International Journal of Electronics and Communication Engineering.
ISSN 0974-2166 Volume 10, Number 1 (2017), pp. 35-44

http://www.irphouse.com

Review of PAPR Reduction Techniques for 5G System

Ritu Kumari[1], Mridul Chawla[2]

[1]M.Tech Scholar, [2]Assistant Professor
Electronics & Communication Engineering Department Deenbandhu Chhotu Ram University of Science and Technology Murthal-131039, Sonepat (Haryana), India.

Abstract

Orthogonal Frequency Division Multiplexing (OFDM) in 5G system has a main drawback of high Peak-to-Average Power Ratio (PAPR). Diverse techniques of PAPR diminishment and criteria for selection of PAPR diminishment methods are discussed in this paper.

Keyword: CCDF, HPA, OFDM, PAPR, BER.

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a higher order modulation techniques in 5G which have advantage of high efficiency and less delay. This is the reason, OFDM has been decided for information rate correspondence and has been generally utilized as a part of numerous remote correspondence benchmarks, for example Digital Video broadcasting(DVB).

However, there are challenging issue in the creation of the OFDM system. One of the significant issue is its elevated PAPR. Therefore, the OFDM receiver's recognition capability is exceptionally perceptive to the nonlinear gadgets used in its circuitry, such as Digital-to-Analog convertor (DAC) and High Power Amplifier (HPA). Most remote framework utilize HPA at the sender to acquire adequate transmit power and HPA is normally worked at or close to the saturation region to attain greatest output power competence, so in this manner nonlinear deformation because of eminent PAPR of information signal will come within the channel. If HPA is not worked in linear part with extensive power back- off, it is difficult to maintain out of band power underneath as far as possible. It prompts to inefficient amplification and costly transmitter. Therefore to utilize features of OFDM, PAPR reduction techniques should be studied.

A commonly used performance measure for PAPR lessening scheme is Complementary Cumulative Distribution Function(CCDF).Various techniques are utilized for PAPR reduction like Clipping[1]-[6],Coding [7]-[13],Partial Transmission Scheme(PTS) and Selective Mapping(SLM)[14]-[30] and Dispersive SLM(DSLM) [33].

In this paper we will discuss these techniques.

II. DEFINATION OF PAPR

PAPR is of two types:

A. Continuous –time PAPR

It is proportion among the highest instantaneous power and normal power of base-band signal x(t).

$$PAPR[x(t)] = \frac{\max_{0 \le t \le NT} [|x(t)|^2]}{P_{av}}$$

where the normal power of x(t) is $P_{av.}$

B. Discrete time PAPR

The discrete time sequence’s PAPR normally decides the complication of digital circuitry in terms of the number of bits important to accomplish a required signal to quantization noise for both digital operation and the DAC. For better approximation the PAPR of continuous time OFDM signal, the OFDM samples are achieved by L time over examining. The over sampled IFFT output is shown as

$$x[n] \triangleq \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k \, e^{j} \frac{2\pi nk}{LN} \, , 0 \le n \le LN - 1$$

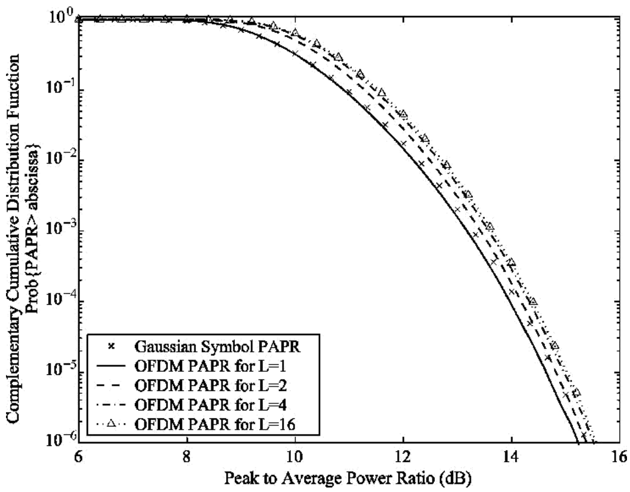

Fig. 1 Statistic of PAPR of OFDM samples oversampled by distinct techniques [32].

Fig .1 demonstrate the allotment of the PAPR of the OFDM signals with N=256 and L= 12416. As demonstrated the biggest PAPR enhancement occurs from L=1,2.However,there is no increment altogether after L=4. The PAPR is characterized by

$$PAPR\{x[n]\} = \frac{\max\limits_{0\le n\le NL-1}[|x[n]|^2]}{E[|x[n]|^2]}$$

Where E {} is expectation operator.

