PAPR REDUCTION FOR FBMC/OQAM SYSTEM WITH MODIFIED PHASE SEQUENCES

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Abstract

FBMC (Filter bank multi carrier modulation) has attained greater interest in recent research works due to its high spectrum efficiency, however like other multi carrier modulation schemes this also suffers from high PAPR. Traditional approaches are not supported for this system due to its overlapping structure, and hence there is always a scope for new approach. This paper presents a new modified phase sequence that can be included with partial transmit sequence is presented. This new phase sequence not only able to decrease the PAPR but also used to preserve the high orthogonality in FBMC systems. Experimental result reveals that the proposed approach could attain promising results when compared in terms of CCDF, BER.

Keywords: *FBMC, Filter bank, Phase sequence, Orthogonality*

1. INTRDOUCTION

Several Multi Carrier modulation (MCM) techniques and methods like OFDM (orthogonal frequency division multiplexing) and MC-CDMA (multi carrier code Division multiple Access) were used to Trans-receive the information even in noisy environments. The main idea of these MCM techniques is to cover a wider area with high quality and provide the transmission at higher data rates with good quality of service and all this has to be achieved in limited cost. There are certain demerits with these MCM methods like high computational complexity and limited spectrum bandwidth [1] [2].

Due to the attractive properties like high spectrum potency, low side lose interference and scope for narrow band interference made the FBMC with OQAM (Offset Quadrature amplitude modulation) modulation more popular in recent proposals [3]. Like all other Multi carrier modulation schemes (MCM) this approach also suffers from high peak to average power ratio (PAPR) that hinders to decrease the potency of high power amplifier (HPA) [3] .

FBMC has drawn much interest in research due to its high spectrum efficiency where the signal is obtained by summing M time shifted OFDM/OQAM symbols each of which is obtained by passing QAM symbols through a prototype filter [4]. FBMC on contrary has very limited number algorithms that involve in reducing the PAPR. Methods like Overlapping Selective Mapping approach (OSLM) [5], Sliding window approach [6] and Multi joint optimization [7] were proposed to handle the problem of PAPR in FBMC systems. Even though most of these methods do not alter the signal but they require side information which limits the bandwidth efficiency.

In this paper, a new modified phase sequence is presented that can be used in PTS scheme to minimize PAPR without use of the side information. In this new phase sequence a exponential constant is convolved with each phase vector such that it gives the room to accommodate more number of sub carriers. The present paper is organized into five sections; section1 presents the introduction to FBMC and need to propose a new approach for PAPR reduction. Section 2 presents a brief literature on the methods proposed by earlier authors which are related to the current work. Section 3presents the working model of the proposed approach, section 4 presents the experimental results that were obtained under different conditions and constraints.

2. Related Work

Multi carrier modulation schemes are intended to transmit the data at higher data rates and also accommodate multi users within the given channel but due to the superimposition of the sub carriers of the users there arises a problem called high PAPR. In literature there are many works presented that were focused on mitigating the PAPR of OFDM systems like clipping [8], Coding techniques [9] Selective mapping techniques [10], partial transmit sequence [11] [12], active constellation [14] , tone reservation [13] and many others .

These methods are not supported exactly for the FBMC systems due to its overlapping structure and also due to the increase in the complexity with the intervention of new approaches hence for this purpose a new set of approaches have been proposed to solve the problem of PAPR while preserving the orthogonality and complexity considerations. The most prevalent techniques for FBMC PAPR reduction are orthogonal selective mapping (OSLM), sliding window tone reservation (SW-TR), multi block joint optimization (MBJO), tone reservation (TR) and Active constellation extension (ACE).

In [5] Skrzypczak et.al proposed the SLM technique can be adapted for the use in FBMC systems. A technique called OSLM is proposed. This technique proposes searching over a longer overlapping interval in order to capture the overlapping properties of FBMC. Therefore contiguous symbols must be modulated in order to exploit the overlapping nature of FBMC. However in [5] the authors tried to point the main drawback with PAPR reduction FBMC, in order to achieve an optimal solution using SLM a huge amount of memory and computational power must be utilized.

