Modification of Existing PAPR Reduction Techniques to Improve PAPR Performance of the System using CCDF

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Abstract

OFDM is a multicarrier modulation technology utilized in various wireless communication systems and standards for its high data rate, high spectral coherence, and tolerance to multi-path fading channels. However, one of the most significant barriers in implementing an OFDM system is decreasing the peak-to-average ratio (PAPR). High PAPR is generated by significant envelope variations in the OFDM signal, which mandates the use of an extremely linear power amplifier. Power amplifiers with a large linear range are massive, costly, and difficult to manufacture. As a result, a plethora of PAPR reduction techniques for OFDM signals has been proposed in the literature. The subcarriers of an OFDM system are narrowband and need precise frequency synchronization between the sending and receiving ends. The primary focus of this research is on PAPR reduction in OFDM systems employing partial transmit sequence (PTS) and selected mapping approaches (SLM).

I. Introduction

The optical communication framework is made up of three parts: the transmitter, the communication channel, and the receiver. The communication channel is an optical fiber, and the optical transmitter and receiver are meant to fulfill the requirements of this communication channel, which distinguishes the two fiber-optic communication frameworks from other frameworks [1]. A full deal > 100 km communication framework and a short pull 50 km communication framework are available. Regardless, because of its high data rates, fiber-optic communication innovation is being pushed by long-haul applications. OFDM [2] is a multi-carrier modulation method that was created more than three decades ago. Recent breakthroughs in digital signal processing and VLSI technology have paved the way for the widespread usage of OFDM technologies in consumer electronics.

OFDM systems are classified based on the type of pulse shaping employed. The first group employs pulses with a length of one symbol interval. This causes frequency overlap across all channels in the system, but no interference occurs since the modulated pulses are orthogonal to each other. The comparatively broad spectral lobes of such brief pulses constitute a disadvantage, especially when the number of channels is minimal. For the rectangular pulses, the sidelobe level falls off as 1/f. A bandwidth-efficient system necessitates the use of several hundred channels. A huge number of channels results in unacceptable latency in various applications.

The OFDM transmission strategy has the accompanying key points of interest:

- Takes out Intra Frequency Interference (IFI) and Inter Symbol Interference (ISI) using a cyclic prefix.
- Channel equalization ends up fewer complexities by utilizing versatile equalization methods with single carrier frameworks.
- It is conceivable to utilize maximum likelihood decoding with sensible intricacy, as seen in OFDM that is computationally productive by utilizing FFT systems to execute the modulation and demodulation capacities.

- It can deal with severe channel conditions without complex equalization filters.

According to the findings, OFDM cannot be considered for 5G due to the major difficulties in conveying highly correlated signals with extremely high PAPR [5]. PAPR reduction is the sole answer and is critical in developing new waveforms for 5G communications. As a consequence, the implementation would be geared toward PAPR reduction by combining strategies to reach the desired objectives. The paper is divided into four parts of equal length. Section 1 provides an overview of the role of OFDM. Section 2 goes into detail about the literature survey. The third section focuses on the methodology used. Section 4 explains the results obtained. Finally, section 5 summarizes the entire document.

Ii. Literature Survey

Bakkas et al. [6] proposed and investigated Palm Clipping, a novel clipping method based on hyperbolic cosine. The authors used computer simulations to test and analyze its performance concerning PAPR and bit error rate by altering the Clipping Ratio and modulation techniques. The obtained findings reveal that depending on the kind of modulation, a gain of 7 to 9 dB in terms of PAPR reduction are feasible. Furthermore, in terms of PAPR and BER, the approach provides a potent alternative that may be employed as a PAPR reduction tool for OFDM-based systems.

Sarowa et al. [7] highlighted some of the main strategies for mitigating the unfavorable consequences of the PAPR problem to make the OFDM system more operationally efficient. For the 'Haar' and 'Db8' wavelets, simulation findings reveal that wavelet-based OFDM beats FFT-based OFDM systems by more than 2 dB. Furthermore, considerable reductions in PAPR are achieved using the suggested hybrid strategies i.e., wavelet OFDM + clipping technique. The suggested hybrid system is further examined using various modulation approaches, and it is discovered that using a Haar wavelet hybrid with a companding technique over 16QAM yields significantly improved PAPR results. The wavelet OFDM may be used with other PAPR reduction approaches to improve performance even more.

