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Comparison of Spectral Efficiency in OFDM and Filter Bank Multi Carrier Modulation Technique

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ABSTRACT

Recent Scenarios on 5G technology emphasize on the need for better spectral efficiency to improve the data rate. In today's mobile communication systems, cyclic-prefix-based orthogonal frequency division multiplexing (CP-OFDM) has been widely adopted. In 4G technology Cyclic prefix is the major problem due to duplication of symbol rate. In order to overcome these issues, 5G uses the filter bank Multi-carrier Modulation technique is employed. By using technique called Prototype filter that is designed for improving data rate. By Comparing OFDM, the filter bank multicarrier Modulation method where Side lobes were suppressed and hence spectral efficiency has improved.

Keywords: Filter bank Multicarrier, Cyclic Prefix, Spectral Efficiency

INTRODUCTION

FBMC was considered as an alternate waveform to OFDM in the 3GPP RAN study phase I during 3GPP Release 14. Recent discussions on the fifth generation (5G) wireless communications have initiated a much stronger wave of interest in deviating from the main stream of OFDM systems. This shift of interest is clearly due to limitations of OFDM in the more dynamic and multiuser networks of future. The 5GNOW has identified four alternative choices of waveforms to better serve 5G needs. These waveforms that are all built based on some sort of filtering may be thought as adoptions of FBMC method to suit different needs of various applications. the conditions required for signalling a parallel set of PAM symbol sequences through a bank of overlapping filters within a minimum bandwidth. To transmit PAM symbols in a bandwidth-efficient manner, Chang proposed Vestigial Sideband (VSB) signalling for subcarrier sequences. Most authors have used the name offset QAM (OQAM) to reflect the fact that the in-phase and quadrature components are transmitted with a time offset with respect to each other. Moreover, to emphasize the multi-carrier feature of the method, the suffix OFDM has been added, hence, the name OQAM-OFDM.Channel equalization in FBMC systems is discussed in Methods of carrier and symbol timing acquisition and tracking in FBMC systems are reviewed in if each subcarrier is sufficiently narrow such that it can be approximated by a flat gain, two real taps per subcarrier would be sufficient for equalization

The paper emphasis is on the recent works of the author and his students. Many shortcomings of OFDM in dealing with the requirement of the next generation of wireless systems A method of designing FBMC systems for a near-optimum performance in doubly dispersive channels is presented and its superior performance over OFDM is shown. FDM has been adopted in the broad class of DSL standards as well as in the majority of

The theory of FBMC, particularly those of CMT and SMT, has evolved over the past five decades by many researchers who have studied them from different angles. Early studies have presented their finding in terms of continuous-time signals. The more recent studies have presented the formulations and conditions for ISI and ICI cancellation in discrete-time, for example, from the author of this paper and his group, have revisited the more classical approach

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and presented the theory of CMT and SMT in continuous time.

It is believed that this formulation greatly simplifies the essence of the theoretical concepts behind the theory of CMT and SMT and how these two waveforms are related. It also facilitates the design of prototype filters that are used for realization of CMT and SMT systems. Thus, here, also, we follow the continuous-time approach of Moreover, to give a complement presentation to those of an attempt is made to discuss the underlying theory mostly through the *time-frequency phase-space*, with minimum involvement in mathematical details.

PROPOSED SYSTEM

Filter Bank Multi-carrier (FBMC) is a new waveform technique having few advantages over OFDM a contender for 5G. The only fundamental change is the replacement of the OFDM with a multi-carrier system based on filter banks at the TX and RX. Other differences are given below. CP extension required and therefore reduces Bandwidth (BW) efficiency in OFDM. Not required and hence conserves BW in FBMC. Large Side lobes in OFDM compared to FBMC for frequency spectrum.

