Performance analysis in Different Modulation Techniques Using SUI Modeling in OFDM System

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Abstract- *Orthogonal Frequency Division Multiplexing (OFDM) and Multiple Input and Multiple Output (MIMO) are two main techniques employed in 4th Generation Long Term Evolution (LTE). In OFDM multiple carriers are used and it provides higher level of spectral efficiency as compared to Frequency Division Multiplexing (FDM). In OFDM because of loss of orthogonality between the subcarriers there is inter-carrier interference (ICI) and inter-symbol interference (ISI) and to overcome this problem use of cyclic prefixing (CP) is required, which uses 20% of available bandwidth. Wavelet based OFDM provides good orthogonality and with its use Bit Error Rate (BER) is improved. Wavelet based system does not require cyclic prefix, so spectrum efficiency is increased. It is proposed to use wavelet based OFDM at the place of Discrete Fourier Transform (DFT) based OFDM in LTE. We have compared the BER performance of wavelets and DFT based OFDM.*

Keywords- OFDM, Bit Error Rate, FFT, DFT, AWGN, FDM.

I. INTRODUCTION

The revolution of wireless communications certainly was one of the most extraordinary Changes underlying our contemporary world although we may not realize it, everyday our lives are profoundly affected by the use of radio waves. Radio and television transmissions, radio-controlled devices, mobile telephones, satellite communications, and radar and systems of radio navigation are all examples of wireless communications happening around us. However, less than a hundred years ago, none of these existed, while the telegraph and telephone were most common for communication, which required direct wire connection between two places.

There mark able advancement in communication of today is the result of an Italian scientist, Gugliemo Marconi, as he began experiments using radio waves for communication in 1895. These invisible transmittable waves travelled in air, and since the receiving and transmitting equipment was not connected by wires, the method of communication used was then recognized as wireless communication. Marconi's first success was in 1897, as demonstrated radio’s ability to provide continuous contact with ships sailing the English Channel. By 1920, radio circled the globe and the first radio transmitter was developed and broadcasted programs for the public. Later, the idea of the radio was adopted by Television, radar and communication systems, due to the advancement in electronics Equipment and enabled radio waves to be sent over greater distances.

A. The Cellular Concept:

The world's first cellular network was introduced in the early1980s,using analog radio transmission technologies such as AMPS(Advanced Mobile Phone System), The cellular concept, a diagrammatic representation is presented in Figure1.1

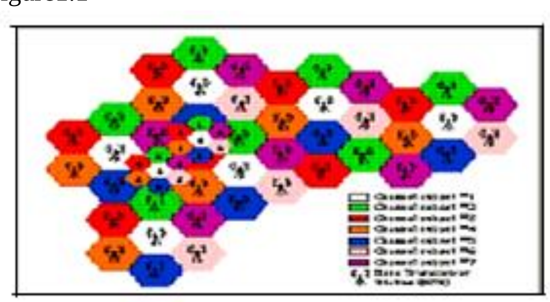

Fig 1.1: Cellular Concept

In Figure above, each colored cell is viewed as the (approximate) coverage area of a particular land site. Each cell uses a distinct set of frequencies (channels) and is shown by the difference in color between cells. However, cells that are far enough a part to avoid co-channel interference can reuse the same channel set. In the cellular concept, a mobile user is allowed mobility as a call is "handed off" from one cell to another as the user leaves one cell and enters another.

The AMPS cellular system was very popular. However, with the gigantic increase in Subscribers in order of million each year, the AMPS cellular systems began to over loading capacity and became incapable of delivering sufficient air time to reach user .To overcome the problem, more effective multiple access techniques were invented.

B. Bit Error Rate:

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion or bit synchronization errors. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage. The bit error probability pe is the expectation value of the BER. The BER can be considered as an approximate estimate of the bit error probability. This estimate is accurate for a long time interval and a high number of bit errors.

II. OFDM GENERATION

To generate OFDM successfully the relationship between all the carriers must be carefully controlled to maintain the orthogonality of the carriers. For this reason, OFDM is generated by firstly choosing the spectrum required, based on the input data, and modulation scheme used. Each carrier to be produced is assigned some data to transmit. The required amplitude and phase of the carrier is then calculated based on the modulation scheme (typically differential BPSK, QPSK, or QAM). The required spectrum is then converted back to its time domain signal using an Inverse Fourier Transform. In most applications, an Inverse Fast Fourier Transform (IFFT) is used. The IFFT performs the transformation very efficiently, and provides a simple way of ensuring the carrier signals produced are orthogonal.

