IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Simultaneous reduction of PAPR and OBP in NC-OFDM Based Cognitive Radio Systems using APOCNCS and New SLM Methods

Yaramala Phanirani

M.Tech Student, Dept. of ECE, JNTUA College of Engineering, Ananthapuramu, INDIA

Abstract ____Cognitive Radio (CR) systems are using for intelligently transferring the secondary users to vacant frequency bands for effective utilization of spectrum. Non-Contiguous Orthogonal Frequency Division Multiplexing (NC-OFDM) based cognitive systems are gives the best spectrum utilization and same systems are suffering from peak to mean power ratio (PAPR) and out of desired band power (OBP)these two causes the performance degradation of the system. In this paper, we propose an algorithm called "Alternative Projections onto Convex and Non-Convex Sets" that reduces the PAPR and OBP simultaneously and new SLM algorithm for better PAPR reduction. The alternate projections are carried onto the sets such that to form an iteration, which will converge to the given limits of OBP, max amplitude, and in-band-power.

Keywords: **Cognitive Radio, NC-OFDM and Convex optimization.**

I. Introduction

The present efforts in the wireless communication have been concentrated on concurrent transmission of high data rates, which looks impossible due to spectrum limitation problem. To overcome this spectrum conflicts Cognitive radio (CR) system is a one of the effective solutions. In Cognitive Radio (CR) spectrum range is shared among the authorized (PU) users and secondary users (SU) in shared way or astute strategy. SU users get the spectrum in two methodologies. In the first method SU user can access the spectrum in the time interval when the primary users are not using spectrum and in the second method concept of shared methodology i.e. as long as the primary users are not disturbed by SU users power levels. This necessity makes the unauthorized users continuously satisfy interference limitations. The topmost difficulty facing in the spectrum perception is to take a dynamic decision on detection of the signal with high reliability. We have diverse range of detecting approaches which are comprehensively characterized as energy detection, matched filter detection, waveform recognition and cyclostationary discovery methods. Percept the spectrum called as spectrum perception to find out the availability of spectrum holes.CR radio adjust the parameters like beam pattern, kind of modulation, frequency and so on intellectually in order to give trustable communication.

Orthogonal Frequency Division Multiplexing (OFDM) alone cannot be used in cognitive radio. Because it cannot sense for vacant sub-carriers. So, Cognitive Radio (CR) uses Non-Contiguous Orthogonal Frequency Division Multiple access (NC-OFDM) system that can sense the spectrum for vacant sub-carriers through spectrum sensing. It enables to use vacant spectrum (which is not used by primary users at current time) for sending secondary users data through the communication channel. NC-OFDM system is a multicarrier modulation scheme which converts frequency selective fading channel into flat fading channel. Hence the equalizer is simple for this system to mitigate ISI. However, NC-OFDM system has two minuses. They are namely Peak to mean Power Ratio (PAPR) and Out of desired Band Power (OBP). [1], which implements Iterative clipping and selective filtering technique on the OFDM signal. By this BER accomplishment of the system is decreased as it iteratively modifies the signal to a great extent.

L. Li, and D. Qu introduced a novel method for PAPR reduction in [2]. In this method, the phase factors that reduce the peak to mean power of the OFDM data used in the PTS processing. The convergence speed of decoding is too large and degradation of the error-correcting is observed in this scheme of PAPR reduction. [3] proposed a method called "lowering of PAPR ratio of OFDM system using a companding technique" . It is m-law companding technique that minimizes PAPR at the cost of an improving in the mean signal power. There are several methods are already claiming in literature to decrease the out of-band power (OBP). Some of the methods are mentioned here. [8] proposed a method called "multiple choice sequences" modifies the primarily transmitted sequence into a set of sub sequences and selects the one with the lowest out of band power. combining cancelled sub carriers and modulated filter banks to reduce the sidelobes [9]. To do it both cancellation carriers (CCs) and modulated filter banks (MFB) are used. The factors which influence the reduction are filter's roll of factor, number of CCs. Interference Cancellation Technique for Multi Band-OFDM cognitive Radio"[10], which uses few sub-carriers as the secure guard bands that reduces the interference with the adjacent sub-carriers and also reduce the sidelobe signal power. This reflects in the decrease of spectral efficiency of the system. IN [16], which various alternating signals are produced and signal with little PAPR and side lobes is chosen as transmitted signal. This method doesn't achieve significant reduction in peak to mean power and OBP and it requires many sub-carriers to store side information, which results in decrease of data rates. In[17]" Signal Cancellation(SC)" method, in which portion of the outer constellation points on secondary user sub-carriers are extended on timely manner while many SC symbols are summed up on primary user sub-carriers to make the appropriate SC for the joint decrease of PAPR and OBP, this method reduce the BER performance and requires more power. Yanqing LIU and Liang DONG proposed "Projections on to convex sets (POCS)" [18] in which dual convex sets are mentioned to decrease PAPR and OBP jointly. mentioned two algorithms, in which, algorithm 2, reduces PAPR and the algorithm1 reduces OBP reduction which is superior to that of PAPR.

