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Performance Techniques for Reducing Peak-to-Average Power Ratio at Orthogonal Frequency Division Multiplexing Systems

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ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is a special case of multicarrier transmitted, where a single data stream is transmitted over a number of lower rate subcarrier. One of the main issues of OFDM is high Peak-to-Average Power Ratio (PAPR) of the transmitted signal which adversely affects the complexity of power amplifiers, In this paper we will discuss techniques used to reduce PAPR selective mapping (SLM), clipping, partial transmit sequence (PTS), techniques are implemented for PAPR reduction of OFDM signal at transmitter. Comparison of these PAPR reduction techniques is done based on CCDF and BER performance of the system.

Keywords:- Peak-to-Average Power Ratio; Clipping; Partial Transmit Sequence.

I. Introduction

The common advantage of future generations of wireless technology is the convergence of multimedia services such as voice, image, and video and information communications. This requires wireless platforms to ensure high speeds of information transmission.

In the fourth-generation spread technology called Orthogonal Frequency Division Multiplexing (OFDM) used in communication systems, is to split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously over a number of the subcarrier.

Orthogonal Frequency Division Multiplexing (OFDM) is widely used in many digital communication systems due to its advantages such as high bit rate, strong immunity to multipath and high spectral efficiency but it suffers a high Peak-to-Average Power Ratio (PAPR) at the transmitted signal [1].

Orthogonal Frequency Division Multiplexing (OFDM) system a multiplexing technique that divides the bandwidth into multiple frequency subcarriers. OFDM also uses multiple sub-carriers but the sub-carriers are closely spaced to each other without causing interference, removing guard bands between adjacent subcarriers.

Here all the subcarriers are orthogonal to each other two periodic signals are orthogonal when the integral of their product, over one period, is equal to zero [2].

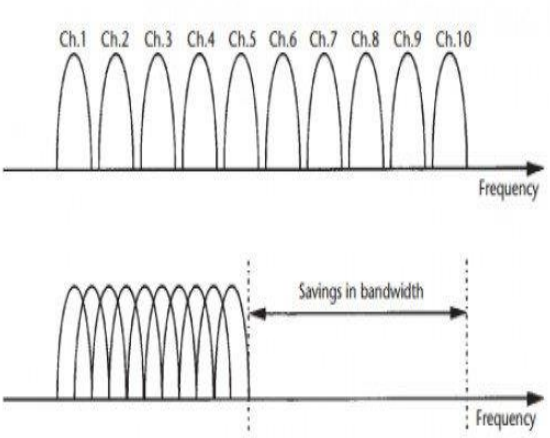

Figure (1) Orthogonal Frequency Division Multiplexing (OFDM) Multicarrier modulation

$$\int_a^b \varphi n(t)\varphi m(t)\,dt = 0 \qquad (1)$$

Where $n \neq m$

Peak to Average Power Ratio (PAPR). The PAPR of OFDM signal sequence is defined as the ratio between the maximum instantaneous power and its average power, which can be written for the oversampled OFDM signal symbol: [3]

$$PAPR = \frac{\max_{n=0,1,\ldots,NL} |x(n)|^2}{E[|x(n)|^2]} \qquad (2)$$

Where is the expectation operator and $P_{avr} = E[|x(n)|^2]$ is the average power.

The above power characteristics can also be described in terms of their magnitudes (not power)

$$CF = \sqrt{PAPR}$$

By defining the crest factor (CF) as (3)

Impact of PAPR on the performance of OFDM system one of the most serious problems is the high

Peak-to-Average Power Ratio (PAPR) of the transmitted OFDM signal, Since this large peaks introduce a serious degradation in performance when the signal passes through a nonlinear High-Power-Amplifier (HPA); the power amplifier at the transmitter needs to have large linear range of operation [4].

The non-linearity of HAP leads to in-band distortion which increases Bit Error Rate (BER) and out-of-band radiation, which causes adjacent channel interference

The peak to average power ratio (PAPR) of a transmitted signal is one of the main challenges in wideband multi-carrier systems that use the OFDM.

