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Performance of DFT and WAVELET Based OFDM System Based on BER Analysis Using Different Modulation Techniques

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ABSTRACT: In 4th generation Long Term Evolution (LTE) system, Orthogonal Frequency Division Multiplexing (OFDM) and Multi Input and Multi Output (MIMO) techniques are used. In Orthogonal Frequency Division Multiplexing (OFDM) multiple carriers are used , so it provides high level of spectral efficiency as compared to other multiplexing techniques. There is an orthogonality existing between the subcarriers in Frequency Division Multiplexing(OFDM). Due to the loss of orthogonality between subcarriers in Frequency Division Multiplexing (OFDM), there is an inter carrier interference(ICI) and inter symbol interference(ISI) occurred. To remove this type of interferences by using cyclic prefix in the OFDM system but it requires 20% of available bandwidth so the power loss increases, spectral efficiency reduced and Bit Error Rate(BER) is reduced. The wavelet based OFDM provides good orthoganality between the subcarriers and the use of cyclic prefix in the system is also removed so that the power loss is reduced, spectral efficiency and Bit Error Rate(BER) are improved. In our proposed method wavelet based OFDM is used in place of Discrete Fourier Transform(DFT) based OFDM in 4th generation Long Term Evolution(LTE) system. We have compared BER performance of DFT and wavelet based OFDM.

KEYWORDS: LTE, OFDM, DFT, wavelet, BER**.**

I.INTRODUCTION

In presents days the requirement of data rates are increasing exponentially for each user because the usage of smart phones and internet are high when compared to the last decade so the efficient usage of spectrum is required to provide such a high data rates to users. The efficient use of spectrum is not possible by using single carrier communication because in single carrier communication we are using equalisers to enhance strength of the signal in presence of noise and fading also occurred. In order to flexible utilisation of spectrum we are using multicarrier communication. The main idea of multicarrier communication is divide the serial high data rates streams into a large number of low data rates parallel streams. There are mainly two advantages by using this multicarrier communication when compared to single carrier communication, first one is there is no use of signal enhancement in presence of noise and second one is the long symbol duration is used in multicarrier communication the effect of fading is also reduced. The orthogonal frequency division multiplexing uses multicarrier communication for providing high data rates. In OFDM there is an orthogonality between the subcarriers to provide high level of spectral efficiency because of orthoganility the subcarriers are overlapped in frequency domain.

The elementary waveforms in Discrete Fourier Transform are sine and cosine waveforms. There is a loss of orthogonality between the subcarriers in Discrete Fourier Transform based OFDM due to multipath propagation of a signal, it results two types of interferences namely inter symbol interference(ISI) and inter carrier interference (ICI). The inter symbol interference occurred between successive symbols of same subcarrier and inter carrier interference occurred between different symbols at different carriers. The inter symbol interference and inter carrier interference are eliminated by using cyclic prefix in the system but it requires more power hence bandwidth inefficiency occurred. The elementary waveforms in wavelet transform are wavelets there is no sine and cosine waveforms in wavelet transform. The wavelet transform based OFDM system provides good orthogonality between the sub carriers hence there is no question of interferences like inter symbol interference and inter carrier interference it means that the wavelet transform based OFDM system eliminates ISI and ICI without using cyclic prefix in the system so the power in the system

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reduced and provide good bandwidth efficiency as compared to Discrete Fourier Transform based OFDM. There are different research works are done on OFDM recently some authors explain the performance of the wavelet based OFDM system compared with DFT based OFDM by taking different channels with different wavelets like haar and dB2 and some authors compare the performance of the wavelet based OFDM system with DFT based OFDM by taking Bit Error Rate is a performance parameter with Rayleigh fading channel.
In this paper we are comparing performance of a wavelet based OFDM with conventional OFDM by taking bit error rate is a performance parameter by using different modulation techniques like QPSK, 16 QAM and 64 QAM in long term evolution.

