SimaHydTO – Virtual Commissioning with SIMIT and PLCSIM Advanced

TIA V16 / SIMIT 10.3 Upd1 / PLCSIM Advanced V4.0

https://support.industry.siemens.com/cs/ww/en/view/109756217

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1 Introduction

This application example demonstrates possibilities of virtual commissioning using SimaHydTO simulation with SIMIT and SIMATIC S7-PLCSIM Advanced. For this purpose, a template for hydraulic axes was designed and used in the demo project. Goal of the simulation is showing the movement of a hydraulic axis which will be controlled by the SIEMENS SimaHyd Technology Object (*SimaHydTO*) within a SIMATIC S7-1500 PLC. The PLC program for this example was prepared in TIA Portal and virtually commissioned with help of a digital twin created in SIMIT.

The SIMIT simulation software in this application example was used to provide the SimaHydAxis template with following components:

- Visualization of the hydraulic axes
- Simulation of the hydraulic cylinder behavior (simplified)
- Simulation of drives
- Simulation of encoders
- Simulation of IOs for pressure sensors and valves
- Simulation of control panel

1.1 Overview

This application example shows how to use SIMIT for the simulation of hydraulic axes controlled by SimaHydTO and delivers a template to reuse the simulation model in several machines.

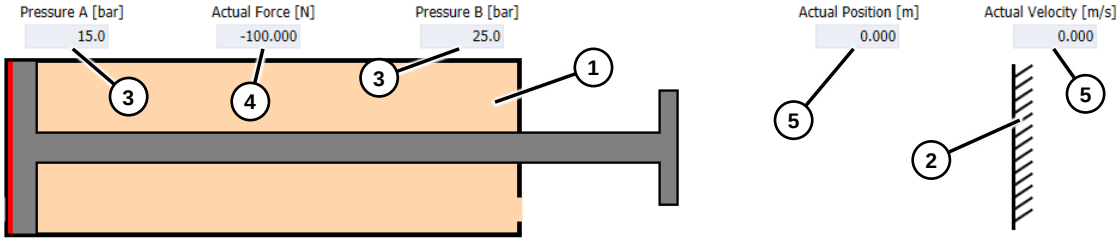
Therefore, following topics are implemented and will be explained in this document:

- Usage of the SIMIT Template
- Hydraulic axis simulation
- Analog input and output simulation
- PROFIdrive telegram 2 simulation
- External encoder simulation
- Operation of the example project

1.2 Simulation model description

A simulated axis consists of a hydraulic cylinder with an optional fixed stop position (see Figure 1-1). The movement of the piston will be shown graphically. There are also simulated and simplified values for pressures in both cylinder cambers which result to a force at the piston.

Figure 1-1 Simulated hydraulic cylinder



(1) Hydraulic cylinder
(2) Optional: Fixed stop
(3) Pressure in both cylinder chambers
(4) Actual force at the piston
(5) Position and speed value of the piston

1.3 Limitations of the simulation model

The simulation model of the hydraulic axis is based on a simple calculation with a PTn-element and an integrator. In this example, movement is not a result of volume flow and pressure. Forces and pressures of the SIMIT model are a result of the motion calculations.

1.4 Components used

This application example has been created with the following software components:

Table 1-1 Software components

Component	Article number
STEP 7 Professional V16 Upd4	6ES7822-1AA06-0YA5
SIMATIC S7-PLCSIM Advanced V4.0 SP1	6ES7823-1FA00-0YA5
SIMIT S V10.3 Upd1	6DL8913-0AK30-0AB5

This application example consists of the following components:

Table 1-2 Components

Component	File name
Documentation	109756217_SIMIT_model_for_SimaHydTO_DOC_v100_en.pdf
SIMIT project	109756217_SIMIT_SimaHydTO_ExampleProject_v100.simarc
STEP 7 project	109756217_SimaHydTO_PROG_SIMITExample_V16_v02.x02.zap16
SIMIT template	SimaHydAxisV100.simtpl

Limitations

The application example does not provide information on the following topics

- Basics of TIA Portal configuration
  https://support.industry.siemens.com/cs/ww/en/view/109773506
- Basics of SIMIT
  https://support.industry.siemens.com/cs/ww/en/view/109780242
- Basics of Virtual Commissioning
  https://support.industry.siemens.com/cs/ww/en/view/109758943

In order to understand this application example, it is assumed that readers have adequate knowledge of these topics.

