International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 4 Issue 7, July-2015

A Comprehensive Study on Effective Channel Estimation Technique for MIMO-OFDM System

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Abstract: The concepts of MIMO and OFDM were combined with the emerging intent of exploiting the advantages of both techniques. This combination has given the development to MIMO-OFDM wireless communication systems with the expectation of having spectrally efficient, high data rate system that is robust to frequency selective fading channels. With the area of applications of the MIMO-OFDM system expanding very fast, the requirement for an improved functioning of the systems is becoming very high. As a result, more research efforts are being directed towards achieving better MIMO-OFDM Systems performance. However, one of the major challenges to either single antenna i.e. SISO OFDM or MIMO-OFDM communication systems is means of providing accurate channel state information (CSI) at the receiver end of the systems for coherent detection of the transmitted signal. If the CSI is not available at the receiver, the transmitted signal could only be demodulated and detected through a non-coherent method such as the differential demodulation technique. However, the employment of non-coherent detection method is at the expense of about 3-4 dB loss in signal-to-noise ratio (SNR) compared with using the coherent detection method.

Keywords: AMUD, LMS Algorithm, MIMO, SISO OFDM, Spatial Multiplexing.

I. INTRODUCTION

Adaptive MIMO OFDM was also presented by Wong who assumes knowledge of the intravenous channel gain for bits and power allocation algorithm in all users to improve transmit power, bit error rate and coverage for a given outage probability. With no knowledge of the channel, the objective is to maximize the transmission rate, while guaranteeing a prescribed error performance, under the constraint of fixed transmit-power. Transmit diversity scheme employing Space-Time Block Code (STBC) helps to increase number of antennas. This scheme has been presented by Alamouti [1]. He also showed the possibility of implementing such a scheme for a 2x2 MIMO system and pointed to a generalization of 2xM MIMO system, where M is the number of receiving antennas. This scheme has been modified by Tarokh et. al. [2], [3] to increase order of diversity in Multiple Input Multiple Output (MIMO). Multiplexing schemes are more robust when SNR of received signal is high enough, while MIMO diversity scheme shows satisfactory performance at low SNR conditions [4]. MIMO diversity scheme provides higher reliability while MIMO multiplexing gives higher throughput. The STBC produces the best performance at low range to medium range of SNR whereas spatial multiplexing (SM) provides high throughput at high SNR The overall effects of multiple inputs multiple output system can be summarized in terms of reduction of the bit error rate increase in system capacity and more efficient use of the transmitted power.

The wireless communication devices must have very high spectrum efficiency and the capacity of overcoming the channel fading in the environment of multi-path channel. In wireless telecommunications, multipath is the propagation phenomenon that results in radio signals' reaching the receiving antenna by two or more paths. Causes of multipath include atmospheric ducting, ionosphere reflection and refraction, and reflection from water bodies and terrestrial objects such as mountains and buildings. The effects of multipath include constructive and destructive interference, and phase shifting of the signal. Since the shape of the signal conveys the information being transmitted, the receiver will make mistakes when demodulating the signal's information. If the delays caused by multipath are great enough, bit errors in the packet will occur. The receiver won't be able to distinguish the symbols and interpret the corresponding bits correctly. This leads to an error in the symbol decoding.

Combining OFDM with multiple input multiple output (MIMO) technique increases spectral efficiency to attain throughput of 1 Gbit/sec and beyond, and improves link reliability [3]. MIMO concept can be implemented in various ways, if we need to use the advantage of MIMO diversity to overcome the fading then we need to send the same signals through the different MIMO antennae, and at the receiver end, the different antennae will receive the same signals traveled through diverse paths. If we want to use MIMO concept for increasing capacity then we need to send different set of data at the same time through the different MIMO antennae without the automatic-repeat request of the transmission. Theoretically, MIMO technique to be efficient the antenna spacing needs to be at least half the wavelength of the transmitted signal, even though, in some recent research this theoretical bound has been conquered and recently some broadband mobile phones support more than one antenna [3]&[4]. Efficient implementation of MIMO-OFDM system is based on the Fast Fourier Transform (FFT) algorithm and MIMO encoding, such as Alamouti Space Time Block coding (STBC)

