DIGITAL TACHOMETER

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NOVEMBER 2005

"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : ....

Supervisor : EN.ABDUL RAHIM BIN ABDULLAH

Date : 9 NOVEMBER 2005

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Fakulti Kejuruteraan Elektrik
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NOVEMBER 2005

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references"

Signature : ....

Student : YUSLIZA BINTI ISMAIL

Date : 9 NOVEMBER 2005

Special dedicated to my family..

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ABSTRACT

This project is about digital tachometer. Tachometers are used to measure the velocity or speed of a rotating object in RPMs. Compares to analog system, digital is more accurate and easy to read the measurements as display on the screen. PIC microcontrollers from Microchip was use in this digital tachometer project. The main part of this project is encoding and decoding the digital signals. This problem makes it desirable to use a microprocessor, since the data registers can be use to store and parse the digital values at appropriate times. PIC16F877A has been chosen as a central processing unit in this project. This digital tachometer uses infra red sensors to detect the speed of motor and then the signal will be sent to the PIC. Next, the value will be display by 7 segments LED display. Using serial port connection, this tachometer can be connected to the computer and the value then can be display on the computer by Microsoft Visual Basic 6.0. At the end of this project, after implemented the hardware, the troubleshooting is the most important action that must be taken in order to achieve the objective of this project.

ABSTRAK

Projek ini adalah mengenai tachometer digital. Seperti yang kita tahu, tachometer digunakan untuk mengukur kelajuan motor yang berputar dalam unit RPM. Jika dibandingkan dengan sistem analog, system digital adalah lebih tepat dan mudah untuk dibaca nilai pengukurannya pada skrin. *Microcontroller* keluaran Microchip akan digunakan dalam projek ini. Bahagian utama projek ini adalah proses *encode* dan *decode* signal digital. Masalah ini memerlukan projek ini menggunakan *microprocessor* memandangkan *data register* boleh digunakan untuk menyimpan dan menghuraikan nilai digital pada masa yang sesuai. PIC16F877A telah dipilih sebagai unit pemproses utama dalam projek ini. Tachometer digital ini menggunakan sensor infra merah untuk mengesan kelajuan motor dan seterusnya signal dari sensor akan dihantar ke PIC untuk diproses. Setelah itu nilai bacaan kelajuan akan dapat dipaparkan menggunakan paparan LED 7 segemen. Dengan menggunakan sambungan serial port, tachometer ini akan dapat disambungkan ke komputer dan bacaan kelajuan juga akan dapat dipaparkan di komputer dengan menggunakan perisian Microsoft Visual Basic 6.0. Di akhir projek, setelah perkakasan disiapkan, *troubleshooting* adalah langkah penting yang perlu diambil bagi mencapai objektif projek.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 DIGITAL TACHOMETER

As we know, tachometers are the instrument that indicates the speed, usually in revolutions per minute (rpm), at which an engine shaft or motor, is rotating. Some tachometers, especially those used in automobiles, are similar in construction and operation to automotive speedometers. Other types, often connected directly to the shaft whose speed they indicate, are small electric generators whose output voltage is proportional to speed. This voltage is applied to a voltmeter whose dial is calibrated in speed units. Another type, it used only with engines having an ignition system, operates by counting the pulsations of current or voltage in the ignition system, the number of these being proportional to the speed of the shaft.

There are two types of tachometer in the market which is analog and digital tachometer. In this case, digital tachometer has been chosen as a title of project because compares to analog system, digital is more accurate and easy to read the measurements as display on the screen. Digital tachometer is an optical encoder that determines angular of velocity of a rotating shaft or motors. Nowadays, although there are many tachometers in the market, but this one has its own advantage.

1.2 OBJECTIVES AND PROJECT SCOPE

The main objective and aim of this project is to measure the speed of the motor in RPMs. Besides, the objective for this project is to construct a digital tachometer using PIC microcontroller system and also to display the reading of the measurement using 7 segment LED display.

With use other connection, the tachometer will be connected to the computer and being expect to display the reading and all the results on the computer and read by a real time. Furthermore, with doing this project we can understand more about programming of PIC.

