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Implementation of IDWT OFDM system in LabVIEW

Adrija Roy[1], Prof. Anoop Singh Poonia[2]
[1,2]Department of Electronics & Communication Engineering, VGU, Jaipur

Abstract-Orthogonal Frequency Division Multiplexing (OFDM) is a kind of multi-carrier modulation, which divides the available spectrum into a number of parallel subcarriers and each subcarrier is then modulated by a low rate data stream at different carrier frequency. The conventional OFDM systems uses IFFT and FFT at the transmitter and receiver respectively but DWT-OFDM is an alternative approach to this conventional FFT based OFDM system. In this paper, we have designed an IDWT OFDM system in LabVIEW for use in various wireless techniques.
Keywords— FFT OFDM, DWT OFDM, ISI, ICI, BER.

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is one of the very promising wireless technologies.[1] In OFDM because of lack of orthogonality between the subcarriers there is Inter Carrier Interference (ICI) and Inter Symbol Interference (ISI) and to solve this problem use of cyclic prefixing (CP) is required, which uses 20% of available bandwidth. DWT OFDM systems do not require cyclic prefix, so spectrum efficiency increases.[2], [3] Discrete Wavelet Transform (DWT) is broadly considered as an efficient approach to replace FFT in the conventional OFDM systems due to its better time-frequency localization, bit error rate improvement, interference minimization, improvement in bandwidth efficiency and many more advantages. In communication systems, when the signal is transmitted over the channel, noise and unwanted interferences are introduced which leads to the distortion of transmitted signal. Hence, error control coding techniques are used to mitigate the effect of such channel distortions. The original data sequence is appended with redundant bits to increase the reliability of the system by adding cyclic prefix; which also answers the problem of ISI. The succeeding second section deals with the proposed DWT OFDM system model. Third section describes the simulation of the DWT OFDM system. The fourth section discusses the results and conclusion.

II. PROPOSED DWT OFDM SYSTEM

In DWT OFDM the IFFT block is replaced with IDWT block and FFT with DWT. Because of the nature of the DWT, ICI can be avoided without the cyclic prefix.[4] Mallet algorithm (popularly known as sub band coding) is used to calculate DWT, the sequence is applied to a series of high pass filters and low pass filters.

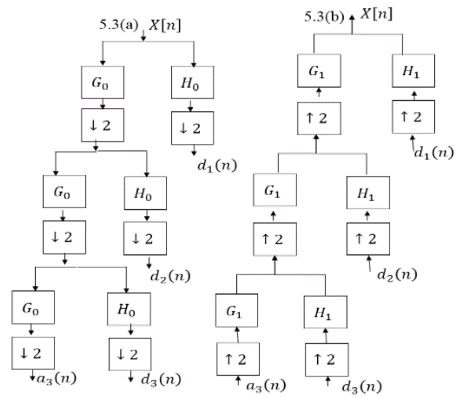

Fig 1.3(a) and (b) explains the DWT analysis filter and IDWT synthesis filter respectively.[1]

Low pass filter (G_0) produces approximate coefficients known as scaling function and high pass filter (H_0) produces detailed information d_n known as wavelet function.

The final result is obtained by convoluting the output received at each level of decomposition in DWT, and construction at IDWT. In this DWT computation the successive filtering involves down sampling procedure.[5] IDWT is just reverse process of DWT computation. It involves same filtering process in the reverse order with up sampling.[6]

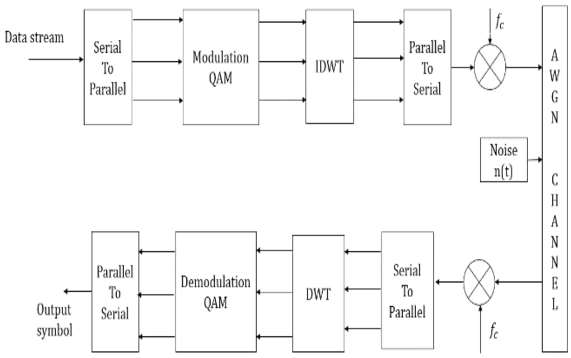

Fig 1.4 proposed DWT OFDM system model[6], [7]

