DESIGN AND IMPLEMENTATION OF A MICROPROCESSOR BASED TEMPERATURE CONTROLLER WITH REAL TIME DISPLAY

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Abstract: **The objective of the project was to automate and control temperature for a server room. The system is allowed entry of a desired room temperature within a prescribed range and to exhibit overshoot and steady-state temperature error of less than 1 degree displaying the value in real time. The details of the design developed, based on a PIC18F452 microcontroller are described. Time, cost and energy are saved by delivering power efficiently using this system. It can be applied in industries, auditoriums, green house buildings, server rooms and nuclear facilities. It is shown that the solution requires broad knowledge drawn from several engineering disciplines including electrical, mechanical, and control systems engineering.**

Keywords: Temperature, Sensor, Display, Control, Microcontroller, Real Time.

1 INTRODUCTION

Most people still rely on electricity as it has proven itself to be an integral part of our lives – a grand sector of the nation's economy depends on power. The average temperature in Nigeria ranges from 23 degrees Celsius to 34 degrees Celsius and proper cooling is needed to make the body feel comfortable at all times. Temperature is a physical property of a body that underlies the common notions of hot and cold. Temperature plays an important role in all fields of natural science, including physics, geology, chemistry, atmospheric sciences and biology. [1]

Temperature control as defined by Wikipedia.com is a process in which the temperature value of an object is taken and the passage of heat energy into or out of the object is adjusted to achieve a desired temperature. [2]

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) have listings for suggested temperature values and air flow rates in different types of buildings and different environmental circumstances. For example, a single office in a building has an occupancy ratio per square meter of 0.1. The room temperature recommended is 21.1 degrees Celsius (70 degrees Fahrenheit). A comfortable room temperature depends on individual needs and other factors. According to the West Midlands Public Health Observatory (UK), 22 degrees Celsius (71.6 degrees Fahrenheit) is the recommended living room temperature and 18 degrees Celsius (64.4 degrees Fahrenheit) is a good bedroom temperature. [3]

Section 2 gives a more detailed statement of the problem, including performance specifications, and Section 3 describes the students' design. Section 4 makes up the bulk of the paper, and discusses in some detail several aspects of the design process which offer unique pedagogical opportunities. Finally, Section 5 offers some conclusions.

2 PROBLEM STATEMENT

In the Nigerian society today, prototypes of implemented designs or schematic diagrams are not recognized or carried out here, instead they are taken out of the country to be designed or implemented. A policy to protect the production of such products where Nigeria has comparative production cost advantage has to be created.

3 PROJECT SIGNIFICANCE

A temperature controller is a closed loop control system which senses the temperature of the environment and compares it with a user-fed threshold temperature value and changes the speed of fan accordingly. Such kind of product prototype is of great importance in industrial applications, as a little or abrupt change in the required temperature may bring voids in the functioning of systems or deteriorate the quality of the product being manufactured. Office Buildings, Auditoriums, Nuclear Plants and Pharmaceutical Industries, including Green House Buildings can make use of this intelligent technology. Table 3.1 shows the system specification.

There are three main functions of this system:

- ❖ To monitor the recent value of temperature within the set range using the temperature sensor.
- ❖ To track the changes in temperature to change the speed of the fan proportionally.
- ❖ To display actual temperature values in degrees Celsius.

Table 3.1: Temperature Controller Specifications

Temperature Sensor	
Range	(-)70°C - 150°C
Accuracy	0.5°C
LCD	
Operating Temperature	(-)30°C - 75°C
Operating Voltage	5V

4 METHODOLOGY

This shows the steps involved in the design and implementation of the system.