To suppress the side lobes in FBMC, the Prototype filter is implemented. One main difference between OFDM and FBMC is the filtering applied to the subcarriers, and the more accurate placement of these subcarriers, because FBMC is meant to support multiple simultaneous users on any given RF channel, each user is assigned a different set of subcarriers. This requires more accurate placement of individual subcarriers by all users, and less interference between adjacent subcarriers. And the more accurate placement is also supposed to facilitate spectrum sensing, for cognitive radios. CP extension required and therefore reduces Bandwidth (BW) efficiency in OFDM. Not required and hence conserves BW in FBMC Large Side lobes in OFDM compared to FBMC for frequency Spectrum. For correct detection, multiple access interference (MAI) cancellation should be performed at the receiver in OFDM. MAI is suppressed due to the excellent frequency localization of the subcarriers in FBMC

Highly sensitive to the carrier frequency offset in OFDM. Less sensitive and hence performs significantly with the increase of the user mobility in FBMC. Highly sensitive to the carrier frequency offset in OFDM. Less sensitive and hence performs significantly with the increase of the user mobility in FBMC. Degraded spectrum sensing performance due to the spectral leakage in OFDM signals. High spectrum sensing resolution in FBMC

BLOCK DIAGRAM

FBMC Transmitter

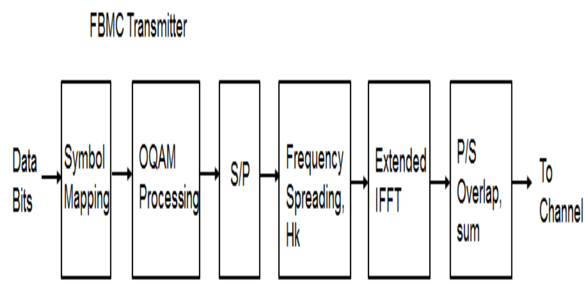

Fig1: FMBC Transmitter

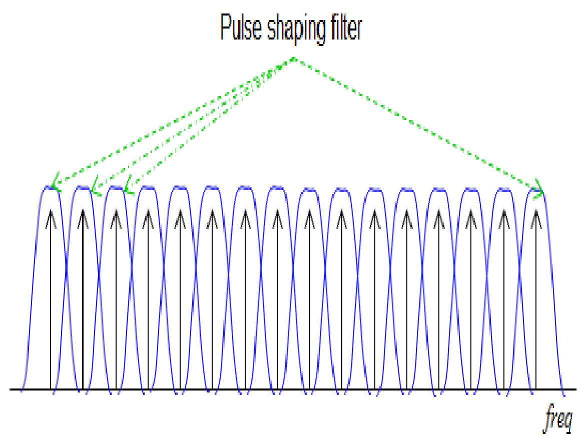

Fig 2: Pulse Shaping of FBMC Filter

The critical steps for FBMC are to implement filters for each sub channels and align the multiple filters into a filter bank. The way to build the filter bank is we design a basic form (template) of a filter called prototype filter. Once we finish the design of the prototype filter, prototype filter design for FBMC/OQAM systems is proposed in this study. The influence of both the channel estimation and the stop-band energy is taken into account in this method. An efficient preamble structure is proposed to improve the performance of channel estimation and save the frequency spectral efficiency. To accelerate the convergence and obtain global optimal solution, an improved genetic algorithm is proposed. Especially, the

History Network and pruning operator are adopted in this improved genetic algorithm. Simulation results demonstrate the validity and efficiency of the prototype filter designed in this study.

FDM and FBMC known as the multicarrier techniques which is the data symbols will be transmitted simultaneously over the multiple frequency subcarriers. Their nature of multicarrier signals gives in-build support for frequency selective link/rank adoption. The main difference between OFDM and FBMC is the pulse shaping applied at each subcarrier. Most of the wireless mobile communication technology that was developed today is based on OFDM. FBMC is an advancement of OFDM. The basic change in the FBMC system is the replacement of the CP in OFDM with the multicarrier system based on filter bank