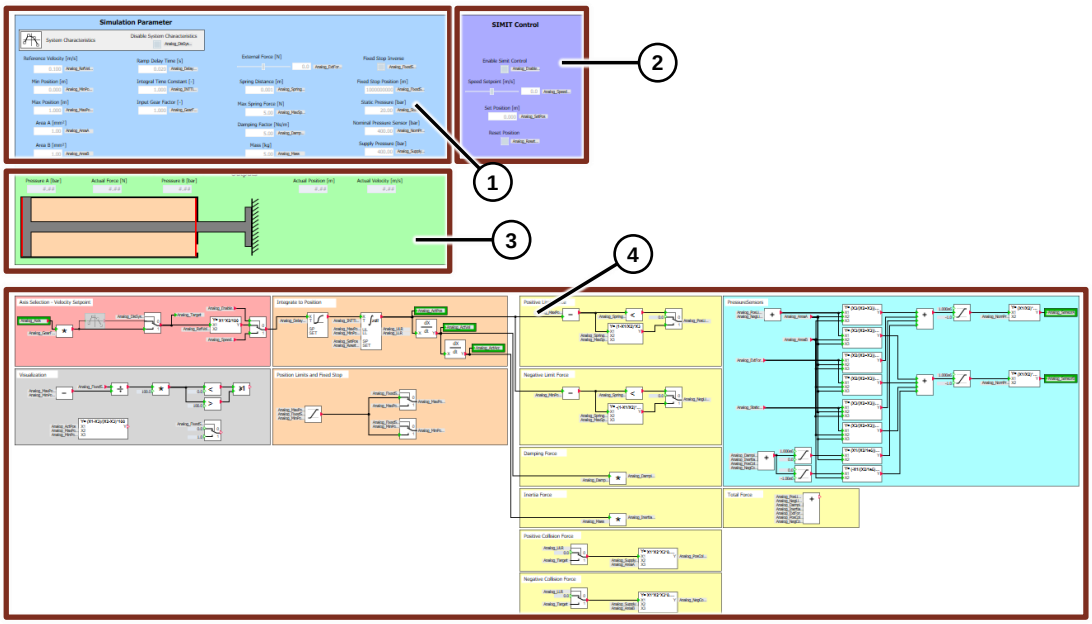
2 SimaHydAxis SIMIT Template

The *SimaHydAxis* template can be integrated in SIMIT as template. Every instantiated *SimaHydAxis* simulates one hydraulic axis without PLC coupling. Depending on the control of the axis, the PLC coupling and drive simulation must be implemented manually.

2.1 SimaHydAxis chart

The *SimaHydAxis* chart includes separated backed areas for different purposes (see Figure 2-1). These contain the user interfaces to parameterize (1) and manually control (2) the simulation model. Additionally, there is a visualization of an exemplary hydraulic cylinder where the simulated motion and pressure values can be monitored (3). Underneath the visualization model of the axis the calculation of the hydraulic axis can be found (4).

Figure 2-1 *SimaHydAxis* simulation chart



(1) Parameterizing the simulation model

(2) Manual control of the hydraulic axis

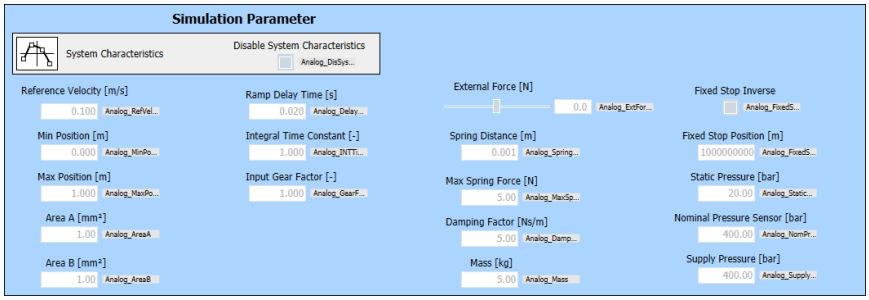
(3) Visualization of the motion and pressure values

(4) Calculation of the simulation model

2.1.1 Parameters

Parameterizing the *SimaHydAxis* is done via the included control panel (see Figure 2-2). Make sure to set the constant values before the start of the simulation to keep them. Adjusted parameters during the simulation will not be kept.

Figure 2-2 Simulation parameters and manual control



The areas *A* and *B* of the cylinder are used for the simulation of the pressure values. If force calculation is needed, make sure to parameterize the areas like in the PLC / HMI.

Forces can be applied to the axis by the slider as an external force or by the damping factor (force dependent on the velocity) and the mass (force dependent on the acceleration).

Additionally, there are springs at the positive and negative hard stops of the cylinder. By selecting their lengths and maximum forces, pressure will be built up when the cylinder is reaching the upper or lower limit.

The static, nominal and supply pressure for the cylinder are part for the pressure and resulting force simulation.

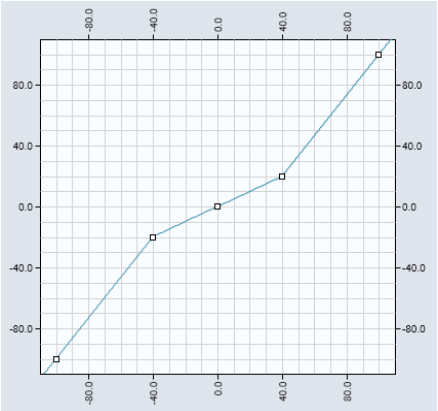
NOTE

Forces and pressures do not have impact on the movement of the hydraulic axis. In this simulation, they are a result of the axis motion.

It is also possible to simulate a hard stop of the cylinder by selecting a position value which is in range of the cylinder stroke. The hard stop can be prepared for both movement directions.

