Technical University of Denmark

31342 Introduction to Programmable Logic Controllers

Exercise 8

Serial

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Instructor:

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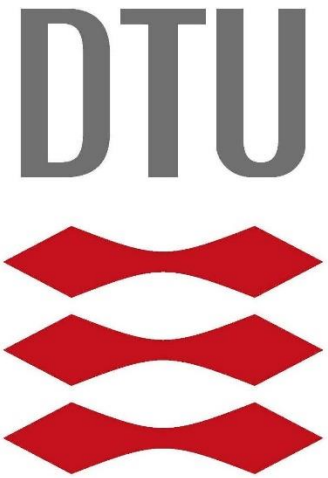

Spring, April 26, 2019

Part 1: Reading the Version of the Arduino:

The version of the arduino is read by sending V (86 as byte) command via a COM_SEND function block and receiving via a COM_REC function block. It can be seen that the version of the arduino is v2.5.

Part 2: Control of the Room Light:

The control of the room light is achieved by reading and storing in a byte array named *light* the status of the light at every 0.2 second. (the enables of the sending and receiving function blocks will be explained in the next part.) The 2nd element of *light* array contains the actual status of the light. 48 means the light is off; 49 means the light is on. The assignment of the green light on the control box is done by using EXTRACT function block that outputs the desired bit in a byte. The implementation is shown in the Figure 1.

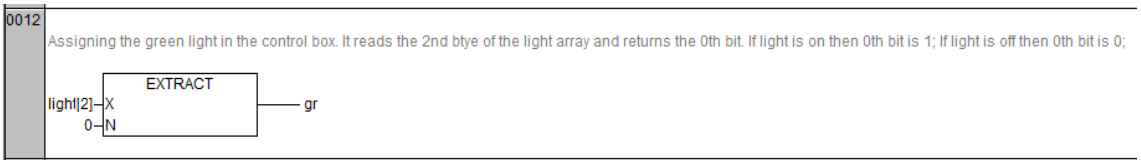

Figure 1: The assignment of the green light in the control box

The control of the light is done by sending A (65 as byte) to turn on and B (66 as byte) to turn off. The switch one on the control box is assigned to these COM_SEND function blocks enable. The implementation is shown in the Figure 2.

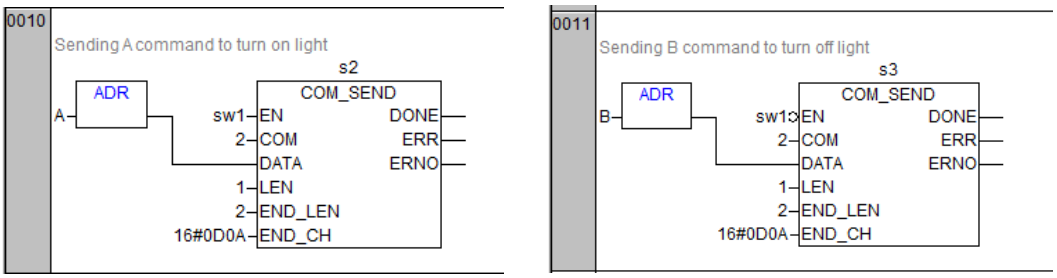

Figure 2: Sending the commands to control the light

Part 3: Control of the Heater:

In order to control the heater and light in the room at the same time, the commands corresponding to each response of the arduino should be sent and read at different times since sending and reading more than one command at the same time are not possible. The requirement of sending at different times is accomplished via the enables of COM_SEND and COM_REC function blocks for reading the temperature, the status of light and heater. The enables are assigned in a way that only one of them is true for 0.1 second of the period of 0.3 second.

The implementation is done by the following:

- There is a master timer (t7) that indicates the period of 0.3 second. It resets t1 and t3 at every 0.3 second.
- There are 2 timer sets that assign the enables for COM_SEND and COM_REC function blocks for reading the temperature (entemp), the status of light (enlight). The setup for enlight is the same as the one described in the lecture. On the other hand, the setup for entemp is delayed by 0.1 second.
- The assignment of the last enable (enheat) is done by using NOR gate with the inputs entemp and enlight since it outputs true when both of its inputs are false.

The implementation of assignments of the enables is shown in the Figure 3. (ignore the timer t6 for this part.)

