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Performance and Analysis of OFDM Signal Using Matlab Simulink

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Abstract: *Multi-carrier modulation is an attractive technique for fourth generation .OFDM is based on multicarrier modulation technique. In OFDM system the bit stream is divided into many different sub channels. An efficient and distortionless scheme for peak power reduction in OFDM is proposed. In this paper, a set of mapping where the actual transmit signal is selected. From this set of signal reduced PAPR. Simulation results are shown. The lowest PAPR is compared with conventional work. It is also compared BER to SNR and best result is achieved.*

Keywords: *BER, IFFT, OFDM, PAPR, Phase Rotation, QAM, QPSK, SLM etc.*

I. Introduction

Orthogonal frequency division multiplexing (OFDM) has been recently seen rising popularity in wireless application. OFDM properties like high spectral efficiency, robustness to channel fading, immunity to impulse interference, uniform average spectral density, and capacity to handle very strong echoes and less non-linear distortion, immunity to inter-symbol interference. The main disadvantages of OFDM systems is that it exhibits a high peak to average power ratio, namely the peak value of some of the transmitted signal could be much larger than the typical values. To reduce PAPR, many techniques have been proposed, such as clipping, partial time sequence, interleaving, nonlinear companding transforms, hadamard transforms, SLM technique etc. The selected mapping method (SLM) provides good performance for PAPR reduction, and this requirement usually results in high computational complexity. Several techniques have been proposed based on low-complexity selected mapping schemes for Peak-to-Average Power Ratio reduction in OFDM Systems.

In recent years OFDM is employed in Digital Television Broadcasting (such as the digital ATV Terrestrial Broadcasting), European Digital Audio Broadcasting (DAB) and Digital Video Broadcasting Terrestrial (DVB-T), and numerous Wireless Local Area Networks (e.g. IEEE 802.11a operating at 5 GHz) and European Telecommunications Standard Institute (ETSI) Broadband Radio Access Networks (BRAN)'s High Performance Radio Local Area Network (HIPERLAN) Type-2 standard.

The organization of this paper is as follows. Section II presents OFDM signal model and formulae, Section III presents the problem of PAPR and algorithm of least PAPR. Section IV presents the figure and table of simulation results. Section V presents conclusion of simulation results.

II. Orthogonal Frequency Division Multiplexing (OFDM)

Orthogonal Frequency Division Multiplexing is a frequency–division multiplexing (FDM) scheme utilized as a digital multi–carrier modulation method. A large number of closely spaced orthogonal sub–carriers is used to carry data. The data is divided into several parallel streams of channels, one for each sub–carriers. Each sub– carrier is modulated with a conventional modulation scheme (i.e. QPSK) at a low symbol rate, maintaining total data rates similar to the conventional single carrier modulation schemes in the same bandwidth. Orthogonal Frequency Division Multiplexing is a special form of multicarrier modulation which is particularly suited for transmission over a dispersive channel. Here the different carriers are orthogonal to each other that is they are totally independent of one another. This is achieved by placing the carrier exactly at null in modulation spectra of each other.

Two periodic signals are orthogonal when the integral of their product over one period is equal to zero. For the case of continuous time:

$$\int_0^T \cos(2\pi n f_0 t)\cos(2\pi m f_0 t)\,dt = 0 \quad (1)$$

For the case of discrete time:

$$\sum_{K=0}^{N-1} \cos\left(\frac{2\pi kn}{N}\right)\cos\left(\frac{2\pi km}{N}\right)dt = 0 \quad (2)$$

Where, $m \neq n$ in both cases.

Fig. 1: The area under a sine and a cosine wave over one period is always zero.

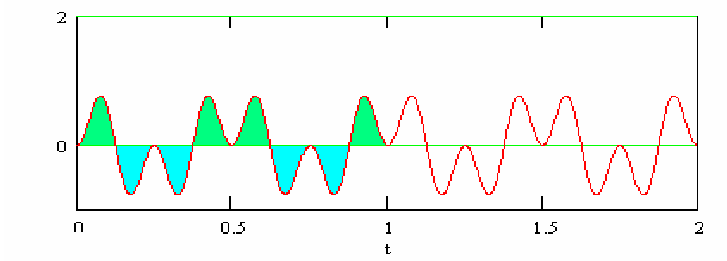

Fig 2: The area under a sine wave multiplied by its own harmonic is always zero.

