3L04

Lab 4 – Temperature Sensor

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Abstract:

In this lab we experiment with two different types of temperature sensors to log the temperature in a room and the change in temperature with respect to time when the sensors are submerged in an ice bath. The experiments are carried out to gain a better understanding of the internal workings of each sensor and their respective pros and cons. This information aids us in being able to select appropriate sensors for different situations. The analog temperature module which uses a NTC thermistor to determine the temperature was used to log the temperature in a room for 10 mins. The initial recording was 25.4 degrees Celsius and the final recording was 24.69 degrees Celsius which also happened to be the most occurring value (mode). The mean room temperature was calculated to be 24.83 degrees Celsius and the standard deviation of the data was found to be 0.2035135. When submerged in the ice bath, the sensor starts at 24.33 degrees and starts to drop drastically. Equilibrium was reached after approximately 4 minutes with the final recorded temperature being 6.35 degrees Celsius. The same experiment when repeated with the K-type thermocouple gave an initial reading of 28.75 degrees, dropping very slowly as it reached equilibrium at a final temperature of approximately 25.25 degrees Celsius. The mean room temperature was calculated to be 26.4168 degrees and the standard deviation of the data was found to be 1.0018. When redone with the ice bath, the initial temperature started off at 24.75 degrees which then drastically dropped after submersion. Equilibrium was reached after approximately 4 minutes again at a temperature of 9.5 degrees Celsius.

Introduction:

The intended learning outcomes of this lab is to gain a better understanding of the working principles of a temperature sensor. This is done by assembling a simple electrical circuit using a temperature sensor and using it to make a series of measurements. This experiment will allow us to determine the appropriate uses of different types of sensors and their varying efficiency in different applications.

Experimental Details:

The experiments starts off with a simple circuit consisting of an analog temperature module connected to an Arduino. The relevant code is uploaded and then using the serial monitor, the functionality of the sensor is tested by touching the sensor and blowing on it. The serial monitor should respond accordingly to confirm the sensor is working as intended. Once confirmed, PuTTY is used to log the room temperature for ten minutes in an excel file. After ten minutes, PuTTY is closed and the data recorded in the excel file is used to make a graph of temperature vs time. The mean temperature, standard deviation, maximum and minimum is then calculated using this data.

Once completed, PuTTY is restarted again with a new excel file and the sensor is now submerged into an ice bath after proper water proofing. The sensor was enclosed in sandwich bag which was then placed in the ice bath until the temperature reached equilibrium. This is observed on the PuTTY interface. Once stabilized, PuTTY is closed and the data in this new excel file is used to produce another graph of temperature vs time.

The same two processes are then repeated with a K-type thermocouple probe.

Results:

Thermistor Sensor for Room temperature

Mean temperature (calculated using excel formula) = 24.83094371 degrees Celsius
Standard Deviation (calculated using excel formula) = 0.2035135 degrees Celsius
Maximum temperature (excel function) = 25.4 degrees Celsius
Minimum temperature (excel function) = 24.51 degrees Celsius

