Review of PAPR Reduction for MIMO-OFDM Radar with DWT and DCT Multiple Constraints

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***Abstract*— In recent times, the demand for multimedia data services has grown up rapidly. One of the most promising multi-carrier systems, Orthogonal Frequency Division Multiplexing (OFDM) forms the 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 the 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. The nonlinearity of the HPA exhibits amplitude and phase distortions, which cause loss of orthogonality among the subcarriers, and hence, inter-carrier interference (ICI) is introduced in the transmitted signal. Not only that, but high PAPR also leads to in-band distortion and out-of-band radiation. This paper emphasis mainly on the PAPR reduction of the MIMO-OFDM system using partial transmits sequence (PTS) and precoding 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 compounding 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**

I. INTRODUCTION

This work will be used as a 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 the first-generation system was introduced and till now, there has been rapid growth in the field of communication and mobile technology. In Wireless Technology, there have been subtle increases in peak bitrate 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 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 advanced wideband 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 a high power amplifier (HPA) at the output of the 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 passes through such HPA, peaks are clipped non-linearly and intermodulation distortion is 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 to 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, the MIMO system greatly increases the channel capacity, which is proportional to the total number of transmitter and receiver arrays. Second, the MIMO system provides the advantage of spatial variety: each

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one transmitting signal is detected by the whole detector array, which not only improved system robustness and reliability but also reduces the impact of Intersymbol interference (ISI) and the channel fading[9, 12].

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 Linlong Wu 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 a lot of advantages that can decrease receiver complexity, provides heftiness against narrowband interference and has the capability to reduce multipath fading. The major problem of MIMO-OFDM is high PAPR, which leads to a reduction in Signal to Quantization Noise Ratio of the converters, which also degrades the efficiency of the power amplifier at the transmitter. In this paper, we mainly focus on one of the 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 the 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 a 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 the 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 systems. 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 a 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 sequences. It chooses the lowest PAPR and selects sequences for transmission. As an outcome, the adaptively selected mapping increases the power efficiency and reduces 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 a 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].

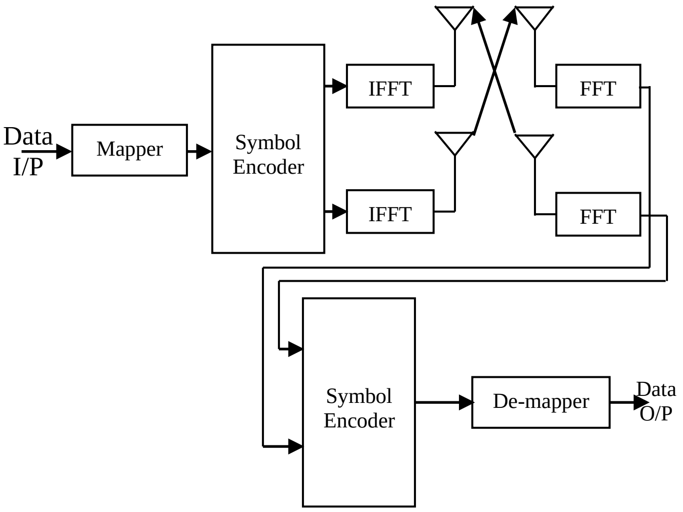
TABLE I. SUMMARY OF LITERATURE REVIEW

Title	Author/ Publication	Methodology	Parameter/ Demerits
Transmit Waveform/Receive Filter Design for MIMO Radar With Multiple Waveform Constraints	Linlong Wu, Prabhu Babu, and Daniel P. Palomar / IEEE 2018	Design the 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 the 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 FBMC / OQAM systems based on multi-data block PTS and TR methods	H. Wang, X. Wang, L. Xu, and W. Du/ IEEE 2016	Design OFDM System based on PTS and TR method	PAPR = 8.7 dB and BER = 12 dB/ Large Error
Minimizing High PAPR in OFDM System Using Circulant Shift Codeword	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 the 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

III. SYSTEM MODEL

MIMO, in combination with OFDM, is widely used nowadays due to its best performance in terms of the capacity of channels, high data rate and good outcome in frequency selective fading channels. In addition to this, it also improves the reliability of the link. This is attained as the OFDM can transform the frequency-selective MIMO channel to frequency flat MIMO channels [8]. So it is widely used in future broadband wireless systems/communications. The cyclic prefix is a copy of the last part of the 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 an analog form which is accomplished by IFFT. It basically converts the signal from the frequency domain to the time domain. Prior to the 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 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.

