*2016 IEEE International Conference on Advances in Electronics, Communication and Computer Technology (ICAECCT)*
*Rajarshi Shahu College of Engineering, Pune India. Dec 2-3, 2016*

# *WHT and Double WHT: An effective PAPR reduction approach in OFDM*

Mr. Suraj Shete
*Electronics engineering Dept.*
*FAMT, Ratnagiri,India.*
*suraj.shete390@gmail.com*

Mr. Girish Bhide
*Electronics engineering Dept.*
*FAMT, Ratnagiri,India.*
*girishbhide72@gmail.com*

Mr. Mahesh Jadhav
*Electronics engineering Dept.*
*FAMT, Ratnagiri,India.*
*jadhavmaheshcoep@gmail.com*

***Abstract* —With rapid growth in communication orthogonal frequency division multiplexing (OFDM) is multi-carrier communication technique becomes more popular which is used in both wired and wireless communication. OFDM consist of multiple carriers over single channel for signal transmission. OFDM is the time domain signal which is made up of several sinusoids and due to this sinusoids Peak to Average Power Ratio (PAPR)of OFDM signal increases. Due to this high PAPR transmission efficiency reduces so PAPR is major drawback of OFDM. There are several PAPR reduction techniques but, pre-coding techniques shows better result. In this paper, we propose Walsh Hadamard Transform (WHT) and Double Walsh Hadamard Transform (Double WHT). The proposed scheme shows the better results.**

***Keywords — CCDF, Double WHT,ISI,OFDM,PAPR,WHT.***

## I. INTRODUCTION

Communication plays a vital role to link entire globe (today into outer space). In communication we transfer information from one point to another. With the evolution of new technologies there is rapid growth in the field of communication. Thus communication becomes basic aspect of our daily life. Initial days signals were sent in the analog domain, now are being sent more and more in the digital domain. Digital communication is secure and have more advantages so everyone is try to prefer digital communication. In digital communication a new technique is introduced called multi carrier communication. Multi-carrier signals have more benefits over single carrier signals. OFDM is one of the multi-carrier communication technique which consist of multiple carriers over single channel so sometimes it is called Multi-tone modulation. It is useful for both wired and wireless communication. The basic principle of OFDM system is-The whole input signal is splitted into orthogonally placed sub-carriers and these subcarriers are used to carry the data from the transmitter to the receiver. OFDM have large amplitude variations and due to this large variations peak power of signal increases which makes Peak to Average Power Ratio (PAPR). With increase in high peaks usually drive the power amplifier into saturation, clipping of the transmitted signal, reduces transmission efficiency. So for flexible transmission, PAPR should be low.

### A. *OFDM and PAPR*

The principle of OFDM transmission is- huge number of orthogonal, closely spaced, overlapping narrow-band sub-carriers are transmitted in parallel manner. A high data rate stream (input stream) is split into a number of lower rate data streams and these lower rate data streams are transmitted simultaneously over a number of sub-carriers. The available transmission bandwidth is divided in equal proportion with the help of sub-carriers. The separation of the sub-carriers is carried out such that there is very compact spectral utilization of available bandwidth and each sub-carrier being modulated at a low bit rate. With the help of conventional modulation scheme such as Quadrature Phase Shift Keying (QPSK), Binary Phase Shift Keying (BPSK) and Quadrature Amplitude Modulation (QAM) each sub-carrier is modulated. The advantage of OFDM system is- symbol duration increases, the amount of dispersion in time caused due to multipath delay is reduced, large data transmission at same time. Thus OFDM is one of the popular technology for wideband digital communication. OFDM technology is used in many applications like ADSL, Li-FI, 4G technology, power-line network, wireless networks, DVB, DAB etc. Due to the Presence of guard band in single carrier system problem of ISI introduces. In OFDM noise is minimized by larger number of sub-carriers. OFDM signal sends many low speed transmissions simultaneously and hence it avoids the problem of Inter Symbol Interference (ISI).

