Study of Different PAPR Reduction Technique for 5G MIMO System

Sumit Soni[1], Prof. Prakash Saxena[2]
M. Tech. Scholar, Dept. of Electronics and Communication Engineering, BIST, Bhopal[1]
Head of Dept., Dept. of Electronics and Communication Engineering, BIST, Bhopal[2]

Abstract— Massive system is of great interest for researchers and research laboratories all over the world. OFDM is widely used in contemporary communication systems for its good robustness in multipath environment, and its high spectral efficiency. The capacity of wireless system can be increased dramatically by employing Multiple Input Multiple Output, (MIMO) antennas. The combination of MIMO and OFDM system is found to be very beneficial. A major drawback of OFDM-MIMO System is its high Peak to Average Power Ratio (PAPR) Reduction. The peak power of a signal is a critical design factor for band limited communication systems, and it is necessary to reduce it as much as possible. Many PAPR reduction techniques have been used to reduce PAPR. Select mapping (SLM) is one of the most well-known peak-to-average power ratio (PAPR) reduction techniques proposed for MIMO-OFDM systems. However the computational complexity of traditional PTS method is tremendous. In this paper studied of different PAPR technique, based on MIMO-OFDM system, which can achieve better PAPR performance at much less complexity.

Keywords— **SLM, MIMO, OFDM, PAPR**

I. INTRODUCTION

In this modern era, communication plays a vital role. A communications system, also known as a communications network, is a series of different telecommunications systems, transmission systems, and terminal equipment that can be integrated and interconnected to form a unified, monolithic structure. It can be wired and wireless, and the communication method can be guided or unguided. The standard medium in wired communication systems is a physical path laid using cables such as coaxial, twisted, and, more recently, optical fibers. These cables are used to propagate the signals from one point to another point. Such a type of transmission through cables is known as a guided medium [1, 2]. In wireless communication, space is the medium used for signal propagation. It is an unguided transmission system because it does not require any physical channel for signal propagation. Antennas in wireless communication systems would transmit and receive the signals. First, the antennas at the transmitter side convert the electrical signals to electromagnetic waves, i.e., radio signals. Then electromagnetic waves propagate through space, and the receiver receives them. Finally, antennas at the receiver side transform electromagnetic waves into electrical signals. Hence, both the transmitter and receiver consist of an antenna [3].

Wireless communication is highly beneficial, and it has the following numerous benefits: Cost-Effective: Since wireless communication systems do not need any infrastructure or cables, the cost for this system is significantly less and highly economical. Highly mobile: The wireless system is highly mobile, and it can be installed anywhere at any time, even in remote places [4].

Installed Easily: The infrastructure is required for wireless communication is straightforward to implement.

Highly Reliable: Since there are no cables and other infrastructure, the wireless system has no chance of failure and damage. Hence it is highly reliable.

Recovery after a disaster: Despite fires, floods, or other disasters, the loss of wireless communication infrastructure is low in wireless communication systems. Even though there are several benefits, there are certain disadvantages to wireless communication systems [5].

The disadvantages are:
Electromagnetic Interference: Since the transmission of signals is through space, there is a high possibility that the signals will interfere with each other.

Insecure: The wireless system is highly insecure as the signals are transmitted through space from one point to another.

Health Issues: Continuous exposure to any radiation is dangerous and can cause health issues.

II. SYSTEM MODEL

MIMO in combination with OFDM is widely used nowadays due its best performance in terms of capacity of channels, high data rate and good outcome in frequency selective fading channels. In addition to this it also improves reliability of link. This is attained as the OFDM can transform frequency selective MIMO channel to frequency flat MIMO channels [6, 7]. So it is widely used in future broadband wireless system/communications. Cyclic prefix is the copy of last part of OFDM symbol which is appended to the OFDM symbol that is to be transmitted. It is basically 0.25% of the OFDM symbol. We can say that one fourth of the

