International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 12 | Dec -2016 www.irjet.net p-ISSN: 2395-0072

PAPR Reduction techniques in OFDM System Using Clipping & Filtering and Selective Mapping Methods

Okello Kenneth [1], Professor Usha Neelakanta[2]

[1] *P.G. Student, Department of Electronics & Telecommunication Engineering, Ahmedabad Gujarat, India*
[2]*Department of Electronics & Telecommunication Engineering, Ahmedabad Gujarat, India*

---***---

Abstract - *Due to multiple application of OFDM signal like military HF radio links, BRAN, DAB and DVB-T and there was need to change from analogy domain data sending to digital domain data sending, also changing of single carrier to multiple sub carriers' data transmission. Orthogonal frequency division multiplexing (OFDM) plays tremendous advantages including channel conversion due it orthogonality of the sub carriers, special efficiency and robustness against ISI and ICI. One worst disadvantage of OFDM is high PAPR at the transmitter which reduces the peak power for transmission. Several techniques to reduce high PAPR including clipping and filtering, selective mapping (SLM), Partial transmit sequence (PTS), companding and Tone injection have been proposed. In this article two effective methods for multi efficiency PAPR reduction are discus and compared in terms of percentage reduction level to lowest PAPR using Mathlab simulation with QAM modulation techniques.*

Key Words: OFDM, PAPR, Clipping and Filtering, Selective Mapping (SLM), Partial Transmit Sequence (PTS), Tone Injection (TI).

1. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is the key technology which is employed in 4G wireless communication systems such as Long Term Evolution (LTE), worldwide interoperperbility for microwave access (WiMAX) and Long Term Evolution Advanced (LTE-A) . OFDM are forms of multicarrier transmission for broadband wireless communication systems i.e. it has a large bandwidth up to about 20MHz. The background behind OFDM is that it divides the frequency spectrum into subcarriers and the subcarriers are made mutually independently orthogonal to each other to avoid interference. The data in each subcarrier are transforming from serial to parallel channel for simultaneous transmission in different channel. The Inverse fast Fourier transform (IFFT) is used to produce orthogonal data subcarriers where the input data samples are modulated either by (e.g. QAM or PSK) and after they are jointly correlated. The FFT transform the cyclic prefix time domain signal to it equivalent frequency spectrum. OFDM has significant challenge due to symbol time been less than the delay spread leading to InterSymbol interference (ISI) which is overcome by cyclic prefix or guard band concept.

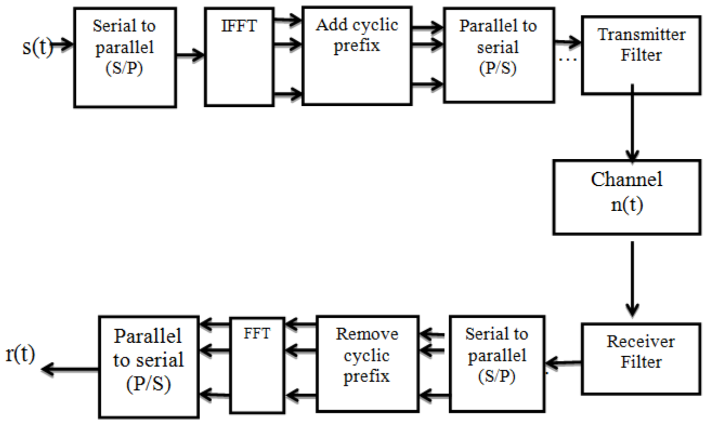

Fig -1: Block diagram of OFDM system

1.1 Mathematical formula of OFDM signal.

In OFDM systems, let consider data block of length N vector$X = [X_0 X_1 \dots \dots \dots . X_{N-1}]^T$, and the duration of any symbol X in the set $X_0 X_1 \dots \dots \dots . X_{N-1}$ is T which represents one of the subcarriers set. As the N subcarriers transmit the signal in orthogonal way as in the fig (2), we can have,$f_n = n\Delta f$ where $n\Delta f = {}^1/_{NT}$ and NT is the duration of the OFDM data block X. The data block for the OFDM signal is given by equation (1).