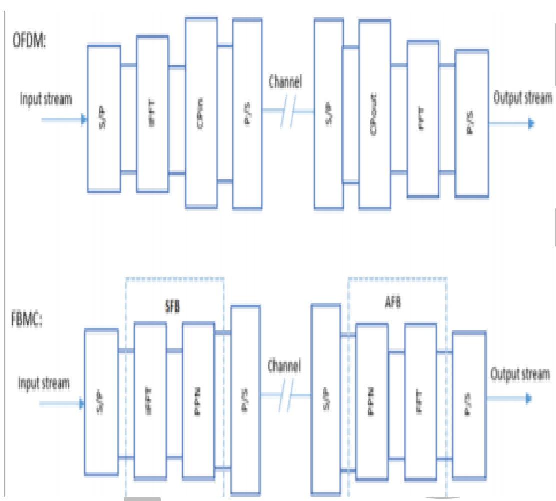

Fig 3 : Comparison of OFDM and FBMC

There is no CP needed in the FBMC system, so it provided more effective use of the radio resources and have more spectral containment signals. Filter bank can be defined as an array of the N filters that will be processed the N input signals to generate N outputs. There are two types of the filter bank in this system which is analysis filter bank (AFB) and synthesis filter bank (SFB) FBMC systems are a subclass of Multicarrier (MC) systems. FBMC modulation is a multicarrier modulation method in which a set of synthesis and analysis filters are employed at the transmitter and receiver respectively [17,18]. The filters uses in the FBMC systems are a set of bandpass filters.

In this filter, the frequency shifted or modulated versions of a prototype low pass filter. FBMC offers a better spectral containment than OFDM as the filter bandwidth, so the selectivity is a parameter that can be assorted during low pass prototype design. Besides that, FBMC gives the better bandwidth efficiency compared to OFDM In the OFDM system, CP extension required, so it reduces the bandwidth efficiency, but in the FBMC system, CP are not required and hence conserves the bandwidth. Besides that, OFDM is very sensitive to the carrier frequency offset (CFO). Meanwhile for the FBMC system, it is less sensitive, so it performs significantly with the increase of the consumer mobile network. Multi-carrier system can be described by a synthesis-analysis filter bank, i.e. a trans-multiplexer structure.

The synthesis filter bank is composed of all the parallel transmit filters and the analysis filter bank consists of all the matched receive filters. The most widely used multicarrier technique is OFDM, based on the use of inverse and forward FFT for the analysis and the synthesis filter banks. The prototype filter of OFDM is a rectangular window whose size is equal to the duration of the FFT. In order to keep a flexible frequency and time block allocation, a preamble-based burst approach is considered. Synchronization and channel estimation is performed using the training sequence. Its structure has been defined and is illustrated in Figure 4 It is composed of a preamble of duration *P*-FBMC symbols (*P* is set to 4 in Figure 2).

The preamble has been designed to accurately detect the start of the burst and gives an estimate of the channel frequency response prototype filter design for FBMC/OQAM systems is proposed in this study. The influence of both the channel estimation and the stop-band energy is taken into account in this method. An efficient preamble structure is proposed to improve the performance of channel estimation and save the frequency spectral efficiency. To accelerate the convergence and obtain global optimal solution, an improved genetic algorithm is proposed. Especially, the History Network and pruning operator are adopted in this improved genetic algorithm. Simulation results demonstrate the validity and efficiency of the prototype filter designed in this study. However, efficient frequency domain FBMC receiver algorithms have to be considered to fully benefit from the scheme. A first attempt at a practical implementation in the frequency domain for FBMC has been proposed in receiver block.

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The power spectral density of the FBMC transmit signal is plotted to highlight the low out-of-band leakage.

OFDM Modulation with Corresponding Parameters

For comparison, we review the existing OFDM modulation technique, using the full occupied band, however, without a cyclic prefix. Comparing the plots of the spectral densities for OFDM and FBMC schemes, FBMC has lower side lobes. This allows a higher utilization of the allocated spectrum, leading to increased spectral

FBMC Receiver with No Channel

The example implements a basic FBMC demodulator and measures the BER for the chosen configuration in the absence of a channel. The processing includes matched filtering followed by OQAM separation to form the received data symbols. These are de-mapped to bits and the resultant bit error rate is determined. In the presence of a channel, linear multi-tap equalizers may be used to mitigate the effects of frequency-selective fading.The receive-end processing is shown in the following diagram.

