A NOVEL PAPR MITIGATION TECHNIQUE USING MODIFIED PTS

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Abstract

Orthogonal Frequency Division Multiplexing (OFDM) is a spectrally efficient multicarrier modulation technique for high speed data transmission over multipath fading channels. OFDM modulation schemes offer many advantages for multicarrier transmission at high data rates over time dispersive channels, particularly in mobile applications. One of the main issues of OFDM is high Peak-to-Average Power Ratio (PAPR) of the transmitted signal which adversely affects the complexity of power amplifiers. In this paper, we have purposed a modified PTS scheme which requires very less no of phase vectors and also less no of bits to be transmitted for synchronization at receiver. We have carried out the results for modified scheme and ordinary OFDM system which shows a great reduction in PAPR of the signal.

Words— **Orthogonal frequency-division multiplexing (OFDM), peak-to-average power ratio (PAPR), Partial Transmit Sequence (PTS).**

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I.INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has become a promising solution for various high-speed wireless data transmission systems due to its inherent robustness against multipath fading channels with certain implementation advantages over single carrier systems, [1]. One of the major drawbacks of OFDM signals (or more generally, multicarrier signals) is its waveform with a relatively high Peak-to-Average Power Ratio (PAPR) caused by the approximated Gaussian distribution output signal samples. OFDM signals therefore can cause serious problems including a severe power penalty at the transmitter. This is particularly not affordable in portable wireless systems where terminals are battery-powered.

A number of PAPR reduction schemes have been analyzed to alleviate this undesirable property of OFDM signals such as Amplitude Clipping, Coding, Selective Mapping (SLM) and Active Constellation Extension (ACE), companding using Hadamard Transform, Zadoff-Chu Matrix Transform. Amplitude Clipping seems to be the simplest method, but it was found that it causes undesirable in-band and out-of-band distortions. Use of coding could offer the best PAPR reductions. However, the cost of the associated complexity and data rate reduction render it less popular. Partial Transmit Sequence (PTS) comes to be a bandwidth efficient and highly reducing PAPR scheme [8, 9, 10]. Inspired by the principle of the PTS technique, in this paper we propose a novel low-complexity technique that can be operated after the IFFT process and effectively reduce the PAPR. By designing an intelligent selection strategy to generate a time domain sequence per OFDM-block, which can be used to randomize the amplitude of the time domain samples at output of the IFFT process, the PAPR of the OFDM signal can be significantly reduced with minimal complexity. We will refer to the proposed technique as the modified PTS technique. It will be shown that the modified PTS technique can achieve better PAPR performance while at the same time requires far less operational complexity than the PTS technique.

II. OFDM SYSTEM AND PAPR

Baseband modulated symbols are passed through serial to parallel converter which generates complex vector of size X [2].

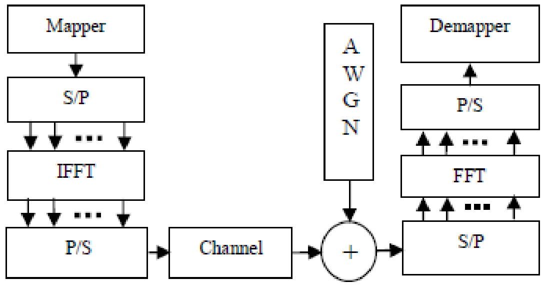

Fig 1Block diagram of a general OFDM system.

Complex vector of size as

$$X = [X0, X1, X2\ldots X\ -1]^T.$$

X is then passed through the IFFT block. The complex baseband OFDM signal with subcarriers represented by

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k \,.\, e^{j2\pi \frac{n}{N} k} \quad (1)$$