Peak to average power ratio (PAPR) Reduction Schemes: There are a number of techniques used to deal with the PAPR problem: Clipping and Filtering. Selective Mapping (SLM). Coding / Complement block coding. Partial Transmit Sequence (PTS). Tone reservation and tone injection. Nonlinear (-law / exponential commanding).

Clipping Techniques: The simplest PAPR reduction method consists basically in clipping the high parts of the signal. Amplitude that is outside the allowed region.If the OFDM symbol s is clipped at a level A, then the clipped signal ~ s is

$$s = \begin{cases} A & |s| \le A \\ Ae^{j\emptyset(s)} & |s| > A \end{cases} \qquad (4)$$

Where$^{\phi}$ is the phase of s.

This technique is the simplest of implementation but it has the following drawbacks: Clipping causes in-band distortion, which degrades the performance of the BER. Clipping causes out-of-band radiation, resulting in adjacent interference. This can be reduced by filtering, and thus clipping and Filtering (CF) operation is used in [5].

Clipping is performed always at the transmitter; receiver signal depends on the clipped signal estimated. In general, since the receiver has to calculate two important parameters like location and size of the clipping signals at one clipping per OFDM symbol. Clipping method may cause in-band distortion or out of band radiation into the OFDM system leading to peak regrowth especially in nonlinear system. This may affect the bit error rate performance (BER) and increases the signal to noise ratio (SNR) [6].

The out-of-band signals caused can be reduced by filtering. However, when the signal is clip at a certain level, some peak power reduces lower and filtering the clipped signal can reduce out-of-band radiation at the cost of peak re-growth and hence as explained in Figure (4).

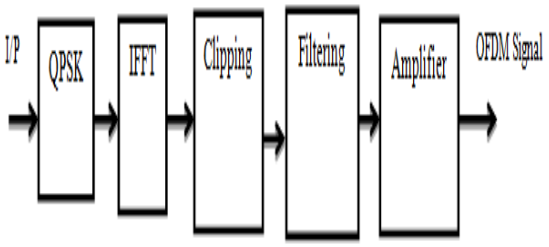

Figure (2) Block diagram clipping and filtering

Partial transmit sequences (PTS) is one of the most important methods that is used to reduce the peak-to-average power ratio (PAPR) in orthogonal frequency division multiplexing **(**OFDM) system**.** The crucial idea of partial transmit sequences algorithm is to divide the original OFDM symbol [7].

Data into sub-data which is transmitted through the sub-blocks which are then multiplied by the weighting value, which were differed by the phase rotation factor until choosing the optimum value which has low PAPR.

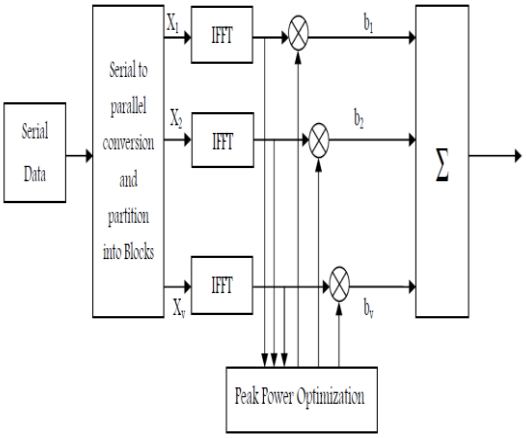

Figure (3) PTS technique implementation

The data sequence X in the frequency domain is sub-divided into ***v*** sub-sequence which was transmitted in sub-blocks without overlapping and having equal size of N which contains N/V non-zero values in each sub-block [8].

Sub-block vector in the frequency domain can be written as follows.

