International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 07, July 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

PAPR REDUCTION TECHNIQUES IN OFDM

Komal Choudhary, Deepak Sawale

[1]*M.Tech* , [2]*Assistant Professor,*

[1,2]*Digital Communication, SIRT, Indore (INDIA)*

Abstract–(Review paper)

The emission for long range wireless systems requires the use of power amplifiers (PA), but the use of OFDM systems, among others, exhibits high amplitude peaks of the modulated signal envelope and hence significant variations in instantaneous power. For OFDM systems, the "Peak-to-Average Power Ratio" (PAPR) parameter, which has a direct influence on the PA, must be taken into consideration.

PAPR reduction techniques include techniques for processing the signal prior to transmission. This paper presents a review for PAPR reduction techniques.

Keywords –BER, Clipping, Companding, OFDM, PAPR, SLM.

I. INTRODUCTION

Communication systems have evolved considerably, especially in recent years. Generally they are used for the remote transmission and in real time of the voice, but also of data like a message of text, an electronic mail, an image or even a video. Two methods are used for transmitting the data, the first so-called serial method where the different symbols are transmitted sequentially one after the other. For this method, in a multipath environment, the performance of these systems is sometimes seriously limited and requires the use of complex equalization circuits to combat interference between symbols. In this case the capacity of the equalization systems limits the bit rate. For the second method, known as the parallel system, the data will be transmitted at a low bit rate, but on a large number of carriers, in contrast to the first method or the transmission is done on a single high-rate carrier.

Several techniques and technologies are used to achieve high throughput. An example of these techniques is the so-called OFDM multi-carrier modulation. Like all other techniques, multi-carrier modulation has advantages as well as disadvantages. The advantages relate mainly to the robustness of the signal with respect to the multipath fading channel and the optimum spectral size.

One of the disadvantages is represented by the amplitudefluctuations of the envelope of the modulated signal and therefore by large variations in instantaneous power. The Peak-to-Average Power Ratio (PAPR), which takes into account these power variations, is an indispensable parameter in the characterization of envelope modulations. On the communication chain there are non-linear elements such as power amplifiers (PA) whose operation depends directly on the modulated signal power, and the PAPR becoming sufficiently high, this will cause problems at the level of the PA).

Different PAPR reduction techniques exist [1] - [5]. Some techniques act on the amplifier to avoid saturation of the input signal and other techniques are based instead on a processing performed directly at the signal. In most of these techniques, the receiver must not be informed of the type of processing performed in transmission before amplification. These techniques include conventional clipping. This technique captures the input signal

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

by reducing the PAPR, but the main disadvantage is represented by a strong degradation of the bit error rate (BER).

II. PEAK-TO-AVERAGE POWER RATIO

The parameter PAPR gives us an idea about the behaviour of the signal, specifically on the peaks of amplitude and therefore of power. The latter has a direct influence on the power amplifier (AP). If we consider an observation window T of the signal s (t), the PAPR represents the ratio between the maximum power and the average power of the signal s (t) over the interval T.

The expression of the classical PAPR is given by:

$$PAPR = \frac{\max_{t\in[0,T]}|s(t)|^2}{\frac{1}{T}\int_0^T |s(t)|^2 dt} \qquad (1)$$

Whenever there is a peak in the signal, the PA must consume more energy to transmit it. However, it is necessary to optimize energy consumption especially in wireless transmissions.

The power amplifiers are characterized by a saturation zone. One must works as close as possible to this zone. In order to optimize the use of the PAs, different PAs with different saturation zones are used. That treatment takes place within the PAs. The other method is to process the signal in order to get closer to the saturation zone. This method is the subject of our study.

The reduction of the PAPR has been the subject of several studies and several methods have been proposed.

We have just seen that there are two types of PAPR reduction. The first acts directly on the PA, the second handles the signal. The latter acts on the OFDM signal to be transmitted. In the literature, we find different methods, such as those in which the receiver must be informed of the type of processing performed in transmission before amplification, such as selective mapping (SLM), and other types such as clipping, does not have to receive information from the issue.

We limit our study to the following techniques:

2.1 Selected Mapping (SLM)

Selected Mapping (SLM) approaches have been proposed by R.W. Bauml in 1996 [6]. This method is used for minimization of peak to average transmit power of multicarrier transmission system with SLM. A complete set of signal under test is generated signifying the same information in SLM, and then the most favorable signal is selected having least PAPR and it is then transmitted. In the SLM, the input data structure is multiplied by random series and resultant series with the lowest PAPR is chosen for transmission. This allows the receiver to recover the original data with the multiplying sequence which can be sent as coded information [6].

