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Study and Experimental Analysis on FBMC and OFDM

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ABSTRACT

In next-generation wireless communication, high data rates are becoming increasingly important. Multicarrier technologies like Filter Bank Multicarrier (FBMC)and Orthogonal frequency division multiplexing (OFDM) are used to boost the performance of wireless communication systems. FBMC and OFDM are two modulation techniques for 5G that will be compared in this paper. This paper analyzes the merits of FBMC and OFDM modulation techniques based on their Spectral Density, Spectral Efficiency, Peak to Average Power Ratio (PAPR), and Bit Error Rate (BER). According to simulation results, FBMC modulation has a lower BER, a higher PAPR, is more spectral efficient, has higher Spectral Density, and is more efficient than OFDM modulation. Thus, FBMC is a better form of communication than OFDM.

Keywords : FBMC, OFDM, Multicarrier, 4G, 5G, PAPR, BER, PSD, SNR.

I. INTRODUCTION

Wireless technologies and mobile communication technologies continue to improve very rapidly every day [1]. Because of this, wireless communication systems are required to communicate at higher rates, have greater capacity, and utilize the bandwidth more efficiently [20]. The term wireless communication refers to communication that does not use wires or enhanced conductors [18]. The shortage of spectrum resources requires the system to improve its spectrum utilization [19]. Traditional MIMO technology uses minimal spectrum resources to meet users' performance demands [2].With wireless networking, phones, portable audio players, two-way radios, mobile phones, and personal digital assistants (PDAs) are used [1]. Wireless mobile technologies have evolved over the years, beginning with 0G and continuing to 5G [22].

The number of users connects to the current wireless communication systems have grown exponentially due to the increased use of wireless applications [3]. The importance of ensuring ultra-high data rates, ultra-wide radio coverage and a large number of connected devices that are highly efficient and have low latency motivates researchers and network designers to develop solutions for these fundamental problems [4]. Fifth-generation (5G) wireless networks will be enabled through the use of intelligent and efficient wireless network solutions [3]. 5G networks must be prepared to face major challenges in order to be reliable, secure, and efficient [3]. As of now, 5G networks are not capable of delivering fully automated, immersive services with everything available as a service [5]. While 5G will offer many advantages over today's systems, it may not be able to meet the demands of smart, automated, and intelligent systems ten years from now [5]. Compared to 4G communication systems, the 5G network provides new features and provides a higher quality of service [5].

Dynamic spectrum access networks have been widely discussed in recent years due to the growth of the internet and the increasing demand for high data rates from users[23]. The DSA network uses multiple frequency spectrums to employ multiple nodes [6]. A cyclic prefix approach to OFDM (CP-OFDM) is by far the most prevalent application of multicarrier systems, as it allows wireless nodes to share a subset of these subcarriers among themselves in a distributed, simultaneous manner [7]. When the nodes are part of different administrative units, it is difficult to achieve the tight timing and synchronization requirements inherent in OFDM [17]. If there is no synchronization between the signals of different users, mutual interference results. The CP used also exerts a substantial reduction in bandwidth efficiency as it is chastely redundant in terms of information. With a multicarrier communication system called FBMC, the disadvantages of OFDM were overcome. The past few decades have seen high data rates transmitted through multicarrier communication techniques [8]. Multi-carrier modulation involves splitting a large bit stream into multiple sub streams, which can then be sent over multiple sub channels [22]. The sub channels will have orthogonal behavior when propagation conditions are ideal [8]. As a result, sub channels have lower data rates than total channels, and corresponding sub channel bandwidths are

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lower than system bandwidths [9]. OFDM is the most popular and renowned multicarrier technology used for wireless communication [10]. High data rates will be necessary for future communications systems, so conventional OFDM will need to accommodate lower latency and a flexible allocation of frequency and time resources [11]. In FBMC, Saltsburg provides better subcarrier spectral shaping than OFDM systems to correct the problems of OFDM[21]. The process is achieved by designing a prototype filter that simplifies equalization even without CP, while at the same time minimizing interference in the subcarriers more effectively [12].

