Novel Framework for Enhancing Communication Performance Quality in 5G Networks

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***Abstract*—The existing telecommunication standard hypothetically cater up the user's demands at the cost of short delay, power drainage, not so standard throughput. We reviewed the existing literatures of bit loading and power allocation to find more inclination towards 3G and 4G-based enabling technologies (OFDM-Orthogonal Frequency Division Multiplexing) and less towards 5G-based enabling technologies (e.g. FBMC-Filter Bank Multiple Carrier) almost no work is done towards 5G network. Hence, we present a framework of bit loading and power allocation that uses FBMC, incorporates a new encoding, and introduced a novel modulation technique over a stream of signal to find it more optimally supporting the demands of 5G networks. The study outcome was found to possess lower error rate, higher data delivery performance, lower power usage, and faster processing time in comparison to existing legacy standards.**

Keyword - OFDM, FBMC, Bit Loading, Power Allocation, Transmit Power, Data Delivery, Throughput, Modulation, 5G

I. INTRODUCTION

With the advent of mobile networks and telecommunication standards, there has been increasing evolution of the communication standards e.g. 2G, 3G, 4G (or LTE), and 5G. At present, majority of the consumers uses 3G and majority of them are swarming over services offered by 4G networks [1]. However, with the launch of 5G by the year 2020 there can be an expected paradigm shift in mobile consumer market [2]. It is imperatively anticipated that trillions of the communication devices will be connected by 5G networks just using a single network [3]. Hence, 5G network can really act as a boon for much demanded IoT (Internet-of-Things) market in next 5 years. Hence, 5G actually targets to reduce the delay in service deliveries. Till now, OFDM (Orthogonal Frequency Division Multiplexing) is undoubtedly the most exercised approach in 3G and 4G network owing to its advantages [4]. However, there are new set of challenges even before OFDM as the industry is moving with a faster pace towards new communication features e.g. 5G [5]. The pitfalls of the existing system are spectrum of non-continuous nature, restricted resources, low flexibility, delay, power consumption, etc. [6]. Because of these problems it is quite a difficult task for implementing conventional bit loading and power allocation algorithms on upcoming 5G. It is required that existing OFDM techniques should be further investigated for its applicability of addressing such problems and to render more compatible features for upcoming wireless standards of multicarrier modulation schemes. There is an increasing inclination towards multicarrier schemes as the waveforms generated by such schemes are inflicted with various problems. At present, the usage of 4G i.e. LTE-based communications uses guard bands for other forms of conventional network in order to cater up the dynamic demands of spectral mask [7]. However, such phenomenon significantly disrupts the performance of optimal spectral efficiency as well as sometimes it even resists to use the band [8]. This is one of the major pitfalls that evolve due to severe orthogonality as well as constraints (related to synchronicity in physical layers) [9]. Considering a case of interference of uncoordinated type generated from any forms of cells (pico/femto), it is imperative to furnish higher level of coordination in order to retain efficient synchronicity as well as orthogonal characteristic. Apart from this, the final problem related to temporal and spectral fragmentation in such wireless communication techniques evolved from OFDM. Therefore, there is a need of an efficient and optimized modulation technique that allocates maximum frequencies with time synchronization. Hence, it can be concluded that research work towards conventional OFDM system should be redefined as they are totally inapplicable for upcoming 5G networks by any means. There is a need that research-based community should be highly encouraged to address such limitations of legacy OFDM-based practices. A closer look into existing reputed research publishers e.g. IEEE Xplore shows that there are approximately 4031 research journals in OFDM, 739 research journals in OFDMA, and only 47 research journals in FBMC printed during the year 2010 till now. This, itself, is bigger evidence that more emphasis was always laid on OFDM principle and not on FBMC (Filter-Bank Multiple Carrier) principle, which is the only enabling technology for 5G communication.

This paper therefore introduces a framework that exclusively redefines the FBMC in order to evolve up with a new scheme to offer minimal error rate, better throughput, lower transmit power, and reduced algorithm processing time in 5G networks. Section II discusses about the existing research work towards bit loading and power allocation followed by brief discussion on the problem identification in Section III. Discussion of proposed contribution is carried out in Section IV followed by briefing of adopted research methodology in Section V. Algorithm implemented to design the proposed system is elaborated in Section VI followed by discussion towards result obtained in proposed system in Section VII. Finally, the research summary is briefed as conclusion in Section VII.

II. Related Work

This section discusses about the significant research work being carried out in the area of bit loading and power allocation in wireless communication system. Although we have reviewed certain techniques and introduced our concepts in our prior work [10][11], this section will further upgrade more information about it.

