OFDMA FOR 4G/5G LTE BASED SYSTEM USING 16QAM TECHNIQUE

ABHISHEK B. M[1], DR B. R. SUJATHA[2]

[1]*M Tech Electronics and communication, Malnad College of Engineering, Hassan, Karnataka, India*

[2]*Associate professor, Head of Department,Electronics And Communication, Malnad College of Engineering, Hassan, Karnataka, India*

Abstract— *OFDMA provides the transmission of large amount of data by sharing the bandwidth to the more number of users. The users can access the data without any delay or distortion. The technique used in this is by subcarriers which carriers the small amount of data. The number of subcarriers will provide the access for the more number of users. While transmitting the data they undergo few factors i.e. Bit Error Rate, low PAPR. Hence this paper is focused on OFDMA with modulation technique 16 QAM which provides quadrature orthogonal accessing of data in the physical layer*.

Key words— **LTE Long Term Evolution, QOS Quality Of Service, PRB Physical Resource Block, TTI Transmit Time Interval, 3GPP Third Generation Partnership Project**.

1. INTRODUCTION

OFDMA is used in LTE downlink process. It can be explained by packet scheduling scheme like 802.11a. Now a days it is a right core technology in wireless communication. When a data is transmitted over a channel in a bandwidth it is distorted due to multipath this can be avoided by breaking the available bandwidth into number of sub carriers. However it results in bandwidth flexibility and better frequency diversity and it leads to complexity and high system cost. The important elements in wireless communication are the channel estimation and the channel parameters which improves the performance of wireless systems as well as OFDMA systems.

There are two important factors in this technique namely:

1. Subcarriers
2. Symbols

Each of the above are independently helps the user to access the data by reserving some frequency in the bandwidth for the transmission of some data and few symbols. Again few frequencies are allotted for remaining data hence entire process will follow this until the required transmission is completed.

The 3GPP and IEEE 802.11a also utilizes OFDMA as the basic modulation scheme. Hence 802.11a uses CSMA which is essentially a listen before talk scheme. For example when access point becomes more traffic for a station, it monitors the activity of the channel. When it becomes idle, it starts to decrease as internal timer which is randomized as long as the access point is idle. When it becomes zero the access point will starts transmit a packet by PHY layer of about 2000 bytes to a specific station. The back-off period reduces collisions but it cannot be completely eliminated.

1.1 Conventional Packet Oriented Network LTE 802.11A with a PHY Layer Preamble and Header

Every 802.11a packet in the PHY layer uses the entire bandwidth for the transmission of packets. The 802.11a PHY network packet is shown in figure 1.

It contains data payload of length 64 to 2048 bytes. If the transmission of packet is successful the receiving station sends an acknowledgement. Rests of the packets that are unacknowledged are discarded. Hence each packet is followed by a PHY preamble which is 20 microsecond in duration. The main aspects of PHY preamble are

1. Signal Detection
2. Antenna Diversity Selection
3. Setting AGC
4. Frequency Offset Estimation
5. Timing Synchronization
6. Chanel Estimation

