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PERFORMANCE ANALYSIS OF MIMO-OFDM SYSTEM WITH PERFECT CHANNEL ESTIMATION AND BEAMFORMING TECHNIQUE

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ABSTRACT

Multiple transmit and receive antennas can be used to form multiple-input multiple-output (MIMO) channels to increase the capacity by a factor of the minimum number of transmit and receive antennas. In this paper, orthogonal frequency division multiplexing (OFDM) for MIMO channels (MIMO-OFDM) is considered for wideband transmission to mitigate intersymbol interference and enhance system capacity. The MIMO-OFDM system uses two independent space-time codes for two sets of two transmit antennas. At the receiver, the independent space–time codes are decoded using prewhitening, followed by minimum-Euclidean-distance decoding based on successive interference cancellation. This work mainly aims at estimating the perfect channel by using the delayed feedback, where the feedback is estimated at the receiver and feedback to the transmitter. Here we use guard bits for the OFDM signals.By checking out with the estimators result in MATLAB we found LS to be a perfect channel. Therefore delayed feedback is the best technique for the channel estimation.

Key Words: Multiple-input multiple-output channels (MIMO), orthogonal frequency division multiplexing (OFDM), parameter estimation, and wireless communications.

I INTRODUCTION

HIGH DATA-RATE wireless access is demanded by many applications. Traditionally, more bandwidth is required for higher data-rate transmission. However, due to spectral limitations, it is often impractical or sometimes very expensive to increase bandwidth. In this case, using multiple transmit and receive antennas for spectrally efficient transmission is an alternative solution. Multiple transmit antennas can be used either to obtain transmit diversity, or to form multiple-input multiple-output (MIMO) channels.

Many researchers have studied using multiple transmit an-tennas for diversity in wireless systems. Transmit diversity may be based on linear transforms [1] or space–time coding [2]. In particular, space–time coding is characterized by high code efficiency and good performance; hence, it is a promising technique to improve the efficiency and performance of or-thogonal frequency division multiplexing (OFDM) systems. On the other hand, the system capacity can be significantly improved if multiple transmit and receive antennas are used to form MIMO channels [3]–[6]. It is proven in [4] that, com-pared with a single-input single-output (SISO) system with flat Rayleigh fading or narrowband channels, a MIMO system can improve the capacity by a factor of the minimum number of transmit and receive antennas. For wideband transmission [7], space–time processing must be used to mitigate intersymbol interference (ISI). However, the complexity of the space–time processing increases with the bandwidth, and the performance substantially degrades when estimated channel parameters are used [8].

In OFDM [9]–[11], the entire channel is divided into many narrow parallel subchannels, thereby increasing the symbol du-ration and reducing or eliminating the ISI caused by the multi-path. Therefore, OFDM has been used in digital audio and video broadcasting in Europe [12], and is a promising choice for future high-data-rate wireless systems. Multiple transmit and receive antennas can be used with OFDM to further improve system performance. We have studied OFDM systems with adaptive antenna arrays for co-channel interference suppression [13] and transmit diversity based on space–time coding, delayed trans-mission, and permutation [14]–[16]. In particular, a channel pa-rameter estimator for OFDM systems with multiple transmit antennas was proposed in [14] and simplified in [16]. Optimum training sequences for OFDM with multiple transmit antennas were also proposed in [16].

In this paper, we study multiple transmit and receive antennas for OFDM to form MIMO channels (MIMO-OFDM). Our focus here is perfect channel estimation and delayed feedback. The rest of this paper is organized as follows. In Section II, we introduce MIMO-OFDM systems and introduce the proposed system model. We then present channel estimation for MIMO-OFDM systems in Section III. Finally, we demonstrate the performance of MIMO-OFDM systems using our new techniques by computer simulation in Section

II. PROPOSED SYSTEM MODEL

A MIMO-OFDM system with four transmits and $p(p\geq4)$ receive antennas is shown in Fig. 1. Though the figure shows MIMO-OFDM with four transmit antennas, the techniques de-veloped in this paper can be directly applied to OFDM systems with any number of transmit antennas.

