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PC based oscilloscopes by using PIC (sofware) / Mohd Hanif Mohd Noor.

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FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : **PC BASED OSCILLOSCOPE BY USING PIC (SOFTWARE)**

Sesi Pengajian : **2006/07**

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PC BASED OSCILLOSCOPE BY USING PIC (SOFTWARE)

MOHD HANIF BIN MOHD NOOR

This Report Is Submitted In Partial Fulfillment Of Requirements For The Bachelor Degree of Electronic Engineering (Computer Engineering).

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka

April 2007

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DECLARATION

"I hereby declare that this report is result of my own effort except for works that have been cited clearly in the references."

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Name : Mohd Hanif Bin Mohd Noor

Date : 4 Mei 2007

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Signature : .....

Supervisor's name : Norhashimah Bt Mohd Saad

Date : 4 Mei 2007

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DEDICATION

For my beloved parents and for your advice and teach;
brothers and sisters for your supports;
friends and colleagues for the helps and attentions;
lecturers in Faculty of Electronics and Computer Engineering
Universiti Teknikal Malaysia Melaka (UteM)
for the all of the knowledge given.

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ACKNOWLEDGEMENT

First of all, I would like to thank Allah the All Mighty, which with his bless, I manage to complete this thesis. I want to say thank you to my supervisor, Miss Norhashimah Bt Mohd Saad. I am especially grateful to my father, mother and members of my family, for all their support and understanding along my study.

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.

There are other thank for my friend Mohd Hafiz for help and idea and all namely those with whom I did not have the pleasure of interacting personally, but whose contributions are extremely valuable, nevertheless.

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ABSTRAK

Projek ini dilakukan adalah untuk mencapai kefungsian yang sama seperti sebuah osiloskop, ia menggunakan satu mikropengawal PIC untuk pemerolehan data (termasuk analog litar) yang memindahkan data dari luar untuk dipaparkan di dalam komputer (melalui RS232). Ia dikenali sebagai osiloskop digital. Dengan menggunakan aplikasi perisian Visual Basic 6.0 ia boleh memaparkan bentuk gelombang seperti kelihatan di dalam sebuah osiloskop yang sebenar. Aplikasi perisian ini mempunyai beberapa ciri-ciri tambahan yang tidak terdapat di dalam sebuah osiloskop yang sebenar ia juga mempunyai ciri – ciri yang fleksibel untuk tambahan di dalam aplikasi perisian ini bagi meningkatkan lagi keupayaannya tanpa menggunakan perkakasan yang lain. Osiloskop digital ini mempamerkan gelombang berfrekuensi rendah dalam masa nyata. Bacaan yang telah dipaparkan akan disimpan di dalam pengelog data.

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ABSTRACT

This project attempts to achieve the same functionality as a traditional oscilloscope, using a PIC microcontroller for data acquisition (including appropriate analogue circuitry) which transfers the data to the PC (via RS232). A Visual Basic 6.0 based software application will then display the waveform as it would appear on a traditional CRT oscilloscope. This software application will have additional features not present on a traditional oscilloscope with greater flexibly as additional features can be added as their developed without the need for new hardware. The digital based oscilloscope should display very low frequency waveforms in real-time. Value that had been shown will be store in data logger.

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CHAPTER 1

INTRODUCTION

1.1 HISTORY OF OSCILLOSCOPE

Oscilloscopes traditionally are hardware based using a CRT (Cathode Ray Tube) designed to display voltage variations (periodic or otherwise); they are bulky, expensive and have difficultly displaying low frequency waveforms.

"The word 'Oscilloscope' is an etymological hybrid. The first part derives from the Latin 'oscillare', to swingbackwards and forwards; this in turn is from, 'oscillum', a little mask of Bacchus hung from the trees, especially in vineyards, and thus easily moved by the wind. The second part comes from the Classical Greek 'skopein', to observe, aim at, examine, from which developed the Latin ending 'scopium', which has been used to form names for instruments that enable the eye or ear to make observations." [1].

The heart of the traditionally CRT oscilloscope is the display screen itself, the CRT. "The CRT is a glass bulb which has had the air removed and then been sealed with a vacuum inside. At the front is a flat glass screen which is coated inside with a phosphor material. This phosphor will glow when struck by the fast moving electronics and produce light, emitted from the front and forming the spot and hence the trace. The rear of the CRT contains the electron 'gun' assembly. A small heater element is contained within a cylinder of metal called the cathode. When the heater is activated by applying a voltage across it, the cathode temperature rises and it then emits a stream of electrons." [2].

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This project attempts to achieve the same functionality as a traditional oscilloscope, using a PIC microcontroller for data acquisition (including appropriate analogue circuitry) which transfers the data to the PC (possibly via RS232, USB or Parallel). A Microsoft Windows based software application will then display the waveform as it would appear on a traditional CRT oscilloscope. This software application will have additional features not present on a traditional oscilloscope (e.g. printing / saving waveforms) with greater flexibly as additional features can be added as their developed without the need for new hardware.

