

# A Comparison on Different Techniques for PAPR and BER Reduction in OFDM Communication Systems

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**Abstract** - Orthogonal Frequency Division Multiplexing (OFDM) is an environment friendly multicarrier modulation scheme in wi-fi communication. It is used in functions like 4G (fourth generation) cellular Communications, wi-fi networks, digital television, electricity line networks and audio Broadcasting. It gives each benefits and hazards for multicarrier transmission. The most important benefits are the removal of Inter Carrier Interference (ICI) and Inter Symbol Interference (ISI) in the signal. But OFDM's one of the most important harmful components are excessive Peak-to-Average Power Ratio (PAPR) price of the transmitted sign which relatively impacts the strength amplifiers complexity. Several strategies to overcome and decrease PAPR such as Tone Reservation (TR), selective mapping (SLM), clipping and filtering, partial transmit sequence (PTS), et are proposed and implemented. Detailed description and comparisons of all methods are mentioned in this paper.

**Key Words:** PAPR; BER; PTS; OFDM; SLM;

## 1.INTRODUCTION

With extended demand for excessive first-rate verbal exchange offerings in 4G and 5G, it's been a top notch undertaking to enhance the Quality of Service (QoS) and reduces the extend time. To overcome and fulfil this requirement, a method known as Orthogonal Frequency Division Multiplexing (OFDM) is encountered. It over various outfalls like preserving excessive information rate, excessive bandwidth efficiency, low computational complexity and casting off multipath fading [1].

OFDM is a unique case of the frequency division multiplexing (FDM), which is used with the aid of the American National Defense Department for navy communications. Compared with the traditional FDM, OFDM lets in the spectrums from exclusive subcarriers that are orthogonal to be overlapped with every other, which improves the spectral effectivity of the system. The idea of OFDM methods used to be first proposed by using RW Chang in 1965. In 1967, Saltcberg analysed the overall performance of OFDM systems. In 1970, OFDM science was once patented at the USPD and then after it was once used in navy verbal exchange systems. In 1971, SB Weinstern and PM Ebert employed the Discrete Fourier Transform (DFT) into the MCM. in practice, the Fast Fourier

Transform (FFT) implementation of the DFT has made OFDM modulation and demodulation possible and very successful. In the 1980s, ISI was once diminished when Peled and Ruic delivered cyclic prefix (CP) into the simple OFDM indicators to have the orthogonality renovation amongst subcarriers [2].

The demand for information transmission in cellular conversation has improved consistently. OFDM device has won pastime in the fourth-generation cell conversation due to its potential to grant excessive bandwidth effectivity and excessive information price in each digital audio and video broadcasting wi-fi communication.

The fundamental precept of OFDM is to cut up a high-data charge circulate into a variety of decrease statistics price streams in parallel the use of a number of orthogonal subcarriers. When the subcarriers have excellent spacing and fulfill the orthogonality, their spectra will overlap [1,2,3]. The use of orthogonal subcarriers allowed the subcarrier's spectra to overlap, as a consequence growing the spectral efficiency. As lengthy as orthogonality is maintained, it is feasible to recover the man or woman subcarriers' sign notwithstanding their overlapping spectr If the product of two deterministic alerts is equal to zero, these indicators are stated to be orthogonal to every different [1]. OFDM affords many blessings over service modulation; however, the principal situation with the scheme is the excessive peak-to-average strength ratio (PAPR) that distorts the sign if the transmitter includes nonlinear factors such as electricity amplifier, influences the sign and consequences in the attenuation of the acquired sign [4].

The excessive PAPR of OFDM potential that if the sign is now not to be distorted, many of the factors in the transmitter and receiver need to have a broad dynamic range. The output amplifier of the transmitter should be very linear over a broad vary of sign levels. In wi-fi system, the price and energy consumption of these amplifiers are frequently the vital layout constraints [5, 6]. Moreover, the presence of a giant wide variety of subcarriers with various amplitude effects in excessive peak-to-average energy ratio of the device (OFDM) and has implication in the effectivity of the radio frequency amplifier. This degrades the bit error fee and will increase the fee of the system.

