ISSN (ONLINE):2456-5717
International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.4, Issue.4, April 2018

Efficiency Improvement of 4g Technology by Reducing Peak to Average Power Ratio (PAPR)

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Abstract – **In wireless communication, parallel transmission of symbols using multi carriers is applied to achieve high efficiency in terms of throughput and better transmission quality. Orthogonal Frequency Division Multiplexing (OFDM) is one of the techniques for parallel transmission. It effectively mitigates the effect on performance due to Inter symbol Interference and delay spread caused by wireless medium. However high peak to average power ratio (PAPR) is a major demerit of OFDM system. High PAPR leads to increased complexity of circuit and reduced efficiency of RF amplifier. Partial Transmit Sequence (PTS) is one of the most promising techniques for PAPR reduction. In conventional PTS scheme the computation of optimal phase factors necessitates exhaustive searching of all possible and allowable phase factors, this leads to exponential increase of computation complexity in terms of complex additions and multiplications as number of sub block increases. In this paper to reduce Computational complexity phase factors are reduced to {1,-1, j,-j}**

Keywords: **OFDM, PTS, PAPR, CCDF, BER.**

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is an attractive technique for today's broad band communications and high speed data transmission over multipath fading channels. OFDM is widely implemented in various high speed wireless communication standards like Digital Audio Broad Casting(DAB),Terrestrial Digital Video Broad casting(DVB-T), IEEE802.11a(WLAN),IEEE 802.16d(WMAN) standards .4G pertaining to its high band width efficiency and its immunity towards ISI and delay spread. OFDM avoids ISI problem by sending many low speed transmissions simultaneously in addition of cyclic prefix (CP) [1-3]. In OFDM system output is superposition of multiple sub-carriers. In this case some instantaneous power output might increase greatly and become far higher than the mean power of system. To transmit signals with such high PAPR, it requires power amplifiers with very high power scope. These kinds of amplifiers are very expensive and have low efficiency-cost. If the peak power is too high, it could be out of the scope of the linear power amplifier. This gives rise to non-linear distortion which changes the superposition of the signal spectrum resulting in performance degradation. If no measure is taken to reduce the high PAPR, MIMO-OFDM system could face serious restriction for practical applications .By reducing PAPR the cost and complexity of various components in OFDM system can be reduced. If no measure is taken to reduce the PAPR,MIMO-OFDM system could face serious restriction for practical applications [4-7].To solve PAPR problem variety of techniques are introduced like clipping[8-11], companding[12], coding[13], selective mapping(SLM) [14],Partial Transmit Sequence(PTS)[15-17].PTS scheme

improves PAPR statistics of an OFDM signal considerably without any in band distortion and out of band radiation[18].Many PAPR reduction techniques result in performance degradation in terms of BER as compared to original OFDM signal. The definition of OFDM signal and mathematical expression of PAPR are described in section II. Section III describes normal PTS scheme in section IV Proposed PAPR reduction is discussed sections contains result analysis and conclusion is given in section VI

