ISSN- 2394-5125 Vol 6, Issue 6, 2019

PAPR Reduction in OFDM using DHT and WHT

Kancheti Spandana[1], Beril Susan Philipi[2]
Assistant Professor[1,2]
Department of ECE
MREC

Abstract- High Peak to Average Power Ratio (PAPR) is one of the major drawbacks in Orthogonal Frequency Division Multiplexing (OFDM). The High PAPR increases the complexity of Analogue to Digital (A/D) and Digital to Analogue (D/A) convertors and also reduces the efficiency of RF High Power Amplifier (HPA). In this paper we present an analysis of Discrete Hartley Transform (DHT) pre coded OFDM system using M-QAM (where M=16, 32, 64, 256). We compare the computer simulation results of DHT pre-coded OFDM system with DFT pre coded OFDM system, Walsh Hadamard Transform (WHT) pre coded OFDM system, Selected Mapping (SLM) based OFDM system and OFDM conventional. Simulation results show that the PAPR of DHT pre-coded OFDM system is lower than WHT pre-coded OFDM system, SLM-OFDM system and OFDM conventional. We also concluded in this paper that DFT pre-coded OFDM system has zero PAPR.

Index Terms- OFDM, PAPR, DHT, DFT, WHT

I. Introduction

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier transmission scheme that has become the technology of choice for next generation wireless and wireline digital communication systems because of its high speed data rates, high spectral efficiency, high quality service and robustness against narrow band interference and frequency selective fading [1]. OFDM thwarts Inter Symbol Interference (ISI) by inserting a Guard Interval (GI) using a Cyclic Prefix (CP) and moderates the frequency selectivity of the Multi Path (MP) channel with a simple equalizer. This leads to cheap hardware implementation and makes simpler the design of the receiver. OFDM is widely adopted in various communication standards like Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), Digital Subscriber Lines (xDSL), WirelessLocal Area Networks (WLAN), Wireless Metropolitan Area Networks (WMAN), and Wireless Personal Area Networks (WPAN) and even in the beyond 3G Wide Area Networks (WAN) etc. Additionally, OFDM is a strong candidate for Wireless Asynchronous Transfer Mode (WATM).However, among others, the Peak to Average Power Ratio(PAPR) is still one of the major drawbacks in the transmitted OFDM signal [2]. Therefore, for zero distortion of the

OFDM signal, the HPA must not only operate in its linear region but also with sufficient back-off. Thus, the RF High Power Amplifier (HPA) with a large dynamic range are required for OFDM system. These amplifiers are very expensive and are major cost component of the OFDM system. Thus, if we reduce the PAPR it not only means that we are reducing the cost of OFDM system and reducing the complexity of the Analogue to Digital (A/D) and Digital to Analogue (D/A) convertors, but also increasing the transmit power, thus, for same range improving received Signal to Noise Ratio (SNR), or for the same SNR improving range.

A large number of PAPR reduction techniques have been proposed in the literature. Among them, schemes like constellation shaping [3], coding schemes [4,5], phase optimization [6], nonlinear companding transforms [7],

ISSN- 2394-5125 Vol 6, Issue 6, 2019

Tone Reservation (TR) and Tone Injection (TI) [8,9], clipping and filtering [10], Partial Transmit Sequence (PTS) [11],Precoding based Selected Mapping (PSLM) [12], precoding based techniques [13] and Selected Mapping (SLM) [14] are popular.

II. Literature Survey

In [10] Wang and Tellambura proposed a soft clipping technique which preserves the phase and clips only the amplitude. They also put a lot of effort to characterize the performance and discover someproperties to simplify the job. However, the PAPR gain is only estimated by simulations and is limited to a specific class of modulation technique.

In [11] Han and Lee proposed a PAPR reduction technique based on Partial Transmit Sequence technique in which they divide the frequency bins into sub blocks and then they multiply each sub-block with a constant phase shift. Choosing the appropriate phase shift values reduces PAPR. The most critical part of this technique is to find out the optimal phase value combination and in this regard they also proposed a simplified search method and evaluated the performance of the proposed technique.

