APPR Combined PTS Technique for Reduction of PAPR in OFDM Systems

Sampath Kumar C
Department of Electronics and Communication Engineering
National Institute of Technology
Warangal, India
sampathkumarchepuri@gmail.com

P Hari Krishna Prasad
Department of Electronics and Communication Engineering
National Institute of Technology
Warangal, India
phkp@nitw.ac.in

***Abstract*— High growth in multimedia based applications has increased the need for high data rates and bandwidth efficiency. Orthogonal Frequency division multiplexing (OFDM) is best choice in this regard which supports high data rates and bandwidth efficiency. As the number of subcarriers used in OFDM systems increases the data rates supported by it also increases at the cost of high Peak to average power ratio. The high PAPR leads to non-linearities in the system which is unwanted. Upcoming OFDM systems may drive the number of subcarriers used to meet the thrust of data rate demands. So it is required to alleviate the high PAPR that appear. Partial transmit sequence (PTS) is a technique for reduction in PAPR among other techniques. In this paper a method which combines both PTS and Adaptive Peak Power Reduction techniques (APPR). APPR uses an adaptive algorithm to maintain the peak level of modulated signal. In simulations this method shows the better reduction in PAPR and BER performance too.**

***Key words*—Adaptive Peak Power Reduction, Orthogonal Frequency Division Multiplexing, PAPR Reduction Techniques, Partial Transmit Sequence**

INTRODUCTION

The present need for information and increase in growth of multimedia wireless applications, increased the demand for the techniques which supports high mobility and data rates and uses the available bandwidth effectively. In order to achieve this goal OFDM is the best choice. OFDM is used in the physical layer of WiMAX and LTE systems as transmission scheme. It is also used by different applications like DSL, DVH-B.

OFDM has an advantage over frequency selective fading channels. Despite these advantages of OFDM it also has drawbacks like ICI, ISI and high PAPR problems. ICI and ISI problems reduced by introduction guard interval between different OFDM symbols. Several techniques are proposed in the literature to mitigate the problem of high PAPR [1]. These are mainly classified into three categories. Multiple signaling and probabilistic techniques, signal distortion techniques and coding techniques [1]. Among all the techniques PTS technique produce better reduction in PAPR.

In this paper a method which combines PTS and APPR techniques is used which reduce the PAPR further and BER performance also increased. In this method the input data is divided into sub-blocks. In every sub block, the subcarriers are weighted by phase factors. Then this data is fed to APPR to reduce PAPR further. APPR controls the gain of the signal by using an adaptive algorithm over a defined range [2]. Combining these methods at a time reduce the PAPR and high BER performance is also achieved.

OFDM AND PAPR PERFORMANCE

Orthogonal Frequency Division Multiplexing

In OFDM multiple carriers are used to modulate multiple data bits simultaneously. In OFDM system, input data is converted into parallel data. In OFDM system the subcarriers are orthogonal to each other. These subcarriers are modulated by the parallel streams obtained from serial to parallel convertor. The obtained OFDM signal [1] is

$$X(t) = \sum_{m=1}^{N} X_m \qquad (1)$$

Where X_m is the parallel data stream

N is the number of sub blocks

Peak to Average Power Ratio

The major drawback of OFDM system is high PAPR which occurs when the instantaneous power is more than the average of the signal. The PAPR of the signal X(t) [1] is

$$PAPR\big(X(t)\big) = \frac{P_{max}}{P_{avg}} \qquad (2)$$

Where,

P_{max} is instantaneous power of the signal,

P_{avg} is average power of the signal.

Complementary Cumulative Distribution (CCDF)

CCDF is the most factual metric to evaluate PAPR performance [1]. Reduction capability of PAPR is evaluated by CCDF reduction. CCDF gives the probability of the OFDM signal exceeding a specified threshold value.

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$$CCDF[PAPR(X^n(t))] = prob[PAPR(X^n(t) > \delta)] \quad (3)$$

PAPR REDUCTION SCHEMES

The literature [1] presents several reduction schemes. These reduction techniques are mainly categorized into three types. Multiple signaling and probabilistic techniques, signal distortion techniques and coding techniques.

Multiple Signaling and Probabilistic Techniques

These techniques work in two types. First one is to make different permutations of OFDM signal and transmitting one with least PAPR. And the second way is to change the OFDM signal by introducing phase shifts or by changing the constellation points. To minimize the PAPR, the modification parameters are optimized. Partial transmit sequence [3] [4] and selective mapping techniques belong to this category.

A. Signal Distortion Techniques

In this type, the transmitted OFDM signal is distorted before passing the signal through the power amplifier. These schemes decrease the PAPR considerably at the cost of in band and out of band distortions which lead to increased BER. The best-known signal distortion techniques are clipping and filtering, peak windowing and companding techniques [1].

B. Coding Techniques

The error control ability of some coding techniques makes them a choice to perform reduction in PAPR. Linear block codes and golay sequence codes are used [1].

