

Develop the CPS data acquisition software components

Work objective

Learning how to use a simple temperature transducer, together with a data acquisition board and a **LabVIEW** Virtual Instrument, for making temperature measurements.

Readings

Access the following information sources:

<https://en.wikipedia.org/wiki/Temperature>

A temperature is an objective comparative measure of hot or cold. It is measured by a thermometer, which may work through the bulk behavior of a thermometric material, detection of thermal radiation, or particle kinetic energy. Several scales and units exist for measuring temperature, the most common being Celsius (denoted °C; formerly called centigrade), Fahrenheit (denoted °F), and, especially in science, Kelvin (denoted K).

<http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/temper.html>

<http://scienceworld.wolfram.com/physics/Temperature.html>

Temperature (sometimes called thermodynamic temperature) is a measure of the average kinetic energy of the particles in a system. Adding heat to a system causes its temperature to rise. While there is no maximum theoretically reachable temperature, there is a minimum temperature, known as absolute zero, at which all molecular motion stops. Temperatures are commonly measured in the Kelvin or Celsius scales, with Fahrenheit still in common use in the United States.

<http://zonalandeducation.com/mstm/physics/mechanics/energy/heatAndTemperature/heatAndTemperature.html>

If you measure it in degrees Kelvin, then the temperature value is directly proportional to the average kinetic energy of the molecules in the substance.

<http://www.onlineconversion.com/temperature.htm>

https://en.wikipedia.org/wiki/Temperature_measurement

<https://en.wikipedia.org/wiki/Thermocouple>

<https://en.wikipedia.org/wiki/Thermistor>

https://en.wikipedia.org/wiki/Resistance_temperature_detector

The Measurement System

The temperature transducer which is going to be used is SEN-VRM-05 from RoboFun (<http://www.robofun.ro/>).

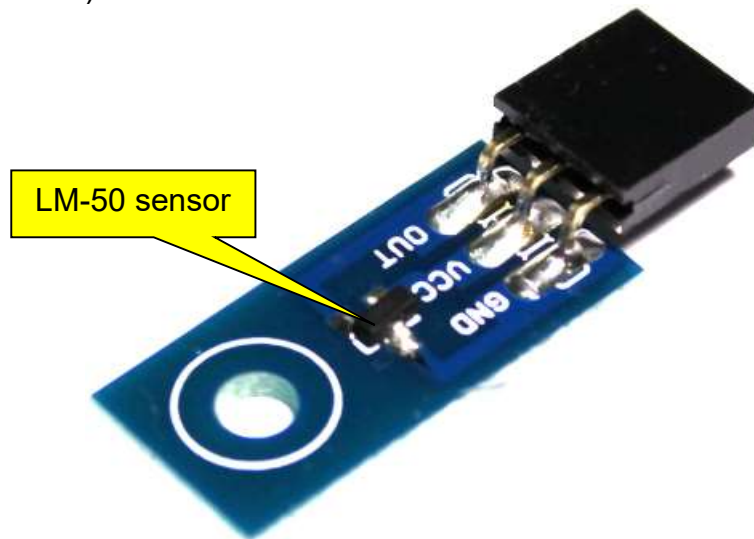


Fig. 4.1: The SEN-VRM-05 temperature transducer

The SEN-VRM-05 transducer is using the **LM-50** integrated circuit temperature sensor (thermistor based) manufactured by Texas Instruments (<http://www.ti.com/>).

As it can be seen in the LM-50's technical datasheet, the sensor is able to measure temperatures between $-40\text{ }^{\circ}\text{C}$ and $+125\text{ }^{\circ}\text{C}$ with an accuracy of around $\pm 3\text{ }^{\circ}\text{C}$.

The LM-50 sensor has three pins, called **VCC**, **OUT** and **GND**.

For operating, a supply voltage between 4.5 V and 10 V has to be provided to the sensor using pins **VCC** and **GND**.

For powering the sensor, the voltage generated by the **USB-6001** data acquisition board between its **5V** and **DGND** terminals on the right connector (see Fig. 2.16) will be used (Fig. 4.2).

The sensor's output voltage can be measured between the **OUT** and **GND** pins.

