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A new scheme to reduce PAPR of the OFDM system combining Hann Peak Windowing and Single Pooling method

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ABSTRACT: *Wireless communication is the fastest increasing industry. In such enabling technologies Orthogonal Frequency Division Multiplexing (OFDM) is more effective and significant for both wired and wireless communication systems in the present and future. It has a lot of advantages. But some common problems such as channel noise, Doppler shift frequency effects, peak to average power ratio (PAPR), channel detection, time synchronization error, and phase error limit the performance of the OFDM system. Among them, the time domain OFDM signal which is the sum of several sinusoids leads a high peak to average power ratio (PAPR) is one of the major disadvantages of OFDM system. In this thesis, we study the PAPR problem of the OFDM system. There are many conventional techniques to reduce the PAPR problem. The techniques which were studied through this thesis are Simple Clipping, Hann Peak Windowing, Kaiser Peak Windowing, Hadamard Transform, Single Pooling method and combining method of Hadamard Transform and Single Pooling method. We have been able to realize these techniques comparative performance for bit error rate and PAPR problem. Besides, a new scheme is combining of Hann Peak Windowing and Single Pooling method technique, which is more effective to reduce the PAPR problem in an OFDM system, which is being proposed in this thesis. Implementing those technique effects is using simulation software MATLAB 2010 and the performances were analyzed with this platform.*

Key Words: *BER, Clipping, Hann, Hadamard, OFDM, PAPR, Single Pooling.*

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I. INTRODUCTION

Communication is one of the main important aspects of human life. Wireless communication brings a global changeto this aspect. Now, it is very much required to improve the performances of the existing modulation techniques using in telecommunication, since wireless communications have been playing one of the fastest-growing fields in the past several years [1][2].In this successive way, the Orthogonal Frequency Division Multiplexing (OFDM) is the greatest modulation technique that is used in both broadband wired and wireless communication systems. It has been bringing a global change for 3G and 4G technologies in telecommunication sectors in the world [3].OFDM system brings many advantages but it is not free from disadvantages too. Peak-to-average power ratio (PAPR) is one of the major problems of the OFDM system. Though it is a great problem, there are many useful techniques for reducing PAPR. Those techniques are mainly divided into two segments. One is the Signal Scrambling technique and another is the Signal Distortion technique. All the coding and simulation methods are included in the Signal Scrambling technique and all the clipping and windowing methods are included in the Signal Distortion technique[4].Signal Scrambling technique shows a better performance than the Signal Distortion technique. Signal Scrambling technique has some advantages too. The most attractive feature of this technique is, this does not cause any distortion of the OFDM signal. But when the number of symbols increasing, then the complexity of the system will be increasing[5].

Orthogonal frequency division multiplexing (OFDM) is a modulation technique that is now used in most new and emerging broadband wired and wireless communication systems because it is an effective solution to inter-symbol interference caused by a dispersive channel [6].The first proposal to use orthogonal frequencies for transmission appears in a 1966 patent by Chang of Bell Labs [7].The proposal to generate the orthogonal signals using an FFT came in 1969 [8].The cyclic prefix (CP), which is an important aspect of almost all practical OFDM implementations, was proposed in 1980 [9].The breakthrough papers by Telatar and Foschini on multiple antenna systems fuelled another wave of research in OFDM [10][11].OFDM began to be considered for practical wireless applications in the mid–the 1980s. Cimini of Bell Labs published a paper on OFDM for mobile communications in 1985 [12],while in 1987, Lassalle and Alard, based in France considered the use of OFDM for radio broadcasting and noted the importance of combining forward error correction (FEC) with OFDM. With the rapid enlargement of digital communication in recent years, the need for high-speed data transmission has increased. Multicarrier communication systems "were first conceived and implemented in the 1960s[13] [14]. Since many communication systems being developed use OFDM, it is a worthwhile research topic. Some examples of current applications using OFDM include GSTN (General Switched Telephone Network), Cellular radio, DSL & ADSL modems, DAB (Digital Audio Broadcasting) radio, DVB-T (Terrestrial Digital Video Broadcasting), HDTV broadcasting, HYPERLAN/2 (High-Performance Local Area Network standard), and the wireless networking standard IEEE 802.11 [15][16].

One problem of multipath is that the FM radios while driving in a city: the signal is cut by noise when moving.Generally, we speak of a frequency selective channel. That's why the channel is also time-varying. Equalization aims to compensate for the problems introduced by frequency selectivity [17].Another effect that affects digital transmission is that the signal coming from different paths has different time delays depending on the length of the path. A consequence of that is the memory of channel which causes interference between symbols received (ISI). The cause of strong Intersymbol Interference (ISI) and equalization is needed to correct that problem [18].A major advantage of OFDM is that it transfers the complexity of transmitters and receivers from the analog to the digital domain. While many details of OFDM systems are very complex, the basic concept of OFDM is quite simple [19] [20].

In this thesis paper, we have to able to describe some useful methods for reducing PAPR in the OFDM system.The objective of this thesis is to study of the OFDM system, the study of one of the major problem PAPR of an OFDM system, some methods for reducing PAPR of OFDM system, comparative discussion of those PAPR reduction techniques and find out better one, identifying various limitations and problems with the aspects of those methods and proposing a new scheme for reducing PAPR.we have considered the transmitter and receiver section of OFDM system. For reducing PAPR we consider Hadamard transform, some clipping method and some windowing method. For the focus on our objectives, we may consider the following facts:

- To study different types of modulation techniques.
- To study of PAPR problem of the OFDM system.
- To study different methods of reducing the PAPR problem.
- To reduce PAPR efficiently.
- Simulation and solution for high PAPR problem.

