Model-Based Software Design

Laboratory 2 Report

Components of the working group (max 2 people)

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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 $\dot{l} = \frac{dl}{dt} < 0$

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

While, when the level is increasing

$$\dot{l} = \frac{dl}{dt} < 0$$

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

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

External physical interfaces

Name	Direction	Type
Level_cm	Input	Analog
Out_Flow_m³/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.

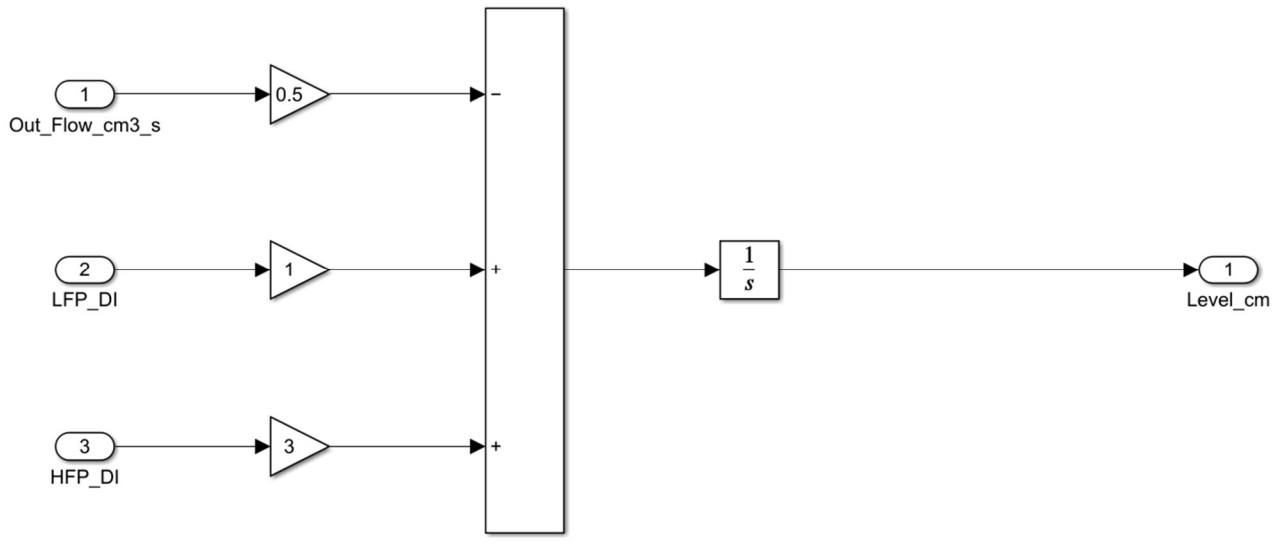

Figure 1: Plant of the system

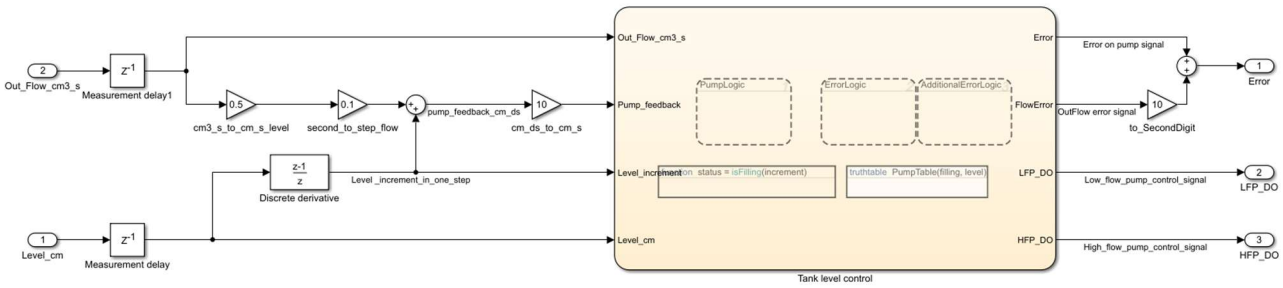

Figure 2: Controller of the system

