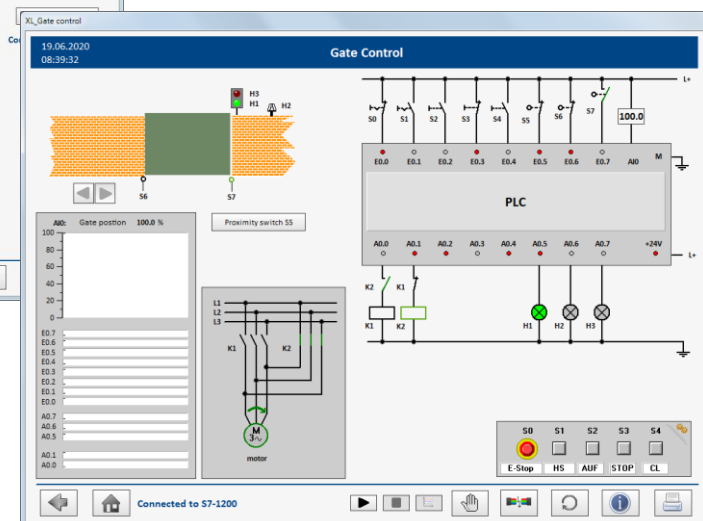
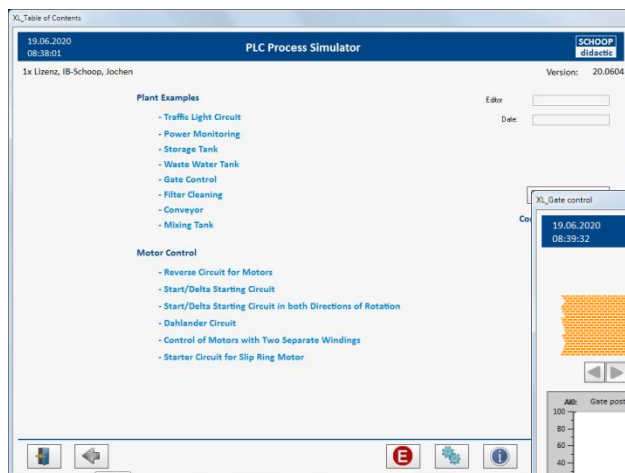
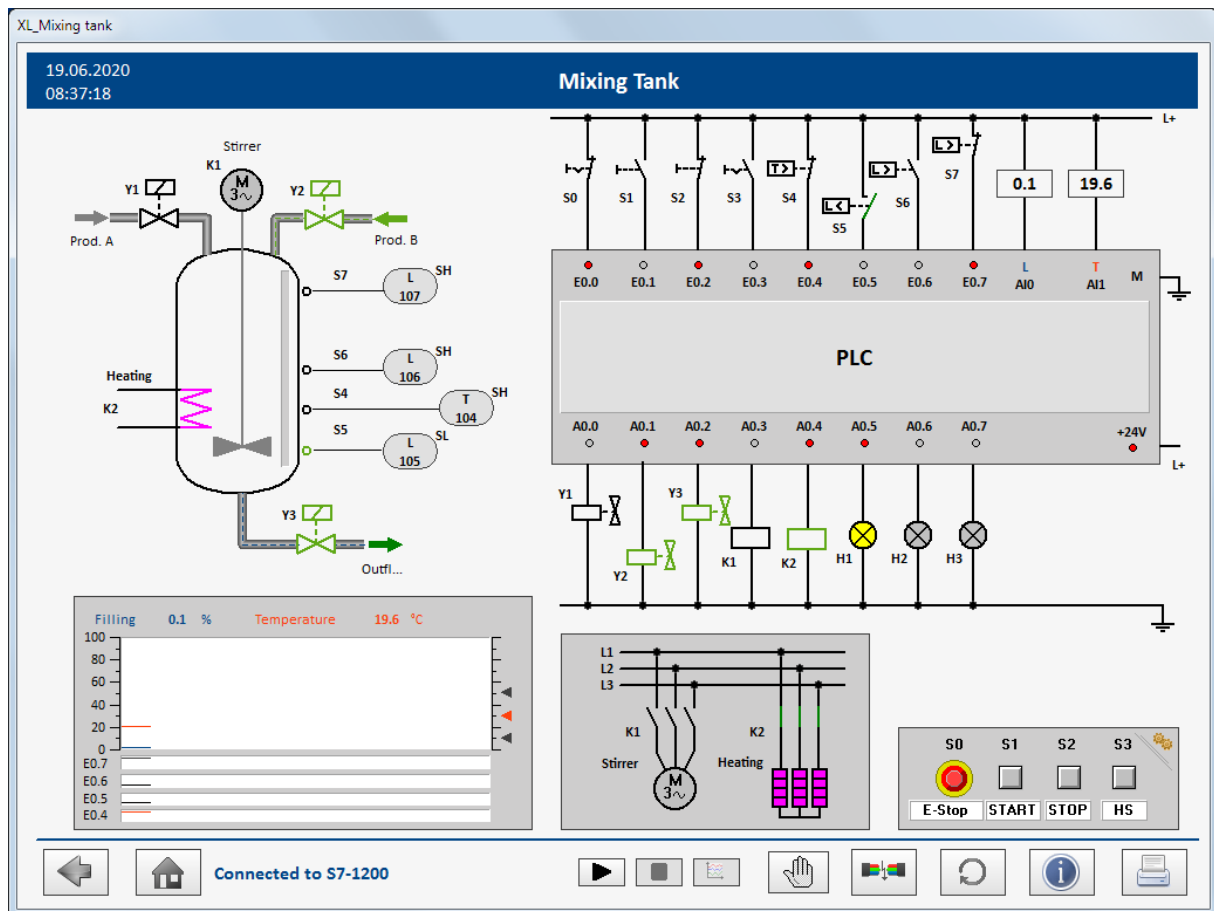


# PLC Process Simulator



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## Introduction

The PLC process simulator is software to make it easier to learn how to solve control engineering problems. This includes developing the processes and then implementing them as a PLC program. The software contains clearly visualized simulations of technical systems. These can be controlled with the PLC and the result can be followed live on the PC. There is no risk that technical components can be damaged by incorrect programming.

This tutorial was developed by the engineering office Dr.-Ing. Schoop in close cooperation with vocational teachers from the field of automation technology. The engineering office Dr.-Ing. Schoop has many years of experience in the field of industrial automation.

## Operating Instructions

Starting page of the course is always the directory. The program also should be closed from this page by clicking the window icon.



The Button „Connection to the PLC“ will open the signal assignment to the PLC (pdf).



More information of the program WinErs is available at the button with the WinErs-Logo.

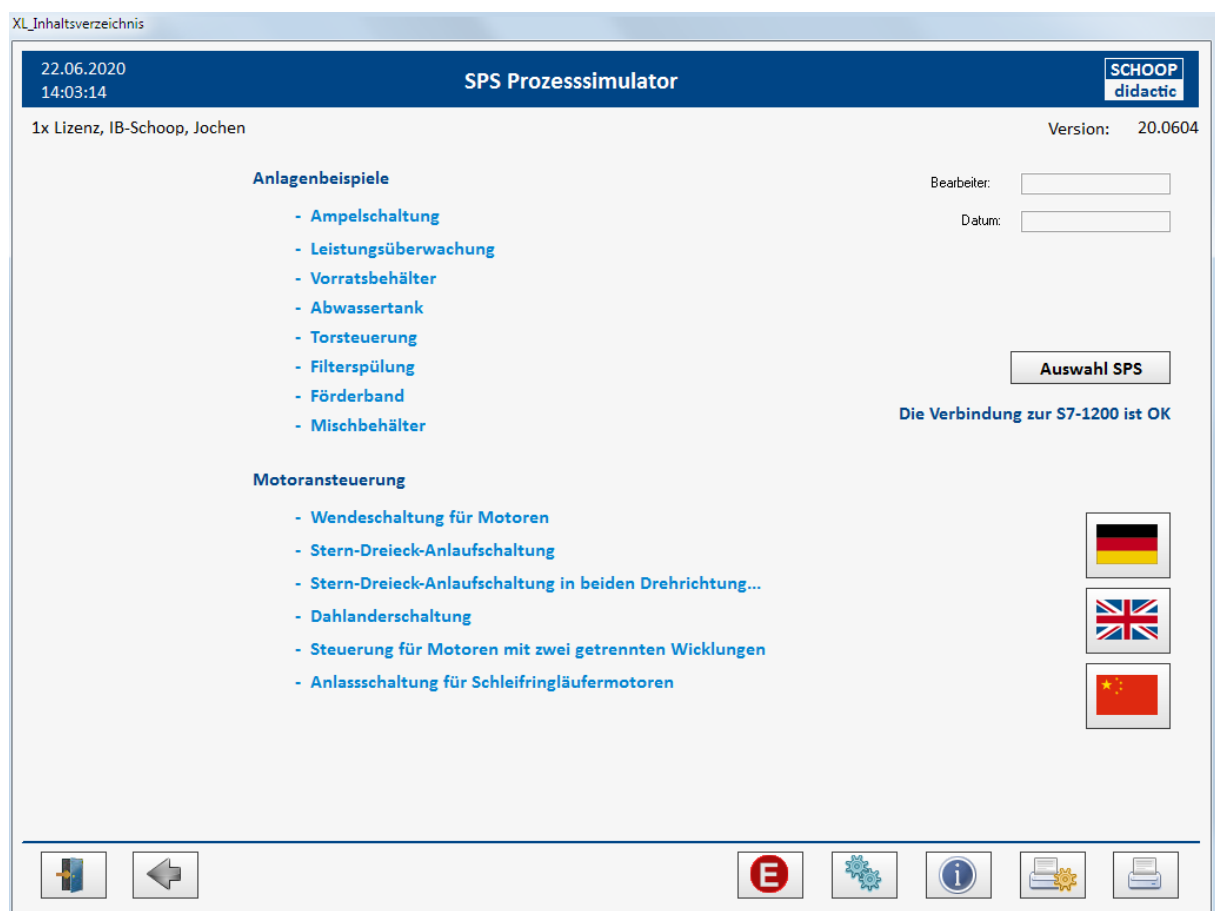


You can change to the different pages of the course by clicking the topics (colour change to green).

