International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8s
DOI: https://doi.org/10.17762/ijritcc.v11i8s.7240
Article Received: 29 April 2023 Revised: 22 June 2023 Accepted: 03 July 2023

Design and Performance Analysis of the Dynamic Reduction of Intrinsic Interference Suppression and BER using QAM-based FBMC for MU-MIMO Communications

Dr. Sapna Kumari. C[1], Niranjankumar[2], Dr Revanna CR[3], Dr. Neelappa[4] and Veeramma Yatnalli[5]
[1]Assistant Professor Dept. of ECE, NITTE Meenakshi Institute of Technology, Bangalore, India,
[2]Assistant Professor, Department of Electronics and Communication Engineering, Government Engineering College, Hassan
[3]Assistant Professor, Department of Electronics and Communication Engineering, Government SKSJIT, K.R.Circle, Bangalore
[4]Professor & HoD, Department of Electronics and Communication Engineering, Government Engineering College, Hassan,
[5]Department of Electronics and Communication Engineering, JSS Academy of Technical Education, India
sapnakumaricc@gmail.com[1], niranjankumarphd23@gmail.com[2], revannacr2008@gmail.com[3]
neel.m.dy@gmail.com[5] and veerammayatnakki@jssated.ac.in[5]

Abstract— The present research work is focused on the study of co-channel interface with its minimization techniques without influencing its performance, in turn, which is desired to achieve the minimized complexity of Quadrature Amplitude Modulation (QAM)-based Filter Bank Multi-Carrier (FBMC) to minimize the interference and increase the spectral features with consideration of intrinsic features extractions for the ML (Maximum Likelihood) synthesis systems. The valid measures are given various concerns under consideration, to start with the consideration of the evaluation of the Cyclic Prefix Orthogonal Frequency Division Multiplexing (CP-OFD performance metrics along with the FBMC/QAM in signal transmission in a dedicated fading channel for the evaluation of the modulation order and BER as a required trade-off for quality assessments. From the results, it can be noted that the proposed FBMC QAM has performed better when compared with conventional FBMC systems. The present research also includes considering and calculating the efficiency of nonlinear channels with the Multi-User Multiple Input Multiple Output (MU-MIMO) and FBMC/QAM techniques. In continuation, the obtained results are dominating significantly to access the possible solution to meet the efficiency of the proposed system. In the next part of the research, it is considered with implementation of the sub-detector during the downlink of the system with the technique of threshold-driven strategy for better accuracy and minimization of the complexity in terms of ML detection in terms of order of its modulation. The calculations of the proposed technique with better BER are done on the recent MATLAB platform with its simulation demonstration for its detailed observation.

Keywords- OFDM, ML detector, MU-FBMC, QAM, CP-OFDM

I. INTRODUCTION

The FBMC which is abbreviated as Filter Bank Multicarrier Modulation has become a major practical solution for multiple accessing methods and modulations in telecommunication services with Fifth generation networks. Emission of OOB is reduced by pulse shaping data about the carrier of modulation and also throughput is improved by removing CP blocks which are not necessary. FBMC systems [1], [2] are identified as an alternate solution for (OFDM) Orthogonal Frequency Division Multiplexing to communicate in the future with wireless medium and have advantages given as (i) symbol transmission without the use of CP, (ii) suitable time and localization of frequency, (iii) OOB emission is minimized, that is low radiation. These advantages make the adaption of an asynchronous environment. Although FBMC systems have major advantages when compared to the techniques such as OFDM, the absence of orthogonality among the neighboring subcarriers is one of the most important areas of consideration when considering performance. Thus, FBMC systems use OQAM – Offset Quadrature Amplitude Modulations [3] to provide the solution to the above problems. But the FBMC system is restricted by the OQAMs framework which is staggered and avoids the direct incorporation of conventional approaches such as reduced PAPR [5], estimation of the channel [4], MIMO [7], and channel equalization [6]. To solve these disadvantages, the FBMC-QAM system has recently worked on many types of research. To solve the limitation on spectrum availability in future wireless communications, systems using large-scale multiple antennas are implemented to match the requirements of heavy mobile

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8s
DOI: https://doi.org/10.17762/ijritcc.v11i8s.7240
Article Received: 29 April 2023 Revised: 22 June 2023 Accepted: 03 July 2023

traffic in the communication environments using wireless for low-cost spectral systems of FBMC. On another side of the matter, the FBMC system with multi-carrier modulations is designed as a strong communication approach in the wireless environment for increased speed and intern improving the reliability and spectral efficiency against ISI – Inter Symbol Interference in selective frequency channels in the wireless environment for multi-users. In addition, at the receiver, diversity is required to satisfy the reliability of the transmission of information through the time-dependent communication channel futures and phase shifts, because the FBMS system easily gets affected by the losses in the channel.

