Comparative Study of Reducing the PAPR of OFDM using the Methods of Clipping and SLM

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***Abstract*— Orthogonal Frequency Division Multiplexing (OFDM) is an well-structured multicarrier modulation that underlines most of the current and next era of high-speed wireless communication systems. When there are large number of subcarriers are used, the OFDM is characterized by high peak to average power ratio (PAPR). A high PAPR is one of the problems. It is nothing but a nonlinear distortion produced when passed through the power amplifier at the front end of the transmitter. In this paper, two techniques such as clipping and filtering and selected Mapping (SLM) is proposed and compared. The results are done by simulation and show that by using clipping and filtering, PAPR is 10.6189 db with better efficiency and for SLM technique PAPR is 13.4129db.**

Keywords—OFDM, PAPR, Clipping and Filtering, SLM,

I. INTRODUCTION

Rapidly at anywhere, anytime the requirement for better-standard communication services is growing up day by day. For the system designers it is a great demand to reduce the effect of delay and to improve the Quality of Service, for these techniques. To fulfill all these requirements, one attractive technology is OFDM and this is a multicarrier modulation technique [1][2][3]. The data transmission rate for this technique has better efficiency of bandwidth and it has low implementation complexity and good robustness to multi-path interference .This OFDM technique have been adopted in Asymmetric Digital Subscriber line (ADSL), Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), Digital terrestrial broadcast system and this technology is efficient for 4th and 5th generation communications systems [2].

PAPR is the major drawback of OFDM system which is occurred when the large numbers of carriers are formed by adding independent modulated subcarriers [2]. The OFDM signal is passed over the channel to a nonlinear power amplifier. At the transmitter side, the High Power Amplifier (HPA) working on an extremely enormous linear range is required to reduce high PAPR, otherwise the Bit Error Rate (BER) will be increased, because of the non - linearity of the HPA, Which causes in-band distortion and the out of band distortion is due to adjacent channel interference.

In this paper, two techniques are discussed for reducing PAPR. They are Clipping and filtering and selective mapping. The PAPR reduction is assessed for these techniques and the performance is compared.

The paper is organized as follows. The OFDM system is presented in segment II. The PAPR reduction techniques are discussed in segment III. Segment IV is of results and discussions. At last, conclusions are discussed in segment V.

II. OFDM SYSTEM

The OFDM system is shown in fig.1, initially the input signals are modulated which are successive in nature and are modulated by using different modulation techniques such as QPSK etc., and these samples are clubbed at the transmitter using IFFT/ IDFT. After performing IFFT/IDFT they are going to generate data subscribers which are orthogonal in nature. The vectors having a N length data block is represented as

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

For the symbol X_K the duration in the set X is T and also it is nothing but the sub-carriers set. For a data block which is complex in nature, the transmitted OFDM signal is given by

$X(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_N e^{j2\pi n \Delta f t}$ $0 \le t \le NT$ (2)

Where $j=\sqrt{-1}$,

Δf is the subcarrier spacing.

NT is the period of data block.

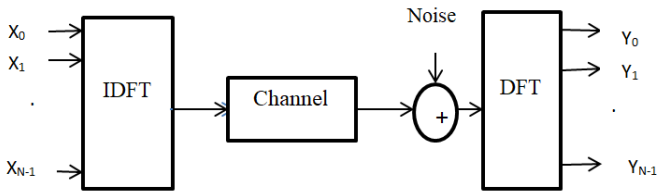

Fig. 1 Implementation of OFDM

By using a subcarriers which are large in number a high PAPR in OFDM is introduced [4], [5], [6]. PAPR can be defined as the relationship between the samples maximum power in a transmit OFDM symbol and its average power. The same phase of N signals are added coherently to produce a peak signal which the average of the N times signals. PAPR theoretically can vary from maximum of $10\log_{10}$ (N) (dB), where N is the number of subcarriers.

$$PAPR = \frac{\max |x(n)|^2}{E|x(n)|^2} \quad (3)$$

Where |x (n)| is the magnitude of OFDM signal x(n)

E[ ] denotes the expectation operator.

Due to high PAPR, the transmitting side power amplifiers are carried into saturation, so that the performance of BER gets degraded. The signal mean power is reduced by

avoiding the Power Amplifier into saturation. Hence, this reduces the BER performance and the SNR. Therefore, the maximum power of the signal is reduced so that the problem of PAPR is reduced. The different techniques of reducing PAPR has been proposed.

