PAPR Reduction in MIMO-OFDM System using SLM and Median Filtering

Mohsin Gangat, Prof. Neelesh Nema, Prof.Ashutosh Gupta
Department of Electronics and Communication
RKDF College of Engineering, Bhopal

Abstract: Orthogonal frequency division multiplexing (OFDM) has been received as a standard for different high information rate wireless correspondence frameworks because of the ghastly transmission capacity effectiveness, heartiness to recurrence specific blurring channels, and so forth. Not with standing, usage of the OFDM framework involves a few challenges. One of the real disservices is the high peak-to-average power ratio (PAPR),which brings about entomb transporter impedance, high out-of-band radiation, and bit lapse rate execution corruption, basically because of the nonlinearity of the high power amplifier. This paper proposed a technique which significantly enhanced the performance of the MIMO OFDM system in addition with selective mapping(SLM), here we have used median filtering which is linear in nature and does not increases the complexity of the system. From simulations results it is clear that the proposed approach is making future technology more robust for OFDM system.

Index Terms: Orthogonal frequency division multiplexing (OFDM), partial transmits sequences (PTS), peak-to-average power ratio (PAPR), selected mapping (SLM), and tone reservation (TR).

I. Introduction

Recently, orthogonal frequency division multiplexing (OFDM) has been regarded as one of the core technologies for various communication systems. Especially, OFDM has been adopted as a standard for various wireless communication systems such as wireless local area networks [1], wireless metropolitan area networks, digital audio broadcasting, and digital video broadcasting. It is widely known that OFDM is an attractive technique for achieving high data transmission rate in wireless communication systems and it is robust to the frequency selective fading channels [2]. However, an OFDM signal can have a high peak-to-average power ratio (PAPR) at the transmitter, which causes signal distortion such as in-band distortion and out-of-band radiation due to the nonlinearity of the high power amplifier (HPA) and a worse bit error rate (BER) [3]. In general, HPA requires a large back off from the peak power to reduce the distortion caused by the nonlinearity of HPA and this gives rise to a low power efficiency, which is a signicantly burden, especially in mobile terminals. The large PAPR also results in the increased complexity of analog-to-digital converter (ADC) and digital-to-analog converter (DAC).Thus, PAPR reduction is one of the most important research areas in OFDM systems. PAPR reduction schemes can be classified according to several criteria. First, the PAPR scheme scans are categorized as multiplicative and additive schemes with respect to the computational operation in the frequency domain. Selected mapping (SLM) and partial transmit sequences (PTS) are examples of the multiplicative scheme because the phase sequences are multiplied by the input symbol vectors in the frequency domain [4]. On the other hand, tone reservation (TR) [5], peak canceling, and clipping [6] are additive schemes, because peak reduction vectors are added to the input symbol vector. Second, the PAPR reduction schemes can be also categorized according to whether they are deterministic or probabilistic. Deterministic schemes, such as clipping and peak canceling, strictly limit the PAPR of the OFDM signals below a given threshold level. Probabilistic schemes, however, statistically improve the characteristics of the PAPR distribution of the OFDM signals avoiding signal distortion. SLM and PTS are examples of the probabilistic scheme because several candidate signals are generated and that which has the minimum PAPR is selected for transmission. Besides the PAPR reduction schemes, the single carrier frequency division multiple access (SC-FDMA) scheme has been proposed for alleviating the PAPR problem in uplink transmission. The SC-FDMA is an adopted multiple access scheme for uplink transmission in the long term evolution (LTE) of cellular systems by the third generation partnership project (3GPP). It is clear that the PAPR of SC-FDMA is lower than that of OFDMA, because SC-FDMA transmits the input symbols sequentially using a single carrier, while OFDMA transmits the input symbols in parallel. There have been several papers summarizing the PAPR reduction schemes [7]–[9]. In these papers, PAPR reduction schemes are compared according to various criteria, which include the PAPR reduction capability, average power increase, BER degradation, data rate loss, computational complexity, and out-of- band radiation. Jiang and Han briefly deal with the issues of PAPR in the multiuser OFDM systems [7], [8]. In [9], it is mentioned that the low complexity PAPR reduction schemes maybe applicable to mobile communication systems. Although numerous schemes have been proposed to solve the PAPR problem, no specific PAPR reduction scheme can be considered as the best solution. Since the criteria involve trade-offs, it is needed to compromise the criteria to meet the system requirements. The aim of this paper is to review the conventional PAPR reduction schemes and the various modifications of the Conventional PAPR Diminishment plans for accomplishing a low computational many-sided quality.

