Component Level Laboratory

Thermistor and First Order Time Response

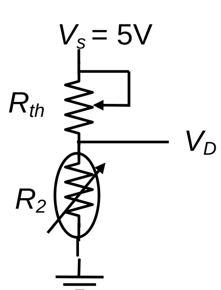
Objective: The objectives of this experiment are to study the thermistor as a temperature sensor and the property of the first order time response which it exhibits. Lab VIEW will be used to collect data and display the time response of the temperature sensor when the temperature is changed suddenly, i.e., step change. You will analyze the data to determine the time constant of the sensor.

1. Background

A thermistor is a semiconductor sensor exhibiting a nonlinear resistance variation with temperature. In general, thermistor resistance decreases (negative slope) when the temperature increase. Tables of resistance versus temperature are often provided by the manufacturer. The electrical circuit symbol of a thermistor is simply a variable resistor.

Like any resistor, the thermistor obeys Ohm's Law in that the voltage dropped across the sensor is the product of the current through the sensor times its current resistance value. Like any resistor, when current is passed through the thermistor it will dissipate energy as a power given by: $P = I^2R$

When the thermistor dissipates energy in this way it heats up, i.e., its temperature rises. This is very important because it means that the sensor will not be indicating the true temperature of the environment since it is acting as a self-heater. To account for this effect the thermistor specifications include a *dissipation constant*, P_D in mW/^{o}C, which allows an estimate of how much temperature rise, or *self-heating*, the thermistor will experience because of dissipated energy, $\Delta T = P/P_D$ in which ΔT is the temperature rise due to the power dissipation and P is the power. In any measurement system using the thermistor the self-heating must be made less than the required measurement resolution by keeping P low.



As shown in the divider circuit, Rth represent the Thermistor. Given the configuration, calculate the divider resistance R2 that will cause 20mW power dissipation by the Thermistor when Rth = 3kΩ.

2. First Order Time Response

The thermistor exhibits first order time response. This means that if the sensor is exposed to a sudden temperature change, there will be a lag as the resistance changes from the old value to the new value.

Suppose the resistance is R_i for the initial temperature and will be R_f for the new temperature. At $t = 0$ the sensor is exposed to a sudden temperature change from the initial temperature to the new temperature. The time lag in resistance changing from R_i to R_f is given by the expression: $R(t) = R_i + (R_f - R_i)[1 - e^{-t/T}]$ in which T is the *time constant* of the sensor.

For thermistors the value of the time constant is specified as a range from the fastest value, when the sensor is in good thermal contact (GTC) with the environment, to the slowest value when it is in poor thermal contact (PTC). For example a well stirred oil bath is GTC because the thermistor will adopt the oil temperature very quickly while dry, still air is PTC because there will be a greater time required for the thermistor to come into thermal equilibrium with the air.

In this experiment, you will use LabVIEW to build data acquisition system that takes in temperature values measured by thermistor, record the its resistance value when temperature changes, study its first order dynamic behavior, and determine its time constant.

Reminder: Bring your breadboard to the lab!