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Ant Colony Optimisation Technique:Reduction of PAPR for FBMC-OQAM System

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Abstract

Future remote frameworks need to direct a monstrous scope of suitable use cases, alongside high information rates, framework to framework interchanges and low-dormancy transmissions. This requires an adaptable test of the accessible time recurrence assets, presently not attainable in conventional Orthogonal Frequency Division Multiplexing (OFDM) as a result of its terrible otherworldly conduct. For such various applications, Filter Bank Multi-Carrier (FBMC) [1] turns into a green option in contrast to OFDM in view of a lot higher ghostly properties. In this paper, we consider FBMC dependent on Offset Quadrature Amplitude Modulation (OQAM), in a nutshell FBMC, in light of the fact that it accomplishes most extreme ghastly proficiency.

Keywords:

Multicarrier Modulation, FBMC-OQAM, PAPR, Ant Colony Optimization, Bit Error Rate

1. Introduction

Future wireless systems have to guide a massive range of viable use cases, along with high data rates, system to system communications and low-latency transmissions. This requires a flexible challenge of the available time frequency resources, now not feasible in traditional Orthogonal Frequency Division Multiplexing (OFDM) because of its bad spectral behaviour. For such numerous applications, Filter Bank Multi-Carrier (FBMC) [1] becomes an green alternative to OFDM because of much higher spectral properties. In this paper, we consider FBMC based

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totally on Offset Quadrature Amplitude Modulation (OQAM), in brief just FBMC, because it achieves maximum spectral efficiency.

So far, in step with the characteristic of FBMC-OQAM indicators, some advanced algorithms have been proposed to reduce PAPR values of FBMC-OQAM systems. For example, an algorithm with half of complexity of system primarily based on selective mapping (SLM) is proposed to reduce PAPR values in FBMC-OQAM structures [2]. The FBMC-OQAM alerts are divided into many sub-blocks, and then the segmental partial transmit sequence (S-PTS) algorithm is applied to lessen the PAPR values within the FBMC-OQAM systems [3]. However, these current PTS algorithms of the FBMC-OQAM systems are notably complicated. The main motives are superposition of different section carriers for statistics indicators and interaction of adjacent statistics blocks in FBMC-OQAM systems.

There are many PAPR reduction strategies for OFDM structures, as clipping, coding, non-linear compounding, ton reservation and ton injection, selective mapping (SLM) and partial transmit sequence (PTS) [4]. Among these methods, the PTS method is the maximum efficient and distortion-much less scheme for PAPR discount in OFDM structures. Hence PTS approach is considered for FBMC-OQAM system. In PTS method, the input information block is split into several impartial sub-blocks, the inverse FFT (IFFT) technique is implemented to each independent sub-block and each corresponding time-domain signal is multiplied by way of a segment rotation factor. The objective of the PTS scheme is the selection of segment factors which will reduce the PAPR of the combined signal of all sub-blocks [4]. In the PTS, the exhaustive seek complexity of optimal section elements exponentially will increase with the variety of sub-blocks and phase rotation elements the variety of sub-blocks and phase rotation elements.

Next, the clipping method is used to in addition reduce PAPR, and compressed sensing (CS) is used to get better the clipping signal, thereby stopping excessive degradation of BER at the receiver. Although recovery processing will increase the complexity on the receiver, the overall complexity of the system is still decrease than within the conventional machine. CS is an innovative technique to reduce the quantity of measurements even as still presenting the statistics as required to reconstruct the original signal [5][6].

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2. FBMC-OQAM System Model

FBMC-OQAM system is shown in fig 1. The difference between the OFDM and FBMC is the OQAM processing and filtering. OQAM processing is required to acquire the orthogonality between subcarriers because there is overlap among neighbouring subchannels in FBMC. In OQAM processing, real and imaginary element are not transmitted concurrently as they both are delayed through half of the symbol duration. The term 'offset' in OQAM, suggests the time shift of the sub-carrier spacing among the imaginary element and the real part of a symbol [8]. OQAM also increases the symbol rate by way of 2.

Filter banks are utilized in FBMC to filter out each subcarrier. At the transmitter, Synthesis filter bank is used even as at the receiver evaluation filter bank is used. A prototype filter is designed preserving in view the Nyquist Criterion. In FBMC transmission, the filter out is separated into two parts, one a part of that filter is used at the transmitter and the opposite element is used at the receiver.

