DIGITAL BASEBAND PROCESSING FOR ULTRA WIDEBAND (UWB) SYSTEM

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Date : 9th May 2008

For my beloved parent and siblings.

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ABSTRACT

This project is build up for digital baseband processing of Ultra Wideband (UWB). Ultra wideband is a wireless technology for transmitting large amounts of digital data over a wide spectrum of frequency bands with very low power for a short distance. Ultra wideband radio not only can carry a huge amount of data over a distance up to 230 feet at very low power (less than 0.5 milliwatts), but has the ability to carry signals through doors and other obstacles that tend to reflect signals at more limited bandwidths and a higher power. Ultra wideband can be compared with another short-distance wireless technology, Bluetooth, which is a standard for connecting handheld wireless devices with other similar devices and with desktop computers. The main objective of this project is to analyze the performance of Ultra Wideband (UWB) system. Then, a transmitter and receiver for the system will be design using Matlab Simulink software. Lastly, the software design in Matlab will be simulate.

ABSTRAK

Projek ini bertujuan untuk membina sebuah sistem pemprosesan isyarat digital untuk *Ultra Wideband (UWB)*. UWB adalah salah satu teknologi tanpa wayar yang digunakan untuk menghantar data melalui frekuensi spektrum yang luas. Ia tidak hanya menghantar maklumat yang banyak melalui jarak melebihi 230 kaki menggunakan kuasa elektrik yang sangat rendah (kurang daripada 0.5 miliwatt), tetapi mempunyai kemampuan untuk membawa isyarat pada jalur lebar yang terhad dan kuasa elektrik yang tinggi. UWB boleh dibandingkan dengan teknologi tanpa wayar berjarak dekat iaitu *Bluetooth*. *Bluetooth* digunakan untuk menghantar maklumat di antara dua atau lebih alat tanpa wayar (contohnya telefon bimbit). Objektif utama projek ini adalah untuk membuat analisis mengenai prestasi sistem UWB. Kemudian, model penghantar dan penerima akan dibina menggunakan perisian Matlab Simulink. Akhir sekali, model-model yang dibina di dalam perisian tersebut akan di simulasi.

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LIST OF ABBREVIATIONS

BPSK	-	Binary Frequency Shift Keying
CE	-	Consumer Electronic
DOT	-	Department of Transportation
DSP	-	Digital Signal Processing
FEC	-	Forward Error Correction
FFT	-	Fast Fourier Transform
FH	-	Frequency Hopping
FHSS	-	Frequency Hopping Spread Spectrum
GFSK	-	Gaussion Frequency Shift Keying
GUI	-	Graphical User Interface
IEEE	-	International Electric Electronic Engineering
ISI	-	Intersymbol Interference
IFFT	-	Inverse Fast Fourier Transform
LAN	-	Local Area Network
NB	-	Narrowband
OEM	-	Original equipment manufacturer
OFDM	-	Orthogonal Frequency Division Multiplexing
PC	-	Personal computer
PDAs	-	Personal Digital Assistants
PHY	-	Physical
QAM	-	Quadrature Amplitude Modulation
QPSK	-	Quadrature Phase Shift Keying
RF	-	Radio Frequency

SS	-	Spread Spectrum
USB	-	Universal series bus
UWB	-	Ultra Wideband
WLAN	-	Wireless Local Area Network
WPAN	-	Wireless Personal Area Network

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CHAPTER 1

INTRODUCTION

This chapter consists of the project background, the objectives and scopes of project, the problem statement, methodology and the work schedule. It will give the overview of the whole project, from the beginning until the implementation part.

1.1 Project Background

Ultra Wideband (UWB) is an exciting new technology that creates a world of opportunities for new wireless applications. UWB technology transmits information by generating radio energy at specific time instants over a large bandwidth. It is ideal for portable multimedia devices because of its inherent low power consumption and high bit rates. UWB is likely to revolutionize the consumer electronic market in the near future such as Wireless USB devices and Wireless communication for High-Definition devices. UWB has the power to eliminate the majority of wires to and from multimedia devices.

In this project, the software for transmitter and receiver baseband processing that uses digital signal processing (DSP) for coding, decoding, modulating and demodulating data will be develop using Matlab Simulink block diagrams. By using

digital signal processing for the radio allows for greater flexibility and accuracy when designing radio system. This project will use QPSK (Quadrature Phase Shift Keying) modulation and will be multiplexed with OFDM (Orthogonal Frequency Division Multiplexing).