One of the preliminary probabilistic methods is SLM method for reducing the PAPR problem. The good side of selected mapping method is that it doesn't eliminate the peaks, and can handle N number of subcarriers. The drawback of this method is the overhead of side information that requires to be transmitted to the receiver of the system in order to recover information. In this a set of sufficiently different data blocks representing the information same as the original data blocks are selected. Selection of data blocks with low PAPR value makes it suitable for transmission [6].

2.2 Partial Transmit Sequence (PTS)

Partial Transmit Sequence (PTS) technique have been proposed by S.H. Muller and J.B. Hubber in 1997 [7]. This method is based on the phase shifting of sub-blocks of data and multiplication of data structure by random

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

vectors. This method is flexible and effective for OFDM system. The main purpose of this method is that the input data frame is divided into non-overlapping sub blocks and each sub block is phase shifted by a constant factor to reduce PAPR [7].

PTS is probabilistic method for reducing the PAPR problem. PTS method works better than SLM method [7]. The main advantage of this scheme is that there is no need to send any side information to the receiver of the system, when differential modulation is applied in all sub blocks. Transmitting only part of data of varying sub-carrier which covers all the information to be sent in the signal as a whole is called Partial Transmit Sequence Technique [7].

2.3 Other Techniques for PAPR Reduction

There are several solutions proposed in the literature that could be employed by the system. Most of these algorithms possess a high computational complexity, especially for a large number of subcarriers. Some of the reduction techniques are discussed in the following sections [6] [7].

2.3.1. Clipping Technique

In this approach, one can perform time-domain based clipping or frequency-domain based clipping. The simplest approach for PAPR reduction is to deliberately clip the amplitude of the signal to a predefined value before amplification. However, there are several drawbacks of this approach, such as signal distortion and spectral re-growth. Hence simple clipping is not enough, one has to use coding techniques that are applied to OFDM signals in order to find the optimum threshold for every specific signal. However, this technique works well only when the number of subcarriers is small, because at higher subcarriers, the clipping ratio (CR) is to be very low which will lead to more distortion [8].

2.3.2. Companding Technique

Any invertible function with compression feature can be used for companding. Here one can apply the invertible transformation so as to recover the signal back at the receiver. First a quadrature demodulator generates the estimate of transformed signals with the help of receiver signal level control and low pass filter [8]. Using the inverse function of compression, the nonlinear distortion introduced by the compressor is corrected after reconstruction at the receiver with an expander [8].

2.3.3. Linear Combination

This is a new technique, based on modifying the time domain signal after taking IFFT, such that the resulting PAPR is reduced. Using this algorithm, the maximum and minimum of the time domain signal is replaced by the linear combination of them [8]. In this method, peak of the signal will be reduced while the average is kept constant. This method will require transmission of some extra information from transmitter to the receiver [8].

III. LITERATURE REVIEW

High PAPR of the transmit signal is a major drawback of multicarrier transmission such as OFDM. S.H. Han et al. (2005) reviewed some of the important PAPR reduction techniques for multicarrier transmission including amplitude clipping and filtering, coding, partial transmit sequence, selected mapping, interleaving, tone reservation, tone injection, and active constellation extension. Also, the criteria for PAPR reduction technique selection in OFDM and MIMO-OFDM has been discussed [9].

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

R. Marsalek (2006) presented a technique based on adaptive symbol selection principle, with several replicas of signal created using set of interleavers incorporated inside an IFFT block at OFDM transmitter. This paper also discuss some practical aspects of the method – influence of zero padding and pilot positions. A problem of pilot subcarriers positions has also been discussed. This method also requires sending side information about the interchanging used for transmitted signal with lowest PAPR [10].

J. H. Wen et al . (2007) proposed a PAPR reduction scheme to choose the corresponding symbol patterns with a low PAPR in the expanded signal space. However, the scheme has a high complexity for the selection of symbol pattern with the smallest signal power in a larger expanded signal space. The scheme could be realized as a signal mapping from the original information symbols to the corresponding patterns. With the selection of the corresponded symbol patterns, the PAPR could be greatly reduced. According to the simulation results with this scheme, while the length of the data frame is 16 bit and the signal expansion with adding 1 bit and 2 bits, the PAPR changing rate could be 20% and 16% of the original PAPR, respectively. However, there is no prominent improvement on PAPR reduction with more than 8 bits for using the signal expansion scheme [11].

