THE TEMPERATURE CONTROL SYSTEM

NOOR FAEZAH BINTI HAMDI

This Report Is Submitted In Partial Fulfillment Of Requirements For The Degree of Bachelor In Electrical Engineering (Industrial Power)

Fakulti Kejuruteraan Elektrik
Kolej Universiti Teknikal Kebangsaan Malaysia

March 2005

"I agree that this report is my own work except the quotation and summary, each that I mentioned the source."

Signature : ....

Author's Name : Noor Faezah binti Hamdi

Date : 9/3/05

Dedication

This report is dedicated to my father Haji Hamdi bin Awi, my mother Hajah Slemah binti Rajak, the rest of the family and friends.

This report would never happen without your support.

ABSTRACT

The objective of the project was to develop a temperature control system for maintaining a preset sequence of specified temperatures in a liquid substance during the mixing process in a boiler. The dc power supply is responsible for powering each part of the system. The temperature of the liquid chemical is sensed by a temperature-sensitive resistor called a thermistor. The temperature of the chemical mixture determines the resistance of the thermistor. The temperature-to-voltage conversion circuit produces an output voltage that is proportional to the temperature. The output goes to an analog-to-digital converter (ADC) which converts the voltage to digital form. The digital processor adds the appropriate scaling and linearization to the digitized voltage and sends it to the heater control circuit that is programmed to sequence through a series of set-point temperatures during the mixing process. The heater control circuit compares the set-point temperature to the actual temperature as measured by the temperature-to-voltage conversion circuit and makes the proper adjustments of the heating element. The details of the design developed were based on a Microchip PIC16F84a, are described. The pedagogical value of the problem is also discussed through a description of some of the key steps in the design process. It is shown that solution required broad knowledge drawn from several engineering disciplines including electrical, mechanical and control systems engineering.

ABSTRAK

Objektif projek ini adalah untuk membina satu sistem pengawalan suhu yang digunakan untuk memastikan suhu yang telah ditetapkan adalah terkawal di dalam tangki pendidihan semasa proses pencampuran bahan kimia di industri. Bekalan kuasa arus terus digunakan untuk membekalkan kuasa ke setiap bahagian di dalam sistem ini. Suhu bahan kimia dikesan oleh perintang peka suhu yang dipanggil *thermistor*. Litar pengubah suhu-voltan menghasilkan voltan keluaran yang berkadaran dengan suhu yang dikesan. Isyarat voltan keluaran itu seterusnya dihantar kepada pengubah analog ke digital di mana voltan dalam bentuk analog akan ditukar kepada bentuk digital. Kemudian pengawalmikro yang telah diprogramkan akan menentukan arahan seterusnya berdasarkan nilai titik penetapan suhu. Litar kawalan pemanas berfungsi dengan membandingkan nilai titik penetapan suhu dengan suhu sebenar yang diukur oleh litar pengubah suhu ke voltan dan ia akan menentukan kadar pemanasan yang sesuai kepada elemen pemanas. Maklumat lanjut tentang rekabentuk sistem berdasarkan kepada penggunaan PIC16F84A Microchip diterangkan dengan lebih lanjut. Permasalahan dari segi langkah-langkah penting dalam mereka bentuk turut diambil kira. Ini menunjukkan bahawa penyelesaian masalah memerlukan pengetahuan dari cabang kejuruteraan yang lain termasuklah elektrikal, mekanikal dan kejuruteraan sistem kawalan.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Temperature control is widely used in various processes. These processes, no matter it is a process of large industrial plant, or a process in home appliance, share several unfavorable features such as non-linearness, interference, dead time, and external disturbance, etc. Conventional control approaches usually cannot achieve satisfactory results for this kind of processes. The project that will be discussed here is the microcontroller based temperature control system.

CHAPTER 1

PROJECT OVERVIEW

The design project is originated from a real-world application. The motivation is that a custom controller targeted specifically for the application should be able to achieve the same functionality at a much lower cost.

1.1 Objective

The objective of the project is to develop a temperature control system for industrial where the system was to allow entry of desired temperature in prescribed range.

1.2 Problem Statements

The basic idea of the project is to replace the relevant parts of the available system with a custom-designed system. The application dictates that temperature settings are usually kept constant for long periods of time, but it is nonetheless important that step changes be tracked in a reasonable manner.

Temperature measurement and control are vital in many industrial processes. Accurate control of the temperature is essential in nearly all chemical processes. In some applications, an accuracy of around 5-10^0 C maybe acceptable. There are also some industrial applications which require better than $\pm 1^0$ C accuracy.

