International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 35, Issue 01) and (Publishing Month: October 2016)
(An Indexed, Referred and Impact Factor Journal)
ISSN: 2319-6564
www.ijesonline.com

Effect of Different Types of Cyclic Prefix on Performance of LTE Network

Yasir Mohamed Osman[1], Prof. Khalid Hamid Bilal[2] and Dr. Amin Babiker Abdelnabi[3]

[1,3]Faculty of Engineering, Alneelain University, Khartoum, Sudan
[2]University of Science and Technology, Khartoum, Sudan

Publishing Date: October 26, 2016

Abstract
IEEE 802.16 OFDM used in Long Term Evolution (LTE) which selected by 3GPP to be used in air interface is designed for multicarrier to sends data over hundreds of parallel carrier which increases data rate. OFDM scheme is suffer by inter-symbol interference (ISI) problem which distort the signal and this lead to degrade in the performance of OFDM system. The one of the techniques used for reducing the effects of ISI is cyclic prefix (CP) to ensure the recovery of the symbol. In this paper, we are studied the effect of CP on Bit Error Rate (BER) performance on LTE Network for 802.16 OFDM Physical down link channel in the 3GPP Long Term Evolution (LTE) standard. Simulation is performed using MATLAB software program for different type of CP with different type of large fading and different Signal to Noise ratio SNR. The results were obtained in terms of tables and graphs for Bit error rate versus signal to noise ratio.

***Keywords**: BER, SNR, CP, Simulation, IEEE 802.16, LTE.*

I. Introduction

In September 2007 the 3GPP family was extended with another member, the Evolved UTRAN (E-UTRAN). The work with creating the concept was officially started in the summer of 2006 when the study phase was successfully completed and the 3GPP work item “3G Long Term Evolution – Evolved Packet System RAN” (LTE) commenced with standard IEEE802.16 [1].This new standard is marketed as 4G Long Term Evolution (LTE).

3GPP LTE is the evolution of the Third-generation of mobile communications, UMTS, to the Fourth generation technology that is essentially a wireless broadband Internet system with voice and other services built on top. The specifications related to LTE are formally known as the evolved UMTS terrestrial radio access (E-UTRA) and evolved UMTS terrestrial radio access network (E-UTRAN), but are more commonly referred to by the project name LTE. The starting requirements of LTE are presented in [2] and [3].

OFDM and MIMO are two key factors in LTE .The use of OFDMA with adaptive modulation technique (QPSK-QAM) related to channel state and the use of MIMO Multiple input Multiple output to boost the throughput .

The LTE radio interface is based on OFDM (Orthogonal Frequency Division Multiplex) and OFDMA (Orthogonal Frequency Division Multiple Access) in DL with CP and SC-FDMA (Single Carrier Frequency Division Multiple Access) in UL with CP. These techniques are well suited for flexible bandwidth operation. OFDM/OFDMA has been selected by 3GPP because of its robustness to multipath propagation in wideband channels, inherent support for frequency diversity and easiness integration with MIMO antenna schemes. Inside each subcarrier Adaptive Modulation and Coding (AMC) is applied with three modulation schemes (QPSK, 16QAM and 64QAM) and variable code rates.

Operators can deploy LTE in different regions with different frequency bands and bandwidths available. LTE also supports both frequency division duplex (FDD) and time division duplex (TDD). OFDM also shows very good performance in highly time dispersive radio environments (i.e. many delayed and strong multipath reflections). That is because the data stream is distributed over many subcarriers. Each subcarrier will thus have a slow symbol rate and correspondingly, a long symbol time. The mobile propagation channel is typically time dispersive: multiple replicas of a transmitted signal are received with various time delays due to multipath resulting from reflections the signal incurs along the path between the transmitter and receiver. Time dispersion is equivalent to a frequency selective channel frequency response. This leads to at least a partial loss of orthogonality between sub-carriers. The result is inter-symbol interference not only within a sub-carrier, but also between sub-carriers. To prevent an overlapping of symbols and reduce intersymbol interference, a guard interval Tg is added at the beginning of the OFDM symbol. The guard time interval, or cyclic prefix (CP) is a duplication of a fraction of the symbol end. This means that the Inter Symbol Interference (ISI) is reduced. The users in DL are separated with OFDMA, which means that each user has its own time- and frequency resources. The uplink transmission technique, SC-FDMA, is realized in a similar manner as for the downlink (OFDM) and is also called DFTS-OFDM (Discrete Fourier Transform Spread – OFDM). The time domain structure is also similar in uplink and downlink. SC-FDMA has a couple of dBs lower PAPR (Peak to Average Power Ratio) than OFDM. The lower PAPR is one of the reasons for the choice of SC-OFDM for the uplink since the power amplifier in the UE can be made more power efficient and manufactured at a lower cost. The radio resources are defined in the time- and frequency domain and divided into so called resource blocks. Dynamic channel dependent scheduling allocates a number of these time- and frequency resources to different users at different times [4].The information data stream is parallelized and spread across the sub-carriers for transmission. The process of modulating data symbols and combining them is equivalent to an Inverse Fourier Transform operation (IFFT) in DL. This results in an OFDM symbol of duration Tu which is termed 'useful symbol length'. In the receiver, the reverse operation is applied to the OFDM symbol to retrieve the data stream--which is equivalent to a Fast Fourier Transform operation (FFT) in UL. The architecture of LTE network is shown in fig (1) below:

