Kuwait Journal of Engineering Research
ISSN: 2984-8016
Vol 1 Issue 1 (2023)

Numerical Simulation and Meta Heuristic Design of Peak Average and Power Ratio Reduction Technique for 4th Generation OFDM Communication System

Sonika Shivam [1], Avinash Sharma [2]
[1]M.Tech (Scholar), Department of ECE, JIT, Jaipur, Rajasthan, India
[1]Assistant Professor, Department of ECE, JIT, Jaipur, Rajasthan, India
Email: sonikaranchi@gmail.com[1], jitavinash@gmail.com[2]

Submitted: 16/01/2023 **Revised**: 25/02/2023 **Accepted**: 15/03/2023

Abstract— Channel capacity and peak average to power ratio are two crucial factors in this rival wireless communication system that promise dependable communication across wireless medium. High peak to average power ratios have an impact on amplifier ratings in OFDM systems and prospective 5G system contenders like FBMC and UFMC. The growth of wireless network users is periodically driving up the demand for channel capacity. To increase the capacity of various fading channels, Multiple Input Multiple Output and Orthogonal Frequency Division Multiplexing (MIMO-OFDM) is a solid option. The power allocation technique is still used, though, and this limits the channel capacity. The Water Filling power allocation method determines the current channel capacity. The goal is to design an effective PAPR reduction method for the OFDM system based on an enhanced Partial Transmit Sequence (PTS). The water filling technique has also been used in the suggested research to offer capacity augmentation of the MIMO OFDM system for improving the effectiveness of the OFDM system. The suggested study has been contrasted with related modern algorithms like clipping and selective mapping. To visualize the effectiveness of the suggested method, capacity improvement strategies have also been contrasted. In the proposed system, there was an additional 5% reduction in peak average to power ratio and channel capacity. MATLAB is used to do a detailed analysis, and the results are then fully explored to gain a greater understanding of the dynamics of cooperative networks.

Keywords: DCT, DWT, OFDM, MSE, AWGN, GUI, BER, MIMO OFDM, FFT OFDM, QPSK, PAPR, FDM, SLM, PTS.

I. INTRODUCTION

Multicarrier modulation is a subset of OFDM (Orthogonal Frequency Division Multiplexing). An OFDM signal is made up of a constant number of modulated carriers that are closely spaced. The side bands extend on both sides of a carrier signal when some sort of modulation, such as speech or data, is applied. To correctly demodulate all of the data, a receiver must be able to receive the entire signal. As a result, when signals are sent close to one another, there should be a safety band between them and enough space between them for the receiver to be able to discern between them using the filter. In the case of OFDM, this does not occur. Because they are orthogonal for one another, even when the sidebands of each carrier overlap, they might still be received without any interference. This is possible by maintaining an operator spacing equal to the reciprocal of the symbol period (Ts). The finest test that remote correspondence engineers look at is probably increasing the phantom productivity of remote correspondence frameworks. While there is a great need for information rate because to an increase in supporters and the number of visual and auditory applications, which require a large amount of transmission capacity, the available transfer speed is slow and expensive. It is being actively considered that OFDM, with its horrifyingly effective versions like MIMO-OFDM and other access variations like OFDMA, will be able to meet the requirements of both current and future distant frameworks. Given that pragmatic correspondence frameworks are top force bound, such adjustments provide difficulties. When an envelope top is present, the framework must be able to accommodate a rapid sign force that is significantly greater than the sign normal force. This necessitates the use of a force enhancer (PA) or low working force efficiencies. [12] [15]

In contrast to single carrier frameworks, the OFDM framework necessitates exact and narrow frequency synchronization since it uses narrowband subcarriers. In keeping with this, there should be a little frequency balancing between the broadcast and received signals. The Doppler Effect or confusion between the neighboring oscillator frequencies of the transmitter and the recipient may cause the frequency imbalance to appear. The sign on a particular subcarrier won't remain free of the other subcarriers as a result of the carrier frequency balancing (CFO), which disturbs the orthogonally between the subcarriers. Inter-carrier interference (ICI), a phenomena with this name, is a crucial test for noise/error-free demodulation and the finding of OFDM pictures.