The IFFT performs the reverse process, transforming a spectrum (amplitude and phase of each component) into a time domain signal. An IFFT converts a number of complex data points, of length, which is a power of 2, into the time domain signal of the same number of points. Each data point in frequency spectrum used for an FFT or IFFT is called a bin. The orthogonal carriers required for the OFDM signal can be easily generated by setting the amplitude and phase of each bin, then performing the IFFT. Since each bin of an IFFT corresponds to the amplitude and phase of a set of orthogonal sinusoids, the reverse process guarantees that the carriers generated are orthogonal.

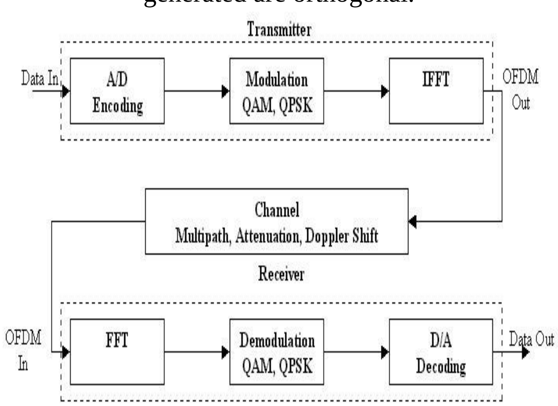

Figure 2.1: OFDM Block Diagram

Fig. 2.1 shows the setup for a basic OFDM transmitter and receiver. The signal generated is a base band, thus the signal is filtered, then stepped up in frequency before transmitting the signal. OFDM time domain waveforms are chosen such that mutual orthogonality is ensured even though sub-carrier spectra may overlap. Typically QAM or Differential Quadrature Phase Shift Keying (DQPSK) modulation schemes are applied to the individual sub carriers. To prevent ISI, the individual blocks are separated by guard intervals wherein the blocks are periodically extended.

The Fast Fourier Transform (FFT) transforms a cyclic time domain signal into its equivalent frequency spectrum. This is done by finding the equivalent waveform, generated by a sum of orthogonal sinusoidal components. The amplitude and phase of the sinusoidal components represent the frequency spectrum of the time domain signal.

However, OFDM is not without drawbacks. One critical problem is its high peak-to-average power ratio (PAPR). High PAPR increases the complexity of analog-to-digital (A/D) and digital-to-analog (D/A) converters, and lowers the efficiency of power amplifiers. Over the past decade various PAPR reduction techniques have been proposed, such as block coding, selective mapping (SLM) and tone reservation, just to name a few . Among all these techniques the simplest solution is to clip the transmitted signal when its amplitude exceeds a desired threshold. Clipping is a highly nonlinear process, however. It produces significant out-of-band interference (OBI).

A good remedy for the OBI is the so-called companding. The technique ‘soft’ compresses, rather than ‘hard’ clips, the signal peak and causes far less OBI. The method was first proposed in, which employed the classical μ-law transform and showed to be rather effective. Since then many different companding transforms with better performances have been published. This paper proposes and evaluates a new companding algorithm. The algorithm uses the special airy function and is able to offer an improved bit error rate (BER) and minimized OBI while reducing PAPR effectively. The paper is organized as follows. In the next section the PAPR problem in OFDM is briefly reviewed.

III. METHODOLOGY

In previous works use of Discrete Fourier Transform was proposed for the implementation of OFDM. Wavelet transform show the potential to replace the DFT in OFDM. Wavelet transform is a tool for analysis of the signal in time and frequency domain jointly. It is a multi resolution analysis mechanism where input signal is decomposed into different frequency components for the analysis with particular resolution matching to scale . Using any particular type of wavelet filter the system can be designed according to the need and also the multi resolution signal can be generated by the use of wavelets. By the use of varying wavelet filter, one can design waveforms with selectable time/frequency partitioning for multi user application. Wavelets possess better orthogonality and have localization both in time and frequency domain. Because of good orthogonality wavelets are capable of reducing the power of the ISI and ICI, which results from loss of orthogonality.

To reduce ISI and ICI in conventional OFDM system use of cyclic prefix is there, which uses 20% of available bandwidth, so results in bandwidth inefficiency but this cyclic prefix is not required in wavelet based OFDM system. Complexity can also be reduced by using wavelet transform as compared with the Fourier transform because in wavelet complexity is O[N] as compared with complexity of Fourier transform of O[N log2N]. Wavelet based OFDM is simple and the DFT based OFDM is complex. Wavelet based OFDM is flexible as well and because better orthogonality is provided by it, there is no any need of cyclic prefixing in wavelet based OFDM, which is required in DFT based OFDM to maintain orthogonality so wavelet based system is more bandwidth efficient as compared with the DFT based OFDM. In discrete wavelet transform (DWT), input signal presented will pass through several different filters and will be decomposed into low pass and high pass bands through the filters. During decomposition the high pass filter will remove the frequencies below half of the highest frequency and low pass filter will remove frequencies that are above half of the highest frequency. The decomposition halves the time resolution because half of the samples are used to characterize the signal similarly frequency resolution will be doubled and this decomposition process will be repeated again for obtaining the wavelet coefficients of required level. Two types of coefficients are obtained through processing, first ones are called detailed coefficients obtained through high pass filter and second ones are called coarse approximations obtained through low pass filter related with scaling process. After passing the data through filters the decimation process will be performed. The whole procedure will continue until the required level is obtained. This decomposition can be given as where x[n] is the original signal, g[n] is impulse response of half-band high pass filter and h[n] is impulse response of half-band low pass filter. yhigh [k] and ylow [k] are obtained after filtering and decimation by a factor of 2.