2. MIMO-OFDM SYSTEM

The general structure of MIMO-OFDM system is shown in figure 1. The proposed system consists of 2 transmit and 2 receive antennae. The OFDM signal for each antenna is obtained by applying the inverse Fast Fourier transform (IFFT) and can be detected using Fast Fourier transform (FFT) [5]. A pilot sequence is inserted and used for the channel estimation. Also, a cyclic prefix is inserted in front of the OFDM symbol at the last step of OFDM modulation block. The time length of the cyclic prefix should be greater than the maximum delay spread of the channel. The main function of the cyclic prefix is to guard the OFDM symbol against Inter Symbol Interference (ISI), hence, this cyclic prefix is called the guard interval of the OFDM symbols [Ref]. The MIMO coding can use several encoders such as STBC, VBLAST and Golden coding. In this paper, the conventional MIMO-OFDM system is implemented using Alamouti STBC with two transmits and two receive antennas.

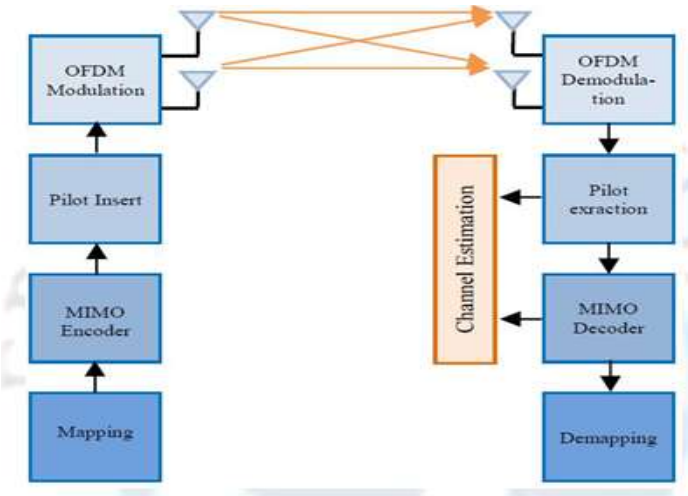

Figure 1: MIMO-OFDM system model.

3. NEW TRANSMISSION MODEL

The new transmission model is suitable for symmetric channels, such as the transmission between two base stations, microwave links, or radio beam transmission. The proposed MIMO-OFDM model is shown in the following figure 2.

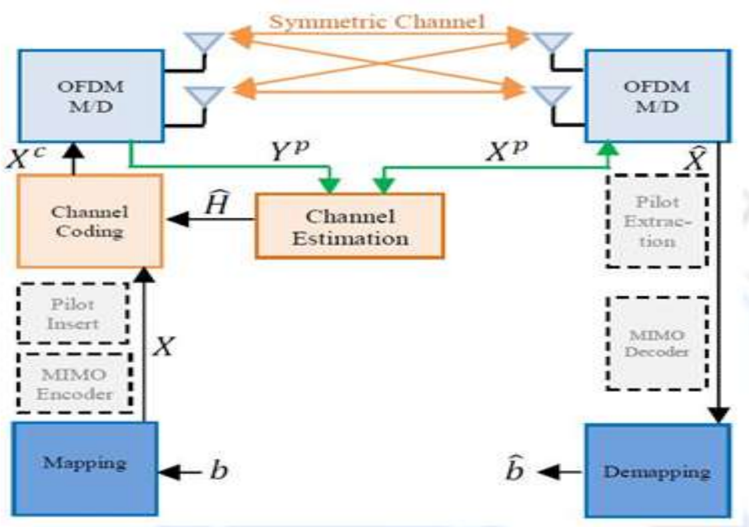

Figure 2: Proposed MIMO-OFDM system model for symmetric channel

In this new MIMO-OFDM model, the channel parameters are estimated from a pilot data transmitted by the receiver end. These estimated parameters are used by a special channel coding block to adapt the transmitter signal to the diverse channel impairments and variations. To reduce the system complexity we have removed the pilot insert, the pilot extraction, the MIMO encoder and the MIMO decoder from the conventional MIMO-OFDM scheme.

