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Image Transmission through OFDM System under the Influence of AWGN Channel

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Abstract: OFDM system is one among the modern techniques which is most abundantly used in next generation wireless communication networks for transmitting many forms of digital data in efficient manner than compared with other existing traditional techniques. In this paper, one such kind of a digital data corresponding to a two dimensional (2D) gray-scale image is used to evaluate the functionality and overall performance of an OFDM system under the influence of modeled AWGN channel in MATLAB simulation environment. Within the OFDM system, different configurations of notable modulation techniques such as M-PSK and M-QAM are considered for evaluation of the system and necessary valid conclusions are made from the comparison of several observed MATLAB simulation results.

Keywords: AWGN, OFDM, BPSK, QPSK, M-PSK, M-QAM

I. INTRODUCTION

In a communication system, in order to make use of the channel capacity, it is desirable to transmit more than one signal on the same transmission media. This is possible to process called multiplexing. The field of electronics can be classified in to three major classes: Computers, communications and control .The computer field is the youngest of three, while communications industry is the oldest, since electronics really started with radio communication. Orthogonal Frequency Division Multiplexing (OFDM) is a key wireless broad band technology, it support large bandwidth and data rate is very high.

In single carrier communication system, the symbol period must be much greater than the delay time in order to avoid inter symbol interference (ISI).Since data rate is inversely proportional to symbol period, having long symbol periods means low data rate and communication in efficiency [1].OFDM is used to divide the transmission channel into a number of sub channel, can get high bit rate and good spectrum efficiently [2].

In this paper is discussed as follows: OFDM modulation schemes are discussed in section II, Gray scale image in section III, Results and Discussion in section IV and Conclusion in section V.

II.OFDM

In wireless communication system Orthogonal Frequency Division Multiplexing (OFDM) is a new modulation system for its several advantages and it is as shown in fig.1. In multi carrier communication system, transmit more than signals at same time through separate channels at lower data rate or sub carriers. In single carrier communication system transmit more than one signal through same transmission media, are interfere each other, but in multi carrier system due to sub carriers the signals are do not interfere with other, and from each sub carriers the transmitted signals are recovered[1].In single carrier transmission the symbol rate of ‘Ts’ symbols per second, the band width required this is equal to twice the nyquist rate To transmit higher data rate in single carrier transmission, it required wider bandwidth. However, as the symbol rate increases, the signal bandwidth becomes larger. In wireless channel the signal bandwidth is larger than the coherence bandwidth, the link suffer from multipath fading, occurring the Inter symbol interference (ISI) [3][4].

OFDM is a parallel transmission scheme, where a high-rate serial data stream is split up into a set of low-rate sub streams, each of which is modulated on a Separate SC (FDM). Thereby, the bandwidth of the SCs becomes small compared with the coherence bandwidth of the channel; that is, the individual SCs Experience flat fading, which allows for simple equalization. This implies that the symbol period of the sub streams is made long compared to the delay spread of the time-dispersive radio channels [5]-[14].

