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BER Performance of OFDM System in Rayleigh Fading Channel Using Cyclic Prefix

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Abstract— *In this research paper, we will focused on the bit error rate (BER) performance of Orthogonal-frequency division multiplexing (OFDM) of various modulation techniques. The Orthogonal Frequency Division Multiplexing (OFDM) is the popular modulation technique for the many wireless communication systems. In the wireless system, the signal transmitted into channel bounces off from the various surfaces resulting in the multiple delayed versions of the transmitted signal arriving to the receiver. The OFDM has trusted to be very effective in mitigating adverse multi-path effects of a broadband channel. The multiple signals are obtained due to the diffraction and reflection of electromagnetic waves around objects .The bit error rate (BER) performance of this type of systems are evaluated in the additive white Gaussian noise (AWGN) channel. The BER performance of the transmission modes are calculated by calculating the bit error rate (BER) versus signal to the noise ratio (SNR) under the Additive white Gaussian noise (AWGN), channel.*

Keywords—BER, UWB, SNR, AWGN, OFDM, QPSK, BPSK, QAM, Rayleigh fading.

I. INTRODUCTION

It is very important to calculate the performance of the wireless systems by considering the transmission characteristics, parameters of the wireless channel and the device structure.The Bit Error Rate Ratio (BER) is considered to be one of the most extensively used performance measures for wireless communication systems and hence it has been extensively studied. In our research paper, we proposed a novel approach to calculate the average probability of error by using OFDM modulation techniques and by considering an approximation of the spatial filter.

In present time, ULTRA WIDE BAND (UWB) communication technology is an emerging as a popular standard for high-data-rate applications over wireless communication networks. Due to the use of its high-frequency bandwidth ,the UWB can achieve very high data rates over the wireless connections of multiple system devices at a low transmission power close to the noise floor.Since the power level required for the UWB transmissions is low, so UWB devices will not generate significantly harmful interference to the other communication standards. A major difference between conventional radio transmissions and the UWB is that – the conventional systems sends information by changing the power level, frequency, and/or phase of a sinusoidal wave whereas in the UWB transmissions information is transmitted by generating radio energy at the specific time intervals and covering a large bandwidth, thus enabling pulse-position or time modulation.In the wireless channels, several models have been introduced and investigated to calculate SNR. Every models are a function of the distance between the transceiver, the path loss exponent and the channel gain. The Several probability distributed functions are also available to model a time-variant parameter i.e. channel gain.

It is highly believed that the OFDM results in an improved multimedia download services requiring high data rates communications, but this condition is significantly controlled by inter-symbol interference (ISI) due to the existence of the multiple paths. The Multicarrier modulation techniques, including OFDM modulation are considered as the most depending technique to overcome this problem .The OFDM technique is a multi-carrier wireless transmission technique which is being considered as an excellent method for the high speed bi-directional wireless communication of data.

II. OFDM TECHNIQUE

The Orthogonal frequency division multiplexing (OFDM) is a wireless communications technique that breaks a communications channel into a number of equally spaced frequency bands. A sub-carrier having a portion of the user information is sended in each band. Each sub-carrier is the orthogonal (i.e. independent of each other) with other sub-carrier; distinguishing OFDM from the commonly used

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frequency division multiplexing (FDM) technique. The FDM is a modulation technique that transmits multiple signals simultaneously over a single transmission path.

TheOrthogonal frequency-division multiplexing (OFDM) is the modulation technique for the European standards such as the Digital Audio Broadcasting (DAB) and the Digital Video Broadcasting (DVB) systems. The Orthogonal frequency-division multiplexing (OFDM) is a process of encoding digital data on the multiple carrier frequencies. The data are transmit over parallel sub-channels with each sub-channel modulated by the modulation scheme such as BPSK, QPSK, QAM etc. The benefitof theOFDM is its ability to cope with severe channel conditions compared to a single carrier modulation scheme but still maintain the data rates of a conventional scheme with the same bandwidth. The Orthogonal Frequency Division Multiplexing has become one of the main physical layer techniques used in the modern communication systems.