$X = \sum_{v=1}^{V} bvXv \qquad (5)$

The time domain for the above sub-block vector can be yield by applying IFFT function, that is

$X = IFFT(X) = \sum_{v=1}^{V} bvXv \qquad (6)$

Cumulative distributive function (CCDF) is to describe the probability of the random variable with the given probability Distribution function complementary cumulative distributive function is also called as tail distribution which is used to illustrate the PAPR of OFDM signal. The output curve is used to conclude the design parameters of the Modulation system.

The CCDF of an OFDM system to measure the PAPR can be given as:

CCDF= Pr (PAPR>PAPR0) *(7)*

Where P_r is the probability distribution function and $PAPR_0$ is the threshold value.

RESULTS AND DISCUSSION

Simulation results for the PAPR Reduction for OFDM System simulated in MATLAB are shown in Figures 4-5. In this paper, three methods were simulated Partial Transmit Sequence (PTS) and selective mapping (SLM) and Clipping methods Show in Figures 5. The simulation results show that using the Partial Transmit Sequence (PTS) method is the best performance and efficiency in reducing PAPR in OFDM system; because PAPR is decreased From 24 dB to 5.6 dB.

After simulation found Partial Transmit Sequence (PTS) technique is the best solution for the PAPR problem in OFDM System As shown in Fig (8).

The Table (1) below illustrates some of the parameters used in the simulation

Table (1) Parameters used in the simulation

Subcarrier number N	1024
Oversampling factor L	4
Modulation scheme	QPSK

Figure 4 illustrates the use of the three ways to reduce the PAPR in OFDM System.

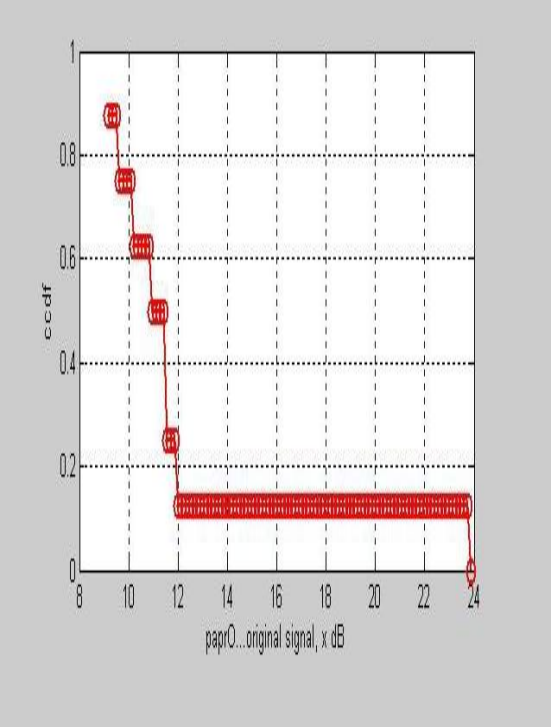

Figure (4) original signal OFDM signal

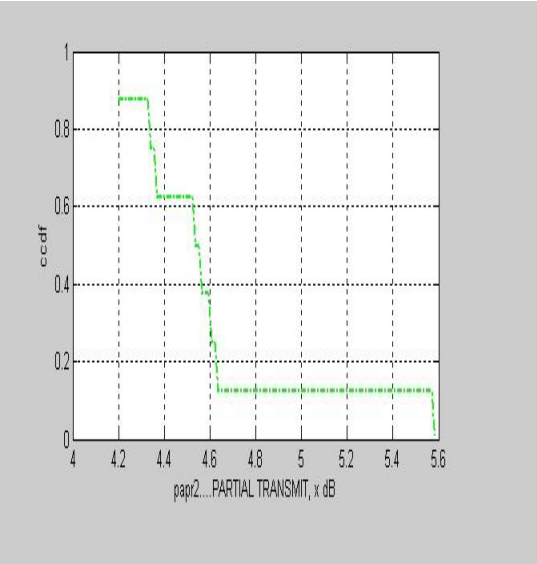

Figure (5) Partial Transmit Method

Figure.5 illustrates the performance of the system has been improved by more than 5 dB using PTS technique.

