Journal of Theoretical and Applied Information Technology
20th August 2014. Vol. 66 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

REDUCED COMPLEXITY ADJACENT PHASE SEQUENCE MATRIX BASED PAPR OPTIMIZATION IN OFDM SYSTEMS

[1] M. PALANIVELAN, [2] SHEILA ANAND
[1] Associate Professor, Rajalakshmi Engineering College, Chennai, India.
[2] Dean (Research) Computer Studies, Rajalakshmi Engineering College, Chennai.
E-mail: [1]palanivelan.m@rajalakshmi.edu.in

ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation scheme used in high speed communication systems. OFDM system is being extensively used in several broadband communication systems like Wireless local area network (WLAN), Worldwide interoperability for Microwave access (Wi-Max), Digital video broadcasting (DVB) and Digital audio broadcasting (DAB). However, the limiting factor remains the occurrence of high Peaks in OFDM signals, when transmitted through power amplifier causes in-band and out-of-band distortion and increase in Bit error rate (BER). The most popular quantification metric of envelope variation of OFDM signal is the Peak-To-Average Power Ratio (PAPR). The reduction in PAPR is desirable in order to obtain power efficiency of the amplifier. This paper proposes an efficient Adjacent Phase Sequence Matrix (APSM) method that is based on special matrices (Circulant, Riemann, Hilbert and Hadamard) for optimizing PAPR of OFDM signals. The proposed technique does not require the transmission of side information to the receiver for original phase recovery. Further, the proposed technique reduces computational and phase search complexity. The proposed scheme has been analyzed with random data, image and audio input to validate multimedia requirements. The results show that the proposed scheme offers better PAPR reduction and BER performance.

Keywords: *Adjacent Phase Sequence Matrix (APSM), Complementary Cumulative Distribution Function (CCDF), Peak to Average Power Ratio (PAPR), APSM-Circulant (APSM-Ci), APSM-Riemann (APSM-Ri), APSM-Hilbert(APSM-Hi), APSM-Hadamard(APSM-Ha).*

1. INTRODUCTION

High speed data communication for wireless systems uses OFDM as a promising technique, due to its typical robust performance on frequency selective fading channels. Digital signal processing has made a great impact in the development of this scheme [18]. International standards for 2G and 3G wireless communication use OFDM for physical layer transmission. These include IEEE 802.11, IEEE 802.16, IEEE 802.20, European telecommunication standard institute (ETSI) and Broadcast radio access network (BRAN). 4G wireless standard Long Term Evolution (LTE) also uses OFDM.

High Peak-to-Average Power Ratio (PAPR) is one of the main drawbacks in OFDM systems [2, 3]. The occurrence of high PAPR causes nonlinearity in the power amplifier leading to in-band and out-of-band radiations that degrades bit error rate performance. Various methods for PAPR reduction in OFDM systems have been already presented to avoid the occurrence of large PAPR. Partial Transmit Sequence (PTS) and Selective Mapping (SLM) are the most effective probabilistic schemes to reduce large PAPR [8]. Finding the optimum phase requires exhaustive search over all possible combinations of allowed phase factors and search complexity exponentially increases with the number of sub blocks. In this paper, we propose an Adjacent Phase Sequence Matrix (APSM) that uses special matrices to reduce computational and phase search complexity and to optimize PAPR.

OFDM mitigates multipath fading by dividing the data to be transmitted over a large number of relatively narrowband channels. OFDM consist of a block of 'N' data streams X_k ; (k=0, 1, ... N-1), of

Journal of Theoretical and Applied Information Technology
20th August 2014. Vol. 66 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

vector X, which will be transmitted in parallel . These 'N' parallel data streams are then used to modulate 'N' orthogonal subcarriers [10, 14, 23]. Each baseband subcarrier is given as

$$\phi_k(t) = e^{j2\pi f_k t} \quad (1)$$

where f_k is the k[th] subcarrier frequency. The sub carrier frequencies f_k are equally spaced as given by

$$f_k = \frac{k}{NT} \quad (2)$$

where $0 \le t \le NT$ orthogonal and NT denotes the useful data block period. OFDM data symbol multiplexes N modulated subcarriers *x (t)* as given as,

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k \phi_k(t), \qquad 0 \le t \le NT \quad (3)$$

The main drawback of OFDM signal is that, it has high PAPR due to its nature of multicarrier modulation [7, 12, 21, 24]. PAPR is a random variable, because it is a function of input data, which is also a random variable. Therefore, PAPR can be calculated by finding the average number of times that the envelope of a signal crosses a given level. PAPR is defined by as in equation (4),

$$PAPR = \frac{\max_{t\in[0,T]} |x(t)|^2}{E\{|x(t)|^2\}} \quad (4)$$

where E{.} is the expected value operator. In general, most of the signals works in discrete time domain, therefore; we need to oversample the continuous signal x (t) by an over sampling factor of L, which is an integer larger than or equal to one, to approximate true PAPR values. The L- time oversampled signal x_k is given in (5),

$$x_k = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n \phi_n(k) \quad (5)$$

where $\phi_n(k) = e^{j2\pi nk/LN}$; for k=0,1,…,LN-1.
PAPR is expressed as in (6)

$$PAPR = \frac{\max[|x_k|^2]}{E[|x_k|^2]} \quad (6)$$

where $E[|x_k|^2]$ denotes average value over the time duration of OFDM symbol.

