MICROCONTROLLER BASED TEMPERATURE CONTROLLING SYSTEM

A PROJECT REPORT

Submitted in Partial Fulfilment for the degree of

Bachelor of Technology in

ELECTRONICS & COMMUNICATION ENGINEERING

From

MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY

Formerly known as

WEST BENGAL UNIVERSITY OF TECHNOLOGY

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January 2022

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CERTIFICATE

This is to certify that the project report entitled ***"Microcontroller Based Temperature Controlling System"*** *submitted by* ***" Kaustav Das, Abhijit Kumar Manna, Soumyajit Das, Manas Mukherjee"*** *for 7th semester examination have been prepared following the guidelines of B.Tech degree in Electronics & Communication Engineering, awarded by the Maulana Abul Kalam Azad University of Technology, formerly known as West Bengal University of Technology. They have carried out the project work under my supervision.*

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ACKNOWLEDGEMENT

It is a great privilege for us to express our profound gratitude to our respected professor Dr. Atanu Banerjee, Electronics & Communication Engineering, M.C.K.V. Institute of Engineering, for his constant guidance, valuable suggestions, supervision and inspiration throughout the course work. We are also indebted to the Head of the Department Dr. Swarup Kr. Mitra, Electronics & Communication Engineering, M.C.K.V. Institute of Engineering for permitting us to pursue the project. We would like to take this opportunity to thank all the respected Professors of this department for being a perennial source of inspiration and showing the right path at the time of necessity.

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ABSTRACT

This project is a microcontroller based temperature controller system. The user sets the temperature of a system or an environment, simultaneously the DHT11 temperature and humidity sensor reads the temperature of the environment. The algorithm designed compares the user set temperature with the environment or system temperature and sequentially signals the fan or heater to operate to satisfy the user set temperature. In all this process a 16X2 LCD display has been used which simultaneously displays the data from the sensor and the user set temperature. LCD makes the system more user interactive. ATMega 328 microcontroller is the heart of this project. With the help of Atmega 328 micro-controller based on Arduino Uno board, the system responds by turning ON and OFF the two (2) loads (fan or a heater) automatically depending on the temperature difference in the room. The fan is triggered ON and the heater is triggered OFF when the room temperature is higher than the set temperature, the heater is triggered ON and the fan is triggered OFF when the room temperature is lower than the set temperature and when the user's temperature has been reached the system does not operate the heater nor the fan. The system was designed and made working using all hardware needed to design the system. Arduino IDE has been used to write the code which was then loaded to microcontroller.

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1. INTRODUCTION

The 21st Century was greeted with very unpredictable and unfavourable temperature conditions. The Green-House effect has left our world exposed and this resulted in a lot of uncertainties in our weather conditions and climate generally. There has been a growing need for the temperature of certain areas to be kept within a certain range. For this types of uncertainty microcontrollers gives an ultimate solution in the advancement of the smart controlling systems as an artificial brain given to the system. A microcontroller is mainly a single chip microprocessor suited for control and automation of machines and processes. Today, microcontrollers are used in many disciplines of life for carrying out automated tasks in a more accurate manner. Almost every modern day device including power tools, toys, office machines employ microcontrollers for their operation. Microcontroller essentially consists of a Central Processing Unit (CPU), timers and counters, interrupts, memory, input/output ports, analog to digital converters (ADC) on a single chip. With this single chip integrated circuit design of the microcontroller the size of the control board is reduced and power consumption is low. This project incorporates the design and development of a temperature monitoring and controlling system using microcontroller and LCD. The main target for this system is to have it designed and implemented such that it is cost-effective. This project consists of two modules- one is the temperature monitoring and the other is the temperature controlling. The temperature sensor senses the temperature and the inbuilt ADC in the temperature sensor sends data to microcontroller which is further processed by the microcontroller and the temperature is displayed in the LCD. The user's temperature requirement is the input to the microcontroller in the form of a set-point and the microcontroller then compares the ambient temperature against this set-point and further controlling signal is send to relays which satisfies user's requirement. If the temperature goes above the set-point then the cooler goes on and if the temperature goes below the set-point then the heater is switched on. The values of temperature obtained from the sensor are analysed using Arduino.

1.1 IMPORTANCE OF A TEMPERATURE CONTROL SYSTEM

The Importance of a Temperature Control System can be grouped into three basic areas:

1.1.1 Economic Importance – Temperature Control Systems are economically important as they have the duty of ensuring that the energy supply reaching the house/office/industry is economized and managed as much as possible. This it achieves by making sure that the heating and cooling units are only functioning when they are needed. The Control System further ensures that the energy bills that would be paid by the company or individual are “efficient”, because the bill would only cover energy that was efficiently utilized

1.1.2. Safety Objective – Temperature Control Systems have saved the day in many places where they are being used. Electrical Fires have been minimized because these Control Systems turn off heating and cooling units when they are not necessarily in use, thus preserving lives and property.

