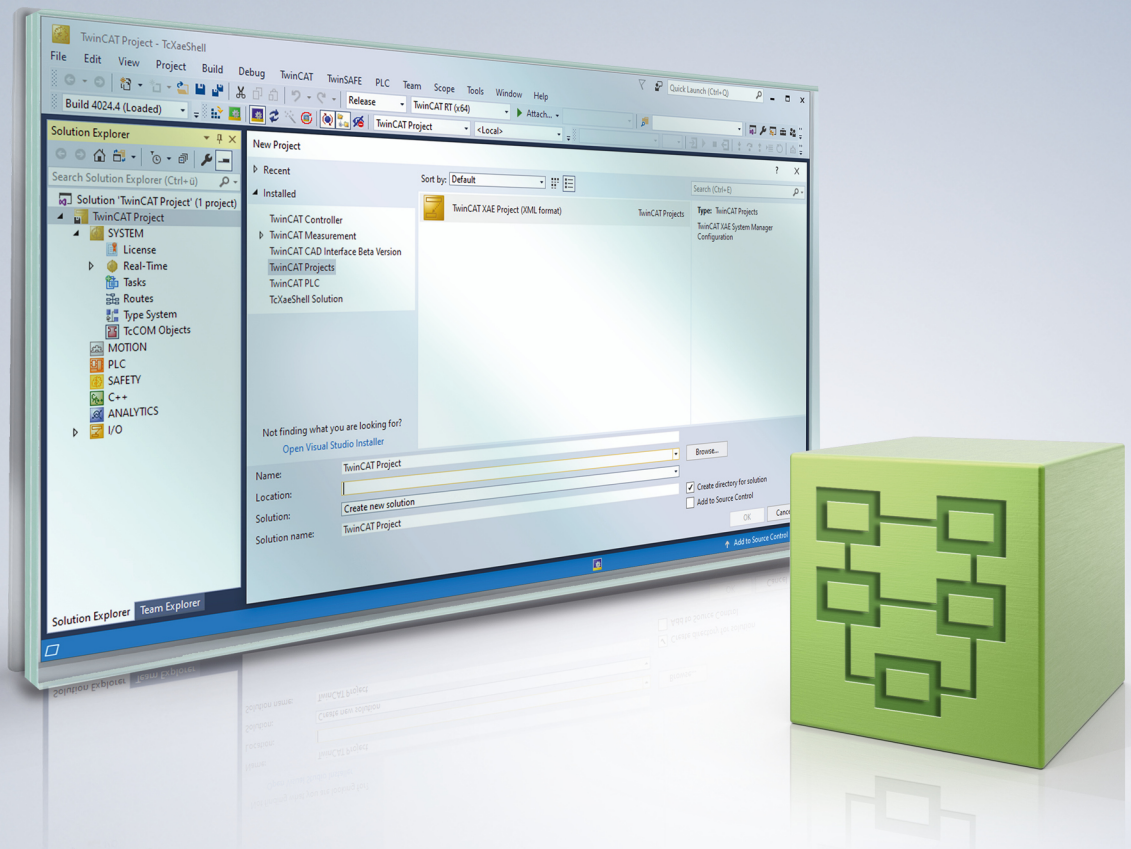
BECKHOFF New Automation Technology

Manual | EN

TE1421

TwinCAT 3 | Simulation Runtime for FMI



2024-08-09 | Version: 1.0.0

Table of contents

1 Foreword

1.1 Notes on the documentation

This description is intended exclusively for trained specialists in control and automation technology who are familiar with the applicable national standards.
For installation and commissioning of the components, it is absolutely necessary to observe the documentation and the following notes and explanations.
The qualified personnel is obliged to always use the currently valid documentation.

The responsible staff must ensure that the application or use of the products described satisfies all requirements for safety, including all the relevant laws, regulations, guidelines, and standards.

Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.
We reserve the right to revise and change the documentation at any time and without notice.
No claims to modify products that have already been supplied may be made on the basis of the data, diagrams, and descriptions in this documentation.

Trademarks

Beckhoff®, TwinCAT®, TwinCAT/BSD®, TC/BSD®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, Safety over EtherCAT®, TwinSAFE®, XFC®, XTS® and XPlanar® are registered and licensed trademarks of Beckhoff Automation GmbH.
If third parties make use of designations or trademarks used in this publication for their own purposes, this could infringe upon the rights of the owners of the said designations.