You can return to the last page displayed using the button.



The printer available for printouts must be selected or confirmed once using the button shown.



Click on one of the items in the start menu to get to the tasks

All worksheets have a control bar at the bottom.

The home symbol allows you to switch to the table of contents.

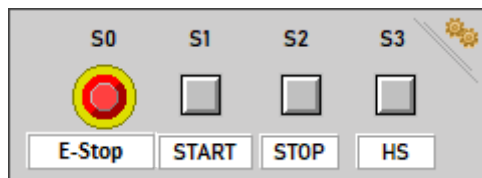


On the right are the actions that affect the current page:

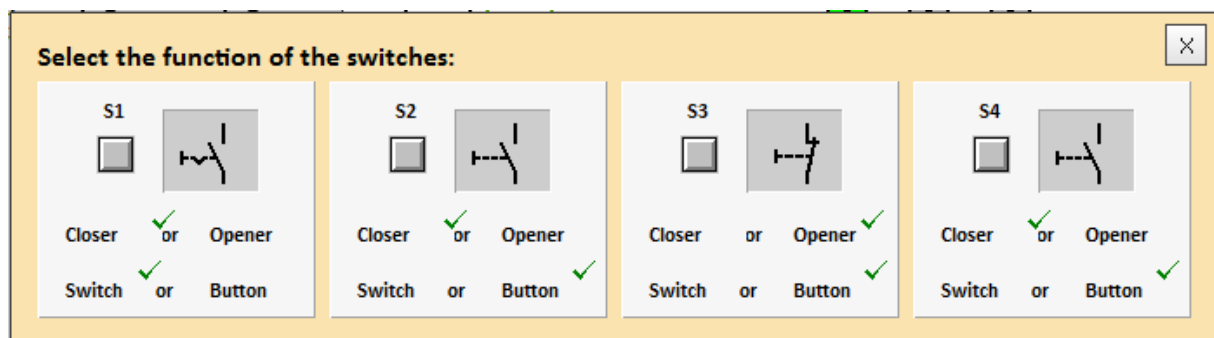


- Measurement settings:
  - Display: „Measurement in progress“ (red Point)
  - Start measurement
  - Stop measurement
  - Show measurement (diagram)
- Operate the simulation in manual mode
- Show window for the simulation of sensor errors
- Reset, restore initial conditions
- Open manual
- Print out current page (*Printer setup on „Start page“*)

Switches and buttons can be found on the sides in the following form :



The switches respectively the buttons can be set using the gear symbol. For switches S1, S2, S3, etc., you can set whether they work as switches or buttons as well as openers or closers:

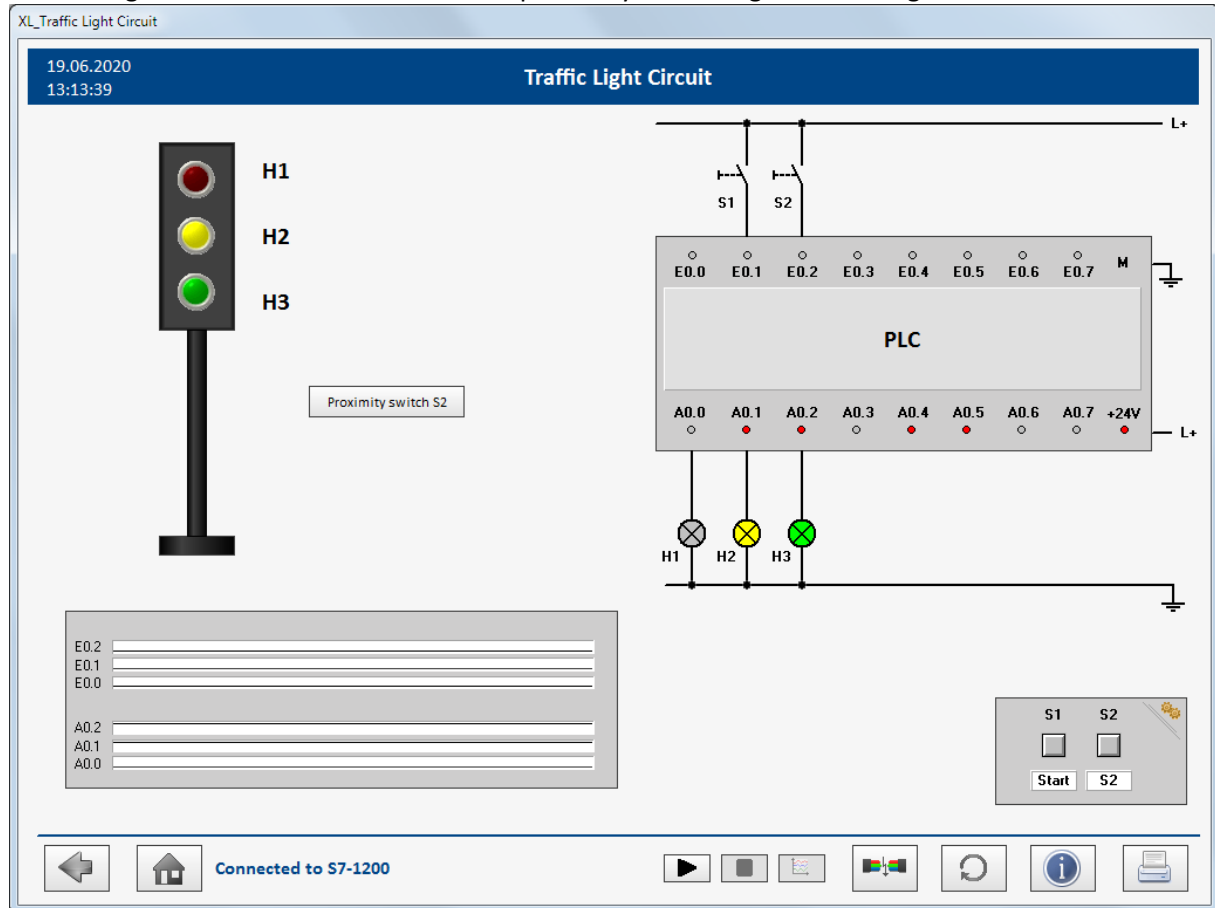


## Tasks

The individual systems and tasks are described below.

### Traffic Light Circuit

A traffic light for cars is to be controlled. A proximity switch registers waiting cars.



### Operating Elements

- H1     Rede lamp
- H2     Yellow lamp
- H3     Green lamp
  
- S1     Start-button
- S2     Proximity switch

### Task:

When the start button is pressed, the traffic light switches to red. The yellow lamp should be switched on after five seconds. After three seconds, the yellow and red lamps should be switched off and the green lamp should be switched on. After 60 seconds the green lamp will turn off and the yellow lamp will turn on for five seconds. Then the red lamp is switched on for 60 seconds. Now the cycle starts again.

If the proximity button is pressed during the red phase, the traffic light should change from yellow to green after three seconds.

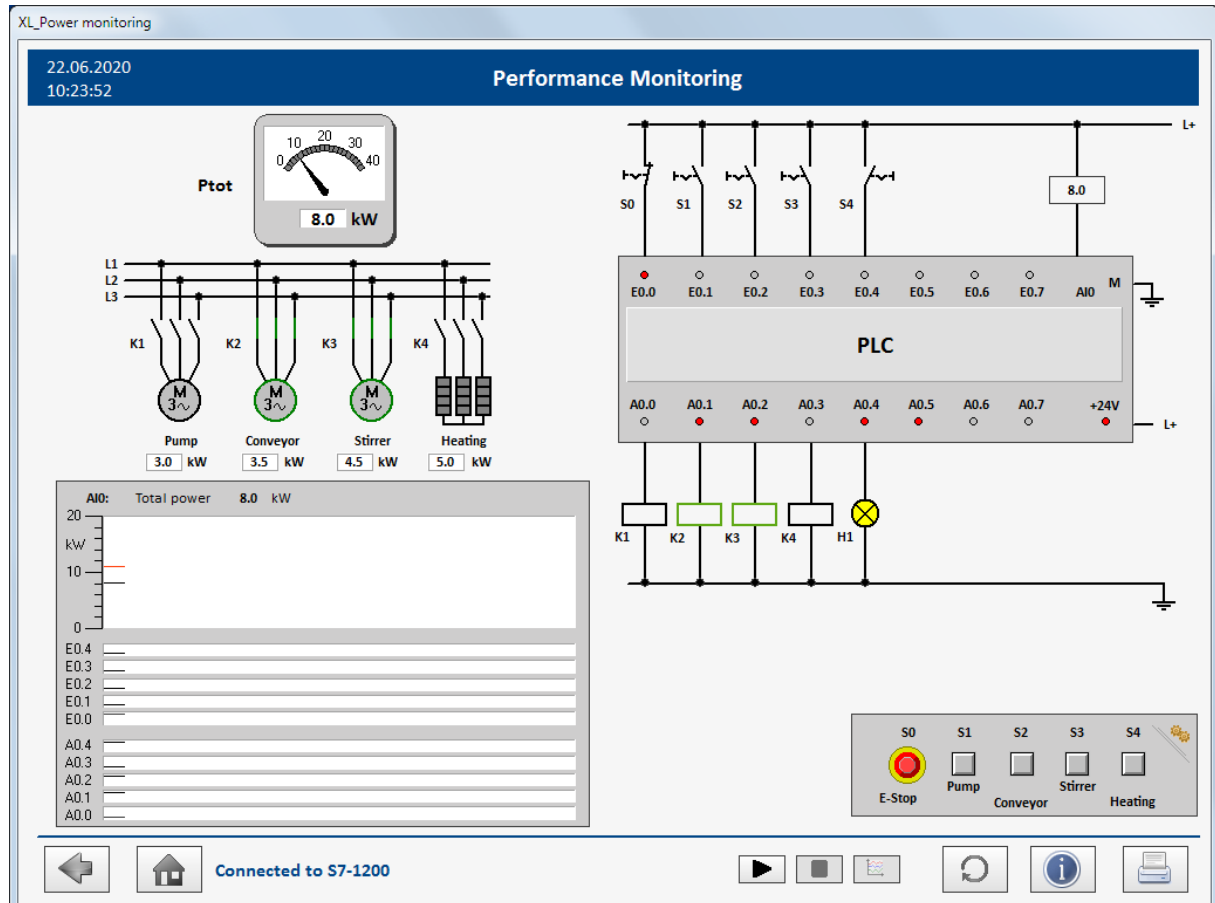
## Performance Monitoring

The electricity supplying companies (EVU) sell electric power to their customers. If, in normal case, an average power is connected to the electrical grid of the EVU (and thus accounted!) but temporarily a much higher output is demanded, the diameter of the power cables as well as the potential power plants capacity have to hold this maximum power available.