$$y_{high}[k]=\sum_n x[n]\, g[2k-n]$$
$$y_{low}[k]=\sum_n x[n]\, h[2k-n] \qquad (1)$$

In inverse discrete wavelet transform (IDWT), the reverse process of decomposition is performed, so here firstly up sampling is done then the signal is passed through the filters. The data obtained after filtering is combined to obtain reconstructed data. Number of levels during reconstruction will be same as that of the decomposition.

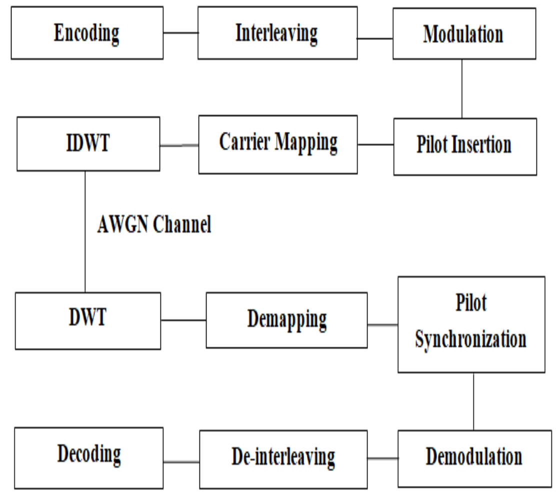

Fig. 3.1: Wavelet Based Proposed OFDM System Design

In this proposed model we are using IDWT and DWT at the place of IDFT and DFT. AWGN channel is used for transmission and cyclic prefixing is not used. Here first of all conventional encoding is done followed by interleaving then data is converted to decimal form and modulation is done next. After modulation the pilot insertion and sub carrier mapping is done then comes the IDWT of the data, which provides the orthogonality to the subcarriers. IDWT will convert time domain signal to the frequency domain. After passing through the channel on the signal DWT will be performed and then pilot synchronization where the inserted pilots at the transmitter are removed then the demodulation is done. Demodulated data is converted to binary form and the de-interleaved and decoded to obtain the original data transmitted.

A. BER Performance Evaluation:

By using MATLAB performance characteristic of DFT based OFDM and wavelet based OFDM are obtained for different modulations that are used for the LTE, as shown in figures 3-5. Modulations that could be used for LTE are QPSK, 16 QAM and 64 QAM (Uplink and downlink). QPSK does not carry data at very high speed. When signal to noise ratio is of good quality then only higher modulation techniques can be used. Lower forms of modulation (QPSK) does not require high signal to noise ratio.

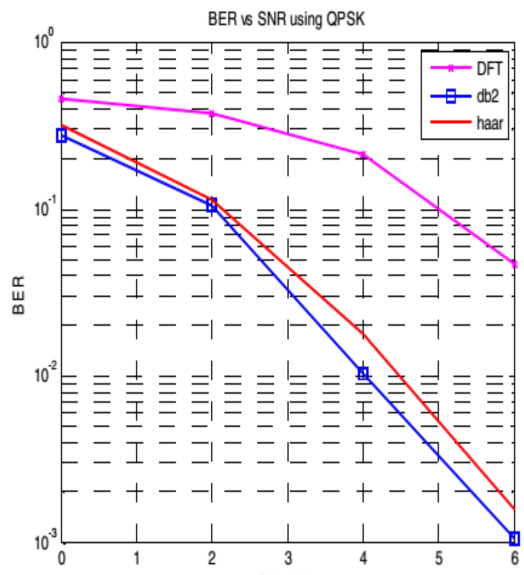

Fig. 3.2: BER Performance of Wavelets and DFT Based OFDM System Using QPSK Modulation.

For the purpose of simulation, signal to noise ratio (SNR) of different values are introduced through AWGN channel. Data of 9600 bits is sent in the form of 100 symbols, so one symbol is of 96 bits. Averaging for a particular value of SNR for all the symbols is done and BER is obtained and same process is repeated for all the values of SNR and final BERs are obtained. Firstly the performance of DFT based OFDM and wavelet based OFDM are obtained for different modulation techniques. Different wavelet types daubechies2 and haar is used in Wavelet based OFDM for QPSK, 16-QAM, 64-QAM, It is clear from the figure, that the BER performance of wavelet based OFDM is better than the DFT based OFDM.

