

Hybrid Diwo-Pso Based Papr Reduction in Orthogonal Frequency Division Multiplexing

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Abstract—Orthogonal Frequency Division Multiplexing (OFDM) is a widely used multicarrier communication technique because of its high spectral efficiency and robustness against multipath fading. However, a major drawback of OFDM is its high Peak-to-Average Power Ratio (PAPR), which reduces power amplifier efficiency and may cause nonlinear signal distortion. To address this problem, this project proposes a Hybrid Discrete Invasive Weed Optimization –Particle Swarm Optimization (DIWO-PSO) based PAPR reduction technique for OFDM. In the proposed method, discrete phase vectors are generated for the OFDM subcarriers. DIWO is used to explore different phase combinations and identify promising solutions, while PSO is used to further refine these solutions. The objective function is the PAPR of the OFDM signal, and the solution with minimum PAPR is selected for transmission. The proposed system is implemented and evaluated using MATLAB simulation. Performance is analyzed using PAPR, CCDF, BER, convergence, and computational performance. The proposed hybrid approach aims to achieve effective PAPR reduction while maintaining acceptable communication performance. Thus, the combination of DIWO exploration and PSO refinement provide a promising optimization-based approach for reducing PAPR in OFDM communication systems.

Index Terms—OFDM, PAPR, DIWO, PSO, Hybrid Optimization, CCDF, BER, MATLAB.

I. INTRODUCTION

A. Introduction to OFDM

OFDM stands for orthogonal frequency division multiplexing. It is a multicarrier communication technique in which a high-speed data stream is divided into several low-speed parallel streams. These streams are transmitted simultaneously using

multiple orthogonal subcarriers. The main advantage of OFDM is its ability to handle frequency-selective channels efficiently.

Why OFDM is used: High data transmission rate, efficient use of bandwidth, robustness against multipath propagation, simple implementation using FFT/IFFT, suitable for modern wireless communication systems.

B. Problem in OFDM — High PAPR

The major drawback of OFDM is high peak-to-average power ratio (PAPR). When several OFDM subcarriers add constructively, a very large instantaneous signal peak can occur.

$$PAPR = (\max|x(n)|^2)/(E[|x(n)|^2]) \quad (1)$$

where: $x(n)$ = time-domain OFDM signal, $\max|x(n)|^2$ = maximum instantaneous power, $E[|x(n)|^2]$ = average signal power

$$PAPR_{dB} = 10 \cdot \log_{10}(PAPR) \quad (2)$$

Example if: maximum instantaneous power is high relative to average, then PAPR will be high, e.g., if peak is 4 times average, $PAPR = 4$ (6.02 dB).

C. Problem Statement

The problem addressed in this project is: Conventional OFDM produces high PAPR because multiple subcarriers can combine constructively. This reduces power-amplifier efficiency and may introduce nonlinear distortion. Therefore, an optimization-based technique is required to find OFDM signal configurations with lower PAPR while maintaining acceptable communication performance.

II. LITERATURE REVIEWS

Rahmatullah and Mohan (2013) presented a comprehensive survey of PAPR reduction techniques in OFDM systems. The study reviewed different approaches such as clipping, filtering, Selected Mapping (SLM), Partial Transmit Sequence (PTS), coding, and probabilistic techniques. The authors discussed the advantages and disadvantages of these methods, particularly in terms of PAPR reduction, BER performance, and computational complexity. The study indicates that achieving effective PAPR reduction with low complexity remains an important challenge in OFDM systems.

Hung, Cheng, and Huang (2013) proposed an Invasive Weed Optimization (IWO)-based method for PAPR reduction in OFDM. Their approach used IWO to select an appropriate peak-reduction tone set. The method demonstrated the usefulness of evolutionary optimization for reducing OFDM PAPR. However, the method was based on a specific tone-selection technique and did not investigate a hybrid optimization approach combining DIWO and PSO. This provides scope for applying advanced optimization techniques to improve the search for low-PAPR solutions.