Pancaldi et al. [12] have taken different cases of wireless communication system in narrowband channels. The authors have studied the time-frequency domain of the power-line channels. The study outcome was tested over the OFDM communication channel assessed using spectral density and have addressed the problems pertaining to both bit loading as well as power allocation system. Bodinier et al. [13] have introduced a discussion on 5G waveforms and presented an interference table to explore the best solution to minimize loading of transmit power problems in 5th generation of mobile networks. The study outcome was assessed using interference and transmitted bits mainly. Study towards 5G network was also studied by Hasan et al. [14] with respect to channel allocation viewpoint. The technique discussed in the paper presents a unique optimization theory for addressing the interference problems using swarm intelligence concept. The authors have used genetic algorithm and particle swarm optimization for enhancing the sharing of spectrum in 5G networks. The study outcome was assessed using interference, network allocation, and objective value on multiple iterations. Another study of the 5G network was discussed by Gueguen et al. [15] most recently where the authors have presented a novel provisioning system in inter-cellular system in order to assist the overloaded cells and thereby optimizing channel capacity. The concept of bit-loading was also seen considering the case of cognitive radio in the work carried out by Kliks [16]. The author has introduced a Mercury-Waterfillling technique to incorporate maximum flexible characteristic in applications of cognitive radio.

The study of bit loading problems was emphasized in the work carried out by Mehmood et al. [17] in featured cabling technology called as DOCSIS 3.1. The technique discussed by the authors allocates specific bit loading exercises on the cable modems on the basis of similarity over the SNR value of each subcarrier. . A different form of problem of allocation was seen in the work of Zhuang et al. [18] where the core motive was to increase the capacity of downlink transmission of cognitive radio networks. The study outcome was assessed using capacity and transmission rate over interference threshold. Zhao et al. [19] have presented an adaptive technique that optimizes the power factor over the wireless networks. The investigation shows that transmitted power is directly proportional to SNR. Mehmood and Belfiori [20] have presented a technique of bit loading using greedy approach for multicarrier system. Hassan and Henkel [21] have discussed a study where the bit loading has been prioritized over communication channel for video transmission. The proposed technique uses greedy approach to achieve power minimization. The most recent work carried out by Vo et al. [22] has focused on reducing power for multicarrier system like Orthogonal Frequency Division Multiplexing (OFDM). Using simulation based approach, the study used the bits amount to be added or removed to be restricted by active subcarriers and random value of tolerance. The advantage of this approach is its simpler approach while the limitation is that its outcome is not benchmarked effectively. Ghoreishi and Aghvami [23] have investigated nearly similar problems over downlink OFDMA networks. The technique maintains minimal bit rate by dropping the data from the main stream considering constraints of both delay and quality of experience. The approach thereby introduces a scheduling scheme using analytical approach for better bit loading and power allocation performance. The advantages of such approach is its focus on specific problems of bit loading, however, it fails to retain efficiency on power conservation on varied channel condition. Huang et al. [24] have discussed about a technique that focuses on energy conservation in the wireless network. The motive of this technique is also to minimize the probability of outage. Usage of Channel State Information (CSI) was also seen in many approaches as it can assists in exploring better communication channel in wireless network. Once of such significant approach was seen to be used in work of Wang et al. [25] who have used dynamic programming to derive an effective scheduling scheme. The technique has proved that it is possible for performing power allocation as well as bit loading in case of incorrect CSI data. Prasuna and Padmaja [26] have presented a technique of power allocation using statistical analytical approach. The technique reduces the mean square error of the signal that is corrupted by noise. George and Amrani [27] have presented a unique case where allocation of error rate is discussed considering the case study of OFDM networks. The study outcome was assessed using spectral efficiency and error rate mainly on increasing SNR. The complexity of the algorithm was also found to be lowered.

Maity and Basak [28] have addressed the problem of power allocation in cognitive radio networks. The technique has used standard decode and forward relay mechanism in order to enhance the capacity of the transmission. Exactly similar direction of the work was also adopted in the study of Thumar et al. [29] where an iterative algorithm for power allocation as well as controlling of channel capacity has been presented. The authors have raised the problem of non-linearity in the optimization approach. The study mainly deals with resource allocation policy using CSI-based data. The initial step of this technique consists of performing power allocation followed by bit loading. The simulation study was carried out for both single and multi-users with bandwidth sizing.

Although, there are many research work being carried out in bit loading and power allocation problems in wireless network, but there are almost no significant research work carried out in towards 5G network considering similar problems. The next section highlights the addresses explored in existing studies.

III. Page Style Problem Identification

From the previous section of existing research work, it can be found that focus on bit loading and power allocation problems was more directed towards OFDM system only which is limited to only 3G networks mainly. Hence, case study of upcoming networks e.g. 5G has never been studied exclusively for bit loading and power allocation problems, although few theoretical papers exists. Another bigger hurdle is that existing system cannot be enhanced to make it suitable for 5G networks even if all of them have used multi-carrier system. This is because in all the existing mechanism are based on its dependencies towards using cyclic prefix and guard interval, which no longer finds its usage in 5G network. Moreover existing mechanisms also suffers from degraded spectral efficiencies because of insertion of cyclic prefix. Another bigger research gap is there is absolutely no standard or benchmarked modeling of any framework that claims higher throughput and minimized transmit power in 5G networks. Hence, there is a need of address unexplored research area for upcoming 5G network with respect to bit loading and power allocation. The next section briefs about the contribution of the proposed system in order to address this research problems.

