

TEMPERATURE-CONTROL SYSTEM

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award of the Bachelor of Electrical Engineering
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MY DECLARATION

I declare that this thesis entitled “ *Temperature Control 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 :

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Date : 12 May 2009

DEDICATION

Specially dedicated to
my beloved parents, friends and supervisor whom always
gave me supports to fulfill my thesis

ACKNOWLEDGMENT

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I would like to like to thank my supervisor, Mr. Fairuz Rizal Bin Mohamad Rashidi for encouragement, guidance, critics and friendship all advices and supports throughout this final project. I am also very thankful to all lecturers of Faculty of Electrical Engineering for their guidance, advices and motivation. Without their continued support and interest, this thesis would not have been the same as presented here. Thank you very much for good co-operation.

ABSTRACT

This project title is 'Temperature-Control System' which is a particular system for server room. For the circuit, it consists of temperature sensor, PIC, LCD, driver circuits, AC air heater and AC motor. Three drivers are used for triggering process to switch on the AC heater and another two are for triggering levels of the motor. This motor will operate based on two temperature ranges and that means, it has two levels of speed. The function of this system is for controlling the temperature value inside of a regular room automatically. It will operate based on the values or ranges of temperature in the room which is detected by the temperature sensor. If the temperature in the first range (0°C to 15°C), the air heater will be operated to heat the server room which in very cold temperature. If it is in the second range (16°C to 25°C) this system will not be enabled because it's achieving normal temperature range. If temperature in range 26°C to 40°C, motor will be triggered for level 1 to decrease the temperature value. If it is more than 40°C, the motor will be triggered for level 2 and its speed becomes faster at this level. The both output devices are important to maintain the temperature value in the room. This system can be categorized in automatic system class and solve users' problem. The problem always happen if air-conditioner broke down and definitely, the room becomes hotter or temperature increases. Besides that, temperature becomes too cold and influenced by weather from outside of the sever room. With that, the motor and air heater are important to keep maintaining the sever room in suitable temperature range. This system has temperature sensor which may detect the surrounding temperature and the outputs are operated based on the temperature ranges. Programming of the PIC is a important basic to read data or accept signal from the sensor. In the same time, it maintains the temperature inside of the room and make it suitable for user.

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LIST OF SYMBOL

$^{\circ}\text{C}$ - degree Celcius

A - ampere

mA - miliampere

μF - microfarad

Ω - ohm (resistor)

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CHAPTER 1

INTRODUCTION

1.1 Background

Recently, automatic temperature control system is rapidly gaining in popularity. This system is designed which is supposed to keep the temperature inside a server room within required range that lies in the region of 16°C to 25°C. It will be a backup system when server room cooling system fails and temperature range is out of normal. The current temperature within the server room is measured by using a temperature sensor. When the current temperature is below the lower limit of the desired range, the server room must be heated by using a heating element, air heater. If it is in the first upper limit 25°C to 40°C, the server room is cooled by using an AC fan at level 1. If temperature achieves more than 41°C, the speed of the fan will be turned to level 2. When the current temperature is within or successfully turned back to the required range, no control action is needed. The current temperature of the room must be continuously displayed on the LCD. The controller should use LEDs as backup display to indicate the current state of temperature. This makes user is easily to know current temperature range in the server room.

1.2 Project Objective

The main objective of this project is to design an automatic system to keep maintaining temperature inside a server room within required range. The specific objectives of this project are listed as followed :

- 1) To read data from temperature sensor
- 2) To integrate in the PIC
- 3) To be able to control temperature in a server room

1.3 Project Scopes

This project concentrates on controlling the temperature inside the server room automatically based on current temperature range. To achieve all the objectives, the developer needs to have knowledge on the following elements:

- 1) Output voltages from LM35DZ and convert them to byte values.
- 2) Particular formula that must be created by developer to convert the byte values to Centigrade scalar (for LCD display).
- 3) Commands of LCD.
- 4) PIC programming to develop whole-system programming.
- 5) Driver circuit operation and function of each component

1.4 Thesis Outline

This thesis contains 6 chapters and they are outlined as below :

Chapter 1 explains the introduction that includes concept of temperature control system. It also outlines objective and scope of this system.

