Module 2, Lesson 1 – Connecting a thermistor to the NXT computer

Student

Purpose of this lesson

- Connect a thermistor to an NXT computer.

- Compare the circuitry inside the NXT which allows it to measure voltages.

- Use circuit equations to predict how NXT measurements will vary with temperature.

Materials

Copy of the lesson

1 NXT

1 NXT connector cable

1 Thermistor

Hook up wire

1 Soldering iron

Solder

Graph paper (or Excel)

Procedure
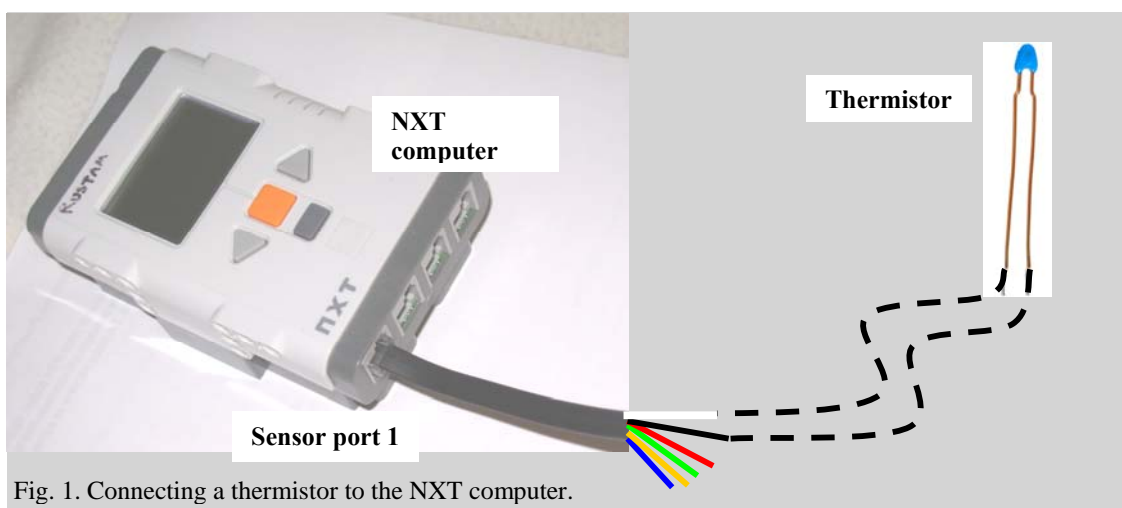
Connecting a thermistor to the NXT computer

Fig. 1. Connecting a thermistor to the NXT computer.

1) Cut an NXT connector cable in half (or obtain a half cable from your teacher).

2) Find the black and white wires, strip them carefully and solder them to the wires leading to your thermistor.

3) *Once you have completed the soldering*, you can then plug the connector cable into sensor port 1 on the NXT (see fig. 1). **Do not solder the wire while it is still connected to the NXT – the internal circuits could be damaged by heat.**

How does an NXT measure voltage?

When you connect a thermistor across the terminals of the NXT computer, you are forming almost the same circuit previously built with the resistor and the multimeter (see module 1, lessons 3, 4 and 5). The differences are:

▪ Previously you used a 9V battery, but inside the NXT there is the equivalent of a 5V battery.

▪ Previously you put the multimeter across the resistor in the potential divider circuit, but inside the NXT there is a voltmeter that will be measuring the voltage across your thermistor.
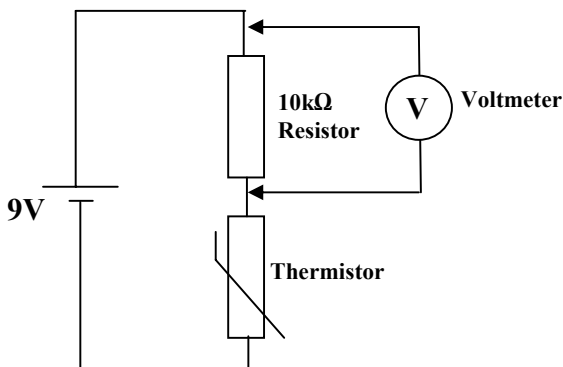
Your previous circuit looked like this:

NXT circuit is like this:

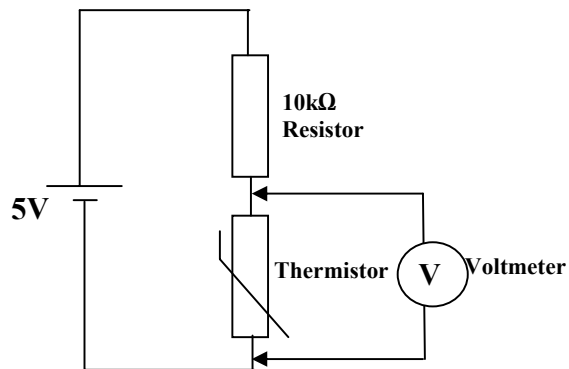Fig. 2a. Temperature sensor circuit from module 1.

