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Comparative Study of PAPR Reduction Techniques

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***Abstract*— Orthogonal Frequency Division Multiplexing (OFDM) is a widely used modulation and multiplexing technology which gives the basic supports of many telecommunication standards. Orthogonal Frequency Division Multiplexing (OFDM), which is one of multi-carrier modulation (MCM) techniques, offers a considerable high spectral efficiency, multipath delay spread tolerance, immunity to the frequency selective fading channels and power efficiency. However, still some challenging issues remain unresolved in the design of the OFDM systems. One of the major problems is high Peak-to-Average Power Ratio (PAPR) of transmitted OFDM signals. Here in this paper, we had done the comparative analysis of different PAPR reduction techniques such as Enhanced Iterative Flipping Partial Transmit Sequence (EIFPTS), Partial Transmit Sequence (PTS), Iterative Flipping Partial Transmit Sequence (IFPTS) and Selective Mapping Technique (SLM) that are several transmitting techniques used while working with Orthogonal Frequency Division Multiplexing (OFDM).**

***Index Terms*— Selective Mapping Technique (SLM), Partial Transmit Sequence (PTS), IFPTS, EIFPTS, OFDM and Peak-to-Average Power Ratio (PAPR)**

I. INTRODUCTION

A) OFDM

One of the most attractive multiplexing techniques for fourth generation (4G) wireless communication is orthogonal frequency division multiplexing technique. Basically OFDM is a multicarrier modulation technique and its dynamic range is three or four times larger than a single carrier system.

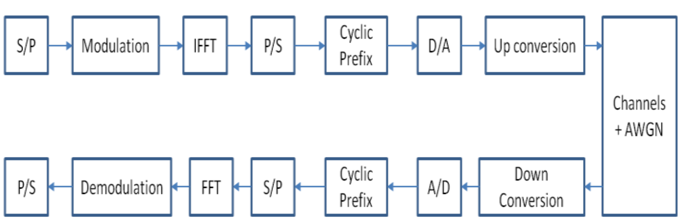

Fig. 1: Block Diagram of OFDM

One of the types of frequency division multiplexing technique is OFDM (i.e., Orthogonal Frequency Division Multiplexing Technique). It is utilized as a digital multi-carrier modulation method. For data carrying a large number of closely spaced orthogonal sub-carriers is used.

When the product of integral part of two periodic signals over one period is equal to zero, both signals are termed as periodic signals.

For case of continuous time:

$$\int_0^T \cos(2\pi nft)\cos(2\pi mft)\,dt = 0$$

(Here m ≠n)

For case of discrete time-

$$\sum_{k=0}^{n-1} \cos\left(\frac{2\pi kn}{N}\right)\cos\left(\frac{2\pi kn}{N}\right)dt = 0$$

B) PAPR

Peak to average power ratio of any transmitted signal (t) is the ratio of average power and maximum instantaneous power.

PAPR =
$$\max\,[|Xn|\,0 < n < LN - 1]/E|X\,n| \qquad 0 < t < T$$

Here, E {.} denotes expectation operator i.e. average power. PAPR is the most widely used parameter that is used to manipulate dynamic range of time-domain OFDM signal. Also the most frequently used performance measure parameter for PAPR reduction is Crest Factor.

C) SLM

This technique i.e., selective level mapping was proposed by Bauml in 1965. It is used for minimizing peak to average transmit power in case of multicarrier transmission system. As SLM technique do not impose any restriction on modulation applied in the sub carriers or on their numbers, hence it is known to be most flexible technique. Without any signal distortion, PAPR is effectively get reduced using this technique. But this technique is having higher system complexity and computational burden.

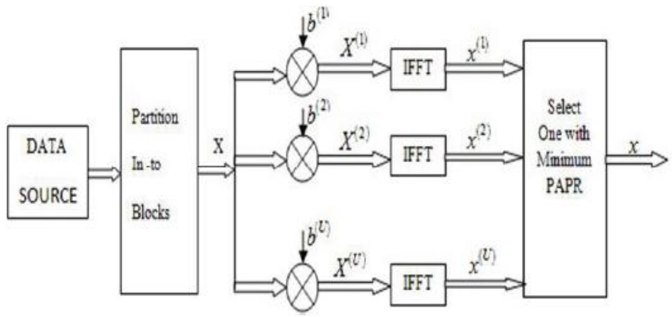

Fig. 2: Block Diagram of SLM

D) PTS

Partial transmit sequence is an effective and flexible power reduction scheme of OFDM that was recommended by Muller and Hubber. In this technique, the data blocks of orthogonal frequency division multiplexing of N symbols are partitioned into M sub blocks. And then each sub blocks are multiplexed by one of the P factors, which is generated randomly.

