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Performance Evaluation of Orthogonal Frequency Division Multiplexing Using Different Modulation Schemes

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***Abstract*— Orthogonal Frequency Division Multiplexing (OFDM) is a modulation technique which is used to meet the growing demand for high data bit rate and efficient spectral usage in a wireless communication system. The scheme provides maximum data rate, robustness against multipath fading and bandwidth saving. In this paper, the scheme was evaluated using Bit Error Rate value, through the Additive White Gaussian Noise (AWGN), Rayleigh and Rician fading channels using different modulation techniques. Bit Error Rate (BER) gives a good indication of the performance of a particular modulation scheme. The Orthogonal Frequency Division Multiplexing model was simulated using Simulink, the Results obtained showed that AWGN is a preferred channel for its wireless communication system regardless of the modulation scheme employed with the exception of Binary Phase Shift Keying BPSK which gave a better bit error rate value using the Rician fading channel. Conclusively, this indicates that modulation techniques are adversely affected in fading channels as opposed to Additive White Gaussian Noise channel.**

Index Terms—Additive White Gaussian, Bit Error Rate, Modulation, Orthogonal Frequency Division Multiplexing, Rayleigh, Rician,

I. Introduction

The steady and massive growth of digital wireless communication systems has introduced a lot of constraints in the available bandwidth. There is a steady increase in the demand for high data rate for surfing the internet to perform tasks like video streaming, e-mailing and other multimedia applications.

OFDM, the underlying technology of the 4G/LTE network is a promising modulation scheme, which enables non-line of sight (LOS) wireless access system over wide areas. It is thus a technique by which the increasing need for high speed data rate communication can be achieved. Orthogonal Frequency Division Multiplexing (OFDM) is a special form of multi-carrier transmission technique in which a single high rate data stream is divided into multiple data streams [1].

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The orthogonality of the OFDM system provides for non-interference of the overlapping subcarriers in the frequency domain. This reduces inter-symbol interference (ISI) due to channel dispersion in time caused by multipath delay spread. Hence the system exhibits delay spread tolerance and efficient spectral usage as a result of increase in the symbol duration for the lower rate parallel subcarriers. Inter-symbol interference (ISI) is further reduced in every OFDM symbol by introducing guard time in between.

An OFDM based system gains importance in wireless applications in the fact that it provides greater immunity to multipath fading and impulse noise and eliminates the need for equalisers [2]. [3] The main advantage of OFDM signals is that it uses Inverse Fast Fourier Transformation (IFFT) and Fast Fourier Transformation (FFT) for modulation and demodulation respectively.

The performance of a data communication system can be determined from its BER which is a function of the number of error bits in a transmitted signal, that is, the signal to noise (SNR) ratio.

In this paper, I have presented an analysis of the significance of BER (Bit Error Rate) under different scenarios such as different noise channels and different modulation techniques in an OFDM system using Simulink.

II. OFDM System Model

The main building blocks of the OFDM model are shown below in figure 1.

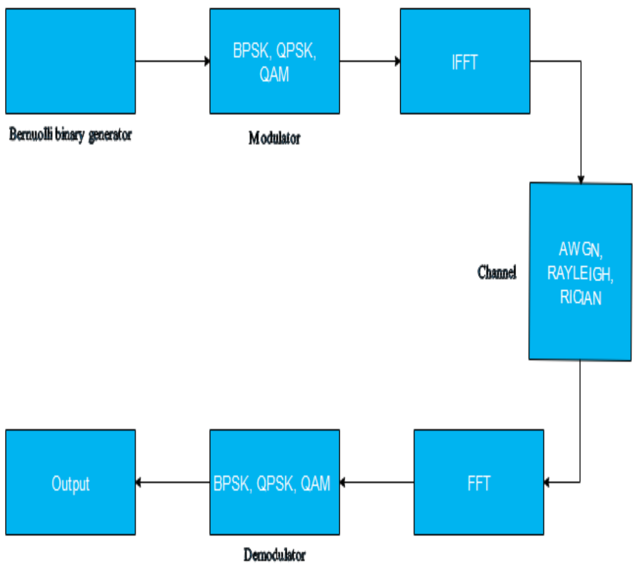

Figure 1: Block diagram of OFDM system

OFDM can be modelled using various transforms, different modulations and channel coding [4].
In this paper, I used the Fast Fourier Transformation (FFT) and its inverse (IFFT), which is a discrete Fourier transform algorithm.
The conversion of parallel low rate frequency domain signals to time domain at the transmitter and time domain signals to frequency domain at the receiver is performed using IFFT and FFT operations [5].
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III. CHANNEL MODEL

The noise channel models employed are

A. AGWN (Additive White Gaussian Noise)

An AWGN model is a channel with white Gaussian as the noise source. It is the most commonly used model channel simulation [6]. It is used to transmit signals while signals travel from the channel and simulate background noise of channel.