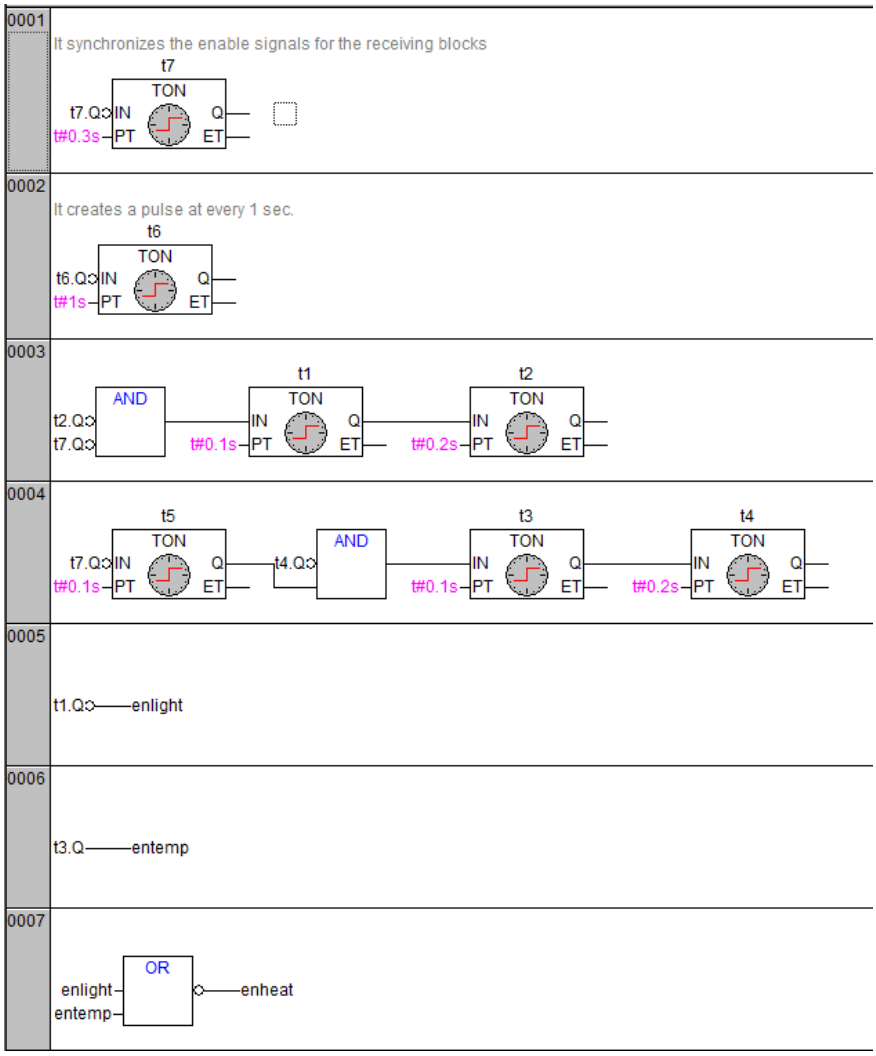

Figure 3: Assignments of the enables of COM_SEND and COM_REC function blocks for temperature, light and heater

The trace that displays the patterns of the enables is shown in the Figure 4.

