Improved Channel Estimation Based on Physical Layer Security in OFDM using Alamouti Encoding and BPSK

Akhil Mulani[1], Shobha Sharma[2]
[1]*P.G. Student*, [2]*Asst. Professor*
[1,2]*Department of Electronics and Communication, SAL Institute of Technology and Engineering Research, Ahmedabad*

Abstract - The communication system has it maximum vulnerability at the physical layer and the noises introduces during the transmission of signal through channel and the security from noises and the interferences need to be establish to make system performance better and better. The bit error rate is the figure of merit to check system from end-to-end, and in this paper the proposed methodology is adopted to reduce the BER to certain optimum level than the previous one. The proposed methodology improving the OFDM based wireless system integrating with the BPSK modulation scheme and Alamouti encoding, and such proposed combination makes system better in terms of bit error. The optimum BER achieved is $2x10^{-5}$.

Keywords - Physical Layer Security, Channel Estimation, BPSK and QAM-Modulation.

I. INTRODUCTION

Research on digital communication systems has been greatly developed in the past few years and offers a high quality of transmission in both wired and wireless communication environments. Coupled with advances in new modulation techniques, Orthogonal Frequency Division Multiplexing (OFDM) is a well-known digital multicarrier communication technique and one of the best methods of digital data transmission over a limited bandwidth.

Digital communication system is a system in which information is conveyed from one point to another by using a finite set of discrete symbols. This system has been the subject of numerous research over the past fifty years of its introduction. As such, during the last three decades, the development and use of digital communication systems, has extensively increased and are still becoming more and more attractive due to the ever increase in demand for data communication, ease of regeneration of digital signals, high flexibility and availability of options for data processing in comparison to analogue transmission [1, 2]. Block diagram of a typical digital communication system is shown in Fig. 1.1.

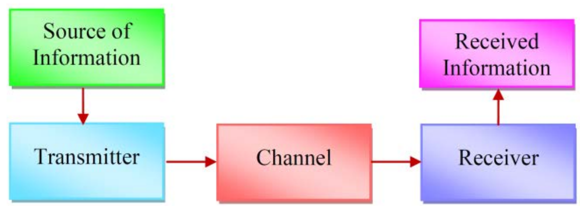

Fig. 1.1 A standard digital communication system

When a digital signal or so called ideal binary digital pulse, propagates along a digital transmission line as depicted in Figure 1.2, two basic mechanisms greatly affect the shape of the waveform by degrading the pulse shape as a function of line length [2]: (i) As all transmission lines and circuits have some non-ideal frequency transfer function, there is a distorting effect on the ideal pulse; and (ii) Unwanted electrical noise or other interferences further distort the pulse waveform.

Circuits responsible for performing this function at regular intervals along a digital transmission system are known as regenerative repeaters [2]. One of the main advantages of digital communication systems is that they are less subject to distortion and interference, in comparison to analogue communication systems, as binary digital circuits operate in one of the two states (i.e. state 0 or 1) and hence disturbance must be large enough to change the circuit operating point from one state to the other. Such two-state operating systems ease signal regeneration and thus prevent noise and other disturbances from accumulating in transmission. In addition, with digital techniques, extremely low error rates producing highly reliable signals are possible through error detection and correction [2]. In addition to the mentioned advantages, digital communications has some other important advantages as follows:

- Digital circuits available in digital communications are reliable and can be produced at low cost
- Digital hardware lends itself to flexible implementation
- Digital communication techniques offer themselves naturally to signal processing functions that protect against interference and jamming, or that provide encryption and privacy
- A great deal of data communication can be carried out, from computer to computer, or from digital instruments or terminal to computer. Such digital terminations are naturally best served by digital communication links

Digital communication systems need to allocate a significant share of their resources to the task of synchronization at various levels. Despite all the advantages, there exist one main disadvantage of facing degradation, as value of Signal-to-Noise Ratio (SNR) drops below a certain threshold, the quality of service can change from very good to very poor [2].

