Performance Analysis Of OFDM Using QPSK And 16 QAM

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Abstract

OFDM stands for Orthogonal Frequency Division Multiplexing. In this paper performance analysis of OFDM system using QPSK and 16 QAM has been reported. BER v/s SNR curves are simulated to analyse the performance.

Index Terms – OFDM, QPSK, 16 QAM.

1. Introduction

Orthogonal frequency division multiplexing (OFDM) is a modulation scheme that is especially suited for high-data-rate transmission in delay-dispersive environments. It converts a high-rate datastream into a number of low-rate streams that are transmitted over parallel, narrowband channels that can be easily equalized. OFDM splits the information into N parallel streams, which are then transmitted by modulating N distinct carriers (henceforth called subcarriers or tones). Symbol duration on each subcarrier thus becomes larger by a factor of N. In order for the receiver to be able to separate signals carried by different subcarriers they have to be orthogonal [1]. OFDM is special case of modulation and multiplexing [2]. Wireless telecommunications is the transfer of information between two or more points that are not physically connected [3]. Now in the today's modern day world there are lot of problems and different kinds of challenges in the telecommunication industry related to the limited spectral width available. This problem is intelligently handled by the experts by utilizing OFDM for data transmission and data reception. OFDM handles the traffic more effectively than other techniques available in the market as OFDM utilizes the available bandwidth by splitting into several narrow band channels for parallel and simultaneous transmission of data [4]. In the OFDM system the data to be transmitted is assigned to the different individual carriers. The required phase and amplitude of the carrier is calculated based upon the modulation scheme (like QPSK, 16 QAM etc.) for example if we are required to transmit 4 bit data then we have to choose 4 different carrier signals which are orthogonal to each other. Each carrier is assigned to a different bit and its phase and amplitude are chosen according to modulation scheme used in different cases. QPSK is one of most popular linear modulation technique. A QPSK signal can be depicted using two dimensional constellation diagram with four points [5].

2. OFDM System Model

The OFDM system model represents the different major blocks which are required for the data transmission and reception using OFDM. We have used the QPSK and 16 QAM modulation techniques in this model and analysed their performance.

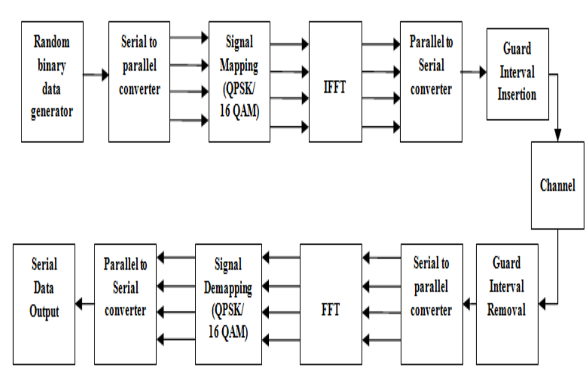

Figure 1: OFDM System model for Transmission and Reception of Data.

2.1. Random binary data generator

Simulations of many physical processes and engineering applications frequently require using a number (or a set of numbers) that has a random value. MATLAB® software has commands like rand, randint, randn etc. that can be used to assign random numbers to variables [6]. In MATLAB®SIMULINK® software there is Bernoulli random binary generator block which is used to generate random binary numbers. In this model the random binary data generator generates random binary data.

2.2. Transmitter

It consists of serial to parallel converter block, signal mapping block, IFFT block, parallel to serial converter block, guard interval insertion block.

2.2.1. Serial to Parallel Converter. In this block serial data is available as input which is formatted into the word size required for transmission, for example 2 bit/word for QPSK and 4 bit/word for 16 QAM and then shifted into a parallel format. The data is then transmitted in parallel by assigning each data word to one carrier in the transmission [7, 8]. In this way the serial to parallel converter converts the serial data stream into parallel data stream.

2.2.2. Data Modulation. Data is modulated before transmission. This is done by signal mapping block. The data which is to be transmitted on each different carrier is differentially encoded with the previous symbols and then it is mapped into a phase shift keying format, which can be either QPSK or 16 QAM in this case. Differential encoding requires an initial phase reference so an extra symbol is added at the beginning for this requirement. After that the data on each symbol is mapped to a phase angle based on the modulation method. For example for QPSK the phase angles which are used are 0, 90,180 and 270 degrees. Constant amplitude signal is generated by using phase shift keying; it also reduces problems regarding amplitude fluctuations due to fading of the signal [7, 8].

2.2.3. Inverse Fast Fourier transform (IFFT). This Block calculates the inverse fast fourier transform of length M input where M must be a power of two. When other input sizes are considered for work the zero pad blocks are utilized to pad or to truncate the length so that it will be of size M. The output obtained is always frame based. The frequency domain data is converted into time domain signal by the IFFT and it also maintains the orthogonality among the carriers.

