UNIVERSITÄT ZU LÜBECK
INSTITUT FÜR TECHNISCHE INFORMATIK

Exercise Sheet 2

Parallel processes

Lecture *Real-Time Systems*, Summer semester 2021

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A discussion forum for the exercise can be found at: `moodle.uni-luebeck.de`.

In this exercise the control for a multi processing station, shown in figure 0.1, is to be created.
Use the TIA-Portal and SIMIT templates from the Moodle.

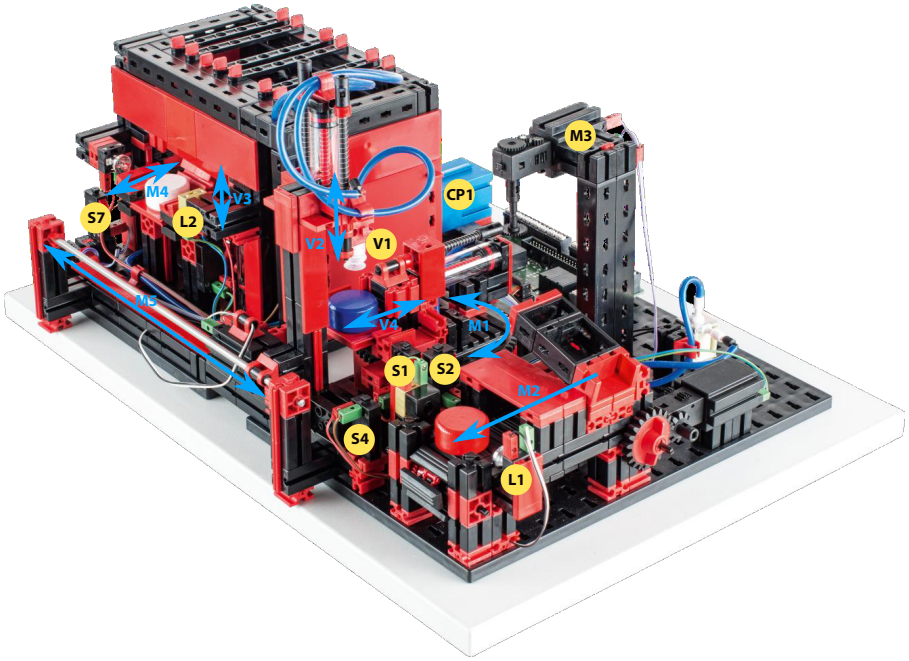

Figure 0.1: Multi processing station. Not all signals are shown. Check the SIMIT simulation for missing signals.

The following signal tags are used to control the multi processing station:

	Tag	**Type**	**True**	**False**
Reference switches	S1 - L7	NO	triggered	untriggered
Light barriers	L1, L2	NC	uniterrupted	interrupted
Motors	M1 - M5	-	turning	stoped
Pneumatic valves	V1 - V4	-	opened	closed
Heater	LED1	-	on	off
Air compressor	CP1	-	on	off

In TIA Portal, the tags have the prefix **"MPS_"**. Control signals for motors also have a suffix that indicates the direction.
A comment is also provided for each tag, which explains its meaning in more detail.

The multi processing station consists of four substations through which a workpiece is transported and manipulated.

The oven is the first substation. It has a tray, in which a workpiece can be placed. A light detects a workpiece. The tray can be moved by a motor to the inside of the oven. To do this the oven door has to be opened pneumatically with pneumatic pistons and an air compressor. Inside the oven is a LED, which emulates a heating element. Two reference switches tell wether the workpiece tray is fully extended and therefore inside the oven or retracted and thus in its homing position.

The gripper can trasport workpieces between the oven and the turntable. It has a pneumatic piston to lower the gripper onto the workpiece underneath it and a suctioncup activated by a valve, to pick it up. The gripper is moved horizontally by a motor and also has two limit switches on both ends.

The turntable has a pneumatic piston attached to it for unloading and saw at its 12 o'clock position. The turntable moves a workpiece unloaded onto it to the saw or the conveyor belt by turning. It has three position switches, one at which the table faces towards the gripper, one at the saw and one at the conveyour station. The saw can be activated to manipulate a workpiece underneth. When facing to the conveyor belt, a workpiece can be unloaded with the pneumatic piston.

The conveyor belt is located at the end of the multi processing station. It can move a workpiece towards the next part of the factory. It is equipped with a lightbarrier at its end, to know when a workpiece is leaving this station.

The exact procedure at the individual stations is described in the following subtasks. The *Pipelining* principle is to be implemented in the later implementation of the multi processing stations control. This means that several workpieces can be processed or transported in parallel in the different stations. There can be a *maximum one workpiece* per station.