In [8] gives an introduction to FBMC's advantages and complexities of the limitations of the QAM – Quadrature Amplitude Modulation which is a traditional one. The fundamental method and probabilistic measures for multi-carrier systems of modulation completely depend on the efficiency of the spectrum, localization of time and frequency, and orthogonality. Many times there will be tradeoffs among these characteristics are done. The real value of a complex number is first mapped during the offset modulation mapping process, followed by the imaginary value of a complex number. Squeezing in the frequency-time introduces an interference or noise in the OQAM, which will be transformed into the imaginary part. This imaginary part noise will greatly affect the performance of the system of FBMC-OQAM. To solve this issue, replacing the real orthogonal part with the complex orthogonal part is required. In particular, complex orthogonal properties in the FBMC OQAM systems can be reestablished by the allocation of information symbols in the frequency or in time to avoid congestion. This allows the system to use all approaches of conventional OFDM. Symbol spreading is done by FFT spreading method [8], in frequency as well as the time domain method called Walsh Hadamard spread [9] is widely used. The information symbols are distributed in precise positions of time, distributed to the subcarriers, and referred to as block-spread FBMC OQAM. The important limitation of these methods is that these methods make increase sensitivity to the double-selective channels. To overcome the tradeoff between QAM as well as OQAM qualities and also to protect all spectral characteristics of FBMC systems, several techniques to enhance the quality of the receiver are implemented.

II. LITERATURE SURVEY

In real-time applications, the orthogonality property is being implemented only by FBMC-OQAM, which affects both the symbols that are received with intrinsic imaginary ISI and the vital functions that are accomplished at the receiver. Although FBMC-OQAM gives exact synchronization due to its exceptional localization of the features, intrinsic interferences repeatedly occur in the complex domain due to the nonexistence of orthogonality. For the system of FBMC-OQAM, the beamforming with coordinated ones allows the signals with multi-user MIMO as presented by the authors of [10] for reducing the intrinsic interference. The authors of [11] introduced a system for canceling the partial approximation interference with the reduced complexity using the Viterbi algorithm. The authors of [12] proved that the performance of the presented channel estimating method was improved concerning the parameters like intrinsic interference and efficiency in power, in comparison with the auxiliary pilot channel estimating method. Thus, the above-proposed method can be taken as one better approach for solving the problem of intrinsic intrusion in FBMC-OQAM. This system uses the modulation index which was proposed by the authors of the [13] to reduce the intrinsic intrusion on the total system performance. The BER produced at the receiver end of FBMC IM is improved by using the constellation of gray code for mapping the selected bits and their Hamming distance of them. The authors of the [14] proposed a maximum likelihood detecting method to address the issue of multi-dimensional residual intrusion of FBMC-QAM. The proposed system at the receiver was designed based on MIMO which improves the performance of BER with the consideration of the complexity of computation. In the work of the authors of [15], overlapping symbols of modulated FBMC are changed into independent parallel transmission by employing linear transformation, which is based on Singular Value Decomposition (SVD). This proposed approach illustrated that it linearly improves the performance measures like BER and OOBE – Out of Band Emission by using QAM order in comparison with FBMC QAM traditional methods. The authors of [16] proposed an intrusion cancellation method using an iterative approach for removing the ICI and ISI in FBMC QAM systems. The intrusion cancellation removes the integration of the received data and separates it into even-numbered and odd-numbered sub-carriers. This will suppress the effect of interferences on the system performance. To decrease the effect of intrusion in FBMC-QAM systems, the authors of [17] proposed weighted vectors which are designed for the equalization of MMSE. The non-orthogonal filter's effect on the BER performance is evaluated here. The research work of the authors [18] minimizes the non-orthogonality and degradation of BER and improves the performance of the FBMC QAM using different prototype filters such as SRRC, IOTA which is abbreviated as Square Root Raised Cosine, and Isotropic Orthogonal Transformation Algorithm respectively. In recent times, QAM with FBMC is implemented effectively to reduce intrinsic intrusion. The power limitations and performance constraints of the fifth-generation network system are proposed by the authors of [19], which has several challenges such as consumption of energy, merged transceivers

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8s
DOI: https://doi.org/10.17762/ijritcc.v11i8s.7240
***Article Received**: 29 April 2023 **Revised:** 22 June 2023 **Accepted:** 03 July 2023*

along with reduced complexity, in addition, these methods do not apply to the conventional approaches. In wireless communication, orthogonality plays a significant task as it minimizes the drawbacks of interference and improves the QoS. Moreover, the design of a system that uses multiple antennas emerged, because of the substantial rise in the number of end-users. These users have to be considered along with the increased rate of data and the need for a good rate of traffic [20], [21].

The intrinsic intrusion was minimized due to the transmission of signals that are allowed by the coordinated beamforming with MIMO for the FBMC QAM system suggested by the researchers [22]. The authors of [23] introduced a system for canceling the partial approximation interference with the reduced complexity using the Viterbi algorithm. The authors of [24] proved that the performance of the presented channel estimating method was improved concerning the parameters like intrinsic interference and efficiency in power, in comparison with the auxiliary pilot channel estimating method. The authors of the [25] proposed a maximum likelihood detecting method to address the issue of multidimensional residual intrusion of FBMC-QAM. The MIMO-based system at the receiver is proposed in this work which improves the performance of BER with the consideration of the complexity of computation. To address the limitations of the lack of orthogonality and degrading quality, the authors of [26] proposed the FBMC QAM framework using the pre-coding method.