This „availability“ causes a lot of costs to the EVU. Therefore the tariffs are differentiated according to the quantity and the maximum value of the consumed quantity.

In industrial companies there are often 2 EVU-power meters for measurement of the „consumed“ electrical energy. The first meter registers the kWh consumption until a certain maximum value of connected loads. If this value is exceeded the maximum meter counts the electrical energy. The kWh-values of the maximum meter are accounted to a much higher tariff than the normal tariff.

Thus, concerned companies try to avoid those power peaks, which may activate the maximum meter. Helpful are circuits, which signal the exceeding of the maximum value or switch off non-required electrical equipment.



### Task 1:

Develop a circuit, that signals the exceeding of a preset maximum value (11kW) at the indicator light (H1). For the operation values of the electrical equipment see the values stated in the chart. If possible design an optimized circuit.

### Task 2:

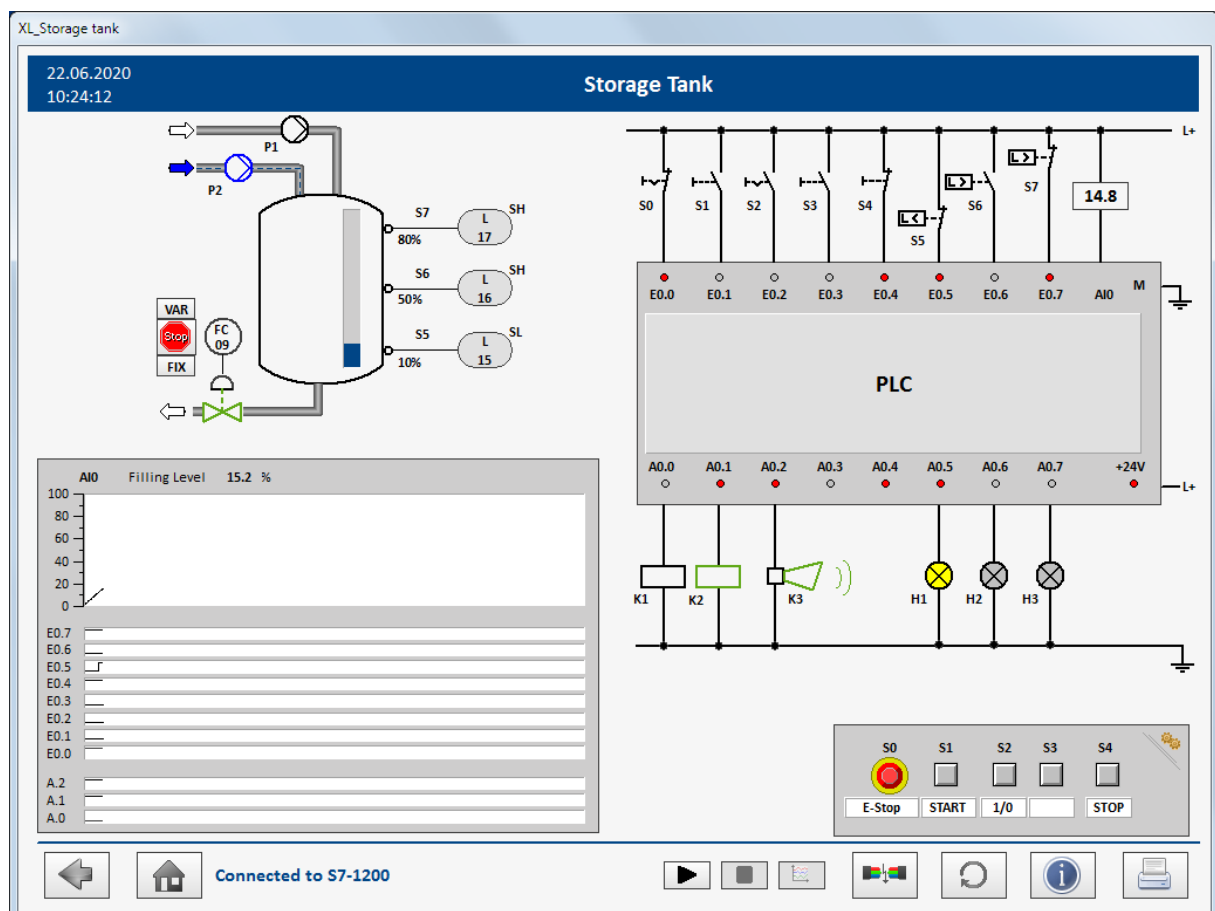
In our described system the production process allows to turn-off the heating of a temperature controlled basin for short terms. This avoids an exceeding of the maximum value and thus disadvantages in the production process.

Enhance your circuit, so the auxillary contactor is switches off (if S4 is switched) if the maximum value is exceeded. In case S4 was not yet switched but right now is, the heating should not be activated.

### Task 3:

Enhance the function diagram by the emergency OFF function (E-stop). When emergency OFF is pushed all contactors and indicator lights should shut-off at once.

## Storage Tank



The RI-flow diagram shows the storage tank for cooling water. The system supplied by a control valve (FC09) permanently requires variably changing quantities of cooling water. The pumps P1 (K1) and P2 (K2) are controlled to store a sufficient quantity of water for all operating conditions.



There are two pumps with different flow rates, thus in case of low water demand, the high-output pump with high operation energy is not requested.

The drain of the storage tank could be set to a constant value (button "FIX"), a process dependent value (button "VAR") or switched off (button „Stop“).

#### **Task 1:**

First test the flow rate of the pumps in manual operation. Therefore switch to variable drain. Try to have a sufficient quantity of water in the storage tank permanently.

Check the changing fill levels in the diagram.

#### **Task 2:**

Develop a pump control, that switches on both pumps at very low fill level (less than L 15). If fill level is between the lower pair of sensors only the high-output pump P2 should regulate the water quantity. Pump P1 is only in operation if the fill level is between the upper pair of sensors. Above the sensor L 17 no water supply is necessary. The pump control is put to operation by the main switch S2. Pushing the emergency OFF (E-stop) will shut down any electrical equipment.

Fill level under the lowest sensor is indicated by indicator lamp H1 and horn K3. Indicator lamp H2 signals the completely filled tank (above the upper sensor). If the combination of those sensor signals indicates an unrealistic fill level (possibly due to an error), indicator lamp H3 indicates this "failure of sensor". Use the S3 button as an acknowledgement button.

### **Waste Water Tank**

Within a production plant all arising waste water is gathered in a tank. Draining of the tank is done by pump P1 and only if required.

#### **Task 1:**

If the fill level is over switch LS 106 the tank should be pumped off until the fill level is lower than LS 105. The system should be switched on at S2. The drainage automatism should be started at S1 and should be stopped at S4. Emergency off (E-stop) should interrupt the control circuit.

#### **Task 2:**

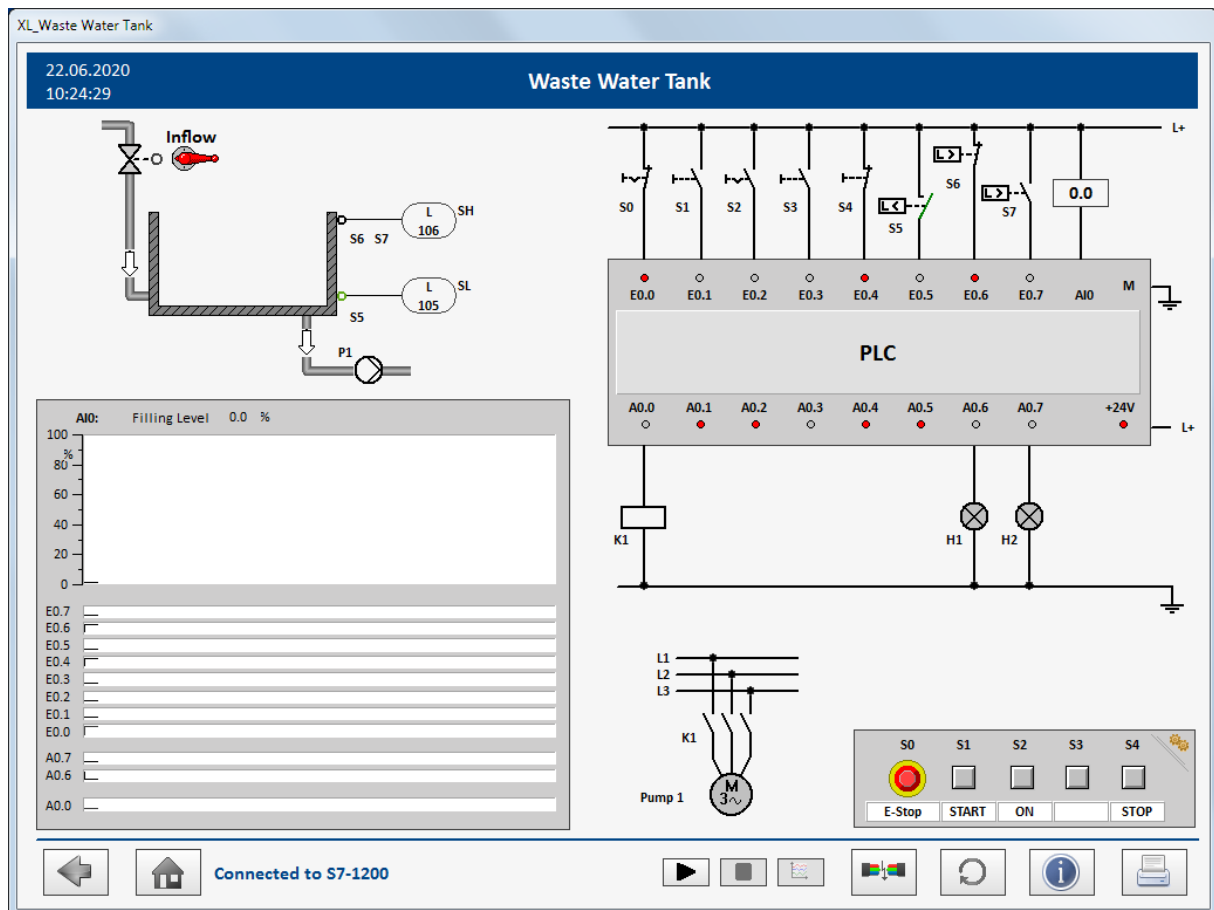
Extend the circuit so that the pump P1 is in operation 5 more seconds after the fill level is under LS105.

