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A TREE SEED TUNED PARTIAL TRANSMIT SEQUENCE APPROACH FOR IMPROVING PEAK TO AVERAGE POWER RATIO IN UNIVERSAL FILTER MULTI CARRIER FOR 5G COMMUNICATION

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Abstract: Universal Filter Multi-Carrier (UFMC) plays a significant role in an asynchronous transmission because of its high spectral efficiency. However, the effectiveness and efficacy of the UFMC systems is hindered by the high peak to average ratio (PAPR), which in turn decreases the potency of power amplifiers. Over the years, a number of approaches have been developed for reducing the PAPR in UFMC systems; however these systems used conventional PAPR reduction techniques that were highly complex and ineffective. Therefore, an improved and reliable UFMC model is proposed in this paper that is based on Partial Training Sequence (PTS) and Tree Seed Algorithm (TSA). The main objective of the proposed model is to reduce the PAPR value and complexity of the UFMC systems. To achieve the desired objective, a signal is generated at the transmitted end and upon which modulation and filtration techniques are applied by using 16-QAM modulator and ChebyShev filter. The PTS then generates a wide range of phase combinations with reduced PAPR value and TSA selects the best signal with least PAPR. The performance of the proposed hybrid UFMC model is analyzed and compared with traditional UFMC and OFDM models in MATLAB 2015 software. The simulation outcomes were determined in terms of PAPR, BER and Spectral efficiency. The results attained showcased that proposed model is providing effective results with least PAPR values.

Index Terms - PAPR reduction, OFDM systems, Optimization algorithms, soft-computing approaches, UFMC systems.

I.INTRODUCTION

Since its inception, wireless technology has advanced tremendously. Globally, the number of wireless subscribers has increased dramatically during the last decade. In addition, the need for wireless technology has grown for a variety of services such as the Internet, website surfing, video streaming, and multimedia-based apps. Long Term Evolution (LTE) was launched in 2010 as the fourth generation 4(G) of cellular networks. It was designed primarily to give high data bandwidth to tightly synced devices such as tablets and smart phones [1]. Ushering in the notion of the Internet of Things (IoT), the mobile internet is likely to be widely utilized for machine-to-machine connections in future. Hence the upcoming fifth-generation (5G) cellular networks will have to deal with Machine Type Communications (MTC) in addition to a growing number of human-driven devices like smart phones with increasing data rates. Low-end sensors will be used to control much of this new sort of traffic. Consisting of brief bursts and managed by a large number of terminals, MTC will be intermittent by nature. As a result, in order to fulfill additional requirements, the 5G air interface will be needed. A multi-carrier modulation method known as orthogonal frequency-division multiplexing (OFDM) is used by the 4G air interface. As it allows each sub-carrier to be influenced by a frequency flat channel, this waveform's multi-carrier nature makes it appealing in multi-path scenarios. With the inclusion of a cyclic prefix (CP), the channel convolution is further cyclic, allowing easy sub-carrier equalization with just a single tap on each channel [2]. While OFDM offers several benefits to the future 5G cellular network, it also has a number of shortcomings [3]. Its utility gets restricted in highly fragmented spectrums with many users due to the presence of its sinc-shaped spectrum. Some powerful out of the band radiations are produced by this sinc-shaped spectrum. Furthermore, it's extremely sensitive to time and frequency offsets, necessitating careful synchronization to minimize human influence. In order to support 5G communications, new modulation schemes must be explored. The advantages of OFDM must be preserved while the disadvantages are addressed in these new transmission methods.