II. DEFINITION OF OFDM SIGNAL AND PAPR

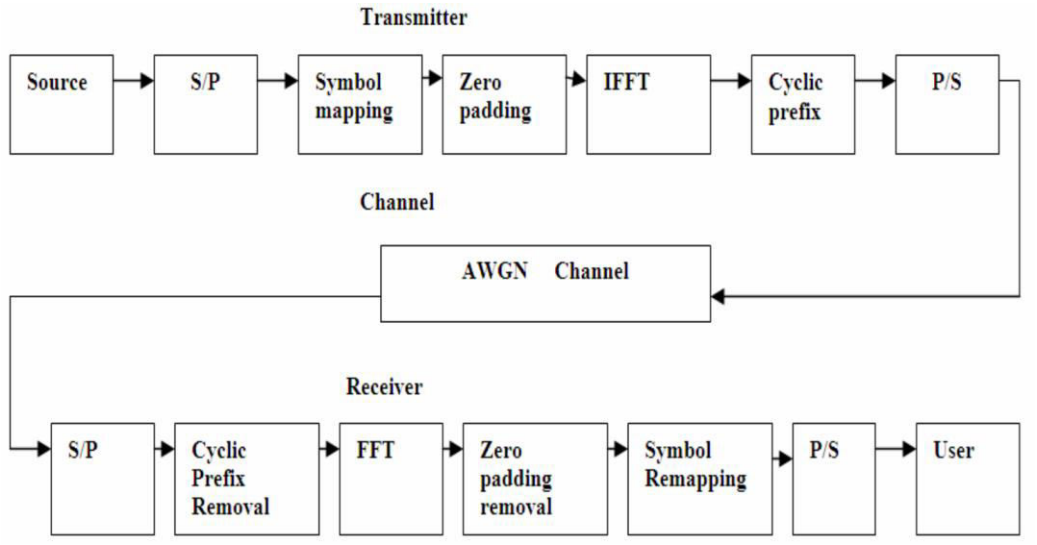

Fig. 1 Block diagram of OFDM system

The block diagram of OFDM signal is shown in the figure 1.OFDM system achieves high data rates by splitting the data over several orthogonal subcarriers each modulated at low rate .OFDM signal with N subcarriers is expressed as

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} x_k \emptyset_k(t) \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where

x_k = Input data symbols carried by k^{th} sub carrier

$$\emptyset_k(t) = \begin{Bmatrix} e^{j2\pi f_k t, t\in(0,T)} \\ 0, other\ wise \end{Bmatrix}$$

$$f_k = f_0 + \frac{k}{T}, k = 0,1,2 \dots\dots N-1$$

T =symbol duration

The PAPR of transmitted signal is defined as ratio of peak power to the average power of the signal and can be expressed as [8]

$$PAPR = \frac{\max_{0 \le n \le K-1} |x_n|^2}{E\{|x_n|^2\}} \dots\dots\dots\dots\dots\dots\dots (2)$$

as a performance measure the Complementary Cumulative Distribution Function ($CCDF$) is one of the most frequently used for $PAPR$ reduction technique, which denotes the probability that $PAPR$ of data block exceeds a given threshold and is calculated by using $MATLAB$ defined function $hCCDF = comm.CCDF$.

