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OFDM Channel Analysis between FFT and Wavelet Transform Techniques

Quosay Jalil[1], S Nagakishore Bhavanam[2]
[1]Student, M.Tech., [2]Assistant Professor
[1,2]University College of Engineering & Technology,
Acharya Nagarjuna University,
Andhra Pradesh, INDIA.

***Abstract**: Nowadays In 4G (MIMO-OFDM) Communication is Role on World from this communicate channel we are going face problem on Interference between Transmitter Users for this In our project We are implement through Transformation method for OFDM systems of transmits and receive antennas with cyclic prefix (CP) .In OFDM multiple carriers are used and it provides higher level of spectral efficiency as compared to Frequency Division Multiplexing (FDM). In OFDM because of loss of orthogonality between the subcarriers there is inter carrier interference (ICI) and inter symbol interference (ISI) and to overcome this problem use of cyclic prefixing (CP) is required, which uses 20% of available bandwidth. Comparison between the conventional FFT based OFDM systems with DWT based OFDM system have been made according to some conventional and non-conventional modulation methods over AWGN. The wavelet families have been used and compared with FFT based OFDM system and found that DWT based OFDM system is better than FFT based OFDM system with regards to the bit error rate (BER) performance.*

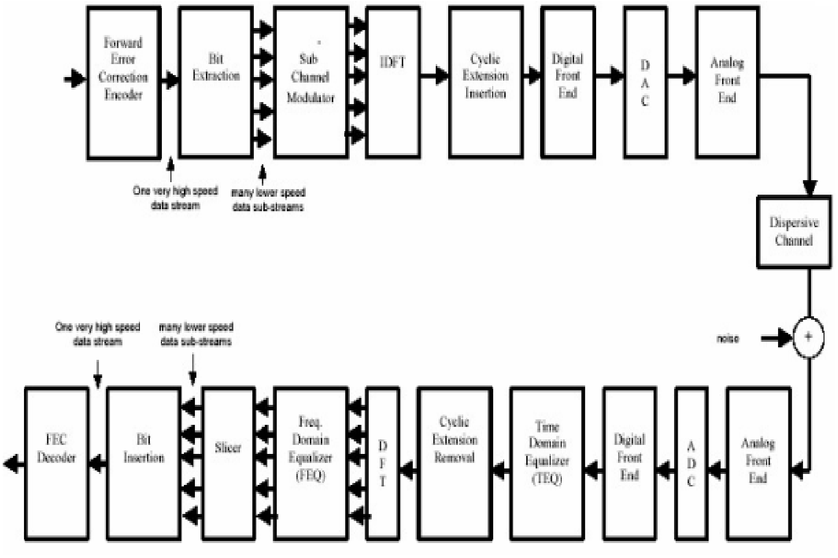
***Keywords**: MIMO-IOFDM, CP, FFT, BER*

I. Introduction

Orthogonal frequency-division multiplexing (OFDM), is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. OFDM meets the LTE requirement for spectrum flexibility and enables cost-efficient solutions for very wide carriers with high peak rates. Each user is allocated a number of so-called resource blocks in the time/frequency grid. The more resource blocks a user gets, and the higher the modulation used in the resource elements, the higher the bit-rate. Which resource blocks and how many the user gets at a given point in time depend on advanced scheduling mechanisms in the frequency and time dimensions. The interfaces of both OFDM and OFDMA work by separating a single signal into subcarriers, or, in other words, by dividing one extremely fast signal into numerous slow signals that optimize mobile

Access, as the sub channels can then transmit data without being subject to the same intensity of multipath distortion faced by single carrier transmission. The numerous subcarriers are then collected at the receiver and recombined to form one high speed transmission.

