

A Novel Approach For Ofdm Model Design Using Wavelet Packet Transform

Laxmi Prasad Mishra, Mihir Narayan Mohanty

Abstract: In this growing age, wireless communication demands higher data types transmission with less error or no error. This tends for multipath propagation of radio signals. As a result, the constructive signals, destructive interference as well as phase shifting can be handled smoothly. OFDM technique is one of the solutions for such purpose. The model of OFDM system needs to be improved for better communication. In this paper, authors try to develop a model based on wavelet packet transform (WPT) that releases contamination of the channels. Simultaneously the use of WPT model, there will be no used of cyclic prefix (CP). Further the models is verified for different channels like AWGN, Rayleigh and Rician fading channels for different techniques. It is found that the Raleigh's channel is better than other two channels and considered for QAM transmission that satisfies multi carrier modulation. BER is measured and exhibited in the result section as the proof of the proposed model.

Keywords: Orthogonal Frequency Division Multiplexing (OFDM), Rayleigh fading channel, Discrete Wavelet Packet Transform (DPWT), Quadrature Amplitude Modulation (QAM).

1. INTRODUCTION

Single carrier communication system developed to support good quality voice and low speed data service in a wireless environment. With the increase in demand for multimedia services there was a need to support high data rate transmission in wireless system. With the increase in the data rate the symbol duration decreases and the effect of multipath fading becomes severe. The equalizer which is required to combat the effect of fading for a single carrier is complex and difficult to design. Thus OFDM is a type of multicarrier communication system which reduces the effect of multipath fading. It equalizes the effect of multipath fading using simple single tap equalizer in frequency domain. OFDM converse serial high data rate signal in to low data rate parallel streams which modulated the bank of narrowband orthogonal sub-carriers [1-4]. Due to the process of transmission of data in parallel using narrow band sub carrier the frequency selective fading channel is converted to flat fading channel. The effect of frequency flat fading channel is equalized using single tap equalizer. Thus OFDM is suitable for high data rate wireless communication. However OFDM has the drawback of sensitive to synchronization error and high PAPR. The standard OFDM systems are developed with the IFFT and FFT based techniques for multiplexing and transmission. It uses cyclic prefix for which the delay spread of the channel exceeds the channel impulse response. Cyclic prefix minimizes the ISI but it reduces the power efficiency and throughput [5-11]. Therefore, IFFT and FFT is replaced by wavelet transform. The wavelet transform uses low pass filter and high pass filter operating as quadrature mirror filters for better reconstruction and orthonormal properties. Due to orthonormal properties and its ability to split the time frequency plane, wavelet based OFDM is introduced [12-17]. WLAN is a major wireless system generally used in most practical purposes such as offices and home networks. With 2.4GHz band WLAN, other systems such as Bluetooth or Microwave often interferes.

In indoor wireless communication multipath fading occurs due to several obstructions for which the transmission rate decreases as well as the system performance degrades. By using Wavelet packet transform multipath fading and several interference can be reduced. Wavelet packet transform avoids the cyclic prefix which unnecessary consumes extra bandwidth to mitigate the effect of ISI caused due to multipath channel. When tone and impulse interference is added to TDM and OFDM all the data are lost. But by introducing wavelet transform based modulation these interference can be separable [9-18].

2. OFDM SYSTEM DESIGN

OFDM system is an efficient model for multipath propagation. Data can be taken from multiple stations and combined to a multiplexed single stream for transmission in OFDM system. All the subcarriers are synchronized to each other in such a way that the interference can be controlled carefully. The orthogonal packing redness the guard band and improves spectral efficiency. There are many methods to make the subcarriers orthogonal and to prevent the interference among each other. The basic block diagram is shown in Fig. 1.

