Temperature Monitoring and Control System

Final Report : Electronics Workshop 2

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1.0 Introduction:

1.1 AIM (Problem Statement):

- To monitor and control the temperature in a cardboard cabin of 30 cm^3.
- A feedback control system is to be designed to maintain the temperature in the cabin to the temperature set by the user.
- A display of the current temperature along with a recording of temperature over a specific period of time.

1.2 Applications:

- The concept of the project can be extended to the temperature control inside the room. (eg: Smart AC or Smart Heater). Here it is used for the comfort of Normal User.
- To maintain the temperature or set temperature in a predefined way inside a closed vessel in biology or chemistry lab. (eg 50˚ C for an hour and then decreasing by 1˚ C every 5 minutes for next one hour)
- To Save Power Usage by automatically controlling the speed of the fan as per temperature variation.
- In future,it can be integrated with Internet of Things. The temperature control through the internet using phone and computers.

1.3 Working Principle Involved:

Our project is an example of a closed loop control system. The parameter given is temperature and we are supposed to maintain the temperature as per the wish of the user.

Like any control system, it has a feedback loop. To vary the temperature, it has two major modules.

- Cooling Module
- Heating Module.

The system sets up the modules and observes its effect on the system and then updates the modules based on the feedback to minimize the error in its working.

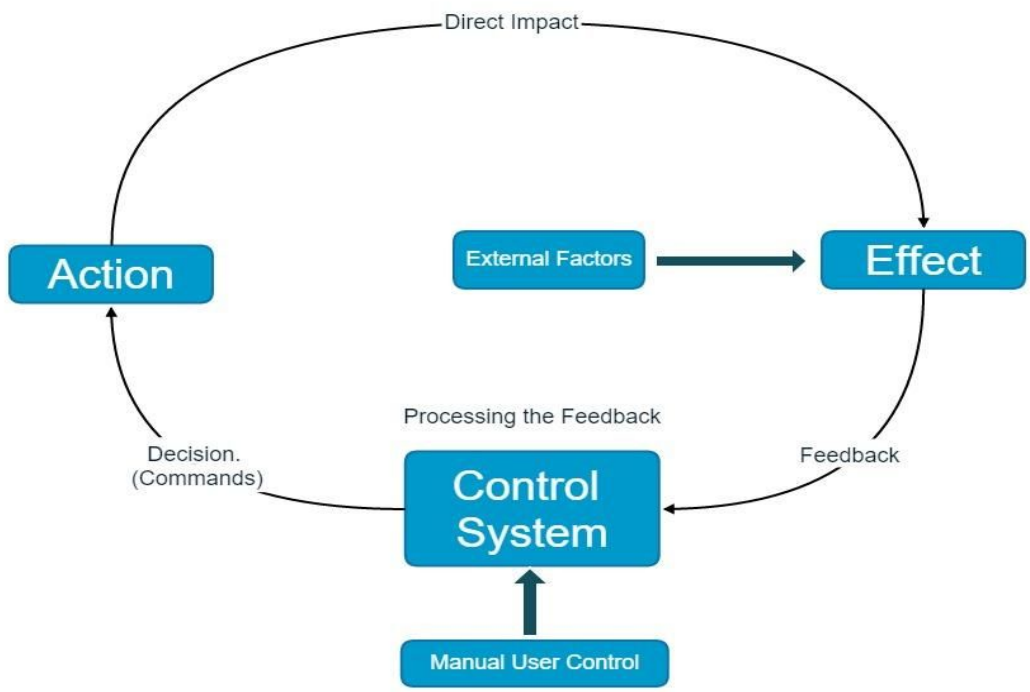


Figure : Control System

Cooling module and heating module are chosen to be a 12V DC fan and 100 W AC bulb respectively. The following choice is done as per the availability of the components. The aim is to demonstrate the concept. The modules can be replaced with better components with a slight change in our system.

2.0 Main Project:

2.1 Approach:

Our approach to the problem statement was to divide the problem statement in subproblem and then integrate them together.

Subdivision of Problem:

1. Sensing the Temperature
2. User Interface for setting temperature
3. Action Systems
4. Central Unit

2.2.1 Sensing the Temperature

Idea:

- The current flowing through the diode changes as per the temperature of the surrounding. However directly measuring through the normal diode is very hard and relation with temperature is not linear.