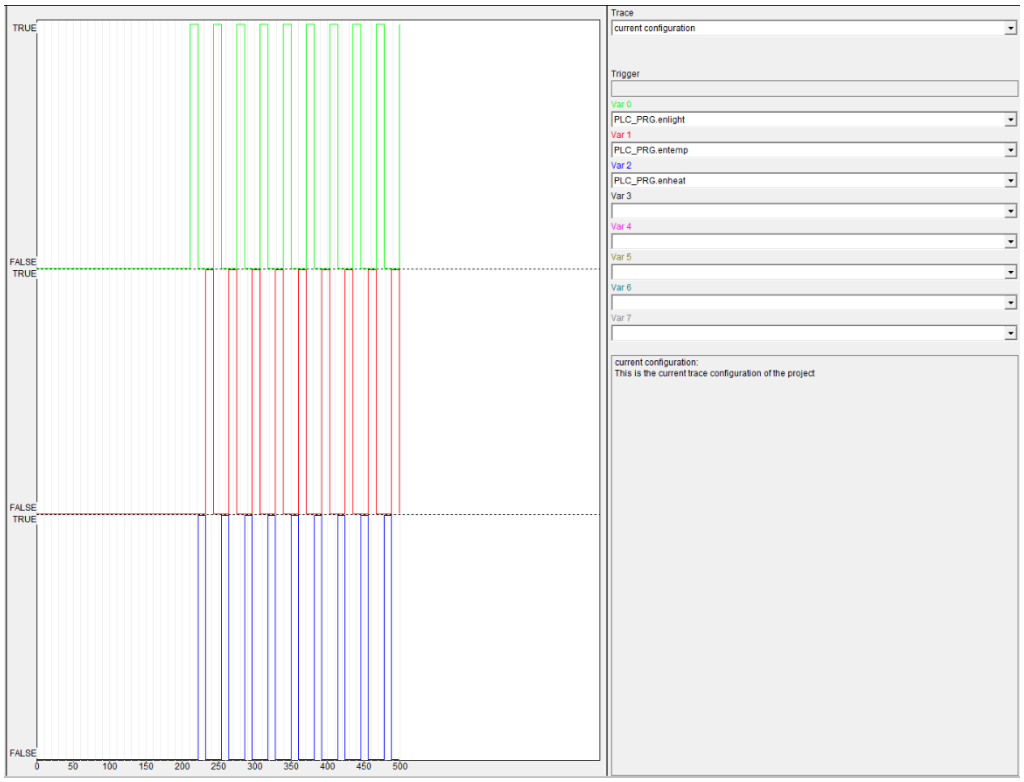

Figure 4: The enables of COM_SEND and COM_REC function blocks for temperature, light and heater

The temperature is multiplied by 10 to be able to store as an integer. The implementation is shown in the Figure 5.

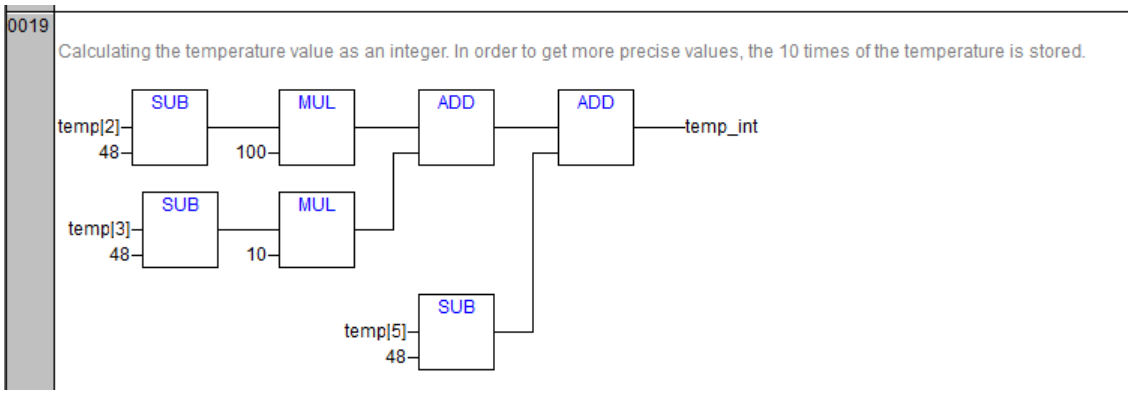

Figure 5: The storage of the temperature

The control of the heater is achieved by using LE and GE function blocks. And sending the commands is done when enheat is true in order not to disturb the temperature and light status reading process. The implementation and sending commands are shown in the Figure 6.

