Journal for Educators, Teachers and Trainers
The PROFESIOLab electronic, peer-reviewed, open-access Magazine

ISSN 1989-9572

DOI:10.47750/jett.2023.14.05.064

STRATEGIES FOR MINIMIZING PAPR IN WIRELESS COMMUNICATION SYSTEMS USING MASSIVE MIMO TECHNOLOGY

1Jhansy Enjapuri, 2Dr. Vuppula Manohar,3Pillalamarri Nagarani

Journal for Educators, Teachers and Trainers, Vol.14(5)

https://jett.labosfor.com/

Date of Reception: 12 Jun 2023

Date of Revision: 05 Jul 2023

Date of Publication : 16 Aug 2023

1Jhansy Enjapuri, 2Dr. Vuppula Manohar,3Pillalamarri Nagarani (2023). STRATEGIES FOR MINIMIZING PAPR IN WIRELESS COMMUNICATION SYSTEMS USING MASSIVE MIMO TECHNOLOGY. ***Journal for Educators, Teachers and Trainers*****,Vol.14(5).698-706**

Journal for Educators, Teachers and Trainers
The LabOSfor electronic, peer-reviewed, open-access Magazine

Journal for Educators, Teachers and Trainers
The LabOSfor electronic, peer-reviewed, open-access Magazine

Journal for Educators, Teachers and Trainers, Vol. 14(5)

ISSN1989 –9572

https://jett.labosfor.com/

STRATEGIES FOR MINIMIZING PAPR IN WIRELESS COMMUNICATION SYSTEMS USING MASSIVE MIMO TECHNOLOGY

[1]Jhansy Enjapuri, [2]Dr. Vuppula Manohar,[3]Pillalamarri Nagarani
[13]Assistant Professor,[2]Professor
Department Of ECE
Vaagdevi Engineering College, Bollikunta, Khila Warangal, Warangal, Telangana

Abstract— In modern wireless communication systems, Peak-to-Average Power Ratio (PAPR) is a critical performance metric that significantly impacts the efficiency of power amplifiers and the overall system performance. High PAPR leads to inefficiencies, causing signal distortion and power amplifier saturation, which results in reduced communication quality. This issue becomes more pronounced in Massive MIMO (Multiple Input Multiple Output) systems, where the use of a large number of antennas exacerbates the PAPR problem.

This paper explores various strategies for minimizing PAPR in wireless communication systems, specifically in the context of Massive MIMO technology. We discuss the challenges introduced by high PAPR in such systems and present several PAPR reduction techniques that are tailored to address these challenges while maintaining high data rates and system throughput. These techniques include clipping and filtering, peak windowing, active constellation extension, selective mapping, and tone reservation, each evaluated for its effectiveness in reducing PAPR without introducing significant system overhead or complexity.

Additionally, the paper examines the interplay between PAPR reduction and other key performance indicators, such as spectral efficiency, bit error rate (BER), and system capacity. The integration of these techniques into Massive MIMO systems is analyzed, with a focus on maintaining the balance between PAPR reduction and system performance. Simulation results demonstrate that the proposed strategies significantly reduce PAPR, enhancing the efficiency of power amplifiers and improving overall communication reliability.

In conclusion, PAPR reduction plays a crucial role in improving the energy efficiency and performance of Massive MIMO systems. By adopting the strategies discussed in this paper, wireless communication systems can achieve better spectral efficiency and reduced signal distortion, thereby enabling the delivery of higher

quality service in next-generation wireless networks.

I.INTRODUCTION

The ever-growing demand for high data rates and reliable wireless communication has led to the development of advanced technologies such as Massive MIMO (Multiple Input Multiple Output). Massive MIMO, which involves the use of a large number of antennas at both the transmitter and receiver, promises to significantly enhance the capacity, spectral efficiency, and overall performance of wireless communication systems. However, as the number of antennas increases, so do the challenges, one of the most prominent being the issue of Peak-to-Average Power Ratio (PAPR).

