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SIMPLIFIED THERMOMETRY: CRAFTING A BASIC TEMPERATURE SENSOR

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Abstract: This paper outlines the procedure for crafting a simple and effective temperature sensor using a minimal quantity of materials. Temperature sensors measure the heat energy or coldness emanating from an object or system, enabling the detection of any physical temperature change and producing the output in the context of light. This paper highlights the creation of a user-friendly sensor, empowering ordinary individuals to engage in sensor technology. By employing readily available and uncomplicated components, the approach ensures accessibility, encouraging widespread participation and innovation in sensor development for diverse applications. This document elucidates the process of creating a straightforward thermometer suitable for everyday use in measuring required temperatures.

***Keywords*— LM358, Resistor, Thermistor, Potentiometer, LED**

1. **Introduction:** In contemporary electronic applications, the demand for accurate and versatile temperature sensing systems has witnessed a surge, driven by diverse fields such as industrial automation, environmental monitoring, and consumer electronics. This paper introduces a novel temperature sensing approach that leverages the LM358 [1] operational amplifier, a thermistor [2] and a potentiometer to create a robust and customizable temperature sensor. This integration proves particularly beneficial in many applications across various industries. The LM358, thermistor, and potentiometer [3]

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assembly provides invaluable data for regulating processes, ensuring safety measures, and optimizing overall system performance. The collective synergy of these components underscores their significance in creating a reliable and adaptable temperature sensing solution.

2. **Literature Review:** The creation of user-friendly sensors aims to empower everyday individuals, allowing them to actively engage in sensor technology. By utilizing easily accessible components, this approach ensures inclusivity and innovation in developing sensors for various applications. It offers a comprehensive understanding of crafting a simple thermometer for everyday use in measuring temperatures. Hence his device that is uncomplicated and accessible, encouraging broader involvement and creativity in the advancement of sensor technology. Arifur Rahman et al., have stated that temperature changes are linked to molecular energy, but measuring it directly is challenging. Temperature sensors like mercury or alcohol thermometers, indirectly gauge temperature by tracking substances that expand or change properties with temperature variations. Calibration to standard scales ensures accuracy. Alternatives include thermocouples, resistance thermometers, silicon sensors, and radiation thermometers for diverse applications. [4] The Hunuh et al., have explained that when heat is added to a system, it increases the molecular motion, leading to a rise in temperature. Ensuring processors operate reliably and at anticipated speeds necessitates adherence to specified temperature ranges, underscoring the vital role of temperature specifications in optimal processor performance. [5] Uglijsa Jovanovic et al. have presented an overview of temperature sensors used for PV module temperature measurement. It explains the issues with the contact temperature sensor and compares the accuracy of four contacts and one non-contact sensor using a thermal imaging camera. This paper introduces a system for measuring the temperature of solar photovoltaic modules. Overcoming contact sensor challenges, the system ensures accuracy, flexibility, and cost-effectiveness, as demonstrated through analysis and comparison with a high-quality thermal imaging camera [6]. Stefan Marinca et al., have proposed a novel temperature sensor architecture that demonstrates in the realm of temperature measurement, ensuring accurate readings

and maintaining consistent linearity between parts is crucial. This addresses the requirement for an ever more precise temperature sensor, whether it operates autonomously or becomes an integral component within a conventional mixed-signal process. This article presents a groundbreaking temperature sensor architecture that not only demonstrates admirable accuracy but also consistent part-to-part linearity. The architecture is designed to meet the escalating demand for precise temperature sensors, accommodating their use as standalone devices or integration into a standard mixed-signal process. Furthermore, the implemented architectural principle, executed on a standard 0.18μm CMOS process, showcases exceptional accuracy, surpassing ±1.5°C across a broad temperature range from -40 to 125°C. Notably, this achievement obviates the necessity for meticulous oil bath calibration, enhancing the efficiency and convenience of temperature sensing applications. [7] Shi-wen Chen et al., presents a process, voltage and temperature sensor without a voltage/current analog-to-digital converter (PVT). It describes the design and implementation of the PVT sensor and shows its advantages in terms of high accuracy, low power etc. Traditional temperature sensors rely on ADC for digital output conversion, while the proposed sensor generates a clock frequency proportional to temperature, converting it into a corresponding digital code. The code is influenced by PVT variations, mitigated by two additional sensors for voltage and process monitoring. [8] Pyoungwon Park et al., described a temperature sensor using thermistor and LM358 operational amplifier. The paper shows the circuit design and the calculation of the thermistor resistance and temperature. The paper also demonstrates the sensor output using an LED and a multimeter. [9]

3. **Design and Implementation:** One common and versatile method for temperature sensing utilizes a thermistor in conjunction with an LM358 operational amplifier. The LM358, a dual-operational amplifier IC, amplifies and processes the thermistor's output voltage. A fixed resistor collaborates with the thermistor, forming a voltage divider circuit that determines the sensor's effective temperature range. The LM358 and the circuit are powered by a stable 5V power supply. A breadboard, facilitating solder-free prototyping,

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aids in component assembly and testing. NTC (Negative temperature coefficient) exhibits significant resistance variations with temperature changes. It also serves as the temperature-sensitive element. It forms a voltage divider circuit with a fixed resistor, producing an output dependent on temperature. The LM358, functioning as a comparator or amplifier, responds to temperature-induced voltage variations from the thermistor, a temperature-sensitive resistor. The Potentiometer, an adjustable resistor, fine-tunes circuit sensitivity and sets a reference voltage for the LM358. These components constitute the fundamental elements for crafting a basic temperature sensor using an LM358 operational amplifier and a thermistor. These components can be used to make a circuit that accurately measures temperature and provides voltage output corresponding to temperature.

