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Evaluating the Impact of OFDM Parameters on the Operation of the LTE System in Different Conditions

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Abstract: *These days we find an enormous growth in wireless communication technologies. The use of OFDM in wireless systems has created a way to provide high data rates, less intercarrier interference(ICI), and less intersymbol interference(ISI). OFDM has become the core of most 4G communication systems, a Long Term Evolution (LTE) system. OFDM system divides the available signal spectrum into smaller bandwidths and transmits them to the receiver without interference with each other by inserting the cyclic prefix in between the signals. LTE uses OFDM for downlink, SC-FDMA for uplink and MIMO for enhanced throughput. The OFDM uses inverse fast fourier transform(IFFT) and fast fourier transform(FFT) for conversion of data. The system performance is measured by correlating the signal to noise ratio to bit error rate. The system performance is evaluated to study the effect of various LTE design parameters by simulating in MATLAB*

Keywords: Orthogonal Frequency Division Multiplexing (OFDM); Inverse Fast Fourier Transform (IFFT); Fast Fourier Transform (FFT); Cyclic Prefix (CP); Bit Error Rate (BER); Signal to Noise Ratio (SNR).

I. INTRODUCTION

OFDM is a multicarrier modulation technique used in wideband digital communication because of its ability to cope with severe channel conditions without complex equalization filters;e.g. attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath. Channel equalization is simplified because OFDM may be viewed as using many slowly- modulated narrow band signals rather than one rapidly- modulated wideband signal. The low symbol rate makes the use of a guard interval between symbols possible affordable, making it to handle time-spreading and eliminate ISI and ICI[1-8].The aim of our paper is to give an idea of what is an OFDM system, its main structure and the analysis of the obtained results of the simulations testing. This OFDM system is able to support different M-QAM modulation schemes. Also this paper aims to study the effect of the variation of different design parameters on OFDM systems with different digital modulation schemes. The next part of this paper is organized as follows; section-II provides the related work, section-III introduces OFDM overview, LTE and section-IV presents simulation results, and conclusions.

II. RELATED WORK

Moisés Serra [3] shows the design of an OFDM transmitter as a part of an OFDM demonstrator Hiperlan/2 based, Ma. José Canet [4] shows implementation issues of a digital transmitter for an OFDM based WLAN systems and benchmarks some optimized VHDL area results against System Generator results, Canet's work is focused on the solutions for the OFDM signal generation in base-band and in intermediate frequency (IF). Chris Dick [5] emphasizes the suitability of high- level design tools when designing sophisticated systems, and the importance to design FPGA systems rather than ASIC to one day accomplish the SDR "Software Defined Radio" concept and gives a high-level overview of the FPGA implementation giving some deep to the synchronization, packet detection, preamble correlate channel estimation and equalization; that is mainly at the OFDM receiver. Ludovico de Souza et al. [6] present a FPGA implementation capable to support 802.11 wireless modems but just as a validating and prototyping stage for an ASIC. Joaquin Garcia, Rene Cumplido [7] focuses on the FPGA suitability to support IF processing for the Std. IEEE 802.11a and the resource area and timing requirements either for rapid prototyping or to take advantage of re- configurability

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in order to be able to support different standards. Y. Awad, L. H. Crockett and R. W. Stewart [8] investigate the efficient FPGA implementation of an OFDM transceiver design for the IEEE 802.20 physical layer. Paul Guanming Lin [9] demonstrates the concept and feasibility of an OFDM system, and investigates how its performance is changed by varying some of its major parameters. This objective is met by developing a MATLAB program to simulate a basic OFDM system. O. Grigoriadis, H. S. Kamath [8]use a MATLAB simulation of OFDM to see how the BER of a transmission varies versus the SNR

III. OFDM OVERVIEW & LTE

OFDM is digital modulation scheme used in broadband wireless systems that encounter large delay spreads. OFDM avoids temporal equalization with the help of a cyclic prefix technique with a small penalty in channel capacity. line of sight propagation means the transmitter and receiver should be installed such that they are visible to each other. Wherever Line-of-Sight (LoS) is not achievable then it results in multipath dispersion, which could limit the maximum data rate. OFDM technology is the best suited to overcome these difficulties, allowing nearly arbitrary data rates on dispersive channels. [1].