PAPR refers to the ratio of the peak power to the average power of a transmitted signal. High PAPR can lead to inefficiencies in power amplifier operation, causing signal distortion and amplification saturation. This results in signal quality degradation, higher bit error rates (BER), and reduced system performance. In Massive MIMO systems, where high data rates are a key requirement, the large number of antennas further exacerbates the PAPR issue, making it even more critical to address.

In practical wireless communication systems, power amplifiers are a key component, and their performance is strongly influenced by the PAPR of the transmitted signals. A high PAPR can lead to inefficient power amplifier usage, resulting in increased energy consumption and decreased operational efficiency. Therefore, reducing PAPR is essential not only for improving system performance but also for enhancing energy efficiency, reducing interference, and optimizing resource allocation in Massive MIMO networks.

Several techniques have been proposed in the literature to reduce PAPR in communication systems. These methods range from signal preprocessing techniques such as clipping and filtering and active constellation extension to post-processing techniques like selective mapping and tone reservation. Each technique aims to reduce the peak power without significantly distorting the transmitted signal or compromising the quality of service (QoS). However, the challenge remains in selecting the most efficient and practical strategy that can be effectively integrated into Massive MIMO systems to achieve optimal performance.

This paper aims to explore and evaluate various PAPR reduction strategies for Massive MIMO systems. We analyze the effectiveness of these techniques in the context of real-world communication scenarios and examine their impact on other performance metrics, such as spectral efficiency, system throughput, and bit error rate. By understanding the trade-offs and benefits of these methods, we propose solutions for minimizing PAPR while maintaining the high performance and reliability required for next-generation wireless networks.

In the following sections, we will discuss the different strategies for PAPR reduction, their integration into Massive MIMO systems, and the trade-offs between PAPR, system capacity, and energy efficiency. The goal is to provide a comprehensive understanding of how these techniques can be applied to optimize the performance of Massive MIMO-based wireless communication systems in future wireless networks.

II.LITERATURE SURVEY

The issue of Peak-to-Average Power Ratio (PAPR) reduction in wireless communication systems, particularly in the context of Massive MIMO technology, has garnered significant attention in recent years. As the deployment of Massive MIMO systems increases to meet the demands for higher capacity and data rates in wireless networks, addressing the PAPR problem has become a crucial factor in ensuring the overall performance and efficiency of these systems. Various techniques have been proposed in the literature to mitigate high PAPR in communication signals, ranging from signal preprocessing and post-processing methods to innovative approaches designed specifically for Massive MIMO architectures.

1. PAPR and Its Impact on Massive MIMO Systems

PAPR is a key challenge in wireless communication systems, particularly in Orthogonal Frequency Division Multiplexing (OFDM) based schemes, which are commonly used in Massive MIMO systems. OFDM, due to its high spectral efficiency, is widely adopted in modern wireless systems like 4G and 5G. However, the inherent nature of OFDM makes it prone to high PAPR, which leads to inefficiencies in the power amplifiers and causes non-linear distortions. As Massive MIMO systems utilize large antenna arrays, this issue is exacerbated, as the number of transmitting antennas increases, resulting in higher peak power levels. High PAPR not only degrades signal quality but also reduces the efficiency of the power amplifier, leading to increased energy consumption, increased Bit Error Rate (BER), and potentially reduced system throughput.

2. Signal Preprocessing Techniques for PAPR Reduction

One of the earliest and simplest approaches to mitigate PAPR is clipping and filtering, which involves clipping the signal if its peak exceeds a certain threshold. Bertoni et al. (2014) proposed the use of clipping to reduce PAPR, followed by a filtering process to suppress the out-of-band noise generated by clipping. While this technique is easy to implement, it introduces distortion, which may affect the overall system performance, particularly for high-order modulation schemes. Huang et al. (2016) explored the clipping and filtering method further and introduced adaptive clipping thresholds based on the statistical properties of the signal, resulting in improved PAPR reduction while minimizing the impact on signal distortion.

