PAPR Reduction with Amplitude Clipping & Filtering, SLM & PTS Techniques for MIMO-OFDM System: A Brief Review

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Abstract— Nowadays MIMO-OFDM has become a popular technique for 4G wireless communications**.** OFDM technique combined with multiple antennas at transmitter and receiver point to high data rate, low complexity and diversity. One of the major drawbacks in the MIMO-OFDM is high peak-to-average power ratio (PAPR).Clipping & Filtering, Selective Mapping (SLM), Partial Transmit Sequence (PTS) are some of the techniques which minimizes the PAPR. In this review paper, different techniques of PAPR reduction have been studied.

Keywords-Orthogonal division multiplexing division (OFDM), Multiple-input multiple-output (MIMO), peak-to-average power ratio (PAPR), Selected mapping (SLM), Partial transmit sequence (PTS).

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I. INTRODUCTION

MIMO is a radio antenna technology for digital wireless communication that uses multiple transmitters antenna and multiple receivers antenna. By increasing the multiple antennas it is possible of linearly rises the throughput. MIMO has been known to enhance quality, channel robustness and boost capacity. The MIMO system uses multiple antenna configurations to enhance the high data rate [1-4]. OFDM is a popular scheme for wideband wireless digital communication. OFDM converts the frequency selective channel into set of parallel flat fading channel for simple implementation and robustness. OFDM is based on FDM (frequency Division Multiplexing) schemes. OFDM is a digital multi-carrier modulation technique in which each sub-carrier symbols are narrowly-spaced orthogonal .It maintain total data rate as similar to conventional single-carrier modulation ,when information symbol is divided into several parallel streams , each sub-carrier is modulated with a conventional modulation schemes such as (QAM, QPSK, BPSK, etc.) at a minimum symbol rate in the same bandwidth . OFDM divides the spectrum amongst a set of orthogonal overlapping carrier that is a principle of OFDM system. OFDM is a very efficient scheme to eliminate inter-symbol interference and multipath fading with low complexity in a wireless channel. OFDM is used to reduce the multipath propagation problem whereas MIMO is used for spectral efficiency bandwidth [5-6]. The MIMO with OFDM system is a promising solution which provides high data rate, high spectral efficiency, low complexity and diversity. MIMO-OFDM is a popular scheme for broadband wireless technology which support data rate in excess of 100Mbps. The 4G mobile communication, DAB (digital audio broadcasting), DVB (digital video broadcasting) are few application of MIMO-OFDM [7]. Advantages of MIMO-OFDM System: a).Multiple Antennas leads to diversity. b).OFDM is efficient implement with the use of FFT which means no need for the banks of oscillators and demodulator associated with each subcarrier. c).It helps the system to reduce the effect of inter-symbol interference with very low complexity in a wireless channel. d).MIMO-OFDM includes more number of carriers to achieve high data rate and high quality of service (QOS).Besides advantages there are some challenges also. One of the major problems of MIMO-OFDM system is Peak-to-Average Power Ratio (PAPR).Various techniques which minimizes the PAPR in MIMO-OFDM system like Clipping & Filtering, Selected mapping(SLM), Partial transmit sequence(PTS) etc. These techniques achieve PAPR reduction at the expense of loss of data rate, rise in the transmit signal power, bit error rate (BER) and computational complexity .Clipping & Filtering is one of the simplest techniques of PAPR reduction in system. It reduces PAPR but at the expense of rising the BER and affect the data rate whereas SLM and PTS are good PAPR reduction performance without degradation of the BER but their computational complexity increases as the number of sub-carriers increases.

