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PAPR Reduction Technique for Universal Filter Multi Carrier

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***Abstract* — With the rapid growth of wireless communication in recent years, the need for high-speed data transmission has been increased. The mobile telecommunication industry faces the problem of providing the technology that can able to support a variety of services ranging from voice communication with a bit rate of few kbps to wireless multimedia in which bit rate up to Gbps. Many system waveforms have been proposed for 5G communication where UFMC is an adequate waveform candidate for 5G communication network due to MIMO compatability, but it also suffers from Peak to average power ratio(PAPR) as in Orthogonal Frequency Division Multiplexing (OFDM). This project concentrates on reducing the PAPR for universal filtered multicarrier signal by using signal scrambling technique with natural inspired search algorithms as optimizers. The signal scrambling technique is a base method for reducing the crest factor in multicarrier communication which inherits the same method for UFMC with Fireflies Algorithm (FA) as optimizers which is a natural inspired search algorithm.**

Keywords* — *5G, Multi carrier systems, OFDM, UFMC, PAPR, Firefly algorithm

I. INTRODUCTION

Throughout the last decade, Orthogonal Frequency Division Multiplexing (OFDM) was the prevailing waveform generation technique that has been widely used in most of the telecommunication systems such as LTE, WiFi, WiMAX and power line communication (PLC) [1]. Although with several merits, for instance, ease of implementation and multiple-input multiple-output (MIMO) - friendliness, OFDM has some instant drawbacks such as high sidelobe levels and sensitivity to carrier frequency offset (CFO). The future communication shall aim at a relaxation of non-orthogonality and asynchronous transmission. Clearly, faced with these scenarios, pure OFDM transmission might be inefficient. Recently, filter bank based multi-carrier (FBMC) has arised much interest as a substitution for OFDM [2]. By filtering each subcarrier, FBMC provides very strong sidelobe suppression with integrated poly-phase filter-banks. However, a quite remarkable weakness of FBMC is the requirement for relatively long filter length, which may induce extra delay in addition to hardware complexity and thus infeasible for the short burst traffic. To deal with it, universal filtered multi-carrier (UFMC) has been proposed. By filtering a series of successive subcarriers, UFMC can achieve lower out-of-band (OOB) emission as compared to OFDM and it is capable of supporting segmented spectrum, low latency and asynchronous framework.

According to the requirements, the future 5G mobile networks should provide higher performance compared to LTE-Advanced networks, including data transmission rate up to 20 Gb/s, network latency up to 1 ms and the number of serviced devices up to 1 million per square kilometer. Development of new data transmission methods to enhance spectral efficiency gives rise to the amount of data transmitted in mobile networks and high data transmission rate in 5G networks at limited frequency resource. Nowadays, the most commonly used data transmission technology in broadband wireless systems is Orthogonal Frequency Division Multiplexing (OFDM) [3]. OFDM is used in communication systems such as LTE / LTE-Advanced and IEEE 802.11a/g/n/ac, ensuring their high spectral efficiency. However, those characteristics which OFDM provides in 4G networks are no longer enough to meet the high requirements of 5G networks [4]. Therefore, a promising technology for 5G networks is new technologies such as Filter Bank Multicarrier (FBMC) and Universal Filtered Multi-Carrier (UFMC), Generalised Frequency Division Multiplexing (GFDM). The future mobile network will serve different types of mobile devices from Smartphones with relatively high cost, and characterized by high productivity, to simple sensors and actuators, which must have low power consumption and cheap element base, 5G networks should allow transmit data using simplified synchronization systems with time-frequency distortion. Since the wireless access has to be flexible, scalable, content aware, robust, reliable and efficient in terms of

both energy and spectrum. These are the strong indicators that at least for some of the mentioned applications the OFDM waveform is not suitable.

The rest of the paper is organized as follows: In section II, the limitations of OFDM is given. In section III, the UFMC System model is described. In section IV, the firefly algorithm is detailed. In section V; the Simulation results is explained. In section VI, the conclusion is provided.