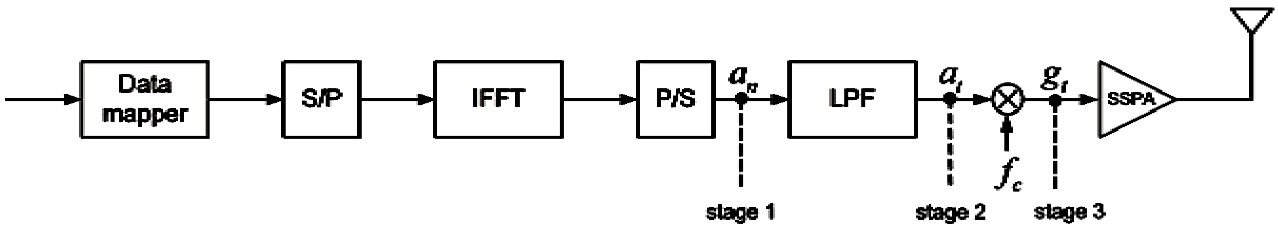

Figure 1. OFDM transmitter

This paper is sorted out as takes after: Section II defines PAPR and investigates the aspects of PAPR. At that point, we examine the ordinary PAPR lessening plans in Section III. Modifications of the routine PAPR decrease plans with a low computational many-sided quality are displayed and the numerical effects are examined in Section IV. At long last, the closing comments are given in Section.

II. OFDM SYSTEM MODEL AND PAPR

A. OFDM System Model

Let A =[A0 A1 ⋯AN−1]T denote an input symbol vector in the frequency domain, where A_k represents the complex data of the kth subcarrier and N is the number of subcarriers. The input symbol vector is also called the input symbol sequence. The OFDM signal is generated by summing all the N modulated subcarriers each of which is separated by 1/N ts in the frequency domain, where ts is the sampling period. Then, a continuous time baseband OFDM signal is defined as

$$a_t = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} A_k e^{j2\pi \frac{k}{Nt_s} t}, \;\; 0 \le t < Nt_s$$

The discrete time baseband OFDM signal an sampled at the Nyquist rate t = nts can be given as

$$a_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} A_k e^{j2\pi \frac{k}{N} n}, \;\; n = 0, 1, \cdots, N-1$$

Let a = $[a_0\ a_1\ \cdots a_{N-1}]$ T denote a discrete time OFDM signal vector. Then, corresponds to the inverse fast Fourier transform (IFFT) of A, that is, a = QA, where Q is the IFFT matrix. The block diagram of OFDM transmitter is described in Fig. 1.

Let $a_L = [\ a_{0,L}\ a_{1,L}\ \cdots a_{LN-1,L}]^T$ be an oversampled discrete time OFDM signal vector where an,L is the oversampled discrete time OFDM signal sampled at t = nt_s/L written as

$$a_{n,L} = \frac{1}{\sqrt{N}} \sum_{k=0}^{LN-1} A'_k e^{j2\pi \frac{k}{LN} n}, \;\; n = 0,\ 1, \cdots, LN-1$$

where A’k is

$$A'_k = \begin{cases} A_k, & 0 \le k \le N-1, \\ 0, & N \le k \le LN-1. \end{cases}$$

Continuous time baseband OFDM signals can be approximately represented by L times oversampled discrete time base- band OFDM signals. It is shown in [10] that choosing L =4 is sufficient to approximate the peak value of the continuous time OFDM signals.

