2012 IACSIT Coimbatore Conferences
IPCSIT vol. 28 (2012) © (2012) IACSIT Press, Singapore

MSE Performance Measure of Lifting Discrete Wavelet Transform for OWDM

Anitha.K[1,+] , Dharmistan.K.Varugheese[2], N.J.R.Muniraj

Department of E.C.E, Arunai Engineering College, Tiruvannamalai, Tamilnadu, India[1]
Department of E.C.E, Karpagam Engineering College, Coimbatore, Tamilnadu, India[2]

Abstract. As we move in to the future there is a rising demand for high performance, high capacity and high bit rate wireless communication systems to integrate wide variety of communication services such as high-speed data, video and multimedia traffic as well as voice signals. Discrete wavelet transform (DWT) is faster than FFT hence it's replaced by transform technique for OFDM. This project proposes a fast lifting discrete wavelet transform technique for both designing wavelets and performing the transformation. By implementing LDWT for OWDM, It is able to increase the spectral efficiency and also decrease the bit error rate. This paper presents a performance measure of MSE by using lifting discrete wavelet transform.

Keywords. DWT,LDWT, OFDM,MSE

1. Introduction

With the advent of fourth generation (4G) wireless standards such as WiMAX and LTE, broadband video transmission with robust quality of Service (Qos) has become a reality. Reliable video communication is essential for key applications such as surveillance, video conferencing, mobile gaming etc. OrthogonalFrequency Division Multiple Access (OFDMA) is the most attractive physical layer technology for 4G broadband wireless networks due to its robustness to inter symbol interference arising from multipath interference combined with a low complexity IFFT/FFT based implementation. Hence, it is suitable for transmitting high data rates over wireless links, one of the key requirements for video and audio transmission.

In wireless applications especially, predicting the channel impulse response length is a tedious task, and moreover, this length can be so big that the Performance loss due to insertion of a long cyclic prefix becomes unacceptable. So other techniques have to be introduced. One can try to look for other compensating techniques, making the overall system more and more complex. Another solution is to replace the Fourier Transform by a transform that is less susceptible to all these channel effects, and that can thus more easily compensate for the resulting effects. The Wavelet Transform is proposed by several authors to be such a transform.Its longer basis functions allow more flexibility in the design of the waveforms used, and can offer a higher degree of sidelobe suppression. In DWT OFDM, the modulation and demodulation are implemented by wavelets rather than by Fourier transform. Wavelet based system was found having small bit error rate probability than that of the Fourier transform based system. The purpose of the research was to implement and find the transform that performs better in the wireless channels that are mostly multipath. In this paper proposes lifting wavelet transform is the suitable transform for OWDM. Lifting Wavelet transform features and requirements are discussed below in detail. The proposed approach displays a good reduction in bit error rate in comparison with the different types of wavelets.

+ Corresponding author.
E-mail address: anitha16ramesh@yahoo.co.in

2. Orthogonal Wavelet Division Multiplexing

In order to design o multicarrier modulation with a significant time and frequency localization properties , a given solution is to use the wavelet theory [7].A technology in which transforms could be used to modulate data in to a number of sub channels is called orthogonal wavelet division multiplex (OWDM). OWDM using the discrete wavelet transform is amultiplexing transmission method in which data is assigned to wavelet sub bands having different time and frequency resolution[8].The main advantage of using OWDM is that it is a very flexible system. By analyzing the wavelets, it can be seen that there is an overlap of the frequency response between the sub channels resulting in a certain amount of aliasing. By increasing the order of the wavelet, the effects of aliasing can be decreased and thus the orthogonality between the sub bands.

2.1. Wavelet Based Modulation

Wavelet modulation also known as fractal modulation is a modulation technique that makes use of wavelet transformations to represent the data being transmitted. One of the objectives of this type of modulation is to send data at multiple rates over a channel that is unknown. If the channel is not clear for one specific bit rate, meaning that the signal will not be received, the signal can be sent at a different bit rate where thesignal to noise ratio is higher [4]. A wavelet is a waveform of effectively limited duration that has an average value of zero. The advantage of wavelet transform over other transforms such as Fourier transform is that it is discrete both in time as well as scale. The transform is implemented using filters. One filter of the analysis (wavelet transform) pair is a low-pass filter (LPF), while the other is a high-pass filter (HPF). Each filter has a down-sampler after it, to make the transform efficient. In many application areas, the wavelet transform is more efficient at representing signal features that are localized in both time and frequency [4]. Over the past 15 years, wavelet analysis has become a standard technique in such diverse areas as geophysics, meteorology, audio signal processing, and image compression [2].

