Performance analysis of Integer wavelet packet transform (IWPT)- OFDM , WPT-OFDM and FFT-OFDM based on QAM modulation

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Abstract:-

Now a day's OFDM is widely used in various application mainly in wireless communication. It suffers from Inter symbol Interference (ISI). To mitigate the effect of ISI the cyclic prefix (CP) is used resulting loss in bandwidth. So DWT and WPT are used in place of FFT. By these transform the spectral containment of the channel is better since they are not using CP. In this paper we have compared the FFT based OFDM with DWT, WPT and IWPT-OFDM. IWPT-OFDM has been suggested to improve BER – performance.

KeyWords:- DWT, WPT, IWPT,BER.

I. INTRODUCTION

Orthogonal frequency-division multiplexing (OFDM)
It is a method of encoding digital data on multiple carrier frequencies. OFDM was developed as a popular scheme for digital communication whether wireless or with copper wires, use in digital television , wireless network , audio broadcasting and 4G mobile communication . OFDM is a frequency division multiplexing (FDM) used as a digital multi - career modulation. In this method a large number of closely spaced orthogonal sub careers are used to carry data.

Each sub career is modulated with a modulation scheme such as QAM, PSK. Now a day's number of users is increasing so there is need for high data rate modulation scheme. OFDM is one of the best modulation methods for this requirement. But OFDM suffers from Inter Symbol Interference (ISI) to avoid this ISI we use cyclic prefix. Due to use of cp there is loss of bandwidth. To overcome this loss FFT used in OFDM is replaced by DWT, WPT & IWPT.

II. FFT BASED OFDM

Block diagram of OFDM system is shown in fig.1. the inverse and forward block can be replaced by FFT based OFDM,DWT based OFDM,WPT based OFDM or IWPT based OFDM.
The output in discreate time domain is as.

$$X_k(n) = 1/\sqrt{N}\sum_{i=0}^{N-1} X_m(i)\exp(j2\pi ni/N)$$

Where $Xk\ (n)0 \leq n \leq N-1$ is a sequence in the discrete time domain and

$Xm(i) \leq$ i≤N-1 are complex number .

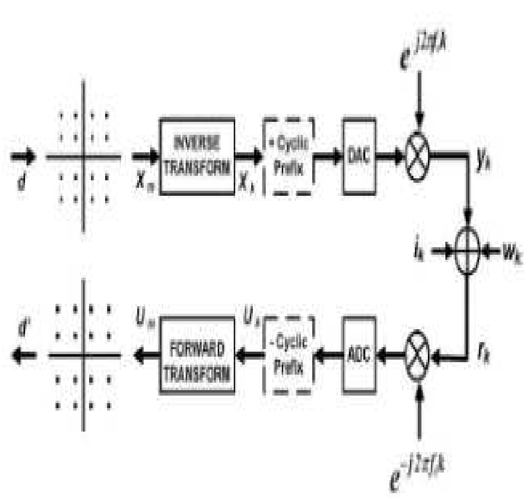

Fig.1

The cyclic prefix is added before transmission to minimize the Inter symbol interference (ISI) and at the receiver side the cyclic prefix is removed to obtain the data in discrete time domain. Than it is fed to FFT. FFT convert time domain data into frequency domain data. The output of FFT in frequency domain is as given below.

$$Um\ (i) = \sum_{n=0}^{N-1} Uk(n)\exp^{(-j2\frac{ni}{N})}$$

As OFDM requires CP to remove Inter Symbol interference (ISI) ,this causes overhead and sometimes this overhead may be much large for system to be effective .

Another solution is to replace the Fast Fourier Transform by Wavelet transform. In DWT the modulation and demodulation is perform by Wavelet rather than by Fourier transform. By using Wavelet ISI , ICI can be reduce without use of CP[1][2][3][5].

III. WAVELET BASED OFDM

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 predictable, 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 (DWT) is used in a variety of signal processing applications, such as video compression, Internet communications compression, object recognition and numerical analysis[4] .

