PAPR REDUCTION IN OFDM SYSTEMS USING PRECODING TECHNIQUES

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Abstract : OFDM plays a major role in communication. But there are some disadvantages involved in the process which disturbs the performance of OFDM system. High PAPR is the main drawback in any OFDM system. There are many ways to decrease PAPR in OFDM systems. In this paper, we discussed some of the precoding techniques like Discrete Cosine Transform, Discrete Fourier Transform, Discrete Hartley Transform, Walsh Hadamard Transform. We simulated and compared results of PAPR values of above mentioned Precoding techniques using MATLAB tool.

***IndexTerms* – OFDM, PAPR, Precoding Techniques.**

I. INTRODUCTION

OFDM modulation is a popular wireless and wired communication transmission method. It is multi carrier modulation method with a large bandwidth and less power consumption. As a result, it has become a popular technique for high speed communications. One of OFDM's primary disadvantage is the high PAPR of the transmitted signals. If PAPR value is high, the linear properties of the amplifier are lost and data retrieval by the receiver maybe unsuccessful. The PAPR in OFDM systems is always random. The difficulty originates from the modulation process itself since several combined together to produce the OFDM signal to be broadcast, and the subcarriers may not have the same peak strengths. Because of the range limitation over which the transmitter amplifier functions linearly, OFDM systems are often constrained to a low peak power.

OFDM is a kind of modulation that uses a number of closely spaced carriers called subcarriers that are orthogonal to each other, i.e. all other carriers are nulls during the peak of a carrier. Sidebands are distributed when modulated data is allocated to a subcarrier. A receiver must receive the complete signal, including the sidebands, in order to effectively demodulate the data. As a result, the signals must be separated enough. Fig-1 shows the block diagram of OFDM system.

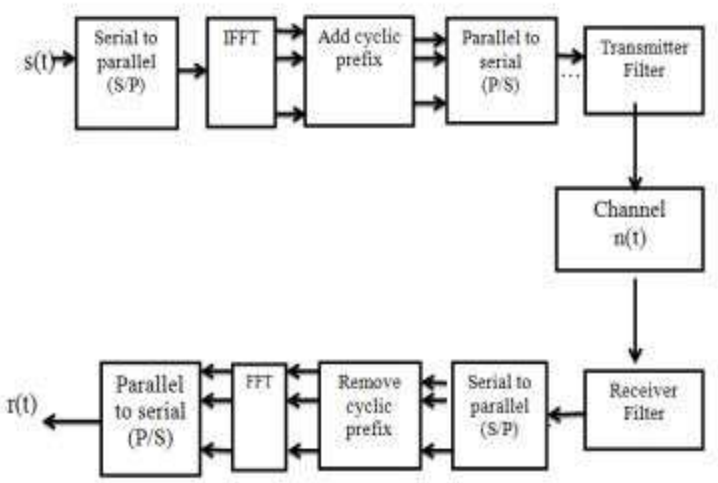

Fig-1: Block Diagram of OFDM System

1.1 OFDM Systems

OFDM is based on the idea that all subcarriers are in orthogonal to one another. The subcarriers in OFDM are represented by exponential signals at in the OFDM signal, where sampling period is 0, the discrete samples of these signals with sampling instances at are said to be orthogonal, implying that the system is both orthogonal and orthonormal. The orthogonality criterion mentioned above is required for OFDM to reduce inter-carrier interference (ICI) The guard interval must be inserted between two continuous symbols in order to reduce it. The cyclic extension of OFDM signals using Cyclic Prefix is one approach to add guard interval. The OFDM symbols are extended by Cyclic Prefix by adding the symbol's last samples to the front. The mathematical equation of OFDM is given by

$$X(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi n \Delta f t} \qquad 0 \le t \le NT \qquad (1)$$

Where, NT is the duration of the OFDM data block X, N is the number of sub carriers present. The term orthogonality can be defined as the presence of data at the peak of a sub-carrier while other sub-carriers are pointing to zero.

II. LITERATURE REVIEW

There are various methods described in various papers such as Amplitude Clipping and Filtering, Selective Mapping Technique, Signal Distortion Technique, Peak Windowing, Peak Cancelling and Companding. Each of the above mentioned methods have their own drawbacks like high computational complexity, degradation in BER performance, high average power, requirement of additional transmit power or Bandwidth expansion. some of them are less effective than the precoding techniques.

To avoid these, we have worked on precoding techniques which have limited drawbacks compared to above mentioned techniques and also have high efficiency. Precoding techniques are new evolving techniques which are implemented in 4G and 5G technologies which results in less complexity, and high BER performance of OFDM systems.