4. SPATIAL MULTIPLEXING

The spatial multiplexing was invented and prototyped by Bell Laboratory and is called Bell Labs layered space/time (BLAST) [1]. Spatial multiplexing technique offers increase in the transmission rate (or capacity) for the same bandwidth with no additional power expenditure. In this technique, input data stream is split into two half-rate streams and transmitted simultaneously from two transmit antennas. The receiver, having complete knowledge of the channel, recovers these individual bit streams and combines them so as to recover the original bit stream. A variety of techniques can be used at the receiver to separate the various streams from one another. These techniques include Zero Forcing (ZF), Minimum Mean Squared Estimation (MMSE) and Maximum Likelihood detection (ML). Since the receiver has knowledge of the channel, it provides receive diversity, but the system has no transmit diversity since the data streams are completely different from each other. This can be extended to more number of antennas.

In SM, input symbols are divided equally and transmitted over two transmit antennas. The signal received by the two antennas are given by,

$r_1=h_{11}S_1+h_{12}S_2+n_1$ …………..(1)

$r_2=h_{22}S_1+h_{22}S_2+n_2$ …………..(2)

The received signal in matrix form,

$$\begin{bmatrix} r_1 \\ r_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix} \ldots\ldots (3)$$

S_1 and S_2 symbols are placed on OFDM subcarrier for further transmission through channel. In general, received signal can be represented as,

$R = Hs + N$ …….(4)

where H is channel matrix of size (n x m) and N is complex random variable representing receiver noise and interference.

5. SPACE TIME BLOCK CODE

Alamouti presented [2] space diversity scheme which has been modified by Tarokh et. al. to form generalized Space-Time Block Coding (STBC) [3], [4]. This scheme provides transmit and receive diversity to MIMO system. The scheme uses two transmit antennas and two receive antennas and may be defined by the following three functions:

- Encoding and deciding transmission sequence information symbols at the transmitter,
- Combining signals with noise at the receiver and
- Maximum likelihood detection.

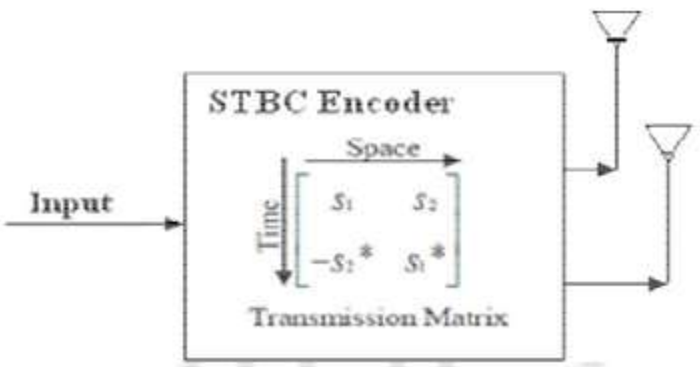

Figure 1: STBC encoder diagram

S_1 is transmitted from antenna 1 and S_2 is transmitted from antenna 2 in first time slot t. In second time slot (t+1), $-S_2^*$ is transmitted from antenna 1 and S_1^* is transmitted from antenna 2, where
(*) denotes the conjugate of a number [2].

