MODIFIED SLM SCHEME FOR EFFICIENT PAPR REDUCTION IN OFDM SYSTEMS

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ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is an attractive technique due to its high speed data transmission and robustness for time selective channels. However, the major drawback of OFDM system is high Peak-to-Average Power Ratio (PAPR). In this paper two PAPR reduction schemes have been introduced, one is conventional Selected Mapping (SLM) scheme and a new proposed Block Selected Mapping (BSLM) scheme to obtain efficient PAPR reduction in OFDM system. In proposed BSLM scheme OFDM symbol sequence were partitioned into several blocks and then multiplied each block sequence with various phase rotation sequences for generating alternative signals as candidates and then select the one with the lowest PAPR for actual transmission. Simulation result shows that proposed BSLM scheme provides a better PAPR reduction performance compare to conventional SLM scheme, and also observed that increasing the partition of blocks, large PAPR reduction can be obtained.

Keywords: Orthogonal Frequency Division Multiplexing (OFDM), Peak-to-Average Power Ratio (PAPR), Selected Mapping (SLM), Block Selected Mapping (BSLM), Complementary Cumulative Distribution Function (CCDF).

INTRODUCTION

In recent years, Orthogonal Frequency Division Multiplexing (OFDM) has become the most widely adopted technique in various wireless systems due to its high spectrum efficiency, easy implementation and channel robustness, but it also has some drawbacks such as the large deviation in envelope of OFDM signal, which causes high Peak-to-Average Power Ratio (PAPR) [1]. Since many subcarrier components are added in transmitted OFDM signals via an IFFT operation, OFDM system can have high peak values in the time domain. Therefore, OFDM systems have high PAPR. This high PAPR mainly affected the efficiency of power amplifier in the transmitter [2]. When high PAPR signals are transmitted through a nonlinear device, such as RF-amplifier, out-of-band energy and in-band distortion have been generated through this high peak signal. The performance of OFDM system is seriously affected by this distortion [3]. In past few years several approaches have been proposed for reducing the PAPR and improving the OFDM system performance. These techniques include clipping and filtering, selected mapping, partial transmit sequence, tone reservation and tone insertion [4]. These techniques can reduce PAPR of OFDM system but not considered satisfactory. This paper is proposed and analysed a new modified Selected Mapping scheme, called “Block Selected Mapping (BSLM) scheme,” which provides the better PAPR reduction and improves the OFDM system performance. It can effectively transform the original OFDM signal into several blocks and then multiply each block sequence by various phase rotation sequences for generating alternative signals as candidates and after that IFFT have been applied for generating time domain symbol sequences and then select the one sequence with the lowest PAPR for actual transmission.

The paper is organized as follows: Section 2 describe the transmission and reception procedure of OFDM system and PAPR problem in OFDM system. In section 3 basic SLM scheme has been introduced for PAPR reduction. In section 4, proposed BSLM scheme has been carried out. Section 5 shows all the simulation results of PAPR reduction performance and section 6 shows the conclusion of this paper.

OFDM PAPR DESCRIPTION

Fig. 1 shows the block diagram of an OFDM system [5], Let N denote the number of subcarriers used for parallel information transmission and let $X(k)$ $(0 \leq k \leq N\text{-}1)$ denote the k^{th} complex modulated symbol in a block of N information symbols. The outputs of N-point IFFT of $X(k)$ are *denoted by* x_n and can be expressed as [6]

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X(k)\ \exp\left(\frac{j2\pi kn}{N}\right). \qquad (1)$$

The PAPR of discrete-time OFDM can be expressed as [7]

$$\text{PAPR}_s(x_n) = 10.\log_{10} \frac{Max\{|xn|^2\}}{E\{|xn|^2\}} \text{(dB)}. \qquad (2)$$

