CHANNEL SYNCHRONIZATION AND CYCLIC SHIFT EQUALIZATION CP-FREE OFDM SCHEME

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ABSTRACT— Filter bank multicarrier with pulse amplitude modulation (FBMC-PAM) is a candidate waveform for the fifth generation of wireless networks (5G). It can transmit at the same rate as orthogonal frequency division multiplexing (OFDM) opposed to the conventional FBMC-based systems. It also has a minimum overlapping factor leading to a transmit signal with a shorter ramp-up and ramp-down than the existing FBMC-based systems. However, this brings some shortcomings to the FBMCPAM system in terms of equalization. In this paper, performance of FBMC-PAM is studied in massive multiple-input multipleoutput (OFDM) channels. It is discussed that although in massive OFDM channels, multiuser interference as well as channel noise average out, there remains some residual interference due to the channel distortions even for an infinite number of base station (BS) antennas. Consequently, the signal to interference ratio (SIR) saturates after the number of BS antennas reaches a certain value. To quantify this saturation level, we find an upper bound for the SIR performance of FBMC-PAM in such channels. Then, our theoretical analysis is confirmed through simulations. Moreover, it is shown that by choosing an appropriate number of subcarriers, although the SIR saturates, FBMC-PAM can equalize the channel efficiently and the error floor in the bit error rate (BER) can be completely removed. We have chosen OFDM as a benchmark, because of its infinite SIR in multipath channels. We also show that FBMC-PAM provides even a better BER performance than OFDM due to its higher bandwidth efficiency.

Keywords— OFDM; multicarrier ; FBMC ; PAM ; OFDM ; asynchronous access ;

I. INTRODUCTION

Multi-input-multi-output techniques belong to the group of leveling methods. In multicarrier frameworks recurrence area balance is known to yield prevalent execution and, in channel bank multicarrier (FBMC) frameworks, the approach presents no extra deferral [1,2]. The partner is an expansion in computational intricacy relative to the covering factor. At that point, the accompanying inquiries can be raised: by what method can OFDM procedures be joined with the recurrence area usage of FBMC frameworks, what sort of execution can be come to and what advantages can be normal.

The issue is managed in this paper for an as of late presented conspire named FBMC-PAM, which highlights worked in recurrence space handling. The approach depends on the lapped change, which is a flag handling strategy created three decades back for discourse and sound pressure [3]. A key property of the channel bank got is that the impedance between neighboring sub-channels is dropped by stage movements of π/2 and impeccable reproduction is accomplished without station bending. This is interestingly with the current FBMC plans, in view of offsetquadrature abundancy balance (OQAM), which abuse the nulls of the obstruction channel motivation reactions. A noteworthy shortcoming of OQAM tweak is that it requires multiplying the image rate and, in like manner, multiplying the calculation speed in handsets [4]. In the FBMC-PAM plot, recurrence area evening out is executed in the recipient, which prompts elite channel adjustment and transporter recurrence counterbalance remuneration, as required by portable frameworks [5]. Some OFDM procedures are hard to actualize in FBMC frameworks, because of the covering of nearby images, and lost execution and an expansion in complexity are generally observed [6,7]. Here, the focus is on two such techniques, namely OFDM 2x1 (a.k.a. Alamouti) and multi-user OFDM.

II. FBMC-PAM

The scheme is based on the following transform

$$T_s(n,k)=\sin(n\pi/2M)\,e^{-j(n+M/2)(k+1/2)\frac{\pi}{M}};\ 0\leq n,k\leq 2M-1 \qquad (1)$$

where n and k are time and recurrence lists individually. In network shape, this change is the result of the slanting framework D(sin(nπ/2M)), the lattice of the ordinary odd discrete Fourier change of size 2M and the corner to corner grid. It characterizes an examination channel manage an account with the accompanying highlights the model channel is the discrete sine channel. The surmised recurrence reaction, acquired by taking the Fourier change of the nonstop sine channel is

$$H_{\sin}(f)=\frac{2}{\pi}\frac{\cos(\pi f 2M)}{1-(4fM)^2} \qquad (2)$$

Note that the frequency response of this filter decreases as 2 /1 f , instead of /1 f for the OFDM filter, leading to a significant improvement in spectral separation. - the frequency shifts are odd multiples of 1/4M.