III. PAPR REDUCTION TECHNIQUES

A. Clipping and Filtering

In this method, before passing through linear power amplifier the OFDM signal is clipped off. There are two types clipping distortions they are in band distortion and out of band distortion. The spectral spreading is due to the In-band distortion and it is removed by the process of filtering, but the BER performance is degraded for out-of-band distortion and by filtering this cannot be reduced. However, by sampling the signal more than the Nyquist rate and considering IFFT length longer, in-band distortion effect will be decreased and the signal band is detached by filtering the signal band and the noise gets reshaped. The spectral efficiency is preserved by clipping the filtered signal so that the out of band distortion will be eliminated. [7].

The block diagram of clipping and filtering is depicted in Fig. 2 [7]. The OFDM symbol is realized by passing the data symbols of QPSK to the IFFT/IDFT module. If the OFDM signals will be in band, if this signal will be clipped directly and it cannot be decreased by filtering. Therefore sampling at a rate greater than the Nyquist rate is done. Then, the bandpass samples, x which are real valued, are clipped at amplitude A as follows:

$$y = \begin{cases} -A & ,if\ x < -A \\ x, if -A \le x \le -A \\ A & ,if\ x < A \end{cases} \qquad (4)$$

After clipping, filtering will be done and transmitted. The reverse operations are done at the receiver.

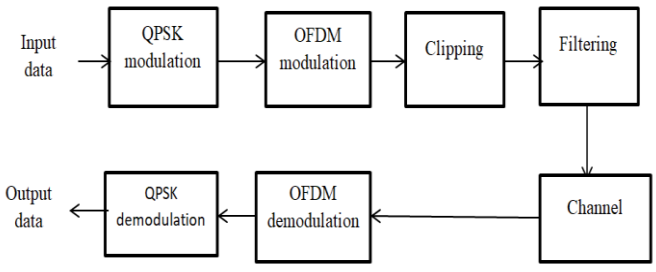

Fig.2 Block diagram of clipping and filtering

B.Selective Mapping

Selective mapping (SLM) is also the method for reducing PAPR [8]. In this technique, different OFDM symbols having varying from X_m, $0 \le m \le M-1$ of length N are produced and has the same information as OFDM symbol x, then the symbol with least PAPR will be transmitted. Then, the OFDM symbol x which is mathematically is expressed as

$$x = argmin_{0 \le m \le M-1}\ [PAPR(x_m)] \qquad (5)$$

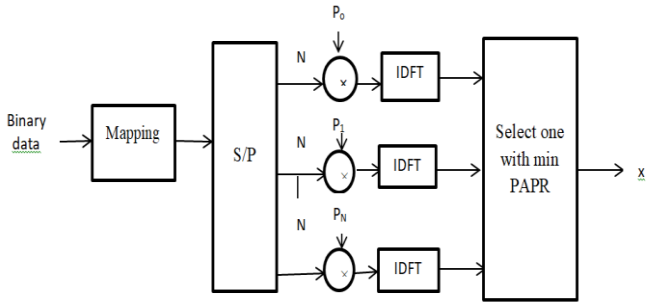

Fig. 3 Block diagram of OFDM transmitter with SLM.

The sequences having the phase P_m is multiplied by element by element with the original data block $X = [X_1, X_2, \ldots X_N]$, before taking IDFT. In order to simplify the operation, the phase sequences P_m will be set to $\{\pm 1, \pm j\}$ and are executed without multiplication. Then the resultant modified OFDM symbol X_m, $0 \le m \le M-1$, is the IDFT of the multiplication of each element of X and P_m.

$$x_m = IDFT[X_1 e^{j\emptyset m_1} X_2 e^{j\emptyset m_2} \ldots\ldots X_N e^{j\emptyset m_N}] \qquad (6)$$

The SLM technique block diagram is shown in Fig. 3[4]. Due to the side information the data transmission rate at the receiver decreases and is transformed to the selected phase sequence to recover the original symbol sequence. The phase sequences P_m, $0 \le m \le M-1$, will be stored at the transmitter and receiver. If the side information is erroneous then the whole system is destroyed. Therefore there must be side information must be strongly protected.

