

Topic 8: Design, implementation and programming of the **Thermistor Interface** for the Slow Control System MPD-NICA, on the NImyRIO and LabView platforms.¹

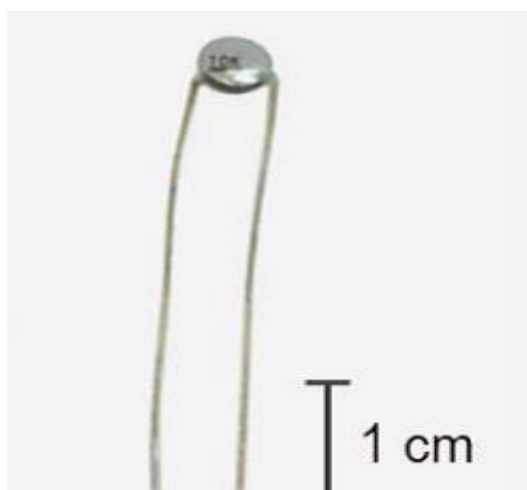
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8 Thermistor

The Thermistor – a contraction of “thermal” and “resistor” – is a two-terminal semiconductor device whose resistance varies with temperature. Most thermistors are of the negative temperature coefficient (NTC) type, meaning their resistance varies inversely with temperature.



*Figure 8-1; Pictures the NImyRIO StarterKit:
Thermistor.*

8.1 Learning Objectives:

After completing the activities in this chapter you will be able to:

- [a] Explain the thermistor principles of operation,
- [b] Measure the thermistor resistance a voltage divider and analog input,
- [c] Convert the measured resistance to temperature with the Steinhart-Hart thermistor equation,
- [d] Size the voltage-divider resistor for the best measurement sensitivity and range.

¹ Developed on the basis of educational materials: National Instruments, IBM, Reichle & De-Massari, Microsoft, Warsaw University of Technology, Joint Nuclear Institute Research

8.2 Component Demonstration

Follow these steps to demonstrate correct operation of the thermistor.

8.2.1 Select these parts from the NImyRIO StarterKit:

- [a] Thermistor, 10 k Ω , EPCOS B57164K103J,

http://www.epcos.com/inf/50/db/ntc_09/LeadedDisks__B57164__K164.pdf

- [b] Resistor, 10 k Ω

- [c] 0.1 μ F ceramic disk capacitor, marking “104”,

<http://www.avx.com/docs/Catalogs/class3-sc.pdf>

- [d] Breadboard

- [e] Jumper wires, M-F (4x)

8.2.2 Build the interface circuit:

Refer to the schematic diagram and recommended breadboard layout shown in Figure 8.2. The interface circuit requires four connections to NImyRIO MXP Connector B (see Figure A.1 Appendix):

- [a] 5-volt power supply \rightarrow B/+5V (pin 1)

- [b] Ground \rightarrow B/GND (pin 6)

- [c] Temperature measurement \rightarrow B/AI0 (pin 3)

- [d] Supply voltage measurement \rightarrow B/AI1 (pin 5)

Measure the resistance of the 10 k Ω resistor with an ohmmeter, as this value is required for the LabVIEW VI.

8.2.3 Run the demonstration VI:

- [a] Download

<http://www.ni.com/academic/myrio/project-guide-vis.zip>

- [b] if you have not done so previously and unpack the contents to a convenient location,

- [c] Open the project Thermistor demo.lvproj contained in the subfolder Thermistor demo,

- [d] Expand the hierarchy button (a plus sign) for the myRIO item and then open Main.vi by double-clicking,

- [e] Confirm that NImyRIO is connected to your computer,

- [f] Run the VI either by clicking the Run button on the toolbar or by pressing Ctrl+R.

Expect to see a “Deployment Process” window showing how the project compiles and deploys (downloads) to NImyRIO before the VI starts running.

NOTE: You may wish to select the “Close on successful completion” option to make the VI start automatically.

