TEMPERATURE CONTROL USING PIC

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PROJEK SARJANA MUDA II

Tajuk Projek : TEMPERATURE CONTROL USING PIC

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Dedicated especially to my beloved parent

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ABSTRACT

This project is about designing a temperature control using PIC Microcontroller. This system consist an element of heating, temperature sensor, keypad, fan, relay and PIC Microcontroller. The PIC Microcontroller uses as a control unit and to collect input data, processing the data and release output data. The significant of this project is to show the connection of a PIC microcontroller with system and implement it with input and output devices in order to control the temperature. For this project user is allowed to select either one among the other temperature targets that earlier mode by designer. System will do instruction that program inside the PIC microcontroller followed the selected mode. Instruction that program inside the PIC Microcontroller is programmed to achieve the temperature target that select by user. To achieve the temperature target our system is used heater and fan. Both of these devices will control using PIC Microcontroller. Heater use to heating and fan is to cooling. Either one of this device will ON in one period of time in order achieve the temperature target.

ABSTRAK

Projek ini membincangkan tentang merekabentuk satu sistem kawalan suhu menggunakan PIC Mikrokawalan. Sistem ini menggunakan element pemanas, sensor suhu dan beberapa alat lain. Sistem kawalan suhu ini akan mengunakan PIC Mikrokawalan sebagai pusat kawalan untuk mengumpul data masukan memproses dan juga keluaran data. Kepentingan projek ini adalah untuk menunjukkan secara ringkas bagaimana untuk memggunakan PIC Microkawalan didalam sesuatu sistem dan sebagai pusat kawalan dengan peranti masukan dan keluaran dalam mengawal suhu. Dalam project ini, pengguna boleh memilih salah satu suhu tetapan yang telah ditetapkan oleh pereka. Sistem akan melakukan arahan yang telah diprogramkan di dalam PIC Microkawalan menggikut mode yang telah di pilih. Arahan yang diprogramkan di dalam PIC Microkawalan tersebut adalah bertujuan untuk mencapai suhu tetapan yang dipilih. Penggawalan suhu ini dilakukan menggunakan elemen pemanas dan juga kipas. Kedua – dua alatan ini dikawal oleh PIC Microkawalan. Elemen pemanas digunakan untuk memanas manakala kipas digunakan untuk penyejuk. Salah satu daripada kedua - dua alatan ini akan dihidupkan dalam satu jangka tertentu untuk mencapai suhu tetapan.

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INTRODUCTION

1.1 Overview of project

This project is to design the temperature control using microcontroller. The temperature is controlled by using fan and heater. User is allowed to select the target temperature and system will ON or OFF the fan and heater base on the current temperature. Target temperature and current temperature will be displayed through LCD. Microcontroller PIC16F877A use as the control unit for this system. All the operation of system is controlling by this PIC Microcontroller.

1.2 Objectives of project

The objectives of this research are as follows:

a. To design a temperature control system
b. PIC microcontroller is used as the control unit for this system
c. This system able to control the temperature on the selected of temperature target

1.3 Problem statement

Temperature is change in linearity whether increasing or decreasing. It changes proportionally with the time. When the voltage is supply to the conventional heater, the element heating will continuously heat until the maximum value of temperature.. It cannot achieve the target value of temperature as the set value because it doesn't have a controller to control it temperature. The problem statement that will face for this project is to create the control that able to control the temperature reading. The created system should be able to control this temperature at one point as the selected point.

1.4 Scope of Works

The scopes of work for this project are

a. Design hardware temperature controller
b. This temperature controller is control by PIC microcontroller
c. This system is design to able control three of temperature target

1.5 Research Methodology

To completed this project several step is taken and it is list below

Step 1:	Prepare the Gantt chart for guideline and progress line
Step 2:	Study and understand about the Micro C compiler and Proteus 7.0
Step 3:	Do researches about the system of temperature control
Step 4:	Develop the programming
Step 5:	Design the temperature control using Proteus 7.0
Step 6:	Run the simulation of system
Step 7:	Design the temperature control (Hardware)
Step 8:	Implement simulation in hardware
Step 9:	Troubleshoot the circuit of temperature control

This entire step will follow until the end of project in order to create a temperature controller system using PIC. For further explanation this all step will discuss more detail in chapter 3 of this thesis.

1.6 Outline of Thesis

This thesis consists of six chapters. The first chapter discuss about overview of project, objective, problem statement, scope of this project and research methodology. Chapter two discuss more on literature review that was related to this project. While in Chapter three it more discuss on the methodology. In this chapter it will discuss more detail about overview of methodology, discussion base on theory of devices that use in this project and all possible hardware that will used. Beside that the characteristic of controller that will use also discuss in this chapter three. Chapter 4 will discus about PIC Microcontroller. While the next chapter is discuss about result and discussion. The results of the project, problem encountered, discussion and all analysis done in 2 semesters will be discuss in this chapter. Final chapter will be discussing about conclusion and future work for the project.