Patents

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents:
EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702
and similar applications and registrations in several other countries.

EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany

Copyright

1.2 For your safety

Safety regulations

Read the following explanations for your safety.
Always observe and follow product-specific safety instructions, which you may find at the appropriate places in this document.

Exclusion of liability

All the components are supplied in particular hardware and software configurations which are appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

Personnel qualification

This description is only intended for trained specialists in control, automation, and drive technology who are familiar with the applicable national standards.

Signal words

The signal words used in the documentation are classified below. In order to prevent injury and damage to persons and property, read and follow the safety and warning notices.

Personal injury warnings

⚠ DANGER

Hazard with high risk of death or serious injury.

⚠ WARNING

Hazard with medium risk of death or serious injury.

⚠ CAUTION

There is a low-risk hazard that could result in medium or minor injury.

Warning of damage to property or environment

NOTICE

The environment, equipment, or data may be damaged.

Information on handling the product

This information includes, for example:
recommendations for action, assistance or further information on the product.

1.3 Notes on information security

The products of Beckhoff Automation GmbH & Co. KG (Beckhoff), insofar as they can be accessed online, are equipped with security functions that support the secure operation of plants, systems, machines and networks. Despite the security functions, the creation, implementation and constant updating of a holistic security concept for the operation are necessary to protect the respective plant, system, machine and networks against cyber threats. The products sold by Beckhoff are only part of the overall security concept. The customer is responsible for preventing unauthorized access by third parties to its equipment, systems, machines and networks. The latter should be connected to the corporate network or the Internet only if appropriate protective measures have been set up.

In addition, the recommendations from Beckhoff regarding appropriate protective measures should be observed. Further information regarding information security and industrial security can be found in our https://www.beckhoff.com/secguide.

Beckhoff products and solutions undergo continuous further development. This also applies to security functions. In light of this continuous further development, Beckhoff expressly recommends that the products are kept up to date at all times and that updates are installed for the products once they have been made available. Using outdated or unsupported product versions can increase the risk of cyber threats.

To stay informed about information security for Beckhoff products, subscribe to the RSS feed at https://www.beckhoff.com/secinfo.

2 Overview

The Functional Mock-up Interface (FMI) is a free standard for exchanging or coupling simulation models created with different simulation tools. This is often the case when the models are provided by different suppliers or domain-specific simulation tools are used to simulate the different aspects of a machine or plant. A simulation tool that supports FMI allows a model to be exported or imported as a Functional Mock-up Unit (FMU).

The TwinCAT 3 Simulation Runtime for FMI enables the coupling between TwinCAT 3 and another tool with FMI import function (FMI importer tool). This allows you to export a TwinCAT 3 configuration with the TwinCAT Usermode Runtime as an FMU. This can then be executed in any tool with an FMI import function. Execution takes place in Usermode context, i.e. not in real-time. The calculations of the FMI importer tool and TwinCAT 3 are synchronized.

For example, the FMI importer tool can be a tool for the physical modeling of a machine. Software-in-the-loop simulations (SiL simulations) can be carried out by coupling with the TwinCAT 3 Simulation Runtime for FMI. SiL simulations are tests in which the control software is tested in an emulated environment (Usermode Runtime). For example, functional tests can be carried out on the PLC code or various operating scenarios can be tested using a simulation model.

3 Installation

System requirements

Technical data	Description
Operating system	Windows 10/ 11
Minimum TwinCAT version	TwinCAT 3.1.4026.8
TwinCAT licenses	TE1421 Simulation Runtime for FMI
Supported FMI versions	FMI 2.0, 3.0

TwinCAT Package Manager

The product is installed via the TwinCAT Package Manager. Further information on this can be found in the installation documentation.

TwinCAT Package Manager UI

Install the following Workload via the TwinCAT Package Manger user interface in order to be able to use the product:

TE1421 | Simulation Runtime for FMI

TwinCAT Package Manager command line program

You can use the TcPkg **C**ommand **L**ine **I**nterface (CLI) to display the available workloads on the system:

```
tcpkg list -t workload
```

Use the following command to install the Workload:

```
tcpkg install TE1421.SimulationRuntimeForFMI.XAE
```

For use with Motion

To be able to use NC axes in the Usermode Runtime, install the following packages via the command line:

- TwinCAT.XARUM.NCPTP
- TwinCAT.XARUM.AdvancedMotion

Licensing

The TwinCAT 3 Simulation Runtime for FMI tool is an engineering product. Licensing is therefore carried out exclusively on the engineering system.

