



# IJEAST

INTERNATIONAL JOURNAL  
OF ENGINEERING APPLIED SCIENCE  
AND TECHNOLOGY



**VOLUME : 1    ISSUE : 5    Print / Issue Publication Date: 09-Oct-2016**



**ISSN : 2455-2143**



Indexed In



[WWW.IJEAST.COM](http://WWW.IJEAST.COM)

[editor@ijeast.com](mailto:editor@ijeast.com)



# PAPR REDUCTION TECHNIQUE USING MODIFIED SLM IN OFDM SYSTEM

Mukul

M. Tech Research Scholar, Department of ECE,  
BRCM CET, Bahal, Bhiwani, India

Dr. Sajjan Singh

Associate Professor, Department of ECE  
BRCM CET, Bahal, Bhiwani, India

**Abstract**— High Peak to Average Power Ratio (PAPR) is still a challenging area and complex issue for OFDM system. The radio transmitter stations for covering and receiving an adequate amount of transmitted power in their most wanted area has to use (HPA) High Power Amplifier. In order the High Power Amplifier to have the most output power usefulness must be designed to work lock to the saturation state. A factor which is called memory less nonlinear distortion due to the high PAPR of input signals will influence the communication channels. It can reason the out-of-band power to be kept under the precise limits if the high power amplifier doesn't work in linear region. This condition can cause unproductive amplification and costly transmitters, so it is necessary to explore PAPR reduction techniques for OFDM system. For reducing PAPR many techniques have been suggested. In this paper we will propose our modified selective mapping (SLM) method for a conventional OFDM system.

**Keywords**— Peak to Average Power Ratio, High Power Amplifier, Orthogonal Frequency Division Multiplexing, and Selective mapping

## I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has grown to a popular communication technique for high speed communication in the last decade. Being an important member of the multicarrier modulation (MC) techniques, Orthogonal Frequency Division Multiplexing (OFDM), is also called Discrete Multitone Modulation (DMT). It is based upon the principle of frequency division multiplexing (FDM) where each frequency channel is modulated with simpler modulation scheme [1]. It splits a high rate data stream into a number of lower rate streams that are transmitted at the same time over a number of orthogonal subcarriers. That the carriers are placed exactly at the nulls in the modulation spectra of each other using Orthogonality is achieved. Therefore OFDM is an advanced modulation technique which is suitable for high-speed data transmission due to its advantages in dealing with the multipath propagation problem, high data rate and bandwidth efficiency [2]. Although OFDM principles have been developed over several decades, its implementation for high data rate communications has only recently become

popular by the reduced cost and availability of suitable signal processing components which make it a competitive technology for commercial applications also.

### A. Peak to Average Power Ratio:

It is defined as the ratio between the maximum power and the average power for the envelope of a baseband complex signal  $\tilde{s}(t)$  i.e.

$$PAPR\{\tilde{s}(t)\} = \frac{\max|\tilde{s}(t)|^2}{E|\tilde{s}(t)|^2}$$

Also we can write this PAPR equation for the complex pass band signal  $s(t)$  as

$$PAPR\{s(t)\} = \frac{\max|s(t)|^2}{E|s(t)|^2}$$

### B. Effect of High PAPR:

The linear power amplifiers are being used in the transmitter so the Q-point has to be in the linear region. Due to the high PAPR hence the clipping of signal peaks takes place which generates in-band and out-of band distortion then the Q-point moves to the saturation region [3]. Which again reduces its efficiency and enhances the cost due to keep the Q-point in the linear region the dynamic range of the power amplifier should be increased. In this paper our objective should be to reduce this PAPR.