In [12] authors developed PSLM technique for PAPR reduction. In this technique Zadoff-Chu based precoder is applied after the multiplication of phase rotation factor and before the IFFT in the SLM-OFDM system. The proposed PSLM technique is signal independent and it does not require any complex optimization technique. In [13] authors proposed Zero PAPR Zadoff-Chu precoder based technique for Single Carrier Frequency Division Multiple Access (SCFDMA).This technique is efficient, signal independent, distortion less, it does not require any optimization algorithm and PAPR is completely eliminated.

III.Proposed Work

The OFDM system splits the high speed data stream into a number of parallel low data rate streams and these low rates data streams are transmitted simultaneously over a number of orthogonal subcarriers.To generate OFDM successfully the relationship between all the carriers must be carefully controlled to maintain the orthogonality of the carriers. For this reason, OFDM is generated by firstly choosing the spectrum required, based on the input data, and modulation scheme used. Each carrier to be produced is assigned some data to transmit. The required amplitude and phase of the carrier is then calculated based on the modulation scheme (typically differential BPSK, QPSK, or QAM).

The required spectrum is then converted back to its time domain signal using an Inverse Fourier Transform. In most applications, an Inverse Fast Fourier Transform (IFFT) is used. The IFFT performs the transformation very efficiently, and provides a simple way of ensuring the carrier signals produced are orthogonal.

The IFFT performs the reverse process, transforming a spectrum (amplitude and phase of each component) into a time domain signal. An IFFT converts a number of complex data points, of length, which is a power of 2, into the time domain signal of the same number of points. Each data point in frequency spectrum used for an FFT or IFFT is called a bin. The orthogonal carriers required for the OFDM signal can be easily generated by setting the amplitude and phase of each bin, then performing the IFFT. Since each bin of an IFFT corresponds to the amplitude and phase of a set of orthogonal sinusoids, the reverse process guarantees that the carriers generated are orthogonal.

ISSN- 2394-5125 Vol 6, Issue 6, 2019

The signal generated is a base band, thus the signal is filtered, then stepped up in frequency before transmitting the signal. OFDM time domain waveforms are chosen such that mutual orthogonality is ensured even though sub-carrier spectra may overlap. Typically QAM or Differential Quadrature Phase Shift Keying (DQPSK) modulation schemes are applied to the individual sub carriers. To prevent ISI, the individual blocks are separated by guard intervals wherein the blocks are periodically extended.

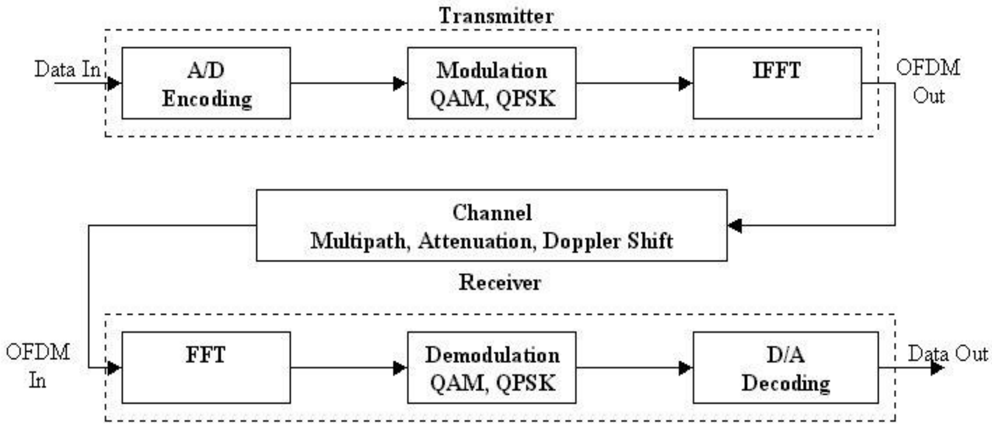


Fig.1.OFDM Block Diagram

Baseband modulated symbols are passed through serial to parallel converter which generates complex vector of size N We can write the complex vector of size N as $X = [X_0, X_1, X_3, \dots\dots\dots..X_{N-1}]^T$