CHAPTER II

LITERATURE REVIEW

2.1 Literature Review Overview

This chapter discuss about reviews of existing project created to get an idea about the project design, conception and any information that related to improve the project. With different concept and design, there are other creations and innovations of projects done by other people. Researches related to this project also covered in this chapter.

Many researches are carried out using the PIC Microcontroller to control the operation of any system. Using the PIC Microcontroller is used to creating system operated as automatically system.

2.2 Microcontroller

A microcontroller is a single-chip device that contains memory for program information and data. It has logic for programmed control reading inputs, manipulating data and sending outputs. It is a programmable integrated circuit that can be used to control the operation of the system. In other words, it has built-in interfaces for input/output (I/O) as well as central processing unit (CPU).

Microcontroller differs from a microprocessor in many ways. Microprocessor needs other component like memory, or components for receiving and sending data. However, microcontroller which integrates a number of the components of a microprocessor system onto a single microchip, i.e. the central processing unit (CPU) core, memory for both read only memory (ROM) and random access memory (RAM) and some parallel digital Input/Output.

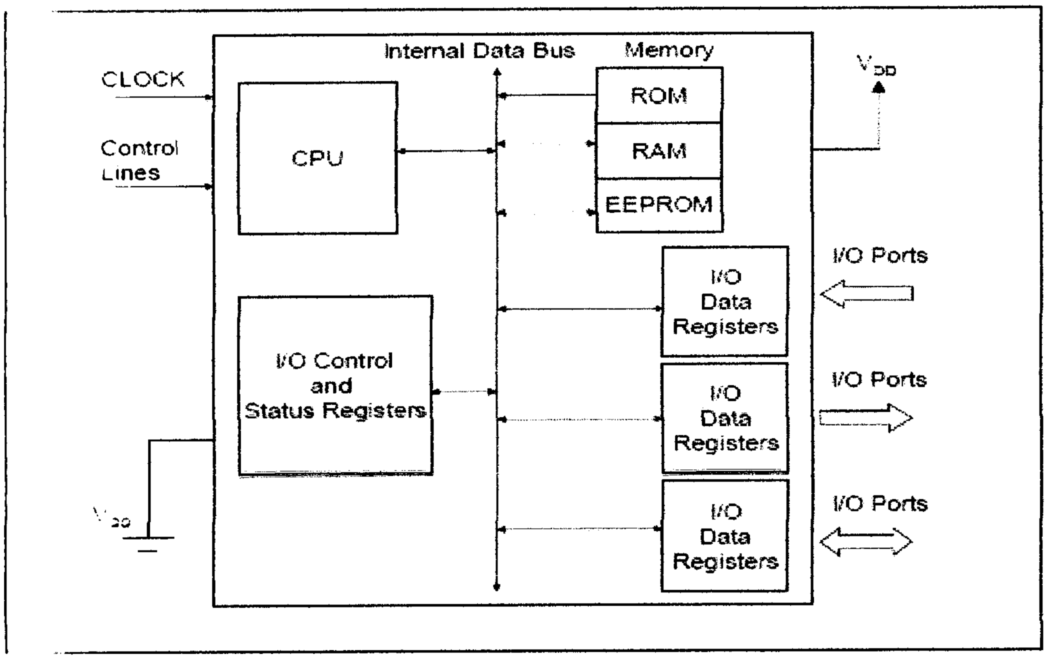

Figure 2.1 Block Diagram of a single chip microcontroller

Figure 2.1 shows a generic block diagram of microcontroller unit (MCU). Internally, it has three basic parts: the central processing unit, memory and registers. They are connected by an internal bus. Externally, it has pins for power, input/output (I/O), and some special signals. I/O pins are grouped into units called I/O ports.

