Implementation of Orthogonal Frequency Division Multiplexing (OFDM) using MATLAB

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Abstract— This paper discusses the implementation of an OFDM in wireless communication. Orthogonal frequency division multiplexing (OFDM) is a technique of encoding digital data on multiple carrier frequencies. OFDM is mainly chosen modulation technique for wireless communication. In OFDM scheme, large number of orthogonal, narrow band subchannels or sub carriers transmitted in parallel, divides the transmission band width. The separation of sub carriers is theoritically negligible such that there is an compact spectral utilization. The bit error rate and the ISI in multipath in standard techniques like QAM are high which are reduced by implementing the OFDM technique.

Key words: OFDM, Orthogonality, Overlap, ISI, QAM

I. INTRODUCTION

A common drawback found in high-speed communication is inter-symbol interference (ISI). ISI happens if the transmission interferes with itself and therefore the receiver cannot decode the transmission efficiently.It is a method of distortion of a symbol within which one symbol interferes with consequent symbols. As a result of the signal reflects from heavy objects like mountains or buildings, the receiver sees over one copy of the signal. In communication system, this can be known as multipath. Since the indirect ways take longer time to travel the receiver, the delayed copies of the signal mix with the original signal and that results in ISI. This project target on Orthogonal Frequency Division Multiplexing (OFDM) analysis and simulation.

OFDM is initially studied by river PATANG in 1966.OFDM is very appropriate for high-speed communication because of its resistance toISI. The communication systems increase their information transfer speed, the time for every transmission essentially comes shorter. Since the delayed time caused by multipath remains constant, ISI is becoming a limitation in high data rate communication. OFDM avoids this drawback by sending several low speed transmissions at the same time.

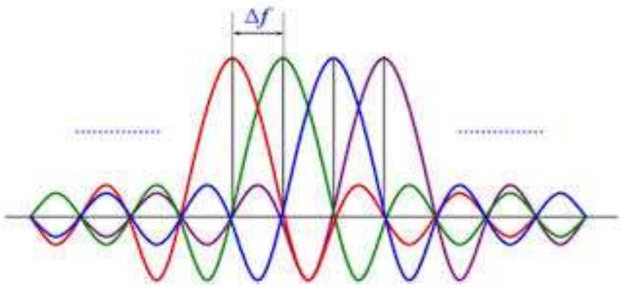

Fig. 1: Input Signals for OFDM

II. OBJECTIVE OF OFDM

This project focus on Orthogonal Frequency Division Multiplexing (OFDM) analysis, simulation, and implementation. OFDM is very appropriate for high speed communication because of its resistance to ISI. As the communication systems increase their information transfer speed, the time for each transmission will become shorter. Since the delayed time caused by multipath remains constant, ISI becomes a limitation in high-data-rate communication. OFDM avoids this drawback by causing severallow speed transmissions at the same time for example, below figure shows 2 ways totransmit a similar four items of binary information. Suppose that this transmission of information takes four seconds. Then, each piece of information within the left image contains a length of 1 second. On the other side, OFDM would send the four items simultaneously. During this case, each bit of information has a length of 4 seconds. This longer length reduce the effect of ISI. Other reason in using OFDM is low-complexity implementation for high speed systems compared to previous single carrier techniques.