At time$n$, each of two data blocks, $,\{k][n\ k = 0, 1, \ldots\}$ for $i=1$ and 2, is transformed into two different signals, $\{t_{2(i-1)+j}[n,k] : k = 0, 1, \ldots, j = 1, 2\}$ for $i=1$ and 2, respectively, through two space–time encoders. The OFDM signal for the ith transmit antenna is modulated $,$by $t_i[nk]$ at the kth tone of the nth OFDM block.

From the figure, the received signal at each receive antenna is the superposition of four distorted transmitted signals, which can be expressed as

$$r_j[n,k] = \sum_{i=1}^{4} H_{ij}[n,k] t_i[n,k] + w_j[n,k] \qquad (1)$$

for $j = 1, \ldots, p$. $w_j[n,k]$ in (1) denotes the additive complex Gaussian noise at the jth receive antenna, and is assumed to be zero-mean with variance $\sigma 2$ and uncorrelated for different n’s, k’s, or j’s. $H_{ij}[n,k]$ in (1) denotes the channel frequency response for the kth tone at time n, corresponding to the ith transmit and the jth receive antenna. The statistical characteris-tics of wireless channels are briefly described in Section II-B.

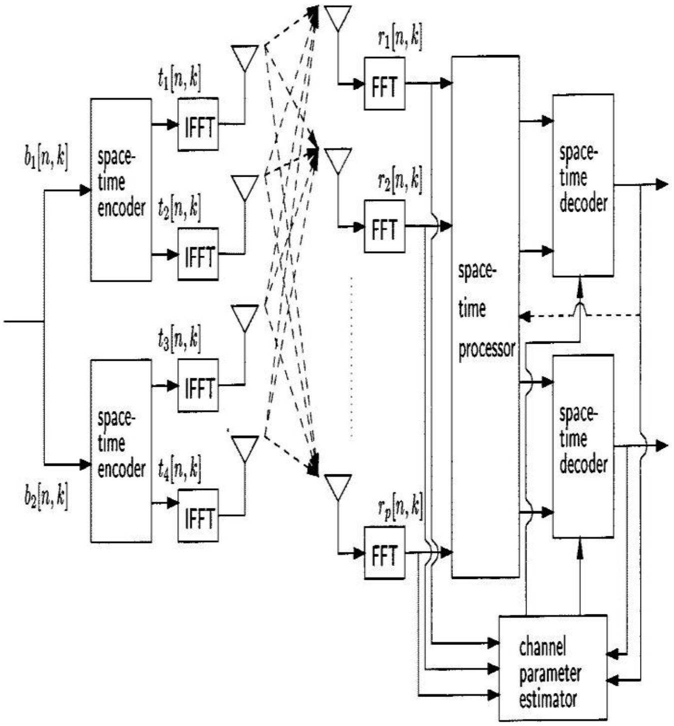


Fig. 1. MIMO-OFDM system.

The input–output relation for OFDM can be also expressed in vector form as

$$\mathbf{r}[n,k] = \mathbf{H}_1[n,k]\mathbf{t}_1[n,k] + \mathbf{H}_2[n,k]\mathbf{t}_2[n,k] + \mathbf{w}[n,k] \qquad (2)$$

where

$$\mathbf{r}[n,k] \triangleq \begin{pmatrix} r_1[n,k] \\ \vdots \\ r_p[n,k] \end{pmatrix} \qquad \mathbf{w}[n,k] \triangleq \begin{pmatrix} w_1[n,k] \\ \vdots \\ w_p[n,k] \end{pmatrix}$$

and

$$\mathbf{t}_i[n,k] \triangleq \begin{pmatrix} t_{2i-1}[n,k] \\ t_{2i}[n,k] \end{pmatrix}$$

$$\mathbf{H}^{i}[n, k] \triangleq \begin{pmatrix} H_{2i-1\ 1}[n,k] & H_{2i\ 1}[n,k] \\ & \cdot \\ H_{2i-1\ p}[n,k] & H_{2i\ p}[n,k] \end{pmatrix}.$$

To achieve transmit diversity gain and detect the transmitted signal, a space–time processor must extract the required signals for space–time decoders. Note that both the space–time processor and space–time decoding require channel state information.

