PAPR Reduction of OFDM signals using Selective Mapping and Partial Transmit Sequence

Abha Sharma
Computer Science and Engineering
Meerut Institute of Engineering and Technology
Meerut, India
abhasharmait@gmail.com

Ajay Kumar Singh
Computer Science and Engineering
Meerut Institute of Engineering and Technology
Meerut, India
ajay41274@gmail.com

Abstract—Orthogonal Frequency Division Multiplexing (OFDM) has been currently under intense research for broadband wireless transmission due to its robustness against multi-path fading. In multi-carrier modulation, the most commonly used technique is OFDM, it has recently become very popular in wireless communication. The main drawback of OFDM is Peak to average power ratio (PAPR). This paper present selective mapping (SLM) technique and partial transmit sequence (PTS) technique to reduce PAPR. These proposed techniques show better performance to reduce PAPR.

Keywords- OFDM, PAPR, SLM, PTS

I. INTRODUCTION

Orthogonal frequency-division multiplexing (OFDM) [1] has drawn significant interests over past decade for its robustness against the multipath fading channels. It is an effective high speed data transmission scheme without using very expensive equalizers and it has been proposed as the air interface for broadband wireless applications such as wireless local area networks (WLANs). One of the major drawbacks of OFDM systems is that the OFDM signal exhibits a high peak-to-average power ratio (PAPR) [2]. Such a high PAPR necessitates the linear amplifier to have large dynamic range which is difficult to accommodate. OFDM systems, a few methods for PAPR reduction have also been proposed, such as amplitude clipping and filtering coding technique, SLM technique and PTS technique. The clipping technique employs clipping or nonlinear saturation around the peaks to reduce the PAPR. It is simple to implement, but it may cause in-band and out-of-band interferences while destroying the orthogonality among the sub-carriers. The coding technique is to select such code words that minimize or reduce the PAPR. It causes no distortion and creates no out-of-band radiation, but it suffers from bandwidth efficiency as the code rate is reduced. It also suffers from complexity to find the best codes and to store large lookup tables for encoding and decoding especially for a large number of sub-carriers. In this paper we apply SLM and PTS to reduce PAPR.

II. PAPR OF OFDM

The major problem that faces while implementing this system is the high PAPR of this system. A large PAPR increases the complexity of the A/D and D/A converter and reduces the efficiency of the radio frequency (RF) [3] power amplifier. PAPR is defined as the ratio of maximum value of power and the average value of power of a given signal.

Peak to Average Power Ratio (PAPR) = (maximum power of a signal) ⁄ (Average power of a signal)

PAPR can be defined in db

PAPR (in db) = 10 log 10 * (maximum power of a signal) / (Average power of a signal)

The complex baseband OFDM signal for N subcarriers represented as

$$X(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi n\Delta f\tau} \quad 0 \leq t \leq NT$$

III. SLM TECHNIQUE

In this technique whole set of candidate signal represent the same signal and then the most favourable signal is chosen and then transmitted. The side information must be transmitted with the chosen signal. It generates the set of favourable blocks at the transmitter end which represent the original information and then chooses the most favourable block for transmission. Here the input block given by X=[X(0),X(1),…..X(N-1)] is multiplied with U different phase sequences Pu= $[P_0^u\ ,P_1^u\ ….P_{N-1}^u]^T$ to produce a modified data block given by

$$X^u = [X^u[1], X^u[2]\ X^u[N-1]]^T$$

The IFFT of U independent sequences are taken to produce the time domain sequences

$X^u = [X^u[0], X^u[1]\ X^u[N-1]]^T$ among which the one with the lowest PAPR[4] is selected for transmission.The amount of PAPR reduction for SLM[5] depends on the number of phase sequences U and the proper design of the phase sequences. The SLM technique is developed from the idea of symbol scrambling. Figure A shows the SLM-OFDM system. SLM is existing distortion less peak-to-average power ratio reduction schemes that has been proposed for orthogonal frequency division multiplexing. This is an effective and distortion less technique used for the PAPR reduction in OFDM. The input QAM modulated input data sequence X is given as is multiplied with the phase vector d_v=exp(j2πΦ) . Where the phase sequence can be written as:

$$\Phi = [\ \Phi_0, \Phi_1, \Phi_2\ \Phi_{V-1}]\quad \Phi\epsilon[0,\Omega]$$

Here the phase vector is applied to reduce the PAPR. This phase vector is multiplied by the subcarrier of OFDM for reduction the peak. Only the phase which phase vector have less peak is multiplied subcarriers. Transmitter and receiver know the phase vector. The phase vector circularly rotates. The rotation which has minimum peak is selected and send rotation number as side information. The benefit of this SLM[6] scheme is that there is very less side information is used for reducing PAPR in OFDM systems.

