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A Review: Orthogonal Frequency Division Multiplexing Based on Wavelet transforms

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Abstract - *Now-a-days all communication systems are using multi carrier modulation (MCM) techniques which are nothing but transmitting data by dividing it into separate components and then sending them over separate carrier signals. Orthogonal frequency division multiplexing (OFDM) is one amongst such type of technique. In this technique the available spectrum is divided into number of parallel subcarriers. This system suffers from high peak to average power ratio (PAPR), poor BER performance and carrier frequency offset (CFO). This work aimed at studying the effect of high PAPR and BER performance of the system. The objective is to study different methods used for reduction of PAPR and how the wavelet transform can improve the system BER performance and spectral efficiency.*

Key Words: **DWT based OFDM, PAPR, Turbo code, BER performance.**

1. INTRODUCTION

In today's communication world, having more number of users in limited bandwidth allocation and high bitrate transmission is the main task for every service provider. OFDM has been proved to be an effective way to meet this demand. Higher spectral efficiency, noise resistance and elimination of equalizers these are advantages which makes it better than any other multiplexing techniques. Even though OFDM based on FFT is introduced few years ago, the researchers change their mind towards the wavelet based OFDM system due to its several advantages like better orthogonality, better bandwidth utility, resistance towards fading and lesser complexity. However, in OFDM system, there is an issue of PAPR breaking down the BER [1]. This is because the signal presented in non-linear region of high power amplifier (HPA) which causes inter-modulation distortion. Overcome such a problem caused by PAPR, reduction techniques are employed [1].

However, OFDM has many favourable circumstances over FDM yet it experiences inter carrier interference and inter symbol interference when multiple carriers are utilized and because of this interferences loss of orthogonality happens, with a specific end goal to defeat these obstructions utilization of cyclic prefix has turned out to be mandatory. Be that as it may, use of CP (cyclic prefix) indicates enormous erroneous effect on bandwidth efficiency, as the cyclic prefix approach expends about 20% of bandwidth and BER execution excessively influenced by Cyclic prefix. The fast Fourier transform (FFT) is replaced by discrete wavelet transform (DWT) to achieve better spectral efficiency [3].

In following section, the conventional OFDM system and proposed OFDM system architecture is presented. The discussion of the methods used for reduction of PAPR i.e. clipping and companding is presented.

2. FOURIER BASED OFDM (FFT-OFDM)

The OFDM is a multicarrier modulation system in which accessible spectrum is sub-separated into number of sub-carriers. Recurrence separating among them is chosen such that orthogonality is accomplished among the sub-carriers. The block diagram of Fourier based (FFT) OFDM system is as appeared in fig. 1. The inverse and forward blocks in this system will be IFFT and FFT individually. The information generator first creates the arbitrary information bit streams. The serial information is gathered into bits or word as indicated by modulation technique utilized as a part of the system and after that each bit or word is changed over into parallel piece stream [3]. This information is then into symbol utilizing modulator and these symbols are gone through the IFFT block and produce N parallel information streams. At that point to limit inter-symbol interference (ISI) cyclic prefix (CP) is added before transmission. At receiver side precisely turn around technique is done to decipher the information. The CP is evacuated to get information in time area and afterword it goes through FFT block to get data recuperation.

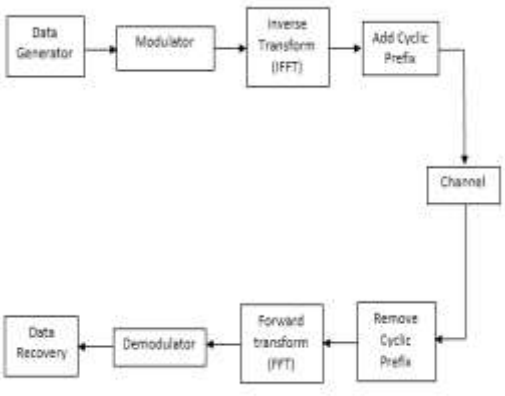


Fig. 1 Fourier based (FFT) OFDM system

3. WAVELET BASED OFDM (DWT-OFDM)

The block diagram of wavelet based OFDM system is shown in fig. 2 [2].

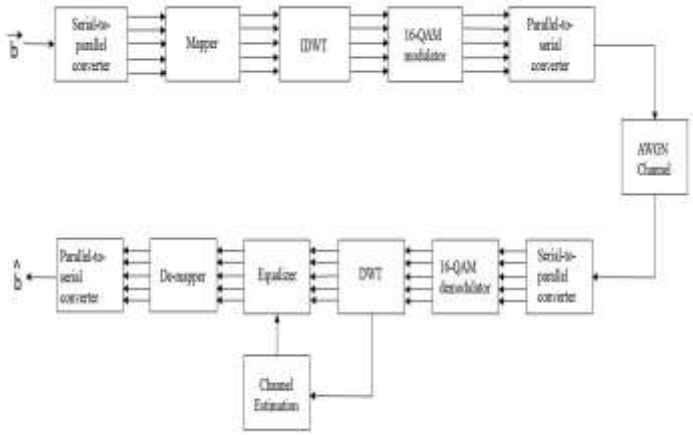


Fig. 2 Wavelet based (DWT) OFDM system.