III. PAPR DIMINISHMENT SCHEMES

A. Clipping

This is most straight forward way of PAPR lessening .In it we clip the part of signal which are outer to the permitted area [11].

The amplitude clipping is

$$A(X) = \begin{cases} x, & |x| \le B \\ B, & |x| > B \end{cases}$$

Where B is specified clipping level and positive real number, x is signal value, A(X) is amplitude function.

Usually, the transmitter perform the clipping function. On the other hand the clipping is evaluated at the receiver which has happened and to balance the received OFDM signal in like manner. So, receiver needs to gauge two parameter : Size and location of clip. It is not easy to find these parameters .Due to it, there are both interior band and exterior band emission within the system, which debases the system functioning and bit error rate and spectral effectiveness

B. Coding Scheme

If we include many signals (say M) which have same phase then the power generated is M time the normal power. So the main initiative of coding technique is that we can achieve PAPR diminishment if occurrence of signals with same phase is minimised.

Jones *et al*[7] presented a basic coding technique in which a three bit information is converted into four bit word by Summing Simple Odd Parity Code(SOBC) at the ending bit over the means of communication. The major advantage of SOBC technique is diminishment of PAPR for a codeword upto 4 bit. Afterward, Wulich[34] used the Cyclic Coding (CC) and Fragiacomo anticipated a proficient Simple Block Code (SBC) to decrease the PAPR of information signals [31]. Though if frame size is huge then SBC is not successful. So Compliment Block Coding(CBC) and Modified Compliment Block Coding(MCBC) were used to diminish the PAPR without the confinement of frame dimension. The main advantage of CBC and MCBC is its adaptability on picking the rate of coding, frame dimension and minimum implementation problems. In outline, the inbuilt capacity of error control and straightforwardness of execution make coding technique more capable for possible OFDM framework plan. It achieve good PAPR lessening but there is loss of coding rate.

C. PTS and SLM

In the PTS technique PAPR diminishment is achieved by dividing the information signal block X into M disjoint sub-blocks shown by the vectors $X(m)_m = \{0,1,2 \dots \dots M-1\}$ [14] as shown in Fig 2.So we get

$$\mathrm{X} = \sum_{\mathrm{m}=0}^{\mathrm{M}-1} \mathrm{X(m)}$$

where $\mathrm{X(m)} = [\mathrm{X}_{\mathrm{m},0}\ , \mathrm{X}_{\mathrm{m},1}, \dots \dots \mathrm{X}_{\mathrm{m},\mathrm{N}-1}]$.

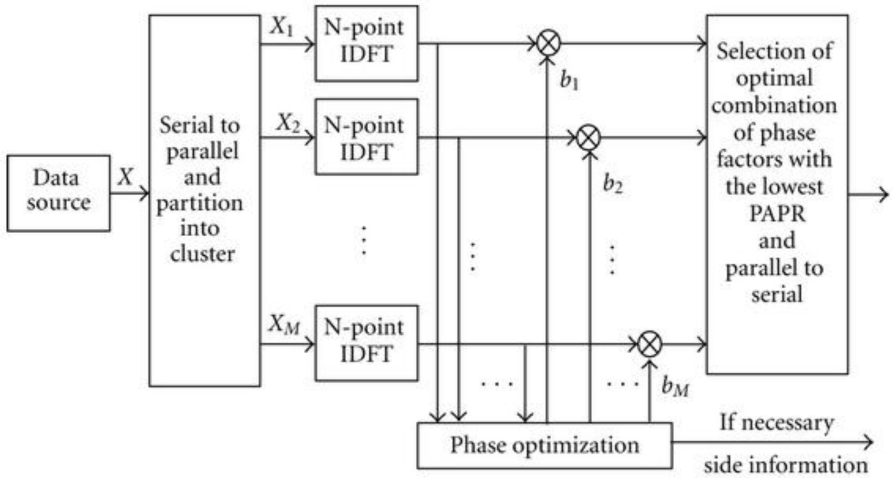

Fig. 2 PTS technique block diagram [32]

In PTS technique, the famous sub-block dividing systems is further divided in three parts [14]: interleaved, close to and pseudo random divider. The sub-block X(m) are changed into M time –domain partial series .

$$X^{(m)} = \left[x_0^{(m)} x_1^{(m)} \ldots \ldots x_{LN-1}^{(m)}\right] = IFFT_{LN\times N}\left[X^{(m)}\right]$$

A phase factors b is used to independently rotate these partial sequences. The OFDM signals with minimum PAPR which is acquired by joining these M sub block is

$$X^{\sim} = \sum_{m=0}^{M-1} b_m X^{(m)}$$

But in PTS there are two vital issues ought to be illuminated : A)To decrease the high mathematical complication in finding the best possible phase factors. B) The overhead of best possible phase factors because extra data is sent to receiver to properly decode the transmitted information.