#### **Task 3:**

Enhance your circuit by one more output for indicator light H1. It should signal if sensor S6  $L_{max}$  and sensor S5  $L_{min}$  reports at the same time.

#### **Task 4:**

The indicator light H2 should signal, when the upper sensor switches due to exceeding S6. Both indicator lights only could be turned on, if main switch (S2) is activated.



## Gate Control

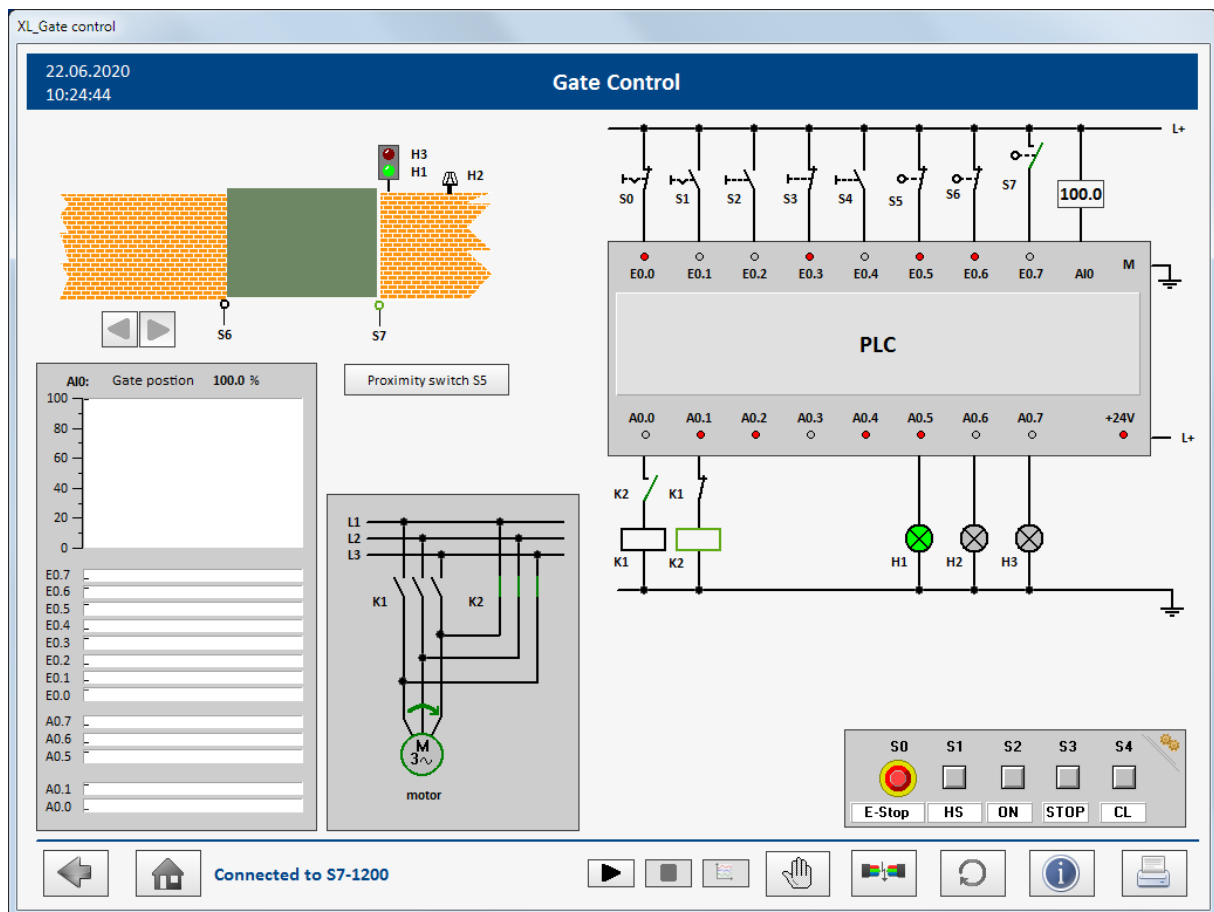
The gate of a company site should be opened and closed power-operated. A signal light (red/ green) allows passage when completely opened. A yellow warning light flashes, while the door is moving.

### Task 1:

Switching elements S0 – S4 are available.

- S0: Emergency OFF (E-stop) shut down motor operation and control at once. (indicator lights are not shut down!)
- S1: The main switch turns on/off the complete system (even indicator lights).
- S2: By pressing the „ON“ button the control starts to open the gate.
- S3: The „STOP“ button interrupts the gate motion anytime. The gate first moves after pressing „ON“ or „CL“.
- S4: The gate will close after pressing button „CL“.
- S6 and S7 switch after reaching the gates' end position and stop its' motion. S6 is switched when the gate is completely opened and S7 when the gate is completely closed.
- If a person enters the danger zone of the gate, the proximity switch (S5) is activated and stops the motion.
- Contactor K1 causes the motor to left rotation, therefore the gate will be opened.
- The gate is closed by contactor K2.
- The control should be designed in a way, that an intermediate power failure will not cause an uncontrolled restart.

- If button „ON“ and „CL“ are pressed at once, the control makes sure that the gate will not move at all.
- If from one motion direction should be changed to the other, the “STOP” button has to be pressed first.



## Task 2:

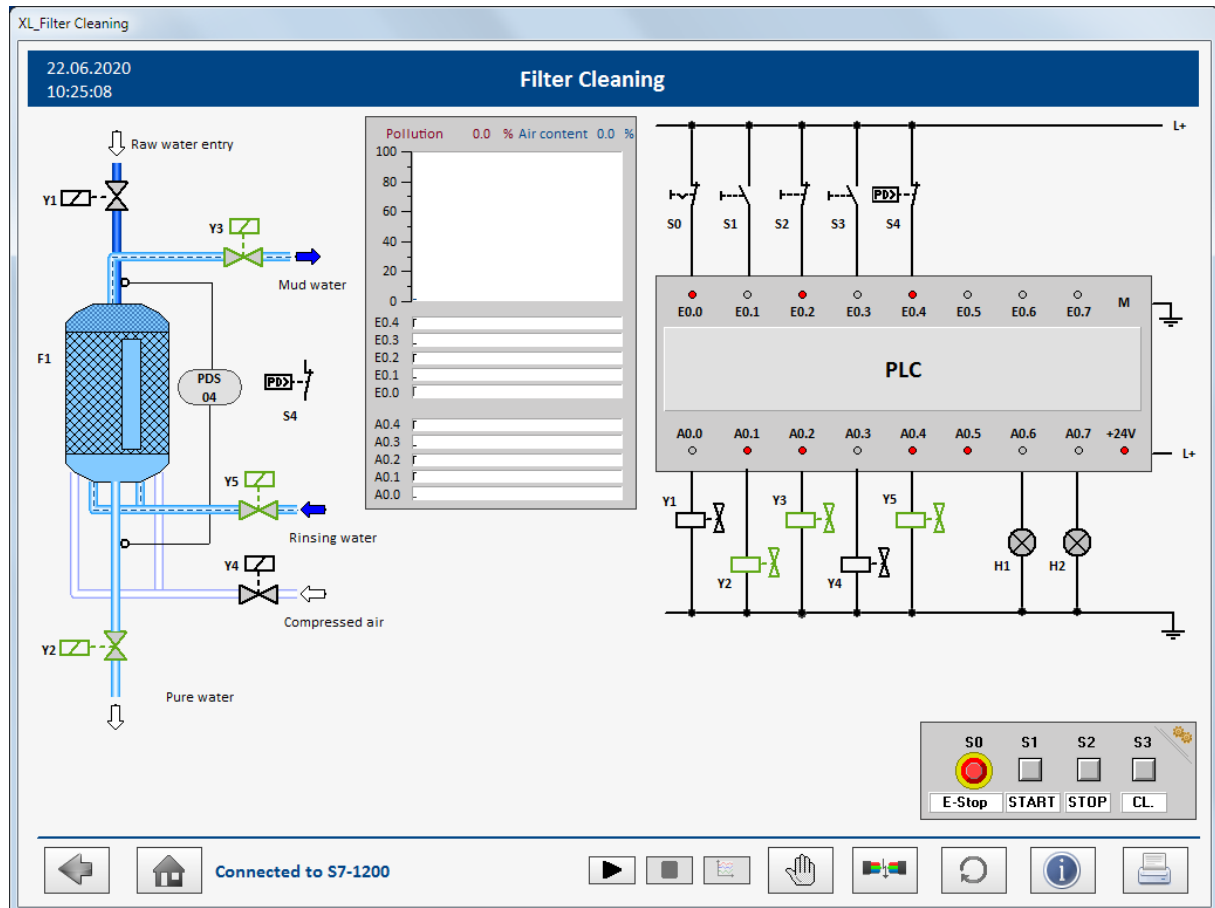
Switch the indicator lamps H1, H2 and H3 as follows:

- Lamp H1 (green) allows passage, as soon as the gate is **completely** opened.
- Lamp H2 (yellow linking light) warns at **each** gate movement. (*when switched with 1-signal the warning light blinks automatically*)
- Lamp H3 (red) forbids passage. It indicates, that the gate is not completely open.
- Main switch S1 has to be turned on, so the indicator lamps could be activated.

