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Performance Evaluation of PAPR in OFDM system based on PTS and SLM Techniques

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***Abstract*—Orthogonal Frequency Division Multiplexing has been widely adopted in many wireless communication systems. Even though with many advantages it has disadvantage that the time domain of OFDM signal is a sum of subcarrier sinusoidal, which gives high Peak to Average Power Ratio (PAPR).High Peak-to-Average Power Ratio (PAPR) is one of the major and important drawback of the Orthogonal Frequency Division Multiplexing. Many methods have been proposed to solve the high PAPR of the OFDM signals. In this paper, a new modified technique is proposed which is based on SLM (selected Mapping) and PTS (Partial transmit sequence) scheme to reduce the PAPR of the OFDM system using MATLAB, which provides a better simulation results. This simulation compares the performance of two i.e. the SLM (Selected Mapping) and PTS (Partial Transmit Sequence) with the new modified technique.**

Keywords: OFDM, PAPR, SLM, PTS.

I. INTRODUCTION

Multicarrier modulation systems, often also called as orthogonal frequency division multiplexing (OFDM), are competing well with single carrier systems. Frequency division multiplexing (FDM) uses multiple subcarrier in the same channel which explain the concept of single carrier modulation. The total data rate to be sent in the channel is divided between the various subcarriers. OFDM system has an advantage over a single carrier system is its better performance in its terms of fading effects. OFDM is a digital transmission techniques developed to meet the increasing g demand for higher data rates in communication which can be used in both wireless and wired system.

By the use of orthogonal subcarriers it would allow the subcarriers' spectra to get overlap, thus increasing the spectral efficiency. As the orthogonally is maintained, it is still possible to reconstruct the original individual subcarriers signals. The OFDM system has a one drawback which is denoted as PAPR (Peak-to-Average power ratio). When multiple signals are added together to form the multicarrier signal, as a result these peaks are generated. In OFDM system, data to be transmitted is divided into narrowband subcarriers. OFDM system is superposition of many narrowband subcarriers. When all the peaks are added together, the large peak appears. At certain time instances, the peak amplitude of the signal is large and at the other times is small, that is, the peak power of the signal is larger than the average power of the signal. This high PAPR reduces system efficiency and then increases the cost of the RF power amplifier. To reduce PAPR many techniques are introduced. Two important techniques i.e. Selected Mapping (SLM) and Partial transmit Sequence (PTS) are used. In this paper, new modified scheme is proposed with help of above two techniques which gives better result.

II. OFDM SYSTEM

OFDM is a block modulation scheme where a block of information symbols is transmitted in parallel on sub-carriers. Initially the input data samples are mapped onto phase shift keying (PSK) or Quadrature Phase shift keying and then using FFT at receiver and IFFT at the transmitter side, they will convert to time domain and frequency domain respectively. Orthogonal data subcarriers produced by IFFT. An OFDM symbol consist of frequency spacing of a block of modulation symbol and N orthogonal subcarriers by the frequency spacing is Δf. The bandwidth is divided into N equally spaced subcarriers.

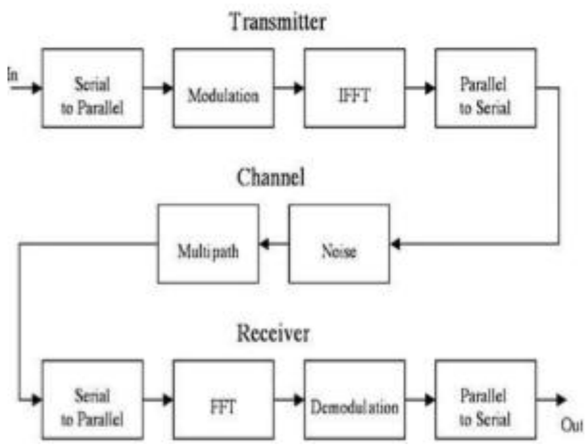

Fig1. An OFDM System

All the subcarriers are orthogonal to each other with in a time interval of length T=1/ Δf. Then within the time interval T the following signal of the m-th OFDM block period can be described by equation

$$x_m(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_{m,n}\, g_n(t\text{-}mT)$$

Where, gn(t) is defined through equation below

$$g_n(t) = \begin{cases} \exp(j2\pi\Delta ft), & 0 \le t \le \Delta T \\ 0 & \text{else} \end{cases}$$

Where, gn(t) is a rectangular pulse applied to each subcarrier. The total continuous time signal x(t) which contains all the OFDM blocks is shown by equation,

$$x(t) = \frac{1}{\sqrt{N}} \sum_{m=0}^{\infty} \sum_{n=0}^{N-1} X_{m,n}\, g_n(t\text{-}mT)$$

Now, consider a single OFDM symbol (m = 0) without loss of generality. This can be shown because there is no overlap between different OFDM symbols. Since m = 0, Xm,n can be replaced by Xn . Then, the OFDM signal can be described as follows:

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n\, e^{j2\pi n\Delta ft}$$

III. PAPR DEFINATION

Basically peak-to-average power ratio (PAPR) is the most popular parameter used to evaluate the dynamic range of the time-domain OFDM signal or signal envelop variation or the crest factor (CF) where PAPR=CF2. Crest factor is another parameter which is widely used in the literature, and defined as the square root of the PAPR.

