BER Analysis of Digital Modulation Schemes for OFDM system

Patel Bhaveshree Anilbhai[1], Professor Shipa Rana[2]

[1]P.G Student, Department of Electronics and Communication Engineering,L.D.C.E.Ahmedabad,Gujarat,India.
[2]Professor, Department of Electronics and Communication Engineering,L.D.C.E.Ahmedabad,Gujarat,India.

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Abstract - *Orthogonal Frequency division multiplexing becomes an essential modulation scheme that supports high data rate, which is the prime requirement for wireless communication. This paper presents suitability of digital modulation techniques for an OFDM system. The performance in between these modulation techniques is analyzed and best suited with respect to low Bit Error Rate (BER) is transmitted. Orthogonal Frequency Division Multiplexing also reduce the inter-symbol Interference (ISI). Simulation is carried out on the software named MATLAB. Simulation is carried over both BPSK and QPSK to obtain the optimum value of BER and SNR.*

***Key Words*: Orthogonal frequency division multiplexing (OFDM), Carrier frequency offset (CFO), Inter carrier interference (ICI)**

1. INTRODUCTION

In recent years high speed wireless data communications have found many application areas like Orthogonal Frequency Division Multiplexing (OFDM).The principles of OFDM modulation have been used since the 1960s. But in recent years, this technology has crossed the limitations into the real world of modern communication systems to combat Inter Symbol Interference (ISI) through multicarrier modulation.

OFDM has proved to be very effective in mitigating adverse multipath effects of a broadband wireless channel. Counteracting the frequency selectivity of multipath channels by multiplexing information on different orthogonal carriers is the key to the OFDM success. Indeed, if a cyclic prefix is inserted between successive OFDM symbols, the overall system can be viewed as composed of N parallel frequency flat channels. So, now it becomes the underlying technology for various new applications such as digital audio broadcast (ETSI), digital video broadcasting-terrestrial (DVB-T) (ETS), wireless LAN (802.11a and g, 802.16a and b and Hiper LAN2(ETSI)), broadband wireless (MMDS, LMDS), XDSL, and home networking. Actually, as of today, OFDM has replaced DSSS for 802.11a and 802.11g wireless LAN application. In 802.11 and 802.16, there are several data modulation schemes that are used with OFDM, such as Binary Phase Shift Keying (BPSK), quadrature amplitude modulation (QAM) to cover data rates for different needs. The bit error rate (BER) performance of these systems evaluated in additive white Gaussian noise (AWGN) channel. In this technique, modulation, mapping rate are dynamically adapted based on channel condition to increase the system performance in terms of Bit Error Rate (BER) and throughput (bps) in various conditions such as channel mismatch, Doppler spreads, fading, etc. By using gray bit mapping in different types of modulation schemes, bit constellation is rearranged where every adjacent bit constellation differ by only one bit. Symbol energy and symbol error rate also converted into bit energy and bit error rate to reduce bit error rate for different types of modulation schemes. In this paper, we are trying to figure out the way, which is Rayleigh fading channel for improving the performance of transmitting information. We present the average BER performance for different MPSK and M-QAM and use gray coded bit mapping for different modulation schemes to get BER performance with OFDM technique in Raleigh fading channel. The numerical results are computed and plotted for M=16 and 64.

2. OFDM SYSTEM MODEL

1.1 Channel Model

In a multipath environment, it is reasonably intuitive to visualize that an impulse transmitted from the transmitter will reach the receiver as a train of pulses. When there are large numbers of paths, applying Central Limit Theorem, each path can be modeled as circularly complex Gaussian random variable with time as the variable. This model is called Rayleigh fading channel model. A circularly symmetric complex Gaussian random variable is of the form,

$$Z = X + jY \tag{1}$$

Where, real and imaginary parts are zero mean independent and identically distributed Gaussian random variables. For a circularly symmetric complex Gaussian random variable Z,

$$E[z] = E[e^{j\Theta}Z] = e^{j\Theta}E[Z] \tag{2}$$

The statistics of a circularly symmetric complex Gaussian random variable is completely specified by the variance $\sigma^2=E[Z^2]$Now, the magnitude z which has a probability density is called a Rayleigh random variable.

$$p(z) = \frac{z}{\sigma^3} e^{\frac{-z^2}{2\sigma^2}}, z \geq 0 \tag{3}$$

This model, called Rayleigh fading channel model, is reasonable for an environment where there are large number reflectors.

1.2 OFDM transceiver

Before transmitting information bit in Raleigh fading channel through the OFDM transmitter we use different modulation schemes and also gray bit mapping, which is shown in Fig. and information data are modulated in a baseband fashion by the IFFT. Then the data is transmitted to the channel. The receiver performs the inverse process of the transmitter.