Manipulating the valve characteristic can be done via the *Parameters* of the “diagram block” (see Figure 2-3). The valve characteristic defines the ratio between analog input and volume flow output of the valve. This valve characteristic depends on the selected hydraulic valve and must be respected by the PLC control logic.

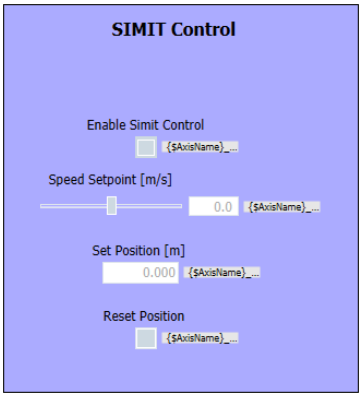
Figure 2-3 Valve characteristics



2.1.2 Manual Control

Take over control of the simulation model with the *SIMIT Control* panel as seen in Figure 2-4.

Figure 2-4 SIMIT Control

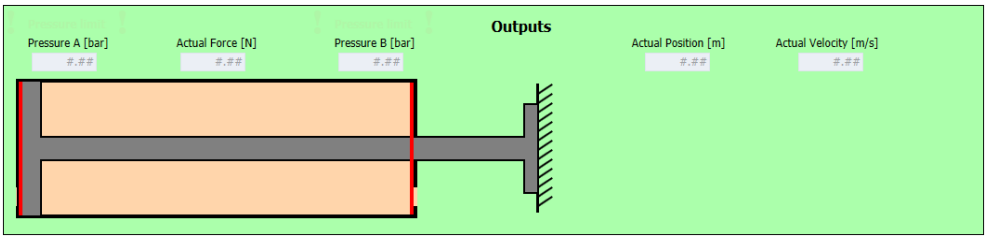


Enabling the simit control and setting the *Speed Setpoint* will ignore the incoming setpoint of the connected actor. Resetting the position to the desired value can be done without enabling SIMIT Control.

2.1.3 Visualization of the hydraulic axis

The resulting movement of the axis will be visualized in the *Outputs* area of the *SimaHydAxis* chart (see Figure 2-5). Pressures and motion values will also be displayed.

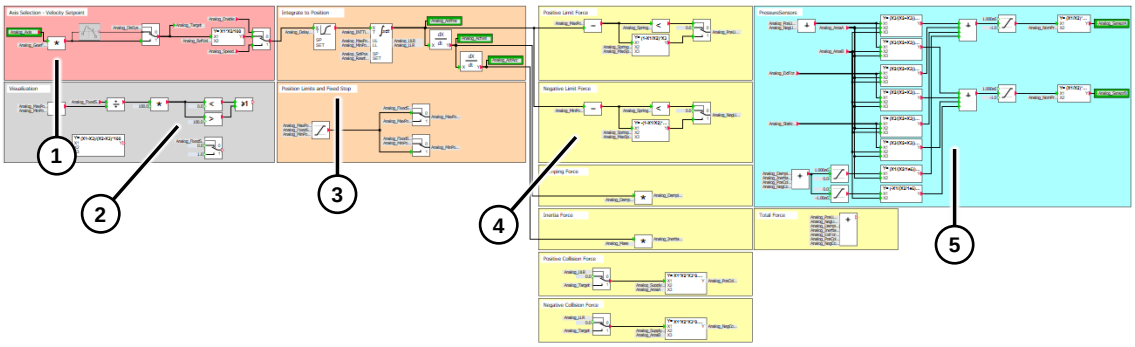
Figure 2-5 Outputs



2.1.4 Calculation of the hydraulic axis

The calculation model of the hydraulic axis is separated in blocks with different colored backgrounds (see Figure 4-1).

Figure 2-6 Overview of the calculation of the hydraulic axis



(1) Red

Axis velocity setpoint with integrated valve characteristics

(2) Grey

Calculations for the visualization

(3) Orange

Axis position determination with position limits and fixed stop calculation for resulting motion values

(4) Yellow

Forces calculations

(5) Blue

Conversion from forces to pressures

All calculation blocks are part of the *STANDARD* component-library of SIMIT and adjustments of the calculation can be made.

Connectors which are used outside the chart are backed with green color. These include the input of the velocity setpoint and the outputs of the resulting position, velocity and acceleration and the pressure values for both chambers.

2.2 Instantiating the template

The *SimaHydAxis* template can be integrated in SIMIT as a *user template* in the *Templates* task-card and then be instantiated in the project. Check the SIMIT documentation for more information and how to integrate new templates \4\.

2.2.1 Instantiating a single axis

To instantiate the axis template, simply drag and drop the *SimaHydAxis* template in SIMIT from the *User templates* to the desired folder in the project (see Figure 2-7). It is necessary to instantiate the axis with a unique name (see Figure 2-8).

NOTE It is necessary to close the template chart before dragging and dropping it to the SIMIT project.

