Walsh Hadamard Precoded Circular Filter Bank Multicarrier Communication

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Abstract- Filter bank multi-carrier with offset quadrature amplitude modulation (FBMC/OQAM) avoids the usage of the guard band by using simple prototype filter design. Thus the spectrum efficiency is achieved. FBMC is very sensitive to carrier frequency offset (CFO) and timing offset (TO). In this paper, a zadoff-chu sequence based preamble is presented. This is designed in a manner to reduce the carrier frequency and timing synchronization and at the same time improves the spectral efficiency. The zadoff-chu sequence based preamble (or pilot) used to design the FBMC frame more synchronized to the receiver i.e., sufficient channel estimation and phase tracking is achieved. This method also controls the out of band emissions and create non orthogonal waveforms, thus the overall system performance such as bit error rate over AWGN channels is investigated. In order to analyze the peak to average power values (PAPR), this paper also presents the complementary cumulative distribution curve (CCDF) performance of the FBMC signal with different multicarrier systems.

I. INTRODUCTION

A. Introduction

OFDM [1] has a fundamental problem making it unattractive for future wireless communication services. Its performance always suffers from high out-of-band emission generated from the side lobes of the modulated subcarriers since the orthogonality is always destroyed by the synchronization mismatch. In order for OFDM systems to meet the strict requirements of time and frequency synchronization, guard interval, guard band and some techniques to reduce OOBE must be employed in the real-world applications at the cost of spectral and/or power efficiency, large papr values and reduced bit error rate performance.

Fifth generation (5G) radio access technology is expected to take a huge advantages [2] over previous radio generations by supporting cognitive radio, machine type communication. the demerits of OFDM systems are founded that its large out-of –band emissions, which affect the spectrum utilization, Doppler frequency shift, bit error rate and large peak-to-average power ratio. thus improving robustness different techniques are presented in 5G, they are filter bank multicarrier (FBMC) [3], universal filter multicarrier (UFMC) [4], Generalized frequency-division multiplexing (GFDM) [5]. Among all this advanced techinqus, fbmc is more suitable waveform candidate for 5g because of its high spectrum utilization and reduced out of band emissions. Even though, fbmc having the drawback of CFO and TO synchronization. Means the fbmc system is very sensitive to the carrier parameters at the receiver side.

In this paper, FBMC/OQAM is considered by using new zadoff chu sequence [6] based preamble design with frequency localized prototype filters, such as the PHYDYAS filters [7], with linear multi-tap equalizers and the bit error rate (BER) performances are better for FBMC compared with OFDM [8] and with other 5G radio access technologies. Meanwhile, FBMC is attaining a higher spectral efficiency by removing the guard band [9]. The channel estimation becomes difficult because of the real field orthogonality for FBMC [10]. to solve this problem proposed scheme, where the intrinsic interference can be canceled.

B. Problem Statement:

In OFDM, Orthogonality between subcarriers, this allows controlling ICI, this canbe obtained by ensuring time and frequency synchronization at the receiver. OFDM is characterized by very large side lobes, rectangular pulse shaping filters exhibit poor stop band attenuation and thus it require guard band at the spectrum edges in order to control out-of-band emissions. Also OFDM use cyclic prefix to reduce ISI, which limits the spectral efficiency. One of the alternatives to OFDM is FBMC/OQAM [29]. This multicarrier modulation format does not transmit a cyclic prefix or guard band and shapes subcarriers using well frequency-localized waveforms that suppress signals' side lobes, thus providing larger spectral efficiencies than OFDM and other 5g techniques.

However, the absence of guard band in FBMC makes subcarrier signals are no longer orthogonal, hence resulting in both inter-symbol interference (ISI) and inter-carrier interference (ICI) [30]. This results in carrier frequency, time and phase mismatch between transmitters to the reciver. Thus FBMC becomes sensitive to carrier frequency offset (CFO) and timing offset (TO). Even though the FBMC system has high spectral efficiency at the same time it has high PAPR values, which is caused by the filter used for each subcarrier.

C. Project significance:

Recently, preamble based (or pilot based) synchronization has received more attention because it reduces system complexity. In this paper, Zadoff Chu sequence based preamble is designed. It is based on a relatively long preamble in order to improve the CFO estimation performance as well as avoid intrinsic interference. After CFO and TO correction, the Zadoff–Chu sequencepreamble can be reused for channel estimation. In this paper, a periodic Zadoff–Chu sequence preamble is considered, and both STO and CFO estimators are designed based on a least-square approach. This is a time domain approach and exhibits a stable performance independently of the actual TO. It also provides good robustness against multipath channels but has rather moderate complexity. By using Zadoff–Chu sequence preamble, accurate CFO can be obtained, these results in reduced PAPR values and improved bit error rate performance.

II. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

The Basis of OFDM system:

The basic structure of an OFDM system is introduced. Then, the signal transmission procedure is stated from the mathematical point of view. Beyond this, the effect of CFO on the transmitted signal is presented in the second part of this chapter.

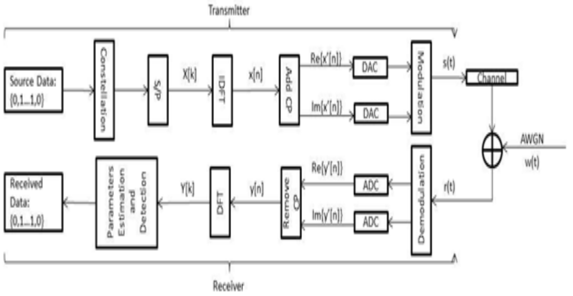

Fig.1: Block Diagram of OFDM system

In an OFDM system, there are mainly two components, transmitter and receiver. Each component has several steps to process the signal in order to properly transmit the data from the transmitter to the receiver. Fig. 3.1 illustrates is a block diagram of a typical OFDM communication system.

The source data are a sequence of binary bits, for example, 11100100. The incoming bit stream of 1s and 0s is multiplexed into N parallel bit streams. Then, the N parallel bit stream are independently mapped in the frequency domain into complex symbols, denoted by X[k], in a given constellations such as phase shift Keying (PSK) or quadrature amplitude modulation (QAM), [37].

PSK is a digital modulation scheme that transfers the source data by modulating the phase of the carrier (or subcarriers), which uses a finite number of phases, each assigned to a unique pattern of data bits. Usually, each phase encodes an equal number of bits. Each pattern of bits forms the symbol that is represented by the particular phase. Fig. 3.2 shows the constellation diagram for 4-PSK modulation.

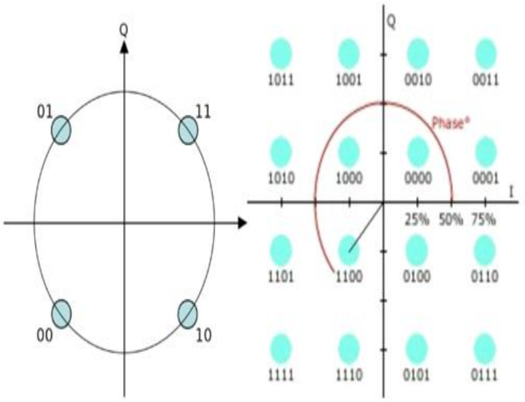

Fig.2: a) 4-PSK Fig. 3.2: b)16-QAM

QAM is another digital modulation scheme that transfers source data by modulating the phase and amplitude at the same time. QAM arranges the source data in a square grid with equal vertical and horizontal spacing, each constellating point within the grid represent a set of bits. The constellation diagram for 16-QAM is shown in Fig. 3.2.

Moreover, the Discrete Fourier Transform (DFT) is an essential tool for a DFT-based OFDM system since the orthogonality of its subcarriers is preserved by the DFT. The DFT and Inverse Discrete Fourier Transform (IDFT) are being used to transfer the data between the time domain and the frequency domain. In an OFDM system, ISI caused by a time-dispersive channel can be eliminated by adding a cyclic pre x (CP) as a guard interval to a block of OFDM signal. The length of the CP must be greater than the delay spread of the channel. A CP is a set of symbols that is copied from the last part of each OFDM symbol block after the IDFT operation and then it is appended to the beginning of the block. Finally, the receiver can completely eliminate ISI by discarding the samples of the CP part before the DFT operation, as shown in Fig. 3.1.

Basically, OFDM technique consists of dividing the flow of entrance data over orthogonal channels. In this way, and based on the orthogonality principle, the interference between each transmission channel is minimal. Another advantage that comes from this approach is related to the assumptions about the noise in each channel.

Over a large and unique passband channel it is difficult (impossible in fact, in many situations) to assume that the model noise is AWGN (Additive Noise Gaussian Noise). That is important because if the model is know, and it is correct, one can select the best way of frequency equalization.

Implementation

- **Mapping the constellation**

The encoder of the constellation maps the m bits of the channel in a point a + jb in the constellation of the modulator.

Decoding receives that point and the remap as the m transmitted bits**.**

- **Encoder of the constellation**

It is important to notice that in that mapping it is just made a conversion of bits for the fasor that acts, however it is not made any modulation, as in the case of QAM, because that as shown, it is done by IFFT. It is necessary to specify how the constellation will be to be mapped, to implement that block.