From the amplitude distribution of the output OFDM signal, it is easy to compute the probability that the instantaneous amplitude will be above a given threshold. This is performed by calculating Cumulative Distribution Function (CDF) and Complimentary CDF (CCDF) [6,11,15]. The probability 'p' that the PAPR given by equation (7) exceeds a threshold 'p_0' known as CCDF can then be defined by

$$p(PAPR > p_0) = 1 - (1 - \exp(-p_0))^N \quad (7)$$

The rest of the paper is organized as follows. In section 2 we present a brief review of existing techniques based on probabilistic schemes. In section 3, the proposed system is discussed and section 4 gives the simulation results supporting the ideas presented. Section 5 concludes the paper.

2. RELATED WORK

Partial Transmit Sequence (PTS) is one of the commonly used technique to reduce PAPR of OFDM signal. In PTS technique, data block of N symbols is partitioned into V number of disjoint sub blocks, $X_m=[X_{m,0}, X_{m,1,\ldots\ldots} X_{m,N-1}]^T$, where m=1,2,3….V, such that $\sum_{m=1}^{V} X_m = X$ and the sub blocks are combined, to minimize the PAPR in the time domain. The L-times oversampled time domain signal X_m ; m=1,2,3……V, is obtained by taking an IFFT of length NL on X_m concatenated with (L-1)N zeros, called partial transmit sequences [1,13,22]. The time domain signal after combining is given in equation (8),

$$x'(b) = \sum_{m=1}^{v} b_m \bullet x_m \quad (8)$$

The set of allowed phase factor (P) is given as, $p = \{e^{j2\pi l/w}\}$ where l=0, 1, 2……W-1 and W is the number of allowed phase factors. Therefore, exhaustive phase search is required to find the optimum signal *x'(b)*. PTS require V number of IFFT operations for each data block, which leads to higher computational complexity . The side information (SI) required in this scheme is given as,

$$\log_2 W^{m-1}, \text{ where } m=1,2,3\ldots.M. \quad (9)$$

resulting in poor bandwidth efficiency. Alternatively, time domain signal 'x' and phase sequences 'b' can be arranged in matrix form as given in equations (10) and (11) .

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

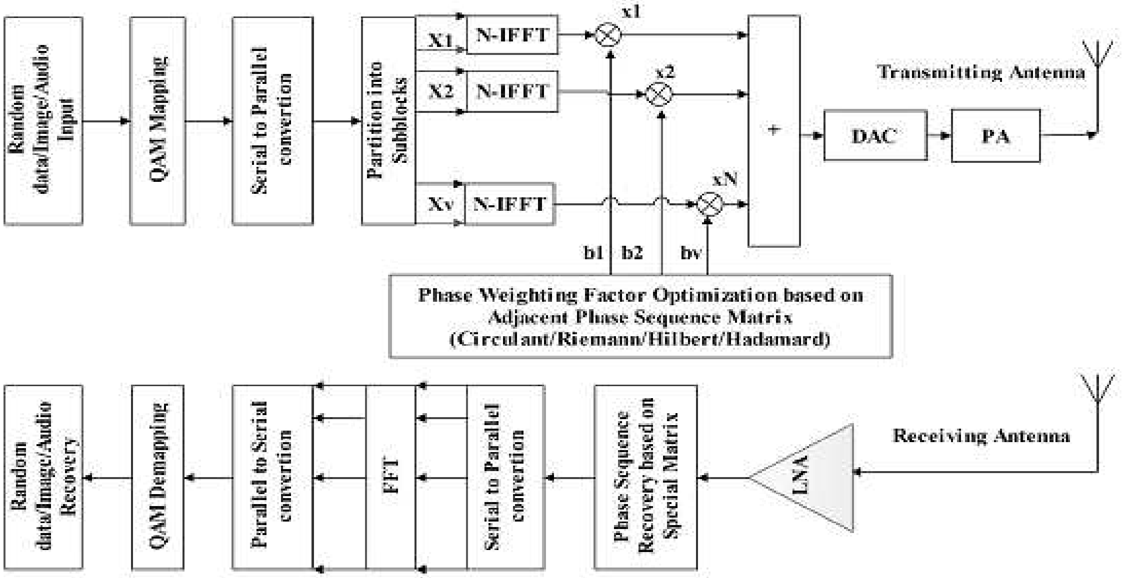

Fig 1. Proposed OFDM system with APSM

It can be noted that all the elements of each row of the matrix 'b' are of the same values [17]. To have exact PAPR calculation at least four times over sampling by L is necessary but the number of phase sequences to multiply the matrix X will remain the same.

$$x = \begin{bmatrix} x_{1,0} & x_{1,1} & \dots & x_{1,NL-1} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ x_{v,0} & x_{v,1} & \dots & x_{NL-1} \end{bmatrix}_{VXNL} \quad (10)$$

$$b = \begin{bmatrix} b_1 & b_1 & \dots & b_1 \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ b_v & b_v & \dots & b_v \end{bmatrix}_{VXN} \quad (11)$$

Therefore, a new sequence has been proposed to reduce complexity of the conventional PTS scheme. The random generation of phase sequences in (12) using allowed phase factors {+1, -1} is proposed. However, random generation of phase sequences also requires Side information (SI). Therefore, system demands more spectrum. In our proposed work, we have generated phase sequences through various special matrices such as Circulant, Hadamard, Riemann and Hilbert in Adjacent phase sequence form to reduce computational and phase search complexity.

