International Journal of Multidisciplinary and Current Research

Research Article

ISSN: 2321-3124
Available at: http://ijmcr.com

Performance Analysis of OFDM System with PSK Modulation over Rayleigh Fading Channel

Madhvi Jangalwa

Institute of Engineering & Technology Devi Ahilya University, Indore

Accepted 04 October 2013, Available online 18 October 2013, (**Sep/Oct 2013 issue**)

Abstract

Orthogonal Frequency Division Multiplexing (OFDM) is a special form of multicarrier transmission technique. OFDM mitigates Inter Symbol Interference (ISI) caused by delay spread of wireless channel. Also it offers high data rate, high Spectral Efficiency (SE), and immunity against Narrow Band Interference (NBI). Therefore it has been adopted in many wireless standards such as worldwide interoperability for microwave access (WiMAX) and Long Term Evolution (LTE). Spectral Efficiency (SE) is one of the major issues in wireless communication system. In wireless communication system SE depends on modulation technique. This study investigates the SE and Bit Error Rate (BER) performance of OFDM system over Rayleigh fading channel for different Phase Shift Keying (PSK) modulation techniques. Simulation results show that minimum SE obtained with the Binary Phase Shift Keying (BPSK) modulation technique at lower SNR. The comparative study of BER over different modulation techniques show that minimum BER can be achieved with the BPSK modulation technique.

Keywords: *Orthogonal Frequency Division Multiplexing (OFDM), Inter Symbol Interference (ISI), Spectral Efficiency (SE), Narrow Band Interference (NBI), WiMAX, Long Term Evolution (LTE), Bit Error Rate (BER), Rayleigh fading channel , Phase Shift Keying (PSK), Binary Phase Shift Keying (BPSK)*

1. Introduction

The next generation wireless communications systems demand higher data rates transmission in order to meet the high quality services. Research in wireless digital communications techniques have been growing very rapidly in the last few decades, resulting more reliable wireless communication systems that operate at higher spectral efficiency. Since there have been an increased in demand for higher data rate transmission, the systems are incorporating the multi-carrier transmission techniques. Therefore, OFDM is one of the efficient methods in wireless systems were presented by R. V. Van et al [1]. In [2] H. Prasad et al discussed that there is need to provide high spectral efficiency and high data rate in a mobile environment for new services like multimedia, internet, digital video broadcasting, wireless LANs (IEEE 802.11a, IEEE 802.11g). But the transmission of higher data rates makes a highly hostile radio channel. To combat the problem, the OFDM seems to be a solution. It is worth mentioning here that OFDM can be seen as either a modulation technique or a multiplexing technique. In OFDM the available spectrum divided into many overlapping carriers. These multicarriers should be orthogonal. By using overlapping multicarrier this technique can save almost fifty percent of bandwidth. OFDM is a special case of multicarrier transmission, where a single data stream is transmitted over a number of low data rate subcarriers [1,4]. This low symbol rate will decrease the effects of ISI and reduce the complexity of the receiver. One of the main reasons to use OFDM is to increase the robustness against frequency selective fading or narrowband interference. In single carrier system a single fade or interferer can cause the entire link to fail, but in multicarrier only a small percentage of the subcarriers will be affected [3-5].

Spectral efficiency and bit error rate of OFDM system over Rayleigh fading channel for different Phase Shift Keying (PSK) modulation techniques is investigated in this paper. Simulation results show that better spectral efficiency obtained with the Binary Phase Shift Keying (BPSK) modulation technique. The comparative study of BER over different modulation techniques show that minimum BER can be achieved with the lower modulation technique.

The rest of the paper is organized as follows: Section 2 describes the transmitter and receiver model for OFDM system. Performance results are shown in section 3 and conclusion is given in section 4.

2. System Model

System model is based on OFDM in which split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers. The relative amount of dispersion in time caused by multipath delay spread is decreased because the symbol duration increases for lower rate parallel subcarriers. Therefore it is used to enhance the data rate transmission between transmitter and receiver. OFDM transmitter and receiver are described in next section.

