Title

Title - Digital Thermometer using Arduino and LM35 Temperature Sensor.
Subtitle:A cost-effective and accurate temperature monitoring system

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Introduction

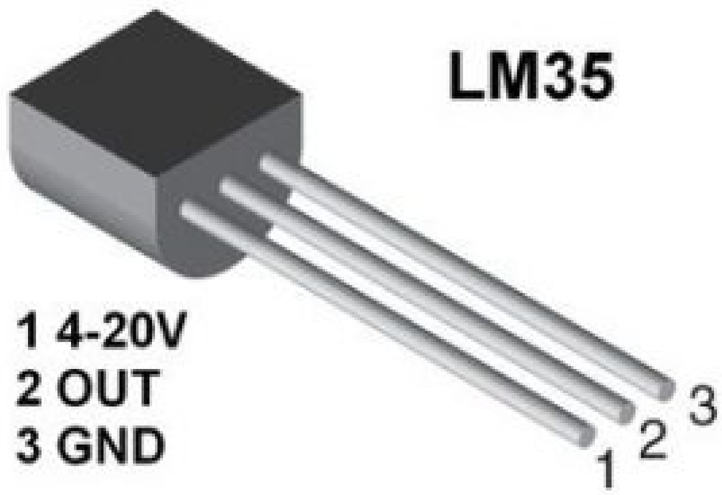
- A digital thermometer is an electronic device that measures temperature and displays it digitally.
- This project uses an LM35 temperature sensor with an Arduino microcontroller to provide real-time temperature readings.
- The system is simple, low-cost, and suitable for various applications such as home automation and weather monitoring.

Components Required

1. **Arduino Board (Uno/Nano/MEGA) –** Main microcontroller to process the data.
2. **LM35 Temperature Sensor –** Converts temperature into an analog voltage.
3. 1**6x2 LCD Display –** Displays temperature readings (Optional: Serial monitor output).
4. **Connecting Wires –** For connections between components.
5. **Breadboard –** For assembling the circuit.
6. **Buzzer (Optional) –** For alert system when temperature exceeds a threshold.

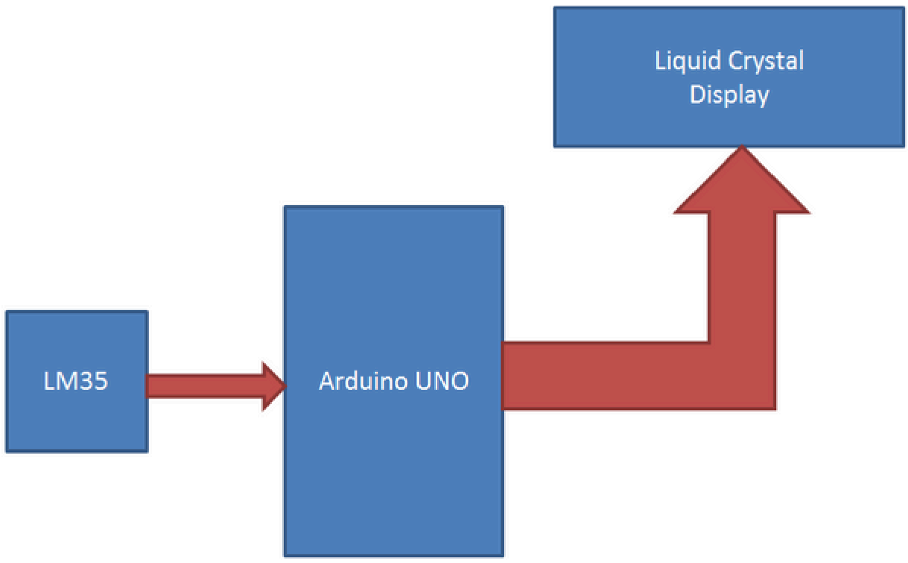
LM35 Temperature Sensor:

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range.



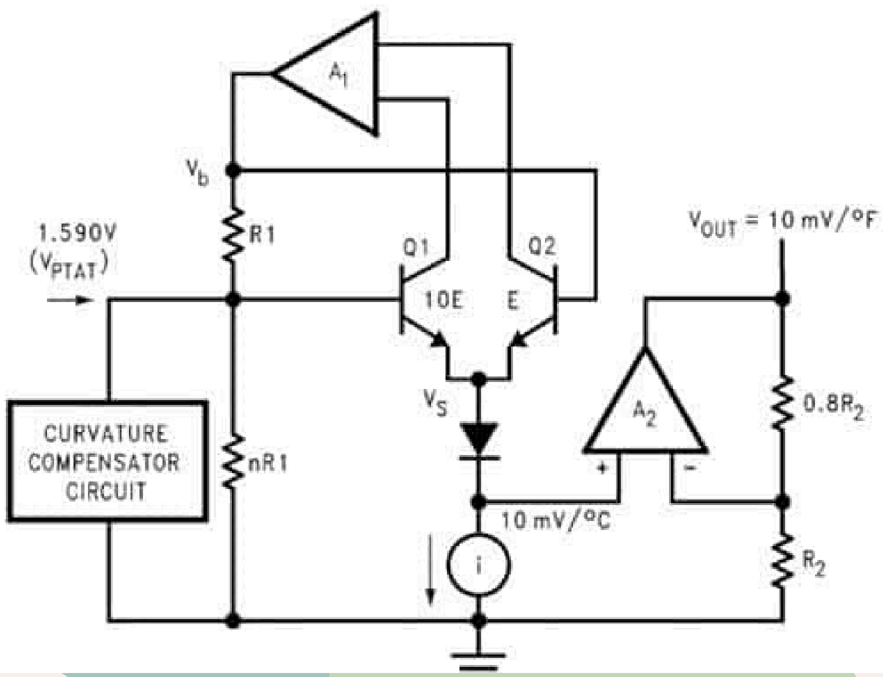
Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device make interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 μA from the supply, it has a very low self-heating of less than 0.1°C in still air

