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Walsh Hadamard Transform: A new approach for PAPR reduction in OFDM

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***Abstract*: OFDM and MC-CDMA are multi-carriercommunication techniques which are used in bothwired and wireless communication. OFDM is thetime domain signal which is a sum of severalsinusoids and due to this sinusoids Peak to AveragePower Ratio (PAPR) of OFDM signal increases. Due to this transmission is not effective so PAPR is major drawback of OFDM. There are several PAPR reduction techniques but, pre-coding techniques shows better result. This paper represents anew pre-coding technique-Walsh Hadamard Transform (WHT). From the obtained results we can conclude that WHT is attractive solution to PAPR problems of OFDM signals as compared to other pre-coding techniques.**

***Keywords*:CCDF.ISI,OFDM,PAPR,WHT.**

I. INTRODUCTION

Day by day there is rapid growth in the field of communication. Communication plays a vital role in daily life. Initially signals weresent in the analog domain, now are being sent moreand more in the digital domain. Multi-carrier signals have more benefits over single carrier signals.CDMA and OFDM are multi-carrier systems now-a-days beingimplemented commonly. For both wiredand wireless communication OFDM multi-carriercommunication technique is used. The principle of OFDM system is-The whole input signal is splitted into orthogonally placed sub-carriers and these subcarriers are used to carry thedata from the transmitter to the receiver.[1]Due to the Presence of guard band in single carrier system problem of ISI introduces. In OFDM noise is minimized by largernumber of sub-carriers. OFDM signal sends many low speedtransmissions simultaneously and hence it avoids theproblem of Inter Symbol Interference (ISI). OFDM istime domain signal which is a made up of severalsinusoids and this sinusoids peak power increases which makes Peak to AveragePower Ratio (PAPR). Due to this high peaks usually drive thepower amplifier into saturation, clipping of the transmitted signal and PAPR also introduces in-band and out band interference.

A) OFDM and PAPR:

The principle of OFDM transmission is- large number of orthogonal,overlappingnarrow-band sub-carriers are transmitted in parallel manner. A high datarate stream is split into a number of lower rate streams and these lower rate data streams are transmitted simultaneously over a number of sub-carriers.The available transmission bandwidth is divided with the help of sub-carriers. The separation of the sub-carriers is made 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. Thus OFDM is one of the popular technology for wideband digital communication. OFDM technology is used in many applications like 4G technology, power-line network, wireless networks, DVB, DAB etc.

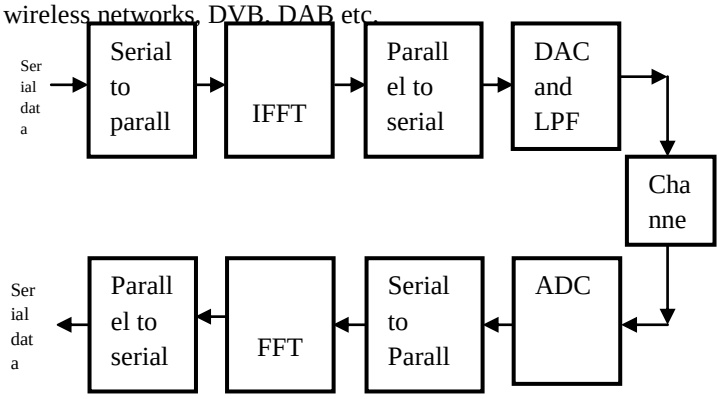

Fig. 1.Conventional OFDM system

To generate OFDM we want to first choose the spectrumrequired, based on the input data and modulationscheme used. Each subcarrier is to beassignedsome data to transmit. OFDM consist number ofindependent modulated sub-carriers. This leads toproblem of peak to average power ratio(PAPR). ThenPAPR is defined as- It is the ratio of maximum instantaneous power and average powerof OFDM symbol.

PAPR= max [| x(t)|^2] / [{E(A)}^{2}] (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 paddingIFFT source data with zeroes. Due to PAPR clipping introduces also power amplifier is in saturation. These are the major drawbacks of OFDM system so in this paper we represent WHT method which is more efficient way because in WHT 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) pre-coding method 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 a orthogonal,non-sinusoidal, linear transform. WHT performs linear, orthogonal operations on input signal[2]. 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[3].The kernel of WHT can be written as-

$H_1 = [1]$ (2)

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

$$H_{2N} = \frac{1}{2N}\begin{bmatrix} H_N & H_N \\ H_N & H_N^{-1} \end{bmatrix} \quad (4)$$

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 is shown in Fig. 2.Here the pre-coding matrix transform represents proposed Walsh HadamardTransform (WHT) pre-coding technique used in our simulations. The performance of the WHT method 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 recoded.We will compare the simulation results of proposed system WHT pre-coded OFDM method and conventional OFDM method.

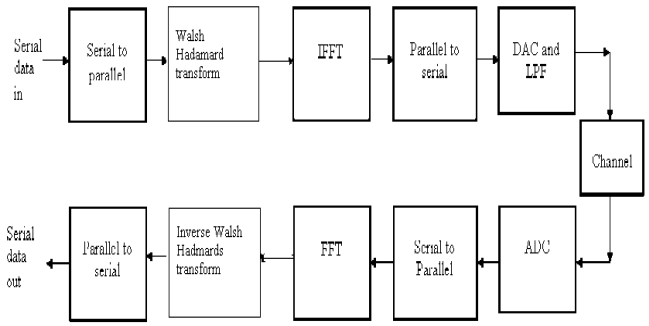

Fig.2. Proposed WHT OFDM system

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.

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[4]. The system block diagram is show at Figure. 2.

The signal processing is carried out in following manner:

Step1: The input signal X is complex vector transformed by hadamard matrix (pre-coding matrix).

i.e. Y = PX

Step2:Then IFFT operation is performed on Y like-

y=IFFT (Y), where y= [y (1),y (2)…….y (n)]^T

Step3: At the receiver end FFT transform is applied to the signal y^ (n), i.e. Yˆ = FFT (**y**ˆ (n)) .
Where y ˆ = [yˆ(1) ,yˆ(2)……y ˆ(N)]^T

Setp4:Then inverse hadamard transform is applied to the signal Y^
i.e. X^ = P^T Y^.
Then the obtained signal X^ is de-mapped to bit stream.

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 system conventional OFDM systems.For Random Channel –For random channel and random input all QPSK,BPSK and QAM modulation techniques are effective.

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 WHTtechniques are: there is no bandwidth expansion, no power increase, and no data rate loss, no Bit Error Rate (BER) degradation and distortion-less.

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