Lakshmmi and Kanmani [8] produced OFDM symbols using Offset QPSK as the modulation mechanism, analyzed the peak power and peak-to-average power ratio, then used the proposed strategy to minimize it. The signal distortion category included the lossy coding approach. MATLAB was used to run the simulation. The simulation results of the suggested technique have been addressed, as well as the amount of decrease obtained in the peak to average power ratio and the amount of the bit error rate.

Al-Jawhar et al. [9] used The PTS approach to minimize the F-OFDM system's high PAPR value. The performance of this system was then compared to that of the OFDM system. Furthermore, for both PTS and non-PTS systems, additional significant aspects were considered and analyzed for instance frequency localization, bit error rate, and computational. The simulation findings demonstrated that, when compared to OFDM, F-OFDM based on PTS achieved greater levels of PAPR, BER, and OOBE performance. Using the PTS technique moreover, does not influence F-BER OFDM's performance.

A partial transmits sequence strategy based on adaptive particle swarm optimization has been proposed by Hosseinzadeh Aghdam et al. [10]. Besides, to reduce computational complexity, the suggested technique looked for the best combination of phase rotation parameters in a short amount of time. The suggested strategy greatly lowered the PAPR and computational complexity, according to the experimental findings.

Mesri et al. [11] illustrated the partial transmit sequence technique to lower the PAPR in an orthogonal frequency division multiplexing system. Regardless of its benefits, the PTS

The approach is regarded computationally costly owing to the use of several Inverse fast Fourier transforms (IFFT) and the necessity for extensive analysis to determine the ideal phase factor. The key aim was thus to remove the IFFT blocks. A surprising method was employed, which was mostly based on analyzing the available data in random-access memory. Furthermore, the least PAPR value is computed and its associated address is accurately established; this address is the side information to be given to the OFDM receiver to retrieve the users' actual data. Furthermore, the efficiency of the new-PTS method's so-called complexity reduction is highlighted to reduce the number of searches required to get the greatest PAPR performance, which considerably reduced computational complexity overhead. As a result, the numerical analysis and comparison investigation revealed that the suggested PTS system provided overall excellent performance in terms of both bit error rate and PAPR reduction.

Al-Jawhar et al. [12] introduced a novel low complexity method (Gray-PF-PTS) based on a special mapping rule that combined the Gray code with the left feedback shift register operation. According to the numerical results, the Gray-PF-PTS method greatly reduced computational complexity while preserving PAPR reduction performance when compared to the standard PTS approach. The PAPR, bit error rate, and power spectrum density (PSD) characteristics of OFDM and F-OFDM systems based on the Gray-PF-PTS method, have also been used to explore OFDM and F-OFDM systems.

In his study, Akurati et al. [13] offered a new hybrid SLM-companding strategy to improve PAPR reduction. Nonlinear companding approaches such as Logarithmic Rooting Companding (LogR) and Tangent Rooting Companding (TanhR) reduced the PAPR from 9.8 dB to 3.6 dB and 6.2 dB, respectively. It also improved system efficiency and minimized the need for complicated hardware. The suggested method's findings are stated; consequently, it may be applied in impending 5G wireless communications systems.

Jawhar et al. [14] presented an analytical assessment of the standard PTS approach and its variations in three areas: frequency-domain, modulation stage, and time-domain. Over 26 modified PTS techniques were assessed for their ability to increase the performance of PAPR reduction and computational complexity level. Although the DSI-PTS methodology has lower computational complexity than the other frequency domain techniques, the CO-PTS method decreases system computational complexity more than the other modulation-stage methods, according to the data.

Furthermore, in time-domain approaches, the GPW-PTS technique has a low computational cost while maintaining a high PAPR rating. The rows exchange-interleaving PTS technique is the optimum solution for minimizing the PAPR, as per mathematical findings value in the frequency domain while retaining a low level of complexity. The cooperative PTS technique outperformed the modulation stage approaches in PAPR reduction and computing complexity, whereas the cyclic shift sequence PTS method exceeded the time domain methods in PAPR reduction and computing complexity.

Timoshenko et al. [15] shared their experience with creating signals that would be used in the 5G standard on USRP-2943R. The possible alternatives for lowering the signal's peak factor while raising out-of-band emissions were disclosed. When novel signal generating strategies were used, there was a chance to win. Thus, a loss of just 8 dB in out-of-band emissions as compared to traditional UFMC and FOFDM was still improved by 20 decibels than classic OFDM.