III. MULTI-USER ENVIRONMENT FOR WIRELESS SYSTEMS

A. Multi-user for Wireless system

The FBMC has low out-band-emission properties when implemented in multiuser networks, hence the significance of the network is not good. The spectral efficiency is improved by the use of the multiuser access network, as it allows the extra adaptable distribution of the system to be used. While receiving the signals, the individual user data can be recognized and identified in the multi-user detection system. The offset frequency of various users can be managed. To encourage orthogonality, in the ambiance of the multi-user environment [27]. The extreme characteristics of Stringent Synchronization are necessary for the achievement of the orthogonality of the multi-user environment. In FBMC systems, the traditional methods of equalization are appreciated use. The property of spectral filtration, in the FBMC, will minimize the disruption of the signals, in-between the non-synchronous users. The performance of the system is improved and the interference is reduced by the use of the technique FBMC OQAM. The system is still considered to be insufficient for future generations, as the extensive delay in the QoS is high. The channel equalization is used to accomplish the capacity of the multiple access objectives in the Multi-User Multi-Input Multi-Output Channels for optimization of BER. To manage the huge system of IoT (Internet of Things), the multi-GHz, and the Millimeter-Wave (mmW) systems are developed [28]. An appropriate spatial signature is used to access the identical channel resources for the multiple users that use the same channel in the Multi-users MIMO system. This system is further regarded as Space-Division Multiple Access. There is a large number of mobile-station that are used to link the various paths in the MU MIMO system. There exist multiple antennas in the MT and the AP. As per the observations made by the experiments conducted, in the existing MU MIMO system, the carrier drift occurs for the mobility factor with the sensible carrier drift. On the downlink side, it is observed to have significant path interfaces for the system. The Benefits of MU-MIMO are mentioned below:

- Data Rate is enhanced as the data transmission and the reception rate are increased in the channel.
- The channel attenuation is strengthened, and hence the QoS level has been increased to a good amount. Compact device modeling is achieved, in the 5G model.

A significant amount of gain can be accomplished when we use the traditional MIMO system. If the channel is linear and has a high SNR gain bound, then the gain of multiplexing is also increased. The arrays of the antenna are decomposed into autonomous regions on the uplink side of MU MIMO, this is how the conventional MIMO system reacts differently. The channel is affected by the Doppler Effect as well as the channel delay spread passes through limited diversity to outperform the conventional MIMO system [29]. This is closely correlated with the number of antennas, therefore efficiency dropped significantly. The achieve robustness in the overall MU-MIMO system, the CCI must be suppressed. This helps in the suppression of selective fading in the channels. The Multi-Packet Reception (MPR), is used in the WLANs for the MU-MIMO system. In the short intervals, the propagation of the data that causes the interference will produce a high throughput for the SU-MIMO in a well-established system. At the same time, the MU-MIMO has the least collision probability with a higher throughput rate. To ensure the proper data rates, a mathematical model is proposed [30] that determines the energy level that is required for the allocation. This research work uses a precise beamforming vector, to estimate the probability which is used to control and monitor the transmitted power of the system. With a greater number of antennas in the user equipment (UE), the base station seems to have a complicated radio frequency chain. Increases the power consumption and computational overhead of the system. Semi-blind Channel Estimation is

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8s
DOI: https://doi.org/10.17762/ijritcc.v11i8s.7240
***Article Received**: 29 April 2023 **Revised:** 22 June 2023 **Accepted:** 03 July 2023*

employed in [31] to identify active users who improve the performance of the multiple users-MIMO systems. At the base station, Quantized data converters are employed [32]. This reduces the complexity of the hardware and improves energy consumption, avoiding the effect of levels of QoS. Linear-Quantized Pre-Coder (LQPC), Is used to evaluate the distorted low-resolution data converters. LQPC is developed considering the MMSE.

Table 1 System Parameters

Users used in Design	Number of links	Mapper used	Size of FFT	Spread in delay produced in Channels	power and delay in channel	Velocity	Channel model
8	12	64-QAM	128 points	1/4	E^-P/3 P=0...9.	2-100km/hr.	ITU vehicular channel B

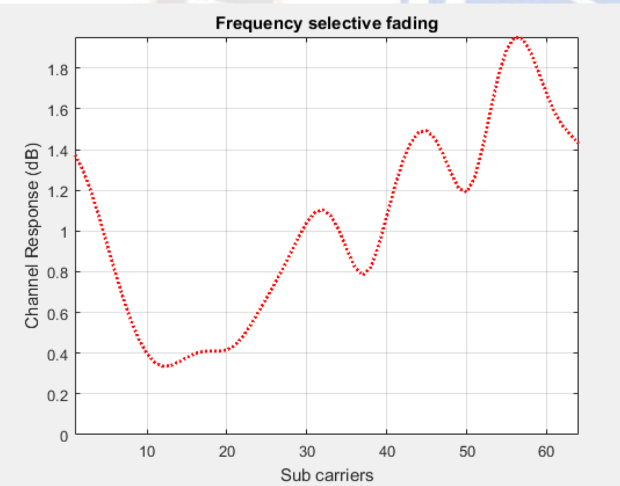


Fig.1: the plot of Channel Response Vs. Frequency selective fading.

The Gaussian channel noise is mixed with the channel non-linearity, this is used to develop a unique channel parameter, that combines with the symbol interference and Co-channel interference. Every multipath element will acquire a highly discriminative data channel. This establishes a channel matrix. the correlation between the Doppler factor and the spread delay metrics is utilized. Depending on the individuals present in the multi-user environment, power delay profiles, mapping rate of every path, and other measurements are tabulated in Table 1. The tabulation shows that symbol interference and channel interference are greater in a non-linear channel. This encourages a Real-World Multiuser channel environment. This is evidence to validate the Mu-MIMO system performance metrics.

