INVESTIGATION OF INDEX MODULATION FOR MIMO OFDM WITH INTERCARRIER INTERFERENCE CANCELLATION

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ABSTARCT:

Multiple-enter more than one outputs orthogonal frequency department multiplexing with index modulation (MIMOOFDMIM) is novel multicarrier transmission approach which has been proposed currently as an opportunity to classical MIMO-OFDM. The number one idea of OFDM-IM is the usage of the indices of the energetic subcarriers in an OFDM machine as an additional supply of facts. In this paper extraordinary papers are surveyed associated with Multiple-Input Multiple-OutputOFDM with Index Modulation: Low-Complexity Detector Design. In this speak about MIMO device. Index modulated orthogonal frequency department multiplexing(IM-OFDM) is a newly proposed approach, which achieves drastically advanced mistakes performance and pinnacle-to average power ratio (PAPR) in evaluation with classical OFDMdue to the activation of partial subcarriers. However, inside the presence of inter-company interference (ICI), errors detection of the subcarrier indices may also withoutissue arise, such that the overall performance of IM-OFDM is seriously degraded and may be even worse than classical OFDM. To remedy this hassle, in this paper, we advocate tailoring the mind of classical ICI self-cancellation and –course cancellation to IM-OFDM with two mapping techniques, i.e., symmetric mapping and mirror mapping. Thanks to the joint format of the grouping and mapping techniques, the proposed schemes inherit the IM-OFDM one-of-a-kind feature of in part activated subcarriers but with decreased ICI. Monte Carlo Simulations validate that the proposed schemes substantially outperform traditional OFDM with ICI cancellation in additive

white Gaussian noise (AWGN) channels with frequency deviation without sacrifice of the spectral performance and increase of the computational complexity

