Improved pre coding scheme for PAPR minimization in MIMO OFDM communication system

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Abstract:

High-speed transmission across a dispersive communication channel is made possible by the multicarrier transmission technology, which is particularly appealing. One of the crucial problems to be solved while creating multicarrier transmission systems is the PAPR problem. We discussed PAPR reduction strategies for multicarrier transmission in this paper. The proposed method is found to be effective at lowering PAPR without sacrificing transmit signal strength, BER, or increasing computational complexity. This method is based on orthonormal beam forming weights precoded using MIMO OFDM data, together with optimized solution searching using a constant modulus approach. Applications for QPSK, 16QAM, and 64QAM modulations are displayed.

Keywords: CMA, OFDM, MIMO System, QAM.

1. Introduction:

Due to its suitability for high-speed wireless multiple access communication systems, OFDMA has recently received a lot of attention. All of OFDM's advantages remain when OFDMA takes over. Nonetheless, OFDMA likewise experiences similar defects as OFDM. Consequently, OFDMA also experiences significant PAPR. Because only a portion of each subcarrier in an OFDMA data block is demodulated by each user's receiver, several existing PAPR reduction methods that were initially developed for OFDM make downlink demodulation of OFDMA systems more challenging [6]. Each user must process the entire data block and then demodulate the allocated subcarriers to extract their own information if downlink PAPR reduction is achieved using OFDM-designed methods. As a result, the receiver of each user receives more processing. An explanation of the changes that an OFDMA downlink makes to PAPR reduction strategies can be found in the following sections. Because only some of the subcarriers in each data block are modulated by each user's transmitter, the PAPR issue for an OFDMA uplink transmission is not as severe as it would be for a downlink transmission. The capacity and efficiency of wireless communication systems can be enhanced by using multiple transmit and receive antennas. When compared to a single-input, single-output (SISO) system with flat Rayleigh fading or narrowband channels, it has been demonstrated that the system capacity can be increased by a factor of the minimum number of transmit and receive antennas in a MIMO system [7, 8]. To increase wideband channel capacity and reduce inter-symbol interference, OFDM and MIMO must be used together. Multicarrier transmission, also known as discrete multitone (DMT) or orthogonal frequency-division multiplexing (OFDM), is increasingly being used in wired and wireless applications. The increased interest in this method is primarily attributable to the recent advancements in computerized signal handling technology. Worldwide norms for OFDM-based high velocity remote correspondences have previously been created by the IEEE 802.11, IEEE 802.16, and ETSI Broadcast Radio Access Organization (Wheat) boards. Due to its improved resistance to multipath fading and impulsive noise, reduced requirement for equalizers, and effective hardware implementation through fast Fourier transform (FFT) methods, an OFDM-based system may be appealing for wireless applications. The high peak-to-average power ratio (PAPR) of the transmit signal is one of the main disadvantages of multicarrier transmission. At the point when the pinnacle communicate power is restricted by application or administrative limitations, multicarrier transmission's typical power is lower than that of steady power tweak plans. Multicarrier transmission loses range as a result. In a similar vein, the send power enhancer should be utilized in its original location (i.e., with a significant information backoff), where the power change is inefficient, in order to prevent extraterrestrial enhancement of the multicarrier signal as a result of bury tweak between subcarriers and out-of-band radiation. This could antagonistically impact the battery span of compact applications. A high PAPR may outweigh any potential advantages of multicarrier transmission systems in some low-cost applications. The PAPR problem has been dealt with in a variety of ways. Tone reservation (TR), tone injection (TI), active constellation extension (ACE), and tone injection (TI), as well as multiple signal representation methods like partial transmit sequence (PTS), selected mapping (SLM), and interleaving, are examples of these. Coding, amplitude clipping, clipping and filtering, and coding are also examples. Data rate loss, computational complexity, transmit signal power, etc. are undeniably worked on by these techniques. to reduce PAPR at the expense of other aspects. In fact, in addition to multicarrier transmission, the PAPR issue can arise in a variety of other situations. Most of the time, the PAPR doesn't have any problems when there are signs of consistent adequacy. However, dealing with signals whose PAPR is not constant is essential. Because it combines signals from multiple users, a DS-CDMA transmission, for instance, encounters the PAPR issue, particularly in the downlink.

