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A Review on Design of Massive MIMO-OFDM for Less ISI

Smriti Rai*, Prof. Rajender Singh Yadav**
*M.Tech. Scholar,
Gyan Ganga Institute of Technology and Sciences, Jabalpur, MP, India
**[2]Asst. Professor
Electronics and Communication Department,GGITS, Jabalpur, MP, India

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Abstract:

The massive MIMO technique has played the most important role in 5G wireless communication. It is anticipated that the new techniques employed in massive MIMO will not only improve peak service data rates significantly, but also enhance capacity, coverage, low-latency, efficiency flexibility, compatibility and convergence, thus meeting the focusing demands imposed by optimal detection. This paper presents the optimal detection of data symbol in massive MIMO for 5G wireless communication. Based on the frequency non-selective fading MIMO channel, we consider three difference detectors for recovering the transmitted data symbols and evaluate their performance for Rayleigh fading and additive white Gaussian noise (AWGN). At the results, we show that the probability of error rate (PER) performance of the detectors are significantly discussed. In paper have presented an overview of Massive MIMO systems in wireless communication which are the breakthrough in wireless communication technology nowadays. MIMO systems are used to improve the noise and interference performances of a channel. In the paper, MIMO systems are used to expand channel capacity and BER are also highlighted. The discussion then proceeds further towards the limitations and advancements in this technology. In modern scenario massive MIMO includes merger of OFDM with MIMO. By the use of MIMO-OFDM, very high data rates are achieved. Maximum Likelihood massive multiple-input multiple-output (MIMO) systems utilize hybrid beam forming techniques to alleviate the implementation complexity of combining a large number of antennas. this work proposed a hybrid processing algorithm via matrix decomposition for Maximum Likelihood massive MU-MIMO systems. Both inter-user interference (IUI) and inter-stream interference (ISI) within the user are taken into consideration. This work derive a Maximum Likelihood Data Detector and Inverse Channel Data Detector for less ISI. In the large system analysis, this work prove that the proposed algorithm can obtain unconstrained optimal performance when the number of antennas is infinite. The results indicate that the proposed algorithm outperforms other existing hybrid designs in terms of BER.

Keywords **— Massive MIMO; optimal detector; Rayleigh fading channel; PER; 5G wireless communication**

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I. INTRODUCTION

The standard mobile technology is in the trends of digital transformation, a challenging new capabilities that will benefit research and development as a whole. The step from 4G to 4.5G was being lunched [1]-[2], and the industry is toward to, initially in the advances LTE and then in 5G, will be even greater [3]. Standards that have been planned; that process expected will be in 2020 timeframe [4]. However, almost of operators have demonstrated many of 5G capabilities, and also showed pre-standard networks for fixed applications as early as 2017 [5]. The 5G is not to replace LTE, but in most deployments will co-exist with it high speed technologies tightly integrated in a manner transparent to users [6]-[7]. Many of the capabilities that will make 5G so effective are appearing in advanced forms of LTE. With carrier aggregation (CA) [8], for example, operators have not only harnessed the potential of their spectrum holdings to augment capacity and performance, but the technology is also the foundation for entirely new capabilities, such as operating LTE in unlicensed bands. With long-term evolution (LTE) growth in smart phones and usage limited by population, innovators are turning their attention to the Internet of Things (IoT), which promises billions of new wireless connections. Enhancements to LTE followed by 5G capabilities will connect wearable computers, avast array of sensors, and other devices, leading to better health, economic gains, and other advantages. 5G addresses not only IoT deployments on a massive scale, but also applications previously not possible that depend on ultra-reliable and low- latency communications. Although a far more fragmented market than smart phones, the benefits will be so great that the realization of IoT on a massive scale is inevitable. The only question is how, exactly, the market will evolve [9]-[10].

5G research and development accelerates, in early stages of definition through global efforts and many proposed technical approaches, could start to be deployed close to 2020 and continue through 2030. The trends of development are focusing on propagation limitation [11]-[12], massive MIMO antennas [13]-[14], beam-steering [15]-[16], beam tracking, dual connectivity, carrier aggregation, small-cell architectures. These have been on research work increasingly, in particular, the massive MIMO provides the essential roles to enhance the channel capacity and spectral efficiency. To understand what the massive MIMO is, the massive MIMO or large scale antenna system is a form of multiuser MIMO in which the number of antennas at the base station is much larger than the number of devices per signal resource. The massive MIMO systems, which are equipped with tens or even hundreds of antennas. Firstly, energy efficiency can be significantly increased by massive MIMO system as they concentrate power on a shape direction. Secondly, system throughput can be gained by utilizing multi-user MIMO (MU-MIMO). Lastly, massive MIMO systems are more robust than conventional MIMO system as they offer excessive degree of freedom. Although the massive MIMO can achieve orders of increase in spectral efficiency, but one of which is the practical signal detection algorithm in the uplink due to the increased multi- user interference (MUI).

