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Implementation and Comparative analysis of Orthogonal Frequency Division Multiplexing (OFDM) Signaling

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Abstract**—***Orthogonal Frequency Division Multiplexing (OFDM) is one of the effective modulation techniques for high speed communication system. The radio frequency bandwidth at frequency ranges which allows reasonable spatial coverage is a limiting factor. Therefore, alternative wireless transmission is developed. Visible light communication using white LED's offers the potential for such alternative. OFDM allows the transmission of high data rates over broadband radio and it does not require any powerful channel equalization, but it is very sensitive for nonlinear effects due to the high peak-to-average power ratio generated (owned) by their transmitted signals. OFDM has grown rapidly in the field of wireless and wired communication systems because of its advantages. Main problem with OFDM is high peak to average power ratio which affects the performance and efficiency of high power amplifier used in ratio system. In this paper, we will define OFDM performance and its comparative analysis with QAM.*

I. INTRODUCTION

High speed data transmission plays very important role in our daily life. Radio frequency bandwidth at frequency ranges which allow reasonable spatial coverage is a limited factor. So we make use of alternative wireless transmission means that is visible light communication using white LED.
Main reasons of using white LED are as follows:

- Bandwidth is not limited
- Existing local power line infrastructure can be utilized potentially
- No requirement of expensive RF units, transmitters and receivers devices are cheap

White LED can offer very high brightness, very low power consumptions and long lifetime. One of the unique features of white LED's is that they can serve two purposes at some time- Lighting and high speed wireless data transmission. In case of LED transmission, there is no health regulations to restrict the transmit power. For high transmission rates like video conference, digital TV or video on demand, then the optical transmission with almost unlimited bandwidth can be used. White LED offers very high brightness and very low power consumptions so it can serve two purposes at the same time: lighting and high speed wireless data transmission. High transmission rate are required for video conference, digital TV (Television), then optical transmission with near about unlimited bandwidth can be used.

OFDM is considered as a strong candidate for wireless data transmission technology in broadband cellular networks. In OFDM system, a high data rate serial data stream is split up into a set of low rate sub-streams. The orthogonality is achieved by selecting a special equidistant set of discrete carrier frequencies. This operation is performed by the IFFT (Inverse fast Fourier transforms) at transmitter. At receiver, the FFT (Fast Fourier Transform) is used to demultiplex the parallel data stream. In Orthogonality Intersymbol Interference (ISI) is introduced so to remove ISI guard interval (GI) with a cyclic prefix is introduced to preserve the orthogonality between sub channels.

II. HARDWARE ARCHITECTURE: SYSTEM DESCRIPTION

In this section, we will introduce the transmission systems, channel model, and the pilot-symbol-assisted (PSA) channel estimation for OFDM systems. In addition, we summarize the properties of the image codec to be used in our simulation.

OFDM System

In the given figure we can see that a high-level diagram of an OFDM system. At the transmitter, input signals are arranged into blocks by a serial-to-parallel (S/P) converter, and the data in each block are mapped into a set of complex constellation points, i.e. {X[0,k],….., X[N-1,k]}. The mapped data block is often referred to as an OFDM block. Here, is the total number of sub channels, and denotes the index of the OFDM blocks.

