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Performance Comparison of MIMO-OFDM System

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Abstract — **In this paper, we exhibit 2×2 MIMO framework utilizing alamouti space time Block code for level blurring channel. In non level blurring channel i.e. recurrence particular multipath channel, convolution of the channel drive reaction with STBC yield crushes the orthogonality of the STBC that can be comprehended by utilizing Orthogonal Frequency division Multiplexing (OFDM). At long last, we contrast Performance of OFDM and CP (cyclic prefix) over awgn channel for diverse balance methods utilizing BER examination.**

Keywords— **MIMO, STBC, OFDM**

I. INTRODUCTION

In remote correspondence frameworks, sources (frequency and time sources) are critical as they focus the breaking point for transmission quality and throughput. For the most part, the idea of parallel transmission is connected to attain high throughput and a superior transmission quality. MIMO framework utilizes the idea of parallel transmission in diverse way.table.1 thinks about the idea of parallelism as connected by OFDM, CDMA, and MIMO.

Table.1
Parallelism in CDMA, OFDM, and MIMO

	Signal parallel in	**Signal separated in**	**Type of "parallel"**
OFDM	Time domain	Frequency domain	Semi-software parallelism
CDMA	Time and frequency domain	Code domain	Software parallelism
MIMO	Time and frequency domain	Space domain	Hardware parallelism

MIMO and savvy radio wire framework are generally being concentrated on for occupation in present and promising new remote correspondence framework. Shrewd radio wire framework, which are based with numerous reception apparatus on get or transmit side, offer an assortment of additions, for example, enhance SNR because of assorted qualities of gathering or transmission furthermore upgrade signal quality from obstruction concealment. Notwithstanding these, MIMO frameworks likewise give extra preference of increment information correspondence rate for the same SNR by utilizing the different spatial multiplexing modes accessible for correspondence.

II. SPACE TIME BLOCK CODE

The research on STC focuses on improving the system performance by employing extra transmits antennas. In general, the designs of STC amounts to finding transmit matrices that satisfy certain optimality criteria. Constructing STC, researcher has to trade-off between three goals: simple decoding, minimizing the error probability, and maximizing the information rate. The essential question is: How can we maximize the transmitted date rate using a simple coding and decoding algorithm at the same time as the bit error probability is minimized?

A). Alamouti Code

Historically, the Alamouti code is the first STBC that provides full diversity at full data rate for two transmit antennas [2]. A block diagram of the Alamouti space-time encoder is shown in fig.1.The information bits are first modulated using an M-ary modulation scheme.

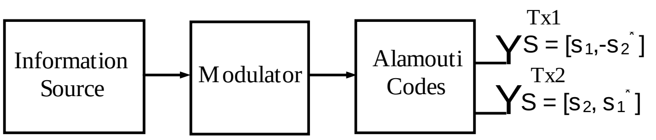


Fig. 1 A block diagram of the Alamouti space-time Encoder.

The encoder takes the block of two modulated symbols s1 and s2 in each encoding operation and hands it to the transmit antennas according to the code matrix [5].

$$s = \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix} \qquad (1)$$

It is clear that the encoding is performed in both time (two transmission intervals) and space domain (across two transmit antennas).

$$ss^H = \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix} \begin{bmatrix} s_1^* & -s_2 \\ s_2^* & s_1 \end{bmatrix}$$

$$= \begin{bmatrix} |s_1|^2 + |s_2|^2 & 0 \\ 0 & |s_1|^2 + |s_2|^2 \end{bmatrix}$$

$$= \left(|s_1|^2 + |s_2|\right) I_2 \qquad (2)$$

Where I2 is a (2 × 2) identity matrix. This property enables the receiver to detect s_1 and s_2 by a simple linear signal processing operation. At receiver, only one receives antenna is assumed to be available. The channel at time t may be modelled by a complex multiplicative distortion h1 (t) for transmit antenna one and h2 (t) for transmit antenna two. Assuming that the fading is constant across two consecutive transmits periods of duration T, we can write [4].