1.1. Multi Carrier Modulation System

By splitting the frequency spectrum into several subcarriers, MCM is an effective method for overcoming communication channel difficulties [4]. In future communication networks, the frequency selective multipath effect are easier to deal with than with single carrier modulation (SCM). Multicarrier modulation (MCM) provides various benefits over single carrier modulation, including less sensitivity to multipath fading, decreased susceptibility to interference induced by impulsive noise, and improved immunity to ISI. These advantages are achieved owing to the splitting of the data that has been transmitted into several components and using separate carrier signals to transmit each of these components. Some of the significant MCM waveforms are; OFDM, FBMC, GFDM and UFMC. Usually, these signals are filtered either on the basis of Sub-carrier or sub-band filters. In case of filter-bank multi-carrier (FBMC) and generalized frequency-division multiplexing (GFDM) the signals are filtered by using a sub-carrier. While as, Sharp filters are used in the universal filtered multi-carrier (UFMC) modulation to filter the signal on a sub-band basis.

1.2. Comparison of Modulation Techniques

To summarize, we have summarized the attributes of OFDM, FBMC, GFDM, and UFMC in Table 1 in accordance with the preceding introductions, including the PAPR, out of band, and spectral efficiency. We can create a general comparison of these four types of waveforms based on these features. Each waveform's superiority and inferiority are likewise clearly displayed. Depending on the application circumstance, we may choose from a variety of waveforms.

Table 1 Comparison of features among OFDM, GFDM, FBMC, UFMC

Parameters	OFDM	GFDM	FBMC	UFMC
PAPR	H	L	H	M
Out Of Band	H	L	L	L
Spectral Efficiency	M	M	H	H
CP	Y	Y	NO	NO
Orthogonality	Y	N	YES	YES
Synchronization Requirement	H	M	NO	L
Ease Of Integration With MIMO	Y	Y	L	Yes
Latency	Short	Short	Long	Short
Effect Of Frequency Offset	M	M	M	M

Each of these four modulation waveforms have their own set of disadvantages and advantages, as can be observed. In this paper, the main focus is given to UFMC systems as they can effectively satisfy the future machine communications.

1.3. Universal Filter Multi-Carrier (UFMC) and its Working

In UFMC model, the subcarriers are grouped to sub-bands which are subsequently filtered. The number of carriers used per sub band and the filter settings are usually the same in UFMC and FBMC in order to prevent aliasing. Non-contiguous sub-bands, on the other hand, are conceivable to allow for more flexible spectrum usage. As a result, UFMC may be thought of as a hybrid of OFDM and FBMC. Alike, Interleave-Division Multiple-Access (IDMA); users can be segregated in this way, depending on their interleaves. As a result, the system will gain an additional degree of freedom, become more robust against crosstalk, and help to maximize the capacity of multiple access channels (MAC). All in all, the concepts offer an energizing approach for 5G wireless system designers to meet the new challenges. The basic principle of UFMC is to group the sub-components in multiple bands, with each band filtering separately from OFDM and filtering across the whole band. Whereas, each component is independently filtered by FBMC. The advantages of OFDM and FBMC are combined by UFMC, which is a unique 5G waveform. OFDM may be considered a unique UFMC case, in certain aspects. The fact that many OFDM research discoveries can be minimally changed and transferred straight to UFMC is the largest advantage of it being chosen as the main waveforms of 5G [5]. In order to prevent inter-symbol interference, improve system's spectral efficiency and efficiently avoiding important spectral resources, cyclic prefix is not used by UFMC systems.

1.3.1. Working of UFMC

Individual sub carriers are filtered in FBMC, whereas the full band is filtered in filtered OFDM. UFMC, on the other hand, filters a sub-carrier group. Filtered OFDM, FBMC, and UFMC multi-carrier multi-carriers all differ in this way. In UFMC, the filter length gets reduced by grouping the subcarriers. QAM which is compatible with current MIMO is employed in UFMC in order to maintain the complex orthogonality. The whole band of 'N' sub carriers is divided into numerous sub bands in this example. There are a set number of sub carriers in each sub band. There is no requirement to use all sub bands for transmission in the transmitter part. Inverse Fast Fourier Transform (IFFT) is used to remove sub band carrier interference. Sub bands are calculated and zeros are allocated for unallocated carriers at each Point IFFT. The frequency domain (Xi) is converted to the time domain (xi) via IFFT. The time domain signals from the IFFT are now sent through a Band filter block with a length of 'L'. A band filter with the length 'L' is used to filter the output of each sub band. Actually, Chebyshev window/filtering process is used by band filters. The IFFT outputs are filtered using parameterized side lobes attenuation. The entire band filters' outputs are now summed at the end and passed via the channel.

