The Combined Scheme of Selective Mapping and Clipping for PAPR Reduction of OFDM

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Abstract –**Orthogonal Frequency Division Multiplexing is used for recent wireless systems. It is highly spectral efficient and it also performs well in multipath fading environment. However, OFDM signals exhibit high PAPR which needs to be reduced for improved performance of OFDM. This paper combines Selective Mapping and Clipping methods for betterPAPR reductionof OFDM signal. Selective Mapping is PAPR reduction techniques to provide good performance without exhibiting any signal distortion. Selective Mapping method is employed and then clipping is performed to achieve further reduction in PAPR. Clipping is performed due to its own advantages such as less complex circuitry and simple computations. Simulation results of combined scheme of Selective Mapping and Clipping show that it can achieve significant PAPR reduction compared to individual methods.**

Keywords –Clipping,CCDF, OFDM, PAPR, OFDM,SLM

NOMENCLATURE

CCDFComplementaryCumulativeDistribution Function
PAPRPeak-to-Average Power Ratio
OFDM Orthogonal Frequency Division Multiplexing

I. INTRODUCTION

OFDM can provide higher data rates required for many recent wireless standards. OFDM has been adopted for several broadcast standardsand also forwireless standards such as802.11g, 802.11n,WIMAX[1].OFDM is also being used for dedicated short range communication in Vehicular Ad-hoc Network. An OFDM has many closely spaced orthogonal carriers. Orthogonality between carriers minimizes interference and helps to achieve high frequency spectrum efficiency. In OFDM ,orthogonality between subcarriers can be achieved if the frequency separation between N subcarriers (Δf) is (1/NTs)where NTs is symbol duration[2].The data to be transmitted is spread over these subcarriers and each orthogonal subcarrier is modulated at reduced data rate and then these subcarriers are summed together for transmission[3]. Despite of numerous merits, OFDM systems have some drawbacks. One major limitation of OFDM systems is high PAPR.It degrades the performance of power amplifier used at OFDM transmitter [4].A large PAPR is produced in OFDM systems because of superposition of many individual sinusoidal subcarriers. When these sinusoids aligned in phase are added coherently, OFDM signal can have large amplitude resulting in a high PAPR at the IFFT output. These large peaks with high PAPR can distort the OFDM signals which lead to out of band distortion and also in band distortion [5]. Due to this, bit-error-rate (BER) increases at the receiver. Use of power-amplifiers with a wide linear range can reduce distortion or BER. However, it leads to high equipment cost and high battery power consumption [6]. To deal with this problem, several techniques have been introduced for reduction of high PAPR [7].

This paper simulates combined technique of Selective mapping and Clipping for reducing the PAPR. PAPR of OFDM is introduced in section II. Section IIIpresents Selective Mapping technique in brief. Clipping technique is introduced in section IV. Section V presents combined scheme of Selective Mapping and Clipping. Section VI shows simulation results of individual SLM and Combined method of SLM and Clipping. Conclusions are listed in section VII.

II.PAPR OF OFDM

In OFDM, RF power amplifiers cannot operate efficiently due to high PAPR. This amplifier must be used in its linear region to combat distortion, out-of-band noise and BERdegradation. Low PAPR makes the power amplifier operate efficiently and also reduces the complexity of DAC and ADC.PAPR is ratio of maximum signal power to average signal power.

$$PAPR = \frac{P_{peak}}{P_{Average}} \quad (1)$$

$$PAPR = \frac{max_t |x(t)|^2}{E_t[|x(t)|^2]} \quad (2)$$

And discrete time PAPR is given by equation (3).

$$PAPR = \frac{max_n |x(n)|^2}{E_n[|x(n)|^2]} \quad (3)$$

Mathematically, IFFT output x_n, is expressed as:

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k W_N^{nk} \quad (4)$$

PAPR of discrete time signals determines number of bits required for transmission and thus complexity of digital operation.

III.SELECTIVE MAPPING

Selective mapping (SLM) is probalistic and distortion less technique for PAPR reduction.Though PTS [Partial Transmit Sequence] and SLM are similar and have almost same benefits,SLM is better than PTS with respect to number of data vectors. As no of data vectors increases, complexity in PTS increases substantially. PTS method requires more bits of side information than SLM [8]. Oversampling and filtering does not increase PAPR dramatically in SLM as it increases in PTS**.** Figure 1 shows the basic principle of SLM. The basic idea is to produce U alternative transmit sequences from the same data source and then to select the transmit signal exhibiting the lowest PAPR [9]. As the PAPR is determined by the sequence of the transmit data vectors; X_m multiplying the data vectors by some random phase will change the PAPR properties after the IFFT. Mathematically, a set of U differentphasesequences are generated. The original input data X [X_1, X_2,…,Xm] is multiplied with different transmit sequences P=[$P_1^{(u)}$ $P_2^{(u)}$,…,$Pm^{(u)}$] where (u=0,1,…. U-1) and then multiplied output of data blocks are transformed into time domain with help of IFFT. Thesenewly generated data blocks in time domain have different PAPR,X(u)=[$X_1^{(u)}$, $X_2^{(u)}$,…$X_{N-1}^{(u)}$].Then PAPR of these independent data blocks are compared and the sequence with minimum PAPR is transmitted.If each mapping is considered statically independent, then CCDF of PAPR will be