Also, in SLM, different input symbol sequences are generated by multiplying information sequence with phase sequence Then IFFT operation is performed on all input sequences and one with the minimum PAPR is transmitted [30]. Fig. 3 which is block diagram of the SLM system shows that every information square is manifold by V distinct phase factors of length N, $B^v = (b^1\ b^2 \ldots\ldots b^v)$,resulting in V different blocks. Therefore OFDM signal becomes as

$$x^v(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n\, b_{v,n}\ e^{j2\pi f_n t}$$

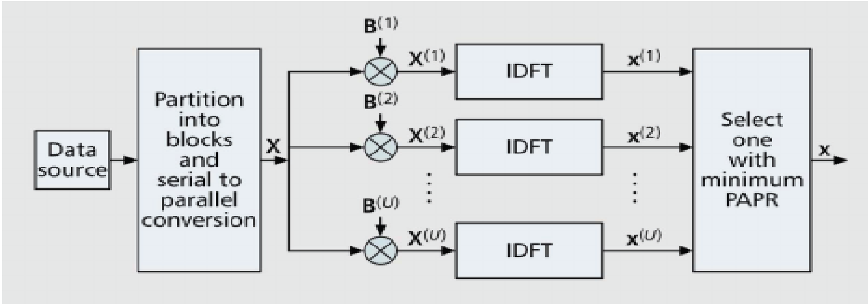

Fig.3 SLM technique block diagram [32]

The data block which has minimum PAPR from all the blocks is transmitted. The mathematical complication and number of the bits for transmitting extra data has been diminished by some extended SLM [25].

Both PTS and SLM are distortion less scheme with no power increase and no data loss. Although, PTS performance is better than SLM, but it require more side information.

D. DSLM

DSLM which stands for dispersive SLM is an extended and universal version of SLM. In it, different phase rotation vectors which are independent and identically distributed are used to rotate each symbol. One symbol from optically rotated symbols is selected on the basis of minimum PAPR which is derived over [0,4T] instead of [0,T].This technique is called Dispersive SLM[33] because it deals with time dispersive nature of signals .

IV. CRITERIA OF PAPR REDUCTION

While applying different methods of PAPR diminishment we have to maintain the excellent functioning of system with reference to various factors.

A. **Excellent ability of PAPR diminishment:** While choosing the PAPR diminishment method, the factor should be kept in mind that it have minimum destructive issues. For example interior band and exterior band distortion.

B. ***Minimum normal power:*** PAPR is reduced but normal power of system is enhanced , which results in reduction of the bit error rate performance of system .

C. ***Minimum difficulty in implementation:*** Usually, complex schemes provide better PAPR lessening. But time and hardware requirements should be minimum.

***D. No extension in bandwidth*:** If there is expansion in bandwidth then it result into data rate loss because of side information. So it should be avoided or should be as minimum as possible.

***E. No BER performance degradation*:** We should consider those methods for which there is enhancement in BER on the receiver end.

Fig. 4 shows, different plot of the CCDF for a randomly generated OFDM symbols and different PAPR lessening schemes. All the method used in given figure can reduce the PAPR to a great extent but their performance are different.

