TECHNIQUES OF REDUCING PAPR AND BER OF OFDM SYSTEM

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Bachelor of Engineering with Honours
(Electronic and Telecommunications Engineering)
2009

UNIVERSITI MALAYSIA SARAWAK

R13a

BORANG PENGESAHAN STATUS TESIS

Judul: TECHNIQUES OF REDUCING PAPR AND BER OF OFDM SYSTEM

SESI PENGAJIAN: 2008/2009

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Dedicated to my beloved parents, family members and friends

TECHNIQUES OF REDUCING PAPR AND BER OF OFDM SYSTEM

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This project is submitted in partial fulfilment of

the requirements for the degree of Bachelor of Engineering with Honours

(Electronics and Telecommunications Engineering)

Faculty of Engineering

UNIVERSITI MALAYSIA SARAWAK

2008/2009

ACKNOWLEDGEMENT

I first of all would like to thank my project supervisor, Mdm. Ade Syaheda Wani Marzuki of Universiti Malaysia Sarawak for the excellent guides, encouragements and advices given during the completion of this report. Besides, I would also dedicate my gratitude to Miss Maimum for guiding and helping me on solving problems regarding on SIMULINK simulations of my project.

I would also like to express my gratitude to my friends for their help, advice and encouragement. My deepest appreciation also goes to my boyfriend, Mr. Lee K.Y for his understanding and support throughout the completion of this project.

Finally yet importantly, I wish to thank my beloved family especially my parents who had always given their outmost encouragements to me during the process of completing this report.

ABSTRAK

Pada abad ke-21 ini, kebanyakan aplikasi tanpa wayar, seperti 'indoor wide-band mobile radio' sistem komunikasi tanpa wayar lebar-jalur internet, komunikasi multimedia menunjukkan keperluan yang tinggi terhadap teknik generasi transmisi tanpa wayar yang dapat memberikan kadar perpindahan maklumat yang tinggi untuk memberi qualiti tranmisi yang lebih baik. Pemultipleksan Frekuensi Terbahagi Orthogon (OFDM) merupakan salah satu teknik yang mampu menyelesaikan masalah yang berkaitan dengan kepelbagaian lintasan dan kepudaran pilihan saluran frekuensi dengan efisien dan ia juga imun terhadap gangguan jalur sempit. Kelemahan OFDM yang mempengaruhi prestasinya termasuk kuasa nisbah puncak-ke-purata (PAPR) yang tinggi, frekuensi tidak sepadan, dan fasa isyarat yang tidak diinginkan. Projek ini membangunkan sistem komunikasi berdasarkan teknik modulasi OFDM dengan menggunakan alat SIMULINK dalam MATLAB. Skema Pengekodan blok telah digunakan untuk mengurangkan PAPR dalam sistem OFDM. Kadar Kesalahan Bit (BER) juga dikira dan dikaji. Teknik Generator Matrix merupakan teknik yang paling efektif dalam mengurangkan PAPR dan juga BER dalam system OFDM.

ABSTRACT

In this 21st century, many wireless applications, such as indoor wide-band mobile radio systems, broadband communication wireless internet, and multimedia communications have great demand on a next generation wireless transmission technique that can provide high data transfer rate for better transmission quality. Orthogoanl Frequency Division Multiplexing, OFDM is one of the techniques capable in eliminate problems associated with multipath and frequency selective fading channels efficiently and has the ability to robust against narrowband interference. The disadvantages in OFDM which affects its performance include large Peak-To-Average Power Ratio (PAPR), Phase Noise and Frequency Offset. This project developed a communication system based on OFDM modulation techniques by using SIMULINK tools in MATLAB. Block Coding Schemes has been employed to reduce the PAPR of the OFDM system. The BER performances of the OFDM system are also measured. The Generator Matrix is the most effective techniques of PAPR and BER of the OFDM system.

