

Implementation of UFMC Modulation Technique

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Abstract – This article gives explanation about the aspects of Universal Filtered Multi Carrier system and gives us an initiative about the merits of latest modulation technique for expanding 5G Communication Systems. In 4G technology, Orthogonal Frequency Division Multiplexing is an excellent choice but it also has some shortcomings. OFDM method has some complications such as high Peak to Average Power Ratio (PAPR), side band leakage is another problem in OFDM. By taking into consideration the above parameters, a stir to another technique called Universal Filtered Multi Carrier (UFMC) is used because of good spectrum usage. This paper also clarifies about the UFMC system model. Based on the Simulation results in MATLAB, the spectrum exploitation of UFMC system is much better than OFDM system.

Keywords– BER, OFDM, PAPR, UFMC, QAM

I. INTRODUCTION

UFMC is a multi-carrier modulation technique which in general is a simplification of filtered OFDM and FBMC. Basically, in filtered OFDM, the complete band is filtered whereas separate sub-carriers are filtered in anticipation of FBMC. But in UFMC, filtering is done over a set of sub-carriers [6]. This forms a chief difference between filtered OFDM, FBMC and UFMC multi-carrier. Sub-carrier grouping assists in minimizing filter length in UFMC. In UFMC, QAM works with the existing MIMO to sustain complex orthogonality.

The entire section of the UFMC transmitter is shown in Figure 1. Here the complete band of ‘N’ sub-carriers are subdivided into several sub-bands. The number of sub-carriers in each sub-band is fixed. There is no requirement to employ all sub-bands at the transmitter for the transmission. To cast aside sub-band interference, Inverse Fast Fourier Transform (IFFT) is used. At every single N-point IFFT, sub-bands are calculated, and nulls are assigned for unreserved carriers. IFFT interchange frequency domain (X_i) to time domain (x_i). Subsequent to N-point IFFT, the result may be dictated as After this, the time domain signal that is arriving from the IFFT proceeds towards the band filter of length ‘L’ block. The output of the individual sub-band is then filtered by band filter which can be stated as

$$Y=H.$$

Where H is named toeplitz matrix with measure (N+L-1) and ‘~Q’ is called as Inverse Fourier matrix. Essentially, band filters optimize Chebyshev window/filtering procedure. The parametric attenuation of the side lobes is exploited to process outputs for IFFT. The resultant coming from the band filters are now applied to the channel and transferred from the channel to the UFMC receiver. The 2N-point Fast Fourier Transform (FFT)

UFMC recipient. FFT transforms time domain data to frequency domain data. It is represented as an equivalence. $Y=FFT$ { [With the aim to avoid Inter Symbol Interference (ISI), guard intervals of zeros are add-on within succeeding IFFT symbols. The major reason behind ISI is because of transmitter filter delay. In order to acquire N length frequency domain signal ‘Y’, sub carriers are cast-off. Right away, this data proceeds for equalization course and after that the unique data bits are recovered by symbol demapping.

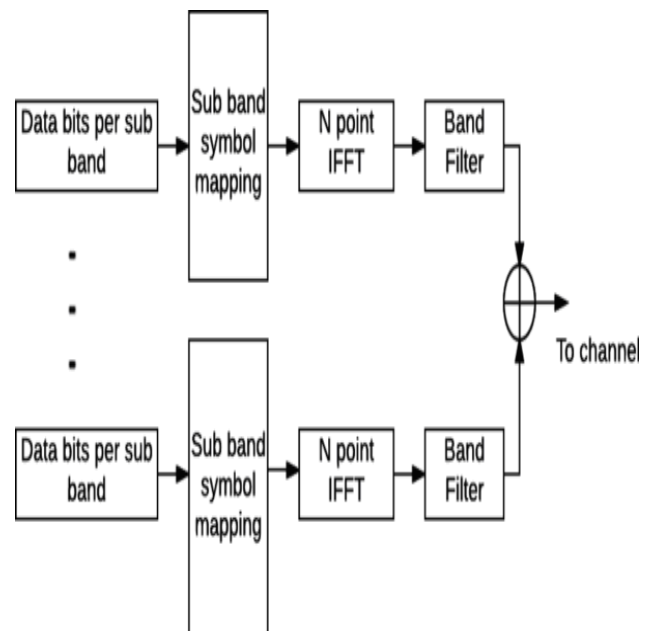


Fig.1.UFMC Transmitter section.

