ECE F434

DIGITAL SIGNAL PROCESSING

Assignment

PAPR reduction in LTE network using both peak windowing and clipping techniques

by-

Arkya Aditya 2021A8PS0276P

Akshat Garg 2021AAPS0261P

Shreyansh Vanjani 2021AAPS2242P

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ABSTRACT

The aim of this paper is to use below mentioned techniques to reduce PAPR. The research work describes clipping and windowing techniques such as quadratic amplitude modulation (QAM) and additive white Gaussian noise (AWGN) as channel conditions. The simulation results show that in those techniques with clipping threshold level of 0.7, there is a reduction of PAPR of 8 dB, and the reduction of PAPR for the peak windowing when considering Kaiser window is about 11 dB.

OFDM

Orthogonal Frequency Division Multiplexing (OFDM) is a digital modulation technique used in communication systems to transmit data over a number of parallel data streams or channels. It is widely used in wireless communication systems, including Wi-Fi, 4G, and 5G. It works by dividing the available spectrum into multiple subcarriers, each modulated with a different data stream. These subcarriers are orthogonal, meaning they are spaced in such a way that they do not interfere with each other. This allows for efficient use of the available bandwidth and is well-suited for high-data-rate applications in wireless communication systems.

PAPR

Peak-to-Average Power Ratio (PAPR) reduction is a technique used in the context of Orthogonal Frequency Division Multiplexing (OFDM), to minimize the difference between the peak and average power levels of the transmitted signal.

OFDM signals can exhibit high peak amplitudes, leading to inefficiencies in power amplification. A high PAPR necessitates power amplifiers with large dynamic ranges, reducing overall power efficiency. Managing PAPR helps improve power efficiency in the transmitter.A reduced PAPR contributes to better signal integrity. Distortions caused by high PAPR can affect the decoding process at the receiver, leading to errors in data recovery. Managing PAPR helps maintain signal quality and reliability.

$$\mathrm{Sp}(t) = \mathrm{Se}(t) * \mathrm{Wf}.$$

The PAPR after peak windowing is expressed as

$$\mathrm{PAPR} = \max|\mathrm{Sp}(t)|^2 / E|\mathrm{Sp}(t)|^2.$$

CLIPPING

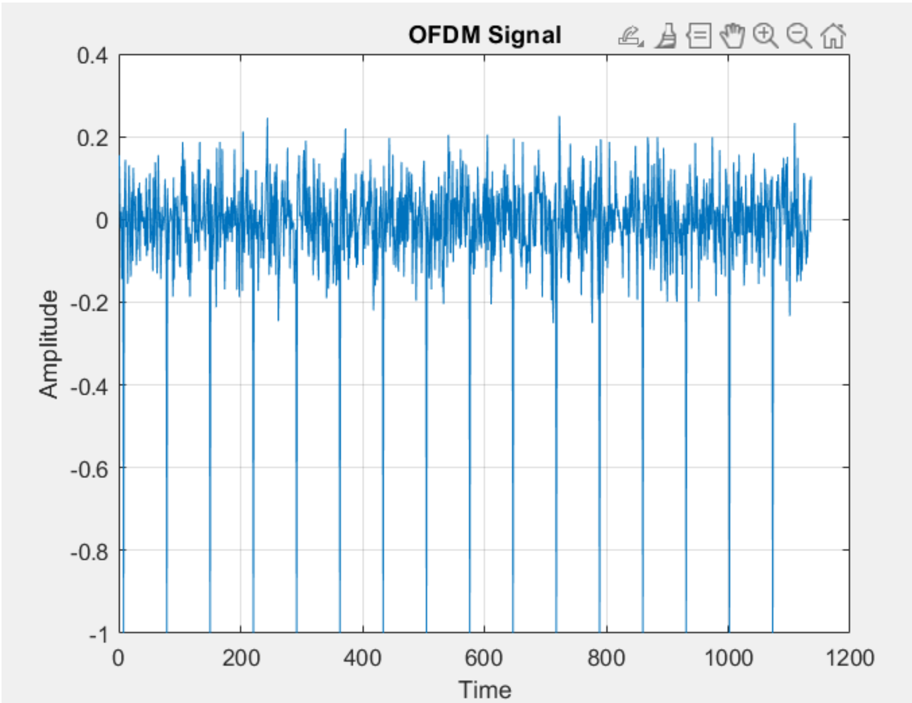
Clipping in Peak-to-Average Power Ratio (PAPR) reduction involves intentionally limiting the amplitude of a signal by truncating or clipping its peaks that exceed a predefined threshold. This technique reduces the peak power of the signal, mitigating the adverse effects of high PAPR in communication systems, especially in Orthogonal Frequency Division Multiplexing (OFDM). While clipping is a straightforward approach to PAPR reduction, it introduces distortion to the signal, necessitating additional measures to maintain signal quality. The trade-off lies in achieving power efficiency without compromising communication system integrity.

