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Performance of Orthogonal Frequency Division Multiplexing (OFDM) Communication System with Different Noisy Environment and Various Modulation Techniques

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Abstract: Orthogonal frequency division multiplexing (OFDM) is capable of encountering multipath interference problem through its special characteristics of transmitting multi-carriers simultaneously in parallel form. OFDM is the key technology, due to its high data rates transmission and efficient utilization of available bandwidth. This paper introduces the analysis of OFDM with different modulation techniques and for different channel environment. Main emphasis of this paper is to analyze the results of different noisy channels which are AWGN, Rayleigh and Rician multipath fading. OFDM system model is simulated by using matlab's simulink software. Finally, the simulation results of 16-PSK/QAM and 256-PSK/QAM modulation techniques are compared.

Keywords: Orthogonal frequency division multiplexing (OFDM); Inter-channel interference (ICI); Inter-symbol interference (ISI); Cyclic prefix (CP).

1. Introduction

In Orthogonal frequency division multiplexing (OFDM) technique rather than sending a wideband signal carrying the data, same signal is divided in several numbers of signals, each carried by separate carrier and are transmitted over the channel in parallel form. This parallel transmission system greatly expands the pulse-length and increases the performance of anti-multipath fading[1]. The important aspect of OFDM system is its high data transmission rate without inter-symbol interference and inter-channel interference. OFDM is especially suitable for high speed and wide bandwidth wireless data transmission [2]. OFDM technology has been widely used in High-bit-rate digital subscriber line (HDSL- upto 1.6Mbps), Asymmetric digital subscriber line (ADSL- upto 6Mbps), Very-high-speed digital subscriber line(VDSL-upto 100Mbps), Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), high-definition television (HDTV), wireless local area network

(WLAN)[3,4] and soon will be playing an important role in communication systems.

2. Basic Principle of OFDM

The basic idea behind the multi-carrier signal transmission is to eliminate the problem of Inter-symbol interference (ISI) and also inter-channel interference (ICI) with efficient utilization of the frequency spectrum. The conventional frequency division method needs lots of filters for processing each sub-carriers individually at transmitting and receiving end which results in higher cost and increase in complexity at reception. OFDM technology can make the transmission of data distributed to each sub-carrier, making the symbol period longer than the multi-path delay, so as to effectively combat multi-path fading[5]. In order to reduce the complexity at receiving end, OFDM system uses digital signal processing technique in the process of assigning different sub-carriers for carrying signals. The hardware system required for transmission and reception setup in OFDM system would become complex without Discrete Fourier Transform, but the use of FFT and IFFT respectively at receiver and generator makes it simple for receiving signal.

The main reason for opting OFDM system is to tackle two problems, one is inter-symbol interference(ISI) caused by the spread of transmitted pulse width also known as “delay spread” which can be solved by adding guard interval having length greater than the largest delay spread. Another technique known as OFDM/OQAM (offset OFDM) can be used, which doesn’t require guard intervals[6]. Secondly, multipath interference can also be named as inter-channel interference (ICI), the remedy is to add cyclic prefix (CP) in the front of the every symbol to eliminate ICI. Multi-ary digital modulation is implemented to improve frequency spectrum utilization in each narrowband signal. The modulation methods selected can be different for different carriers in OFDM communication system. Each carrier can be assigned with different modulation types, such as BPSK, QPSK, 8-PSK, 16-QAM, 16-PSK, 64-QAM, 64-PSK also 256-QAM, 256-PSK etc.

In the OFDM modulation method, firstly the random integer input data are converted into sequence of data bits. The data bits are directly mapped to complex modulation symbols by using respective signal constellation[7] as shown in constellations diagrams. Then serial to parallel conversion of signal is done so that these signals can be imposed on different carriers. Any of the Multi-ary modulation method can be used to transform the signal into frequency-domain. Now, Inverse Fast Fourier Transform (IFFT) operation is done on the signals to multiplex them. Also they are made orthogonal to each other and further signals are converted from frequency to time domain. To avoid Inter-symbol interference and Inter-channel interference, cyclic prefix is added to every signal frame and parallel to serial conversion for transmitting the signals. Finally, Signals are converted from digital form to analog form by D/A conversion, so that further it can be imposed on high frequency carriers which will be suitable for transmission purpose. As we know baseband signal can't be sent directly for transmission because they will attenuate quickly and data will be lost. At the receiving end, exactly opposite operation is performed. From received signal firstly cyclic prefix are extracted, then by performing fast Fourier Transform (FFT) the time-domain signal is transformed into frequency-domain, the OFDM signal's demodulation is carried out and further processing is completed in receiver. OFDM system schematic diagram is shown in Fig. 1.