The technique proposed in [6] is a SW-TR technique; this technique is clipping based techniques that much like TR (tone reservation) for OFDM and utilizes reserved sub carriers to counteract the peaks in the original FBMC signal. A sliding window is utilized in order to clip the FBMC over an interval of the window length. The technique suffer from the same drawbacks as TR for OFDM namely a decrease in BER performance of the system and due to the addition of non data carrying subcarriers a lower through put is to be expected which results in an effective increase in the BER of the system.

The MBJO technique in [7] utilizes a dynamic programming (DP) optimization based PTS technique. The DP is employed to find the most optimal phase rotation factors that can be utilized in order to reduce the PAPR of the signal. This technique provides good results as the overlapping nature of FBMC is fully accounted for. However, this performance much like PTS for OFDM, is at the expense of an exponential increase in complexity with an increase in prototype filter length and the number of phase factors used. From the above discussions it is evident that there is always a scope for new approach that can be used to minimize PAPR in FBMC/OQAM systems.

3. Proposed Approach

Figure 1 below shows the proposed approach block diagram, which consists of 'N' number of sub carriers, after the QAM modulation the input symbols are first converted into parallel form by serial to parallel converter which can be represented as

$$X = [X^0, X^1, \dots\dots\dots\dots, X^{M-1}] \quad (1)$$

Where 'M' is the number of data blocks and X_m is the m[th] data block which is defined as $X^m = [X_0^m, X_1^m \dots\dots\dots.. X_{N-1}^m]^T$, Where 'N' represents the number of subcarriers. Here h(t) is the response of the prototype filter. Here in this paper the prototype filter coefficients is represented below

$$h(t) = \alpha(c(0) + 2\sum_{i=1}^{K-1}(-1)^i c(i)\cos(\frac{2i\pi}{KN}t)) \quad (2)$$

Where α is the normalization factor and c(i),i=0,1……K-1 are given as c(0)=1 ,c(1)=0.97195 c(2)=0.7071 c(3)=0.23514

The modulated symbols in N orthogonal sub carriers is represented as

$$S_n^m(t) = \{c_n^m h(t - mT) + j d_n^m (t - \frac{T}{2} - mT)\} e^{jn(\frac{2\pi}{T}t + \frac{\pi}{1})} \quad (3)$$

Then $S_n^m(t)$ on all the N sub carriers are added up together to obtain

$$S^m(t) = \sum_{n=0}^{N-1} s_n^m(t) \quad (4)$$

Here after S^m is denoted as S^u for the ease of understanding. These symbols are convolved with the new phase factors. Let us consider a V-tuple phase vector is defined as

$$S^u = [S_0^u \; S_1^u \; \dots . S_{V-1}^u] \quad (5)$$

Where $0 \le v \le V-1$ and $0 \le u \le U-1$, for instance $S_V^u = 0$ implies phase offset of 0, in order to embed side information into u[th] rotating vector b[u] , then each rotating factor is multiplied by $e^{j\theta s_v^u}$ where θs_v^u is the phase offset $0 \le \theta s_v^u < 2\pi$, then the modified phase rotating vector can be represented as

$$\overline{b^u} = [\overline{b_0^u} \; \overline{b_1^u} \dots \overline{b_{V-1}^u}]$$

$$= [b_0^u e^{j\theta s_0^u} \; b_1^u e^{j\theta s_1^u} \dots\dots b_{V-1}^u e^{j\theta s_{v-1}^u}] \quad (6)$$

The modified signal modifies the equation (1) and can be represented as

$$S'^u = \sum_{v=1}^{v} S_v \overline{b^u}_v$$

In this scheme, S'^u with minimum PAPR is selected as the candidate signal. The new phase sequences [15] are found in below table 1.

