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STUDIES ON DWT BASED OFDM FOR LTE SYSTEM

A. Delphina Josline and N. Hariprasad
Department of Electronics and Telecommunication Engineering, Sathyabama University, Tamil Nadu, India
E-Mail: adelphij@gmail.com

ABSTRACT

Long Term Evolution (LTE) is a technology that allows operators to achieve a very high data rate of 4G and more. Different types of modulation and multiplexing schemes are used in order to form high data rate systems. Orthogonal Frequency Division Multiplexing (OFDM) is one such modulation and multiplexing scheme which offers very high data rate. IFFT and FFT block forms the major part of OFDM transmitters and receivers respectively in the conventional OFDM system that is used currently. In order to increase the data rate further, the FFT based OFDM system is replaced by DWT based OFDM. This paper provides the comparison between the conventional OFDM and DWT based OFDM system with-in the technical limitations as applicable for LTE systems.

Keywords: LTE, FFT OFDM, DWT OFDM, BER.

1. INTRODUCTION

The number of mobile users are ever increasing day to day this leads to the demanding increase in the data rate for the users. The new era wireless system in order to meet the demands of the user needs different types of new generation wireless system such as LTE (Long Term Evolution), this is one of the scenarios which promises a very high data rate of 4G and more. LTE is widely known as 4G LTE, it is a standard for wireless communication to provide high-speed data for mobile phones and data terminals. This system offers a high data rate of 100Mbps for downlink and 50Mbps for uplink; the bandwidths that can be considered are 1.4, 2.5, 5, 10, 15 and 20MHz [1]. In order to increase the capacity and speed of wireless data networks latest signal processing techniques and modulations schemes are made use of. The LTE technology offers a number of advantages over other wireless technologies such as increased data rate, decreased latency, supports variable bandwidth, compatible with the earlier versions or the older networks [2]. LTE has the ability to manage and support fast-moving mobiles and also provides for the usage of multi-cast and broadcast streams. It also supports both frequency-division duplexing (FDD) and time-division duplexing (TDD). The requirements of an LTE system are met by Orthogonal Frequency Division multiplexing (OFDM).

OFDM is a Frequency-division multiplexing (FDM) based scheme which is used as a digital multi-carrier modulation method. It is a better technology for broadband data transfer. This method works on the principle of separating a single signal into a number of subcarriers which implies that the extremely fast signals of high rate data-streams are divided into numerous slow signals having low rate data-streams and transmitted [3]. These numerous subcarriers are then collected at the receiver and are recombined together forming a single high speed signal corresponding to the initially transmitted signal. The data stream before being transmitted is modulated using the Phase Shift Keying schemes [4]. The divided carrier signal after this stage is again modulated on the main carrier that is considered using Inverse Transform. This signal is added with the cyclic prefix at this stage. This process is carried out at the transmission side, to this signal at the receiving end corresponding Transform is performed to retrieve the subcarriers and demodulation is done to retrieve the data. Figure-1 shows the block diagram of an OFDM based LTE system.

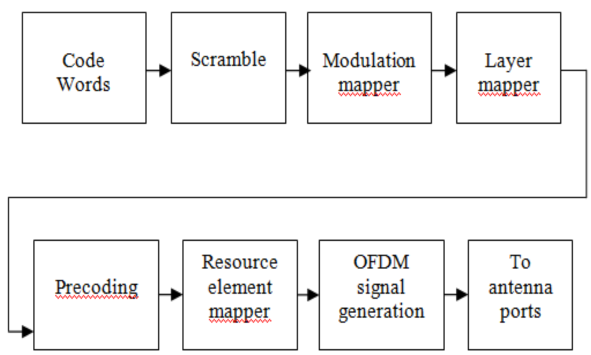

Figure-1. OFDM based LTE system.