INTRODUCTION

Multiple-enter a couple of-output orthogonal frequency department multiplexing (MIMO-OFDM) may be a key technology for several wireless communiqué structures, due to its excessive spectral performance [6]. Recently, big-scale multiuser MIMO structures with tens to many antennas at the lowest-station (BS) have acquired important hobby. The motivation to undergo in mind such massive-scaleMIMO systems is their capability to satisfy the growing demands for better output and advanced great-of-organization of next generationmultiuser Wi-Fi verbal exchange systems [6]. Due to the reality the sign of every purchaser is needed to be extracted from the received interfered sign on the BS receiver [6], one key issue within the fashion of a practical receiver for large-scale MIMO-OFDM systems is the manner to reduce the extremely good of detection even as not lots compromise in simple performance. Orthogonal frequency branch multiplexing (OFDM) has turn out to be one maximum of the most commonplace multicarrier transmission techniques for wideband Wi-Fi communications in modern-day-day years. Because of its benefits like inexperienced implementation and strength to frequency selective fading channels, OFDM has been enclosed in numerous necessities like long time Evolution (LTE), IEEE 802.11x Wi-Fi community area network (LAN), virtual video broadcasting (DVB) and IEEE 802.16e-WiMAX. Considering the advantages of more than one-enter multiple-output (MIMO) structures over single antenna systems like progressed rate and power performance, the aggregate of OFDM and MIMO transmission strategies appears as a sturdy one-of-a-type for future wireless standards like 5G and past. [4] OFDM with index modulation (OFDM-IM) [10] may be an ultra-modern multicarrier transmission method that has been deliberate as every other to classical OFDM. Stimulating from the SM idea, in OFDM-IM, index modulation strategies are completed for the indices of the furnished subcarriers of an OFDM gadget. In OFDM-IM method, simplest a hard and fast of to be had subcarriers are desired as active regular with the records bits, even as the final inactive subcarriers are set 0. In exceptional words, the facts is transmitted no longer best with the useful resource of the records symbols determined on from M-ary sign constellations, but moreover with the useful resource of the indices of the active subcarriers. Not like classical OFDM, the quantity of energetic subcarriers can be adjusted within the OFDM-IM scheme, and this flexibility inside the device fashion offers a stimulating alternate-off among mistakes performance and spectral performance. Moreover, it is been verified that OFDM-IM has the ability to understand a more potent errors ordinary performance than classical OFDM for low-to-mid spectral overall performance values. Due to its adjustable form of lively subcarriers, OFDM-IM can be a potential candidate now not best for immoderate pace Wi-Fi communications structures but furthermore for tool-to-machine (M2M) communications systems that need low strength intake. OFDM is considered as a promising multicarrier transmission approach for excessive information fee Wi-Fi conversation structures because of its sufficient robustness to deal with radio channel impairments and excessive spectrum normal performance [1]. Recently, novel OFDM scheme known as IM-OFDM has been suggest[2] [3], which conveys the statistics bits no longer only by way of the use of the M-ary constellation signs as in classical OFDM, but furthermore through the indices of the energetic subcarriers. It has been validated that IM-OFDM achieves higher mistakes preferred performance than traditional OFDM beneath splendid channel situations [3]. IM-OFDM is also established to have reduced PAPR [4], which appreciably moderates the requirement of the amplifier dynamic range and consequently attributes the practicality of low-price and distinctly energy inexperienced to the implementation of IM-OFDM. Thus, a number of researches emerge to similarly beautify the overall performance of IM-OFDM. [5] Proposes to organization subcarriers in an interleaved way and harvests tremendous common overall performance development [6]. In [7], the authors talk the most proper choice of the energetic subcarrier gadgets. [8], [9] exercise index modulation to in-phase and quadrature additives to beautify the spectrum overall performance. The writer in [10] proposes coordinate interleaving to accumulate variety advantage in IM-OFDM.Due to the reality that all subcarriers are strictly designed to be orthogonal, OFDM is liable to frequency offset because of Doppler shift and/or transceiver imperfection, whichdestroys the orthogonality among subcarriers and for this reason substantially deteriorates the machine normal overall performance. Unfortunately, ICI does a bargain more harm to IM-OFDM because the power leakagefrom the energetic subcarriers to the inactive ones considerably will boom the possibility of faulty detection of subcarrierstates and in turn misleads the detection of transmitted symbolsat the lively subcarriers. Thus, IM-OFDM demonstrates evenworse performance than classical OFDM inside the presence of ICI [11].In the literature, numerous countermeasures were proposed for OFDM system to fight ICI. Among them, ICI self-cancellation schemes [12] - [14] and -path cancellation schemes [15] - [16] are broadly common due to their simplicity and effectiveness. The essential concept of ICI self-cancellation is to repeat the constellation symbols at the subcarriers according to particular mapping techniques in a single OFDM block, so that the interference brought through a selected subcarrier can be cancelled by way of manner of its counterpart. Accordingly, in –course cancellation schemes, the photo repetitions are assigned to the adjacent OFDM blocks and ICI cancellation is accomplished through manner ofthe arithmetical operations among the two blocks. However, because of the special shape of IM-OFDM, i.e., the partly activated subcarriers and subcarrier grouping, the mapping policies in traditional ICI cancellation schemes not hold.To experience the low PAPR of IM-OFDM beneath ICI,the joint format of IM-OFDM with ICI cancellation strategies will become a pressing and difficult assignment. Our preceding artwork [17] proposes ICI self-cancellation with adjoining mapping for IM-OFDM in hobby of its clean implementation and effectiveness. However, we would love to deal with that adjoining mapping is suboptimal due to the reality the neighboring subcarriers in every organization are more likely to revel in correlated fading, which can be very not unusual in automobile-to-automobile communications [18] [19] and could notably degrade the device generic overall performance Motivated via manner of this, in this paper, we leverage upon our in advance paintings and endorse to introduce the symmetric mapping and mirror mapping techniques to IM-OFDM systems to similarly decorate the general standard overall performance, which is probably greater hard to mix with IM-OFDM however greater effective. Specifically, we keep in mind the precept of every classical ICI self-cancellation and towpath transmission schemes, and get in touch with them IM-OFDM with ICI self-cancellation and IM-OFDM with -path cancellation, respectively. To format the schemes without sacrificing the man or woman of IM-OFDM, the mapping techniques are mutually designed with the grouping and modulation strategies, which might be: Symmetric Symbol Repetition (SSR), Symmetric Conjugate Symbol Repetition (SCSR), Mirror Symbol Repetition (MSR) and Mirror Conjugate Symbol Repetition (MCSR) for IMOFDM with ICI self-cancellation, and a couple of) Symmetric Conversion Transmission (SCVT), Symmetric Conjugate Transmission (SCJT), Mirror Conversion Transmission (MCVT) and Mirror Conjugate Transmission (MCJT) for IM-OFDM with path cancellation. The transceiver systems of all of the proposed schemes have similar regular complexity to that of traditional OFDM with ICI cancellation. It is confirmed through simulations that the proposed IM-OFDM with ICI cancellation schemes exhibit better tool normal performance than conventional OFDM with ICI cancellation in AWGN channels beneath organization frequency offset (CFO).