1.1.3. Wastage of Resources Prevention – In Homes and Industries alike, much wastage of useful resources have been prevented as a result of the use of Temperature Control Systems. These Systems efficiently manage the temperature of storage areas, thus keeping stored items at temperatures that extend their value period.

1.2. HOME ENVIRONMENT OVERVIEW

The Home is usually the most inhabited place in any society. The need to keep the home environment thermally conductive should be of paramount concern in any society that wants to maintain happy and healthy citizens. Areas in the home that are usually occupied by people, such as the living room and bedrooms need to be maintained within habitable temperature ranges. The human body has a set-point temperature of about 27°C. Extremely higher or lower temperatures can result in damage to some body organs or tissues and eventual death. These issues become more pertinent in areas of the home that are occupied by infants. Adults could possibly find their way around “thermal discomforts”, but infants may not. Other areas of the home that are used as storage areas for perishable food items also need to be thermally regulated in order to prevent accelerated decay of such items. This makes necessary the need for a Temperature Control System within the home.

1.3 MAIN IDEA BEHIND THE PROJECT

The aim of the project was to implement an automatic room temperature control system. The automatic room temperature control system utilized temperature sensors to detect the temperature of the room. When the current temperature exceeds the set-point temperature, the Controller triggers on a cooling system made up of a set of brushless fans. These fans would cool the room until the current temperature fell below the set-point temperature. When the current temperature below the set-point temperature, controlling triggers on a heating system made up of a set heating bulb. The heating bulb would warm up the room until the current temperature rises up to the set temperature. The system is built with a temperature sensor that is placed in the system that detects the current temperature and displays the value on the LCD. An Arduino reads the data from the temperature sensor which is in output voltage. The system will operate in three different conditions depending on the range of temperature. When the current temperature value reaches higher than the desired value, the fan will start functioning and the bulb will turns on temperature goes below desired point . Any changes in temperature in the room are continuously displayed on the LCD.

2. LITERATURE REVIEW

In the past few years, the need for automation has increased and has been widely applied to cooling and heating systems. There are plenty of commercial temperature control systems which can be bought from manufacturers or inventors, and also, quite a lot of work has been published in this area

These designs are not easy to use in terms of programming and temperature adjustment. The systems work on the benefits of using temperature adjustable and fan temperature control systems. These systems are either one time programmable or need analog adjustment which is not accurate and more difficult to use.

More recent, real time based temperature control using Arduino was published(Amoo et al,2014). The system uses Arduino based on ATMEL 89C51, which is just one of the applications of Arduino. The system is not simple in terms of operation as it is tedious to change the reference temperature. The system is similar to the ones presented by the authors in the following systems;

1. A precision temperature controller using embedded system.(Pimpal Gaonkar et al, 2011).

2. Design and experiment about temperature control system of sealing machine based on Fuzzy PID. (Cao et al, 2011).

Other works based on temperature control do exist in different areas and different applications. Such work such as electric cable interference temperature monitoring in power transmissions(Li et al, 2011), server room temperature measurement using Bluetooth embedded system(Loup et al, 2011), control system for communication room using wireless temperature monitoring system (Bing and Wenyao, 2011) and temperature sensor and Zigbee based temperature measurement(Pengfei et al, 2011)do exist. These systems have the same problem of cost as well as the need for experts in re-programming.

Goswami [3]have proposed an Embedded System for Monitoring and Controlling Temperature and Light. In this system microcontroller AT 89S52 is used which is a 40 pin IC. The temperature measurement and light intensity from the channels of ADC 0809 are taken. The performances of the channels are distinguished on the basis of its accuracy. The accuracy indicates how accurately the sensor can measure the actual and the real world parameter. In our system we have used a 28 pin IC ATMega 328.

M Ramu and CH. Rajendra prasad[4] have discussed about Cost Effective Atomization of Indian Agricultural System using 8051 Microcontroller and GSM technologies. This project finds application in domestic agricultural field. In civilian domain, this can be used to ensure faithful irrigation of farm field, since we have the option of finding the moisture level of soil in a particular area.

This leaves a gap for the design of a system that is not only simple, cost effective, efficient, easy to program and one that minimizes components so as to reduce the size of the design. The automated room temperature controller system thus comes in handy to provide solutions to the gaps that can be noted in the previous systems. It is simple, cost effective and can be used to provide real-time air conditioning for both home and commercial institutions.