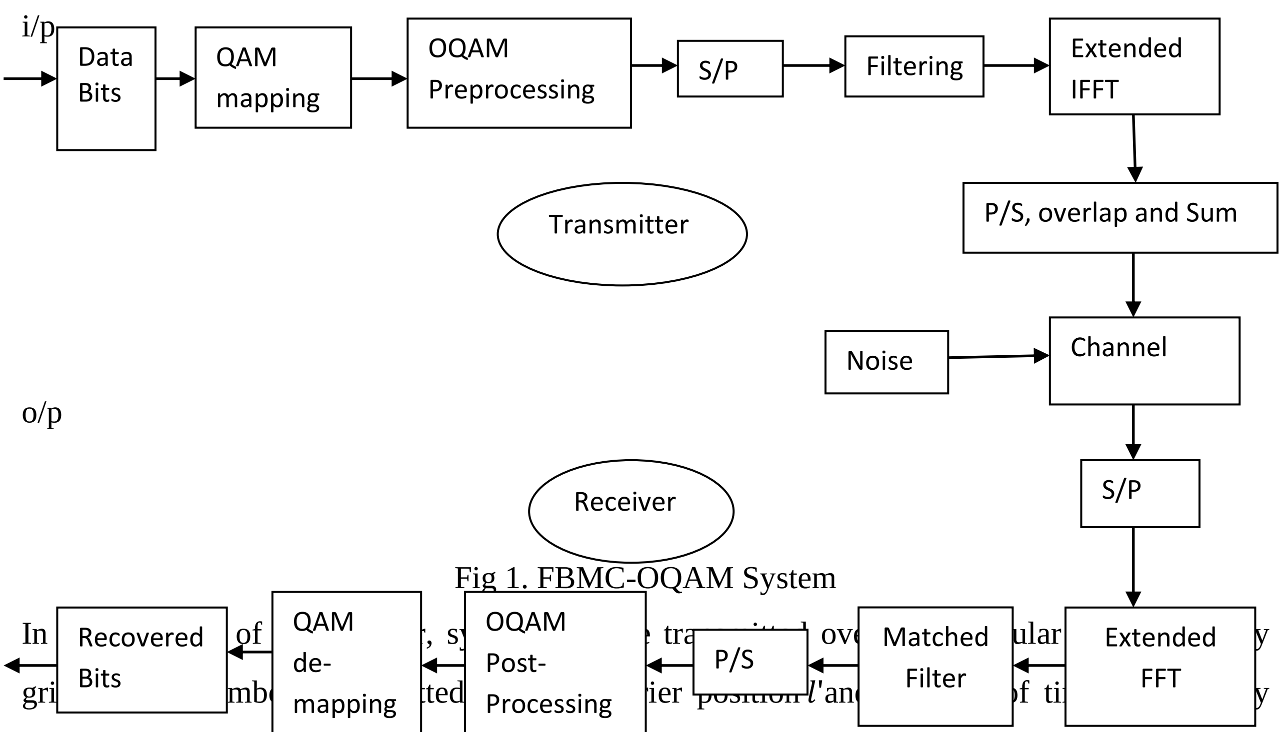

Fig 1. FBMC-OQAM System

'k'The transmitted signal $s(t)$ of a transmission block consisting of Lsubcarriers and Kmulticarrier symbols can be written as

$$s(t) = \sum_{k=1}^{K} \sum_{l=1}^{L} g_{l,k}(t) x_{l,k} \quad (1)$$

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where, basic pulse is termed as $g_{l,k}(t)$, essentially, a time and frequency shifted version of the prototype filter $p(t)$:

$$g_{l,k}(t) = p(t - kT)e^{j2\pi lF(t-kT)}e^{j\theta_{l,k}} \quad (2)$$

with Tbeing the time spacing and $F$the frequency spacing (subcarrier spacing). The received symbols $y_{l,k}$are then obtained by projecting the received signal $r(t)$ onto the basis pulses $g_{l,k}(t)$

$$y_{l,k} = \langle r(t), g_{l,k}(t)\rangle = \int_{-\infty}^{\infty} r(t)g_{l,k}^{*}(t)dt \quad (3)$$

A desired property of the basis pulses $g_{l,k}$is orthogonality, that is,$\langle g_{l1,k1}(t), g_{l2,k2}(t)\rangle = \delta(l_1 - l_1), (k_1 - k_2)$, because it simplifies the detection process. Unfortunately, it is not possible to find basis pulses $g_{l,k}(t)$which are (complex) orthogonal, have maximum spectral efficiency of TF= 1, and are localized in both, time and frequency, according to the Balian-Low theorem [9].