H. Y. Sakran et al. (2008) proposed a combined interleaving method with peak windowing. This technique combines two basic PAPR reduction methods interleaving and windowing methods. The main advantage of the proposed combination reduce PAPR, decrease the BER over conventional techniques, and improve the spectrum efficiency. Simulation results show that this technique simultaneously decrease Bit Error Rate (BER), reduce the PAPR by 3.5dB and improve out of band radiation, in presence of nonlinear power amplifier model [12].

H.Y. Sakran et al. (2009) presented a combination of interleaving technique and companding technique to reduce PAPR. This scheme is compared with the system that uses the clipping technique for reduction of PAPR. By using this scheme, the PAPR of OFDM signal can be reduced by 6.8dB over the original system, i.e., without PAPR reduction. Also, SNR decreases by more than 5dB for Bit Error Rate (BER) of 10^{-3} over the original system. Moreover, this scheme gives improvement of more than 4.5dB for BER of 10^{-3} over the system that uses clipping [13].

V.B. Malode et al. (2010) proposed a technique to reduce PAPR by probabilistic method, modified selective mapping technique using the standard arrays of linear block codes. Lowest PAPR in each co-set of a linear block codes as its co-set leader from several transmitted signal is selected. The study also compared PAPR for QPSK/DQPSK-OFDM with and without SLM. Peak value for the modified SLM technique is 4.77dB and average value PAPR is 2.8dB [14].

One of the effective methods used for reducing PAPR in OFDM systems is PTS. In the conventional PTS (CPTS) several inverse fast Fourier transform (IFFT) operations and complicated calculation to obtain optimum phase sequence, increases the computational complexity of CPTS. P. S. Varahram et al. (2011) proposed a technique to reduce the number of IFFT operations to half at the expense of a slight PAPR degradation. Simulations are performed with QPSK modulation with OFDM signal and Saleh model power amplifier. The effects of digital pre-distortion (DPD) to increase the linearity and efficiency of the Saleh model power amplifier (PA) are also examined in this paper [15].

M. Pant et al. (2012) use companding technique to reduce the PAPR within OFDM systems. Companding OFDM symbols prior to transmission using the μ-Law can significantly improve PAPR reduction. Several authors have proposed schemes for reducing peak amplitude, such as clipping, PTS, and selective mapping, subcarrier power adjustment, linear combination. Here the companding of OFDM signal in time domain to reduce PAPR is discussed. Complementary Cumulative Distributed Function (CCDF) of PAPR reduction techniques is also presented. PAPR reduction for companding factor, μ=1 is 4.7dB and for companding factor, μ=2 the PAPR reduction is 5.7dB. The value of CCDF=10^{-2} is taken [8].

R. Baranwal et al. (2012) proposed the comparison of the effect of different modulation (QPSK, DQPSK, and 4-QAM) on PAPR value of OFDM signal and its reduction by using selective mapping phase rotation method. Reducing PAPR of OFDM signal is important for increasing the performance of communication equipment. This paper demonstrates the least PAPR of OFDM using different modulation technique like QPSK, DQPSK and 4-QAM.The optimization of PAPR value by phase rotation on different modulation is presented. The proposed Selective Mapping with phase rotation technique is simple and achieves significant reduction in PAPR. In PAPR (dB) with and without phase rotation is found 2.461dB, 1.685dB and 3.239dB for QPSK, DQPSK and 4-QAM respectively [16].

Selected mapping (SLM) is one efficient technique which reduces the peaks of a signal considerably. One drawback associated with this technique is its computational complexity. The computational complexity is directly related to the complexity of the IFFT block and increases as the number of sub-carriers increases. I. Mohd. Hussain (2013) presented a technique called PSM to reduce the computational complexity as well as to improve the PAPR performance of the conventional SLM technique. In this technique the IFFT block is divided into smaller blocks and each block is used as a separate SLM block. Partial outputs of all sub-blocks are concatenated to form the final sequence. This technique achieves a reduction of around 3dB in PAPR performance at CCDF of 10^{-3} [17].

IV. CONCLUSION

This paper has been devoted to the study of the PAPR and the different methods of reducing it. As we have seen, different methods are envisaged, one based on the processing of the AP and the second based on the transmitted signal processing. Before the transmission, the latter has two types, one of which must transmit information of any kind to the receiver in order to reconstruct the transmitted signal and the other simpler method where the receiver processes the received signal without having information on the operation Carried out on issue.

