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Effect of channel Fading (Rayleigh) in OFDM-STBC Technique

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Abstract — The challenge of transmit diversity design for the multiple-antenna fading channel has been met with several novel modulation and error correction techniques in the recent past. Space-time block codes operate on a block of input symbols producing a matrix output over antennas and time. Unlike traditional single-antenna AWGN block codes, full rate space-time block codes do not provide coding gain. Their key feature is the provision of full diversity with extremely low encoder/decoder complexity. In this paper we discuss modulation technique of OFDM in multiple channel diversity. The variable length modulation index of carrier signal is encoded with channel interference and reduction of noise. This paper proposes a compromise between STBC (known designs, simple ML (maximum likelihood) decoding, no coding gain) and OFDM (difficult to design, expensive ML decoding, coding gain). We concatenate AWGN with STBC in order to obtain coding gain. Then we compare the performance of concatenated STBC with fading by keeping transmit power and spectral efficiency fixed.

Keywords - OFDM, STBC, AWGN, ML DECODING, CHANNEL FADING

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has been adopted as the modulation technique for various current and proposed wireless systems. It provides high data rates, high spectral efficiency. It eliminates the need for multi-tap equalizers in frequency selective channels by dividing the available bandwidth into several narrow band channels. These channels can be allocated to different users to transmit data at a higher rate.

Each signal will experience differences in attenuation, delay and phase shift while travelling from the source to the receiver. This can result in either constructive or destructive interference, amplifying or attenuating the signal power seen at the receiver. Strong destructive interference is frequently referred to as a deep fade and may result in temporary failure of communication due to a severe drop in the channel signal-to-noise ratio.

Inverse Fast Fourier Transform and Fast Fourier Transform (FFT) are employed at the transmitter and receiver respectively to modulate and demodulate the signal. It also has an advantage that can avoid the interference among subcarriers by inserting the guard interval longer than delay spread of channel. In conventional FDM, adjacent channels are well separated using a guard interval. In order to realize the overlapping technique, crosstalk between adjacent channels must be reduced. Therefore, orthogonality between subcarriers is required. The subcarriers are data modulated using phase shift keying (PSK) or quadrature amplitude modulation (QAM). At the peak spectral response of each subcarrier all other subcarrier spectral responses are identically zero. Following data modulation, symbols are fed through a serial-to-parallel conversion process. Each PSK or QAM symbol is assigned a subcarrier and an inverse DFT (IDFT) performed to produce a time domain signal.

Transmit signal undergoes frequency-selective fading when the wireless channel has a constant amplitude and linear phase response only within a channel bandwidth narrower than the signal bandwidth. In this case, the channel impulse response has a larger delay spread than a symbol period of the transmit signal. Due to the short symbol duration as compared to the multipath delay spread, multiple-delayed copies of the transmit signal is significantly overlapped with the subsequent symbol, incurring inter-symbol interference (ISI) and inter-carrier interference (ICI). However, the system faces multi-cell interference due to fading channel resulting in degradation of bit-error rate (BER).

(OFDM) system is used to minimize multi-cell interference [5-7], where space time block code (STBC) is used to gain diversity effect among several base stations. STBC site diversity system transmits the encoded signals from several base stations and these signals are combined at the receiver with STBC decoding operation. STBC branches and the scrambling codes are assigned to each base station to maintain orthogonality of signals between the cells and to reduce interference among them.

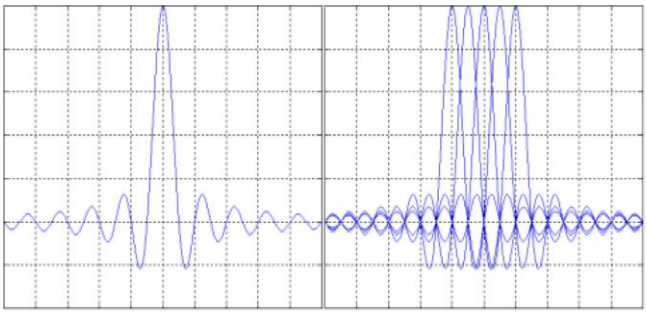
We first introduce the Alamouti code [5], which is a simple two branch transmit diversity scheme. The key feature of the scheme is that it achieves a full diversity gain with a simple maximum-likelihood decoding algorithm. In this paper, we also present STBC with a large number of transmit antennas based on orthogonal designs [3]. The decoding algorithms for space-time block codes with both real and complex signal constellations are used. The performance of the schemes on MIMO fading channels under various channel conditions is evaluated by simulations.

