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MIMO-OFDM Performance Analysis between Discrete Fourier and Discrete Wavelet Transform Techniques in LTE

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Abstract: Orthogonal Frequency Division Multiplexing (OFDM) is one of the main techniques employed in 4th Generation Long Term Evolution (LTE). In OFDM because of loss of orthogonality between the subcarriers there is intercarrier interference (ICI) and intersymbol 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 OFDM is used at the place of Discrete Fourier Transform (DFT) based OFDM in LTE. Compared the BER performance of wavelets and DFT based OFDM and implementation is done for SISO antenna configuration. It is proposed to use MIMO antenna configuration. Also along with BER, SER plots can be taken .BER performance of MIMO configuration can be obtained.

Keywords: MIMO, LTE, OFDM, BER.

I. INTRODUCTION

In the current and future mobile communications systems, data transmission at high bit rates is essential for many services such as high quality audio and video and mobile integrated service digital network. When the data is transmitted at high bit rates, over mobile radio channels, the channel impulse response can extend over many symbol periods, which lead to Inter-symbol Interference (ISI). In OFDM signal the bandwidth is divided into many narrow sub-channels which are transmitted in parallel. Each sub-channel is typically chosen narrow enough to eliminate the effect of delay spread. OFDM is multi-carrier modulation technique for transmission of signals over wireless channels. It converts a frequency-selective fading channel into a collection of parallel sub channels, which greatly simplifies the structure of the receiver. The time domain waveform of the subcarriers are orthogonal, yet the signal spectral corresponding to different subcarriers overlap infrequency domain.

Hence, the available bandwidth is utilized very efficiently in OFDM systems without causing the ICI (inter-carrier interference).Wavelet transform is a tool for studying signals in the joint time–frequency domains. Wavelets have compact support (localization) both in time and frequency domain, and possess better orthogonality. Orthogonal wavelets are capable of reducing the power of inter symbol interference (ISI) and inter carrier interference(ICI) which are caused by loss of orthogonality betweenthe carriers as a result of multipath propagation over the wireless fading channels. In OFDM inter symbol interference (ISI) and inter channel interference (ICI) reduced by use of cyclic prefix (CP).

In wavelet based OFDM, CP is not required. CP is 20% or more of symbol. Thus wavelet based OFDM gives 20% or more bandwidth Efficiency. Wavelet based OFDM is less affected by Doppler shift. In wavelet based OFDM a prototype wavelet filter provides both orthogonality and good time–frequency localization. Wavelet provides phase linearity and significant out-of-band rejection. Itsenergy compaction is also high.

II. EXISTING SYSTEM

Compared the BER performance of wavelets and DFT based OFDM system. The performance comparison is based on SISO antenna configuration.

A. DFT BASED OFDM SYSTEM

OFDM is one of the main techniques employed in LTE to enhance the data rate. Spectrum efficiency and flexible utilization of spectrum is highly required today for different wireless communication related applications. In multicarrier communication the main idea is to divide the data into several streams and using them to modulate different carriers.

The two main advantages of multicarrier communication are, first one is there is no requirement of signal enhancement for noise which is required in single carrier because of the equalizers and second is because of long symbol duration reduced effect of fading. For conventional OFDM system sinusoids of DFT form an orthogonal basis function set.

In DFT the transform correlates its input signal with each of sinusoidal basis function, here orthogonal basis functions are the subcarriers used in OFDM. At the receiver the signals are combined to obtain the information transmitted. Practically, Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT) are used for the implementation of the OFDM system because less number of computations required in FFT and IFFT. Multiple replicas of the signal are received at the receiver end because of the time dispersive nature of the channel, so frequency selective fading results and to reduce this interference guard interval is used, which is called cyclic

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prefix. Cyclic prefix is copy of the some fraction of symbol end. As long as the channel delay spread remains within the limit of the cyclic prefix there would not be any loss in orthogonality. For LTE, in the downlink data of different users is multiplexed in frequency domain and access technique is called Orthogonal Frequency Division Multiple Access (OFDMA).