2. Related Work:

Ruizhe Zhang and coauthors al. (In a wide band THz massive multiple information multiple result (MIMO) symmetrical recurrence division multiplexing (OFDM) framework with shaft squint, the precoding plan issue was looked at (2020) [1]. In the beginning, we plan two brand-new scant radio recurrence chain receiving wire structures—completely associated and subarray—for the system. By planning the combination simple/advanced precoding at the transmitter and the simple consolidate vector at the collector simultaneously, we create a normal rate boost problem in light of the planned construction.

To improve digit error rate (BER) execution in mixture beamforming frameworks, Seulgi Lee et al. (2020) [2] proposed a half breed precoding procedure based on different information different result symmetrical recurrence division multiplexing (MIMO-OFDM) framework. The full-advanced beamforming framework in OFDM looks better than the standard cross breed beamforming framework. The reenactment results demonstrate that the proposed conspiracy has a higher BER execution and normal aggregate rate than the conventional cross breed beamforming framework.

Hikaru Kawasaki and other et al. (2021) [3] proposed an emotional straight precoding strategy to identify serious issues. OFDM frameworks with high PAPR and high OOBE are two examples. Hypothetical scenarios demonstrate its sufficiency. The mathematical studies also show that the proposed method can achieve robust OOBE concealment while maintaining flawless BER execution regardless of transmission data transfer capacity. It is said that the exhibition orientation of the PAPR is the same as that of a typical DFT-s-OFDM. The proposed method has the advantage over the standard OFDM method in that it can simultaneously achieve a solid OOBE concealment of approximately 25 dB at band-edges.

Ku Hsin-Wen et al. al., (Precoding and joining calculations for the mm Wave MIMO-OFDM framework were introduced in 2021) [4]. The majority of the activities that use lattice reversal to register ideal precoders and combiners can be avoided. The wideband cross breed precoding and joining framework's high-throughput execution is therefore truly feasible in this way.

Stavros Domouchtsidis and coauthors al. (2021) [5]: An appropriate SLP arrangement and two MIMO-OFDM frameworks with the smallest bit DACs and ADCs were presented in this article. It was determined that the precoding configuration was a non-direct least squares problem that required division into two NP hard blended discrete perpetual obliged problems. An iterative calculation based on the CCD system was used to successfully resolve the issues.

3. Methodology:

The transmit signal model is created in a way that demonstrates WiMAX compatibility. We have only taken into consideration one block of time at this time to outline the intended work. Take into consideration a beam-generating weight matrix W(q), where q=1,, M, multiplied by a matrix D(q) in the q-th RB, to produce transmit sequences X(q) = W(q)HD(q). In a matrix X, where the Mt rows represent the N symbols that will be transmitted from the Mt antennas, they are compiled with guard intervals. The X can be written as:

$$\mathbf{X=W^{H}D}$$

where W is a block-diagonal matrix that also takes into account guard intervals. The geographical data in the frequency domain is represented by Matrix X. Time-domain MIMO-OFDM transmit data can be obtained by utilizing the IDFT of the beam generated data matrix X.

$$\mathbf{Y= XF^{H}=W^{H}DF^{H}}$$

where the IDFT matrix is labeled $\mathbf{F^{H}\varepsilon Є^{NxN}}$, and $\mathbf{Y\varepsilon Є^{MtxN}}$ contains the transmitted OFDM sequences for each M_t antenna. if $B=DF^{H}$ in the time-domain data matrix. The OFDM block with a beam formed then is

$$\mathbf{Y=W^{H}B}$$

The complete number of subcarriers Nt that will be sent by Mt recieving wires, and, which represents normal send power per test, are both characterized. Utilizing beamforming and the IDFT meaningfully affects the generally send power in the event that the pillar framing network W is considered orthonormal frameworks W(q).
The PAPR metric, which measures distortion caused by the OFDM signal's peak, is defined as:

$$\text{PAPR (Y)=}\frac{\alpha Nt||Vec(Y)||2}{||Vec(Y)||2}$$

With average power equal to the infinity norm, the constant modulus (CM) signal has the lowest PAPR. To convert the OFDM symbols in Y into a useful signal S with a lower PAPR, we constructed a prior matrix that ought to be a CM signal.
To meet the straightforwardness and low piece blunder prerequisites (q), we premultiply every RB, D(q), with an inclining scaling grid. The beneficiary sees this as a blurring channel impact. The scaling is only maintained for the phase in order to lower the BER. As a result, the transmit matrix for MIMO-OFDM takes the place of Y and is

$$\mathbf{S\text{-}\ W^{H}\Omega DF^{H}}$$

The PAPR reduction problem is to design ω as if we define W = Vecdiag (Ω).

$$\mathbf{Min||Vec(s)||^{2}\ s.t.||Vec(s)||^{2}=P}$$

where $P = \alpha N_t$ is a fixed total transmit power. Iteratively solving a series of quadratic convex subproblems was the optimization strategy used.