3. PAPR and PTS

A. Peak Average Power Ratio

From equation (1), the signal in time domain generatedby IFFT operation consists N number of independentlymodulated and orthogonal subcarriers withlarge peak values (PAPR) when added up at the output ofIDFT block. The PAPR of the FBMC-OQAM signal in discretetime is defined as the ratio between the maximum powerand the average power of the complex FBMC signal, and itcan be defined as

$$\mathrm{PAPR}\{s[t]\} = \frac{\max\{|s[t]|^2\}}{E\{|s[t]|^2}, 0 \leq n \leq LN - 1 \quad (4)$$

wheres[t] is given by (1) and E{ · } denotes the expectedvalue (average power).

The reduction of PAPR technique is categorised into main parts one is distortion-less technique and the other is distortion technique [10]. These two techniques are applied before and after the IFFT stage. Distortion less is used before stage of IFFT and distortion is used after performing of IFFT operation. The performance of the transmitting and receiving signals trade off between two main important parameters one is PAPR and other is BER.

The occurrence of peak power is exhibited when the modulated symbols are pooled up with the same phase of the signals. From (4) the peak power can be reduce by increasing the value of denominator or by decreasing the value of numerator or by doing both. Theeffectiveness of a PAPR reduction technique is measured bythe complementary cumulative distribution

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function (CCDF),which is the probability that PAPR exceeds some threshold,i.e.: CCDF = Probability (PAPR >$p0$) (5)

Where, $p0$ is the threshold.

B. Partial Transmit Sequence

In the PTS technique, an input data block of N symbolsis divided into M disjoint sub-blocks. Then, the IFFT foreach sub-block is separately performed and then weighted bya corresponding complex phase factor $b_m = \exp(j\emptyset_m)$ ($\emptyset_m$=[0,2π), 1≤m≤M). The phase factors are selected to minimizethe PAPR of the combined signal of all sub-blocks. Fig. 2 shows a block diagram of the FBMC transmitter with the PTStechnique. The stream of input data Sis partitioned into Mnumber of orthogonal sub-blocks S_m and the IFFT for eachsub-block is performed and weighted by a phase factor bm. Theobjective is to select the set of phase factors b_m that minimizesthe PAPR of the combined time domain signal s, where sisdefined as:

$$s = \sum_{m=1}^{M} b_m s_m = \sum_{m=1}^{M} b_m IFFT\{S_m\} = \sum_{m=1}^{M} \widetilde{b_m} s_m \quad (6)$$

The phase factors are chosen to minimize the PAPR, whichcan be written as:

$$\left[\widetilde{b_1}, \widetilde{b_2}, \dots \dots, \widetilde{b_M}\right] = \arg\min(max|\sum_{m=1}^{M} b_m s_m|) \quad (7)$$

The corresponding time-domain signal with the lowestPAPR can be expressed as:

$$s = \sum_{m=1}^{M} \widetilde{b_m}\, s_m \quad (8)$$

C. Clipping Technique

The peak signal is clipped when the signal exceeds the threshold limit, this technique is known as clipping.The clipped signal $\tilde{s}$is representedby

$$\tilde{s}(t) = \begin{cases} Ae^{j\theta}, |s(t)| > A, \\ s(t), |s(t)| < A \end{cases} \quad (9)$$

where $A = \sigma . E\{|s(t)|\} > 0$ and σ is the clipping ratio.While clipping can be easily performed at the transmitter,this results in BER degradation without clipping signalrecovery.

4. Ant Colony Optimization for PAPR Reduction

The ACO algorithm is one of the transformative figuring strategies [11]. The principle reason for existing was to simulate the arbitrary development of Ants. Ant Colony Optimization depends on the strategy known as Swarm Intelligence, which is a part of Artificial Intelligence. The main

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calculation was meaning to look for an ideal way in a graph, in light of the conduct of ants looking for a way between their colony and the source of food.

We propose an Ant colony optimization to decrease the high PAPR of FBMC-OQAM framework in the PTS procedure with lower computational complexity. The rousing source of ACO is the pheromone trail laying and following conduct of genuine ants which use pheromones as a correspondence medium. In relationship to the natural model, ACO depends on the circuitous correspondence of a state of straightforward specialists, called (artficial) ants, mediated by (artificial) pheromone trails. The pheromone trails in ACO fill in as circulated, numerical data which the ants use to probabilistically develop answers for the issue being solved and which the ants adjust during the calculation's execution to reflect their search experience [12].

In an enormous space of phase vectors that each worth measurement speaks to a factor, a lot of variables can be a point or a spot in this space. The best spot is the arrangement that has the least PAPR.

Algorithm

The Ant Colony optimization based PTS algorithm is given as:

Step1: Initialise input data $s = S_{1,}S_2, S_3, \dots \dots \dots \dots . S_M$

Step2: Serial bit of data converted to parallel bits

Step3. Rotating the phase of bits and applying Ant Colony optimization for the bits

Step 4. Initialization of the Ant System(pheromone), $A_{initial}$

Step5: updates the pheromone trail

Step6: pheromone of the entire system evaporates and the process of construction andupdate is iterated.