3. PROPOSED SYSTEM

In this paper, we propose the use of Adjacent Phase Sequence Matrix (APSM) technique to optimize PAPR and reduce phase search & computational complexity of the OFDM system based on PTS technique [9,11,22]. This extends our previous work with special matrices such as Circulant, Hadamard and Hilbert to obtain phase sequences for the Selective Mapping (SLM) technique [4,5,16]. The previously obtained experimental results show that matrix based approaches offer better PAPR reduction in comparison with the conventional SLM scheme.

Proposed APSM for PAPR optimization uses PTS is shown in Fig. 1. The input data stream is generated from random data source, image and audio sources. Data is mapped on to Quadrature Amplitude Modulation (QAM) constellation. These serially mapped symbols are converted into parallel, and then symbols are partitioned into sub blocks based on PTS. Each sub-block is multiplied with phase sequence generated through APSM.

The structure of APSM matrix 'b' given in equation (12), has 'S' rows and the oversampling

Journal of Theoretical and Applied Information Technology
20th August 2014. Vol. 66 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

factor does not have any effect on the proposed matrix, as oversampling will add zeros to the vector 'x'.

$$b=\begin{bmatrix} b_{1,1} & \cdots & b_{1,1} & , & b_{1,2} & \cdots & b_{1,2} & \cdots & b_{1,N/S} & \cdots & b_{1,N/S} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ b_{v,1} & \cdots & b_{v,1} & , & b_{v,2} & \cdots & b_{v,2} & \cdots & b_{v,N/S} & \cdots & b_{v,N/S} \\ b_{v+1,1} & \cdots & b_{v+1,1} & , & b_{v+1,2} & \cdots & b_{v+1,2} & \cdots & b_{v+1,N/S} & \cdots & b_{v+1,N/S} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ b_{s,1} & \cdots & b_{s,1} & , & b_{s,2} & \cdots & b_{s,2} & \cdots & b_{s,N/S} & \cdots & b_{s,N/S} \end{bmatrix} \quad (12)$$

Required adjacent matrix size can be decided by the designer based on PAPR reduction and complexity. If the number of allowed phase factor (W) is constant, then value of 'S' depends on the number of sub blocks V. If the system requires more number of subcarriers, then for better PAPR reduction, essentially we need to consider more number of sub blocks. Increase in sub blocks simultaneously increases the number of phase sequences to be optimized, leading to greater complexity in phase search. In our proposed system, even if the number of sub carriers increases, the phase search complexity is reduced. After phase sequence multiplication, the sequence which yields minimum PAPR will be selected and transmitted. At the receiver end, special structure of the proposed APSM helps the receiver to recover data without any side information. In this model, channel noise is assumed to be Gaussian. After phase recovery, signals passes through Fast Fourier Transform (FFT) block and are de-mapped to recover the original data. Further, if more PAPR reduction is preferred by compromising complexity of the system we can extend the number of rows in equation (13), by satisfying the following condition $S=UW^{v-1}$, where U=1,2,3………D_N. If the higher value of 'U' is preferred to accommodate the large number of sub blocks, complexity is also increases. APSM Pseudo code for PAPR optimization is given in Fig. 2. The proposed APSM technique to reduce PAPR is described as a flow diagram in Fig. 3. Most of the PAPR reduction techniques use random phase sequences for optimization.

This random search in phase, forces transmitter to send side information to the receiver to recover the original data signals. This addition of SI, increases the bandwidth requirements, and phase search complexity. If the number of used subcarriers is high, it also proportionately increases the PAPR.

Initiate number of sub blocks 'v';

(V_1, V2, V3, V4, ..., V_v)

Initiate length of sub block 'N'

Define fitness function f (b), b= [b1, b2...b_{NL}] ;

where NL= 1,2,3,4…S

Define $PAPR_0$, PAPR, APSM, S_MAT, L

Define Maximum number of iteration (K)

Declare x, temp, y // Integer Variables

Find $S=W^{v-1}*U$, where W is the allowed phase set and U is an integer

Generate phase sequence matrix based on S_MAT

// Standard matrix

Evaluate and accumulate x = N/S

  if (x=1)

  Use S_MAT

  else

Generate APSM matrices as

  $U = [U_1 \;\; U_2 \ldots\ldots Us]_{s*s}$,

where $U_1=\begin{bmatrix} U_{1,1} \\ U_{2,1} \\ \vdots \\ \vdots \\ U_{S,1} \end{bmatrix}$

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

```
        Ux= [(U1,x… U1,x U2,x…
U2,x …  …Us, x … Us, x] N*s
        end
        while (iteration number
≤ K) do
        while (NL<S) do
        initialize   temp, small, y
; integer
        small =PAPR0
        // PAPR0 is for the
original data block with S_MAT
        if (iteration number <K)
        multiply [U1,1,1 U1,1,2
U1,1,3… … …U1,1,NL ]  with a
                      sub block
        temp=y;
        if(temp< small)
        small=y  // Sub block
which has minimum PAPR
        ENDIF;      ENDIF;
```