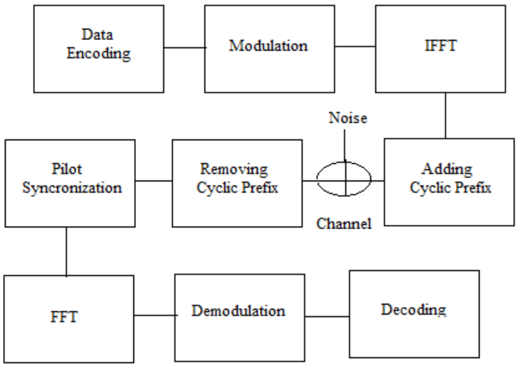

Fig. 1 DFT based OFDM transmitter and receiver

In the uplink of the LTE access technique used is Single Carrier-Frequency Division Multiple Access (SC-FDMA). High Peak Average Power Ratio (PAPR) occurs due to random constructive addition of subcarriers and results in spectrum spreading of signal leading to adjacent channel interference. So power linearization techniques and compression point amplifier need to be used to overcome this problem. These methods can be implemented at base station (BS), but are expensive to implement at user equipment (UE). Hence LTE uses SCFDMA with cyclic prefix on uplink, which will result in reduction of PAPR because of the presence of single carrier. Due to single carrier modulation effect of ISI will be high in uplink and to overcome from its effect low complexity equalizer will be required but SC-FDMA is not sensitive to frequency offset and Doppler shift. In OFDM subcarriers used are orthogonal to each other. Orthogonality causes the subcarriers to overlap in frequency domain, so the bandwidth efficiency is obtained without any ICI. ISI and ICI are generally caused by loss of orthogonality between the carriers caused by multipath propagation of the signal in Discrete Fourier Transform (DFT) based OFDM. ISI is between successive symbols of same sub-carrier and ICI is among different signals at different subcarriers. Both are avoided by use of cyclic prefixing which causes power loss and bandwidth inefficiency in DFT based OFDM.

B. WAVELET BASED OFDM SYSTEM

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. 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.

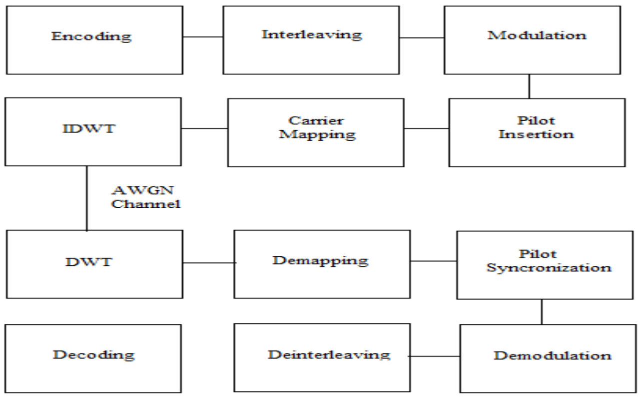

Fig. 2 Wavelet based proposed OFDM system design

As shown in figure 2, 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.

III. PROPOSED SYSTEM

It is proposed to use MIMO antenna configuration. Also along with Bit Error Rate (BER), symbol error rate (SER) plots can be taken and BER comparison for different MIMO configuration can be obtained.

A. MIMO antenna configuration

Multiple input multiple output (MIMO) achieves better BER than the existing single input single output (SISO) system at the same signal to noise ratio (SNR).MIMO

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system delivers higher data rate. Selection combining technique is used at the receiver where the strongest signal is selected.

Fig. 3 MIMO antenna system

IV. 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 4-12. Modulations that could be used for LTE are QPSK, 16 QAM and 64 QAM (Uplink and downlink).

A. Results for SISO antenna system

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 fig. 4, fig. 5 and fig. 6 that the BER performance of wavelet based OFDM is better than the DFT based OFDM.