B. Rayleigh.

Rayleigh fading is caused by multipath reception. It is applicable when there is no dominant propagation along a line of sight (LOS) between transmitter and receiver[7]. In this environment objects attenuate, reflect, refract and diffract the signal received at the receiver. [8] The resultant signal received at the receiver is the sum of all the reflected and scattered waves.

C. Rician.

Rician fading is a part of Rayleigh fading with the introduction of a strong line of sight path in the Rayleigh fading environment [7]. The received signal comprises of both the direct and scattered multipath waves.

IV. MODULATION TECHNIQUES

A. BPSK (Binary Phase Shift Keying)

BPSK is the simplest form of PSK. It uses two phases, one for logic 1 and the other for phase for logic 0[8]. For the transmission of 1 bit the phase shift is 0 degree and for 0 bit transmission the phase shift is 180 degree [4].

B. QPSK (Quadrature Phase Shift Keying)

QPSK is an example of M-ary PSK modulation technique. It is a type PSK whereby two bits are varied at once selecting one of four possible carrier phase shifts. It is similar to 4QAM and has twice the bandwidth efficiency of BPSK.

C. QAM (Quadrature Amplitude Modulation)

QAM is a combination of both Amplitude Shift Keying (ASK) and Phase Shift Keying (PSK). QAM is the encoding of the information into a carrier wave by variation of the amplitude of both the carrier wave, a quadrature carrier that is 90 degree out of phase with the main carrier in accordance with two input signal [9]. It is a hybrid modulation technique. A variety of forms of QAM are available, some are 4QAM, 8QAM, 16QAM, 32QAM, 64QAM, 256QAM etc. An advantage of using the QAM is that it is a higher form of modulation, hence its able carry more bits of information per symbol. It also has superior power efficiency to M-ary PSK.

D. BER (Bit Error Rate)

BER is a measure of the quality of a transmission system. It is defined as the rate at which errors occur in a transmission system.
BER is the ratio of the number of errors to the total number of transmitted signals.

$$BER = \text{number of error bits} / \text{total number of transmitted bits}$$

BER is the most reliable channel quality estimate because it reflects the channel quality irrespective of the source or the nature of the quality degradation.

V. SIMULATION MODEL

This paper used Simulink for the simulation. Simulink is an environment of multi-domain simulation and mode – based design for dynamic and embedded by system [10] in [8].
The different model of OFDM based on FFT and the different channels (AWGN, Rayleigh and Rician) are show in the figures 2 – 6.