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NOMENCLATURE

b_N	-	constant sequence of length N
GHz	-	Giga Hertz (unit)
G_N	-	generator matrix with N dimensions
K	-	the order of frequency
k	-	index of the frequencies
M	-	arbitrary of M-ary
Mbps	-	Mega bits per second
MHz	-	Mega Hertz (unit)
N	-	number of frequency
N	-	number of subcarriers
s(t)	-	OFDM signal
t'	-	position of a local maximum of the envelop
W	-	Watt (unit)
w (t)	-	window function
$X(k)$	-	FFT Sinusoids
$X(n)$	-	coefficients of the sine and cosine of frequency

α	-	attenuation constant
$\boldsymbol{\pi}$	-	pi

LIST OF ABBREVIATIONS

ADSL	-	Asymmetric Digital Subscriber Lines
ADDCE	-	Average-Decision Directed Channel Estimation
AWGN	-	Additive White Gaussian Noise
BCM	-	Block Coded Modulation
BER	-	Bit Error Rate
BPSK	-	Binary Phase Shift Keying
CDMA	-	Coded Division Multiple Access
CFO	-	Carrier Frequency Offset
CP	-	Cyclic Prefix
CPE	-	Common Phase Error
DAB	-	Digital Audio Broadcasting
DFT	-	Discrete Fourier Transform
DMT	-	Discrete Multi-Tone
DVB	-	Digital Video Broadcasting
FDM	-	Frequency Division Multiplexing
FEC	-	Forward Error Correction
FFT	-	Fast Fourier Transform
FIR	-	Finite Impulse Response
FM	-	Frequency Modulation
GUIDE	-	Graphical User Interface Development Environment
HDSL	-	High-Speed Digital Subscriber Lines

HDTV	-	High Definition Television
HIPERLAN	-	High Performance Radio Local Area Network
ICI	-	Inter-Carrier Interference
IEEE	-	Institute of Electrical and Electronics Engineers
ETSI	-	European Telecommunication Standard Institute
IFFT	-	Inverse Fast Fourier Transform
LO	-	Local Oscillator
MCM	-	Multi Carrier Modulation
MMAC	-	Metropolitan Milwaukee Association of Commerce
OFDM	-	Orthogonal Frequency Division Multiplexing
PAPR	-	Peak-To-Average Power Ratio
PEP	-	Peak Envelop Power
PSD	-	Power Spectral Density
PSK	-	Phase Shift Keying
QAM	-	Quadrature Amplitude Modulation
QPSK	-	Quadrature Phase Shift Keying
SNR	-	Signal-to-Noise Ratio
VHDSL	-	Very High-Speed Digital Subscriber Lines
VLSI	-	Very Large Scale Integration
WAND	-	Wireless Asynchronous Transfer Mode (ATM) Network Demonstrator
WiMAX	-	Worldwide Interoperability for Microwave Access

CHAPTER 1

INTRODUCTION

1.1 Introduction

Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier transmission technique that has been recently recognized as an excellent method for high speed bi-directional wireless data communication [1]**.** Over the last decade, orthogonal frequency division multiplexing has been exploited for several communication application such as wideband communication over mobile radio FM channels, Asymmetric Digital Subscriber Lines (ADSL), High-speed Digital Subscriber Lines (HDSL), Very High-speed Digital Subscriber Lines (VHDSL), Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), and HDTV terrestrial broadcasting [2].

1.2 Background of OFDM

The concept of using parallel data transmission by means of Frequency Division Multiplexing (FDM) was published in mid 60s [3, 4]. Some early development can be traced back in the 50s. A U.S. patent was filled and issued in January, 1970. The idea was to use parallel data streams and FDM with overlapping sub channels to avoid the use of high speed equalization and to combat impulsive noise, and multipath distortion as well as to fully use the available bandwidth.

The initial applications were in the military communications. In the telecommunications field, the terms of Discrete Multi-Tone (DMT), Multichannel Modulation and Multicarrier Modulation (MCM) are widely used and sometimes they are interchangeable with OFDM. In OFDM, each carrier is orthogonal to all other carriers. However, this condition is not always maintained in MCM. OFDM is an optimal version of multicarrier transmission schemes.

For a large number of sub-channels, the arrays of sinusoidal generators and coherent demodulators required in a parallel system become unreasonably expensive and complex. The receiver needs precise phasing of the demodulating carriers and sampling times in order to keep crosstalk between sub channels acceptable. Weinstein and Ebert [5] applied the Discrete Fourier Transform (DFT) to parallel data transmission system as part of the modulation and demodulation process. In addition to eliminating the banks of subcarrier oscillators and coherent demodulators required by FDM, a completely digital implementation could be built around special-purpose hardware performing the Fast Fourier Transform (FFT).

Recent advances in Very Large Scale Integration (VLSI) technology enable making of high-speed chips that can perform large size FFT at affordable price. In the 1980s, OFDM has been studied for high-speed modems, digital mobile communications and high-density recording. One of the systems used a pilot tone for stabilizing carrier and clock frequency control and trellis coding was implemented. Various fast modems were developed for telephone networks. In 1990s, OFDM has been exploited for wideband data communications over mobile radio FM channels, High-Bit-Rate Digital Subscriber Lines (HDSL, 1.6 Mb/s), Asymmetric Digital Subscriber Lines (ADSL, 1,536 Mb/s), Very High-speed Digital Subscriber Lines (VHDSL, 100 Mb/s), Digital Audio Broadcasting (DAB) and HDTV terrestrial broadcasting [6].