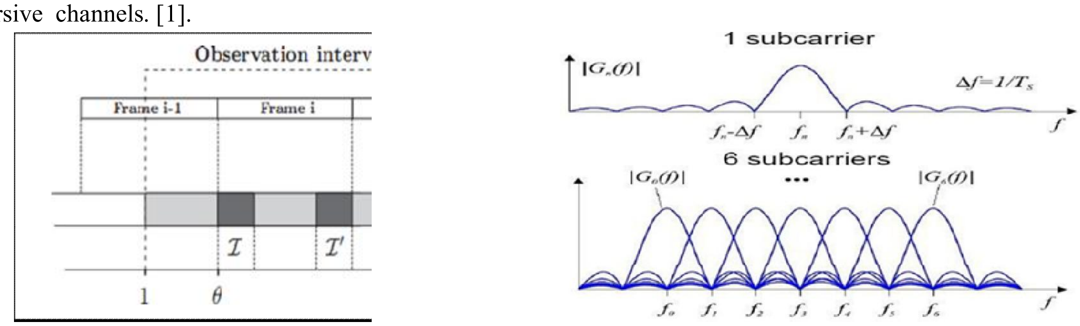

Fig.1 OFDM Subcarriers in Frequency Domain

Each subcarrier can be modulated independently as shown in Fig.3.1 The frequency spectra of the subcarriers overlap, but the subcarrier signals are mutually orthogonal as shown in Fig. 3.1 [11].orthogonal means phase shift is maintained in between the signals to avoid interference.

A. Advantages of OFDM

In general, OFDM systems have the following advantages: (i) better usage of t h e spectrum.; (ii) resistant to frequency selective fading; (iii) Eliminates ISI (Inter-Symbol Interference) and ICI (Inter-Carrier Interference); (iv) can recover lost symbols due to the frequency selectivity of channels; (v) channel equalization; (vi) computationally efficient [1].

B. Disadvantages of OFDM

OFDM systems have the following disadvantages:
(i) High synchronism accuracy;
(ii) Multipath propagation must be avoided in other orthogonality not be affected, and
(iii) high peak-to-average power ratio.

C. OFDM Transceiver

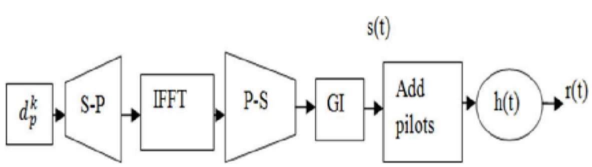

Fig. 2 OFDM block diagram

D. OFDM Transmitter

The main components of OFDM transmitter are shown in Fig.3 [8]. The randomizer is used as random bit generator. The first three blocks are used for data coding and interleaving. The coded bits will be mapped by the constellation modulator using Gray codification, this way an + jbn values are obtained in the constellation of the modulator. The serial to parallel converter converts the data bits from the serial form to the parallel form. The Inverse Fast Fourier Transform (IFFT) transforms the signals from the frequency domain to the time domain; an IFFT converts a number of complex data points, of length that is power of 2, into the same number of points but in the time domain. The number of subcarriers determines how many sub-bands the available spectrum is split into [1, 2]. The Cyclic Prefix (CP) is a copy of the last N samples from the IFFT, which are placed at the beginning of the OFDM frame to overcome ISI problem. It is important to choose the minimum necessary CP to maximize the efficiency of the system [6].

E. OFDM Receiver

The main blocks of OFDM receiver are observed in Fig.3 [9]. The received signal goes through the cyclic prefix removal and a serial-to-parallel converter [1]. After that, the signals are passed through an N-point fast Fourier transform to convert the signal to frequency domain. The output of the FFT is formed from the first M samples of the output. The demodulation can be made by DFT, or better, by FFT, that is it efficient implementation that can be used reducing the time of processing and the used hardware [4]. FFT calculates DFT with a great reduction in the amount of operations, leaving several existent redundancies in the direct calculation of DFT [3-5].

F. OFDM symbols

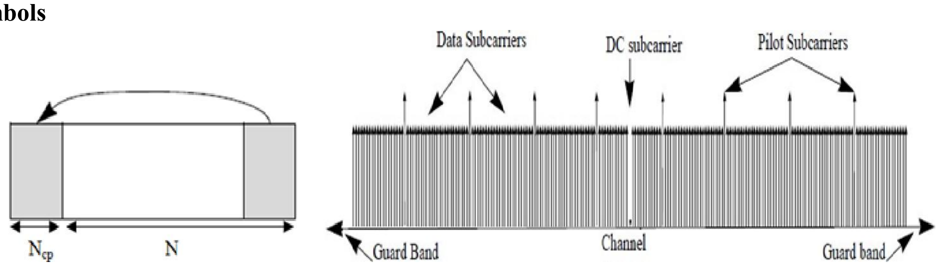

Fig. 4: OFDM symbol in frequency domain

OFDM symbols can be represented both in time domain as well as frequency domain. It consists of guard band, subcarriers, etc. guard band is used to separate the subcarriers to avoid interference. In OFDM the guard band is called the cyclic prefix. A cyclic prefix is a part of the last symbol used.