II. SYSTEM MODEL

Consider a continuous spectrum having N sub carriers that are allocated to licensed users. Spectrum-perception finds unused sub carriers that are not access by licensed users, and the NC-OFDM system makes us to use these sub carriers for transmitting the data of secondary users via channel. For NC-OFDM systems, these sub carriers are normally called to as active sub carriers, and the remaining are called null sub carriers. A discrete-time NC-OFDM signal can be defined as

$$x[n] = x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{k=N-1} X_k e^{j2\pi\frac{kn}{N}}, \quad n = 0,1,2,..N-1 \quad (1)$$

here X_k is the SU users' data prepare to transmit on active sub carriers, 1/NTs is subcarrier interval, where Ts and NTs are sampling and symbol periods. For precise computation of IBP and OBP, the discrete-time NC-OFDM signal is modified to a continuous time domain NC-OFDM signal using interpolation filter h1(t). The continuous time NC-OFDM signal can be represented as

$$x(t) = h_I(t)\left(\sum_{n=-N_{cp}}^{N-1} x_n\, \delta(t - nT_s)\right), \quad (2)$$

where Ncp is the cyclic prefix (CP) length. CP is useful to decrease ISI. The energy spectrum of x(t) is represented as

$$E(f) = \frac{L^2}{N}\left|H_I(f) \sum_{k=0}^{k=N-1} X_k \mathrm{sinc}L(f - f_k) e^{-j\pi(f-f_k)T_s(L-2N_{cp}-1)}\right|^2 \quad (3)$$

Where $L=N+N_{cp}$, $f_k=k/NTs$, $H_I(f)$ is Fourier transform of interpolation filter $H_I(t)$. The cummulative energy of the NC-OFDM signal can be deduce from the energy spectrum E(f) is given below

$$E_{total} = \int E(f)dt \quad (4)$$

We estimate the energy spectrum of the NC-OFDM signal by utilizing N_t likely distributed frequency samples, and the samples are $\{g_{m}{}_{m=1}^{Nt}\}$. We can show the summed-up energy and power of the signal given below

$$E_{Total} = \frac{L^2}{N}\Delta g \sum_{m=1}^{Nt}\left|HI(gm) \sum_{k=0}^{N-1} Xk\mathrm{sinc}L(gm - fk)e^{-j\pi(gm-fk)Ts(L-2Ncp-1)}\right|^2 \quad (5)$$

$$P_{Total} = \sum_{m=1}^{Nt}\left|HI(gm) \sum_{k=0}^{N-1} Xk\mathrm{sinc}L(gm - fk)e^{-j\pi(gm-fk)Ts(L-2Ncp-1)}\right|^2 \quad (6)$$

$$= \|S_t X\|_2^2$$

Where St is a Nt by N matrix

$$S_t = \begin{pmatrix} S(g1-fo)\; S(g1-f1) \ldots .S(g1-f_{(N-1)}) \\ S(g2-fo)\; S(g2-f1) \ldots .S(g2-f_{(N-1)}) \\ \cdot \\ \cdot \\ S(gNt-fo)\; S(gNt-f1) \ldots .S(gNt-f_{(N-1)}) \end{pmatrix} \quad (7)$$

Here, $S(g-f) = H_I(g)\mathrm{sinc}L(g-f)e^{-j\pi(g-f)Ts(L-2Ncp-1)}$, g_m and f_k are normalized frequency sample and normalized frequency in the the total measured range respectively. X is given by

$$X = [X_o\, xX_1 \ldots .. X_{N-1}]^T$$

OBP is defined as the power of signal in the null carriers' band. Suppose Ntp is the number of frequency samples with index Ko having null subcarriers spectrum and the total power of N_{tp} samples is OBP and can be implied as

$$P_{OBP} = \left\|S_{tp}X\right\|_2^2 \quad (8)$$

where S_{tp} is an out of band power matrix having dimension of $N_{tp} \times N$ and is estimated by get rid of the rows of St matrix hat are not includes in Ko. Let Nts is the number of samples with index K_I belongs to the active subcarrier spectrum, the total number of samples in the NC-OFDM signal can be given as $N_t = N_{tp} + N_{ts}$. The total power of these samples are termed as in band power (IBP) and defeined as

$$P_{IBP} = \|S_{ts}X\|_2^2 \quad (9)$$

$N_{ts} \times N$ is the dimension of in band power matrix S_{ts} and which is estimated by get rid of the rows of St matrix, which are not included in K_I. This spectrum is approximated using $N_t = 2048$ samples such way each subcarrier interval has 32 samples. As there are 48 active subcarriers, the total number of samples in the active subcarrier spectrum is $N_{ts} = 1536$ (48 × 32), with numbered set $K_I = \{1, 2, 3, \ldots, 512, 769, \ldots, 1280, 1537, \ldots, 2048\}$, and the total power of these samples denotes IBP. The other $N_{tp} = 512$ (16 × 32) samples out of 2048 moves to to the null subcarrier spectrum with numbered set $Ko = \{513, \ldots, 768, 1281, \ldots, 1536\}$. If we add up the power in these samples, we get the out of band power. Here, the NC-OFDM signal is oversampled with factor J times to get precise max voltage level and the PAPR of the signal. The oversampled NC-OFDM signal can given as

$$x[n] = x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{k=N-1} X_k e^{j2\pi\frac{kn}{NJ}}, \quad n = 0,1,2,..,JN-1 \quad (10)$$

