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Numerical Simulation and Design of Low PAPR FBMC Communication System for 5G Applications

Vaibhav Vashistha[1], Mr.Avinash Sharma[2]
[1]Jaipur Institute Of Technology
Jaipur, Rajasthan
vashistha9a@gmail.com
[2]Assistant Proffesor
Department of ECE
jitavinash@gmail.com

Abstract- Unlike SC-FDMA (Single-Carrier Frequency Division Multiple Access), merging only DFT (Discrete Fourier Transform) addition with FBMC-OQAM (filter group multi-carrier with offset quadrature amplitude modulation) only cuts the marginal PAPR. (Peak-to-average power ratio). To take advantage of the single carrier effect of DFT extension, special conditions for the coefficients of the IQ (in-phase and quadrature phase) channels of every single subcarrier ought to be met. As a beginning point, we first originate this form, which we call the ITSM (Identical Time-Shifted Multi-Carrier) condition. Then, depending on this condition, we put forward a new FBMC for low PAPR. The foremost features of the offered way out are summarized as: First, to additionally raise the PAPR reduction, we created four candidate versions of the FBMC waveform for DFT spreading out and ITSM conditions and carefully chosen one with the least peak power. Even with various candidate generations, unlike the traditional SI (Side information) based PAPR reduction scheme, the focal computational fragments (such as DFT and IDFT) are shared and need only be executed one time. Therefore, matched to the prior DFT-expanded FBMC, the overhead in complexity is small, and the recommended pattern can realize a PAPR reduction comparable to SC-FDMA. Second, in the projected pattern each one pass on only two bits of SI from a block of FBMC-OQAM symbols. And so, the SI overhead is meaningfully lesser than a conventional SI-based scheme such as SLM (Selective Mapping) or PTS (Partial Transmission Sequence).The whole work is executed using MATLAB software. The PAPR of FBMC system has been significantly reduced after the application of proposed algorithm. PAPR was reduced by 25 % after the use of DFT spreading and ITSM conditioning.

Keywords*:* FBMC (filter bank based multi- carrier), PAPR (Peak-to-Average Power Ratio), OQAM (offset QAM), HPA (High power amplifier), SC-FDMA (Single-carrier FDMA), DFT (Discrete Fourier Transform), ITSM (Identically Time Shifted Modulation), SI (Side Information).

I. INTRODUCTION

Mobile wireless industry has started its technology creation, revolution and evolution since early 1970. Cellular communication industry has witnessed explosive growth in mid-1990. The rapid worldwide growth in cellular telephone subscribers has demonstrated conclusively that wireless communications is a robust, viable voice and data transport mechanism. The wide spread success of cellular has led to the development of newer wireless systems and standards for many other types of telecommunication traffic besides mobile voice telephone calls. We can attain diversity signals through a range of transmission (ideally) like time, frequency or space independent fading paths and constructive at the receiver combination. Multiple input- multiple-output (MIMO) having a plurality of transmit and receive antennas use spatial diversity.

However, the paper "MIMO principle “Assumed frequency flat fading MIMO channel. Orthogonal Frequency Division Multiplexing (OFDM) is its ability to alleviate the multipath modulation scheme. In OFDM, high-speed data stream is divided into narrow band data flow Nc, Nc points corresponding to the sub-carriers or sub-channels, namely a OFDM symbol comprises a QAM or PSK modulation, for example N symbols. As a result, the symbol duration than those with the same symbol rate of a single carrier system is N times longer. High PAPR and inter-carrier interference (ICI) are the two major problems in the OFDM system implementation. Instead of using complex exponential

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functions, cosine functions, wavelets can be used as orthogonal basis to implement multi-carrier scheme. This can be synthesized using discrete cosine transform (DCT) and DWT. For quickly implementation, these algorithms can provide fewer computational steps than FFT based OFDM. Under the approached paper, our main is to propose a new type of FBMC where its waveform has low PAPR without involving any complicated PAPR reduction scheme. The main designs factors involve are low complexity overhead and negligible SI overhead.

II. PROBLEM STATEMENT AND OBJECTIVES

This paper is mainly created on the combination of DFT spreading and ITSM-conditioned FBMC, a new kind of FBMC with lower PAPR is proposed. Our work initiated from deriving special condition called ITSM (identically time shifted multicarrier) condition.

