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Improvement of FBMC over OFDM System in terms of PSD and BER

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Abstract:
Multicarrier modulation techniques are widely used for transmission as it is used to generate a signal waveform which gives spectral efficiency and is adaptable to the present conditions in the world. There are several waveforms of multicarrier modulations, some of the more widely known schemes are OFDM and FBMC.OFDM offers several advantages like orthogonality and low complexity at the transmitter and receiver by replacing number of modulators or demodulators. The major challenge in frequency selective channel is Inter Block Interference (IBI) which can be reduced by cyclic prefix OFDM (CP-OFDM).Although OFDM offers several advantages, it can be regarded that OFDM calls for facing challenges when it has to be applied on complex technologies. For example, the use of Orthogonal Frequency Division Multiple Accesses (OFDMA) needs to be synchronized at the input base station. This synchronization turned out practically difficult to build mobile environments where the affects due to Doppler shifts of various users are difficult to track leading to Inter Carrier Interference (ICI). Further, the filters which are associated with the OFDM carrier have relatively large sidebands which results in Out Of Band radiations (OOB). All the challenges that are associated with the use of OFDM or Cyclic-prefix OFDM can be overcome by a new system namely Filter Bank Multi Carrier (FBMC) which is basically a form of Multi carrier modulation. Filter Bank Multi carrier system can rather be considered as an evolved version of cyclic-prefix OFDM. Unlike OFDM which filters the whole band, FBMC filters each and every subcarrier individually. In this paper, the challenges occurred due to OFDM have been addressed and a contrast is drawn proving that the filter bank multi carrier could be more effective solution to be employed in various networks. A comparison has been drawn between FBMC and OFDM based on their power spectral densities, PAPR, BERversus SNR comparison using mat lab.

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Keywords: **OFDM, FBMC, CP-OFDM, OQAM, BER**

I. INTRODUCTION

Wireless communication is the quickest developing technology, which turned out to be significant after the appearance of 5G systems. Advancement of remote advances is going to arrive at its fourth generation (4G) and 5G portable systems will concentrate on the improvement of the client terminals where the terminals will approach diverse remote advances simultaneously and will consolidate various streams from various advances. Looking past, remote access advances have followed distinctive developmental ways focused on bound together objective identified with execution and productivity in high portable condition. The present 4G LTE waveform balance strategies like OFDM has gotten noteworthy improvement information rates by presenting the idea of keeping up symmetry among different subcarriers yet couldn't ready to furnish with terminal answers for some difficulties. Like the use of cyclic prefix and watchman groups in OFDM brings about lost 10-16% of unearthly proficiency and misuse of range band prompting the convenience of less number of clients over a particular recurrence go. On considering the downsides of the 4G waveform plan rule of OFDM and to meet the developing clients prerequisites another 5G waveform that could ready to carry extra focal points to cell framework

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Execution turned into a need. The unique highlights of 5G waveform plan incorporates exceptionally high information rate remote availability up to 10 Gbps, IOT(Internet of things) applications, WRAN (wireless regional area network) and so forth..,

In This manner this two wave form modulation techniques differs from each other as far as these performance with regards to different key parameters like spectral efficiency and spectral density implies how productive is the band utilized for the data transfer alone. Bit error ratio (BER) means the number of error bits occurred over a given time period, Signal to noise ratio (SNR) indicates the amount of noise present over a sign at a given instant [1,2].

II. OFDM

OFDM stands for orthogonal frequency division multiplexing. The OFDM working is based on the principle of spreading, in this process the high speed data which is to be transmitted is transmitted over a large number of low carriers. Here the low carriers are orthogonal to each other. And the frequency spacing between the carriers was done by using fast Fourier transform method .In general when the data is transmitted serially there is a chance of interference ,if the interference occurs the whole channel would be collapsed which means the data is lost. So in OFDM the data which is to be transmitted to receiver is sent parallel in order to avoid interference, here the input data is a serial one which is converted to parallel by using serial to parallel converter. In ofdm, even when two signals of different carriers overlap or mix with each other there will not be any interference because those carriers are orthogonal to each other. Orthogonality means the integral product of the carrier sinusoids over a particular period of time. In CP- OFDM the carriers which are transmitted parallel are provided with guard bands which are nothing but time intervals to avoid interference problem. Hence because of CP (cyclic prefix) there is less chance of Inter channel Interference and Inter symbol Interference. But there are some disadvantages in OFDM like out of band radiations which means ofdm system contains Large number of side lobes which is undesirable , and the other disadvantage is it consists of high peak to average power ratio value and it also contains high bit error ratio value .