In general, the PAPR of OFDM signals x(t) is defined as the ratio of the maximum instantaneous power and its average power

$$PAPR[x(t)] = \frac{\max_{0 \le t \le NT} [|x(t)|^2]}{P_{av}}$$

Where Pav is the average power of x(t) and is given by:

$$P_{av} = \frac{1}{NT} \int_0^{NT} |x(t)|^2\, dt$$

The PAPR of the discrete time sequences typically determines the complexity of the digital circuitry in terms of the number of bits necessary to achieve a desired signal to quantization noise for both the digital operation and the DAC.C. However, we are generally more concerned with reducing the PAPR in the case of continuous domain, but the cost and power dissipation of the analogue components generally dominates. To get good approximation the PAPR of continuous-time OFDM signals, where the OFDM signals Samples can be obtained by L times oversampling. PAPR reduction techniques are two types. Distortion based techniques and Redundancy based techniques. In distortion based techniques the time domain signals are directly suppressed for which the power signal exceeds a certain threshold level. Examples of this type are clipping method, Variable length scheme method etc. In Redundancy based techniques number of candidate signals are generated and then selects the one signal which will have minimum PAPR for the transmission of signals. An example is SLM method.

IV. CCDF OF THE PAPR

The cumulative distribution function (CDF) of the PAPR is used to performance measures for PAPR reduction techniques. The complementary CDF (CCDF) is commonly used instead of the CDF. The CCDF of the PAPR shows the probability that the PAPR of a data block exceeds a given threshold value. In a simple approximate expression is derived for the CCDF of the PAPR of a multicarrier signal with Nyquist rate sampling. The CDF of the amplitude of a signal sample is given by

F(z) = 1 – exp(z).

What we want to derive is the CCDF of the PAPR of a data block. The CCDF of the PAPR of a data block with Nyquist rate sampling is derived as

P (PAPR >z) = 1 – P(PAPR £ z)
= 1 – F(z)N
= 1 – (1 – exp(–z))N.

This expression assumes that the N time domain signal samples are mutually independent. When oversampling is applied. Also, this expression is not accurate for a small number of subcarriers since a Gaussian assumption does not hold in this case. Therefore, there have been many attempts to derive more accurate distribution of PAPR.

V. PAPR TECHNIQUES

a. The Partial Transmit Sequence (PTS) Technique:

In this technique, inputs data block of N symbols is partitioned into M disjoint sub-blocks, which are transformed into M time-domain partial transmit sequences. These partial sequences are rotated independently with the help of phase factors. The objective is to optimally combine the sub-blocks to obtain the time domain OFDM signals with the lowest PAPR. Further, there are two important issues that should be solved in PTS:

(A) High computational complexity for searching the optimal phase factors.

(B) The overhead of the optimal phase factors as side information needed to be transmitted to receiver for the correct decoding of the transmitted bit sequence.

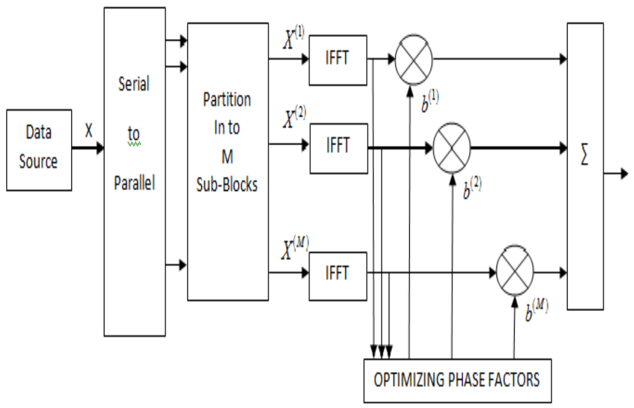

Fig2. *Partial Transmit Sequence (PTS) Technique*

The PTS algorithm can be explained as follows:

- Divide the given OFDM sub-carriers into the M no. disjoint subblock's.
- Generate the OFDM signal for each individual sub-block by taking IFFT of each.
- Then, combine the M output OFDM signals with weighting factors.
- The weighting factors are generated with the help of optimization algorithm.

b. The Selected Mapping (SLM) Technique :

In proposed technique, the transmitter generates a set of blocks which is sufficiently different from the data blocks, the generated blocks represents the same information as the original data block, and selects the most favourable for transmission. To obtain alternative input symbol sequence the input data is get multiplied by each of the phase sequence. The IFFT operation is made with each of these alternative input data sequences. Further the one which having lowest PAPR is selected for transmission purpose (Fig.3). The ability of PAPR reduction in SLM depends on: (a) The number of phase factors, and (b) The design of the phase factors.

