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# ANALYSIS OF PAPR REDUCTION IN MIMO- OFDM SYSTEM BY USING PTS AND DCT

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**ABSTRACT**

Multiple-Input Multiple-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) is awell-defined method which has acquiredremarkable interests as aupcoming candidate for the new Generation wireless communication systems. However, though it has many advantages, the major disadvantages of MIMO-OFDM is its high peak to average power ratio (PAPR). In this paper, we are analysing the MIMO-OFDM Systems in different methods to minimize Peak Average Power Ratio. An OFDM system is used as multicarrier digital modulation techniques in most of the communications and wireless applications. The huge peak to average power (PAPR) ratio is the major demerit in OFDM Systems and many different methods have been proposed in earlier days. Here we are proposing a new method by combining the modified PTS and Discrete Cosine Transformation (DCT) in a single system. The design approach is so flexible and no loss in data rate.

**Keywords** MIMO-OFDM; peak-to-average Power Ratio (PAPR); Partial Transmit Sequences (PTS); Discrete Cosine Transform (DCT).

## I. INTRODUCTION

The Multi Input Multi Output orthogonal frequency division multiplexing (MIMO-OFDM) has acquired a notable interest as anencouraging candidate for the upcoming Generation wireless communication systems. Along with the simplicity of equalization in Orthogonal Frequency Division Multiplexing (OFDM) modulation, it combines the capacity and diversity gain of MIMO systems for better performance. Using wireless multipath fading channels high bandwidth efficiency can be achieved [1, 2]. To enhance the performance of link reliability and data rates,MIMO systems uses many transmitting and receiving antennas. To enhance the coverage area link reliability is calculated with the help of transmitting and receiving antenna diversity[3]. Using spatial multiplexing high data rates multiplexing[4] is achieved, where individual data bits are transmitted in parallel over different transmitting antennas. OFDM has been newly accepted for many systems such as American IEEE802.11, the European equivalent HiperLan/2, digital video and audio broadcasting. OFDM is a MCM transmission technique, which splits the accessible spectrum into multiple carriers, individually being modulated by a less rate data stream. For high speed transmission OFDM is very much suitable because of its advantages such as robustness in frequency selective fading streams, managing multipath fading effects, more spectral efficiency and ease design of transmitter. But OFDM has a demerit of huge PAPR which makes the power amplifier to work in nonlinear region and which makes more complicated design of data convertors. Apart from this due to high peaks power amplifiers will be saturated which in turn leads to increase the inter modulation products which makes distortion in out of band. Like OFDM, even MIMO-OFDM has a same drawback i.e., high PAPR. Hence, to minimise the PAPR high dynamic range amplifier is suitable, but it increases the cost of the system and reduces efficiency. Several methods have been implemented and proposed in order to minimise the peak average power. Some of these methods are based on phase sequencing and Partial Transmit Sequence (PTS)[6, 7, 8] and Selected Mapping (SLM)[8, 9, 10]. Some others methods which will not require side information such as clipping and filtering[11, 12, 13], tone

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reservation[14, 15], block coding[16], and ACE [17]. In this paper, we analyse the combination of PTS method with DCT and WPT for MIMO-OFDM systems. For the proposed scheme, the PTS method is applied for individual transmitting antenna. With the help of CCDF distribution the PAPR can be determined of the MIMO-OFDM systems, the chosen parameters must have less PAPR for individual transmitting antenna.

## II. OFDM SYSTEM

The general structure of OFDM is shown in the Figure 1. It includes Transmitter, Channel and Receiver. A detailed explanation of each is given below.