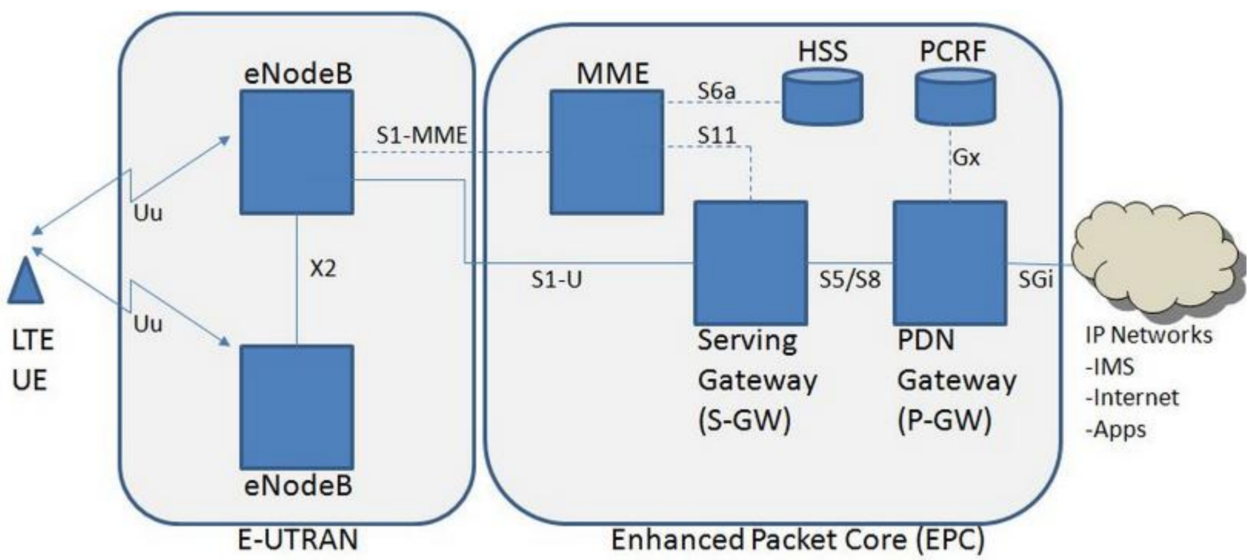


Figure 1: Architecture of LTE Network

International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 35, Issue 01) and (Publishing Month: October 2016)
(An Indexed, Referred and Impact Factor Journal)
ISSN: 2319-6564
www.ijesonline.com

II. Descriptive Analysis

Figure (2) shows complete OFDM trans-receiver. The basic principle of OFDM is to split high-rate data stream into number of lower rate streams that are transmitted simultaneously over a number of subcarriers [5]. The key component of OFDM is FFT/ IFFT witch modulates a block of input QAM values onto a number of subcarriers. In the receiver, subcarriers are demodulated by FFT, which perform reverse operation of IFFT. In practice, IFFT can be made by using FFT. Therefore same hardware will be used for the both which reduces the complexity of communication system [6].Second important feature of OFDM system is coding and interleaving. Some successive subcarriers in the OFDM system may suffer from deep fading, in which the received SNR is below the required SNR level.

In order to deal with the burst symbol errors, Forward Error Correction (FEC) is used with interleaving to correct errors in bits at the receiver side without the need for re-transmission. The FEC codes can make error corrections only as far as the errors are within the error-Correcting capability, but they may fail with burst symbol errors. Due to this code average errors convert into random errors, for which interleaving techniques are used. The third key principle is the introduction of a cyclic prefix and zero padding as a Guard Interval to reduce interference between the symbols (ISI) [7]. The organization of data into blocks is carried out by the serial to parallel converter (S/P). Following the parallel to serial converter (P/S) after the inverse FFT, time-windowing may be applied to reduce the side lobes of the transmitted spectrum [8,9].

