



# PAPR Detection Using TR and Clipping & Filtering (CF)-Reduction Technique for 5G Communication System (5G-CS): Comparative Analysis



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## Abstract

The multi-carrier system is the primary system under a sophisticated 5G communication infrastructure, but Smart Grids (SGs) expedite secure, large-scale, and efficient two-way communication between the power supply and management. One of the most significant limitations of the 5G multi-carrier (MC) system is the high peak-to-average power ratio (PAPR), which prevents the effective design of the 5G analog front end. Tone reservation (TR) is a method for PAPR reduction that maximizes efficiency while minimizing signal distortion by expanding frequency domain freedom. In this paper the performance analysis has been done between TR and Clipping-Filtering Technique for 5G Communication System. TR predistribution and freedom in the frequency domain are subjected to a probabilistic analysis in relation to the amplitude of its constituent samples.

**Keywords:** PAPR; OFDM; 5G; Clipping

## Introduction

The most widely used method for transmitting data over a channel with distinct characteristics from those of other data transmission methods is OFDM. In this case, there is no interference between the signals because the sub-carriers are orthogonal to one another. The OFDM signal is widely used due to its strength against frequency selective fading, simplicity of receiver implementation, and high bandwidth efficiency [1-3]. Additionally, it can withstand critical conditions without requiring intricate coordination filters. Due to its large number of mutually orthogonal subcarriers, it has a high spectral efficiency. The receiver implementation is made simpler by the single-tap equalization. Long symbol duration and ample guard intervals are used to guarantee this. The baseband signal is distorted when PAPR rises above a certain threshold in OFDM, which is cause for concern. A High-Power Amplifier nonlinearly amplifies the input signal when the base-band signal with a high PAPR value passes through it. Because of this nonlinear amplification, further transmission cannot be properly recovered [4-6].

## Overview of 5G

5G is the new age network that is known for its exhibition. After 1G, 2G, 3G, and 4G networks, it will become the new global standard for wireless communication. It makes possible a brand-new type of technology that is intended to virtually connect [7-9] the entire world and all machines, objects, and devices. The goal of this technology is to offer a more consistent user experience to a larger number of users, as well as increased availability, ultra-low latency, high reliability, massive network capacity, and multi-Gbps peak data speeds. 5G is a unified form of communication that has a higher capability of the air interface [10,11]. It connects new industries with greater efficiency and enhances their products. It has been improved to deliver new services, empower novel deployment models, and enable user experiences of the next generation. The three distinct types of networks that make up the 5G networking architecture are intended to collaborate in the future. The three bands are called Low Band 5G, Mid Band 5G, and High Band 5G. The 5G network has very low latency and

is about 10 times faster than the 4G LTE network. This makes it possible to send messages quickly without having to be close to a tower [12]. 5G networks use a higher wave frequency and have a wider spectrum bandwidth, which means they can send more data. With a wide spectrum, more devices can join and operate at a faster rate. Additionally, 5G at its foundational level enables faster downloads, facilitating efficient business operations and supporting applications in education, smart cities, and vehicle technologies [13-15].

**PAPR**

PAPR is defined as the Peak to average power ratio (PAPR) which is calculated by taking the mean between the peak power amplitude of the waveform with respect to its RMS value of it, which is expressed in decibels (dB). The mathematical calculation for the calculation of PAPR can be written as

$$PAPR[x(t)] = \frac{P_{peak}}{P_{average}} = 10 \left( \frac{[|X(n)|^2]}{E[|X(n)|^2]} \right) \quad (1)$$

Where  $P_{Peak}$  = mod of peak amplitude,  $P_{Average}$  = Average pinnacle power  $E[.]$  = rms value,  $X(n)$  Transmitter side OFDM Signals. IFFT procedure is applied on the regulated input information images  $X_k$  and  $X_n$  which produces the transmitted side OFDM signals, and it is addressed as

$$X_n = \frac{1}{\sqrt{N}} \sum_{(k=0)}^{(N-1)} X_k \cdot W_N^{nK} \quad (2)$$

There are a number of methods for lowering the PAPR in OFDM systems. Partial Transmit Sequence, Tone Reservation, Selective

Mapping, Clipping and Filtering, Linear Block Coding, Sub-Block Coding, and Interleaving Strategy are the techniques [16-18]. The BER performance is taken care of in this paper because TR and CF do not affect user data by reserving subcarriers for peak-cancellation signals and TR does not affect user data. Additionally, the receiver does not require side information for user data recovery. C&F is preferred due to the clipping method's ability to reduce peak levels at a minimal cost of system degradation and the rare occurrence of extremely high peaks [19,20].