Fig. 2b. Internal circuit of NXT when connected to an external thermistor.

The NXT circuit doesn't *look* like the diagram because the 5V battery, the 10kΩ resistor and the voltmeter are all hidden inside the NXT, see fig. 3 on the next page:
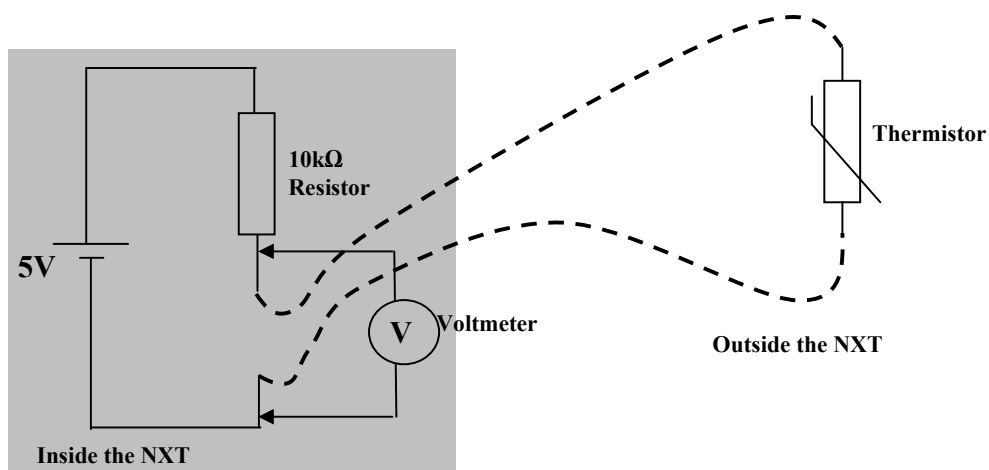
Fig. 3. Internal circuitry of the NXT (shown in grey box), connected to an external thermistor. *Note that this is EXACTLY the same circuit as fig. 2b. If you don't understand this, ask your teacher.*

The voltmeter inside the NXT can pass a number, which represents the voltage, to a program which is running on the NXT. **You will write this program yourself in the next lesson!**

The voltage measured by the NXT is given by the potential divider equation:

$$V_{NXT} = \frac{R_T}{(10000\Omega + R_T)} \times 5 \qquad \textbf{equation 1}$$

(see module 1, lessons 4 and 5) , where R_T is the resistance of the thermistor.

Assessment 1

Use equation 1 and your graph for temperature versus resistance for the thermistor (i.e. temperature versus R_T (expressed in Ω), **which you created in module 1, lesson 3**), to plot a graph which predicts what voltages will be measured by the NXT at different temperatures (i.e. V_{NXT} versus temperature).

Temperature °C	0	10	20	30	40	50	60	70	80
Copy resistance values from Module 1, Lesson 3									
Resistance (kΩ)									
Convert kΩ to Ω by multiplying by 1000									
Resistance (Ω)									
V_{NXT} (V)									

Assessment 2 - Units of measurement

a) The voltmeter inside the NXT outputs "raw" numbers from 0 to 1023, to represent voltages from 0 to 5V. Hence, for every one volt on the above graph, the NXT will read 1023/5 = about 205 units. Using this information, now plot another graph to predict what the "raw numbers" will be, from 0-1023, as measured by the NXT voltmeter, versus temperature.

b) Approximately, what is the range of "raw" NXT numbers that spans the range of temperatures that you expect to measure in the environment (say from 0 - 40°C).

c) The NXT's internal voltmeter can only output *integers*, i.e. it can only handle distinct whole numbers without any fractions or decimals (in the range 0 – 1023). How many such distinct intervals can be output by the NXT's internal voltmeter over the temperature range of 0 - 40°C? Hence, what is the best *resolution* that can be attainable by a temperature measuring system that is built using your thermistor and an NXT? Remember, that by *resolution* of a sensor, we mean the smallest difference between two temperatures that can be distinguished or measured by the sensor.