Equation (10) is given in discrete-time baseband signal notation as

$$x = FX$$

where F is the inverse discrete Fourier transform (IDFT) matrix of dimension JN × N. We compute the max voltage level of the NC-OFDM signal as

$$\tau_{Peak} = \|FX\|_\infty \quad (11)$$

By limiting the Γ_{Peak} level, we can limit the max power of the NC-OFDM signal; hence peak to average power reduced. The PAPR is defined as

$$PAPR = \frac{Peak\ power}{Average\ Power} = \frac{max|x_n|^2}{E[|x_n|^2]} \quad (12)$$

generally, the oversampling factor J accepts an integer, such that J ≥ 4, to approximate PAPR, the method used in the study given by Liu and Dong [14], few subcarrier frequencies are distributed or varying weights to decrease PAPR and OBP, and this effects data speeds. All the null subcarrier frequecnies and some active subcarrier frequencies are allocated for these weights. The transmitter and receiver block diagrams for the presenting system are given in Figures 1 and 2, respectively as shown in the below.

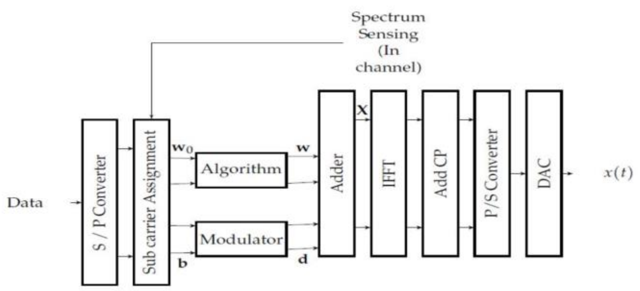

Figure 1: OFDM transmitter block Diagram

In the NC-OFDM system, typically, the modulated data vector d is connected to the IFFT block. However, in the presenting system, the modelled data is given to the IFFT block, as illustrated in Figure 1.

The frequency-domain representation of signal X is mentioned below as

$$X = d + w \quad (13)$$

D is the complex modulated data vector $d \in C^{Nx1}$ with non-zero element at D, such that

$$d[k] = \begin{cases} d_k, & k \in D, \\ 0, & othewise \end{cases} \quad (14)$$

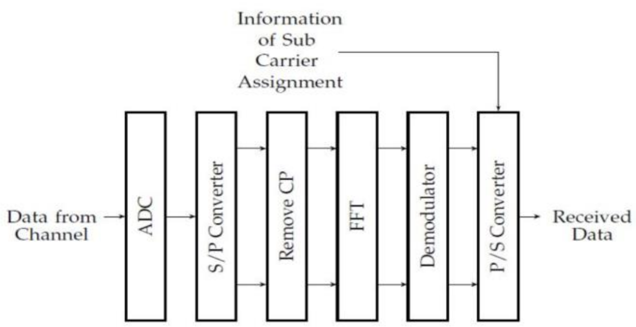

Figure 2: OFDM Receiver Block Diagram

where D is the index set of the NC-OFDM subcarrier frequencies that transport modulated data, where w is the complex weight vector w∈CN×1, with non-zero elements at W such that the IBP, peak amplitude and OBP of the NC-OFDM signal depend on X data, which is subjected to weight vector w. so, by varying the weight vector w, we can decrease the IBP, max amplitude and OBP of the NC-OFDM signal.

III. ALTERNATIVE PROJECTIONS ONTO CONVEX AND NON-CONVEX SETS(APOCNCS) ALGORITHM ALTERNATIVE PROJECTIONS

If all points lie on the line joining of two points in a set, present in the same set, then that set is called Convex set, otherwise which is a Non-Convex set Mathematically, convex set is defined as, Set A is convex if the line segment between any two points in A lies in A, i.e.$\forall x_1, x_2 \in A, \forall\theta \in [0,1]$

$$\theta x_1 + (1-\theta)x_2 \in C \quad (15)$$

Here two convex sets and one non-convex set defined based on the given constraints of the IBP, max amplitude, and OBP of the NC-OFDM signal, such that

$$A = \left\{X \middle| \left\|S_{tp}X\right\|_2^2 \le P_{OBP}, (I - I_w)X = d\right\} \quad (16)$$

$$B = \{X | \|FX\|_\infty \le \tau_{Peak}, (I - I_w)X = d\} \quad (17)$$

$$C = \{X | \|S_{ts}X\|_2^2 \ge P_{IBP}, (I - I_w)X = d\} \quad (18)$$

where $\Gamma Peak$ is the peak amplitude limit, PIBP is the IBP limit and POBP is the OBP limit. I is an identity matrix having dimensions N × N and I_w is an N × N diagonal matrix, defined as

$$I_w[i,j] = \begin{cases} 1, i \in W \\ 0, otherwise \end{cases} \quad (19)$$

where I_w is used to extract non-zero elements of w whose indexes are given in W vector.