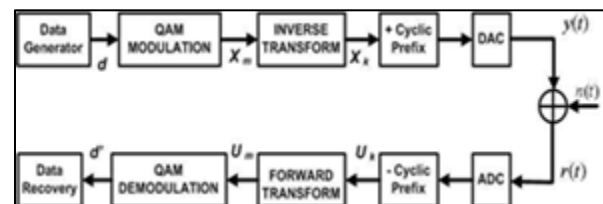


Fig-1. Block diagram of OFDM system using FFT

In this case, a cyclic prefix has been appended for the transformed output (X_k). To eliminate the effect of ISI cyclic prefix is provided before transmission. In the given OFDM symbol 25% of cyclic prefix is provided in the last part [3-9]. The AWGN has to be provided with a suitable power input for data transmission. The original signal is fetched at the receiver using the reverse operation. To recover the data we need to extract the cyclic prefix and process it using FFT. The frequency domain representation obtained from the FFT is provided below.

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The OFDM transmitter output signal can be represented by:

$$S(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j(2\pi kn/N)} \quad (1)$$

$$= \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j(2\pi f_k t_n)} , n = 0,1,2, \dots N - 1, \quad (2)$$

Frequencies $f_k = k/N\Delta t$ have to be maintained orthogonality condition., $t_n = n\Delta t$ and Δt denotes symbol duration corresponding to the serial data sequence X_k where N denotes number of subcarrier and $1/\sqrt{N}$ is the scaling factor. IFFT is used to convert the frequency domain signal into its time domain at the transmitter and the reverse operation take place at the receiver using FFT. Many works have been done using orthogonal frequency division multiplexing [2-19], but this requires sharp filtering and is not spectrally efficient. The sub carriers when closely placed, bandwidth can be efficiently utilized and at the same time they can be recovered properly.

3. MODEL DESIGN FOR MULTI CARRIER MODULATION USING WAVELET PACKET TRANSFORM

Use of wavelet packet transform in wireless communication has many advantages such as [13-20]:

- i) If can create different subcarriers of different symbol length and bandwidth for better communication.
- ii) If can arrange the time-frequency components in such a way that minimizes the channel interferences and disturbances.
- iii) Signal diversity can be exploited in mobile communication system without inter cellular interference, ISI and ICI.
- iv) Because if its compress in activity, less power can be consumed for transmission.

In Figure.2, data d_k is converted in to symbols X_{mi} with the help of 16-QAM at the transmitter. The serial representation X_{mi} has a vector XX for transposing to CA . Further up sampling of the signal is carried out. The approximation coefficients are obtained from up sampled LPF signal. The detailed coefficients are obtained from HPF and are used as wavelet coefficients in this work. The detailed coefficients are fed to the IDWT. This work utilized the Haar wavelet family for the proposed simulation which has provided better results than OFDM using FFT. To recover the original signal, DWT& 16-QAM demodulation is carried out at the receiver.

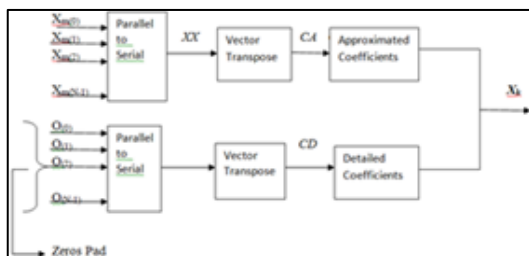


Figure. 2: Transmitter of the Proposed Model

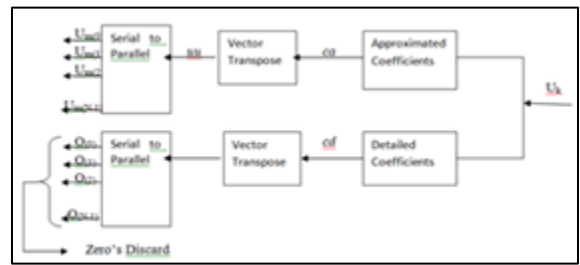


Figure. 3: Receiver of the Proposed Model

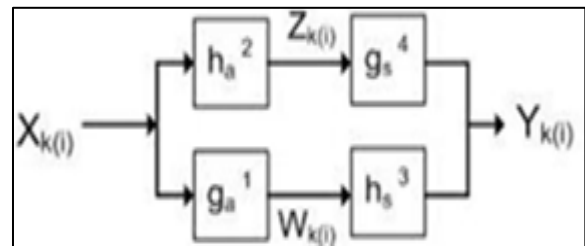


Figure. 4: A simple two-fold filter bank Model

The filter bank model can reconstruct the signal perfectly and the steps are given below. The condition for reconstruction is that the expected output is to be equal with the input signal [15-21]. With the delay element insertion the input is modified as $Y_k(i) = X_k(i-n)$ where n can be considered as 1 for simple task. Further the following steps are given for the algorithm to perform the mathematical operation:

Selection of the coefficients for f_i will lead to $f_i = \{j, j\}$.