## II. PAPR OF AN OFDM SIGNAL

Let us signify the data block of length as a vector  $X=[X_1, X_2, \dots, X_{N-1}]^T$  where  $N$  is equal to the number of subcarriers and  $(.)^T$  denotes transpose. The duration of a data symbol  $X_m$  in  $X$  is  $T$ . Each data symbol in  $X$  modulate some of a set of subcarriers  $\{f_{m,m}=1,2,\dots,N-1\}$ . The  $N$  subcarriers are selected to be orthogonal, that is,  $f_m=m\Delta f$ , where  $\Delta f=1/NT$  and  $NT$  is the period of an OFDM data block. The complex envelope of the transmitted OFDM signals given by

$$x(t) = \frac{1}{\sqrt{N}} \sum_{m=0}^{N-1} X_m \cdot e^{j2\pi f_m t}, 0 < t < NT \quad \text{----- (1)}$$

The PAPR of the transmitted signal in (1) is defined as



$$PAPR = \frac{\max|x(t)|^2}{\frac{1}{NT} \int_0^{NT} |x(t)|^2 dt} \quad \text{----- (2)}$$

Estimate NP equidistant samples of (1) will be measured where P is an integer which is equal to 1 or larger than [8]. This ‘P-times oversampled’ are represent as a vector and obtained as [4]

$$x_k = x\left(k, \frac{T}{P}\right) = \frac{1}{\sqrt{N}} \sum_{m=0}^{N-1} X_m \cdot e^{j\frac{2\pi km}{NP}},$$

$$k = 0, 1, \dots, NP - 1 \quad \text{----- (3)}$$

Series {X<sub>k</sub>} of the OFDM data block X with (P-1) zero padding can be interpreted as the inverse discrete Fourier transform. Which corresponds to the case of P=1 that PAPR of the continuous-time OFDM signal cannot be obtained accurately by the use of the Nyquist rate sampling. The PAPR compute from the P-times oversampled time-domain signal samples is given by

$$PAPR = \frac{\max|x(k)|^2}{E|x(k)|^2} \quad \text{----- (4)}$$

Where E [.] denotes expectation

### III. IMPROVED SELECTED MAPPING TECHNIQUE FOR OFDM SIGNAL

#### A. SLM Technique:

The SLM technique is shown in Fig. 1 the input data is partition into a data block X of length N. The data block of OFDM is multiplied element by element with phase sequences B(u) = [b<sub>u,0</sub>, b<sub>u,1</sub> ... b<sub>u,N-1</sub>], u=1,2,...U, to make the phase rotated OFDM data blocks where X(u)=[X<sub>u,1}X<sub>u,2}X<sub>u,3}...X<sub>u,N-1}</sub>]<sup>T</sup>, where X<sub>u,m}=X<sub>m}b<sub>u,m}</sub>, m=0,1,2...N-1.. The unmodified OFDM data block provided that the phase sequence using U phase rotated OFDM data blocks signify the same information. OFDM data block in the set of the phase rotated OFDM data blocks to take in unmodified [5] it may set the first phase sequence B (1) as all one vector of length. Here applying the SLM technique to X, (1) become</sub></sub></sub></sub></sub>

$$x^{(u)}(t) = \frac{1}{\sqrt{N}} \sum_{m=0}^{N-1} X_m \cdot b_{u,m} \cdot e^{j2\pi f_m t},$$

$$0 < t < NT, \text{ and } u = 1, 2, \dots, U \quad \text{----- (5)}$$

U phase rotated OFDM data blocks by using PAPR is calculated from eqn (3) and (4). One of the lowest PAPR is chosen between the phase rotated OFDM data blocks and transmitted. The transmitted of information about the selected phase sequence to the receiver as side information. The reverse operation should be performed to recover the unmodified OFDM data block at the receiver side.

The U IDFT operations for each OFDM data block in SLM technique needs. The smallest integer which does not exceed the number of required side information bits is [log<sub>2</sub>U] where [y] denotes. The phase sequences are chosen in a way such that the phase rotate OFDM data blocks are adequately different. In the conventional SLM technique, there is no constraint on the

building of the phase sequences. Though, we put a structural control on the phase sequences for the improved SLM technique describes below.

