Modeling Simulation and Performance Analysis of PAPR in FBMC 5G System

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Abstract - **Recently, filter bank multi-carrier (FBMC) has appeared great interest as an alternative to orthogonal frequencies Division Multiplexing (OFDM). FBMC plan has increased Frequency efficiency and low out of band (OOB) emissions Compared to OFDM. However, FBMC still encounters high positions Peak-to-average power ratio (PAPR) in OFDM systems. Some OFDM-based PAPR reduction technology has been adopted FBMC system. In this paper, new technologies for PAPR reduction The proposed FBMC system is based on its evolution Use phase rearrangement (PR) and modified PR (MPR) techniques Used in OFDM systems. Different from SC-FDMA (single carrier frequency division) Multiple access), just combine DFT (Discrete Fourier Transform) Spread spectrum and FBMC-OQAM (filter bank multi-carrier With offset quadrature amplitude modulation) only leads to The marginal PAPR (peak average power ratio) is reduced. Using the single carrier effect of DFT propagation, special The condition of the IQ coefficient of each subcarrier (in phase Should be satisfied with the quadrature phase channel. In order to further increase the quantity reduced PAPR, we generate DFT extension and ITSM condition in FBMC waveform and select the one with the lowest peak power. Even if there are multiple Candidate generation, the main calculation part such as DFT Share with IDFT, just execute once, unlike traditional SI (side information) based PAPR reduction Program.**

keywords - **FBMC,PAPR, OFDM, PSNR, BER,DFT, FBMC-OQAM, DFT-Spread FBMC**

I. INTRODUCTION

The "orthogonal" part of the OFDM name describes that there is a mathematical relationship between the frequencies of the carriers in the system. In a normal FDM system, the many carriers are spaced apart in such way that the one can receive the signal using conventional filters and demodulators. In such receivers, one have to be introduced guard band between the different carriers and the addition of these guard bands in the frequency domain results in a degrading of the spectrum efficiency. It is possible, however, to arrange the carriers in an OFDM signal so that the sidebands of the individual carriers overlie and the one can receive the signal without any adjacent carrier interference. In order to maintain this the carriers must possess the orthogonal property. The receiver behaves as a bank of demodulators, translating down each carrier to DC, the resulting signal then being unified over a symbol period to recover the raw data. If the other carriers all beat down to frequencies which, in the time domain, have a whole number of cycles in the symbol period (t), then the integration process results in zero contribution from all these carriers. Thus the carriers are linearly independent (i.e. orthogonal) if the carrier spaced by the multiple of 1/t.

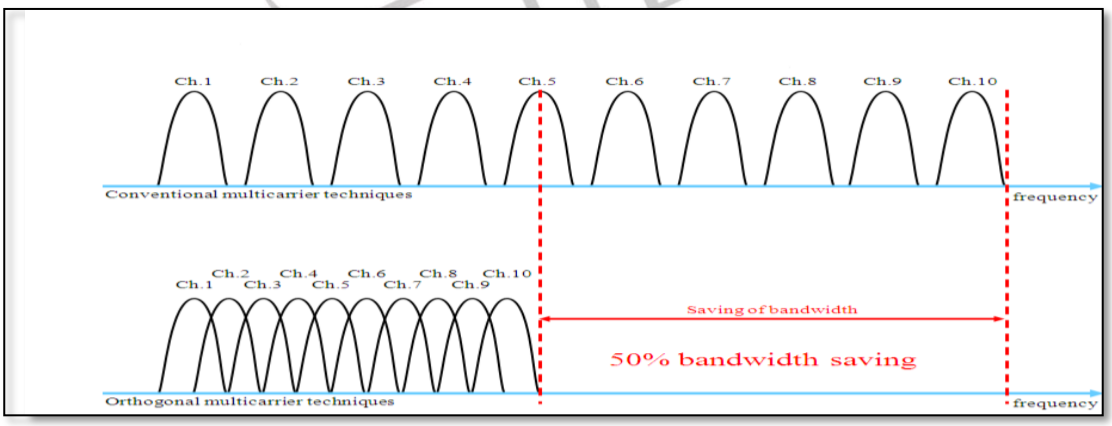

Fig:1. Frequency spectrum FDM Vs OFDM

Orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation scheme, where the frequencies of the subcarriers are demoniacally related. In other words, a multicarrier modulation scheme equipped with orthogonal subcarriers is called OFDM. Let X_k for k=0 to n-1 be the set of complex symbols to be broadcasted by multicarrier modulation, the continuous time domain MCM signal can be expressed as

$$x(t) = \sum_{k=0}^{N-1} Xk\ exp(j2\pi fkt) \quad \text{for } 0 \le t \le T_s$$

$$= \sum_{k=0}^{N-1} Xk\varphi k\ (t) \qquad \text{for } 0 \le t \le T_s$$

where $f_k = f_o + k\Delta f$ and

$$\varphi_k(t) = \begin{cases} \exp(j2\pi f_k t) & 0 \le t \le T_s \\ 0 & \text{otherwise} \end{cases}$$