G. Long Term Evolution(LTE)

LTE is a 4G wireless standard used for mobile phones and data terminals for high speed communication. The 3GPP(third generation partnership project) developed this standard. LTE is employed in both indoor and outdoor environments. LTE uses OFDM for downlink and SC-FDMA for uplink. LTE uses FDD,TDD and half duplex FDD duplexing. LTE supports 1.4, 3,5,10,15,20MHz frequencies. The modulation 75Mbps,150 Mbps, 300Mbps etc.

IV. METHODOLOGY

A Modulations used The types of modulations used in both indoor and outdoor environments are PSK and QAM.
In this part the simulation of different OFDM systems with different M- QAM schemes using MATLAB Simulink tools will be obtained. The effect of different parameters on the simulation of the OFDM system using MATLAB program is discussed through the following experiments. After that the comparison between these systems will be illustrated and then we can determine the best one of them.

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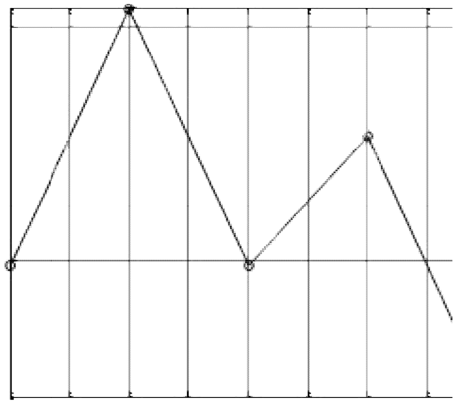
V. SIMULATION RESULTS

Indoor (16-QAM)

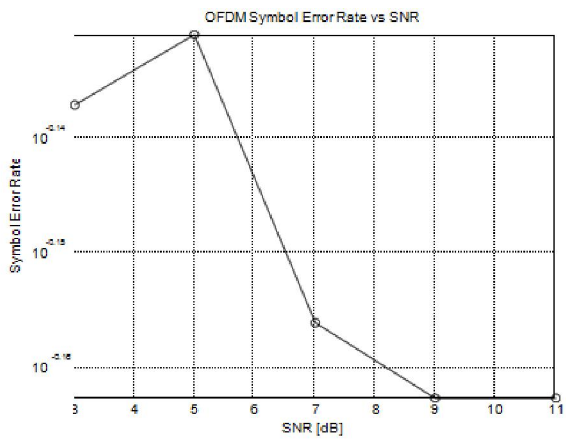
OFDM Symbol Error Rate vs SNR



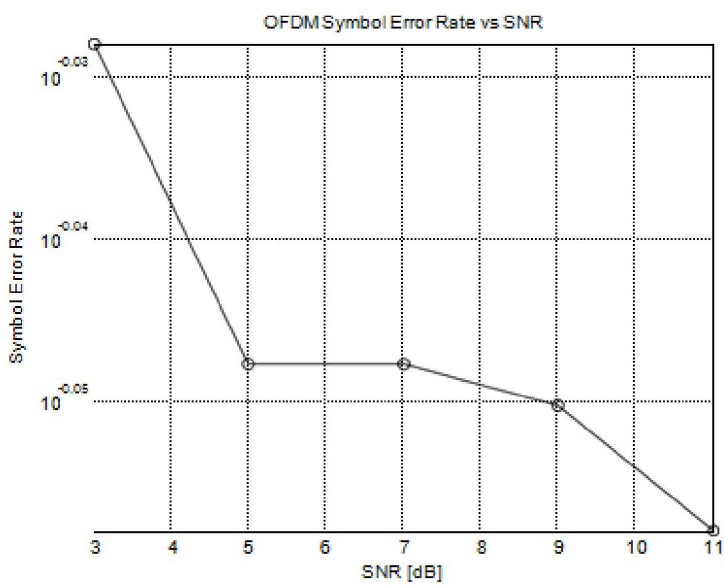
Symbol error rate

SNR [dB]

Outdoor(16-QAM)