3. Proposed Method

The lifting scheme is a technique for both designing wavelets and performing the transformation. Actually it is worthwhile to merge these steps and design the wavelet filters while performing the wavelet transform. This is called second generation wavelet transform. This technique was introduced by Wim Sweldens. A wavelet is a waveform of effectively limited duration that has an average value of zero. The comparative difference between wavelets and sine waves, which are the basis of Fourier analysis is that sinusoids do not have limited duration, they extend from minus to plus infinity and where sinusoids are smooth and conventional wavelets tend to be irregular and asymmetric. As the well known technique of signal analysis Fourier analysis consists of breaking up a signal into sine waves of various frequencies, similarly, wavelet analysis is the breaking up of a signal into shifted and scaled versions of the original (or mother) wavelet. The discrete wavelet transform applies several filters separately to the same signal. In contrast to that, for the lifting scheme the signal is divided like a zipper. Then a series of convolution-accumulate operations across the divided signals is applied.The discrete wavelet transform applies several filters separately to the same signal. In contrast to that, for the lifting scheme the signal is divided like a zipper. Then a series of convolution-accumulate operations across the divided signals is applied [9]. The basic idea of lifting is the following: If a pair of filters (h,g) is complementary, that is it allows for perfect reconstruction, then for every filters has the pair are (h',g),(h,g') .

$$h'(z) = h(z) + s(z^2).g(z) \tag{1}$$

$$g'(z) = g(z) + t(z^2).h(z) \tag{2}$$

Each such transform of the filter bank is called a lifting step[10]. A sequence of lifting steps consists of alternating lifts that is, once the lowpass is fixed and the highpass is changed and in the next step the highpass is fixed and the lowpass is changed. Successive steps of the same direction can be merged.

3.1. Features

The main feature of the lifting-based discrete wavelet transform scheme is to break up the high-pass and low-pass wavelet filters into a sequence of smaller filters that in turn can be converted into a sequence of upper and lower triangular matrices. The basic idea behind the lifting scheme is to use data correlation to remove the redundancy. The lifting algorithm can be computed in three main phases, namely: the split phase, the predict phase and the update phase.

3.2. Drawbacks of Existing Method

- Excessive computational complexity.
- Reduced bandwidth and spectral efficiency.
- High computational cost.

3.3. Advantages of Proposed Method

- Reduced computational complexity.
- The lifting scheme, which entirely relies on the spatial domain, has many advantages compared to filter bank structure, such as lower area, power consumption.
- The lifting scheme can be easily implemented by hardware due to its significantly reduced computations.
- Lifting has other advantages, such as "in-place" computation of the DWT, integer-to-integer wavelet transforms (which are useful for lossless coding),
- It can be used to generate a multiresolution analysis that does not fit a uniform grid.

3.4. Block Diagram for Forward Lifting Scheme Transforms

The figure 1 shows the block for forward lifting scheme transforms.

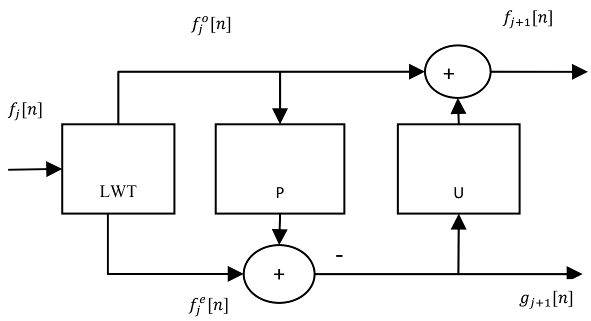

Fig. 1: Block Diagram for Forward Lifting Scheme transforms

Steps in forward lifting wavelet transform

- Lazy wavelet transform splits signal $f_j[n]$ in two new signals: the odd samples signal denoted by $f_j^o[n]$and the even samples signal denoted by$f_j^e[n]$.
- Prediction step: Its objective is computing a prediction for the odd samples, based on the even samples (or viceversa). This prediction is subtracted to the odd samples creating an error signal $g_{j+1}[n]$.
- Update step: This step recalibrates the low frequency branch with some of the energy removed during sub sampling. It uses the predicted odd samples $g_{j+1}[n]$ to prepare the even ones $f_j^e[n]$ (or viceversa). This update is subtracted to even samples producing the signal denoted by $f_{j+1}[n]$.

3.5. LWT based OWDM

The figure 2 shows the OWDM system with lifting wavelet transform blocks (ILWT / LWT).