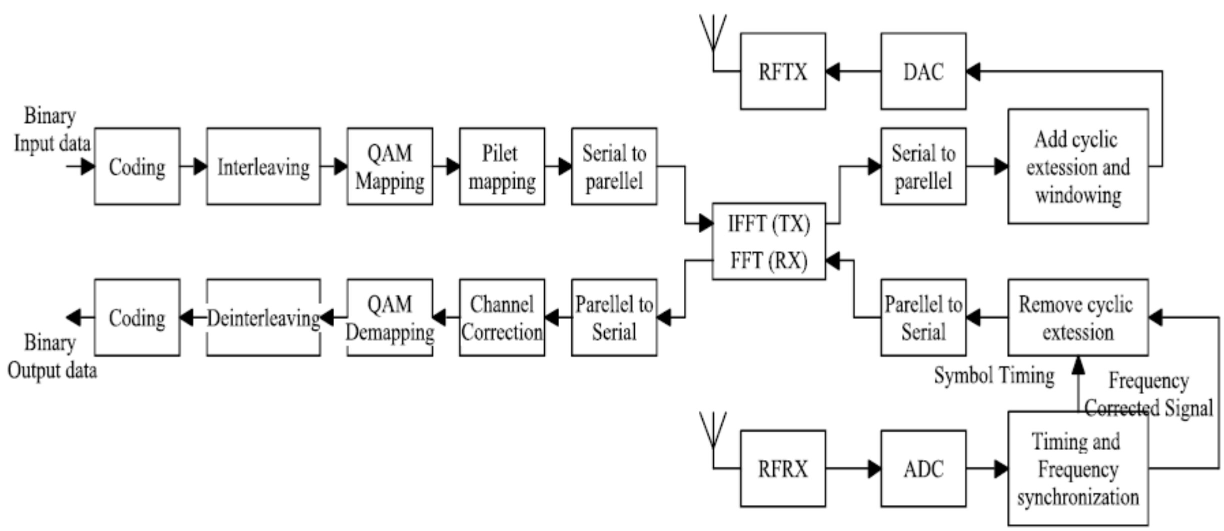


Figure 2: OFDM Trans-Receiver

The logarithm of LTE operation is presented in figure (3) below:

Figure 3: Logarithm of LTE Operation

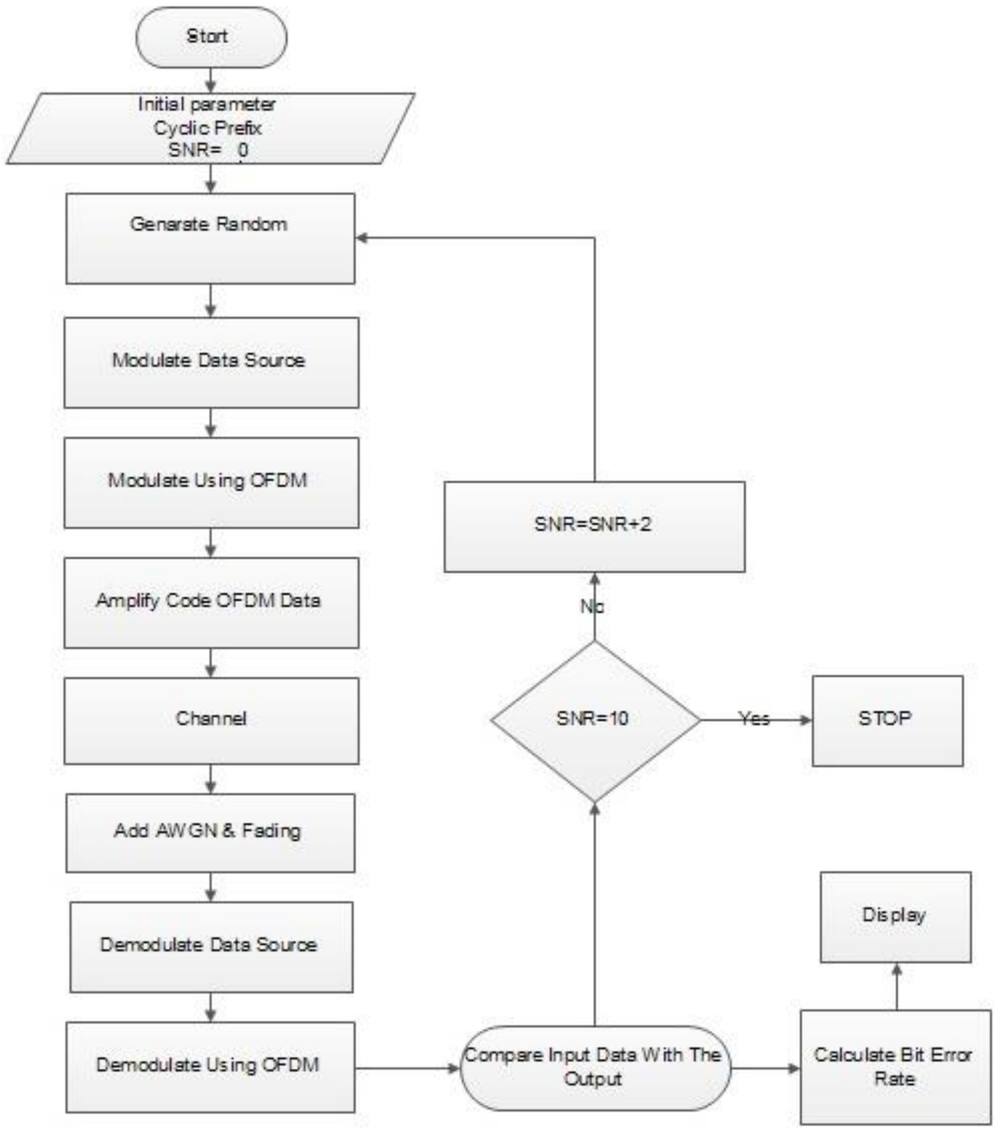
The random data source for the user had been modulated with the addition of cyclic prefix and starting with a signal to noise ratio 0 sequentially to10 stepped with 2 , then the data will be encoded using OFDM , then the OFDM signal will be transmitted after amplification and the signal will be non linear. At the channel side the kinds of the multipath fading and the Additive White Gaussian Noise (AWGN) was added. Then in the receiver side the OFDM signal transmitted will be demodulated and decoded, and the gain and phase will be compared, then the signal will be demodulated and returned back to its main form. The returned signal will be compared with the transmitted signal to calculate the bit error rate.