A comparative analysis is used to reduce the PAPR problem in both the Matlab2010 code and the simulation method in our respective analyses. We will use different types of PAPR reduction technics. Simple Clipping, Hann Windowing, Kaiser Windowing, Hadamard Transform, Single Pooling method and combining the method with Hadamard Transform and Single Pooling will be used as PAPR reduction technique and we will give a proposal, which is our New Scheme PAPR reduction method in this thesis. We also try to establish it as the best PAPR reduction model in this thesis. Mathematical analysis and extensive computer simulations can be used to evaluate our proposed algorithm. We may think the respective results with an evolutionary development of reducing PAPR. It might be possible to expect an overall success in the respective field.

II. MATERIALS AND METHODS

2.1 Mathematical Formulation of PAPR

The measurement of a waveform, calculated from the peak power of the waveform divided by the average power of the waveform is called crest factor or a peak-to-average ratio (PAR) or peak-to-average power ratio (PAPR). If we consider a complex signalx(t),

The peak to average power ratio for this signal defined as,

$$\text{PAPR} = \frac{\text{The peak or maximum power of the signal } x(t)}{\text{The average or mean power of the signal } x(t)} = \frac{\max[x(t)x*(t)]}{E[x(t)x*(t)]} = \frac{\text{Max}\,[|x(t)|^2]}{E[|x(t)|^2]} \quad (1)$$

Where,

The peak or maximum power of the signal $x(t)$ is= $\max[x(t)x*(t)]$

The average or mean power of the signal $x(t)$is = $E[x(t)x*(t)]$

Corresponding to the conjugate operator = ( )*

In the case of the OFDM system, we can define PAPR as follows,

$$\text{PAPR of OFDM system} = \frac{\text{Max}\left(\text{total signal} * \text{signa l}'\text{s conjugate}\right)}{\text{Avg}\left(\text{total signal} * \text{signa l}'\text{s conjugate}\right)}$$

$$= \frac{\text{Max}\left(\sum_{k=0}^{N-1} a_k e^{j2\pi k\frac{t}{T}} . \sum_{k=0}^{N-1} a_k e^{-j2\pi k\frac{t}{T}}\right)}{\text{Avg}\left(\sum_{k=0}^{N-1} a_k e^{j2\pi k\frac{t}{T}} . \sum_{k=0}^{N-1} a_k e^{-j2\pi k\frac{t}{T}}\right)} \qquad (2)$$

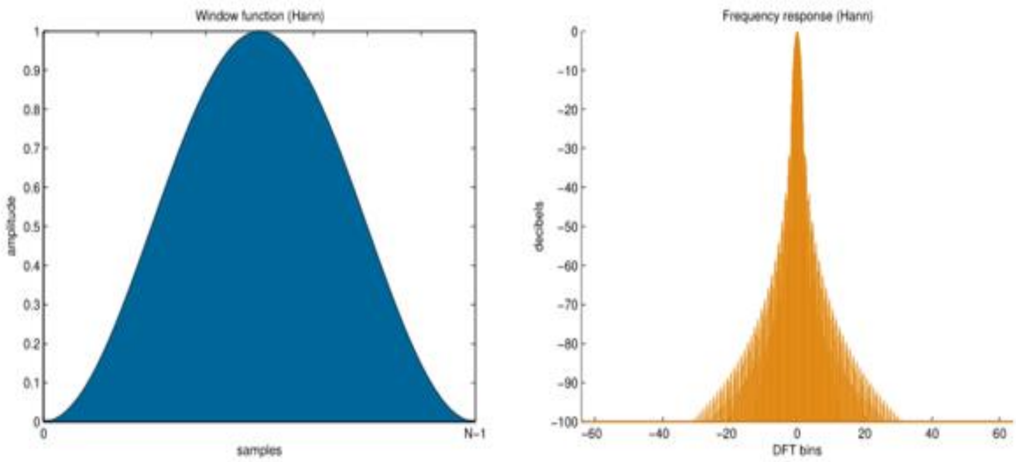
We know that, In the case of the OFDM system, OFDM signals are the results superposition of many different subcarriers. So we can calculate the PAPR from the ratio of peak amplitude and the average amplitude of the subcarrier signals.

2.2 Hann Window

The Hann function, named after the Austrian meteorologist Julius von Hann, is a discreteprobability mass function. Hann function is defined by

$$w(n) = 0.5\left(1 - \cos\left(2\pi\frac{n}{N}\right)\right) \text{ Here N = 0, 1, 2,.................N-1} \qquad (3)$$

The advantage of the Hann window is very low aliasing, and the tradeoff is slightly decreased resolution (widening of the main lobe). If the Hann window is used to sample a signal in order to convert to the frequency domain, it is complex to reconvert to the time domain without adding distortions. The time response and frequency response of the Hann window is given below



(a) (b)

Figure1: (a) Window response of Hann Function (b) Frequency response of Hann Function

2.3 Single pooling

Single pooling technique is one of the most popular symbol pairing techniques. This single pooling technique is used as an ideal PAPR reduction technique forthe OFDM system. In this technique, we subdivided the total OFDM signal into several numbersof symbols.The transmitter structure of our proposed single pooling system is drowning in Figure 3.7. In the transmission section of the single pooling system, the data of time-domain signals are passes through the serial to parallel converter. Then the signal processed under IFFT. Completing IFFT it is applying single pooling. After that, the signal of the minimum PAPR pair is sent into the transmitter.

