CLASSICAL CLIPPING: A FUTURE PROSPECTIVE TO REDUCE THE PAPR IN OFDM SYSTEM

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ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier transmission technique that becomes the best choice in wireless high-data-rate transmission. The drawbacks of OFDM are high Peak-to-Average Power Ratio (PAPR) and sensitivity to frequency offset. High PAPR Decreases the amplifier's efficiency. The simplest PAPR reduction method is clipping, but it gives in-band and out-of-band distortion that degrades the performance of the system. There are Various types of clipping, such as classical clipping, deep clipping, and smooth clipping. The Classical Clipping method is focused in this paper for reduction of PAPR 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)***

I 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 [1]. 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). It happens because of superposition of the in-phase signals. High PAPR Causes inefficiency in the amplifier. In many low-cost applications, high PAPR reduces the Potential advantages. Clipping is the simplest PAPR reduction technique. There are many research papers about Clipping [1, 2].

II OVERVIEW OF OFDM, PAPR, & CLIPPING

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. There are many methods on PAPR reduction such as Clipping, Coding, Selective Mapping (SLM), Interleaving, Nonlinear Companding Transform, Hadamard Transform, Partial Transmit Sequence (PTS) etc. Clipping the OFDM signal in digital part is simplest technique. It produces the peak reduction at lower cost. 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 [3].

In 60 GHz CMOS radio transceivers because of its simple implementation and effective PAPR reduction with small degradation. 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.

2.1 OFDM and PAPR

OFDM signal in discrete form can be expressed as

$$x(n) = \sum_{n=0}^{N_{sc}-1} X[k] e^{\frac{j2\pi kn}{N_{sc}}} \qquad (1)$$

Where X [k] is the modulated signal and N_{sc} is the number of sub-carriers. Observation of Eq. (1) leads us to simplify the notation by using N-point IFFT to yield the OFDM signals. By using IFFT, the complexity of the transmitter can be reduced.

The PAPR can be defined as the ratio between maximum power and average power in one OFDM symbol. It denotes as

$$PAPR = \frac{\max|s[k]|^2}{E\{|s[k]|^2\}} \qquad (2)$$

Where E {•} is the expectation of random signal. The PAPR is usually analyzed by using Statistical parameters, namely the complementary cumulative density function (CCDF). CCDF shows the probability that PAPR exceeds a certain level [4].

2.2 Clipping

Clipping means to cut the signal's amplitude exceeding a certain level. This is the simplest method for reducing the PAPR. It, however, causes in-band and out-of-band distortion and therefore degrades the BER and increases the out-of-band emission respectively [5].

As stated before, this paper only discusses three types of clipping: classical, deep, and smooth. The formula for each type of clipping is given by

Classical clipping

$$f(r) = \begin{cases} r, & r \leq A \\ A, & r > A \end{cases} \qquad (3)$$

Deep clipping

$$f(r) = \begin{cases} r, & r \leq A \\ A - P(r - A), & A < r \leq \frac{1+P}{P}A \\ 0, & r > \frac{1+P}{P}A \end{cases} \qquad (4)$$

Smooth clipping

$$f(r) = \begin{cases} r - \frac{1}{b}r^3, & r \leq 1.5A \\ A, & r > 1.5A \end{cases} \qquad (5)$$

where A is clipping level, p is depth factor, and b = 27 $A^2/4$. Another parameter that Characterizes the clipping performance is clipping ratio that is given by $CR = A/\sigma$, where is σ the rms level of the OFDM signal.

The transfer functions of the three types of clipping are shown in Figure 1.