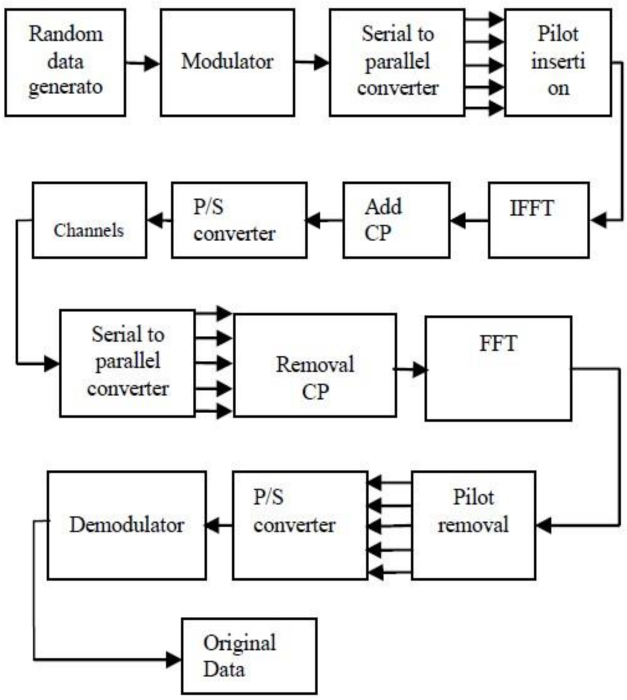

Fig -1: OFDM Block Diagram

3. RELATION BETWEEN E_b/N_0 AND E_s/N_0 IN OFDM

The relation between symbol energy and the bit energy is as follows:

$$\frac{E_s}{N_0} = \frac{E_b}{N_0}\left(\frac{n.DSC}{n.FFT}\right)\left(\frac{T_d}{T_d + T_{cp}}\right) \quad (4)$$

4. DIGITAL MODULATION TECHNIQUE IN OFDM

4.1 M-ary PSK Modulation in OFDM Model

The general analytic expression for M-ary PSK waveform is:

$$S_i(t) = A.cos(w_c t + \varphi_i t) \quad (5)$$

The parameter E_s is symbol energy, T_s is symbol time duration, and 0¡t¡T_s For BPSK modulation, M=2, and for QPSK modulation M=4, and the modulation data signal shifts the phase of the waveform $S_i(t)$ The BPSK bandwidth efficiency is 1 bit/Hz, while QPSK bandwidth efficiency is 2 bits/Hz.

1) BER calculation for M-ary PSK in Rayleigh fading channel:

$$PSKP_e = \frac{1}{\pi}\int_{\frac{-\pi}{2}}^{\frac{\pi}{2}-\alpha} \frac{cos^2\Theta}{cos^2\Theta + \rho sin^2\alpha} \quad (6)$$

4.2 M-ary QAM Modulation in OFDM Model

The general analytic expression for M-ary QAM waveform is:

$$S_i(t) = A_{mc}cos(w_c)t - A_{ms}sin(w_c)t \quad (7)$$

where i= 0,1,2, , M and T_s is the symbol interval, which is related to the bit interval by $T_s = mT_b$, where $m = log_2M$ represents the number of bits per symbol. The quadrature amplitudes A_{mc} and A_{ms} range over a set of d,3d,5d,. .

1) BER calculation for M-ary QAM in Rayleigh fading channel:

$$P_s(e) = \frac{4B}{\pi}\int_0^{\frac{\pi}{2}} \frac{sin^2\Theta}{sin^2\Theta g\gamma_s} d\Theta \quad (8)$$

5. FACTOR AFFECTING BER

There are different kinds of factor which can effect Bit Error Rate are as follows:

1) **Interference**: The interference levels present in a system are generally set by external factors and

cannot be changed by the system design. However it is possible to set the bandwidth of the system. By reducing the bandwidth the level of interference can be reduced. However reducing the bandwidth limits the data throughput that can be achieved.

2) **Increase the power level:** It is possible to increase the power level of the system so that the power per bit is increased. This has to be balanced against factor including the interference levels to other users and the impact of increasing the power output on the size of the power amplifier and overall power consumption and battery life, etc.

3) **Lower order modulation:** Lower order modulation schemes can be used, but this is at the expense of data throughput.

4) **Reduced Bandwidth:** Another approach that can be adopted to reduce the bit error rate is to reduce the bandwidth. Lower levels of noise will be received and therefore the signal to noise ratio will improve. Again this results in a reduction of the data throughput attainable.

6. IEEE 802.11 SPECIFICATIONS

IEEE 802.11 is a set of standards carrying out wireless local area network (WLAN) computer communication in the 2.4, 3.6 and 5 GHz frequency bands. The IEEE 802.11a standard specifies an OFDM physical (PHY) layer that splits an information signal across 52 separate subcarriers. Four subcarriers are pilot subcarriers and the remaining 48 subcarriers provide separate wireless pathways for sending the information in a parallel fashion. The resulting subcarrier frequency spacing is 0.3125 MHz (for a 20 MHz bandwidth with 64 possible frequency slots).

