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Survey of PAPR-BER Reduction for MIMO Systems for 5G Application

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ABSTRACT: Multiple Input Multiple Output (MIMO) in combination with Orthogonal Frequency Division Multiplexing (OFDM) is of great interest for researchers and research laboratories all over the world. OFDM is widely used in contemporary communication systems for its good robustness in multipath environment, and its high spectral efficiency. The capacity of wireless system can be increased dramatically by employing Multiple Input Multiple Output, (MIMO) antennas. The combination of MIMO and OFDM system is found to be very beneficial. A major drawback of OFDM-MIMO System is its high Peak to Average Power Ratio (PAPR) Reduction. The peak power of a signal is a critical design factor for band limited communication systems, and it is necessary to reduce it as much as possible. Many PAPR reduction techniques have been used to reduce PAPR. Partial transmit sequence (PTS) is one of the most well-known peak-to-average power ratio (PAPR) reduction techniques proposed for MIMO-OFDM systems. However the computational complexity of traditional PTS method is tremendous. In this paper studied of partial transmit sequence (PTS) technique, based on two antennas STBC MIMO-OFDM system, which can achieve better PAPR performance at much less complexity. The main idea behind this is to separate the input data vector, generated by Alamouti algorithm, into real and imaginary parts and separately multiplied with phase factors. The optimum weighting coefficient of antenna two can be directly obtained by appropriating mapping from that of antenna one which leads further to reducing complexity computation.

KEYWORDS: PTS, , STBC, MIMO, OFDM, PAPR

I. INTRODUCTION

Wireless communication is revolutionary advancement in the recent decades, which has changed the face to latest telecommunications. The global system for mobile (GSM) cellular standard, which was formulated in 1992 has been rapidly adopted by billions of cellular users for voice communication. The advent of internet packet-based data networks has ushered an ever increasing demand for ubiquitous data access over these wireless networks. This has led to a progressive advancement of wireless communication from traditional voice-based networks to internet, multimedia, and video service networks. In this process, successive generation of wireless standards has evolved to support the rich high data rate wireless ecosystem, which basically comprises the 3G and 4G of growth of radio communications. Orthogonal FDMA is focused on 4G standards for instance Long Term Evaluation (LTE) as 802.11 a/g/n. the extended kind of OFDMA is single carrier -FDMA (SCFDMA) or localized FDMA (LFDMA) to minimize the demerits which exist in OFDMA and in OFDM [1]. The Orthogonal FDMA (OFDMA) has a significant role in present day communications. Therefore, it offers faster and more reliable communication service. It follows on the initial procedures of frequency division multiplexing (FDM); the conventional FDM units can't effectively utilize available range between neighboring carriers. The undesirable data is aggravated with addition of guard bands instead of transmitting completely separate signals [2]. The evolutionary process of SC-FDMA and OFDMA can be carried out in the LTE physical layer by probabilistic schemes known as Selective Mapping (SLM) and Partial Transmit Sequence (PTS), adaptive modulation -shift keying with emphasis on PAPR. According to various research studies, it may be informed that PTS gives higher PAPR reduction than SLM. Moreover, when commanding is performed μ -law produces better results compared to A-law [3].

For uplink transmission, SC-FDMA works better for LTE standard than OFDMA. Reduced PAPR for multiuser communication is the greatest merit, as BER is not affected. Subcarrier mapping techniques can be used for transmission which is either distributed SC-FDMA or localized SC-FDMA. The special category of distributed mode is interleaved SC-FDMA which maintains equidistance over entire bandwidth [4, 5]. Due to characteristic pattern of single carrier communication, the main merit in SCFDMA compared to OFDMA is less PAPR facilitating relaxed design parameter transmit path of subcarrier. This is so because in OFDM, transmitted symbols varies with subcarriers

based on IDFT/IFFT and where as in SC-FDMA transmitted symbols are deal with N- DFT/FFT block. A relevant idea is mixing up of transmission of single carrier with suitable frequency equalizer (SC-FDE); IDFT/DFT are not used in the transmitter. A cyclic prefix transforms linear to circular convolution. To reduce PAPR, the methods involving are distortion, distortion less (probabilistic), coding techniques and hybrid spreading strategies. DCT is based on Fourier analysis and structure having complex variation with bandwidth equivalent to DFT based structures which have equal subcarriers. The subcarrier mapping schemes are depending on distributed and localized mode in SC-FDMA. Spreading of the input in DFT/DCT can be considered in IFFT/IDCT which changes peak to average ratio of multicarrier signal to single carrier type. This can be specifically utilized in SC-FDMA and for uplink of LTE standards in 4G mobile communications due to resource allocated by PAPR behavior.

