Effect of Different Modulation on PAPR and Its Reduction

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***Abstract*—As the technology grow in wireless communication, the concept of multicarrier modulation come into picture. Orthogonal Frequency Division Multiplex(OFDM) prove itself invaluable for multicarrier modulation.OFDM subcarriers can overlap to make full use of the spectrum but at the peak of each subcarriers spectrum, the power in all the other subcarriers is zero. One of the major disadvantages of OFDM signal is large PAPR, which require power amplifier with large linear (gain) ranges. But to increase efficiency of power amplifier it gain become nonlinear and corresponding OFDM signal distort. So, a need for technique which reduces PAPR.Selective Mapping with phase rotation is one of the techniques to reduce PAPR .In this paper we have to compare the effect of different modulation (QPSK, DQPSK, and 4-QAM) on PAPR value of OFDM signal and its reduction by using selective mapping phase rotation method.**

***Keywords* — OFDM, PAPR, 4- QAM, QPSK, DQPSK, IFFT**

INTRODUCTION

OFDM has become an attractive technique and gained more popularity recently. Many new communication systems have selected OFDM because its good properties, e.g. tolerance to inter-symbol interference and good spectral efficiency, capacity to handle very strong echoes and less non-linear distortion .So OFDM[1] signal is adopted by 4G community. Existing 3G systems uses single carrier modulation technique whereas OFDM which is otherwise known as Multicarrier Modulation see Figure 1 sends a high speed data stream by splitting it up to multiple lower speed stream by using serial to parallel converter and transmitting it over a lower bandwidth. Its offer higher data capacity in a given spectrum while allowing a simpler system design. Creating orthogonal subcarriers in the transmitter is easy using an inverse FFT.To ensure this orthogonality is maintained at the receiver (so that the subcarriers are not misaligned), the system must keep the transmitter and receiver clocks closely synchronized-within 2 parts per million in 802.11a systems.In general, an FFT implementation is much simpler than the RAKE receivers used for CDMA and decision-feedback equalizers for TDMA. However, a major drawback of OFDM is the high peak to- average power ratio (PAPR) of the transmitted signal, which requires power amplifier with large linear ranges. Hence, power amplifier requires more back-off which in turn reduces the power efficiency. Some other problems include phase distortion, time-varying channel and time synchronization. There are various technique is used to reduce the PAPR of OFDM signal like clipping,SLM technique, Partial transmit sequence(PTS)[13] of which Selective mapping with phase rotation is used in this paper.

OFDM is used as the modulation method for Digital Audio Broadcasting (DAB) and terrestrial Digital video Broadcasting (DVT-T) in Europe, and in asymmetric digital subscriber line (ADSL).Wireless local area network use OFDM as their physical layer transmission technique.OFDM is also a strong candidate for IEEE wireless personal area network standard and for fourth generation (4G) cellular systems.

II. ORTHOGONALITY OF SIGNAL

Orthogonal signals [2] can be viewed in the same perspective as we view vectors which are perpendicular/orthogonal to each other. The inner product of two mutually orthogonal vectors is equal to zero. Similarly the inner product of two orthogonal signals is also equal to zero.

Let $\phi 1(t) = e^{j2\pi f_k}$ and $\phi 2(t) = e^{j2\pi f_m}$ be two complex exponential signals whose inner product, over the time duration of T, is given by:

$$M = \int_{kT}^{(k+1)T} \phi 1(t)\, \phi 2^{*}(t) \text{----------------(1)}$$

When this integral is evaluated, it is found that if f_k and f_m are integer multiples of 1/T then M equals zero. This implies that for two harmonics of an exponential function having a fundamental frequency of 1/T, the inner product becomes zero. But if $f_m = f_k$ then M equals T which is nothing but the energy of the complex exponential signal in the time duration of T.

This paper is organized as follows section II gives orthogonality of Signals. An overview of system model is given in Section III.Brief description of Selective mapping with Phase rotation technique is given in section IV.Algorithm for reduced PAPR is given in section V.Simulation parameter in section VI and finally Simulation result with conclusion is given in section VII,VIII.