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

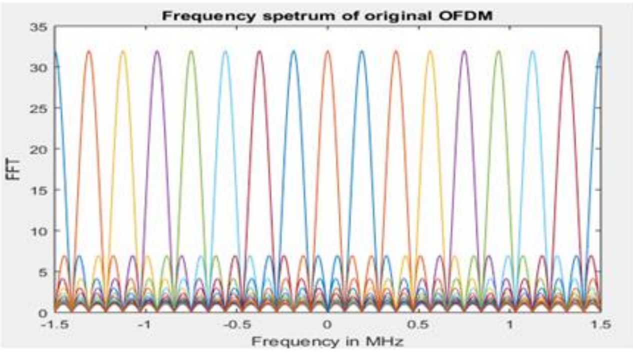

Fig -2: Frequency spectrum of original OFDM

An OFDM symbol in baseband is defined as in equation (2).

$$X(t) = \frac{1}{\sqrt{N}} \sum_{N=^{n}/_{2}}^{^{n}/_{2}-1} (a_n + {}^{n}/_{2} \exp\left(\frac{j2\pi nt}{T}\right)) s(t) \qquad (2)$$

Where , $a_n + {}^{n}/_{2}$ in equation (2) denotes the complex symbol modulating the $n-th$ carrier, $s(t)$ is the time window function defined in the interval $[0,T]$, n is the number of subcarriers, and T is the OFDM symbol period. Subcarriers are spaced $\Delta f = 1/T$ apart and it is represented in figure (3).

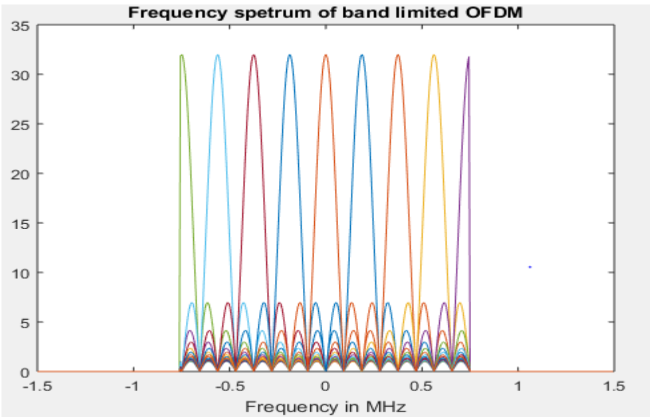

Fig -3: Frequency spectrum of band limited OFDM

2. PEAK TO AVERAGE POWER RATIO (PAPR) FOR OFDM SIGNAL:

In OFDM system, the main drawback is high peak to average power ratio (PAPR).The high PAPR is significantly caused due IFFT operation where data symbols across subcarrier add up to produce high peak power value. This causes the signal amplifiers to operate into the nonlinear region leading to in band distortion and out of band radiation. The in-band distortion degrades system performances and out of band radiation causes the adjacent channel interference (ACI) due to neighbor band effect and degradation of bit error rate (BER) performance.

The peak to average power ratio (PAPR) of a continuous time signal is given by

$$PAPR = \frac{P_{Peak}}{P_{Average}} = \frac{max\ |x(t)|^2}{E\ |x(t)|^2} \quad (3)$$

And for the discrete time signal $PAPR = \frac{max\ |x(n)|^2}{E\ |x(n)|^2}$ (3)

Where P_{Peak} denotes peak value, $P_{Average}$ means average output power. E denotes the expected value; X_n denotes the transmitted OFDM signals. If the number of subcarriers (N) is increased, the PAPR power also increases. Large X_n are zero mean Gaussian random variables. And for X_n complex Gaussian the OFDM signal is Rayleigh distributed with variance σ_n^2, and the phase of the signal is uniform

$$\tilde{F}_{PAPR_{max}}(PAPR_0) = 1 - F_{PAPR_{max}}(PAPR_0)^N \quad (4)$$

The fixation of threshold value ranges from zero to maximum value. To calculate the threshold value the equation (5) below is used.

$$Threshold = \left(\frac{PAPR_{max} - PAPR_{min}}{PAPR_{max} PAPR_{min}}\right) \quad (5)$$

Threshold value is updated regularly and a CCDF curve is drawn

$$Efficiency = \left|\frac{(1 - PAPR_{db})}{PAPR_{db}}\right| \times 100\% \quad (6)$$

The equation (6) is used to determine the percentage reduction in peak power of a given symbols.

2.1 Reduction Technique

Several techniques approaches have been proposed and implemented to reduce PAPR problem into different categories i.e. distortion and without distortion.