The OFDM system is sensitive towards synchronizations errors which might disturb the orthogonality among the subcarriers hence CP is added to avoid inter-symbol interference (ISI) and inter-carrier interference (ICI) [5]. The inter-symbol interference denotes the interference between the successive symbols present in the same sub-carrier and inter-channel interference denotes the interference occurring between two symbols present in different sub-carriers. Cyclic prefix is This leads to the need for proper synchronization at the receiving end. This multicarrier modulation scheme offers better performance over single-carrier modulation methods. This method when used offers advantages like frequency selective fading and narrow-band interference over other wireless technologies available [6]. Figure-2 shows the block diagram of an OFDM system.

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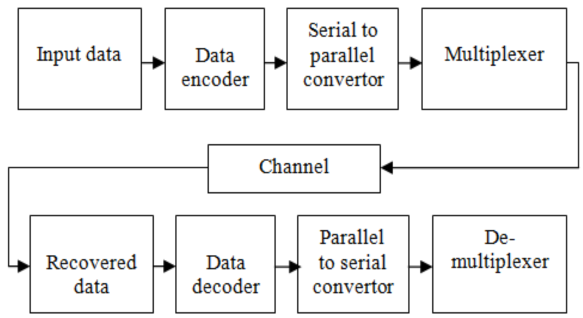

Figure-2. OFDM system.

In the following sections, section II presents FFT-OFDM for LTE system. Section III presents the system model. Section IV presents the various simulation parameters and section V presents the various computer simulation results of the proposed method, and section VI concludes the paper.

2. EXISTING IFFT/FFT BASED SYSTEM

The development of the communication system in the recent years which are based on OFDM is an important factor for the research and implementation of FFT/IFFT algorithms [7]. In a conventional OFDM system the approach used is the IFFT/FFT based system. The system makes use of the IFFT and FFT algorithms at the transmitter and the receiver respectively. The signals are multiplexed and transmitted simultaneously over a number of subcarriers that are available for data transfer. The input stream of data is fed to the system these are subdivided into M number of sub channels by passing through a serial to parallel convertor thus producing M parallel streams of data. These M symbols are passed over to the IFFT block which performs L point IFFT operation. The output of this stage is in the form of time domain signal thus producing L time-domain samples. After this stage cyclic prefix is added in order to ensure orthogonality and to avoid inter symbol interference by forming a guard interval. The ISI may occur in the multi path channel due to the previously delayed transmitted bits. Hence in order to ensure proper transmission without interference the cyclic prefix is added. The obtained processed signal is then passed over the channel. At the receiver end the signal is distorted due to the presence of the noise and the interferences that are present in the channel disturbing the transmitted signal. The received signal is again processed to retrieve the original data by removal of the cyclic prefix and then serial to parallel conversion. The obtained signals are passed through an L-point FFT which converts the signal back to the frequency domain signal. This corresponds to the original M output samples. The modulation carried out is using 16-QAM. This FFT based OFDM system is incorporated in the LTE system. In the system cyclic prefix (CP) is used in order that the interference between the symbols present in the subcarriers is avoided. However the usage of CP reduces the data throughput and the efficiency. It also reduces the spectral containment of the channel which is a disadvantage [3,8]. Due to these disadvantages present the alternate method suggested to replace Fourier based analysis is the Wavelet analysis.[3,8].

3. SYSTEM MODEL

The proposed model is an IDWT/DWT based OFDM for an LTE system. The analysis of the low and high frequency signals are possible using this wavelet analysis. To measure the low frequency movements the wavelets stretches into long functions making it possible to analyze the very small changes in the signal. In the similar way in order to analyze very high frequencies the wavelets are compressed to short functions. The signal is obtained by filtering the signal iteratively into the high frequency components and low frequency components. The input signal is passed into a low pass filter and a high pass filter [9]. The high pass filter is denoted by s[n], it allows all the high frequency signals. The low pass filter is denoted by r[n], it allows the signal below the highest frequency. This process is carried out iteratively by decomposition of the signal. In this filtering process the down sampling is done by a factor of 2. The Figure-3 represents the decomposition of the signal.

