Peak to Average Power Ratio Reduction in 4G Wireless Communication

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***Abstract*— In this paper we propose the reduction of PAPR by comparing Constant Modulus Algorithm and selected mapping with Constant Modulus Algorithm, Selected mapping and tone reservation. Constant Modulus Algorithm is used in adaptive equalization algorithm. The aim of adaptive equalization is to recover the unknown input data sequence to the unknown channel based on the probabilistic nature of the input data sequence. The receiver receives the data sequence by maintaining constant modulus property. The results of CMA and SLM are compared with Selected Mapping (SLM), Tone Reservation (TR) and Constant Modulus Algorithm CMA.**

***Index Terms*— Orthogonal frequency division multiplexing (OFDM), Selected mapping (SLM), Tone reservation(TR), Constant modulus algorithm (CMA).**

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) [1],[2],[3] is widely used in wireless communication applications with high-speed data transmission. In Orthogonal Frequency Division Multiplexing the large data symbols are divided into a set of smaller data symbols. OFDM is a multi carrier transmission system transmitting more data symbols on sub-carriers through transmission medium at high data rate. The OFDM signal has amplitude with a very large dynamic range therefore it needs radio frequency power amplifiers with a large peak to average ratio.

In SLM technique the data symbols are mapped and multiplied with phase factors. The approach is applicable to all types of modulation, with any number of sub carriers. The tone reservation method takes advantage of the orthogonality between the subcarriers. When the information bits are modulating sub-carriers, other unused subcarriers are used as a basis for the reduction of PAPR. In Constant Modulus Algorithm the PAPR is reduced by updating its weight vectors and maintaining constant modulus.

II. PAPR

The peak to average power ratio for a signal x(n) is defined as

$$\text{PAPR} = \frac{\max\left|x(n)\right|^2}{E\left[\left|x(n)\right|^2\right]} \qquad (1)$$

The CCDF of PAPR is given by

$$\Pr(\text{PAPR} > \gamma_o) = 1 - \Pr(\text{PAPR} < \gamma_o) \qquad (2)$$

The CCDF is used to measure PAPR of a signal. The CCDF of PAPR increases with the number of subcarriers.

III. SELECTED MAPPING

Selected Mapping technique [1],[3],[4] is used to make fewer occurrences of peaks than reducing the peaks. In selected mapping initially data sequence is applied to serial to parallel converter which converts serial data sequence into parallel data sequence. This data is multiplied with phase factors, then applied to IFFT for converting to time domain. In the time domain signal data with less PAPR is selected and sent the information about less PAPR symbol over transmission medium to the receiver. Fig-1 shows the block diagram of selected mapping technique for minimizing the high PAPR.

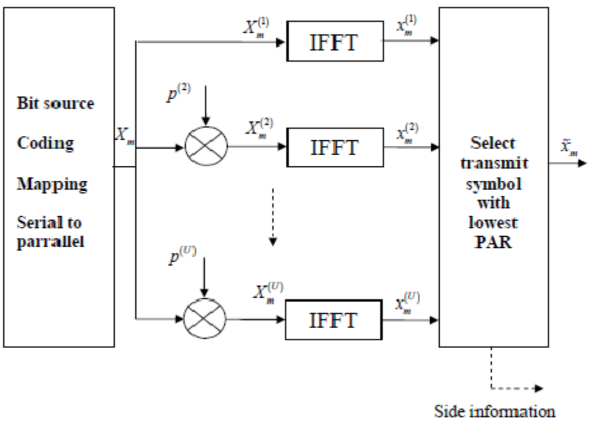

Figure 1: Block diagram of SLM technique

The CCDF of the data sequence PAPR above certain threshold γ_o is written as Pr ($\gamma > \gamma_o$). The probability of PAPR less than a threshold γ_o can be written as

$$\Pr(\gamma < \gamma_o) = F(\gamma_o)^N = (1-\exp(\gamma_o))^N \qquad (3)$$

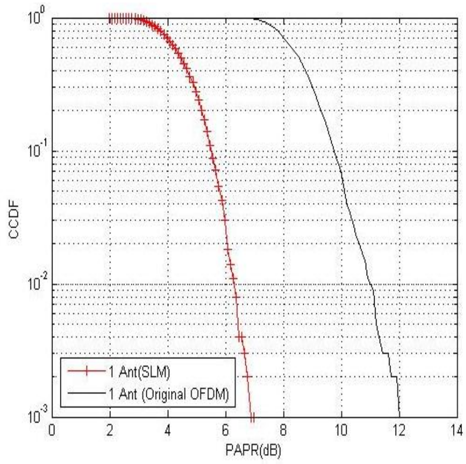

Figure 2: PAPR reduction using SLM

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In this case, the probability of PAPR greater than γ_o is equals to the product of each independent probability. This process can be written as

$$\Pr\{PAPR > \gamma_o\} = (P\{PAPR > \gamma_o\})^M = (1-(1-\exp(-\gamma_o))^N) \quad (4)$$