To reply to the abovementioned problems, distinctive techniques and methods have been proposed via researchers such as coding techniques, tone injection, filtering, oversampling and a couple of sign representation. The fundamental cause of this find out about is to endorse methods for the reduction of peak-to-average energy ratio in OFDM device with emphasis on 4G network. In this paper, two methods are proposed to clear up the hassle discovered when the usage of the OFDM system: the height windowing and the clipping techniques.

## 2. OFDM AND PAPR

### 2.1 OFDM system

Orthogonal frequency division multiplexing (OFDM) is a most environment friendly and broadly used multiplexing and modulation science for 4G and 5G telecommunications requirements which consists of digital radio broadcasting, digital terrestrial tv (DTT), wi-fi neighborhood region networks (LANs), et OFDM structures consist of two components the transmitter aspect and the receiver aspect [3].

#### OFDM transceiver

The integral precept of OFDM is to break up the reachable bandwidth into more than one sub-carriers. As the quantity of subcarriers increases, it receives extra immune to frequency selective fading, and statistics fees are additionally increasing. However, quantity of sub-carriers can't be extended arbitrarily due to the fact it will increase the complicated structure of the machine and image intervals that make transmission extra touchy to the time incoherence of the channel.

The hassle of the complicated plan of the gadget used to be treated via Weinstein and Ebert with the implementation of OFDM modulation through Inverse Discrete Fourier Transform (IDFT) and demodulation by means of Discrete Fourier Transform (DFT). To illustrate this considers one OFDM image with N one-of-a-kind subcarriers and anticipate that  $s(t)$  is sampled at each time interval  $T_s=N$  (Figure 1).

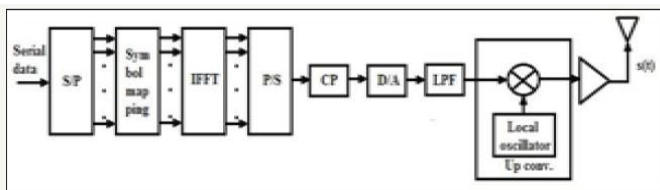


Fig -1: OFDM Modulation block diagram

#### OFDM machine transmitter

The incoming serial facts is the data that wishes to be transmitted thru the channel the use of OFDM system. The serial records is transformed into N special parallel records

streams with the aid of the use of serial to parallel converter. These symbols can be modulated with the aid of the use of extraordinary modulation strategies and given to the IFFT block as an enter [3].

IFFT block offers the digital time area sign for the given input, and this parallel information is transformed into serial records by using the usage of parallel to serial converter. The cyclic prefix is added between two OFDM symbols to cancel the impact of ISI due to channel dispersion. Now this digital time sign is transformed into actual time waveform with the use of digital to analog converters. The accessible baseband sign is up transformed to an RF ignore band sign with the use of a mixer or modulators.

#### Channel model

The phenomenon of noise and multipath surroundings can be expected by means of the use of channel model. Generation of noise can be carried out by way of including few random information to the OFDM image and multipath surroundings can be generated through including attenuated and delayed copies of the OFDM signal.

#### OFDM receiver

At the receiver end, the acquired OFDM signal is down transformed the use of the demodulator and sampled with analog-to-digital converters to acquire the digital time area signal. The digital time area sign is demodulated by means of the usage of FFT, and the records that is transmitted can be extracted via the use of image demapper [4] (Figure 2).

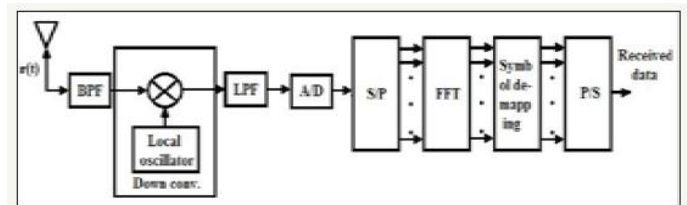


Fig- 2: OFDM System receiver.

#### Characteristics

OFDM has quite a few facets which entice builders to plan a number preferred applications. Even OFDM reveals severa benefits over the household of traditional serial modem schemes which are as follows:

A. Implementation complexity: The complexity is considerably decrease evaluating to the single service gadget for a unique extend spread.