Problem Statement- The problem statement of this paper is **"Design, Simulation and Performance Assessment for Low PAPR FBMC for 5G Applications".**

Objectives- The main objectives are as follows:

- To check modulation and demodulation operation in FBMC system.
- To simulate and analyze bit error rate (BER) in FBMC system.
- To calculate and plot peak to average power ratio CCDF curve for FBMC systems and comparison with OFDM systems.
- To simulate and compare modulation and demodulation pattern of potential 5G waveforms (OFDM, UFMC and FBMC).

III. DESIGN OF PROPOSED WORK

The purpose of this project is to put forward a new type of FBMC for a low PAPR. Unlike SC-FDMA (single carrier-frequency division multiple access), by merging DFT (Discrete Fourier Transform) spreading and FBMC-OQAM (filter bank multicarrier with offset quadrature amplitude modulation) fallouts in only marginal PAPR (peak to average power ratio) reduction. In order to make use of the single carrier effect of DFT spreading, a special condition of the coefficients at each subcarrier's IQ (In-phase and Quadrature-phase) channels need to be satisfied. We initiated the work by first deriving out the ITSM (identically-time-shifted-multicarrier) condition. Afterwards, depending on this condition, we propose a new type of FBMC for low PAPR.The main features of the proposed work are summarized as:

- Generation of four candidate versions of the DFT-spread so as to enhance the reduction of PAPR amount.
- Deriving of ITSM-conditioned FBMC waveform & hence selecting the one with minimum peak power.

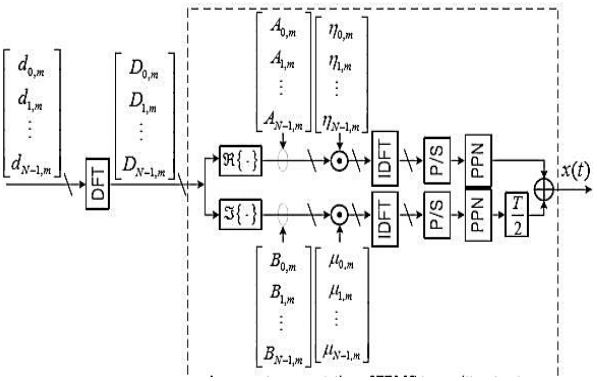

Fig. 3.1 Implementation Structure of DFT-Spread FBMC

- **Comparison is done as per Phase Shift pattern with/without DFT-Spreading**

PAPR reduction is limited to 0.6 dB-0.8 db. Also, in overlapped channel single carrier signal is imperfectly made. After study on various works based on PAPR reduction, it can be confirmed that by ITSM-conditioned phase shift pattern; the substantial PAPR reduction is further achieved. Moreover, this gain is achieved only by properly setting and without any hardware block or computation complexity overhead.

The further PAPR fall by the ITSM-conditioned phase shift pattern over the non-ITSM-conditioned phase shift patterns is restricted to 0.6 dB ~ 0.8 db. This is due to the fact that single carrier effect is realized only in the overlapped interval between the IQ channels of the OQAM symbol. In addition, even in the overlapped interval, the single carrier signal is defectively made because of non-rectangular pulse shaping. To overcome this constraint, an advance upgraded scheme employing a candidate selection idea introduced in following section

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- **Combining candidate selection scheme with ITSM-Conditioned and DFT-Spread FBMC**

Table3. 1: Switching Rule for Four Versions of the Waveform

Version	Switching control bit	Switching control bit
	0	0
	1	0
	1	1
	0	1

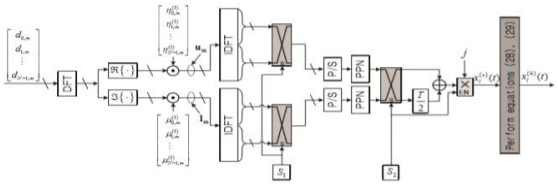

Fig. 3.2 Complexity Efficient Transmitter of the Proposed FBMC

IV EXPERIMENTAL RESULTS AND ANALYSIS

The previous chapter discussed about the details of design flow of the targeted work. This chapter discusses about experimental scenarios and results obtained low PAPR FBMC system. In this chapter, we will first associate the proposed scheme with pure (non-DFT spread) FBMC and prior DFT propagation schemes Simulation based PAPR results. Proposed structure greatly reduced PAPR. Hence, addition to DFT propagation, the offered program also has factors to further improve PAPR fall, i.e. choosing among four waveform deviations have different peak powers.