Distortion method includes clipping and companding whereas distortionless methods also include clipping and filtering, selective mapping, partial transmit sequence, tone injection etc.

In this section, we mainly discuss two typical techniques such as Selective Mapping and Amplitude clipping and filtering for PAPR reduction in OFDM systems.

A. Amplitude Clipping and Filtering

Amplitude clipping is one of the simplest reduction techniques for PAPR. Amplitude Clipping reduces the peak level of the input signal to a predetermined value. According to S. H. Han and J. H. Lee [1] the basic idea of this technique is to clip the parts of the signals that have high peak outside of the allowed region. The following equation (7) shows the amplitude clipping.

$$Y(t) = \begin{cases} -L & if\ x(t) < -L \\ x(t) & if\ -L \le x(t) \le L \\ L & if\ x(t) > L \end{cases} \quad (7)$$

Where $Y(t)$ is passband clipped signal, L is pre- specified clipping level and $x(t)$is passband signal.

Clipping is performed always at the transmitter; receiver signal depends on the clip signal estimated. In general, since the receiver has to calculate two important parameter like location and size of the clipping signals at one clipping per OFDM symbol. Clipping method may cause in band distortion or out of band radiation into the OFDM system leading to peak regrowth especially in nonlinear system. This may affect the bit error rate performance (BER) and increases signal to noise ratio (SNR).The outof-band signals caused can be reduced by filtering. However when the signal is clip at a certain level, some peak power reduces lower and filtering the clipped signal can reduce out-of band radiation at the cost of peak re-growth and hence as explained in fig (4).

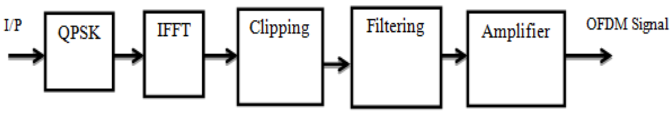

Fig -4: Block Diagram of Clipping and filtering process

Table -1: Parameters used for clipping and filtering

Parameter	Value
Modulation	QAM
Channel Models	AWGN
FFT Size	256
Sub Carriers	200
Clipping Level	0.79
Phase Sequence	8

B. Selective Mapping Technique (SLM):

The propose method for the reduction of peak to average transmit power of multicarrier modulation systems with selected mapping in 2013[7]. In selected mapping (SLM) the whole set of information symbol are loaded into the subcarrier and turn in serial and parallel after, the data block are form and then the most favorable signal with less PAPR is chosen and transmitted. The basic idea of this technique is based on the phase rotation sequence. The lowest PAPR signal shall be selected for transmission from a number of different data blocks independently.

In figure (5), Consider each data block

$B(U) = [b_{u,0} b_{u,1} \ldots\ldots b_{u,N-1}]^T$ multiplied by U phases of length N, u=1, 2, 3.....U, resulting in U modified data blocks. To include the unmodified data block in the set of modified data blocks, take set $B(1)$ as the only one vector of length N. The modified data block for the u^{th} phase sequence, $P(U) = [P_0 b_{u,0} P_1 b_{u,1} \ldots\ldots P_{N-1} b_{u,N-1}]^T$, u =1,2,3.....U. Among the modified data blocks $P(u)$, u = 1, 2, 3........U, the one with the lowest PAPR is selected for transmission. The side information needs to be eventually transmitted along with the selected phase sequence where the receiver will determined the source of the information.

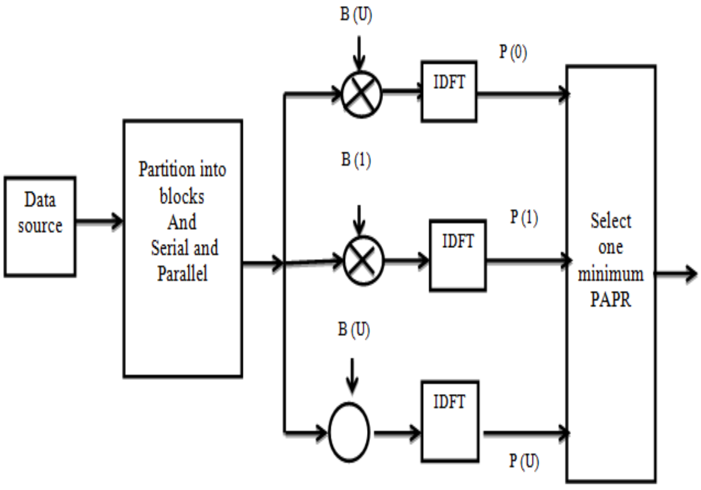

Fig -5: The Block Diagram of Selected Mapping Technique

This scheme, statistically independent symbol sequence $B(U)$ 1≤u≤U, is generated by multiplying the input data symbol sequence and the phase rotation matrix $P^{(u)}$ 1≤ u ≤ U, where U is the number of candidate OFDM signals. Therefore PAPR can be expressed as equation (8)