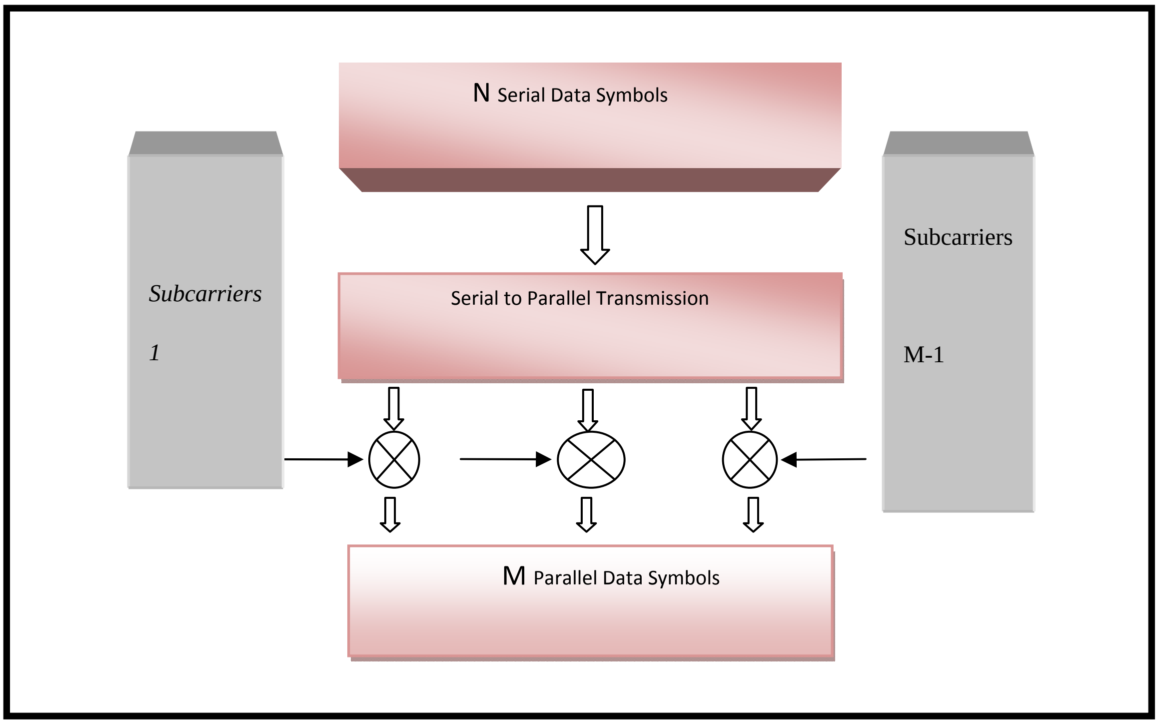


Figure1: Multicarrier Transmission Technique

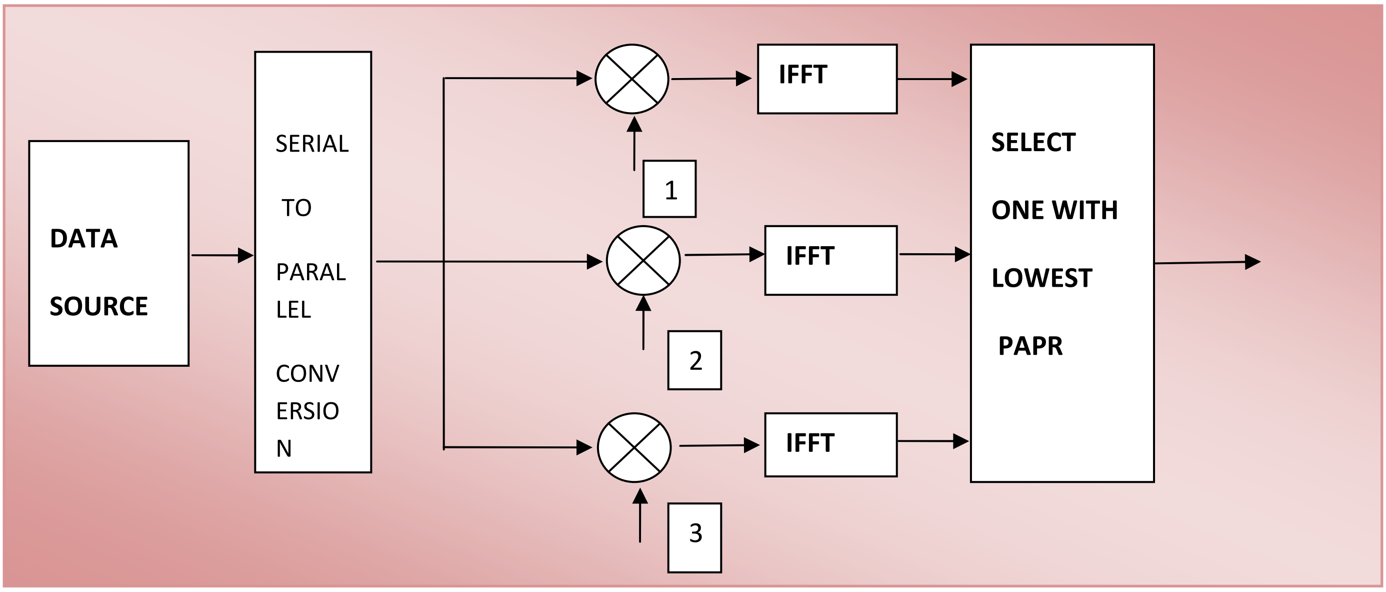
III.SYSTEM MODEL

Assume that the data (bit) stream is generated by using Random integer generator block of MATLAB/SIMULINK. These data value are modulated by using QPSK, DQPSK, and 4-QAM modulation. For simplicity, assume a square constellation such as square QAM .Let us denote the data block of length *M as* a vector **X** = $[Y0, Y1, ------, Y_{M-1}]T$ where *M* is equal to the number of subcarriers. Then it is given to serial to parallel converter which generates a four copy of data value. By looking carefully, these data value are in frequency domain. These frequency domain data value are given phase rotation from 1,2,3……….V.After that it is given to IFFT of size 64 which convert frequency domain signal into time domain signal.IFFT also maintain the orthogonality of these subcarriers. The number of subcarriers is given by dividing no. of data value with IFFT.The complex envelope of the transmitted OFDM signal is given by

$$y(t) = \frac{1}{\sqrt{M}} \sum_{m=0}^{M-1} Y_m \, e^{j2\pi t f_m} \;, 0 \le t \le MT \quad \text{------------- (2)}$$

Now, the peak to average power ratio is calculated by using the formula.

$$\text{PAPR} = \frac{\text{Ppeak}}{\text{Paverage}} = \frac{\max_{0 \le t < MT} |y(t)|^2}{\frac{1}{MT}\int_0^{MT} |y(t)|^2} \text{---------------- (3)}$$



1, 2, 3:- CARRIERSWISE PHASE (U) SEQUENCES

Figure2: Block Diagram of OFDM Transmitter with the SLM Technique1

IV.SELECTIVE MAPPING WITH PHASE ROTATION TECHNIQUE

