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Performance Analysis of MIMO-OFDM for 5g MIMO System

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***Abstract*- In this research paper basic concepts of 5G MIMO system is discussed in detail and BER performance of OFDM system for 5G MIMO system is simulated and results are shown on display. A novel technique CMA method to minimize PAPR reduction is proposed so that bit error rate performance can be improve significantly. Number of symbol considered 100, number of transmitter antenna is taken two and number of receiving antenna is taken three for analyzing BER performance and channel estimation using least square estimator.**

***Index Terms*- PAPR, MIMO, OFDM, Bit Error Rate, Signal to Noise Ratio**

1.INTRODUCTION

Fast adaptation of telecommunication technologies and services by different sects of society, and parallel development of advanced technologies at hardware and software levels are key drivers behind the success of the telecom industry, which has come a long way from the first generation cellular technology to the present day's fourth generation (4G) cellular technology. As we are moving from the world of "Internet for People" to the "Internet of Things", which aims to connect 50 billion users and devices around the world by 2020, next generation cellular technologies that can provide ultra-high bandwidth, ultra-high data rate, zero latency, high speed mobility, and high energy efficiency are foreseen. Technology pioneers are working on 5'th generation (5G) cellular technologies that meet requirements of the next generation wireless devices, and this study provides an overview on the 5G platform as to how different stake holders are gearing up towards the next generation cellular technology. The report further tries to offer a broad level analysis/overview of their existing patent holdings and attempts to bring light to how telecom operators around the world are setting up and/or planning to set up the required infrastructure for the fifth generation wireless technology, and how Reliance Jio, among other Service Operators/Providers in India, can use their competitive strength to become a prominent stake holders in this domain.

2. LITERATURE REVIEW

The exponential increase in demand for multimedia services and mobile broadband along with the requirements set by the fourth industrial revolution, including internet of- things (IoT), industrial internet, massive machine-type communications (mMTC), vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications, have confirmed the need for a new wireless communication standard, namely 5G. The targets set by operators and vendors for 5G typically include latencies below 1 ms, an area capacity of 1 Tbps/km2, and support for a 100x increase in connected devices compared to that of Long Term Evolution-Advanced (LTE-A) [1]. Another common requirement for 5G is a minimum user-throughput of 50Mbps for everyone [2]. This includes vehicular users in urban environments. Therefore, 3rd generation partnership project (3GPP) has set a requirement that the next generation of radio access shall efficiently support users with velocities up to 30km/h in dense urban environments [3].
Network densification is commonly seen as a natural way of evolving towards 5G [4]. In particular, UDNs with a continuous coverage, i.e. continuous ultra-dense networks (C-UDNs), have been shown to be an attractive approach for achieving the aforementioned targets for 5G in sub-6 GHz, especially for vehicular and mobile users [5]. In fact, the performance of practical massive multiple-input multiple-output (M-MIMO) systems with macro- or microcell

deployments is limited by channel aging and pilot contamination [5], [6]. Scenarios with stationary or quasi-static users allow for exploiting in a more efficient and practical manner the benefits of M-MIMO systems in terms of degrees-of-freedom, large array gain and subsequent low transmit power, as well as low-cost of site acquisition and reuse.

Wide-scale deployment of C-UDNs requires backhaul solutions that are cost effective, reliable and scalable [7]. In particular, wired backhaul is typically seen as an infeasible approach for UDNs due to the high -cost of deployment [8]. On the other hand, millimeter wave (mmW) based solutions typically require line-of-sight (LoS) conditions between the aggregation point and the UDN-access nodes (ANs), or proper network planning [9]. However, thorough cell planning typically increases the deployment cost of the network and limits the scalability of such an approach. Moreover, the decision made at the 2015 world radio communication conference (WRC'15) of postponing regulatory aspects of mmW-bands for mobile broadband communications to 2019 [10], provide an incentive for backhaul solutions that operate in sub-6 GHz and possibly in-band with the access network. This is particularly relevant due to the limited available spectrum in sub-6 GHz, and allows for a timely adoption of 5G by the year 2020.