IV. PROPOSED DESIGN OF FBMC WITH 64 QAM

The FBMC provides improved orthogonality in contrast to CP-OFDM. As the FBMC process the offset QAM modulation methods for the signals, the spectral efficiency is optimized. This reduces the drawback of multi-carrier interference. The intrinsic interference is obtained, with the real orthogonality in FBMC-OQAM. Equation (1), gives the baseband modulation of the discrete FBMC symbols.

$$x[n] = \sum_{k=0}^{M-1} \sum_{d=0}^{N-1} a_{d,k} X\left[n - \frac{yM}{2}\right] e^{j\frac{2\pi k}{M}\left(n-\frac{Z}{2}\right)} e^{j\theta k,d} \;---(1)$$

'M' is used to represent the length of the FFT. The coefficient value is represented by g[n]. the delay time by Z, phase term is represented as $\varphi_{k,}$ $a_{k,d}$ is the real values of the OQAM. The received signal is derived from the equation (1), as the inner product of x[n] as well as the time-delayed version of gk,d[n

$$r_{k,d} = \sum_{n=-\infty}^{+\infty} x[n].\, g^{*}k, d[n] \;----(2)$$

This equation (2) is rewritten as

$$r_{d,k} = a_{d,k} + \sum_{m=-\infty}^{+\infty} X_{d,k} X^{*}_{d,k}[n] \;------(3)$$

Equation (3) represents, the summation of the imaginary valued intrinsic interference. Considering the complex-valued QAM, that develops the loss in orthogonality. There is a lot of similarity between the proposed framework and the current framework FBMC/QAM. But at the receiver end, the channel will have perfect state information. The input of each block is a complex value. The intrinsic interference is improved by using FBMC/QAM. Taking into consideration of the cost orthogonality, the FBMC/QAM system improves the stability of the system.

B. Orthogonality

In the system of Multi-Carrier Modulation, to recover the transmitter symbol the orthogonality is considered the vital part. The complex orthogonality in OFDM is accomplished by the rectangle pulse in time of the system. This also serves the ambiguity function that decays the frequency gradually. The orthogonality over the dispersive channels is typically used to describe a cyclic application of OFDM if CP is higher than the channel impulse. If the channel situations are critical, the sustainment of the transmitted symbol, with its property of orthogonality is difficult. To ensure the orthogonality of the FBMC is used to shape the filter. The shaping is based on the modulation method used. The real or the complex values can be mapped onto the data.

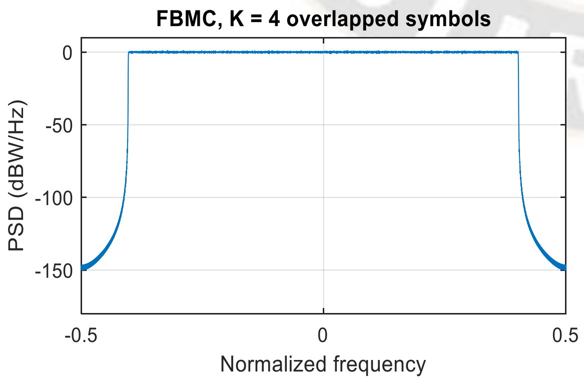
International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8s
DOI: https://doi.org/10.17762/ijritcc.v11i8s.7240
***Article Received**: 29 April 2023 **Revised:** 22 June 2023 **Accepted:** 03 July 2023*

C. Equalization of Channel

Time-frequency localization is quite good in the conventional FBMC-OQAM. It just possesses a few OOBE features. As a result of the Inter-Carrier Interface and Inter Symbol Interface. The orthogonality of OOBE will reduce gradually, as the time and frequency selectiveness of the channel will increase. If there is a Frequency Selective Fading in the system, then the response of the channel never remains flat. Hence, equalization of the channel is considered to be one of the most complex processes. The inter-antenna interference is optimized and the bandwidth efficiency means increased, whenever the MIMO is used with FBMC. This also increases the complexity of the task. To evaluate the efficiency of the equation, in the selectivity of the frequency. The pregnancy channel cannot be selected marginally, in the MIMO FBMC/OQAM framework, as it is prohibited. The frequency robustness of the Doppler spread is increased as the FBMC is maintained to have limited value.

D. Frequency-selective channels

The robust system of FBMC is the only technique that is used for 3 different purposes. For reliable communication in time, dispersive frequency channels, and multiple access systems. The Multi-Carrier (MC) and FBMC have seen working principles. Several narrow channels were created, with the subdivision of the spectrum. There are very few techniques to shape the filters, one technique is FBMC which is a multi-carrier system. This system has a better OOB criterion, compared to CPOFDM; This is shown in Figure 2. The effects of transmitting any signal over a selective frequency are ICI and ISI, which are produced by multi-carrier modulation systems. For the frequency selected channels in the interference, find the insignificant in the sub channel in the flat in the QoS. This can be accomplished in the traditional equalizers in the MMSE equalizers.