IV. TONE RESERVATION

In Tone Reservation [2],[3],[5], tones are used for reducing PAPR. These tones do not carry any information and used for peak reduction. This restricts the data vector X, and the tone vector C to lie in different frequency subspaces.

$$X_k + C_K = \begin{cases} C_K, K \in L \\ X_k, K \in L^c \end{cases} \quad (5)$$

The subset of used tones are denoted by L={i_0,.. i_L} with L $\leq$N, where N represent the set of all tones in the multi carrier symbol L^C is the complement of L in N and represent information carriers. The addition of these reserved tones c to a data-bearing signal x a new composite signal

$$\bar{x}[n] = x[n] + c[n] = IFFT\,(X_K + C_K) \quad (6)$$

Since symbol demodulation is performed in the frequency domain on a tone-by-tone basis, the reserved sub-channels can be discarded at the receiver, and only the data-bearing sub-channels are used to determine the transmitted bit stream. The PAPR becomes

$$PAPR = \frac{\max|x(n)+c(n)|^2}{E[x(n)]^2} \quad (7)$$

The PAPR can be reduced by optimizing c(n) so that $\max|x(n)+c(n)|^2$ can be smaller than $\max|x(n)|^2$.

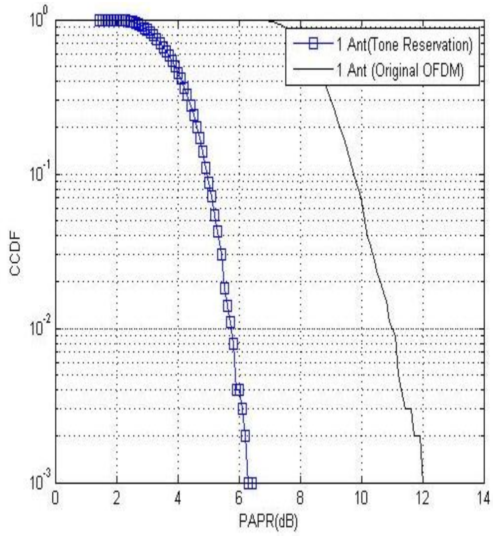

Figure 3: PAPR reduction using TR

V. CMA

Equalization is used to correct frequency distortion in communication system. Constant Modulus Algorithm [6],[7],[8] is used in adaptive equalizer. Many modulation techniques like FM, PM, FSK, PSK have constant modulus. The Constant Modulus Algorithm is efficient adaptive equalization algorithm and it is used in many applications because it is not required carrier synchronization.

The adaptive equalization performs on data without reference to data signal. Instead, the adaptive equalization relies on the knowledge of the signal structure and its probabilistic nature to perform equalization. The source is unknown but has constant modulus: $|S_k|$ =1for all k.

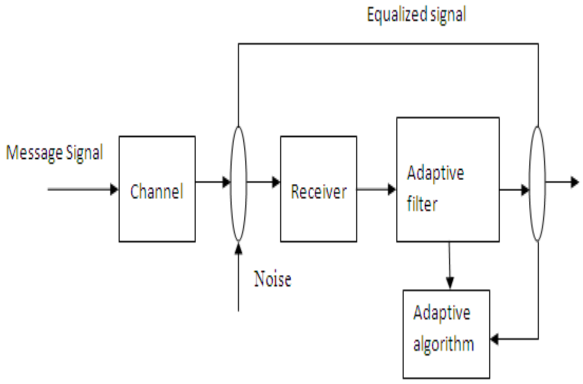

Figure 4: PAPR reduction using CMA

In CMA we use cost function and weight vector for minimizing modulus variation. Figure 5 shows CCDF of constant modulus algorithm.