$$h1\,(t) = h1\,(t + T) = h1 = |h1|e^{j\theta 1}$$
$$h2\,(t) = h2\,(t + T) = h1 = |h2|e^{j\,\theta 2} \qquad (3)$$

Where |hi| and θ_i, I = 1, 2 are the amplitude gain and phase shift for the path from transmit antenna i to the receive antenna. The received signals at the time t and t + T can then be expressed as:

$$r1 = s1h1 + s2h2 + n1$$
$$r2 = -s2^{*}h1 + s1^{*}\,h2 + n2 \qquad (4)$$

Where r1 and r2 are the received signals at time t and t + T, n1 and n2 are complex random variables representing receiver noise and interference. This can be written in matrix form as:

$$r = Sh + n \qquad (5)$$

Where $h = [h1, h2]^T$ is the complex channel vector and n is the noise vector at the receiver.

III. OFDM

STBC can greatly improve the system performance over flat fading channels. In non flat fading channel, such as frequency selective multipath channel, convolutions of the channel, impulse response with STBC output destroy the orthogonality of the STBC. Using OFDM we can solve this problem and STBC with OFDM can be effectively used in non flat fading channels.

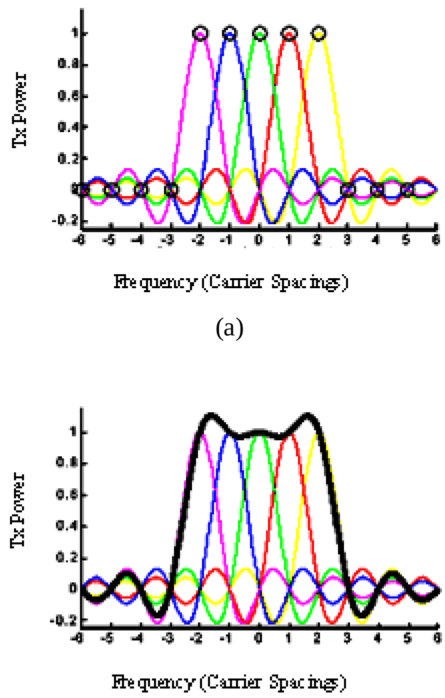
A).OFDM Principle

Signals are orthogonal if they are mutually independent of each other. Orthogonality is a property that allows multiple information signals to be transmitted perfectly over a common channel and detected, without interference. Loss of orthogonality results in blurring between these information signals and degradation in communications. Sets of functions are orthogonal to each other if they match the conditions in (6) [3].

$$\int_0^T S_i\,(t)\,S_i\,(t)\,dt = \begin{cases} C & i=j \\ 0 & i\neq j \end{cases} \qquad (6)$$

(7) Shows a set of orthogonal sinusoids, which represent the sub carriers for an unmodulated real OFDM signal.

$$S_K\,(t) = \begin{cases} \sin\,(2\,\pi\,kf_0 t) & 0<t<T \quad k=1, 2 \ldots M \\ 0 & \text{Otherwise} \end{cases} \qquad (7)$$



(a)

(b)

Fig. 2 Frequency response of the sub carriers in a 5 tone OFDM signal

Where, f_0 is the carrier spacing, M is the number of carriers, T is the symbol period. The transmission bandwidth is *Mf o*.Another way to view the orthogonality property of OFDM signals is to look at its spectrum. In the frequency domain each OFDM sub carrier has a sync, sin(x)/x, frequency response, as shown in Figure 2. This is a result of the symbol time corresponding to the inverse of the carrier spacing. As far as the receiver is concerned each OFDM symbol transmitted for a fixed time (TFFT) with no tapering at the ends of the symbol.

B). OFDM Transceiver

Figure 3.Shows the block diagram of a typical OFDM transceiver. The transmitter section converts digital data to be transmitted, into a mapping of sub carrier amplitude and phase. It then transforms this spectral representation of the data into the time domain using an Inverse Discrete Fourier Transform (IDFT). The Inverse Fast Fourier Transform (IFFT) performs the same operations as an IDFT, except that it is much more computationally efficiency and so is used in all practical systems. In order to transmit the OFDM signal the calculated time domain signal is then mixed up to required frequency.

