PAPR REDUCTION OF OFDM SIGNAL USING WALSH HADAMARD TRANSFORM

Mr. Suraj Shete, Prof. R.N.Patil, Prof. P. M. Jadhav
Electronics Engineering Dept, DKTE's TEI, Ichalkaranji.

ABSTRACT

OFDM is a subset of frequency division multiplexing in which a single channel utilizes multiple sub-carriers on adjacent frequencies. In addition the sub-carriers in an OFDM system are overlapping to maximize spectral efficiency. That means OFDM is multi-carrier communication technique which is used in both wired and wireless communication. OFDM is the time domain signal which is a sum of several sinusoids and these sinusoids makes Peak to Average Power Ratio (PAPR).PAPR is major drawback of OFDM. There are several PAPR reduction techniques but, pre-coding is an efficient method for PAPR reduction. This paper represents a new pre-coding technique-Walsh Hadamard Transform (WHT). The obtained results show that WHT is attractive solution to PAPR problems of OFDM signals.

KEYWORDS: OFDM, PAPR, WHT, CCDF.

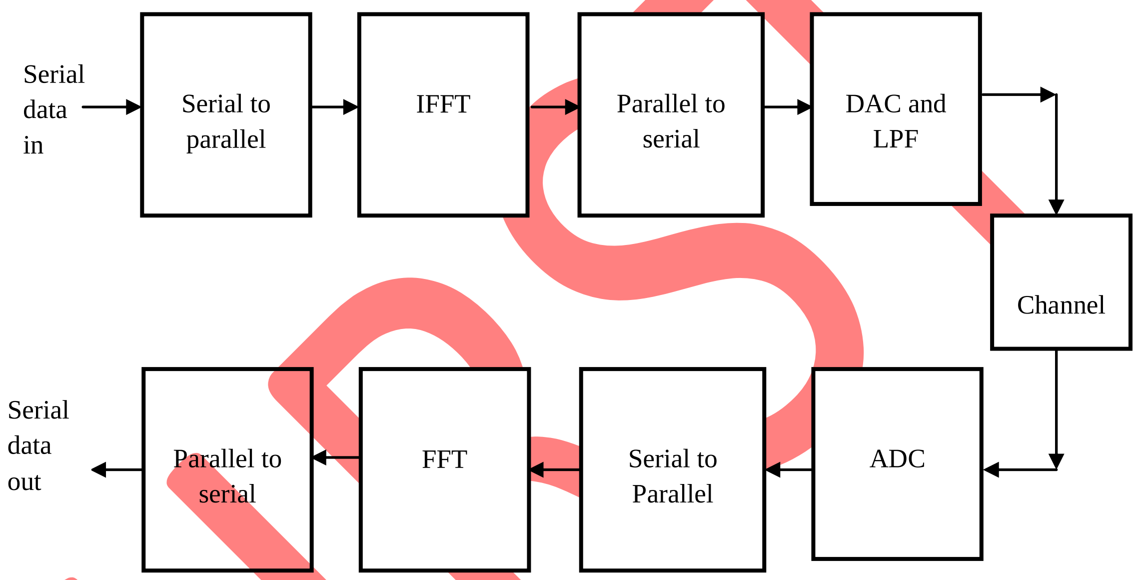
INTRODUCTION

Communication is one of the important aspects of life. With the advancement in age and its growing demands, there has been rapid growth in the field of communications. Signals, which were initially sent in the analog domain, are being sent more and more in the digital domain these days. For better transmission, even single-carrier waves are being replaced by multi-carriers. Multi-carrier systems like CDMA and OFDM are now-a-days being implemented commonly. OFDM is multi-carrier communication technique which is used in both wired and wireless communication and used for transmitting large data over multiple carriers. In the OFDM system, orthogonally placed sub-carriers are used to carry the data from the transmitter end to the receiver end. Presence of guard band in this system deals with the problem of ISI and noise is minimized by larger number of sub-carriers. OFDM sends many low speed transmissions simultaneously and hence it avoids the problem of Inter Symbol Interference (ISI). OFDM is time domain signal which is a sum of several sinusoids and this sinusoids makes Peak to Average Power Ratio (PAPR).The high peaks usually drive the power amplifier into saturation, clipping the transmitted waveform and introducing in-band and interference.