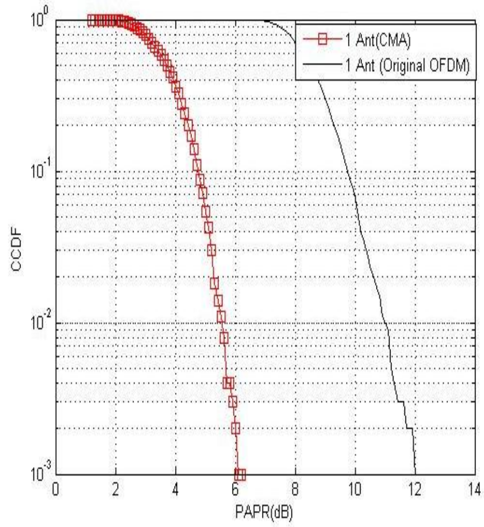

Figure 5: PAPR reduction using CMA

VI. PRAPOSED WORK (CMA+SLM)

PAPR is reduced in CMA, but further reduction is possible by combining Constant Modulus algorithm with scrambling technique Selected Mapping (SLM). In selected mapping (SLM) method phase factors are used for making fewer occurrences of peaks than reducing peaks. In this technique no side information is required.

The receiver is synchronized to the received signal and adjusted to the equalizer without training sequence. The Constant Modulus Algorithm is employed for the Adaptive Equalization. In CMA source is unknown but source has constant modulus: $|S_k|$ = 1 for all k. Many communication signals have the constant modulus (CM) property: FM, PM, FSK, PSK,... by using this constructed a receiver weight vector w such that

$y_k = \mathbf{W}^H x_k = \hat{S}_k$ where $\mathbf{W}^H$ is weight factor.

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In this work PAPR is reduced by maintaining low BER. In CMA with SLM technique cost function and weight vector are used for minimizing modulus variation. Figures-6 and 7 show the comparison of CCDF, BER of CMA and SLM with Constant Modulus algorithm, Selected Mapping, Tone Reservation and Original OFDM.

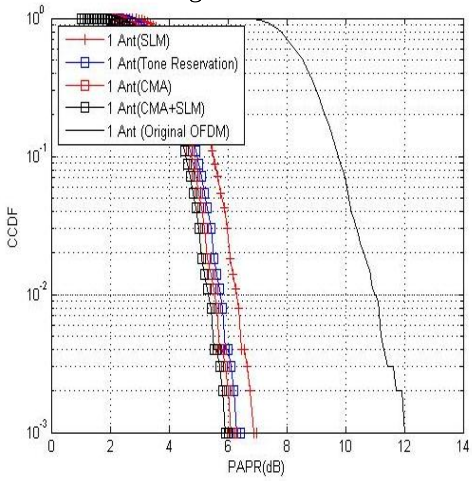

Figure 6: Comparison of CCDF

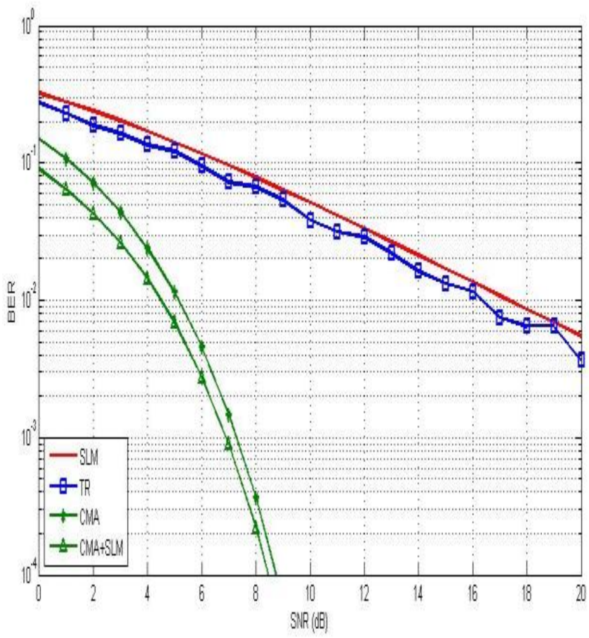

Figure 7: BER of SLM, TR, CMA, CMA+SLM

VI. CONCLUSION

In this paper compared the different PAPR reduction techniques like constant modulus algorithm with selected mapping, constant modulus algorithm, tone reservation and selected mapping. The PAPR is smallest in constant modulus algorithm with selected mapping. Figure 7 showed that BER is lowest in our work when compared with other techniques.

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