OFDM symbol is taken as CP (cyclic prefix) and appended to each OFDM symbol. IFFT is used at the transmitter and FFT is used at the receiver which substitutes the modulators and demodulators. Doing so eliminates the use of banks of oscillators and coherent demodulators. Moreover the complex data cannot be transmitted as it is; therefore it is first converted to analog form which is accomplished by IFFT. It basically converts the signal from frequency domain to time domain. Prior to IFFT operation symbol mapping is performed which is nothing but the modulation block. Any of the widely used modulation techniques can be applied like BPSK, QPSK, QAM, PSK etc. Further there are higher order modulations are also available which provide more capacity at little expense of BER performance degradation [8]. After IFFT block pilot insertion is done and then CP (cyclic prefix) is added. Figure 1 below shows the block diagram constituting MIMO and OFDM. Any antenna configuration for the MIMO can be used according to the system requirement. Higher the configuration more will be the capacity and more will be the computational complexity of the transceiver design. It is seen that in the case of estimating channel the computational complexity is increased. Mapper defines the modulation to be used. Symbol encoder takes the shape of the STBC (Space Time Block Code) if spatial diversity is to be used and it takes the shape of the de-multiplexer/multiplexer if spatial multiplexing is to be used.

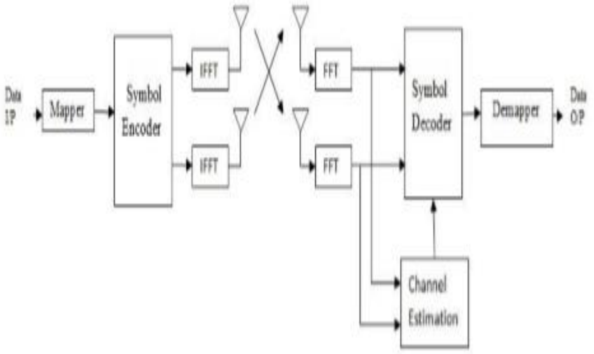

Figure 1: MIMO-OFDM system model

The received signal at j^{th} antenna can be expressed as

$$R_j[n.k] = \sum H_{ij}[n,k]\, X_i\, [n,k] + W[n,k] \qquad (1)$$

Where H is the channel matrix, X is the input signal and W is noise with zero mean and variance.

$$\begin{bmatrix} Z_1 \\ Z_2 \\ \vdots \\ Z_N \end{bmatrix} = \begin{bmatrix} H_{1,1} & H_{1,2} & \dots & H_{1,NT} \\ H_{2,1} & H_{2,2} & \dots & H_{2,,NT} \\ \vdots & \vdots & \ddots & \vdots \\ H_{NR,1} & H_{NR,2} & \dots & H_{NR,NT} \end{bmatrix} \begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_{NT} \end{bmatrix} + \begin{bmatrix} M_1 \\ M_2 \\ \vdots \\ M_{NT} \end{bmatrix} \qquad (2)$$

Also $b_i[n,k]$ represents the data block i^{th} transmit antenna, n^{th} time slot and k^{th} sub channel index of OFDM. Here i and j denoted the transmitting antennas index and receiving antenna index respectively.

The MIMO-OFDM system model [9] with NR receives antennas and NT transmits antennas can be given as:

Where, Z represents O/P data vector, H denotes Channel matrix, A denotes I/P data vector and M represents Noise vector. The wireless channel used is AWGN channel. After receiving the signal the CP is removed then the pilots are also removed from main signal received. After this the signal that is in time domain can be again converted to frequency domain by taking FFT of the received signal.

The sequence on each of the OFDM block is then provided to channel estimation block where the received pilots altered by channel are compared with the original sent pilots. Channel estimation block consists of the algorithms that are applied to estimate the channel.

