SIEMENS

SIMOTION

SIMOTION SCOUT
SIMOTION LAD/FBD

Programming and Operating Manual

Valid as of version 5.1

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

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Preface

Scope

This document is part of the **SIMOTION Programming** documentation package.

This document applies to SIMOTION SCOUT, the engineering system of the SIMOTION product family in product version V5.1 in conjunction with:

- A SIMOTION device with the following versions of a SIMOTION Kernel:
  - V5.1
  - V4.5
  - V4.4
  - V4.3
  - V4.2
  - V4.1 [1]
  - V4.0 [1]
  - V3.2 [1]

  [1] V4.5 is the last product version of SIMOTION SCOUT that will support these versions of the SIMOTION Kernel.
- The relevant version of the following SIMOTION Technology Packages, depending on the kernel:
  - Cam
  - Path (Kernel as of V4.1)
  - Cam_ext
  - TControl

Information in this manual

The following is a list of chapters included in this manual along with a description of the information presented in each chapter.

- **Description** (Chapter 1)
  This chapter shortly defines the LAD and FBD programming languages.
- **LAD/FBD Editor** (Chapter 2)
  In this chapter you can learn about the various operator control options in the LAD/FBD Editor.
- **Software Programming** (Chapter 3)
  This chapter shows how to proceed during programming.
- **Functions** (Chapter 4)
  This chapter describes how to apply individual LAD/FBD commands and gives an outline of their function.

- **Debugging Software / Error Handling** (Chapter 5)
  This chapter describes how to test a program and find errors in created programs.
- **Application Examples** (Chapter 6)
  You will be given an introduction to the LAD and FBD programming languages using some simple examples.
- **Appendix**
  - Key combinations
    This appendix contains the keystroke combinations for frequently used commands.
- **Index**
  Keyword index for locating information.

SIMOTION Documentation

An overview of the SIMOTION documentation can be found in the SIMOTION Documentation Overview document.

This documentation is included as electronic documentation in the scope of delivery of SIMOTION SCOUT. It comprises ten documentation packages.

The following documentation packages are available for SIMOTION product level V5.1:

- SIMOTION Engineering System Handling
- SIMOTION System and Function Descriptions
- SIMOTION Service and Diagnostics
- SIMOTION IT
- SIMOTION Programming
- SIMOTION Programming - References
- SIMOTION C
- SIMOTION P
- SIMOTION D
- SIMOTION Supplementary Documentation

Hotline and Internet addresses

SIMOTION at a glance

We have compiled an overview page from our range of information about SIMOTION with the most important information on frequently asked topics - which can be opened with only one click.

Whether beginner or experienced SIMOTION user – the most important downloads, manuals, tutorials, FAQs, application examples, etc. can be found at

https://support.industry.siemens.com/cs/ww/en/view/109480700

Additional information

Click the following link to find information on the following topics:

- Documentation overview
- Additional links to download documents
- Using documentation online (find and search manuals/information)

https://support.industry.siemens.com/cs/ww/en/view/109479653

My Documentation Manager

Click the following link for information on how to compile documentation individually on the basis of Siemens content and how to adapt it for the purpose of your own machine documentation:

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Training

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http://www.siemens.com/sitrain

FAQs

Frequently Asked Questions can be found in SIMOTION Utilities & Applications, which are included in the scope of delivery of SIMOTION SCOUT, and in the Service&Support pages in **Product Support**:

https://support.industry.siemens.com/cs/de/en/ps/14505/faq

Technical support

Country-specific telephone numbers for technical support are provided on the Internet under **Contact**:

https://support.industry.siemens.com/cs/ww/en/sc/2090

Table of contents

Fundamental safety instructions

1

1.1 General safety instructions

⚠ WARNING

Danger to life if the safety instructions and residual risks are not observed

The non-observance of the safety instructions and residual risks stated in the associated hardware documentation can result in accidents with severe injuries or death.

- Observe the safety instructions given in the hardware documentation.
- Consider the residual risks for the risk evaluation.

⚠ WARNING

Danger to life caused by machine malfunctions caused by incorrect or changed parameterization

Incorrect or changed parameterization can cause malfunctions on machines that can result in injuries or death.

- Protect the parameterization (parameter assignments) against unauthorized access.
- Respond to possible malfunctions by applying suitable measures (e.g. EMERGENCY STOP or EMERGENCY OFF).

1.2 Industrial security

Note

Industrial security

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit http://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under http://www.siemens.com/industrialsecurity..

⚠ WARNING

Danger to life as a result of unsafe operating states resulting from software manipulation

Manipulation of the software, e.g. viruses, trojans, malware or worms, can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a state-of-the-art, integrated industrial security concept for the installation or machine.
- Make sure that you include all installed products in the integrated industrial security concept.
- Protect files on removable storage media against malware through appropriate protective measures, e.g. virus scanners.

1.3 Danger to life due to software manipulation when using removable storage media

⚠ WARNING

Danger to life due to software manipulation when using removable storage media

The storage of files on removable storage media involves a high risk of infection, e.g. via viruses or malware. Incorrect parameter assignment can cause machines to malfunction, which can lead to injuries or death.

- Protect the files on removable storage media against harmful software through appropriate protective measures, e.g. virus scanners.

Description

2

2.1 Description

This chapter will give you a brief overview of ladder logic (LAD) and function block diagram (FBD).

2.2 What is LAD?

LAD stands for ladder logic. LAD is a graphical programming language. The statement syntax corresponds to a circuit diagram. LAD enables simple tracking of the signal flow between conductor bars via inputs, outputs and operations.
LAD statements consist of elements and boxes which are graphically connected to networks (which are displayed in conformity with the IEC 61131-3 standard). LAD operations follow the rules of Boolean logic.

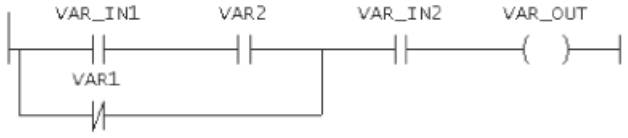


Figure 2-1 Representation of a network in LAD

The LAD program can also be displayed as an FBD program.

The LAD programming language

The LAD programming language features all the elements required for the creation of a complete user program. LAD features an extensive command set. This includes the various basic operations with a comprehensive range of operands and how to address them. The design of the functions and function blocks enables you to structure the LAD program clearly.

The program package

The LAD programming package is an integral part of the basic SIMOTION software, so that after your SIMOTION software has been installed, all editor, compiler and test functions for LAD are available for use.

2.3 What is FBD?

FBD stands for function block diagram. FBD is a graphics-based programming language that uses the same type of boxes used in boolean algebra to represent logic (networks are displayed in conformity with the IEC 61131-3 standard). In addition, complex functions (e.g. mathematical functions) can be represented directly in conjunction with the logic boxes.

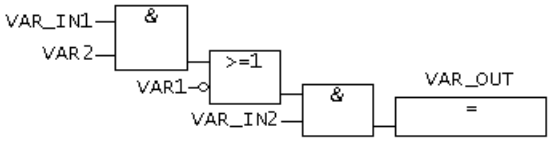


Figure 2-2 Representation of a network in FBD

The FBD program can usually also be displayed as an LAD program.

The FBD programming language

The FBD programming language features all the elements required for the creation of a complete user program. FBD features an extensive command set. This includes the various basic operations with a comprehensive range of operands and how to address them. The design of the functions and function blocks enables you to structure the FBD program clearly.

The program package

The FBD programming package is an integral part of the basic SIMOTION software, so that after your SIMOTION software has been installed, all editor, compiler and test functions for FBD are available for use.

2.4 Unit, program organization unit (POU) and program source

The term "unit" represents a program source.

The terms "program organization unit (POU)" and "LAD/FBD program" are generic terms and may refer to a program, a function (FC), or a function block (FB).

The term "program source file" is a generic term and may refer to a LAD/FBD unit, an MCC unit or an ST source file.

LAD/FBD editor

3

3.1 The LAD/FBD editor in the workbench

The workbench represents the framework for SIMOTION SCOUT. Using the workbench tools, you can carry out all the steps required to configure, optimize, and program a machine in order to complete a required task.

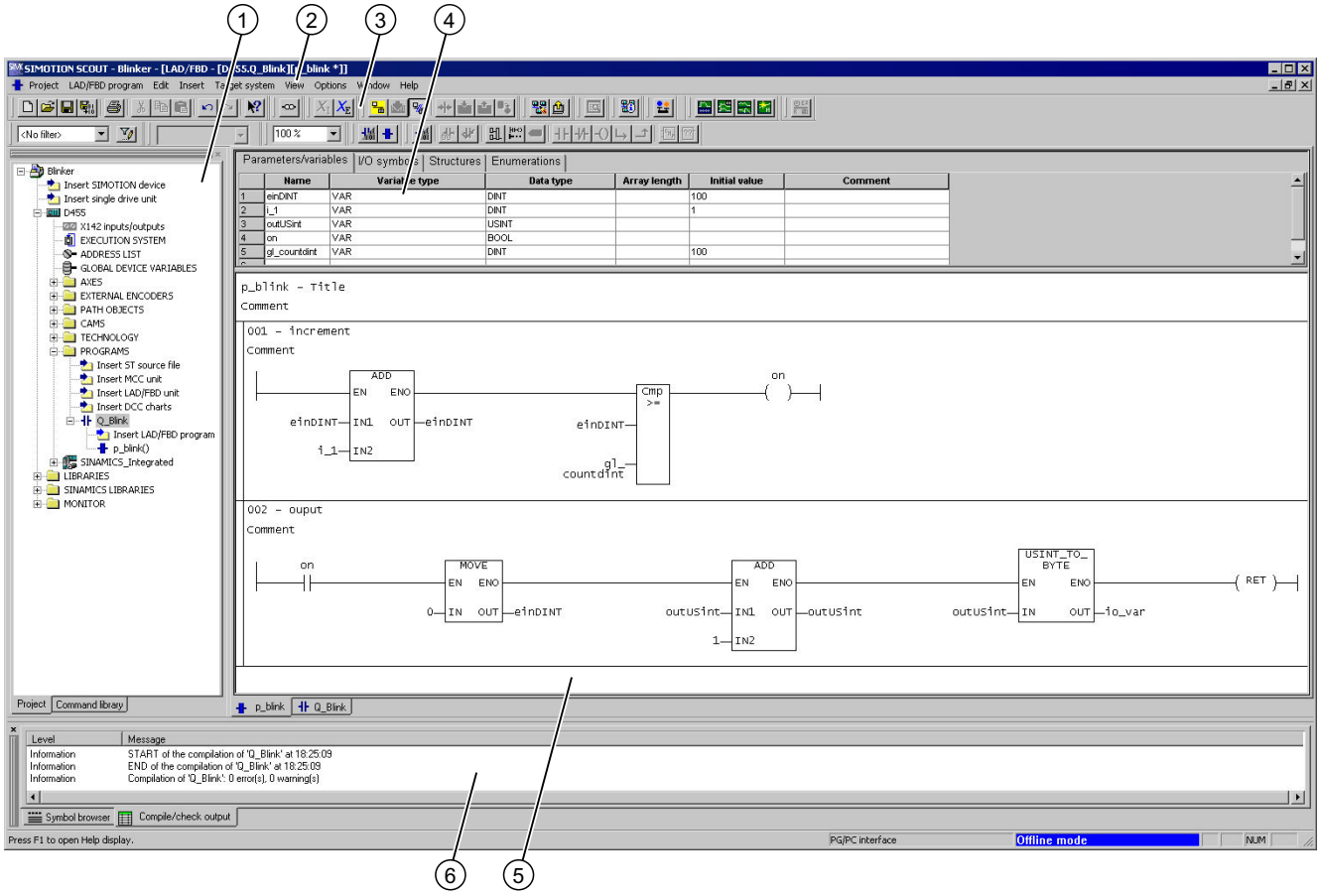


Figure 3-1 Elements of the workbench in a LAD/FBD program

The workbench contains the following elements:

- ① Project navigator
  The project navigator shows the entire project and its elements as a tree structure.
- ② Menu bar
  The menu bar contains menu commands which you can use to control the workbench, call up tools, etc.
- ③ Toolbars
  Many of the available menu commands can be executed by clicking the appropriate icon in one of the toolbars.

- ④ Declaration tables
  Declaration tables are used for LAD/FBD units and programs. You define variables and constants in the declaration tables.
- ③ Working area
  You carry out job-specific operations in this area. The working area contains an LAD/FBD program, a declaration table, and an editor for graphical displays.
- ⑥ Detail view
  More detailed information about the elements selected in the project navigator are displayed, e.g. the windows **Symbol browsers**, **Compile/check output**.

3.2 Maximizing working area and detail view

The windows working area and detail view can be set to maximum zoom.

The selection is made under the following menu items:

- **View > Maximize working area** (e.g., when creating programs)
  or
- **View > Maximized detail view** (e.g., monitoring global variables)

3.3 Enlarging or reducing the content of the working area

There are several options available to change the size of the LAD/FBD editor's display, i.e. the size of the elements in this area.

- **Zoom** list on the **Zoom factor** toolbar:
  Select a factor from the **Zoom** list, or enter an integer value of your own choice.
  - or -
  View > Zoom in menu command or **View > Zoom out.**
  - or -
  Key combination **Ctrl+Num+** (enlarge) or **Ctrl+Num-** (reduce).
  - or -
  Press the **Ctrl** key while turning the mouse wheel.

This change always applies to the active LAD/FBD editor. The setting is only saved when saving if changes have been made in the respective editor window.

3.4 Bringing the LAD/FBD editor to the foreground

If several LAD/FBD editors are open in the working area, these are usually overlaid. This means that only the top LAD/FBD editor is visible. There are several ways to bring the concealed editors to the foreground.

To bring the editor to the foreground, proceed as follows:

- Select the appropriate tab below the working window
  - or -
  Select the appropriate program name in the Window menu.
  - or -
  Press the **Ctrl+Tab** key combination as often as required.

3.5 Hiding and displaying the declaration table

If you need more space, you can hide the **Interface (exported declaration)** declaration area and/or the declaration area for a LAD/FBD program completely

To hide and display the declaration table, proceed as follows:

1. Double-click the separation line to hide the declaration table.
2. In order to display the declaration line again, double-click the separation line again.

3.6 Enlarging/reducing the declaration table

To change the size of the declaration table, proceed as follows:

1. Move the mouse cursor onto the separation line until the mouse pointer changes to a double line.
2. Hold down the left mouse button and drag the separation line upwards in order to reduce the size of the declaration area.
   - or -
   In order to enlarge the declaration area, move the separation line downwards.

3.7 Operation

3.7.1 Operating the LAD/FBD editor

The LAD/FBD editor provides the programmer with a variety of different operator input options. Alternatives for executing individual operator inputs include the following:

- The menu bar
- Context menus
- Toolbars

- Key combinations
- Texts and variables can be moved to the input field with drag-and-drop:
  - From the project navigator
  - From the declaration tables
  - From the detail view (Symbol browser tab, address list, watch table)
  - From the command library

3.7.2 Menu bar

You can start all of the programming functions from the menu bar.

The LAD/FBD program item only appears if a LAD/FBD editor is active in the working area.

3.7.3 Context menu

To use the context menu for an object, proceed as follows:

1. Select the appropriate object with the left mouse button (left click).
2. Briefly click the right mouse button.
3. Left-click the appropriate menu item.

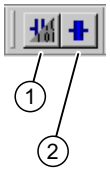
3.7.4 Toolbars

The dynamic toolbars contain icons for important, frequently used functions, e.g. for inserting or saving elements.

The "dynamic toolbar" changes depending on which workspace is active/selected, e.g. MCC chart, ST program or LAD/FBD program.

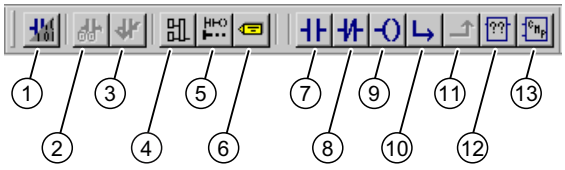
The toolbars can be positioned as required within the Workbench. Once moved, they can be shown or hidden using **View > Toolbars**.

The LAD/FBD editor toolbar contains the full range of LAD/FBD commands. The command list is displayed whenever the workspace for a program is active or open.



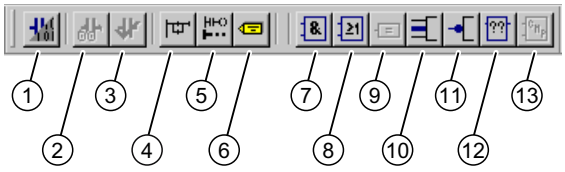
1) Accept and compile
2) Insert LAD/FBD program

Figure 3-2 Picture of the toolbar for a LAD/FBD unit



1) Accept and compile
2) Program status
3) Symbol check and type update
4) Switch to FBD
5) Insert network
6) Jump label ON/OFF
7) Insert NO contact
8) Insert NC contact
9) Insert coil
10) Open branch
11) Close branch
12) Insert comparator
13) Insert an empty box

Figure 3-3 View of the LAD editor toolbar



1) Accept and compile
2) Program status
3) Symbol check and type update
4) Switch to LAD
5) Insert network
6) Jump label ON/OFF
7) Insert AND box
8) Insert OR box
9) Insert assignment
10) Binary input
11) Negate binary input
12) Insert comparator
13) Insert an empty box

Figure 3-4 View of the FBD editor toolbar

3.7.5 Key combinations

Use the key combinations for fast operation in the LAD/FBD editor.

Within an LAD/FBD network, you can switch between LAD/FBD elements, select the required input/output of an LAD/FBD element and switch to the adjacent LAD/FBD network using the **left/right arrow buttons** and the **up/down arrow buttons**. Using the **Return** key, you can open the input field of a selected input/output and make an entry as well as close the field again using the **Return** key.

The shortcuts (Page 359)available in the LAD/FBD editor are listed in the Appendix.

3.7.6 Drag&Drop of variables

Variables are dragged from the detail view (**Symbol browser**, **Watch table** or **Address list** tab) and dropped in the input field.

To paste in variables using drag&drop, proceed as follows:

1. Left-click the line number of the variable you wish to move.
   The line with the variables is highlighted.
2. Keeping the left mouse button pressed, drag the line number into the input field of the parameter screen form.
3. Release the left mouse button. The variable is pasted in at the selected position.

3.7.7 Drag&drop from the declaration tables

Variable names can be dragged from a declaration table and dropped into an LAD/FBD network.

To paste in variable names using drag&drop, proceed as follows:

1. Left-click the line number with the name of the variable you wish to move.
   The line is shown on a black background.
2. Continue to press the left mouse button as you drag the variable name to any input field.
3. Release the left mouse button.
   The variable name is pasted in at the selected position.

3.7.8 Drag&drop within the declaration table

You can change the order of the variable declaration in the declaration table.

To change the order using drag&drop, proceed as follows:

1. Left-click the line number of the variable you wish to move.
   The line is shown on a black background.
2. Press the **Shift** key and continue to press the left mouse button as you drag the line to the desired position in the declaration table.
   A red line indicates the point of insertion.
3. Release the left mouse button.
   The line moves to the corresponding position.

Note

To move several adjacent lines together, hold the **Shift** key down as you select the lines you wish to move.

3.7.9 Using Drag&Drop for LAD/FBD elements

LAD/FBD elements can be pasted into the LAD/FBD network from the project navigator (**Command library** tab) using drag-and-drop.

To paste in LAD/FBD elements using drag&drop, proceed as follows:

1. Left-click the required LAD/FBD element.
2. Hold the left mouse button down and drag the LAD/FBD element into the ladder diagram line of the LAD/FBD network.
3. Release the left mouse button.
   The LAD/FBD element is pasted in at the selected position.

3.7.10 Command call drag&drop

The commands in the command library can be inserted into LAD/FBD programs.

To insert command calls using drag&drop, proceed as follows:

1. Left-click the required command call.
2. Continue to hold the left mouse button down as you drag the command call to the LAD/FBD program.
3. Release the left mouse button.
   The command call is inserted at the selected position.

3.7.11 Drag&Drop of command names

Command names can be moved using drag-and-drop from the project navigator (tab **Command library**) into the input field of an empty box that has already been generated.

To paste in **command names** using drag&drop, proceed as follows:

1. Left-click the required command name.
2. Holding the left mouse button down, drag the command name into the input field of an empty box.
3. Release the left mouse button.
   The command name is pasted in at the selected position.

3.7.12 Using drag&drop for elements in a network

To insert elements in a network using drag&drop, proceed as follows:

1. Left-click the required LAD element.
2. To move an element, proceed as follows:
   Holding the left mouse button down, drag the element to the required position in the ladder diagram line.

3. To copy an element, proceed as follows:
   Keeping the **CTRL** key depressed, drag the element with the left mouse button to the required position in the ladder diagram line.
4. Release the left mouse button.
   The LAD element is inserted at the selected position.

3.7.13 Using drag&drop for functions and function blocks from other sources

Successfully compiled functions and function blocks from other source files can be pasted into a ladder diagram line from the project navigator. The connection to the "original source" is automatically entered in the **Connections** tab of the current source file.

To paste in functions and function blocks using drag&drop, proceed as follows:

1. Left-click the required FC/FB.
2. Holding the left mouse button down, drag the FC/FB into the input field of an empty box.
3. Release the left mouse button.
   An FC/FB call box is pasted in.

3.7.14 Automatic completion (Autocomplete)

In the LAD/FBD editor, you can automatically complete identifiers. A drop-down list box with identifiers that begin with the previously entered characters will be displayed. This operates on a context-sensitive basis, whereby the expected type for the identifier being sought and its visibility in the current program context determine which entries are displayed as options in the drop-down list box.

Depending on the context, the entries displayed in the drop-down list box are filtered and sorted:

- The filtering process may determine, for example, that only structure components are displayed for a structure.
- Entries are sorted according to their relevance to the context, with the more relevant identifiers appearing higher in the list (e.g. local variables are listed before global variables).

With LAD/FBD source files and LAD/FBD programs, the identifiers can be completed automatically in the following input fields/editable drop-down list boxes:

- Declaration table of the LAD/FBD unit
  - "Type" column
  - "Variable type" column
  - "Data type" column
- Declaration table of the LAD/FBD program
  - "Variable type" column
  - "Data type" column
- Input fields for the inputs of an LAD/FBD element (variables and other symbols for the expected type)

- Input fields for the outputs of an LAD/FBD element (variables for the expected type)
- Input field for the instance variable of a function block (variables for the expected FB type (box type))
- Input field for the NC contact, NO contact, and coil LAD elements (BOOL type variables)

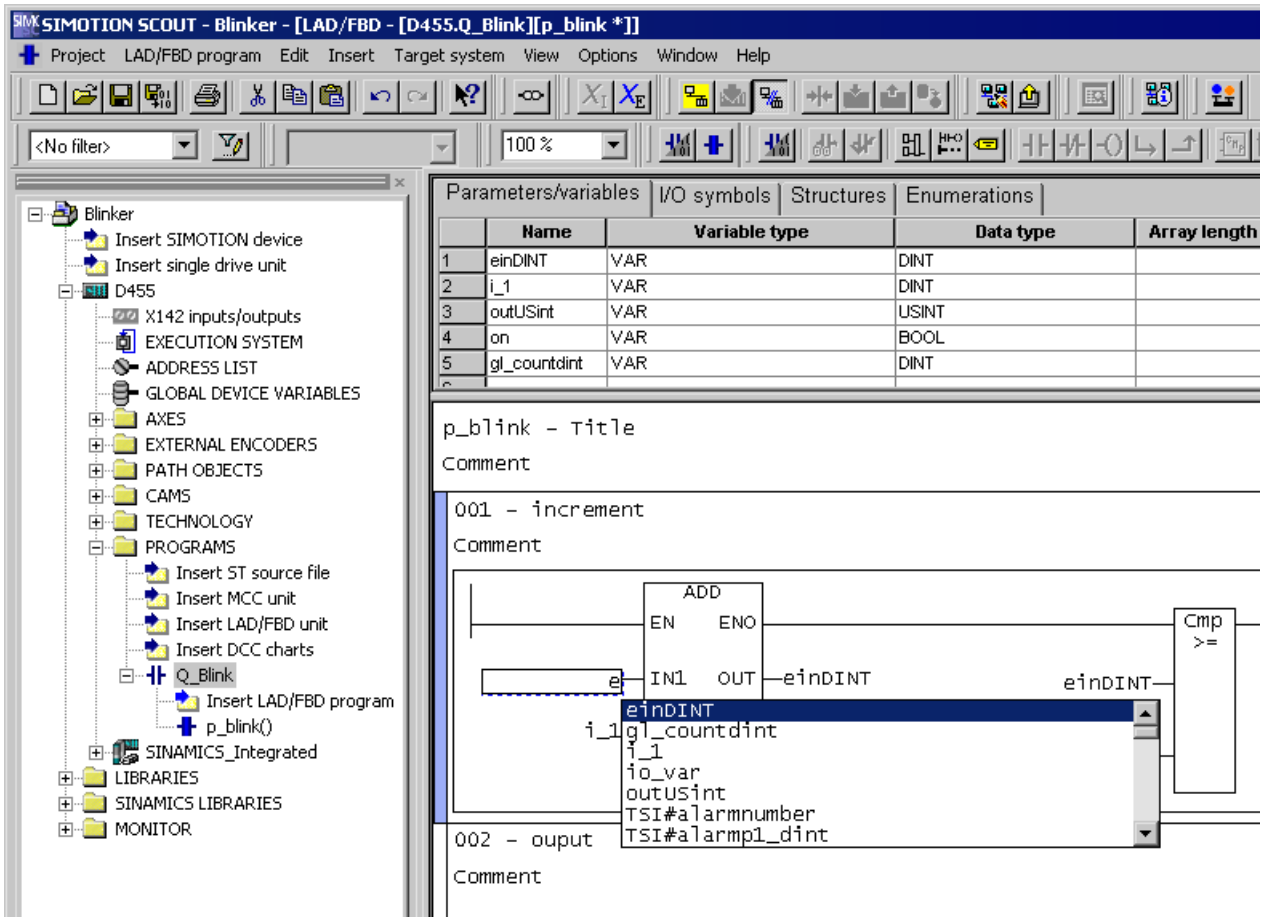


Figure 3-5 Automatic completion of an identifier at the input for an LAD/FBD element

Procedure

To complete an identifier automatically (Autocomplete), proceed as follows:

1. Write the first characters of the identifier (e.g. the first letters of a word) in the input field/ editable drop-down list box.
2. Press the **Ctrl+space** key combination.
   A drop-down list box opens containing the filtered/sorted identifiers for the current context. The identifiers listed start with the characters input so far or the characters up to where the cursor is positioned within an existing identifier.

Note

When the drop-down list box has been expanded and is editable (by clicking the ▾ symbol), automatic completion is already activated.

3. Expand or refine the options displayed:
   - Enter additional characters.
   - Delete characters.
   - Move the cursor with the left/right arrow keys.
4. Select the required identifier with the up/down arrow keys.
5. Press the **Return** key.
   The identifier is accepted by the input field/editable drop-down list box and the current word is overwritten.

Note

If only a single identifier is offered for selection, the selection window will not be opened and the identifier completed immediately.

Functional description

The following identifiers that begin with the specified characters will be offered:

- ST expressions
- ST program sections
- Identifiers from the command library
- Library, unit, POU, or system function names
- For technology objects including their system variables and configuration data
- Identifiers for the relevant LAD/FBD unit or LAD/FBD program:
  - Program organization units (POU) and FB instances
  - Data types
  - Variables and constants
  - Structure elements
- Identifiers from imported program sources

Note

Identifiers from the relevant LAD/FBD unit or LAD/FBD program or from imported program sources will only be displayed correctly if the corresponding program source has been compiled.

The display operates on a context-sensitive basis, i.e. only those types of identifiers that are appropriate at the associated location of the LAD/FBD unit or LAD/FBD program are offered:

- Within a declaration table, data types and variable types only
- Within a program organization unit (POU), no data types
- For a structure (e.g. var_struct.xx), only structure components

3.8 Settings

3.8.1 Settings in the LAD/FBD editor

You can define the layout for creating a program in the LAD/FBD programming language:

1. To change the settings, select the **Options > Settings** menu command.
   The **Settings** dialog box opens.
2. Select the tab **LAD/FBD editor**.
3. Make the required settings here.

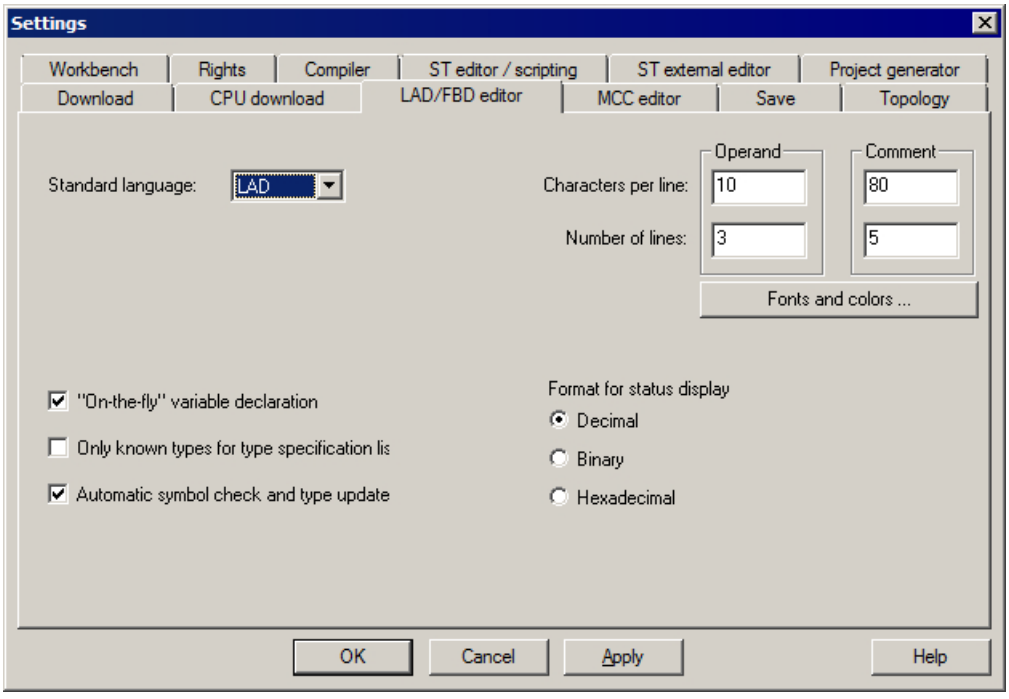


Figure 3-6 LAD/FBD editor settings

4. Click **OK** or **Accept** to confirm.

The table below contains a description of the individual parameters.

Table 3-1 LAD/FBD editor parameter settings

Parameter	Description
Default language	Defines the default graphical programming language for creating a new LAD/FBD program in the LAD/FBD editor.
"On-the-fly" variable declaration	If activated, a dialog box appears when an unknown symbol is entered in the LAD or FBD diagram. You can carry out the variable declaration in this dialog box. See: Defining variables in the Variable declaration dialog box ("on-the-fly" variable declaration) (Page 117)

Parameter	Description
Only known types if type lists exist	If activated, only those function blocks which also have an entry in the Connections tab appear in the list of data types. See: Setting the data type list of the declaration table
Automatic symbol check and type update	If active, an automatic symbol check and type update take place once changes affecting the LAD/FBD program open in the LAD/FBD editor have been made in the project. The automatic symbol check and type update are activated by default in the LAD/FBD editor. See: Activating automatic symbol check and type update Example of a type update (Page 36) Example of a symbol check (Page 38) Deactivating automatic symbol check and type update Performing symbol check and type update at a specified time
Operand	You can change the options for displaying the operand by entering the number of **Characters per line** and **Number of lines** for the Operand field. Changes to settings are only applied to LAD/FDB editors that are opened afterwards.
Comment	You can change the options for displaying the comment by entering the number of **Characters per line** and **Number of lines** for the Comment field. Changes to settings are only applied to LAD/FDB editors that are opened afterwards.
Fonts and colors	You can change the fonts and colors of the LAD/FBD editor. See: Changing fonts Changing colors Changes to settings are only applied to LAD/FDB editors that are opened afterwards.
Format for status display	Format in which the values of variables with bit data type are displayed in program status and variable status. See: Starting and stopping the program execution monitoring (Page 298) Variable status (Page 293)

3.8.2 Activating automatic symbol check and type update

To enable automatic symbol check and type update, follow these steps:

1. Select the **Options > Settings** menu item.
2. Select the tab **LAD/FBD editor**.
3. Activate the checkbox **Automatic symbol check and type update**.
4. Confirm with **OK**.

Note

The automatic symbol check and type update is activated by default in the LAD/FBD editor.

If the symbol check is activated, the automatic symbol check and type update is performed for an LAD/FBD program if the following requirements are met:

- changes are made in the project (see list below) which impact upon the LAD/FBD program
- the focus is on the LAD/FBD program, i.e. it is opened in the KOP/FUP editor, or the LAD/FBD editor from the LAD/FBD program which is already open appears in the foreground (Page 24)

In the event of subsequent changes within a project, automatic symbol check and type update is performed for an LAD/FBD program if the change affects the LAD/FBD program:

- A program source is changed, e.g. deleted or renamed.
  The changes are only identified for associated program sources and their LAD/FBD programs when the changed program source is compiled. In other words, to enable the automatic symbol check and type update to take place, the changed program source must be compiled before the focus changes to an LAD/FBD program from an associated program source.
- The declaration tables in the LAD/FBD source file and/or from LAD/FBD programs within the LAD/FBD source file are changed.
  The symbol check/type update takes place for an LAD/FBD program belonging to the LAD/FBD source file if the changes affect that LAD/FBD program.
  The following cases are possible:
  - A declaration table is changed within an LAD/FBD program.
    The automatic symbol check and type update only takes place after changing from the declaration table to the network.
  - The change within a declaration table takes place within an LAD/FBD program and affects another LAD/FBD program within the same program source.
    The automatic symbol check and type update takes place when the focus is on that other LAD/FBD program.
  - Changes within a declaration table take place within a program source and affect an LAD/FBD program in another program source.
    The automatic symbol check and type update for the LAD/FBD program from another program source can only take place once the changed program source has been compiled.
- A technology object (such as an axis) used by the LAD/FBD program is changed.
  The automatic symbol check and type update takes place when the focus is on the LAD/FBD program.

Note

The term "LAD/FBD program" is a generic term and may refer to a program, a function (FC), or a function block (FB).

If you click the mouse on the relevant place in the network (box parameter, input field, symbol highlighted in red) following a symbol check/type update, the tool tip indicates the following:

- the expected data type among the box parameters
- The data type of the variable with labeled input fields
- the cause of trouble in symbols which are highlighted in red whereby the symbol errors may have the following reasons:
  - The specified symbol does not exist
  - The specified symbol is not visible in the current context (incorrect or missing entry of the connections in the declaration table)
  - The specified variable does not have the appropriate type

Note

The symbol check is automatically updated as soon as the declaration table has been edited and left.
All errors, including errors in the declaration table, are displayed in the detail view.

3.8.3 Example of a type update

Introduction

During the type update all the data types used are updated:

- the list of permitted data types in an input field
- an LAD/FBD program's box type, i.e. in terms of the creation type (program, FB or FC) selected for the LAD/FBD program
- a box's interface in terms of the list of permitted data types per box parameter
- other data types (structures, enumerations, etc.)

For example, a structure AAA {a : BOOL} is used in an LAD/FBD program. If this structure is changed, e.g. AAA {a : BOOL, b : LREAL}, this change is applied by the LAD/FBD program during the type update.

Initial situation

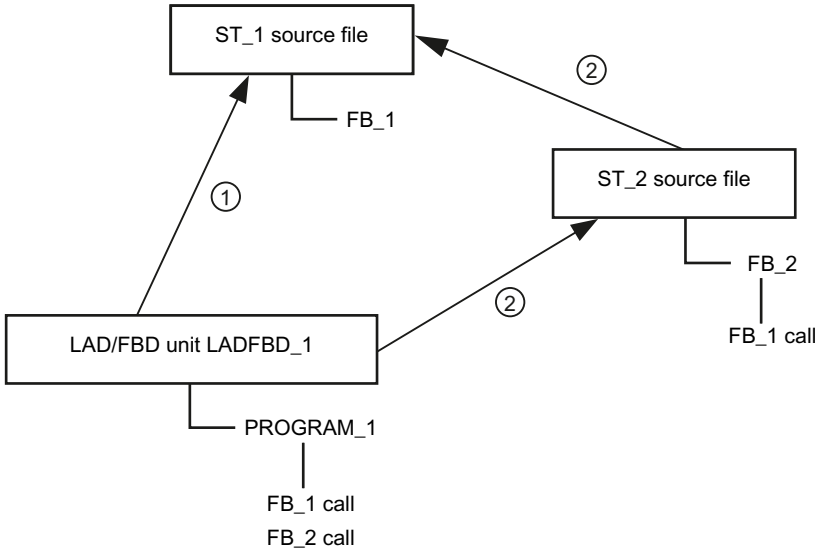
The following are present:

- an ST source ST_1 with a function block FB_1
- an ST source ST_2 with a function block FB_2
- an LAD/FBD unit LADFBD_1 with an LAD/FBD program PROGRAM_1
- FB_1 is called within ST_2, i.e. a connection (Page 164) to ST_1 has to be declared in the ST_2 declaration table

- FB_1 is called within PROGRAM_1, i.e. a connection (Page 164) to ST_1 has to be declared in the LADFBD_1 declaration table
- FB_2 is called within PROGRAM_1, i.e. a connection (Page 164) to ST_2 has to be declared in the LADFBD_1 declaration table

How the type update works

This is a special scenario where a program source (in this case LADFBD_1) imports another program source (in this case ST_1) both explicitly and by means of inheritance. Inheritance takes place via another imported program source (in this case ST_2) which, in turn, imports other sources (in this case ST_1).



① LADFBD_1 explicitly imports ST_1

② LADFBD_1 imports ST_1 by means of inheritance (ST_1 → ST_2 → LADFBD_1)

Figure 3-7 Special scenario of explicit import and inheritance

Changes are now made at the interface of the FB_1, for example one or more input/output parameters are added (see also interface adjustment in FB/FC (Page 193)) and ST_1 is recompiled.