Fig. 1: The OFDM system block



The difference between OFDM and OFDMA is that OFDMA has the ability to dynamically assign a subset of those subcarriers to individual users, making this the multi-user version of OFDM, using either Time Division Multiple Access (TDMA) (separate time frames) or Frequency Division Multiple Access (FDMA) (separate channels) for multiple users. OFDMA simultaneously supports multiple users by assigning them specific subchannels for intervals of time. Point-to-point systems are OFDM, and do not support OFDMA. Point-to-multipoint fixed and mobile systems use OFDMA.OFDM technologies typically occupy nomadic, fixed and one-way transmission standards, ranging from TV transmission to Wi-Fi as well as fixed Wi-MAX and newer multicast wireless systems like Qualcomm's Forward Link Only (FLO). OFDMA, however, adds true mobility to the mix, forming the backbone of many of the emerging technologies including LTE and mobile Wi-MAX.

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II. FFT Based OFDM

OFDM transmitter was described using sinusoidal components. Generally, an OFDM signal can be represented as

$$OFDM\ signal = c(t) = \sum_{n=0}^{N-1} s_n(t) sin(2\pi f_n t)$$

S (t) = symbols mapped to chosen constellation (BPSK/QPSK/QAM etc..,)

F n = orthogonal frequency

This equation can be thought of as an IFFT process (Inverse Fast Fourier Transform). The Fourier transform breaks a signal into different frequency bins by multiplying the signal with a series of sinusoids. This essentially translates the signal from time domain to frequency domain. But, we always view IFFT as a conversion process from frequency domain to time domain. FFT is represented by

$$X(k) = \sum_{n=0}^{N-1} x(n) sin(\frac{2\pi kn}{N}) + j \sum_{n=0}^{N-1} x(n) cos(\frac{2\pi kn}{N})$$

Whereas its dual, IFFT is given by

$$x(n) = \sum_{n=0}^{N-1} X(k) sin(\frac{2\pi kn}{N}) - j \sum_{n=0}^{N-1} X(k) cos(\frac{2\pi kn}{N})$$

The equation for FFT and IFFT differ by the co-efficient they take and the minus sign. Both equations do the same thing. They multiply the incoming signal with a series of sinusoids and separate them into bins. In fact, FFT and IFFT are dual and behave in a similar way. IFFT and FFT blocks are interchangeable. Since the OFDM signal (c (t) in the equation above) is in time domain, IFFT is the appropriate choice to use in the transmitter, which can be thought of as converting frequency domain samples to time domain samples. Well, you might ask: s (t) is not in frequency domain and they are already in time domain; so whats the need to convert it into time domain again? The answer is IFFT/FFT equation comes handy in implementing the conversion process and we can eliminate the individual sinusoidal multipliers required in the transmitter/receiver side. The following figure illustrates how the use of IFFT in the transmitter eliminates the need for separate sinusoidal converters. Always remember that IFFT and FFT blocks in the transmitter are interchangeable as long as their duals are used in receiver.

III. DWT Based OFDM System

The wavelet transform is usually represented as MRA. The wavelet transform decomposes the signal using a set of basis function into different resolution subspaces …..V-2< V-1 < V0 < V1 <……The decomposition is done using a basis function and a wavelet function and there translation and dilation. The dilated and translated scaling function forms the basis of the various subspaces. i.e. {ø (t)} forms a basis for V0 . The wavelet functions forms a subspace orthogonal to the basis formed by the scaling function. The scaling and the wavelet function both satisfy some dilation equation.

$$\phi (t) = \sum \phi(2t-n)h(n)$$

If ø (t) should be orthonormal to its translated then h[n] should satisfy the orthonormality condition

$$\sum h[n]h[n-2m] = \delta[m] \text{ and } \sum(-1)n$$

$$h[n] = 0$$

Given a sequence we can find another sequence g[n] such that the function satisfying the Dilation equation

$$\Psi (t) = \sum \Psi (2t-n)\, g[n]$$

This function is orthonormal to the scaling function is called the wavelet function. Using the wavelet and the scaling function we decompose the signal into two subspaces orthogonal to each other. Thus if the original signal is in space V0 then using the scaling and wavelet function we decompose it into subspaces V1 and W1 . In the classical wavelet transform the subspace V1 is further decomposed into orthogonal subspaces V2 and W2.We see that ø (t) occupies only half the frequency space of ø (2t) and similarly for the wavelet function. Thus this decomposition can be considered as decomposition into high and low frequency domain. In discrete wavelet transform we can represent the process of decomposition as low and high pass filtering and then down sampling by 2. The filter coefficients are given by g[-n] and h[-n]. The filter with coefficients h[-n] forms a low pass filter while the filter with g[-n] forms a high pass filter. Thus the wavelet transform can be constructed by using QMF filter banks. The low passed and the high passed signals are down sampled by 2. The low pass signal can again be decomposed into high and low pass signals.