II. GENERATION

First-Generation Systems (1G):- In 1970, 1G (First generation) was introduced for voice communication. 1G was an analog system with frequency modulation technique for radio transmission using Frequency Division Multiple Access (FDMA). 1G system was Advanced Mobile Phone System (AMPS), Total Access Communication Systems (TACS) and Nordic Mobile Telephone (NMT). In North America, two 25 MHz bands were allocated to AMPS, one for downlink transmission from the base station to the mobile unit (869- 894 MHz) and the other for uplink transmission from the mobile to the base station (824-849 MHz) [5].

In 1985, the Federal Communications Commission (FCC) enabled the commercial development of wireless LANs (WLAN) by authorizing the public use of the Industrial, Scientific, and Medical (ISM) frequency bands for wireless LAN products.

Second Generation Systems (2G):- The 2nd generation system was accomplished in 1990's. The 2G mobile communication system is a digital system. Today in different parts of the world, it is used for voice communication and other services such as SMS and e-mail. In this generation Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA) are used with frequency band 850-1900 MHz. Also in this age, GSM technology uses eight channels per carrier with a gross data rate of 22.8 kbps (a net rate of 13 kbps) in full rate channel and a frame of 4.6 milliseconds (ms) duration. The 2.5G and 2.75G are enhancement of this generation. 2G standards are GPRS, Enhanced Data Services for GSM Evolution (EDGE), Interim Standard (IS) as IS-54 and IS-136 systems currently provide data rates of 40-60 Kbps. The IS-95 systems support higher data using a time-division technique called High Data Rate (HDR) [6].

Third Generation Systems (3G):- Third generation (3G) services combine high speed mobile access with Internet Protocol (IP)-based services. The 3G technology supports both for packet and circuit switched data transmission which is compatible to 2G. The 3G technology includes the services such as wireless web base access, email, video conferencing and multimedia services. The 3G devices may share the same wireless network and be connected to internet anytime, anywhere. 3G provides different data rates from 384 kbps for pedestrian use, 144 kbps for vehicular use and 2 Mbps for indoor office use depending on mobility and environment. The frequency band is 1.8 - 2.5 GHz [7]. Different versions of wireless LAN (WLAN) standards exist in the 2.4 GHz and 5 GHz bands [8].

Fourth Generation Systems (4G):- 4G is an enhanced version of 2G and 3G. Recently 3GPP (third Generation Project Partner) has introduced LTE Advanced version as 4G standard. A 4G system provides a comprehensive and secure IP based services. 4G gives the facilities such as voice, streamed multimedia and data to users at anytime, anywhere with much higher data rates than earlier generations. 4G can provide larger demanding requirements in terms of QoS. 4G applications are wireless broadband access, video chat, Multimedia Messaging Service (MMS), mobile TV, HDTV and Digital Video Broadcasting (DVB) etc. The 4G wireless system is for Global and seamless roaming between different wireless systems, hot spots and pedestrian environments data rate 100M~1Gbps, vehicular environments rate up to 100 Mbps and high spectrum efficiency. MIMO technology is used in 4G to get high data rate and reliability [9].

Fifth Generation System (5G)

5G networks are digital cellular networks, in which the service area covered by providers is divided into small geographical areas called *cells*. Analog signals representing sounds and images are digitized in the phone, converted by an analog to digital converter and transmitted as a stream of bits. All the 5G wireless devices in a cell communicate by radio waves with a local antenna array and low power automated transceiver (transmitter and receiver) in the cell, over frequency channels assigned by the transceiver from a pool of frequencies which are reused in other cells. The local

antennas are connected with the telephone network and the Internet by a high bandwidth optical fiber or wireless backhaul connection. As in other cell networks, a mobile device crossing from one cell to another is automatically "handed off" seamlessly to the new cell [10].

There are plans to use millimeter waves for 5G. Millimeter waves have shorter range than microwaves, therefore the cells are limited to smaller size; The waves also have trouble passing through building walls. Millimeter wave antennas are smaller than the large antennas used in previous cellular networks. They are only a few inches (several centimeters) long. Another technique used for increasing the data rate is massive MIMO (multiple-input multiple-output). Each cell will have multiple antennas communicating with the wireless device, received by multiple antennas in the device, thus multiple bit streams of data will be transmitted simultaneously, in parallel. In a technique called beamforming the base station computer will continuously calculate the best route for radio waves to reach each wireless device, and will organize multiple antennas to work together as phased arrays to create beams of millimeter waves to reach the device.

The new 5G wireless devices also have 4G LTE capability, as the new networks use 4G for initially establishing the connection with the cell, as well as in locations where 5G access is not available [11].

III. LITERATURE REVIEW

Zhitong Xing 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 unearthy 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/N₀ for ROFHCC plot is around 2.3 dB lower than TPWC conspire.

