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Research Article

Peak-to-average Power Ratio Methods to Improve the Performance of Multicarrier Modulation Systems

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Abstract: The objective of this review is Comprehensive description for Peak to Average Power Ratio (PAPR) reduction methods in Orthogonal Frequency Division Multiplexing (OFDM) multicarrier modulation systems to provide the researchers in this field with a broader understanding of the high PAPR problem in OFDM systems and Classification of the available solutions to mitigate the problem. Also, we discuss and make some remarks on the criteria for PAPR reduction methods. In wireless multicarrier communication systems, the major drawback of transmit signal is high Peak to Average Power Ratio. Transmitters have a lot of devices such as Power Amplifiers (PA), PAs are often designed to operate at non-linear region to reduce power consumption. However, non-linear transfer functions of PAs may be led to high peaks of amplitude levels resulting a high peak levels of multicarrier signal while average power still approximately fixed depended on PA specifications. This mean, PAPR will be increased caused high complexity, bandwidth expansion, spectral spillage and degradation of system performance. One important type of multicarrier modulation systems is OFDM.

Keywords: And complementary cumulative distribution function (CCDF), Orthogonal Frequency Division Multiplexing (OFDM), Peak to Average Power Ratio (PAPR)

INTRODUCTION

Over the years, many techniques have been proposed to avoid high PAPR problem in multicarrier modulation systems such as OFDM. Different PAPR reduction techniques have been found, the major drawback of wireless multicarrier modulation system is huge PAPR as compared with acceptable ratio. For the reason, the transmitter must have high linear range process to amplify the transmitted signal in order to receive it without clipping the signal and to design transmitter's components with low complexity, else the transmit signals will be exposed to non-linear distortion, resulting in high, PAPR, signals interference and degradation in performance of system (Pradabpet *et al*., 2013).

PAPR techniques are mostly Summarized into five categories as follows:

Signal distortion: Peak Windowing, Companding technique, Envelope Scaling, Peak Reduction Carrier, Clipping and Filtering, (Wang and Luo, 2011).

Signal distortion less: As Coding techniques which have many methods such as (Block Coding Techniques, Permutation Sequences, Cyclic coded, Dummy sequences insertion DSI, Pseudo Noise Coding PN, Turbo Coding and Golay Sequences).

Multiple signaling: There are many methods here also such as (Interleaving Technique, Trellis shaping, Active Constellation Extension (ACE), Orthogonal Pilot Sequences (OPS), Neural Network (NN), Dynamic Symbol Pairing Technique, carrier-by-carrier partial response signaling and Linear Phase Rotation Vector technique) (Bani *et al*., 2012; Boonsrimuang *et al*., 2012).

Pre-distortion methods: Such as (Tone Reservation (TR), Tone Injection (TI) and Pre-coding or Pulse Shaping) (Chen *et al*., 2011).

Probabilistic (scrambling) techniques: Such as in ((SLM) Selected Mapping and (PTS) Partial Transmit Sequence (Wang and Liu, 2011).

Hybrid techniques: Pradabpet *et al*. (2013).

In this study, an investigation and description of high PAPR problem based on the contracture of the

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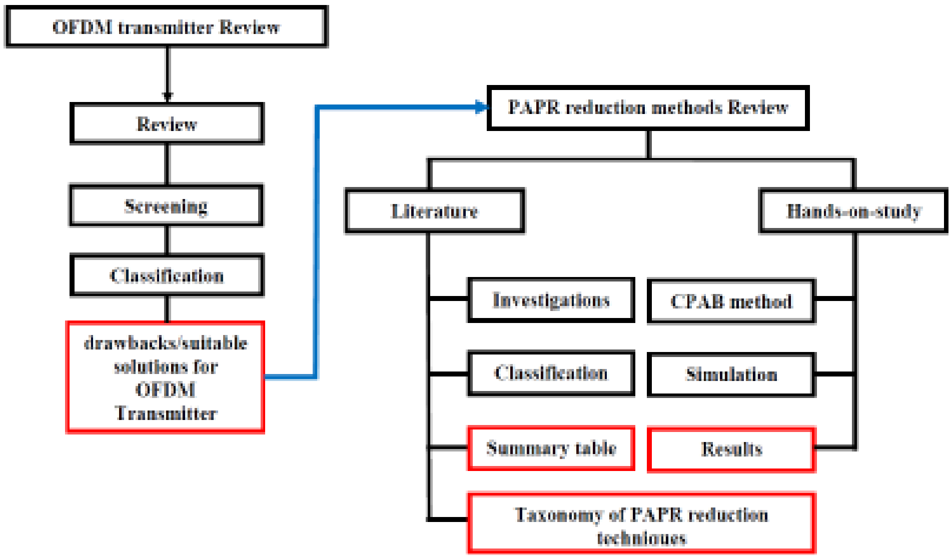

Fig. 1: Conceptual framework summarizing this work

OFDM signals. Thus, six typical techniques of PAPR reduction are classified and propose a new method in details. Finally, additional discussion and analysis in of PAPR issue for OFDM technology.

As shown in Fig. 1, the OFDM transmitter review; an overview description and graphical summary for problems and suitable solutions in transmitter side of OFDM system. The literature part comprises a survey; a literature classification and tabular summary of the PAPR reduction methods. The hands-on study adopts additional new method to reduce PAPR named Clipping Peaks Amplifying Bottom (*CPAB*) and compare with the PAPR reduction studies.

PAPR IN OFDM SYSTEM

In OFDM systems, a block of N symbols are formed with each symbol modulation and N is the number of sub carriers, as shown in Fig. 2, the construction of OFDM transmitter with the most devices can be used (Braun, 2014).

High PAPR of OFDM signal is one of major problems of OFDM system in wireless communication. If PAPR still high, it will cause to reducing the efficiency of power amplifier, lost the orthogonality feature which it specially for OFDM system between sub-carriers, degrades the BER performance and high complexity analog to digital (ADC) and digital to analog (DAC) system. But the major disadvantages of a high PAPR are firstly increased complexity in DAC/ADC circuit and second, reduction is efficiency of RF amplifiers (Jiang and Wu, 2008).

