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LTE-Advanced System Based On MIMO-OFDM For Rayleigh Channel

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***Abstract*— This paper presents a model which is MIMO Channel based Orthogonal Frequency Division Multiplexing system for LTE-Advanced system. MIMO-OFDM system evolved as one of the main features of LTE-Advanced. OFDM with cyclic prefix (CP)is a key element for LTE-Advanced to reduce intersymbol interference(ISI). The performance of the proposed model is done in terms of bit error rate(BER) for rayleigh channel. The experimental results shows better performance for BPSK and 16QAM.**

***Index Terms*— BER, CYCLIC PREFIX, , INTERLEAVER, ISI, LTE-ADVANCED, MIMO, OFDM, EbNo, RAYLEIGH CHANNEL.**

I. INTRODUCTION

LTE-A system, which is being standardized in 3GPP as part of LTE Release 10 (evolved Universal Mobile Telecommunications System [UMTS] terrestrial radio access network [EUTRAN]), aims at fulfilling or exceeding the requirements for International Mobile Telecommunications Advanced(IMT-A) as set by International Telecommunication Union-Radio communication Sector(ITU-R). With the increasing need for mobile communication services for large number of users, the 3GPP LTE-Advanced system has proposed technologies e.g., enhanced MIMO, that can provide higher spectral efficiency with effective transmission. To provide a higher capacity, LTE evolves to LTE-Advanced mainly by increasing the peak data rate, the spectral efficiency and the number of simultaneously active subscribers and improving the usage of MIMO techniques and the performance at cell edges. The starting point of LTE-Advanced is the Release 10, however the LTE/LTE-Advanced technology is continuously enhanced by adding new techniques and improving existing ones. Indeed the enhancements for LTE-Advanced continues on Releases 11 and 12, and nowadays, the evolution of specifications is moving towards Fifth Generation of Mobile Communications Technology (5G)[1]. To achieve peak data rates required by IMT-Advanced, MIMO-OFDM evolved as one of the main features of LTE-Advanced. MIMO-OFDM system is a combination of MIMO and OFDM technologies. MIMO is an smart antenna technology which uses multiple antennas at both the receiver and transmitter side. The MIMO technique in combination with OFDM has been shown as a good approach for high spectral efficiency wideband systems. The fading process experienced by each subcarrier is close to frequency, and therefore, it can be modeled as a constant complex gain. This consideration allows to obtain the MIMO channel matrix on a subcarrier basis and thus simplify the implementation of a MIMO scheme. The MIMO-OFDM basics are described in[1]. By combining MIMO and OFDM in LTE-A its can support more antennas and larger bandwidths, which is an advantage to increase data rate. The increasing popularity of this technique is its spectral efficiency and higher data rates [8].

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In MIMO-OFDM system, IFFT is used at transmitter side and FFT is used at receiver side to generate orthogonal subcarriers. In this system, cyclic prefix is added to data before transmission through channel to combat ISI. The purpose of using cyclic prefix is to increase the delay spread of a channel. Some of the advantages to be highlighted are its high spectral efficiency; reduction in impulse noise and robustness to ISI. The use of cyclic prefix reduces the efficiency of system. The transmission over wireless channel causes ICI and ISI. The ISI results from time dispersion nature of multipath propagation and ICI from frequency dispersion caused by Doppler shift[5]. In this paper the performance of conventional based OFDM system with MIMO-OFDM LTE-A system using different modulation techniques like BPSK, QPSK, 16QAM, 64QAM is presented.

The paper is organized as follows: Section II briefly describes the OFDM system for LTE Advance model. In Section III discussed the MIMO principle. Section IV presents the LTE-ADVANCED system. Section V presents the simulation results and minimum BER analysis of the proposed model and compared with existing 4G communication system. Section VI concludes the paper.

II. OFDM SYSTEM

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation technique in which the spectrum of the subcarriers overlap on each other. Orthogonality is maintained among the subcarriers in OFDM. Orthogonal frequency division multiplexing (OFDM) technique was adopted in LTE-A since it is a promising tool for combating the Inter-Symbol Interference (ISI). Subcarriers has fixed number of cycles in a time interval and also number of cycles through which individual next subcarriers differs is one [3]. Input data is mapped into the complex plane using some modulation technique. The mapped data is transformed from serial format to parallel format and inverse transform is applied on the parallel data to generate OFDM symbols.

After normalizing all the OFDM IFFT symbols, the mathematical discrete-time representation for these symbols is:

$$x(k) = \left(\frac{1}{N}\right)\sum_{n=0}^{N-1} X(n)e^{\frac{j2\pi kn}{N}}, k = 0,1,2,\ldots,N-1 \quad (1)$$

The parallel data is then converted to serial format and cyclic prefix is appended. At the receiver side, the received OFDM data symbols converted to the time domain by using the FFT [3]:

$$Y(n) = \sum_{k=0}^{N-1} y(k) e^{\frac{-j2\pi kn}{N}}, n = 0,1,2,\ldots,N-1 \quad (2)$$

The data transmitted is impaired by the channel. The receiver functions to receive the data and performs the inverse operations on it.