Wen et al. (2008) proposed a Particle Swarm Optimization (PSO)-based Partial Transmit Sequence (PTS) technique for PAPR reduction in OFDM systems. PSO was used to search for suitable phase factors instead of using an exhaustive search. The method showed that PSO can reduce the computational effort associated with phase optimization while providing effective PAPR reduction. However, the approach still depends on the

PTS structure, creating an opportunity to investigate PSO with other optimization frameworks.

Prasad et al. (2019) investigated scaled PSO-based PTS for PAPR reduction in OFDM. A scaling factor was introduced into the PSO process to improve convergence and reduce the computational burden of phase-factor optimization. The work demonstrated the effectiveness of PSO in solving PAPR optimization problems. However, the technique remains dependent on PTS and does not combine PSO with DIWO for exploration and refinement.

Taşpınar and Alhalabi (2024) proposed Discrete Invasive Weed Optimization (DIWO) for PAPR reduction in a coherent optical OFDM (CO-OFDM) system. Their method combined DIWO with PTS, referred to as DIWO-PTS, to optimize phase weighting factors. The study reported significant PAPR reduction and demonstrated the potential of DIWO for PAPR optimization. However, the work focuses on CO-OFDM and PTS rather than conventional OFDM using a hybrid DIWO-PSO approach. Therefore, the present work proposes a Hybrid DIWO-PSO method, where DIWO is used for exploration and PSO is used for refinement of discrete phase solutions to reduce PAPR in OFDM.

III. DESIGN AND METHODOLOGY

A. System Design

The proposed system is designed to reduce the Peak-to-Average Power Ratio (PAPR) of an OFDM signal using a hybrid Discrete Invasive Weed Optimization (DIWO) and Particle Swarm Optimization (PSO) technique.