(A) Modulation

In modulation, a message signal, which contains the information, is used to control the parameters of a carrier signal, so as to impress the information onto the carrier. analogue – denoted by $m(t)$ digital – denoted by $d(t)$ – *i.e.* sequences of 1's and 0's The message signal could also be a multilevel signal, rather than binary; this is not considered further at this stage.

Fig. 2: The tree structure of the Wavelet decomposition

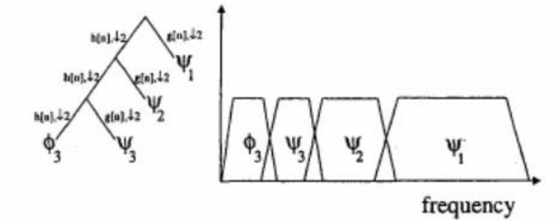
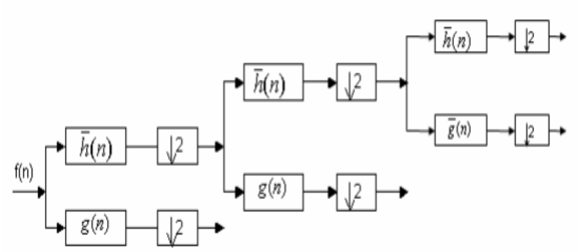
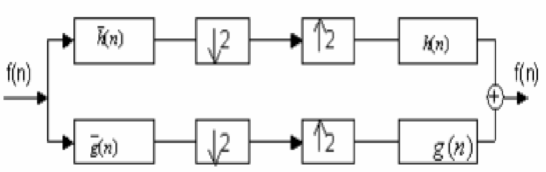


Fig. 3: A Structure of wavelet decomposition



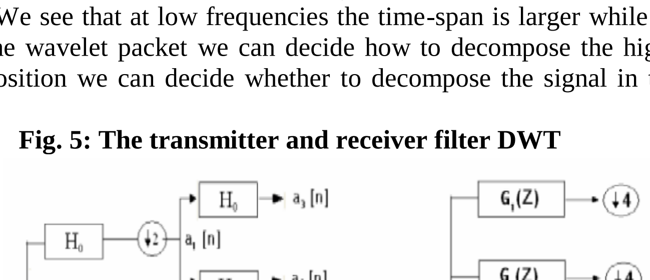
The synthesis side can be considered as up sampling by 2 and then filtering the low and high pass coefficient at the k-th level and then adding the two and this gives the low pass coefficient at the (k-1) level and similar structure at the subsequent levels give back the signals. The filter of the synthesis side can be determined from the analysis side filter by the perfect reconstruction condition. This gives a variety of filter's and this leads to the various families of wavelets. A 1st level decomposition and reconstruction is shown below for QMF filters.

Fig. 4: The 2 channel QMF



In wavelet transform we do the decomposition of just the low pass coefficients. A generalization of this is the wavelet packet transform in which the decomposition is done along both the high and low pass coefficients. Also we make use of the identities that when a signal is down sampled and then passed through a filter (H (z)) and it is equivalent to passing the signal through a filter (H(z2)) and then down sampling. Thus the wavelet packet transform can be represented as below. The frequency time plot of Wavelet transform and wavelet packet transform is shown below. We see that at low frequencies the time-span is larger while at high frequencies the time-span is smaller. For the wavelet packet we can decide how to decompose the high and low frequencies parts as after each decomposition we can decide whether to decompose the signal in the low/high frequency domain or not.

