PAPR Reduction by using Modified SLM-PTS Techniques in OFDM

S.V.Kiran[1], K.L.V. Prasad[1], R Anil Kumar[1]

[1]Dept of ECE, Aditya College of Engineering & Technology

***Abstract:*-Communication is one of the important aspects of life. With the advancement of age and its growing demands, there has been rapid growth in the field of communications. Signals, which were initially sent in the analog domain, are being sent more and more in the digital domain these days. For better transmission, even single–carrier waves are being replaced by multi–carriers. Multi–carrier systems like CDMA and OFDM are now a day's being implemented commonly. OFDM has important advantages in dealing with the frequency selective nature of high data rates. In the OFDM system, orthogonally placed sub–carriers are used to carry the data from transmitter end to receiver end. Presence of guard band in this system deals with the problem of Inter Symbol Interference (ISI) and noise is minimized by large number of sub–carriers. But the large Peak – to- Average power ratio of these signal have some undesirable effects on the system. In this paper we focused on methods to reduce the PAPR in the system so that this system can be used more commonly and effectively. Due to the fact that OFDM is an underlying technology of most modern wireless communication systems one can use and expand the projects to study not only the OFDM system but also other wireless communication.**

***Keywords* – OFDM, CDMA, ISI, PAPR, guard band.**

I. INTRODUCTION

The concept of OFDM is quite simple but the practically of implementing it has many complexities, so it is a fully software project. OFDM is a digital multi carrier modulation scheme which uses a large number of closely spaced orthogonal sub carriers.

In wireless communication systems the OFDM technique is a widely popular and attractive scheme for high data rate transmission because it can scope with frequency selective fading channel. The modulator and demodulators of OFDM systems can be simply implemented by employing IFFT and FFT to make the overall system efficient and effective. OFDM is a parallel transmission scheme where a high rate serial data stream is split up into a set of low rate sub streams each of which is modulated on a separate sub carriers.

OFDM depends on orthogonality principle. Orthogonality means, it allows sub carrier which are orthogonal to each other that means cross talk between co channel is eliminated and inter carrier guard bands are not required.

$$PAPR[x(t) = \frac{[|x(t)_{max}|^2]}{E[|x(t)|^2]} \quad (1)$$

$$\int_a^b \emptyset_m(t)\emptyset_m^*(t)dt = 0 \quad (2)$$

The functions $\emptyset_m(t)\ and\ \emptyset_m^*(t)$ are said to be orthogonal with respect to each other over the interval a<t<b if they satisfy the condition.

The advantages of OFDM system are given as-

- *Saving of Bandwidth*

The OFDM system is more bandwidth efficient in comparison to Frequency Division Multiplexing (FDM). As shown in figure 1.2(a), in FDM technique numerous distinct carriers are spaced apart without overlapping where in OFDM system the sub-carrier overlap each other due to orthogonality features. Due to overlapping of sub-carriers the usage of bandwidth reduced drastically and also reduced the guard bands for the separation of sub-carriers.

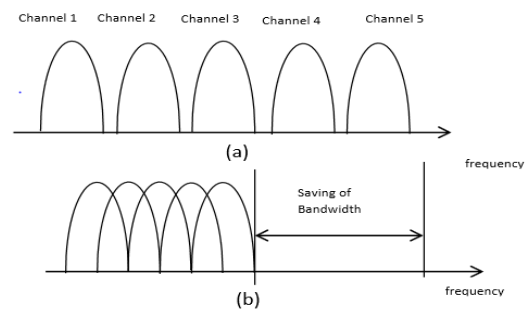

Fig.1.Comparison of (a) conventional multi-carrier technique and orthogonal multi-carrier modulation technique

- Easy to implement modulation and demodulation
- Easy Equalization
- Susceptible to frequency selective fading
- Protection against Inter symbol interference

Major problems of OFDM system

Despite of several advantages, the OFDM systems also have some major problems

Like –

- *High Peak to Average Power Ratio (PAPR) of transmitted signal-*

Presence of a large number of subcarriers with varying amplitude results in a high peak to average power ratio (PAPR) of the system with large dynamic range, which in turn affects the efficiency of the RF amplifier.

II. LITERATURE REVIEW

A. PAPR (Peak to average power ratio)

In OFDM one of the major disadvantages is high PAPR. This phenomenon results from that in the time domain, an OFDM signal is the superposition of many narrow band sub carriers. At certain times instances the peak amplitude of the signal is large and at the other times is small that is the peak power of the signal is substantially larger than the average power of the signal. The influence of high PAPR reduces system efficiency and then increases the cost of the RF power amplifiers.

$$\mathbf{PAPR= 10log_{10}} \frac{P_{peak}}{P_{avg}}$$

B. OFDM PAPR DESCRIPTIONS

A discrete-time OFDM model with N subcarriers is considered. With the linear property of the N narrowband subcarriers, the discrete-time OFDM signals can be written as

$$\mathbf{x(n)}=\frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} X(K)e^{j\frac{2\pi kn}{N}} \qquad (4)$$

Where

n = 0, 1. . . N − 1. For simplicity, we can have x = IFFT {X},

where X = [X(0), ...,X(N − 1)]T and x =[x(0), ..., x(N −1)] T . Because of the statistical independency of the transmitted subcarriers, the time domain OFDM samples x(n) are approximate Gaussian distribution.

