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A Novel Algorithm for peak to Average Ratio Reduction in Wireless OFDM Systems

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Abstract: *In OFDM systems, the major obstacle is that the multiplex signal exhibits a very high peak-to-average power ratio (PAR) In this paper propose a new novel method to reduce the PAR.A simple and attractive technique is Active cancellation extension used. However, we observe it cannot achieve the minimum PAR when the target clipping level is set below an initially unknown optimum value. A low clipping ratio is the problem in OFDM system to overcome this AEC algorithm with adaptive clipping control. However the simulation results shows our algorithm can reach the minimum Peak to Average for several clipping ratios, and also in AWGN channel we calculate the tradeoff between PAR and the loss in Eb/No.*

Keywords: *Peak-to-average ratio (PAR), active constellation extension (ACE), adaptive, OFDM, BER, AWGN.*

I. INTRODUCTION

Orthogonal frequency division multiplexing is a very attractive technique for high speed data transmission in mobile communications due to various advantages such as high spectral efficiency, robustness to channel fading, immunity to impulse interference, and capability of handling very strong multi-path fading and frequency selective fading without having to provide powerful channel equalization . In recent years, several industrial standards based on OFDM have been emerged, such as the Terrestrial Digital Video Broadcast (DVB-T), the IEEE 802.11 Wireless Local Area Network (WLAN) scheme, as well as the IEEE 802.16 Broadband Wireless Access (BWA), particularly, Wireless Metropolitan Area Networks (IEEE 802.16d) WiMAX.

Besides a lot of advantages, some drawbacks become apparent, when using OFDM in transmission systems. A major obstacle is that the multiplex signal exhibits a very high peak-to-average power ratio (PAR). Therefore, nonlinearities may get overloaded by high signal peaks, causing inter modulation among subcarriers and, more critical, undesired out-of-band radiation. If RF power amplifiers are operated without large power back-offs, it is impossible to keep the out-of-band power below specified limits. This leads to very inefficient amplification and expensive transmitters so that it is highly desirable to reduce the PAR [3]. Several schemes have been proposed to reduce the PAPR. These techniques can mainly be categorized into Signal scrambling techniques and Signal distortion techniques [1]. Signal scrambling techniques are all variations on how to scramble the codes to decrease the PAPR. Coding techniques can be used for signal scrambling. Golay complementary sequences, Shapiro-Rudin sequences, M-sequences, Barker codes can be used to efficiently reduce the PAPR. However, with the increase in the number of carriers, the overhead associated with exhaustive search of the best code would increase exponentially. More practical solutions of the signal scrambling techniques are block coding, selective mapping and partial transmit sequences.

In this paper, to solve the low clipping ratio problem of CBACE, we introduce a new method of ACE for PAR reduction. Here, The PAR reduced by extending some modulation constellation points without any loss of data in outside of constellation. The cost of this is low and complexity also low, so that's why we proposing Active constellation extension. The algorithm provides a suboptimal solution to the given clipping ratio, because the clipping ratio is predetermined at the initial stage. However, the CB-ACE algorithms have a low clipping ratio problem in that they cannot achieve the minimum PAR.

In this correspondence clipping ratio problem of CBACE, we introduce a new method Active constellation extension for to reduce the PAR. Our algorithm based on the clipping with an adaptive clipping control, which allows us to find the optimal clipping level. simulation results shows that our algorithm can achieve the minimum Peak to Average Ratio regardless of the low target clipping level, and also calculate the tradeoff between PAR and BER over an AWGN channel in terms of clipping ratio.

II. TOPICS RELATED TO PROPOSED CONCEPT

A.Peak to Average Ratio:

OFDM signals have a higher peak-to-average ratio (PAR) often called a peak-to-average power ratio (PAPR) than single-carrier signals do. The reason is that in the time domain, a multicarrier signal is the sum of many narrowband signals. At some time instances, this sum is large and at other times is small, which means that the peak value of the signal is substantially larger than the average value. This high PAR is one of the most important implementation challenges that face OFDM, because it reduces the efficiency and hence increases the cost of the RF power amplifier, which is one of the most expensive components in the radio.

B.The PAR Problem:

When transmitted through a nonlinear device, such as a high-power amplifier (HPA) or a digital to analog converter (DAC) a high peak signal, generates out-of-band energy (spectral re growth) and in-band distortion (constellation tilting and scattering). These degradations may affect the system performance severely. The nonlinear behavior of an HPA can be characterized by amplitude modulation/amplitude modulation (AM/AM) and amplitude modulation/phase modulation (AM/PM) responses. Figure (1) shows a typical AM/AM response for an HPA, with the associated input and output back-off regions (IBO and OBO, respectively).