**Techniques Used for Analysis**

**Tone Reservation (TR)**

In OFDM subcarriers, some sum-held subcarriers are utilized to convey PAPR decrease coefficients as opposed to conveying client information and are likewise named pinnacle decrease coefficients. Because some of the subcarriers are reserved for carrying the peak-reduction coefficients, there is a loss in data rate. It is represented as :

$$R_f = \frac{M}{P} \quad (3)$$

where the number of carriers and reserved subcarriers in an OFDM symbol are referred to as M and P, respectively (Figure 1). The following equation is used to explain the low PAPR transmit signal generation in the tone reservation concept.

$$s(n) = x(n) - c(n) = x(n) - \frac{1}{\sqrt{N}} \sum_{(k=0)}^{(N-1)} C(k) e^{\frac{j2\pi kn}{N}} \quad (4)$$

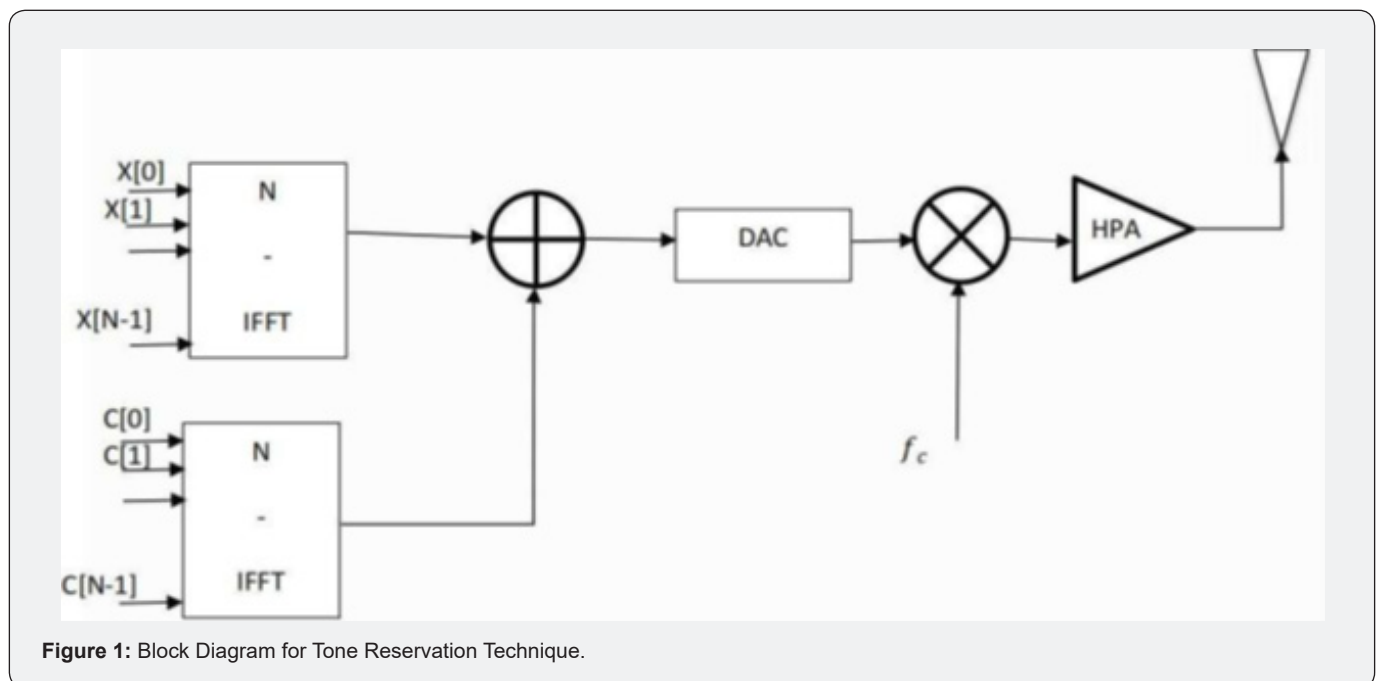


Figure 1: Block Diagram for Tone Reservation Technique.