III. DESCRIPTION

A. SELECTIVE MAPPING (SLM)

In the SLM technique, the transmitter generates a set of sufficiently different candidate data blocks by multiplying the same number of different phase sequences, all representing the same information as the original data block. IFFT operation is performed on each of these alternative input data sequences and then the sequence with the lowest PAPR is transmitted. Information about the selected phase sequence should be transmitted to the receiver as side information. For the successful implementation of SLM OFDM systems, the SLM technique multiple IFFT operations and side information for each data block. The SLM technique is also known as the classical SLM. The block diagram for this technique is shown below

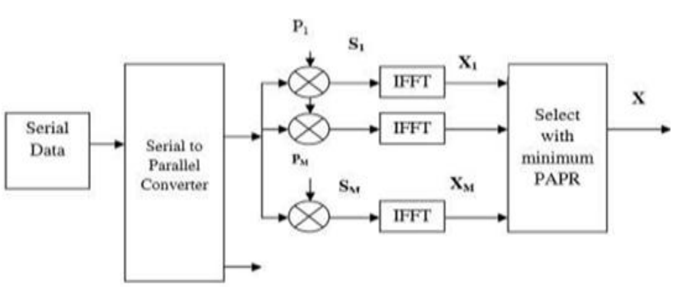

Fig.2. Block diagram of Selective Level Mapping

OFDM system with SLM technique to reduce the PAPR with mathematical expression:

Let the input data is defined as:

$$X = [X_0, X_1, X_2, \dots \dots \dots \dots \dots, X_{N-1}] \qquad (5)$$

Each data block is multiplied with U different phase factor;

Then Phase rotated sequence due to phase rotation factor B^{vu} can be written as:

$$X^{vu} = IFFT(X \otimes B^{vu}) \qquad (6)$$

Where

$$B^u = [bv_0^u, bv_1^u, bv_2^u, \dots \dots \dots . v_{N-1}^u]^T$$

With phase sequence $|bv_n^u| = (n = 0,1, N-1)$

We are usually selected (±1) for avoiding complexity for complex multiplication or to add unmodified data in to modified data. After that multiply input data with U different phase factor the modified data for U phase sequence can be written as:

$$X^u = [X_0 bv_{u,0}, X_1 bv_{u,1}, X_2 bv_{u,2}, \dots \dots \dots \dots \dots .., X_{N-1} bv_{u,N-1}]$$

u=0, 1, 2…U-1.After the PAPR comparisons among the U data sequence x (u), the optima mapped one x with the minimum PAPR is selected for transmission.

$$\hat{x} = \arg min_{0 \le u}[PAPR(X^{VU})] \qquad (7)$$

PAPR reduction effect will be better U is increased.SLM method can effectively reduce PAPR without any signal distortion.

B. PARTIAL TRANSMIT SEQUENCE (PTS)

PTS shows advanced capability to reduce the PAPR as the SLM technique. It is also reduces the complexity of the system. This method is based on phase shifting of sub blocks of data. The basic idea of partial transmits sequences algorithm is to divide the original OFDM sequence into several subsequences and for each sub-sequences multiplied by different weights until an optimum value is chosen. The block diagram of PTS as shown below

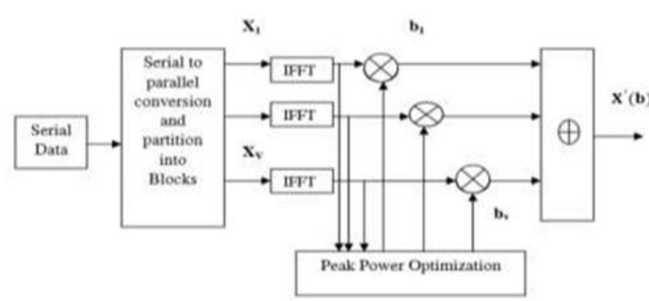

Fig.3. Block diagram of Partial Transmit Sequence

PTS is most important method used to reduce PAPR in OFDM system and it can be presented in two main steps. First, by dividing the original OFDM signal into a number of sub-blocks.

Secondly, adding the phase rotated sub-blocks to develop a number of candidate signals to pick the one with smallest PAPR for transmission.

There is another way that can also be used to express PTS method by multiplying the original OFDM signal with a number of phase sequences.