Data bits are sent to the UFMC receiver from the channel. 2N-point Fast Fourier Transform (FFT) is used by the UFMC receiver. The frequency domain data is converted using FFT. Guard intervals of zeros are provided between consecutive IFFT symbols to prevent Inter Symbol Interference (ISI). A delay in the transmitter filter causes Inter Symbol Interference (ISI). Even sub carriers are deleted in order to get the N-length frequency domain signal 'Y'. The data is now equalized, and symbol de-mapping is used to recover the original data bits. When compared to other multi-carrier modulation schemes, UFMC offers good spectral efficiency and less overhead. However, one of the major drawbacks in UFMC model is that it undergoes through huge Peak to average power ratios (PAPR), that degrade the performance of power amplifiers. A huge number of researchers proposed different techniques for reducing the PAPR in UFMC system.

In the next section II of this paper, some of the recently proposed PAPR reduction models in UFMC are discussed and based on this literature some problems are drawn out. Section III, discusses the proposed work and its methodology. Section IV, results are analyzed and finally conclusion is written.

II. LITERATURE SURVEY

Over the years, a substantial number of methods based on ML and DL have been proposed for reducing the peak to average power ratio (PAPR) in UFMC systems. Some of them are discussed here; **Khelouani et al. [6]** suggested a UFMC based model and named it as. RadCom waveform in which the complexity of the system was reduced. They also proposed multicarrier code division multiple accesses (MC-CDMA) for detecting multiusers and increasing the power efficacy. **A. F. Almutairi et al. [7],** proposed a new and unique filter named as, filter (Fractional Powered Binomial Filter or FPBF) for UFMC systems in order to improve the signal to interference ratio (SIR) in various sub carrier spacing. The model also reduced the PAPR along with FPBF in UFMC systems. **M. S. Noorazlina, et al. [8],** proposed a PAPR reduction model in MIMO OFDM systems in which they used Enhancement Asymmetric Arithmetic Coding (EAAC) approach along with the total number of antenna configurations. **R. T. Kamurthi and S. R. chopra. [9]**Suggested a multi carrier transmission model in which they dealt with the intercarrier interference problems in OFDM systems. Moreover, they implemented the UFMC to subcarriers so that the out of band side lobe and ICI is minimized in the asynchronous transmission. In both perfect and non-perfect frequency synchronization between UEs and BSs, UFMC outperformed OFDM.**B. Khan, et al. [10]**Reviewed and discussed the spectrum use of UFMC systems in 5G environment. The purpose of this article was to discuss the modulation techniques for 5G wireless communication and reinforce the need for UFMC. Results revealed that spectrum utilization of the UFMC system was substantially better than that of the OFDM system**. A. Hazareena and B. A. Mustafa. [11]**Presented a practical scheme for designing an anti-interference filter for UFMC systems in which they considered the Nyquist condition, in-band distortion as well as the out-of-band emission. The results revealed that proposed UFMC model yields better results in terms of BER. **B. Hadjer et al. [12],** proposed a computationally efficient multi-carrier waveform for future wireless communication systems wherein resource blocks were divided into two groups of odd and even. After this, they applied the filtering approach in two groups and not on the separate RB as was eh case in standard UFMC model. **Sayyari, Reza et al. [13]** presented an effective PAPR reduction approach based on precoding and dummy sequence insertion (DSI) techniques for reducing the computational complexity in PTS. The suggested technique outperformed precoding and PTS-based alternatives in terms of PAPR reduction and BER. **Q. Zheng et al. [14]** proposed a unique PAPR suppress approach based on SLM based on Improve Genetic Algorithm (IGASLM). Based on simulation results, the proposed algorithm significantly reduced PAPR in UFMC systems; the PAPR is reduced in proposed model when compared with standard PTS, DFT-precoding method and traditional GA.**I. Baig et al. [15],** examined the performance of waveforms in the fifth generation, such as universal-filtered multi-carrier method (UFMC), resource block filtered orthogonal frequency-division multiplexing (RB-F-OFDM), filtered-OFDM (F-OFDM), and filter-bank multi-carrier (FBMC). Because of its resilience in terms of high mobility and CFO, simulation findings showed that RB-F-OFDM was appropriate for high-speed scenarios.