Chapter 2 describes the architecture used and gives a brief review of system board architecture, sensor module, display module, driver circuit module and output module.

Chapter 3 provides description and discussion on the design of the hardware of each module in the systems. The module consists of microcontroller board, sensor , LCD display, driver circuit and output devices.

Chapter 4 explains the development of the software and system operation. This chapter also includes the flowchart of whole system.

Chapter 5 presents testing and result that conducted to each module. This chapter includes the integrated system testing which all the modules are combined.

Chapter 6 summarizes the overall conclusion for this thesis and a few future recommendations.

CHAPTER 2

LITERATURE REVIEW

This literature review explains about all components and circuits which are used for the system including specification of them.

2.1 Temperature Sensor



Figure 1.1

The LM35DZ series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. This temperature sensor may detect over -55°C to 150°C temperature range and suitable for the scope of project which temperature range is from 0°C to 60°C . It can be used with single power supplies, or with plus and minus supplies. It can be supplied from 4 to 30 Volt and in this project, it is directly supplied with 5V from voltage regulator. As it draws only 60 mA from its supply, it has very low self-heating, less than 0.1°C in still air. It is available in the plastic TO-92 transistor package. It has $10.0\text{ mV}/^{\circ}\text{C}$ scale factor and it may operate from 4 to 30 volts. For the system, it will send a signal in voltage to the PIC that will read and convert it to degree Celsius.

2.2 PIC 16F877

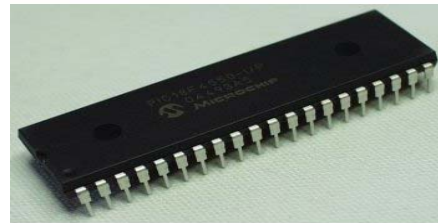
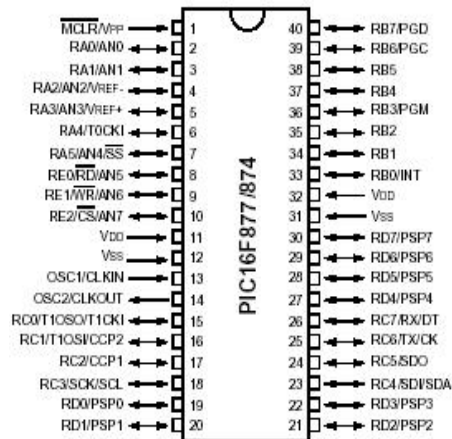


Figure 1.2

16Fxxx devices contain between 64 and 1024 bytes of non-volatile data memory that can be used to store program data and other parameters even when the power is turned off. This case is also similar to the other type of PICs such as PIC12F6xx, 16F6xx and 18F8xx. For this project, the program size can be categorized in medium and does not require big memory of PIC. Five ports are included from A to E. The temperature sensor, LM35DZ is connected through PORTA which this port can be analog input. PORTB can be software programmed for internal weak pull-up on all inputs and LCD is one of suitable hardware for this purpose. PORTC has various capabilities which it can be the Timer oscillator, SPI Data In, SPI Data Out, Capture Input, Compare Output, Data I/O, Asynchronous Transmit or Synchronous Clock and Asynchronous Receive or Synchronous Data. PORTD is bi-directional I/O port which similar to PORTE. All these ports are enough for the connections to another hardware such as LEDs, driver circuits and LCD. Software Microcode studio is used for the compiling purposes. PIC must be supplied with 5V that already regulated by voltage regulator. Clock circuit must be connected to PIC and crystal value may effect the speed of data reading process in the PIC.