II. OFDM COMMUNICATION SYSTEM

Among the techniques that have been used to design a digital communication system, Orthogonal Frequency Division Multiplexing (OFDM) has been referred to as one of the most advantageous technique. OFDM systems have been widely recognised as a bandwidth efficient transmission technique for wireless communications. This multicarrier transmission technique has been gaining more and more interest from communications and signal processing communities [3].

The main idea of these systems is that the whole bandwidth is divided into much smaller sub-bands whilst preserving orthogonality between the bands, using Fast Fourier Transform (FFT) and its inverse (IFFT). The main motivation of this band division is to mitigate the Inter Symbol Interference (ISI) problems associated with the wide-band transmissions available in frequency selective channels [4].

OFDM is sometimes referred to as a frequency-domain approach to communications, and has important advantages when dealing with the frequency-selective nature of high data rate communication channels. In addition, it benefits from a high spectral efficiency, simple implementation, strong multipath tolerance, robust against narrowband co-channel interference and channel fading etc. Moreover, one of the main advantages of using OFDM technique is that the transmission signal is affixed with the cyclic prefix (CP), assisting it in counteracting the effects of delay.

III. PROPOSED METHODOLOGY

The physical layer security from the noise and interference attacks can be reduced by estimating the channel and adopting the respective counter techniques as per the nature of the system as well as physical channel(layer). The certain techniques will help to make security against the noises better and reduce their effects on the final outputs. In this paper the OFDM based system is used which is already better wireless system, here multiple input multiple output (MIMO) is integrated with the OFDM to make system little bit better in terms of recovery of the signal at receiver side.

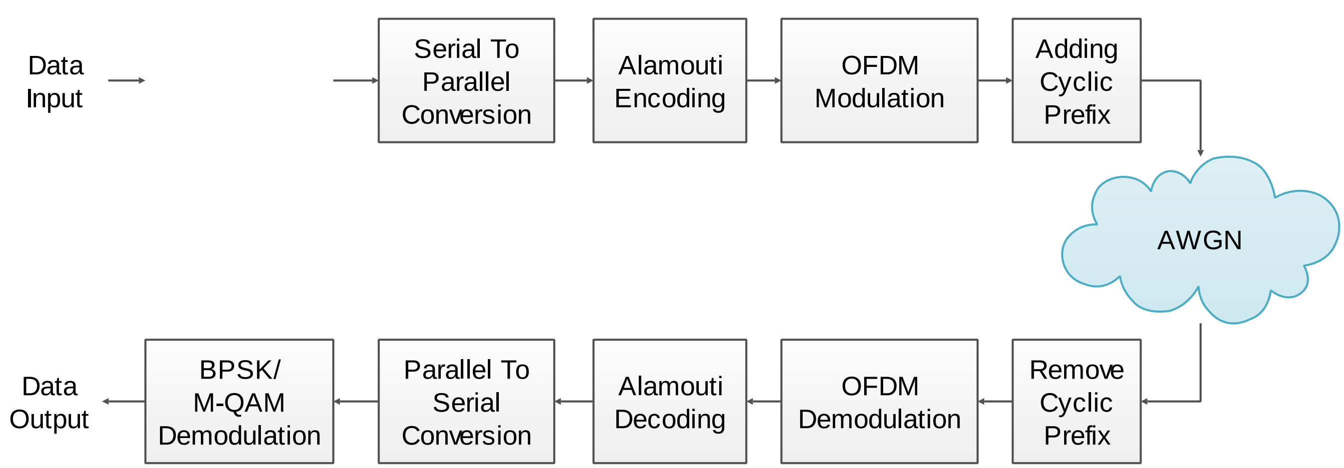

Fig. 3.1 Block Diagram of Proposed Methodology

The system is equipped with the BPSK or m-QAM modulation techniques so that the signal can be processed in protected manner at transmitter itself. The modulated signal is further encoded with the Alamouti encoding which is an added security to the signal. The following system arrangement recover signal significant lower error at the output because of modulation and Alamouti encoding with OFDM-MIMO system. The block diagram is shown in the Fig. 3.1.