Kumari [16] introduced a unique wavelet-based OFDM model intending to improve orthogonality and spectral efficiency via the use of different modulation methods. The use of wavelet-based OFDM was remarkable in that it requires no spectral efficiency, and the absence of the cyclic prefix improved bandwidth efficiency as bandwidth expands simultaneously. Finally, the wavelet-based OFDM communication model outperformed the standard FDM communication model in terms of BER. The simulation results demonstrated the usage of wavelet-based OFDM rather than DWT-based OFDM in LTE, as well as a comparison of wavelet-based OFDM with DFT-based OFDM.

The self-adaptive multi-population differential evolution algorithm was used by Hocine et al. [17]. He suggested a suboptimal PTS technique (SAMDE). By evolving each sub-population of individuals through several generations, the self-adaptation of control parameters and structured population managed high-quality solutions with little processing cost.

Sengar and Bhattacharya [18] discussed various critical elements and offered mathematical scrutiny, including the distribution of the PAPR employed in OFDM systems. SLM and PTS, two signal scrambling techniques, were being investigated to reduce PAPR; both of these have the potential to result in significant reductions in PAPR. In terms of minimizing PAPR, the PTS approach outperformed the SLM method.

Iii. Methodology Used

The PAPR is the connection between a sample's peak power and its average power in a certain OFDM transmit symbol. PAPR is defined as the ratio of a peal signal power to its average power. When many subcarriers in a multicarrier system are out of phase with each other, PAPR occurs. They differ from one another at different phase values at each moment. When all points reach their maximum value at the same moment, the output envelope rapidly increases, resulting in a 'peak' in the output envelope.

Iv. Results And Discussions

This section displays and discusses the results.

Table 1
Parameters used in Tone Injection and Companding Algorithm

Parameters	Values
Number of FFT points	1024
Number of Guard	212
Overlapping symbols(k)	4
Number of symbols	5
Bits per Subcarrier	2
Modulation Method	4QAM,16 QAM
Modulation scheme	OQAM

- *Clipping*: The clipping approach is the most basic way to lower the PAPR of an OFDM system. Clipping can contribute in-band distortion or out-of-band radiation into an OFDM system, causing peak regrowth, especially in nonlinear systems.

Figures 2 and 3 show the results of normalized frequency and clipping for PAPR. As a result of the filtering, a spectrum regrowth can be seen in Fig. 3 for the PAPR of both systems. PAPR regrowth is greatly influenced by the number of unused subcarriers. When additional unmodulated subcarriers are used, more nonlinear distortion is eliminated from the signal, causing the peaks to reappear. The impacts of clipping can be seen clearly in Fig. 3 on the spectral characteristics, where nonlinear products arise in the baseband, generating a wide side lobe. This leakage is eliminated by filtering the unused subcarriers.

- *Selected mapping (SLM)*: For orthogonal frequency division multiplexing systems, SLM can reduce the peak-to-average power ratio (PAPR). Phase sequences are paired with data in SLM to provide alternative signals, decreasing the PAPR. Based on mathematical correlation analysis of the alternative signals, this work presents a unique approach for analyzing the impacts of different phase sequence sets in SLM-OFDM.

Figure 4 depicts the PAPR graph for SLM. The PAPR's CCDF may be used to assess the effectiveness of any PAPR reduction approaches. This CCDF provides us with the information we need to establish an appropriate power amplifier operation point, i.e., back off, with the least amount of distortion.

- *Filter Bank Multicarrier (FBMC)*: FBMC is a multicarrier modulation technology that is commonly employed in high-data-rate cellular and wireless networks.
- *Partial Transmit Sequence (PTS)*: PTS might be employed in OFDM systems to minimize the high peak-to-average power ratio. PTS creates a large number of candidate signals and selects the best signal with the moderate PAPR for transmission.

Figure 6 depicts the outcome of the CCDF of PAPR of OFDM utilizing the PTS approach as the number of sub-block V fluctuates. It is noted that the performance of PAPR upgrades as the number of sub-blocks grows.

Figure 7 is a graph comparing PAPR reduction approaches. The accompanying graph clearly illustrates that the suggested approach outperforms the previous PAPR reduction strategies in terms of values.

Conclusion And Future Scope

Some PAPR reduction strategies for multicarrier transmission are explored in this study. Many approaches for lowering the PAPR have been presented, all of which have the potential to significantly lower the PAPR. By retaining a polyphase-based FBMC implementation, the suggested technique enables a low-complexity PAPR reduction implementation in FBMC systems, and the favorable findings given provide more evidence for considering FBMC as an alternative to OFDM.

Declarations

Compliance with Ethical Standards:

This article does not contain any study involving animals and human participants performed by any of the authors.