IV. Proposed System

The prime aim of the proposed system is to present a framework that significant supports maximized bit loading process with minimal dissipation of transmit power. For this purpose, the proposed system develops an architecture (Fig.1) where the transmitting device takes the input of any signal, applies a set of algorithm to finally obtain the processed (or rather reconstructed) signal on the receiving end. A new modulation scheme using Filter Bank Multi Carrier (FBMC) where the filtering of the unit sub channels are carried out. The system also deploys a filter with a narrow band as well as enhanced length of duration. By doing so, the prominent advantage will be to achieve a superior control over each individual filter banks. The problems of power emission over futuristic wireless standards e.g. 4G as well as 5G can be easily addressed here by controlling the power emission towards each of the subcarriers.

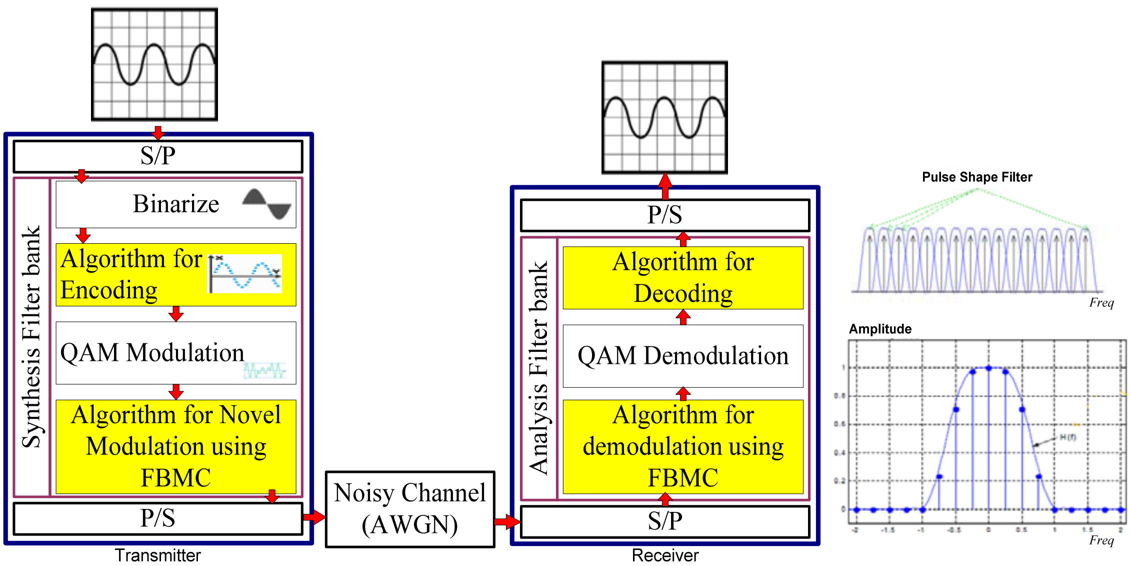

Fig.1 Schematic Architecture of Proposed System

The significant contribution towards adoption of this system will be to obtain a better version of spectral efficiency along with some impressive rate of data with absolutely zero dependency on cyclic prefix. The significant aspect of this design principle is that both the synthesis and analysis filters are designed on the principle of pulse shape filtering. The process allows every sub-channel to be passing through band-pass filters. Hence, the secondary study contribution will be to develop such novel modulation technique considering executing a filter towards every sub channels as well as developing a numerous numbers of filters to be applied for filters banks. The study develops such novel modulation scheme The process is quite easier, we use test carrier and main carrier on the filter design and then we place the test-carrier and main carrier on certain specific amplitude to obtain the results. The transmitting module takes the data bits and subjects it to symbol mapping which is followed by offset quadrature amplitude modulation (QAM). The resultant data is converted from serial to parallel converter, which are further subjected to frequency spreading followed by extended inverse FFT. The resultant data is converted from parallel to serial, which is finally fed to noisy channel. On the receiver end, the modulated data obtained from the noisy channel is initially subjected to serial to parallel converter followed by extended FFT and frequency dispreading. After parallel to serial conversion, a post processing is carried out using offset QAM followed by symbol demapping in order to obtain reconstructed signal. In the proposed modulation, the algorithms offers a comprehensive encoding and modulation schemes where filters for both test carriers and main carriers are implemented and incorporated in the form of chain. This design has positive impact on the efficiency on channel capacity even in heavy traffic condition with higher feasibility of spectral efficiency to be obtained. Moreover, as the filters are equally spaced (and there is no guard interval) so it offers benefit over mitigating cross talk events in wireless communication over 5G. We choose to develop this in this manner in order to overcome one of the pitfall of conventional FBMC i.e. lower data rates (although it offer better power allocation)

V. RESEARCH METHODOLOGY

The proposed study has adopted analytical research methodology to further enhance the operations of bit loading and power allocation system over upcoming 5G communication standards. It is well known fact that the concept of bit loading and power allocation is majorly studied with respect to conventional multi-carrier systems e.g. OFDM. However, the supportability of OFDM ceases till 4G communication mainly. It is anticipated that by 2020, when 5G will come up with a commercial practices it will be considered as much better substitute of its legacy standards. As the core backbone of 5G is FBMC, hence, we introduce a novel concept where we apply FBMC modulation scheme to upgrade the performance of throughput and minimize the transmit power to much larger extent. The prime target of adopting the proposed methodology is to overcome the significant issues in existing multicarrier system e.g. OFDM. We address two prime issues of OFDM i.e. i) its dependencies on cyclic prefix, ii) presence of redundancies that minimizes throughput and drain power, iii) unsynchronized signals have issues of interference and spectral leakage.