II. LIMITATIONS OF OFDM

OFDM has certain constraints like cyclic-prefix overhead, Sensitivity to frequency offset CFO, Spectral re-growth and High PAPR makes it not the most reasonable waveform for all the focused on applications of 5G. In OFDM to ride with ICI in the case of multipath fading, cyclic prefix is best ever technique used. But the cyclic prefix introducing additional bits to the transmitting data so data redundancy increased. The orthogonality in OFDM is based on the perfect synchronization carriers of transmitter and receiver. If frequency offset introduced between the transmitter and receiver the orthogonality will be lost in OFDM and causing Inter-Carrier Interference (ICI). In OFDM the orthogonality is assured with the perfect synchronization of transmitter and receiver for a symbol period. For this the OFDM symbol will be suddenly discounted the transmission after every symbol duration. This sudden discontinuity will cause spikes in the frequency domain. This out-of-band radiation will affect by the adjacent carriers. Another challenge with OFDM is the high PAPR. The high PAPR in an OFDM system essentially arises because of IFFT operation. In OFDM the transmitted samples are IFFT samples of information symbols. Different symbols loaded on to the sub-carriers are random, and depending on their nature, they can occasionally all add-up across subcarrier to produce a high peak value that gives rise to a very high instantaneous swing with respect to the normal mean value. The nonlinearity of the power amplifier generates in-band and out-of-band distortion. Because of these drawbacks researchers looking for an alternative waveform that are complement the weaker aspects of OFDM.

III. UFMC SYSTEM MODEL USING SIGNAL SCRAMBLING TECHNIQUE

In UFMC, the data symbols are divided and applying indi-vidually to N point IFFT blocks called resource blocks and filter individually, later it's combined to form a UFMC symbol. So the proposing method that applies the phase rotation to each resource block to form a low PAPR combination of 'B' resource blocks and phase vector 'P' of length 'B' [8]. One optimizer has to design to select an optimum solution of resource block and phase vector combination as shown in Figure 3.1

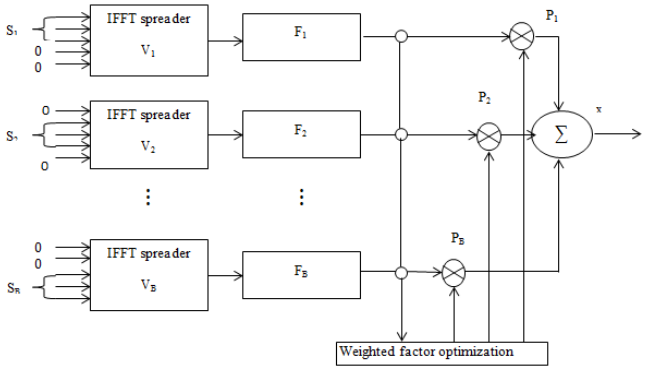

Figure 3.1 Block diagram of signal scrambling technique for UFMC

$$x=\sum_{i=0}^{B-1} F_i V_i S_i P_B \qquad (3.1)$$

where, P_B is phase vector which gives the low PAPR. These optimal phase vectors PB have to send as side data to receiver to retrieve the original UFMC symbol [10]. The optimizer has to select the phase factor by capture the data from the output from the filter and search the vec¬tor of dimensions 'B'. If possible phase factors are 'a' then size of a vector space is aB.In order to find an optimum solution from a large search space,the heuristic search method has been developed. There are lot of heuristic search methods which are inspired by natural evolution procedure. Genetic Algorithm(GA), Paricle Swarm Optimization (PSO), Ant Bee Colony (ABC) and Firefly Algorithm(FA) which are the meta-heuristic algorithms as optimizers. In this project, Firefly

algorithm is used as an optimizer due to the Speed of convergence is very high in probability of finding the global optimized answer.

IV. FIREFLY ALGORITHM

FA was based on the flashing patterns and behavior of fireflies. The pattern of flashes is often unique for a particular species. The flashing light is produced by a process of bioluminescence; the true functions of such signaling systems are still being debated [12]. However, two fundamental functions of such flashes are to attract mating partners (communication) and to attract potential prey. In addition, flashing may also serve as a protective warning mechanism to remind potential predators of the bitter taste of fireflies. The rhythmic flash, the rate of flashing and the amount of time between flashes form part of the signal system that brings both sexes together. Females respond to a male's unique pattern of flashing in the same species, whereas in some species such as Photuris, female fireflies can eavesdrop on the bioluminescent courtship signals and even mimic the mating flashing pattern of other species so as to lure and eat the male fireflies who may mistake the flashes as a potential suitable mate. Some tropical fireflies can even synchronize their flashes, thus forming emerging biological self-organized behavior.