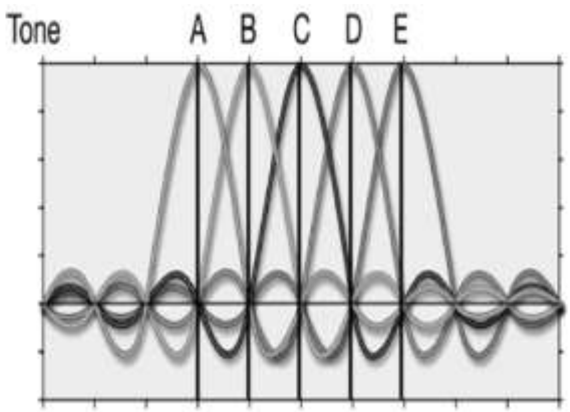

Fig.1: OFDM Tones

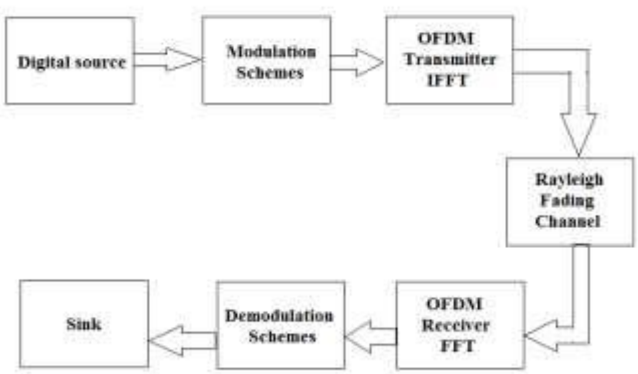

Fig.2: Block diagram of OFDM Transmitter and Receiver

III. CHANNEL MODEL

1. AWGN Channel : When the impairedcommunication channel are linear addition of wide band or the white noise consisting constant spectral density over infinite period and the amplitude is Gaussian distribution then such a channel model is known as AWGN channel [1].

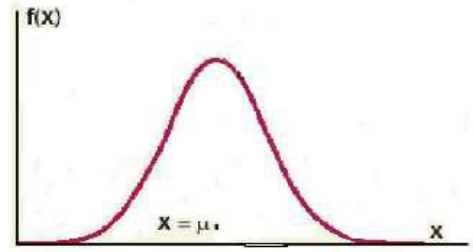

Fig.3:Gaussian distribution of white noise

The High data rate communication over the additive white Gaussian noise channel (AWGN) is limited by the white noise .The received signal in the interval range $0 \leq t \leq T$ may be given as$r(t)=sm(t) + n(t)$

Where n(t) represents the sample function of additive white Gaussian noise (AWGN) process with power- spectral density.

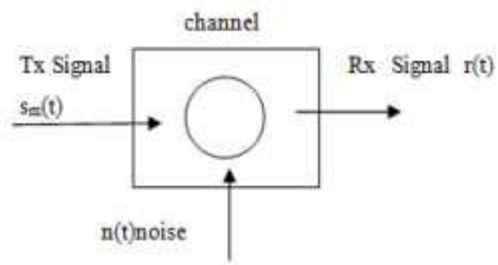

Fig.4: Model for received signal passed through AWGN channel

2. Rayleigh channel model: TheRayleigh fading environment is described by the many multipath components, each having relatively similar signal magnitude, and uniformly distributed phase, that means there is no line of sight (LOS) path between transmitter and receiver.The channel in which the signal takes various path to reach the receiver after getting reflect from various objects in the environment. The signal receiving at receiver is sum of the reflected signal and the main signal. The signal in the environmentget diffracted or reflected from the objects like tree, building,moving vehicle etc and imposes problem when the envelope of the ndividual signal is added up [2].

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Fig.5: Rayleigh Fading Scenario

3. Rician channel model: When the line of sight propagation path is exist between transmitter and receiver ,then the dominant stationary signal component persists, the fading of the channel is called as Rician channel. The white noise which occurs because of Rician channel is explained as Rician distribution. The Random multipath components arriving at the receiver side comes from thedifferent angles superimposing on a stationary signal [3].

IV. MODULATION SCHEMES

(i). Binary Phase Shift Keying (BPSK)

The PSK uses a finite number of phases; each areassigned with a unique pattern of binary digits. Generally, each phase encodes an equal number of the bits. Each pattern of the bits generates the symbol that is denoted by the particular phase. The BPSK is the simplest type of phase shift keying (PSK). It consists of two phases which are separated by 180° and so they can also be named as 2-PSK. It does not matter exactly that where the constellation points are positioned, and in the below figure they are represented on the real axis, at 0° and 180°.