II.CONVENTIONAL OFDM SYSTEM

As we discussed earlier the elementary functions of Discrete Fourier Transform is sine and cosine waveforms. These sinusoids in the Discrete Fourier Transform based OFDM system produces orthogonal basis function set, these orthogonal basis functions are subcarriers in OFDM system. In Discrete Fourier Transform the transform correlates its input signal with orthogonal basis functions. There is a different signals occurred at the receiver, all the signals at receiver are combined to obtain the transmitted signal. The block diagram of conventional OFDM system as shown in below figure1In practical Fast Fourier Transform(FFT) and Inverse Fast Fourier Transform(IFFT) are used to design OFDM system as compared to DFT and IDFT because there is a less number of computations required in FFT based system as compared to DFT based system.
Due to the time dispersive nature of the channel multiple number of replicas of transmitted signal is occurred at the receiver it is known as frequency selective fading this type of the interference is removed by providing the guard band between the subcarriers, the guard band is known as cyclic prefix. If the channel delay spread is within the limit of cyclic prefix then there is no loss of orthogonality in the system otherwise loss of orthogonality will occurred.

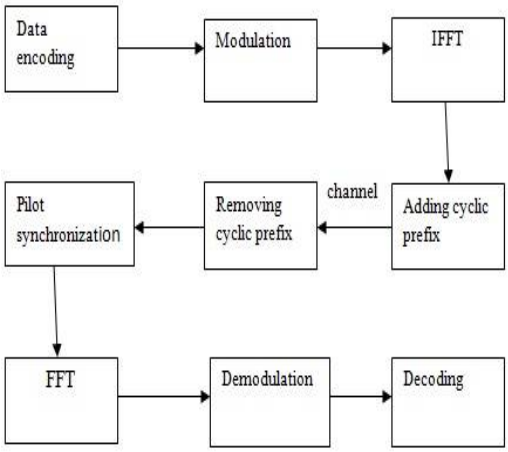

Fig1:- conventional OFDM system

In the downlink long term evolution(LTE) access technique used is orthogonal frequency division multiple access(OFDMA) because the accessing of downlink data of different users are multiplexed in frequency domain and in the uplink long term evolution access technique used is single carrier frequency division multiple access (SC-FDMA). High peak average power ratio occurred due to random constructive nature of subcarriers hence it leads to spectrum spreading of signal is called adjacent channel interference this problem can be eliminated by using linearization techniques and compression point amplifier, these techniques are implemented at the base station is easy but it is expensive to implement at user equipment. LTE uses SC-FDMA with cyclic prefix on uplink, it will reduce peak average power ratio(PAPR) because here we are using single carrier but due to the single carrier modulation ISI increased this can be reduced by using low complexity equalisers. SC-FDMA is not that much sensitive to Doppler shift.

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III.WAVELET BASED OFDM SYSTEM

In previously we are using Discrete Fourier Transform to design an OFDM system. The DFT is used to analyze signal in only time domain but not in frequency domain so in case of wavelet transform the signal can be analyzed in both time and frequency domain. Wavelet transform is a multi resolution technique where the input signal is decomposed into different frequency components for the analysis with particular resolution matching to scale. Wavelet based OFDM system provides good orthogonality between the subcarriers so it provides the higher spectral efficiency when compared to DFT based OFDM system. Due to loss of orthogonality between subcarriers in conventional OFDM system inter symbol interferences and inter carrier interference occurred hence we are using cyclic prefix to reduce these interferences but it requires 20% of available bandwidth and power loss also increased. The wavelet based OFDM system does not required cyclic prefix because it provides good orthogonality between subcarriers hence there is no interference in system. By using wavelet based OFDM system we reduced power loss and provides good spectral efficiency when compared to conventional OFDM system. The complexity of the system is also reduced by using wavelet transform when compared to fourier transform. The complexity of wavelets is O[N] and the complexity of fourier transform is O[N $\log_2$N].the wavelet based OFDM systm is flexible when compared with conventional OFDM system.

In Discrete wavelet Transform the input signal is passing through the several high pass and low pass filters. The high pass filter is used to remove half of the frequencies that are below the half frequency and the low pass filter is used to remove half of the frequencies that are above the half frequency. The frequencies that are obtained at low pass filter again passing through the high pass and low pass filter again the same procedure mentioned above is repeated until the required level. The output coefficients that are occurred at high pass filter is called detailed coefficients and at the low pass filter is called coarse approximation. The decomposition is depends on the length of the signal.after passing the data through the filters decimation will takes place and the whole process is repeated until the required level is obtained. The decomposition process is given by

$Y_{high}[k] = \sum x[n]\, g[2k-n]$

$Y_{low}[k] = \sum x[n]\, h[2k-n]$

Where x[n] is input signal, g[n] and h[n] are impulse response of high pass and low pass filter respectivel and $Y_{high}[k]$, $Y_{low}[k]$ are the output coefficients after filtering and decimation by 2. The inverse process of decomposition is doing in inverse discrete wavelet transform(IDWT). In IDWT first up sampling by 2 is performed after that filtering is done to obtain original signal.