Fig 2. APSM Pseudo Code

For example, OFDM based IEEE 802.16 (Wi-Max) uses 360 subcarriers to meet the channel bandwidth requirement of 5MHz and Long Term Evolution (LTE) standard uses 1200 sub carriers to meet channel bandwidth requirement of 20MHz, which drastically raises peak power and complexity of the system. In APSM, rise in complexity due to increase in number of subcarriers is reduced by limiting the phase set, which are formed from Circulant, Riemann, Hilbert, and Hadamard matrices.

a. *Adjacent Phase sequence Matrix (APSM)*

In this work, we have generated phase sequences through various special matrices such as Circulant, Hadamard, Riemann and Hilbert in Adjacent phase sequence form [21]. A Circulant matrix is a special form of matrix, where each row vector is rotated one element to the right relative proceeding row vector . Circulant matrix is diagonalized by a Discrete Fourier Transform (DFT), and hence they can be easily solved. Sample 4x4 Circulant matrix C1 is given as in (13),

$$C1=\begin{bmatrix}-1 & -1 & 4 & -1\\ -1 & -1 & -1 & 4\\ 4 & -1 & -1 & -1\\ -1 & 4 & -1 & -1\end{bmatrix} \tag{13}$$

Riemann matrix of order 4 x 4 is given in equation (14),

$$R=\begin{bmatrix}1 & -1 & -1 & -1\\ -1 & 2 & -1 & -1\\ -1 & -1 & 3 & -1\\ -1 & -1 & -1 & 4\end{bmatrix} \tag{14}$$

Hilbert matrix with dimensions 4 x 4 is given in equations (15),

$$HL=\begin{bmatrix}1 & 1/2 & 1/3 & 1/4\\ 1/2 & 1/3 & 1/4 & 1/5\\ 1/3 & 1/4 & 1/5 & 1/6\\ 1/4 & 1/5 & 1/6 & 1/7\end{bmatrix} \tag{15}$$

Hadamard matrix is a square matrix whose entities are either +1 or -1 and have orthogonal rows. Hadamard matrix (H) of order *n*, is then given as (16),

$$H_n = H_1 \otimes H_{n-1} = \begin{bmatrix}H_{n-1} & H_{n-1}\\ H_{n-1} & -H_{n-1}\end{bmatrix}$$

$$=\begin{bmatrix}1 & 1\\ 1 & -1\end{bmatrix} \tag{16}$$

If the number of subcarriers in each sub block 'N' and number of iterations 'S', gives N/S=1, we can use standard matrix (S_MAT) by extending the equations (13) to (16) of order 8 by 8 . Each row of extended matrix is considered as a phase sequence for PAPR optimization. Phase sequences generated are multiplied point wise with the input signal sequence given in equation (10).

If N/S ≠ 1,we propose the use of APSM matrices given in equations (17) to (20) which are obtained from equations (13) to (16) and named APSM-Ci, APSM-Ri, APSM-Hi and APSM-Ha respectively. If the numbers of used subcarriers are high, we need to divide the data block into large number of sub blocks to yield an optimized PAPR

Journal of Theoretical and Applied Information Technology
20th August 2014. Vol. 66 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

sequence; this will increase the size of each row (N) and number of iterations(S).

$$A_c=\begin{bmatrix} -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & 4 & 4 & 4 & 4 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & 4 & 4 & 4 & 4 \\ 4 & 4 & 4 & 4 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & 4 & 4 & 4 & 4 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \end{bmatrix} \tag{17}$$

$$A_R=\begin{bmatrix} 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & 2 & 2 & 2 & 2 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & 3 & 3 & 3 & 3 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & 4 & 4 & 4 & 4 \end{bmatrix} \tag{18}$$

$$A_{Hi}=\begin{bmatrix} 1 & 1 & 1 & 1 & 1/2 & 1/2 & 1/2 & 1/2 & 1/3 & 1/3 & 1/3 & 1/3 & 1/4 & 1/4 & 1/4 & 1/4 \\ 1/2 & 1/2 & 1/2 & 1/2 & 1/3 & 1/3 & 1/3 & 1/3 & 1/4 & 1/4 & 1/4 & 1/4 & 1/5 & 1/5 & 1/5 & 1/5 \\ 1/3 & 1/3 & 1/3 & 1/3 & 1/4 & 1/4 & 1/4 & 1/4 & 1/5 & 1/5 & 1/5 & 1/5 & 1/6 & 1/6 & 1/6 & 1/6 \\ 1/4 & 1/4 & 1/4 & 1/4 & 1/5 & 1/5 & 1/5 & 1/5 & 1/6 & 1/6 & 1/6 & 1/6 & 1/7 & 1/7 & 1/7 & 1/7 \end{bmatrix} \tag{19}$$

$$A_{Ha}=\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & 1 & 1 & 1 & 1 \end{bmatrix} \tag{20}$$

If the number of iterations 'S' can be kept constant even when the 'N' is increased, the computational and phase search complexity are greatly reduced but PAPR reduction is less. Conversely, the number of iterations 'S' can be increased to equal the number of sub carriers, there is more reduction in PAPR. However, computational and phase search complexity increases. Hence, there is a trade-off between PAPR optimization and computational & phase search complexity. The proposed structure can easily extend in to large number of subcarrier systems.