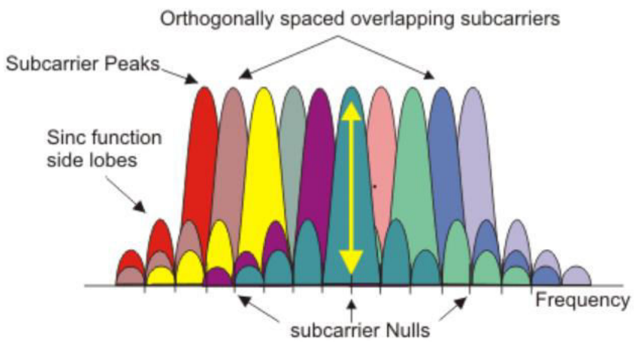

Figure 1. OFDM signal frequency Spectrum

II. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

Multicarrier OFDM systems overlap the frequency spectrum of the subcarriers with the fewest frequencies and achieve orthogonality between the different subcarriers [17]. OFDM was developed by Chang. The interference between orthogonal signals is avoided if the bands of signals overlap significantly [17]. Through the use of OFDM, several subcarriers can be created which will transmit various types of information across a range of frequencies [8]. All of these subcarriers would have to be orthogonal. The precise mathematical definition of orthogonality is when the integral of a function over a specified time interval is 0. Since the transmission channels for broadband signals are frequency-specific, their range is generally restricted [13]. An OFDM technique can be used to counter a frequency selective channel [2]. The total bandwidth of a frequency selective channel is divided into N sub bands with equal spacing in OFDM to convert it into N frequency flat channels. The carriers used in the modulation are orthogonal, so they do not interfere [17]. To accomplish this, the transmitter uses IFFT. The receiver recovers the information using FFT. Since the OFDM waveform has a large sideband, a guard band is left to select the next channel [21]. When guard bands are used, OFDM becomes less efficient [17]. In this way, a new method of improving spectral efficiency has been developed known as FBMC. In FBMC, an IFFT is used to increase spectral efficiency of the waveform [8]. The higher PAPR in OFDM is one of the biggest problems [14]. There are several ways to reduce PAPR [15].

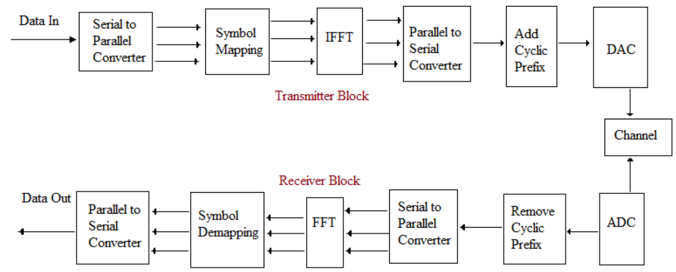

Figure 2. OFBM - Block Diagram

III. FILTER BANK MULTI CARRIER

By including generalized pulse shaping filters to OFDM, FBMC eliminates the limitations of OFDM and creates well-localized sub channels both in time and frequency [8]. Due to their high spectral containment capabilities, FBMC systems offer a more efficient use of radio resources without the need for CP [6]. FBMC was first developed in the 1960s. This is another extension of OFDM. Multicarrier modulation schemes can be categorized into different types, but the best is FBMC, among them. Selecting the filter is the most significant part of analyzing OFDM and FBMC. Based on filter banks, a multicarrier system can be developed to replace OFDM [28].

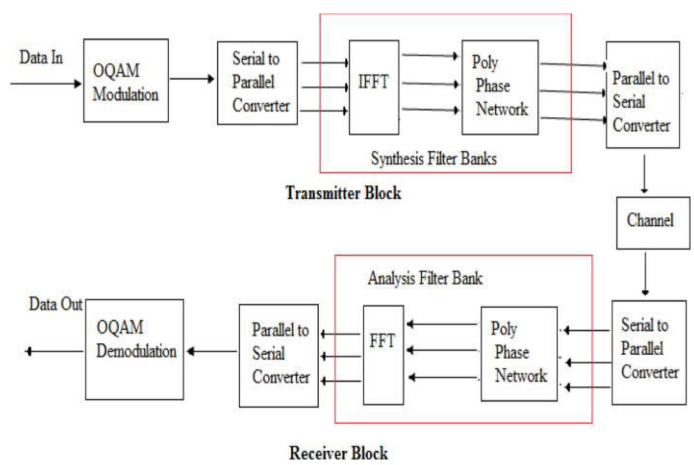

Figure 3. FBMC - Block diagram

A synthesis filter bank replaces CP on the IFFT side, while an analysis filter bank replaces CP on the FFT side[8]. Because FBMC systems have more spectra containment signals, they can use resources effectively when CP is not required [15]. A pulse shaping filter can be added to FBMC to produce well-localized sub channels in both the frequency and time domains, demonstrating the possibility of capturing the maximum transmission rate in traditional FBMC systems [8]. After OQAM has pre-processed a set of

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data, symbols are processed through a synthesis filter bank. To control adjacent spectral leakage and localization of frequencies, the prototyping filter can be selected appropriately [24]. Signals are processed at the receiver through a filter analysis, followed by post-processing with OQAM at the transmitter to ensure that they are perfectly reconstructed. This modulation technique uses OQAM modulation and enables pulse shaping filters [25]. This modulation technique has higher side lobe decay than OFDM [26]. The bandwidth efficiency is high. This makes it suitable for co-operative multipoint applications [27]. This type of wireless communication is more suitable for environments with high mobility compared to OFDM [16].

IV. RESULTS AND DISCUSSION

Fig. 4 illustrates the PSD versus normalized frequency for OFDM and FBMC signals, a comparison between them. For both OFDM and FBMC, the spectrum is generally flat until a normalized frequency of 0.2. OFDM however has a very large sideband when compared to FBMC. Furthermore, the side band is further suppressed by increasing the filter coefficients in the FBMC. However, increasing these co-efficient leads to complex at both the transmitter and receiver. We can therefore conclude that FBMC is more spectrally efficient than OFDM, but it comes at the expense of greater complexity.