In case of OFDM system there is a possibility to experience large peaks since the signal shows a random variable characteristic since it is sum of *N* independent complex random variables. ***These different carriers may all line up in phase at some instant and consequently produce a high peak, which is quantified by peak-to-average-power ratio (PAPR).*** This distorts the transmitted signal if the transmitter contains nonlinear components such as power amplifiers (PAs). Since PA is forced to operate in the nonlinear region. The nonlinear effects may cause in-band or out-of-band distortion to signals such as spectral spreading, inter-modulation, or change the signal constellation. The high PAPR is one of the most detrimental aspects in the OFDM system, as it decreases the SQNR (Signal-to-Quantization Noise Ratio) of ADC (Analog-to-Digital Converter) and DAC (Digital-to-Analog Converter) while degrading the efficiency of the power amplifier in the transmitter

The PAPR of OFDM signal in (1) can be represented as

$$\text{PAPR}= \frac{max|x_n|^2}{E[|x_n|^2]} \qquad (2)$$

Where E [.] denotes expectation and the Complementary Cumulative Distribution Function (CCDF) for an OFDM signal can be written as

$$\text{P (PAPR>PAPR0)} = 1 - (1 - e^{-PAPRo})^N \qquad (3)$$

Where PAPR0 is the clipping level. This equation can be read as the probability that the PAPR of a symbol block exceeds some clip level PAPR0 [3].

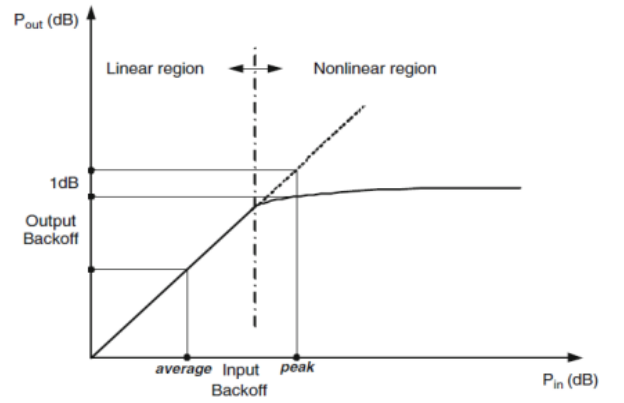

Fig.2 Input Output characteristics of a HPA

III MITIGATION TECHNIQUES AND SYSTEM MODEL

PTS SCHEME

In PTS approach, the input data block is partitioned into disjoint sub-blocks. The sub carriers in each sub block are weighted by a phase rotations. The phase rotations are selected such that the PAPR is minimized. At the receiver, the original data are recovered by applying inverse phase rotations.

Consider we have an input data block $\{ X_{n,n=0,\ 1,2,\ldots\ldots\ldots,N} \}$ is defined as a vector.

The vector X is Partitioned into V disjoint sets. It is represented by vectors $\{X^v, v=1,2,3,\ldots\ldots\ldots,V\}$ where

$$X^0=[X^1,\ldots X^{(N/V)}, ..0\ldots0\ldots0 \quad 0\ldots0]^T$$

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$$X^v= [0\ldots.0\ldots.X^{((v-1)(N/V)+1)},\ldots\ldots..,X^{(v.(N/V))} \quad 0,\ldots0]^T$$

$$X = \sum_{v=1}^{V} X^v$$

Where X^v are the sub-blocks that are

Consecutively located and are of equal size. In case of PAPR the scrambling is applied to each sub-block[5,6].

Each partitioned sub-block is multiplied by a corresponding complex phase factor,

$$b^v = e^{j\phi v}, v = 0,1,2,........,V$$

Subsequently taking its IFFT to yield

$$x = IFFT\{\sum_{v=1}^{V} b^v X^v\} = \sum_{v=1}^{V} b^v IFFT\{X^v\} = \sum_{v=1}^{V} b^v x^v$$

Where { x^v } is referred to as a partial transmit sequence (PTS). The phase vector is chosen so that the PAPR can be minimized which is shown as

$$[\tilde{b}^1,......\tilde{b}^V] = \arg\min_{[b^1,......b^V]} \left(\max_{n=0,1,2,.......,N-1} \left| \sum_{v=1}^{V} b^v x^v[n] \right| \right)$$

Then the corresponding time-domain signal with the lowest PAPR vector can be expressed as

$$\tilde{x} = \sum_{v=1}^{V} \tilde{b}^v x^v$$

The selection of the phase factors $\{b^v\}_{v=1}^{V}$ is limited to a set of elements to reduce the search complexity. As the set of allowed phase factors is

$b = \{e^{j2\pi i/W} \left| i = 0,1,......,W-1\right\}, W^{V-1}$ Sets of phase factors should be searched to find the optimum set of phase vectors. Therefore, the search complexity increases exponentially with the number of sub-blocks[7].