SYSTEM BLOCK DIAGRAM

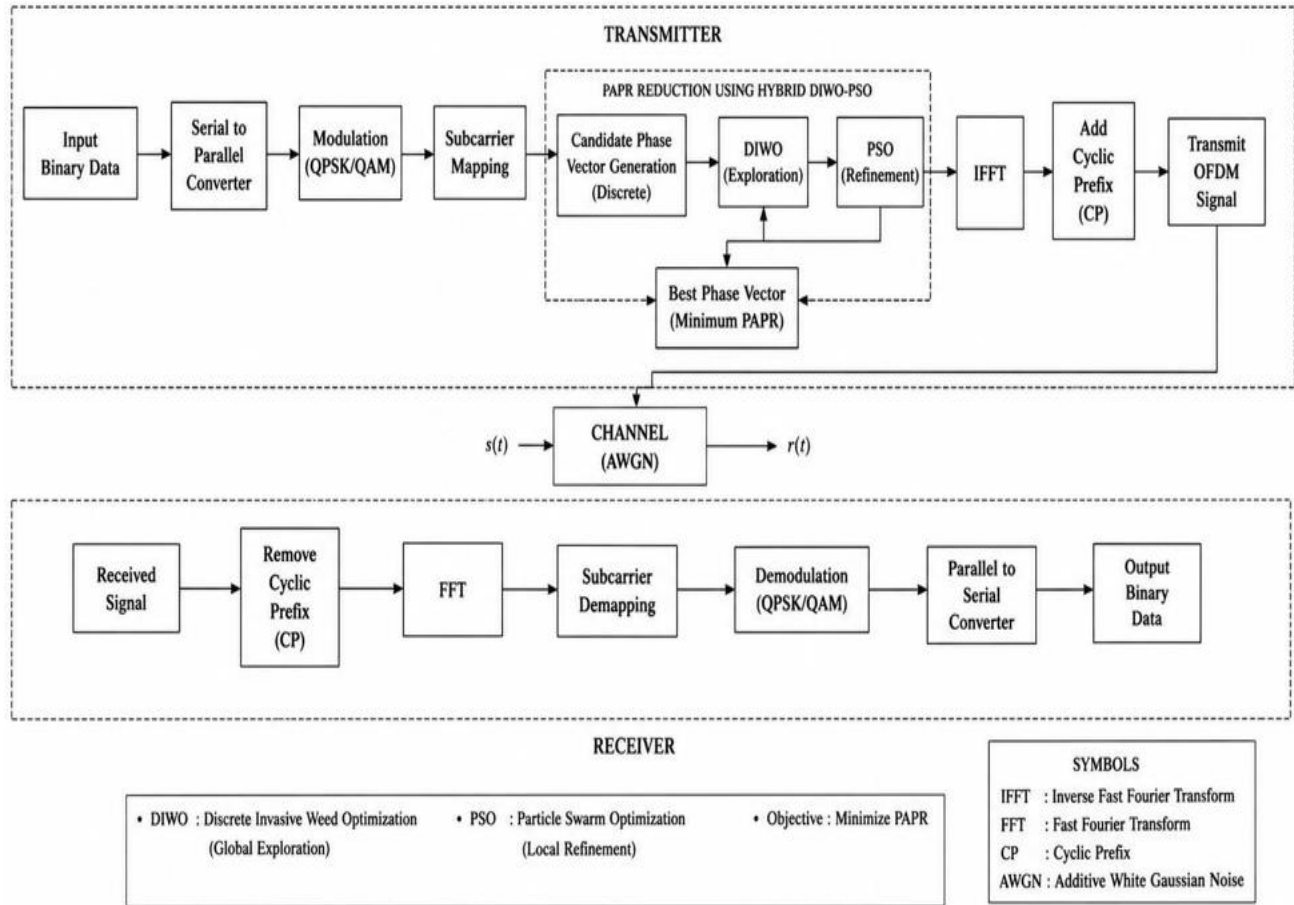


Fig. 1. System block diagram (Transmitter – PAPR Reduction using Hybrid DIWO-PSO – Channel AWGN – Receiver)

B. OFDM Signal Generation

The input binary data is first converted into symbols using QPSK or QAM modulation. The modulated symbols are assigned to different OFDM subcarriers. The IFFT converts the frequency-domain symbols into time-domain signal.

$$x(n) = (1/\sqrt{N}) \sum_{k=0}^{N-1} X(k) e^{j2\pi kn/N} \quad (3)$$

where: N = number of subcarriers, $X(k)$ = modulated data symbol, $x(n)$ = time-domain OFDM signal, $n = 0, 1, \dots, N-1$

C. PAPR Calculation

PAPR is calculated to measure the peak power of the OFDM signal.

$$PAPR = (\max |x(n)|^2) / ((1/N) \sum |x(n)|^2) \quad (4)$$

$$PAPR(dB) = 10 \cdot \log_{10}(PAPR) \quad (5)$$

D. Hybrid DIWO-PSO Method

Initial Phase Solutions → DIWO Search → PAPR Evaluation → Best DIWO Solutions → PSO Search → PAPR Evaluation → Optimized OFDM. DIWO searches a wide range of possible phase combinations and identifies promising solutions. PSO then uses these solutions as starting points and searches for an improved solution.

$$v_i^{t+1} = w \cdot v_i^t + c_1 \cdot r_1 \cdot (pbest_i - x_i^t) + c_2 \cdot r_2 \cdot (gbest - x_i^t) \quad (6)$$