II. SYSTEM DESIGN

Let us consider MIMO with OFDM system to maintain the orthogonality of the carriers. In a MIMO-OFDM system, Let the OFDM symbols N be represented X (0), X (1),.....,X (N-1). The transmitted samples x (0), x(1).....x(N-1) which are IFFT samples information symbols X (0), X (1).....X (N-1)

over the channel . Here, f_n= nΔf, where nΔf=1/NT and NT is the duration of the OFDM symbols. The OFDM symbols N are first passed through serial -to-parallel converter which performs an IFFT operation. After this, IFFT is performed on the modulated signal which is further processed by passing through a parallel-to-serial converter. As the channel is frequency selective samples of current blocks are been interference by the samples from previous block in the OFDM system which is known as inter –symbol interference (ISI).
The discrete time domain be obtained via IFFT operation as [8]

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x_n . e^{j2\Pi n \Delta f t} \ , \ 0 \leq t \leq \text{NT} \qquad (1)$$

Where, Δf is the subcarrier spacing and NT is OFDM symbols block period.
The cyclic Prefix (CP) is prefixing into to the front of the transmitted OFDM samples before the transmission. CP acts as guard interval and helps to remove the inter-symbol interference. Cyclic prefix is removed and individual OFDM samples are passed through FFT operation after then pass through parallel -to-serial .Original OFDM symbols are recovered from modulated signal at the receiver [9]. This is efficient because it based on IFFT at transmitters and FFT at receivers. These are very fast algorithm as a result of entire MIMO-OFDM architecture is very efficient does not employ any matrix inversion.

The PAPR of the transmitted samples is defined as [6]

$$\text{PAPR}(x[n]) = \frac{\max_{0 \leq n \leq N-1} |x[n]|^2}{E|x[n]|^2} \qquad (2)$$

Further, the PAPR rises with N.
Where N = number of sub-carriers.
The high PAPR in an OFDM system essentially arises because of the IFFT operation, where data symbols across sub-carriers can add up to produce high peak value signals. For instance ,in an OFDM system with N sub-carriers and modulation schemes such as (QPSK ,BPSK)modulation ,the PAPR at the output can be high as across 10 db(approx.)i.e. 10 times peak power compared to the average mean[10-11]. The PAPR of the OFDM system is characterized by using CCDF (Complementary Cumulative Distribution Function).CCFD has been employed to describe the probability of the random variable with given probability distribution function and performance of PAPR, which defined as the probability of transmitted OFDM samples exceeding a given threshold .This is given by[7]

$$\text{CCDF}=1-\Pr\{\text{PAPR} \leq z\} = 1-(1-e^{z})^{N} \qquad (3)$$

III. PAPR Reduction Techniques

Peak to average power ratio is the key problem in MIMO-OFDM system. For reducing PAPR several techniques have been studied.

A. Amplitude Clipping and Filtering

1) Introduction

This is one of the easiest technique for PAPR reduction in MIMO-OFDM system .for reducing PAPR in an OFDM system, the amplitude of the high peak of the OFDM signal is clipping before passing it through the power amplifier which is set on a particular threshold level, and if amplitude of signal is greater than threshold value is clipped and rest are filtered out to remove the lower PAPR value. Clipping is a non –linear distortion process which results in In-band distortion and Out-band distortion. It also demolish the orthogonality of OFDM signal .The filtering process cannot be implement to minimize the In-band distortion whereas after clipping process Out-band distortion can be reduced by the filtering process. [12]

$$F(x) = \begin{cases} x, & |x| \leq A \\ Ae^{j\phi(x)}, & |x| > A \end{cases} \qquad (4)$$

Where, F(x) = the amplitude value after clipping.
x = the initial value and A= the threshold value of clipping value.