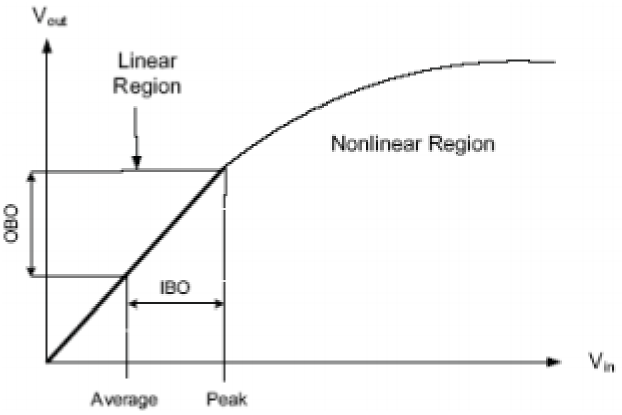

Figure 1: A typical power amplifier response

To avoid such undesirable nonlinear effects, a waveform with high peak power must be transmitted in the linear region of the HPA by decreasing the average power of the input signal. This is called (input) back off (IBO) and results in a proportional output back off (OBO). High back off reduces the power efficiency of the HPA and may limit the battery life for mobile applications. In addition to inefficiency in terms of power, the coverage range is reduced, and the cost of the HPA is higher than would be mandated by the average power requirements. The input backoff is defined as:

$$IBO = 10\log_{10}\frac{P_{in\,sat}}{P_{in}}$$

Where **Pinst** is the saturation power, above which is the nonlinear region, and **Pin** is the average input power. The amount of backoff is usually greater than or equal to the PAR of the signal. The power efficiency of an HPA can be increased by reducing the PAR of the transmitted signal. Clearly, it would be desirable to have the average and peak values are as close together as possible in order to maximize the efficiency of the power amplifier. In addition to the large burden placed on the HPA, a high PAR requires high resolution for both the transmitter's DAC and the receiver's ADC, since the dynamic range of the signal is proportional to the PAR. High-resolution D/A and A/D conversion places an additional complexity, cost, and power burden on the system.

III. CB-ACE IN OFDM SYSTEMS

An OFDM signal consists of the sum of *N* independent signals modulated in the frequency domain onto sub channels of equal bandwidth. As a continuous-time equivalent signal, the oversampled OFDM signal is expressed as

$$x_n = \frac{1}{\sqrt{JN}}\sum_{k=0}^{JN-1} X_k e^{j2\pi\frac{k}{JN}n},\ \ n = 0,1,\ldots,JN-1 \quad (1)$$

where *N* is the number of subcarriers; are the complex data symbols using phase-shift keying (PSK) or quadrature amplitude modulation (QAM) at the Kth subcarrier; and J is the oversampling factor where J ≥ 4, which is large enough to accurately approximate the peaks [4]. In matrix notation, (1) can be expressed as **x** = **Q*X**, where is the inverse discrete Fourier transform (IDFT) matrix of size *JN* × *JN*, denotes the Hermitian conjugate, the complex time-domain signal vector X.

X = $[x_0, x_1, x_2 \dots \dots, . ,$

X= $[X_0, X_1, X_2 \dots\dots, \dots, X_{\frac{N}{2}-1}, 0_{1X(J-1)N}, X_{N/2}, X_{\frac{N}{2}+1} \dots\dots, \dots, X_{N-1}]^T$

Here, we do not consider the guard interval, because it does not impact the PAR, which is defined as

$$\mathrm{PAR}(\mathbf{x}) \triangleq \frac{\max_{0\le n\le JN-1}|x_n|^2}{E[|x_n|^2]}, \qquad (2)$$

Note that (2) does not include the power of the anti-peak signal added by the PAR reduction. Let £ be the index set

$$\min_{\mathbf{C}} \|\mathbf{x}+\mathbf{Q}^*\mathbf{C}\|_\infty^2$$
$$\text{subject to}: X_k + C_k \text{ be feasible for } k\in\mathcal{I}_a, \qquad (3)$$
$$C_k = 0,\ \text{ for } k\notin\mathcal{I}_a$$

