EFFECT OF DOPPLER FREQUENCY AND BER IN FFT BASED OFDM SYSTEM WITH RAYLEIGH FADING CHANNEL

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***ABSTRACT*- As the world moves to the future, there is a rising demand of high performance, high capacity and low Bit Error Rate(BER) in wireless communication, to integrate wide variety of communication services such as high-speed data, video and multimedia traffic as well as voice signals. Orthogonal Frequency Division Multiplexing(OFDM) is a multicarrier system that provides an efficient means to handle high-speed data streams over multipath fading environment. In this paper, we discuss the effect of Doppler frequency in Fast Fourier Transform(FFT) based OFDM system over Rayleigh fading channel. In this paper, multipath fading channel effect and the Bit error Rate (BER) on the performance of OFDM is shown where user's mobility is taken into account. Quadrature Amplitude Modulation (QAM) scheme is used for BER with Rayleigh and Additive White Gaussian Noise(AWGN) channel. It will be implemented in MATLAB to acquire their BER performance and the result is compared.**

Keywords-AWGN channel, channel estimation, BER, RAYLEIGH channel, FFT based OFDM

I .INRODUCTION

OFDM is one of the strong multiplexing techniques for next generation wireless communication due to its high data rate transmission capability, high bandwidth efficiency, its robustness to multipath delay and fading. OFDM is multi carrier parallel transmission technique [1]. In conventional OFDM system, Inverse Fast Fourier transform (IFFT) and Fast Fourier transform (FFT) are used to multiplex the signal together and decode the signal at the transmitter and receiver respectively. In this system, the cyclic prefix is added before transmitting the signal to channel [2].

In an OFDM system, the available bandwidth is divided into N small parts, and a block of N data symbols are modulated on N corresponding subcarriers which are orthogonal to each other .The spectra of the sub carriers are overlapped ,therefore precise frequency recovery is needed. However in the mobile radio environment, the relative movement between transmitter and receiver causes Doppler frequency shifts. In addition, the carriers can never be perfectly synchronized leading to frequency offset. These random frequency errors in OFDM system distort orthogonality between the subcarriers leading to Inter Carrier Interference (ICI) [3].

In this paper two type of modulation techniques are used. Phase Shift Key(PSK) modulation technique is used for understanding the Doppler frequency effect on the OFDM system with RAYLEIGH fading channel while QAM modulation is used for studying the performance of BER in the OFDM system with RAYLEIGH and AWGN

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channel.QAM combines two amplitude modulated signals using the same carrier frequency with a 90 degree phase difference .

This paper is organised as follows: Section II describes the OFDM system using FFT. Section III explains channel estimation using pilot insertion. Section IV describes Rayleigh and AWGN channel. Section V present the simulation parameters, results and analysis for FFT based OFDM system, Doppler frequency effect in RAYLEIGH channel and BER performance of AWGN and Rayleigh channel. Finally, conclusion is presented to summarize the main outcome of this paper.

II.OFDM SYSTEM USING FFT

The block diagram of FFT based OFDM transceiver is shown in FIG.1.The input data is processed by M- ary QAM or PSK modulation .

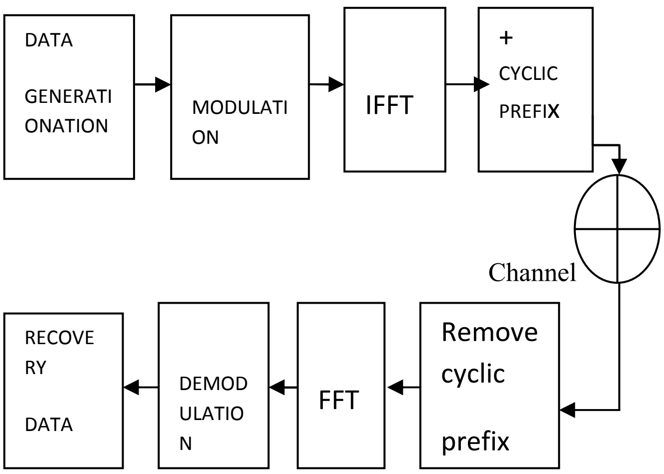

Fig. 1 FFT Based OFDM system

In OFDM System data is carried on narrow band subcarriers in frequency domain [4]. After symbol mapping it is necessary to convert the data stream into parallel form where each parallel data stream represents a sub-channel. Hence serial to parallel converter is used. The output of IFFT is the sum of the information signals in the discrete time domain as following [2]:

$$(x)^k = \frac{1}{N}\sum_{m=0}^{N-1} x^m e^{j2\pi kn/N} \qquad (1)$$

After applying IFFT on the symbols, cyclic prefix is added .and then passed through wireless communication channel. The digital data is converted to serial form and transmitted over the channel. At the receiver side the process is reversed to obtain the data after the FFT, the signal is converted back to the parallel form and demodulated to yield the transmitted signal back. The output of the FFT