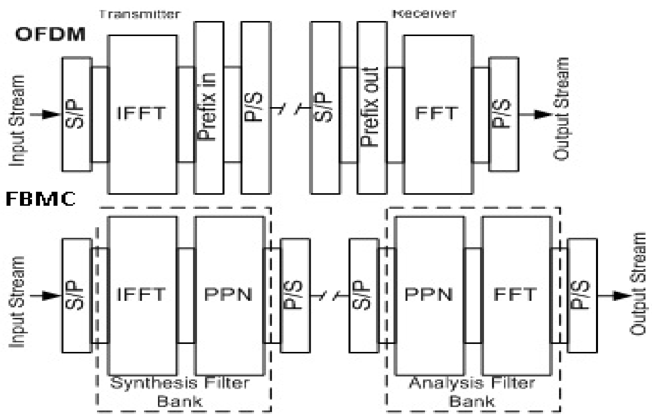

Figure 2. Difference between OFDM and FBMC

Fig.2 highlights the difference in existing system and proposed system that is an enhancement done on the top of OFDM where simple digital signaling processing approaches were adopted to develop the Poly-Phase filter banks with N carriers (PPN). The problems of the side-lobes that spread out in any one side of OFDM can be now eliminated to obtain much superior signal quality in proposed system. The filter bank in the proposed system consists of multiple prototype functions for performing modulations. According to conventional concept of FBMC, an empirical expression for synthesis filter will be [30],

$$G_k(z) = \sum_{t=0}^{L-1} p[m]\exp\left(j.\frac{2\pi k}{M}\left(t - \frac{L-1}{2} \right)\right) z^{-t} \tag{1}$$

Where L is the channel length, M represents modulated function, and t represents maximum index of time. Therefore, an abstract representation of the filter bank would be

$$G(z) = B.W.A(z^M).c(z) \tag{2}$$

In equation (2) , the parameter W will represent Inverse Discrete Fourier Transform matrix, the parameter B will represent a diagonal matrix that consists of elementary multipliers and the parameter A will represent polyphase filters. All these parameters do not exist in OFDM and hence the spectrum of FBMC has superior signal quality as compared to conventional OFDM principle (Fig.3).

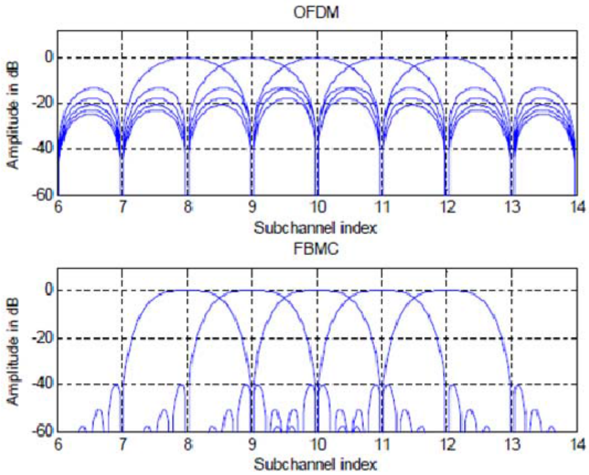

Figure 3. Frequency responses for OFDM and FBMC

However, we choose to carry out further upgrading on FBMC in order to address the bit loading and power allocation optimization performance. The study considers a communication channel with noise and interference with N multi-carrier. The study therefore performs an incorporation of a simple optimization scheme as following: The approach takes the input of signal which is subjected to dimensionality reduction by applying a simple encoding scheme on binarized signal. A flexible block encoding mechanism is applied on the data and encoded number of bits. Further, a novel modulation scheme is applied which performs bit allocation. A new strategy is developed by introducing a test-carrier and immunity parameters in order to lower down the level of redundancies and elevate the data delivery performance in 5G communication channels. The modulation techniques basically formulate an FFT matrix for number of carriers and based on time t, its iteration is generated. Hence, the process actually converges to the optimal data delivery automatically with reduced transmit power level. This will eventually mean that proposed system discretized the signal using a converter considering two cases i.e. i) the quantization level of 2k is performed if k-bits of resolution are found and ii) the converter is assumed to be within -1 to +1 in its range. The system performs M-QAM modulation and finally the modulated signal is allowed to be transmitted through noisy channel. Therefore, a simple analytical approach is deployed to ensure that the process of bit loading and power allocation can be further optimized by minor amendment in the design of the encoding and modulation techniques in FBMC system. The implication of the presented methodology as well as newly incorporated amendments on FBMC approach pertaining to system upgrade is briefly illustrated in algorithm implementation in next section.

VI. Algorithm Implementation

The purpose of the algorithm design is present a robust implementation of bit loading and power allocation in upcoming 5G networks. As discussed in prior section that serviced rendered by 5G communication standards mainly uses backbone of FBMC; therefore, we choose to carry out optimization on the modulation technique that can uphold the throughput performance to a very high degree. The core design of the proposed optimization technique is based on subclasses of multiple carriers in wireless communication channel. There are basically 5 algorithms being designed for the proposed system viz. i) Algorithm for optimization using FBMC, ii) Algorithm for Encoding, iii) Algorithm for novel FBMC Modulation, iv) Algorithm for novel FBMC Demodulation, and v) Algorithm for Decoding.