4. Result and Discussion:

In order to lower the PAPR prior to data transmission, this paper will examine the performance outcomes of precoding MIMO OFDM symbols with a constant modulus method. Methodology provides information on applied methods in depth. Utilizing the MATLAB 2010 application and MATLAB scripting instructions, the PAPR reduction algorithm was developed. The constructed simulation is used multiple times for various combinations of modulation methods and transmitting antenna counts.
The data is created in binary format and then modulated using QPSK, 16QAM, and 64QAM modulation techniques in a loop with ten iterations. For each modulation, the number of transmitting antennas varies from Mt=1, 2, and 3. in which the number of antennas is Mt. The algorithm returns SISO results when Mt equals one; However, MIMO OFDM results are produced when Mt = 2 or 3.
Following instances are constructed in this way for three distinct modulation types and three different numbers of antennas:

- CASE 1: QPSK Modulation-
    - (a) Mt=1 (b) Mt=2 and (c) Mt=3
- CASE 2: 16QAM Modulation-
    - (b) Mt=1 (b) Mt=2 and (c) Mt=3
- CASE 3: 64QAM Modulation-
    - (c) Mt=1 (b) Mt=2 and (c) Mt=3

The PAPR value is calculated for each of the aforementioned scenarios, both with and without the constant modulus algorithm-based precoding of MIMO OFDM signals. The plotting of the results can be found in the sections that follow.

4.1 Case 1: QPSK Modulation-based PAPR reduction performance analysis in MIMO OFDM:

By applying QPSK modulation to the binary data, random data was generated, and 1024-symbol blocks of OFDM were produced. We presented the results of error convergence for the CMA method iterations used to produce binary data with the lowest PAPR after QPSK modulation, when phase shifting makes the data more complex.

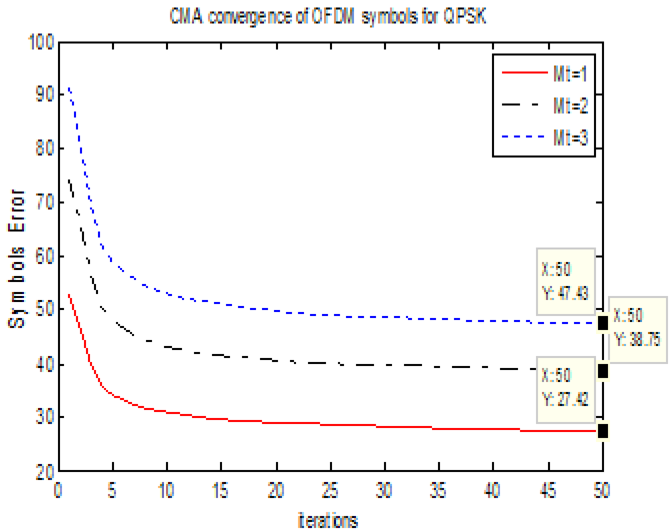

Fig. 1. Collective plots for the CMA algorithm's PAPR reduction using symbol error convergence for QPSK MIMO OFDM data transmission

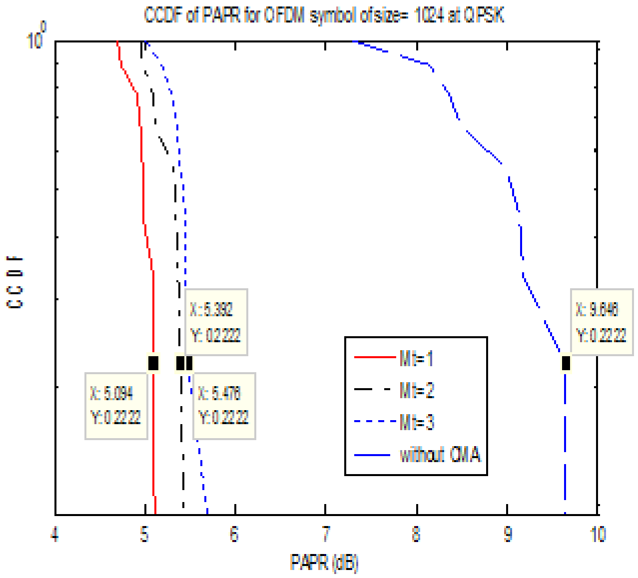

Fig. 2. Collective plots using the CMA algorithm to reduce PAPR for QPSK MIMO OFDM data transmission for CCDF vs. PAPR.