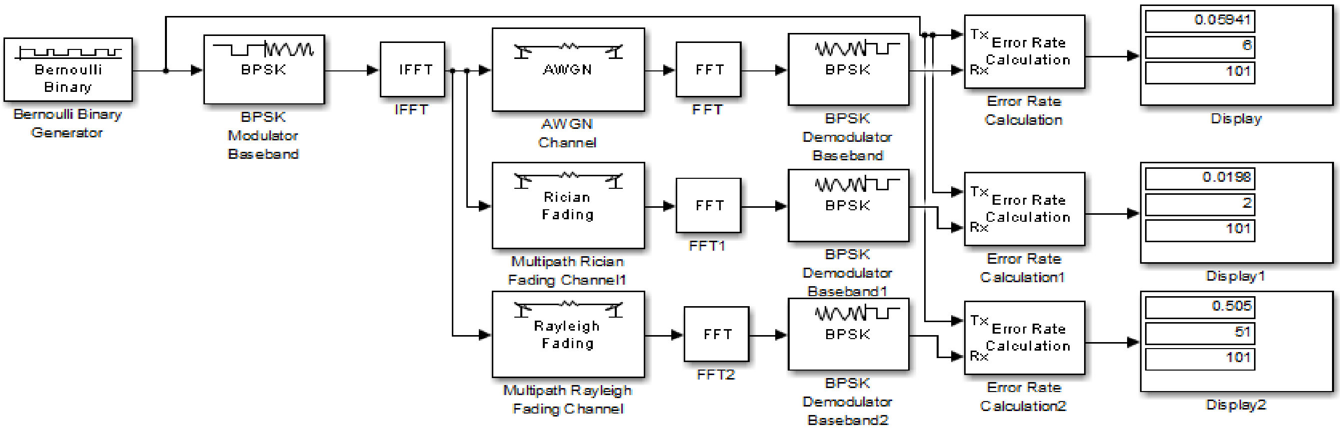

Figure 2: OFDM model with BPSK modulation

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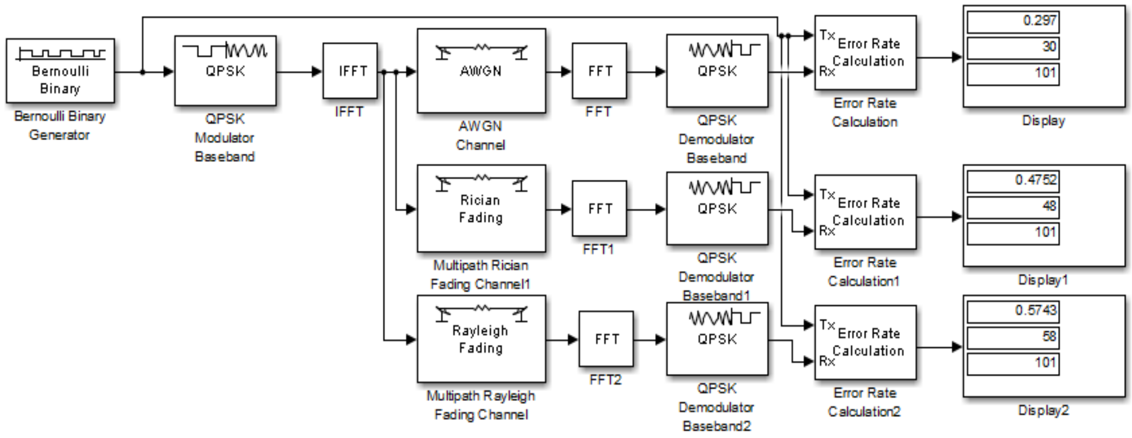

