IMPLEMENTATION OF AUTOMATIC TEMPERATURE CONTROLLER USING IC 741

ECB1204 ANALOG INTEGRATED CIRCUIT

A PROJECT REPORT

Submitted by

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in partial fulfillment for the award of the degree

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K. RAMAKRISHNAN COLLEGE OF TECHNOLOGY (AUTONOMOUS)

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BONAFIDE CERTIFICATE

Certified that this project report titled **“IMPLEMENTATION OF AUTOMATIC TEMPERATURECONTROLLER USING IC741”** is the bonafide work of **AKASH K (2303811710621009), ESHWARAN K (2303811710621025), HARI PRASATH M**
(2303811710621029) who carried out the project under my supervision. Certified further, that to the best of my knowledge the work reported herein does not from part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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INTERNAL EXAMINER **EXTERNALEXAMINER**

DECLARATION

We jointly declare that the project report on **“IMPLEMENTATION OF AUTOMATIC TEMPERATURE CONTROLLER USING IC741”** is the result of original work done by us and best of our knowledge, similar work has not been submitted to **“ANNA UNIVERSITY CHENNAI”** for the requirement of Degree of **BACHELOR OF ENGINEERING**. This project report is submitted on the partial fulfillment of the requirement of the award of Degree of **BACHELOR OFENGINEERING**.

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CHAPTER 1

PROBLEM STATEMENT

1.1 Introduction:

An automatic temperature controller is a crucial system used to maintain desired temperature levels in various applications, such as incubators, greenhouses, and cooling systems. This project utilizes an IC 741 operational amplifier as a comparator, an NTC thermistor as a temperature sensor, and a power transistor for load control. The thermistor generates a temperature-dependent voltage, which is compared to a reference voltage set by a potentiometer. Based on this comparison, the circuit activates or deactivates a cooling or heating device, like a fan or heater. The use of a transistor instead of a relay ensures faster switching, reduced noise, and improved reliability. This cost-effective and efficient design demonstrates the practical application of electronic components for automated temperature management.

1.2 Background of the work

Temperature regulation is a fundamental requirement in many fields, including industrial automation, environmental monitoring, and household appliances. Traditional methods of temperature control often relied on manual intervention, which was inefficient and prone to inaccuracies. With the advancement of electronics, automated systems have become the preferred choice for maintaining desired temperature levels due to their precision, reliability, and ease of use.

The operational amplifier IC 741 is widely used in analog electronic circuits for its versatility and simplicity. Paired with a thermistor, which is a cost-effective and reliable temperature sensor, it can create a basic yet effective temperature monitoring system. By leveraging the comparator functionality of the IC 741, it becomes possible to detect when the temperature deviates from a set threshold and respond accordingly. Power transistors, instead of relays, further enhance the design by providing faster response times, reduced mechanical wear, and noise-free operation.

This project builds on these principles to create a practical automatic temperature controller. It integrates basic electronic components to form a system that senses temperature changes and controls a load (such as a fan or heater) to maintain a desired range. The simplicity, low cost, and effectiveness of this approach make it suitable for diverse applications.

1.3 Key Features:

This highlights several key challenges that need addressing:

- **Automatic Operation:**
  - Automatically senses temperature changes and controls a cooling or heating device without human intervention.
- **Adjustable Temperature Threshold:**
  - Allows users to set the desired temperature threshold using a potentiometer for versatile applications.
- **Cost-Effective Design:**
  - Utilizes inexpensive and readily available components such as IC 741, a thermistor, and a transistor.
- **Compact and Simple Circuit:**
  - The circuit is easy to build, making it suitable for beginners and practical for small-scale applications.

- **Fast Switching with Transistor:**
    - Replaces relays with a power transistor for faster response, reduced noise, and improved durability.
- **Reliable Temperature Sensing:**
    - Uses an NTC thermistor for accurate and reliable temperature monitoring.
- **Protection Mechanisms:**
    - Includes a flyback diode to protect the transistor from voltage spikes when controlling inductive loads like fans.
- **Energy Efficiency:**
    - Activates the load only when necessary, reducing power consumption.
- **Wide Applicability:**
    - Suitable for applications like incubators, cooling systems, greenhouses, and more.