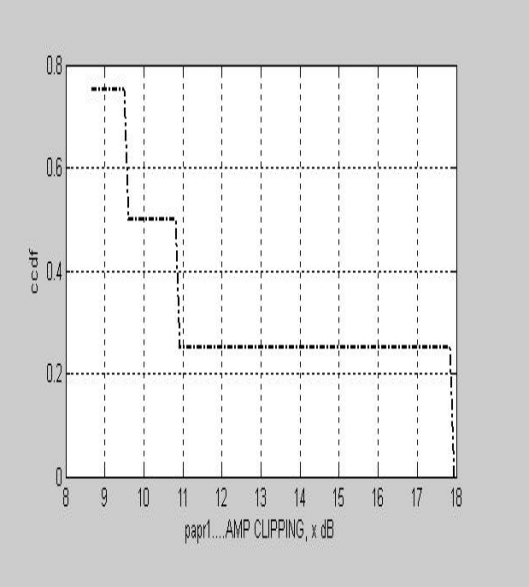

Figure (6) Clipping Method

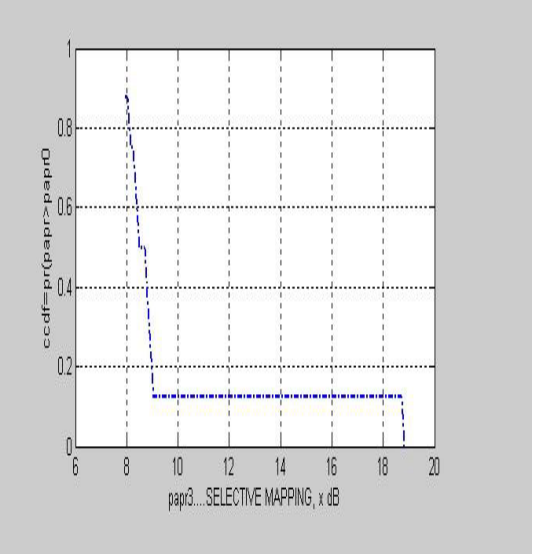

Figure (7) Selective Mapping Method

Figures 4-7 comparison of PAPR reduction performances between PTS algorithm and SLM algorithm and clipping algorithm with N = 1024 and QPSK modulation

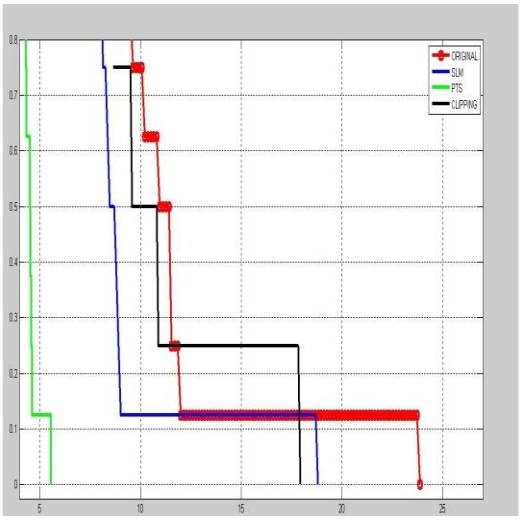

Figure (8) Comparison of PAPR reduction performances between PTS and SLM and clipping

Performance comparison of PAPR reduction between PTS and SLM and clipping. It is clear from this result the PTS PAPR reduction technique gives better performance than other techniques.

VI. CONCLUSION

There are several techniques to reduce the PAPR in OFDM transmission system. All PAPR reduction techniques have advantages and limitations. This paper discussed the concept of OFDM system and PAPR Reduction in OFDM and The PAPR reduction techniques clipping and SLM and PTS. From the results, It is observed that the performance of the system has been improved by more than 5 dB using PTS technique. As seen from the above Figure (8) partial transmit sequence (PTS) gives a better reduction ratio in dB using complementary cumulative distribution function (CCDF) as compared with selective mapping (SLM) and clipping.

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