where **C** is the extension vector whose components,

are non zero only if $k \in £_a$

However, this optimal solution for this ACE formulation of PAR reduction is not appropriate for practical implementation due to high computational complexity. Thus, the CB-ACE algorithms are introduced [1], [2]. The basic idea of the CB-ACE algorithm is to generate the anti-peak signal for PAR reduction by projecting the clipping in-band noise into the feasible extension area while removing the out-of-band distortion with filtering. Thus, the CB-ACE method is considered as a repeated-clipping-and filtering (RCF) process with ACE constraints as follows:

$$\mathbf{x}^{(i+1)} = \mathbf{x}^{(i)} + \mu\tilde{\mathbf{c}}^{(i)} \qquad (4)$$

where μ is a positive real step size that determines the convergence speed, i is the iteration index, the initial signal is, $\boldsymbol{x}^{(0)}$ and $\boldsymbol{c}^{\sim(i)}$ is the anti-peak signal at the ith iteration as follows:

where $c_n^{(i)}$ is the clipping sample, which can be obtained as follows:

$$c_n^{(i)} = \begin{cases} (|x_n^{(i)}| - A)e^{j\theta_n}, & \text{if } |x_n^{(i)}| > A \\ 0, & \text{if } |x_n^{(i)}| \le A \end{cases}, \qquad (5)$$

where $\theta n = \arg(-x_n^i)$ The clipping level A is related to the clipping ratio γ as $\gamma = \frac{A^*}{E\{|x_n|^2\}}$ In general, we expect more

PAR reduction gain with a lower target clipping level; the existing CBACE algorithms cannot achieve the minimum PAR for low target clipping ratios, because the reduced power by low clipping decreases the PAR reduction gain in ACE. The original symbol constellations move toward the origin with the decreasing clipping ratio in [6], which places the clipped signal constellations outside the feasible extension region. The number of $\mathcal{E}_a$, corresponding to the number of reserved tones in tone reservation (TR), as in [7], decreases with low clipping ratio, which in turn degrades the PAR reduction capacity in ACE.

IV. PROPOSED CONCEPT AND ALGORITHM

The main objective of our proposed algorithm is to control both the clipping level and convergence factor at each iteration and to iteratively minimize the peak power signal greater than the target clipping level. The cost function is defined as

$$\xi(I^{(i)}) \triangleq \min_{\mu,A} \|\mathbf{x}^{(i)} + \mu\tilde{\mathbf{c}}^{(i)} - Ae^{j\Phi^{(i)}}\|_2^2 \tag{6}$$

Where $\emptyset^{(i)}$ is the phase vector of $x^{(i)}+\mu c^{\sim(i)}$ at the i th iteration and $I^{(i}$represents the set of time indices at the ith iteration,

$$I^{(i)} = \{\forall n \text{ s.t. } n \in [0, JN-1]\}$$

Step 0: Initialize the parameters

- Select the target clipping level *A*.
- Set up the maximum number of iterations *L*.

Step 1: Set $i = 0,, x^{(0)}) = \mathbf{x}$ and $A^{(0)} = A$.
Step 2: Compute the clipping signal in (5); if there is no clipping signal, transmit signal, **x**(*i*).
Step 3: Transfer the clipping signal into the anti-peak signal subject to ACE constraint;
Convert into $c^{(i)}$into $C^{(i)}$

- Project $C^{(i}$ onto the feasible region in ACE and remove the out-of-band of $C^{(i)}$
- Obtain $c^{\sim(i)}$ by taking the IDFT.

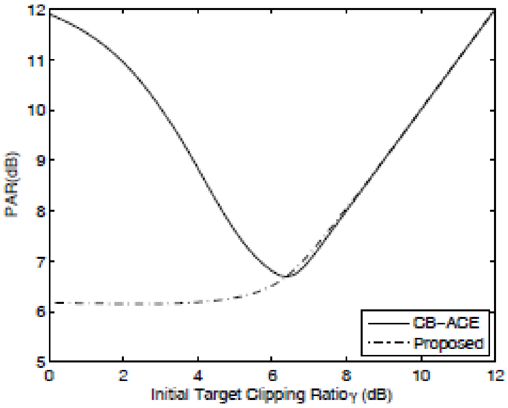

Figure 2: The achievable PAR of CB-ACE and the proposed algorithm for an OFDM signal with a 12dB PAR, for different initial target clipping ratios.