The output of the IDWT block is given by:

$$S(k) = \sum_{m=0}^{\infty}\sum_{n=0}^{\infty} s_m^n 2^{m/2}\psi(2_k^m - n)$$

Where S_m^n is the wavelet coefficient & $\psi(t)$ is the wavelet function with compressed factor *m* times and shifted *n* times for each subcarrier.[5]

The output from the DWT block is given by the equation:

$$S_m^n = \sum_{k=0}^{N-1} S(k)2^{m/2}\psi(2_k^m - n)$$

In the transmitter side after constellation mapping N parallel data streams are available. Using these data, wavelet subcarriers with orthonormal properties are constructed.

Initially the parallel data stream is converted to serial and represented as a vector. Then the vector is converted to parallel matrix by vector transposing.[8]

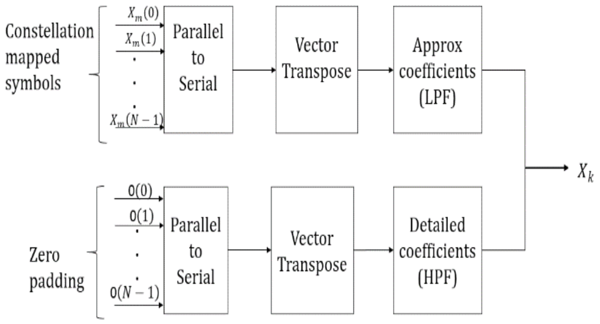

Fig 1.5 IDWT transmitter block[8], [9]

To get the wavelet coefficients, same procedure is followed with zero padding, and the vector transposed output is High pass filtered.

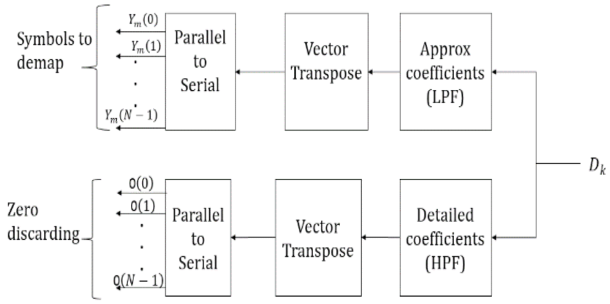

Fig 1.6 DWT receiver block[8], [9]

2.1 IDWT/DWT over IFFT/FFT for OFDM system

In IFFT/FFT in order to reduce ISI cyclic prefix is used. DWT do not use cyclic prefix hence the spectral containment of channel is better when compared with FFT.[9] Bandwidth wastage & transmission power is also reduced because of the same reason. Instead of cyclic prefix, zero padding & vector transposing is done to remove ISI in DWT/IDWT. When performance of both system are compared wavelet based OFDM systems are found to give better performance.[10]

III. SIMULATION AND RESULTS

The types of wavelet used is Haar, filter length is selected as 16, samples per symbol is 16, roll of factor (α) is equal to 0.5 are kept constant for all values of waveform generated. The results are shown below.

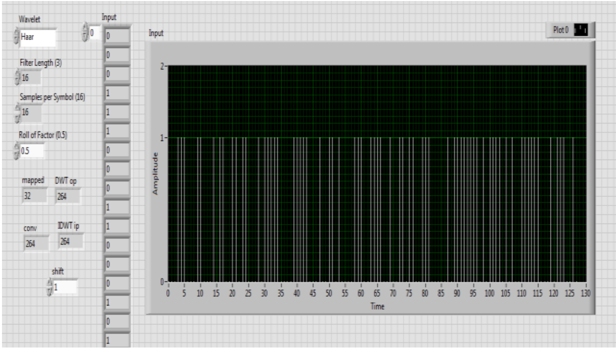

Fig 3.1 shows the input waveform generated for the random bit sequence.