CHAPTER 2

DESIGN PROCEDURE

2.1 System Requirements

The design of the fire alarm system begins with defining its requirements:

- **Power Supply:**
  - Stable DC power supply of 12V to power the circuit and load
- **Sensor:**
  - NTC thermistor with a nominal resistance of 10kΩ at 25°C, suitable for sensing temperatures in the desired range (e.g., 25°C to 50°C).
- **Control Components:**
  - IC 741 operational amplifier for comparing the sensed temperature voltage with the reference voltage.
  - 10kΩ potentiometer to set the adjustable reference voltage for the desired temperature threshold.
- **Switching Components:**
  - BD139 or TIP122 power transistor to switch the load ON and OFF based on the comparator output.
  - 1N4007 flyback diode to protect the transistor from voltage spikes caused by inductive loads.
- **Mechanical Components:**
  - Breadboard for prototyping or PCB for a permanent setup.
  - Cooling or heating device, such as a 12V DC fan or heater module.

- **Environmental Conditions:**
    - Designed to operate within an ambient temperature range of **0°C to 50°C** for accurate performance.

2.2 Components Selection

- IC 741: The IC 741 operational amplifier is used as a comparator in the circuit. It compares the voltage from the temperature sensor (thermistor) with the reference voltage to determine if the temperature has crossed the set threshold.
- NTC Thermistor: A 10kΩ NTC thermistor serves as the temperature sensor. Its resistance decreases as the temperature increases, providing a voltage signal proportional to the surrounding temperature.
- Potentiometer: A 10kΩ potentiometer is used to set the reference voltage for the IC 741. This allows the user to adjust the temperature threshold at which the load is activated.
- Power Transistor (BD139 or TIP122): This transistor acts as a switch to control the load (e.g., fan or heater). It enables fast and reliable switching of high-current loads based on the IC 741 output.
- Flyback Diode (1N4007): A 1N4007 diode is placed across the load to protect the transistor from voltage spikes generated by inductive loads like DC fans.
- Resistors: Fixed 10kΩ resistors are used in the voltage divider circuit with the thermistor and as pull-down resistors where needed.
- DC Fan (Load): A 12V DC fan serves as the cooling device. It operates efficiently with the transistor acting as the control switch.

2.3 Circuit Design

The design of the fire alarm system is divided into three main sections:

- **Sensor Circuit:**

  The temperature is detected using an NTC thermistor connected in a voltage divider configuration with a fixed 10kΩ resistor. The thermistor's resistance decreases with rising temperature, causing the voltage across it to vary accordingly. This temperature-dependent voltage is fed to the inverting input of the IC 741 operational amplifier.

- **Reference Voltage Circuit:**

  A 10kΩ potentiometer is used to generate an adjustable reference voltage. The reference voltage is applied to the non-inverting input of the IC 741, allowing the user to set the temperature threshold for activating the load.

- **Comparator Circuit (IC 741):**

  The IC 741 is configured as a comparator:

  - If the voltage from the thermistor (inverting input) is lower than the reference voltage (non-inverting input), the comparator output goes HIGH.
  - If the thermistor voltage exceeds the reference voltage, the output switches to LOW.

- **Load Control Circuit:**

  The output of the IC 741 is connected to the base of a BD139 **(**or TIP122**)** transistor through a 1kΩ resistor. The transistor functions as a switch:

  - When the IC 741 output is HIGH, the transistor turns ON, activating the connected load (e.g., a 12V DC fan).
  - When the IC 741 output is LOW, the transistor turns OFF, deactivating the load.

- **Protection Circuit:**

  A 1N4007 diode is placed across the load (fan) in reverse bias to prevent damage to the transistor from voltage spikes caused by inductive loads during switching.

- **Output Section:**

  The controlled device, such as a 12V DC fan, is connected to the collector of the transistor, with its positive terminal connected to the 12V power supply. The emitter of the transistor is connected to ground. This ensures the load receives sufficient current when activated.