Enter the measured resistance of the 10 k Ω resistor as R [ohms].

8.2.4 Expected results:

The demo VI displays the measured resistance of your thermistor; expect to see a value close to 10 k Ω at room temperature. Try heating the thermistor by gently pinching the thermistor body with your fingertips; you may also use a drinking straw or hair dryer to blow warm air on the thermistor. You should observe the resistance going down. How low can you make the resistance?

Use a plastic sandwich bag filled with two ice cubes or crushed ice. Surround the thermistor with ice and you should observe the resistance going up. How high can you make the resistance?

Click the Stop button or press the escape key to stop the VI and to reset NImyRIO; a myRIO reset causes all of the digital I/O pins to revert to input mode.

8.2.5 Troubleshooting tips:

Not seeing the expected results? Confirm the following points:

- [a] Glowing power indicator LED on NImyRIO,
- [b] Black Run button on the toolbar signifying that the VI is in runmode,
- [c] Correct MXP connector terminals—ensure that you are using Connector B and that you have the correct pin connections.

8.3 Interface Theory

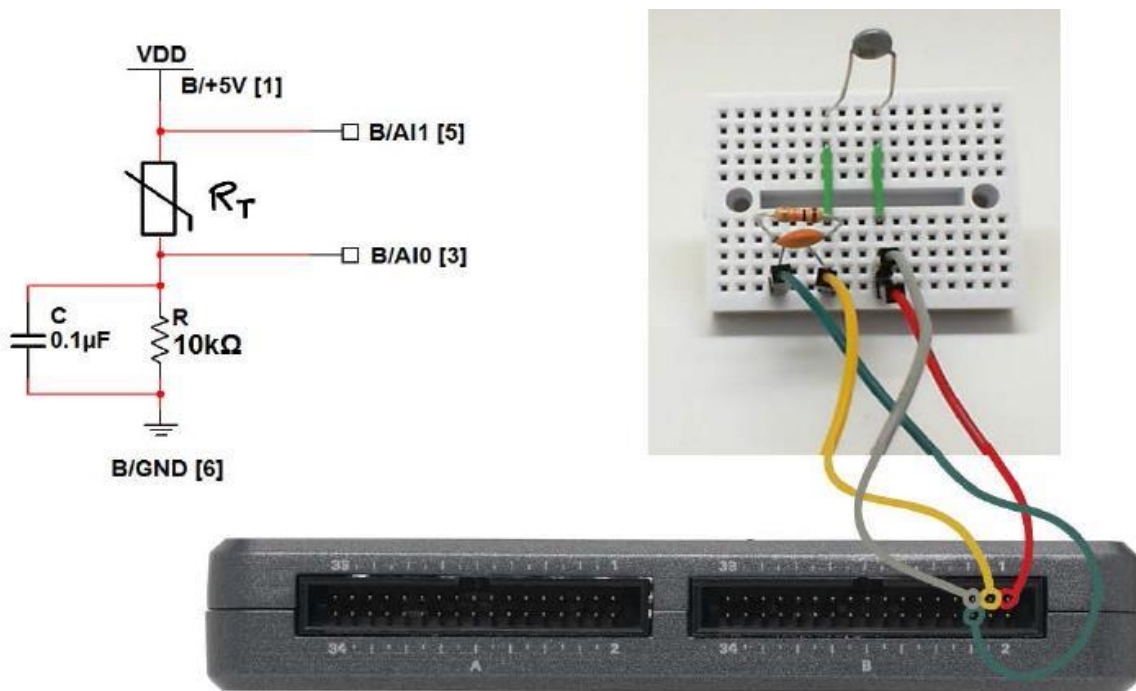


Figure 8-2; Demonstration circuit for thermistor: schematic diagram, recommended breadboard layout, and connection to NImyRIO MXP Connector B.