In order to properly evaluate the proposed plan from the following aspects its design goal is low PAPR, low computational complexity and negligible SI overhead, we compare these three factors in various PAPR reduction schemes of FBMC. Schemes in [5] and [8] are considered for comparison because they are called both Typical PAPR reduction scheme for FBMC, and based on PTS and SLM respectively. Instead of an analog solution in [5, 8] which are quite problematic, we picked up the values of PAPR from its CCDF curves which were provided for comparison in those papers.

A. Performance Analysis between Contending Waveforms

The PAPR and BER of FBMC and UFMC over OFDM is matched. The simulation plots two graphs with reference to the same correspondingly. PAPR analysis shows that the PAPR of FBMC Signal is greater than that of OFDM and UFMC.

It also overshadows the high power spectral density merit and bandwidth utilization merit of FBMC signal. It is requisite to overcome this issue by applying proper mechanism to reduce PAPR of FBMC signals.

The comparative assessment of PAPR for FBMC with respect to other signals has been described in figure 4.1

It proves that there is significant rise in PAPR of FBMC signal as compared to other contender waveforms.

In next section we have simulated the PAPR with proposed DFT spreading and ITSM conditioning methodology to understand its impact on the value of PAPR.

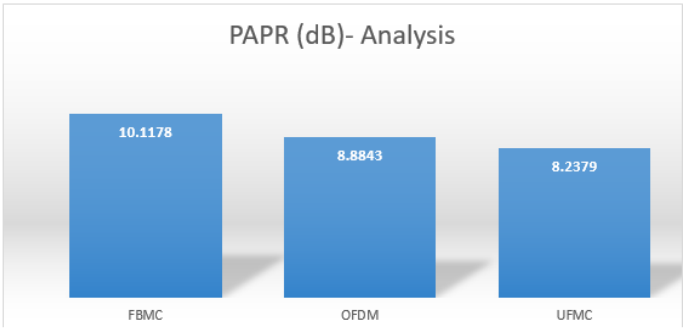

Fig. 4.1 PAPR Analysis of FBMC, OFDM and UFMC

B. Simulation of Proposed PAPR Reduction Scheme for FBMC System

The PAPR of FBMC system has been simulated using DFT spreading and ITSM condition. It was perceived that there was noteworthy reduction in the PAPR of the FBMC system as linked to the original waveform.

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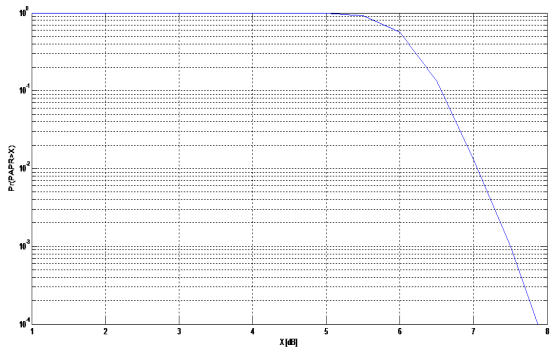

Fig. 4.2 (a) Analysis of PAPR – FBMC System

It was also detected that the reduction in PAPR stayed consistent even while changing parameters like number of subcarriers as well as no of symbol per frame as well as sub frames. The CCDF plot of FBMC system with ITSM conditioning and DFT spreading is shown in figure 4.2.

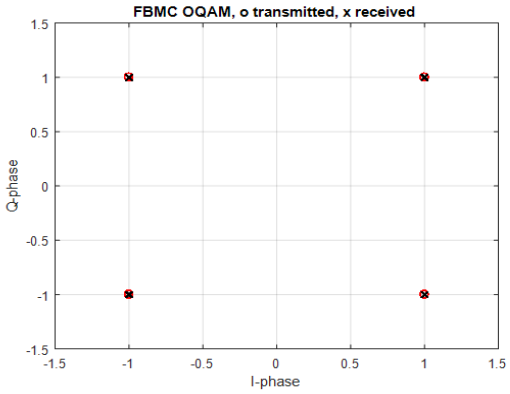

Fig.4.2 (b) Analysis of PAPR – FBMC System

Table 4.1 Analysis of Proposed Methodology

Type of Waveform	PAPR (dB) (Initial)	PAPR(dB) (After Methodology)	Percentage Decrease in PAPR
FBMC	10.1178	7.5	25.87 %

The PAPR of FBMC system has been significantly reduced after the application of proposed algorithm. PAPR was decreased by 25 % after the application of DFT spreading and ITSM conditioning. Also the drawback of side information which is persistent in conventional PAPR reduction techniques such as clipping, partial transmit sequence and Selective mapping is too overcome.