**Clipping and Filtering**

In OFDM systems, it is one of the most effective methods for lowering PAPR. where a predetermined value for the input signal

is used to clip the peak signal. It always occurs after modulation, and the receiver signal is impacted by the clip signal estimation. In OFDM systems, clipping has been observed to cause peak

regrowth in nonlinear systems and in-band contortion or out-of-band broadcast. As a result, it has a negative impact on the signal-to-noise ratio (SNR) and bit error rate (BER). Out-of-band signals are dealt with through filtering. When the signal is clipped

at certain levels, the peak power decreases, and the out-of-band radiation can be reduced by filtering the clipped signal at the expense of peak regrowth. The above effects are explained in the (Figure 2).

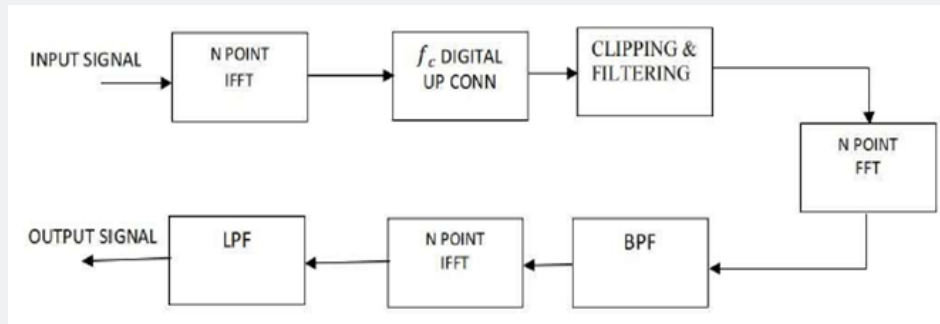


Figure 2: Block Diagram for Clipping and Filtering Technique.

The average signal is a carrier frequency-modulated side-lobe signal. The side lobe-modulated signal's clipped form is referred to as clipped by us. The following equation depicts this signal's expression: The clipping ratio can be represented as follows:

$$\text{clipped} = -\text{avg},$$

$$\text{clipped} = \text{avg},$$

$$\text{clipped} = -\text{avg}, \text{ and}$$

$$\text{clipped} > \text{avg}.$$

The clipping level is denoted by CLP.

Clipping ratio is equal to  $\text{CLP}/\sigma$ , where  $\sigma$  is the OFDM signal's RMS value and is well-known to be  $N$  for the baseband and  $N/2$  for the pass-band.