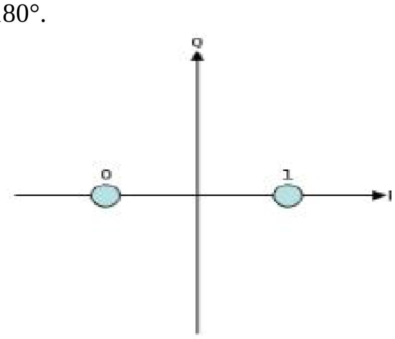

Fig.6:Constellations for BPSK

(ii) Quadrature Phase Shift Keying (QPSK)

The QPSK have four points on the constellation diagram, and areequispaced around a circle. With four phases, QPSK can encode the two bits per symbol, shown in the figure with gray coding to reduce the bit error rate (BER) — some times it misperceived as twice the BER of the BPSK. The mathematical studies shows that QPSK can used either to double the data rate when compared with a BPSK system while maintaining the same bandwidth of the signal, or to maintain the BPSK data ratebut halving the needed bandwidth.

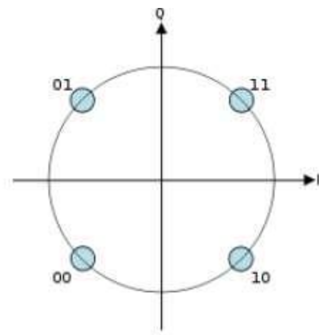

Fig.7: Constellation for QPSK

(iii). Quadrature amplitude modulation (QAM)

TheQAM is the modulation scheme which encode the information into a carrier wave by varying the amplitude of both the carrier wave and a - quadrature carrier that is 90° out of phase with the main carrier wave in accordance with the two input signals. It means that, the amplitude and the phase of the carrier wave are simultaneously varied in accordance to the information we want to transmit.The symbol rate is one fourth of the bit rate. So this modulation format produces a more spectrally efficient transmission. It is more efficient than BPSK, QPSK.

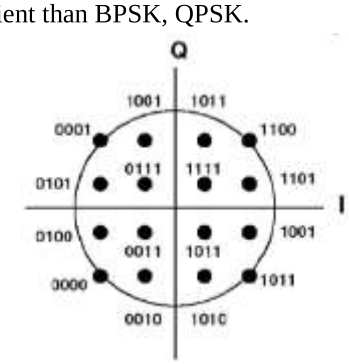

Fig.8: Constellation for QAM

V. RESULTS AND ANALYSIS

The software MATLAB R2010a has been used to program and simulate the complete environment. The various parameters that have been initialized and various built in functions have been used to implement the complete design of the system.For this research work, Communication Systems Toolbox has been used along with standard MATLAB mathematics and graphics functions.

The various simulation parameters used in this research work are shown in below table-

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Table.1: Simulation Parameters

Parameter	Value
Number of Subcarriers	512
FFT Length	512
Bandwidth	$5x10^6$
Sampling Frequency	2xBW
Cyclic Pad Length	64 bits
Modulation Technique	BPSK, QPSK, 16QAM, 64 QAM

Simulation Results and Graphs

MATLAB software has been used to simulate the OFDM scheme with different modulation schemes and the performance is plotted in the form of Bit Error Rate (BER) vs Signal to Noise Ratio(SNR) plots, as shown in the below figures. The probability of error has also been computed and plotted against the SNR. Figure 12 shows the power spectral density plot against the sampling frequency, which shows the orthogonality of the OFDM signals.