However, independently of the format of the constellation, the block encoder can be made through a consultation at a conversion table, implemented by LUT that exists in LCs of OFDM s. For instance, for a 4-QAM constellation in such a way that a and b are binary numbers of 3 bits, and are converted to complement two.Attempt that the entrance of the encoder a binary number of m bits, and that the exit generates two binary numbers, one in phase, the, and other in quadrature, b, whose size is defined by IFFT.

- **Decoder of the constellation**

In the receiver, the point of the constellation transmitted it can have changed due to the noises of the transmission channel, mistake in the time of sampling of the receiver and several other causes. Therefore it is necessary to define a threshold so that it can be made the decision on which point in the constellation the received sign is acting. That is the function of the decoder. For the system exemplified above the bit 0 is converted for 010b and the bit 1 for 110b. In that case, the decoder is implemented in a simple way, sticks to the most significant (that indicates the sign) bit to do the decoding, and generating a binary number of m bits again. For systems in that the constellation diagram is larger than 4-PSK it will be necessary the implementation of more advanced methods, like a neural network.

- **Implementation of Butterfly**

The sum used in the butterfly possesses the same algorithm, so much for FFT as for IFFT. To avoid overflow danger due to sum in complement two, it is made the extension of the sign in the binary number, repeating the most significant bit, like this to the if it adds 2 binary numbers of 10 bits, we will have of first to do the extension of the sign, obtaining like this, two numbers of 11 bits, to do the sum, where the result will also be of 11 bits. That procedure has to be done every time that will add or to subtract a number.

Already for the multiplication, the exit has to be of the size of the sum of the number of bits of the two multiplicands. In that way, to do the multiplication of two numbers of 10 bits, we will have to an exit of 20 bits. That procedure has to be done to each multiplication. If there is not impediment, it can be made a rotation for right (divisions for two) in the numbers and to reduce its size, since in the end of the procedure a corresponding multiplier is applied.

The order as it will be made the butterfly is defined by the decimation of the radix. If it goes TD, first it is made multiplication and later the sum. If it goes FD, first it is made the sum and then it is made the multiplication. The existent multiplication in the butterfly demands a certain attention, because, if it be not implemented efficiently, it will degrade the acting of FFT a lot. Basically, there is two methods to do the multiplication: to store in a table the sine values and cosine or to make calculations in place through CORDIC.

- **Use of the memory**

The algorithm of FFT consists of catching the data of the memory (2 for radix-2 and 4 for radix-4), do the butterfly and to return the data made calculations for the memory. Once the data of entrance of the butterfly were already processed there is no more reason of keeping them.

Then we can save the data processed in the same position of memory. With that, the amount of necessary memory will be fixed (look bellow).That implementation is not useful for OFDM, because in that system, while FFT is processing, it is not possible to write the data of the entrance in the memory. Another problem is that the exit has to be stored to make the cyclic-prefix. To solve the problem of the cyclic-prefix, a RAM memory can be put in the exit to store the data. And for the system to work in a continuous way, it is necessary that the entrance memory has double size and separate the content in two parts, so that while FFT is reading of a part, be possible to write in the other and vice-versa. It is also necessary to include another RAM memory so that after the first reading FFT can store and to process the data without interfering in the entrance memory, as can see in the figure bellow.

III. FBMC/OQAM

A. Block Diagram:

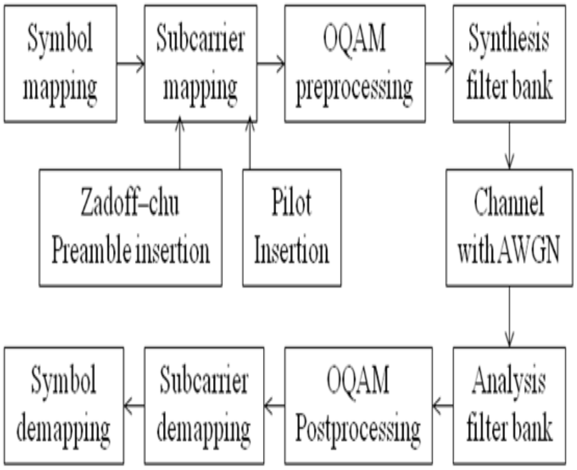

Fig4: Proposed block diagram for FBMC

The block diagram consist of transmitter, receiver and channel with auto white Gaussian noise.

B. Transmitter:

Symbol mapping: The random input data given to the symbol mapping, where the digital data is modulated using the any one of digital technique namely QPSK, 4-QAM or 64-

QAM.the main function of this block is it converts the incoming binary data into symbols and maps those symbols as a frame. The BER [20] rate of the system is mainly depend on this block.