III. Mathematical Model

Bit error rate BER is a parameter which gives an excellent indication of the performance of a data link such as radio or fiber optic system. As one of the main parameters of interest in any data link is the number of errors that occur, the bit error rate is a key parameter. Knowledge of the BER also enables other features of the link such as the power and bandwidth, etc to be tailored to enable the required performance to be obtained.

Bit Error Rate BER = Number of errors/Total Number of bits sent

IV. Computer Model



V. Implementation

The computer model implemented with MATLAB software program which characterize with a library function for transmitters module and channel and receiver which is powerful for communication, and it has built LTE system module. Using the following parameters:

Parameter	Value
Signal to noise Ratio SNR (dB)	0,2,4,6,8,10
Bandwidth (MHz)	10
Number of symbols per burst	2
Cyclic Prefix	1/4 & 1/8
Fading Mode	Large (Rayleigh fading , Rician fading)
Channel Coding Technique	Space Time Block Code (STBC)
Maximum Doppler Shift (Hz)	0.5
K Factor	4

VI. Results and Discussion

Simulator executed and results were obtained in terms of tables and graphs below for BW=10MHz, CP=1/4 and 1/8 with different fading.

Table 1: BER for Rayleigh Fading

SNR	BER(cp1/4) Rayleigh	BER(cp1/8) Rayleigh
0	0.3367	0.346
2	0.06745	0.0719
4	0.001397	0.001649
8	0.004461	0.004632
10	0	0

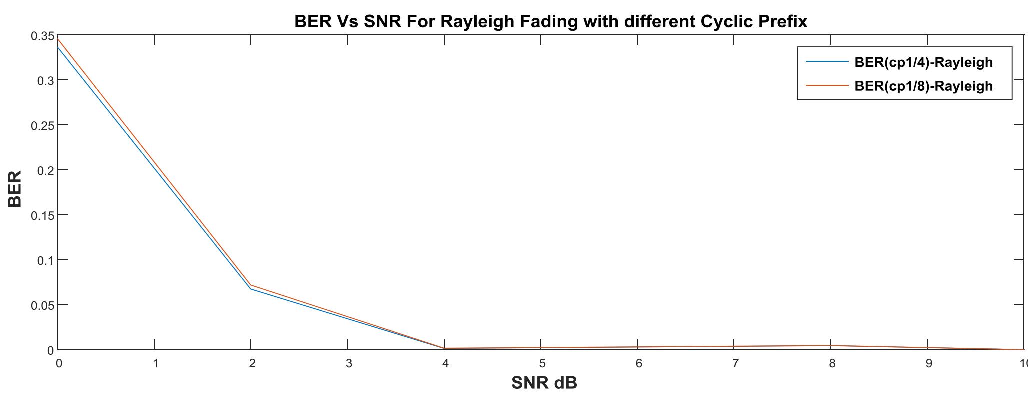


Figure 4: BER Vs SNR for Rayleigh Fading with CP=1/4 and 1/8

Table 2: BER for Rician Fading

SNR	BER(cp1/4) Rician	BER(cp1/8) Rician
0	0.3436	0.35
2	0.06185	0.0646
4	0.001316	0.001407
8	0.00313	0.003514
10	0	0