$$W[k] = \begin{cases} w_k, & k \in W \\ 0, & otherwise \end{cases} \quad (20)$$

Here W is the index valued set of the NC-OFDM subcarrier frequencies that transport weights. The APOCNCS is such a useful algorithm that it modifies three parameters at a time. The projection operator of vector g onto non-convex or convex set S is mentioned as $\pi_s(g) = \arg min\|g - f\|_2$ where S is a non-convex or convex set. It is necessary to cautious in taking the limits of OBP, IBP and max amplitude, such that sets A, B, and C should not zero element sets i.e not empty. If the sets are empty the APOCNCS algorithm becomes infeasible, and we do not get the convergence for the algorithm. The projection onto convex set A operator is

$$\pi_A(X) = \arg\min\|X - X^1\|_2 \ \ X' \in A \quad (21)$$

The projection to the convex set A from vector X using mathematical notation given as

$$X = \pi_A(X) \quad (22)$$

The solution to Equation (22) can be obtained by solving the subsequent convex optimization problem which is equivalent to projection onto the set A.

$$\min_{X'} \|X - X'\|_2 \quad (22)$$

Subjected to : $\left\|S_{tp}X'\right\|_2^2 \le P_{OBP} \quad (23)$

$$(I - I_w)X' = d \quad (24)$$

The solution to Equation (26) can be estimated by resolving the subsequent convex optimization problem which is equivalent to projection onto the convex set A. The projection onto convex set B given as is

$$\pi_B(X) = \arg\min\|X - X^1\|_2 \ \ X' \in B \quad (25)$$

The projection onto convex set B from vector X can be modelled as

$$X = \pi_B(X) \quad (26)$$

The solution to Equation (31) can be estimated by solving the subsequent convex optimization problem which is equivalent to projection onto the convex set C.

$$\min_{X'} \|X - X'\|_2 \qquad (27)$$

Subjected to: $\|FX'\|_\infty \leq \tau_{Peak}$ (28)

$$(I - I_w)X' = d \quad (29)$$

The operator of the projection onto convex set C is

$$C(X) = \arg\min \|X - X^1\|_2 \;\; X' \in C \qquad (30)$$

The projection onto convex set C from vector X can be modelled as

$$X = \pi_C(X) \quad (31)$$

$\tilde{w}$ and $\tilde{w}^*$ are two $N_w \times 1$ column vectors that erases zeros in the w and w′, accordingly, and $N_w = |W|$, where |W| is the monominal of set w. For example, if w= [w_1 0 0 w_2] ^{T}, then $\tilde{w}$ becomes $\tilde{w}$ = [w1 w2]^T. The projection onto set C is equivalent to the subsequent optimization problem.

$$\min_{\tilde{w}'} \|\tilde{w} - \tilde{w}'\|_2 \qquad (32)$$

Subjected to: $\|S_{ts}T_w\tilde{w}' + S_{ts}d\|_2^2 \geq P_{IBP}$ (33)

Here T_w is an $N \times N_w$ dimensional matrix that retrieve w from $\tilde{w}$ as w=T_w $\tilde{w}$. For example, if w=[w_1 0 0 w_2]^T, then

$$T_w = \begin{pmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 1 \end{pmatrix}^T \qquad (34)$$

The Karush-Kuhn-Tucker (KKT) condition [14] of problem (33) and (35) is given as

$$2(\tilde{w} - \tilde{w}^*) + \lambda\left(2T_w^H S_{ts}^H (S_{ts}T_w\tilde{w}' + S_{ts}d)\right) \qquad (35)$$

where w˜ is the effective solution and λ is the dual variable w.r.t the in-band power limits. For given λ, the ˜w* can be estimated from (36) as

$$\tilde{w}^* = (I - \lambda T_w^H S_{ts}^H S_{ts} T_w)^{-1}(\tilde{w} + \lambda T_w^H S_{ts}^H S_{ts} d) \qquad (36)$$

To calculate the projected vector onto convex set C that has the required w can be explained by the following algorithm given as.

Algorithm:

1. 1.Initialize $\lambda \epsilon (0,1)$.
2. compute $\tilde{w}^*$ as per (36)
3. if $\|S_{ts}T_w\tilde{w}^* + S_{ts}d\|_2^2 \geq P_{OBP}$, is not met repeat the step 2 as long as the above equation converges
4. $w = T_w\tilde{w}^*$ *and* $X = d + w$.