When PROGRAM_1 is opened in the LAD/FBD editor, the FB_1 call is automatically updated, i.e. a type update occurs via which the changed interface is updated.

Despite the fact that the type update runs error-free, the compiler issues an error message during the compilation of LADFBD_1 because the import of ST_1 by inheritance via the imported ST_2 presupposes that ST_2 is also recompiled.

In order to recompile ST_2 without errors, the changed interface of the FB_1 call must be updated manually within ST_2.

Note

If program sources are imported which import other program sources themselves (inheritance), an error message may be output by the compiler during the compilation of the program source which is being imported, even if the type update runs error-free.

3.8.4 Example of a symbol check

Introduction

During the symbol check, the symbols used in the network are checked in context.

For example, the network includes a box with a BOOL-type input. An LREAL-type variable is now assigned to this input. The symbol check determines that this variable cannot be used in this context and, therefore, flags up this variable in red.

Initial situation

The following are present:

- an ST source ST_1 with the unit variable VAR_1
- an LAD/FBD unit LADFBD_1 with an LAD/FBD program PROGRAM_1
- the unit variable VAR_1 is used within PROGRAM_1, i.e. a connection (Page 165) to ST_1 has to be declared in the LADFBD_1 declaration table

How the symbol check works

The unit variable VAR_1 is now changed, e.g. the name is changed.

If ST_1 is recompiled after this change, the unit variable VAR_1 is invalid in LADFBD_1.

When PROGRAM_1 is opened in the LAD/FBD editor, an automatic symbol check is performed, i.e. the changed variable is highlighted in red lettering.

The changed variable must be updated manually in PROGRAM_1.

3.8.5 Deactivating automatic symbol check and type update

The automatic update of the symbol check and type database should only be deactivated if computation speed is unduly reduced, e.g. if a large project is being processed on a slow computer and the hourglass is displayed after any change in the declaration table or in referenced external units.

To deactivate automatic symbol check and type update, proceed as follows:

1. Select the **Options > Settings** menu item.
2. Select the **LAD/FBD editor** tab.
3. Deactivate the **Automatic symbol check and type update** checkbox.
4. Confirm with **OK**.

Note

If the automatic symbol check is deactivated, the display may sometimes be inaccurate, e.g. after an external call has been inserted, the call box interface may be incorrectly displayed (i.e. not updated), or not displayed at all. This is because the current information only becomes available to the LAD/FBD editor after the "Symbol check and type update at a specified time" (Page 39) has been called.

3.8.6 Perform symbol check and type update at a specified time

To perform a symbol check at a specified time, proceed as follows:

- Select the **LAD/FBD program > Symbol check and type update** menu item (shortcut Ctrl+T).
  - or -
  Click the **Symbol check and type update** icon.

Note

The symbol check at a specified time can only be performed when the "Automatic symbol check and type update" (Page 34) is deactivated.

3.8.7 Setting the data type list of the declaration table

In the declaration area, all function blocks of the project not used in the program are stated in the list of data types by default.

To improve clarity, it is possible to set that only those function blocks are displayed for which an entry in the **Connections** tab exists.

To set the data type display, proceed as follows:

1. Select the **Options > Settings** menu item.
2. Select the tab **LAD/FBD editor**.
3. Click the **Only known types if type lists exist** check box.
4. Confirm with **OK**.

3.8.8 Changing fonts

Use the following procedure to change the font of the LAD/FBD editor:

1. Select the **Options > Settings** menu item.
2. Select the tab **LAD/FBD editor**.
3. Click the **Fonts and colors button**.
   The **Fonts and colors** dialog box with the **Fonts** tab appears.
4. Select the font, font size, type, or display you require.

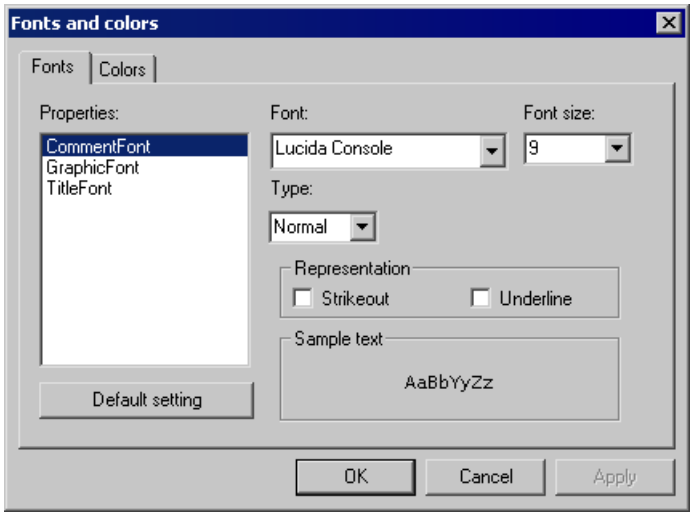


Figure 3-8 Fonts and colors dialog box

5. Confirm with **OK**.

Changes to settings are only applied to LAD/FDB editors that are opened afterwards.

3.8.9 Changing colors

Use the following procedure to change the colors of the LAD/FBD editor:

1. Select the **Options > Settings** menu item.
2. Select the tab **LAD/FBD editor**.
3. Click the **Fonts and colors button**.
   The **Fonts and colors** dialog box appears.
4. Click the **Colors** tab.

5. Choose a color.

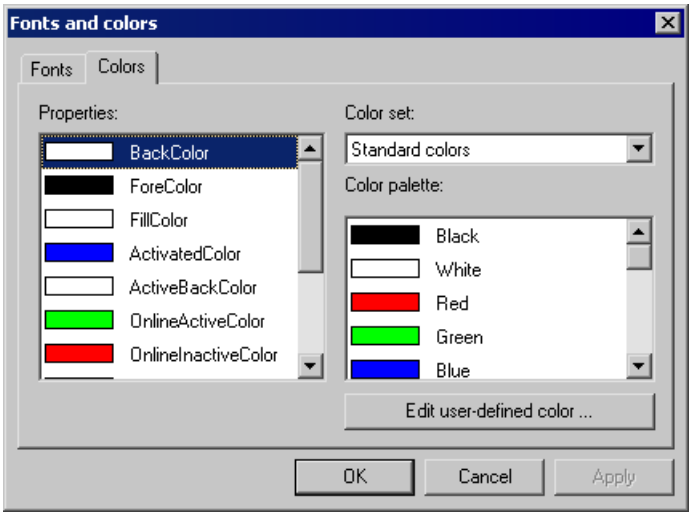


Figure 3-9 Fonts and colors dialog box

6. Confirm with **OK**.

Changes to settings are only applied to LAD/FDB editors that are opened afterwards.

3.8.10 Calling online help in the LAD/FBD editor

The online help can provide assistance for many of the operating steps. Call up the online help using either the:

- **Help** menu
  - Help topics
  - Context-sensitive help
  - Getting Started
- General help with the F1 key
- **Help** button, which appears in an open dialog box
- Context-sensitive help with the Shift+F1 key combination or the arrow with question mark icon (also for LAD/FBD elements in a network).

LAD/FBD programming

4

4.1 Programming software

This chapter describes the various operator control options in the LAD/FBD editor and the basic procedure for LAD/FBD programming.

4.2 Managing LAD/FBD source file

LAD/FBD units are assigned to the SIMOTION device on which the LAD/FBD programs contained in the unit will subsequently be run (e.g. SIMOTION D455-2). They are stored in the project navigator under the SIMOTION device in the PROGRAMS folder.

The individual program organization units (POU, LAD/FBD programs) are stored under a LAD/FBD unit.

Note

ST source files, MCC units and DCC charts are also stored in the **PROGRAMS** folder under the SIMOTION device.

For a description of the SIMOTION ST (Structured Text) programming language, refer to the SIMOTION ST Programming and Operating Manual.

For a description of the SIMOTION MCC (Motion Control Chart) programming language, refer to the SIMOTION MCC Programming and Operating Manual.

4.2.1 Inserting a new LAD/FBD source file

LAD/FBD units are assigned to the SIMOTION device on which the LAD/FBD programs contained in the unit will subsequently be run (e.g. SIMOTION D455-2).

There are several ways of inserting a new LAD/FBD unit.

- In the project navigator: in the **PROGRAMS** folder using the **Insert LAD/FBD unit** element
- Select the **PROGRAMS** folder in the project navigator and choose the command **Insert > Program > LAD/FBD unit** in the menu.
- Select the **PROGRAMS** folder in the project navigator and choose the command **Insert new object > LAD/FBD unit** in the context menu.

Procedure

To insert a new LAD/FBD unit using the context menu:

1. Open the appropriate SIMOTION device in the project navigator.
2. Select the **PROGRAMS** folder.
3. Select the **Insert new object > Insert LAD/FBD unit** context menu.
4. Enter the name of the LAD/FBD unit.
   The names of program sources must comply with the rules for identifiers (Page 97): They are made up of letters (A … Z, a … z), numbers (0 … 9), or single underscores (_) in any order, whereby the first character must be a letter or underscore. No distinction is made between upper- and lower-case letters.
   The permissible length of the name depends on the SIMOTION Kernel version:
   - SIMOTION Kernel as of version V4.1: a maximum of 128 characters.
   - SIMOTION Kernel up to version V4.0: a maximum of 8 characters.

   Names must be unique within the SIMOTION device. Protected or reserved identifiers (Page 361) are not permitted.
   Existing program sources (e.g. LAD/FBD units, ST source files) are displayed.
5. You can also enter an author, version, and a comment.
6. Activate the **Open editor automatically** checkbox.
7. If necessary, select the **Compiler** tab and make any local compiler settings; see Local compiler settings (Page 54).
8. Confirm with **OK**.

Note

When you click **OK**, the LAD/FBD unit is transferred to the project only. The data, together with the project, is only saved to the data carrier if you select, for example, **Project > Save**, **Project > Save and compile changes**, or **Project > Save and recompile all**.

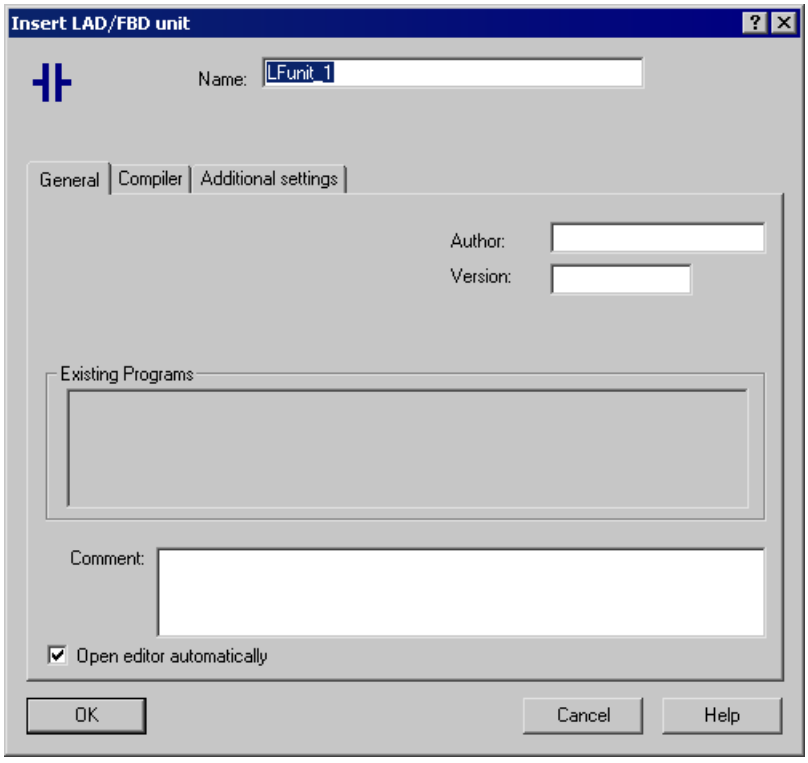


Figure 4-1 Insert LAD/FBD Unit dialog box

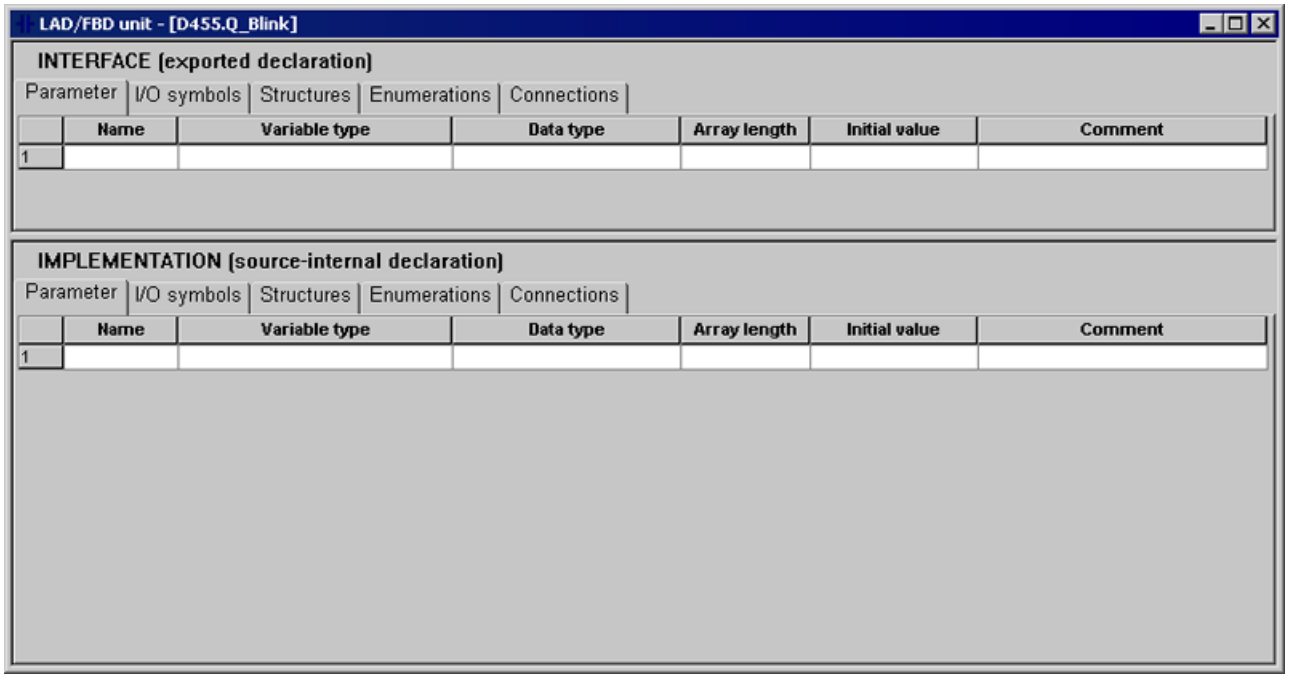


Figure 4-2 New LAD/FBD unit (declaration table for the interface and implementation sections)

4.2.2 Opening an existing LAD/FBD source file

Procedure

To open an existing LAD/FBD unit, proceed as follows:

1. Open the subtree of the appropriate SIMOTION device in the project navigator.
2. Open the **PROGRAMS** folder.
3. Select the required LAD/FBD unit.
4. Select the **Open** context menu.
5. Only for LAD/FBD units with know-how protection (Page 48):
   If the LAD/FBD unit (or a program of this unit) is not already open and the login assigned to the LAD/FBD unit is not yet logged in:
   - Enter the corresponding password for the displayed login.
     The know-how protection for this unit is temporarily canceled (until the unit and all its programs are closed).
   - If required, activate the "Use login as a standard login" checkbox.
     You will be logged in with this login and can now open additional units to which the same login is assigned without having to re-enter the password.

The LAD/FBD unit (declaration table) opens in the workspace. Multiple units can be opened.

Note

You can also double-click the required LAD/FBD unit to open it.

4.2.3 Saving and compiling a LAD/FBD source file

Requirements:

Ensure that the LAD/FBD unit or one of the associated LAD/FBD programs is the active window in the workbench.

To save a LAD/FBD unit and all its associated LAD/FBD programs in the project and start the compiler:

- Select the **Save and compile** icon in the LAD/FBD editor toolbar.
  - or -
  Select the **LAD/FBD unit > Save and compile** menu item.
  - or -
  Select the LAD/FBD unit or a LAD/FBD program in the project navigator and select **Save and compile** in the context menu.
  - or -
  Shortcut **Ctrl+B**.

Note

Save and compile only applies the changes to LAD/FBD units and associated LAD/FBD programs in the project. The data is only saved to the data carrier, together with the project, if you select **Project > Save** or **Project > Save and compile changes**.

A LAD/FBD unit can also be saved outside the project (exported).

Error messages and warnings relating to compilation are displayed in the **Compile/check output** tab in the detail view.

4.2.4 Closing a LAD/FBD source file

To close a LAD/FBD unit opened in the working window, proceed as follows:

1. Click the **x** button (cross) in the title bar of the dialog box of the LAD/FBD unit.
   - or -
   Select the **LAD/FBD unit > Close** menu item.
   - or -
   Select **Windows > Close all windows** menu item.
   - or -
   Shortcut **Ctrl+F4**.
   If the changes have not yet been saved in the project, you can save or cancel them, or abort the close operation.

4.2.5 Cut/copy/delete operations in a LAD/FBD source file

A LAD/FBD source file can be cut or copied together with all its associated LAD/FBD programs and pasted into the same or another SIMOTION device.

It is not possible to paste in a LAD/FBD source file that has been deleted.

To **cut**, **copy** or **delete**, proceed as follows:

1. In the project navigator, select the required LAD/FBD source file.
2. In the context menu, select the appropriate item (**Cut**, **Copy**, or **Delete**).
3. Change the name, if necessary (refer to "See also").

See also

Renaming a LAD/FBD source file (Page 53)

4.2.6 Inserting a cut or copied LAD/FBD source file

To paste in a cut or copied LAD/FBD source file:

1. Under the SIMOTION device, select the **PROGRAMS** folder.
2. In the context menu, select **Paste**.
   The LAD/FBD source file is pasted in under a new name.
3. If required, amend the name.

4.2.7 Know-how protection for LAD/FBD source files

You can protect LAD/FBD units against being accessed by unauthorized third parties. Protected LAD/FBD units and all associated LAD/FBD programs can only be opened or exported in EXP format when the password is entered.

The SIMOTION online help provides additional information on know-how protection.

Note

If you export in XML format, the LAD/FBD units are exported in an encrypted format. When importing the encrypted XML files, the know-how protection, including login and password, is retained.

4.3 Exporting and importing LAD/FBD source files

The export and import functions offer you the option of saving a LAD/FBD source file outside the project on your hard disk so that you can copy it from there into another project.

4.3.1 Exporting a LAD/FBD source file in XML format

You can use an XML export to save an LAD/FBD unit in a directory outside the project, independently of any particular version or platform.

To export a LAD/FBD unit in XML format:

1. In the project navigator, select the required LAD/FBD unit.
2. Select the **Expert > Save project and export object** context menu or the **Project > Save and export** menu.
3. Select the directory for the XML export and confirm with **OK**.

Note

Structures (e.g. several POUs in one unit, advance binary switching) can be used with SIMOTION Kernel as of version V4.1. These structures may not be supported by previous versions.

Note

LAD/FBD units with know-how protection can also be exported in XML format. The LAD/FBD units are exported in encrypted format. When importing the encrypted XML files, the know-how protection, including login and password, is retained.

4.3.2 Importing LAD/FBD source files as XML data

To import a LAD/FBD source file in XML format:

1. In the project navigator, select the **PROGRAMS** entry or a LAD/FBD source file.
2. In the context menu, select **Import object** or **Expert > Import object**.
3. Select the XML data to be imported and click **OK** to confirm.
   The LAD/FBD source file is inserted.

4.3.3 Exporting a POU in XML format

Note

Structures (e.g. several POUs in one unit, advance binary switching) can be used with SIMOTION Kernel as of version V4.1. These structures may not be supported by previous versions.

You can use an XML export to save individual program organization units in a directory outside the project, independently of any particular version or platform.

To export a POU in XML format, proceed as follows:

1. In the project navigator in the LAD/FBD unit, select the POU you want to export.
2. In the context menu, select **Export as XML**.
3. Only for POUs in LAD/FBD units with know-how protection and which are not already open:
   If the associated LAD/FBD unit (or a POU of this unit) is not already open and the login assigned to the LAD/FBD unit is not yet logged in:
   - Enter the corresponding password for the displayed login.
     The know-how protection for this chart is temporarily canceled (for this export).
   - If required, activate the **Use login as a standard login** checkbox.
     You will be logged in with this login and can now export or open additional units to which the same login is assigned without having to re-enter the password.
4. Select the directory for the XML export and confirm with **OK**.
5. Enter the path and file name for the XML export and click **Save** to confirm.

The POU is saved as XML format; the file name is given the default extension *.xml

Note

A POU with know-how protection is exported without protection.

4.3.4 Importing a POU from XML format

To import a POU in XML format, proceed as follows:

1. In the project navigator, select the **PROGRAMS** entry or a LAD/FBD unit.
2. In the context menu, select **Import object**.
3. Select the XML data to be imported and click **OK** to confirm.
   The POU is inserted.

4.3.5 Exporting a LAD/FBD source file in EXP format

With the export in the EXP format, you can save an LAD/FBD unit in a format that can also be interpreted by third-party controllers.

To export an LAD/FBD unit in EXP format, proceed as follows:

1. Select the LAD/FBD unit in the project navigator.
2. Select the context menu **Expert > Export as .EXP**.
3. Only for LAD/FBD units with know-how protection (Page 48) and which are not already open:
   If the LAD/FBD unit (or a program of this unit) is not already open and the login assigned to the LAD/FBD unit is not yet logged in:
   - Enter the corresponding password for the displayed login.
     The know-how protection for this unit is temporarily canceled (for this export).
   - If required, activate the **Use login as a standard login** checkbox.
     You will be logged in with this login and can now export or open additional units to which the same login is assigned without having to re-enter the password.
4. Enter the path and file name for the EXP export and click **Save** to confirm.

The LAD/FBD unit is saved in EXP format and given the file extension *.exp by default.

Note

The export of an LAD/FBD unit in EXP format and subsequent import of the EXP data can change the structure of the networks in the LAD/FBD programs. The compilation result remains unchanged.

An LAD/FBD unit with know-how protection is exported without protection.

4.3.6 Importing EXP data into a LAD/FBD source file

With the import of EXP data, you can create an LAD/FBD unit from third-party programs that are available EXP format.

To import EXP data into a LAD/FBD unit:

1. Select the LAD/FBD unit in the project navigator.
2. Select the context menu **Expert > Import from .EXP**.
3. Select the EXP file to be imported.
4. Select the program sources to which Connections (Page 164) care to be created.
5. Confirm with **OK**.

The EXP file is imported into the LAD/FBD unit and the corresponding LAD/FBD programs created. The connections to the selected program sources are also created.

Note

Note the following when importing EXP data:

- It is possible to import from XOR to FBD.
- Preconnection with simple data types (signal connection) is not generally supported.
- The original structure is retained when you import data from EXP files. If the structure cannot be compiled due to type conflicts, the relevant parameters are highlighted in red.
  A type conflict can be resolved by manual revision.

4.4 LAD/FBD source files - defining properties

4.4.1 Defining the properties of a LAD/FBD source file

Procedure

1. Under the SIMOTION device, open the **PROGRAMS** folder.
2. Select the required LAD/FBD unit.

3. Select the **Edit > Object Properties** menu command.
4. If necessary, select further tabs to make local settings (only valid for this LAD/FBD unit):
   - **General** tab: General details for the LAD/FBD unit, e.g. timestamp of the last change and the storage location of the project (see figure).
   - **Compiler** tab: Local settings of the compiler (Page 54) for code generation and message display.
   - **Additional settings** tab: Display of the compiler options in accordance with the current compiler settings (see the SIMOTION ST Programming and Operating Manual).
   - **Compilation** tab: Display of the compiler options during the last compilation of the LAD/FBD unit (see the SIMOTION ST Programming and Operating Manual).
   - **Object address** tab: Set the internal object address of the LAD/FBD unit. The object addresses of the other program sources are displayed.

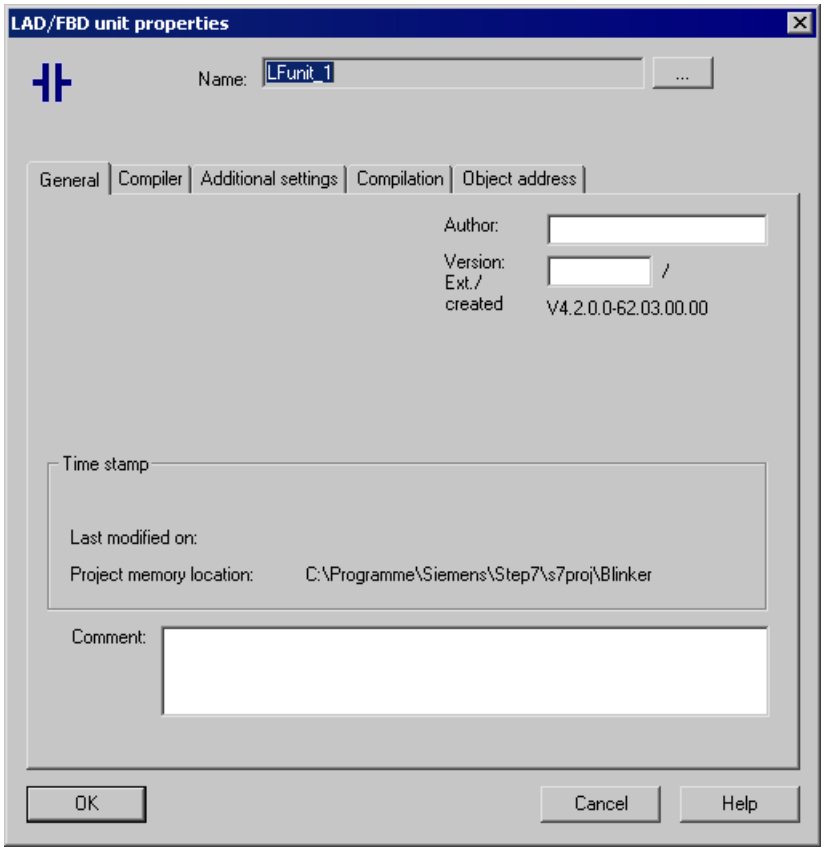


Figure 4-3 Properties of a LAD/FBD source file

4.4.2 Renaming a LAD/FBD source file

To rename a LAD/FBD source file:

1. Open the Properties window of the LAD/FBD source file.
2. Click ... .
3. Confirm the message with **OK** and enter the new name in the **New name** input field of the **Change Name** dialog box.
4. Acknowledge the entries with **Apply**.

4.4.3 Making settings for the compiler

You can define the compiler settings as follows:

- globally for the SIMOTION project, always applicable to all programming languages, see Global compiler settings (Page 53)
- locally for an individual LAD/FBD source within the SIMOTION project, see Local compiler settings (Page 54)

4.4.3.1 Global compiler settings

The global settings are always valid for all programming languages within the SIMOTION project. If there are global settings which only apply to specific programming languages, this is specified on the **Compiler** tab.

Procedure

1. Select the menu **Options > Settings**.
2. Select the **Compiler** tab.
3. Make the settings in accordance with the parameter description in the SIMOTION ST Programming and Operating Manual.
4. Confirm with **OK**.

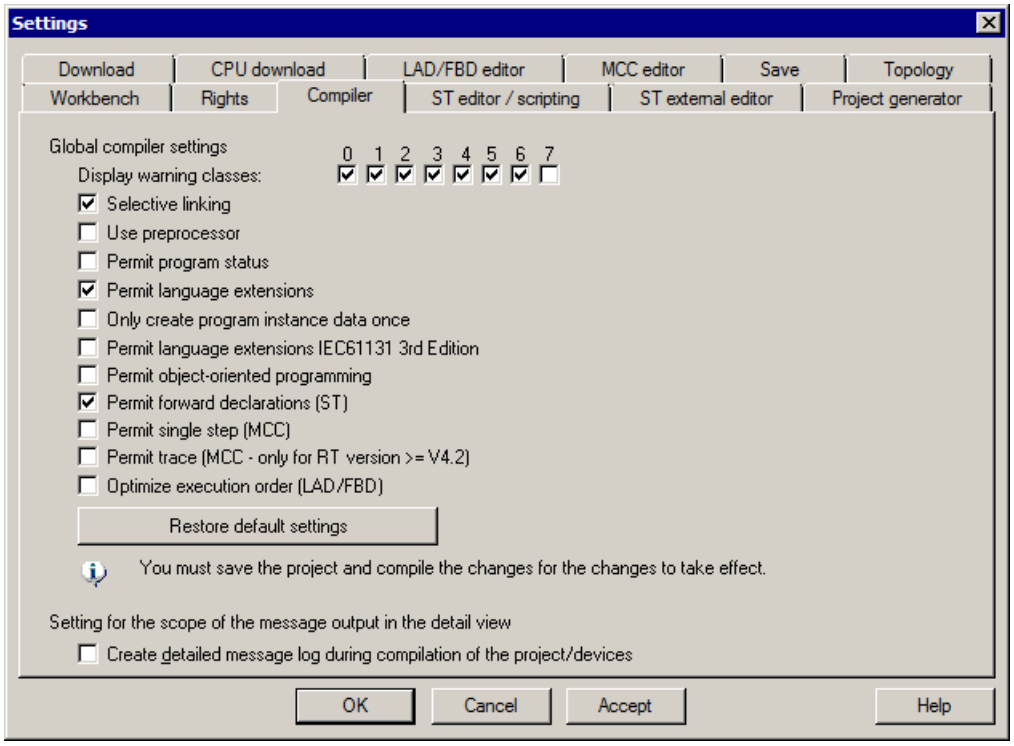


Figure 4-4 Global compiler settings

Parameter

For a description of the parameters of the global compiler settings, refer to SIMOTION ST Programming and Operating Manual.

4.4.3.2 Local compiler settings

Local settings are configured individually for each LAD/FBD unit; local settings overwrite global settings.

Procedure

To select the compiler options, proceed as follows:

1. Open the Properties window for the LAD/FBD unit (see Defining the properties of an LAD/FBD unit (Page 51)).
2. Select the **Compiler** tab.
3. Define the settings according to the following table.
4. Click **OK** to confirm.

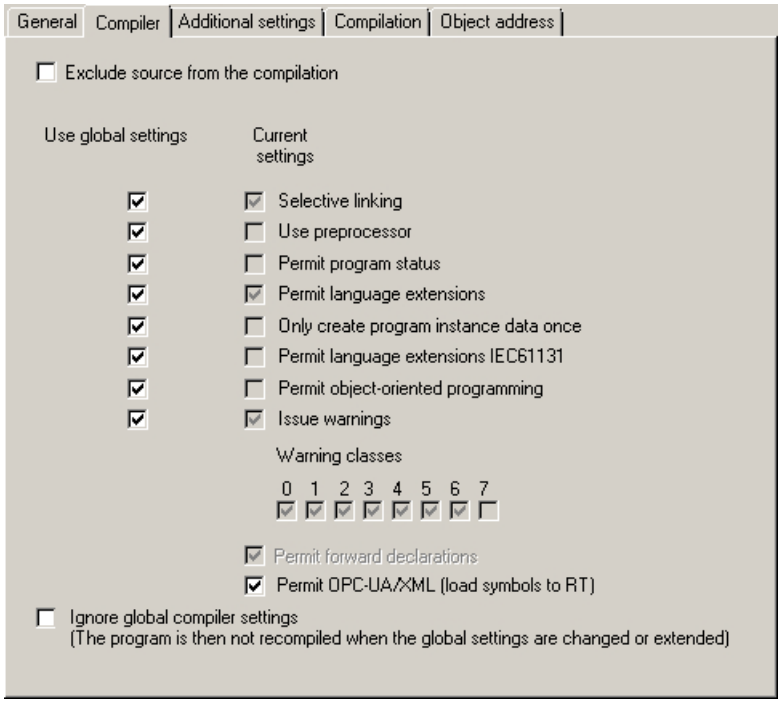


Figure 4-5 Local compiler settings for LAD/FBD units in the Properties window

The current compiler options (the combination of global and local compiler settings which currently applies) for the program source are displayed on the **Additional settings** tab. The compiler options used the last time the program source was compiled can be seen on the **Compilation** tab.

The SIMOTION ST Programming and Operating Manual contains further information on what the compiler options mean.

Table 4-1 Local compiler settings

Parameter	Description
Exclude the source from the compilation	**Active**: This source is not compiled upon compilation of the project, the device or the library (e.g. Menu **Project > Save and recompile all**). The source is marked accordingly in the project navigator. Corresponding information is provided upon compilation. **Inactive** (standard): The source is compiled upon compilation of the project, the device or the library.
Use global settings	This checkbox is available for every parameter which also has a global setting. This is where you define whether the global settings are adopted or whether the local settings will apply. See the description under Effectiveness of global or local settings in the SIMOTION ST Programming and Operating Manual. Use the second checkbox or the other checkboxes for the relevant parameters (described below) to define the local settings.
Selective linking[1]	**Active**: Unused code is removed from the executable program. **Inactive**: Unused code is retained in the executable program. **Gray background** (display only): The global setting displayed is adopted (when "Use global settings" = active).

Parameter	Description
Use preprocessor[1]	**Active**: Preprocessor is used, see SIMOTION ST Programming and Operating Manual. **Inactive**: Preprocessor is not used. **Gray background** (display only): The global setting displayed is adopted (when "Use global settings" = active).
Enable program status[1]	**Active**: Additional program code is generated to enable monitoring of program variables (including local variables). **Inactive**: Program status not possible. **Gray background** (display only): The global setting displayed is adopted (when "Use global settings" = active). See Program status (Page 297).
Permit language extensions[1]	**Active**: Language elements are permitted that do not comply with IEC 61131-3. • Direct bit access to variables of a bit data type, see the SIMOTION ST Programming and Operating Manual. • Accessing the input parameter of a function block when outside the function block, see the SIMOTION ST Programming and Operating Manual. • Calling a program while in a different program, see the SIMOTION ST Programming and Operating Manual. **Inactive**: Only language elements are permitted that comply with IEC 61131-3. **Gray background** (display only): The global setting displayed is adopted (when "Use global settings" = active).
Only create program instance data once[1]	**Active**: The local variables of a program are only stored once in the user memory of the unit. This setting is required when calling a program while in a different program, see the SIMOTION ST Programming and Operating Manual. **Inactive**: The local variables of a program are stored according to the task assignment in the user memory of the associated task. **Gray background** (display only): The global setting displayed is adopted (when "Use global settings" = active). See Memory areas for the variable types in the SIMOTION ST Programming and Operating Manual. For further information, refer to the SIMOTION Basic Functions Function Manual.

Parameter	Description
Permit language extensions, IEC61131 3rd edition[1]	**Active**: Additional language elements can be used in accordance with IEC 61131-3 3rd edition. The corresponding keywords are locked as reserved or protected identifiers. • Nested block comments (ST) • CONTINUE statement (ST) • Standard-compliant system functions LOWER_BOUND and UPPER_BOUND for determining the limits of a dynamic ARRAY • Additional system functions: – FROM_BIG_ENDIAN – FROM_LITTLE_ENDIAN – IS_VALID – TO_BIG_ENDIAN – TO_LITTLE_ENDIAN **Inactive**: The additional language elements cannot be used. The corresponding keywords are not locked. **Gray background** (display only): The global setting displayed is adopted (when "Use global settings" = active). **Note** When saving the project in the old project format: Projects in which language elements that require this compiler option are used cannot be compiled correctly in SIMOTION SCOUT versions earlier than V4.5.
Permit object-oriented programming[1]	**Active**: The keywords for object-oriented programming according to IEC 61131-3 3rd edition are locked as reserved or protected identifiers. General references (Page 136) can also be formed. **Inactive** (standard): The keywords for object-oriented programming are not locked. **Gray background** (display only): The global setting displayed is adopted (when "Use global settings" = active). **Note** Independently of the setting the program organization units created in ST sources using object-oriented programming (e.g. classes, methods) can be used in this source. No program organization units can be created in LAB/FBD using object-oriented programming. When saving the project in the old project format: Projects in which language elements that require this compiler option are used cannot be compiled correctly in SIMOTION SCOUT versions earlier than V4.5.

Parameter	Description
Issue warnings Warning classes[1]	In addition to error messages, the compiler can issue warnings and information. You can set the scope of the warning messages to be issued. "Issue warnings" checkbox: **Active**: The compiler issues the warnings and information according to the warning class selection that follows. **Inactive**: The compiler suppresses all warnings and information concerning this source file. The checkboxes for the warning classes are hidden. **Gray background** (display only): Operating on a global setting basis, the compiler always issues warnings and information in accordance with the global warning class selection shown below (if "Use global settings" = active). "Warning classes" checkboxes (only if "Issue warnings" = active): **Active**: The compiler issues warnings and information for the selected class. **Inactive**: The compiler suppresses warnings and information for the associated class. **Gray background** (display only): The global setting displayed is adopted (when "Use global settings" = active). See also Meaning of the warning classes in the SIMOTION ST Programming and Operating Manual.
Permit forward declarations	Forward declarations enable you to use program organization units (POUs) before they are completely defined. See the SIMOTION ST Programming and Operating Manual. This setting is always **active**. Forward declarations are always permitted for the LAD/FBD programming language.
Permit OPC-UA / -XML (load symbols to RT)	**Active:** Symbol information for the unit variables of the LAD/FBD unit is available in the SIMOTION device. This is required for: • The *_exportUnitDataSet* and *_importUnitDataSet* functions; see the SIMOTION Basic Functions Function Manual • The watch function of IT DIAG **Inactive:** Symbol information is not created.
Exclude the source from the compilation	**Active**: This source is not compiled upon compilation of the project, the device or the library (e.g. Menu **Project > Save and recompile all**). The source is marked accordingly in the project navigator. Corresponding information is provided upon compilation. **Inactive** (standard): The source is compiled upon compilation of the project, the device or the library.
Ignore global compiler settings (The program is not compiled again if the global settings are changed or extended.)	**Active:** The global settings of the compiler are ineffective for all parameters. The "Use global settings" checkboxes cannot be selected and are grayed out. When changing the global compiler settings, the LAD/FBD unit is not recompiled. **Inactive:** The checkboxes "Use Global Settings" can be selected for all parameters and are presented against a white background. These checkboxes specify whether the global properties are taken over for the corresponding parameters. See the description under Effectiveness of global or local settings in the SIMOTION ST Programming and Operating Manual.

