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Review of PAPR Reduction for MIMO-OFDM Systems in 5G Communication System

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ABSTRACT
In recent time, the demand for multimedia data services has grown up rapidly. One of the most promising multi-carrier system, Orthogonal Frequency Division Multiplexing (OFDM) forms basis for all 5G wireless communication systems due to its large capacity to allow the number of subcarriers, high data rate and ubiquitous coverage with high mobility. OFDM is significantly affected by peak-to-average-power ratio (PAPR). Unfortunately, the high PAPR inherent to OFDM signal envelopes will occasionally drive high power amplifiers (HPAs) to operate in the nonlinear region of their characteristic curve. This paper emphasis mainly on the PAPR reduction of MIMO-OFDM system using partial transmits sequence (PTS) and pre-coding techniques. Some other techniques such as amplitude clipping have low-complexity; on the other hand, they suffer from various problems such as in-band distortion and out-of-band expansion. Signal companding methods have low-complexity, good distortion and spectral properties; however, they have limited PAPR reduction capabilities. Advanced techniques such as coding, partial transmit sequences (PTS) and selected mapping (SLM), have also been considered for PAPR reduction.

Keywords— PTS, STBC, MIMO, OFDM, PAPR.

INTRODUCTION
This work will be used as Potential reference in nature and will aim to provide a basic understanding of OFDM as a candidate technology for 5G systems. It presents detailed performance results for OFDM with different modulation techniques, under different channel conditions and finally provides a comparison with an OFDM based communication system. Since 1980 when first generation system was introduced and till now there is seen a rapid growth in the field of communication and mobile technology. In Wireless Technology there has been subtle increases in peak bit rate in previous generations (0G to 4G). With every passing decade, the mobile generation is changing and as the current generation is 4G introduced in early 2010. The year 2020 is said to be the year for the fifth generation (5G) systems which is smarter and sophisticated technology.

Fifth generation (5G) innovation is intended to give staggering and wonderful information capacities, unhindered call volumes, and unlimited information communicate inside the most recent versatile working framework. Thus, it is more astute innovation, which will interconnect the whole world unbounded. 5G will give a nonexclusive way to deal with make organize performs considerably more adaptable and all inclusive, keeping in mind the end goal to adapt to heterogeneous conditions and necessities. It will execute merging amongst settled and versatile systems administration administrations with the related systems.

OFDM has been proposed as a transmission technique to bolster rapid information transmission over remote connections in multipath situations. Amid the most recent forty years, OFDM has formed into a famous plan for wideband advanced correspondence, whether remote or over wires, utilized as a part of uses, for example, computerized TV and sound television, remote systems administration and broadband web access [6]. OFDM system also utilized digital-to-analog converters (DAC) and analog-to-digital converters (ADC) in its signal processing loop. To help high PAPR, a high accuracy DAC and ADC are required, which is exceptionally costly for a given examining rate of the framework. While, a low-exactness DAC and ADC would be less expensive, yet its quantization commotion will be noteworthy, and therefore it diminishes the SNR when the dynamic scope of DAC and ADC increments to help high PAPR. Along these lines, the PAPR diminishment is basic for an OFDM framework for accomplishing better power effectiveness, huge territory scope and low BER. Most of the wireless communication systems employed high power amplifier (HPA) at the output of transmitter to obtain sufficient transmits power for large area coverage. For achieving maximum power efficiency, the HPA is usually operated at or near the saturation region. When high peak power signal pass through such HPA, peaks are clipped non-linearly and inter-modulation distortion are induced at the output. This additional interference leads to an increase in BER.

MIMO has been developed for many years for wireless systems. One of the earliest MIMO to wireless communications applications came in mid-1980 with the breakthrough developments. . Since then, several academics and engineers have made significant contributions in the field of MIMO. Now MIMO technology has aroused interest because of its possible applications in digital television, wireless local area networks, metropolitan area networks and mobile communication. First, MIMO system greatly increases the channel capacity, which is in proportional to the total number of transmitter and receiver arrays. Second, MIMO system provides the advantage of spatial variety: each one transmitting signal is detected by the whole detector array, which not only improved system robustness and reliability, but also reduces the impact of Inter symbol interference (ISI) and the channel fading.