Block diagram



Working Principle

In order to understand the working principle of the lm35 temperature sensor, we have to understand the linear scale factor. In the features of lm35, it is given to be +10 mills volt per degree centigrade. It means that with an increase in output of 10 mills volt by the sensor out pin the temperature value increases by one. For example, if the sensor is outputting 100 mills volt at vout pin the temperature in centigrade will be 10-degree centigrade. The same goes for the negative temperature reading. If the sensor is outputting -100 mills volt the temperature will be -10 degrees Celsius.

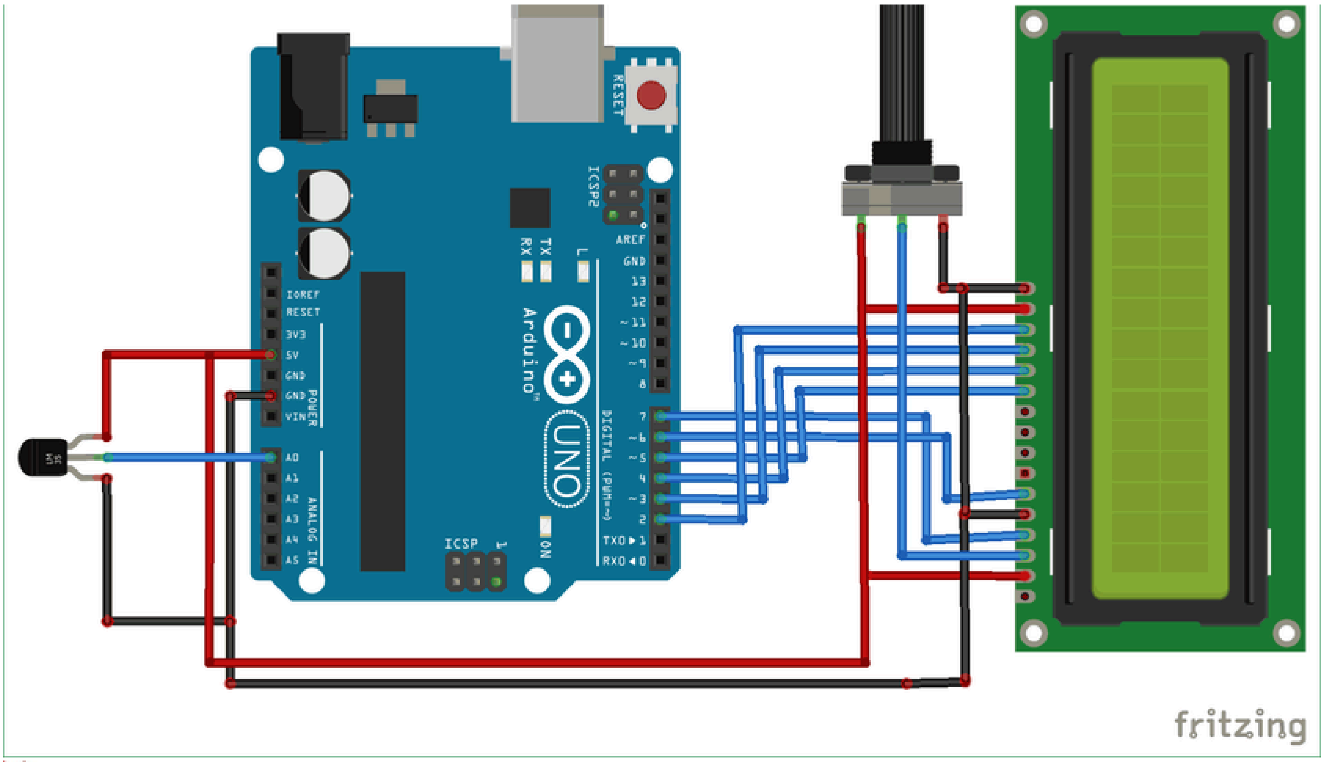


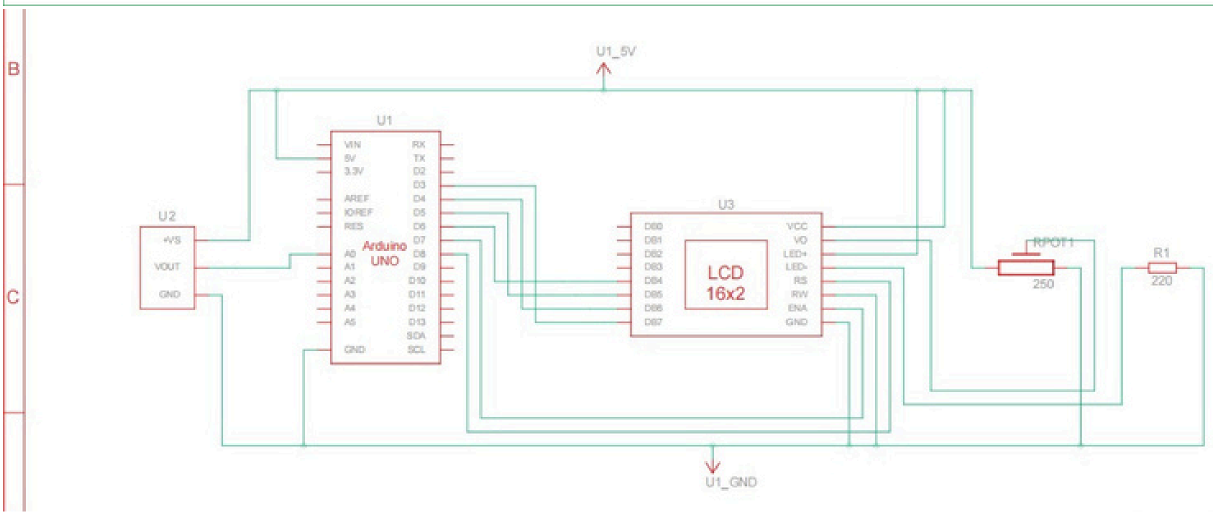
The circuit diagram is shown above. Briefly, there are two transistors in the center of the drawing. One has ten times the emitter area of the other. This means it has one-tenth of the current density since the same current is going through both transistors. This causes a voltage across the resistor R1 that is proportional to the absolute temperature and is almost linear across the range we care about. The "almost" part is taken care of by a special circuit that straightens out the slightly curved graph of voltage versus temperature. The amplifier at the top ensures that the voltage at the base of the left transistor (Q1) is proportional to absolute temperature (PTAT) by comparing the output of the two transistors.

The amplifier at the right converts absolute temperature (measured in Kelvin) into either Fahrenheit or Celsius, depending on the part (LM34 or LM35). The little circle with the "i" in it is a constant current source circuit. The two resistors are calibrated in the factory to produce a highly accurate temperature sensor. The integrated circuit has many transistors in it — two in the middle, some in each amplifier, some in the constant current source, and some in the curvature compensation circuit. All of that is fit into the tiny package with three leads.

Circuit Diagram

- **LM35 Sensor:** VCC to 5V, GND to GND, OUT to A0 of Arduino.