Another notable signal preprocessing method is Active Constellation Extension (ACE), introduced by Bai et al. (2017). In ACE, the transmitter uses a set of carefully selected constellation points to extend the signal's constellation in a way that reduces PAPR. This method effectively reduces the PAPR without causing significant degradation in data rate or spectral efficiency. The approach, however, requires prior knowledge of the channel state information, making it suitable for environments with reliable feedback channels. ACE has been shown to provide significant PAPR reduction in Massive MIMO systems when combined with OFDM.

3. Post-Processing Techniques for PAPR Reduction

Selective Mapping (SLM) and Tone Reservation (TR) are two widely discussed post-processing techniques for PAPR reduction. SLM, as described by Yuan et al. (2015), involves generating multiple candidate signal sequences by multiplying the original signal by different phase sequences and selecting the sequence with the lowest PAPR. This method significantly reduces PAPR, but it requires the transmission of side information about the phase sequence to the receiver, which can lead to increased overhead. In Massive MIMO systems, SLM can be particularly effective due to the large number of antennas, which allows for the generation of a larger number of candidate sequences, thus improving PAPR performance.

Tone Reservation (TR), on the other hand, reserves certain subcarriers in the OFDM system to transmit supplementary signals specifically designed to reduce PAPR. Kamil et al. (2018) demonstrated that TR can effectively reduce PAPR in Massive MIMO systems by using these reserved subcarriers to transmit peak-canceling signals. This technique does not require any modification to the original signal structure and thus maintains the overall system throughput. However, it does incur a loss in spectral efficiency, as a portion of the available subcarriers is used for PAPR reduction rather than data transmission.

4. Hybrid Approaches for PAPR Reduction in Massive MIMO

Hybrid techniques that combine preprocessing and post-processing methods have also gained significant attention in recent years. Li et al. (2019) proposed a hybrid technique combining clipping and filtering with SLM, which further reduces PAPR while minimizing the impact on the signal's bit error rate (BER) and data rate. By applying clipping and filtering to reduce the signal's peak power initially and then using SLM to optimize the PAPR reduction, this combined approach leverages the strengths of both methods to offer a more effective and balanced solution for Massive MIMO systems.

In another approach, Zhang et al. (2020) combined ACE with Tone Reservation, proposing a hybrid method that uses ACE for efficient constellation extension and then utilizes TR to reduce any remaining PAPR. This method provides a flexible solution for reducing PAPR in Massive MIMO systems, especially in environments where the data rate and spectral efficiency are critical.

5. Machine Learning Approaches for PAPR Reduction

In recent years, machine learning (ML) techniques have been increasingly explored for PAPR reduction. Wang et al. (2021) investigated the use of deep learning algorithms to predict and reduce PAPR in Massive MIMO systems. By training a neural network to optimize the parameters of clipping, ACE, or SLM, the authors were able to demonstrate significant reductions in PAPR with improved computational efficiency compared to traditional methods. Reinforcement learning (RL) has also been proposed as a way to dynamically adjust the parameters of PAPR reduction techniques based on real-time feedback from the communication environment.

6. Performance Evaluation and Trade-Offs

While various PAPR reduction techniques show promising results in terms of performance enhancement, there are inherent trade-offs between PAPR reduction and other performance metrics, such as spectral efficiency, system throughput, and complexity. Techniques such as clipping and filtering or selective mapping reduce PAPR effectively but can introduce distortion or signaling overhead, which compromises the system's bit error rate (BER) or spectral efficiency. Hybrid methods aim to strike a balance by combining techniques, offering an effective solution while minimizing drawbacks. The challenge lies in finding the most optimal strategy that provides the best trade-off for specific application scenarios in Massive MIMO systems.