III. LITERATURE REVIEW

Zhitong Xing and others [1], isolated balanced repeat division multiplexing (f-OFDM) is seen as one of the competitor for future compact correspondence because of its versatile limit arrangement for different circumstances. Regardless, the unique handset structure of f-OFDM makes impedance testing extremely challenging, particularly in the uplink with non-ideal synchronization. This review examines the uplink obstruction of f-OFDM frameworks under non-ideal synchronization; taking into account the transporter recurrence offset (CFO) and timing offset (TO) of numerous client equipment (UE). A few sub-impedances separate the obstruction. After inferring the close structure articulations of each sub-obstruction and its distinction, reproductions are used to validate the inferences. First, the effects of non-ideal variables and framework boundaries like CFO, TO, watch band (GB), and subcarrier dividing (SCS) on the uplink impedance of f-OFDM frameworks are reproduced and examined on the basis of the inferred shut structure articulations. This study is affirmed by automatic encounters, and the speculative derivation of hindrance agrees with the multiplication result. Second, previous f-OFDM frameworks utilized Hanning window channels, which resulted in piece blunder rate (BER) awkwardness between subgroups. Accordingly, the effect of waveform channel on the impedance and BER is similarly analyzed in this assessment. Results show that ideal hindrance and BER displays over Hanning window channels can be gotten by using reasonable channel settings. Plus, a couple of channel design rules are shut. By and large, the assessment and reenactments uncover various normal impedance ascribes of f-OFDM, which will help the future f-OFDM system plans.

Ebubekir Memisoglu and Associates [2], due to its numerous advantages, OFDM will probably continue to be utilized in previous 5G (B5G) correspondence frameworks in addition to being sent in 5G frameworks. However, the high top-to-average power proportion (PAPR) of OFDM systems is a major drawback, particularly when transmitting large amounts of data. A regularization improvement based adaptable cross breed companding and cutting plan (ROFHCC) for reducing PAPR in OFDM frameworks is presented in this paper. The companding capacity has two sections to simplify the plan. It restricts the sign examples with amplitudes greater than a predetermined value to a consistent incentive for both low power pay and peak power loss. For signals with tests under a given sufficiency, they are stretched out by a direct companding limit. For bit error rate (BER) and power unearthly thickness (PSD) execution, we develop a regularization enhancement model to mutually improve the companding contortion as well as the congruity of the companding capacity. The reproduction results show that the proposed companding plan outperforms the referred to companding plans for the same PAPR execution. For example, when the typical sign power is normalized to be 1, we pick both PAPR for ROFHCC plan and two-piecewise companding (TPWC) scheme as 4 dB, then, we can find that at BER=10 - 4 , the base required E b/N 0 for ROFHCC plot is around 2.3 dB lower than TPWC contrive.

S. Rajasekaran et al. [3], in the field of current remote correspondences, symmetrical recurrence division multiplexing (OFDM) is one of the most common advancements. However, the framework's high top to average power proportion (PAPR) issue has severely restricted its application range, making it impossible to present. For the purpose of further improving the PAPR execution of OFDM frameworks, incomplete send succession (PTS) was proposed. Nevertheless, its presentation significantly increases the framework's computational complexity. In light of the majority of time-area tests, a low-intricacy PTS plot is proposed and two new measurements for selecting these examples are presented in this paper. Additionally, a gathering strategy has been employed with the proposed conspire to reduce computational complexity. Reenactment results show that the proposed low-complexity PTS plan can outfit an ideal PAPR decline execution with more computational multifaceted design save reserves.

Z. Zhou et al. [4], for the chosen planning (SLM)-based unevenly cut optical symmetrical recurrence division multiplexing (ACO-OFDM) visible light correspondence (VLC) framework, a novel low-intricacy least sufficiency contrast (MAD) decoder is proposed. With the proposed plot, a specific plan of symmetric vectors is expected to restrict the top to-average power extent (PAPR) of sign without the transmission of side information (SI) and recover SI capriciously by the proposed Frantic decoder. Reproduction results demonstrate that the proposed plot actually reduces the PAPR, and the cycle error rate execution of an ACO-OFDM framework equipped with a MAD decoder is very similar to that of a traditional chosen planning (CSLM) conspire equipped with the greatest probability decoder, albeit at a much lower level of complexity.

