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PERFORMANCE COMPARISON OF FAST DISCRETE HARTLEY TRANSFORM (FHT) AND FAST FOURIER TRANSFORM (FFT) OFDM SYSTEMS

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ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is a technique used in 3G and 4G mobile networks for higher data rates. In future also we must use OFDM for high data rates. OFDM is nothing but Inverse Discrete Fourier Transform (IDFT). DFT and IDFT produce complex values. In general the procedure of OFDM is, first we will perform any digital modulation scheme on raw bits. This is because the OFDM is not a modulation technique (representing the message by using carrier) but multiplexing technique (more number of carriers is used to represent information). Quadrature Amplitude Modulation (QAM) is the better digital modulation technique among all other digital modulation techniques because it gives high data rates with more accuracy. But the problem is QAM+OFDM gives complex numbers. We have to convert them into real before transmission and after reaching the destination again we have to get back the original complex numbers. This is an unnecessary complexity in the system. This procedure not only wastes the time but also increases the errors. In this paper we removed the digital modulation technique and FFT is replaced with Fast Discrete Hartley Transform (FHT) to not only reduce complexity but also improve accuracy.

Keywords: *OFDM; Inverse Discrete Fourier Transform; Discrete Hartley Transform; Quadrature Amplitude Modulation; Fast Discrete Hartley Transform*

1 INTRODUCTION

Orthogonal Frequency Division Multiplexing is a modulation system that is being used by many of the latest wireless communications. A large number of closely spacing sub-carrier signals which are orthogonal to each other are used to carry data on several parallel data paths called as channels. Each of the sub-carrier signal is modulated with a conventional digital modulation formats (like Quadrature Amplitude Modulation (QAM)) at a low symbol rate. Major advantages of OFDM are finds applications which need high data rates; provide immunity to ISI by using cyclic prefix, no need to employing bank of oscillators. It allows simultaneous transmission of orthogonal subcarriers over a common channel, thus making efficient use of available spectrum, results in high Spectral Efficiency.

This paper starts with the introduction of the topic in section I. Section II presents a Typical OFDM system model. Discrete Hartley Transform (DHT) is introduced in section III and section IV. Section V provides signal processing steps to implement a DHT. Simulation results are conferred in section VI and finally the Conclusion is given in VII.

II. FORMULATION OF GENERAL OFDM

Typically, N independent data symbols are modulated by using digital baseband modulation schemes like Quadrature Amplitude Modulation (QAM). OFDM signal is nothing but sum of those N independent modulated data symbols. The time-domain OFDM symbols $X = [x_0, x_1, ..., x_{LN-1}]^T$ can be calculated as

$$x_n = \frac{1}{\sqrt{NL}} \sum_{k=0}^{N-1} X_k . e^{j2\pi \frac{kn}{NL}}, \quad 0 \le n \le NL - 1, \qquad (1)$$

Where $n = 0,1,..., LN-1$ time is index and L is the upsampling factor.

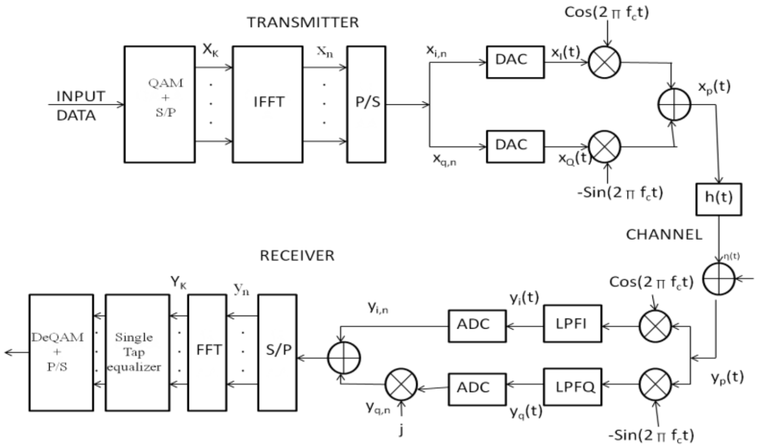

Fig 1. Block diagram of OFDM system with DFT & QAM.

