



# PAPR REDUCTION USING EIGHT FACTORS ROTATING PHASE SHIFT TECHNIQUE BASED ON LOCAL SEARCH ALGORITHM IN OFDM

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## ABSTRACT

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Orthogonal frequency division multiplexing (OFDM), Multi-Carrier (MC) system, is a popular standard in wireless communication for its enabling high throughput data transfer. However, the MC signal usually has a high peak-to-average power ratio (PAPR), which involves a wide-dynamic-range, power consuming amplifier. Whenever the signal height is greater than the amplified linear region, the signal is distorted. In this paper, propose a novel scheme that rotating phase shift (RPS) technique based signal scrambling is proposed to reduce PAPR in OFDM systems. In addition, the pilot phase signal is picked out by RPS technique applied new algorithm the local research to alleviate scrambling information corruption and show discernible advancements. So, our technique improves over the existing ones in the same category. The transmitted signal of OFDM is tested with Mobile WiMAX IEEE 802.16e standard, that compared the various phase shift with a slight computational complexity is studied. The simulation result shows that original signal at pilot-assisted QAM is capable of bringing down the electrical PAPR by about 3.5 times as a modest complementary cumulative distribution function (CCDF) point of  $10^{-3}$  for  $M=8$  low complexity. In addition, the best phase-shift factor was selected to reduce the monetary value of computational complexity.

**Contribution/ Originality:** The paper contributes the first logical analysis eight factors rotating phase shift (RPS). The proposed method is applied local research algorithms to reduce peak-to-average power ratio based on OFDM.

## 1. INTRODUCTION

OFDM is an attractive multicarrier modulation technique candidate for high bit rate digital video broadcasting and wireless communication systems. In OFDM, the effects of multipath delay spread can be easily minimized through multiple frequency bands, which provide high power efficiency, high spectral efficiency, low inter-symbol interference, and immune-selective frequency fading. However, PAPR remains a challenging issue in OFDM systems [1]. Lately, many PAPR techniques have been reported by researchers to describe its CCDF, which mainly can be categorized into signal scrambling techniques [2] can be classified to three techniques: selective mapping

(SLM) [3] permutation [4] and partial transmission sequence (PTS) [5]. PTS and SLM are examples of the probability scheme because the pulse sequences are generated and reproduced by the input symbol vectors in which the best candidate signals will be selected to minimize PAPR in the frequency domain [5]. The exhaustive search of phase factors using conventional PTS scheme leads to sub-block increases in terms of multiplications and complex additions.

A program to reduce PAPR has been suggested [6] in which the succession of phase shift is periodical, with a low complexity, and to reduce the PAPR, the same procedure is used as in the C-PTS. In Yang, et al. [7] the authors suggested a new method of low-complexity PTS, which involves the transformation sequence time-domain league and combine them, thereby reducing the computational complexity. In Sahoo and Patra [8] the phase already working on the C-PTS factors are taken out, along with the introduction of the periodic way each time without block specific degree symbol and transformation circular movable part quadrature phase components. This method reduces the computational complexity in addition to a decrease in the height of the average power ratio when compared to the tubes with colorful images. For the PTS system, the phase shift multipliers are given only to the subcarriers between pilot subcarriers including the auxiliary subcarrier. The initial values of auxiliary subcarriers are one after the PAPR reduction process will proceed to the phase shift multiplier of the consistent partition. A complex modulation scheme can be employed on the auxiliary subcarriers to transmit the phase shift information instead of the simple multiplication. In addition, For the SLM system, the auxiliary subcarriers carry information about the scrambling code. The code has created such that the values at the pilot subcarriers are unity and the values at the auxiliary subcarriers from an information sheet. This means that information extracted from the auxiliary subcarriers uniquely determines which code was used. In addition, binary symbols and BPSK modulation are used on the auxiliary subcarrier to minimize the error on code retrieval.

For the proposed RPS system, it is not necessary to hold a side information channel. The auxiliary subcarriers are used as extra pilots to enhance channel estimation when channel estimation is required. On the other hand, the pilot and auxiliary subcarriers are used together to autonomously recover the phase break when the receiver has channel state information. Since there is no addition or alteration of the signal after PAPR reduction, there will be no peak regrowth. To have a fair evaluation of all PAPR reduction systems and the original system, the number has set of data-bearing subcarriers to be equal and measure the BER of each organization. The auxiliary pilots are used for channel estimation when they are not required for transporting scrambling information.

## 2. THEORETICAL BACKGROUND

### A. OFDM Signal Characteristics

An OFDM symbol is made of subcarriers modulated by constellation mapping. This mapping can be achieved from phase-shift keying (PSK) or quadrature amplitude modulation (QAM). For an OFDM system with  $N$  subcarriers, the high-speed binary serial input stream is denoted as  $\{a_i\}$ . After a serial to parallel (S/P) conversion and constellation mapping, a new parallel signal sequence  $\{d_0, d_1, d_2, \dots, d_i, \dots, d_{N-1}\}$  is obtained;  $d_i$  is a discrete complex-valued signal [9]. Here,  $d_i \in \{\pm 1\}$  when BPSK mapping is adopted. When QPSK mapping is used:  $d_i \in \{\pm 1, \pm i\}$ . Each element of the parallel signal sequence is supplied to  $N$  orthogonal subcarriers  $\{e^{j2\pi f_0 t}, e^{j2\pi f_1 t}, \dots, e^{j2\pi f_{N-1} t}\}$  for modulation, respectively. Finally, modulated signals are added together to

form an OFDM symbol. Use of discrete Fourier transform simplifies the OFDM system structure. The complex envelope of the transmitted OFDM signals can be written as:

$$x(t) = \sum_{k=0}^{N-1} X[k] e^{(j2\pi k \Delta f t)} \quad 0 \leq t \leq NT \quad (1)$$

Each OFDM subcarrier uses a bandwidth  $\Delta f$  so small that the frequency response can be assumed to be constant for that subcarrier. Signals with large  $N$  become Gaussian distributed with probability density function (PDF) given by Foschini and Gans [10].

$$Pr\{x(t)\} = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{x(t)^2}{2\sigma^2}} \quad (2)$$

Where, standard deviation  $\sigma, \sigma^2$  is the variability of  $x(t)$ .