For having a unit magnitude, rational factors are chosen in a particular manner. This signal is transmitted if the PAPR of the resulting OFDM symbol less then threshold. In case of vice versa, another set of rotational factors is generated and PAPR of the OFDM symbol is compared with the threshold. This process get repeat till the OFDM signal becomes less than that of threshold or maximum number of iterations is reached.

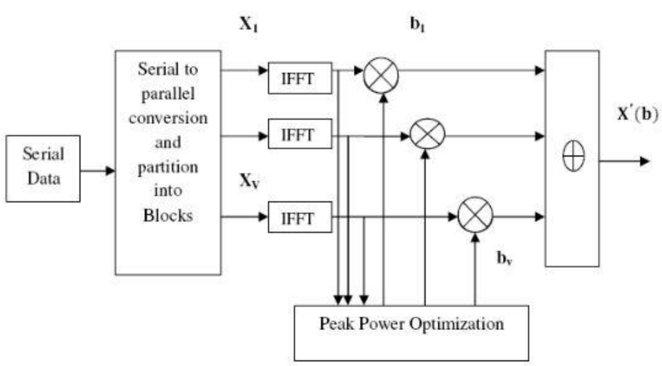

Fig. 3: Block Diagram of PTS

E) IFPTS

This is a sub optional technique for partial transmit scheme and was developed by Cimini and Sollenberger. Iterative flipping partial transmit scheme (IFPTS) is a simplified scheme that reduces the computational complexity with the number of sub blocks M.

The algorithm of iterative flipping partial transmit scheme can be described as:

1) As described in the PTS scheme, partition of the input data X into M disjoint sub blocks is done to form the partial transmit sequence.
2) It is further initialized by 1 for all M and PAPR is computed.
3) The resulting PAPR is recomputed after the change in the first bit.
4) If the new PAPR is similar than the updating of -1 is done in the previous step.
5) In this fashion, algorithms repeats until all M bits have been explored.

F) EIFPTS

Enhanced iterative flipping technique is a modified version of Cimini and Sollenberg's IFPTS technique. The basic idea of EIFPTS techniques is to keep more phase factors in the first sub blocks that is not necessarily to be minimum if we allow it to change until we continue the procedure up to the end sub blocks.

As in the previous case of iterative flipping algorithm, one keeps only one phase set in each sub block. Even then also, the phase set is chosen in the first sub block that is not necessary to be minimum, if we allow it to change. The basic idea of EIFTPS is that, we keep more phase factors in first sub block rather to keep only one phase. And final decision is getting delayed till the end of sub blocks.

II. LITERATURE SURVEY

[1] Pankaj Gupta proposed Performance Analysis of Peak to Average Power Ratio Reduction Techniques in OFDM System. In this paper, different PAPR reduction techniques are analyzed and compared with standard OFDM [17].

[2] Shilpa Jaswal proposed Comparative analysis of SLM and Iterative Flipping PAPR Reduction Techniques. In this paper we have discussed different PAPR reduction techniques and compared Selective Mapping and Iterative Flipping with each other [18].

[3] Kamal Singh proposed Comparative Analysis of PTS and Iterative Flipping Scheme for Reduction of PAPR in OFDMA Networks. In this paper partial transmit sequences (PTS) and iterative flipping schemes are discussed to reduce PAPR and compared with original scheme (without PAPR reduction scheme) [19].

[4] Byung Moo Lee proposed An Enhanced Iterative Flipping PTS Technique for PAPR Reduction of OFDM Signals. In this chapter, we propose an enhanced version of the iterative flipping algorithm to reduce the performance gap between the iterative flipping algorithm and the ordinary PTS technique. In the proposed algorithm, there is an adjustable parameter to allow a performance/ complexity trade-off [20].

III. METHODOLOGY

One of the major problems associated with OFDM is its high PAPR. In this paper, we proposed an enhanced version of the iterative flipping algorithm to efficiently reduce the

PAPR of OFDM signal. There is an adjustable parameter so that one can choose based on performance/ complexity trade-off. Simulation results show that this new technique gives good performance with significantly lower complexity compared with the ordinary PTS technique

Following steps were following while doing the research work:

1) Initialize necessary parameters for OFDM signals. (No. of carriers, No. of bits per symbol, No. of symbols per carriers, SNR).
2) Initialize necessary parameters for PAPR evaluation (No. of sub blocks).
3) Generate OFDM signal with the initialized parameters.
4) Evaluate PAPR of the generated OFDM signal using SLM technique.
5) Evaluate PAPR of the generated OFDM signal using PTS technique.
6) Evaluate PAPR of the generated OFDM signal using Iterative Flipping PTS technique.
7) Evaluate PAPR of the generated OFDM signal using Enhanced Iterative Flipping PTS technique.
8) Calculate corresponding CCDF of IFPTS technique.