1.2 Objectives

A preliminary objective of this project is to build up and gain an understanding of the Ultra Wideband (UWB) signal including the system capabilities and applications. This began with a determination of the salient temporal characteristics of UWB signals that included minimal descriptions of their modulation schemes for data and/or voice. Then, key fundamental aspects of UWB signal behavior were derived from first principles. This provided a basis for identifying what to measure and the effects certain temporal characteristics have on the spectral characteristics.

Then, a Digital Signal Processing for Ultra Wideband (UWB) system will be develop using Matlab Simulink software. In this part, a transmitter and a receiver for this system will be design to analyse the characteristic of UWB signal. The Simulink model is based on the Orthogonal Frequency Division Multiplexing (OFDM).

The final objective is to test the performance of UWB system that had been develop in Matlab Simulink software. The system will be simulating to get the output from the transmitter and receiver.

1.3 *Problem Statement*

Nowadays, communication system required high data rate and faster data transmission with minimum error and losses. Therefore, Ultra Wideband (UWB) System is developing for wireless technology that promises high data rates over short distances and precise location. The main reasons why this project has been creating are its proposed data transfer speeds of 480 Mb/s, its low power consumption while transmitting at these high speeds, and its spatial capacity. UWB is projected at having upwards of 6 devices working simultaneously at 480 Mb/s within a range of 10 m, which is unheard of in today's wireless communications.

1.4 Scope of Work

The scopes of this project are divided into three parts which is study, simulation and testing. The first step is to study about Ultra Wideband (UWB) system and its characteristic through books and journals. The performance of UWB System will be analyse for transmitting large amounts of digital data over a wide spectrum of frequency bands with very low power for a short distance.

Then, it will goes to simulation parts where a transmitter and receiver for baseband processing will be develop by using Matlab Simulink software that uses digital signal processing for coding, decoding, modulating and demodulating data. In this part, there are many types of modulation technique that will be used such as Quadrature Phase Shift Keying (QPSK) and Orthogonal Frequency Division Multiplexing (OFDM).

After completed the build up of UWB system in a Simulink, the software design will be simulate to see its performance. From the output of the transmitter and receiver, the characteristics of UWB signal could be analyze.

1.5 Methodology

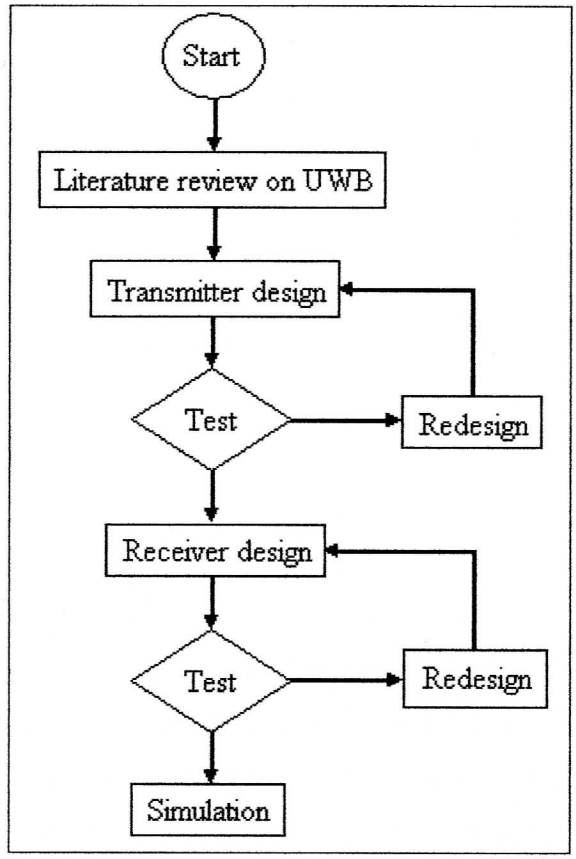

Figure 1.1: Flow Chart of whole project

The flow chart above shows the process of developing Baseband Signal Processing for UWB system using Matlab. Firstly, literatures on UWB are done in order to understand about the performance of UWB system. Then, the transmitter and receiver will be design based on the specifications of UWB. After the software designs are completed, it will be simulate in order to see the characteristics of UWB signal.

