Analysis of Selective Mapping PAPR Reduction Technique in OFDM System

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Abstract- OFDM technology is very useful due to high data rate transmission. Due to high data rate transmission and robustness against multipath channel fading OFDM technique has been widely adopted in many wireless communication system. OFDM is one of the attractive multicarrier modulation scheme for fourth generation wireless communication system. OFDM signal consist of multiple carrier frequency It is a technique basically used for high bit rate transmission through various sub channels at lower data rates. During Transmission one major problem which is responsible for degradation of signal during transmission is its high peak to average power ratio. To deal with the problem of peak to average power ratio which leads to linearity it require expensive amplifier with good linearity. The main objective of this paper is to analyze the PAPR performance of Selective mapping technique by parameter variation.

Index Terms- **Binary Phase Shift Keying (BPSK), Complementary Cumulative Distribution Function (CCDF), Orthogonal Frequency Divisions Multiplexing (OFDM), Peak-To-Average Power Ratio (PAPR), Selected Mapping (SLM), Partial Transmit Sequence (PTS).**

1. INTRODUCTION

Communication plays important role in our life. OFDM is very attractive digital modulation technique used in mobile communication for high speed data transmission. OFDM is a multicarrier wireless communication system used for transmitting large amount of data [1]. It is a multicarrier digital modulation scheme whose range is four times greater than that of single carrier modulation scheme. To meet out the requirement of higher data rates and high spectral efficiency a new digital multicarrier modulation scheme is developed in communication field which is suitable for both wired and wireless environment. New promising digital multicarrier modulation scheme to fulfill these requirements in the telecommunication field is orthogonal frequency division multiplexing (OFDM)[2].

The technology was first conceived in the 1960s and 1970s. A major shortcoming associated with OFDM is its high peak to average power ratio due to number of sub carriers which is responsible for signal degradation during transmission or seriously limit the efficiency of power amplifier. Due to number of advantages OFDM technique has been widely adopted for a number of applications such as standard for audio broadcasting (DAB), digital video broadcasting (DVB), HIPERLAN/2,wireless LAN (IEEE802.11x) and WiMAX ,etc [3]. Due to efficient usage of bandwidth it is considered to be the modulation technique for next generation 4G networks. Benefit of OFDM is that it can be efficiently implemented by using the fast-fourier transform (FFT) algorithm, and the receiver implementation becomes simple since each channel or sub-carrier can be treated as narrow-band instead of a more complex wide-band channel. It is well known that OFDM is spectrally efficient but power inefficient due to the large peak-to average power ratio (PAPR) inherent in the OFDM signals, a high PAPR value makes the signal vulnerable to nonlinearities in the transmission.

The main objective of OFDM is to divide high data rate bit stream in to number of lower parallel bit stream which are used to modulate different number of subcarriers by using fourier transform[4]. These subcarriers overlapped with each other in frequency domain form, thus to increasing the transmission rate, In OFDM a guard band is inserted to eliminate the effect of intersymbol interference (ISI).OFDM system has number of advantages like immunity to inter-symbol interference ,high spectral efficiency, robustness in frequency selective fading channels and capability of handling strong multipath fading.

The problem of Peak to average power ratio can be analyzed by using its complementary cumulative distribution function (CCDF).In OFDM signal peaks increase the inter modulation distortion which results increase in the error rate. By reducing the peak to average power ratio it allows higher power amplifier to transmit a fixed peak power level which further improve the overall signal to noise ratio (SNR)

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at the receiver end. The instantaneous output of an OFDM system often has large signal fluctuations as compared to traditional single-carrier systems. This requires number of system devices, such as power amplifiers, A/D converters and D/A converters, must have operated with large linear dynamic ranges.

II. SYSTEM MODEL

For OFDM system implementation, Inverse Fast Fourier Transform (IFFT) is usually being utilized to modulate multiple sub-band signals in an OFDM. In OFDM system, the information data symbol are passed through serial to parallel convertor and modulated using different modulation scheme like Quardrature amplitude modulation (QAM), binary phase shift keying (BPSK) and quardrature phase shift keying (QPSK) to form a complex vector of size N. Here single signal bit is divided into N different parallel routes An N point FFT or IFFT operation is used to modulate and demodulate the data [5].