2.2.4. Guard Interval Insertion. OFDM has sufficient high level of immunity against multipath delay spread of the signal. To make OFDM system more immune to multi path delay spread guard period/interval is inserted between transmitted symbols. Guard period is added to the start of each symbol. Due to the guard period insertion the multipath signals from the previous symbol die away before the information from the current symbol is obtained. Due to the guard interval/period insertion the symbols are converted into a serial time waveform. This is called the baseband signal for the OFDM data transmission process.

2.3. Channel

Channel consists of a channel model to which transmitted signal is applied. This channel model consists of Multipath Rayleigh fading channel block and AWGN channel block. Multipath fading Delay Spread can be added by adding Multipath Rayleigh fading channel. Signal to noise ratio is set to the signal by adding a known amount of white Gaussian noise to the signal, this is done by using AWGN channel block [7, 8].

2.4. Receiver

It consists of guard interval removal block, serial to parallel block, FFT block, signal demapping block, parallel to serial block. The different blocks of the receiver perform the opposite operation as compared to the transmitter blocks. The guard interval/period is removed. The FFT of each symbol is utilized to find the original transmitted signal spectrum. The phase angle of each transmitted carrier is evaluated and converted back to the data word by demodulating the received phase, this is done by signal demapping block. The data words are combined back to the same word size as the original data was transmitted [7, 8].

3. OFDM System performance using QPSK and 16 QAM

The performance of OFDM system using QPSK and 16 QAM can be compared by using the simulation results shown in this section.

3.1. Parameters Used

The different major parameters used and their values are given in this section.

PARAMETER	VALUE
Symbol Length	1280
IFFT Size	128
Used carrier number/Used subcarriers in one OFDM symbol	128
OFDM Symbols per frame	10
Modulation	QPSK,16 QAM

Table 1: OFDM system parameters for simulation.

3.2. Simulation Results

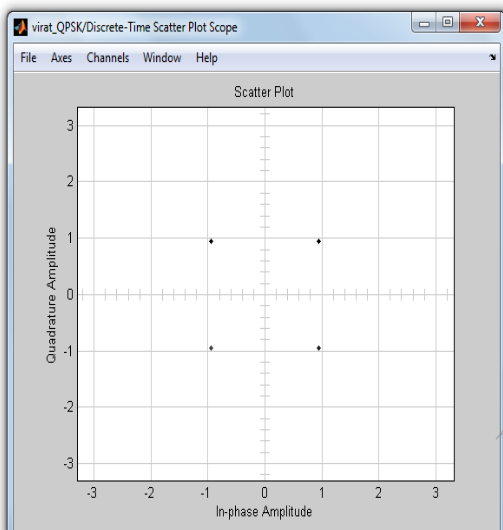

Figure 2: QPSK constellation after QPSK Mapping.

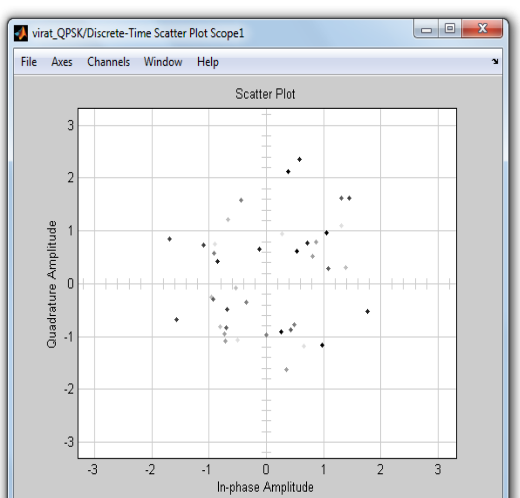

Figure 3: QPSK constellation before QPSK demapping.

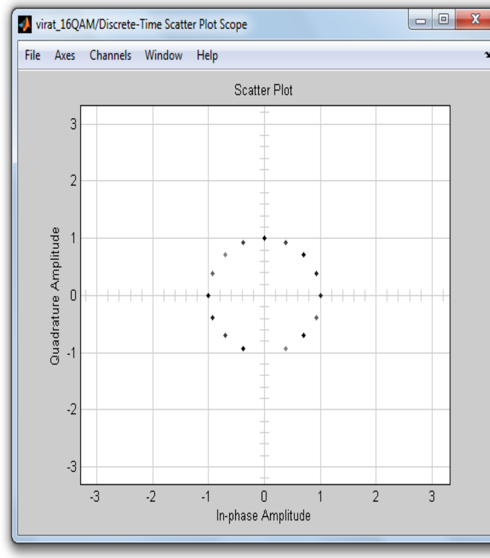

Figure 4: 16 QAM Constellation peak symbol power after 16 QAM Mapping.