1. System Model

Now-a-days UFMC is a highly research involved 5G modulation method. UFMC, a novel multicarrier modulation technique works equivalent to the generality of filtered OFDM and FBMC modulations. Unlike self-

subcarrier modulation in FBMC, a group of subcarrier modulation is performed in UFMC. The subcarrier grouping reduces the length of the filter compared with FBMC and also reduces time to perform modulation. QAM type of modulation is used in UFMC. Transmitter block diagram is shown in Fig.1 and Receiver block diagrams of UFMC are shown in Fig.2 and the system parameters of UFMC are displayed in Table I.

Massive MIMO is an extension of MIMO which essentially groups together a large number of antennas at the transmitter and receiver to provide better throughput and spectrum efficiency. In general, massive means very large. So, installing a very large antenna array at each base station to serve numbers of users simultaneously is known as Massive MIMO.

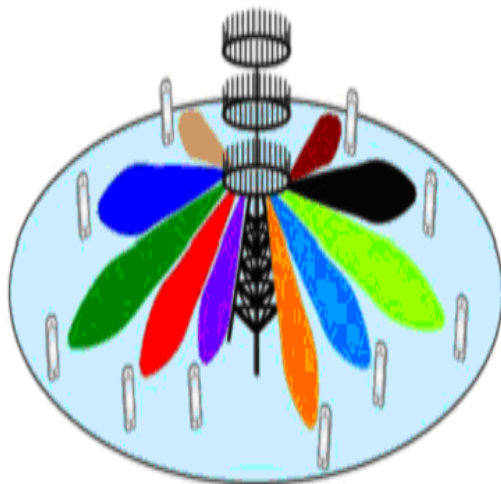


Fig.2. Massive MIMO Technology.

Table -I: System parameters

Ufmc (universal-filtered multi-carrier)

Parameter	Value
Total number of FFT points	512
Sub band Offset	156
Sub band Size	20
Filter Length	43
Side lobe attenuation	40
Bits per sub carrier	2,4,6,8
Number of sub bands	10
SNR (dB)	15

The robustness depicted by the UFMC especially in overcoming the inter-carrier interference discussed above has made the technique to be applauded as it matches perfectly with the 5G network requirements. UFMC can

be defined as a "multi-carrier signal format with orthogonal subcarriers to handle the problem of loss of orthogonality at the receiver end." Practically, UFMC can be said to be a generalization of filtered OFDM and FBMC techniques combined. However, the UFMC system applies sub-band filters which help the system to accommodate short burst communication, which is comparable to FBMC as it functions using the same principle. As a result of the application of sub-bands filters in the UFMC, the system has a much higher spectral efficiency as compared to other techniques discussed earlier. Moreover, the system does not rely on cyclic prefix insertion, and therefore there is no repetition of bits which are similar and therefore, the system uses the entire available spectrum efficiently.

Another important feature which helps UFMC to be more compatible with the 5G network is that the technique has fewer side lobes and this helps the entire system to have less interference on the neighboring sub-carriers. Usually, OFDM conveys data by using large blocks of independently modulated sub-carriers and these increase the Peak-to-Average Power Ratio (PAPR) especially when they are introduced in phase. However, the total bandwidth in UFMC is divided into sub-bands and this helps to decrease the PAPR as subcarriers add accumulation in the system is less as compared to OFDM for instance. As such, UFMC has a low PAPR than OFDM which makes the earlier method to be promoted for the 5G network.

II. LITERATURE REVIEW

Hyunsoo Kim, Jonghyun Bang, et al- A community of sub-carriers are used in UFMC filtering. UFMC system not only enables QAM delivery, but also offers short-frame duration lower out-of-band radiation. UFMC can be efficient for uplink assisting multiple users at a time. UFMC is basically a combination of Filtered OFDM and FBMC modulation scheme. In OFDM, the complete band is filtered whereas UFMC allows filtering of sub band consisting of certain group of sub-carriers.

Grouping of sub-carriers allows one to reduce filter extent in the UFMC system. In UFMC, QAM is used that interacts with the current MIMO in order to preserve the complex orthogonality. Here, the entire sub-band comprising 'N' sub-carriers gets separated into a number of sub bands. Each sub band is associated with a few sub-carriers. It is not necessary to use all sub bands at the transmitter side during transmission. In order to minimize sub-band carrier interference, IFFT is employed. In this way, sub-bands are calculated at every single N-point IFFT and zeros are placed at unallocated carriers.