### Simulated Results

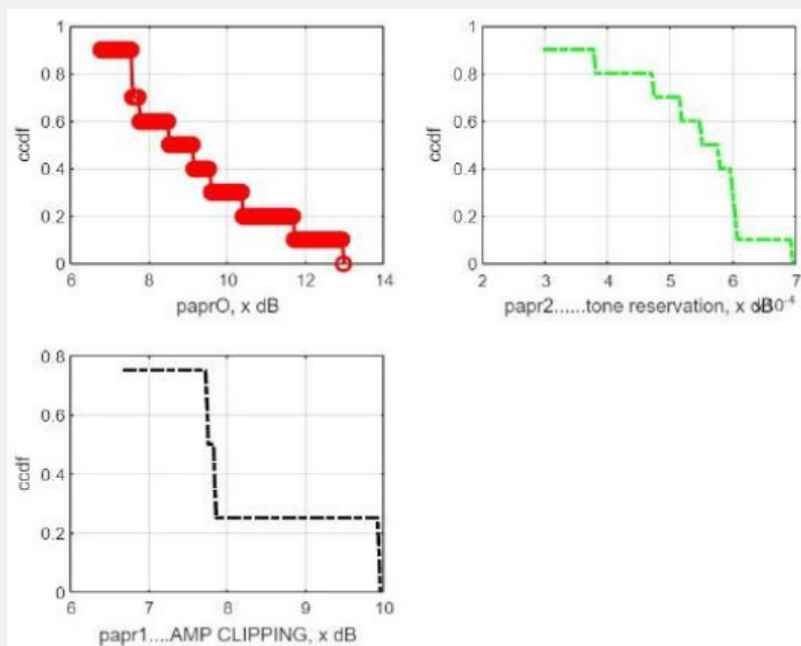


Figure 3(a,b,c): The PAPR reduction GAIN vs. CCDF for Clipping, TR, and the original signal.

The IFFT modulation index and the IFFT binary length are contrasted in an analysis of the magnitude of carrier frequency in terms of carriers. Taking the IFFT binary length of 1024 into consideration, the magnitude of the carrier frequency varies from 0 to 1, with a tendency for some points to have a value of zero and others to have a value of one. When the data enters the in-phase state, the value changes to 1. Figure 3 depicts the graphical analysis of the original OFDM signal, the TR signal, and the CF signal in terms of gain in relation to the CCDF of the respective received signal, which will be incorporated into 5G. comparing the gain and bit error rate of all the signals in relation to CCDF. The

PAPR reduction GAIN vs. CCDF for Clipping, TR, and the original signal are compared in (Figures 3a-3c).

**Parametric Analysis**

The gain compared to CCDF for original, C&F, and TR is shown in the table below. Because TR has a much smaller ratio between the maximum PAPR and the average PAPR, it can be inferred that TR is more efficient than C&F and the original received signal. The parametric examination of the dissected procedure is displayed in (Table 1).

**Table 1:** Comparison of gain with respect to CCDF.

Sl. No.	CCDF $P_r$ (PAPR>PAPRO)	Original Signal Gain(dB)	TR Gain (dB)	Clipping Gain(dB)
1	0.9	7.52197	3.766	7.2156
2	0.8	7.54891	4.6944	7.71778
3	0.7	7.58469	5.0578	7.7264
4	0.6	7.96103	5.386	7.74004
5	0.5	8.58827	5.6631	7.75107
6	0.4	9.15279	5.9457	7.91045
7	0.3	9.9682	5.9861	8.01376
8	0.2	10.7836	6.0644	8.314
9	0.1	12.1008	6.9144	8.9468

**Conclusion**

The primary method TR and clipping, which saturated the overshooting signal amplitude to a predetermined value to reduce the PAPR. However, these techniques cause significant distortion within the band and noise outside the band. In the event that the signal exceeds the predetermined clipping level, the clipper directly limits the signal envelope. However, the discussed scheme smoothed and reduced the overall peak power regrowth, thereby further reducing the PAPR effect and achieving the highest reduction value.

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**References**

1. Shaikh MHN, Bohara VA, Aggarwal P, Srivastava A (2020) Energy Efficiency Evaluation for Downlink Full-Duplex Nonlinear MU-MIMO-OFDM System with Self-Energy Recycling. IEEE Systems Journal14: 3313-3324.
2. Liu R, Hai X, Du S, Zeng L, Bai J et al. (2021) Application of 5G network slicing technology in smart grid. Proceedings of the 2021 IEEE 2<sup>nd</sup> International Conference on Big Data, Artificial Intelligence and

