THE STUDY OF PEAK-TO-AVERAGE POWER RATIO (PAPR) REDUCTION IN WAVELET BASED MULTICARRIER

SITI ROKIAH BT RAMLI

UNIVERSITI TEKNOLOGI MALAYSIA

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SITI ROKIAH BT RAMLI

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Specially dedicated to my beloved husband, parents, family members, fellow friends and everyone who have guided and inspired me throughout my life.

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ABSTRACT

Wireless digital communications is rapidly expanding, resulting in a demand for wireless systems that are reliable and have a high spectral efficiency. As we move in to the future there is a rising demand for high performance, high capacity and high bit rate wireless communication systems to integrate wide variety of communication services such as high-speed data, video and multimedia traffic as well as voice signals. As proven by the success of orthogonal frequency division multiplexing (OFDM), it provides an efficient means to handle high-speed data streams over a multipath fading environment .In recent years, wavelet packets are introduced to the communication field as an orthogonal base for multicarrier modulation, and attract a lot of attention of experts engaged in this filed [13]. This is because wavelet OFDM implementation provides performance gains over Fourier based OFDM, due to superior spectral containment properties of wavelet filters. Peak to Average Power Ratio (PAPR) is one of the serious problems in any wireless communication system using multi carrier modulation technique which reduces the efficiency of transmit high power amplifier. In this project, the PAPRs reduction in wavelet based multicarrier modulation (WMCM) systems will be studied by employing clipping as PAPR reduction technique and we will analyze the performance of PAPR by using Complementary Cumulative Distribution Function (CCDF).

ABSTRAK

Sistem komunikasi tanpa wayar semakin berkembang menyebabkan permintaan untuk sistem ini yang mana diakui dan mempunyai kecekapan yang tinggi. Semakin kita bergerak ke masa hadapan, kenaikan permintaan untuk untuk prestasi dan kapasiti yang tinggi dan ‘bit rate’ sistem komunikasi tanpa wayar yang tinggi untuk menyatukan berbagai telekomunikasi servis seperti “high speed data”, video dan trafik multimedia seperti “voice signal”. Ini telah dibuktikan dengan kejayaan “orthogonal frequency division multiplexing (OFDM)” yang menyediakan kecekapan untuk mengendali “high speed data streams” melalui persekitaran “multipath fading”. Sejak kebelakangan ini, “wavelet packet” diperkenalkan ke dalam bidang komunikasi sebagai “orthogonal based” untuk “multicarrier modulation”, yang mana menarik banyak perhatian pakar di dalam bidang ini. Ini kerana “wavelet OFDM”menunjukkan prestasi yang lebih menarik berbanding dengan “Fourier based OFDM”, disebabkan oleh penyekatan yang tinggi oleh “wavelet filters”. “Peak to Average Power Ratio (PAPR)” merupakan masalah yang paling serius di dalam mana-mana siatem komunikasi tanpa wayar yang menggunakan teknik “multicarrier modulation”. yang mana mengurangkan kecekapan di dalam memancarkan kuasa penguat. Di dalam projek ini, pengurangan PAPR di dalam “wavelet based multicarrier modulation (WMCM)’ akan dikaji dengan menggunakan “clipping” teknik, dan “complementary cumulative distribution function (CCDF)” akan di analisis.

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LIST OF ABBREVIATIONS

BER	-	Bit Error Rate
DAB	-	Digital audio broadcasting
DFT	-	Discrete Fourier Transform
DFT-OFDM	-	Discrete Fourier Transform based OFDM
DVB	-	Digital video broadcasting
DWT	-	Discrete Wavelet Transform
DWT-OFDM	-	Discrete Wavelet Transform based OFDM
FFT	-	Fast Fourier Transform
Haar	-	Haar wavelet family
ICI	-	Inter-Carrier Interference
IDWT	-	Inverse Discrete Wavelet Transform
IFWT	-	Inverse Fast Fourier Transform
IFFT	-	Inverse Fast Wavelet Transform
ISI	-	Inter-Symbol Interference
MCM	-	Multi-Carrier Modulation
MRA		Multi-Resolution Analysis
OFDM		Orthogonal Frequency Division Multiplexing
PTS		Partial transmit sequence
QoS		Quality of service
TR		Tone reservation
UWB		Ultra Wideband
WLAN		Wireless local area networks

CHAPTER 1

INTRODUCTION

1.0 Background

The communication systems and communication networks of the future will fundamentally improve the way people communicate. One among the services expected to have major impact in the future include wireless communication that will permit mobile telephony and data transfer anywhere on the planet . Delivering and receiving these services to the large and rapidly growing commercial markets has created new technological challenge in signal design, modulation, detection, and signal processing. For wireless communication systems, limited bandwidth allocations coupled with a potentially large pool of users restrict the bandwidth availability to the users. The success of wirelesses communication systems thus depends heavily on the development of bandwidth efficient data transmission schemes.