In SLM technique firstly [11], the input information is divided into OFDM data block **Y**, which consists of *M* symbols, by the serial-to parallel conversion and then data block **Y** is multiplied carrier wise with each one of the *U* different phase sequences $B^{(u)}$, resulting in a set of *U* different OFDM data blocks

$$Y^{(u)} = [Y_0^{(u)}, Y_1^{(u)} ----, Y_{M-1}^{(u)}]^T \qquad ------------------------- \quad (4)$$

$$Y_m^U \quad = \quad Y_m . B^U \qquad ------------------------------ \quad (5)$$

$m = 0, 1, \cdot\cdot, M - 1$, $u = 1, 2, \cdot\cdot, U$. Then all phase rotation (*U)* alternative data blocks are transformed into time domain to get transmit OFDM symbol y^u = IFFT $\{Y^u\}$.The information on the selected phase sequence must be transmitted to the receiver. All U phase rotated OFDM data blocks represented the same information as the unmodified OFDM data block Provided that the phase sequence is known [13]. After applying the selective mapping phase sequence, the complex envelope of the transmitted OFDM signal becomes

$$y(t) = \frac{1}{\sqrt{M}} \sum_{m=0}^{M-1} Y_m \; e^{j2\pi t f_m}, \; 0 \leq t \leq MT \; ------------------------------(-6)-$$

Here, MT is the duration of an OFDM data block. Output data of the lowest PAPR is selected to transmit. Figure 2 shows the block diagram of OFDM transmitter with Selective mapping phase rotation technique. This technique effectively reduces Peak to Average Power Ratio without any signal distortion. But the system become complex. This complexity can less by reducing the number of IFFT block [3, 4, and 5].Here IFFT block also maintain the orthogonality of subcarriers.