This paper is related to the work in [11] and [12] where in-band M-MIMO solutions for wireless backhaul of UDNs in sub-6 GHz are also considered. In particular, the analysis in [11] assumes that each UDN-AN is associated with a single user node (UN) on a given time-frequency resource, i.e. multi-user multiple-input multiple-output (MIMO) (MU-MIMO) in the access network is not considered. Moreover, the interference caused to the UN from neighboring

UDN-ANs is assumed negligible. Finally, an uncorrelated Rayleigh fading channel model is used in [11] and perfect channel state information (CSI) at transmitter (CSIT) is assumed therein. The work in [12] focuses on the case where the UDN-ANs may have full-duplex capabilities. However, single-antenna UDN-ANs are assumed, and independent and identically distributed (IID) channels are considered, i.e. spatial correlation is not taken into account. Our work considers multi antenna transceivers at the ANs and the numerical results provided in this paper are based on a realistic raytracing channel model.

This paper is also related to the work in [9] where MU-MIMO techniques are proposed for providing high capacity links to small cells. However, the work in [9] considers mmW frequencies for the backhaul and assumes that the access network operates at different frequencies than that of the backhaul. Our paper considers in-band simultaneous DL transmissions in the backhaul and access network, and proposes modifications to state-of-the-art MU-MIMO techniques in order to mitigate in-band interference. Our work considers a sub-6 GHz operating frequency and provides extensive numerical results that allow one to assess the performance of a practical in- band backhaul scheme in terms of system throughput. Note that the path-loss at sub-6 GHz is significantly smaller than that in mmW frequencies, and the interference caused by in-band backhaul to the access network is typically higher for sub-6 GHz systems. Hence, state-of-the-art MU-MIMO techniques need to be modified in order to mitigate in-band interference. This is considered herein. In particular, multiple UNs are scheduled simultaneously on the same time-frequency resources, and these UNs are equipped with multi antenna transceivers. Transmit (in UL) and receive (in DL) beamforming are employed by the UNs, and each user is associated with a single spatial data stream. The association between UN and AN is dynamic and may change within a few transmission time intervals (TTIs) depending on the channel quality. Agiven UN is scheduled by a single AN, and Coordinated Multi-Point (CoMP) transmissions are not considered. Hence, the network synchronization requirements of our approach are not as stringent as in CoMP. Also, CoMP schemes are typically sensitive to channel aging, and in this paper emphasis is given to mobile UNs that can have velocities of around 50 km/h. Nevertheless, a mild coordination among UDN-ANs is still needed in our scheme for sharing scheduling decisions and interference information for link adaptation purposes. Otherwise, we consider that the ANs are independent and have individual baseband processing.

3. EVOLUATION OF WIRELES TECHNOLOGIES

Wireless technology has come back a protracted manner from analog communication systems to electronic communication system, which might connect users and devices for peer-to-peer communication and web communication. The subsequent key aspects of wireless technologies have evolved and have formed generations of cellular technology: radio access, data rates, and information measure and switch schemes. This section of the report mentions, in short, the evolution of wireless and cellular systems supported these four main key aspects, specifically radio access, data rates, bandwidth, and switch schemes.

Exhibit-4 below represents a high-level graphical illustration of various generations of wireless technology, their evolution time, data rate, and standards.

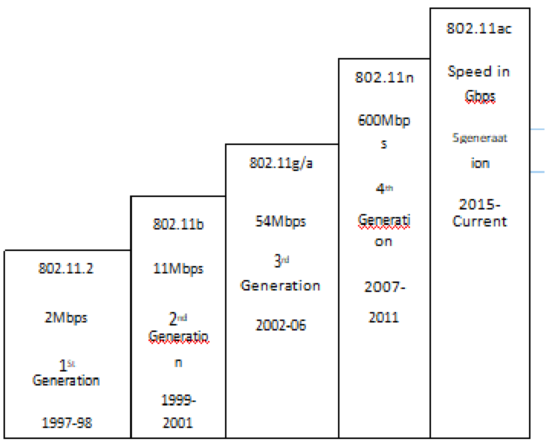

Fig - 1: Wireless Technology Standards 3.1 First Generation Systems (1G)

First generation wireless systems (1G) was an analog system that used frequency modulation technique for radio transmission using frequency division multiple access (FDMA) with channel capacity of 30 KHz and frequency band of 824-894 MHz. 1G was based on an Advance Mobile Phone Service (AMPS) technology and was pioneered for voice service in early 1980‘s.