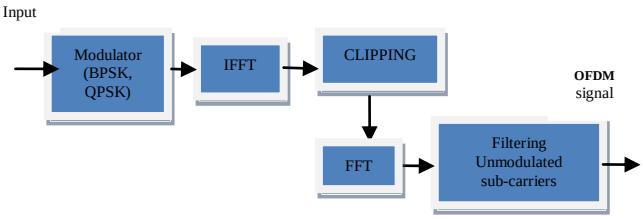

Figure 2. The Block diagram of Amplitude Clipping and Filtering Technique

2) Related work

In 2006 Robert J.Baxley et al.[13] proposed a constrained clipping technique for reducing the PAPR value of the system. The proposed method consists of two different processing units, one is in-band EVM constrained and other is out-of-band spectral constrained .Results show that with the help of in-band algorithm and out-of-band algorithm minimizes 4.5dB PAPR and main advantage of proposed algorithm is that all processing is done at the transmitter side. In 2008 Urban, J. [14] discussed the PAPR reduction technique by simplified clipping and filtering with bounded distortion. As a results show that technique reduced PAPR value but BER increase and also minimizes noise immunity and complexity. In 2012 W.Aziz et al.[15] discussed clipping and filtering technique which is a simple to implement and reduces the PAPR value by clipping the peak of maximum power signal. PAPR reduces the system performance by degrading affects of transmitter amplifier as well as SQNR of ADC/DAC .As the results show that PAPR is a bit increased but on the other side interference is reduced. The PAPR causes distortion of OFDM

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signals when passed through non-linear amplifier is explained by Shilpa bavi et al.[8] in 2015. In this paper, clipping & filtering method of PAPR reduction have been proposed & implemented. Simulation results show that due to the deceased clipping level, more part of the signals is clipped. Hence the bit error rate is increasing which results in reducing peak-to-average power ratio.

B. Selected Mapping (SLM)

1) Introduction

In the selective mapping (SLM) method, some independently input data sequences are generated same information at the transmitter end same like original input data blocks, then to select the most blocks which having low PAPR value and makes it suitable for transmission .let us consider MIMO-OFDM system with N orthogonality sub-carriers .A data blocks is a vector $X(x_n)_N$ composed of N complex symbols , each of them representing modulation symbol transmitted over a sub – carrier. X is multiplied element by element with U vector $B_u=(b_{u,n})_N$ composed of N complex numbers $b_{u,n}$ uϵ{0,1.....U-1},defined so that| $b_{u,n}$ | =1,where|.|reperesents the modulus operator .Each resulting vectors $X_u = (x_{u,n})_N$, where $x_{u,n} = b_{u,n}.x_n$,produces after IFFT ,a corresponding OFDM signal $s_u(t)$ given by[12]

$$s_u(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x_{u,n} e^{j2\Pi n \Delta f t}, \quad 0 \le t \le T \qquad (5)$$

Where, T is the duration of OFDM signal

The main motivate of this technique is to select one with lowest PAPR for the serial transmission figure shows the basic block diagram of selection mapping techniques(SLM) .