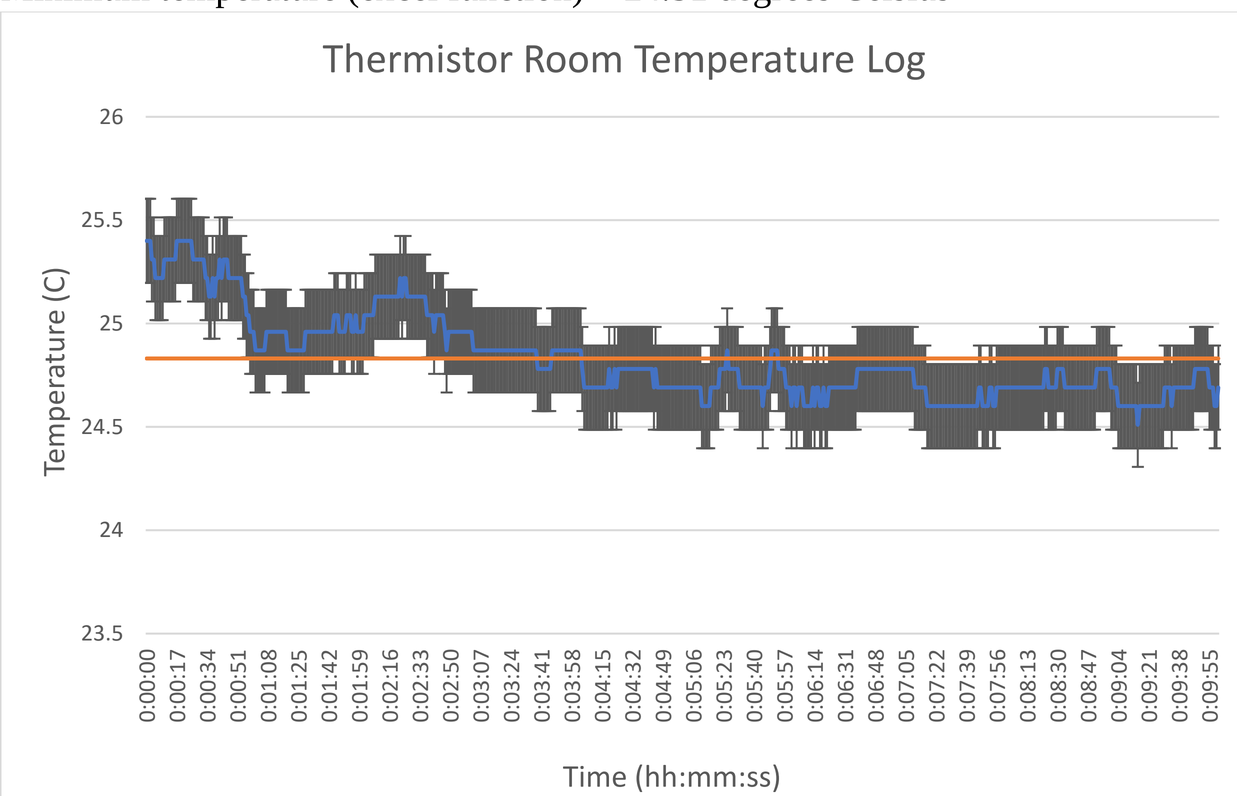

Figure 1: Plot of Room temperature vs Time (thermistor)

Thermistor sensor submerged in ice bath

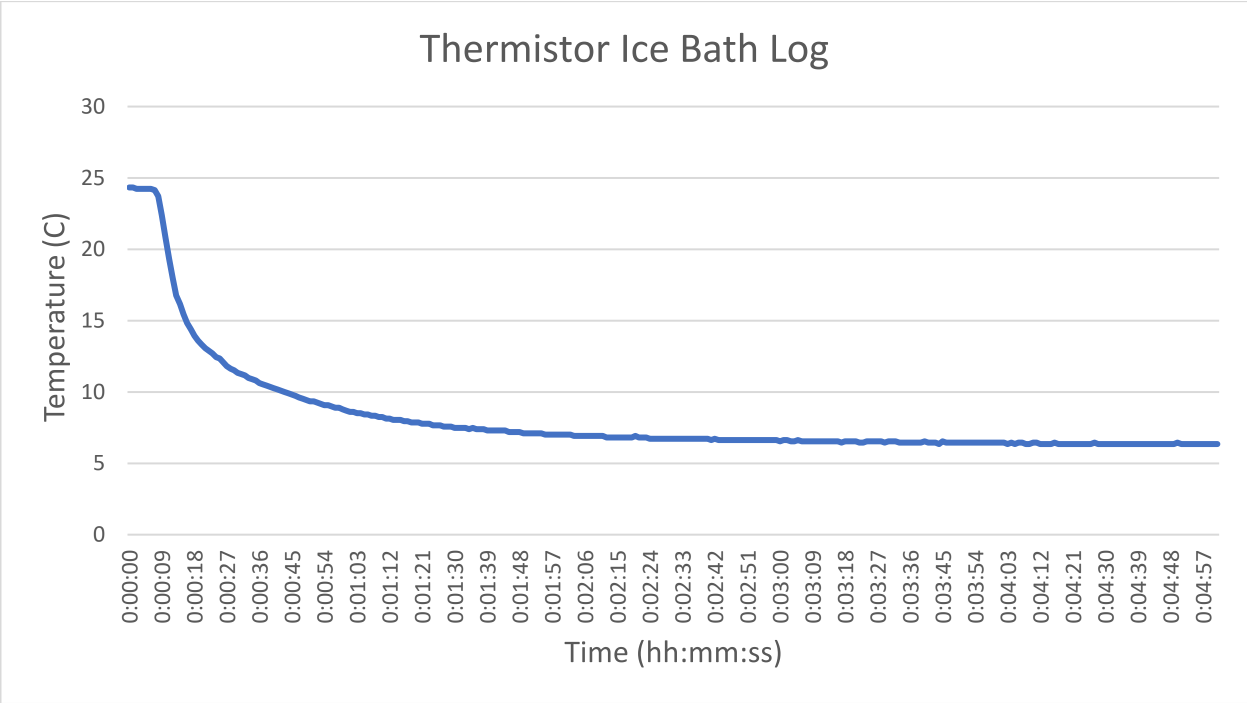

Figure 2: Plot of Temperature vs time (Thermistor in Ice Bath)