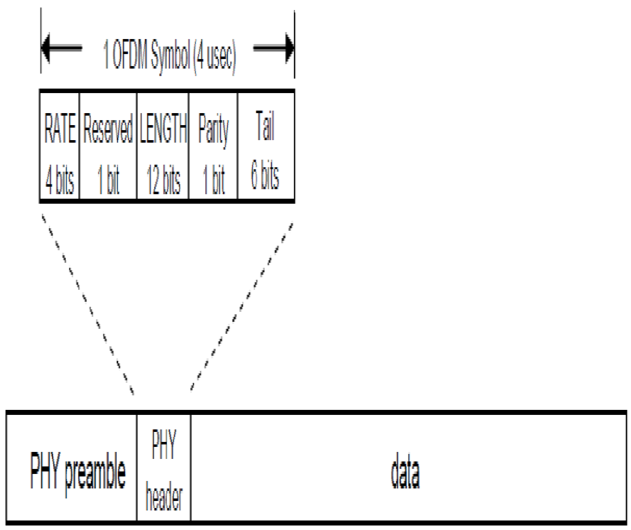

Fig 1 conventional packet oriented network with preamble and header

The address of projected recipient is not present in PHY preamble. Because it is present in packet data and it is deduced at MAC layer. The packet oriented method of 802.11a has the advantage of simplicity. Every packet is assigned to a particular recipient. Although the back off period of CSMA scheme is in idle time. So it offers an inefficiency. This preamble is also overhead of network and it reduces efficiency especially for small packets. In general the efficiency of an 802.11a system is about 50percent i.e ,a network with a data of 54Mbps, the typical throughput is about 25-30Mbps. Few inefficiencies can be reduced by minimizing the usage of CSMA. The present versions of protocol include this approach. The unacknowledged packets can also be reduced by acknowledging packets in groups rather than separately. Instead of many improvements it is very difficult to drive packet oriented network efficiency beyond 65 to 70 percent.

2. METHODOLOGY

I. Different coding algorithms are employed for the DL physical channels. For the common control channel (CCPCH).
II. Modulation is restricted to QPSK.
III. The PDSCH uses up to 64 QAM modulation. For control channels, coverage is the paramount requirement..
IV. The PDSCH uses QPSK, 16QAM, or 64QAM depending on channel conditions. As a result, coding gain is emphasized over latency.
V. Rate 1/3 turbo coding has been selected for the PDSCH.

3. SYSTEM DESCRIPTION

LTE has the specifications which can fulfill the requirements of next generation mobile networks. In order to enhance the performance of mobile communication few factors like low latency, higher system throughput and high data rate system are designed. It focuses on the usage of frequency bands which results in low last per bit, low terminal power utilization and a large area of services with high data rate and low cost. The typical downlink data rate is about 100Mbps in a 200MHZ downlink spectrum and 50Mbps maximum rate. It has a scalable bandwidth from 20MHz, 15MHz, 10MHz and less than 5MHz. OFDMA allows parallel transmission of data on orthogonal narrow band subcarriers.

In OFDMA the FFT space is splits into sub channels. These sub channels in a group forms a subcarrier. In order to reduce the frequency selective fading the subcarriers from one sub channel are spreaded along the transmitted channel spectrum. Hence each and every user will be allocated one or more sub channels within one OFDM symbols. However to sufficiently place the number of users, the number of subcarriers in the OFDMA is usually very large. The number of users directly relates to the efficiency and performance of OFDMA systems which offers much flexibility and better frequency diversity. Thus it leads to higher system cost and complexity.

They are categorized into three problems they are:

- Each receiver has to be implemented an N-point FFT in downlink and it does not offers the large number of sub channels or subcarriers that the user acquires in one OFDM symbol. If the number of subcarriers is high the complexity associated with FFT in each user's receiver is also high.
- It has a severe PAPR because of large number of users.
- Finally the entire system is very sensible to the CFO because of the small subcarrier duration. These are the problems exists in number of byte in IEEE 802.16a.
- In OFDMA system since the channel is subdivided into sub channels the transmission is in parallel which increases the symbol duration and reduces the ISI. The signals are placed in reciprocally perpendicular to the axis at right angles to one another and their sum is equal to zero which eliminates mutual interference.

4. BLOCK DIAGRAM

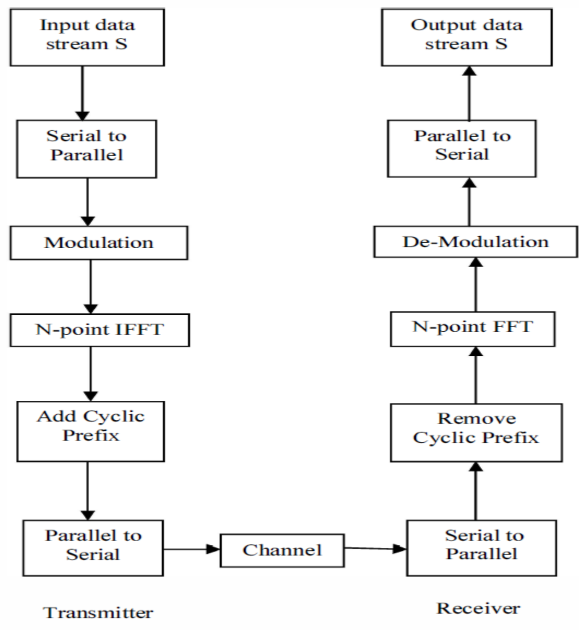

Figure 2. shows the block diagram of OFDMA.