In this paper, we will compare different subcarrier index and measure the CIR at particular Normalized frequency which gives the comparable result for standard OFDM theory and ICI theory. Then we are measure BER for BPSK modulation technique which compares the results between Rayleigh Theory and Rayleigh simulation which improve the throughput.

The rest of paper is organized as follows. In Section II, the system model for OFDM system. The Section III covers the performance analysis. Section IV presents the improved simulation results followed by a conclusion in Section V.

II. SYSTEM MODEL

Much of the research focuses on the high efficient multicarrier transmission scheme based on "orthogonal frequency" carriers.



(a) **(b)**

Fig.1 (Spectra of an OFDM (A) sub channel (b) Signal)

Figure 1(a) shows the spectrum of the individual data of the subchannel. The OFDM signal, multiplexed in the individual spectra with a frequency spacing b equal to the transmission speed of each subcarrier, is shown in Figure1(b). Figure 1 shows that at the center frequency of each subcarrier, there is no crosstalk from other channels. Therefore, if we use DFT at the receiver and calculate correlation values with the center of frequency of each subcarrier, we recover the transmitted data with no crosstalk.

At the transmitter, the signal is defined in the frequency domain. It is a sampled digital signal. The amplitudes and phases of the carriers depend on the data to be transmitted. The data transitions are synchronized at the carriers, and can be processed together, symbol by symbol. Figure 2 shows the block diagram of an OFDM system using FFT and PN sequence.

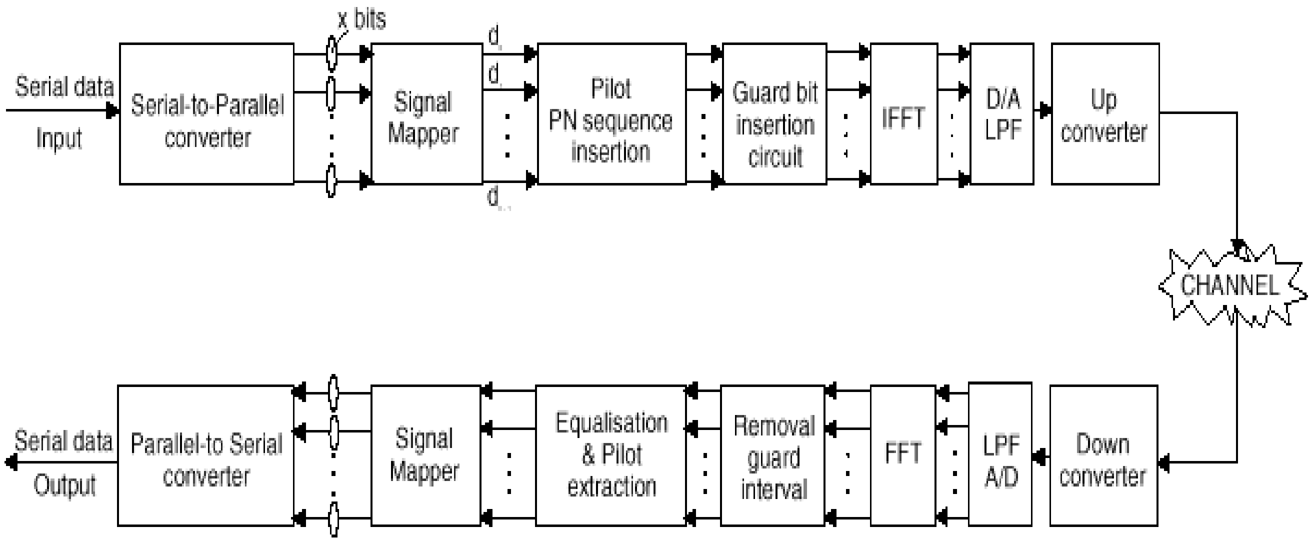


Fig. 2 (An OFDM system using FFT and pilot PN sequence)

The (N-point) discrete Fourier transform (DFT) is:

$$X_p[k] = \sum_{n=0}^{N-1} x_p[n] e^{-j(2\pi/N)kn}$$

The (N-point) inverse discrete Fourier transform (IDFT) is:

$$X_p[k] = \sum_{n=0}^{N-1} x_p[n] e^{-j(2\pi/N)kn}$$

III. PERFORMANCE ANALYSIS

A typical communication system consists of a transmitter, a channel, and a receiver. Space-time coding involves use of multiple transmit and receive antennas, as illustrated n Figure 3. Bits entering the space-time encoder serially are distributed to parallel sub-streams. Within each sub-stream, bits are mapped to signal waveforms, which are then emitted from the antenna corresponding to that sub-stream. The scheme used to map bits to signals is the called a space-time code. Signals transmitted simultaneously over each antenna interfere with each other as they propagate through the wireless channel. Meanwhile, the fading channel also distorts the signal waveforms. At the receiver, the distorted and superimposed waveforms detected by each receive antenna are used to estimate the original data bits.