Windowing

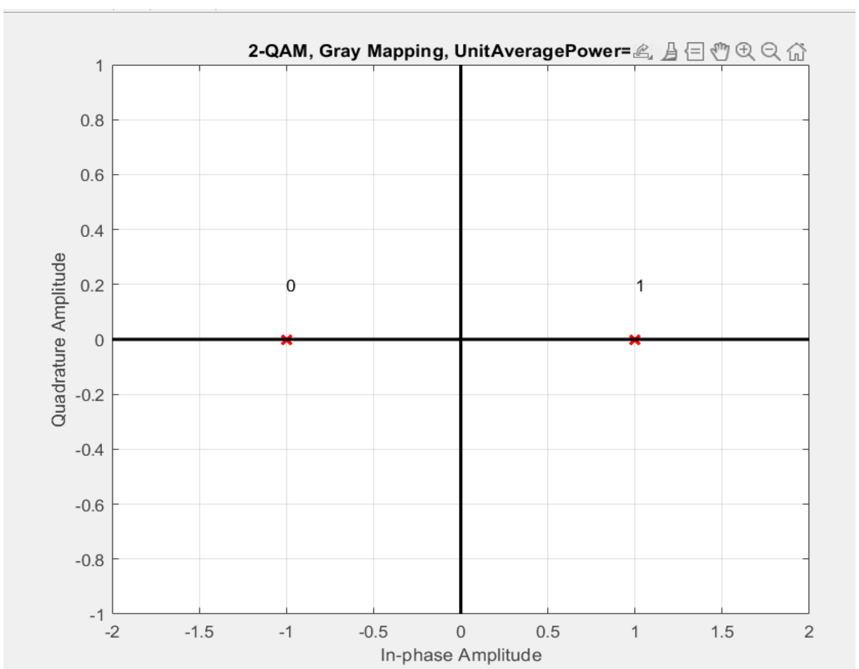
Peak windowing consists of removing larger peaks at the cost of increased BER and out of band radiation. It provides better PAPR migration with better spectral properties. Large signal is multiplied with a specific window. Windowing using Peak-to-Average Power Ratio (PAPR) reduction in OFDM, involves multiplying the time-domain signal by a window function before transmission. This technique smoothly reduces signal amplitude at the edges, curbing peaks and lowering PAPR. Unlike clipping, windowing aims to balance PAPR reduction without introducing severe distortion, offering a trade-off between efficiency and signal quality. Careful selection of window parameters ensures an optimal compromise, making windowing a nuanced approach to address the challenges of high PAPR in communication systems.