When used in a multicarrier receiver, a set of 2M sub-channels is obtained, which are centered on odd multiples of half the sub-channel spacing 1/2M. For efficient implementation, expression (1) is rewritten

as $$T_i(n,k)=\frac{1}{2}\left(e^{-jn(k+1)\frac{\pi}{M}}-e^{-jnk\frac{\pi}{M}}\right)e^{-jk\frac{\pi}{2}}e^{j\frac{\pi}{4}} \qquad (3)$$

This relates to the recurrence area execution of the channel bank which comprises of a quick Fourier change (FFT) of size 2M, the sine channel with coefficients [1 – 1], stage pivots by products of - π/2 and a settled stage move π/4. A multicarrier transmission framework is acquired with the assistance of a transmitter playing out the converse tasks, in particular stage moves by products of π/2, sine channel and opposite FFT of size 2M. Note that the term exp(jπ/4) in (3) is discretionary in the framework, since it presents a settled revolution of the transmitted star groupings. A definite depiction of the plan is given in [5]. The square outline of the framework is appeared in figure 1.

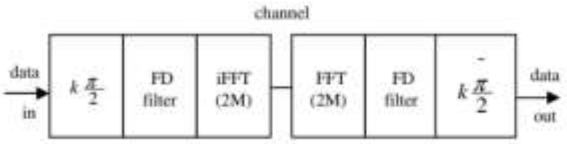


Fig.1. Principle of the FBMC-PAM transmission system

III. SYSTEM MODEL

The system is assumed to be made of a transmitter with NT antennas and several separate users with a total number of antennas smaller than NT . The OFDM technique is described below considering NT =4 [8]. The approach exploits singular value decomposition. Let us consider a first user equipped with 2 antennas in its receiver. The modulation matrix is V, S is the matrix of the singular values and U is the demodulation matrix.
Then, the channel matrix of user 1 is factorized as follows:

H1 = USV……………. (17)

The particular vectors V1 and V2 characterize the flag space for client 1 and the solitary vectors V3 and V4 characterize the invalid space. In the event that client 1 is separated from everyone else, the adjustment grid comprises of the 2 vectors V1 and V2 , the demodulation network in the recipient being U', however in the event that client 2 is presented in the framework, the balance lattice must be adjusted appropriately. The direct setup is appeared in figure 8. The signs of the 2 clients must be transmitted in the invalid spaces of each other. Give us a chance to accept that client 2 has a single antenna receiver and its channel matrix H2 is 1x4. The signal has to be transmitted in the null space of user 1. The derivation of the corresponding modulation vector W3 begins with the combination of the physical 1x4 channel vector H2 with the singular vectors V3 and V4 , which yields

[h21 h22]=[H2V3 H2V4] ………….(18)

At that point, the channel lattice of client 1 is factorized as takes after.The solitary vectors V1 and V2 characterize the flag space for client 1 and the particular vectors V3 and V4 characterize the invalid space. On the off chance that client 1 is separated from everyone else, the adjustment lattice comprises of the 2 vectors V1 and V2 , the demodulation network in the beneficiary being U', however in the event that client 2 is presented in the framework, the balance grid must be adjusted in like manner. The direct arrangement is appeared in figure 8. The signs of the 2 clients must be transmitted in the invalid spaces of each other. Give us a chance to accept that client 2 has a solitary radio wire beneficiary and its channel framework H2 is 1x4. The flag must be transmitted in the invalid space of client 1. The deduction of the comparing regulation vector W3 starts with the mix of the physical 1x4 channel vector H2 with the particular vectors V3 and V4 .
The cope with this situation, reduced-rate FBMC-PAM is considered first. If overlapping of consecutive emitted symbols is avoided, the corresponding interference terms desappear. This leads to a reduction of the bit rate by a factor equal to the overlapping factor K with respect to full rate. This might look impractical, except for small K. In the FBMCPAM scheme considered here, K=2, which means that the bit rate reduction with respect to CP-OFDM is less than 2, depending on the cyclic prefix (CP) length.
Beneath, the approach is exhibited with the execution of OFDM 2x1 in FBMC-PAM with the sine model channel and K=2. The square graph of the FBMC-PAM framework outfitted with OFDM is portrayed in figure 2. OFDM precoding happens at the contribution of the 2M-iFFT in the transmitter and the disentangling is performed at the yield of the 2M-FFT in the recipient. The advantage is that there is no impedance because of the covering of neighboring subchannels, just the obstruction because of conceivable covering of images in the time space, made by timing counterbalance or channel twisting. The cost to be paid is the multiplying of the computational intricacy as for OFDM, since the measure of the FFT is multiplied