Step7: ACS only the best solution computed sincethe beginning of the computation is used to globally update the pheromone($A_{initial}$ to A_{best})

Step8: the final evaporation phase is substituted by a local updating of thepheromone applied during the construction phase. Each time an ant moves fromthe current city to the next the pheromone associated to the edge is modified.

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Step10. Find the best value and form a unique phases

Step11. Obtain the Min PAPR signal

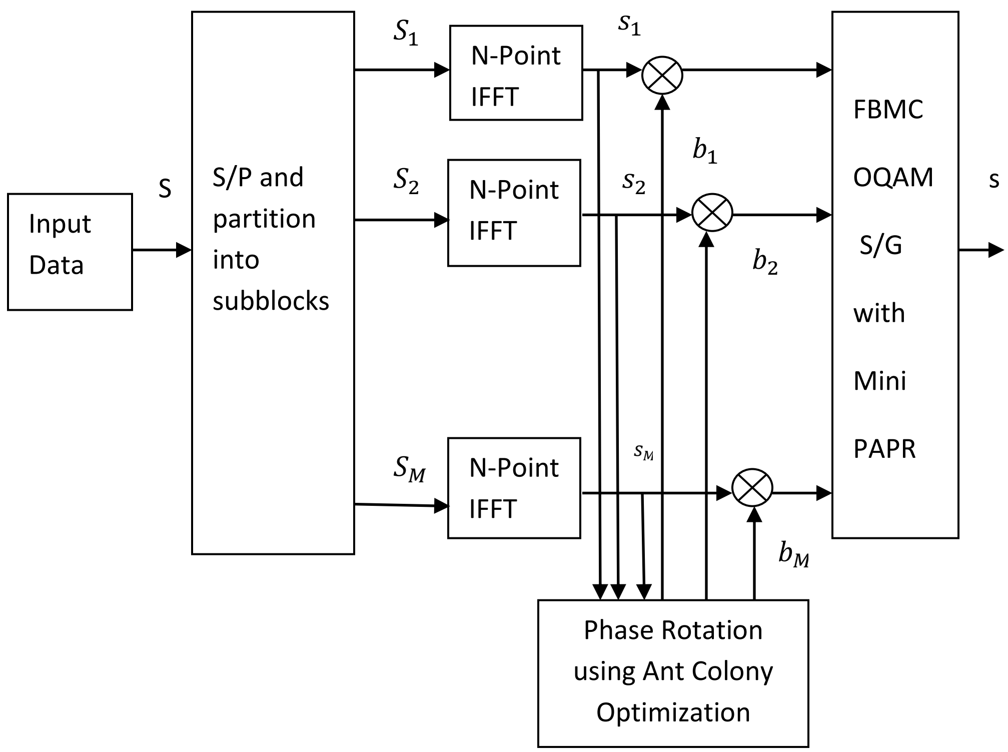

Fig 2. Proposed PTS-ACO Technique

Optimization in the ACO starts with randomly generated solution $A_{initial}$ An ant chooses the next road depending on the probability which is associated with pheromone amount. The probability can be determined by:

$$p_{ij}(t) = \frac{[\tau_{ij}]^{\alpha}}{\sum_{j=1}^{2}[\tau_{ij}]^{\alpha}} \tag{10}$$

where$p_{ij}(t)$ is the probability related with the connection between the bits $i$and$j$, $\tau_{ij}(t)$ is the artificial pheromone of the connection and α is a weight parameter. The shortest path (A_{best}) which minimizes the PAPR is stored. This steps are repeated until an evaluation number is reached.

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BER Analysis

A significant things of the introduced PTS-ACO based PAPR decrease plans is that they cause no degradation of BER execution. In addition, an improvement in BER can be accomplished beneath the following conditions. The assumption of the signal which is first transmitted with maximum magnitude is unity. In the process of utilizing PAPR decrease the maximum peak value is diminished. The new PAPR reduced signal would now be able to be re-intensified until the most extreme significance arrives at attachment once more (likewise fitting the PAPR decreased sign into the first range). Expecting an AWGN channel, the equivalent noise power is summed up with both the remarkable and the reamplified PAPR diminished signals per frame

5. Results and Discussion

In this study we consider 10000 symbols with subcarriers of 64 and some reserved carriers inorder to transmit the clipping signals. Thesymbols are then passed through the PHYsical layer for DYnamic spectrum AccesS(PHYDYAS) prototypefilter with an overlapping factor $k = 4$. There are 4 and 8subblocks, and the phase factors are 1 and −1.In this paper, the sparsitylevels are considered and are set to 15, 30, and 90. By using this sparisty levels, PAPR reduction is observed and differentiated.