Because the sensor's supply voltage and output voltage have a common **GND** pin, it means that the output voltage has to be measured using the **RSE** mode and the sensor's **OUT** pin has to be connected to the data acquisition board's **AI 0** terminal (see Fig. 2.2) on the left connector (Fig. 4.3).

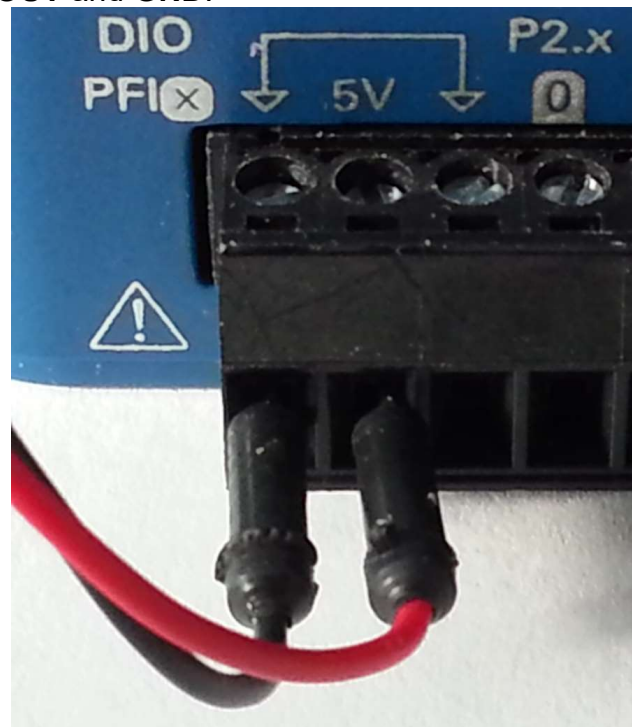


Fig. 4.2: Connections for powering the sensor

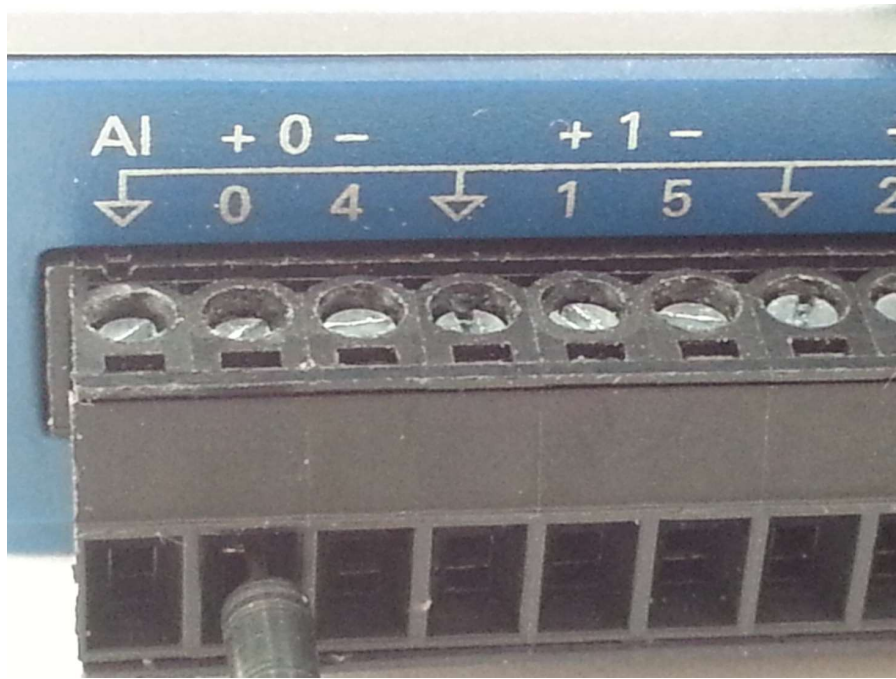


Fig. 4.3: Connection to the AI 0 terminal

- Connect the wires from the sensor to the data acquisition board as seen in Fig. 4.4
- Connect the data acquisition board to one of the computer's USB ports
- Open the **Measurement & Automation Explorer (NI MAX)** software
- Check that the data acquisition board is connected
- Click the **Self-Test** button to check that the board is functioning normally
- Open the **Analog Input** tab of the **Test Panels**
- Set the **RSE** input configuration
- Perform some test measurements using a rate of 1 kHz and reading 100 samples at a time



Fig. 4.4: Connecting the sensor to the data acquisition board

Create a **NI MAX** task called **Lab 4 Temp**, having the **N Samples** acquisition mode and above mentioned parameters.