The digital based oscilloscope should display very low frequency waveforms in real-time, but for higher frequency waveforms it is necessary to read a finite number of samples storing them into RAM. Once the memory is full (or the preset number of samples has been reached) the PIC will stop sampling and transfer the data to the PC, when ACK (acknowledgment) is received from the PC the PIC will start sampling again. This is known as a "Storage Oscilloscope", but there are disadvantages e.g. it's impossible to continuously monitor a waveform in real-time for more than the amount of samples that can be stored into the buffer as there would be gaps in the data.[4]

Digital storage oscilloscopes have two main advantages over traditional analogue scopes: -

i. The ability to observe slow and very slow signals as a solid presentation on the screen. "Slow moving signals in the 10-100 Hz range are difficult to see and measure on a normal analogue oscilloscope due to the flicker of the trace and the short persistence of the spot on the screen. Very slow moving signals, less than 10 Hz, are impossible to view on an analogue scope. As fast as the spot traces out the waveform, the image fades and disappears before a complete picture can be formed." [2].

ii. The ability to hold or retain a signal in memory for long periods. The PIC microcontroller has a built-in ADC (8, 10 or 12 bits) which has a voltage range of 0 to 5V. This voltage range is not ideal as most oscilloscopes have a much wider voltage range including negative voltages (e.g. -100

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to 100V); hence an analogue circuit is required to reduce the voltage positive signals so they fall between 2.5 and 5V and voltage negative signals between 0 and 2.5V (i.e. bipolar). The built-in ADC on the PIC is slow and will limit the maximum sampling frequency; hence an external Flash ADC with direct memory access will be required to produce a high-performance digital storage oscilloscope (e.g. AD9070 – 10Bit, 100MSPS ADC).

There are commercial digital scopes, but they are expensive and have small displays (unless they have video outputs or are based on PC displays).

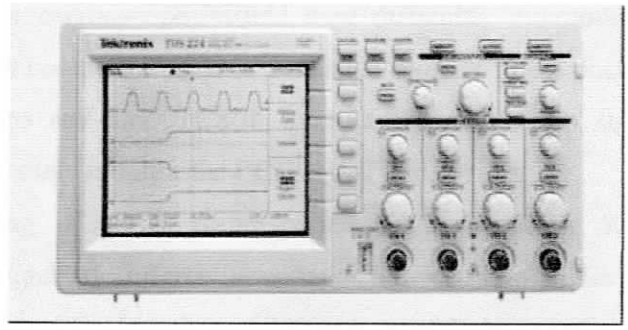

Figure 1.0 100Mhz Channel Digital Storage Oscilloscope

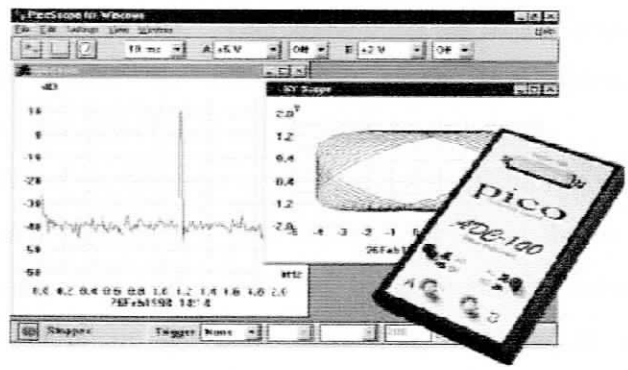

Figure 1.1 100 kHz Dual Channel PC based storage oscilloscope

Advantages of the PC based oscilloscope: -

i. Large screen using data projector for demonstration purposes.
ii. All Windows / GUI advantage such as cut & paste into documents.
iii. Data logging (e.g. streaming real-time data to disk).

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iv. Remote monitoring (e.g. via the internet remotely control / view the oscilloscope from any where in the world).

v. Low cost (expected to be less than RM50).

vi. Software upgradeable.

There are many possible applications for this PC based oscilloscope: -

i. Monitoring of sound waves, which are difficult to monitor on a traditional oscilloscope due to the low frequencies involved.

ii. Monitoring of an ECG signal, again because this is such a low frequency traditional oscilloscopes would have difficultly monitoring such a signal. ECG data could be logged and emailed directly to the doctor for diagnosis, or perhaps real-time TCP/IP internet communication so that the doctor could remotely monitor the ECG signal in real-time.

iii. Monitoring of serial communications, for example RS232 works on the principal of differential voltages between two cables twisted together; hence the PC based oscilloscope could be used to view serial communications. Two oscilloscope channels would be used, and the PC software will automatically add the two channels together producing a virtual trace (A+B). This monitoring of serial communication is extremely useful for educational usage (e.g. learning how serial data is transmitted).[1]

iv. The PC based oscilloscope is ideal for demonstration purposes, for example using data projector a class of student could be introduced to the oscilloscope, with real waveforms being monitored (signal generator, or even a microphone for sound waves) and displayed on a large projector display.

v. Because of the low cost of the PC based oscilloscope, it is economical for a school / technical college to have large quantities available for students. Unlike traditional analogue scopes which are expensive and students are forced to share equipment, because it is not economical to purchase enough scopes for every student.