LITERATURE SURVEY

- Beixiong Zheng et al.[1] “Multiple-Input Multiple-Output OFDM with Index Modulation: Low-Complexity Detector Design”, in this paper proposed two low-complexity detectors derived from the SMC theory for the MIMO-OFDMIM system. The first proposed subblock-wise detector draws samples at the subblock level, exhibiting near-optimal performance for the MIMO-OFDMIM system. The second proposed subcarrier-wise detector draws samples at the subcarrier level, exhibiting substantially reduced complexity with a marginal performance loss. An effective legality examination method has been also developed to couple with the subcarrier wise detector. Computer simulation and numerical results have validated the outstanding performance and the low complexity of both proposed detectors.
- Ertu˘grul Bas¸ar et al.[2] “Multiple-Input Multiple-Output OFDM with Index Modulation”, A novel scheme called MIMOOFDM with index modulation has been proposed as an alternative multicarrier transmission

technique for 5G networks. It has been shown via extensive computer simulations that the proposed scheme can provide significant BER performance improvements over classical MIMO-OFDM for several different configurations. The following points remain unsolved in this study: i) performance analysis, ii) the selection of optimal N and K values, iii) diversity techniques for MIMO-OFDM-IM, and iv) Implementation scenarios for high mobility.

- Ertugrul Basar et al.[3] "On Multiple-Input Multiple-Output OFDM with Index Modulation for Next Generation Wireless Networks", In this study, the recently proposed MIMO-OFDM-IM scheme has been investigated for next generation 5G wireless networks. For the MIMO-OFDM-IM scheme, new detector types such as ML, near-ML, simple MMSE, MMSE-LLR-OSIC detectors have been proposed and their ABEP have been theoretically examined. It has been shown via extensive computer simulations that MIMO-OFDM-IM scheme provides an interesting trade-off between complexity, spectral efficiency and error performance compared to classical MIMO-OFDM scheme and it can be considered as a possible candidate for 5G wireless networks. The main features of MIMO-OFDM-IM can be summarized as follows: i) better BER performance, ii) flexible system design with variable number of active OFDM subcarriers and iii) better compatibility to higher MIMO setups. However, interesting topics such as diversity methods, generalized OFDM-IM cases, high mobility implementation and transmit antenna indices selection still remain to be investigated for the MIMO-OFDM-IM scheme. Ertu˘grul
- Bas¸ar et al.[4] "Performance of Multiple-Input Multiple-Output OFDM with Index Modulation", In this paper, proposed ML and near-ML detectors for the recently introduced MIMO-OFDM-IM scheme to improve its error performance compared to MMSE based detection. The ABEP upper bound of the MIMO-OFDM-IM scheme with ML detection has been

derived and it has been shown that the derived theoretical upper bound can be used as an efficient tool to predict the BER performance of the MIMO-OFDMIM scheme. It has been shown via computer simulations that MIMO- FDM-IM scheme can provide significant improvements in BER performance over classical MIMO-OFDM using different type of detectors and MIMO configurations.