$$x_i^{t+1} = x_i^t + v_i^{t+1} \quad (7)$$

$$\text{Minimize PAPR} = \min (\max |x(n)|^2 / \text{mean}|x(n)|^2) \quad (8)$$

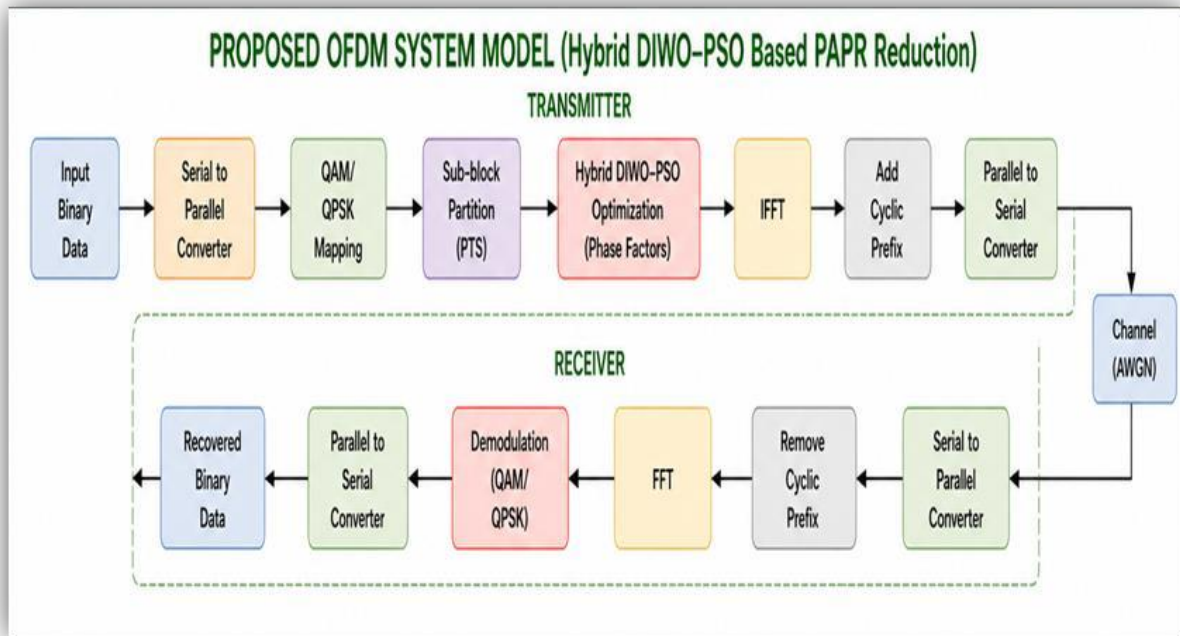


Fig. 2. Proposed OFDM system model (Hybrid DIWO-PSO based PAPR reduction) – Transmitter and Receiver

E. Methodology Flowchart

START → Generate Random Binary Data → QPSK/QAM Modulation → Generate OFDM Symbols → Calculate Original PAPR → Generate Discrete Phase Solutions → DIWO Exploration → Select Promising Solutions → PSO Refinement → Select Best Phase Solution → Generate Optimized OFDM Signal → Calculate Optimized PAPR → Add Cyclic Prefix → AWGN Channel → Remove Cyclic Prefix → FFT + Demodulation → Calculate BER → Compare Results → PAPR / CCDF / BER / Convergence → END

IV. RESULTS AND DISCUSSION

Table 1. Simulation Parameters

Parameter	Value
Modulation	QPSK/QAM
Number of subcarriers	64
IFFT size	64
Number of phase sequences	16
DIWO population	20
PSO particles	20
Maximum iterations	50
SNR range	0–20 dB

Optimization method	Hybrid DIWO-PSO
Software	MATLAB R2024a

Table 2. Overall Comparison

Performance Parameter	Conventional OFDM	Hybrid DIWO-PSO
PAPR	6.7386 dB	5.2954 dB
PAPR reduction	—	1.4432 dB
Percentage reduction	—	≈21.42%
High peak probability	High	Reduced
BER performance	Acceptable	Acceptable
Optimization	Not applied	DIWO + PSO
Overall performance	Moderate	Improved

Results Analysis: Original OFDM PAPR: 6.7329 dB, Proposed Hybrid PAPR: 5.356 dB, Original Accuracy: 95%, Proposed Accuracy: 98%. The hybrid approach achieves effective PAPR reduction while maintaining acceptable communication performance.