For $k = 0, 1, 2...N-1$. The subcarriers become orthogonal if $Ts\,\Delta f = 1$, and such a modulation scheme is called OFDM, where Ts and Δf are called the OFDM symbol duration and the subcarrier frequency spacing respectively. In case of orthogonal subcarriers $x(t)$denotes a time domain OFDM signal.The orthogonality among sub carriers can be viewed in time domain as shown in Fig. 3.5.Each curve represents the time domain view of the wave for a subcarrier. As seen from Fig.3.5, in a single OFDM symbol duration, there are integer numbers of cycles of each of the subcarriers.

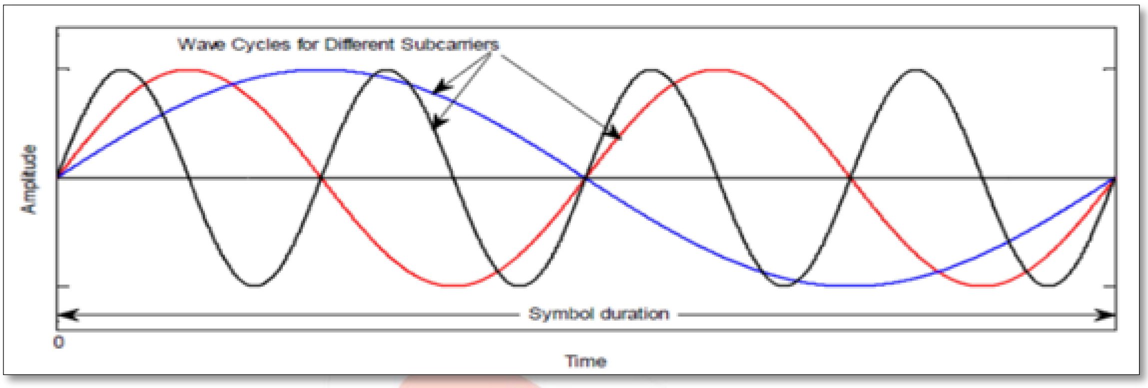

Fig 2.Time domain representation of the signal waveforms to show orthogonality among the subcarriers

Because of the orthogonality condition, we have

$$1/T_s \int_0^{Ts} \varphi k(t)\ \varphi j*(t)\ dt$$
$$1/T_s \int_0^{Ts} ej2\pi(fk - fl)\ t\ dt$$
$$= \delta\ [k-l]$$

Equation shows that φ_k (t) for k=0 to N-1 is a set of orthogonal functions. Using this property the OFDM signal can be demodulated as

$$= \quad 1/Ts \int_0^{Ts} x(t)ej2\pi fk\ t\ dt$$
$$= \quad 1/Ts \int_0^{Ts} \left(\sum_{l=0}^{N-1} x(t)\varphi k(t)\right) \varphi j*(t)\ dt$$
$$= \sum_{l=0}^{N-1} x\ l\ \delta\ [k\text{-}l]$$
$$= x_k$$

II. FBMC (Filter Bank Multi Carrier)

FBMC modulation scheme is a wide range Multi-carrier scheme. Sub channel modulation Executed by IFFT - similar to OFDM systems then filter through each subchannel specifically designed Prototype filter. Offers a wide range of filters In the literature, it can be adapted to FBMC [11]. The key role of this filter is that it has a positive impact Regarding the spectral characteristics of the transmitted signal. In This section first introduces the FBMC transmitter block diagram. Descriptive statistics and spectrum metrics Study the modulation signal. Prototype filter with pulse in FBMC modulationThe response of p0 is applied to the subcarriers.These filters conform to the Nyquist criterion. Because The signal will have better spectral efficiency than OFDM signal. Filter bank multi-carrier (FBMC) has been added Interest in systems such as cognitive radio and opportunity dynamics Spectrum access. Most likely to be considered As a viable alternative to orthogonal frequency division multiplexing (OFDM). FBMC was introduced as [1] as an alternative To OFDM and improve spectral efficiency and low With (OOB) radiation. Good local waveform supply Flexible use of resources and help in both domains Increase computational complexity. However, complexity Can be greatly reduced by using a multiphase implementation [2]. Although FBMC is better than OFDM, The FBMC system also has high major drawbacks. The peak-to-average power ratio (PAPR) of the transmitted signal. Due to the overlapping structure of FBMC signals, PAPR Cannot use reduction techniques for OFDM systems Used directly in the FBMC system. Several conventional OFDM Adopt PAPR reduction technology (eg [3], [4])FBMC system.There are several research focus Reduce the PAPR of the FBMC system [5] - [8]. Reduce PAPR FBMC technology based on active constellation expansion FBMC is introduced in [9]. PTS [6] and SLM [7] are bothHowever, they introduced a high PAPR reduction System complexity, may require auxiliary information Was spread. In [8], based on PAPR reduction scheme.

