2014 IEEE International Conference on Computing and Communications Technologies (ICCCT'14)

A COMBINED PTS & SLM APPROACH WITH DUMMY SIGNAL INSERTION FOR PAPR REDUCTION IN OFDM SYSTEMS

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***Abstract*— A novel combined approach of SLM (Selective Mapping), PTS (Partial Transmit Sequence) and DSI (Dummy Signal Insertion) is proposed to diminish PAPR (Peak to Average Power Ratio) and OBI (Out of Band Interference) in OFDM (Orthogonal Frequency Division Modulation) systems. The efficiency of OFDM decreases while the cost of installing HPA (High Power Amplifier) increases when the PAPR factor is high. A lot of research has been done to minimize this factor. The proposed method reduces the computational complexity by minimizing the number of IFFT (Inverse Fast Fourier Transform) operation to a half and the results show an effective decrement of PAPR by 0.6 ~ 1.4 dB. It also proved from the simulation results that it has 3.2 ~ 4 dB lower OBI when compared against the conventional and existing methods.**

Keywords—OFDM, SLM, PTS, DSI, PAPR, Power amplifier.

I. INTRODUCTION

Single Carrier transmission for high data rate requires wider bandwidth which is compensated by using equalizers, but, if signal bandwidth exceeds coherence bandwidth then the channel suffers from multipath fading which leads to ISI (Inter Symbol Interference). The frequency selectivity of the channel using single carrier can be overcome by multiple carriers for desirable high data rate. OFDM [1]-[5] technique is one of the multicarrier transmissions where the frequency selectivity of the channel is separated into N orthogonal narrowband subchannels. Due to this orthogonal division the high data is transmitted in parallel in terms of low data rate without undergoing to ISI. OFDM plays an important role in wireless communication systems such as DVB, DAB, WPAN, WMAN, WLAN, WiMAX. Though it has many advantages, due to high peaks of 'N' narrowband subcarriers of OFDM signal, which is in time domain. OFDM suffers from high PAPR. Hence, it degrades the efficiency of the system by increasing the cost of RF amplifier.

In literature, various techniques were proposed to reduce PAPR which are basically separated into two categories: Signal Distortion [7]-[10] and Signal Scrambling techniques [11]-[16] with respect to cost and system efficiency [6]-[19].

One of the simplest distortion methods is clipping technique which employs clipping the peaks to reduce the PAPR but introduces in-band radiation by degrading BER (Bit Error Rate) performance and OBI which is diminished by filtering scheme. Other distortion method was proposed based on μ-law companding and exponential companding which degrades the error performance.

Other PAPR reduction techniques [11], namely PTS [12], SLM [13] and DSI [18] are proposed in the literature [14], [15]. In SLM, OFDM signal of length 'N' is multiplied with 'W' different phase vectors and least PAPR is chosen for transmitting the signal, whereas in PTS, the signal is partitioned into multiple disjoint subblocks which are multiplied by different rotating factors until an optimum PAPR is achieved. If number of subblocks increases the computational complexity for selecting the optimum PAPR also increases; and it is time consuming factor. SLM technique requires SI (Side Information) of phase vectors and OFDM signals to the receiver for data recovery which happens to ruin data rate. Dummy Signal Insertion (DSI) is more productive than miscellaneous PAPR techniques. The dummy signals are appended with input data before IFFT which increases the bandwidth. Insertions of dummy signal affect the transmission efficiency; and the processing time is longer.

A new hybrid scheme is proposed comprising of SLM & PTS methods with dummy signal insertion. The paper is organized as follows: Section I comprises of Introduction; section II discusses the OFDM and PAPR; Section III explains about the hybrid mechanism to diminish PAPR; section IV focuses on the implementation of the proposed hybrid model; section V elaborates the simulation results and discussions and section VI consists of conclusion.

II. OFDM PAPR DISCUSSION

The baseband OFDM complex signal G(0)=G(1)=............G(N-1)= $\pm a$ in time domain for N narrowband subcarriers which are orthogonal is represented as

$$g(k) = \frac{1}{\sqrt{N}} \sum_{i=0}^{N-1} G(i) e^{\frac{j2\pi ki}{N}} \quad (1)$$

Where information bits i=0,1,2…N-1. $g(k)$=k[th] IFFT sample.