3.2 Second Generation Systems (2G)

Second generation systems (2G) transitioned from analog communication system to digital communication system during late 1990’s and is still the most used wireless data communication system in different parts of the world. The second generation wireless technology was based on GSM standards, and provides data services (e.g. SMS, e-mail, web browsing etc.) in addition to regular voice service. 2G uses two digital modulation schemes, namely time division multiple access (TDMA), and the code division multiple access (CDMA) and operates in frequency band of 850-1900 MHz. In 2G, GSM technology uses eight channels per carrier with a gross data rate of 22.8 kbps (a net rate of 13 kbps) in the full rate channel and a frame of 4.6 milliseconds (ms) duration. Few of the main benefits of 2G networks over their counterpart 1G networks include their capability to digitally encrypt phone conversations, being efficient on the spectrum by allowing far greater mobile phone penetration levels, and ability to provide data services for mobile starting with SMS text message, and multimedia services. Though 2G has its successors, it is still the most widely used wireless technology in developing countries, which would take time to build up the necessary infrastructure for 3G, much talked about 4G, and the future generation 5G.

3.3 Third Generation Systems (3G)

Third generation (3G) systems combine high-speed mobile access with Internet Protocol (IP)-based services that came in the global market during 2002. The technology is still under adaptation by many developing countries that had some delay in infrastructure development and spectrum licensing. Countries such as India and China with massive population are still building up infrastructure to provide 3G connectivity across the nation. 3G platform is basically based on a set of standards used for mobile devices and mobile telecommunications services and networks that comply with the International Mobile Telecommunications-2000 (IMT-2000) specifications set by the International Telecommunication Union (ITU). The main features of 3G technology include wireless web-based access, multimedia services, email, and video conferencing. The 3G W-CDMA air interface standard had been designed for “always-on” packet-based wireless services that allow computers, entertainment devices, and telephones to share a common wireless network and be connected to Internet anytime, anywhere. 3G systems offer high data rates of up to 2 Mbps, over 5 MHz channel carrier width depending on mobility/velocity, and high spectrum efficiency. 3G communication works on frequency band of 1.8 - 2.5 GHz and provides data rate of up to 2 Mbps. In a broad estimation, there are almost 8,000 standard essential patents (FRAND) relating to the 483 technical specifications that form the 3GPP and 3GPP2 standards. In a high level analysis, it is observed that top 12 companies/assignees accounted in 2004 for 90% of the patents in this technology segment, which include Qualcomm, Ericsson, Nokia, Motorola, Philips, NTT DoCoMo, Siemens, Mitsubishi, Fujitsu, Hitachi, Inter Digital, and Matsushita. Apart from the standard essential patents disclosed by these companies, there are numerous other patents that have not been declared by some of these companies. For instance, it has been noted that the patent portfolio of Nortel and Lucent indicates a long list of patents that may be held standard essential.

3.4 Fourth Generation Systems (4G)

4G wireless communication systems, also referred to as LTE, form part of the recent standard for wireless packet data transmission that provides faster data rate and connects people and devices to Internet. 4G standard was designed to be used for anytime anywhere access/transfer of data by users/devices to provide a comprehensive and secure IP based solution where facilities such as voice, streamed multimedia and data will be provided to users/device at much higher data rates compared to previous generations. The technology and infrastructure development to support 4G standard is still under development in several countries (In another section, we will cover 4G spectrum infrastructure and spectrum licensing with respect to India). 4G services are provided at frequency bands of 2-8 GHz, and can support data rates from 2Mbps to 1 Gbps. 4G networks is required for high speed application such as wireless broadband access, Multimedia Messaging Service (MMS), mobile TV, HDTV content transfer, Digital Video Broadcasting (DVB), video chat, and live steaming. There are several technology advancements such as MIMO, smart antennas, cognitive antennas, among others that are taking place to support better data rate, and provide mobility with good data rate. These advancements can be categorized as LTE advance technologies and will be inducted in next version 4G standards. Though the 4G standard is designed to cater the present and near future wireless network requirements, it will not be adequate to support 50 billion users/devices that are expected to connect to the wireless internet after 2020, and hence the industry pioneers are gearing up for the next generation wireless technology.

A 4G system, in addition to the usual voice and other services of 3G, provides mobile broadband Internet access, for example to Laptops with wireless modems, to smart phones, and to other portable devices. Potential and current applications include mobile web access, IP telephony, gaming services, high-definition TV, mobile TV, video conferencing, 3Dtelevision, and cloud computing.

Table - 1: Specifications of 4G

Characteristics	Range
Frequency Band	2-8 GHz
Bandwidth	5-20MHz
Data Rate	20Mbps
Access	OFDM (TDMA)
FEC Code	Concatenated Codes
Switching	Packet
Mobile Top Speed	200Kmph

As the report is tried to be slightly tailored for Reliance Jio, the subsequent section provides the activity and strength of Reliance Jio with relation to their 4G focus.