2.1 OFDM Transmitter

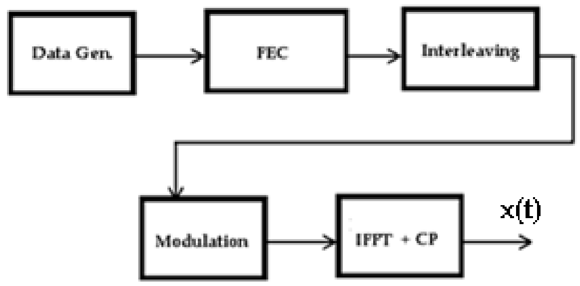

Fig.1 OFDM Transmitter Model

Fig-1 shows the simulation model of OFDM transmitter. Randomly generated data are fed to forward error correction (FEC) block where data are encoded by Reed Solomon and convolutional coding. FEC code has high gain and adopted in many wireless standards such as WCDMA and WiMAX. This coded data are interleaved and modulated. For modulation BPSK, QPSK and 16-PSK are used. The modulated output is transmitted simultaneously on N parallel subcarriers of bandwidth Δf. These parallel subcarriers are orthogonal to each other and can be generated by using Inverse Fast Fourier transform (IFFT). There after cyclic prefix is used as a guard interval to minimize the effect of inter carrier interference (ICI). Finally parallel to serial converter (P/S) converts parallel data into serial data stream and transmit over channel. Let us denote N frequency domain subcarrier as X = [X_0, X_1, X_2,…….., X_{N-1}]. In time domain operation x = [x_0, x_1, ………., x_{N-1}]. Thus the sampled transmitted sequence is given by

$$x[n] = \frac{1}{N}\sum_{k=0}^{N-1} X[k]e^{\frac{j2\pi kn}{N}} \quad , \quad 0 \le n \le N \qquad (1)$$

2.2 OFDM Receiver

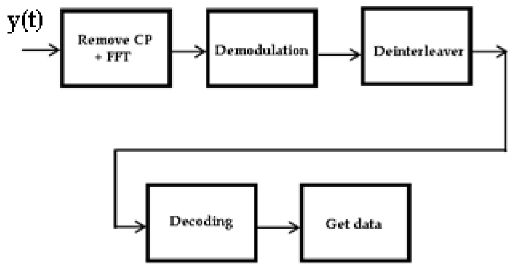

Fig.2 OFDM Receiver Model

Receiver model of OFDM is shown in Fig-2. From serial to parallel converter (S/P) received signal converts serial data into parallel. Cyclic prefix is removed from parallel converted data and then multicarrier demodulation is performed. These data are demodulated. The output of demodulator passes through the channel decoder to obtain the users data. The received signal is given by

$$y[n] = \sum_{k=0}^{N-1} Y[k]e^{\frac{j2\pi kn}{N}} \quad , \quad 0 \le n \le N \qquad (2)$$

Where *y[n]* is the sampled received signal and *Y[k]* is the received complex modulation symbol of the *kth* subcarrier. The received symbol after multicarrier demodulation is

$$Y[k] = H[k]X[k] + \eta \qquad (3)$$

Where *H[k]* is the transfer function of the channel and η is additive noise of the channel.

The spectral efficiency is presented in several ways in the literature. The spectral efficiency of a channel is a measure of the number of bits per second per Hz. We derived the spectral efficiency using the relation [5]:

$$\eta_s = (1 - P_e)^l kr \qquad (4)$$

Where, P_e is the bit error rate, l is the number of bits in the block, k *is* the number of bits per symbol and r the overall coding rate.

3. Simulation Results

Physical layer of mobile WiMAX is simulated using OFDM. Each block of OFDM transmitter and receiver is individually coded in MATLAB. The OFDM simulation parameters are given in Table 1. The system used for simulation employs RS and convolution channel coding. In channel coding rate is taken as ½, and ¾. For simulation the Rayleigh fading channel is used.

Table 1 OFDM parameters of fixed WiMAX

S.No	Parameters	Values
1	FFT size	256
2	Number of used data subcarrier	192
3	Number of pilot subcarrier	8
4	Number of null/guardband subcarrier	56
5	Cyclic prefix	1/4
6	Coding rate	½, ¾

Fig-3 shows spectral efficiency of OFDM system for BPSK and QPSK modulation respectively. In figure it is observed that better spectral efficiency obtained with the Binary Phase Shift Keying (BPSK) modulation technique. Also lower coding rate has better spectral efficiency than the higher coding rate at lower SNR.