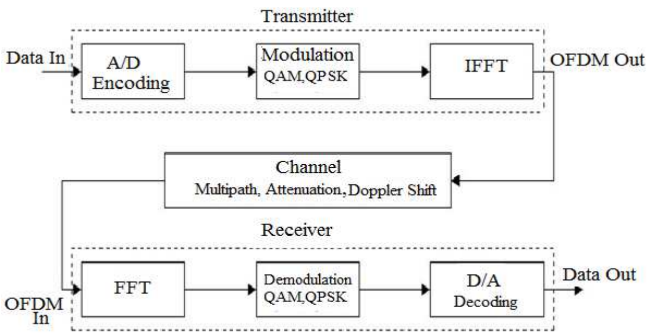

Fig 1: Block Diagram of OFDM System

After signal mapping, the modulation is implemented using inverse fast Fourier transform (IFFT). A cyclic prefix is then inserted to eliminate inter-symbol-interference (ISI). Finally, the modulated data block and the cyclic prefix are converted to an OFDM symbol by a parallel-to-serial (P/S) converter. At the receiving end the cyclic prefix is discarded, and demodulation is performed by fast Fourier transform (FFT). When the length of the cyclic prefix is longer than the length of the channel impulse response then the interference between two consecutive OFDM symbols is eliminated. In this case, the channel can be viewed as a set of parallel independent sub-channels, and the received signal is represented as

$Y[n, k]= H[n, k]X[n,k] + w[n,k], \quad n= 0,1,.., N-1$

Where Y[n,k] represents the received signal, X[n, k] denotes the transmitted signal, and H[n, k]and w[n,k] are the channel frequency response and the additive Gaussian noise, respectively. Here n is the index of sub channels, and k is the index of OFDM blocks. The channel noise samples {w[n, k]} are modeled as Gaussian random variables with zero mean and variance σ^2 and are assumed that it is independent for different n's or k's.

Main Issues with OFDM

1. **Peak-to-Mean Power Ratio:** An OFDM signal may exhibit a high instantaneous peak power with respect to the average signal level, seeing that the OFDM signal is the superposition of a large number of modulated sub-channel signals. Here we have to r*educe the peak-to-mean power ratio* and i*mprove the amplification stage of the transmitter*.
2. **Synchronization:** To optimize the performance of an OFDM link, time and frequency synchronization between the transmitter and receiver is of absolute importance.
3. **Co-channel Interference:** Co-channel interference in cellular communications systems are combated by combining adaptive antenna techniques with OFDM transmissions.

III. DESIGN METHODOLOGY

During the design methodology in MATLAB we use encoding provided at the input of OFDM and then store the encoded OFDM Signal to a wav file. And in last stage decoding is provided in OFDM for output.

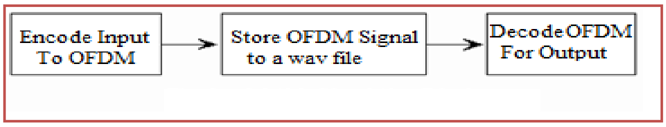

Fig 2: MATLAB Simulation Block Diagram

Subsystems Description: Encoding of the input to the system

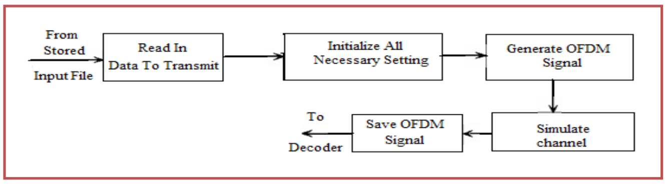

Fig 3: Encoded System

The first block reads in the data for transmission. The second block performs all the initializations needed to perform the encoding and transmission of the input. Next step simulates a typical channel that will be the medium over which the OFDM will propagate. The last block in the encoding section simply saves the generated OFDM signal to a specified file within the same directory as the input wav file.

a) Decoding of the input to the system

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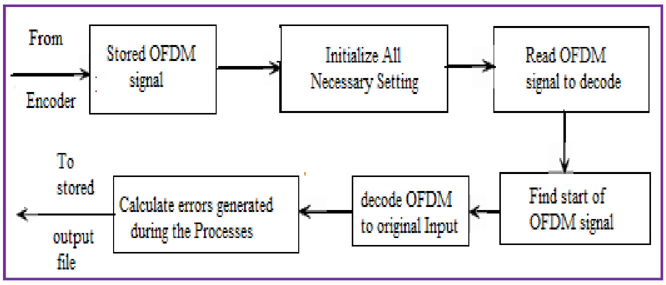

Fig 4: Decoded System

IV. MATLAB IMPLEMENTATION

In this paper During MATLAB implementation we implement QAM modulation and demodulation, 16-QAM modulation and demodulation, 16-PSK modulation and demodulation and OFDM modulation and demodulation.