- Internet of Things Engineering (ICBAIE), Nanchang, China, pp. 740-743.
3. Ye G (2021) Research on reducing energy consumption cost of 5G Base Station based on photovoltaic energy storage system. Proceedings of the 2021 IEEE International Conference on Computer Science, Electronic Information Engineering and Intelligent Control Technology (CEI), Fuzhou, China, pp. 480-484.
4. Pradhan D, Priyanka KC (2020) RF-Energy harvesting (RF-EH) for sustainable ultra dense green network (SUDGN) in 5G green communication. Saudi Journal of Engineering and Technology 5(6): 258-64.
5. Mahmud MH, Hossain MM, Khan AA, Ahmed S, Mahmud MA et al. (2020) Performance Analysis of OFDM, W-OFDM and F-OFDM Under Rayleigh Fading Channel for 5G Wireless Communication. Proceedings of the 2020 3<sup>rd</sup> International Conference on Intelligent Sustainable Systems (ICISS), Thoothukudi, India, pp. 1172-1177.
6. Ren J, Wang T, Wang C, Li D (2020) Low-PAPR Superimposed Layered ACO-OFDM for VLC Systems. Proceedings of the 2020 12th International Conference on Communication Software and Networks (ICCSN), Chongqing, China, pp. 178-181.
7. Fidele M, Damien H, Eric N (2020) Effect of Window Size on PAPR Reduction in 4G LTE Network Using Peak Windowing Algorithm in Presence of Non-linear HPA. Proceedings of the 2020 IEEE 5th International Conference on Signal and Image Processing (ICSIP), Nanjing, China, pp. 1128-1133.
8. Pradhan D (2020) A Comprehensive Study of Renewable Energy Management for 5G Green Communications: Energy Saving Techniques and Its Optimization, Journal of Seybold Report 25(10): 270-284

9. Munni TN, Hossam EH (2021) A Hybrid Method Based on SLM and Exponential Companding Technique to Reduce the Peak to Average Power Ratio (PAPR) in an OFDM System. Proceedings of the 2021 International Conference on Automation, Control and Mechatronics for Industry 4.0 (ACMI), Rajshahi, Bangladesh, p. 1-5.
10. Liu X, Zhang X, Zhang L, Xiao P, Wei J et al. (2020) PAPR Reduction Using Iterative Clipping/Filtering and ADMM Approaches for OFDM-Based Mixed-Numerology Systems. IEEE Transactions on Wireless Communications 19: 2586-2600.
11. Pradhan D, Dash A (2020) An Overview of Beam Forming Techniques Toward the High Data Rate Accessible for 5G Networks, International Journal of Electrical, Electronics and Data Communication 8(12): 1-5.
12. Zhang SY, Shahrava BA (2021) SLM Scheme for PAPR Reduction in Polar Coded OFDM-IM Systems without Using Side Information. IEEE Transactions on Broadcasting 67(2): 463-472.
13. Dash A, Devasis Pradhan, Hla Myo Tun, Zaw Min Naing (2022) M-MTC for Optimized Communication in 5G. Journal of Network Security Computer Networks 8(3): 1-8.
14. Devasis P, Priyanka KC (2019) Effectiveness of Spectrum Sensing in Cognitive Radio toward 5G Technology. Saudi Journal of Engineering and Technology 4(12): 473-785.
15. Xing Z, Liu K, Huang K, Tang B, Liu Y (2020) Novel PAPR reduction scheme based on continuous nonlinear piecewise companding transform for OFDM systems. China Communications. 17: 177-192.
16. Wang H, Wang X, Xu L, Du W (2016) Hybrid PAPR Reduction Scheme for FBMC/OQAM Systems Based on Multi Data Block PTS and TR Methods. IEEE Access 4: 4761-4768.
17. Xiao Y, Zhang L, Imran M (2019) Active Constellation Extension for Peak Power Reduction Based on Positive and Negative Iterations in OFDM Systems. Proceedings of the 2019 UK/ China Emerging Technologies (UCET), Glasgow, UK, p. 1-5.
18. Wu C, Lu Y, Liu G (2012) An Improved Clipping Scheme Based on TR for PAPR Reduction in OFDM Systems. Proceedings of the 2012 IEEE 12th International Conference on Computer and Information Technology, Chengdu, China, pp. 598-601.
19. Li Z, Jin N, Wang X, Wei J (2021) Extreme Learning Machine-Based Tone Reservation Scheme for OFDM Systems. IEEE Wireless Communications Letters 10(1): 30-33.
20. Li L, Tellambura C, Tang X (2019) Improved Tone Reservation Method Based on Deep Learning for PAPR Reduction in OFDM System. In Proceedings of the 2019 11<sup>th</sup> International Conference on Wireless Communications and Signal Processing (WCSP), Xi'an, China, p. 1-6.



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