[1] Global setting is also possible (**Options > Settings > Compiler** menu), see Global compiler settings (Page 53). See also the description on Effectiveness of global or local compiler settings in the SIMOTION ST Programming and Operating Manual.

4.5 Managing LAD/FBD programs

LAD/FBD programs are the individual program organization units (program, function, function block) in a LAD/FBD source file. They are stored under the LAD/FBD source file in the project navigator.

4.5.1 Inserting a new LAD/FBD program

You can insert a new LAD/FBD program as program organization unit (POU) for an existing LAD/FBD source as follows (see Inserting a new LAD/FBD source (Page 43)):

- In the project navigator: Below an LAD/FBD unit using the element **Insert LAD/FBD program**
- Select the required LAD/FBD unit in the project navigator followed by **Insert > Program > LAD/FBD program**
- Open the required LAD/FBD unit and select the **Insert LAD/FBD program** icon in the **LAD/FBD unit** toolbar

Procedure

To insert a new LAD/FBD program, proceed as follows:

1. Open the appropriate SIMOTION device in the project navigator.
2. Open the **PROGRAMS** folder and a LAD/FBD unit.
3. Double-click the entry **Insert LAD/FBD program**.
4. Enter the name of the program in the **Insert LAD/FBD program** dialog box.
   Names for LAD/FBD programs must comply with the Rules for identifiers (Page 97): They are made up of letters (A … Z, a … z), numbers (0 … 9), or single underscores (_) in any order, whereby the first character must be a letter or underscore. No distinction is made between uppercase and lowercase letters. Protected or reserved identifiers (Page 361) are not allowed.
   The permissible length of the name is 25 characters.
   The names must be unique within the LAD/FBD source. The names of all exportable program organization units (POUs) must also be unique within the SIMOTION device. The names of all LAD/FBD programs of the program source as well as the names of all exportable POUs of the device are displayed.
5. Select Program, Function, or Function block as the **Creation type**. See also Changing the LAD/FBD program creation type (Page 66).
6. For the Function creation type only:
   Select Return value data type as the Return type
   (<--> for no return value).
7. Activate the **Exportable** checkbox if you want the LAD/FBD program to be accessible from other program sources (LAD/FBD unit, MCC source files, or ST source files) or from the execution system.
8. You can also enter an author, version, and a comment.

9. Activate the **Open editor automatically** checkbox.
10. Click **OK** to confirm.

Note

When you click **OK**, the LAD/FBD program is transferred to the project only. The data is only saved to the data carrier, together with the project, if you select, for example, **Project > Save**, **Project > Save and compile changes**, or **Project > Save and recompile all**.

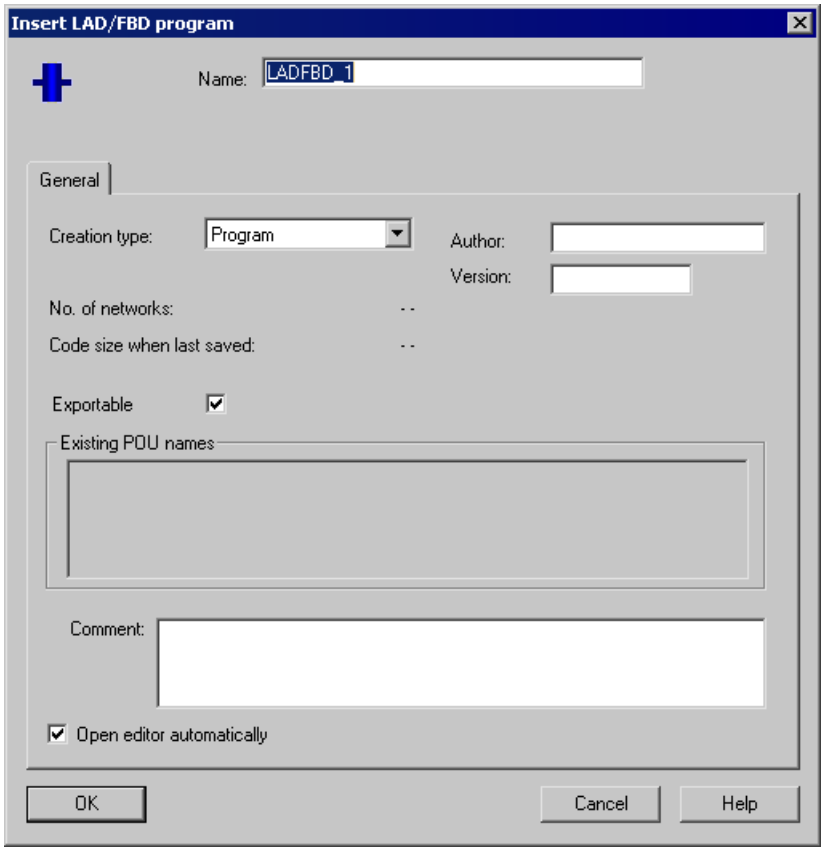
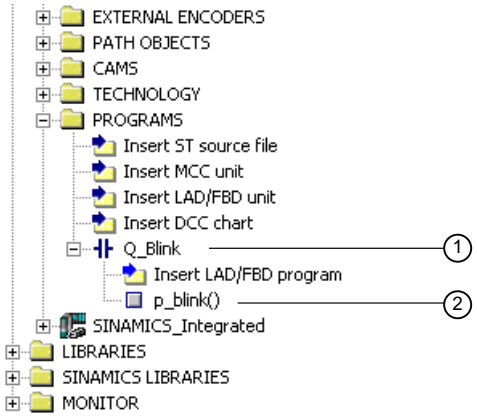


Figure 4-6 Insert LAD/FBD program dialog box



① Name of the LAD/FBD unit

② Name of the LAD/FBD program

Figure 4-7 Displaying the unit and program name in the project navigator

4.5.2 Opening an existing LAD/FBD program

All LAD/FBD programs belonging to an LAD/FBD unit are located in the project navigator underneath the LAD/FBD unit.

Procedure

To open an available program, proceed as follows:

1. Open the subtree of the appropriate SIMOTION device in the project navigator.
2. Open the **PROGRAMS** folder.
3. Open the LAD/FBD unit containing the required LAD/FBD program.
4. Select the required LAD/FBD program.
5. Select the **Open** context menu.
6. Only for programs below LAD/FBD units with know-how protection (Page 48):
   If the LAD/FBD unit (or a program of this unit) is not already open and the login assigned to the LAD/FBD unit is not yet logged in:
   - Enter the corresponding password for the displayed login.
     The know-how protection for this unit is temporarily canceled (until the unit and all its programs are closed).
   - If required, activate the "Use login as a standard login" checkbox.
     You will be logged in with this login and can now open additional units to which the same login is assigned without having to re-enter the password.

The LAD/FBD program opens in the working area. Several LAD/FBD programs can be opened at the same time.

Note

You can also double-click the required LAD/FBD program to open it.

4.5.3 Defining the order of the LAD/FBD programs in the LAD/FBD source file

As of Version V4.2 of SIMOTION SCOUT, the user no longer needs to respect the POU order in the LAD/FBD unit, as this no longer has any role to play in terms of compilability. The user may wish to change the POU order so that the POUs are arranged in a more logical way from his or her own perspective.

Exception

When a project is saved in a format older than Version V4.2 of SIMOTION SCOUT, the order of the LAD/FBD programs in the LAD/FBD source file is of relevance as far as compilation is concerned. A subroutine (function, function block, or program ("program in program")) must be defined before it is used. This is the case when the LAD/FBD program of the subroutine appears in the project navigator above the LAD/FBD program in which it is used. If necessary, reorder the charts (see Subroutine call of function (FC) (Page 176)).

Prior to saving a project in a project format earlier than version 4.2, you can test the project for downward compatibility (i.e. the correct POU order, etc.) via Project > Old project format > Test the project for downward compatibility.

Procedure

To change the order:

1. Select a LAD/FBD program in the project navigator.
2. In the context menu, select **Up / Down**

4.5.4 Copying the LAD/FBD program

To copy a LAD/FBD program:

1. In your LAD/FBD unit, select the POU you want to copy.
2. In the context menu, select **Copy**.
3. Select the LAD/FBD unit which is to be inserted in the POU.
4. In the context menu, select **Insert.**
   The LAD/FBD program is inserted.

4.5.5 Saving and compiling a LAD/FBD program

An asterisk is appended in the title bar of the project to the name of a program which has been modified but not yet saved.

Note

The entire unit and its POUs are saved and compiled

To save the LAD/FBD program and start the compilation:

1. Click the **Save and compile** icon in the LAD/FBD editor toolbar.
   - or -
   Select the **LAD/FBD program > Save and compile** menu item.
   - or -
   Select the LAD/FBD program in the project navigator and select **Save and compile** in the context menu.
   - or -
   Shortcut **Ctrl+B**.
   - or -
   If you want to save and compile all the available LAD/FBD programs, select the **Project > Save and compile changes** menu command.
   If any errors occur during compilation, the error locations are displayed in the **Detail view**.
2. To fix an error, double-click an error message in the detail view in the **Compile / check output** tab.
   The faulty element is selected and positioned in the window.

Note

Backward compatibility

This SCOUT program version supports structures (e.g. several POUs in one unit, advance binary switching) which may not be able to be processed by previous versions.

4.5.6 Closing a LAD/FBD program

To close a LAD/FBD program opened in the working window, proceed as follows:

1. Click the **x** button (cross) in the title bar of the dialog box of the LAD/FBD **program**.
   - or -
   Select the **LAD/FBD program > Close** menu item.
   - or -
   Select the **Windows > Close all** menu item.
   - or -
   Shortcut **Ctrl+F4**.
   If the changes have not yet been saved, you can save or cancel them, or abort the close operation.

4.5.7 Deleting the LAD/FBD program

To delete a LAD/FBD program:

1. In the project navigator, select the required LAD/FBD program.
2. In the context menu, select **Delete**.

Note

It is not possible to insert a LAD/FBD program that has been deleted.

4.6 LAD/FBD programs - defining properties

The properties of a LAD/FBD program are specified when it is inserted.

However, these properties can be viewed and modified by doing the following:

1. Open the **PROGRAMS** folder under the SIMOTION device in the project navigator.
2. Open the required LAD/FBD unit.
3. Select the required LAD/FBD program.
4. From the context menu, select **Properties**.
   The **LAD/FBD program properties** dialog box opens.

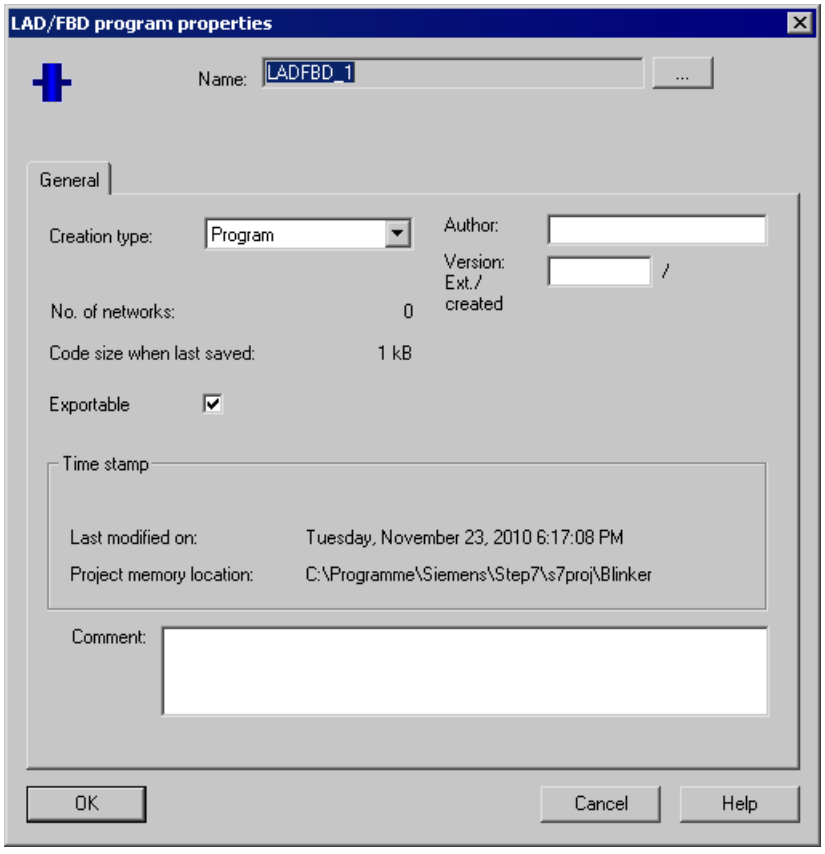


Figure 4-8 Properties of an LAD/FBD program

4.6.1 Renaming a LAD/FBD program

To rename a LAD/FBD program:

1. Open the property view for the LAD/FBD program.
2. Click ... .
3. Confirm the message with **OK** and enter the new name in the **New name** input field of the **Change Name** dialog box.
4. Acknowledge the entries with **Apply**.

4.6.2 Changing the LAD/FBD program creation type

To change the LAD/FBD program creation type:

1. Select the new creation type:
   Program
   Programs can be compared with function blocks. Local variables can be stored here either statically or temporarily. In contrast to FBs or FCs, programs can be assigned to a task or an execution level in SIMOTION SCOUT.
   Programs cannot be called up with parameters. Therefore, unlike FBs and FCs, programs do not have any formal parameters.
   Function block (FB)
   A function block (FB) is a program with static data, i.e. all local variables retain their values after the function block has been executed. Only variables explicitly declared as temporary variables lose their value between two calls.
   Before an FB is used, an instance must be defined: Define a variable (VAR or VAR_GLOBAL) and enter the name of the FB as data type. The FB static data is saved in this instance. You can define multiple instances of an FB, with each instance being independent of the others.
   The static data of an FB instance are retained until the next time the instance is called; the static data are reinitialized when the variable type of the FB instance is reinitialized.
   Data transfer to the FB takes place via input or input/output parameters, and the data return from the FB takes place via input/output parameters or output parameters.
   Function (FC)
   A function (FC) is a function block without static data, that is, all local variables lose their value when the function has been executed. They are reinitialized the next time the function is started.
   Data transfer to the function takes place by means of input parameters; output of a function value (return value) is possible.

4.7 Printing source files and programs

You can print general information about the LAD/FBD source files and programs. Various print options can be set for the printout.

To print LAD/FBD units and programs, proceed as follows:

1. Select a LAD/FBD source file or program in the project navigator.
2. From the context menu, select **Print** or **Print preview**.
   The **Print** dialog box will appear, enabling you to set various print options.

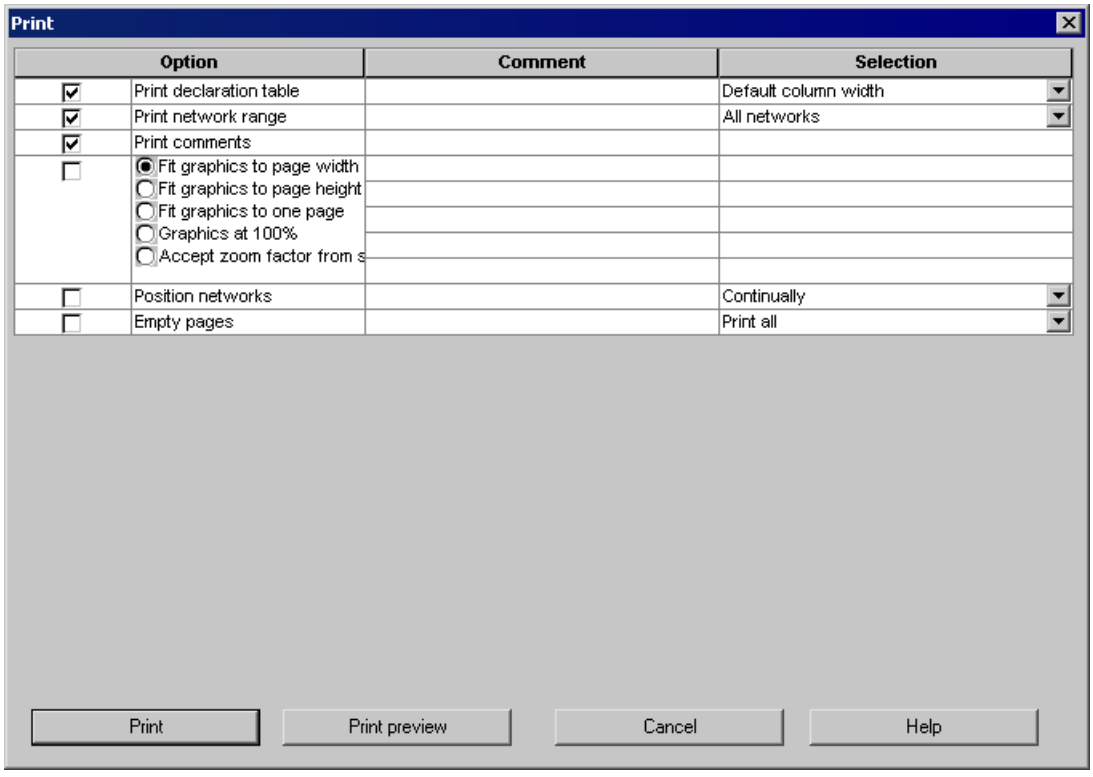


Figure 4-9 Dialog box for setting print options

3. Click the **Print** button.
   The source file or LAD/FBD program is printed with the selected options. General information, the declaration table and diagram all appear in the printout.

4.7.1 Printing a declaration table

To print a declaration table, proceed as follows:

1. Activate the **Print declaration table** check box.
2. Select **Column widths by screen**.
   The contents of the declaration table are printed with the set column widths.
   - or -
   Select **Default column widths**.

4.7.2 Printing a network area

To print a network area, proceed as follows:

1. Activate the **Print network area** check box.
2. Select **All networks**.
   - or -
   Select **Selected networks only**.
   Prints only the networks selected in the editor (blue selection mark on the left side).

4.7.3 Printing comments

You can only select this option if you have already selected the **Print network area** option.

To print comments, proceed as follows:

1. Activate the **Print comments** check box.
2. To obtain a shorter, more concise print image, unselect the **Print comments** option.

4.7.4 Defining print variants

To define the print variant, proceed as follows:

1. Activate the check box.
2. Select **Scale graphics to page width**.
   The print image is scaled so that the widest LAD/FBD network fits on one page width. The print image is one page in width and one or more pages in length, depending on the size of the program.
   - or -
   Select **Scale graphics to page height**.
   The print image is scaled so that the entire graphic fits on one page height. The print image is one page in length and takes up one or more page widths, depending on the width of the networks.
   - or -
   Select **Scale graphics to one page**.
   The print image is reduced so that all networks fit on one page.
   - or -
   Select **Graphic at 100%**.
   The image is printed in its original size. The print image can consist of more than one page vertically or horizontally.
   - or -
   Select **Save screen zoom factor**.
   The image is printed according to the zoom factor set in the editor. The print image can consist of more than one page vertically or horizontally.

Note

If the print image consists of more than one page, an index page is printed to give an overview.

4.7.5 Placing networks

With **Placing networks** you define how the networks are distributed over the pages for printing.

To place networks, proceed as follows:

1. Activate the **Place networks** check box.
2. Select **Continuous**.
   The networks are printed one after another. Page breaks are not taken into account in this case.
   - or -
   Select **All on new page**.
   All networks are printed beginning on a new page. If a network is longer than one page, it is printed on the next page.
   - or -
   Select **Optimized**.
   This minimizes the horizontal break between networks to save more space. E.g.: If a network does not fit on the current page and is not longer than one page, this network will be printed on the next page. If the network is longer, then a page break must be inserted.

4.7.6 Blank pages

You can select how blank pages are printed out. The layout is displayed on the index page. Pages marked with an X are omitted.

To set the printing of blank pages, proceed as follows:

1. Activate the **Blank pages** checkbox.
2. Select **Print all**.
   All blank pages are printed.
   - or -
   Select **Omit at end**.
   Blank pages at the end are not printed. Blank pages in the middle are retained.
   - or -
   Select **Omit all**.
   Blank pages in the middle and at the end are omitted.

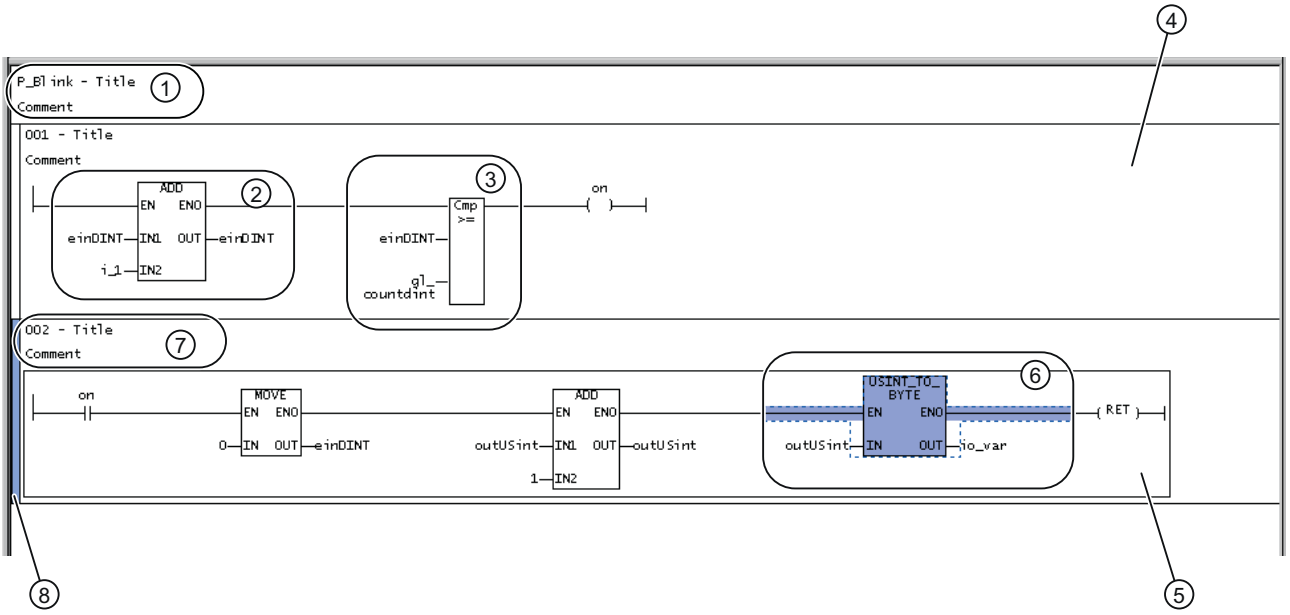
4.8 LAD/FBD networks and elements

The LAD/FBD program is organized in networks which are displayed in the editor area. A network contains a logic circuit representing the ladder diagram line.

The rules for the structure of a network according to IEC standard 61131-3 apply to the display of a network. Several LAD/FBD elements and boxes can be inserted, copied or deleted in a network.

Note

Use the key combinations (Page 27)for fast operation in the LAD/FBD editor.



①	Name of program and comment field	⑤	Network 2
②	Call box	⑥	Selected LAD element
③	LAD element	⑦	Name of network and comment field
④	Network 1	⑧	Selected network

Figure 4-10 Display of the networks in the LAD/FBD editor

See also

Numbering the networks (Page 71)

4.8.1 Inserting networks

To paste in a network:

1. Select an existing network or click in the working window of the open LAD/FBD program.
2. From the context menu, select **Insert network**.
   - or -
   Select **LAD/FBD program > Insert network**.
   - or -
   Click the **Insert network** icon.
   The new network is pasted in directly after the network which is currently selected. If no network is selected, the new network is pasted in at the front.

See also

LAD/FBD networks and elements (Page 69)

4.8.2 Selecting networks

The relevant networks have to be selected before they can be copied.

To select networks:

1. Select the desired network.
   The network is selected (see figure).
   - or -
   If you want to select several adjacent networks, click the first required network and then, keeping the **Shift** key depressed, click the last one required.
   - or -
   If you want to select several networks which are not adjacent to one another, hold the **Ctrl** key down and click each network you need.

Selected networks are indicated by a light blue edge on their left-hand side. You can choose the selection color in the **LAD/FBD editor** tab of the **Settings** dialog box.

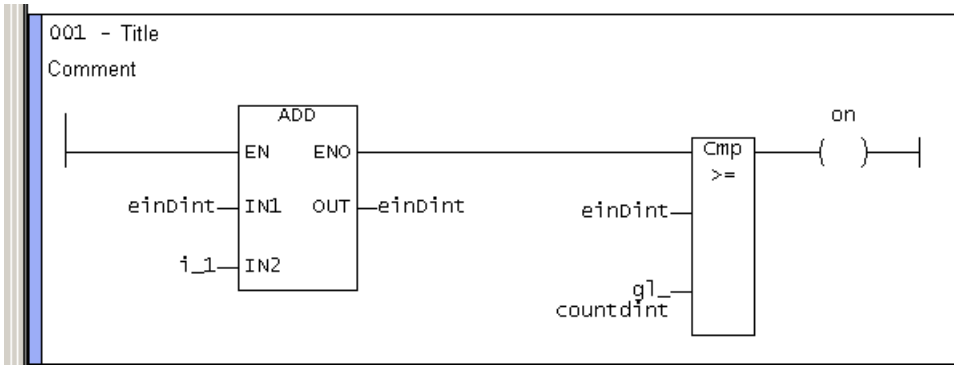


Figure 4-11 Selected network

See also

Settings in the LAD/FBD editor (Page 33)

4.8.3 Numbering the networks

When a network is pasted in, it is automatically given the next consecutive number. This number is unique and is used to identify the network.

Note

You cannot change the numbering. When a network is deleted, the numbering is automatically adjusted.

See also

LAD/FBD networks and elements (Page 69)

4.8.4 Enter title/comment

Titles and comments

By default, the LAD/FBD program and/or the network contain a title and a comment field. The title and comment texts are language-dependent.

Language-dependent texts

You can use the **Project > Language-dependent texts** menu item to import and export ASCII files containing translations of LAD/FBD network comments and symbol browser comments (I/O variables, global device variables).

The exported files (**Export** button) can be re-imported into the project using the import function (**Import** button) once they have been translated.

After a language change, the user-defined comments in the project are available in the respective compiled languages.

Assigning a title

The title/name is used for the documentation of the LAD/FBD program or network. It is initialized with the name "Title".

To enter a title, proceed as follows:

1. Click in the title line.
2. Enter a different title/name in the window which appears.
   There is no maximum text length. The length of text visible on the screen depends on the font, font size and screen resolution.

Entering/modifying comments

You can enter a comment in every program or network.

To enter a comment, proceed as follows:

1. Click in the comment line.
2. Enter the text of the comment in the window which appears.
3. To change an existing comment, double-click the existing comment.
4. Overwrite the now selected text.

Showing/hiding a comment line

In every program/network, you can hide a comment that has been entered:

To hide and show comments, proceed as follows:

1. Click in the working window of the open LAD/FBD program.
2. From the context menu, select **Display > Comments on/off**.
   - or -
   Select the **LAD/FBD program > Display > Comments on/off** menu item.
   - or -
   Shortcut **Ctrl+Shift+K**.

This change always applies to the active LAD/FBD editor. The setting is only saved when saving if changes have been made in the respective editor window.

4.8.5 Showing/hiding a jump label

You can paste a jump label in every network.

To paste in or hide jump labels, proceed as follows:

1. Select the network in which the jump label is to be pasted.
2. From the network context menu, select **Jump label ON/OFF**.
3. Enter the text of the jump label in the window that appears.
   Only alphanumeric characters and underscores are allowed during input. The text length of a label must not exceed 480 characters.

   Note

   The jump label is deleted if it contains an error and cannot be corrected.

4. If you want to hide a jump label, select the required jump label and select **Jump label ON/OFF** in the context menu.

See also

Overview of jump operations (Page 256)

4.8.6 Copying/cutting/pasting networks

If a network is copied or cut, and then pasted in again, all LAD/FBD elements in the network are taken with it.

To copy a network, proceed as follows:

1. Select the required network.
2. In the context menu, select **Copy**or **Cut**.
   - or -
   Select the **Edit > Copy** or **Edit > Cut** menu item.
   The copied network can be pasted again at any place or even in other LAD/FBD programs. A new/copied or cut network is always pasted in after the selected network. If no network is selected, the new network is placed as the first network.

4.8.7 Undo/redo actions

Note

The following actions cannot be undone:

- Save
- Save and compile

To undo or redo actions, proceed as follows:

1. Select the **Edit > Undo** menu command or the **Undo** symbol.
   The actions are undone in reverse order.
2. If you want to redo one or more undone actions, select the **Edit > Redo** menu item or the **Redo** icon.

4.8.8 Deleting networks

To delete a network:

1. Click in a network in the open LAD/FBD program.
2. From the context menu, select **Delete network**.

4.9 Displaying LAD/FBD elements

4.9.1 LAD diagram

LAD diagram

The LAD diagram complies with Standard IEC 61131-3 and is organized around the binary ladder diagram line. The ladder diagram line begins with a vertical line (conductor bar) and ends with a coil, call-up (box) or with a jump to another network. In between, there are special LAD elements (NO contacts, NC contacts, connectors), general logical elements (SR, RS flipflop), system components call-ups (e.g arithmetic operations), and user functions or function blocks.

Rules for entering LAD statements

- Start of a LAD network
  The left conductor bar is the network's starting point. Crossed lines are not permitted in a LAD diagram. The following elements are not permitted at the beginning of a network: (P), (N), (#).
- LAD network termination
  Every LAD network must terminate with a coil or a box. Multiple outputs are possible.
  The following LAD elements may not be used to terminate a network:
  - (P),
  - (N),
  - POS,
  - NEG,
  - Comparator.
- Placement of empty boxes
  Empty boxes can be placed anywhere in a network except on the right-hand edge or in a parallel branch. Preconnection at binary inputs is supported.
- Placement of coils
  Coils are automatically placed on the right-hand edge of the network, where they are used to terminate a branch.

- Parallel branches
  Parallel branches are
  - opened downward and closed upward.
  - opened behind the selected LAD element.
  - closed behind the selected LAD element.

  Another branch can be inserted between two parallel branches.
  To delete a parallel branch, you must delete all LAD elements of this branch.
  When the last LAD element is removed from the branch, the rest of the branch is also removed.
  The following elements are not permitted in the parallel branch:
  - (P),
  - (N),
  - (#),
  - Empty box.

  The following elements are permitted in the parallel branch:
  - Contacts,
  - Comparators,
  - Edge detection (POS, NEG).

  Parallel branches which branch directly off the power rail are an exception to these placement rules: All elements can be placed in these branches.
- Constants and enums
  Binary operations can also be assigned constants (e.g. TRUE or FALSE).
  FB/FC parameters can be connected with constants that reflect the parameter data type.
  If a parameter is connected with an enum value that is not unique project-wide, preface the enum value with the enum type separated by #.

4.9.2 Meaning of EN/ENO

Enable input (EN) and enable output (ENO) of the LAD box

The LAD box enable input (EN) and enable output (ENO) parameters function according to the following principles:

- If EN is not enabled (i.e., the signal is set to "0"), then the box will not execute its function, and ENO is not enabled (i.e., the signal is also "0").
- If EN is enabled (i.e., the signal is set to "1"), then the appropriate box executes its function, and then ENO is also enabled (i.e., the signal is also "1").

4.9.3 FBD diagram

FBD diagram

An FBD diagram complies with IEC standard 61131-3.
The main binary signal line begins with a logic box (top left) and ends with an assignment, call (box), or with a jump to another network. In between, there are logic elements (AND, OR box), general logic elements (SR, RS flip-flop), system component call-ups (e.g. arithmetic operations), and user function or function block call-ups.

Rules for entering FBD statements

- Placement of boxes
  Empty boxes (flipflops, counters, timers, arithmetic operations, device-specific commands, TO-specific commands, etc.) can be attached to boxes with binary connections (&, =1, XOR).
  Preconnections on binary inputs (e.g. S input on flipflop) are allowed.
  Separate connections with separate outputs cannot be programmed in a network. Junctions are not supported.

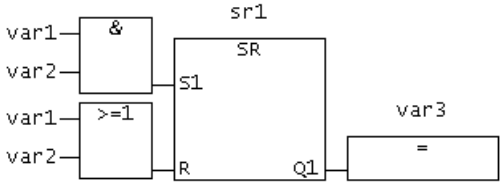


Figure 4-12 FBD with binary preconnection

- &, >=1, XOR boxes
  Binary inputs can be inserted, deleted, or negated in these boxes.
- Enable input/enable output
  Connection of the enable input EN and/or the enable output ENO of boxes is possible.
- Constants and enums
  Binary operations can also be assigned constants (e.g. TRUE or FALSE).
  FB/FC parameters can be connected with constants that reflect the parameter data type.
  If a parameter is connected with an enum value that is not unique project-wide, preface the enum value with the enum type separated by #.

4.9.4 Converting between LAD and FBD representation

Converting from LAD to FBD representation

To switch from **LAD to FBD representation**, proceed as follows:

1. Open an existing LAD project.
2. Select the **LAD/FBD program > Switch to FBD** menu item.
   - or -
   Click the button for "Switch to FBD" (Ctrl+3 shortcut) in the LAD editor toolbar.
   The project is now displayed in the **FBD** programming language.

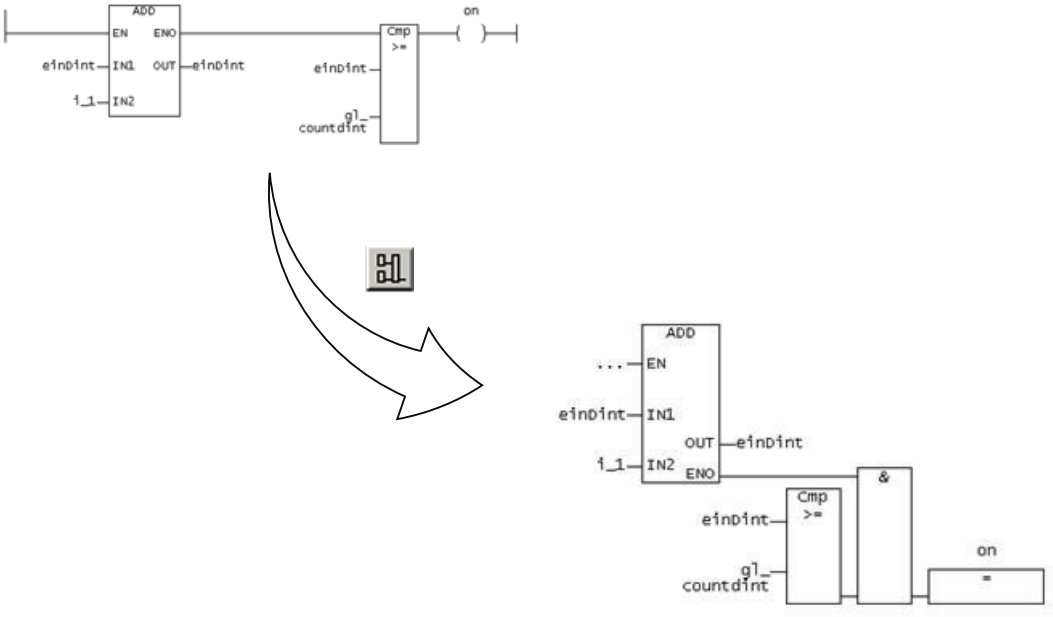


Figure 4-13 Switching from LAD to FBD

Note

A conversion sequence of **LAD - FBD - LAD** always produces the original network.

Anything generated in LAD can always be displayed in FBD.

Converting from FBD to LAD representation

To switch from **FBD to LAD representation**, proceed as follows:

1. Open an existing FBD project.
2. Select the **LAD/FBD program > Switch to LAD** menu command.
   - or -
   Click the button for "Switch to LAD" (Ctrl+1 shortcut) in the FBD editor toolbar.
   The project is now displayed in the **LAD** programming language.

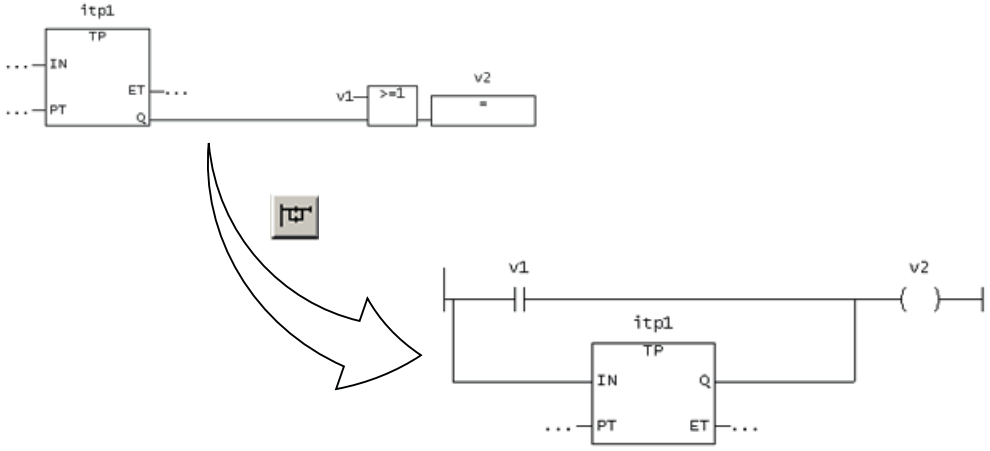


Figure 4-14 Switching from FBD to LAD, example with OR box

Note

A conversion sequence of **FBD- LAD- FBD** only produces the original LAD network if the FBD structure can be converted to LAD.

Something generated in FBD cannot always be displayed in LAD.

Example of a non-convertible FBD structure

Figure 4-15 FBD structure with binary XOR box

4.10 Editing LAD/FBD elements

4.10.1 Inserting LAD/FBD elements

LAD/FBD elements are usually inserted to the right of the selected position in the network.

