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COMPARISON OF PTS AND SLM TECHNIQUE IN OFDM SYSTEM

Reena Rathour[1], Dr. Shelendra Singh Tomar[2], Prof. A. C. Tiwari[3]
Student M. Tech. (D.C.) [1], Professor[2], Professor & HOD[3]
eng.reena@gmail.com[1]
Department of Electronics and Communication
LNCT Indore (M.P.) India

Abstract

Orthogonal Frequency Division Multiplexing (OFDM) system is a multicarrier system use to transfer data at high rate. But it consists a major problem known as Peak to Average Power Ratio (PAPR) which results serious degradation in performance of OFDM system when a non-linear power amplifier is employed in system. The Partial Transmit Sequence (PTS) is one of the most well-known PAPR reduction technique for OFDM system. In this paper, a PTS technique is propose to reduce the high Peak to Average Power Ratio (PAPR). The simulation result shows that our proposed PTS technique, achieves better reduction of PAPR at reduced computational complexity when compared to SLM technique.

Key Word: - OFDM, PAPR, SLM, PTS

I. INTRODUCTION

Orthogonal frequency division multiplexing is a very attractive technique for the transmission of high-bit-data rate in wireless communication system due to many advantages that it offers in fading channels [1]. OFDM is a method of transmitting data simultaneously over many equally spaced carrier frequencies, using Fourier transform method for modulation and demodulation. However, some issues remain unresolved regarding OFDM system, one of the major problem is high Peak-to-Average Power Ratio (PAPR) of transmitted OFDM signals because OFDM signal is the sum of many narrowband signals. The high PAPR degrades system's performance as it may cause inter-modulation and out-of-band radiation [2]. In order to overcome this problem, the transmission amplifier must operate within its linear region to avoid spectral distortion and the degradation of Bit-error-rate (BER). Therefore, it is very mandatory to reduce the PAPR of an OFDM signal. There are some characteristics of the PAPR, in which, the distribution of PAPR, is a major characteristic in OFDM systems, generally known as Complementary Cumulative Distribution Function (CCDF). Many solutions to the PAPR problem have been proposed including Clipping and filtering, Tone Reservation (TR), Tone Injection (TI), Partial Transmit Sequence (PTS) and Selective Mapping (SLM) [2].

II. PEAK-to-AVERAGE POWER RATIO

Peak to average power ratio is a signal property that is calculated by dividing the peak power amplitude of the waveform by the RMS value of it, a dimensionless quantity which is denoted as dB. In digital transmission when the waveform is represented as signal samples, the PAPR is define as in equation 1[1].

$$PAPR = \frac{\max(|S[n]|^2)}{E\{|S[n]|^2\}},\ 0 \le n \le N-1 \quad (1)$$

Where S[n] represents the signal samples, $\max(|S[n]|^2)$ denotes the maximum instantaneous power and $E\{|S[n]|^2\}$ is the average power of the signal.

III. PAPR REDUCTION METHOD

PAPR reduction is a well-known signal processing topic in multi-carrier transmission and large number of techniques appeared in the literature during the past years. These techniques include amplitude clipping and filtering, tone reservation (TR), coding, active constellation extension (ACE) and multiple signal representation methods such as partial transmit sequence (PTS), selected mapping (SLM) and interleaving [4]. The existing approaches are different from each other in terms of requirements, and most of them enforce various restrictions to the system. Therefore, careful attention must be paid to choose a proper technique for each specific communication system.

A. Selective Mapping (SLM)

Selective mapping is based on the idea of generating multiple copies of the original signal through some series of codes. The copy of signal with lowest PAPR is chosen for transmission. The side information (index of the transmitted signal) is required at the receiver to recover the original signal. As the number of subcarrier increases, larger the set of codes required to obtain a required PAPR (5-6dB). High-computational complexity and need to transmit side-information have been criticized in the original SLM [5]. Many efficient variants have emerged recently.

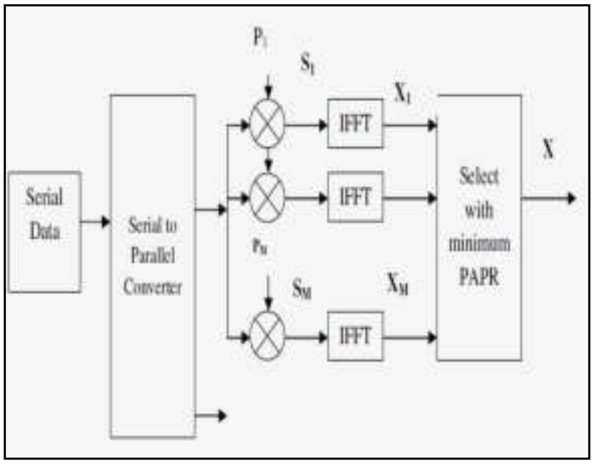

Fig. 1. Basic principles of selected mapping [4]

In selected mapping method, firstly M statistically independent sequences which represent the same information are generated, and next, the resulting M statistically independent data blocks s_m as in equation (2)

$$\boldsymbol{S}_m=[Sm,0,Sm,1,\ldots,Sm,N-1]T,\ m=1,2,\ldots,M \qquad (2)$$

then forwarded into IFFT operation simultaneously. Finally, at the receiving end, OFDM symbols:

$$\boldsymbol{x}_m= [x=1, 2, 4, 4, 5, 6, 7, 8, 9,\ldots,]^T \quad \ldots\ldots\ldots 1.3$$

In discrete time-domain are acquired, and then the PAPR of these M vectors are calculated separately. Eventually, the sequences x_d with the smallest PAPR will be elected for final serial transmission. Fig.1 illustrates the basic structure of selected mapping method for suppressing the high PAPR.