Overview of Reliance Jio 4G Spectrum Reliance wants no introduction, and in sum, is headquartered in Mumbai and may be a leading organization within the domain of telecommunication. antecedently referred to as Infotel Broadband, that is currently subsidiary of Reliance Industries Ltd., the broadband service supplier is that the solely company in Asian nation Bharat that non-heritable PAN India 4G spectrums in associate auction control by Government of India. Infotel Broadband non-heritable 4G spectrum for Pan Bharat for Rs. 12,848 crores ($2.7 billion) in 2010, and shortly thenceforth, Reliance Industrial bought 95%of its stake for 4800 large integer sand marked its entry in telecommunication domain, and have become the sole company United Nations agency have received 4G spectrum for all the circles.

3.5 Introduction of 5G

Though not such that by any standardization body, the fifth generation wireless technology are often loosely outlined as a packet switched wireless system with wide space coverage and high turnout that addresses the challenges baby-faced by 4G/LTE and

IMT technology, and might meet the need of over fifty billion wireless devices on the far side 2020 through:
Ultra-High Bandwidth: one thousand times higher wireless capability in comparison with 2010 capability Ultra-High knowledge Rate: give rate of over one Gbps Zero Latency: but ten milliseconds of period
High Speed Mobility: one Gbps rate in high quality, and over one Gbps rate in low quality with but ten time unit of switch time
High Energy Efficiency: Having up to ninetieth of energy per service provided
High Security: give network level security and higher user controlled privacy

4. SYSTEM MODELLING

In this paper we tend to planned OFDM-MIMO application for 5G network. Multiple-input, multiple-output orthogonal frequency-division multiplexing (MIMO-OFDM) is that the dominant air interface for 4G and 5G broadband wireless communications. It combines multiple-input, multiple-output (MIMO) technology, that multiplies capability by transmittal completely different signals over multiple antennas, and orthogonal frequency-division multiplexing (OFDM), that divides a radio channel into an oversized variety of closely spaced sub-channels to supply additional reliable communications at high speeds. Analysis conducted throughout the mid-1990s showed that whereas MIMO may be used with alternative in style air interfaces like time-division multiple access (TDMA) and code-division multiple access (CDMA), the mix of MIMO and OFDM is most sensible at higher knowledge rates.
MIMO-OFDM is that the foundation for many advanced wireless native space network (wireless LAN) and mobile broadband network standards as a result of it achieves the best spectral potency and, therefore, delivers the best capability and knowledge outturn. Greg Raleigh fictional MIMO in 1996 once he showed that completely different knowledge streams might be transmitted at a similar time on a similar frequency by taking advantage of the very fact that signals transmitted through area bounce off objects (such because the ground) and take multiple ways to the receiver. That is, by exploitation multiple antennas and precoding the information, completely different knowledge streams might be sent over different ways. Raleigh recommended and later established that the process needed by MIMO at higher speeds would be most manageable exploitation OFDM modulation, as a result of OFDM converts a high-speed knowledge channel into variety of parallel lower-speed channels.
The OFDM-based wireless native space network (WLAN) normal IEEE 802.11ac is taken into account, however the results square measure applicable additional usually. A diagram of the receiver of IEEE 802.11ac normal is shown in Figure 2[13]. It contains eight RFs, eight Guard Interval removers (GIs), eight FFTs, a MIMO decoder, eight de-mapper and de-interleaver, a spatial-stream de-parser, AN encoder de-parser, a descrambler, a synchronization block, and a channel estimation block. Looking on the required rate in compliance with 802.11TGac, the modulation theme may be Binary section Shift Keying (BPSK), Quaternary section Shift Keying (QPSK), or construction modulation (QAM) with 1–6 bits. The FFT/IFFT processor needs to calculate synchronal 1–8 knowledge sequences looking on the quantity of spatial sequence, the guard interval and also the FFT size.