In this paper, we discuss the performance evaluation of the existing detection methods of data symbol in the massive MIMO system. Consider a transmission channel and system model that employs the multiple transmitting antennas and the receiving antennas, as shown in Fig. 1. We assume that the detector knows the elements of the channel matrix H perfectly. At the detector, we employ an optimal detector with the maximum likelihood detector (MLD), the minimum mean square error (MMSE), and inverse channel detector (ICD) is discussed. Simulation result show that the probability of error rate performance of the three detector in a Rayleigh fading channel is most easily verified by using Monte Carlo computer simulation. Furthermore, the simulation results are also examined the number of users.

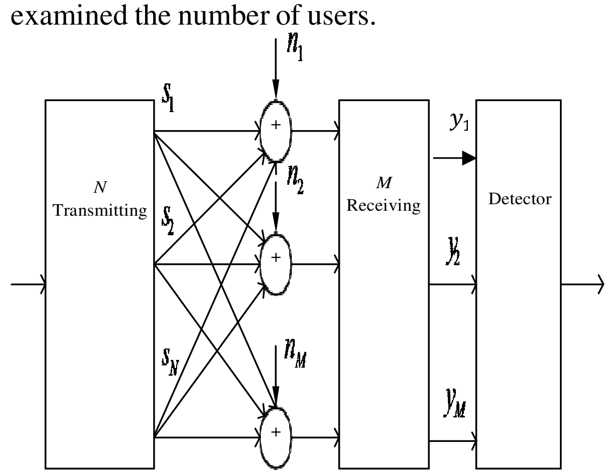

Fig. 1 An uplink communication system with the massive MIMO antennas for 5G wireless communication.

The goal is to design and simulate Massive MIMO-OFDM System using proposed Maximum Likelihood Data Detector and Inverse Channel Data Detector and to Analyze proposed LTE-Advanced System design Massive MIMO-OFDM in Rayleigh Fading Channel and reduce ISI and analyze the performance of the proposed model in terms of Bit Error Rate(BER) and Analyze the variations of signal to noise ratio (SNR) with bit error rate for different modulators, like BPSK, QPSK, 16-QAM, 64-QAM.

***1.1 Orthogonal Frequency Division Multiplexing*:** Next generation communication system is beyond the current 4G IMT-A communication standards. The combination massive MIMO-OFDM is beneficial since OFDM enables support of more antennas and larger bandwidths since it simplifies equalization dramatically in massive MIMO systems. The main idea behind OFDM is the so-called Multi-Carrier Modulation (MCM) transmission technique. MCM is the principle of transmitting data by dividing the input bit stream into several parallel bit streams, each of them having a much lower bit rate, and by using these sub-streams to modulate several carriers[2]. The first systems using MCM were military high frequency radio links in the late 1950s and early 1960s, like Kineplex, Andeft and Kathryn[2]. OFDM is a special form of MCM with densely spaced sub-carriers and overlapping spectra, whose main idea was patented by Chang, from the Bell Labs, in 1966[2]. OFDM abandoned the use of steep band pass filters that completely separated the spectrum of individual sub-carriers, as it was common practice in older analogue FDMA systems. Instead, OFDM time domain waveforms are chosen such that mutual orthogonality is ensured even though carrier spectra may overlap. Orthogonality is achieved by performing a Fourier Transform (or equivalently a Fast Fourier Transform) on the input stream[2].