Many techniques can solve this problem, but each has its own advantages and disadvantages. Where high PAPR problem occurs at the transmitter side that one causes it is the peak power of the signal can be up to N times the average power (where N is the number of sub-carriers). From the central limit theorem process for a large number of subcarriers, the peaks and baseband of the OFDM signal are statistically random. Assuming the samples to be mutually uncorrelated, the probability of the Peak-to-Average Power Ratio (PAPR) exceeds a limit threshold, γ can be given by:

$$\text{Probability }\{\text{PAPR}>\gamma\} = [1- (1 - e^{-\gamma})^{N}]$$

where,

$$\gamma > 0$$

Also the PAPR 'calculations by the following equation (Pradabpet *et al*., 2013):

$$PAPR = \frac{(x_k^{\ 2})_{\max}}{E\{x_k^{\ 2}\}} \qquad 1 \le k \le N \tag{1}$$

Low PAPR came from high average power of OFDM signal when the a peak power is fixed because related with transmitter power limitations.

Nonlinearity of power amplifier: Multicarrier modulated signals like the OFDM signal are more sensitive to the nonlinearities signals such as Inverse Fast Fourier Transform (IFFT) blocks, Power Amplifier (PA) nonlinearity and other transmitter devices. However, PA nonlinearity in multicarrier modulations mostly due to high PAPR. Therefore, because PA's nonlinearity have been the dominant effect, PAs characteristics will be discuss.

In general, there are explained two types of PAs; Traveling Wave Tube Amplifier (TWTA) with severe

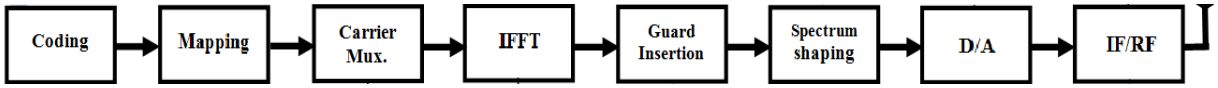

Fig. 2: Baseband of OFDM transmitter

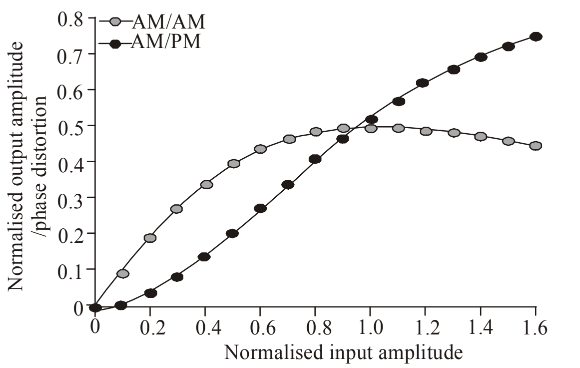

Fig. 3: The normalized AM/AM and AM/PM transfer curves of TWTA

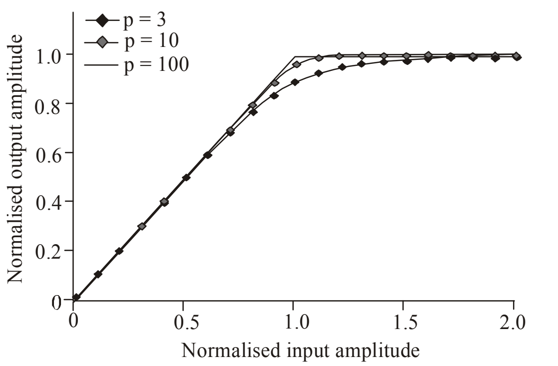

Fig. 4: The normalized AM/AM transfer curve of SSPA for p = 3, 10 and 100

AM/PM conversion and Solid-State Power Amplifier (SSPA) with zero AM/PM conversion. Therefore, memory less nonlinearities with frequency-nonselective response is a common approach model as AM/AM and AM/PM conversion of the nonlinear amplifier.

TWTA model: It is commonly used, an example of the memory less Saleh's TWTA model is considered. As shown in Fig. 3. The model characteristics of the TWTA are showed (Al-Dalakta, 2012).

SSPA model: The SSPA model is commonly used in mobile and cellular communications. An example of memory less Rapp's SSPA model is considered as the AM/AM and AM/PM profiles and it can easy describe by:

$$A(p) = G\frac{p_n}{\left[1+\left(\frac{p_n}{A_o}\right)^{2p}\right]^{1/2p}} \tag{2}$$

A_0 denotes the maximum output of PA due to maximum input, p is smoothness factor of the SSPA and p_n is absolute value of the time-domain samples at the HPA input. Transition smoothness from the linear region to limiting region can be controlled by p. Fig. 4 depicts the AM/AM characteristic of the SSPA model for various values of p. (Al-Dalakta, 2012).

PAPR METHODS OVERVIEW

This section will present a literature review for a certain common methods of PAPR reduction in multicarrier modulation system as following.

Signal distortion techniques: In these techniques, the PAPR reduction process with distorting the non-linear OFDM signal. Where the techniques are implemented after generating OFDM signal (after the Inverse Fast Fourier Transform stage).

Clipping and filtering: The most simple and straight forward method is repeated clipping and filtering, which seems adequate to handle the problem for current systems. There are no old and new methods here and as far as this method knows practically the most popular to implement the OFDM system (Wang and Luo, 2011), Fig. 5 shows the amplitude variation of an OFDM signal and peaks exceed the threshold value.

The disadvantages of the clipping technique are led to a distortion in the OFDM signal, consequential high degradation in performance of bit error ratio BER, It also leads to out-of-band noise, which imposes out-of-band interference signals to neighboring channels. By filtering process that is easy to reduce the out-of-band noise, but the effect of filtering process influences high-frequency components of in-band signal when the clipping is carry out with the Nyquist sampling rate and filtering after clipping may be mitigated out-of-band noise at the cost of peak. The filtered signal also may go over the given clipping threshold (Li and Cimini, 1998). However, other methods have been found to mitigate the effects of amplitude clipping process like Iterative Clipping and Filtering (ICF) process has been given by (Zhu *et al*., 2013). Zhu *et al*. (2013) the clipping and filtering are interpreted as a procedure of adding an extra signal to the original signal.