The scopes for this project are:

- It can measure the velocity or speed of the motor only.
- PIC 16F877 will be used and the Visual Basic 6.0 programmer is important to display all the results at the computer.
- All the reading will be displayed using 7 segment LED display.
- The tachometer will be connected to the computer by using serial port.

1.3 REPORT OUTLINE

In this project report there have 5 chapters altogether. Chapter 1 gives some brief introduction about this project and also the objectives and scope of this project. This chapter also include the report outline for this project, project background and also some problems statement of this project.

The literature review in order to get an idea about the project will be discussed in chapter 2. In this chapter, it reviews the related works that have been done by other people all over the world.

Then in chapter 3 it consists five main sections where this chapter is the main part of this report. The four main sections are:

a. Project Design
b. Circuit Design
c. Programming PIC
d. Hardware implementation
e. Testing and troubleshooting

Chapter 4 brings further discussion about the project, the results and also analysis based on the results.

In chapter 5, it gives the conclusion about the project that has been done.

1.4 PROJECT BACKGROUND

Chapter 1 provides necessary background of this project such as the controller specifications and the basic principal of PIC microcontroller. A brief introduction to the concept of application is given to provide basic understanding of the project.

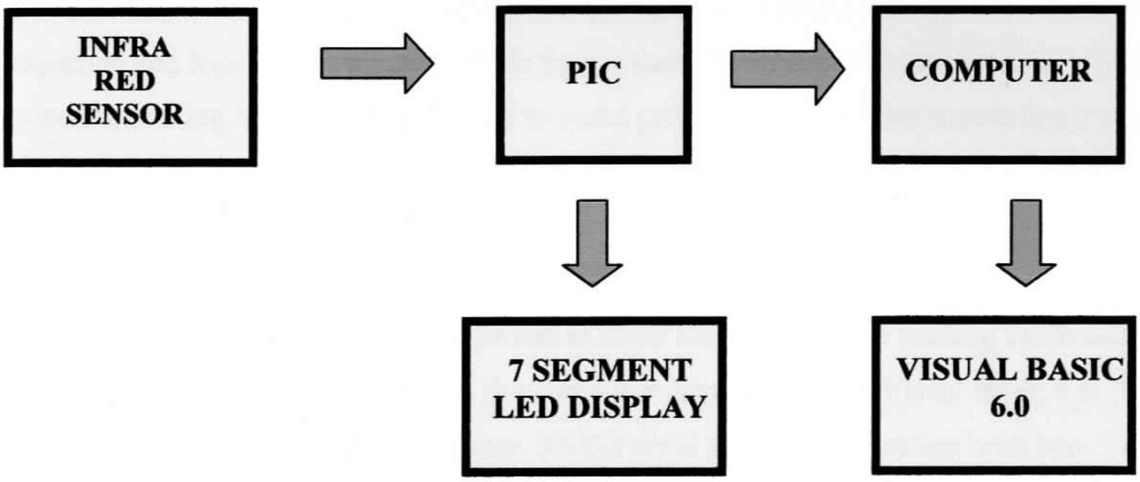

Figure 1.1: Block Diagram for Digital Tachometer Project

The main part of this project is encoding and decoding the digital signals. This problem makes it desirable to use a microprocessor, since the data registers can be use to store and parse the digital values at appropriate times. For instance, to transmit a series of digital ones and zeros, several registers can be loaded with the entire code and shifted out of the registers as the code is transmitted. In addition, the speed of modern microprocessors eases timing issues, and the flexibility of software.

Infra red sensor is being use to detect the speed of the motor. It consists of transmitter and receiver. Infra red sensor circuit is quite simple, easy to understand and also cheaper than other types of sensor. The transmitter circuit in the sensor will get the signal and then transmit it to the receiver. After the receiver receives the signal from the transmitter, the signal will be sent to controller part for the next process.