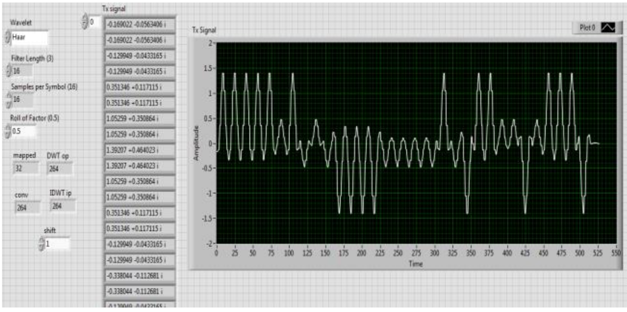

Fig. 3.2 The signal to be transmitted and its waveform for IDWT OFDM

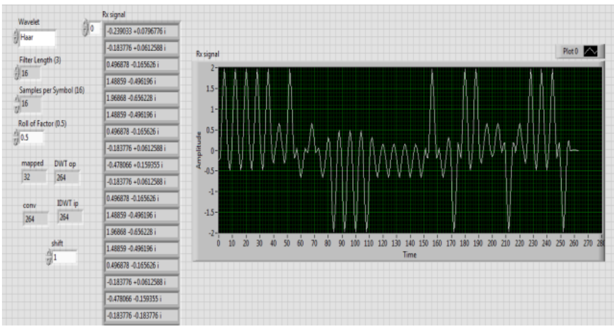

Fig. 3.3 The received signal and waveform generated for DWT OFDM

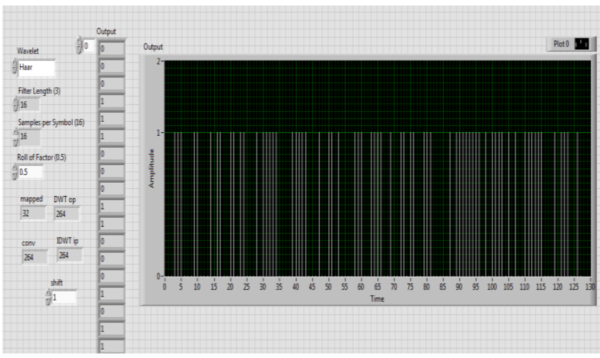

Fig. 3.4 The output signal and waveform

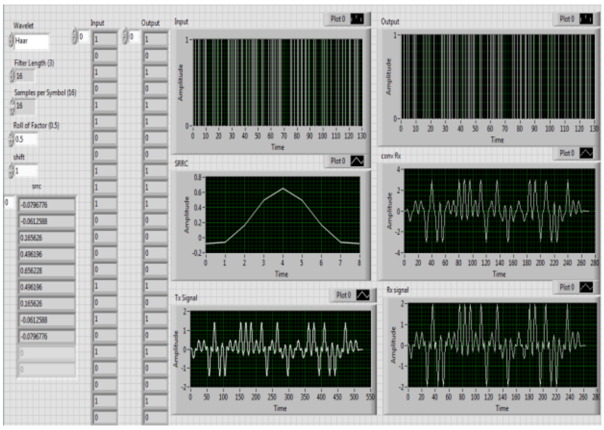

Fig. 3.5 the input and output signal along with its waveforms

IV. CONCLUSION

The DWT-OFDM model as an alternative for FFT-OFDM system is capable of achieving better BER and less transmitter power. Fourier based systems need addition of cyclic prefix whereas DWT based OFDM systems do not need cyclic prefix because of the overlapping nature of their properties, thereby increasing the bandwidth efficiency by approximately 25%. In this paper, a DWT based OFDM system was designed with 16-QAM as the modulation technique using LabVIEW.

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