Performance Analysis of Clipping based PAPR Reduction Technique in UFMC Systems

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Abstract

Universal filtered multi-carrier (UFMC) is one of the strongest candidates waveform to overcome the shortness of orthogonal frequency division multiplexing (OFDM) and for the future mobile communication system. UFMC system provides robust, high spectral efficiency and minimal out-of-band(OOB) emission communication system. However, UFMC system has high peak-to-average power ratio (PAPR) problem like other multi-carrier transmission systems. This paper study performance of Clipping method in different threshold level for PAPR reduction in UFMC system.

Ⅰ. Introduction

Wireless communication systems are changing rapidly to fulfill the demand for Internet-of-Everything (IoE) and real-time communication. It reflects on economic development and flexibility [1]. UFMC system is the combined form of orthogonal frequency division multiplexing (OFDM) and Filter Bank Multicarrier (FBMC). UFMC carries the basic feature of OFDM system. Instead of filtering the whole frequency band, it uses sub-band filter like FBMC system. In UFMC system, each sub-carriers are divided into sub-bands. and filter is applied to each sub-band. For filtering UFMC system used Dolph-Chebyshev filter.

Like other multicarrier transmission systems UFMC system also have PAPR problem which reduces system performance. In general PAPR reduction technique can be classified into three groups as distortion, encoding, and probabilistic approaches. Each of the systems has its own limitations. Among all PAPR reduction techniques, clipping is the simplest method. It requires low computational complexity and minimum hardware complexity unlike selected mapping (SLM), partial transmit sequence (PTS), Tone Reservation [2] etc. The main contribution of this paper are as follow:

- Reduce PAPR in UFMC system using the Classic Clipping method.
- As a performance analysis of PAPR reduction technique reduces complementary commutative-distribution function (CCDF) compare to original UFMC system [3].
- BER graph also almost same as original signal in Additive White Gaussian Noise(AWGN)

The rest of the paper is organized as follows. system model and PAPR introduces in section II, In section III, describes Clipping and CCDF method. Section IV, presents the simulation work. Finally, the paper is conclude in section V and provides some future work direction

Ⅱ. System model and PAPR

Figure 1, shows UFMC transmitter block diagram. As from the figure input signal first mapped as QAM symbol and divided into sub-bands with fixed size. Then the signal goes through the N-point inverse fast Fourier transform (IFFT). The signal can be defined as

$$\mathrm{x_b} = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} x_b(c) e^{\frac{j2\pi cn}{N}} \qquad (1)$$

Where x_b are the sub-bands, x_b is the sub-carrier. Dolph-Chebyshev filter is applied and combined together and make the signal as

$$\mathrm{s(n)} = \sum_{b=1}^{B} x_b * f_b \qquad (2)$$

Where f_b is the filter impulse on each sub-band. PAPR of the candidate signal $\mathrm{s(n)}$ can be expressed as-

$$PAPR = 10\log_{10}\frac{P_{peak}}{P_{average}} = 10\log_{10}\frac{\max_{n}[|s(n)|^2]}{E[|s(n)|^2]} \qquad (3)$$

where $\mathrm{E}[.]$ is the expected value. P_{peak} is the highest instantaneous power and $P_{average}$is the average power of the signal.

Ⅲ. Clipping and CCDF

PAPR can be reduced by clipping the signal at a fixed level. Consider the signal clipped at level and phase remain same. Then clipping described as

$$c(s) = \begin{cases} s, & s \le C \\ C, & s > C \end{cases} \qquad (4)$$

where s is previous step of clipping, $\mathrm{c(s)}$ is the result signal after clipping and C is the clipping level