IV. SIMULATION RESULTS

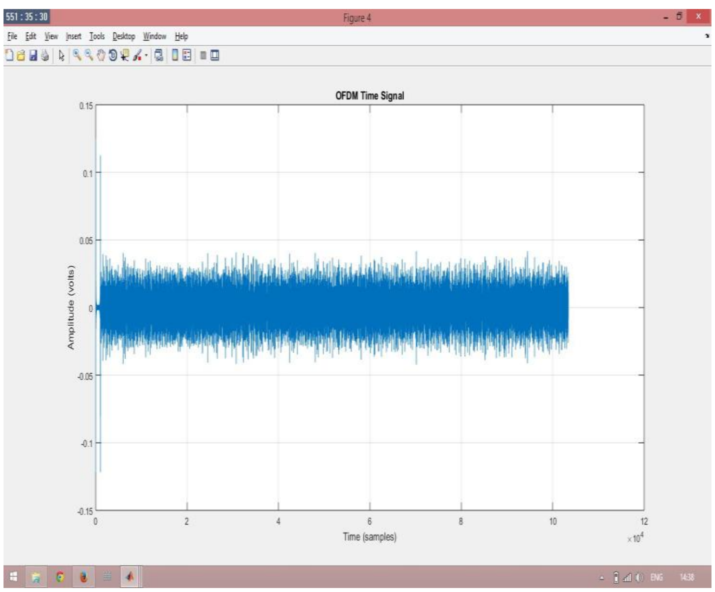

Fig. 4: OFDM Time Domain Signal

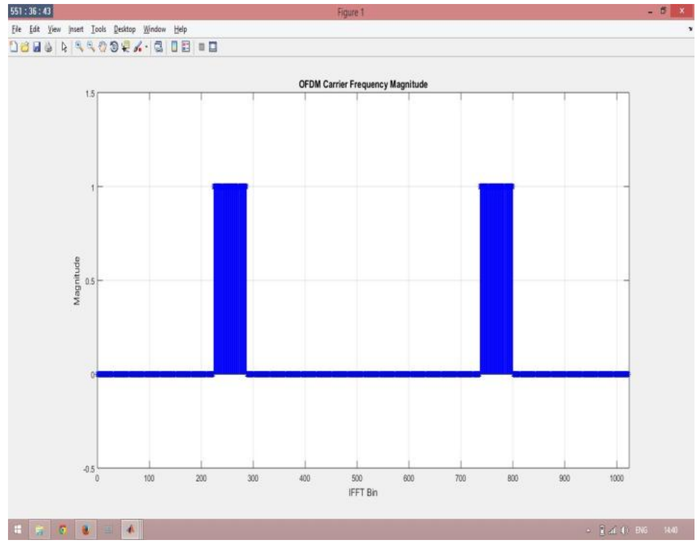

Fig. 5: OFDM Carrier Transmit

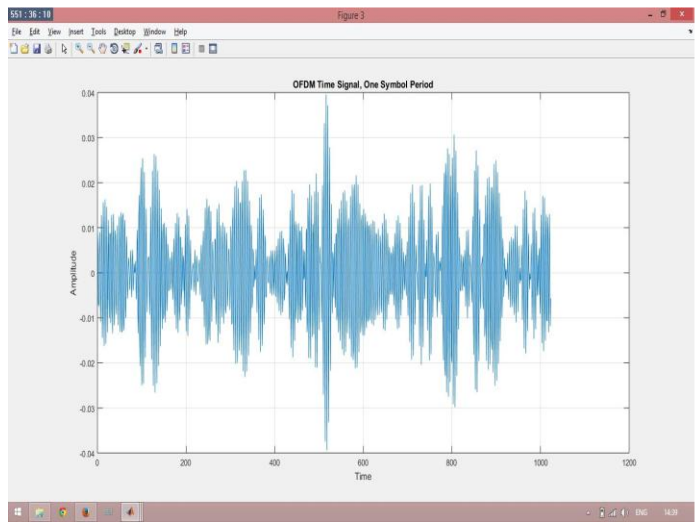

Fig. 6: Spectrum in Time Domain

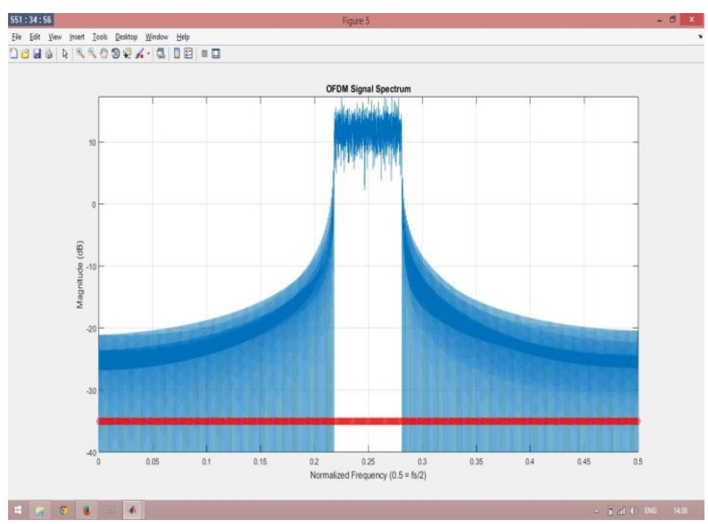

Fig. 7: LOFDM Signal Spectrum

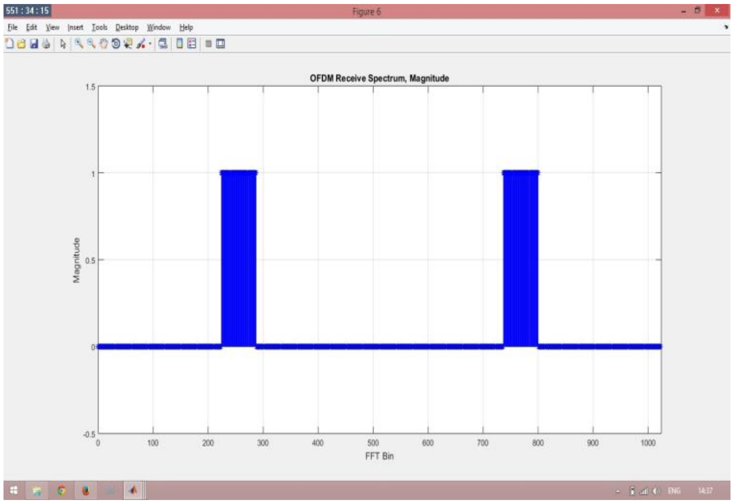

Fig. 8: OFDM Carrier Receive

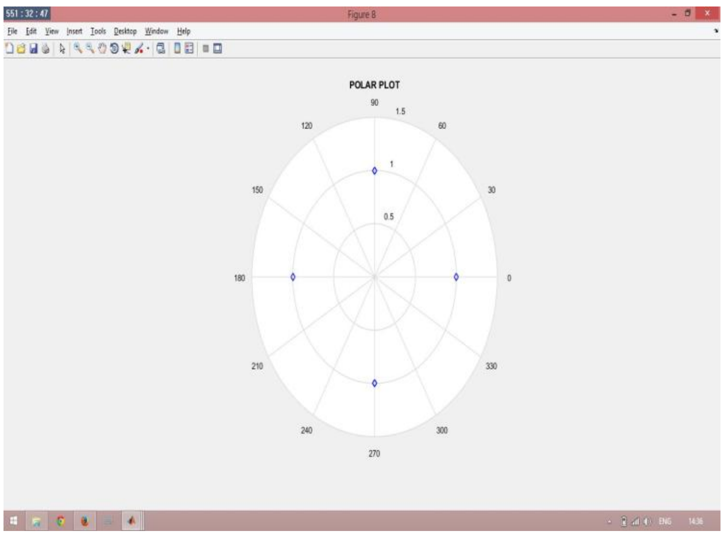

Fig. 9: Polar Plot of OFDM

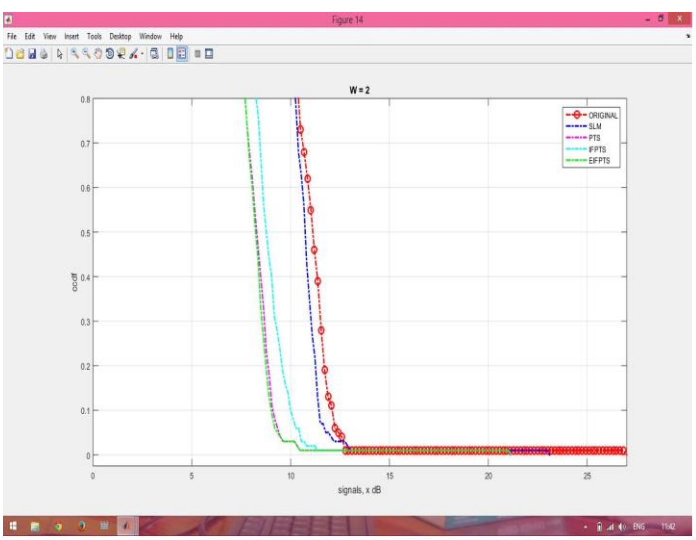

Fig. 10: CCDFs of PAPR in SLM,PTS, iterative, enhanced iterative and original schemes with