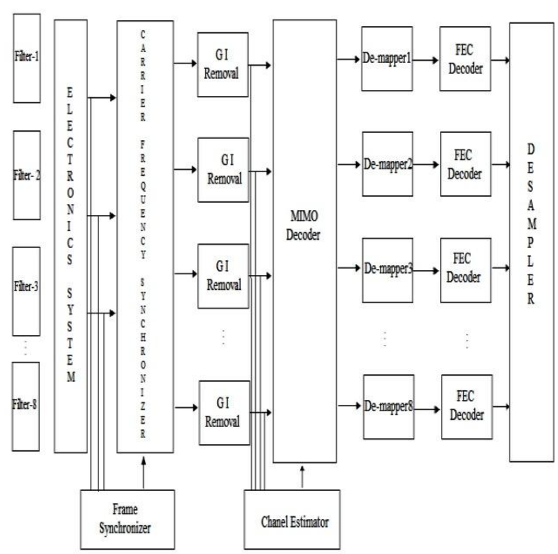

Fig – 2: Block Diagram of the Receiver of IEEE 802.11ac Standard

Algorithm

Given a sequence, $x(n)$ an N-point discrete Fourier transform (DFT) is defined as

$$X(K) = \sum_{n=o}^{N-1} x(n) W_N^{kn} \quad K = 0, \ldots \ldots 127$$

(1)

Where $x(n)$ and $X(K)$ are complex numbers. The twiddle factor is

$$W_N^{kn} = e^{-j\frac{2\pi kn}{N}} = \cos\left(\frac{2\pi kn}{N}\right) - jsin(\frac{2\pi kn}{N})$$

(2)

In (1.1), the computational complexity is $O(N)^2$ through directly performing the required computation. By using the FFT algorithm, the computational complexity can be reduced to $O(Nlog_r N)$ where r means the radix-r FFT. The radix-r FFT algorithmic program is simply derived from DFT by moldering the N-point DFT into a collection of recursively connected r-point FFT remodel, if Nis an influence of r. Higher base FFT algorithmic program has less variety of the nontrivial complicated multiplications, compared with the radix-2 FFT algorithmic program that is that the simplest type all told FFT algorithms [14]. In associate example for 128-point FFT, the amount of nontrivial complicated multiplications of radix-8 FFT algorithmic program is 152, that is barely fifty eight.9% of that of radix-2 FFT algorithmic program [14].Thus, so as to save lots of power dissipation of the complicated multiplier factor operation, radix-8 FFT algorithmic program chosen to scale back the amount of nontrivial complicated multiplications. The mixed-radix FFT algorithmic program, together with radix-2 and radix-8 FFT algorithmic program, is required to effectively implement 128-point FFT.

The IFFT of an N -point sequence X(k),k=0,..,N-1 is defined as

$$x(n) = \frac{1}{N} \sum_{k=0}^{N-1} X(K) W_N^{-kn} \qquad K = 0,,,127$$

(3) In order to implement the IFFT algorithm more efficiently, above equation can be written as [15],

$$x(n) = \left(\frac{1}{N}\right) \left\{ \sum_{k=0}^{N-1} X^*(K) W_N^{-kn} \right\}^* K == 0,,,127$$

(4) According to above equation, the IFFT can be performed by taking the complex conjugate of the incoming data first and then the outgoing data without changing any coefficient in the original FFT algorithm so that the hardware implementation can be more efficient.

PAPR Reduction Technique

PAPR reduction techniques vary according to the needs of the system and are dependent on various factors. Vennila et al explained PAPR reduction. PAPR reduction capacity, increase in power in transmit signal, loss in data rate, complexity of computation and increase in the bit error rate at the receiver end are various factors which are taken into account before adopting a PAPR reduction technique of the system. Han and Lee (2005) have given an overview of Peak to Average Power Ratio Reduction Techniques, while Muller and Huber (1997) have compared the PAPR reduction schemes. PAPR reduction techniques are clipping, SLM (Selective Mapping) and CMA (CONSTANT MODULUS ALGORITHM)

5. RESULTS & DISCUSSION

Parameters of 5g MIMO system for OFDM application are number of subcarrier 128, FFT length is 64, no. of transmitting antenna is two and number of receiving antenna is 3 and range of signal to noise ratio is considered 3 to 15dB and number of monte carlo to find the value of each point is 100. Number of blocks is taken 100, guard time interval is ¼, number of channel taps between each transmit-receive antenna is 6. Mean square error is calculated using least square estimation for channel estimation. The graph of BER rate is plotted in below fig. 3.

