BER Analysis of MIMO-OFDM System Using NAKAGAMI-M Distribution

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***Abstract*- With the evolution of the wireless system, the demand for high speed data services have been increasing day by day, which is impossible to be achieved by the conventional serial data transmission system, without trade-off between high speed data services and increasing the bandwidth of the system. Here, both the options are inconvenient, as one never demands the degradation of the service quality (because if we increase data rate in serial data transmission ISI will gradually increase which make the extraction of actual information at receiver nearly impossible) and secondly the need for extra spectrum in a limited spectrum scenario. In order to overcome this problem new parallel data transmission system was proposed, which is known as OFDM system.**

This study gives a summary of the basics of MIMO-OFDM technology and focuses on the BER Analysis of MIMO-OFDM systems. The signal detection technology used in present work work for MIMO-OFDM system is Nakagami Distribution. In the study, the analysis of high level of modulations on MIMO-OFDM system is obtainable.

The grouping of OFDM systems with MIMO technology has delivered us with increase in link reliability as well as an improvement in spectral competence.

Index terms- BER ANALYSIS, OFDM, MIMO, Nakagami-M Distribution etc

I. INTRODUCTION

OFDM has become a popular technique for transmission of signals over wireless channels [1]. OFDM has been adopted in several wireless standards such as digital audio broadcasting (DAB), digital video broadcasting (DVB-T), the IEEE 802.11a [2] LAN standard and the IEEE 802.16a MAN standard. OFDM is also being pursued for dedicated short-range communications (DSRC) for road side to vehicle communications and as a potential candidate for fourth-generation (4G) mobile wireless systems.

OFDM converts a frequency-selective channel into a parallel collection of frequency flat sub-channels. The subcarriers have the minimum frequency separation required to maintain orthogonality of their corresponding time domain waveforms, yet the signal spectra corresponding to the different subcarriers overlap in frequency. Hence, the available bandwidth is used very efficiently.

If knowledge of the channel is available at the transmitter, then the OFDM transmitter can adapt its signaling strategy to match the channel. Due to the fact that OFDM uses a large collection of narrowly spaced sub-channels, these adaptive strategies can approach the ideal water pouring capacity of a frequency-selective channel. In practice this is achieved by using adaptive bit loading techniques, where different sized signal constellations are transmitted on the subcarriers.

II. LITERATURE REVIEW

S. Moghe et.al [17] introduced a new generation of IEEE 802.11n wireless network standard. The objective is to obtain numerical values for various measures of networking performance of IEEE 802.11n. The initial approach was to investigate the abilities of IEEE 802.11n standard to model a transmitter and receiver that communicated over a user defined channel. Simulation of single OFDM symbol SISO system followed by MIMO is presented. Also, the performance of the system using Matlab’s built in BER tool in both SISO and MIMO Techniques is tested. Different Variation in BER on varying Parameters like Delay and K factor are carried out in the work.

Y. Wu et.al [18] gives an idea about the theoretical framework for the analysis of code diversity. It can be applied to an arbitrary space–time code, but the value of code diversity will depend on the particular choice of code. It is also shown that it not only improves the diversity and coding advantages for general space time codes but also enables optimal decoding performance with low complexity decoding and only a small number of feedback bits. The method of code diversity also reduces the capacity loss associated with some forms of space–time coding. The code diversity scheme presented here is more robust than other low-rate feedback schemes such as transmit antenna selection and its variations. A new family of full-rate circulant codes are introduced and the advantage of suboptimal linear decoding in combination with code diversity is also demonstrated.

III. MIMO-OFDM SYSTEM

3.1 Introduction

OFDM is simple to use on channels that exhibit time delay spread or, equivalently, frequency selectivity. Frequency selective channels are characterized by either their delay spread or their channel coherence bandwidth which measures the channel decorrelation in frequency. The coherence bandwidth is inversely proportional to the root-mean-square (rms) delay spread.