Fig. 5: The transmitter and receiver filter DWT

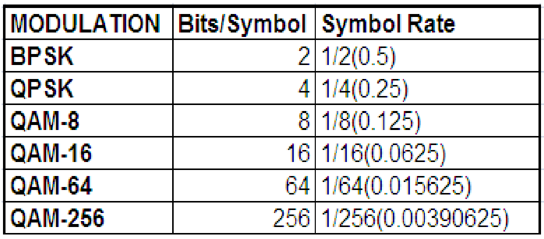


The OFDM implemented by using IFFT's and FFT's have some problems. The OFDM suffers from ISI (inter symbol interference) –This is usually taken care of by using a adding a cyclic prefix greater than the channel length but this may not always be possible. This occurs due to loss of orthogonality due to channel effects. Time and Frequency Synchronization- the OFDM requires time and frequency synchronization to get a low bit error rate. Carrier Frequency Offset- The offset between the carrier frequency and the frequency of the local oscillator also causes a large bit error rate.

Due to these problems we need to look at other type of modulation to generate the carrier. One of these is the wavelet transform. The wavelet transform is proposed by many authors, it has a higher degree of side lobe suppression and the loss of orthogonality leads to lesser ISI and ICI. In Wavelet OFDM the FFT and IFFT is replace by DWT and IDWT respectively. For the Wavelet transform we see that from the time-frequency plot that the basic Wavelet transform offers lesser flexibility than the wavelet packet transform. For the wavelet packet transform we can construct an algorithm to do the decomposition such that the effect due to the noise (assuming that we know the frequency that is affected most by the noise and the time when it affected most).The transmitter and receiver are shown in the figure below. At the transmitter the data is first M-array modulated and then serial to parallel converted first then up sampled and then passed through an IDWPT filter bank. At the receiver the data is passed through an Analysis Filter bank and then parallel to serial converted and then M-array demodulated.

This is the case for wavelet packet transform; some researchers have also used wavelet transform. In such a case the IFFT and FFT's in the OFDM are just replaced by the DWT/IDWT to give the DWT-OFDM The wavelet can be implemented using QMF filter banks' but this cannot full fill linear phase filtering, therefore some authors have suggested the use of bi-orthogonal filter banks, bi-orthogonal filters provide linear phase filtering and the design is flexible. The design of the transmitter and receiver based on bi-orthogonal filter banks is similar to the above design with the filters being the bi-orthogonal filters.

Table 1: Modulation and symbol Rate relationship



MODULATION	Bits/Symbol	Symbol Rate
BPSK	2	1/2(0.5)
QPSK	4	1/4(0.25)
QAM-8	8	1/8(0.125)
QAM-16	16	1/16(0.0625)
QAM-64	64	1/64(0.015625)
QAM-256	256	1/256(0.00390625)

IV. Conclusions

We see that DWT-OFDM performs much better than the DFT-OFDM over AWGN and Rayleigh channel with low SNR. Also we find that use of Wavelet's reduces the overhead thus giving a larger bandwidth. The wavelet packet is much better than the implementing just the wavelet transforms as it is more flexible. The bi-orthogonal wavelets though may provide some advantage and better flexibility doesn't perform well for some wavelets considered to the theoretical case.

V. References

[1] Communication Systems, 4th edition, Simon Haykin, John Wiley and Sons,Inc.

[2] C. V. Bouwel, et. al, Wavelet Packet Based Multicarrier Modulation, IEEECommunications and Vehicular Technology, SCVT 200, pp. 131-138, 2000.

[3] B. G. Nagesh, H. Nikookar, Wavelet Based OFDM for Wireless Channels, IEEEVehicular Technology Conference, Vol. 1, pp. 688-691, 2001.

[4] LI Wiehua, et.al, Bi-orthogonal Wavelet Packet based Multicarrier modulation.