The main concept in OFDM is orthogonality of the sub-carriers. Since the carriers are all sine/cosine wave, we know that area under one time period of a sine or a cosine wave is zero.
Let's take a sine wave of frequency m and multiply it by a sinusoid (sine or a cosine) of a frequency n, where both m and n are integers. The integral or the area under this product is given by

$$F(t) = \sin(mwt) * \sin(nwt) \tag{3}$$

By the simple trigonometric relationship, this is equal to a sum of two cosine of frequencies (m-n) and (m+n).

$$= \frac{1}{2}\cos(m-n) - \frac{1}{2}\cos(m+n)$$

$$= \int_0^{2\Pi} \frac{1}{2}\cos(m-n)\, wt - \int_0^{2\Pi} \frac{1}{2}\cos(m+n)\, wt$$

$$= 0 - 0$$

$$= 0$$

These two components are each a sinusoid/cosine, so the integral is equal to zero over one period.

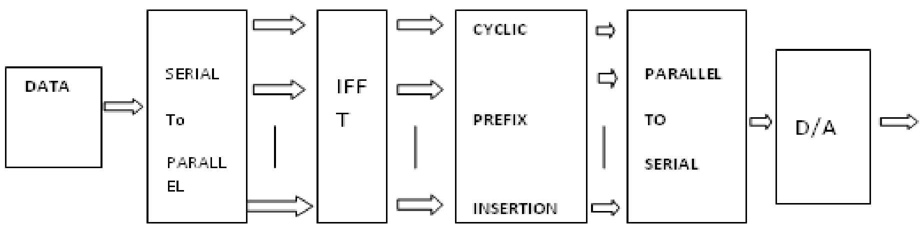

Fig.3: OFDM Transmitter System

In figure 3, IFFT is performed on the modulated signal which is further processed by passing through a parallel– to–serial converter. In order to avoid ISI we provide a cyclic prefix to the signal. The Cyclic Prefix or Guard Interval is a periodic extension of the last part of an OFDM symbol that is added to the front of the symbol in the transmitter, and is removed at the receiver before demodulation.
The cyclic prefix has to two important benefits –
1 .The cyclic prefix acts as a guard interval. It eliminates the inter – symbol interference from the previous symbol.
2 .It acts as a repetition of the end of the symbol thus allowing the linear convolution of a frequency –selective multipath channel to be modeled as circular convolution which in turn may be transform to the frequency domain using a discrete fourier transform. This approach allow a simple frequency domain processing such as channel estimation and quality.

the received data is first made to pass through a low pass filter and the cyclic prefix is removed. FFT of the signal is done after it is made to pass through a serial – to – parallel converter. A demodulator is used, to get back the original signal.

III. THE PAPR OF OFDM SYSTEM

The PAPR of OFDM is defined as the ratio between the maximum power and the average power, The PAPR of the OFDM signal X (t) is defined as

$$\text{PAPR} = \frac{p_{\text{peak}}}{p_{\text{average}}} = \frac{\max_{0\leq t<MT} |x(t)|^2}{\frac{1}{MT}\int_0^{MT} |x(t)|^2} \qquad (4)$$

Presence of large number of independently modulated sub-carriers in an OFDM system the peak value of the system can be very high as compared to the average of the whole system. This ratio of the peak to average power value is termed as Peak-to-Average Power Ratio. Coherent addition of N signals of same phase produces a peak which is N times the average signal.

The major disadvantages of a high PAPR are-

* Increased complexity in the analog to digital and digital to analog converter.
* Reduction is efficiency of RF amplifiers.

The main objective of this technique is to generate a set of data blocks at the transmitter end which represent the original information and then to choose the most favorable block among them for transmission. Let us consider an OFDM system with N orthogonal sub–carriers. A data block is a vector composed of N complex symbols , each of them representing modulation symbol transmitted over a sub–carrier. X is multiplied element by element with U vector composed of N complex numbers, defined so that , where |.| denotes the modulus operator. Each resulting vector which, produced after IDFT, a corresponding OFDM signal is given by

$$S_u(t) = \frac{1}{\sqrt{N}}\sum_{n=0}^{N-1} x_{u,n}\, e^{j2\pi n\Delta f t} \qquad 0 \leq t \leq T \qquad (5)$$

Where T is the OFDM signal duration and Δf = 1/T is the sub-carrier spacing.

Among the modified data blocks, the one with the lowest PAPR is selected for transmission. The amount of PAPR reduction for SLM depends on the number of phase sequences *U* and the design of the phase sequences.