The $g(k)$ samples which are Gaussian distributed, the PAPR is:

$$PAPR = \frac{\max\{|g(k)^2|\}}{E\{|g(k)|^2\}} \quad (2)$$

The expectation operator:

$$E\{|g(k)|^2\} = \frac{1}{N^2} \sum_{i=0}^{N-1} E\{\frac{|G(i)|^2}{a^2}\} = \frac{a^2}{N} \quad (3)$$

PAPR of an OFDM is characterized by CCDF (complementary cumulative distributive function) as:

$$\bar{F}(par_0) = pr(pap > pap_0) \quad (4)$$

III. HYBRID SCHEMES

The Conventional Hybrid (CH) scheme comprises of merging the SLM method with PTS method [15].

In [16] other three Hybrid methods AH, SH and MH were proposed for better PAPR results. Additional Hybrid (AH) method which is the combination of modified SLM and CH scheme was implemented. Despite the reduction of the IFFTs, the performance of PAPR was not improved.

The Switching Hybrid (SH) method is the Conventional Hybrid scheme with switching method was implemented, but the effect of PAPR reduction was not compromised. To further the improvement, a Modified Hybrid (MH) method was implemented which the combination is of AH and SH.

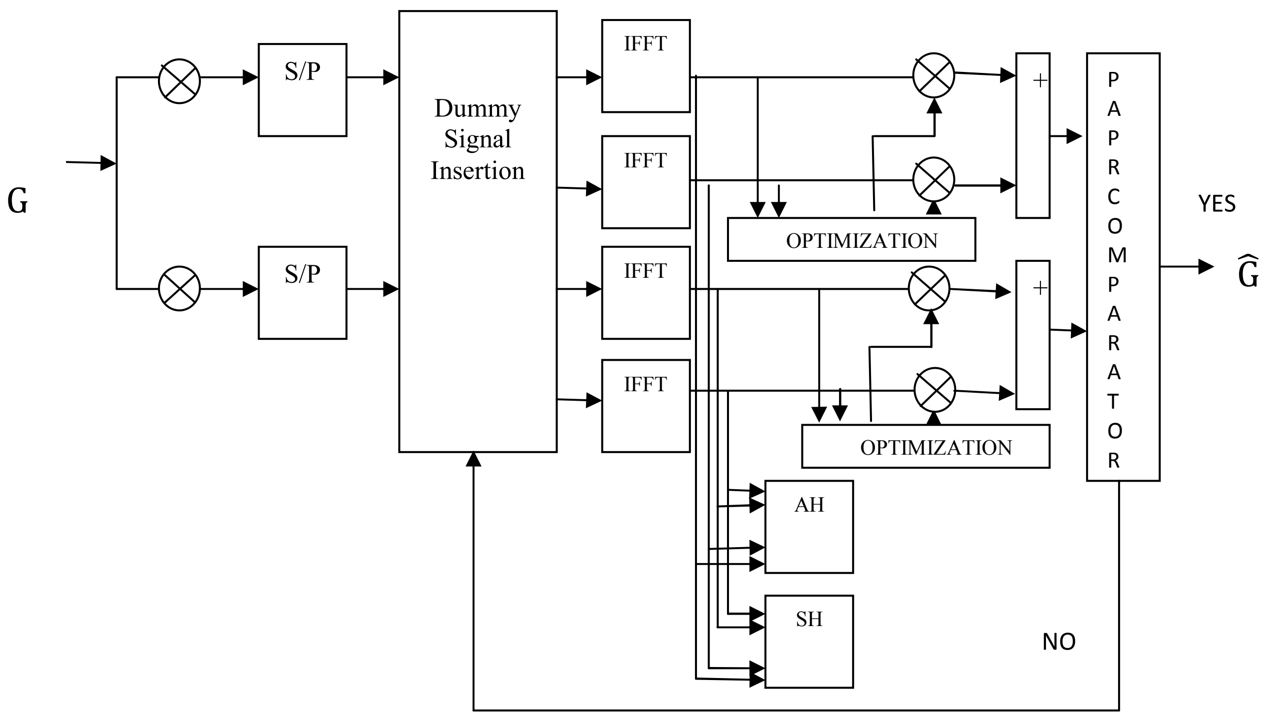

Fig.1.Proposed Scheme

The incoming OFDM signals are multiplied with 'W' different phase rotation sequences and then the IFFT of these 'W' independent signals are partitioned into 'V' disjoint subblocks and each subblock is multiplied by different rotating factors. Here V=2 is considered and each signal $\hat{g}(u)$ is represented as