Step 4: Update $x^{(i)}$ in (4) and *A* minimizing (6). Compute the optimal step size μ,

$$\mu = \frac{\Re[\langle \mathbf{c}^{(i)}, \tilde{\mathbf{c}}^{(i)} \rangle]}{\langle \tilde{\mathbf{c}}^{(i)}, \tilde{\mathbf{c}}^{(i)} \rangle}, \tag{7}$$

where R defines the real part and ⟨, ⟩ is the complex inner-product. Adjust the clipping level *A*

$$A^{(i+1)} = A^{(i)} + \nu\nabla_A, \tag{8}$$

Where the gradient with respect to *A* is

$$\nabla_A = \frac{\sum_{n\in I_1^{(i)} \cup I_3^{(i)}} |c_n^{(i+1)}|}{N_p} \tag{9}$$

and ν is the step size with $0 \le \nu \le 1$ and *Np* is the number of peak samples larger than *A*.

Step 5: Increase the iteration counter, *i* = *i*+1. If $i < L$, go to *Step 2* and repeat; otherwise, transmit signal, $x^{(i)}$.

Compared to the existing CB-ACE with complexity of order (*JN* log*JN*), the complexity of our proposed algorithm slightly increases whenever the adaptive control is calculated in (8). However, this additional complexity of the adaptive control is negligible compared to that of order *O*(*JN* log*JN*).

V. MATLAB/SIMULINK RESULTS

In this section, we illustrate the performance of our proposed algorithm using computer simulations. In the simulations, we use an OFDM system with 2048 subcarriers and M-QAM constellations on each subcarrier. To approximate the continuous-time peak signal of an OFDM signal, the oversampling rate factor J = 8 is used in (1). For a fast convergence rate, the optimal adaptive scaling is applied. Fig. 2 compares the achievable PAR of CB-ACE with the optimal adaptive scaling with that of our proposed algorithm for an OFDM signal with an initial 12dB PAR and 16-QAM modulation, for different target clipping ratios γ from 0dB to 12dB. In the case when CB-ACE is applied, we find the minimum achievable PAR, 6.62dB, is obtained with a target clipping ratio of 6.4dB, which shows that CB-ACE depends on the target clipping ratio, as we mentioned in the previous section. The PAR reduction gain becomes smaller with a decreasing target clipping ratio from the optimal value of 6.4dB. Thus, we must carefully select the target clipping ratio

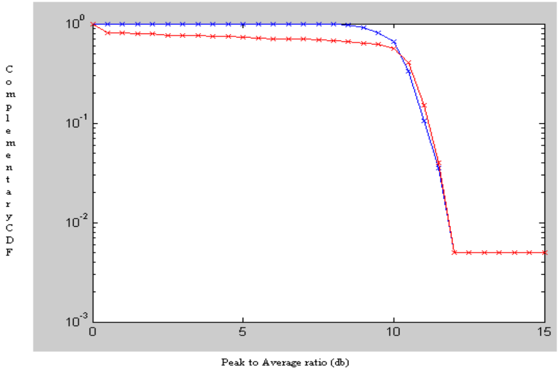

Figure-3 PAR CCDF comparison of the CB-ACE and the proposed method for different initial target clipping ratios

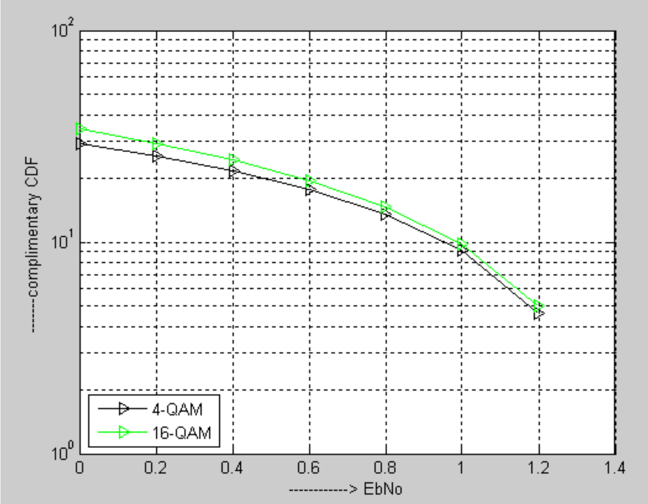

Figure 4: PAR for CCDF 10−3 vs loss in *Eb/No* at the BER of 10−3 for different QAM constellation orders of the proposed algorithm.