By choosing the sub-carrier spacing properly in relation to the channel coherence bandwidth, OFDM can be used to convert a frequency selective channel into a parallel collection of frequency flat sub channels. Techniques that are appropriate for flat fading channels can then be applied in a straight forward fashion. The frequency domain of an OFDM and FDM system is represented in the diagram below for ten channels.

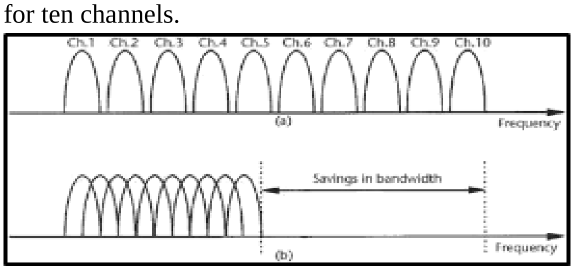

Fig. 3.1: Notion of the OFDM signal (a) straight multicarrier method and (b) orthogonal multicarrier modulation method

OFDM is like FDM method aside from that the 'N' sub-transporters are made symmetrical to one another over the OFDM image (outline) length Ts. By symmetry of the transporters, we imply that the bearer frequencies fulfill the accompanying necessity:

$f_k = f_0 + k/T_s$, k=1,2,…N-1 (3.1)

Key advantages of OFDM Transmission:

OFDM is a proficient method to manage multipath; for a given defer spread, the usage unpredictability is altogether lower than that of a solitary bearer framework with an equalizer.

In generally moderate time-shifting channels, it is conceivable to improve limit fundamentally by adjusting the information rate per SC as indicated by the sign to-commotion proportion (SNR) of that specific SC.

Application of OFDM

During the previous decade, OFDM has been embraced in numerous remote correspondence benchmarks, including European advanced sound telecom, earthbound computerized video broadcasting, and satellite earthbound intelligent multiservice framework in China. Also, OFDM has been considered or endorsed by numerous IEEE standard working gatherings, for example, IEEE 802.11a/g/n, IEEE 802.15.3a, and IEEE 802.16d/e.

3.2 OFDM Signal Model

Fig. 3 2 shows the block diagram of an OFDM system with SISO configuration.