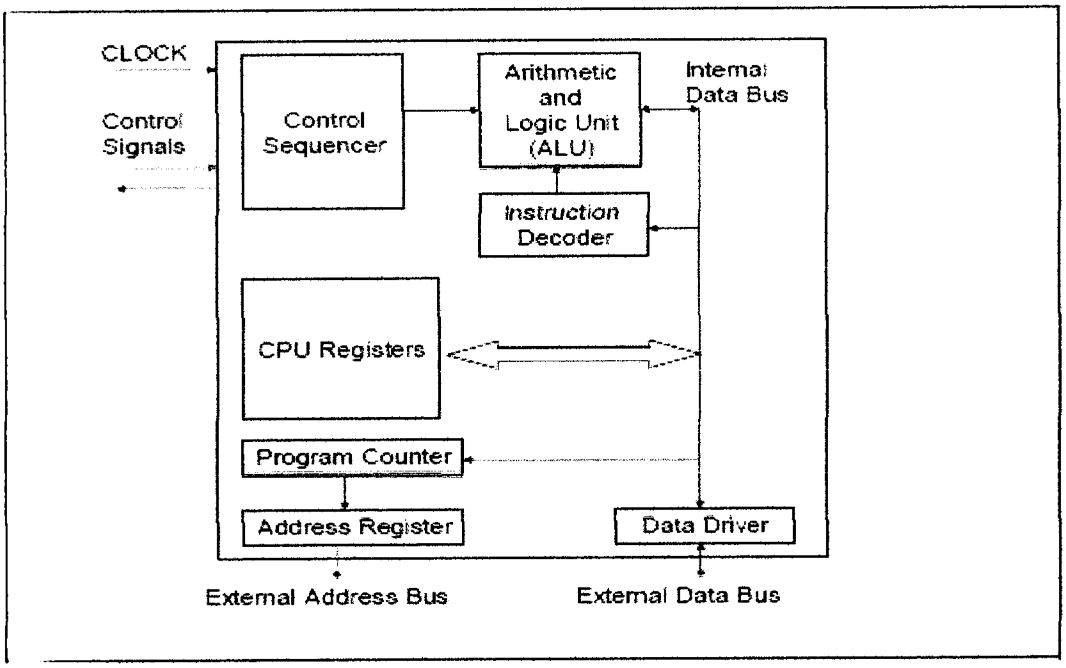

Figure 2.2 Block Diagram of a Central Processing Unit (CPU)

The CPU controls the operation of the microcontroller. It executes program instructions. Note that the COU has its own registers. The program counter is a special register that tell the CPU where to get an instruction or data byte. The other registers store specialized data or address information. The instruction decoder tells the arithmetic and logic unit what to do with the data. The control sequencer manages the transfer of instruction and the data bytes along the internal data bus. The address register set the condition of the address bus. The external address bus selects a specified location in memory. The data driver conditions data signals to be sent to or from memory or I/O registers.

CHAPTER III

METHODOLOGY

3.1 Project Overview

In this chapter, methodology of this project is described with more details about how the methodology can influence the expected results that scheduled. Figure 3.1 below described the methodology that used to complete the proposed project. All the flow of project is illustrate using the flow chat.