III. CHANNEL ESTIMATION

Channel is estimated at the receiver and fed back to the transmitter. By estimating the perfect channel we can say how the signal propagates from the transmitter to the receiver. It can also help to determine the type of channels (Rayleigh, Ricean, and Pedestrian). To estimate the perfect channel there are certain estimators like LS (Least square), MMSE (Minimum mean square error), TD-LMMSE (Time domain- Least minimum mean square error), TDD-LMMSE (Time domain- Least minimum mean square error- ignoring channel covariance), TD Qabs LMMSE(Time domain- Least minimum mean square error- ignoring smoothing matrix).Estimators equations are given below

LS is given by

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

MMSE is given by

$$H_{MMSE} = FR_{hY}R_{YY}^{-1}Y$$

TD-LMMSE is given by

$$\hat{h}_{lmmse} = R_{hh_{ls}}R_{h_{ls}h_{ls}}^{-1}\hat{h}_{ls} == R_{hh}\left(R_{hh} + \sigma^{2}{}_{n}(XX^{h})^{-1}\right)^{-1}\hat{h}_{ls}$$

TDD-LMMSE is given by

$$R_{YY}\ R_{YY} = E\{YY\} = XFR_{hh}F^{H}X^{H} + \sigma^{2}I_{N}$$

TD Qabs LMMSE is given by

$$W_{N}^{nk} = \frac{1}{N}e^{-j2\pi(n/N)k}$$

III. Per-Antenna power constraint for variable bound SINR constraint

- The joint cooperative beam forming and admission control for cognitive radio network with per antenna power constraint for secondary user under variable SINR constraint is given by

•

$$\min_{\mathbf{w}_p,\{\mathbf{w}_k,s_k\in\{-1,1\}\}_{k=1}^{K}} \sum_{j=1}^{M}\left\|\mathbf{w}_{p_j}\right\|^2+\sum_{k=1}^{K}\left\|\mathbf{w}_k\right\|^2+L*\sum_{k=1}^{K}s_k^2$$

Subjectto:

$$\sum_{j=1}^{M}\left\|\mathbf{w}_{p_j}\right\|^2+\sum_{k=1}^{K}\left\|\mathbf{w}_k\right\|^2\le P_{\max}$$

$$\sum_{k=1}^{K}\left\|\mathbf{w}_k\right\|^2=\frac{1}{N_t}$$

$$\left|\mathbf{h}_{p_j}^H\mathbf{w}_{p_j}\right|\ge\sqrt{\gamma_p\left(\sum_{i=1}^{K}\left|\mathbf{h}_{sp_j}^H\mathbf{w}_{s_i}\right|^2+\sum_{\substack{l=1\\l\neq j}}^{M}\left|\mathbf{h}_{p_j}^H\mathbf{w}_{p_i}\right|^2+N_0\right)}$$

$$\sqrt{\gamma_{s_{\min}}\left(\sum_{j=1}^{M}\left|\mathbf{h}_{ps_i}^H\mathbf{w}_{p_j}\right|^2+\sum_{\substack{l=1\\l\neq i}}^{K}\left|\mathbf{h}_{s_i}^H\mathbf{w}_{s_i}\right|^2+N_0\right)}-\left(\left|\mathbf{h}_{s_i}^H\mathbf{w}_i\right|+s_k\right)\le 0$$

$$\left(\left|\mathbf{h}_{s_i}^H\mathbf{w}_i\right|+s_k\right)-\sqrt{\gamma_{s_{\max}}\left(\sum_{j=1}^{M}\left|\mathbf{h}_{ps_i}^H\mathbf{w}_{p_j}\right|^2+\sum_{\substack{l=1\\l\neq i}}^{K}\left|\mathbf{h}_{s_i}^H\mathbf{w}_{s_i}\right|^2+N_0\right)}\le 0$$

