Volume 4, Issue 3, March 2014 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Analyse the Performance of OFDM in Wireless Communication System

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***Abstract** — FDMA, TDMA and CDMA are the well known multiplexing techniques used in wireless communication systems. While working with the wireless systems using these techniques various problems encountered are (1) multi-path fading (2) time dispersion which lead to inter symbol interference (ISI) (3) lower bit rate capacity (4) requirement of larger transmit power for high bit rate and (5) less spectral efficiency. In a typical terrestrial broadcasting, the transmitted signal arrives at the receiver using various paths of different lengths. Since multiple versions of the signal interfere with each other, it becomes difficult to extract the original information. The use of orthogonal frequency division multiplexing (OFDM) technique provides better solution for the above mentioned problems. OFDM technique distributes the data over a large number of carriers that are spaced apart at precise frequencies. The benefits of OFDM are high spectral efficiency, resiliency of RF interference, and lower multi-path distortion. OFDM is a powerful modulation technique that is capable of high data rate and is able to eliminate ISI. The OFDM based wireless communication system design includes the design of OFDM transmitter, and OFDM receiver. Using MATLAB, simulation of OFDM was done with different modulation techniques using different transform techniques. The digital modulation schemes such as BPSK and QPSK were selected to assess the performance of the designed OFDM system*

***Key words:** OFDM, FDM, BPSK, QPSK.*

1. INTRODUCTION

In order to solve the bandwidth efficiency problem, orthogonal frequency division multiplexing was proposed, where the different carriers are orthogonal to each other. With OFDM, it is possible to have overlapping sub-channels in the frequency domain, thus increasing the transmission rate. This carrier spacing provides optimal spectral efficiency. Today, OFDM has grown to be the most popular communication system in high-speed communications. OFDM is becoming the chosen modulation technique for wireless communications [1]. OFDM can provide large data rates with sufficient robustness to radio channel impairments.

OFDM is a combination of modulation and multiplexing. Multiplexing generally refers to independent signals, those produced by different sources. In OFDM the question of multiplexing is applied to independent signals but these independent signals are a sub-set of the one main signal. In OFDM the signal itself is first split into independent channels, modulated by data and then re-multiplexed to create the OFDM carrier [1].

OFDM is a special case of Frequency Division Multiplex (FDM) [1]. In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-carriers are transmitted in parallel. These carriers divide the available transmission bandwidth. The separation of the sub-carriers is such that there is a very compact spectral utilization.

2. IMPORTANCE OF ORTHOGONALITY

The main concept in OFDM is orthogonality of the sub-carriers. The "orthogonal" part of the OFDM name indicates that there is a precise mathematical relationship between the frequencies of the carriers in the system. It is possible to arrange the carriers in an OFDM Signal so that the sidebands of the individual carriers overlap and the signals can still be received without adjacent carriers interference [8]. In order to do this the carriers must be mathematically orthogonal. The Carriers are linearly independent (i. e. orthogonal) if the carrier spacing is a multiple of $1/T_s$. Where, T_s is the symbol duration [6]. The orthogonality among the carriers can be maintained if the OFDM signal is defined by using Fourier transform procedures [5]. The OFDM system transmits a large number of narrowband carriers, which are closely spaced.

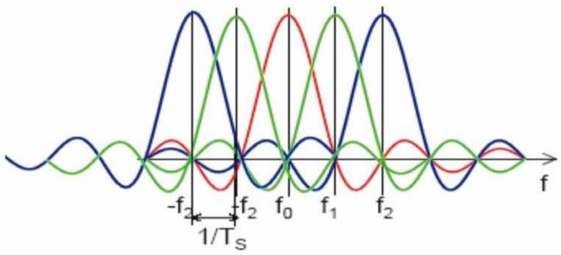

Fig 2.1 Example of OFDM spectrum for 5 orthogonal carriers

3. OFDM IS A SPECIAL CASE OF FDM

3.1 Frequency division multiplexing:

Each signal will occupy separate frequency band. To provide adjacent channel interference protection, signals are moved further apart. So here the spectrum is not used completely [7].

Fig. 3.1 Spectrum of FDM

3.2 OFDM frequency dividing:

Large number of orthogonal, overlapping, narrow band sub carriers is transmitted [3]. Since these carriers are orthogonal to each other, when added together, they do not interfere with each other. In FDM, we do not generally have frequencies that follow the above relationship [4]. Here spectrum is used almost twice. So there is a earn in spectral efficiency.

