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Estimation of MIMO-OFDM Based Channel for High Data Rate Wireless Communication

Deeparani Mishra[1], Sikha Mishra[2], Mihir N. Mohanty[3*]
ITER, Siksha O' Anusandhan University, Bhubaneswar, Odisha, India

***Abstract*— The demand of users increases day by day in context of wireless communication. The current research emphasizes on many factors such as data rate, type of modulation, and characteristics of the channel. Out of all the factors, channel estimation is the interest in this work. In this paper, the channel estimation based on MIMO-OFDM has been performed. The multiple-input multiple-output(MIMO) system is developed using multiple antennas, where the Space Time Block Coding(STBC), has been tested over Rayleigh's flat fading channel. The concept for wireless communication using MIMO-OFDM has been considered and tested step-by-step. The noise analysis, Bit Error Rate (BER), Symbol Error Rate (SER) has been evaluated. The comparison result of Least Square (LS) method and Minimum Mean Square Error (MMSE) method shows the performance for slow fading environment, that leads the further improvement.**

***Keywords*—MIMO, OFDM, Channel Estimation, BER, LS, MMSE**

I. INTRODUCTION

Wireless communication is an interesting area of research for the modern society in many aspects like, efficient technology in terms of error rate and occupation bandwidth. Blind channel estimation based work has been done in [1]. A Multiple Input Multiple Output (MIMO) communication system, combined with Orthogonal Frequency Division Multiplexing (OFDM) as MIMO-OFDM modulation technique can achieve a reliable high data rate transmission over wireless channels [2]. It achieves this by higher spectral efficiency and link reliability or diversity (reduced fading) [3], [6]. Because of these properties, MIMO is a current theme of international wireless research. Recently, there has been growing interest in providing a broad range of services including wire-line voice quality and wireless data rates of about 64–128 kb/s (ISDN) using the cellular (850-MHz). Rapid growth in mobile computing is inspiring many proposals for even higher speed as well as reliable data services. The requirement to provide reliable high data rate communication over the wireless channel has led to the development of efficient modulation and coding schemes [4-5], [7-8]. A wireless channel suffers from time-varying impairments like multipath fading, interference and noise. Diversity is an effective method to combat the fading of the wireless channel [6]. Thus, link reliability is improved. Various types of diversities are there such as time/frequency/space/polarization/angle diversity. But the time and frequency diversity lead to loss in bandwidth. Employing multiple antennas at the transmitter and/or at the receiver, spatial diversity mitigates fading without sacrificing resource leads in gaining the popularity.

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier transport technology for high data rate communication system. but these systems in Fading channel environment has gained a broad interest. For instance its applicability to Digital Audio Broadcasting (DAB), Digital T.V Broadcasting (DTB), Wireless Local Area Network(WLAN) has already been investigated [1], [9]. Coherent detection and accurate channel estimation is required at the receiver to obtain reasonable performance in slow fading channel i.e. in the time in variant channels the estimation of channel response can be obtained by LS estimation scheme. But in wireless application, the MMSE, BER and SER for data transmission is most important. OFDM systems performance is mostly degraded in fast fading channel due to intercarrier interference [10]. That leads the interest in this work and the performance has been evaluated.

The paper is summarized as follows. Section II describes OFDM based MIMO technique. Section III is for the design of the model based upon Phase Shift Keying over Reyleigh channel .IV represents channel estimation of the model & V follows the result. Finally section VI concludes the paper with the scope for future work.

II. PRINCIPLES OF MIMO OFDM SYSTEMS

In this paper the multi-antenna system is considered. A digital source in the form of a binary data stream is fed to a simplified transmitting block encompassing the functions of error control coding and mapping to complex modulation symbols such as BPSK, QPSK, M-QAM. The latter produces several separate symbol streams which range from independent to partially redundant to fully redundant. Each is then mapped onto one of the multiple transmitting antennas. Mapping may include linear spatial weighting of the antenna elements or linear antenna space–time coding. After upward frequency conversion, filtering and amplification, the signals are launched into the wireless channel. At the receiver, the signals are captured by possible multiple antennas, then demodulation and de-mapping operations are performed to recover the message. This determines the class and performance of the multi-antenna solution which is implemented.

