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Survey paper on PAPR Reduction of Massive MIMO System for mm-wave Communication

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ABSTRACT: In a cellular network, the demand for high throughput and reliable transmission is increasing in large scale. One of the architectures proposed for 5G wireless communication to satisfy the demand is Massive MIMO system. The massive system is equipped with the large array of antennas at the Base Station (BS) serving multiple single antenna users simultaneously i.e., number of BS antennas are typically more compared to the number of users in a cell. This additional number of antennas at the base station increases the spatial degree of freedom which helps to increase throughput, maximize the beamforming gain, simplify the signal processing technique and reduces the need of more transmit power. The advantages of massive MIMO can be achieved only if Channel State Information (CSI) is known at BS uplink and downlink operate on orthogonal channels - TDD and FDD modes.

KEYWORDS: Massive MIMO, Channel State Information, FDD, TDD

I. INTRODUCTION

In recent times, multimedia data services have developed to set up in the 4th generation (4G) wireless communication system. The technologies developed in a modern wireless communication system are robust to multipath channel environment and more bandwidth efficient due to the bounded spectrum and the huge number of users in multimedia data service. These technologies are known as a multi-carrier communication system that provides not only a high data rate but also affords high reliability at minimum cost for large users. Existing communication bandwidth for multi-carrier system is divided by a large number of subcarriers unlike single carrier system holds whole bandwidth. Hence, the bandwidth of each subcarrier occupies smaller than single carrier bandwidth. Therefore, these great features that have multicarrier based technologies influence us to learn Orthogonal Frequency Division Multiplexing (OFDM) [1]. The 4G wireless communication system is based on OFDM technologies which have a high data rate of about 100 Mbps, handling globally with high mobility and massive ability in terms of a large number of subcarriers. The Digital Audio Broadcasting (DAB) and Digital Video Broadcasting Terrestrial (DVB-T) are based on OFDM technology that has been used in Europe and high data rate wired links is Asymmetric Digital Subscriber Line (ADSL). Also, some wireless networking standards High Performance Radio Local Area Network version (HIPERLAN/2) and Institute of Electrical and Electronics Engineers (IEEE) 802.11a, g are OFDM based technology which works on the physical layer with data rates of between 8 and 55 Mbps. Some properties of the OFDM system make it better than single-carrier systems. The major benefit of the OFDM system is immunity to frequency selective fading.

High PAPR is one of the most common problems in OFDM. A high PAPR brings disadvantages like increased complexity of the ADC and DAC and also reduced efficiency of radio frequency (RF) power amplifier. One of the simple and effective PAPR reduction techniques is clipping, which cancels the signal components that exceed some unchanging amplitude called clip level. However, clipping yields distortion power, which called clipping noise, and expands the transmitted signal spectrum, which causes interfering [20]. Clipping is nonlinear process and causes inband noise distortion, which causes degradation in the performance of bit error rate (BER) and out-of-band noise, which decreases the spectral efficiency [21]. Clipping and filtering technique is effective in removing components of the expanded spectrum. Although filtering can decrease the spectrum growth, filtering after clipping can reduce the out-of-band radiation, but may also cause some peak re-growth, which the peak signal exceeds in the clip level [2, 3]. The technique of iterative clipping and filtering reduces the PAPR without spectrum expansion. However, the iterative signal takes long time and it will increase the computational complexity of an OFDM transmitter [4, 5].

But without performing interpolation before clipping causes it out-of-band. To avoid out-of-band, signal should be clipped after interpolation. However, this causes significant peak regrowth. So, it can use iterative clipping and frequency domain filtering to avoid peak regrowth. In the system used, serial to parallel converter converts serial input data having different frequency component which are base band modulated symbols and apply interpolation to these symbols by zero padding in the middle of input data. Then clipping operation is performed to cut high peak amplitudes and frequency domain filtering is used to reduce the out of band signal, but caused peak re-growth [6]. This consists of two FFT operations. Forward FFT transforms the clipped signal back to discrete frequency domain. The in-band discrete components are passed unchanged to inputs of second IFFT while out of band components are null. The clipping and filtering process is performed iteratively until the amplitude is set to the threshold value level to avoid the peak out-of band and peak regrowth.