At first N symbols are generated randomly and transmitted to the transmitter. These symbols are passed to the serial to parallel converter and the data on every line. The input data stream on each carrier is then mapped by using anyone one of the modulation schemes i.e QPSK. Then inverse FFT provides the corresponding time waveform. Then the N symbols are sent to the IFFT and performs the N-FFT operation. The output is N time sample. Then the guard intervals are added at the start of each sample and are known as addition of cyclic extension in the prefix. Then the length of output signal is extended. Then it is passed through the serial to parallel converter and it is transmitted through a channel. The channel is applied to transmit the signal. It allows the signal to noise ratio to be controlled. These signals are set by inserting a sufficient amount of Additive White Gaussian Noise.

At the receiver the reverse operation of the transmitter section takes place. The transmitted signal is passed by the channel are then converted by serial to parallel converter and the guard interval is removed. Then it is passed through the N-FFT which converts the time domain signal into frequency domain signal. The signal is developed and passed through parallel to serial converter and results in sample output.

4.1 Types of frames

Type1 Radio Frame Structure

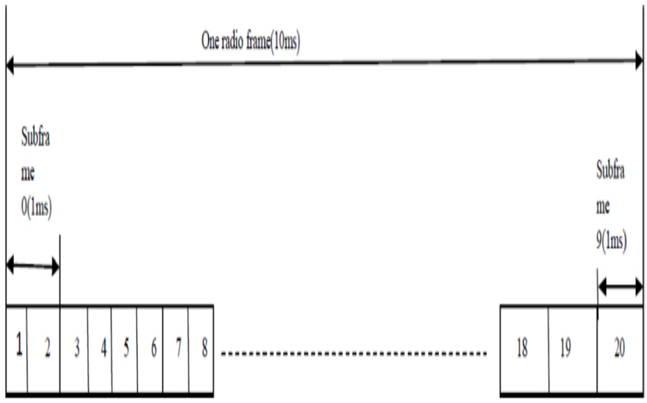

Figure 3 Type 1 Radio frame structure

Every frame is longer and consists of 20 slots of length, numbers upto 0 to 19. A sub frame is divides as two consecutive slots. 10 sub frames are allocated to the downlink. The uplink and downlink are separated in frequency domain. In each half duplex FDD operation the user equipment does not transmit and receive at same timing. Hence there is no such condition in full duplex FDD.

Type 2 Radio Frame Structure

This is applicable for the systems which employs TDD. Each radio frame length consists of two half frames of length. Each half frames consists of 8 slots of length and and all sub frames are defined as 2 slots. These sub frames are reserved for downlink transmission. In these radio frames of both 5msec and 10msec switch point periodicity is supported

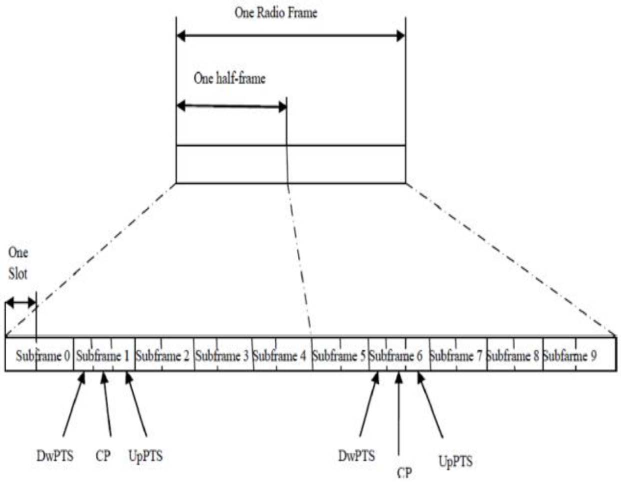

Figure 4 Type 2 Radio frame structure

OFDMA scheme is one of the best choices in multiplexing techniques for the 3GPP LTE downlink systems. Even though it involves extra difficulty in requisites of resource scheduling, hence it is immensely advanced to packet oriented approaches in conditions of effectiveness and latency. In OFDMA, users are owed a definite amount of subcarriers for a determined quantity of time. These are known as physical resource blocks (PRBs) in the LTE specifications. PRBs therefore have both the time and frequency element. Provision of PRBs is operated by a scheduling utility at the 3GPP base station.