$$(PAPR > P_0) = 1 - (1 - e^{-P_0})^N \quad (8)$$

Where N is the sub carrier and U is the phase sequence.

Table -2: Parameters used for Selective Mapping

Parameter	Value
Modulation	QAM
Channel Models	AWGN
Sub- Carrier	256
Phase Sequence	8

We apply parameter in table (2) in the equation (7) to determine the reduction amplitude peak power level and the threshold value using equation (5) where the lowest PAPR is experienced.

C. Simulation Results

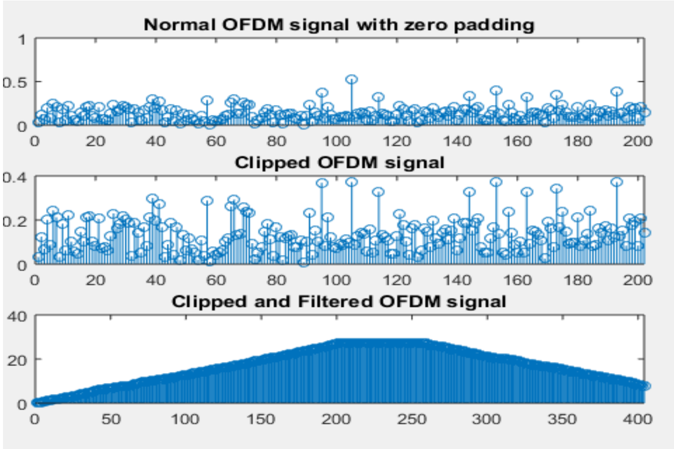

Fig -6: Results for clipping and Filtering

In figure (6) before applying clipping and filtering, the normal OFDM signal peak power is within 0.5 with normal PAPR 7.3 After the signal is clipped the peak amplitude reduces within the range of 0.4 with different amplitude level still with distortion and peak regrowth. After filtering the signal, the peak power level decreases to 2.4 along with increase in the sampling number without any distortion. The Power of 2 and less than number of Symbols preferably < 32, gives better PAPR reduction ratio than other phases.

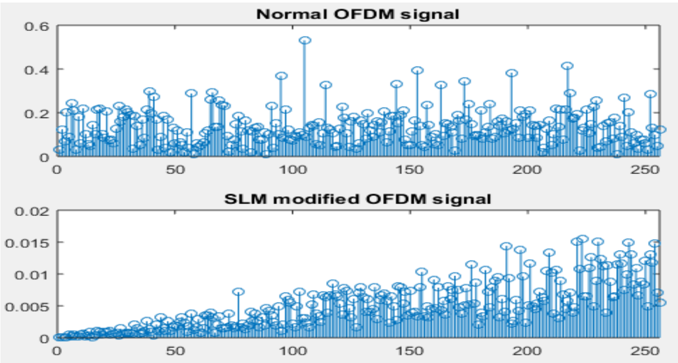

Fig -7: Results for Selective Mapping (SLM)

The result in fig (7) shows that, before selective mapping the amplitude peak level is very high at 0.6 with original PAPR of 22.8 By applying Selective Mapping the peak power reduces to approximately 0.02 and hence low PAPR is experienced

3. COMPARISON BETWEEN CLIPPING AND FILTERING WITH SELECTIVE MAPPING

In comparing the two methods, the efficiency of Clipping and Filtering is 61.9 % and the efficiency of selective mapping is about 21.9%. So we conclude that clipping and filtering gives more reduction in PAPR than selective mapping of about 39.9%.