The reversal of f_i with every other value negated and given as, $r_i = \{j, -j\}$.

r_s is considered as reversal of f_i as $r_s = \{j, j\}$ and vice versa.

At the time of input with delay considered and are applied to r_i and f_i . The outputs are

$$X_k(a) = j(Y_k(a) - i(Y_k(a-1))) \quad (4)$$

$$D_k(a) = i(Y_k(a) + j(Y_k(a-1))) \quad (5)$$

Similarly, considering that $x_k(a)$ and $D_k(a)$ are delayed by 1, then i can be replaced by $(a-1)$ as follows

$$X_k(a-1) = i(Y_k(a-1) + j(Y_k(a-2))) \quad (6)$$

$$D_k(a-1) = j(Y_k(a-1) - i(Y_k(a-2))) \quad (7)$$

The output $O_k(a)$ can be written as

$$O_k(a) = f_s X_k(a) + r_s D_k(a) \quad (8)$$

or,

$$O_k(a) = -iX_k(a) + jX_k(a-1) + jD_k(a) + iD_k(a-1) \quad (9)$$

4. RESULTS AND DISCUSSION

In the first phase, the comparison among three different channels for OFDM are shown in figure 5. Further the proposed wavelet packet transform base for multi carrier model with modulation with Rayleigh channel is shown in figure 6. The model is verified for BPSK, QPSK and QAM modulation and the performance is shown for 16-QAM.

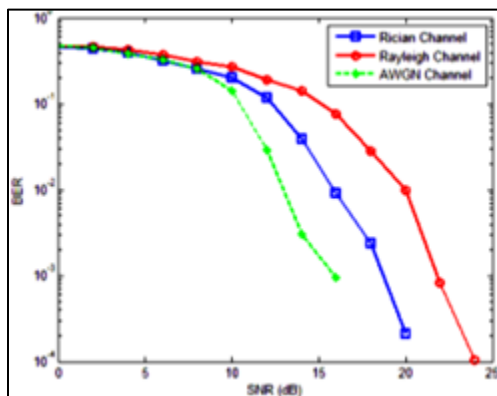


Fig-5. BER Comparison for different OFDM Channels

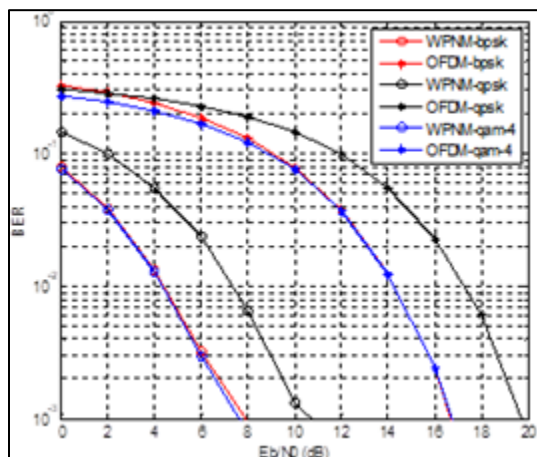


Fig-6. BER Comparison between WPT and FFT based OFDM Model

5. CONCLUSIONS

This is the investigation of the proposed model for multi carrier modulation with OFDM. The comparison of OFDM and WPTMCM system has been investigated using different types of modulation techniques such as BPSK, QPSK, 16-QAM over Rayleigh channel etc. From the result, it has been observed that the QAM modulation provides better result as compared to BPSK and QPSK modulation. For different type of channels may be investigated along with the use of various wavelets. This has been given for future scope.

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