- Beixiong Zheng et al.[5] “Low-Complexity ML Detector and Performance Analysis for OFDM With In-Phase/Quadrature Index Modulation”, In this letter, we've planned a low-complexity detector supported the milliliter criterion, that dispenses with a priori data of the noise variance and also the potential realizations of the active subcarrier indices. supported the framework of OFDM-I/Q-IM using the planned milliliter detector, the straight line ABEP and also the actual coding gain achieved by OFDMI/Q-IM are derived, that absolutely matches the simulation results. Moreover, the exact coding gain including the spectral efficiency price has provided a clear plan of a basic trade-off between the system performance and also the spectral efficiency of OFDM-I/Q-IM by the adjustment of the quantity of active subcarriers.
- Sheng Wu et al.[6] “Low-Complexity Iterative Detection for Large-Scale Multiuser MIMO-OFDM Systems Using Approximate Message Passing”, For the detection of large-scale multiuser MIMO-OFDM systems, we have proposed a range of low-complexity approximate message passing algorithms that can offer desirable tradeoff between performance and complexity. It is verified through extensive simulations that our proposed approximate message passing algorithms can achieve near optimal performance with low complexity. Compared with existing turbo detection algorithms, the proposed schemes can achieve or even outperform the performance of some complex algorithms, such as the iterative decoding based on STS-SD and MMSESIC. In addition, the number of iterations required to achieve near-optimal performance is

small and does not increase with the system dimension.