X is then passed through the IFFT block. The complex baseband OFDM signal with N subcarriers can be written as

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k . e^{-2\pi\frac{n}{N}k}$$

Where k=0, 1, 2,…..N-1

Here j=$\sqrt{-1}$

and the PAPR of OFDM signalPAPR=$\frac{\max|x_n|^2}{E[|x_n|^2]}$

where E [.] denotes expectation and the Complementary

Cumulative Distribution Function (CCDF) for an OFDM signal can be written as

P (PAPR >PAPR0) = 1 – $(1 - e^{-PAPR_0})^N$

where PAPR0 is the clipping level. This equation can be read as the probability that the PAPR of a symbol block exceeds some clip level PAPR0.

The Discrete Hartley Transform (DHT) Pre-coding:

The DHT is a linear transform N-point DHT can be defined as

ISSN- 2394-5125 Vol 6, Issue 6, 2019

$$H_k = \sum_{n=0}^{N-1} x_n \left[cos\left(\frac{2\pi nk}{N}\right) + sin\left(\frac{2\pi nk}{N}\right)\right]$$

$$= \sum_{n=0}^{N-1} x(n).\ cas\left(\frac{2\pi nk}{N}\right)$$

Where $cas\,\theta = cos\,\theta + sin\,\theta$ and $k = 0, 1 \ldots N\text{-}1$

$$p_{m,n} = cas\left(\frac{2\pi mn}{N}\right)$$

P is pre-coding matrix of size N×N. m and n are integers from 0 to N-1. The DHT is also invertible transform which allows us to recover the X_n from H_k and inverse can be obtained by simply multiplying DHT of H_k by 1/N.

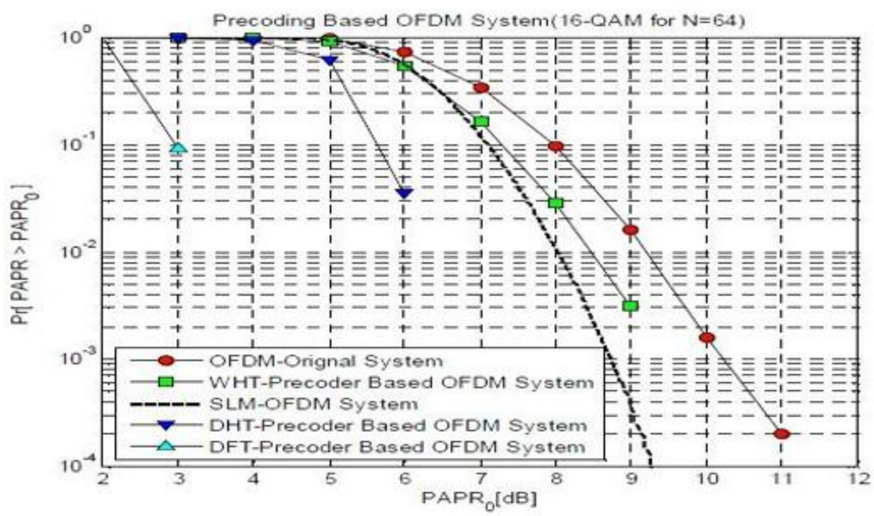
ISSN- 2394-5125 Vol 6, Issue 6, 2019

IV. SIMULATION RESULTS

The randomly generated data is modulated by M-QAM (where M = 16, 32, 64, 256), PAPRAnalysis these modulated symbols aresimulated and plotted in MATLAB. Here wehave compared the performance of the DHTPrecoding with DFT Precoding, WHTPrecoded OFDM, SLM OFDM and with theOriginal OFDM Systems.

Figure 3 shows the performance analysis for M = 16. Which gives that the DHTPrecoding gains 3, 2.4, 1.99 db over OFDMOriginal, WHT-Precoding and SLMPrecodingrespectively. But it lags 3 db gain behind the DFT Precoding.

