ISSN 2229-5518

Comparative Analysis of Daubechies wavelets in OWDM with OFDM for DVB-T

Rama Kanti, Dr. Manish Rai
Department of Electronics and Communication Engineering
Galgotia College of Engineering and Technology, Greater Noida, U.P., India
E-mail: ramapatel03@gmail.com,manishrai1968@gmail.com

Abstract— OWDM scheme is shown to be overall quite similar to Orthogonal Frequency Division Multiplexing but with some additional features and improved characteristics, the aim of this paper is to investigate the effect of wavelets on the performance of the OWDM (Orthogonal Wavelet Division Multiplexing) system. This paper is focused on the performance analysis of OFDM with OWDM for DVB-T system and also analysis the performance of two wavelets Daubechies one (db1) and Daubechies two (db2) in OWDM for DVB-T system. This paper provides an analysis of a technique for both designing wavelets and to measures respective performances, called Orthogonal Wavelet Division Multiplex (OWDM), an alternative to OFDM, which uses a Discrete Wavelet Transform (DWT) instead of using the IFFT to generate the output and has a lower computational complexity with increases flexibility and low multipath propagation loss. The two wavelets of Daubechies family are considered with increasing order to ascertain which wavelet transform is the most suited for use in an AWGN channel and measure the performance in terms of Variance and Signal to noise ratio (SNR)for AWGN channel in comparison with OFDM and illustrates the next level analysis of new system comparing different wavelets.

Index Terms- OWDM, OFDM, SNR,db1,db2, DVB-T, IFFT,DWT,Variance .

1 Introduction

In 1997, the world's first commercial digital terrestrial services launched by UK, the next few years the digital broadcasting has been set up in many countries. Digital Video Broadcasting Terrestrial standard has been developed in Europe. It uses Orthogonal Frequency Division Multiplex and Orthogonal Wavelet Division Multiplex as modulation scheme. In OFDM, the signal is being transmitted at a high data rate in serial transmission; the signal will be affected by the channel than a lower bit rate signal. Chang proposed than an alternative to serial transmission i.e. parallel transmission. In parallel transmission, the bit rates per subcarrier were lower.The aim of this service was to facilitate the switch off in the analogue services thus potentially freeing up a large number of RF channels for more services. OFDM is underlying technology of the DVB-T standard and comprises of an IFFT (Inverse Fast Fourier Transform) at the transmitter and FFT (Fast Fourier Transform) at the receiver which performs the frequency division multiplex. One advantage of OFDM over serial transmission in DVB-T that OFDM has a natural resilience for multipath. Even with its inherent advantage, there are some drawback to OFDM being the inflexibility and increase in computational complexity of the system. This means more complex devices are needed to reduce the power consumption. Instead of the different part of the symbol in different ways, there are small numbers of parameters that can be change in OFDM. An alternative is used the wavelet to separate the sub-band components like OFDM does. The system is called OWDM. The use of filters in the wavelet domain has been used for multi carrier resolution analysis of time varying signals. With OWDM, it is possible to dynamically allocate the number of sub-bands and bandwidth of each. With all this in mind, this paper OWDM as an alternative to OFDM in DVB-T which employs a true time -frequency division multiplex using wavelet which may provide more flexibility [1]-[3].The objective of this paper is to identify how the new OWDM system can be compared with the existing OFDM system so simulation were first run using OFDM as the RF modulation front-end. Following this, the OFDM block was replaced with the OWDM block with same tests run. This paper is to investigate two wavelets of Daubechies family with increasing order to ascertain which wavelet transform is the most suited for use in an AWGN channel and compare the performance of OWDM with OFDM in terms of Variance and SNR for an AWGN environment with DVB-T parameters of 3/4 rate convolutional encoding, 64-QAM modulation and 1/32 Guard Interval.[4]-[7]