Competing Interests:

The authors have no competing interests to declare that are relevant to the content of this article. The authors have no financial interest in any material discussed in this manuscript.

Research Data Policy and Data Availability Statements:

The authors confirm that the data used to support the findings of this study are available with in the manuscript and the Raw data that support the findings of this study are available from the corresponding author upon request.

Conflict of Interest Statement:

The authors have no financial or non-financial interest in the subject matter or materials discussed in this manuscript. This manuscript is a part of research work performed. The authors declare that they have no conflicts of interest.

Author Contribution:

Study Conception and Design: Harsh Dhiman, Dr Charu Madhu, Vijay Kumar and Daljeet Kaur

Material preparation, data collection and analysis: Harsh Dhiman and Dr Charu Madhu

First draft of manuscript: Harsh Dhiman

Approval to final manuscript: Harsh Dhiman, Dr Charu Madhu, Vijay Kumar and Daljeet Kaur

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Figures

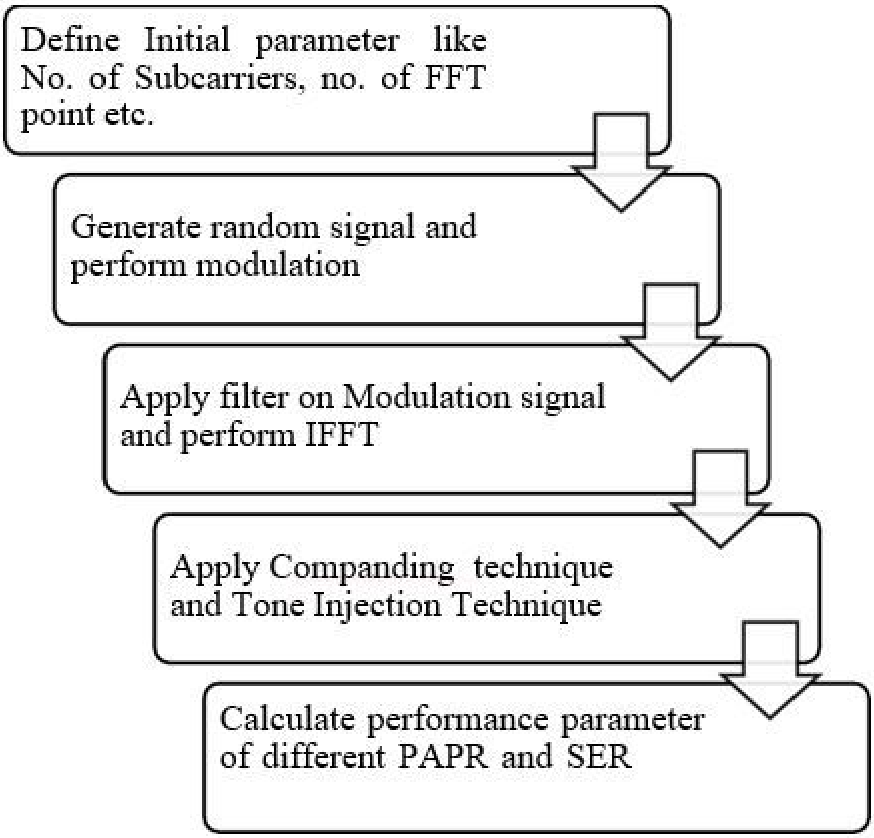

Figure 1

Flow Chart of PAPR Reduction Performances in Tone injection and Companding Methods

