PAPR Evaluation of Generalized Frequency Division Multiplexing System

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Abstract— **The goal of the work is to analyse PAPR reduction performance in 5G communication. 5G communication technology is beyond 4G and LTE technology and expected to be employed around 2020. Research is going on for standardization of 5G technology. One of the key objective of 5G technology is to achieve high data rate by reduction of PAPR value. For this a large bandwidth is needed. Since limited frequency resources are available, the frequency spectrum should be efficiently utilized to obtain high data rate. High PAPR is always a problem in multicarrier communication system. GFDM is also a multicarrier communication system, so it also suffers from high PAPR problem. To reduce the PAPR several PAPR reduction techniques have been presented. All simulations are implemented on MATLAB.**

***Keywords- OFDM, GFDM, FBMC, MATLAB* etc.**

I. INTRODUCTION

Currently, fourth generation wireless communication systems have been employed in most of the countries in the world. However, there are still some challenges like an explosion of wireless mobile devices and services, which cannot be accommodated even by 4G, such as the spectrum scarcity and high energy consumption [1]. Wireless system designers are continuously facing the increasing demand for mobility required and high data rates by new applications and that's why they have started research on fifth generation wireless systems that are expected to be employed beyond 2020. 5G technology stands for fifth generation mobile technology which is the standard beyond 4G and LTE-advanced. There are different challenges in 5G, to overcome these we need new breakthroughs and new technologies. Some of the promising technologies for 5G communication are massive MIMO, cognitive radio, visible light communications, spatial modulation, mobile femto cell, green communication.

The difficulty in simulating the real world network topology makes experimental trials a fundamental source of information for the performance analysis. For instance, as the propagation model limits the simulation assumptions by acquiring experimental data from practical scenarios we are able to validate our hypothesis [1]. It is for this reason that test bed networks are essential to proof the effectiveness of the novel techniques that will boost the network throughput.

Since their first commercial appearance at the early 80s, the cellular networks have evolved in a vertiginous race. This evolution is stimulated and urged by the continuous increase in the demand of the subscribers in terms of accessibility, quality and speed. Besides, these networks are being developed in a polymorphic way so the services offered to the users are increasing in terms of quantity and complexity. At first instance, the mobile networks were designed to cope only with voice traffic over analogue channels. Standards were created to establish a proper regulation frame so the companies and organizations could work in the same line and guarantee a compatibility between networks and terminals [2].

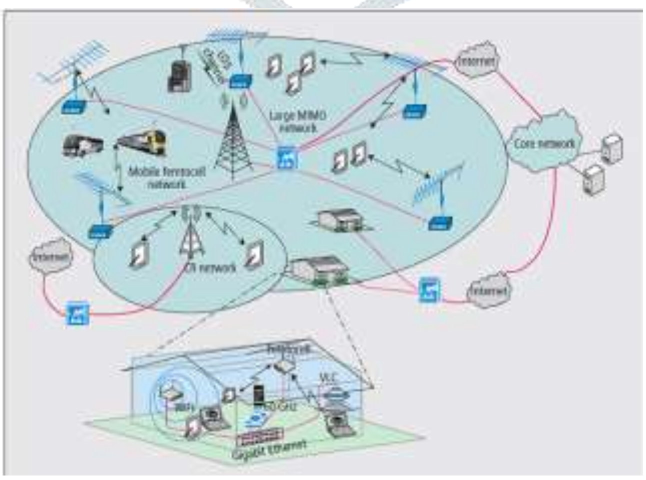

Figure 1: 5G Wireless Cellular Architecture

The latest age in mobile communication, that we use nowadays is the fourth generation technically called IMT Advanced. Similarly to the preceding generations, the ITU is the responsible for regulating and setting the requisites for terminals and equipment that work under this technology. In the beginning, there were two systems commercially deployed, Long Term Evolution (LTE) and Wi-MAX. Despite the companies were offering these brand as 4G, their characteristics didn't fulfil the whole requirements arranged by the ITU-R for the fourth generation standards. For example, in terms of data speed, the early LTE release 8 established target peak data rate of 100 Mbit/s in the downlink for the 3rd category equipment which is not enough to comply with the 4th generation requirements demanded.

