Digital Logic and Design (Lab)

Project Report

Temperature Monitoring and Alarm System

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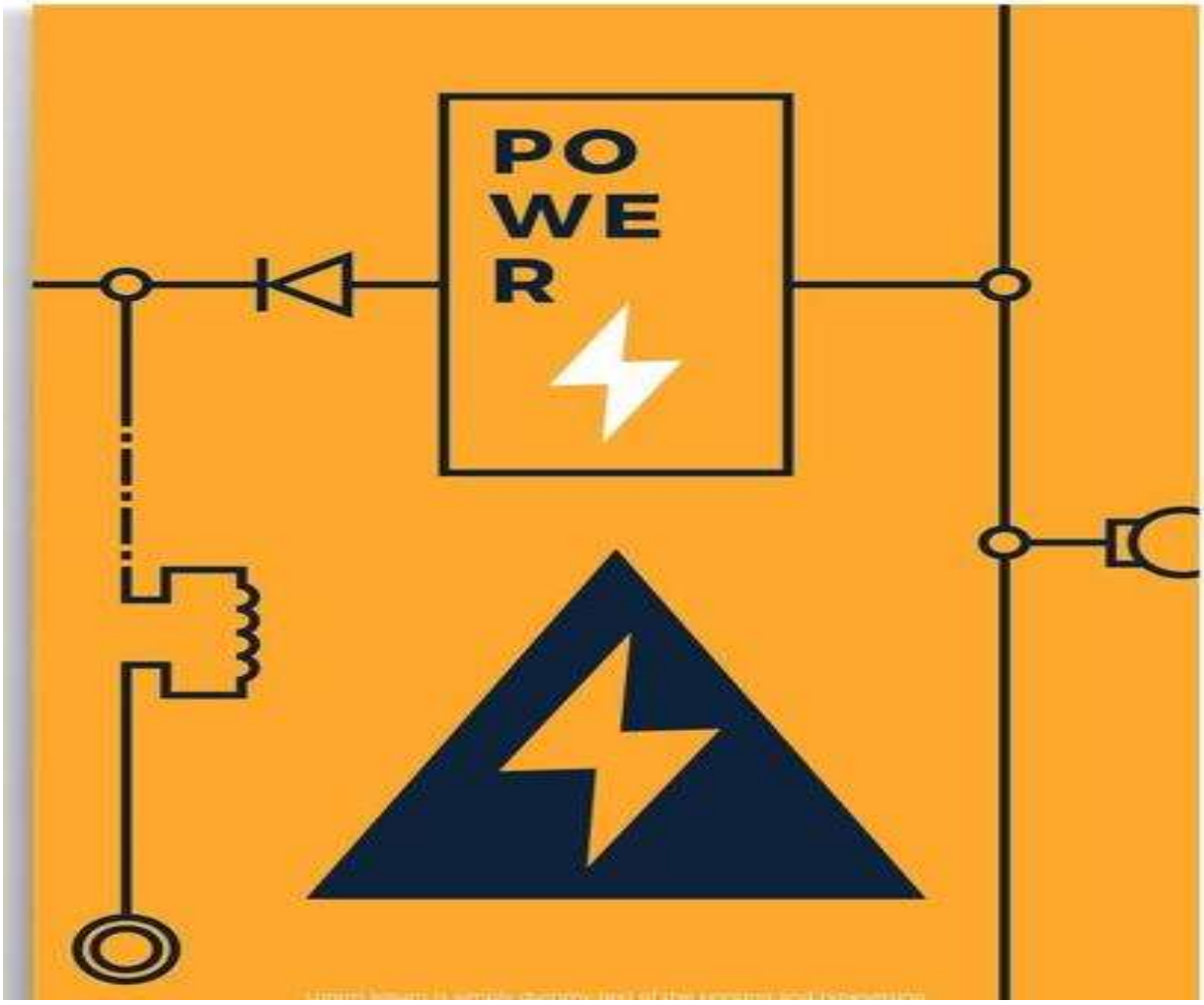


Project Summary

Objective: This project aims to design and implement a **Temperature Monitoring and Alarm System.** The system monitors ambient temperature using an LM35 temperature sensor, displays the current temperature on a seven-segment display, and activates visual and audio indicators based on pre-defined thresholds. This project is significant in environments requiring real-time temperature monitoring to prevent overheating or other temperature-related hazards.