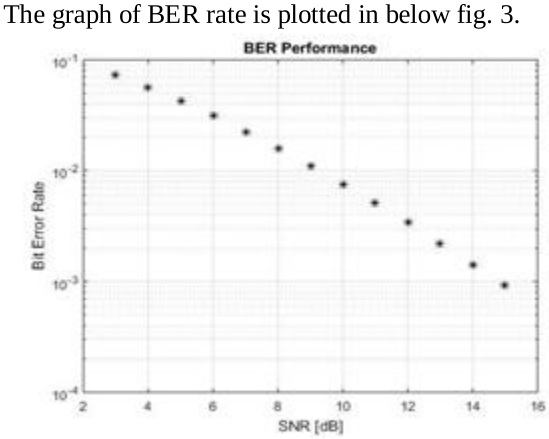

Fig – 3: Bit Error Rate Performance

And value of mean square error is shown in fig. 4

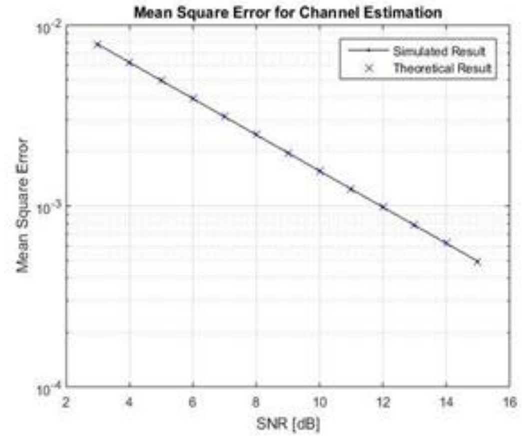

Fig – 4: Mean Square Error for LSE Channel Estimation

Bit error rate performance for different modulation technique is analyzed and simulated on matlab and results are shown on fig. 5

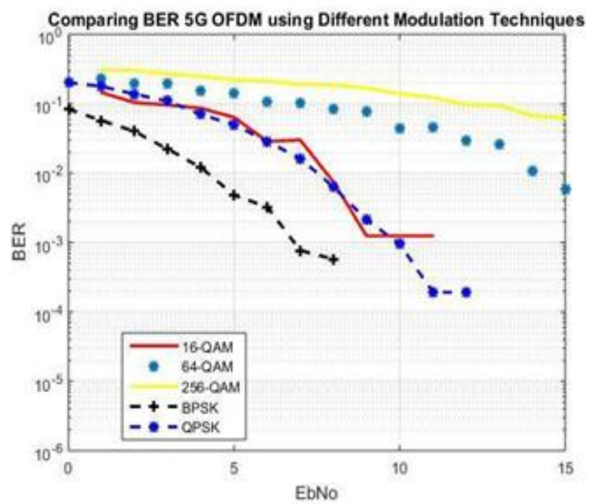

Fig – 5: BER of 5G OFDM for BPSK, QPSK, QAM

From above fig. 5 it can be conclude that bit error is higher in case of QAM modulation technique as compared to BPSK and QPSK. QAM 16 performed better as compared to QAM 64 and QAM 256. Hence as number of constellation increases bit error also increases but transmission speed is good. That's why speed in 5G mimo system is better but chances of error is also high. Hence we need a good PAPR reduction technique to improve BER performance.

Peak amplitude power reduction technique is used to minimize the ber for 5G OFDM system. Four different techniques of PAPR reduction normal, clipping, SLM and CMA technique is used and compared and results are shown in fig. 6.

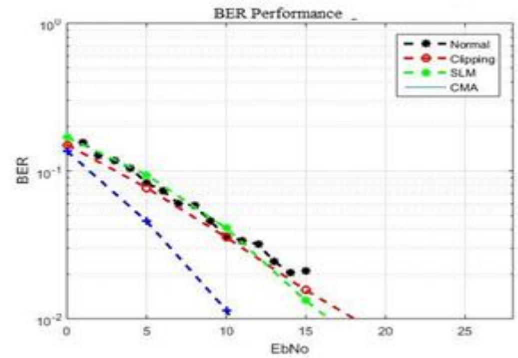

Fig – 6: BER Performance for Normal, Clipping, SLM and CMA PAPR reduction Techniques

6. CONCLUSIONS

This paper concludes the BER performance of OFDM for 5G MIMO system. Simulation is worked out in MATLAB software version 2017a. BER performance for signal to noise ratio (SNR) from 0 to 15 is analyzed and from the results it can be conclude that as SNR increases Bit error rate decreases. BER is also calculated for different modulation scheme. In this research paper BPSK, QPSK and QAM-16, QAM-64 and QAM-256 is analyzed and BPSK found best in terms of error and QAM-256 found best in terms of speed. Hence we can say that QAM-1024 and higher constellation QAM are useful for 5G applications. Finally PAPR values of OFDM signal is calculated and different PAPR reduction technique is applied and CMA technique performed best as its BER is less as compared to other.

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