III. Multiple Input Multiple Output (MIMO)

MIMO (multiple input, multiple output) is an smart antenna technology in which multiple antennas is used at both side. With the multiple antennas it is easy to combine information from various signals thus improving data and speed integrity and also to mitigate errors by increasing transmission rate. The MIMO technology is a very effective method of increasing the capacity of the channel and system [7]. MIMO diagram is shown in Fig. 1.

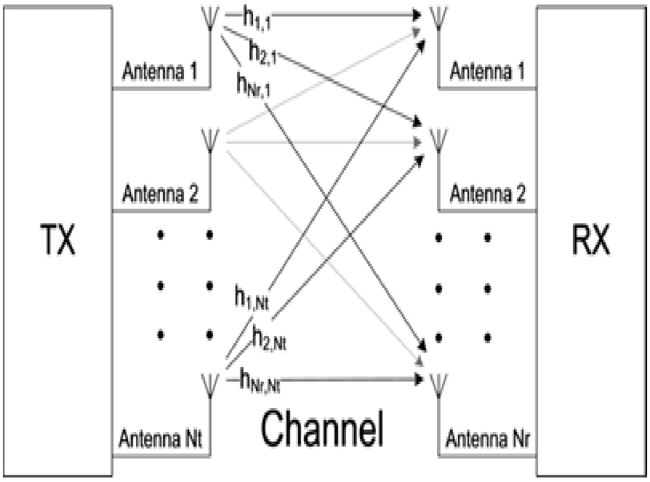

Fig.-1: Block diagram of MIMO transmitter and receiver

IV. LTE-Advanced Model

The physical connection of our system is illustrated as the block diagram in Fig. 2.

The information bits are transmitted by Bernoulli binary generator with 20 samples per frame, encoder comprises of CRC generator and initially encoded by the Turbo encoder with a data rate equal to 1/3. The encoded bits are then interleaved. LTE-Advanced supports a various modulation and coding, and can be applied depending upon the channel condition. The encoded data stream is modulated with modulation schemes, namely BPSK, QPSK, 16-QAM and 64-QAM

Orthogonal Frequency-Division Multiplexing (OFDM) was adopted in LTE-Advanced to counter the Inter-Symbol Interference (ISI). The Cyclic prefix is appended to the OFDM symbol after the IFFT to mitigate the ISI effects. The channel is used as MIMO channel. The rest of the reception process is straightforward, since it is just the reverse of the one having taken place at the transmitter, as described above. Fourier based OFDM is a multicarrier modulation technique which generates orthogonal subcarriers. This implements the rectangular window which creates high side lobes which is one of the cause of ICI.

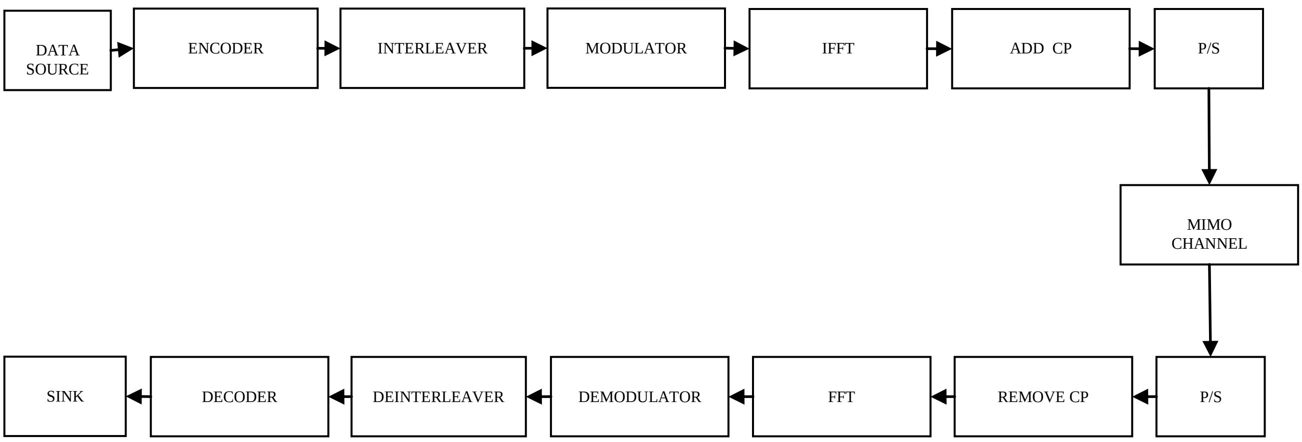

Fig.-2: Block diagram of LTE-ADVANCED SYSTEM

V. Simulation Results

A. *BER Analysis of LTE-Advanced Model*

In this section we present simulation results to evaluate the performance of the designed MIMO-OFDM LTE-Advanced transceiver. The measure used to assess and evaluate the performance is the achieved bit error rates (BER) for the different proposed modulators. Table. I-II shows the BER results for BPSK modulator and corresponding plot are shown in Fig. (3-4).

