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Performance Improvement of OFDM System and Papr Reduction

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Abstract--One of the major concerns of Orthogonal Frequency Division Multiplexing (OFDM) systems are its high Peak to Average Power Ratio (PAPR) values. These high PAPR values result in serious degradation in performance when a non-linear power amplifier is employed. The Conventional Partial Transmit Sequence (C-PTS) technique is one of the highly efficient methods for PAPR reduction in OFDM systems. Unfortunately, the number of Inverse Fast Fourier Transform (IFFT) operations employed in C-PTS technique is large and this adds to the computational complexity of the technique. In our proposed Hybrid technique, we have combined the C-PTS technique with predefined phase factor multiplication method. The peaks of the OFDM signal are compressed by making the out of phase sub blocks to in phase sub blocks. All the extra IFFT operations that are required for C-PTS technique are avoided by our proposed method. Signal clipping and filtering result in reducing PAPR values even further. The simulation results show that our proposed (post-phase optimized)PTS technique achieves better reduction compared to the Amplitude Clipping and Selective Level Mapping(SLM) technique at levels of reduced computational complexity.

Index Terms—OFDM, IFFT, PAPR,SLM, C-PTS.

I. INTRODUCTION

With the ever growing demand of high data rate in the present generation, many multi carrier transmission techniques were evolved. OFDM is one of such technique. OFDM is a parallel transmission scheme, where a high-rate serial data stream will be splitted into a set of low-rate sub streams, each of which will be modulated on a separate sub carrier (FDM). Thereby, the bandwidth of the sub carriers will become small compared to the coherence bandwidth of the channel; that is, the individual sub carriers experience flat fading, which allows for simple equalization. This implies that the symbol period of the sub streams is made long compared to the delay spread of the time-dispersive radio channel. By selecting a special set of (orthogonal) carrier frequencies, high spectral efficiency is obtained because the spectra of the sub carriers overlap, while mutual influence among the sub carriers can be avoided. The orthogonal placing of the sub carriers leads to high spectral efficiency. It is increasingly being adopted as the technology of choice for 4g communication systems. It is the technology of choice in many wireless communication systems, such as Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB) and Wireless Local Area Network (WLAN). Despite all these advantages, OFDM technique also suffers from a few drawbacks. An OFDM signal consists of a number of independently modulated sub carriers, which can give a large peak-to-average power ratio (PAPR) when added up coherently. A large PAPR brings disadvantages like an increased complexity of the analog-to-digital (A/D) and digital-to-analog (D/A) converters and a reduced efficiency of the RF power amplifier. In order to reduce PAPR, several techniques have been proposed. The Partial Transmit Sequence (PTS) scheme is one of the efficient techniques for PAPR reduction without introducing signal distortion to the source. The PTS technique partitions an input data block into distinct sub blocks that are consequently located and of equal size. The phases of the sub blocks are optimized with proper phase rotation factors to get the signal with the smallest peak. In this paper, we have proposed a hybrid scheme based on PTS ,The proposed technique provides better PAPR performance when compared to the SLM and Clipping techniques. The reduction in PAPR leads to better overall performance of the OFDM system. This paper is organized as follows. Section I deals with the introduction to OFDM systems. Section II deals with the, basics of Peak to Average Power Ratio (PAPR). Section III explains Selective Level Mapping (SLM)) in detail., and our proposed Simplified PTS Technique. The simulation results are discussed in section IV. Finally, the conclusion is provided in section V. The proposed technique can be used as an alternative for improving the performance of OFDM systems as it provides better PAPR reduction when compared to the conventional methods.

II. PEAK TO AVERAGE POWER RATIO

In an OFDM system, the input data symbol vector is represented by X= [X_0 ,$_1$,..., X_{N-1}] in the frequency domain. The discrete

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time OFDM signal X(t) is generated by the modulation with 'N' orthogonal subcarriers and by performing the IFFT operation on X The discrete time OFDM signal X(t) as follows,

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k \; e^{j2\Pi f_k t}, 0 \le t \le NT$$

Where N is the number of subcarriers and t is the discrete time index, X_k denotes the transmitted data symbol modulated onto the kth carrier. PAPR is the ratio between the maximum power and the average power of the discrete time OFDM signal x(t) . The PAPR of the OFDM signal x(t) is given by

$$PAPR[x(t)] = \frac{Ppeak}{P_{avg}} = 10 \, log_{10} \frac{\max[|x(n)|^2]}{E[|x(n)|^2]}$$