Therefore, received signal in matrix form would be,

$$\begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} S_1 & S_1^* \\ S_2 & S_1^* \end{bmatrix} + \begin{bmatrix} n_{11} & n_{12} \\ n_{21} & n_{22} \end{bmatrix} \ldots\ldots\ldots(5)$$

Then maximum likelihood detection (ML) detects the signal which depends upon Euclidian distance between two signals. We have done Simulation of STBC as per our previous paper [11, 12].

International Journal of Mobile Network Communications & Telematics (IJMNCT) Vol. 4, No.5,October 2014

The input data is passed through spatial multiplexing block into two streams. The output of each stream is given to Alamouti space time block coding with antenna configuration of (2×2). Output of STBC encoder is the input to OFDM transmitter. This transmitter is with (4x4) antennas. Then the signal is passed through Rayleigh fading channel. AWGN noise is added to each signal. Input data stream having symbols S_1, S_2, S_3, S_4 are equally divided by spatial multiplexing and passed through STBC encoder as stated in Table 1.

Table 1: Hybrid MIMO Transmitted signals

Time	Antenna 1	Antenna 2	Antenna 3	Antenna 4
t	S_1	S_3	S_2	S_4
t+1	$-S_3$	S_1	$-S_4$	S_2

The Hybrid MIMO system equations in matrix form would be as under,

$$\begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \\ r_{31} & r_{32} \\ r_{41} & r_{42} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} & h_{14} \\ h_{21} & h_{22} & h_{23} & h_{24} \\ h_{31} & h_{32} & h_{33} & h_{34} \\ h_{41} & h_{42} & h_{43} & h_{44} \end{bmatrix} \begin{bmatrix} S_1 & -S_3^* \\ S_3 & S_1^* \\ S_2 & -S_4^* \\ S_4 & S_2^* \end{bmatrix} + \begin{bmatrix} n_{11} & n_{12} \\ n_{21} & n_{22} \\ n_{31} & n_{32} \\ n_{41} & n_{42} \end{bmatrix} \ldots\ldots(6)$$

The received antenna signals after combining are passed through maximum likelihood detection (ML)

6. SYSTEM MODEL

In this paper, the simulation model of the Hybrid MIMO-OFDM system with antenna configuration of (4×4) has been designed and developed. The model is shown in Figure 3. The parameters used in the simulation are given in Table 2.

Table2: Parameters Used for MIMO-OFDM System

Parameters	Specifications
Channel Model	Rayleigh fading channel
Modulation	QPSK,16QAM, 64QAM,
Noise	AWGN
Detector	ML,MMSE detector
Antenna configuration	2×2 and 4×4 antennas
Antennas Transmitting Power	Equally
FFT Size	512

The system is divided into two main blocks namely the transmitter and the receiver. The channel is assumed as Rayleigh fading channel. The data is generated with a random integer generator. This data is passed through convolutional channel encoder and modulated through QPSK and MQAM and then to Hybrid MIMO encoder. In Hybrid MIMO encoder first modulated symbols are spatial multiplexed into two streams. The output of each stream is given to 2×2 Alamouti space time block coding. Output of Hybrid MIMO encoder is the input of OFDM encoder [13] and then data passed through Rayleigh fading channel. At the receiver side first cyclic prefix is removed then OFDM decoder is used to decode the data then data passed through STBC combiner to select the most possible and efficient combination from received data.

7. RESULTS

In our thesis we calculate the Bit error rate and channel capacity for SISO, MIMO-OFDM, AMUD MIMO-OFDM for number of transmitting and receiving antennas NR=Nr=2*2 and 4*4. Here we use the adaptive multiuser technique in MIMO-OFDM to reduce Bit error rate. We implement these results by using BPSK, M ary-PSK and M ary-QAM modulation technique.