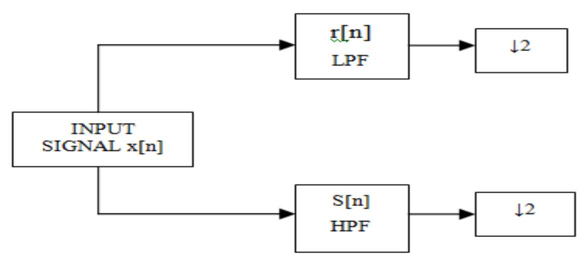

Figure-3. wavelet decomposition.

The decomposition signal is denoted by the following representation,

$$Z_{LOW}(k) = \sum_{n=0}^{m} x(n)\, h(2k-n) \quad (1)$$

$$Z_{HIGH}(k) = \sum_{n=0}^{m} x(n)\, g(2k-n) \quad (2)$$

The Figure-4 represents the DWT-OFDM for an LTE system. This model makes use of the haar wavelet to perform the desired operations. The mathematical representation of the haar wavelet is ,
If k = 0 , Haar function is defined as a constant,

$$h_o(t) = 1/\sqrt{N} \quad (3)$$

If k > 0 , Haar function is defined as,

$$h_k(t) = 1/\sqrt{N} \begin{cases} 2^{\frac{p}{2}} & \frac{q-1}{2^p} \le t < (q-0.5)/2^p \\ 2^{\frac{p}{2}} & \frac{q-0.5}{2^p} \le t < q/2^p \end{cases} \quad (4)$$

otherwise is 0. In this representation, $k = 2^p + q - 1$.

The wavelet used in this model implementation is Haar wavelet. The input to the system from the code generator is encoded and passed to perform the modulation scheme which in this system is 16-QAM. 16

QAM (Quadrature Amplitude Modulation) is that, where it has 16 state. It has four different amplitude levels.

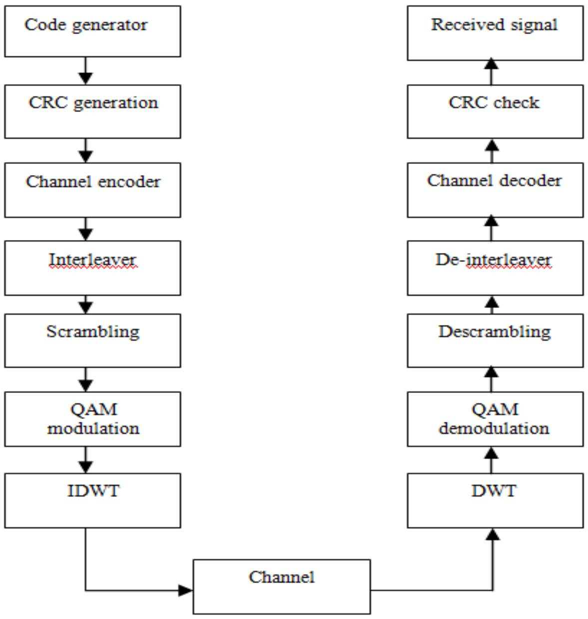

Figure-4. DWT-OFDM for LTE system.

The modulation process is performed on the channels that are considered. Over this processed signal inverse wavelet transform is carried out and is used for transmission. The signal at this stage is the output and is sent over the channel. At the receiving end the signal is processed in the reverse manner so as to retrieve the original signal that was initially considered for the process. The (Haar) chosen wavelet for the simulation purpose is found to have lesser error rate when compared to that of FFT-OFDM for LTE system.

4. SIMULATION PARAMETERS

We evaluate the Bit Error Rate in the system model of the FFT-OFDM based LTE system and DWT-OFDM based LTE system. The parameter of OFDM is considered as per the LTE standard of sub-channel spacing 15 kHz and a bandwidth 10 MHz. The table below shows the simulation parameters that are used in the implementation process.

Table-1. Parameters.