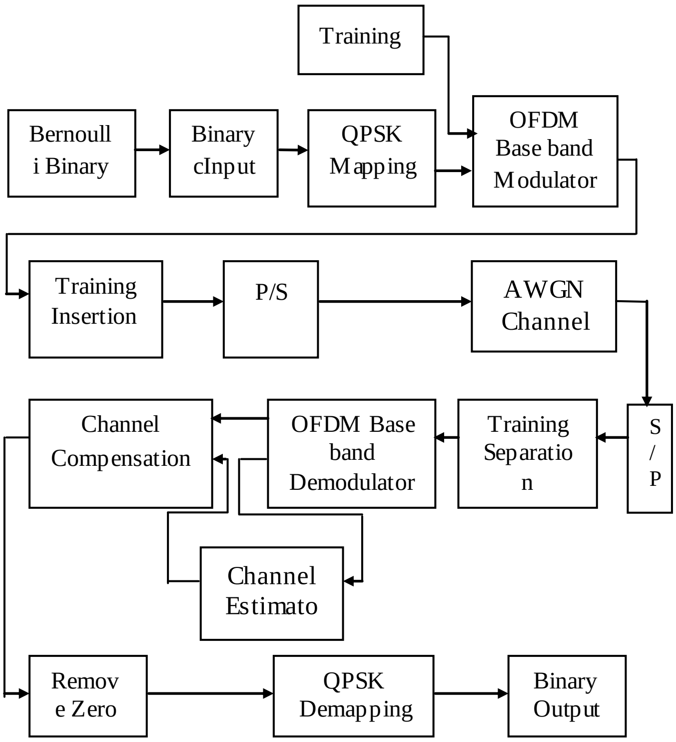


Fig. 3 Block diagram showing a basic OFDM Transceiver.

The receiver performs the reverse operation of the transmitter, mixing the RF signal to base band for processing, then using a Fast Fourier Transform (FFT) to analyse the signal in the frequency domain. The amplitude and phase of the sub carriers is then picked out and converted back to digital data. The IFFT and the FFT are complementary function and the most appropriate term depends on whether the signal is being received or generated. In cases where the signal is independent of this distinction then the term FFT and IFFT is used interchangeably.

C).Guard Period

The effect of ISI on an OFDM signal can be further improved by the addition of a guard period to the start of each symbol.

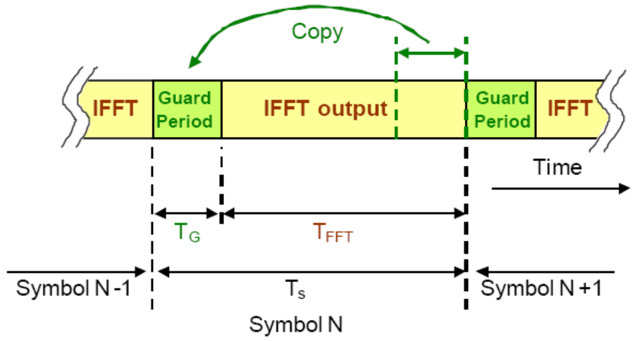


Fig. 4 Addition of a guard period to an OFDM signal.

In fig (4), The total length of the symbol is *Ts*=*TG* + *TFFT*, where *Ts* is the total length of the symbol in samples, *TG* is the length of the guard period in samples, and *TFFT* is the size of the IFFT used to generate the OFDM signal. In addition to protecting the OFDM from ISI, the guard period also provides protection against time-offset errors in the receiver [6].

IV. CHANNEL MODEL

A). AWGN Channel

The additive white Gaussian noise (AWGN) channel provides a simplistic view of a communication channel by modeling the presence of noise without accounting for distortion due to signal fading. The AWGN channel is a discrete-time channel with continuous input and output alphabets. At time *t*, the channel output *t Y* is defined as.

$$Y_t = X_t + V_t \tag{8}$$

Where *X t* is the transmitted signal and is independent of *V t*, which is the i.i.d. additive noise term with Gaussian distribution and covariance matrix ΦV = E [**VV** *] $=\sigma^2$ *I nR*, where $(\cdot)^*$ represents complex conjugation [7].