$$(x)^m = \sum_{k=0}^{N-1} x^k e^{j2\pi km/N}$$

III. CHANNEL ESTIMATION USING PILOT INSERTION

The model adopted for the channel estimation is block–type pilot insertion in which channel estimation symbols carriers are employed as pilots. If the channel is invariable during the block, there will be no error in the channel estimation as the pilots are sent at all carriers. The estimation can be performed by using LEAST SQUARE(LS) method. Assuming the inter symbol interference is dropped by guard interval we write Y(K) as-

$$Y(K)=Xh+n$$

Where Y is received vector, X is a matrix containing the transmitted signalling points on its diagonal, h is a channel attenuation vector, n is the vector of Gaussian noise[4]

(a)Least square method of channel estimation

The goal of the channel least square distance is to minimize the square distance between the received signal and the original signal [1]

Assuming the received signal after FFT is

$$Y(K)=C(K)X(K)+Z(K)$$

Where K is a subcarrier index C is the channel, X is the pilot data and Z is the noise .The LS estimate of the channel is then computed by-

$$C(K)=Y(K)\backslash X(K);$$

Upon dividing the received signal by the known pilot, in the absence of noise this gives the correct estimation.

IV. RAYLEIGH AND AWGN FADING CHANNEL

RAYLEIGH fading is a statistical model for studying the effect of a propagation environment on a radio signal, such that is used by wireless devices RAYLEIGH fading models assume that the magnitude of a signal that has passed through such a transmission medium will vary randomly or fade according to a RAYLEIGH distribution.

Rayleigh fading is a reasonable model where many objects in the environment scatter the radio signal before it arrives at the receiver. If there is no dominant component to the scatter, then such process will have zero mean and phase evenly distributed 0 and 2π radians. Calling this random variable R, it will have a probability density function.

$$P_R(r)=2\pi/\Omega e^{-r^2/\Omega} ,r\geq 0$$

Where $\Omega = E(R^2)$

ADDITIVE WHITE GAUSSIAN noise (AWGN) channel is a universal channel model for analyzing modulation schemes. In this model, the channel does nothing but add a white Gaussian noise to the signal passing through it. This implies that the channel's amplitude frequency response is flat(thus with unlimited or infinite bandwidth) and phase frequency response is linear for all frequencies so that modulated signal pass through it without any amplitude loss and phase distortion of frequency components . AWGN channel is a theoretical channel used for analysis purpose only.[6]

The received signal in the interval of $0\leq t\leq T$ may be expressed as-

$$R(t)=S(t)+n(t)$$

Where n(t) denotes the sample function of additive white Gaussian noise channel(AWGN) process with power spectral density

V. SIMULATION RESULTS AND ANALYSIS

FFT based OFDM system are implemented using MATLAB and graphical result are found showing the bit error rate (BER)of the system

Parameters	**FFT based OFDM channel with AWGN channel**	**FFT based OFDM channel with RAYLEIGH channel**
No of sub carriers	64	64
FFT size	128	128
No of bits	4000	4000
Total no of OFDM symbols	1000	1000
Modulation method	16 QAM	16 QAM

Table1.Parameters selection for simulation of FFT based OFDM –

(a) SIMULATION -

AIM- To find the Bit Error Rate (BER) of the OFDM system and plot this against the SIGNAL TO NOISE Ratio (SNR) Using AWGN channel

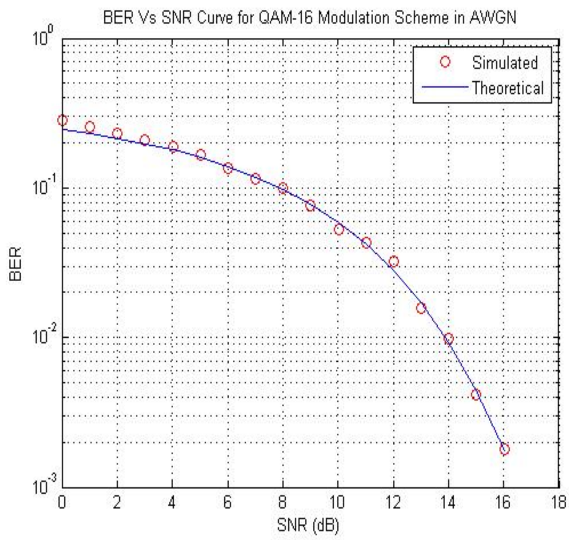

Figure 2 BER:16 QAM over AWGN channel

As shown in the figure-2 when signal to noise ratio is increasing the value of Bit Error rate (BER) is decreasing. In case of SNR = 8dB for QAM modulation, an error of 0.1 is recorded, and in case of SNR=16dB, an error rate of 0 .001 is noticed, hence the error is linearly decreasing.