W. Hu et al. [5], this paper propose a different actual layer design for uplink different access using symmetrical recurrence division multiplexing (OFDM). With fixed decoder inactivity, it focuses on immediate low-inertness remote applications, such as the transmission of control data in machine-to-machine (M2M) and device-to-gadget (D2D) exchanges. For high coding gain and recurrence variety and low top to average power proportion (PAPR) flagging, our proposed framework uses a well-balanced combination of subcarrier bouncing and super-symmetrical convolutional codes. The low PAPR nature enhances the transmission range upgrade and further develops the power effectiveness at a power intensifier (PA).

Y. Hori et al. [6], in addition, ghostly effectiveness can be elevated to a higher level by presenting non-symmetry among clients through the task of arranging subcarriers in a similar manner for various clients. Multiuser discovery (MUD) is used to reduce different access impediments caused by clients switching in an unsymmetrical way. Speculative explanations of vague piece screw up rate for the proposed system with MUD are moreover advanced. Numerical results uncover that our proposed system achieves higher immovable quality and higher absurd viability than the standard balanced repeat division different access (OFDMA)- based structure.

Ashna Kakkar et al. [7], MIMO-OFDM, or multiple input, multiple output orthogonal frequency division multiplexing, is an appealing transmission method for systems with high bit rates. Like OFDM, one principal inconvenience of MIMO-OFDM is the high top to-average power proportion (PAPR) of the transmitter's result signal on various radio wires. The best performance for PAPR reduction is provided by the partial transmit sequences (PTS) method. However, the traditional PTS method has a tremendously high computational complexity. In this paper, a helpful and substitute PTS (C-A-PTS) plot for STBC MIMO-OFDM framework is proposed which can accomplish almost ideal PAPR execution at significantly less intricacy. The advanced algorithm's effectiveness is demonstrated by the simulation results.

Ho-Lung Hung et al. [8], they concentrated on the effect of nonlinear gadgets on OFDMA signals. As a result, they employ FDMA (Frequency Division Multiple Access) and OFDM modulation simultaneously. The nonlinear interference levels on the received signals and an analytical spectral analysis of the transmitted signals are made possible by their findings. They thought about nonlinear signal processing methods that work with OFDM signals that have been sampled. For the analytical characterization of the transmitted signals, they will make use of the Gaussian nature of OFDMA signals with numerous subcarriers. In, they presented an analytical tool for assessing the effects of nonlinear distortion on OFDMA signal-based systems.

P. Kothai et al. [9], they proposed the novel transceiver schemes for the MIMO interference channel based on the mean square error (MSE) criterion. Their goal is to optimize the system performance under a given feasible degree of freedom. They also proposed tire robust MSE based transceiver schemes that take channel estimation error into account. In specific, two types of MSE were studied. One is the total MSE among all users without considering user fairness, and the other is the maximum per-user MSE when user fairness is concerned. In, the channel model used in the simulations is a quasi-static flat Rayleigh fading channel. They also proposed robust Sum-MSE Minimization and Min-Max algorithm in the presence of channel estimation errors.

Muhammet Nuri Seyman et al. [10], they provided analytical framework for calculating the large-system throughput of a MIMO cellular network with channel estimation errors. The studies assumed that each AP only decodes the users in its service region without AP cooperation. If the average path gain of one link is relatively low, ignoring its contribution is worth consideration while slightly sacrificing system performances but greatly reducing system complexity. In addition to the optimal MMSE detector, this study also utilizes the suboptimal but simple linear MMSE (LMMSE) detector. It finally, they have reported that the weak path hardly contains useful information, and the additional training segment seems to be wasted and decrease the available data transmission period.

IV. PAPR REDUCTION TECHNIQUE

A few reductions schemes are described. Authors proposed Amplitude clipping technique that reduces the greatest level of the input signal to a predetermined value. Later, introduced is coding technique, in the technique 3 bits with the addition of a final bit across the channels to reduce the PAPR. This segment in the OFDM system looks at five conventional reductions of PAPR strategies. These strategies are stated below.

