PAPR Reduction of OFDM Using Recurring SLM with Cyclic Block Codes Schemes

Pratima Manhas[1] , Dr.M.K Soni[2]
[1]Research Scholar, FET, ECE Deptt, [2]ED& Dean, FET
Manav Rachna International University
Faridabad, India
[1]pratimamehak@gmail.com
[2]ed.fet@mriu.edu.in

***Abstract*—Orthogonal Frequency division multiplexing (OFDM) is a type of multicarrier modulation (MCM) technique which plays an important role in 4th generation of wireless network. One major flaws present in this method is high Peak to Average power ratio (PAPR). A modified SLM technique using cyclic block codes is presented in this paper. The simulation study verifies that the PAPR reduction by proposed method (modified SLM) is better than the existing technique (SLM).**

Keywords*—Orthogonal Frequency Division Multiplexing *(OFDM),* Selective Mapping *(SLM),*Multicarrier modulation(MCM), cyclic block codes, peak-to-average-power-ratio *(PAPR),*Complementary Cummulative Distribution Function (CCDF), *QPSK.

I. INTRODUCTION

With the rapid development in telecommunication technology, high speed communication is placed at upper most priority level. A wide variety of modulation methods are proposed that fulfill this primary objective in communication. Orthogonal Frequency division multiplexing is one of the technique used to provide higher data rate. Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation (MCM) method used for wireless communication, Digital audio broadcasting(DAB),Modems and ADSL[1].This technique has various advantages over other existing methods such as more resistant to selective fading, ability to recover from the interference and inter symbol and inter frame interference (ISI), effective and suitable utilization of available spectrum[2].OFDM suffers from high peak to average power ratio(PAPR) [3-4].High value of PAPR will cause clipping in OFDM signal and enable an amplifier to operate in nonlinear section. This nonlinearity will result in in-band distortion and out-band radiation. They have adverse effect such as the in –band distortion will degrade the performance of the system and out-band radiation results in causing interference among adjacent channel. Thus this additional interference in the system will result in increasing Bit Error Rate. One way to overcome this situation is to use high dynamic range linear power amplifier, but utilization of this solution is not effective, and too expensive.

The paper is organized in different sections. section II gives brief description about Orthogonal Frequency Division Multiplexing technique. Section III discusses the brief introduction to PAPR reduction. Section IV deals with the block diagram of SLM technique .Section V comprises the proposed method which is modified version of existing SLM technique. Section VI discusses the comparison of both proposed method and existing method by simulation study. Lastly result is concluded in section VII.

II. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING TECHNIQUE

OFDM is a combination of both modulation and multiplexing technique. In OFDM, bandwidth is divided into parallel orthogonal sub-carrier signals which is used to carry data on several channels. Then each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation(QAM) or phase-shift keying(QPSK)) at

978-1-4673-7231-2/15/$31.00 ©2015 IEEE

a low symbol rate which results in maintaining ,total data rates similar to conventional *single-carrier* modulation .This OFDM has various advantages such as have more resistant to selective fading, ability to recover from the interference and inter symbol and inter frame interference (ISI), effective and suitable utilization of available spectrum, channel equalization is easier. One major limitation of using OFDM method is high peak to average power ratio (PAPR), commonly the PAPR value for some transmitted signal is much larger than the usual values. This PAPR factor enables the amplifier to work in nonlinear section. Thus, because of this different subcarriers suffer from inter modulation and this brings additional interference in the system that results in growing Bit Error Rate. The increased value of PAPR results in of band distortion and spectral spreading.

III PAPR OF OFDM SYSTEM

As OFDM signal consists of multiple modulated carriers and able to generate a high peak to average power ratio (PAPR), when these parallel carriers are added up. If N carrier signals which are added together constitute same phase then they generate a peak power which is N times the average power. The increased value of PAPR factor results for clipping noise, non–linear distortion of Power amplifier, BER performance debasement and enhances complexity factor in analog to digital (A/D) or digital to analog (D/A) converter.

Let us suppose that, N length data block is represented by the vector as shown $X=[X_0, X_1, X_2 \ldots X_{N-1}]$ T where T indicate the duration of any member from set X (X_k), and delineate any single subcarriers $\{f_n$,n=0,1,…..,N-1$\}$. The characteristic feature of multiple subcarriers which are selected to transmit signal is that, they are orthogonal to one another, therefore we have $f_n = n \Delta f$, where $n \Delta f = 1/NT$ .In this NT indicates the duration of data blocks in OFDM process. Equation (1) represents the PAPR of transmitted signal.

$$PAPR=P_{peak}/P_{avg.} = \max [|x_n|^2] /E [|x_n|] \ldots (1)$$

Thus, PAPR is the Peak (P_{peak}) to Average (P_{avg}) Power Ratio. E[.] = Expectation operator and indication of average power.