Figure 2

Normalized Frequency

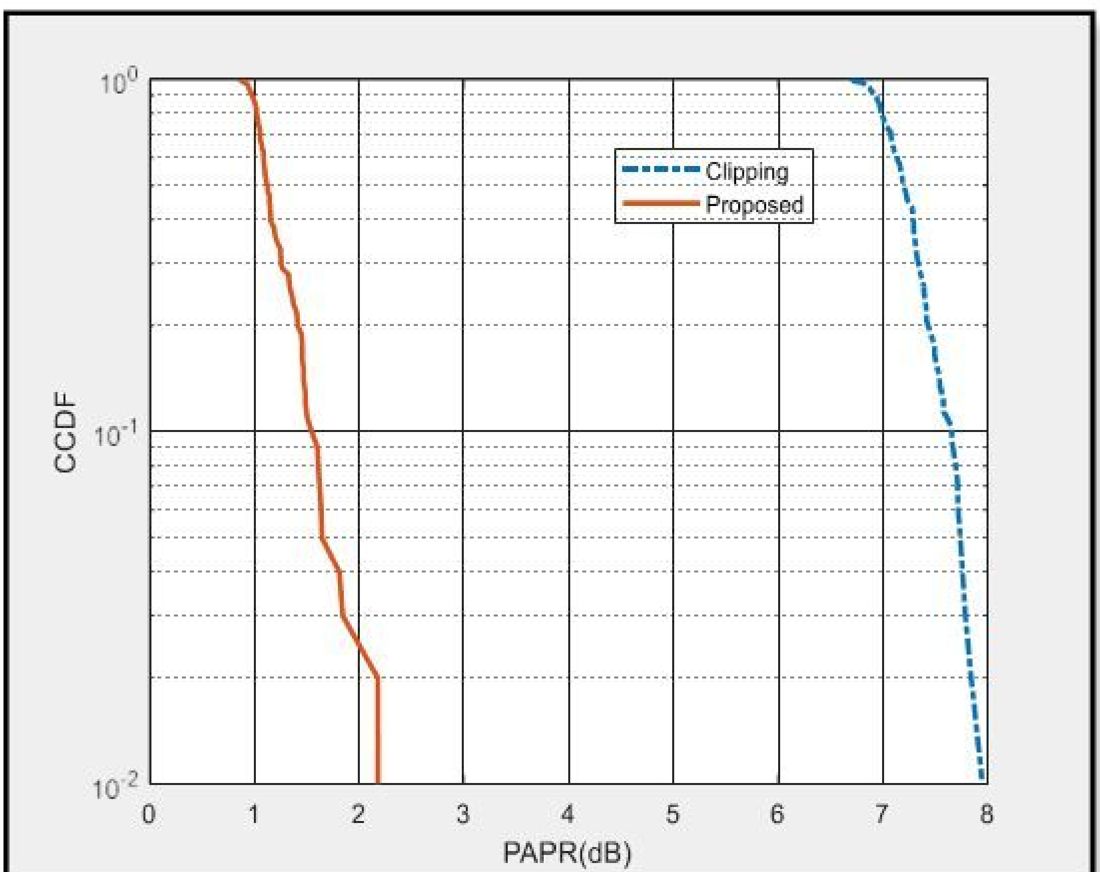

Figure 3

PAPR for Clipping

Figure 4

PAPR for SLM

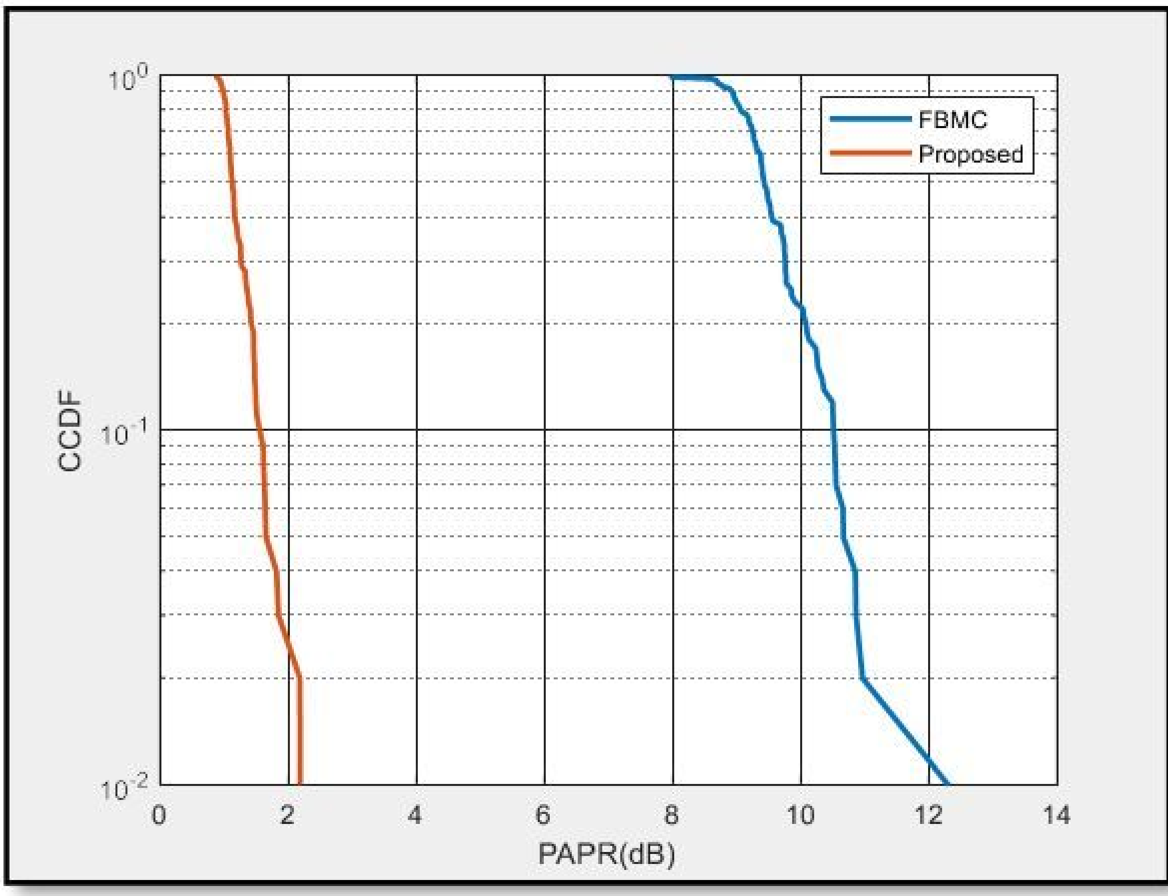