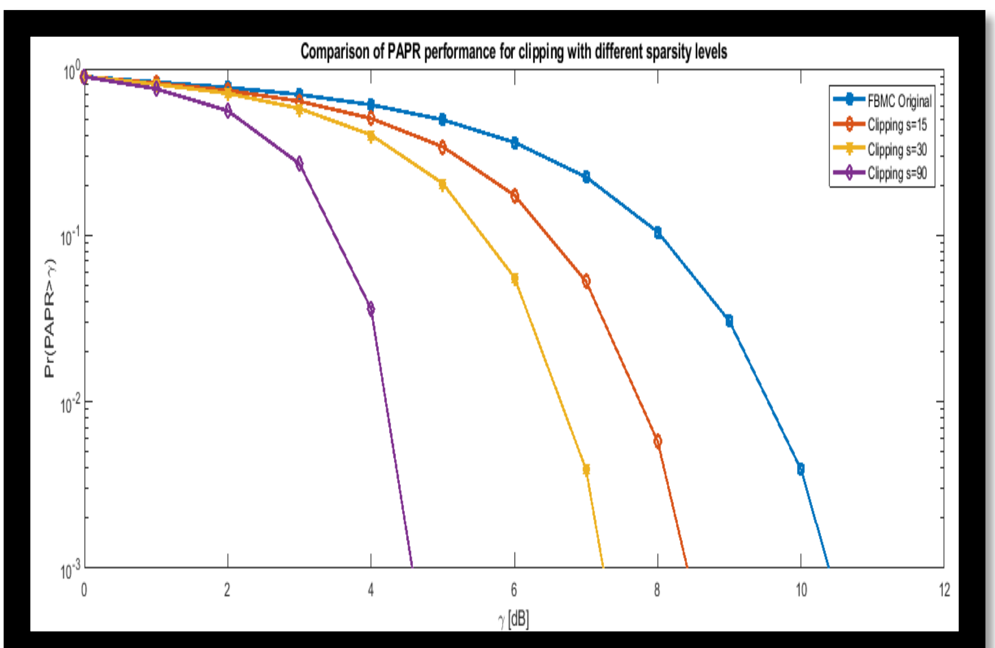

Fig 3.Comparison of PAPR performance for clipping with different sparsity levels

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From fig 3 it is observed that for a fixed probability of 10^{-3} , the original FBMC 10.6dB is the γ value and as the level of sparsity increases the value of γ is reduced. For s=90 the value of γ is around 4.6dB which is 6dB less compared to original FBMC signal.

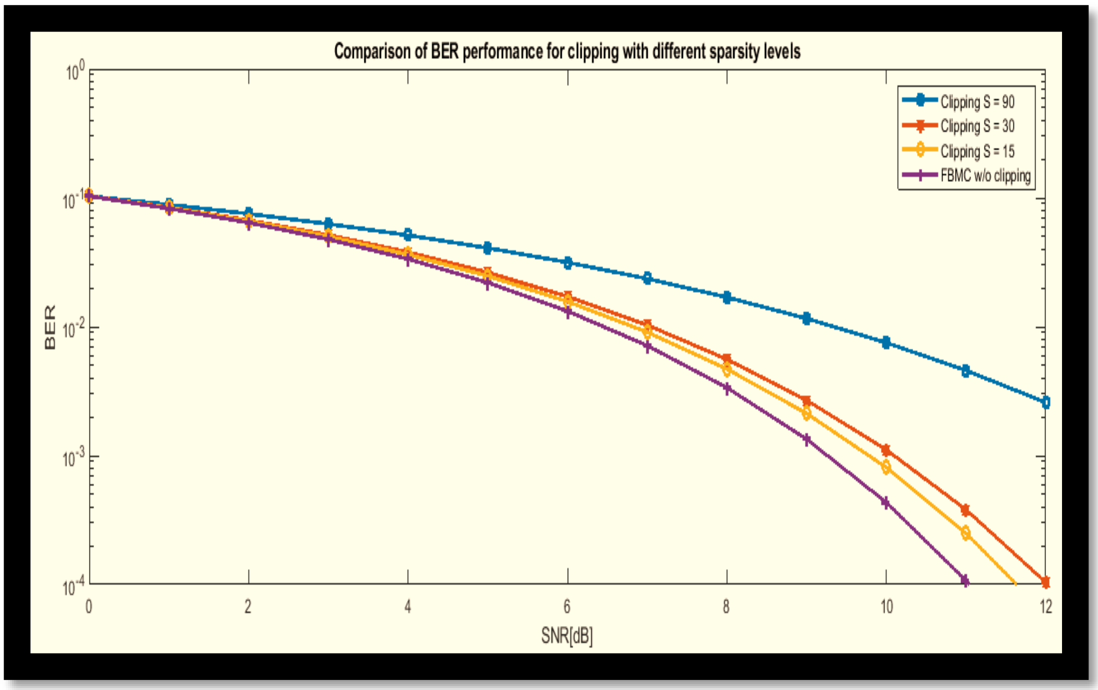

Fig 4.. Comparison of BER performance for clipping with different sparsity levels