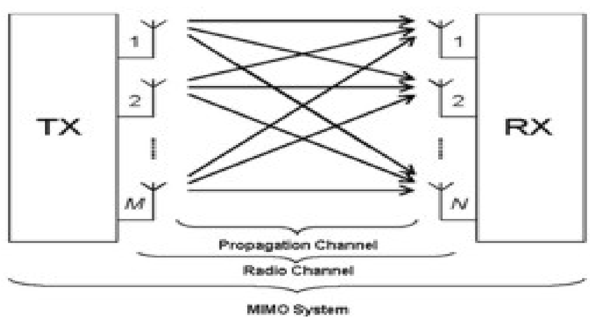

Fig. 1. Basic Structure of MIMO systems

OFDM is widely applied in wireless communication due to it's high rate of transmission capacity with high bandwidth efficiency. The use of PSK in OFDM systems avoids to track a time varying channel however it limits the no. of bits per symbol and low SNR generally. The system is actually based on spreading the high speed data to be transmitted over a large number of low rate carriers. The carriers are orthogonal to each other and frequency spacing between them are created by using the Fast Fourier transform (FFT). An OFDM signal is basically a bundle of narrowband carriers transmitted in parallel at different frequencies from the same source. The incoming data is first converted from serial to parallel and grouped into x bits each to be modulated by either Quadrature Amplitude Modulation (QAM), or Quadrature Phase Shift Keying (QPSK), or Binary Phase Shift Keying (BPSK). The required spectrum is then converted back to its time domain signal using an Inverse Fast Fourier Transform (IFFT), commonly used in most applications. A parallel to serial converter is used for serial transmission of data. Finally the discrete signals are converted back to analogue.

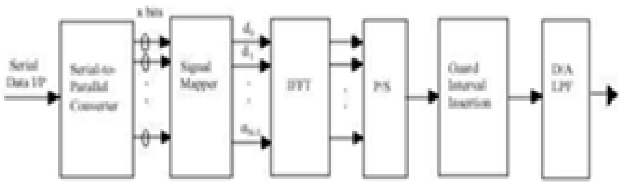

Fig. 2. OFDM transmitter

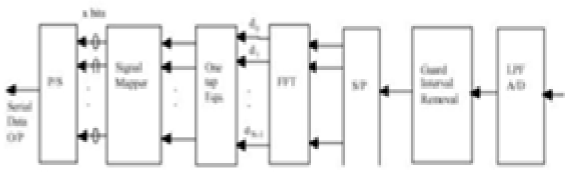

Fig 3. OFDM Receiver

III. DESIGN OF SYSTEM MODEL

Considering a system as shown in Fig where x_k are the transmitted symbols, h(t) is channel impulse response $\tilde{n}(t)$, is white complex Gaussian Channel noise and y_k are the received symbols.

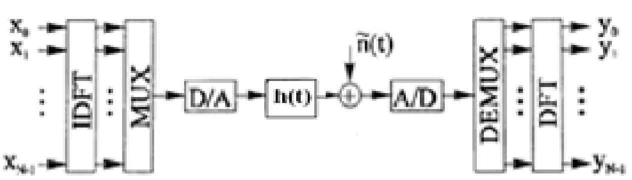

Fig. 4. Base-band OFDM system

Here the channel impulse response h(t) is treated as

$$\mathrm{h}(\mathrm{t}) = \sum_{m} a_m \delta(\mathrm{t} - \tau_{\mathrm{m}} \mathrm{T_s}) \qquad (1)$$

Where α_m are the complex amplitudes.