### B. PAPR in OFDM

Remains until now, several challenging problems remain unsolved in the design of the OFDM systems. One of the major problems is high PAPR of transmitting OFDM signals. So, the OFDM receiver's detection efficiency is really sensitive to the nonlinear devices used in its signal processing loop, for example, High Power Amplifier (HPA) and, Digital to Anlage Converter (DAC) which may severely impair system performance due to induced spectral regrowth and detection efficiency degradation. Such as, most radio systems employ the HPA in the sender to obtain sufficient transmits power and the HPA are generally operated at or near the saturation region to achieve the maximum output power efficiency, and hence the memoryless nonlinear distortion due to high PAPR of the input signals will be introduced into the communication channels. If the HPA has not functioned in the linear region with large power back-off, it is impossible to keep the out-of-band power below the specified limits. This situation contributes to very expensive transmitters and inefficient amplification [2]. Consequently, it is significant and compulsory to study the characteristics of the PAPR including its reduction and distribution in OFDM systems, so that utilize the technical features of the OFDM. Basically, the definition describes PAPR as the ratio of peak power to the average power of the signal and it can be written as:

$$PAPR = \frac{P_{peak}}{P_{average}} = \frac{\max_{0 \leq n \leq kr-1} |x|^2}{E\{|x|^2\}} \quad (3)$$

Where,  $P_{peak}$  represents peak output power,  $P_{average}$  means average output power,  $E\{.\}$  denotes expectation.

Especially, a baseband OFDM signal with  $N$  subcarrier has:

$$PAPR_{max} = 10 \log_{10}(N) \text{ (dB)} \quad (4)$$

PAPR cannot be calculated directly from the sampled signal  $x$  in Eq. (3), because the tops of the signal may be present between sampling times. There is thus a need to over sampling with excessive biggest factor than or equal to four to estimate PAPR [11]. Sequence of samples with excessive factor  $R$  can be expressed as:

$$X[n] = \sum_{k=0}^{[N/2]-1} X[k] e^{j2\pi kn/NR} \sum_{k=\frac{N}{2}}^{N-1} X[k] e^{\frac{j2\pi(NR-N+k)n}{NR}}, n = 0, 1, \dots, NR - 1 \quad (5)$$

Let  $\mathbf{x} = [x_0, \dots, x_{NR-1}]$ , then the PAPR can be approximated as:

$$PAPR \approx \frac{\|\mathbf{x}\|_2^{\infty}}{\|\mathbf{x}\|_2^2/(NR)} \quad (6)$$

This Eq. (3) to find PAPR with an oversampling factor  $R = 8$  in all cases because it is a good compromise between computational cost and accuracy.

As one of the characteristics of the PAPR, the distribution of PAPR, which bears stochastic characteristics in OFDM systems, often can be expressed in terms of Complementary Cumulative Distribution Function (CCDF). Recently, some researchers reported on the determination of the PAPR distribution based on different theories and hypotheses. The probability that the PAPR of a data block exceeds a given threshold  $s$  is calculated by Monte Carlo Simulation [12] as:

$$P(PAPR > s) = 1 - P(PAPR \leq s) = 1 - (1 - e^{-s})^N \quad (7)$$

Where the CCDF for an OFDM system having Rayleigh distribution is given as:

$$F(s) = 1 - e^{-s} \quad (8)$$

Simultaneously of the characteristics of the PAPR, which bears stochastic characteristics in OFDM systems, often can be expressed in terms of CCDF. There are many PAPR reduction techniques, which are well summarized in Lim, et al. [2]. PAPR reduction methods can be classified into four categories:

### C. PAPR Reduction Signal-Scrambling Methods

This is mainly classified into three schemes: PTS, SLM, and permutation method.

**The PTS approach** reduces the PAPR; the PTS method partitions a set  $k$  of subcarriers into  $P$  disjoint subcarrier subsets  $k_p, p = 1, \dots, P$  such that  $\bigcup_{p=1}^P k_p = k$ . Then, PTS finds multipliers  $b_p [p]$  for each subset such that it has a low PAPR [5].

$$\tilde{\mathbf{x}}(t) = \sum_{p=1}^P b_p [p] \sum_{k \in M/m} X[k] e^{i2\pi \Delta f t} \quad (9)$$

There are many studies to determine the best partitioning policy: contiguous, interleaving, and random. The random one works best and the interleaving is the worst. Even though the  $b_p [p]$  can be any value, practically we set  $|b_p [p]| = 1, \forall p$  i.e., shift only the phase of each partition. Despite PAPR reduction capability gains as the number of partitions increases, the computational complexity grows exponentially in  $P$  with exhaustive search for the best  $b_p [p]$ . The method has lowered complexity by reducing the number of FFT calculations without sacrificing PAPR reduction capability [5].

The SLM method resembles PTS but instead of subcarrier partitioning, SLM uses predetermined codes  $C_m = [C_m[0]C_m[1] \dots C_m[N-1]]^T, m = 1, 2, \dots, M$  multiplying the data. The signal with the lowest PAPR is selected and transmitted [3].

$$\tilde{x}^m(t) = \sum_{k=0}^{N-1} C_m[k]X[k]e^{i2\pi\Delta f t}, m = 1, 2, \dots, M \quad (10)$$

Although there are infinitely many possibilities for the multipliers, in practice the transmitter and receiver must agree on a finite number of sets of multipliers beforehand. The transmitter then selects the  $C_m$  that minimizes the PAPR of the signal. SLM can be viewed as PTS with random partitioning.

The permutation method [4] and the selective-scrambling method are similar. Let  $X = [X_0X_1 \dots X_{N-1}]^T$  be a data vector to be modulated. The interleaving method uses permutation functions  $\pi_m : k \rightarrow K, m = 1, 2, \dots, M$  to generate a vector  $X^{(m)} = [X_{\pi_m(0)}X_{\pi_m(1)} \dots X_{\pi_m(N-1)}]^T$ . The selective-scrambling method uses  $M$  scramblers whose parameters are distinct to permute the data vector  $X$  to get  $X^{(m)}$ . These parameters must be uniquely determined by an indicator, so the receiver knows which set of parameters to be used for descrambling. Finally, both methods calculate  $x^{(m)}(t) = IDFT(X^{(m)})$ , and transmit  $x^{(m)}(t)$  with the lowest PAPR.

In all methods, the transmitter must send information about the scrambler, the set of  $\{b_p[p] : p = 1, \dots, P\}$  for PTS,  $C_m$  for SLM,  $\pi_m$  for the interleaving method, and the indicator for the selective-scrambling method to the receiver so that the original data can be retrieved. If both the transmitter and receiver predetermine the set of scramblers, the transmitter can just send the index of the active scrambler. If the cardinality of the scrambler set is  $M$ , side information of  $\lceil \log_2 M \rceil$  bits are needed to convey the scrambling information, thus reducing the effective data rate. This scrambling information creates new concerns. First, the subcarriers carrying the scrambling information may cause the peaks to regrow. Second, corruption of scrambling information of even a single bit will lead to detection error on multiple data bits or even an entire symbol. Thus, the scrambling information needs a robust ECC, which results in even more data rate loss.