The way that OFDM is being used doesn't entirely abuse its potential. The top to average force proportion (PAPR) and inter-carrier interference (ICI) of the OFDM signal can still be reduced in a few ways. The requirement to lower the PAPR of a conventional OFDM signal is thus a key driving factor in our effort.The simplest solution to reduce PAPR is to cut and separate, although this reduces PAPR capabilities at the price of BER execution corruption. Existing directed transforms have a good PAPR lowering capacity, but they have substantial non-straight twisting, which makes their BER displays unreliable. Both strategies also cause in-band bending and out-of-band radiation. Our work's main selling point is improving BER execution using teaching-based PAPR lowering approaches..The linearity of the transmission and receiving systems is a requirement for OFDM. Any non-linearity would result in interference between the carriers due to distortion between the modulations. Unwanted signals will result from this, resulting in interference and harm to orthogonal transmission.The final RF amplifier for multi-carrier systems like OFDM must be able to sustain peaks on the transmitter output due to the high peak-to-average power ratio, since the average power is quite low and results in inefficiency. Peaks are constrained in a few systems. The system might rely on error correction strategies to get rid of these problems even if it generates a distortion that results in high levels of inaccuracies in the data.

II. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

The expanding trade between constrained RF signal bandwidth and high-speed wireless applications is increasing daily [13]. Not only in the wired systems, but also in the wireless mobile systems, new applications are developing. Services with low data rates are currently offered for mobile apps. However, a high data rate is required for multimedia applications. If we raise the data rate in a single carrier system, the symbol duration will also decrease, which will worsen the effects of inter-symbol interference (ISI). Because dispersive wireless channels are stored in the memory of wireless communication systems, ISI is generated. As long as the delay is significantly less than the duration of one transmitted symbol, the effect of ISI on error enforcement of the system is often undetectable (T). This shows that ISI has effectively reduced the symbol rate that the communication system promotes. [7] A system must be put in place to counteract the impacts of ISI if the data rate exceeds the maximum rate at which data may be sent over the channel. Echoes brought on by the channel can be eliminated using channel equalization procedures. However, real-time systems present challenges for such equalizers. In such circumstances, multicarrier modulation algorithms are able to recover.

The "orthogonal" portion of the name OFDM denotes that the frequencies of the carriers in the system have a mathematical connection. In a typical FDM system, the many carriers are divided such that the signal may be obtained using standard filters and demodulators. One guard band must be launched between the several carriers in such receivers, and the inclusion of these guard bands in the frequency domain lowers the spectrum efficiency. It is feasible to organize the carriers so that their respective sidebands overlap and receive the signal without interference from other carriers. These carriers must have the orthogonal property in order to be maintained. The receiver functions as a bank of demodulators, converting each carrier to direct current (DC), and then combining the resultant signal over a symbol period to recover the original data. The integration of the other carriers yields zero if the other carriers deteriorate at frequencies that, in the time domain, have a positive integer number of cycles in the symbol period (t). The continuous time domain Multi Carrier Modulation signal may be represented as [13]:

$$x(t) = \sum_{k=0}^{N-1} Xkexp(j2\pi fkt) \qquad (1)$$

For $0 \le t \le T_s$

$$= \sum_{k=0}^{N-1} Xk\varphi k\ (t) \qquad (2)$$

For $0 \le t \le T_s$

Where $f_k = f_o + k\Delta f$ and

$\varphi_k(t) = \exp(j2\pi f_k t)$ (3)

For $k = 0, 1, 2 ... N - 1$.