## Filter Cleaning

The RI-flow diagram shows a sandbed filter in a closed tank. The raw water pouring in from above, is cleaned in the filter and treated water can be withdrawn at the bottom. The dirt particles of the raw water are deposited in the filterbed, they cause a higher differential pressure between inpouring and outpouring water. If the differential pressure reaches a certain level, the differential pressure sensor (PDS 04) closes its contact (S4). (For simulation purpose the time for filter contamination is considerably reduced). The control now starts the cleaning cycle for the sandbed filter:

The cleaning cycle starts with the closing of valve Y1 and Y2. Pressured air now (Y4) is directed through the sandbed for separating the dirt from the sand grains. The air is discharged at an pressure control valve. In the next step, rinsing water (Y3 and Y5) is additionally directed through the filter till the contamination is cleared. As there is now lots of air in the filter the rinsing process has to go on although after closing the air control valve (Y4). Through Y5 rinsing water is poured through the sandbed and air and mud are washed from the filter through Y3. When all air is washed out the cleaning cycle is stopped and normal operation starts again.



### Task 1:

First try out the system in manual operation. Determine the required times for cleaning with pressured air ( $t_1$ ) and the rinsing process ( $t_2$ ).

### Task 2:

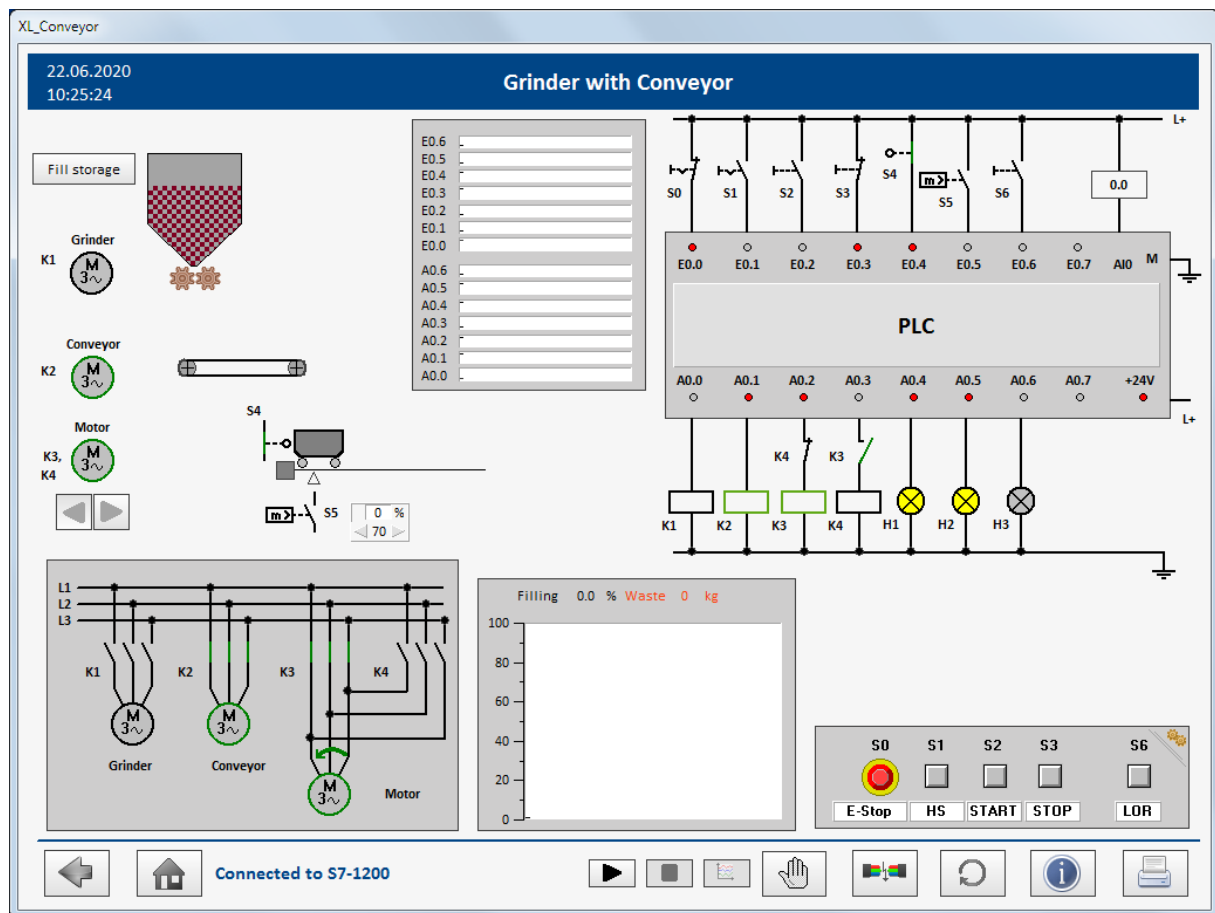
Develop a control circuit for the filter operation:

Normal operation is started at button START (S1). The STOP-button (S2) instantly stops normal operation and the cleaning cycle. E-STOP (S0) also affects the instant closing of all magnet valves. In normal operation the cleaning cycle could be started anytime by pressing the JET-button. The settings of the required timers within the control should be 10% over the determined times of test 1.

### Task 3:

Indicator light H1 indicates the filter operation. Indicator light H2 indicates the cleaning cycle

# Conveyor



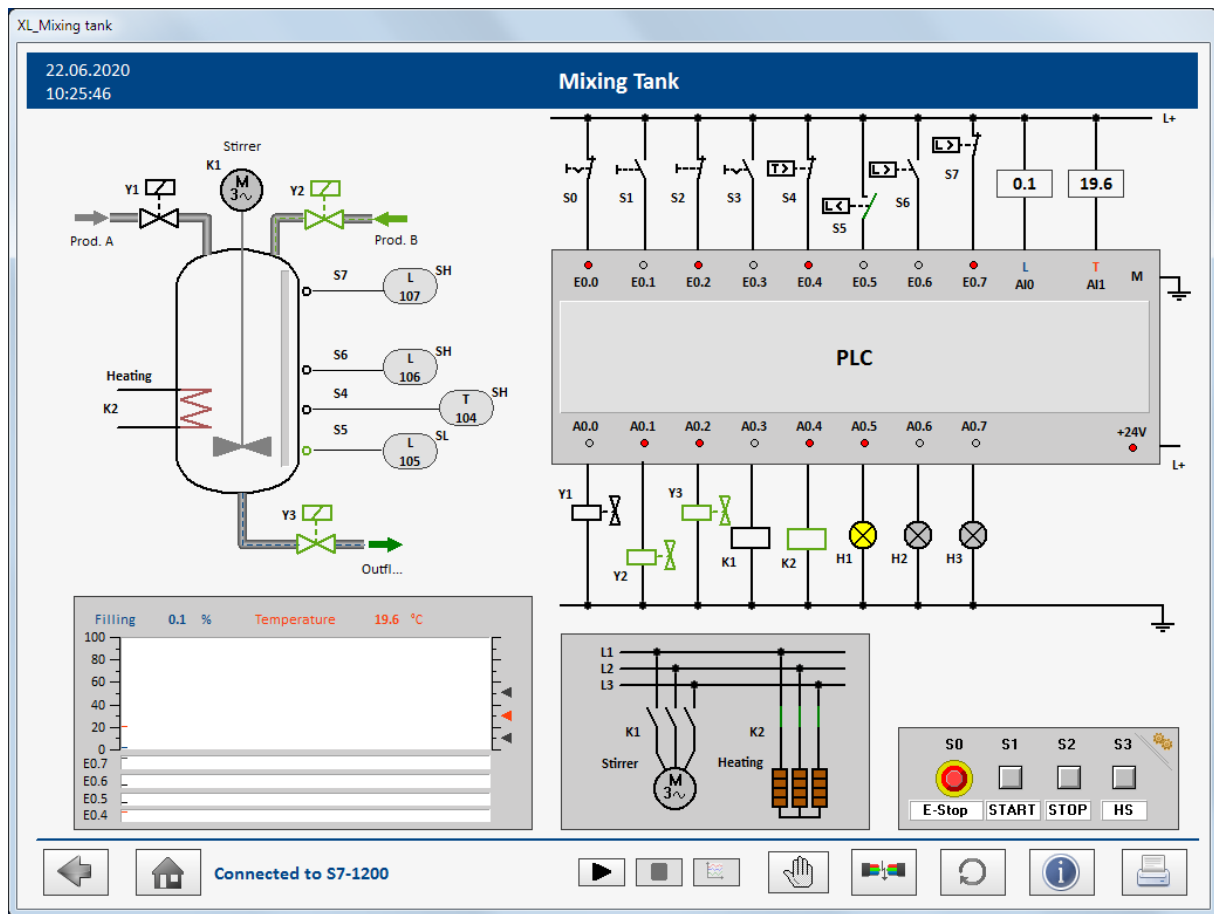
From the storage container material drops down into a running grinder (K1) and thence on a conveyor belt. The belt (K2) transports the granulated material to the carriage. The weighing unit switches contact S5 if the preset filling weight is exceeded. The filled carriage is leaving to get emptied (K4), it dumps the granulated material automatically. When the carriage is returned to the conveyor belt (K3) and has reached the filling position, contact S4 switches.

