Industrial Automation – Spring 2025

Dr. Philipp Sommer
philipp.sommer@epfl.ch

Dr. Jean-Charles Tournier
jean-charles.tournier@epfl.ch

Exercise Sheet: Week 2 (Solution)

Question 1

A PID-controller is used for controlling the heating of a batch in a chemical reactor to the operating temperature. The batch is always too cold when it is poured into the reactor and only heating is applied. However, the colder the batch is when the heating is started, the higher the final temperature goes. What is probably causing this problem? Explain the mechanism and suggest solutions both for the cases that the controller design can and cannot be modified.

Hint: Consider the table on Slide 32

The process experiences an overshoot (probably due to the integral term responding to accumulated errors from the past). If the controller can be modified one could add a derivative term or the integrator value could be limited. If the controller can't be modified, we can make the integral rising action slower (decreasing T_i) and thus reduce the overshoot. Another option is to increase the heating power so that the control signal never reaches the limit. This approach is probably costly, but might give a better behaviour of the process.

Question 2

A sensitive liquid flow is heated by an inductive heater in a section of the tube where it is flowing. The disturbance from the current in the heater makes it impossible to place a temperature sensor close to the heating point. Instead, the sensor is placed a significant bit downstream (approx. 5m). Now it becomes difficult to control the temperature with the intended PID-controller. What is the problem? How can you solve it? Suggest as many possible methods as you can think of. The flow is constant and will not change.

Since there is a significant delay introduced between control action and the measurement of the temperature the control becomes difficult. This could be handled by very moderate parameters in the tuning of the PID-controller, but this is often not an acceptable method since the control quality is bad. To use a more complex controller where we use a model for the heating process that can be used to predict the reaction is one option (advanced control). A practical modification of the process might also be possible. If the pressure conditions allow it, one could use a thinner tube between the heater and the sensor. In this case the speed of the liquid becomes higher with a smaller cross-section and the delay is reduced.

Question 3

You are asked to select the components of the automation system for an elevator in a residential building with 5 floors.

a) What sensors & actuators do you need?

Note: This is a simplified example, a real elevator system is more complex.

Sensors:

- *Optical sensor to detect if there is an obstacle between the door.*

- *Button on each floor to place a request for the elevator.*
- *Buttons inside the elevator to select the desired floor, close/open door and emergency stop/alarm.*
- *Optical/electrical sensors to detect the position of the elevator.*

Actuators:

- *Electrical motor to raise/lower the cables attached to the cabin and counterweight.*
- *Electrical motor to open/close the elevator door.*
- *Relay to switch on/off the light in the cabin.*
- *Visual indicator to acknowledge the request for the elevator.*

b) What type of PLC would you use for this application?

Compact PLCs are optimized for size and costs. The exact model can be chosen to match the number of floors in the building. It is unlikely that additional sensors/actuators will be connected during the lifetime of the system, therefore modularity is not really needed here.

c) Can you estimate the number of input & output signals that need to be connected to the PLC?

Input signals:

- *1 button per floor*
- *1 position indicator per floor*
- *1 optical sensor for the door*
- *1 button per floor on the user panel + open/close door buttons, emergency button*

Output signals:

- *Motor control signal (on/off) or signal for variable speed drive*
- *Signal to open/close the door*
- *Light inside the cabin*
- *Visual indicators inside the cabin*
- *Visual indicator at each floor*

Assuming the building has x floors, we can calculate the number of input/output signals as follows:

Inputs: $x + x + 1 + x + 2 + 1 = 3^*x + 4$

Outputs: $1 + 1 + 1 + x + x = 2^*x + 3$

For a building with 5 floors, we have 19 inputs and 13 output signals.