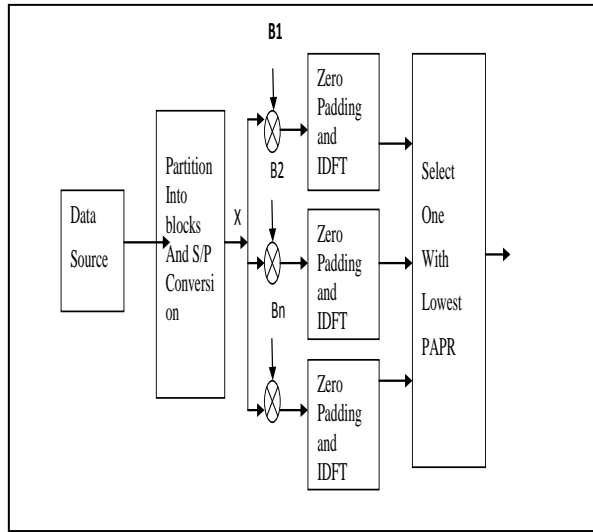


Fig.1 Block diagram of OFDM transmitter with the SLM technique

#### B. Modified SLM Technique for Coded OFDM Signal

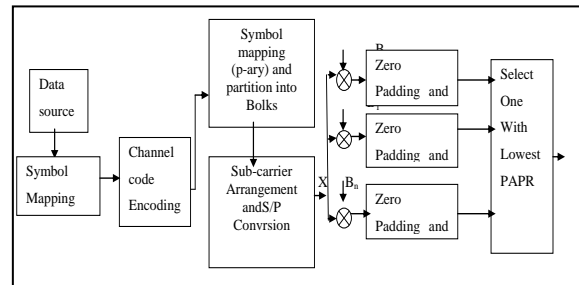


Fig.2 (a) Block Diagram of improved SLM Transmitter

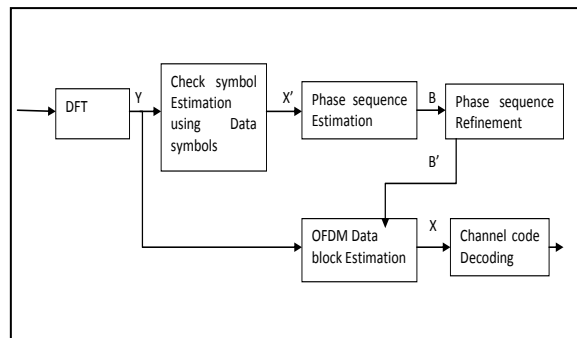


Fig.2(b) Block Diagram of Improved SLM Receiver

Fig. 2(a) and Fig. 2(b) show the block diagram of the improved SLM transmitter and receiver technique. At initial, q-ary



symbols input data is mapped and then processed by a rate  $r=k/n$  code over. The data symbols and check symbols are separately mapped to p-ary symbols after channel code encoding and are group into blocks of length N [6]. The number of code words required to create an OFDM data block of length N is set by

$$M = \frac{N \log_2 p}{n \log_2 q} \quad \text{----- (6)}$$

After collecting M code words, the data symbols and check symbols are arranged suitably among N subcarriers.  $N^*$  (k/n) subcarriers are used to transmit data symbols and the rest  $N^*(n-k)/n$  subcarriers are used for check symbols.

#### IV. RESULTS & DISCUSSION

##### A. Approximation of effect of Non-linearity

We use MATLAB simulations to evaluate the performance of the proposed PAPR reduction technique. To approximate the effect of nonlinearity in the power amplifier in the transmitter, we implement Rapp's model for amplitude conversion. The relation between amplitude of the normalized input signal  $g(A)$  and amplitude of the normalized output signal of the nonlinear power amplifier is given by

$$g(A) = \frac{A}{(1+A^{2p})^{1/(2p)}} \quad \text{----- (7)}$$

Where p is represent the nonlinear characteristic of the power amplifier. As p gets larger then power amplifier approaches a linear amplifier. A good approximation of a general power amplifier we choose  $p=3$ [8]. Fig. 4.1 gives the input-output relation curve. The input signal into the preferred range in the input-output relation curve when the input signal is normalized by a normalization factor to properly fit. It's back into original scale before normalization when normalized output signal is processed. The output back-off (OBO) is depends upon the amount of nonlinear distortion which is defined as

$$OBO = \frac{P_{o,max}}{P_{o,avg}} \quad \text{----- (8)}$$

Where  $P_{o,max}$  is the output power at the saturation point and  $P_{o,avg}$  the power of the output signal.