## Task:

Develop a control for semiautomatic operation. The complete system has to be in initial setting before starting the process (yellow arrow button at the left bottom).

- The main switch HS switches on/off the complete system.
- If the carriage is in filling position but the weighing unit has not signaled a sufficient filling level, the above described process could be started at the START button (S2).
- The process could be stopped at the STOP button anytime. The motors will switch off (not the indicator lights).
- By activation of button S6 (LOR) the carriage goes into initial position, and after activation of S2 the cycle could be started new.
- Activation of emergency OFF (S0, E-Stop) causes a shut-down of all actuators.
- The indicator lights indicate following operation modes:
  - H1: Grinding – and conveyor process
  - H2: Carriage full
  - H3: Carriage empty

## Mixing Tank



A vessel for acidic waste water (prod. A, influx at valve Y1) and alkaline solution (prod. B, influx at valve Y2) is equipped with a mixer and motor (Stirrer K1) and an E-heater (K2). Three filling level sensors (S5, S6, S7) switch after having preset the filling levels. The temperature sensor (S4) could be used for limitation of the product temperature. The vessel could be emptied by valve Y3.

### Task 1:

A mixing system should be controlled automatically. Operation is solely done from the operation panel.

- The system could only get started if the main switch (S3) is switched on.
- If the emergency OFF (E-Stop) is activated at any time all actuators will shut down.
- After releasing the emergency OFF the system has to be prevented from starting automatically

Below described steps are activated by the START button (S1) and could be stopped either by the respective sensors or the STOP button (S2):

- If the vessel is emptied under the level of sensor L 106, the pouring-in of product A could be effected by activation of the START button (S1).
- When reaching the filling level sensor in the middle (S6), product B is pouring in, till the upper filling level sensor (S7) is reached.

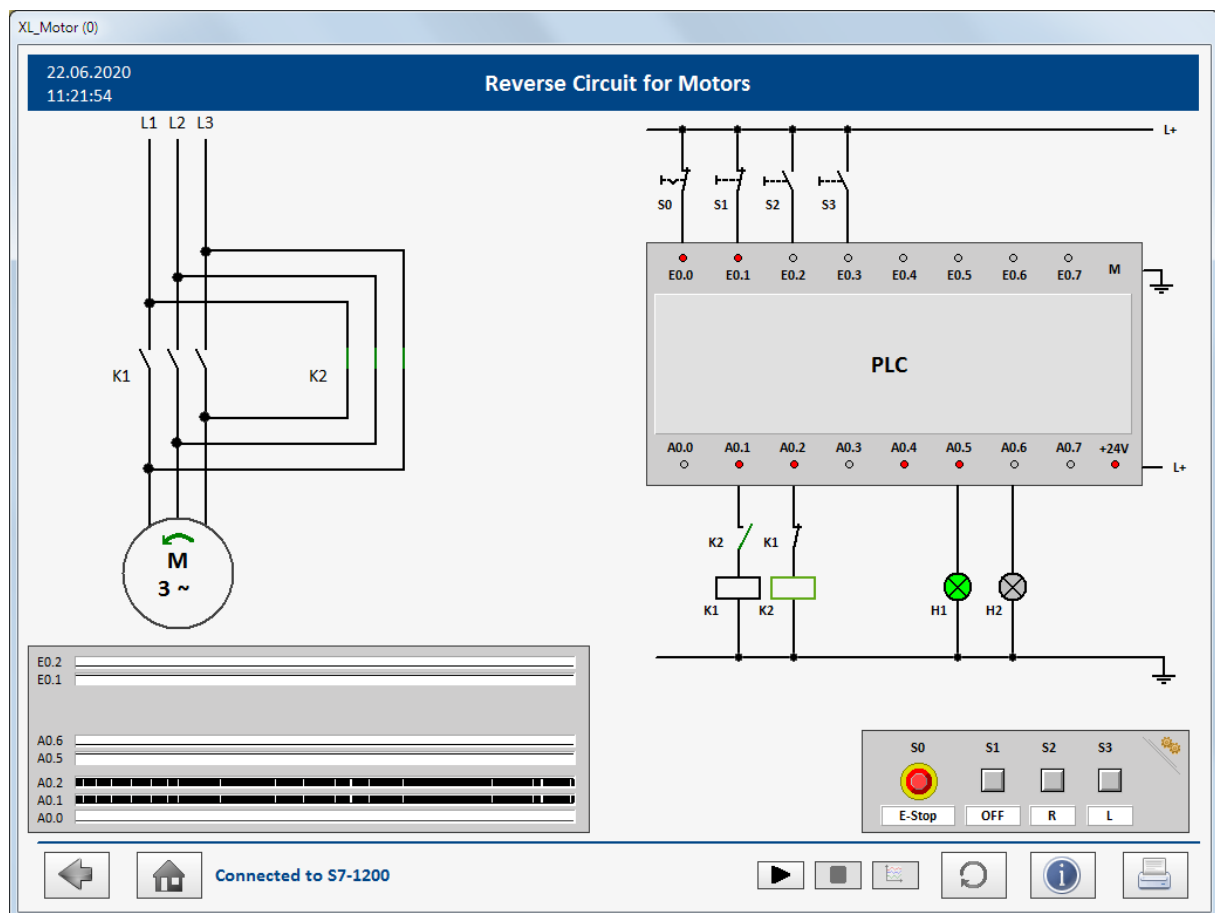
- During the filling period the mixer should also be in process.
- Switch on the heating until the temperature limiting value is reached.
- Last step is emptying the mixing vessel. Below the filling level sensor (S5) the mixer must not be switched on!

### Task 2:

Enhance the circuit by a timer, so the vessel is emptied completely.

## Reverse Circuit for Motors

A conveyor belt should be operated in both directions. The conveying direction could be selected by button.



### Control Elements

- |    |   |
|----|---|
| S0 | E-Stop                                    |
| S1 | OFF-Button                                |
| S2 | On-button clockwise rotation (R)          |
| S3 | Contactor, counter clockwise rotation (L) |
| K1 | Contactor, clockwise rotation             |
| K2 | Contactor, counter clockwise rotation     |

### Task:

A conveyor belt should be operated in both directions. The conveying direction could be selected by button. If button S2 is activated, the motor should rotate clockwise. Therefore K1 has to be switched.

If button S3 is activated, the motor should rotate counter clockwise. Therefore K2 has to be be switched.

Button S1 is for switch-off.

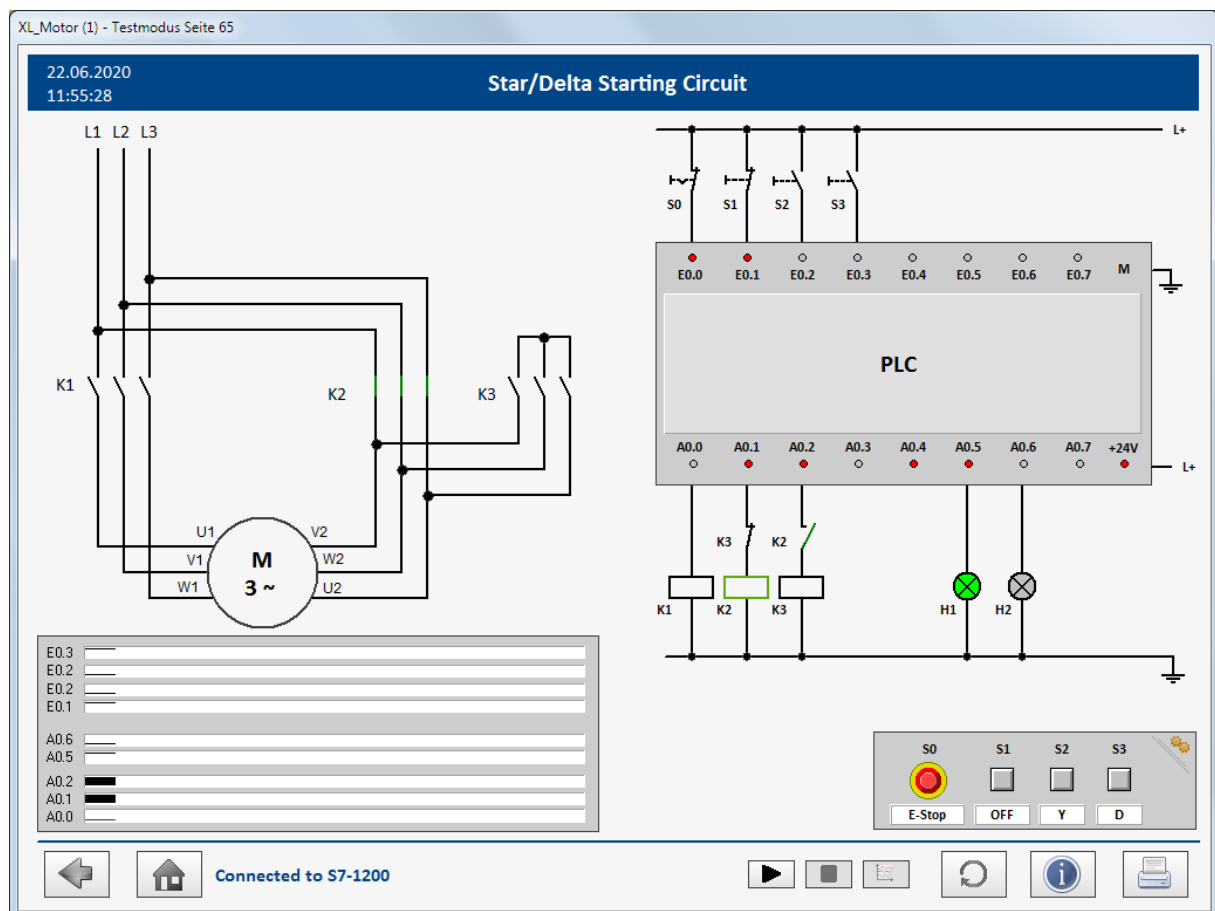
Changing between clockwise and counter clockwise direction is not to be done while the motor is running.