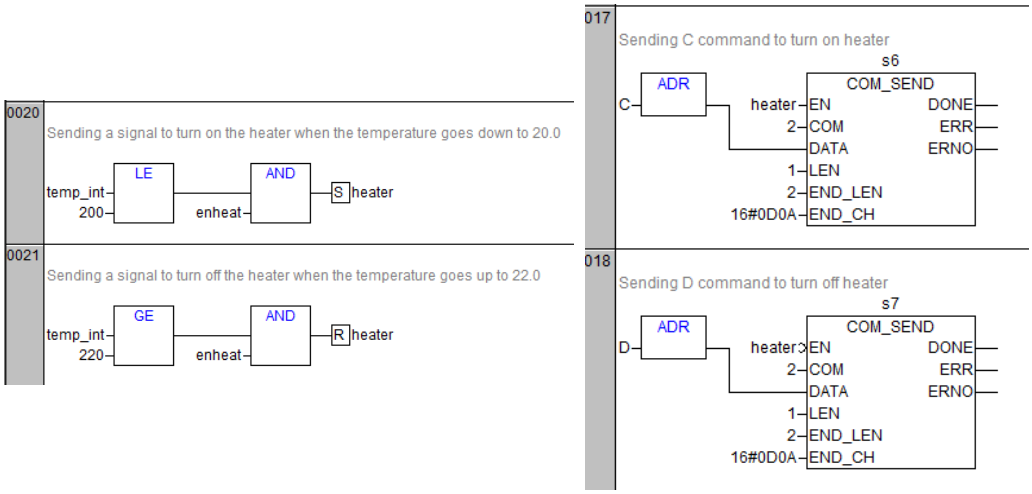

Figure 6: The control of the heater

Part 4: Calculation of the Rate of Temperature Change:

The temperature values can also be stored by using Binary Coded Decimal (BCD) format. In order to store as a BCD, only the integer part of the temperature values is considered. And the function block INT_TO_BCD is used to keep the values as BCD. The implementation is shown in the Figure 7.

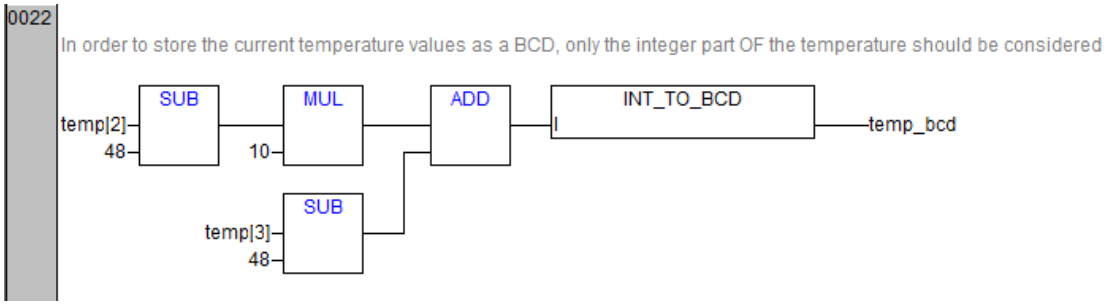

Figure 7: The storage of the current temperature values as BCD

The rate of change in °C per second is calculated as following:

- The temperature value from one second before is stored in last_temp_int.
- The rate of change in °C per second is $\frac{(temp\_int - last\_temp\_int)}{1\ second}$

Note: Since temp_int and last_temp_int contain the value of temperature multiplied by 10, the unit of the rate of change is 10°C per second. In order to correct this issue, the rate of change should be divided by 10.

The implementation of the calculation of the rate of change in temperature is shown in the Figure 8.

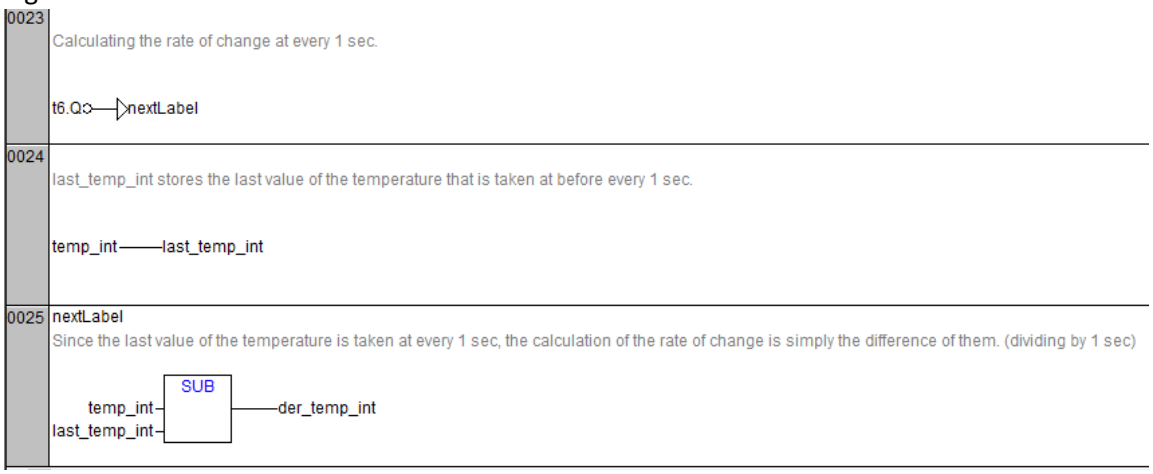

Figure 8: The calculation of the rate of change in temperature

Via the help of jump used in the label 0023 which ensures that last_temp_int is assigned at every 1 second.