E denotes the expectation operation. We can realize the OFDM modulation with N-point IFFT whose outputs are 'N' samples in the time domain . It must be taken into consideration that the PAPR of a continuous – time OFDM signal cannot be accurately represented by the use of N samples per signal period . These samples obtained under the Nyquist sampling rate are not able to show the actual peaks of its corresponding continuous signal. Therefore, oversampling is necessary to make an approximate estimation of the PAPR of the OFDM symbols. The oversampling factor is generally considered to be 4. Since, the input data are random variables, the PAPR which is a function of the input data is also a random variable. The level crossing theorem, which calculates the average number of times that the envelope of a signal crosses a given level, can be used to calculate the PAPR of the given signal. Knowing the amplitude distribution of the OFDM output signals, it is easy to compute the probability that the instantaneous amplitude and power will be above a certain threshold. The CCDF can be used to calculate this probability for different PAPR values.

$$CCDF\,(N , PAPR0) = pr \{ PAPR > PAPR0 \}$$

Where N is the number of subcarriers in an OFDM system and PAPR0 is a certain value of PAPR.

III. PAPR REDUCTION TECHNIQUES AND PROPOSED METHOD

A. Selective mapping

The input data sequences are multiplied by each of the phase sequences to generate alternative input symbols sequences. Each of these alternative input data sequence is made the IFFT operation, and then the one with the lowest PAPR is selected for transmission. In Figure(1) each data block is multiplied by V different phase factors, each of length N, resulting in different data blocks. Thus, the phase sequence after multiplied is Therefore, OFDM signals can be taken as Where Among the data blocks only one with the minimum PAPR is selected for transmission and the matching selected phase factors also should be transmitted to receiver as side information. SLM requires IFFT operation and the number of required bits as side information is for each datablock.

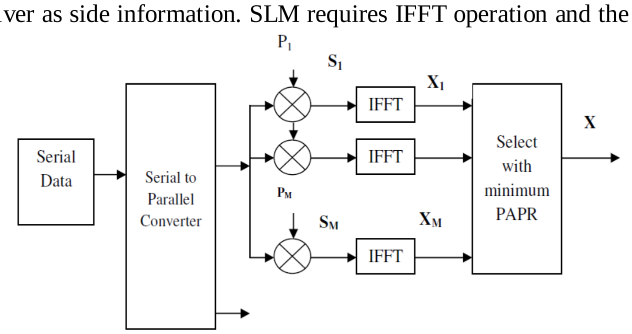

Figure 1. Selective Mapping Technique

B. Proposed Simplified Partial Transmit Sequence Method

The Partial Transmit Sequence (PTS) technique partitions on input data block of N symbols into V distinct sub-blocks as follows

$X_i = [X_0, X_1 , X_2 , ... , X_{v-1}]$

Where in X_i , i=0 to V-1 are the sub blocks that are consecutively located and also are of equal size. In PTS technique, phase rotation is applied to each sub-block independently. Multiplication of each partitioned sub-block by a corresponding complex phase factor $b_{v = e}{}^{j\text{Ø}V}$, v=1,2,..., V subsequently taking its IFFT yields ,

$$X = \sum_{v=0}^{V} X_v \, b_v$$

where $b_{v} = e^{j\varnothing_{v}}, \varnothing_v \in (0.2\pi)$ is a weighting factor been used for phase rotation.The signal in time domain is obtained by applying IFFT operation on, that is $\tilde{x} = IFFT[X] = \sum_{v=0}^{V} b_v X_v$

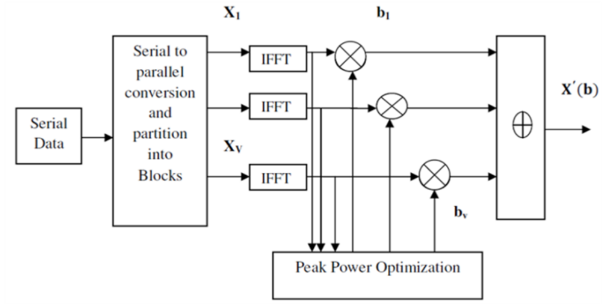

Figure.2. proposed PTS block diagram

Where { $\tilde{x}$ } is referred to as the partial transmit sequence (PTS). The phase vectors are chosen as to minimize the PAPR. It is represented by,

$$b = [b_1, b_2, \ldots, \mathrm{bv}] = \arg\min(\mathrm{b1}, \mathrm{b2}, \ldots, \mathrm{bv})\left(max_{1\le n\le N}\left|\sum_{v=1}^{V} b_v X_v\right|^2\right)$$

Then, the corresponding time-domain signal with the lowest PAPR vector can be selected for transmission.