Fig 4 show the value of Bit error rate for original FBMC signal and different sparsity levels. The increase in level of sparsity there is gradual increase in BER. The original FBMC has good level of error rate.

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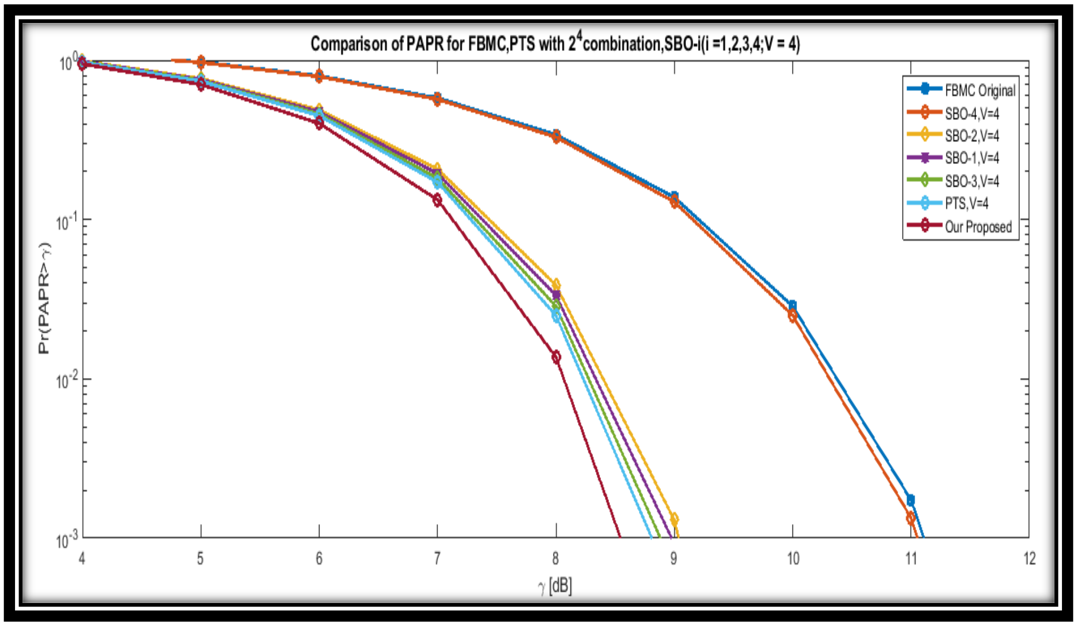

Fig 5. Comparison of PAPR performance for the original FBMC signal, PTS, SBO and ACO

Fig. 5 shows the CCDF curves for the proposed techniquewithout clipping and with four sub-blocks and ACO technique. Here in fig 5, the SBO and ACO is compared by considering four sub-blocks. For 10^{-3} the γ value is 8.5dB which is 2.7dB less compared to FBMC original signal.