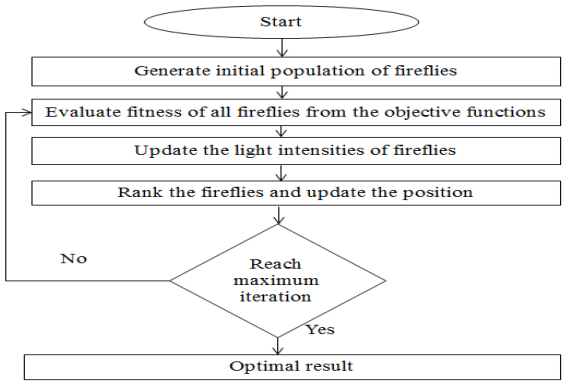

Figure 4.1 Flowchart og Standard Firefly Algorithm

V. SIMULATION RESULTS

The simulations are carried out for UFMC signal using MATLAB software, version R2015a 8.5. The PAPR performance and SER performance can be carried out in this section. The parameters used for the simulation is tabulated in Table–I.

Table-I Simulation Parameters of UFMC using Firefly Algorithm

General Parameters	Number of Sub carriers (N)	1024
	Number of bits per symbol	4
	Modulation Technique	QAM
OFDM	Cyclic Prefix length	72
UFMC	No of Sub Bands (B)	16
	Filter length (L)	100
	Filter type used	Dolph-Chebyshevfilter
UFMC-FA	Number of fireflies	25
	Max iterations	50

Figure 5.1 shows the PAPR performance curve of UFMC by using FA algorithm. From the analysis, the PAPR performance of UFMC by using Firefly algorithm has been reduced from 8.5dB to 7.4dB.So, the PAPR is reduced about 1.2dB.

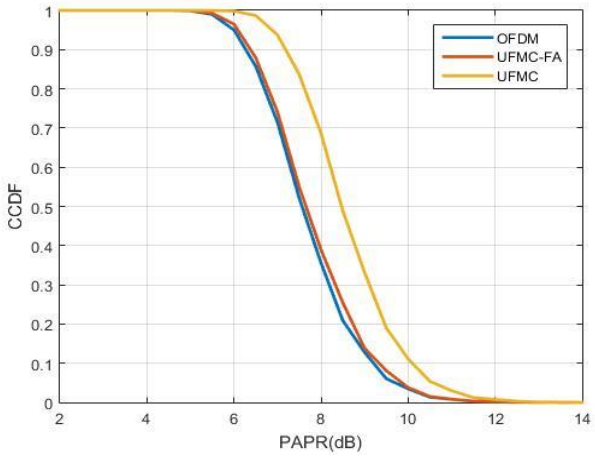

Figure 5.1 PAPR performance of UFMC by using FA algorithm

Figure 5.2 shows the SER performance curve of UFMC by using FA algorithm. The SER performance degrades of about 2.2dB due to QAM modulation. Due to the speed of convergence and multi modal optimality, Firefly algorithm is used as an optimizing technique to reduce the PAPR.By analyzing the Simulation results, the PAPR can be reduced of about 1.2dB. But, the SER performance degrades of about 2.2dB.

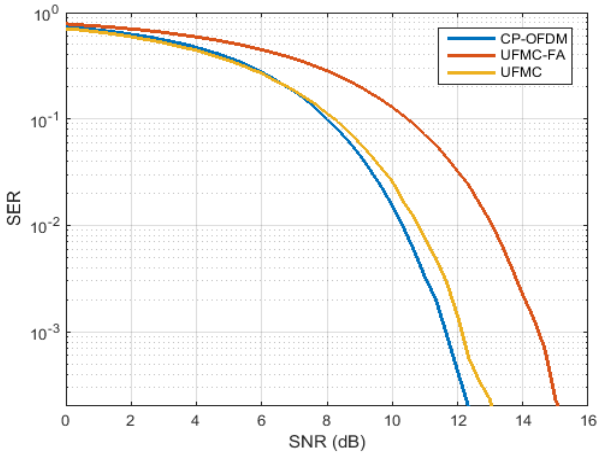

Figure 5.2 SER performance of UFMC using FA algorithm

VI. CONCLUSION

This paper explained the necessity of the waveform candidate for 5G communication network. Due to MIMO compatibility, UFMC waveform was chosen for this project. Though it was applicable for MIMO schemes, it suffered due to high PAPR. In order to reduce high PAPR, Signal scrambling technique with natural inspired search algorithm as an optimizer was used. Due to the ability of managing multimodality optimization and high speed of convergence, Firefly algorithm was used as an optimizing technique. By using FA algorithm, the PAPR of UFMC waveform was reduced of about 1.2dB. But, the SER performance degrades of about 2.2dB due to QAM modulation.

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