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. The DWT of a signal x is calculated by passing it through a series of filters. First the samples are passed through a low pass filter with impulse response "g" resulting in a convolution of the two.

$$Y[n] = (x * g)[n] = \sum_{-\infty}^{+\infty} x[k]g[n-k]$$

The signal is also decomposed simultaneously using a high-pass filter "h". The output gives the detail coefficients

(from the high-pass filter) and approximation coefficients (from the low-pass). It is important that the two filters are related to each other and they are known as a quadrature mirror filters. However, since half the frequencies of the signal have now been removed, half the samples can be discarded according to Nyquist's rule. The filter outputs are then sub sampled by two. The outputs of the low-pass filter and the high-pass filter are shown below and are the convolutions of the input data with the respective filter responses.

$$Y_{low}[n] = (x*g)[n]= \sum_{-\infty}^{+\infty} x[k]g[2n-k]$$

$$Y_{high}[n]= (x*h)[n]= \sum_{-\infty}^{+\infty} x[k]h[2n-k]$$

Integer wavelet transform and integer wavelet packet transform based OFDM

The work in [6] answers the question about how to obtain IWT from given wavelet functions; omitting details, it has been proven that rounding off the output of each filter (see Fig.2, Fig.3) right before adding or subtracting yields a couple of perfect reconstruction forward and inverse IWT. It is straightforward to understand that the same procedure which leads to IWT from wavelet transform can be applied to the wavelet packets transform, yielding the IWPT.

The implementation follows the same scheme used for the IWT. The IWPT tree can be built iterating the single wavelet decomposition step on both the low-pass and high-pass branches, with rounding off in order to achieve the integer transforms. IWPT yields a representation which can be lossless, as it maps an integer valued sequence onto integer valued coefficients in the transformed domain; moreover, it allows for the selection of an adaptive representation, which can match the variable characteristics better than the IWT.

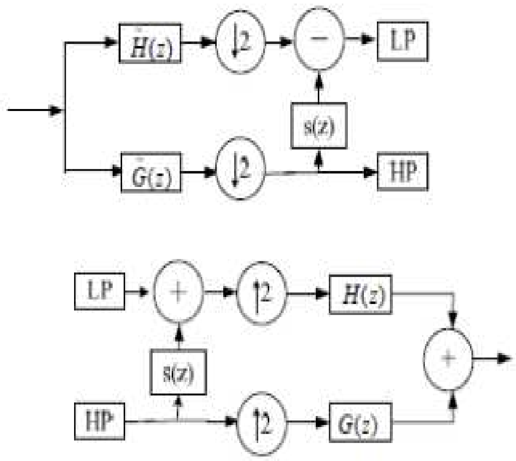

Fig.2 Primal lifting

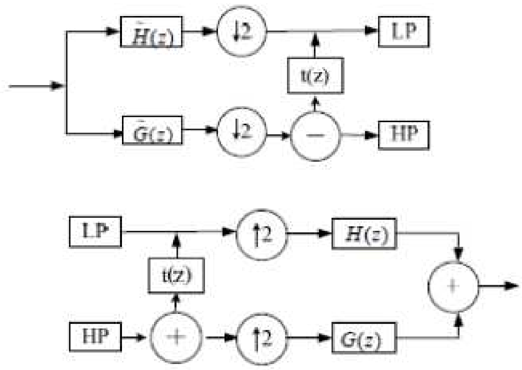

Fig.3 Dual lifting

IV. SIMULATION RESULT

The performance of FFT OFDM, DWT OFDM , WPT OFDM , and IWPT OFDM has been shown by means of MATLAB simulation . The graphical results found show the bit error rate of all the systems.

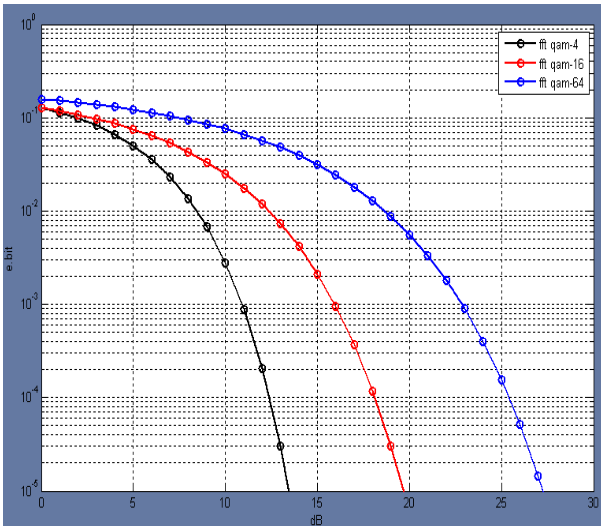

Fig-4.