The above block diagram of general OFDM represents the complexity.

III. DISCRETE HARTLEY TRANSFORM (DHT)

The Discrete Hartley Transform (DHT) is a linear transform, in this N real numbers $[x_0, x_1, ...x_{N-1}]$ is transformed into N real numbers $[H_0, H_1, ... H_{N-1}]$.

The precoding matrix P can be written as:

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$$P = \begin{bmatrix} p_{00} & \cdots & p_{0(N-1)} \\ \vdots & \ddots & \vdots \\ p_{(N-1)0} & \cdots & p_{(N-1)(N-1)} \end{bmatrix} \quad (2)$$

$p_{mn,}$ is given by $p_{mn} = \text{cas}\left(\frac{2\pi nk}{N}\right)$

Where $cas(\theta) = \cos(\theta) + \sin(\theta)$, *k=0, 1, 2,... (N-1).*

The DHT is a invertible transform which allow us to recover the x_n from H_k with same DHT function.

3.1 FAST DISCRETE HARTLEY TRANSFORM

The main drawback with DFT is time consumption. But we can rearrange the formulae of DFT such that we can achieve the butterfly type computation which is present in FFT.
The rearranged formulae is

(3)

(4)

(5)

Where y_n is the even position input and z_n is the odd position input.

4 PROPOSED TECHNIQUE

In this section, the authors propose new OFDM system with FHT.

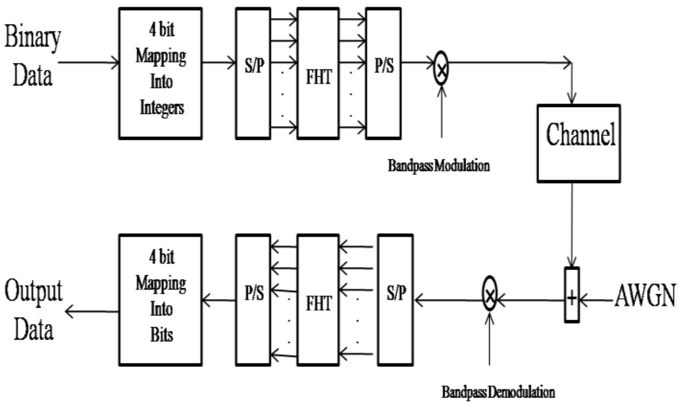

Fig 2. Block diagram of OFDM system with DHT.

The present Fast Discrete Hartley Transform (FHT) system processing steps are given below:

Step1: At a time the system takes 256 bits

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Step2: Converts the bits into 64 integers with each integer represents 4 bits. This process is comparable to QAM in the case of OFDM system but the difference is QAM gives complex numbers. Here we got real values

Step3: These 64 integers are given as input to FHT

Step4: By using a COS function band pass modulation is performed

Step5: Band pass demodulation is performed

Setp6: Integers are given to FHT

Setp7: Output integers of FHT converted into bits

V. SIMULATION RESULTS

Computer simulation results are conferring in this section to evaluate the performance of the proposed technique i.e. Fast Discrete Hartley Transform (FHT) OFDM System in AWGN Channel.