*A.*OFDMSYSTEM MODEL*:*

At first the input data stream is converted to parallel stream by serial to parallel converter depending upon number of subcarriers,let's say from 0 to N-1. Now constellation mapper converts the parallel output from previous block to digitally modulated data after the conversion of bits to modulated data, they should be super imposed on the orthogonal subcarriers for the transmission. The main function of IFFT is to convert from frequency to time domain and it multiplies the incoming data with a series of orthogonal sinusoids.

$$x(n) = \sum x(k) \sin\left(\frac{2\pi kn}{N}\right) - j \sum x(k) \cos\left(\frac{2\pi kn}{N}\right) \quad (1)$$

Here x(k) is the symbol over nth subscriber.

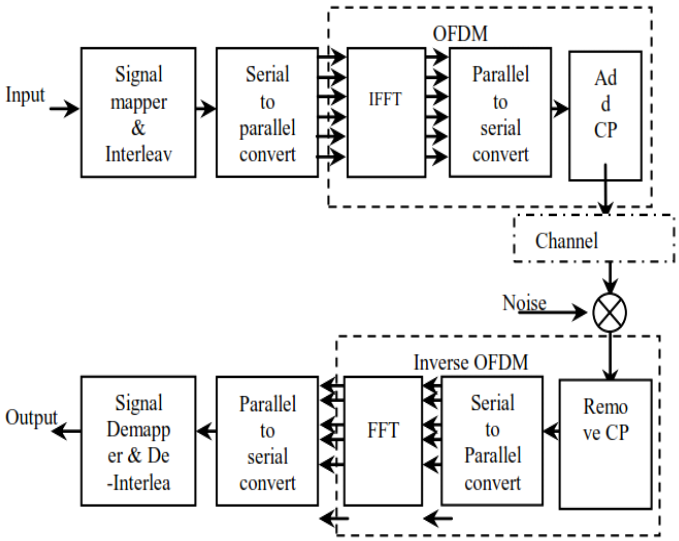

Figure 1: OFDM System Model

Consider a bi-cyclic prefix of length N(CP)(N(CP)<N).The duration of OFDM symbolincreases as T+T(CP), where T(CP)=N(CP)*T/N there for the number of symbols in cyclic prefix is given by N(CP)=T(CP)*N/T

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$$C(t)=\sum_{h=0}^{N-1} S_{n(t)}= e^{j2\Pi nf/N} \quad \text{.....(2)}$$

Here s(t) symbols mapped; f (n) orthogonal frequency. The output of the channel (r) is given by circular convolution of the channel 's impulse response (h) &OFDM symbol with cyclic prefix (x), in frequency domain R=HX, here R=received signal ; X=transmitted signal

$$R = h*x \quad \text{..... (3)}$$

FFT: Translates time domain to frequency domain.
At the received side

The FFT/IFFT length 'N' determines total number of subcarrier present in the OFDM system. After FFT, a single tap equalizer is used to estimate the transmitted OFDM symbol .IT also corrects phase and equalizes the amplitude

$$X = R/H \quad \text{..... (4)}$$

Affective Engagement [2]. The ISA Engagement Scale is adopted in this research.