B). Rayleigh Fading Channel

A more realistic representation of a communication channel, particularly in a wireless environment, is the Rayleigh fading channel. This channel model takes into account signal fading incurred during transmission due to multipath propagation. At time *t*, the channel output *Y t* is defined as.

$$Y_t = H_t X_t + V_t \tag{9}$$

Where *X t*, *V t* and *H t* are independent, with the former two defined as in the AWGN case. *H t* denotes the signal attenuation factor due to the communication environment with its coefficients having Rayleigh distribution with a probability density function (PDF) given by[6].

$$f_H(a) = \begin{cases} 2ae^{-a2} & \text{, if } a>0 \\ 0 & \text{, otherwise} \end{cases} \tag{10}$$

V. SIMULATION RESULT

A).Experiment 1

STBC system is implemented and bit error performance is observed. 0.3163 bit error rate is observed at 1dB SNR value. 0.0158 bit error rate is observed at 30dB SNR value. 1 symbol error rate is observed at 1dB SNR value. 0.1 symbol error rate is observed at 30dB SNR value Shown in fig (5).

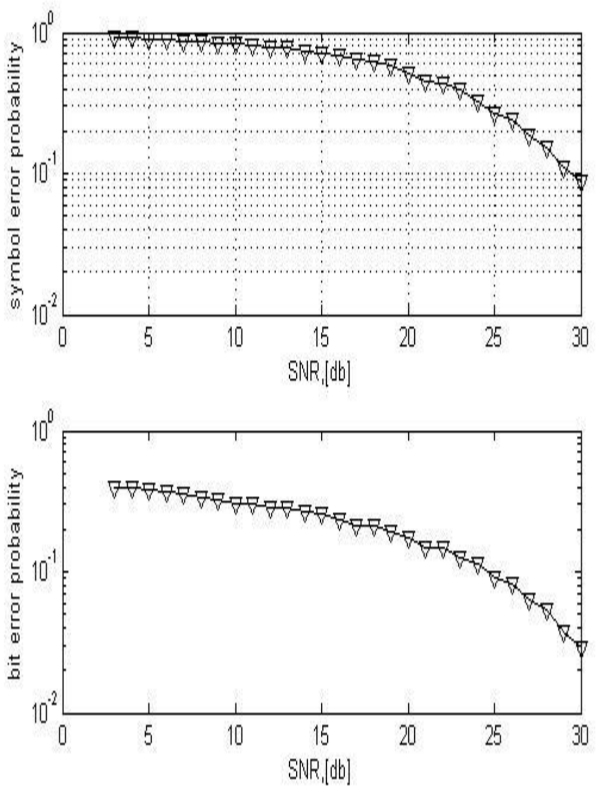


Fig 5:- Output of STBC with awgn channel

To study and implement MIMO OFDM using STBC in mat lab and analysis of same is done. In (fig 6) 0.0001 bit error rate is observed at 19dB SNR value. 0.1 bit error rate is observed at 0dB SNR value. We can observe from the graph that output is not in a proper manner because of problem in receiver part & same for the symbol error.