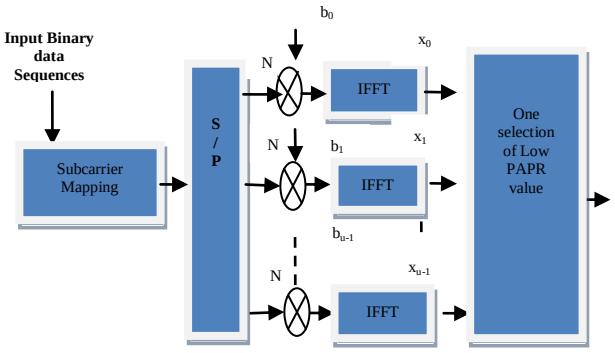

Figure 3 . *The Block diagram of Selective Mapping (SLM) Technique.*

2) Related Work

In 2003 Yung-Lyul Lee et.al[16] described the peak-to-average power ratio (PAPR) performance using selected mapping (SLM) approach. The results concluded that, the concurrent SLM-based method selects the transmitted sequence with low PAPR and recovers the side information very accurately; however, suffering a slight degradation of the PAPR performance compared to the individual SLM approach .With the help of the STF diversity, the overall BER performance in the presence of imprecise side information can be improved. In 2010 Umeda et al.[17] proposed BD transmission selected mapping (BD-SLM) that can reduce PAPR while maintaining the BD effect. Before the linear precoding this technique performs the phase shift to modulation signals. From several phase sequences, it selects a phase sequence that decreases the peak of the time-domain signals .As result BD-SLM can minimizes PAPR in 16 × 4 MIMO-OFDM with four users and the performance degradation. In 2011 Wei Xuefeng[18] have used the copy theory based mixed on the traditional SLM scheme and proposes schemes of MIMO-OFDM system minimizes the SLM PAPR value. According to the simulation results, this improved technique reduces the probability of high PAPR value. In 2015 P.Kothai et .al[19] proposed Adaptive selected mapping (ASLM) Technique. In this technique, sum of isolated input data generated from an OFDM data blocks select the most blocks which having low PAPR value and makes it suitable for transmission. As result The ASLM technique rises power efficiency, minimizes the impulse interference and decease PAPR v by 5.8dB.

C. Partial Transmit Sequence (PTS)

1) Introduction

The main idea of PTS technique is sub- dividing the sequence of original signal into non-overlapping a number of subsequence with each subsequence is phase shifted by a constant factor. Transmitting only a part of information of varying sub-carrier cover all the information to be sent in the signal .PTS is a modified technique of SLM.PTS technique which reduce more PAPR as compared to SLM technique which gives the better performance than SLM and minimize the complexity of PTS technique.

Let input information blocks is divided in M sub-blocks $X_m=[X_0, X_1, X_2, ...X_{N-1}]^T$. The subsequence are combined to reduce the PAPR in the time domain .The complex phase factors, $b_m= e^{j\varphi m}$. The set of phase factors is represents a vector $b=[b_1,b_2,.....,b_m]^T$.

The sub-blocks vector after combining is given by [10]

$$x'(b) = \sum_{m=1}^{M} b_m.x_m \qquad (6)$$

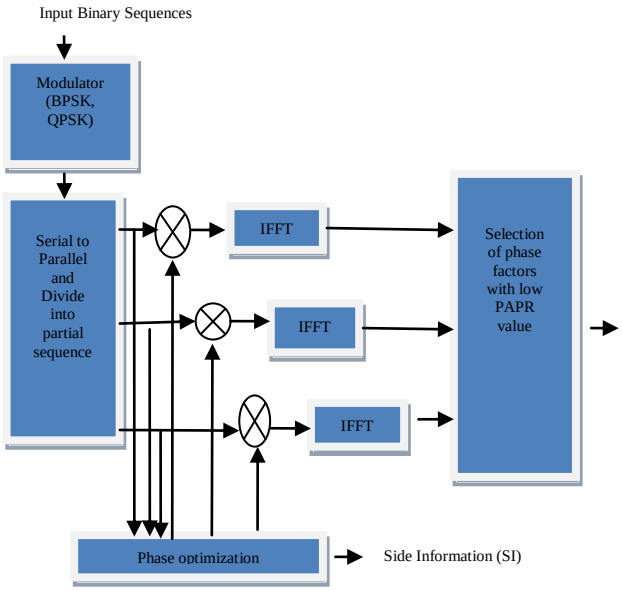

Figure 4. The Block diagram of Partial Transmit Sequence (PTS) Technique.

2) Related Work

In 2011Wang et al. [20] proposed a cooperative PTS (co-PTS) that can reduces peak-to-average power ratio (PAPR) in MIMO-OFDM. In co-PTS are utilized of spatial sub-block circular permutation and alternate optimization. According to the simulation results show tha