Table 1. Comparison of PAPR values for Proposed APSM with original values

PAPR (dB)					
Sample input data	Original	APSM-Ci	APSM - Ha	APSM-Ri	APSM-Hi
1 1 -1 -1 1 1 -1 1	5.93	3.26	4.87	3.01	5.90
-1 -1 1 1 1 -1 -1 1	5.85	4.20	4.48	3.10	5.13
-1 1 1 -1 1 -1 -1 1	4.48	3.18	4.21	3.00	4.11
1 1 1 1 1 1 1 1	9.00	6.21	5.85	4.23	6.02
1 1 1 1 -1 -1 -1-1	9.00	6.46	6.70	4.34	7.32
-1 -1 -1-1 1 1 1 1	9.00	6.21	5.10	4.10	6.31

It is seen that, highest PAPR results when all the bits in a data block are same. From the analysis, we infer that APSM-Ri yields considerable PAPR reduction when compared to APSM-Hi, APSM-Ha and APSM-Ci matrices. APSM works effectively and gives reduced PAPR for all types of data blocks.

4. SIMULATION RESULTS

To compare and evaluate PAPR reduction performance, extensive simulations have been performed based on Adjacent Phase Sequence Matrix (APSM) technique using MATLAB. The simulation parameters used has been summarized in Table 2.

Table.2 Simulation Parameters

Parameter	Specifications
Modulation	QAM
Number of data subcarriers N	64
Over sampling factor	L=4
Number of FFT/IFFT points	N. L
Number of data symbols for simulation	$1x10^5$
Channel	Flat Fading
Bandwidth, BW	1MHz
Sampling Frequency, (BW x L)	4 MHz
Number of Guard Interval Samples	32

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

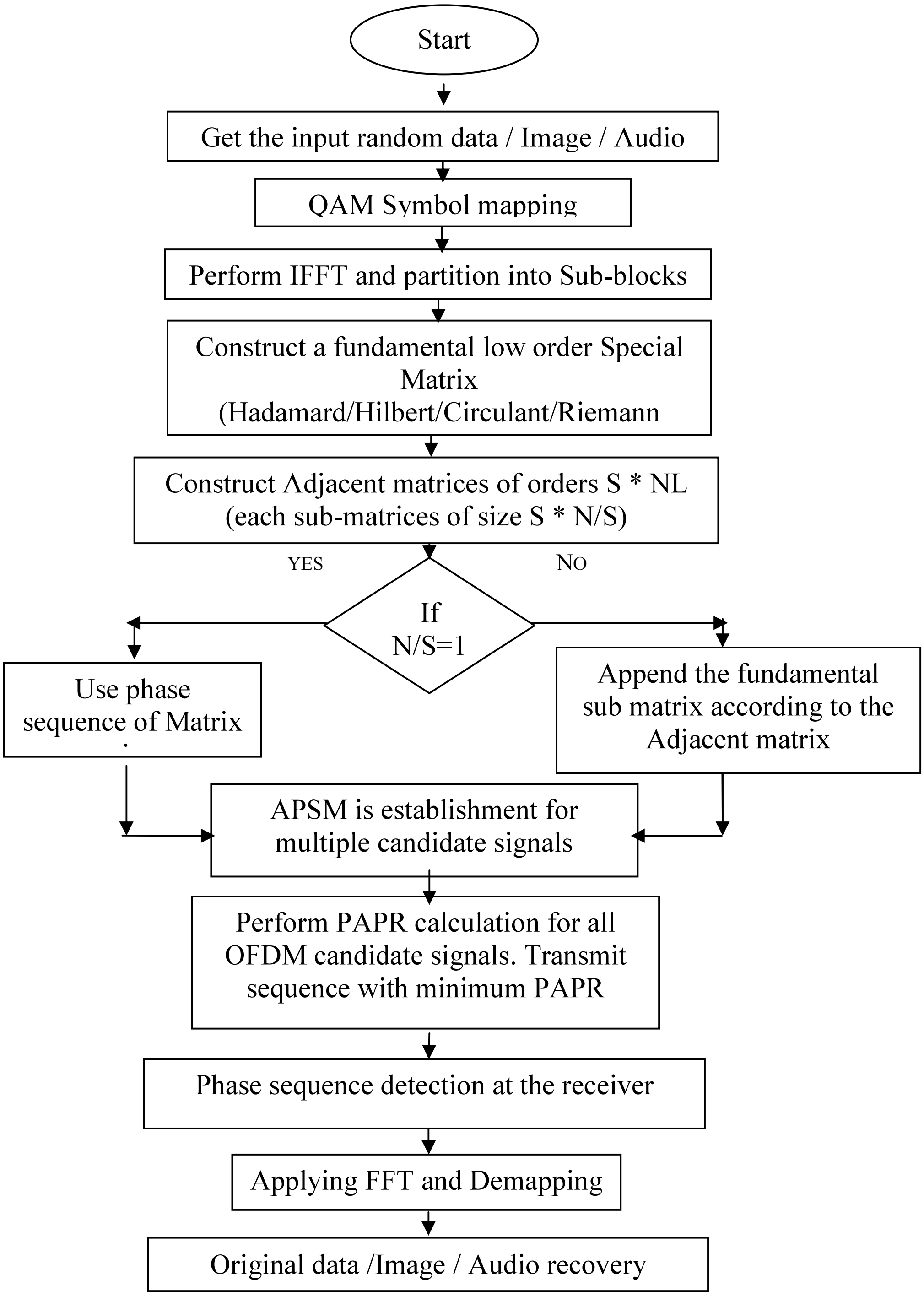

Fig 3. Flow Diagram Of APSM Based OFDM System

Journal of Theoretical and Applied Information Technology
20th August 2014. Vol. 66 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

An OFDM system with number of data subcarriers N=64, and 16-point Quadrature Amplitude Modulation (16-QAM) has been considered for simulation. Each modulated symbol was transmitted through L.N-point IFFT and L=4 oversampling was employed to estimate PAPR precisely. Circularly symmetric, complex Gaussian noise with zero mean and unit variance was considered. To analyze PAPR reduction and power amplifier efficiency, a class A power amplifier was considered as it is most linear with power efficiency [19].