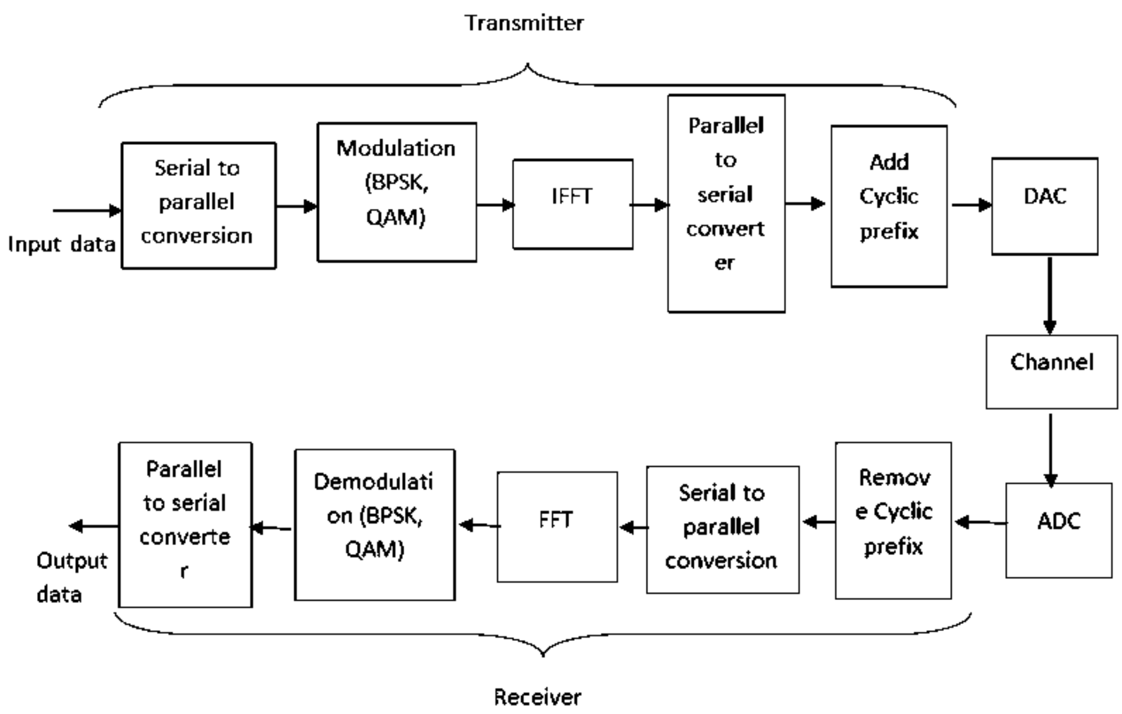


**Figure 1 General block diagram of OFDM**

### A. OFDM Transmitter

The transmitter consists of serial to parallel converter, modulation technique, IFFT of N-point, p/s converter, cyclic prefix adder, analog to digital converter. The function of each block is explained below.

The function of S/P block is to convert the incoming serial input data into 'n' bits N analogous data. The output of this block is provided to the modulation block. The function of the modulation is to map the incoming data into the complex values constellation such as BPSK, QAM. In BPSK there are two possible phases and hence one bit of information in conveyed in each slot. The function of IFFT is to convert the frequency domain signal into a time domain signal. The output of the modulator is fed to the Inverse Fourier Fast Transform, N similar data is converted into a time domain signal.

Once the signal is reconstructed into time domain then the signal is transformed into serial pattern. In between the two successive OFDM symbol a cyclic prefix is appended as a guard interval in order to avoid inter symbol interference. Then the data is converted into analog data and transmitted to channel.

### B. Different Types of channel

The communication in between the receiver and transmitter is through the channel. In communication network there is wired and wireless communication channel. Here the different types of wireless channels are described.

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**AWGN Channel**

The acronym of AWGN is Additive White Gaussian noise channel. This channel is a simple medium in wireless digital communication system. It is a constant addition of white noise with anidentical spectral density. The analytical expression of the AWGN channel isrepresented in equation (1.1)