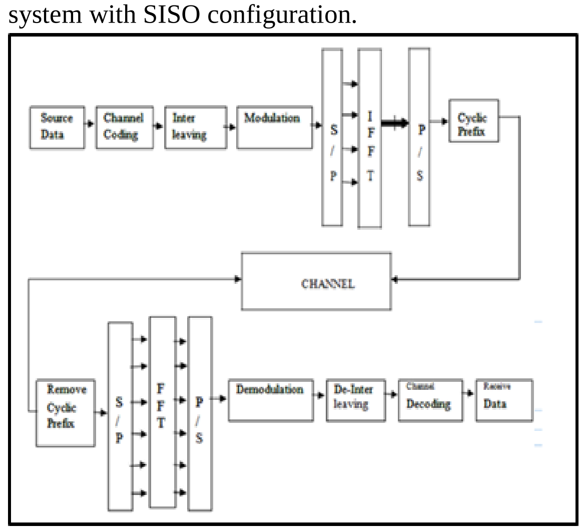

Fig. 3.2: Block Diagram of OFDM system

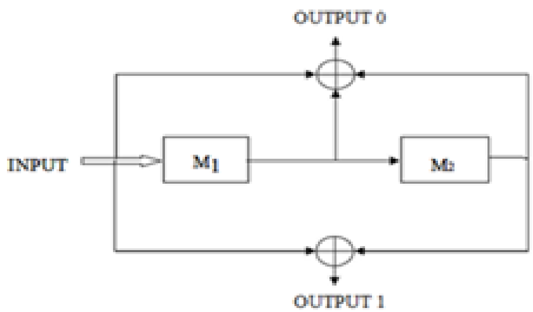

Fig. 3.3: Block Diagram of Convolutional Encoder k/n = 1/2 , m=2

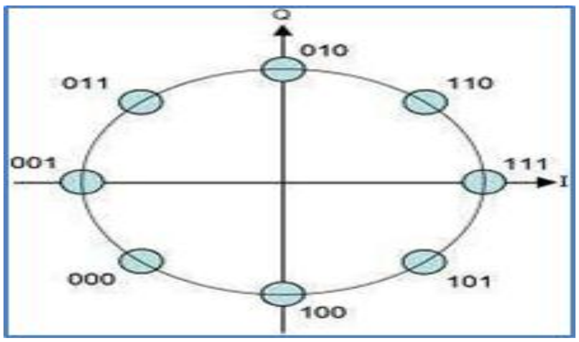

Fig. 3.4: Signal-space diagram for 8-PSK

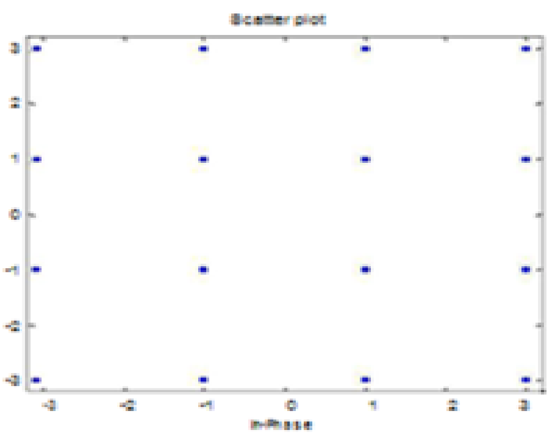

Fig. 3.5: QAM Constelations for 16-QAM

write bits

read bits

b0	b8	b16	b24	b32	b40
b1	b9	b17	b25	b33	b41
b2	b10	b18	b26	b34	b42
b3	b11	b19	b27	b35	b43
b4	b12	b20	b28	b36	b44
b5	b13	b21	b29	b37	b45
b6	b14	b22	b30	b38	b46
b7	b15	b23	b31	b39	b47

Fig. 3.6: Bit write and read structure of 8×6 Block Interleaver

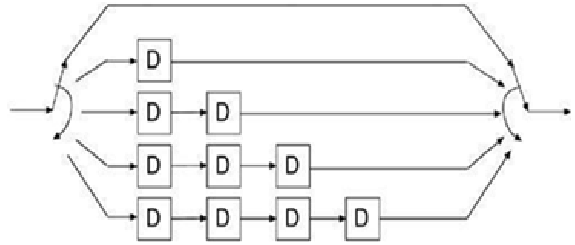

Fig. 3.7: Basic structure of Convolutional Interleaver

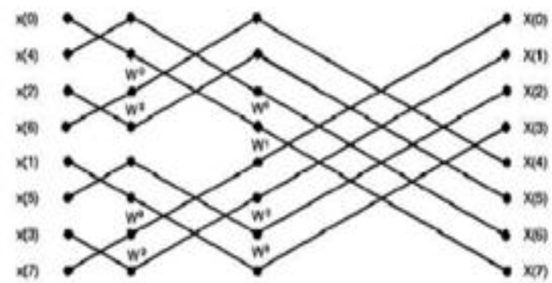

Fig. 3.8: An FFT Implementation (Decimation In Time)