<u>Simulation Parameters</u>

S.NO	PARANETERS	VALUES
1	Number Of Antennas In Primary Transmit	2
2	Number Of Antennas In CRBS	2
3	Maximum total power ($P_{\max}$)	2 mw
4	Noise variance (N_o)	-60dbm
5	Large constant (L)	10^{10}
6	Primary users SINR target	10db
7	Target SINR at SR(fixed SINR constraint)	5db
8	Target SINR at SR(Bounded SINR constraint)	3db to 5db
9	Number Of secondary users	4 to 16
10	Monte-Carlo simulations	1000 runs

IV. RESULTS

For different modulation with *N* branch diversity, assuming channel information is known and fading channel the performance analysis is made in this work. The noise added by the channel is also presumed to be Gaussian random noise. The goal of our analysis is to highlight the performance of this system by comparing them with various interconnected systems. For analysis of the effectiveness of this system a performance measure is made between the Es No (in dB) and Channel MSE.

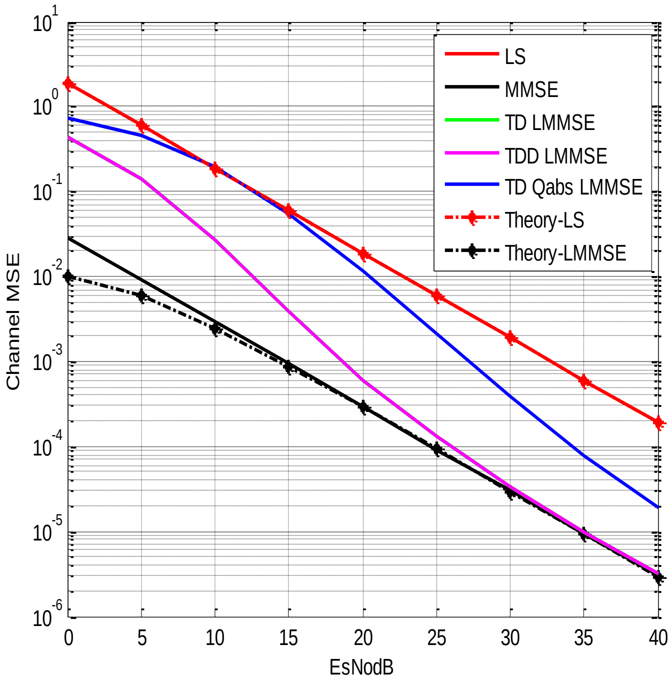


Fig. 1. EsNo (db) Vs. Channel MSE for MIMO-OFDM system

The system shown in Fig.2 consists of a MIMO-OFDM implementation with channel estimators. It shows the diverge performance for the various channels. In below Fig.3 it shows the difference of TDD LMMSE from TD LMMSE by comparing Fig,1 and Fig.2.

In this graph it has the theoretical output and also the output from the MATLAB simulation. By comparing both these outputs perfect channel is estimated.

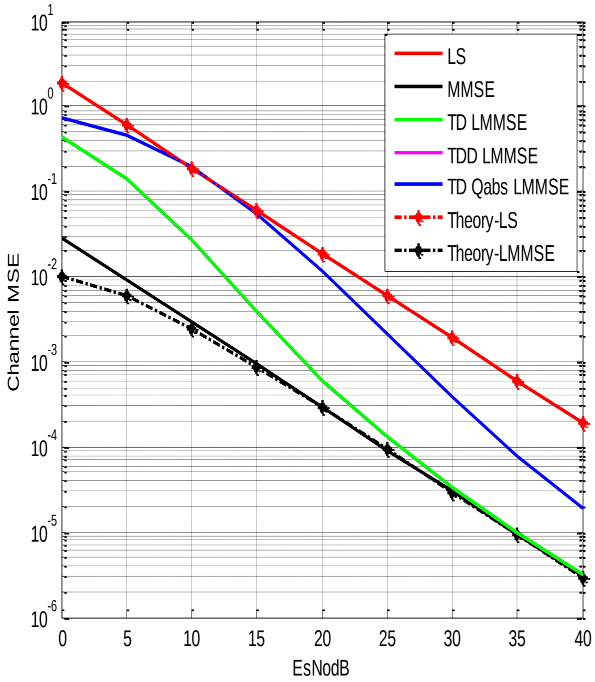


Fig.2. EsNo vs. Channel MSE for MIMO-OFDM system

From both these figures we could see that in Least square estimator the curve of both theoretical and graphical datas are constant, whereas in every other cases it differs from one another. Hence we can infer that LS is the perfect channel estimator.