MIMO SYSTEM

Digital communication using Multiple-Input Multiple-Output (MIMO) systems is one in all the most important technical breakthroughs in modem communication. MIMO systems are simply outlined because the systems containing multiple transmitter antennas and multiple receiver antennas. Communication theories show that MIMO systems will offer a probably very high capability that, in several cases, grows some linear with the quantity of antennas. Recently, MIMO systems have already been implemented in wireless communication systems, particularly in wireless LANs (Local area Networks). Completely different structures of MIMO systems have additionally been planned by industrial organizations within the Third Generation Partnership Project (3GPP) standardizations, as well as the structures planned. The core plans below the MIMO systems are that the ability to show multi-path propagation, that is usually an obstacle in typical wireless communication, into a profit for users. The main feature of MIMO systems is space-time process. Space-time Codes (STCs) are the codes designed for the utilization in MIMO systems. Space-Time Codes (STCs) are the codes designed for the use in MIMO systems. In STCs, signals are coded in both temporal and spatial domains. Among different types of STCs, orthogonal Space-Time Block Codes (STBCs) possess a number of advantages over other types of STCs.Multiple-input, multiple-output orthogonal frequency-division multiplexing (MIMO-OFDM) is the dominant air interface for 4G and 5G broadband wireless communications. It combines multiple-input, multiple-output (MIMO) technology, which multiplies capacity by transmitting different signals over multiple antennas, and orthogonal frequency-division multiplexing (OFDM), which divides a radio channel into a large number of closely spaced subchannels to provide more reliable communications at high speeds. Research conducted during the mid-1990s showed that while MIMO can be used with other popular air interfaces such as time-division multiple access (TDMA) and code-division multiple access (CDMA), the combination of MIMO and OFDM is most practical at higher data rates.MIMO-OFDM is the foundation for most advanced wireless local area network (wireless LAN) and mobile broadband network standards because it achieves the greatest spectral efficiency and, therefore, delivers the highest capacity and data throughput. Greg Raleigh invented MIMO in 1996 when he showed that different data streams could be transmitted at the same time on the same frequency by taking advantage of the fact that signals transmitted through space bounce off objects (such as the ground) and take multiple paths to the receiver. That is, by using multiple antennas and precoding the data, different data streams could be sent over different paths. Raleigh suggested and later proved that the processing required by MIMO at higher speeds would be most manageable using OFDM modulation, because OFDM converts a high-speed data channel into a number of parallel lower-speed channels. Gregory Raleigh was first to advocate the use of MIMO in combination with OFDM. In a theoretical paper, he proved that with the proper type of MIMO system—multiple, co-located antennas transmitting and receiving multiple information streams using multidimensional coding and encoding—multipath propagation could be exploited to multiply the capacity of a wireless link.[5] Up to that time, radio engineers tried to make real-world channels behave like ideal channels by mitigating the effects of multipath propagation. However, mitigation strategies have never been fully successful. In order to exploit multipath propagation, it was necessary to identify modulation and coding techniques that perform robustly over time-varying, dispersive, multipath channels. Raleigh published additional research on MIMO-OFDM under time-varying conditions, MIMO-OFDM channel estimation, MIMO-OFDM synchronization techniques, and the performance of the first experimental MIMO-OFDM system.[6][7][8][9] Raleigh solidified the case for OFDM by analyzing the performance of MIMO with three leading modulation techniques in his PhD dissertation: quadrature amplitude modulation (QAM), direct sequence spread spectrum (DSSS), and discrete multi-tone (DMT).[10] QAM is representative of narrowband schemes such as TDMA that use equalization to combat ISI. DSSS uses rake receivers to compensate for multipath and is used by CDMA systems. DMT uses interleaving and coding to eliminate ISI and is representative of OFDM systems. The analysis was performed by deriving the MIMO channel matrix models for the three modulation schemes, quantifying the computational complexity and assessing the channel estimation and synchronization challenges for each. The models showed that for a MIMO system using QAM with an equalizer or DSSS with a rake receiver, computational complexity grows exponentially (more specifically, quadratically) as data rate is increased. In contrast, when MIMO is used with DMT computational complexity grows linearly (more specifically, log-linearly) as data rate is increased. Raleigh subsequently founded Clarity Wireless in 1996 and Airgo Networks in 2001 to commercialize the technology. Clarity developed specifications in the Broadband Wireless Internet Forum (BWIF) that led to the IEEE 802.16 (commercialized as WiMAX) and LTE standards, both of which support MIMO. Airgo designed and shipped the first MIMO-OFDM chipsets for what became the IEEE 802.11n standard. MIMO-OFDM is also used in the 802.11ac standard and is expected to play a major role in 802.11ax and fifth generation (5G) mobile phone systems. Several early papers on multi-user MIMO were authored by Ross Murch et al. at Hong Kong University of Science and Technology.[11] MU-MIMO was included in the 802.11ac standard (developed starting in 2011 and approved in 2014). MU-MIMO capacity appears for the first time in what have become known as "Wave 2" products. Qualcomm announced chipsets supporting MU-MIMO in April 2014.[12] Broadcom introduced the first 802.11ac chipsets supporting six spatial streams for data rates up to 3.2 Gbit/s in April 2014. Quantenna says it is developing chipsets to support eight spatial streams for data rates up to 10 Gbit/s.[13] Massive MIMO, Cooperative MIMO (CO-MIMO), and HetNets (heterogeneous networks) are currently the focus of research concerning 5G wireless. The development of 5G standards is expected to begin in 2016. Prominent researchers to date include Jakob Hoydis (of Alcatel-Lucent), Robert W. Heath (at the University of Texas at Austin), Helmut Bölcskei (at ETH Zurich), and David Gesbert (at EURECOM).[14][15][16][17] Trials of 5G technology have been conducted by Samsung.[18] Japanese operator NTT DoCoMo plans to trial 5G technology in collaboration with Alcatel-Lucent, Ericsson, Fujitsu, NEC, Nokia, and Samsung