$$P(PAPR>z)=F(z)^N = (1-(1-e^{-z})^N)^U \quad (5)$$

where U istotal number of phase sequences
N is total number of subcarriers
Z is threshold
z is any real no.

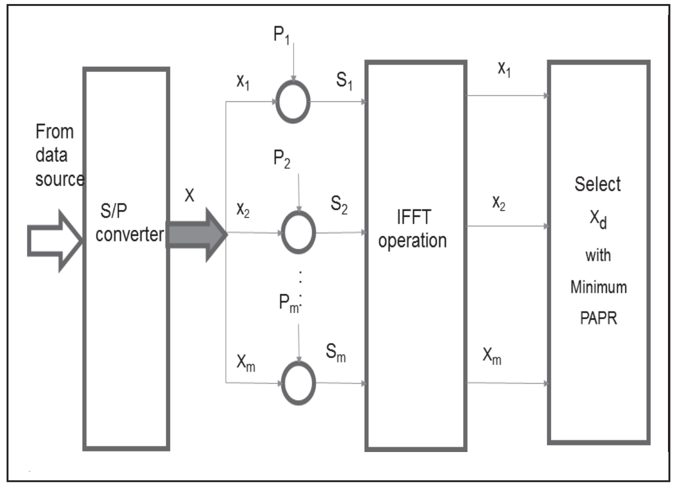

Fig. 1. Basic Principles of Selective Mapping

SLM needs to transmit $\log_2 U$ side information bits to recover each data block. This can result into some loss of transmission efficiency. The amount of PAPR reduction is proportional to number of phase sequences U.

IV.CLIPPING

Clipping is simplest technique used for reducing PAPR [11]. It is very easy to implement and doesn'trequire extra bandwidth andpower. In Clipping, the parts of the signals that have high peak above threshold level or outside of the allowed region are clipped. Consider X(n) represent the original OFDM signal and $X_c(n)$ is the clipped part of X(n)**.** The following equation shows the amplitude clipping,

$$X_c(n) = K \text{ if } X(n) > K$$

$$= X(n) \text{ if } X(n) \le K$$

Where K is a positive real number and it denotes predefined threshold level of Clipping.Noadditional information is required for clipping technique. In this, amplitude K's maximum peak value is taken so that OFDM signal will remain within the particular region and the symbols going beyond the specified region will be clipped. Clipping method is a nonlinear process andit producesloss of data or distortion which may affect the BER. Filtering can improve BER performance if it is used after clipping.

V.COMBINED SLM and CLIPPING

The hybrid method of SLM and Clipping is used to reduce PAPR.In SLM, a set of U alternative transmit sequences from the same data source are used to generate the new data blocks with different PAPR values but representing the same original data and then data block with the lowest PAPR is selected. Clipping block is added to improve PAPR reduction. Figure 2 shows block diagram of hybrid method.