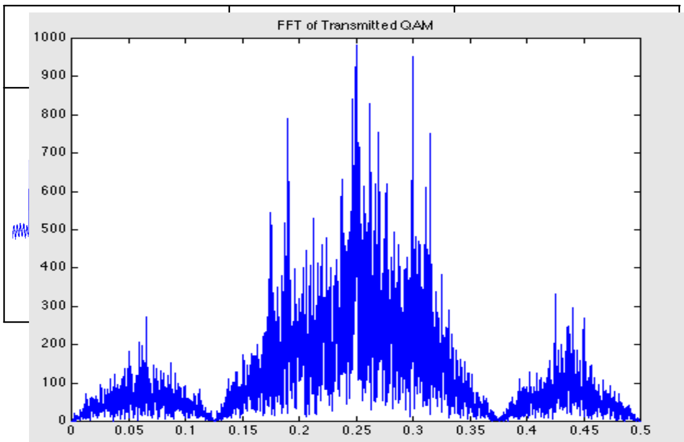

Fig 5. FD representation of QAM data transmission

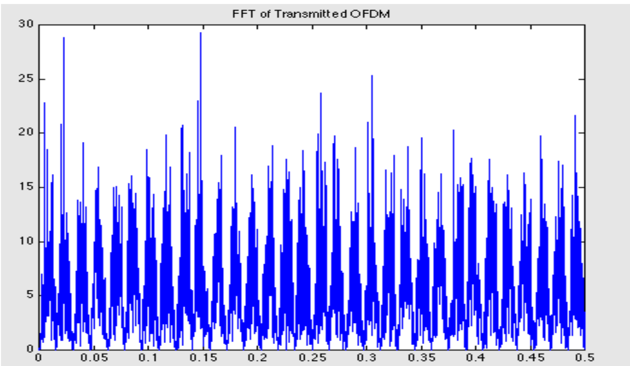

Fig 6.FD representation of OFDM data transmission

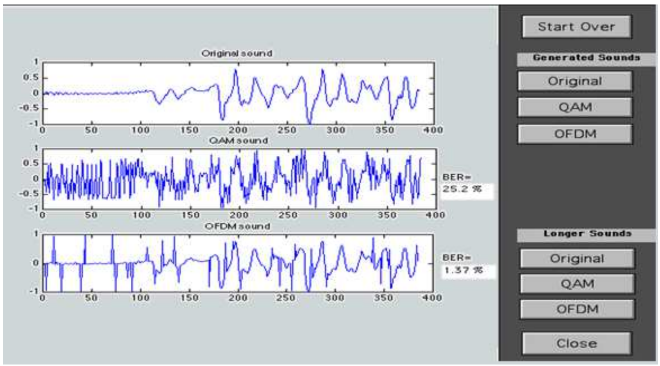

Fig 7. Final plots of recovered sound files for OFDM and QAM

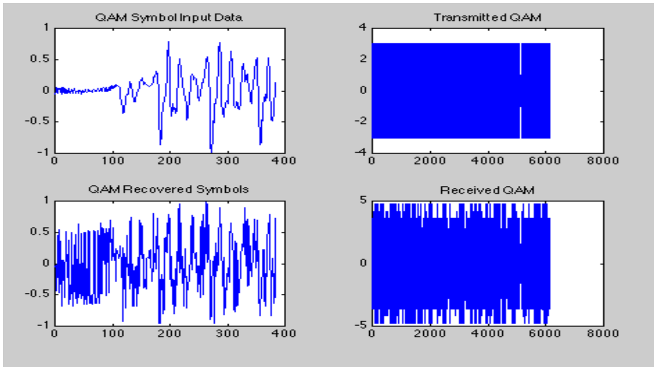

Fig 8. 16-QAM Input and Output

QAM Signal has received with some distortion or some error, which is BER, has with some error.