##### B. Performance analysis in terms of Symbol Error Rate (SER)

Fig. 3.1, 3.2, 3.3 shows SER analysis of the proposed technique, ordinary SLM technique and unmodified OFDM. Proposed scheme perform better than ordinary SLM scheme over entire range. To quantify results take  $E_b/N_o=5\text{db}$ , here SER for unmodified scheme is  $10^{-2}$ , for ordinary SLM it is  $9 \cdot 10^{-3}$  and for proposed scheme it is  $2 \cdot 10^{-4}$ . It is closely related to the value of n, k or the code rate  $r= k/n$  difference in PAPR enhancement between the improved technique and the ordinary SLM technique. Here is small difference between the CCDF of

the projected technique and that of the ordinary SLM technique if code rate is close to 0. The larger the difference is on the contrary the higher the code rate.

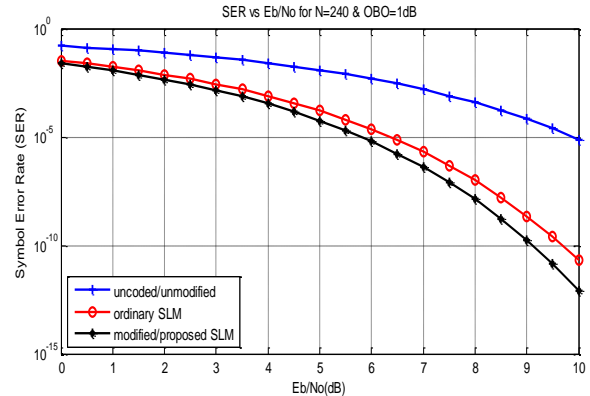


Fig. 3.1: Comparative SER analysis OFDM, OFDM with SLM & proposed scheme at OBO =1 dB

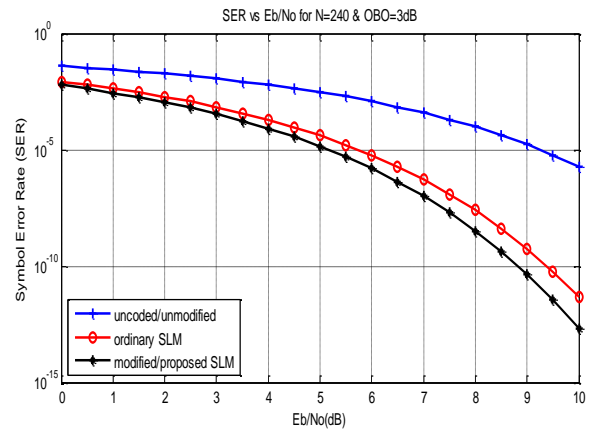


Fig. 3.2: Comparative SER analysis OFDM, OFDM with SLM & proposed scheme at OBO =3 dB

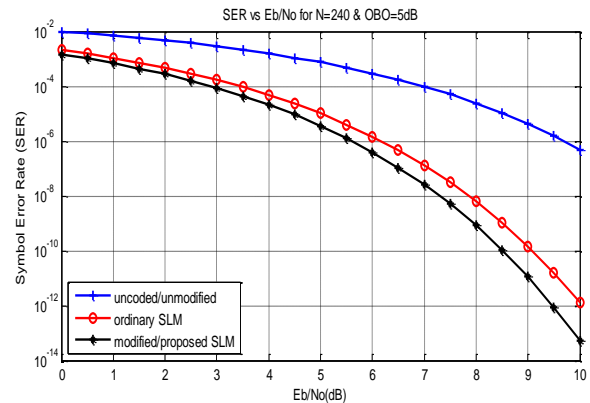


Fig. 3.3: Comparative SER analysis OFDM, OFDM with SLM & proposed scheme at OBO =5 dB