K1 and K2 are not to be chosen at the same time.

For safety measurements there is an emergency OFF S0. If S0 drops, K1 and K2 should be reset.

### Star/Delta Starting Circuit

A motor should be started in star-delta connection.



### Control Elements

S0	E-Stop	K1	Mains contactor
S1	OFF-Button	K2	Delta contactor



- S2 Button for star connection (Y)  
S3 Button for delta connection (D)

K3 Star contactor

### Task:

A motor should be started in star-delta connection. If button S2 is activated, star contactor K3 and mains contactor K3 are switched, the motor is driven in star connection. If button S3 is activated, star contactor K3 drops out and the delta contactor switches and stays in operation. Button S1 stops the motor. For safety measures an emergency OFF (S0) is integrated.

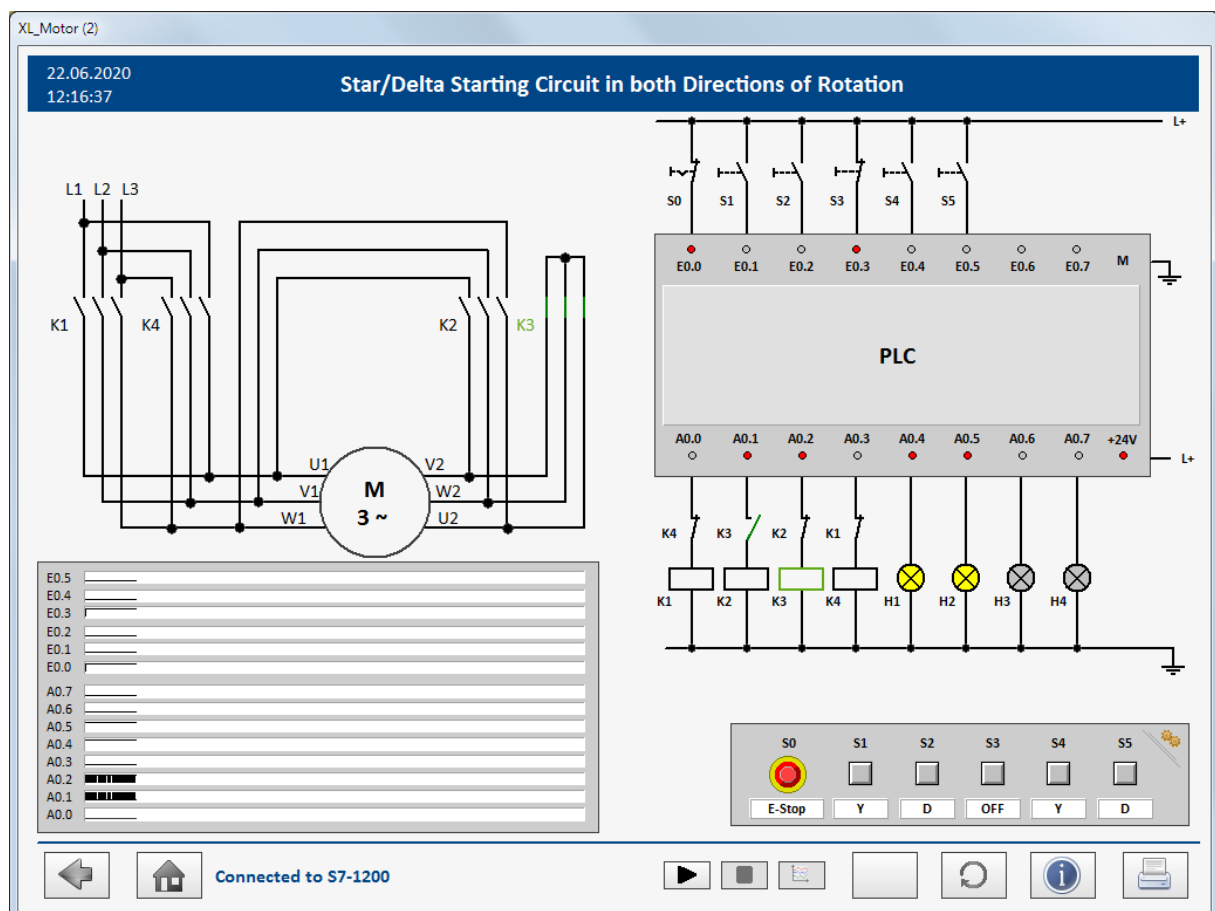
Caution: The star contactor K3 and delta contactor K2 have to be interlocked.

### Additional Task:

Enhance your circuit, so the motor automatically changes from star to delta connection after 3 secs. (in this case S2 is the start button, S3 is not used).

## Star-Delta-Connection for both Rotation Directions

A motor should start in the star circuit. Both directions of rotation should be possible.



### Control Elements

- S0 Emergency OFF (E-Stop)  
S1 On-button for star connection, counter clockwise rotation (Y)  
S2 Button for delta connection, counter clockwise rotation (D)

S3	Off-button (OFF)
S4	On-button for star connection clockwise rotation (Y)
S5	Button for delta connection, clockwise rotation (D)
K1	Mains contactor, clockwise rotation
K2	Delta contactor
K3	Star contactor
K4	Mains contactor, counter clockwise rotation
H1, H2, H3, H4	Indicator lamp

### Task 1:

#### *Clockwise rotation:*

A motor should start rotation in star connection. If button S4 is activated, star contactor K3 and mains contactor K1 are contacted, the motor rotates clockwise/star. If button S5 is activated, the star contactor K3 drops out and delta contactor K2 is contacted and stays in operation. The motor is stopped at button S3.

#### *Counter clockwise rotation:*

A motor should start rotation in star connection. If button S1 is activated, star contactor K3 and mains contactor K4 are contacted, the motor rotates counter clockwise/star. If button S2 is activated, the star contactor K3 drops out and delta contactor K2 is contacted and stays in operation. The motor is stopped at button S3.

For safety measures the emergency OFF S0 is integrated.

Direct change of the rotation direction must not be possible. Change of the rotation direction is only possible by switching off and switching on again. Repeated activation of button S1 and S4 have to be effectless while the motor is running. Activation off-button S3 affects a contactor-drop out and the motor stops.

**Caution:** The star contactor K3 and delta contactor K2 as well as the mains contactors for clockwise and counter clockwise rotation (K1 and K4) have to be interlocked.

### Task 2:

Use the indicator lights for following function indications:

H1	Indicator light, star connection, counter clockwise rotation
H2	Indicator light, delta connection, counter clockwise rotation
H3	Indicator light, star connection, clockwise rotation
H4	Indicator light, delta connection, clockwise rotation

### Task 3:

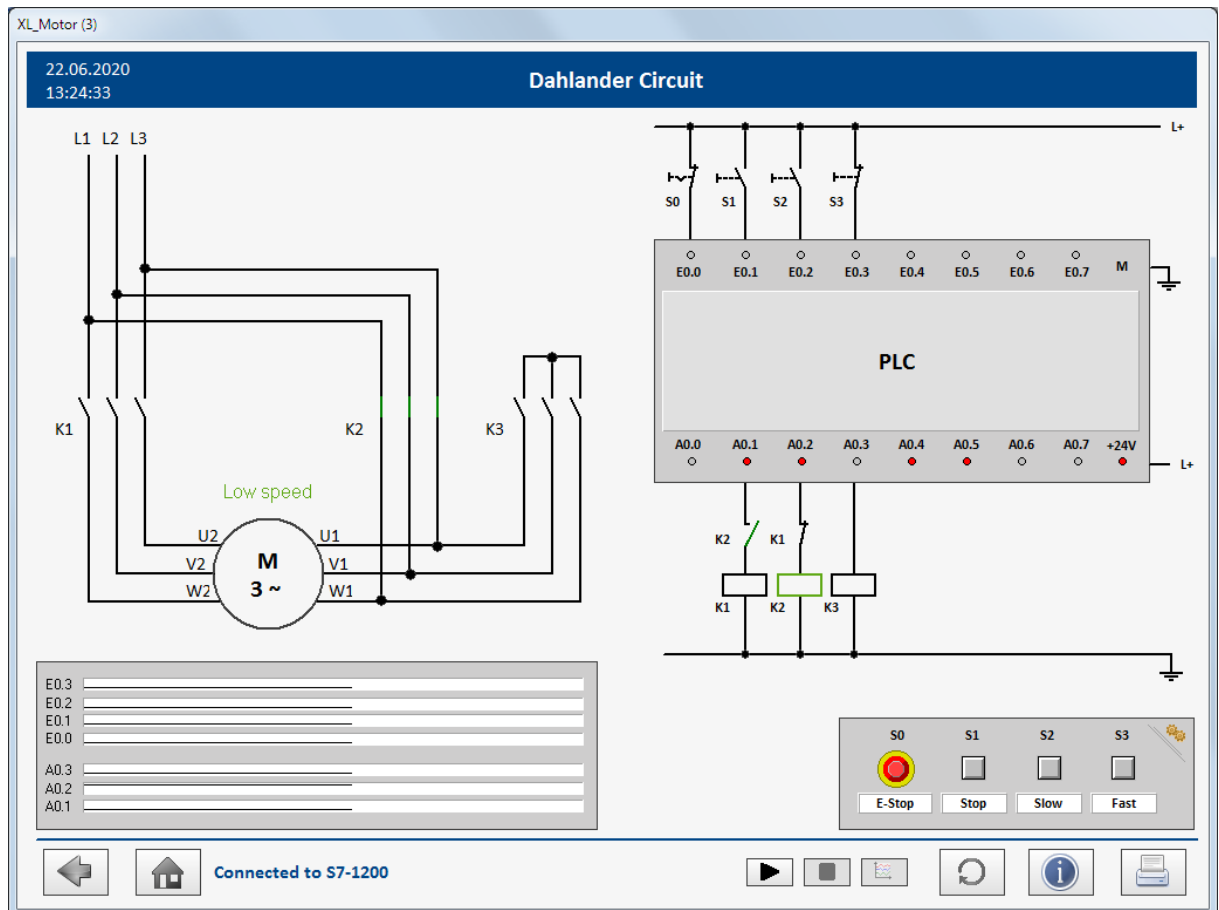
Enhance your circuit, so the motor automatically changes from star to delta connection after 3 secs. (in this case S1 and S4 are start-buttons, S2 and S5 are not used).