K-Type Probe for room temperature

Mean temperature (calculated using excel formula) = 26.416805 degrees Celsius
Standard Deviation (calculated using excel formula) = 1.00184128 degrees Celsius
Maximum temperature (excel function) = 29 degrees Celsius
Minimum temperature (excel function) = 24.5 degrees Celsius

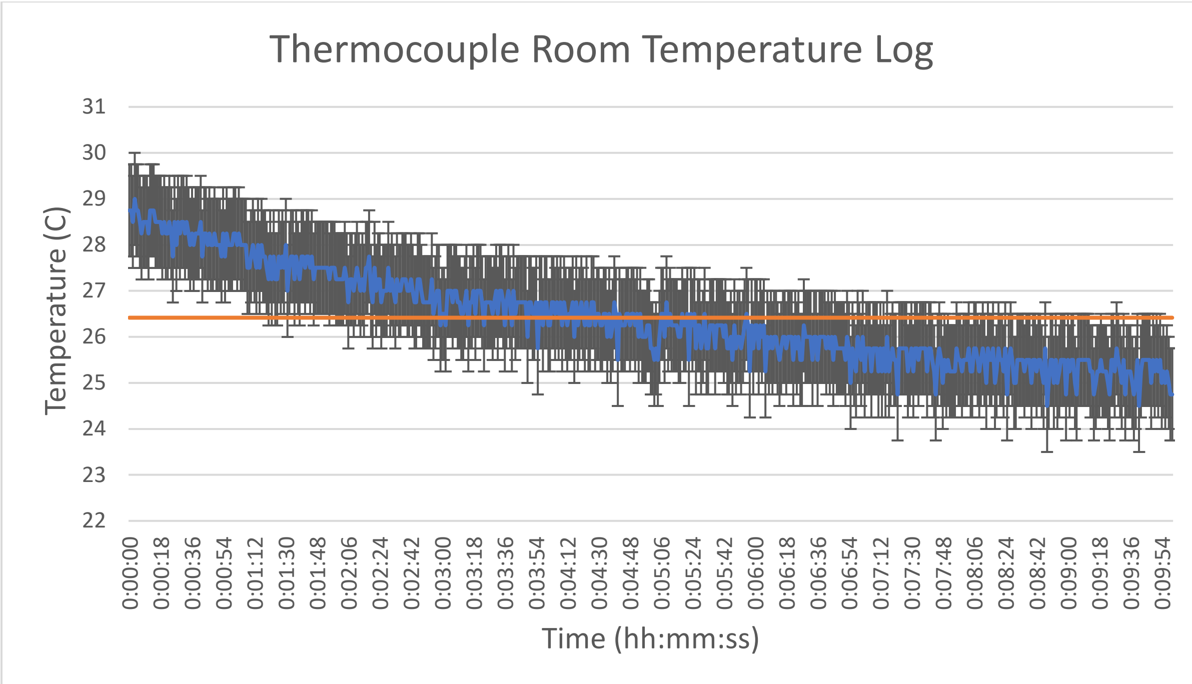

Figure 3: Plot of Room temperature vs time (thermocouple)