for CB-ACE. On the other hand, we observe that our proposed algorithm can achieve the lower minimum PAR even when the initial target clipping ratio is set below the CB-ACE optimal value of 6.4dB. It is obvious that our proposed algorithm solves the low target clipping ratio problem associated with the CB-ACE, as shown in Fig.3 . Fig. 4 considers two algorithms: CB-ACE and our proposed method for three different initial target clipping ratios, γ = 0dB, 2dB, and 4dB, in terms of their complementary cumulative density function (CCDF). The solid line curve at the right is plotted for the original OFDM signal. The marked lines correspond to the PAR reduced signals of CB-ACE and our proposed method after 10-iterations, which we have confirmed is sufficient for convergence. For a 10−3 CCDF, CB-ACE with initial target clipping ratios of γ = 0dB, 2dB,and 4dB can achieve a 0.14dB, 0.89dB, and 2.95dB PAR reduction from the original PAR of 12dB, respectively. In other words, when the target clipping ratio is set low, the achievable gain in PAR reduction decreases, which is opposite to our general expectation, but is consistent with the trend shown in Fig.1.On the other hand, our proposed algorithm shows about a 5.6dB reduction gain in PAR at 10−3 CCDF for all three of the initial low target clipping ratios. Fig. 4 plots the performance of our proposed algorithm considering both PAR and loss in *Eb/No* over an AWGN channel for the different M-QAM symbols. The x-axis indicates the loss in *Eb/No* with respect to *Eb/No* of the original OFDM signal for a given targeted BER of 10−3, and the y-axis shows the required PAR at a CCDF of 10−3. The tradeoff curves for M-QAM symbols is plotted as a function of the target clipping ration γ, ranging from 10dB to 0dB in increments of -1dB. The curve with triangles down is for QAM, the curve with triangles up is for 16-QAM, and the one with squares is for 64-QAM. For a clipping ratio of 10dB, the three curves meet each other at a PAR of 10dB. As the clipping ratio decreases, the symbols move toward the bottom right direction; the achievable PARs for different constellation sizes are moving to their minimum points with a decreasing clipping ratio. Our proposed algorithm reaches the minimum PARs: 5.55dB, 6.42dB, and 7.07dB for QAM, 16-QAM, and 64-QAM, respectively. These different minimum PARs come from the inherent ACE constraint that the higher the order of the constellation, the less flexibility [5]. However, we observe that the loss in *Eb/No* for each different constellation is about 1.06dB, even though the achievable minimum PAR depends on the constellation size. It is clear that our proposed algorithm provides the tradeoff curve between PARs and the loss in *Eb/No* for the M-QAM constellations as a function of the target clipping ratio.

VI. CONCLUSION

In this paper propose a new novel method to reduce the PAR.A simple and attractive technique is Active cancellation extension used. However, we observe it cannot achieve the minimum PAR when the target clipping level is set below an initially unknown optimum value. A low clipping ratio is the problem in OFDM system to overcome this AEC algorithm with adaptive clipping control. The minimum Peak to Average for several clipping ratios, and also in AWGN channel we calculate the tradeoff between PAR and the loss in *Eb/No* **.**

References

[1] Kitaek Bae, , Jeffrey G. Andrews, and Edward J. Powers" Adaptive Active Constellation Extension Algorithm for Peak-to-Average Ratio Reduction in OFDM," in *IEEE Commun. Lett*, Vol. 14, No. 1 pp. 39— 41 , Jan ,2010.

[2] L. Wang and C. Tellambura, "An adaptive-scaling algorithm for OFDM PAR reduction using active constellation extension," in *Proc. IEEE Veh. Technology Conf.*, Sep. 2006, pp. 1–5.

[3] E. Van der Ouderaa, J. Schoukens, and J. Renneboog, "Peak factor minimization using a time-frequency domain swapping algorithm," *IEEE Trans. Instrum. Meas.*, vol. 37, no. 1, pp. 145–147, Mar. 1988.

[4] C. Tellambura, "Computation of the continuous-time PAR of an OFDM signal with BPSK subcarriers," *IEEE Commun. Lett.*, vol. 5, no. 5, pp. 185–187, May 2001.

[5] Y. Kou, W.-S. Lu, and A. Antoniou, "New peak-to-average powerratio reduction algorithms for multicarrier communications," *IEEE Trans. Circuits and Syst.*, vol. 51, no. 9, pp. 1790–1800, Sep. 2004.

[6] M. Friese, "On the degradation of OFDM-signals due to peak-clipping in optimally predistorted power amplifiers," in *Proc. IEEE Globecom*, Nov. 1998, pp. 939–944.

[7] J. Tellado, *Multicarrier Modulation with Low PAR: Applications to DSL and Wireless*. Boston: Kluwer Academic Publishers, 2000.

[8] B. S. Krongold and D. L. Jones, "PAR reduction in OFDM via active constellation extension," *IEEE Trans. Broadcast.*, vol. 49, no. 3, pp. 258– 268, Sep. 2003