### 3. PROPOSED ROTATING PHASE-SHIFT TECHNIQUE

The RPS method is a difference of signal scrambler through the use of a set of multipliers to reduce the PAPR of a signal prior to applying it to the amplifier as shown in Fig. 1. Let  $S_C(f)$  be the frequency response of a scrambling filter such that  $S_C[k] = S_C(k\Delta f)$  for  $k = 0, \dots, N-1$ ,  $\tilde{x}(t)$  represents the transmitted OFDM signals, which are obtained by taking IFFT operation on modulated input symbols  $X[k]$ .  $\tilde{x}(t)$  is expressed as:

$$\tilde{x}(t) = \sum_{k=0}^{N-1} S_C[k]X[k]e^{j2\pi k\Delta f t} \quad (9)$$

All scrambling techniques endeavor to find  $S_c$  that reduces the PAPR of  $\tilde{x}$  when compared with that of  $x$ . The RPS method first partitions the bandwidth such that the subcarriers in each segment are contiguous, and then finds a continuous  $S_c(f)$  that minimizes the PAPR of  $\tilde{x}$ .

While the number of subcarriers in each partition has necessarily been equal, we equally partition the bandwidth to simplify the problem. Yet this problem is hard since we have to solve two problems simultaneously: Minimize  $|\tilde{x}|^\infty$ , and Maximize  $|\tilde{x}|^2$  as clearly shown in Eq. (6). Solving the first problem alone yields  $S_c(f) = 0, \forall f$  as a trivial optimal solution. Therefore, we further enforce two constraints at first step set  $|S_c(f)| = 1, \forall f, i. e., S_c(f) = e^{j\theta(f)}$ . Then, the PAPR minimization is simplified to minimize  $|\tilde{x}|^\infty$ , since  $1/T \int_0^T |\tilde{x}(t)|^2 dt = \sum_k |S_c[k]X[k]|^2 = \sum_k |X[k]|^2$  by Parseval's equation. Moreover, as a second step, enforce  $\theta(f)$  to be a piecewise linear function of  $f$  and requiring that the rotate phase changes in a partition,  $\theta(f_{p1}) - \theta(f_{p2})$ , be restricted to a small number of values, where  $f_{p1}$  and  $f_{p2}$  are the frequencies of the subcarriers at the partition boundaries.

The second constraint makes the solution of the problem searchable. Finding  $S_c(f)$  using the above method has many advantages. First, it needs low computation at the transmitter to find  $S_c(f)$  and at the receiver to estimate the transfer function,  $\tilde{S}_c(f)$  and the amplifier input,  $F^{-1}\{S_c(f)X(f)\}$ , has reasonably low PAPR. Finally, the receiver can utilize the existing channel estimator to equalize the effect of RPS mechanism and recover the original signal. In other words, no explicit scrambling information has to be sent to the receiver.

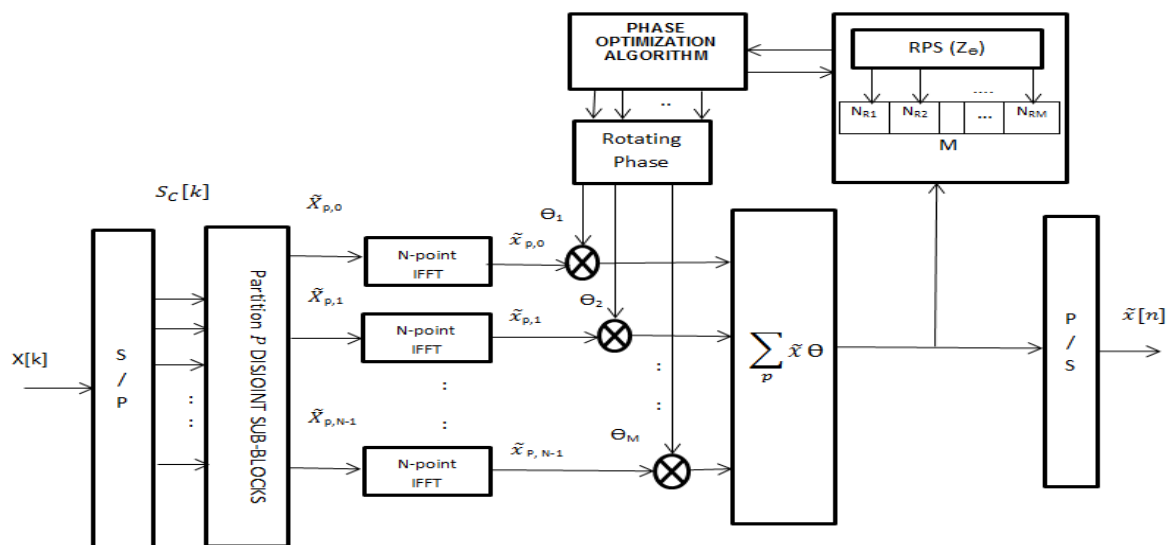


Figure-1. OFDM with RPS PAPR reduction

The proposed search algorithms, is used to find the minimum PAPR signal. This algorithm requires  $P \cdot N_R$  iterations. Though, any iteration of the algorithm does IFFT only on  $N/P$  subcarriers and costs  $C_O((\frac{N}{P}) \log(\frac{N}{P}))$ .

Where, let  $X$  be the OFDM signal with  $N$  the total number of subcarriers and  $\varphi = \{\varphi_1, \varphi_2, \dots, \varphi_M\}$  be a set of valid phase shifts. It splits  $X$  into  $P$  each of which has  $k$  subcarriers so that  $N = P \cdot k$ . Search is a strategy that works well on optimization problems with the minimize PAPR, the search algorithm for the OFDM signal to minimize PAPR shown in Algorithm 1.

**Algorithm 1: Local Search**

- **Let:**  $\theta = \{\theta_1, \theta_2, \dots, \theta_P\}$  be phase at partition limit.
- **Require:**  $X > 0, P > 0, k > 0, \varphi > 0$ ;
- **Initalize:**  $x_{op}(t) = X[0]$ ;  $\theta = \varphi_M, R_m = 0$ .
- **For**  $p = 1:P$  **do**

$$X_p[n] = \begin{cases} X[n], & n = r_{p-1} + 1, \dots, r_p \\ 0, & \text{otherwise} \end{cases}$$