The PTS technique requires V IFFT operations for each data block and $\left[\log_2 W^V\right]$ bits of side information. The PAPR performance of the PTS technique is affected by not only the number of sub-blocks, V, and the number of the allowed phase factors, W, but also the sub-block partitioning.

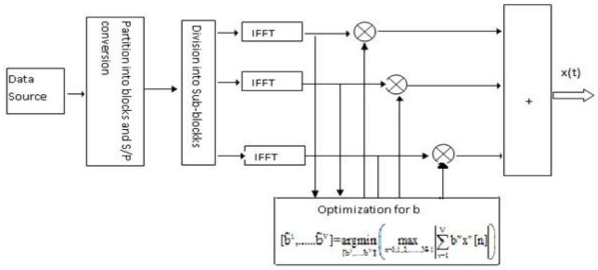

Fig 3 Block Diagram Of PTS Scheme

Proposed Optimized Reduction Scheme:

Choosing $b^v \in \{\pm 1, \pm i\}(W = 4)$ is widely used in conventional systems. We can set $b_1 = 1$ without loss of performance. Accordingly, in order to determine other weights, we need an exhaustive search for (M-1) phase rotations. In this search, W^{V-1} sets of candidate vectors on phase rotations are prepared and one of them is selected as the optimum set of phase rotations. So from the case of conventional PTS schemes we have to compute 4^{W-1} no. of calculations for finding the phase rotation vectors. The proposed scheme provides a better solution for computation of the phase vectors. The proposed scheme is detailed below:

1. Assume N_{sb} define the no. of sub-blocks into which the input data is to be partitioned.
2. Define the size of the sub-carriers (N) and the Oversampling Factor for the OFDM signal.
3. Define 'r', where 2^r becomes the no of times the value of v is to be calculated for finding the minimum PAPR.
4. Assume b^v=1 for v=. $1:N_{sb}$
5. Find PAPR for equation (4.2) and set it as PAPR_min.
6. Increment v by 1, and then again find the PAPR for equation (4.2) with the value of $b^v = -1$.
7. If PAPR>PAPR_min then set the value of $b^v = 1$.
8. Now update the value of PAPR_min by PAPR.
9. If PAPR<PAPR_min then set the value of $b^v = 1$.
10. Now continue the process until $v < 2^r$ by incrementing the value of v by one every times and going back for calculating the value of PAPR from step(7)

11. When v becomes equal to 2^r, then exit the process with the set of optimal phase vectors $\tilde{b}^v$.

Here from the algorithm we can see that the no. of phase rotation vectors depends upon the value of 2^r where r=3, 4, 5, 6, 7, 8…. However we cannot exceed the value of r after r=8 as this will not give a more change in the value of PAPR. From the PTS scheme where the no of computation were 4^{Nsb-1} we come to a result with computation equals to $2^r, r = 3,4,5,6,7,8$. So the performance of this algorithm increases as the no of sub-blocks. As we know that every PTS scheme requires side information has to be sent over channel to correctly recover the signal at the receiver. So in the purposed scheme the no of bits required for the side information reduces to 'r' which was 'Nsb' in case of the conventional PTS scheme.