OFDM AND PAPR

For wired and wireless communication OFDM is more popular modulation technique. In an OFDM scheme, a large number of orthogonal, overlapping, narrow-band sub-carriers are transmitted in parallel manner. Then each sub-carrier is then modulated with a conventional modulation scheme such as Quadrature Phase- Shift Keying (QPSK), Binary Phase- Shift Keying (BPSK) and Quadrature Amplitude Modulation (QAM).A high-rate data stream is split into a number of lower rate streams to be transmitted simultaneously over a number of subcarriers. Since the symbol duration increases for lower rate parallel sub-carriers, the amount of dispersion in time caused due to multipath delay is reduced. These carriers divide the available transmission bandwidth. The separation of the sub-carriers is such that there is a very compact spectral utilization and each being modulated at a low bit rate. In a conventional frequency division multiplex the carriers are individually filtered to ensure there is no spectral overlap.

Below figure shows generation of conventional OFDM system.



OFDM is generated by first choosing the spectrum required, based on the input data and modulation scheme used. Each carrier to be produced is assigned some data to transmit. OFDM consists of lots of independent modulated sub-carriers. This leads to problem of peak to average power ratio (PAPR). Then PAPR is defined as- the ratio period between the maximum instantaneous power and its average power during an 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. Oversampling can be performed by padding IFFT source data with zeros. So PAPR is major drawback 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. There are different PAPR reduction techniques like signal scrambling , signal distortion and pre-coding techniques. But pre-coding techniques are less complex and there is no distortion in result. In pre-coding techniques Walsh Hadamard Transform (WHT) have more efficient as compared to others. Thus implementation of WHT pre-coding method to reduce Peak to Average Power Ratio (PAPR) in conventional Orthogonal Frequency Division Multiplexing (OFDM) system is more effective than other techniques.

WHT TECHNIQUE

The Walsh Hadamard Transform (WHT) is a non-sinusoidal, orthogonal linear transform. WHT decomposes a signal into set of basic functions. These functions are Walsh functions, which are square waves with values of +1 or -1 . The proposed hadamard transform scheme may reduce the occurrence of the high peaks comparing the original OFDM system. The idea to use the WHT is to reduce the autocorrelation of the input sequence to reduce the peak to average power problem and it requires no side information to be transmitted to the receiver.

The kernel of WHT can be written as-

$H_1 = [1]$- - - - [2]

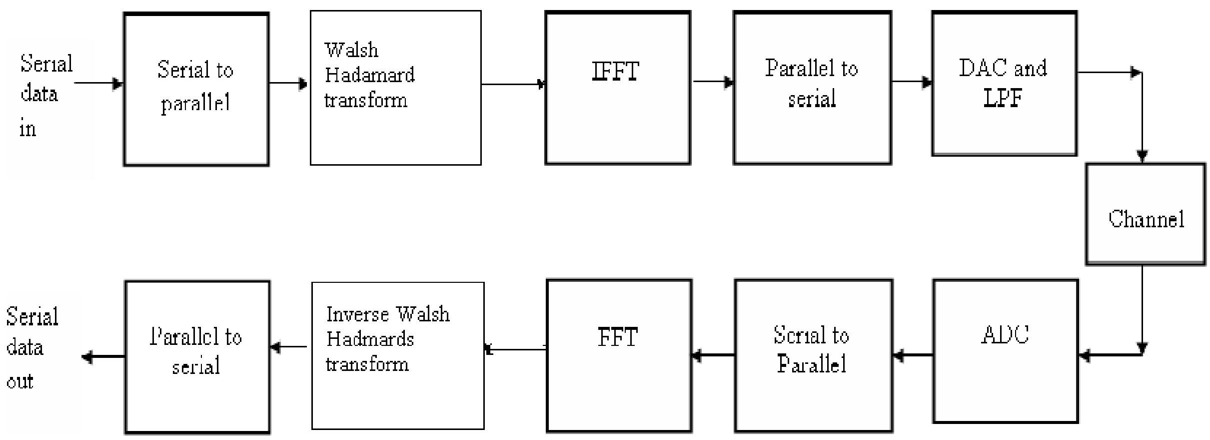
$$H_2 = \frac{1}{2}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$ - - - - [3]

$$H_{2N} = \frac{1}{2N}\begin{bmatrix} H_N & H_N \\ H_N & H_N^{-1} \end{bmatrix}$$ - - - - [4]

The kernel of the WHT acts as a pre-coding matrix P of dimension N=L×L.