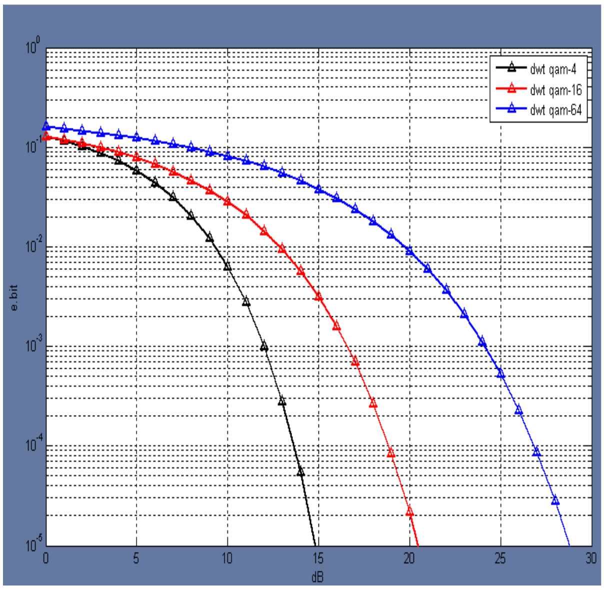

Fig-5.

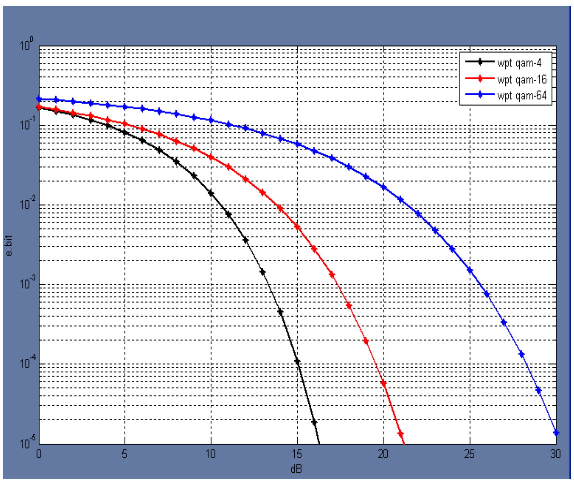

Fig-6.

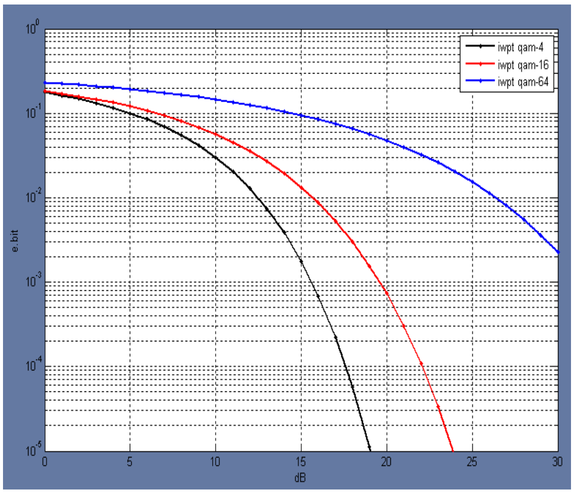

Fig-7.

As shown in figure-4,5,6,and 7. It is found that IWPT based system performs better in terms of bit error Rate.

V. CONCLUSION

We presented the simulation approaches for DWT-OFDM ,WPT-OFDM and IWPT OFDM as alternative substitutions for FFT-OFDM. The results in terms of BER performance were also obtained for all of them.

REFERENCE

[1] R. Mirghani, and M. Ghavami, “Comparison between Wavelet-based and Fourier-based Multicarrier UWB Systems”, *IET Communications*, Vol. 2, Issue 2, pp. 353-358, 2008.

[2] R. Dilmirghani, M. Ghavami, “Wavelet Vs Fourier Based UWB Systems”, *18th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications*, pp.1-5, September 2007.

[3] M. Weeks, *Digital Signal Processing Using Matlab and Wavelets*, Infinity

Science Press LLC, 2007.

[4] Michael Weeks, Digital Signal Processing Using MATLAB and Wavelets. Infinity Science Press LLC, 2007.

[5] S. R. 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”, *9th IEEE International Multitopic Conference*, pp. 1-6, Dec 2005

[6] R. C. Calderbank, I. Daubechies, W. Sweldens, and B.Yeo,“Wavelet Transforms that Map Integers to Integers”,*Applied and Computational Harmonic Analysis*, 1998, Vol. 5, no. 3, pp. 332-369,160.