Figure 2-7 Drag and drop the template to a project folder

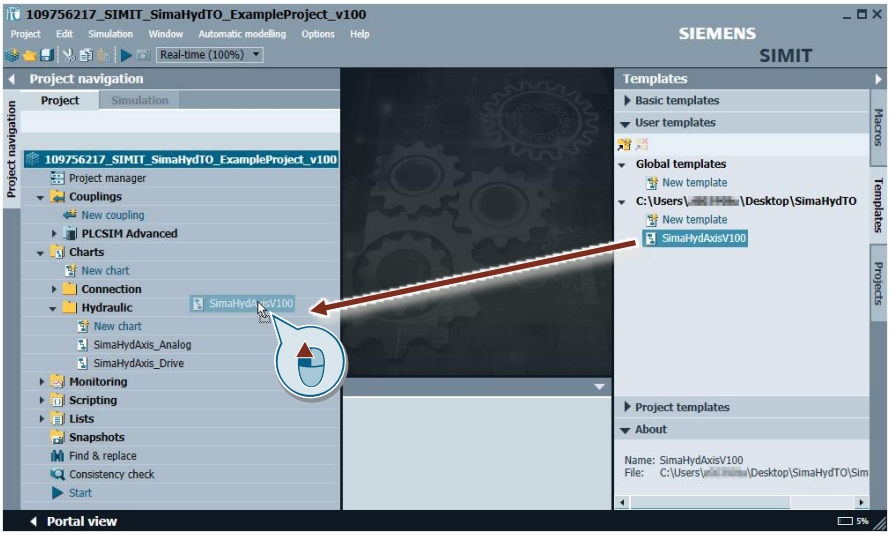
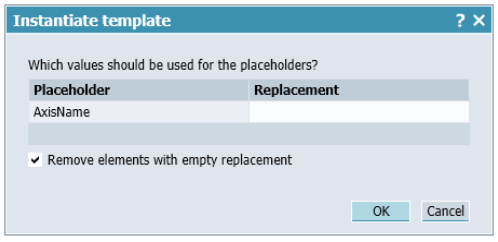


Figure 2-8 Instantiating templates with a unique name

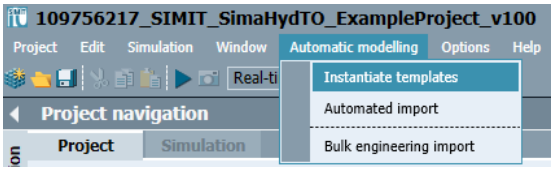


All placeholders *{$AxisName}* will be replaced with the chosen replacement name.

2.2.2 Instantiating multiple axes

Instantiate multiple axes at once with the *Instantiate template* function of SIMIT (see Figure 2-9). Follow the rules for instantiating which are described in the SIMIT manual \4\.

Figure 2-9 Automatic modeling and instantiating templates



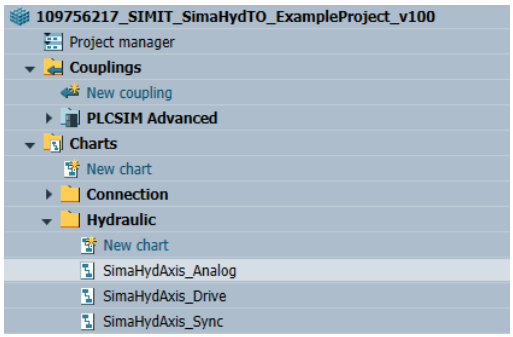
An example of a table for the import is shown below (see Table 2-1).

Table 2-1 Table for the automatic modelling process

HIERARCHY	TEMPLATE	CHART	AxisName
Hydraulic	\SimaHydAxis	SimaHydAxis_Analog	Analog
Hydraulic	\SimaHydAxis	SimaHydAxis_Drive	Drive
Hydraulic	\SimaHydAxis	SimaHydAxis_Sync	Sync

The import is resulting in a SIMIT project tree with the three axes (see Figure 2-10).

Figure 2-10 Resulting multiple instances



3 Example Project

Depending on the simulation purpose it can be useful to simulate the behavior of the hydraulic axes either in the PLC or in SIMIT.

There are additional simulation function blocks in the original *SimaHydTO* project (*109756217_SimaHydTO_DOC_v2.0_en.docx*) included to simulate the behavior of the axes in a simplified way. Functional standalone tests can be done \7\.

For more advanced simulations, it is recommended to use SIMIT to simulate the behavior of the axes and sensors. The original hardware interface will be used for the coupling and the simulated components can be integrated in a simulation for a whole machine without changing the PLC program. Additionally, the PLC will not be loaded by the simulation function blocks and there will be an additional visualization to animate the simulated component. Furthermore, the hydraulic axis can be visualized in a 3D simulation as NX MCD.

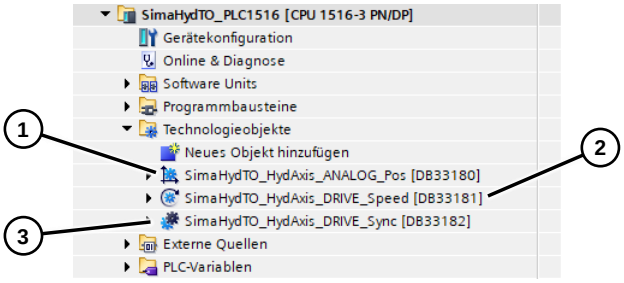
3.1 TIA Portal

The TIA project for this simulation example does not include simulation function blocks in the PLC. Changing from PLC internal simulation of the hydraulic axes to the SIMIT simulation using the *SimaHydAxis* template is described in chapter 5 Optional: TIA program changes.

