



Optimization of Massive MIMO-OFDM Systems for PAPR Reduction

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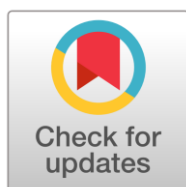
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Received: 13-06-2020

Accepted: 30-09-2020



Abstract: Of late there has been an increase in use of wireless communication system. The recent approach used is Massive-MIMO technology. But in the current scenario where spectrum is limited, the demand for high data degrades the quality of services. Therefore, OFDM system was proposed. Though coupling OFDM system with MIMO can further improve the performance of next generation wireless systems, there are certain issues like antenna design, channel estimation, PAPR etc. which requires due consideration. Amongst them, PAPR is the major problem that contributes high in performance degradation. To overcome this issue, Modified Firefly algorithm is used which was inspired the behaviour of fireflies. With the firefly algorithm, PAPR is highly reduced leading to better performance.

Keywords: Massive-MIMO-OFDM, PAPR, Firefly Optimization

1. Introduction

The communication and technology industry are going through turbulent times. Instead of simple voice calls of the past, now want the **3A's-Anything, Anywhere, Anytime** communication. This leads to the evolving of wireless communications. Wireless communication on simply wireless is the process of transferring information or power from one point to two or more points that are not connected physically by means of electrical conductors [1].

With the recent evolution of next generation networks, Massive-MIMO seems to be effective candidate for the prominent hassle-free communication. Massive MIMO deals with a greater number of low power antennas highly forecasting with OFDM concepts.

2. Mimo-OFDM

The MIMO have the numerous receiving

antennas transmitting the various signals and OFDM separates the different channels into sub channels for exact and rapid correspondence [2]. Because of this high unearthly proficiency, it is the reason for WLAN organizes versatile broadband correspondence [3]. The transmitter and receivers are utilized for performing beam forming and diversity actions. In the OFDM, numerous channels are isolated into various sub channels that are firmly separated for dependable correspondence [4]. This course of action wipes out most noteworthy issue in the MIMO-OFDM.

The MIMO-OFDM framework, receivers do not accurately decode the transmitted signals, because of the Inter Symbol Interference (ISI) [1]. The high rate information streams separated into low rate streams that are transmitted parallel in sub channels. Each subcarrier signals are isolated by guard bands,

for that message signals are not covered between them. Utilizing the channels at beneficiary end, the subcarriers are demodulated for isolating the frequency bands. On the off chance that one signal is meddled with resulting signals that lessens the unwavering quality of correspondence [3]. Due to the multipath spread, Inter Symbol Interference happens. The progressive signals are combined as a result of the nonlinear recurrence reaction of a channel. ISI has great impact on both transmitter and receiver ends [3, 5]. Bit error rate happens because of Inter Symbol Interference.

A. Guard Bands:

The ISI is expanded when the signal span is shorter in the high rate of information correspondence. Inter Symbol Interference is anticipated by the guard bands [3]. At the point when the guard interval is longer than delay spread, it does not produce overlapping of signals and do not leads to ISI [5].

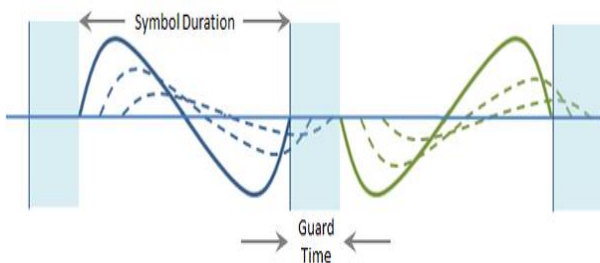


Fig 1. Guard interval between symbols

MIMO - OFDM decoders work at low SNR. The major drawback of OFDM is high PAPR of the transmitted signal [4]. The signal power gets large peaks, so that the amplifiers work at saturation region which prompts to signal distortion. Protect interim in guard interval is embedded in two ways. Those are zero padding and cyclic extensions. The cyclic extension is the cyclic prefix or cyclic suffix. The subcarrier for every client and each frame is contrastingly appointed.

a. Cyclic prefix

Delay dispersion additionally prompts to lost orthogonality between the subcarriers, and therefore to inter carrier interference (ICI) [1]. Fortunately, both these negative impacts can be disposed of by an extraordinary sort of watch interval, called the cyclic prefix. The accessible data transmission is devoured by cyclic prefix at low rate, which diminishes ghastly limit. This cyclic prefix reduces spectral efficiency.