B. Peak-to-Average Power Ratio

The PAPR of the discrete time baseband OFDM signal is defined as the ratio of the maximum peak power divided by the average power of the OFDM signal [4], that is,

$$\mathrm{PAPR}(a_n) \triangleq \frac{\max_{0\le n\le N-1} |a_n|^2}{P_{av}(a_n)}$$

With

$$P_{av}(a_n) = \frac{1}{N}\sum_{n=0}^{N-1} \mathrm{E}\{|a_n|^2\}$$

Where E{·}denotes the expected value. For the uncoded OFDM system, we can assume that the input symbols are identically and independently distributed, that is,

$$\mathrm{E}\{A_i A_j^*\} = \begin{cases} \sigma^2, & i = j, \\ 0, & i \neq j. \end{cases}$$

From Parseval's theorem, the average power P_{av} (a) is σ^2. An alternative measure of the envelope variation of the OFDM signals is the crest factor ζ which is the ratio of the maximum to the root mean square of the signal envelope, defined as

$$\zeta(a_n) \triangleq \frac{\max_{0\le n\le N-1} |a_n|}{\sqrt{P_{av}(a_n)}}.$$

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The PAPR of the continuous time baseband OFDM signal at defined as the ratio of the maximum instantaneous power divided by the average power of the OFDM signal, can be expressed as

$$\mathrm{PAPR}(a_t) \triangleq \frac{\max_{0\le t< Nt_s} |a_t|^2}{P_{av}(a_t)}$$

Where

$$P_{av}(a_t) = \frac{1}{Nt_s}\int_0^{Nt_s} \mathrm{E}\{|a_t|^2\}dt$$

And the PAPR of the continuous time pass band OFDM signal g_t is also defined as

$$\mathrm{PAPR}(g_t) \triangleq \frac{\max_{0\le t< Nt_s} |g_t|^2}{P_{av}(g_t)}.$$

The discrete time baseband OFDM signs, which constitute the yield of the IFFT square, are converted to ceaseless time baseband OFDM motions by a low-pass filter called DAC, where the top force might be expanded while keeping up a steady normal force. Generally, the PAPR of the consistent time base- band OFDM indicators is bigger than that of the discrete time base- band OFDM motions by 0.5~1.0 db [10], [11]. Blending the persistent time baseband OFDM sign with the radio recurrence produces the consistent time pass band OFDM indicator. It doesn't change the top control however the normal force of the pass band OFDM indicator is a large portion of the normal force of the constant time base band OFDM sign. Hence, the PAPR of the ceaseless time pass band sign is by and large bigger than that of the consistent time baseband OFDM motion by 3 db. At that point, the relationship between PAPRs is given as

$$\mathrm{PAPR}(a_n) \le \mathrm{PAPR}(a_t) < \mathrm{PAPR}(g_t).$$

III. Previous Work

Upgraded PAPR markers are regularly unnecessary for it commonly strains the straightforward equipment. Upgraded PAPR signs may oblige an endless scope of component linearity from the straightforward circuits which typically realizes tip top devices and improved energy use with more level adequacy (for e.g. power enhancer need to work with greater again off to help linearity). In OFDM schema, some information groupings may achieve improved PAPR than others. For example, an information plan that obliges all such transporters to transmit their most amazing amplitudes would completely realize an upgraded yield PAPR. Hence by preventive the possible information progressions to an immaterial sub set, it should be possible to achieve yield markers with an ensured low yield PAPR.

IV. Proposed Methodology

Another SLM plan with low computational multifaceted nature is proposed, this is a strategy for applying the SLM plan with median filtering in the existing system. In this plan, the signal is first filtered with median filtering and the selective mapping is applied which significantly enhanced the performance of the system i.e. reduction in PAPR.