III. FBMC

FBMC represents filter bank multicarrier modulation system. FBMC modulation is considered as developed CP-OFDM. In OFDM, the entire band is separated though in FBMC, each sub-bearer is sifted independently. So as to accomplish symmetry counterbalance QAM adjustment idea is utilized in this manner FBMC is not orthogonal to the complex plane. The key disadvantage of OFDM is that it causes interference with unsynchronized signals. When carriers are modulated utilizing FBMC, side lobes are removed and gives much more clear outcomes. FBMC has a greatly improved utilization of the accessible limit and can offer higher information rates inside a given radio range. Cyclic prefix is likewise not required in FBMC.Different types of FBMC are Quadrature amplitude modulation (QAM) or OFDM-OQAM, Cosine modulated filter bank(CMT). In Cosine modulated filter bank modulation, a common low pass prototype is translated to the required centre frequencies by modulating it with a cosine function. The preference of modulation for the subcarriers is usually PAM followed by QAM. The current FBMC system implementations uses the concept of spreading of frequency, where it uses IFFT signal with length N*K on which the symbols are overlapped with the N/2 delay. The imaginary part is delayed of half symbol duration than the real part .By applying frequency spreading equalization we can acquire accurate equalization of symbols which in turn reflects that higher data rates can be acquired and also we can able to restore complex orthogonality.

B. System Model:

In FBMC system, the transmitted symbols are transferred from series to parallel by a serial to parallel converter first. Then the converted parallel data undergoes modulation which gives OQAM signal. The OQAM signal which we got is then transformed into an signal where filtering process takes place by each sub carrier with the use of synthesis filter bank consisting IFFT.

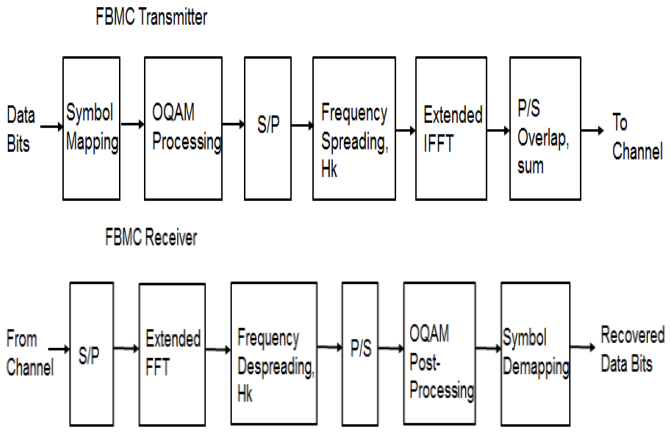

Figure 2: FBMC Transmitter and Receiver

IV. CHANNELS

Communicating data or an Information signal from transmitter/receiver to receiver /transmitter requires some form of path way or medium called CHANNEL. Channel plays an crucial role in

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wireless communication since it can degrade the information signal by adding multipath fading and Doppler effects (if channel is mobile). Correct knowledgedge of channels is a fundamental perquisite for the design of a wireless communication system.

1) Additive White Gaussian Noise (AWGN) :

In general this awgn noise is added to the modulated signal, it is named as white noise because it contain frequency components of all ranges , and the reason it is called Gaussian is because the white Gaussian noise has the shape of Gaussian probability density function. It has constant pdf over the entire frequency band .

$$r(t)=X(t)+A(t) \quad \text{.....(5)}$$

Where X(t) is transmitted signal and A(t)is AWGN

2) Rayleigh Channel :

In Rayleigh fading , the changes in the parameters or characteristics of a signal are treated statistically . it removes the fading effects caused due to delays . Rayleigh fading can be applied to best when there is no dominant propagation in line of sight (LOS) in between transmitter and receiver.

The probability density function is given as

where, .

$$p_R(r) = \frac{2r}{\Omega} e^{-r^2/\Omega}, \; r \geq 0$$

where $\Omega = \mathrm{E}(R^2)$.

V.PARAMETERS

1) Power Spectral Density:

The power spectral density defines how well the signal power is distributed over the frequency domain. It also determines the bandwidth in which the information contains.

2)BER and SNR:

BER: BER stands for bit error rate. It can be calculated by ratio of number of error bits or wrong bits to the total number of transmitted bits . It is better if a system has a low BER value.

SNR: SNR stands for signal to noise ratio. It can be defined as the ratio of power of wanted signal to the power of unwanted or noise signal. It is better if a system has high SNR value which means the system has low noise.

3)PAPR:

PAPR stands for Peak to Average power ratio . It can be defined as ratio of Peak amplitude power to the Average amplitude or root mean square of the waveform. It is better if a system has low PAPR value , But MIMO systems has High PAPR values which is undesirable, single input systems will have less PAPR value.

