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A Comprehensive Survey on PAPR Reduction Techniques for OFDM Systems

Sonu Jamre[1] Prof. Vijay Bisen[2] Prof. Neha Khatri[3]

ABSTRACT: With increasing number of cellular network users, large data being generated and limited bandwidth available for systems, efficient multiplexing techniques are needed that use the available bandwidth efficiently for IoT Systems. One of the most efficient multiplexing techniques available presently is Orthogonal Frequency Division Multiplexing (OFDM). It is widely used in cellular and internet of things (IoT) based applications. One of the major challenges that OFDM suffers from is high value of Peak to Average Power Ratio (PAPR). This causes high Bit Error Rates and reduced Quality of Service. Hence it is necessary to reduce the PAPR of the OFDM systems. Several techniques have been employed so far for the reduction of PAPR in OFDM systems. This paper presents a review on the most common PAPR reduction techniques for OFDM systems.

Keywords:* *Cellular Networks, Orthogonal Frequency Division Multiplexing (OFDM), Peak to Average Power Ratio (PAPR), PAPR reduction.

I. INTRODUCTION

For any bandwidth constrained cellular system, the bandwidth would be limited, hence an effective multiplexing technique is needed. Thus, OFDM is widely chosen as the multiplexing technique for several applications such as cellular networks, IoT, Local Area Networks (LANs), WiMax etc. While transmitting the OFDM based IoT data, it is mandatory to ensure high reliability (Quality of Service) by reducing the BER value. However, this a severely challenging with fading condition and high power amplifiers need to be used to boost the OFDM signals. Hence, it is necessary to reduce the PAPR of the system to avoid the distortions in the finally received OFDM signal to maintain high reliability and Quality of Service.

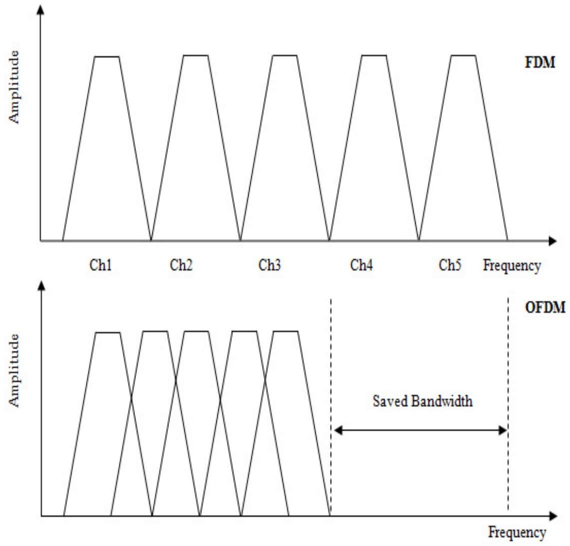

Fig.1 Spectra of FDM and OFDM

Figure 1 shows the spectra of OFDM and FDM (frequency division multiplexing). It can be seen that OFDM helps to save critically important bandwidth. Use of OFDM has 2 benefits:

1. The saved bandwidth can be used to accommodate more users
2. The saved bandwidth can be distributed among users to provide them with more bandwidth.
3. Higher bandwidth per user means high speed of data transfer.

II. PEAK TO AVERAGE POWER RATIO.

The peak to average power ratio (PAPR) of the system is defined as the ratio of the peak power to that of the average power of the system

Mathematically, it is defined as:

$$PAPR = \frac{\max\{X(t)^2\}}{mean\{X(t)^2\}} \qquad (1)$$

Here,

PAPR stands for peak to average power ratio

X(t) is the transmitted signal

Max represents the peak of the signal

Mean represents the average value

The significance of this term lies in the fact that the PAPR gives the deviation of the signal from the average power thereby making higher distortions in High Power Amplifiers (HPAs). OFDM inherently suffers from high PAPR which results in increased errors at the receiving end of networks. Thus it is necessary to reduce the PAPR of the system.

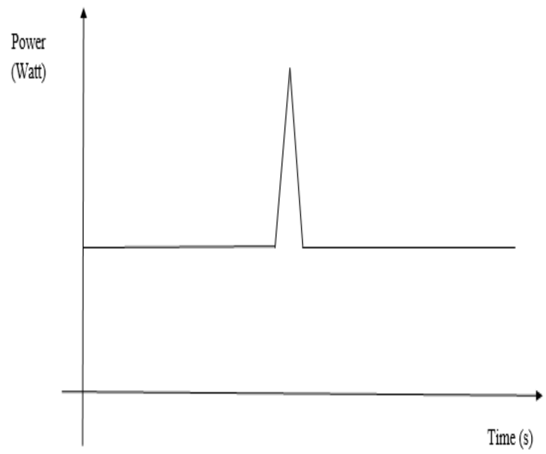

Fig.2 Graphical representation of PAPR

Figure 2 shows the graphical representation of PAPR of the system where the peak power greatly exceeds the average power.