Subcarrier mapping: The need of subcarrier mapping will be useful for the FBMC frame creation. In generally, the FBMC frame [18] consist of preambles, data pilots and data subcarriers. The data subcarriers are generated from the symbol mapping output data.

Moreover, in framed data, each frame is equipped with a preamble that is specially designed for fast tuning of carrier frequency and timing synchronization at the receiver, upon the receipt of each packet. Pilots [21] are used for the efficient channel estimation and equalization that is needed in order to realize spectral efficiency, spectrum sharing approaches or high mobility scenarios. Pilots are also used for the phase tracking of the each received packet.

OQAM preprocessing: In FBMC systems, any kind of modulation can be used whenever the subcarriers are separated. For example, if only the subcarriers with even or odd (anyone) index are used, then there is no overlap and QAM modulation can be employed. However, all the subcarriers must be used and a specific modulation is needed to provide high spectral efficiency in frequency domain.

So overlapping between neighboring subcarriers situation is occurred, for this purpose orthogonality is needed between subcarriers. It is achieved by using the real part of the iFFT inputs with even index and the imaginary part of the iFFT inputs with odd index. By doing this complex to real conversion, the orthogonality is achieved in real domain. And OQAM [7] scheme can simultaneously employ an improved pulse shaping, and interpolation by factor 2 for transmit at the Nyquist rate.

Channel: Channel is a communication medioum, in which all the generated waveforms will be travel. The channel contains the several parameters. They are, Velocity specifies the mobile's velocity relative to the base station. Propagation Distance specifies the distance between base station and the mobile station, Path Loss identifies whether the large-scale path loss is included. A set of four [23-25] modified International Telecommunication Union (ITU) channel models are using for multipath fading of the channel. The waveform gets affected by noise in channel only.

C. Receiver

The ideal receiver performs the exact opposite operation to that of transmitter. But the parameters (time, frequency and phase) of transmitted FBMC signal must be observed exactly across the receiver. So this is achieved by practical receiver only by introducing the extra functions to the receiver. They are timing and frequency synchronization, channel estimation, channel equalization and phase tracking.

Time, frequency and phase synchronization: Synchronization is needed in any receiver to compensate for any difference between the carrier frequency of the incoming signal and the local oscillator frequency used across demodulator. In FBMC, timing offset (to) and carrier frequency offset (cfo) [17] results in ISI and ICI. Pilot aided and blind synchronization methods [13] are used to provide the synchronization.

Phase tracking method [26] which may be used to track any residual carrier off set during the payload transmission of an FBMC frame. The payload starts with an accurate estimate of the carrier phase. However, without any carrier tracking loop, the carrier phase may drift over the length of the payload. Hence, there is need to design a phase-locked loop (PLL) that forces any built up phase error to zero.

Channel estimation: FBMC only satisfies the orthogonality in the real domain, which causes it suffering from intrinsic interference even if perfect Timing and frequency synchronization is achieved. However, to avoid the intrinsic interference originated from neighboring symbols in the time domain, more than a couple of FBMC symbols either pilots or preambles [27] must be allocated only for channel estimation purpose. Generally the pilots are used to cancel the interference. By doing so, the received main pilots become interference-free, and channel estimation can be performed.

Channel equalization: In FBMC receivers, equalization [28] is performed at the output of the analysis filter banks. The channel equalization can be implemented in the frequency domain or in the time domain, depending on the receiver analysis filter bank implementation. It is often assumed that each subcarrier has a small bandwidth; hence, the channel may be assumed to be flat over each subcarrier band. In this situation, a single-tap equalizer per subcarrier is enough.

In cases where the flat gain approximation may be insufficient of channel and where carrier and clock mismatch between the transmitter and receiver is inevitable, multitap equalizer per subcarrier band may be necessary. A tap-spacing of half symbol interval is the most convenient option. Apart from this operations analysis filter bank, OQAM, post processing, subcarrier demapping and symbol demapping also performed. Those operations are exact opposite to the transmitter.

IV. WALSH HADAMARD PRECODED FBMC

A. Introduction

The fifth generation (5G) of cellular networks is coming [1]. One of the main requirements of 5G networks is to increase the data rate about 1000 times the current data rate of 4G networks [2]. To support such a huge rate increase, intensive research on the physical layer – the waveform design has been carried out. Orthogonal frequency division multiplexing (OFDM), which is the dominant technology for 4G networks, can still be a good candidate for 5G networks since it has good qualities such as efficient implementation, single tap equalization for each subcarrier, and being easy to pair with

MIMO. However, the high peak-to-average-power ratio (PAPR) and spectral sidelobes of OFDM signals need to be addressed. Generalized frequency division multiplexing (GFDM) is proposed for the air interface of 5G networks in [3]. In GFDM, the information symbols are organized in an array of subcarriers and subsymbols. The complex symbols on each subcarrier are filtered with a filter that is circularly shifted in time and frequency of a prototype filter. Filtering helps to improve the spectrum localization of GFDM signals.