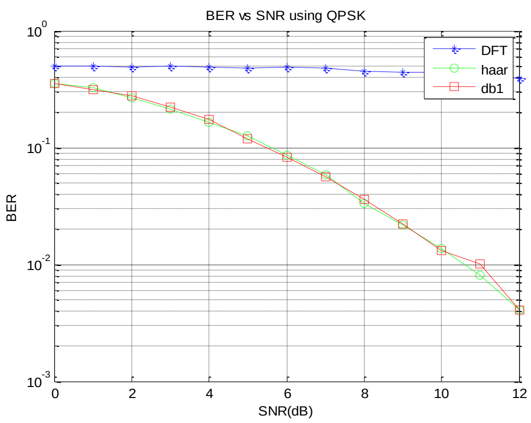

Fig. 4 BER performance of DFT and wavelet using QPSK

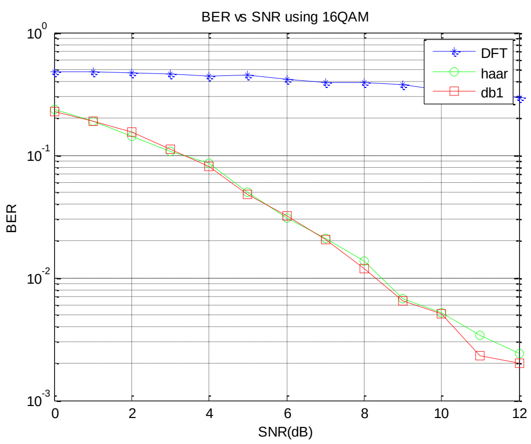

Fig. 5 BER performance of DFT and wavelet using 16-QAM

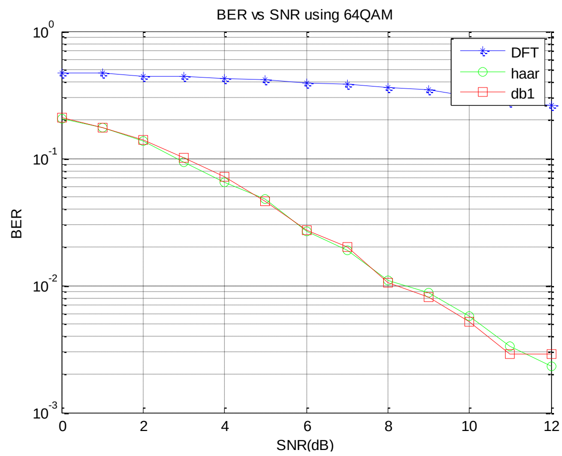

Fig. 6 BER performance of DFT and wavelet using 64-QAM

B. Results for MIMO antenna system

It is clear from the fig. 7, fig. 8 and fig. 9 that the BER performance of MIMO antenna system is better than SISO antenna system.

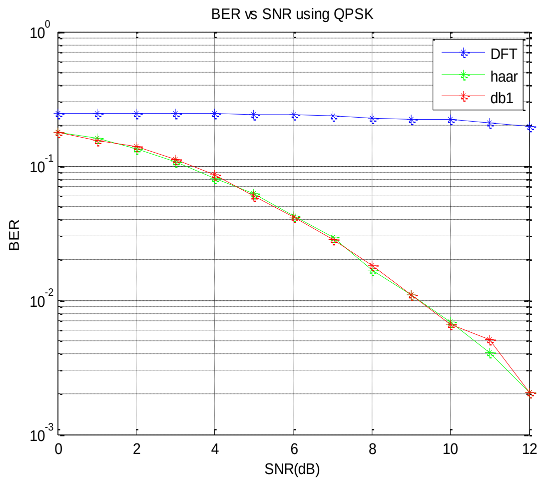

Fig. 7 BER performance of DFT and wavelet using QPSK

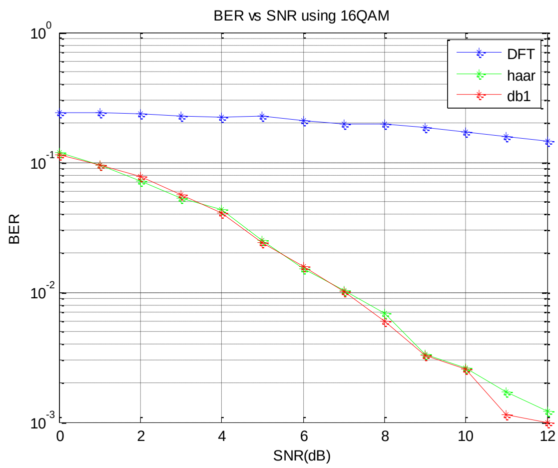

Fig. 8 BER performance of DFT and wavelet using 16-QAM

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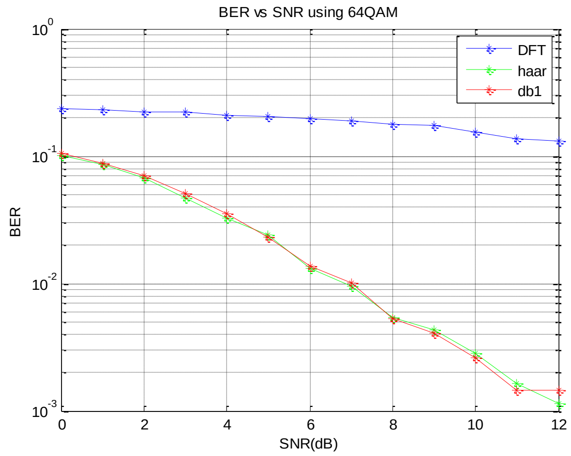