Figure 3: OFDM model with QPSK modulation

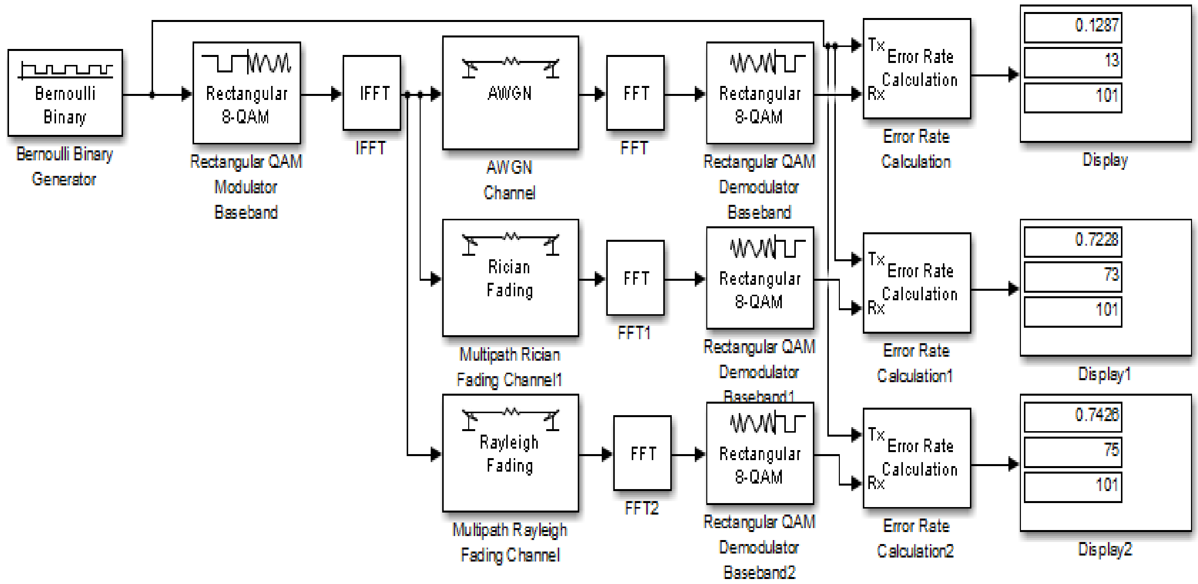

Figure 4: OFDM model with 8QAM modulation

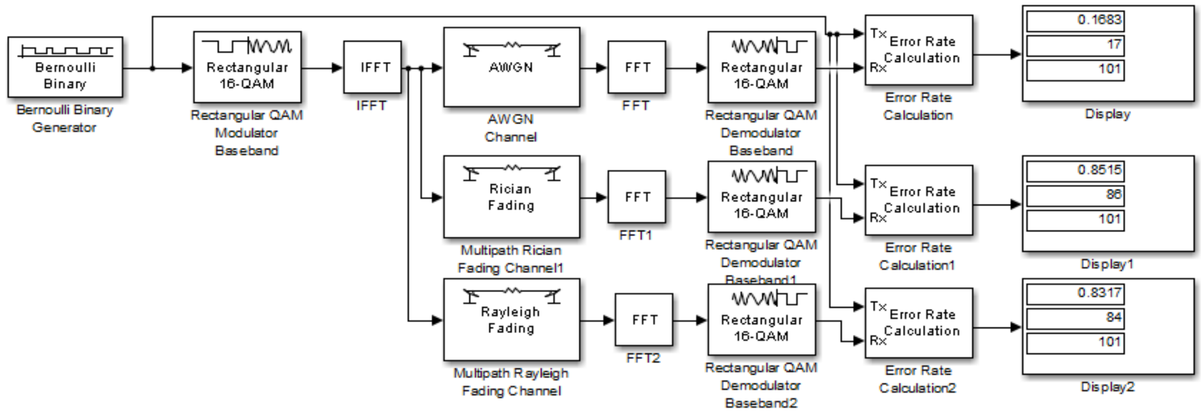

Figure 5: OFDM model with 16QAM modulation

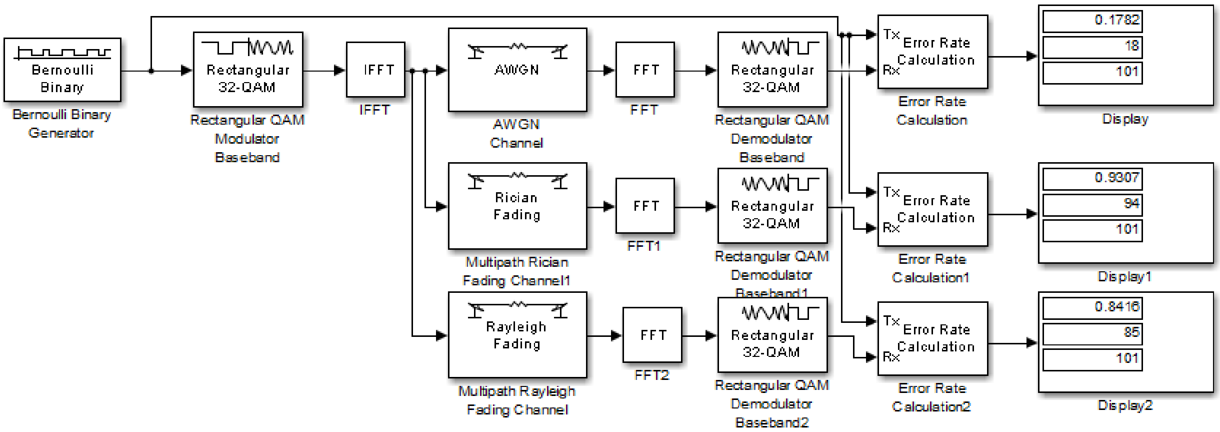

Figure 6: OFDM model with 32QAM modulation

Table 1: Simulation parameters

PARAMETERS	VALUE
CHANNEL CODING	NONE
TRANSFORM	FFT
NOISE CHANNEL	AWGN, RAYLEIGH, RICIAN
MODULATION TYPE	BPSK, QPSK, QAM(8, 16, 32)
K – FACTOR (FOR RICIAN)	1
EB/NO (FOR AWGN)	10

VI. SIMULATION RESULTS

In this section the results obtained from the computer simulation program are presented. The results are presented in Tables 2 – 4 while the corresponding graphs are shown in figure 7 – 9.

Table 2:BER for different modulation schemes using AWGN

Channel	Modulation type	BER
AWGN	BPSK	0.05941
	QPSK	0.297
	8QAM	0.1287
	16QAM	0.1683
	32QAM	0.1782

Table 3: BER for different modulation schemes using Rayleigh

Channel	Modulation type	BER
Rayleigh	BPSK	0.505
	QPSK	0.5743
	8QAM	0.7426
	16QAM	0.8317
	32QAM	0.9307

Table 4: BER for different modulation schemes using Rician

Channel	Modulation type	BER
Rician	BPSK	0.0198
	QPSK	0.4752
	8QAM	0.7228
	16QAM	0.8515
	32QAM	0.8416