The complementary cumulative distribution function (CCDF) is used when PAPR value exceeds the threshold. Thus the probability of the PAPR of the discrete signal exceeds a threshold z_0 is given by

$$\Pr(\text{PAPR}_s \geq z_0) = 1 - (1 - \exp(-z_0))^N \qquad (3)$$

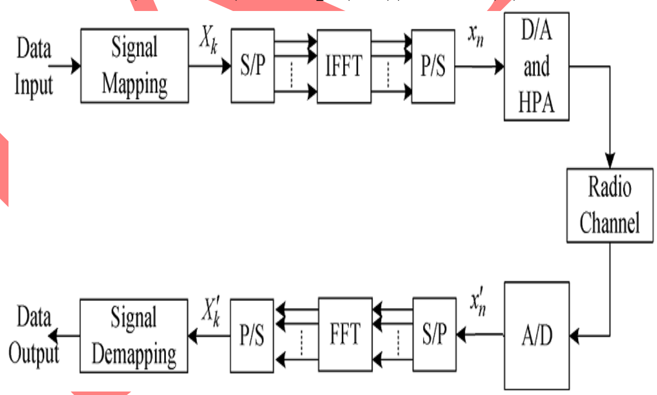

Fig. 1: OFDM Block Diagram

SELECTED MAPPING SCHEME

In an OFDM system selected mapping (SLM) scheme is the most effective PAPR reduction scheme. Bauml, Fischer and Huber had introduced the first SLM scheme, in 1996 [8]. This technique is mainly based on the phase rotation sequences. In this scheme, several different candidate data blocks have been generated by multiplied with several different phase sequences, each of length N. all represents the same information as the original data block, the lowest PAPR signal is selected for transmission from a number of different data blocks. Fig. 2 shows a block diagram of SLM scheme [9] [10].

Original input data X $[X_0, X_1, \ldots, X_{N-1}]^T$ are multiplied with predetermined independent phase sequences $P^{(u)} = [P_0^{(u)}, P_1^{(u)}, \ldots\ldots, P_{N-1}^{(u)}]^T$ (u =0,1, U-1) to generate U candidate sequences $x^{(u)} = [x_0^{(u)} + x_1^{(u)}, \ldots\ldots, x_{N-1}^{(u)}]^T$ of length N. Then transform the signal from frequency domain to time domain using IFFT operation to each sequence. Finally the candidate sequence is calculated by [6]

$$x^{(u)} = \mathrm{IFFT}\{X \otimes P^{(u)}\} \qquad (4)$$

where $\otimes$ indicate a component-wise multiplication. In the last step, compared the PAPR among the U candidate sequences $x^{(u)}$ and the most favourable mapped one $\hat{x}$ with the lowest PAPR is selected for transmission. That is given by,

$$\hat{x} = \arg\min_{0 \le u \le U-1}[PAPR(x^{(u)})]. \qquad (5)$$

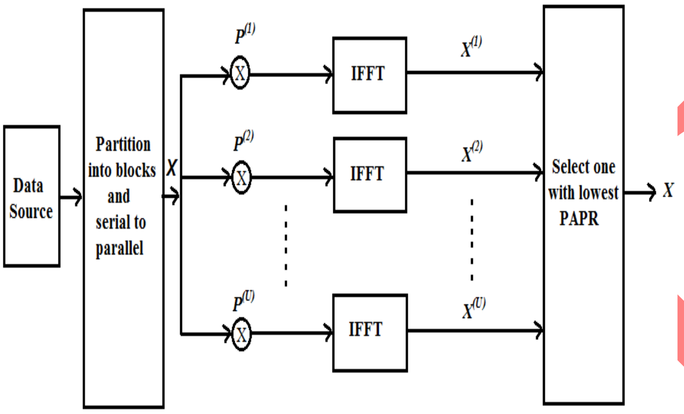

Fig. 2: Block Diagram of Selected mapping technique

PROPOSED BLOCK SELECTED MAPPING SCHEME

In order to improve the PAPR reduction performance in an OFDM system, a proposed BSLM scheme is developed. In this scheme, the original OFDM signal sequence is partitioned into several blocks, whose number is denoted by B. Then each block is multiplied by U phase rotation sequences for generating alternative signals as candidates, after that IFFT have been applied for generating time domain symbol sequences and then select the one sequence with the lowest PAPR for actual transmission. The block diagram of proposed BSLM scheme is shown in Fig. 3.