Fig. 9 BER performance of DFT and wavelet using 64-QAM

C. SER comparison

SER 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 10-12.

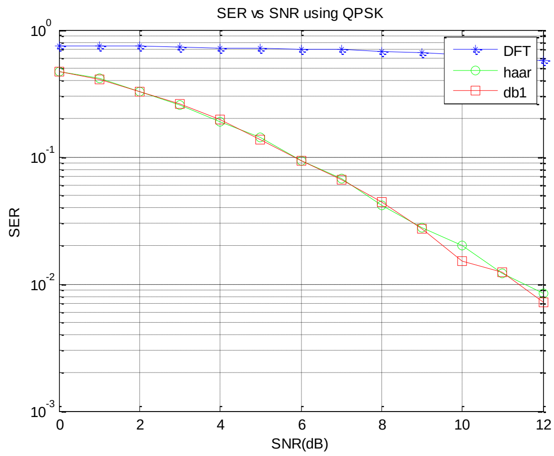

Fig. 10 SER performance of DFT and wavelet using QPSK

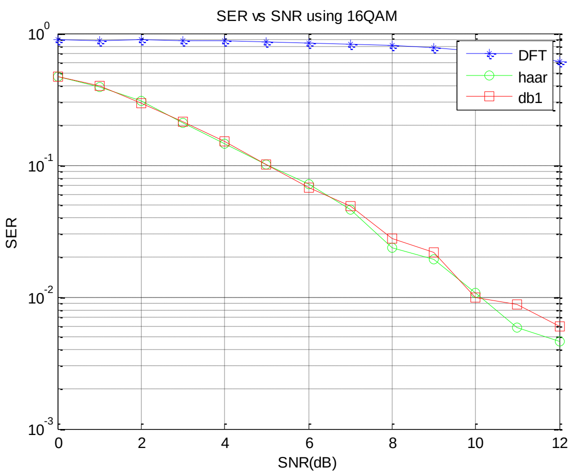

Fig. 11 SER performance of DFT and wavelet using 16-QAM

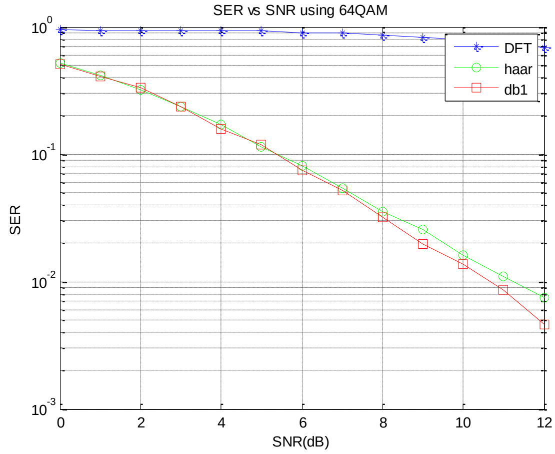

Fig. 12 SER performance of DFT and wavelet using 64-QAM

V. CONCLUSION

Performance analysis of wavelet based OFDM system and compared it with the performance of DFT based OFDM system. From the performance curve it is clear that the BER curves obtained from wavelet based OFDM are better than that of DFT based OFDM. The system proposed can deliver better transmission characteristics than the existing system. The proposed system increases the spectral efficiency as well as power efficiency.

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BIOGRAPHY

M.Jayalakshmi received the B.Tech degree in Electronics and Communication Engineering from M.G University in 2013. Currently pursuing M.tech in Communication Engineering at Mount Zion College of Engineering under M.G University. She works with Mobile Communication field and studying the same field for the last 3 years. Works in developing MATLAB based systems for LTE based systems and published more than 3 papers on the same.