The controller part or we call this as microcontroller functions as the brain of the system. In this system, the controller part or the central processing unit is PIC16F877A. It processes all the input from the sensor and provides an appropriate output based on the sequence and logic of the program made by the user. It controls everything in the whole system including its own visual display to make programmed and give instruction to the controller.

In this project, it has been expected to show the results or the reading value using 7 segment LED display and also on the computer using Microsoft Visual Basic 6.0. To connect this tachometer to the computer, RS232 serial port connection has been use.
RS 232 can be defining as a series data transfer from one point to another. It simple, easy to understand and universal.

When the tachometer has successfully connected, the reading for the speed of motor can be shown on the screen using Microsoft Visual Basic 6.0. To display this reading, Visual Basic 6.0 programming must be build.

1.5 PROBLEM STATEMENT

Normally in life there is some problem that occur and the solution sometime need us to create a new project. As we know there are many tachometers in the market nowadays. Each tachometer has its own advantages but it is hard to modify them so with doing this project we can modify the tachometer according to demand.

For instance, if we want to collect and keep the data speed of the motor, we can only take the reading manually. So with this project, the data speed will not be taking manually anymore. We can directly connect the tachometer to the computer and save all the reading value.

But the reading that will be display using 7 segment LED display perhaps will get some error compare to the reading that show on the computer.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews existing project created to get an idea about the project design, conception and any information that related to improve the project. There are many tachometer projects that have been done by other people with differences concept and design.

The early design tachometer is based on the principle of the monostable multivibrator, which has one stable state and one quasistable state. The circuit is normally in the stable state, producing no output. However, when a triggering current pulse from the ignition system is received, the circuit transitions to the quasistable state for a given time before returning again to the stable state.

In this way, each ignition pulse produces a clean pulse of fixed duration that is fed to the gauge mechanism. The more such fixed duration pulses the gauge receives per second, the higher it reads. The monostable multivibrator is still used in tachometers today, although the tendency is to use voltage pulses rather than current pulses, the latter requiring that the ignition coil current passes through the tachometer on its way to the coils.

The late design tachometer was in no way an improvement on the early type, indeed the change seems to have been made to save money. Integrated Circuits (IC's) were in their infancy in the late 1960's and were both expensive and not proven to be robust in automobile applications. While a very sophisticated monostable multivibrator can now be bought for a few pennies as an IC, Smith's Industries chose to use discreet components in the MGB tachometers. The early design used 17 components but this was changed in the late tachometer to a far inferior circuit using just 7 components. The late design tachometer was never intended for use in positive ground vehicles.

In 1998, Andrew Huang in his project took advantage of the integrated timing unit (ITU) feature of the SH-1 to determine the duration between ignition pulses in the engine of his Toyota Corolla. From this number, it is easy to derive the number of RPMs. The signal from the engine is taken off the ignition diagnostic port, found near the driver's side shock absorber housing in the engine compartment. That signal is a 12V p-p nominal square wave with ignition occurring on the rising edges.

The two cautions when using this signal are that there are 400V spikes on the rising edge, and that grounding this signal is potentially very damaging to the ignitor. He use an opto-isolator to help protect against the spikes, and carefully routed the wire and shorting the ignition to ground. On the back end of the opto-isolator, he uses a TTL buffer to provide a little extra protection in case the opto-isolator breaks down. Note that the engine makes one revolution every two ignition pulses.

Steves on his website *www.geocities.com/steves_workshopwas/tachometer.htm,* has created a tachometer that only made from the electronic kits. The display unit for the tachometer has only 2 digits and in the ordinary way it will display on hundreds and thousands of revolutions. The times 10 converter simply gives 10 pulses per revolution and enables the same equipment to display tens and hundreds of revolutions without complicating the electronics.

In his project, Steves uses an infra-red transceiver/receiver which is mounted on a magnetic base and is angle adjustable to enable a good signal to be established. To get more accurate reading, he use the x10 converter with his Stirling engine.