Part 5: Display of Temperature and Temperature Rate:

Some example of traces that display the temperature and the temperature rate of change are shown in the Figure 9.

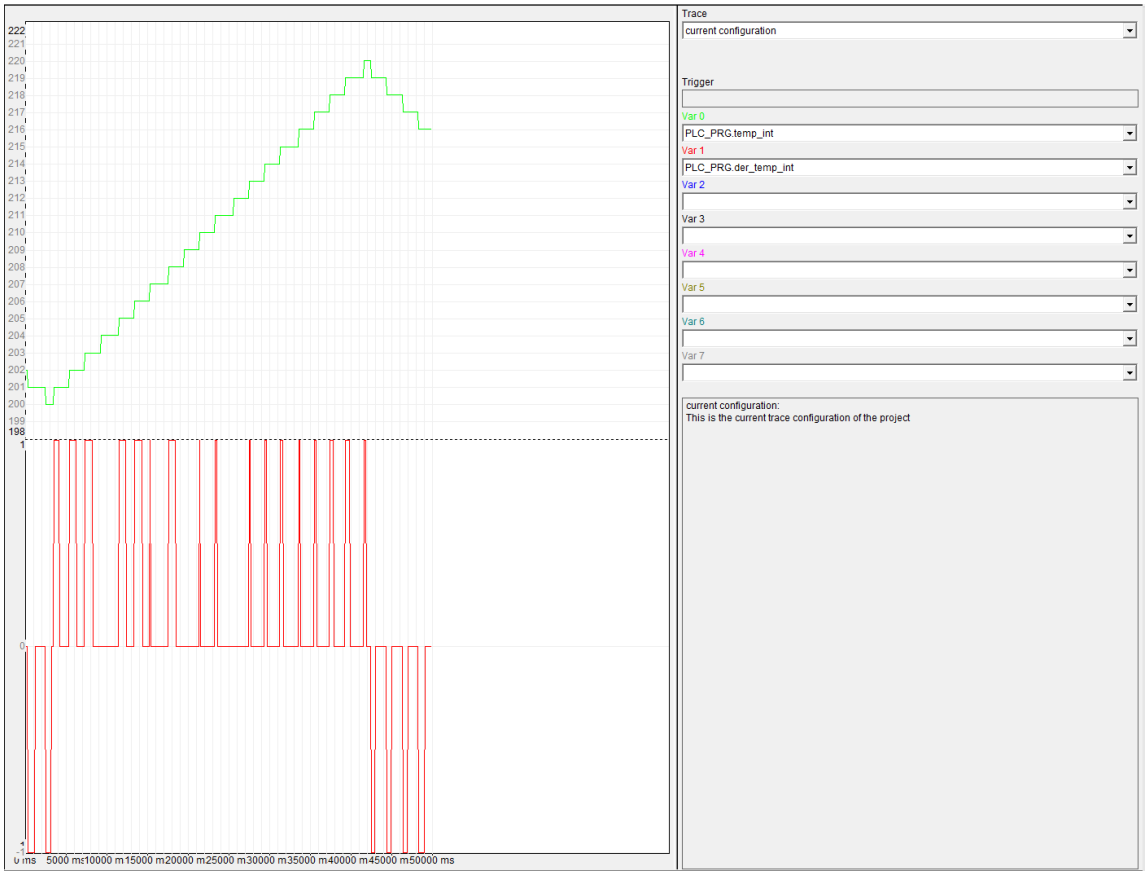

Figure 9.a: 1st example of trace that display the temperature and the temperature rate of change