FBD elements are usually inserted at a boolean input of a block or at an assignment (left).

Special case:

If the right-hand edge of a network or a coil (LAD) or an assignment (FBD) is selected, the next element is added in the network on the left-hand side of it.

To insert an LAD/FBD elements:

1. Select the position in a network behind which you want to insert an LAD/FBD element.
2. Insert an LAD/FBD element:
   - Via the icons on the toolbar
   - Using the menu item, e.g. **LAD/FBD program > Insert element > Empty box**
   - With a drag and drop operation from the **Command library** tab
   - By double-clicking the element in the **Command library** tab
   - By selecting the element in the **Command library** tab and confirming with the **Enter key**

   The selected LAD/FBD element is inserted and the placeholders and ... are inserted for variables and parameters.

Note

A red **???** symbol indicates mandatory parameters that must be connected.

A black ... character string indicates optional parameters that can be connected.

Move the cursor over the parameter name to display the expected data type.

4.10.2 Syntax check in LAD

An automatic syntax check during input prevents the incorrect placement of elements.

- NOT in parallel branch
- FB/FC call in parallel branch
- Connector in parallel branch
- Check 0 -> 1 edge and 1 -> 0 edge in parallel branch
- XOR in parallel branch

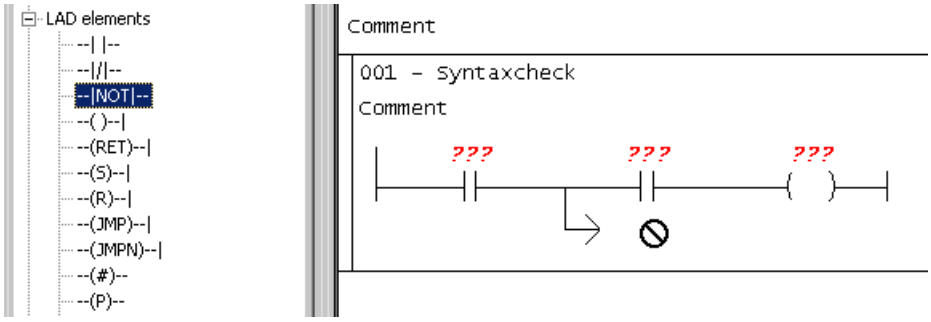


Figure 4-16 Syntax check

4.10.3 Selecting LAD/FBD elements

LAD/FBD networks must be selected before they can be deleted, for example.

To select an individual LAD/FBD element:

- Click the required LAD/FBD element.
  The LAD/FBD element is selected (see figure below).

To select several consecutive LAD/FBD elements, proceed as follows:

1. Click the first LAD/FBD element to select it.
2. Then, keeping the **Shift** key pressed, click the last LAD/FBD element to be selected.
   The consecutive LAD/FBD elements are selected.

To select several specific LAD/FBD elements, proceed as follows:

1. Click the first LAD/FBD element to select it.
2. Keeping the **Ctrl** key pressed, click all the other LAD/FBD elements to be selected.
   The specific LAD/FBD elements are selected.

Selected LAD/FBD elements have a light blue background. You can choose the selection color in the **LAD/FBD editor** tab of the **Settings** dialog box.

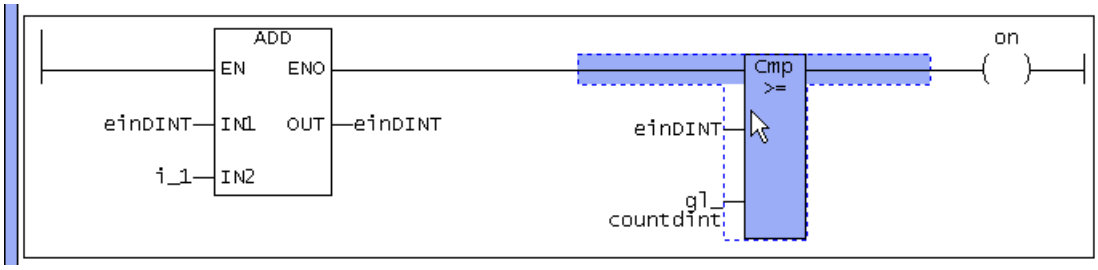


Figure 4-17 Selected LAD/FBD elements

4.10.4 Copy/cut/delete operations in LAD/FBD elements

To **copy/cut/delete**, proceed as follows:

1. Select a LAD/FBD element.
2. In the context menu or in the **Edit** menu, select e.g. **Copy**.
   The copied/cut LAD/FBD element can be inserted into other LAD/FBD programs.
   If you delete an FB/FC box with binary preconnections, this results in several open branches (in LAD) or sub-networks (in FBD) which can be further connected.

4.10.5 LAD/FBD elements - defining parameters (labeling)

To label the elements, proceed as follows:

1. Click the parameter.
2. Label the parameter:
   – Select the corresponding parameter from the pull-down menu (for box-type only).
   - or -
   – Enter the appropriate variable.
   - or -
   – Drag the corresponding variable from the declaration table using a drag-and-drop operation.
3. Confirm the entry with the **Return** key.

See also

Setting call parameters (Page 89)

Defining variables in the Variable declaration dialog box ("on-the-fly" variable declaration) (Page 117)

4.10.6 Labeling LAD/FBD elements with the symbol input help dialog

To label the element with the **Symbol input help**, proceed as follows:

1. Select the parameter you want to label.
2. Right-click to open the context menu.
3. Click the **Symbol input help menu.**
   - or -
   Call the symbol input help with the key shortcut **Ctrl+Alt+H.**
   The **Symbol input help** dialog box opens. The tree structure shows all variables which exist in the project and which can be used.
4. Select the desired variable and click **OK** to confirm.
   The label is entered in the selected parameter. If the variable is defined in another program source or in a library, a Connection (Page 164) is created automatically.

4.10.7 Setting the LAD/FBD element display

In order to ensure a manageable view of relatively large call boxes, you can set the display mode of **LAD/FBD elements**.

To set the **LAD/FBD element** display, proceed as follows:

1. Click in the editor area of the LAD/FBD program.
2. Select the required display mode:
   - In the context menu, select **View > No box parameters** or the **LAD/FBD program > View > No box parameters** menu item.
     - or -
   - In the context menu, select **View > Only assigned box parameters** or the **LAD/FBD program > View > Only assigned box parameters** menu item.
     - or -
   - In the context menu, select **View > Mandatory and assigned box parameters** or the **LAD/FBD program > View > Mandatory and assigned box parameters** menu item.
     - or -
   - In the context menu, select **View > All box parameters** or the **LAD/FBD program > View > All box parameters** menu item.
     This box parameter setting is also saved when storing.

Note

If a call box has non-represented parameters, this is indicated by **...** at the bottom of the box.

4.10.8 Select box type with empty box

Requirement

You have inserted an empty box into the network, e.g. via the **LAD/FBD program > Insert element > Empty box** menu.

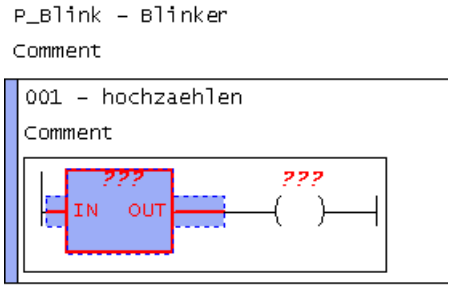


Figure 4-18 Empty box

Specify empty box

There are two alternatives for specifying the box type:

- Via an editable combo box (Page 84)
- Via the call assistance (Page 86)

4.10.8.1 Specify the box type via the editable combo box

Requirement

Empty box is inserted.

Procedure

How to open the editable combo box at the empty box (alternatives):

- Select Empty box and press **Enter**.
- Click on the **???** field.

The editable combo box opens.

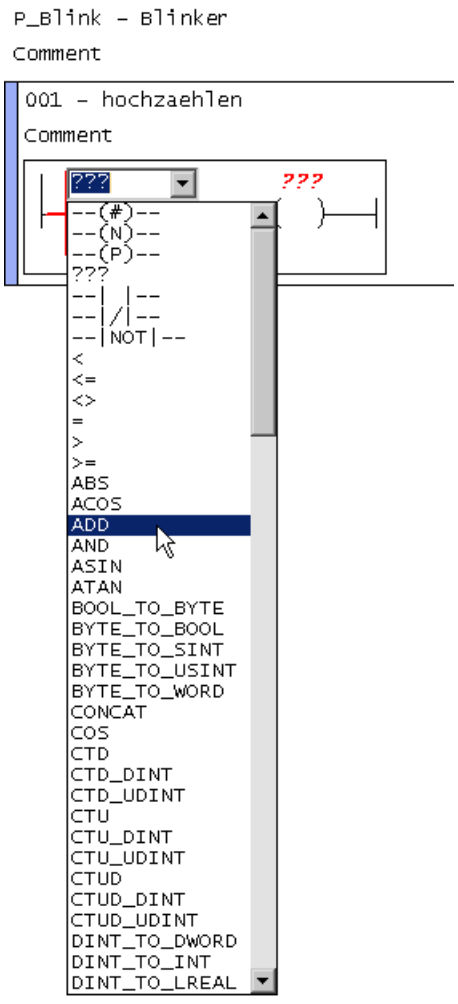


Figure 4-19 Drop-down menu for the combo box

The following are available for selection in the drop-down menu:

- The standard functions and function blocks, see Functions (Page 211)
- The functions and function blocks of the own LAD/FBD source
- The functions and function blocks exported into connected program sources or libraries
- The public methods of exported classes (as of Kernel V4.5) and function blocks defined in connected ST source files or libraries.

Select the required box type. Alternatively, you may enter the box type into the combo box.

The empty box is replaced by the appropriate box for selection.

4.10.8.2 Specify box type via call assistance

Requirement

The empty box is inserted.

Procedure

How to open the call assistance:

- Double-click the **???** field.

The “Call assistance” window opens.

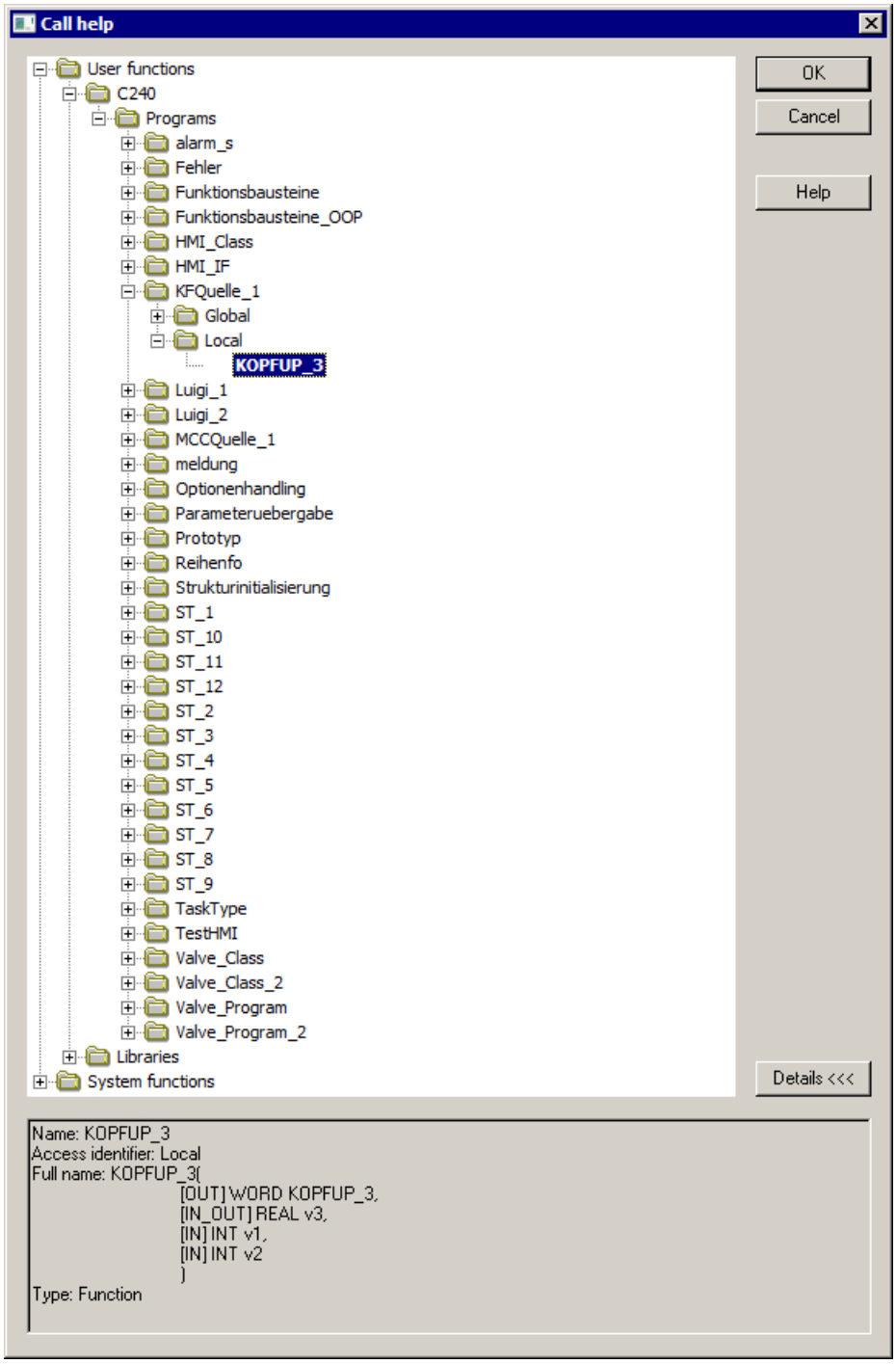


Figure 4-20 Call assistance

The following are displayed as roots in a tree topology:

- User functions
  All program sources for the SIMOTION device and for the libraries for the project are displayed beneath this. You can select the following program organization unit (POE):
  - All functions and function blocks of the own LAD/FBD source
  - The functions and function blocks exported into program sources or libraries
  - The public methods of exported classes (as of Kernel V4.5) and function blocks defined in ST source files or libraries.
- System functions
  The standard functions and function blocks, see Functions (Page 211)

Information about the selected POE can be found in the window footnote. This information can be hidden with the **Details <<<** button.

Selecting the required POE (alternatives):

- Select the desired POE and click **OK**.
- Double-click the desired program organization unit.

The “Call assistance” window closes and the empty box is replaced by the appropriate box for selection.

4.10.9 Setting the call parameter for an individual parameter

To set an individual call parameter, proceed as follows:

1. Double-click the parameter input/output you want to set.
   The **Enter call parameter for individual parameter** dialog box appears.

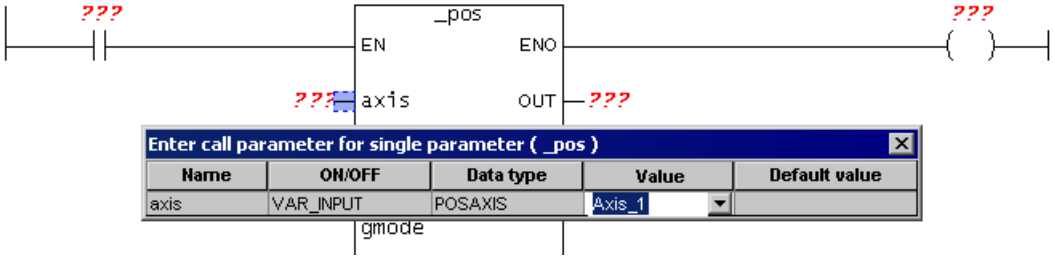


Figure 4-21 Dialog box for setting an individual call parameter

2. Assign a variable or value to the parameter from the **Values** list.
3. Confirm your selection twice with the Enter key to close the dialog box again.

4.10.10 Setting call parameters

To set the call parameters, proceed as follows:

1. Label the type parameters of the box.
2. Double-click the box.
   - or -
   In the shortcut menu, select **Call parameters ...**.
   The **Enter call parameters** dialog box appears.
   Only variables which have already been declared and symbols/variables offered by the system are displayed.

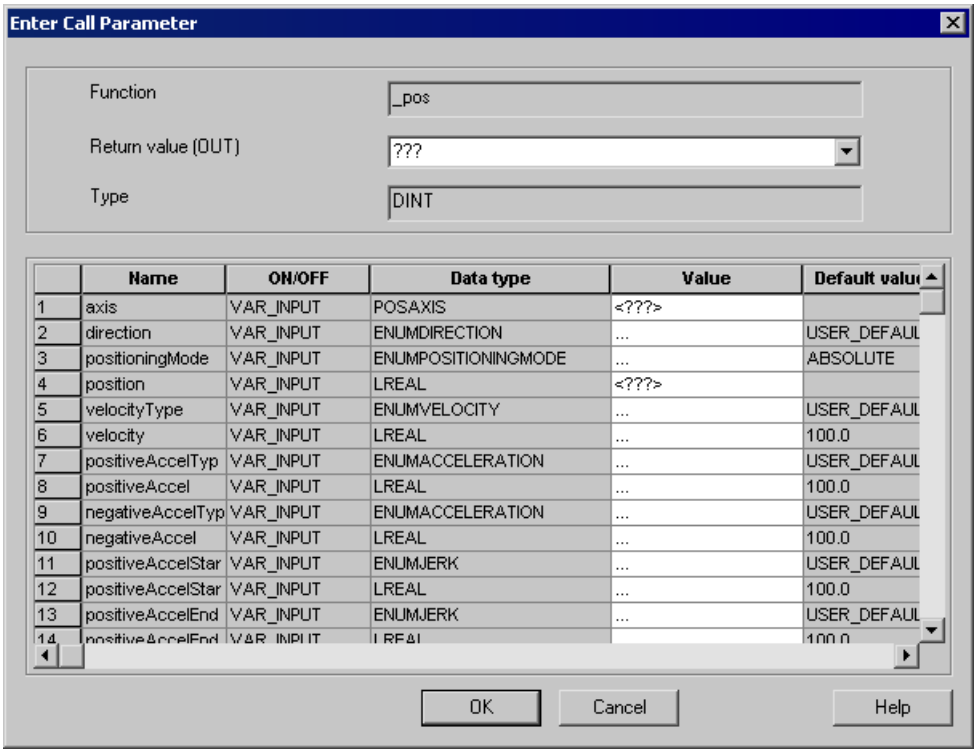


Figure 4-22 Dialog box for setting call parameters

3. Enter:
   - **Instance**
     Here, you enter the instance of the function block or the class.
   - **Return value**
     Here you assign the function or method return value to a variable of the calling program.
   - **Value**
     Here, you can assign current variables or values to the parameters.

   See also Overview of subprogram call parameters (Page 171).
4. Confirm with **OK**.

Note

The **Value** list includes all visible symbols in the current target (variables, Enum values, etc.) whose type matches the data type of the parameter. Implicit data type conversion is taken into consideration here. You can select a symbol from the list or enter one yourself.

The value of string constants must be entered in inverted commas
(e.g. 'st_until')

4.11 Command library

4.11.1 LAD/FBD functions in the command library

The command library appears automatically as a tab in the project navigator. The command library stays open after the programming window is closed.

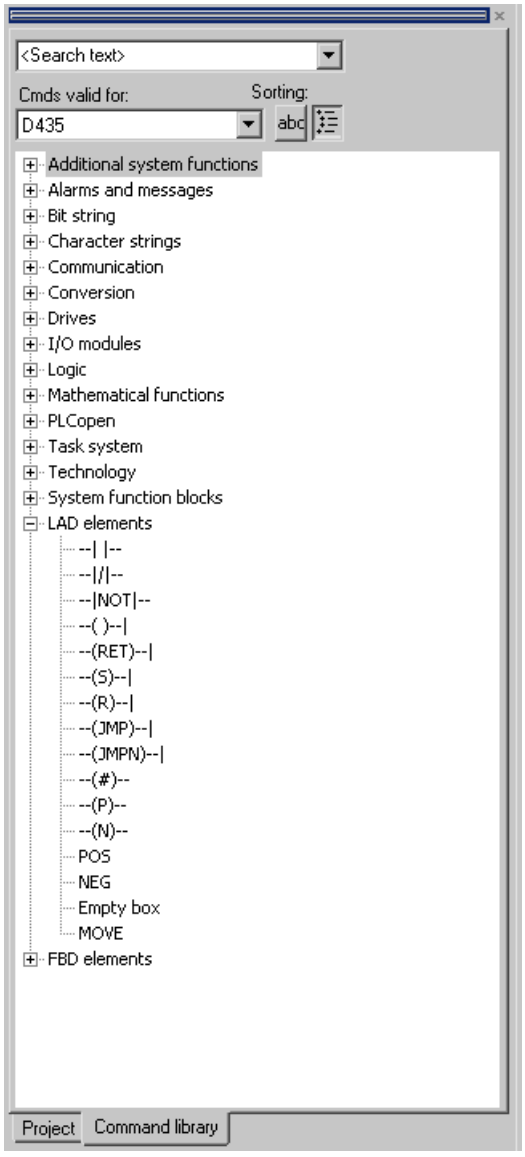


Figure 4-23 Command library tab of the project navigator

4.11.2 Inserting elements/functions from the command library

To paste elements/functions into a programming window:

1. Left-click the desired function in the command library, drag the function onto the editor window while keeping the left mouse button depressed and then release the left mouse button.
   - or -
   Double-click the desired function.
   - or -
   Select the desired function and press the Enter key.

LAD/FBD elements are usually pasted in to the right of the selected position in the network. FBD elements are usually pasted in at a boolean input of a block or at an assignment (left).

4.11.3 Description of PLCopen blocks

PLCopen blocks are preferably used for the programming of motion control tasks in the LAD/FBD programming language. The PLCopen blocks are intended for use in cyclic programs/tasks.

The following standard function blocks are available in the command library in SIMOTION. They are certified in accordance with "PLCopen Compliance Procedure for Motion Control Library V1.1".

The details and the use of the PLCopen blocks are described in the PLCopen Blocks Function Manual.

An example for the use of the PLCopen blocks is contained in Section "Positioning axis program (Page 340)".

Table 4-2 Single-axis function blocks for the axis

Function block	Description
_MC_Power()	Enabling/disabling axis
_MC_Stop()	Stopping the axis
_MC_Home()	Homing axis/clearing absolute value encoder offset
_MC_MoveAbsolute()	Absolutely positioning axis
_MC_MoveRelative()	Relatively positioning axis
_MC_MoveVelocity()	Traversing axis at defined velocity
_MC_MoveAdditive()	Positioning relative to current target position (traversing axis using an additional, defined path, relative to current position setpoint)
_MC_MoveSuperimposed()	Superimposed positioning (traversing axis relative to current motion)
_MC_PositionProfile()	Traveling through position/time profile (traversing axis along a predefined, fixed position/time profile)
_MC_VelocityProfile()	Traveling through velocity/time profile (traversing axis along a predefined, fixed velocity/time profile)
Basic functions	
_MC_Reset()	Resetting errors/alarms on the axis or triggering a restart
_MC_ReadActualPosition()	Reading the actual position of axis

Function block	Description
_MC_ReadStatus()	Reading the status of an axis
_MC_ReadAxisError()	Reading the error of an axis
_MC_ReadParameter()	Reading axis parameter and outputting in data type LREAL
_MC_ReadBoolParameter()	Reading axis parameter and outputting in data type BOOL
_MC_WriteParameter()	Writing axis parameter of data type LREAL
_MC_WriteBoolParameter()	Writing axis parameter of data type BOOL
In addition to the standard function blocks, the following function block is available for an axis:	
_MC_Jog()	Continuous or incremental jogging

Table 4-3 Multi-axis function blocks for the axis

Function	Description
_MC_GearIn()	Starting gearing (synchronizing master and slave axis while taking into account a positional relationship described by a fixed gear ratio)
_MC_GearOut()	Terminating gearing (desynchronizing master and slave axis)
_MC_CamIn()	Starting camming (synchronizing master and slave axis while taking into account a positional relationship described by a cam)
_MC_CamOut()	Terminating camming (desynchronizing master and slave axis)
_MC_Phasing()	Changing phase shift between the leading axis and following axis

Table 4-4 Function blocks for the external encoder

Function	Description
_MC_Power()	Enabling external encoder
_MC_Reset()	Resetting external encoder
_MC_Home()	Homing external encoder
_MC_ReadActualPosition()	Reading actual position of external encoder
_MC_ReadStatus()	Reading external encoder status
_MC_ReadAxisError()	Reading external encoder error
_MC_ReadParameter()	Reading external encoder parameter and outputting in data type LREAL
_MC_ReadBoolParameter()	Reading external encoder parameter and outputting in data type BOOL

4.11.4 Special features of the command library

Special features

The following ST commands have no corresponding function that can be used with LAD/FBD:

- BOOL := _checkequaltask([IN]TASK, [IN]TASK)
  Two **StructTaskID** or two **StructAlarmID** can be compared to one comparator.
- StructAlarmID := _getalarmid([IN]ALARM)
  These alarm commands can be found in the **_alarm** name space (_alarm.myalarm).
- StructTaskID := _gettaskid([IN]TASK id:=TaskIdThis)
  The task commands can be found in the **_task** name space (_task.backgroundtask).

Examples for parameters of type _alarmid and _starttaskid

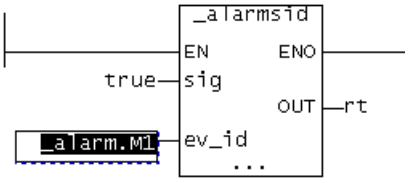


Figure 4-24 Examples for StructAlarmID

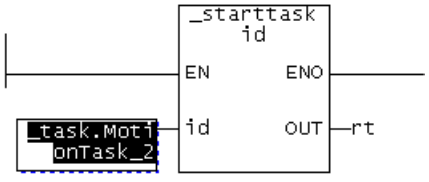


Figure 4-25 Example for StructTaskID

4.12 General information about variables and data types

4.12.1 Overview of variable types

The following table shows all the variable types available for programming with ST.

- System variables of the SIMOTION device and the technology objects
- Global user variables (I/O variables, device-global variables, unit variables)
- Local user variables (variables within a program, a function, or a function block)

System variables

Variable type	Meaning
System variables of the SIMOTION device	Each SIMOTION device and technology object has specific system variables. These can be accessed as follows: • Within the SIMOTION device from all programs • From HMI devices You can monitor system variables in the symbol browser.
System variables of technology objects	

Global user variables

Variable type	Meaning
I/O variables	You can assign symbolic variable names to the I/O addresses of the SIMOTION device or the peripherals. This allows you to have the following direct accesses to the I/O: • Within the SIMOTION device from all programs • From HMI devices You create these variables in the symbol browser after you have selected the I/O element in the project navigator. You can monitor I/O variables in the symbol browser.
Global device variables	User-defined variables which can be accessed by all SIMOTION device programs and HMI devices. You create these variables in the symbol browser after you have selected the GLOBAL DEVICE VARIABLES element in the project navigator. Global device variables can be defined as retentive. This means that they will remain stored even when the SIMOTION device power supply is disconnected. You can monitor global device variables in the symbol browser.
Unit variables	User-defined variables that all programs (programs, function blocks, and functions) can access within a unit (source file). You declare these variables in the declaration table of the source file: • In the interface section: These variables are exported and can be used in other units (e.g. ST source files, MCC source files, LAD/FBD source files) after a connection has been defined (Page 165). They are also available on HMI devices as standard. • In the implementation section: You can only access these variables within the source file. You can declare unit variables as retentive. This means that they will remain stored even when the SIMOTION device power supply is disconnected. You can monitor unit variables in the symbol browser.

Local user variables

Variable type	Meaning
	User-defined variables that can only be accessed within the program/chart (program, function, function block) in which they were defined.
Variable of a program (program variable)	Variable is declared in a program. The variable can only be accessed within this program. A differentiation is made between static and temporary variables: • Static variables are initialized according to the memory area in which they are stored. Specify this memory area by means of a compiler option. By default, the static variables are initialized depending on the task to which the program is assigned (see *SIMOTION Basic Functions* Function Manual). You can monitor static variables in the symbol browser. • Temporary variables are initialized every time the program in a task is called. Temporary variables cannot be monitored in the symbol browser.
Variable of a function (FC variable)	Variable is declared in a function (FC). The variable can only be accessed within this function. FC variables are temporary; they are initialized each time the FC is called. They cannot be monitored in the symbol browser.
Variable of a function block (FB variable)	Variable is declared in a function (FB). The variable can only be accessed within this function block. A differentiation is made between static and temporary variables: • Static variables retain their value when the FB terminates. They are initialized only when the instance of the FB is initialized; this depends on the variable type with which the instance of the FB was declared. You can monitor static variables in the symbol browser. • Temporary variables lose their value when the FB terminates. The next time the FB is called, they are reinitialized. Temporary variables cannot be monitored in the symbol browser.

4.12.2 Scope of the declarations

Scope of variable and data type declarations according to location of declaration

Location of declaration	What can be declared here	Scope
Symbol browser	• Global device variables • I/O variables	The declared variables are valid in all units (e.g., ST source files, MCC source files, LAD/FBD source files) of the SIMOTION device. All programs, function blocks, and functions in all units of the device can access the variables.
Interface section of the unit[1]	• Unit variables • Data types • Symbolic accesses to the fixed process image of the BackgroundTask	The declared variables, data types, etc., are valid in the entire unit (e.g., ST source file, MCC source file, LAD/FBD source file); all programs, function blocks, and functions within the unit can access them. In addition, they are also available in other units after connection (see Define connections (Page 165)).

Location of declaration	What can be declared here	Scope
Implementation section of the unit[1]	• Unit variables • Data types • Symbolic accesses to the fixed process image of the BackgroundTask	The declared variables, data types, etc., are valid in the entire unit (e.g., ST source file, MCC source file, LAD/FBD source file); all programs, function blocks, and functions within the source file can access them.
POU (program/ function block/ function)[2]	• Local variables • Data types • Symbolic accesses to the fixed process image of the BackgroundTask	The declared variables, data types, etc., can only be accessed within the POU in which they were declared.
[1] MCC and LAD/FBD programming languages: in the declaration table of the respective source file. [2] MCC and LAD/FBD programming languages: in the declaration table of the respective chart/program.		

4.12.3 Rules for identifiers

Names for variables, data types, charts/programs must comply with the following rules for identifiers:

1. They are made up of letters (A to Z, a to z), numbers (0 to 9), and underscores (_).
2. The first character must be a letter or underscore.
3. This can be followed by as many letters, digits or underscores as needed in any order.
4. Exception: You must not use more than one underscore in succession.
5. Both upper- and lower-case letters are allowed. No distinction is made between upper- and lower-case notation (thus, for example, Anna and AnNa are regarded as identical).

Note

Reserved identifiers

Reserved identifiers may only be used as predefined. You may not declare a variable or data type with the name of a reserved identifier.

There is no distinction between upper- and lower-case notation.

You can find a list of all the identifiers whose meanings are predefined in SIMOTION in the SIMOTION Basic Functions Function Manual.

Note

Identifiers for SIMOTION devices

Identifiers for SIMOTION devices do not have to comply with rules specified above. When used in SIMOTION SCOUT they must be enclosed in double inverted commas (", ASCII code $22). See the SIMOTION ST Programming and Operating Manual.

4.12.4 Frequently used arrays in declarations

4.12.4.1 Reference (as of kernel V4.5)

References can be formed as of version V4.5 SIMOTION Kernel. The compiler option (Page 53) "Object-oriented programming" must also be activated.

By activating the **Reference** checkbox, you specify that the declared variable (or the component of a structure) contains the reference to the specified data type. This means that the variable can contain address information for a variable of the specified data type.

The following are permitted as data types to which references can be formed:

- Elementary data types (e.g. INT, DINT, REAL, WORD, TIME, STRING)
- User-defined data types (UDT)
- System data types
- Function blocks, provided they contain at least one static variable
- Classes (from ST sources)

No references can be formed to the following data types because references exist already:

- Technology object data types
- Object-oriented interfaces (from ST sources)
- General references
- I/O references (from ST sources)

4.12.4.2 Array length and array element

A field is a chain of variables of the same type that can be addressed with the same name and different indices.

You can define the variable as a field [0...N-1] by entering a field length N.

You have the following options for entering the field length:

- You can enter a constant positive integer value.
- You can enter a value range with ".." separating the min. and max. values.
- You can enter a constant expression of data type DINT (or of a data type that is implicitly convertible to DINT).

If the field is empty, a single variable is set up rather than a field.

Example definition of a field in the declaration table

	Name	Variable type	Data type	Array length	Initial value	Comment
1	const_1	VAR_GLOBAL CONSTANT	INT		11	constant
2	const_2	VAR_GLOBAL CONSTANT	INT		5	constant
3	array_4	VAR_GLOBAL	INT	11	11(5)	specification of the array length by value
4	array_5	VAR_GLOBAL	INT	const_1	11(5)	specification of the array length by constant expression
5	array_6	VAR_GLOBAL	INT	-5 .. 5	11(5)	specification of the array length by range of values
6	array_7	VAR_GLOBAL	INT	const_2 .. 3 * const_2	11(5)	specification of the array length by range of values as constant expression
7						

Figure 4-26 Defining the length of a field

Example of use of field elements in a variable assignment

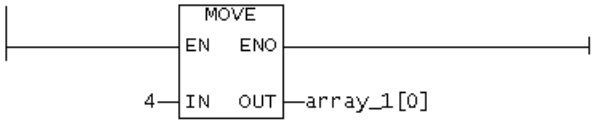


Figure 4-27 Use of field elements in a variable assignment

4.12.4.3 Initial value

You can specify an initialization value in this column. You can specify this initialization value as a constant or an expression. The following are permissible:

- Constants
- Arithmetic operations
- Bit slice and data conversion functions

Variables of a technology object data type cannot be assigned an initialization value. They are always initialized by the compiler with TO#NIL.

Initialization of arrays

Per default, the compiler assigns all array elements the initialization value of the data type. The initialization values can be changed by specifying an array initialization list according to the following example.

Table 4-5 Preassignment of array elements

10(1)	10 array elements [0..9] are pre-assigned the same value "1".
1,2,3,4,5	5 array elements [0..4] are pre-assigned different values "1", "2", "3", "4" and "5".
5(3),10(99),3(7),2(1)	The following array elements are pre-assigned the following values: • Five array elements [0..4] with the same value "3". • 10 array elements [5..14] with the same value "99". • 3 array elements [15..17] with the same value "7". • 2 array elements [18..19] with the same value "1".

Definition of these initialization values in the declaration table:

	Name	Variable type	Data type	Array length	Initial value	Comment
1	array_1	VAR_GLOBAL	INT	10	10(1)	all array elements equal
2	array_2	VAR_GLOBAL	INT	5	1,2,3,4,5	all array elements diverse
3	array_3	VAR_GLOBAL	INT	20	5(3),10(99),3(7),2(1)	several array elements respectively equal
4						

Figure 4-28 Definition of the initialization values of an array

Initialization of structures

Per default, the compiler assigns all components of a structure the initialization value of their data type. By specifying an initial value for a component, their initialization can be changed.

When using the structure in another declaration (e.g. variable or structure definition), the initialization values of individual components can be changed by assigning a structure initialization list, enclosed in round brackets ( ), in accordance with the following example.

	Structure name	Element name	Data type	Array length	Initial value	Comment
1	type_struct_1	s11	INT		1	
2		s12	DINT	3	3(2)	
3		s13	UDINT		3	
4	type_struct_2	s21	LREAL		3.0	
5		s22	DWORD		16#0000_FFFF	
6	type_struct_3	s31	type_struct_1		(s11 := 10, s12 := [3(20)])	
7		s32	type_struct_2		(s22 := 16#0000_00FF)	
8		s33	REAL		10.0 / 3.0	
9						

Figure 4-29 Definition of the initialization values of a structure

Instance-specific initialization of classes and function blocks

For the instance formation of classes and function blocks created during the object-oriented programming, variables declared as VAR OVERRIDE or VAR PUBLIC can be initialized instance-specific. The initialization values specified for the definition of the associated program organization unit (POU) are overwritten.

If instance-specific initializable variables exist in a class or function block, the **Start value** field cannot be edited for the instance formation. The **...** button is displayed instead.

Proceed as follows to initialize the instance variables instance-specific:

1. Click the **...** button.
   A window opens.
   In this window, all initializable variables are present as a structure initialization list of the Structured Text (ST) programming language. A differentiation is made between necessary and optional initializations.
2. Enter the initialization values of the associated variables.
   Also adapt the comment characters appropriately (e.g. "//").
3. Click **OK** to confirm.

4.12.4.4 Comments

A comment can be entered in this column. It may contain any characters or special characters.

4.12.5 Sorting in the declaration tables

You can specify a sorting order for a column in the declaration tables. The lines of the declaration table are arranged so that the entries (character strings) of the relevant column are sorted according to the sorting criterion. The characters are sorted according to their ANSI code; the sorting is not case-sensitive.

The following sorting criteria are available:

- **Sort in ascending order**
  Alphabetic sorting is ascending order (0 … 9, a …z).
- **Sort in descending order**
  Alphabetic sorting is descending order (z … a, 9 … 0).
- **Original order**
  No sorting. The lines of the declaration table are arranged in the order of declaration.

As long as the sorting order is not accepted (see below), the following applies:

- The sorting only affects the display. The data storage remains unchanged.
- The declaration table is saved in the original order.
- The compiler processes the declaration table in the original order.

Special features when sorting structures and enumerations

When sorting structures (Page 107) and enumerations (Page 108), the following applies:

- When sorting according to the **Structure name** or **Enumeration name** column:
  - The structures or enumerations are sorted according to their names.
  - The elements of these structures and enumerations remain in their original order.
- When sorting according to the other columns:
  - The structures and enumerations remain in their original order.
  - The elements within the structures and enumerations are sorted.

Special feature of pragma lines

For the declaration tables of a unit (interface section and implementation section), the following applies:

If in the declaration of unit variables (Page 114) (Parameters tab), pragma lines (Page 120) are available, the lines are sorted between the individual pragma lines.

Note

In the sorted view of a declaration table, the following is not possible:

- Insertion of new elements (e.g. variables, structures, enumerations as well as elements of structures and enumerations).
- Insertion of new or copied lines.
- Insertion of pragma lines.