1.2 Multiple Input Multiple Output(MIMO): MIMO (multiple input, multiple output) in 1998 Bell Laboratories successfully demonstrated the MIMO system under laboratory conditions. In the following years Gigabit wireless Inc. and Stanford University developed a transmission scheme and jointly held the first prototype demonstration of MIMO. MIMO is an antenna technology for wireless communications in which multiple antennas are used at both the source (transmitter) and the destination (receiver) [6]. The antennas at each end of the communications circuit are combined to minimize errors and optimize data speed. MIMO is one of several forms of smart antenna technology, the others being MISO (multiple input, single output) and SIMO (single input, multiple output)[6]. By adopting Multiple-Input Multiple-Output (MIMO) and Orthogonal Frequency-Division Multiplexing (OFDM) technologies, indoor wireless systems could reach data rates up to several hundreds of Mbits/s and achieve spectral efficiencies of several tens of bits/Hz/s, which are unattainable for conventional single-input single-output systems. The enhancements of data rate and spectral efficiency come from the fact that massive MIMO and OFDM schemes are indeed parallel transmission technologies in the space and frequency domains, respectively. MIMO-OFDM when generated OFDM signal is transmitted through a number of antennas in order to achieve diversity or to gain higher transmission rate then it is known as MIMO-OFDM. Efficient implementation of MIMO-OFDM system is based on the Fast Fourier Transform (FFT / IFFT) algorithm and MIMO encoding, such as Alamouti Space Time Block coding (STBC), the Vertical Bell-Labs layered Space Time Block code VBLASTSTBC, and Golden Space-Time Trellis Code (Golden STTC) [6].

1.3 Rayleigh Fading Channel: Rayleigh fading is a statistical model for the strong influence of a propagation environment on a radio signal, used by wireless communication devices. Rayleigh fading models consider that the magnitude of a signal that has passed through a transmission channel or medium will vary often and in a random manner, or fade, according to a Rayleigh distribution- the radial component of the addition of two uncorrelated Gaussian random variables. For wireless communications, the envelope of the received carrier signal is Rayleigh distributed; such a type of fading is called Rayleigh fading[7].

II. LITERATURE WORK

Wei Wu [1] work on Millimeter-wave (mmWave) massive multiple-input multiple-output (MIMO) systems utilize hybrid beamforming techniques to alleviate the implementation complexity of combining a large number of antennas. In this paper, they propose a hybrid processing algorithm via matrix decomposition for mmWave massive MU-MIMO systems. Both inter-user interference (IUI) and inter-stream interference (ISI) within the user are taken into consideration. They derive a closed-form expression of digital and analog precoder/combiner to achieve nearlyoptimal performance. In the large system analysis, they prove that the proposed algorithm can obtain unconstrained optimal performance when the number of antennas is infinite. The results indicate that the proposed algorithm outperforms other existing hybrid designs in terms of BER and sum-rate.

Arkady Molev Shteiman [2] analyze the resiliency of Massive Multiple-Input Multiple-Output (M-MIMO) systems to Inter-Symbol Interference (ISI) when diversity combining techniques are used at the Base Station (BS). They show that Maximum Ratio Combining (MRC) alone can equalize an ISI channel as the number of antennas grows unbounded. Additional constraints on the nature of the channel must be postulated depending on whether the information of the Angle-of-Arrival (AoA) is exploited at the receiver or not. Interestingly, the simpler Equal Gain Combiner (EGC) receiver is also able to equalize the channel as the number of antennas grows but, in this case, at least one channel path must be Ricean faded. These findings are confirmed via simulation on WSSUS channels and channels generated with a ray tracing engine simulating a real BS deployment in downtown Hong Kong and Shanghai. Finally, the observed scaling law indicates that normalized ISI power decreases *N*-fold for every *N*-fold increase in the number of antennas at the BS.

Ruchi Varshney [3] presented an overview of Massive MIMO systems in wireless communication which are the breakthrough in wireless communication technology nowadays. MIMO systems are used to improve the noise and interference performances of a channel. In the paper, MIMO systems are used to expand channel capacity and BER are also highlighted. The discussion then proceeds further towards the limitations and advancements in this technology. In modern scenario massive MIMO includes merger of OFDM with MIMO. By the use of MIMO-OFDM, very high data rates are achieved.

III. PROPOSED MODEL

For the proposed work massive MIMO-OFDM LTE-Advanced System have been reviewed through many research papers related to massive MIMO and FFT-OFDM. To provide low bit error rate (BER) at given Signal to Noise ratio and its simulation is now very important field of interest. So designing a software tool for field engineer particularly in the next generation communication model is the problem formulation of this paper works. To solve this problem, proposed method uses a massive MIMO and OFDM for Rayleigh Channel. A design of proposed work will be done in MATLAB SIMULINK 2017a. 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. The performance evaluation for the Single Channel massive 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 AWGN channel and observed better BER of 0.0092 at 5db SNR and BER of 0.0065 at 9db SNR for 16QAM. For designing of massive MIMO-OFDM LTE-Advanced System number of antenna, channel conditions, size of FFT and the loss in data due to channel noise would be major analyzing parameters. By experimenting for set of input digital data the proposed model will be designed to make user friendly for any design engineer.