The Complex vector is written as:

$$X= [X_0, X_1, X_2 \dots\dots\dots\dots\dots\dots\dots\dots\dots . . X_{N-1}]^T \qquad (1)$$

Complex vector X is passed through IFFT block. After IFFT transform the signal can be written as

$$x_n = \frac{1}{\sqrt{N}} \sum_{K=0}^{N-1} X_k W_N{}^{nK} \qquad (2)$$

Here x_n represent the transmitted OFDM signal, N is the number block size.

2.1 Peak Average Power Ratio (PAPR)

The Peak to Average power ratio of OFDM signal is defined as the ratio between average signal power and the maximum peak power .Theoretically the large number of peak in OFDM system can be expressed by using parameter peak to average power ratio (PAPR) and it is mathematically expressed as [6]

$$\text{PAPR}=\frac{P_{PEAK}}{P_{AVERAGE}}=10\log 10\,\frac{\max[|x_n|^2]}{E[|x_n|^2]} \qquad (3)$$

Where P_{PEAK} represents the peak power of OFDM signal and $P_{AVERAGE}$ represents the average power of OFDM signal.

In OFDM when baseband signal reaches its maximum theoretical value then PAPR is defined as…

$$\text{PAPR (db)} = 10\log(N) \qquad (4)$$

One of the another important parameter commonly used in OFDM system is Crest factor which is used to evaluate the range of continuous time OFDM signal and envelop fluctuation where the value of PAPR is equal to square of crest factor i.e. PAPR= $(CF)^2$ .The Crest Factor (CF) is defined as the ratio between maximum amplitude of OFDM signal s (t) and root mean square (RMS) of the waveform [7].

$$\text{CF(s(t))}=\frac{\max[|s(t)|]}{E[|s(t)^2|]} = \sqrt{PAPR} \qquad (5)$$

2.2 Complementary Cumulative Distribution CCDF of PAPR in OFDM

The Complementary Cumulative Distribution Function is one of the most widely used parameter which is used to evaluate the performance of any PAPR reduction technique. Normally we used Complementary CDF in place of Cumulative Distribution Function (CDF) [8]. The cumulative distribution function of the peak power per OFDM symbol can be found based on the assumption of the uncorrelated samples. This parameter is helpful to find out the probability that PAPR of particular data block exceed a certain threshold value [9].The Cumulative Distribution Function of sampled valued signal is expressed as:

$$F(z)=1-\exp(-z) \qquad (6)$$

Assuming that multicarrier OFDM system contain same data bits that are mutually independent with each other and free from oversampling operation, In this case if the probability distribution function for PAPR less than certain threshold value is therefore defined as:

$$P(PAPR)F(Z)^N=(1-\exp(z))^N \qquad (7)$$

If the probability of PAPR exceed a certain threshold value than "Complementary Cumulative Distribution Function" can be mathematically represented as:

$$P(PAPR>Z)=1-P(PAPR\leq Z)=1-F(Z)^N$$

$$=1-(1-\exp(-Z))^N \qquad (8)$$

III. PAPR REDUCTION TECHNIQUES

At present there are number of different techniques have been proposed by different authors to dealing with the problem of PAPR [10] [11].These techniques vary according to the need of system depend upon the number of factors such as PAPR reduction capacity and spectral efficiency. There are number of factors which are considered important while adopting any PAPR reduction technique increasing transmit signal power, loss in data rate, computational complexity, and increased bit error rate at receiver end. These techniques are basically divide in to two parts signal scrambling and signal distortion techniques. The purpose of signal scrambling technique is to scramble OFDM signal with different

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variation of codes or scrambling sequence and eliminates the peaks to achieve PAPR reduction and select one which has lowest PAPR value for transmission [12]. Different coding techniques Barker codes, M sequences, Golay Complementary and Shapiro-Rudin sequences have been used for reduction of PAPR. The main problem associated with these techniques is that as numbers of carrier's increases while searching for best code the associated overhead will also increases exponentially. This type of approach include: Selective Mapping (SLM), new phase SLM and Partial Transmit Sequences (PTS. SLM) method applies scrambling rotation to all sub-carriers independently while PTS method only takes scrambling to part of the sub-carriers. In SLM or PTS there will be no restriction on type of modulation and number of subcarriers. In new phase SLM scheme the SLM and PTS schemes are combined and the rows of the normalized Riemann matrix are used as phase sequence set for PAPR reduction. Signal distortion techniques include Peak windowing, envelop scaling etc.