2.3 Voltage Regulator

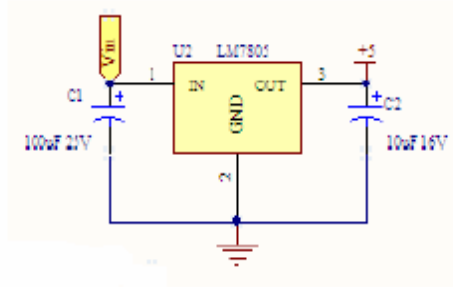


Figure 1.3

Every electronic circuit requires a power supply. The required power can either be provided from a battery or main voltage then to reduced level before it is used in the circuit. Voltage regulator is supposed to convert voltage which is from power supply that current value must be fixed first. It consists of a regulator integrated circuit, 7805 IC and filter capacitors such as 10 μF and 100 μF . 7805 is a 3-pin IC with a maximum current capacity of 100 mA. One of the pins of 7805 is connected to the +V terminal of the power supply and it is in parallel with a 10 μF capacitor. Second pin is connected to the -V terminal. The third pin provides 5V output and 100 μF capacitor should be used in parallel with this pin. In applications where a larger current is required, the 7805 regulator IC can be used. This is pin compatible with the low-power 78L05 and it has a maximum current capacity of 1A. It should be used with a heat sink which may decrease the heat that produced during transferring and converting process from 9V to 5V.

2.4 LCD



Figure 1.4

Liquid crystal display (LCD) is required to display a message and the value of a variable. In temperature-control application, it is required to display the value of the temperature dynamically. LCDs are alphanumeric displays which are frequently used in microcontroller-based applications. Some of the advantages of LCDs are their low cost and lower power consumption. For the LCD of this project, it may incorporate back lighting so that they can be viewed in dimly lit conditions. Its code is JHD44780 which only displays value in one line or one row and not like VCM that required to display in two rows. Besides, it also well known as parallel LCD which connected to the microcontroller I/O ports using 4 or 8 data wires. Data is transferred from the microcontroller to the LCD in parallel form. There is a difference between parallel with serial. Serial LCDs are connected to the microcontroller using only one data line and data is transferred to the LCD using the standard RS232 asynchronous data communication protocols. They are easier to use but usually cost more than the parallel ones. Serial LCDs also have advantage that only one wire is required to interface them to the microcontroller, thus saving the I/O pins. The programming of a parallel LCD is usually a complex task and requires a good understanding of the internal operation of the LCDs,

including the timing requirements. Pic Basic Pro language provides special or particular commands for displaying data on HD44780. User has to connect the LCD to the appropriate I/O ports and then, these special commands are used to simply send data to the LCD. The display has a 16-pin connector for interfacing to a microcontroller. The table 1 shows the pin configuration of the LCD.

Table 1.1 Pin Configuration of LCD

| Pin No | Name | Function |
|---------------|-----------------|-----------------|
| 1 | V _{SS} | Ground |
| 2 | V _{DD} | Positive Supply |
| 3 | V _{EE} | Constrast |
| 4 | RS | Register select |
| 5 | R/W | Read/write |
| 6 | E | Enable |
| 7 | D0 | Data bit 0 |
| 8 | D1 | Data bit 1 |
| 9 | D2 | Data bit 2 |
| 10 | D3 | Data bit 3 |
| 11 | D4 | Data bit 4 |
| 12 | D5 | Data bit 5 |
| 13 | D6 | Data bit 6 |
| 14 | D7 | Data bit 7 |
| 15 | V _{SS} | Ground |
| 16 | V _{DD} | Positive Supply |

2.4.1 Connection of the LCD to the microcontroller

PIC Basic Pro compiler by default assumes that the LCD is connected to specific pins of the microcontroller. It assumes the following connections:

| LCD | Microcontroller |
|-----|-----------------|
| D0 | RB0 |
| D1 | RB1 |
| D2 | RB2 |
| D3 | RB3 |
| D4 | RB4 |
| D5 | RB5 |
| D6 | RB6 |
| D7 | RB7 |
| E | RD3 |
| RS | RD2 |

The R/W pin of the LCD is not used and it is directly connected to the ground. This means LCDIN is not used for the programming of LCD display. The contrast adjustment is done by connecting a potentiometer to VEE or pin 3 of the LCD.

