BIT ERROR RATE PERFORMANCE OF OFDM-QAM MODULATION AND WHT OFDM-QAM MODULATION USING RAYLEIGH AND RICIAN CHANNEL

Suraj A. Shete\textsuperscript{1}, Prashant M Jadhav\textsuperscript{2}, Rahul P Tivarekar\textsuperscript{3}, Bhakti Y. Sathe\textsuperscript{4}

\textsuperscript{1,3,4}Assistant Professor, FAMT Ratnagiri
\textsuperscript{2}Assistant Professor, DKTE’s TEI Ichalakaranji

Abstract—Multi-carrier transmission schemes like MC-CDMA and OFDM communication overcome many issues appear in Single carrier communication systems. Due to these reasons multi-carrier communication systems becomes more popular in today’s life. In addition, multi-carrier communication systems frequently used in 4G, 5G technologies. Therefore, OFDM plays a vital role in our day-to-day life. OFDM used in both wired as well as wireless communication. However, in OFDM transmission, problem of Bit Error Rate (BER) is increases. Therefore, in this paper, we proposed WHT OFDM that reduces BER of entire transmission. Here we compare results with conventional OFDM and WHT OFDM.

Keywords – BER, MC-CDMA, OFDM, PAPR.

I. INTRODUCTION

In communication, we transfer information from one end to other end. With the evolution, communication plays a vital role in our day-to-day life. Communication is carried out using wired as well as wireless medium. Initially Single carrier communication systems in which only one carrier is used for transmission purpose. Nevertheless, for high speed and more data transmission purpose single carrier system fails. Multi carrier communication technique reduces the drawbacks of Single carrier communication. In multi-carrier communication, data is transfer through multiple carriers. There are mainly two multi carrier communication techniques popularly used are Multi Carrier-Code Division Multiple Access (MC-CDMA) and Orthogonal Frequency Division Multiplexing (OFDM). In OFDM, all sub-carriers placed in orthogonal manner. In Conventional OFDM, Bit Error Rate (BER) during transmission increases due to orthogonal and multiple carriers. The basic principle of OFDM system is-The whole input signal is split into orthogonally placed sub-carriers and these subcarriers are used to carry the data from the transmitter to the receiver. OFDM have large amplitude variations and due to this large variations peak power of signal increases which makes Peak to Average Power Ratio (PAPR) as well as Bit Error Rate(BER) increases. With increase in high peaks usually drive the power amplifier into saturation, clipping of the transmitted signal, reduces transmission efficiency. Therefore, for flexible transmission, PAPR and BER should be low.

There are different techniques such as Signal distortion techniques, Probabilistic techniques and pre-coding techniques. Pre-coding techniques shows better results as compared to other techniques, so in this paper we represent WHT pre-coding method which is more efficient way because in this method no bandwidth expansion, no power increase, no data rate loss occurs.

II. OFDM AND BER

The principle of OFDM transmission is- huge number of orthogonal, closely spaced, overlapping narrow-band sub-carriers are transmitted in parallel manner. A high data rate stream (input stream) is split into a number of lower rate data streams and these lower rate data streams are transmitted
simultaneously over a number of sub-carriers. The available transmission bandwidth is divided in equal proportion with the help of sub-carriers. The separation of the sub-carriers is carried out such that there is very compact spectral utilization of available bandwidth and each sub-carrier being modulated at a low bit rate. With the help of conventional modulation scheme such as Quadrature Phase Shift Keying (QPSK), Binary Phase Shift Keying (BPSK) and Quadrature Amplitude Modulation (QAM) each sub-carrier is modulated. The advantage of OFDM system is - symbol duration increases, the amount of dispersion in time caused due to multipath delay is reduced, large data transmission at same time. Thus OFDM is one of the popular technology for wideband digital communication. OFDM technology is used in many applications like ADSL, Li-FI, 4G technology, power-line network, wireless networks, DVB, DAB etc. Due to the Presence of guard band in single carrier system problem of ISI introduces. In OFDM noise is minimized by larger number of sub-carriers. OFDM signal sends many low speed transmissions simultaneously and hence it avoids the problem of Inter Symbol Interference (ISI).