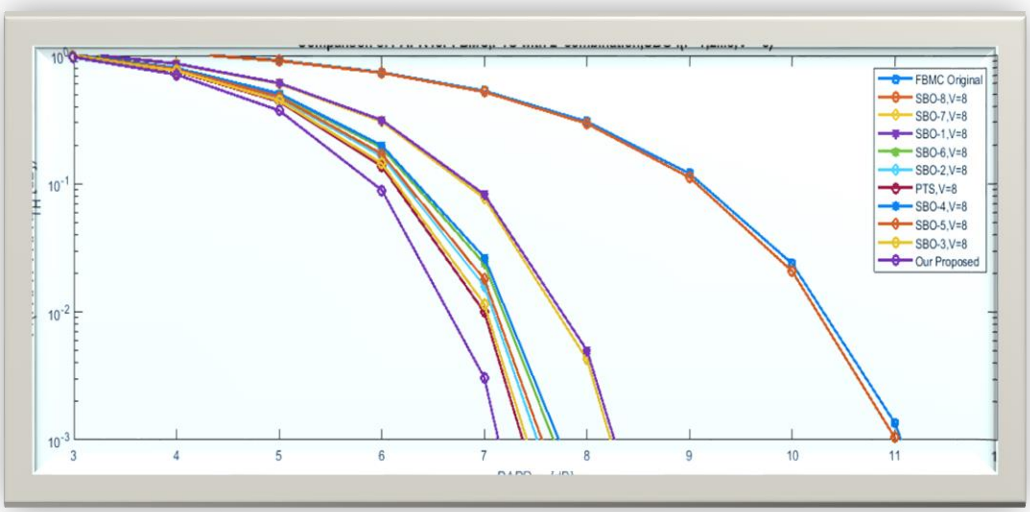

Fig 6Comparison of PAPR performance for the original FBMC signal, PTS, SBO and ACO for V=8

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Now consider 8 subblocks and compare the results for various techniques in which proposed method gives best result as shown in fig 6. The $PAPR_{Th}$value at 10^{-3} is 7.2dB which is 4dB less compared to FBMC original signal.

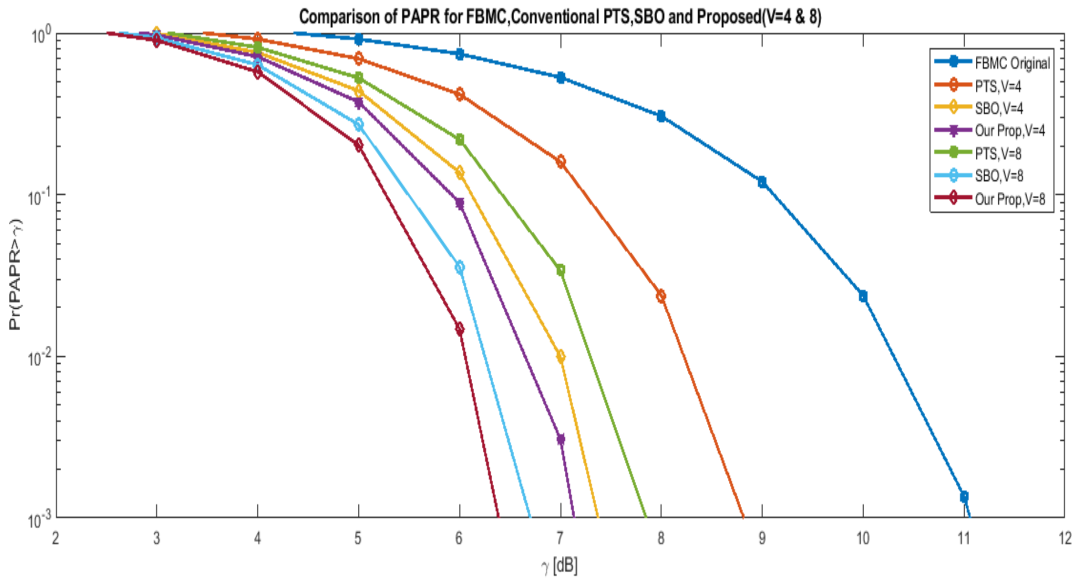

Fig 7 Comparison of PAPR performance for the original FBMC signal,conventional PTS, SBO and proposed ACO technique (V= 4 and 8).

The γ value decreased with the increase in sub-blocks is shown in fig 7. Considering the proposed technique, the γ value is 6.4dB for 8 sub-blocks and 7.3dB for 4 sub-blocks at 10^{-3}.