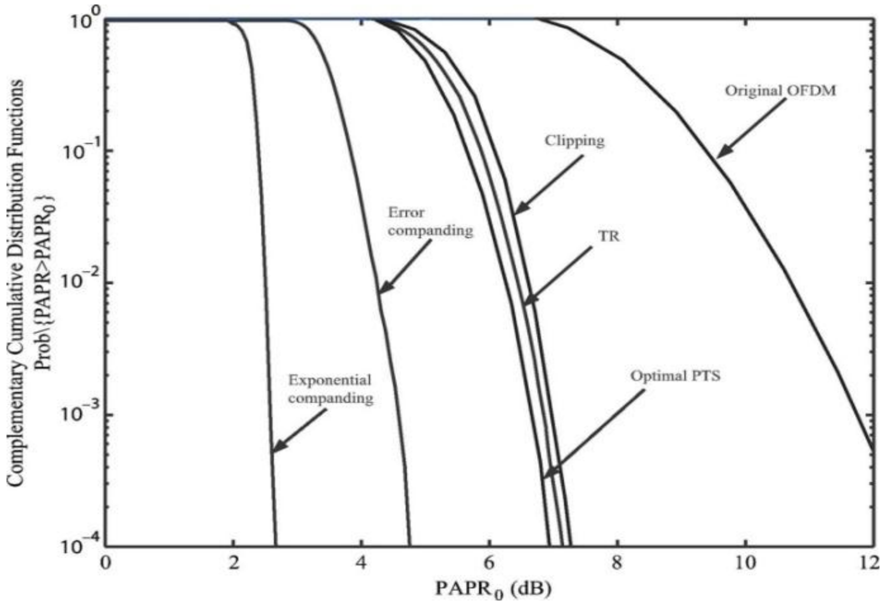

Fig. 4 Comparison of different PAPR reductions's CCDF [32]

V. CONCLUSION

OFDM is broadly conveyed in wireless 5G system because of its spectral competence and robustness of channel. But high PAPR is an issue in OFDM. In this paper we studied various PAPR diminishment methods, which have both merits and demerits (loss in data rate, degraded BER, increment in signal power, increased complexity).These techniques should be utilized according to the application.

REFRENCES

[1] Y. 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] W. Y. Zou and Y. Wu, “COFDM: An overview,” IEEE Trans. Broad-casting, vol. 41, no. 1, pp. 1–8, Mar. 1995.

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

[4] H. Ochiai and H. Imai, “Performance of the deliberate clipping with adaptive symbol selection for strictly band-limited OFDM systems,” IEEE Journal on Selected Areas in Communications, vol. 18, no. 11, pp2270–2277, Nov. 2000.

[5] S. M. Ju and S. H. Leung, “Clipping on COFDM with phase on demand,” IEEE Communications Letters, vol. 7, no. 2, pp. 49–51, Feb. 2003.

[6] G. L. Ren, H. Zhang, and Y. L. Chang, “A complementary clipping transform technique for the reduction of peak-to-average power ratio of OFDM system,” IEEE Trans. Consumer Electronics, vol. 49, no. 4,922–926, Nov. 2003.

[7] A. E. Jones, T. A. Wilkinson, and S. K. Barton, “Block coding scheme for reduction of peak-to-average envelope power ratio of multicarrier transmission systems,” IEE Electronics Letters, vol. 30, no. 8, pp. 2098–2099, Dec. 1994.

[8] P. Y. Fan and X. G. Xia, “Block coded modulation for the reduction of the peak to average power ratio in OFDM systems,” IEEE Trans. Consumer Electronics, vol. 45, no. 4, pp. 1025–1029, Nov. 1999.

[9] D. Wulich and L. Goldfeld, “Reduction of peak factor in orthogonal multicarrier modulation by amplitude limiting and coding,” IEEE Trans. Communications, vol. 47, no. 1, pp. 18–21, Jan. 1999.

[10] T. Ginige, N. Rajatheva, and K. M. Ahmed, “Dynamic spreading code selection method for PAPR reduction in OFDM-CDMA systems with 4-QAM modulation,” IEEE Communications Letters, vol. 5, no. 10, pp. 408–410, Oct. 2001.

[11] K. Yang and S. Chang, “Peak-to-average power control in OFDM using standard arrays of linear block codes,” IEEE Communications Letters, vol. 7, no. 4, pp. 174–176, Apr. 2003

[12] T. Jiang and G. X. Zhu, “Complement block coding for reduction in peak-to-average power ratio of OFDM signals,” IEEE Communications Magazine, vol. 43, no. 9, pp. S17–S22, Sept. 2005.

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

[14] S. H. Han and J. H. Lee, “PAPR reduction of OFDM signals using a reduced

complexity PTS technique," IEEE Signal Processing Letters, vol. 11, no. 11, pp. 887–890, Nov. 2004.

[15] A. Alavi, C. Tellambura, and I. Fair, "PAPR reduction of OFDM sig-nals using partial transmit sequence: An optimal approach using sphere decoding," IEEE Trans. Communications Letters, vol. 9, no. 11, pp. 982–984, Nov. 2005.

[16] N. T. Hieu, S. W. Kiom, and H. G. Ryu, "PAPR reduction of the low complexity phase weighting method in OFDM communication system," IEEE Trans. Consumer Electronics, vol. 51, no. 3, pp. 776–782, Aug. 2005.