(b) SIMULATION-

AIM- To find the bit error rate of an OFDM system and Plot it against the SIGNAL- TO NOISE RATIO (SNR) using RAYLEIGH channel and then compare with AWGN channel.

Transmitted OFDM system-

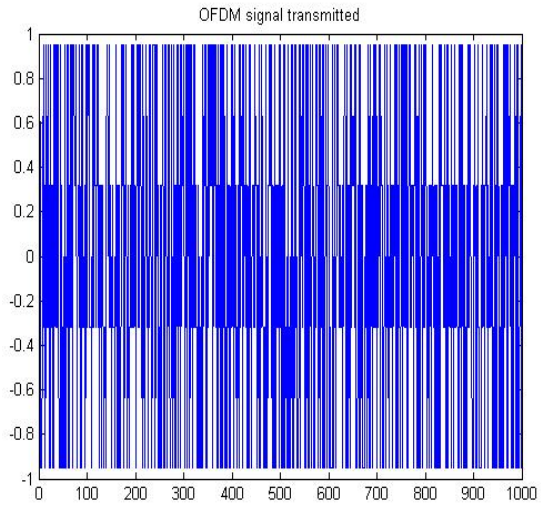

Figure 3: OFDM signal transmitted using 16 QAM modulation

Received OFDM system with RAYLEIGH fading channel Using 16 QAM modulation.

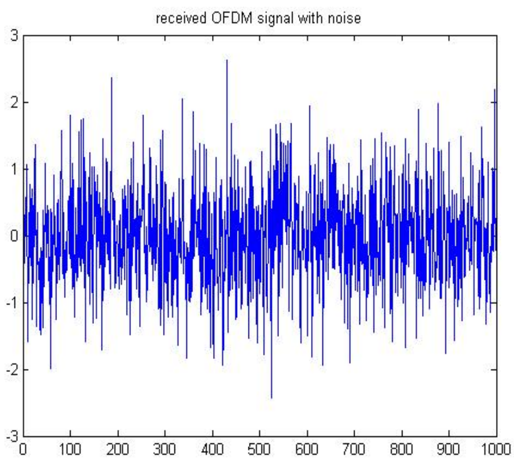

Figure 4: received signal through RAYLEIGH fading channel

When The OFDM system is passed through the RAYLEIGH fading channel, the received signal is highly affected.

The following figure 5 shows the comparison of BER between the two different channels. For the small value of SNR the BER is quite large and as the SNR value increases BER decreases.

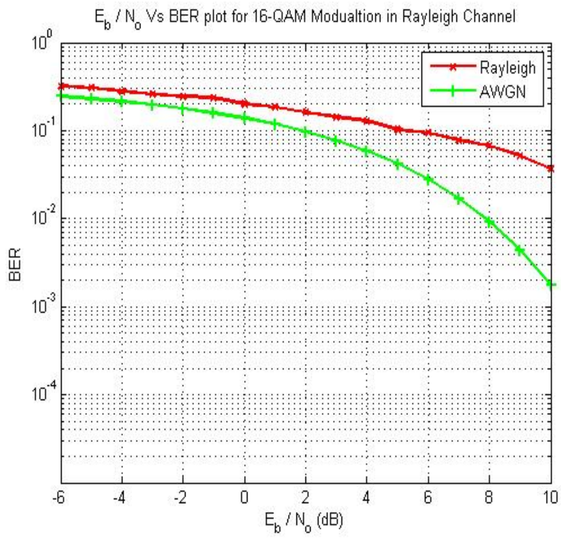

Figure 5: Comparison of BER between RAYLEIGH and AWGN channel

In Figure 5, the BER in AWGN linearly decreases but in the Rayleigh fading channel the BER reduces very slowly.

(c) SIMULATION-

AIM- The performance of OFDM is evaluated for different values of Doppler frequency

Table 2 –Parameter selection of Doppler frequency For OFDM system:

System bandwidth	10 MHZ
Sampling Frequency	11.429MHZ
Sampling Time	88nsec
FFT size	1024
Guard interval length	256
No of Pilot Bits	1024
Channel model	RAYLEIGH channel

When Doppler frequency Fd=0, implies that there is no mobility in the user. It is considered as the RAYLEIGH flat fading.