CHAPTER II

LITERATURE REVIEW

This chapter will explain in detail about the theory and concept of the project. The main objective is to explain the perspective and method that is used in the research. Besides, this chapter also shows the theory and concept that are being used to overcome the problems that occurred during this project implementation. Understanding the theory is important and will be used as the guideline in doing the research.

2.1 Introduction

Wireless connectivity has enabled a new mobile lifestyle filled with conveniences for mobile computing users. Consumers will soon demand the same conveniences throughout their digital home, connecting their PCs, personal digital recorders, MP3 recorders and players, digital camcorders and digital cameras, gaming systems, personal digital assistants (PDAs), and cell phones, to connect to each other in a wireless personal area network (WPAN) in the home. But today's wireless LAN and WPAN technologies cannot meet the needs of tomorrow's connectivity of such a host of emerging consumer electronic devices that require high bandwidth.

A new technology is needed to meet the needs of high-speed WPANs. Ultra-wideband (UWB) technology offers a solution for the bandwidth, cost, power consumption, and physical size requirements of next-generation consumer electronic devices. UWB enables wireless connectivity with consistent high data rates across multiple devices and PCs within the digital home and the office. This emerging technology provides the high bandwidth that multiple digital video and audio streams require throughout the home. With the support of industry workgroups, such as the wireless universal serial bus (USB) workgroup, and technology leaders, like Intel, UWB technology promises to make it easy to create high speed WPANs that can connect devices throughout the home.

During year 2000, a new technology was coming to the fore-that of Ultra Wideband. The principle of UWB is to transmit short abrupt pulse of radio energy. Because these have sharp transitions in the time domain, they result in a very broad frequency spectrum. One of the key solution purposed resulted in the transmissions that spread over a band from 1 to 3 GHz. Much like CDMA, however, because the information is spread over a wide band, it is possible to transmit at a very low power level and use the processing gain resulting from the excess bandwidth usage to recover the signal from the noise. Hence, the principle of UWB is to transmit in bands already occupied by other transmission but at such a low level that the signal is below the noise floor of the existing devices and thus does not impact their operation. This typically results in transmitted power levels on the order of 50 μW [1].

2.2 Ultra Wideband Technology

UWB differs substantially from conventional narrowband radio frequency (RF) and spread spectrum technologies (SS), such as Bluetooth Technology and 802.11a/g. UWB uses an extremely wide band of RF spectrum to transmit data. Besides that, UWB is able to transmit more data in a given period of time than the more traditional

technologies. Figure 2.1 shows the comparison of narrowband (NB), spread spectrum (SS) and UWB signals concepts.

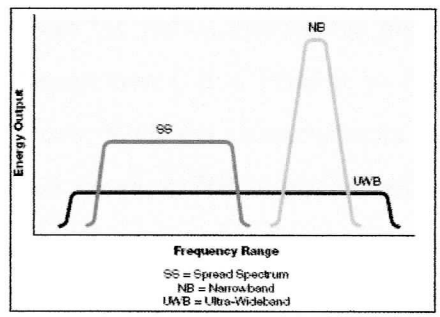

Figure 2.1: Comparison of narrowband (NB), spread spectrum (SS), and ultra-wideband (UWB) signals concepts.

The potential data rate over a given Radio Frequency link is proportional to the bandwidth of the channel and the logarithm of the signal-to-noise ratio (Shannon's Law). RF design engineers typically have little control over the bandwidth parameter, because this is dictated by FCC regulations that stipulate the allowable bandwidth of the signal for a given radio type and application. Bluetooth Technology, 802.11a/g Wi-Fi, cordless phones, and numerous other devices are relegated to the unlicensed frequency bands that are provided at 900 MHz, 2.4 GHz, and 5.1 GHz. Each radio channel is constrained to occupy only a narrow band of frequencies, relative to what is allowed for UWB.

UWB is a unique and new usage of a recently legalized frequency spectrum. UWB radios can use frequencies from 3.1 GHz to 10.6 GHz—a band more than 7 GHz wide. Each radio channel can have a bandwidth of more than 500 MHz, depending on its center frequency. To allow for such a large signal bandwidth, the FCC put in place severe broadcast power restrictions. By doing so, UWB devices can make use of an extremely wide frequency band while not emitting enough energy to be noticed by narrower band devices nearby, such as 802.11a/g radios. This sharing of spectrum