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DESIGN AND SIMULATION OF TEMPERATURE CONTROL OF CHAMBER BASED ON AUTOMATIC FAN SPEED CONTROL

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***Abstract* - This paper presents the design and implement of microcontroller based temperature control using electric fan. The electric fan automatically switches the speed according to change inner temperature of the box. The system contain LM35 temperature sensor, 89C51 microcontroller, fan interface circuit and the box. This inner temperature is compared with the set value by the user and if the temperature above the set values the fan ON as per the requirement and if the temperature below the set values the fan OFF automatic.**

***Keywords* - LM35, 89C51, ADC, box, fan.**

I INTRODUCTION

Generally, electronic device produce more heat, so that heat should be reduced in order to protect the device. There are many ways to reduce heat. One way is to switch on the fan spontaneously. Here describe a circuit that automatically switches the fan when it detects the temperature inside the box greater than its threshold value. The system made use of: AT89C51 Microcontroller, Temperature sensor (LM35), Analog to Digital Converter (ADC) [1]. PID controllers have been used for industrial processes because of their simplicity and robustness.

A. *Objectives*

1) To create an automatic Fan system that can monitor the box temperature and compare with set value using a temperature sensor.
2) To design a close loop control system with combination of hardware and software.

II SYSTEM OVERVIEW

This project mainly controls the speed of fan according to the inner environment of box temperature. The temperature sensor (LM35) senses an actual temperature of the box to the ADC in voltage form which is linearly proportional to the Celsius (Centigrade) temperature and not requires any external calibration. The LM35 sensor has a linear +10.0 mV/°C scale factor and a temperature range from -55°C to +150°C. AT89C51 microcontroller is used to acquire temperature reading from ADC. To collect temperature data from ADC microcontroller compare single to set value by user and generate signal to control circuit. This control circuit control the fan speed according to signal comes from the microcontroller. Control system can be classified as either open loop or closed loop. In open loop system output has no influence of the input action. Also open loop does not having feedback path. While closed loop system has a feedback path from the output of the controlled process to the input of the control system. So, closed loop system monitor the temperature and control the fan by switching to appropriate speed.

III SYSTEM ARCHITECTURE

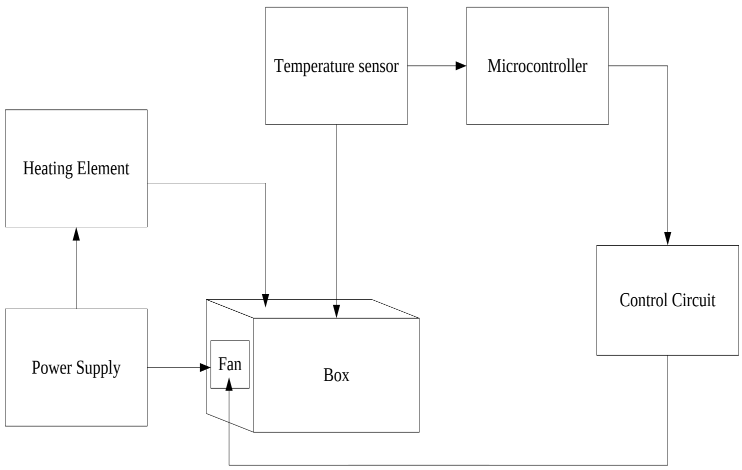

Fig. 1 System Block Diagram

A. *The Temperature Sensor (LM35)*

The LM35 is precision integrated-circuit temperature sensors with an output voltage linearly proportional to temperature (in °C). The device is used with single power supplies. It is rated to operate over a -55 to +150°C

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temperature range. [3] The scale factor is .01V/°C. It can be measured more accurately than with a thermistor.