If no license is available on the engineering system, a trial license is automatically used. The trial license limits the use of TwinCAT 3 Simulation Runtime for FMI to 180 simulation seconds and five signals.

4 Workflow for carrying out a simulation

The procedure for carrying out a simulation with the TwinCAT 3 Simulation Runtime for FMI is described below. It first describes how the FMU is configured in TwinCAT 3 and then describes the procedure for execution in the FMI importer tool.

4.1 Creating an FMU

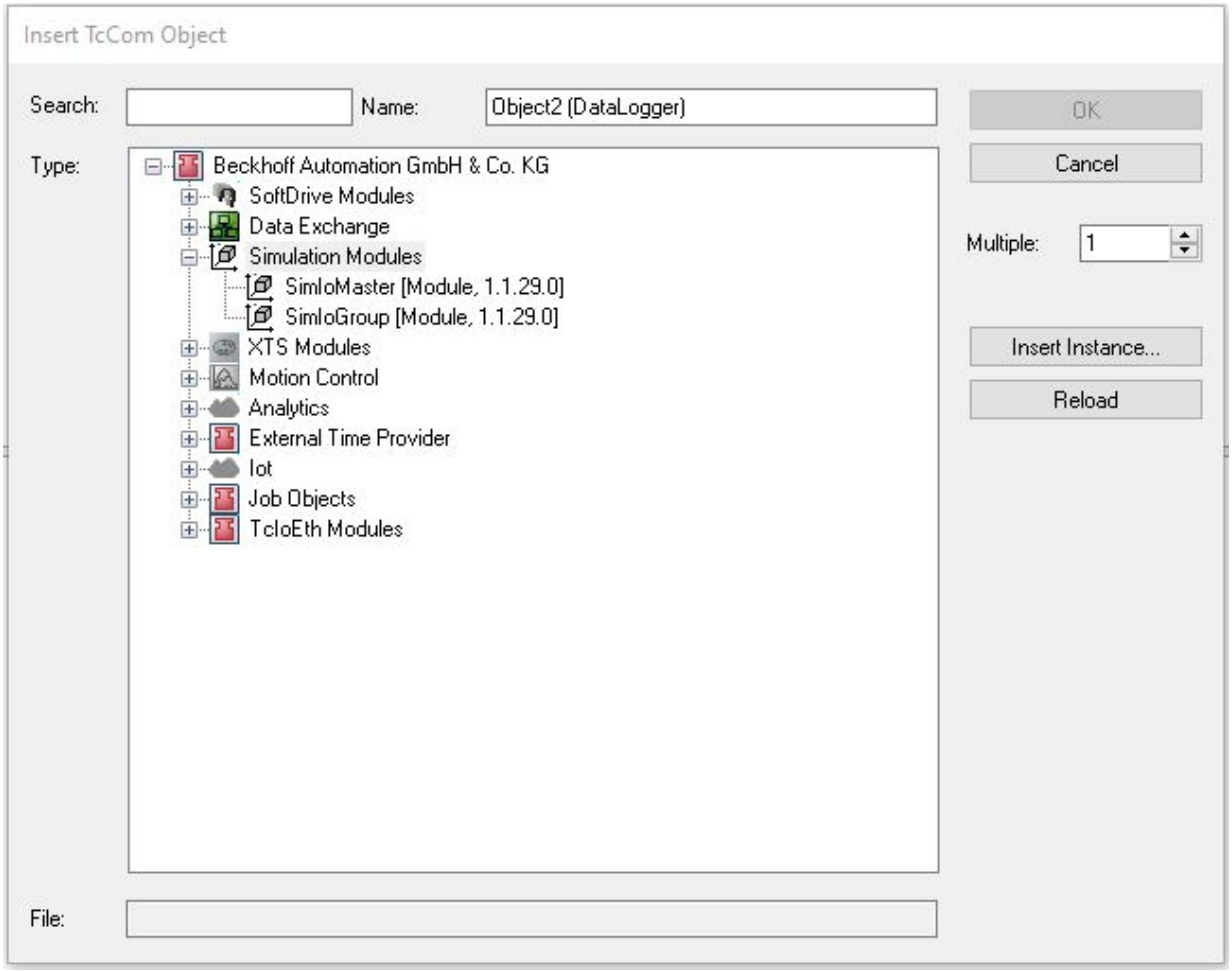
The Runtime Functional Mock-up Unit (FMU) is exported via the user interface in TwinCAT 3. To do this, you must first configure the project. The following chapter explains the process using an example where an NC axis is simulated.