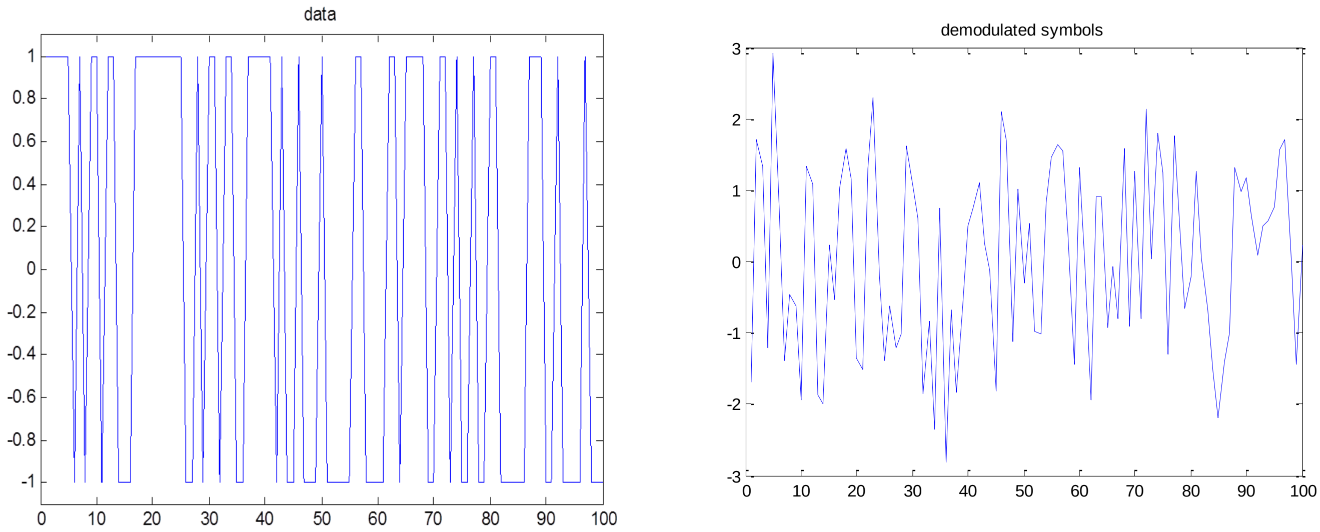
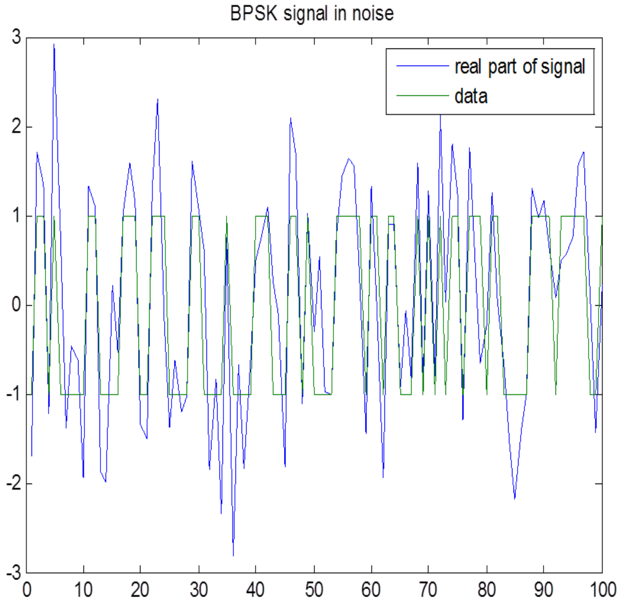


Fig.3. Input signal fed into the MIMO-OFDM system

Above shown figure represents the input signal fed into the MIMO-OFDM proposed system. The output and demodulated signals are shown in the below figures.



