Task 3: Completion of a Digital Twin

1. Educational objective

In this lab task, you shall gain practical experience with the creation of digital twins in Siemens Mechatronics Concept Designer (MCD). The created digital twin shall be part of a complete digital twin of a sorting plant and will be tested at the end of the lab with virtual commissioning using the software-in-the-loop method.

2. System description

The main part of the digital twin of the Sorting Plant for this task is already implemented in Mechatronics Concept Designer. It is the same model of a Sorting Plant, which you used for the virtual commissioning in lab task 1. However, the model is not complete. In the digital twin, the thrust cylinder that pushes the cylinder workpieces of the conveyer is missing.
Your task is to add the thrust cylinder together with its limit switches and its kinematics to the digital twin. You start by creating the static model and afterwards you shall create the dynamic model. Then you have to create the signals and map the signals to the signals of the PLC program running in PLCSim advanced. You shall validate your model with the virtual commissioning including the simulation of the Sorting Plant in MCD, the simulation of the PLC in PLCSim Advanced and the simulation of the HMI in the WinCC Advanced simulator as you did in Lab task1.

The lab is based on a workshop that Mr. Webert (and I) developed for Siemens and we will use the original Siemens documents created by Mr. Webert. However, these documents show the creation process for the complete Sorting Plant model, and **you only need the parts for the creation and integration of the thrust cylinder and for the creation and mapping of the additional signals**.

3. Preparation for this lab task

- Work through this document.
- Work through the following chapters in document "sce-150-004-mcd-tia-com-digital-twin-at-education-static-model-nx-hs-darmstadt-1219-en.pdf" thoroughly:
  - chapter 4 "Theory",
  - chapter 5 "Task",
  - introduction (page 17) of chapter 7 "Structured step-by-step instructions",
  - chapter 7.1 "Section: Creating a model",
  - chapter 7.1.1 "Section: Creating a sketch",
  - chapter 7.1.6 "Modeling the base of the thrust cylinder" (and chapter 7.1.2),
  - chapter 7.1.7 "Modeling of the head of the thrust cylinder" and
  - chapter 7.1.9 "Modeling the limit switch for the thrust cylinder",
  - introduction of chapter 7.2 (page 60),
  - chapter 7.2.6 "Inserting and positioning the thrust cylinder" (and chapter 7.2.2) and
  - chapter 7.2.11 "Inserting and positioning the limit switches" (and chapter 7.2.9).

- Work through the following chapters in document “sce-150-005-mcd-tia-com-digital-twin-at-education-dynamic-model-mcd-hs-darmstadt-0120-en.pdf” thoroughly:
  - chapter 4 “Theory”,
  - chapter 5 “Task”,
  - introduction of chapter 7 “Structured step-by-step instructions”,
  - chapter 7.2 “Definition of rigid bodies”,
  - chapter 7.3 “Specifying the fixed joints”,
  - chapter 7.4.5 “Creating collision bodies for the ejector head” (and chapter 7.4.1),
  - chapter 7.5 “Definition of a sliding joint for the ejector”,
  - chapter 7.6 “Position control for ejector” and
  - chapter 7.9 “Collision sensors for the light sensors and limit switches”.

- Work through the following chapters in the document “sce-150-006-mcd-tia-com-digital-twin-at-education-signal-mapping-mcd-hs-darmstadt-0220-en.pdf” thoroughly:
  - chapter 1 “Goal”,
  - chapter 4 “Theory”,
  - chapter 5 “Task”,
  - introduction of chapter 7 “Structured step-by-step instructions”,
  - chapter 7.1 where you should concentrate on
    - the “Section: Creation and connection of signals with the signal apapter”,
    - the paragraphs starting with the descriptions for the parameters “csLimitSwitchCylinderNotExtended", "csLimitSwitch CylinderRetracted", "pcCylinderHeadExtend" and "pcCylinderHeadRetract" on pages 21 and 22 and
    - on pages 26 to 29.
  - section 7.2 and
  - chapter 7.3.

4. <u>Lab execution</u>

The lab takes place in presence at the university in room D11 / 0.74.
You will work in the lab in groups of three to which you were assigned during lab scheduling. Because you are using expensive professional industrial software for which there are no free or low-cost student licenses, you cannot do the lab at home.

On the Lab-PC you are working in a virtual machine and it is a good idea to use the full screen mode for this VM, if it is not already in this mode. On the desktop of the VM you will find the icons to start “TIA Portal”, “S7-PLCSIM Advanced” and “Mechatronics Concept Designer”.

In this lab, it is especially important to work in a team with distributed tasks. The documentation typically first describes the general process for the following design step, which applies to all subsequent components, and then describes the parameters for the design step for the individual components. One way of dividing the team would therefore be, for example, that one person operates the software MCD, one person is responsible for the general process and the third for the special parameters. This would mean that one of you operates the Mechatronics Concept Designer via AnyDesk. Another team member could have the general description, etc. chapter 7.11 "Section: Creating a sketch" in the documentation in front of her/him and give the general instructions for the individual steps. The third team member can have the component-specific part in front of her/him, e.g. 7.1.6 "Modeling the base of the thrust cylinder" and can give the values of the individual parameters.