3.1 Architecture of Proposed Model: The massive MIMO-OFDM LTE-Advanced system was modeled using Matlab (version 2017a) to allow various parameters of the system to be varied and tested. The aim of doing the simulations was to measure the performance of massive MIMO-OFDM LTE-Advanced system under different modulation techniques, and to allow for different testing configuration. The massive MIMO-OFDM LTE-Advanced system was modeled using Matlab and is shown in Figure 2 and Figure 3 A brief description of the model is provided below.

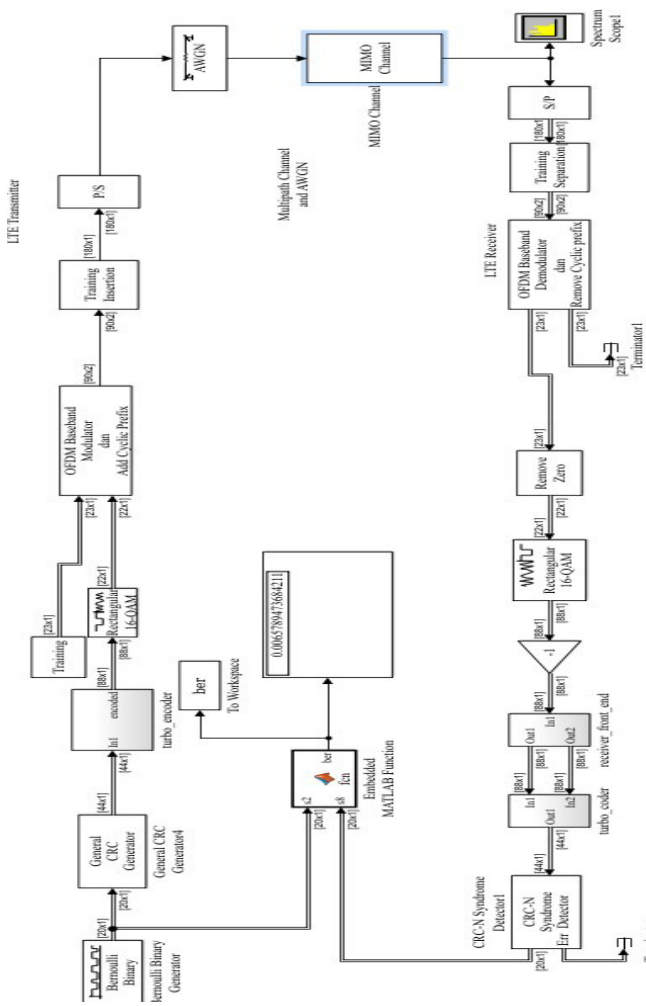

Fig.2 Block diagram of LTE-ADVANCED SYSTEM for 16QAM

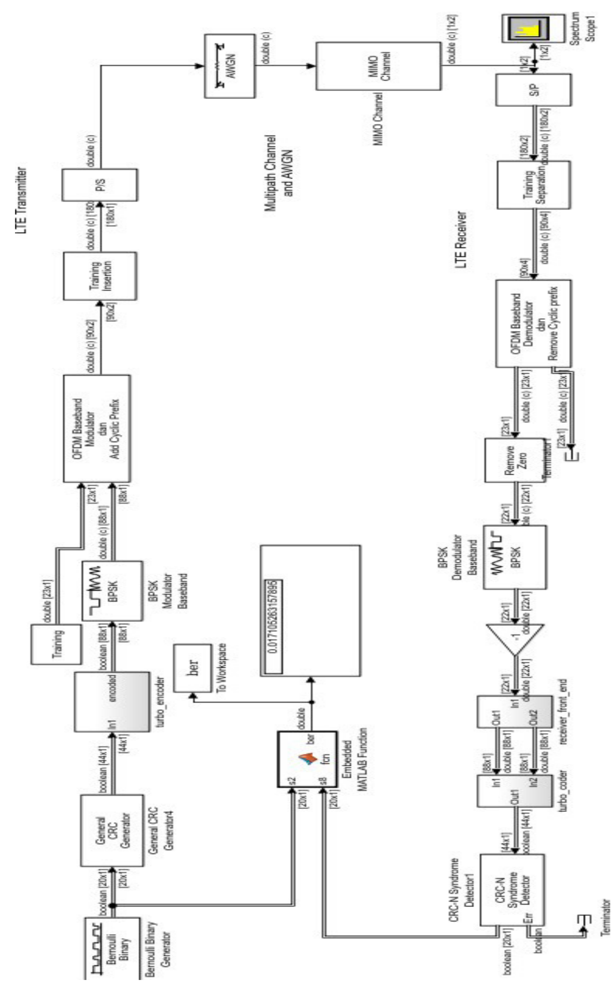

Fig.3 Block diagram of LTE-ADVANCED SYSTEM for BPSK Modulator

Bernoulli Binary Generator is used as the digital information source, bits are transmitted by Bernoulli binary generator with 20 samples per frame. General CRC Generator is an 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. The interleaver used is a random interleaver. Modulator Baseband which encodes the input data, 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. OFDM

Block is used for orthogonal frequency division multiplexing, this block plays a key role in LTE Advanced system. The main idea behind OFDM is the so-called Multi-Carrier Modulation (MCM) transmission technique. MCM is the principle of transmitting data by dividing the input bit stream into several parallel bit streams, each of them having a much lower bit rate, and by using these sub-streams to modulate several carriers[2] The main drawback of OFDM is Inter symbol Interference(ISI) to remove this cyclic prefix is added after this block.