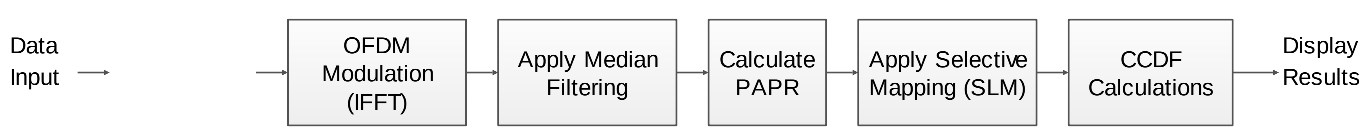

Fig. 4.1 Block Diagram of Proposed Methodology

In light of the proposed SLM with filtering plan, the computational intricacy is lessened contrasted with the expected SLM plan, on the grounds that median filtering is linear in nature and so that it does not added the complexity in the system.

The below flow chart explains the step by step execution of proposed methodology. The first step is to create the environment like practical situations for communication and for this we need to declare some variables. After variable initialization the data stream is generated which helps to calculate various parameters.

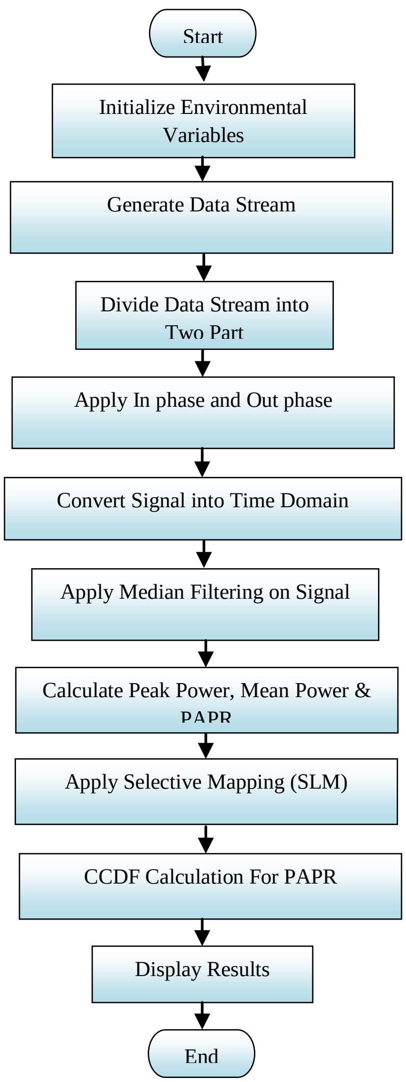

Fig. 4.1 Flow Chart of Proposed Methodology

Separate the data stream in-phase and out-phase, then transform signal in time domain so that it can be transmitted through channel. After that apply median filtering than calculate mean power and average power, and then apply selective mapping for calculations of PAPR.

Compare the results for SLM alone and SLM with median filtering and we can identify from the results that the proposed methodology is giving better results than previous methods.

V. Simulation Results

The MIMO-OFDM system has been performed on MATLAB (R2011a) v7.12. For simulation the system is designed with the help of variables, which creates a practical environment for calculating results in various conditions.

The simulation results shows the complementary cumulative distribution function (CCDF) versus peak to average power ratio(PAPR), and the proposed methodology we are giving here that is selective mapping(SLM) with median filtering gives better results than SLM alone. Simulations results also show the comparison with the theoretical values of the PAPR. System simulations have been performed with different FFT sizes and OFDM symbols as the results changes with changes in FFT size and symbols.