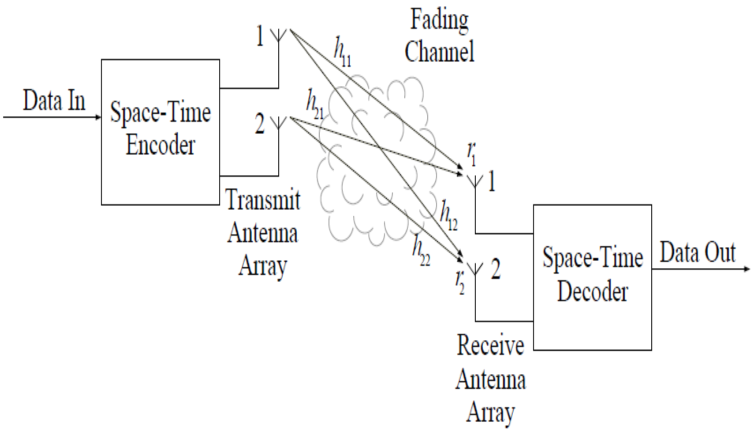


Fig. 3 (Space-time coding Technique)

A. *Space-Time Block Codes (STBC)*

The Alamouti scheme achieves the full diversity with a very simple maximum-likelihood decoding algorithm. The key feature of the scheme is orthogonality between the sequences generated by the two transmit antennas. This scheme was generalized to an arbitrary number of transmit antennas by applying the theory of orthogonal designs. The generalized schemes are referred to as space-time block codes (STBCs). The space-time block codes can achieve the full transmit diversity specified by the number of the transmit antennas n_T, while allowing a very simple maximum-likelihood decoding algorithm, based only on linear processing of the received signals [3].

B. *Space-Time Block Encoder*

Figure 4 shows an encoder structure for space-time block codes. A STBC is defined by an $n_T \times p$ transmission matrix X. Here n_T represents the number of transmit antennas and p represents the number of time periods for transmission of one block of coded symbols. The modulated signals are encoded by a space-time block encoder to generate n_T parallel signal sequences of length p according to the transmission matrix X. These sequences are transmitted through n_T transmit antennas simultaneously in p time periods. In the space-time block code, the number of symbols the encoder takes as its input in each encoding operation is k. The number of transmission periods required to transmit the space-time coded symbols through the multiple transmit antennas is p. In other words, there are p space-time symbols transmitted from each antenna for each block of k input symbols. The rate of a space-time block code is defined as the ratio between the number of symbols the encoder takes as its input and the number of space-time coded symbols transmitted from each antenna. It is given by,

$$R = \frac{k}{p}$$

The spectral efficiency of the space-time block code is given by,

$$\eta = \frac{rb}{B} = \frac{rsmR}{rs} = \frac{km}{p} \text{ bits/s/ Hz}$$

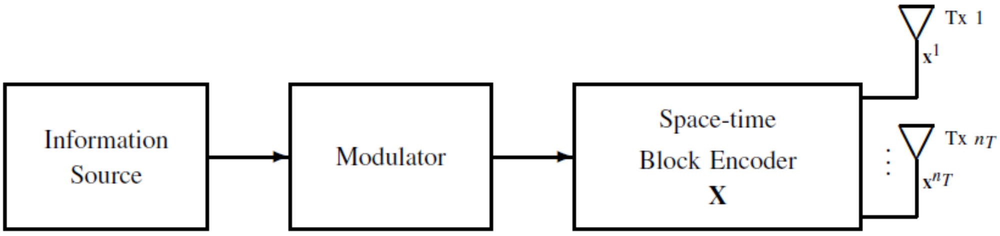


Fig.4 (A Block Diagram of Space-Time Block Encoder)

The entries of the transmission matrix **X** are linear combinations of the k modulated symbols $x_1, x_2, \ldots, x_k$ and their conjugates $x_1^*, x_2^*, \ldots, x_k^*$. In order to achieve the full transmit diversity of n_T, the transmission matrix **X** is constructed based on orthogonal designs such that

$$X \cdot X^H = c\,(\mathrm{l}\, x_1\, \mathrm{l}^2 + \mathrm{l}\, x_1\, \mathrm{l}^2 + \ldots + \mathrm{l}\, x_k\, \mathrm{l}^2)\, I_{nT}$$

Where c is a constant, $\mathbf{X}^H$ is the Hermitian of **X** and $\mathbf{I}_{nT}$ is an $n_T \times n_T$ identity matrix. The i^{th} row of **X** represents the symbols transmitted from the i^{th} transmit antenna consecutively in p transmission periods, while the j^{th} column of **X** represents the symbols transmitted simultaneously through n_T transmit antennas at time j.