Here the presenting APOCNCS algorithm, the starting projection is made onto non-convex set C, subsequently by projections onto convex sets B and A to finish a complete iteration. After completing some iterations, the claiming algorithm converges to limit cycle or vector point. The flow chart of the APOCNCS algorithm is presented in Figure 3. Here M is the number of constellation points in the modulation methodology. For instance, M is 4 for the quadrature phase shift keying (QPSK) modulation method. Simulations are performed to get BER.

$$PAPR = \frac{Peak\ power}{Average\ Power} = \frac{\|FX\|_\infty^2}{E[|FX|^2]} \qquad (37)$$

E[.] is the mean operator. CCDF is broadly employed for computing the peak to mean decrease performance.

$$CCDF = P_r\{PAPR > PAPR_0\} \qquad (38)$$

To assess BER, we considered (12) and (15). The signal is transmitted via AWGN channel. At the receiver end, the NC-OFDM system take out the modulated message data vector corresponding to d, and is demodulated to get binary data. We computed BER by set side by side transmitted and received bits.

The BER mathematical expression of the system is

$$P_e = Q\left(\sqrt{\frac{3E_b log_2 M}{N_0(M-1)}}\right) \qquad (39)$$

Here, M is the number of constellation points in the modulation method. To estimate the complexity of convex optimization problem on set C first as we make initial projection on to set C. The number of real multiplications required for convex optimization problem explains the complexity of projection onto the set C.

The convex optimization problem for projection on to convex set C is mentioned by the algorithm I that uses most acceptable weight vector w˜*given by equation (36). For computation of $(I - \lambda T_w^H S_{ts}^H S_{ts} T_w)$ requires $2N_w^2$ real multiplications. To compute its inverse additional $2N_w^3$ real multiplications is essential as per Cholesky decomposition given in [20]. The computation of $(\tilde{w} + \lambda T_w^H S_{ts}^H S_{ts} T_w d)$ requires $2N_w$ real multiplications, specified that $T_w^H S_{ts}^H S_{ts} d$is already calculated.The computation of $(I - \lambda T_w^H S_{ts}^H S_{ts} T_w)^{-1}(\tilde{w} + \lambda T_w^H S_{ts}^H S_{ts} T_w d)$ requires additional $4N_w^3$ real multiplications. If it requires K iterations for algorithm I to meet, then it will consider K ($2N_w^3$ + $6N_w^2$ +$2N_w$) real multiplications for the projection onto the convex set C. presume that

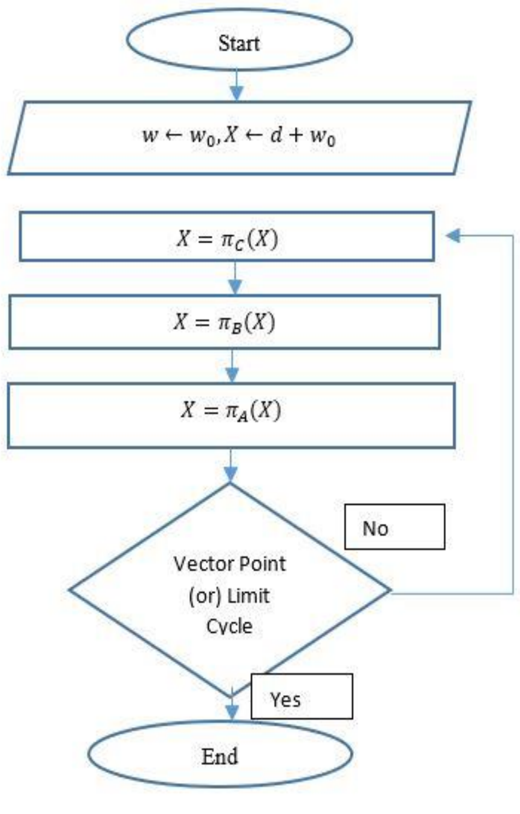

Figure 3: Algorithm flow chart

$(I - \lambda T_w^H S_{ts}^H S_{ts} T_w)^{-1}$ is previously calculated and conserve with a set of λ's. Then the number of real multiplications essential is given as $K(4N^2_w + 2N_w)$.The complexity of the projection onto convex set C is $O(N2_w)$. The projection onto the set B and onto the set A requires convex optimization tools. It normally has more complexity and is very complex to estimate [18]. The complexity view given in [17], [22], complexity of convex optimization problem to the projection onto the set B is also mentioned like a Second Order Cone Program (SOCP), then it's complexity is given as $O(N^3)$ along with IIFT operation has complexity of O(JNlogJN). The total complexity now is $O(N^3 + JNlogJN)$. The projection onto convex set A defined by the equations (23), (24), (26) is equal to the algorithm 3 presenting in [18]. The algorithm 3 has complexity likely to the complexity of projection onto convex set C. Finally the conclusion is APOCNCS algorithm has more complexity than the existing algorithms.