1.3 Principles of OFDM

The reason why the OFDM is being widely used is its reliability, efficiency in transmitting signals with high speed. The principle of OFDM is to divide the transmission channel into a number of orthogonal sub-channels or subcarriers. This channel partitioning method attempts to construct a set of parallel sub-channels that are largely independent [2]**.** OFDM is based on the FDM principle where it uses multiple frequencies to transmit multiple signals simultaneously in parallel. Each signal has its own frequency range (sub-carrier) which is then modulated by data. Each sub-carrier is separated by a guard band to ensure that they do not overlap as shown in Figure 1.1. These sub-carriers are then demodulated at the receiver by using filters to separate the bands. However, the OFDM effectively compresses multiple modulated carriers tightly together, reducing the required bandwidth but keeping the modulated signals orthogonal so they do not interfere with each other.

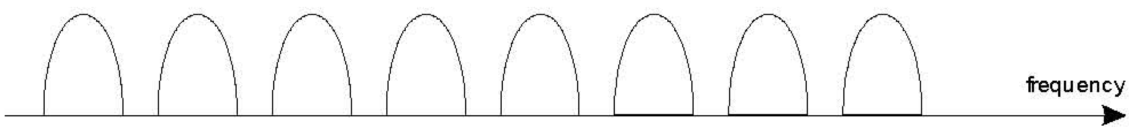

Figure 1.1: Conventional Frequency Division Multiplex (FDM) multicarrier modulation technique [1].

OFDM is similar to FDM but much more spectrally efficient by spacing the sub-channels much closer together (until they are actually overlapping) as shown in Figure 1.2. This is done by finding frequencies that are orthogonal, which means that they are perpendicular in a mathematical sense, allowing the spectrum of each sub-channel to overlap another without interfering with it. Figure 1.2 shows there is great reduction of the required bandwidth by removing the guard bands and allowing the signals to overlap. In order to demodulate the signal, a DFT or FFT chips are needed [1].

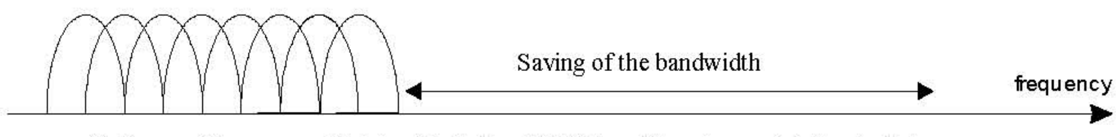

Figure 1.2: Orthogonal Frequency Division Multiplex (OFDM) multicarrier modulation technique [1].

1.4 Orthogonality of OFDM

Some previous researchers have been reviewed to give the new researchers some ideas on the OFDM. The important aspects of OFDM have been contributed in their works. In [7], to work out OFDM successfully, the orthogonality of the carriers is to be maintained and the relationship between carriers must be controlled carefully. Thus, the spectrum required, based on the input data and the modulation scheme used should be the first priority when generating OFDM. Each carriers which to be produced is assigned some data to transmit.

According to [7], the required amplitude and phase of the carrier is then calculated based on the modulation scheme, for typical instances, the differential Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), or Quadrature Amplitude Modulation (QAM.). The IFFT is then used to convert the required spectrum back to its time domain signal. The IFFT is usually used for its efficiency in performing the transformation and provides easier path of ensuring the carriers signals produced are orthogonal.

1.5 FFT and IFFT

Besides, in [7], the concepts of FFT and IFFT are discussed. For the FFT, it transforms a cyclic time domain signal into its equivalent frequency spectrum. This is achieved by finding the equivalent waveform, generated by a sum of orthogonal sinusoidal components. The amplitude and phase of the sinusoidal components represent the frequency spectrum of the time domain signal. Inversely, the IFFT transform a spectrum (amplitude and phase of each component) into a time domain signal. An IFFT converts a number of complex data points, of length that 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 generated by simply setting the amplitude and phase of each frequency bin and performing the IFFT later. The orthogonality of the carriers generated is assured since each bin of an IFFT is corresponds to the amplitude and phase of a set of orthogonal sinusoids [7].