The above mentioned system is executed on the simulation tool and its flow of execution is shown with the help of flow chart of the algorithm in Fig. 3.2. The flow of information through various stages and changes briefly mentioned in the chart.

The steps are as follows:

a. *Start of simulation*
b. *Create simulation environment with the help of variable declaration and system variables*
c. *Generate data to transmit through system (to evaluate system)*
d. *Modulate data either with BPSK or with m-QAM technique (for different performance)*
e. *Convert signal from serial to parallel (OFDM Symbol conversion)*
f. *Encode symbols with Alamouti Encoding Technique*
g. *Perform IFFT operation(OFDM Modulation)*
h. *Adding Cyclic Prefix (Extra information to the signal)*
i. *Normalize the multipath channels*
j. *Transmit through AWGN channel which is encountered with the noises during transmission*
k. *Now the received signal is processed to remove added Cyclic information*
l. *Perform FFT operation (OFDM Demodulation)*
m. *Decode the signal with Alamouti Decoding*
n. *Demodulate signal with BPSK or m-QAM respectively*
o. *Convert parallel signal to serial (OFDM symbol to data stream)*
p. *Calculate Bit Error Rate(BER)*
q. *Compare results of different modulation techniques as well as making changes in system parameter like FFT size subcarrier length, and symbol length(shown in the result section)*
r. *End of simulation process*

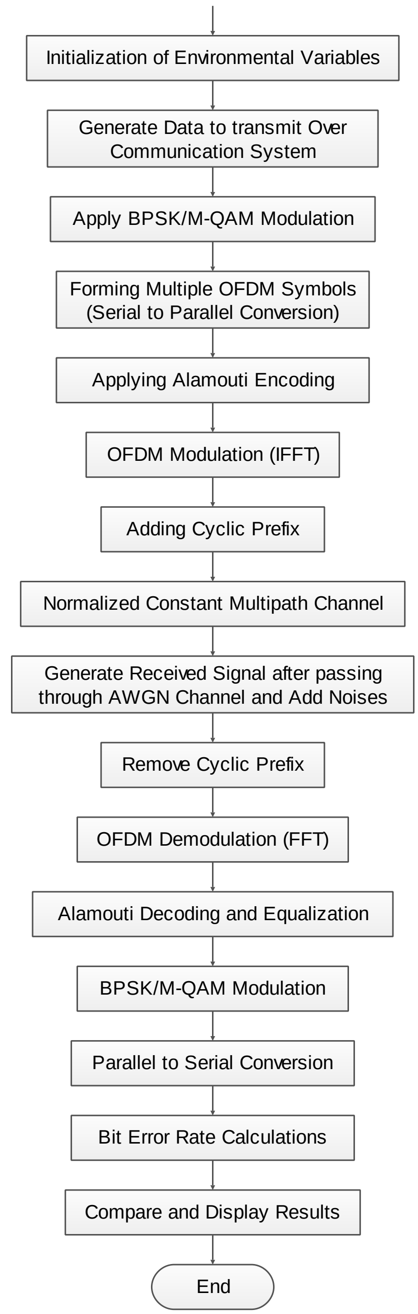

Fig. 3.2 Flow chart of proposed system algorithm

IV. SIMULATION RESULTS

The detailed explanation of the proposed system algorithm is done in the previous section, and the results are shown in this section.

The results are calculated between signal to noise ratio in decibal (SNR in dB) and bit error rate(BER) with three different modulation techniques, i.e. BPSK, and m-QAM. m is taken 8 and 16 for better results other configurations are not giving optimum values. The system parameter are also changed to analyze the behavior of the system to make out optimum combination of parameter for lower bit error rate(BER).