Run the task in **NI-MAX** to check that is functioning as expected.

Create a **LabVIEW** Virtual Instrument for reading the data.
The Virtual Instrument's front panel may look like in Fig. 4.5.

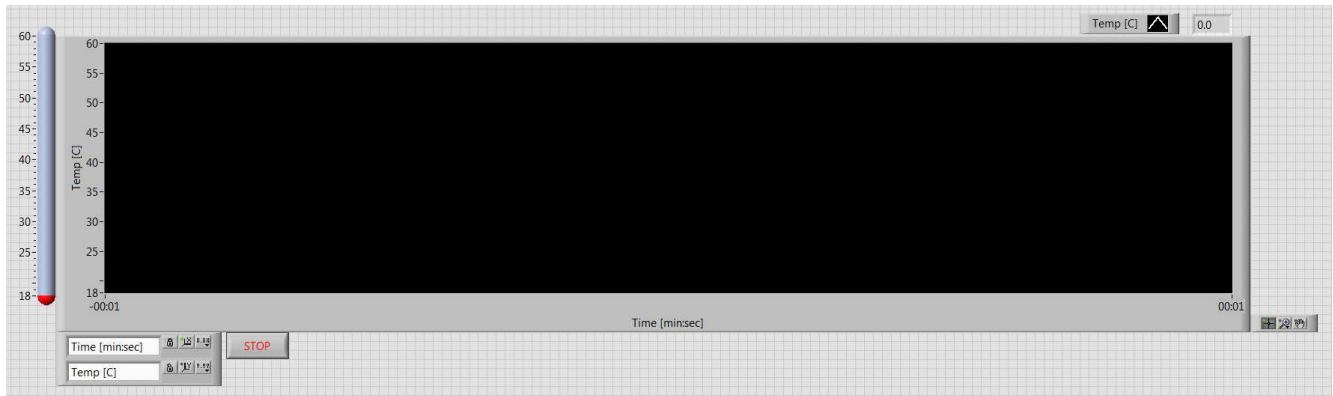


Fig. 4.5: Front panel example

The **Lab 4 Temp** task is not working in the continuous mode, but is reading only 100 samples, so the task may have to be started and then stopped during each iteration of a **While** loop.

Because the temperature is a slow changing parameter, it will be enough if an iteration of the **While** loop will be performed every second and, at each iteration, the mean value of the 100 measured samples will be computed and displayed.

For transforming the value of the measured temperature from Volts to degrees Celsius, find a formula, based on the information found in the LM-50's technical datasheet, using the sensor's DC offset and the range of the ideal output voltages.

Test the Virtual Instrument by measuring the room temperature and comparing the values with those obtained by other teams.

Experimental setup

You will have to use the AC section of the experimental setup from Lab 1 and to determine the temperature variations when measurements are made for different light bulbs (having different powers) and placing the sensor at different distances (e.g. 3 cm and 8 cm) from the light bulb (Fig. 4.6).