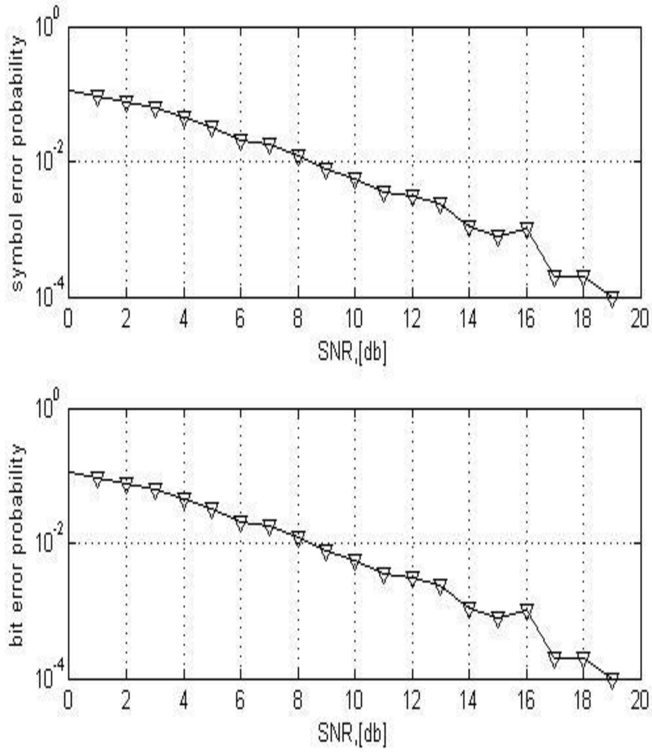


Fig. 6 Output of 2*2 MIMO-OFDM using STBC with Rayleigh channel

B).Experiment 2

In this Experiment comparison of three modulation tech is observed that at 25dB SNR value in 64-QAM bit error rate is 0.0001 but in 16-QAM and 8-QAM at 18dB and 16dB SNR value respectively bit error rate is 0.0002 and 0.0001.but bit error rate not goes to exactly 0.0000 For n=38400 bits in fig (7).

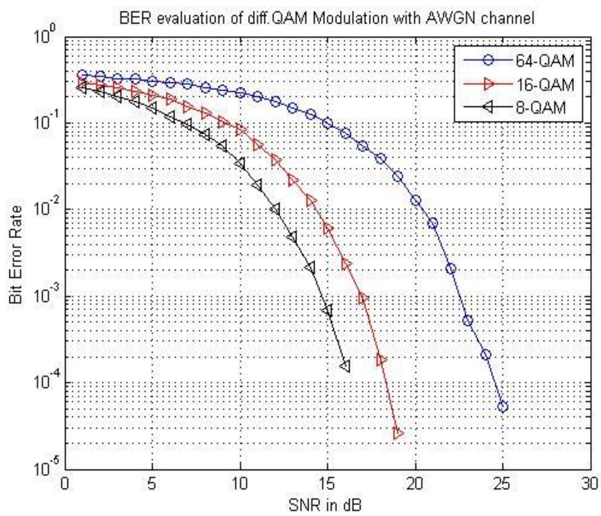


Fig. 7 Comparison of three modulation technique.

In this Experiment comparison of 64-QAM modulation tech with and without cp is observed. At 25dB SNR value bit error rate is 0.0001 and it goes to 0.0000 at 26dB SNR value with cp but in without cp at 24dB SNR value bit error rate is 0.0004 but bit error rate not goes to exactly 0.0000 For n=38400 bits in fig (8).

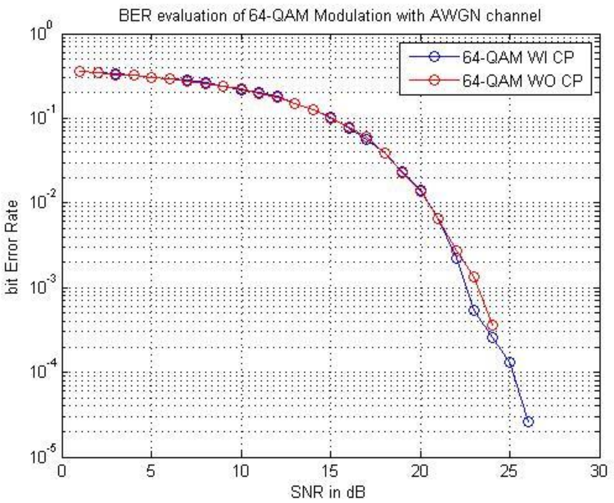


Fig. 8 Comparison of 64-QAM with & without cp

VI. CONCLUSIONS

We have taken BER analysis for 2×2 MIMO using alamouti STBC using flat fading channel. The same analysis is taken using OFDM for various modulation technique and we conclude that 8-QAM is better than other. In non flat fading channel, OFDM is combine with MIMO using Space Time Block Code where diversity is obtain in space as well as time. The results show that we can minimize bit error up to 0.0001 at 19dB SNR.

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