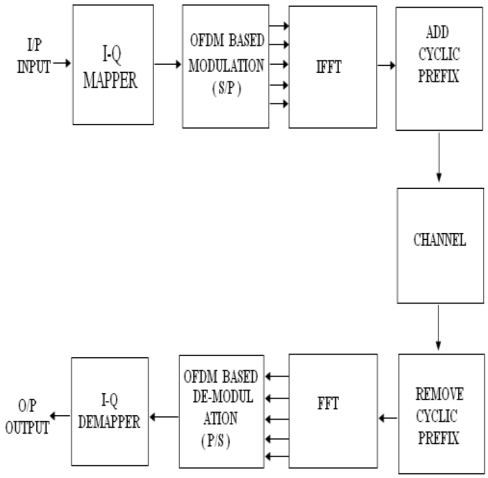

Fig. 1. Baseband OFDM system Diagram

3. OFDM System Simulation

Simulink, developed by the Math works, is a tool for multi-domain simulation and model-based design for dynamic systems and communication systems[7]. Simulink is a graphical extension of Matlab used for modeling, simulation and analysis purposes within graphical user interface space. In this paper, Simulink in MATLAB is used to create a simulation model.

Here, Random integer generator is used as data source to generate a binary sequence. Different digital M-ary (M-PSK, M-QAM) modulation schemes are used to obtain constellation mapping diagram and frequency spectrum plot of transmitter and receiver both. For analysis of the system only receiver's graph have been showed in this paper. In signal-space diagram, each dot denotes the position of the phase relative to the intersection of the axes I (for in-phase) and Q (for quadrature)[8].Signal undergoes serial to parallel transform before OFDM. Later, Inverse Fast Fourier Transform (IFFT) operation is performed and cyclic prefix are added to avoid inter-symbol interference. Now the different channels performances are used for analysis namely Additive White Gaussian Noise (AWGN) channel, Multipath Rayleigh fading channel and Multipath Rician fading channel. Thus OFDM system performance will be studied under different noisy environments. Finally, the contrary process is used for reception of signal at the receiver end. At the end, Comparison between different noise channels is shown in Table 1. Actual simulation model is as shown in fig. 2.