2 General Configuration

2.1 Ofdm

OFDM has been adopted in a number of wireless applications including Digital Audio Broadcast (DAB), Digital Video Broadcast (DVB), and Wireless Local Area Network (WLAN) standards such as IEEE802.11g and Long Term Evolution (LTE). OFDM is a technique widely used in wireless communication systems due to its high data rate transmission capability with high bandwidth efficiency and also its robustness to multi-path fading without requiring complex equalization techniques. The DVB-T Orthogonal Frequency Division Multiplexing system uses multi carrier transmission. In the OFDM system, Inverse Fast Fourier Transform/Fast Fourier Transform (IFFT /FFT) algorithms are used in the modulation and demodulation of the signal. The length of the IFFT/FFT vector determines the resistance of the system to errors caused by the multipath channel. The common modulation for the carrier is QPSK, 16 QAM or 64- QAM. In case of using 16 QAM modulation, the no. of states is 16, so 1 symbol represents 4 bits. If we simulate all the carriers in the constellation diagram we get not just one discrete point but many points forming a "cloud" and representing each state. In case of Additive Guassian White Noise (AGWN) the "cloud" gets bigger and the receiver may decide incorrectly resulting in bit error. The big difference between OFDM and OWDM is that in OFDM, the FFT performs sub band decomposition with a specific number of sub bands at well defined intervals, with OWDM; it is possible to dynamically allocate the number of sub bands and the bandwidth of each. Of course, if there were sufficient levels, the OWDM would start to resemble the OFDM Symbol.

2.2 DVB-T

DVB-T European-based consortium standard for the broadcast transmission of digital terrestrial television that was first published in 1997 and first broadcast in the UK in 1998. The DVB-T Standard is published as EN 300 744, Framing structure, channel coding and modulation for digital terrestrial television. DVB-T is multi carrier system where each carrier modulated digitally. DVB-T has been adopted or proposed for digital television broadcasting by many countries, using mainly VHF 7 MHz and UHF 8 MHz channels whereas Taiwan, Colombia, Panama, Trinidad and Tobago and the Philippines use 6 MHz channels. DVB-T standard uses coded Orthogonal Frequency Division Multiplexing (COFDM) as modulation scheme. In COFDM, forward error correction is applied to the signal before transmission. Except this property, COFDM is same as OFDM. This is to be overcome a errors in the transmission due to lost carriers from channel noise, frequency selective noise and other propagation effects. The main focus of this project is on OFDM and OWDM, but in real-life application any practical system will be use forward error correction thus would be COFDM.The DVB-T network operator can choose one of the two modes of operation.

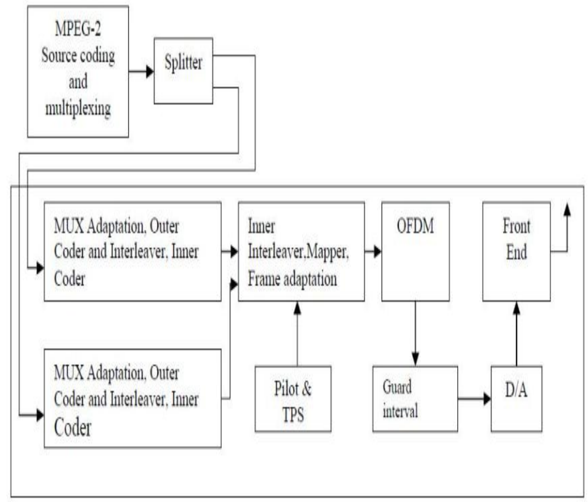

Fig.1.0 Digital Video Braodcasting Terrestrial

First is 2K mode which is suitable for single transmitter operations and small single frequency networks (SFN) with limited transmitter distance.It employs 1705 carriers. 8K mode is suitable for single transmitter operations and small and large single frequency networks (SFN). It employs 6817 carriers. Existing DVB-T modes produce a transport capacity of 5-15 Mbps (1-3 TV Programs) suitable for mobile receivers. A simplified block diagram of the European DVB-T standard is shown in the figure below. A digital signal processor (DSP) performs most of the processes described in this diagram.