TABLE I. BER Results For BPSK Modulators

Eb/No(in dB)	BER
1	0.5
2	0.45
3	0.41
4	0.35
5	0.3
6	0.26
7	0.17
8	0.09
9	0.0065

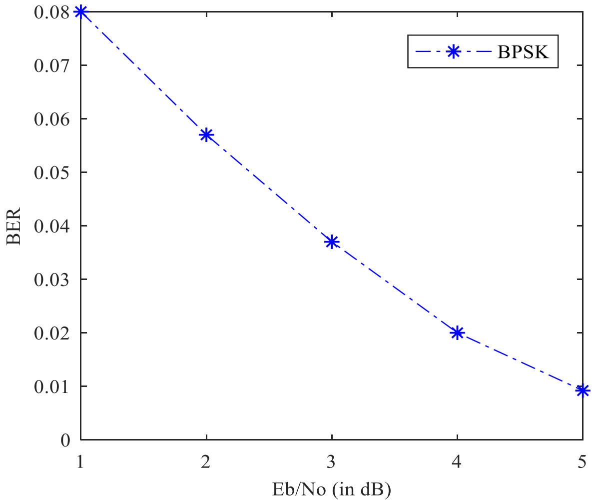

Fig: - 3: Eb/No Vs BER for BPSK

TABLE II. BER Results For 16QAM Modulators

Eb/No(in dB)	BER
1	0.08
2	0.057
3	0.037
4	0.02
5	0.0092

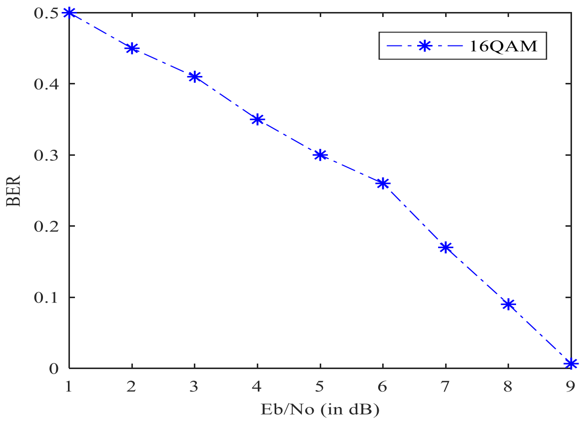

Fig: - 4 : Eb/No Vs BER for 16QAM

B. *Eb/No Vs BER for different Modulator*

The transceiver performance in terms of bit error rate (BER) versus Eb/No for BPSK, 16QAM, 64QAM, QPSK modulation formats, respectively are presented here. Fig. 5 show the results and are self explanatory and clearly show the performance ,as Eb/No increases bit error rate decreases.

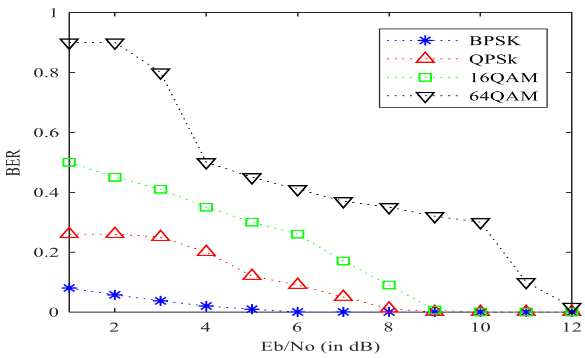

Fig: -5: Eb/No Vs BER for different modulators

C. *Comparison of LTE-Advanced with Existing LTE system*

The performance evaluation for the Single Channel MIMO-OFDM system with different modulation is experimented and compared with reference model[2]. The proposed model is designed for 20 samples per frame and using a turbo code generator of rate 1/3 with rayleigh channel and observed better BER of 0.0092 at 5db SNR for BPSK and BER of 0.0065 at 9db SNR for 16QAM as shown in Table III.

TABLE III. Minimum Ber Comparision

System Name	Eb/No	Modulator used	Minimum BER
Proposed Model	9	16 QAM	0.0065
Reference Model [2]			0.02
Proposed Model	5	BPSK	0.0092
Reference Model [2]			0.012

VI. CONCLUSION

This paper concludes with the successful implementation of single channel MIMO-OFDM LTE-Advanced system. Bit error rate (BER) is used for measuring performance. We used four different modulators namely, BPSK, QPSK, 16QAM, 64QAM.Results shows that as we increase EbNo then BER decreases. The experimental results shows better performance for BPSK and 16QAM at 5db and 9db.Multiple transmitter and receiver can be used in future to extend this paper work.

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