From the literature survey, it is observed that UFMC is one of the reliable and low latency wireless communication system that can be used effectively in asynchronous transmissions. Despite several of its qualities have been investigated in recent times, there are very few studies that analyses its effectiveness in a structured way. However, the problem with the current UFMC system is that they undergo through huge PAPR values which downgraded the performance of entire UFMC system. This high PAPR in multi-carrier modulation schemes degraded the performance of UFMC models by decreasing the effectiveness of analog to digital converter and power amplifier which leads to high energy consumption. In addition to this, it was also observed that the standard PAPR reduction techniques like PTS, SLM, clipping etc. are not providing effective and efficient results when used in UFMC systems individually. Therefore, effective hybrid PAPR reduction techniques must be proposed for mitigating the high PAPR problem in UFMC systems.

III. THEORETICAL FRAMEWORK

In this work, a new, effective, reliable with low latency UFMC model, that is based on evolutionary optimization Tree Seed Algorithm (TSA) algorithm. The main objective of proposed approach is to reduce the PAPR value in UFMC systems so that communication efficacy is enhanced. As mentioned earlier, that standard PAPR reduction techniques like clipping, clipping and filtering, tone injection, selected mapping, and partial transmit sequence (PTS) are not providing effective results when implemented separately in UFMC systems. However, among these techniques the traditional Partial Transmit Sequence (PTS) is considered superior because of its ability to reduce PAPR in multi carrier systems considerably. Unfortunately, the enumerative search complexity of the PTS for determining the ideal phase combinations keeps on rising significantly with the increase in total number of sub-blocks. In order to reduce the computational complexity of the PTS PAPR reduction scheme, TSA algorithm is used along with PTS in proposed model. The TSA algorithm not only aids in enhancing the search ability of PTS but it also reduces the computational complexity which in turn boots the performance of UFMC systems. One of the major reasons for using the Tree-seed algorithm in the proposed work is its controlled search tendency, and ability to generate number of solutions for a given problem. The relationship between trees and their seeds is the phenomenon of the TSA technique employed in the suggested strategy. Trees grow to the surface of the earth by their seeds naturally. With the passage of time, these seeds grow and become trees. The surface of these trees can be assumed as the search space for optimization issue while as the position of trees and seeds can be viewed as the potential solutions for the given optimization problem. The detailed description of proposed TSA based UFMC model is explained in the next section of this paper.

3.1. RESEARCH METHODOLOGY

In order to achieve reduced PAPR ratio in UFMC systems, the proposed system undergoes through number of steps, whose description is given in brief in this section.

Step 1: Initially, a UFMC model is initialized in which different parameters like total number of sub-carriers, sub-bands; sub-carriers per sub-band, length of sub-band filters used are defined along with their specific values in Table 1. Along with this, the side lobe attenuation of 40 and ChebyShev filter and 16-QAM modulation type is used in the proposed UFMC model.