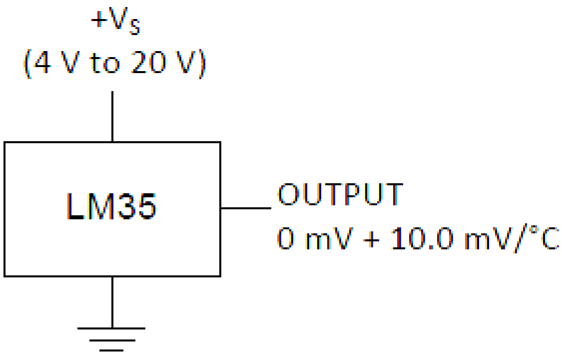

Fig. 2 Basic Centigrade Temperature Sensor [3]

The general equation used to convert output voltage to temperature is:

Temperature (°C) = V_{out} * (100°C/V)

So, if V_{out} is 1V then, Temperature =10°C

The LM35 is directly coupled to Analog to Digital Converter (ADC) for further processing.

B. The Analog to Digital Converter (ADC0809)

The ADC0809 is used to convert an analog voltage variation into digital pulses. This is IC having 8-Channel A/D Inputs with Addressable multiplexer so that channel selection can be done automatically. The 8-bit A/D converter uses successive approximation as the conversion technique. The device eliminates the need for external zero and full-scale adjustments. Also, Easy interfacing to microprocessor is to provide by the latch and decoded multiplexer address inputs and latched TTL TRI-STATE outputs. [4] The pin diagram of ADC0809 is shown in below figure.

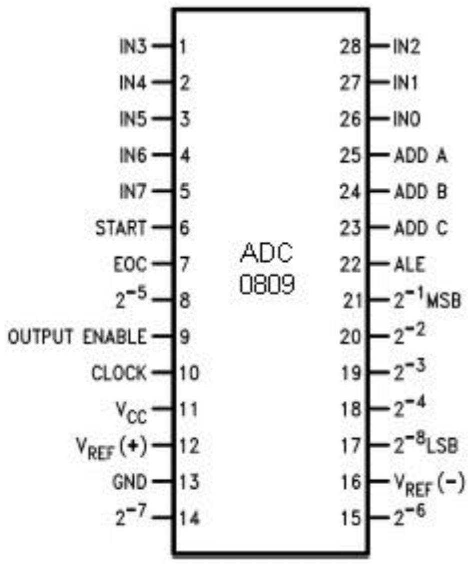

Fig. 3 Pin Diagram of ADC0809 [4]

C. The AT89C51 Microcontroller

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set and pin out. [5] In 40 pin AT89C51, there are four ports designated as P_1, P_2, P_3 and P_0. All these ports are 8-bit bi-directional ports. The on-chip flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. The Atmel AT89C51 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.

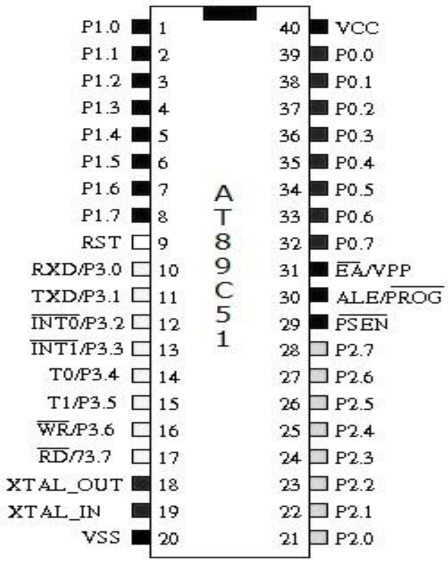

Fig. 4 Pin Diagram of AT89C51 microcontroller [5]

The AT89C51 provides the following standard features: 4K bytes of flash, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, five vector two-level interrupt architecture, a full duplex serial port, and on-chip oscillator and clock circuitry. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The power-down mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

D. Control Circuit

In control circuit consist of electric circuit which using an optocoupler, transistor, triac and resisters. Here control circuit getting PWM signal from microcontroller is applied to transistor through optocoupler. Optocoupler consist of a photo-transistor and a LED inside the same packet. The phototransistor turns on or conducts current when the internal LED lights.