Procedure

To sort the entries of the declaration table:

- Double-click the appropriate column header.
  The sorting changes between the sorting criteria.
  A double-click in another column header results sorting in ascending order according to this column.
- Or alternatively:
  - Move the cursor to the appropriate column header.
  - Select the sorting criterion in the context menu

  The sorting is performed according to the selected sorting criterion.
  The original order can only be selected in the context menu of a sorted column.

Accepting the sorting order

Proceed as follows:

1. Move the cursor to an arbitrary column header.
2. Select **Accept sorting order** in the context menu.

The sorting order is taken over as original order.

Note

Observe the following when accepting the sorting order in a declaration table:

- No "Undo" possible.
- The data storage and the declaration order are changed.
- The corresponding unit is changed and must be compiled again.
- The compiler processes the declaration table in the changed order.
- The relevant variable blocks are initialized during the download of the unit.
- HMI-relevant data is no longer consistent.

4.13 Data Types

A data type is used to determine how the value of a variable or constant in a program source is to be used.

The following data types are available to the user:

- Elementary data types (Page 103)
- User-defined data types (UDT) (Page 107)
  - Enumerations
  - Structures (Struct)
- Technology object data types (Page 109)
- System data types (Page 111)

4.13.1 Elementary data types

Elementary data types define the structure of data that cannot be broken down into smaller units. An elementary data type describes a memory area with a fixed length and stands for bit data, integers, floating-point numbers, duration, time, date and character strings.

All the elementary data types are listed in the table below:

Table 4-6 Bit widths and value ranges of the elementary data types

Type		Reserv. word	Bit width	Range of values
Bit data type Data of this type uses either 1 bit, 8 bits, 16 bits, or 32 bits. The initialization value of a variable of this data type is 0.				
	Bit	BOOL	1	0, 1 or FALSE, TRUE
	Byte	BYTE	8	16#0 to 16#FF
	Word	WORD	16	16#0 to 16#FFFF
	Double word	DWORD	32	16#0 to 16#FFFF_FFFF
Numeric types These data types are available for processing numeric values. The initialization value of a variable of this data type is 0 (all integers) or 0.0 (all floating-point numbers).				

Type		Reserv. word	Bit width	Range of values
	Short integer	SINT	8	-128 to 127 (-2**7 to 2**7-1)
	Unsigned short integer	USINT	8	0 to 255 (0 to 2**8-1)
	Integer	INT	16	-32_768 to 32_767 (-2**15 to 2**15-1)
	Unsigned integer	UINT	16	0 to 65_535 (0 to 2**16-1)
	Double integer	DINT	32	-2_147_483_648 to 2_147_483_647 (-2**31 to 2**31-1)
	Unsigned double integer	UDINT	32	0 to 4_294_967_295 (0 to 2**32-1)
	Floating-point number (per IEEE -754)	REAL	32	-3.402_823_466E+38 to -1.175_494_351E-38, 0.0, +1.175_494_351E-38 to +3.402_823_466E+38 Accuracy: 23-bit mantissa (corresponds to 6 decimal places), 8-bit exponent, 1-bit sign.
	Long floating-point number (in accordance with IEEE-754)	LREAL	64	-1.797_693_134_862_315_7E+308 to -2.225_073_858_507_201_4E-308, 0.0, +2.225_073_858_507_201_4E-308 to +1.797_693_134_862_315_7E+308 Accuracy: 52-bit mantissa (corresponds to 15 decimal places), 11-bit exponent, 1-bit sign.
Time types These data types are used to represent various date and time values.				
	Duration in increments of 1 ms	TIME	32	T#0d_0h_0m_0s_0ms to T#49d_17h_2m_47s_295ms Maximum of 2 digits for the values day, hour, minute, second and a maximum of 3 digits for milliseconds Initialization with T#0d_0h_0m_0s_0ms
	Date in increments of 1 day	DATE	32	D#1992-01-01 to D#2200-12-31 Leap years are taken into account, year has four digits, month and day are two digits each Initialization with D#0001-01-01
	Time of day in increments of 1 ms	TIME_OF_DAY (TOD)	32	TOD#0:0:0.0 to TOD#23:59:59.999 Maximum of two digits for the values hour, minute, second and maximum of three digits for milliseconds Initialization with TOD#0:0:0.0
	Date and time	DATE_AND_TIME (DT)	64	DT#1992-01-01-0:0:0.0 to DT#2200-12-31-23:59:59.999 DATE_AND_TIME consists of the data types DATE and TIME Initialization with DT#0001-01-01-0:0:0.0
String type Data of this type represents character strings, in which each character is encoded with the specified number of bytes. The length of the string can be defined at the declaration. Indicate the length in "[" and "]", e.g. STRING[100]. The default setting consists of 80 characters. The number of assigned (initialized) characters can be less than the declared length.				
	String with 1 byte/character	STRING	8	You may use all the characters in the extended ASCII character set (ASCII code $00 to $FF). Default ' ' (empty string)

Note

During variable export to other systems, the value ranges of the corresponding data types in the target system must be taken into account.

See also

Value range limits of elementary data types (Page 105)

General data types (Page 106)

Elementary system data types (Page 106)

4.13.1.1 Value range limits of elementary data types

The value range limits of certain elementary data types are available as constants.

Table 4-7 Symbolic constants for the value range limits of elementary data types

Symbolic constant	Data type	Value	Hex notation
SINT#MIN	SINT	-128	16#80
SINT#MAX	SINT	127	16#7F
INT#MIN	INT	-32768	16#8000
INT#MAX	INT	32767	16#7FFF
DINT#MIN	DINT	-2147483648	16#8000_0000
DINT#MAX	DINT	2147483647	16#7FFF_FFFF
USINT#MIN	USINT	0	16#00
USINT#MAX	USINT	255	16#FF
UINT#MIN	UINT	0	16#0000
UINT#MAX	UINT	65535	16#FFFF
UDINT#MIN	UDINT	0	16#0000_0000
UDINT#MAX	UDINT	4294967295	16#FFFF_FFFF
T#MIN TIME#MIN	TIME	T#0ms	16#0000_0000[1]
T#MAX TIME#MAX	TIME	T#49d_17h_2m_47s_295ms	16#FFFF_FFFF[1]
TOD#MIN TIME_OF_DAY#MIN	TOD	TOD#00:00:00.000	16#0000_0000[1]
TOD#MAX TIME_OF_DAY#MAX	TOD	TOD#23:59:59.999	16#0526_5BFF[1]
[1] Internal display only			

4.13.1.2 General data types

General data types are often used for the input and output parameters of system functions and system function blocks. The subroutine can be called with variables of each data type that is contained in the general data type.

The following table lists the available general data types:

Table 4-8 General data types

General data type	Data types contained
ANY_BIT	BOOL, BYTE, WORD, DWORD
ANY_INT	SINT, INT, DINT, USINT, UINT, UDINT
ANY_REAL	REAL, LREAL
ANY_NUM	ANY_INT, ANY_REAL
ANY_DATE	DATE, TIME_OF_DAY (TOD), DATE_AND_TIME (DT)
ANY_ELEMENTARY	ANY_BIT, ANY_NUM, ANY_DATE, TIME, STRING
ANY	ANY_ELEMENTARY, user-defined data types (UDT), system data types, data types of the technology objects

Note

You **cannot** use general data types as type identifiers in variable or type declarations.

The general data type is retained when a user-defined data type (UDT) is derived directly from an elementary data type (only possible with the SIMOTION ST programming language).

4.13.1.3 Elementary system data types

In the SIMOTION system, the data types specified in the table are treated in a similar way to the elementary data types. They are used with many system functions.

Table 4-9 Elementary system data types and their use

Identifier	Bit width	Use
StructAlarmId	32	Data type of the alarmId for the project-wide unique identification of the messages. The alarmId is used for the message generation. Please refer to the *SIMOTION Basic Functions* Function Manual. Initialization with STRUCTALARMID#NIL
StructTaskId	32	Data type of the taskId for the project-wide unique identification of the tasks in the execution system. Please refer to the *SIMOTION Basic Functions* Function Manual. Initialization with STRUCTTASKID#NIL

Table 4-10 Symbolic constants for invalid values of elementary system data types

Symbolic constant	Data type	Meaning
STRUCTALARMID#NIL	StructAlarmId	Invalid AlarmId
STRUCTTASKID#NIL	StructTaskId	Invalid TaskId

4.13.2 User-defined data types

4.13.2.1 Defining user-defined data types (UDT)

You can create user-defined data types in units and programs/charts:

- Structures (Page 107)
- Enumerations (Page 108)

The scope of the data type declaration (Page 107) depends on the location of the declaration.

4.13.2.2 Scope of the data type declaration

You create derived data types in the declaration tables of the source file or the program/chart. The scope of the data type declaration depends on the location of the declaration.

- In the declaration table of the unit, **Interface (exported declaration)** section:
  The data type is valid for the entire source file; all programs/charts (programs, function blocks, and functions) within the source file can access the data type.
  These variables are also available, if appropriately connected (see Define connections (Page 165)), in other source files (or other units).
- In the declaration table of the unit, **Implementation (unit-internal declaration)** section:
  The data type is valid in the source file; all programs/charts (programs, function blocks, and functions) within the source file can access the data type.
- In the declaration table of the program/chart:
  The data type can only be accessed within the program/chart in which it is declared.

4.13.2.3 Defining structures

You define structures in the declaration tables of the unit or the program/chart. The scope (Page 107) of the structures depends on the location of the declaration.

To define structures, proceed as follows:

1. Select the declaration table and, if applicable, the section of the declaration table for the desired scope.
2. Select the **Structures** tab.
3. Enter the name of the structure.

4. In the same line, enter:
   - The name of the first component in the **Element name** field.
   - Data type of the component.
     You can select already defined data types.
     See also:
     Elementary data types (Page 103).
     User-defined data types (Page 107).
     Technology object data types (Page 109).
     System data types (Page 111).
   - Activating the optional **Reference** checkbox to declare a general reference to the data type.
     See also: Reference (Page 98).
   - Optional array length (to define the array size).
     See also: Array length and array element (Page 98).
   - Optional initial value (initialization value).
     See also: Initial value (Page 99).
   - Optional comment.
     See also: Comment (Page 101).
5. Enter additional elements of the structure in the following lines; leave the **Structure name** field empty.
6. Begin the definition of the new structure by entering a new name in the **Structure name** field.

Example

This example shows the definition of a structure with three components:

	Structure name	Element name	Data type	Reference	Array length	Initial value	Comment [English (United States)]
1	t_struct	comp_1	INT	☐			
2		comp_2	REAL	☐	5	3(2), 2(3)	
3		compp_3	STRING	☐		'Example'	
4				☐			

Figure 4-30 Definition of a structure

4.13.2.4 Defining enumerations

You define **enumerations** in the declaration tables of the unit or the program/chart. The scope (Page 107) of the enumerations depends on the location of the declaration.

To define enumerations, proceed as follows:

1. Select the declaration table and, if applicable, the section of the declaration table for the desired scope.
2. Select the **Enumerations** tab.
3. Enter the name of the enumeration.

4. In the same line, enter:
   - The name of the first element
   - Optionally, the initialization value of the enumeration data type
5. Enter additional elements of the enumeration in the following lines; leave the **Enumeration name** field empty.
6. You begin the definition of the new enumeration by entering a new name in the **Enumeration name** field.

Example

This example shows the definition of an enumeration data type with the name **Color** and the enumeration elements **Red**, **Blue**, and **Green**, as well as the initialization value (initial value) **Green**.

If no initialization value is entered during the enumeration definition (data type declaration), the first value of the enumeration is assigned to the data type. In this example, this means **Red** would be used for the initialization because it is defined as the first enumeration element.

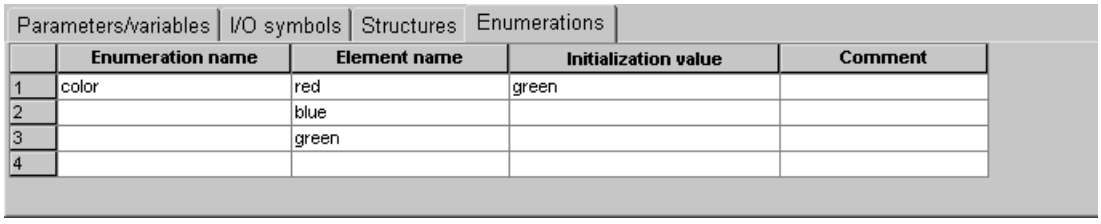


Figure 4-31 Definition of an enumeration data type

4.13.3 Technology object data types

4.13.3.1 Description of the technology object data types

You can declare variables with the data type of a technology object (TO). The following table shows the data types for the available technology objects in the individual technology packages.

For example, you can declare a variable with the data type *posaxis* and assign it an appropriate instance of a position axis. Such a variable is often referred to as a reference.

Table 4-11 Data types of technology objects (TO data type)

Technology object	Data type	Contained in the technology package
Drive axis	DriveAxis	CAM, PATH[1], CAM_EXT
External encoder	ExternalEncoderType	CAM, PATH[1], CAM_EXT
Measuring input	MeasuringInputType	CAM, PATH[1], CAM_EXT
Output cam	OutputCamType	CAM, PATH[1], CAM_EXT

Technology object	Data type	Contained in the technology package
Cam track	_CamTrackType	CAM, PATH[1], CAM_EXT
Position axis	PosAxis	CAM, PATH[1], CAM_EXT
Following axis	FollowingAxis	CAM, PATH[1], CAM_EXT
Following object	FollowingObjectType	CAM, PATH[1], CAM_EXT
Cam	CamType	CAM, PATH[1], CAM_EXT
Path axis[1]	_PathAxis	PATH[1], CAM_EXT
Path object[1]	_PathObjectType	PATH[1], CAM_EXT
Fixed gear	_FixedGearType	CAM_EXT
Addition object	_AdditionObjectType	CAM_EXT
Formula object	_FormulaObjectType	CAM_EXT
Sensor	_SensorType	CAM_EXT
Controller object	_ControllerObjectType	CAM_EXT
Temperature channel	TemperatureControllerType	TControl
General data type, to which every TO can be assigned	ANYOBJECT	

[1] Available as of version V4.1.

You can access the elements of technology objects (configuration data and system variables) via structures (see SIMOTION Basic Functions Function Manual).

Table 4-12 Symbolic constants for invalid values of technology object data types

Symbolic constant	Data type	Meaning
TO#NIL	ANYOBJECT	Invalid technology object

See also

Inheritance of the properties for axes (Page 110)

4.13.3.2 Inheritance of the properties for axes

Inheritance for axes means that all of the data types, system variables and functions of the TO driveAxis are fully included in the TO positionAxis. Similarly, the position axis is fully included in the TO synchronizedAxis, the following axis in the TO pathAxis. This has, for example, the following effects:

- If a function or a function block expects an input parameter of the driveAxis data type, you can also use a position axis or a synchronized axis or a path axis when calling.
- If a function or a function block expects an input parameter of the posAxis data type, you can also use a synchronized axis or a path axis when calling.

4.13.4 System data types

There are a number of system data types available that you can use without a previous declaration. And, each imported technology packages provides a library of system data types.

Additional system data types (primarily enumeration and STRUCT data types) can be found

- In parameters for the general standard functions (see SIMOTION Basic Functions Function Manual)
- In parameters for the general standard function blocks (see SIMOTION Basic Functions Function Manual)
- In system variables of the SIMOTION devices (see relevant parameter manuals)
- In parameters for the system functions of the SIMOTION devices (see relevant parameter manuals)
- In system variables and configuration data of the technology objects (see relevant parameter manuals)
- In parameters for the system functions of the technology objects (see relevant parameter manuals)

4.14 Variables

Variables are an important component of programming and provide structure to programs. They are placeholders which can be assigned values that can be accessed several times in the program.

Variables have:

- A specific initialization behavior and scope of validity
- A data type and operations which are defined for that data type

User and system variables are differentiated. User variables can be defined by the user. System variables are provided by the system.

4.14.1 Keywords for variable types

The various keywords for variable types are shown in the following table.

Description of keywords for variable types

Keyword	Description	Use
Global user variables (declared in the interface or implementation section of the unit[1])		
VAR_GLOBAL	Unit variable; can be accessed by all POUs within the source file. If the variable was declared in the interface section, it can be used in another source file once a connection has been defined in its declaration table (see Define connections (Page 165)).	FB, FC, program

Keyword	Description	Use
VAR_GLOBAL RETAIN	Retentive unit variable; retained during power outage.	FB, FC, program
VAR_GLOBAL CONSTANT	Unit constant; cannot be changed from the program.	FB, FC, program
Local user variables (declared within a POU[2])		
VAR	Local variable (static for FB and program, temporary for FC)	FB, FC, program
VAR_TEMP	Temporary local variable	FB, FC, program
VAR_INPUT	Input parameters: Local variable; value is supplied from external source and can only be read in the FB or FC.	FB, FC
VAR_OUTPUT	Output parameters: Local variable; value is sent to an external destination by the FB. It can be read as an instance variable after being called by the FB (FB instance name.variable name).	FB, FC
VAR_IN_OUT	In/out parameter; the FB or FC accesses this variable directly (by means of a reference) and can change it directly.	FB, FC
VAR OVERRIDE	Static variable whose initialization value can be overwritten for an instance formation. The compiler option (Page 53) "Permit object-oriented programming" must be activated.	FB
VAR CONSTANT	Local constant; cannot be changed from the program.	FB, FC, program
[1] MCC and LAD/FBD programming languages: in the declaration table of the associated source file. [2] MCC and LAD/FBD programming languages: in the declaration table of the associated chart/program.		

4.14.2 Defining variables

Variables are defined in the symbol browser or in the declaration table of the source file or chart/program. The following table provides an overview of where the relevant variable is defined.

Definition of variables

Variable type	Defined in...
Global device user variables	Symbol browser
unit variable	Declaration table of the source file as VAR_GLOBAL, VAR_GLOBAL RETAIN or VAR_GLOBAL CONSTANT
Local variable	Declaration table of the program/chart as: • VAR, VAR_TEMP, or VAR CONSTANT • Additionally for function blocks as VAR_INPUT, VAR_OUTPUT, VAR_IN_OUT • Additionally for functions as VAR_INPUT, VAR_IN_OUT
I/O variable	Symbol browser
Symbolic access to the fixed process image of the BackgroundTask	• Declaration table of the source file • Declaration table of the program/chart (programs and FB only)

4.14.2.1 Use of global device variables

Global device variables are user-defined variables that you can access from all program sources (e.g. ST source files, MCC source files) of a SIMOTION device.

Global device variables are created in the symbol browser tab of the detail view; to do this, you must be working in offline mode.

Here is a brief overview of the procedure:

1. In the project navigator of SIMOTION SCOUT, select the **GLOBAL DEVICE VARIABLES** element in the SIMOTION device subtree.
2. In the detail view, select the **Symbol browser** tab and scroll down to the end of the variable table (empty row).
3. In the last (empty) row of the table, enter or select the following:
   - **Name** of variable
   - **Data type** of variable (only elementary data types are permitted)
4. Optionally, you can make the following entries:
   - Activation of **Retain** checkbox (This declares the variable as retentive, so that its value will be retained after a power failure.)
   - **Field length** (array size)
   - **Initial value** (if array, for each element)
   - **Display format** (if array, for each element)

You can now access this variable using the symbol browser or any program of the SIMOTION device.

In ST source files, you can use a global device variable, just like any other variable.

Note

If you have declared unit variables or local variables of the same name (e.g. *var-name*), specify the global device variable with *_device.var-name*.

An alternative to global device variables is the declaration of unit variables in a separate unit, which is imported into other units. This has the following advantages:

1. Variable structures can be used.
2. The initialization of the variables during the STOP-RUN transition is possible (via Program in StartupTask).
3. For newly created global unit variables, a download in RUN is also possible.

Please refer to the SIMOTION Basic Functions Function Manual.

4.14.2.2 Declaring a unit variable in the source file

The unit variable is declared in the unit. The scope of validity of the variable is dependent on the section of the declaration table in which the variable is declared:

- In the interface section of the declaration table (INTERFACE):
  The unit variable is valid for the entire unit; all programs/charts (programs, function blocks, and functions) within the unit can access the unit variable. It is exported and can be used in other source files or units (e.g. ST source files, MCC units, LAD/FBD units) after a connection has been defined (Page 165). It is also available on HMI devices as standard. The total size of the unit variables that can be exported to HMI devices is limited to 64 KB per unit.
- In the implementation section of the declaration table (IMPLEMENTATION):
  The unit variable is valid in the unit only; all programs/charts (programs, function blocks, and functions) within the unit can access the unit variable.

If you insert pragma lines (Page 120) into the declaration table, you can split the unit variables into data blocks with a separate version code (Page 131). You can also use the pragma lines to define a separate initialization behavior (Page 126) for each of these data blocks and change the defaults for HMI export (Page 132).

Proceed as follows; the unit (declaration table) is open, see Open existing program source (Page 46):

1. In the declaration table, select the section for the desired scope.
2. Then select the **Parameters** tab.
3. Enter:
   - Name of the variable.
   - Variable type.
     See also: Keywords for variable types (Page 111).
   - Data type of the variables.
     You can select already defined data types.
     See also: Data types (Page 103).
   - Activating the optional **Reference** checkbox to declare a general reference to the data type.
     See also: Reference (Page 98).
   - Optional array length (to define the array size).
     See also: Array length and array element (Page 98).
   - Optional initial value (initialization value).
     See also: Initial value (Page 99).
   - Optional comment.
     See also: Comment (Page 101).

The variable is then declared and can be used immediately within the unit.

Note

Outside the unit (e.g. in the symbol browser), the variable is only available after the unit has been compiled.

INTERFACE (exported declaration)

Parameter | I/O symbols | Structures | Enumerations | Connections

	Name	Variable type	Data type	Reference	Array length	Initial value	Comment [English (United States)]
1	var_in1	VAR_GLOBAL	REAL	☐			
2				☐			

IMPLEMENTATION (source-internal declaration)

Parameter | I/O symbols | Structures | Enumerations | Connections

	Name	Variable type	Data type	Reference	Array length	Initial value	Comment [English (United States)]
1	var_in2	VAR_GLOBAL	BOOL	☐			
2	var_out	VAR_GLOBAL	INT	☐	10		
3				☐			

Figure 4-32 Example: Declaring a unit variable in the unit

Note

The declaration table of the unit is read each time parameters are assigned for a command. Inconsistent data within the declaration table may, therefore, cause unexpected error messages during parameter assignment.

4.14.2.3 Declaring local variables

A local variable can only be accessed within the program/chart (program, function, function block) in which it is declared.

We distinguish between the following:

- Static variables:
  Static variables retain their value over all passes of the unit section (block memory).
- Temporary variables:
  Temporary variables are initialized each time the unit section is called again.

See also: Initialization of local variables (Page 127).

If you insert a pragma line (Page 120) at the start of the declaration table, you can influence the initialization of static variables of programs (Page 128).

Proceed as follows; the program/chart with the declaration table is open (see Open existing program source (Page 46)):

1. In the declaration table, select the **Parameters/Variables** tab.
2. Enter:
   - Name of the variable.
   - Variable type for variables.
     See also: Keywords for variable types (Page 111).
   - Data type of the variables.
     You can select already defined data types.
     See also: Data types (Page 103).
   - Activating the optional **Reference** checkbox to declare a general reference to the data type.
     See also: Reference (Page 98).
   - Optional array length (to define the array size).
     See also: Array length and array element (Page 98).
   - Optional initial value (initialization value).
     See also: Initial value (Page 99).
   - Optional comment.
     See also: Comment (Page 101).

The variable is now declared and can be used immediately.

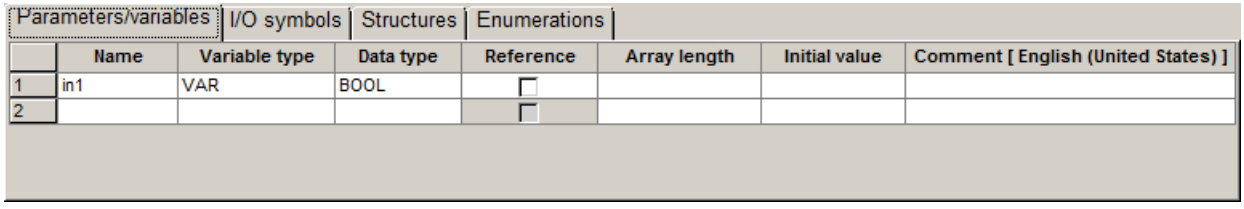


Figure 4-33 Example: Declaring a local variable in the chart/program

Note

The declaration table of the program/chart is read each time parameters are assigned for a command. Inconsistent data within the declaration table may, therefore, cause unexpected error messages during parameter assignment.

4.14.2.4 Defining variables in the Variable declaration dialog box ("on-the-fly" variable declaration)

As soon as you enter an unknown variable in the parameter screen form for an MCC command or an LAD/FBD graphic, the **Variable declaration** dialog box appears.

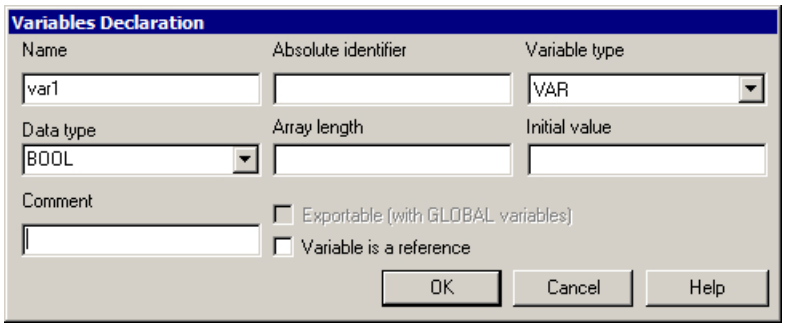


Figure 4-34 Variable declaration dialog box

Note

In order for the **Variable declaration** dialog box to appear, the **on-the-fly variable declaration** checkbox must be activated in the **Settings** dialog box.

Procedure

To define variables "on-the-fly" in the **Variable declaration** dialog box, proceed as follows:

1. Enter only the name of the variables in an input field of the parameter screen for an MCC command or LAD/FBD graphic and press the **Return** key.
   If the entered identifier is not a valid variable name, the dialog box **Variable declaration** appears.
2. Enter:
   - Another variable name, if required.
   - The **Data type** of the variables
     Available for selection are all elementary data types (Page 103) and, where appropriate, the data type suitable for the input field.
     Select the data type or enter the identifier of a data type.
   - The **variable type**.
     Available for selection are all permitted keywords for variable types (Page 111).
     Select the variable type.
     If you select a global variable type (e.g. VAR_GLOBAL), the checkbox **Exportable** becomes active.
   - The **Absolute identifier** for access to the fixed process image of the background task (Page 153).
     You can only enter the identifier for the absolute access to the fixed process image of the background task if you have selected a data type that is included in the general data types (Page 106) ANY_BIT or ANY_INT.
     Enter the absolute identifier according to the Syntax (Page 160).
     The variable is displayed in the register **I/O symbols** of the declaration table.
   - Optional **array length**.
     Here, you specify the size of the array.
     Not available if an absolute identifier is entered.
     See also: Array length and array element (Page 98).
   - Optional **initial value** (initialization value).
     Not available if an absolute identifier is entered.
     See also: Initial value (Page 99).
   - Optional **comment**.
     See also:Comment (Page 101).
   - Activating the optional **Reference** checkbox to declare a general reference to the data type.
     See also: Reference (Page 98).

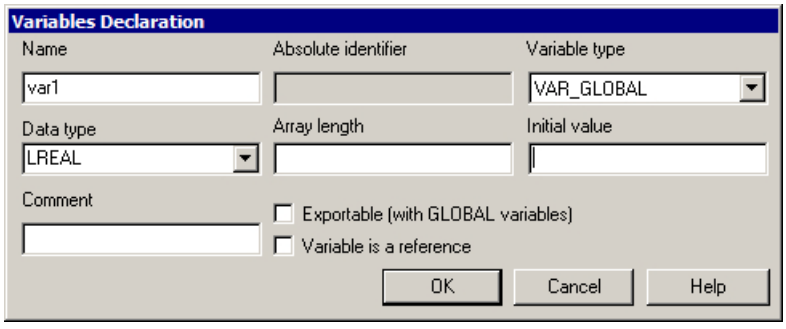


Figure 4-35 Example: Variable declaration

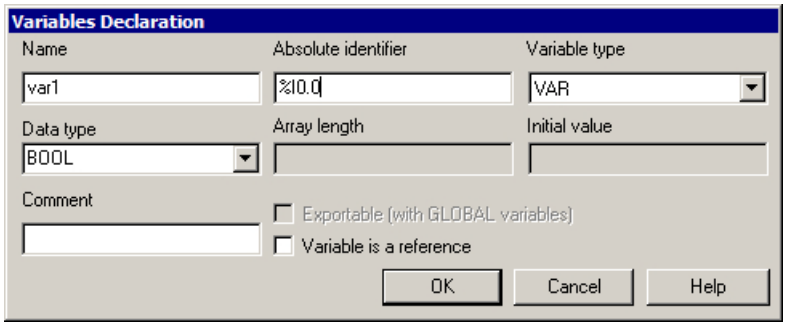


Figure 4-36 Example: Variable declaration (absolute name)

3. Confirm with **OK**.

Result

The variable is defined and entered in the declaration table of the source or the MCC chart or the LAD/FBD program, depending on the selected variable type and the **Exportable checkbox:**

- With local variables (e.g. VAR), the **Exportable** checkbox has a gray background and the new variable is entered in the declaration table of the MCC chart or the LAD/FBD program.
- With global variables (e.g. VAR_GLOBAL), the **Exportable** checkbox is shown activated:
  - If the **Exportable** checkbox is activated, the new variable is entered in the implementation section of the unit's declaration table.
  - If the **Exportable** checkbox is not activated, the new variable is entered in the interface section of the unit's declaration table.

Note

If you leave the **Variable declaration** dialog box by clicking **Cancel**, your input remains as it is, and the variable is not created.

4.14.2.5 Pasting pragma lines during variable definition

Pragma lines in declaration tables have the following function:

- In declaration tables of units (declaration of unit variables):
  Pragma lines in the interface section or implementation section of the declaration table split the variables of the respective section into different subsections:
  - The 1st subsection begins at the start of the relevant table and finishes at the 1st Pragma line.
  - All the other subsections start at one pragma line and finish at the next (or at the end of the table if starting at the last pragma line).

  Within these subsections of the table, each of the variables declared with VAR_GLOBAL or VAR_GLOBAL RETAIN forms a data block with a separate version code (Page 131). If the version code is changed, only the data block concerned will be initialized during a download.
  Configure the pragma line in order to change the initialization behavior or the HMI export of the next data block (see following Section *Pragmas in the declaration tables of the unit variables*).
- In the declaration table of a program/chart (declaration of local variables):
  Line 1 may only contain one pragma line for changing the initialization behavior of programs' static variables (see the section titled *Pragmas in the declaration tables for local variables* later in this document).

Note

The SIMOTION Kernel version partially determines the effectiveness of pragma lines. This is specified for individual parameters.

Inserting a pragma line

To insert a pragma line into the declaration table, proceed as follows:

1. Select the **Parameters** tab (for unit variables) or **Parameters/variables** tab (for local variables).
2. In the declaration table, set the cursor to the number of the line at which a new data block is to be started.
   Only line 1 can be used in the declaration table for local variables.
3. Select the **Insert pragma line** context menu.
   A new line containing the **Pragmas** button only is inserted above the line.
4. Left-click the **Pragmas** button.
   A window containing configuration options for the relevant declaration table opens.
5. Enter the settings.
6. Confirm with **OK**.

Pragmas in the declaration tables for unit variables

A pragma line has been inserted into the declaration table for unit variables. If you click the "Pragmas" button in the table, the following window appears:

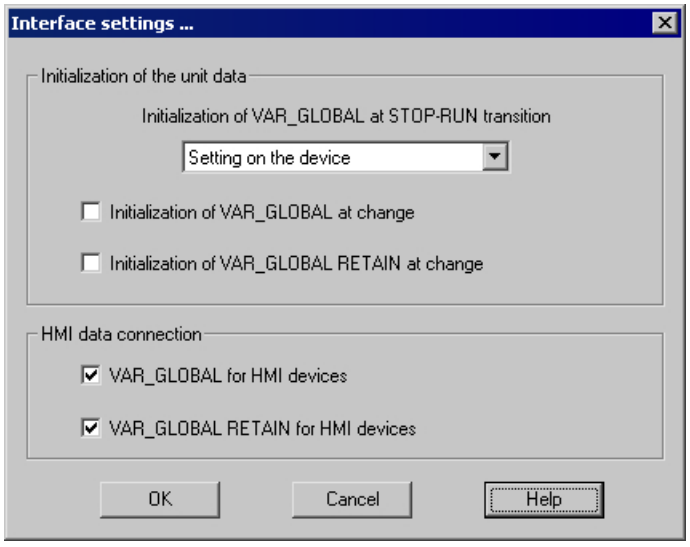


Figure 4-37 Pragma settings in the declaration table for unit variables (e.g. interface section)

This window is for making the settings below. These influence the data block following the pragma line:

Table 4-13 Parameters for pragma settings in the declaration table for unit variables

Parameter		Description
Initialization of unit data		
	Initialization of VAR_GLOBAL during STOP-RUN transition	Only as of version V4.1 of the SIMOTION Kernel. This setting determines whether the next data block of the non-retentive unit variables is initialized during the transition from STOP to RUN operating state. **Setting on the device** (standard): • As of version V4.2 of the SIMOTION Kernel: The setting made on the SIMOTION device applies. • Up to version V4.1 of the SIMOTION Kernel: Variables are **not** initialized. **Always**: Variables are initialized. **Never**: Variables are **not** initialized.
	Initialization of VAR_GLOBAL during a change	This setting determines whether a download for the next data block of the non-retentive unit variables can be performed in RUN if the version code has changed. **Active**: A download in RUN is possible. **Inactive** (standard): A download in RUN is **not** possible.
	Initialization of VAR_GLOBAL RETAIN during a change	This setting determines whether a download for the next data block of the retentive unit variables can be performed in RUN if the version code has changed. **Active**: A download in RUN is possible. **Inactive** (standard): A download in RUN is **not** possible.
HMI data connection		

Parameter		Description
		Use the settings below to change which unit variables are available on which HMI devices by default. Detailed description of the HMI export, in particular the effect of the settings depending on SIMOTION Kernel version: see Variables and HMI devices (Page 132).
	VAR_GLOBAL for HMI devices	**Active** (standard in the interface section): The next data block of the non-retentive unit variables is available on HMI devices. **Inactive** (standard in the implementation section): The next data block of the non-retentive unit variables is **not** available on HMI devices.
	VAR_GLOBAL RETAIN for HMI devices	**Active** (standard in the interface section): The next data block of the retentive unit variables is available on HMI devices. **Inactive** (standard in the implementation section): The next data block of the retentive unit variables is **not** available on HMI devices.

Pragmas in the declaration tables for local variables

A pragma line has been inserted into line 1 of the declaration table for local variables. If you click the "Pragmas" button in the table, the following window appears:

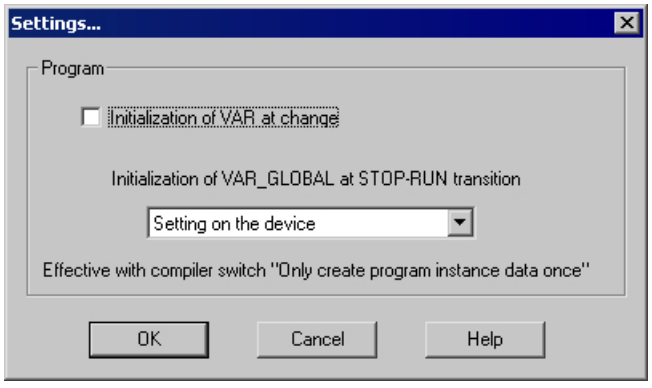


Figure 4-38 Pragma settings in the declaration table for local variables

You can make the following settings in this window:

Note

These settings only take effect in the following scenarios:

1. The "Only create program instance data once" compiler option is active on the higher-level unit.
2. The creation type of the program/chart is "Program".

Table 4-14 Parameters for pragma settings in the declaration table for local variables

Parameter	Description
Initialization of VAR during a change	This setting determines whether a download for the next static variables can be performed in RUN if the version code has changed. **Active**: A download in RUN is possible. **Inactive** (standard): A download in RUN is **not** possible.
Initialization of VAR during STOP-RUN transition	Only as of version V4.1 of the SIMOTION Kernel. This setting determines whether the next static variables are initialized during the transition from STOP to RUN operating state. **Setting on the device** (standard): • As of version V4.2 of the SIMOTION Kernel: The setting made on the SIMOTION device applies. • Up to version V4.1 of the SIMOTION Kernel: Variables are **not** initialized. **Always**: Variables are initialized. **Never**: Variables are **not** initialized.

4.14.3 Time of the variable initialization

The timing of the variable initialization is determined by:

- Memory area to which the variable is assigned
- Operator actions (e.g. source file download to the target system)
- Execution behavior of the task (sequential, cyclic) to which the program was assigned.

All variable types and the timing of their variable initialization are shown in the following tables. You will find basic information about tasks in the *SIMOTION Basic Functions* Function Manual.

The behavior for variable initialization during download can be set: To do this, as a default setting select the **Options > Settings** menu and the **Download** tab or define the setting during the current download.

Note

You can upload values of unit variables or global device variables from the SIMOTION device into SIMOTION SCOUT and save them in XML format.

1. Save the required data segments of the unit variables or global device variables as a data set with the function *_saveUnitDataSet*.
2. Use the **Save variables** function in SIMOTION SCOUT.

You can use the **Restore variables** function to download these data sets and variables back to the SIMOTION device.

For more information, refer to the SIMOTION SCOUT Configuration Manual.

This makes it possible, for example, to obtain this data, even if it is initialized by a project download or if it becomes unusable (e.g. due to a version change of SIMOTION SCOUT).

4.14.3.1 Initialization of retentive global variables

Retentive variables retain their last value after a loss of power. All other data is reinitialized when the device is switched on again.