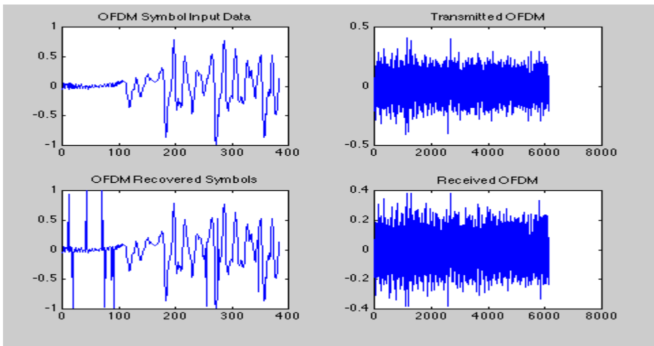

Fig 9. OFDM input and output

OFDM has some error less than QAM Signal.

OFDM Transmission 16-QAM transmission

Original Sound **BER= 0.01%,** **BER= 21.2%**

Binary Error= 17 **Binary Error= 35,957**

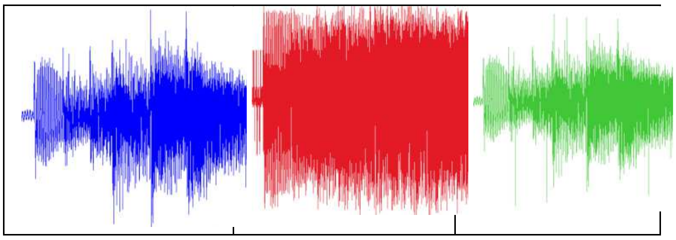

Fig 10. Comparison the sound signal of QAM and OFDM

This figure shows final plot of the recovered sound files along with the Bit Error Rate (BER) for OFDM and QAM. Here we can see that in QAM sound BER is 25.2% and in OFDM sound BER is 1.37%. Then click any key of the 3 buttons to hear these sounds. Since OFDM handless multipath better, the sound is less distorted.

V. CONCLUSION

OFDM is very attractive technique for wireless communications due to its high data rate, spectrum efficiency and channel robustness. It is more suitable or better than QAM. One of the serious drawbacks of OFDM is its high peak-to-average power ratio because a multicarrier signal consists of a number of independent modulated sub carriers. OFDM based method provide comparably good results. OFDM is a special case of wideband multicarrier modulation in which multiple symbols are transmitted in parallel using different sub-carriers with overlapping frequency bands that are mutually orthogonal. An equivalent wideband frequency bandwidth is separated into a number of narrowband signals. The time dispersion caused by multipath delay is reduced because the symbol duration of a narrowband signal will be larger than that of a wideband transmission scheme. The overlapping multicarrier techniques can implement the same number of channels as conventional FDM system but with a reduced amount of bandwidth. In conventional FDM, adjacent channels are separated using a guard band. In order to utilize the overlapping technique, crosstalk between adjacent channels must be reduced through orthogonality between sub-carriers.

In OFDM, each subcarrier has an integer number of cycles within a given time interval T, and the number of cycles by which each adjacent subcarrier differs is exactly one. This implementation adds orthogonality to the subcarriers. The subcarriers are data modulated using phase shift keying or quadrature amplitude modulation. The amplitude spectrum of each modulated subcarrier using either PSK or QAM has a sinc2 shape. At the peak spectral response of each subcarrier all other subcarrier spectral responses are identically zero.

A wide variety of techniques have been proposed for estimating and adjusting both timing and carrier frequency. Next, a DFT is used to demodulate all subcarriers. To demodulate the subcarriers using PSK or QAM modulations, reference phase and amplitude of the constellation on each subcarrier are required.

VI. ACKNOWLEDGEMENT

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