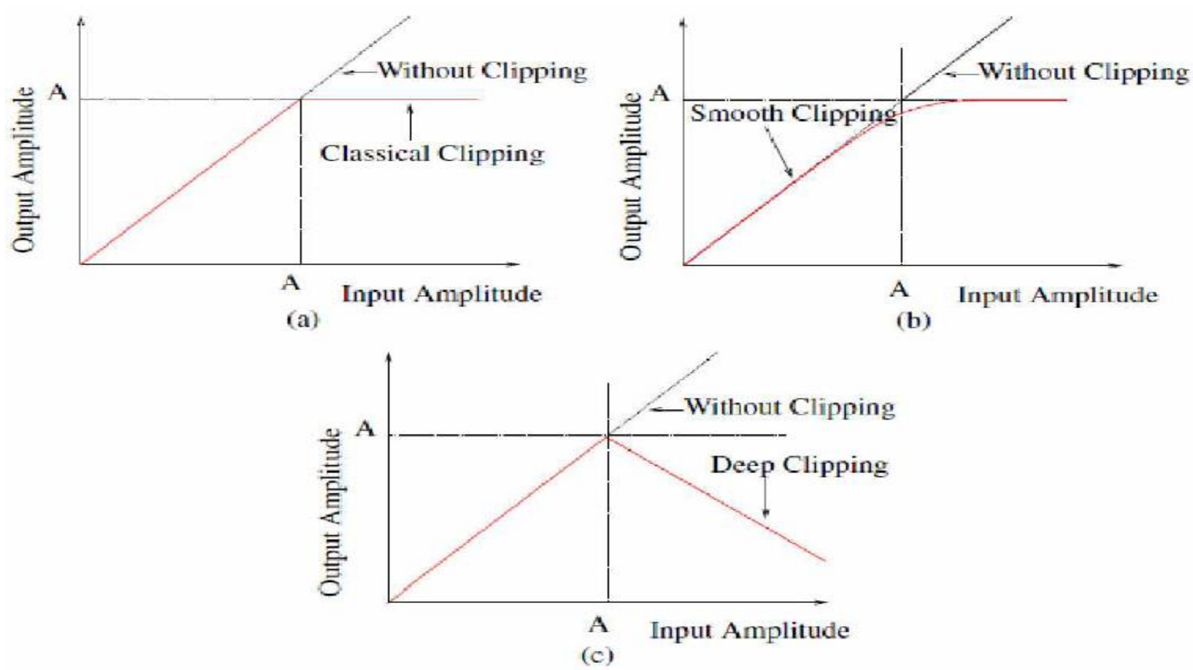

Figure 1: Clipping Transfer Functions: (a) Classical Clipping, (b) Deep Clipping, (c) Smooth Clipping

III 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 [6]

$$x(n) = \begin{cases} |x(n)| \; if \; |x(n)| \leq A \, (threshold) \\ A \quad if \; |x(n)| > A \, (threshold) \end{cases} \tag{6}$$

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. 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. 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 [4,5].

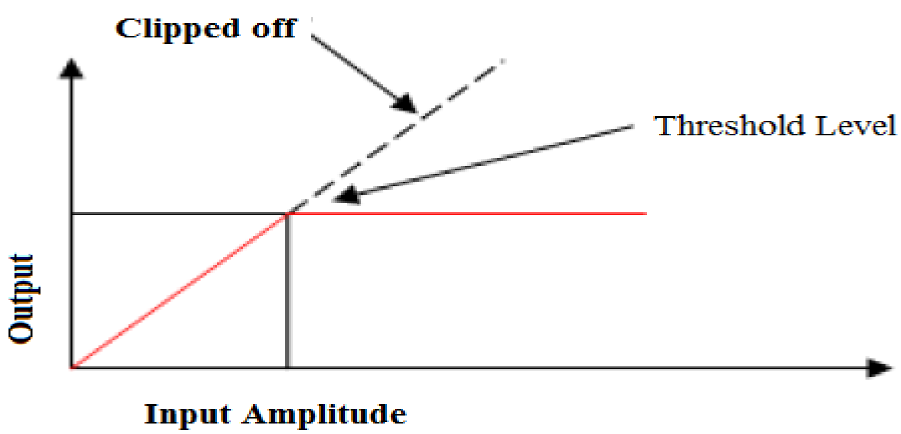

Figure 2: Clipping Method

The general form of BPSK equation yields two phases:

$$S_n(t) = \sqrt{\frac{2E_b}{T_b}} \left(\cos\left(2\pi f_c t + \pi(1-n)\right)\right), n = 0, 1 \tag{7}$$