2.1 PAPR

PAPR stands for Peak to average power ratio. Having less PAPR, in a system results in low signal to noise ratio and less distortions. It can improve the performance of the system.

$$\text{PAPR}_{db} = 10\log\left(\frac{abs(x[n])\wedge 2}{mean(x[n]\wedge 2)}\right) \quad \textbf{(2)}$$

The PAPR value can be calculated in decibels using Eq-2. In above equation abs can be defined as the absolute value of the signal x(n) which implies the peak power of the OFDM signal, whereas mean is defined as the average power of OFDM signal.

III. METHODOLOGY

In this method, we insert cyclic prefix to serve as a guard interval between two continuous symbols such that there will be no intersymbol interference. Adding cyclic prefix cannot decrease PAPR to a large extent. So we perform precoding techniques on OFDM signals which has cyclic prefix.

3.1 Algorithm

1) The data input which is to be transmitted will be generated randomly, so each time we simulate we get different PAPR value.
2) To the input data, perform quadrature amplitude modulation technique.
3) The data stream obtained which is in serial form, this is to be converted into parallel data block filled column wise. This depends upon the presence of number of sub carriers which implies the number of sub carriers must be equal to number of rows.
4) For every column of the data, we should perform distributed sub carrier mapping in such a way that, the data bits will be assigning to sub carriers.
5) Now we perform IFFT on the above sub carriers which leads us generating an OFDM signal.
6) The cyclic prefix should be added to the OFDM symbols obtained.
7) The above mentioned algorithm should be repeated for each other column of input data block.
8) Thus we get OFDM symbols and by combining all these OFDM symbols, the OFDM signal is obtained.
9) Now the PAPR value can be calculated by finding out the peak and average power values of the OFDM signal.

3.2 Precoding Techniques

3.2.1 Discrete Cosine Transform

1) Apply DCT function to QAM modulated data.
2) Follow step-4 to step-10 as mentioned in above algorithm.

$$X(k) = a(k)\sum_{n=0}^{N-1} x(n)\cos\left(\frac{(2n+1)k\pi}{2N}\right) \quad \text{where } k = 0,1,\ldots., N-1$$
$$a(k) = \begin{cases} \sqrt{\frac{1}{N}} & k=0 \\ \sqrt{\frac{2}{N}} & k=1,\ldots.N-1 \end{cases} \quad \textbf{(3)}$$

where N is number of sub-carriers
Eq-3 represents DCT function.

3.2.2 Discrete Fourier Transform

1) Apply FFT on QAM modulated data.
2) Follow step-4 to step-10 as mentioned in above algorithm.

$$X(k) = \sum_{n=0}^{N-1} x(n)e^{\frac{-j2\pi nk}{N}} \quad \text{where } k = 0,1,\ldots., N-1 \quad \textbf{(4)}$$

Where N is number of sub carriers.
Eq-4 represents DFT function

3.2.3 Walsh Hadamard Transform

1) Reshape the QAM modulated data into columns
2) Apply FWHT on QAM modulated data.
2) Follow step-4 to step-10 as mentioned in above algorithm.

$$H_1 = [1],\ H_2 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix},\ H_{2N} = \frac{1}{\sqrt{2N}}\begin{bmatrix} H_N & H_N \\ H_N & H_N^{-1} \end{bmatrix} \quad \textbf{(5)}$$

Where N represents the matrix corresponding to the nth sub carrier.
H respresents Hadamard Transform
Eq-5 represents WHT matrix

3.2.4 Discrete Hartley Transform

1) Reshape QAM modulated data into columns.
2) Apply DHT on QAM modulated data.
3) Follow step-4 to step-10 as mentioned in above algorithm.

$$X(K) = (1/\sqrt{N}) \sum_{n=0}^{n=N+1} (Sin(\Pi n/N) + Cos(\Pi n/N))(\exp(-2\Pi nK/N) \quad \textbf{(6)}$$

Where N is number of sub carriers.
Where K has values from 0:N+1
Eq-6 represents DHT function

IV SIMULATION RESULTS AND ANALYSIS:

The OFDM signal generated is shown below.