2.3 **Owdm**

In DWT -OWDM, the modulation and demodulation are implemented by wavelets rather than by Fourier transform. OWDM using the discrete wavelet transform is a multiplexing transmission method in which data being assigned to wavelet sub bands having different time and frequency resolution. Wavelet based system establishes a small bit error rate probability than that of the Fourier transform based system. Wavelet modulation is modulation scheme to make use of wavelet transformations corresponding to the data being transmitted. The advantage of wavelet transform than other transforms such as Fourier transform is discrete both in time as well as scale. By increasing the order of the wavelets, the effect of aliasing can be decreased and therefore the orthogonality between the sub bands. OWDM allows each subcarrier to have different coding and different modulation depending on the channel requirements so increase in flexibility. The other advantage of OWDM is increase in resilience to frequency selective fading by increasing the error correction on the effected sub-bands and decrease in computational complexity from:

ISSN 2229-5518

O N = N log2N to O N = N

Wavelets:-

When performing a frequency analysis of a signal, often, if there is minimal variation in time, Fourier transform with appropriate windowing will provide accurate information. If however, there are fast fluctuations in the time domain or the time domain contains information that is relevant to how the frequency domain information is reacting, a time-frequency analysis is necessary. There are several mechanisms that can be used to do this but the most common three are the Short-Time Fourier Transform (STFT) that works by sweeping a window over the time-domain signal and presents a three dimensional spectrograph; the wavelet transform and wavelet packets.[9]-[15]. The wavelet transform maps a time function into a two dimension function of α instead of w - frequency, where α is called the scale and is the translation of the wavelet function along the time axis. The continuous waveform transform of a signal s (t) can be defined as

$$CWT(a,\tau) = \frac{1}{\sqrt{a}} \int s(t).\psi \frac{(t-\tau)}{a} dt \quad .....(1)$$

Where CWT is the Continuous Wavelet Transform, t is the time, Ψ (t) is the basic (or mother wavelet) and

the Ψ(t-τ)/α√a is the baby wavelet made by either stretching or compressing the mother wavelet.[17].

Proposed System

The use of filters in the wavelet domain has been predominantly used for multi-resolution analysis of time varying signals. The big difference between OFDM and OWDM is that in OFDM, the FFT performs sub band decomposition with a specific number of sub bands at well defined intervals. Whereas OWDM, it is possible to dynamically allocate the number of sub bands and the bandwidth of each sub bands.

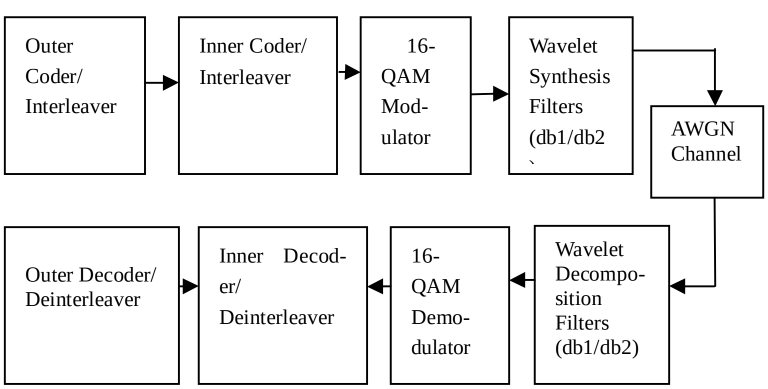

Fig.2.0 Proposed system block diagram

3 SIMULATION & RESULTS

Now the system is simulated, the effects of showing different wavelets in the OWDM as compare with OFDM and analysis their response to Additive White Gaussian Noise (AWGN). Proposed model was considered taking in a binary sequence, 64-level Quardature amplitude modulation (64-QAM) on the stream, buffer up the results into a fixed symbol size and then pass the buffer through the OWDM modulator. The overall buffer size was set to 2048 symbols as per the DVB-T 2K system and only 2 levels of decomposition were used at this time. The decision to present the results without coding was to demonstrate the error correction capabilities of the wavelet transform themselves. To compare the different wavelets, the buffered Quardature modulated block (containing the same information for each trial) was passed through the different wavelet filters. The output from the filter was passed through the AWGN channel with decreasing Signal to Noise Ratio (SNR) and then demodulated.