B. Robustness in opposition to slim band interference: An interferer can smash the conversation hyperlink in single service whilst a small quantity of sub provider get affected in multicarrier.

C. Spectral efficiency: The conduct of orthogonality accommodated a massive wide variety of sub provider in a very slender spectral place therefore will increase the spectral efficiency.

D. Immunity in opposition to frequency selective fading: Each subcarrier has slim bandwidth in evaluation to usual bandwidth of the signal. It converts a frequency selective fading channel into a number of almost flat fading channels.

## 2.2 PAPR

The transmitted sign of OFDM famous a excessive height strength when brought in the equal section at IFFT. When these indicators excite the nonlinear traits of the HPA, it motives out-of-band radiation, which in addition distorts the indicators in adjoining bands and its regions. This excessive height energy reduces the effectivity of HPA and degrades the overall performance of the OFDM system. To estimate the distortion which is brought on with the aid of nonlinearity, a commonplace parameter used is PAPR.

The PAPR of OFDM non-stop time baseband transmitted sign  $x(t)$  is represented as the ratio of maximum on the spot strength to common power. Its equation is:

The important consequences of excessive PAPR are

- A. Increased complexity in the ADC and DA
- B. Reduced effectivity of RF (radio frequency) amplifiers [5].

## 3. RELATED WORK

To come out with a suitable reduction in PAPR, researchers proposed the recursive Golay complementary sequence [7] and the consequences confirmed that the PAPR of the sequence is bounded up to 3.6 dB and the records price is bounded up to 3.6 d The writer of [8] proposed a PAPR reduction technique with low computation complexity primarily based on a mixture of cuckoo search optimization algorithm with top windowing scheme in OFDM system. In [9], the writer proposed that new segmentation schemes to beautify the PAPR mitigation overall performance of the top windowing algorithm remember upon the range of partitioned sub-blocks, the variety of the segment rotation vectors, and the form of the segmentation scheme utilized. The consequences show that the PAPR values at the complementary cumulative distribution characteristic (CCDF) 10–3 are 10.96 dB for unique OFDM, 7.62 dB for random search algorithm, 7.45 dB for PSO algorithm, 6.8 dB for cuckoo search algorithm and 6.37 dB for foremost algorithm.

A systematic evaluation of specific PAPR reduction techniques in OFDM structures was once carried out [10]. The lookup proposed easy methods for the reduction of excessive peak-to-average energy ratio based totally on clipping and differential scaling, in orthogonal frequency

division multiplexing (OFDM). The proposed up- and downscaling strategies had been to acquire PAPR reduction of the order of 8.5 dB from 12 dB PAPR initially. A reduction of 3.5 dB was once done for PAPR when keeping the bit error price (BER) inside a margin of three instances the BER price at the overall performance certain at signal-to-noise ratio (SNR) of 10 d The overall performance contrast of two clipping-based filtering strategies for PAPR reduction in OFDM sign [11] was once proposed to remedy the important universal trouble of OFDM strategies which is excessive peak-to-average electricity ratio described as the ratio of the top energy to the common strength of the OFDM sign [12].

To remedy the predominant hassle in OFDM, the excessive peak-to-average energy ratio, the usage of windowing approach and to enhance the BER, the approach proposed is Kaiser and Hamming which makes use of cumulative distribution function. The end result simulation suggests that Hamming and Kaiser have a lot of variations on the equal spectrum attribute [13]: in Hamming windowing technique, at normalized frequencies – 1 and 0.9989 MHz, the spectral densities are – 81.5 and – 46.05; in Kaiser windowing technique, at normalized frequencies – 2 and 1.998, the spectral densities are – 81.5 and – 46.05. The energy spectral frequency is equal for one of a kind normalized frequency however they are equal for most value.

To the research, one-of-a-kind literature and work has been reviewed. Lee & Kim [6], proposed scheme makes use of clipping operation to acquire more suitable PAPR reduction of OFDM signals. Since the top regrowth of sign is mitigated via adaptively enhancing the CT, the proposed scheme can efficiently decorate the PAPR reduction overall performance and additionally decrease the quantity of iterations. Wang & Luo [7] investigates.

