"I/We admit that to have read this report and it has followed the scope and quality in partial fulfillment of requirements for The Bachelor Degree of Electronic Engineering (Computer Engineering)."

(contains numerous grammatical errors)

Signature : .....

Name : MR AMIR BIN ABDUL AZIZ

Date : 23 APRIL 2007

DESIGN AND IMPLEMENTATION OF A USB-BASED DATA ACQUISITION SYSTEM

ZURAIDAH BT MOHD PAHMI

A thesis submitted in fulfillment of the
requirements for the award of the degree of
Electronic Engineering (Computer Engineering)

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

APRIL, 2007

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek	:	**DESIGN AND IMPLEMENTATION OF A USB-BASED DATA ACQUISITION SYSTEM**
Sesi Pengajian	:	**2006/2007**.....

Saya .....**ZURAIDAH BT MOHD PAHMI** .....
(HURUF BESAR)
mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

Alamat Tetap: No 5, Jalan Lim Khoon Huat,
10460 Georgetown,
Penang

Tarikh: 23 APRIL 2007

Tarikh: 23 APRIL 2007

I declare that this thesis entitled "*Design and Implementation of a USB-Based Data Acquisition System*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : ZURAIDAH BT MOHD PAHMI

Date : 23 APRIL 2007

Specially dedicated to
My beloved parents and, sisters who have encouraged, guided and inspired me
throughout my journey of education

ACKNOWLEDGEMENT

Firstly, I want to thank to Allah for blessing me in progress to develop this USB-based data acquisition system. I would like to extend my gratitude and heartfelt to all of the people who helped to make this project a reality, especially my supervisor Mr Amir Shah b Abdul Aziz who shares his time and attention to make sure my project is done with success. I would like to acknowledge the contributions of my colleagues at Universiti Teknikal Malaysia Melaka (UTeM), who contributed to this project. Without their support this project may have not came to fruition. The continued support through all phases by the Faculty of Electronic and Computer Engineering and Mr Sani Irwan b Salim, my beloved friends; Nur Alwani bt Hashim Afzan bt Abd. Jalal, and Nur Asyikin bt Othman were invaluable for the completion of this work. I also would like to express my appreciation to my parent, who gave full executive support to the whole project. There are other thank; namely those with whom I did not have the pleasure of interacting personally, but whose contributions are extremely valuable, nevertheless.

ABSTRACT

'Design and Implementation of a USB (Universal Serial Bus)-Based Data Acquisition System' project requires device measure data at a fixed interval and then sends them to a personal computer (PC) for storage and display. The data acquire may come from an analog-to-digital converter connected to a variable voltage source. This project separated into two parts that are PC which control the software while PIC18F4550 microcontroller controls the hardware. The communication between hardware and software executed when the hardware receive analog input voltage from power supply and USB protocol used to transfer the data to display at the PC as digital display. Since USB connections supply power, only one cable is required to link the data acquisition device to the PC, which most likely has at least one USB port. In addition, the USB's high-speed data transfer (from the data acquisition device to the PC) allows for a real-time display of acquired data, besides eliminating the need for expensive memory in the acquisition device.

ABSTRAK

Projek 'Rekaan dan perlaksanaan system penerimaan data berteraskan USB (bas bersiri umum) memerlukan peranti untuk mengukur data pada sela yang tetap dan menghantar data tersebut ke komputer peribadi (PC) untuk simpanan dan paparan. Data perolehan pada system datang daripada peralihan analog ke digital disambung ke sumber voltage yang berubah. Projek ini dibahagikan kepada dua bahagian iaitu aturcara PC yang mana mengawal perisian manakala PIC18F4550 mikropengawal mengawal perkakasan. Komunikasi antara perkakasan dan perisian dilaksanakan apabila perkakasan menerima voltan masukan analog daripada bekalan kuasa dan protokol USB digunakan untuk memindahkan data bagi dipaparkan pada PC sebagai paparan digital. Disebabkan sambungan USB membekalkan kuasa, hanya satu kabel diperlukan untuk menghubungkan peranti penerimaan data ke PC yang mana berkemungkinan mempunyai lebih dari satu pangkalan USB. Tambahan pula, kelajuan tinggi pemindahan data pada USB (daripada peranti penerimaan data ke PC) membenarkan paparan masa nyata pada perolehan data di samping penghapusan keperluan untuk memori yang mahal dalam penerimaan data.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