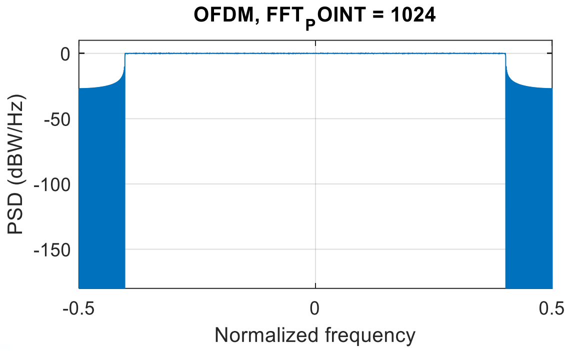


Fig.2. Analysis of Performance metrics between OFDM vs FBMC

For the channels of the higher selective ranges, the performance reduction is observed in the linear equalizers. This initiates failure in the desired quality of service. As it is aware, there is no longer availability of the flat sub-channel. The frequency selective channel is utilized for the experimental results that are simulated, as well as the performance of the machine learning techniques used, and the experimental findings are explained in Fig 3.1. This performance analysis is also termed the BER analysis of performance. The analysis is made for the FBMC QAM with the higher delay in the spread frequency of the selective channel. The performance difference between the ML, MMSE, as well as, BER will increase significantly in the outcome analyzed.

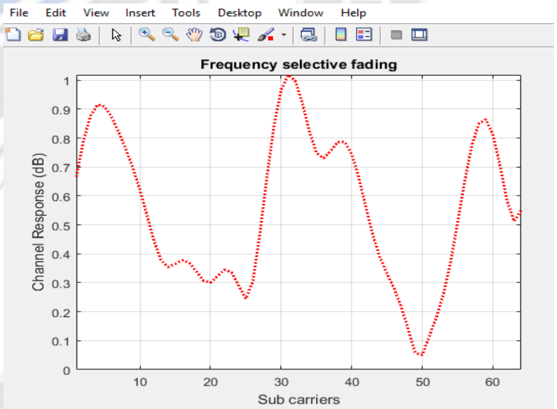


Fig.3. Analysis of FBMC QAM's performance over double delay spread frequency selective channels

E. Selection of Time in Channels

After the selection of channel under Doppler effects, during orthogonality, the losses which are most related to QAM-based MIMO and MU-MIMO are produced, the significant errors performance which is based rate, this is because a huge number of users are sensitive to the co-channel channel interferences. The suggested multiple user-MIMO communication systems are primarily intended to normalize the Doppler spectrum with concerning error rate consequence gap by considering mobility factors with respect to fast fading. When compared to MMSE, ML speeds up the iterative process of soft decoding by tracking

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8s
DOI: https://doi.org/10.17762/ijritcc.v11i8s.7240
***Article Received**: 29 April 2023 **Revised:** 22 June 2023 **Accepted:** 03 July 2023*

fluctuations occurring in the channel. The main disadvantage of QAM-based FBMC is simulated when the channel turns out of time selective and it is impacted the orthogonality of the subcarriers and it is mainly because of inter-carrier interference (ICI). The work mainly focuses on the appropriate estimation of the cascaded channel using the MMSE model without making any design complexity trade-off to deal with optimal pre-coding and RIS matrix formulation for a controlled channel environment. Both the downlink of the synchronous CDMA wireless communication system and the uplink of the asynchronous CDMA wireless communication system are proposed to use new, improved blind multiuser detection algorithms. The effect of the interfering users is suppressed by the new techniques by using an essential cross-correlation matrix between the nearby symbols as a constraint. Based on two separate sets of optimal criteria and a constraint created by the cross-correlation matrix, two enhanced blind multiuser generalized receivers are created. Only with the channel estimation of the desired user can the proposed generalized receivers be implemented blindly. The suggested improved blind generalized receivers outperform the traditional blind detectors significantly, according to simulation results.

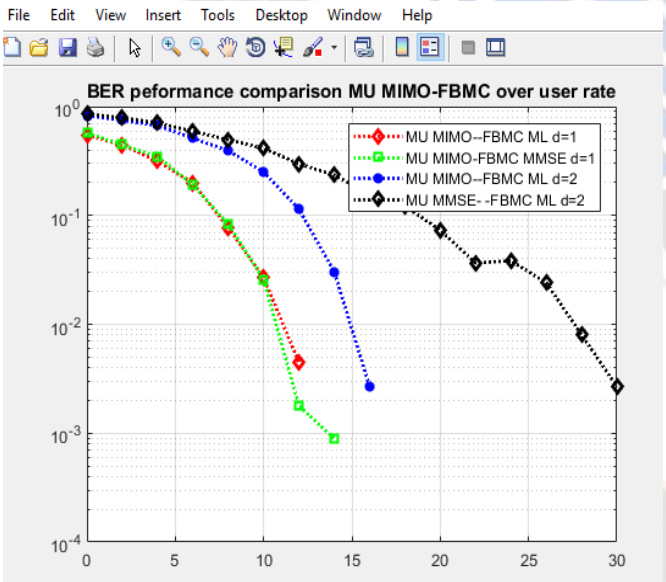


Fig.4. Analysis of the Error Rate in the FBMC QAM in the Fast Fading Vehicular Channel

Fig. 4 is depicting the BER performance in the analysis of the FBMC QAM, in the vehicular fast-fading-time selective channel. The MMSE decoder and FBMC QAM decoder are compared to analyze the structures. If other methods are used, the proposed systems improve the performance. The BER rates are minimized, to enhance the performance of the system. This helps to recombine ML detectors and FBMC QAM. The error rate in the simulator will reduce to lower values. The other methods are used to compare the other substitutional methods.