Figure 1 shows the block diagram of SLM technique.

After multiplying the phase vector with subcarrier and taking IFFT[7] operation

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k * d_{v,k}\, e^{j2\pi nk/N}$$

where x_n is the OFDM symbol.

d_0

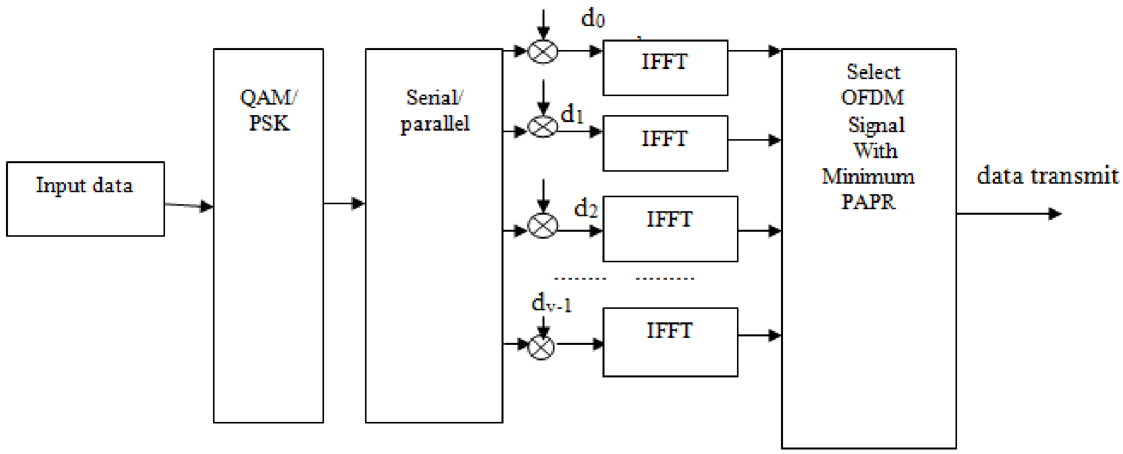

Fig.1: Block diagram of SLM

IV. PTS TECHNIQUE

The PTS [8] partitions an input block of N symbols into V disjoint sub blocks as

$X=[X^{0}$ -,-X^{1} $X^{V-1}]^{T}$

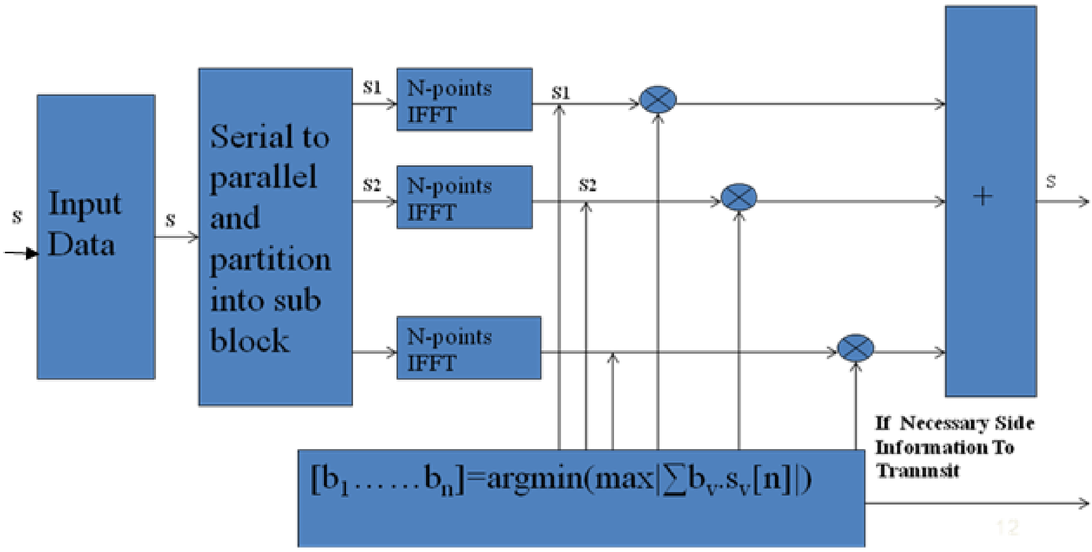

Fig.2: Block diagram of PTS

Figure 2 shows the block diagram of PTS technique. Each partitioned sub block is multiplied by complex phase vector $b_v = e^{j\Phi(v)}$ where v=1,2,V.