V. ALGORITHM FOR REDUCED PAPR

1. Generate data value of size Y = Y1, Y2, Y3…….YM.
2. These data value are modulated using QPSK, DQPSK, and 4-QAM.
3. These data value are given phase rotation (U) from 1 to 4 degree. We get $Y_n^u = Y_n B^u$.
4. After giving phase rotation we get signal $Y^u = Y_1^u, Y_2^u, Y_3^u$, -----------$Y_m^u$.
5. These Y^u frequency domain signal given to IFFT which convert it into time domain y^u.The signal from each IFFT is orthogonal signals (subcarriers).

6. Now, calculate the PAPR by using the equation no.3 and select the least PAPR OFDM signal.

VI. .SIMULATION PARAMETER

No. of Sub Carriers	: 900
IFFT Size	: 64
Phase rotation (U)	: 4
Modulation	: QPSK, DQPSK, 4-QAM
No. of Data points	: 57600
Constellation mapping	: 32

VII.SIMULATION RESULT

All the simulation will be performed in MATLAB 7.8.When we calculate the PAPR without phase rotation selective mapping technique for DQPSK Modulation the PAPR is found to be 9.796dB.But when selective mapping with phase rotation for same modulation is used the PAPR value found to be 8.111dB.So, the value reduced by factor 1.685dB.Figure 3,4 shows the PAPR of BASIC OFDM system using QPSK,DQPSK modulation.