- **For**  $m=1:M$  **do**

$$R_{m+1} = R_m + \frac{(r_p + 1)(r_{p-1})}{2}$$

$$X_p^m[n] = X_p[n] e^{j(\theta_p + \frac{R_m}{R_{m+1} - R_m}) \varphi_m};$$

- **IF**  $n < r_p$  **then**

$$x_0^m(t) = \text{ifft}(X_p^m)$$

- **Else empty**  $R_{m+1}$  , *otherwise*  $n$
- **End**

$$m_{op} = \text{argmin}_{m=1:M} (\text{Max}_{0 \leq t \leq \tau} (|x_{op}(t) + x^m(t)|));$$

$$x_{op}(t) = x_{op}(t) + x^{m_{op}}(t);$$

$$\theta_p = \theta_{p-1} + \varphi_{mop};$$

- End
- Return  $x_{op}(t), \theta, R_m$

#### 4. ROTATING PHASE-SHIFT PARAMETERS

In this section, there are considered the factors that contribute to the PAPR reduction performance of RPS. Let  $N_R$  be the number of valid phase shifts,  $\xi$  the rotating factor,  $R_{ph}$  the rotation of a range of possible phase shifts,  $M$  the maximum number of division phase shift, and  $Z_\emptyset$  the step size of the phase shifts.  $Z_\emptyset$  is split into eight sections are measured circle  $2\pi$  as show Figure 2. Phase delay values for RPS algorithm are in  $(R_{ph}, 0)$ . As a zero phase shift is always one of the valid phase shifts, the relationship of these factors can be defined as:

$$\left(1 - \frac{\xi^{2N_R}}{N_R}\right) Z_\emptyset = R_{ph} \tag{10}$$

Where,  $N_R = 1, 2, 3, 4, 5, 6, 7, 8$  and  $\xi = +j, -j, +1, -1, M = 8$ , it can be illustrated calculating the previous equation, taking into account all or most of the possible cases according to the following tables. In the general without a phase shift shown in Table 1. Also, the Table 2 achieves the same situation, but when  $\xi = +1, -1$ . Thus, the tables turn most of the other cases also with phase shift e.g.  $-\pi/8$  as shown in Table 3.

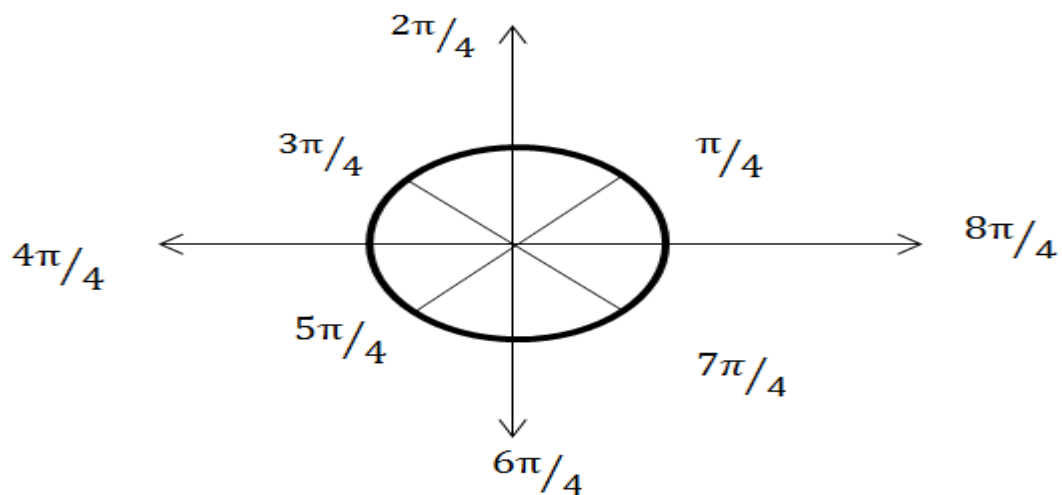


Figure-2. Rotate magnitude constant  $\xi$ ,  $M=8$ .



Table-A.1. Phase lags ( $R_{ph}$ ) at  $\xi = \pm j$

| $N_R$ | $Z_\phi$  |           |            |          |            |            |            |          |
|-------|-----------|-----------|------------|----------|------------|------------|------------|----------|
|       | $\pi/4$   | $\pi/2$   | $3\pi/4$   | $\pi$    | $5\pi/4$   | $3\pi/2$   | $7\pi/4$   | $2\pi$   |
| 1     | $\pi/2$   | $\pi$     | $3\pi/2$   | $2\pi$   | $5\pi/2$   | $\pi$      | $3\pi/2$   | $2\pi$   |
| 2     | $\pi/8$   | $\pi/4$   | $3\pi/8$   | $\pi/2$  | $5\pi/8$   | $3\pi/4$   | $7\pi/8$   | $\pi$    |
| 3     | $\pi/3$   | $2\pi/3$  | $\pi$      | $4\pi/3$ | $5\pi/3$   | $2\pi$     | $\pi/2$    | $2\pi/3$ |
| 4     | $3\pi/16$ | $3\pi/8$  | $9\pi/16$  | $3\pi/4$ | $15\pi/16$ | $9\pi/8$   | $21\pi/16$ | $3\pi/2$ |
| 5     | $3\pi/10$ | $6\pi/10$ | $9\pi/20$  | $6\pi/5$ | $3\pi/2$   | $9\pi/5$   | $\pi/10$   | $2\pi/5$ |
| 6     | $5\pi/24$ | $5\pi/12$ | $5\pi/8$   | $5\pi/6$ | $25\pi/24$ | $5\pi/4$   | $35\pi/24$ | $5\pi/3$ |
| 7     | $2\pi/7$  | $4\pi/7$  | $6\pi/7$   | $8\pi/7$ | $10\pi/7$  | $12\pi/7$  | $2\pi$     | $2\pi/7$ |
| 8     | $7\pi/32$ | $7\pi/16$ | $21\pi/32$ | $7\pi/8$ | $35\pi/32$ | $21\pi/16$ | $49\pi/32$ | $7\pi/4$ |

Table-A.2. Phase lags ( $R_{ph}$ ) at  $\xi = \pm 1$

| $N_R$ | $Z_\phi$  |           |            |          |            |            |            |           |
|-------|-----------|-----------|------------|----------|------------|------------|------------|-----------|
|       | $\pi/4$   | $\pi/2$   | $3\pi/4$   | $\pi$    | $5\pi/4$   | $3\pi/2$   | $7\pi/4$   | $2\pi$    |
| 1     | $2\pi$    | $2\pi$    | $2\pi$     | $2\pi$   | $2\pi$     | $2\pi$     | $2\pi$     | $2\pi$    |
| 2     | $\pi/8$   | $\pi/4$   | $3\pi/16$  | $\pi/2$  | $5\pi/8$   | $3\pi/4$   | $7\pi/8$   | $\pi$     |
| 3     | $\pi/6$   | $\pi/3$   | $\pi/2$    | $2\pi/3$ | $5\pi/6$   | $\pi$      | $7\pi/6$   | $4\pi/3$  |
| 4     | $3\pi/16$ | $3\pi/8$  | $9\pi/16$  | $3\pi/4$ | $15\pi/16$ | $9\pi/8$   | $21\pi/16$ | $3\pi/2$  |
| 5     | $\pi/5$   | $2\pi/5$  | $3\pi/5$   | $4\pi/5$ | $\pi$      | $6\pi/5$   | $7\pi/5$   | $8\pi/5$  |
| 6     | $5\pi/24$ | $5\pi/12$ | $5\pi/3$   | $5\pi/6$ | $25\pi/24$ | $5\pi/4$   | $35\pi/24$ | $5\pi/3$  |
| 7     | $3\pi/14$ | $3\pi/7$  | $9\pi/14$  | $6\pi/7$ | $15\pi/14$ | $9\pi/7$   | $3\pi/2$   | $12\pi/7$ |
| 8     | $7\pi/32$ | $7\pi/16$ | $21\pi/32$ | $7\pi/8$ | $35\pi/32$ | $21\pi/16$ | $49\pi/32$ | $7\pi/4$  |