2.1 ATMega 328 (ARDUINO)

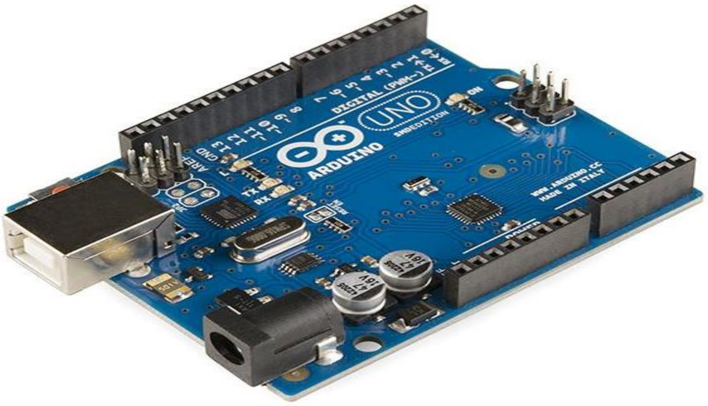

Fig 2.1 – Image of ATMega 328 microcontroller circuit

Table 2.1.1 Specification table of ATMega 328 microcontroller

Microcontroller	ATmega328
Operating Voltage	5V Input
Voltage	7-12V
Input Voltage	6-20V
Digital I/O Pins	14
Analog Input Pins	6
DC Current per I/O Pin	40 mA
Current for 3.3V Pin	50 mA
Flash Memory	32 KB
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

2.2 DHT11 Temperature and Humidity sensor.

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor with a calibrated digital signal output. It uses exclusive digital-signal-acquisition technique and temperature & humidity sensing technology; it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

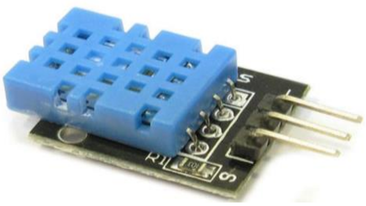

Fig 2.2.1 – Image of DHT 11 Temperature sensor

2.3 LCD DISPLAY

Fig 2.3.1 - Image of LCD display circuit

Since the data from the microcontroller needs to be displayed a HD44780 based Liquid Crystal Display – JHD162A is used. The display section consists of 16*2 LCD, which is used to display the temperature.

2.4 RELAYS

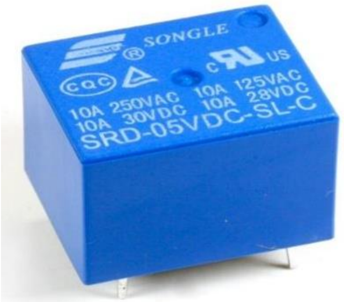

Fig 2.4.1 Image of Relay circuit

There are two relays connected. It operates in two modes-Normally Open (NO) and Normally Closed (NC). Different devices can be controlled i.e. they can be turned on/off whenever required. Two 5V relays are used to control the hardware for maintaining temperature as set by the user, one for the heater and the other for the cooler.

3. WORKING PRINCIPLE

The circuit is based on DHT11 digital temperature sensor and ATMega328P microcontroller. DHT11 has a dedicated NTC(Negative Temperature Coefficient) to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The microcontroller accepts the output of DHT11 and displays numerically on LCD display. The output from DHT11 is connected to pin-5 of microcontroller, which is the digital pin . We have interfaced LCD with I2C connector for easy deployment. The adapter is an 8-Bit I/O Expander chip – PCF8574. This chip converts the I2C data from an Arduino into the parallel data required by the LCD display. It has 4-pins,VCC,GND,SCL,SDA. VCC pin is connected to +5V and GND to common ground, SCL and SDA pins to microcontrollers SCL and SDA pins respectively. For driving the fan(cooler), we have connected pin-2,pin-3 of microcontroller to pin-2,pin-7 of L293D motor driver IC. We have used relay as we require High Voltage/Current as AC source, On Low Voltage Side, Signal(S) pin of relay is interfaced with pin-2 of microcontroller for controlling heater, VCC pin connected to +5V and GND to common ground whereas on High Voltage side, we have connected one terminal of live wire of bulb to NO(Normally Open) pin and another to Common pin. The setpoint is controlled through two push buttons through pull-down resistors which are connected with pin-6,pin-7 of microcontroller. We have used +5V D.C from microcontroller itself to power required electronic components.

