International Conference on Recent Advances and Future Trends in Information Technology (iRAFIT2012)
Proceedings published in International Journal of Computer Applications® (IJCA)

Reducing Peak to Average Power Ratio by Classical Clipping over BPSK and QPSK in OFDM System

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ABSTRACT
Peak to Average Power Ratio (PAPR or PAR) is main problem of Orthogonal Frequency Division Multiplexing. The Classical Clipping method is focused in this paper for reduction of PAR using different modulation techniques. Through the Analysis, it is shown that Clipping using QPSK is better than BPSK.

General terms
Multiplexing, Quadrature Phase Shift Keying (QPSK), Binary Phase Shift Keying (BPSK).

Keywords
Peak to Average Power Ratio, Classical Clipping, Orthogonal Frequency Division Multiplexing (OFDM)

1. INTRODUCTION
The multicarrier modulation technique also called Orthogonal Frequency Division Multiplexing (OFDM) has nowadays gained popularity for current and future wireless systems. OFDM technique is spectrally efficient and very robust to wireless multipath fading environment. Therefore, OFDM has been adopted in many standards and systems like DAB/DVB (digital audio/video broadcasting) system, Wireless Local Area Network (WLAN), mobile worldwide interoperability for microwave access (Mobile WiMax), 3G LTE, and IEEE 802.16 systems. One of the major drawbacks of OFDM is its high Peak to Average Power Ratio (PAPR). In OFDM, the subcarriers are added constructively to form large peaks. High peak power requires High Power Amplifiers (HPA), A/D and D/A converters. Peaks are distorted nonlinearly due to amplifier imperfection in HPA. If HPA operates in nonlinear region, out of band and in-band spectrum radiations are produced which appears as the adjacent channel interference. Moreover if HPA is operated in nonlinear region with large power backs-offs, it would not be possible to keep the out-of-band power below the certain limits. This further leads to inefficient amplification and expensive transmitters. To prevent all these problems, power amplifiers has to be operated in its linear region [1]. There are many methods on PAPR reduction such as Clipping, Coding, Selective Mapping (SLM) [2], Interleaving [3][4], Nonlinear Companding Transform [5][6], Hadamard Transform [7], Partial Transmit Sequence(PTS) etc. Clipping the OFDM signal in digital part is simplest technique. It produces the peak reduction at lower cost. But Clipping is the nonlinear method which further distorts the OFDM signal. The out-of-band radiation is produced by Filtering. Filtering causes peaks to regrow. Iterative clipping and filtering (ICF) works in recursive way to achieve less PAPR. Its modified version such as Simplified Clipping and Filtering (SCF) and one Time Iteration and Filtering is proposed in [5].The strength of Clipping and Filtering method is based on total degradation and results show that it degrades the system performance instead of an improvement**.** This method is still considered as a good choice in 60 GHz CMOS radio transceivers because of its simple implementation and effective PAPR reduction with small degradation [6]. Although a no. of techniques of PAPR reduction have been summarized by many researchers, still there is requirement of an effective PAPR reduction technique which could give the best tradeoff between the capacity of PAPR reduction and data rate loss.

2. SYSTEM DESCRIPTION

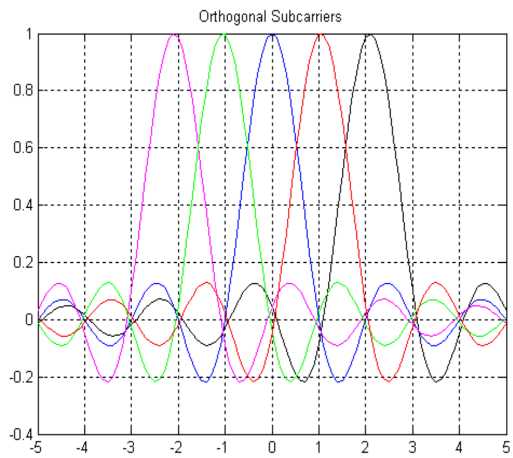

Figure 1. Orthogonal Subcarriers

An OFDM System consists of N subcarriers. The OFDM symbol $x(t), 0 \leq t \leq T$, consist of N complex baseband data $X_0, X_1, \ldots, X_{N-1}$ carried on N subcarriers, chosen to be orthogonal with constant spacing Δf. The OFDM symbol $x(t)$ is

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi\Delta f t}, 0 \leq t \leq T \qquad (1)$$

The Bandwidth of OFDM symbols is $B = \Delta f.N$ and symbol time $T = 1/\Delta f$. X_k is the complex baseband data modulating the k-th subcarrier for $x(t)$.The PAPR of OFDM symbol may be defined as ξ in [8]

$$\xi = \frac{\max\ t \in [0,T)\ |x(t)|^2}{P_{av}}, \qquad (2)$$

Where P_{av} is the average power of the transmitted symbol and maximum sought over the symbol duration defined as $P_{av} \triangleq E\{|x(t)|^2\}$. Where $E\{.\}$ is the expectation operator.