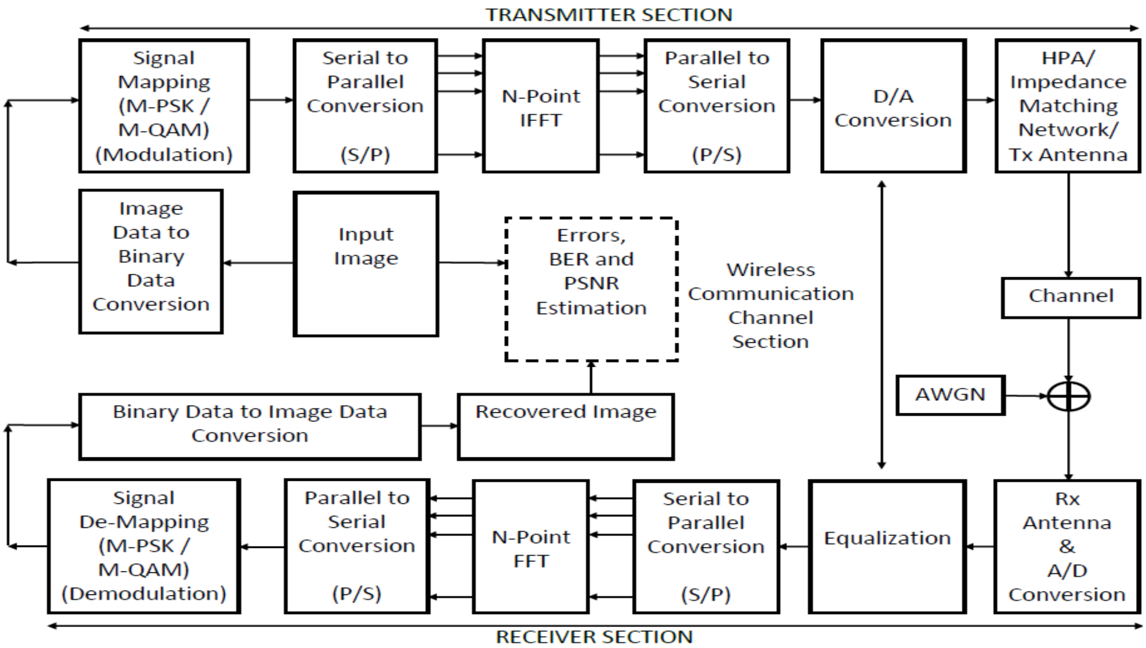

Fig. 1 Block Diagram of OFDM system

III.GRAY SCALE IMAGE

The Test Image chosen for the evalation of OFDM System for Image Transmission is shown in Fig. 2. This is one of the default image which is available within the MATLAB Database and most widely used by researchers worldwide. It can be accessed by name ‘Casino’. This

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image is available in .JPG format having size as 1024 X 1024. So the total number of pixels are 10,48,576. Each pixel value is represented in unsigned integer format of 8-bits (uint-8). Initially this image is not in a suitbale form for direct transmission through OFDM system. For transmitting this image which is availabe in matrix or two dimensional signal, we need to do some pre-processing for converting this 2D image into 1D signal.

Read the image which is available by default in 1024 x 1024 size and represented in uint8 format. Convert it into double format and reshape the data to change from matix represenion of 1024 x 1024 into vector representation of 1 x 1048576. Now we succcessfully converted 2D signal to 1D signal. This signal is now partially ready for transmission purpose. In the final step, depending upon the modulation technique used, we need to convert the vector data into suitable form. For example, if we use BPSK modulation, then we need to convert the vector data into binary data (two signalling elements i.e. 0s and 1s). For QPSK modulation, we need to convert the vector data into binary data (four signalling elements i.e. 00, 01, 10 and 11 ≈ 0, 1, 2 and 3 respectively).

Fig. 2 Casino Test Image

This data is used as source data or input image signal for the OFDM transmitter. At the receiver, after recovering the digital bits, the original image can be reconstructed by performing inverse operations corresponding to the operations as discussed in the above mentioned algorithm. The source data which is in serial form is converted to parallel form by S/P so as to assign the data onto multiple sub-carriers and modulated by any of the M-PSK or M-QAM Technique. After modulation, IFFT operation is performed and finally the signal is converted from parallel form to serial form by using P/S for transmission purpose. At the receiver corresponding inverse operations are performed so as to efficiently recover the transmitted image. Table I. shows the characteristics of the source signal. Table II, shows the properties and corresponding values which are considered in MATLAB simulation.