There are growing needs for controlled and maintained temperature control system especially for the industrial. In order to increase the production level, the industry needs to implement a new temperature control system which could control and maintain the temperature at the desired set point. It helps them to reduce energy usage during the non-controlled burning. Also, it helps to reduce safety risks where no human operator is needed to control the temperature of the chemical liquid.

As for the project itself, there are a few problems that have been encountered. Most of the simulators available do not provide components or device that will be used in this project. A few simulations had been done by modifying the devices with the other devices that performed the same function. For example, the thermistor is replaced with the resistor but with different values for the temperature-to-voltage conversion circuit simulation.

The scope for this project is only limited to the measuring and control of the temperature between the ranges of 45°C to 55°C. Thus the main requirements boil down to;

- allowing a temperature set-point to be entered.
- displaying set-point

1.3 Project Methodology

The methods that will be used to achieve the objectives of the project generally can be divided into five (5) parts that are:

1. Planning
2. Research/ study
3. Design/ Implementation
4. Testing
5. Final result

1.3.1 Planning

To begin the proposed project and in order to make it successful, proper planning is needed and should be taken into account.

1.3.2 Research/ Study

The second step to accomplish this project is to do some research/ to study the related subject that later will be used. The subjects are:

a) Thermistor

b) Analog-to-Digital Converter

c) Microcontroller

The importance of this step is to make sure that the subject is fully understood. The disadvantages and advantages of each and every related topic or material is well known, to do comparison and to decide for the best and most suitable components or material use, to be aware of the outcome and lastly to be prepared for any unexpected event.

1.3.3 Design/ Implementation

This stage is where all the information that is gathered is being used to design and implement. There are two major components of the project here that are the hardware and the software (microcontroller). The hardware components will be carried out before the programming takes place. At this stage, some obstacles is expected to be face and dealt with.

1.3.4 Testing

The final stage before the final result is testing. The objectives are to make sure that the project is successful and to scan for any unexpected outcome so that it can be fixed and improved.

1.3.5 Final Result

The last stage and also the final step are to indicate the successful of the project.

1.4 System Design

The requirement for digital temperature displays and set-point entry alone are enough to dictate that a microcontroller-based design is likely the most appropriate. Figure 1.1 shows the block diagram of the project design.

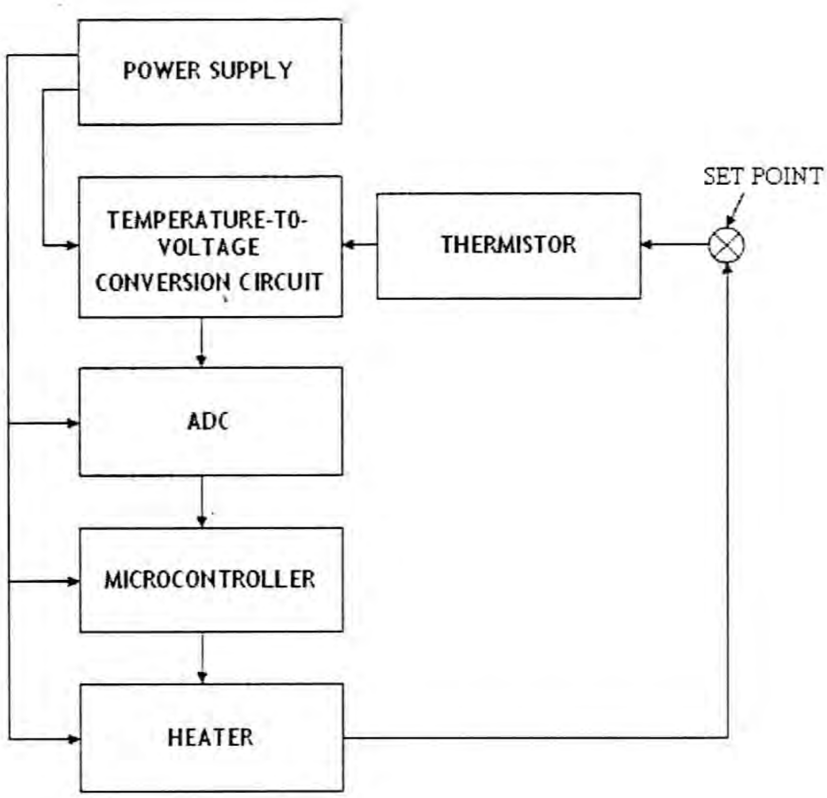

Figure 1.1: Block diagram of the temperature control system

The microcontroller, PIC16F84A is the heart of the systems. It accepts inputs from four input buttons which allow specification of the set-point temperature, and it displays set-point temperatures using liquid crystal diode display driver. All these inputs and outputs are accommodated by parallel ports on the 16F84A. Liquid temperature is sensed using a pre-calibrated thermistor and input via one of the PIC16F84A's pin.