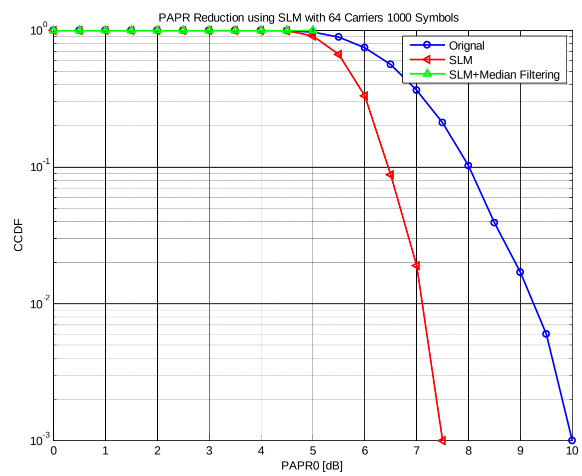

Fig. 5.1 CCDF vs PAPR with 64 carriers and 1000 symbols

Fig. 5.1 shows the performance of the system for theoretical, SLM alone and SLM and median filtering, with 64 carriers and 1000 symbols. From the results is it clear that the proposed methodology gives better results than previous methods.

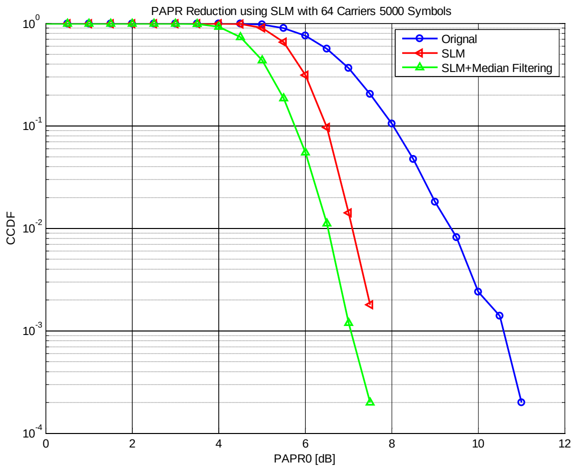

Fig. 5.2 CCDF vs. PAPR with 64 carriers and 5000 symbols

Similarly in Fig. 5.2 shows the performance of the system for theoretical, SLM alone and SLM and median filtering, with 64 carriers and 5000 symbols. From the results is it clear that the proposed methodology gives better results than previous methods.

Fig. 5.3 shows the performance of the system for theoretical, SLM alone and SLM and median filtering, with 128 carriers and 1000 symbols. From the results is it clear that the proposed methodology gives better results than previous methods.

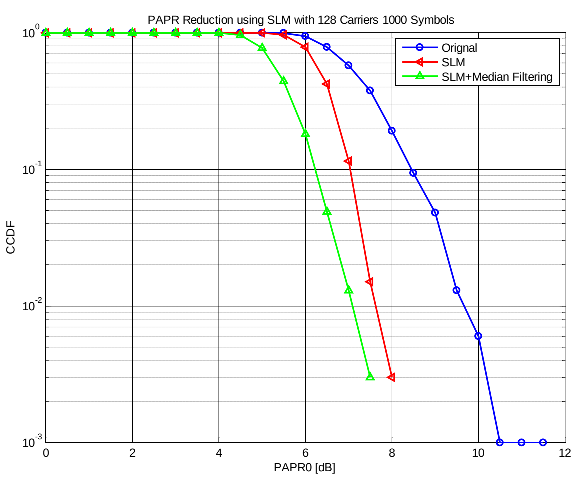

Fig. 5.3 CCDF vs. PAPR with 128 carriers and 1000 symbols

VI. Conclusions and Future Scope

The high PAPR is acknowledged to be one of the real draw-backs of OFDM frameworks, on the grounds that the huge indicator fluctuation offers ascent to the low power effectiveness. In this paper, we proposed accepted PAPR decrease plans SLM with median filtering for accomplishing a low computational multifaceted nature. Despite the fact that numerous PAPR decrease schemes have been created, none of them satisfies business necessities or has been embraced as a standard for remote correspondence frameworks. However, the modified PAPR diminishment plans with low computational intricacy might be connected to high information rate OFDM frameworks. Future studies on PAPR lessening may incorporate a combo of diversity.

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