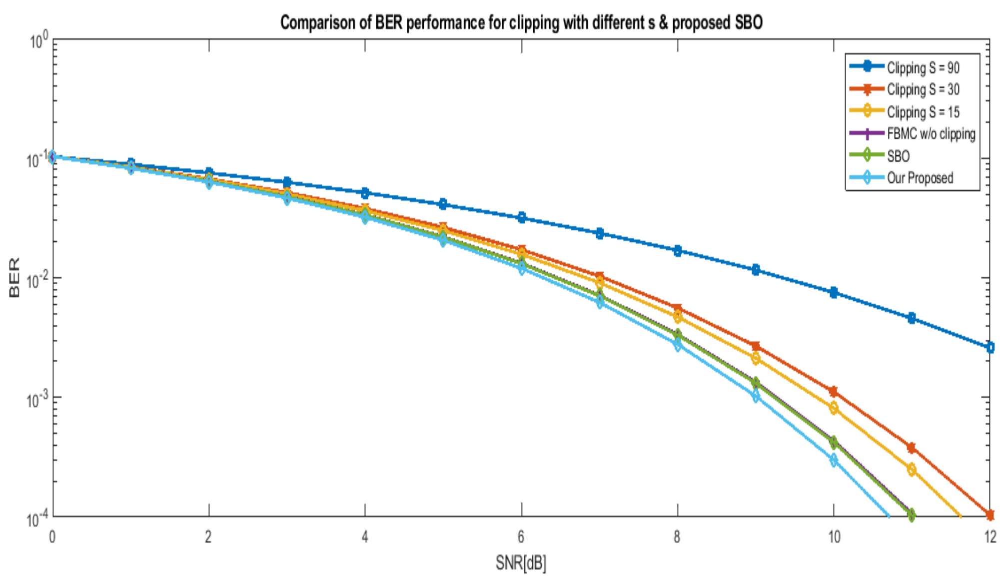

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Fig 8. Comparison of BER performance for clipping with different *s* , *SBO* and forthe proposed ACO technique.

The BER w.r.t SNR is compared with original FBMC and different techniques like PTS, SBO and ACO. The clipping technique with a scarcity level of 90 has good range of BER compared to other techniques which are applied to FBMC system.

6. Conclusion

FBMC framework assumes a significant role in forthcoming high speed communication world. PAPR is one of the issues of FBMC framework. In this paper we have introduced an Ant colony optimization algorithm which is inspired by the conduct of ants. Simulation results show that this method has diminished the PAPR value. This investigation built up a strategy to decrease the high peaks in transmitted signals in considering the qualities of FBMC-OQAM signals. The proposed procedure enhances the information blocks and along these lines utilizes certain datablocks with lengths indistinguishable from the given segment length to enhance other data blocks. Next, a constrained arrangement of phase factors is extracted from every conceivable combination to decrease the computational complex nature of the procedure. To get both i.e good BER execution and PAPR decrease, the clippingresidual signals are recovered using the CS method.The result obtained using ACO technique is compared with segment based optimization and PTS techniques, among this the proposed ACO techniques has low PAPR and BER.

References

[1] B. Farhang-Boroujeny, “OFDM versus filter bank multicarrier,” IEEESignal Processing Magazine, vol. 28, no. 3, pp. 92–112, 2011.

[2] J. Panya, S. Sunisa, B. Pornpawit, and B. Pisit, “PAPR reduction inFBMC-OQAM signals with half complexity of trellis-based SLM,” inInt. Conf. on Advanced Commun. Technology, Feb. 2018, pp. 1–5.

[3] Y. Chen, Z. Li et al., “PAPR reduction of OQAM-OFDM signals usingsegmental PTS scheme with low complexity,” IEEE Trans. on Broadcast.,vol. 60, no. 1, pp. 141–147, Mar. 2014.

[4] Y. Rahmatallah, S. Mohan, Peak-to-average power ratio reduction inOFDM systems: A survey and taxonomy, IEEE Commun. Surv. Tutor.15 (4) (2013) 1567–1592.

[5] R. F. H. Fischer and F. Waeckerle, “Peak-to-average power ratioreduction in OFDM via sparse signals: transmitter-side tone reservationvs. receiver-side compressed sensing,” in *OFDM 2012, 17th InternationalOFDM Workshop 2012 (In-OWo'12); Proceedings of,* pp. 1-8, 2012.

[6] M. Gay, A. Lampe, and M. Breiling, “An adaptive PAPR reductionscheme for OFDM using SLM with clipping at the transmitter, and sparsereconstruction at the receiver,” in *Signal and Information Processing(ChinaSIP), 2014 IEEE Chinal Summit International Conference on*, July2014, pp. 678-682.

[7] Ji-Hyun Moon, Ye-Ri Nam, and Jeong-Ho Kim, " PAPR Reduction in the FBMC-OQAM Systemvia Segment-Based Optimization", DOI 10.1109/ACCESS.2018.2794366, IEEEAccess.

[8] M. Bellanger, “FBMC Physical Layer: A Primer,” *PHYDYAS, January*,pp. 1–31, 2010

[9]R. Nissel and M. Rupp, “Enabling low-complexity MIMO in FBMCOQAM,” in IEEE Globecom Workshops (GC Wkshps), 2016.

[10] Y. Rahmatallah and S. Mohan, ``Peak-to-average power ratio reduction inOFDM systems: A survey and taxonomy," *IEEE Commun. Surveys Tuts.*,vol. 15, no. 4, pp. 1567_1592, 4th Quart., 2013.

[11] Filbert H. Juwono and DadangGunawan, “The Effectiveness of Using Source Coding to Reduce PAPR in OFDM System” Senior Member, IEEE 2010.

[12] Marco Dorigo and Thomas Stutzle, “The Ant Colony OptimizationMetaheuristic: Algorithms, Applications, and Advances”

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