In Fig. 4.1 system is evaluated with BPSK, 8-QAM and 16-QAM modulation with 100 symbols and 64-subcarriers and found BER's optimum value $2x10^{-5}$ with BPSK modulation.

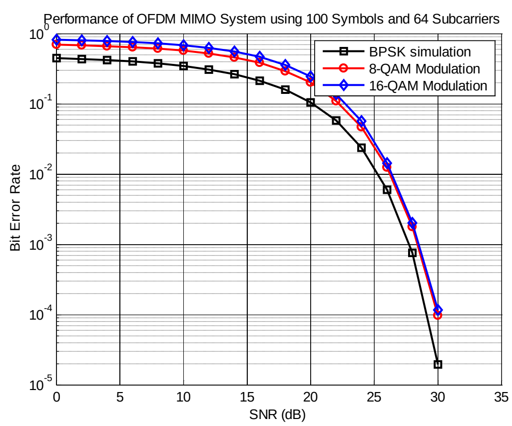

Fig. 4.1 BER performance of the system with 100 symbols and 64 subcarriers

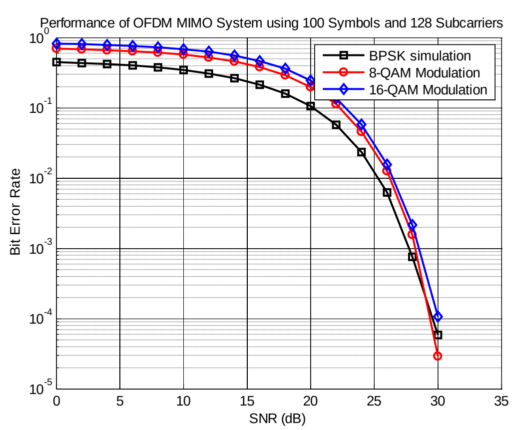

Fig. 4.2 BER performance of the system with 100 symbols and 128 subcarriers

In Fig. 4.2 system is evaluated with BPSK, 8-QAM and 16-QAM modulation with 100 symbols and 128-subcarriers and found BER's optimum value $3x10^{-5}$ with 8-QAM modulation.

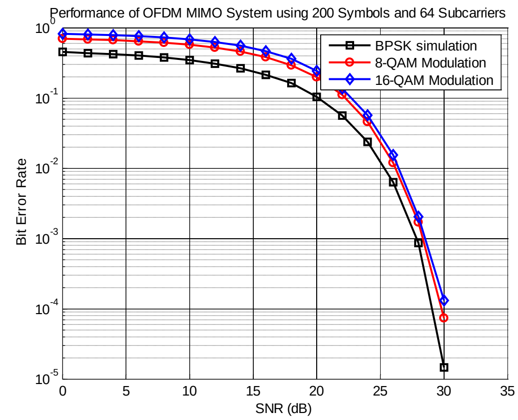

Fig. 4.3 BER performance of the system with 200 symbols and 64 subcarriers

In Fig. 4.3 system is evaluated with BPSK, 8-QAM and 16-QAM modulation with 200 symbols and 64-subcarriers and found BER's optimum value $1.5x10^{-5}$ with BPSK modulation.

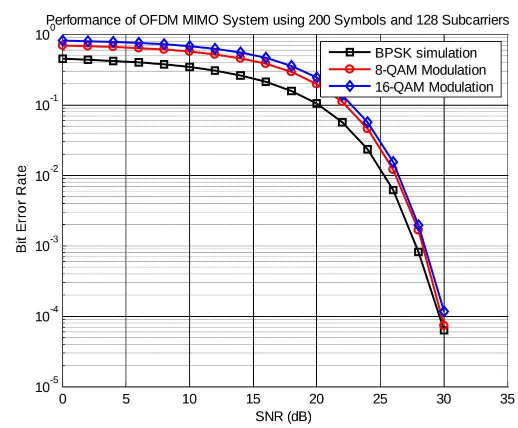

Fig. 4.4 BER performance of the system with 200 symbols and 128 subcarriers

In Fig. 4.4 system is evaluated with BPSK, 8-QAM and 16-QAM modulation with 200 symbols and 128-subcarriers and found BER's optimum value $6x10^{-5}$ with BPSK modulation.