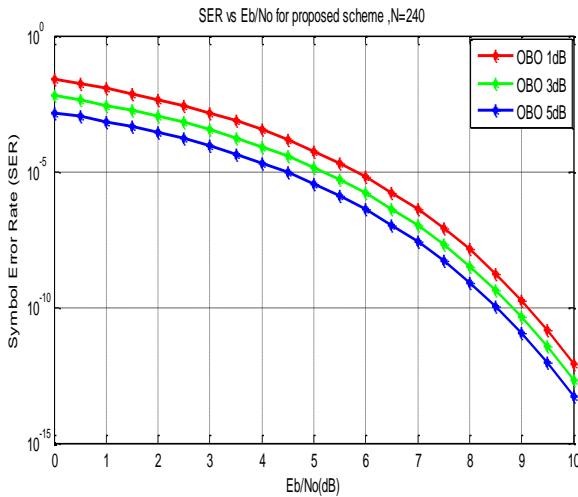


Fig. 3.4: Comparative SER scheme for various OBO levels.

Fig. 3.4 show the SER for OBO= 1dB, OBO= 3dB, OBO= 5dB respectively. Performance of system is better for larger value of OBO since the amount of nonlinear distortion is less for larger OBO.

### C. Performance analysis in terms of CCDF

Fig. 3.5, 3.6, and 3.7 plots the approximate expression for the CCDF of the unmodified OFDM, ordinary SLM technique and proposed SLM technique. Fig. 3.5 and 3.7 shows the CCDF of PAPR for  $N=120$  ( $N$  represent block length) and Fig. 4.6 and 4.8 shows that for  $N=240$ . The CCDF of the unmodified OFDM signal is plotted by using with  $\alpha=2.3$ . The CCDF of the conventional SLM technique is plotted by using with  $\alpha=2.3$  and that of the modified SLM technique is plotted by with  $\alpha=2.3$  and  $\beta=0.8, 0.75, 0.70$  for  $U=8, 16, 32$ , respectively.

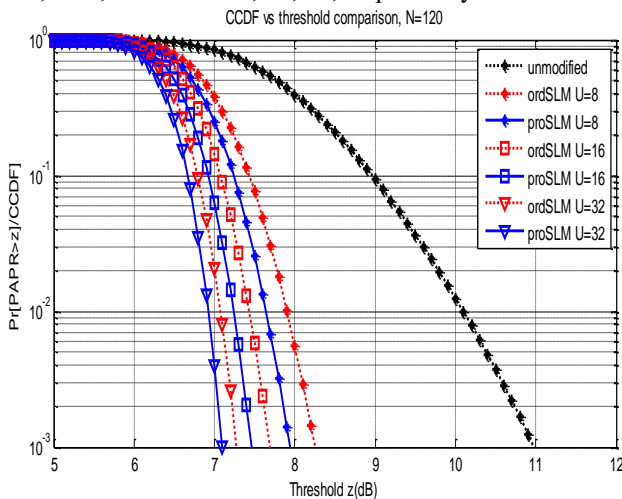


Fig. 3.5: Comparative analysis of OFDM, OFDM with SLM & proposed scheme in terms of CCDF,  $N=120$  ( $N$  represent block length)

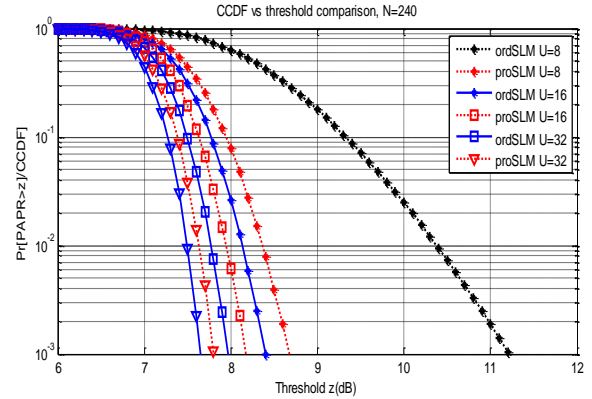


Fig. 3.6: Comparative analysis of OFDM, OFDM with SLM & proposed scheme in terms of CCDF,  $N=240$