- The IC used in the project to measure the temperature is LM-35. The working principle of LM35 is as follow:

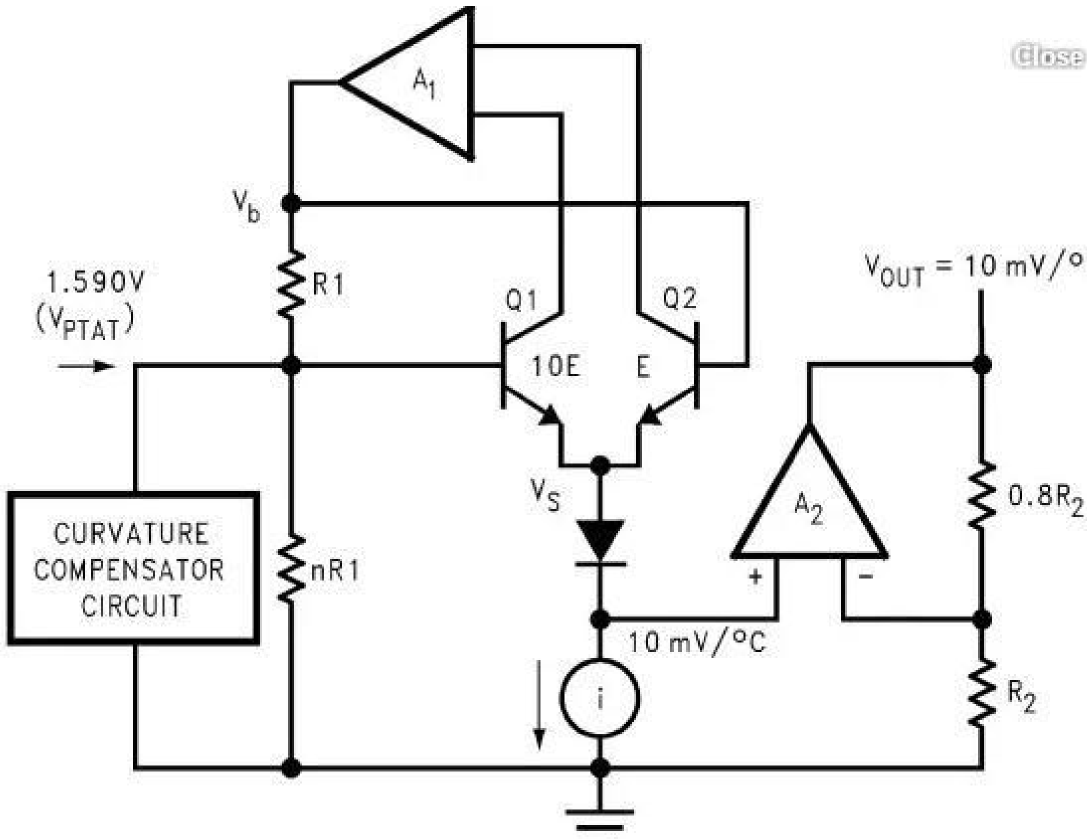


Figure : LM-35 Sensor

- There are two transistors whose emitters are connected such a way that same current flows through them. This current changes as per the temperature. Configuration is in such a way that the voltage drop across R1 is in proportional to absolute temperature.

- The relation with the temperature is almost linear in this circuit.

- A2 converts the corresponding Kelvin to ˚ C value voltage by highly accurate resistors R2.

Implementation:

- LM35 sensor is used which changes the output voltage between the reference voltage and ground as per the room temperature in ˚ C scale.

- LM35 works for whole range of -55˚ to 150˚ C.

- This output terminal given to ADC and analog value is read. This analog value is then multiplied by proper scaling to get an answer in degree Celsius.

i.e. answer of analog value between 0-1023 is divided by 9.31 for 5V reference voltage to get box temperature.