PTS technique partitions and input data block of N symbols into V disjoint sub-blocks as follows:

$$X = [x^0, x^1, x^2, \dots \dots .., x^{v-1}]^T \quad (8)$$

Wherex^i the sub blocks that are consecutively located and are also of equal size, scrambling is applied to each sub block which rotating its phase independently in the PTS technique. Then each partitioned subblock is multiplied by a corresponding complex phase factor

$$b^v = e^{j\emptyset v} \quad (9)$$

Where v = 1, 2… V, subsequently taking its IFFT to yield:

$$X = IFFT\{\sum_{V=1}^{V} b^v x^v\} = \sum_{v=1}^{v} b^v . IFFT\{x^v\} = v = 1V b_{vx} \quad (10)$$

Wherex^v is referred to as PTS .The phase vectoris chosen so that the PAPR can be minimized which is shown as:

$$\lfloor b^{-1}, \dots \dots, b^v \rfloor = (\max | \sum_{v=1}^{v} b^v x^v(n) |) \quad (12)$$

Where n= (0, 1 ... N-1)

The number of computations in this suboptimal combination algorithm is V, which is much fewer than that required by the original PTS technique which make

$$(V << W^v) \quad (13)$$

Then the corresponding time-domain signal with the lowest PAPR vector can be expressed as:

$$\boldsymbol{x} = \sum_{v=1}^{v} b^v x^v \quad (14)$$

SLM AND PTS:

The difference between SLM and PTS is that the SLM applies independent scrambling rotations to all subcarriers, while the PTS only applies scrambling rotations to subcarrier sub blocks. Both SLM and PTS are important probabilistic schemes for PAPR reduction. SLM produce independent multiple frequency signals. PTS divides the frequency vector into some sub blocks before applying the phase transformation. In this case it is more advantageous than SLM if amount of computational complexity is limited.

IV. SIMULATION RESULTS

In this section, we present simulation results to show the performance of the proposed scheme and compare the proposed scheme with Original, PTS, SLM, SLM combined with PTS and SLM with new phase sequence schemes. Simulation has been done in MATLAB and simulation carried out using 256 subcarriers with BPSK modulation scheme. Other parameters taken are oversampling rate equal to 4 and no of sub blocks. The four values: 2, 4, 8 and 16 are taken for this parameter. The 5000 iterations are taken for the simulation. The phase factor taken is [1,-1]

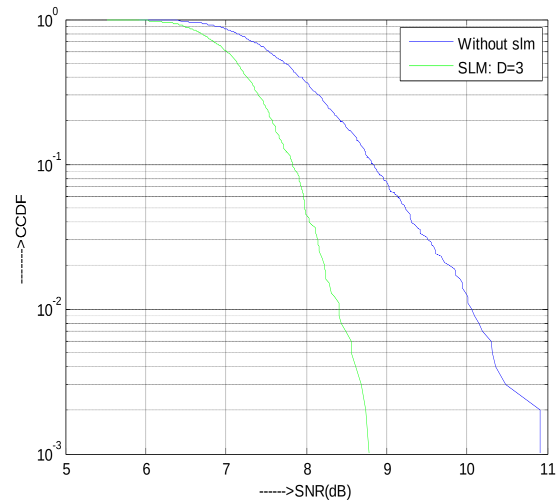

Fig.4. Block diagram of Partial Transmit Sequence

complement cumulative distribution function (CCDF) of PAPR in original, partial transmit, selective mapping, selective mapping with new phase sequence as rows of normalized Riemann matrix and proposed schemes for the different values of sub blocks are shown in Fig. 4. Here CCDF describes the probability that the PAPR of given data exceeds a predefined fixed threshold PAPR. For M=2 the CCDFs of PAPR in various schemes is given in Fig. 4. The result graphs show that the proposed scheme gives better PAPR reduction in PAPR than the partial transmit, selective mapping and selective mapping combined with partial sequence butis more complex than the all other.