PCB	-	Printed Circuit Board
LED	-	Light Emitting Diode
IDE	-	Integrated Development Environment
CPU	-	Central Processing Unit
HID	-	Human Interface Device
PC		Personal Computer
PIC	-	Peripheral Interface Controller
RISC	-	Reduce Instruction Set Computer
ROM	-	Read Only Memory
SIE	-	Serial Interface Engine
USB	-	Universal Serial Bus
ADC	-	Analog to Digital Converter

CHAPTER 1

INTRODUCTION

In this chapter, the meaning of USB will be discussed briefly. The project background, the objectives of the project, the scope of work of this project, methodology and the layout of the thesis will be covered as well.

1.1 BACKGROUND

The objective of this project is to design and implement a basic USB-based data acquisition system. The proposed device will measure data at a fixed interval and then send them to a personal computer (PC) for storage and display. It means that, when the analog input given to the circuit, the circuit communicates with the PC to display output. This project can be adapted to suit many applications such as temperature-monitoring system, water-level-monitoring system and PC-based oscilloscope. This USB device controlled by microcontroller type PIC18F4550 and supported by integrated circuits as driver and other electronic component. The process flow is shown in figure 1.1.

Figure 1.1: Process Flow

1.1.1 USB

Universal Serial Bus is a serial bus standard that is connecting devices usually used to connect peripherals to a PC. USB was designed to replace and improve upon legacy ports such as RS232 serial port and the IBM parallel port. These improvements include offering devices the option to be powered by the host with a maximum power consumption of 500mA per physical connector, plug-and-play support, swappable and the ability to instantly add more USB ports by attaching a USB hub up to a maximum of 127 ports including all hubs, with the root hub also taking up a port. USB is a serial bus which uses 4 shielded wires that are two for power like +5v and GND, and two differential data signals which is labeled as D+ and D- in pin out. In USB data cable Data+ and Data- signals are transmitted on a twisted pair. No termination needed. Half-duplex differential signaling helps to combat the effects of electromagnetic noise on longer lines.

1.2 OBJECTIVES

1) To study all aspects of the USB protocol and focus on one type of microcontroller which is the USB-enabled PIC18F4550).
2) To design and implement both the hardware and software (PC and microcontroller) required to realize a USB-based data acquisition system.

1.3 PROBLEM STATEMENT

There are many instances in which data (e.g. temperature, water level, pressure etc) need to be measured, manipulated, and displayed. It is proposed here to take advantage of the extended capabilities of a modern PC to handle all data manipulation (e.g. storage, calculation, display etc) tasks. This will simplify the need of external hardware to simple data measurement circuitry. Ideally, the external hardware will need to send the measured data to a pc via a well-defined protocol. Here, it is to propose the USB protocol for such data transfers.

USB is ideal for data acquisition applications. Since USB connections supply power, only one cable is required to link the data acquisition device to the PC, which most likely has at least one USB port. In addition, the USB's high-speed data transfer (from the data acquisition device to the PC) allows for a real-time display of acquired data, while eliminating the need for expensive memory in the acquisition device. USB finally makes installation of peripherals hassle-free because it provides true plug-and-play and hot swapping. In fact, connecting peripherals is as simple as plugging in a lamp. Once plugged in, the device is ready to run. USB makes it easy for a developer of PC-based test systems to create a work cell network of measurement instruments without having to resort to complex data communication of hardware and software. This lowers the time and cost of integrating different sensors, instruments and related devices into a highly flexible data acquisition system.

USB delivers an inexpensive, easy-to-use connection between data acquisition devices/instruments and PCs. Manufactured PCs are currently equipped with USB ports; therefore it is not necessary to purchase a dedicated controller to interface to a USB-based data acquisition device or instrument. USB provides an alternative to traditional computer bus technologies such as PCI, PXI or FireWire by featuring plug-and-play

functionality, built-in operating system configuration and multi-drop cabling which allows user to connect multiple devices from the same port.

1.4 SCOPES OF WORK

The requirement of this project is to allow the PC to display output via communication with the circuit through given inputs. This project can be divide into two parts such personal computer (PC) programming and PIC microcontroller programming. PC programming will include data storage (e.g. database programming) USB-based communication. PIC programming, data will concern internal analog-digital converter (ADC) programming that is for PC display data in digital output, interfacing to PC display, timer/interrupt programming and USB-based communication for PIC-PIC communicating.