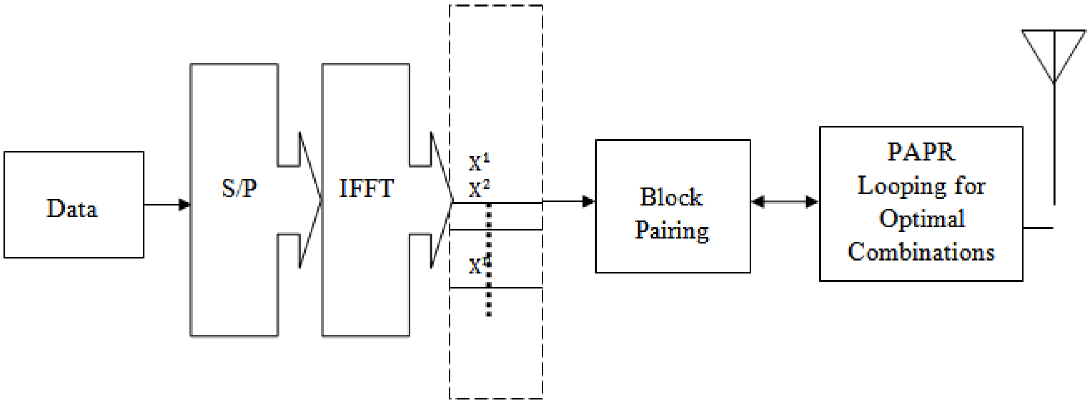


Figure 2: Transmitter block diagram of the single pooling system

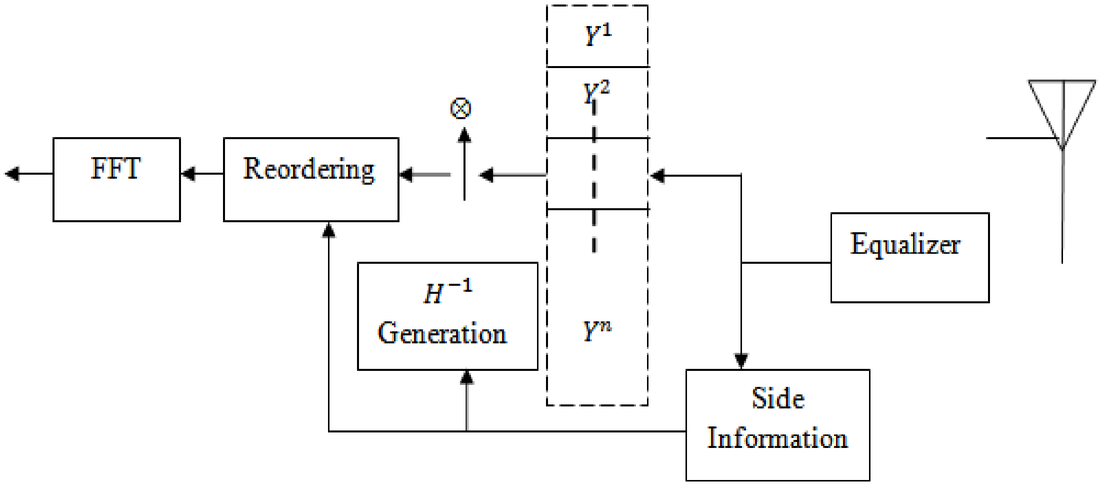


Figure 3: Receiver block diagram of the single pooling system

A diagram of the receiver is given in Figure 3.8, which clearly shows the receiver structure of our proposed single pooling system. To recover the original OFDM symbols, the receiver should know which two symbols and how they combine. The receiver has to build a Hanning window. All the original OFDM symbols can be resolve by simply multiplying the received symbols with Hann^{-1} and resort to the order according to the side information. Finally, done the FFT of the received signal and got the estimated output signal.

2.4 Hadamard Transform

The Hadamard transform H_m is a $2^m \times 2^m$ matrix, the Hadamard matrix scaled by a normalization factor that transforms 2^m real numbers or complex numbers x_n into 2^m real numbers X_k. The Hadamard transform can be defined in two ways: recursively, or by using the binary (base-2) representation of the indices n and k.
Recursively, we define the 1 × 1 Hadamard transform H_0 by the identity $H_0 = 1$, and then define $H_m$form > 0 by:

$$H_m = \frac{1}{\sqrt{2}}\begin{pmatrix} H_{m-1} & H_{m-1} \\ H_{m-1} & -H_{m-1} \end{pmatrix} \quad (4)$$

To reduce the PAPR of the OFDM signal, we used in our thesis Hadamard transform scheme. The input data stream is transformed by the Hadamard transform. Then the transform data steam is used as an input to the IFFT signal processing unit.

The signal processing algorithm steps are bellowed.