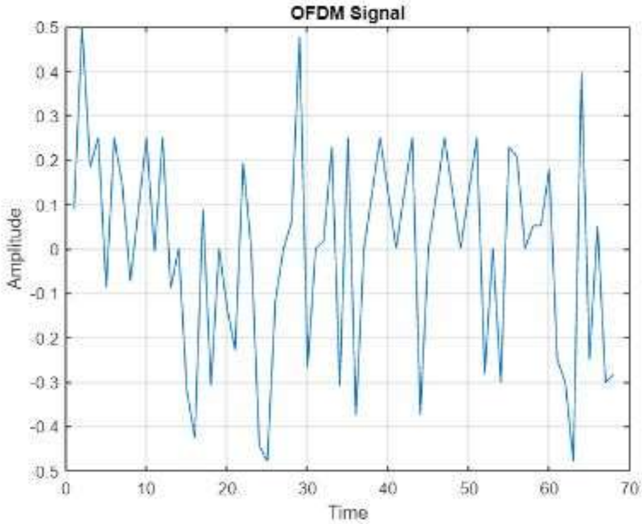

Fig 2: Generated OFDM signal

The PAPR value obtained in the above OFDM signal: 11.9387dB. In general PAPR value of an OFDM signal lies around 12 dB. The CCDF plot for 4 precoding techniques is as shown below.

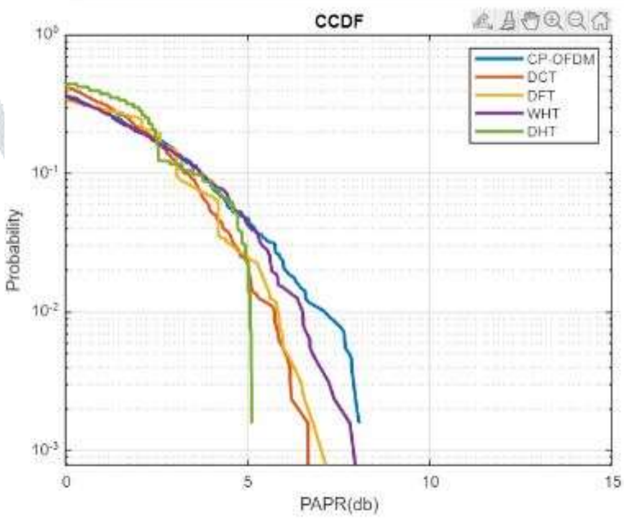

Fig 3: CCDF Plot

CCDF is a plot between Probability and PAPR in dB. X-axis represents PAPR in dB and Y-axis represents Probability.

4.1 Comparison of various Precoding Techniques

Precoding Technique	**PAPR(dB)**
Cyclic Prefix OFDM	8.1091
Discrete Cosine Transform	7.7786
Discrete Fourier Transform	7.9137
Walsh Hadamard Transform	9.0848
Discrete Hartley Transform	8.1058

Table 1: Comparitive results of different precoding techniques

Based on our analysis, we found that Discrete Cosine Transform is more efficient in decreasing the PAPR value when compared with other precoding techniques.

V CONCLUSION:

In this paper, we have compared different PAPR techniques and found out Discrete Cosine Transform is best among them. The PAPR value of the OFDM signal obtained is 11.9387dB. In the DCT we have got PAPR around 7.7786 dB, which indicates that PAPR has reduced more than 4dB which results in less complexity of the system and high BER performance which implies there is no data loss when the signal is received at the receiver end. This helps in OFDM systems to perform better in 5G Technologies.

REFERENCES

[1] M. Jamal, M. Tarik, Alexander Isar, “Precoding techniques in OFDM systems for PAPR reduction”, 16th IEEE Mediterranean Electrotechnical Conference, 2012.

[2] Baig and V. Jeoti, "PAPR Reduction in OFDM Systems : Zadoff-Chu Matrix Transform Based Pre/Post-Coding Techniques", IEEE Second Conference on Computational Intelligence, Communication Systems and Networks, pp505-510, Pahang, June 2010.

[3] Yasir Rahmatallah and Seshadri Mohan, “Peak-To-Average Power Ratio Reduction in OFDM Systems: A Survey And Taxonomy”, IEEE Communications Surveys & Tutorials, Vol. 15, No. 4, Fourth Quarter 2013.

[4]T. Jiang and G. Zhu, “Nonlinear companding transform for reducingpeak-to-average power ratio of OFDM signals,” IEEE Trans. Broadcast.,vol. 50, no. 3, pp. 342–346, Sep. 2004.

[5]X. Li and L. J. Cimini, Jr., “Effect of Clipping and Filtering on the Performance of OFDM,” IEEE Commun. Lett., vol. 2, no.5, May 1998, pp. 131–33.

[6] V. Sudha and Dr. D. Sriram Kumar, “PAPR Reduction of OFDM System using PTSmethod with different Modulation Techniques”, 2014 International Conference on Electronics and Communication System (lCECS -2014).

[7] Hem Dutt Joshi and Rajiv Saxena, “PAPR reduction in OFDM systems using precoding with clipping”, 2011 International Conference on Communications, Computing and Control Applications (CCCA)