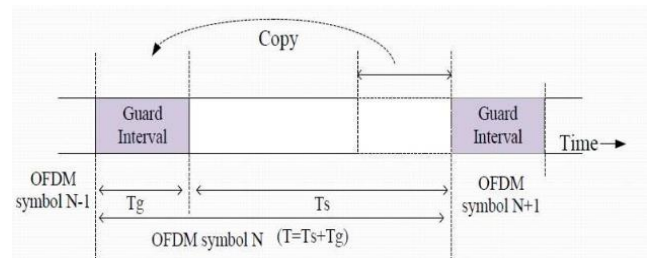


Fig 2. Insertion of cyclic prefix

b. Issues in MIMO-OFDM:

In current scenario where spectrum is limited, the demand for such high-speed data degrades the quality of the services. Hence, OFDM system was proposed in this literature to overcome the problem of limited spectrum. Also integrating OFDM system with MIMO can further improve the performance of upcoming generation wireless systems [1, 3]. More number of antennas are used at both transmitter and receiver side in MIMO system. This exploits spatial diversity. So, MIMO OFDM has been adopted as one of the most important techniques for upcoming mobile wireless systems [4].

However, there are few design issues/challenges while considering MIMO-OFDM system like, synchronization, Inter-Symbol- Interference (ISI), Inter- Carrier- Interference (ICI), Peak-to-Average-Power-Ratio (PAPR), etc. that requires due consideration [1].

c. Peak-to-Average Power Ratio (PAPR)

The PAPR of the signal, $x(t)$ is then given

as the proportion of the peak instantaneous energy to the normal power, composed as:

$$PAPR = \max_{0 \leq t \leq T} \frac{|x(t)|^2}{|E|x(t)|^2} \text{ ---- (1)}$$

Here,

$E [.]$ is the expectation factor.

$x(t)$ Amplitude of the complex pass-band signal.

PAPR is the proportion between the most extreme power and the normal force of the unpredictable pass band signals [1, 3]. In the OFDM framework with N subcarriers, the greatest power happens when the majority of the N subcarrier parts happen to be included with indistinguishable stages. We are regularly keen on finding the likelihood that the signal power is out of the straight scope of the HPA [4]. Towards this end, we first consider the dissemination of yield signs for IFFT in the OFDM framework. While the information signs of N-point IFFT have the autonomous and finite

sizes which are consistently appropriated for QPSK and QAM, we can accept that the genuine and nonexistent parts of the time-space complex OFDM signals have asymptotically Gaussian circulations for an adequately substantial number of subcarriers by as far as possible hypothesis [1].

3. Existing Models

A. PAPR Reduction Techniques:

PAPR reduction techniques are broadly classified into the distinctive methodologies [4]:

- Clipping and filtering
- Block coding
- Partial transmit sequence (PTS)
- Tone injection (TI) scheme
- Tone reservation (TR) scheme
- Selective mapping (SLM)
- Cross-Entropy (CE) method

Table 1. Comparison of Existing Techniques

Reduction Technique	Parameter			Operation required at Transmitter (TX)/Receiver (RX)
	Less Distortion	Power raise	Defeat data rate	
Clipping and Filtering	No	No	No	TX: Clipping RX: None
Block Coding	Yes	No	Yes	TX: Coding RX: Decoding
Partial Transmit Sequence (PTS)	Yes	No	Yes	TX: N times IDFTs operation RX: Side information extraction, inverse PTS
Tone Reservation (TR)	Yes	Yes	Yes	TX: Parallel to serial RX: Serial to parallel
Tone Injection (TI)	Yes	Yes	No	TX: N times IDFTs operation RX: N TIMES DFTs operation
Selective Mapping (SLM)	Yes	No	Yes	TX: N times IDFTs operation RX: Side information extraction, inverse SLM

B. Drawbacks:

Clipping causes in-band signal bending, bringing about BER execution corruption [6-10]. Clipping likewise causes out-of-band radiation, which forces out-of-band impedance signs to neighboring channels. Code blocking process is highly complexes because the entire process is performed using algebraic function [6]. This complexation affect the bandwidth efficiency. The PTS requires several Inverse Fast Fourier Transform (IFFT) operations are performed [8]. Selective mapping strategy is the overhead of side data that requires to be transmitted to the recipient of the framework keeping in mind the end goal to recover information [9, 11, 12].

4. Proposed Technique

A. Firefly Algorithm

The recent modern approach for optimization process in any technology for best solutions, firefly algorithm is engaged. This was formally developed by Dr. Xin She Yang in 2007 at university of Cambridge.

This was inspired by the behavior of fireflies. Any fireflies have unique flashing pattern. Usually female flies respond to the unique flashing pattern of the male flies. When the distance between the flies increases, the light intensity becomes weaker and weaker [13, 14]. This is more like a particle swarm intelligent. Their attractiveness is proportional to brightness and those both decreases as distance increases.

