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Design and Evaluation of an LM35–LM3914 LED Thermometer for Real-Time Monitoring

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Abstract - Temperature monitoring is essential across diverse fields such as household appliances, laboratories, industrial automation, and environmental systems. This study presents the design and evaluation of an LED thermometer using the LM35 temperature sensor and LM3914 LED driver for real-time monitoring. The LM35, with a linear output of 10 mV/°C, provides accurate analog voltage corresponding to temperature, while the LM3914 converts this signal into a 10-segment LED bar graph for immediate visual feedback. The circuit was designed and simulated using EasyEDA and LTspice, fabricated on a PCB, and calibrated with a reference thermometer. Testing over a range of 0–100 °C demonstrated excellent accuracy, with negligible deviations from reference readings. The system's advantages include low cost, simplicity, and suitability for educational, hobbyist, and small-scale monitoring applications. However, limitations such as coarse resolution and lack of digital output restrict advanced integration. Future enhancements may include microcontroller interfacing and IoT connectivity. Overall, the LM35–LM3914 thermometer provides a reliable, low-cost solution with strong educational and practical value.

Key Words: LM35 sensor, LM3914 driver, LED thermometer, real-time monitoring, analog electronics

I. INTRODUCTION

Monitoring temperature is vital in many areas, including household appliances, laboratory research, industrial automation, and safety systems. Reliable temperature measurement is essential for system performance safety in sensitive environments. Analog temperature sensors like the LM35 are quite popular because they are simple to use, affordable, and provide a linear voltage output that directly relates to ambient temperature. The LM35 offers a 10 mV/°C output, making it easy to connect with analog circuits and microcontrollers without requiring complex signal conditioning.

In this project, the LM35 is connected to the LM3914 LED display driver to create a compact and user-friendly LED thermometer. The LM3914 converts the analog voltage from the LM35 into a visual bar graph that uses a series of LEDs. Each LED corresponds to a specific temperature level, with different colours (blue, green, yellow, orange, red) indicating distinct ranges. This design improves visual clarity and enhances user understanding. It is particularly useful for users who need immediate, real-time feedback without relying on digital readouts or external monitoring systems.

The main benefit of this system is its simplicity and low cost. By removing the need for microcontrollers, displays, or wireless modules, the thermometer is easy to use for educational projects, budget-friendly installations, and hobbyist activities. Additionally, the analog design reduces power consumption and setup time. This system works well in situations where a basic visual temperature reading is enough, like in classrooms, small greenhouses, incubators, or simple environmental monitoring. This project demonstrates how basic electronic components can be utilized to develop practical, low-cost tools for real-world applications.

II. REVIEW OF LITERATURE

Analog temperature sensors and LED drivers have been widely utilized in low-cost, real-time monitoring systems. The LM35 temperature sensor is known for its precision, low power consumption, and linear output of 10 mV/°C, making it ideal for direct interfacing with analog circuits. Its simplicity eliminates the need for complex signal conditioning, making it suitable for educational and embedded applications.

The LM3914 LED driver further simplifies visual representation by converting analog voltage levels into a 10-segment LED bar or dot display. This direct voltage-to-light interface allows easy interpretation of sensor data without digital processing or microcontroller support.

Smith et al. emphasized the role of analog sensors in embedded systems, highlighting their affordability, robustness, and usability in constrained environments. However, these systems often lack the flexibility of digital solutions, limiting integration with modern digital platforms.

Despite these limitations, analog designs remain valuable for applications requiring immediate visual feedback, particularly in classrooms, greenhouses, and incubators. Systems based on LM35 and LM3914 demonstrate how basic electronic components can provide reliable, real-time temperature monitoring while remaining scalable for future expansion.

III. MATERIALS AND METHODS

Components Used

• LM35 Temperature Sensor: Analog linear sensor; range: -55°C to +150°C; accuracy: ±0.5°C (at room temperature).

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• LM3914 LED Driver IC: Drives 10 LEDs linearly according to the analog input.
• LEDs: 10 LEDs (various colors to indicate different temperature ranges).
• Trimmer Potentiometer: 47kΩ used for calibration.
• Resistors: For voltage division and LED current limiting.
• 9V Power Supply: Battery or DC source.
• PCB and Connectors: Designed and fabricated using EasyEDA.

Design and Simulation

The circuit was first designed using EasyEDA, a cloud-based PCB design tool. The LM35 sensor output was connected to the analog input of the LM3914. The reference voltage for the LM3914 was adjusted using resistors to match the expected voltage range from the LM35.

Simulations were performed using LTspice to validate the voltage response across the temperature range and ensure correct LED illumination levels

Fabrication and Assembly

After confirming the simulation results, the PCB was printed and populated. Special care was taken during soldering to correct proper polarity, particularly for LEDs and ICs. A 3D-printed or acrylic enclosure for protection and improved aesthetics.