This method can significantly improve the PAPR performance of OFDM system. The reasons behind that are: Data blocks $\boldsymbol{S}m=[Sm,0,Sm,1,\ldots,Sm,N-1]^T$, $m=1,2,\ldots,M$ are statistical independent, assuming that for a single OFDM symbol, the CCDF probability of PAPR larger than a threshold is equals to $p[1]$. The general probability of PAPR larger than a threshold for k OFDM symbols can be expressed as pK. It can be verified that the new probability obtained by SLM algorithm is much smaller compared to the former. Data blocks $\boldsymbol{S}$m are obtained by multiplying the original sequence with M uncorrelated sequence $\boldsymbol{P}$m. In the reality, all the elements of phase sequence $P1$ are set to 1 so as to make this branch sequence the original signal.

B. Phase Transmit Sequence (PTS)

In the PTS technique, an input data block of N symbols is partitioned into various sub-blocks. The subcarrier in each sub-block are weighted by a phase factor for that sub-block. The phase factors are selected in such a way that the PAPR of the combined signal get minimize.

In conventional PTS approach, it is required to calculate the PAPR value at each step of the algorithm, which will introduce tremendous trials to achieve the optimum value of PAPR. Then after, to make the receiver to identify different phases, phase factor **b** is required to send the receiver as sideband information (usually the first sub-block $b1$, is set to 1). The optimization is achieved by searching thoroughly for the best phase factor. Theoretically, **b**= [$b1$, 2,…] is a set of discrete values, and number of computation will be required for the OFDM system when this phase collection is very large.

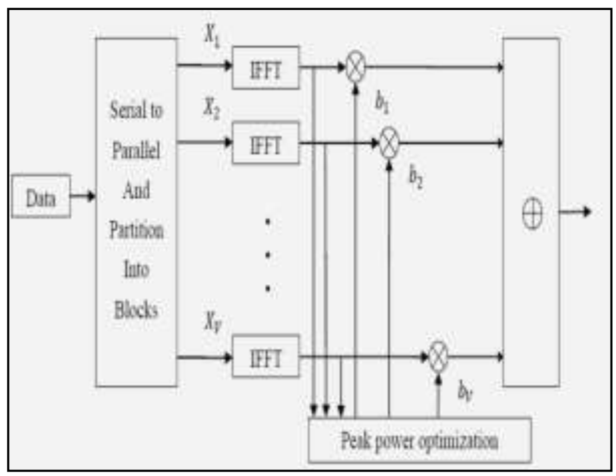

Fig. 2 Block diagram of PTS algorithm [4]

Fig. 2 is the block diagram of PTS algorithm. At first, the data information in frequency domain **X** is separated into V non-overlapping sub-blocks and each sub-block has the same size N. Hence, we know that for every sub-block, it contains N/V nonzero elements and set the rest part to zero. Each sub-block vector is given by:

$$\hat{X} = \sum_{v-1}^{V} b_v X_v \qquad (4)$$

where, $b_v = e^{j\emptyset_v}(\emptyset_v \in [0,2\pi])$, $\{v = 1,2,3,4,\ldots\ldots V\}$

b_v, is a weighting factor been used for phase rotation. Time domain signal X is obtained by applying IFFT operation on $\hat{X}$, that is:

$$X = IFFT(\hat{X}) = \sum_{v-1}^{V} b_v IFFT(X_v) = \sum_{v=1}^{V} b_v . \boldsymbol{X}_v \qquad (5)$$

Select one suitable factor combination $b = [b1, b2, \dots, bv]$ which makes the result optimum. The combination can be given by:

$$b = [b1, b2, \dots, bv]$$
$$= argmin_{(b1,b2,\dots,bv)} \left(max_{1 \le n \le n} \left| \sum_{v=1}^{V} b_v . \boldsymbol{X}_v \right|^2 \right) \qquad (6)$$

In this way we can find the best **b** so as to optimize the PAPR performance. The additional cost we have to pay is the extra *V*-1 times IFFTs operation.

IV. SIMULATION RESULTS

The PAPR reduction performance is evaluated by the Cumulative Complementary Distributive Function (CCDF). In order to analyze the PAPR reduction of OFDM system we compared here both PTS and SLM technique, simulation has been performed using MATLAB 2013a. The number of sub-carriers employed is 64, number of OFDM symbols 10000, number of sub-band N=64, and oversampling factor L=4. In Figure 3, Based on the principles of PTS algorithm, it is apparent that the ability of PAPR reduction using SLM is affected by the route number *M* and subcarrier number *N*. Therefore, simulation with values of *M* and *N* will be conducted..