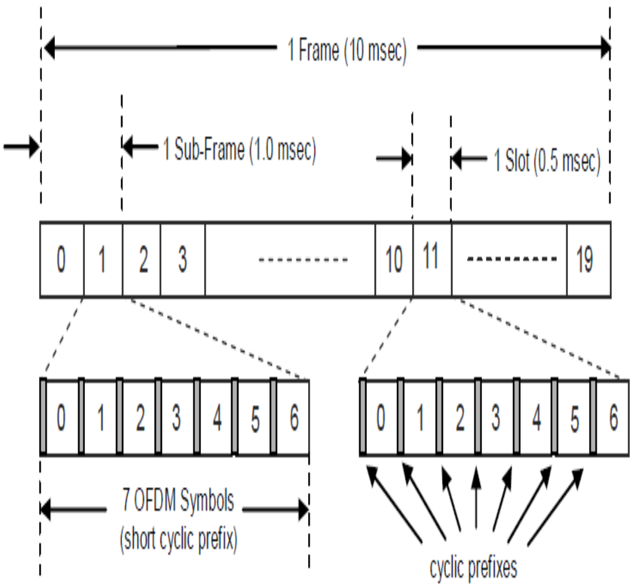

Figure 5: LTE Generic Frame Structure

5 DOWNLINK LTE SYSTEM MODEL

The resource which is allocated to a user in the downlink LTE system is expressed in both frequency and time domain and is called a Resource Block (RB). In the frequency province, the RB consists of 12 successive sub-carriers (180 kHz total bandwidth) and in the time province it consists of one time slot of 0.5 ms period. A time period consists of 7 OFDM symbols. Packet development is performed at eNodeB at 1 ms time (Transmit Time Interval, TTI) and two successive RBs (in time domain) are allocated to a user. It is understood that users report their channel circumstances (Signal-To-Noise-Ratio, SNR) on each RB to allocate eNodeB at each TTI and channel coverage is implicit to be error-free. The reported channel settings are decided based on the calculated SNR values of the sub-carrier situated at the centre frequency of every RB.

At every TTI and on each RB, packet scheduler (located at the eNodeB)chooses a user with the uppermost precedence depending on the packet scheduling algorithm and transmits packets to the user based on the reported SNR value discussed earlier. Figure 6 shows a generalized model of packet scheduling algorithm in the downlink LTE system.

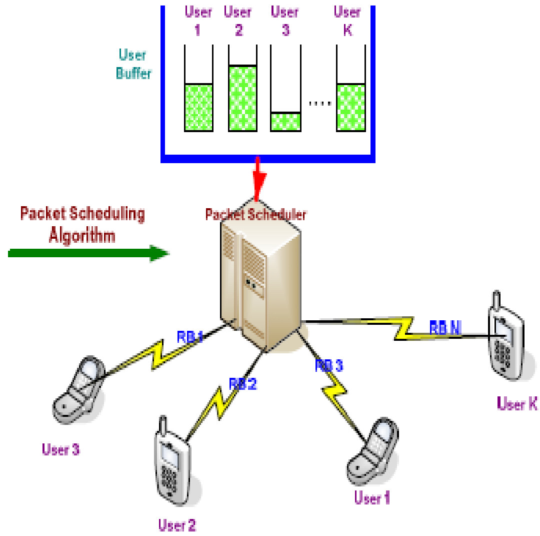

Figure 6: Downlink LTE System Model.

The organization of scheduling algorithm is accepted by LTE standard. It can not only achieve the high system performance but also sustain the proportional equality. Each user is assigned the demanded resource according to the predefined QOS constraints. In the meantime it can evade the latency and starvation of the lower precedence service type connections.