B. System Model

In the proposed WHT-C-FBMC system, the information symbols are processed in blocks, each involving K subcarriers and M time slots. Let sk,m = s R k,m + jsI k,m be the complex QAM data symbol associated with the kth subcarrier and mth time slot. To enable offset QAM (OQAM) modulation, the real and imaginary parts of a complex QAM symbol are separated and arranged in a K × 2M matrix as follows:

$$\mathbf{A} = \begin{bmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,2M-1} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,2M-1} \\ \vdots & \vdots & \ddots & \vdots \\ a_{K-1,0} & a_{K-1,1} & \cdots & a_{K-1,2M-1} \end{bmatrix} \\ = \begin{bmatrix} s^R_{0,0} & s^I_{0,0} & \cdots & s^R_{0,M-1} & s^I_{0,M-1} \\ s^R_{0,0} & s^I_{0,0} & \cdots & s^R_{0,M-1} & s^I_{0,M-1} \\ \vdots & \vdots & \ddots & \vdots & \\ s^R_{0,0} & s^I_{0,0} & \cdots & s^R_{0,M-1} & s^I_{0,M-1} \end{bmatrix}. \qquad (1)$$

The block diagram of the WHT-C-FBMC transmitter is illustrated in Fig. 1, where the K data streams inputs are the K rows of matrix A. This structure is basically the polyphase structure presented in [8], except that a WHT precoder is applied to the input. The WHT is applied for each column of A as

a˜m = W$_K$Am(2)

where am is the mth column of A, WK is a K × K WalshHadamard matrix and a˜m is the mth precoded column vector.

$$\mathbf{W}_K = \frac{1}{\sqrt{K}} \begin{bmatrix} \mathbf{W}_{K/2} & \mathbf{W}_{K/2} \\ \mathbf{W}_{K/2} & -\mathbf{W}_{K/2} \end{bmatrix}, \ \mathbf{W}_2 = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}. \qquad (3)$$

In an OQAM system, the phase offsets are introduced to the real and imaginary components of QAM symbols on different subcarriers as follows:

bm = JmA˜m (4)

where Jm = diag([j m, jm+1, . . . , jm+K−1]). Then, the WHT-C-FBMC transmitted signal is then given as [7]

$$x[n] = \sum_{k=0}^{K-1} \sum_{m=0}^{2M-1} j^{k+m} \tilde{a}_{k,m} g[(n - mK/2)_{KM}] e^{j2\pi kn/K}, \qquad (5)$$

where n = 0, 1, . . . , KM − 1, a˜k,m is the kth element of a˜m, g[n] is the impulse response of a prototype filter, which has KM coefficients, and g[(n − z)w] denotes cyclically shifting g[n] by z positions with period w.

The polyphase structure [8] for the implementation of (5) as shown in Fig. 1 is the most efficient method and can be described clearly in matrix form. Let x = [x[0], x[1], . . . , x[KM − 1]]⊤, and g = [g[0], g[1], . . . , g[KM − 1]]⊤ be the transmitted vector and vector of filter coefficients, respectively. Then the matrix form representation of (5) is

$$\mathbf{x} = \sum_{m=0}^{2M-1} \mathbf{G}_m \mathbf{R} \mathbf{F}_K^H \mathbf{b}_m, \qquad (6)$$

where FK is the K-point FFT matrix, R = [IK, . . . , IK] ⊤, Gm = diag(Φmg) = diag([g0,m, g1,m, . . . , gKM−1,m]), and Φm is a KM × KM circulant matrix whose first column has only one non zero value, which is the (mK/2)th element with value 1. In this structure, bm is first transformed into the time domain by multiplying it with an inverse FFT matrix, FH K. Upsampling is performed by repeating the K × 1 transformed vector M times with the KM × K matrix R. The resulted vector is pulse-shaped by point-wise multiplication with the circularly shifted version of the prototype filter, which is Φmg. Then the transmitted signal is obtained by summing all pulseshaped subsymbol vectors. Substituting (2) and (4) into (6), the transmitted signal of WHT-C-FBMC can be expressed as

$$\mathbf{x} = \sum_{m=0}^{2M-1} \mathbf{G}_m \mathbf{R} \mathbf{F}_K^H \mathbf{J}_m \mathbf{W}_K \mathbf{a}_m, \qquad (7)$$