IV. SIMULATION RESULTS

We performed extensive simulations in MATLAB® in order to evaluate performance of the proposed modified PTS based OFDM systems. The simulations details are taken for the OFDM signal with 256 no of subcarriers and the no of the sub-blocks in the proposed scheme are varied to change the PAPR of the signal. As we go on increasing the no of sub-blocks (16, 64,128) the value of PAPR goes on decreasing with the associated value of factor 'r'. We have considered the results onto CCDF platform. The same scenario parameters are applied to study both the traditional OFDM scheme and the optimized scheme. The performance of both the schemes is compared in terms of PAPR by computing their CCDF plots. With the variation in the parameter 'r'and the no of sub-blocks the best condition for PAPR of the OFDM signals has been evaluated. With the help of CCDF plots, the PAPR of signal is plotted against the probability for minimum PAPR in a Two Dimensional graph. The CCDF plot compare PAPRo [dB] versus Pr [PAPR>PAPRo] with PAPRo [dB] on X-axis and Pr [PAPR>PAPRo] on Y-axis.

Parameter Name	Value
No. of Sub-Carriers, N	256
No. of Sub-blocks, Nsb	16,64,128
Sampling Frequency,fs	4 MHz
Carrier Frequency,fc	2MHz

Oversampling Factor, Nos	4
Type of Modulation	16 QAM
Decision Frequency,fd	1KHz
No. of FFT blocks for iteration	3000

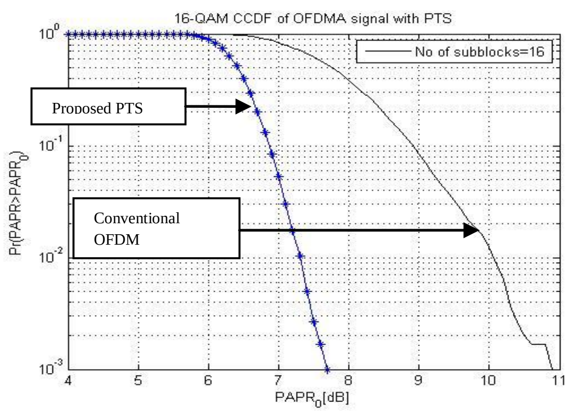

Fig. 4 CCDF for sub-blocks =16, with the value of r = 4.

In fig 4 we are taking the OFDM signal with No. of Sub-blocks=16 with subcarriers N=256 and is plotted with the value of ‘r=4’ as we can see from figure that PAPR reduces from the conventional OFDM scheme.

In fig 5 we have considered the OFDM signal With 256 Subcarriers, and the no of sub-blocks has been increased in this case. So the value of r also has to be increased. We have Plotted the CCDF for the value of r=6 which shows a change in the PAPR of the Optimized

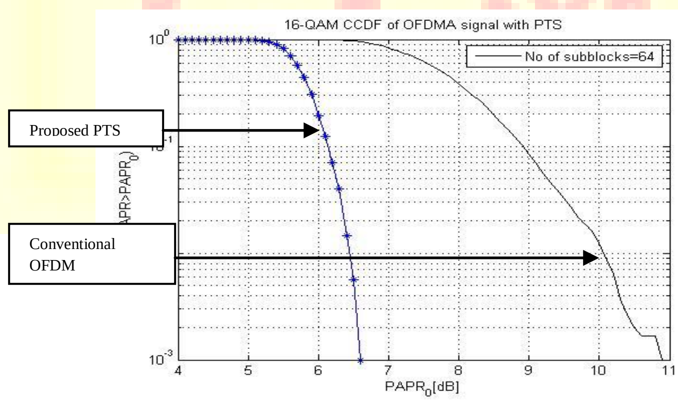

Fig 5 CCDF for sub-blocks =64, with the value of r=6

Fig 5 CCDF for sub-blocks =64, with the value of r=6

In the third scenario, as we go on increasing the no. of sub-blocks the PAPR also goes on decreasing. As here we can see that as No. of sub-blocks becomes 128 then the PAPR decreases as we go on increasing the value of 'r'.