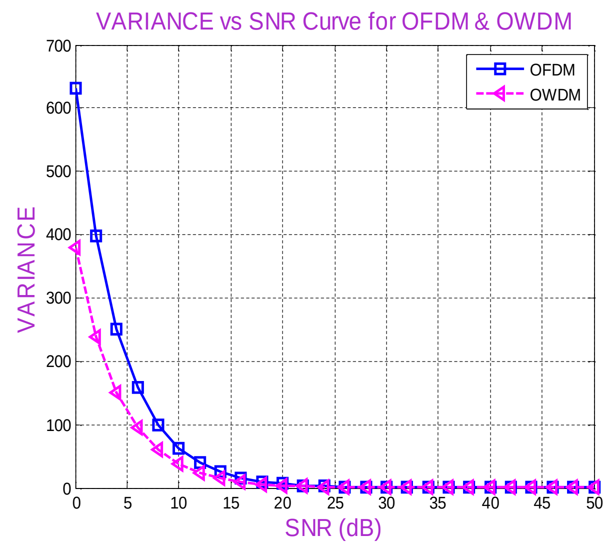

Fig.3.0 Variance vs SNR for OFDM and OWDM (db1wavelet filter in OWDM)

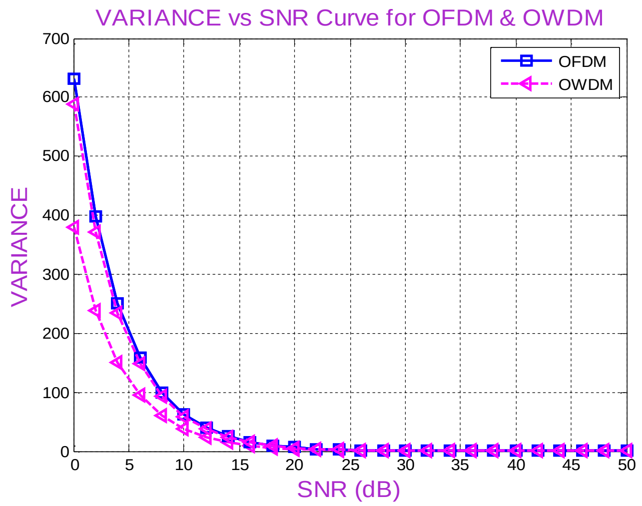

Fig.4.0 Variance vs SNR for OFDM and OWDM (db1/db2)

Fig.4.0 shows the relationship of the Variance to the SNR for the wavelet transform where the different trace lines in Fig 4.0 depict the two different wavelet filter of Daubechies family and OFDM. Fig.3.0 and Fig.4.0 depict the results of simulating the OWDM with different wavelet filters and comparing the variance at the output of the QAM demodulator against the channel signal to noise ratio (SNR). From Fig.4.0 it can be seen that as order of the filter increases in Daubechies family, their variance increases, it means performance of system decreases. The variance versus the SNR of the db1 in OWDM is less as compare to db2 and OFDM as well, this means OWDM system has lower computational complexity, increases flexibility and low multipath propagation loss.