Plots using clipping as reduction technique

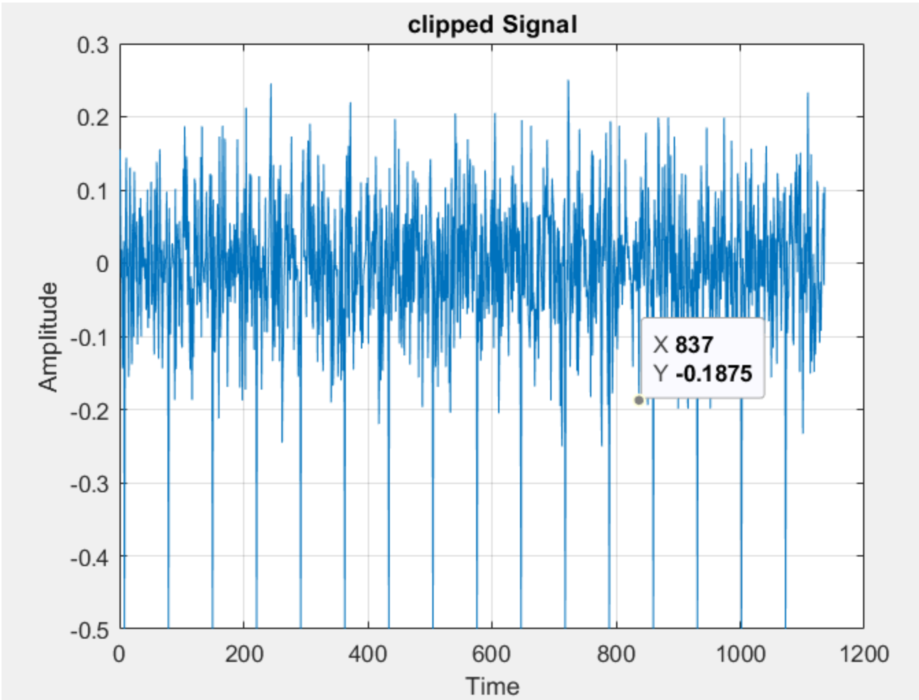
1.1 randomly generated OFDM signal after 4-QAM Modulation