Software on the PIC16F84A implements the temperature control algorithm, maintains the temperature displays and alters the set-point in response to the input buttons. Figure 1.2 shows the flowchart of the temperature control system.

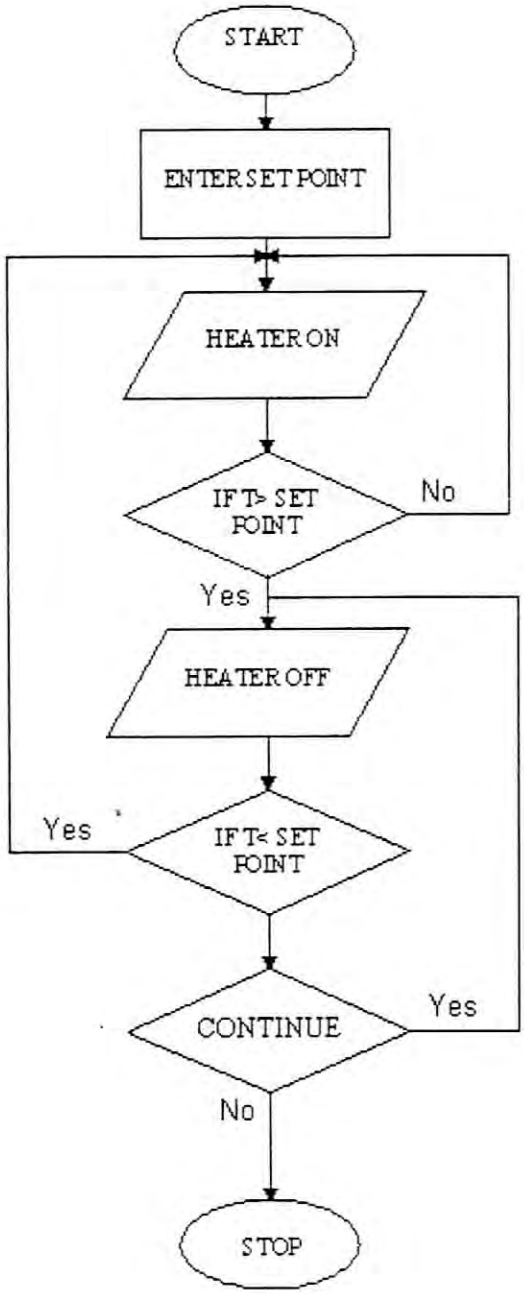

Figure 1.2: Temperature control flowchart

1.5 Conclusion

It is important to determine the objective of this project and identify the problem statements. In order for this project to be completed, the objective must be understood clearly and also the design of the system need to be studied before going any further.

CHAPTER 2

LITERATURE REVIEW

Each component or device to be used in the design process must first need to be studied and reviewed. Research over the previous design projects also important where it helps to improve and update the project design.

2.1 Objective

The objective of the literature review is to specify and identify types and details of the components to be used for the design process.

2.2 Thermistor Probe NTC B57276K123A30

Thermistors are temperature resistive passive semiconductors which exhibit a large change in electrical resistance when subjected to a small change in body temperature.

NTC thermistors exhibit many desirable features for temperature measurement and control. Their electrical resistance decreases with increasing temperature and the resistance-temperature relationship is very non-linear. Depending upon the type of material used and the method of fabrication, thermistors can be used within the temperature range -50° C to $+150^\circ$ C. The resistance of a thermistor is referenced to 25° C and for most applications the resistance at this temperature is between 100O and 100kΩ.

As for this project, thermistor probe NTC (B57276K123A30) is used and it features a few advantages such as suitable for use in corrosive environment, compact stainless steel case and cost-effective ready-to-use sensor. Apart from that, the thermistor probe offered few options that are alternative resistance ratings, rated temperatures and resistance tolerance available on request.

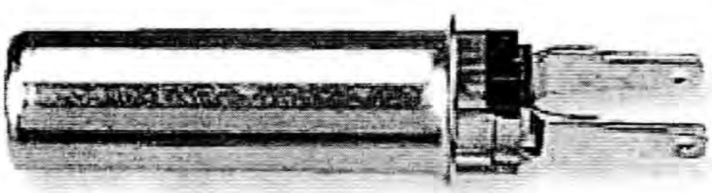

Figure 2.1: Thermistor Probe NTC