To address the above challenges and meet 5G system requirements we require a dramatic change in the design of cellular architecture [3]. One of the key ideas to design the 5G cellular architecture is to separate outdoor and indoor scenario. Because 80% of the time we are in indoor condition, and there is a huge penetration loss through building. So we need to avoid this situation. This will be associated with distributed antenna system (DAS) and massive MIMO.

The paper is ordered as follows. In section II, it represents related work with the proposed system. In Section III, It defines the description of the requirement of the 5g system. Section IV describes the problem definition of system. Finally, the conclusion is explained in Section V.

II. 5G COMMUNICATION

The main challenges in 5G are:

- To serve the extremely large amount of users
- Efficiently use of spectrum
- Reduce power consumption
- To support high mobility
- To support avalanche of traffic volume 1000× in ten years
- To support large diversity of user cases and requirement

OFDM is not suitable for 5G because of its low spectral efficiency and synchronization problem. So we have to search for new waveform contenders for 5G communication. Some of the promising waveform contenders are Generalized Frequency Division Multiplexing (GFDM), Universal Filtered Multicarrier (UFMC), Filter Band Multicarrier (FBMC) and Bi-orthogonal Frequency Division Multiplexing (BFDM).

GFDM

Generalized frequency division multiplexing (GFDM) is a non-orthogonal, multicarrier communication scheme which is proposed to address emerging requirements in cellular communications system such as efficient use of spectrum and machine-to-machine communication with special attention to asynchronous low duty cycle transmission and exploration of non-continuous bandwidths. In GFDM we can transmit multiple symbols per sub-carrier which is not possible in OFDM. GFDM uses block based transmission which is enabled by circular pulse shaping of the individual sub-carriers.

Out of band radiation is reduced by applying different length pulse shaping filters and cyclic prefix is used to reduce ISI and ICI.GFDM is a good choice for short burst application. As a generalization of OFDM, GFDM is compliant with OFDM when the number of symbols per subcarrier is chosen to be one. GFDM can reach BER performance of OFDM while out of band radiation can be reduced by using pulse shaped subcarriers and thus minimizing interference to the legacy system when it is used in cognitive radio application.

UFMC

Filter bank multicarrier (FBMC) filters the signal on per subcarrier basis while orthogonal frequency division multiplexing (OFDM) filter the signal on single shot. UFMC is a way between these two techniques. In UFMC we apply filtering to subsets of the complete band instead of single subcarriers or the complete band. In this way we can get the benefit of better subcarrier separation from FBMC and less complexity from OFDM. UFMC outperforms FBMC and OFDM in some, but not all, of the different aspects relevant for communication.

FBMC

Filter Bank Multicarrier system consist of a bank of filters in transmitter and receiver side. These filters are frequency and phase shifted version of a prototype filter. Prototype filter is the basis of FBMC system which separate two symbols in such a way that minimum out of band radiation occurs. Prototype filter is designed to get low out of band radiation between subcarriers. In filter bank multicarrier (FBMC), the CP can be removed and subcarriers can be better localized in time and frequency, by using advanced prototype filter design. This makes it leading contender for 5G communication.

BFDM

In bi-orthogonal frequency division multiplexing (BFDM) symbols can be perfectly recovered by using bi-orthogonality approach. Bi-orthogonality is a weaker form of orthogonality, here transmit and receive pulses are no longer orthogonal to each other. This approach is well suited for transmission of long symbol pulses. It has the drawback that spectral re-growth is possible due to periodic setting when calculating the bi-orthogonal pulses.