METHOD COMBINING PTS AND APPR

Partial Transmit Sequence

In PTS technique, input data is partitioned into a number of disjoint sub blocks [3] [4] [5]. IFFT is applied for these sub blocks separately. Then these blocks are weighted by phase factors. Phase factors are considered in such a way as to minimize the PAPR of the signal.

Let X be considered as the input data. It is divided into sub blocks. Then X is represented as

$$X = \sum_{m=1}^{M} X_m \quad (4)$$

In PTS the weighted combination of sub blocks are to be formed.

$$X' = \sum_{m=1}^{M} b_m X_m \quad (5)$$

Where b_m is phase factor.

In time domain the signal is

$$x' = \sum_{m=1}^{M} b_m x_m \quad (6)$$

x_m is the partial transmit sequence. It is obtained by IFFT of X_m.

Adaptive Peak Power Reduction

APPR guide the peak of modulation signal by using an adaptive algorithm [2] [6]. Fig 1 gives the block diagram of APPR and Fig 2 [2] represents PAPR reduction method which combines PTS and APPR.

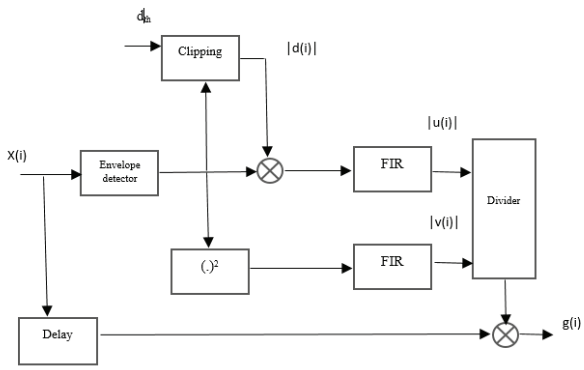

Fig 1: Block diagram of APPR

This approach decreases the peak of the signal over a predefined range. Input for the APPR block is OFDM signal.

Component $|d(i)|$ in fig 1 [2] is generated by

$$d(i) = \begin{cases} d_{th} exp\{j.\arg(x(i))\} & |x(i)| > d_{th} \\ x(i) & |x(i)| \le d_{th} \end{cases} \quad (7)$$

And then, $|x(i)|$ and $|d(i)|$ are multiplied. The result of multiplication is fed to FIR filter. It produces the cross correlation between these signals weighted by b_j is given by

$$u(i) = \frac{1}{M+1} \sum_{m=-M/2}^{M/2} b(m + M/2).\, x(i-m).\, d^*(i-m) \quad (8)$$

Where the weighing factor $b(j)$ is given Blackman-Harris window function

$$b(j) = 0.35875 - 0.48829 \cos\left(\frac{2\pi j}{M}\right) + 0.14128 \cos\left(\frac{4\pi j}{M}\right) - 0.01168 \cos\left(\frac{6\pi j}{M}\right) \quad (9)$$

At the same time, the auto correlation function of $|x(i)|$ weighted by $b(j)$ is calculated as,

$$v(i) = \frac{1}{M+1}\sum_{m=-M/2}^{M/2} b\left(m+{}^{M}\!/_{2}\right).x(i-m).x^{*}(i-m) \qquad (10)$$

The gain is,

$$g(i) = \begin{cases} {}^{u(i)}\!/_{v(i)} & v(i) > 0 \\ 1 & v(i) = 0 \end{cases} \qquad (11)$$

This gain is multiplied with modulation signal there by reducing the peak of the signal.

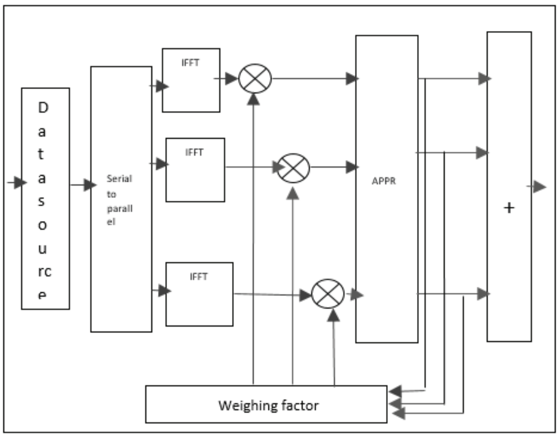

Fig 2: Block diagram of method combining PTS and APPR

RESULTS AND DISCUSSIONS

Simulation results are shown to compare and evaluate the performance of PTS, the method combining both techniques. The chosen parameters for this simulation are listed in table 1.

TABLE I: The parameter used for simulation

Number of data sub-carriers	48
Modulation	64-QAM
d_{th}	0.8
Number of sub-blocks	4
Number of data sub carriers	48
Window function	Blackman-Harris
Channel model	AWGN Channel
Data Rate	54 Mbps
Phase rotations	0, π/2, π, 3π/2
Number of FFT points	64

C. PAPR performance

Fig 3 illustrates the performance of PAPR. It shows the PAPR performance of techniques PTS, APPR. The method which combines PTS and APPR can reduce PAPR better than PTS.