Fig. 4 and Fig. 5, shows the CCDF of PAPR in APSM for random input data with N=64. It can be observed that, at CCDF of 0.4, APSM with Riemann offers 8 dB, which is 7dB lesser than the actual value for random data input.

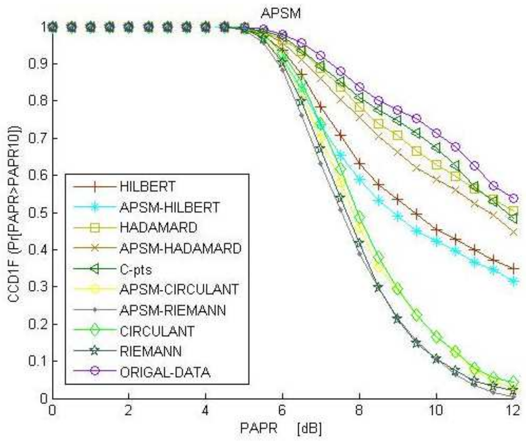

Fig 4. CCDF Of PAPR In APSM For Random Data Input With N=64

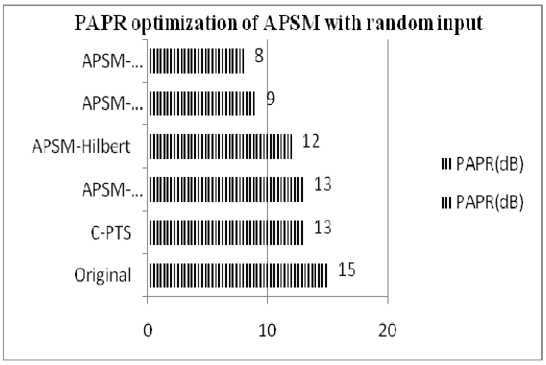

Fig 5. PAPR Reduction Performance Of APSM With Special Matrices For Random Data Input

From the results, it can be noted that APSM with Riemann matrix has performed the best in PAPR reduction as compared to other schemes. Fig. 6 to Fig. 8, shows the input image, CCDF performance and study of our proposed APSM technique with image input. It is observed that PAPR reduction performance of all the proposed technique performs well for image input and APSM-Ri gives the best result.

Fig.6 . Input Image

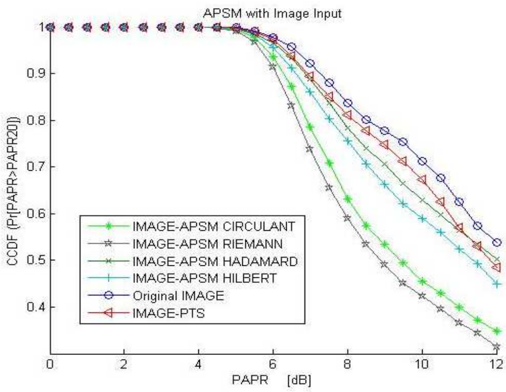

Fig.7. CCDF Of PAPR In APSM With Image Input

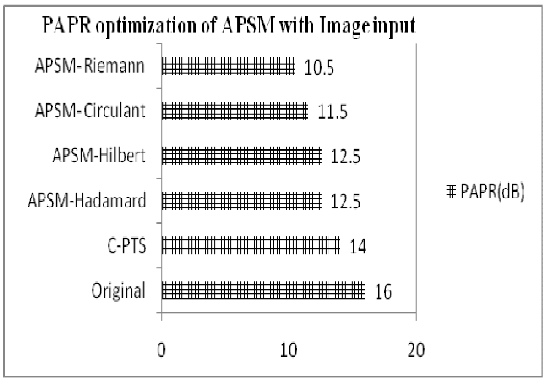

Fig 8. PAPR Reduction Performance Of APSM With Special Matrices For Image Input

Fig. 9 to Fig. 11 shows, audio input sample, CCDF performance and study of

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

our proposed APSM technique with audio input respectively.

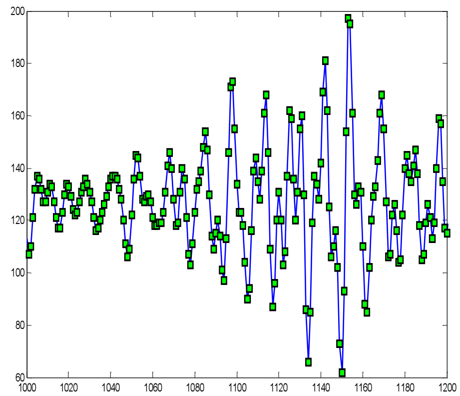

Fig 9. Audio Input Sample

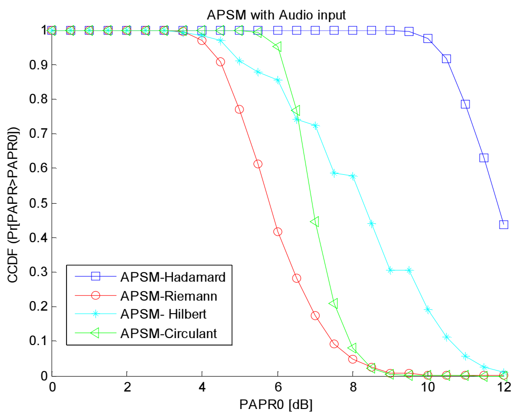

Fig 10. CCDF Of PAPR In APSM With Audio Input

It can be observed that PAPR reduction performance of proposed technique performs well suited for audio input and APSM-Ri gives the best result.