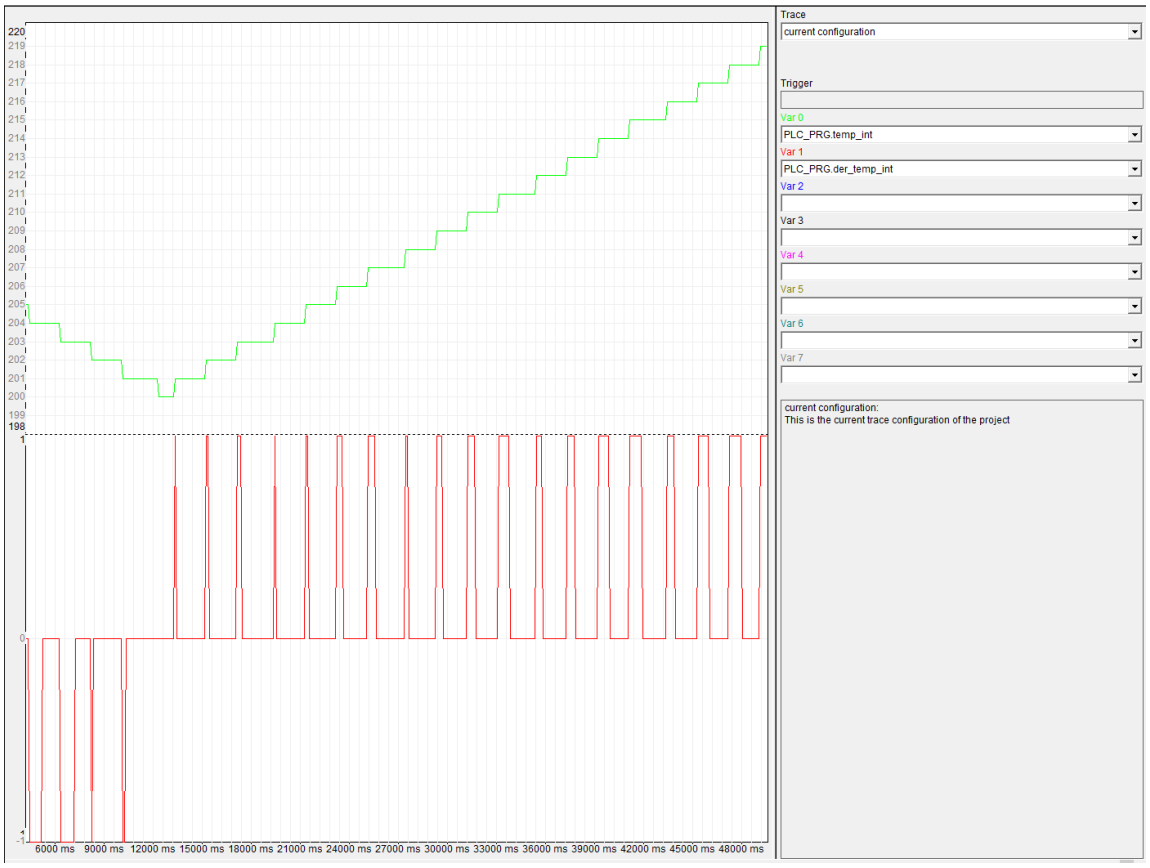

Figure 9.b: 2nd example of trace that display the temperature and the temperature rate of change

