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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-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.

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II.OFDM:

In wireless communication system Orthogonal Frequency Division Multiplexing (OFDM)[11] 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].

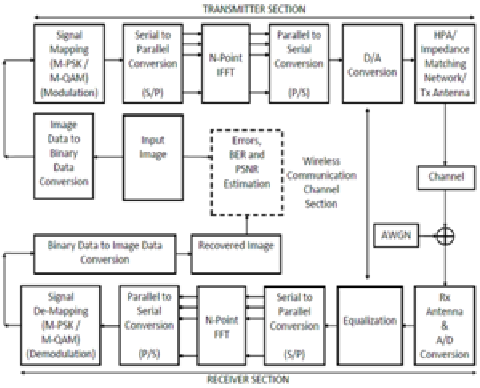

Fig. 1 Block Diagram of OFDM system

III.GRAY SCALE IMAGE:

The Test Image chosen for the evaluation of OFDM[7][8] System for Image Transmission[12][13][14] is shown in Fig. 2. This is one of the default images which is available within the MATLAB Database and most widely used by researchers worldwide. It can be accessed by name 'Cameraman', 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 suitable form for direct transmission through OFDM system. For transmitting this image which is available in matrix or two dimensional signals, 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 sizes and represented in uint8 format. Convert it into double format and reshape the data to change from matrix representation of 1024x 1024 into vector representation of 1 x 1048576. Now we successfully 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 signaling elements i.e. 0s and 1s). For QPSK modulation, we need to convert the vector data into binary data (four signaling elements i.e. 00, 01, 10 and 11 0, 1, 2 and 3 respectively).

Fig.2 Cameraman Test Image

This data is used as source data or input image signal for the OFDM transmitter.

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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	BPSK,QPSK, 16—QAM, 64-QAM
Channel	AWGN
Range of SNR in dB considered for evaluating BER	0-40dB

IV.AWGN:

Additive white Gaussian noise (**AWGN**)[6] is a basic noise model used in Information theory to mimic the effect of many random processes that occur in nature.

The modifiers denote specific characteristics:

- **Additive** because it is added to any noise that might be intrinsic to the information system.
- **White** refers to the idea that it has uniform power across the frequency band for the information system. It is an analogy to the color white which has uniform emissions at all frequencies in the visible spectrum.
- **Gaussian** because it has a normal distribution in the time domain with an average time domain value of zero.

Wideband noise comes from many natural sources, such as the thermal vibrations of atoms in conductors (referred to as thermal noise, shot noise, black body radiation from the earth and other warm objects, and from celestial sources such as the Sun. The central limit theorem of probability theory indicates that the summation of many random processes will tend to have distribution called Gaussian or Normal. AWGN is often used as a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral

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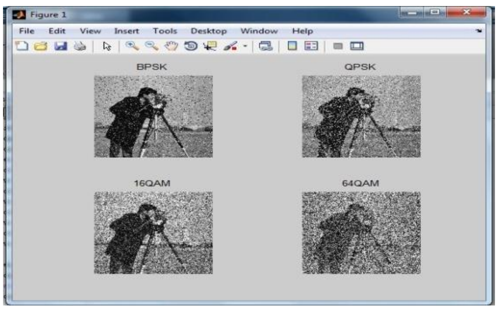
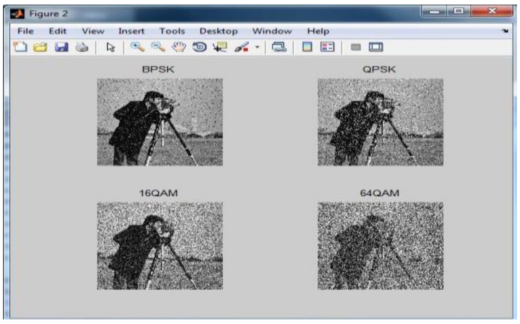
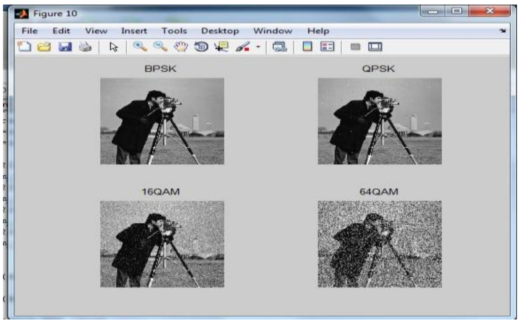
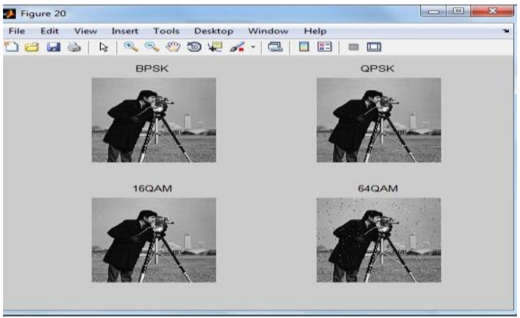
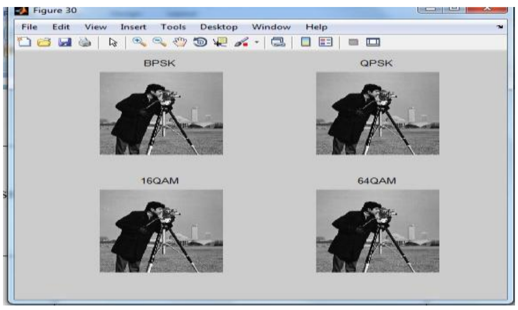
density and a Gaussian distribution of amplitude. The model does not account for fading, frequency selectivity, interference, nonlinearity or dispersion. However, it produces simple and tractable mathematical models which are useful for gaining insight into the underlying behavior of a system before these other phenomena are considered. The AWGN channel is a good model for many satellite and deep space communication links. It is not a good model for most terrestrial links because of multipath, terrain blocking, interference, etc. However, for terrestrial path modeling, AWGN is commonly used to simulate background noise of the channel under study, in addition to multipath, terrain blocking, interference, ground clutter and self interference that modern radio systems encounter in terrestrial operation.