Peak windowing: The height of the window technique similar to the clipping method, but with further improvement. Reducing the out-of-band emission used

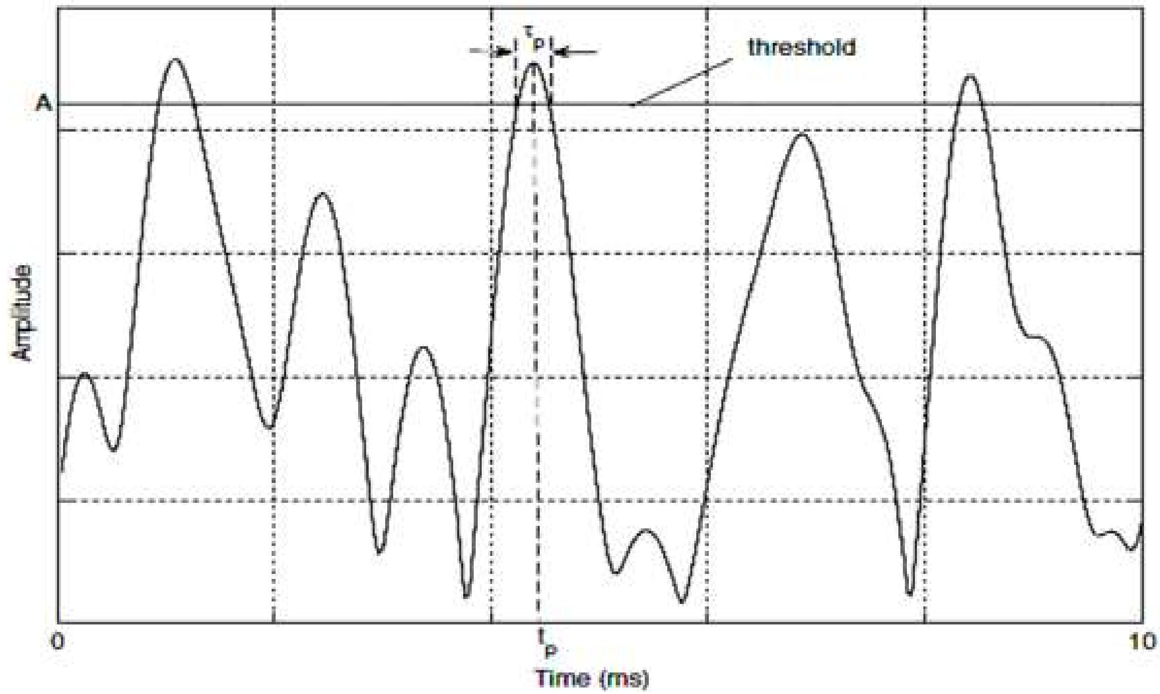

Fig. 5: Clipping of OFDM signal peak (Wang and Luo, 2011)

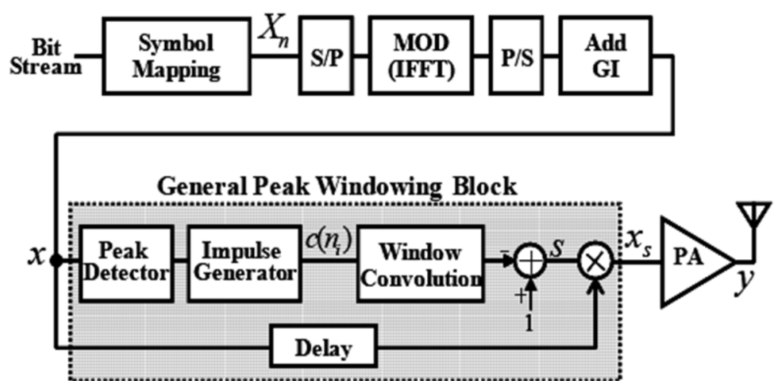

Fig. 6: OFDM system with peak window technique

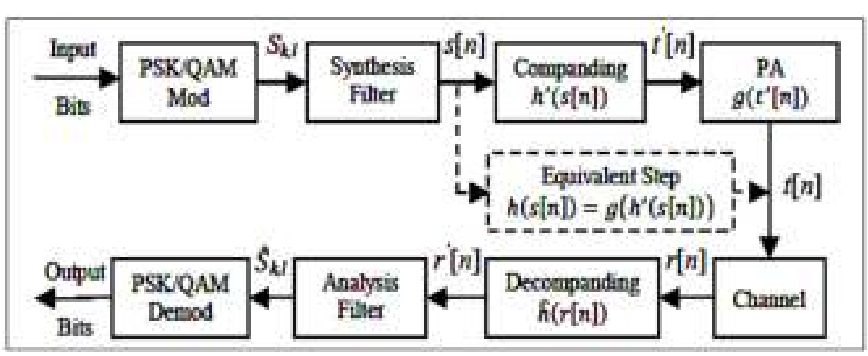

Fig. 7: Companding technique to reduce PAPR

narrow band windows such as Gaussian window to fade peak of signals. As a matter of fact, any window with a low time domain and having acceptable spectral properties can be used. In 2008, an advance peak windowing technique has been found by Cha *et al*. (2008) as shown in Fig. 6, which it improves of normal peak windowing technique. It effectively reduces the peak of signals to the most wanted threshold level in case when the successive peaks take place within a half of the window length.

Companding techniques: in 1999, the first Nonlinear Companding Transform (NCT) was given by Wang *et al*. (1999). It has shown better performance than that of clipping method. These transforms have advantages; suitable complexity and no bandwidth extension. One important example of the Non linear companding is an exponential transform (Jiang *et al*., 2005) that increases the low amplitude signals and decreases the high amplitude signals; resulting that, the average power of the transmitted signals is increased and at the same time the peak amplitude value become small. Thus, the PAPR will decrease. But increasing in the average power causes the HPA to operate in closely to the saturation region; subsequently the system BER performance will degrade.