The system is then modeled using a N-point discrete time Fourier Transform (DFT_N) as[4]

$$\mathrm{y} = \mathrm{DFT_N}(\mathrm{IDFT_N}(\mathrm{x}) \otimes \frac{h}{\sqrt{n}} + \tilde{n}) \qquad (2)$$

The system describedby in above equation can be written as set of N-independent Gaussian Channels, $y_k=h_k x_k+n_k$, k=0……..N-1.

Where h_k = complex channel attenuation given by $h=(h_0,h_1 \ldots h_{n-1})^T$ and $n=(n_0,n_1 \ldots n_{n-1})^T$ is an i.i.d complex Zero mean Gaussian noise vector. so in matrix notation the ofdm system is described as

$$\mathrm{y} = \mathrm{XFg} + \mathrm{n} \qquad (3)$$

where X is the input data matrix and elements of X are on its diagonal and

$$F = \begin{pmatrix} W_N^{00} & \cdots & W_N^{0(N-1)} \\ \vdots & \ddots & \vdots \\ W_N^{(N-1)0} & \cdots & W_N^{(N-1)(N-1)} \end{pmatrix} \qquad (4)$$

Is the DFT matrix with

$$W_N^{nk} = 1/\sqrt{N} e^{-j2\pi nk/N} \qquad (5)$$

IV. CHANNEL ESTIMATION OF MIMO-OFDM MODEL

A wireless channel model can be considered both in time domain and frequency where the features are stationary and ergodic in nature. Therefore, the estimation of channel is one of the emerging area of resources.

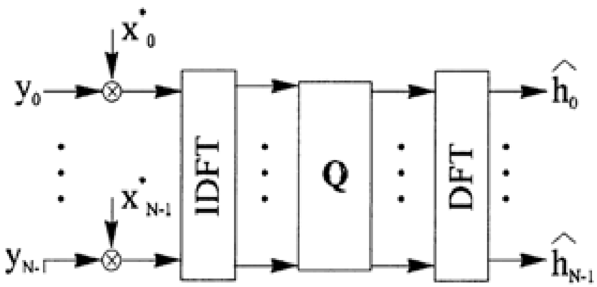

Fig. 5. Estimator Structure

A. MMSE AND LS CHANNEL ESTIMATOR

Let the channel vector h is Gaussian and un-correlated with channel noise n , the MMSE estimate of h becomes

$$\hat{h}_{MMSE} = R_{hy} R_{yy}^{-1} y \qquad (6)$$

where

$$R_{hy} = E\left\{hy^H\right\} = R_{hh}F^H X^H$$

$$R_{yy} = E\left\{yy^H\right\} = XFR_{hh}FHX^H + \sigma_n^2 I_N$$

are the cross covariance matrix between h and y and the auto covariance of y. Further R_{hh} is the auto covariance matrix of h and σ_n^2 denotes the noise variance E{ l n_kl ^{2}}. These two quantities are assumed to be know. So the MMSE estimates (h_{MMSE}) is represented by

$$\hat{h}_{MMSE} = F\hat{h}_{MMSE} = FQ_{MMSE} F^H X^H y \qquad (7)$$

Where Q_{MMSE} ,

$$Q_{MMSE} = R_{hh}[\left(F^H X^H XF\right)^{-1} \sigma_n^2 + R_{hh}]^{-1}(F^H X^H XF)^{-1} \qquad (8)$$

The LS estimator for channel impulse response h is analyzed as follows:-

$$\hat{h}_{LS} = FQ_{LS}F^H X^H y \qquad (9)$$

where

$$Q_{LS} = \left(F^H X^H XF\right)^{-1} \qquad (10)$$

considering the two equations we have

$$\hat{h}_{LS} = X^{-1}y \qquad (11)$$

From eqn (7) and (11) it is observed that the MMSE estimator suffers from a high complexity, whereas the LS estimate has a high mean square error. So a modification of these is presented in the next section.

V. RESULTS

Simulation results demonstrate that the performance of LS and MMSE method are quite well in wireless communication. Even though MMSE estimator is more complex than LS, it provides reduced SER and BER.

