3rd/July/2024 Atsushi Saito

About Report of Experiment using Thermistor

Analyze and summarize the data of the experiment using thermistor "103AT-2".

★Contents of the report：

1. Summarization of your designed measurement circuit and the simulation results of your circuit.
   - Circuit diagram - Result of AC analysis - Result of parametric analysis

2. Graph plot of calibration curve for your measurement circuit as follows:
   * The pre-measured data will be used for this. The data is on the tab "Data for calibration curve" in the file "2024_Data_for_exercise.xlsx".

   Horizontal axis: Output voltage from measurement circuit
   Vertical axis: Temperature calculated from constant resistance by using *Eq*.(1)
   *** Linear function of calibration curve** which is determined by least square method is necessary.

   The relation between sensor resistance and temperature is expressed as follows:

   $$R_m = R_0 \cdot exp\left\{B\left(\frac{1}{T_m} - \frac{1}{T_0}\right)\right\} \quad \cdot \cdot \cdot Eq.(1)$$

   R_m : Sensor resistance that is in a state of measurement temperature.
   R_a : Sensor resistance that is in a state of standard temperature**.
   ** In the case of 103AT-2, 10kΩ@25℃
   B : B value of the sensor device. In the case of 103AT-2, B=3435[K]
   from data sheet (This value determines the sensitivity for temperature change.).
   T_m : Measurement temperature. Unit is "K".
   T_a : Standard temperature***. Unit is "K".
   *** In the case of 103AT-2, T_a = 25℃

3. Graph plot of measured data (On the tab "Measured data" in the file "2023_Data_for_exercise.xlsx").
   And your comments for the plot.
   Horizontal axis: Time, Vertical axis: Output Voltage

4. Calculation of measured temperature and its graph plot. And your comments.
   Horizontal axis: Time, Vertical axis: Temperature
   ※ When you calculate temperature from measured output voltage, you can use the linear function for calibration curve " * ".

5. Refer next page and analyze the sensor response of your thermistor by Eq.(2) for an equivalent circuit composed in resistors and capacitors. And your comments.

6. Describe the effectiveness of analyzing sensor response based on response model and its application.

About submission of Report.
Deadline: July 17 2024
Submission method: via Scomb
File format of the report: PDF file
*** If you have any problem, please feel free to contact me by e-mail.**
My e-mail address: saitoa@sic.shibaura-it.ac.jp

About Equivalent Circuit expression of thermistor's response

Thermistor's response can be expressed by an equivalent electric circuit composed with resistances and capacitances. Because analogy is found between "heat flow" in temperature measurement and "current flow" in electrical circuit. It is useful to analyze sensor response based on response model, especially equivalent circuit.

★ Physical means:

Resistor: Resistance for heat propagation (temperature change)
Capacitor: Capacitance of heat

★Equivalent circuit for heat propagation:

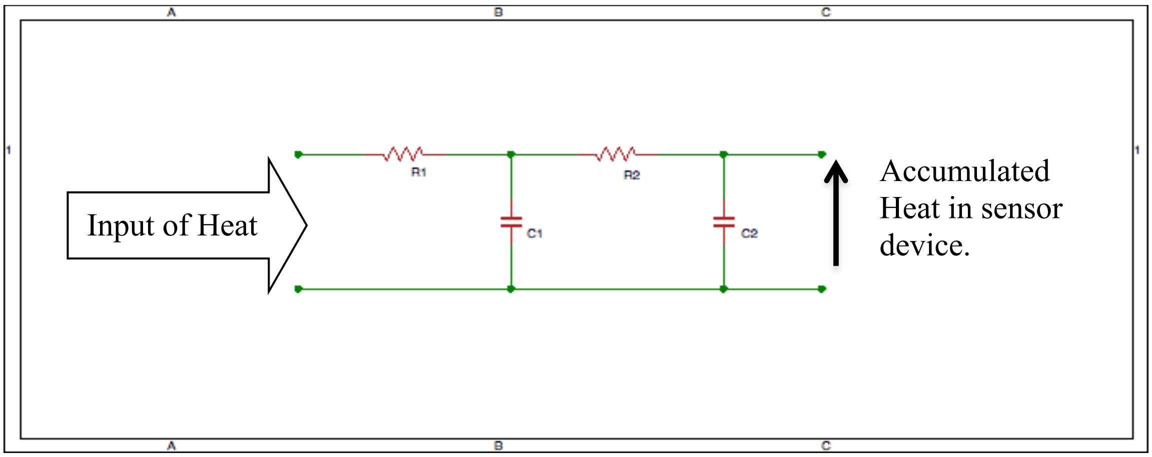

Fig. An equivalent circuit for heat propagation on sensor device

R1 : Resistance for heat propagation of measurement environment****.
C1 : Capacitance of heat of measurement environment****.
**** In our case, measurement chamber (plastic bottle)
R2 : Resistance for heat propagation of a sensor device*****.
C2 : Capacitance of heat of a sensor device*****.
***** In our case, Thermistor "103AT-2"

★ Response function based on the equivalent circuit

$$T(t) = T_e + \{T(0) - T_e\}\{1 - (e^{-\frac{t}{\tau_1}} - 1)(e^{-\frac{t}{\tau_2}} - 1)\} \quad \cdot \cdot \cdot Eq.(2)$$

$T(t)$: Sensor device temperature at the time "t".
T_e: Temperature of measurement object (In our case, temperature of hot water).
$T(0)$: Temperature at start of measurement (In our case, temperature of atmosphere).
τ_1: (Thermal) Time constant "C_1R_1" of measurement environment.
In our case, plastic bottle.
τ_2: (Thermal) Time constant "C_2R_2" of sensor device.
In our case,
"103AT-2" has the thermal time constant 15[s]
from sensor's data sheet.