$$\left\{\widehat{r_1^{(w)}}, \widehat{r_2^{(w)}}\right\} = \min_{\widehat{\{r_1^{(w)}, r_2^{(w)}\}}} \{\textstyle\sum_{v=1}^{2} r_v^{(w)} G_v^{(w)}\} \quad (5)$$

where w=1, 2…W

$$\hat{G}^w = \sum_{v=1}^{2} \hat{r}_v^w \, G_v^w \quad (6)$$

The subblocks are multiplied by rotating factors until optimum PAPR is obtained.

IV. PROPOSED SCHEME

In proposed scheme for better performance of PAPR reduction without increasing IFFT, the MH method is used by inserting dummy signals.

From the proposed scheme of Fig.1, $\{G_1^{(w)}, G_2^{(w)}\}$ pairs, where $1 \le w \le W$, are the incoming symbols of the AH model and SH model respectively.

Insertions of dummy signal affect the transmission efficiency [17]:

$$TE = \frac{Q}{Q+U} \, X \, 100 \, [\%] \quad (7)$$

After producing the dummy signals they are added to the input data: Thus a new signal 'S' is fabricated from 'Q' data and 'U' dummy signals (U<Q).

$$S = [G_q, Z_u] \quad (8)$$

$$G_q = [\, G_{q,0}\,, G_{q,1}\,, \ldots \ldots, G_{q,N-U-1} \,], \text{ q=1,2…Q}$$

is data signal and $Z_u = [\, Z_{u,0}\,, Z_{u,1}\,, \ldots \ldots, Z_{u,Q-1} \,]$,

u=1,2…U is dummy signal.

When optimum PAPR is obtained it is compared with the pre-defined threshold value. If the obtained PAPR is lower than pre-defined value, then the signal is transmitted, else the dummy signal is again procreated as indicated in block diagram with feedback. This process is called iteration. The iterations can be repeated continuously to achieve desired PAPR, therefore processing time increases. Here the dummy signals are in complementary sequence [18] so that the dummy sequence when added with input data are replaced with zeros [19]. This makes IFFT length to be remained same and decoding in the receiver becomes easier.

V. SIMULATION RESULTS

Fig.2, Fig3 and Fig4 shows the CCDF curves of Conventional hybrid(CH),Modified Hybrid(MH), Dummy signal Insertion (D) and proposed techniques for number of phase rotations = $\{\pm 1, \pm j\}$, number of sub blocks V=2. Here we considered the number of DSI is 55 which do not have any significant effect on transmission efficiency. It can be observed that for number of symbols = 1024, number of subcarriers= {16, 32} with QPSK, 16-QAM modulation, the proposed scheme outperforms the CH, MH and D with an improvement of 2dB, 1.5dB and 1dB at CCDF= 0.1 % when M (number of candidate signals) =2.

The simulated PSD of the modified signals is illustrated in Fig. 5.

