PAPR Reduction in OFDM using Reduced Complexity PTS with Companding

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Abstract — **The efficiency of high power amplifiers (HPA) is improved by many peak-to- average power ratio (PAPR) reduction Techniques. The probabilistic methods scramble the signal by computing with phase factors. Partial transmit Sequence (PTS) is one of the techniques which reduces PAPR. The computational complexity of PTS can be reduced by using cost function Qs for each OFDM symbol. The symbols with Qn ≥ threshold are considered as the signal with lowest PAPR. To promote the lowest PAPR a μ- law and A- law companding is used without amplifying the complexity.**

***Keywords* — Companding, OFDM, PAPR, PTS**

I. INTRODUCTION

. Orthogonal Frequency Division Multiplexing (OFDM) is an navigating technology for 3G and 4G Wireless and Mobile communication. OFDM is multiplexer and muticarrier technology disburses the data over large number of carriers spaced at definite frequencies. The interval provides orthogonality. OFDM is operated in [1] wired coaxial line i.e., xDSL cables and wireless communication like DVB, DAB, IEEE802.11, IEEE802.20, WiFi, WiMax. OFDM is a multicarrier which suprpress multipath distortion and improves spectral efficiency. Due to orthogonal carriers, OFDM signal has high PAPR which lowers efficiency of HPA. The high PAPR is mitigated by many techniques [2] like clipping, peak windowing, peak cancellation, companding, tone reservation, tone injection or by distorting the signal or by scrambling and spreading the signal like selected mapping(SLM), partial transmit sequence(PTS) [3][4], interleaving, precoding by using liable sequences. The hardware complexity is less in PTS technique but computational complexity increases as the number of IFFT's increases. The computational complexity is reduced by many reduced PTS techniques [5]- [8]. One technique is by applying Cost Function Qn to OFDM symbols [8]. To reduced complexity PTS summation, the A-law or μ- law compander is fixed to further improve HPA efficiency without hardware complexity.

A. OFDM

OFDM discrete time signal with oversampling (L)

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{n-1} X_k e^{\frac{j2\pi f_k t}{L}} \qquad \text{for } k = 0,1, \dots\dots\dots NL-1$$

B. *PAPR*

The PAPR for discrete – time version x[n] is:

$$PAPR(x[n]) = \max_{0\le n\le N-1} \frac{|x[n]|^2}{E[|x[n]|^2]}$$

$$PAPR\,\{x(t)\} = \frac{P_{peak}}{P_{avg}}$$

II. PAPR REDUCTION TECHNIQUES

A. Partial Transmit Sequence

The data symbols are separated by V disjoint subblocks. These subblocks continuous time OFDM siganl is computed with weighting factor $b_v = e^{j\theta i}$ for i = 0, ...V-1.

The symbols with optimum PAPR is selected.

B. Reduced Complexity Partial Transmit Sequence [8]

The OFDM PTS signal is:

$$x_{pts} = \sum_{v=1}^{V} b_v\, x_{v,s} \quad \text{for } b_v = e^{j\theta i} \text{ with 's' samples}$$

The power of above equation:

$$|x_{pts}|^2 = \left|\sum_{v=1}^{V} b_v\, x_{v,s}\right|^2 = \left(\sum_{v=1}^{V} b_v\, x_{v,s}\right)\left(\sum_{v=1}^{V} b_v\, x_{v,s}\right)^*$$

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$$= \underbrace{\sum_{v=1}^{V} |x_{v,s}|^2}_{Qs} +$$

$$\sum_{v1=1}^{V} \sum_{\substack{v2=1 \\ v2 \neq v1}}^{V} (b_{v1} x_{v,s})(b_{v2} x_{v2,s})^*$$

Qs is the sum of power of samples at time s in V subblocks. Samples with $Q_s \geq \frac{\emptyset_s}{V}$ is processed in each symbol for calculating PAPR ($\emptyset_s$minimum power).