The value of ξ can be as large as N for Quadrature Phase Shift Keying (QPSK) symbols. However large PAPR occurs rarely. The PAPR can be best marked by its statistical parameter, Complementary Cumulative Distribution Function (CCDF). For proper values of PAPR oversampling is necessary. L is the oversampling factor. L=1 determines discrete-time signal sampled at Nyquist rate, whereas L=4 gives sufficient samples to capture continuous-domain signal peaks. The oversampled signal can be obtained by (L-1)N zero-padding in the middle of the original input vector and converting frequency domain signal into time domain. The OFDM signal sampled at time instant $t = n\Delta t$ is then expressed as

$$x(n) \triangleq x(n\Delta t), n = 0, \ldots, LN-1 \qquad (3)$$

3. CLIPPING AND FILTERING METHOD

The method of Clipping and Filtering can be described with two modulation techniques, QPS and BPSK. The OFDM signal contains high peaks so it is transferred from the clipping block shown in fig 3. In this when amplitude is greater than the threshold value, the amplitude is clipped off shown in fig 2, while saving the phase. The clipped sample is given by

$$x(n) = \begin{cases} |x(n)| & if \ \ |x(n)| \le A(threshold) \\ A & if \ \ |x(n)| > A(threshold) \end{cases} \qquad (4)$$

The out-of-band radiations occurred without filtering due to non linearity. To reduce the interference to neighboring channels, out-of-band components must be reduced with a band limiting filter [1]. The peak growth becomes small after filtering the oversampled signal. The repeated clipping and filtering can reduce the peak regrowth and increases the system cost. So there has been a tradeoff between PAPR and system cost also.

The Modulated data can be of any type BPSK, QPSK[9]. In this paper we are trying to show the effect of clipping and filtering between the modulated data using constellation mapping of QPSK and BPSK.

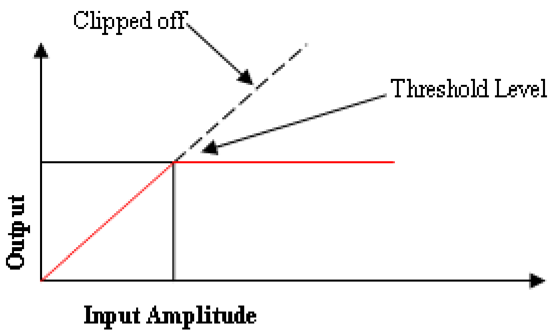

Figure 2. Clipping Method

The general form of BPSK equation yields two phases

$$S_n(t) = \sqrt{\frac{2E_b}{T_b}}(\cos(2\pi f_c t + \pi(1-n)), n = 0,1 \qquad (5)$$

The general form of QPSK equation yields four phases

$$S_n(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(2\pi f_c t + (2n-1)\left(\frac{\pi}{4}\right)\right), n = 1,2,3,4 \quad (6)$$

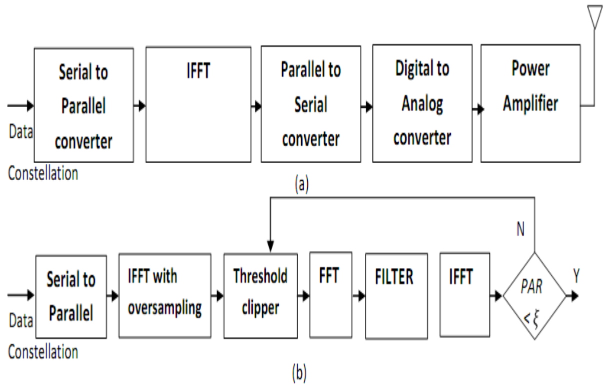

Figure 3. Block Diagram of (a) Original OFDM system. (b)Modified OFDM system using Clipping

4. RESULTS AND SIMULATIONS

We use the computer simulations to evaluate the performance of the proposed PAPR reduction technique over two types of

modulated data. As a performance measure for proposed technique, we use the CCDF of the PAPR (on y-axis).