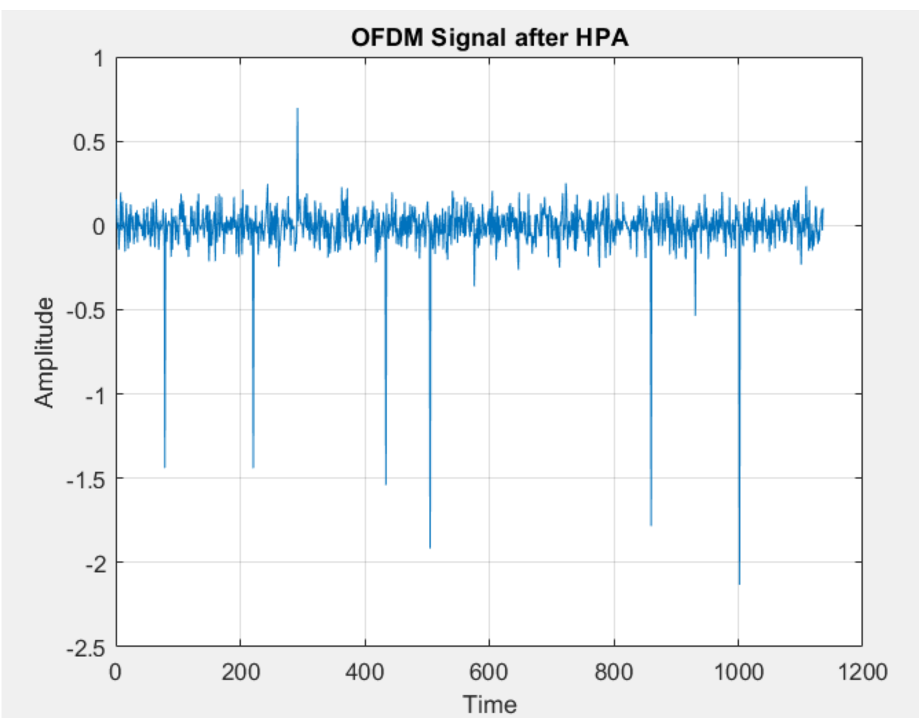
1.2 QAM Constellation



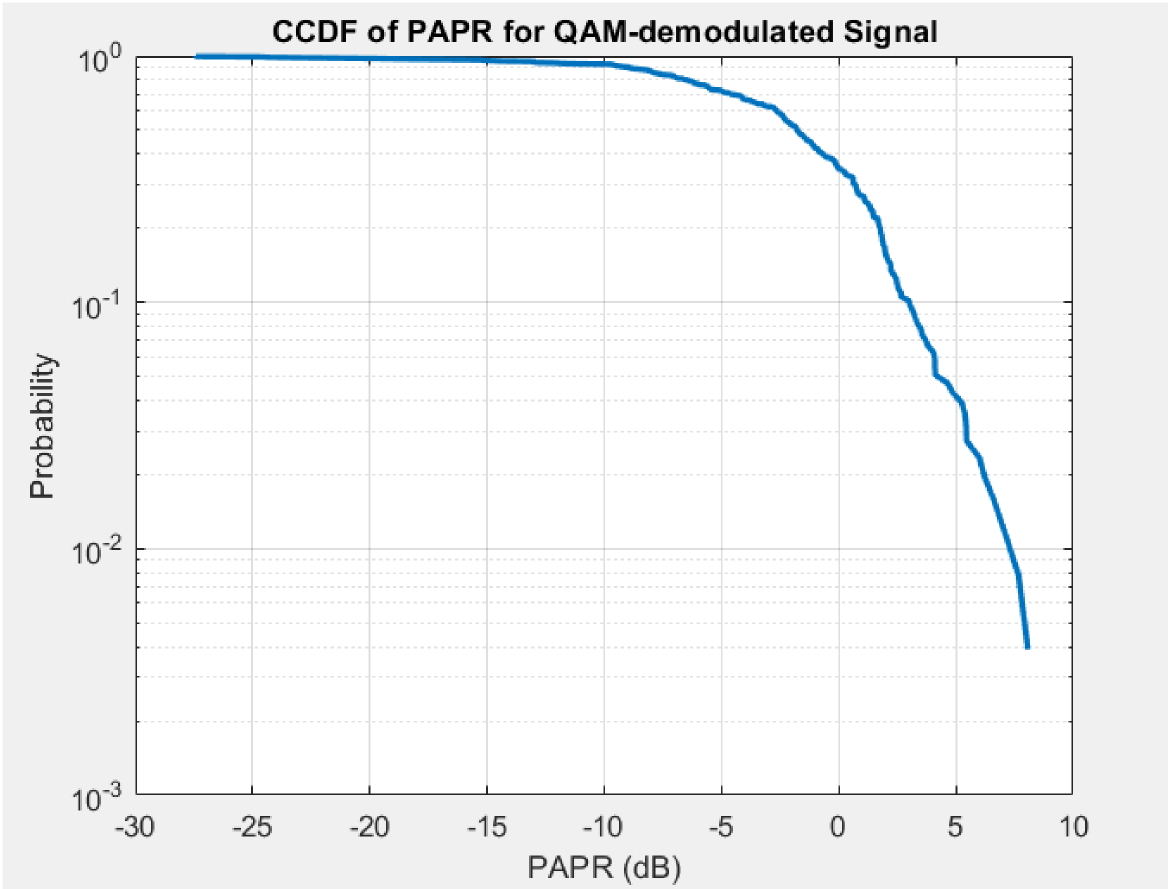
1.3 Clipped OFDM signal



1.4 Clipped signal after passing