7. SIMULATION RESULTS

The OFDM system is developed, analyzed, and simulated in Matlab version 10. The performance results for such system in three types of modulation are obtained using the OFDM parameters listed below:

1) No. of bits per symbol: 52
2) No. of symbols:10^4
3) FFT size: 64
4) No of data sub carriers: 52

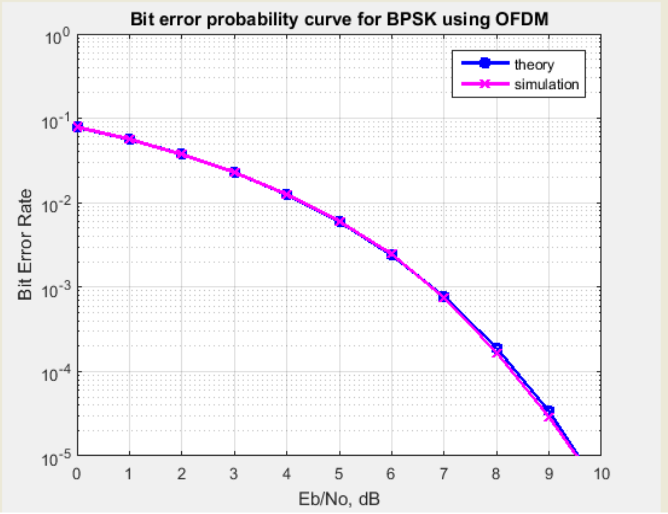

Fig -2: BER FOR BPSK OFDM

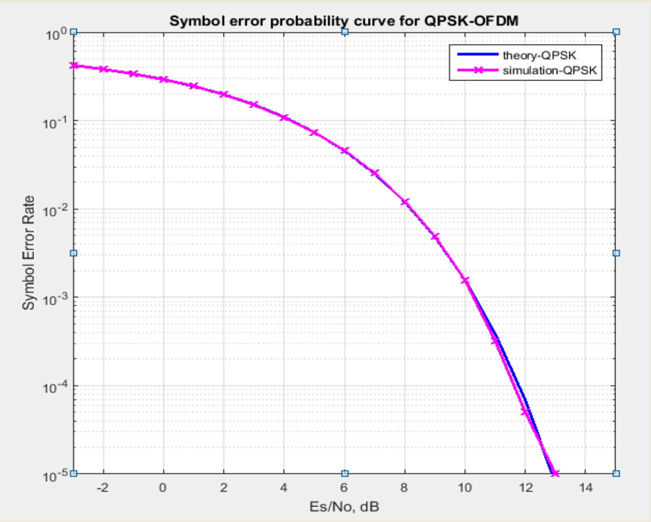

Fig -3: BER FOR QPSK OFDM

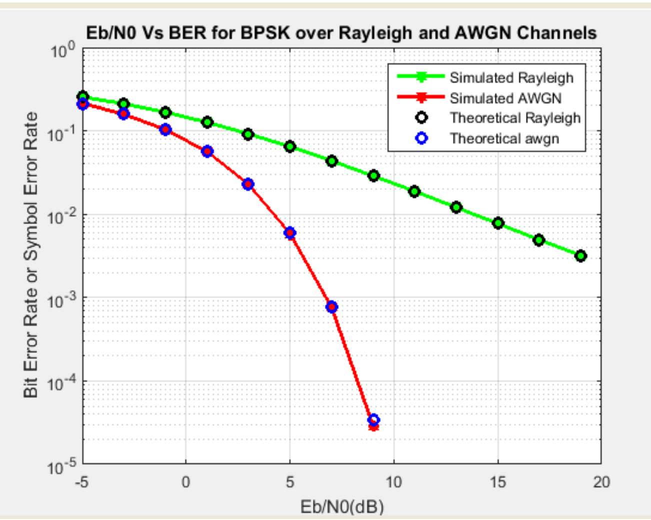

Fig -4: Comparative BER For BPSK OFDM

8. CONCLUSIONS

The presence of multipath in wireless OFDM transmission does not allow AWGN channel assumption due to fading. In this paper the performance of OFDM in AWGN wireless channel models is evaluated. In the OFDM systems with AWGN channel, there are wide difference gain from over 64 point at the higher values of SNR, where one can obtain more gains when the SNR increases. The SNR for each modulation takes into account the number of bits per symbol, and so the signal power corresponds to the energy per bit times the number of bits per symbol. The lower Doppler frequency as compared to its performance at the higher frequency. The performance will be reduced as the number of constellation mapping points increased from 8 to 64 point. The higher Eb/No required for transferring data means that more energy is required for each bit transfer. Based on convolution coding the cost/complexity may increase

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