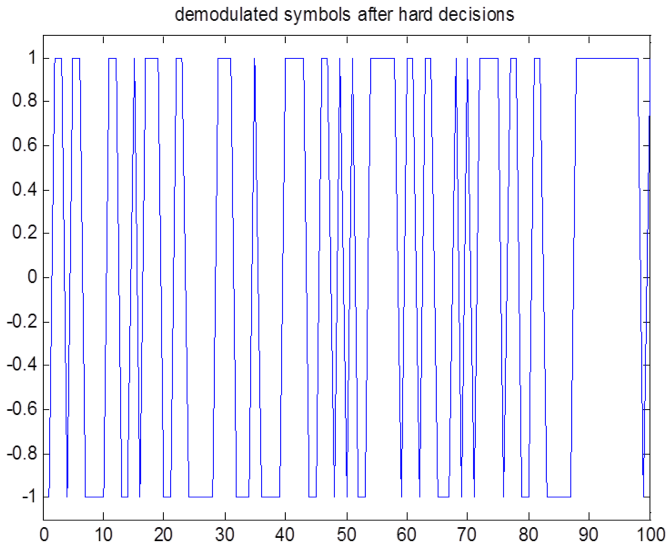


Fig.4. Modulated input signal

In the figure.4 it shows the modulated input signals fed into the amplifier. Here it is the BPSK signal in noise.

Fig.5 Demodulated symbols of the output signal

This figure shows the demodulated symbols of the signal. Here data's are present in this signal. Next figure shows the demodulated symbols after hard decisions. Thus by which the output is determined.

Fig.6. Demodulated symbols after hard desicions

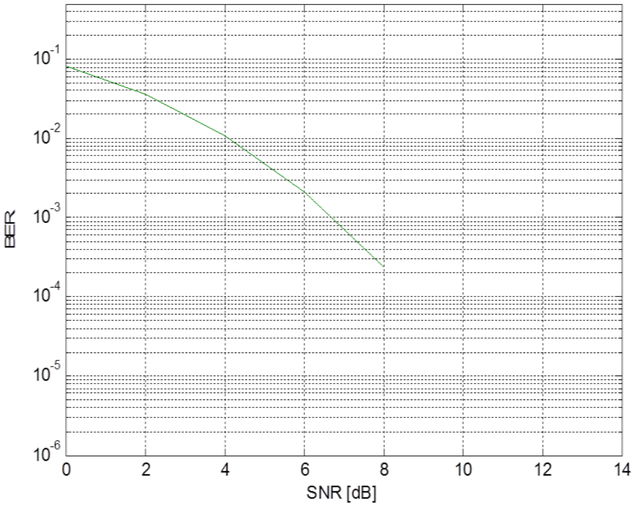


Fig.7. SNR (dB) Vs. BER of MIMO-OFDM system

This figure shows the high performance of MIMO-OFDM system using channel estimation and delayed feedback.

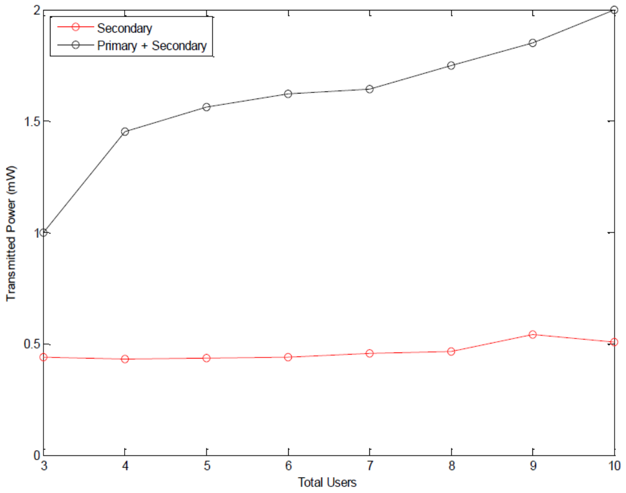


Figure 2. Transmit power with respect to number of admitted secondary users

V. CONCLUSION

The results shown above give an increase in the performance when an MIMO-OFDM system using channel estimation and delayed feedback. The channel estimator LS is the detrimental aspects in this system. So to have an even superior performance *Per Antenna Power Constrain Technique* will also be appended in the future work. This will form The Most Efficient Way of Communication.

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