DESIGN AND SIMULATION OF OQAM BASED FILTER BANK MULTICARRIER (FBMC) FOR 5G WIRELESS COMMUNICATION SYSTEMS

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Abstract— A wireless communication is looking for higher bandwidth with greater spectral efficiency. Multicarrier communication technology has been suggested as a suitable candidate to utilize the white spaces in the spectrum. OFDM was the first multicarrier technique proposed for 4G (LTE-A) and has been successfully deployed in 4G systems. But due to the use of cyclic prefix and the high PAPR the OFDM communication system cannot be suitable for 5Gs. This paper discusses how FBMC can be designed and proves that it is the most efficient waveform selection for next generation wireless communication i.e. 5G communication system.

Keywords— FBMC, Offset, Filter Bank, Polyphase Network, Sub Channel Equalization, 5G Wireless Technologies.

I. INTRODUCTION

5G Technology stands for 5th Generation Mobile technology. 5G mobile technology has changed the means to use cell phones within very high bandwidth and higher data rates. User never experienced ever before such a high value technology. Nowadays mobile users have much awareness of the cell phone (mobile) technology. As we have seen every new cell phone releases with typical application which requires higher data rate and the efficient spectral efficiency. We notice that the mobile user is increasing in a sec which results in increase in the traffic. Since, the smartphone releases with many connectivity services which can connect more devices which requires higher data rate which 4G system cannot provide the required data rate due to the high PAPR and the Spectrum leakage. Orthogonal Frequency Division Multiplexing (OFDM) is the current dominant technology for broadband multicarrier communications. It is widely adopted because of a number of advantages like orthogonality of subcarrier signals within its neighboring sub carrier closely spaced orthogonal subcarrier partition the available bandwidth into narrow sub-band and simplified carrier and symbol synchronization due to the special structure of OFDM symbols. FBMC technique has the potential to increase the bit rate, due to the reduced guard bands and the absence of the cyclic prefix needed in OFDM. FBMC gives also the possibility to allocate different subcarriers to different non-synchronized users in a spectrally efficient manner. The out of band rejection is efficient in FBMC because individual filter are allocated for individual subcarrier which reduces the guard band. But the out-of-band emission of FBMC is highly sensitive to the carrier frequency offset in OFDM. Less sensitive and hence performs significantly with the increase of the user mobility in FBMC. So we moved to Filter Bank Multiple Carrier (FBMC), an alternative technique for OFDM. The only fundamental change is the replacement of the OFDM with a multicarrier system based on filter banks at the Transmitter and Receiver. The filter bank multicarrier techniques in future cellular communication system increases the spectral efficiency and the perfect bandwidth utilization. The only disadvantage is that the design of filter will be complex.

II. BLOCK DIAGRAM OF FILTER BANK MULTICARRIER SYSTEM

![FBMC Transmitter Structure](image)

Fig1: FBMC Transmitter Structure
In the FBMC block diagram the Offset Quadrature Amplitude Modulation (OQAM) preprocessing, Polyphase network and OQAM post processing are not present in OFDM block diagram. It uses QAM mapping followed by the application of offset of M/2 samples in time domain between the in phase (I) and quadrature (q) components of complex signal. The term offset refers to the time shift of half of the sub channel per sub carrier. The resulting OQAM mapper enables an efficient reduction of Inter carrier interference (ICI) and intersymbol interference (ISI). The separation process is known as analysis filter banks and the recombination process is known as synthesis filter banks. Both this filter banks are combined together in order to achieve the accurate reconstructions of signals. OQAM post-processing has two operations: First operation is multiplication by $\theta$ pattern that is followed by the operation of taking the real part. Second operation is real to complex conversion, in which two successive real valued symbols form a complex valued. In this sense the real to complex conversion decreases the sample rate. FBMC applies a filtering operation through the introduction of a poly phase network after IFFT. This block also reduces ICI and ISI. In this sense the real to complex conversion decreases the sample rate. A time offset of half a QAM symbol period (T/2) is applied to either the real part or the imaginary part of the QAM symbol.

### III. DESIGN OF FBMC TRANSMITTER

The entire model in this paper is designed and simulated using the software called SystemVue 2013.01. Here we have used random bits as the input signal which is then converted to the integer. The Bits to integer converter model converts the bits value into its corresponding integer. Digital Modulation model can be used to generate digital modulation signal on baseband, including the basic modulation schemes. The modulation scheme selected here is 16QAM. The oversampling ratio used is 16. The Set Sample Rate model associates the sample rate with its input signal and creates a timed signal at its output. Here the sample rate provided is 1.6e+007 Hz. The CxToRect model converts input complex values to output real and imaginary values. This model reads one sample from the input and writes one sample to each of the output. For two successive sub-channels, say $m$ and $m+1$, the offset are applied to the real part of the QAM symbol in sub-channel, while $m-1$ is applied to the imaginary part of the QAM symbol. Incoming signal from the multiplier is passed through CxToRect where real signal is passed through FIR.
filter and also through delay block. In delay block unit delay is applied to the incoming signal. The transmitter side involves the multiplication of theta ($\theta$) and the beta ($\beta$). Here the value of theta we have used $1,j,1,j,1,j,...$ for even and $j,1,j,1,j,1,...$ for the odd. The value of beta we have used is 0.2 in case of even and 0.4 in case of odd. Here the poly phase filtering using the set of digital filters has been considered. The polyphase filter is design using the set off three FIR filters. Data element is applied to one input of the IFFT and it modulates one carrier. It uses overlapping factor of $k$ and modulates $2k-1$ carriers. As we go on increasing $k$ factor then the out of band rejection will be low and the spectral efficiency will be high. Each subcarrier is allocated with individual filters. Here IFFT and FFT size is $M$ with sampling frequency is 1 with $M$ carrier, therefore carrier frequency is $1/M$.