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1.2 OBJECTIVE

i. To ease the used of oscilloscope.
ii. To take signal from outside and see the output to be analyzed.
iii. To replace computer as an oscilloscope
iv. To ensure that the hardware and the software can be communicate by using interface.
v. To manipulate signal in certain shape into computer.

1.3 SCOPES OF WORK

The scope of work of this project is concentrates to software. Visual Basic 6.0 is use in this project as the software to develop the graphic user interface (GUI). This GUI is also made to ensure that it will work as real oscilloscope included all the function that usually by user. For example; each button must have its own function. Briefly, the system contained many stages of operations necessary in a successful model. In this project also have data logger. Data logger is an electronic instrument that records measurements (temperature, relative humidity, light intensity, on/off, open/closed, voltage, pressure and events) over time. Typically, data loggers are small, battery-powered devices that are equipped with a microprocessor, data storage and sensor. Most data loggers utilize turn-key software on a personal computer to initiate the logger and view the collected data. First of all, the system contained an external circuit layout that was used to do the Analog to Digital converting, the Digital to Analog scaling, the clocking, and the aliasing detection. The other stages are internal to the computer, such as; the I/O card interface, and the Visual Basic programming which displayed the data. In this write up we will be describing all the necessary components and how they are implemented into the system functions. We will also be describing the system software and the necessary program that allows the computer to interface with the external circuit. Finally, we will give a description of the background information we received from a local company, stating the current marketing digital oscilloscope that operates on the personal computer.

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1.3.1 Hardware Design

For hardware part, first method is making some researches to find suitable hardware by surfing internet. The researches about the information and data about the hardware will be done and make sure that hardware is suitable, available and also low cost. The purpose of this project is to design, built and test a low-cost PC-based digital real-time / storage oscilloscope. The main reasoning behind hardware development was to keep the hardware cost to an absolute minimum.

It was decided to use the PIC16F877 (flash version), "The PIC16F877 is a high-performance FLASH microcontroller that provides engineers with the highest design flexibility possible. In addition to 8192x14 words of FLASH program memory, 256 data memory bytes, and 368 bytes of user RAM, PIC16F877 also features an integrated 8-channel 10-bit Analogue-to-Digital converter. Peripherals include two 8-bit timers, one 16-bit timer, a Watchdog timer, Brown-Out-Reset (BOR), In-Circuit-Serial Programming™, RS-485 type USART for multi-drop data acquisition applications, and I2C™ or SPI™ communications capability for peripheral expansion. Precision timing interfaces are accommodated through two CCP modules and two PWM modules. But in this project, only use 2-channel.

1.3.2 Software Development

For software part, the design of the interface part on PC's monitor is develop by using Visual Basic and then programmed by programming language. Besides that, the writing of the Visual Basic programming language must follow to the specification of the hardware part. Finally, the integration of the hardware and software part will be implementing so that it will produce a complete model of Digital PC Oscilloscope. The data will be directed to the monitor of the PC and will reproduce a wave form that represents the signal.

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CHAPTER 2

LITERARUTE REVIEW

2.1 BACKGROUND STUDY

Design and construct the hardware required for data acquisition, including analogue circuit design for insuring input voltage falls between 0 and 5V (ADC min and max range). Pick a transport medium for relaying data to the PC (USB, RS232, parallel or PCI) and discuss the advantages, disadvantages and the reasons why it was picked. Design and construct the hardware required (e.g. MAX232, etc...) to interface the PIC microcontroller with the chosen medium. Design a communication protocol for relaying data from the PIC to the PC in real-time (perhaps including a check-sum or CRC). Discuss the advantages and disadvantages of using a check-sum or CRC in this real-time mode. Design a Windows based C++ application capable of displaying low-frequency waveforms (up-to 2 channels simultaneously <5 KHz) in real-time (i.e. the graphic subsystem). This application should directly communicate with the PIC using the chosen transport medium. The application must be user- friendly and should be Windows 95/98/NT/ME/2000/XP compatible. Design PIC embedded software for reading the ADC at a certain sample rate and transferring the data to the PC in real-time. A basic simulation program for simulating the PIC microcontroller, allowing the communication protocol to be tested before the hardware has been constructed. This simulation program should be able to simulate a waveform at an adjustable frequency, hence making it possible to easily test the graphic display and triggering methods in the windows based oscilloscope program. Demonstrate the entire system working together as a basic real-time low-frequency oscilloscope (<5KHz).