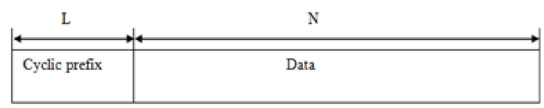

Fig. 3.9: Cyclic Prefix in OFDM Transmission

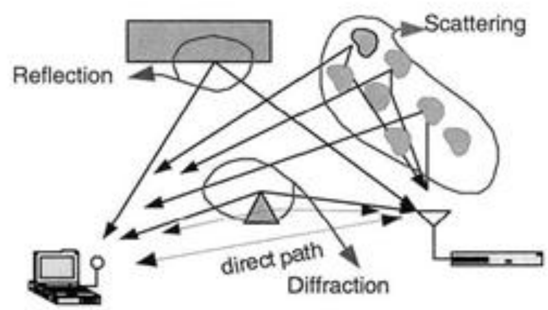

Fig 3.10: Wireless Propagation

Reflection occurs when the signal hits a surface where partial energy is reflected and the remaining is transmitted into the surface. Reflection coefficient, the coefficient that determines the ratio of reflection and transmission, depends on the material properties. Diffraction occurs when the signal is obstructed by a sharp object which derives secondary waves. Scattering occurs when the signal impinges upon rough surfaces, or small objects. Received signal is sometimes stronger than the reflected and diffracted signal since scattering spreads out the energy in all directions and consequently provides additional energy for the receiver which can receive more than one copies of the signal in multiple paths with different phases and powers. Figure 3.10 illustrates the propagation mechanisms

MIMO System Model

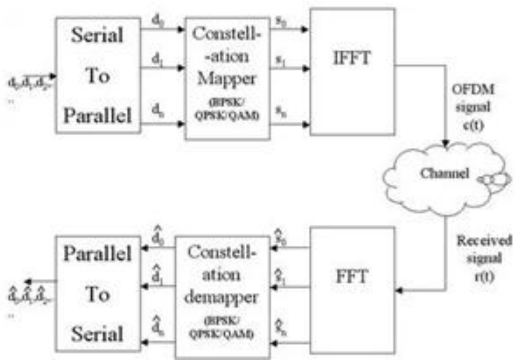

Fig 3.11: Complete OFDM Communication System

IV-RESULTS AND DISCUSSIONS

In this study, performance metric of orthogonal frequency division multiplexing (OFDM) system is analyzed over a composite fading channel, i.e., generalized K-fading channel. Here, OFDM system is considered which includes repetition code to enhance the wireless link performance with simplicity. But error rate (BER) performance is evaluated using (16-QPSK) over generalized K-fading channel. This channel model considers Nakagami-m distribution to define multipath and gamma distribution to represent shadowing effects. Simulation results demonstrate that improved system performance can be achieved by using repetition code in severely faded environment. A comparative study of coded and uncoded system is also given in this paper. Consequently, BER performance is improved with the increase of shape parameters.

4.1Nakagami Distribution

The Nakagamidistribution or the Nakagami-m distribution is a probability distribution related to the gamma distribution. It has two parameters: a shape parameter {m ≥1/2} and a second parameter controlling spread {Ω >0}. {\displaystyle Y} {\displaystyle X={\sqrt {Y}}\,}

4.2 OUTCOMES

The graph below (Fig 4.1) is plotted by using only MIMO system with the assistance of Nakagami Distribution:

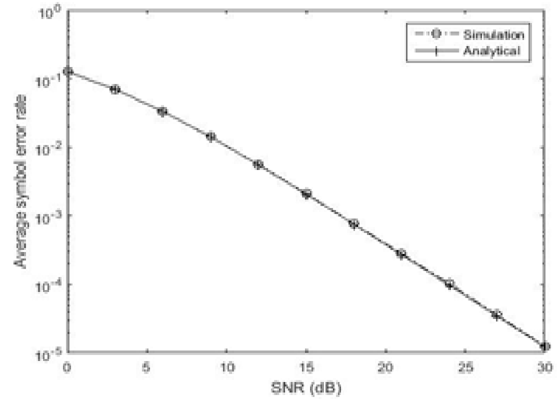

Fig. 4.1: Average Symbol Error Rate vs SNR for MIMO system

It is observed that for ⟦10⟧^(-4) Bit error rate, the SNR obtained is 22.5 dB. Whereas, in case MIMO-OFDM system, the SNR obtained is 25 dB, which is shown in Fig 4.2.