- **Stabilization Circuit:**

  A 0.1µF capacitor is placed across the power supply to filter out noise and provide a stable voltage for smooth circuit operation.

Circuit Diagram:

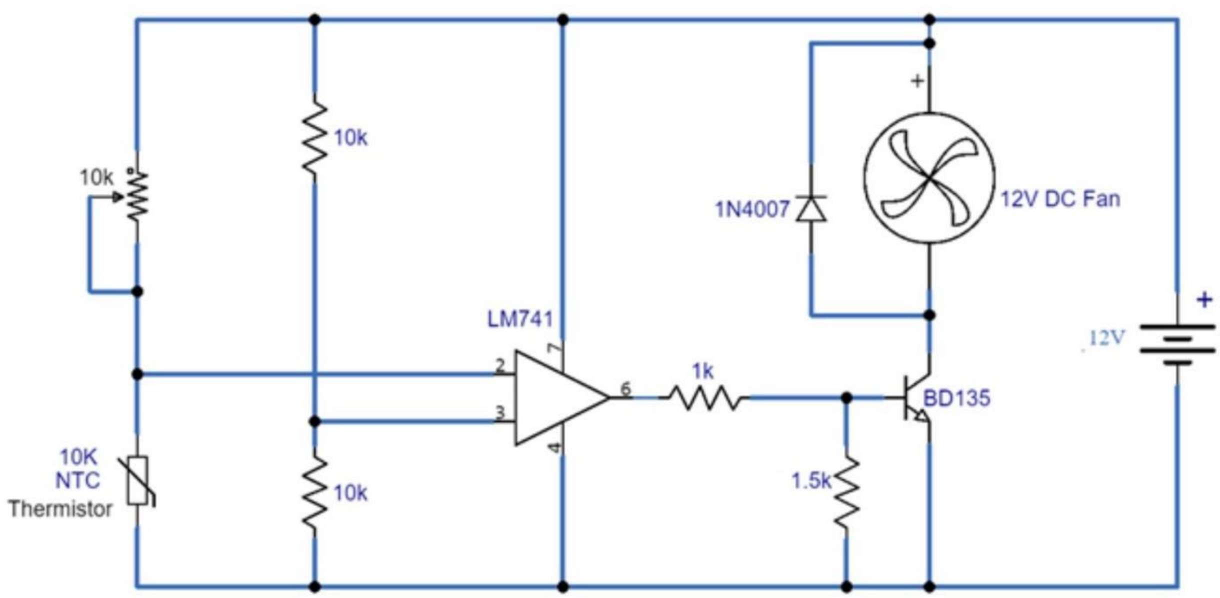

Fig 2.1 : Circuit Diagram of Proposed Model

2.4 Calculating Component Values

2.4.1 Thermistor Selection (NTC Thermistor)

- The thermistor's resistance varies with temperature, so it's important to select a thermistor with an appropriate resistance at the reference temperature (typically 25°C). For example, a 10kΩ NTC thermistor is commonly used, with a typical resistance of 10kΩ at 25°C.

To calculate the voltage across the thermistor in a voltage divider circuit, use the formula:

$$V_{out} = V_{in} \times \frac{R_T}{R_T + R_{fixed}} \qquad \text{........ (1)}$$

Where:

V_{in} is the supply voltage (12V in this case),

RT is the thermistor resistance (depends on temperature),

R_{fixed} is the fixed resistor (10kΩ).At 25°C, if the thermistor resistance is 10kΩ, the voltage across it will be:

$$V_{out} = 12V \times \frac{10k\Omega}{10k\Omega + 10k\Omega} = 6V \qquad \text{............ (2)}$$

As the temperature increases, the resistance of the thermistor decreases, and the output voltage decreases proportionally. This voltage will then be fed into the comparator input.

2.4.2 Potentiometer (Reference Voltage)

A 10kΩ potentiometer is used to adjust the reference voltage for the IC 741 comparator. The potentiometer is connected in a voltage divider arrangement between 12V and ground. The wiper of the potentiometer provides a variable voltage, which can be adjusted to set the temperature threshold.