Clipping and Filtering Technique

The most widely recognized and regularly utilized PAPR decrease strategy is sufficiency clipping. Clipping segments of signs over a specific limit level or conveying the message without cutting beneath that level might be utilized to this system. In-band contortion diminishes the BER execution of OFDM gadgets in the section method. While out-of-band radiation is brings down effectiveness. Out-of-band radiation may exist minimized by extracting the signal after it has been clipped, but in-band amplification cannot be reduced [11].

Nonlinear Companding Transforms

One of the interesting approaches is that Non-linear Companding Transforms (NCT) helps to reduce PAPR. In addition to reduce PAPR, these transformations have two key advantages: the complexity in implementation is low and no scope for expansion of bandwidth [9]. The exponential transform, which extends the small amplitude signals and compresses the high amplitude signals, is an example of the NCT, as a consequence, the total strength of the transmitted signals increases, while the PAPR decreases. The HPA will now operate near the saturation area due to the rise in average capacity, the BER output of the device will deteriorate subsequently. The second approach provides the optimal balance between PAPRs within the presented approach, assesses system performance, and assesses BER [10].

Cuckoo Search Optimization Technique

Cuckoo search (CS) is an optimization technique and is evaluated in 2009 by Xin-she Yang and Squash Deb et al., 2018. In direct combat, host birds are associated with attacking cuckoos. If a host tracks bird eggs that are not theirs, it may dump unknown eggs or hand over the house. Female parasitic cuckoos, for instance, are likewise extremely had practical experience in copying the tones and plans of the eggs of a couple of picked has, for example, the New World brood-parasitic Tapera.

The breeding behaviour of cuckoo search has idealized and can be extended to different problems of optimization. It appears that other metaheuristic algorithms in applications will perform the optimization process for the said problem [11].

Each egg in the home addresses an answer, and another arrangement is a cuckoo egg. The objective is to substitute a not very great arrangement in the homes by utilizing new and hypothetically better arrangements (cuckoos). Each home has one egg in the least difficult structure. The calculation can be stretched out to more mind-boggling circumstances in which each home contains a few eggs mirroring a bunch of arrangements.

Ant Colony Optimization

In solving many numerical problems, one of the optimization techniques which is the Ant Colony optimization algorithm is a probabilistic method that can be reduced towards searching better ways across graphs in computer science and operations studies.

This algorithm belongs to the Ant Colony Algorithms family and conducts several metaheuristic optimizations in swarm intelligence techniques. The first algorithm, suggested by Salehinejad and Talebi, 1992 tried to track down the most ideal route in a chart zeroed on the conduct of ants looking for a way between their province and a food source. The underlying definition has been broadened to address a bigger class of mathematical issues, and thus, a few issues have arisen, fixated on various features of ant activities [12].

Particle Swarm Optimization

It tackles an issue by producing a populace of competitor arrangements, which are alluded to as particles, and pushing these particles around in the pursuit space utilizing straightforward numerical formulae dependent on the molecule's area and speed. Every molecule's way is driven by its most popular nearby area, however, it is likewise driven into the most popular hunt space areas, which change as different particles find better positions. The algorithm was simplified, and optimization was discovered to be possible [13]. The book by Kennedy and Eberhart discusses many metaphysical dimensions of the PSO and swarm's knowledge. PSO is a metaheuristic in the sense that it allows little or no assumptions regarding optimizing the problem and will check for very large candidate solution spaces. PSO, more specifically, would not use the optimized gradient of the problem, implying that PSO does not need separation of the optimization problem, as conventional optimization approaches such as regression decline and quasi-Newton methods do [14, 15].

V. CONCLUSION

The summation of subcarriers could result in a sign with very large amplitude or one with very small amplitude, depending on the user data. Therefore, the signal's peak power is much higher than the average power. A nonlinear power amplifier creates out-of-band radiations due to the high PAPR. This would result in low power conversion efficiency in the transmit power amplifier if it were operated in the linear region. Furthermore, the multicarrier modulation OFDM has been replaced by MIMO-OFDM, reducing the transmit signal's PAPR value. The shortcomings of the pre-existing PAPR reduction drove the need for innovative and effective PAPR reduction strategies.