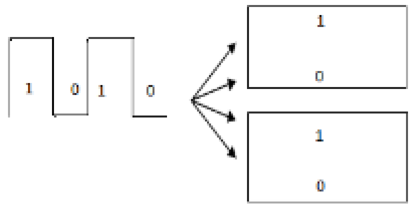

Fig. 2: Previous transmission mode vs OFDM Communication

III. ORTHOGONALITY

Signals are orthogonal if they are mutually independent to each other. Orthogonality is a property that enables multiple information signals to be transmitted over a common channel and produces, without any interference. Loss of orthogonality leads to blurring between these information signals. TimeDivision Multiplexing (TDM) permits transmission of multiple information signals over one channel by allocating different time slots to every separate information signals. During each time slot, only the signal from a single source is transmitted preventing any interference between the multiple information sources. Due to this TDM is orthogonal in nature. Although these methods are orthogonal the term OFDM reserved for a special type of FDM. The subcarriers in an OFDM are spaced in such a way they are theoritically possible to maintainorthogonality between them. OFDM achieves orthogonality within the frequency domain by allocating each of the separate information signals onto completely different subcarriers. OFDM signals are made up from the sum of sinusoids, each corresponding for reserved special type of FDM. The baseband frequency of every subcarrier is chosen in a way they are integer multiple of the inverse of symbol time, which results in all subcarriers have an integer multiple of cycles per second. As an order this subcarriers are orthogonal to each other.

IV. METHODOLOGY

The transmitter initially converts the input signals from a serial stream to parallel sets.Every set of information contains one symbol Si, for every subcarrier for example, a collection of 4 data will be [S0 S1 S2 S3]. Before performing the Inverse Fast Fourier Transform (IFFT), this data set is arranged on the horizontal axis within the frequency domain as shown in Figure.An inverse Fourier transform converts the frequency domain data set into samples of the corresponding time domain representation of data. Specifically, the IFFT is helpful for OFDM as a resultit generates samples of a wave with frequency parts satisfyingorthogonality conditions. Then, the parallel to serial block creates the OFDM signal by consecutive outputting the time domain samples.

The channel simulation permits examination of common wireless channel characteristics like noise, multipath, and clipping.By adding random data to the transmitted signal, noise is simulated. Multipath simulation involves adding attenuated and delayed copies of the transmitted signal to the original signal. Finally, clipping simulates the problem of amplifier saturation. This addresses a practical implementation drawback in OFDM wherever the peak to average power ratio is high.The receiver performs the inverse of the transmitter. First, the OFDM data signals are splitted from a serial stream into parallel sets. The Fast Fourier Transform (FFT) converts the time domain samples back to a frequency domain samples. Finally, the parallel to serial block converts this parallel data signals into a serial stream to recover the original input data required.

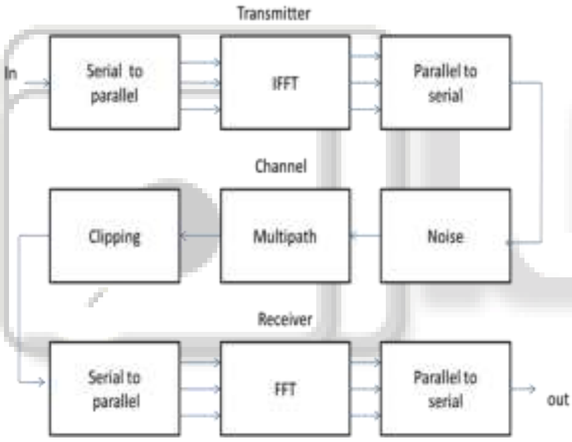

Fig. 3: OFDM simulation flow chart

V. ADVANTAGES

1) Makes economical use of the spectrum by permitting overlap.
2) Eliminates ISI and IFI through use of a cyclic prefix.
3) Using an adequate channel coding and interleaving can recover symbols lost as a result of the frequency selectivity of the channel.
4) Channel effort becomes easier than by using adaptive equalization techniques with single carrier systems.
5) It is possible to use maximum likelihood decoding with reasonable complexity.

VI. DISADVANTAGES

1) The OFDM signal contains a noise like amplitude with a large dynamic range; so it needs RFpower amplifiers with a high peak to average power ratio.
2) It is more sensitive to carrier frequency offset and drift than single carrier system are due to leakage of DFT.

VII. RESULT OF MATLAB SIMULATION

The MATLAB simulation accepts inputs of binary data signals and text files. It then generates the corresponding OFDM transmission, simulates a channel, tries to recover the input file, and performs an analysis to work out the transmission error rate. so as to check OFDM to a standard single carrier communication system, a 16-QAM simulation can be performed.