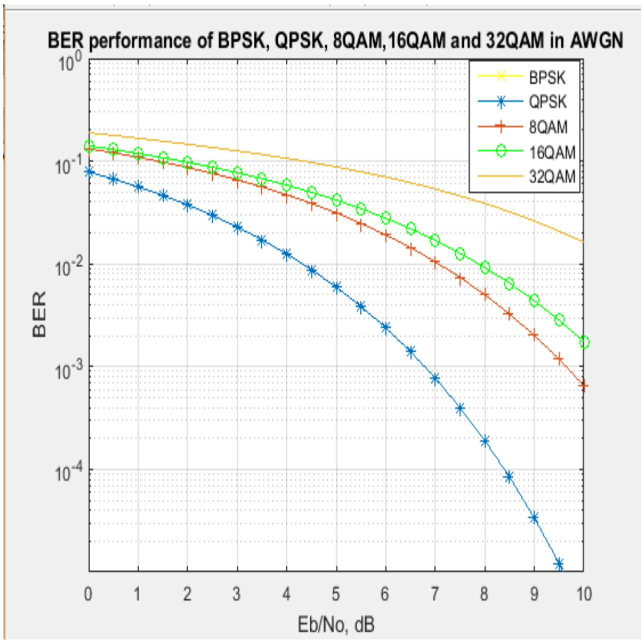

Figure 7: BER performance of BPSK, QPSK, 8QAM, 16QAM, and 32QAM in AWGN

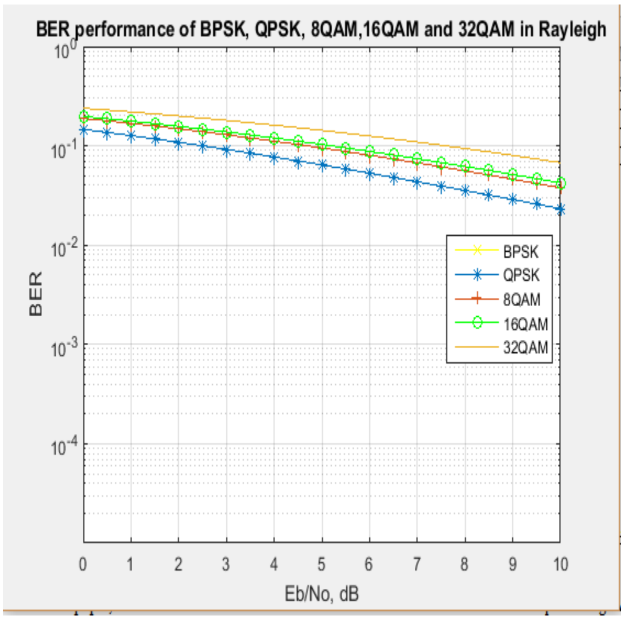

Figure 8: BER performance of BPSK, QPSK, 8QAM, 16QAM and 32QAM in Rayleigh

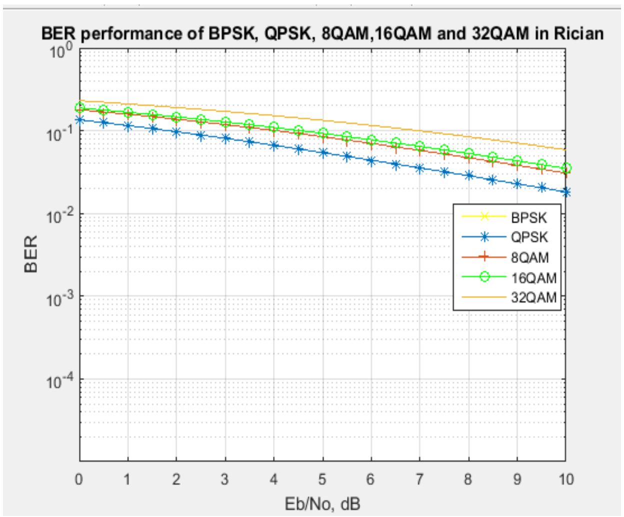

Figure 9: BER performance of BPSK, QPSK, 8QAM, 16QAM and 32QAM in Rician

VII. CONCLUSION

The OFDM system is a unique modulation technique capable of meeting the increasing high demand for data in wireless communications. BER was used to quantify the integrity of the data transmitted through the OFDM system.

In this paper, BER of different OFDM based modulation techniques was evaluated using AWGN, Rayleigh and Rician noise channel and simulated using Simulink. The result showed that in an FFT based OFDM system without channel coding the AWGN produces a better BER value regardless of the modulation schemes employed.

A further analysis shows that the BPSK modulation scheme have a better BER as compared to other modulation schemes regardless of the noise channel used.

Conclusively, a BPSK OFDM system using FFT without channel coding produces minimum value of BER for Rician, followed by AWGN and then Rayleigh fading channels. The result shows that modulation techniques are adversely affected in fading channels as opposed to AWGN channel.

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