IV. SIMULATION RESULTS

NC-OFDM system is modeled with 64 sub carriers. The Quadrature phase shift keying (QPSK) is carrie out to modulate the binary data. Here we considered Nt = 2048, Nts = 1536, Ntp = 512 and Ncp = 16. Null carriers are used for weight varying purpose, while computing the PAPR, the oversampling factor value J = 4, and the weights are started from zero. Four repetitive iterations are taken into the account for the APOCNCS algorithm. BER performance of the defined model is computed via MATLAB and CVX tool simulations under AWGN channel properties.

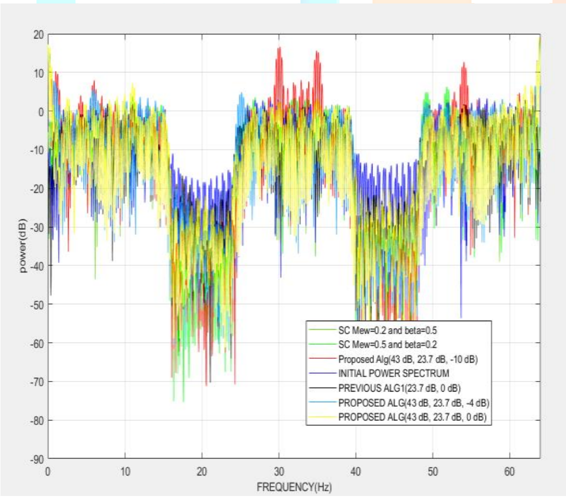

Figure 4: Power Spectral density of NC-OFDM for various algorithms

Two convex optimization algorithms are mentioned in this paper proposed by Liu and Dong [14] for reducing the OBP and PAPR simultaneously, but only one parameter at a time reduced greatly. In the algorithm 1, OBP is decreased in the wish trend, but PAPR curve trend follows such that at starting PAPR curve for 23.7 dB, 0 dB and 23.7 dB, −4 dB, so, the PAPR decreased performance is not fair as expected. In algorithm 2, the PAPR decrease is not up to the mark at a CCDF of 10^{-1}, as the curve trend follows the starting PAPR curve, and decrease is fair after that. However, the limit 23.7 dB, −4 dB has returned poor results for the decrease of out of band power, which are presented in Figures 6 and 7. generally, there is a deal between the OBP and PAPR, it means when one tries to reduce OBP, PAPR may increase and converse also. so we have to set the limits of PAPR to below 23.7 dB, PAPR will decrease, but OBP will improve at the same time when try to reduce the out of band power from 0 dB to − 4 dB, see Figure 6 for the limits 23.7 dB, 0 dB and −4 dB's. The proposed algorithm named APOCNCS that decreases both PAPR and OBP parallelly. For the limits 43 dB, 23.7 dB, 0 dB, the claiming algorithm decreases peak to mean power from 10.85 dB to 8.45 dB, out of band power from 10.8 dB to 0 dB, for the CCDF of 10−3. At the same limits(23dB, 0dB) the previous algorithm 1 decreases peak to mean power from 10.85 dB to 9.63 dB, OBP from 10.8 dB to 0 dB for the same CCDF value. It is evident that the presenting algorithm gains almost 1.2 dB improvement in PAPR compared that of the previous algorithm 1. Further, we conclude that for the limit 43 dB, 23.7 dB, 0 dB, the decrease of peak to mean power is higher that of previous algorithms up to a CCDF of 10−2.