through High Power Amplifier (HPA)

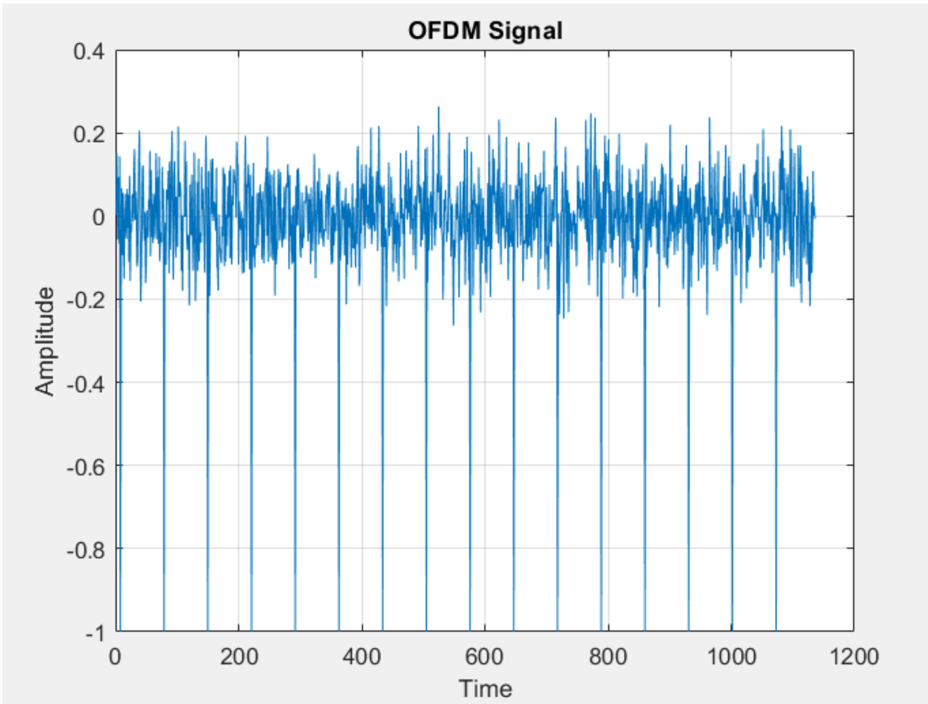


1.5 Complementary cumulative distribution function for received signal