Table-A.3. Phase lags with phase shift  $-\pi/8$ 

| $N_R$ | $Z_\phi$  |            |            |            |            |            |            |             |
|-------|-----------|------------|------------|------------|------------|------------|------------|-------------|
|       | $\pi/8$   | $3\pi/8$   | $5\pi/8$   | $7\pi/8$   | $9\pi/8$   | $11\pi/8$  | $13\pi/8$  | $15\pi/8$   |
| 1     | $\pi/4$   | $3\pi/4$   | $5\pi/4$   | $7\pi/4$   | $\pi/4$    | $3\pi/4$   | $\pi/4$    | $3\pi/4$    |
| 2     | $\pi/16$  | $3\pi/16$  | $5\pi/16$  | $7\pi/16$  | $9\pi/16$  | $11\pi/16$ | $13\pi/16$ | $15\pi/16$  |
| 3     | $\pi/6$   | $\pi/2$    | $5\pi/6$   | $7\pi/6$   | $3\pi/2$   | $11\pi/6$  | $\pi/6$    | $\pi/2$     |
| 4     | $3\pi/32$ | $9\pi/32$  | $15\pi/32$ | $21\pi/32$ | $27\pi/32$ | $33\pi/32$ | $39\pi/32$ | $45\pi/32$  |
| 5     | $3\pi/20$ | $9\pi/20$  | $3\pi/4$   | $21\pi/20$ | $27\pi/20$ | $33\pi/20$ | $39\pi/20$ | $\pi/4$     |
| 6     | $5\pi/48$ | $5\pi/16$  | $25\pi/48$ | $35\pi/48$ | $15\pi/16$ | $55\pi/48$ | $65\pi/48$ | $25\pi/16$  |
| 7     | $\pi/7$   | $3\pi/7$   | $5\pi/7$   | $\pi$      | $9\pi/7$   | $11\pi/7$  | $13\pi/7$  | $\pi/7$     |
| 8     | $7\pi/64$ | $21\pi/64$ | $35\pi/64$ | $49\pi/64$ | $21\pi/32$ | $77\pi/64$ | $91\pi/64$ | $105\pi/64$ |

## 5. SIMULATION RESULTS

Table 4 shows the IEEE802.11a test system, which is used as a test system for PAPR reduction. Here, the number of subcarriers used are  $N=64$  and the pseudo-random partition scheme is applied for each carrier, adopting 16QAM constellation mapping, the weighting factor being  $\xi \in \{\pm 1, \pm j\}$ .

Table-4. IEEE802.16e Parameters

| Parameters                       | Value  |
|----------------------------------|--|
| No. of generating an OFDM signal | 10000  |
| No. Subcarriers N                | 64   |
| Modulation                       | 8QAM, 16QAM, 32QAM   |
| IFFT&FFT size                    | 512  |
| Rotating factor Rps              | $2\pi$ , $5\pi/8$ , $5\pi/6$ , $15\pi/16$ , $\pi$ , $25\pi/24$ , $15\pi/14$ , and $35\pi/32$ |
| No. of phase shift M             | 8  |
| No. Partitions P                 | 4  |

Source: Nahar and Gazali [13]

Nine scenarios examined the proposed algorithm by measuring the effectiveness of each  $(N_R, Z_\phi, R_{ph})$  parameter on the PAPR reduction as follows:-

- From Table, 1 marked four sets of fixes  $Z_\phi$  equal  $5\pi/4$ . Figure 3 shows that  $(3, 3\pi/4, 5\pi/3)$  is the best and  $(7, 3\pi/4, 10\pi/7)$  is the worst.

2. From Table 1 marked four sets of  $N_R$ . Figure 4 shows that  $(3, 3\pi/2, 2\pi)$  yields the best result and  $(3, \pi, 4\pi/3)$  is the worst.
3. From Table, 1 marked four sets of fixes  $Z_\phi$  equal  $\pi/4$ . Figure 5 shows that  $(3, \pi/4, \pi/3)$  is the best and  $(7, \pi/4, 2\pi/7)$  is the worst. In addition, the parameter  $(2, \pi/4, \pi/8)$  batter than  $(8, \pi/4, 7\pi/32)$ .
4. From Table 2 assume  $N_R$  equal 8, which the parameters used in the fourth row, marked with  $Z_\phi$  and  $R_{ph}$ . Figure 6 shows that  $(8, \pi/2, 7\pi/16)$  yields the best result and  $(8, 7\pi/4, 49\pi/32)$  is the worst.
5. From Table 2,  $(N_R, Z_\phi, R_{ph})$   $(5, 7\pi/4, 7\pi/5)$  to compare the effect of seven different phase shift  $(1, 7\pi/4, 2\pi)$ ,  $(2, 7\pi/4, 7\pi/8)$ ,  $(3, 7\pi/4, 7\pi/6)$   $(4, 7\pi/4, 21\pi/16)$ ,  $(6, 7\pi/4, 35\pi/24)$ ,  $(7, 7\pi/4, 3\pi/2)$  and  $(8, 49\pi/32)$  is the best. Figure 7 shows that the phase shifts  $(7, 7\pi/4, 2\pi)$  have the poorest performance comparisons.
6. In same Table 2 assume  $N_R$  equal 5, which the parameters used in the fourth row, marked with  $Z_\phi$  and  $R_{ph}$ . Figure 8 shows that  $(5, 5\pi/4, \pi)$  yields the best result and  $(5, 7\pi/4, 7\pi/5)$  is the worst.
7. From Table 3, Fix  $Z_\phi = 13\pi/8$ , then set  $(N_R, R_{ph})$  to  $(1, \pi/4)$ ,  $(2, 13\pi/16)$ ,  $(3, \pi/6)$   $(4, 39\pi/32)$ ,  $(5, 39\pi/20)$ ,  $(6, 65\pi/48)$ ,  $(7, 13\pi/7)$  and  $(8, 91\pi/64)$ . Figure 9 shows that the phase shifts  $(7, 13\pi/7, 13\pi/48)$  have the poorest performance comparisons to phase shift  $(6, 13\pi/8, 65\pi/48)$  in PAPR minimization.
8. Figure 10 show that the phase shifts  $(3, 3\pi/8, \pi/2)$  have the poorest performance comparisons when used Table 3 marked eight sets of fixes  $Z_\phi$  equal  $3\pi/8$ .
9. Let  $N_R$  equal 7, which the parameters used in the second row of Table 3 marked with  $Z_\phi$  and  $R_{ph}$ . Figure 11 shows that  $(7, 7\pi/8, \pi)$  yields the best result and  $(7, 13\pi/8, 13\pi/7)$  is the worst.