Step 1: The sequence of in data, X is transformed by in order Hadamard matrix.
$Y = HX$ Here H is the Hadamard matrix.

Step 2: The Hadamard transformed data sequence Y is inputted to the IFFT unit. The time-domain signal output of the IFFT unit is
$y = [y(1)y(2)y(3) \ldots \ldots \ldots \ldots y(N)]$ (5)

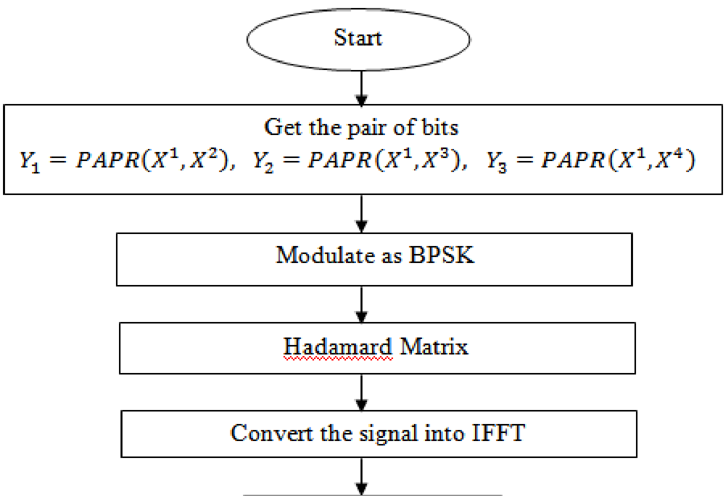
Step 3: FFT transform is performed on the received signal, $r(n)$ that is
$Y_r = FFT\{r\}$, Here r= $[r(1)(2)r(3) \ldots \ldots \ldots \ldots r(N)]$ (6)

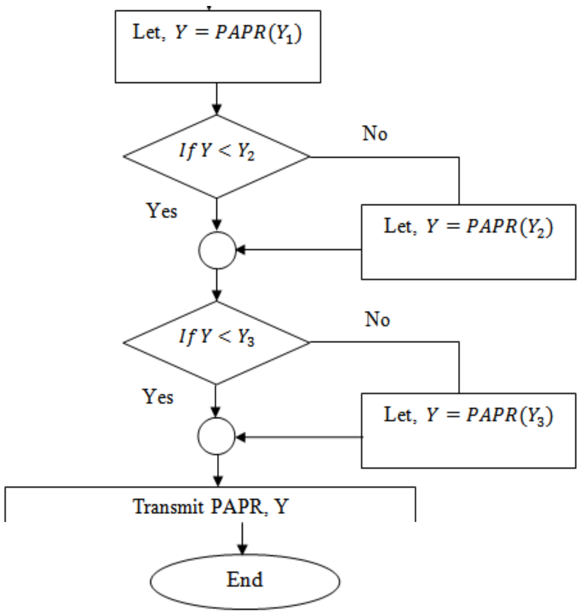
Step 4: Finally Inverse Hadamard Transform is performed to the signal , Y_r that is $X_r = H^T Y_r$. Then the signal X_r is demaped to the bitstream.

2.5 Algorithm for the New Scheme of PAPR Reduction

1. Start the program.
2. Get the number of bits of PAPR and make the pairs in a block as an input.
3. Generate random of '1's and '0's as an array which is taken as the message signal.
4. Modulate the input signal in BPSK modulation.
5. Generate Hadamard Matrix.
6. Multiply different modulated signals with Hadamard Matrix.
7. Multiply different phase constants for different paths.
8. Take IFFT for every path.
9. Calculate the PAPR for each path.
10. Select the path which has minimum PAPR.
11. Take the corresponding transform for every path.
12. Take FFT for every path.
13. Choose the threshold level.
14. Compare the result.
15. And finally, choose the path which is the minimum PAPR.

2.6 Flow Chart for New Scheme Method





2.6 System Model for Simulation

To simulate the above PAPR reduction technique of the OFDM system, we used MATLAB 2010. Firstly we have taken 256 numbers of symbol data in both the BPSK modulation technique and 4-QAM modulation technique generated by random data generators to simulate the PAPR while using the combining model of Hadamard Matrix and Single pooling method. For all the cases we have taken 64 and 128, the number of subcarriers.

III. RESULTS AND DISCUSSION

3.1. Simulation Result of Hann Windowing

Below Figure 4.3 we see that the PAPR of the original OFDM transmitted signal is higher than the Hann windowing signal. In this case, the ccdf of the PAPR is showing almost zero, when the original OFDM signal is in about 10.5 dB. On the other hand, the ccdf of the PAPR is showing almost zero, when the Hann winding OFDM signal shows the result of PAPR is about 6.5 dB. Therefore from this, we get an idea, the ccdf of the PAPR of Hann winding in the OFDM system is lower than the Clipping modulation technique. These figures also show thatthe Hann windingsignal reduces the PAPR of almost 4 dB concerning the original OFDM signal.