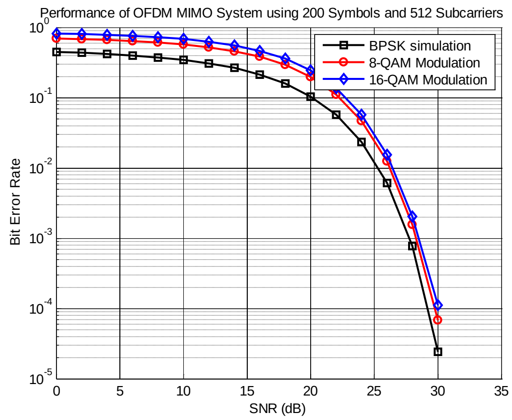

Fig. 4.5 BER performance of the system with 200 symbols and 512 subcarriers

In Fig. 4.5 system is evaluated with BPSK, 8-QAM and 16-QAM modulation with 200 symbols and 512-subcarriers and found BER's optimum value 2.3×10^{-5} with BPSK modulation.

V. CONCLUSION AND FUTURE SCOPE

From the simulation results it can be analysed that the OFDM based system integrated with multiple input multiple output (MIMO) technology and BPSK or m-QAM modulation with equipped with Alamouti encoding scheme made system's physical layer more secure than the previous techniques. The optimum performance of the system is 1.5×10^{-5} with 200 symbols and 64 subcarriers utilizing BPSK modulation. The improvement in the physical layer security can be further enhanced with the other complex encoding techniques or the effect of noises also can be reduced by the utilization of the digital filter at the receiver side.

REFERENCES

[1] Z. Peyton and JR. Peebles (1987). *Digital Communication Systems*. USA: Prentice/Hall International Inc. pp. 5 – 6.

[2] Bernard Sklar (Jan 2001). Digital Communications Fundamentals and Applications. 2nd ed. California and University of California, Los Angeles: Prentice/Hall International Inc. pp. 2-5, 169

[3] M. Engels (2002). Wireless OFDM systems: How to make them work?, Springer. pp. 33-48.

[4] H. Koivo, and M. Elmusrati (2009). Systems Engineering in Wireless Communications. : John Wiley & Sons Ltd. page 239. .

[5] B.P. Crow, I. Widjaja, L.G. Kim, and P.T. Sakai. (Sept. 1997). IEEE 802.11 Wireless Local Area Networks. IEEE Communications Magazine. Volume 35, Issue: 9, pp. 116 - 126.

[6] K. Maxwell. (Oct. 1996). Asymmetric digital subscriber line: interim technology for the next forty years. IEEE Communications Magazine. Volume 34, Issue: 10, pp. 100–106.

[7] V. Oksman and S. Galli. (Oct. 2009.). G.hn: The New ITU-T Home Networking Standard. IEEE Communications Magazine. Volume 47, Issue: 10, pp. 138–145

[8] C. Eklund, R.B. Marks, K.L. Stanwood, and S. Wang. (June 2002). IEEE standard 802.16: a technical overview of the Wireless MANTM air interface for broadband wireless access. IEEE Communications Magazine. Volume 40, Issue: 6, pp. 98–107.

[9] Adarsh B. Narasimhamurthy, Mahesh K. Banavar, and Cihan Tepedelenlio glu. (2010). In: OFDM Systems for Wireless Communications. Morgan & Claypool. Chapter 3, pp. 13-14.

[10] T. Esmailian, F.R. Kschischang and P.G. Gulak. (2000). Characteristics of Inbuilding Powelines at high frequencies and their channel capacity. International Symposium on Power Line Communications (ISPLC), pp. 52 – 59.