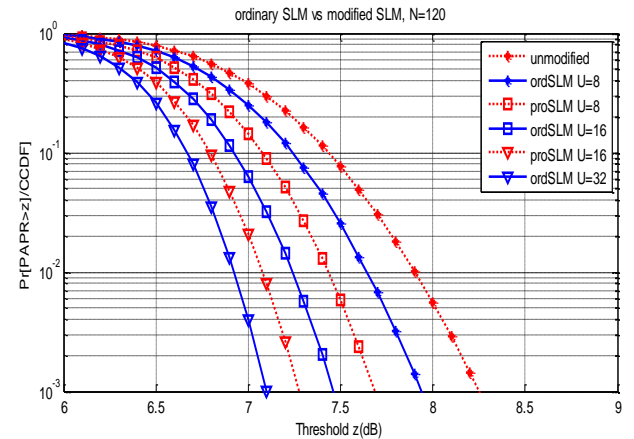


Fig. 3.7: Comparative analysis ordinary SLM & proposed scheme in terms of CCDF,  $N=120$

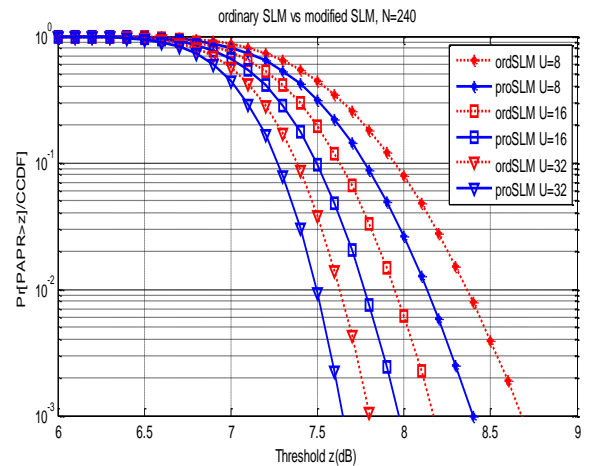


Fig. 3.8: Comparative analysis of ordinary SLM & proposed scheme in terms of CCDF,  $N=240$

As  $U$  increase performance improves as because with  $U$  no. of phase sequences increases, those are multiplied with incoming data sequence so no. of phase rotated data sequence increases. If no. of phase rotated data sequence is more among which we have to select and transmit, definitely performance increase.



With N performance degrades. As N represent block length, if element in block increase, more be the chances of error would be there.

With randomness performance improves, randomness is nothing but probability, if it is more closer to one, means we are very much sure of something, result would be better in that case too.

**D. Contribution of this paper:**

This paper proposes an efficient technique which has the potential to reduce PAPR significantly over scheme present in literature without affecting spectral efficiency of the system. Also its implementation complexity is less. It works well with arbitrary number of subcarriers for any type of baseband modulation used.

**TABLE 1.1 OVERALL ANALYSES OF DIFFERENT TECHNIQUES:**

| Name of schemes    | Name of parameters |                |                |                                   |                                          |
|--------------------|--------------------|----------------|----------------|-----------------------------------|------------------------------------------|
|                    | Signal Distortion  | Power Increase | Data rate Loss | Computational Complexity          |                                          |
|                    |                    |                |                | Transmitter processing            | Receiver processing                      |
| Amplitude clipping | Yes                | No             | No             | Amplitude clipping                | none                                     |
| (SLM)              | No                 | No             | Yes            | M IFFTs ,WM 1 complex vector sums | Side information extraction, inverse PTS |
| (SLM MODIFIED)     | No                 | No             | NO             | U IFFTs                           | Side information extraction, inverse SLM |

Above table 1.1 shows the parameters used in different PAPR reduction techniques. As shown in the table there is signal distortion in the amplitude clipping technique for the PAPR reduction. Due to the signal distortion in the amplitude clipping method desired information should not be reach to the receiver. The conventional SLM technique data rate loss increased so to overcome these losses we used modified SLM technique.