4.2 CASE 2: Using the 16QAM Tweak, a decrease in performance in MIMO OFDM was examined:

Using 16QAM modulation on the binary data, random data was generated, and 1024-symbol blocks of OFDM were produced. We have given the aftereffects of blunder combination respect to the emphasess participated in the CMA technique to create the information at most reduced PAPR following 16QAM tweak, where the twofold information becomes complicated because of stage moving.

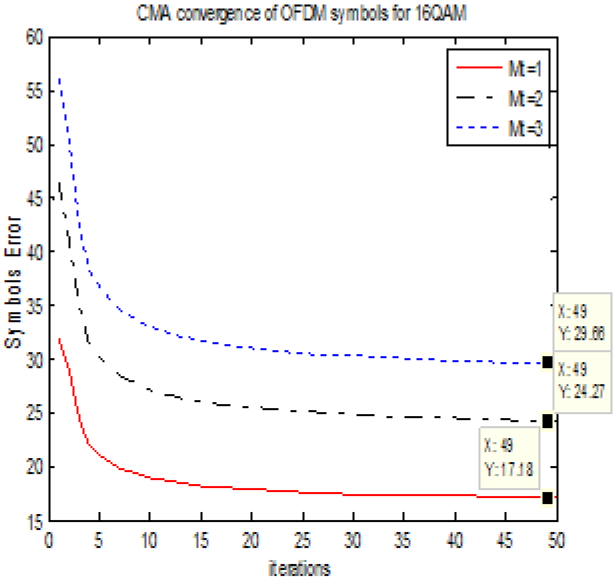

Fig. 3. Plots for the CMA algorithm's symbol error convergence and PAPR reduction for 16QAM MIMO OFDM data transmission.

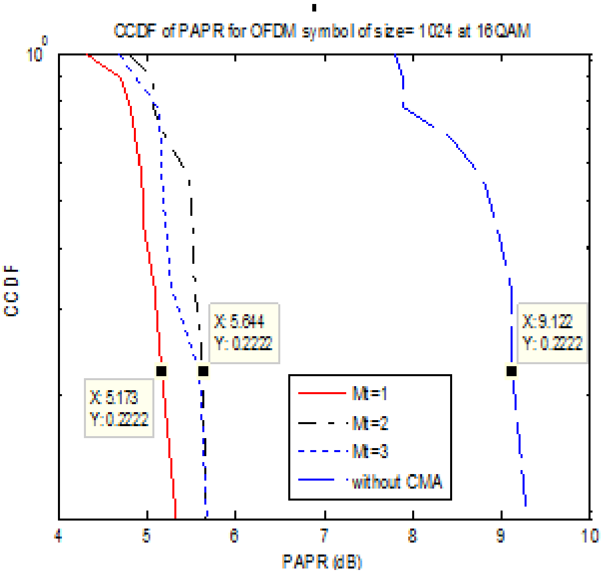

Fig. 4. Using the CMA algorithm to reduce PAPR for 16QAM MIMO OFDM data transmission, collective plots of CCDF versus PAPR.

4.3 CASE 3-PAPR decrease execution examination in MIMO OFDM utilizing 64QAM Balance:

Random data was generated in this instance, and 64QAM modulation of the binary data led to the production of OFDM blocks with 1024 symbols. After 64QAM modulation, phase shifting makes binary data more complicated, and we plotted the error convergence results in relation to the number of CMA algorithm iterations required to produce the lowest PAPR data after pre-coding the OFDM blocks..