K-Type probe submerged in Ice Bath

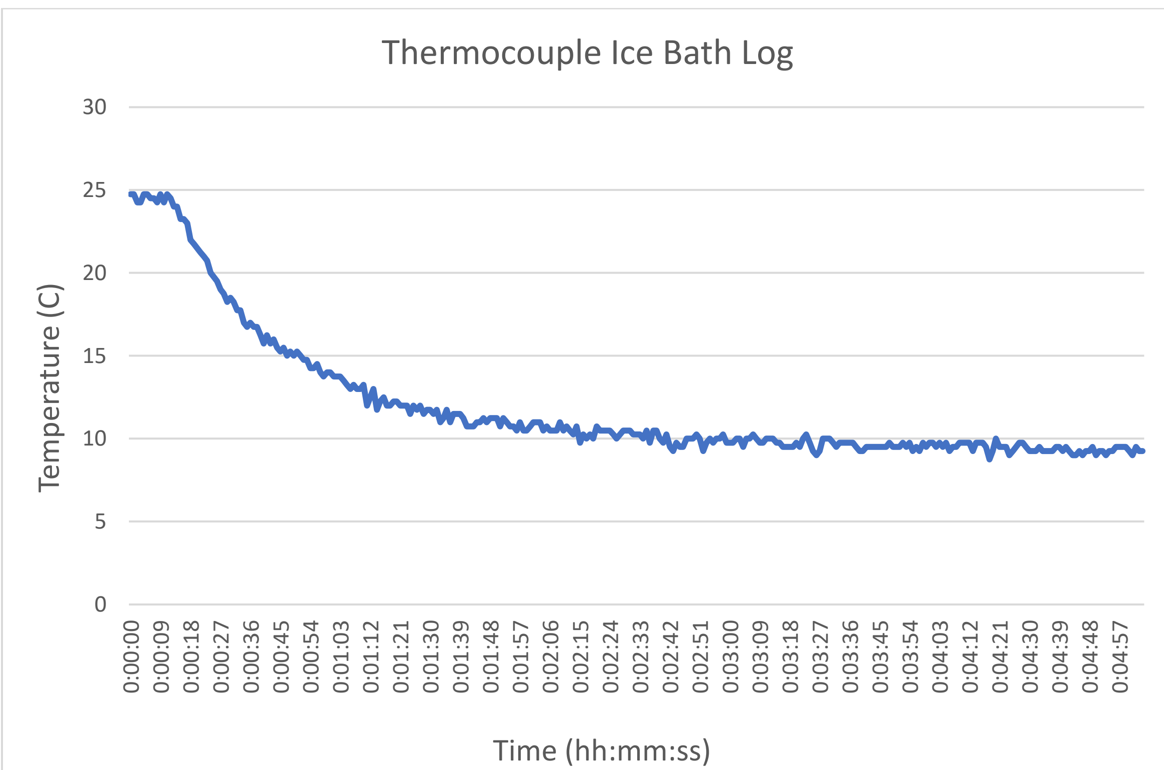

Figure 4: Plot of temperature vs time (thermocouple in ice bath)

Discussion:

3.3:

The standard deviation is the spread of the data and how close it is on average to the mean value.

The standard deviation was found to be 0.2 degrees Celsius.

Therefore:

Tmean = $24.83 \pm 0.2\ degrees\ celcius$

Tmax = $25.4 \pm 0.2\ degrees\ celcius$

Tmin = $24.51 \pm 0.2\ degrees\ celcius$

The maximum and minimum do not fall within one standard deviation from the mean. The minimum falls within two standard deviations from the mean but the maximum does not.

To identify when the system reaches thermal equilibrium, we observe the output in the serial monitor or PuTTY interface. Ideally, we would wait for the temperature to entirely stabilize at one value but since there are uncertainties and external hindering factors involved, the device is said to have reached thermal equilibrium when the temperature starts fluctuating between just two values.

To find the time constant the following calculation is performed:

$$T\tau = Tmin + 0.37 * (Tmax - Tmin) = 12\ degrees\ celcius$$

$$\tau = 26\ seconds$$

The time constant of a thermistor is useful to engineers as they are non-linear devices. It allows to determine the sensitivity of a thermistor and its threshold value (when the resistance begins to increase/decrease exponentially). This in turn aids them in selecting the appropriate thermistor for different scenarios.

4.3:

The standard deviation is the spread of the data and how close it is on average to the mean value.

The standard deviation was found to be 1 degrees Celsius.

Therefore:

Tmean = 26.416805 $\pm 1\ degrees\ celcius$

Tmax = 29 $\pm 1\ degrees\ celcius$

Tmin = 24.5 $\pm 1\ degrees\ celcius$

The maximum and minimum do not fall within one standard deviation from the mean. The minimum falls within two standard deviations from the mean but the maximum does not.

To identify when the system reaches thermal equilibrium, we observe the output in the serial monitor or PuTTY interface. Ideally, we would wait for the temperature to entirely stabilize at one value but since there are uncertainties and external hindering factors involved, the device is said to have reached thermal equilibrium when the temperature starts fluctuating between just two values.

To find the time constant the following calculation is performed:

$$T\tau = Tmin + 0.37 * (Tmax - Tmin)$$

$$\tau = 50\ seconds$$