IV. DESIGN OF FBMC RECEIVER

For the designing purpose we have used the digital bits followed by the sub channel processing and the IFFT. Here it acts as the demodulator. Here also the value of beta is same as that of transmitter. The receiver is modelled with the sub channel equalization. The sub channel is modelled using the three tap FIR filter. The carrier will overlap at some instant of time. Hence this equalizer overcomes these problems. This model implements a real arithmetic adaptive filter (FIR or IIR) using the Least Mean Squares (LMS) algorithm. The LMS algorithm tries to minimize the error between the desired signal and the output of the filter based on the Least Squares (LS) criterion. Sub channel equalization can cope up with the variation in time and frequency and the phase and amplitude distortions.

V. FBMC IN 5G WIRELESS SYSTEM DESIGN

A multi solution can have similar performance, efficiency and low signal processing complexity as that of OFDM solution, yet has better PAPR performance and is less sensitive to RF impairments such as phase noise and power amplifier nonlinearities. Because of the high directivity of the mm-wave transmission, the mm-wave channel is relatively flat and the equalization of a single carrier solution may be simpler than what is required for a highly frequency-selective channel. Due to the reuse of low cost power amplifier the PAPR performance is very desirable in mm-wave frequency. The FBMC in 5G wireless communication is shown is fig4.
The above model is designed using the simulated transmitter and receiver model. 5G wireless communication uses the FBMC as a waveform. It offers additional benefits as compared to OFDM. The regular CP is replaced by null symbols where null symbols are appended at the end of a group of symbols. The first additional advantage of NCP-SC over a regular CP method (OFDM included) is that the null portion enables a built-in guard period for switching of RF beams without destroying the CP property. The second advantage is that since the FBMC block includes the group of data symbols plus the null symbols (i.e., the CP), the CP size in FBMC can be dynamically changed without changing the number of symbol blocks per frame. Initially the random bits are used as an input source which is then mapped using the mapper. The mapper depends upon the value of input provided. Here we have used QPSK modulation. Then the input from the mapper is fed to FBMC data source, in the source, FBMC baseband signal with preamble symbols and data symbols is produced. Preamble symbol is formed by two superimposed ZC sequences. FBMC Complex Splitter separates complex data into real part and imaginary part finished the first step of OQAM modulation. After that IFFT is performed by extended IFFT or PPN IFFT which is chosen by parameter FilterBankStructure. After forming the frame by commutator, OQAM modulation is performed. At last idle interval is added. At the receiver end rest of all baseband single is sent to FBMC Fractional Frequency Estimator. Timing and integer frequency synchronization are performed in Synchronization as long as the fractional frequency offset compensated baseband single is achieved. Finally the data is fed to the sink where the power is optimized and analysed.

V. SIMULATION AND RESULTS

In the above simulations QPSK has been used for the DFT filter bank system and the OFDM system as modulation alphabet for each of the subcarriers. Digital Modulation model can be used to generate digital modulationsignal on baseband, including the basic modulation schemes. Here the modulation scheme used is 16 QAM (quadrature amplitude modulation) and the over sampling ratio is used as 16. (The simulation results are shown in fig 5 and 6.)
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Fig8. Time Domain signal of FBMC Receiver

From the above graphs we can say that if the number of subcarriers is increased from M=16to M=64 then peak of the worst case is certainly increased too.

Fig9. Transmitter and receiver of FBMC model

The above simulation is considered for the model of FBMC, Fig4. Here the red waveform represents the transmitter of FBMC model whereas blue represents the receiver section. In the above results the receiver is delayed with the time of 100µs, which is almost identical to the transmitter. Since it is wireless communication system which consists of transmitter and receiver. Both these models are separated by a transmission channel which is accompanied by a noise, jamming and other interferences. As per the simulation results this model the amount of data transmitted from the transmitter section is fully received at the receiver, which means the system has lesser interference as compared to existing OFDM technology and proves that it is the most efficient multicarrier technique for future wireless communication technology, i.e. 5G Technology. From the above simulations we can clearly state that the out of band rejection of FBMC is far better as compared to that of OFDM. Due to the absence of cyclic prefix in FBMC, it provides much better spectral shaping of the subcarrier which results in the increase in spectral efficiency. Since 5G requires higher bandwidth, son from the above simulation results we can clearly say that the FBMC model has the capacity to overcome the spectrum leakage. Multicarrier systems allow for an adaptation to the frequency response of the channel by using different modulation techniques and power allocation for the respective subcarriers. In this way the appropriate solution can be achieved and the available bandwidth can be used very efficiently. This can be utilized for simplifying the equalization of intersymbol (ISI) and inter carrier interference (ICI) when no cyclic prefix is used.

CONCLUSION

In this paper we have designed the FBMC transmitter and receiver section and further it is proposed in 5G wireless communication system. At the transmitter section we have used the transform decomposition method, and the OQAM processing and the synthesis filter bank. In receiver section we have used the polyphase network, sub channel processing and the OQAM post processing. In order to reduce the computational complexity we have used multistage filter banks. This paper is focused on designing of FBMC and fulfillment as the efficient waveform for the 5G communication system. From the simulation results we can clearly sat that the drawbacks of OFDM are solved by the filter bank multicarrier. FBMC applies filtering on a per-subcarrier basis to provide out of band spectrum characteristics. The baseband filtering is done using either a poly phase network or an extended IFFT. Filtering can use different overlap factors (i.e., K factor) to provide varying levels of out-of-band rejection.
REFERENCES