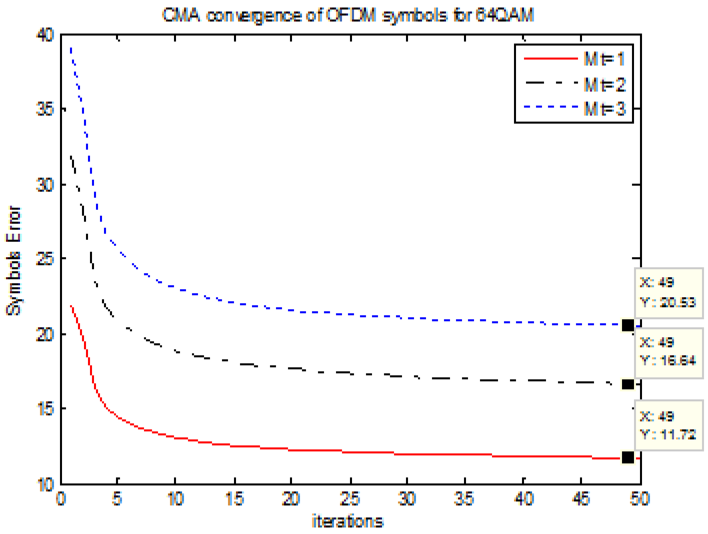

Fig. 5. Plots for the CMA algorithm's symbol error convergence and PAPR reduction for 64QAM MIMO OFDM data transmission.

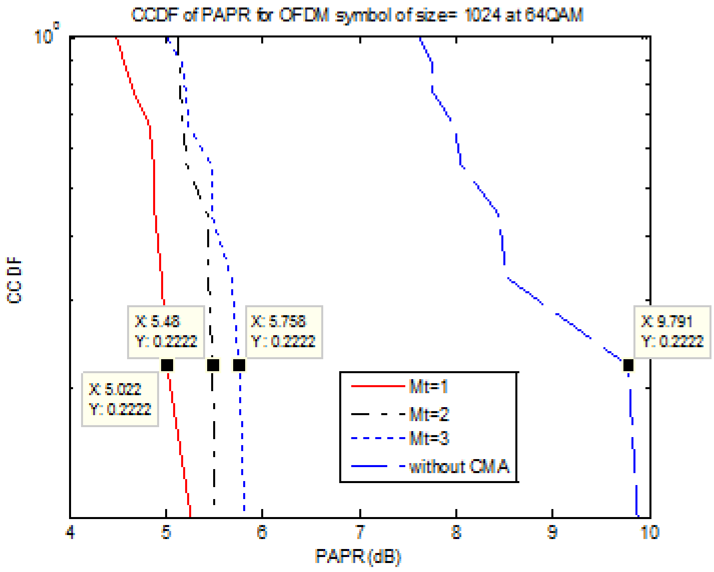

Fig. 6. Collective plots using the CMA algorithm to reduce PAPR for 16QAM MIMO OFDM data transmission for CCDF vs. PAPR.

Table 1. Recap the Output of the Proposed PAPR Reduction Technique's Results

Modulation	**QPSK**			**16 QAM**			**64 QAM**		
No. of Transmitter (MT)	1	2	3	1	2	3	1	2	3
PAPR Max	5.094	5.392	5.476	5.172	5.644	5.644	5.022	5.48	5.758

Symbolic Error	27.42	38.75	47.43	17.18	24.27	29.66	11.72	16.64	20.53

5. Conclusion:

We have created a PAPR reduction method based on pre coding that is specifically designed for multiuser MIMO systems. This research updates a sequential programming approach created in MATLB for the purpose of solving the amplitude optimization problem in PTS in MIMO-OFDM systems. For communication lines with high data rates and ten OFDM blocks containing 1024 symbols, the proposed method's computational complexity is demonstrated. The specifically designed method is extremely effective for a variety of continuous handling applications because the PAPR loads are evaluated iteratively for each OFDM information block. This cutting-edge PAPR decrease technique for MIMO-OFDM/An is created by utilizing a consistent modulus calculation (CMA) with two calculation configuration steps. In the initial step, time domain signals from multiple OFDMA resource blocks are linearly combined using pre-coding weights. The second step in lowering the signal PAPR is to optimize the pre-coding weights to reduce output signal modulus or amplitude flickers. The compatibility of this approach is evaluated using MIMO OFDM systems with QPSK, 16 QAM, and 64 QAM modulation schemes and a variety of transmitting antenna counts. This method is applicable to both MIMO and SISO systems at the same performance level because the lowered PAPR is observed in the range of 5.5 dB for MIMO systems and 5 dB for SISO systems. Furthermore, QPSK balance has been found to have the least image blunder.

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