4.2 Flowchart: Flowchart of the overall process of the LTE Advanced design is shown below in figure 4. Cyclic Prefix is done to remove Inter symbol Interference . The Cyclic prefix (CP) acts as a guard time between successive blocks. It is a copy of the last part of the transmitted OFDM symbol which is appended in front of the same symbol for each transmitted OFDM symbol. Inter-symbol interference and inter-carrier interference are the two major consequences of the transmission over time varying frequency selective channels[3]. The cyclic prefix is used in the proposed LTE Advanced transceiver, to reduce the influence of the inter-symbol interference and also it converts a discrete time linear convolution into a discrete time circular convolution. However, the length of the cyclic prefix must be at least the same or longer than the length of the channel impulse response, in order to prevent the occurrence of interference [3].

Parallel To Serial consists of Unbuffer block. The Unbuffer block unbuffers an Mi-by-N input into a 1-by-N output. That is, inputs are unbuffered row-wise so that each matrix row becomes an independent time-sample in the output. The rate at which the block receives inputs is generally less than the rate at which the block produces outputs.

Additive White Gaussian Noise (AWGN) Channel block adds white Gaussian noise to a real or complex input signal. When the input signal is real, this block adds real Gaussian noise and produces a real output signal. When the input signal is complex, this block adds complex Gaussian noise and produces a complex output signal. This block inherits its sample time from the input signal.