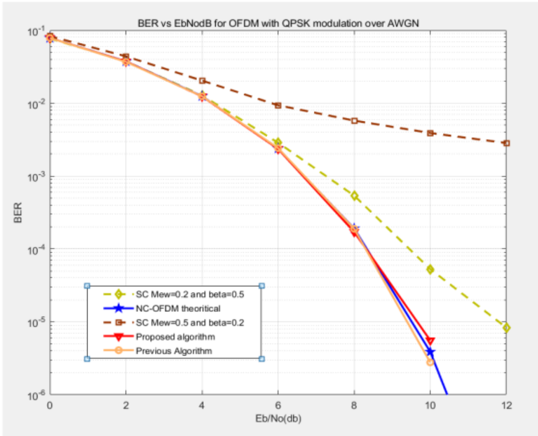

Figure 5: BER performance of NC-OFDM system

The previous and the presenting methodologies are compared in the Tables 1 and 2. Further when we decrease OBP to − 10 dB with the presenting algorithm for limits 43 dB, 23.7 dB, −10 dB in Figure 7, we got good reduction in PAPR observe the results in Figure 7. It means the proposing algorithm shows the superior results that of algorithm 1 for the given limits 23.7 dB, 0 dB and −4 dBs. The presenting algorithm gains a favorable trade between PAPR and OBP than the previous algorithms. The APOCNCS also compared with the single carrier methodology for various β and μ values. The PAPR decrease of SC methodology gains when the power of the single carrier methodology increases, that is, when μ increases and the out of band power reduces as β lowers. When we have taken a high μ=0.5 value and lower β=0.2 value, for which both PAPR and OBP reduction performance would be good. It is observed that the reduction in performance of the SC method is comparable in OBP and is good in PAPR when collate with that of APOCNCS for the limits 43 dB, 23.7 dB, 0 dBs. The BER performance is degraded: For lower decrease the performance of the SC method for μ = 0.2 and β = 0.5, the reduction of BER performance is less but weak as OBP and PAPR reduction performance improves. The claiming algorithm does not modify the modulated message data. So, the BER curve go around with the theoretical values of the NC-OFDM system. The respective simulation results are given in Figure 5. The power spectrum of the NC-OFDM signal for the SC, the previous and proposed algorithms are given in Figure 4. Using new SLM algorithm the reduction in PAPR is better to the existing algorithms as mentioned in the fig.7.

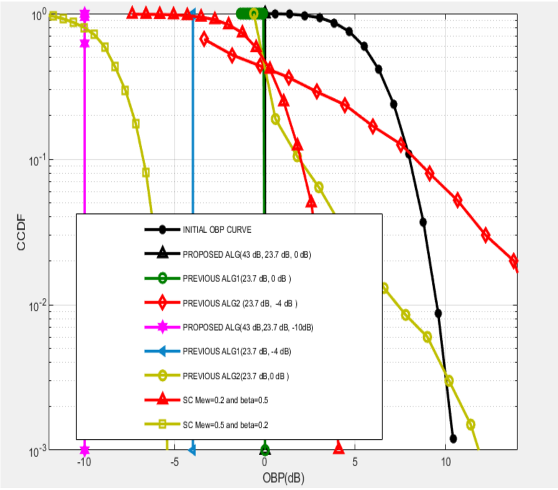

Figure 6: CCDF verses OBP (dB) simulations

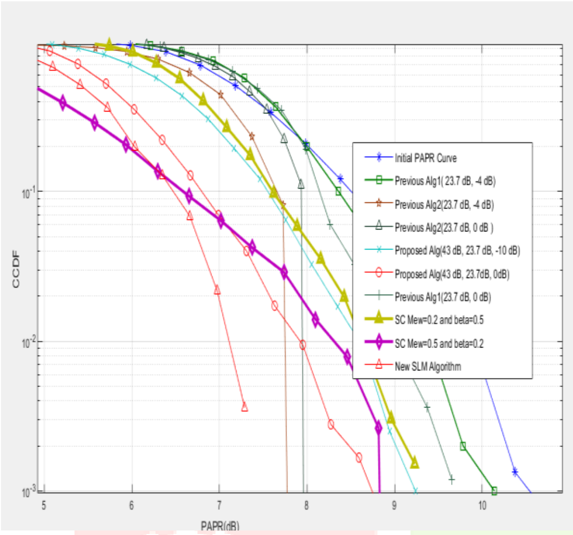

Figure 7: CCDF verses PAPR (dB) simulations

The new SLM algorithms provides better PAPR results compare to the others as mentioned in the fig.7 but the OBP results will deviate from the desire level the same work is going on to improve the OBP power reduction using new SLM and other convex optimization ways to improve the simultaneous reduction PAPR and OBP power. Nearly 1.3dB better reduction is obtained from the new SLM algorithm for PAPR reduction.

The obtained results are tabled in the Table 1 and Table 2.

Table 1: CCDF verses OBP (dB) observation Table

CCDF	10^{-1}	10^{-2}	10^{-3}
Initial OBP values (dB)	8	9.5	10.8
Existing Alg1(23.7 dB,0 dB)	0	0	0
Existing Alg1(23.7 dB,−4 dB)	-4	-4	-4
Existing Alg2 (23.7 dB, 0 dB)	3.5	7	12.3
Existing Alg2 (23.7 dB, −4 dB)	7.5	16	17.8
SC (μ = 0.2, β = 0.5)	2.3	3	4
SC (μ = 0.5, β = 0.2)	−7.3	−6	−5.5
Proposed Algorithm (43 dB, 23.7 dB, 0 dB)	0	0	0
Proposed Algorithm (43 dB, 23.7 dB, −10 dB	−10	−10	−10

Table 2: CCDF verses PAPR(dB) observation Table

CCDF	10^{-1}	10^{-2}	10^{-3}
Initial PAPR values (dB)	8.6	9.8	10.85
Existing Alg1 (23.7 dB,0 dB)	8.15	8	9.63
Existing Alg1 (23.7 dB, −4 dB)	8.4	9.2	10.1
Existing Alg2 (23.7 dB, 0 dB)	7.9	7.95	8
Existing Alg2 (23.7 dB, −4 dB)	7.6	7.75	7.79
SC (μ = 0.2, β = 0.5)	7.6	8.7	9.3
SC (μ = 0.5, β = 0.2)	6.6	7.9	8.85
Proposed Alg(43 dB,23.7 dB, 0 dB)	6.8	7.86	8.45
Proposed Alg (43 dB, 23.7 dB, −10 dB)	7.5	8.6	9.15