N.Rani and Shanti Rani et al- UFMC, the Multi-carrier modulation technique is basically the generalization of Filtered OFDM and FBMC. In OFDM, the filtering is

usually done in the entire band whereas individual sub-carriers are filtered in FBMC. But in case of UFMC, a group of sub-carriers or sub-band is filtered that make it unique from that of the previous techniques [6]. This is the principal disparity between the multi-carrier filters OFDM, FBMC and UFMC. Assemblage of sub-carriers contributes towards the reduction of UFMC filter length. In UFMC, QAM works in collaboration with existing MIMO's to sustain the complex orthogonality. Figure 1 shows the entire UFMC transmitter section. Here, the entire 'N' band is fragmented into several sub bands.

A fixed number of sub-carriers for assigned for each sub-band. There is no need to employ all sub-bands during broadcast in the transmitter side. Inverse Fast Fourier Transform (IFFT) is one of the methodologies used to eliminate the sub-band carrier interference. Sub-bands and zeros are reserved for unallocated carriers at each N-point IFFT. IFFT transforms frequency domain (X_i) into a time space (x_i). Hence, time field signals that arrives from IFFT moves to Band filter having length 'L'. For this, Chebyshev window / filter operation is used in the band filter. Here parameterized attenuation is adopted to filter resulting IIFT outputs.

Data bits are sent to the UFMC processor from the source. 2N-point Fast Fourier Transform (FFT) is the UFMC recipient. Time domain data are converted to the frequency domain with FFT. In order to avoid Inter Symbol Interference (ISI), zero guard intervals are employed in between consecutive IFFT pattern. ISI is caused by the filter adjournment of the transmitter. Also, sub-carriers are ignored for N-length frequency domain signals 'Y.' Now, this data gets forwarded for equalization and thus, data bits are recovered with the help of symbol re-modulating.

Frank Schaich, Thorsten Wild and Yejian chen.- However, this OFDM technology is insufficient to satisfy the higher requirements of 5G and so innovative technologies like Filter Bank Multi Carrier (FBMC) and the Filtered Universal Multi Carrier (UFMC) came into existence. Also, FBMC is proved to be the inappropriate choice because of its outsized filter length that affects the decoding period of the symbol and its composite MIMO recipient configuration. FBMC is not also suited for critical accident or delay applications. The best 5G nominee is UFMC. thus, a group of sub-carriers is defined by UFMC filtering. The UFMC system not only allows the propagation of QAM and MIMO systems but also provides a limited frame period with a lower output radiation. UFMC is suitable for uplink with multiple users at a time.

Xiaoming Chen, Shuai Zhang and Anxue Zhang.- With an explicit accomplishment to focus on the shared coupling impacts on MIMO-UFMC core, we foresee conclude time synchronization as well as improved

channel estimation. For easiness and without any loss of comprehensive description, we obtain spatial multiplexing in associate with zero-compelling MIMO decoder (Schenk et al., 2005) in our context.

III. RESULTS AND DISCUSSION

Table -II: PAPR values for UFMC and OFDM for different mapping schemes at 5dB SNR

Mapping Technique	PAPR of UFMC	PAPR of OFDM
4 QAM	9.04	8.4377
16 QAM	8.2379	8.8843
64QAM	8.6229	9.9269
256 QAM	8.0416	7.2553

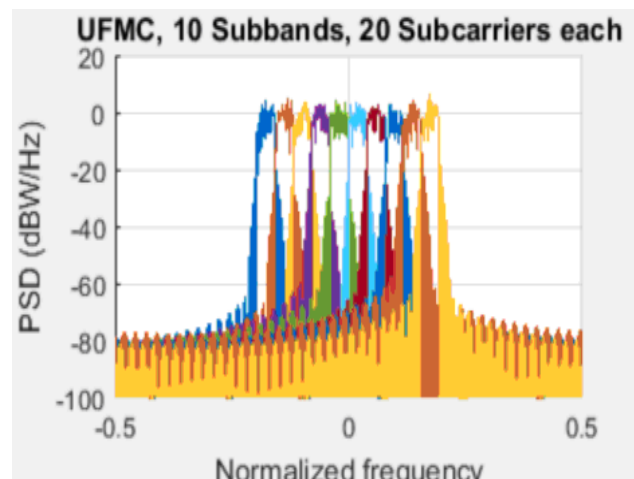


Fig.3. PSD of UFMC

Universal Filtered Multi-Carrier Modulation is done for 10 sub-bands that are a part of this study. Among these, 20 sub-carriers are been tested for normalized PSD.