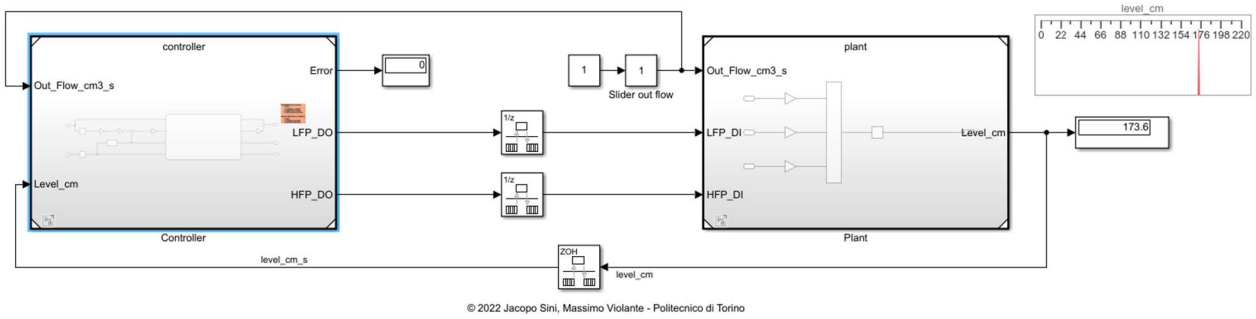

Figure 3: interaction between Plant and Controller

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

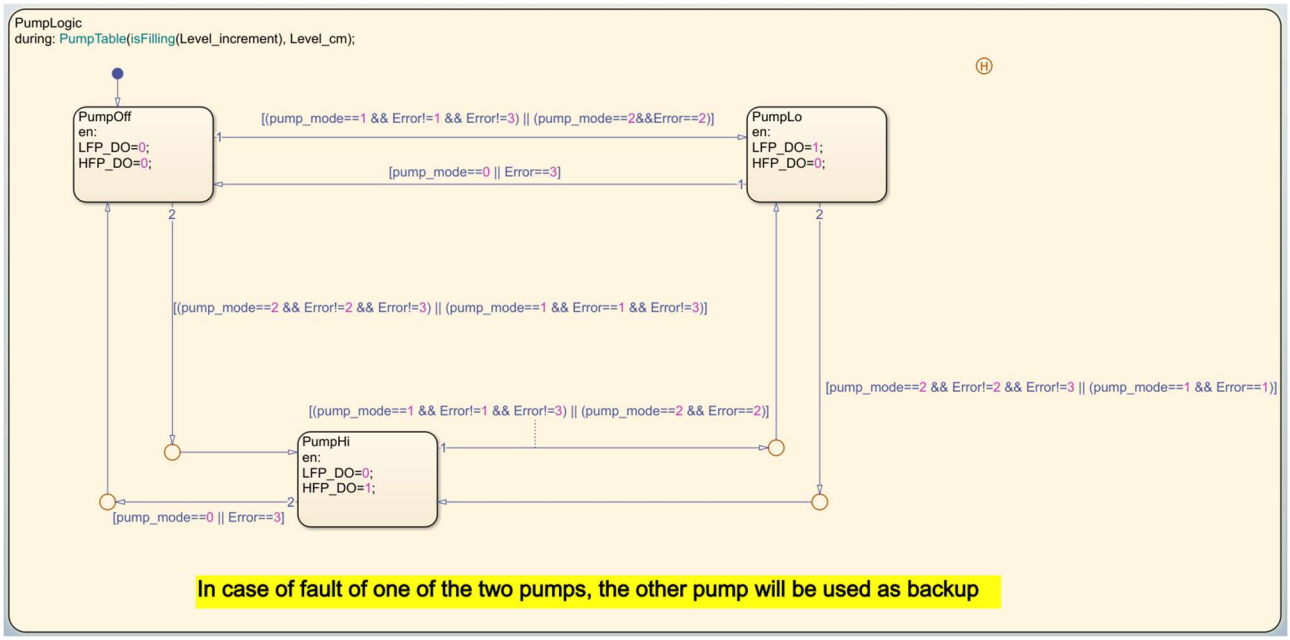

Figure 4: PumpLogic

Condition Table

	DESCRIPTION	CONDITION	D1	D2	D3	D4	D5
1	The level is increasing	filling == 1	F	F	T	T	-
2	The level is below 150cm	level < 150	T	F	-	-	-
3	The level is below 175cm	level < 175	-	T	-	-	-
4	The level is over 180cm	level > 180	-	-	F	T	-
5	The level is over 155cm	level > 155	-	-	T	-	-
		ACTIONS: SPECIFY A ROW FROM THE ACTION TABLE	A3	A2	A2	A1	A4

Action Table

	DESCRIPTION	ACTION
1	Pumps off	A1: pump_mode = 0;
2	Low pump on High pump off	A2: pump_mode = 1;
3	Low pump off High pump on	A3: pump_mode = 2;
4	Pump mode remain inalterate	A4: pump_mode = pump_mo