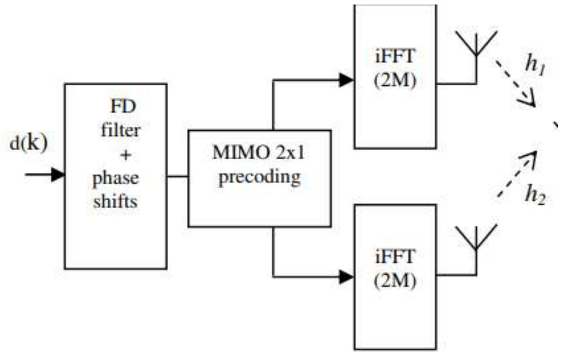


Fig 2a FBMC-PAM TRANSMITER

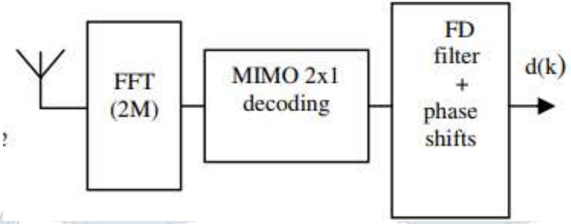


Fig 2b FBMC-PAM RECIVER

At the output of the frequency domain (FD) filter in the transmitter, due to the addition of 2 data samples with the phase shift π/2, a QAM signal is obtained and fed to the iFFT, as pointed out in the previous section. Then, conventional OFDM 2x1 precoding can be implemented. In the receiver, the OFDM decoding takes place at the output of the FFT and, then, the output data sequence is obtained through FD filtering, phase shifts and detection.

For reference, the curve of FBMC-PAM with a single antenna in the transmitter is also included. A feature of FBMC-PAM is its robustness to timing offset (TO). The BER curve obtained with TO = M/2=128 is also included in the figure. There is some degradation, due to the fact that the FFT window misses a section of the desired symbol and contains instead a corresponding section of the adjacent symbol. Overall, the efficiency of the OFDM processing is clearly visible and the robustness of FBMC-PAM to timing offset in this context is illustrated.

A key favorable position of the STBC approach is that all the preparing is completed in the recipient and there is no compelling reason to influence the channel to state data (CSI) accessible at the transmitter side. Nonetheless, there is no adaptability with respect to the transmitted power, which must be shared similarly by the two recieving wires, independent of the channel lessening.

IV. SIMULATION REULTS

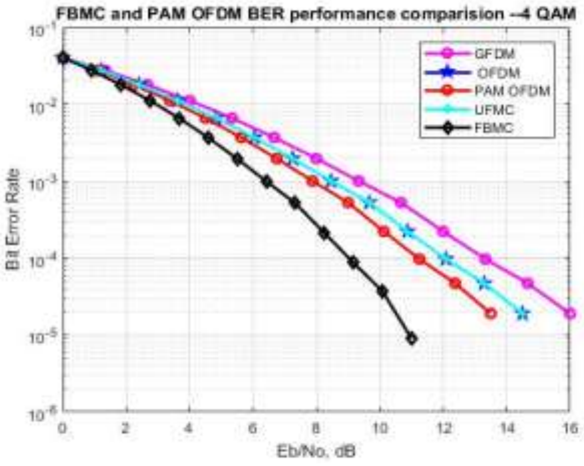


Fig. 3 FBMC and PAM OFDM BER performance-4QAM

Fig. 3 shows that WHT-C-FBMC performs 2.5 dB better than WHT-GFDM at the BER level of 10−4 even with a large constellation such as 64-QAM. Since WHT-GFDM is based on GFDM, which is a non-orthogonal system, the interference between subsymbols and subcarriers is intensified in a FSC. That makes the BER performances of WHT-GFDM worse than that of WHT-C-FBMC, which is an orthogonal system. WHTGFDM and WHT-C-FBMC offer even a larger performance gain under Channel B. Specifically, WHT-GFDM is 5 dB better than the non-precoding scheme, while WHT-C-FBMC achieves 7.5 dB SNR gain at BER = 10−4.