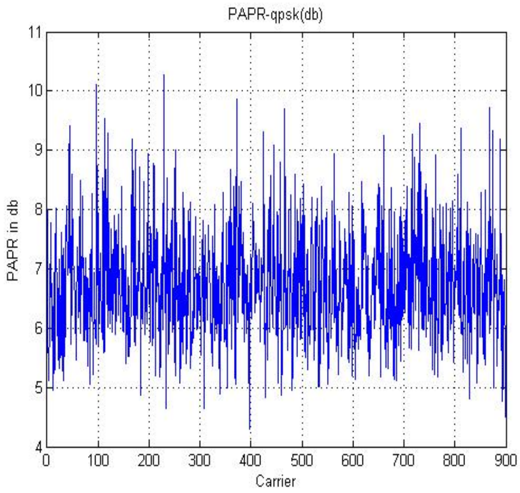


Figure3: PAPR of BASIC QPSK OFDM System

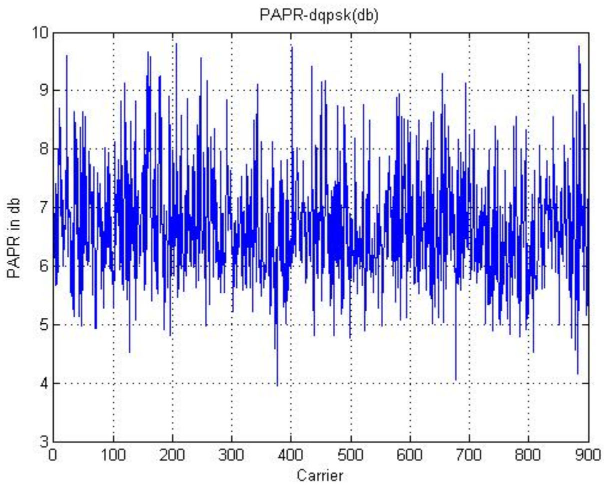


Figure4: PAPR of BASIC DQPSK OFDM system

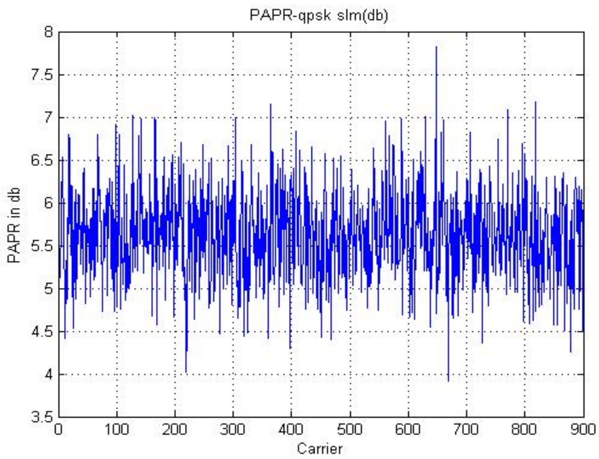


Figure5: PAPR of BASIC QPSK OFDM system with SLM technique

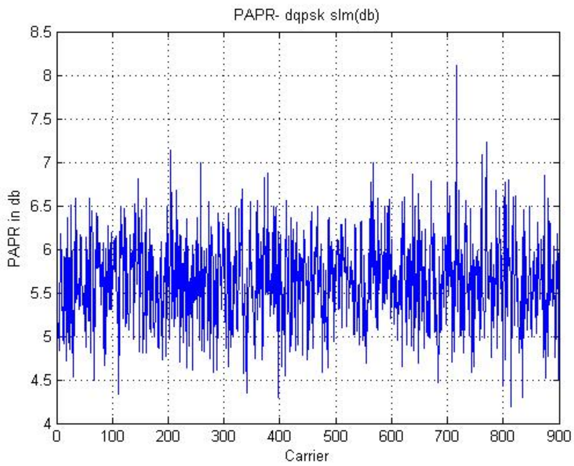


Figure6: PAPR of BASIC DQPSK OFDM system with SLM Technique

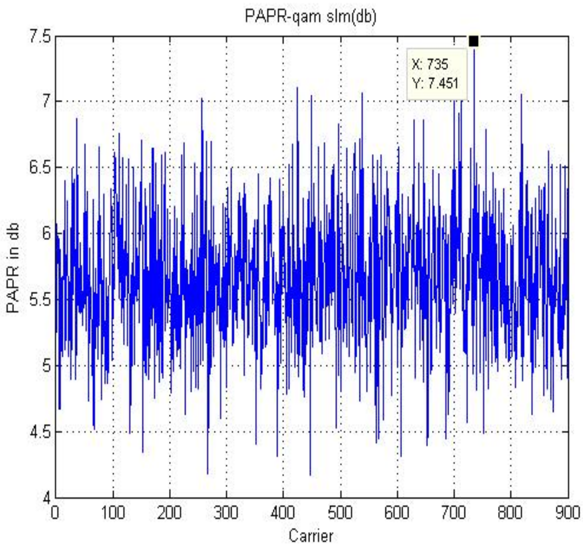


Figure7: PAPR of BASIC 4-QAM OFDM system with SLM Technique

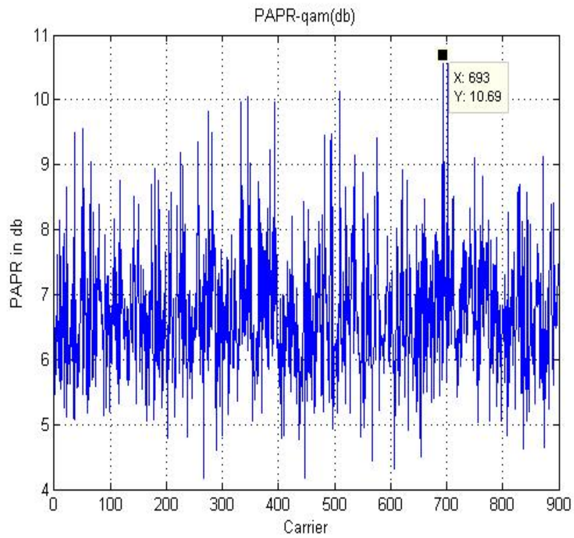


Figure 8: PAPR of BASIC 4-QAM OFDM system without SLM technique

Also when we calculate the PAPR of BASIC OFDM system using QPSK, 4-QAM modulation the value come out to be 10.28dB and 10.69dB as shown in figure 3, 8 But when we apply the phase rotation technique to OFDM signal the reduced PAPR value come out to be 7.819dB, 7.451dB as shown in figure 5, 7.so the value reduced by 2.461dB, 3.239dB. From below Table 1 shows that more PAPR value is reduced with 4-QAM modulation its come out to be 3.239dB.

Table1: Comparison of Different Modulation with PAPR of OFDM signal

Comparison of Peak to Average Power Ratio(dB) With & Without Phase Rotation	**QPSK**	**DQPSK**	**4-QAM**
Without Phase Rotation	10.28	9.796	10.69
With Phase Rotation	7.819	8.111	7.451
Difference in Peak To Average Power Ratio (dB) Without & With Phase Rotation	2.461	1.685	3.239

VIII. CONCLUSION

Reducing PAPR of OFDM signal is important for increasing the performance Of Communication equipment. So in this paper of all the different modulation (QPSK, DQPSK, and 4-QAM) on OFDM signal we can able to find the least PAPR of OFDM signal. Also optimize the PAPR value by phase rotation technique, on doing different modulation on OFDM signal. The proposed Selective Mapping with phase rotation technique is simple and achieves significant reduction in PAPR. Results of simulation of SLM technique show that the least PAPR reduction of OFDM system for 4-QAM modulation of all three modulations sees table1. Which further results in high performance of wireless communication. With the rising demand for efficient use of frequency spectrum, OFDM proves invaluable to 4G communication systems.