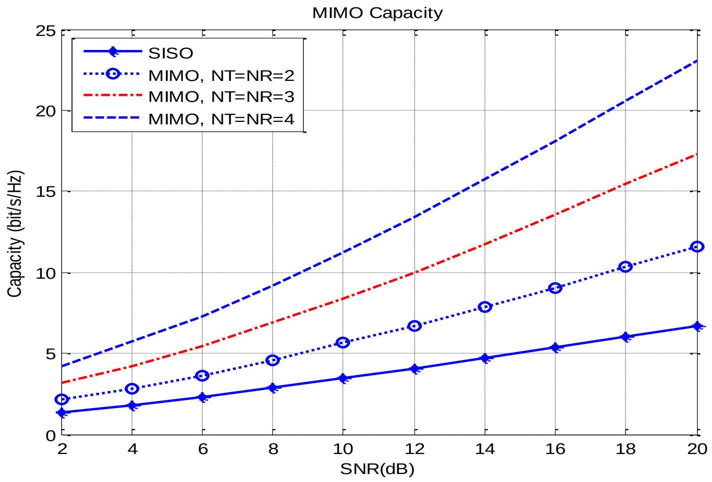

Fig 3: Plot for channel capacity for SISO and MIMO system

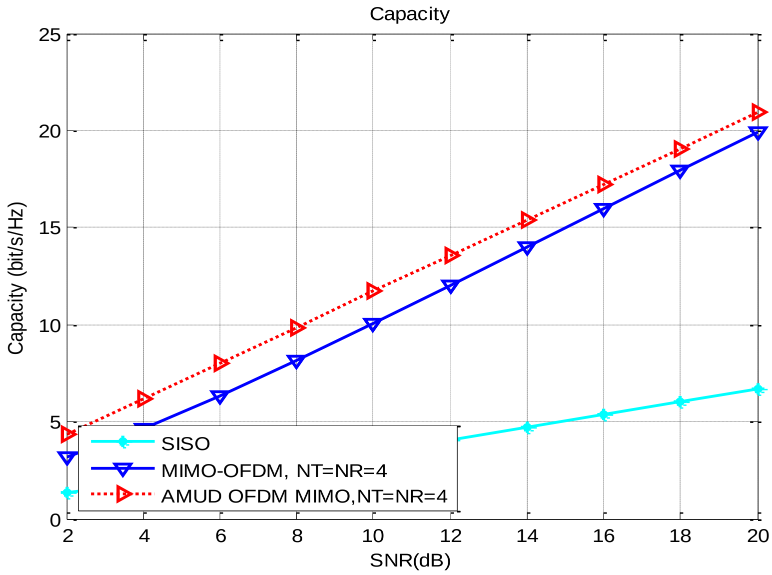

Fig 4: Plot for channel capacity for SISO, MIMO and MIMO-OFDM-AMUD system