**TABLE 1.2 COMPARISONS BETWEEN PAPR REDUCTION TECHNIQUES:**

| Reduction Techniques | PAPR at CCDF of | PAPR(dB) |
|----------------------|-----------------|----------|
| Modified SLM         | $10^{-3}$       | 7.1      |
| SLM                  | $10^{-3}$       | 9        |
| PTS                  | $10^{-3}$       | 8.93     |

Table 1.2 shows the comparison of peak average power ratio between conventional SLM and modified SLM i.e proposed technique. Conventional PAPR for the SLM technique is 9 dB at  $10^{-3}$  CCDF and 11.1 dB at  $10^{-5}$  CCDF. Proposed or modified SLM technique shows the 7.1 dB PAPR at  $10^{-3}$  CCDF .By obtaining low PAPR power consumption in the system reduced and data rate also enhanced in the modified SLM based technique.

**V. CONCLUSION**

The performance difference b/w the improved technique and the conventional (Selective Mapping) SLM technique is due to the fact that, in the improved technique, the phase sequences have a drawback on their structure and thus the improvement of PAPR provided by the improved technique is not so much as the that from the conventional selective mapping method. In OFDM show the performance of Modified SLM that introduced the better PAPR reduction of 7.1dB can be achieved for suitable low power consumption communication system. The above achievements show the less power consumption of mobile terminal which is more suitable for next generation broadband wireless communication OFDM downlink system.

**VI. REFERENCES**

- [1] B.S. Krongold, K. Ramchadran, and D.L Jones, "Computationally Efficient Optimal Power Allocation Algorithms for Multicarrier Communication Systems," *IEEE Transaction Communication*, Vol.48, no.1, pp.23-27, Jan. 2000.
- [2] L.J. Cimini, Jr.B. Daneshrad, and N.R Sollenberger, "Clustered OFDM with Transmitter Diversity and Coding," in proceeding of *IEEE Global Tele. Communications. Conf.*, pp. 703-707, 1996.
- [3] P. H. Moose, "A Technique for Orthogonal Frequency Division Multiplexing Frequency Offset correction," *IEEE Transaction. Communication*, Vol. 42, no.10, pp. 2908–2914, 1994.
- [4] Gaurav Sikri and Rajni "A Comparison of Different PAPR Reduction Techniques In OFDM Using Various Modulations" *International Journal of Mobile Network Communications & Telematics (IJMNCT)*, Vol.2, No.4, August, 2012.
- [5] Misha Arora1, Er. Parvinder Singh "Reduction of Papr In OFDM Using Cross Grid Approach Of SLM and Clipping" *International Journal of Advanced Research in Computer and Communication Engineering*, Vol. 2, Issue 10, October 2013.
- [6] Monika Phulia and O.P. Sahu "Peak-to-Average Power Ratio (PAPR) Reduction of OFDM Signals Using a Modified PTS Technique" *International Journal of Electronic and Electrical Engineering*, Volume 7, pp. 79-84, No. 2014.

# IJEAST

INTERNATIONAL JOURNAL  
OF ENGINEERING APPLIED SCIENCE  
AND TECHNOLOGY

## ABOUT IJEAST

International Journal of Engineering Applied Science and Technology (IJEAST) is a peer-reviewed, open access journal that publishes high-quality research papers in the field of Engineering, Applied Science and Technology.

IJEAST aims to provide a platform for researchers, academicians, and professionals to share their innovative ideas, research findings, and practical experiences with the global scientific community.

## FOCUS AREAS

- Engineering
- Applied Science
- Technology
- Innovation & Development
- Interdisciplinary Studies



### PEER REVIEWED

All submissions are rigorously peer reviewed to ensure quality.



### OPEN ACCESS

Free and unrestricted access to research for all.



### GLOBAL REACH

Connecting researchers and professionals worldwide.



### TIMELY PUBLICATION

We ensure a swift and efficient publication process.



For more information, visit our website

[www.ijeast.com](http://www.ijeast.com)



INTERNATIONAL JOURNAL  
OF ENGINEERING APPLIED SCIENCE  
AND TECHNOLOGY

✉ [editor@ijeast.com](mailto:editor@ijeast.com)

🌐 [www.ijeast.com](http://www.ijeast.com)

📍 India



2455-2143