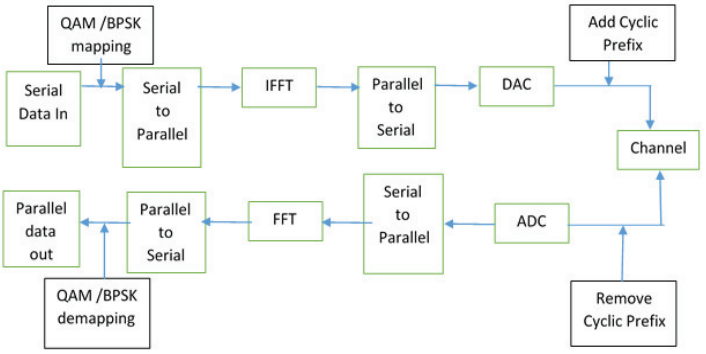


Fig. 1. Conventional OFDM system

To generate OFDM signal we want to first choose the spectrum required, based on the input data and modulation scheme used. Each subcarrier is to be assigned some data to transmit. OFDM consist number of independent modulated sub-carriers. The input data stream is split into low bit stream (sub-carrier data) and this data is passed on the individual sub-carrier. This leads to problem of peak to average power ratio (PAPR).

Then PAPR is defined as- It is the ratio of maximum instantaneous power and average power of OFDM symbol.

$$PAPR = \max [|x(t)|^2] / [\{E(A)\}^2] \quad (1)$$

Where max $[|x(t)|^2]$ is maximum or peak power and $[\{E(A)\}^2]$ is average power of transmitted symbol. To get proper values of PAPR oversampling is necessary. The required oversampling is performed by padding IFFT source data with zeroes. Due to PAPR clipping introduces also power amplifier is in saturation. PAPR introduces additional interference, also Bit Error Rate (BER) increases. These are the major drawbacks of OFDM system so we want to reduce PAPR. There are several PAPR reduction techniques like Signal distortion techniques, Probabilistic techniques and pre-coding techniques. Pre-coding techniques shows better results as compared to other techniques, so in this paper we represent WHT and Double WHT pre-coding methods which is more efficient way because in both methods no bandwidth expansion, no power increase, no data rate loss occurs. Also no Bit Error Rate (BER) degradation happens and it is distortion-less. Thus implementation of Walsh Hadamard Transform (WHT) and Double WHT pre-coding methods to reduce Peak to Average Power Ratio (PAPR) in conventional Orthogonal Frequency Division Multiplexing (OFDM) system is more effective as compared to other techniques.

B.*WHT Technique*

The Walsh Hadamard Transform (WHT) is an orthogonal, non-sinusoidal, linear transform. WHT performs linear, orthogonal operations on input signal. WHT map a signal into set of basic functions. These functions are Walsh functions, which are square waves in the nature with values of +1 or -1. The proposed hadamard transform scheme may reduce the occurrence of the high peaks as compared to the original OFDM system. The kernel of the WHT acts as a pre-coding matrix P of dimension N=L*L

WHT reduces the autocorrelation of the input sequence and this autocorrelation reduce the PAPRproblem and it doesn't require any side information.The kernel of WHT can be written as-

$$H_1 = [1] \quad (2)$$

$$H_2 = \frac{1}{2}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \quad (3)$$

## II. PROPOSED WORK

The proposed work is carried out in following manner-

The PAPR of OFDM with WHT Pre-coding technique has been evaluated by simulation. To show analysis of the proposed system, the data is generated randomly then the signal can be modulated by QPSK, BPSK and QAM respectively. Here we will modulate the signal using QAM only. The block implementation of WHT method is shown in Fig. 2 and block implementation of Double WHT is shown in Fig.3. Double WHT means we use WHT two times at transmission section as before IFFT and after IFFT and similarly at receiver section. Here the pre-coding matrix transform represents proposed Walsh Hadamard Transform (WHT). The performance of the WHT and Double WHT methods for PAPR reduction scheme will be evaluated using the complementary cumulative distribution (CCDF) function of the PAPR of the OFDM signal. The CCDF (p) of the PAPR for WHT is recorded. We will compare the simulation results of proposed systems with conventional OFDM method.