II. PAPR TECHNIQUES

There have been many new approaches developed during the last few years. Several PAPR reduction techniques have been proposed in the literature. These techniques are divided into two groups. These are signal scrambling techniques and signal distortion techniques. The signal scrambling techniques are:

- Block coding
- Selective Level Mapping (SLM)
- Partial Transmit Sequences (PTS)
- Signal scrambling techniques work with side information which minimized the effective throughput since they commence redundancy. Signal distortion techniques introduce band interference and system complexity also. Signal distortion techniques minimize high peak dramatically by distorting signal before amplification. The signal distortion techniques are:
 - Clipping
 - Peak windowing
 - Peak cancellation
 - Peak power suppression • Weighted multicarrier transmission

Block Coding Techniques:- Coding techniques can be applied for signal scrambling, M sequences, Golay complementary sequences, Shapiro-Rudin sequences codes can be used to reduce the PAPR efficiently. This Block coding technique has been proposed by Wilkinson and Jones in 1965 for the minimization of the peak to mean envelope power ratio of multicarrier communication system [1]. The key object in this paper is that PAPR can be minimized by block coding the data. The block coding techniques have three stages for the development. The first stage works with the collection of appropriate sets of code words for any number of carriers, any M-ary phase modulation method, and any coding rate. The second stage works with the collection of the sets of code words which enable proficient implementation of the encoding/decoding. The third stage offers error deduction and correction potential. There different methods for the collection of the sets of code words. The mainly insignificant method, order to search the peak envelope power (PEP) for all possible code words for a certain length of given number of carriers. This technique is simple and accurate for short codes because it needs extreme computation. Natural algorithms are mainly sophisticated searching techniques. It can be used for the collection of longer code words. A selection of code words select from searches for encoding and decoding can be performed with a look up table or using combinatorial logic exploiting the mathematical structure of the codes minimization when the frame size is bigger. Large PAPR reduction can be achieved if the long information sequence is separated into different sub blocks, and all sub block encoded with System on a Programmable Chip (SOPC). There are many likely spaces, where the odd parity checking bits can be put into each frame to minimize PAPR. For further minimization of PAPR, redundant bit location optimized sub-block coding (RBLO-SBC) optimizes these locations redundant Combination optimized sub-block coding scheme (COSBC) optimizes the combination of the coded subblocks, where two coding schemes instead of one is used to encode the same information source.

Block Coding Scheme with Error Correction:- This Block coding scheme with Error Correction has been proposed by Ahn and et.al in [12] to introduce a new block coding proposal for minimization of peak to average power ratio (PAPR) of an Orthogonal Frequency Division Multiplexing (OFDM) system. Block coding has error correction capability. In block coding method, the OFDM symbol can be reduced by selecting only those code words with lower PAPR. In this paper, the key object of the method is proposed that properly designed block codes can not only minimize the PAPR, but also give error correction capability. A k bit

data block (e.g. 4-bit data) is encoded by a (n, k) block code with a generator matrix 'G' in the transmitter of the system. Followed by the phase rotator vector b to produce the encoded output $x=a.G+b(\text{mod } 2)$.

To achieve the accurate generator matrix and phase rotator vector that make sure the minimum PAPR for the OFDM system, check all the 2^n codes and choose only 2^k codes that obtain the minimum PAPR. After that generator matrix 'G' and the phase rotator vector 'b' are produced; which are used mapping between these symbols combination and input data vector 'a'. The converse functions of the transmitter are executed in the receiver system. The parity check matrix 'H' is achieved from the generator matrix 'G', with an exception that the effect of the phase rotator vector b is removed before calculations of syndromes. Contrasting the method in [1], which only presents error detection; this method can improve the overall system performance and provides error correction capability.