4.1.1 Configuring the System Manager

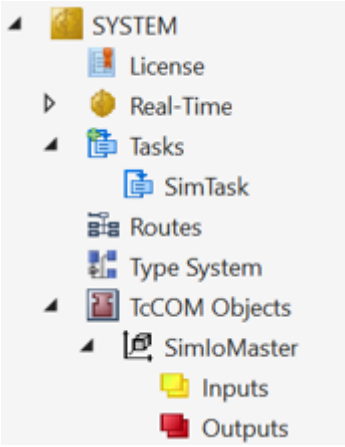
To configure the project, create a TcCOM object in the System Manager with the inputs and outputs of the FMU according to the following scheme:

Creating the SimIoMaster module

1. Right-click on **TcCOM Objects** in the System Manager.
2. Select **Add New Item...**.
3. Select **SimIoMaster** under Beckhoff Automation GmbH & Co. KG > Simulation Modules.



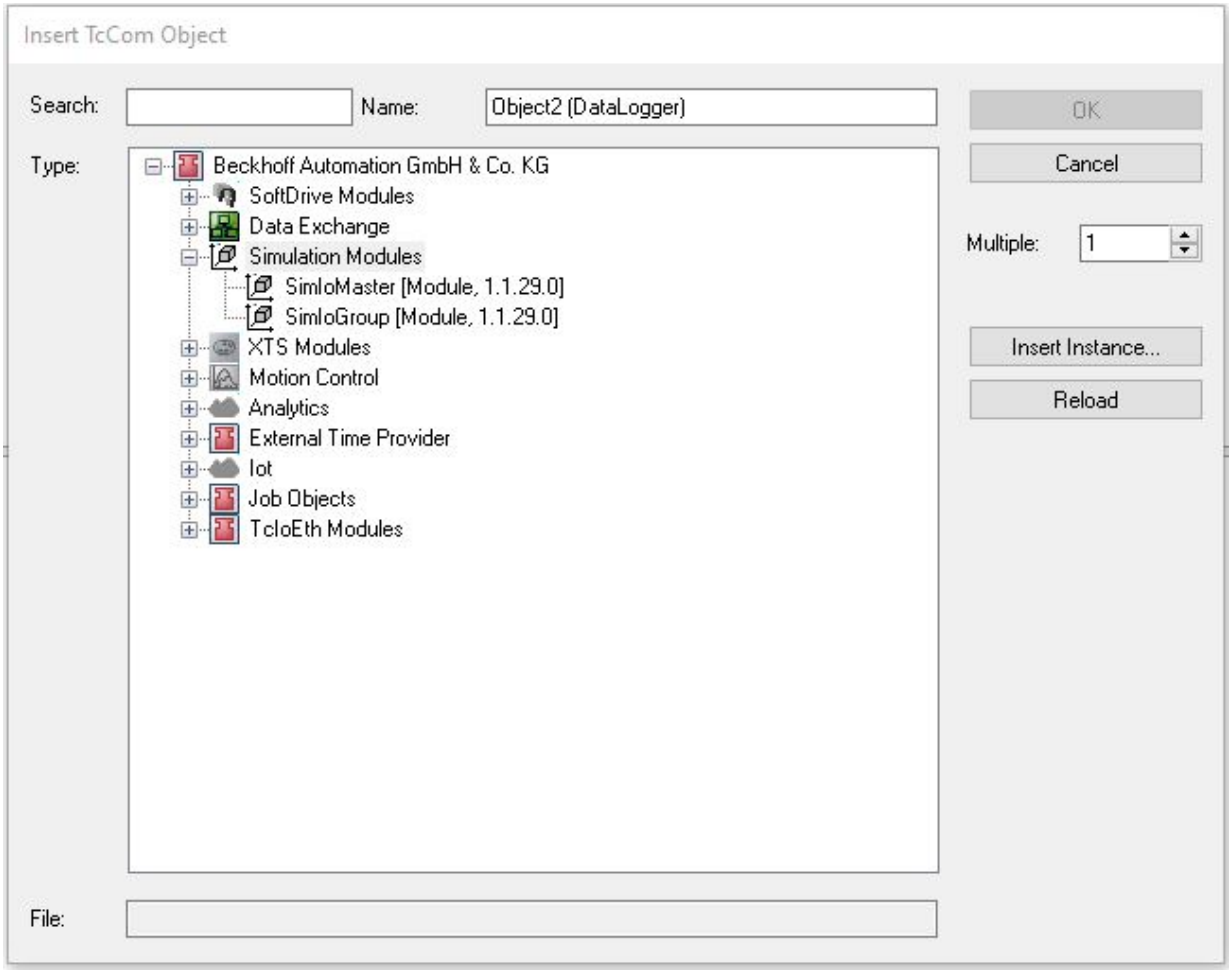
⇨ The SimIOMaster is inserted.