IV. PROPOSED WAVELET BASED OFDM SYSTEM

The block diagram of proposed wavelet based OFDM design as shown in given figure

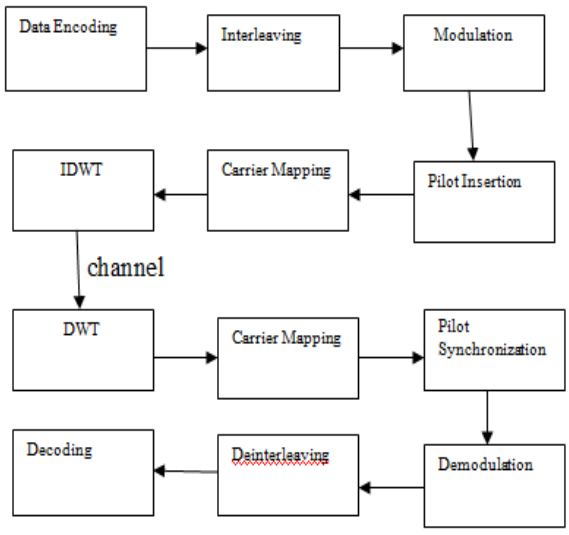

Fig2:- proposed wavelet based OFDM system

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In this proposed method DWT and IDWT are used in place of FFT and IFFT as shown in figure and AWGN channel is used for transmission. the cyclic prefix is not used in this method. First data is encoded followed by interleaving are used to convert the data in decimal form next modulation is done . pilot insertion and carrier mapping is done after modulation then it comes to IDWT. It provides orthogonality between subcarriers and it also convert the time domain signal into frequency domain after that the signal is transmitted through Stanford University Interm(SUI-3) omni channel and AWGN channel. First DWT is done at the receiver end followed by carrier mapping and pilot synchronisation is done. After that demodulation is occurred, it is used to convert the data into binary form. The interleaving ang decoding is used to get the original signal.

V. RESULT AND DISCUSSION

By using MATLAB software we compared the performance characterstics of wavelet based OFDM system and Discrete fourier transform based OFDM system by using different modulation techniques and two types of channels that is SUI-3 omni channel and AWGN channel. The figures 3-6 shows the performance of systems. The modulation techniques that are used in the OFDM system are QPSK, 16 QAM, 64 QAM. By comparing all the results the wavelet based OFDM provides good performance when compared to conventional based OFDM system by using different modulation techniques and the suiemodel channel based system provides good results when compared to AWGN channel in lower cell range.

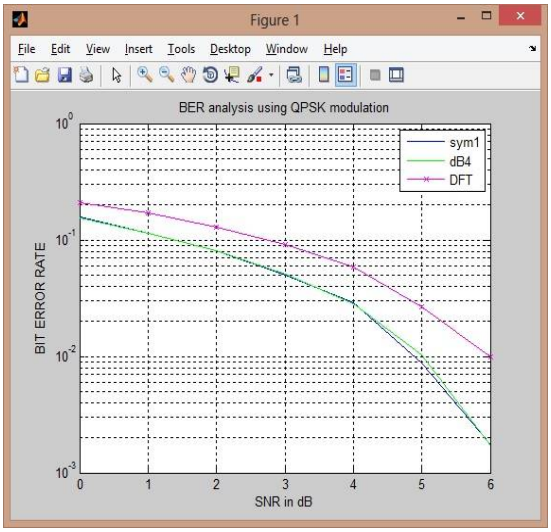

Fig3:- BER analysis of wavelets and DFT based system using QPSK modulation and AWGN channel