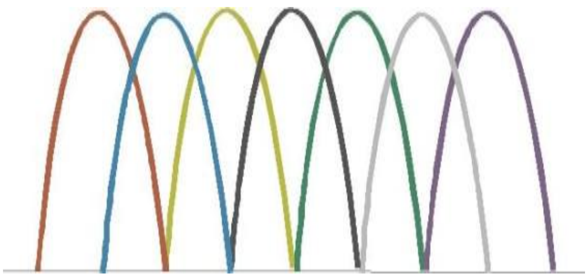

Fig.3.2 Spectrum of OFDM

4. OFDM SIMULATION AND RESULTS

4.1 OFDM SYSTEM SIMULATION WITH BPSK:

The bit error rate calculated by comparing the input data from a transmitter with input data from a receiver [1]. It calculates the bit error rate by dividing the total number of unequal pairs of data elements by the total number of input data elements from source.

4.1.1 Simulation Results for OFDM with BPSK:

No. of bits transmitted = 12000
No. carriers used = 6

Bits per each carrier = 2000

TABLE 4.1: BER results for OFDM model using BPSK modulation

SNR(dB)	BER(using BPSK)
0	0.0757
1	0.0564
2	0.0388
3	0.0215
4	0.0118
5	0.0057
6	0.0022
7	$8.3x\ 10^{-4}$
8	$2.5x\ 10^{-4}$
9	0

These are categorized as tabular results, and graphical results. Signal to Noise ratio (SNR) also called as E_b / N_o, where E_b is bit energy and No is noise energy. SNR values in dB are adjusted every time by adding noise in the AWGN channel. For particular SNR value system is simulated and corresponding probability of error (Bit Error Rate, BER) is calculated. These results are noted in Table 4.1. Figure 4.1 shows the nature of the BER versus SNR curve [2]. As we go on increasing the SNR value, bit error rate reduces.

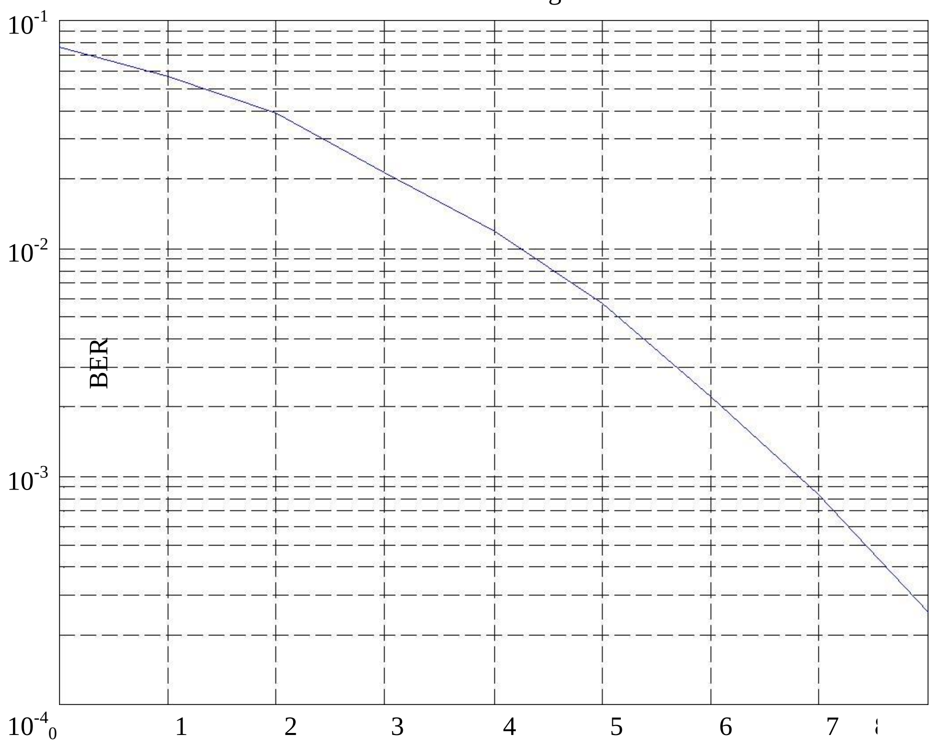

Fig 4.1 BER versus SNR curve for OFDM with BPSK

4.2 OFDM SYSTEM SIMULATION WITH QPSK:

Simulation of OFDM with QPSK modulation technique is similar to the simulation of OFDM with BPSK modulation [1]. The difference is that the BPSK modulator/demodulators are replaced by the QPSK modulator/demodulators. The QPSK modulator modulates using the quaternary phase shift keying method [5]. The output is a baseband representation of the modulated signal. The QPSK demodulator demodulates a signal that was modulated using the quaternary phase shift keying method.

4.2.1 Simulation Results for OFDM with QPSK:

The entire simulation process to be carried out is similar to that of OFDM with BPSK scheme. For particular SNR value system is simulated and corresponding probability of error (Bit Error Rate, BER) is calculated [2]. These results are noted in Table 4.2. Figure 4.2 shows the nature of the BER versus SNR curve. As we go on increasing the SNR value, bit error rate reduces.