5.1 Packet Scheduling Algorithms

Packet scheduling algorithm indicates an approach on how to transmit packet proficiently by using appropriate scheduling criteria such that specific performance metrics are fulfilled. In a Non-Real Time (NRT) service background, channel condition is the most regular scheduling criterion being considered while system throughput and fairness are being used when evaluating the performance of packet scheduling algorithms. The system throughput and fairness are defined as below:

System throughput is defined as the total size of transmitted packets per second and can be mathematically expressed as:

$$systemthroughput = \frac{1}{T}\sum_{i=1}^{K}\sum_{t=1}^{T} ptransmit_i\,(t) \quad \dots (2)$$

where $ptransmit_i(t)$ is the size of transmitted packets of user i at time t, K is the total number of users and T is the total simulation time.

The Fairness is defined as the variation in service levels which is the total size of transmitted packets between the most and the least served users for a given algorithm over a given time frame. The algorithm with the highest fairness value obtained from the following equation indicates that it has the best fairness performance over other algorithms.

$$fairness = 1 - \frac{ptotaltransmit_{max} - ptotaltransmit_{min}}{\sum_{i=1}^{K}\sum_{t=1}^{T} psize_i(t)} \quad \ldots (3)$$

where ptotal transmit$_{max}$ and ptotal transmit$_{min}$ are the total size of the transmitted packets of the most and the least served users respectively for each evaluated algorithm while psize$_i$(t) is the size of all packets of user i that arrived at eNodeB buffer at time t.

The highest rate (Max-Rate), proportional fair (PF) and round robin (RR) are the packet scheduling algorithms developed to sustain for NRT services in single carrier wireless systems. The Max-Rate algorithm always selects the user with the highest reported SNR value. This algorithm efficiently utilizes radio resource because it selects packets of users with a high-quality channel conditions for transmission.

On the other hand, the algorithm has low fairness performance as it withdraws a user with low SNR value from receiving any packets unless the user's channel condition improved. Given that fairness has been an issue in Max-Rate algorithm, the RR algorithm was developed to address the problem. RR meets fairness by allocating an equal share of packet transmission time to each user. However, throughput performance corrupts significantly as the algorithm does not fulfill on the reported SNR values when transmitting the selected user's packets. To provide a balance between throughput and fairness, PF algorithm was proposed. PF was originally developed to support the NRT service in a code division multiple access high data rate (CDMA-HDR) system. The metric k is defined as the ratio of:

$$k = \operatorname{argmax} \frac{r_i(t)}{R_i(t)} \quad \ldots (4)$$

And

$$R_i(t) = \left(1 - \frac{1}{t_c}\right) * R_i\,(t-1) + \frac{1}{t_c} * r_i(t-1) \quad \ldots (5)$$

where $r_i(t)$ and $R_i(t)$ are the achievable data rate and the average data rate of user i at time t, respectively, and tc is the size of an update window. $r_i(t-1)=0$ if user i is not selected for transmission at time $t-1$. The size of the update window enable PF algorithm to maximize throughput and satisfy fairness for each user.

5.2Advantages of OFDMA

- As a multiplexing layer in wireless systems OFDMA offers a number of advantages.
- Most favorable resource allocation choice due to orthogonality in together time and frequency.
- Flexible and dynamic resource allocation to match user requirements and channel circumstances.
- Enhanced ability to execute quality of service (QOS) features such as priority, latency, data rate and error rate.

Possible to avoid pulsed carriers by removing the need for TDMA operation be legible, approximately 8 to 12 point type.

6 SIMULATED RESULTS

In this section we will evaluate the performance of the system by obtained results. The signals which carriers the OFDMA symbols will be transmitted in the spectrum or channel which offers the sub channels. These sub channels contains number of subcarriers inside a resource block as explained in above section.