V. RESULTS AND DISCUSSION

The paper compares and implements the two methods, FBMC OQAM with the detector of MMSE and FBMC OQAM. Other existing methods are compared with the proposed methods; this indicates the enhanced results of the proposed methods in the error rate. The system performance is enhanced when the FBMC OQAM is used with ML detectors as the BER rate is lowered. The simulation results clearly demonstrate how the proposed strategy reduces error rates when compared to alternative approaches. An analysis is made to examine the effect of the Doppler effect, and the Frequency Selective Fading Method (FSFM) in the proposed technique. The influence of the Doppler effect and the FSFM is analyzed in the MU MIMO system. The advanced ML detectors show robust behaviors in the MU MIMO FBMC systems. The path-independent delay profile, ‘θ’ has a wide range of carried drift in every individual multipath of the component. Figure 5 demonstrates the variation of the performance rate of the BER according to the suggested rate of the Multi Users MIMO FBMC QAM system. The Doppler effect's impact and the performance systems of mathematical models are addressed and evaluated.

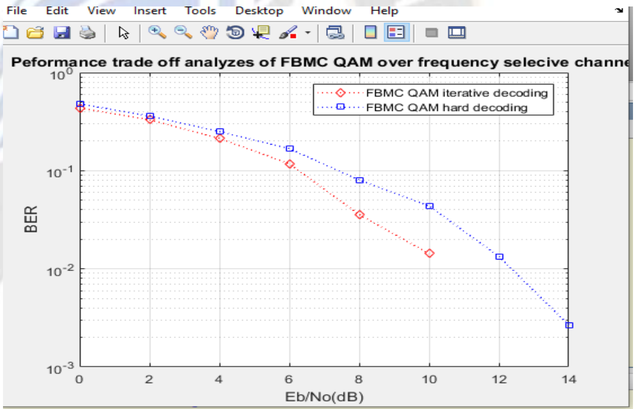


Fig.5. BER performance measurements of Multiple User MIMO FBMC QAM

A. *Performance Analysis*

The FBMC QAM system under consideration is simulated using MATLAB 17a. The simulated results from MATLAB are used to examine the performance. The verification of the proposed and CP OFDM regarding the penalty is analysed. The performance analysis between the FBMC/QAM ML, as well as CP-OFDM MMSE on the parameter of BER, is shown in Figure 6. As per the suggestion, the comparison of the FBMC ML QPSK and the OFDM MMSE-QPSK is simulated and done. The cyclic prefix –OFDM MMSE detector has a match with higher-order modulation methods.

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8s
DOI: https://doi.org/10.17762/ijritcc.v11i8s.7240
***Article Received**: 29 April 2023 **Revised:** 22 June 2023 **Accepted:** 03 July 2023*

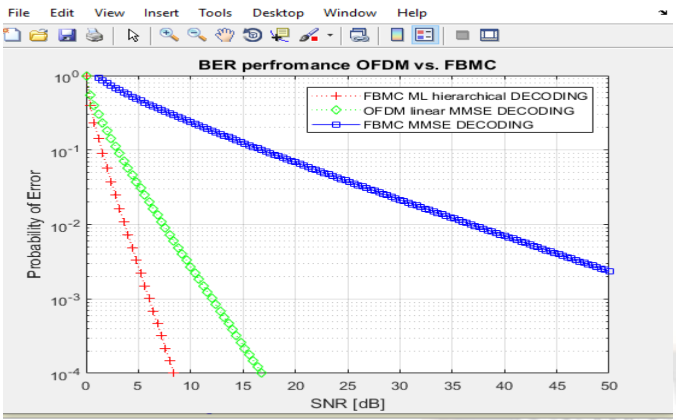


Fig.6. Performance analysis of the BER, in the QAM modulation methods of MMSE vs. FBMC ML

Table 2 Comparison between proposed work and existing MU-MIMO system

	Proposed			
Parameter	SNR	BER	PAPR	MMSE
K=2	18dB	0.001	5.13	$0.853x10^{-4}$
K=3	19bD	0.031	5.63	$0.153x10^{-4}$
K=4	20dB	0.6145	5.89	$0.20x10^{-4}$
Existing [1]				
	SNR [2]	BER [3]	PAPR [2,3]	MMSE [4]
K=2	0.29	0.01	10 to 10^{-3}	$0.853x10^{-4}$
K=3	2.68	$6x10^{-1}$	10 to 10^{-2}	$0.153x10^{-4}$
K=4	3.64	0.02	10 to 10^{-1}	$0.20x10^{-4}$

The proposed MU-MIMO and FBMC are successfully designed and simulated using MATLAB 2017A environment and a comparison has been made between proposed and recently published articles in terms of SNR, BER, PAPR, and MSE as shown in Table.2, and it found that BER and MMSE are optimized by 23% compared to existing.