The general form of QPSK equation yields four phases:

$$S_n(t) = \sqrt{\frac{2E_b}{T_b}} \cos\left(2\pi f_c t + (2n-1)\left(\frac{\pi}{4}\right)\right), n = 1, 2, 3, 4 \tag{8}$$

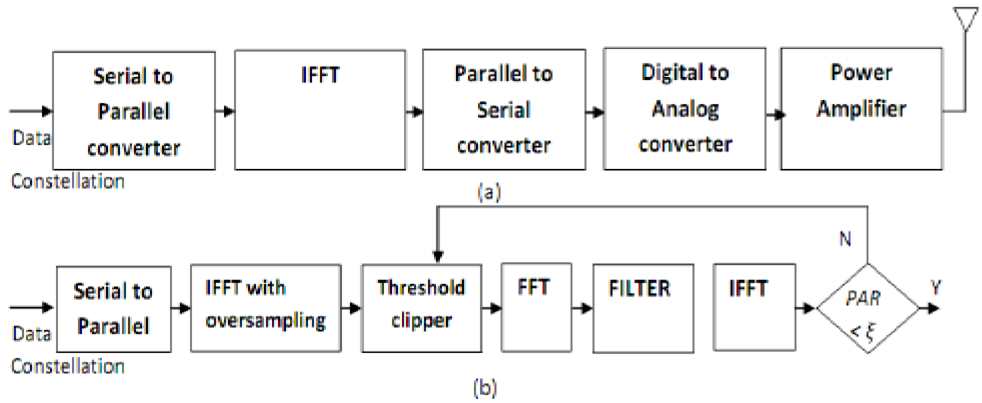

Figure 3: Block Diagram of (a) Original OFDM System. (b)Modified OFDM System Using Clipping

IV 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). 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.