Table 2: Showing UFMC Initialization Parameters

Parameters	Symbol	Values
Number of sub-carriers	N	512
Number of Sub-bands	B	10
Subcarriers per Sub-band	K	20
Length of the sub-band filters	L	43
Filter side-lobe attenuation	-	40
Filter type	-	Chebyshev
Modulation type	-	16-QAM

Step 2: After this, the entire sub-carrier band (N) in the UFMC system is split into multiple of sub-bands once the model is started, and every sub-band emits data bits. There are a predetermined number of sub-carriers for each sub-band, and it is not necessary to use every sub-band in communication phase. The 16-QAM modulator is used to modulate the data bits produced.

Step 3: In the next phase of the model, N-pt IFFT is calculated for each sub-band in modulated signals and zeros are inserted in the data sequence for unallocated carriers

Step 4: Once the N-pt-IFFT is calculated, the next step is to filter these signals. For this, Chebyshev filter along with parameterized side lobe attenuation is used in the proposed work that filters the IFFT signals for every sub-band. The primary reason for filtering IFF signal is to reduce the out of band spectral emissions in the model.

Step 5: In the next step, the proposed hybrid TSA based UFMC model is initialized, in which population size, iterations, lower bound, upper bound, decisions variables and search tendency (ST) is defined. The specific values for each parameter are mentioned in table 3 below:

Table 3: Showing Initialization parameters for hybrid TSA-PSA-UFMC model

TSA Parameter	Value
No of Population	20
Iteration	5
Lower Bound	1
Upper Bound	256
No of Decisions Variable	1
ST	0.1

Step 6: After this, a set of ideal phase combinations are determined by the PTS PAPR reduction technique in the proposed model for asynchronous transmission. The search tendency of the PTS for selecting the best phase is improved by the TSA which selects the best combination with reduced PAPR value among the set of phase combinations. After that, the decreased PAPR signal is delivered via the channels and received at the receiver side.

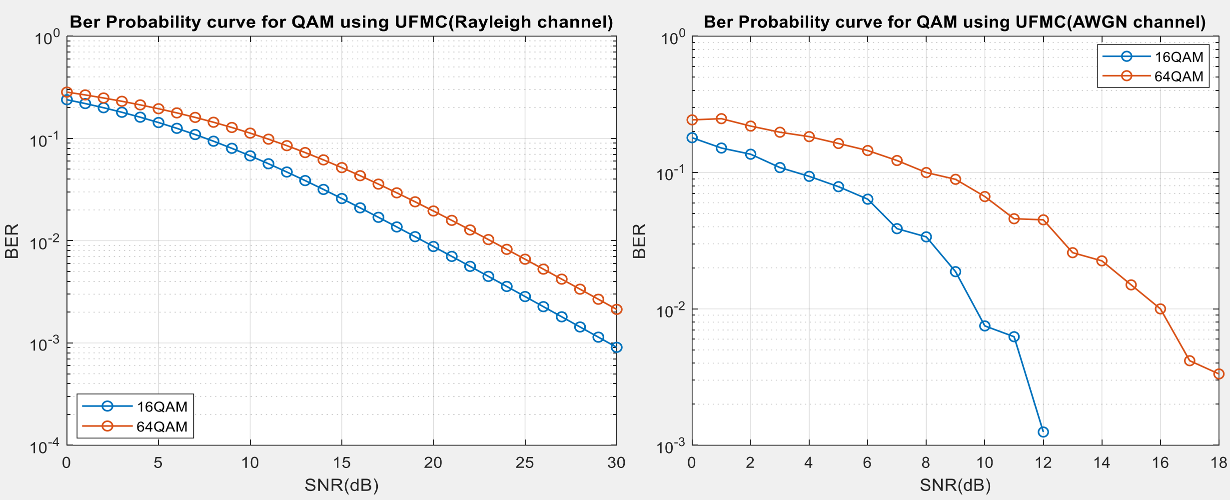
Step 7: Lastly, the performance of the proposed TSA-based PAPR reduction method is assessed and compared to the conventional OFDM and UFMC model system in terms of PAPR, spectral efficiency and BER. The results attained are discussed in the next section of this paper.