VI. CONCLUSION

This paper is a working proof of a reliable MU-MIMO FBMC QAM system. The system is considered with multiple channels and worst-case scenarios. The longer delay of the well-spread Doppler shift is also created for the channel parameter. In contrast, the efficiency of the signal detector throughout the system is illustrated only when ML is utilized with MMSE detection. The application of the ML is demonstrated in Figure 4 which is implemented using the proposed method MU MIMO. As a result, the conventional MMSE approach nowadays provides a higher value for the QoS with an improved SNR component. A few of the best results of the model are discussed below.

- All the information required for multipath propagation, frequency selection, as well as fast-fading problems is extracted from all available sources.
- The channel matrix is often used to evaluate the ITU vehicular outdoor channel parameters which are developed using a finite set of channel coefficients.
- At last, the channel characteristics affect the channel interference as well as the symbol. The multipath channel concept with the maximum delay as well as high mobility is also included.

The proposed work enables us to examine the efficiency of the FBMC QAM, which helps in finding out the best possible structure, in the suppressed intrinsic interface and this helps to formulate a system that is a cost-effective signal detector in MU-MIMO. By enhancing the system's QoS rate, finite interference operation analysis is made. Few other comparisons of the proposed technique with QPSK and 16 QAM have been tested. Advanced ML detection is employed, and its impact on the FBMC QAM system is evaluated. Its performance is also contrasted with that of the CP-OFDM MMSE detector. The effectiveness of ICI and ISI interference is verified on the demonstration of the evaluated channels. These interferences are the major difficulties of the multi-carrier system. Comparisons between the FBMC QAM's error rate performance and that of high-time as well as frequency-selective channels are performed. Several static measurements are employed to assess the effectiveness of FBMC OQAM over CP OFDM. A simple linear signal detection system is significantly insufficient to provide excellent QoS, as per the simulation findings that were obtained in this model. The final words of conclusion can be stated as: based on the obtained simulation results, The FBMC OQAM gives an excellent performance. The orthogonal losses can also be compensated effectively if the receiver is added with an ML detector. This addition will increase the robustness of the signal detector.

CONFLICT OF INTEREST

This work is my own research work and not the submitted work was carried out with a conflict of interest. Therefore, we are declared that no conflict of interest".

AUTHOR CONTRIBUTIONS

This work is carried out in three phases, the first phase is the identification of the problem and its solutions by Author A and Author B, the second phase is design & implementation by Author C and Article is written by Author D. Finally, the version of the article is reviewed by all Authors and all are approved.

REFERENCES

[1] Nissel, Ronald, and Markus Rupp. "Pruned DFT-spread FBMC: Low PAPR, low latency, high spectral efficiency." IEEE Transactions on Communications, 4811-4825, 2018.

[2] Varlamov, V.O.; Lobov, E.M.; Lobova, E.O. Investigation of FBMC-OQAM Equalization with Real Interference Prediction Algorithm Properties for MIMO Transmission Scheme. Sensors, 23, 2111, **2023**. https://doi.org/10.3390/s23042111.

[3] Han Wang. et.al, Machine learning-enabled MIMO-FBMC communication channel parameter estimation in IIoT: A distributed CS approach, Digital Communications and Networks, ISSN 2352-8648, 2022https://doi.org/10.1016/j.dcan.2022.10.012.

[4] S. Singh, P. Singh, S. Sahu, K. Vasudevan and H. B. Mishra, "Uplink Transmission in MU Multi-Cell Massive MIMO-FBMC Systems over Ricean Fading," 2021 IEEE 94th Vehicular Technology Conference (VTC2021-Fall), Norman, OK, USA, pp. 01-06, 2021, doi: 10.1109/VTC2021-Fall52928.2021.9625371.

[5] Nadal, Jeremy, Charbel Abdel Nour, and Amer Baghdadi. "Design and evaluation of a novel short prototype filter for FBMC/OQAM modulation." IEEE Access 6, 19610-19625, 2018.

[6] Ghorab, L.E., Badran, E.F., Zaki, A.I. et al. Multicarrier technique for 5G massive MIMO system based on CDMA and CMFB. Opt Quant Electron 55, 25, https://doi.org/10.1007/s11082-022-04272-9, 2023

[7] Singh, Prem, et al. "Semi-blind, training, and data-aided channel estimation schemes for MIMO-FBMC-OQAM systems." IEEE Transactions on Signal Processing, 4668-4682, 2019.

[8] Annam, S. ., & Singla, A. . (2023). Estimating the Concentration of Soil Heavy Metals in Agricultural Areas from AVIRIS Hyperspectral Imagery. International Journal of Intelligent Systems and Applications in Engineering, 11(2s), 156 –. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/2519

[9] Nissel, Ronald, and Markus Rupp. "On pilot-symbol aided channel estimation in FBMC-OQAM." 2016 IEEE international conference on acoustics, speech, and signal processing (ICASSP). IEEE, 2016.

[10] Na, Dongjun, and Kwonhue Choi. "Low paper FBMC." IEEE Transactions on Wireless Communications 17.1, 182-193, 2017.

[11] Ren, Defeng, et al. "Per-Subcarrier RLS Adaptive Channel Estimation Combined with Channel Equalization for FBMC/OQAM Systems." IEEE Wireless Communications Letters 9.7, 1036-1040, 2020.