Creating a SimIoGroup module

Add the SimIoGroups under the SimIoMaster.

1. Right-click on the SimIoMaster module you have created.
2. Select **Add New Item...**.
3. Select **SimIoGroup** under Beckhoff Automation GmbH & Co. KG > Simulation Modules.



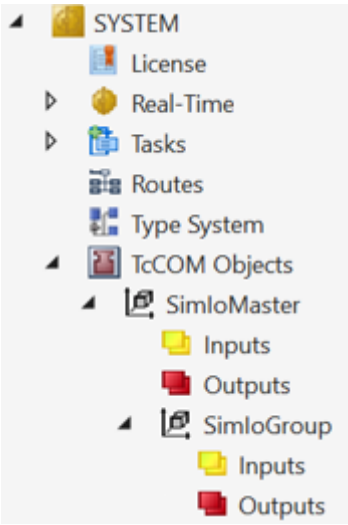
4. Under each SimIoGroup, you define the inputs and outputs of the FMU.

⇨ You must create at least one group, but you can add as many groups as you need. The SimIoGroups can be structured as required.

Creating a symbol using the example of an axis

A variable is added to the SimIOGroup below:

1. Right-click on **Outputs** of the created SimIoGroup module.



2. Select **Add New Item...**.
3. For example, select **NCTOPLC_AXIS_REF**.
4. Confirm with the **OK** button.
   ⇨ In the next step, you must assign a task to the SimIoMaster module.
5. To do this, create a new task under SYSTEM > Tasks.

⇨ Once you have created the axis in the next step, you can link the variable.

Example of creating an axis

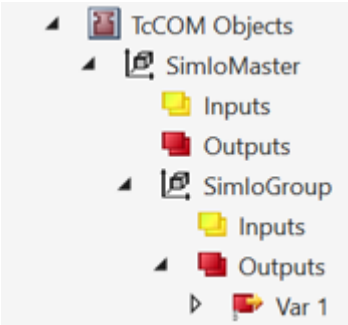
1. Left-click on the **Motion** node.
2. Select **Add New Item...**.
3. Select **NC/PTP NCI Configuration**.
4. Confirm with **OK**.
5. Right-click on **Axes**.
6. Select **Add New Item...** here too.
7. Confirm with **OK**.

⇨ The axis has been created.

⇨ Next, the axis parameters can be linked to the variable already created in the SimIoGroup

Signal linking

1. Left-click on **Var 1**.



2. Select **Change Link...**.
3. Select under MOTION > NC task 1 SAF > Axes > Axis 1 **ToPlc**

4. Confirm with **OK**.

⇨ The link has been created.