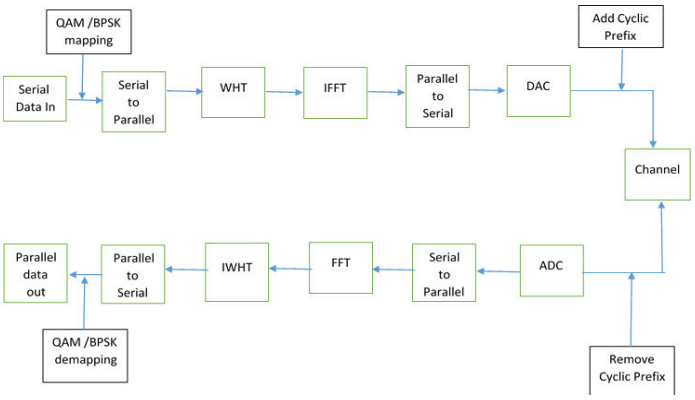


Fig. 2. Proposed WHT OFDM system

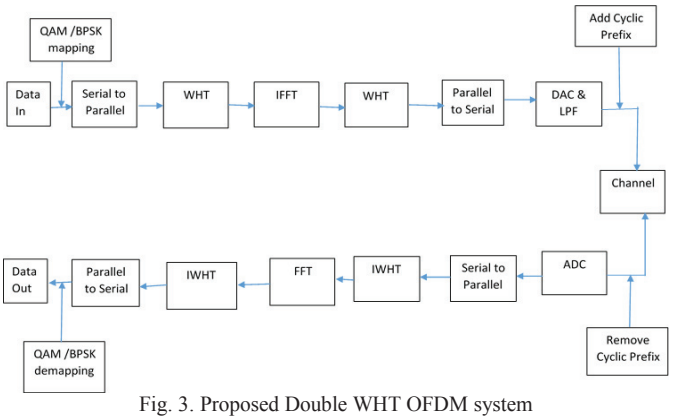


Fig. 3. Proposed Double WHT OFDM system

A. *Implementation steps of proposed work*

In proposed work, the kernel of the WHT acts as a pre-coding matrix P of dimension $N=L\times L$ and this pre-coding matrix is applied to constellations symbols before the IFFT to reduce the correlation among the input sequence. In the pre-coding based systems baseband modulated data is passed through S/P converter which generates a complex vector whose size is L and that can be written as - $X=[X_0,X_1, \ldots\ldots,X_{(L-1)}]^T$.

Then pre-coding is applied to this complex vector which transforms this complex vector from this we get a new vector of length L that can be written as $Y=PX= [Y_0,Y_1, \ldots,Y_{(L-1)}]^T$ where P is a pre-coder matrix and X is constellations symbols.

The steps will be carried out like this-

To reduce the PAPR of OFDM signal, a reduction PAPR scheme that uses hadamard transform. The input data stream is firstly transform by hadamard transform then the transformed data stream is fed to the IFFT signal processing unit. Then transformed signal is passed through parallel to serial converter, DAC and channel. The reverse process is takes place at receiver. The system block diagram is show at Fig. 2. The main difference between WHT and Double WHT is that, in WHT we find transform before IFFT at the transmitter end and in Double WHT we find WHT transform before IFFT as well as after IFFT at transmitter section. Means we find WHT of IFFT transformed signal. The symbol block diagram for Double WHT is shown in Fig. 3.

## III. RESULTS

In this section, the data is generated randomly then the signal is modulated by QPSK,BPSK and QAM modulation techniques respectively. And we compared the simulation results of proposed systems with conventional OFDM system.For Random Channel –For random channel and random input all QPSK,BPSK and QAM modulation techniques are effective. Here we summarize some output results using BPSK, QPSK, and QAM. Also here we compare conventional OFDM, WHT OFDM and Double WHT OFDM.

Also the comparison according with different data points is shown in Table I, II and III. Here we consider QAM modulation technique.

The output PAPR in CCDF is shown in Fig.4 and Fig.5.