In this scheme the input data block S is partitioned into V disjoint sub-blocks as $S_v=[S_{v,o}, S_{v,1}, L, S_{v,N-1}]^T$,1<=v<=V Thereby, each symbol S_n is contained exactly in one part S_v; the remaining symbols of S_v are set to zero. Then, each partitioned sub-block is multiplied by a corresponding complex phase factor $b_v=e^{j\Phi(v)}$, with $\Phi(v)€[0,2\pi)$ and v=1,2,V, subsequently taking its IFFT to yield,

$$S_v= \text{IFFT } \{\sum b_v g \text{IFFT}\{S_v\}=\sum b_v s_v$$

The phase vectors are selected so that the PAPR of the combined signal is minimized.

V. COMPARISON BETWEEN SLM AND PTS

In the PTS scheme, all the entries in S_v are multiplied by the same rotation b_v. It is clear that the PTS method is a special case of the SLM[9] method. For PTS method, the number of rotation factor b_v may be limited in a certain range. W^{V-1} accessorial information sequences are required in PTS-OFDM[10], where W denotes the number of the phase factors. And the redundant bits of side information are as follows:

$R_{ap}=(V-1)\log_2 W$

In SLM[11], U accessorial information sequences are required in OFDM with U vectors P_u and the redundant bits of side information are as follows:

$R_{ap}= \log_2(U-1)$

VI. CONCLUSION

High PAPR of transmitted signal is one of the major drawbacks of OFDM systems. In this paper we proposed an alternative PAPR reduction technique based on combination of a selective mapping method with partial transmit sequence method.

REFERENCES

[1] Abhishek Arun Dash "OFDM Systems and PAPR Reduction Techniques in OFDM Systems", Bachelor Thesis, Department of Electronics and Communication Engineering National Institute of Technology, Rourkela 2006 – 2010.

[2] Malhar Chauhan, Saurabh patel and Hardik patel , "Different Techniques to Reduce the PAPR in OFDM System" , International Journal of Engineering Research and Applications (IJERA), Vol. 2 , ISSN: 2248-9622, Issue 3, pp. 1292-1294 , May-Jun 2012 .

[3] Waleed Khalil, "Introduction to the Special Section on the IEEE Radio Frequency Integrated Circuits (RFIC) Symposium", IEEE Journal of Solid-State Circuits, Vol. 49, no. 5, pp. 1079-1080, May 2014.

[4] Md. Ibrahim Abdullah, Md. Zulfiker Mahmud, Md. Shamim Hossain, and Md. Nurul Islam , "Comparative Study of PAPR Reduction Techniques in OFDM", ARPN Journal of Systems and Software, Vol.1, ISSN 2222- 9833, No.8 , pp. 263-269 , November 2011.

[5] Pawan Sharma and Seema Verma, "PAPR Reduction of OFDM signals using selective mapping with turbo codes ", International Journal of Wireless & Mobile Networks (IJWMN) , Vol. 3, No. 4 , pp. 217-223, August 2011.

[6] Himanshu Bhusan Mishra,"PAPR Reduction of OFDM Signals Using Selected Mapping Technique", Master Thesis, Department of Electronics and Communication Engineering National Institute of Technology, Rourkela 769 008 Odisha India.

[7] Christian Siegl and Robert F. H. Fischer, "Partial Transmit Sequences for Peak-to-Average Power Ratio Reduction in Multiantenna OFDM", Hindawi Publishing Corporation EURASIP Journal on Wireless Communications and Networking, Vol. 2008, Article ID 325829, 11 pages ,doi:10.1155/2008/325829.
[8] S. H. Han and J. H. Lee, "An overview of peak-to-average power ratio reduction techniques for multicarrier transmission",
[9] IEEE Wireless Communications, Vol. 12 , no. 2, pp. 56–65, 2005.
[10] Lakhendrakumargupta ,Brajendrakumar, Ashish mishra and Asutosh kumar, "PAPR Reduction using modified Selective Mapping Technique", International Journal of Advanced Technology & Engineering Research, Vol. 3, ISSN 2250-3536, Issue 3, pp. 130-133, May 2013.
[11] D.Narendra and Dr.P.Sudhakara Reddy, "PAPR Reduction Technique in OFDM System For 4G Wireless Applications Using Partial Transmit Sequence Method", Quest Journals Journal of Electronics and Communication Engineering Research, ISSN :2321-59411, pp: 38-42 Issue 2013 .
[12] Shweta Jain, Vikas Gupta and Divya Jain,"PAPR Reduction using modified Selective Mapping Technique and Turbo Coding", International Journal of Advanced Engineering Technology, Vol. II, E-ISSN 0976-3945, Issue IV, pp. 427-430, October-December 2011.