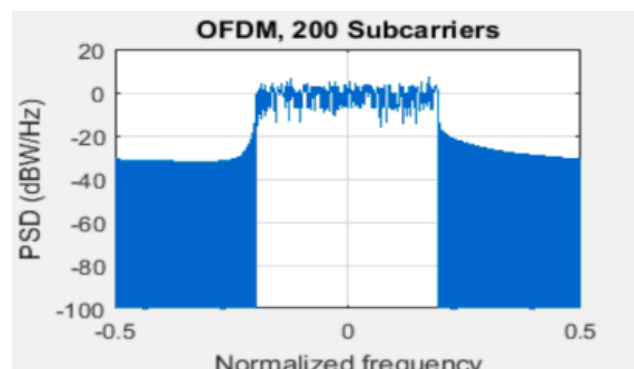


Fig. 4.PSD of OFD

Orthogonal Frequency Division Multiplexing (OFDM) is a type of digital modulation, a method of encoding digital data on multiple carrier frequencies, it is used for 200 sub carriers in the above against normalized and PSD.

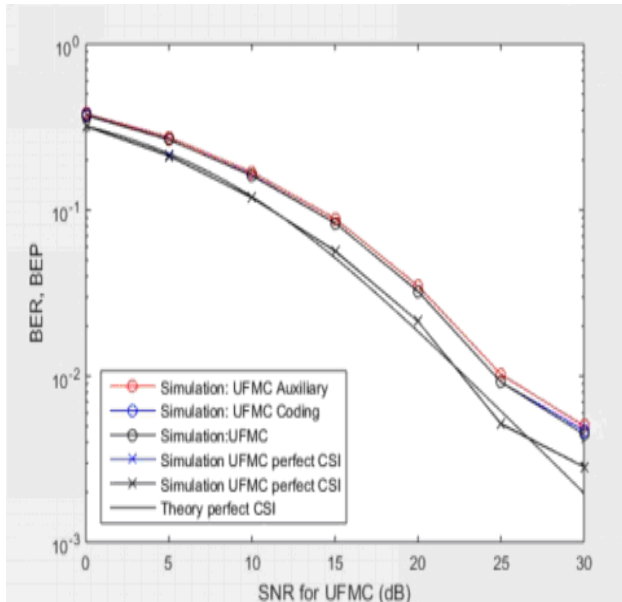


Fig 5. BER of different mapping techniques.

BER that is Bit Error Ratio is evaluated for various mapping techniques. It is found that simulation of UPMC Auxiliary has good range and shows less error ratio.

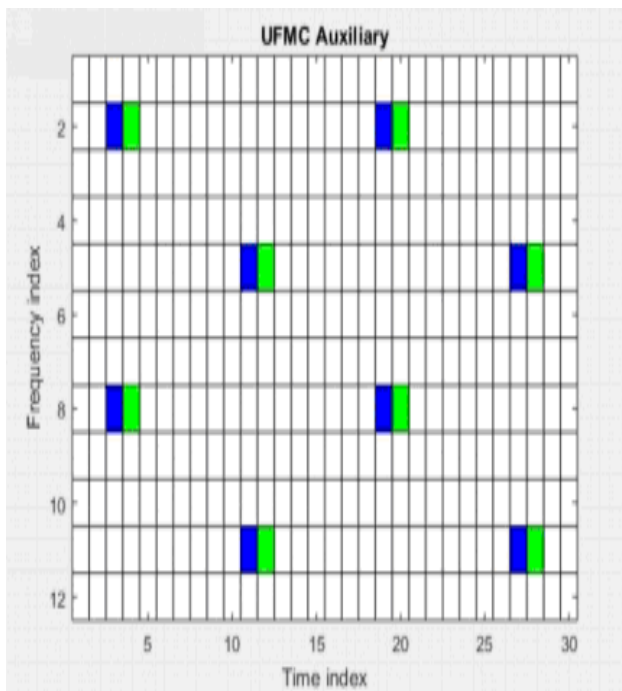


Fig 6 Time Index vs Frequency index UPMC Auxiliary which has good ratio is calculated above against time and frequency index.