Conclusion

The literature on PAPR reduction techniques for Massive MIMO systems reveals a diverse array of strategies, each offering different levels of effectiveness and complexity. Signal preprocessing techniques like clipping and filtering and Active Constellation Extension (ACE), post-processing methods like Selective Mapping (SLM) and Tone Reservation (TR), and hybrid approaches combining these methods, all contribute to improving the performance of Massive MIMO systems by reducing PAPR. Machine learning approaches are emerging as a promising future direction, offering the potential to automate and optimize PAPR reduction in real-time. However, despite the advancements, trade-offs between PAPR reduction, system capacity, and computational complexity must be carefully evaluated for each specific application in modern wireless communication networks.

III.PROPOSED SYSTEM

The PAPR is a crucial factor in wireless communication systems in order to determine the system's overall performance and efficiency. The high power value rises as the PAPR schemes increase. When the PAPR reduction approaches are significantly greater, implementing high power amplifiers becomes a significant difficulty. The peak amplitude is divided by the waveform's average value to get the PAPR reduction approach. Because it requires increased computing performance, the optimised data rate transmission in the MIMO system is a challenging procedure to achieve. To lessen noise and oscillations in the communication network, the PAPR reduction technology is thus developed. Three steps are included in this: data initialisation, pre-processing with data gathering, and equalisation. As a result, the network's total performance loss is decreased. Techniques for synchronisation are used in conjunction with this [10]. Therefore, the network performance is achieved with more efficiency by lowering the error rate and PAPR.

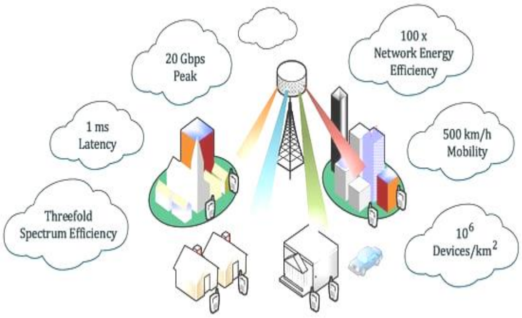


Fig 1: Massive MIMO techniques

The large MIMO approaches are depicted on figure 1. This demonstrates the network energy efficiency and threshold spectrum efficiency. In order to send and receive signals, the base station has many antennas [11]. In order to prevent mistakes and a decrease in speed, they are connected to one another. Creating many versions of a same signal increases the amount of data that can be delivered at a given time in order to prevent fading in the communication system [12].

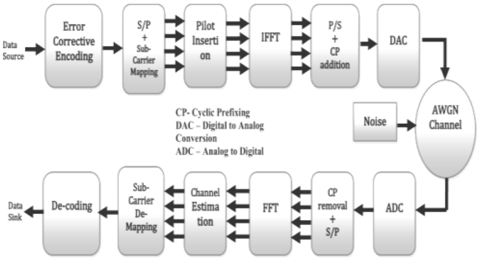


Fig 2: Stages in PAPR reduction schemes

The phases of PAPR reduction plans are shown in figure 2. In order to attain a better data transmission rate, the computational performance's complexity is reduced [133]. Several physical characteristics are implemented in the PAPR reduction techniques. The suggested algorithms are carried out to higher convergence in order to achieve improved transmission quality in wireless technology. The lack of PAR reduction measures in the wireless communication system results in both bit rate error and transmission data rate loss [14].

To prevent radiation and signal distortion, a digital analogue converter (DAC) is utilised. It must function at very large surface areas to prevent radiation and signal distortion. This falls into two categories: whole block approach and subblock strategy [15]. The communication network's transmission power and overall computing performance become more difficult due to the lack of PAPR methods [16].

III.METHODOLOGY

The transmission of data in a multiple input multiple output system requires a large number of subcarriers, including a high peak to average power ratio. The partial transmit sequence (PTS) technique can be used to get rid of this.