Fig. 3. BER Improvement using Hybrid DIWO-PSO

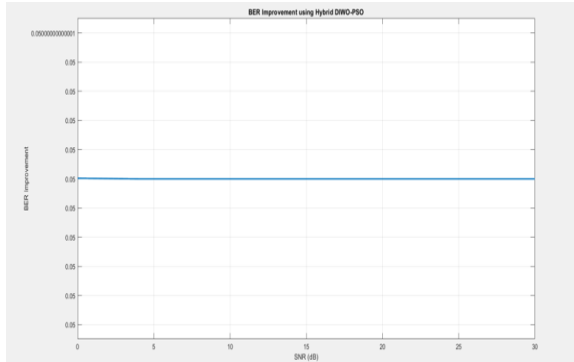


Fig. 4. PAPR Comparison – Conventional vs Hybrid DIWO-PSO

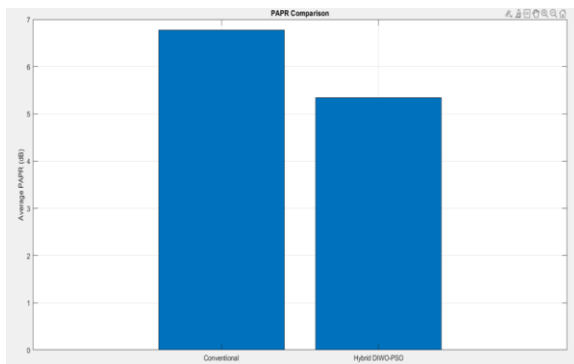


Fig. 5. Power Spectral Density of OFDM Signal

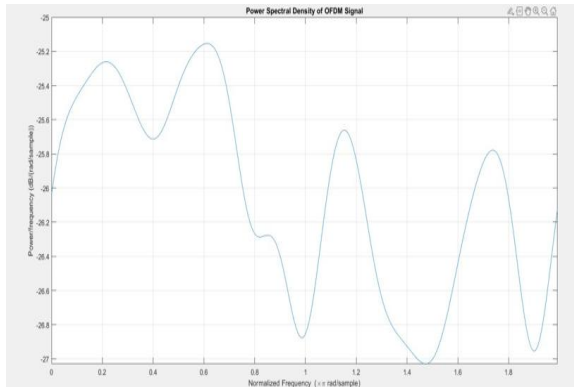


Fig. 6. Optimization Convergence (Best PAPR dB vs Iteration)