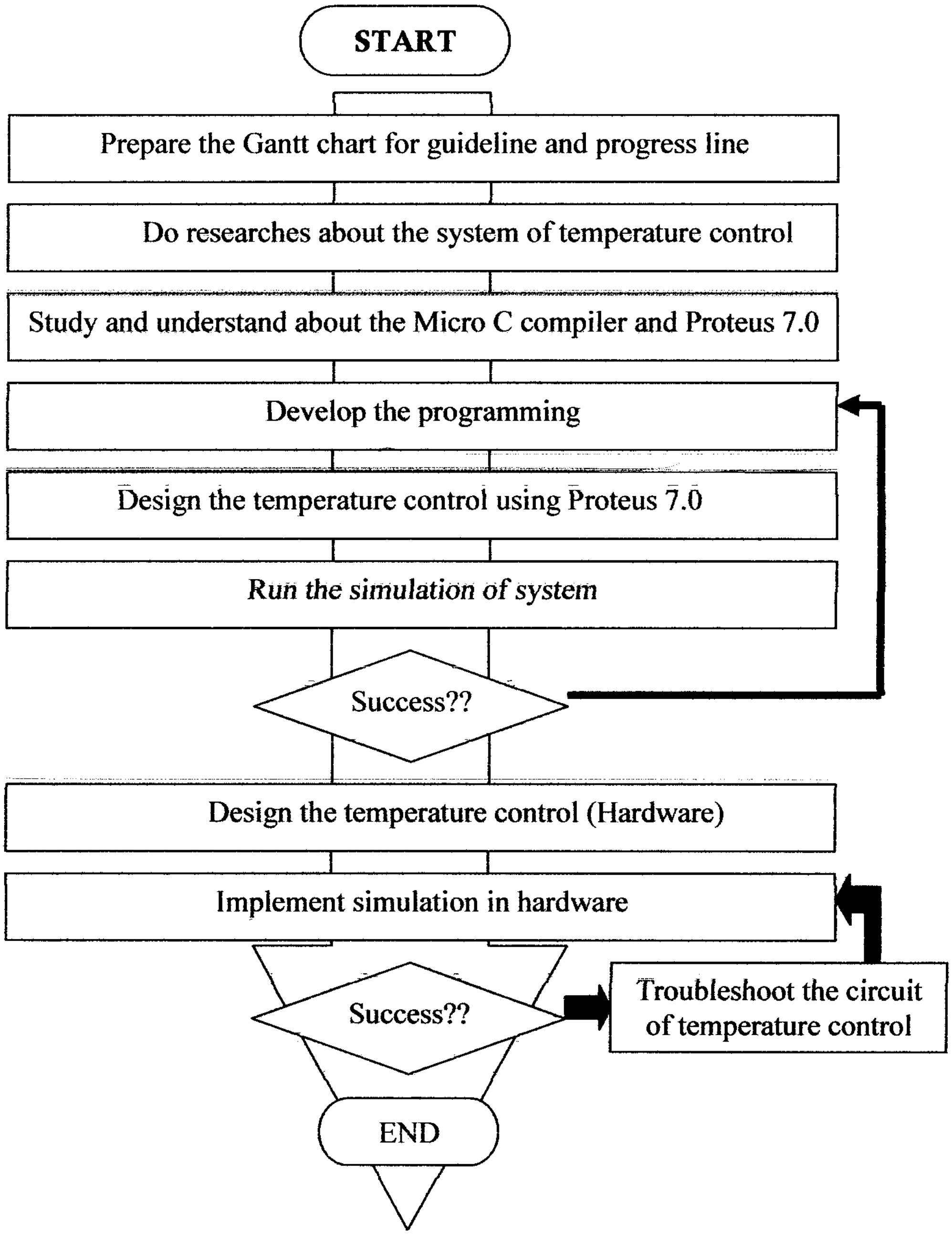

Figure 3.1 Block diagram of methodology

Figure 3.1 shows the block diagram of the methodology that will follow in order to accomplish the task. Refer to the figure 3.1 preparing the Chant chart for guideline and progress is the first step done in list of this methodology. It is used as the guideline in order to completing this project to avoid legging of completing each task.

Before more go future with the system, there have to understand the concept of control system. This step is to study and understands the temperature control system. Researching is done through the internet, lecture note, reference books and the other related references. The system that will be developed should be able to control the temperature reading. The main part in this system is such as PIC16F877A, keypad, LCD heater 240V and fan 12V. PIC16877A is used as control unit of this system while keypad is as the input. The LCD, heater and fan was assign as output. System that design should be a close loop system.

Each mechanism involve in this system must clearly understand to avoid thesis out of it objective. With clearly understand each process and mechanism involve in this system will easy to design the circuit of system. After this mechanism is totally clear understand by the designer, the next step that must done is to understanding about the Micro C complier and Proteus 7.0. Both of this software is needed in order to design this temperature control system. Micro C complier is used to develop the program coding of this system. It was write in C language. Written program coding in C language is more easily compare to write the program coding in assembly language. Using the Micro C compiler user is easy to understand while read the coding and flowed it flow. The Micro C complier was widely use among the student and lecture. This will become the advantages to the students in order to learn how to use this complier. Additional, inside the micro C complier there was consist lot of example and guideline how to use this complier. It was very helpful and good for the beginner. While used of the software Proteus 7.0 was to design the circuit of this system. Inside this software it was has all components and PIC microcontrollers. Most of IC and PIC microcontroller is able get in the library of this Proteus 7.0.

The next step that has done after study and understands how to use software Micro C and Proteus 7.0 is to develop the program coding. Coding of this system is written in C language and use micro C complier. While for the circuit of this system was design used Proteus 7.0. Run of this system can just used this Proteus 7.0. Before that the hex file of the program coding that complied from Micro C must import into the Control system PIC16F877A in our design circuit in Proteus 7.0.

Design the circuit of the temperature control is the next step of our progress in order to completing this project. The constructed circuit is flowed as the design in Proteus 7.0. Circuit that design is should be has control unit, keypad as input, beside fan, LCD and heater as the output. Circuit of input, output and control unit will design separately. It will make the process of trouble shout of circuit is more easily. After all the circuit is design with success, the next step is to assemble it together.

Test the circuit is in order to know whether the design circuit is run properly or not. If yes, the project is done and completely successful. If not, the processes return back to process design the circuit. This process is continuous until hardware design is run properly.

3.2 Theory on Devices

This part of this chapter will discuss about the brief theory of some main components and circuits that is implemented into this project

3.2.1 LCD display

LCD display is use in created the hardware of this system. It used to display the reading value of temperature. There are several ports for this LCD display. Port K is an 8-bit bi-directional port. It's used for the LCD display module. If the port is not used for the LCD display, it can be used as a general-purpose I/O port.

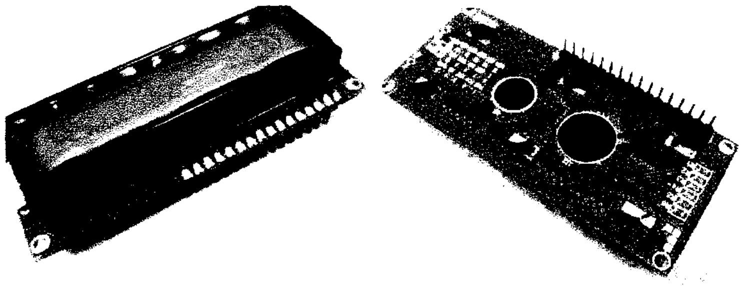

Figure 3.2 LCD display

The pin outs of J11 and J12 are as follows:

Pin 1	GND	
Pin 2	VCC (5V)	
Pin 3	Via a 220 Ohm resistor to GND	
Pin 4	PK0	RS pin for LCD module
Pin 5	PK7	R/W pin for LCD module
Pin 6	PK1	EN pin for LCD module
Pin 7	Not used	
Pin 8	Not used	
Pin 9	Not used	
Pin 10	Mot used	
Pin 11	PK2	DB4 pin for LCD module
Pin 12	PK3	DB5 pin for LCD module

Pin 13	PK4	DB6 pin for LCD module
Pin 14	PK5	DB7 pin for LCD module
Pin 15	Via a 22 Ohm resistor to VCC	LED backlight for LCD
Pin 16	GND	

PK2-PK5 (not PK4-PK7) is used to drive DB4-DB7 of the LCD module. The LCD module is hard-wired for write-only operation. Experienced user can cut a trace between pin 2 and pin 3 of J5 on solder side, and then install a 3-pin male header on J5 to make it for both read and write operations. The jumper on the J5 can be used to select the Read/write function of the LCD module. It's write-only if the jumper is place at the right position. It supports both the read and writes functions if the jumper is placed at the left position.

3.2.2 Temperature Sensor (LM35)

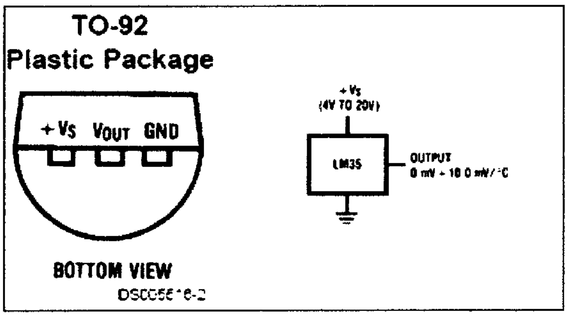

Figure 3.3 LM 35

The LM34 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Fahrenheit temperature. The LM34 thus has and advantage over linear temperature sensors calibrated in degrees Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Fahrenheit scaling. The LM34 does not require any external calibration or trimming to provide typical accuracies of ±1/2°F at room temperature and ±1 1/2°F over a full −50 to +300°F temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM34's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies or with plus and minus supplies. As it draws only 75 μA from its supply, it has very low self-heating, less than 0.2°F in still air. The LM34 is rated to operate over a −50° to +300°F temperature range, while the LM34C is rated for a −40° to +230°F range (0°F with improved accuracy). The LM34 series is available packaged in hermetic TO-46 transistor packages, while the LM34C, LM34CA and LM34D are also available in the plastic TO-92 transistor package. The LM34D is also available in an 8-lead surface mount small outline package. The LM34 is a complement to the LM35 (Centigrade) temperature sensor.

3.2.3 Keypad 4x4

The AVR configure the PortB as PB0-PB3 inputs and PB4-PB7 outputs. At the first, the AVR put the pin PB4 at logic '0' to enable the column1 (the first 4 keys) and reading the state of the keys. If we have pressed any of the 4 first keys then the AVR send the number of the key to the LCD display. If we have not pressed any of 4 first keys, the AVR put the PB4 at logic '1' and PB5 at logic '0' to enable the 2nd column. It read the state of the keys and displays the result to LCD until to read the 16th key. After that, the circuit starts again to read from the 1st key (1st column).

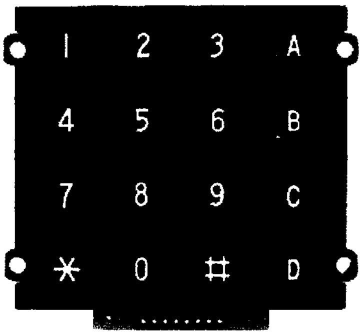

Figure 3.4 keypad 4x4

3.2.4 Heater Coil

- Hot beverages on the go
- Works in any electrical system in the world
- Switches automatically between 110 and 220 volts

Heater coil is designed for both domestic and international travel and can be plugged into any electrical system anywhere in the world. And there's no need to worry about switching back and forth from 110 to 220 because this unit does it internally. Simply plug it in and it automatically adjusts itself accordingly.

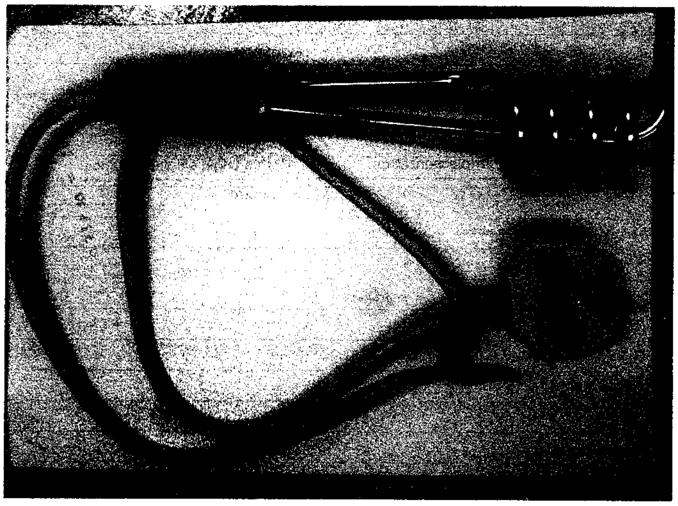

Figure 3.5 Heater coil

3.2.5 Fan 12V

Supply by 12V DC. Suitable use install in small of space part. It was easy to install and able to bringing anywhere. In addition to providing extended life expectancy, 12V fans offer superior management of offensive noise.