Retentive global variables are initialized:

- When the backup or buffer for retentive data fails.
- When a memory reset (MRES) is performed.
- With the restart function (Del. SRAM) in SIMOTION P320 or P350.
- By applying the *_resetUnitData* function, possible selectively for different data segments of the retentive data.
- When a download is performed according to the following description.
- With a firmware update (upgrade) or activation of a kernel in accordance with the following description.

Behavior during download

Table 4-15 Initializing retentive global variables during download

Variable type	Time of the variable initialization
Retentive global device variables	The behavior during the download depends on the *Initialization of retentive program data and retentive global device variables* setting[1]: • **Yes**[2]: All retentive global device variables are initialized. • **No**[3]: The retentive global device variables are only initialized if their version code is changed. See: Version code of global variables and their initialization during download (Page 131).
Retentive unit variables	The behavior during the download depends on the *Initialization of retentive program data and retentive global device variables* setting[1]: • **Yes**[2]: All retentive unit variables (all units) are initialized. • **No**[3]: A data block (= declaration block)[4] of the retentive unit variables in the interface or implementation section is only initialized[5] if its version code is changed. See: Version code of global variables and their initialization during download (Page 131).

[1] Default setting in the **Options > Settings** menu, **Download** tab, or the current setting for the download.

[2] The corresponding check box is active.

[3] The corresponding check box is inactive.

[4] With the **SIMOTION ST** programming language:
A data block of the retentive unit variables corresponds to a VAR_GLOBAL RETAIN/END_VAR declaration block in the interface section or implementation section.
With the **SIMOTION MCC** and **SIMOTION LAD/FBD** programming languages:
A data block of the retentive unit variables is formed as follows from the variables declared with VAR_GLOBAL RETAIN in the interface section or implementation section of the declaration table: Pragma lines (Page 120) within a section of the declaration table separate the variables into different data blocks.

[5] Initialization of a changed data block also occurs during a download in RUN mode, provided the following condition is fulfilled:
With the **SIMOTION ST** programming language
The following attribute has been specified within a pragma: { BlockInit_OnChange := TRUE; }.
With the **SIMOTION MCC** or **SIMOTION LAD/FBD** programming languages:
A pragma line (Page 120) is inserted in the declaration table with the following check box enabled in this line: *Initialization of VAR_GLOBAL RETAIN during a change*. All the variables declared with VAR_GLOBAL RETAIN up to the next pragma line or the end of the table form a data block accordingly.
For information on the general conditions for a download in RUN, see the SIMOTION Basic Functions Function Manual.

Behavior during upgrade or configuration change

When the SIMOTION device is upgraded to a new version of the SIMOTION Kernel or if the configuration is changed, the retentive variables are initialized as described below:

Table 4-16 Initialization of retentive global variables during upgrade or configuration change

Variable type	Time of the variable initialization
Retentive global device variables	This data is always initialized.
Retentive unit variables	This data can be retained. See section "Retaining retentive data" in the "Basic Functions for Modular Machines" Function Manual.

4.14.3.2 Initialization of non-retentive global variables

Non-retentive global variables lose their value during power outages. They are initialized:

- During the initialization of retentive global variables (Page 124), e.g. during a firmware update or overall reset (MRES).
- During switch-on.
- By applying the *_resetUnitData* function, possible selectively for different data segments of the non-retentive data.
- During a download as described in the following table.
- During the transition from STOP to RUN mode as described at the end of the section.

Behavior during download

Table 4-17 Initializing non-retentive global variables during download

Variable type	Time of the variable initialization
Non-retentive global device variables	The behavior during the download depends on the *Initialization of non-retentive program data and non-retentive global device variables* setting[1]: • **Yes**[2]: All non-retentive global device variables are initialized. • **No**[3]: The non-retentive global device variables are only initialized if their version code is changed. See: Version code of global variables and their initialization during download (Page 131).
Non-retentive unit variables	The behavior during the download depends on the *Initialization of non-retentive program data and non-retentive global device variables* setting[1]: • **Yes**[2]: All non-retentive unit variables (all units) are initialized. • **No**[3]: A data block (= declaration block)[4] of the non-retentive unit variables in the interface or implementation section is only initialized[5] if its version code is changed. See: Version code of global variables and their initialization during download (Page 131).

[1] Default in the **Options > Settings** menu, **Download** tab, or the current setting for the download.

[2] The corresponding check box is active.

[3] The corresponding check box is inactive.

[4] With the **SIMOTION ST** programming language:
A data block of the non-retentive unit variables corresponds to a VAR_GLOBAL/END_VAR declaration block in the interface section or implementation section.
With the **SIMOTION MCC** or **SIMOTION LAD/FBD** programming languages:
A data block of the non-retentive unit variables is formed as follows from the variables declared with VAR_GLOBAL in the interface section or implementation section of the declaration table: Pragma lines (Page 120) within a section of the declaration table separate the variables into different data blocks.

[5] Initialization of a changed data block also occurs during a download in RUN, provided the following condition is fulfilled:
With the **SIMOTION ST**
programming language: The following attribute has been specified within a pragma in the relevant declaration block: { BlockInit_OnChange := TRUE; }.
With the **SIMOTION MCC** or **SIMOTION LAD/FBD** programming languages:
A pragma line (Page 120) has been pasted into the declaration table and the following check box is activated: *Initialization of VAR_GLOBAL during a change*. All the variables declared with VAR_GLOBAL up to the next pragma line or the end of the table form a data block accordingly.
For information on the general conditions for a download in RUN, see SIMOTION Basic Functions Function Manual.

Behavior during STOP-RUN transition

The values of non-retentive global variables are retained by default during the transition from STOP to RUN mode.

You can, however, make a setting whereby the non-retentive global variables are initialized during the STOP-RUN transition:

- **As of Version V4.2 of the SIMOTION Kernel**, by activating the **Initialization of non-retentive global variables and program data during STOP-RUN transition** checkbox on the SIMOTION device.
  With non-retentive unit variables, this setting can be overwritten by a pragma or pragma line (Page 120) in the relevant data blocks of the program sources.
- **As of Version V4.1 of the SIMOTION Kernel**, by a pragma or pragma line in the relevant data blocks of the program sources (only with non-retentive unit variables):
  - With the **SIMOTION ST** programming language:
    Specify the following attribute within a pragma in the relevant VAR_GLOBAL/END_VAR declaration block: { BlockInit_OnDeviceRun := ALWAYS; }
  - With the **SIMOTION MCC** or **SIMOTION LAD/FBD** programming languages:
    Paste a pragma line (Page 120) with the following setting into the declaration table: "*Initialization during STOP-RUN transition* = **Always**". All the variables declared with VAR_GLOBAL up to the next pragma line or the end of the table form a data block which is initialized during the STOP-RUN transition.

Note

With SIMOTION devices up to SIMOTION Kernel Version V4.0, non-retentive global variables are never initialized during the STOP-RUN transition.

4.14.3.3 Initialization of local variables

Local variables are initialized:

- For the initialization of retentive unit variables (Page 124).
- For the initialization of non-retentive unit variables (Page 126).
- Also, according to the following description:

Table 4-18 Initialization of local variables

Variable type	Time of the variable initialization
Local program variables	Local variables of programs are initialized differently: • Static variables (VAR) are initialized according to the memory area in which they are stored. See: Initialization of static program variables (Page 128). • Temporary variables (VAR_TEMP) are initialized every time the program of the task is called.
Local variables of function blocks (FB)	Local variables of function blocks are initialized differently: • Static variables (VAR, VAR_IN, VAR_OUT) are only initialized when the FB instance is initialized. See: Initialization of instances of function blocks (FBs) (Page 129). • Temporary variables (VAR_TEMP) are initialized every time the FB instance is called.
Local variables of functions (FC)	Local variables of functions are temporary and are initialized every time the function is called.

Note

You can obtain information about the memory requirements of a POU in the local data stack using the Program Structure (Page 201) function.

4.14.3.4 Initialization of static program variables

The following versions affect the following static variables:

- Local variables of a unit program declared with VAR
- Function block instances declared with VAR within a unit program, including the associated static variables (VAR, VAR_INPUT, VAR_OUTPUT).

The initialization behavior is determined by the memory area in which the static variables are stored. This is determined by the "Only create program instance data once" (Page 53) compiler option.

- For the deactivated "Only create program instance data once" compiler option (default):
  The static variables are stored in the user memory of each task which is assigned to the program.
  The initialization of the variables thus depends on the execution behavior of the task to which the program is assigned (see SIMOTION Basic Functions Function Manual):
  - Sequential tasks (MotionTasks, UserInterruptTasks, SystemInterruptTasks, StartupTask, ShutdownTask): The static variables are initialized every time the task is started.
  - Cyclic tasks (BackgroundTask, SynchronousTasks, TimerInterruptTasks): The static variables are only initialized only during the transition from STOP to RUN operating state.
- For the activated "Only create program instance data once" compiler option:
  This setting is necessary, for example, if a program is to be called within a program.
  The static variables of all programs from the program source (unit) involved are only stored once in the user memory of the unit.
  They are thus initialized together with the non-retentive unit variables, see Initialization of non-retentive global variables (Page 126).
  They are not initialized by default during the transition from STOP to RUN operating state. You can, however, make a setting whereby they are initialized during the STOP-RUN transition:
  - **As of version V4.2 of the SIMOTION Kernel**, by activating the **Initialization of non-retentive global variables and program data during STOP-RUN transition** checkbox on the SIMOTION device.
    This setting can be overwritten by a pragma or pragma line (Page 120) in the data block of the relevant program organization unit (POU).
  - **As of version V4.1 of the SIMOTION Kernel**, by a pragma or pragma line in the data block of the relevant program organization unit (POU):
    With the **SIMOTION ST** programming language:
    Specify the following attribute within a pragma in the VAR/END_VAR declaration block:
    { BlockInit_OnDeviceRun := ALWAYS; }
    With the **SIMOTION MCC** or **SIMOTION LAD/FBD** programming languages:
    The declaration table starts with a pragma line (Page 120) containing the following setting: "*Initialization during STOP-RUN transition* = **Always**". All the variables declared with VAR in the table are initialized during the STOP-RUN transition.

4.14.3.5 Initialization of instances of function blocks (FBs) or classes

The initialization of a function block instance (Page 181) or a class instance (as of version V4.5 of the SIMOTION Kernel) is determined by the location of its declaration:

- Global declaration (within VAR_GLOBAL/END_VAR in the interface of implementation section):
  Initialization as for a non-retentive unit variable, see Initialization of non-retentive global variables (Page 126).
- Local declaration in a program (within VAR / END_VAR):
  Initialization as for static variables of programs, see Initialization of static variables of programs (Page 128).

- Local declaration in a function block (within VAR / END_VAR):
  Initialization as for an instance of this function block.
- Declaration as in/out parameter in a function block or a function (within VAR_IN_OUT / END_VAR):
  For the initialization of the POU, only the reference (pointer) will be initialized with the instance of the function block remaining unchanged.

Note

You can obtain information about the memory requirements of a POU in the local data stack using the Program Structure (Page 201) function.

4.14.3.6 Initialization of system variables of technology objects

The system variables of a technology object are usually not retentive. Depending on the technology object, a few system variables are stored in the retentive memory area (e.g. absolute encoder calibration).

The initialization behavior (except in the case of download) is the same as for retentive and non-retentive global variables. See Initialization of retentive global variables (Page 124) and Initialization of non-retentive global variables (Page 126).

The behavior during the download is shown below for:

- Non-retentive system variables
- Retentive system variables

Table 4-19 Initializing technology object system variables during download

Variable type	Time of the variable initialization
Non-retentive system variables	Behavior during download, depending on the *Initialization of all non-retentive data for technology objects* setting[1]: • **Yes**[2]: All technology objects are initialized. – All technology objects are restructured and all non-retentive system variables are initialized. – All technological alarms are cleared. • **No**[3]: Only technology objects changed in SIMOTION SCOUT are initialized. – The technology objects in question are restructured and all non-retentive system variables are initialized. – All alarms that are pending on the relevant technology objects are cleared. – If an alarm that can only be acknowledged with *Power On* is pending on a technology object that will not be initialized, the download is aborted.
Retentive system variables	Only if a technology object was changed in SIMOTION SCOUT, will its retentive system variables be initialized. The retentive system variables of all other technology objects are retained (e.g. absolute encoder calibration).

[1] Default in the **Options > Settings** menu, **Download** tab, or the current setting for the download.

[2] The corresponding checkbox is active.

[3] The corresponding checkbox is inactive.

4.14.3.7 Version ID of global variables and their initialization during download

Table 4-20 Version code of global variables and their initialization during download

Data segment		Description of version code
Global device variables		
	Retentive global device variables Non-retentive global device variables	• Separate version code for each data segment of the global device variables. • The version code of the data segment changes for: – Add or remove a variable within the data segment – Change of the identifier or the data type of a variable within the data segment • This version code does not change on: – Changes in the other data segment – Changes to initialization values[1] • During downloading[2], the rule is: This data segment is only initialized when the version code of a data segment is changed.
Unit variables of a unit		
	Retentive unit variables in the interface section Retentive unit variables in the implementation section Non-retentive unit variables in the interface section Non-retentive unit variables in the implementation section	• Several data blocks (= declaration blocks)[3] are possible in each data segment. • **Separate version code** for each data block. • The version code of the data block changes for: – Add or remove a variable in the associated declaration block – Change of variable sequence in the relevant declaration block – Change of the identifier or the data type of a variable in the associated declaration block – Change of a data type definition (from a separate or imported[4] unit) used in the associated declaration block – Add or remove declaration blocks within the same data segment **before** the associated declaration block • This version code does not change on: – Add or remove declaration blocks in other data segments – Add or remove declaration blocks within the same data segment **after** the associated declaration block – Changes in other data blocks – Changes to initialization values[1] – Changes to data type definitions that are not used in the associated data block – Changes to functions • During downloading[2], the rule is: This data block is only initialized when the version code of a data block is changed[5]. • Functions for data backup and initialization take into account the version code of the data blocks.
Retentive variables of function blocks and classes (The instances are declared as non-retentive unit variables)		

Data segment		Description of version code
	Non-retentive unit variables in the interface section	Only as of version V4.5 of the SIMOTION Kernel. • The retentive variables of all instances within a declaration block (VAR_GLOBAL / END_VAR) are summarized as a separate retentive data block • to which a separate version code is assigned. • The version code of this retentive data block changes: – The data structure of the retentive local variables for the instances within the declaration block changes. – The sequence of the declaration blocks (VAR_GLOBAL / END_VAR) within the program source changes. • During downloading[2], the rule is: This data block is only initialized when the version code of a data block is changed[5]. • Functions for data backup and initialization take into account the version code of the data blocks.
	Non-retentive unit variables in the implementation section	

[1] Changed initialization values are not effective until the data block or data segment in question is initialized.

[2] If *Initialization of retentive program data and retentive global device variables* = No and *Initialization of non-retentive program data and non-retentive global device variables* = No.
In the case of other settings: See the sections "Initialization of retentive global variables (Page 124)" and "Initialization of non-retentive global variables (Page 126)".

[3] With the **SIMOTION ST** programming language:
A data block corresponds to a VAR_GLOBAL/END_VAR or VAR_GLOBAL RETAIN/END_VAR declaration block in the interface section or implementation section.
With the **SIMOTION MCC** or **SIMOTION LAD/FBD** programming languages:
A data block of the non-retentive unit variables is formed as follows from the variables declared with VAR_GLOBAL or VAR_GLOBAL RETAIN in the interface section or implementation section of the declaration table: Pragma lines (Page 120) within a section of the declaration table separate the variables into different data blocks.

[4] The use of units depends on the programming language, refer to the relevant section (Page 165).

[5] Initialization of a changed data block also occurs during a download in RUN mode, provided that the following condition is fulfilled:
With the **SIMOTION ST** programming language
The following attribute has been specified within a pragma: { BlockInit_OnChange := TRUE; }.
With the **SIMOTION MCC** or **SIMOTION LAD/FBD** programming languages:
A pragma line (Page 120) is inserted in the declaration table with the following check box enabled in this line: *Initialization of VAR_GLOBAL during a change*. All the variables declared with VAR_GLOBAL up to the next pragma line or the end of the table form a data block accordingly.
For information on the general conditions for a download in RUN, see SIMOTION Basic Functions Function Manual.

4.14.4 Variables and HMI devices

Exported variables

The following variables are exported to HMI devices where they are available:

- System variables of the SIMOTION device
- System variables of technology objects
- I/O variables
- Global device variables

- Retentive and non-retentive unit variables of the interface section (default setting).
  Change this default as follows:
  - In the SIMOTION ST programming language:
    For each declaration block with the following pragma: `{ HMI_Export := FALSE; }`.
    See also Controlling compiler with attributes.
  - In the SIMOTION MCC and SIMOTION LAD/FBD programming languages:
    For the variable declarations following a pragma line (Page 120), if you deactivate the *VAR_GLOBAL for HMI devices* or *VAR_GLOBAL RETAIN for HMI devices* parameters in this pragma line.

  The unit variables of a data block identified in this way are not exported to HMI devices. The HMI consistency check is also omitted for them during the download.
- Non-retentive static variables (VAR) of programs provided that the compiler option "Only create program instance data once" is activated
- Non-retentive static variables (VAR) of function blocks
  This is the default setting when the compiler option "Permit object-oriented programming" is enabled. Change this default as follows:
  - In the SIMOTION ST programming language:
    For each declaration block with the following pragma: `{ HMI_Export := FALSE; }`.
    See also Controlling compiler with attributes.

  The variables of a data block identified in this way are not exported to HMI devices. The HMI consistency check is also omitted for them during the download.
  The pragma is not evaluated if the compiler option "Permit object-oriented programming" is **not** activated. The export behavior cannot be changed.
- Non-retentive public variables (VAR PUBLIC) of classes (default setting, as of version V4.5 of the SIMOTION Kernel)
  Change this default as follows:
  - In the SIMOTION ST programming language:
    For each declaration block with the following pragma: `{ HMI_Export := FALSE; }`.
    See also Controlling compiler with attributes.

  The variables of a data block identified in this way are not exported to HMI devices. The HMI consistency check is also omitted for them during the download.

Note

The total size of the unit variables that can be exported to HMI devices is limited to 64 KB per unit.

The effect of the `{ HMI_Export := FALSE; } / { HMI_Export := TRUE; }` pragma (or the *VAR_GLOBAL for HMI devices* or *VAR_GLOBAL RETAIN for HMI devices* settings in a pragma line) depends on the SIMOTION Kernel version:

- As of Version V4.1 of the SIMOTION Kernel:
  The pragma affects the export of the corresponding declaration block to HMI devices **and** the structure of the HMI address space:
  - Only those variables in declaration blocks exported to HMI devices occupy the HMI address space.
  - Within the HMI address space, the variables are arranged according to order of their declaration.
- Up to Version V4.0 of the SIMOTION Kernel:
  The pragma affects **only** the export of the corresponding declaration block to HMI devices. The HMI address space is also occupied by unit variables of the interface section whose declaration blocks are not assigned to HMI devices.
  Within the HMI address space, the variables are sorted in the following order:
  - Retentive unit variables of the interface section (exported and not exported).
  - Retentive unit variables of the implementation section (only exported).
  - Non-retentive unit variables of the interface section (exported and not exported).
  - Non-retentive unit variables of the implementation section (only exported).

  Within these segments, the variables are arranged according to order of their declaration.

Non-exported variables

The following variables are **not** exported to HMI devices and are **not** available there:

- Retentive and non-retentive unit variables of the implementation section (default setting)
  Change this default as follows:
  - In the SIMOTION ST programming language:
    For each declaration block with the following pragma: `{ HMI_Export := TRUE; }`
    See also Controlling compiler with attributes.
  - In the SIMOTION MCC and SIMOTION LAD/FBD programming languages:
    For the variable declarations following a pragma line (Page 120), if you activate the *VAR_GLOBAL for HMI devices* or *VAR_GLOBAL RETAIN for HMI devices* parameters in this pragma line.

  The unit variables of a data block identified in this way are exported to HMI devices. Consequently, they undergo the HMI consistency check during downloading.
- Local variables (VAR, VAR_TEMP) of functions or methods
- Temporary variables (VAR_TEMP) of programs, function blocks or classes
- Retentive local variables (VAR RETAIN) of programs (as of version 4.5 of the SIMOTION Kernel)

- Retentive local variables (VAR RETAIN) of function blocks (as of version 4.5 of the SIMOTION Kernel)
  This is the default setting when the compiler option "Permit object-oriented programming" is enabled. Change this default as follows:
  - In the SIMOTION ST programming language:
    For each declaration block with the following pragma: `{ HMI_Export := TRUE; }`.
    See also Controlling compiler with attributes.

  The variables of a data block identified in this way are exported to HMI devices. Consequently, they undergo the HMI consistency check during downloading.
  The pragma is not evaluated if the compiler option "Permit object-oriented programming" is **not** activated. The export behavior cannot be changed.
- Retentive local variables (VAR RETAIN) of classes (default setting, as of version 4.5 of the SIMOTION Kernel)
  Change this default as follows:
  - In the SIMOTION ST programming language:
    For each declaration block with the following pragma: `{ HMI_Export := TRUE; }`.
    See also Controlling compiler with attributes.

  The variables of a data block identified in this way are exported to HMI devices. Consequently, they undergo the HMI consistency check during downloading.
- Non-retentive static variables (VAR) of programs provided that the compiler option "Only create program instance data once" is **not** activated
- Non-retentive protected or private variables (VAR, VAR PROTECTED, VAR PRIVATE) of classes (default setting, as of version V4.5 of the SIMOTION Kernel)
  Change this default as follows:
  - In the SIMOTION ST programming language:
    For each declaration block with the following pragma: `{ HMI_Export := TRUE; }`.
    See also Controlling compiler with attributes.

  The variables of a data block identified in this way are exported to HMI devices. Consequently, they undergo the HMI consistency check during downloading.

Example for the SIMOTION ST programming language

Table 4-21 Example for the control of the HMI export with the corresponding pragma

```
INTERFACE
    VAR_GLOBAL
        // HMI export
        x1 : DINT;
    END_VAR
    VAR_GLOBAL
        { HMI_Export := FALSE; }
        // No HMI export
        x2 : DINT;
    END_VAR
    // ...
END_INTERFACE

IMPLEMENTATION
    VAR_GLOBAL
        // No HMI export
        y1 : DINT;
    END_VAR
    VAR_GLOBAL
        { HMI_Export := TRUE; }
        // HMI export
        y2 : DINT;
    END_VAR
    // ...
END_IMPLEMENTATION
```

4.15 General references (as of kernel V4.5)

4.15.1 Defining general references

General references contain the address assignment to a variable or an instance of a function block or class:

General references require a SIMOTION Kernel as of version V4.5. The compiler option (Page 53) "Permit object-oriented programming" also must be activated.

References can be defined as variables or elements of structures.

To do this, activate the **Reference** checkbox in the **Parameters/variables** or **Structures** tab in the declaration table of the program source or program organization unit. The declaration is also possible as array element. See also the description for the "Reference (Page 98)" checkbox.

This creates the "Reference to data type" (REF_TO *data_type*) that can contain the address to an existing data type (reference data type).

The following are permitted as data types to which references can be formed:

- Elementary data types (e.g. INT, DINT, REAL, WORD, TIME, STRING)
- User-defined data types (UDT)
- System data types
- Function blocks, provided they contain at least one static variable
- Classes (from ST sources)

No references can be formed to the following data types because references exist already:

- Technology object data types
- Object-oriented interfaces (from ST sources)
- General references
- I/O references (from ST sources)

Variables of general references can be declared in the interface and implementation sections as well as in all program organization units and classes. The data type to be referenced must be declared beforehand and lie within the scope of the POU. The declaration as element of a structure or an ARRAY is also possible.

All variable types for the relevant program organization unit are permitted with the exception of:

- VAR_IN_OUT.
  Arrays, structures, function blocks or classes that contain general references may nonetheless be transferred as VAR_IN_OUT.
- VAR RETAIN or VAR_GLOBAL RETAIN is not permitted.
  However, structures that contain at least one element other than reference types (general references, data types of the technology objects, object-oriented interfaces), can be stored retentive.
- VAR CONSTANT or VAR_GLOBAL CONSTANT is not meaningful.
  General references must be initialized with "NULL".

4.15.2 Forming general references

A reference to a variable is formed with the REF standard function (in := *var_name*). This function is described in detail in the "SIMOTION Basic Functions" Function Manual.

The REF function can be used on the following variables:

- Retentive and non-retentive unit variables or instances of classes or function blocks or their elements declared as such.
- In methods within classes or function blocks:
  - Static variables (VAR) of the higher-level class or function block (including instance variables for classes or function blocks).
  - The THIS keyword. Enables access to the instance variable of the higher-level class or function block.
- In function blocks:
  - Static variables (VAR) of the function block (including instance variables of classes or function blocks).
  - The THIS keyword. Permits access to the instance variable of the function block.

The variable must be able to be read and written.

Not permitted are:

- Variables of technology object data types
- Variables of object-oriented interfaces
- Variables of general references
- Retentive local variables within classes or function blocks
- I/O variables
- Global device variables
- Constants

The return value has the data type "Reference to the data type of the input parameter *in*". The return value can be assigned with the assignment operator ":=" to a variable that has REF_TO *type* data type. A data type conversion is not possible.

Note

Note for instances of function blocks that are passed as in/out parameter (VAR_IN_OUT):

- The REF function cannot be used for static variables (VAR) of function blocks imported from technology packages or device-independent libraries.

The restriction does not apply to class instances.

4.15.3 Operations with general references

Assignment operator ":="

For the assignment of a reference variable, the address of the variable rather than the variable value is passed. Consequently, the reference data types must be identical on both sides of the operator. No implicit data type conversion is possible.

The only exception is for references to classes. A reference to a derived class of a reference to the base class can be assigned here.

For the assignment, no check is made for the validity of the reference; the assignment is always possible.

An explicit assignment with NULL is also possible.

The validity of references should be checked by comparing with NULL before use.

Dereferencing with operator "^"

The reference content can be accessed with the postfix operator "^", e.g. *ref_var*^.

If the reference does not contain a valid value at runtime, the processing task is aborted and the ExecutionFaultTask called.

Before access, a check for validity by comparison with NULL is recommended.

Multilevel dereferencing is possible, e.g. reference to a structure that contains further references. Dereferenced variables can be used anywhere in expressions.

If a method is called via a reference to a class or function block, the class or function block must be dereferenced.

Dereferenced values cannot be used as actual parameters for the _releaseSemaphore() and _testandSetSemaphore() system functions.

Dynamic type conversion with the operator "?="

The operator "?=" can be used for dynamic type conversion only with references to classes and with interface variables (variables for object-oriented interfaces). It supports the following variants:

- Assignment between references to classes.
- Assignment of a reference to a class for an interface variable.
  Whereby, the reference to a class must be specified with the dereferencing operator "^".
- Assignment of an interface variable for a reference to a class.
- Assignment between interface variables

A dynamic type conversion is performed if the following two conditions are satisfied:

1. The variable to the right of the operator contains the reference to the instance of a class.
2. For the variable to the left of the operator, the following applies:
   - The variable is an interface variable:
     The object-oriented interface that this variable has as data type must implement the class on the right-hand side.
   - The variable is a reference to a class:
     This class corresponds to the class on the right-hand side or is a base class for this class.

In this case, the reference on the right-hand side is converted and transferred to the left-hand side.

If the type conversion fails, the variable on the left-hand side contains the "NULL" value.

Comparison operators

Only the comparison operators "=" and "<>" can be used to check for equality or inequality.

The operators ">", "<", ">=", "<=" as well as the MIN and MAX standard functions are not permitted.

4.16 Access to inputs and outputs (process image, I/O variables)

4.16.1 Overview of access to inputs and outputs

SIMOTION provides several possibilities to access the device inputs and outputs of the SIMOTION device as well as the central and distributed I/O:

- Via direct access with I/O variables
  Direct access is used to access the corresponding I/O address directly.
  Define an I/O variable (name and I/O address) without assigning a task to it. The entire address space of the SIMOTION device can be used.
  It is preferable to use direct access with sequential programming (in MotionTasks); access to current input and output values at a particular point in time is especially important in this case.
  Further information: Direct access and process image of the cyclic tasks (Page 144).
- Via the process image of cyclic tasks using I/O variables
  The process image of the cyclic tasks is a memory area in the RAM of the SIMOTION device, on which the whole I/O address space of the SIMOTION device is mirrored. The mirror image of each I/O address is assigned to a cyclic task and is updated using this task. The task remains consistent throughout the whole cycle. This process image is used preferentially when programming the assigned task (cyclic programming).
  Define an I/O variable (name and I/O address) and assign a task to it. The entire address range of the SIMOTION device can be used.
  Direct access to this I/O variable is still possible: Specify direct access with *_direct.varname*.
  Further information: Direct access and process image of the cyclic tasks (Page 144).
- Using the fixed process image of the BackgroundTask
  The process image of the BackgroundTask is a memory area in the RAM of the SIMOTION device, on which a subset of the I/O address space of the SIMOTION device is mirrored. The mirror image is refreshed with the BackgroundTask and is consistent throughout the entire cycle. This process image is used preferentially when programming the BackgroundTask (cyclic programming).
  The address range 0 .. 63 can be used. Exception: I/O addresses that are accessed using the process image of the cyclic task can only be used with the setting “Common process image” (Page 155) (as of Kernel V4.2).
  Further information: Access to the fixed process image of the BackgroundTask (Page 153).

A comparison of the most important properties is contained in "Important properties of direct access and process image" (Page 141).

You can use I/O variables like any other variable, see "Access I/O variables" (Page 163).

Note

An access via the process image is more efficient than direct access.

4.16.2 Important features of direct access and process image access

Table 4-22 Important properties of direct access and process image access

	Direct access	Access to process image of cyclic tasks	Access to fixed process image of the BackgroundTask
Permissible address range	Entire address range of the SIMOTION device **Exception**: I/O variables comprising more than one byte must not contain addresses 63 and 64 contiguously (example: PIW63 or PQD62 are not permitted).		Addresses 0 .. 63. **Exception**: Up to version V4.1 of the SIMOTION Kernel or the "Separate process image" setting, addresses used for the process image of the cyclic tasks are not permitted.
Address configuration	Necessary. The addresses used must be present in the I/O and appropriately configured. The "Rules for I/O addresses for direct access and the process image of the cyclic tasks" (Page 147) must be observed.		Not necessary. Addresses that are not present in the I/O or have not been configured can also be used.
Assigned task	None.	Cyclic task for selection: • SynchronousTasks, • TimerInterruptTasks, • BackgroundTask.	BackgroundTask.
Memory area for process images	-	Depends on the SIMOTON Kernel version: • Up to version V4.1: Separate memory areas in all cases • As of version V4.2: Option to select a common memory area	

<table>
<tr><th></th><th>Direct access</th><th>Access to process image of cyclic tasks</th><th>Access to fixed process image of the BackgroundTask</th></tr>
<tr><td>Update</td><td>• Onboard I/O of SIMOTION devices C230-2, C240, and C240 PN:
Update occurs in a cycle clock of 125 µs.
• With I/O devices
– via PROFIBUS DP or PROFINET on an isochronous SIMOTION device[1]
– via DRIVE-CLiQ
– Onboard I/O of SIMOTION D devices:
The update is performed in the position control cycle clock[2].
• With I/O devices
– via PROFIBUS DP or PROFINET on a non-isochronous SIMOTION device[1]
– via P-Bus:
The update is performed in the interpolation cycle[2] [3].
Inputs are read at the start of the cycle clock.
Outputs are written at the end of the cycle clock.</td><td>Update occurs with the assigned task:
• Inputs are read before the assigned task is started and transferred to the process input image.
• Process output image is written to the outputs after the assigned task has been completed.</td><td>An update is made with the BackgroundTask:
• Inputs are read before the BackgroundTask is started and is transferred to the process input image.
• Process output image is written to the outputs when the BackgroundTask is complete.</td></tr>
<tr><td rowspan="2">Consistency</td><td>–</td><td>During the entire cycle of the assigned task.
Exception: Direct access to output occurs.</td><td rowspan="2">During the entire cycle of the BackgroundTask.
Exception: Direct access to output occurs.</td></tr>
<tr><td colspan="2">Consistency is only ensured for elementary data types.
When using arrays, the user is responsible for ensuring data consistency.</td></tr>
<tr><td>Use</td><td>Preferred in MotionTasks</td><td>Preferred in the assigned task</td><td>Preferred in the BackgroundTask</td></tr>
<tr><td>Declaration as variable</td><td colspan="2">Necessary, for the entire device as an I/O variable in the symbol browser.
Each byte of the address range may only be assigned to a single I/O variable.
Syntax of I/O address: e.g. PIW1022, PQ63.3.</td><td>Possible, but not necessary:
• For the entire device as I/O variable in the symbol browser
• As unit variable
• As local static variable in a program</td></tr>
<tr><td>Download of new or changed I/O variables</td><td colspan="2">Only possible in STOP mode.</td><td>-</td></tr>
</table>

	Direct access	Access to process image of cyclic tasks	Access to fixed process image of the BackgroundTask
Use the absolute address	Not supported.		Possible, with the following syntax: E.g. %IW62, %Q63.3.
Byte order when forming the process image	-	As supplied by the I/O	Depends on the SIMOTION Kernel version and the memory area setting for the process images: • Up to version V4.1 or the "Separate process image" setting: Always Big Endian • As of version V4.2 and the "Common process image" setting: As supplied by the I/O
Byte order during access	Depends on I/O		Always Big Endian
Writeability of inputs	No	Depends on the SIMOTION Kernel version: • Up to version V4.1: No • As of version V4.2: Yes	Yes
Write protection for outputs	Possible; **Read only** status can be selected.	Not supported.	Not supported.
Declaration of arrays	Possible.		Not supported.
Further information	Direct access and process image of the cyclic tasks (Page 144).		Access to the fixed process image of the BackgroundTask (Page 153).
Responses in the event of an error	Error during access from user program, alternative reactions available: • CPU Stop[4] • Substitute value • Last value See SIMOTION Basic Functions Description of Functions.	Error during generation of process image, alternative reactions available: • CPU stop[5] • Substitute value • Last value	Error during generation of process image, reaction: CPU stop[5] **Exception**: If a direct access has been created at the same address, the behavior set there applies.
		See SIMOTION Basic Functions Description of Functions.	
Access			
• In the RUN operating state	Without any restrictions.	Without any restrictions.	Without any restrictions.
• During the StartupTask	Possible with restrictions: • Inputs can be read. • Outputs are not written until StartupTask is complete.	Possible with restrictions: • Inputs are read at the start of the StartupTask. • Outputs are not written until StartupTask is complete.	Possible with restrictions: • Inputs are read at the start of the StartupTask. • Outputs are not written until StartupTask is complete.

	Direct access	Access to process image of cyclic tasks	Access to fixed process image of the BackgroundTask
• During the ShutdownTask	Without any restrictions.	Possible with restrictions: • Inputs retain status of last update • Outputs are no longer written.	Possible with restrictions: • Inputs retain status of last update • Outputs are no longer written.

[1] A SIMOTION device is considered isochronous if at least one PROFIBUS DP or PROFINET interface is operated isochronously (constant bus cycle time). For SIMOTION D there is an exception with the DP Integrated interface to which the SINAMICS Integrated is connected.

[2] The following SIMOTION devices are updated in the Servo_fast cycle or IPO_fast cycle, if the cycles are configured: D445-2 DP/PN, D455-2 DP/PN (as of version V4.2) and D435-2 DP/PN (as of version V4.3).

3 IPO or IPO_2 adjustable, see “Setting system cycle clocks" section in the Basic Functions Function Manual.

[4] Call the ExecutionFaultTask.

[5] Call the PeripheralFaultTask.

4.16.3 Direct access and process image of cyclic tasks

Property

Direct access to inputs and outputs and access to the process image of the cyclic task always take place via I/O variables. The entire address range of the SIMOTION device (Page 146) can be used.

A comparison of the most important properties, including in comparison to the fixed process image of the BackgroundTask (Page 153) is contained in "Important properties of direct access and process image" (Page 141).

Note

Observe the rules for I/O addresses for direct access and the process image of the cyclical tasks (Page 147).

It is particularly important that every address used in an I/O variable is available in the I/O and configured; each byte in the address range may be assigned to no more than one I/O variable (does not apply to access with data type BOOL).

A detailed status of I/O variables (Page 151) can be read as of version V4.2 of the SIMOTION Kernel, for example, in order to check the availability of the I/O variables.

Direct access

Direct access is used to access the corresponding I/O address directly. Direct access is used primarily for sequential programming (in MotionTasks). The access to the current value of the inputs and outputs at a specific time is particularly important.

For direct access, you define an I/O variable (Page 148) without assigning it a task.

Process image of the cyclic task

The process image of the cyclic tasks is a memory area in the RAM of the SIMOTION device, on which the whole I/O address space of the SIMOTION device is mirrored. The mirror image of each I/O address is assigned to a cyclic task and is updated using this task. The task remains consistent throughout the whole cycle. This process image is used preferentially when programming the assigned task (cyclic programming). The consistency during the complete cycle of the task is particularly important.

For the process image of the cyclical task you define an I/O variable (Page 148) and assign it a task.

Direct access to this I/O variable is still possible: Specify direct access with *_direct.var-name*.

Note

An access via the process image is more efficient than direct access.

Additional properties as of version V4.2 of the SIMOTION Kernel

As of version V4.2 of the SIMOTION Kernel, direct access to inputs/outputs and the process image of the cyclic tasks offers additional properties:

- As far as the process image of the cyclic tasks is concerned, a common memory area with the fixed process image of the BackgroundTask can be set (standard with newly created devices)
- As far as the process image of the cyclic tasks is concerned, I/O variables for inputs can be written to (i.e. they can be assigned values).
- A detailed status of I/O variables (Page 151) can be read, for example, in order to check the availability of the I/O variables.

Memory area with the fixed process image of the BackgroundTask

- **As of version V4.2 of the SIMOTION Kernel**, selecting a "Common process image" setting on the device ensures the memory area for the fixed process image of the BackgroundTask is a subset of the memory area for the process image of the cyclic tasks.
- **Up to version V4.1 of the SIMOTION Kernel** or the "Separate process image" setting on the device (as of version V4.2 of the SIMOTION Kernel), the fixed process image of the BackgroundTask and the process image of the cyclic tasks occupy different memory areas.