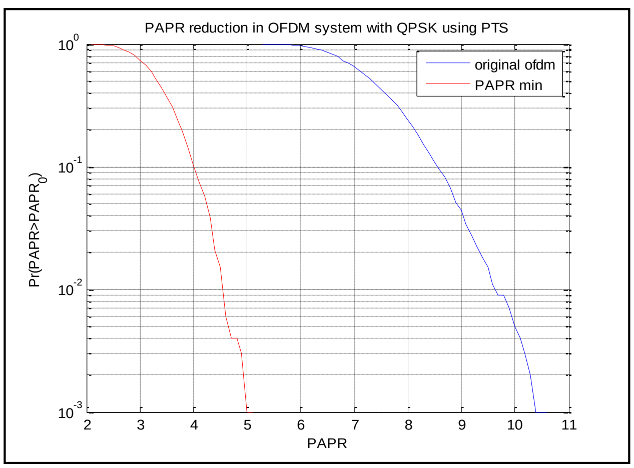

Fig. 2. Performance of PTS Technique in OFDM system.

Table 1. Observation Table for PTS Technique

Used Parameter	CCDF (P_r)	Original OFDM	PTS-PAPR
QPSK Modulation with AWGN Channel	10^{-1}	8.6 dB	4.0 dB
	10^{-2}	9.6 dB	4.5 dB
	10^{-3}	10.4 dB	5.1 dB

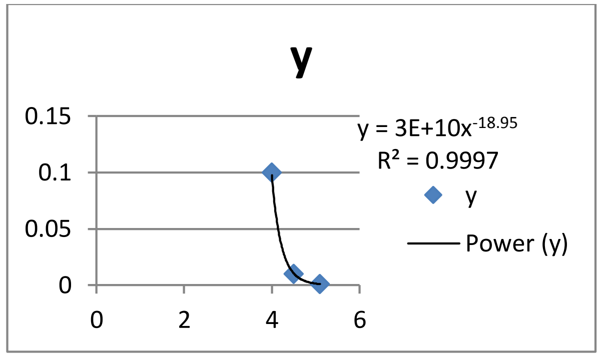

Fig. 3 Prediction Curve of PTS technique

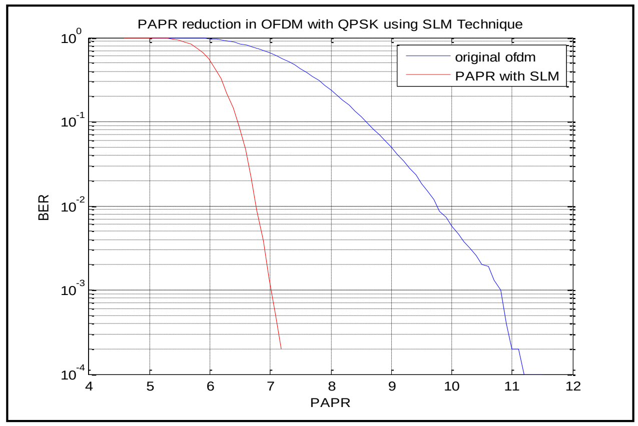

Fig. 4 Performance of SLM Technique in OFDM system.

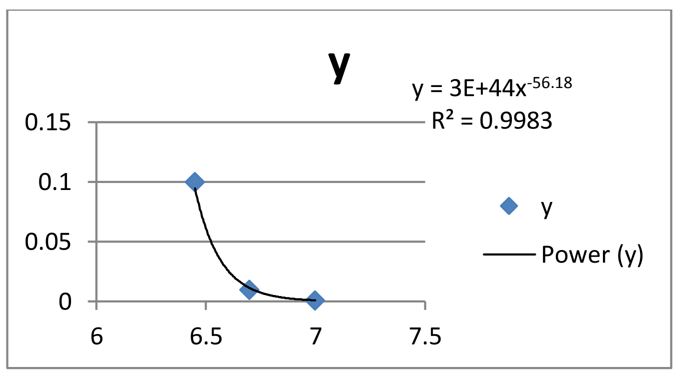

Fig. 5 Prediction Curve of SLM technique

Table 2. Observation Table for SLM Technique

Used Parameter	CCDF (P_r)	Original OFDM	SLM-PAPR
QPSK Modulation with AWGN Channel	10^{-1}	8.60 dB	6.45 dB
	10^{-2}	9.80 dB	6.70 dB
	10^{-3}	10.80 dB	7.00 dB

V. CONCLUSION

The CCDF of PAPR is obtained by MATLAB simulation. It can be clearly seen that the proposed PTS technique has better PAPR performance when compared to the original OFDM methods. It has been observed that the original signal has a high PAPR value of 10.4dB. The Partial Transmit Sequence technique (PTS) reduces the PAPR value to about 5.1dB. By regression analysis too, we can see that PTS results are much better than SLM technique. Value of R^2 is 0.999 for PTS and 0.998 for SLM.

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