Selected Mapping (SLM):- Selective Mapping (SLM) approaches have been proposed by Bauml in 1965 [13]. This method is used for minimization of peak to average transmit power of multicarrier transmission system with selected mapping. A complete set of candidate signal is generated signifying the same information in selected mapping, and then concerning the most favorable signal is selected as consider to PAPR and transmitted. In the SLM, the input data structure is multiplied by random series and resultant series with the lowest PAPR is chosen for transmission. To allow the receiver to recover the original data to the multiplying sequence can be sent as 'side information'. One of the preliminary probabilistic methods is SLM method for reducing the PAPR problem. The good side of selected mapping method is that it doesn't eliminate the peaks, and can handle any number of subcarriers. The drawback of this method is the overhead of side information that requires to be transmitted to the receiver of the system in order to recover information.

Partial Transmit Sequence (PTS):- Partial Transmit Sequence (PTS) technique has been proposed by Muller and Hubber in 1997 [14]. This proposed method is based on the phase shifting of sub-blocks of data and multiplication of data structure by random vectors. This method is flexible and effective for OFDM system. The main purpose behind this method is that the input data frame is divided into non-overlapping sub blocks and each sub block is phase shifted by a constant factor to reduce PAPR. PTS is probabilistic method for reducing the PAPR problem. It can be said that PTS method is a modified method of SLM. PTS method works better than SLM method. The main advantage of this scheme is that there is no need to send any side information to the receiver of the system, when differential modulation is applied in all sub blocks.

Interleaving:- Technique Interleaving technique has been proposed by Jayalath and Tellambura [2], for reduction peak to average power ratio of an OFDM transmission. A data randomization technique has proposed for the minimization of the PAPR in this paper.

The notion that highly correlated data structures have large PAPR can be reduced, if long correlation pattern is broken down. Also, this paper proposes an additive method to minimize the complexity. The basic idea in adaptive interleaving is to set up an initial terminating threshold. PAPR value goes below the threshold rather than seeking each interleaved sequences. The minimal threshold will compel the adaptive interleaving (AL) to look for all the interleaved sequences. The main important of the scheme is that it is less complex than the PTS technique but obtains comparable result. This method does not give the assurance result for PAPR reduction. In this circumstance, higher order error correction method could be used in addition to this method.

Tone Reservation (TR):- Tone Reservation (TR) method is proposed for PAPR reduction [15]. The main idea of this method is to keep a small set of tones for PAPR reduction. This can be originated as a convex problem and this problem can be solved accurately. The amount of PAPR reduction depends on some factors such as number of reserved tones, location of the reserved tones, amount of complexity and allowed power on reserved tones. This method explains an additive scheme for minimizing PAPR in the multicarrier communication system. It shows that reserving a small fraction of tones leads to large minimization in PAPR ever using with simple algorithm at the transmitter of the system without any additional complexity at the receiver end. Here, N is the small number of tones, reserving tones for PAPR reduction may present a non-negligible fraction of the available bandwidth and resulting in a reduction in data rate. The advantage of TR method is that it is less complex, no side information and also no additional operation is required at the receiver of the system. Tone reservation method is based on adding a data block and time domain signal. A data block is dependent time domain signal to the original multicarrier signal to minimize the high peak. This time domain signal can be calculated simply at the transmitter of system and stripped off at the receiver.



III. LITERATURE REVIEW

Ebubekir Memisoglu et al. [1], OFDM keeps on being sent in 5G correspondence frameworks and is probably going to be utilized in past 5G (B5G) correspondence frameworks also, because of its many benefits. In any case, one significant disadvantage with OFDM frameworks is its high top to-average power proportion (PAPR), particularly with huge data transfer capacity transmissions. In this paper, we have given a regularization improvement based adaptable cross breed companding and cutting plan (ROFHCC) utilized for PAPR decrease in OFDM frameworks. To decrease the plan intricacy, the companding capacity has two sections. It limits the sign examples with amplitudes over a given worth to a consistent incentive for both pinnacle power decrease and little power pay. For signals with tests under a given adequacy, they are extended by a direct companding capacity. We construct a regularization enhancement model to mutually enhance the companding contortion as well as the congruity of the companding capacity for bit mistake rate (BER) execution as well as power unearthly thickness (PSD) execution. Reproduction results demonstrate that for a similar PAPR execution, the proposed companding plan enjoys an upper hand over the referred to companding plans. For instance, when the normal sign power is standardized to be 1, we pick both PAPR for ROFHCC plan and two-piecewise companding (TPWC) conspire as 4 dB, then, at that point, we can track down that at $BER=10^{-4}$, the base required E_b/N_0 for ROFHCC plot is around 2.3 dB lower than TPWC conspire.