Exercise 1 Piplining Interface

The stations work piplined, they therefore need an interface to communicate their status with other stations.

Think about what signals are needed to synchronise the transport of workpieces between stations.
Create a new data type called **StationInterface** that can be used in all stations and therefore contains all information for synchronisation. You can create a new data type by selecting "**SIM-PLC/PLC data types/Add new data type"** in the project tree. Create all necessary signals as data type Bool.

When implementing the individual substations, you can now use this interface by creating a signal with the data type **StationInterface** as the input of the block for the previous station and for the following station, as well as an output signal for the station to be implemented itself.

You can access a function blocks output signals by its DB followed by the signal. For example *"Oven_DB".interface* accesses the output signal *"interface"* of the functionblock *"Oven"*.

Keep in mind that the first and last substations also have a predecessor and successor station, though their functionality will not be implemented directly in this exercise.

Exercise 2 Station Control

As preparation you should watch this video to better understand the processing inside the multi processing station:
https://youtu.be/P4K4ioASgUg

In this task, you should implement the various substations of the multi processing station one by one, using the interface you have created earlier. You can run and test the substations by calling the created function blocks in **MPS_Control** and using the SIMIT simulation (see exercise 3). The sequence controls of the individual stations must be implemented in **GRAPH**. The implementation language of their states is up to you.
In the initial step, all stations are moved to their initial position and then all actuators are switched off, if possible.

(a) Control - Oven

The initial position of the oven is reached when the tray has moved back to the gripper **(S6)**. The oven door must be kept open **(V3)** so that the tray can be moved through **(M4)** and remain in the initial position. If the placing of a workpiece in the initial position is detected, the tray has to be moved into the oven **(S5)**. The oven door has to be closed behind it and the heater **(LED1)** has to be switched on for 5 seconds. When the workpiece has finished heating, it needs to be moved outside and held ready for pick-up. If it has been picked, the program cycle should be started again.

(b) Control - Gripper

The initial position of the gripper is at the turntable **(S4)**. Whenever the gripper is moved, it must be retracted **(V2)** so that it does not bump into anything. When the gripper is signalled that a workpiece is ready to be picked up from the oven, it moves there **(S7)** and grips the workpiece by lowering it and then activating the vacuum gripper **(V1)**. The lowering and gripping takes two seconds each. Once the workpiece has been gripped, the gripper moves to the turntable and places it there. To do this, the gripper must first be lowered **(V2)** and then deactivated **(V1)**. The process starts again from the beginning after the workpiece has been successfully deposited.

(c) Control - Turntable and saw

The initial position of the turntable is facing in the direction of the gripper **(S1)**. When a workpiece is placed on the turntable, it moves **(M1)** to the saw **(S3)**, which has to process the workpiece for 3 seconds before it is moved to the conveyor belt **(S2)**. If the turntable is facing the conveyor belt and it is not loaded, the pneumatic piston **(V4)** pushes the workpiece onto the conveyor belt. The extending of the piston takes 2 seconds. If the workpiece has been transferred successfully, this station also starts again from the beginning.

(d) Control - Conveyor station

The conveyor belt has reached its starting position as soon as no workpiece is lying on it **(L1)**. If the loading of a workpiece is detected, it is transported to the light barrier at the exit **(L1)**. There it waits until the next station (not implemented here, but the interface must exist) is no longer occupied, before the conveyor belt is activated for 3 seconds to continue transportation.

Exercise 3 Simulation

Simulate your PLC programme in SIMIT. Check that all stations are working and that the whole plant can be filled with workpieces by not removing the workpiece at the exit of the conveyor. Make sure that the processing of all workpieces works when, after filling the plant, the workpieces are removed piece by piece at the exit of the conveyor station.

At the beginning of the simulation, there are no workpieces in the plant and all stations start at a random position. After the oven has reached its starting position, you can put a randomly coloured workpiece into the system by pressing the Put button. This interrupts the light barrier **L2**. When a workpiece is processed completely and is ready for further transport in the light barrier of the conveyor belt, it can be removed by pressing the Take button. This means that **L1** is no longer interrupted and the station after the conveyor station signals its readiness.

In the TIA Portal template, the two variables Start and End are given in the MPS_Control-FB. They are to be used to simulate the predecessor and successor stations of the oven and the conveyor belt.

In contrast to the previous task sheet, the simulation is computed on the PLC itself to minimise waiting times when starting the SIMIT simulation. You can reset the simulation by stopping and restarting the PLC in online mode. This requires, that the reset switch in SIMIT is switched on before the PLC is stopped. The reset switch must be switched off again after starting the PLC. It is still possible to reset the simulation by pressing the Play and Stop buttons in SIMIT.