Significance:

The system ensures safety by indicating:

1. **Safe Temperature Range**: A green LED lights up.
2. **Near-Threshold Alert**: A yellow LED activates when temperatures are near the set limit.
3. **High-Temperature Alarm**: A red LED lights up with a buzzer to signal dangerous temperatures.

Significance of the Circuit in Real Life

This circuit has practical applications in various real-life scenarios, ensuring safety and efficiency in environments where temperature monitoring is critical. For instance:

1. **Industrial Settings:** Prevents overheating of machinery or equipment by providing early alerts.
2. **Healthcare Applications:** Ensures safe temperature conditions for sensitive medical equipment or storage of vaccines.

3. **Data Centers:** Prevents server overheating by activating alarms for unsafe conditions.

This system ensures timely responses to temperature deviations, protecting both equipment and human lives.

Functionality:

1. The LM35 sensor reads the temperature.
2. The data is processed by a comparator-based logic circuit and displayed on a seven-segment display.
3. Based on the thresholds:
    a. **Green LED** lights up for safe temperature.
    b. **Yellow LED** warns of approaching limits.
    c. **Red LED and buzzer** activate for dangerous temperatures.

Components List

Software used: Proteus (for circuit simulation)

Component	Quantity	Description
LM35	1	Temperature sensor
TC7107	1	ADC for seven-segment display driver
Seven-Segment Display (common anode)	3	Displays temperature in °C
741 (Op-Amp)	6	Operational amplifiers as comparators
Potentiometers (RV1-RV6)	6	Adjustable temperature thresholds
LEDs (Green,Yellow,Red)	3	Visual indicators
Buzzer	1	Audio indicator for high temperature
Resistors	Multiple	For current limiting and pull-down

Capacitors	Multiple	Stabilization and filtering
AND	3 gates	Ensures only the correct LED or buzzer is activated for each range.
NOT	3 gates	Inverts comparator outputs to manage LED/buzzer activation logic.
Power Supply (Battery)	1	Provides power to the circuit

Implementation Details

Circuit Design and Logic

The circuit consists of the following modules:

1. **Temperature Sensor (LM35):**
    a. Outputs a voltage proportional to the temperature (10mV/°C).
    b. Connected to the inputs of a voltage comparator for processing.
2. **Comparator Circuit:**
    a. Adjustable thresholds set using potentiometers (RV1 to RV6).
    b. Comparators (U3, U4, U7, U8, U11, U12) determine whether the current temperature is below, near, or above the threshold values.
3. **Display Logic:**
    a. The output of the LM35 is sent to the TC7107 IC, which converts the analog input into a digital signal and drives a **three-digit seven-segment display**.
4. **Indicator LEDs and Buzzer:**
    a. Logic gates (NOT and AND) process the comparator outputs to control LEDs (green, yellow, red) and the buzzer.

Thresholds

LED	Thresholds (degree Celsius)
Green	1 to 49
Yellow	50 to 99
Red + Buzzer	100 to 149

Logic Function for Safe Range (Green LED):

- Input Conditions: Temp < Lower Threshold
- Truth Table:

Temp	Output (D1 - Green)
< T1	1 (ON)
≥ T1	0 (OFF)

Logic Function for Near-Threshold (Yellow LED):

- Input Conditions: T1 ≤ Temp < T2
- Truth Table:

Temp Range	Output (D2 - Yellow)
< T1	0 (OFF)
T1 to T2	1 (ON)
> T2	0 (OFF)

Logic Function for Dangerous Temperature (Red LED + Buzzer):

- Input Conditions: Temp > Upper Threshold
- Truth Table:

Temp	Output (D3 - Red, Buzzer)
≤ T2	0 (OFF)
> T2	1 (ON)

1. Circuit Overview

The circuit is divided into the following functional sections:

- **Temperature Sensing**
- **Comparator Logic**
- **Indicator System (LEDs and Buzzer)**
- **Seven-Segment Display**

2. Temperature Sensing with LM35

- **Component Function:**
  - The LM35 sensor outputs a voltage proportional to the ambient temperature, at a rate of **10mV per °C.** For example:
    - 25°C → 250mV
    - 50°C → 500mV

        - 100°C → 1000mV (1V)
- **Circuit Operation:**
    - The LM35 is powered with a 5V DC supply.
    - Its output voltage is fed into a **buffer circuit** (usually an operational amplifier like 741 in a unity gain configuration) to stabilize the signal and prevent loading effects.
    - The buffered output is then sent to:
        - **Comparator circuit** for range classification.
        - **ADC (Analog-to-Digital Converter)** in the display driver for temperature display.