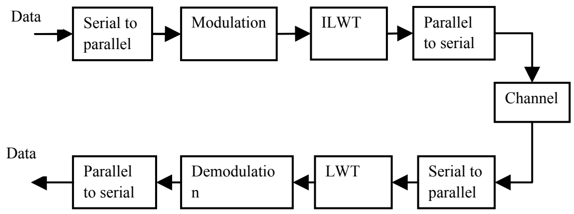

Fig 2: Block Diagram for LWT Based OWDM

3.6. Design Methodology

- Model the LWT/ILWT block.
- Then model the OWDM block by integrating the coding/map, serial to parallel, LWT/ILWT, parallel to serial and decoding / demap block.
- The final stage of development is verification and simulation.

4. Simulation Analysis

The simulation is done in MATLAB and the output graph of discrete wavelet transform is obtained between frequency and power level in graph 3. In the graph 4 the output is obtained between the frequency and the power level for lifting wavelet transform.In graph 3shows the decomposition of low frequency and high frequency discrete wavelet transform. The graph 4 shows the decomposition of low frequency and high frequency lifting discrete wavelet transform.

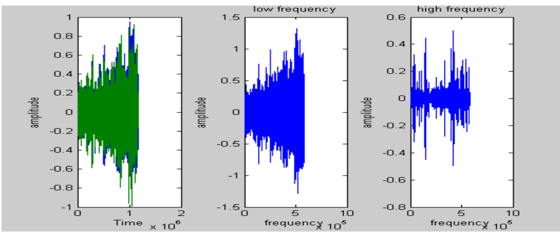

Fig. 3: Matlab Output for Discrete Wavelet Transform (DWT) Modulation

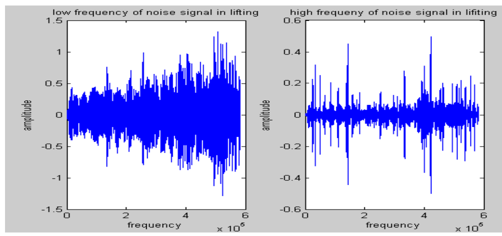

Fig. 4: Matlab Output for Lifting Wavelet Transform (LWT) Modulation

5. Simulation and Future Work

Recently the Wavelet Transform has also been proposed as a possible transform to generate the sub channels in a multicarrier system, with the advantage of flexibility of the transform and the higher suppression of side lobes compared to the side lobes of the rectangular window in the Fourier Transform. Different wavelets are available there for implementation of discrete wavelet transform and lifting discrete wavelet transform.The simulation results, the proposed approach displays a good reduction in bit error rate in comparison with the different types of wavelets.

6. References

[1] S.Baig, F. U. Rehman, and M. J. Mughal, “Performance comparison of DFT, discrete wavelet packet and wavelet transforms, in an OFDM transceiver for multipath fading channel” in Proceedings of 9th International Multitopic Conference, INMIC’05, 2005, pp. 1-6.

[2] M. K. Lakshmananm, and H. Nikookar, “A review of wavelets for digital wireless communication” Springer Journal on Wireless Personal Communication, vol. 37, no. 3-4, pp. 387-420, 2006.

[3] R. S. Manzoor, R. Gani, V. Jeoti, N. Kamel, and M. Asif, “Implementation of FFT using discrete wavelet packet transform (DWPT) and its application to SNR estimation in OFDM systems” IEEE International Symposium on Information Technology, Kuala Lumpur, Malaysia, 2008.

[4] H. Zhang, D. Yuan, M. Jiang, and D. Wu, “Research of DFT-OFDM and DWT-OFDM on different transmission scenarios” in Proceedings of ICITA’04, 2004, pp. 31-33

[5] N.Yuan, “An Equalization Technique for High Rate OFDM Systems” M.Sc. Thesis University of Saskatchewan .Saskatoon, Dec.2003

[6] C. V. Bouwel, et. al, “Wavelet Packet Based Multicarrier Modulation” IEEE Communications and Vehicular Technology, SCVT 200, pp. 131-138, 2000 .

[7] M. Gautier, M. Arndit, J. Lienard, “Efficient Wavelet Packet Modulation For Wireless Communication” The Third Advanced International Conference On Telecommunications (Aict'07), Pp. 278- 284, April 2007.
[8] S.L.Linfoot, “Wavelet families for orthogonal wavelet division multiplex’’,Eletronis Letters,28th August 2008,Vol.44.No.18
[9] T.S.N.Murthy,K.DeerghaRao, “Performance of MB-OWDMUWB Signals in Wireless Communications”, Pp.1646-1649, 2010.
[10] G. Quellec, M. Lamard, G. Cazuguel, B.Cochener, and C. Roux, "Adaptive Nonseparable Wavelet Transform via Lifting and its Application to Content-Based Image Retrieval," Image Processing, IEEE Transactions on , vol.19, no.1, pp.25-35, Jan. 2010.