The Complementary Cumulative Distribution function (CCDF) is used to calculate the PAPR .It is given in equation (2)

$$CCDF(N, PAPR_0) = 1 - (1 - e^{-PAPR_0})^N \quad \ldots (2)$$

IV SLM TECHNIQUE

In OFDM systems, various methods of reduction of PAPR are used. They are divided into:-

- Distortion Method
1. Clipping
2. Companding
3. Tone Injection
4. Tone Reservation

- Non Distortion Method
1. Selective Mapping (SLM)
2. Partial Transmit Sequence(PTS)

The Distortion method is easier and simpler but it is a cause for decreasing the performance of system. The non distortion method is more commonly used as it results in better performance. From the above two methods in Non distortion technique , this paper deals with the SLM technique as it achieve better performance than the PTS technique. By combining the SLM and QPSK technique for mapping, not only decreases the PAPR in OFDM method but also reduces complexity in design.

This Selective Mapping method [6-9] for a given set of different signals (where all signals represents the same information) ,the signal with lowest PAPR value is selected. An admirable feature of SLM method is its flexibility which is provided because it does not impose any restraints on the modulation performed on subcarriers and number of subcarrier. Figure 1 shows the operation of SLM method. The data stream after serial to parallel conversion is given by vector $X=[X_0, X_1, X_2 \ldots X_{N-1}]^T$. In the beginning each input

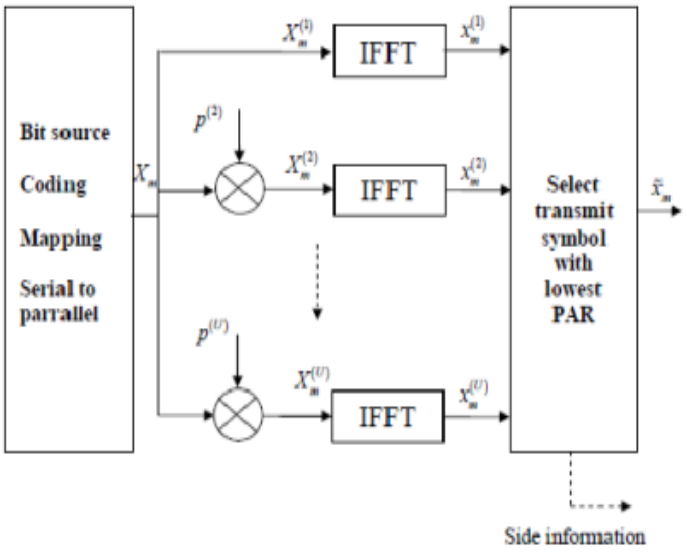

Fig. 1: Block diagram of SLM technique

(X_n^u) is described by an equation-(3).

$$x_n^{(u)} = [x_0^{(u)} .. x_1^{(u)}, \ldots\ldots\ldots x_{N-2}^{(u)}]^T \quad \ldots(3)$$

Where n = 0, 1, 2-------N-1,

and u = 0,1,2...to rotate OFDM data block by u phase.

All rotated, OFDM data block comprises the same information as comprised by the non-modified data block .

Thus, by applying the SLM method the OFDM signal with N modulated carrier is represented as:

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x_n e^{j 2\pi n \Delta f t}, \qquad 0 \le t \le NT \quad \ldots\ldots (4)$$

Where NT indicates the duration of data block in OFDM process .A signal with the least PAPR is selected to transmit data. The SLM method (Section IV) is suitable for reducing the PAPR without causing any damage to signal but on other hand it increases the complexity and computational overhead. The rise in complexity can be reduced by lessen the number of IFFT block.

V PROPOSED WORK

Mapping sequence (cyclic code with QPSK based SLM) is selected to reduce the peak to average power ratio (PAPR) of OFDM signal.

However, the previous method (conventional SLM) by increasing the level of complexity a high value of PAPR is obtained. Thus, conventional SLM method have higher complexity factor. In this paper the CCDF & Power spectral density of original SLM is compared with proposed SLM by using Mat lab tool.

To reduce this rise in the complexity of SLM the □ vector changed only of its odd components whereas its even component are supposed to have value 1 for 1000 iteration, and other part of process remains unchanged. Following algorithm is used:-

Step 1: Get the input signal vector(X) of length D and let N=integer

Step 2: Modulate signal with QPSK modulation and generate signal (Y)

Step 3: Generate parallel signal by parallel generator [α –α αj –αj] where 0<α<=1

Step 4: For each value of α do following

Step5: for i=1: N

Step 5.1: Generate φ (i) of length D keeping the even values as 1.