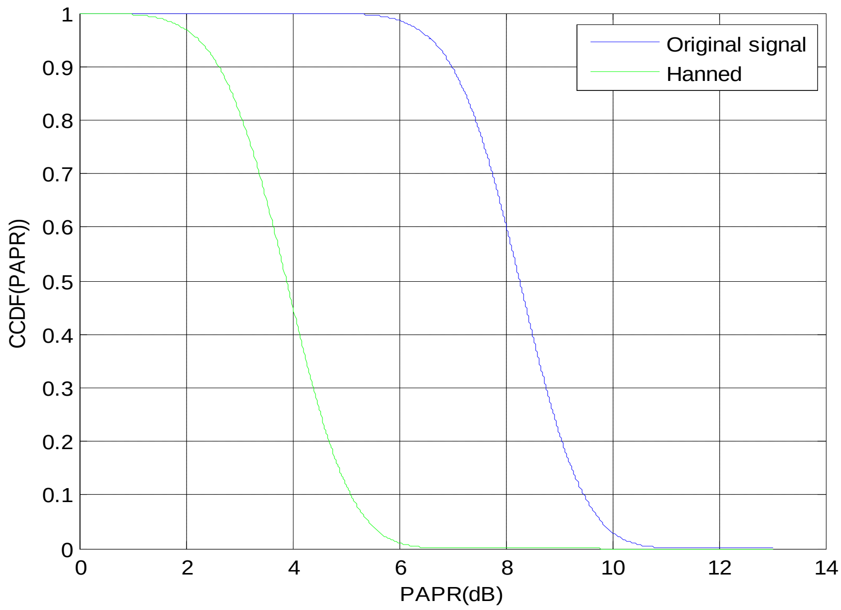


Figure 4: Simulation Result of PAPR of OFDM signal and after applying Hann Window

Table 1: Result of PAPR reduction for Hann Window

PAPR of original OFDM signal (dB)	After Applying Hann Windowing (dB)	Probability of PAPR
10.5	6.5	4

3.2. Simulation Result of Single Pooling Method

In Figure 5 we see that the PAPR of the original OFDM transmitted signal is higher than the Single Pooling signal. In this case, the ccdf of PAPR is showing almost zero, when the original OFDM signal is in about 11 dB. On the other hand, the ccdf of the PAPR is showing almost zero, when the Single Pooling OFDM signal shows the result of PAPR is in about 9.5 dB. Therefore from this, we get the idea that the ccdf of PAPR of Single Pooling in the OFDM system is lower than the Clipping modulation technique. But its PAPR reduction probability is lower than the other PAPR reduction techniques. These figures also show that the Single Pooling signal reduces the PAPR is almost 1.5 dB concerning the original OFDM signal.

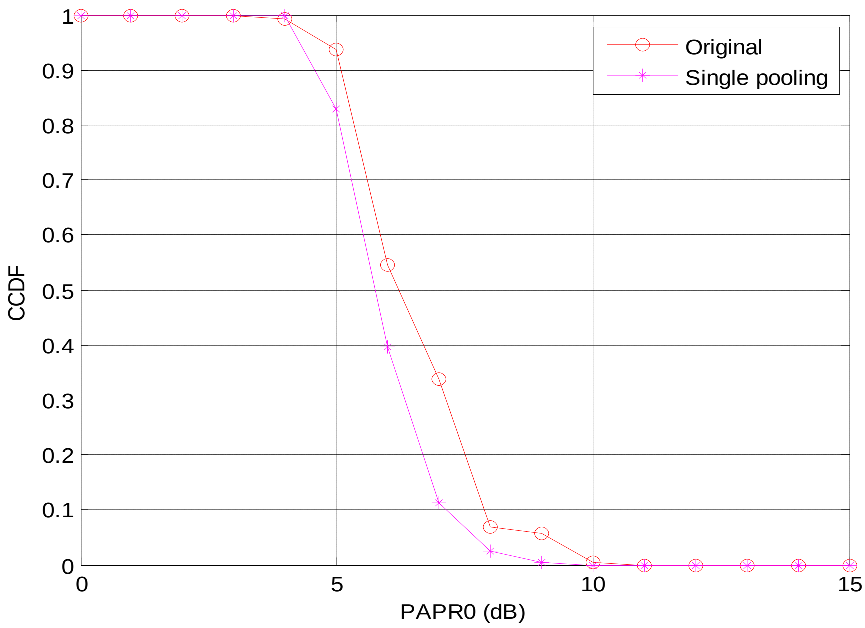


Figure 5: Simulation result of PAPR for the original OFDM signal and after applying a single Pooling method

Table 2: Result of PAPR reduction for single Pooling

PAPR of original OFDM signal (dB)	After Applying Single Pooling (dB)	Probability of PAPR
11	9.5	1.5

3.3. Simulation Result of Hadamard Transform

We are realizing from Figure 4.5 that the PAPR of the original OFDM transmitted signal for binary PSK modulation simulated by the system model described in the previous chapter. Here the ccdf of the PAPR has reduced to almost zero after about 24.5 dB PAPR for the original OFDM signal while it becomes zero after about 15.5 dB PAPR in using Hadamard transform. This indicates that the ccdf of PAPR of OFDM reduces almost 9 dB after performing Hadamard transform.