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

$$X^{(w)} = [X_0{}^{(w)}, X_1{}^{(w)} ----, X_{M-1}{}^{(w)}]^\wedge T \qquad (6)$$

Where, $X_m^w = X_m B_m^w$, $m = 0, 1, \cdot\cdot, M-1$, $w = 1, 2, \cdot\cdot, w$.

$$X_m^w = X_m B_m^w \qquad (7)$$

$$B^w = [X_0{}^{(w)}, X_1{}^{(w)} ----, X_{M-1}{}^{(w)}]^\wedge T \qquad (8)$$

Then all *w* alternative data blocks are transformed into time domain to get transmit OFDM symbol x^w=IFFT $\{X^{(w)}\}$.

The transmit sequence $\tilde{x} = x^{(\tilde{w})}$, where $\tilde{w}$ = arg $\{min_w$ max $|\mathbf{x}\ (w)|\}$, is selected. The information on the selected phase sequence must be transmitted to the receiver. Where m = 0,1,2,3 ……….M-1 .w = 0, 1, 2 …W, to make w phase rotated OFDM data blocks. All w phase rotated OFDM data blocks represented the same information as the unmodified OFDM data block Provided that the phase sequence is known. After applying the SLM technique, the complex envelope of the transmitted OFDM signal becomes

$$X(t) = \frac{1}{\sqrt{M}}\sum_{m=0}^{M-1} X_m\, e^{j2\pi t f_m},\ 0 \leq t \leq MT \qquad \text{-------------}5$$

Here, MT is the duration of an OFDM data block. Output data of the lowest PAPR is selected to transmit.

Algorithm for least PAPR:

1) Firstly 16 sinusoidal subcarriers are taken. These are available subcarriers (QPSK Modulation) assuming all one positive.

   X1 =sin ((2*180*100*t) +w)
   X2 =sin ((2*180*200*t) +w)

X3 =sin ((2*180*300*t) +w)

.

.

.

X16= sin ((2*180*1600*t) +w)

These subcarriers are orthogonal to each other because in general for all integers' m and n, sinmx, sinny, cosmx, cosmy are orthogonal to each other. These frequencies are called harmonics.

2) Giving these entire subcarrier phase shift(w) 0 to 90.
3) Now sum of all these entire subcarriers sum = x1+x2+x3+x4+………..+x15+x16. (9)
4) Calculate the PAPR according to the formula given in equation (6)

For comparison of BER and SNR :

1) No. of Carriers: 64
2) coding used: Convolutional coding
3) Single frame size: 96 bits
4) Total no. of Frames: 100
5) Modulation: 16-QAM
6) No. of Pilots: 4
7) Cylic Extension: 25%(16)

IV. SIMULATION RESULT

Simulation is carried with MATLAB 7.8 to evaluate the performance of the different phase rotation on OFDM Signal, for reducing PAPR, BER and SNR