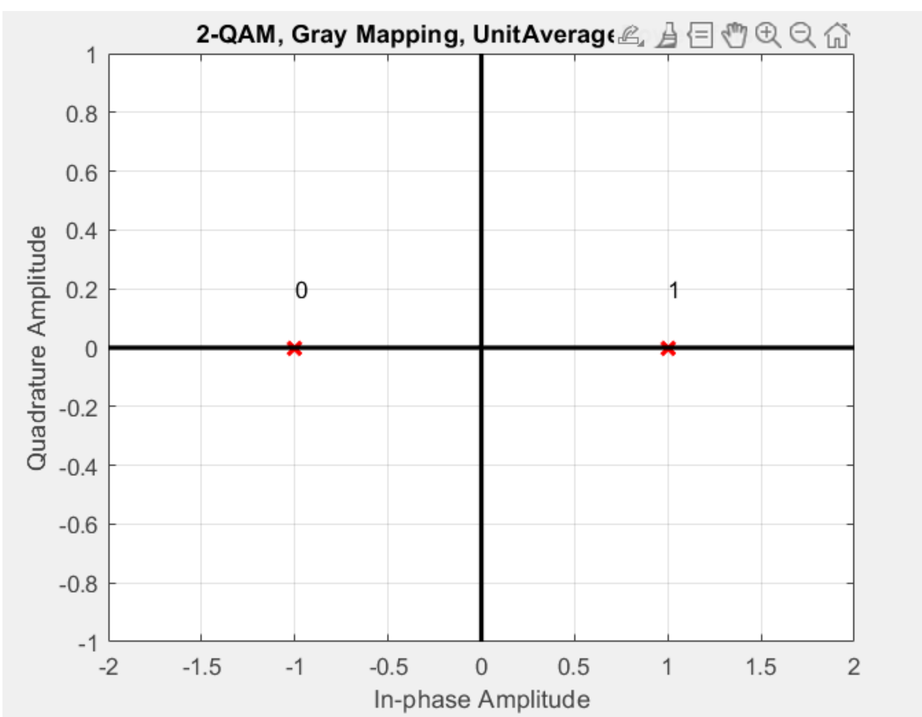


Plots using clipping as reduction technique

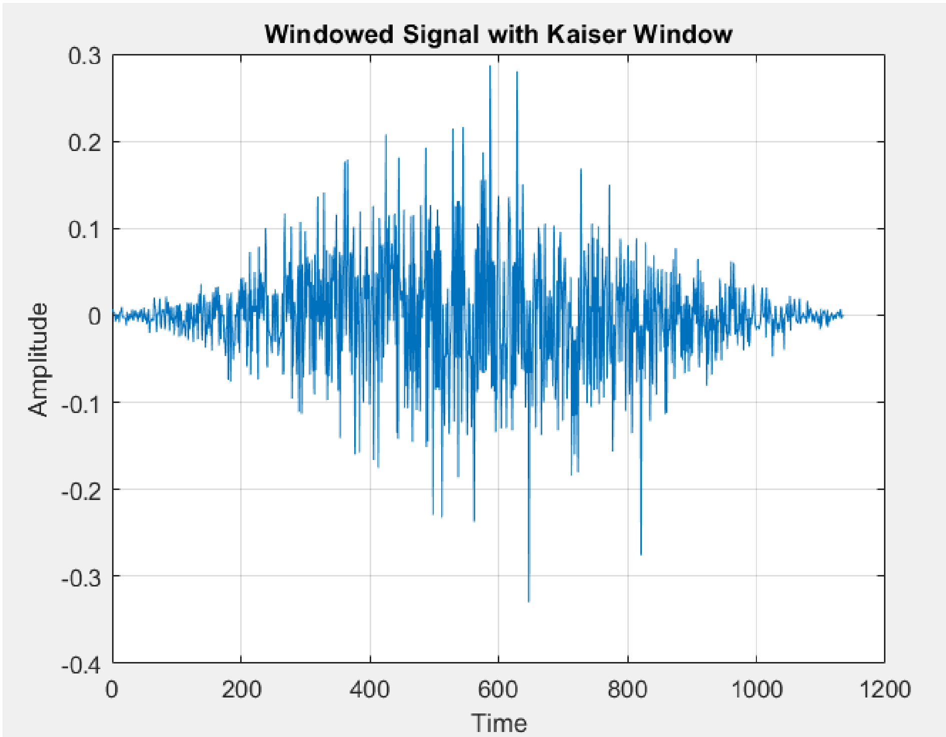
1.1 randomly generated OFDM signal after 4-QAM Modulation