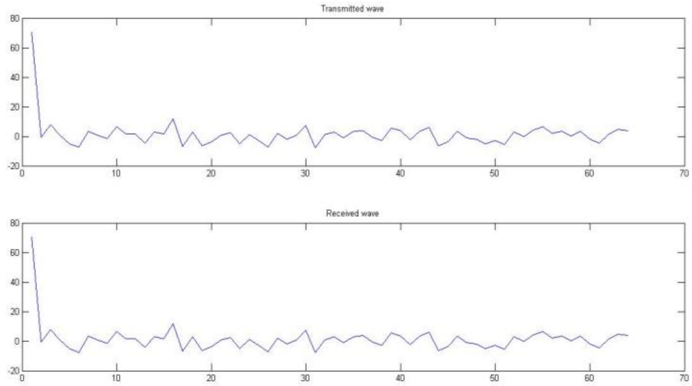

Fig 3.Waveforms of OFDM system with DHT

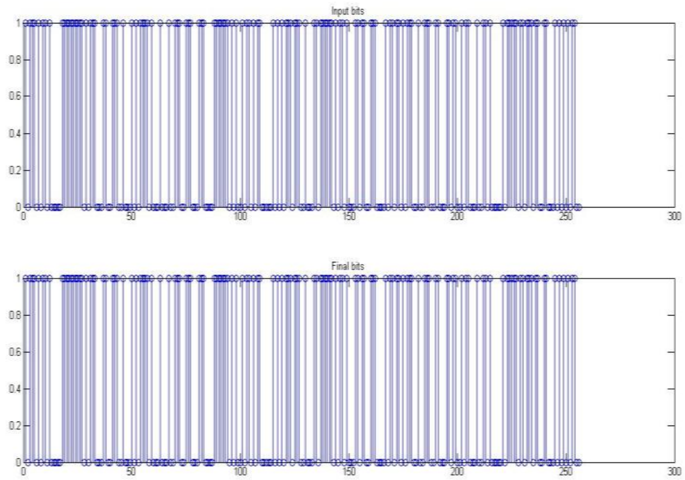

Fig 4. Bitwise comparison of OFDM system with DHT

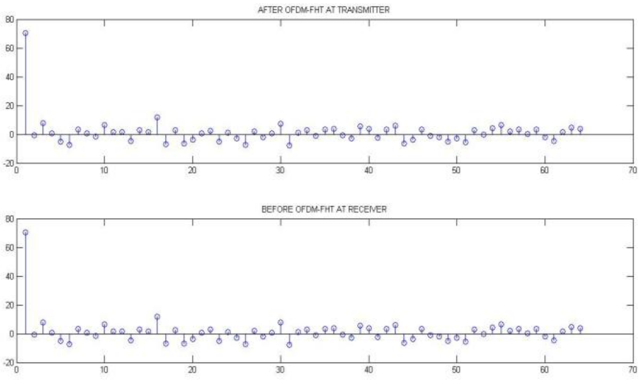

Fig 5. Responses of OFDM system with DHT

VI. CONCLUSION

In this work same input is used for both OFDM with FFT and OFDM with FHT systems for comparison purpose which is mentioned below

[1,0,1,1,1,0,1,0,1,1,0,1,0,0,0,0,0,1,1,1,1,1,1,1,1,1,0,1,0,1,1,1,0,0,0,1,1,0,0,1,1,1,0,0,1,0,0,0,1,0,1,0,1,1,1,1,0,1,0
,0,0,1,0,0,0,1,0,0,1,1,1,0,0,1,1,1,0,0,0,1,1,1,0,0,0,0,1,1,1,1,1,1,1,0,1,0,1,0,0,1,0,1,1,0,1,0,1,1,0,0,0,0,0,1,0,1,0,1,0
,1,1,1,0,1,1,1,0,0,1,0,0,0,1,1,0,1,1,1,1,1,1,0,1,0,1,1,0,1,0,0,0,1,1,0,1,1,0,0,1,1,1,0,0,0,0,1,0,1,1,0,1,1,0,1,0,1,1,1,0
,0,1,0,0,1,1,1,0,0,1,1,0,0,0,1,1,0,1,1,0,0,1,0,1,1,0,0,0,1,0,0,1,1,0,1,0,0,0,0,0,1,0,1,1,1,1,1,0,1,1,0,1,1,1,0,1,1,0,0,1
,1,0,0,0,1,0,1,0,1,0,1,0,1,1,0,0]

For this input the OFDM with FFT got 83 bit errors for 256 bits input and OFDM with FHT systems got 0 bit errors for 56 bits. In future we can also make this OFDM with FHT faster.

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