2.2.2 User Interface

Idea:

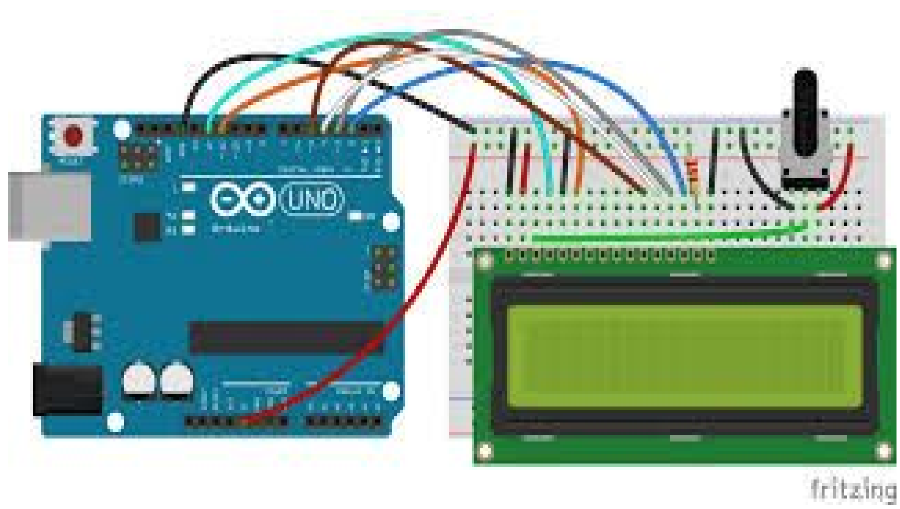
- To create a display for user set temperature and present temperature.
- We need to get temperature value that the user wants to set inside the box. We tried the following user interface method.

1. The first one was to use a Laptop. So the user enters the desired temperature in the computer and as central

part i.e. microcontroller is connected to the computer. We can send that data to the microcontroller.Laptop is also used for dumping the code.

Implementation:

- 16:2 display is connected with Microcontroller.
- First line will display Set temperature and Next line will display Present Temperature.



16:2 LCD display

2.2.3 Action System

Idea:

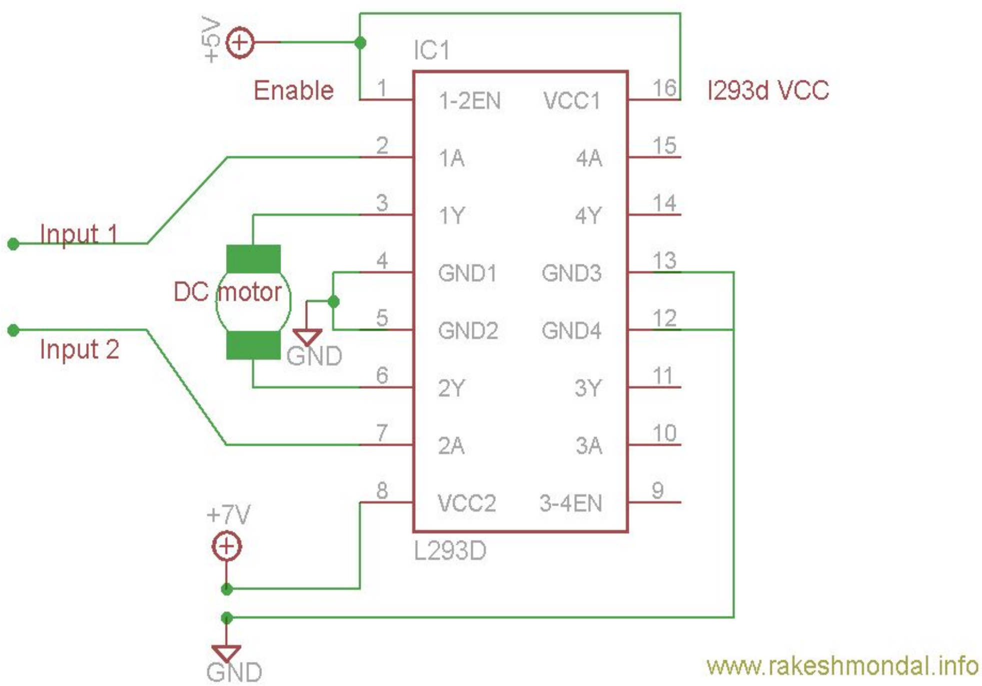
- To decrease the temperature: Exhaust Fan which is controlled by PWM.

- To increase the temperature: 100 Watt Bulb. (Ideally heater but as cube is small 100 W bulb works well enough.)

Implementation of Varying Speed Fan:

- PWM as per the difference between set temperature and present temperature is generated.

