LabView in instrumentation (55492), Fall 2011

Thermostat exercise

In this exercise you will make electrical connections and a VI that controls the temperature of a small heater by using National Instruments multifunction IO device USB-6008. Please notice, that USB-6211 can not be used in this work, because it has low current supply capability. You should make a thermostat which asks a setpoint value from the user and keeps the temperature near to that value. You should also show the current temperature to the user.

Please be extremely careful with electric connections. Wrong connections may permanently damage the electronic circuits used in this work. Read this paper entirely before any connections.

Heater controller

Heater is a small resistor which is glued to a semiconductor temperature sensor (LM 35). Controller adjusts voltage level suitable to the sensor and controls heater current with a transistor. Led shows when the heater is on. Heater takes about 100 mA, which is well within USB 6008 IO device's capabilities, but too much for USB 6211. So make sure that you use USB-6008 in this work. 0.5 W heating power is enough to raise the temperature about 10-15 ºC above the room temperature. LM35 gives a voltage proportional to the temperature. Factor is 10 mV/ºC and zero point is 0 ºC.

Heater controller has the following electric connections:

V_{cc}
+ 5V power supply. Use IO device's 5V supply line.

GND
Ground. Connect this to IO device's GND.

Temp+
Analog temperature signal, positive. Connect this to IO device's positive analog input.

Temp-
Analog temperature signal, negative. Connect this to IO device's negative analog input.

Heater
Digital input. Logic 1 (+5 V) turns on the heater.

IO device

In this work you use National Instrument's NI USB-6008 Multifunction IO device. The details of this unit can be found in manual, which can be downloaded from the manufacturer's webpages. This versatile IO device has many interesting functions: AD-converters, DA-converters, digital IO-lines, counter etc.

On-off controller

In this work you should build a simple on-off controller with hysteresis. Hysteresis prevents repetitive transients near the setpoint. It is important in many applications, for example where switching causes wear (mechanical contactors) or causes electromagnetic noise (high powered systems). On-off controller works so, that when temperature increases above the upper limit (setpoint + ½*hysteresis) controller turns the heater off. Then system starts to cool and when temperature decreases below the lower limit (setpoint – ½*hysteresis) the heater is turned on.

This kind of a controller is commonly used in practical thermostats (in buildings, cars, refrigerators, etc.). It is cheap and it can be implemented in many ways, for example mechanically without electricity. Obviously it is not very accurate. In such situations for example a PID controller can be used.

Building a VI

Your VI should ask the setpoint and hysteresis from the user. User must be able to set the heater manually on, off and in automatic on-off controlled mode. Temperature must be shown to user (for example the thermometer in LabView). You can communicate with the IO device by using the NI-DAQ Assistants.

Practical advice

You can start from the user interface. Think what kind of controls and indicators you need. Then build the necessary logic to control the heater. Read the IO device's manual and select electric connections you need. Find out the correct terminals and connect the controller to the IO device. Be extremely careful with connections, wrong connections may damage electronics. Do not hesitate to ask, if you are not absolutely sure.

Temperature sensor gives quite a low output voltage. Select the differential input range which is low enough to give the best possible resolution (-1 - +1 V). 1-4 Hz reading rate should be

enough but it is a good idea to reduce the noise by using higher sampling rate and averaging few tens of samples.

You can start experiments with a setpoint value about 5 ºC above room temperature and hysteresis 0.5-2 ºC. You can also warm the temperature sensor with your fingers to test reading part of the VI. The sensor is a black component which is glued to a resistor on the opposite end of circuit board than cables.

Always remember the safety when you work with electronics. Think everything twice, check everything twice and connect only once, in the right way. Do not hesitate to ask help or confirmation from assistant. There is no risk for personal injuries with these low voltages and currents but unfortunately, it is practically impossible to make electronics to withstand any possible errors in connections.