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# Exploring PTS method in MIMO advanced waveforms signal for 5G network security analysis

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## Abstract

Peak-to-average power ratio (PAPR) issues lead to a reduction in the scheme's throughput. In this research, we propose a beneficial method for lowering the high PAPR of

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an orthogonal frequency division multiplexing (OFDM) system, called partial transmission sequence (PTS). The PTS method of PAPR reduction in advanced waveforms will depend on the usage of PAPR reduction technologies in 5G waveforms. This paper presents the simulation of an OFDM PTS reduction technique. The simulation results demonstrate that the proposed approach performs better than the conventional PAPR reduction approach. Further. it is also seen that enhances network security by increasing data diversity, reducing interference, and improving resilience against eavesdropping and jamming attacks.

***Subject Classification:*** *94A05.*

***Keywords:*** *5G, Security, NOMA, Physical layer.*

## 1. Introduction

One of the best strategies for reducing the structure's high peak amplitude is PTS. To lower the large amplitude of the optical waveform and increase system efficiency, the OFDM symbols are weighted with the best intelligent PTS phase factor. A high peak-to-average power ratio (PAPR) is orthogonal frequency division multiplexing's (OFDM) main flaw. There are numerous PAPR reduction techniques that have been suggested to solve the PAPR issue. The partial transmit sequence (PTS) method is a well-known way to lower an OFDM signal's PAPR statistics. By adjusting the multiplied weighting factor of sub-blocks for both data sub-carriers and clusters, the PTS approach can lower the PAPR. As more weighting variables and clusters are added, the PAPR reduction performance can be greatly enhanced by the PTS technique. However, when the number of weighting variables or clutter increases, more side information must be communicated to the receiver in order for the receiver to recover the original data. Numerous methods, including clipping, coding, selected mapping, partial transmit sequences, tone injection, and tone reservation, have been devised to reduce PAPR. For OFDM, the selected mapping (SLM) and partial transmit sequences (PTS) peak power reduction techniques are effective and distortion-free. While in PTS the transmitter builds its transmit signal with low PAPR by coordinating the addition of correctly phase-rotated signal pieces[1], SLM requires the transmitter to choose one advantageous transmit signal from a set of sufficiently varied signals that all reflect the same information. We provide a novel weighting factor in this work that can enhance PAPR reduction performance over the traditional PTS method. The suggested approach does not include any extra side information or system complexity. When compared to the traditional PTS method, the suggested method can improve both PAPR and BER performance while maintaining the same amount of side information. In order to demonstrate the efficacy of the suggested strategy, this research presents a variety of computer simulation results [2]. Currently, NOMA is more than just an idea; it has been adopted as a regular procedure in a number of transmission networks. When NOMA is used, the power amplifier (PA) is forced to shift into a nonlinear zone due to the high peak-to-average power ratio (PAPR) that it experiences. The multi-carrier technique's power amplifier enters a nonlinear area due to the high value of PAPR. The entire system's performance decreases when the power amplifier's performance deteriorates. [3] The PAPR problem in multi-carrier techniques like selective mapping (SLM) and partial transmit sequence (PTS) is addressed in this paper using a variety of approaches. The results of the simulation show that the proposed PTS performs better than both the standard SLM and PTS. In this study, we show a unique low-complexity partial transmit sequence (PTS) method for orthogonal frequency division multiplexing (OFDM) systems [4] with peak-to-average power ratio (PAPR) reduction using the random phase sequence matrix (RPSM). The goal of this paper is to look into different ways to reduce PAPR and give detailed information about how to set up an OFDM system [5]. This paper [6] shows how WP-OFDM for PTS techniques and PSO-based PTS approaches work. A hybrid matched filter (HMF) method based on the fusion of two matched filters (MF) was used in this study to construct a unique 5G spectrum sensing technique [7]. We propose a novel CS algorithm for 5G waveforms in this article. The complexity of CS is decreased by limiting the computation of cyclostationary features and the signal autocorrelation. To figure out how well 5G waveforms work, the energy detection (ED) and spectrum sensing (CS) techniques, which are based on cognitive radio (CR), are used. The study's findings demonstrate that the suggested CS algorithm performed well in terms of detection and gained 2 dB in comparison to the industry norms [8]. [9] This study suggests a suboptimal particle swarm optimization (PTS) method based on a modified PSO algorithm. The latter makes use of heuristics to quickly identify complex weighting elements that are best matched. The superior effectiveness of the suggested strategy in terms of PAPR mitigation and computational burden is determined by comparing it to existing techniques. In this work [10], we present a hybrid strategy based on energy detection (ED) and cyclic stationary feature detection (CFD). A brand-new, distortion-free technology called partial transmit sequence (PTS) can be employed to enhance PAPR performance. However, multiple IFFT operations are performed when PTS methods are implemented in OFDM systems, which increases computational complexity. This paper [11] discusses a new methodology to lessen the computational cost of PTS-based PAPR reduction strategies in OFDM transmitters. Compared to selective mapping (SLM), clipping and filtering (C&F), companding, and the original signal for 256-QAM, the research shows that the PTS effectively lowers the PAPR to 0.4 dB, 1.9 dB, 3.8 dB, and 8.7 dB. The PTS, SLM, C&F, and companding techniques all reduce the PAPR of OMWC for 64-QAM from 11.1 dB to 1.9 dB, 3.3 dB, and 5.2 dB, respectively. Additionally, it maintains the framework's BER while enhancing spectral performance [12].