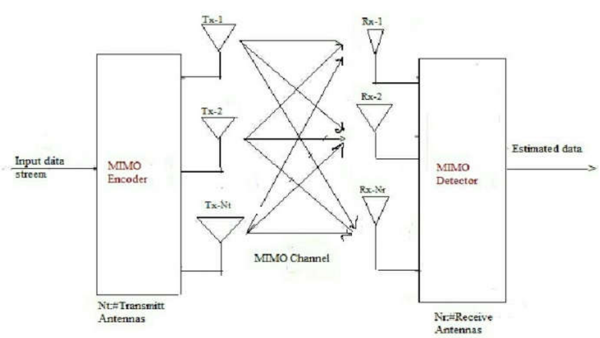

Fig.1. MIMO Systems

OPERATION:

In modern usage, the term "MIMO" indicates more than just the presence of multiple transmit antennas (multiple input) and multiple receive antennas (multiple output). While multiple transmit antennas can be used for beamforming, and multiple receive antennas can be used for diversity, the word "MIMO" refers to the simultaneous transmission of multiple signals (spatial multiplexing) to multiply spectral efficiency (capacity).Traditionally, radio engineers treated natural multipath propagation as an impairment to be mitigated. MIMO is the first radio technology that treats multipath propagation as a phenomenon to be exploited. MIMO multiplies the capacity of a radio link by transmitting multiple signals over multiple, co-located antennas. This is accomplished without the need for additional power or bandwidth. Space–time codes are employed to ensure that the signals transmitted over the different antennas are orthogonal to each other, making it easier for the receiver to distinguish one from another. Even when there is line of sight access between two stations, dual antenna polarization may be used to ensure that there is more than one robust path. OFDM enables reliable broadband communications by distributing user data across a number of closely spaced, narrowband subchannels.[1] This arrangement makes it possible to eliminate the biggest obstacle to reliable broadband communications, intersymbol interference (ISI). ISI occurs when the overlap between consecutive symbols is large compared to the symbols' duration. Normally, high data rates require shorter duration symbols, increasing the risk of ISI. By dividing a high-rate data stream into numerous low-rate data streams, OFDM enables longer duration symbols. A cyclic prefix (CP) may be inserted to create a (time) guard interval that prevents ISI entirely. If the guard interval is longer than the delay spread—the difference in delays experienced by symbols transmitted over the channel—then there will be no overlap between adjacent symbols and consequently no intersymbol interference. Though the CP slightly reduces spectral capacity by consuming a small percentage of the available bandwidth, the elimination of ISI makes it an exceedingly worthwhile tradeoff. A key advantage of OFDM is that fast Fourier transforms (FFTs) may be used to simplify implementation. Fourier transforms convert signals back and forth between the time domain and frequency domain. Consequently, Fourier transforms can exploit the fact that any complex waveform may be decomposed into a series of simple sinusoids. In signal processing applications, discrete Fourier transforms (DFTs) are used to operate on real-time signal samples. DFTs may be applied to composite OFDM signals, avoiding the need for the banks of oscillators and demodulators associated with individual subcarriers. Fast Fourier transforms are numerical algorithms used by computers to perform DFT calculations.[2] FFTs also enable OFDM to make efficient use of bandwidth. The subchannels must be spaced apart in frequency just enough to ensure that their time-domain waveforms are orthogonal to each other. In practice, this means that the subchannels are allowed to partially overlap in frequency.MIMO-OFDM is a particularly powerful combination because MIMO does not attempt to mitigate multipath propagation and OFDM avoids the need for signal equalization. MIMO-OFDM can achieve very high spectral efficiency even when the transmitter does not possess channel state information (CSI). When the transmitter does possess CSI (which can be obtained through the use of training sequences), it is possible to approach the theoretical channel capacity. CSI may be used, for example, to allocate different size signal constellations to the individual subcarriers, making optimal use of the communications channel at any given moment of time. More recent MIMO-OFDM developments include multi-user MIMO (MU-MIMO), higher order MIMO implementations (greater number of spatial streams), and research concerning massive MIMO and cooperative MIMO (CO-MIMO) for inclusion in coming 5G standards. MU-MIMO is part of the IEEE 802.11ac standard, the first Wi-Fi standard to offer speeds in the gigabit per second range. MU-MIMO enables an access point (AP) to transmit to up to four client devices simultaneously. This eliminates contention delays, but requires frequent channel measurements to properly direct the signals. Each user may employ up to four of the available eight spatial streams. For example, an AP with eight antennas can talk to two client devices with four antennas, providing four spatial streams to each. Alternatively, the same AP can talk to four client devices with two antennas each, providing two spatial streams to each.[3] Multi-user MIMO beamforming even benefits single spatial stream devices. Prior to MU-MIMO beamforming, an access point communicating with multiple client devices could only transmit to one at a time. With MU-MIMO beamforming, the access point can transmit to up to four single stream devices at the same time on the same channel. The 802.11ac standard also supports speeds up to 6.93 Gbit/s using eight spatial streams in single-user mode. The maximum data rate assumes use of the optional 160 MHz channel in the 5 GHz band and 256 QAM (quadrature amplitude modulation). Chipsets supporting six spatial streams have been introduced and chipsets supporting eight spatial streams are under development. Massive MIMO consists of a large number of base station antennas operating in a MU-MIMO environment.[4] While LTE networks already support handsets using two spatial streams, and handset antenna designs capable of supporting four spatial streams have been tested, massive MIMO can deliver significant capacity gains even to single spatial stream handsets. Again, MU-MIMO beamforming is used to enable the base station to transmit independent data streams to multiple handsets on the same channel at the same time. However, one question still to be answered by research is: When is it best to add antennas to the base station and when is it best to add small cells? Another focus of research for 5G wireless is CO-MIMO. In CO-MIMO, clusters of base stations work together to boost performance. This can be done using macro diversity for improved reception of signals from handsets or multi-cell multiplexing to achieve higher downlink data rates. However, CO-MIMO requires high-speed communication between the cooperating base stations.