W=2 sub blocks (No. of sub-carriers=256, SNR=100)

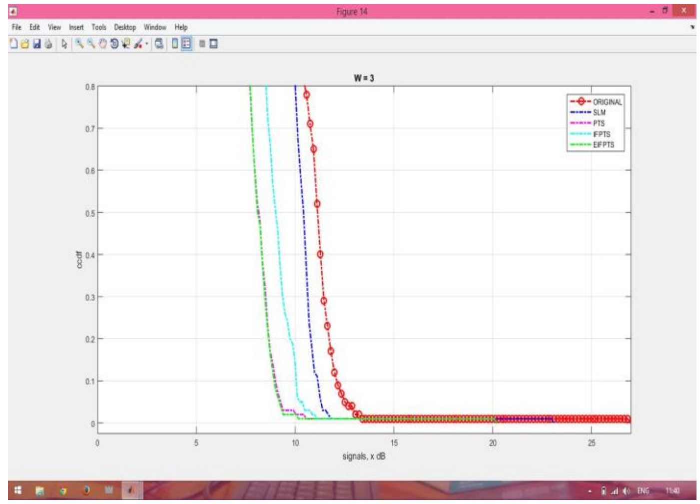

Fig. 11: CCDFs of PAPR in SLM, PTS, iterative, enhanced iterative and original schemes with
W=3 sub blocks (No. of sub-carriers=256, SNR=100)

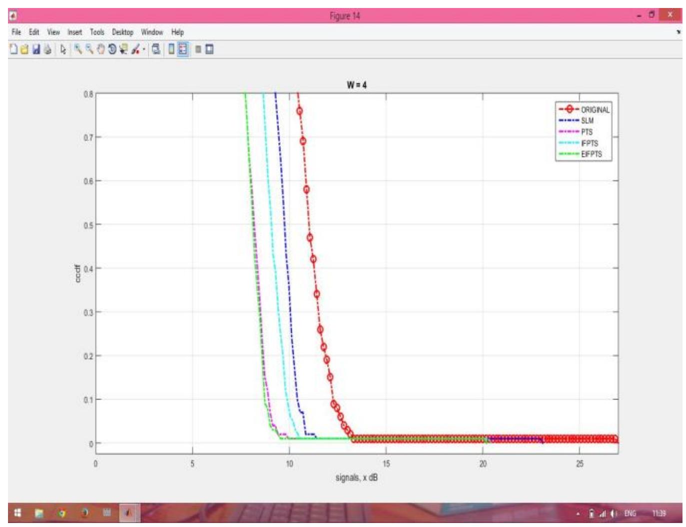

Fig. 12: CCDFs of PAPR in SLM, PTS, iterative, enhanced iterative and original schemes with
W=4 sub blocks (No. of sub-carriers=256, SNR=100)

V. CONCLUSION

Comparative study is done between four PAPR reduction techniques i.e. Enhanced Iterative Flipping Partial Transmit Sequence (EIFPTS), Partial Transmit Sequence (PTS), Iterative Flipping Partial Transmit Sequence (IFPTS) and Selective Mapping Technique (SLM). In this paper, Enhanced Iterative Flipping Partial Transmit Sequence (EIFPTS), Partial Transmit Sequence (PTS), Iterative Flipping Partial Transmit Sequence (IFPTS) and Selective Mapping Technique (SLM) schemes are used for PAPR reduction in OFDM systems. The simulation results show that all the schemes can lower the PAPR, but Enhanced iterative flipping PTS scheme gives good performance with significantly lower complexity compared with the ordinary PTS technique and the other techniques.

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