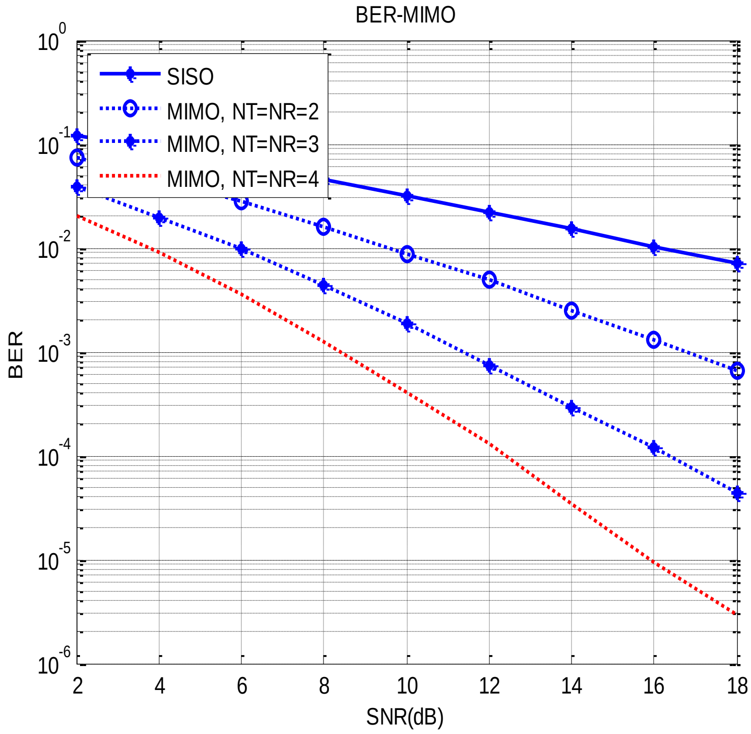

Fig 5: Plot for BER for SISO, MIMO system

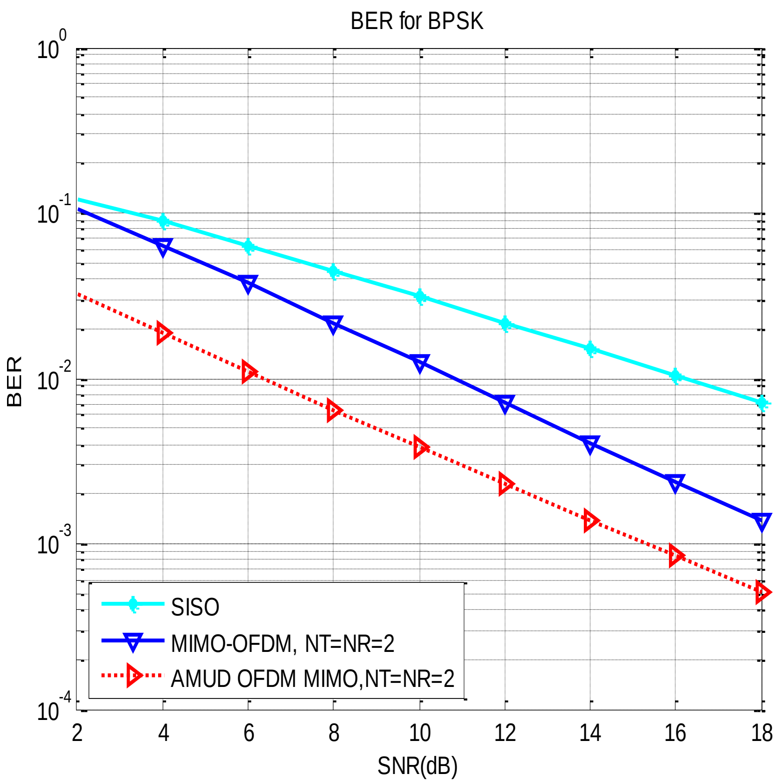

Fig 6: Plot for BER for SISO, MIMO-OFDM, MIMO-OFDM-AMUD a system using BPSK modulation NT=NR=2