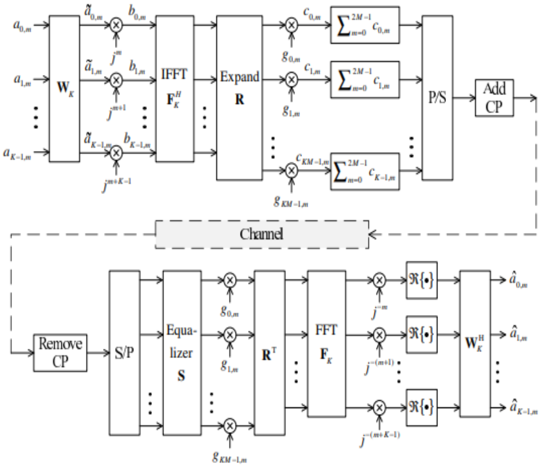

Fig. 5.: Equivalent complex baseband WHT-C-FBMC system.

Channel estimation: The proposed Preamble symbol is chosen to do channel estimation as it can be used to generate pilot sequence. Because the value of preamble symbols in transmitter is known and the repeated structure formed cyclic prefix in preamble that make it robust to multipath. The least-squares channel response estimate at subcarrier i can be obtained as: Hi=Yi/Xi, where Yi is the received symbol and Xi is the transmitted preamble symbol on the ith subcarrier.

Phase Tracking: The compensated phase is estimated by pairs of pilots and zc sequence preambles in frame. The tracking aims at computing a channel estimate by using transmitter and receiver data on the pilots at two different time instants. The phase is calculated as the mean value of the angles of pilots and preambles.

V. FBMC BASED MASSIVE MIMO

A. FBMC Principles

Let dm,n denote the real-valued data symbol transmitted over the mTH subcarrier and nTH symbol time index. The total number of subcarriers is assumed to be M . To avoid the interference between the symbols and maintain the orthogonality, the data symbol dm,n should be phase adjusted using the phase term ejθm,n , where θm,n = π2 (m + n). Accordingly, each symbol has a ± π2 phase difference with its adjacent neighbors in time and frequency. The symbols are then pulse-shaped using the prototype filter p(l), which has been designed such that q(l) = p(l) ∗ p∗(−l) is a Nyquist pulse with zero crossings at M sample intervals. The functions am,n(l) can be thought as a set of basis functions that are used to modulate the data symbols. Note that the spacing between successive symbols in the time domain is M/2 samples. In the frequency domain, the spacing between successive subcarriers is 1/M in normalized frequency. It can be shown that the basis functions am,n(l) are orthogonal in the real domain.

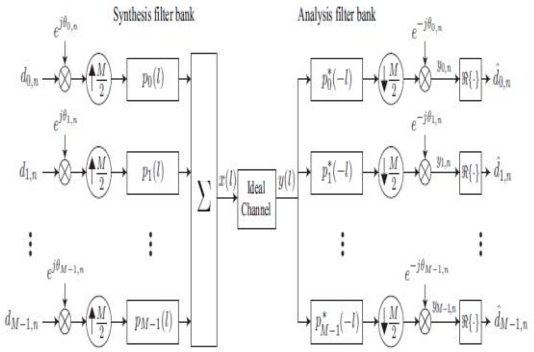

Fig.6: Block diagram of the FBMC transceiver in discrete time

Fig. 6.1 shows the block diagram of the FBMC transceiver. Note that considering the transmitter prototype filter p(l), and the receiver prototype filter p∗(−l), the overall effective pulse shape q(l) = p(l) ∗ p∗(−l) is a Nyquist pulse by design.

Also, in practice, in order to implement the synthesis (transmitter side) and analysis (receiver side) filter banks efficiently, one can incorporate the polyphase implementation of filter banks to reduce the computational complexity, [15].The presence of a frequency-selective channel incurs some interference on the received symbols, and thus, one may adopt some sort of equalization to retrieve the transmitted symbols at the receiver side. Let h(l) denote the impulse response of the channel. In this project, I limit our study to a case where the channel impulse response remains time invariant over the interval of interest. However, in highly frequency-selective channels, where the above assumption is not accurate, more advanced equalization methods should be deployed to counteract the channel distortions, [10].