II LITERATURE REVIEW

Owing to the signal structure difference between the filter bank multicarrier with offset quadrature amplitude modulation (FBMC/OQAM) and the orthogonal frequency-division multiplexing (OFDM) systems, the existing technologies to reduce the peak-to-average power ratio (PAPR) for OFDM systems are not suitable for the FBMC/OQAM systems. The main idea of this joint optimization scheme is clipping and filtering the processed FBMC/OQAM signal, whose probability of the peak value has been reduced by the IBPTS technique. Meanwhile, aided by the knowledge of convex optimization, the IBPTS-ICF joint optimization scheme can effectively reduce the signal distortion. The excellent PAPR reduction performance of the proposed scheme has been confirmed in our simulations by Junhui Zhao et al. [1].

The implementation of MIMO with OFDM is an effective and more attractive technique for high data rate transmission and provides burly reliability in wireless communication. It has lot of advantages which can decrease receiver complexity, provides heftiness against narrowband interference and have capability to reduce multipath fading. The major problem of MIMO-OFDM is high PAPR which leads to reduction in Signal to Quantization Noise Ratio of the converters which also degrades the efficiency of power amplifier at transmitter. In this paper we mainly focus on one of scrambling and non-scrambling technique Iterative clipping and filtering, and partial Transmit sequence (PTS) which results in better performance. The two techniques once united or combined in the system prove that along with trimming down the PAPR value, the power spectral density also gets smoother by Ashna Kakkar et al. [2].

A combination of multiple-input multiple output (MIMO) signal processing with orthogonal frequency division multiplexing (OFDM) is regarded as a promising solution for enhancing the performance of next generation wireless local area network (WLAN) systems. However, like OFDM, one main disadvantage of MIMO-OFDM is that the signals transmitted on different antennas might exhibit a prohibitively large peak-to-average power ratio (PAPR). Partial transmit sequence (PTS) provides attractive PAPR reduction performance in OFDM or MIMO-OFDM. Unfortunately, it leads to prohibitively large computational complexity. In this paper, types of low-complexity PTS schemes are proposed to reduce the PAPR for MIMO-OFDM systems that use Firefly algorithm (FA) and space-frequency block codes (SFBC). Simulation results show that FA based on PTS can reduce computational complexity dramatically and achieve better PAPR reduction performance compared to ordinary PTS by Ho-Lung Hung et al. [3].

The filter bank multicarrier with offset quadrature amplitude modulation (FBMC/OQAM) is being studied by many researchers as a key enabler for the fifth-generation air interface. In this paper, a hybrid peak-to-average power ratio (PAPR) reduction scheme is proposed for FBMC/OQAM signals by utilizing multi data block partial transmit sequence (PTS) and tone reservation (TR). In the hybrid PTS-TR scheme, the data blocks signal is divided into several segments and the number of data blocks in each segment is determined by the overlapping factor. In each segment, we select the optimal data block to transmit and jointly consider the adjacent overlapped data block to achieve minimum signal power. Then, the peak reduction tones are utilized to cancel the peaks of the segment FBMC/OQAM signals. Simulation results and analysis show that the proposed hybrid PTS-TR scheme could provide better PAPR reduction than conventional PTS and TR schemes in FBMC/OQAM systems. Furthermore, we propose another multi data block hybrid PTS-TR scheme by exploiting the adjacent multi overlapped data blocks, called as the multi hybrid (M-hybrid) scheme. Simulation results show that the M-hybrid scheme can achieve about 0.2-dB PAPR performance better than the hybrid PTS-TR scheme et al. H. Wang [4].