## Dahlander Circuit

A fan motor should be operated at two speeds.

### Control Elements

S0	Emergency OFF (E-Stop)	K1	Load contactor, rapid
S1	Stop-button	K2	Load contactor, slow
S2	Button for low speed (Slow)	K3	Star contactor
S3	Button for high speed (Fast)		



### Task 1:

A fan motor should be operated in two rotation speeds. If button S2 is activated the contactor K2 contacts. The motor drives in low speed. If button S3 is activated, contactor K1 and K3 get contacted and stay in operation, K2 drops out. The fan rotates in high speed.

If the off-button S1 is activated all contactors drop out and the motor stops. The circuit has to be secured by button- and contactor interlocking.

### Task 2:

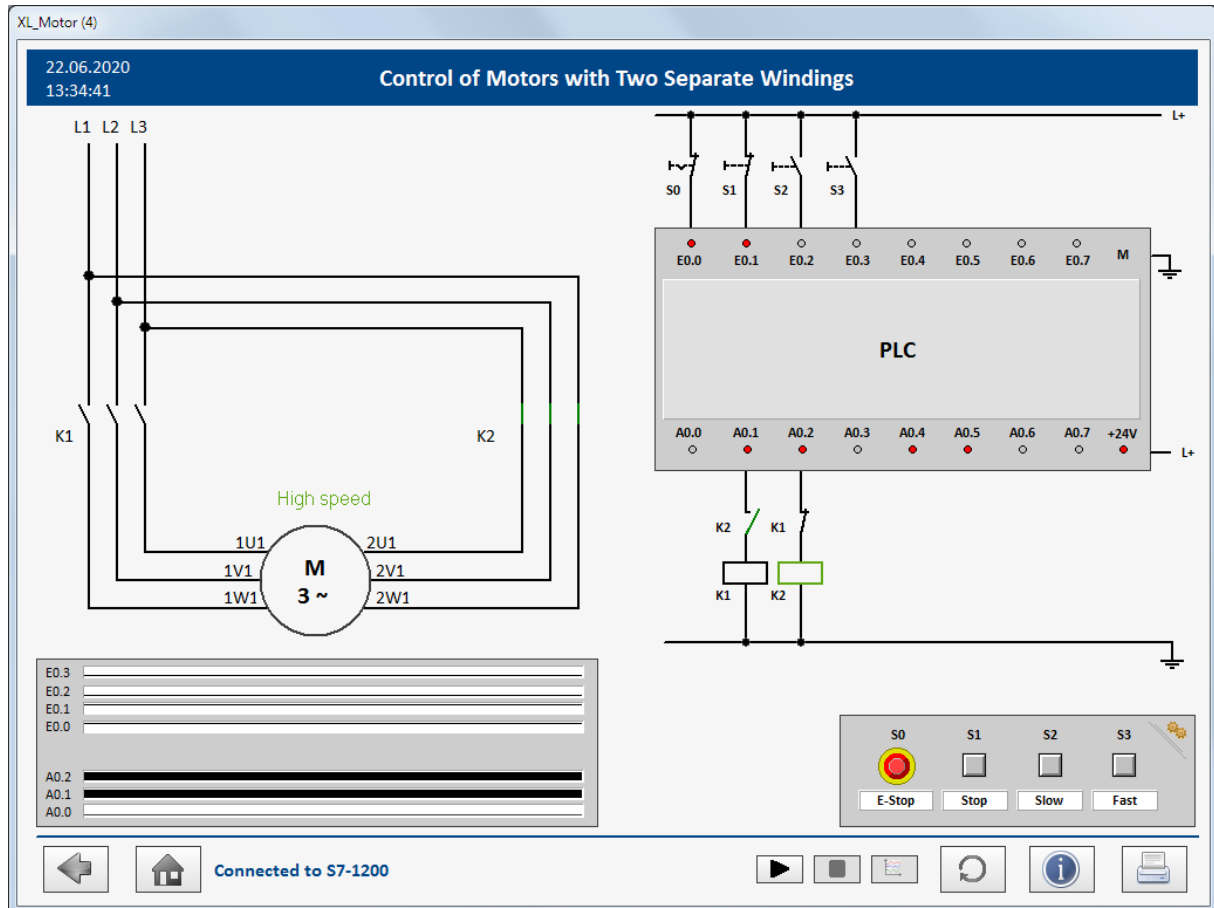
Enhance your circuit, so the motor changes from low speed to high speed 10 secs. after start up.

## Control of Motors with Two Separate Windings

A motor with two rotation speeds should run in one direction.

## Control Elements

S0	Emergency OFF (E-Stop)	K1	Load contactor, slow
S1	Stop-Button	K2	Load contactor, fast
S2	Button for low rotation speed (Slow)		
S3	Button for high rotation speed (Fast)		



## Task:

A motor with two rotation speeds should run in one direction. When activating button S2, the contactor K1 contacts and the motor runs in low speed. When activating button S3, the contactor K2 contacts and K1 drops out. The motor runs in high speed.

When activating button S1 both contactors drop out and the motor stops.

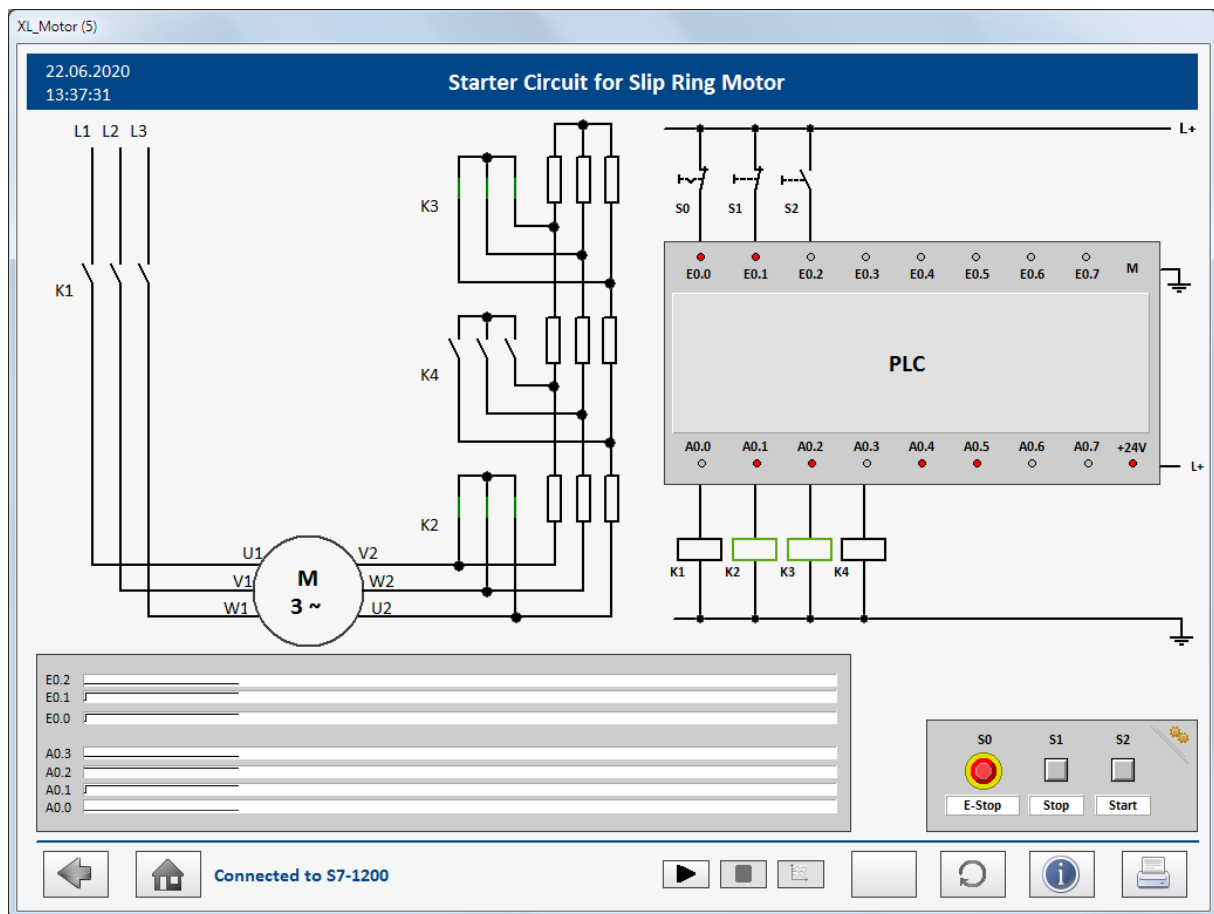
## Starter Circuit for Slip Ring Motor

A slip ring motor should be started in a 3-step starter circuit:

## Control Elements

S1	Stop-Button
S2	Start-Button
K1	Mains contactor

- K2 Star contactor for continuous operation
- K3 Star contactor for 1. start step
- K4 Star contactor for 2. start step



### Task:

A slip ring motor should be started in a 3-step starter circuit. By pressing S2 the main contactor K1 contacts. The motor starts with all starting resistances. After 3 secs. the starting contactor K3 contacts. Thus the first partial resistance of the starter circuit is deactivated. After 3 more secs. the starting contactor K3 contacts. Thus the second partial resistance of the starter circuit is deactivated. After 3 more secs. the star contactor K2 contacts. The motor now runs in continuous operation with short-circuited slip ring. The starting resistances are inactive.

By activation of S1 all contactors drop out and the motor will stop.