B. Massive MIMO FBMC

The symbol ↓ M2 denotes decimation with the rate of M2. In (6), hmm′ (l) is the equivalent channel impulse response between the transmitted symbols at subcarrier m′ and the received ones at subcarrier m. This includes the effects of the transmitter pulse-shaping, the multipath channel, and the receiver pulse-shaping; see Fig. 1. According to (5), the demodulated symbol ym,n undergoes interference originating from other time-frequency symbols. In practice, the prototype filter p(l) is designed to be well localized in time and frequency. As a result, the interference is limited to a small number of neighboring symbols around the desired time-frequency point (m, n). In order to devise a simple equalizer to combat the frequency-selective effect of the channel, it is usually assumed that the symbol period, M/2, is relatively large compared to the channel length, L. With this assumption, the demodulated signal ym,n can be expressed. The term um,n is called the intrinsic interference and is purely imaginary. This term represents the contribution of the intersymbol interference (ISI) and intercarrier interference (ICI) from the adjacent time-frequency symbols around the desired point (m, n). Based on (7), the effect of channel distortions can be compensated using a single-tap equalizer per subcarrier.

VI. RESULT ANALYSIS

In Every 5G radio access technologies, the random input data must be converted as symbols. For this purpose, Modulation type qpsk or 4-qam is used in this paper. Number of subcarriers, this parameter is directly related to the spectrum utilization of the system. As the number of subcarriers is increased the spectrum utilization will be used. In this paper for all the 5G radio access technologies same amount of subcarrier are considered, which is 128, among this 120 are Data carriers and 8 are Pilot carriers. Sampling rate, this parameter specifies the system bandwidth. For all 5g air interfaces 20mhz-bandwidth is considered.

Every digital system needs to satisfy the Nyquist Shannon sampling theorem required to avoid aliasing , i.e., Nyquist rate must be greater than twice the sampling rate. So in order to achieve the Nyquist rate interpolation is the best method. .In this project, the interpolation is treated as **over sample ratio**. This ratio should be **twice** to maintain nyqusit theorem.

After generation of frame, in order to transmit this frame or group of frames into channel, the frame must be modulated by radio frequency Carrier wave, thus the RF signal will be needed. In this paper 1GHZ spectrum is considered with the carrier Signal power of 0.01watts.

In FBMC, prototype filter used in both transmitter and receiver. In this project, PHYDYAS prototype filter is using, which is having Filter overlap factor of 4 and corresponding coefficients are P[0]=1, p[1]= 0.9715983, p[2]= 1/root(2) and p[3]= 0.235. As discussed in preamble design section, for FBMC, the Root index 1 is 7, Root index 2 is 3.

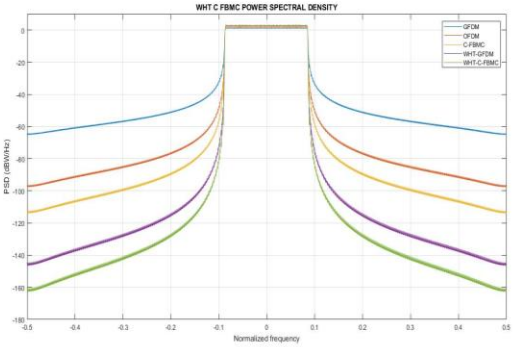

Fig.7: Spectrumof WHT-CFBMC system

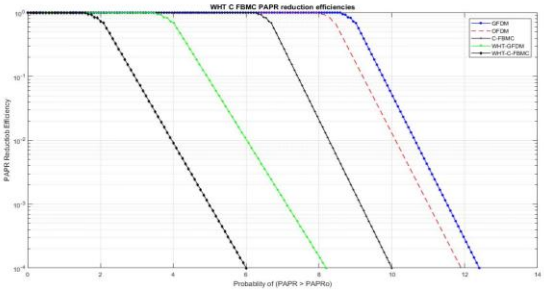

Fig.8: PAPR of WHT-CFBMC system

From figure 7.2, at 1% of CCDF, the PAPR values of FBMC is reduced to 2db by comparing with the OFDM PAPR value and other 5g air interface techniques. The F-OFDM and UFMC are having the same PAPR values of OFDM. The GFDM is having more PAPR values then OFDM which is become a drawback for GFDM.

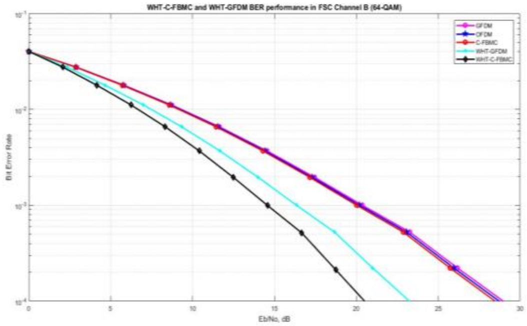

Fig.9: WHT-C-FBMC and WHT-GFDM BER performance in FSC Channel B.