Table: I Characteristics of Cameraman Test Image

Property	Value
Original Image Size	1024 x 1024
Total Pixels	1048576
Each Pixel Data Size	8-bits
For BPSK Transmission Size of Source Signal Data or Signal Elements	1048576*8 = 8388608
For QPSK Transmission Size of Source Signal Data or Signal Elements	8388608/2 = 4194304
For 16-PSK / QAM Transmission Size of Source Signal Data or Signal Elements	8388608/4 = 2097152
For 256-PSK / QAM Transmission Size of Source Signal Data or Signal Elements	8388608/8 = 1048576

Table: II MATLAB Simulation Parameters

Property	Value
Total Number of Sub-Carriers & FFT Size	512
Type of Guard Interval inserted after IFFT at Transmitter	Cyclic Prefix
Modulation Schemes	QPSK, 4-QAM,16-PSK, 16-QAM
Channel	AWGN
Range of SNR in dB considered for evaluating BER	0 dB – 30 dB

IV. Results and Discussion

The comparison of recovered images at three different SNRs i.e. 0 dB, 15dB and 30 dB respectively corresponding to different modulation techniques as shown in Table. III. The signal constellation diagrams for 16-PSK and 16-QAM both at transmitter and at receiver as shown in Fig. 3, and Fig. 4. The performance of OFDM system in terms of total errors and achieved BER at different SNRs corresponding to different modulation schemes are shown in Table III.

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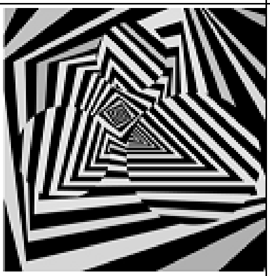
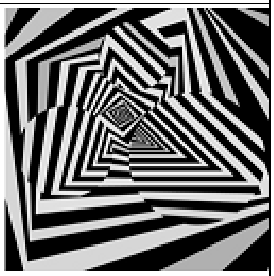
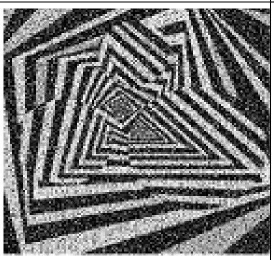
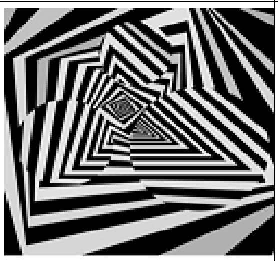
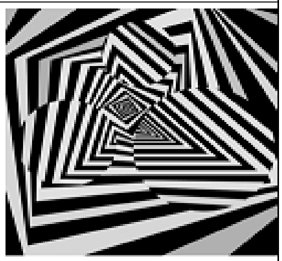
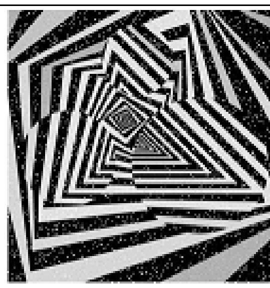
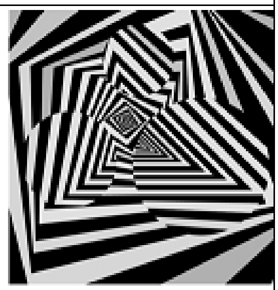
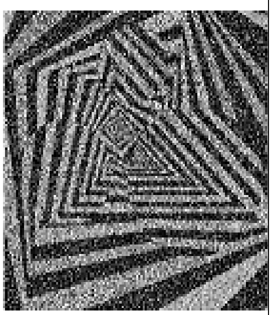
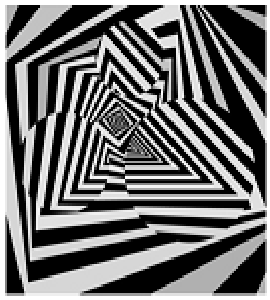
Table: III Comparison of Recovered Images at the OFDM Receiver