Multicarrier transmission is a promising technique for high bit rate transmission in wireless communication system. Multicarrier modulation (MCM) is a technique of transmitting data by dividing the input data stream into parallel sub streams that are each modulated and multiplexed onto the channel at different carrier frequencies. Its divides the incoming high rate data among multiple carriers modulated at lower rates. By transmitting simultaneously *N* data symbols through *N* carriers the symbol rate is reduced to the one N^{th} of the original symbol rate, and therefore the symbol duration is increased by *N* times. This leads to a transmission system which is robust against channel dispersions or fading, impulse noise and multipath interference. MCM increases wireless capacity without increasing bandwidth. In the MCM method, the sub-channels are orthogonal and their spectra overlap over one another. Therefore more carriers can be packed in a given bandwidth leading to a very high spectral efficiency. Because of the parallel transmission in MCM the symbol duration is increased which is also an advantage in channels having impulsive noise characteristics.

The Orthogonal Frequency Division Multiplexing (OFDM) is a MCM technique that is widely adopted and most commonly used today which is offers a considerable high spectral efficiency, multipath delay spread tolerance, immunity to the frequency selective fading channels and power efficiency. In the OFDM, the carriers are static sine or cosine functions. As an alternative to OFDM other orthogonal bases could be used for multi-carrier systems.

The wavelet packet modulation (WPM) was proposed by Lindsey [1] in 1997 as an alternative to OFDM. The fundamental theories of OFDM and WPM have many similarities in their way of functioning and performance but there are some significant differences which give the two systems distinctive characteristics. OFDM signals only overlap in the frequency domain while the wavelet packet signals overlap in both, time and frequency. Due to time overlap WPM systems did not use cyclic prefix (CP) or any kind of guard interval (GI) that is commonly used in OFDM systems. OFDM utilizes CP to overcome interference caused by dispersive channels.

The greatest motivation for pursuing WPM systems lies in the freedom they provide to communication systems designers. Unlike the Fourier bases which are static sine or cosines, WPM uses wavelets which offer flexibility and adaptation that can be tailored to satisfy an engineering demand. By altering the design specifications a wavelet based system that is more robust against synchronization errors could be developed without compromising on spectral efficiency or receiver complexity.

A significant problem in MCM is the possibility of high Peak-to-Average Power Ratio (PAPR) in transmitted signals. A large PAPR brings disadvantages like an increased complexity of the analog-to-digital and digital-to-analog converters and a reduced efficiency of the RF power amplifier. These large peaks increase the amount of inter modulation distortion resulting in an increase in the error rate. The average signal power must be kept low in order to ensure that the transmitter amplifier operates in the linear region. Minimizing the PAPR allows a higher average power to be transmitted for a fixed peak power, improving the overall signal to noise ratio at the receiver. Usually, the systems are constrained to a limited peak power due to the limitation of the dynamic range over which the transmitter amplifier operates linearly.

1.1 Problem Statement

High PAPR of transmitted signal is a major drawback for MCM system such as OFDM and WPM. The peak of the MCM signal can be up to *M,* the number of subcarriers, times the average power. A MCM signal consists of a number of independently modulated subcarriers, which can give a large PAPR when added up coherently. When *M* signals are added with the same phase, they produce a peak power that is *M* times the average power.

In OFDM, the carriers are static sine and cosine function, but WPM use wavelets which is offer flexibility and adaptability that can be tailored to satisfy an engineering demand.

The problem of high peak amplitude is most severe at the transmitter output due to its nonlinear component such as power amplifier. A better solution to this PAPR problem is by reducing the PAPR of the transmitted signal with some manipulations of the MCM signal itself. This approach has encouraged many researchers to propose a variety of techniques for PAPR reduction.

1.2 Project Objectives

The objectives of this project are as follows:

i. To investigate the PAPR performance in wavelet-based multicarrier modulation (WMCM) system.

ii. To reduce PAPR by using PAPR reduction techniques such as the clipping technique.

iii. To study and analyze the performance evaluation of this works for complementary cumulative distribution function (CCDF).

1.3 Scope of the Project

The scope of this project is to investigate the PAPR performance in wavelets based multicarrier modulation, and then by using PAPR reduction technique based on clipping method, we will analyze the performance of PAPR by using Complementary Cumulative Distribution Function (CCDF). The project will be conducted using MATLAB simulations.

1.4 Report Organization

This report is organized as following: Chapter 2 provides the literature review to multicarrier modulation, OFDM, wavelets and PAPR reductions including specifies the clipping technique to reduce PAPR in WPM. Chapter 3 explains the methodology that have used in this project. Then, chapter 4 provides result and discussion for the simulations. Finally, Chapter 5 discussed the improvement to future project and conclusion.

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