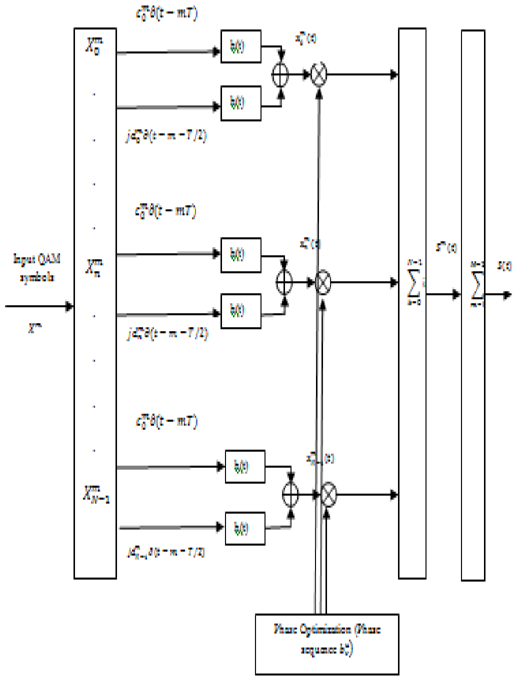

Figure 1: Phase optimization for PAPR reduction in FBMC/OQAM system

4. Results and Discussions

The experiment is conducted with N=1024 sub carriers studied under 4, 16,256 QAM schemes. The proposed modified phase sequence (FBMC-MPS) is compared against traditional PTS [16], FBMC-PTS and FBMC sequential approach (FBMC-SEQ) [17] [18]. Figure 2 shows the PAPR analysis of the approach in terms of complementary cumulative distribution is presented with4-QAm modulation and U=16 . It can be observed from the figure that the MPS scheme attains a decrement by 0.6db when compared against SEQ approach and 0.9db with traditional PTS scheme.

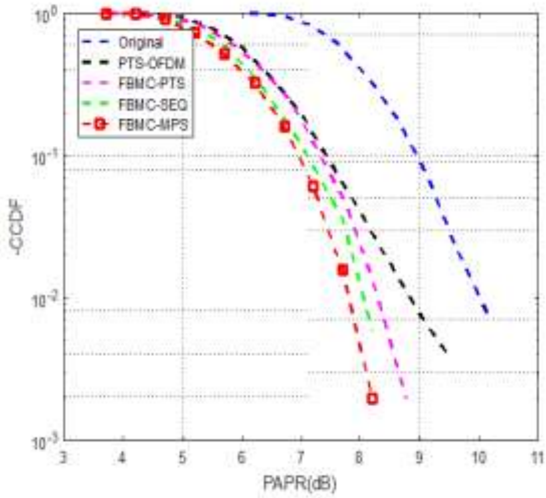

Figure 2: PAPR analysis of the proposed approach for 4-QAM modulation for U=16, N=1024

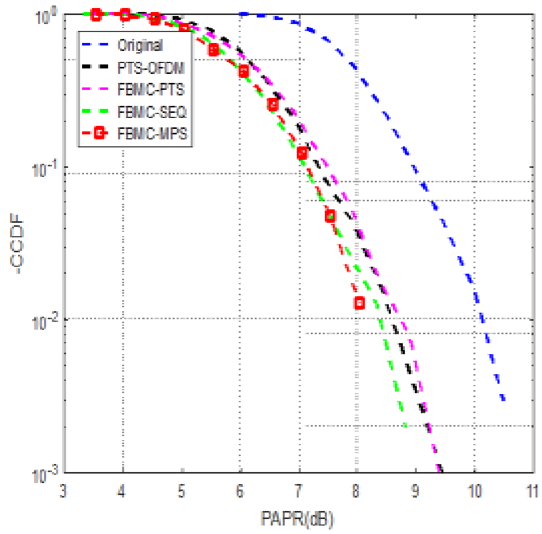

Figure 3: PAPR analysis of the proposed approach for 256-QAM modulation for U=16, N=1024