$$R(t) = X(t) + N(t) \tag{1.1}$$

where

X(t) is signal transmitted

N(t) is background noise

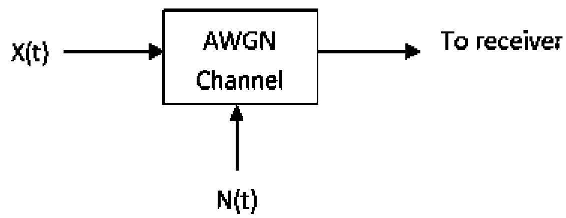


**Figure 2 structure of AWGN model**

Figure 2 depicts the input output structure of AWGN channel. AWGN channel is a benchmark for comparison of theefficiency evaluation of wireless communication system. This channel is suitable for satellite communication. It is not benefited for earthbound links where interference and multipath are not taken into account. [5] discussed about Improved Particle Swarm Optimization. The fuzzy filter based on particle swarm optimization is used to remove the high density image impulse noise, which occur during the transmission, data acquisition and processing. The proposed system has a fuzzy filter which has the parallel fuzzy inference mechanism, fuzzy mean process, and a fuzzy composition process. In particular, by using no-reference Q metric, the particle swarm optimization learning is sufficient to optimize the parameter necessitated by the particle swarm optimization based fuzzy filter, therefore the proposed fuzzy filter can cope with particle situation where the assumption of existence of “ground-truth” reference does not hold. The merging of the particle swarm optimization with the fuzzy filter helps to build an auto tuning mechanism for the fuzzy filter without any prior knowledge regarding the noise and the true image. Thus the reference measures are not need for removing the noise and in restoring the image. The final output image (Restored image) confirm that the fuzzy filter based on particle swarm optimization attain the excellent quality of restored images in term of peak signal-to-noise ratio, mean absolute error and mean square error even when the noise rate is above 0.5 and without having any reference measures.

**Rayleigh fading channel**

When a signal is transmitted and received over a multipath propagation phenomenon channel. The multipath droop happens because of ionospheric effects, and hindrance such as towers, mountain and buildings. This channel uses a Rayleigh distribution function which helps to models the droop effects of propagation medium on a transmitted signal.

**C. OFDM Receiver**

The reverse procedure is done at the receiver of OFDM. The analog data is converted into digital, form which the guard interval is removed. These unguarded OFDM symbol is converted into a N parallel symbols. Each symbol is given to FFT block which converts the symbol into a frequency domain.

The FFT output is expressed as given in equation (1.2)

$$X(k) = F(k)x(k) + w(k), \ \ for \ \ 0 \leq k \leq N-1 \tag{1.2}$$

Where
w(k) – noise component of channel in frequency domain
F(k) – FFT which can be written as in equation (1.3)

$$F(k) = \frac{1}{\sqrt{N}} \sum_{l=0}^{L-1} h_l e^{\frac{j2\pi kn}{N}}, \quad k = 0,1, \dots\dots, N-1 \qquad (1.3)$$

The symbol x(k) is recovered back and demodulated using BPSK or QAM and converted into a serial pattern.

**Peak Average Power Ratio (PAPR)**

Any multi carrier modulation signal is the summation of large number of independent and orthogonal signals. So, the envelope of the multi carrier signal change enormously. This fluctuation is determined by the proportion of the high value of multi carrier signal to the mid value of the multi carrier signal and is named as peak-to-average-power-ratio (PAPR).

Let us assume the data bits be Xn where the value of n sweeps from 0 to N-1. N is the length sub-carriers of this modulation system. Hence the concurrent block of required data of OFDM signal creation is given by equation (1.4)

$$X = [X_0, X_1, \dots\dots\dots., X_{N-1}] \qquad (1.4)$$

Hence the OFDM complex base band signal is depicted in equation (1.5)

$$X(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi n\Delta f t}, 0 \le t \le NT \qquad (1.5)$$

where$\Delta f$ is the subcarrier spacing
T is the period for symbol.

For the above signal, the PAPR can be given as follows:

$$\mathrm{PAPR} = \frac{\max_{0\le t\le NT}[|x(t)|^2]}{1/NT \int_0^{NT} |x(t)|^2 dt} \qquad (1.6)$$

where x(t) is input signal.

The peak average power is a crucial parameter which decreases the behaviour of power RF amplifier in wireless communication system. If the average power is less than the RF power amplifier operates in an efficient way else there is a large back off in linear amplification of the signal. This in turn introduces a non-linearity in the high-RF power amplifier which degrades BER. In order to keep the high-power amplifier in a linear region is done by many algorithms like removal of envelop and reconstruction, Cartesian feedback method, feed forward method, linear amplification using nonlinear devices [15-17]. Above method makes the amplifier to work in linear region, which gives a better performance.

## III. PARAMETERS THAT INFLUENCE THE PAPR

**A. Number of sub-carriers (N) in OFDM system:** Number of sub-carriers is directly proportional to PAPR. As number of subcarrier increases PAPR also increases and decreases when sub carrier reduces at the same time code rate also decreases.