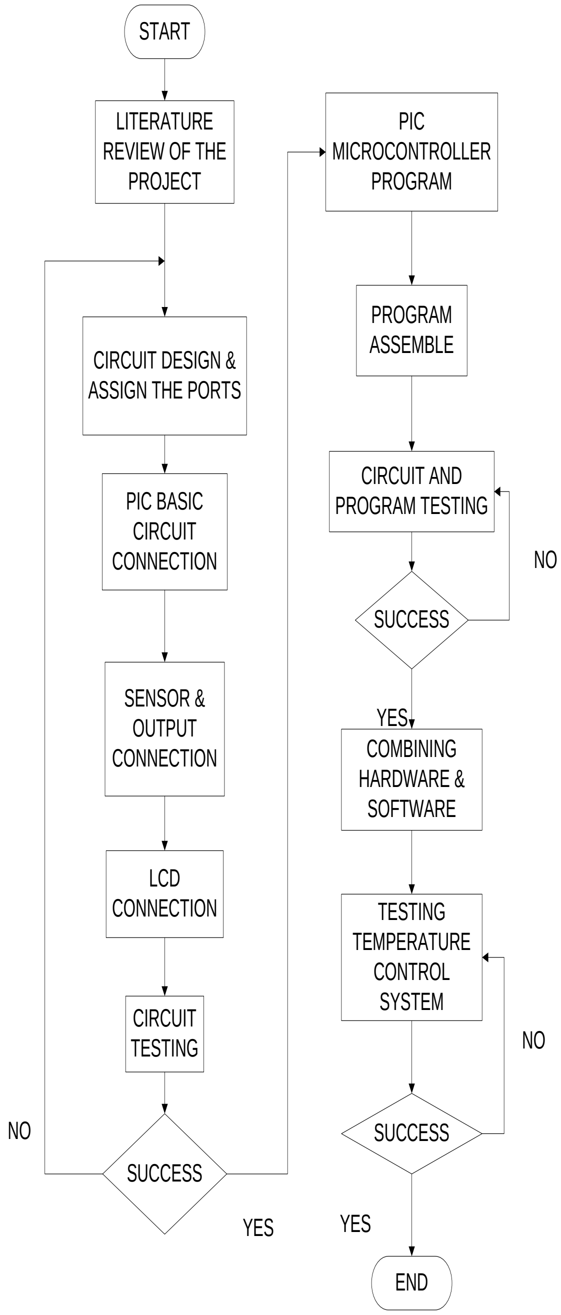

Figure 4.1: Methodology applied in the production of the system

5 SYSTEM DESIGN

The requirements for digital temperature displays and fan control alone are enough to dictate that a microcontroller-based design is likely the most appropriate. Figure 3.1 shows a block diagram of the hardware design.

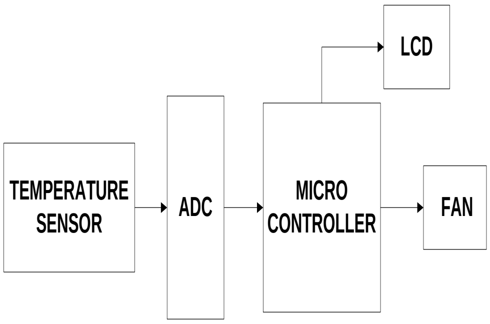

Figure 3.1: Temperature Controller Hardware Block Diagram

The microcontroller, PIC18F452, is the heart of the system. It accepts inputs from a semiconductor type temperature sensor, LM35 which allows for the measurement of the current room temperature, and it is then displayed using LCD. All these inputsand outputs are accommodated by parallel ports on the microcontroller. Finally, a pulse-width modulation (PWM) output on the microcontroller is used to drive the fan.Figure 3.2 shows the schematic diagram of the output electronics and the interfacing to the PIC18F452. The LCD display is driven by Hitachi HD44780 LCD controllerconnected to pins RD0–RD5 (Port D) configured as output pins. A potentiometer is connected to Pin 3 (VEE) of the LCD for changing contrast level. Finally, Pin 17 (CCP1) on Port C which connects fan operating on the principle of PWM which controls the fan speed by turning the fan on and off continuously at a switching frequency that is much faster than what would affect the load

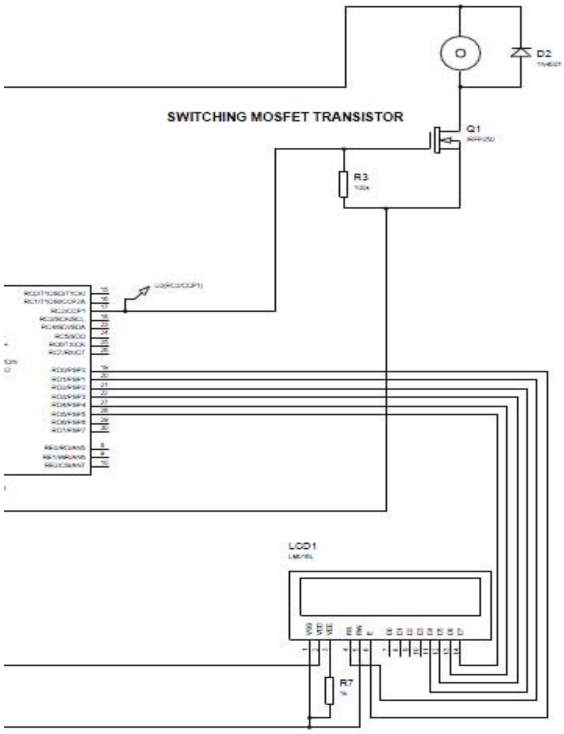

Figure 3.2: Schematic Diagram of the output interfacing with the microcontroller

The fan always gets full 12V when turned on. The pulse width (length) defines the fan power.The power is the relation between the duty cycle and off time. The duty cycle is linearly proportional to the fan speed.Figure 3.3 shows the relation between the PWM pulse and the fan speed. The green line indicates the fan speed.

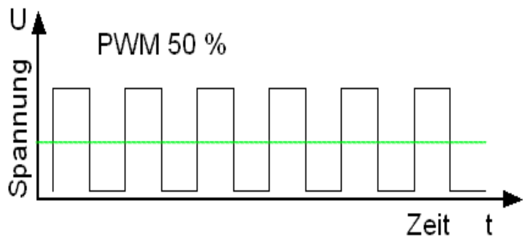

Figure 3.3: Relationship between the PWM pulse and fan speed

Duty cycle is expressed in percent, 100% being fully on. It is calculated using the formula;

$$Duty\ Cycle = \frac{T_{ON}}{T_{Total}} \times 100\%$$

The power needed to operate this system requires transformation and rectification. Full wave rectification was used to produce the necessary DC voltage required: 12V and 5V as seen in Figure 3.4. The voltage from the mains (220/240V AC) is stepped down by a transformer to 12V AC, then rectified to 12V DC by a diode bridge. The 12V DC passes through the voltage regulator to give a clean 5V DC.