Orthogonal Frequency Division Multiplexing (OFDM) has been widely used in various high data rate wireless communications standards. The high peak-to-average power ratio (PAPR) has however been known to be a constant problem in OFDM systems. The high PAPR in the OFDM system has led to many problems such as signal distortion, energy spilling to the adjacent channel and reducing system performance gradually. In this paper, a technique involving the manipulation of codeword using circulant shift will be introduced. The key idea of the proposed technique is to generate scramble data sequences like the conventional selective mapping (SLM) technique. The simulation results showed that the proposed technique overcame original OFDM signals and conventional SLM with a 19.5% improvement and 1.1 dB difference from conventional SLM. Besides that, the proposed technique offered a lower computationally complexity where the number of IFFT blocks can be reduced by about 57% as compared to conventional SLM et al. E. Abdullah [5].

Energy efficiency is essential in mobile communication networks. High Peak-Average Power Ratio (PAPR) has been an inherent drawback of Orthogonal Frequency Division Multiplexing (OFDM) for decades. The peak value of power signals causes two serious problems where it reduces the power efficiency of Radio Frequency (RF) amplifier and increases the computational complexity in analog to digital (A/D) and digital to analog (D/A) converters. Consequently, this would increase the cost of extending the linear range of the RF amplifier as well as the complexity of the A/D or D/A converter. The motivation to reduce the high PAPR is influenced by the current demands of telecommunication consortium that are aiming for reduced power, high data rates and low-cost system. A method to reduce high PAPR by using this novel selective bit permutation method is introduced. This method does not only provide a better PAPR reduction performance but also to maintain the error performance at the receiver compared to the other method such as Selective Mapping (SLM) and Data Position Permutation (DPP) et al. Abdullah [6].

Multiple-Input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) is reliable and most attractive technique for high data rate communications. MIMO uses spatial diversity to accept multiple "best" signals simultaneously. Each antenna is able to transmit or receive signals, where the legacy system can only accept the single "best" signal. The main drawback of orthogonal frequency division multiplexing systems is high Peak to Average Power Ratio (PAPR), which results in poor power efficiency, degradation in bit-error-rate (BER) performance, and spectral spreading efficiency. The needed measure for better wireless communication is to reduce PAPR. The proposed system introduces Adaptive Selected mapping (ASLM) techniques. In this technique, the sums of separated data blocks are created from an OFDM data block using a set of phase sequence. It chooses lowest PAPR and selects sequences for transmission. As an outcome, the adaptive selected mapping increases the power efficiency and reduces the impulse interference by P. Kothai et al. [7].

The high peak-to-average power ratio (PAPR) in orthogonal frequency division multiplexing (OFDM) systems not only increases the complexity of the analog-to-digital (A/D) and digital-to-analog (D/A) converters but also reduces the efficiency of the radio frequency (RF) power amplifier. In this paper, we present a data position permutation (DPP) method, which is based on a selected mapping (SLM) scheme, for reducing the PAPR in OFDM systems. The candidate signal on each branch of the SLM scheme is generated by permuting the position and rotating the phase of the original data. In addition, a modified DPP method with lower bit error rate (BER) is proposed. The simulation results show that the proposed method provides better performance with regard to complexity, spectrum efficiency, and BER as compared to that of the SLM-based dummy sequence insertion (SLM-DSI) method et al. J. Wen [8].

The two related optimization problems, maximizing the minimum of weighted rates under a sum-power constraint and minimizing the sum-power under rate constraints, are considered. They assumed that the Gaussian input and that each signal is decoded at no more titan one receiver. The complexity is high because the steepest ascent algorithm for the weighted sum-rate maximization needs to be solved repeatedly for each weight vector searched by the ellipsoid algorithm. Then the solution does not satisfy the single-user water-filling structure. They can be used in admission control and in guaranteeing the quality of service. In, finally the mappings were used for many other optimization problems by Amhaimar Lahcen et al. [9].