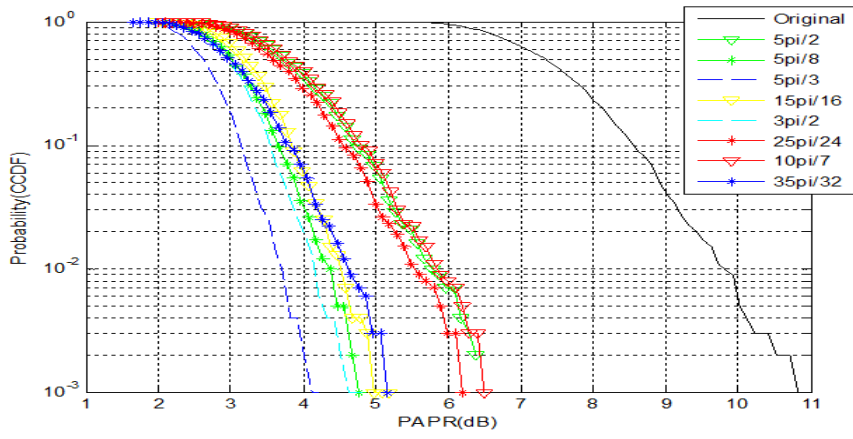


Figure-3. Effect of RPS parameters on PAPR minimization in Table 1, Fix  $Z_0 = 3\pi/2$  and set  $(N_R, R_{ph})$

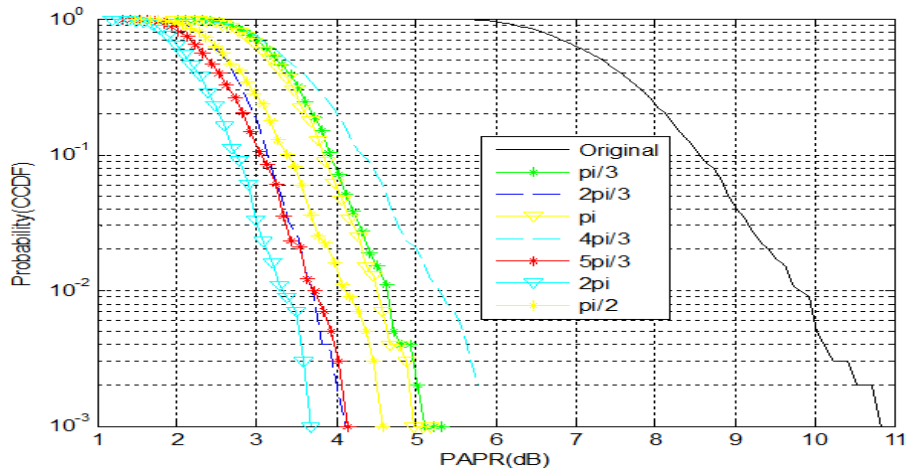


Figure-4. Fix  $N_R = 3$  and set  $(Z_0, R_{ph})$ .

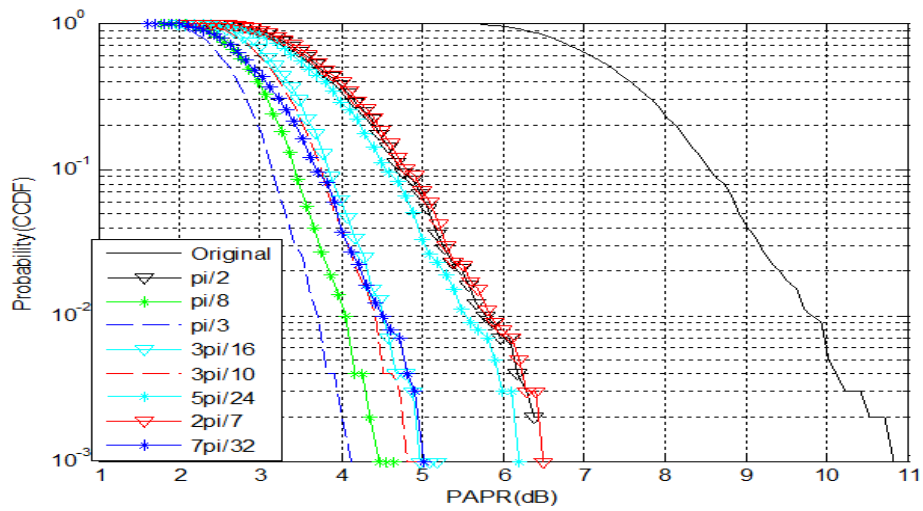


Figure-5. Fix  $Z_0 = \pi/4$  and set  $(N_R, R_{ph})$ .

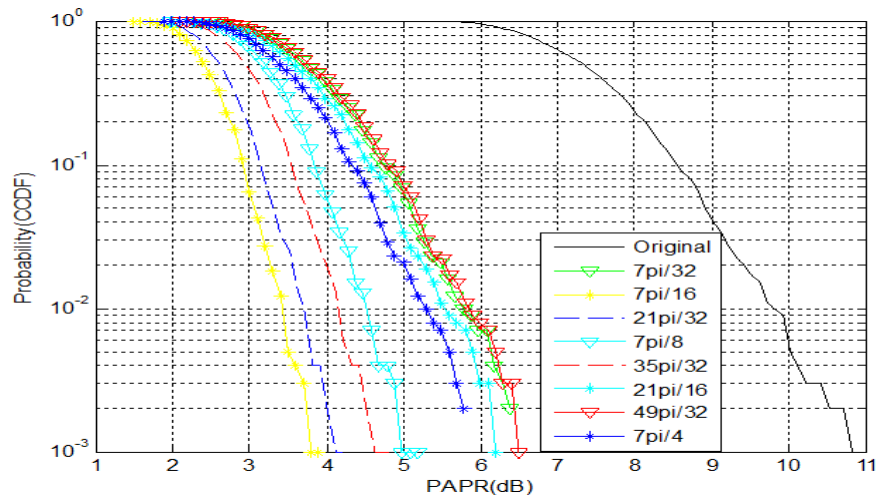


Figure-6. Effect of RPS parameters on PAPR minimization in table 2 Fix  $N_R = 8$  and set  $(Z_\emptyset, R_{ph})$ .