3.1.1 Setup

This project includes three different technology objects (see Figure 3-1) to show the use of the SimaHyd PLC template.

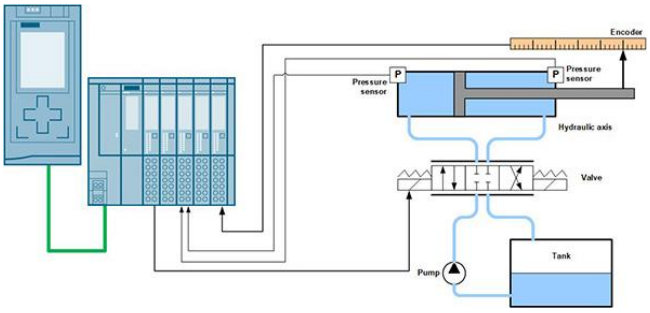
Figure 3-1 SimaHyd technology objects



(1) Positioning axis
(2) Speed axis
(3) Synchronization axis

As well as the positioning axis (1), the synchronization axis (3) is using an encoder at the hydraulic axis (see Figure 3-2). Both axes can be position controlled. However, the speed axis (2) is speed controlled without an encoder.

Figure 3-2 Running a hydraulic axis on a SIMATIC S7-1500(T)



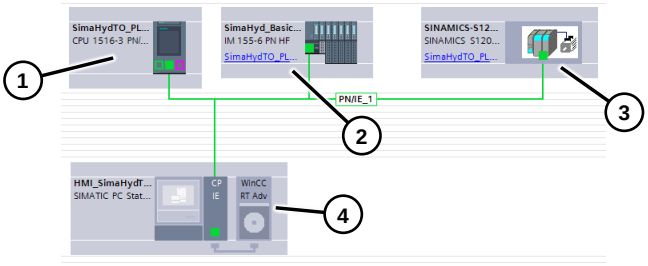
Due to the differences between the three axis types, there are different signal types used:

- The position-controlled axis (1) uses an analog value to control the valve while the pump is running constantly. Feedback from the encoder and the pressure sensors is being sent to the PLC.
- The speed axis (2) uses drive telegram 2 to set the speed value of the pump while there is no control of the valve to move the axis. The only feedback is coming from both pressure sensors.
- The synchronization axis (3) uses drive telegram 2 to control the pump speed. Via encoder and both pressure sensors, the PLC is getting feedback from the axis.

3.1.2 Hardware configuration

Following the hardware configuration of the TIA project is described (see Figure 3-3).

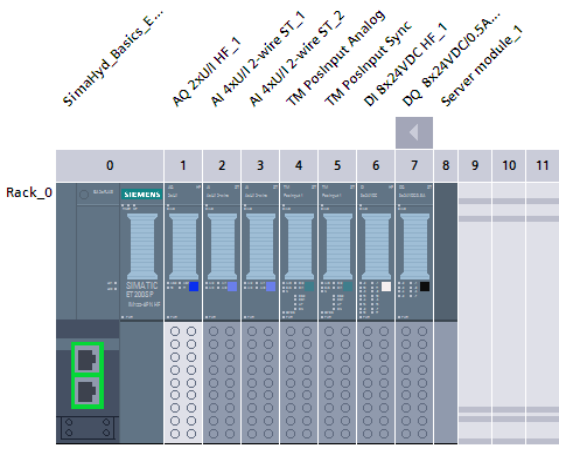
Figure 3-3 Hardware configuration



(1) SIMATIC CPU 1516-3 PN/DP (6ES7 516-3AN01-0AB0)
(2) SIMATIC ET200SP IM 155-6PN HF (6ES7 155-6AU00-0CN0)
(3) SINAMICS S120 CU310-2 PN V5.2 (6SL3 040-1LA01-0AA0)
(4) SIMATIC PC Station (WinCC RT Adv)

The decentralized periphery ET200SP is supplied with numerous submodules (see Figure 3-4).

Figure 3-4 SIMATIC ET200SP



- *AQ 2xU/I HF*

  Analog output for controlling the valve of the positioning axis
- *AI 4xU/I 2-wire ST_1*

  Analog inputs for pressure sensors of the positioning and speed axis
- *AI 4xU/I 2-wire ST_2*

  Analog inputs for both pressure sensors of the synchronization axis
- *TM PosInput Analog*

  Telegram 83 communication for the encoder of the positioning axis
- *TM PosInput Sync*