Figure 3: CCDF Comparison of DHT-Precoder Based OFDM System with DFT-Precoder Based OFDM System, WHT-Precoder Based OFDM System, SLM-OFDM (V = 2) System and OFDM Original System for 16-QAM



ISSN- 2394-5125 Vol 6, Issue 6, 2019

Figure 4: CCDF Comparison of DHT-Precoder Based OFDM System with DFT-Precoder Based OFDM System, WHT-Precoder Based OFDM System, SLM-OFDM (V = 2) System and OFDM Original System for 32-QAM

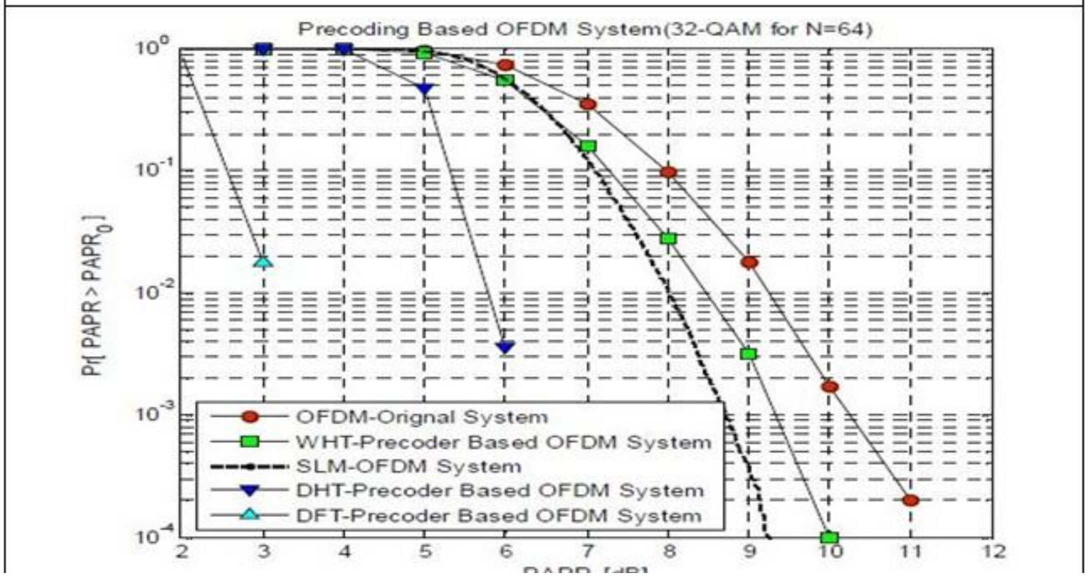
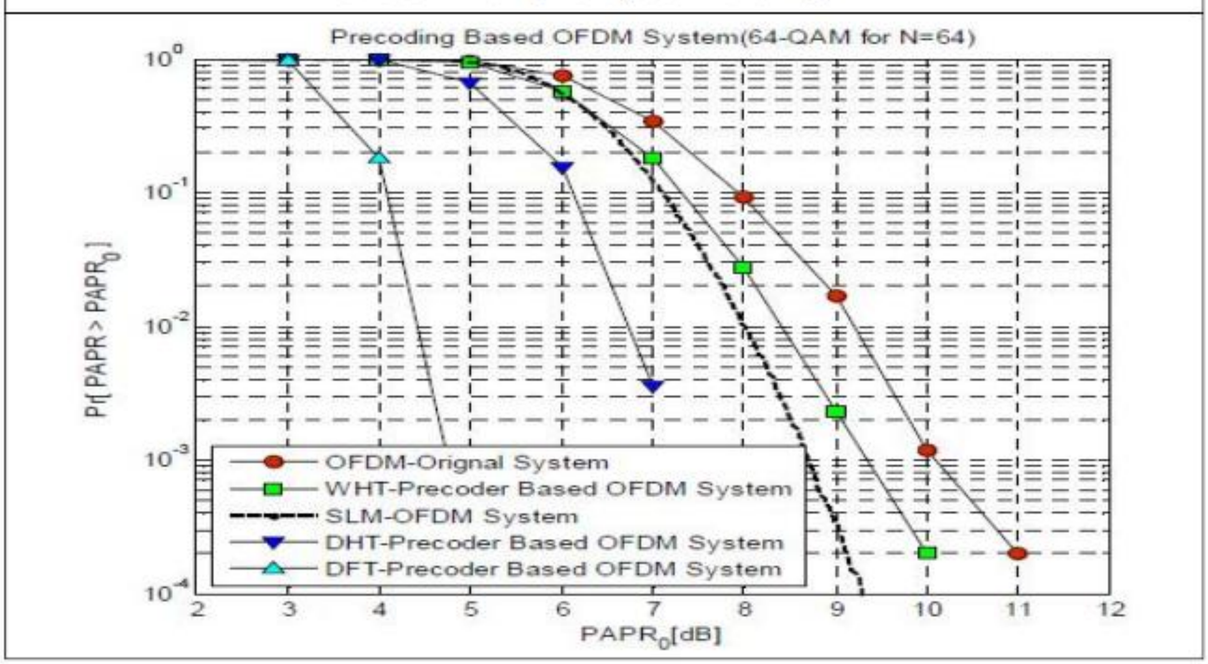