If Tsf = 1, where Ts stands for symbol time and f for subcarrier frequency spacing, the subcarriers become orthogonal. A time domain OFDM signal is represented by the symbol x(t) in the case of orthogonal subcarriers. As seen in Fig. 1, the orthogonally arranged sub carriers may be seen in the time domain. Each curve shows how a subcarrier's wave appears in the time domain. As can be observed from Fig. 1, each subcarrier undergoes an even number of cycles over the course of an individual OFDM signal.

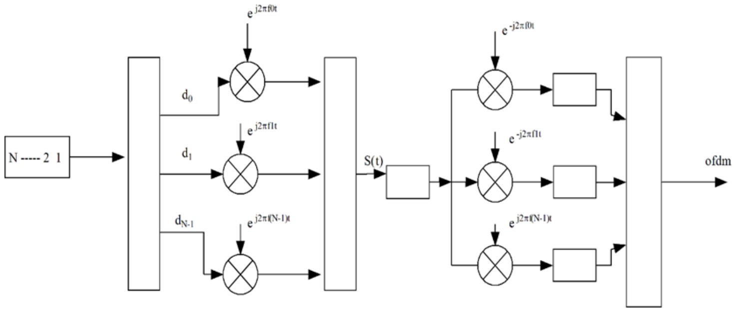

Fig.1 Block diagram of OFDM signal modulation

Therefore, if the carriers are spread by a multiple of 1/t [12], they are orthogonal and linearly independent. The frequencies of the subcarriers in the multicarrier modulation system known as OFDM are demoniacally connected. In other terms, OFDM refers to a multicarrier modulation method that includes orthogonal subcarriers. In order to broadcast the information symbols in parallel to one another across the communication channel, multicarrier modulation, and particularly OFDM, is one of the remising alternatives.

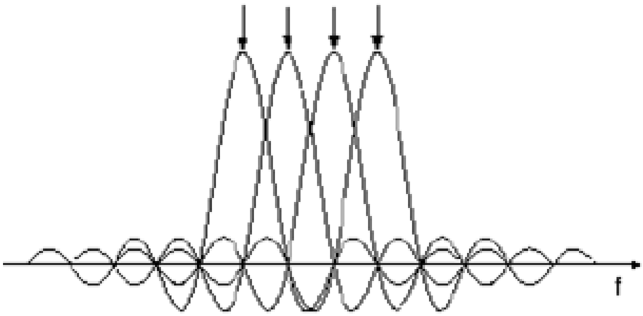

Fig. 2 Frequency Spectrums FDM vs. OFDM

By maintaining a symbol span that is far greater than the channel delay spread, we are able to develop a system that supports high data rates and can readily overcome the effects of ISI without the need of complicated channel equalization mechanisms. Orthogonal Frequency Division Multiplexing (OFDM) is a technique that enables large data rates to be sent over very hostile channels at a comparably low level of complexity [6].

III. PEAK AVERAGE TO POWER RATIO AND PTS

The transmitted OFDM signals, which are produced by applying the IFFT operation to modulated input symbols, are identified by the PAPR, which is the ratio of the highest power to the average power of the complex pass band signal. When phase values are the same, the peak power of received signals for an OFDM system with N sub-carriers equals N times the average power. At PAPR (dB) = 10log N, the PAPR of a baseband signal will theoretically achieve its maximum value. The Crest Factor (CF), another significant metric, is defined as the ratio of the greatest amplitude of the OFDM signal at time t to the root-mean-square (RMS) of the waveform. The peak value of a signal is typically equal to the maximum value in its envelope. Many times, the PAPR performance of OFDM signals is assessed using particular characterization constants that have a connection to probability. The PAPR of the transmit signal s(t) is described by the following equation, where E and T stand for the expectation value and the symbol length, respectively. For reliable results while measuring at baseband, an oversampling factor of at least 4 should be used:

$$PAPR = \frac{\max_{t\in[0,T]} |s(t)|^2}{E\left\{|s(t)|^2\right\}} \qquad (4)$$

The expression Pr PAPR > PAPR0 represents the original signal sequence's PAPR's CCDF when it exceeds a threshold. As a result, given K statistically independent signal waveforms, CCDF may be expressed as Pr PAPR > PAPR0k, resulting in a modest chance of PAPR exceeding the same threshold. This method employs signal scrambling.