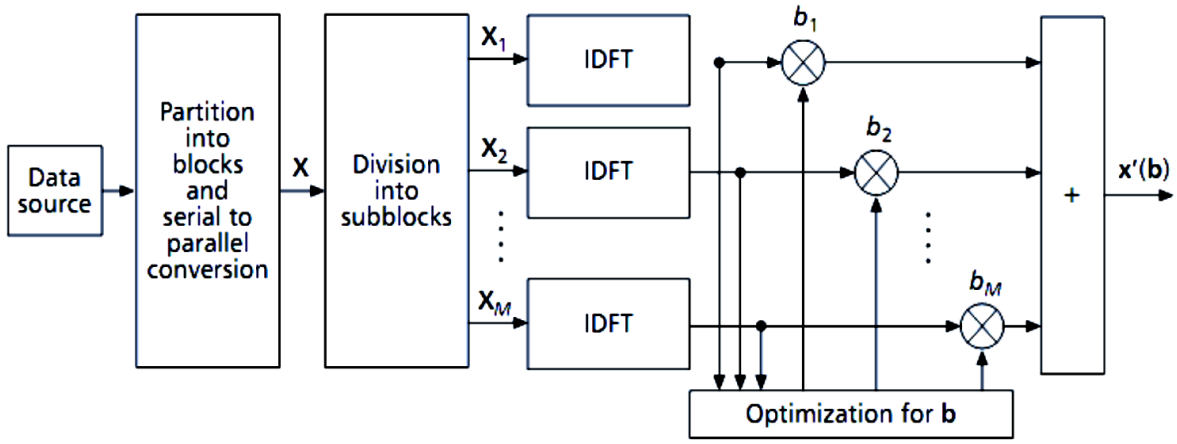

Fig. 2 Block diagram of normal PTS scheme

III. PARTIAL TRANSMIT SCHEME (PTS)

Partial Transmit Sequence (PTS) technique has been proposed by Muller and Hubber in 1997. This proposed method is based on the phase shifting of sub-blocks of data and multiplication of data structure by arbitrary vectors. This method is flexible and effective for OFDM system. The main purpose behind this method is that the input data frame is divided into non-overlapping sub blocks and each sub block is phase shifted by a constant factor to reduce PAPR.PTS is probabilistic method for reducing the PAPR problem. It can be said that PTS method is a modified method of SLM. PTS method works better than SLM method. The main advantage of this scheme is that there is no need to send any side information to the receiver of the system, when differential modulation is applied in all sub blocks. Transmitting only part of data of varying subcarrier which covers all the information to be sent in the signal as a whole is called Partial Transmit Sequence Technique .In the PTS scheme an input data block of N symbols is divided into V disjoint sub blocks. Each sub sequence multiplied by different weights until an optimum value is chosen. The phase factors (weights) are selected such that the PAPR of the combined signal is minimized .The data vector $[X = x_0, x_1 \dots\dots\dots\dots x_{N-1}]^T$ is divided in V disjoint sets$\{X_V, V = 1,2 \dots \dots V\}$ using same number of carrier for each group than V group sum

$X' = \sum_{V=1}^{V} X_V b_V \dots\dots\dots\dots\dots\dots\dots\dots (3)$
where
$b_V = e^{j\emptyset_v}$ are the phase factors .

The phase factor is chosen such that PAPR of x' is minimum

$$[b_1 \dots . b_V] = \underset{(b_1 \dots b_V)}{argmin} \left[\underset{n = 0,1 \dots . . N-1}{max} |\sum_{v=1}^{V} b_v x_v(n)| \right] \dots 4)$$

Corresponding time domain signal with lowest PAPR is

$$X' = \sum_{V=1}^{V} X_V b_V \dots \dots \dots \dots \dots \dots \dots \dots . . (5)$$

The main issue with PTS technique is its complexity .Another factor that may affect the PAPR reduction performance in PTS is the sub block portioning. The PTS scheme works with an arbitrary number of sub carriers at any modulation scheme. Complexity in PTS technique is also to send the side information because only those candidates are selected those have lesser PAPR.

IV. PROPOSED METHOD

High computational complexity, due to search of phase vectors through a high dimensional vector space is a potential problem for practical implementation of PTS .To circumvent this issue Hybrid or RP-IP T PTS is proposed in this paper. In the proposed method phase factor is restricted to $\{1, -1, j, -j\}$ to reduce the computational complexity.

Algorithm:

- *Modulated data is divided into M(=4) sub blocks*
- *Perform IFFT operation on each sub block*
- *Separate real and imaginary parts of each sub block*
- *To find phase vector for a particular sub block keep all phase vectors equal to 1 for real part and j for imaginary part*
- *find PAPR for first sub block with all four possible combinations of phase vectors*
- *fix the phase vector for first subcarrier , the combination which gives minimum PAPR*
- *Similarly find phase vectors for remaining sub blocks*
- *Optimum PAPR value is obtained at the end of M^{th} (=4) sub block*

V. RESULT ANALYSIS

Simulation is performed using MATLAB R 2015b version 8.3.The PAPR of proposed technique is compared with conventional PTS and Tree PTS. The proposed scheme achieves better PAPR reduction as shown in table 1.The proposed technique shows good performance in reception of the data even after it is passed through AWGN channel. As compared to the other techniques considered in this experimentation maximum reduction in the BER (figure 4) is offered by proposed scheme. In an OFDM system PAPR of the system is one of the major concern, but accurate reception of data is equally important. At the same time the computational complexity of the PTS system has to be reduced so as to make the system practically realizable .All these aspects are precisely taken care of in the proposed scheme. Table 1 summarizes the results of all three methods including proposed one .From table 1 it is obvious that in the proposed scheme PAPR is reduced 4 times to that of conventional PTS scheme. Figure 3 shows PAPR versus CCDF graph.