The PTS technique suffers from the complexity of searching for the optimum set of phase vector, especially when the number of sub blocks increases. Various schemes have been proposed to reduce this complexity[5].The sub-optimal combination algorithm, which uses the binary phase factors of {1, -1, j, -j} is one such example. The algorithm can be summarized as follows:-

Partition the input data into V sub blocks as in equation 1

Set all the phase factors bv = 1 for v=1: V,

TABLE I. PARAMETERS USED IN SLM AND PTS TECHNIQUES

Parameters	***Values used***
Number of sub-carriers (N)	4,16,32,64
Oversampling factor (OF)	4
Modulation scheme	BPSK,QPSK, 4-QAM,16-QAM
Route numbers used in SLM (pre-phase optimization) method ,(M)	4
Number of sub-blocks used in PTS(post-phase optimization) method, (V)	4
Total number of combinations or IFFT	64
Number of generated OFDM signal	256
Length of Cyclic Prefix as guard intervals	1/4 of 256 = 64
Total length of OFDM waveform at transmitter	320

IV. SIMULATION RESULTS

A. OFDM Waveform

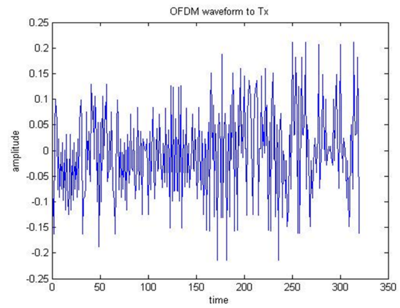

Figure.3. OFDM waveform

The above figure shows the representation of 320 point OFDM data including guard intervals.

B. Proposed (Post-Phase Optimized) PTS Method For PAPR Reduction

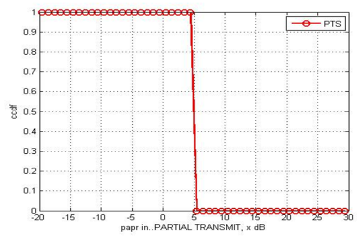

Figure.4 PAPR plot of proposed PTS method

Figure(4) represents the CCDF Vs PAPR of OFDM signal , and PAPR is reduced to 5.8dB using proposed PTS method.

C. PAPR Reduction Using Amplitude Clipping, SLM and PTS Methods

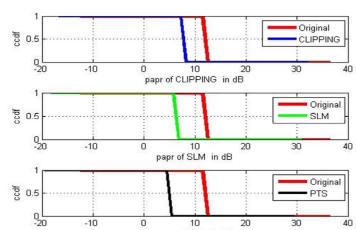

Figure.5 PAPR plot using various methods as PAPR reduction techniques

D. Comparison Of Amplitude Clipping ,SLM And Proposed PTS Techniques As PAPR Reduction Schemes

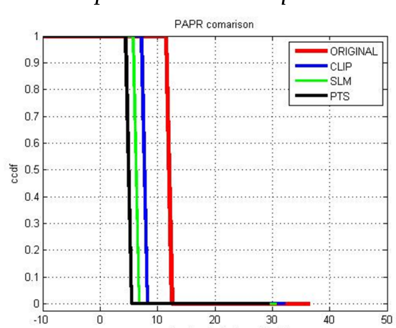

Figure.6 over all comparison between various PAPR reduction techniques

In above figure, it is clear that the proposed Simplified Partial Transmit Sequence method produces lower Peak to Average Power Ratio 5.8dB than other two methods, Clipping and Selective Level Mapping which produces the PAPR in 7.8 and 6.4 in dB respectively.

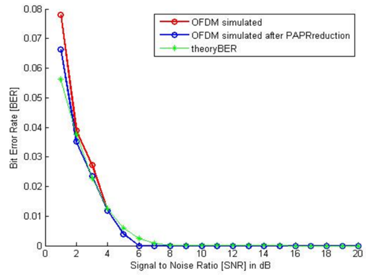

Figure.7 BER comparison after reduction of PAPR in OFDM system using post-phase optimized PTS method

V. CONCLUSION

OFDM is a attractive and better technique for wireless communications due to its spectrum efficiency and channel robustness. One of the considerable drawbacks of OFDM systems is that the composite transmit signal can exhibit a very high Peak to Average Power Ratio when the input sequences are highly correlated. In this paper, several important aspects are described and mathematical analysis is provided, including the distribution of the PAPR used in OFDM systems. Three typical signal scrambling techniques, Amplitude Clipping, SLM and PTS are investigated to reduce PAPR, all of which have the potential to provide substantial reduction in PAPR. Proposed Post Phase optimized PTS method performs better than SLM method in reducing PAPR.

