed new technique is very effective and the performance of BER and capacity of the system can be achieved.

2. System Modelling

The transmiter scheme of the system model is shown in Figure1.

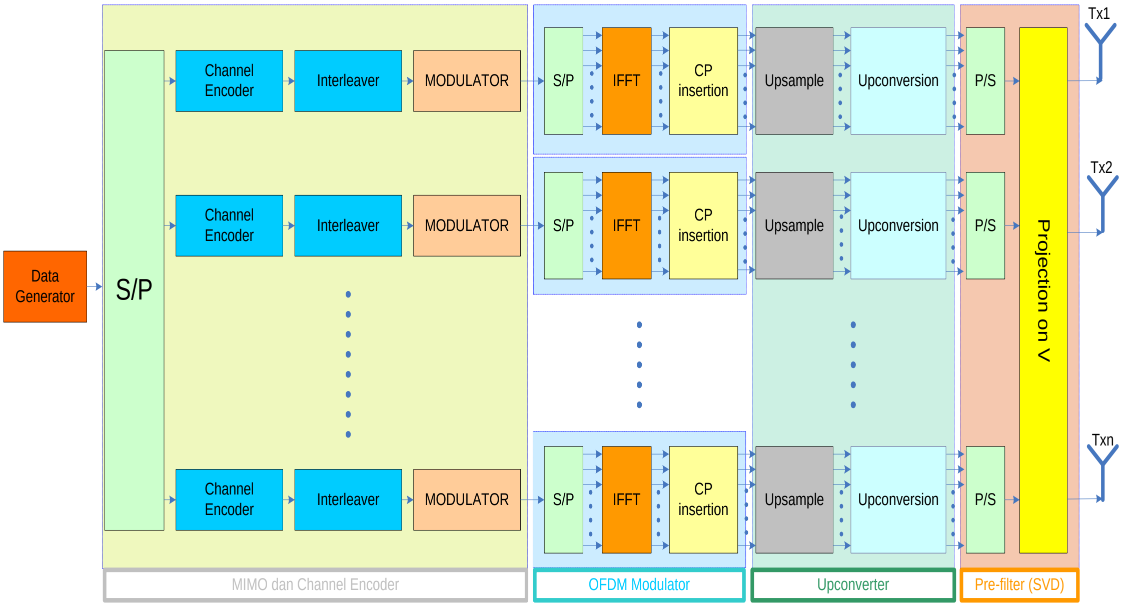

Figure 1 Transmitter scheme of system

The transmited data are generated by data generator. With serial to parallel algortihm, data are divided into some data stream (depends on number transmit antenna). In this simulation, data are divided into 2 stream data. Convolutional encoder is used here as a channel encoder to minimizing error rate while data rae transmitted. In addition, the code rate values that used for convolutional encoder in this simulation are 2/3, 1/2, and 1/3. To minimizing burst error in transmition data, interleaver is used. For the next step, the data are mapped into complex symbol through data modulator, that three type of modulation used here, that are QPSK, 16-QAM and 64-QAM.

IFFT and also FFT in receiver side, are main component in OFDM system. OFDM subchannel parameter using ULTRA WIDEBAND COMMNICATION SYSTEM parameter. Width of each bandwidth channel is 10 MHz. 256 subcarrier will become subchannel with carrier frequency between 3400-3600 MHz or located in band frequency 3.5 GHz. Every subchannel modulated by IFFT, in order to representate data in time domain. Then, OFDM symbol complex resulted from IFFT is combined into serial data and the cyclic prefix is added to avoid ISI and ICI. And then, the upsampling data with factor 4 and upconversion data throught into passband to facilitate transmision of complex signal. Before transmission signal, the matrices V of SVD scheme that have function as prefilter, multiply with signal in purpose to get symbols. From here, the data will be transitted from transmit antenna.

At the receiver side, the process that happen to signal are inverse from process in the transmitter side, as shown in Figure 2. Because in this system model, SVD operation is used to define the matrices channel, the symbol that received by receive antenna multiply with demultiplex matrices U^h , that act as postfilter. Then, signal will process with downconversion, downsample, cyclic prefix removal, FFT, Demodulator, Deinterleaver and Channel decoder.