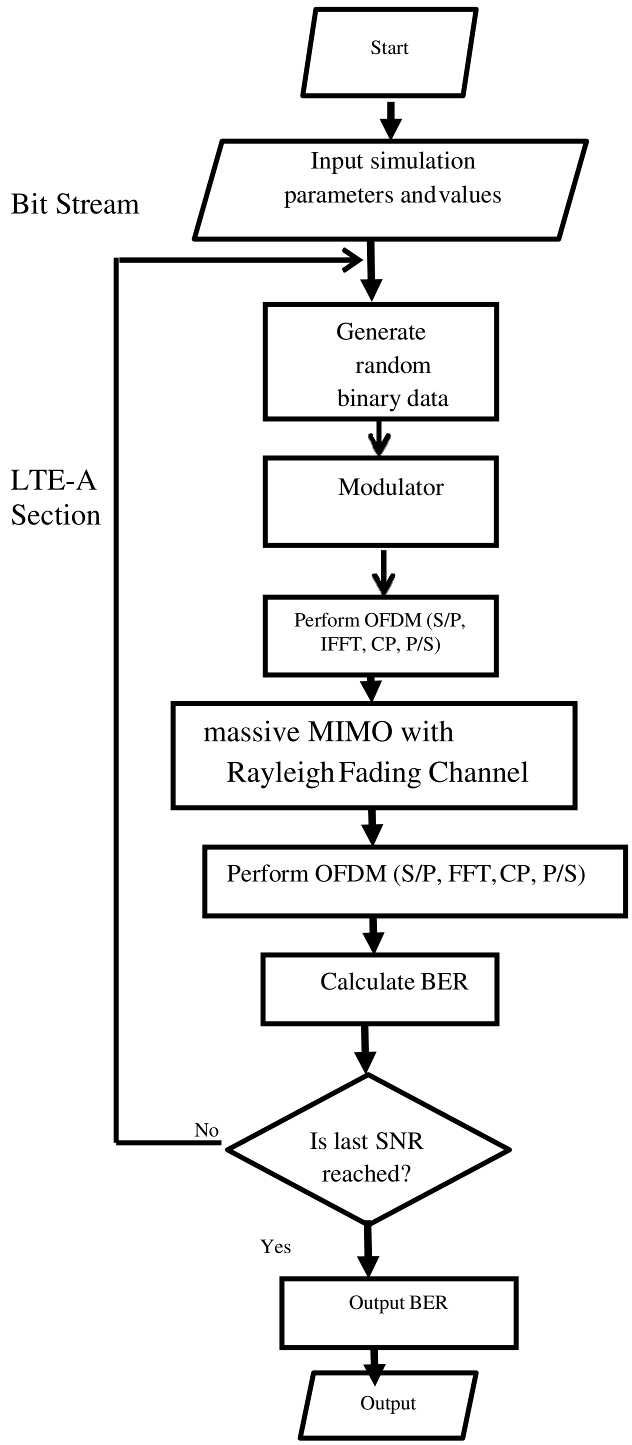

Fig.4 Flow Chart of LTE Advanced system

BER Tool application enables to analyze the bit error rate (BER) performance of communications systems. BER Tool computes the BER as a function of signal-to-noise ratio. It analyzes performance either with Monte-Carlo simulations of MATLAB functions and Simulink models or with theoretical closed-form expressions for selected types of communication systems. The demodulation process is reverse of the modulation process to get the input signal, and to check the difference between input and output signal BER Tool is used.

Multiple Input Multiple Output (massive MIMO) Channel Block is an antenna technology for wireless communications. The massive MIMO Channel block filters an input signal using a multiple- input multiple-output (massive MIMO) multipath fading channel. Fading distribution specify the fading distribution of the channel as Rayleigh or Rician. In this model our selection is Rayleigh. Spectrum Analyzer block, referred to here as the scope, displays frequency spectra of signals. The Spectrum Analyzer block accepts input signals, through one or more input ports, with the following characteristics:

- Discrete sample time
- Real- or complex-valued
- Fixed number of channels of variable length
- Floating- or fixed-point data type

The proposed model combines the advantages of both massive MIMO and OFDM, and provides effective solutions to ISI and spatial diversity (increase robustness). OFDM can completely remove ISI by adding cyclic prefix. massive MIMO systems add space diversity to systems, so they can increase robustness of the systems, for example transmitter send one symbol from two antenna, if one channel between transmitter and receiver is in bad condition then it is more probable in SISO system to fail, but in massive MIMO system that symbol fail in one channel but received in another channel, then we can say massive MIMO is robust. From the simulation results, we can see that massive MIMO-OFDM LTE-Advanced system outperforms in comparison to reference paper in terms of BER performance.

IV. CONCLUSION

This paper presents the basic principles of massive MIMO-OFDM LTE-Advanced for next generation wireless communication system. Multiple Input Multiple Output (massive MIMO) in combination with Orthogonal Frequency Division Multiplexing (OFDM) is a recently proposed technique for multiple access communication. Thus, the number of antenna in massive MIMO and cyclic prefix used in OFDM must be carefully designed to ensure good performance, low memory requirements and low computational complexity.

Performance of the proposed model is experimented and compared for different modulators like BPSK, QPSK, 16QAM, 64QAM .Comparison is done in terms bit error rate (BER) with other alternative technologies in wireless communication system. The input data sequence is digital since it's a digital modulation scheme.

This work concludes with the successful implementation of proposed single channel massive MIMO-OFDM LTE-Advanced system for next generation wireless communication system. The proposed model is experimented for different parameters like, different modulators and found quite efficient. Performance of the proposed model is experimented and compared for different modulators namely, BPSK, 16QAM, 64QAM, and QPSK for Rayleigh Fading channel with transmitter and receiver, and observed for better BER, and convergence are fast for wireless communication system. Bit error rate (BER) is used for measuring performance. Results shows that as we increase energy per bit to noise ratio(E_b/N_o) then BER decreases. The experimental results shows better performance for BPSK and 16QAM at 5db and 9db respectively, when compared with reference paper.

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