S. No.	Type of LTE system		
	Parameters	**FFT-OFDM for LTE**	**DWT-OFDM for LTE**
1	Number of bits	256	256
2	Block size	25	25
3	Cyclic prefix	Yes	No
4	Size of FFT	16	No
5	Modulation	16 QAM	16 QAM

5. SIMULATION RESULTS

The transforms that were used for OFDM in LTE system are FFT and DWT. The simulation is obtained for EbNo and BER. The simulation design of 16-QAM is carried out for both FFT-OFDM for LTE system and DWT-OFDM for LTE system. The parameter of OFDM as per the LTE standard of sub-channel spacing 15 kHz and a bandwidth 10 MHz which has the size of FFT as 512 is implemented. A 16-QAM modulation is used. Figure-5 shows the performance of such a system of FFT-OFDM for LTE system. Figure-6 shows the performance of DWT-OFDM for LTE system.

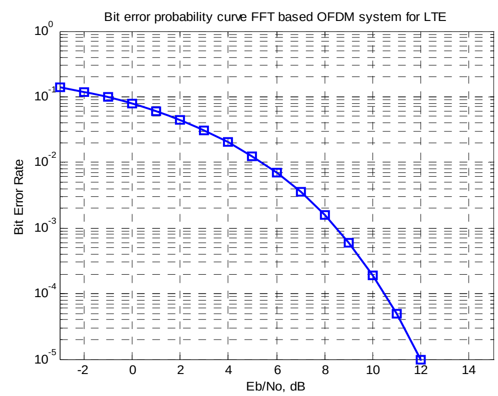

Figure-5. FFT-OFDM for LTE system.

Figure-5 indicates the simulation done for Eb/No for the range -2 to 14. The modulation technique used for implementation is 16-QAM and is used with the cyclic prefix. The results indicate that the error rate is 12 dB.

The BER plot for DWT-OFDM is given in Figure-6 it indicates the simulation done for Eb/No for the range -2 to 14. The modulation technique used for implementation is 16-QAM. The wavelet used for this simulation process is Haar. During the simulation process other wavelet functions were also checked but Haar function shows better performance.

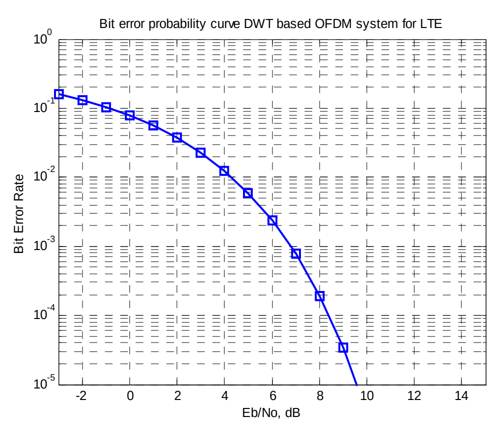

Figure-6. DWT-OFDM for LTE system.

The wavelet based OFDM for LTE system simulation model is similar to that of the conventional OFDM used for LTE system. Cyclic prefix is needed in FFT-OFDM for LTE whereas it is not needed for DWT-OFDM for LTE system. The results indicate that the error rate for this simulated analysis is 9.5 dB.

6. CONCLUSIONS

The behavior of DWT-OFDM for LTE system and FFT-OFDM for LTE system is studied and simulation is done for the same. DWT based analysis is suggested as an alternate for FFT based analysis. . Unlike Fourier transform based system which requires cyclic prefix, during transmission cyclic prefix is not needed in wavelet based analysis.16-QAM modulation is used in the simulation process. Haar function is used in the wavelet analysis as it provides a better performance when compared with the other wavelet functions. For the OFDM the parameters for LTE specifications of sub-channel spacing 15 kHz and a bandwidth 10 MHz has been used. The results were plotted in terms of BER and EbNo. Through comparison of the results it is clear that DWT-OFDM for LTE system is superior when compared to that of FFT-OFDM for LTE system. The error rate can be minimized by using DWT-OFDM for LTE when compared to FFT-OFDM for LTE.

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