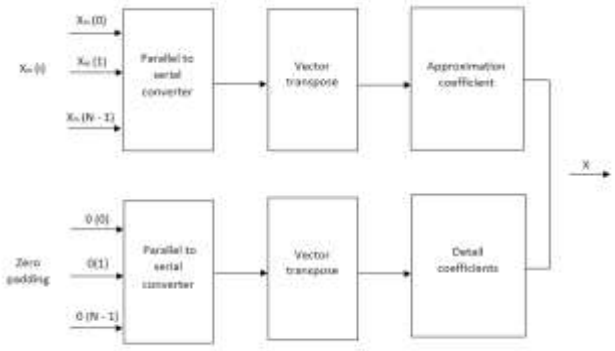
Here likewise as past one information generator first creates arbitrary serial information streams. This information streams are gone through the encoder which is only a turbo encoder and interleaver and after that information is gone through the modulator to change over the information streams into symbol in light of the modulation technique utilized. In wavelet based OFDM, there is no any cyclic prefix because of overlapping nature of wavelet properties which leeway of this system. The information is prepared through IDWT block and the output of this block is given by [1],

$$f(k) = \sum_{m=0}^{\infty} \sum_{n=0}^{\infty} U_m^n \, 2^{\frac{m}{2}} \, \Psi\left(2_k^m - n\right) \quad (1)$$

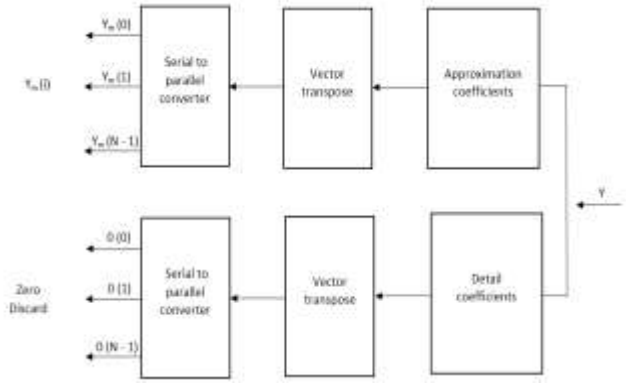
Where k is the quantity of subcarriers, the wavelet coefficients is indicated by which speak to motion in position on time-axis and scale and Ψ(t) is the wavelet work with compacted factor m and shifted component n for each subcarrier. At the receiver side the entire method is turned around. The information is gone through the channel and it is given to the DWT block at receiver side. The output of DWT block is given by,

$$D_m^n = \sum_{k=0}^{N-1} d(k) \; 2^{\frac{m}{2}} \, \Psi\left(2_k^m - n\right) \quad (2)$$

The principle favorable position of wavelet based OFDM system over FFT based OFDM is that it discrete in both time and scale. It comprise of the filters. One filter is low pass channel (LPF) and second is high pass filter(HPF). The inward transceiver of wavelet based OFDM is shown in below fig. a and fig. b respectively.



(a) DWT based OFDM system Transmitter part



(b) DWT based OFDM system Receiver part

A. DWT-OFDM Transmitter

On the DWT-OFDM transmitter side, mapping of the serial information bits into OFDM symbols X_m inside the parallel information streams $X_{m(i)}$ is done by modulator. Where i lies in the vicinity of 0 and N-1. Every information stream $X_{m(i)}$ is gone through parallel to serial converter to make a vector. Consequently, the flag is up-sampled and low pass filter accomplish the low frequency signal. Additionally, vectors are produced from the zero padding signals which is convolved with high pass filter to get detail coefficients or it is likewise called as wavelet coefficient.

B. DWT-OFDM Receiver

On the DWT-OFDM receiver side, precisely switch process is happened. Here the yield information Y is disintegrated into two sections and given to high pass filter and low pass filter to acquire estimate and detail coefficient separately. Where the yield of low pass filter is gone through demodulator then again, the yield of high pass filter is disposed of as it doesn't contain just zero components and no any helpful data. Before demodulation, the transpose of information is gone through serial to parallel converter and original information is recovered.

Both these filters need to fulfill the orthonormal bases so as to work as wavelet transform [3].

IV. PAPR REDUCTION TECHNIQUES

A. CLIPPING

As name suggest in clipping method, signal above perticular value gets clipped. Only certain level of signal is kept around this value [1]. If A is the average clipping value considered then (5) defines the clipping as:

$$f(a) = \begin{cases} a & a \le A \\ A & a \ge A \end{cases} \quad (3)$$

Where 'a' is amplitude signal. The same is respresented in terms of complex envelope as,

$$X = \begin{cases} xe^{\phi} & x \le A \\ Ae^{\phi} & x > A \end{cases} \quad (4)$$

B. COMPANDING

A companding techniques basically consist of the compressor and expander. The aim of this technique is, compression of peak signals and expansion of small signals [1].

$$y = \frac{(V \log(1+\mu|s(t)|))}{\log(1+\mu)} sgn(x) \quad (5)$$

where the maximum value of trasnmitted signal is indicated by v, μ is parameter of μ-law and the signum function is indicated by sgn. Companding uniformaly distribute signal power so that in non-linear region it make constant.

CONCLUSION AND DISCUSSUION

OFDM which is one of the multicarrier modulation technique is discussed here in detail. To improve the spectral efficiency, DWT based OFDM system is proposed here. Also the OFDM system suffering from high PAPR. So to reduce this we have discussed two techniques i.e. clipping and companding out of which clipping method is much easier than the companding technique which is used in this system has been discussed.

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