H. Chen et al. [2], 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. [3], 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 conspiracy. Reenactment results demonstrate that the proposed low-intracacy PTS plan can furnish an ideal PAPR decrease execution with more computational intracacy reserve funds.

Z. Zhou et al. [4], an original low-intracacy 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) conspiracy with greatest probability decoder, yet at much lower intracacy.

W. Hu et al. [5], 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. [6], 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. [7], 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.

Ho-Lung Hung et al. [8], they studied the impact of nonlinear devices on OFDMA signals. Therefore, they combine an OFDM modulation with an FDMA (Frequency Division Multiple Access) scheme. Their results allow an analytical spectral characterization of the transmitted signals, as well as the computation of the nonlinear interference levels on the received signals. They considered the nonlinear signal processing schemes which operate on a sampled version of the OFDM signal. They will take advantage of the Gaussian nature of OFDMA signals with many subcarriers for the analytical characterization of the transmitted signals. In, they presented an analytical tool to evaluate nonlinear distortion effects on systems employing OFDMA signals.

IV. PAPR REDUCTION TECHNIQUE

Several PAPR reduction techniques are available in the literature. These methods are basically divided in four categories:

1. Signal Distortion.
2. Coding Methods,
3. Probabilistic (Scrambling) Techniques
4. Pre-distortion Methods.

Every method has some drawbacks and merits. There is always a trade-off between PAPR reduction and some other factors like bandwidth, computational complexity, average power etc. An ideal PAPR reduction technique should have following characteristics:

- High capability of PAPR reduction with few harmful side effects such as in-band distortion and out-of-band radiation.
- Low implementation complexity: Due to high implementation and computational complexity the delay in transmission increases which reduces data rate.
- Low average power: any increase in average power requires a larger linear operation region in HPA and thus resulting in the degradation of BER performance.
- No bandwidth expansion: The bandwidth is a costlier resource for any wireless communication systems. Therefore, it is required to reduce PAPR without increasing bandwidth of transmitted signal. The bandwidth expansion directly results in the data code rate loss due to side information. Therefore, the loss in bandwidth due to side information should be avoided or at least be kept minimal.
- No BER performance degradation: The PAPR should be reduced but not at the cost of BER reduction. The BER performance should be same as that of the original OFDM system.
- Without additional power needed: Any increases in power requirement reduce the efficiency of system, and power is an important resource for any wireless communication system. Therefore, it is necessary for any PAPR reduction scheme to reduce PAPR without increasing power requirement.
- No spectral spillage: The PAPR reduction techniques should not destroy the inherent feature (orthogonally) of OFDM signal.

Many PAPR reduction techniques are proposed in the literature. In this section, we investigate some such techniques and discuss their advantages and disadvantages in terms of PAPR reduction capability, BER degradation and computational complexity [20]. The PAPR reduction schemes are majorly divided into two categories

- a) Distortion Based Techniques
- b) Non-distortion Techniques

Distortion Based Techniques

The schemes that introduce spectral re-growth belong to this category. Distortion based techniques are the most straightforward PAPR reduction methods. Furthermore, these techniques distort the spectrum, this spectrum distortion or “spectral re-growth” can be corrected to a certain extent by using filtering operation.

Clipping and Filtering

Clipping is one of the simplest techniques to reduce the PAPR of OFDM signal. It reduces the peak of the OFDM signal by clipping the signal to the desired level. This operation can be implemented on discrete time samples prior to the DAC or by designing the power amplifiers with saturation level lesser than the OFDM signal dynamic range. The amplitude clipper limits the peak of the envelope of the input OFDM signal to a predetermined threshold value or otherwise passes the input signal unperturbed.

Iterative Clipping and Filtering:- Jean Armstrong proposed the repeated clipping and filtering scheme [14], in which clipping and frequency domain filtering operations are repeated several times to reduce both the out of-band radiation and PAPR to the desired level. The PAPR performance and amount of out of-band radiation mainly depends on the number of iterations to be performed, more the number of iterations lesser is the value of out-of-band radiations and PAPR. But, the computational complexity of iterative clipping and filtering scheme increases with the number of iterations. We have studied the effect of iterative clipping and filtering of OFDM signal through computer simulation. In this simulation, we have considered an amplitude clipper with a threshold $\gamma = 0.01$ and four iterations.

V. CONCLUSION

The pulse shaping method has been propounded to reduce the PAPR of the transmitted OFDM signals and improve its power spectrum simultaneously. However, different pulse shaping waveforms result in different error probabilities of the system. None of the aforementioned methods achieve simultaneously good PAPR reduction, high coding rate and low computation complexity. Hence, in the present work an attempt has been made to further improve the PAPR reduction in OFDM and MIMO-OFDM systems to improve the efficiency of power amplifiers by adopting modified partial transmit sequence in combination with interleaving, FEC, superimposed training sequences and pulse shaping methods.

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