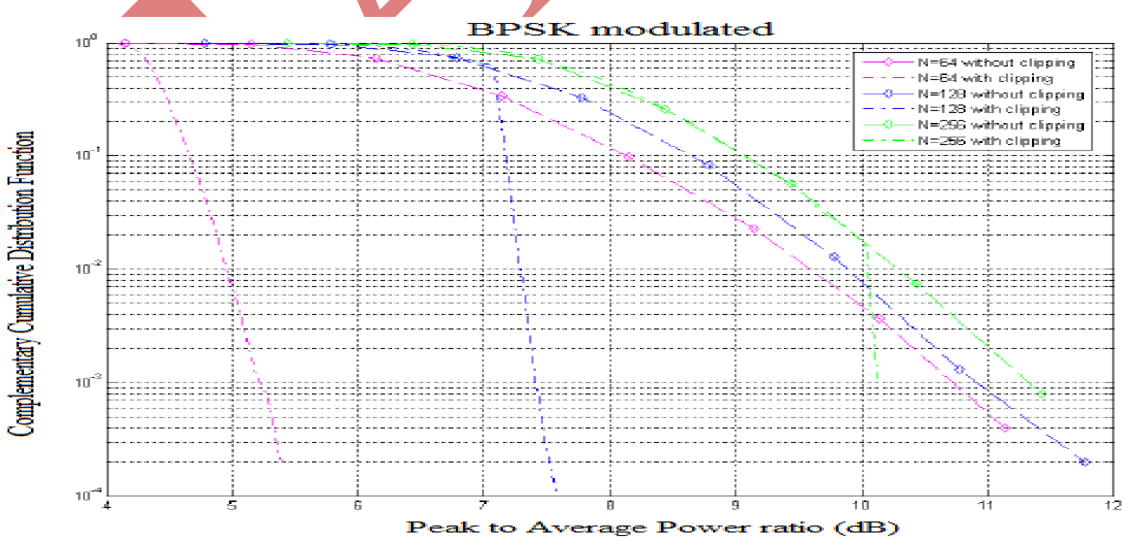

Figure 4: BPSK modulated data with clipping

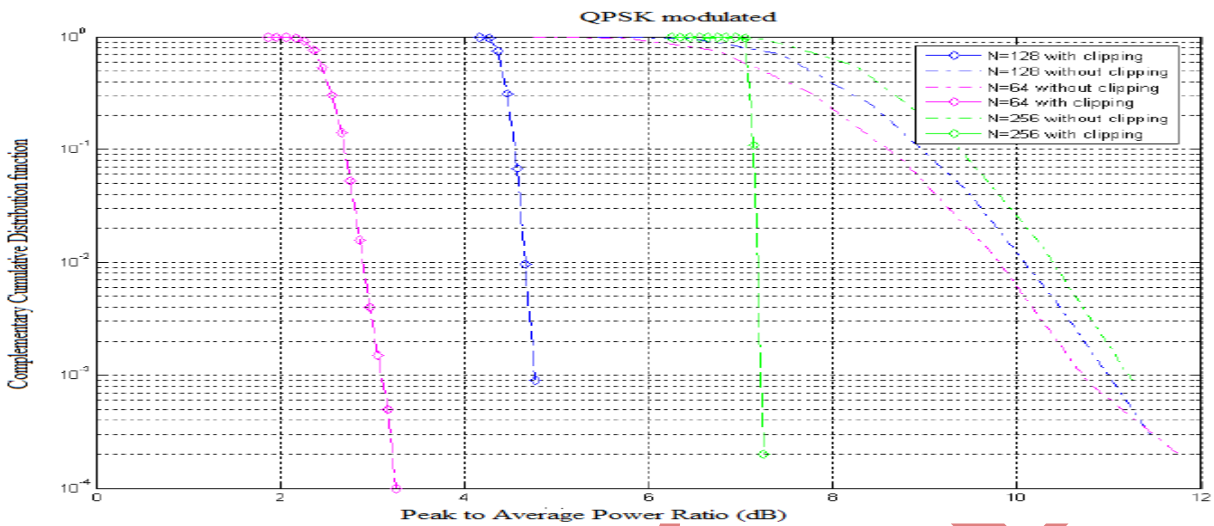

Figure 5: QPSK modulated data with Clipping

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.

V 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.

REFERENCES

[1] H.G. Ryu "Combination of PAPR reduction and linearization for the OFDM communication system," *Wireless Commun. and Mobile Computing*, pp.46-52,Vol.54,No.2, Feb.2010

[2] T. Jiang, Y. Wu, "An Overview: Peak-to-Average Power Ratio Reduction Techniques for OFDM Signals," *IEEE Transactions on broadcasting*, Vol.54, No.2 pp.257-68, June 2008

[3] T. Jiang, Y. Imai, "An overview: peak-to-average power ratio reduction techniques for OFDM signals," *IEEE Trans. On Wireless Communications*, pp.56-57, June 2008

[4] S.H. Han, J.H. Lee, "An overview of peak-to-average power ratio reduction techniques for multicarrier transmissions," *IEEE Wireless Communication*, pp.56-65, April 2005

[5] L.Q.Wang, C. Tellambura, "A Simplfied Clipping and Filtering Technique for PAR Reduction in OFDM systems," *IEEE Signal Processing Letters*, Vol.12, No.6, pp.453-456, June 2005

[6] A.K. Gurung, F.S. Al-Qahtani, A.Z. Sadik, Z.M. Hussain, " Power Savings Analysis of Clipping and Filtering method in OFDM Systems," *IEEE ATNAC*, pp.204-208, 2008

[7] M. Park, H. Jun, J. Cho, N. Cho, D. Hong, C. Kang, "PAPR reduction in OFDM transmissions using Hadamard transform", *IEEE International Conference of Communications*, Vol.1, pp.430-33, June 2000

[8] L. Wang and C. Tellambura, "An Overview of Peak-to-Average Power Ratio Reduction Techniques for OFDM systems," *IEEE International Symposium on Signal Processing and Information technology*, pp.840-845, 2006

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