III. RELATED WORK

This section presents the major noteworthy contribution in the domain of research on PAPR reduction in OFDM systems in tabular form.

S.No	Authors	Approach	Publication
1.	Xing et al.	A companding and clipping hybrid scheme for PAPR reduction for OFDM systems	IEEE 2021
2.	Lv et al.	Genetic Algorithm (GA) based partially transmitted sequences (PTS) algorithm for PAPR reduction.	IEEE 2020
3.	Gopi et al.	Optimized Selective Mapping through hybrid of linear integer programming (LIP) and Selective Mapping (SLM)	IEEE 2020
4.	Aghdam et al.	Combination of Particle Swarm Optimization (PSO) and Partially Transmitted Sequences (PTS) for PAPR reduction.	Elsevier 2019.
5.	Rao et al.	PTS and grey wolf optimization hybrid algorithm for PAPR reduction.	Springer 2019.

6.	Xiao et al.	Low PAPR OFDM with Implicit Side Information and reduced Complexity for IoT Networks	IEEE 2018
7.	Sultan et al.	Chaotic Constellation Mapping for Physical-Layer Data Encryption in OFDM-PON	IEEE 2018
8.	Adnan et al.	Chaotic Walsh–Hadamard Transform for Physical Layer Security in OFDM-PON	IEEE 2017
9.	Zhang et al.	Physically Secured Optical OFDM by Employing Chaotic Pseudorandom RF Subcarriers	IEEE 2107
10.	Wei Zhang et al.	Joint PAPR Reduction and Physical Layer Security Enhancement in OFDMA-PON	IEEE 2016
11.	Chongfu Zhang et al.	Hybrid time-frequency domain chaotic interleaving for physical-layer security enhancement in OFDM based IOT systems	IEEE 2016
12.	Hu et al.	Chaos-OFDM based Partial Transmit Sequence Technique for Physical Layer Security in OFDM-PON	IEEE 2015
13.	Yang et al.	Chaotic signal scrambling for physical layer security in OFDM-PON	IEEE 2015
14.	Liu et al.	Physical Layer Security in OFDM based on Dimension-Transformed Chaotic Permutation	IEEE 2014
15.	Wei Zhang et al.	Chaos Coding-OFDM based IoT QAM IQ-Encryption for Improved Security in OFDMA-PON	IEEE 2014

Table.1 Existing Approaches for PAPR reduction

IV. CCDF FOR PAPR ANALYSIS

The Peak to Average Power Ratio (PAPR) can be analyzed using a probability function called the Complementary Cumulative Distribution Function or CCDF. Mathematically CCDF for PAPR can be defined as:

$$y = Prob\,(PAPR > PAPR_0) \qquad (2)$$

The CCDF of the PAPR denotes the probability that the PAPR of a data block exceeds a given threshold $PAPR_0$.

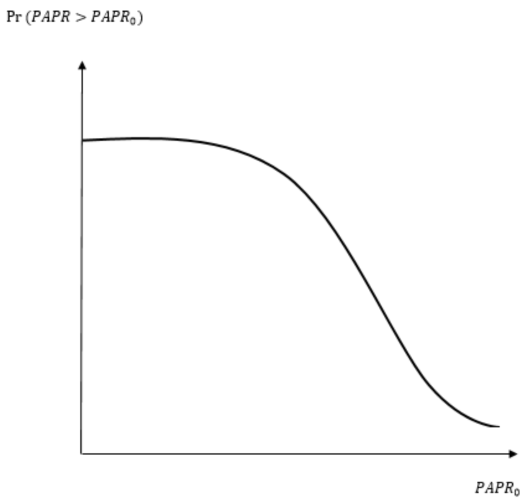

Fig.3 Typical PAPR CCDF graph for OFDM systems

Figure 3 shows a typical CCDF graph for the PAPR analysis. The graphs shows that as the value of PAPR increases, the chances or probability that the system PAPR would exceed the threshold PAPR reduces. A quick drop in the CCDF graph for low values of PAPR is desirable.

V. CONCLUSION

It can observed that cellular and IoT applications are bandwidth constrained. OFDM is one of the most effective multiplexing techniques for cellular systems but suffers from the problem of high PAPR. It is necessary to reduce PAPR and also ensure no or very data loss. This paper presents a review on the fundamentals of OFDM along with the problem of PAPR. The various PAPR reduction techniques used in contemporary work have also been cited.

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