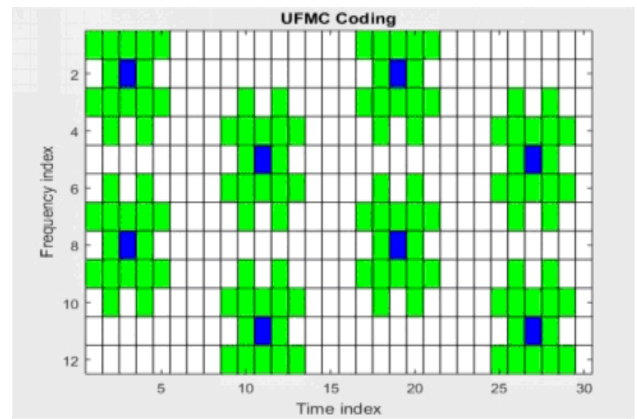


Fig 7 UPMC Coding

UPMC Coding is evaluated above against time and frequency index.

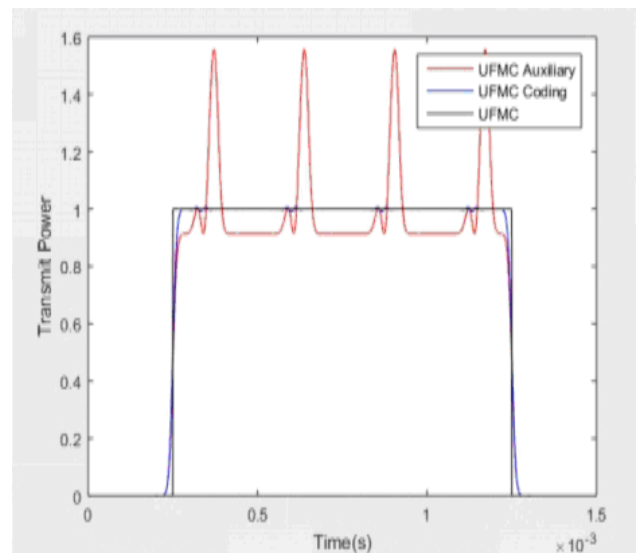


Fig 8. UPMC Coding and Auxiliary UPMC

A graph is shown above that compares UPMC Coding and Auxiliary UPMC. It is visible that UPMC Auxiliary has high transient power with respect to time and others have relatively less.

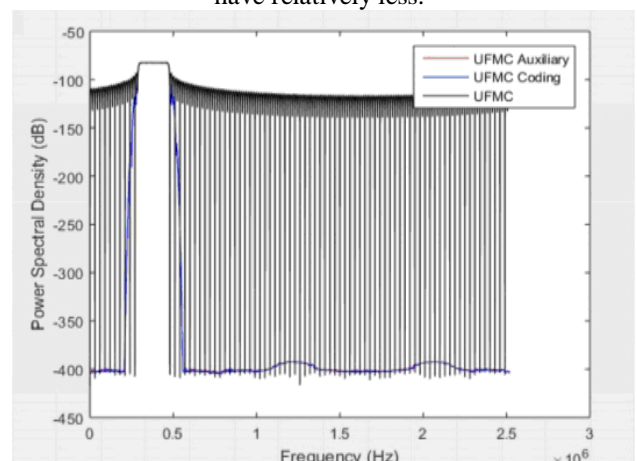


Fig 9 Frequency vs Power Spectral Density

A graph is shown above that compares UFMC Coding and Auxiliary UFMC. It is visible that UFMC Auxiliary has high transient power with respect to time and others have relatively less.

IV. CONCLUSION

Thus, from the above discussion, it is cleared that the spectrum utilization in UFMC is much better in contrast to OFDM. Effective use of spectrum signifies the range up to which data can be transmitted and hence, it is proved with this context that UFMC has large coverage. Also, it can be noted that the PAPR values for both UFMC and OFDM are 8.2848 dB and 7.5653 dB. Hence it is proved that the PAPR value of UFMC is much improved when compared to that of OFDM while opting 16 QAM mapping technique. However, OFDM have some shortcomings like high peak-to-average and side band leakages. With the advancement of Internet of Things (IOT) and the act in the direction of user centric processing makes OFDM technique unsuitable. Therefore, UFMC is the right contender for 5G.

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