A. Algo-1 (Algorithm for optimization using FBMC)

This algorithm is primarily responsible for performing optimization of the network and channel resources that result in effective bit loading and power allocation. The algorithm basically takes the input of S (input-signal) and M (size of QAM array), which is processed to give the output of Srec (Reconstructed Signal). In this process, the algorithm uses various simulation parameters e.g. ρ (Signal Modulation), l (length of matrix), d1 (binarized data), σm (FBMC Modulated data), ndata (noisy data), σd (FBMC Demodulated data), φe (Encoded

Data), φd (Decoded Data), and QTX (Transmitted data after QAM modulation). The steps involved in this algorithm are shown as follows:

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1. Algorithm for optimization using FBMC

Input: S, M, ρ, l, d1, σm, ndata, σd, φe, φd, QTX

Output: Srec

Start

1. init S, M
2. φe →algo-2 (bin(S))
3. d1=encd2b(φe')
4. p1=log2(M)-mod(size(d1),log2(M))
5. QTX→ρQAM((M), p1, l(p1/log2(M), log2(M))
6. σm→Algo-3 (QTX)
7. ndata→(AWGN(σ))
8. σd→Algo-4(ndata)
9. φd→decb2d(QRX, σd) [QRX→ρQAM((M)]
10. φd→algo-5
11. Srec→ φd

End

The algorithm takes the input as Signal S (Line-1) and converts it into binarized signal that is further subjected to algorithm-2 for performing encoding (Line-2). A simple encoding is performed that inverses the encoded data φe and converts from decimal to binary further (Line-3). A simple empirical representation of modulation is carried out to further obtained the encoded signal to be subjected to FBMC modulation scheme (Line-4). A new function for signal modulation using QAM is designed that uses mathematical representation shown in Line-5 in order to obtain the modulated data of QAM (QTX). This data is required to be transmitted to the receiver over 5G channel. Hence, it is required that this data should be further modulated by FBMC approach (line-6). Complying with the real-world situation, this data is corrupted by noise (Line-7). The noisy data is now subjected to demodulation technique using FBMC approach (Line-8) in the receiver side. It also extracts the receiving data QRX in the receiver in order to perform decoding from binary to decimal number (Line-10) which is further subjected to decoding.

B. Algo-2 (Algorithm for Encoding)

This algorithm is mainly responsible for performing encoding operation. The algorithm takes the input of binarized signal S (i.e. raw-signal) and applies simple forward error correction codes (Line-1). Based on empirical value of a variable z and N (number of information in bits), the algorithm computes its iteration i. The algorithm than formulates the data with lowered dimension (Line-5) and apply block-based encoding mechanism to finally obtain the encoded data (Line-6). The steps of the algorithm are as shown below:

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2. Algorithm for Encoding

Input: S, N, r, i, e, benc

Output: φe (Encoded Data)

Start

1. e→FEC(Input) {Input=bin(S)}
2. z=N-r
3. i=size(Input, z)/N
4. for j=1:i
5. data=matrix(Input(1+(j+1))*N: N*j)
6. φe→benc(e, data);
7. End

End

The prime novelty of this algorithm in empirical form is that it significant controls the dimensions of all incoming data to a large extent exclusively based on the number of carriers N. This features, therefore, has higher supportability of scalability in transmission over 5G networks with the maximum throughput. As the data size lowers down, the transmit power too reduces to a large extent.

C. Algo-3 (Algorithm for Novel Modulation using FBMC)

This algorithm is responsible to carry out a novel modulation scheme over FBMC on the encoded data. Basically, after taking the input of encoded data, the algorithm processes parameters e.g. n (total number of carrier), p (total number of test-carrier), sc (total number of data sub-channel), δ (Immunity parameter), L (Channel Length), Is(Location of data), QTX (Transmitted data after QAM modulation), Tr/Tx (Transmitter / receiver), Ep (Power allocated to test carrier), Es (Power allocated to main carrier), which upon processing yields σm (FBMC Modulated data). The algorithm defines a function (Fourier) F in Line-2 and performs the XOR operation on all the carriers (Line-3). For modulation, the variable F and inverse of QTX is considered (Line-4)). Considering all the frames, the data is modulated considering both power factor for test-carrier and core carrier (Line-6 and Line-7) for the transmitter. This process is also followed by inverse Fast Fourier Transform operation. The steps included in this algorithm are shown below:

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3. Algorithm for novel modulation using FBMC

Input: n, p, sc, δ, L, Is, QTX, Tr/Tx, Ep, Es

Output: σm

Start

1. define n, p, sc, δ, L
2. $F = \exp(2pi\sqrt{(-1)}/n)$
3. Is=XOR(1:n, Ip), where Ip=1:8:n
4. FBMC_MOD_data=[F, QTX']
5. For k=1: frames //frames=size(QTX)/n
6. Tr(Ip)=Ep*modulate(Ip)
7. Tr(Is)=Es*modulate(Is)
8. σm =ifft(Tr, n)
9. End

End

The algorithm also uses a new parameter called as immunity parameter which is responsible for ensuring non-redundant and non-colliding signals on multiple carriers thereby optimizing the power and bit allocation to higher level. The interesting part of this design is that the applicability of the frequency domain for optimally formulating the sub-channels in order to obtained specific spectral performance. Similarly, the algorithm is not dependent on any redundant data check (e.g. cyclic prefix), which occurs in 3G/4G communication scheme.