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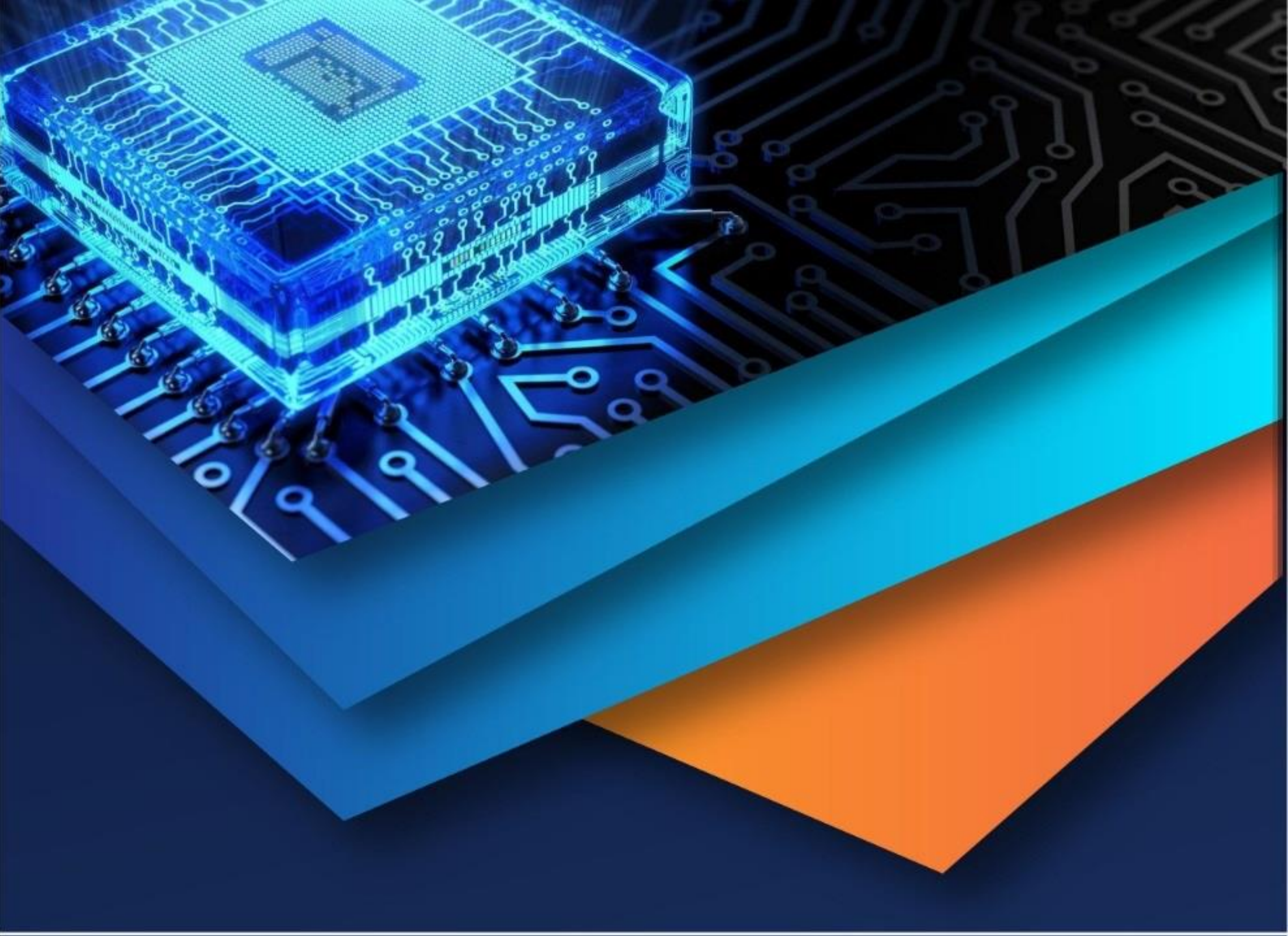

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