- With a 10kΩ potentiometer, the voltage range for the reference will be from 0V to 12V depending on the wiper position.

The reference voltage at the non-inverting terminal of the IC 741 can be calculated by adjusting the potentiometer to match the threshold temperature at which the load should be activated.

2.4.2 Resistor for Base of Transistor

1kΩ resistor is chosen for the base of the BD139 or TIP122 transistor. This resistor limits the current flowing into the base of the transistor to protect the transistor and ensure proper switching.

To calculate the base current (IbIb) for the transistor:

$$I_b = \frac{V_{in} - V_{be}}{R_b} \quad \text{…….. (3)}$$

Where:

- Vin is the voltage from the IC 741 (either 0V or 12V),
- V_{be} is the base-emitter voltage (typically 0.7V for BD139 or TIP122),
- R_b is the base resistor (1kΩ).

Assuming Vin is 12V (when the comparator output is HIGH):

$$I_b = \frac{12V - 0.7V}{1k\Omega} = \frac{11.3V}{1k\Omega} = 11.3mA \quad \text{………. (4)}$$

This current is sufficient to drive the transistor into saturation for switching the load (fan or heater).

2.4.4. Flyback Diode

- A 1N4007 diode is used to protect the transistor from voltage spikes caused by the
- inductive load (e.g., a fan). This diode needs to withstand the maximum current that flows through the load. The 1N4007 diode has a peak repetitive reverse voltage of 1000V and a forward current rating of 1A, which is suitable for a 12V DC fan.

2.4.5 Load Selection (DC Fan)

- The 12V DC fan should operate with a current of approximately 0.5A. The transistor chosen (BD139 or TIP122) must handle the load current, and the base resistor ensures the transistor switches fully on without overheating.The power consumed by the fan can be calculated as:

$$P = V \times I = 12V \times 0.5A = 6W \quad \text{…. (5)}$$

This indicates that the transistor should be able to handle 6W of power dissipation.

- Power Supply**:** Connect a 12V DC supply to power the IC 741, thermistor, and other components.
- Temperature Sensor**:** Wire the NTC thermistor in a voltage divider with a 10kΩ resistor. Connect the thermistor to the inverting input (Pin 2) of the IC 741.

- Reference Voltage**:** Connect a 10kΩ potentiometer between 12V and ground, with the wiper providing the reference voltage to the non-inverting input (Pin 3) of IC 741.
- IC 741 Comparator**:** Connect the output (Pin 6) of IC 741 to the base of a BD139/TIP122 transistor through a 1kΩ resistor.
- Transistor Switching**:** Connect the collector of the transistor to the fan's positive terminal, and the emitter to ground.
- Flyback Diode**:** Place a 1N4007 diode in parallel with the fan to protect from voltage spikes.
- Noise Filtering**:** Add a 0.1µF capacitor across the IC 741 power supply terminals.
- Grounding**:** Ensure all components share a common ground for proper operation.

2.6 Testing and Debugging

After assembly, it's time to test the fire alarm system. The following steps should be taken:

- Power On: Check if the 12V power supply powers the circuit properly.
- Thermistor Test: Measure the voltage across the thermistor; it should change with temperature.
- IC 741 Output: Verify that the output voltage of IC 741 switches between HIGH and LOW based on temperature.
- Transistor Test: Ensure the BD139/TIP122 transistor is activated when IC 741 output is HIGH, powering the fan.
- Flyback Diode: Confirm the 1N4007 diode protects the transistor from voltage spikes.
- Noise Filtering: Ensure the 0.1µF capacitor stabilizes the power supply.