H. Chen et al. [3], separated symmetrical recurrence division multiplexing (f-OFDM) is viewed as one of the contender for future portable correspondence due to its adaptable boundary setup for various situations. In any case, the impedance examination of f-OFDM is significantly difficult because of its unique handset structure, particularly in the uplink with non-ideal synchronization. The uplink obstruction of f-OFDM frameworks under non-ideal synchronization, in which transporter recurrence offset (CFO) and timing offset (TO) of numerous client gear (UE) are thought of, is examined in this review. The obstruction is ordered into a few sub-impedances. The shut structure articulations of each sub-obstruction and its difference are first inferred, and afterward checked by means of reproductions. Based on the inferred shut structure articulations, first, the impacts of non-ideal variables and framework boundaries, like CFO, TO, watch band (GB), and subcarrier dividing (SCS), on the uplink impedance of f-OFDM frameworks, are reproduced and examined. This study is confirmed by programmatic experiences, and the hypothetical inference of obstruction concurs with the reproduction result. Second, Hanning window channels are utilized by past f-OFDM frameworks, bringing about piece blunder rate (BER) awkwardness between sub-groups. Thus, the impact of waveform channel on the impedance and BER is likewise examined in this examination. Results demonstrate that preferable obstruction and BER exhibitions over Hanning window channels can be gotten by utilizing sensible channel settings. Besides, a few channel configuration rules are closed. In general, the examination and reenactments uncover numerous natural impedance attributes of f-OFDM, which will help the future f-OFDM framework plans.

S. Rajasekaran et al. [4], symmetrical recurrence division multiplexing (OFDM) has been one of the standard advances in the fields of current remote correspondences. In any case, its own high top to average power proportion (PAPR) issue can disable the presentation of framework, which has extraordinarily confined its wide applications. Incomplete send succession (PTS) was proposed for further developing the PAPR execution of OFDM frameworks. Be that as it may, its presentation extraordinarily builds the computational intricacy of the framework. In this paper, a low-intricacy PTS plot is proposed in view of the predominant time-area tests, and two new measurements for picking these examples are presented. Moreover, to additionally lessen the computational intricacy, gathering strategy has been engaged with proposed conspire. Reenactment results demonstrate that the proposed low-intricacy PTS plan can furnish an ideal PAPR decrease execution with more computational intricacy reserve funds.

Z. Zhou et al. [5], an original low-intricacy least sufficiency contrast (MAD) decoder is proposed for chosen planning (SLM)-based unevenly cut optical symmetrical recurrence division multiplexing (ACO-OFDM) noticeable light correspondence (VLC) framework. With the proposed plot, a particular arrangement of symmetric vectors is intended to limit the top to-average power proportion (PAPR) of sign without the transmission of side data (SI) and recuperate SI aimlessly by the proposed MAD decoder. Reproduction results show that the proposed plot diminishes the PAPR really and the cycle blunder rate execution of ACO-OFDM framework with MAD decoder is extremely near that of traditional chose planning (CSLM) conspire with greatest probability decoder, yet at much lower intricacy.

W. Hu et al. [6], this paper proposes another actual layer design in view of symmetrical recurrence division multiplexing (OFDM) for uplink different access. It focuses on high unwavering quality with fixed decoder inactivity focusing on emanant low-inertness remote applications, for example, transmission of control data in machine-to-machine (M2M) and gadget to-gadget (D2D) interchanges. Our proposed framework depends on the prudent mix of subcarrier bouncing and super-symmetrical convolutional codes for accomplishing high coding gain and recurrence variety, along with Golay integral successions for low top to-average power proportion (PAPR) flagging. The low PAPR nature further develops the power effectiveness at a power intensifier (PA) and subsequently adds to the transmission range upgrade.