Figure 5: CCDF Comparison of DHT-Precoder Based OFDM System with DFT-Precoder Based OFDM System, WHT-Precoder Based OFDM System, SLM-OFDM (V = 2) System and OFDM Original System for 64-QAM



ISSN- 2394-5125 Vol 6, Issue 6, 2019

Figure 6: CCDF Comparison of DHT-Precoder Based OFDM System with DFT-Precoder Based OFDM System, WHT-Precoder Based OFDM System, SLM-OFDM (V = 2) System and OFDM Original System for 256-QAM

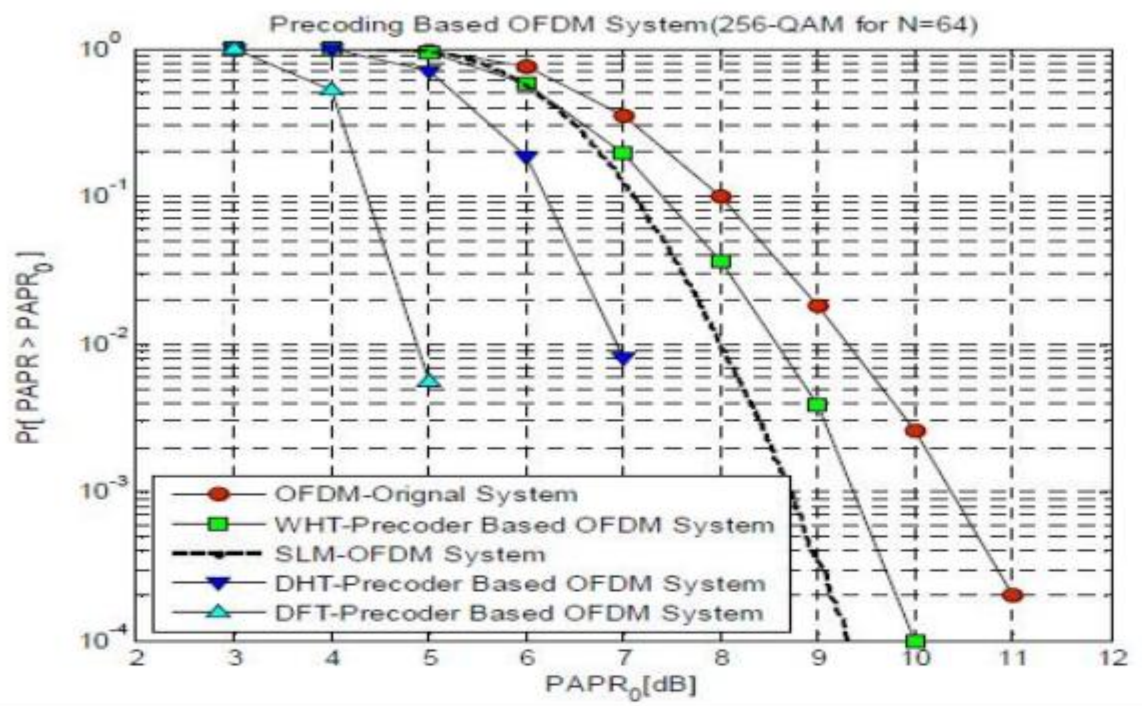


Figure 4 shows the performance analysis for 'M = 32'. Which gives that the DHT Precoding gains 3, 2.4, 1.99 db over OFDMOriginal, WHT-Precoding and SLM Precoding respectively. But it lags 2.5 db gain behind the DFT Precoding.

Figure 5 shows the performance analysis for 'M = 64'. Which gives that the DHT Precoding gains 2.8, 3, 1.0 db over OFDMOriginal, WHT-Precoding and SLM Precoding respectively. But it lags 1.9 db gain behind the DFT Precoding.

Figure 6 shows the performance analysis for M = 256. Which gives that the DHT Precoding gains 2.2, 1.5, 1.7 db over OFDMOriginal, WHT-Precoding and SLM Precodingrespectively. But it lags 1 db gain behind theDFT Precoding.

V. CONCLUSION

In this paper, we have analyzed the PAPRof DHT-Pre-coded OFDM system for MQAM (where M = 16, 32, 64, 256). MATLABsimulation shows that DHT-Pre-codedOFDM System shows better PAPR gain as compared to Conventional OFDM-Original system, WHT-Pre-coder Based OFDMsystem and SLMOFDM (with V = 2) systemrespectively. The DHT-Pre-coded OFDMsystem does not require any power increase, complex optimization and sideinformation to be sent for the receiver. It requires simple circuitry as there is nocomplex operations.

References