Four companding approaches have been presented in Rahmatallah *et al*. (2011), linear nonsymmetrical transform, linear symmetrical transform, nonlinear nonsymmetrical transform and nonlinear symmetrical transform. Among the presented approaches, the first approach presents the best as compare with good reduction in the PAPR and high performance in BER. As shown above Fig. 7 is OFDM system with Companding scheme.

Signal distortion less: for these Techniques, the PAPR reduction process with adding processes to the non-linear OFDM signal. Where these techniques are implemented before generating OFDM signal (before the Inverse Fast Fourier Transform stage at transmitter side).

Coding techniques: The coding techniques used several error properly codes in order to reduce PAPR. These techniques be appropriated before the OFDM signal generation (before IFFT stage). Where N signals are added at the same phase which there are to produce a high peak power equal approximately to (N) times the average power. The essential design of all coding methods for the reduction of PAPR is to mitigate the expectable probability of the in phase (N) signals. It gives us no distortion signal and makes no out of band waves, but the system suffers from bandwidth effectiveness as the code rate is minimize. It also has more complexity exactly for a large number (N) of subcarriers.

There are many methods to implement coding technique, firstly, it was found in 1994 by Jones *et al*. (1994). This method uses simple block coding scheme. Its basic method is to plan 3 bits data into 4 bits codeword by adding a Simple Odd Parity Code (SOBC) at the last significant bit through the channels. The main disadvantage of SOBC method is that it can reduce PAPR only for a 4-bit codeword. Secondly, in 1996, which applied the Cyclic Coding (CC) method to reduce the PAPR. Then Golay complementary sequence published by Bai *et al*. (2012), Dummy sequences insertion DSI, Pseudo Noise Coding PN, Turbo Coding, finally and Permutation Sequences (Boonsrimuang *et al*., 2012; Bani *et al*., 2012). In short, the most drawbacks of all coding techniques are that they caused a lot of reducing in the transmission speed.

Multiple signaling techniques: many methods under this category as mentioned such as (Interleaving Technique, Neural Network (NN), Linear Phase Rotation Vector technique, carrier-by-carrier partial response signaling, Orthogonal Pilot Sequences (OPS), Trellis shaping, Active Constellation Extension (ACE) and Dynamic Symbol Pairing Technique) (Bani *et al*., 2012).

Probabilistic (scrambling) techniques: There are depended on scrambling of each symbol in OFDM signal with diverse scrambling distributions and selecting that sequence which gives smallest PAPR. It decreases the efficiency of spectral with high complexity occurs when the number of subcarriers increase. In addition, it cannot guarantee the PAPR below a required level. The methods like Selective Mapping (SLM) and Partial Transmit Sequence (PTS) are the example of probabilistic techniques.

Selected Mapping (SLM): In SLM and as illustrate in Fig. 8, set of OFDM signals are generated to create the same data block, after that transmitting one of them to next stage with the smallest PAPR. Because SLM needs many IFFT blocks, the complexity is the biggest drawback. On other hand, the data rate is decreased because the side information also have to be transmitted).

Ning *et al*. (2012) presented a SLM methods to reduce the computational complexity, bit error rate and the transmitted side information. After collection, the samples were shipped back to M sections SLM process, each one of them is multiplied by M different phase sequences.

$a^{(m)} \equiv \left[a_0^{(m)}, a_1^{(m)}, a_2^{(m)}, \ldots\ldots, a_{M-1}^{(m)}\right]$ with m = 0, 1, 2,….., M-1, therefore, a new input sequences are generated as shown below:

$$d^{(m)} = d \circ a^{(m)} \quad m = 0, 1, \ldots\ldots, M-1 \tag{3}$$

where, $a^{(0)}$ is set as a unity vector and that can select randomly other victors: $a^{(m)}$, m = 1, 2,….. , M-1 but

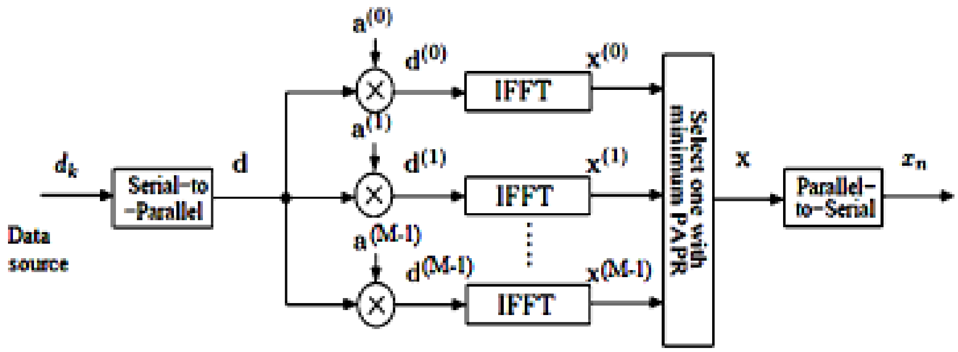

Fig. 8: Conventional SLM block diagram

with complex form as a phase values {±1, ±j}. Then, every branch of M-branches SLM is applied to IFFT unit. The resulting of the sequence is:

$$x_n^{(m)} = \frac{1}{\sqrt{N}} \sum_{q=0}^{N-1} d_q\, a_q^{(m)}\, e^{j2\pi qn/N}$$
$$n = 0, 1, ...,\ N-1 \tag{4}$$

where,

M : Number of partition in SLM scheme
$a^{(M)}$: Complex weighting phase sequence for the SLM scheme
$d^{(M)}$: Alternative input sequence for the SLM scheme
x : Data sequence
x_n : Time-domain data samples of (x)
d : Signal constellations sequence
d_n : Frequency-domain samples of (d)

At the end of process, the minimum PAPR must be chosen by computing the PAPR of M - branches SLM with set of phase vectors $a^{(0)}$, …… , $a^{(M-1)}$ to continue with the next stages of transmission OFDM signal.