MODULATION TECHNIQUE	**SNR=0**	**SNR=15**	**SNR=30**
QPSK			
4-QAM			
16-PSK			
16-QAM			

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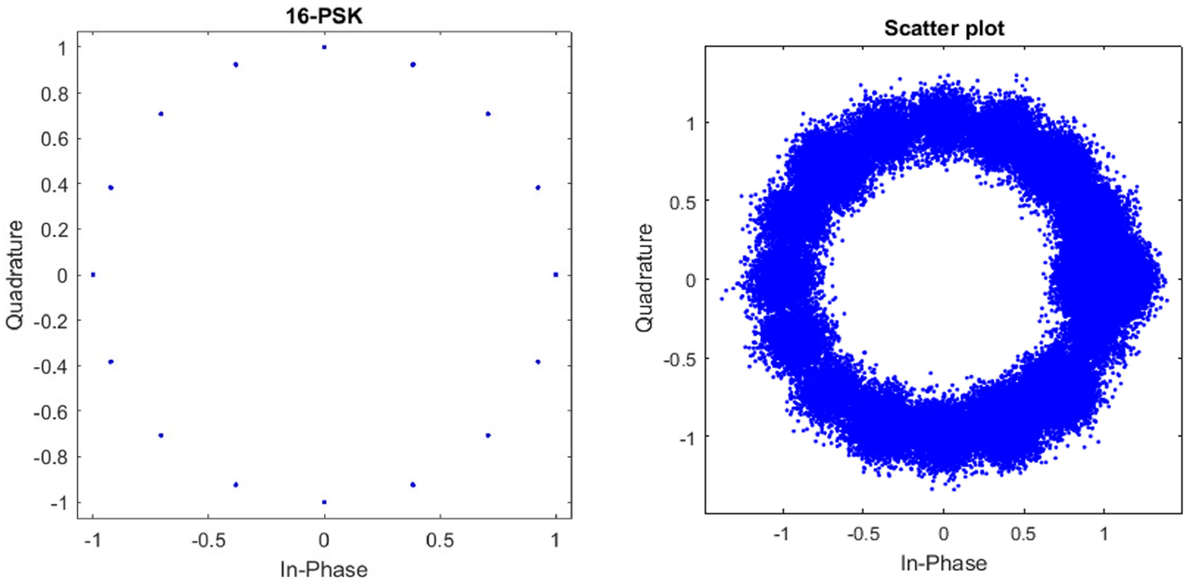

Fig. 3. Constellation Diagrams for 16-PSK at Transmitter (After Modulation) and at Receiver (Before Demodulation at SNR=17dB)

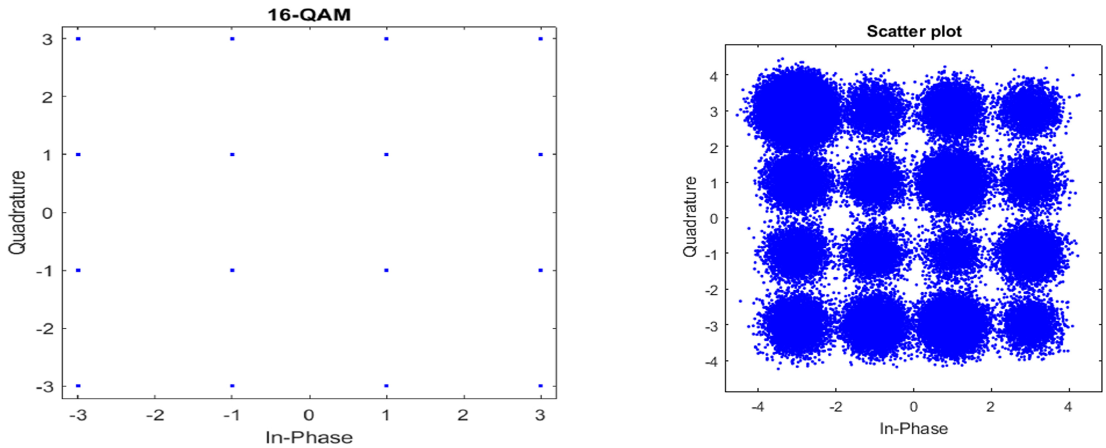

Fig. 4. Constellation Diagrams for 16-QAM at Transmitter (After Modulation) and at Receive