SIMULATION RESULTS:

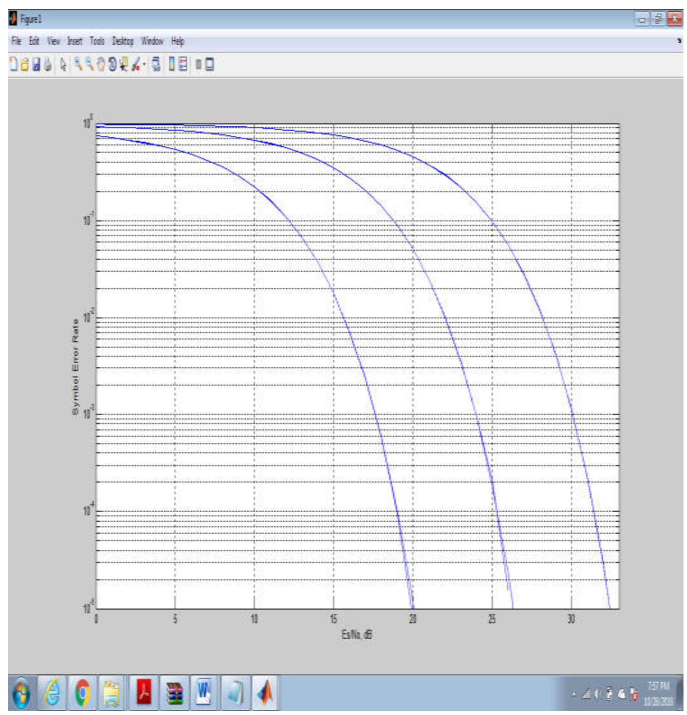

Fig:comparison graph of BER vs SNR for proposed mimo- OFDM-Ici with existing M-QAM where M=16