D. Algo-4 (Algorithm for demodulation using FBMC)

This algorithm is responsible for carrying out demodulation and considers almost the similar parameters like the prior algorithm except for ndata (noisy data), Spilot (Transmitted test carrier), Ypilot (Received test carrier), and τ (Channel coefficient in time domain). The steps included are as follows:

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4. Algorithm for demodulation using FBMC

Input: n, p, sc, δ, L, ndata, Tr/Tx, Spilot, Ypilot, τ, Ep, Es

Output: σd

Start

1. define n, p, sc, δ, L
2. $F = \exp(2pi\sqrt{(-1)}/n)$
3. Is=XOR(1:n, Ip), where Ip=1:8:n
4. FBMC_DEMOD_data=[ndata']
5. For k=1: frames //frames=size(ndata)/n
6. Tx→ eval(σm)
7. Tx1→Tx(δ+1:N+ δ)
8. Tx2→fft(Tx1, n)
9. Spilot→Tr(Ip), Ypilot→Tx2(Ip)
10. $G = (E_p.size(I_p))^{-\mu}$

11. $\mu = 1.[\sqrt{E_p * diag(S_{pilot}).[F(1:L), I_p]^T}\,]^T$

12. τ=G.Ypilot & σd = Tx/(fft(τ, n)

13. End

End

Although, majority of the steps of this algorithm is similar to that of modulation, except for Line-6-12. The algorithm takes the input of noisy modulated data and performs the demodulation with much reduced transmit-power. A new global optimized parameter G is formulated which is meant for minimizing the power allocated to test-carrier depending upon the channel length and total number of subcarriers.

E. Algo-5 (Algorithm for Decoding)

This algorithm mainly performs decoding operation on the demodulated outcome from the prior algorithm. The input to the algorithm is basically the demodulated data σd, which after processing yields φd (Decoded Data). The steps included in the algorithm is as shown below

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5. Algorithm for Decoding

Input: η, i, e, bdec

Output: φd

Start

1. init η, σd
2. i=size(e)/ η
3. for j=1:i
4. data=(e(1+(i-1)* η: η*i))
5. φd→bdec(FEC, data')
6. End

End

The algorithm applies block-based decoding mechanism in order to obtain the decoded data. A simple block-based decoding mechanism was applied on error corrected code along with inverse of data obtained (Line-3-Line-5). The process is faster and doesn't require much processing time to acquire the resultant of reconstructed signal.

Table 1 Notation Used

	Symbols	**Parameters**
1	S	input-signal
2	M	size of QAM array
3	ρ	Signal Modulation
4	l	length of matrix
5	d_l	binarized data
6	σ_m	FBMC Modulated data
7	n_{data}	noisy data
8	σ_d	FBMC Demodulated data
9	φ_e	Encoded Data
10	φ_d	Decoded Data
11	Q_{TX}	Transmitted data after QAM modulation
12	N	number of information in bits
13	r	remainder obtained from *binarized* image
14	e	encoded error corrected data
15	i	iteration
16	b_{enc}	block encoding
17	n	total number of carrier
18	p	total number of test-carrier

19	sc	total number of data sub-channel
20	δ	Immunity parameter
21	L	Channel Length
22	I_s	Location of data
23	T_r/T_x	Transmitter / receiver
24	E_p	Power allocated to test carrier
25	E_s	Power allocated to main carrier
26	S_{pilot}	Transmitted test carrier
27	Y_{pilot}	Received test carrier
28	τ	Channel coefficient in time domain
29	η	Block Length
30	b_{dec}	block decoding

VII. RESULT ANALYSIS

This section discusses about the outcomes obtained by implementing the proposed system. In order to obtain the results, the algorithms of the proposed system was testified with following values of initialization viz. the power range of the test-carrier (Ep) is kept in the range of 1-5 watt while that of data carriers (Es) is between 22-30 watt. The proposed system was testified over multiple value of M (=2, 4, 16, and 64) for QAM array while the Signal-to-Noise Ratio is kept in the range of -30 to +30 dB. The major performance parameter for the proposed system is bit error rate, throughput, power, and processing time mainly. Fig.4-Fig.6 represents the individual outcome of the proposed system over various scenarios while Fig.7-Fig.9 represents comparative analysis outcome.