No. of bits transmitted = 12000 No. carriers used = 6

Bits per each carrier = 2000

TABLE 4.2: BER results for OFDM model using QPSK modulation

SNR(dB)	BER(using QPSK)
0	0.2088
1	0.1802
2	0.1475
3	0.1125
4	0.0807
5	0.0554
6	0.0313
7	0.0172
8	0.0090
9	0.0035
10	0.0015
11	5.83×10^{-4}

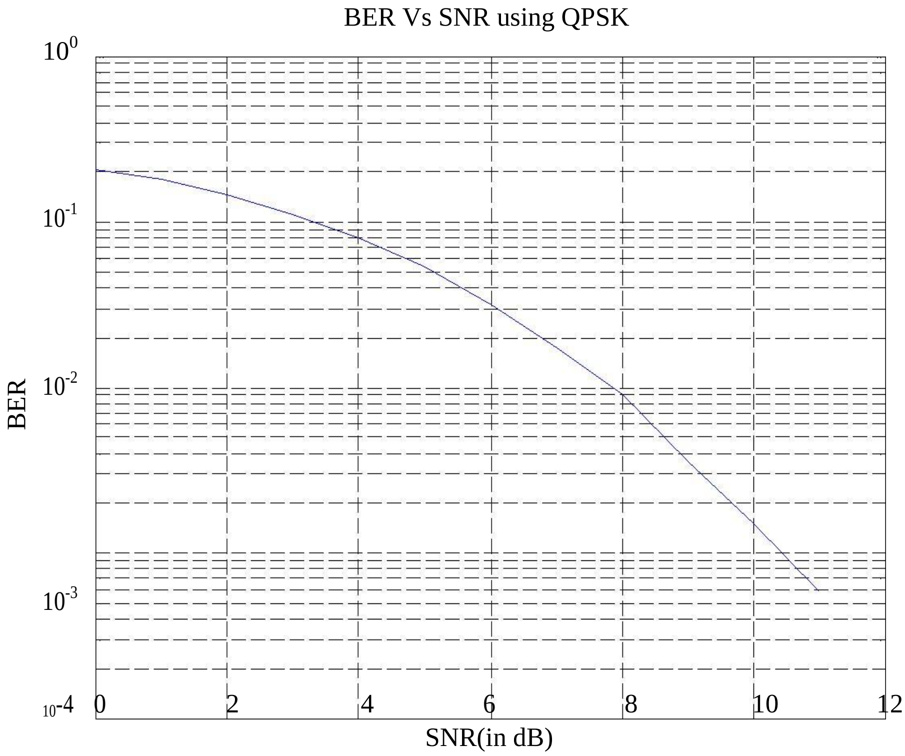

Fig 4.2 BER versus SNR curve for OFDM with BPSK

4.3 COMPARISONS OF OFDM SYSTEMS WITH QPSK AND BPSK

Figure 4.3 shows comparison of the BER versus SNR curves obtained in the OFDM systems with BPSK and QPSK modulation schemes [2]. It is clearly observed that the curve in latter system is always above the curve in the earlier system.