III. System Design

In the transmitter, first the binary information is encoded using a convolutional encoder and then interleaved. The bits are then mapped using the complex modulation alphabet A, where each symbol X represents M bits. With the use of offset-QAM modulation, the real ($\Re$) and imaginary ($\Im$) parts of the complex modulation symbol X are transmitted with a time offset of half a symbol duration. Finally, prior to transmission, the symbols are overlapped such that they can be separated in the receiver. No

CP is used in FBMC systems to maintain orthogonality of the subcarriers. The discrete modulated baseband signal s[n] of FBMC can be expressed based on the complex modulation symbol Xm[k] at the kth subcarrier during them

$$[n] = \sum_{m=-\infty}^{\infty}\sum_{k=0}^{N-1}\left(\theta_k \Re X_m[k]po[n-mN] + \theta_K + 1\Im\{X_m[k]\}po\left[n-mN-\frac{n}{2}\right]e^{jk(n-mN)\frac{2\pi}{n}}\right)$$

The block diagram of an FBMC transmitter can be seen in Fig. 1. The bitstream b is encoded to the coded bitstream c, then the bits are mapped to complex symbols X according to the modulation alphabet A. Finally Equation (1) is implemented computationally efficiently using an IFFT and a polyphase decomposition of the modulated prototype filters for the real and imaginary parts. Then the two output signals are time staggered and added. To properly design the analog circuits of the transceiver chain a deep understanding of the statistic properties of the transmitted signal must be gathered.

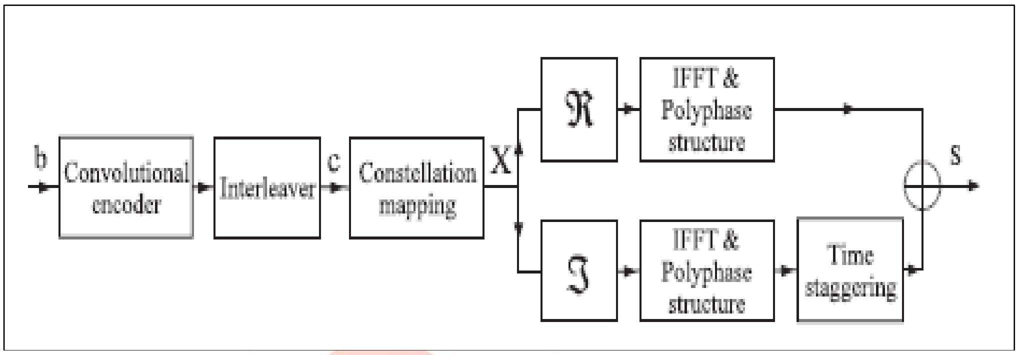

Fig 3.Block Diagram of FBMC Scheme

To properly design the analog circuits of the transceiver chain a deep understanding of the statistic properties of the transmitted signal must be gathered. Such investigations are especially important in case of the design of poweramplifiers which have to work in an efficient manner. A simple technique to describe the dynamics of the transmission signal s[n] is to calculate the PAPR which is defined as

$$\gamma_1 = \frac{max\{|s[n]|^2\}}{E\{|s[n]|^2\}}$$

where |s[n]| is the amplitude of the transmission signal and E{.} is the expectation value. The PAPR in dB is defined as:

$$PAPR(s[n])dB = 10log\_10(\gamma_1)$$

The Complimentary Cumulative Density Function (CCDF) of the PAPR as a function of the number of subcarriers can be seen in Fig. 2 for FBMC. It can be seen that with growing number of subcarriers the PAPR also increases similar to OFDM.