3.1 Selective Mapping Technique

SLM PAPR reduction technique has been first proposed by Bamul.et.al. Selective mapping is a simple PAPR suppression method for OFDM signals. The SLM technique is basically implemented from the idea of symbol scrambling. In this scheme, a set of candidate signals are generated to represent the same information, then the signal with lowest PAPR is selected for transmission [14]. The information about the selection of these candidate signals need to be explicitly transmitted along with the selected signal as side information [13]. Selected mapping technique needs to transmit the information to receiver, with the selected signal, as side information. If there is any error in the received information, then it is difficult for the receiver to recover the information from the transmitted selected signal. Due to this problem a strong protection is needed regarding side information. If the receiver has these side information then the process of decoding become very simple. SLM PAPR reduction technique can be employed for larger number of sub-carriers with moderate complexity.

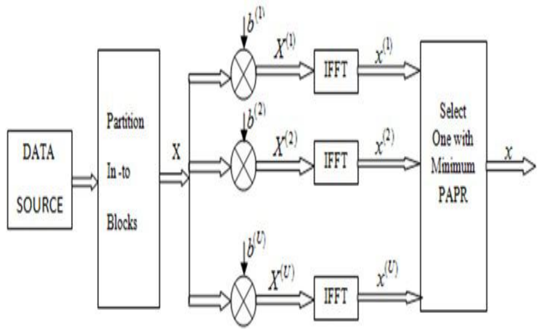

Fig. 2 Block Diagram of Selective mapping technique

The technique contains codes only for PAPR reduction and does not include error correction. The complexity is increased in this scheme due to the multiple numbers of IFFT operations. The need for transfer of side information to the receiver without any margin for transmission errors is very crucial under the fading channels.

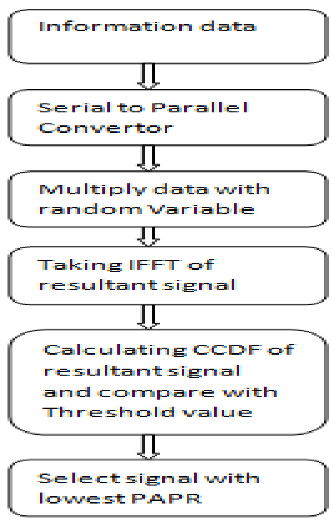

Fig. 2 Flow chart for SLM technique.

Algorithm of Selective mapping technique:

a) Divide the input data in to number of sub blocks and converted into parallel form by using convertor.
b) Then the input data sequences are multiplied by phase sequence to generate input symbol sequence.
c) IFFT operation is made on each of input resultant symbol sequence.
d) Calculate CCDF of resultant signal and compare it with threshold value.
e) Data with lowest PAPR is selected for transmission.

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OFDM system with SLM algorithm to reduce the PAPR with mathematical expression:

Let the input data is defined as:

$$X=[X_0, X_1, X_2, X_3 \dots\dots\dots\dots\dots\dots\dots\dots\dots. X_{N-1}]^T \quad (9)$$

Each data block is multiplied with U different phase factor; Then Phase rotated sequence due to phase rotation factor Bv^u can be written as:

$$X^{vu} = \text{IFFT}(X \otimes B^{(vu)})$$

Where

$$B^u=[bv_0{}^u, bv_1{}^u, bv_2{}^u, bv_3{}^u \dots\dots\dots\dots. b_{vN-1}{}^u]^T \quad (10)$$

With phase sequence with $|bv_n{}^u| = (n = 0, 1, N\text{-}1)$

We are usually selected (± 1) for avoiding complexity for complex multiplication or to add unmodified data in to modified data.

After that multiply input data with U different phase factor the modified data for U phase sequence can be written as:

$$X^u=[X_0 bv_{u,0}, X_1 b_{vu,1}, X_2 bv_{u,2} \dots\dots X_{N-1} b_{vu,N-1}] \quad (11)$$

u=0, 1, 2….U-1.After the PAPR comparisons among the U data sequence *x* (u), the optima mapped one $\hat{x}$ with the minimum PAPR is selected for transmission.

$$\hat{x} = \arg\min_{0 \le U \le U} [\text{PAPR}(X^{(vu)})]$$

PAPR reduction effect will be better U is increased.SLM method can effectively reduce PAPR without any signal distortion.