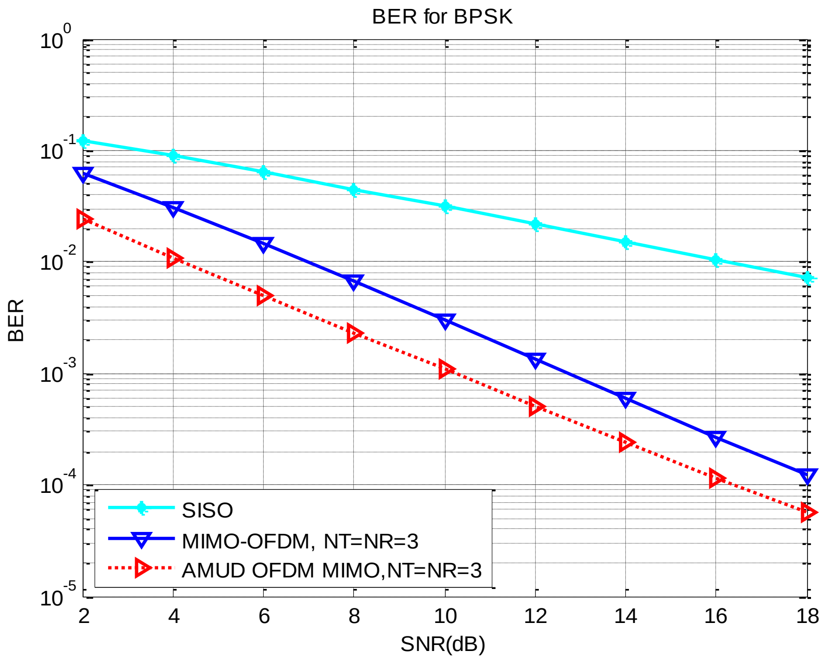

Fig 7: Plot for BER for SISO, MIMO-OFDM, MIMO-OFDM-AMUD a system using BPSK modulation NT=NR=3

CONCLUSION

The MIMO-OFDM system implemented in our thesis involves the use of adaptive multiuser detection which enables mobility, while the system remains tolerant to both known and unknown channel interference. Computational complexity of MIMO-OFDM is linear due to the concept of AMUD. The achievable bit error rate of the following three cases- SISO-OFDM, MIMO-OFDM, and AMUD MIMO-OFDM were compared using different antenna configurations, BPSK modulation, QAM and Rayleigh channel model were used in the simulation. Simulation results shows that AMUD MIMO-OFDM is spectrally efficient and have very small bit error rate as compared to SISO, MIMO-OFDM and AMUD MIMO- OFDM. Therefore AMUD MIMO-OFDM is a promising technique for future wireless communications.

REFERENCES

[1]. A. A. Scaglione, P.Stoica, S. Barbarossa, G. B. Giannakis, and H. Sampath, “Optimal designs for space-time linear precoders and decoders,” IEEE Trans. on Signal Processing, vol. 50, no. 5, pp. 1061–1066, May 2002.

[2]. A.Peled and A. Ruiz, “Frequency domain data transmission using reduced computational complexity algorithms," In Proc. IEEE ICASSP, pp. 964-967, Denver, CO, 1980.

[3]. A. Vahlin and N.Holte,” Optimal ¯nite duration pulses for OFDM," IEEE Trans. Commun., 44(1), pp. 10-14, Jan. 1996.

[4]. A.Tarighat and A. H. Sayed, “MIMO OFDM receivers for systems with IQ imbalances," IEEE Transactions on Signal Processing, vol. 53, no. 9, pp. 3583-3596, Sep. 2005.

[5]. A. Tarighat, R. Bagheri, and A. H. Sayed, “Compensation schemes and performance analysis of IQ imbalances in OFDM receivers," IEEE Transactions on Signal Processing, vol. 53, no. 8, p46] A. Wittneben, “A new bandwidth effcient transmit antenna modulation diversity scheme for linear digital modulation," Proc. ICC, pp. 1630-1634, 1993.123

[6]. Allert van Zelst and Tim C. W. Schenk, “Implementation of a MIMO OFDM-based Wireless LAN system," IEEE Trans. Signal Processing, vol. 52, No. 2, pp.483-494, Feb. 2004.

[7]. B.R.Saltzburg, ”Performance of an efficient parallel data transmission systems, "IEEE Trans. on Comm. Tech., pp. 805-811, Dec. 1967.

[8]. B.Le Floch, M.Alard and C.Berrou, “Coded orthogonal frequency-division multiplexing," Proc. IEEE, 83(6), pp. 982-996, Jun. 1995.

[9]. C. Douillard, M.Jezeque1, C. Berrou, A. Picart, P. Didier, and A. Glavieux, “Iterative correction of intersymbol interference: Turbo-equalization,” European Transactions on Telecommunications, vol. 6, pp. 507–511, Sept. 1995.

[10]. E. Telatar, “Capacity of multi-antenna Gaussian channels," Euro. Trans. Comun., vol. 10, no. 6, pp. 585-595, Nov.-Dec. 1999.