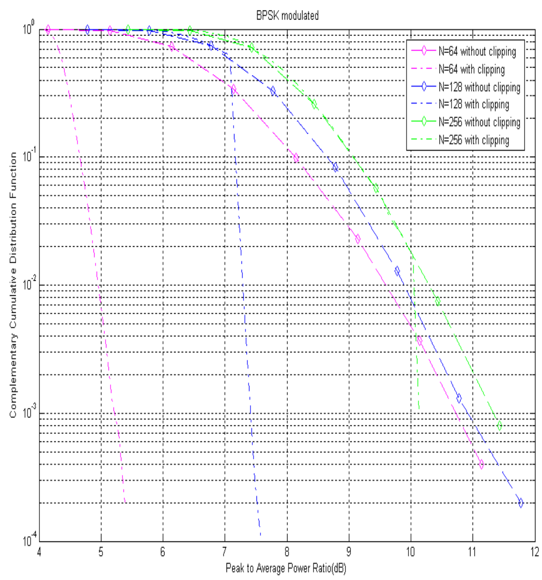

Figure 4. BPSK modulated data with clipping

Performances of the proposed system in fig. 3(b) are compared to OFDM system in fig. 3(a) with QPSK and BPSK symbols modulated for N=64,128,256 subcarriers and the effect of clipping on them is studied.10000 random OFDM blocks were generated to obtain the CCDF. Fig (4) shows the CCDF of PAPR of BPSK signals and results show that if N=64, the decrease in PAPR is 5.525 dB due to the effect of classical clipping. If N=128, the decrease in PAPR is 3.521 dB due to the effect of classical clipping. If N=256, the decrease in PAPR is 1.20 dB due to clipping effect. Fig (5) shows the CCDF of PAPR of QPSK signals and results show that if N=64, the decrease in PAPR is 7.6dB.

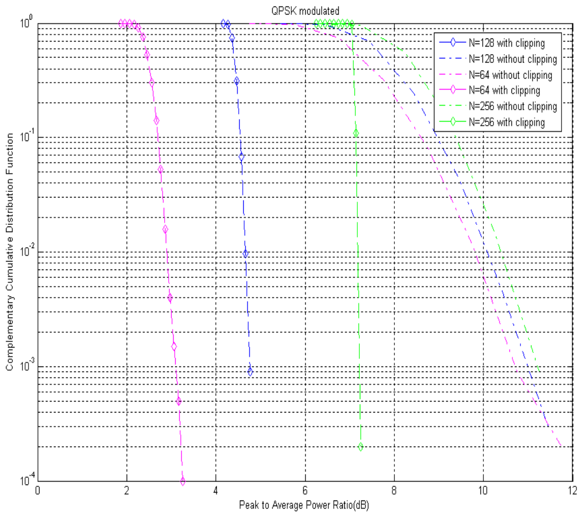

Figure 5. QPSK modulated data with Clipping

If N=128, the decrease in PAPR is 5.95 dB. If N=256, the decrease in PAPR is 3.99 dB due to classical threshold method. Results show that in N=64, BPSK and QPSK is better than N=128, 256. A comparison of BPSK and QPSK with N=64 shows the difference of 2.115 dB.

Table 1. Comparison of PAPR in (dB) as a function of no. of subcarriers for QPSK and BPSK

BPSK	**N=64** without clipping	**N=64** with clipping	**N=128** without clipping	**N=128** with clipping	**N=256** without clipping	**N=256** with clipping
10^{-1}	8.154	4.664	8.655	7.168	9.052	9.051
10^{-2}	9.61	4.958	9.885	7.285	10.28	10.05
10^{-3}	10.74	5.215	10.93	7.409	11.33	10.13
QPSK	**N=64** without clipping	**N=64** with clipping	**N=128** without clipping	**N=128** with clipping	**N=256** without clipping	**N=256** with clipping
10^{-1}	8.6	2.697	8.96	4.538	9.382	7.146
10^{-2}	9.804	2.897	10.07	4.664	10.39	7.183
10^{-3}	10.7	3.100	10.71	4.76	11.21	7.22

5. CONCLUSIONS

In this paper, a classical clipping and filtering technique is introduced to reduce the PAPR in multicarrier system applying BPSK and QPSK with N=64, 128 and 256 subcarriers. The PAPR with BPSK is compared to PAPR in QPSK. Results show that QPSK modulated with N=64 by clipping and filtering is better than BPSK. Taking N=128 with classical clipping is also better than BPSK.

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