Table 1: Modified Phase vectors for U=8

	b_0^u	b_1^u	b_2^u	s_0^u	s_1^u	s_2^u	$\bar{b}_0^u$	$\bar{b}_1^u$	$\bar{b}_2^u$
u=0	1	1	1	0	0	0	1	1	1

u=1	1	1	-1	0	0	1	1	1	$-e^{j\frac{\pi}{6}}$
u=2	1	1	j	0	1	0	1	$e^{j\frac{\pi}{6}}$	j
u=3	1	1	-j	1	0	1	$e^{j\frac{\pi}{6}}$	1	$-e^{j\frac{\pi}{6}}$
u=4	1	-1	1	2	1	0	$e^{j\frac{\pi}{3}}$	$-e^{j\frac{\pi}{6}}$	1
u=5	1	-1	-1	1	1	1	$e^{j\frac{\pi}{6}}$	$-e^{j\frac{\pi}{6}}$	$-e^{j\frac{\pi}{6}}$
u=6	1	-1	j	0	1	2	1	$-e^{j\frac{\pi}{6}}$	$e^{j\frac{\pi}{3}}$
u=7	1	-1	-j	1	2	2	$-e^{j\frac{\pi}{6}}$	$-e^{j\frac{\pi}{3}}$	$-e^{j\frac{\pi}{3}}$
u=8	1	j	1	0	2	0	1	$e^{j\frac{\pi}{3}}$	1

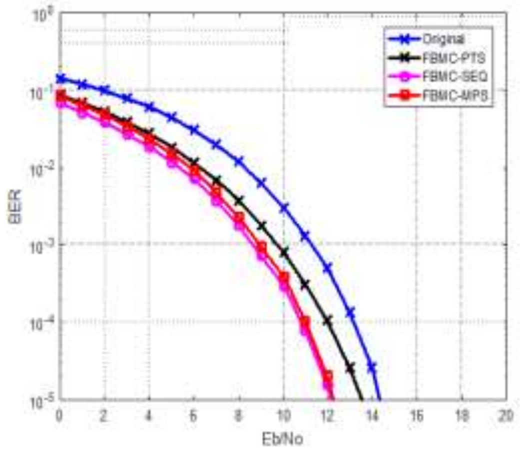

Figure 4: BER performance of the approach with M=16 –QAM and N=1024 under AWGN

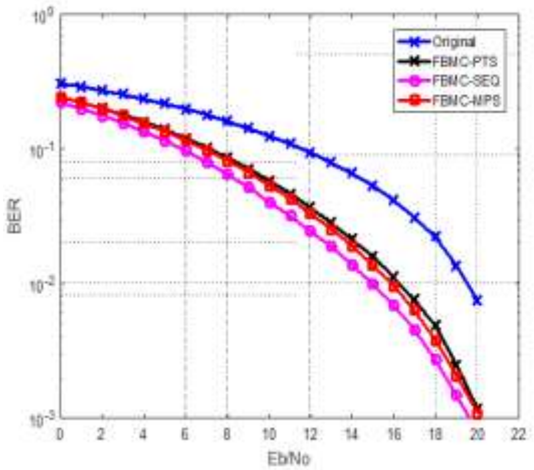

Figure 5: BER performance of the MPS approach with M=256 QAM and N=1024 under AWGN

From figure 4& 5 it can be observed that, though MPS approach yields better performance in terms of PAPR than SEQ but shows slight decrement in BER performance yet this approach is very simpler than FBMC-SEQ approach in implementation. Figure 4 shows the performance when simulated with 4 QAM modulation for N=1024 sub carriers, attain BER of 0.0001 at 10.5dB while the traditional approach attains it at 12dB, thereby it is clear that 1.5 db is preserved in achieving low BER.

5. Conclusion

This paper presents a new modified phase sequences for PTS scheme to reduce PAPR in FBMC /OQAM systems. The approach is compared against several earlier approaches and it was found that the method could able reduce the PAPR around 0.8~1db but could not able to attain low BER than SEQ approach. However this method provides low BER than traditional approach and could able preserve the orthogonality these all can be achieved without the use of side information. This property of the method makes it more venerable for high data rate systems.

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