The rate of a space-time block code with full transmit diversity is less than or equal to one, $R \leq 1$. For space-time block codes with n_T transmit antennas, the transmission matrix is denoted by $\mathbf{X}n_T$. The code is called the space-time block code with size n_T.

IV. SIMULATION RESULTS

As we are comparing the subcarrier index we are getting the different simulation results as per earlier research papers. Then we are measuring carrier to interference power ratio with respect to particular normalized frequency. Figure 5 shows the comparison result of the standard OFDM system and ICI Theory.

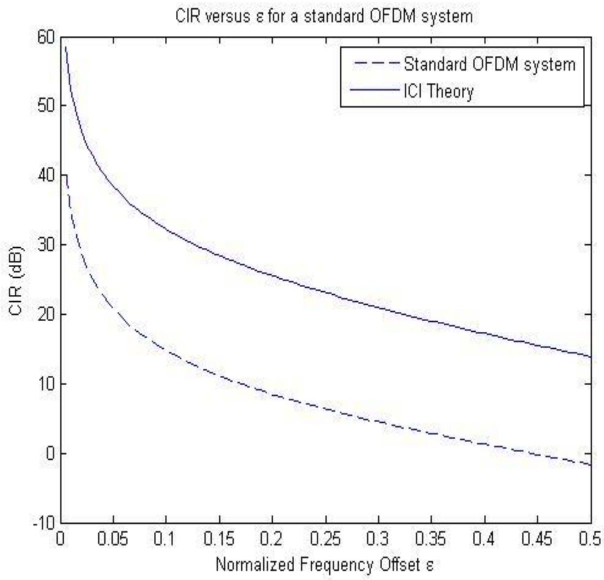


Fig. 5 (CIR versus Ɛ for a standard OFDM System)

BERs are found to discuss the system performance affected by phase noise in the original OFDM system. QPSK modulation and 16QAM modulations are used, the numbers of OFDM sub-carriers is 64 with 4 times over-sampling. AWGN channel are considered. BER versus the required-transmitted-signal-to-noise ratio (E_b/N_o) is the coding efficiency in each method.

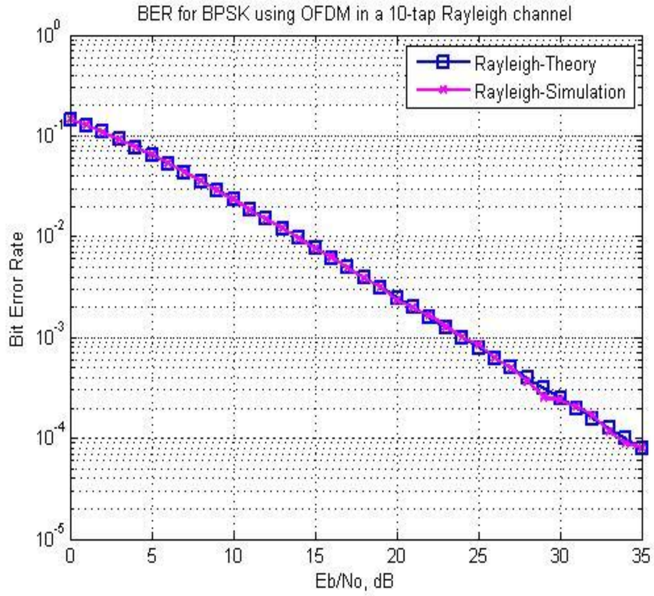


Fig. 6 (BER for BPSK using OFDM in a Rayleigh Channel)

Figure 6 shows the simulation result of BER. Result gives the comparison between 10 tap Rayleigh theory and the simulation using BPSK modulation technique. So we are getting the improve throughput from this techniques.

V. CONCLUSION

This paper validated the different design criteria for STBC in the presence of channel fading model. It presented analytical results that modeled the performance of STBC systems in the presence of CEEs. Training based channel estimation schemes are the most popular choice for STBC systems. The amount of training however, increases with number of transmit antennas used, the number of multi-paths in the channel and a decrease in the channel coherence time. This dependence was shown to decrease the performance gain obtained by increasing the number of transmit antennas in STBC systems, especially in channels with a large Doppler spread (low channel coherence time). In multi-path channels, the training overhead associated with increasing the number of transmit antennas was shown to be so large that no benefit is obtained by using STBC.

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