Fig. 1. MIMO-OFDM system model



The received signal at the jth 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.

The MIMO-OFDM system model [10] with NR receives antennas and NT transmits antennas can be given as:

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

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

IV. PTS SCHEMES

1. SISO PTS Scheme

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

$$X = \sum_{v=1}^{M} X_v \qquad (3)$$

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

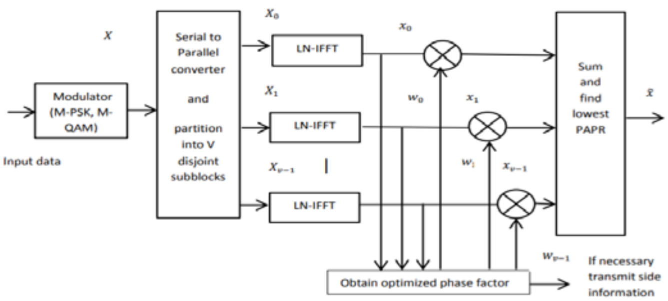
$$X' = \sum_{v=1}^{M} b_v X_v \qquad (4)$$

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 also be 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 the A-PTS scheme to increase the number of candidate sequences, which improves the PAPR performance further.

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



PAPR REDUCTION TECHNIQUE

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

- Signal Distortion.
- Coding Methods,
- Probabilistic (Scrambling) Techniques
- 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 the following characteristics:

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- 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 system. Therefore, it is required to reduce PAPR without increasing the bandwidth of the 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.

V. PROPOSED METHODOLOGY

We have proposed a wavelet-based MIMO-OFDM system for the reduction of PAPR, which effectively reduces the PAPR on the rational selection of phase values. First, the original input signal is modulated with BPSK, QPSK, QAM-16 and PTS technique had been applied, where the phase values are generated using the optimized algorithm. This helps to minimize the PAPR of the input signal. Then discrete wavelet transform is applied and has been followed by DCT, which is applied transmitted through the AWGN channel. At the receiver, the inversion of the transmitter will be done.

Fig. 3. Flow Chart of Proposed Methodology

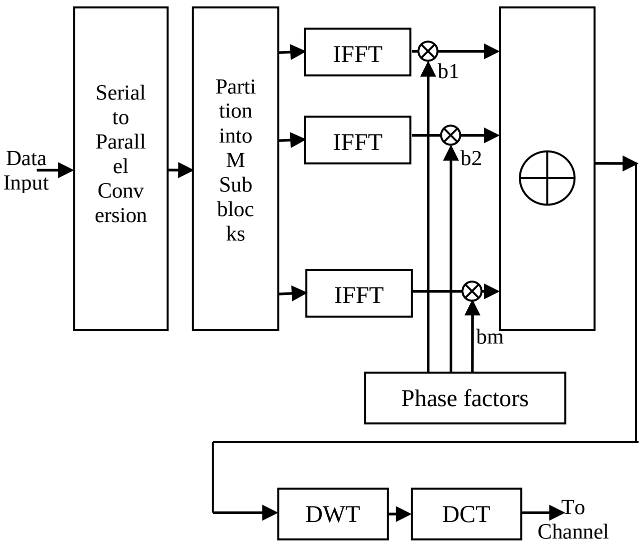

Figure 3 shows the enhanced transmitter block diagram of the presented work. In this research work, conventional OFDM is followed by the WPT and DCT for PAPR reduction and vice versa is also simulated. Both transmitter and receiver are simulated in order to calculate the BER.

VI. 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.
- For 5G wireless communication, Analysis of the 2×1, 2×2 MIMO-OFDM system.
- For the different modulation techniques and PTS, Analysis of the bit error rate (BER) with DWT and DCT technique.
- Analysis of the space-time block code (STBC) used in the MIMO-OFDM system and achieved a better result.

VII. 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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