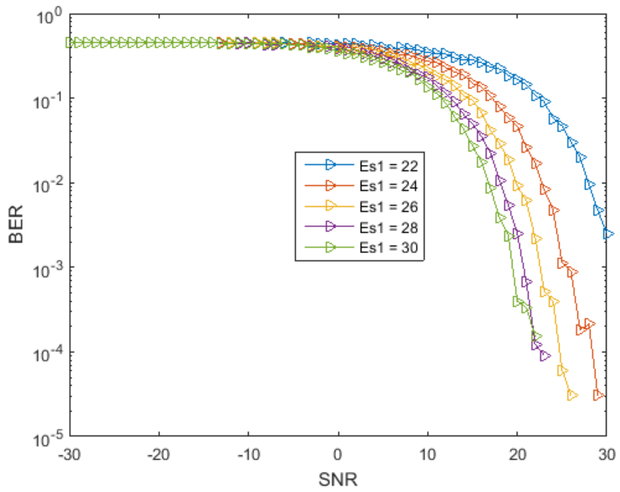

Figure 4 Analysis of BER performance at M=2

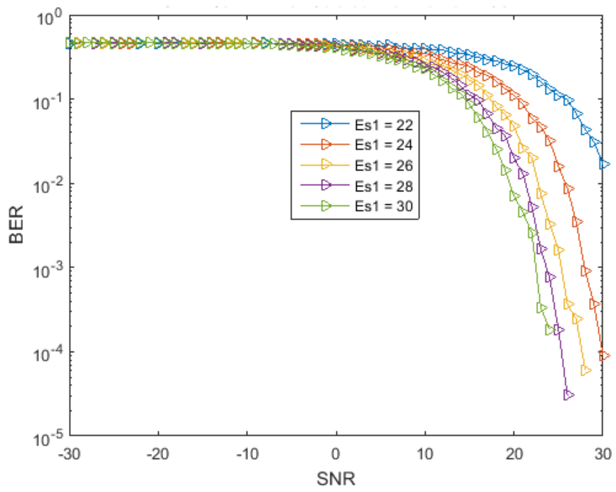

Figure 5 Analysis of BER performance at M=4

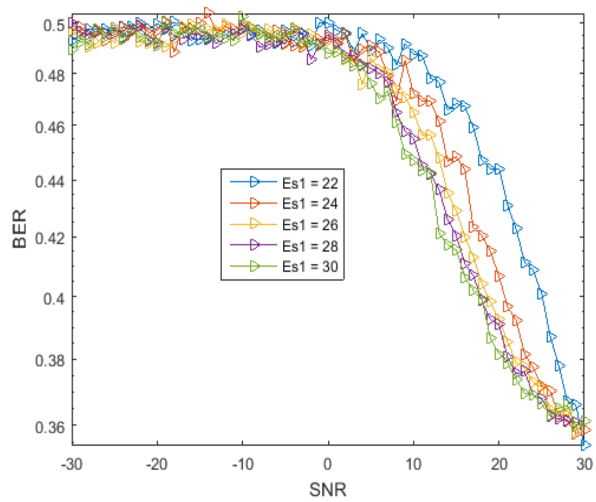

Figure 6 Analysis of BER performance at M=64

Fig.4-Fig.6 shows the impact of multiple forms of carrier power over bit error rate on a control range of SNR considering multiple dimensions of M in QAM modulation. The outcome eventually shows that increasing value of carrier power doesn't degrade the BER performance on different values of M. The proposed system incorporates an enhancement over the conventional FBMC system by introducing a very simple and lightweight modulation technique over constraint of the signal quality measured in SNR. Therefore, the prime target of minimizing the transmit power can be only achieved if the BER is maintained as minimal as possible.

Apart from this, the outcome of the proposed system was also assessed with respect to existing techniques. For this purpose, we consider the work carried out for bit loading and power allocation by Kuo et al. [31], Song et al. [32], Lande et al. [33], and Caus et al. [34] for multicarrier CDMA, OFDM, OFDMA, and FBMC. The comparative analysis was considered for throughput, transmit power consumption, and processing time.