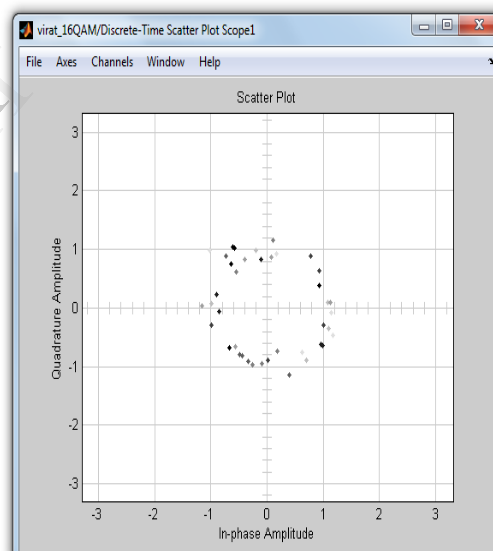

Figure 5: 16 QAM Constellation peak symbol power before 16 QAM Demapping.

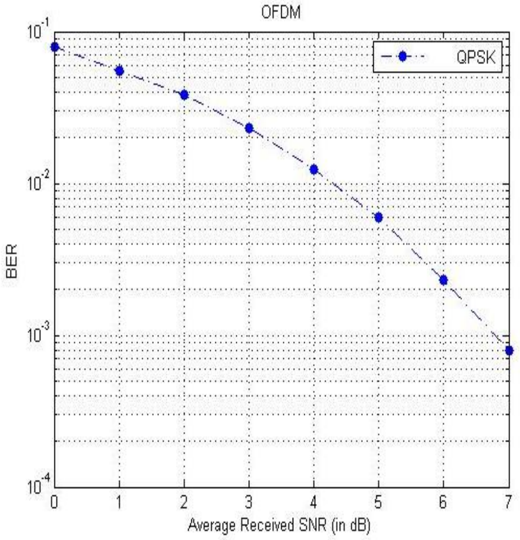

Figure 6: BER v/s SNR curve of OFDM using QPSK.

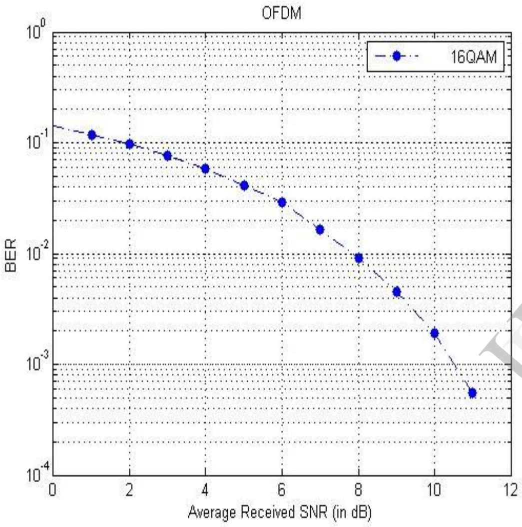

Figure 7: BER v/s SNR curve of OFDM using 16 QAM.

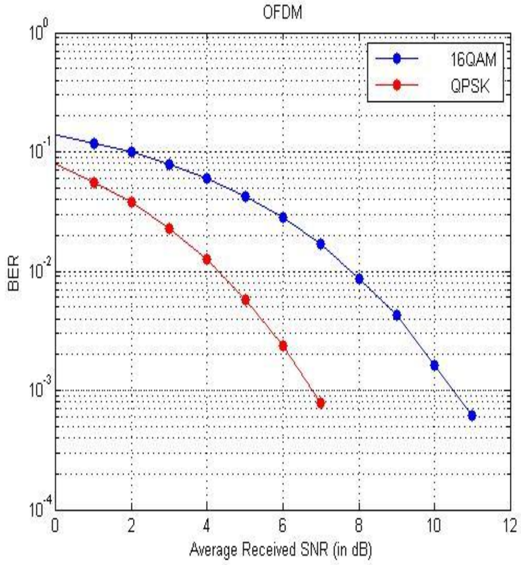

Figure 8: BER v/s SNR comparison curve of OFDM using QPSK and 16QAM.

4. Conclusion

From the above simulations of QPSK Constellation after QPSK mapping and QPSK constellation before QPSK demapping (figures 2, 3) and 16 QAM Constellation peak symbol power after 16 QAM mapping and 16 QAM Constellation peak symbol power before 16 QAM demapping (figures 4, 5) we analyzed that the noise randomly mixes with the transmitted signal somewhere in the transmission path which has affected the constellation of QPSK and 16 QAM in figures 3 and 5 but the received signal phase and amplitude did not change very much with respect to the transmitted signal. From simulation results obtained in figures 6, 7 and 8 we can say that QPSK conveys 2 bits per symbol while on the other hand 16 QAM conveys 4 bits per symbol. Thus the number of bits per symbol carried by 16 QAM is twice more than that carried by QPSK. When we consider the BER, the performance of QPSK is better than 16 QAM because the BER values with respect to the Average received SNR (in dB) in case of QPSK are lower than the values obtained in the case of 16 QAM. The spectral width of 16 QAM is more than that of QPSK; therefore 16 QAM can carry more traffic as compared to QPSK but at the expense of BER. So finally it can be concluded that QPSK has better BER performance than that of 16 QAM but at the expense of spectral width.

5. References

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