Partial Transmit Sequences (PTS): V non-overlapping sub-blocks are used to separate a collection of sub-carriers in an OFDM signal [4]. By adding zeroes to the sub-carriers that are already represented in other sub-blocks, each sub-block travels through zero padding. The IDFT transforms all V sub-blocks into the time domain, resulting in V partial transmit sequences represented by p(k), where k=1...V. The transmit sequence is created by combining PTSs in a linear fashion, where b(k) is the rotation factor. For each OFDM symbol, the optimization is carried out across the rotation factors b(k). It is demonstrated that a reduction in peak power of at least four rotation degrees.

Disjoint sub blocks are created in the PIS technique by breaking up a large data block into smaller ones. The optimization technique obtains a phase weightage factor, which is then multiplied by each sunblock to optimise the PAPR value. The number of subcarriers (N) in an OFDM frame is used to describe the size of the data block. It is then divided into M distinct sub blocks, each of which is represented by the vector X i,i=1,2,...,M.

$$X = \sum_{i=1}^{M} X_i. \qquad (5)$$

The principle structure of PTS method is shown in Figure 3.

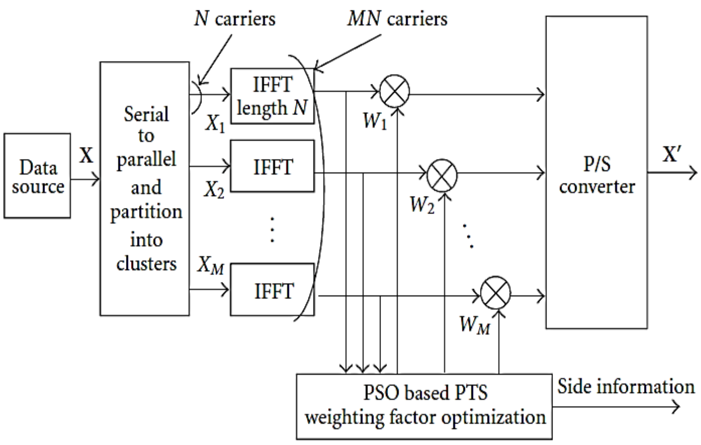

Figure 3 Flow chart of proposed methodology

Here, it is assumed that the clusters X_i constst of a set of subblocks with equal sthes. Then, the goal of the PTS approach is to form a wesghted combination of the M subblocks which is written as

$$\boldsymbol{X'} = \sum_{i=1}^{M} w_i X_i W_i = e^{j\epsilon!} \qquad (6)$$

i=1,2,...,M, where W i i=1 With tn [0,2], you have complete control over the phase weighttang factor. In order to keep the search as simple as possible, the phase weighting factors are often constrained to a small set with a finite number of components. The new time-domatn vector becomes once it has been transformed to the time domain

Kuwait Journal of Engineering Research
ISSN: 2984-8016
Vol 1 Issue 1 (2023)

$$\boldsymbol{x} = IFFT\,\{\sum_{i=1}^{M} \quad w_i X_i\} = \sum_{i=1}^{M} \quad w_i IFFT\,\{X_i\} \qquad (7)$$

Phase weight factors W b i=1,2,...,M rotate these partial sequences in a independent manner. From a comprehensive simulation of all possible _2(M-1) combination, the optimal phase welghting factor W i can be obtained. W=(W 1,W 2,...,W i) is the phase weighting vector that is selected using the PTS technique in order for the PAPR of X_ to be reduced.