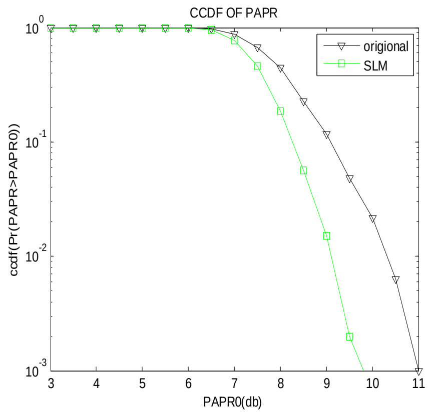
IV. RESULTS AND SIMULATION

The complementary cumulative distribution function (CCDF) of the PAPR is the most commonly used performance measures for PAPR reduction techniques. In this paper selective mapping PAPR reduction technique is analyzed by using different number of sub-blocks. The simulation were performed in matlab (version7.8) .The table summarizes the different parameter used for simulation.

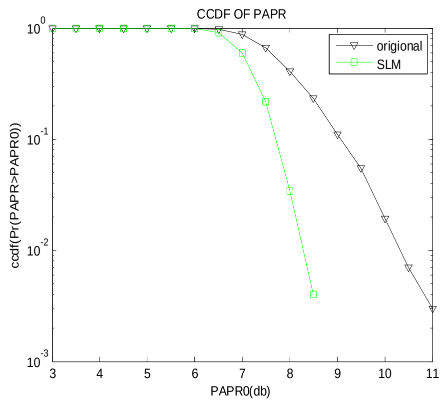
Table: Parameter used for simulation

Simulation Parameter	Value
No of Sub-Carriers(N)	**256**
No of Sub-Blocks(M)	**2,4,8,16,32**
Oversampling Sampling(L)	**4**
Modulation Type	**BPSK**
Phase factor	**[1,-1]**

Fig shows the simulation results for complementary cumulative distribution function vs PAPR for different value of M =2; 4; 8; 16; 32 sub-blocks respectively. The simulation result shows that for higher value of threshold PAPR, the SLM technique offer better result than other PAPR reduction techniques.



CCDF of SLM PAPR and original scheme with M=2 Sub-blocks(N=256,L=4,BPSKmodulation)



CCDF of SLM PAPR and original scheme with M =4 Sub-blocks (N=256, L=4, BPSK modulation)

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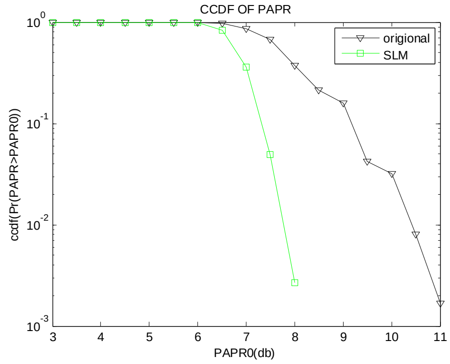
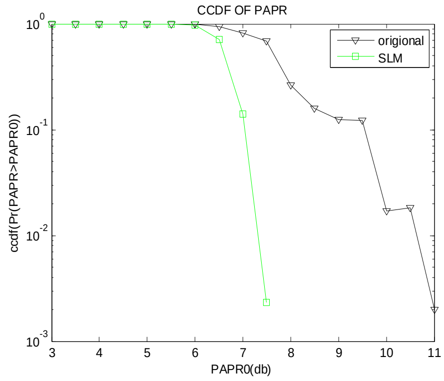
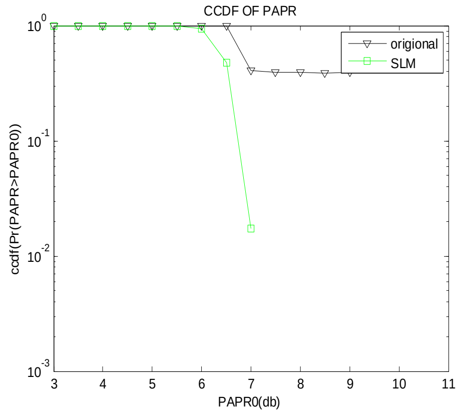


CCDF of SLM PAPR and original scheme with M=8 Sub-blocks (N=256, L=4, BPSK modulation)



CCDF of SLM PAPR and original scheme M =16 Sub-blocks (N=256, L=4, BPSK modulation)



CCDF of SLM PAPR and original scheme with M=32 Sub-blocks (N=256, L=4, BPSK modulation)

V. CONCLUSIONS

As compared to traditional single carrier modulation system the multicarrier modulation system offers better transmission. Selective mapping technique improve the performance of OFDM system with respective PAPR, it can produce independent multiple frequency OFDM signals. From the simulation results it can be concluded that the PAPR performance of SLM technique is better than other techniques. As number of sub-blocks increases the performance of selective mapping scheme is continuously improved.

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