The real and imaginary parts of complex factor corresponding to in-phase components and quadrature components of OFDM symbols, respectively. It is to be noted that in ideal cases, the demodulation is performed based on the assumption of perfect symbol timing, carrier frequency, and phase synchronization. This is usually not practically possible to achieve; therefore, the demodulated signal will not be the exact replica of input signal; resulting in bit error rate (BER). The term BER can be mathematically expressed as the difference of the received demodulated data and the input data by Yuan Ouyang et al. [10].

Table 1: Summary of Literature Review

Title	Author/ Publication	Methodology	Parameter/ Demerits
Peak-to-Average Power Ratio Reduction of FBMC/OQAM Signal Using a Joint Optimization Scheme	Junhui Zhao, Shanjin Ni and Yi Gong/ IEEE 2017	Design MIMO-OFDM system with PTS with non-linear clipping technique	PAPR =8 dB, / No calculate BER
Improvisation in BER and PAPR by using hybrid reduction techniques in MIMO-OFDM employing channel estimation techniques	Ashna Kakkar, Sai Nitesh Garsha, Ojasvi Jain and Kritika/ IEEE 2017	Design MIMO-OFDM system with PTS technique	PAPR = 8.5, dB, / More complexity
Performance of PTS-Based Firefly Algorithm Scheme for PAPR Reduction in SFBC MIMO-OFDM Communication Systems	Ho-Lung Hung, Yung-Fa Huang, Ching-Chuan and Rung-Ching Chen/ IEEE 2016	Design MIMO-OFDM system with SFBC technique	PAPR = 8.7 dB/ Not suitable for large Tx
Hybrid PAPR reduction scheme for	H. Wang, X. Wang, L.	Design OFDM System based on	PAPR = 8.7 dB and BER =
FBMC / OQAM systems based on multi data block PTS and TR methods	Xu, and W. Du/ IEEE 2016	PTS and TR method	12 dB/ Large Error
Minimizing High PAPR in OFDM System Using Circulant Shift Code word	E. Abdullah, A. Idris, A. Saparon/ IEEE 2016	Design OFDM system based on circular shift code word method	PAPR = 9 dB, BER = 11 dB/ Not good signal strength
Selective bit permutation method for Peak-Average Power Ratio (PAPR) reduction in OFDM system	E. Abdullah, A. Idris, A. Saparon/ IEEE 2016	Design OFDM system based on selective bit permutation method	PAPR = 9 dB, BER = 10 dB/ not good signal amplified
PAPR Reduction in MIMO OFDM Using Adaptive SLM Scheme	P. Kothai and R. Prabhu M.E/ IEEE 2015	Design MIMO-OFDM system with SLM technique	PAPR = 9.2 dB, BER = 5.3 dB/ Not stable
SLM-Based Data Position Permutation Method for PAPR Reduction in OFDM Systems	J. Wen, S. Lee, C. Kung / IEEE 2015	Design MIMO-OFDM system with SLM technique	PAPR = 9.2 dB, BER = 8 dB/ Large complexity
PAPR reduction performanc	Amhaimar Lahcen,	Design MIMO-OFDM	PAPR =9.5 dB/

e for WiMAX OFDM systems	Ahyoud Saida, Asselman Adel / IEEE 2015	system with pulse shaping technique	high complexity
Peak-to-Average Power Ratio Reduction Techniques for MIMO-OFDM Systems with STBC/SFBC	Yuan Ouyang, Hungkai Ding/ IEEE 2015	Design MIMO-OFDM system based on STBC/ SBFC system	PAPR = 9.6 dB, BER = 7 dB/ Not suitable for high antenna