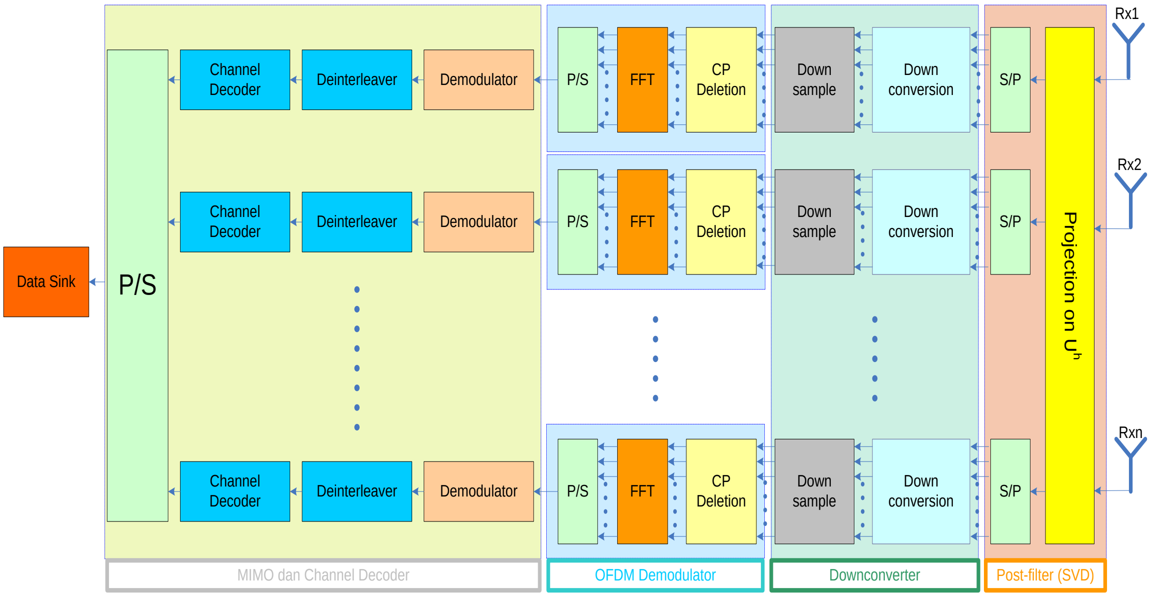

Figure 2. ***Receiver scheme of of system***.

The Singular Value Decomposition (SVD) is a well known matrix factorization technique that factors an *m* by *n* matrix **X** into three matrices. The received signal using SVD channel modelling is shown in Equation 1.

$$y = HVx + \eta \quad \text{.. (1)}$$

Where y is the received signal, H is channel model, V is non singular *orthogonal unitary matrix.*The matrix **S** is defined as a diagonal matrix containing the *singular values* of the matrix **X**. There are exactly *r* singular values, where *r* is the *rank* of **X**. The rank of a matrix is the number of linearly independent rows or columns in the matrix. Recall that two vectors are linearly independent if they can not be written as the sum or scalar multiple of any other vectors in the space. Observe that linear independence somehow captures the notion of a feature or agglomerative item that we are trying to get it. To accomplish we can simply keep the first *k* singular values in **S**, where *k*<*r*. This will give us the best rank-*k* approximation to **X**, and thus has effectively reduced the dimensionality of the original space. Singular value decomposition (SVD) matrices operation used here to diagonalizing channel matrices and get eigen value from that matrices in purpose to estimate channel matrices response. Channel matrices respon result is

$$H = U_H \Sigma_H V_H^* \quad \text{...(2)}$$

Where **Σ** is the diagonal matrix with R x T dimension and its element are singlar matrix of H.

3. Results.

Generally, the results of the simulation can be divided into 2 part, that are system performance graph, consists of BER and channel capacity. System performance is analyzed with system without ECC and system with ECC. Beside that, there other condition that used in this simulatioan to see system performance is the idle user (v = 0 m/s).

Figure 3 shows system performance with BER parameter for system with and without using ECC.

System simulate with idle user. From Figure 3, we can see that BER value for system with ECC better than system without using ECC. This result prove that ECC usage is important and have significant effect in minimizing bit error rate during data transmission. From the graph, also we can see that system with ECC, for QPSK,16 QAM and 64 QAM modulation, reach zeros value of BER at EbNo = 7 dB, 9 dB and 17 dB. In the other hand, for system without ECC, BER = 0 is reached when EbNo = 11 dB and 23 dB for QPSK and 16-QAM modulation. For 64-QAm modulation, BER value never reach zero.