TABLE I: COMPARISON DIFFERENT NORMAL PTS, T PTS AND HYBRID T PTS

PAPR for Normal PTS	PAPR for Tree PTS in	PAPR for Hybrid T

in dB	dB	PTS in dB
13.7029	10.1427	3.5367

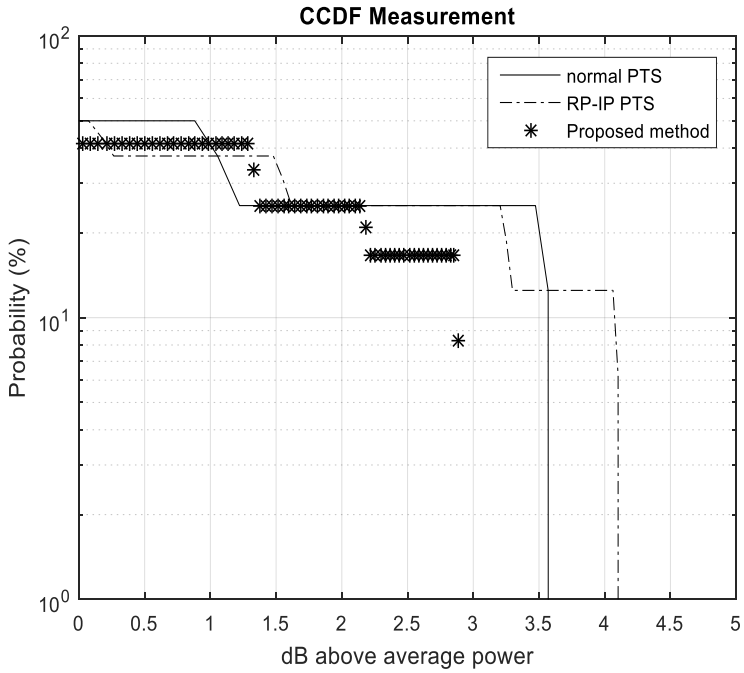

Fig. 3 CCDF measurement

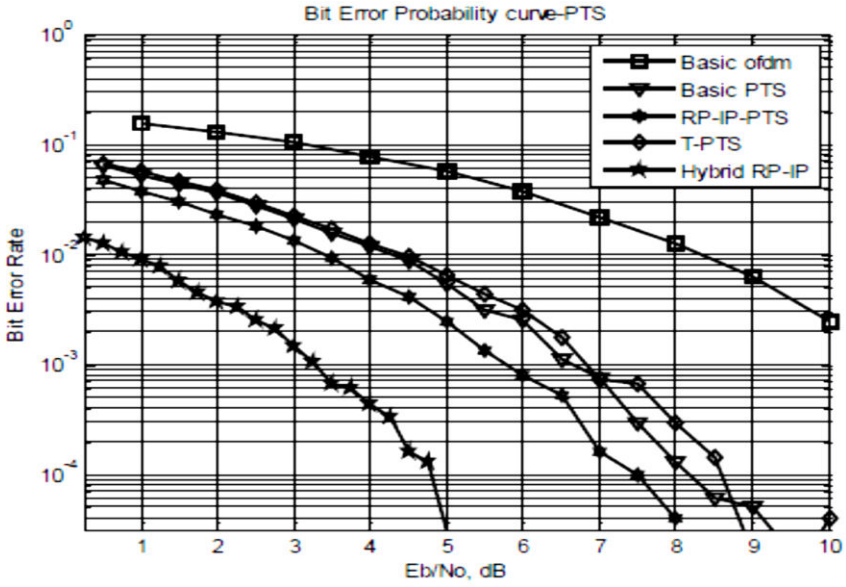

Fig. 4 BER plots for different PTS schemes

VI. CONCLUSION

High value of PAPR is one of the major drawback, which hamper the performance of OFDM system. In conventional OFDM system PTS scheme is one of the most sought choice for

PAPR reduction .But in PTS computation complexity increases as number of sub blocks are increased. The proposed hybrid T PTS shows good reduction in PAPR as compared to normal PTS and TPTS. Proposed technique offers reduced computation complexity and better BER performance than normal PTS and T PTS. The new scheme reduces the Computational complexity significantly.

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