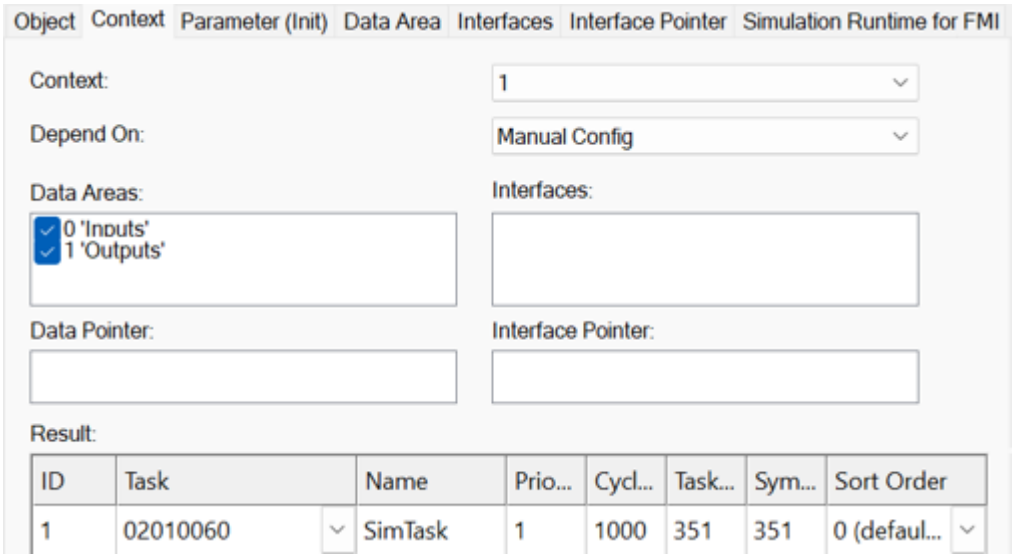
Creating a task

1. Right-click on **Tasks**.
2. Select **Add New Item...**.
3. Then select a TwinCAT task.
4. Confirm with **OK**.

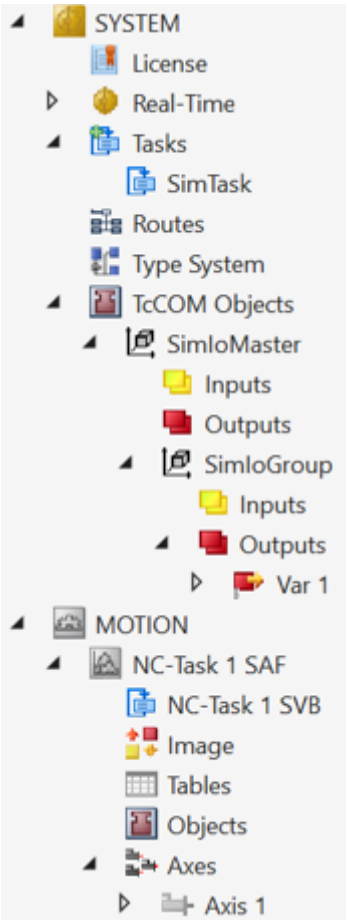
⇨ The task was created.

Assigning the task

1. Left-click on the SimIoMaster module.
2. Select **Context Tab**
3. Use the **Task** drop-down menu to assign the previously created task to the SimIoMaster module.



⇨ The FMU is now ready for export.



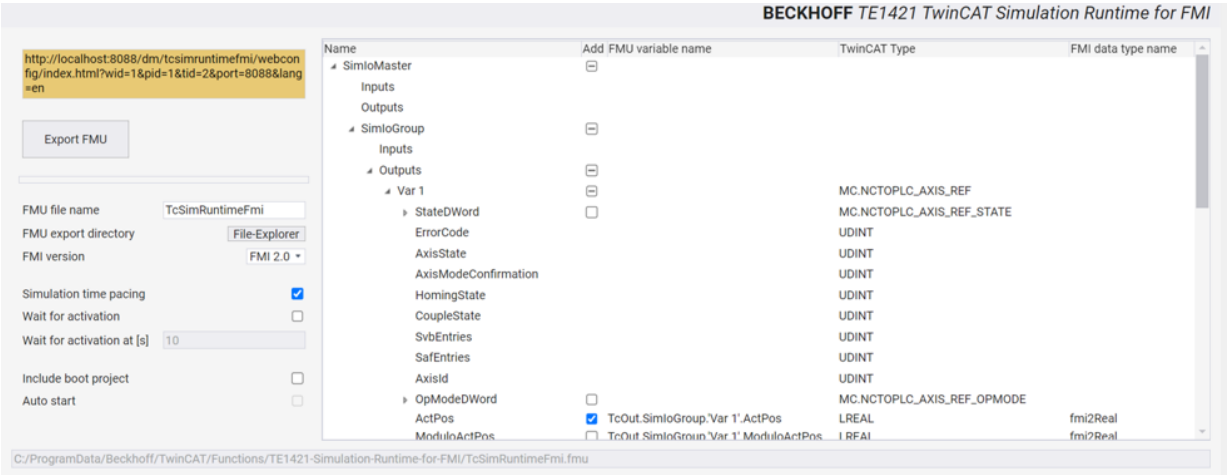
4.1.2 Configuring runtime

Once the project has been configured, you can make further settings and then export the FMU.