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2.2 OSILLOSCOPE

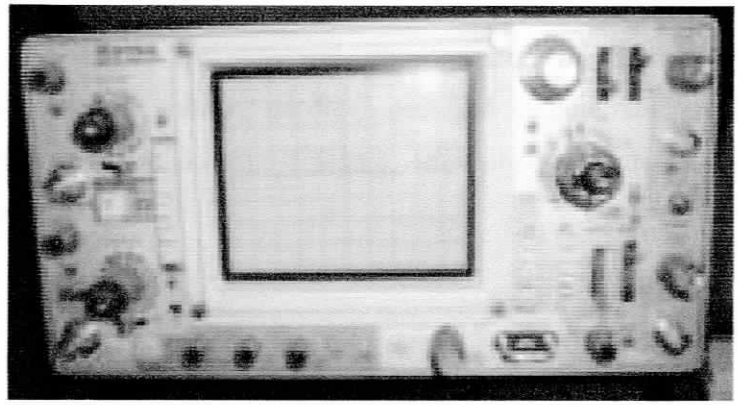

Figure 2.0 Traditional Oscilloscope

Oscilloscope is an electronic measuring instrument which produces a display showing the relationship of two or more variables. In most cases it is an orthogonal (*x*,*y*) plot with the horizontal axis being a linear function of time. The vertical axis is normally a linear function of voltage at the signal input terminal of the instrument. Because transducers of many types are available to convert almost any physical phenomenon into a corresponding voltage, the oscilloscope is a very versatile tool that is useful for many forms of physical investigation. Oscilloscopes are one of the most widely used electronic instruments because they provide easily understood displays of electrical waveforms and are capable of making measurements over an extremely wide range of voltage and time. Although a very large number of analog oscilloscopes are in use, digitizing oscilloscopes (also known as digital oscilloscopes or digital storage oscilloscopes) are preferred, and analog instruments are likely to be superseded. In its simplest form a digitizing oscilloscope comprises six elements:

i. Analog vertical input amplifier;
ii. High-speed analog-to-digital converter and digital waveform memory
iii. Time base, including triggering and clock drive for the analog-to-digital converter and waveform memory;
iv. Waveform reconstruction and display circuits
v. Display, generally, but not restricted to, a cathode-ray tube
vi. Power supplies and ancillary functions.

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In addition, most digitizing oscilloscopes provide facilities for further manipulation of waveforms prior to display, for direct measurements of waveform parameters, and for connection to external devices such as computers and hard-copy units. Because almost any physical phenomenon can be converted into a corresponding electric voltage, oscilloscopes find commercial, engineering, and scientific applications in acoustic research, television-production engineering, and electronics design.

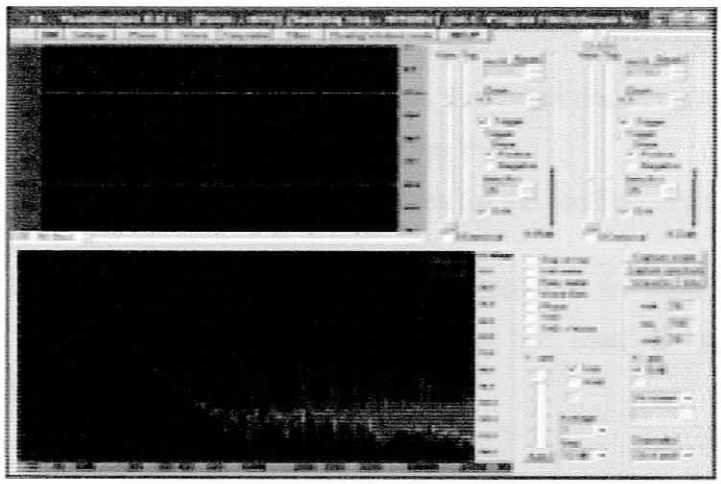

Figure 2.1 Digital PC Oscilloscope

Digital PC Oscilloscope is a new type of "oscilloscope" is emerging that consists of an external analogue-to-digital converter (sometimes with its own memory and perhaps even some data-processing ability) connected to a PC that provides the display, control interface, disc storage, networking and often the electrical power. The viability of these so-called PC-based oscilloscopes depends on the current widespread use and low cost of standardized PCs. This makes the instruments particularly suitable for the educational market, where PCs are commonplace but equipment budgets are often low.

The advantages of PC-based oscilloscopes include:

i. Lower cost (assuming the user already owns a PC).
ii. Easy exporting of data to standard PC software such as spreadsheets and word processors.

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