Partial Transmit Sequence (PTS): PTS is a method to reduce PAPR of an OFDM signal. PTS technique can provide good PAPR reduction performance for OFDM signals. However, it requires an exhaustive search over all combinations of allowed phase factors, resulting in high complexity. PTS technique approximately like the SLM technique, because the most drawback of PTS is also the computational complexity (search complexity for optimal phase factor and more than one IFFT blocks) and low data rate (required side information). Therefore, the researches reduced the complexity and overhead (by reducing/avoiding the usage of side information). Chen *et al*. (2011) is given many different with respect to compute the complexity of PTS/ SLM and it showed that the PTS techniques have less complexity as compared with SLM techniques. Many techniques are proposed to reduce the PAPR and the computational load by improving the conventional method such as (Wang and Liu, 2011), Fig. 9 characterizes the conventional of PTS block diagram. Hence, a block input data, which comprises of N symbols, is partitioned into M disjoint sets $d^{(m)}$, m = 0, 1, …… M-1 and zero padded left/right to get (Chen *et al*., 2011):

$$d^{(m)} = \begin{bmatrix} 0^{1\times mN/M} & ,\{d\}_{mN/M}^{(m+1)N/M-1} \\ ,\ 0^{1\times[N-(m-1)N/M]} & \end{bmatrix} \tag{5}$$

The time-domain vector, $x^{(m)}$, is got by implementing a *N*-point IFFT on every one of the disjoint sets. Also the time-domain samples, $x_n^{(m)}$, can be described as:

$$x_n^{(m)} = \frac{1}{\sqrt{N}} \sum_{q=0}^{N-1} d_q\ e^{j2\pi qn/N} \quad n = 0, 1, ..., N-1 \tag{6}$$

where, d_q, q = 0,1,……, N-1, are input symbols modulated by PSK or QAM and is the discrete time index. Consequently, the complex weighting phase factors, $b(m)$ equal to {±1, ±*j*}, are introduced to scramble the IFFT outputs. Finally, the *M* signals are added to produce the overall time-domain samples:

$$x_n = \sum_{m=0}^{M-1} b^{(m)}\, x_n^{(m)} \tag{7}$$

This scheme is arrived the minimum PAPR value by selecting the optimal combination of phase factors and transmit these factors as side information SI.

Pre-distortion techniques: the pre-distortion techniques are based on the re-orientation or power distribution of modulating signal before IFFT stage. The pre-distortion methods contain discrete Fourier Transform (DFT) distributing.

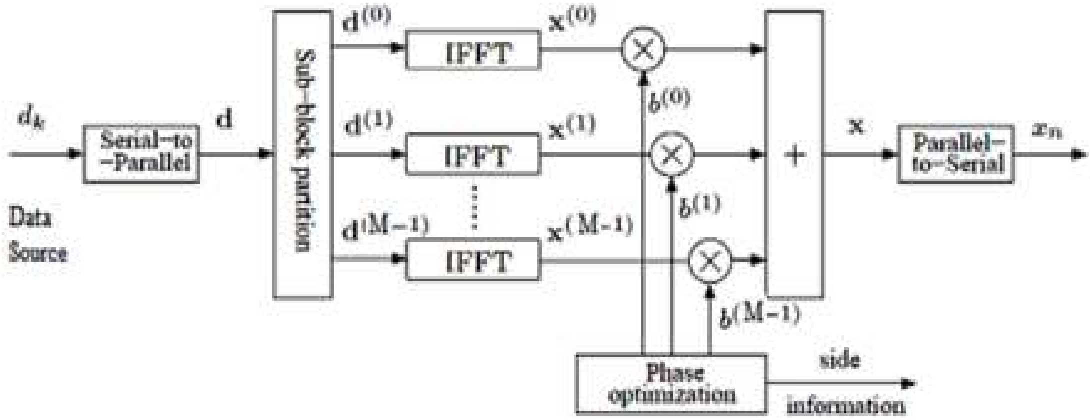

Fig. 9: The conventional PTS block diagram

Tone Reservation (TR) and Tone Injection (TI): TR and TI are two well-known schemes to reduce the PAPR of OFDM systems. The OFDM signal peaks can be reduced by inserting a subset of tone-dependent time-domain signals to the original OFDM signal. The time-domain signal can be calculated easily using different algorithms at the transmitter and discarded at the receiver. Note that the inserted signals have no effect on the data carrying SCs as the SCs are orthogonal in the OFDM systems. The transmitter of the TR scheme sends data on a large subset of SCs to minimise the PAPR reduction.

Increase the constellation size is the main objective in TI scheme to reduce PAPR, where each of the points in the typical basic constellation is mapped into a number of corresponding points. The TI scheme has two significant disadvantages compared to the TR scheme. Firstly, same frequency band is used for both the modified signal and information signal. Secondly, the transmit power signal is increased owing to the injected signal in the TI scheme (Chen *et al*., 2011).

Pre-coding or pulse shaping: It is an flexible active technique, each data block of OFDM signal is multiplied by a pre-coding matrix. It is searched on iterative data-independent to arrive to the optimization. A random subcarriers number and any modulation type can also be used. For system performance, it takes advantage of the frequency variation of the fading multipath channel and improves the performance of OFDM signals in comparison to conventional OFDM. A new pulse shaping method is proposed by Slimane (2007). Then he again proposed another pre-coding technique to reduce PAPR (Slimane, 2007). He presented a good design of generating pre-coding matrix. Subsequently, a necessary condition and proposed a systematic procedure to generate an optimal pre-coding matrix derived by Hao and Lai (2010) which will give high system performance. An important role related with designing of pre-coding matrix takes.

Hybrid techniques: Additional technique named hybrid or combine method which combine two or more different technique to obtain a new method to reduce PAPR but with high complexity and cost (Wang, 2013) offered number of hybrid techniques. These techniques have combined two or more than two techniques for PAPR reduction, for example coding with clipping, SLM with coding, clipping with pre-coding etc Hybrid technology is considered as a good option to reduce PAPR in certain cases as having the most improvements in the techniques used in the hybridization, but as we mentioned earlier there is a rise in complexity and cost, compared with the rest of the possible techniques and use them in systems that require high precision in the first place. Many proposed combined techniques called hybrid techniques like clipping with PTS, clipping with SLM and so on.

DISCUSSION AND SUGGESTION

OFDM transmitter problems/solutions view: As shown in Fig. 10, the drawbacks in OFDM transmitter side and their suitable solutions to mitigate these problems.