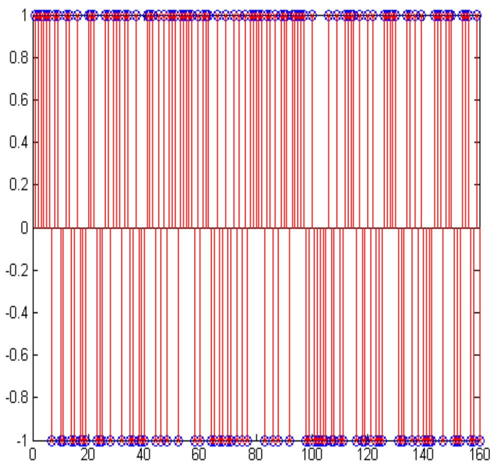

Fig. 6. Transmitted OFDM data

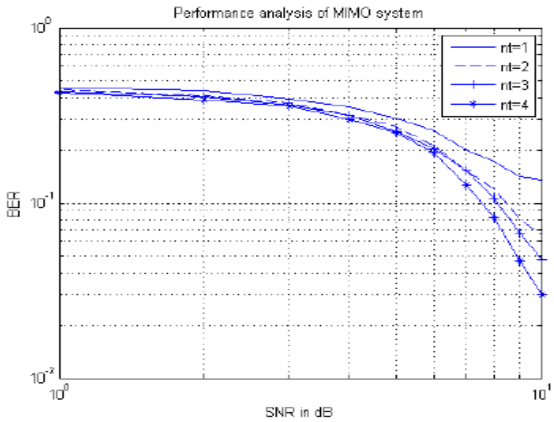

Fig 7. Noise analysis of MIMO system

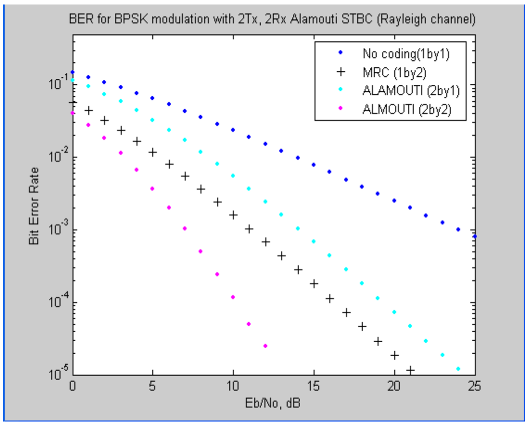

Fig. 8. Comparision of BER vrs SNR for BPSK modulation

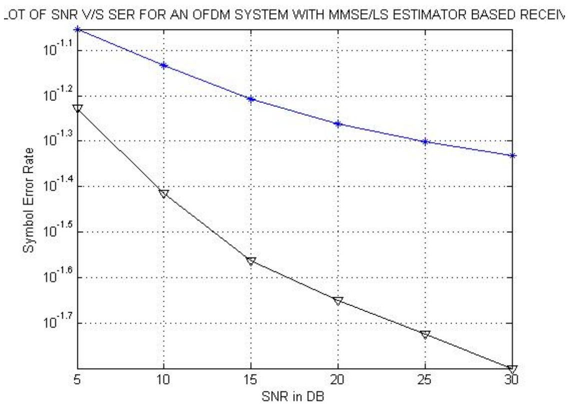

Fig 9:- Comparison of LS & MMSE estimator

VI. CONCLUSION

It is observed from the simulation result that, the SNR value gradually increases, simultaneously the performance of both the estimators is quite good. But MMSE performs more effectively as compared to LS. The paper concludes that though the number of antenna increases, the noise performance of the system improves. But it is advisable not to increase the number of antennas due to cost factor of the system. The Alamouti coding is a remarkable scheme for transmission using two transmit antennas in terms of simplicity and performance. Still there is the scope for improvement of the system performance.

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