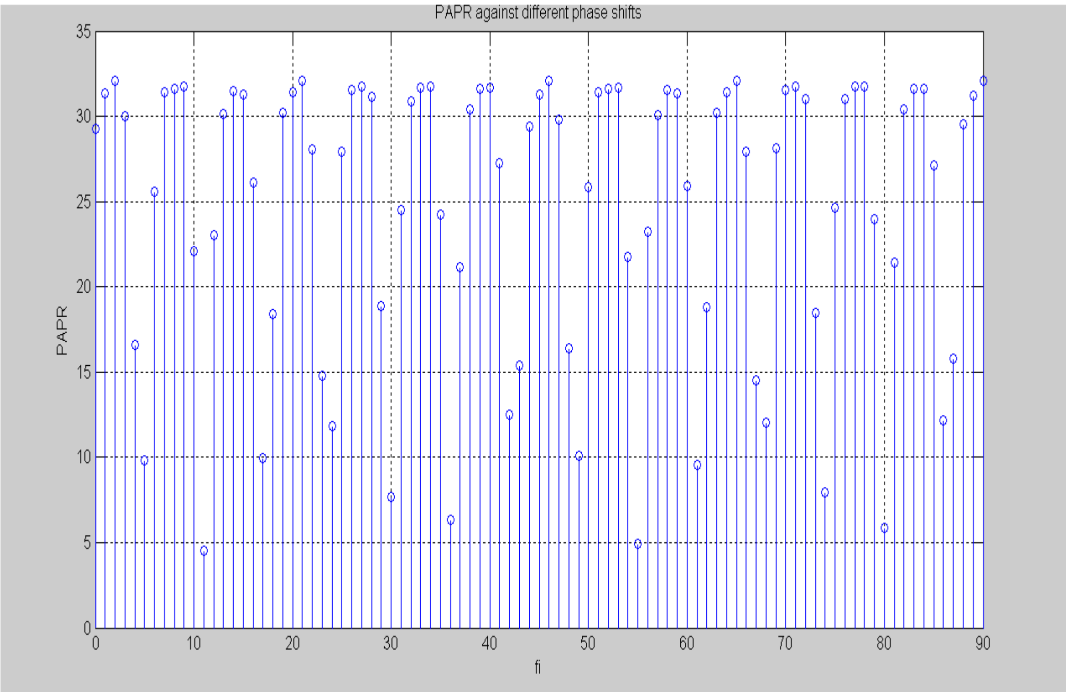

Fig 4: PAPR against different phase shift

From the simulation result we see that if we give all these 16 orthogonal subcarriers with phase rotation (w) of 0 to 90 we get the minimum PAPR at phase rotation 11 as shown in figure 4.The PAPR value at 11 degree and 55 degree is 4.5292dB and 4.9379 dB respectively are least PAPR.

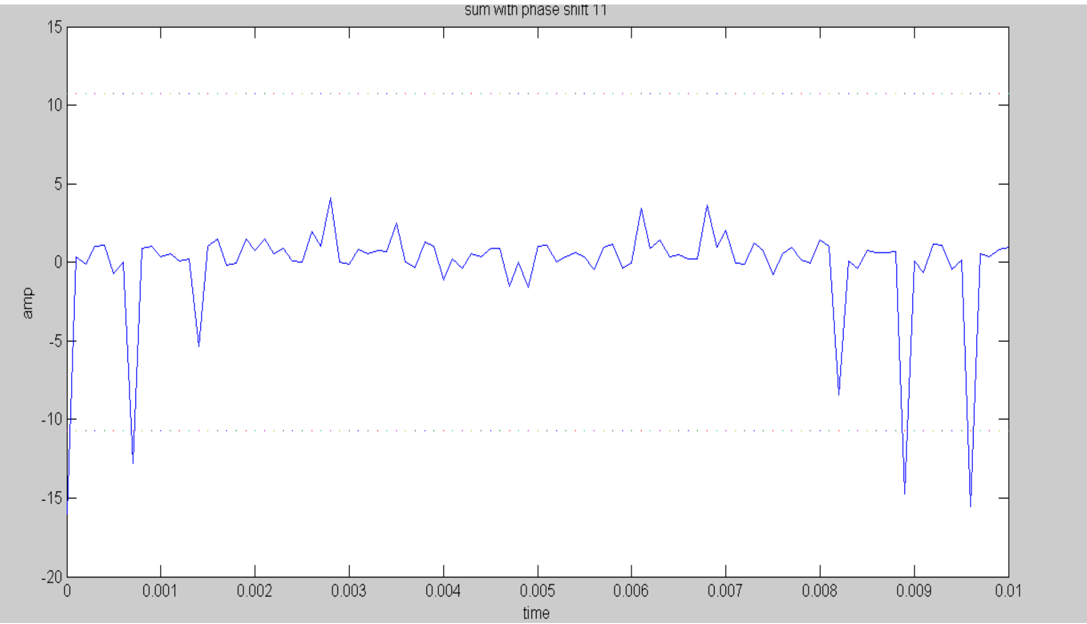

Fig 5: OFDM signal with phase shift 11.

The resulting OFDM signal is shown in figure: 5, After 11 degree Maximum PAPR is obtain at 55 degree (PAPR = 4.9379dB) then 80 degree (PAPR= 5.8447dB)

Table: Gain for PAPR of different phase .

SYSTEM	Max. PAPR in dB
PAPR without phase shift	29.29
PAPR with phase shift 11	4.5292
PAPR with phase shift 55	4.9379
PAPR with phase shift 80	8.447