(a) 64-QAM

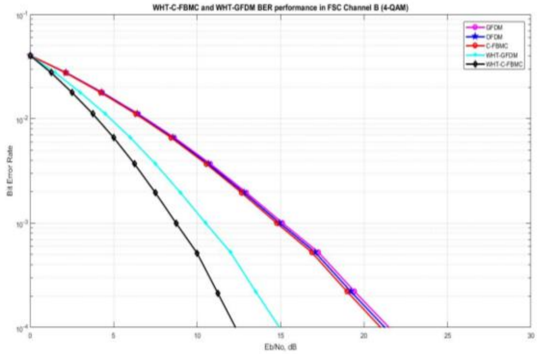

Fig.10: WHT-C-FBMC and WHT-GFDM BER performance in FSC Channel B

(b) 4-QAM

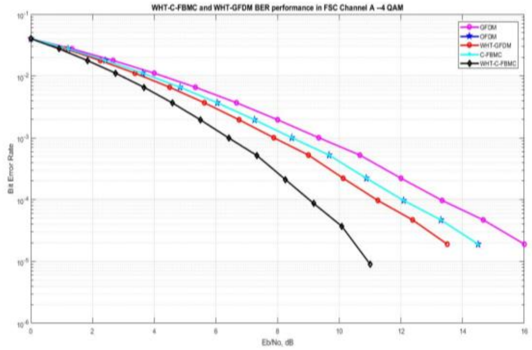

Fig.11: WHT-C-FBMC and WHT-GFDM BER performance in FSC Channel A

(a) 4-QAM

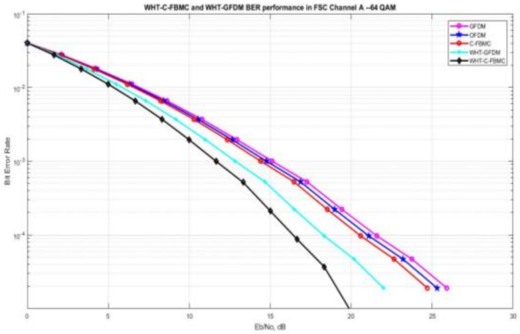

Fig.12: WHT-C-FBMC and WHT-GFDM BER performance in FSC Channel A

(b) 64-QAM

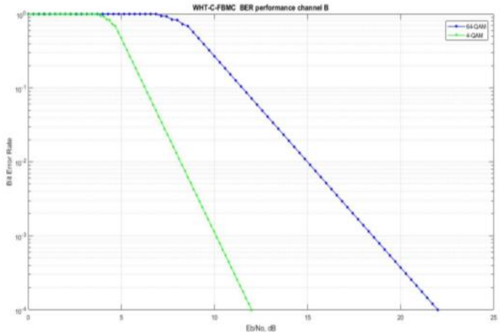

Fig.13: BER vs SNRof WHT-CFBMC system

The bit error rate is the number of bit errors per unit time. The bit error rate is the number of bit errors divided by the total number of transferred bits during a studied time interval. Bit error rate is a unit less performance measure, often expressed as a percentage. From the figure 7.5, the BER response of FBMC is much better than OFDM and UFMC. At 1e-4 of BER, the SNR of FBMC is decreased an amount of 1.6 db to UFMC, 3db to F-OFDM and 5.5 db to the OFDM. And the FBMC BER response is near to the theory response such as QPSK BER.

VII. CONCLUSION& FUTURE SCOPE

This paper proposes a new preamble design and corresponding channel estimation algorithm for FBMC/OQAM system. The Zadoff chu sequence used to generate the long preamble structure for the frame. The performance results show that the proposed preamble based method performs well than the conventional preamble structure in the following attributes spectral efficiency, and reduced PAPR values. Moreover, the proposed algorithm has low complexity which makes efficient bit error rate performance with respect to signal to noise ratio and mean square error. Hence it directly applicable to advanced mobile systems like 5g.

VIII. FUTURE SCOPE:

Future work will be to apply the proposed method to MIMO FBMC, because it offers many exciting problems for research. Channel estimation and synchronization are among interesting issues to work on. Possible application of FBMC in the emerging area of massive MIMO was also highlighted, and a number of advantages that FBMC offers in this application were identified. This, in turn, allows transmission over noncontiguous bands, a property that makes FBMC an ideal choice for many applications, including the uplink of multiuser multicarrier networks and cognitive radios. Extending the current implementation to include a FBMC based communication system would be the next step to further show the usefulness and practicality of FBMC communications and spectrum sensing on a cognitive radio modem.

IX. REFERENCES

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