REFRENCES

[1] L.J.Cimini, Jr, "Analysis and Simulation of a Digital Mobile Channel using OFDM", *IEEE Trans. On Communications*, vol.Com-33, no.7, pp.665-675, July 1985.

[2] Dr. Abhijit Mitra, a Lecture Notes on Mobile Communication, a Curriculum Development Cell Project under QIP, Department of Electronics and Communication Engineering, Indian Institute of Technology, Guwahati India, and November 2009.

[3] Seung Hee Han and Jae Hong Lee, .Modified selected Mapping Technique for PAPR reduction of coded OFDM signal., IEEE Transaction on broadcasting, Vol.50, No.3, pp.335-341, Sept. 2004.

[4] Yang Jie, Chen Lei, Liu Quan and Chan De, .A Modified selected mapping technique to reduce the Peak to Average Power Ratio of OFDM signal. IEEE transaction on consumer Electronics, Vol53, No.3, pp. 846-851, August 2007.

[5] Stefan H.Muller and Johannes B. Huber, .A Comparison of Peak Power Reduction Schemes for OFDM, In Proc. of The IEEE Global Telecommunications conference GLOBECOM. 97, Phonix, Arizona, USA, pp.1-5, Nov. 1997.

[6] R.W Chang, "Orthogonal Frequency Division Multiplexing," *U.S Patent 3388455*, Jan 6, 1970, Filed Nov.4.1966.

[7] B.R. Satzberg, "Performance of an Efficient Parallel Data Transmission System,"*IEEE Trans. Commun. Technol.*, Vol.COM-15, no.6, pp. 805-811, Dec 1967.

[8] X. Li and L. J. Cimini Jr., "Effects of clipping and filtering on the performance of OFDM," IEEE Communication Letters, pp. 131-133, May 1998.

[9] Xiao Huang, Jianhua Lu, Justin Chuang, and Junli Zheng, "Companding transform for the reduction of peak to average power ratio of OFDM signal," IEEE Trans. On Commun. vol. 48, pp. 835-839, May 2001.

[10] A. E. Jones, T. A. Wilkinson and S. K. Barton,"Block coding scheme for reduction of peak to mean envelope power ratio of multicarrier transmission schemes," Electronic Letters, pp. 2098-2099, Dec. 1994.

[11] R. W. Bauml, R. F. H. Fisher, and J. B. Huber, "Reducing the peak-to average power ratio of multicarrier modulation by selected mapping," *Electron. Letter*. vol. 32, no. 22, pp. 2056–2057, Oct. 1996.

[12] Yang Jie, Chen Lei, Liu Quan and Chan De, .A Modified selected mapping technique to reduce the Peak to Average Power Ratio of OFDM signal. IEEE Transaction on consumer Electronics, Vol53, No.3, pp. 846-851, August 2007.

[13] Xin_Chun Wu, Jin_Xiang Wang, Zhi_Gang Mao, .A Novel PTS Architecture for PAPR Reduction of OFDM signals., ICCS IEEE 2008, pp. 1055-1060.

[14] Yang Chan Cho, Seung Hee Han,and Jae Hong Lee ,Selected Mapping technique with novel phase sequences for reduction of an OFDM signal.,pp.4781-4785,2004.

[15] Marco Breiling ,Stefan H. Muller-Weinfurtner and Johanes B.Huber,"SLM Peak-Power Reduction Without Explicit Side Information", IEEE Communications Letters, VOL.5, No.6, pp.239-241, JUNE 2001.

[16] V. Vijayaranjan, DR.(MRs) Sukanesh, An overview of technique for reducing PAPR and its selection criteria for OFDM Radio System.,Journal of Theorithical and Applied IT ,pp.25-36,2005-2009.

[17] Yang Chan Cho, Seung Hee Han, and Jae Hong Lee," Selected Mapping Technique with Novel Phase Sequences for PAPR Reduction of an OFDM Signal," Vehicular Technology conference, 2004.VTC 2004-Fall, 2004 IEEE vol. 7, pp. 4781-4787, Sep 2004.

[18] V. B. Malode, Dr. B. P. Patil," PAPR Reduction Using Modified Selective Mapping Technique", Int. J. of Advanced Networking and Applications, Volume: 02, Issue: 02, Pages: 626-630, August 2010.