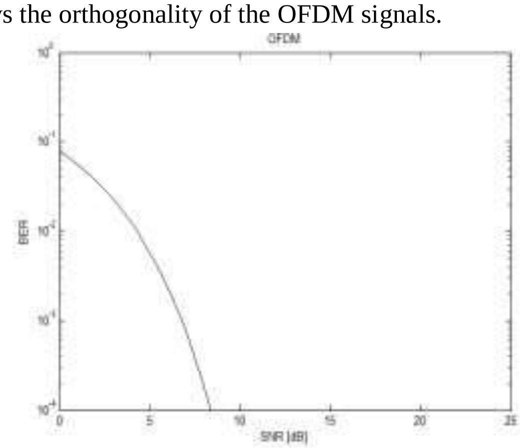

Fig.9: BPSK BER vs SNR curve

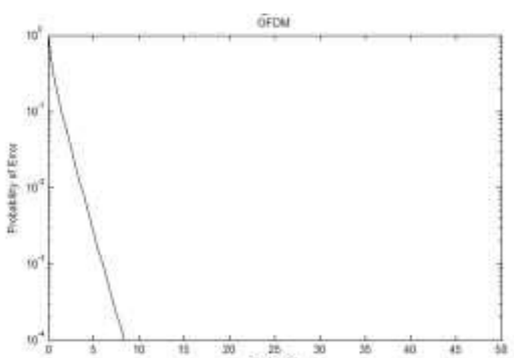

Fig.10: Probability of error for BPSK

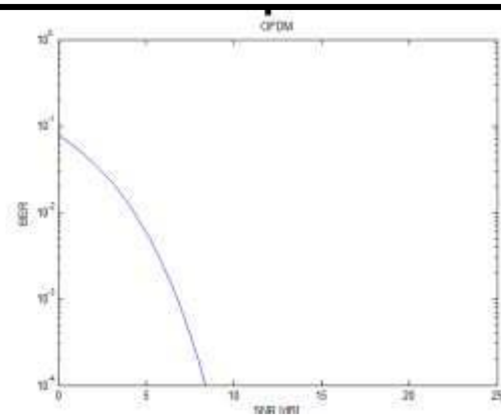

Fig.11: BER vs SNR for QPSK

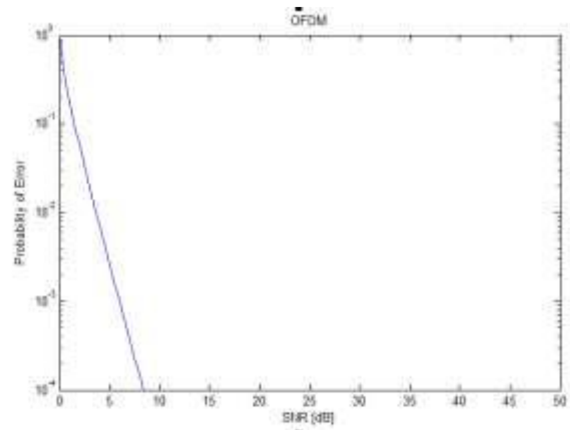

Fig.12: Probability of Error QPSK

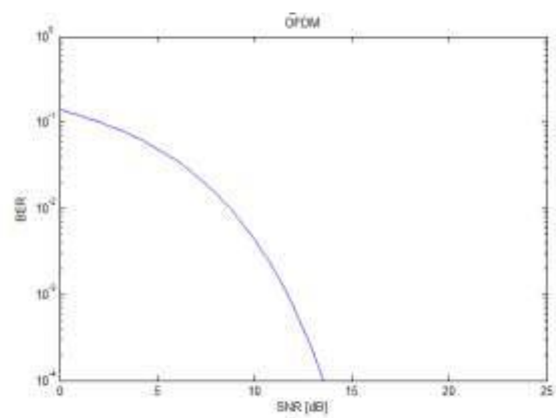

Fig.13: BER vs SNR for 16-QAM

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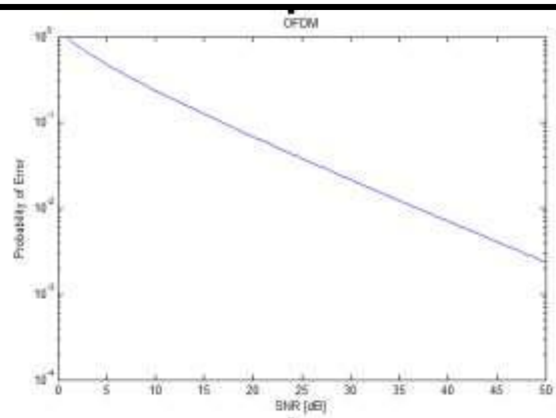