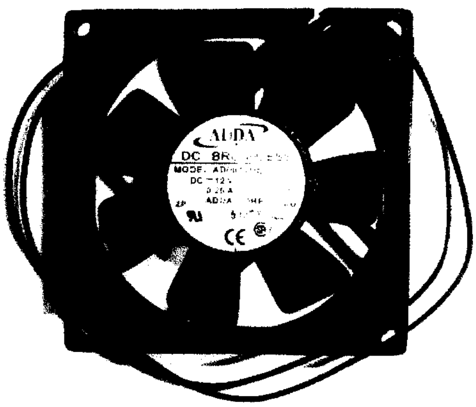

Figure 3.6 Fan 12V

3.3 Voltage regulator

A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. It may be use an electromechanical mechanism, or passive or active electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. With the exception of shunt regulators, all voltage regulators operate by comparing the actual output voltage is too low, the regulation element is commanded to produce a higher voltage. For some regulators if the output voltage is too high, the regulation element is commanded to produce a lower voltage; however, many just stop sourcing current and depend on the current draw of whatever it is driving to pull the voltage back down. In this way, the output voltage is held roughly constant. The control loop must be carefully designed to produce the desired tradeoff between stability and speed of response.

3.3.1 Fixed Positive Voltage Regulator 7805

7805 is an integrated three-terminal positive fixed linear voltage regulator. It supports an input voltage of 10 volts to 35 volts and output voltage of 5 volts. It has a current rating of 1 amp although lower current models are available. Its output voltage is fixed at 5.0V. The 7805 also has a built-in current limiter as a safety feature. 7805 is manufactured by many companies, including National Semiconductors and Fairchild semiconductors. The 7805 will automatically reduce output current if it gets too hot.

It belongs to a family of three-terminal positive fixed regulators with similar specifications and differing fixed voltages from 8 to 15 volts. There are usually packaged in TO220 chip carries, but smaller surface-mount and larger TO3 packages are also available. The last two digits represent the voltage; for instance, the 7805 is a 5-volt regulator. The 7805 is one of the most common and well-know of the 78xx series regulators, as its small component count and medium power regulated 5V make it useful for powering TTL devices.

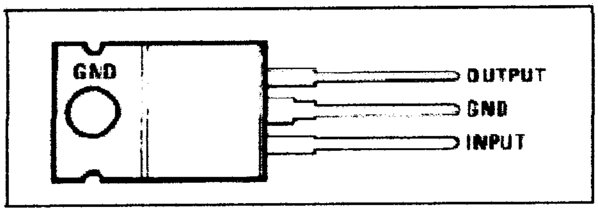

Figure 3.7 Fixed linear voltage regulator 7805

CHAPTER IV

PIC MICROCONTROLLER

4.1 Introduction

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Peripheral Interface Controller"

PICs are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability.

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.

In 1985 GI spun off their microelectronics division, and the new ownership cancelled almost everything — which by this time was mostly out-of-date. The PIC, however, was upgraded with EPROM to produce a programmable channel controller, and today a huge variety of PICs are available with various on-board peripherals (serial communication modules, UARTs, motor control kernels, etc.) and program memory from 512 words to 32kwords and more (a "word" is one assembly language instruction, varying from 12-to-16 bits depending on the specific PICmicro family).

4.1.1 Definition widely used in PIC Microcontroller

Programming language - is a set of commands and rules according to which we write the program. There are various programming languages such as BASIC, C, Pascal, etc. There are plenty of resources on Micro C programming language out there, so we will focus our attention particularly to programming of microcontrollers.

Program - consists of a sequence of commands written in programming language that microcontroller executes one after another.

Compiler - is a program run on computer and its task is to translate the original Micro C code into language of zeros and ones that can be fed to microcontroller. The program written in Micro C and saved as file program.pbas is converted by compiler into assembly code (program.asm). The generated assembly code is further translated into executive HEX code which can be written to microcontroller memory.

Programmer - is a device which we use to transfer our HEX files from computer to microcontroller memory.

4.1.2 Why choose PIC16F877A

PIC is the family of Reduces Instruction Set Computer (RISC) microcontrollers made by Microchip Technology. It is generally regarded that PIC stands for Peripheral Interface Controller, although General Instruments' original acronym for the PIC was "Programmable Intelligent Computer". F is the referred to flash program memory. The PIC16F877A is chosen because of its economical and low cost, available of the chip and its related software and developer. Table 4.1 shows some device features about PIC16F877A.