## 2. Proposed Model

PTS is a powerful way for wireless communication systems like OFDM to deal with high peak power, which can be a big problem when sending signals over a channel. PTS accomplishes this by distributing the energy across the OFDM symbol in order to ensure that no single symbol experiences high peak power. PTS primarily deals with excessive peak power by selectively activating a subset of subcarriers within an OFDM symbol. To do this, the symbol is divided into smaller sub-blocks, and only a portion of the subcarriers that are available in each sub-block are used to convey data. By reducing the number of active subcarriers, PTS successfully reduces constructive interference that can result in high peaks in the transmitted signal. Another method PTS employs to optimize subcarrier selection is the use of phase factors, which guarantees that active subcarriers are carefully chosen to lower peak power. By altering the phase factors and sub-blocks, PTS can test a variety of combinations to find the one that yields the lowest peak power while maintaining the required signal quality. PTS has two benefits: it spreads out the energy throughout the OFDM symbol, allowing for more efficient power utilization; and it lowers the peak-to-average power ratio (PAPR), which helps minimize clipping and signal distortion in high-power amplifiers. As a result, the need for expensive, intricate power amplification stages is reduced, and system reliability is raised. Let N represent the total number of subcarriers in the OFDM symbol, M the Phase factor, which specifies how many subcarriers are active in each PTS sub-block, L the number of PTS sub-blocks in the OFDM symbol (L=NM), and kk the Index of the PTS sub-block $(1 < k < L1)$.

Assuming that $S_k$ is the starting subcarrier index for the k-th sub-block, let's find it.

$$S_k = (k-1)\cdot M + 1 \tag{1}$$

In next step, determine the ending subcarrier index for the kk-th sub-block, denoted as

$$E_k\!: E_k = k\cdot M \tag{2}$$

The set of active subcarrier indices for the kk-th sub-block can be represented as:

$$A_k = \{S_k, S_{k+1} + S_k + 2, \ldots, E_k\} \tag{3}$$

Let's locate $S_k$, supposing it to be the kk-th sub-block's initial subcarrier index. Repeat for all $k = 1$ to $L$ to generate the PTS sequence for the entire OFDM symbol.