C. *Companding Techniques* [9] – [12]

i. A - law companding:

A-law has non-zero value and it has mid riser at the origin point. Hence it contains non-zero value. The practically used value of "A" is 87.6 As shown in Fig. 1 low level inputs the characteristics is linearly segmented and for high level inputs the characteristics is logarithmic segmented.

$$y(x) =$$

$$\begin{cases} y_{max} \dfrac{A \dfrac{|x|}{x_{max}}}{(1+A)} \; sgn(x) & 0 < \dfrac{|x|}{x_{max}} \leq \dfrac{1}{A} \\ y_{max} \dfrac{\left[1 + log_e \left[A \dfrac{|x|}{x_{max}}\right]\right]}{(1 + log_e A)} \; sgn(x) & \dfrac{1}{A} < \dfrac{|x|}{x_{max}} \leq 1 \end{cases}$$

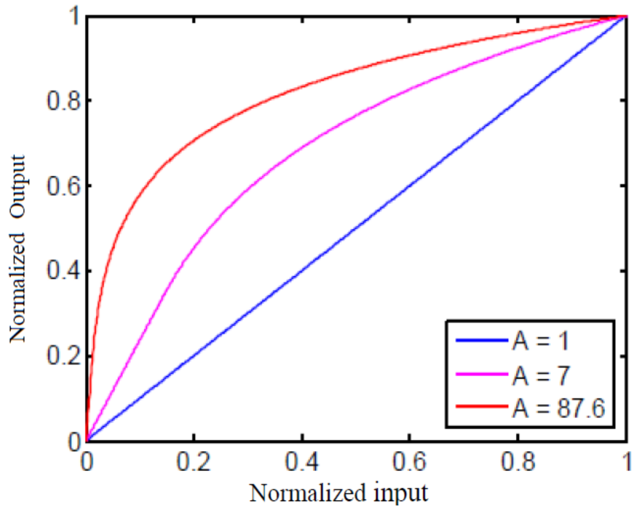

Fig. 1 A - law compressor characteristics

The value of A=87.6 (defined by CCITT (Consultative Committee for International Telephony and Telegraphy)). The A - Law companding is used in PCM for telephone communications.

ii. μ - law companding:

In μ - law companding, as shown in Fig. 2 the characteristics is linear when μ=0 (no compression) which is uniform quantization. μ - law has non-zero value and it has mid tread at the origin point. The practically used value of μ is 255.

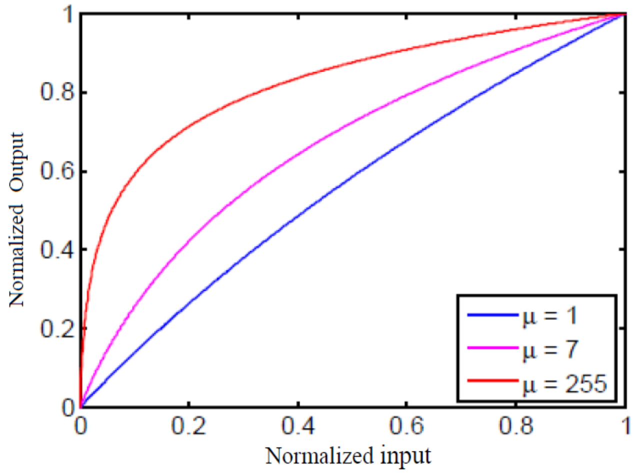

Fig. 2 μ-law compressor characteristics

The μ-law compressor characteristic is defined as:

$$y(x) = V \frac{\log(1+\mu\frac{|x|}{V})}{\log(1+\mu)} sgn(x)$$

Where V: peak amplitude of signal
x: instantaneous amplitude if input signal

III. PROPOSED METHOD

In this method the reduced complexity is combined with linear companding techniques as follows:

- As shown in Fig. 3 the data signal is divided into V disjoint subblocks
- find $x_v = IFFT\{X_V\}$
- compute $Q = \{Q_0, Q_1, \dots\dots\dots\dots\dots\dots, Q_{N-1}\}^T$

$$Q_s = \sum_{v=1}^{V-1} |x_{v,s}|^2 \qquad \text{for} \quad 0 \leq s \leq \text{N-1}$$

- tabulate $Q_s \geq \frac{\emptyset_s}{V}$ as a set(T)
- signals of the samples $s \in$ T are used to compute optimum signal for PAPR
- the computed optimum signal of samples $s \in$ T is again computed by A-law or μ-law companders
- The companded OFDM signal PAPR is calculated.