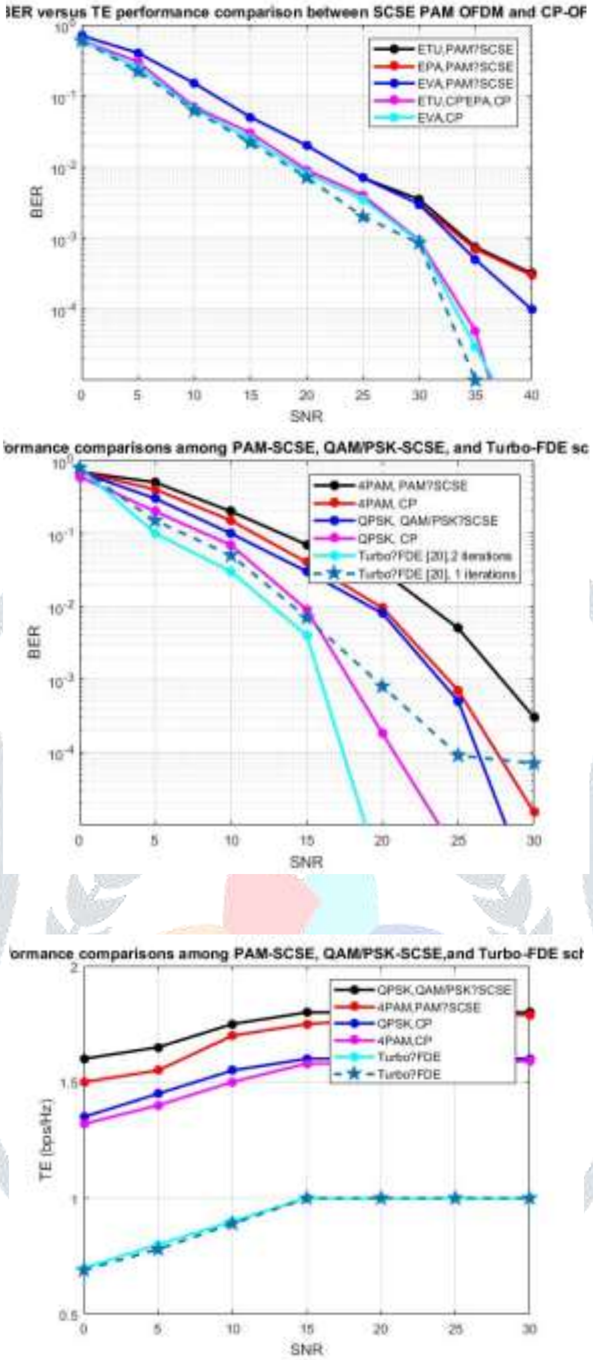
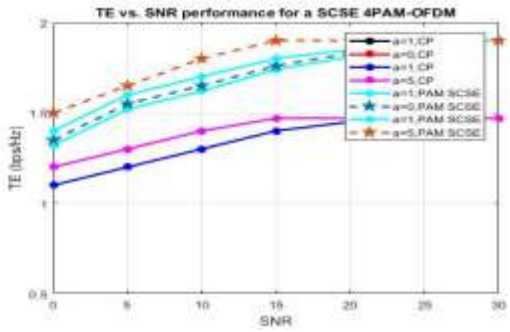


Fig. 4. Performance comparisons among PAM-SCSE, QAM/PSK-SCSE, and Turbo-FDE schemes

Fig. 4 compares the BER/TE performances for PAMSCSE, QAM/PSK-SCSE, and Turbo-FDE schemes, where we used an exponentially power-delay 11-ray Rayleigh fading channel provided in [20], and the number of subcarrier is 64. The curves labeled “Turbo-FDE, 1 iteration” and “Turbo- FDE, 2 iterations” stand for the schemes proposed by [20], where QPSK modulation was used, and bit stream is encoded by a 1/2 convolutional codec with a generator polynomial (x2 + 1; x2 + x + 1). In QAM/PSK-SCSE and PAM-SCSE schemes, QPSK and 4PAM are employed, respectively. CP length is set to be equal to the delay spread, i.e., 10 samples duration.