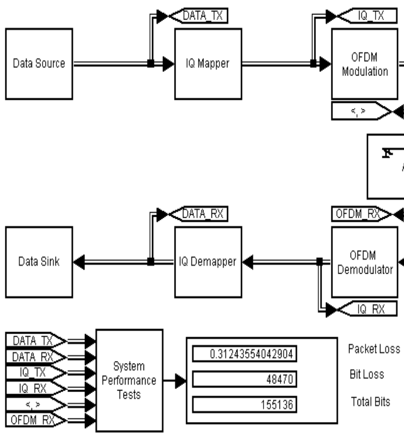

Fig. 2. Simulation model Of OFDM System

1. Ofdm System Simulation With Different Noise Channel

16 PSK with AWGN channel

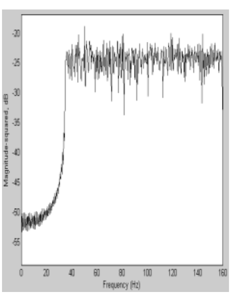

Fig. 3. Frequency Spectrum of 16-PSK

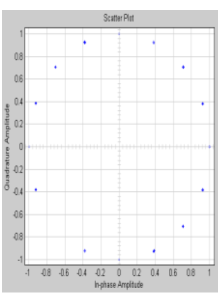

Fig. 4. Constellation Diagram of 16-PSK

16 PSK with Rayleigh multipath fading channel

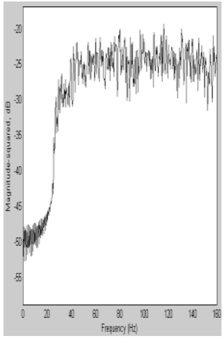

Fig. 5. Frequency Spectrum of 16-PSK

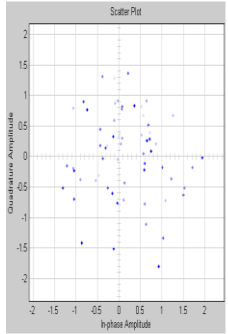

Fig. 6. Constellation Diagram of 16-PSK

16 PSK with Rician multipath fading channel.

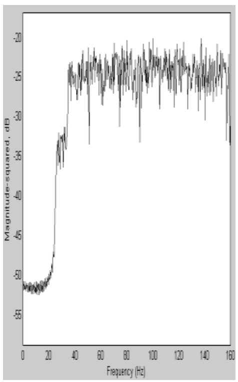

Fig. 7. Frequency Spectrum of 16-PSK

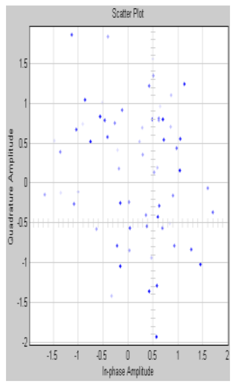

Fig. 8. Constellation Diagram of 16-PSK

16 QAM with AWGN channel

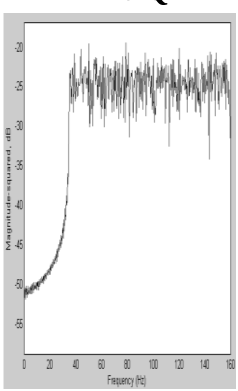

Fig. 9. Frequency Spectrum of 16-QAM

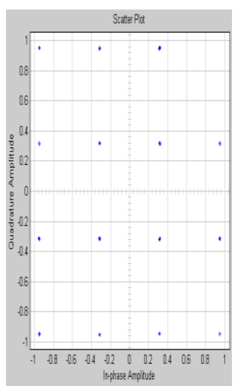

Fig. 10. Constellation Diagram of 16-QAM

16 QAM with Rayleigh multipath fading channel

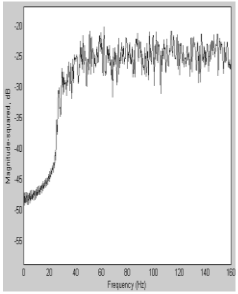

Fig. 11 Frequency Spectrum of 16-QAM

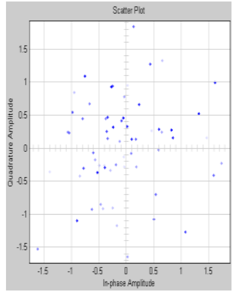

Fig.12 Constellation Diagram of 16-QAM

16 QAM with Rician multipath fading channel

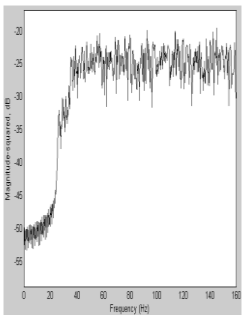

Fig. 13 Frequency Spectrum of 16-QAM

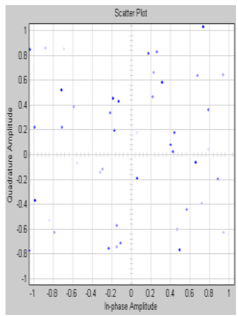

Fig. 14 Constellation Diagram of 16-QAM

256 PSK with AWGN channel.

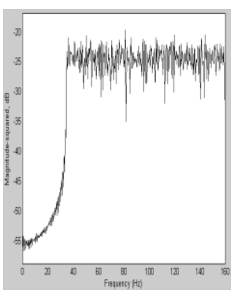

Fig. 15 Frequency Spectrum of 256-PSK

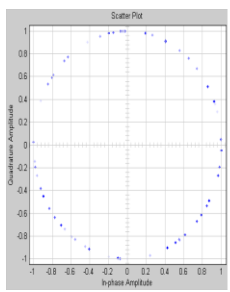

Fig. 16 Constellation Diagram of 256-PSK

256-PSK with Rayleigh multipath fading channel

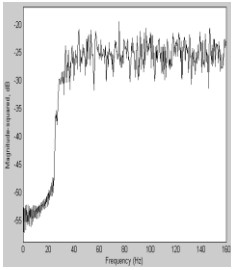

Fig. 17.Frequency Spectrum of 256-PSK

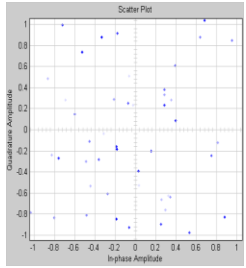

Fig. 18. Constellation Diagram of 256-PSK

256PSK with Rician multipath fading channel.