It combines the mapping procedure with error coding and decoding in order to prevent noise from occurring in the wireless network [17]. Several approaches, including selective mapping, clipping with filtering, and tone reserving, are used to reduce PAPR measures. As a result, the PAPR reduction algorithms use partial transmit sequences [18]. The particle swarm optimisation approaches serve as the foundation for this. In order to prevent signal clipping at the output, PAPR reduction methods are crucial in wireless communication systems. Additionally, it is coupled with signal alteration that is carried out prior to transmission [19].

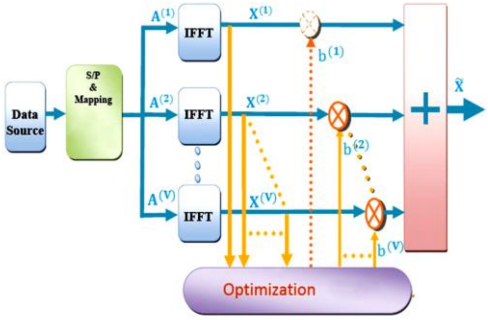


Fig 3: PTS block diagram

The PTS block diagram is shown in figure 3. The particle swarm optimisation techniques are used to accomplish this. A population-based approach that involves the accumulation of particles to move in stages at a certain area is known as particle swarm optimisation [20]. The method aids in the objective function's assessment at every level. [21].

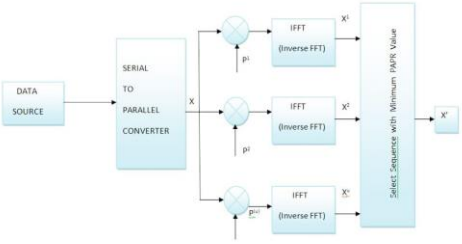


Fig 4: SLM block diagram

The SLM block diagram is shown in figure 4. This is implemented with less computational complexity in the system and is utilised in mild sub carriers. This yields significant outcomes and requires proper coding to safeguard the system's data [22]. As a result, less PAPR are needed for transmission. Therefore, particle swarm optimisation techniques are used to achieve the total decrease.

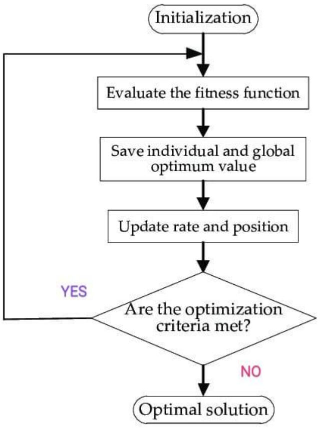


Fig 5: Flowchart

The flowchart showing the particle swarm optimisation methods is shown in figure 5. This covers data initialisation and fitness function analysis.

After which the global optimal value is obtained [23]. This goes through the process of adjusting the location and rate. At last, the ideal answer is found. The process of finding the right answers for challenging situations is one of the artificial intelligence strategies. In the examination of the system's intended output solution, this also entails the maximisation and minimisation processes.

IV. SOFTWARE IMPLEMENTATION AND RESULTS

Matlab Simulink is used to enhance and decrease PAPR techniques in multiple input multiple output systems.

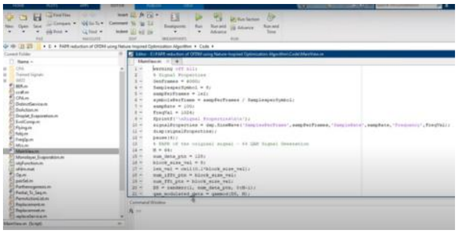
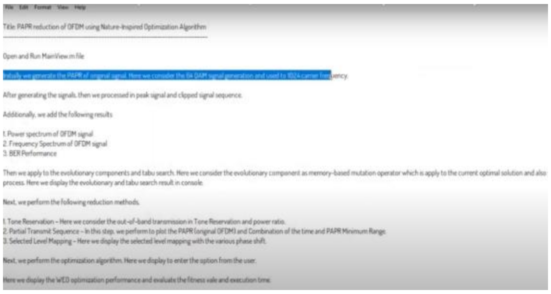


Fig 6: PAPR in matlab

The figure 6 represenst the PAPR reduction technique demonstration in matlab.