Evaluation PAPR reduction: the performance evaluation of different PAPR reduction techniques is usually established through three significant metrics as follows:

- The Complementary Cumulative Distributive Function (CCDF)
- Bit Error Rate (BER)
- Spectral spreading

where, the first metric CCDF is independent of the HPA characteristics that is used at the transmitter side, the other two metrics are relatively affected. When the nonlinearity of the PA is high, in-band and out-of-band distortions are severe leading to higher BER and spectral spreading that is mean degradation in performance of the OFDM system. When a PAPR reduction scheme is implemented, it is important to observe how the scheme affects at least the first two of

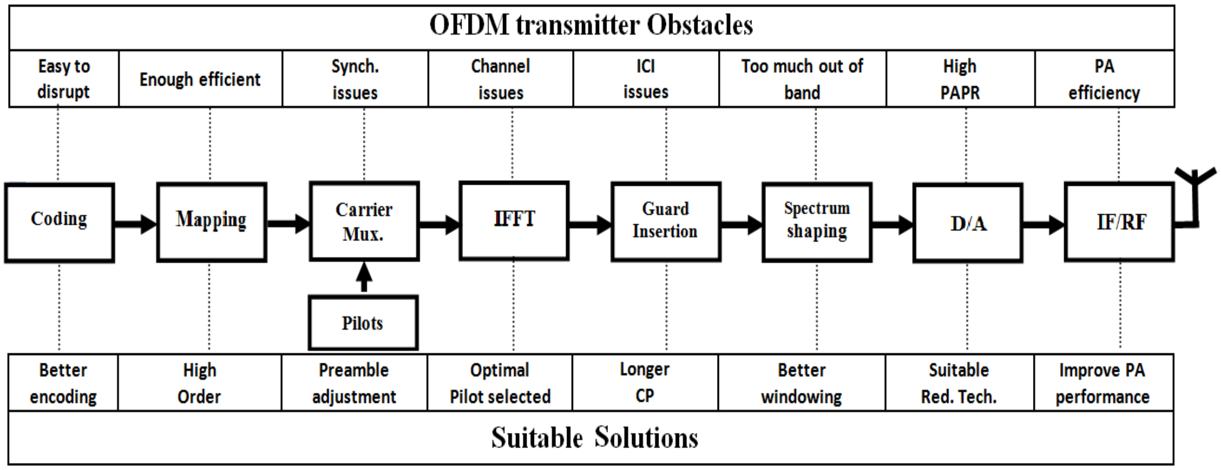

Fig. 10: Conceptual framework for drawbacks/suitable solutions in OFDM transmitter

the three mentioned factors here. Most PAPR reduction methods are changed the OFDM time-domain signal to get a lower PAPR at the expense of some side effects as increasing in the BER and/or spectral spreading. However, it is always desirable to choose the scheme that gives an optimum response or high BER performance, i.e., reducing PAPR with maintain or the BER and spectral spreading significantly fixed or minimized changes if possible (Rahmatallah *et al*., 2011).

Factors for selecting the PAPR reduction technique: All methods have some disadvantages, Trade-off between PAPR reduction and other factors (data rate, computational complexity, average power, BER performance and system components is always presented. A number of factors should be taken into account for selecting the method that can reduce the PAPR effectively while simultaneously maintaining the high performance system. There are as follows (Jiang and Wu, 2008; Cho *et al*., 2010):

High ability PAPR reduction: Clearly, this is the main factor to be considered for choose of the PAPR reduction technique. Here that is looking to percentage of distortion and data lost size. That is mean the PAPR reduction process should be finished with a little bit effects on the OFDM system factors such as in-band distortion and out-of-band radiation.

Maintain mean power of OFDM transmitted signal: The average power of an OFDM transmitted signal maybe increased after implemented a certain PAPR reduction technique such as TR and TI. Because this is situation causes degradation in the BER performance, must be normalized the average power of transmitted signal before PAPR reduction process to the original average power value after this process.

High BER performance in the receiver side: One important goals to reduce PAPR of OFDM signal is to achieve a positive improvement in the BER performance. For example, BER performance degrades due to the in-band distortion in clipping method. In additional, the side information is difficulty recovering at the receiver side in the PTS and SLM methods also it is another reason of BER performance degradation.

Maintain data rate is high without lost: Because of sending the SI, the bandwidth of signal is expanded in a some methods to reduce PAPR such as PTS, SLM and coding Which it leads to reduce data rate. To retrieve the original data rate of the OFDM signal, the side information SI should be fixed.

Minimized computational complexity: Normally, more complex PAPR reduction technique will achieve optimal PAPR reduction. However, a scheme such as PTS reduces the PAPR by optimized selecting of weighing phase factors. Finally, the executing time for PAPR reduction should be reduced to the minimum possible.

No spectral spillage: OFDM system is resistant to the multipath fading; as a result, in order not to defeat this feature in each PAPR reduction techniques, the spectral spillage should be disallowed. Also very important job is maintained on the OFDM orthogonality when PAPR reduction techniques are implemented.

High power amplifier efficiency: The operating point of the PA must be near to the saturation region to increase the PA efficiency; this leads to increase the error rate. Therefore, implement PAPR reduction schemes can get better the BER performance and hence, increase the amplifier efficiency.

The system components factors: The effect of nonlinear devices such as Digital-to-Analogue converters (DACs) and mixers require careful check up. For example, the cost of these devices is a important factor in PAPR reduction methods in the practical considerations. In general, all PAPR reduction techniques satisfy PAPR reduction at the expense of increasing the power of OFDM signal, BER and implementation complexity with decreasing data rate, the relationship between power efficiency of the PA and PAPR reduction should be considered and hence, the lowest possible BER depends on the selective of the PAPR level. This technique is known as an efficient PAPR selection or optimization technique.