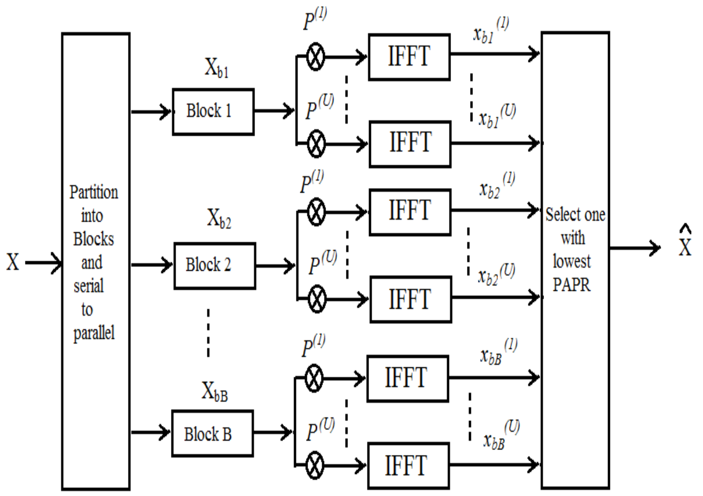

Fig. 3: The block diagram of proposed BSLM scheme

In general, the original OFDM symbol sequence X of length N is expected to be partitioned into B blocks. Each block X_b, where $1 \le b \le B$ is multiplied by different phase rotation sequences $P^{(u)}$, where $1 \le u \le U$. Furthermore, IFFT is applied to each sequence for transforming the signal from frequency domain to time domain. B groups of OFDM sequences $[x_1^{(u)}, x_2^{(u)}, \ldots\ldots\ldots, x_B^{(u)}]$ are employed to generate more alterative OFDM sequences. Thus there are total B*U alternative OFDM sequences generated as the candidate sequences. As a result, the candidate sequences are given by as follows:

$$x_b^{(u)} = \mathrm{IFFT}\{X_b \otimes P^{(u)}\} \qquad (6)$$

In which $\otimes$ denote a component-wise multiplication. The last step is comparing the PAPR among the total candidate sequences $x_b^{(u)}$, the optimal mapped one $\hat{\mathbf{x}}$ with the lowest PAPR will be selected for transmission. That is,

$$\hat{\mathbf{x}} = \min_{1 \le m \le B*U}[PAPR(x_b^{(u)})] \qquad (7)$$

Where, $1 \le b \le B$, $1 \le u \le U$ and $1 \le m \le B*U$.

SIMULATION RESULTS

MATLAB software has been used to verify the performance of conventional SLM and BSLM scheme. Table 1 shows the parameters used for simulation results. Comparative MATLAB simulation result of PAPR performance with conventional SLM scheme for various number of phase rotation sequences (U) are shown in Fig. 4. It shows that the PAPR reduction performance becomes better as the number of phase rotation sequences increases. Fig. 5 shows the PAPR performance with BSLM scheme for $U=4$ and various number of blocks (B). It shows that as the number of block increases, PAPR reduction performance also increased. Fig. 6 shows the comparative simulation result of PAPR performance between conventional SLM and BSLM schemes, similar parameters have to be taken to calculate the PAPR for both schemes (U=4 & B=2). Comparison of PAPR performance between conventional SLM and BSLM schemes for *U*=16 & B=2,4,8 & 16 are shown by Fig. 7.

Table 1 Parameters used in simulation

Simulation Parameters	**Specifications**
Number of OFDM symbols	10000
Number of subcarriers (*N*)	64
Number of blocks (B)	2/4/8/16
Number of phase rotation sequences (*U*)	2/4/8/16
Modulation scheme	QPSK

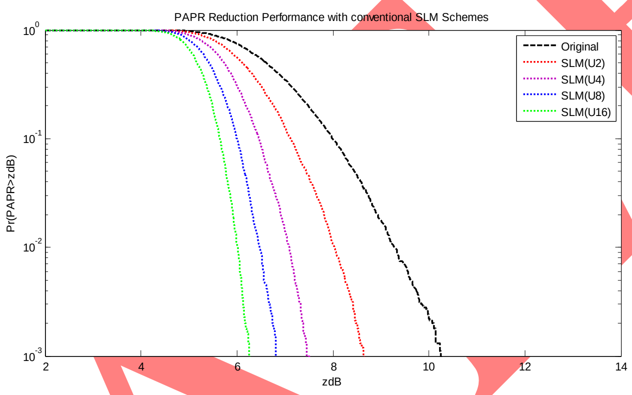

Fig. 4: PAPR performance of SLM scheme with various numbers of phase sequences (*U*=2,4,8 & 16)

Fig. 4 shows that increasing the number of phase sequences, minimum PAPR value can be obtained. Here different phase values have been taken and check the performance of PAPR reduction for every phase value. It is clear from the Fig 4, for *U*=16 it shows the minimum value of PAPR 6.3 dB which is very less compare to without SLM scheme.