Signal clipping is one of the methods of the second type of PAPR reduction. It is simple to implement and reduces the PAPR. The study of these different methods through the reading of several articles, allowed us to note that there are several ways to improve the different methods. An example of these means will be the combination of two methods.

REFERENCES

[1] Goeckel, D.L. and Ananthaswamy, G., 2002. On the design of multidimensional signal sets for OFDM systems. *IEEE Transactions on Communications*, *50*(3), pp.442-452.

[2] Krongold, B.S. and Jones, D.L., 2003. PAR reduction in OFDM via active constellation extension. *IEEE Transactions on broadcasting*, *49*(3), pp.258-268.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

[3] Sterian, C.E.D., Wesolowski, K., Wu, Y. and Patzold, M., 2006, September. Using constellation shaping to reduce the peak and average power of OFDM signals. In *Vehicular Technology Conference, 2006. VTC-2006 Fall. 2006 IEEE 64th* (pp. 1-5). IEEE.

[4] Ochiai, H. and Imai, H., 2002. Performance analysis of deliberately clipped OFDM signals. *IEEE Transactions on communications*, *50*(1), pp.89-101.

[5] Xiao, Y., Lei, X., Wen, Q. and Li, S., 2007. A class of low complexity PTS techniques for PAPR reduction in OFDM systems. *IEEE Signal Processing Letters*, *14*(10), pp.680-683.

[6] R.W. Bauml, R.F.H. Fischer and J.B. Huber, "Reducing the Peak to Average Power Ratio of Multicarrier Modulation by Selective Mapping", IEEE Electronics Letters, vol.32, no.22, pp. 2056-2057, Oct. 1996.

[7] S.H. Muller and J.B. Huber, "OFDM Reduced Peak to Average Power Ratio by optimum Combination of Partial Transmit Sequences", IEEE Electronics letters, Vol.33, No.5, pp. 368-369, Feb. 1997.

[8] M. Pant and D. Nitnawwre, "Performance Improvement of OFDM System Using PAPR Reduction", International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE), ISSN: 2277 128X, Vol. 2, Issue 5, May 2012.

[9] S.H. Han and J.H. Lee, "An Overview of Peak-to-Average Power Ratio Reduction Techniques for Multicarrier Transmission", IEEE Wireless Communications, pp 1536-1284, Vol. 12, Issue 2, April 2005.

[10] R. Marsalek, "On the Reduced Complexity Interleaving Method For OFDM PAPR Reduction", Radio Engineering, Vol. 1, No. 3, September 2006.

[11] J. H. Wen, G.R. Lee and C.Y. Yang, "The PAPR Reduction in OFDM System with the Help of Signal Mapping Scheme", International Journal of Applied Science and Engineering, Vol. 5, Issue 1, pp. 75-80, 2007.

[12] H.Y. Sakran, M. Shokair and A.A. Elazm, "An Efficient Technique for Reducing PAPR Of OFDM System In The Presence Of Nonlinear High Power Amplifier", Progress In Electromagnetics Research, Vol. 2, pp. 233–241, 2008.

[13] H.Y. Sakran, M. Shokairand A.A. Elazm, "Combined Interleaving and Companding for PAPR Reduction in OFDM Systems", Progress In Electromagnetics Research, Vol. 6, pp. 67–78, 2009.

[14] V.B. Malode and B.P. Patil, "PAPR Reduction Using Modified Selective Mapping Technique", IJANA, Vol. 2, Issue: 02, pp 626-630, 2010.

[15] P. S. Varahram and B.Mohd. Ali, "Partial transmit sequence scheme with new phase sequence for PAPR reduction in OFDM systems", IEEE Transactions on Consumer Electronics, ISSN: 0098-3063, Vol. 57, Issue 2, pp. 366-371, May 2011.

[16] R. Baranwal, A. Kumar and C. K. Shukla, "Effect of Different Modulation on PAPR and Its Reduction", International Journal of Computer Science & Engineering Technology (IJCSET), Vol. 3, No. 8 August 2012.

[17] I. Mohd. Hussain, "Low Complexity Partial SLM Technique for PAPR Reduction in OFDM Transmitters", International Journal on Electrical Engineering and Informatics (IJEEI) – Vol. 5, No. 1, March 2013.