Lab 2: Sensors

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1. Introduction

Temperature sensors play a crucial role in many applications, from medical procedures to laboratory settings. In biomedical instrumentation, these sensors are crucial because they allow for accurate monitoring of a patient's body temperature, granting medical professionals the data needed to identify serious medical conditions such as fever or hypothermia, enabling timely diagnosis and treatment interventions. In this experiment, we used an Arduino-controlled temperature sensor to continuously monitor temperature changes over a period. A buzzer and LED will activate once the temperature reaches a predefined threshold. This experiment explores the relationship between temperature changes and time, with a focus on real-time data acquisition and analysis.

Key concepts:

- **Temperature Sensors**: A temperature sensor allows us to efficiently and effectively monitor the temperature of a given thing in a readable form through an electric signal.
- **Analog Signal**: Any continuous-time signal, representing a quantity, over a time-varying parameter.
- **Buzzer**: An electronic component that generates a sound when an electric signal is applied to it.
- **LED**: Semiconductor component that emits light when an electric current flows through it

2. Methods and Materials

- Arduino Leonardo
- Temperature Sensor (e.g., LM35)
- Buzzer
- LED
- Resistors
- Breadboard and jumper wires
- MATLAB software

❖ Running the Experiment

- The circuit was set up by connecting the temperature sensor to Arduino's first analog input (A1), the LED to digital pin 7, and the buzzer to digital pin 9.
- Next, write an Arduino-MATLAB script to:
    - Read the voltage from the temperature sensor.
    - Convert voltage readings to temperature (Celsius) values.
    - Store the temperature and time values.
    - Continuously plot the temperature data in real time for 30 seconds.
    - Activate the LED And buzzer when the temperature exceeds the chosen threshold.

- Introduce temperature variation by directly touching the sensor.
- Record data for at least 30 seconds.
- Analyze the temperature's rate of change and estimate the time required to reach the set threshold.

3. Results

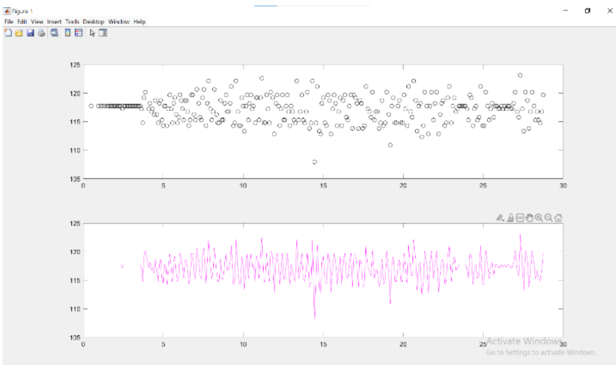

Figure 1 - Measured Temperature for 30 secs in Celsius

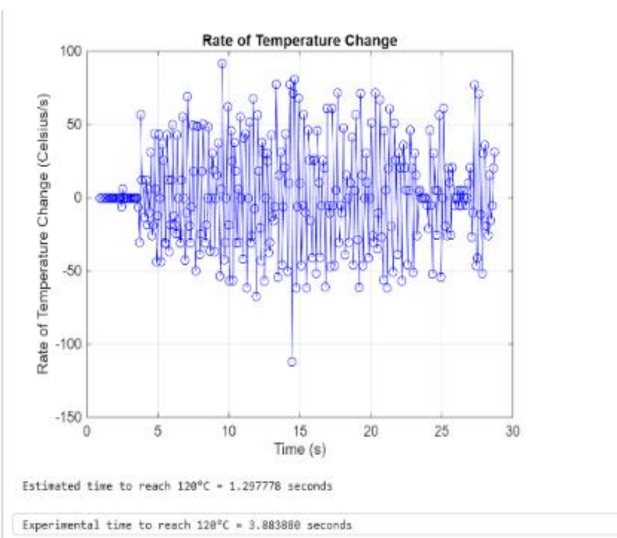

Figure 2 - Temperature Rate of Change

1. **Temperature vs. Time Plot**
    a. Figure 1 displays the recorded temperature values over time (30 seconds). Each data point represents a sampled temperature at the given moment.
    b. The temperature fluctuates are due to environmental variations and introducing temperature changes to the sensor (physical touch).
    c. As expected, introducing an external temperature change (such as touching the sensor or using an air gun) resulted in deviations of the data.
    d. The threshold for triggering the alarm (buzzer and LED) was set at **120°C**, and when this temperature was reached, the system responded accordingly (buzzer sounded and LED lit up).
2. **Rate of Temperature Change vs. Time Plot**
    a. Figure 2 represents the slope of the temperature readings with respect to time, showing how rapidly the temperature is increasing or decreasing.
    b. Large variations in the rate of change suggest dynamic fluctuations due to environmental shifts.
    c. The estimated time to reach 120°C was calculated to be 1.2978 seconds, based on the initial slope and its projected incline.
    d. The actual experimental time to reach 120°C was measured at 3.8838 seconds, demonstrating the discrepancy between the theoretical estimate and real-world behavior.
    e. The deviation is attributed to external factors such as heat dissipation, air conditioning, sensor response time, and/ or

many other external conditions affecting temperature conduction.

The figures provide insight into the circuit and sensor's response characteristics as well as the thermal behavior of the environment under controlled conditions. The vast difference between the estimated and experimental times exemplifies that real-world heating processes are far more complex than the prediction of a simple linear model.

4. Discussion

The experiment's objective was to continuously monitor temperature readings and analyze the rate of temperature change when an external heat source was applied. The system was programmed to activate an LED and buzzer once the temperature exceeded the set threshold of 120°C. The results from the recorded data provide valuable insights into the accuracy of our theoretical predictions and the real-world response of the sensor and the immense disparities between the two.

In Figure 1, we observed fluctuations in the temperature readings, which is a direct result to sensor noise, environmental factors, and variations in the applied heat source. Despite these fluctuations, a clear upward trend was evident when the sensor was exposed to an outside heat source, leading to the activation of the warning system at the set threshold.

Figure 2 revealed a high degree of variability in the slope at which the temperature increased. This variation is due to inconsistent heat application, sensor response time, and external cooling effects. The estimated time to reach 120°C was calculated to be 1.2978 seconds, assuming a constant rate of temperature increase. However, the experimental data showed the sensor took 3.8838 seconds to reach the threshold, indicating a significant discrepancy between theoretical estimation and real-world conditions.

The main challenge encountered during the experiment was ensuring that the MATLAB program ran as intended. Specifically, there were a plethora of issues surrounding the incorrect conversion and calculation of the temperature in Celsius. Our group was plagued with negative readings at a point and the program required substantial debugging. Troubleshooting involved using print statements, stepping through the code, and backtracking until the program functioned expected.

https://youtube.com/shorts/ykdPR6i7X8M?si=nNW3wdqzAoVPv23s

5. References

Arduino Documentation. (2023). *"Using Temperature Sensors with Arduino and Real-Time Plotting."* Retrieved from https://docs.arduino.cc