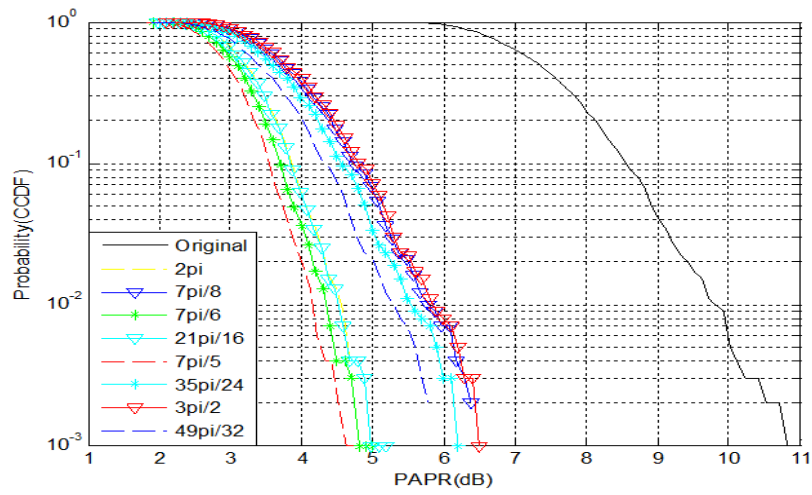


Figure-7. Fix  $Z_\emptyset = 7\pi/4$  and set  $(N_R, R_{ph})$ .

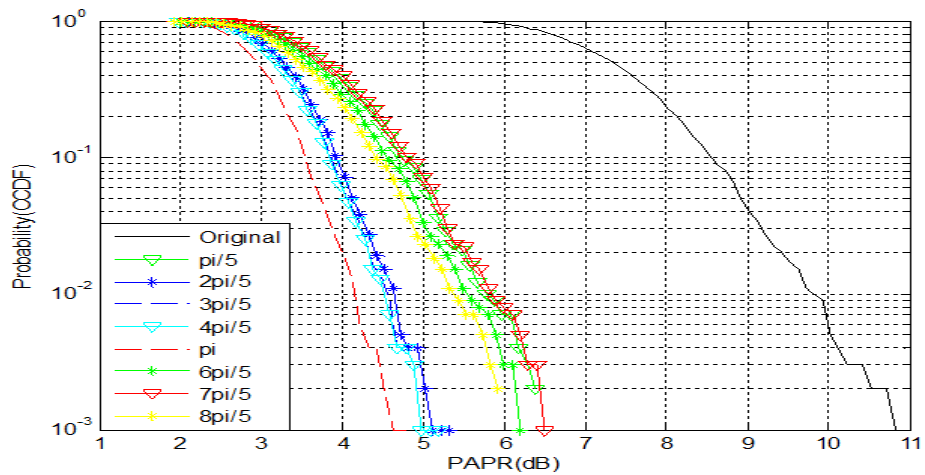


Figure-8. Effect of RPS parameters on PAPR minimization in Table 2 Fix  $N_R = 5$  and set  $(Z_\emptyset, R_{ph})$ .

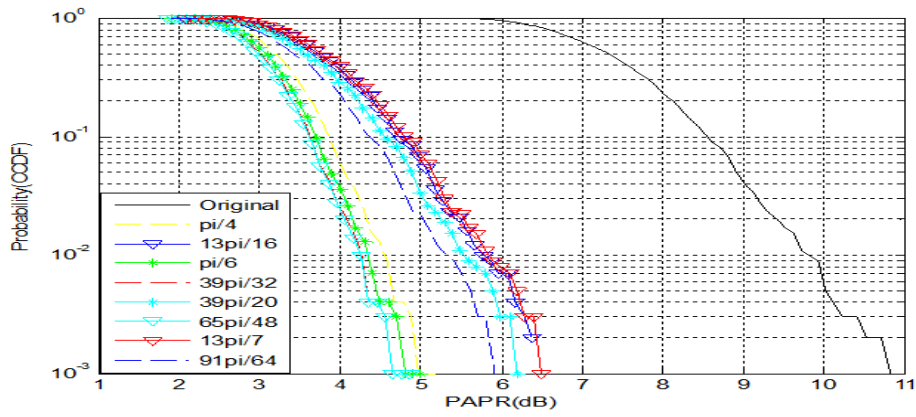


Figure-9. Effect of RPS parameters on PAPR minimization in Table 3, Fix  $Z_0 = 13\pi/8$  and set  $(N_R, R_{ph})$ .

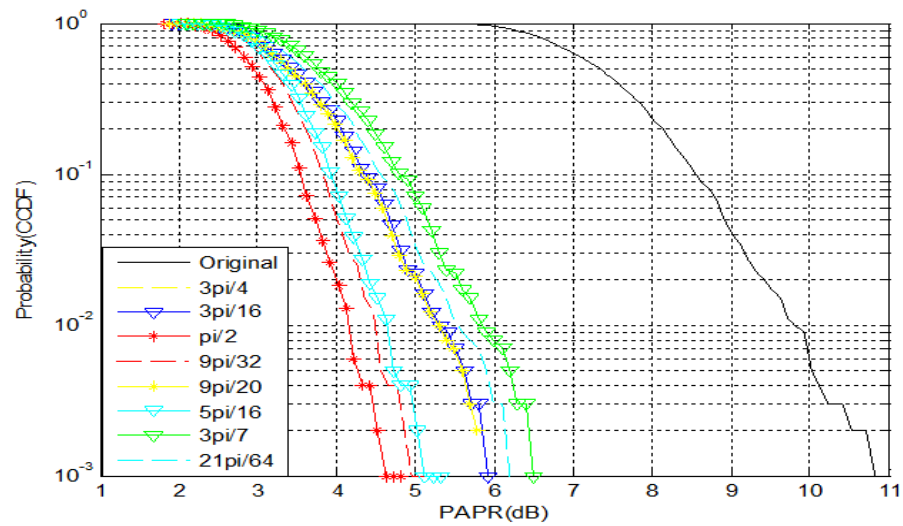


Figure-10. Effect of RPS parameters on PAPR minimization in Table 3, Fix  $Z_0 = 3\pi/8$  and set  $(N_R, R_{ph})$ .