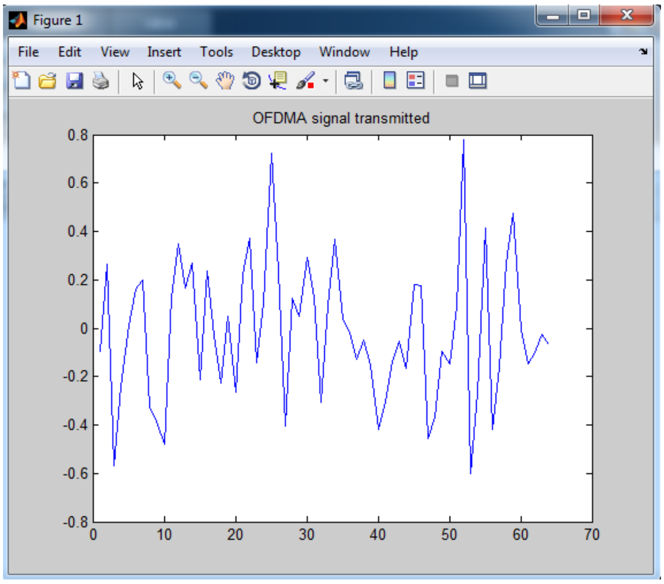

Figure 7 OFDMA signal transmitted

The signal is transmitting through a spectrum or the channel where the allocation of sub carriers for specific users are employed. Figure 7 shows the transmitted spectrum which will changes according to the transmitted media.

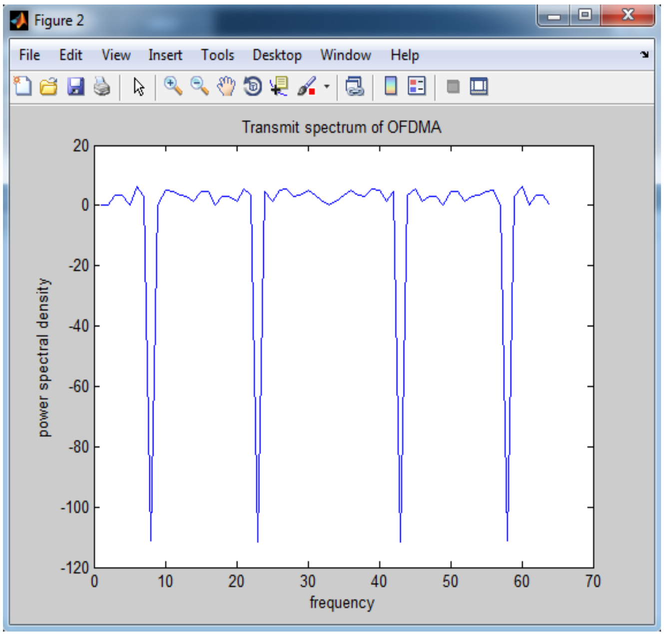

Figure 8 Transmitted spectrum of OFDMA

Finally we got the signal which is transmitted but it contains some noise and also bit error rate. In order to reduce this we also calculated the Bit error rate and signal to noise ratio by plotting a graph which shows the theoretical and also practical values as shown below.

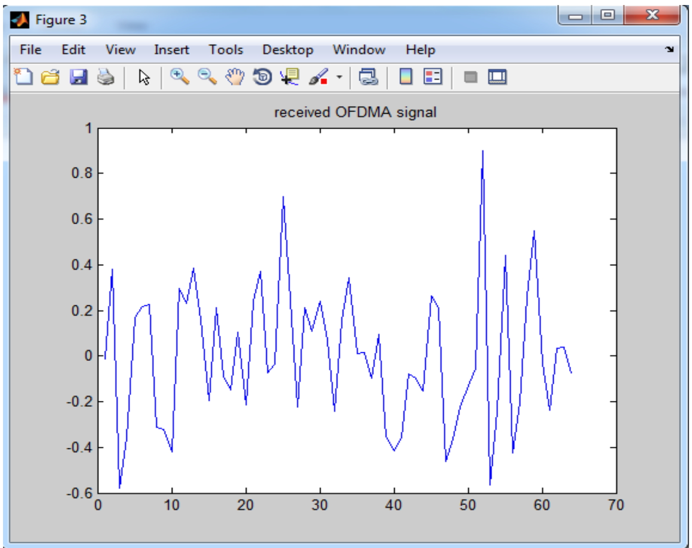

Figure 9 Recieved OFDMA Signal

According to the results of the simulation, where the value of promising error is specified in the plot of Eb/No =0.10 and BER = 10^{-1}, for 64 QAM the system is either feasible or stable, the simulation inaccuracy tends to increase. For 16 QAM the scheme is constant, the theoretical and replication value continued in the similar curve line plane. The time utilization for each cycle of simulation enhance clearly as the SNR enhances.