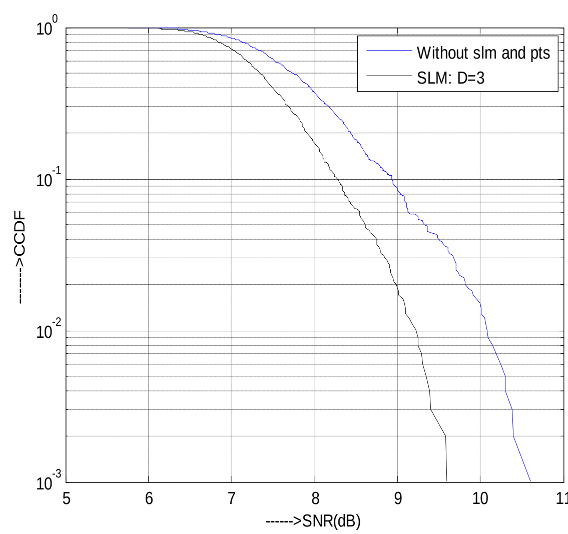

Fig.6. Block diagram of Partial Transmit Sequence

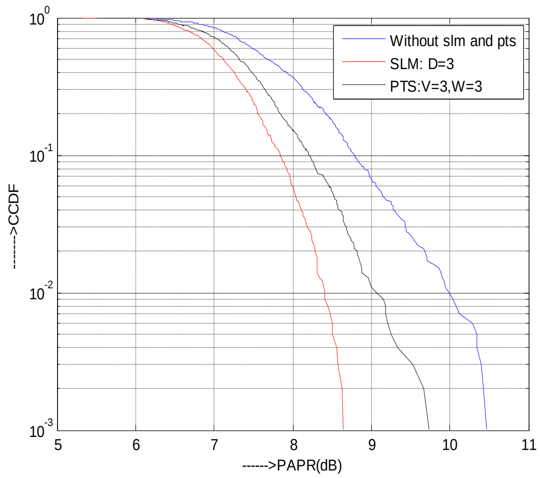

Fig.5. Block diagram of Partial Transmit Sequence

When the number of sub-blocks is four the CCDFs of PAPR in various schemes is given in figure 5. From the figure 5 it can be seen that the performance of proposed, SLM, SLM and PTS combined schemes is much better than that of the previous case (M=2), Fig. 4 illustrates the case of M=8 sub-blocks. In this case, some more changes are observed as compared to the previous case and there is further reduction in PAPR. From the figure 4 to 6 it is concluded that with the increase in number of sub-blocks performance of the schemes increases. Therefore, the proposed schemes offer better reduction in PAPR with increase in the number of sub-blocks. When M=16 the proposed scheme offers better reduction in PAPR than previous cases. Therefore, Simulation results, shows that proposed schemes give more PAPR reduction as compared to other techniques discussed in this paper.

V. CONCLUSION

In this paper, we investigate the PAPR reduction techniques, which are selective mapping (SLM) and partial transmit scheme Fig.3. Block diagram of Partial Transmit Sequence (PTS). The performance analysis defined PAPR reduction of SLM scheme with QPSK modulation M with Fig- 4, PAPR reduction of PTS scheme with QPSK modulation W with Fig-5, and comparisons performance for SLM and PTS scheme with M=4 and QPSK modulation respectively thus although the comparison method of SLM and PTS where PTS method performs better than SLM in reducing PAPR method finally we can define on the basis of fig-6, PTS technique better than SLM technique.

REFERENCES

[1]. J. Tellado "Peak to Average Power Reduction for Multicarrier Modulation", Doctoral Dissertation, Department of Electrical Engineering, Stanford University, 1999.

[2]. A.D.S. Jayalath and C. Tellambura,"Adaptive PTS Approach for Reduction of Peak-to-Average Power Ratio of OFDM Signal", *Electronics Letters*, Vol. 36, No. 14, pp. 1226-1228, 2000.

[3]. H. Breiling, S.H. Muller-Weinfurtner and J.B. Huber, "SLM Peak-Power Reduction without Explicit Side Information", *IEEE Communications Letters*, Vol. 5, No. 6, pp. 239-241, 2001.

[4]. J. Yang, L. Chen and W. Mao, "A Modified Selected Mapping Technique to Reduce the Peak-to-Average Power Ratio of OFDM Signal", *Proceedings of IEEE International Conference on Consumer Electronics*, pp. 1-2, 2007.

[5]. S.H. Muller and J.B. Huber, "OFDM with Reduced Peak to Average Power Ratio by Optimum Combination of Partial Transmit Sequences", *Electronics Letters*, Vol. 33, No. 5, pp. 368-369, 1997.

[6]. J.A. Davis and J. Jedwab, "Peak-to-Mean Power Control in OFDM, Golay Complementary Sequences, and Reed–Muller Codes", IEEE Transactions on Information Theory, Vol. 45, No. 7, pp. 2397-2417, 1999.

[7]. B.K. Shiragapur, U. Wali and S. Bidwai, "Novel Technique to Reduce PAPR in OFDM Systems using Threshold SLM", *Proceedings of 3rd IEEE International Advance Computing Conference*, pp. 515-519, 2013.

[8]. Bahubali K. Shiragapur and UdayWali, "Hybrid Techniques for PAPR Reduction of OFDM Signal", *International Journal of Computer Networking, Wireless and Mobile Communications*, Vol. 5, No. 5, pp. 9-15, 2016.

[9]. S. Meymanatabadi, J.M. Niya and B.M. Tazehkand, "Multiple Recursive Generator-Based Method For Peak-To-Average Power Ratio Reduction In Selected Mapping Without Side Information", *China Communications*, Vol. 10, No. 8, pp. 68-76, 2013