(Before Demodulation at SNR=17dB)

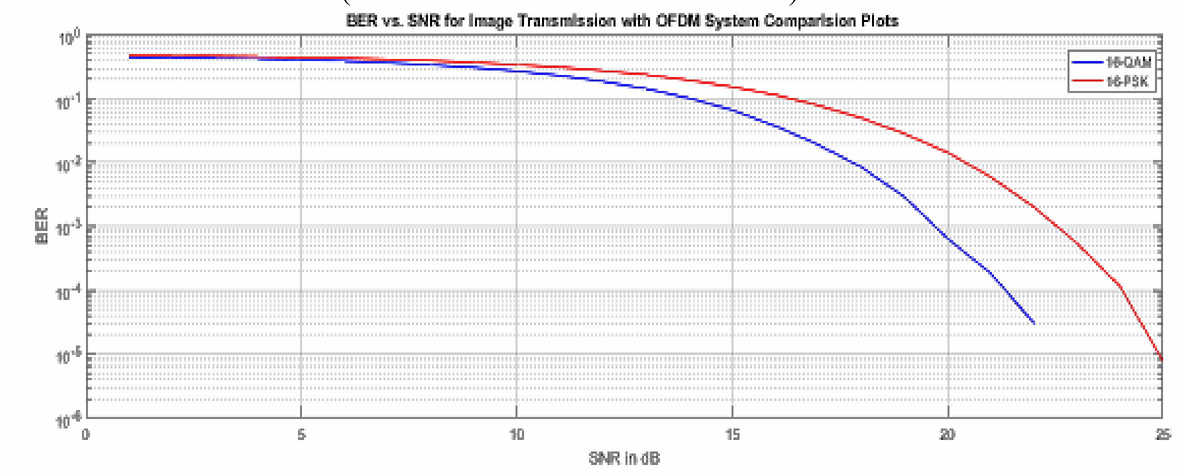

Fig. 5. BER vs. SNR Curve Comparison for 16-PSK and 16-QAM

IV.Comparision Table for 16-PSK &16-QAM

S.NO	Total Pixels in Image	SNR(dB)	Number Of Errors		BER	
			16-PSK	16-QAM	16-PSK	16-QAM
1	1048576	2	121114	119293	0.4827	0.4673
2	1048576	4	115782	113676	0.4685	0.4543
3	1048576	6	105090	100290	0.4357	0.4041
4	1048576	8	96523	84572	0.4196	0.3927
5	1048576	10	81594	72924	0.3867	0.3785
6	1048576	12	68300	41029	0.3690	0.3360
7	1048576	14	35610	30624	0.3264	0.2918
8	1048576	16	23810	7589	0.2873	0.2491
9	1048576	18	13754	1205	0.2367	0.2051
10	1048576	20	3248	687	0.1842	0.1075
11	1048576	22	572	41	0.0946	3.0835e-06
12	1048576	24	84	0	0.0064	0
13	1048576	26	1	0	9.0649e-06	0

Fig. 5 shows the comparison of BER vs. SNR curve comparisons for 16-PSK and 16-QAM respectively.

V. CONCLUSION

The OFDM system has been implemented with different modulation techniques for Image Transmission through AWGN channel. The quality of the recovered image is better at reasonably high SNR values irrespective of the modulation technique used. At low SNR, the quality of the recovered image is very less due to the presence of high amount of AWGN noise. It is found that the OFDM system with 16-QAM modulation technique provides less number of errors, less BER, and high quality of the recovered image at the receiver than compared with the OFDM systems implemented with rest of the techniques.

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