V. RESULTS AND DISCUSSION:

The comparison of recovered images at different SNRs i.e. 0 dB to 40dB respectively is 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[10] at different SNRs corresponding to different modulation schemes are shown in Table III.

Table: III Comparison of Recovered Images at the OFDM Receiver

<table>
<tr><th>SNR In dB</th><th>RECOVERED IMAGES</th></tr>
<tr><td>1</td><td>
</td></tr>
<tr><td>2</td><td>
</td></tr>
<tr><td>10</td><td>
</td></tr>
<tr><td>20</td><td>
</td></tr>
<tr><td>30</td><td>
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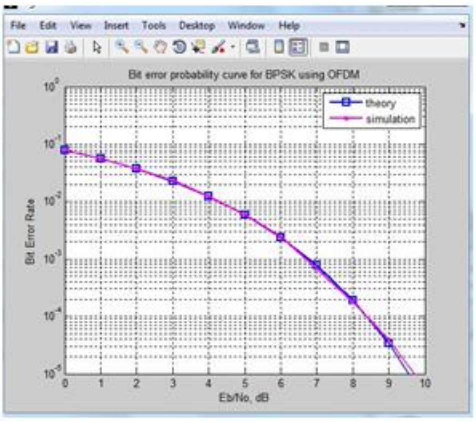

Fig a:bit error probability curve for BPSK using OFDM

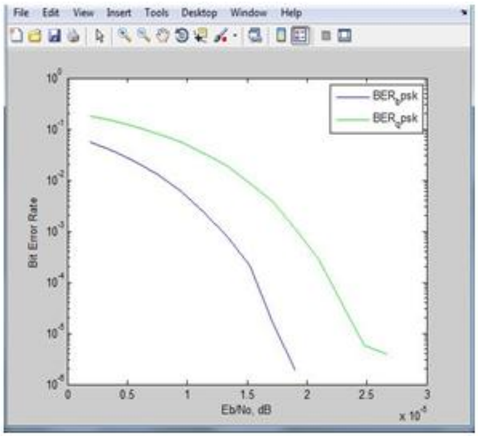

Fig b: bit error probability curve for BPSK and QPSK

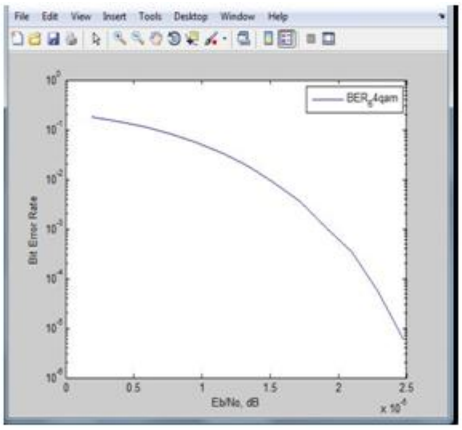

Fig c: BER curve for 4QAM

VI. 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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