IV.RESULTS AND DISCUSSION

By using MATLAB performance characteristic of DFT based OFDM and wavelet based OFDM are obtained for different modulations that are used for the LTE, as shown in figures 5.1-5.3. Modulations that could be used for LTE are QPSK, 16 QAM and 64 QAM (Uplink and downlink). QPSK does not carry data at very high speed. When signal to noise ratio is of good quality then only higher modulation techniques can be used. Lower forms of modulation (QPSK) does not require high signal to noise ratio.

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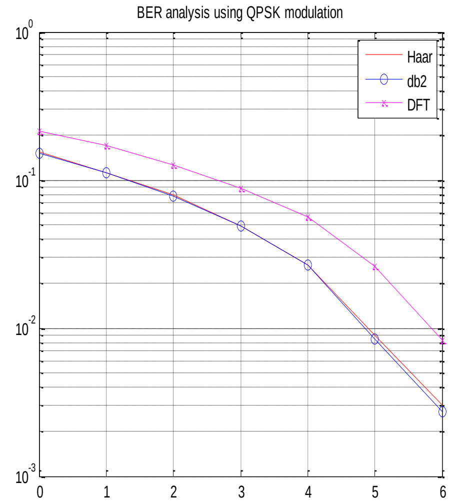

Figure: 5.1 BER Performance of wavelets and DFT based OFDM system using QPSK modulation

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It is clear from the fig. 5.1, fig. 5.2 and fig. 5.3 that the BER performance of wavelet based OFDM is better than the DFT based OFDM. fig. 5.1indicates that db2 performs better when QPSK is used. fig. 5.2 shows that when 16-QAM is used db2 and haar have similar performance but far better than DFT. fig. 5.3, where 64-QAM is used haar and db2 performs better than DFT.

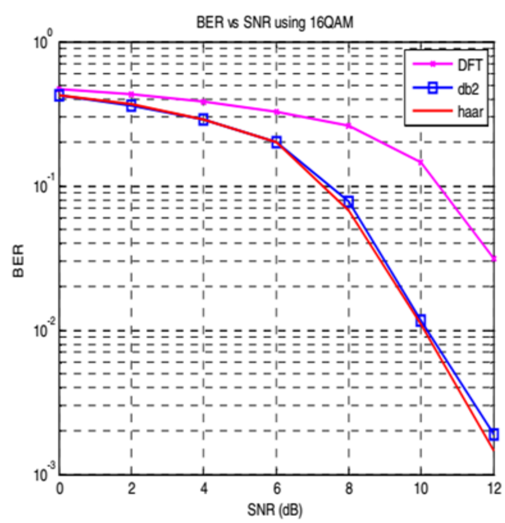

Figure: 5.2 BER Performance of wavelets and DFT based OFDM system using 16- QAM modulation.

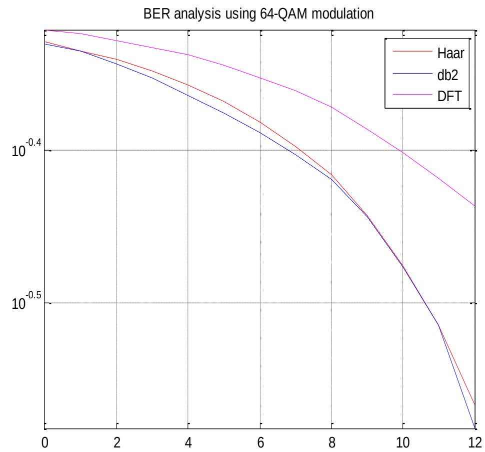

Figure: 5. 3 BER performance of wavelets and DFT based OFDM system using 64- QAM modulation.

V. CONCLUSION

In this paper we analyzed the performance of wavelet based OFDM system and compared it with the performance of DFT based OFDM system. From the performance curve we have observed that the BER curves obtained from wavelet based OFDM are better than that of DFT based OFDM. We used three modulation techniques for implementation that are QPSK, 16 QAM and 64 QAM, which are used in LTE. In wavelet based OFDM different types of filters can be used with the help of different wavelets available. We have used daubechies2 and haar wavelets, both provide their best performances at different intervals of SNR.

The BER value can be reduced when using then Haar function and the convolution encoder. The BER value in the proposed model is low. The proposed model decreases the value of BER for the same S/N ratio used. When increase the number of stages of the proposed model lead to reducing the BER but increase the complexity and cost. The value of BER with one stage convolutional encoder can be obtained for two stage convolutional encoder at nearly 6.5 dB to save more than 3.5 dB which save the system power.

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