2.5 Driver Circuit

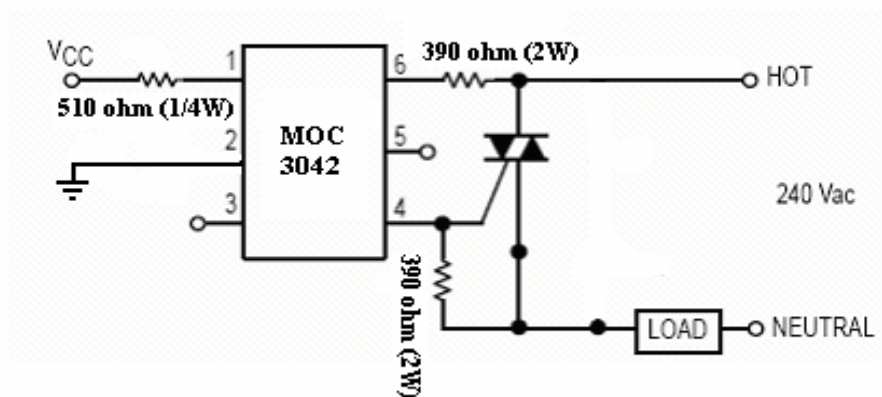


Figure 1.5

MOC3042 is a optocoupler or device consists of gallium arsenide infrared emitting diodes optically coupled to a monolithic silicon detector performing the function of a Zero Voltage Crossing bilateral triac driver. They are designed for use with a triac (Figure 1.5) in the interface of logic systems to equipment powered from 240 Vac lines such as solid-state relays, industrial controls, motors, solenoids and consumer appliances or etc. This design is well known as driver circuit which needs 10 mA for the forward current. It can be used for the triggering process which accepts signal that activated from the port of PIC. The infrared emitting diode will react and automatically detected by the monolithic silicon detector. It replaces the function of relay 240Vac. There are some differences between the both. Relay 240Vac has slow response and needs fairly high current to energize. Some micro electronics circuits cannot drive them directly without additional circuitry. MOC3042 uses light signal diode and detector which are not connected directly. This can safe from any factors of undesired cases. It supplies up to 10mA and it is also short-circuit protected. Furthermore, it requires small-signal frequency compensation to control even large-signal dynamic and it is much faster than relay 240Vac.

2.6 Output Devices



Figure 1.6

AC fan and air heater as shown in Figure 1.6 are chosen for real application purpose. These output devices are supposed to control temperature inside the server room when control action is needed or temperature range inside the server room is out of normal. They are triggered based on the current temperature range and turn back the temperature (out of normal) to required range. They must be powered 240Vac and will be triggered by the driver circuits based on the current temperature range.

2.7 Comparison Between Proposed Project with Researched Project

There is another project which has similar function with proposed project. This project is from Auckland ,New Zealand. A few differences between the both projects are acknowledged.

Electrical Engineering Design 1998 - Project 2

Temperature acquisition and control system

The design group at “North Controllers” created temperature control system to solve the problem of temperature variation in the incubator facility. This system is successfully to keep the temperature inside an incubator within a required range that lies within the region of 10°C to 35°C. The required temperature range is to be set with a user friendly interface from the supervisory computer, enabling the user to specify the minimum and maximum temperatures in the range. The current temperature within an incubator is measured using a temperature sensor. When the current temperature is below the lower limit of the desired range, the incubator must be heated using a heating element, air heater and if it is above the upper limit of the desired range, it will be cooled by using a DC fan. When it is within the desired range, no control action is needed. The current temperature of the incubator must be continuously displayed on the supervisory computer screen, to one decimal place significance (for instance, 26.40C), and updated at least every tenth of a second. In addition, the controller should use LEDs to indicate the current state of temperature in the incubator (within the range, below the low limit or above the high limit).The whole system is controlled MC68HC11

Compared to the proposed project, there are a few differences. This proposed project is supposed to solve the problem when operation of server room cooling system fails to run. The required temperature range is 16°C to 25°C which this range is suitable for inside a server room. AC fan is used because server room is a huge room that requires this fan type and DC type is suitable such as for incubator facility which requires small room or space. Liquid Crystal Display (LCD) is supposed to display current temperature continuously and Peripheral Interface Controller (PIC) as the microcontroller of this project.