III. DESCRIPTION OF PROPOSED SYSTEM

The objective of this work is to evaluate the performance of GFDM on the basis of PAPR value of the system. The characteristics, structure and services that surround this new generation set a requirements frame to be suited by its waveform design. After the vision and the overall objectives of future wireless networks for 2020 and beyond have been defined, standardization activities for a fifth generation (5G) wireless networks have been started. Although it is expected that 5G new radio (NR) will be based on cyclically-prefixed orthogonal frequency division multiplexing (CP-OFDM)-based waveforms along with multiple waveform numerologies, the sufficiency of CP-OFDM-based NR is quite disputable due to the continuing massive growth trend in a number of wireless devices and applications. Therefore, studies on novel radio access technologies (RATs) including advanced waveforms and more flexible radio accessing schemes must continue for future wireless networks.

Generalized frequency division multiplexing (GFDM) is one of the prominent non-CPOFDM- based waveforms. It has recently attracted significant attention from the researchers because of its beneficial properties to fulfil the requirements of future wireless networks. Multiple-input multiple-output (MIMO)-friendliness is a key ability for a physical layer scheme to satisfactorily match the foreseen requirements of future wireless networks. On the other hand, index modulation (IM) concept, which relies on conveying additional information bits through indices of certain transmit entities, is an emerging technique to provide better spectral and energy efficiency.

Generalized frequency division multiplexing (GFDM) is one of the prominent non-CP-OFDM-based waveforms. It has recently attracted significant attention from the researchers because of its beneficial properties to fulfil the requirements of future wireless networks. A GFDM symbol consists KM samples where each of K subcarriers carry M timeslots. These parameters can be tuned to match the requirements of the application. Consequently, GFDM has the flexibility to engineer the time-frequency structure according to the corresponding scenario. In GFDM, each subcarrier is filtered using circular convolution. Therefore, OOB emission of GFDM is considerably low and it can serve for fragmented and opportunistic spectrum allocation purposes. GFDM uses a single CP for an entire block that contains multiple sub-symbols. This enables frequency domain equalization (FDE) and improves the spectral efficiency. Thus, flexible characteristics of GFDM can be easily tuned to address the new requirements.

OFDM is a poor choice for 5G communication because it uses a cyclic prefix which reduces the spectral efficiency of the system. Also high out of band radiation is a problem with OFDM. High PAPR has always been a problem with multicarrier systems which reduces the efficiency of power amplifier in the system. The Power amplifier efficiency is directly related to PAPR. So power amplifier efficiency can be improved by reducing the PAPR of the signal, which will save power and cost of the system.

In downlink, high PAPR causes reduction in performance of system. The various techniques are used to reduce PAPR value in system. PAPR is viewed as an imperative parameter for concentrate the fundamental distinction of SC-FDMA and OFDMA and it demonstrates the power productivity for the transmitted flag. Low PAPR makes the SC-FDMA more favoured than OFDMA in the uplink numerous entrance for 5G because of it is intrinsically single bearer adjustment structure. There is hypothetical articulation between the PAPR and the power productivity of the transmitted flag and it is given by [1]

$$\eta = (\eta_{max}\ 10^{-PAPR})/20 \qquad (1)$$

Where η is the power productivity and η_{max} is the most extreme power effectiveness. It is obvious from the relationship, high PAPR demonstrates the low power effectiveness and low PAPR show high power proficiency. PAPR is characterized as the proportion of pinnacle control plentiful ness of the flag to the normal power abundances of the transmitted flag. The relationship to clarify PAPR as in seems to be (2):

PAPR= peak power of x(t)/ average power of x(t) (2)

On the off chance that there is no heartbeat moulding connected to the flag, the image rate testing gives an indistinguishable PAPR from in the consistent case since SC-FDMA utilizes single transporter balance.

In SLM procedure, the method is to create an arrangement of adequately extraordinary hopeful information hinders by the transmitter where every one of the information squares speaks to an indistinguishable data from the first information piece and select the good having the minimum PAPR for transmission. Computational many-sided quality, PAPR diminishment ability and maintaining a strategic distance from SI are the real issues related with SLM.