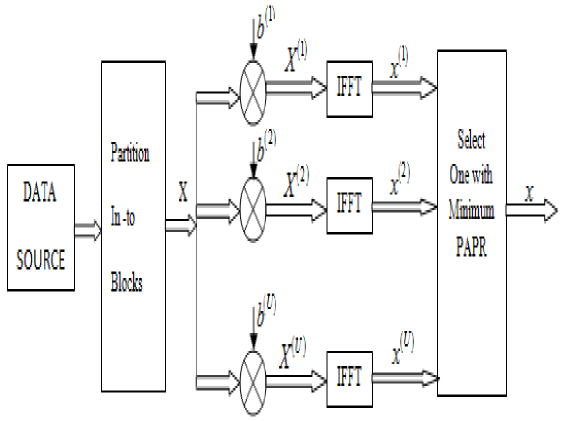

Fig3. *Selected Mapping (SLM Technique)*

The complete SLM technique can be explained in following steps.

- Input data signal is get multiplied with different sequences.
- For each signal the OFDM signal is generated.
- The OFDM signal is generated with lowest PAPR value.

VI. PROPOSED SCHEME

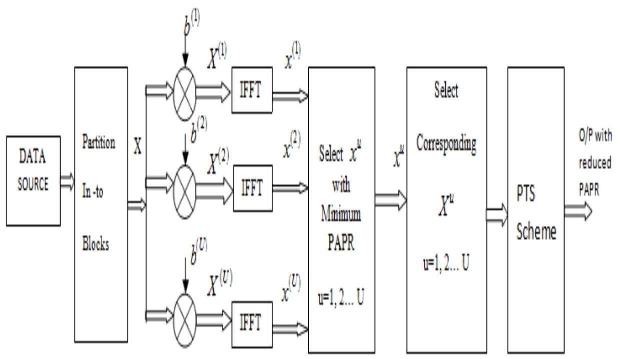

Fig4. Proposed scheme

A new proposed scheme based on the SLM and PTS schemes, which gives the better PAPR reduction performance than the all others schemes which we have discussed in this paper. The proposed scheme is basically a combination of SLM and PTS schemes. In the proposed scheme first SLM scheme is applied and we select the best combination of phase sequence and input data which gives minimum PAPR. Now for further reduction of PAPR, we apply this combination of phase sequence and input data to PTS scheme which further reduces the PAPR. The proposed scheme can be described by the block diagram shown. The Proposed method can be described in following steps:

- Multiplication of the input data signal with U different phase sequences.
- Generate the OFDM signal for each signal (U signals).
- Select the OFDM signal with lowest PAPR i.e. *xu*.
- Select corresponding combination of phase sequence and input data i.e. $X\ u$.
- Apply $X\ u$ as an input to PTS scheme.
- Obtain signal with reduced PAPR after applying the PTS scheme.

VII. Simulation Results

The simulation results shows the proposed scheme which is based on SLM and PTS. The simulation results compared the performance of two i.e. the SLM and PTS with the proposed technique. Further, the simulated results are shown below:

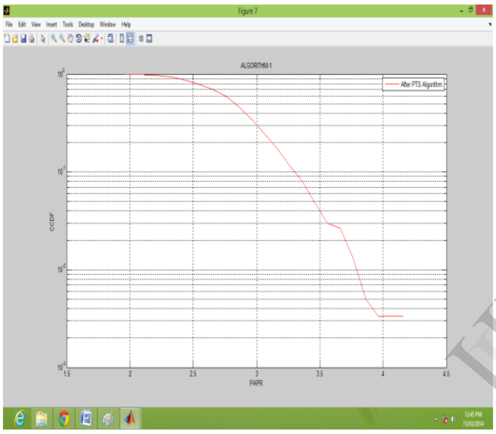

Fig5. PTS Technique

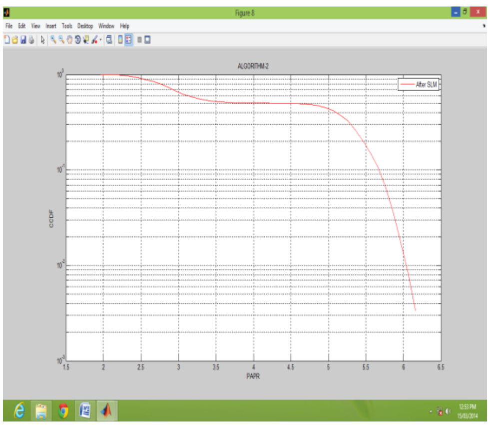

Fig6. SLM Technique

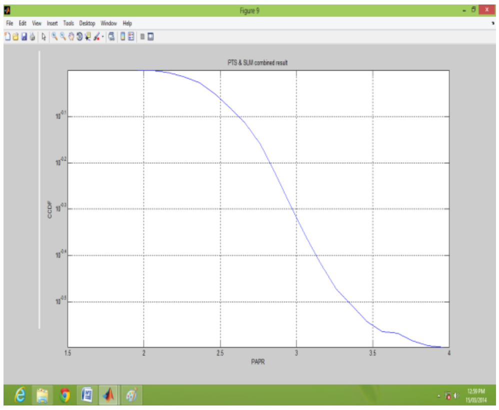

Fig7. SLM and PTS CombinedCCDFs of PAPR in Proposed, PTS, SLM, M=4 sub-blocks (N=256, L=4, QPSK modulation).

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