MBSD Lab #2

Purposes

- Design a tank level control system.
- Validate the control system using the physical model of the tank.

The controller aims at regulating with an on/off logic the liquid level inside a tank. The maximum level of the tank is 200 cm.

Two different pumps can fill the tank:

- High Flow Pump (HFP), capable of a flow equivalent to 3 cm/s;
- Low Flow Pump (LFP), capable of a flow equivalent to 1 cm/s;

The liquid in the tank is used by a process that requires a minimum flow of 0,5 cm^3/s (equivalent to 0,25 cm/s, and linearly mapped, i.e., 2 cm^3/s are equal to 1 cm/s), and a maximum flow of 1 cm^3/s. The flow is measured by a flow meter.

Moreover, the controller shall implement (in a parallel manner, independent from the decision[1]) a plausibility check to determine if the pumps are working correctly (for example, with a flow to the plant of 0,5 cm^3/s and the LFP on, the level in the tank should increase at a rate of 0,75 cm/s).

The plant model receives as inputs:

- The liquid flow from the pumps to the tank (in cm/s);
- The liquid flow to the process (in cm^3/s);

And provides as output:

- The level (in cm);
- An error if the quantity/level becomes negative or over the 200 cm (400 cm^3).

The Simulink project has to be split into 3 files:

- **Harness.slx**, containing reference models for the controller and plant and test stimuli generation
- **Controller.slx**, containing the controller (to be developed)
- **Plant.slx**, containing the physical model.

Templates of these files are available alongside this document.

The deliverable has to be provided as a .ZIP file up to **April 15th at 19:00.** It shall also contain a brief report explaining the design of the controller, using the following template.

[1] The best option is to implement it in the same Stateflow chart as two parallel states.

Tank level control algorithm description

The purpose of the item is to control the level of a tank and to check if the pumps are working properly.

This software unit shall be implemented as a periodic task with a period of 100 ms (10 Hz)

The purpose of the controller is to keep the level l at 180 cm, using the LFP if the level is between 180 and 150 cm, and the HLP in the case the level is below 150 cm.
Due to this limitation, it is better to define the control law as a hysteresis cycle with different thresholds for the ON and OFF conditions of the two pumps.
When the level is decreasing $\dot{l} = \frac{dl}{dt} < 0$:

$$\begin{cases} l < 175 \rightarrow HFP\ off\ AND\ LFP\ on \\ l < 150 \rightarrow HFP\ on\ AND\ LFP\ off \end{cases}$$

While, when the level is increasing $\dot{l} = \frac{dl}{dt} > 0$:

$$\begin{cases} l > 180 \rightarrow HFP\ off\ AND\ LFP\ off \\ l > 155 \rightarrow HFP\ off\ AND\ LFP\ on \end{cases}$$

The two pumps cannot be turned on at the same time.

External physical interfaces

Name	Direction	Type
`Level_cm`	Input	Analog
`Out_Flow_m`^{3}`/s`	Input	Analog
`Error_DO`	Output	Discrete
`LFP_DO`	Output	Discrete
`HFP_DO`	Output	Discrete

Description of the whole system

Draw the I/O block diagram of the plant and of the controller, showing how they interact to each other.

Draw the Finite State Machine (FSM) representing the on/off control logic

Draw the FSM representing the plausibility check on the level behavior.

Controller SW Unit specifications

Provide a brief description of the Controller functionalities and its interfaces.

Interfaces

Name	Unit*	Type	Data Type	Dimension	Min	Max