3. Comparator Logic (741 IC)

- **Purpose:**
    - The comparator circuit compares the LM35's output voltage against predefined thresholds (set by potentiometers) to classify the temperature into ranges:
- **Component Details:**
    - **741 Operational Amplifier:**
        - Each 741 IC is configured as a voltage comparator.
        - The **inverting input (-)** receives the voltage from the LM35.
        - The **non-inverting input (+)** is connected to a reference voltage set by a potentiometer (RV1, RV2, etc.).
    - **Potentiometers (RV1, RV2, RV3):**
        - These are variable resistors used to adjust the reference voltage for the comparators.
        - For example:
            - RV1 sets the threshold for 50°C.
            - RV2 sets the threshold for 100°C.
    - **Comparator Output:**
        - When the LM35 output voltage exceeds the reference voltage, the comparator's output goes high, triggering the corresponding LED or buzzer.
        - Logic gates (NOT, AND) are used to ensure that only one indicator (green, yellow, or red + buzzer) is active at a time.

4. Indicator System (LEDs and Buzzer)

- **Green LED:**
    - Connected to the output of the first comparator.
- **Yellow LED:**

    - Connected to the output of the second comparator
- **Red LED and Buzzer:**
    - The red LED and buzzer are connected to the output of the third comparator
    - A NOT gate ensures the buzzer is off when the red LED is inactive.
- **Logic Circuit:**
    - **NOT Gate:**
    - Inverts the output of one comparator to drive another device
    - **AND Gate:**
        - Combines comparator outputs to prevent conflicting signals

5. Temperature Display on Seven-Segment Display

- **Component:**
    - A **TC7107 IC** is used as an ADC and display driver.
    - It converts the analog voltage from the LM35 into a digital output for the seven-segment display.
- **Circuit Operation:**
    - The LM35's output is scaled to match the ADC's input range (typically 0–2V).
    - The TC7107 processes this signal and drives a **three-digit seven-segment display**, showing the temperature in °C.
        - Example:
            - 25°C → "025"
            - 75°C → "075"
            - 110°C → "110"
- **Display Calibration:**
    - The reference voltage for the TC7107 is set using a precision resistor or potentiometer.
    - This ensures accurate conversion of the LM35's output voltage to the displayed value.

Comparator Logic

- Vin (from LM35): T (temperature in °C, scaled as 10 mV/°C).
- *Vref* (set by potentiometer): Adjustable threshold voltage.

The comparator output depends on the relationship between Vin and Vref :

Vin	***Vref***	**Comparator Output**
LOW (0°C–49°C)	LOW (50°C threshold)	0

HIGH (50°C–100°C)	LOW (50°C threshold)	1
HIGH (>100°C)	HIGH (>100°C)	1
LOW (<100°C)	HIGH (>100°C)	0

K-Map for Comparator Output

We treat Vin and Vref as binary conditions for simplicity (LOW = 0, HIGH = 1).