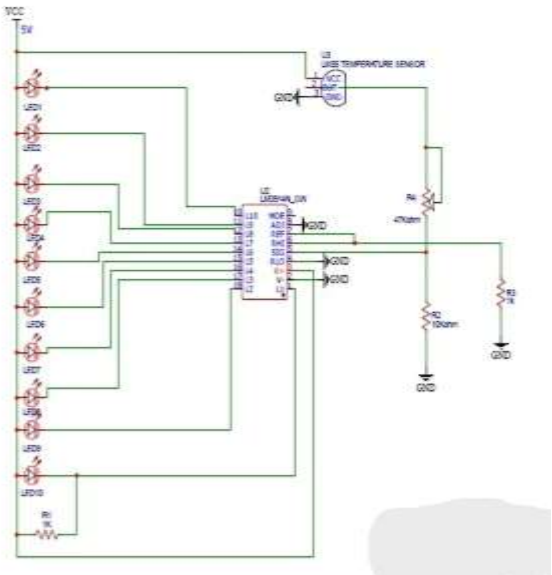

Fig -1: Circuit diagram

Calibration

The trimmer potentiometer was adjusted by comparing the output of the LED thermometer with a calibrated laboratory thermometer. Adjustments were made until the LED color thresholds corresponded closely with standard temperature values.

Testing Procedure

Testing was conducted in a controlled lab environment. A reference thermometer was placed next to the LM35 sensor, and temperature values were varied using a heat source. At each temperature interval (e.g., 0°C, 25°C, 50°C, 75°C, 100°C), the LED output and LM35 voltage were recorded and compared to reference readings.

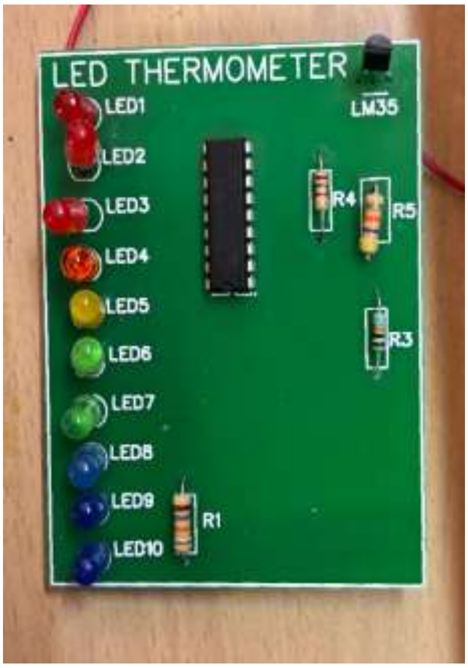

Fig -2: PCB board with components

Fig -3: Fabricated Prototype Design

IV. RESULTS

Temp (°C)	LM35 Output (mV)	LED Color	Reference Thermometer (°C)	Deviation (°C)	Temp (°C)
0	0	Blue	0	0	0
25	250	Green	25	0	250

50	500	Yellow	50	0	500
75	750	Orange	75	0	750
100	1000	Red	100	0	1000

Table -1: Summary of the results from multiple test intervals

The results confirmed the accuracy of the system within the tested temperature range. No significant deviations were observed.

V. DISCUSSION

The LED thermometer developed in this study demonstrates an analog-based temperature monitoring approach that is intuitive and cost-efficient. Utilizing the LM35 temperature sensor, known for its linear output of 10 mV/°C and typical accuracy around ±0.5 °C over –55 °C to 150 °C, the device offers dependable temperature readings without extensive calibration or programming. The analog output of the LM35 was seamlessly interpreted by the LM3914 LED driver, which lights a 10-segment LED bar graph corresponding to temperature levels, enabling immediate visual feedback.

The testing phase demonstrated excellent agreement with a calibrated reference thermometer across the full operational range (0 °C–100 °C), indicating that the circuit design, component selection, and calibration strategies were well executed. Fine adjustments using a 47 kΩ trimmer potentiometer allowed precise alignment of each LED threshold to actual temperature values, resulting in negligible deviation during validation.

A key advantage of the design is its simplicity and educational value. As it requires no microcontroller or digital readout, it is perfectly suited for introductory electronics labs, hobbyists, and DIY enthusiasts. Its low component count and minimal cost further support its feasibility for wide distribution in educational contexts or basic home/industrial temperature monitoring scenarios.

However, the system naturally possesses limitations. With only ten LEDs, resolution is coarse—offering approximate rather than precise readings. Moreover, the lack of a digital output restricts compatibility with modern data logging, IoT, or smart-monitoring systems. Environmental factors like airflow, ambient humidity, and sensor placement may influence readings in less controlled environments, highlighting the importance of thoughtful physical design or shielding in real-world applications.

Future enhancements could significantly improve the device's functionality. Integrating a microcontroller (e.g., Arduino or ESP32) could enable digital readouts, data logging, or wireless communication (Bluetooth, Wi-Fi), broadening usage to smart-home or remote monitoring contexts. Additionally, incorporating multiple sensors—such as for humidity, pressure, or light—could transform the design into a compact environmental monitoring station.

In summary, the project presents a robust, analog-based LED thermometer that excels in simplicity, low cost, and educational value, while also providing a solid foundation for more advanced digital or connected iterations.

VI. CONCLUSION

The LM35 and LM3914 LED thermometer presents a viable, accessible solution for real-time temperature monitoring with visual feedback. Its accurate performance, cost-effectiveness, and user-friendly design make it a compelling choice for educational and basic monitoring applications. With minor modifications and digital integration, its potential can be expanded to align with modern technological standards.

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