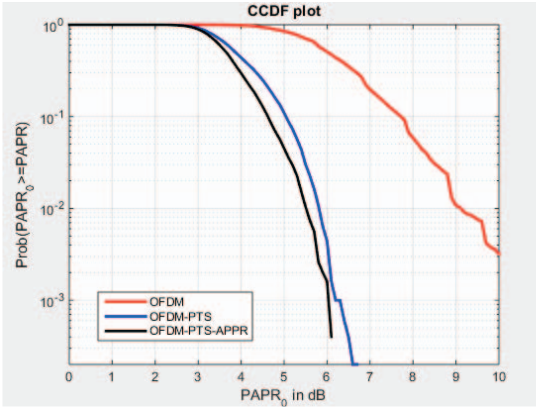

Fig 3: Comparision of PAPR

D. BER performance

Fig 4 depicts the comparison of BER performance of conventional OFDM, PTS and method combining PTS and APPR. It shows better BER performance for the method which combines PTS and APPR.

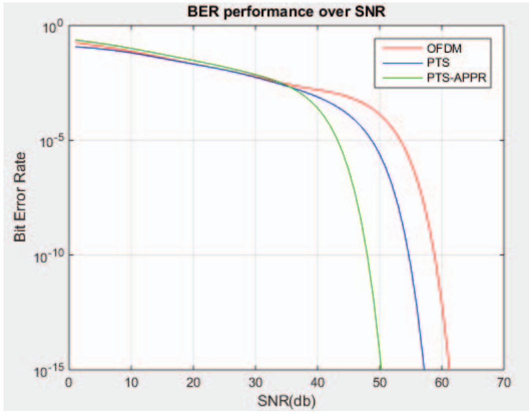

Fig 4: BER performance

CONCLUSIONS

In this paper a method of PAPR reduction which combines PTS and APPR techniques has been compared with PTS technique. In this method the data is fed to PTS technique to reduce PAPR. The sequence with less PAPR is given to APPR block. In simulation results it shows that the PAPR is reduced by approximately 1 dB compared to PTS technique and with respect to BER at SNR of 45 db the combination of PTS and APPR offers a BER of 10^{-5} while PTS offers a value of 10^{-3}. Concerning PAPR and BER, the combination of PTS and APPR provides significant improvement as compared to PTS technique.

REFERENCES

Y. Rahmatallah and S. Mohan, "Peak-To-Average Power Ratio Reduction in OFDM Systems: A Survey And Taxonomy," in *IEEE Communications Surveys & Tutorials*, vol. 15, no. 4, pp. 1567-1592, Fourth Quarter 2013.

C. Pradabpet, S. Yoshizawa, Y. Miyanaga and K. Dejhan, "A new PAPR reduction in OFDM-WLAN systems by hybrid algorithm of PTS and APPR methods," *2007 Asia-Pacific Conference on Communications*, Bangkok, 2007, pp. 145-148.

H. Liang, Y. R. Chen, Y. F. Huang and C. H. Cheng, "A modified genetic algorithm PTS technique for PAPR reduction in OFDM systems," *2009 15th Asia-Pacific Conference on Communications*, Shanghai, 2009, pp. 182-185.

L. S. Hameed, "A combined weighting and PTS technique for PAPR reduction in OFDM signals," *Current Trends in Engineering and Technology (ICCTET), 2014 2nd International Conference on*, Coimbatore, 2014, pp. 228-232.

N. A. Gokkul, A. A. Kumar, S. H. Kumar and M. Ramakrishnan, "Performance improvement of OFDM using hybrid PAPR reduction technique," *Computing, Communications and Networking Technologies (ICCCNT),2013 Fourth International Conference on*, Tiruchengode, 2013, pp. 1-4.

C. Pradabpet, S. Yoshizawa, Y. Miyanaga and K. Dejhan, "Searching phase optimize in PTS-APPR method by GA for PAPR reduction in OFDM-WLAN systems," *Innovative Technologies in Intelligent Systems and Industrial Applications, 2009. CITISIA 2009*, Monash, 2009, pp. 393-397.

L. S. Hameed, "A combined weighting and PTS technique for PAPR reduction in OFDM signals," *Current Trends in Engineering and Technology (ICCTET), 2014 2nd International Conference on*, Coimbatore, 2014, pp. 228-232.

K. Sahu and K. T. Veeramanju, "PAPR Reduction in OFDM System Using Iterative Clipping and Filtering Technique Along with Convolutional Code," *Communication Systems and Network Technologies (CSNT), 2015 Fifth International Conference on*, Gwalior, 2015, pp. 412-415.

C. Anjaiah and Hari Krishna Prasad P., "Mu-Law companded PTS for PAPR reduction in OFDM systems," *Electrical, Computer and Communication Technologies (ICECCT), 2015 IEEE International Conference on*, Coimbatore, 2015, pp. 1-4.