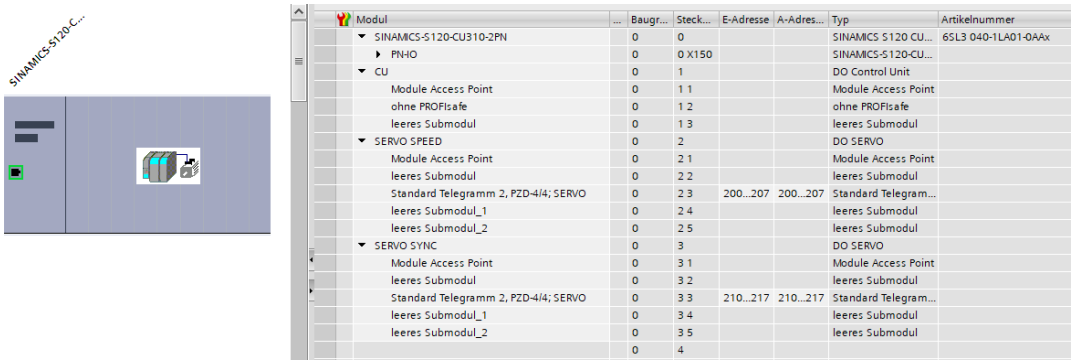
  Telegram 83 communication for the encoder of the synchronization axis
- *DI 8x24VDC HF_1*

  Reserved
- *DQ 8x24VDC/0.5A ST_1*

  Reserved

Within the SINAMICS module both drive ‘telegram 2’ submodules are projected for the speed and the synchronization axis (see Figure 3-5).

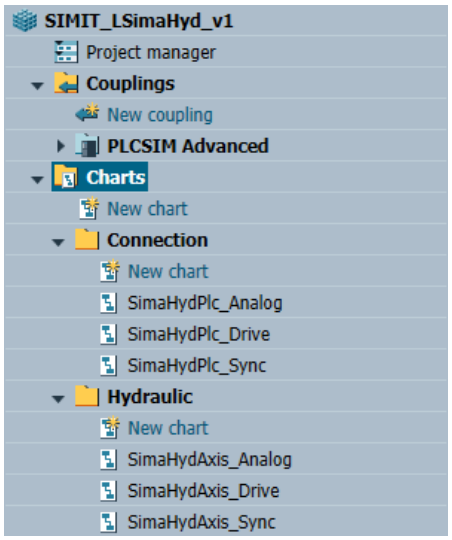
Figure 3-5 SINAMICS S120 CU310-2 PN V5.2



3.2 SIMIT

Within SIMIT there are the three axes simulated with corresponding PLC couplings (see the project structure in Figure 3-6).

Figure 3-6 SIMIT project structure



The project is divided in the folder *Hydraulic* and *Connection*.

Hydraulic

Hydraulic includes the simulation model for three kinds of hydraulic cylinders (see 3.1.1 Setup). These were instantiated from the template as described in chapter 2.2 Instantiating the template.

Connection

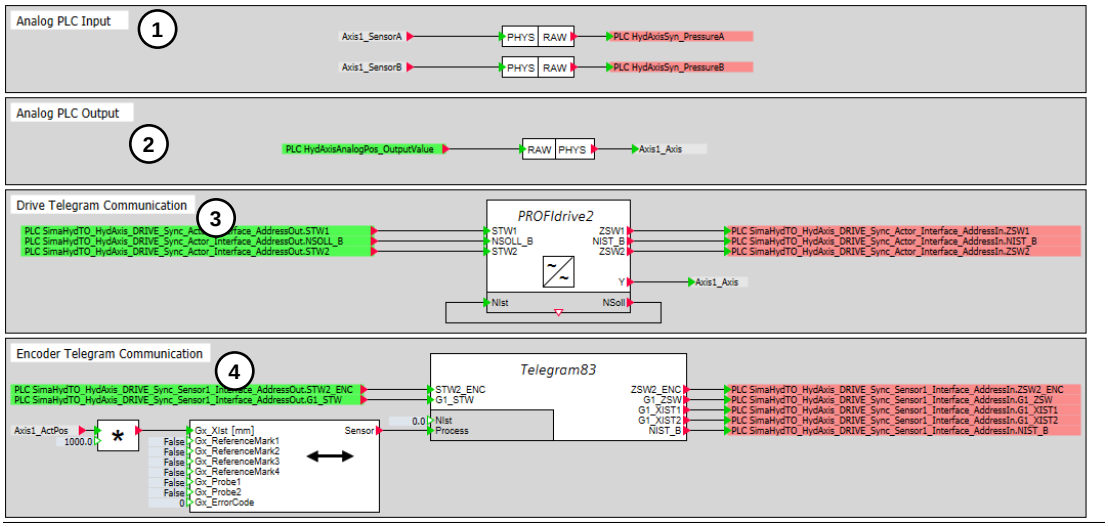
Connection contains the model blocks for PLC communication which are linked to the existing PLC coupling and to the hydraulic axes.

See the examples for a PLC coupling below in Figure 3-7. Besides analog inputs with scaling for pressure sensors (1), there also is an analog output with scaling for valve controls (2). The drive telegram 2 communication only uses one *PROFIdrive2* block from the *STANDARD* library (3) and the encoder telegram 83 communication (4) is used for the linear external encoder located at the linear hydraulic axis.