3.1. SOFTWARE IMPLEMENTATION

In the software implementation part we have developed the code in Arduino programming language for measuring the temperature and set the temperature according to user set temperature input and displaying temperature value on LCD module. The code includes reading temperature from sensor, since the sensor DHT11 has an inbuilt analog to digital converter so the analog to digital conversion in ATMega328 is not used in reading temperature. The code is developed such that only temperature values are being read from sensor, the temperature value is being displayed on 16X2 LCD display and the value is being processed for controlling purpose. The code was developed in Arduino IDE software, the developed code is installed in ATMega328 microcontroller. The Arduino IDE has facilities of boot loading, source code editing, program editing, program debugging with serial monitor and serial plotter, through which stimulation of input output values , voltage values and plotting of voltage values can be observed. The Arduino runtime AVR-GCC library that is supplied with the Arduino development environment , and the on-board bootloader firmware that comes preloaded on the microcontroller of every Arduino board. The Arduino IDE editor and debugger are integrated in a single development software which provides easy embedded projects development. The Arduino IDE can be installed in Windows, Mac OS and Linux.

3.2. HARDWARE IMPLEMENTATION

In the hardware implementation, a breadboard and a verro board is used for temporary testing of circuits. In testing no soldering was done hence the damaging of electronics devices and sockets were prevented. The required hardwire components are written in the below table:

Table 3.2.1 Component Table

Sl. No.	Name of the Component or Electronic Devices	Quantity
1	DHT11 Temperature and humidity sensor	1
2	Arduino Uno R3 ATmega328 microcontroller	1
3	L293d Motor driver IC	1
4	12 V D.C Fan	1
5	5 Watt Bulb	1
6	Single channel Relay	1
7	Push button	2
8	1KΩ Resistor	3
9	Single pole switch	1
10	Bread board	1
11	Verro board	1
12	12V D.C adapter	1
13	9 V D.C battery	1
14	LED	
15	LCD driver IC	1

All electronic devices and components were powered using wires and data from sensor to microcontroller was also transferred using wires.