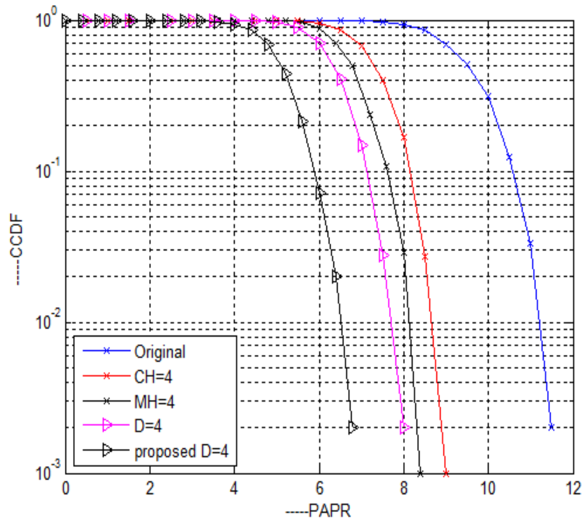

Figure 2: CCDF comparison with QPSK modulation with Nsym =1024 and Nsub=32

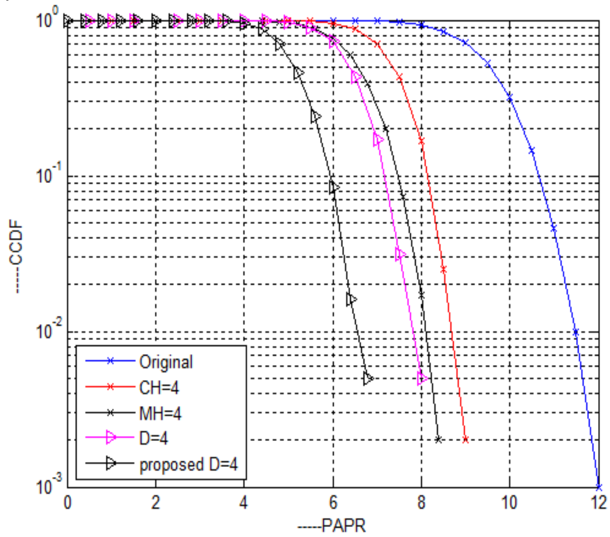

Figure 3: CCDF comparison with 16-QAM modulation with Nsym =1024 and Nsub=32

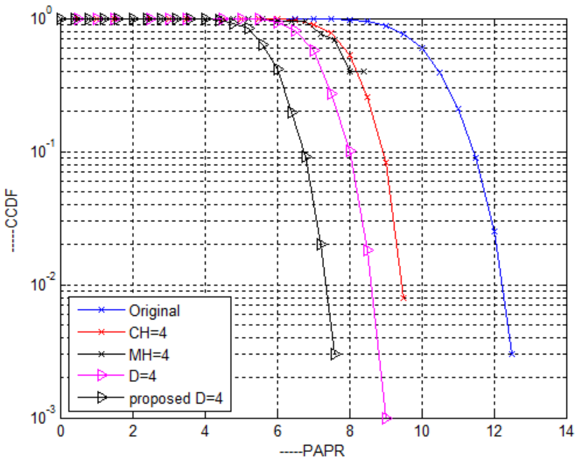

Figure 4: CCDF comparison with QPSK modulation with Nsym =1024 and Nsub=16

CH-Conventional hybrid [16]
MH-Modified Hybrid [16]
D-Dummy signal Insertion [17]
Proposed Method

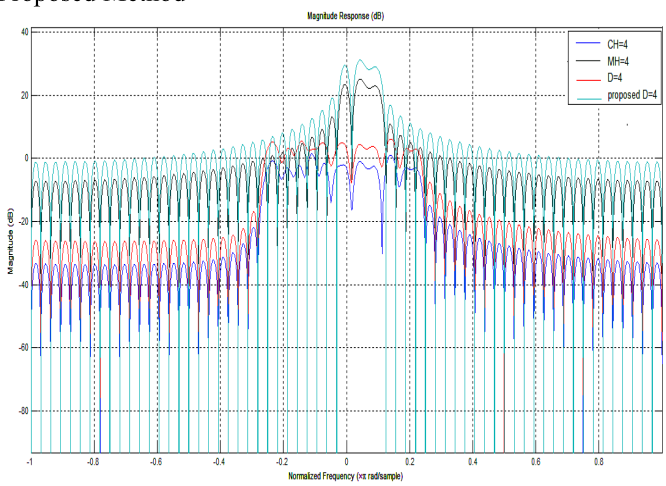

Figure 5: PSD analysis of the [16], [17] and proposed method

VI. CONCLUSION

A hybrid approach with dummy signal insertion is proposed in this paper to diminish PAPR, the system is compared against the other methods that were discussed earlier and it was proven from the simulation results that the proposed method outperforms the existing methods with reduction in PAPR ranging from [0.6 ~1.4] dB which is a good performance. The proposed algorithm produces OBI (Out of band interference) almost 4dB lower than the modified algorithm. By this method, complexity is reduced compared to PTS method.

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