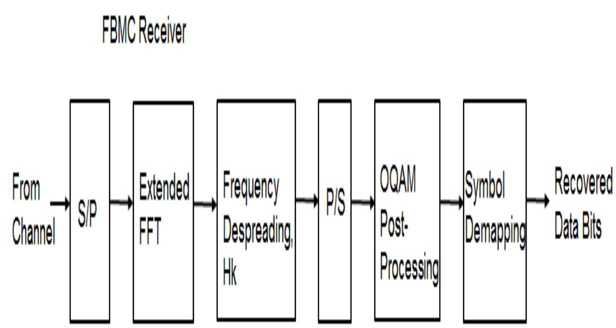

Fig 4: FBMC Receiver

Offset Quadrature Amplitude Modulation (OQAM)

Quadrature Amplitude Modulation (QAM) is widely used in many data communication applications and digital data radio communications. Some of the common forms of QAM include 16QAM, 32QAM, 64QAM, 128QAM and 256QAM. In the QAM, the signal in two carriers shifted in phase by 90° will be modulated and the resultant output consists of both phase and amplitude variations and may also be considered as a mixture of amplitude and phase modulation. Future 5G mobile communication technology will used 256QAM because it is better than 64QAM. This is because the higher QAM numerology reflects the ability to represent more data with the same number of symbols.

The simple concept and low complexity in OFDM systems makes the FBMC systems received a limited attention. The FBMC system offers more robustness to the time and frequency offset than OFDM and does not use any Cyclic Prefix (CP) extension [14]. In the FBMC system, the signal with high spectral containment will be used to reduce the sidelobes of each subcarrier frequency.

Results and Discussion

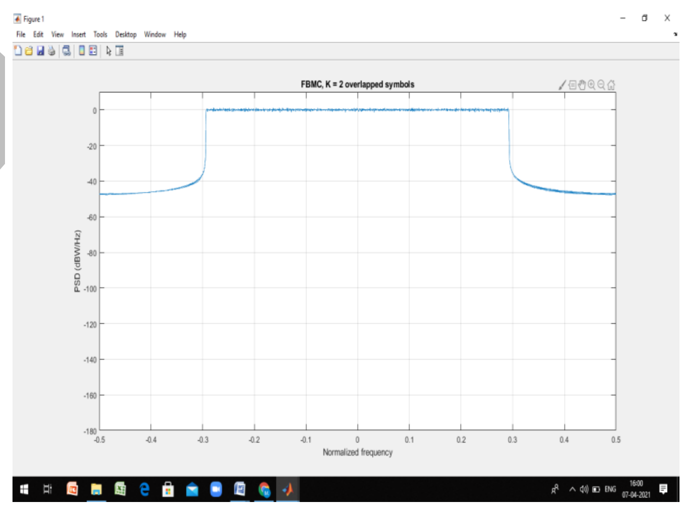

Fig 5: Normalized Frequency of Overlapped Symbols When K=2

The above figure shows the Overlapped symbols of FBMC graph for value of K=2 and Plot the normalized frequency taken in X axis PSD shows the Variation of Spectral efficiency with respect to time