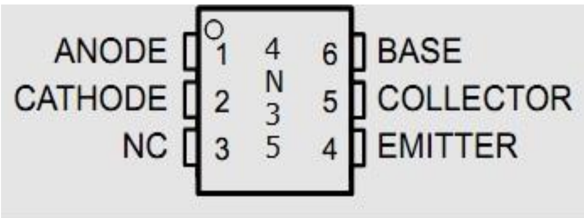

Fig. 5 Pin out Optocoupler [6]

Depending up on the room temperature, the microcontroller generates pulses at variable duty cycle, and these pulses are fed to TRAIC gate through this optocoupler. The isolation provided by the optocoupler keeps the controller is safe from destruction.

E. Power Supply

A power supply is an electronic device. The primary function of a power supply to convert one form of energy to another. It is also called regulated power supply. It consist of an AC input circuit and transformer, a bias supply consisting of a rectifier, filter, regulator and a reference voltage source. The circuit diagram of the regulated power supply shown figure.

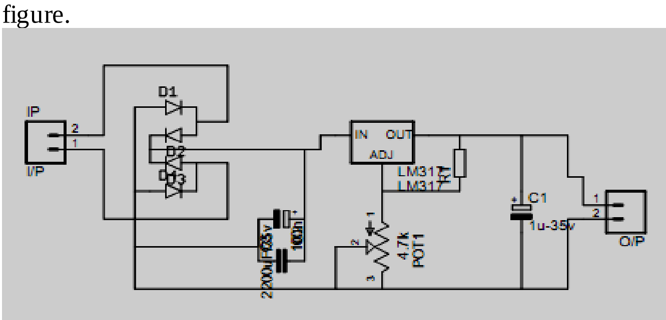

Fig. 6 Power Supply Circuit

In regulator fixes a positive dc output voltage by eliminating ripples.

F. Mathematical Model

The mathematical model of the heating process can be driven as heat balance equation: [2]

Heat input – Heat output = Heat accumulation

$Q_{in}(t) - Q_{out}(t) = Q_{acc}(t)$

Where $Q_{out}(t) = hAdT$

dT = Temperature difference

Unsteady equation is:

$$Q_{in}(t) - hA\,[T(t) - T_{air}(t)] = MCp\frac{dT(t)}{dt}$$

Steady equation at t=0 is:

$$Q_{in}(0) - hA\,[T(0) - T_{air}(0)] = 0$$

The difference between the equations

$$Q_{in}(t) - hAT(t) = MCp\frac{dT(t)}{dt}$$

Taking Laplace Transformation

$Q_{in}(s) - hAT(s) = MCpST(s)$

$$\frac{T(s)}{Qin(s)} = \frac{1/hA}{\frac{MCp}{hAS} + 1}$$

So,

$$\frac{T(s)}{Qin(s)} = \frac{K}{Ts + 1}$$

Where K=1/hA and T=MCp/hA

h = Heat Transfer Co-efficient

A = Surface Area (m^2)

Cp = Specific Heat

M = Mass of air (kg)

The final equation describes the model is:

$$\frac{T(s)}{Qin(s)} = \frac{1}{19.12s + 1}$$

Where, the time constant T is equal to 19.12sec.

IV SIMULATION AND RESULTS

Test 1:

Consider the following values of the parameters of the PID controller and response of these values.

Table-1

Parameter	Kp	Ti	Td
Value (sec.)	0.288	0.124	0.364

Plot:

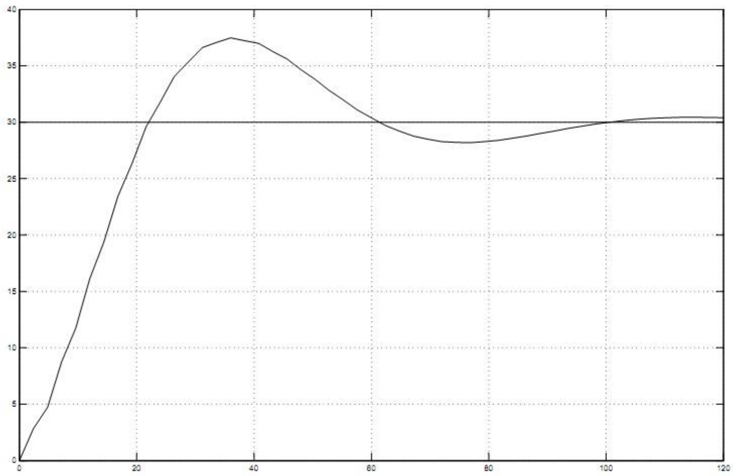

Fig. 7 Scope of the unit step response of the system for test 1

Result Test 1:

Parameter	T_r (s)	T_p (s)	T_s (s)	M_p (%)

Values	16.6	1.25	93	24.7

Test 2:

Table-2

Parameter	Kp	Ti	Td
Value (sec.)	1.83	0.17	1.0

Plot:

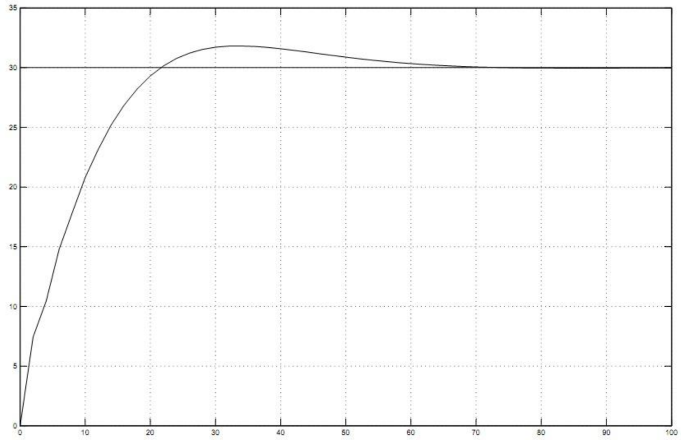

Fig. 8 Scope of the unit step response of the system for test 2

Result Test 2:

Parameter	T_r (s)	T_p (s)	T_s (s)	M_p (%)
Values	15.4	1.06	54.6	6.06

Test 3:

Table 3

Parameter	Kp	Ti	Td
Value (sec.)	1.99	0.10	1

Plot:

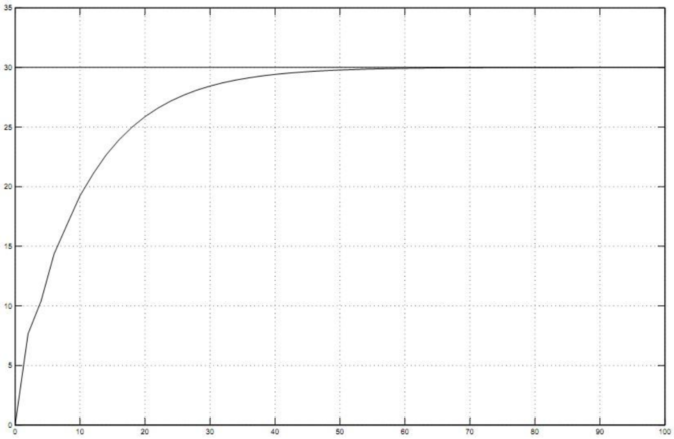

Fig. 9 Scope of the unit step response of the system for test 3

Result 3:

Parameter	T_r (s)	T_p (s)	T_s (s)	M_p (%)
Values	22.5	1	39.7	0

V CONCLUSION

The goal of this paper to develop a microcontroller based temperature control for a close chamber for find the mathematical model for given system and simulate the system in simulink with PID algorithm. It set the temperature of chamber by controlling the fan speed. Also, results show that as per change in PID tuning parameter. We get the proper controlling with less settling time. The present design could provide an optimum automatic control of temperature using PID control to set the fan speed as temperature changes.

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