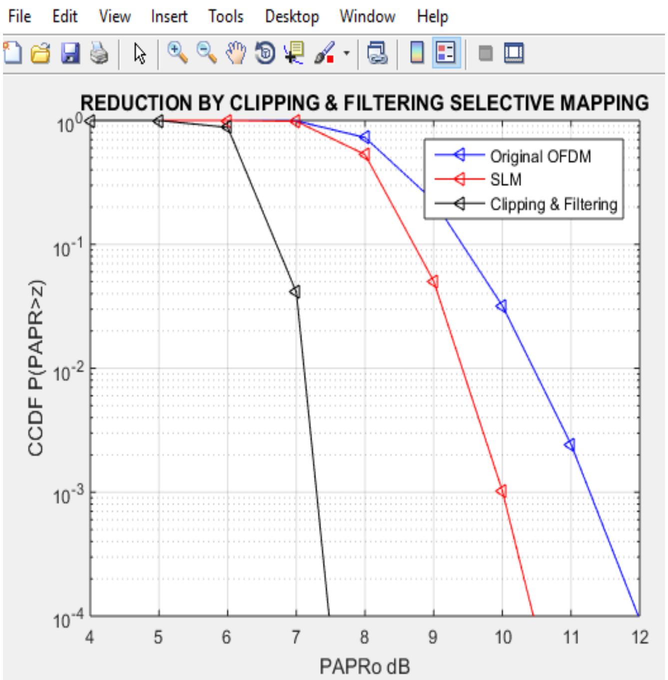

Fig -8: CCDF comparing clipping&filtering with selective mapping (SLM).

As seen from the above fig (8) clipping and filtering gives a better reduction ratio in dB using complementary cumulative distribution function (CCDF) as compared with that of selective mapping. Hence clipping and clipping methods is give preferred lowest PAPR for transmission.

Table -1: comparisons between clipping & filtering and selective mapping

Reduction techniques	Parameters			Operation required at transmitters(TX) and receiver (RX)
	Decrease distortion	Power raise	Defeat Data rate	
Clipping and Filtering (C&F)	No	No	No	TX: Clipping RX: None
Selective Mapping (SLM)	Yes	No	Yes	TX:M times IDFTs operations RX: Side information extraction inverse SLM

4. CONCLUSIONS

In this paper we simulate OFDM with clipping and filtering and selective mapping. Both methods reduces the peak amplitude level leading to increase sampling number, data rates, better spectral efficiency and good performance of Bit error rate (BER).

Two different modulation techniques such as QAM and QPSK are used to determine the separation distance hence, clipping & filtering and selective mapping methods lead to low PAPR.

REFERENCES

[1] S. H. Han and J. H. Lee, "An overview of peak-to-average power ratio reduction techniques for multicarrier transmission," IEEE Wireless Comm, vol. 12, no.2, pp.56-65, Apr. 2005.

[2] Sanjeev Saini and Dr. O.P. Sahu, " Peak to Average Power Ratio Reduction in OFDM System by Clipping and Filtering", International Journal of Electronics Communication and Computer Technology (IJECCT) Volume 2 Issue 3,May 2012.

[3] R. van Nee and R. Prasad, "OFDM Wireless Multimedia communications," Artech House, Boston, MA, 2000.

[4] R.W.Bauml, R.F.H.Fischer, and J.B. Huber, "Reducing the peak-to-average power ratio of multi carrier modulation by selective mapping," IEE Electron. Lett., vol.32, pp. 20562057, Oct. 1996

[5] Malhar Chauhan, Saurabh patel, Hardik patel " Different Techniques to Reduce the PAPR in OFDM System", International Journal of Engineering Research and Applications (IJERA) ,Vol. 2, Issue 3, pp.1292-1294, May-Jun 2013.

[6] Amos Gilat, 'MATLAB An Introduction with Application', Wiley India Edition 2004 [2] Foomooljareon P., and Fernando W.A.C., 'PAPR Reduction in OFDM Systems', Thammasat Int. J. Sc.Tech.Vol.7, No.3, September-December 2002.

[7] YasirRahmatallah, Seshadri Mohan, Member, "Peak-To-Average Power Ratio Reduction in OFDM Systems: A Survey and Taxonomy", IEEE Communications surveys & tutorials, vol. 15, no. 4, fourth quarter 2013.

[8] Yajun Wang, Wen Chen, Chintha Tellambura, ''A PAPR Reduction Method Based on Artificial Bee Colony Algorithm for OFDM Signals'', Actions on Wireless comm unications, vol. 9, No. 10, October 2010.