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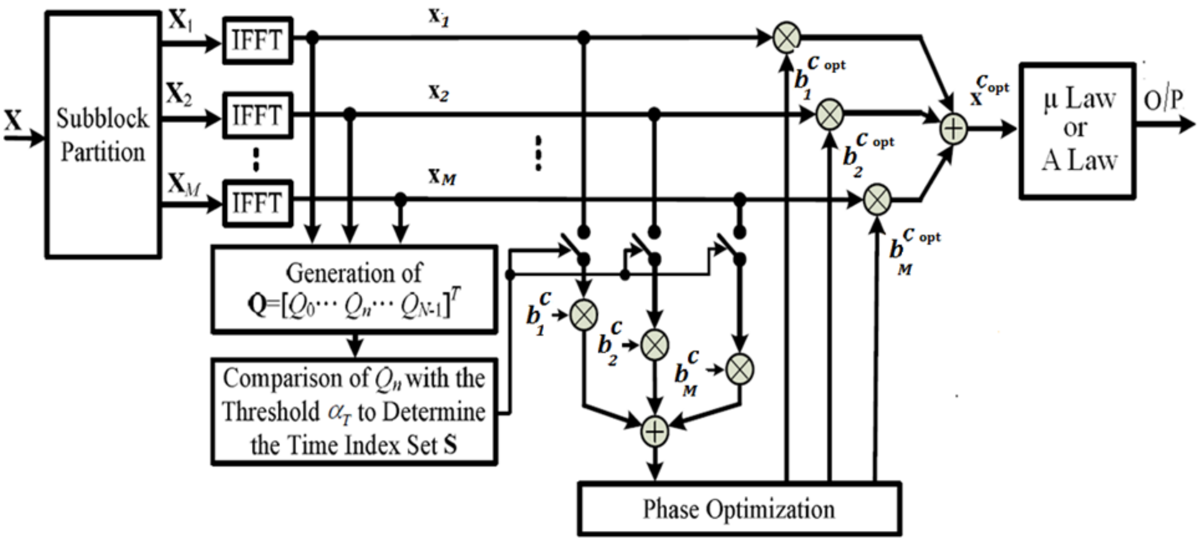

Fig. 3 Reduced complexity PTS with companding OFDM system

IV. SIMULATION RESULTS

To show the performance of PAPR reduction, the OFDM is combined with Reduced complexity PTS and companding methods which are imitative of the existing methods with number of symbols 500, subcarriers 6,16-QAM and V=2 which are simulated by randomly generated data. A CCDF=Prob{PAPR>PAPRo}, was used to present the range of PAPR in term of a probability of occurrence.

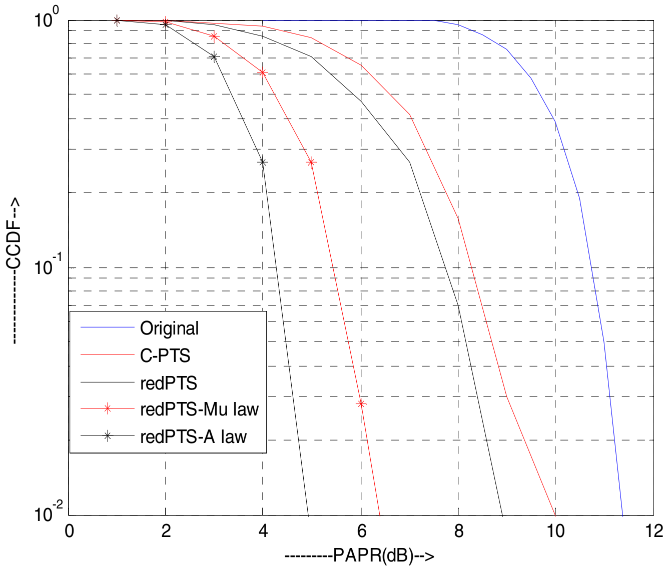

Fig. 4 comparison of PAPR for Reduced complexity PTS with companding OFDM system

As shown in Fig. 4 the PAPR of reduced complexity $\gamma = 0.999$ for N=64 is 9.0dB, the combined approach using A-law PAPR is about 5.0dB for A=90 and µ-law PAPR is 6.3dB for µ=255. Hence the PAPR is reduced by combining method without increasing the complexity.