Outdoor 32 QAM



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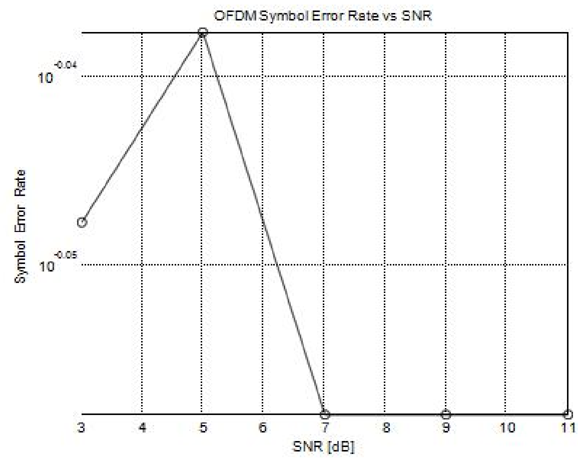
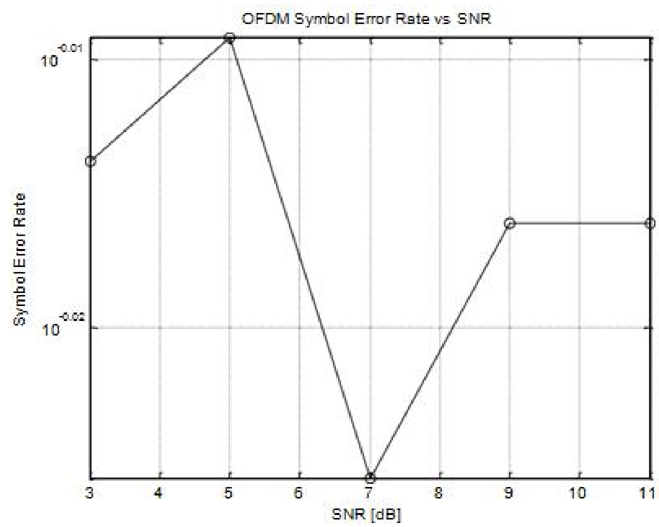
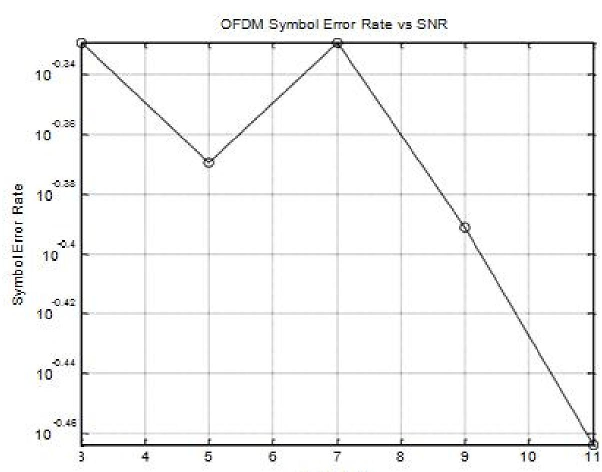
Indoor(16-PSK)



Indoor(32-PSK)



Outdoor(16-PSK)



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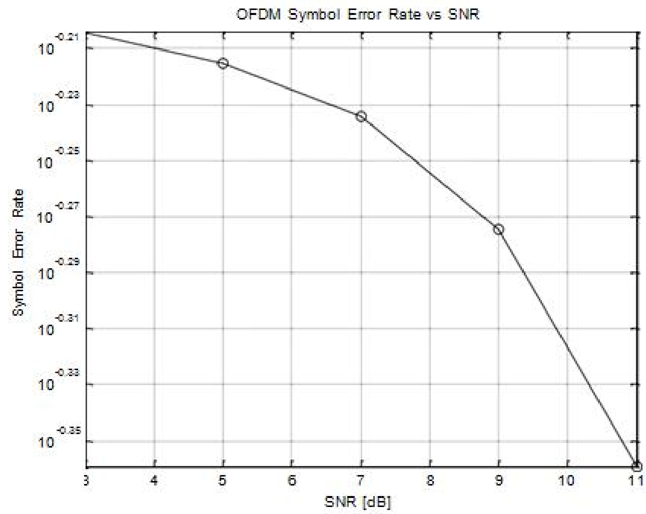
Outdoor(32-PSK)



All the above graphs are plotted for SNR Vs Symbol error rate. The signal to noise ratio indicates the signal power to noise power ratio. More signal power means better efficiency of the system, more noise power indicates less fficiency.

A Experiment-1

The simulation results for the 16-points FFT and 32- points FFT were presented in the above figures for OFDM with 16-QAM, 32-QAM in both LTE indoor and outdoor systems. The result from this experiment is that the more FFT/IFFT length, the more accurate and more practical use of OFDM system; i.e. more subcarriers can be used as shown from the spectra of OFDM signals that are observed in the previous figures.

B Experiment-2

The simulation results for the 16-points FFT and 32- points FFT were presented in the above figures for OFDM with PSK modulation in both indoor and outdoor LTE systems.

VI. CONCLUSION

The simulation results for OFDM system with different M- QAM and PSK schemes have been observed. There were two experiments for that; in the two experiments the changing of FFT/IFFT length has been studied for LTE indoor and outdoor systems. After that the comparison between different OFDM systems has been discussed and we get that the optimum system is the OFDM system with 32-QAM for max SNR and min BER values.

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