In a practical system, the OFDM signals are sent through a Power Amplifier (PA) which is always peak-power limited [20]. Linear amplifiers impose a nonlinear distortion if excited by a large input that causes out-of-band radiation, affects signals in adjacent bands as well as in-band, results in rotation, attenuation and offset on the received signal . The time-domain signal for any OFDM frame $x(t)$ will be clipped if $|x(t)|^2$ is larger than the saturation point of the PA at any time 't'. Clipping results in decoding errors, which increase the BER of the overall system at the receiver. Power saving gain is expresses as, $G_{saving} = 2(PAPR_b - PAPR_a)$, where $PAPR_b$ is the DC power consumed by PA before PAPR reduction and $PAPR_a$ is the DC power consumed by PA after PAPR reduction. Power saving gain of the proposed APSM scheme with random data input is shown in Fig.12.

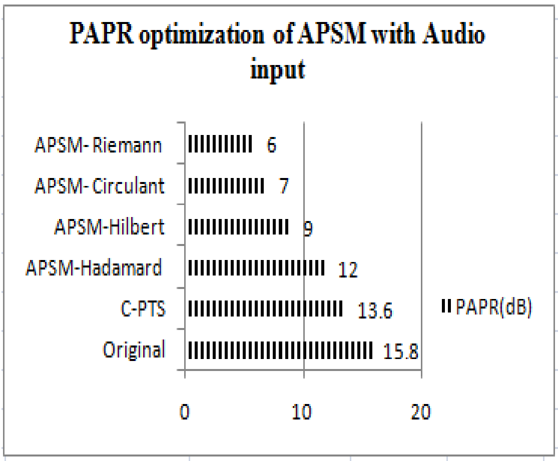

Fig 11. PAPR Reduction Performance Of APSM With Special Matrices For Audio Input

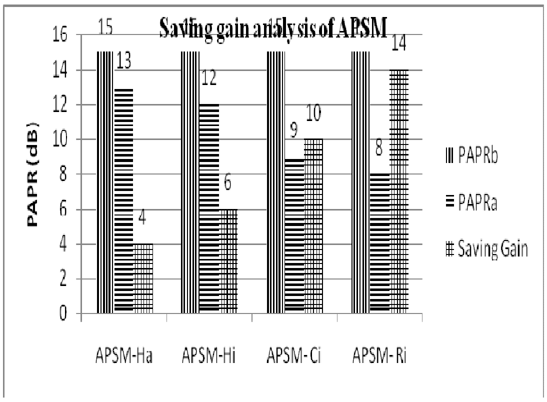

Fig 12. Power Saving Gain Analysis Of Proposed APSM

It can be observed that, all the proposed APSM offers certain amount of power saving, however, APSM-Ri gives the best value of saving gain. Fig. 13 shows the BER performance under flat fading channel obtained for proposed APSM with original OFDM system.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

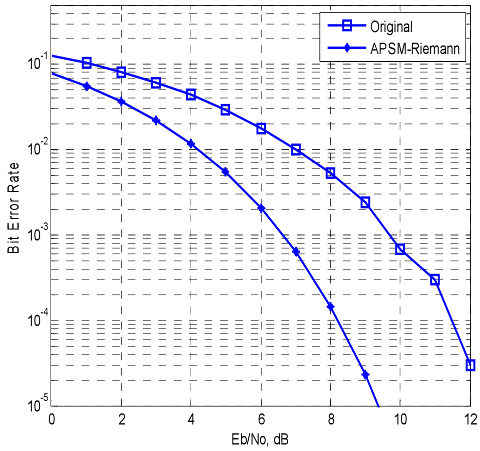

Fig 13. BER Performance Of APSM-Ri With Original OFDM System

5. CONCLUSION

In this paper, an evaluation of the performance on OFDM transmissions in relation to PAPR, BER and Power saving gain using APSM with special matrices has been presented. Adjacent phase sequence matrix has been constructed with special matrices such as Circulant, Riemann, Hilbert, and Hadamard. From simulation results, it was observed that the proposed method offers better PAPR reduction with reduced computational, phase search complexity and increase in efficiency of power amplifier, than conventional PTS schemes. Additionally side information need not be transmitted to the receiver to recover the signal. The proposed technique efficaciously works with image and audio input also. In addition, it is also shown that proposed APSM-Ri scheme offers better BER performance when compared with conventional scheme. This scheme can effectively be implemented in 3G and 4G wireless communication systems.