Configuration interface

1. Left-click on the SimIoMaster node.
2. Select the **Simulation Runtime for FMI** tab.

⇨ The configuration window of the Simulation Runtime for FMI opens.



In the configuration interface of the Simulation Runtime for FMI, you can set the behavior of the runtime on the left-hand side:

Control	Description
Export FMU	Exports the FMU with the corresponding settings.
FMU file name	Name of the exported FMU without file extension, the FMI standard recommends using only ASCII characters.
FMU export directory	Directory for FMU export
FMI version	Version of the FMI specification, FMI 2.0 and FMI 3.0 are supported.
Simulation time pacing	Limits the temporal progression of the simulation to real-time.
Wait for activation	The simulation is prevented from progressing at a certain point in time until the user activates a Solution on the target.
Wait for activation at [s]	Time in seconds, regarding the **Wait for activation** checkbox.
Include boot project	The Solution is built automatically during FMU export and integrated into the FMU.
Auto start	If a boot project has been integrated in the FMU, it is started automatically after initializing the runtime. **Information:** The automatic start of the boot project is only possible if all required TwinCAT licenses are available on the system.

On the right side of the configuration interface, select the signals that should actually appear as inputs and outputs of the FMU. For this purpose, the I/O hierarchy from the System Manager is presented here once again. You can use all variables that have an FMU variable name as inputs and outputs in the FMU. Use the **Add FMU variable name** checkbox to select or deselect it. The corresponding TwinCAT data type and the FMI data type are also displayed. If, for example, only the variable SimIoMaster > SimIoGroup > Outputs > **ActPos** is to be used as the output of the FMU for a drive, you can deselect all other variables and only activate the corresponding checkbox on **ActPos**.

Once you have made all the settings, click on the **Export FMU** button. The export path in the file system is displayed at the bottom of the configuration interface. In the example, the pre-set export directory and the pre-set file name are used:

%ProgramData%/Beckhoff/TwinCAT/Functions/TE1421-Simulation-Runtime-for-FMI/TcSimRuntimeFmi.fmu

4.2 Run simulation

The SiL simulation with the exported FMU does not have to be run on the same system that was used for the export. However, a prerequisite for initializing the runtime within the FMU is that the TwinCAT Standard Workload has been installed on the simulation computer. The package TE1421 | Simulation Runtime for FMI is not required to use the exported runtime FMU.

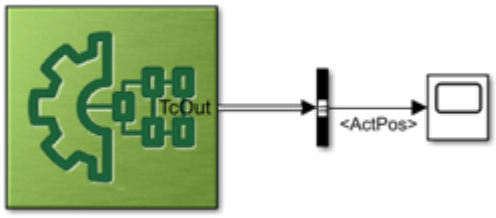
4.2.1 Importing FMU

Once the runtime FMU has been exported from TwinCAT, the next step is to load the FMU from the selected FMI importer tool. The procedure depends on the tool. You can usually select an interface type in the FMI importer tool. This is where you set up co-simulation.

In Simulink®, the **FMU Block** is used for the FMU import. A **Bus selector** and a **Scope Block** are also used in this minimal example. The inputs and outputs of the FMU are interpreted as bus signals in Simulink®, so the bus object must also be created with the command **fmudialog.createBusType** before the first simulation start.

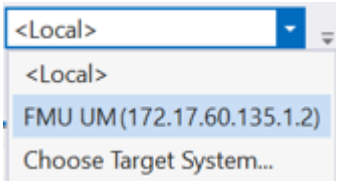
```
fmudialog.createBusType('model/FMU')
```

The resulting block diagram in Simulink® is shown in the figure below:



4.2.2 Starting runtime and simulation

After successfully importing the FMU, you can start the simulation. During the simulation start, the TwinCAT Runtime is initialized within the FMU and can then be selected as a target in TwinCAT 3.1.



