DESIGN AND IMPLEMENTATION OF ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING RECEIVER

NORAZNI BINTI YUSOFF

This report is submitted in partial fulfillment of requirement for the award of Bachelor of Electronic Engineering (Electronic Telecommunication) With Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

April 2010

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : DESIGN AND IMPLEMENTATION ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING RECEIVER

Sesi Pengajian : 2009/2010

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Dedicated to my beloved parents and siblings

ACKNOWLEDGEMENT

Bismillahiranmanirrahim, I would like to express my appreciation to Allah the Mighty because I have finally completed this “Projek Sarjana Muda ” successfully. To my parents, Encik Yusoff Bin Hamzah and Puan Wan Safiah Binti Wan Ahmad and siblings, thank you very much because all of you always with me through difficulty and good times. Without them, this project cannot be achieved easily. Special thanks to my supervisor, Prof Madya Muhammad Syahrir bin Johal, for his support, lessons, advice, ideas and all valuable contribution in this project. Not forget to my PSM friends that gave me ideas, critics and moral support from the beginning until the end. Their assistance will always be remembered throughout my entire life. May Allah always with you all. Last but not least, to the Faculty of Electronic and Computer Engineering (FKEKK), because giving me chance to study and complete my project as part of the Bachelor program in Universiti Teknikal Malaysia Melaka (UTeM).

ABSTRACT

This project is about Orthogonal Frequency Division Multiplexing (OFDM) Receiver. The purpose of this project is to design, simulate and implement OFDM receiver for Digital Video Broadcasting – Terrestrial (DVB-T). OFDM is a modulation technique especially suitable for wireless communication due to its resistance to inter-symbol interference (ISI). The whole system will be developed in the MATLAB simulation environment and then will be implemented in DSP board.

ABSTRAK

Projek ini adalah suatu penerima *Orthogonal Frequency Division Multiplexing* (OFDM). Projek ini bertujuan untuk mereka bentuk, melakukan simulasi dan mengaplikasikan untuk Penyiaran Video Digital - Daratan. OFDM ialah teknik modulasi yang sangat sesuai untuk komukasi tanpa wayar kerana kekebalannya terhadap gangguan antara isyarat simbol (ISI). Keseluruhan sistem akan dibangunkan dalam keadaaan simulasi perisian MATLAB dan diaplikasikan di atas *board* DSP.

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LIST OF ABBREVIATIONS

ADC	-	Analog to Digital Converter
AWGN	-	Additive White Gaussian Noise
BPSK	-	Binary Phase Shift Keying
DAC	-	Digital to Analog Converter
DFT	-	Discrete Fourier Transform
DIF	-	Decimation In Frequency
DIT	-	Decimation In Time
DQPSK	-	Dual-polarization Quadrature Phase Shift Keying
DSP	-	Digital Signal Processing
DTT	-	Digital Terrestrial Television
DVB	-	Digital Video Broadcasting
DVB – T	-	Digital Video Broadcasting – Terrestrial
FDMA	-	Frequency Division Multiple Access
FFT	-	Fast Fourier Transform
ICI	-	Inter-Carrier Interference
IDFT	-	Inverse Discrete Fourier Transform
IFFT	-	Inverse Fast Fourier Transform
ISI	-	Inter-Symbol Interference
OFDM	-	Orthogonal Frequency Division Multiplexing
QAM	-	Quadrature Amplitude Modulation
QPSK	-	Quadrature Phase Shift Keying
RF	-	Radio Frequency
WBMCS	-	Wireless Broadband Multimedia Communication System

CHAPTER 1

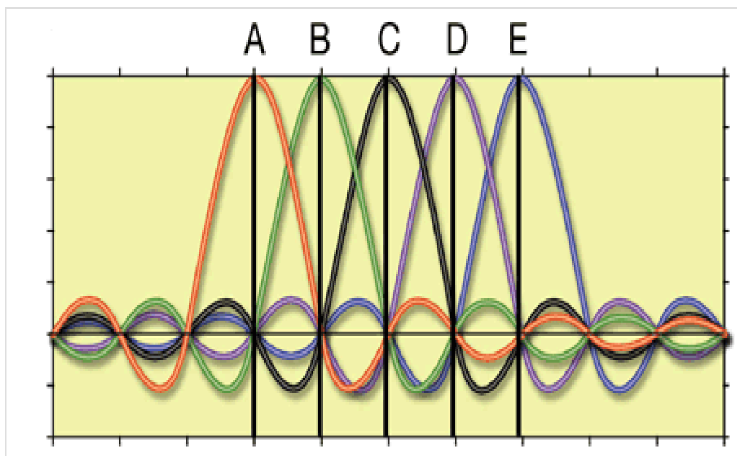
INTRODUCTION

This chapter 1 is contains about the introduction of the project where it involve of the objectives, problem statements and the scope of work.

1.1 Introduction of Project.

This project will focus on Orthogonal Frequency Division Multiplexing (OFDM) receiver research, simulation and implementation due to its resistance to inter-symbol interference (ISI).