Y. Hori et al. [7], besides, by presenting non-symmetry among clients through the task of similar arrangement of subcarriers to different clients, the in general ghostly effectiveness can be gotten to the next level. To smother different access impedance brought about by the non-symmetrical cross-over of clients, multiuser discovery (MUD) is utilized. Hypothetical articulations of inexact bit blunder rate for the proposed framework with MUD are additionally evolved. Mathematical outcomes uncover that our proposed framework accomplishes higher unwavering quality and higher unearthly effectiveness than the customary symmetrical recurrence division different access (OFDMA)- based framework.

Ashna Kakkar et al. [8], Multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM) is an attractive transmission technique for high-bit-rate communication systems. Like OFDM, one main disadvantage of MIMO-OFDM is the high peak-to-average power ratio (PAPR) of the transmitter's output signal on different antennas. The partial transmit sequences (PTS) approach provides optimal performance for PAPR reduction. However the computational complexity of traditional PTS method is tremendous. In this paper, a cooperative and alternate PTS (C-A-PTS) scheme for STBC MIMO-OFDM system is proposed which can achieve nearly optimum PAPR performance at much less complexity. The simulation results prove the effectiveness of the advanced algorithm.

IV. MM-WAVE COMMUNICATION

Communication at mmWave provides multi-gigabit communication services with the use of frequency band from 30 GHz to 300 GHz. At mmWave, available spectrum is supreme to cellular and WLAN microwave systems that operate at frequencies below 10 GHz. The unlicensed spectrum at 60 GHz mmWave band offers 10 to 100 more spectrum than is available for conventional unlicensed WLAN in the Industrial, Scientific, and Medical (ISM) bands and 4G (Fourth Generation) or earlier cellular systems that operate at carrier frequencies below 6 GHz. In particular, it is possible to achieve higher data rates for comparable modulation techniques and provide more resources to be shared among multiple users using large amount of spectrum. However, there are fundamental differences between mmWave communications and other communication systems operating in the microwaves band. There are challenges in physical, medium access control, and routing layers for mmWave communications to make a big impact in the 5G wireless networks [13, 14].

MmWave Challenges

Despite the high carrier frequency and wide bandwidth of mmWave band, there are several technical challenges in the design of circuit components and antennas for mmWave communications.

Integrated circuits and system design:- The high transmit power and wide bandwidth cause severe nonlinear distortion of power amplifiers. Also, phase noise and In-phase and Quadrature (IQ) imbalance are the challenging problems in Radio Frequency (RF) integrated circuits. There are also problems on integrated circuits including on-chip and inpackage antennas, RF power amplifiers, low-noise amplifiers, voltage controlled oscillators, mixers, and analog-to-digital converters.

Interference management;-The interference between links is less due to the directivity of transmission. Thus, simultaneous transmissions can be fully exploited to enhance the network capacity. The coordination mechanism becomes important in the medium access control design [15]. In the indoor environments, it is required to deploy large number of Access Points (APs) to provide seamless coverage, due to the limited range. The interference within each Basic Service Set (BSS) and interference among different BSSs need to be considered. Thus, power control, transmission coordination and concurrent transmission using spatial reuse should be applied to manage interference.

V. CONCLUSION

This thesis presented an overview of Orthogonal Frequency Division Multiplexing (OFDM). For flexibility and adaptability, the OFDM is an attractive candidate for CR systems. This dissertation proposes a novel non-contiguous OFDM (NC-OFDM) technique, where the implementation achieves high data rates of non-contiguous subcarriers while simultaneously avoiding any interference to the transmissions. The main goal of this thesis work was to investigate PAPR reduction techniques for non-contiguous bands of OFDM based CR system. Simulation results of PAPR reduction has shown that the performance of QAM-16 is good compared to others modulation schemes such as BPSK, QPSK. According to the BER results, we need higher value of SNR to achieve the same BER as compared to lower constellation modulation schemes.

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