A convex optimization approach to dynamically regulate the filter response in an ICF manner which limit the PAPR of OFDM symbols. Also, in March 2011 creator Jeon [8] used the similarity amongst the required indicators generated in PTS to advance a new algorithm which achieves low computational complexity in contrast to that of a traditional PTS algorithm.

Chen Ye [9], developed a modified SLM scheme with decreased complexity for lowering PAPR is proposed. This scheme performs the addition of mapped sign sequences to OFDM sign sequences. Li & Wang [10], proposed two low-complexity SLM schemes. Although the proposed architectures have positive PAPR overall performance losses when in contrast to the common SLM scheme however have decrease complexities and their BER performances are precisely the equal as the standard SLM scheme.

## 4. CONCLUSION

In this paper, we have analyzed and in contrast eight PAPR reduction techniques. Among above analyzed techniques, it

was once discovered out that from existing methods no method is totally positive in reduction of PAPR and is the first-rate for the OFDM system. As earlier than deciding on the splendid PAPR technique, a number of different elements like preserving records rate, computational complexity, BER, sign strength have to additionally be taken into acknowledgement. So, it is recommended to recommend height to common energy ratio (PAPR) reduction scheme and sketch a network/model assisting it for OFDM structures after evaluating present traditional methods.

**Table I** Comparison of PAPR and BER Reduction Techniques [1].

REDUCTION TECHNIQUES		MERITS	DEMERITS
1	<p><b>Clipping and filtering</b> This is the easiest method used for a PAPR reduction [12,13]. In this method the amplitude of the enter sign is frozen to a specific valu Suppose <math>x[n]</math> signify the enter signal, and the clipped model of <math>x[n]</math> is denoted by way of <math>x_c[n]</math>, so expression is described as: Where, A is the clipping level</p>	<p>This is a Simple approach. Have excessive PAPR reduction capability. No facet facts is require No alternate at receiver side</p>	<p>Introduce greater distortion. Degrade BER performance</p>
2	<p><b>Coding</b> In the coding technique, some code phrases are used to reduce or limit the PAPR of the signal. It does no longer motive any distortion and no out-of-band radiation production, [1] however it has a downside of decreased bandwidth effectivity as the information price is reduce It additionally suffers from complexity issues, due to the fact it requires giant reminiscence for discovering the fantastic codes and to save massive look up tables, in particular for a massive quantity of subcarriers [1,14].</p>	<p>Have much less distortion. High PAPR reduction capability. No aspect facts is require</p>	<p>The complexity is very high. Data price loss. Require change in each Tx and Rx.</p>
3	<p><b>Active constellation extension (ACE)</b> In ACE, for decreasing PAPR in a specific block, some outer sign constellation factors in every block are prolonged outdoor of the constellation [15].</p>	<p>It is obvious to receiver. There is no loss of statistics rat No facet statistics is require Less distortion of the authentic signal.</p>	<p>Require addition operations after FFT operation in receiver.</p>
4	<p><b>Tone reservation (TR)</b> TR works by way of reserving a few tones inside the transmitted bandwidth and assign them terrific values [14].</p>	<p>No distortion is added to the records bearing tones No facet records is require</p>	<p>Increase in the common electricity per bit, which would possibly limit the BER overall performance improvement. Loss of spectral effectivity due to tone reservation.</p>
5	<p><b>Selected mapping (SLM)</b> In SLM, from the unique information block numerous candidate statistics blocks are generated and the one with lowest PAPR is transmittes At the receiver the reverse operation is carried out to get better the authentic statistics block [15,16].</p>	<p>No distortion is introduce Independent of number of carriers.</p>	<p>Side information is require Degrade BER performanc</p>