Title: PAPR reduction of OFDM using Nature-Inspired Optimization Algorithm

Open and Run MainView.m file

Initially we generate the PAPR of original signal. Here we consider the 64 QAM signal generation and used to 1024 carrier frequency.

After generating the signals, then we processed in peak signal and clipped signal sequence.

Additionally, we add the following results

1. Power spectrum of OFDM signal
2. Frequency Spectrum of OFDM signal
3. BER Performance

Then we apply to the evolutionary components and tabu search. Here we consider the evolutionary component as memory-based mutation operator which is apply to the current optimal solution and also process. Here we display the evolutionary and tabu search result in console.

Next, we perform the following reduction methods.

1. Tone Reservation – Here we consider the out-of-band transmission in Tone Reservation and power ratio.
2. Partial Transmit Sequence – In this step, we perform to plot the PAPR (original OFDM) and Combination of the time and PAPR Minimum Range.
3. Selected Level Mapping – Here we display the selected level mapping with the various phase shift.

Next, we perform the optimization algorithm. Here we display to enter the option from the user.

Here we display the WED optimization performance and evaluate the fitness vale and execution time.

Fig 7: Optimization algorithm

The figure 7 represents the algorithm for particle swarm optimization techniques. Optimization is a process of obtaining a desired solution through the obatined data with performing numerous iterations [24].

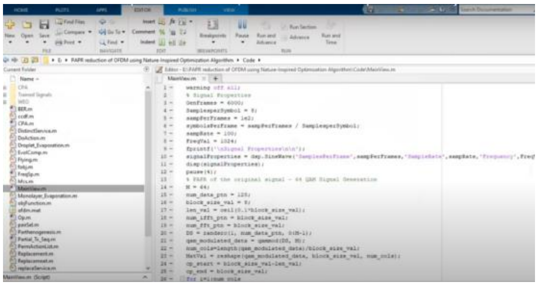


Fig 8: Data pre-processing

The figure 8 represents the data pre-processing and data acquisition techniques. The data preprocesing an important techniques in the reduction process. The data preprocesing helps in obtaining the data without any external disturbances [25].

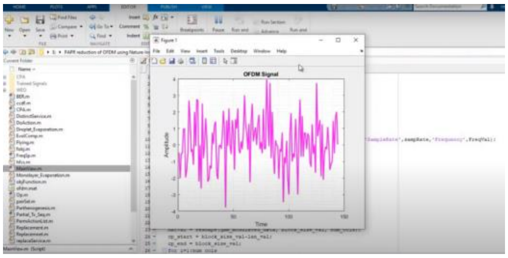


Fig 9: OFDM signal

The figure 9 demonstrates the OFDM signal generation. This is used to encoding the digital data in a multiple carrier frequency. This orthogonal frequency division multiplexing is a form of digital transmission.

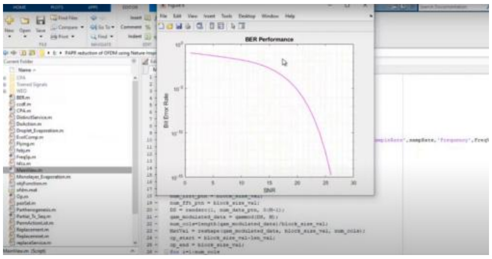


Fig 10 : BER performance

The figure 10 shows the BER performance in the network. The BER performance is defined as the number of bit errors occurred per unit time interval. It is represented in percentage.

V. CONCLUSION

In this paper, we have explored various strategies for minimizing Peak-to-Average Power Ratio (PAPR) in Massive MIMO wireless communication systems. As the demand for higher data rates and more efficient communication systems increases, Massive MIMO technology has emerged as a key enabler of next-generation wireless networks. However, the issue of high PAPR, especially in OFDM-based systems, poses significant challenges that affect system efficiency, energy consumption, and signal quality.