Figure 5: Truth and action tables of PumpMode

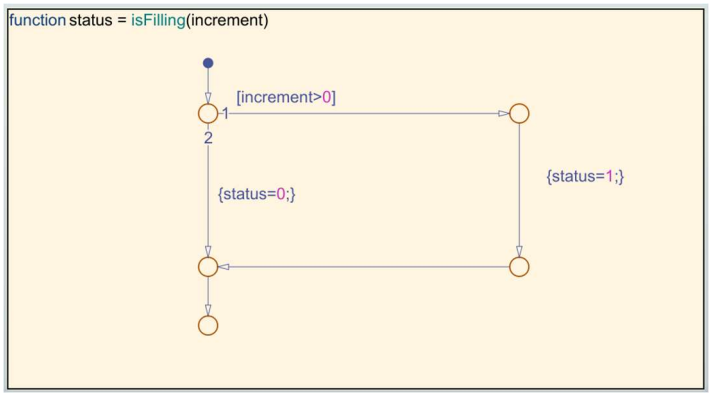

Figure 6: isFilling function

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

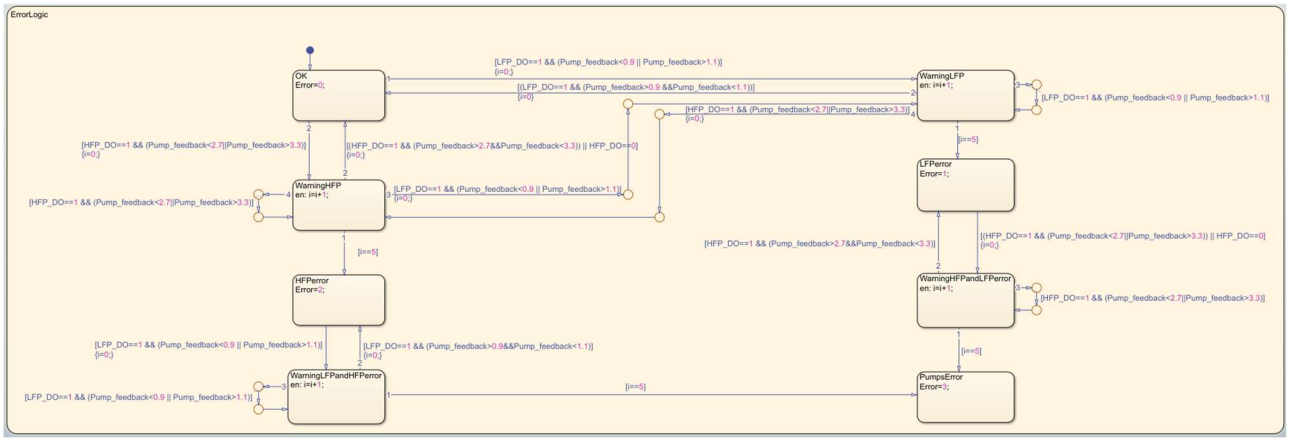

Figure 7: ErrorLogic with plausibility check

Controller SW Unit specifications

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

The controller receives as input:

- *Level_cm*: represent the current level of the tank expressed in cm;
- *Out_Flow_cm3_s*: represent the instantaneous outflow expressed in cm^3/s.

These values will be measured introducing a measurement delay, then manipulated in order to obtain values of *Level_increment* and *Pump_feedback* that will be used as inputs of the stateflow chart.

Inside the stateflow chart we can found:

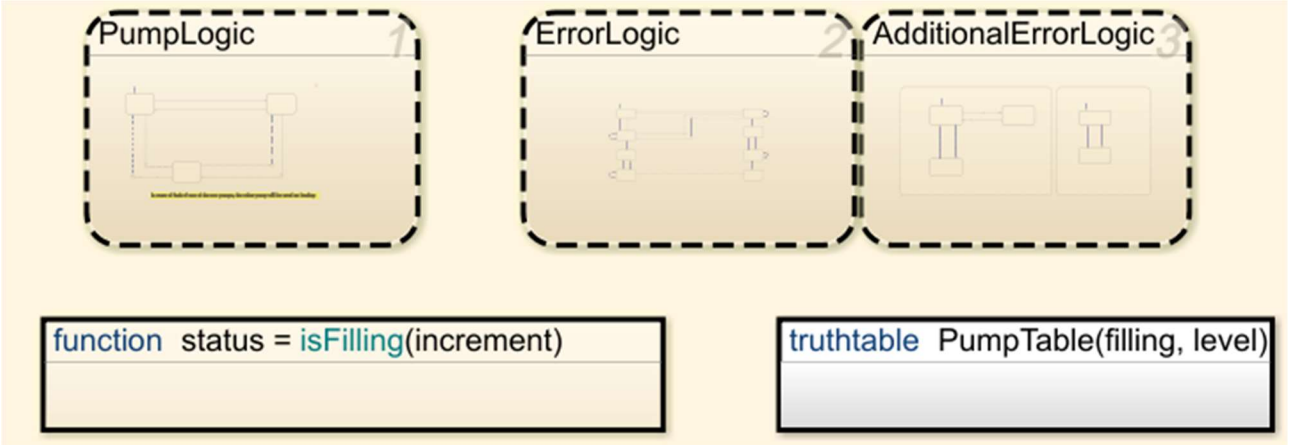

Figure 8: Stateflow chart

- *isFilling function*: transforms the Level_increment value in a Boolean, showing if the level is increasing or decreasing;
- *PumpTable truthtable*: defines the pump_mode based on current level and isFilling result;
- *PumpLogic state*: defines the LFP_DO and HFP_DO outputs based on the pump_mode and in case of fault of one of the two pump, activates the other as a backup;
- *ErrorLogic state*: implements the plausibility check entering a warning state when the Pump_feedback is different from the one expected. The warning will be transformed in an error state if the system will remains in a warning state for a time superior than the transient time of the plant;

- *AdditionalErrorLogic state*: detects when the outflow exceeds its limits and, in parallel, prevents the erroneous simultaneous activation of the two pumps.

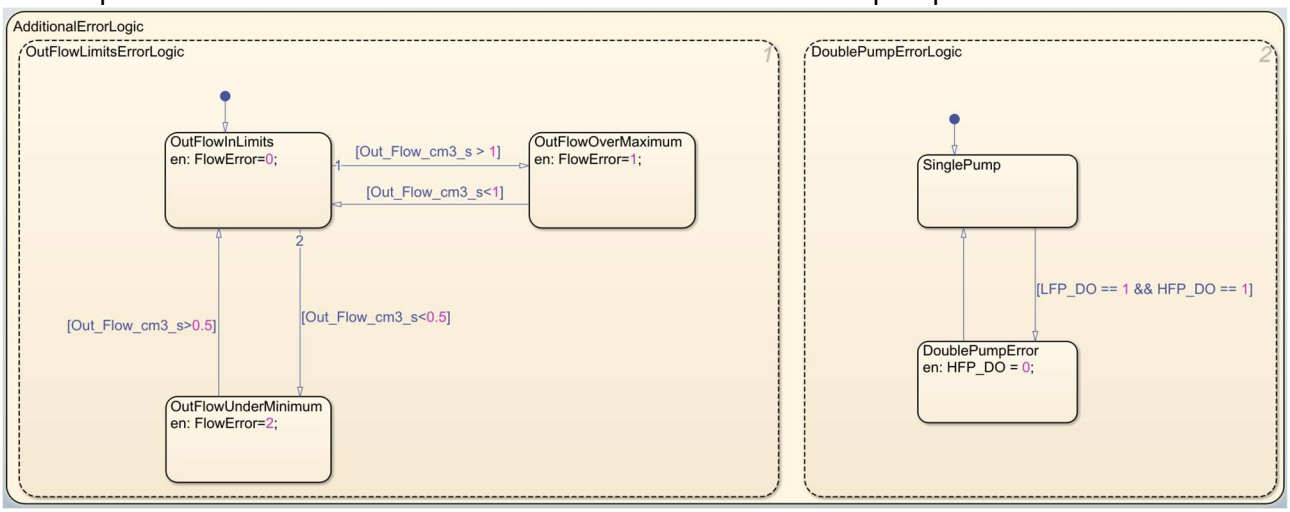

Figure 9: AdditionalErrorLogic

The outputs of the controller are:

- *LFP_DO*: controls the activation of the Low-flow pump;
- *HFP_DO*: controls the activation of the High-flow pump;
- *Error*: is given by the sum of the error founded in the plausibility check and the outflow one multiplied by a 10 factor, in order to visualize them as first and second digit through a display.

  First digit:

  0→No errors;

  1→Low flow pump on error;

  2→High flow pump on error;

  3→Both pumps on errors.

  Second digit:

  0→No errors;

  1→OutFlow over maximum value;

  2→OutFlow under minimum value.

Interfaces

Name	Unit*	Type	Data Type	Dimension	Min	Max
Out_Flow_cm3_s	cm^3/s	Input	Double	1	0.5	1
Level_cm	cm	Input	Double	1	0	200
Error	-	Output	Uint8	1	0	23
LFP_DO	-	Output	Boolean	1	0	1
HFP_DO	-	Output	Boolean	1	0	1