1.5 METHOD OF PROJECT

Before starting the project, literature reviews are conducted on PICs and USB was found as the reference. Besides that, the supervisor also had given the review of PC programming, including USB programming for the project briefing. Then, the review of PIC programming, including internal ADC, USB interfacing and timer/interrupt programming had been making. Later a simple USB-based Human Interface Device (HID) based on Microchip's example and a simple voltage measurement and display board had been realizing. After that, an addition of timer/interrupt programming to control measurement interval (sampling rate) had been making. Simple PC software needs to realize to accept data via USB and display them. Then, an addition of USB programming had done to measurement board to send measured data to PC and addition of advanced features to PC software (data storage, data display etc). Lastly the system integrated and tested before thesis writing.

1.6 LAYOUT OF THESIS

This thesis basically discuss on the construction of the USB-based data acquisition system. Chapter one will discuss on the project introduction. Chapter two will discuss on literature reviews. Chapter three focus on the hardware and software development of project. Chapter four explains on the result and analysis. The conclusion and recommendation of this thesis will be described in the last chapter.

CHAPTER II

LITERATURE REVIEW

This chapter focuses on the related field and knowledge pertaining to the accomplishment of the thesis. Source of information include reference books, papers, journal articles, websites, conference articles and documentations regarding applications and research works.

2.1 INTRODUCTION

USB-based data acquisition system refers to three elements; PIC microcontroller USB and PC display. PIC microcontroller is the main elements. The type of PIC microcontroller used is PIC18F4550. Type of USB port used is 4 pin USB type B. PIC microcontroller as the circuit that accept analog input and use USB type B as connector to display output in PC in digital output.

2.2 WHAT IS PIC?

PIC is a family of RISC microcontrollers made by Microchip Technology [1]. It derived from the PIC1650 which is originally developed by General Instrument's Microelectronics Division.

Microchip Technology does not use PIC as an acronym; in fact the brand name is PICmicro. It is generally regarded that PIC stands for Peripheral Interface Controller, although General Instruments' original acronym for the PIC1650 was "Programmable Intelligent Computer". The original PIC was built to be used with GI's new 16-bit CPU, the CP1600. While generally a good CPU, the CP1600 had poor I/O performance, and the 8-bit PIC was developed in 1975 to improve performance of the overall system by offloading I/O tasks from the CPU. The PIC used simple microcode stored in ROM to perform its tasks, and although the term wasn't used at the time, it is a RISC design that runs one instruction per cycle (4 oscillator cycles).

2.3 WHY USE A MICROCONTROLLER?

Microcontrollers are inexpensive. It is able to store and run programs, making it extremely versatile. For example, a microcontroller can be program to perform functions based on the predetermined situations (I/O line logic) and selections. The microcontroller's ability to perform math and logic functions allows it to mimic sophisticated logic and electronic circuit.

Some programs can make the microcontroller behave like a neutral circuit or a fuzzy logic controller. Microcontroller is responsible for the "intelligence" in the smartest devices in market. There are literally hundreds of microcontrollers are on the market. Listed here are some of the popular 8-bit microcontroller and their features. The following is a list of the lowest cost representative devices from respective manufactures.

COMPANY	DEVICE	ON-CHIP MEMORY	OTHER FEATURES
Atmel	Attiny II	1-kbyte	8-bit timer, analog comparator, watchdog, onchip oscillators, one external interrupt.
Hitachi	H8/3640	8-kbyte ROM 512 Byte RAM	Three, 8-bit timers, one 16-bit PWM timer, one watchdog, two SCI ports, 8-bit ADC, 32kHz sub clock generator.
Microchip	PICR54C	768-byte ROM 25-byte RAM	Twelve I/O pins, 8-bit timer, high current sink/source for direct LED drive, watchdog, timer RC oscillator.
Motorola	68HC705KJ1	1240-byte OTP 64-byte RAM	15-stage multifunction timer, on-chip oscillator, low voltage reset, watchdog, keyboard, interrupt, high current I/O port.
Zilog	28E00	0.5-kbyte OTP 32-byte RAM	One 16-bit timer, Watchdog, four interrupts, 13 I/O pins

Table 2.1: Some 8-bit microcontrollers and their features [2]