A. Purpose of flashing

- The main purposes of flashing are,
- Attract mating partners
 - Attract potential prey
 - Protective warning mechanism

B. working principle of fireflies

In a standard firefly algorithm, there are two important points to be considered. The

formulation of light intensity and the change of attractiveness. Suppose the light intensity I varies with the distance r and light absorption parameter γ exponentially and monotonically [15]. That is

$$I = I_0 e^{-\gamma r^2} \quad \text{----- (2)}$$

Firefly's light attractiveness β is

$$\beta = \beta_0 e^{-\gamma r^2} \quad \text{----- (3)}$$

The distance between two fireflies i and j , at position d_i and d_j can be calculated as,

$$r_{ij} = d_i - d_j \quad \text{----- (4)}$$

$$d_i = d_i + \beta_0 e^{-\gamma^2 r_{ij}^2} (d_i - d_j) + \alpha (\text{rand} - 1/2) \quad \text{----- (5)}$$

The flow of proposed work can be represented in the following figure. 3

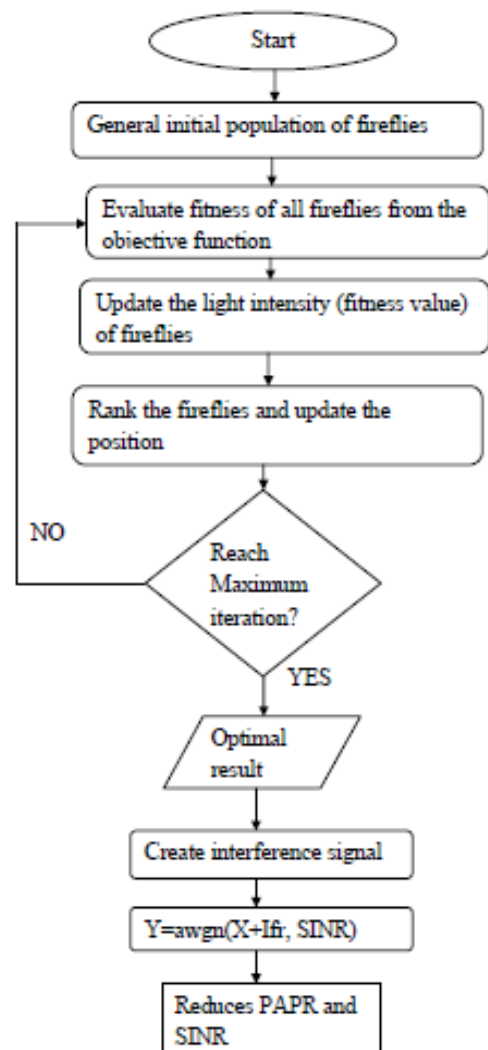


Fig 3. Flowchart of Proposed work

Symbols on FFT are performed to form frames and basic scatter plot is shown in figure 4.

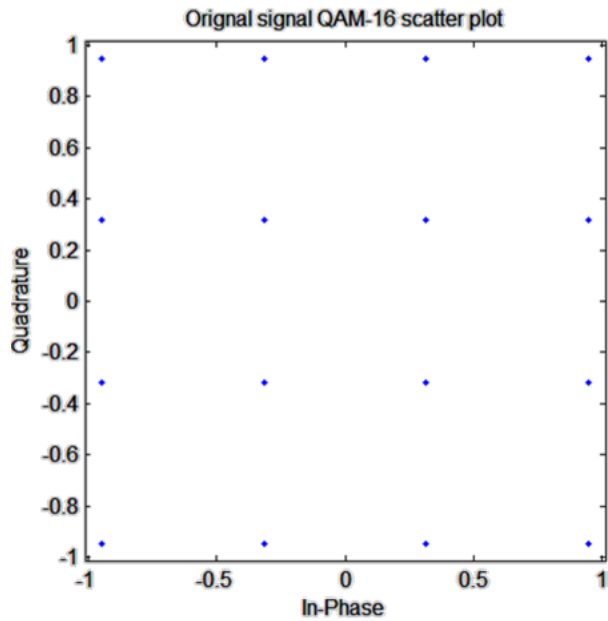


Fig 4. Scatter Plot of 16-QAM

Symbols on FFT are performed to form frames. White Gaussian noise added with the transmitted symbols that is shown in fig 5. Signal is formed as symbols in transmitting medium. N times IFFT is performed.