[17] L. Yang, R. S. Chen, Y. M. Siu, and K. K. Soo, "PAPR reduction of an OFDM signal by use of PTS with low computational complexity," IEEE Trans. Broadcasting, vol. 52, no. 1, pp. 83–86, Mar. 2006.

[18] H. Chen and H. Liang, "PAPR reduction of OFDM signals using partial transmit sequences and Reed-Muller codes," IEEE Communications Letters, vol. 11, no. 6, pp. 528–530, Jun. 2007.

[19] D. H. Park and H. K. Song, "A new PAPR reduction technique of OFDM system with nonlinear high power amplifier," IEEE Trans. Consumer Electronics, vol. 53, no. 2, pp. 327–332, May 2007.

[20] Y. Xiao, X. Lei, Q. Wen, and S. Li, "A class of low complexity PTS techniques for PAPR reduction in OFDM systems," IEEE Signal Pro-cessing Letters, vol. 14, no. 10, pp. 680–683, Oct. 2007.

[21] R. J. Baxley and G. T. Zhou, "Comparing selected mapping and partial transmit sequence for PAR reduction," IEEE Trans. Broadcasting, vol. 53, no. 4, pp. 797–803, Dec. 2007.

[22] S. J. Heo, H. S. Noh, J. S. No, and D. J. Shin, "A modified SLM scheme with low complexity for PAPR reduction of OFDM systems," IEEE Trans. Broadcasting, vol. 53, no. 4, pp. 804–808, Dec. 2007.

[23] D. W. Lim, J. S. No, C. W. Lim, and H. Chung, "A new SLM OFDM scheme with low complexity for PAPR reduction," IEEE Signal Pro-cessing Letters, vol. 12, no. 2, pp. 93–96, Feb. 2005.

[24] C. L. Wang and Q. Y. Yuan, "Low-complexity selected mapping schemes for peak-to-average power ratio reduction in OFDM systems," IEEE Trans. Signal Processing, vol. 53, no. 12, pp. 4652–4660, Dec. 2005.

[25] G. S. Yue and X. D. Wang, "A hybrid PAPR reduction scheme for coded OFDM," IEEE Trans. Wireless Communications, vol. 5, no. 10, pp. 2712–2722, Oct. 2006.

[26] H. G. Ryu, T. P. Hoa, K. M. Lee, S. W. Kim, and J. S. Park, "Improvement of

power efficiency of HPA by the PAPR reduction and pre distortion," IEEE Trans. Consumer Electronics, vol. 50, no. 1, pp. 119–124, Feb. 2004.

[27] S. H. Han and J. H. Lee, "Modified selected mapping technique for PAPR reduction of coded OFDM signal," IEEE Trans. Broadcasting, vol. 50, no. 3, pp. 335–341, Sept. 2004.

[28] Z. Latinovic and Y. B. Ness, "SFBC MIMO-OFDM peak-to-average power ratio reduction by polyphase interleaving and inversion," IEEE Communications Letters, vol. 10, no. 4, pp. 266–268, Apr. 2006.

[29] R. W. Bauml, R. F. H. Fisher, and J. B. Huber, "Reducing the Peak-to-Average Power Ratio of Multicarrier Modulation by Selected Map-ping," IEE Electronics Letters, vol. 32, no. 22, pp. 2056–2057, Oct. 1996.

[30] S. Fragicomo, C. Matrakidis, and J. J. O Reilly, "Multicarrier transmission peak-to-average power reduction using simple block code," IEE Electronics Letters, vol. 34, no. 14, pp. 953–954, May 1998.

[31] T. Jiang and G. X. Zhu, "OFDM peak-to-average power ratio reduction by complement block coding scheme and its modified version," in The 60th IEEE Vehicular Technology Conference 2004 Fall, Los Angeles, USA, Sept. 2004, pp. 448–451.

[32] T.Jiang,Y.Wu,"An Overview: Peak-to-Average Power Ratio Reduction Techniques for OFDM Signal", IEEE Transcation on broadcasting,vol.54,No 2, june,2008.

[33] S.S Krishna Chaitanya Bulusu, Hmaied Shaiek, Daniel Roviras , Rafik Zayani, "Reduction of PAPR for FBMC-OQAM system using Dispersive technique", IEEE Publication ,ISSN : 2154-0217,oct 2014.

[34] D. Wulich, "Reduction of peak to mean ratio of multicarrier modulation using cyclic coding," IEE Electronics Letters, vol. 32, no. 29, pp. 432–433, Feb. 1996.