t co-PTS achieve better PAPR reduction performance in MIMO-OFDM and can minimizes computational complexity .In 2012 Suverna sengar et al.[21]focuses on PAPR reduction performance. Two different techniques one is PTS and other is SLM techniques are used to minimize PAPR. The Performance of the two different PAPR reductions is then compared. According to the result show that PTS technique improves PAPR reduction performance compared to SLM. In 2013 R.Gayathri et al.[9] focuses on reduction of low PAPR and coding, phase rotation and clipping that has been proposed to overcome this issues .Partial transmit sequence(PTS)technique has been proposed to reduces PAPR in OFDM system. Simulation results show that OFDM system has been improved by more than 5dB. In 2015 Khushboo Pachori et al [7] proposed a conventional scheme, active partial sequence to reduce PAPR in MIMO-OFDM. The APS is to combine the approximate gradient project followed by PTS technique. According to the simulation results show that the proposed method achieves less PAPR without sacrificing the BER performance and maintain the data rate as compared to other conventional schemes.

IV. CHALLENGES

1) Highly sensitive to Doppler shift which rises to effect the frequency offset at the receiver in OFDM system.

2) Presence of a large number of independently modulated sub-carriers with varying amplitude results in a high PAPR (Peak to Average Power Ratio).

V. CONCLUSION

MIMO-OFDM system is a very attractive technique for wireless applications. The major disadvantage in MIMO-OFDM system is high peak-to-average ratio .To reduce the effects of high PAPR in MIMO-OFDM systems, Amplitude Clipping & Filtering , SLM & PTS techniques has been discussed. Amplitude clipping & Filtering results in data loss whereas PTS and SLM do not effect data.

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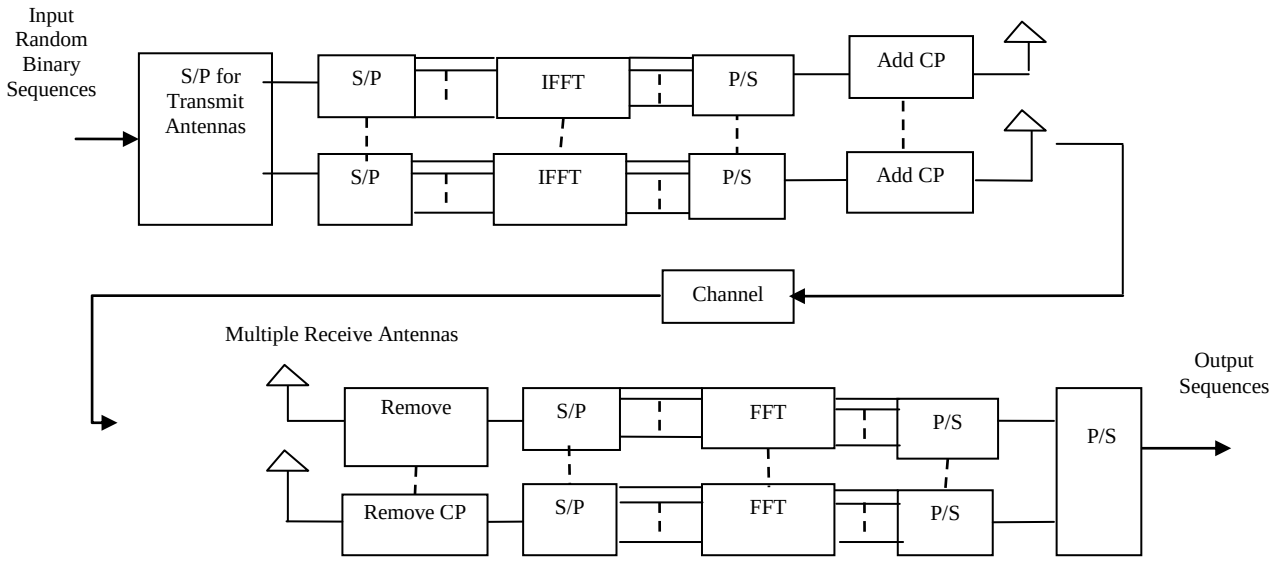

Figure 1. Block Diagram of MIMO-OFDM System