Step 5.2: Multiply φ (i) with the input vector and get Z (Freq domain)

Step 5.3: Compute IFFT and get z (Time domain)

Step 5.4: Determine PAPR using the formula

PAPR=10log ($P_{peak}/P_{avg.}$ = max [$|x_n|^2$] /E [$|x_n|$].

Step 5.5: Increment the value of i

Step 6: Go-to Step5

Step 7: PAPR of length N is obtained.

Step8: Select a threshold Y. One with minimum $PAPR_{\alpha i}$ is used for transmission

Step 9: Go-to Step 4 until α is done

Step 10: Select channel with minimum $PAPR_{\alpha i}$ for all α

Step 11:To compare plot graphs for normal SLM and Reduced Complexity SLM

X axis: Threshold values

Y axis: Pr [PAPR low>Y]

Step 12: It is observed that reducing the complexity increases the PAPR.

.

VI SIMULATION RESULTS

The simulation is performed on input sequence to calculate and compare the result obtained from the existing SLM and proposed SLM. In an OFDM system, QPSK method is used as a signal mapper φ € {±l, ±j}. This experiment was performed in an iterated manner some 1000 times.

Parameters used for simulation:

MATLAB is used to determine the PAPR reduction performance by proposed SLM method. Following parameters are used for simulation study.

TABLE 1: SIMULATION PARAMETERS

Modulation Parameters	QPSK
Number of data subcarriers(N)	256
Total number of data symbols	1000
Size of the phase sequence	256
FFT Size	64
Coding Technique	Cyclic

Fig. 2 indicates the CCDF plot for existing SLM and proposed SLM and results shows that the proposed work has effective outcome than the existing SLM method.

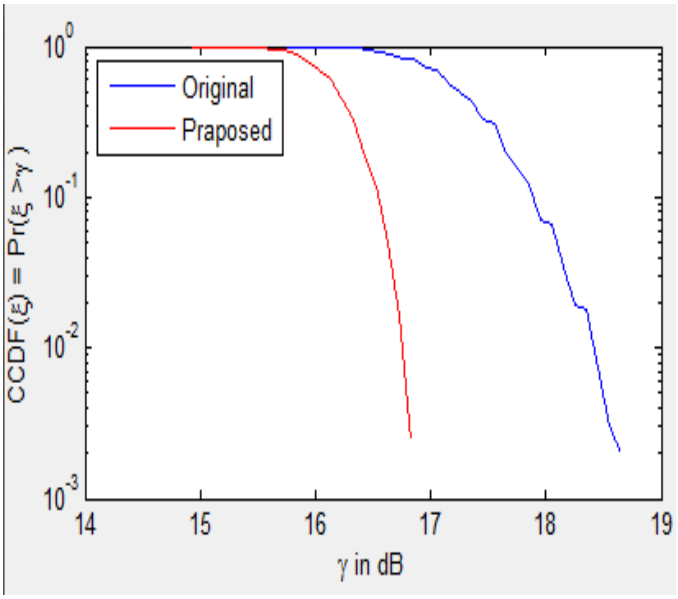

Fig. 2: CCDF plot of PAPR of basic QPSK-OFDM system with the SLM technique and Proposed Work.

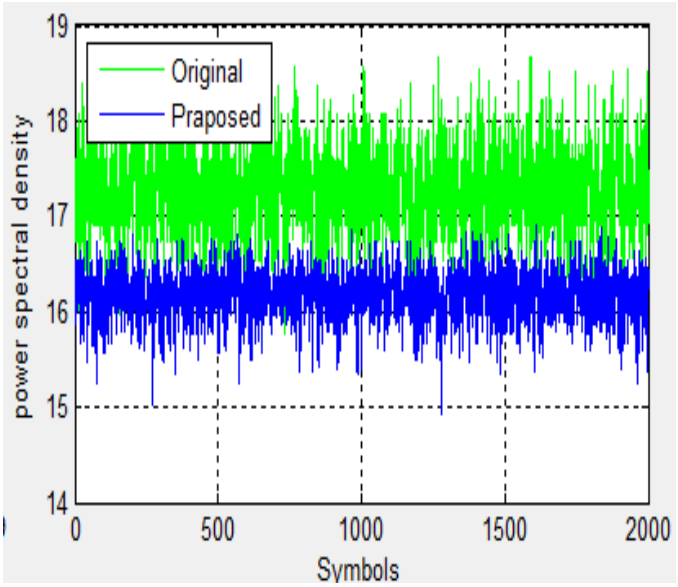

Fig.3: Comparison between Power spectral density of original OFDM PAPR with SLM & PAPR with Proposed Work

Simulation results (Fig.2) shows that by using this phase sequence [1, -1, j, -j] obtained PAPR by existing SLM method is nearly about 19dB. On other hand the PAPR obtained by proposed SLM method is nearly 17dB. Fig. 3indicates the

Power spectral density plot for both existing SLM and proposed SLM method. Thus, by proposed SLM method enables to reduce the PAPR by nearly 2 db and in percentage, it is 11.76 % improvement over original method.