In the example, following communication blocks were used for the different axes:

- The analog (positioning) axis is implemented with both analog in- and outputs (1) (2) and a telegram 83 for the encoder (4).
- The speed (drive) axis is using analog inputs for the pressure sensors (1) and drive telegram 2 (3).
- The sync (synchronization) axis is built with analog inputs (1), drive telegram 2 communication (3) and an external encoder (4).

Figure 3-7 Chart with an example of all used PLC couplings



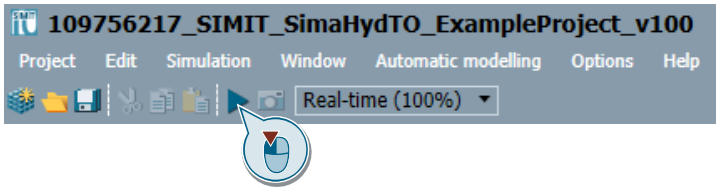
(1) Analog PLC Inputs
(2) Analog PLC Outputs
(3) Drive Telegram 2 Communication
(4) Encoder Telegram 83 Communication

4 Operating the hydraulic axes

4.1 Starting the simulation

The simulation will be started by clicking on the “Start/Play” button (see Figure 4-1). An orange background indicates that the simulation is active. The SIMATIC S7-PLCSIM Advanced instance is automatically started in the background. To see the instance, please additionally start SIMATIC S7-PLCSIM Advanced. After the simulation is started, it is possible to download the TIA project. This is not inevitably necessary since the memory card of the SIMATIC S7-PLCSIM Advanced instance will be saved within the SIMIT project.

Figure 4-1 Starting the simulation



Make sure to also start the HMI simulation from the TIA Project to control and parameterize the hydraulic axes.

4.2 Moving the cylinder

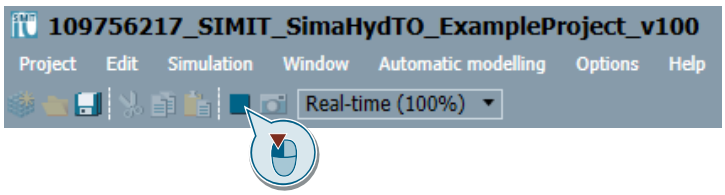
Use the HMI to move the cylinders just like it is described in the *SimaHydTO* documentation /7/.

Operating the axes will be just the same as it is with the PLC integrated simulation function blocks.

4.3 Stopping the simulation

Stop the simulation with the “Stop” button (see Figure 4-2).

Figure 4-2 Stopping the simulation



5 Optional: TIA program changes

NOTE

The TIA project of this example does not include the PLC internal simulation function blocks of the hydraulic axes. The following chapter describes which changes are necessary to change from the PLC internal axis simulation of the original SimaHydTO TIA project (*109756217_SimaHydTO_V16_v02.02_2022 0324_1719.zap16*) to the TIA project of this example with the SIMIT simulation.

Using SIMIT to simulate the axes requires deactivating the PLC-internal simulation FBs and rewiring the necessary In- and Outputs to the ones added to the hardware configuration. This is done in MC-Post Servo [OB95]. An example for one of the three axes (for the synchronization axis) is shown below in Figure 5-1 and Figure 5-2.

Figure 5-1 Rewiring the PLC inputs of the pressure sensors at the call of the hydraulic axis

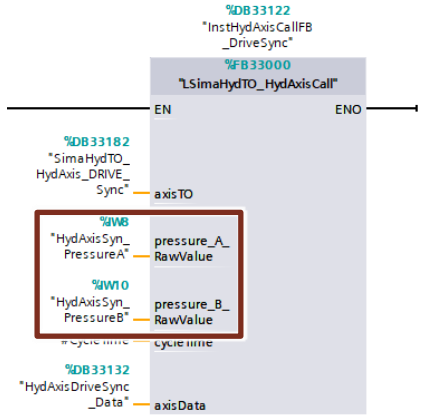
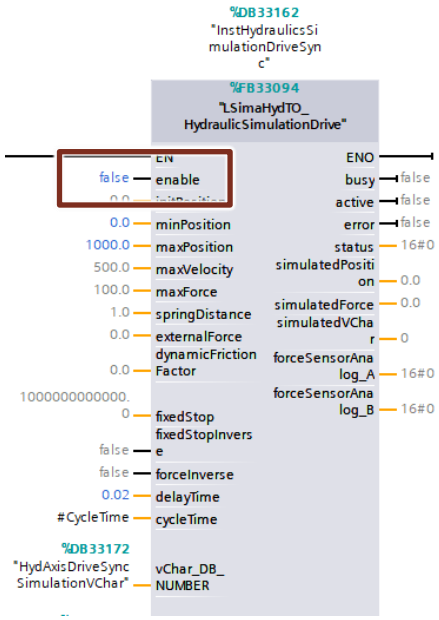
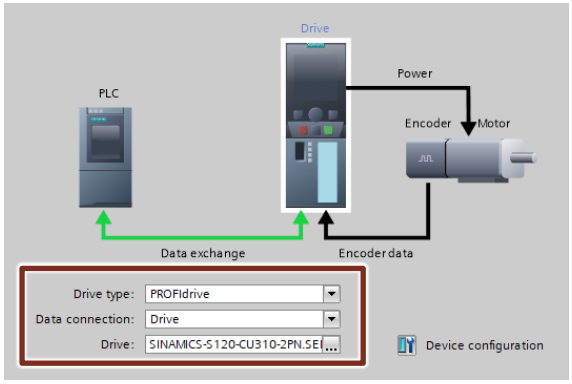