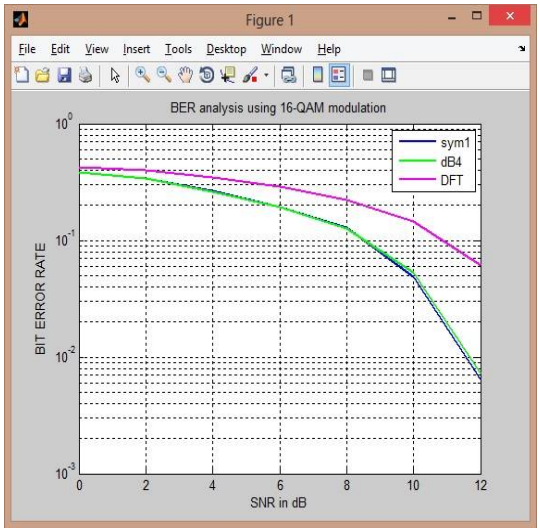

Fig4:- BER analysis of wavelets and DFT based system using 16 QAM modulation and AWGN channel

In fig3 symlet and dB4 wavelets are provides good result at different SNR. At some SNR the symlet wavelet based OFDM system provides better performance than dB4 wavelet based OFDM system and in some other range dB4 wavelet based OFDM system provides good performance than symlet wavelet based OFDM system. In fig 4 symlet wavelet based OFDM system provides better BER performance than dB4 wavelet based OFDM system in all over range. In fig 5 symlet wavelet based OFDM system provides better performance than dB4 wavelet based OFDM system and in some other range dB4 wavelet based OFDM system provides good performance than symlet wavelet based system. In fig6 symlet wavelet based OFDM system provides better performance than dB4 wavelet based OFDM system and in some other range dB4 wavelet based OFDM system provides good performance than symlet wavelet based system and in overall the wavelet based OFDM system using SUIEMODEL provides good BER performance with QPSK modulation technique than the other modulation techniques.

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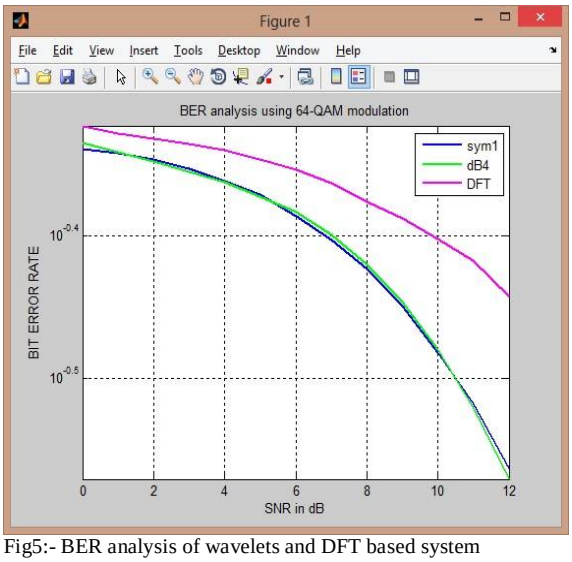

Fig5:- BER analysis of wavelets and DFT based system using 64 QAM modulation and AWGN channel

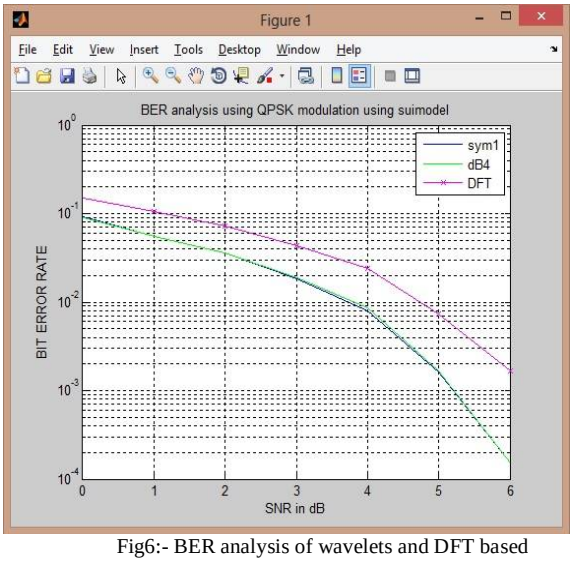

Fig6:- BER analysis of wavelets and DFT based system using QPSK modulation and suimodel

V I. CONCLUSION

In this paper we analyzed performance of DFT based OFDM system and WAVELET based OFDM sytem based on BER analysis by using different modulation techniques and different channels, the WAVELET based OFDM system gives better performance when compared DFT based OFDM system in case of different modulation techniques and different channels.In this paper we are using symlet and dB4 wavelets, both are giving good performance at different SNR and the wavelet based OFDM system with QPSK modulation technique and suimodel gives good performance in the lower cell range areas.

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