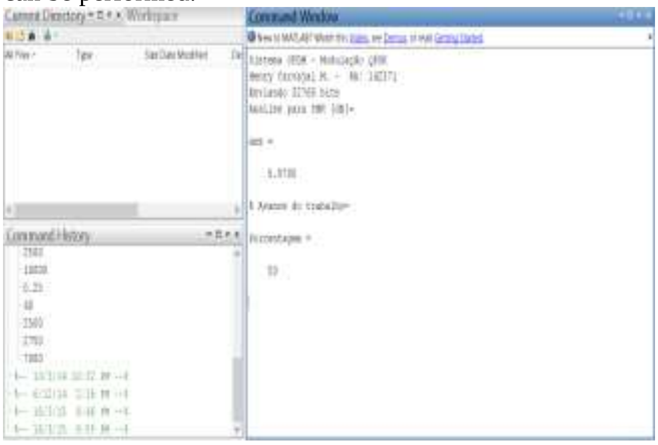

Fig. 4: OFDM Input Sequence

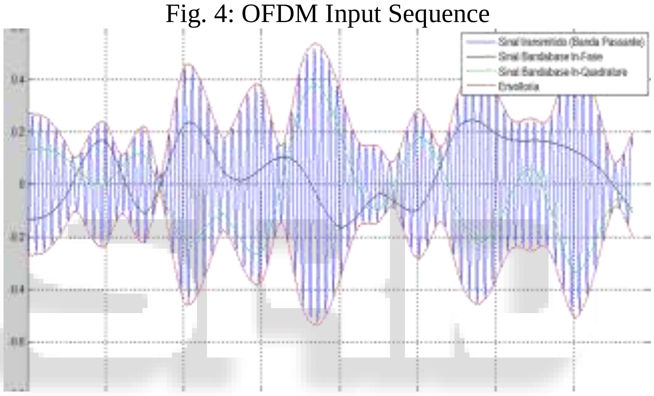

Fig. 5: Transmission of Signals

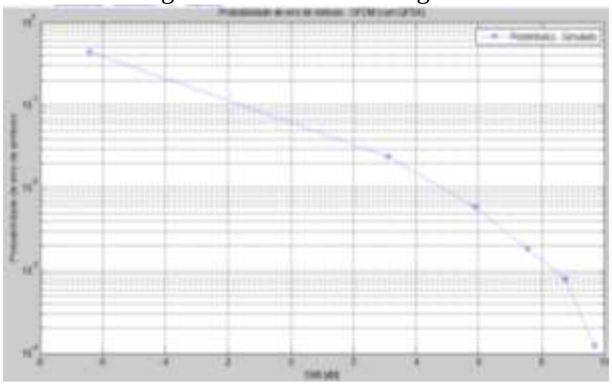

Fig. 6: Probability of Error in QPSK

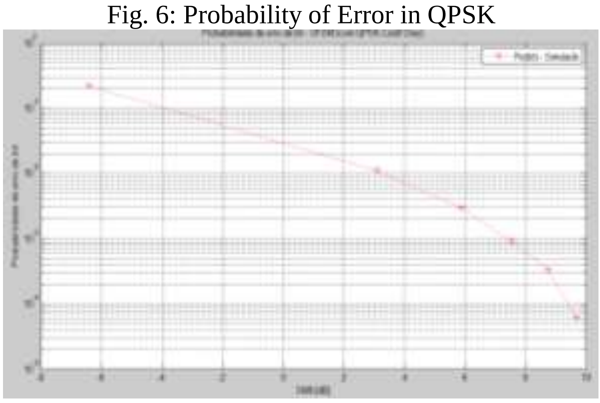

Fig. 7: Bit Error Rate

VIII. CONCLUSION

This paper proves that OFDM is best suited to a multipath channel than a single carrier transmission technique like 16-QAM. This program are particularly valuable for simulating systems that are too complicated to analyze theoretically .OFDM solves the problem of ISI as a result of high data rates. It also provides other advantages like high spectral efficiency.

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