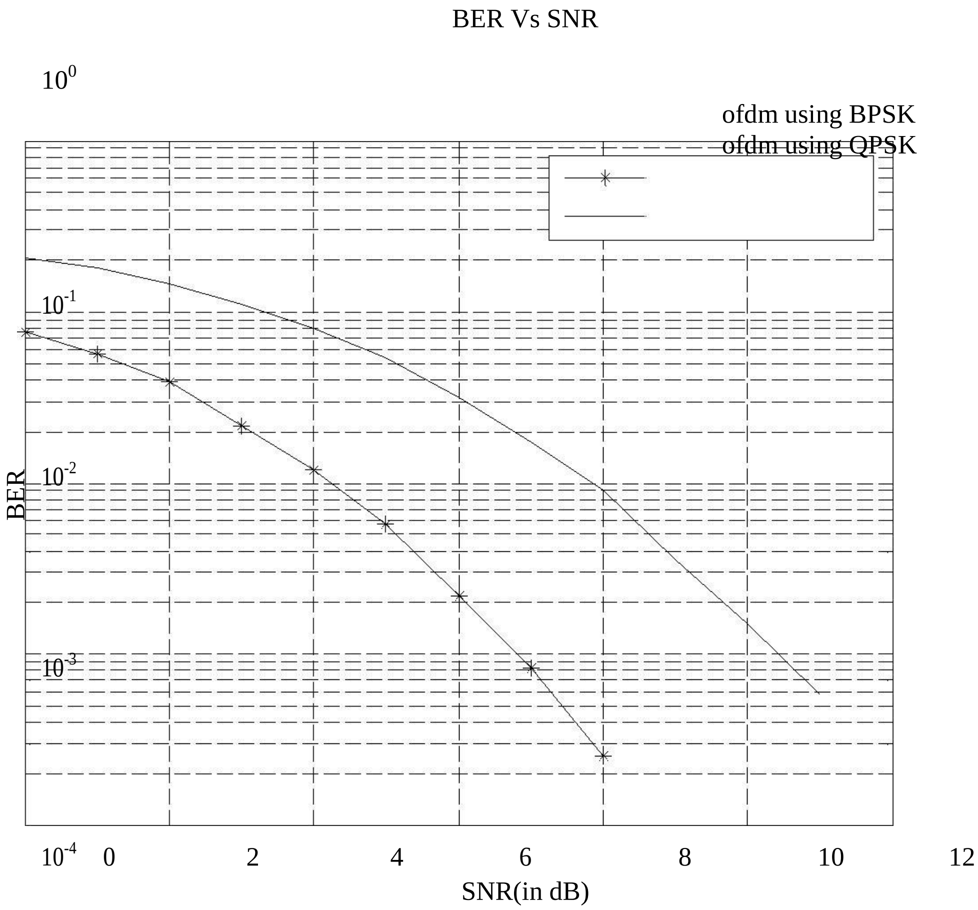

Fig 4.3 Comparison of BER versus SNR of Two Modulation Schemes

5. OFDM APPLICATIONS

OFDM is digital transmission technique developed into a popular scheme for wideband digital communication systems. It is well suited for wideband, high data rate transmissions. The main advantage is that less equalization is necessary. The OFDM use has increased greatly in the last 10 years. Nowadays, OFDM is mainly used for one to many (broadcast) communications like radio or television broadcasting. Examples are digital broadcasting systems such as DAB and DVB [6]. It is now proposed for Digital audio broadcasting such as in Eureka 147 standard and Digital Radio Mondiale (DRM). Digital Audio Broadcasting (DAB) is an international, standardized digital broadcasting system developed by the European EUREKA-147 Project [1].

OFDM is used for modem/ADSL application where it coexists with phone line. For ADSL use, the channel, the phone line, is filtered to provide a high SNR. OFDM here is called Discrete Multi Tone (DMT.) HDSL: High bit rate Digital Subscriber Line is another implementation for symmetric speeds (uplink rate = downlink rate).

HiperLAN2 is the all new high performance radio technology, specifically suited for operating in LAN environments. HiperLAN2 is a technology being developed within the European Telecommunications Standardisation Institute (ETSI). OFDM is the modulation used in the physical layer of HiperLAN2.

OFDM is also in use in wireless internet modem and this usage is called 802.1la.

6. CONCLUSION

The OFDM makes efficient use of available spectrum by allowing overlapping among the carriers. It basically converts the high data rate stream in to several parallel lower data rate streams and thereby eliminating the frequency selective fading. It has been seen that the OFDM is a powerful modulation technique that is capable of high data rate and is able to eliminate ISI. It is computationally efficient due to the use of FFT techniques to implement modulation and demodulation functions. Using MATLAB software, the performance of OFDM system was tested for two digital modulation techniques namely BPSK and QPSK. From the simulation results, it is observed that the BPSK allows the BER to be improved in a noisy channel at the cost of maximum data transmission capacity. Use of QPSK allows higher transmission capacity, but at the cost of slight increase in the probability of error. This is because of the fact that QPSK uses two bits per symbol. Hence QPSK is easily affected by the noise. Therefore OFDM with QPSK requires larger transmit power[1]. From the results, use of OFDM with QPSK is beneficial for short distance transmission link, whereas for long distance transmission link OFDM with BPSK will be preferable.

REFERENCES

1. L Hanzo, M Munster, B J Choi & T Keller, *OFDM and MC-CDMA for broadband multi-user Communications*, New York: IEEE press, 2000.
2. MATLAB 6.5 software, *Modeling tool for communication*, M/s The Mathworks Inc., USA.
3. Simon Haykin, *Digital Communications*, Wiley Publications Ltd, Singapore, 1988.
4. Taub & schilling, principles of communication systems, second edition, TATA McGraw- HILL Publications
5. John G.Proakis, Dimitris G.Manolakis, *Digital signal processing*, Principles, Algorithms, and Applications, Prentice- Hall publications
6. Wikipedia the Free encyclopedia: http://www.wikipedia.org/
7. Multiple-Access Techniques: www.wtec.org/loyola/wireless/02_04.htm
8. B. P. Lathi,"Modern Digital and Analog Communication Systems, Oxford University Press India.