Figure 5

PAPR for FBMC

Figure 6

PAPR for PTS

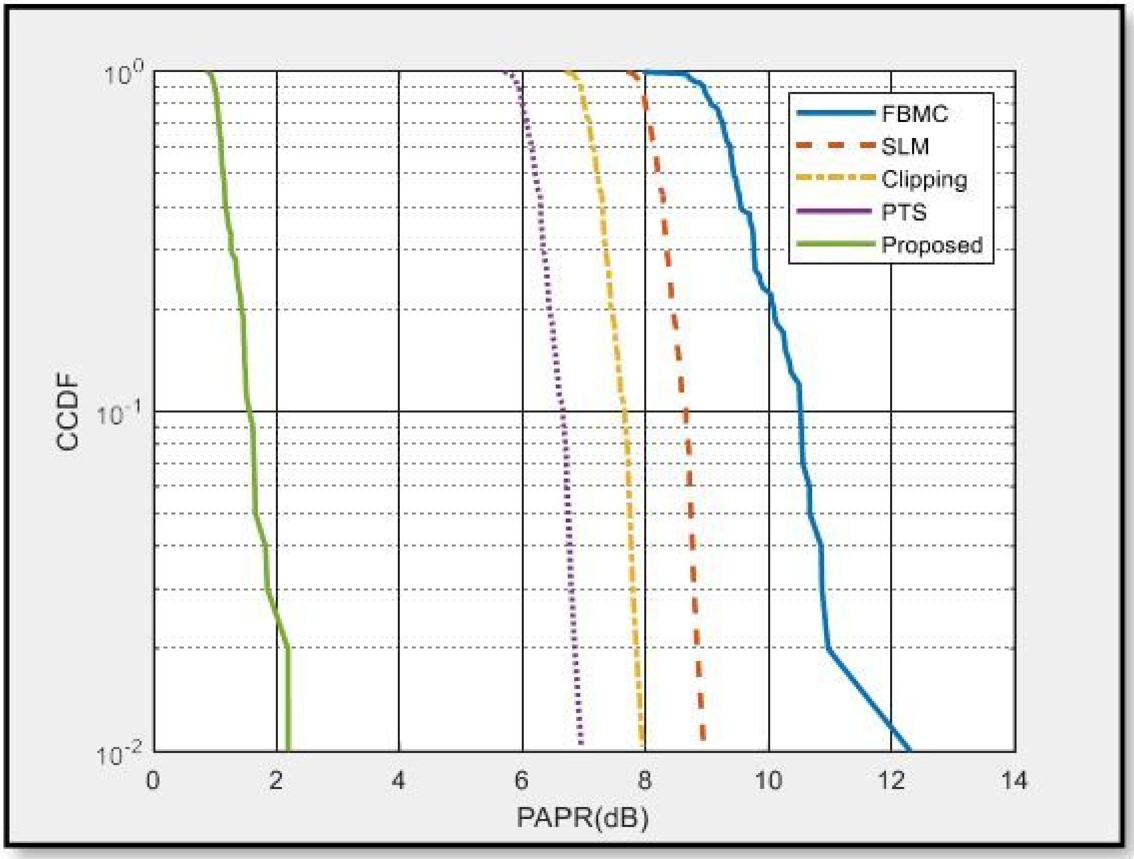

Figure 7

Comparison Graph of PAPR Reduction Techniques