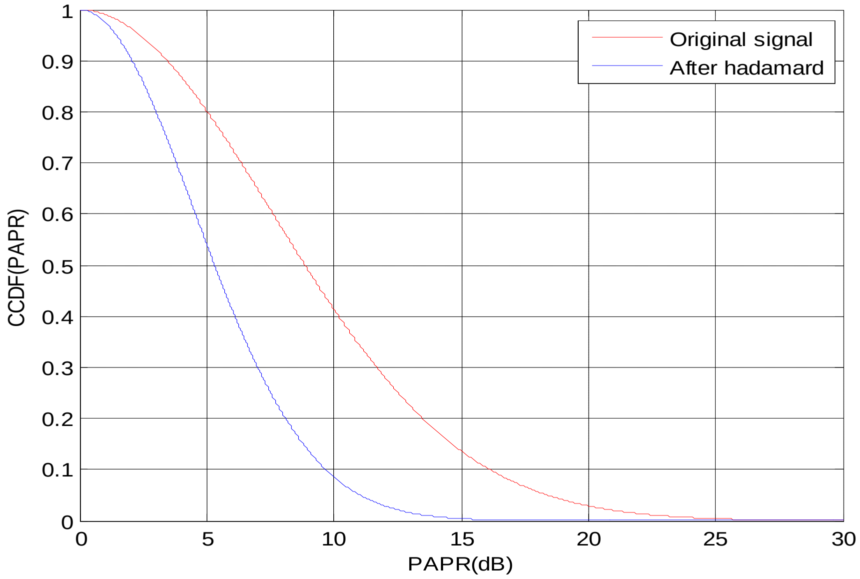


Figure 6: Simulation result of PAPR for the original OFDM signal and after applying Hadamard transform using BPSK

Table 3: Result of PAPR reduction for Hadamard transform using BPSK

PAPR of original OFDM signal (dB)	After Applying the Hadamard Transform (BPSK) (dB)	Probability of PAPR
24.5	15.5	9

3.4.Simulation Result of Our New Scheme

Figure 4.8 shows that the PAPR of the original OFDM transmitted signal is higher than the New Scheme signal. In this case, the ccdf of PAPR is showing almost zero, when the original OFDM signal is in about 11.5 dB. On the other hand, the ccdf of the PAPR is showing almost zero, when the New Scheme OFDM signal shows the result of PAPR is in about 5 dB. Therefore from this, we get an idea, the ccdf of the PAPR of the New Scheme in the OFDM system is lower than the other modulation techniques. PAPR reduction probability is good than the other modulation techniques, but not better. It also New Schemes SNR curve is good. These figures also show that the New Scheme signal reduces the PAPR is almost 6.5 dB concerning the original OFDM signal. This system's complexity is very low. So we can say it’s a perfect PAPR reduction model in the OFDM system and from this, we are inspired to give it as our New Scheme of PAPR reduction model.

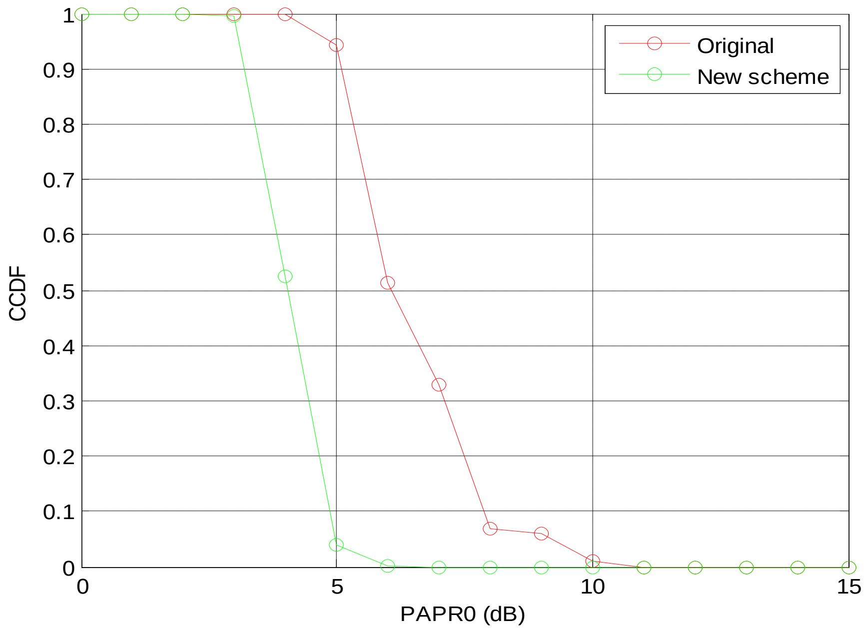


Figure 7: Simulation result of PAPR for the original OFDM signal and after applying New Scheme

Table 4: Result of PAPR reduction for New Scheme

PAPR of original OFDM signal (dB)	After Applying New Scheme (dB)	Probability of PAPR
11.5	5	6.5

3.5. Simulation Result of All Those Techniques

Comparative simulation result of PAPR of OFDM signal after applying all those techniques.