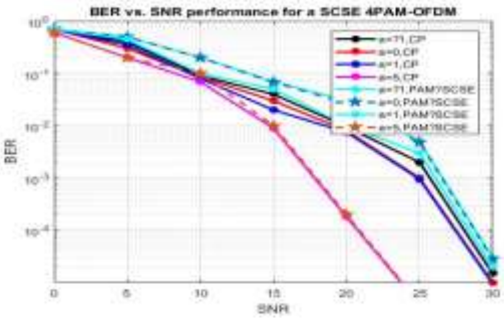


Fig. 4. BER vs. TE performance for a SCSE 4PAM-OFDM system in a 3-ray multipath channel.

In Fig. 4, the number of subcarriers is 8, and 4-ary PAM modulation is used for both CP based scheme and PAM-SCSE scheme. _ is set to -1, 1, 0, and 5 to stand for different power decay speeds of multipath returns, and a larger _ represents a higher power decay speed. The CP length is set to 20 ns, which equals to delay spread.

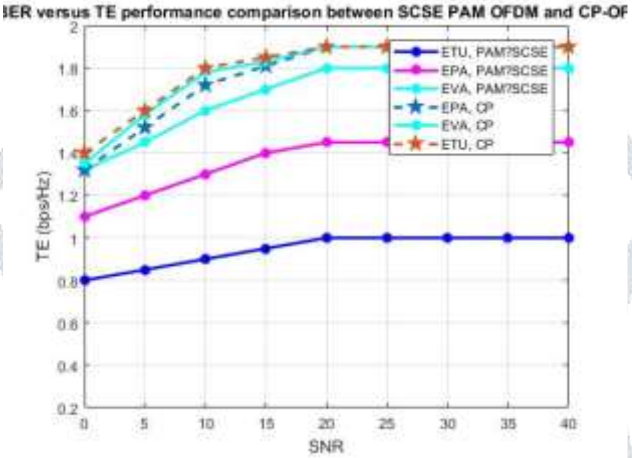


Fig. 5. BER versus TE performance comparison between SCSE PAMOFDM

From Fig.5, we can see that QAM/PSK-SCSE and PAM-SCSE schemes can achieve better TE performances than CP or Turbo-FDE, as neither CP nor coding redundancy is employed; while Turbo-FDE has the worst TE performance owing to 1/2 coding redundancy. It is also observed that Turbo- FDE has a lower BER, which can go even lower, if more iterations are used, than QAM/PSK-SCSE and PAM-SCSE.

CP-OFDM with 3GPP channel models, including Extended Typical Urban (ETU), Extended Pedestrian A (EPA), and Extended Vehicular A (EVA) channels [27] are set differently, TE performances of CP-OFDM appear differently in different channel models. CP-OFDM in EVAchannel has a better TE performance than that in ETU channel, but it has a worse TE performance than that in EPA channel.
A shorter CP length will yield a better TE performance for CP-OFDM, and vice versa. In PAM SCSE-OFDM scheme, TE performances in different models are similar, since the dominant factor of TE is spectrum efficiency rather than BER, unless BER performance is extremely poor. Therefore, SCSE PAM-OFDM will be more attractive than CP-OFDM when spectrum efficiency is an important concern, especially in the scenarios with a relatively long delay spread.

V. CONCLUSION

In this paper, FBMC-PAM, another hopeful waveform for 5G, was contemplated in gigantic MIMO. It was demonstrated that in spite of the fact that in gigantic MIMO channels, multiuser obstruction and channel commotion normal out, the framework execution is constrained because of the lingering channel twists notwithstanding for a substantial number of BS reception apparatuses. As such, when the quantity of BS recieving wires watches out for interminability, the SIR execution immerses. The level of this immersion, which constitutes an upper bound to the framework execution, was logically ascertained regarding channel parameters and the quantity of subcarriers, M. At that point it was talked about that M ought to be set properly to accomplish an objective SIR. Reproduction comes about were given to affirm the hypothetical advancements. In addition, FBMC-PAM has balance issue in single radio wire frameworks prompting a blunder floor in BER execution. This is because of certainty that it just uses two equalizer taps for each subcarrier. Notwithstanding, as we have appeared in this paper, FBMC-PAM can adequately even out the multipath direct in enormous MIMO frameworks and dispose of the BER mistake floor, given that the quantity of subcarriers, M, is legitimately picked. As we have appeared, FBMC-PAM has even a superior BER execution contrasted with OFDM because of its higher transmission capacity effectiveness.

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