REFRENCES

[1] Zhitong Xing, Kaiming Liu, Aditya S. Rajasekaran, Halim Yanikomeroglu and Yuanan Liu, “A Hybrid Companding and Clipping Scheme for PAPR Reduction in OFDM Systems”, IEEE Access 2021.

[2] Ebubekir Memisoglu, Ahmet Enes Duranay and Hüseyin Arslan, “Numerology Scheduling for PAPR Reduction in Mixed Numerologies”, IEEE Wireless Communications Letters, Vol. 10, No. 6, June 2021.

[3] H. Chen, J. Hua, J. Wen, K. Zhou, J. Li, D. Wang, and X. You, ‘‘Uplink interference analysis of F-OFDM systems under non-ideal synchronization,’’ IEEE Trans. Veh. Technol., vol. 69, no. 12, pp. 15500–15517, Dec. 2020.

[4] S. Rajasekaran, M. Vameghestahbanati, M. Farsi, H. Yanikomeroglu, and H. Saeedi, ‘‘Resource allocation-based PAPR analysis in uplink SCMA-OFDM systems,’’ IEEE Access, vol. 7, pp. 162803–162817, 2019.

[5] Z. Zhou, L. Wang, and C. Hu, ‘‘Low-complexity PTS scheme for improving PAPR performance of OFDM systems,’’ IEEE Access, vol. 7, pp. 131986–131994, 2019.

[6] W. Hu, ‘‘SLM-based ACO-OFDM VLC system with low-complexity minimum amplitude difference decoder,’’ Electron. Lett, vol. 54, no. 3, pp. 141–146, 2018.

[7] Y. Hori and H. Ochiai, ‘‘A new uplink multiple access based on OFDM with low PAPR, low latency, and high reliability,’’ IEEE Trans. Commun., vol. 66, no. 5, pp. 1996–2008, May 2018.

[8] Ashna Kakkar, Sai Nitesh Garsha,Ojasvi Jain and Kritika, “Improvisation in BER and PAPR by using hybrid reduction techniques in MIMO-OFDM employing channel estimation techniques”, 7th International Advance Computing Conference, IEEE 2017.

[9] Ho-Lung Hung, Yung-Fa Huang, Ching-Chuan and Rung-Ching Chen, “Performance of PTS-Based Firefly Algorithm Scheme for PAPR Reduction in SFBC MIMO-OFDM Communication Systems”, International Symposium on Computer, Consumer and Control, IEEE 2016.

[10] P. Kothai and R. Prabhu M.E., “PAPR Reduction in MIMO OFDM Using Adaptive SLM Scheme”, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Vol. 03, No. 05, pp. 729-735, May 2015.

[11] Muhammet Nuri Seyman, Necmi Taspmar, "Channel estimation based on neural network in space time block coded MIMO-OFDM system", Digital Signal Processing, Vol. 23, No.1, pp. 275-280, Jan. 2013.

[12] P. Mukunthan and, P Dananjayan," PAPR Reduction based on a Modified PTS with Interleaving and Pulse Shaping method for STBC MIMO-OFDM System", IEEE ICCCNT'12 , 26th _28th July 2012, Coimbatore, India.

[13] L. Yang, K. K. Soo, S. li, and Y. M. SU, “PAPR Reduction Using Low Complexity PTS to Construct of OFDM Signals Without Side Information”, IEEE Transactions on Broadcasting, Vol. 57, No. 2, pp. 4532-4539, June 2011.

[14] Anushree Neogi and Abhijit Mitra “MAP Estimation of CFO and STO for a Convolutionally Coded OFDM System” National Conference on Communications (NCC), pp. 01-05, IEEE 2011.

[15] Chin-Liang Wang and Shun-Sheng Wang and Hsiao-Ling Chang, “A Low-Complexity SLM Based PAPR Reduction Scheme for SFBC MIMO-OFDM Systems”, 978-1-61284-254-7/11 IEEE 2011.