Table 4.1 PIC16F877A devices features

Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
Operating Frequency	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz
RESETS (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
FLASH Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory (bytes)	128	128	256	256
Interrupts	14	15	14	15
I/O Ports	Ports A,B,C	Ports A,B,C,D,E	Ports A,B,C	Ports A,B,C,D,E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin MLF	40-pin PDIP 44-pin PLCC 44-pin QFP	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin MLF	40-pin PDIP 44-pin PLCC 44-pin QFP

Some features of PIC16F877A are summarized as follows:

1. Single-cycle intrusions, except for program branches
2. Up to 8K words of Flash Program Memory, 368 bytes of Data Memory (RAM) and 256 bytes of EEPROM Data Memory
3. Timer0: 8-bit timer/counter with 8-bit prescaler
4. Timer1: 8-bit timer/counter with prescaler, can be incremented during sleep Mode Via external.
5. Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
6. Typically 100,000 erase/write cycle Enhanced Flash Program memory
7. Typically 1,000,000 erase/write cycle Data EEPROM memory
8. Support both assembly and high level language
9. Wide operating voltage range (2.0 volts to 5.5 volts)
10. Low power high speed Flash/EEPROM technology
11. Low power consumption
12. Commercial and Industrial temperature ranges

The block diagram of the PIC16F877A is shown in Figure 4.1

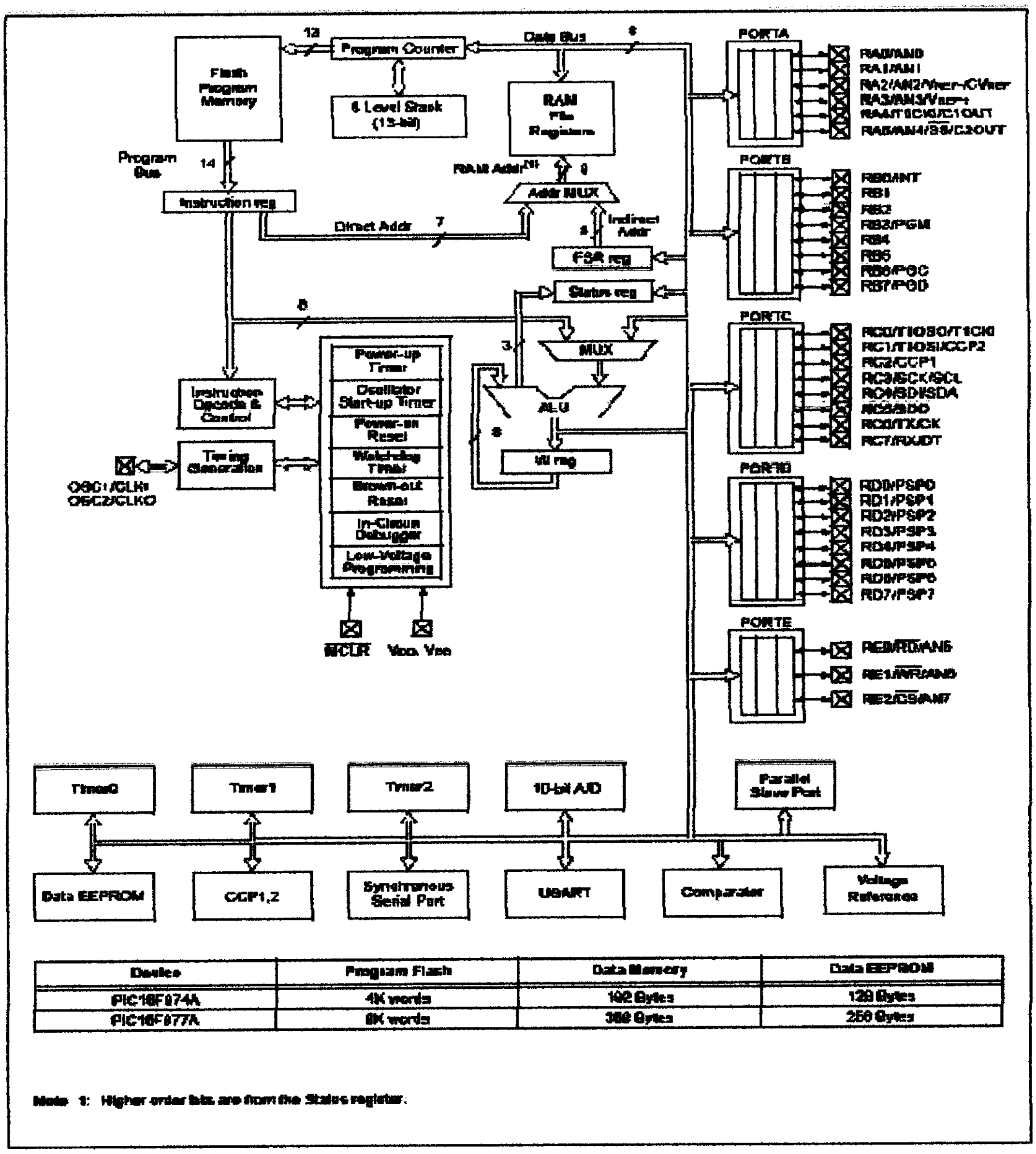

Figure 4.1 Block diagram of PIC16F877A

4.2 PIC16F877A Memory Block

From the block diagram above, PIC16F877A contains Data EEPROM and FLASH Program Memory. The Data EEPROM and FLASH Program Memory are readable and writeable during normal operation (over the full VDD range). There are three memory blocks which are data memory, program memory as well as stack. The program Memory and Data Memory have separate buses so that concurrent access can occur.