To attain better performance in WiMAX2 and LTE the following are purposed, 16 QAM or maximum level of QAM modulation schemes. The Adaptive Modulation Coding scheme can advance multipath performance without the maximum bandwidth modulation. Improvement of OFDMA performance through mapping schemes attains proficient throughput.

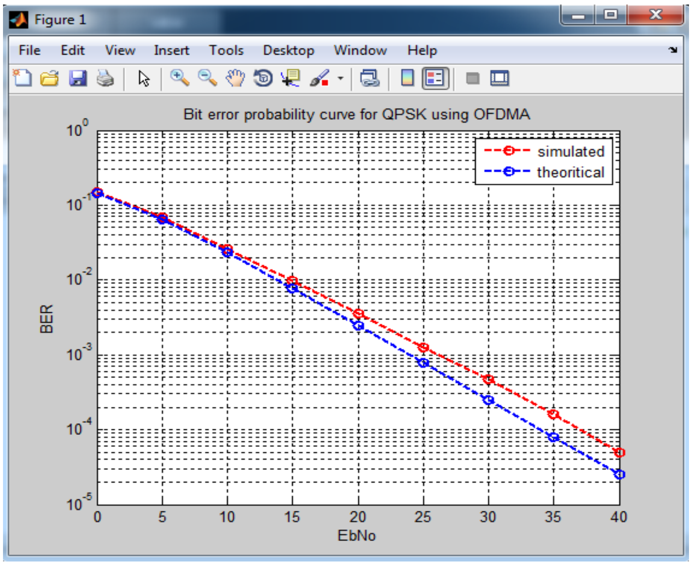

Figure 10 Graph of BER curve v/s EBNO

7 CONCLUSION

Although, the LTE specifications do contain a great deal of useful information. It is entirely possible to construct a reasonably accurate picture of the LTE physical layer in this. This project provides complete description of the LTE PHY. In other instances, the LTE specifications do not contain much detail at this time. The work on the 3GPP LTE specification is still on going at this time.

REFERENCES

[1]. Dr. Kuldip Pahwa, Murtadha Ali Nsaif Shukur , Er. Ankur Singhal, "Implementing OFDMA in Matlab," International Journal of Computing and Corporate Research Volume 3 Issue 6 November 2013.

[2]. Karthik Ravindhra, Siva Subramanian Manohar, and Uma Sankar Govindaswamy, "Long Term Evolution Downlink Physical Layer Simulation in Matlab and Simulink," International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 3, May-Jun 2012, pp.1876-1879.
[3]. Imran Rajwani, Prof. Pravin U. Dere, Dr.Anjali Deshpande, "OFDMA Based Communication System with Low Peak Average Power Ratio," International Journal of Future Computer and Communication, Vol. 1, No. 2, August 2012.
[4]. Jim Zyren ,Dr. Wes McCoy, "Technical Editor Overview of the 3GPP Long Term Evolution Physical Layer 3GPP EVOLUTIONWP," 07/2007 Freescale Semiconductor, Inc.
[5]. L. A. M. R. D. Temino, C. N. I Manchon, C. Rom, T. B. Sorensen, and P. Mogensen, "Iterative channel estimation with robust wiener filtering in LTE downlink," Proc. Int. Con. on Vehicular Technology Conference, pp. 1-5, September 2008.
[6]. D. Astely, E. Dahlman, A. Furuskar, Y. Jading, M. Lindstrom, and S. Parkvall, "LTE: The evolution of mobile broadband," IEEE Commun. Mag., vol. 47, no. 4, pp. 44-51, Apr. 2009.
[7]. Sathoshi Nagata, Yuan Yan, Xinying Gao, Anxin Li, Hidetoshi Kayama, Tetsushi Abe, and Takehiro Nakamura, "Investigation on System Performance of L1/L3 Relays in LTE-Advanced Downlink," IEEE Commun. Mag., 2011.