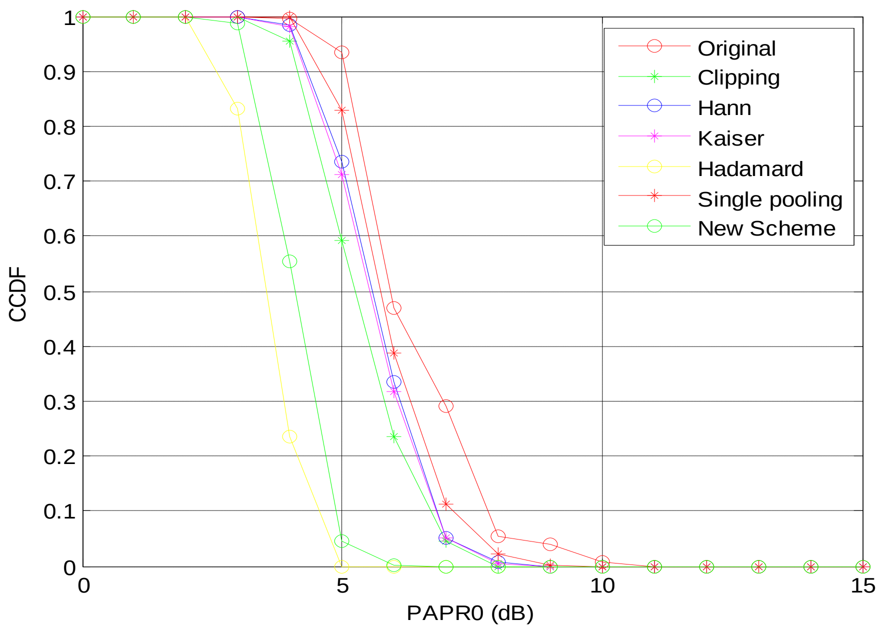


Figure 8: Comparative simulation result of PAPR for original OFDM and after applying Clipping, Hanning, Kaiser, Hadamard, Single Pooling and New Scheme

Table 5: Result of PAPR Reduction of All Analyzing Techniques

Techniques used	PAPR of original OFDM signal (dB)	After Applying the Technique (dB)	Probability of PAPR
Simple Clipping	10.5	9.5	1
Single Pooling	11	9.5	1.5
Hann Windowing	10.5	6.5	4
Kaiser Windowing	11	6.5	4.5
Hadamard Transform	24.5	15.5	9
New Scheme	11.5	5	6.5

3.6. Comparative Simulation Result of BER of OFDM Signal after Applying All those Techniques

- ✓ Below Figure 4.10 shows the comparative curve of BER.
- ✓ The starting point of all the BER curves is very close to each other except Hadamard Transforms the BER curve.
- ✓ Hadamard Transforms BER curve is more effective and it is very much lower than the other curves.
- ✓ Our new scheme systems BER curve is also good with respect to other techniques BER curves.
- ✓ But it is not better than the Hadamard Transforms BER.
- ✓ Moreover, we have decided that our new scheme system is good because it shows low SNR and comparatively low BER and it also its complexity is very poor. So we can say it’s a perfect PAPR reduction technique in the OFDM system.

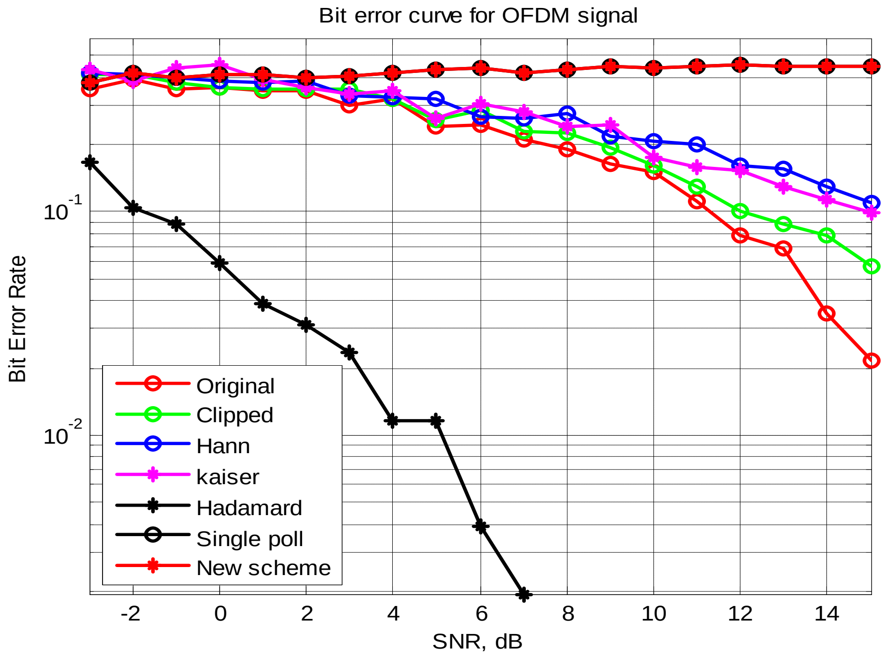


Figure 9: Comparative simulation result of PAPR for original OFDM and after applying Clipping, Hanning, Kaiser, Hadamard, Single Pooling and New Scheme

3.7. Discussion

From the above discussion, we can compare the performance of different types of PAPR reduction techniques in OFDM system. Also, we could visualize the better PAPR reduction ability of my new proposed scheme in comparison with the other methods. In this thesis, we use simple Clipping, Hann Windowing, Kaiser Windowing, Hadamard Transform, simple Single Pooling and the combining technique of Hadamard Transform and Single Pooling method. From here we want to give a comparative idea about the lowest PAPR technique of the OFDM system. So, we will have to decide which the best technique for transmitting the signal is and we apply that technique.