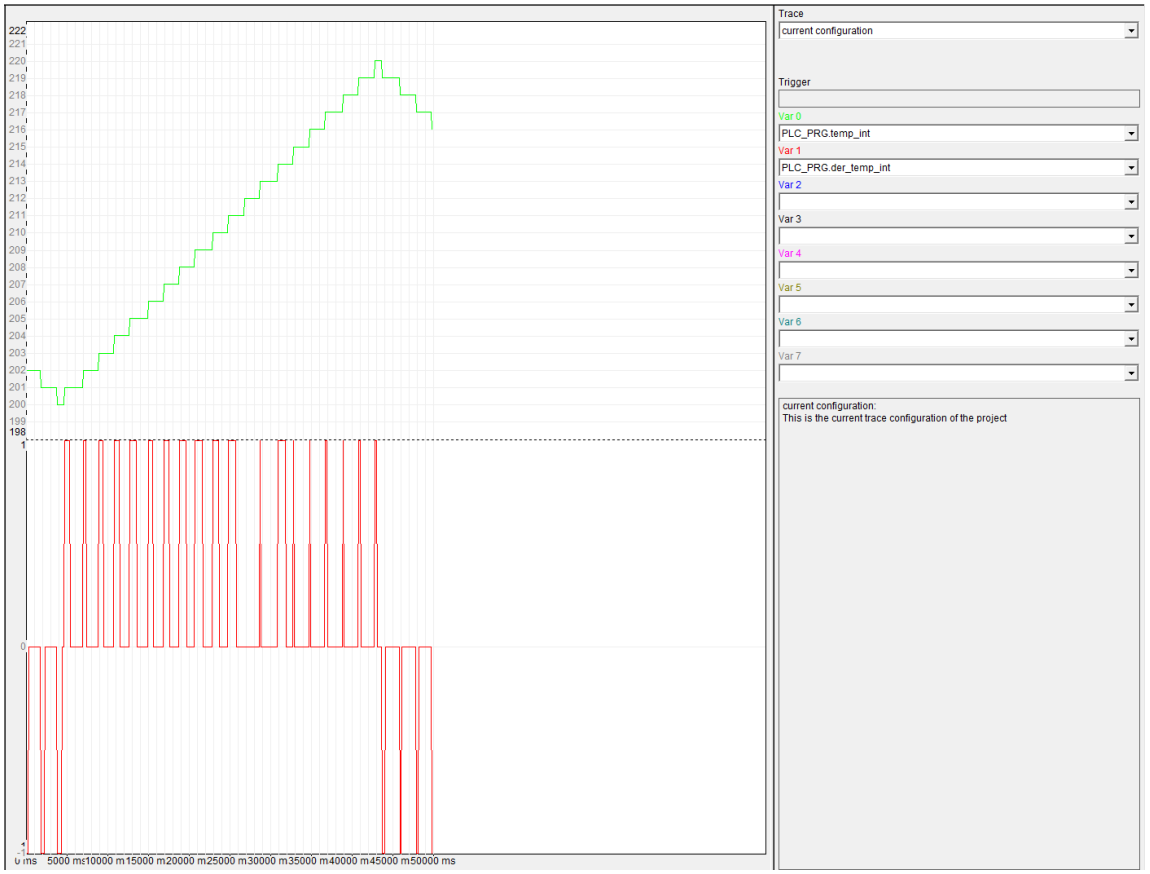

Figure 9.c: 3rd example of trace that display the temperature and the temperature rate of change

Note: The graphs represent the current values multiplied by 10. To get the correct values, the actual values should be divided by 10.

It can be seen from the traces that the change in the temperature occurs discrete not continuous since it is not possible to read the temperature values from the arduino continuously; there should be a discrete time manner. However, using some external code, these graphs can be approximated to continuous curves.

Part 6: Control of the Temperature to be exactly 21 °C:

The controlling the temperature to be at exactly 21°C can be achieved by the following implementation that is shown in the Figure 10.

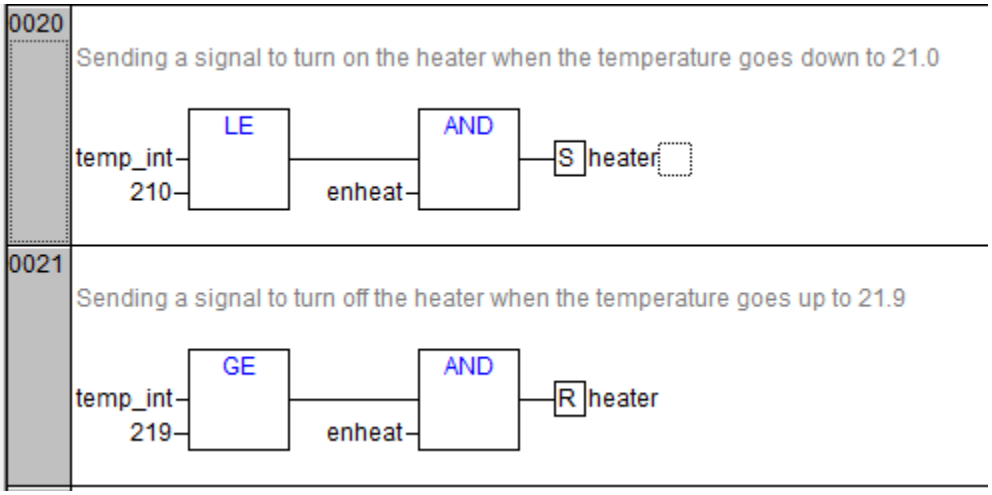

Figure 10: The control of the temperature at 21°C

An improvement with respect to the time that takes to reach the set point (21°C in this case) for the temperature control system can be achieved by adding extra heaters to the room; in this way, the room temperature would increase more rapidly.