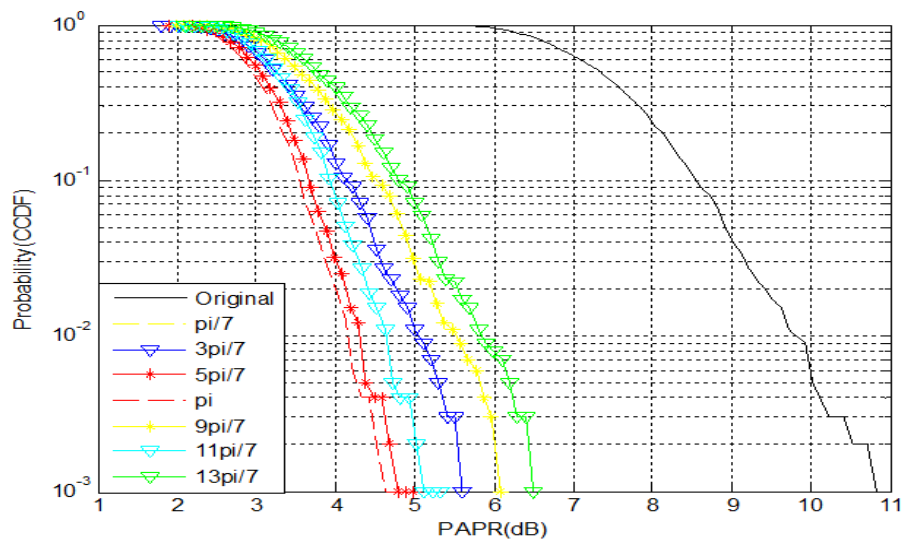


Figure-11. Effect of RPS parameters on PAPR minimization in Table 3 Fix  $N_R = 7$  and set  $(Z_0, R_{ph})$

Table 5 shows the value of reducing the PAPR with different parameters for advanced cases of the three methods, when the parameters RPS, SLM, and PTS are  $(N_R, Z_0, R_{ph})$  equal  $(8, \pi/2, 7\pi/16)$ ,  $C=16$  and  $P=4$ . Fig. 12 shows the effect of BER of the system at various methods clipping reduces the SNR of the signal when modulating Fig. 12(a) at 32-QAM and Fig. 12(b) at 64-QAM for AWGN channels. The PAPR minimization algorithms can improve the BER performance of the system.

Table-5. PAPR (dB) and MMSE with different method

| Parameters (P, C) | PAPR of original signal (dB) | PAPR of PTS (dB) | PAPR of SLM (dB) | PAPR of RPS (dB) | MMSE   |
|-------------------|------------------------------|------------------|------------------|------------------|--------|
| 8QAM              | 12.084                       | 5.9370           | 7.6183           | 3.7564           | 0.0560 |
| 16QAM             | 12.523                       | 6.5663           | 7.9291           | 4.6067           | 0.0453 |
| 32QAM             | 12.867                       | 7.2582           | 8.2250           | 6.2110           | 0.0321 |

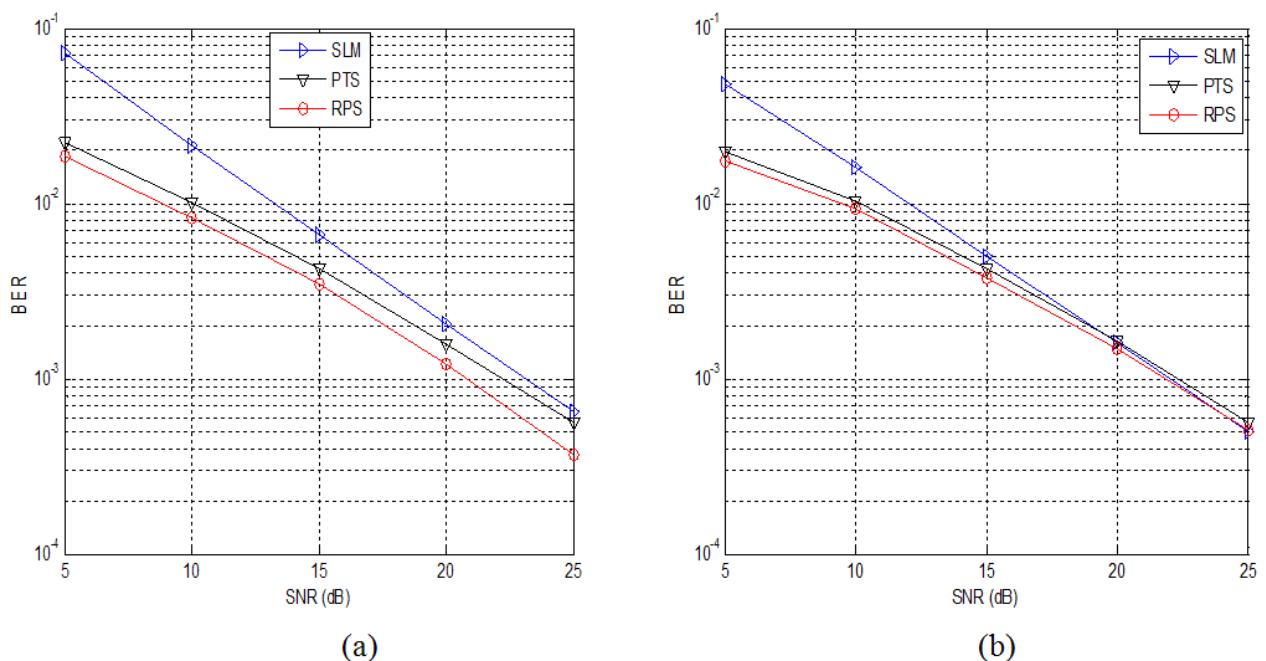


Figure 12. Effects of amplifier saturation on BER in AWGN channel (a) 16-QAM, (b) 32-QAM.

### 6. CONCLUSIONS

The composite OFDM transmits signal considered as serious systems drawbacks which can display a very high PAPR when the input sequences are highly correlated. The RPS technique based enforcing the phase switch to be a rotating function of frequency. The investigation into significant aspects of proposed RPS in term of reduction of PAPR in OFDM systems compared with both the widely reported classical SLM and PTS scrambling techniques. Local search algorithm applied to reduce the cost and complexity. The difference Phase shift is important in this way to receive the best reduction of PAPR, also it depends on choosing a combination of factors such and P and M. The simulation results prove RPS method performs greater reductions in PAPR are even possible at lower values of CCDF without any noticeable degradation in the system error performance compared with both SLM and PTS methods in reducing PAPR under different lag phase shift. In the case of  $R_{ph}$  parameters=  $7\pi/16$ , the shifting the time domain signal at both at  $P=4$  and  $M=8$  results in a PAPR to becomes just 3.756 dB with MMSE equal 0.0543.

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