IV. RESULTS AND DISCUSSIONS

The effectiveness and validation of the proposed hybrid UFMC model is analyzed in the MATLAB software. The experimental results obtained were also compared with the standard OFDM and UFMC models in terms of PAPR, Spectral efficiency and BER. The results obtained for proposed model are discussed in this section.

4.1. Performance Evaluation

The performance of the proposed hybrid UFMC model is firstly evaluated in terms of BER value obtained for Rayleigh channels and AWGN channel for 16-QAM and 64-QAM mapping techniques. The graph obtained for the same is depicted in figure 1 (a) and (b).



(a) (b)

Figure 1 Showing BER value in Rayleigh channel in (a) and AWGN channel in (b)

The BER analysis for proposed UFMC model is shown in figure 2 for Rayleigh channel and AWGN channel. After examining the graph closely, it is analyzed that value of BER is low with 16-QAM modulation type. While as, when BER is compared for both channels it is observed that AWGN with 16-QAM modulation type provides better results with 12dB SNR. On the other hand, the value of BER came out to be 30dB in Rayleigh channel with 16-QAM modulation type.

To prove the effectiveness of the suggested hybrid UFMC approach, its performance is analyzed and compared with the standard OFDM and UFMC models in terms of PAPR. The graph obtained for the same is shown in figure 2.

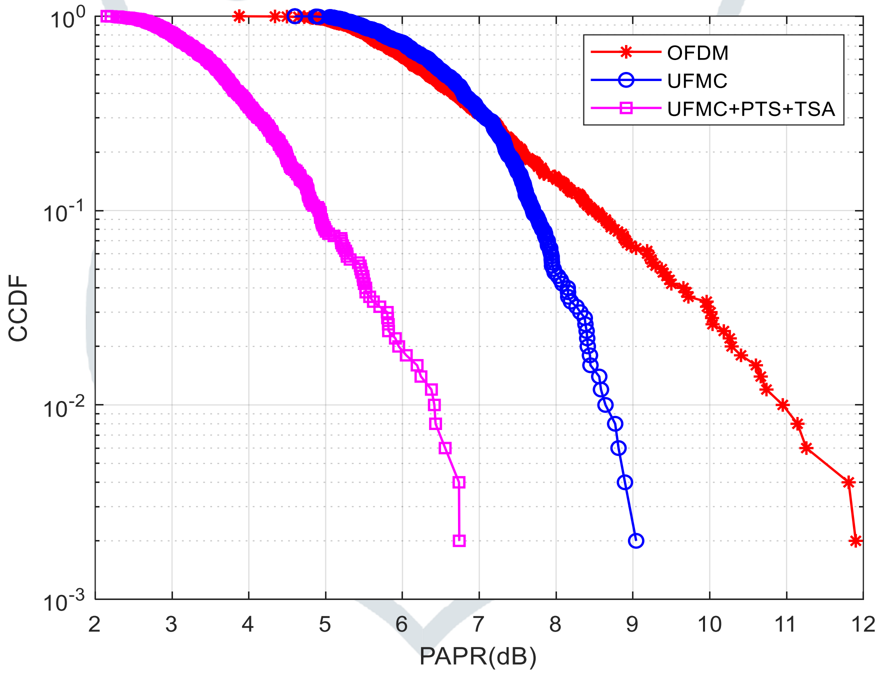


Figure 2 Showing Comparison for PAPR reduction

Figure 3, represents the comparison graph for proposed Hybrid UFMC model and traditional OFDM and UFMC models in terms of PAPR. From the given graph, it is observed that the PAPR value in traditional OFDM and UFMC models was 11.9dB and 9.042dB respectively. On the other hand, the value of PAPR in proposed UFMC+PTS+TSA model came out to be just 6.739dB, thereby demonstrating its supremacy over traditional methods. Table 3 shows the actual PAPR value obtained in both traditional and proposed methods.