We reviewed several PAPR reduction techniques, including signal preprocessing methods such as clipping and filtering and Active Constellation Extension (ACE), as well as post-processing techniques like Selective Mapping (SLM) and Tone Reservation (TR). Each of these methods has its strengths and limitations, with trade-offs between PAPR reduction, spectral efficiency, and system complexity. While simple methods like clipping provide effective reductions in PAPR, they may introduce signal distortion, which can degrade the performance of the system. More complex approaches, such as SLM and TR, offer better performance but incur higher computational overhead and signaling costs.

Hybrid techniques that combine the benefits of multiple methods have shown great promise in achieving optimal PAPR reduction while maintaining high system performance. For example, combining clipping with SLM or integrating ACE with TR has led to significant improvements in PAPR reduction without overly compromising system throughput or spectral efficiency.

Furthermore, the emerging field of machine learning provides exciting opportunities for automating and optimizing PAPR reduction strategies. Techniques like deep learning and reinforcement learning have the potential to dynamically adjust PAPR reduction parameters based on real-time network conditions, offering a more adaptive and efficient solution.

In conclusion, while several techniques have been proposed to address the PAPR challenge in Massive MIMO systems, the selection of the most effective strategy depends on the specific requirements of the communication environment, such as data rates, energy efficiency, and system complexity. Future research should focus on developing more advanced hybrid approaches and leveraging machine learning to further optimize PAPR reduction and improve the overall performance of Massive MIMO-based communication systems. By addressing the PAPR problem efficiently, Massive MIMO systems can achieve better spectral efficiency, reduced power consumption, and ultimately, improved service quality in future wireless networks.

REFERENCES

[1] Hammed, Zainab Sh, Siddeeq Y. Ameen, and Subhi RM Zeebaree. "Massive MIMO-OFDM performance enhancement on 5G." *2021 International Conference on Software, Telecommunications and Computer Networks (SoftCOM)*. IEEE, 2021.

[2] Zayani, Rafik, Hmaied Shaiek, and Daniel Roviras. "PAPR-aware massive MIMO-OFDM downlink." *IEEE Access* 7 (2019): 25474-25484.

[3] Kalinov, Aleksei, et al. "Machine Learning-Assisted PAPR Reduction in Massive MIMO." *IEEE Wireless Communications Letters* 10.3 (2020): 537-541.

[4] Kalinov, Aleksei, et al. "Machine Learning-Assisted PAPR Reduction in Massive MIMO." *IEEE Wireless Communications Letters* 10.3 (2020): 537-541.

[5] Kalinov, Aleksei, et al. "Machine Learning-Assisted PAPR Reduction in Massive MIMO." *IEEE Wireless Communications Letters* 10.3 (2020): 537-541.

[6] Ajayi, Idowu, et al. "PAPR-Aware Artificial Noise for Secure Massive MIMO Downlink." *IEEE Access* 10 (2022): 68482-68490.

[7] Nema, Lucky, and Vikas Gupta. "PAPR Reduction of Massive 5G Systems using Modified PTS with DCT Scheme." *2020 IEEE International Conference for Innovation in Technology (INOCON)*. IEEE, 2020.

[8] Nema, Lucky, and Vikas Gupta. "PAPR Reduction of Massive 5G Systems using Modified PTS with DCT Scheme." *2020 IEEE International Conference for Innovation in Technology (INOCON)*. IEEE, 2020.

[9] hawqi, Farooq Sijal, et al. "A Review of PAPR Reduction Techniques for UFMC Waveform." *2020 4th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)*. IEEE, 2020.

[10] Albreem, Mahmoud A., Markku Juntti, and Shahriar Shahabuddin. "Massive MIMO detection techniques: A survey." *IEEE Communications Surveys & Tutorials* 21.4 (2019): 3109-3132.