4.1. FLOW CHART OF THE SYSTEM

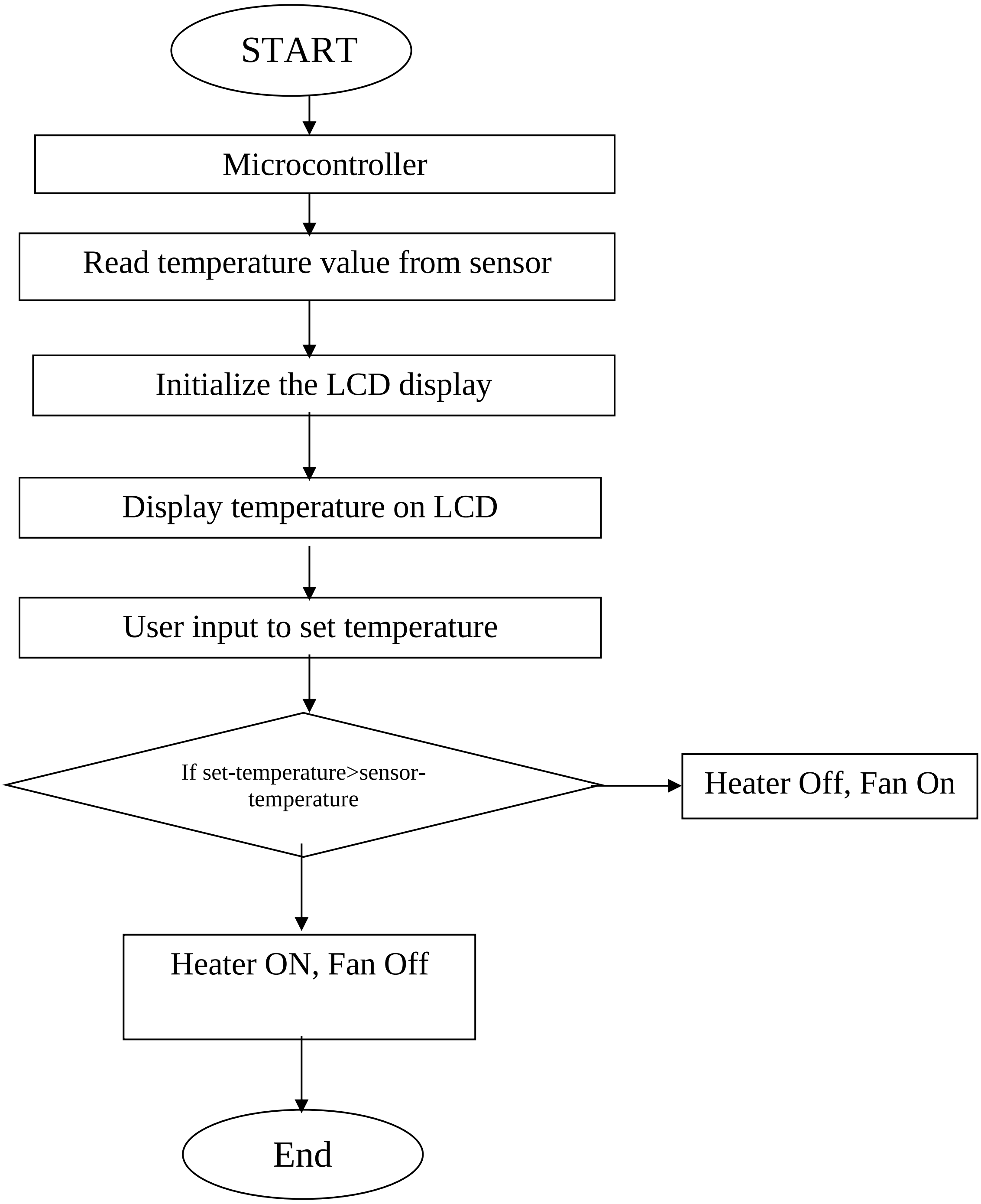

Fig 4.1- Flow Chart of the System

4.2. BLOCK DIAGRAM OF THE SYSTEM

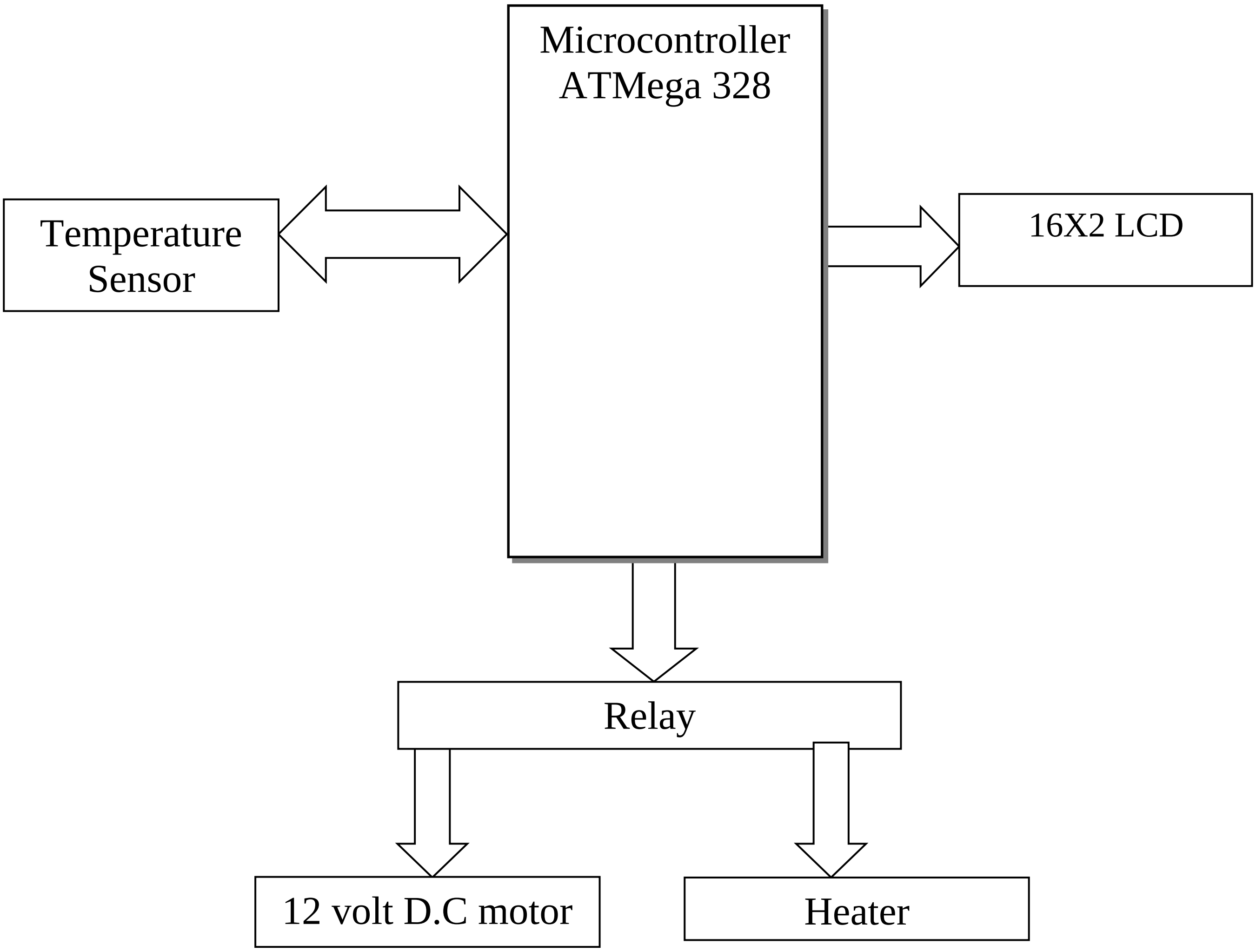

Fig 4.2- Block Diagram of the System

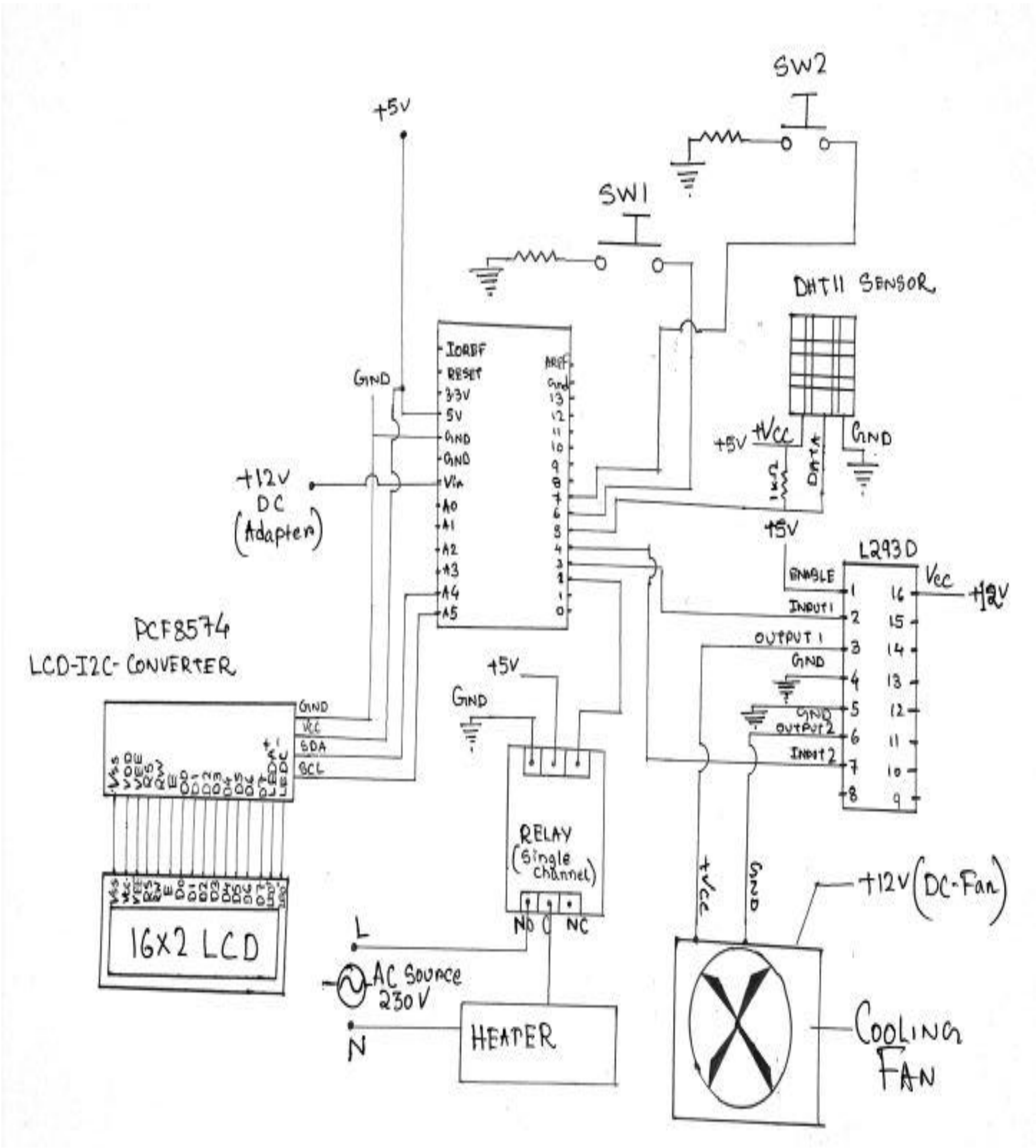

Fig 4.3- Circuit Diagram

5. DATA SHEET

Sl. No.	Set Point (°C)	Room Temperature (°C)	Cooling Fan	Heating Bulb
1.	22 °C	26 °C	ON	OFF
2.	22 °C	24 °C	ON	OFF
3.	22 °C	22 °C	OFF	OFF
4.	22 °C	20 °C	OFF	ON
5.	22 °C	18 °C	OFF	ON
6.	22 °C	20 °C	OFF	ON
7.	25 °C	24 °C	OFF	ON
8.	25°C	25 °C	OFF	OFF
9.	25 °C	26 °C	ON	OFF
10.	18 °C	22 °C	ON	OFF
11.	18 °C	20 °C	ON	OFF
12.	18 °C	18 °C	OFF	OFF