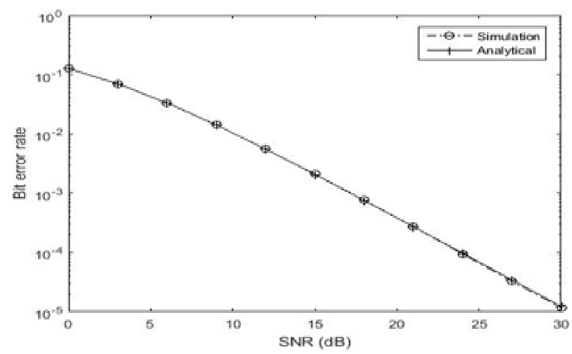

Fig. 4.2: Bit Error Rate vs SNR for MIMO-OFDM system

The data is initially modulated by using the QPSK modulation technique. The BER vs SNR for Nakagami m-distribution over the diversity of 1 to 20 is shown in Fig 4.3.

It is clearly seen that, with increase in the value of 'n', BER is decreasing exponentially and SNR(dB) for a particular BER is increasing.

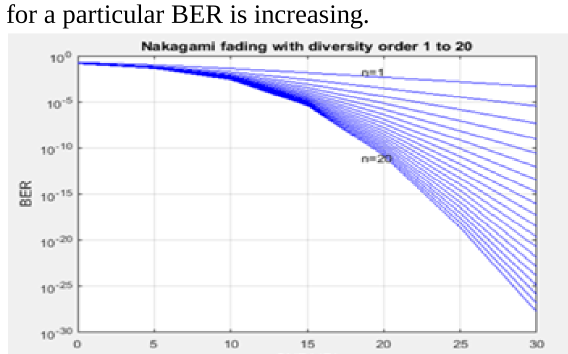

Fig. 4.3: Nakagami fading with diversity order 1 to 20

Different output at the end of each block in a MIMO-OFDM system is depicted in the Fig. below (Fig 4.4)

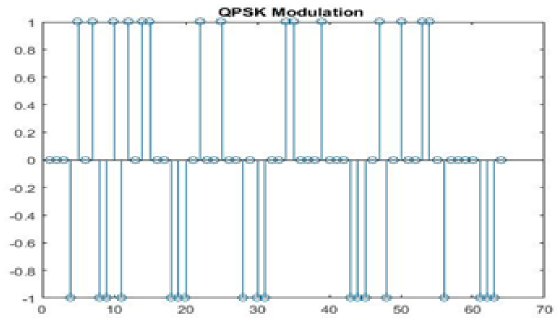

Fig. 4.4: QPSK Modulated Signal

The superimposed modulated signal onto 4 different sub-carriers is shown in Fig 4.5.

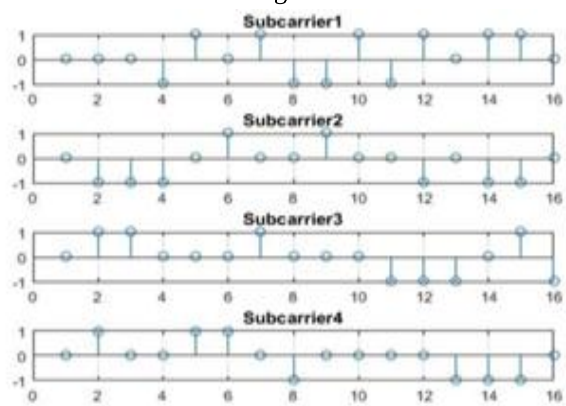

Fig. 4.5: Superimposed Signals onto 4 Different Sub-Carriers

The application of IFFT on these sub-carriers converts them from a frequency domain to time domain which maps the complex data symbols to a Time Domain OFDM symbol (Fig 4.6). The result obtained after adding the cyclic prefix to these 4 sub carriers is shown in Fig 4.7.