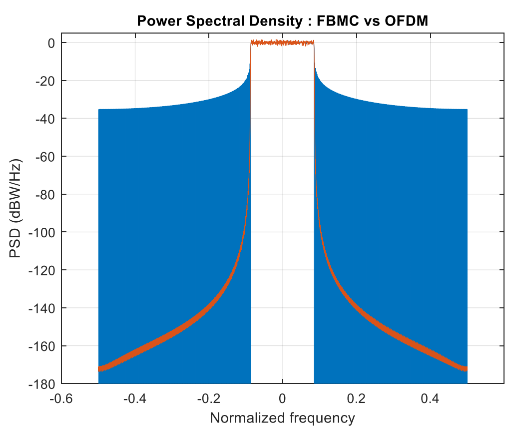

Fig.4. PSD comparison of OFDM and FBMC

Fig. 5 illustrates the frequency spectrum of OFDM and FBMC. FBMC uses a prototype filter and OFDM a rectangular window filter. Because of the rectangular windowing of OFDM, it has strong side lobes, while with FBMC energy is concentrated within a single subcarrier's range.

Fig. 6 represents Spectral Efficiency of OFDM and FBMC. It is generated by changing the duration of the burst between 0 and 50 ms. As the duration of bursts increases, the FBMC's spectral efficiency increases. FBMC's spectral efficiency can be improved with longer burst durations compared to OFDM.

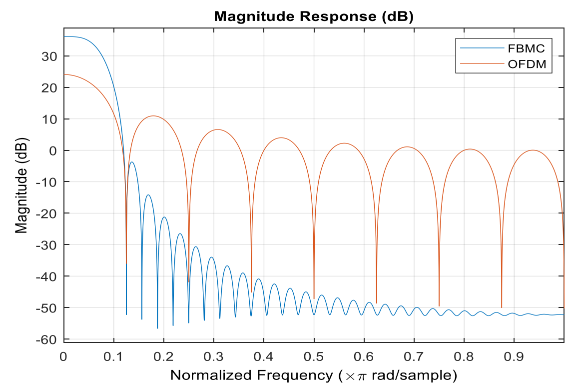

Fig.5 Frequency response of OFDM and FBMC

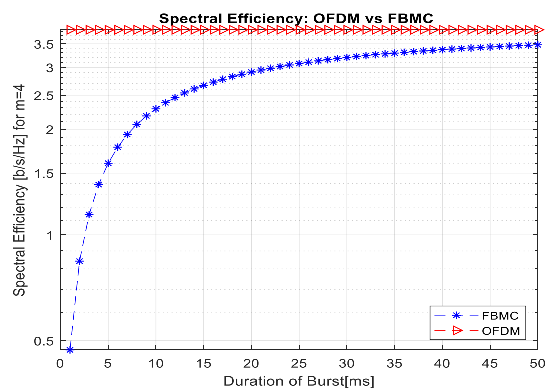

Fig.6. Spectral Efficiency of OFDM and FBMC

Fig. 7 illustrates the SNR vs BER of OFDM and FBMC. In comparison with OFDM, FBMC is the most efficient. We see that the FBMC is better in terms of BER and SNR.

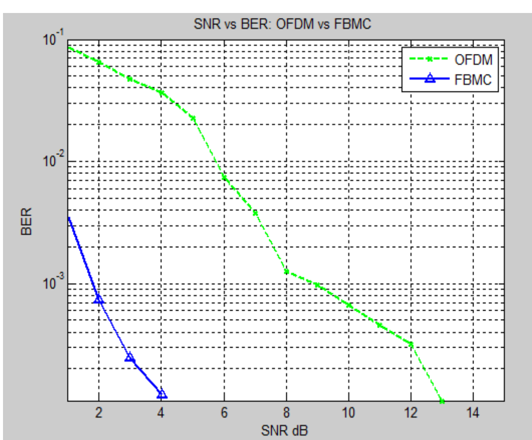

Fig.7. SNR vs BER of OFDM and FBMC

V. CONCLUSION

A comparison between FBMC and OFDM is presented in this paper. To improve existing OFDM bandwidth efficiency, FBMC is introduced in this paper. Comparing FBMC to OFDM, FBMC provides overall better performance, making the technology an ideal candidate for fifth generation mobile networks. Comparisons were conducted on the basis of power spectral density, BER, SNR, frequency response, and SNR. Simulations indicate that FBMC is significantly more effective than OFDM in terms of bit error rate and spectrum efficiency. FBMC performs better than conventional OFDM in terms of efficiency. Accordingly, FBMC would appear to be a more advantageous technique than FBMC.

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Conflict of interest

The authors declare that there is no conflict of interest in this paper.

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