Table 5.1 Datasheet of this Project

6. CODE UPLOADING

6.1 CODE

```
#include <LiquidCrystal_I2C.h>
#include <Wire.h>
#include <DHT.h>
#define Type DHT11
int senseTempPin=5;
DHT HT(senseTempPin,Type);
LiquidCrystal_I2C lcd(0x27,16,2);
const int btn1Pin=6;
const int btn2Pin=7;
const int relayPin=2;
const int mtrPin1=3;
const int mtrPin2=4;
const unsigned long tempSensorInterval=1000;
const unsigned long btn1Interval=100;
const unsigned long btn2Interval=100;
const unsigned long lcdInterval=100;
unsigned long prevBtn1Time=0;
unsigned long prevBtn2Time=0;
unsigned long prevLcdTime=0;
unsigned long prevTempTime=0;
int btn1Value;
int btn2Value;
int setUpTime=2000;
int setTemp;
int tempC;
void setup(){
  Serial.begin(9600);
  lcd.init();
  lcd.backlight();
  HT.begin();
  pinMode(relayPin,OUTPUT);
  pinMode(btn1Value,OUTPUT);
  pinMode(btn2Value,OUTPUT);
  Serial.println("Initializing...");
  lcd.print("Initializing...");
  setTemp=HT.readTemperature();
  delay(setUpTime);
  lcd.clear();
}
void loop(){
  unsigned long currentTime=millis();
  // Task_1: Read Temperature Sensor Value
  if(currentTime-prevTempTime>=tempSensorInterval){
    tempC=HT.readTemperature();
    }
  // Task_2: Turn-On Heater(Light_Bulb) if setTemp>tempC
  if(setTemp>tempC){
    digitalWrite(relayPin,HIGH);
    digitalWrite(mtrPin1,LOW);
    digitalWrite(mtrPin2,LOW);
  }
```

```
  else if(setTemp<tempC){
    digitalWrite(mtrPin1,HIGH);
    digitalWrite(mtrPin2,LOW);
    digitalWrite(relayPin,LOW);
  }
  else{
    digitalWrite(mtrPin1,LOW);
    digitalWrite(mtrPin2,LOW);
    digitalWrite(relayPin,LOW);
  }
  // Task_3: Read Button_1 Status
  if(currentTime-prevBtn1Time>=btn1Interval){
    btn1Value=digitalRead(btn1Pin);
    prevBtn1Time=currentTime;
   }
  // Task_4: Read Button_2 Status
  if(currentTime-prevBtn2Time>=btn2Interval){
    btn2Value=digitalRead(btn2Pin);
    prevBtn2Time=currentTime;
   }
   // Task_5: Display set temperature information on LCD Screen.
   if(currentTime-prevLcdTime>=lcdInterval){
      if(btn1Value!=0){
        if(setTemp<50 and setTemp>0){
         setTemp=setTemp+1;
          lcd.clear();
          lcdDisplay(tempC,setTemp);
        }
      }
     else if(btn2Value!=0){
      if(setTemp<50 and setTemp>0){
        setTemp=setTemp-1;
        lcd.clear();
        lcdDisplay(tempC,setTemp);
       }
     }
     else
          lcdDisplay(tempC,setTemp);
     prevLcdTime=currentTime;
   }
   Serial.println(currentTime);
}
void lcdDisplay(int currtemp,int setTemp){
  lcd.setCursor(0,0);
  lcd.print("Room_Temp: ");
  lcd.print(currtemp);
  lcd.print(char(223));
  lcd.print("C");
  lcd.setCursor(0,1);
  lcd.print("Set_Temp : ");
  lcd.print(setTemp);
  lcd.print(char(223));
  lcd.print("C");
}
```

6.2 HARDWARE SYSTEM AFTER CODE INSTALLING

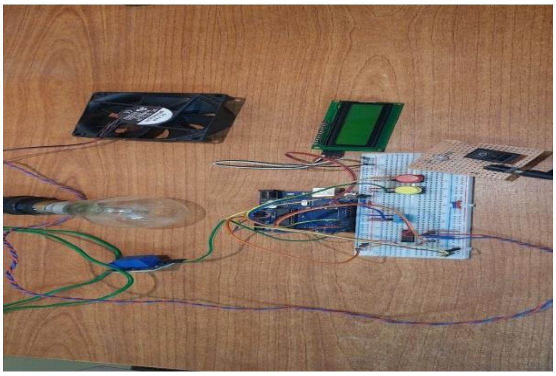

Fig 6.2.1- Hardware connected.