CHAPTER 3

COST OF COMPONENTS

3.1 Approximate Component Cost:

The cost of components for a fire alarm system using the IC 555 timer in India (in INR) can vary depending on suppliers and location. Here's a general breakdown of the components and their estimated costs:

- IC 741:
  - Cost: ₹20 - ₹50
  - The IC 741 is a widely available and inexpensive component.
- Thermistor (for temperature detection)
  - Cost: ₹10 - ₹40
  - Thermistors are used for temperature detection, and the cost depends on the type and sensitivity.
- Resistors
  - Cost: ₹1 - ₹5 each
  - Resistors are very affordable components, with a negligible cost per piece.
- Transistor (NPN type)
  - Cost: ₹10 - ₹20
  - A standard NPN transistor, like the 2N2222, is typically inexpensive.
- Power Supply (Battery or DC adapter)
  - Cost: ₹50 - ₹250
  - The cost of a 9V battery or DC adapter ranges from ₹50 to ₹250, depending on the type (single-use or rechargeable).
- PCB or Breadboard
  - Breadboard: ₹100 - ₹250

- A breadboard is used for prototyping, while a PCB for the final product costs more, typically ranging between ₹200 to ₹400 for a small-sized board.

- Miscellaneous Components
  - Wires, connectors, and soldering materials: ₹50 - ₹200
  - This includes small items such as jumper wires, connectors, and soldering materials like wire and flux

Component Bill:

Table 3.1: cost of the component used in project

Name of component	Range	Cost
IC 741	-	₹ 30
THERMISTER	10 K Ω	₹ 15
POTENTIOMETER	10 K Ω	₹ 10
RESISTER	1KΩ,47 Ω	₹ 5
BD140	PNP	₹ 15
BREAD BOARD	400 pins	₹ 30
DC FAN	12 V	₹ 30
TOTAL		₹ 135

CHAPTER 4

RESULT AND DISCUSSION

4.1 RESULT

The Automatic Temperature Controller system was successfully built and tested, and the following results were achieved:

- Temperature Detection:
  - The NTC thermistor effectively detects temperature changes. As the temperature rises, the thermistor’s resistance decreases, causing the voltage across it to drop. This voltage change is fed into the LM358 operational amplifier for processing.
- Threshold Setting and Triggering:
  - The LM358 op-amp functions as a comparator. When the thermistor voltage exceeds the set threshold (adjusted via the 10kΩ potentiometer), the LM358 output switches from LOW to HIGH, triggering the BD139/TIP122 transistor to activate the fan or cooling system.
- Fan Control:
  - The BD139/TIP122 transistor successfully controls the fan (or load) based on the comparator’s output. When the temperature rises above the set threshold, the fan turns on, and when the temperature drops, the fan turns off.
- Power Supply and Stability:
  - The 9V battery or DC adapter provides the necessary power to the circuit. The system operates reliably, with no fluctuations or instability in performance. The capacitors help to filter out any power supply noise, ensuring smooth and continuous operation of the system.
- Adjustable Temperature Threshold:

- The temperature threshold is easily adjustable using the 10kΩ potentiometer, allowing users to customize the temperature at which the fan activates based on their needs.

- System Response Time:
  - The system quickly responds to temperature changes. The fan activates promptly when the temperature rises beyond the set threshold and deactivates when the temperature falls below it.

4.2 Working Model:

Initial Condition:

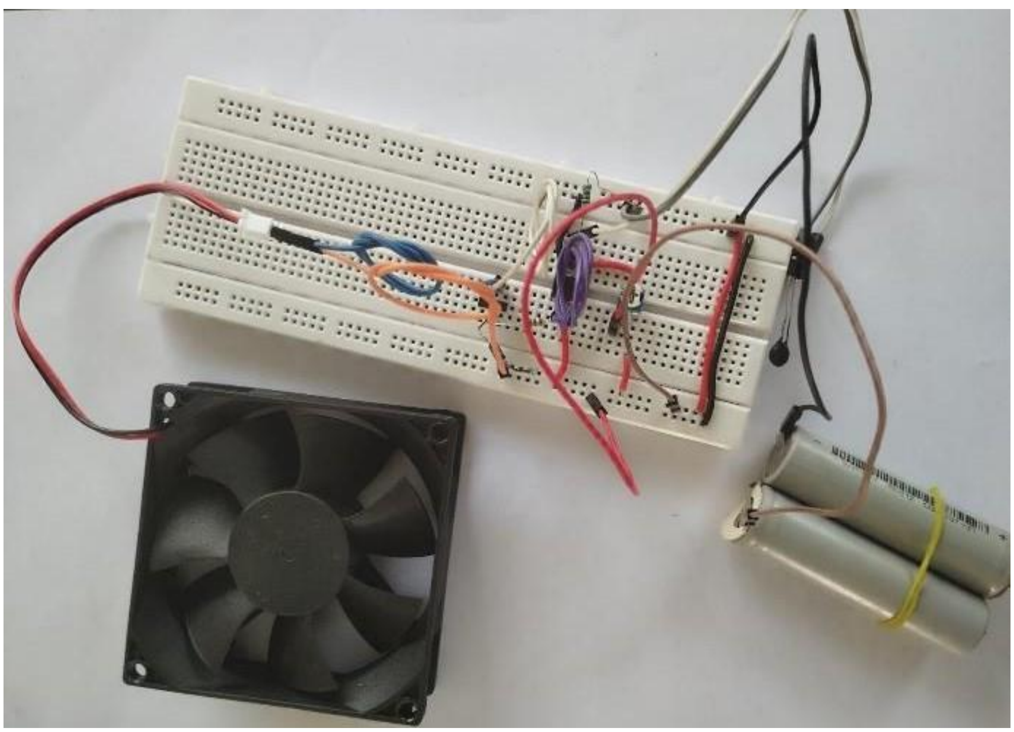

Fig 4.1: Initial condition of proposed model

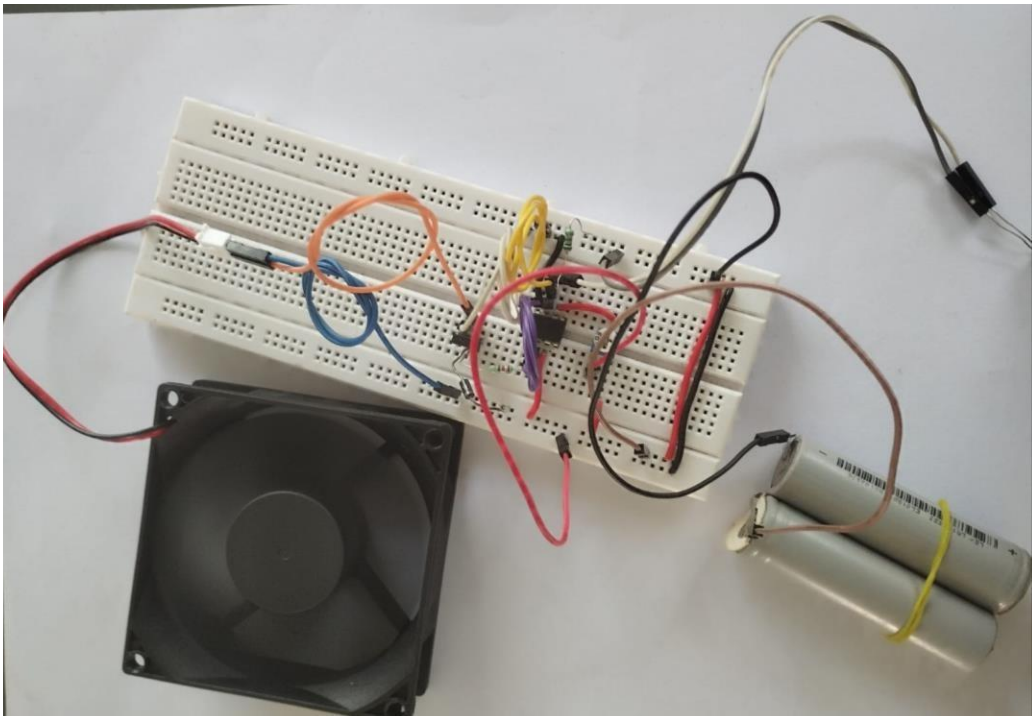

Fig 4.2: Running condition of proposed system

4.3 Conclusion

The Automatic Temperature Controller functions as intended, with reliable temperature sensing, accurate threshold setting, and effective fan control. The system is stable, responsive, and adjustable, making it suitable for use in various temperature-sensitive applications. The circuit demonstrates good performance, and all components work together to provide an efficient and user-friendly solution for automatic temperature regulation.