Table 4: Showing Exact value of PAPR in standard and proposed models

Methods	**PAPR(dB)**
OFDM	11.9
UFMC	9.042
UFMC+PTS+TSA	6.739

Moreover, the performance of the proposed hybrid UFMC approach is validated by comparing it with the standard OFDM and UFMC models in terms of spectral efficiency and the graph is shown in figure 3.

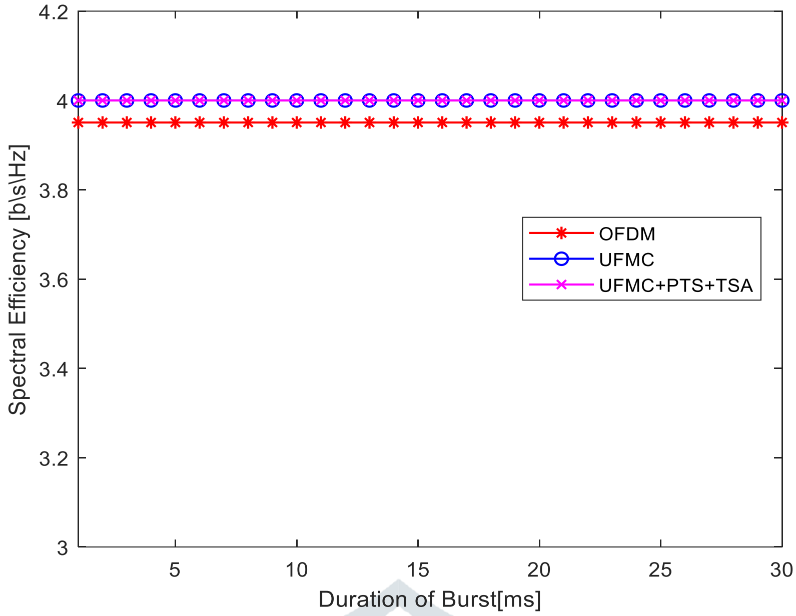


Figure 3 Showing comparisons for spectral efficiency

The above figure (figure 4) represents the comparison graph for spectral efficiency in standard OFDM and UFMC models and proposed hybrid UFMC model. After examining the graph closely, it has been observed the spectral efficiency came out to be less than 4b/s/Hz in standard OFDM system. On the other hand, in case of standard UFMC and proposed hybrid UFMC model, the graph for spectral efficiency was overlapping with each other at 4b/s/Hz.

From the given graphs and tables, it can be concluded that proposed UFMC model is showcasing its efficiency and effectiveness by substantially reducing PAPR in signals.

V. CONCLUSION

In this paper, a highly reliable and low latency based UFMC model is proposed in which Partial Transmit Sequence (PTS) and Tree See algorithm (TSA) has been used for reducing the Peak to average power ratio in UFMC systems. The efficacy of the suggested approach is validated and compared with the standard OFDM and UFMC models in the MATLAB software under different performance criteria. .From the results, it is observed that the value of PAPR in standard OFDM and UFMC models were accounted to be 11.9dB and 9.042dB respectively, whereas, the PAPR value in proposed hybrid UFMC model came out to be just 6.739dB. This data demonstrates that the PAPR value in the suggested model is 5.161 dB lower than the OFDM system, and it is 2.303 dB lower than the standard UFMC system. Moreover, the spectral efficiency achieved in the proposed hybrid UFMC model was 4 b/s/Hz which is better than traditional OFDM systems. In addition to this, the performance of the proposed system was analyzed in terms of BER attained in Rayleigh and AWGN channels with 16-QAM and 64-QAM mapping technique. The results obtained for that case revealed that 16-QAM mapping technique is providing effective results for both channels with BER value just 12dB and 30dB for AWGN and Rayleigh channel respectively.

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