Note

If (and only if) you are also using the fixed process image of the BackgroundTask, it is important to consider the effects of the "Common process image" or "Separate process image" settings on the fixed process image of the BackgroundTask (Page 153).

Table 4-23 Effect of "Common process image" or "Separate process image" settings on the process image of the cyclic tasks

	Common process image	Separate process image
Availability	Only available as of version V4.2 of the SIMOTION Kernel: • Setting available for selection • Standard for newly created devices	Up to version V4.1 of the SIMOTION Kernel applies: • System characteristic, not configurable. The following applies as of version V4.2 of the SIMOTION Kernel: • Setting available for selection • Standard with device upgrades
Download of new or changed I/O variables	Only possible in STOP mode.	Only possible in STOP mode.
Byte order when forming the process image and during access	Depends on connected I/O	
Effects on the fixed process image of the BackgroundTask	See the relevant table in "Access to the fixed process image of the BackgroundTask" (Page 154).	
Further information	Common process image (Page 155)	Separate process image (Page 157)

4.16.3.1 Address range of the SIMOTION devices

The address range of the SIMOTION devices is specified in the following table according to the version of the SIMOTION Kernel concerned. The complete address range can be used for direct access and process image of the cyclical tasks.

Table 4-24 Address range of the SIMOTION devices according to the version of the SIMOTION Kernel

SIMOTION device	Address range for SIMOTION Kernel version						
	V3.2	V4.0	V4.1	4.2	V4.3	V4.4	V4.5
C230-2	0 .. 2047 [3]	0 .. 2047 [3]	0 .. 2047 [3]	–	–	–	–
C240	–	0 .. 4095 [3]	0 .. 4095 [3]	0 .. 4095 [3]	0 .. 4095 [3]	0 .. 4095 [3]	0 .. 4095 [3]
C240 PN [1]	–	–	0 .. 4095 [4]	0 .. 4095 [4]	0 .. 4095 [4]	0 .. 4095 [4]	0 .. 4095 [4]
D410 DP	–	–	0 .. 8191 [3]	0 .. 8191 [3]	0 .. 8191 [3]	–	–
D410 PN	–	–	0 .. 8191 [4]	0 .. 8191 [4]	0 .. 8191 [4]	–	–
D410-2	–	–	–	–	0 .. 8191 [3 4]	0 .. 8191 [3 4]	0 .. 8191 [3 4]
D425	0 .. 4095 [3]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	–	–
D425-2	–	–	–	–	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]
D435	0 .. 4095 [3]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	–	–
D435-2	–	–	–	–	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]
D445	0 .. 4095 [3]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	–	–	–
D445-1 [1]	–	–	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	–	–
D445-2	–	–	–	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]
D455-2	–	–	–	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]	0 .. 16383 [3 4]
P320 [2]	–	–	0 .. 4095 [3]	0 .. 4095 [3]	0 .. 4095 [3]	–	–

SIMOTION device	Address range for SIMOTION Kernel version						
	V3.2	V4.0	V4.1	4.2	V4.3	V4.4	V4.5
P320-4	–	–	–	–	–	0 .. 4095 [3]	0 .. 4095 [3]
P350	0 .. 2047 [3]	0 .. 4095 [3]	0 .. 4095 [3]	0 .. 4095 [3]	0 .. 4095 [3]	–	–

[1] Available as of V4.1 SP2 HF4

[2] Available as of V4.1 SP5

[3] For distributed I/O (over PROFIBUS DP), the transmission volume is restricted to 1024 bytes per PROFIBUS DP line.

[4] For distributed I/O (over PROFINET), the transmission volume is restricted to 4,096 bytes per PROFINET segment.

4.16.3.2 Rules for I/O addresses for direct access and the process image of the cyclical tasks

Note

You must observe the following rules for the I/O variable addresses for direct access and the process image of the cyclic task (Page 144). Compliance with the rules is checked during the consistency check of the SIMOTION project (e.g. during the download).

1. Addresses used for I/O variables must be present in the I/O and configured appropriately in the HW Config.
2. I/O variables comprising more than one byte must not contain addresses 63 and 64 contiguously.
   The following I/O addresses are not permitted:
   - Inputs: PIW63, PID61, PID62, PID63
   - Outputs: PQW63, PQD61, PQD62, PQD63
3. All addresses of an I/O variable comprising more than one byte (e.g. WORD, ARRAY data type) must be within a continuous address range configured in HW Config, e.g. within the address range (slot or subslot) of *one* I/O module.
4. An I/O address (input or output) can only be used by a single I/O variable of data type BYTE, WORD or DWORD or an array of these data types. Access to individual bits with I/O variables of data type BOOL is possible.
5. If several processes (e.g. I/O variable, technology object, PROFIdrive telegram) access an I/O address, the following applies:
   - Only a single process can have write access to an I/O address of an output (BYTE, WORD or DWORD data type).
     Read access to an output with an I/O variable that is used by another process for write access, is possible.
   - All processes must use the same data type (BYTE, WORD, DWORD or ARRAY of these data types) to access this I/O address. Access to individual bits is possible irrespective of this.
     Please be aware of the following, for example, if you wish to use an I/O variable to read the PROFIdrive telegram transferred to or from the drive: The length of the I/O variable must match the length of the telegram.
   - Write access to different bits of an address is possible from several processes; however, write access with the data types BYTE, WORD or DWORD is then not possible.

Note

These rules do not apply to accesses to the fixed process image of the BackgroundTask (Page 153). These accesses are not taken into account during the consistency check of the project (e.g. during download).

4.16.3.3 Creating I/O variables for direct access or process image of cyclic tasks

Create I/O variables for direct access or a process image of the cyclic tasks in the address list of the detail view.

This is only possible in offline mode.

Here is a brief overview of the procedure:

1. Select the "Address list" tab in the detail view and choose the SIMOTION device
   or
   In the project navigator of SIMOTION SCOUT, double-click the "ADDRESS LIST" element in the SIMOTION device subtree.
2. Select the line before which you want to insert the I/O variable and, from the context menu, select **Insert new line**
   or
   Scroll to the end of the table of variables (empty line).
3. In the empty row of the table, enter or select the following:
   - Names of the **I/O variables**
   - **I/O address**
     Select the "IN" or "OUT" entries if you wish to assign symbols to the I/O variable (input or output). As of Version V4.2 of the SIMOTION Kernel the symbolic assignment must be activated, menu **Project > Use symbolic assignment**.
     Or enter a fixed address according to "Syntax for entering I/O addresses" (Page 150).
   - Optional for outputs:
     Activate the **Read only** checkbox if you only want to have read access to the output. You can then read an output that is already being written by another process (e.g. output of an output cam, PROFIdrive telegram).
     A read-only output variable cannot be assigned to the process image of a cyclic task.
   - **Data type** of the variables in accordance with "Possible data types of the I/O variables" (Page 151).

4. Optionally, you can also enter or select the following (not for data type BOOL):
   - **Array length** (array size).
   - **Process image** or direct access:
     Can only be assigned if the **Read only** checkbox is deactivated.
     For process image, select the cyclic task to which you want to assign the I/O variable.
     To select a task, it must have been activated in the execution system.
     For direct access, select the blank entry.
   - **Strategy** for behavior in the event of an error, see SIMOTION Basic Functions Function Manual.
   - **Display format** (if array, for each element), when you monitor the variable in the address list
   - **Substitute value** (if array, for each element).
5. Only if you have selected "IN" or "OUT" as the I/O address (symbolic assignment).
   - In the **Assignment** column, click the **[…]** button.
     A window opens displaying the possible assignment targets of the SIMOTION device and, if necessary, of SINAMICS Integrated. Only those assignment targets are displayed that match the data direction (input/output) and data type.
   - Select the assignment target.
     The **Assignment status** column indicates whether the assignment was successful or not.

   For details regarding symbolic assignment, refer to the SIMOTION Basic Functions Function Manual.

You can now access this variable using the address list or any program of the SIMOTION device.

Details on how to manage the address list can be found in the online help.

Note

Note the following for the process image for cyclic tasks:

- A variable can only be assigned to one task.
- Each byte of an input or output can only be assigned to one I/O variable.

In the case of data type BOOL, please note:

- The process image for cyclic tasks and a strategy for errors cannot be defined. The behavior defined via an I/O variable for the entire byte is applicable (default: direct access or CPU stop).
- The individual bits of an I/O variable can also be accessed using the bit access functions.

Take care when making changes within the I/O variables (e.g. inserting and deleting I/O variables, changing names and addresses):

- In some cases the internal addressing of other I/O variables may change, making all I/O variables inconsistent.
- If this happens, all program sources that contain accesses to I/O variables must be recompiled.

Note

I/O variables can only be created in offline mode. You create the I/O variables in SIMOTION SCOUT and then use them in your program sources (e.g. ST sources, MCC sources, LAD/FBD sources).

Outputs can be read and written to, but inputs can only be read.

Before you can monitor and modify new or updated I/O variables, you must download the project to the target system.

You can use I/O variables like any other variable, see "Access I/O variables" (Page 163).

4.16.3.4 Syntax for entering I/O addresses

Syntax

For the input of the I/O address for the definition of an I/O variable for direct access or process image of cyclical tasks (Page 144), use the following syntax. This specifies not only the address, but also the data type of the access and the mode of access (input/output).

Table 4-25 Syntax for the input of the I/O addresses for direct access or process image of the cyclic tasks

Data type	Syntax for		Permissible address range					
	Input	Output	Direct access		Process image		e.g. direct access D435 V4.1	
BOOL	PIn.x	PQn.x	n: x:	0 .. *MaxAddr* 0 .. 7		-[1]	n: x:	0 .. 16383 0 .. 7
BYTE	PIBn	PQBn	n:	0 .. *MaxAddr*	n:	0 .. *MaxAddr*	n:	0 .. 16383
WORD	PIWn	PQWn	n:	0 .. 62 64 .. *MaxAddr* - 1	n:	0 .. 62 64 .. *MaxAddr* - 1	n:	0 .. 62 64 .. 16382
DWORD	PIDn	PQDn	n:	0 .. 60 64 .. *MaxAddr* - 3	n:	0 .. 60 64 .. *MaxAddr* - 3	n:	0 .. 60 64 .. 16380
n = logical address x = bit number								
MaxAddr =	Maximum I/O address of the SIMOTION device depending on the SIMOTION Kernel version, see Address range of the SIMOTION devices (Page 146).							
[1] For data type BOOL, it is not possible to define the process image for cyclic tasks. The behavior defined via an I/O variable for the entire byte is applicable (default: direct access).								

Examples

Input at logic address 1022, WORD data type: **PIW1022**.

Output at logical address 63, bit 3, BOOL data type: **PQ63.3**.

Note

Observe the rules for I/O addresses for direct access and the process image of the cyclical tasks (Page 147).

4.16.3.5 Possible data types of I/O variables

The following data types can be assigned to the I/O variables for direct access and process image of the cyclical tasks (Page 144). The width of the data type must correspond to the data type width of the I/O address.

If you assign a numeric data type to the I/O variables, you can access these variables as integer.

Table 4-26 Possible data types of the I/O variables for direct access and the process image of the cyclical tasks

Data type of I/O address	Possible data types for I/O variables
BOOL (PIn.x, PQn.x)	BOOL
BYTE (PIBn, PQBn)	BYTE, SINT, USINT
WORD (PIWn, PQWn)	WORD, INT, UINT
DWORD (PIDn, PQDn)	DWORD, DINT, UDINT

For details of the data type of the I/O address, see also "Syntax for entering I/O addresses" (Page 150).

4.16.3.6 Detailed status of the I/O variables (as of Kernel V4.2)

As of version V4.2 of the SIMOTION Kernel, the status of an I/O variable can be queried using *_quality.var-name*, for example, in order to check the availability of the I/O variables. It is supplied as an OR logic operation of the following status values in the DWORD data type and can be assigned to an appropriate variable, for example. The value 16#0000_0000 indicates the connected I/O are operating without error.

The same value is supplied for every I/O variable within an address range (slot or subslot) configured in HW Config.

Table 4-27 Meanings of status values of I/O variables

Value (DWORD)	Bit x = 1	Meaning
16#0000_0000	-	No error occurred.
16#0000_0001	0	**Maintenance required** The connected module signals that it requires maintenance. The component needs to be checked within a foreseeable period (e.g. the printer cartridge must be changed within a period of several days).
16#0000_0002	1	**Maintenance demanded** The connected module demands maintenance. The component needs to be checked soon (e.g. the printer cartridge must be changed immediately).

Value (DWORD)	Bit x = 1	Meaning
16#0000_0004	2	**Warning pending** (drive warning, TM17 warning, etc.) The connected module has signaled a warning. This has been entered in the diagnostics buffer. The precise cause can be determined from the documentation for the relevant module.
16#0000_0008	3	**Fault pending** (diagnostic interrupt, drive fault, TM17 fault, etc.) The connected module has signaled an error. This has been entered in the diagnostics buffer. The precise cause can be determined from the documentation for the relevant module.
16#0000_0010	4	**This parameter assignment does not match the parameter assignment being compared.** A difference was detected when this parameter assignment was compared with the parameter assignment of the connected module. As such, the required functionality cannot be guaranteed. Remedy: Save the project and compile changes, reload both application and counterpart.
16#0000_0020	5	**Application and counterpart are not isochronous** (error involving the dynamic life-sign). Certain telegrams (axis, synchronous operation, output cam, measuring input telegrams) are synchronized by exchanging cyclic life-signs. Errors are detected when the cyclic life-sign is checked. This invalidates the data in the telegram. Remedy: Await synchronization, check the parameter assignment (e.g. does the master application cycle set on the device in HW Config match the position control cycle clock), save the project and compile changes, reload both application and counterpart.
16#0000_0040	6	**I/O cannot be used synchronously in all cycles.** A fast application cycle (Servo_fast) and a slow application cycle (Servo) are running asynchronously in relation to one another. The I/O can only be used synchronously in the cycles associated with the bus cycle. Access from other cycles is asynchronous and inconsistent. Remedy: Call the _synchronizeDpInterfaces() function.
16#0000_0080	7	**I/O cannot be used synchronously** The SIMOTION control is the sync slave on a bus. The bus connection is running synchronously in relation to the sync master, but is not yet running synchronously in relation to the application cycles of the SIMOTION control. Access to the I/O is asynchronous and inconsistent. Remedy: Call the _synchronizeDpInterfaces() function.
16#0000_0100	8	**Bus connection (sync slave) is not isochronous in relation to the sync master.** The SIMOTION control is the sync slave on a bus and has not yet synchronized its bus connection with the sync master. The isochronous I/O on this bus cannot be used yet. Remedy: Switch on/connect the sync master.
16#0000_0200	9	**DP station is deactivated.** The partner module has been deactivated. Remedy: Activate the partner module (_activateDpSlave() function).
16#0000_0400	10	**The partner of the inputs (e.g. I-device, I-slave) is in STOP.** The connected module is in STOP mode and not sending any new data as a result. Remedy: Switch the connected module to RUN.
16#0000_0800	11	**PROFINET: Failure detected by submodule** (e.g. channel error) The connection to the connected device is OK. The error must be searched for in the connected device. Troubleshooting: Diagnostics buffer, device diagnostics with HW Config

Value (DWORD)	Bit x = 1	Meaning
16#0000_1000	12	**PROFINET: Failure detected by module** (e.g. submodule failed, removed, etc.) The connection to the connected device is OK. The error must be searched for in the connected device. Troubleshooting: Diagnostics buffer, device diagnostics with HW Config
16#0000_2000	13	**PROFINET: Failure detected by device** (e.g. device in STOP, module removed, etc.) The connection to the connected device is OK. The error must be searched for in the connected device. Troubleshooting: Diagnostics buffer, device diagnostics with HW Config
16#0000_4000	14	**PROFINET: Failure detected by controller** (e.g. not connected, etc.) There is no connection to a partner on PROFINET. Possible cause: Partner is switched off, cable pulled out, incorrect parameter assignment for connection Troubleshooting: Best to use the PROFINET topology editor in HW Config.
16#0000_8000	15	**Slot/subslot is not connected** (disconnection alarm). The connection to the connected device is OK. The error must be searched for in the connected device (e.g. module/submodule removed). Troubleshooting: Diagnostics buffer, device diagnostics with HW Config
16#0001_0000	16	**Device is not connected** (station failure). There is no connection to a partner. Possible cause: Partner is switched off, cable pulled out.
16#0002_0000	17	**Substitute value behavior during access** There is no connection to the counterpart (sum signal from bits 9 to 16), i.e. there is no valid input data or the output data is not reaching the terminal. The substitute value behavior set (substitute value, last value) takes effect during direct access to this address or during process image updates.
16#4000_0000	30	**Diagnostics address only** No cyclic I/O data is configured for this address. It is possible, however, to query submodule diagnostic information.
16#8000_0000	31	**Address gap** There is no hardware configured for this logical address.

4.16.4 Access to fixed process image of the BackgroundTask

The fixed process image of the BackgroundTask is a memory area in the RAM of the SIMOTION device on which a subset of the I/O address space of the SIMOTION device is mirrored. Preferably, it should be used for programming the BackgroundTask (cyclic programming) as it is consistent throughout the entire cycle.

The size of the fixed process image of the BackgroundTask for all SIMOTION devices is 64 bytes (address range 0 .. 63).

Note

The fixed process image of the BackgroundTask can be used to access addresses that are not available in the I/O or not configured in HW Config. These are treated like normal memory addresses.

Memory area

- **As of Version V4.2 of the SIMOTION Kernel**, selecting a "Common process image" setting on the device ensures the memory area for the fixed process image of the BackgroundTask is a subset of the memory area for the process image of the cyclic tasks.
  I/O addresses can be read and written to using both the fixed process image of the BackgroundTask and the process image of the cyclic tasks.
- **With Version V4.1 and lower of the SIMOTION Kernel** or the "Separate process image" setting on the device (as of Version V4.2 of the SIMOTION Kernel), the fixed process image of the BackgroundTask and the process image of the cyclic tasks occupy different memory areas.
  I/O addresses accessed using the process image of the cyclic tasks cannot be read or written to using the fixed process image of the BackgroundTask. They are treated like normal memory addresses.

Table 4-28 Effect of "Common process image" or "Separate process image" settings on the fixed process image of the BackgroundTask

	Common process image	Separate process image
Availability	Only available as of Version V4.2 of the SIMOTION Kernel: • Setting available for selection • Standard for newly created devices	Version V4.1 and lower of the SIMOTION Kernel applies: • System characteristic, not configurable The following applies as of Version V4.2 of the SIMOTION Kernel: • Setting available for selection • Standard with device upgrades
Memory area	Subset of the memory area for the process image of the cyclic tasks	Separate memory area for the process image of the cyclic tasks
Using I/O addresses accessed using the process image of the cyclic tasks	Possible. Updates use the configured cyclic tasks.	Not supported. The addresses are treated like normal memory addresses.
Byte order when forming the process image	As supplied by the I/O	Always Big Endian
Byte order when accessing the process image	Always Big Endian	Always Big Endian
Access to I/O operating in the Little Endian byte order	Same result as during direct access or for the process image of cyclic tasks (apart from WORD or DWORD data types).	Results differ depending on the I/O variables created for direct access.

	Common process image	Separate process image
Effects on the process image of the cyclic tasks	See the relevant table in "Direct access and process image of the cyclic tasks (Page 146)".	
Further information	Common process image (Page 155)	Separate process image (Page 157)

For information on the order of the Little Endian and Big Endian bytes, please refer to the SIMOTION Basic Functions Function Manual.

A comparison of the most important properties in comparison to the direct access and process image of the cyclic tasks (Page 144) is contained in "Important properties of direct access and process image" (Page 141).

Note

The rules for I/O addresses for direct access and the process image of the cyclical tasks (Page 147) do **not** apply. Access to the fixed process image of the BackgroundTask is not taken into account during the consistency check of the project (e.g. during download).

Addresses not present in the I/O or not configured in HW Config are treated like normal memory addresses.

You can access the fixed process image of the BackgroundTask by means of:

- Using an absolute PI access (Page 159): The absolute PI access identifier contains the address of the input/output and the data type.
- Using a symbolic PI access (Page 161): You declare a variable that references the relevant absolute PI access:
  - A unit variable
  - A static local variable in a program.
- Using an I/O variable (Page 163): In the symbol browser, you define a valid I/O variable for the entire device that references the corresponding absolute PI access.

4.16.4.1 Common process image (as of Kernel V4.2)

As of Version V4.2 of the SIMOTION Kernel, the "Common process image" setting can be selected on the SIMOTION device. This means addresses 0 .. 63 of the process image of the cyclic tasks and the fixed process image of the BackgroundTask occupy the same memory area.

This is the default for SIMOTION devices newly created in the project as of Version V4.2.

Property of the common process image

1. The memory area for the fixed process image of the BackgroundTask (Page 153) is a subset of the memory area for the process image of the cyclic tasks (Page 144).
2. This means I/O addresses already accessed using the process image of the cyclic tasks may also continue to be used for the fixed process image of the BackgroundTask. Updates, however, use the configured cyclic tasks.

3. The following applies when forming the fixed process image of the BackgroundTask: The byte order is the same as supplied by the I/O:
   - Big Endian, e.g. for I/O via PROFIBUS DP, PROFINET, P-Bus, DRIVE-CLiQ
   - Little Endian, e.g. for onboard I/O of C240, C240 PN SIMOTION devices

   Any I/O variable created for the relevant addresses for the purpose of direct access or the process image of the cyclic tasks has no effect on the byte order.
4. Access to the fixed process image of the BackgroundTask always takes place using the Big Endian byte order.
5. These last two properties (nos. 3 and 4) affect access to inputs and outputs operating with the Little Endian byte order (e.g. onboard I/O of C240, C240 PN SIMOTION devices). If the fixed process image of the BackgroundTask is used for access, this leads to the following behavior, regardless of whether I/O variables have been created for the relevant addresses for the purpose of direct access or the process image of the cyclic tasks:
   - Access to individual bytes always supplies the same result via an I/O variable or the fixed process image of the BackgroundTask.
   - With the fixed process image of the BackgroundTask, bytes only change places if data type WORD is used for access.

   Please also refer to the example below.

For information on the order of the Little Endian and Big Endian bytes, please refer to the SIMOTION Basic Functions Function Manual.

Example for common process image: Access to I/O operating with the Little Endian byte order

The digital inputs of the C240 SIMOTION device operate with the Little Endian byte order and occupy addresses 66 (bits 0 ..7) and 67 (bits 0.. 3) by default. The start address is changed to 60 in HW Config to ensure it is in the range occupied by the fixed process image of the BackgroundTask. Addresses 60 and 61 are now accessed using various I/O variables and the process image of the BackgroundTask.

The following three scenarios are considered, which differ in terms of whether and which I/O variables are created for direct access or the process image of the cyclic tasks:

1. Scenario A:
   No I/O variables are created for addresses 60 and 61.
2. Scenario B:
   Two I/O variables with data type BYTE are created for addresses 60 and 61: io_byte_60 (PIB60) and io_byte_61 (PIB61).
3. Scenario C:
   For adresss 60, **one I/O-Variable** with data type WORD is created; this also covers address 61: io_word_60 (PIW60).

Two additional I/O variables are also created in each of the three scenarios, making it possible to access bit 3: io_bit_60_3 (PI60.3) and io_bit_61_3 (PI61.3).

The table below lists which values are generated with the following access types:

- Direct access or access to the process image of the cyclic tasks:
  - Access to individual bytes or the word using the relevant I/O variables
  - Access to each individual byte using the _getInOutByte function (direct access only)
  - Access to the respective bit 3 using the relevant I/O variables
- Access to the fixed process image of the BackgroundTask:
  - Access to individual bytes using an absolute name
  - Access to the word using an absolute name
  - Access to the respective bit 3 using an absolute name

Table 4-29 "Common process image" setting (as of Kernel V4.2): Different types of access to the process images of an input operating with the Little Endian byte order

	Access using	Scenario A [1]	Scenario B [1]	Scenario C [1]
Direct access or access to the process image of the cyclic tasks	io_byte_60 (PIB60)	-	16#08	-
	io_byte_61 (PIB61)	-	16#00	-
	io_word_60 (PIW60)	-	-	16#0008
	_getInOutByte (IN, 60)	16#08	16#08	16#08
	_getInOutByte (IN, 61)	16#00	16#00	16#00
	io_bit_60_3 (PI60.3)	TRUE	TRUE	TRUE
	io_bit_61_3 (PI61.3)	FALSE	FALSE	FALSE
Access to the fixed process image of the BackgroundTask	%IB60	16#08	16#08	16#08
	%IB61	16#00	16#00	16#00
	%IW60	16#0800 [2]	16#0800 [2]	16#0800 [2]
	%I60.3	TRUE	TRUE	TRUE
	%I61.3	FALSE	FALSE	FALSE

[1] Scenarios A, B, or C determine whether and which I/O variables are created for direct access or the process image of the cyclic tasks; see the explanation provided in the body of the document.

[2] The two bytes in the word change places, as a value saved in the Little Endian byte order is being read using Big Endian.

4.16.4.2 Separate process image (up to Kernel V4.1)

With Version V4.1 and below of the SIMOTION Kernel, the process image of the cyclic task and the fixed process image of the BackgroundTask are stored in different memory areas (separate process image).

As of Version V4.2 of the SIMOTION Kernel, the "Separate process image" setting can be selected on the SIMOTION device. This setting ensures there is compatibility with earlier Kernel versions.

It is the default for SIMOTION devices upgraded to Version V4.2 or higher.

Property of the separate process image

1. The fixed process image of the BackgroundTask (Page 153) and the process image of the cyclic tasks (Page 144) are stored in different memory areas.
2. This means I/O addresses that are already accessed using the process image of the cyclic tasks cannot be read or written to using the fixed process image of the BackgroundTask. They are treated like normal memory addresses.
3. I/O variables for direct access influence the fixed process image of the BackgroundTask:
   – The fixed process image of the BackgroundTask is always formed for the relevant addresses in the Big Endian byte order.
4. Access to the fixed process image of the BackgroundTask always takes place using the Big Endian byte order.
5. These last two properties (nos. 3 and 4) affect access to inputs and outputs operating with the Little Endian byte order (e.g. onboard I/O of C230-2, C240, C240 PN SIMOTION devices).
   If an I/O variable is created for the relevant addresses for the purpose of direct access using data type WORD and access takes place using the fixed process image of the BackgroundTask, this leads to the following behavior:
   – Access with the data type WORD supplies the same result via the I/O variable and the fixed process image of the BackgroundTask.
   – Access to individual bytes using the _getInOutByte function (see SIMOTION Basic Functions Function Manual) supplies these in the Little Endian order.
   – Access to the individual bytes or bits with the fixed process image of the BackgroundTask supplies these in the Big Endian order.

   Please also refer to the example below.

For information on the order of the Little Endian and Big Endian bytes, please refer to the SIMOTION Basic Functions Function Manual.

Example for separate process image: Access to I/O operating with the Little Endian byte order

The digital inputs of the C240 SIMOTION device operate with the Little Endian byte order and occupy addresses 66 (bits 0 ..7) and 67 (bits 0.. 3) by default. The start address is changed to 60 in HW Config to ensure it is in the range occupied by the fixed process image of the BackgroundTask. Addresses 60 and 61 are now accessed using various I/O variables and the process image of the BackgroundTask.

The following three scenarios are considered, which differ in terms of whether and which I/O variables are created for direct access:

1. Scenario A:
   No I/O variables are created for addresses 60 and 61.
2. Scenario B:
   Two I/O variables with data type BYTE are created for addresses 60 and 61: io_byte_60 (PIB60) and io_byte_61 (PIB61).
3. Scenario C:
   For adresss 60, **one I/O-Variable** with data type WORD is created; this also covers address 61: io_word_60 (PIW60).

Two additional I/O variables are also created in each of the three scenarios, making it possible to access bit 3: io_bit_60_3 (PI60.3) and io_bit_61_3 (PI61.3).

The table below lists which values are generated with the following access types:

- Direct access:
  - Access to individual bytes or the word using the relevant I/O variables
  - Access to each individual byte using the _getInOutByte function
  - Access to the respective bit 3 using the relevant I/O variables
- Access to the fixed process image of the BackgroundTask:
  - Access to individual bytes using an absolute name
  - Access to the word using an absolute name
  - Access to the respective bit 3 using an absolute name

Table 4-30 "Separate process image" setting or Kernel up to Version V4.1: Different types of access to the process images of an input operating with the Little Endian byte order

	Access using	Scenario A [1]	Scenario B [1]	Scenario C [1]
Direct access	io_byte_60 (PIB60)	-	16#08	-
	io_byte_61 (PIB61)	-	16#00	-
	io_word_60 (PIW60)	-	-	16#0008
	_getInOutByte (IN, 60)	16#08	16#08	16#08
	_getInOutByte (IN, 61)	16#00	16#00	16#00
	io_bit_60_3 (PI60.3)	TRUE	TRUE	TRUE
	io_bit_61_3 (PI61.3)	FALSE	FALSE	FALSE
Access to the fixed process image of the BackgroundTask	%IB60	16#08	16#08	**16#00** [3]
	%IB61	16#00	16#00	**16#08** [3]
	%IW60	**16#0800** [2]	**16#0800** [2]	16#0008
	%I60.3	TRUE	TRUE	**FALSE** [3]
	%I61.3	FALSE	FALSE	**TRUE** [3]

[1] Scenarios A, B, or C determine whether and which I/O variables are created for direct access; see the explanation provided in the body of the document.

[2] The two bytes in the word change places, as a value saved in the Little Endian order is being read using Big Endian.

[3] The two adjacent bytes change places, as the relevant word is saved in the Big Endian order.

4.16.4.3 Absolute access to the fixed process image of the BackgroundTask (absolute PI access)

You make absolute access to the fixed process image of the BackgroundTask (Page 153) by directly using the identifier for the address (with implicit data type). The syntax of the identifier (Page 160) is described in the following section.

You can use the identifier for the absolute PI access in the same manner as a normal variable.

Note

Outputs can be read and written to, but inputs can only be read.

4.16.4.4 Syntax for the identifier for an absolute process image access

For the absolute access to the fixed process image of the BackgroundTask (Page 159), use the following syntax. This specifies not only the address, but also the data type of the access and the mode of access (input/output).

You also use these identifiers:

- For the declaration of a symbolic access to the fixed process image of the BackgroundTask (Page 161).
- For the creation of an I/O variables for accessing the fixed process image of the BackgroundTask (Page 163).

Table 4-31 Syntax for the identifier for an absolute process image access

Data type	Syntax for		Permissible address range	
	Input	Output		
BOOL	%In.x or %IXn.x [1]	%Qn.x or %QXn.x[1]	n: x:	0 .. 63 [2] 0 .. 7
BYTE	%IBn	%QBn	n:	0 .. 63 [2]
WORD	%IWn	%QWn	n:	0 .. 63 [2]
DWORD	%IDn	%QDn	n:	0 .. 63 [2]
n = logical address x = bit number				
[1] The syntax %IXn.x or %QXn.x is not permitted when defining I/O variables. [2] For a separate process image (Page 157), the following applies: No addresses that are used in the process image of the cyclic tasks. See note below.				

Examples

Input at logic address 62, WORD data type: **%IW62**.

Output at logical address 63, bit 3, BOOL data type: **%Q63.3**.

Note

Up to Version V4.1 of the SIMOTION Kernel or the "Separate process image" (Page 157) setting on the device (as of Version V4.2 of the SIMOTION Kernel), the following applies:

- Addresses accessed using the process image of the cyclic tasks cannot be read or written to using the fixed process image of the BackgroundTask.

This restriction no longer applies as of Version V4.2 of the SIMOTION Kernel or with the "Common process image" (Page 155) setting on the device.

Note

The rules for I/O addresses for direct access and the process image of the cyclical tasks (Page 147) do **not** apply. Access to the fixed process image of the BackgroundTask is not taken into account during the consistency check of the project (e.g. during download).

Addresses not present in the I/O or not configured in HW Config are treated like normal memory addresses.

4.16.4.5 Defining symbolic access to the fixed process image of the BackgroundTask

You create symbolic access to the fixed process image of the BackgroundTask in the declaration tables of the source file, MCC chart, or LAD/FBD program (only in the case of programs). The scope of the symbolic process image access is dependent on the location of the declaration:

- In the interface section of the declaration table of the source file (INTERFACE):
  Symbolic process image access behaves like a unit variable; it is valid for the entire source file; all MCC charts or LAD/FBD programs (programs, function blocks, and functions) within the source file can access the process image.
  In addition, these variables are available on HMI devices and, once connected, in other source files (or other units), as well.
  The total size of all unit variables in the interface section is limited to 64 Kbytes.
- In the implementation section of the declaration table of the source file (IMPLEMENTATION):
  Symbolic process image access behaves like a unit variable; it is only valid in the source file; all MCC charts or LAD/FBD programs (programs, function blocks, and functions) within the source file can access it.
- In the declaration table for the MCC chart or LAD/FBD program (only in the case of programs):
  Symbolic process image access behaves like a local variable; it can only be accessed within the MCC chart or LAD/FBD program in which it is declared.
  No symbolic process image access can be declared in functions or function blocks.

Proceed as follows; the source file or the MCC chart or LAD/FBD program (in the case of programs only) with the declaration table is opened:

1. Select the declaration table and, if applicable, the section of the declaration table for the desired scope.
2. Select the I/O Symbols tab.
3. Enter:
   - Name of symbol (variable name)
   - For Absolute ID, the identifier of the absolute process image access (Page 160).
   - Data type of symbol (Page 162) (this must agree with the length of the process image access).

4.16.4.6 Possible data types for symbolic PI access

In the following cases, a data type that differs from that of the absolute PI access can be assigned to the fixed process image of the BackgroundTask (Page 153). The data type width must correspond to the data type width of the absolute PI access.

- For the declaration of a symbolic PI access (Page 161).
- For the creation of an I/O variable (Page 163).

If you assign a numeric data type to the symbolic PI access or to the I/O variables, you can access these variables as integer.

Table 4-32 Possible data types for symbolic PI access

Data type of the absolute PI access	Possible data types of the symbolic PI access
BOOL (%In.x, %IXn.x, %Qn.x. %QXn.x)	BOOL
BYTE (%IBn, %QBn)	BYTE, SINT, USINT
WORD (%IWn, %QWn)	WORD, INT, UINT
DWORD (%IDn, %PQDn)	DWORD, DINT, UDINT

For the data type of the absolute PI access, see also "Syntax for the identifier for an absolute PI access (Page 160)".

4.16.4.7 Example: Defining symbolic access to the fixed process image of the BackgroundTask

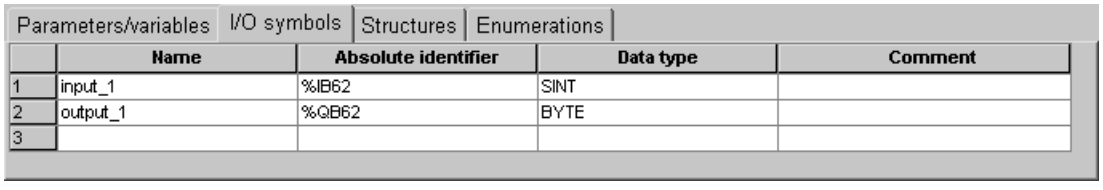


Figure 4-39 Example: Defining symbolic access to the fixed process image of the BackgroundTask

4.16.4.8 Creating an I/O variable for access to the fixed process image of the BackgroundTask

You create I/O variables for access to the fixed process image for the background task in the symbol browser in the detail view; you must be in offline mode to do this.

Here is a brief overview of the procedure:

1. Select the "Address list" tab in the detail view and choose the SIMOTION device
   or
   In the project navigator of SIMOTION SCOUT, double-click the "ADDRESS LIST" element in the SIMOTION device subtree.
2. Select the line before which you want to insert the I/O variable and, from the context menu, select Insert new line
   or
   Scroll to the end of the table of variables (empty line).
3. In the detail view, select the Symbol browser tab and scroll down to the end of the variable table (empty row).
4. In the empty row of the table, enter or select the following:
   - **Name** of variable.
   - Under **I/O address**, the absolute PI access according to the "Syntax for the identifier for an absolute PI access" (Page 160)
     (exception: The syntax %IXn.x or %QXn.x is not permitted for data type BOOL).
   - **Data type** of the I/O variables according to the "Possible data types of the symbolic PI access" (Page 162).
5. Select optionally the display format used to monitor the variable in the symbol browser.

You can now access this variable using the address list or any program of the SIMOTION device.

Note

I/O variables can only be created in offline mode. You create the I/O variables in SIMOTION SCOUT and use them in your program sources.

Note that you can read and write outputs but you can only read inputs.

Before you can monitor and modify new or updated I/O variables, you must download the project to the target system.

You can use I/O variables like any other variable, see "Access I/O variables" (Page 163).

4.16.5 Accessing I/O variables

You have created an I/O variable for:

- Direct access or process image of the cyclic tasks (Page 144).
- Access to the fixed process image of the BackgroundTask (Page 153).

You can use this I/O variable just like any other variable.

Note

Consistency is only ensured for elementary data types.

When using arrays, the user is responsible for ensuring data consistency.

Note

If you have declared unit variables or local variables of the same name (e.g. *var-name*), specify the I/O variable using *_device.var-name* (predefined name space, see the "Predefined name spaces" table in "Name spaces").

It is possible to directly access an I/O variable that you created as a process image of a cyclic task. Specify direct access with *_direct.var-name* or *_device._direct.var-name*.

If you want to deviate from the default behavior when errors occur during variable access, you can use the _getSafeValue and _setSafeValue functions (see *SIMOTION Basic Functions* Function Manual).

For Errors associated with access to I/O variables, see *SIMOTION Basic Functions* Function Manual.