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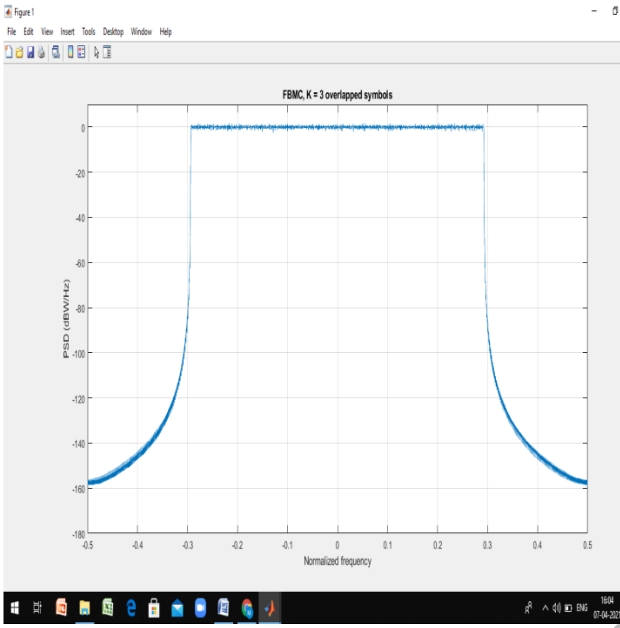


Fig 5: Normalized Frequency of Overlapped Symbols When K=3

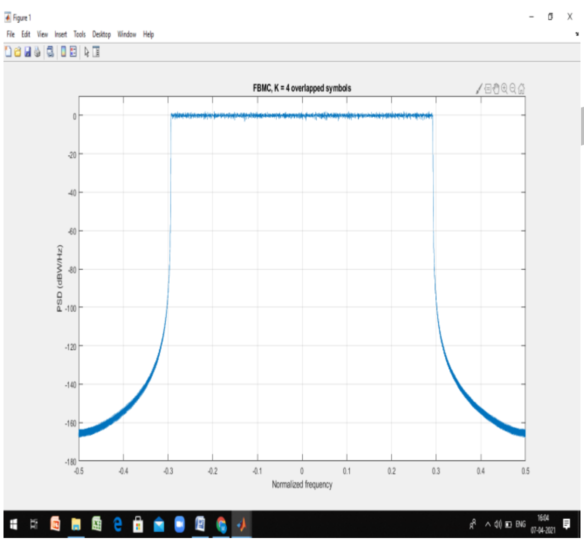
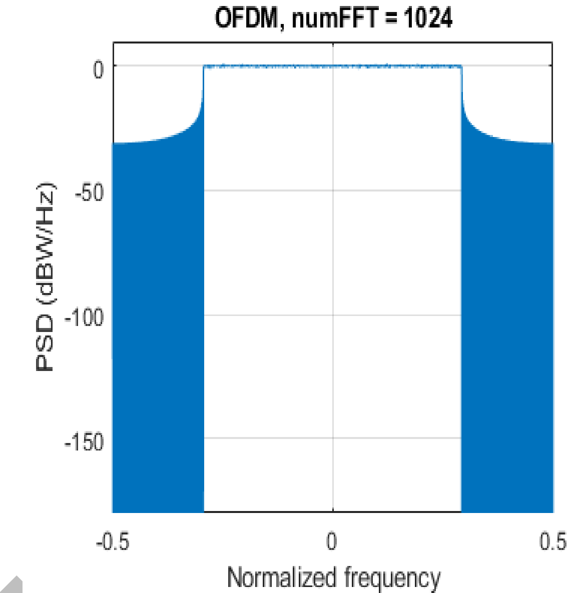


Fig 6: Normalized Frequency of Overlapped Symbols When K=4

The power spectral density of the FBMC transmit signal is plotted to highlight the low out-of-band leakage.



Comparing the plots of the spectral densities for OFDM and FBMC schemes, FBMC has lower side lobes. This allows a higher utilization of the allocated spectrum, leading to increased spectral efficiency.

Conclusion

The example presents the basic transmit and receive characteristics of the FBMC modulation scheme. Explore this example by changing the number of overlapping symbols, FFT lengths, guard band lengths, and SNR values. FBMC is considered advantageous in comparison to OFDM by offering higher spectral efficiency. Due to the per subcarrier filtering, it incurs a larger filter delay (in comparison to UFMC) and also requires OQAM processing, which requires modifications for MIMO processing. In the OFDM system, CP extension required, so it reduces the bandwidth efficiency, but in the FBMC system, CP are not required and hence conserves the bandwidth. Besides that, OFDM is very sensitive to the carrier frequency offset (CFO).

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