6	<p><b>Partial transmit sequences (PTS)</b> The authentic records block is partitioned into <math>V</math> disjoint sub blocks. The subcarriers current in every of these sub blocks are turned around by way of the equal section factor, so the PAPR of the mixture is minimize Also, the reverse operation is carried out at the receiver, to get better the authentic information block [17-19].</p>	<p>Less distortion is introduce Less complex.</p>	<p>Side data is require Degrade BER performanc Involve complicated vector sums at Tx.</p>
7	<p><b>Companding</b> In Companding technique, we make bigger the small indicators whilst compressing the giant alerts so that the immunity of small alerts from noise will increas This compression is carried out at the transmitter stop after the output is taken from IFFT block. Compression of the sign reduces excessive peaks, so in this way PAPR reduction of enter sign takes region [20].</p>	<p>Less distortion is introduce</p>	<p>Loss of statistics rate</p>
8	<p><b>Tone injection (TI)</b> The TI technique, simple concept is to enlarge the constellation dimension so every factor current in the authentic constellation ought to be mapped into more than a few equal points. In an authentic constellation point, the equal constellation factors are brought so PAPR reduce The calculation of the sub-carrier time area alerts additionally offers reduced PAPR [20].</p>	<p>No statistics charge loss.</p>	<p>Require modulo-D addition, after an FFT operation in the receiver.</p>

## REFERENCES

- [1] <http://www.ni.com/en-in/innovations.html>
- [2] Litwin, Louis, Pugel, Michael (2001) The standards of OFDM. RF Signal Processing, pp. 30-48.
- [3] Yao Y, Ma S, Hu J (2013) A PAPR discount scheme with residue range machine for OFDM. EURASIP Journal on Wireless Communications and Networking, pp. 1-11.
- [4] Bingiham J (1990) Multicarrier modulation for records transmission: an thought whose time has come. IEEE Commun Mag 28(5): 5-14.
- [5] Han SH, Lee JH (2005) An overview of peak-to-average strength ratio discount methods for multicarrier transmission. IEEE Wirel Commun 12(2): 56-65.
- [6] Lee BM, Kim Y (2013) An adaptive clipping and filtering approach for PAPR discount of OFDM signals. Circuits, Systems and Signal Processing 32(3): 1335-1349.
- [7] Wang YC, Luo ZQ (2011) Optimized Iterative Clipping and Filtering for PAPR Reduction of OFDM Signals. IEEE Trans Commun 59(1): 33-37.
- [8] Jeon HB, Shin DJ (2011) A low complexity SLM scheme the use of additive mapping sequences for PAPR discount of OFDM signals. IEEE Trans Broadcast 57(4): 866-874.
- [9] Chen Ye (2014) PAPR discount of OQAM-OFDM indicators the use of segmental PTS scheme with low complexity. IEEE Trans Broadcast 60(1): 141-147.
- [10] Li CP, Wang SH (2010) Novel low complexity SLM schemes for PAPR discount in OFDM systems. IEEE Trans Signal processing 58(5): 2916- 2921.
- [11] Yu P, Jin S (2015) A low complexity tone reservation scheme based totally on time area kernel matrix for PAPR discount in OFDM systems. IEEE Trans Broadcasting 61(4): 710-716.
- [12] Yasir R, Seshadri M (2013) Peak-to-average energy ratio discount in OFDM schemes: a survey and taxonomy. IEEE Communications Surveys and Tutorials 15(4).
- [13] Lee BM, Kim Y (2013) An adaptive clipping and filtering approach for PAPR discount of OFDM signals. Circuits, Systems and Signal Processing 32(3): 1335-1349.

- [14] Wang YC, Luo ZQ (2011) Optimized iterative clipping and filtering for PAPR discount of OFDM signals. *IEEE Trans Commun* 59(1): 33-37.
- [15] Jeon HB, Shin DJ (2011) A low complexity SLM scheme the usage of additive mapping sequences for PAPR discount of OFDM signals. *IEEE Trans Broadcast* 57(4): 866-874.
- [16] Liang HY (2015) Integrating constellation extension and modified SLM to minimize PAPR of OFDM systems. *Wireless Personal Communications* 80(2): 709-722.
- [17] Hill G, Faulkner M, Singh J (2000) Reducing the peak-to-average electricity ratio in OFDM by means of cyclically transferring partial transmit sequences. *Electronics Letters* 36: 560-561.
- [18] Hou J, Ge J, Jing Li (2011) PAPR discount of OFDM indicators the usage of PTS scheme with low computational complexity. *IEEE Trans Broadcast* 57(1): 143-148.
- [19] Ghassemi A, Gulliver TA (2008) Fractional sub-blocking for partial transmit sequence OFDM. *IEICE Trans Commun* E91(10): 3166-3173.