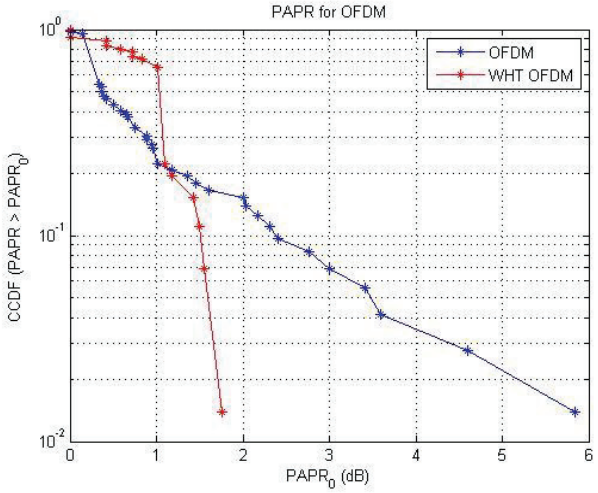


Fig. 4. PAPR comparison between conventional OFDM and WHT OFDM

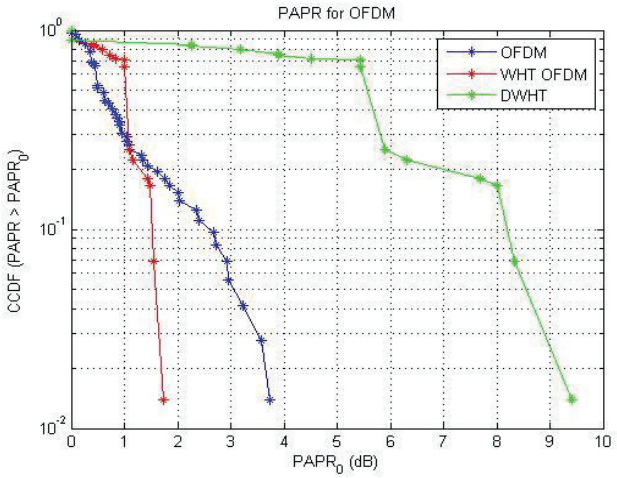


Fig. 5. PAPR comparison between conventional OFDM, WHT OFDM and Double WHT

Table I shows QAM modulation for Random channel for data points 64,128and 256. Double WHT shows better performance.

TABLE I: FOR RANDOM CHANNEL

| MODULATION TECHNIQUE | DATA POINTS | PAPR BEFORE WHT | PAPR AFTER WHT |
|---|---|---|---|
| **QAM** | 64 | 2.2857 | 2.1818 |
| **QAM** | 128 | 2.1573 | 2.1512 |
| **QAM** | 256 | 2.0984 | 2.0317 |

For AWGN Channel QAM modulation technique is more effective.

TABLE II: FOR AWGN CHANNEL

| MODULATION TECHNIQUE | DATA POINTS | PAPR BEFORE WHT | PAPR AFTER WHT |
|---|---|---|---|
| **QAM** | 64 | 1.7778 | 1.1925 |
| **QAM** | 128 | 2.0211 | 1.2549 |
| **QAM** | 256 | 2.0426 | 1.9104 |

For Rayleigh Channel QAM modulation technique is more effective.

TABLE III: FOR RAYLEIGH CHANNEL

| MODULATION TECHNIQUE | DATA POINTS | PAPR BEFORE WHT | PAPR AFTER WHT |
|---|---|---|---|
| **QAM** | 64 | 2 | 1.1925 |
| **QAM** | 128 | 2.1333 | 1.1779 |
| **QAM** | 256 | 2 | 1.9248 |

## IV. CONCLUSION

From the obtained results, it is observed that, WHT pre-coding technique have low PAPR as compared to conventional OFDM system. Also WHT method is less complex as compared to other PAPR reduction techniques. The main advantages of WHT techniques are: there is no bandwidth expansion, no power increase, and no data rate loss, no Bit Error Rate (BER) degradation and distortion-less.

## REFERENCES


[1] M. Park, J. Heeyong, J. Cho, D. Hong & C. Kang, "PAPR Reduction in OFDM Transmission Using Hadamard Transform," IEEE International Conference on Communications, vol. 1, pp. 430- 433, 2000.

[2] Yen Wen Huang Ying Li, "16- QAM Golay Complementary Sequences with New Sequence Lengths", IEEE International Syrnposiurn on Information Theory, 2011.

[3] NavneetKaur and Lavish Kansal,"Reducing the Peak to average Power ratio of OFDM signals through Walsh Hadamard Transform. " Global journal of researches in engineering.