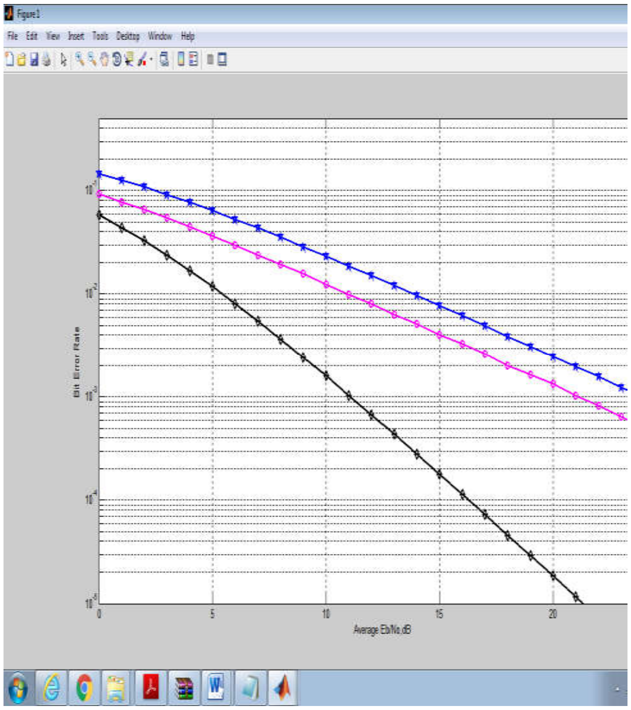

Fig:BER vs SNR for proposed mimo OFDM-Ici with existing M-QAM where M=64.

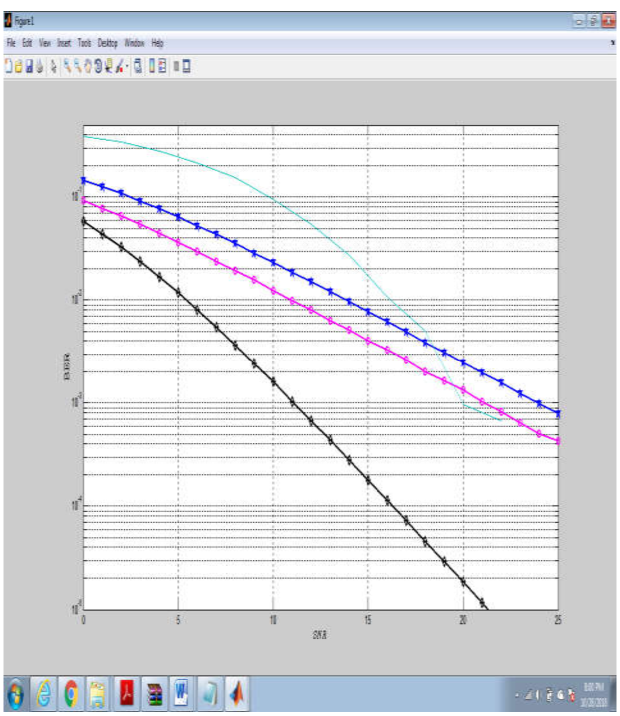

Fig: BER vs SNR plot for all 16, 64, 128 and 256 bit QAM for mimo ofdm ici

CONCLUSION:

ICI self-cancellation and two-path cancellation have been specially tailored to IM-OFDM systems with different mapping methods (adjacent/symmetric/mirror) and operations (conversation/conjugation) adopted to the counterpart of the symbols. The combinations result in several ICI cancellation schemes of IM-OFDM with A(C)SR, S(C)SR, M(C)SR, SC(J)VT and MC(J)VT and all schemes preserve the IM-OFDM nature of partially activated subcarriers. The simulation results have shown that while mirror-mapping and ICI self-cancellation599949 provide the best performance in cooperation with IM-OFDM, all proposed IM-OFDM with ICI cancellation schemes outperform traditional OFDM with ICI cancellation in AWGN channels with CFO.

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