An appropriate value for w(t) ensures that the swarm's global and local exploration abilities are properly balanced, resulting in an improved algorithm. Inertia weight should be set to a large amount, with priority given to global exploration of the search space, linearly decreasing w(t) so as to obtain refined solutions [20-22]. Stochastically varying the relative pull of individual and global best particles is achieved by applying two random functions r 1 and r 2 that, when used individually, generate unfform distributed mumbers in the range [0,1]. The following equation computes the new position of particle I based on the most recent measurements of its velocity:

$$W_i(t+1) = W_i(t) + v_i(t+1) \qquad (8)$$

The particle populations are then relocated in accordance with the newly determined velocities and positions, and tend to group together from various directions. fitness begins agatn. The algorithm iterates through each of these steps until it reaches a dead end.

IV. SIMULATION & RESULT

Numerous computer simulations have been run to determine the PAPR improvements in order to analyse and compare the poor PTS performance. In this case, N = 256 subcarriers are used for QPSK modulation. There are phase weighting factorsW = [0, 2] that were applied. A total of 10,000 random OFDM frames were created in order to derive the PAPR's complementary cumulative distribution function (CCDF). An accurate PAPR requires a fourfold increase in sample rates. In evaluating the effectiveness of PAPR reduction strategies, the CDF (cumulative distribution function) is a commonly used performance metric. For the OFDM system with 256 subcarriers, the CCDF of the PAPR is simulated using the random partition M = 16 and the phase weight factor W = 1M random variables for PTS. As we can see, the PAPR's CCDF gradually improves as the number of generations increases due to the phase weighting factor being constrained. The CCDF of the PAPR has improved as the number of generations has grown. At Pr(PAPR > PAPR0) = 10-3 for generation Gn = 40, the PSO-based PTS approach can achieve a near OPTS technique performance. Gn = c1 = c2 = 2 in Figure 5 shows the PAPR performance of varying numbers of particle generations Gn..

.

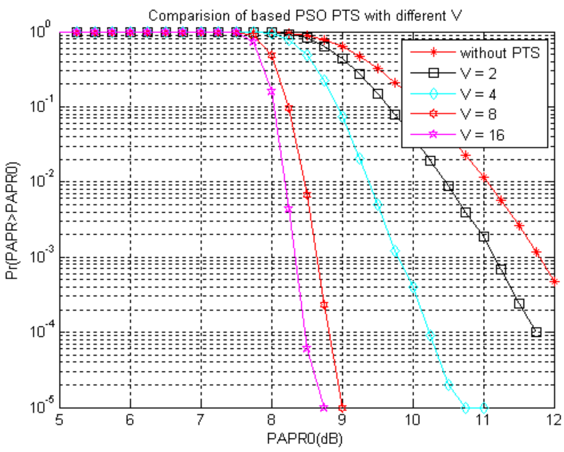

Figure 4. Result of PSO-PTS

As Gn rises, PAPR performance improves. Basically However, when Gn is greater than 40, the improvement is limited. With Gn, however, there is a significant increase in the amount of calculation required. Increasing Gn =

20 to 40 results in only a minor improvement. Gn = 40's computational complexity is twice as high as Gn = 20's. Thus, Gn = 20 is a good choice for our proposed PSO-based PTS technique because of the trade-off between PAPR reduction and computing complexity. This figure demonstrates the outcomes of PSO-assisted PTS as compared to standard OFDM in terms of how many subblocks are used. There are 32 values in the set M, and one of them is M. For 10-3 of the available transmitted OFDM blocks, the PAPR of an OFDM signal surpasses 12 dB.