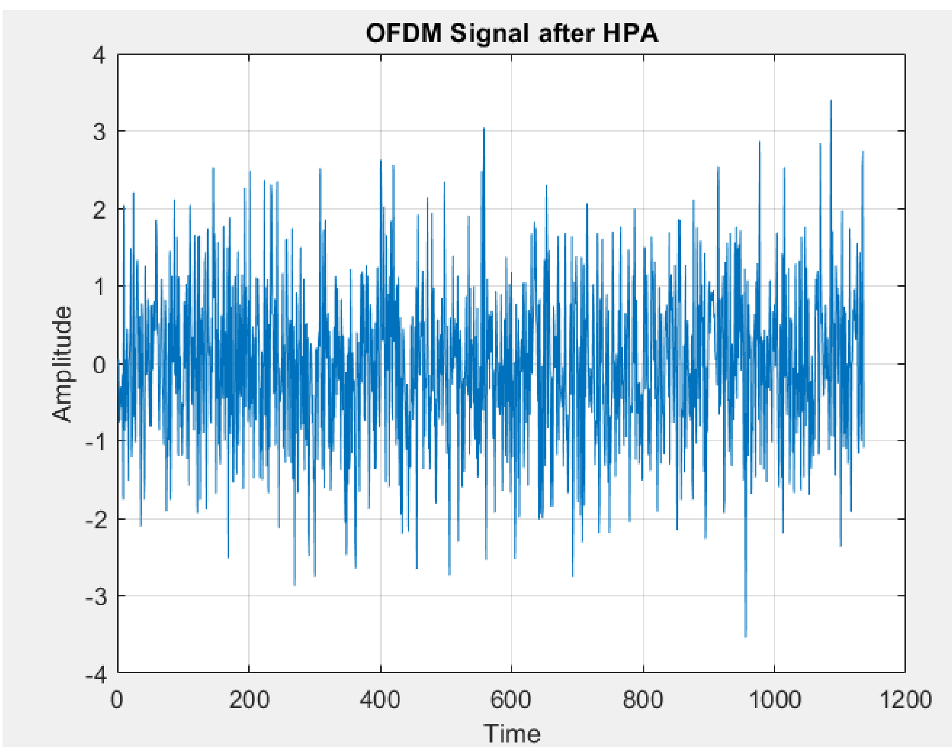
1.2 QAM Constellation



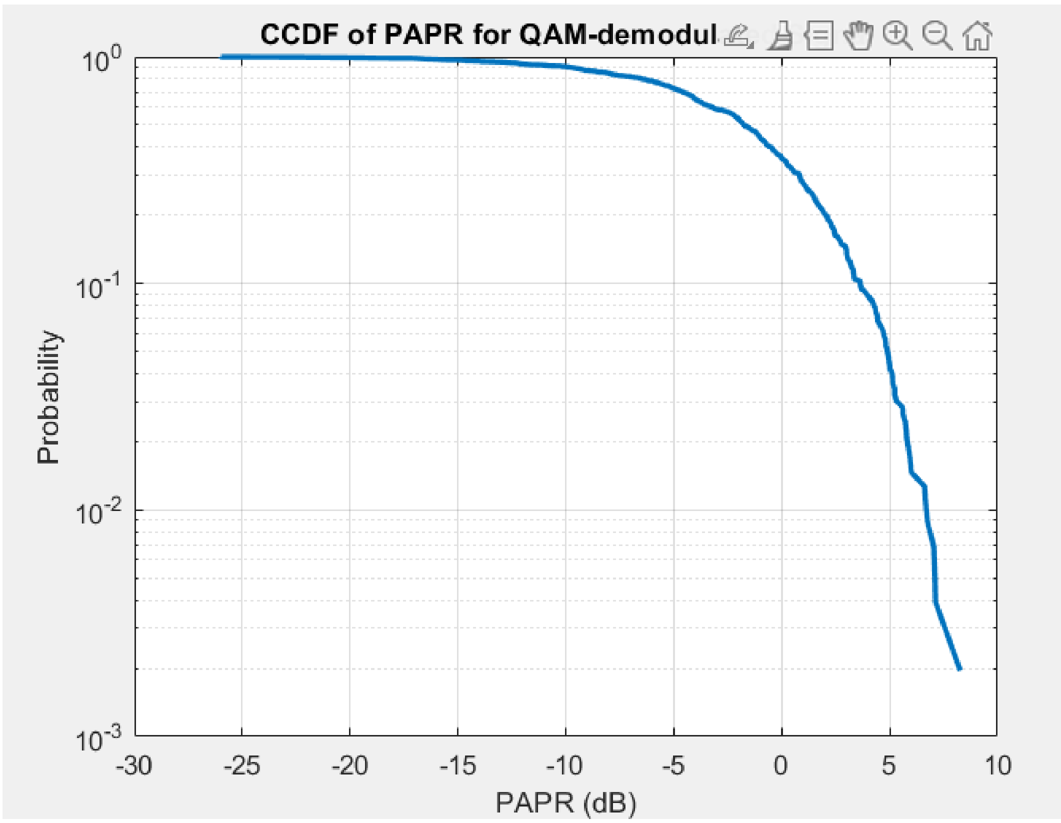
1.3 Windowing of signal with *kaiser* window method



1.4 Windowed signal after passing through High Power Amplifier (HPA)



1.5 Complementary cumulative distribution function for output signal



References

- *Musabe, R., Lionel, M.B., Mugongo Ushindi, V. et al. PAPR reduction in LTE network using both peak windowing and clipping techniques. Journal of Electrical Systems and Inf Technol 6, 3 (2019). https://doi.org/10.1186/s43067-019-0004-1*