4 Conclusion

In this paper we have demonstrated a set of simulation and comparison has been succeeded of different wavelet filters of OWDM with OFDM. From these results , it is suggested that the db1 wavelet (the first wavelet of Daubechies family) is the most suited for OWDM because of the lower variance to noise in channel followed by Daubechies family, while db2 (the second wavelet of Daubechies family) is the least suited because it has high variance. The results showed that there were some OWDM scheme whose variance outperformed that of OFDM and db1 wavelet achieved the best performance compared to other wavelet db2 and OFDM as well. The system presented has no error correction coding, although in a practical system, coding would be included. In this paper, no error correction codes have been incorporated. However, these codes can be considered later on.

References

[1] R. Van Nee and R. Prasad, OFDM for Wireless Multimedia Communications. Artech House, 2000.

[2] L. Hanzo, M. Munster, B. J. Choi, and T. Keller, OFDM and MC-CDMA for Broadband Multi-User Communications, WLANS and Broadcasting. IEEE Press, 2003.

[3] A. R. Sheikh Bahai, B. R. Saltzberg, and M. Ergen, Multi- Carrier Digital Communications: Theory and Applications of OFDM. Springer, 2004

[4] Sobia Baig, Fazal-ur-Rehman, M. junaid Mughal ,"Performance Comparison of DFT, Discrete Wavelet Packet and Wavelet Transforms, in an OFDM Transceiver for Multipath Fading Channel", IEEE Communication Magazine,2004

[5] Deepak Gupta, Torry harris, Vipin B Vats, Kamal K. Garg," Performance Analysis of DFT-OFDM,DCT-OFDM and DWTOFDM in AWGN channel", IEEE Transaction ,The Fourth International Conference on Wireless Mobile Communications, 2007.

[6] A. R. Lindsey, "Wavelet packet modulation: a generalized method for orthogonally multiplexed communications," in IEEE 27th South eastern Symposium on System Theory, pp. 392–396, 1995.

[7] F. Farrukh, S. Baig, and M. J. Mughal ,"Performance Comparison of DFT-OFDM and Wavelet-OFDM with Zero-Forcing Equalizer for FIR Channel Equalization", IEEE Communication Magazine, 2008

[8] K. Abdullah and Z. M. Hussain ,"Performance of Fourier Based and Wavelet-Based OFDM for DVB-T Systems", Australian Telecommunication Networks and Applications Conference,pp.475- 479, 2007.

[9] P. Kaewmanee, R. F. Ormondroyd, C. R. Walters, "Resilient adaptive wavelet packet modulation scheme for Used in Time and Frequency Selective Channels Using the Best Tree Search Algorithm,"2004 IEEE Military Communications Conference, pp. 1566-1571, Milom, 2004.

[10] A. R. Lindsey, "Wavelet packet modulation: a generalized method for orthogonally multiplexed communications," in IEEE 27th South eastern Symposium on System Theory, pp. 392–396, 1995.

[11] Jain, V.K., and Myers, B.A.: 'Communication system using orthogonal wavelet division multiplexing (OWDM) and OWDM-spread spectrum (OWSS) signalling'. US Patent No. 09864676, 6th June 2006

[12] Linfoot, S.L., and Ibrahim, M.K.: 'Flexible modulation for digital terrestrial broadcasting', Electron. Lett., 2006, 42, (23), pp. 1360–1362

[13] Daubechies, I.: 'Ten lectures on wavelets' (Society for Industrial and Applied Mathematics, 3rd edn., ISBN 0-89871-274-2)

[14] M_Vetterli, J. Kovacevic, Wavelets and Subband Coding. Prentice Hall PTR, Englewood Cliffs, New Jersey, 1995.

[15] I. Daubechies, Ten Lectures on Wavelets, Philadelphia: SIAM, 1992.

[16] P.P. Vaidyanathan, "A theory for multiresolution signal decomposition: The wavelet representation" IEEE Trans. Pattern Anal. Machine Intell, vol.11, pp.674-693, Jul 1989.

[17] Mallat, S.: 'A theory for multiresolution signal decomposition: the wavelet representation', IEEE Pattern Anal. Mach. Intell., 1989, 11, , pp. 674–693.