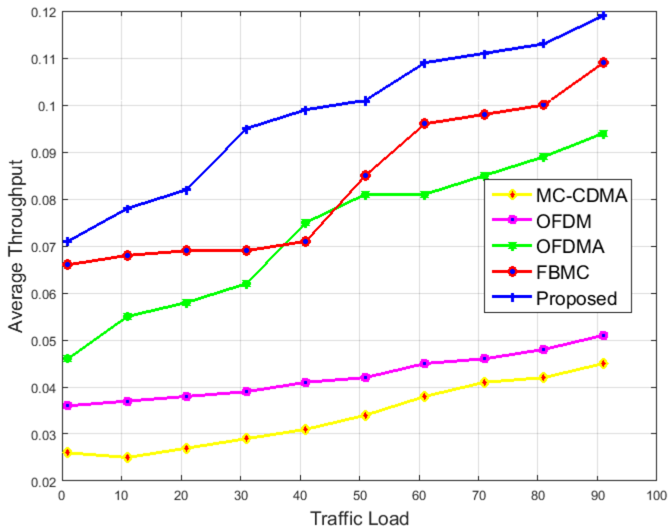

Figure 7 Comparative Performance Analysis of Throughput

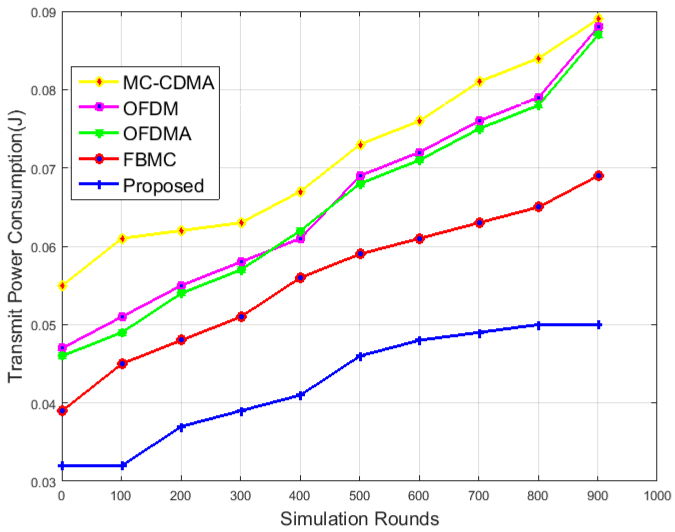

Figure 8 Comparative Performance Analysis of Power

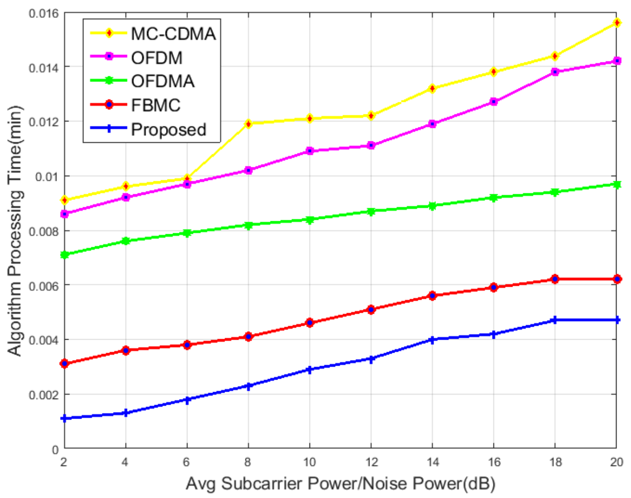

Figure 9 Comparative Performance Analysis of Time

Fig.7 highlights the comparative performance of average throughput of all the techniques. The technique adopted by Kuo et al. [31] has emphasized on reducing error rate considering Signal to interference and noise ratio followed by M-QAM. Although, the accomplishment of BER and BPS (Bits Per Symbol) is found to be considered but the study didn't emphasized on the problem of PAPR (i.e. peak average to power ratio). Hence, the extent of allocation of bits lowers down resulting in throughput minimization as well as calls for more dependency of transmit power dissipation. On the other hand, the work of Song et al. [32] using OFDM overcomes the problems of ISI as well as noise using cyclic prefix, hence, its output is found better than MC-CDMA technique discussed by Kuo et al. [31]. However, it exhibits a very poor performance when it comes to transmit power. Fig.8 shows the evidence that OFDM has quite higher peak of transmit power consumption. The next technique in the comparative analysis is work carried out by Lande et al. [33] by using OFDMA. The author have presented a constrained optimization problem and presented their solution using centralized algorithm. OFDMA is mainly used in 4G networks (mainly on the downlink interfaces). Due to simple approach of receiver design and higher supportability to increase the data rate, the approach of OFDMA is found with much better throughput as compared to conventional OFDM or MC-CDMA (Fig.7). Unfortunately, OFDMA suffers from PAPR just like the others for which reason transmit-power consumption is more (Fig.8). The final round of comparative analysis was carried out with conventional FBMC approach introduced by Caus et al. [34]. This is the only significant work in literature till date pertaining to bit loading and power allocation using FBMC. It doesn't uses cyclic prefix like others (OFDMA, OFDM, MC-CDMA) and it uses filter banks instead. Although FBMC overcomes the minimization of the transmit power problems but it possess a significant challenge to increase its data rate (for which reason applicability of FBMC in MIMO is still an open research issues). The study outcome shows significant improvement in algorithm processing time too (Fig.9). Hence, a better version of optimization technique is presented by proposed system that enhances as well as supports futuristic communication in wireless system.

VIII. CONCLUSION

The usage of OFDM principle is found out to be the best practice for developing existing telecommunication standards e.g. 3G and 4G. However, it offers a superior spectrum efficient as it is quite easier to process as well as manage the levels of processing as per the availability of existing trusted-hand held device. It is also found to operate on maximized rate of data stream associated with wider channel capacity along with its resiliency towards selective fading problems. However, in spite of such advantages feature, OFDM principles are not capable of catering up the demands of upcoming telecommunication standards e.g. 5G. It is because the theory of 5G calls for considering other forms of waveforms which OFDM deny it to be considered. Adoption of new level and types of waveforms has potential advantageous feature as it is no more dependent on using cyclic prefix and it thereby saves a maximum size and shape in the stream of data. Another important factor is transmit-power allocation for the carriers. Unlike Moore's Law, there are various other evolving theories and modeling approach that can render the effective concept of the law with enhanced capability of processing. Hence, 5G standard can effectively cater up the demands of high speed communication standard with full fledge supportability of the pervasive computing. Therefore, in order to address all the above problems in existing standards, the proposed system offers a novel modulation technique that has the capability of catering up maximized rate of data transfer with minimal delay transmission over both short/long burst. It is also capable of instantaneous switching between the down and uplink. The study outcome was also found to have optimal performance with respect to minimal error rate, maximized throughput, lowered power consumption, and lower algorithm processing time in comparison to other existing systems of bit loading and power allocation

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