**Figure1 : Conventional OFDM System**

In digital transmission, Bit Error Rate (BER) is defined as percentage of bits with errors divided by the total number of bits that have been transmitted. BER is usually expressed as ten to a negative power. For example, a transmission might have a BER of 10 to the minus 6, meaning that, out of 1,000,000 bits transmitted, one bit was in error.

\[
\text{Bit Error Rate} = \frac{\text{Number of Errors}}{\text{Total Number of Bits sent}}
\]

**III. RELATED WORK**

As BER increases overall performance of OFDM decreases. So we required to reduce BER. There are different BER reduction techniques like - Signal distortion techniques, Probabilistic techniques and pre-coding techniques. Pre-coding techniques shows better results as compared to other techniques, so in this paper we represent WHT pre-coding method which is more efficient way because in this method no bandwidth expansion, no power increase, no data rate loss occurs.

Proposed Block Diagram for WHT BER reduction is shown in figure 2.
Walsh Hadamard Transform (WHT)

The Walsh Hadamard Transform (WHT) is an orthogonal, non-sinusoidal, linear transform. WHT performs linear, orthogonal operations on input signal. WHT maps a signal into set of basic functions. These functions are Walsh functions, which are square waves in the nature with values of +1 or -1. The proposed hadamard transform scheme may reduce the occurrence of the high peaks as compared to the original OFDM system. The kernel of the WHT acts as a pre-coding matrix \( P \) of dimension \( N=L^2 \)

WHT reduces the autocorrelation of the input sequence and this autocorrelation reduce the PAPR problem and it doesn’t require any side information. The kernel of WHT can be written as -

\[
H_1 = [1] \quad \text{.................... (2)}
\]

\[
H_2 = \frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \quad \text{.................... (3)}
\]

The proposed work is carried out in following manner-

The PAPR of OFDM with WHT Pre-coding technique has been evaluated by simulation. To show analysis of the proposed system, the data is generated randomly then the signal can be modulated by QPSK, BPSK and QAM respectively. Here we will modulate the signal using QAM only. The block implementation of WHT method is shown in Fig. 2. Here the pre-coding matrix transform represents proposed Walsh Hadamard Transform (WHT). The performance of the WHT method for PAPR reduction scheme will be evaluated using the complementary cumulative distribution (CCDF) function of the PAPR of the OFDM signal. The CCDF (p) of the PAPR for WHT is recorded. We will compare the simulation results of proposed systems with conventional OFDM method.

IV. RESULTS

We compared result of BER output of both i.e. Conventional OFDM and WHT applied OFDM. Following table shows the reduced BER in WHT OFDM.
1. **Rayleigh Channel**

| Modulation Technique | Data Points | BER of Conventional OFDM | WHT BER |
|----------------------|-------------|---------------------------|---------|
| QAM                  | 64          | 25                        | 13      |
|                      | 128         | 40                        | 27      |
|                      | 256         | 65                        | 37      |

2. **Rician channel**

| Modulation Technique | Data Points | BER of Conventional OFDM | WHT BER |
|----------------------|-------------|---------------------------|---------|
| QAM                  | 64          | 30                        | 16      |
|                      | 128         | 43                        | 31      |
|                      | 256         | 70                        | 41      |

**V. CONCLUSION**

In this paper, we calculate BER of OFDM signal by using conventional OFDM and WHT OFDM. From the obtained value, we conclude that WHT OFDM have less number of errors as compared to conventional OFDM. Also this technique is pre-coding so there is no data loss, no bandwidth expansion. Rayleigh channel shows better result as compared to Rician channel.

We can expand this research by using Double WHT method i.e. we can use WHT matrix two times at transmitter and receiver.

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