Vin \Vref	0	1
0 (LOW)	0	0
1 (HIGH)	1	1

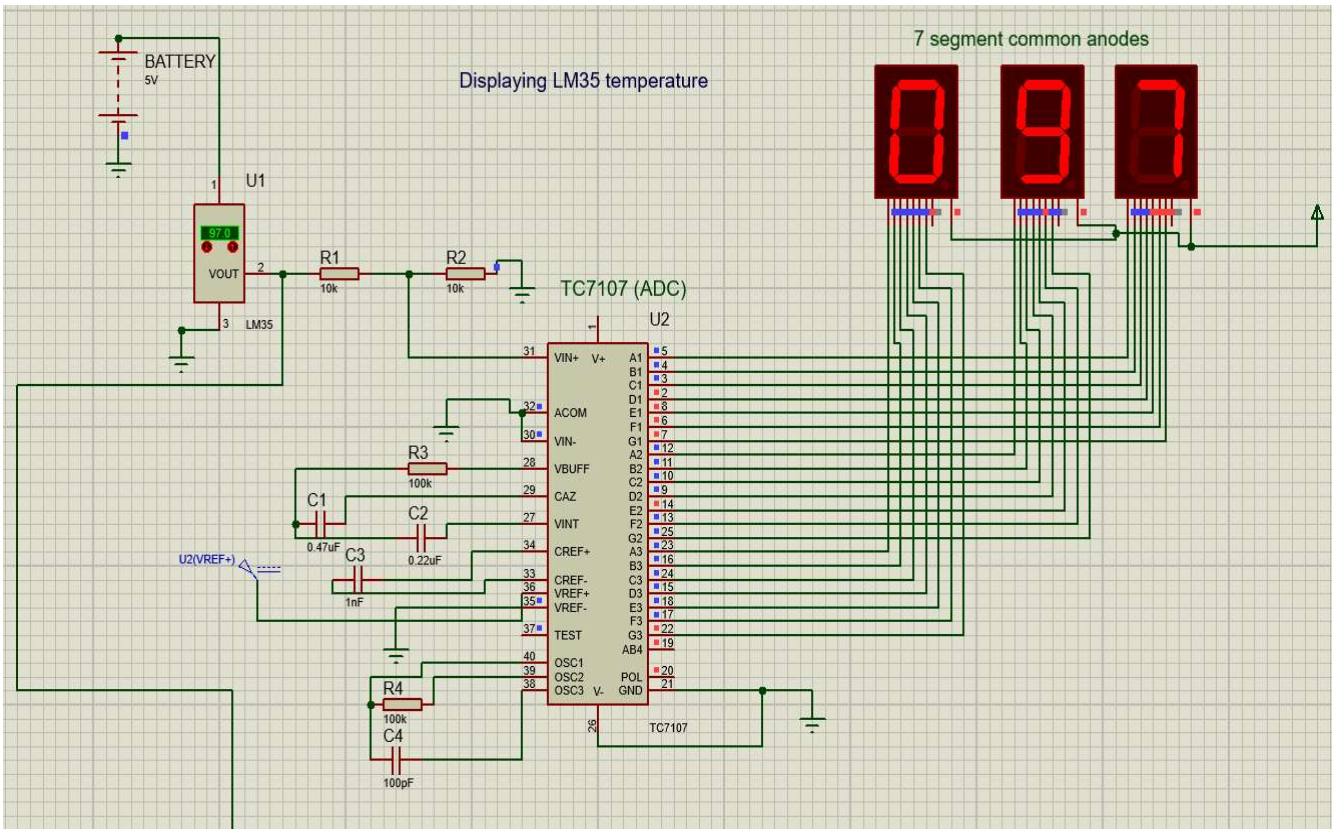
O=Vin

This indicates the output is HIGH when *Vin>Vref*

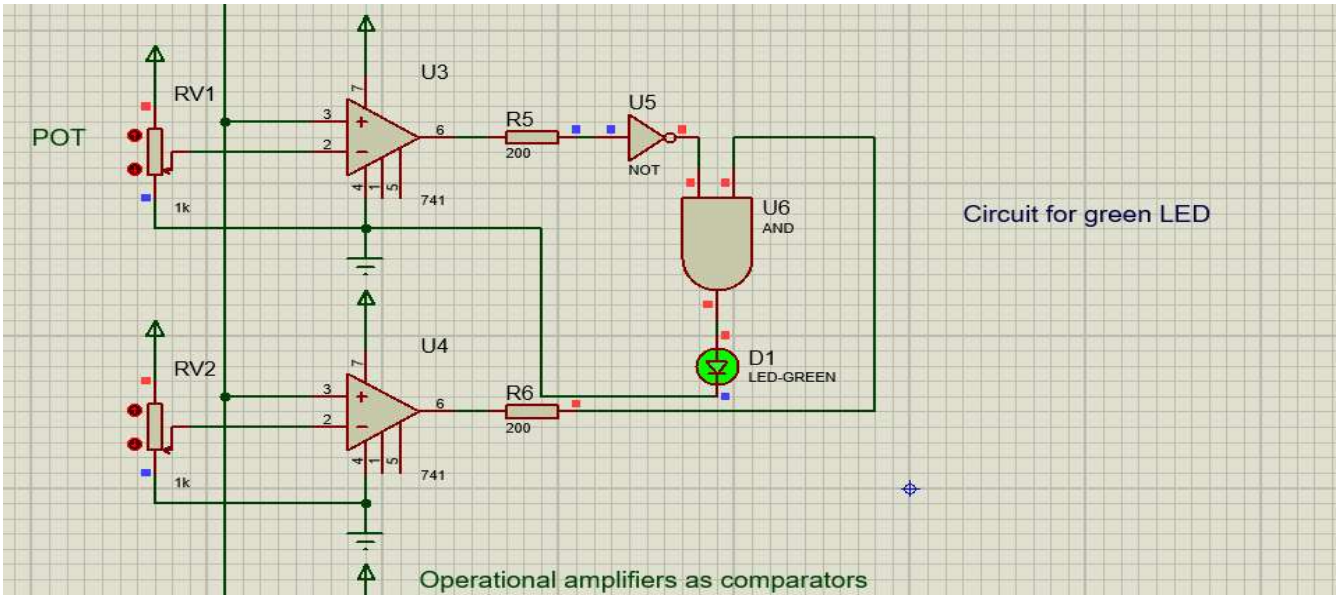
Circuit Design