Classification and comparison of PAPR reduction methods: In general, all PAPR reduction techniques in OFDM signal satisfy PAPR reduction at the expense of increasing the power of OFDM signal, BER (low system performance) and implementation complexity with decreasing data rate. The relationship between power efficiency of the power amplifier PA and PAPR reduction should be considered and hence, the lowest possible BER depends on the selective of the PAPR level. Thus, an additional optimization technique is required to make balance between the parameters when an efficient PAPR reduction method is selected. As known, the hybrid methods are good choice for reducing PAPR but with high computational complexity. Clipping and filtering technique is common method with high BER. However, it can be combined with any other techniques for PAPR reduction. Also, it is discussed that Probabilistic (Scrambling) techniques PTS technique is simple and capable technique of PAPR reduction. Knowing that the performance of PTS technique are depends on the number of subcarrier. So the PTS scheme are the most important schemes used to reduce PAPR. These schemes are efficient and signal distortion less but more complex than other techniques and require recovering the side information at the receiver efficiently.

As shown in Fig. 11, a brief taxonomy of the PAPR reduction methods.

PAPR reduction methods are shown in Table 1. Table 1 summarizes the six typical categories methods to reduce PAPR. It can be seen from this table that Probabilistic methods are efficient reduction, less distortion and better than multiple signaling category

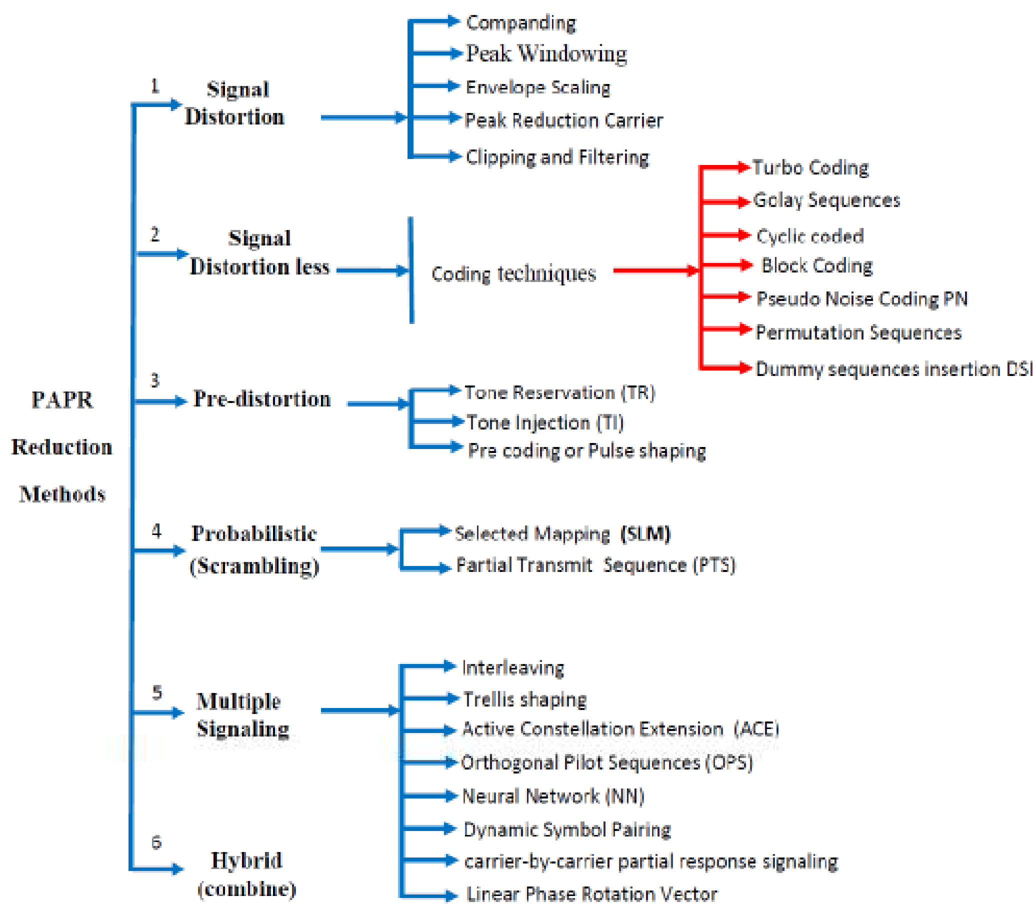

Fig. 11: Graphical classification framework for PAPR reduction methods

Table 1: PAPR reduction techniques comparisons

Category	PAPR reduction	Increase mean power	Computation complexity	Bandwidth expansion	System degradation
Signal distortion	Limit	No	Low	No	Yes
Signal distortion less	Good	No	Low	Yes	No
Pre- distortion techniques	Limit	Yes	High	Yes	Yes
Probabilistic (scrambling)	Good	No	High	Yes	No
Multiple signaling	Good	No	High	Yes	No
Hybrid (combination)	Good	No	High	X	X