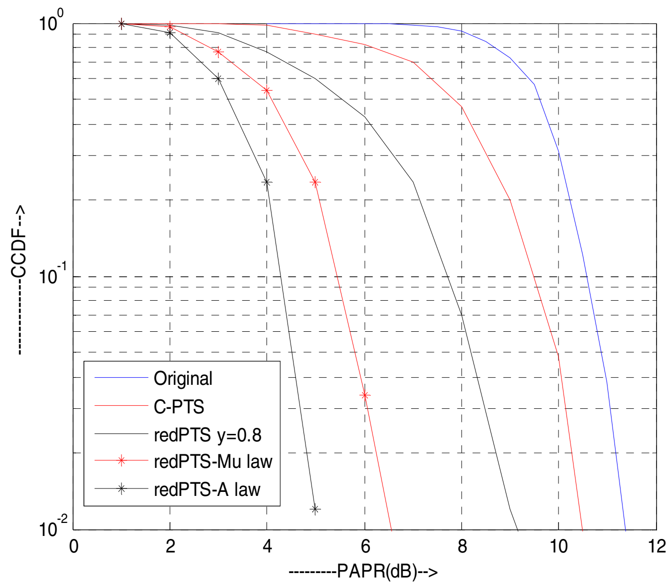

Fig. 5 PAPR of Reduced complexity PTS(γ=0.8000) with companding OFDM system

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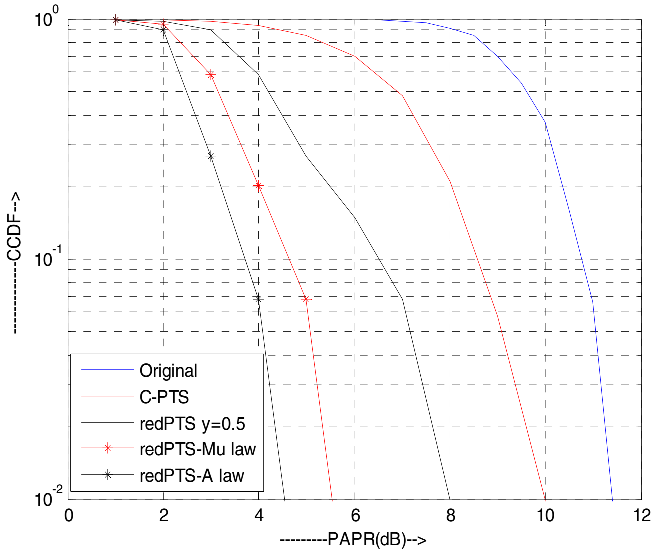

Fig. 6 PAPR of Reduced complexity PTS(γ=0.5000) with companding OFDM system

For the reduced complexity PTS with companding scheme for different values of threshold the PAPR is calculated. The PAPR for γ= 0.8000, threshold = 0.24 of reduced complexity PTS is 9.0dB, reduced complexity PTS with A-law for A=90 is 5dB and μ-law for μ = 255 is 6.2dB as shown in Fig. 5 For γ= 0.5000 PAPR for reduced complexity PTS is 8.0dB, reduced complexity PTS with A-law is 4.2dB and μ-law is 5.6dB as shown in Fig. 6 For γ= 0.1000 PAPR for reduced complexity PTS is 5.9dB, reduced complexity PTS with A-law is 3.8dB and μ-law is 4.2dB as shown in Fig. 7.

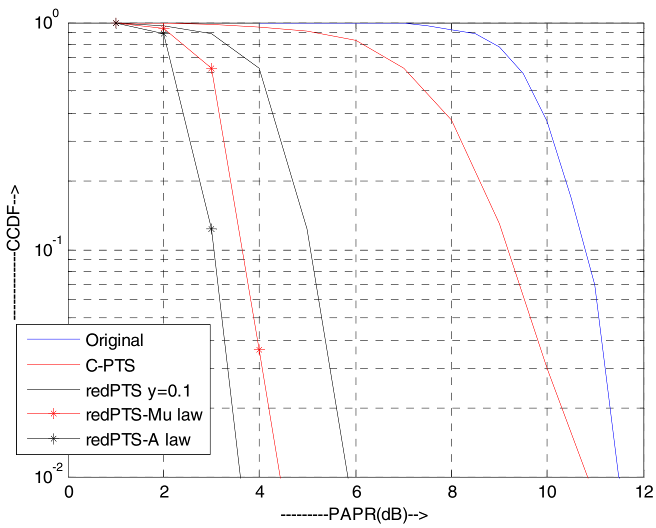

Fig. 7 PAPR of Reduced complexity PTS(γ=0.1000) with companding OFDM system

V. CONCLUSION

In reduced complexity PTS OFDM system [8], the PAPR is reduced compared with conventional PTS. Using this method, the computational complexity is reduced based on the cost function Q_s by summing the samples of the time symbols 's'in V disjoint subblocks. As the γ decreases, the PAPR decreases. The reduced complexity PTS with compading OFDM system further increases the efficiency of high power amplifiers by reducing the PAPR to lower values. For better efficiency, γ=1.000 is considered.

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