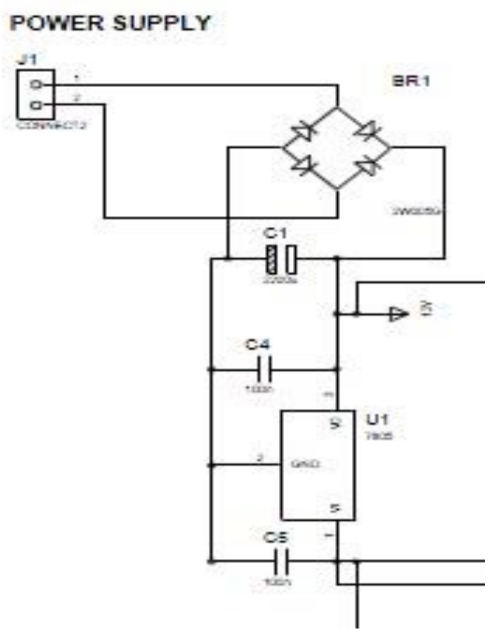

Figure 3.4: Schematic Diagram of the Power Supply Unit

Software on the PIC18F452 implements the temperature control algorithm, maintains the temperature value display, and controls the speed of the fan in response to temperature input. Figure 3.5 shows the flowchart of the process in the display system.

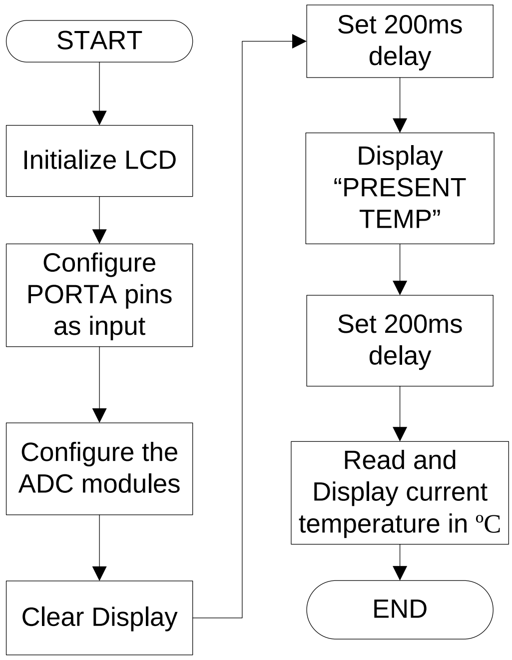

Figure 3.5: Flowchart of the display system

6 TESTING AND ANALYSIS

The hardware components were tested before being implemented on PCB, while the programming was simulated with the circuit design using PROTEUS, a virtual environment used in replicating the real life environment before implementation. The implementation and testing phase are divided into two sections which are the hardware section and the software section.

Microcontroller Application Development

Bread boarding of the peripheral hardware, development of microcontroller software, and final debugging and testing of the custom printed-circuit board for the microcontroller and peripherals all require a development environment which was simulated with PROTEUS.

Printed-Circuit Board

The layout of a simple (though definitely not trivial) printed-circuit board is another practical learning opportunity presented by this project. The final board layout, with package outlines, is shown in Figure 3.6. The relative simplicity of the circuit makes manual placement and routing practical. The layout software used was ARES package and the board was fabricated in-house.

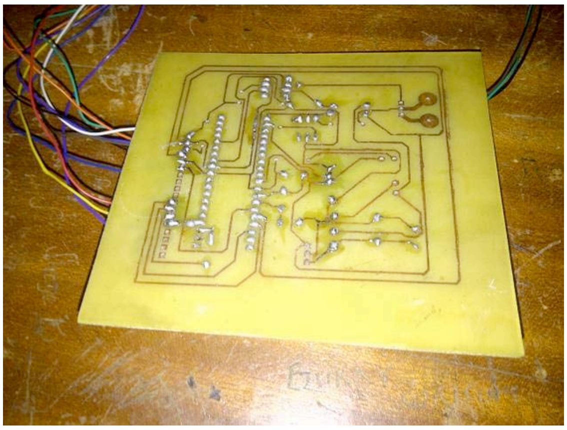

Figure 3.6: Layout for the Microcontroller Board

7 CONCLUSION

In this work, the aim has been to describe an interdisciplinary, undergraduate engineering design project: a microcontroller-based temperature control system with actual temperature display. Development of the project included the use of a microcontroller with simple peripherals, the opportunity to usefully apply introductory level modeling of physical systems and design of closed-loop controls, and the need for relatively simple experimentation (for model validation) and simulation (for detailed performance prediction). Also desirable are some of the technology related aspects of the problem including practical use of switching components and temperature sensors (requiring knowledge of PWM and calibration techniques, respectively), microcontroller selection, use of development systems, and also production of printed circuit board.

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