[12] Nissel, Ronald, Jiri Blumenstein, and Markus Rupp. "Block frequency spreading: A method for low-complexity MIMO in FBMC-OQAM." 2017 IEEE 18th International Workshop on Signal Processing Advances in Wireless Communications (SPAWC). IEEE, 2017

[13] Bank, Walsh Hadamard Precoded Circular Filter. "Multicarrier Communication." Journal Of Engineering Sciences 8.6 (2017).

[14] Zakaria, R & Le Tuyet, D, 'Partial interference cancellation with maximum likelihood sequence detection in FBMC spatial multiplexing system', EURASIP Journal on Advances in Signal Processing, no. 1, pp. 47, 2016.

[15] Choi, JM, Oh, Y, Lee, H & Seo, JS 2017, 'Pilot-aided channel estimation utilizing intrinsic interference for FBMC/OQAM systems, IEEE Transactions on Broadcasting, vol. 63, no. 4, pp. 644-655,2021.

[16] Wang, J., Li, D., Zhang, Z., Chen, X.: Traffic offloading and resource allocation for PDMA-based integrated satellite/terrestrial networks. In: 2022 IEEE 4th international conference on power, intelligent computing and systems (ICPICS), pp. 259–262 https://doi.org/10.1109/ICPICS55264.2022.9873721, 2021.

[17] Zhang, J, Zhao, M, Zhong, J, Xiao, P & Yu, T, 'Optimised index modulation for filter bank multicarrier system', IET Communications, vol. 11, no, 4, pp. 459-467, 2017.

[18] Kim, J, Park, Y, Weon, S, Jeong, J, Choi, S & Hong, D, 'A new filter-bank multicarrier system: The linearly processed FBMC system', IEEE Transactions on Wireless Communications, vol. 17, no. 7, pp. 4888-4898, 2018.

[19] Mahama, S, Harbi, YJ, Burr, AG & Grace, D, 'Iterative interference cancellation in FBMC-QAM systems', In IEEE Wireless Communications and Networking Conference, Morocco, pp. 1-5, 2019.

[20] Han, H, Kim, N & Park, H, 'Design of QAM-FBMC Waveforms Considering MMSE Receiver', IEEE Communications Letters, vol. 24, no. 1, pp. 131-135, 2019.

[21] Ramadhan, Ali Jasim. "Implementation of 5G FBMC PHYDYAS prototype filter." International Journal of Applied Engineering Research 12.23: 13476-13481, 2017.

[22] Larsson, Erik G., et al. "Massive MIMO for next-generation wireless systems." IEEE communications magazine 52.2: 186-195, 2014.

[23] Kim, Changhong, et al. "Introduction to QAM-FBMC: From waveform optimization to system design." IEEE Communications Magazine 54.11: 66-73, 2016.

[24] Zakaria, R. and Le Ruyet, D., 2010, September. A novel FBMC scheme for Spatial Multiplexing with Maximum Likelihood detection. In 2010 7th International Symposium on Wireless Communication Systems (pp. 461-465). IEEE.

[25] Shaheen, Imad A., et al. "Performance evaluation of PAPR reduction in FBMC system using nonlinear companding transform." ICT Express 5.1: 41-46, 2019.

[26] Sim, D., Kim, K., Kim, C. and Lee, C.. A Signal-Level Maximum Likelihood Detection Based on Partial Candidates for MIMO FBMC-QAM System With Two Prototype Filters. IEEE Transactions on Vehicular Technology, 68(3), pp.2598-2608, 2019.

[27] Lee, Kelvin Kuang-Chi. "An Intrinsic Interference Mitigation Scheme for FBMC-QAM Systems." IEEE Access 7: 51907-51914, 2019

[28] Cai, Z, Zhou, Y, Qi, Y, Zhuang, W & Deng, L 2020, 'A Millimeter-Wave Dual-lens Antenna for IoT Based Smart Parking Radar System', IEEE Internet of Things Journal.

[29] Juneja, S, Pratap, R & Sharma, R, 'Semiconductor technologies for 5G implementation at millimeter-wave frequencies–Design challenges and current state of work', Engineering Science and Technology, an International Journal, 2020.

[30] Ravindran, N & Jindal, N, 'Multi-user diversity vs. accurate channel state information in MIMO downlink channels', IEEE

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8s
DOI: https://doi.org/10.17762/ijritcc.v11i8s.7240
Article Received: 29 April 2023 Revised: 22 June 2023 Accepted: 03 July 2023

Transactions on Wireless Communications, vol. 11, no. 9, pp. 3037-3046, 2012.
[31] Sanguinetti, L, Couillet, R & Debbah, M, , ‘Large system analysis of base station cooperation for power minimization, IEEE Transactions on Wireless Communications, vol. 15, no, 8, pp. 5480-5496, 2016
[32] Missaoui, N, Kammoun, I & Siala, M, ‘Efficient user identification and semi-blind channel estimation for MU-MIMO systems’, IEEE Wireless Communications Letters, vol. 6, no. 2, pp. 150-153, 2016.
[33] Jacobsson, S, Duris, G, Coldrey, M, Goldstein, T & Studer, C, ‘Quantized precoding for massive MU-MIMO’, IEEE Transactions on Communications, vol. 65, no. 11, pp. 4670-4684, 2017.