VII CONCLUSION

This paper deals with modified SLM method which has better performance with respect to PAPR reduction. Fig. 1 and 2 represents the results obtained by the proposed method for reducing PAPR. After performing simulation the evaluated value for PAPR reduction by proposed method is nearly 17dB. MATLAB tool is used to obtain the performance of PAPR reduction, which clearly represents that there is significant improvement in performance. The proposed method in this paper will results in PAPR reduction by 2dB which is an improvement of 11.76 % than the original method.

References

[1].Wu and W. Y. Zou, "Orthogonal frequency division multiplexing: A multi-carrier modulation scheme," IEEE Trans. Consumer Electronics, vol. 41, no. 3, pp. 392–399, Aug. 1995.

[2] Shinsuke Hara, Ramjee, "Principle and history of MCM/OFDM," in Multicarrier techniques for 4G mobile communication, Artech House.

[3] ArunGangwar and ManushreeBhardwa j,"An Overview: Peak to Average Power Ratio in OFDM system & its Effect", International Journal of Communication and Computer Technologies vol. 01 – 02, Issue: 02 (IJCCT), ISSN NUMBER: 2278-9723, September 2012

[4] Leman Dewangan, Mangal Singh and NeelamDewangan,"A Survey of PAPR Reduction Techniques in LTE-OFDM System", International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, vol-1, Issue-5, November, 2012.

[5] Tellado J., "Peak to Average Power Ratio Reduction for Multicarrier Modulation," PhD thesis, University of Stanford, Stanford, 1999

[6] Bauml, R.W.; Fischer, R.F.H.; Huber, J.B,"Reducing the Peak-to-Average Power Ratio of Multicarrier Modulation by Selected Mapping," *IEEE Electronics Letters*, Vol.32, pp. 2056-2057, 24 Oct. 1996.

[7] P. W. J.Van Eetvelt, G.Wade, and M.Tomlinson, "Peak to average power reduction for OFDM schemes by selective scrambling," *Electron. Lett.*, vol. 32, pp. 1963-1964, Oct. 1996.

[8] D. Wulich, "Reduction of peak to mean ratio of multicarrier modulation using cyclic coding," Electronic Letters, vol. 32 pp. 432-433, 1996

[9] Baüml R. W., Fischer R. F. H., Hüber J. B., "Reducing the peak-to average power ratio of multicarrier modulation by selective mapping", Electronics Letters, vol. 32, no. 22, pp. 2056–2057, Oct. 1996.

[10] Leman Dewangan, Mangal Singh and NeelamDewangan,"A Survey of PAPR Reduction Techniques in LTE-OFDM System", International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, vol-1, Issue-5, November, 2012.

[11] ArunGangwar and ManushreeBhardwa j,"An Overview: Peak to Average Power Ratio in OFDM system & its Effect", International Journal of Communication and Computer Technologies vol. 01 – 02, Issue: 02 (IJCCT),ISSN NUMBER: 2278-9723, September 2012

[12] Muller S. H., Huber J. B., "OFDM with reduced peak-to-average power ratio by optimum combination of partial transmit sequences", Electronics Letters, vol. 33, no. 5,
pp. 36–69, Feb. 1997.

[13] Cimini L. J., Sollenberger, N. R., "Peak-to-Average Power Ratio Reduction of an OFDM Signal Using Partial Transmit Sequences" IEEE Communications Letters, vol. 4, no. 3, pp. 86-88, March 2000.

[14] Tellado J., "Peak to Average Power Ratio Reduction for Multicarrier Modulation," PhD thesis, University of Stanford, Stanford, 1999

[15] Han S. H., Ciof J. M., Lee J. H., "Tone Injection with hexagonal constellation for peakto-average power ratio reduction in OFDM", IEEE Communications Letters, vol. 10, no.9, pp. 646–648, Sep. 2006.

[16] O'Neill R., Lopes L. B., "Envelope variations and spectral splatter in clipped multicarrier signals," in Proc. IEEE PIMRC'95, Toronto, Canada, pp. 71–75, Sept.1995.

[17] Li X., Cimini Jr. L.J., "Effect of Clipping and Filtering on Performance of OFDM",IEEEcomm.Letters,vol.2,no.5,pp.131-133,July1998.

[18] Armstrong J., "Peak-to-average power reduction for OFDM by repeated clipping and frequency domain filtering", Electronics Letters, vol. 38, no. 5, pp. 246–247, Feb. 2002.