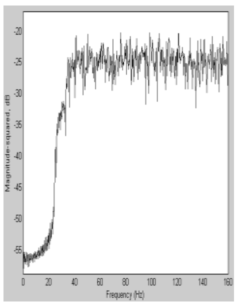

Fig.19 Frequency Spectrum of 256-PSK

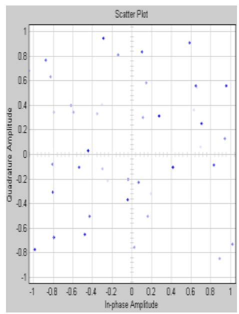

Fig. 20 Constellation Diagram of 256-PSK

256QAM with AWGN channel

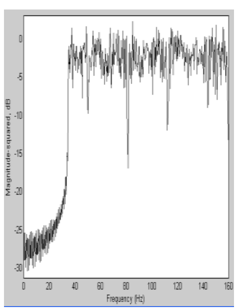

Fig. 21 Frequency Spectrum of 256-QAM

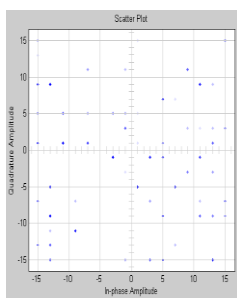

Fig. 22 Constellation Diagram of 256-QAM

256QAM with Rayleigh multipath fading channel

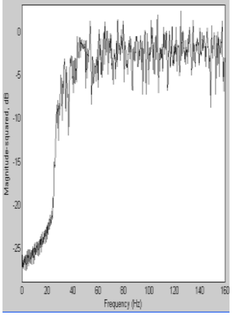

Fig. 23. Frequency Spectrum of 256-QAM

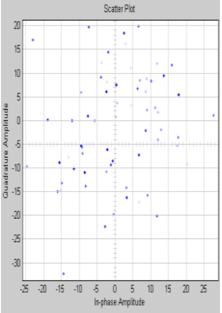

Fig. 24 Constellation Diagram of 256-QAM

256 QAM with Rician multipath fading channel

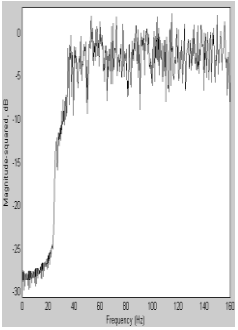

Fig. 25. Frequency Spectrum of 256-QAM

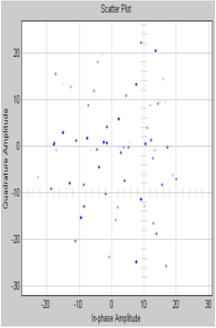

Fig. 26 Constellation Diagram of 256-QAM

Conclusion

OFDM has a strong anti multipath interference capability in high-speed data transfer with high spectral efficiency. Simulation result shows that bit error rate in OFDM system are within the allowable range. From the graphs of frequency spectrum and constellation diagrams and from comparative error rate table, it can be concluded that Additive White Gaussian Noise (AWGN) channel is best suitable for transmitting OFDM signals. We can also predict that the 256QAM performance is far better than other modulation schemes used.

Table I. Comparison Chart of Different Modulation Schemes

16 PSK			
	AWGN Channel	Rayleigh Channel	Rician Channel
Error Rate	0	0.5007	0.3790
No. of Error detected	0	38840	29397
Transmitted bit	77568	77568	77568
16 QAM			
	AWGN Channel	Rayleigh Channel	Rician Channel
Error Rate	0	0.4953	0.2827
No. of Error detected	0	38423	21928
Transmitted bit	77568	77568	77568
256 PSK			
	AWGN Channel	Rayleigh Channel	Rician Channel
Error Rate	0.2827	0.2499	0.2500
No. of Error detected	21928	115903	115983
Transmitted bit	463872	463872	463872
256 QAM			
	AWGN Channel	Rayleigh Channel	Rician Channel
Error Rate	0	0.2495	0.2023
No. of Error detected	0	115739	93860
Transmitted bit	463872	463872	463872

References

1. Lian Hua, Zhao Ruimei, H. U. Boning and P. A. N. G Huawei, Simulation and Analysis of OFDM Communication System, *2nd International Conference on Industrial Mechatronics and Automation*, 2010.

2. Lun Zhang and Zhongpei Zhang, Simulation and Analysis of OFDM System based on Simulink, *IEEE*, (2010).

3. W. U. Chuanling, Key Technologies of Mobile Communication, *2nd D. Beijing University of Posts and Telecommunications Press:Beijin*, (2001) 232-255.

4. L. U. Aiqing, T. I. A. N. Yumin and Z. H. U. Minghua, Matlab Simulation and Performance Analysis of OFDM System, *Computer Simulation*, **22** (2005) 164-168.

5. Xiaojuan Chen, Minglei Zhang and Xue Han, Performance Analysis of Reception for OFDM Communication Systems, *International Conference of Information Technology, Computer Engineering and Management Sciences*, 2011.

6. Mamdouh El Tabach, Jean-Philippe Javaudin and Maryline Hélard, Spatial Data Multiplexing over OFDM/OQAM Modulations, *IEEE*, (2007).

7. T. P. Surekha, T. Ananthapadmanabha, C. Puttamadappa and Members IEEE, Modeling and Performance Analysis of QAM-OFDM System with AWGN Channel, *IEEE*, (2011).

8. Jianhua Lu, K. B. Letaief, Senior Member IEEE, Justin C. I. Chuang, Fellow IEEE and Ming L. Liou, M-PSK and M-QAM BER Computation Using Signal-Space Concepts, *IEEE Transaction on Communications*, **47(2)** (1999).