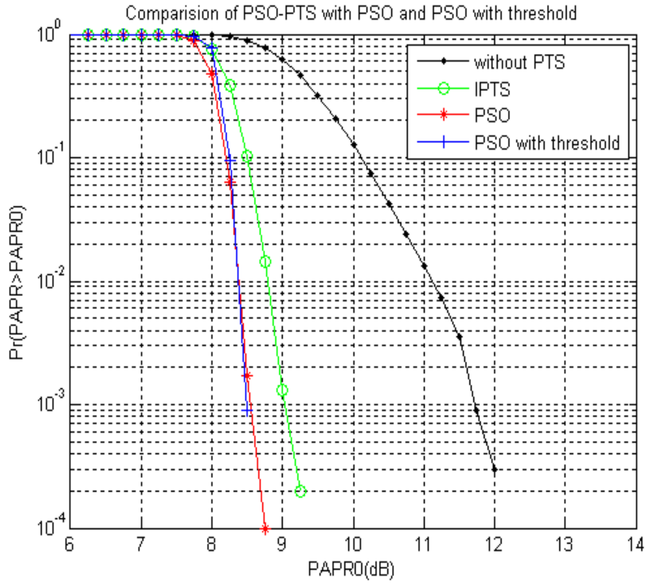

Figure 5.Design of PSO-PTS with thresholding

The CCDF equation yielded the ideal threshold for the number of sub blocks, which is used in this section to reduce calculation complexity. Figure shows the CCDF, Pr(PAPR > PAPR0) for M = 8. The original OFDM frame had a 104 PAPR of 12 dB. 7.6 dB of improvement for OPTS and PSO-PTS for M = 8 compared to 8.4 dB for iteration PTS, with roughly the same performance for M = 8. Table 1 displays the proposed technique's iteration count. The OPTS approach requires 128 iterations every OFDM frame, while the iteration PTS technique takes 16 iterations and the PSO-PTS technique without a threshold requires 88 iterations each OFDM frame. Iteration PTS is just 12.5% (16/128) as difficult as the PTS method. With only 23 iterations required for each OFDM frame, the PSO-PTS method uses a threshold value and is hence simpler. The complexity of the PSO-PTS with threshold is only 18% (23/128 = 0.18). With N = 128, M = 4, and W = 2, the PTS approach shows some PAPR reduction performance for OFDM utilising PSO with c1 and c2 acceleration factors. A greater PAPR depression was observed as the acceleration factors increased

V. CONCLUSION

A new approach to the PAPR-reduction cost function-based problem is developed in this study. Analyzing how well different subblock partitioning algorithms reduce PAPR is one of the goals of this research. Interleaved subblock partitioning has the worst performance of all the subblock partitioning methods. PAPR can be further lowered by increasing the number of subblocks. PSO is used to find the ideal combination of phase weighting factors for PTS, which is formulated as a combination optimization problem and is solved using the PSO technique to achieve almost the same PAPR reduction as that of optimal PTS while maintaining minimal complexity. PSO-based PTS is an excellent strategy for balancing PAPR reduction and computing complexity, according to simulation data. The proposed partition scheme can be adapted to QOS requirements by selecting the appropriate phase weighting factors based on performance and complexity requirements. A superior performance-to-complexity tradeoff can be achieved by using this method, as we showed in our experiments. As a result of this, the proposed approach's performance was marginally deteriorated when compared to the best method, PTS. However, the proposed method has a significantly lower complexity than the optimum method. It's the application of research and analysis that is research. All of the systems given here were simulated using MATLAB with R-2017 edition.

REFERENCES

[1] Hindy, Ahmed, Udar Mittal, and Tyler Brown. "CSI Feedback Overhead Reduction for 5G Massive MIMO Systems." In 2020 10th Annual Computing and Communication Workshop and Conference (CCWC), pp. 0116-0120. IEEE, 2020.

[2] Guo, Jing, Nanxi Li, Zheng Jiang, Shengnan Liu, and Peng Chen. "System-level Evaluation on Practical Massive MIMO Deployment Scenarios for 5G." In 2019 IEEE 5th International Conference on Computer and Communications (ICCC), pp. 993-998. IEEE, 2019.