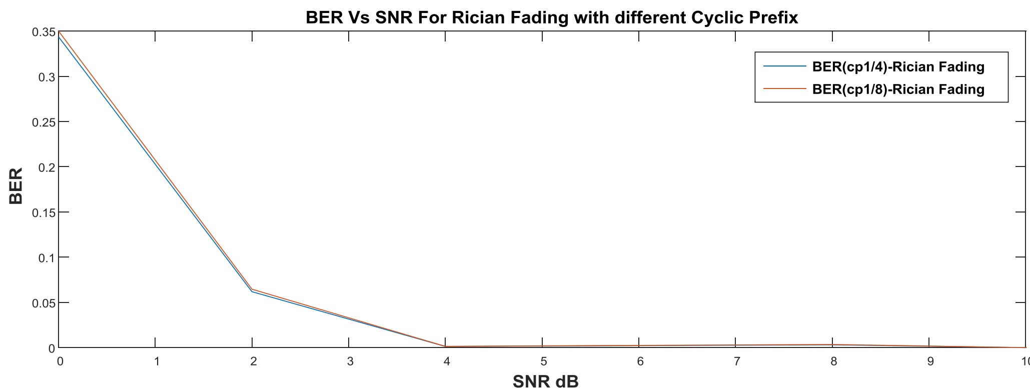


Figure 5: BER Vs SNR for Rician Fading with CP=1/4 and 1/8

From Table (1) and figure (4) Shows the BER performance for different type of fading with STBC for Cyclic prefix =1/4 and 1/8 with BW=10MHz. We observe that as SNR increase, the BER decreased for both type of cyclic prefix. The performance evaluation of BER of Rayleigh fading at cp=1/4 is the best when compared to cp=1/8 for the same fading. BER approach to zero at SNR of 10dB.

From Table (2) and Fig. (5) Shows the BER performance for different type of fading with STBC for Cyclic prefix =1/4 and 1/8 with BW=10MHz. We observe that as SNR increase, the BER decreased for both type of cyclic prefix .The performance evaluation of BER of Rician fading at cp=1/4 is the best when compared to cp=1/8 for the same fading. BER approach to zero at SNR of 10dB.
The BER decreased for both fading when cp=1/4

VII. Conclusion

The BER performance analysis for different type of fading in large scale fading (Rayleigh and Rician fading) with STBC have been done using MATLAB software program for Cyclic Prefix=1/4 and 1/8 with Band Width=10MHz.

References

[1] IEEE Standard 802.16-2004, "Part 16: Air interface for fixed broadband wireless access systems," October 2004. http://ieee802.org/16/published.html
[2] 3GPP, TR 25.913, “Requirements for Evolved UTRA (E-UTRA) and Evolved UTRAN (E-UTRAN) (Release7)”.
[3] “UTRA-UTRAN Long Term Evolution (LTE) and 3GPP System Architecture Evolution (SAE)” [online]. URL: http://www.3gpp.org/Highlights/LTE/LTE.htm.
[4] Ericsson LTE L14 Air Interface - STUDENT BOOK LZT1380999 R1A.
[5] Saltzberg, B.R. Performance of an efficient parallel data transmission system.IEEE Trans Commun., Technol, COM-15, 805–811. (1967)

[6] Ramjee Prasad, OFDM for Wireless Communications Systems, Artech House, Inc. Boston, London (2004)
[7] Yong soo cho, Jaekwon Kim, Won young Yang and Chung G. Kang, MIMO OFDM wireless communication with MATLAB. John Wiley & Sons. (2010).
[8] D. A. Wiegandt, Z. Wu and C.R. Nassar, "High Throughput, High Performance OFDM via Pseudo-Orthogonal Carrier Interferometry Spreading Codes", IEEE Trans. Commun., Vol. 51, No. 7, July 2003, pp. 1123-1134.
[9] F. Horlin, F. Petré, E. Lopez-Estraviz, F.Naessens and L. Van der Perre, "A Generic Transmission Scheme for Fourth Generation Wireless Systems", presentation at WWRF meeting #11, Oslo, June, 2004.