IV RESULTS & DISCUSSION

The behavior of two PAPR reduction techniques is studied and simulated using Matlab. These two techniques clipping and filtering and SLM technique is compared. The parameters which are used for this simulation is given in Table 1.The transmitter and receiver is synchronized to perform the simulation. To avoid inter symbol interference the delay spread is avoided by choosing the length of cyclic prefix length more chosen which is having maximum value.

The simulations are performed with QPSK modulation technique for clipping and filtering method to reduce PAPR with a clipping level (L) of 1.2. For selective mapping 10 OFDM symbols are considered and are multiplied with sequences having 10 different phases and the symbol having less PAPR is transmitted. Clipping and filtering method is more efficient and has efficiency of 53.2873 when compared to SLM technique. The simulated waveforms are shown in figure4, 5 and 6. Table 2 shows the comparison of clipping and SLM technique.

Table 1 Simulation Parameters

Parameters	Specifications
Number of transmitted symbols	64
Number of bits	16
Clipping (L) factor	1.2
Modulation technique	QPSK

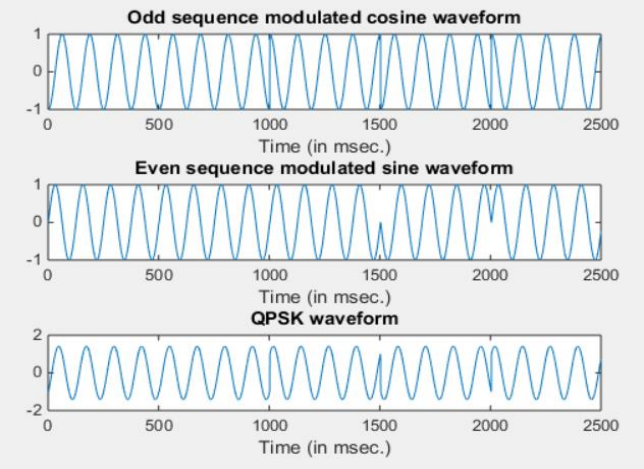

Fig. 4 QPSK waveform

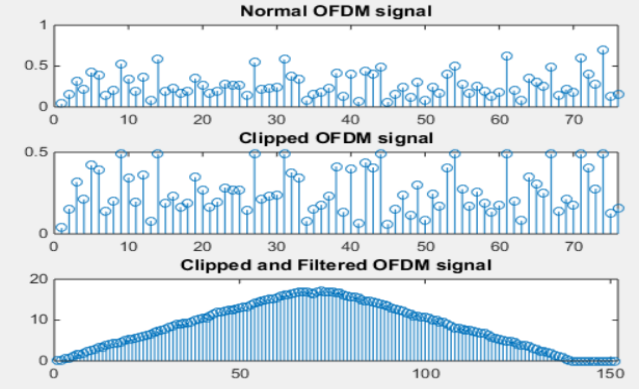

Fig. 5 Clipped and filtered signal

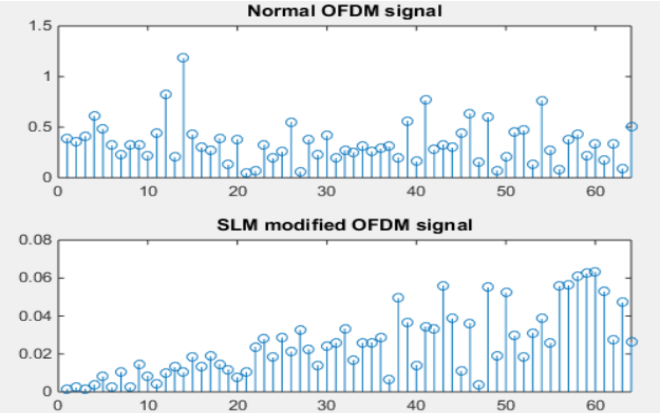

Fig. 6 SLM modified Signal.

Table 2 Comparison of clipping and SLM technique.

Type	PAPR in dB	Efficiency in percentage
Normal OFDM	22.7325	---------
SLM technique	13.4129	40.9965
Clipping and filtering	10.6185	53.2873

V CONCLUSION

Through a communication channel to transmit the data with high speed OFDM is the better choice and it is also a very better technology for transmission over multicarrier. It has various advantages; but it also has one of the disadvantage i.e, very high PAPR. In this paper, two technical methods are used to reduce the PAPR and they are compared. Clipping and filtering method has better PAPR and efficiency when compared to SLM technique. Further, it can be improved for MIMO systems.

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