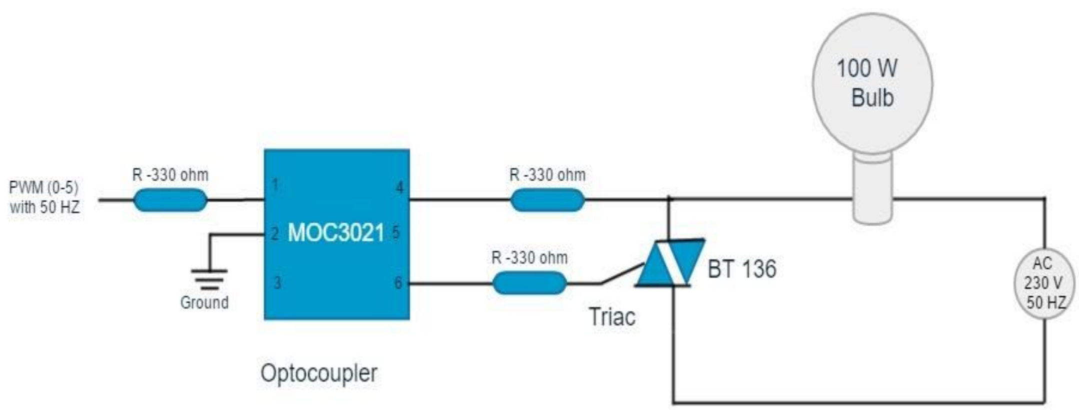
- This PWM is given as input to motor driver IC to which gives the same PWM but with higher voltage from voltage source as microcontroller can't drive the motor by itself.



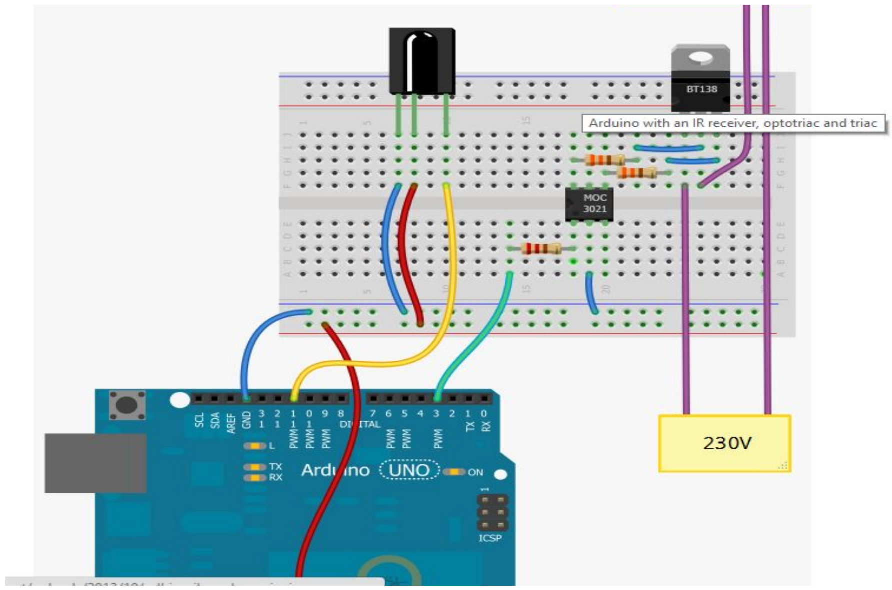
Fan Speed Variation using LM293D

Implementation : Brightness of Bulb:

- The bulb is driven through AC voltage whereas rest of the circuit is DC. This creates a big problem.
- We want to control the Triac which in turn controls the AC voltages as per the voltage in the gate. But we cannot directly give this gate current from out DC circuit.
- For this reason, we require an Optocoupler to communicate between this AC and DC. Optocoupler contains LED in dc part and when we turn it on, it connects two pins in AC part allowing some low current which is given to the Triac BT136 which in turn completes the circuit for AC bulb.



Brightness Variation in Bulb



Fritzing Design

2.2.4 CENTRAL SYSTEM

For the central system, we have used Arduino Uno Microcontroller.
(Reason: Easily available and robust.)

Use of Microcontroller:

- For maintaining the log.
- Reading Analog values of voltage from the sensor as well as user interface.
- Producing PWM for speed and brightness for Fan and Bulb.
- Displaying in temperature on 16:2 LCD display.

- Basically, every other component is connected to the Arduino. Arduino is giving control signals and taking care that everything is working as it's supposed to.