On the VM you will find the folder C:\I40_IIoT\I40_IIoT_Lab3. In this folder, you will find a zipped file "DigitalTwinLab3_NX_MCD.zip" with the incomplete model of the plant, which you are to complete in this lab task. Additionally you will find a compressed TIA projects in this folder “DigitalTwinLab_VirtComm_TIA”, which you shall use for the virtual commissioning at the end of this lab task.

5. Subtasks in this lab task

Start the creation of the model of the thrust cylinder by following the steps of “Section: Creating a model”. To start the Mechatronics Concept Designer double click on the icon on the desktop. Do **not** open the already existing incomplete model in DigitalTwinLab3_NX_MCD now, but create a new model for the base of the thrust cylinder.

a) Then create the static 3D model of the thrust cylinder according to sections 7.1.1 to 7.1.9 of the first document. When creating all these models, the model assSortingPlant must **not** be loaded!

   Afterwards, switch back to windows and extract "DigitalTwinLab3_NX_MCD.zip" (in the windows file explorer right click on the file name and choose “Extract All …” from the context menu) to the folder C:\I40_IIoT\I40_IIoT_Lab3\Group_X (replace X with your group letter). Switch back to the Mechatronics Concept Designer and open assSortingPlant from the GroupX\DigitalTwinLab3_NX_MCD folder. To load only the relevant data of the digital twin, make sure in the options of the open window that the file is only "partially loaded". You should then see the conveyer system including the boxes, workpieces and light sensors but without the thrust cylinder. Then insert and position the modelled cylinder and the limit switches of step 1 into the model assSortingPlant according to chapters 7.2.6 and 7.2.11 of the first document.
   Since the model already contains signals mapped to PLC signals, you must first activate Disconnect in the MCD (select drop down menu of Signal Mapping and click on disconnect) before starting the simulation in MCD, as otherwise MCD will report a runtime error (e.g. “No instances are registered” or that it cannot connect to the signals). While Disconnect is active, MCD does not have any access to the signals of PLCSIM Advanced. Take into account, however, that the Disconnect function is valid until you have clicked on Disconnect again.
   Test the model by starting the simulation in MCD.

b) In the second part of this lab task, you shall create the dynamic 3D model of the thrust cylinder based on the static 3D model from part a) in according to the chapters of the documentation named in the preparation section of this document. Test the model by starting the simulation in MCD from time to time as mentioned in the documentation.

c) In the third part of this lab task, you shall first add the missing signals for the thrust cylinder to the already existing signal adapter saSortingPlan and the already existing symbol table stSortingPlant (**do not create a new signal adapter or a new symbol table** but use the already existing ones!). Start by opening the signal adapter saSortingPlan with a double click on the name in the Physics Navigator. Add the necessary parameters and the signals. When you enter signals or parameters in the assignments for the formulas make sure you do not have any spaces in front of the assigned signal or parameter.

If you exit the signal adapter with "OK" after adding the missing signals, select the existing symbol table stSortingPlant to add the new signals. Do **not** select "Create new symbol table" here, as indicated in the documentation but choose the already existing symbol table!

Then you shall establish the signal connection between the virtual PLC and the digital twin. Start by opening the TIA Portal (double-click on the icon on the desktop) and retrieve the packed TIA project C:\I40_IIoT\I40_IIoT_Lab3\DigitalTwinLab_VirtComm_TIA into the folder C:\I40_IIoT\I40_IIoT_Lab3\Group_X (replace X with your group letter), as you did in the lab task 2 (execute the menu item Project->Open ... in the TIA Portal). Then proceed according to chapter 7.2 of the third document and map the signals of the MCD model to the signals of the TIA project in MCD.

When you refresh the registered instances in the external signal configuration make sure that before you update the tags of the PLCSIM Advanced Instance you have selected the Area "IO" in the Update Options section of the External Signal Configuration window and then check if you only see Input and Output tags in the lower part of the window (and no tags from data blocks DBs). Afterwards you can click on "Update Tags". Activate "Select All" and confirm this by clicking on "OK".

Before you go on, make sure that Disconnect is no longer active.
Complete this laboratory task with a successful Virtual Commissioning according to chapter 7.3 of the document "sce-150-006-mcd-tia-com-digital-twin-at-education-signal-mapping-mcd-hs-darmstadt-0220-en.pdf" and chapter 7.4 of the first document for lab task 2 "sce-150-001-mcd-tia-com-digital-twin-at-education-virtual-commissioning-hsd-0919-en.pdf".

Please call us at the end of each subtask after your tests have been successful, i.e., after creating the static model (part a)), after testing the kinematic of the thrust cylinder and the test of the position controller and the limit switches in the runtime inspector (part b)), and after the Virtual Commissioning (part c)).