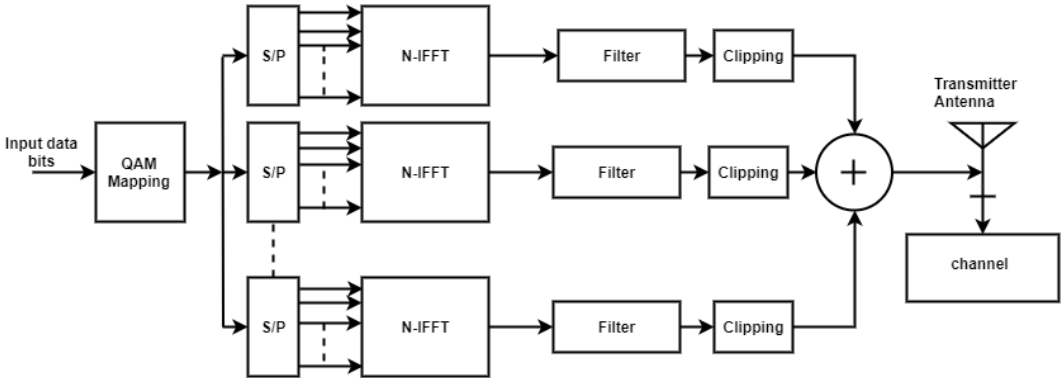

Fig. 1: Block diagram of typical UFMC transmitter.

PAPR performance of a signal can be measured by Complementary Cumulative Distribution Function (CCDF), which can be defined as-

$$\mathrm{P}(\mathrm{PAPR} > PARP_0) = 1 - (1 - e^{-PARP_0})^N \qquad (5)$$

where $PARP_0$ defined as clipping level. This equation measures the probability of a signal PAPR exceed the clipping level $PARP_0$

Ⅳ. Simulation and performance evaluation

Clipping based PAPR reduction of UFMC signal simulation was performed in MATLAB software. 4 QAM signal divided into 10 sub-band of size 20 and goes through the system with size of fast fourier transform(FFT) is 512. After inverse FFT, Chebyshev filter is applied in each sub-band. Clipping is applied in each sub-band. Finally all the signal are grouped together and formed UFMC signal which next pass through the channel.

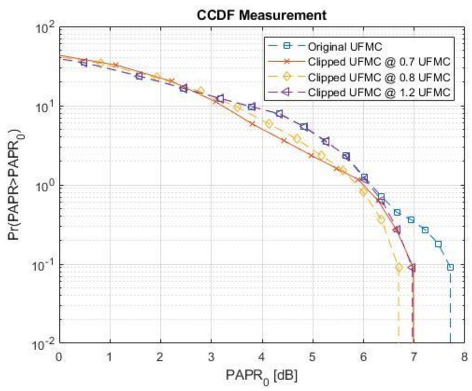

Fig. 2: PAPR value of UFMC system at different clipping level

Ⅴ. Conclusion

Among all PAPR reduction method, clipping is simple to implement and computational complexity low. In this study we investigate the PAPR performance and bit error rate at different clipping level. However the optimal clipping factor is 1.2 where PAPR reduced with low BER rate.

As we can see in the figure 2 and 3, clipping level 1.2 is optimal. At this level the PAPR is reduced and also it does not effect in bit error rate. As bit error rate is same as original signal. In clipping level .8 PAPR is the lowest but clipping at this level create BER.

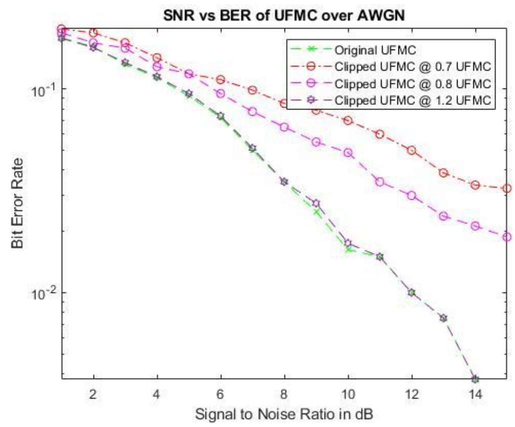

Fig. 3: BER of the UFMC system at different clipping level

ACKNOWLEDGMENT

This research work was supported by Priority Research Centers Program through NRF funded by MEST (2018R1A6A1A03024003) and NRF grant funded by Korea government(MSIT)(2019R1F1A1064055) and the Grand Information Technology Research Center support program (IITP-2021-2020- 0-01612) supervised by the IITP by MSIT, Korea.

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