Specification:

- Arduino is storing 500 temperature values at approx. 3-second interval. (1.5 KB total variable 70% of max)
- Generating PWM at around 40-50 HZ. (Default 490 Hz)
- PWM pins 9,10

2.3 Components

No	Name	Quantity
1	Light Bulb (100W)	1
2	Small Exhaust Fan (DC)	1
3	LM35 Sensor	1
4	16:2 LCD Display	1
5	BT136	1
6	LM293D	1
7	Arduino Uno	1

9	Insulated Box	1
10	Potentiometer	1
11	MOC3011	1

2.4 Temperature Variation Graph: (Observed)

- Heating the box till some specified temperature. (here 45C)
- Samples of temperature at every 3 second.

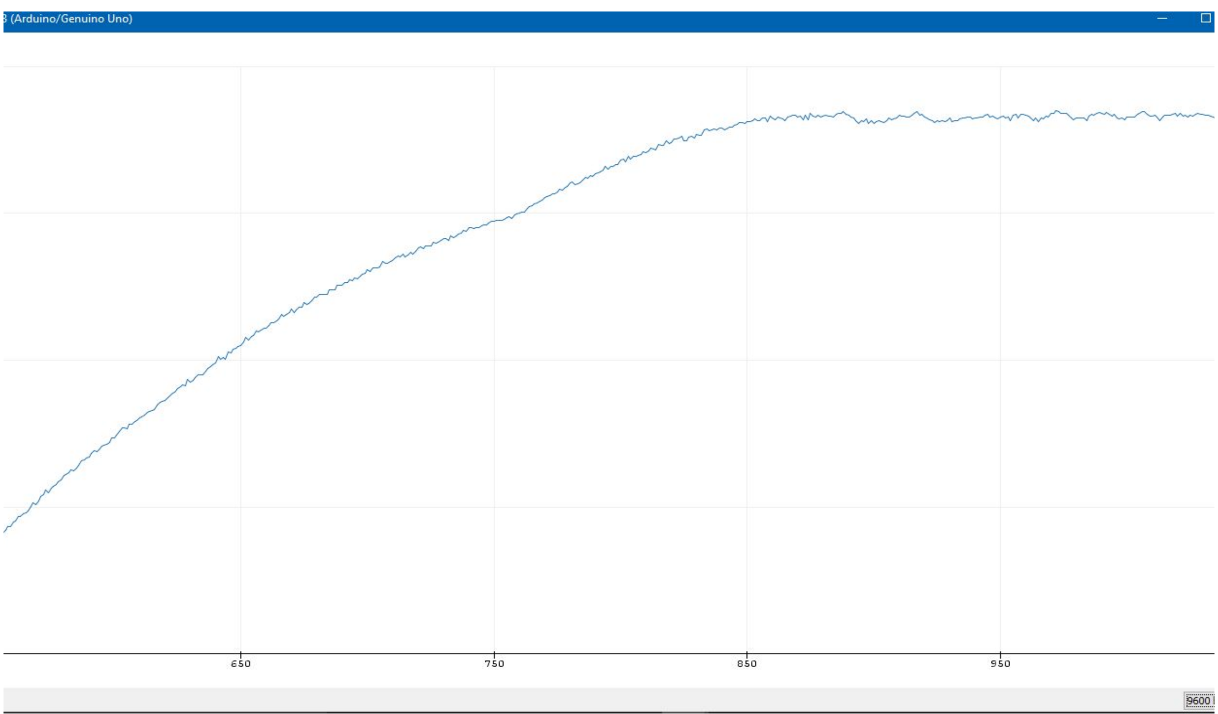


Figure 2.4 Live plot :Temperature vs Time graph

3.0 Challenges

- **Integration of small parts:** The main challenge of the project was to build small modules and then make them work together. The integrating part was challenging.

- **Pin optimization**: In Arduino Uno, we are using 19 pins out of 20. Converted 2 analog pin in digital. Also proper managing and use of multiplexer in 4 digits 7 segment display to reduce pin count.

- **Controlling 230 V AC current using Arduino which is DC:** For this, we had to try a number of circuits. A couple of IC and resistance even got burned down. The way out was to use Optocoupler which avoids any direct connection with AC part.

At the end of the day, we are using almost all memory, all except 1 I/O pins and all three timers in Arduino Uno which was possible only when we optimized the code and pins allocation.

4.0 Future Implementations:

- Adding more sensor like humidity, brightness, pressure etc.

- Integrate it with the Internet of things(IOT)& control through the internet.

- Use the better cooling system to go below room temperature. It would require a better understanding of thermodynamic and related instruments.

THE END