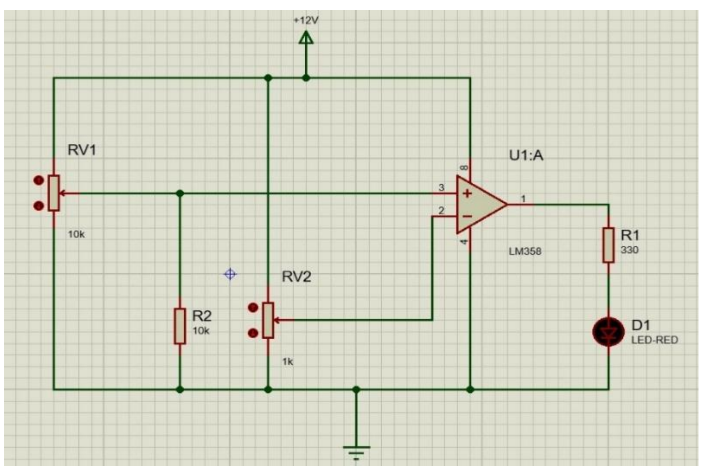

Figure 1: Connection of different parts of circuit

4. **Simulation Parameter:** To define various aspects that are relevant to the simulation process. These parameters are used in the device according to the result needed. Proper consideration of these parameters helps in achieving the desired performance characteristics, allowing the sensor to provide accurate temperature measurements across the specified range and in various operating conditions.

Table 1: Parameter of different devices

Sl. No	Components	Specification
1	Red LED	-
2	Transistor	BC547
3	Resistor	220 Ω, 1KΩ
4	Potentiometer	10K
5	LM358	-
6	Thermistor	-

5. **Result Analysis:** The potentiometer enables the establishment of a reference voltage. This voltage signifies a specific temperature intended for detection. The resistance of the thermistor fluctuates in response to temperature changes. LM358 assesses the voltages present at its inputs. When the voltage at the non-inverting input surpasses the reference voltage, a change in output state occurs. The output voltage at pin 1 of the LM358 will vary based on the temperature detected by the thermistor. Upon the temperature falling below 3 degrees Celsius, an LED is triggered to illuminate. Adjusting the resistance value of the potentiometer/variable resistor, achieved by turning its handle, reduces the circuit's sensitivity when the thermistor is warmed up, causing a decrease in its resistance. This transition takes a few seconds. As the thermistor's resistance diminishes, current starts flowing from positive 9 volts to negative 0 volts. The current then enters the base of the transistors, facilitating the illumination of the LED.

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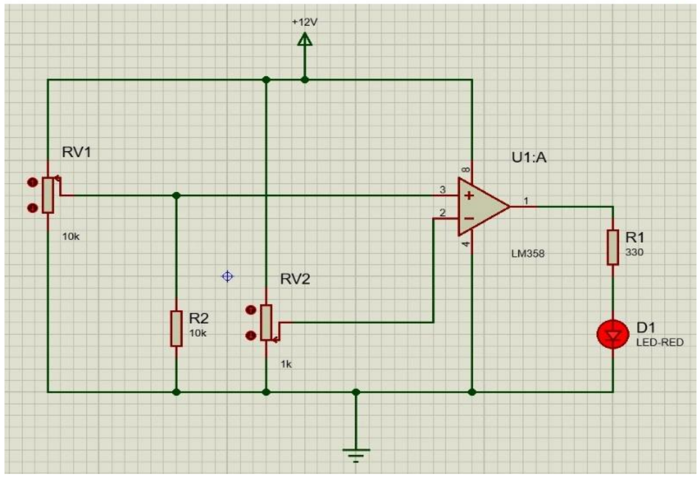

Figure 2: Result after the connection

6. **Conclusion:** Hence, the temperature measurement device, formulated using an LM358 operational amplifier and a thermistor, emerges as a versatile and dependable solution for gauging temperature across diverse applications. This uncomplicated yet efficient sensor capitalizes on the temperature-sensitive attributes of the thermistor, coupled with the amplification capabilities inherent in the LM358, resulting in precise and responsive temperature readings. The straightforwardness of this sensor design, combined with its cost-effectiveness, renders it accessible to students, enthusiasts, and industry professionals engaged in electronics and temperature management. By exploiting the distinctive characteristics of the thermistor and the amplification features of the LM358, this sensor delivers a dependable and effective means for accurate temperature measurement and regulation. Its efficacy lies in its capacity to translate alterations in environmental temperature into practical and actionable data, establishing it as an indispensable tool in contemporary electronics and automation.

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