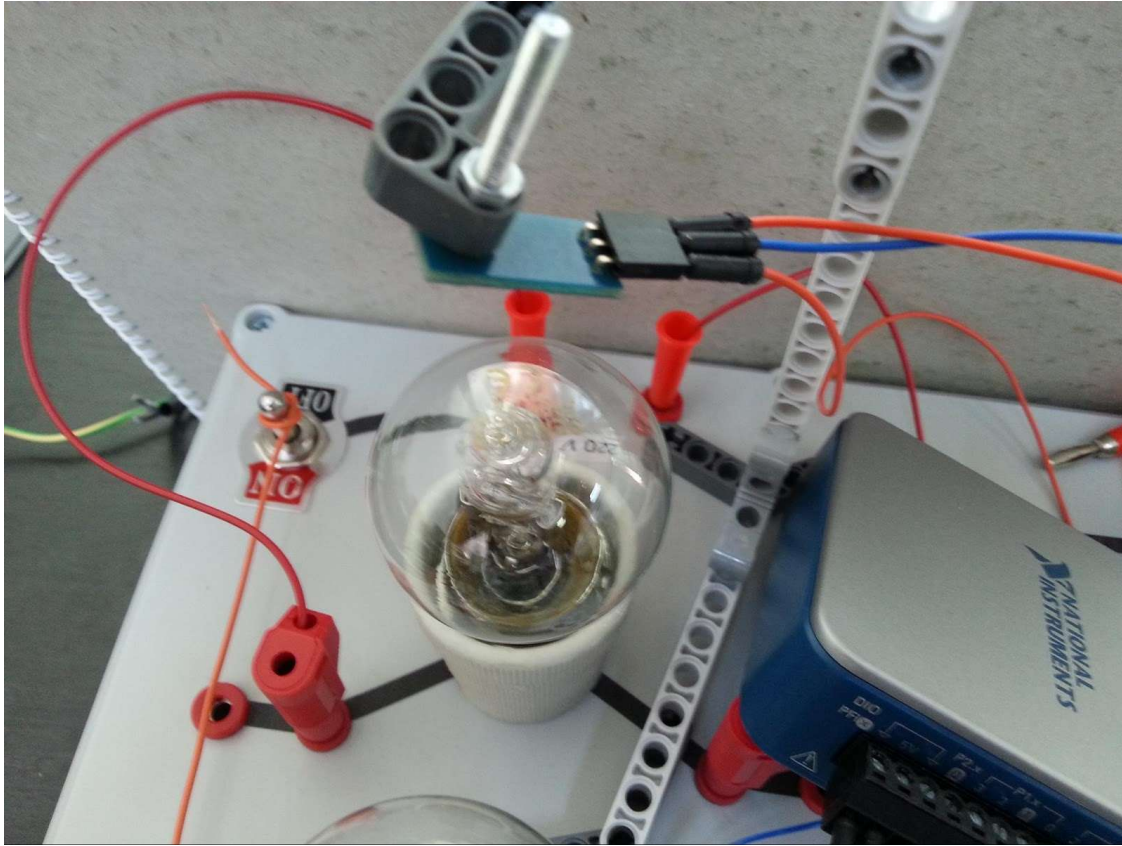


Fig. 4.6: Experimental setup

For each experiment, keep the light bulb turned on until the measured temperature reaches 55 ... 60 °C, then turn the light bulb off and continue measuring until the temperature is going close to the initial value (Fig. 4.7).

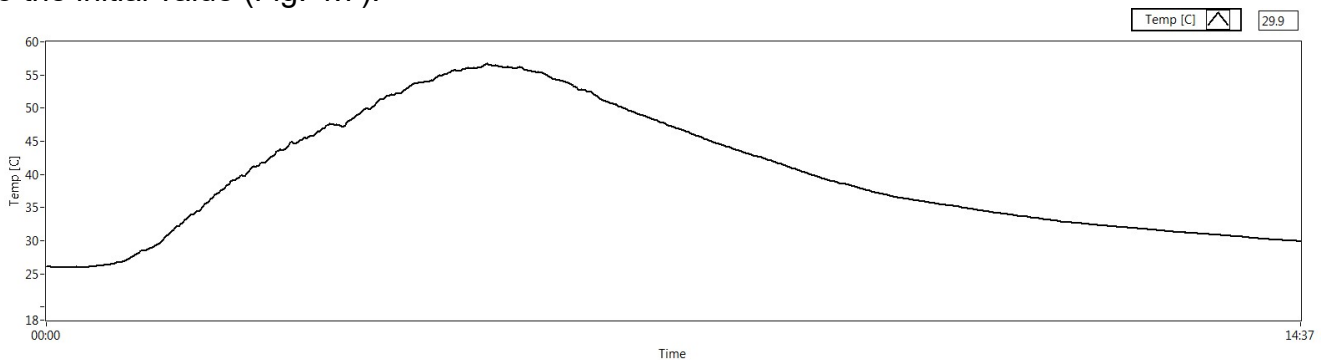


Fig. 4.7: Temperature variation example

Compare the heating speed and the cooling speed (or heating and cooling time) from each experiment and explain the results.