VI. SIMULATION RESULTS

The main theme of this paper is to compare the 5G modulation techniques like FBMC and OFDM and to recommend a perfect waveform for 5G communication. The examination includes the comparison of different parameters like power spectral density and Peak to average power ratio and BER VS SNR.

Parameters	Values
Length	512
Bits Per Sub Carrier	4
Numgaurds	212
Num symbols	100
OFDM	
Cyclic Prefix Length	43
FBMC	
Spreading factor	4

Table 1: System Parameters

C. Comparison of Power Spectral Density:

The below graph shows the comparison of FBMC and OFDM regarding Power spectral density. Power spectral density tells about the distribution of power over the frequency domain, it also tells about that at

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which bandwidth it is better to transmit the bits successfully.

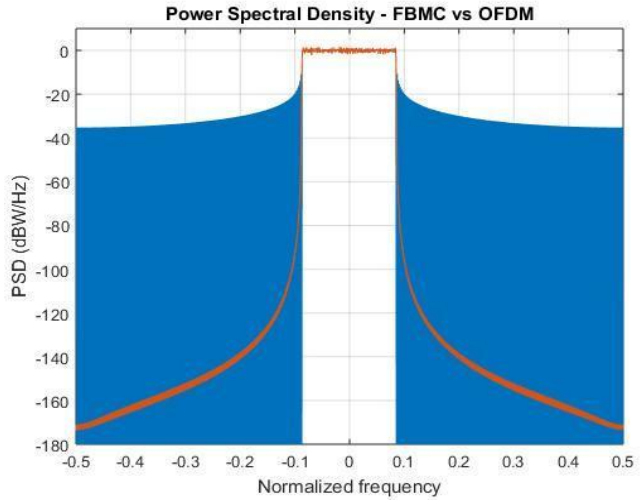

Fig 3. FBMC vs OFDM in PSD

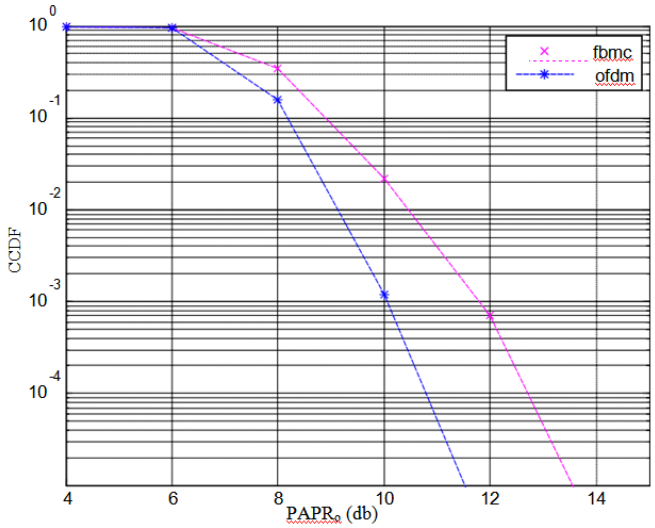

Fig 4. FBMC vs OFDM in PAPR

From the above figure , the region which is in red shows the FBMC and the remaining region represents the OFDM spectral densities. From the graph it is obvious that OFDM has lower spectral density when compared to the FBMC spectral density. And out of all modulation techniques FBMS spectral density has a closer value to the NM (normalized Frequency).

D. Comparison of Peak to average Power ratio

The main drawback in 5G modulation techniques are all modulation techniques has high PAPR values, which is undesirable. It is better for a modulation technique to have low PAPR value high PAPR value increases the power consumption. From the below fig/ graph we can say that out FBMC and OFDM,FBMC has more or high PAPR, next followed by FBMC. Below table shows PAPR values

System	PAPR value in dB
OFDM	11.6
FBMC	14

Table 2 : PAPR values of different systems

E. Comparison of BER VS SNR:

The below figures shows the comparison of BER VS SNR of FBMC and OFDM .forawgn channel the simulation is done with in the range of 0 to 15 db for SNR and for Rayleigh channel its from 0 to 20db. Out of all modulation techniques FBMC has better SNR value which can be examined from the below graph.