V. CONCLUSION

In this paper, the proposed algorithm which can simultaneously reduce the PAPR and OBP, instead of the two POCS algorithms mentioned in the various literature. From the MATLAB simulation results, we observe that there is good decrease of 2.2 dB in PAPR and 10.8 dB decrease in OBP at a CCDF value of 10−3 in the presenting algorithm for the given limits 43 dB, 23.7 dB and 0 dB set side by side to starting PAPR and OBP curves. Thus got good reduction gain performance in both PAPR and OBP. Thus, we can obtain a notable trade-off between PAPR and OBP reduction. Proposed algorithm does not modify the modulated data. since the BER curve stick to the theoretical curve of the NC-OFDM.The computational complexity of the algorithm is high collated to the given previous algorithms mentioned here. If there is a joining among the convex sets, the algorithm meets same limits of OBP, max amplitude, and IBP. Here, we modified the three parameters of the NC-OFDM signal using the APOCNCS algorithm to decrease OBP and PAPR parallelly. The New SLM algorithms for PAPR reduction is better and the out of band power reduction is planned for future activity.

REFERENCES

[1]. B. Wang and K. J. R. Liu, Advances in cognitive radio networks: a survey, IEEE J. Selected Topics Signal Process. 5 (2011), no. 1, 5–23.

[2]. H. Yamaguchi, Active interference cancellation technique for MB-OFDM cognitive radio, in Proc 34th Eur. Microw. Conf. (Amsterdam, The Netherlands), Oct. 2004, pp. 1105–1108.

[3]. 3 J. Zhang et al., Sidelobe suppression with orthogonal projection for multicarrier systems, IEEE Trans. Commun. 60 (2012), no. 2, 589–599.

[4]. 4 D. Qu, Z. Wang, and T. Jiang, Extended active interference cancellation for sidelobe suppression in cognitive radio OFDM systems with cyclic prefix, IEEE Trans. Veh. Technol. 59 (2010), no. 4, 1689–1695.

[5]. 5. R. Xu, H. Wang, and M. Chen, On the out-of-band radiation of DFT based OFDM using pulse shaping, in Proc. Int. Conf. Wireless Commun. Signal Process. (Nanjing, China), Nov. 2009, pp. 1–5.

[6]. 6. W. C. Chen and C.-D. Chung, Spectral precoding for cyclic-prefixed OFDMA with interleaved subcarrier allocation, IEEE Trans. Commun. 61 (2013), no. 11, 4616–4629.

[7]. 7. I. Gutman, I. Iofedov, and D. Wulich, Iterative decoding of iterative clipped and filtered OFDM signal, IEEE Trans. Commun. 61 (2013), no. 11, 4284–4293.

[8]. 8. L. Li and D. Qu, Joint decoding of LDPC code and phase factors for OFDM systems with PTS PAPR reduction, Trans. Veh. Technol. 62 (2013), no. 1, 444–449.

[9]. 9. B. Krongold and D. Jones, Par reduction in OFDM via active constellation extension, IEEE Trans. Broadcast. 49 (2003), no. 3, 258–268.

[10]. H. Li, T. Jiang, and Y. Zhou, An improved tone reservation scheme with fast convergence for PAPR reduction in OFDM systems, IEEE Trans. Broadcast. 57 (2011), no. 4, 902–906.

[11]. A. Ghassemi et al., Joint sidelobe and peak power reduction in OFDM-based cognitive radio, in Proc. IEEE 72nd Veh. Technol. Conf. Fall (Ottawa, Canada), Sept. 2010, pp. 1–5.

[12]. . C. Ni, T. Jiang, and W. Peng, Joint PAPR reduction and sidelobe suppression using signal cancellation in NC-OFDM-based cognitive radio systems, IEEE Trans. Veh. Technol. 64 (2015), no. 3, 964–972.

[13]. A. I. Zak et al., Joint PAPR reduction and sidelobe suppression in NC-OFDM based cognitive radio using wavelet packet and SC techniques, Phys. Commun. 35 (2019), 1–9.

[14]. Y. Liu and L. Dong, Iterative reduction of out-of-band power and peak-to-average power ratio for non-contiguous OFDM, systems based on POCS, IEICE Trans. Commun. E100–B (2017), no. 8, 1489–1497.

[15]. S. Boyd and L. Vandenberghe, Convex Optimization, Cambridge University Press, 2004.

[16]. A. Krishnamoorthy and D. Menon, Matrix inversion using Cholesky decomposition, in Proc. Signal Process.: Algorithms, Architectures, Arrangements, Applicat. (Poznan, Poland), Sept. 2013, pp. 70–72.

[17]. H. H. Bauschkey and J. M. Borweiny, On projection algorithms for solving convex feasibility problems, SIAM REV. 38 (1996), 367–426.