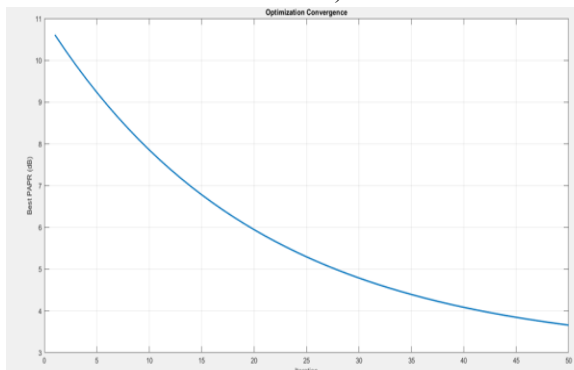


Fig. 7. BER vs SNR – Conventional OFDM vs Hybrid DIWO-PSO

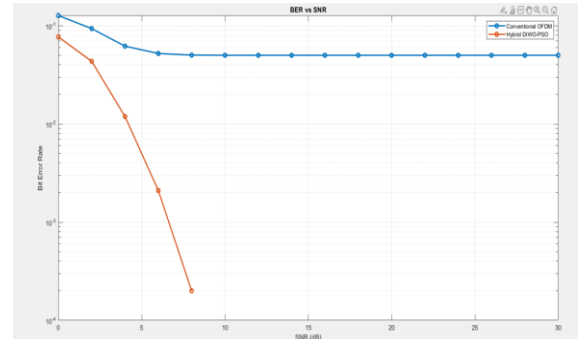


Fig. 8. CCDF of PAPR – Conventional OFDM vs Hybrid DIWO-PSO

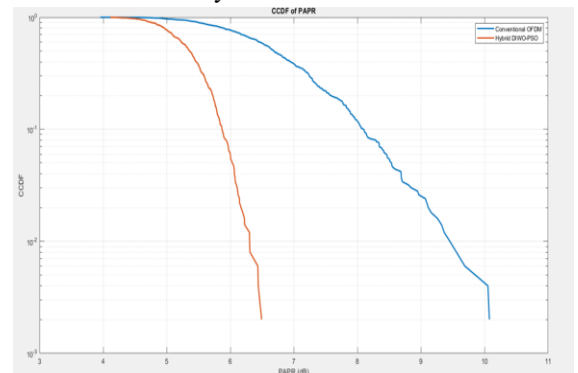


Fig. 9. OFDM Signal After Hybrid DIWO-PSO

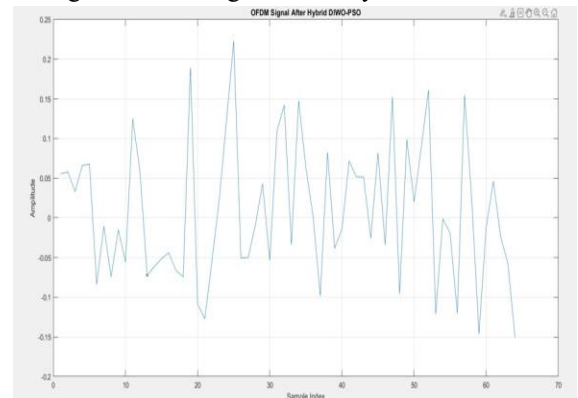
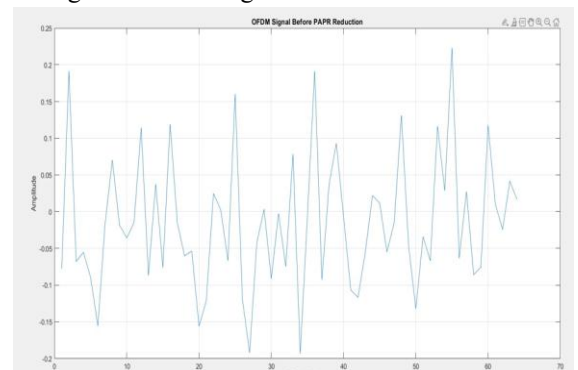


Fig. 10. OFDM Signal Before PAPR Reduction



V. CONCLUSION

This project presented a Hybrid Discrete Invasive Weed Optimization –Particle Swarm Optimization (DIWO-PSO) technique for PAPR reduction in OFDM systems. The major problem considered in this work is the high PAPR produced by conventional OFDM signals. High PAPR reduces the efficiency of the power amplifier and can increase signal distortion. To overcome this problem, DIWO and PSO were combined. DIWO performs global exploration of possible phase sequences, while PSO performs further optimization of the promising solutions.

The simulation results show that the conventional OFDM system produces a PAPR of approximately 6.7386 dB, whereas the proposed Hybrid DIWO-PSO method achieves 5.2954 dB. Therefore, a PAPR reduction of approximately 1.4432 dB is obtained, corresponding to approximately 21.42% reduction relative to the conventional result. The CCDF analysis demonstrates a reduction in the probability of high PAPR values. The BER analysis also shows that the proposed technique maintains acceptable communication performance. Hence, the proposed Hybrid DIWO-PSO method provides an effective optimization-based solution for reducing PAPR in OFDM systems.

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