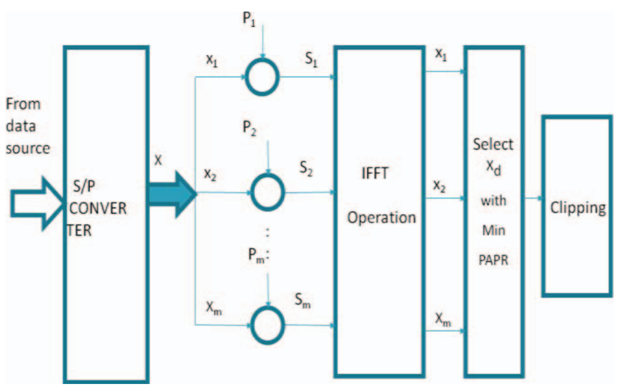

Fig.2. Combined Scheme of Selective Mapping and Clipping

VI. RESULTS AND DISCUSSIONS

Simulations are done in Matlabto evaluate PAPR reduction capability and BER of combined method. The performance of SLM and Combined scheme is evaluated using CCDF. The CCDF can be used to measure probability of PAPR of OFDM exceeding threshold. The simulation results of CCDF of conventional SLM for different values of N (N=64, N=128, N=256)[12] are shown in figure 3, 4 and 5.The Combined scheme of Selective Mapping with Clipping is simulated with subcarrier N=64,N=128, N=256 and the results of the same are shown infigure 6, 7, 8 respectively. From these figures, it can be seen that As N increases, PAPR increases and with increased PAPR, the performance of OFDM degrades. But it is clear from the plots shown in these figures that with the help of PAPR reduction techniques,PAPR is reduced and thus performance of OFDM can be significantly improved. From figure 8, it is seen that for N=256, and for 10^{-2}probability, PAPR of the original OFDM is greater than 14.9dB, whereas for Clipping + Filtering and SLM methods, the PAPR is decreased approximately to 14 dB and 11.4dB respectively. The combined method has 10.8dB PAPR for the same 10^{-2} probability. Thus it is observed that there is 4.1dB improvement with the proposed Combined system compared to originalOFDM system at 10^{-2} probability. It is obvious from the figure 6, 7, 8 that the combined system plays important role of reducing the PAPR considerably over individual Clipping + filtering and conventional SLM method. While reducing PAPR, BER should not be degraded below optimum level. Therefore BER of Combined technique (SLM +Clipping) is calculated and it is compared with Original OFDM and other individual techniques. Simulation results from figure 9 show that BER performance of combined technique is much better than Original OFDM and it also exhibits good PAPR reduction at the same time.

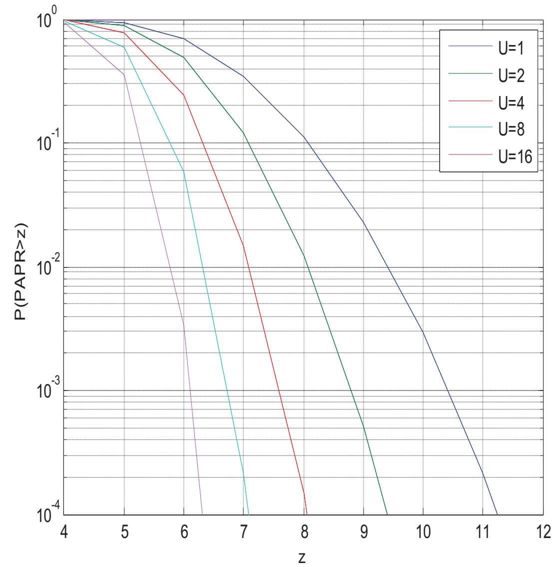

Fig 3. PAPR Reduction in SLM with *N*=64 and U = 1, 2, 4, 8, 16[12]

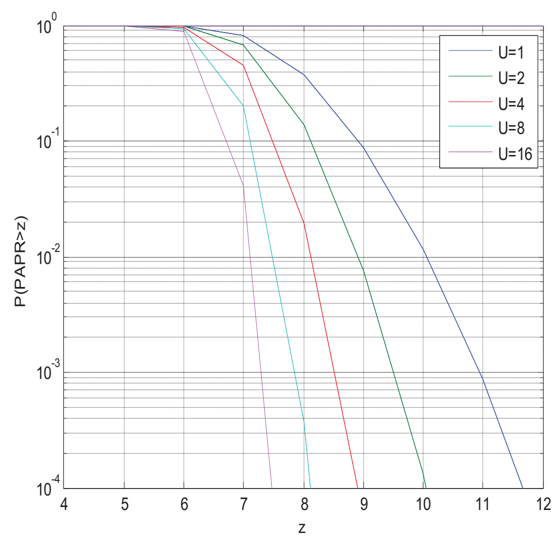

Fig 4. PAPR Reduction in SLM with *N*=128 and U = 1,2,4, 8,16[12]

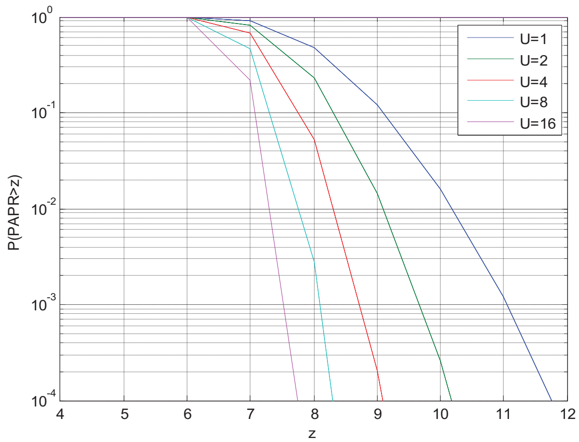

Fig.5: PAPR Reduction in SLM with N=256 and U = 1, 2, 4, 8,16[12]