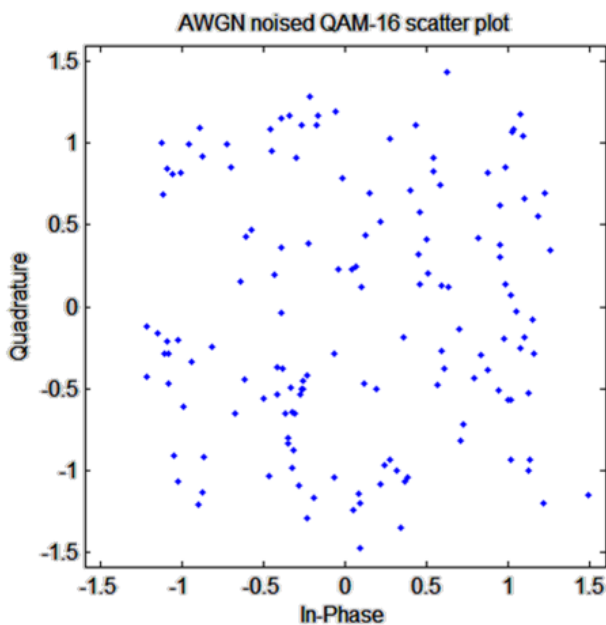


Fig 5. QAM-16 scatter plot with noised samples

Population of firefly to be optimized using Resen brock objective function.

Fitness Function was calculated using,

$$PS_i = \frac{fv_i}{\sum_{i=1}^N fv_i} \quad \text{----- (6)}$$

Fitness function is calculated for different noise variance. And it is represented as D=1,2,3..., depicted in fig.6

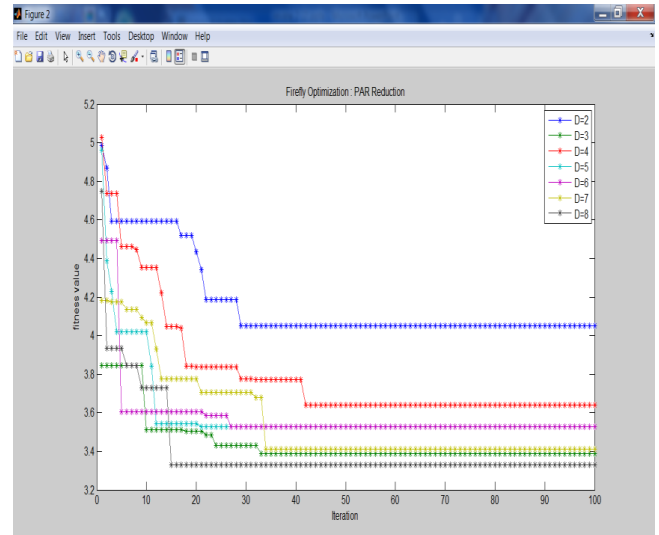


Fig 6. Fitness function optimization for various noise variance

After the optimization process, the reduction in PAPR with respect to fitness function is depicted in fig.7

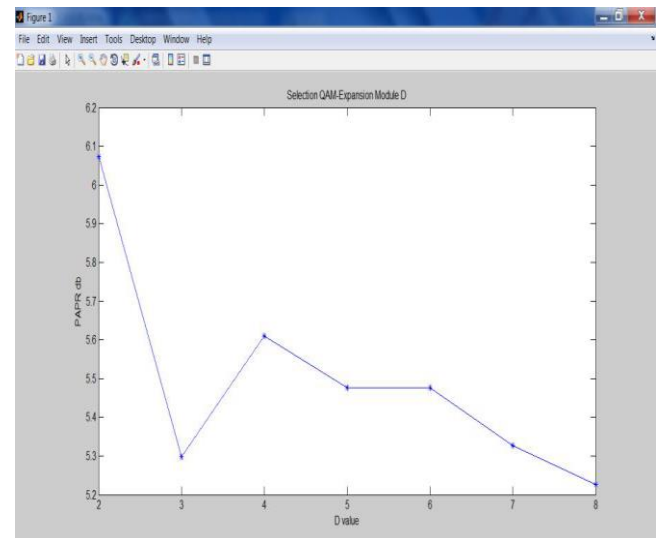


Fig 7. PAPR for QAM-Expansion module

As seen from the results and discussion, PAPR can be reduced with help of optimization using firefly algorithm. Impact of firefly optimization has been retrieved using the fitness function, represented in eqn.6. To test the performance of the proposed algorithm,

computational algorithms were carried. It is important to select α and γ appropriately for good PAPR reduction.

5. Results and Discussion

Compared to the existing scheme, firefly algorithm contributes more in PAPR reduction. We compare our algorithm with various existing algorithms in terms of cumulative distributive function. Results and discussion show that firefly optimization algorithm works better for reducing PAPR in Massive-MIMO system.

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