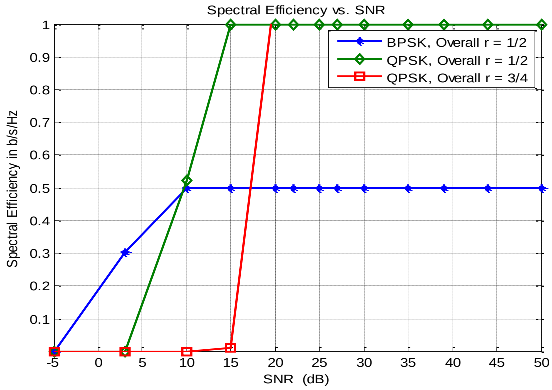

Fig.3 SE versus SNR at different modulation technique and overall rate r = ½, ¾

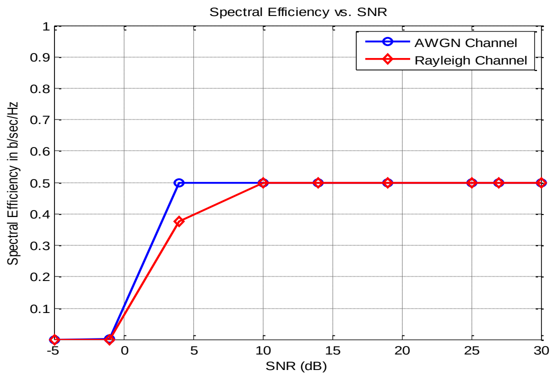

Fig.4 SE versus SNR for BPSK modulation and overall rate r = ½

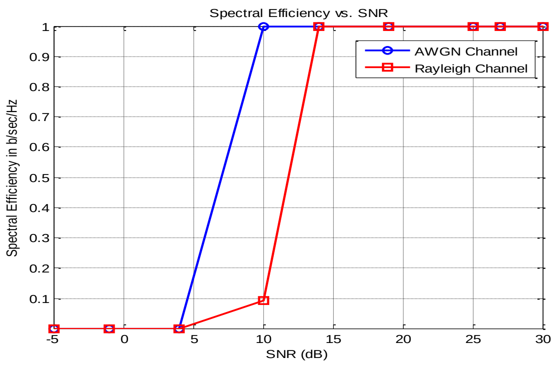

Fig.5 SE versus SNR for QPSK modulation and overall rate r = ½

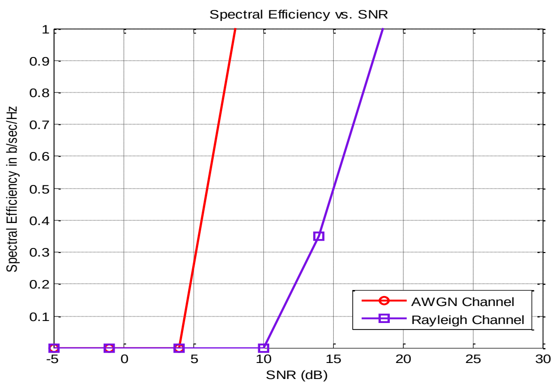

Fig.6 SE versus SNR for QPSK modulation and overall rate r = ¾

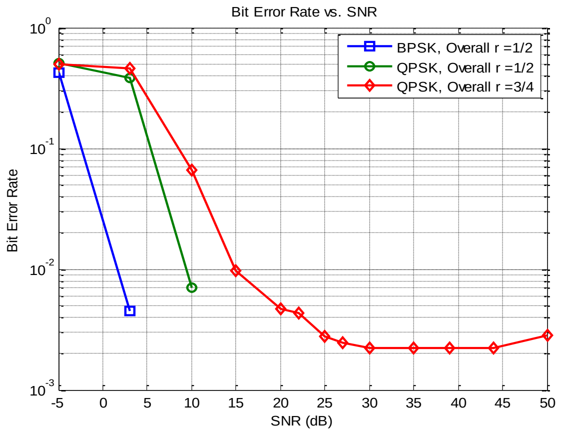

Fig.7 BER versus SNR at different PSK modulation and overall rate r = ½, ¾

Spectral efficiency of OFDM system for AWGN channel and Rayleigh channel is compared in Fig-4, 5 and 6 for different modulation techniques. From results it is clear that with AWGN channel spectral efficiency is better than the Rayleigh channel at lower SNR.

In Fig-7 a comparison of BER performance is made among the different modulation techniques. Coding rates for QPSK are taken as ½ and ¾. For BPSK and QPSK BER is decreasing with channel SNR. Among all these modulation techniques with BPSK improved BER performance is obtained. Performance of QPSK with ½ coding rate is better than the ¾ coding rate.

4. Conclusions

In this paper we described the OFDM system over Rayleigh fading channel. From simulation results it is observed that better spectral efficiency obtained with the Binary Phase Shift Keying (BPSK) modulation technique.

The comparative study of BER over different modulation techniques show that minimum BER can be achieved with the lower modulation technique. Coding rate also affects the BER performance. Less coding rate gives less bit error rate than high coding rate.

References

[1]. R. V. Nee and R. Prasad, (2000), OFDM Wireless Multimedia Communications, Artech House Publishers.

[2]. S. Hara and R. Prasad, (1997), Overview of Multicarrier CDMA, IEEE Communications Magazine, vol. 35, pp. 126–133.

[3]. T. Hwang, C. Yang, G. Wu, S. Li and G. Y. Li., (2009), OFDM and Its Wireless Applications: A Survey, IEEE Transactions on Vehicular Technology, vol.58, no.4, pp. 1673–1694.

[4]. S. Shrikanth, P. A. M. Pandiyan and X. Farnando, (2012), Orthogonal Frequency Division Multiple Access in WiMAX and LTE: A Comparison, IEEE Communication Magazine, pp. 153-161.

[5]. S. Catreux, V. Erceg, D. Gesbert, and R. Heath, (2002), Adaptive Modulation and MIMO Coding for Broadband Wireless Data Networks," IEEE Communications Magazine, pp.108-115.