[5] Haixia Zhang, et. al, Research of DFT-OFDM and DWT-OFDM on DifferentTransmission Scenarios. Proceeding of the second international conference on Information Technology for Application (ICITA 2004)

[6] D.Karamehmedovic, M.K.Lakshmanan and H. Nikookar,"Performance of Wavelet packet modulation and OFDM in presence of carrier frequency and phase noise" Proceedings of the 1stEuropean Wireless Technology Conference, October 2008,Amsterdam, The Netherlands.

[7] R.S. Bodhe, S.S. Narkhede, Shirish Joshi, "Design and Implementation of Baseband Processing for Wavelet OFDM", National Conference e-PGCON2012, Pune.

[8] Andre Ken Lee Ooi, MichealDrieberg and VarunJeoti, "DWT based FFT in practical OFDM systems" IEEE Region Ten Conference, TENCON2006, 14-17Nov2006, Hongkong.

[9] S. Adhikari, S. L. Jansen, M. Kuschnerov, B. Inan, and W. Rosenkranz, "Analysis of spectrally shaped DFT-OFDM for fiber nonlinearity mitigation," Opt. Express, to be published.

[10] S. Nakajima, "Effects of spectral shaping on OFDM transmission performance in nonlinear channels," in Proc. 16th ISTMWC 2007, Budapest, Hungary, Jul., pp. 1–5.

[11] O. Gaete, L. Coelho, B. Spinnler, and N. Hanik, "Pulse shaping using the discrete Fourier transform for direct detection optical systems," in Proc. ICTON, Stockholm, Sweden, Jun. 2011, pp. 1–4, paper We.A1.2.

[12] C. Xia and D. van den Borne, "Impact of the channel count on the nonlinear tolerance in coherently-detected POLMUX-QPSK modulation," in Proc. OFC 2011, Los Angeles, CA, Mar. 2011, pp. 1–3, paper OWO1.1.

[13] Theodores Rappaport, Wireless communication principles and practice, Pearson education, 2nd edition.

[14] Dr. KamiloFeher,Wireless digital communications modulation and spread spectrum applications, Pretice-Hall, 2ndedition.

[15] DharmaprakashAgrawal and Qing Anzeng, Introduction to wireless and mobile system, Vikas publishing house.

[16] JayRanade, series advisor, wireless and networked communication, Mcgraw hill Inc

[17] Mitra, Sanjit K. Digital Signal Processing: A Computer-Based Approach. NewYork: McGraw-Hill, 2001.

[18] M. Guillaud and D. Slock, “Full-rate full-diversity space-frequency coding for MIMO OFDM systems,” in Proc. IEEE Benelux Signal Processing Symp., 2002, pp. S02–14.
[19] Y. (G.) Li, J. H. Winters, and N. R. Sollenberger, “MIMO-OFDM for wireless communications: Signal detection with enhanced channel estimation,” IEEE Trans. Commun., vol. 50, pp. 1471–1477, Sept. 2002.
[20] S. Kaiser, “Spatial transmit diversity techniques for broadband OFDM systems,” in Proc. IEEE Globecom, 2000, pp. 1824–1828.
[21] A. Dammann and S. Kaiser, “Standard conformable antenna diversity techniques for OFDM and its application to the DVB-T system,” in Proc. IEEE Globecom, 2001, pp. 3100–3105.
[22] A. Dammann, P. Lusina, and M. Bossert, “On the equivalence of space–time block coding with multipath propagation and/or cyclic delay diversity in OFDM,” in Proc. Eur. Wireless 2002, pp. 847–851.
[23] J. Tan and G. L. Stüber, “Multicarrier delay diversity modulation for MIMO systems,” IEEE Trans. Wireless Commun., to be published.
[24] A. N. Mody and G. L. Stuber, “Efficient training and synchronization sequence structures for MIMO OFDM systems,” presented at the 6th OFDM Workshop 2001, Hamburg, Germany
[25] “Synchronization for MIMO OFDM systems,” in Proc. Globecom 2001, pp. 509–513.
[26] V. Tarokh, H. Jafarkhani, and A. R. Calderbank, “Space–time block coding for wireless communications: Performance results,” IEEE J. Select. Areas Commun., vol. 17, pp. 451–460, Mar. 1999.