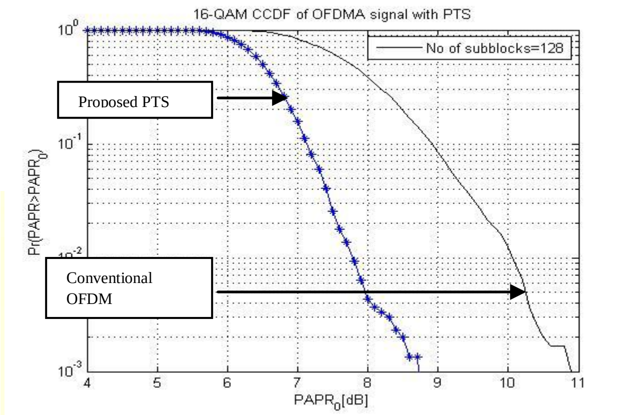

Fig 5 CCDF for sub-blocks =128, with the value of r = 6

As we can see in fig 6 where the value of r=6, the PAPR is less than the Conventional PAPR and as we increase the value of r=7,

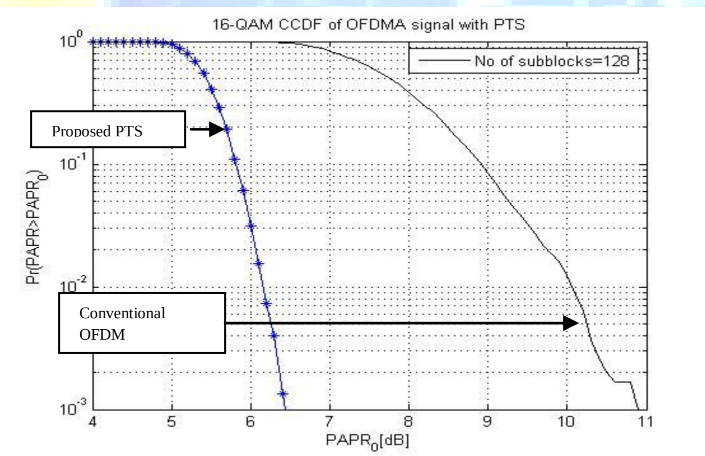

Fig 6 CCDFfor sub-blocks=128 and r=7.

Fig 7 shows a dramatic increase in the reduction of PAPR. Again on further increasing the value of r=8 Fig 8, shows more reduction in the PAPR of the proposed PTS method with respect to the conventional ofdm system

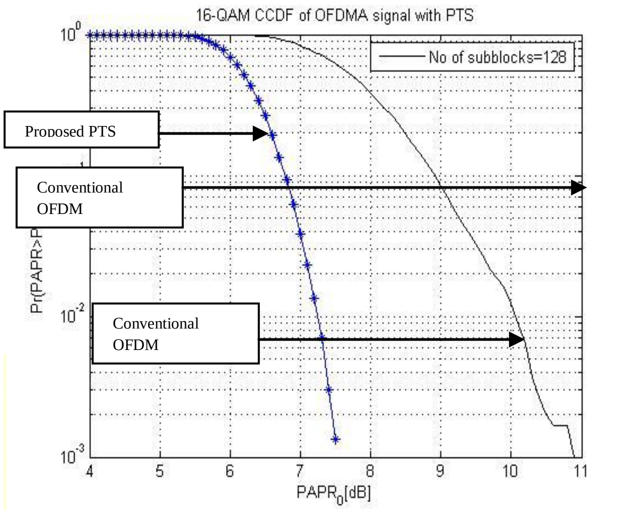

Fig 7 CCDF for sub-blocks =128, with the value of r = 8.

V. CONCLUSION

Since PAPR is a most significant factor in the proper sending and receiving of the OFDM as it depend upon the range of HPA that will make the signal less or more noisy .So this becomes an important factor for comparison of various schemes for their efficient working. In this paper, PTS Scheme for PAPR reduction proposed by various researchers for OFDM Signals is analyzed and a new PAPR reduction scheme called the Optimized PTS scheme is being proposed. This scheme depends upon a factor 'r' that defines the no of times the phase vectors get attached to the modulated and oversampled signal. Also the no bits required for the side information that are to be transmitted with the signal over the channel has also been reduced. With the help of simulations we have proven that the Optimized PTS scheme is more efficient and send less no of side information bits with the channel. In other words this scheme reduces the waste of wireless resources and improves the performance of Orthogonal Frequency Division Multiplexing.

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