From the website ***www.geocities.com/sourabhbiyani/digital_tachometer.htm,*** Sourabh Biyani has built a tachometer and developed measures the speed of the motor in RPM and displays it over 3½-digit display. He also uses the infra red sensor to get the pulses. However, to calculate the output from the sensor, Biyani uses IC 74C925 in his project. He also uses IC 4029B with other circuit to reset and set the IC 74C925 to 0. When the IC is reset the count is initialized to zero and the counting continues for 10 second in the background. In front the counter displays the previously counted signal as it is now latched. Thus in every 10 second, the display changes if there is any change in the RPM of the rotating shaft.

Another Steve, through his website *http://www.steveonweb.com/index* uses his simple tachometer design while developing the Object Avoidance Detector. He uses an infra red LED that is oscillated at a frequency of 38 khz pointed at the propeller. When the propeller passes in front of the IR Led then the light is reflected back to the detector which brings the output voltage low. As the propeller blade passes away from the LED light is no longer reflected back to the sensor so the output voltage goes high. He count the pulses over a certain time period, and then divide the number of counts by the time. Since the sensor is counting two blades the number needs to be divided by two to get the engine speed.

Tan Van Nguyen said, although we can use an analog tachometer, the digital one cost less, performs better, less sensitive to temperature and implements easier in a custom IC. His design's tachometer controls the actuator for the heads of an optical-disk drive. But the principle also applies to other motor-control applications.

Eelke Visser also had created a digital tachometer. For his tachometer, he wanted to update the display every quarter of a second. To reduce errors he measured during an interval of about 0.25 seconds. In this interval the time is measured from the first to the last pulse, and the amount of pulses is counted. The number of pulses measured is counted from zero. The formula he used to calculate the rpm is:

RPM = 30000000 * number_of_pulses_measured / time from first to last pulse

The 30000000 is actually 30 * 1000000. The 1000000 is because the time is in measured microseconds. He show the amount of revolutions per minute (RPM). Therefore, he have to multiply the frequency (=1/time) with 60. However, a 4 cylinder 4 stroke engine ignites twice a revolution so get 60/2=30. Putting it all together gives the formula. This number is put on the display.

Jim McGhee was constructed a digital tachometer for his son's 1999 Ford F150 XL pickup truck. The Tachometer was installed in March of 2001 and had a program update (firmware) in October of 2001. It was built using PIC16C715, MAX7219 for LED display driver and also two Micrel MIC4574 voltage regulators. It also had LM34CZ temperature sensor for internal temperature readout.

Josepino also create a tachometer using PIC16F628. He mention about the sensor that can be use such as optical sensors and magnetic or using a switch. He informs that high voltages can damage the PIC. If the input signal is more than 5 Volts, he suggests using a driver as TTL, CMOS, Amp Operational or transistors.

Embed engineers had designed a tachometer too. They had designed a high impedance, low power analog circuit to produce a clean digital pulse when a magnet or sensing cog passed by the sensor. The circuit operated from 1/2 Hz at 20mm to over 10 KHz at 1mm. For their project, a Microchip PIC16C932 was used to capture the pulses, measure the period between them and invert the data to obtain speed. The result for the tachometer was displayed on a directly-driven 4 digit LCD display and the system is could be configured via DIP switches to the number of pulses per shaft rotation, and the desired output units (RPM, Hz, etc). An integrating mode could display accumulated shaft rotations instead of shaft speed.

In a Cypress Microsystems PSoC Design Challenge, there is one project that created 'A Non-Contact Auto Ranging Digital Tachometer'. The project is for digital tachometer that can be used in measuring RPM of a rotational object. The components including the microcontroller, the digital and analog block are supplied by the PSoC device CY8C27223. The circuit for this project utilizes and infra red LED and a sensor to sense the rotation and LCD display to display the RPM. This digital tachometer can be used in robotics, machine tools and others.

On the website *www.4crawler.com/Diesel/CheapTricks/Tachometer/index.shtm*l, the author mentioned that he decided to design a fully digital tachometer system to avoid the problems occur in his previous project such as the readings provided by the tachometer are not really accurate. Any tachometer simply measures the rate at which some event occurs and it done by counting the events such as contact closures, electrical