Figure 5-2 Deactivating the simulation FB of the synchronization axis



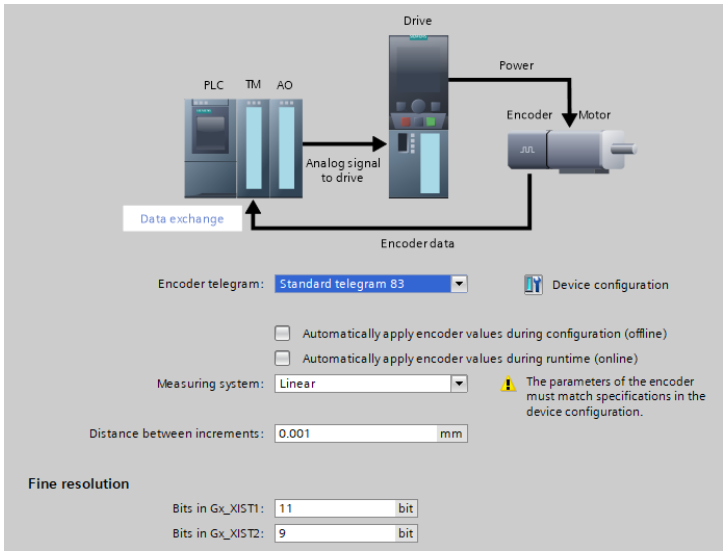
Aside from that there are also changes needed in the technology objects itself (see Figure 5-3). The hardware-interface must be changed from the DBs to the drives and the encoders which are already projected and prepared in the hardware configuration (see 3.1.2 Hardware configuration).

Figure 5-3 Drive Technology Object Setup



Make sure that the encoders are set up correctly (see Figure 5-4). If the hardware-interface is changed from the DB to the encoder, the *Fine resolution* setup is lost in most cases. Set *Gx_XIST1* to 11 and *Gx_IST2* to 9. Deselect the automatically applied encoder values.

Figure 5-4 Setup - Data exchange with encoder



Compile the project to make sure there are no errors in the PLC project after adjusting the parameters.

6 Appendix

6.1 Service and support

Industry Online Support

Do you have any questions or need assistance?

Siemens Industry Online Support offers round the clock access to our entire service and support know-how and portfolio.

The Industry Online Support is the central address for information about our products, solutions and services.

Product information, manuals, downloads, FAQs, application examples and videos – all information is accessible with just a few mouse clicks:

support.industry.siemens.com

Technical Support

The Technical Support of Siemens Industry provides you fast and competent support regarding all technical queries with numerous tailor-made offers – ranging from basic support to individual support contracts.

Please send queries to Technical Support via Web form:

siemens.com/SupportRequest

SITRAIN – Digital Industry Academy

We support you with our globally available training courses for industry with practical experience, innovative learning methods and a concept that's tailored to the customer's specific needs.

For more information on our offered trainings and courses, as well as their locations and dates, refer to our web page:

siemens.com/sitrain

Service offer

Our range of services includes the following:

- Plant data services
- Spare parts services
- Repair services
- On-site and maintenance services
- Retrofitting and modernization services
- Service programs and contracts

You can find detailed information on our range of services in the service catalog web page:

support.industry.siemens.com/cs/sc

Industry Online Support app

You will receive optimum support wherever you are with the "Siemens Industry Online Support" APP. The app is available for iOS and Android:

support.industry.siemens.com/cs/ww/en/sc/2067

6.2 Industry Mall

The Siemens Industry Mall is the platform on which the entire siemens Industry product portfolio is accessible. From the selection of products to the order and the delivery tracking, the Industry Mall enables the complete purchasing processing – directly and independently of time and location:
mall.industry.siemens.com

6.3 Application support

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6.4 Links and literature

Table 6-1

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to this entry page of this application example https://support.industry.siemens.com/cs/ww/en/view/109756217
\3\	Basics of TIA Portal configuration https://support.industry.siemens.com/cs/ww/en/view/109773506
\4\	Basics of SIMIT https://support.industry.siemens.com/cs/ww/en/view/109801804
\5\	Basics of Virtual Commissioning https://support.industry.siemens.com/cs/ww/en/view/109758943
\6\	DRIVES Behavior Library for SIMIT https://support.industry.siemens.com/cs/ww/en/view/109761007
\7\	SIMATIC S7-1500(T): "LSimaHydTO" for hydraulic applications and hydraulic presses https://support.industry.siemens.com/cs/document/109756217

6.5 Change documentation

Table 6-2

Version	Date	Modifications
V1.0	03/2022	First version