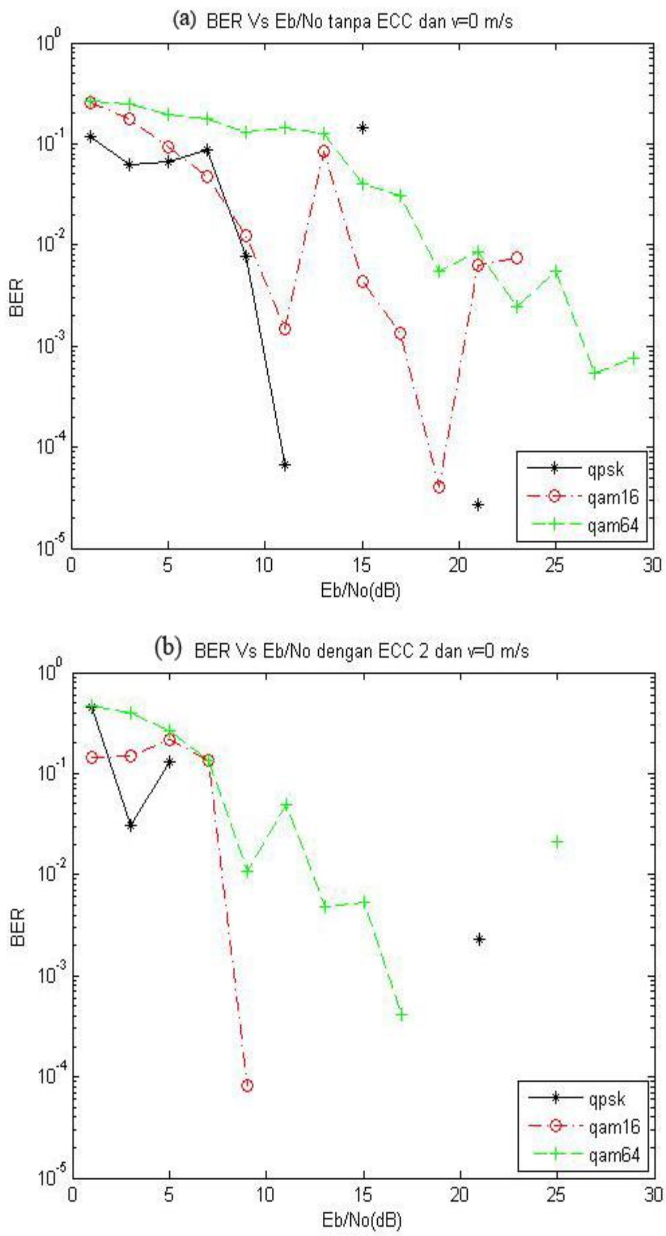

Figure 3 BER vs Eb/No V = 0 m/s

Channel capacity performance is representated in Figure 4. From Figure 4, we can see that channel capacity for system without ECC is lower than system using ECC. This is causedd BER effects toward channel capacity of the system. Systems with lower BER value have high channel capacity.

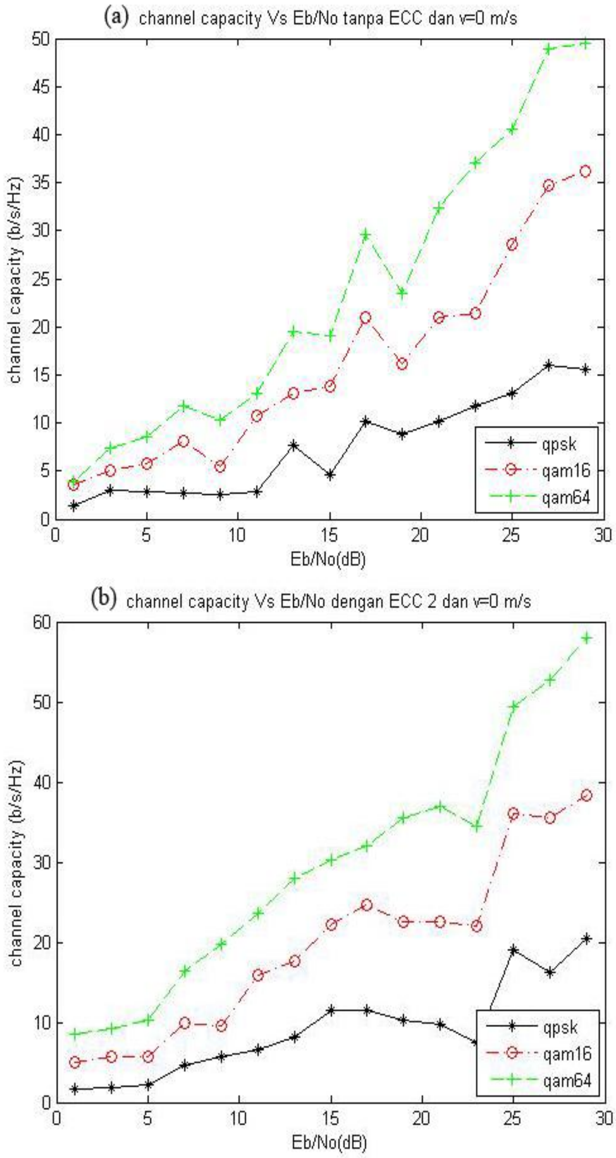

Figure 4. Channel Capacity vs EbNo V = 0 m/s

3. Conclusions

From simulation result of MIMO OFDM based on SVD channel modeling for UWB Communication system, can be concluded as following:

1. Performance of system with ECC is much bettercompared to the system without ECC, we can see from BER and channel capacity the system.
2. Perfomance of the system can be improved using high code rate.

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