REFERENCES:

[1] Baxley.R.J and T Zhou., "Comparing selected mapping and partial transmit sequence for PAPR reduction", *IEEE Trans. Broadcast*., Vol. 53, No. 4, pp.797-803, Dec 2007.
[2] Bumman Kim, Junghwan Moon, Ildu Kim, " Efficiently Amplified", *IEEE Microwave Magazine* , Aug 2010, pp. 87-100.
[3] Chhavi Sharma, Shiv Kumar Tomar and Gupta.A.K, PAPR Reduction in OFDM System using Adapting Coding Technique with Pre distortion Method, *WSEAS Transactions on Communication*, Vol.10, No.9, pp.255-262, September 2011.
[4] Chin-Liang Wang, Sheng-Ju Ku, and Chun-Ju Yang , "A Low- Complexity PAPR Estimation Scheme for OFDM Signals and Its Application to SLM-Based PAPR Reduction", *IEEE Journal of Selected topics in Signal processing*, Vol. 4, No. 3, June 2010, pp.637-645.
[5] Chih-pengli," Novel low complexity SLM schemes for PAPR reduction in OFDM systems", IEEE Transactions on signal processing, Vol.58, No.5, May 2005.
[6] Cimini.L.J, Jr, and Sollenberger.N.R, "Peak-to-Average power ratio reduction of an OFDM signal using Partial Transmit Sequences" *IEEE Communication Letters,* Vol. 4, No. 3,Mar. 2000,pp.86-88.
[7] Eonpyo Hong, Dongsoo Har, " Adaptive phase rotation of OFDM signals for PAPR reduction", *IEEE Transactions on Consumer Electronics"*, Vol. 57, No.4, 2010, pp. 1491-1495.
[8] Hee HS, Hong LJ, "An overview of peak-to-average power ratio reduction techniques for multicarrier modulation", *IEEE wireless communication,* Vol.12. No.2, 2005,pp.56-65.
[9] Ho-Lung Hung, "Using evolutionary computation technique for trade-off between performance peak-to average power ration reduction and computational complexity in OFDM systems" Volume 37, Issue 1, January2011,pages57–70 .
[10] Jing gao, Jinkuan Wang, XinSong and Bin Wang, "PAPR Reduction with Low Computational Complexity for OFDM Systems" Volume 33, 2012, Pages 1401–1407.
[11] Jing Gao, jinkuan Wang, Bin Wang, Xin Song, "A PAPR Reduction Algorithm Based on Harmony Research for OFDM Systems" Procedia Engineering,Volume 15, 2011, Pages 2665–2669.
[12] Jun Hou,JienhuaGc, and Jing Li "Peak-to-Average Power Ratio Reduction Of OFDM Signals Using PTS Scheme With Low Computational Complexity", IEEE Transactions Broadcasting , Vol.57.No. 1,March 2011.
[13] Muller.M.H, J. B. Huber, "OFDM with reduced peak-to-average power ratio by optimum combination of partial transmit sequences", IEEE *Electronic Letters*, Vol.33, no. 22, pp 368-369,1997.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[14] Nikookar.H and K.S. Lisheim, "Random phase updating algorithm for OFDM trans. with low PAPR", *IEEE Trans. Broadcast*., Vol. 48, No. 2, pp 123-128, June 2002.

[15] Ochiai.H and H. Imai, "On the distribution of the peak-to-average power ratio in OFDM signals," I*EEE Trans. on Communications,* Vol.49, No. 2, Feb 2001, pp. 282-289.

[16] Palanivelan.M, Sheila Anand & M.Gunasekaran, "Matrix based low Complexity PAPR Reduction in OFDM Systems", International Journal of Electronics and Communication Technology, IJECT Vo l . 2, Is s u e 2, June 2011.

[17] Pooria Varahram, Borhanuddin Mohd Ali, "Partial Transmit Sequence scheme with new phase sequence for PAPR reduction in OFDM systems", IEEE Trans. On Consumer electronics, Vol.57, No. 2, May 2011, pp.366-370.

[18] Proakis J.G and D.G.Manolakis, "Digital Signal Processing: Principles algorithms, and applications", Fourth Edition, Prentice Hall, 2007.

[19] Robert J Baxley, G.Tong Zhou, " Power saving analysis of Peak to average power ratio reduction in OFDM systems", *IEEE Transactions on Consumer Electronics*, Vol.50, No.3, August 2004, pp.792-798.

[20] Serkan Dursun, Artyom M.Grigoryan, "Nonlinear L2- by - 3 transform for PAPR reduction in OFDM systems" Computers and Electrical Engineering, Elsevier, March 2010, pp.1055-1065.

[21] Tellambura.C, "Computation of continuous time PAR of an OFDM signal with BPSK sub carriers", *IEEE Communication letters*, Vol.5, No.5.pp 185-187,May2001.

[22] Wang and Y. Cao, "Sub-optimum PTS for PAPR reduction of OFDM signals", IEEE electronics letters, Vol.44, No.15, July 2008.

[23] Wu.Y and W.Y.Zou, "OFDM: a multi carrier modulation scheme", *IEEE Transactions on Consumer Electronics*, Vol.41, No.3, Aug 1995, pp.392-399.

[24] Yang.L, R. S. Chen, Y. M. Siu, and K. K. Soo, "PAPR reduction of an OFDM signal by use of PTS with low computational complexity," *IEEE Trans. Broadcast.,* Vol. 52, No. 1, pp. 83-86, March 2006.