In proposed scheme, after setting the parameters, FDMA scheme is used in uplink side and OFDMA scheme is used in downlink side. Only single carrier is used in uplink side and multi-carrier orthogonal signal is provided in downlink side. The main problem in downlink is the problem of PAPR value. High PAPR causes reduction in capacity of system that affects the performance of system. Due to this, suitable PAPR technique is required to reduce its value.

IV. RESULTS OF PROPOSED SYSTEM

In Proposed plot, like PTS, an info piece of length N is apportioned into various disjoint sub-squares. At that point every one of these sub-squares are cushioned with zeros and weighted by a stage factor. Low computational many-sided quality PTS conspire is proposed where two pursuit steps are utilized to discover a subset of stage pivoting vectors with great PAPR lessening execution. In initial step, groupings with low connection or quaternary successions are utilized as introductory stage turning vectors for proposed plot. In initial step, groupings with low connection or quaternary successions are utilized as introductory stage turning vectors for proposed plot. In the second means, to discover extra stage pivoting vectors, a neighbourhood seek is performed in view of the underlying stage vectors with great PAPR decrease execution. The PAPR is interrelated with capacity of system. As the PAPR value is high, it affects the degradation of performance of system.

GFDM is one of the numerous regulation strategies, which gives high unearthly effectiveness, low execution intricacy, less defenceless ness to echoes and non– direct mutilation. Because of these points of interest of the OFDM framework, it is boundlessly utilized as a part of different correspondence frameworks. Be that as it may, the real issue one appearances while actualizing this framework is the high pinnacle – to – normal power proportion of this framework. It watches the after effect of this activity and that the flag "transporters" utilizes T/2 as its day and age. The initial step is to deliver a persistent time flag and to apply a channel g(t), to the unpredictable flag "bearers". The drive reaction, or heartbeat shape. Figure 2 presents the modulation & demodulation of GFDM. Here, 1000 no. of samples are used that helps to represent data.

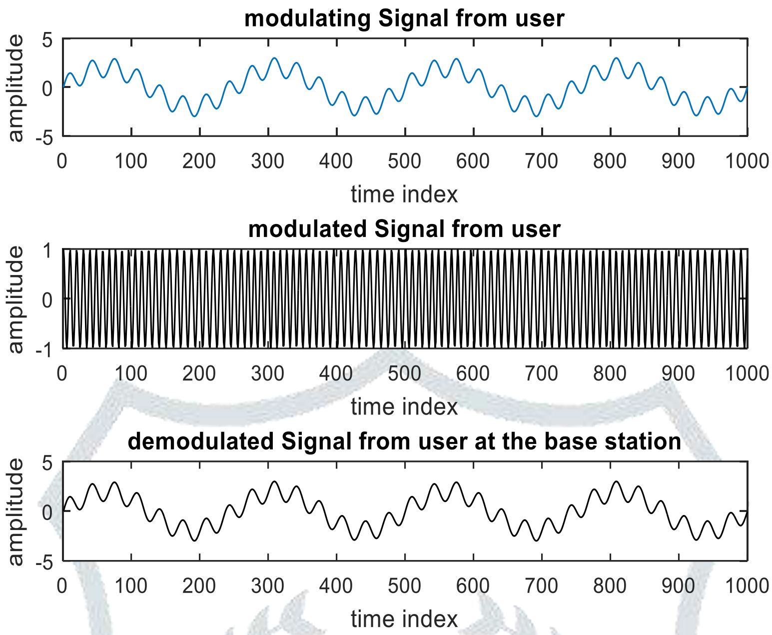

Figure 2: Modulation & Demodulation of GFDM

What's more, GFDM framework requires tight recurrence synchronization in contrast with single bearer frameworks, in light of the fact that in OFDM, the subcarriers are narrowband. Thusly, it is touchy to a little recurrence counterbalance between the transmitted and the got flag. The recurrence counterbalance may emerge because of Doppler Effect or because of confound amongst transmitter and collector neighbourhood oscillator frequencies. Customary OFDM framework utilized IFFT and FFT to multiplex the signs in parallel with diminished multifaceted nature calculation at the transmitter and beneficiary individually. The framework utilizes watch interim and cyclic prefix (CP) with the goal that the postpone spread of the channel turns out to be longer than the channel motivation reaction. The reason is to limit between image impedance between images.