**B. Modulation techniques:** PAPR is linearly dependent on constellation used in modulation techniques.

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## IV. DISTRIBUTION OF PAPR

The PAPR has a random probability distribution which can be manifest interms of Complementary Cumulative Distribution Function (CCDF). The performance of the PAPR is measured using cumulative distribution of PAPR of OFDM signal. The Cumulative Distribution Function (CDF) is basic method usedto calculate thePAPR reduction [18]. This function of a given signal is represented written in equation (1.7)

$$F(z) = 1 - \exp(z) \quad (1.7)$$

where z is a magnitude of complex samples.

The CCDF is given in equation (1.8)

$$P(PAPR > z) = 1 - P(PAPR > z)$$
$$= 1 - (F(z))^N$$
$$= 1 - (1 - exp(-z^N)) \quad (1.8)$$

## V. PARTIAL TRANSMIT SEQUENCE

In OFDM the dominating probabilistic established PAPR reduction method is Partial Transmit Sequence (PTS). The structure of this method is shown in Figure 3. In this procedure the original data X is splitted into N sub group. In each sub-group the sub carriers are added by a phase factor. The assortment of phase factors helps the PAPR is minimised.

The splitted incoming data X is given in equation (1.9)

$$X^{(m)} = [X_0^{(m)}, X_1^{(m)}, X_2^{(m)}, \ldots\ldots\ldots\ldots X_{N-1}^{(m)}] \quad (1.9)$$

m = 1, 2, ……….., M

The addition of the sub groups is the original signal, which is represented in equation (1.10)

$$X = \sum_{m=1}^{M} X^{(m)} \quad (1.10)$$

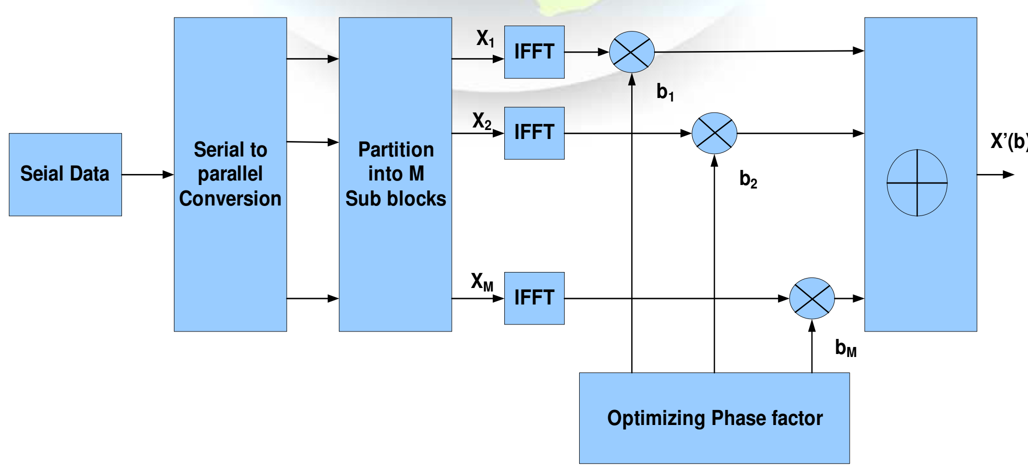


**Figure 3 PTS scheme**

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The different phases of PTS algorithmare given below.

- The OFDM sub carrier is divided into M sub groups.
- For each sub group the OFDM signal is produced by finding IFFT.
- Then the OFDM signal is added with a weighted phase factor $b_i$.
- To coherent receiver should be used to take back the original data.

## VI. PROPOSED METHOD

We have proposed a wavelet based OFDM system for the reduction of PAPR, which effectively reduces the PAPR on rational selection of phase values. First the original input signal is modulated with BPSK and PTS technique had been applied, where the phase values are generated using optimized algorithm. This helps to minimise the PAPR of the input signal. Then wavelet packet transform is applied and has been followed by DCT which is applied with a help of Distributed algorithm then transmitted through a AWGN channel. At the receiver, the inversion of transmitter will be done. The BER is calculated for the proposed system. Once the simulation is done then it is implemented on to the FPGA Board.