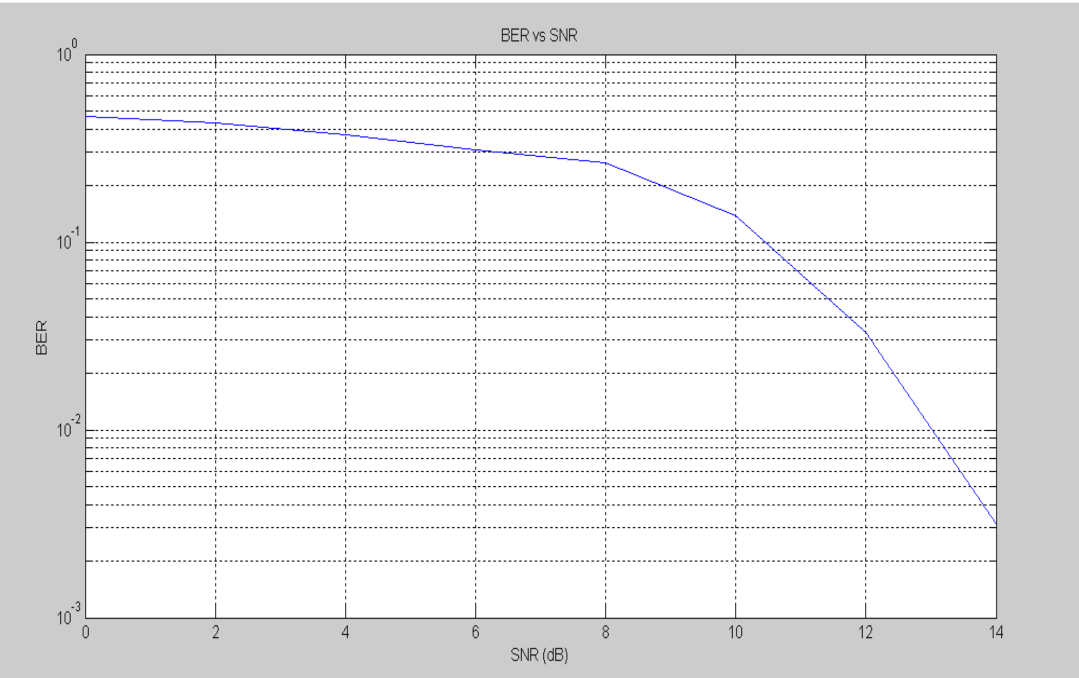

Fig 6: Comparison of BER and SNR

In figure 6, compairing the SNR (dB) and the error in bit rate(BER).

Table SNR and BER

SNR	BER
0	0.4672
2	0.4321
6	0.3231
10	0.1505
14	0.003958

From the table above, as the SNR increases the BER decreases

V. CONCLUSION

It is concluded that for improving efficiency of the Equipment (communication system) reducing PAPR value of OFDM signal. So, in this paper we obtain a particular phase rotation value at which least PAPR is obtain with the rising demand for more number of users on limited frequency spectrum in radio Mobile communication, OFDM prove invaluable to fourth generation communication system and compare BER and SNR for better future technologies and also prove invaluable to fourth generation communication system.

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REFERENCES

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

[2] 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

[3] R.V.Paiement, "Evaluation of Single Carrier and Multicarrier Modulation Techniques for Digital ATV Terrestrial Broadcasting CRC Rep", Ottawa, ON, Canada, CRC-RP-004, 1994.

[4] T.de. Couasnon, et al, "OFDM for Digital TV Broadcasting", Signal Processing, vol.39, pp.1-32, 1994

[5] 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.

[6] "Broadband Radio Access Networks (BRAN); High Performance Radio Local Area Network (HIPERLAN) Type 2; Requirements and Architecture for Wireless Broadband Access", TR 101 031, 1999.

[7] "Broadband Radio Access Networks (BRAN); High Performance Radio Local Area Network (HIPERLAN) Type 2; Requirements and Architecture for Wireless Broadband Access", TR 101 031, 1999.

[8] 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.

[9] chin-liang wang, senior member, ieee, and yuan ouyang , student member, ieee " low-complexity selected mapping schemes for peak-to-average power ratio reduction in ofdm systems " ieee transactions on signal processing, vol. 53, no. 12,december 2005.

[10] V. Vijayarangan, DR. (MRS) R. Sukanesh, "An overview of techniques for reducing peak to average power ratio and its selection criteria for orthogonal frequency division multiplexing radio systems", Journal of Theoretical and Applied Information Technology, © 2005 - 2009 JATIT.

[11] Alireza Zolgha drasli, M.H. Ghamat,"Papr Reduction in OFDM System by using Hadamard Transform in BSLM Techniques" ©2007 IEEE

[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] N.V. Irukulapati, V.K. Chakka and A. Jain "SLM based PAPR reduction of OFDM signal using new phase sequence" ELECTRONICS LETTERS 19th November 2009 Vol. 45 No. 24.

[14] Anil Singh Rathore and Dr. Neelam Srivastava "Analysis of Selected Mapping and Partial Transmit Sequence for PAPR Reduction" Journal of Telecommunications, Volume 5, Issue 1, October 2010.

[15] S. p. vimal, K. r. Shankar kumar," A new slm technique for papr reduction in ofdm systems", European journal of scientific research, ISSN 1450-216x vol.65 no.2, pp. 221-230, 2011.

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