- **LCD Display:** Connected to Arduino via I2C or direct pin connections.
- **Buzzer (Optional):** Connected to a digital pin for alerts.





Code Implementation

```
#include "LiquidCrystal.h"

LiquidCrystal lcd(8, 7, 6, 5, 4, 3);
int sensorPin = A0;  // Explicitly define analog pin

void setup() {
  Serial.begin(9600);
  lcd.begin(16, 2);
  lcd.print("Temp Sensor Ready");
  delay(2000);
  lcd.clear();
}
void loop() {
  int reading = analogRead(sensorPin);

  float voltage = reading * 5.0 / 1024.0; // Assuming
a 5V reference
  float temperatureC = (voltage - 0.5) * 100;
```

```
 Serial.print("Temperature: ");
 Serial.print(temperatureC);
 Serial.println(" °C");

 lcd.setCursor(0, 0);
 lcd.print("Temp: ");
 lcd.print(temperatureC);
  lcd.print(" C   "); // Adding spaces to clear old digits

    delay(1000); // Slower updates for better readability
}
```

- The Arduino code reads data from the LM35 sensor and displays it.
- The code can be modified to display values on an LCD screen.

Applications

- Home automation and smart thermostats.
- Weather monitoring systems.
- Healthcare devices (Body temperature monitoring).
- Industrial temperature control systems.

Advantages

- **High Accuracy:** LM35 provides precise readings with minimal error.
- **Cost-Effective:** Uses inexpensive components.
- **Low Power Consumption:** Efficient operation.
- **User-Friendly:** Easy to build and modify.

Limitations & Future Improvements

- **Limitations:**
  - Limited to a specific temperature range (-55°C to +150°C).
  - Requires calibration for high-accuracy applications.
- **Future Improvements:**
  - Adding wireless connectivity (WiFi/Bluetooth) for remote monitoring.
  - Integrating with IoT platforms for data logging and analysis.

Conclusion

- The project demonstrates a simple yet effective way to measure temperature digitally.
- Using Arduino with an LM35 sensor provides accurate real-time readings.
- With future enhancements, it can be used in smart homes, healthcare, and industrial applications.