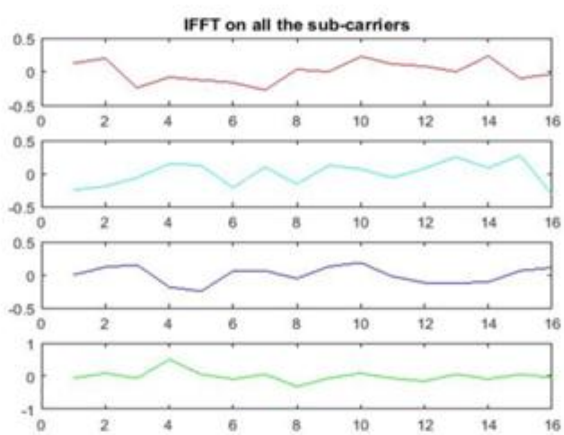

Fig. 4.6: IFFT on 4 Different Sub-Carriers

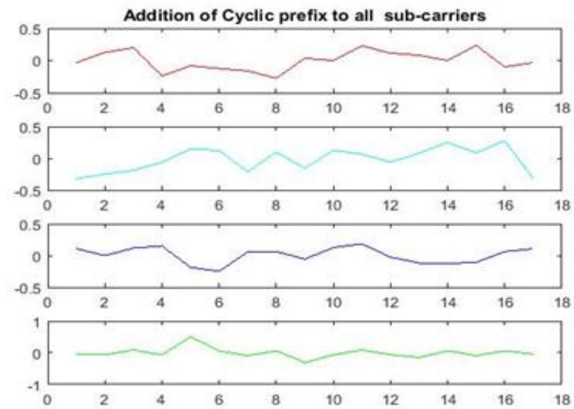

Fig. 4.7: Addition of Cyclic Prefix on 4 Different Sub-Carriers

Final OFDM signal obtained is shown in Fig 4.8, which shows an uniform amplitude of 0.25 obtained throughout.

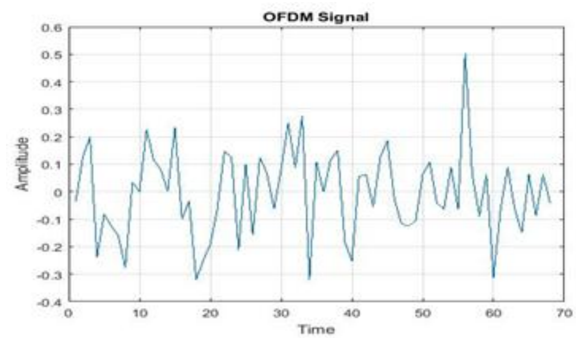

Fig. 4.8: Final OFDM Signal

The PDF obtained for Nakagami m-distribution when 'n' varied from 1 to 5 is shown in Fig 4.9. It is seen that the PDF value decreases with increase in the value of 'n'.

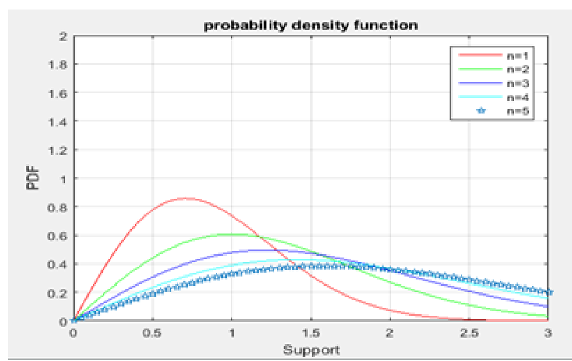

Fig. 4.9: Nakagami m-Distribution

Also, a comparison between QPSK and BPSK has been obtained on the basis of BER vs SNR graph, which is shown in Fig 4.10, where it is obtained that coded QPSK performs well as it reflects higher SNR for less BER values.

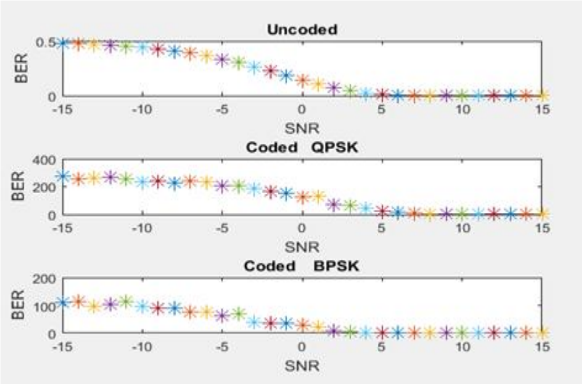

Fig. 4.10: BER vs SNR for QPSK and BPSK

Hence by using a MIMO-OFDM with Nakagami distribution system, the overall SNR of the system can be drastically improved.