### A. Algorithm for proposed OFDM

- Map the input bit stream into BPSK symbols (-1 and +1).
- Divide the input signal into N sub blocks.
- Combine the N sub blocks with the weighted phase value.
- Apply Wavelet Packet Transform.
- Apply Discrete Cosine transform.
- Calculate PAPR for all the techniques.
- Plot the graph SNR vs BER.
- Finally demodulate and detect the transmitted bits at receiver.

Figure 5 shows the enhanced transmitter block diagram of the presented work. In this research work conventional OFDM is followed by the WPT and DCT for PAPR reduction and vice versa is also simulated. Both transmitter and receiver are simulated in order to calculate the BER. The detailed block description is given in the sections of this chapter.

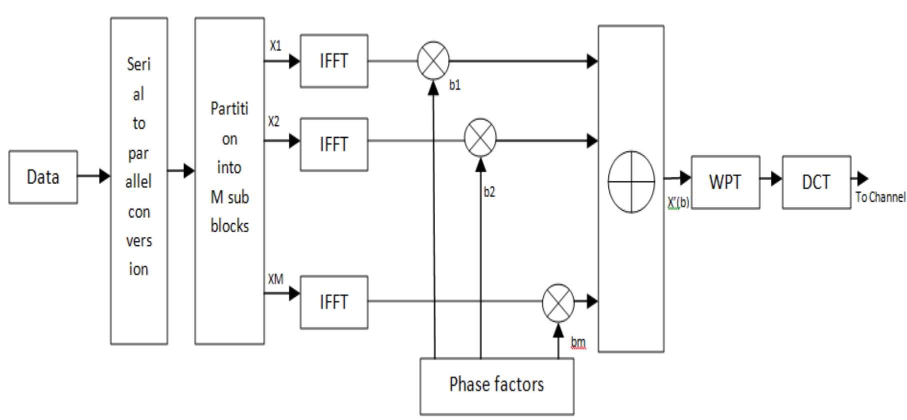


**Figure 4 Enhanced transmitter block diagram**

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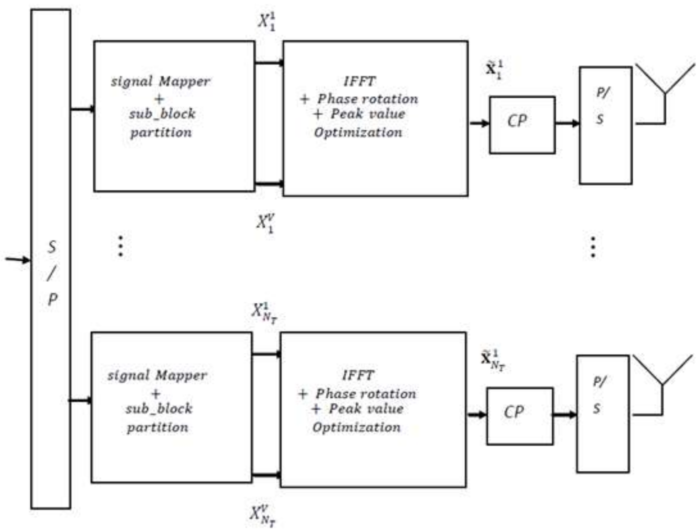


**Figure 5 Proposed transmitter block diagram**

## VII. CONCLUSION

MIMO-OFDM is a very agreeing method for the new wireless digital communication system. Along with the simplicity of equalization in Orthogonal Frequency Division Multiplexing (OFDM) modulation, it combines the capacity and diversity gain of MIMO systems for better performance. However, like conventional OFDM, MIMO-OFDM has a major challenge called high PAPR. Hence, it requires high dynamic range power amplifier, which makes more cost of system and decreases the efficiency of power. In this paper, a method is proposed for minimization of PAPR in MIMO-OFDM systems using PTS method. The PTS is concatenated with DCT and DWT signal processing algorithm to improves the efficiency and reduction of peak power of the MIMO-OFDM system. Because of autocorrelation of DCT the average power will be reduced. Using DWT, the data is divided into high and low coefficient such that the cyclic prefix can be avoided. By using PTS method, the optimum phasesfactors are selected to reduce the average power. henceit is achieved that MIMO- OFDM signals with less PAPR.

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