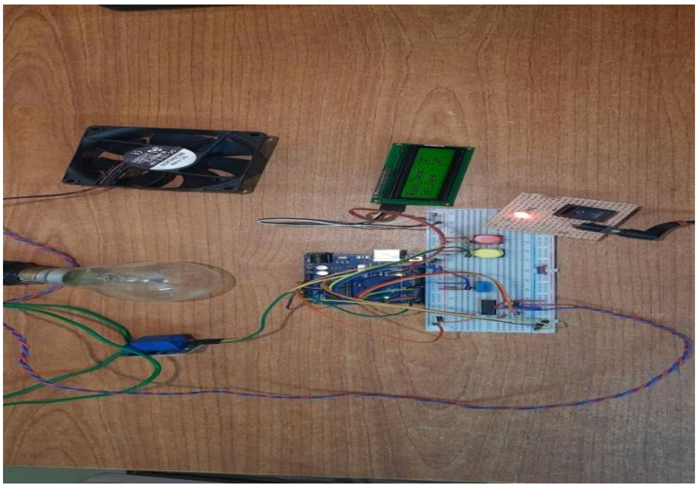

Fig 6.2.2- Temperature set by user.

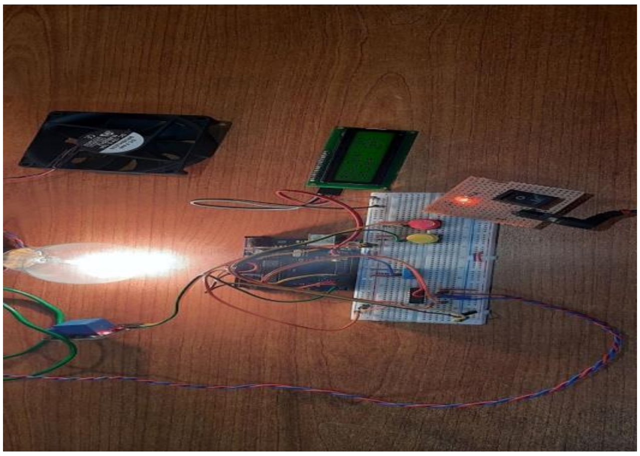

Fig 6.2.3- Execution of algorithm as per user input.

7. APPLICATION

1. Premature babies are less able to control their body temperature than full-term babies. If their environment is too cold, they can lose heat very quickly. For, above uncertain temperature hazards, this temperature controlling system can be implement to give them a living support.

2. Temperature controlling system can be used for keeping eggs warm at a particular temperature range (37.5 °C for chicken eggs) and in the correct humidity with a turning mechanism to hatch them.

3. This system can be implemented both in warn regions and cold regions. This system is a versatile device it, can flexible can change according to the requirement.

4. Temperature controllers can be used in the manufacturing industries. The industries like textile mill, pharmaceutical industry, oil refinery etc. all requires perfect temperature base-point. The temperature controllers can be used to maintain constant temperature of process or plant or any material.

5. It can be used in tea factories to continuously monitor and control the temperature required for processing the tea leaves.

6. It can be used in confectioneries for preservation of the sweets. The system can be used in green houses to control the temperature for the proper growth of plants.

8. FUTURE SCOPE

1. We can monitor more parameters like humidity, light and at the same time control them with respective sensors.

2. We control this system remotely using mobile or internet.

3. We can observe graphs of variations in parameters using a computer.

4. When temperature exceeds the limit, a call or message to the respective given number by connecting and GSM module.

5. We can also implement it in egg hatching where a particular temperature needs to be maintained along with parameters like humidity and light.

9. CONCLUSION

This microcontroller-based temperature controlling system is implemented with active support of DHT11 temperature sensor. The temperature is displayed on the LCD screen and the desired value of temperature is also set. The entire decision making is done with the help of a microcontroller ATMega328. This type of system can be installed in any place where we need to maintain temperature approximately constant. Also, by applying more sensors like light intensity sensor, barometer, humidity sensor etc, more parameters like light, atmospheric pressure and humidity etc can be monitored and controlled which are vital for any industrial process. The system has various advantages over other similar systems such as cost-effectiveness, smaller size, on device display, less complexity and greater portability. This project can be used in industries to measure the temperature and control the temperature as per requirement.

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