In order to statistically describe the probability density function of an FBMC signal, the kurtosisbdenoted as γ2 of the random variable ξ will be employedbin the following discussion. Parameter γ2 of ξ is commonlybdefined as

$$\gamma_2 = \frac{E\{\xi^4\}}{[E\{\xi^2\}]^2} - 3$$

It can be observed that γ2 converges with increasing N (in correspondance with the Central Limit Theorem) to zero rapidly. This means that the FBMC signal is also converging to Gaussian distribution as the number of subcarriers increase.
Nonlinearities present in the transceiver chain – especially caused by amplifiers – canseverely degrade the advantageous properties of FBMC signals' low ACLR as shown in [2].

IV. Simulation And Result

In this work, we have modeled Simulation was done considering Wimax standard in which one RB represents 14 subcarriers over two OFDM symbols in time, containing 4 pilots and 24 data symbols. We have considered 10 MHz system with total 60 RBs.Size of OFDM block is considered to be 1024 including data subcarriers with QPSK modulation and 92 guard subcarriers at each end of the band. MIMO transmit antennas is either Mt,=1, 2 or 4, as will be indicated. A total number of 10,000 OFDM blocks are randomly generated to produce the CCDF curves. For each block, a random complex fading channel is generated, and the beam forming matrices are chosen as the right singular vectors of these channel matrices.

Table-1 (PAPR Calculation OFDM)

Iteration	PAPR (MIMO-OFDM)
1	1.043113e+001

2	8.399582e+000
3	9.407558e+000
4	8.449497e+000
5	8.077563e+000
6	9.015796e+000
7	8.895236e+000
8	1.007338e+001
9	9.197113e+000
10	9.601901e+000

We first compare the MIMO-OFDM scheme with the pure (DFT-spread) FBMC and the previous DFT-spread scheme based on the simulated PAPR results. Fig. 4 shows the PAPR's CCDF curves of the schemes being compared for OQPSK with N=128, OQPSK with N=64 and 16 OQAM with N=128, respectively. The PAPR's CCDF curves of the DFT Spread-FBMC shows better result as compared to MIMO-OFDM System.

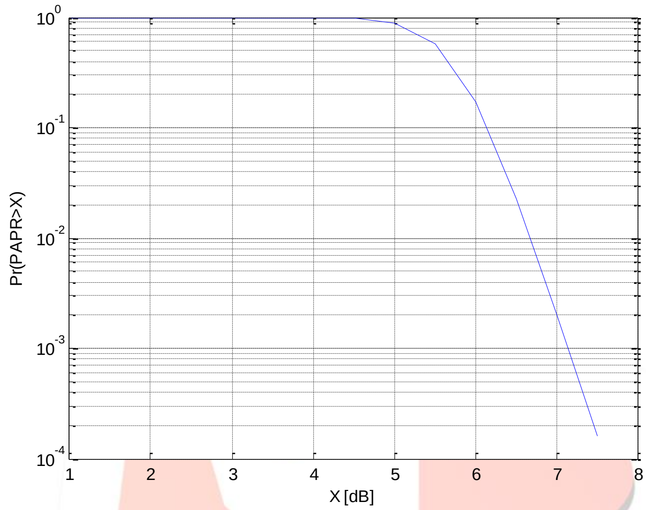

Fig 4. PAPR of FBMC Scheme

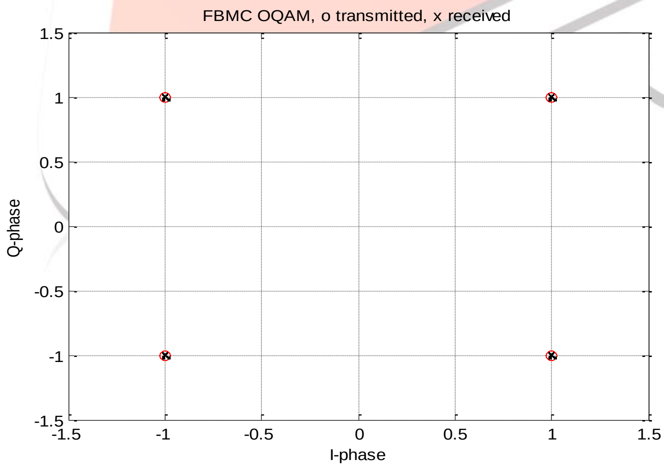

Fig 5. Modulation and Demodulation Operation

V. Conclusion

In this paper, we proposed a low PAPR FBMC scheme and confirmed its outstanding performance compared to the existing PAPR reduction schemes in terms of PAPR reduction gain, computation complexity overhead and SI overhead. We first derived the MIMO OFDM System for analysis. PAPR values were calculated and compared with FBMC scheme and it was found that FBMC performs superior in terms of PAPR making it suitable candidate for potential modulation scheme in 5G system.

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