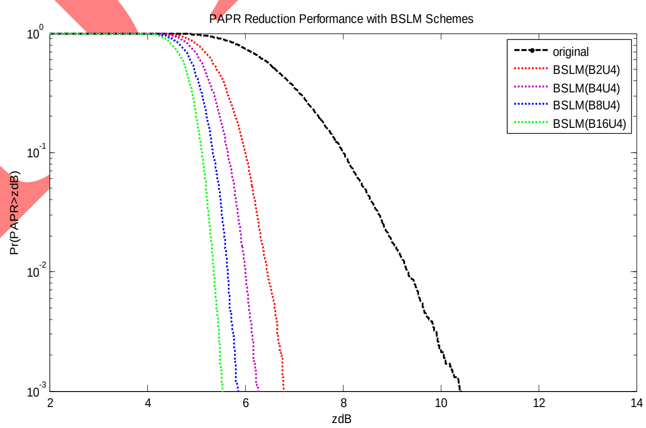

Fig. 5: PAPR performance comparison of BSLM scheme with *U*=4 and B=2,4,8 & 16

Fig. 5 shows that increasing the number of blocks, best PAPR reduction can be obtained. For B=16 & *U*=4 it shows the best value of PAPR 5.5 dB.

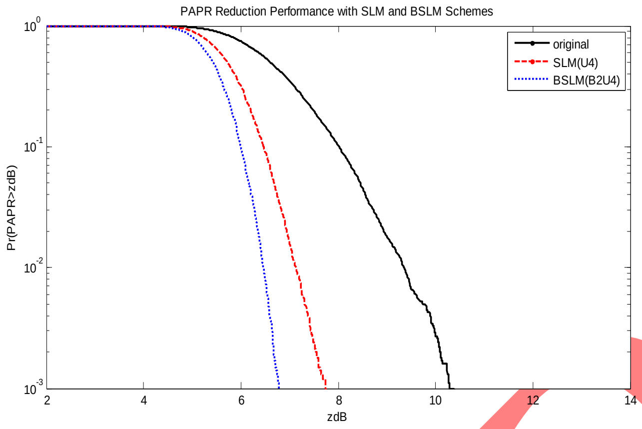

Fig. 6: PAPR performance comparisons between conventional SLM and BSLM schemes with *U*=4 & B=2

Fig. 6 shows comparison between conventional SLM and BSLM schemes with *U*=4 & B=2. It is cleared from the Fig. 6, BSLM scheme shows the better PAPR reduction comparison to SLM scheme.

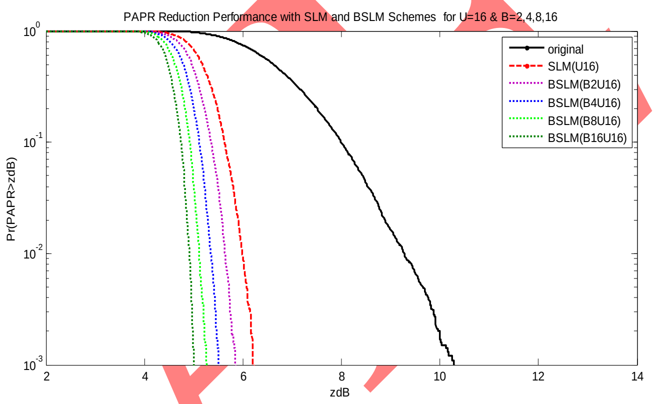

Fig. 7: PAPR performance comparisons between conventional SLM and BSLM schemes with *U*=16 & B=2,4,8 & 16

Fig. 7 shows that increasing the number of blocks, best PAPR reduction can be obtained. For the same parameters PAPR value by SLM scheme was 6.3 dB and it goes down to 5.0 dB for BSLM scheme.

CONCLUSION

In this paper two PAPR reduction schemes have been discussed, a conventional SLM scheme and new proposed BSLM scheme. After the simulation results, it is observed that BSLM scheme provides better PAPR reduction as compared to conventional SLM scheme. It is also concluded that increasing the number of blocks and number of phase sequences large PAPR reduction can be obtained. As can be seen from the Fig. 7, PAPR was 10.4 dB without any scheme, 6.3 dB for SLM scheme and 5.0 dB for proposed BSLM scheme.

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