Program memory has been realized in FLASH technology, which makes it possible to program a microcontroller many times before it is installed into a device and even after its installment if eventual changes in program or process parameters should occur. PIC16F877A devices have a 13-bit program counter capable of addressing an 8K words × 14 bit program memory space with an address range from 000h to 1FFFh. Addresses above the range will wraparound the beginning of program memory. The Reset vector is at 000h and the interrupt vector is at 0004h.

PIC16F877A has a group of 8 memory locations of 13 bits width with special function. This group memory is known as stack. It basic role is to keep the value of return address after a jump from the main program to a subprogram. In order for a program to know how to go back to the point where it started from, it has to return the value of a program counter from a stack. When calls a subroutine counter is being pushed onto a stack. When executing instructions such as RETURN, RETLW or RETFIE, which were executed at the end of a subprogram, program counter was taken from a stack so that program could continue where it was stopped before it was interrupted. Besides, the parameter passing from main program to subprogram will cause a temporary memory location build in the stack. Figure 4.2 indicates the program memory map and stack of PIC16F877A and how subroutine being executed.

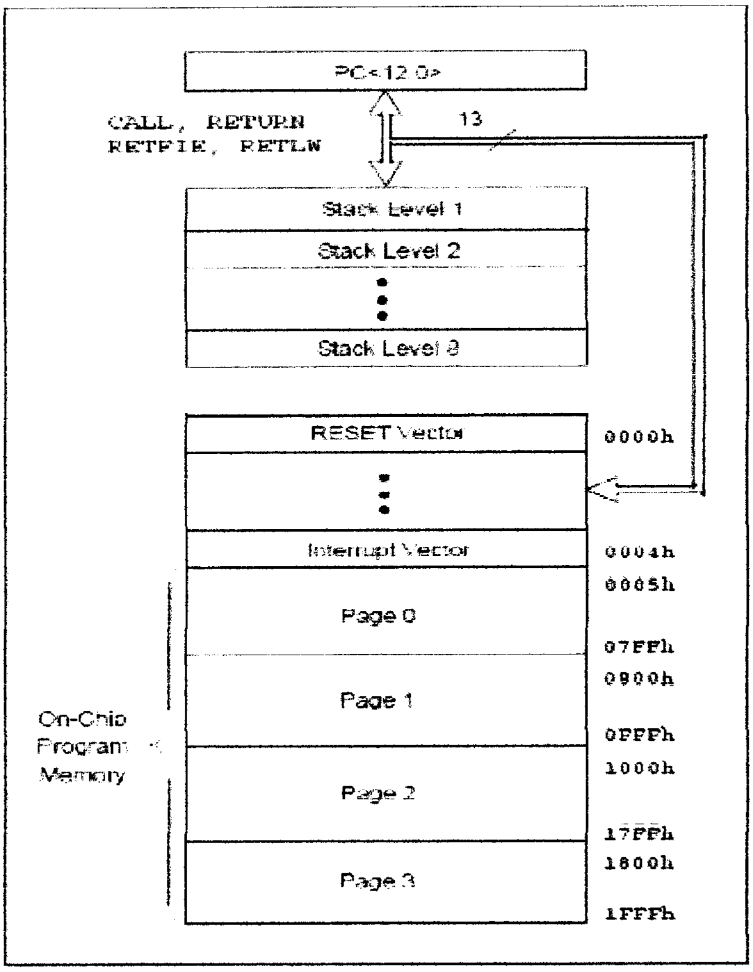

Figure 4.2 Program memory map and stack

Data memories consist of data EEPROM and RAM memories. EEPROM data memory consists of 256 bytes locations whose contents are not lost during losing of power supply. EEPROM is accessed indirectly through EEADR and EEDATA registers. An EEPROM memory usually serves for storing important parameters. There is a strict procedure for waiting in EEPROM, which must be followed in order to avoid accidental writing. RAM memory is partitioned into four banks, which contains the General Purpose Register and the Special Function Registers. Each bank extends up to 128 bytes.