[3] Baeza, Víctor Monzón, and Ana García Armada. "Noncoherent Massive MIMO." Wiley 5G Ref: The Essential 5G Reference Online (2019): 1-28.

[4] Dore, Jean-Baptiste, Robin Gerzaguet, and Dimitri Ktenas. "5G cellular networks with relaxed synchronization: Waveform comparison and new results." In 2016 IEEE 83rd Vehicular Technology Conference (VTC Spring), pp. 1-5. IEEE, 2016.

[5] Kansal, Parnika, and Ashok Kumar Shankhwar. "FBMC vs OFDM waveform contenders for 5G wireless communication system." Wireless Engineering and Technology 8, no. 4 (2017): 59-70.

[6] Gupta, Namrata, Ankush Gupta, Santosh Kumar, Rajeev Mishra, Chhaya Singh, and Anil Kumar Tripathi. "Cross-talk between cognate and noncognate RpoE sigma factors and Zn2+-binding anti-sigma factors regulates photooxidative stress response in Azospirillum brasilense." Antioxidants & redox signaling 20, no. 1 (2014): 42-59.

[7] Khademi, Seyran, and Alle-Jan Van Der Veen. "Constant modulus algorithm for peak-to-average power ratio (PAPR) reduction in MIMO OFDM/A." IEEE Signal Processing Letters 20, no. 5 (2013): 531-534.

[8] Salh, Adeeb, Nor Shahida M. Shah, Lukman Audah, Qazwan Abdullah, Waheb A. Jabbar, and Mahathir Mohamad. "Energy-Efficient Power Allocation and Joint User Association in Multiuser-Downlink Massive MIMO System." IEEE Access 8 (2019): 1314-1326.

[9] Hossain, Tamanna, Md Munjure Mowla, and Md Yeakub Ali. "Energy Efficiency Investigation in Massive MIMO 5G System using Nakagami-m Fading Channel." In 2019 22nd International Conference on Computer and Information Technology (ICCIT), pp. 1-5. IEEE, 2019.

[10] Pedram, Massoud, and Luhao Wang. "Energy Efficiency in 5G Cellular Network Systems." IEEE Design & Test 37, no. 1 (2019): 64-78..

[11] Ohno, Shuichi, Emmanuel Manasseh, and Masayoshi Nakamoto. "Preamble and pilot symbol design for channel estimation in OFDM systems with null subcarriers." EURASIP Journal on Wireless Communications and Networking 2011, no. 1 (2011): 2.

[12] Gangwar, Arun, and Manushree Bhardwaj. "An overview: Peak to average power ratio in OFDM system & its effect." International Journal of Communication and Computer Technologies 1, no. 2 (2012): 22-25.

[13] Ali, Moaaz Elhag, Khaizuran Abdullah, Mohammad Umar Siddiqi, and Ahmad Fadzil Ismail. "Impulsive noise mitigation in Haar DWT based OFDM systems." In 2013 IEEE 11th Malaysia International Conference on Communications (MICC), pp. 321-325. IEEE, 2013.

[14] Gheorghe, Cristina-Gabriela, Radu Dragomir, and Dan Alexandru Stoichescu. "Massive MIMO technology for 5G adaptive networks." In 2019 11th International Conference on Electronics, Computers and Artificial Intelligence (ECAI), pp. 1-4. IEEE, 2019.

[15] Chen, Jung-Chieh. "Application of quantum-inspired evolutionary algorithm to reduce PAPR of an OFDM signal using partial transmit sequences technique." IEEE transactions on Broadcasting 56, no. 1 (2009): 110-113.

[16] Al-Jawhar, Yasir Amer, Khairun Nidzam Ramli, Aida Mustapha, Salama A. Mostafa, Nor Shahida Mohd Shah, and Montadar Abas Taher. "Reducing PAPR with low complexity for 4G and 5G waveform designs." IEEE Access 7 (2019): 97673-97688.