8.3.1 Interface circuit:

Constructing a voltage divider from a thermistor and a fixed-value resistor offers an effective and easy-to-build interface circuit. Placing the thermistor in the top branch of the divider makes the measured voltage increase with higher temperature.

Study the video *Thermistor Characteristics* (4:54)

<https://www.youtube.com/watch?v=US406sjBUxY&feature=youtu.be>

to learn more about thermistor characteristics and the Steinhart - Hart thermistor equation that converts measured thermistor resistance to temperature in degrees Kelvin.

Study the video *Thermistor Resistance Measurement* (6:10)

<https://www.youtube.com/watch?v=PhZ2QICrwuQ>

to learn how to measure the thermistor resistance with a voltage divider, and also how to size the resistor R for best measurement sensitivity and range. Also take a look at Measure Resistance with a Voltage Divider (9:44)

<https://www.youtube.com/watch?v=9KUVD7RkxNI>

for a more complete treatment of voltage dividers as a measurement technique.

8.3.2 LabVIEW programming:

Study the video *Analog Input Express VI* (2:00)

<https://www.youtube.com/watch?v=N6Mi-VjBlmc>

to learn how to use the *Analog Input Express VI* to measure the voltage divider's primary output as well as the voltage divider supply voltage.

8.4 Basic Modifications

Study the video *Thermistor Demo Walk-Through* (2:28)

<https://www.youtube.com/watch?v=xi0VlpGpf4w>

to learn the design principles of Thermistor demo, and then try making these modifications to the block diagram of Main.vi:

- [a] Add the necessary computation to convert the measured resistance to temperature in degrees Celsius; display the temperature on the large front-panel dial indicator. Use the built-in Vis Mathematics | Elementary | Natural Logarithm and Mathematics | Polynomial | Polynomial Evaluation. Use the polynomial coefficient values presented in the earlier video.
- [b] Modify your temperature display to display in degrees Fahrenheit.
- [c] Create a Boolean indicator to indicate when the measured temperature exceeds (or falls below) a preset threshold.

8.5 Integrated Project Ideas

Now that you know how to use the thermistor consider integrating it with other devices to create a complete system, for example:

- [a] Handheld Meter (Topic 39)
- [b] Wireless Sensor (Topic 40)
- [c] Data Logger (Topic 41)
- [d] Steer By Wire (Topic 43)
- [e] Digital Thermometer (Topic 44)
- [f] On-Off Control System (Topic 51)
- [g] Weather Station (Topic 57)

8.6 For More Information

- [a] Thermistors by National Instruments s thermistor characteristics and the Steinhart-Hart thermistor equation:

<http://zone.ni.com/reference/en-XX/help/370466V-01/measfunds/thermistors>

- [b] NTC Thermistors by Vishay s Learn about thermistor principles of operation, selection criteria, design equations, and example circuits and applications:

<http://www.vishay.com/docs/29053/ntcintro.pdf>

Bibliography:

- [a] www.jinr.ru
- [b] www.ni.com
- [c] www.nica.if.pw.edu.pl
- [d] The Multi-Purpose Detector – MPD to Study Heavy Ion Collisions at NICA; (CDR Conceptual Design Report) Version 1.4; Project leaders: A. N. Sissakian, A. S. Sorin, V. D. Kekelidze.
- [e] http://www.epcos.com/inf/50/db/ntc_09/LeadedDisks_B57164_K164.pdf
- [f] <http://www.avx.com/docs/Catalogs/class3-sc.pdf>
- [g] <http://www.ni.com/academic/myrio/project-guide-vis.zip>
- [h] <https://www.youtube.com/watch?v=US406sjBUxY&feature=youtu.be>
- [i] <https://www.youtube.com/watch?v=PhZ2QlCrwuQ>
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- [m] <http://zone.ni.com/reference/en-XX/help/370466V-01/measfunds/thermistors>
- [n] <http://www.vishay.com/docs/29053/ntcintro.pdf>