Fig.14: Probability of Error for 16 QAM

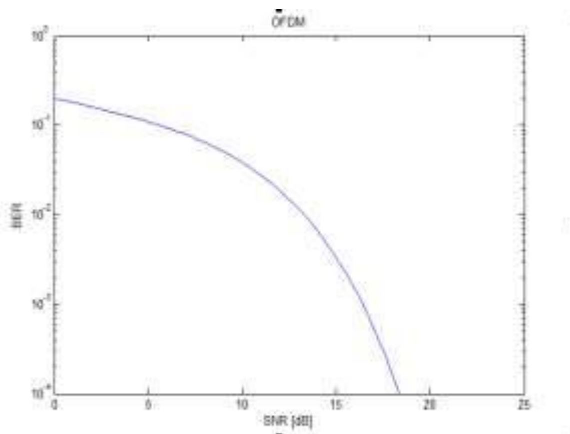

Fig.15: BER vs SNR for 64 QAM

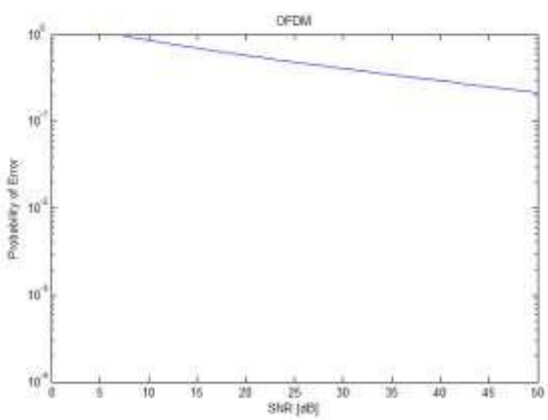

Fig.16: Probability of Error for 16 QAM

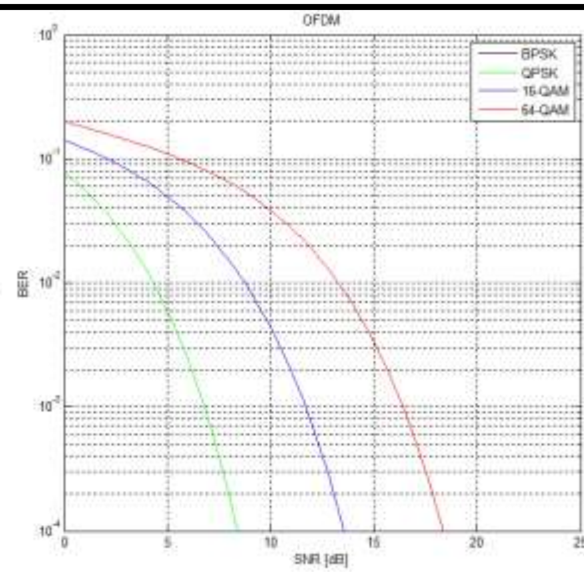

Fig. 17: BER vs SNR plot

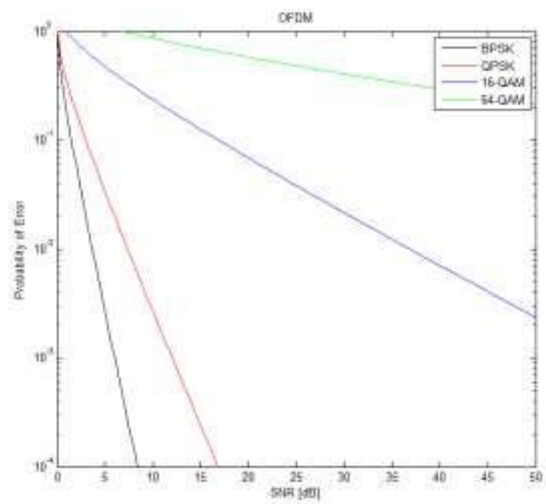

Fig.18: Probability vs SNR

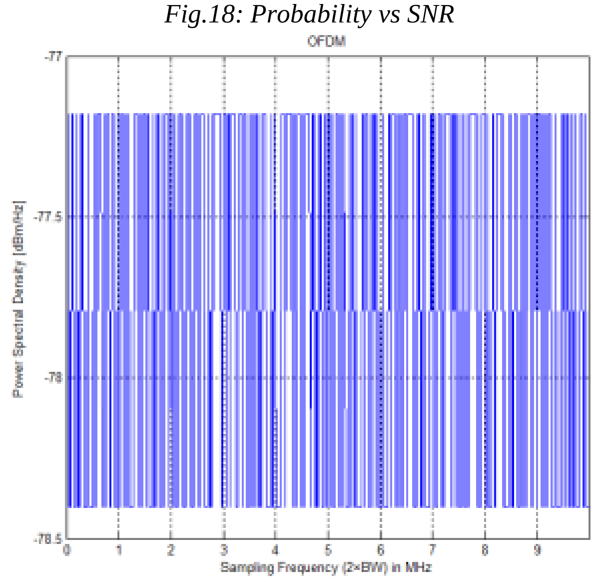

Fig.19: PSD vs Sampling frequency

VI. CONCLUSION

In this research work, the OFDM model of Wireless Communication is implemented and a number of modulation schemes are used viz. BPSK,QAM, QPSK,16PSK,etc. The various performance parameters like BER, SNR etc. are to be evaluated. The channel used is Rayleigh fading Channel, for this research. The research work is intended to study and analyse the performance of OFDM technique under various modulation schemes.

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