IV. CONCLUSION

In this thesis paper, we studied the technical scenario of OFDM. Besides, we also analyze the performance of some of the methodic facts of this OFDM communication system. We studied the main disadvantages of this modern communication system, the PAPR problem, and its different solutions. We applied a simple Clipping method, Hann peak windowing method, Kaiser peak window method, Hadamard Transform and Single Pooling method to solve this problem and showed quite an improvement. We also applied Hadamard transform and single pooling method to reducing PAPR in the OFDM system. We also analyze the performance of those windowing and clipping methods. Finally, we propose a new PAPR reduction scheme, which is the combining method of single Pooling and Hadamard transform. This method's performance is well. This method's performance is good then other Clipping and windowing methods, but it is not better than Hadamard transform. The new scheme's performance is nearly close to the Hadamard transform with respect to PAPR reduction and BER curve in the OFDM system. In this work, we consider it a New Scheme, because its system complexity is very low and it is easier and flexible for the OFDM system and in future higher order pooling systems can be combined with the Hadamard transform. So, from here we are inspired to consider it as a New Scheme. Also, an optimization point of view was given between these two methods throughout this thesis work.

V. ACKNOWLEDGMENT

Md Abu Zahed and Samiran Kumar Mondal contributed equally to this work.

REFERENCES

[1]. S. P. Vimal and K. R. Shankar Kumar, "A New SLM Technique for PAPR Reduction in OFDM System",Journal of Scientific Research, ISSN 1450-216X, © European Journals Publishing, Inc. 2011, pp.221-230, Vol. 65 No. 2 (2011).

[2]. John G. Proakis and Dimitris G. Manolakis, "Digital Signal Processing: Principles and applications", 3rd edition, copyright © 1996 by Prentice-Hall, Inc., pp. 620-662.

[3]. Theodore S. Rappaport, "Wireless Communications Principles and Practice",2nd edition 2002, Prentice-Hall, Inc, 1992.

[4]. Keller, Thomas, and LajosHanzo. "Adaptive Multicarrier Modulation: A Convenient Framework for Time-Frequency Processing in Wireless Communications",IEEE proceedings of the IEEE 88, May 2000, pp. 609-640.

[5]. EldoMabiala, Mathias Coinchon, Eurecom Institute, "Study of OFDM Modulation", 2005.

[6]. Lin Yang and You Mingli, "Dynamic Symbol Pairing PAPR Reduction Technique for OFDM Systems",IEEE, Research and Innovation Center, Alcatel-Lucent Bell Labs Shanghai, November 2009.

[7]. R. W. Chang, "Orthogonal Frequency Multiplex Data Transmission System", USA U.S. Patent 3,488,445, 1966.

[8]. Ashraf A. Eltholth, Adel R. Mikhail, A. Elshiebini, Moawad I. Mooawad, A. I. Abdelfattah, "Peak-to-Average Power Ratio Reduction in Using OFDM Systems Using Haffman Coding", World Academy of Science, Engineering and Technology 43, 2008.

[9]. A. Peled and A. Ruiz, "Frequency-domain data Transmission Using Reduced Computational Complexity Algorithms", Proc. ICASSP 80, Denver, CO, USA, 1980, vol. III, pp. 964-967, IEEE.

[10]. I. E. Telatar, "Capacity of Multi-Antenna Gaussian Channels Technology Memo.", Bell Laboratories, Lucent Technologies, (Published in European Trans. Telecommunication, vol. 10, No. 6, pp. 585-595, Nov./Dec. 1999), October 1995.

[11]. G. J. Foschini and M. J. Gans, "On limits of wireless communications in a fading environment when using multiple antennas",Wireless Pers.Commun., vol. 6, pp. 311–335, 1998.

[12]. L. J. Cimini, Jr., "Analysis and simulation of a digital mobile channel using orthogonal frequency division multiplexing",IEEE Trans.Commun., vol. CM-33, pp. 665–675, 1985.

[13]. Jean Armstrong, Senior Member, IEEE, "OFDM for Optical Communication", Journal of Lightwave Technology, vol. 27, No. 3, February 1, 2009.

[14]. Van Nee, Richard, and Ramjee Prasad, "FDM for Wireless Multimedia Communications", Boston: Artech House, 2000.

[15]. J. A. C. Bingham, "Multicarrier modulation for data transmission: An idea whose time has come",IEEE Commun. Mag., vol. 28, pp. 5–14, 1990.

[16]. J. H. Stott, "The how and why of COFDM",EBUTech. Rev., pp. 43–50, 1998.

[17]. R. van Nee and R. Prasad, "OFDM for Wireless Multimedia Communications", Boston: Artech House, 2000.

[18]. W. Y. Zou and Y. Wu, "COFDM: An overview",IEEE Trans. Broadcasting, vol. 41, pp. 1–8, 1995.

[19]. S. L. Jansen, I. Morita, N. Takeda, and H, Takeda, "20Gb/s OFDM Transmission Over4, 160-km SSMF enabled by RF-pilot Tone Phase Noise Compensation" presented at the proc. OFC/NFOEC 2007, Anaheim, CA, Mar. 25-29, 2007, Paper PDP15.

[20]. Bingham, John A. C. "Multicarrier Modulation for Data Transmission: An Idea Whose Time Has Come", IEEE Communications Magazine, May 1990, pp. 5-14.