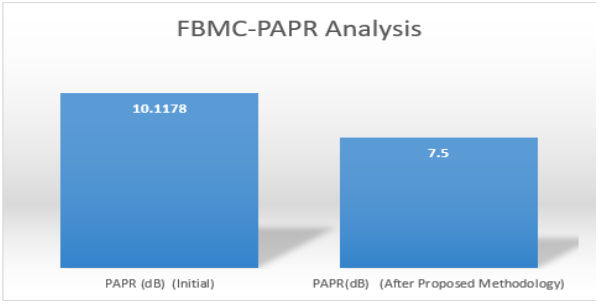

Fig.4.3.Analysis of Proposed Methodology – FBMC System

The proposed technique expands the duration and performance of transmitters and receivers due to consistency in the behavior of waveform.

C. Analysis of Bit Error Rate

Variation in the SNR affects the quality of the constellation. The simulation of BER vs SNR was generated for SNR from to 0 from 15 dB. FBMC has best performance compared to other techniques; it is closer to 0 from 5 dB.

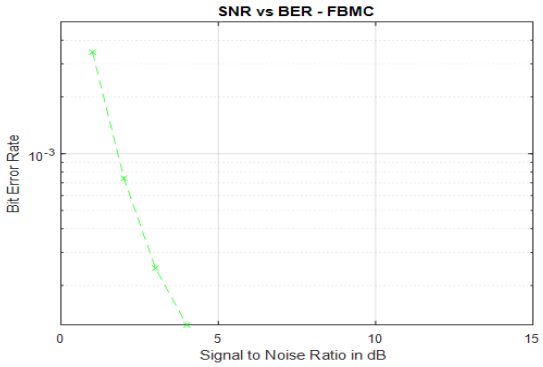

Fig. 4.4 BER Analysis of FBMC

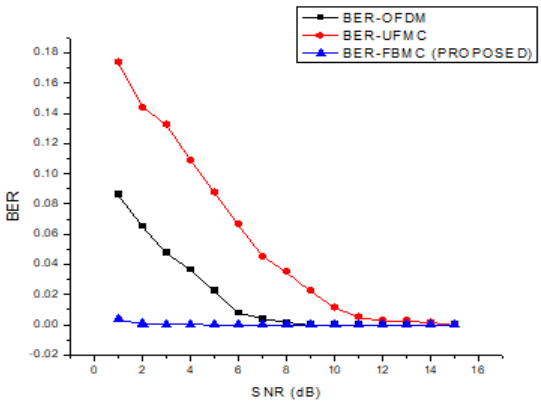

Fig. 4.5 Comparison Graph of BER

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The carry out research work is targeted to reduce the inadequacies of contending waveforms so that resourceful communication system can be established.

V CONCLUSION AND FUTURE SCOPE

Conclusion:

In this work, we recommended a low PAPR FBMC scheme and demonstrate its excellent performance compared to the existing PAPR reduction scheme in terms of PAPR reduction gain, computational complexity overhead and SI overhead. The very first step is to derive the so-called ITSM (Identically time Shifted Multi-Carrier) condition, which takes full improvement of the single-carrier effect of DFT-extended FBMC. Then, to further increase the PAPR reduction, we produced four candidate versions of the FBMC waveform for DFT expansion and ITSM conditions and selected one with the smallest peak power. The PAPR of FBMC system has been significantly reduced after the application of proposed algorithm. PAPR was reduced by 25 % after the use of DFT spreading and ITSM conditioning. It also disables the downside of side information which is persistent in conventional PAPR reduction techniques such as clipping, partial transmit sequence and Selective mapping. The proposed system expands the lifespan and performance of transmitters and receivers due to consistency in manners of waveform. The commenced research is designed to cut the shortcomings of contending waveforms so that resourceful communication system can be established.

Future Scope:

The requirement to condense the PAPR of normal OFDM signal and OFDM signal acquired from conventional schemes has been a main appealing factor for this research work. The thesis aims at exploring and arriving at the schemes for PAPR reduction in OFDM based systems of practical interest in an effective and efficient way. In conclusion it is imperative to emphasize that wavelet theory is still developing. There are many prospects for future work in this area, and are brief as follows:

- **Execution of More Waveforms for Assessment:** Choice of waveforms such as SCMA and other waveforms can be a matter of research in future.
- **Channel Estimation and Parametric Variation:** Channel estimation and more research on parametric variation techniques can be employed for better outcome.

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