1. Ben Slimane S (2007), "Reducing the Peak-to-Average Power Ratio of OFDM Signals Through Pre-coding", IEEE Trans. Vehicular Technology, Vol. 56, No. 2, pp. 686-695.
2. Hee Han S and Hong Lee J (2004), "PAPR Reduction of OFDM Signals Using a Reduced Complexity PTS Technique", Signal Processing Letters, IEEE, Vol. 11, No. 11, pp. 887-890.
3. Homayoun Nikookar and Sverre Lidsheim K (2002), "Random Phase Updating Algorithm for OFDM Transmission with Low PAPR", IEEE Trans. Broadcasting, Vol. 48, No. 2, pp. 123-128.
4. Luqing Wang and Chintha Tellambura (2005), "A Simplified Clipping and Filtering Technique for PAR Reduction in OFDM Systems", Signal Processing Letters, IEEE, Vol. 12, No. 6, pp. 453-456.Ramjee Prasad (2004), "OFDM for Wireless Communications", pp. 11-13, Universal Personal Communications Series.
5. Tellado-Mourelo J (1999), "Peak to Average Power Ratio Reduction for Multicarrier Modulation", Ph.D. Thesis, University of Stanford.
6. van Nee R and de Wild A (1998), "Reducing the Peak-to-Average Power Ratio of OFDM", VTC98.48th IEEE, Vol. 3, May 18-21, pp. 2072-2076.
7. Varun Jeoti and Imran Baig (2009), "A Novel Zadoff-Chu Pre-coder Based SLM Technique for PAPR Reduction in OFDM Systems", Invited Paper, Proceedings of 2009 IEEE International Conference on Antennas, Propagation and Systems (IAS), December 3-5, Johor, Malaysia.
8. R.van Nee and A. de Wild, "Reducing the Peak- To-Average Power\ Ratio of OFDM", Vehicular Technology Conference, 1998. VTC98. 48th IEEE, Volume.3, 18-21 May 1998, pages: 2072- 2076.
9. Yajun Kou, Wu-Sheng Lu and Andreas Antoniou, "A new peak-toaverage power-ratio reduction algorithm for OFDM systems via constellation extension", IEEE Trans. Wireless Communications, vol. 6, no. 5, pp. 1823–1832, May 2007.