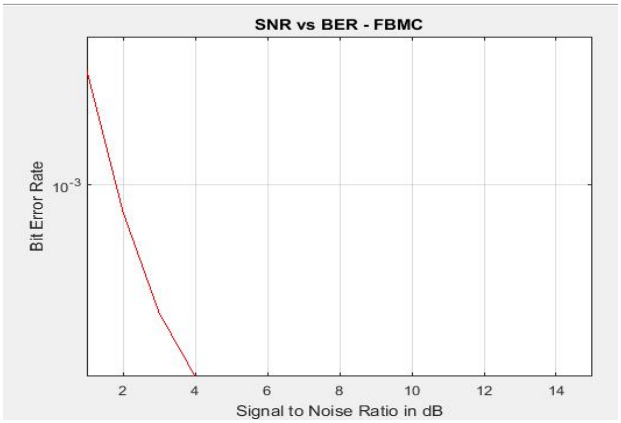

Fig 5. BER vs SNR of FBMC (AWGN)

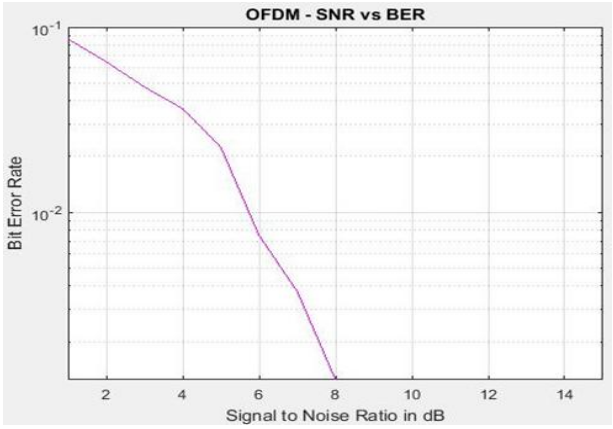

Fig 6. BER vs SNR of OFDM (AWGN)

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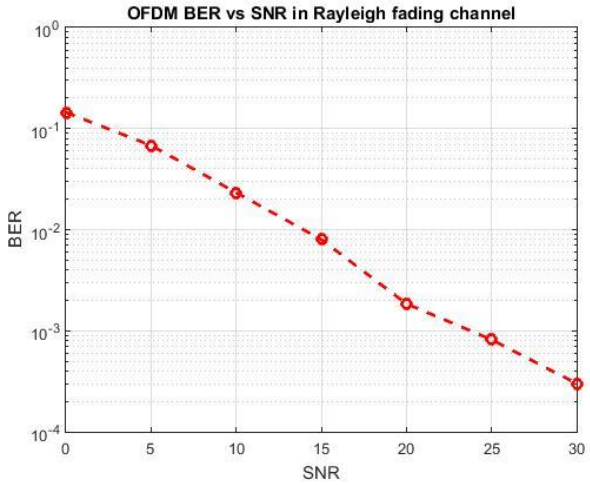

Fig 7. SNR vs BER of OFDM Rayleigh fading channel

Table 3: SNR VS BER of OFDM Rayleigh

OFDM Rayleigh fading channel SNR vs BER		
SNO	SNR	BER
1	0	0.1443
2	5	0.06314
3	10	0.02428
4	15	0.00932
5	20	0.0025

Table 4: SNR VS BER of OFDM AWGN

OFDM AWGN channel BER vs SNR		
SNO	SNR	BER
1	2	0.4335
2	4	0.3889
3	6	0.3282
4	8	0.2415
5	10	0.1593

Table 5: SNR VS BER of FBMC AWGN

FBMC AWGN channel BER vsSNR		
SNO	SNR	BER
1	2	0.0007411
2	4	0.0001235
3	6	0
4	8	0
5	10	0

VII. CONCLUSION

The main aim of this Paper is to compare the performance analysis of 5G modulation techniques like FBMC and OFDM. The comparison is done under different parameters like PAPR, Power Spectral density, BER versus SNR. It is observed that FBMC has improvement in PSD and BER, where as a minute deviation in PAPR. This can also be improved by consideringother practical channels which can be further extension of this paper.

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