Figure below shows diagram for the proposed WHT technique-

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 PAPR analysis of the proposed system, the data is generated randomly then the signal is modulated by QPSK, BPSK and QAM respectively. The block implementation is shown in Fig. 2.Here the pre-coding matrix transform represents proposed Walsh Hadamard Transform (WHT) pre-coding technique used in our simulations. We will evaluate the performance of the PAPR reduction scheme using the complementary cumulative distribution (CCDF) of the PAPR of the OFDM signal. The CCDF (p) of the PAPR for WHT is recoded. OFDM signal is used to express the probability of exceeding a given threshold. We will compare the simulation results of proposed system with WHT pre-coded OFDM systems and conventional OFDM systems.

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 it 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 of size L 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 into 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 coming input data stream is firstly transform by hadamard transform then the transformed data stream is as input to IFFT signal processing unit. The system block diagram is show at Figure. 2.

The signal processing steps are as below:

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

i.e. $Y = PX$

Step2:Then IFFT operation is performed on Y like-
$\mathbf{y}$=IFFT (Y), where $y= [y(1),y(2)\ldots\ldots y(n)]^T$

Step3: Then FFT transform is applied to the signal at receiver end $y\hat{}(n)$, i.e. $Y\hat{} = FFT(\mathbf{y}\hat{}(n))$.
Where $y\hat{} = [y\hat{}(1), y\hat{}(2)\ldots\ldots\ldots y\hat{}(N)]^T$

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

The proposed hadamard transform scheme may reduce the occurrence of the high peaks comparing the original OFDM system. The idea to use the hadamard transform is to reduce the autocorrelation of the input sequence to reduce the peak to average power problem and it requires no side information to be transmitted to the receiver.

PERFORMANCE ANALYSIS

We will compare the simulation results of proposed system with WHT pre-coded OFDM systems and conventional OFDM systems.

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 with WHT pre-coded OFDM systems and conventional OFDM systems.

		TYPE OF CHANNEL							
		AWGN		Random		Rayleigh		Rician	
MODULATION TECHNIQUE	DATA POINTS	Before WHT	After WHT	Before WHT	After WHT	Before WHT	After WHT	Before WHT	After WHT
QAM	64	2.1333	1.8286	1.8824	1.641	1.7778	1.2308	1.9394	1.8286
	128	1.8199	1.2114	2.0757	1.634	1.8916	1.2075	2.1255	1.9104
	256	2.1099	1.8824	1.9492	1.9296	2.1453	2.0317	2.2197	2.0318
QPSK	64	2	1	2.1872	1.893	2	1	2.1943	2.0155
	128	2.3415	1	2.3616	1.893	1.8732	1	2.0315	1.783
	256	1.8596	1	2.2426	1.923	2	1	1.7297	1
BPSK	64	2.1412	1.8957	2.233	2.034	1.8934	1.5	2.7835	2.0654
	128	1.8199	1.634	2.1814	1.6896	2	1	2.9692	2.9444
	256	2.1054	1.983	2.1513	2.0157	2.6532	2.1276	2.5468	2.2156

Table 1 : Comparison of result for different channel and modulation techniques

CONCLUSION

In this paper , we evaluate WHT pre-coding technique which have less PAPR than conventional OFDM system. Also this method is less complex compared to other PAPR reduction techniques. The main characteristics of WHT techniques are :no bandwidth expansion, no power increase, and no data rate loss, no Bit Error Rate (BER) degradation and distortion-less.

(IJRST) 2015, Vol. No. 5, Issue No. I, Jan-Mar **ISSN: 2249-0604**

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