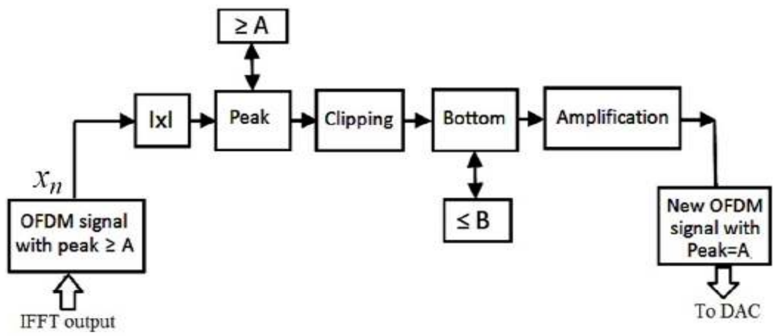

Fig. 12: CPAB block diagram

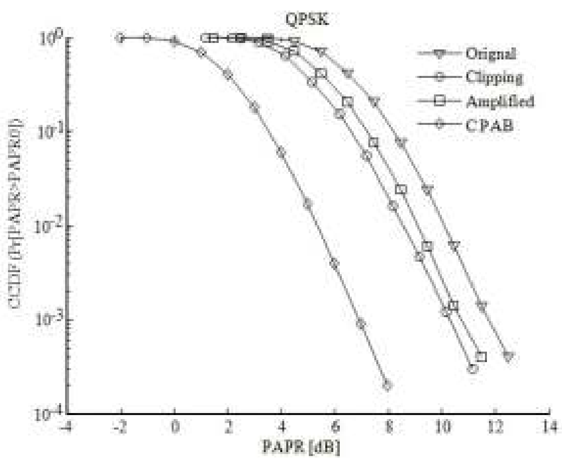

Fig. 13: First scenario: PAPR performance of OFDM signal

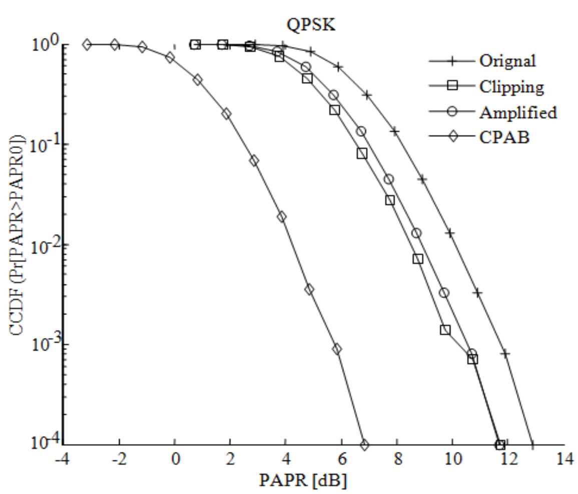

Fig. 14: Second scenario: PAPR performance of OFDM signal

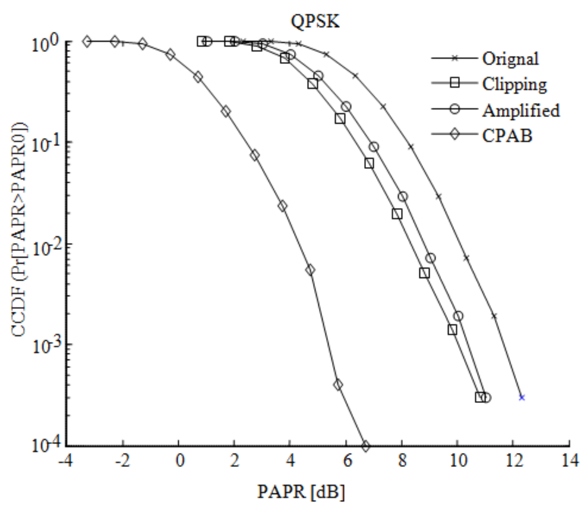

Fig. 15: Third scenario: PAPR performance of OFDM signal

with respect to PAPR reduction. However, these methods are more implemented complexity than other schemes and the data rate is decreased as result of SI bits transmission. The SLM method can be achieved with less complexity than the PTS. In additional, the required bits for SI are fewer in SLM technique (Hasan and Singh, 2012). On the other side, the PTS can achieve more PAPR reduction. In addition, good PAPR reduction techniques capability have more complex as mention above.

X is don't care dependent which methods will be combined to reduce PAPR.

New CPAB hybrid method: Clipping peaks amplifying bottoms hybrid method by clipping the OFDM signal amplitude to clipping threshold *A* and amplifying the bottoms to the amplification threshold *B*.

Clipping lead to minimize the amplitude while amplifying process shifts up the mean of the OFDM signal. Thus, PAPR will decrease. However, because high mean power leads to out of band radiation and system degradation, *B* is limited. Block diagram of CPAB method is shown in Fig. 12 where, x_n is the output IFFT block include high PAPR.

The simulation parameters with typical OFDM system are summarized in, 64 subcarriers, QPSK constellation modulation mapping and an oversampling rate equal 4 in which oversampled OFDM sequences. Results of PAPR reduction performance will show in different scenarios figures as following.

A can be taken as a percentage value from the peak value of OFDM signal while *B* will be organized by may scenarios as shown below.

First scenarios (*B* = - *A*): That is clear value of *B* represent the negative value of the percentage of maximum OFDM signal. It leads to get new OFDM signal with amplitude equal to *A* and bottoms of signal equal to *B*. As shown in Fig. 13, when CCDF equal to 10^{-2}, PAPRs are 10 dB, 8.65 dB and5.6 dB for the original, amplifying, clipping and CPAB respectively.

Second scenario (B = - percentage of mean value): That is clear value of *B* represent the negative value of the percentage of mean OFDM signal. It leads to get new OFDM signal with amplitude equal to *A* and bottoms of signal equal to *B*. As shown in Fig. 14, when CCDF equal to 10^{-2}, PAPRs are 10 dB, 8.45 dB and 4.32 dB for the original, amplifying, clipping and CPAB respectively.

Third scenario (B = - (maximum bottom-D): D denotes to difference between maximum bottom and minimum bottom. That is clear value of *B* represent the negative value as shown in above relationship. It leads to get new OFDM signal with amplitude equal to *A* and bottoms of signal equal to *B*. As shown in Fig. 15, when CCDF equal to 10^{-2}, PAPRs are 10 dB, 8.35 dB and4.26 dB for the original, amplifying, clipping and CPAB respectively.

CONCLUSION

As mentioned, OFDM is one striking modulation techniques for wireless communication system due to its multicarrier, spectrum efficiency and channel robustness. Transmitted signal with high PAPR is one serious drawback in OFDM systems exactly when several subcarrier are adding at same time. Thus, with higher number of subcarriers in wireless multicarrier modulation systems likely OFDM system in order to achieve higher data rates, the subject of reducing PAPR should be increased importance. There are a lot of PAPR reduction methods have been presented, all these methods are served for substantial reduction in PAPR. However, the considerations to select which one dependent on high degradation of system performance, increase mean power of transmit signal, the cost of loss in data rate and high computational and implementations complexity. For this, there wasn't generated a standard method to reduce PAPR in order to depend for the reduction purpose in multicarrier modulation systems. On other side, the requirements of system devices such as filters, DAC and PA also have been chosen with respect to select an appropriate PAPR reduction method. In this study, we described Six typical categories of methods to reduce PAPR for multicarrier OFDM modulation system. Paper suggested a new CPAB method to reduce PAPR with three scenarios of selecting *B*. Finally, the paper strongly hope, it may be valuable contribution with Comprehensive review to serve the specialized field of system design in wireless multicarrier modulation.

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