(due to the circuit being large it is pasted in parts for better understanding)

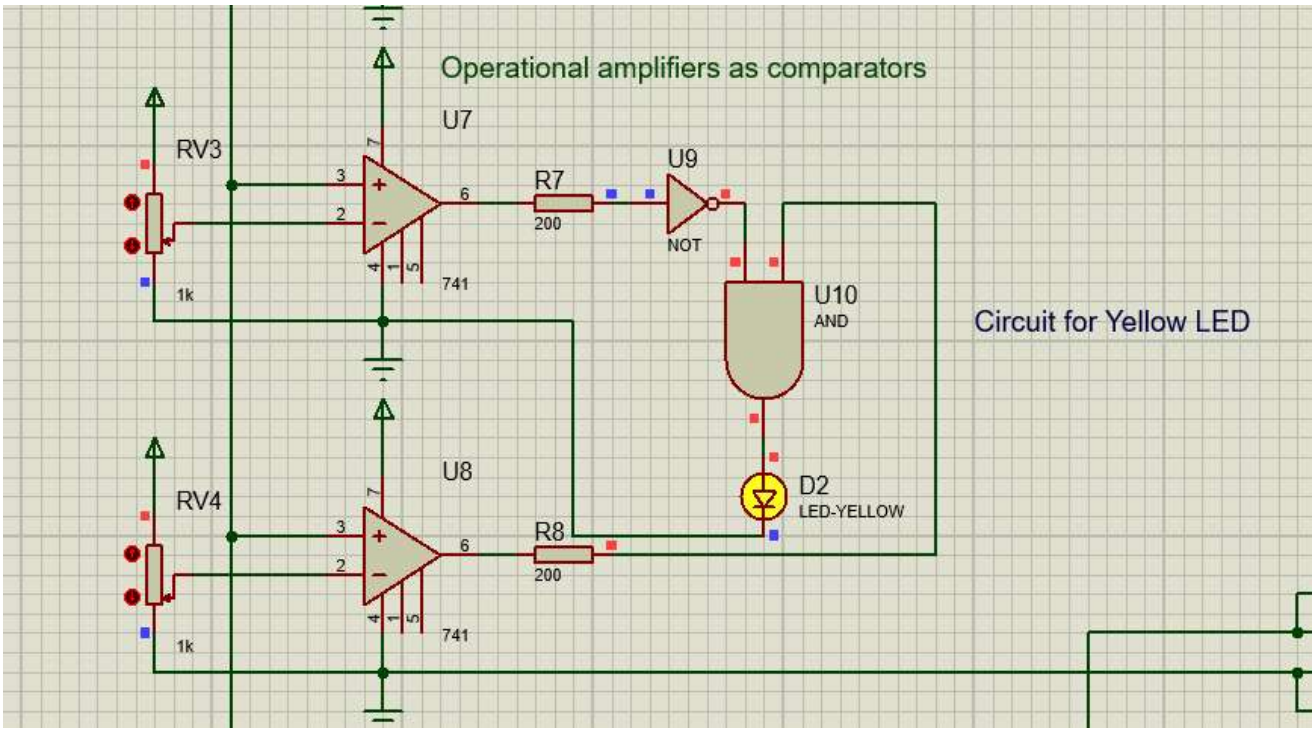
Displaying LM35 Temperature



Green LED Part



Yellow LED Part



Red LED and Buzzer