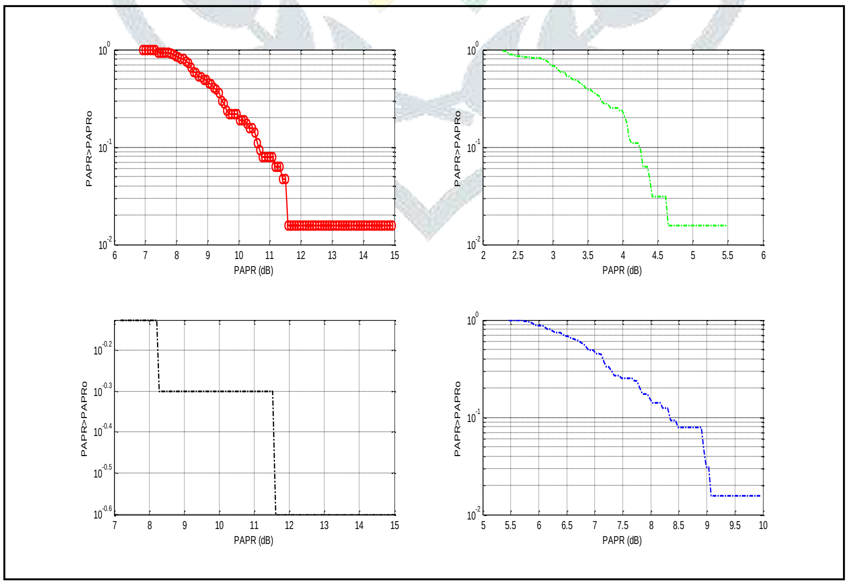

Figure 3: PAPR Comparison of Different Techniques with Proposed Method

GFDM is an extremely alluring strategy for transmission and has turned out to be one of the standard decisions for high – speed information transmission over a correspondence channel. It has different points of interest; yet additionally has one noteworthy disadvantage: it has a high PAPR. PAPR is by and large used to describe the envelope change of the OFDM flag and it is characterized as the proportion of the most extreme immediate capacity to its normal power. Nearness of a vast number of autonomously regulated sub-transporters in an OFDM framework the pinnacle estimation of the framework can be high when contrasted with the normal of the entire framework. This proportion of the crest to normal power esteem is named as Peak-to-Average Power Ratio. Intelligent expansion of N signs of the same stage delivers a pinnacle which is N times the normal flag. The significant impediments of a high PAPR is the expanded unpredictability in the simple to computerized and advanced to simple converter and second is the diminishment is productivity of RF enhancers. The execution examination of various procedures appear in table 1 and results demonstrate that the proposed method gives better PAPR esteem when contrasted with different systems.

Table 1: Performance Comparison of PAPR Response

S.N.	METHOD	PAPR VALUE
1	ORIGINAL SIGNAL	12.063
2	AMPLITUDE CLIPPING	12.352
3	SELECTIVE MAPPING	9.191
4	PROPOSED TECHNIQUE	4.679

V. CONCLUSION

Generalized frequency division multiplexing (GFDM) scheme, as a new type waveform design program, aims to suppress out of band radiation in traditional orthogonal frequency division multiplexing (OFDM) scheme in 4G and relieve the increasingly intensive spectrum resources. This paper presents a performance evaluation of the generalized FDM system on basis of PAPR technique. FBMC is also a promising waveform candidate for 5G technology which gives high spectral efficiency and low out of band radiation required for 5G communication. There are several PAPR reduction techniques proposed for system. It also provides a performance comparison of system with other techniques. In this work, GFDM system is presented and its PAPR is evaluated and then compared with different techniques.

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