Depending on the export settings of the FMU, you can set TwinCAT to Run Mode in various ways. You have the following options here:

- If no boot project has been included in the FMU, the TwinCAT Solution can be activated with the **Activate configuration** button.
- If a boot project is included in the FMU, the included boot project can be activated with the **Restart TwinCAT System** button. Alternatively, the **Activate configuration** button can be used to activate the current Solution on the target.
- If a boot project exists and the **Auto start** feature has also been activated, the boot project contained in the FMU is automatically activated.

The automatic start of the boot project is only possible if all required TwinCAT licenses are available on the system.

If TwinCAT is in Run Mode, you can move the NC axis.

1. Click on the **Axis 1** node.
2. Select the **Online** tab.
3. Enable the axis for manual movement by clicking on **Enabling > Set** and selecting **All** .
4. Use the **+** and **-** buttons to move the axis.

⇨ The **ActPos** output of the FMU runtime displays the corresponding numerical values of the axis in the FMI importer tool.

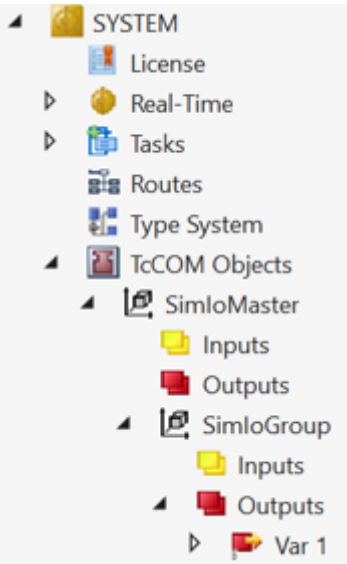
4.2.3 Warnings and errors

All warnings and errors of the runtime FMU are transferred to the FMI importer tool via the FMI log mechanism. The display of warnings and errors depends on the tool. However, as some of the warnings and errors are not displayed by the FMI importer tools, a log file is also created. The log file can be found by default under the following path:
%ProgramData%/Beckhoff/TwinCAT/Functions/TE1421-Simulation-Runtime-for-FMI/TE1421-Simulation-Runtime-for-FMI.log

5 Scan inputs and outputs of the FMU

After you have initialized the TwinCAT Runtime within the FMU and TwinCAT is in Config Mode, you can scan the System Manager configuration. This is particularly helpful if the FMU has been passed on, but not the associated TwinCAT Solution.

1. Click on the **TcCOM Objects** node.
2. Click on the magic wand in the toolbar (**Scan target instances**).
   ⇨ The I/O configuration contained in the FMU is created in the System Manager.



3. Set the task for the scanned SimIoMaster module.

⇨ You can then set TwinCAT to Run Mode and perform the SiL simulation as described in the previous chapter [▶ 15].

6 Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

Download finder

Our download finder contains all the files that we offer you for downloading. You will find application reports, technical documentation, technical drawings, configuration files and much more.

The downloads are available in various formats.

Beckhoff's branch offices and representatives

Please contact your Beckhoff branch office or representative for local support and service on Beckhoff products!

The addresses of Beckhoff's branch offices and representatives round the world can be found on our internet page: www.beckhoff.com

You will also find further documentation for Beckhoff components there.

Beckhoff Support

Support offers you comprehensive technical assistance, helping you not only with the application of individual Beckhoff products, but also with other, wide-ranging services:

- support
- design, programming and commissioning of complex automation systems
- and extensive training program for Beckhoff system components

Hotline:	+49 5246 963-157
e-mail:	support@beckhoff.com

Beckhoff Service

The Beckhoff Service Center supports you in all matters of after-sales service:

- on-site service
- repair service
- spare parts service
- hotline service

Hotline:	+49 5246 963-460
e-mail:	service@beckhoff.com

Beckhoff Headquarters

Beckhoff Automation GmbH & Co. KG

Huelshorstweg 20
33415 Verl
Germany

Phone:	+49 5246 963-0
e-mail:	info@beckhoff.com
web:	www.beckhoff.com

More Information:
www.beckhoff.com/te1421

Beckhoff Automation GmbH & Co. KG
Hülshorstweg 20
33415 Verl
Germany
Phone: +49 5246 9630
info@beckhoff.com
www.beckhoff.com