III SYSTEM MODEL

MIMO in combination with OFDM is widely used nowadays due its best performance in terms of capacity of channels, high data rate and good outcome in frequency selective fading channels. In addition to this it also improves reliability of link. This is attained as the OFDM can transform frequency selective MIMO channel to frequency flat MIMO channels [8]. So it is widely used in future broadband wireless System or communications. Cyclic prefix is the copy of last part of OFDM symbol which is appended to the OFDM symbol that is to be transmitted. It is basically 0.25% of the OFDM symbol. We can say that one fourth of the OFDM symbol is taken as CP (cyclic prefix) and appended to each OFDM symbol. IFFT is used at the transmitter and FFT is used at the receiver which substitutes the modulators and demodulators. Doing so eliminates the use of banks of oscillators and coherent demodulators. Moreover the complex data cannot be transmitted as it is; therefore it is first converted to analog form which is accomplished by IFFT. It basically converts the signal from frequency domain to time domain. Prior to IFFT operation symbol mapping is performed which is nothing but the modulation block. Any of the widely used modulation techniques can be applied like BPSK, QPSK, QAM, PSK etc. Further there are higher order modulations are also available which provide more capacity at little expense of BER performance degradation. After IFFT block pilot insertion is done and then CP (cyclic prefix) is added. Figure 1 below shows the block diagram constituting MIMO and OFDM. Any antenna configuration for the MIMO can be used according to the system requirement. Higher the configuration more will be the capacity and more will be the computational complexity of the transceiver design. It is seen that in the case of estimating channel the computational complexity is increased. Mapper defines the modulation to be used. Symbol encoder takes the shape of the STBC (Space Time Block Code) if spatial diversity is to be used and it takes the shape of the de-multiplexer/multiplexer if spatial multiplexing is to be used.

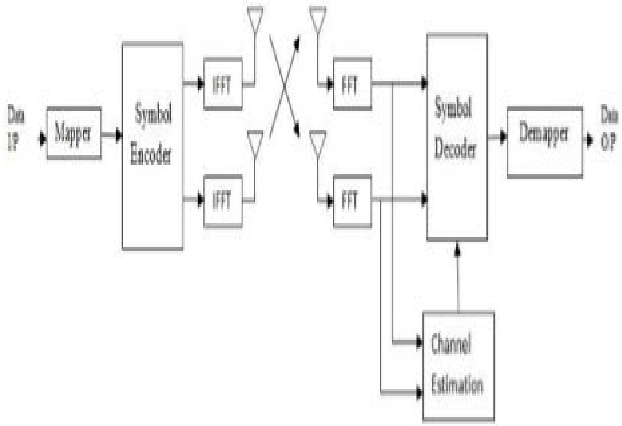

Figure 1: MIMO-OFDM system model.

The received signal at j^{th} antenna can be expressed as

$$R_j[n,k] = \sum H_{ij}[n,k]\, X_i\,[n,k] + W[n,k] \qquad (1)$$

Where H is the channel matrix, X is the input signal and W is noise with zero mean and variance. Also $b_i[n,k]$ represents the data block i^{th} transmit antenna, n^{th} time slot and k^{th} sub channel index of OFDM. Here i and j denoted the transmitting antennas index and receiving antenna index respectively.

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The MIMO-OFDM system model [9] with NR receives antennas and NT transmits antennas can be given as:

$$\begin{bmatrix} Z_1 \\ Z_2 \\ \vdots \\ Z_N \end{bmatrix} = \begin{bmatrix} H_{1,1} & H_{1,2} & \cdots & H_{1,NT} \\ H_{2,1} & H_{2,2} & \cdots & H_{2,NT} \\ \vdots & \vdots & \ddots & \vdots \\ H_{NR,1} & H_{NR,2} & \cdots & H_{NR,NT} \end{bmatrix} \begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_{NT} \end{bmatrix} + \begin{bmatrix} M_1 \\ M_2 \\ \vdots \\ M_{NT} \end{bmatrix}$$

Where, Z represents O/P data vector, H denotes Channel matrix, A denotes I/P data vector and M represents Noise vector. The wireless channel used is AWGN channel. After receiving the signal the CP is removed then the pilots are also removed from main signal received. After this the signal that is in time domain can be again converted to frequency domain by taking FFT of the received signal.

The sequence on each of the OFDM block is then provided to channel estimation block where the received pilots altered by channel are compared with the original sent pilots. Channel estimation block consists of the algorithms that are applied to estimate the channel.