## 3. Simulation Results

Advanced waveforms in MIMO systems offer benefits like increased data rates, improved spectral efficiency, and enhanced signal robustness. However, they also introduce security challenges that require thorough analysis. Firstly, these advanced waveforms, such as quadrature amplitude modulation (QAM), can make it more challenging for eavesdroppers to intercept or decipher the transmitted data due to their intricate modulation and spreading techniques. This is a security advantage. Additionally, the multiple antennas in MIMO provide spatial diversity, making it difficult for attackers to capture the complete signal. However, understanding the potential of beamforming and precoding in MIMO is crucial to prevent signal leakage. On the other hand, MIMO systems are susceptible to spatial jamming and interference. Security analysis should consider the resilience of the system against these threats and the potential countermeasures like power control and adaptive beamforming. Moreover, key management and encryption protocols are critical to safeguard the wireless communication in MIMO systems. These protocols should be designed to handle the unique challenges posed by advanced waveforms. In conclusion, a comprehensive security analysis for advanced waveforms using MIMO entails evaluating the benefits of complexity against potential vulnerabilities and implementing robust encryption and countermeasures to ensure secure and reliable wireless communication. By adjusting the number of sub-blocks (V) and as indicated in Figure 1, the proposed is applied to FBMC. Peak power at the CCDF of $10^{-3}$ is lower than the original FBMC PAPR (11.2 dB) at 5.8 dB (proposed PTS V = 4), 6.6 dB (proposed

PTS V = 2), 7.8 dB (C-PTS), and 9.9 dB (C-SLM). The proposed method's PAPR curves are examined (V = 2, 4). Peak power is reduced from the initial PAPR of NOMA11.4 dB to 2.9 dB, 3.6 dB, 6.8 dB, and 7.8 dB at the complementary cumulative distribution function (CCDF) of $10^{-3}$, as illustrated in Figure 2. The proposed method's PAPR curves are examined (V = 2, 4). As shown in Figure 3, the peak power goes down from the initial PAPR of OFDM, which was 10.2 dB, to 6, 5, 8, and 9 dB at the CCDF of $10^{-3}$. Figure 4 provides the PSD of the NOMA waveform. It is evident that the PSD approaches significantly minimize the side-lobe of the NOMA, resulting in effective spectral efficiency. The PSD values of the original NOMA waveform are -1750 for NOMA, -1852 for FBMC, and -2116 for OFDM. This improves battery life, supports more devices, and lessens signal interference. Data accuracy is ensured by enhanced PSD, enabling precision.

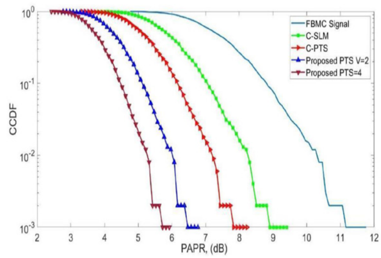


**Figure 1**

**PAPR FBMC Performance**

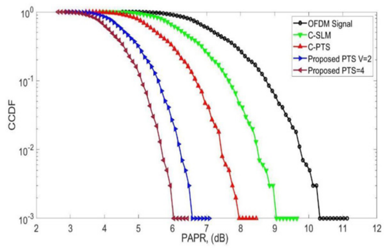


**Figure 2**

**PAPR NOMA Performance**

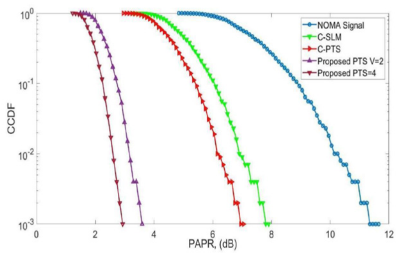


**Figure 3**

**PAPR OFDM Performance**

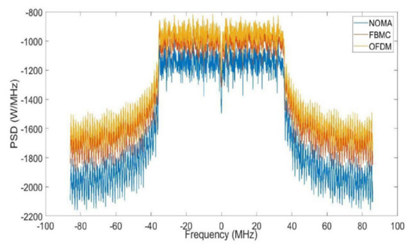


**Figure 4**

**PSD Analysis**

## 4. Conclusion

Numerous multi-carrier approaches have been presented and examined during the past three decades. A lot of work has gone into developing new multiple-access mechanisms that will allow numerous users to share resources at once. NOMA, the most recent technology, has two distinct aspects, including power-domain and code-domain NOMA. According to the users' power levels, the resource block is multiplexed in the NOMA power domain. The resource block is simultaneously made available to a certain user in the code domain NOMA by the code. The biggest flaw in multi-carrier schemes like OFDM, UFBMC, and NOMA is PAPR. PAPR is severely impairing the system performance of all multi-carrier approaches. The PTS technique is suggested in this work as a solution to the PAPR issue. The experimental results show that the proposed strategy is much superior to the existing NOMA strategies.

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