Different antenna configurations were used for analysis and in all the cases there was an improvement in SNR and when compared with systems that only used MIMO system. One important advantage of MIMO OFDM system is data capacity, as it combines advantages of both MIMO and OFDM.

V-CONCLUSION

5.1 Conclusion

In the present work, a thought regarding the presentation of the MIMO-OFDM frameworks at higher tweak levels and for various radio wire setups is exhibited. Execution of MIMO-OFDM framework is broke down under various blurring channels. MIMO-OFDM framework can be actualized utilizing higher request regulations to accomplish enormous information limit. Be that as it may, there is an issue of BER (bit mistake rate) which increments as the request for the balance increments. Since on expanding the request for balance the choice area for the demodulator in the group of stars outline additionally diminishes, because of this the demodulator will create incorrect outcomes at its yield. The channel will contort the sign all the more seriously at lower estimations of SNR (sign to commotion proportion). These mutilations will cause the moving of the heavenly body purposes of the sign and this will make the demodulator produce the debased outcomes at its yield. Be that as it may, as SNR is expanded the impact of the mutilations presented by the channel will likewise continues diminishing, because of this the BER will likewise diminishes. Along these lines enormous information limit can be accomplished over the current channels by utilizing higher request balances, the main thing that ought to be remembered is the degree to which we can build the estimations of the SNR. Higher the SNR higher will be the information limit.

The rationale of utilizing high request recieving wire setup is to build the space assorted variety, which will further diminish the BER at given SNR when contrasted with lower request Antenna designs.

REFERENCES

[1] L. J. Cimini, "Analysis and simulation of a digital mobile channel using orthogonal frequency division multiplexing", IEEE Transaction on Communications, Vol. 33, Issue 7, pp. 665–675, July 1985.

[2] Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: High-Speed Physical Layer in the 5 GHz Band, IEEE Standard 802.11a-1999.

[3] Roger B. Marks, Ken Stanwood and Chang IEEE Standard for Local and Metropolitan Area Networks Part16: Air Interface for Fixed Broadband Wireless Access Systems", IEEE802.16-2004, 1 October, 2004

[4] S. Alamouti, "A simple transmit diversity technique for wireless communications", IEEE Journal on Selected Areas of Communication, Vol. 16, pp. 1451–1458, Oct. 1998.

[5] V. Tarokh, H. Jafarkhani and A. R. Calderbank, "Space–time block codes from orthogonal designs", IEEE Transactions on Information Theory, Vol. 45, pp. 1456–1467, July 1999.

[6] G. Ganesan and P. Stoica. 2001. "Space-time block codes: a maximum SNR approach", IEEE Transactions on Information Theory, Vol. 47, Issue 4, May 2001, pp. 1650–1656.

[7] P. W. Wolniansky, G. J. Foschini, G. D. Golden and R. A. Valenzuela, "V-Blast: An architecture for realizing very high data rates over the rich-scattering channel", International Symposium on Signals, Systems and Electronics, pp. 295–300, 1998.

[8] J. Ha, A. N. Mody, J. H. Sung, J. Barry, S. Mclaughlin and G. L. Stuber, "LDPC coded OFDM with Alamouti/SVD diversity technique," IEEE Journal on Wireless Personal Communication, Vol. 23, Issue 1, pp. 183–194, Oct. 2002.

[9] M. Jiang and L. Hanzo, "Multiuser MIMO-OFDM for next generation wireless systems," In Proceedings of IEEE, Vol.95, Issue 7, pp.1430-1469, July 2007.