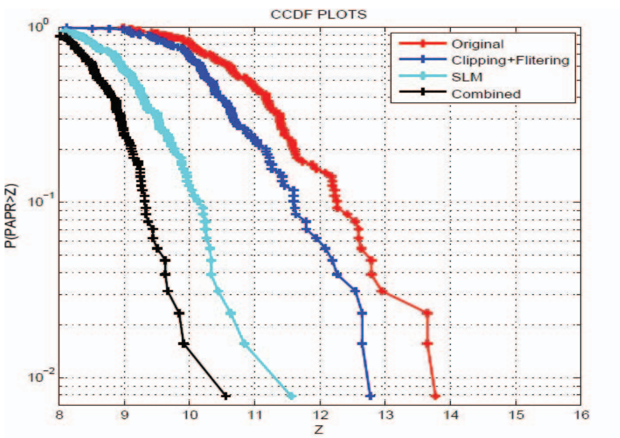

Fig.6: PAPR Reduction for Combined scheme (SLM + Clipping) with N=64

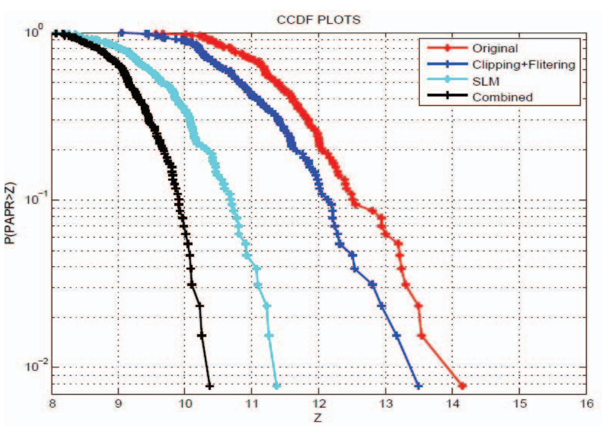

Fig 7. PAPR Reduction for Combinedscheme(SLM + Clipping) with N=128

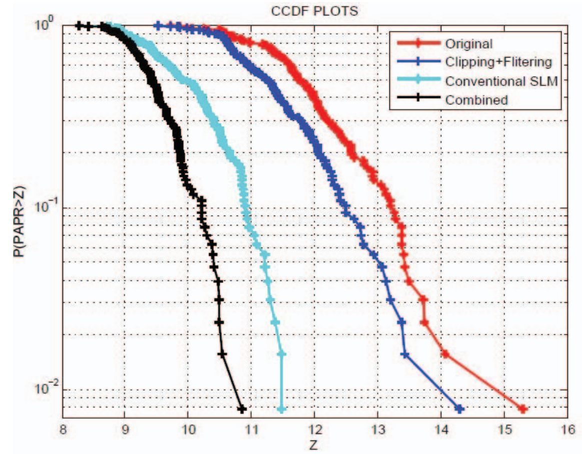

Fig.8 : PAPR Reduction for Combined scheme(SLM + Clipping) with N=256

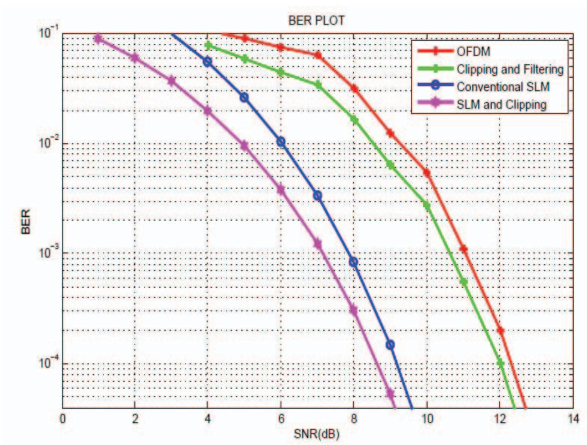

Fig.9: Comparison of BER of Proposed Combined Technique (SLM + Clipping) with other PAPR Reduction Schemes and Original OFDM.

VII. CONCLUSION AND FUTURE SCOPE

Simulation results of conventional SLM show that as value of N increases, PAPR increases. It can be reduced by increasing the number of phase sequences in SLM.But increasing phase sequences can increase complexity. The proposed PAPR reduction technique based on combination of Conventional SLM and Clipping is simulated and it can be seen that combinedmethod achieves greater reduction in PAPR compared to individual methods. At the same time, good BER performance is achieved for combined scheme of Conventional SLM and Clipping compared to conventional OFDM system.To reduce power consumption or to save energy, Reduction of PAPR is highly important especially for Internet of Things. SIGFOX protocol can be used further to connect wireless nodes with very less energy consumption in Wide Area Network.

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