Aerospace Engineering Masters program

#43169 Avionics and Spacionics

Module M1: Basic electronic modules

Practical project:
Measurement and Signal Conditioning of an NTC Thermistor

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Laboratory Guide: Measurement and Signal Conditioning of an NTC Thermistor

1 Objective

This laboratory work aims to study the use of Negative Temperature Coefficient (NTC) thermistors in temperature measurement applications. The experiment will involve constructing a basic electrical circuit to sense temperature using an NTC, followed by designing a conditioning circuit using operational amplifiers (op-amps) to amplify the signal and remove offset voltages. At the final stage proper voltage sources will be generated from a single "board supply voltage".

2 Equipment Required:

- NTC thermistor
- Resistors
- Operational amplifiers (e.g., MCP6022, rail-to-rail opamps)
- Bench power supply
- Breadboard and connecting wires
- Digital multimeter and thermometer (requested for loan at the DETI warehouse)
- Oscilloscope
- Function generator (optional, for testing signal conditioning)
- Temperature source: power resistor

3 Part 1: NTC Thermistor Electrical Circuit

3.1 Understanding the NTC Thermistor

An NTC thermistor is a type of resistor whose resistance decreases as temperature increases. The relationship between temperature and resistance can be modeled using the Steinhart-Hart equation or approximated by the B-parameter equation.

For the purposes of this experiment, we will focus on creating a simple voltage divider to read the change in resistance as a measurable voltage.

3.2 Building the Basic NTC Circuit

The thermistor will be connected in a voltage divider configuration to convert its resistance changes into a corresponding voltage output.

You should use the configuration presented at the T class and tune the system to work in the range 20ºC to 80ºC. The supply voltage is 5 V DC (from the bench power supply, for now).

3.3 Instructions:

- Design the circuit

- Compute the expected voltage output over the instrument's measurement range
- Place the thermistor on the surface of the power resistor and vary the applied voltage. Place the thermometer side-by-side (so both measure the same spot of the power resistor)
- For a given temperature (that depend on the voltage applied to the power resistor and the ambient temperature) measure the output voltage and the temperature (using the thermometer)
- Repeat this process for several temperatures
  - Don't forget to wait some time for taking measurements after changing the voltage applied to the power resistor, to let the process stabilize
- Compare the measured values with the expected ones

4 Part 2: Signal Conditioning Circuit Using Op-Amps

The voltage output from the voltage divider circuit may be too small for practical measurement, and is affected by offset. So, you should design a conditioning circuit that varies the output voltage from 0 V to 5 V as the temperature varies from 20ºC to 80ºC (approximately linearly).

4.1 Instructions:

- Design the signal conditioning circuit (using opamps)
- Compute the expected voltage output over the instrument's measurement range
- Place the thermistor on the surface of the power resistor and vary the applied voltage. Place the thermometer side-by-side (so they measure the same spot of the power resistor)
- For a given temperature (that depend on the voltage applied to the power resistor and the ambient temperature) measure the output voltage and the temperature (using the thermometer)
- Repeat this process for several temperatures
  - Don't forget to wait sometime for taking measurements after changing the voltage applied to the power resistor, to let the process stabilize
- Compare the measured values with the expected ones

5 Part 3: Power supply

Practical circuits usually work form a single power supply that often has not a well defined value (e.g. a battery, whose voltage varies with the charge status, load, temperature, etc.). The objective of this stage is to make your project work from a single power source (12 VDC, in the case). Please be careful to use the right circuits to obtain voltage values with the necessary conditions.

5.1 Instructions:

- Design the voltage supply circuits. Please justify your choices.
- Compute the expected voltages at the critical points of the circuit, and compare them with the actual measurements
- Place the thermistor on the surface of the power resistor and vary the applied voltage. Place the thermometer side-by-side (so they measure the same spot of the power resistor)
- For a given temperature (that depend on the voltage applied to the power resistor and the ambient temperature) measure the output voltage and the temperature (using the thermometer)

- Repeat this process for several temperatures
  - Don’t forget to wait sometime for taking measurements after changing the voltage applied to the power resistor, to let the process stabilize
- Compare the measured values with the expected ones

6 Deliverables

The only deliverable is a written report, submitted via eLearning, until one week after the last class of Module 1.

The report should have up to seven pages, pdf format, singe column and 11pt font, structured as follows:

- Page 1:
  - Identification of the course unit and assignment
  - Identification of the group members (first name, last name and ID number)
- Pages 2-6:
  - Brief description (diagrams and text) of the circuits that have been implemented
    - Discussion/justification for the design decisions
  - Measurements and critical analysis (comparison between expected values and the ones obtained in practice, discussion of eventual discrepancies, etc.)
  - Overall discussion of the quality of the project/results
  - Conclusions
  - Bibliography

Annexes can be added up and do not count for the 7 page limit set above.
One of the mandatory annexes is a full electrical circuit.