For Fd=0Hz

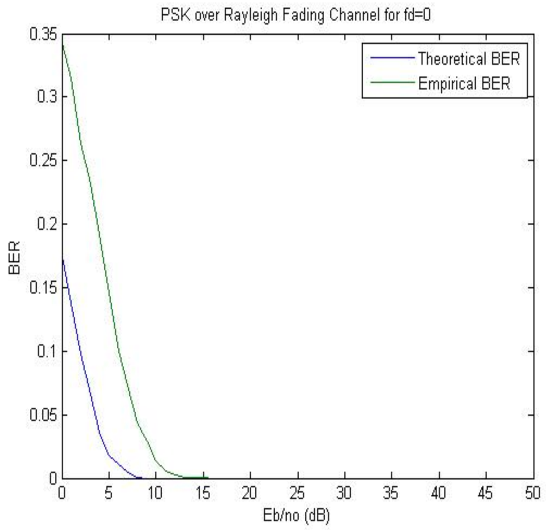

Figure 6: Doppler frequency is equal to zero

In figure 6, the result is bit far away from the theoretical. This is because of the removal of cyclic prefix and the pilot symbol, causing overall reduction in transmitted power.

FOR Fd= 10Hz

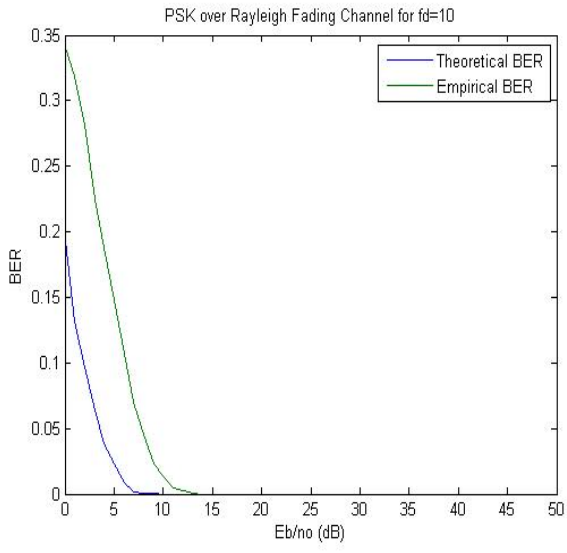

Figure 7: Doppler frequency is 10Hz over the RAYLEIGH fading channel.

In the comparison between the figure 5 and figure 6 there is less difference in the BER.

When the Fd = 50 Hz:-

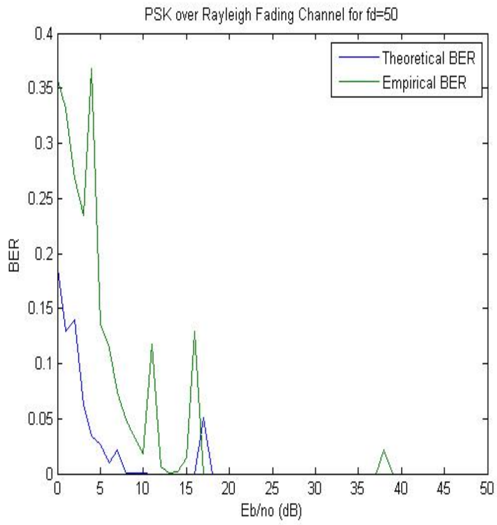

Figure 8: Doppler frequency is 50 Hz with PSK modulation.

Figure 8 shows the effect represented by change in Doppler frequency causing the system performance to degrade.

When the higher value of Doppler frequency is taken, Fd= 100 Hz

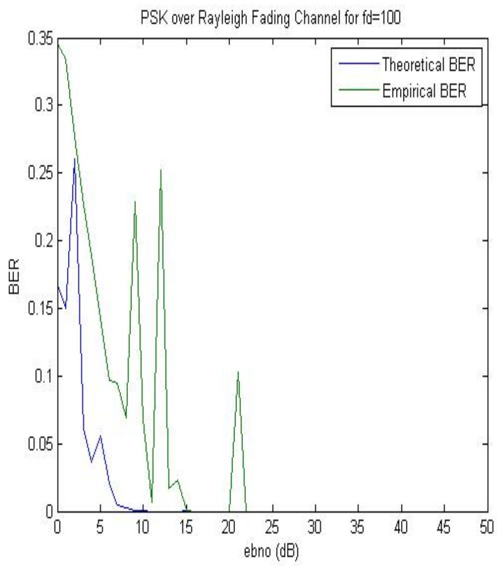

Figure 9: higher Doppler frequency over RAYLEIGH fading channel

In the Figure 9 the performance of the OFDM system degrades. Here it is showing the larger fluctuation in the system

VI. CONCLUSION

The BER performance of the FFT based OFDM system can be found over AWGN and RAYLEIGH fading channel using the 16 QAM modulation schemes. From the plots of the BER, it is concluded that when the Signal to Noise Ratio(SNR) is very low it does not have any impact on the BER. However if Signal to Noise Ratio is increased the BER is reduced accordingly. From the performance of both the channels it is found that QAM modulation is better than other modulation because it is more bandwidth efficient. The Doppler frequency effect is shown in Figure 6 to Figure 9, it represented that the as the Doppler frequency increases the BER is highly effected and it reduces the system performance.

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