OFDM is reducing amount of wasted spectrum by dividing the message to be transmitted into a number of frequency carriers and spacing these carriers very close to each other. It allows the spectrum to overlap, and because they are orthogonal, they do not interfere with each other since detection for one carrier is made at the point where all other carriers are null. By allowing the spectrum to overlap, the overall amount of spectrum required is reduced.



OFDM spectrum

Figure 1.0: Example of OFDM spectra

After researching OFDM, simulation in MATLAB will be completed. The main part of this project will be using the simulation results as a guide to implement the demodulation of OFDM on a DSP board. The MATLAB code will need to be converted to either C or Simulink. This makes the code compatible with the software tool for the particular DSP board. To test the DSP code, the input and output vectors of the MATLAB simulation and DSP implementation will be verified to correspond.

1.2 Objectives

The main objective for this project is to design and simulate the OFDM receiver by using MATLAB software. The receiver will receive signal from OFDM transmitter and will implement in DSP board.

The other objective is to improve the performance of the system using MATLAB in different number of sub-carriers such in:

1. 853 sub-carriers
2. 1200 sub-carriers
3. 1705 sub-carriers

1.3 Problem statement

A common problem found in high speed communication is inter-symbol interference (ISI). ISI occurs when a transmission interferes with itself and the receiver cannot decode the transmission correctly.

Because the signal reflects from large objects such as mountains and building, the receiver sees more than one copy of the signal. In communication terminology, this is called multi-path. Since the indirect paths take more time to travel to the receiver, the delayed copies of the signal interfere with the direct signal, causing ISI.

In DVB-T, the performance of the OFDM system will improve if we use the higher level of the modulation. The level of modulation is the numbers of the sub-carriers that we varied are in range 2k mode (853 until 1705)

1.4 Scope of Work

The scopes of the project are focuses on the design and implementation of OFDM base band receiver for DVB-T. This project focuses on the core processing block of receiver. This designs implement 853, 1200 and 1705 sub-carriers. Once the receiver receive OFDM signal from the transmitter, that signal will be channeled to the OFDM modulator using Fast Fourier Transform (FFT) technique. The sub-signals will be merged and then will be passed trough Digital-Analog-Converter (DAC).

The digital input from transmitter will be compared to digital output from receiver to measure the system performances. Once the signal converted into analog waveform, it will then displays on oscilloscope. The second scope is to implement the design to DSP hardware development board. This process is implemented if all designs are correctly verified and simulated using particular software.

CHAPTER 2

LITERATURE REVIEW

This chapter is to discuss some fundamental ideas OFDM receiver.

2.1 Background Study

The development of the Digital Video Broadcasting (DVB) standard was started in 1993. DVB is a transmission scheme based on the MPEG-2 standard, as a method for point to multipoint delivery of high quality compressed digital audio and video. It is an enhanced replacement of the analogue television broadcast standard, as DVB provides a flexible transmission medium for delivery of video, audio and data services.

DVB-T is a technical standard, developed by the DVB project, which specifies the framing structure, channel coding and modulation for digital terrestrial television (DTT) broadcasting. It is the DVB European based consortium standard for the broadcast transmission of digital terrestrial television that first broadcast in United Kingdom in 1997. This system transmits compressed digital audio, video and other data in an MPEG transport stream using OFDM modulation. This type of modulation, which uses a large number of sub-carriers, delivers a robust signal that has the ability to deal with very severe channel conditions. There are two choices for the number of sub-carriers known as 2k mode or 8k mode. These are actually 1705 or 6817 carriers that are approximately 4kHz or 1kHz apart.

2.2 Digital Video Broadcasting-Terrestrial

In an OFDM scheme, a large number of orthogonal, overlapping, narrow band, sub-channels or sub-carreirs, transmitted in parallel, divide the available transmission bandwidth. The attraction of OFDM is mainly due to how the system handles the multi-path interference at the receiver. A detailed description of OFDM can be found OFDM transmission where we can find the expression for one OFDM symbol starting at $t = t_s$ as follows:

$$s(t) = \mathrm{Re}\left\{ \sum_{i=-\frac{N_s}{2}}^{\frac{N_s}{2}-1} d_{i+N_s/2} \exp\left(j2\pi \left(f_c - \frac{i+0.5}{T} \right)(t-t_s) \right) \right\},\ t_s \le t \le t_s + T$$

$$s(t) = 0,\ t < t_s \quad \wedge \quad t > t_s + T$$

(2.1)

where d_i are complex modulation symbols, Ns is the number of sub-carriers, T the symbol duration and fc the carrier frequency. The equation (2.1) is given in the DVB-T standard as the emitted signal. The expression is

$$\mathrm{s}(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{m=0}^{\infty} \sum_{l=0}^{67} \sum_{k=K_{min}}^{K_{max}} c_{m,l,k} \cdot \Psi_{m,l,k}(t) \right\}$$

(2.2)

where

$$\Psi_{m,l,k}(t) = \begin{cases} e^{j2\pi \frac{k'}{T_U}(t-\Delta-l\cdot T_S-68\cdot m\cdot T_S)} & (l+68\cdot m)\cdot T_S \le t \le (l+68\cdot m+1)\cdot T_S \\ 0 & \text{else} \end{cases}$$

(2.3)