PTS Schemes

1. SISO PTS Scheme

In the SISO-PTS scheme, the original data sequence in the frequency domain is partitioned into M disjoint, equal length sub blocks Xv (v = 1, 2... M) as follows.

$$X = \sum_{v=1}^{M} X_v$$

By multiplying some weighting coefficients to all the subcarriers in every sub-block, we can get the new frequency sequence.

$$X' = \sum_{v=1}^{M} b_v X_v$$

Finally, at each transmitting antenna, there are (V-1) sub blocks to be optimized, and the candidate sequence with the lowest PAPR is individually selected for transmitting. Assume that there are W allowed phase weighting factors. To achieve the optimal weighting factors for each transmitting antenna, combinations should be checked in order to obtain the minimum PAPR [10].

2. Alternate PTS (A-PTS)

In, the idea of alternate optimization is introduced, and it can be also applied to PTS in multiple antennas OFDM systems, denoted as alternate PTS (A-PTS). Different from ordinary PTS, phase weighting factors are needed only for half of the sub blocks in A-PTS. That is to say, starting from the first sub block, every alternate sub block is kept unchanged and phase weighting factors are optimized only for the rest of the sub blocks, which leads to the reduction of computational complexity. In this way, the computational complexity is greatly reduced at the expense of PAPR performance degradation [11]. Employed spatial sub block circular permutation for A-PTS scheme to increase the number of candidate sequences which improves the PAPR performance further.

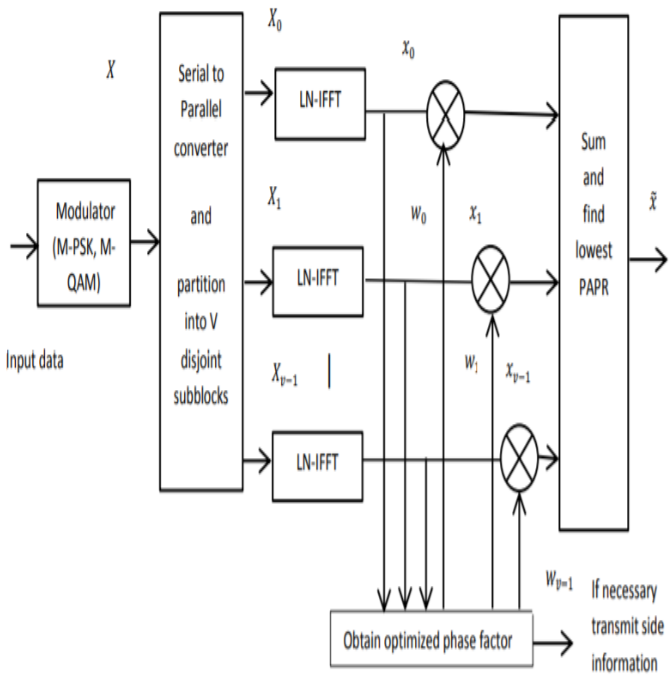

Figure 2: Block diagram of the PTS scheme with two transmit antennas.

IV EXPECTED OUTCOME

This research project expects to have the following outcomes by the end of the project.

- The PAPR of the MIMO-OFDM signal can also be reduced by using PTS with DWT and DCT technique.
- Analysis of the 2×1, 2×2 MIMO-OFDM system for 5G wireless communication.
- Analysis of the bit error rate (BER) for the different modulation technique and PTS with DWT and DCT technique.
- Analysis of the space time block code (STBC) used in MIMO-OFDM system and achieved better result.

V CONCLUSION

An extended approach cooperative and alternate partial transmit sequence named PTS was proposed for STBC MIMO-OFDM - 5G which makes uses of conjoint optimization of the PAPR for both real and imaginary parts. A high PAPR, between the two antennas, is selected to be transmitted. The proposed method performs well in terms of simulation results as well as the complexity of computation.

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