4.17 Connections to other program source files or libraries

In the declaration table of a unit, you can define connections to:

- LAD/FBD units under the same SIMOTION device
- MCC units under the same SIMOTION device
- ST source files under the same SIMOTION device
- Libraries

This will then allow you to access the following in this unit:

- For connected program sources (Page 165), the following items which are defined there
  - Functions
  - Function blocks
  - Programs (optional)
  - Unit variables
  - User-defined data types (structures, enumerations)
  - Symbolic accesses to the fixed process image of the BackgroundTask
- For connected libraries (Page 166), the following items which are defined there
  - Functions
  - Function blocks
  - Programs (optional)
  - User-defined data types (structures, enumerations)

Program sources and libraries must be compiled beforehand.

For information about the library concept, see also the SIMOTION ST Programming Manual.

Note

Libraries can be created in all programming languages (MCC, ST, or LAD/FBD).

4.17.1 Defining connections

4.17.1.1 Procedure for defining connections to other program sources (units)

Connections to other units (program sources) are defined in the declaration table of the source file. The mode of action of a connection is dependent on the section of the declaration table in which it is defined.

- In the interface section of the declaration table:
  The imported functions, variables, etc., will continue to be exported to other units and to HMI devices. This can lead to name conflicts.
  This setting is necessary, for example, if unit variables are declared in the interface section of the source file with a data type that is defined in the imported program source.
- In the implementation section of the declaration table:
  The imported functions, variables, etc. will no longer be exported.
  This setting is usually sufficient.

Proceed as follows; the source file (declaration table) is open (see Open existing program sources (Page 46)):

1. In the declaration table, select the section for the desired mode of action.
2. Select the **Connections** tab.

3. For the connection type, select: **Program/Unit**
4. In the same line, select the name of the unit to be connected:
   Units (program sources) must be compiled beforehand.

4.17.1.2 Procedure for defining connections to libraries

Connections to libraries are defined in the declaration table of the source file.

Proceed as follows; the unit (declaration table) is open, see Open existing program sources (Page 46):

1. In the interface section of the declaration table, select the **Connections** tab.
2. For the connection type, select: **Library**.
3. In the same line, select the name of the library to be connected.
   Libraries must be compiled beforehand.
4. Optionally, you can define a name space for libraries, see Using name space (Page 166):
   To do this, enter a name under **Name space**.

Note

When programming the "Subprogram call" command (see Inserting and parameterizing subroutine calls (Page 170)) with a library function or a library function block, the connection to the library is automatically entered into the declaration table of the program source.

4.17.2 Using the name space

You can optionally assign a name space to every connected library. You define the designation of the name space when connecting the library (see How to define connections to libraries (Page 166)).

It is important to specify the name space if the current LAD/FBD program/MCC chart or program source contains variables, data types, functions, or function blocks with the same name as the connected library. The name space will then allow you specific access to the variables, data types, functions, or function blocks in the library. This can also resolve naming conflicts between connected libraries.

If you wish to use variables, data types, functions, or function blocks from the connected library in a command in the LAD/FBD program or MCC chart, insert the designation of the name space in front of the variable name, etc., from the library and separate them with a period (for example, namespace.var_name, namespace.fc_name).

Name spaces are predefined for device-specific and project-specific variables, direct accesses to I/O variables, and variables of TaskId and AlarmId in the following table: If necessary, write

their designation before the variable name, separated by a period, e.g. *_device.var_name* or *_task.task_name*.

Table 4-33 Predefined name spaces

Name space	Description
_alarm	For AlarmId: The _alarm.name variable contains the AlarmId of the message with the name identifier – see SIMOTION Basic Functions Function Manual.
_device	For device-specific variables (global device user variables, I/O variables, system variables, and system variables of the SIMOTION device)
_direct	For direct access to I/O variables – see Direct access and process image of the cyclic tasks (Page 144). Local name space for _device. Nesting as in _device._direct.*name* is permitted.
_project	For names of SIMOTION devices in the project; only used with technology objects on other devices. With unique project-wide names of technology objects, used also for these names and their system variables
_quality	As of Version V4.2 of the SIMOTION Kernel: For the detailed status of I/O variables (Page 151). A value with data type DWORD is supplied. Local name space for _device. Nesting as in _device._quality.*name* is permitted.
_task	For TaskID: The _task.name variable contains the TaskId of the task with the *name* identifier – see SIMOTION Basic Functions Function Manual.
_to	For technology objects configured on the SIMOTION device and their system variables and configuration data Not for system functions and data types of the technology objects. In this case, use the user-defined name space for the imported technology package, if necessary.

4.18 Subroutine

Universal, reusable sections of a program can be created in the form of subroutines.

When a subroutine is called, the program branches from the current task into the subroutine. The commands in the subroutine are executed. The program then jumps back to the previously active task.

Subroutines can be called repeatedly, as required, by one or more LAD/FBD programs of the SIMOTION device.

Subroutine as a function (FC), function block (FB), or program

The creation type of a subroutine can be a function (FC), a function block (FB) or, as an option, a program ("program in program").

- Function
  A function (FC) is a subroutine without static data, that is, all local variables lose their value when the function has been executed. They are re-initialized when the function is next started.
  Data are transferred to the function using input or in/out parameters; the output of a function value (return value) is also possible.
- Function block
  A function block (FB) is a subroutine with static data, that is, local variables retain their value after the function block has been executed. Only variables that have been explicitly declared as temporary lose their value.
  An instance has to be defined before using an FB: Define a variable (VAR or VAR_GLOBAL) and enter the name of the FB as data type. The FB static data is saved in this instance. You can define several FB instances; each instance is independent from the others.
  The static data of an FB instance remain stored until the instance is next called; they are reinitialized when the variable type of the FB instance is initialized again (see Initialization of instances of function blocks (FB) (Page 129)).
  Data are transferred to the FB using input parameters or in/out parameters; the data are returned from the FB using in/out or output parameters.
- Program ("program in program")
  You also have the option of calling a program within a different program or a function block. This requires the following compiler options to be activated (see Global compiler settings (Page 53) and Local compiler settings (Page 54)):
  - "Permit language extensions" for the program source of the calling program or function block and
  - "Only create program instance data once" for the program source of the called program. The static data of the called program is stored in the user memory of the program source (unit) of said called program.

  Most of the programming work involved in assigning the programs to the tasks can be performed by calling up programs within another program. In the execution system, only one associated calling program needs to be assigned to the tasks concerned.
  A program is called without parameters or return values.
  Further information on calling a program within a program can be found in the ST Programming and Operating Manual.

Note

The activated "Only create program instance data once" compiler option causes:

- The static variables of the programs (program instance data) to be stored in the user memory of the program source (unit) (see the SIMOTION ST Programming and Operating Manual). This also causes the initialization behavior to change (see the SIMOTION ST Programming and Operating Manual).
- All called programs with the same name to use the same program instance data.

Exchange of information between the subroutine and calling program

Function (FC) and function block (FB) as a subroutine

Information is exchanged between the subroutine and the calling program using transfer parameters or global variables (e.g. unit variables).

Transfer parameters can be input, input/output or output parameters. They are defined in the declaration table for the subroutine:

- Input parameters: As variable type VAR_INPUT
- In/out parameter: As variable type VAR_IN_OUT
- Output parameter (for FB only): As variable type VAR_OUTPUT

For functions, a function value can be returned; you specify the data type of the return value when you paste in (create) the function (see Paste in function (FC) or function block (FB) (Page 169)).

You assign current values to the input and/or in/out parameters when you call the subroutine (FC or FB instance). You may only assign user-defined variables to the in/out parameters of an FB because the called FB accesses the assigned variables directly and can therefore change them.

The output parameters of an FB can be read-accessed as often as required in the calling program.

A function does not formally contain any output parameters, since the result of the function can in this case be assigned to the return value of the function.

See also the examples of functions (Page 174) and function blocks (Page 179).

Program as subroutine ("program in program")

A program is called without parameters or return values. This means that information can only be exchanged between the calling program and the called program (subroutine) using global variables (e.g. unit variables).

See also

Inserting a subroutine call into the LAD/FBD program and assigning parameters (Page 170)

4.18.1 Inserting a function (FC) or function block (FB)

The creation dialog is similar to that of an LAD/FBD program:

1. LAD/FBD unit must already exist (see Managing LAD/FBD programs (Page 59)).
2. In the project navigator, open the relevant LAD/FBD unit.

3. Double-click the entry **Insert LAD/FBD program**.
   The input screen form opens.
   - Enter the name of the LAD/FBD program (see Rules for identifiers (Page 97)).
   - For the creation type, select **Function** or **Function block**.
   - With creation type Function only:
     Select the data type of the return value as the return type (<--> for no return value).
   - Check the **Exportable** option if the function or function block is to be used in other program source files (LAD/FBD, MCC or ST source files).
     When the checkbox is cleared, the LAD/FBD program can only be used in the associated LAD/FBD unit.
   - You can also enter an author, version, and a comment.
   - Confirm with **OK**.
4. Program the instructions in the function or function block.
   Assign an expression to the return value of a function (= function name) or to the output parameters of a function block.
5. Accept and compile the LAD/FBD unit. The subroutine you have created will then be displayed in the list.

4.18.2 Inserting a subroutine call into the LAD/FBD program and assigning parameters

In order to execute a call of a subroutine (function, function block, or program), the relevant subroutine must have been inserted into the network of an LAD/FBD program from the project navigator using drag-and-drop. When the subroutine inserted into the network is reached during a program run, the subroutine is called and the program branches from the current task into the subroutine.

You can use drag-and-drop to insert the following FCs, FBs, and programs into an LAD/FBD program and call them as a subroutine:

- Functions, function blocks, or programs of the same LAD/FBD unit or a different program source (e.g. MCC unit, ST source file).
- Library functions or library function blocks from a program library.

The subroutine call is parameterized, i.e. specifications are made as to which variables are to be transferred when the subroutine is called and returned once it has been executed, in the **Enter Call Parameter** parameter screen form.

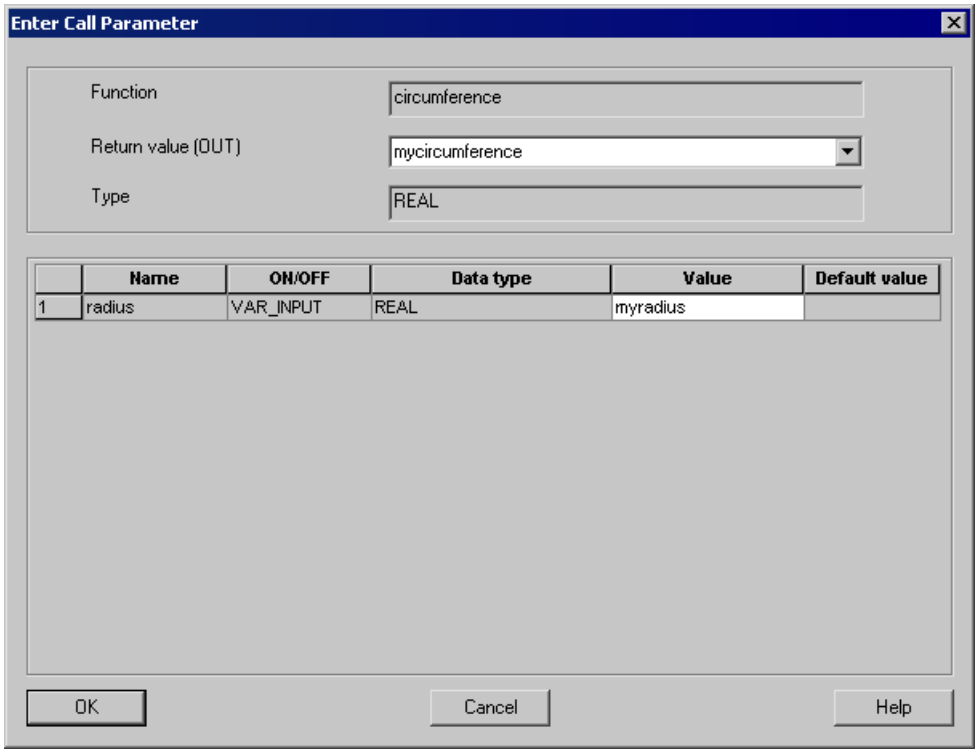


Figure 4-40 Parameterization of a function's subroutine call

Note

Saving a project in a format older than Version V4.2 of SIMOTION SCOUT

Pay attention to the order of the LAD/FBD programs in an LAD/FBD unit. A subroutine (function, function block, or program ("program in program")) must be defined before it is used. This is the case when the subroutine appears above the LAD/FBD program in which it is used in the project navigator. If necessary, reorder the LAD/FBD programs.

See also: Subroutine call of the function (FC) (Page 176)

Note

The term "LAD/FBD program" is a generic term and may refer to a program, a function (FC), or a function block (FB).

4.18.2.1 Overview of parameters for

You can set the following parameters when parameterizing the subroutine call:

Overview of Subroutine call parameters

Field/Button	Explanation/instructions
Subroutine type/ Subroutine	The type and name of the subroutine are displayed here: **Function** A function is a sub-program that has no memory beyond the call. In other words, the data is lost once the function has run and the output parameters and return value have been transferred. A function can also have a return value (function value) in addition to input, in/out and output parameters. **Function block** A function block is a sub-program which has a memory beyond the call. In other words, the values of the function block are retained after it has run. Variables of the data type for this function block must be declared. These variables are identified as instances of the function block; they include the memory of the function block beyond the calls. A function block only has input, in/out and output parameters but does not have a return value. The output parameters of the function block can be accessed even at a later time (after the function block has run) at the function block instance. **Program ("program in program")** You also have the option of calling a program within a different program or a function block. This requires the following compiler options to be activated, see Global compiler settings (Page 53) and Local compiler settings (Page 54): • "Permit language extensions" for the program source of the calling program or function block and • "Only create program instance data once" for the program source of the called program. The static data of the called program is stored in the user memory of the program source (unit) of said called program. The same program instance data is used every time the program is called. A program is called without parameters or return values.
Subprogram type/ subprogram (continued)	**Method** Methods are structuring tools for object-oriented programming. They largely correspond with functions, but are encapsulated in higher-level structuring tools (classes, function blocks). You can only generate methods and classes in the Structured Text (ST) programming language. Nevertheless classes and public methods (access identifier PUBLIC) can be used in LAB/FBD. A SIMOTION Kernel as of version V4.5 is mandatory for classes and their methods. Activating the following compiler options is recommended, see Global settings of the compiler (Page 53) and Local settings of the compiler (Page 54): • “Permit object-oriented programming” for the LAD/FBD source file of the LAD/FBD program being called. Variables of the data type for the higher-level structuring tools (class, function block) must be declared. These variables are identified as instances, and include the memory of the higher-level structuring tool beyond the calls. The methods themselves have no memory beyond the call. In other words, the data is lost once the method has run and the output parameters and return value have been transferred. A method can also have a return value (function value) in addition to input, in/out and output parameters.

Field/Button	Explanation/instructions
Instance	For subprogram type "function block" or “method": • In the case of a “function block” subprogram type: Here, enter the name of the function block instance. The instance contains the memory of the function block in the form of instance data. You define the instance as a variable whose data type is the name of the function block in one of the following ways: – In the declaration table of the LAD/FBD source as VAR_GLOBAL or – In the declaration table of the LAD/FBD program as VAR. • The following applies to “method” subprogram types: Enter the name of the class or function block instance to which the method belongs here. The instance contains the memory of the class or the function block in the form of instance data. You define the instance as a variable whose data type is the name of the class or of a class derived from this or the name of the function block in one of the following ways: – In the declaration table of the LAD/FBD source as VAR_GLOBAL or – In the declaration table of the LAD/FBD program as VAR.
Return value	For subprogram type "Function" or “Method": Here, you enter the variable in which the return value is to be stored. The type of variable must match the return value type.
Type	For subprogram type "Function" or “Method": The data type of the return value is displayed.
List of transfer parameters	
Name	The name of the transfer parameter is displayed here.
On / Off	The variable type of the transfer parameter is displayed here. **VAR_INPUT** Input parameters (for functions, function blocks and methods) **VAR_IN_OUT** In/out parameters (for functions, function blocks and methods) **VAR_OUTPUT** Output parameters (for functions, function blocks and methods)

Field/Button	Explanation/instructions
Data type	The data type of the transfer parameter is displayed here.
Value	Mandatory parameters are marked with "<???>" and optional parameters with "...". • The following applies to functions (FC) and methods: – Input parameters without a declared initial value and in/out parameters are mandatory parameters. – Input parameters with a declared initial value and output parameters are optional parameters. A subroutine call will only be functional if all the mandatory parameters are set. • The following applies to function blocks (FB): All parameters are optional. • The following applies to programs ("program in program"): No parameters present. Here, you can assign current variables or values to the transfer parameters: • Input parameter (variable type VAR_IN): Here, you enter a variable name or an expression. The assignment of system variables or I/O variables is permissible; type transformations are possible. • In/out parameter (variable type VAR_IN): Enter a variable name; the variable must be directly writable and readable. System variables of SIMOTION devices and technology objects are not permitted nor are I/O variables. The data type of the in/out parameter must correspond to that of the assigned variables; application of type transformation functions is not possible. • Output parameter (variable type VAR_OUTPUT): The assignment of an output parameter to a variable is optional. – The following applies to function blocks: You can also access an output parameter after executing the function block. – The following applies to functions and methods: The values for the output parameters are lost after executing the function or method unless they have been assigned in the parameter screen. When assigned in this parameter screen form: Enter a variable name. The data type of the output parameter must correspond to that of the assigned variables; the application of type transformation functions is not possible.

4.18.3 Example: Function (FC)

You want to create a subroutine with a circumference calculation for a circle. The calculation is performed in a function (FC). This is named **Circumference**.

The circle circumference calculation can thus be called as a subroutine by any task.

Formula for circumference calculation: Circumference = PI * 2 * radius

You define the Radius and PI variables in the declaration table of the function.

4.18.3.1 Creating and programming the function (FC)

1. In the project navigator, open the LAD/FBD unit in which you want to create the function.
2. Double-click the entry **Insert LAD/FBD program**.
   - Enter the name **Circumference**.
   - For creation type, select **Function**.
   - For return type (data type of return value), select **REAL**.
   - Click **OK** to confirm.
3. In the declaration table, define the **radius** input parameters, the **diameter** parameter, and the **PI** constant.

Parameters/variables | I/O symbols | Structures | Enumerations

	Name	Variable type	Data type	Array length	Initial value	Comment
1	radius	VAR_INPUT	REAL			
2	PI	VAR CONSTANT	REAL		3.14159	
3	diameter	VAR	REAL			
4						

Figure 4-41 Declaring variables (e.g. input parameters) in the LAD/FBD program

4. Click the **Insert Network** button on the LAD editor toolbar.
   A network is inserted into the **Circumference** function.
5. Drag the LAD/FBD element **MUL** from the command library and drop it into the network of the **circumference** function twice.
6. Program the circumference calculation for the return value by assigning the variables accordingly to the input/output parameters of the two **MUL** LAD/FBD elements.

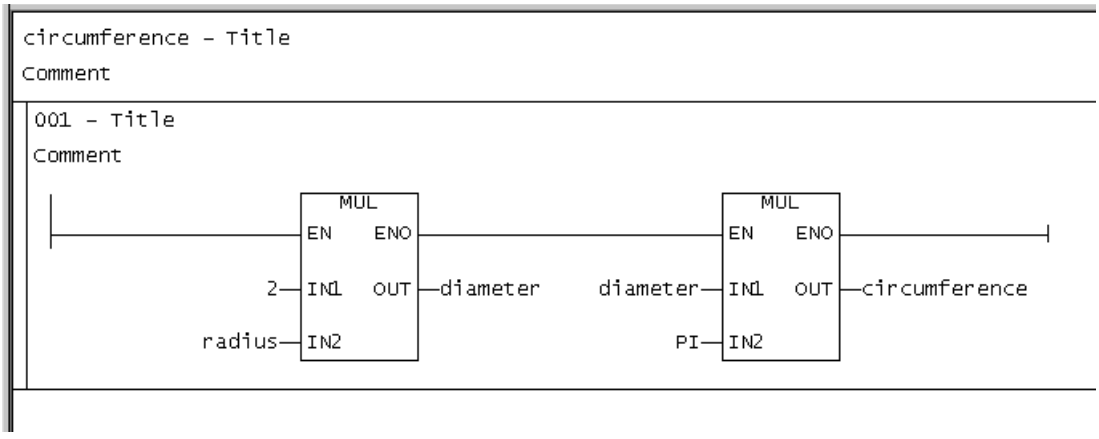


Figure 4-42 Programming the **Circumference** subroutine (e.g. assignment to a return value)

7. Accept and compile the LAD/FBD unit.

You have now finished programming the **Circumference** function.

Note

The term "LAD/FBD program" is a generic term and may refer to a program, a function (FC), or a function block (FB).

4.18.3.2 Subroutine call of function (FC)

The function (FC) is called from a program in the example.

1. Create an LAD/FBD program as a program in the same LAD/FBD unit (see Inserting a new LAD/FBD program (Page 59)):
   - Enter the name **Program_circumference**.
   - For creation type, select **Program**.
   - Click **OK** to confirm.
2. Declare the following in the LAD/FBD unit or the LAD/FBD program:
   - The **mycircum** variable.
     The return value of the "Circumference" function is assigned to this variable.
   - The **myradius** variable.
     This variable contains the radius and is assigned to the input parameter **Radius** of the **Circumference** function.

   Note that the validity range of the variables is dependent on the declaration location (see Define variables (Page 112)).

	Name	Variable type	Data type	Array length	Initial value	Comment
1	mycircum	VAR	REAL			
2	myradius	VAR	REAL			
3						

① You can continue to use the myumfang (mycircum) variable in the program.

Figure 4-43 Declaring a variable in the LAD/FBD program

3. Click the **Insert Network** button on the LAD editor toolbar.
   A network is inserted into the **Program_circumference** program.
4. Drag the **Circumference** function from the project navigator and drop it into the network of the **Program_circumference** program.
5. Select the inserted function, **Circumference**, followed by the **Parameterize call** command from the context menu.

6. Assign parameters to the subroutine call in the **Enter Call Parameter** parameter screen form.

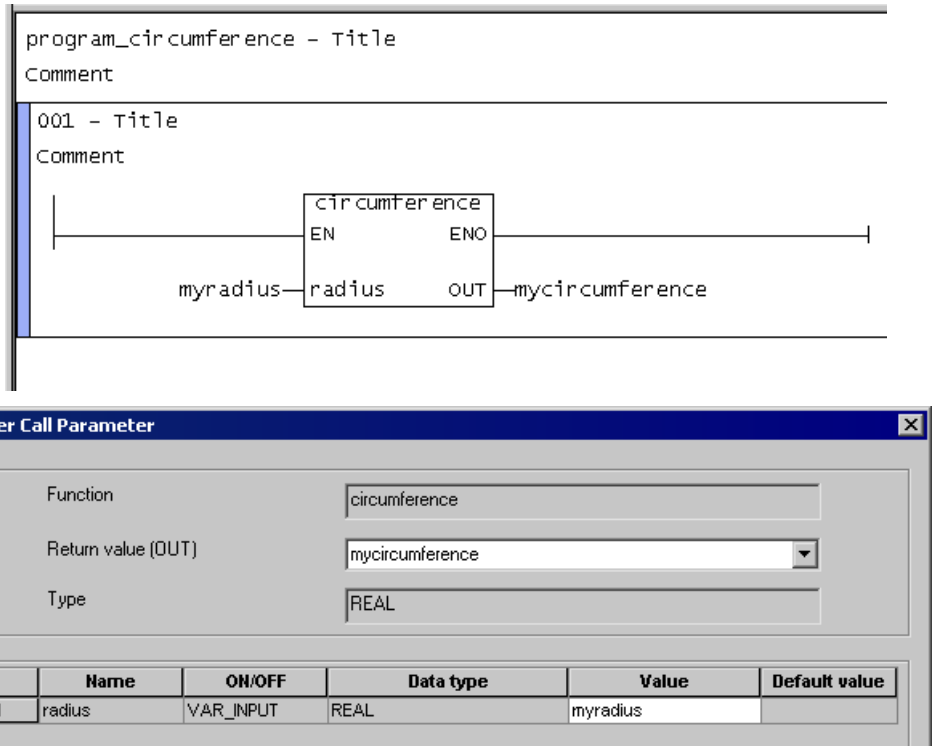


Figure 4-44 Opened parameter screen form for assigning parameters to the subroutine call

Note

Mandatory parameters are marked with "<???>" and optional parameters with "...". A subroutine call will only be functional if all the mandatory parameters are set.

7. Accept and compile the LAD/FBD unit.

You have now finished programming the subroutine call.

Note

The term "LAD/FBD program" is a generic term and may refer to a program, a function (FC), or a function block (FB).

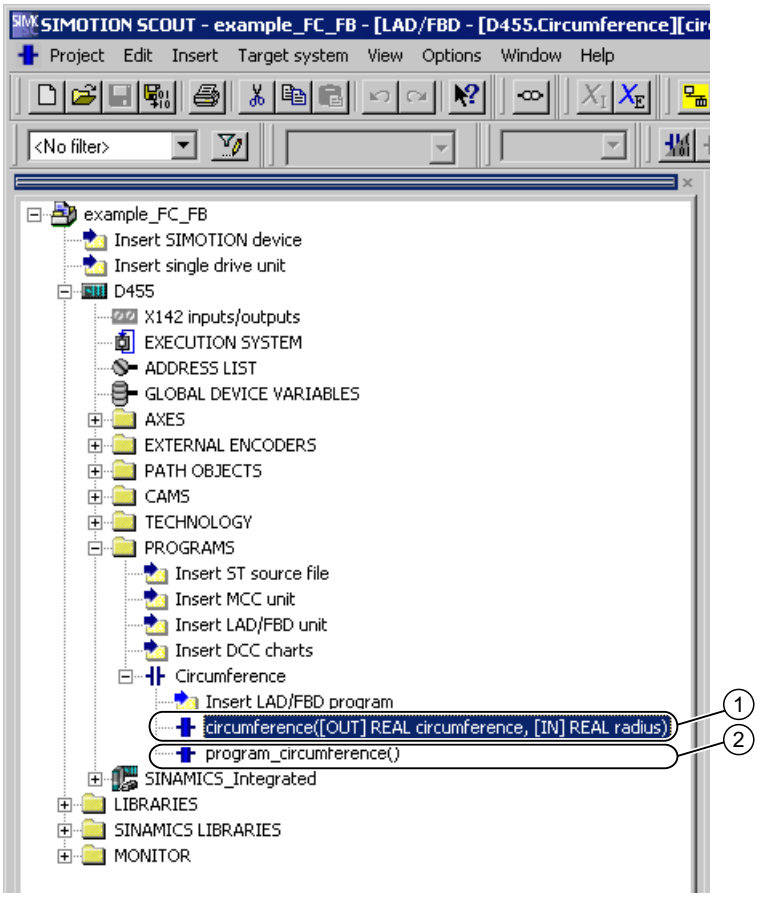
Note

Saving a project in a format older than Version V4.2 of SIMOTION SCOUT

Pay attention to the order of the LAD/FBD programs in the LAD/FBD unit (see figure below). A subroutine (function, function block, or program ("program in program")) must be defined before it is used. This is the case when the MCC chart of the subroutine appears in the project navigator above the chart in which it is used.

As far as the example described here is concerned, the LAD/FBD program with the function (FC) must appear in the project navigator above the LAD/FBD program containing the program with the subroutine call.

In other words, the **circumference** function must be positioned above the **program_circumference** program in the project navigator. If necessary, reorder the LAD/FBD programs by selecting the relevant LAD/FBD program in the project navigator, then selecting the **Down** or **Up** command in the context menu.



① **Circumference** function

② **Program_circumference** program, which contains the subroutine call of the **Circumference** function

Order of LAD/FBD programs

4.18.3.3 Opening the function (FC) directly from the subroutine call

You can open subprograms directly from their respective subprogram call by using the context menu:

- This works regardless of the programming language (ST, MCC, LAD/FBD) used to create the subprogram.
- The subprogram opens in a separate editor or an editor already opened for the subprogram is moved to the foreground.

A subprogram may be a:

- User-defined function (FC)
- User-defined function block (FB)
- User-defined program called as a subprogram ("program in program")
- Library function
- Library function block
- Library program called as a subprogram ("program in program")

Procedure

To open the FC directly from the subprogram call, proceed as follows:

1. In the LAD/FBD network, select the subprogram call used to call the FC.
2. Select the **Open called block** command in the context menu (Ctrl+Alt+O shortcut).

The FC opens in a separate editor or an editor already opened for the FC is moved to the foreground.

Note

If the called FC has not yet been created, the **Open called block** command appears inactive (grayed out) in the context menu.

Note

If the called FC is in a program source with know-how protection, the same steps that apply when opening the protected program source directly also apply here (see Know-how protection for LAD/FBD units (Page 48)).

4.18.4 Example: Function block (FB)

You want to calculate a following error. The calculation is performed in a function block (FB) named **FollError**. The following error calculation can thus be called as a subroutine by any task.

Formula for following error calculation: Difference = Specified position – Actual position

Define the required input and output parameters Set position, Actual position, and Difference (with the other variables, if necessary) in the LAD/FBD program (function block) or LAD/FBD unit.

4.18.4.1 Creating and programming the function block (FB)

1. In the project navigator, open the LAD/FBD unit in which you want to create the function block.
2. Double-click the entry **Insert LAD/FBD program**.
   - Enter the name **FollError**.
   - For creation type, select **Function block**.
   - Confirm with **OK**.
3. In the declaration table, define the variables (e.g. input and output parameters).

	Name	Variable type	Data type	Array length	Initial value	Comment
1	Setpoint_position	VAR_INPUT	LREAL			
2	Actual_position	VAR_INPUT	LREAL			
3	Difference	VAR_OUTPUT	LREAL			
4						

Figure 4-45 Declaring variables (e.g. input and output parameters) in the LAD/FBD program

4. Click the **Insert network** button on the LAD editor toolbar.
   A network is inserted into the **FollError** function block.
5. Drag the LAD/FBD element **SUB** from the command library and drop it into the network of the **FollError** function block.
6. Program the following error calculation by assigning the variables accordingly to the input/ output parameters of the **SUB** LAD/FBD element.

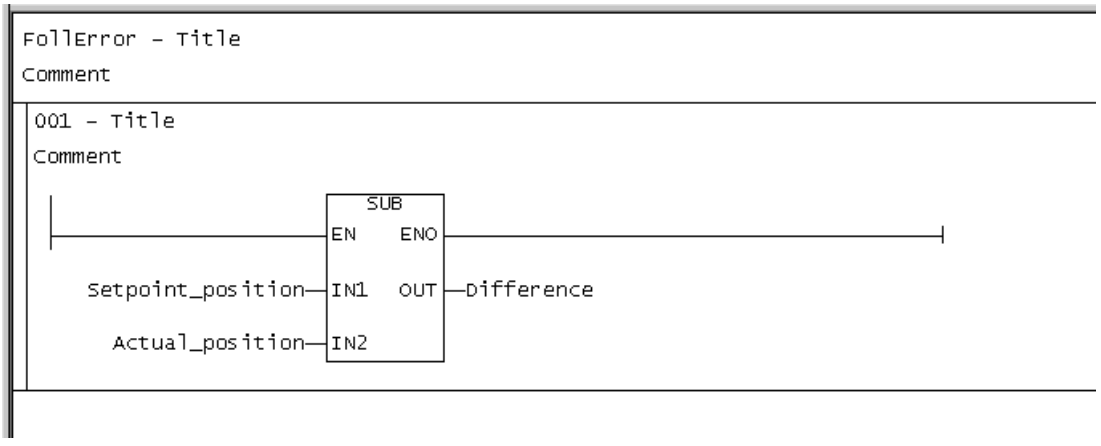


Figure 4-46 Programming the following error calculation

7. Accept and compile the LAD/FBD unit.

You have now finished programming the **FollError** function block.

Note

The term "LAD/FBD program" is a generic term and may refer to a program, a function (FC), or a function block (FB).

4.18.4.2 Subroutine call of function block (FB)

In this example, the function block (FB) is called from a program.

1. Create an LAD/FBD program as a program (see Inserting a new LAD/FBD program (Page 59)).
2. Create a function block instance.
   - In the LAD/FBD unit or LAD/FBD program, declare the instances of the function block along with the variables.

   Note that the validity range of the instance and variables is dependent on the declaration location (see Define variables (Page 112)).
3. Call the function block:
   - Program the subroutine call.
4. After executing an instance of the function block, you can access the output parameters at any location in the calling program.
   - Program the **MOVE** command.
5. Accept and compile the program.

You have now finished programming the subroutine call.

4.18.4.3 Creating a function block instance

Before you can use a function block, you must define an instance. Each instance of an FB is independent of the others; once an instance has ended, its static variables remain stored.

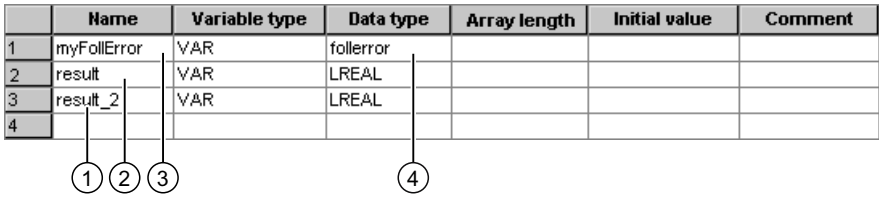
Instances of an FB are defined in the declaration tables of the LAD/FBD source or of the LAD/FBD program. The scope of the instance declaration is dependent on the location of the declaration:

- In the interface section of the declaration table of the LAD/FBD source:
  The instance behaves like a unit variable; it is valid for the entire LAD/FBD source; all LAD/FBD programs (programs, function blocks, and functions) within the LAD/FBD source can access the instance.
  The instance is also available:
  - On HMI devices
  - In other LAD/FBD source files (or other units) once connected, see “How to define connections to other units (program sources)” (Page 165).

  The total size of all unit variables in the interface section is limited to 64 Kbytes.
- In the implementation section of the declaration table of the LAD/FBD source:
  The instance behaves like a unit variable which is only valid in the LAD/FBD source; all LAD/FBD programs (programs, function blocks, and functions) within the LAD/FBD source can access the instance.
- In the declaration table of the LAD/FBD program (for programs and function blocks only):
  The instance behaves like a local variable; it can only be accessed within the LAD/FBD program in which it is declared.

Proceed as follows (the LAD/FBD source or the LAD/FBD program with the declaration table is open, see “Opening an existing LAD/FBD source” (Page 46) or “Opening an existing LAD/FBD program” (Page 61)):

1. Select the declaration table and, if applicable, the section of the declaration table for the desired scope.
2. Select the **Parameters** tab.
3. Enter or select the following:
   - **Name** of instance (variable name – see Rules for identifiers (Page 97))
   - **Variable type** VAR or VAR_GLOBAL, depending on the declaration location (in LAD/FBD program or LAD/FBD source respectively)
   - Designation of the function block as **data type**.
4. Declare the other variables.



	Name	Variable type	Data type	Array length	Initial value	Comment
1	myFollError	VAR	follerror			
2	result	VAR	LREAL			
3	result_2	VAR	LREAL			
4						

① The output parameter Difference is assigned to the variable Result_2 during subsequent program runtime. You can use the Result_2 variable for other purposes in the program.

② The output parameter Difference is assigned to the variable Result in the subroutine call. You can use the Result variable for other purposes in the program.

③ Creating an instance

④ Select the required FB as the data type.

The created function blocks are offered as data types in the drop-down list box depending on the LAD/FBD editor settings (Page 39):

- Only function blocks with the same program source or from connected program sources or libraries
- All function blocks defined in the project

Figure 4-47 Defining an instance of the function block and variables in the LAD/FBD program or the LAD/FBD unit

4.18.4.4 Programming the subroutine call of the function block

1. Drag the **FollError** function block from the project navigator and drop it into the network of the **program_FollError** LAD/FBD program.
2. Select the inserted function block, **FollError**, followed by the **Display > All Box Parameters** command from the context menu.
   All the input/output parameters of the inserted function block **FollError** are shown.

   Note

   Mandatory parameters are marked with "???" in the LAD/FBD network and optional parameters with "...". Function blocks (FBs) only have optional parameters.

3. Select the inserted function block, **FollError**, followed by the **Parameterize call** command from the context menu.

4. Assign parameters to the subroutine call in the **Enter Call Parameter** parameter screen form:
   – Enter the instance **myfollerror**, defined in the declaration table, in the **Instance** field.

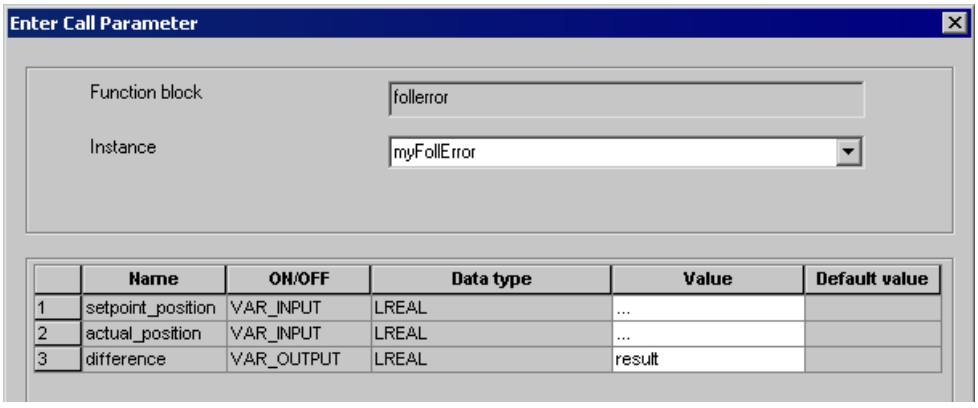


Figure 4-48 Opened parameter screen form for assigning parameters to the subroutine call

Note

Mandatory parameters are marked with "<???>" and optional parameters with "...". Function blocks (FBs) only have optional parameters.

Assign the current values to the transfer parameters:

– Input parameters: Variable or expression
– In/out parameter: Directly readable/writable variable
– Output parameter (optional): Variable
  In the example, for the **Difference** output parameter select the **Result** variable in the **Value** column.

You can use drag-and-drop to assign unit variables and system variables from the detail view to the input, output, or in/out parameters of the instance of the **FollError** function block inserted into the LAD/FBD network.

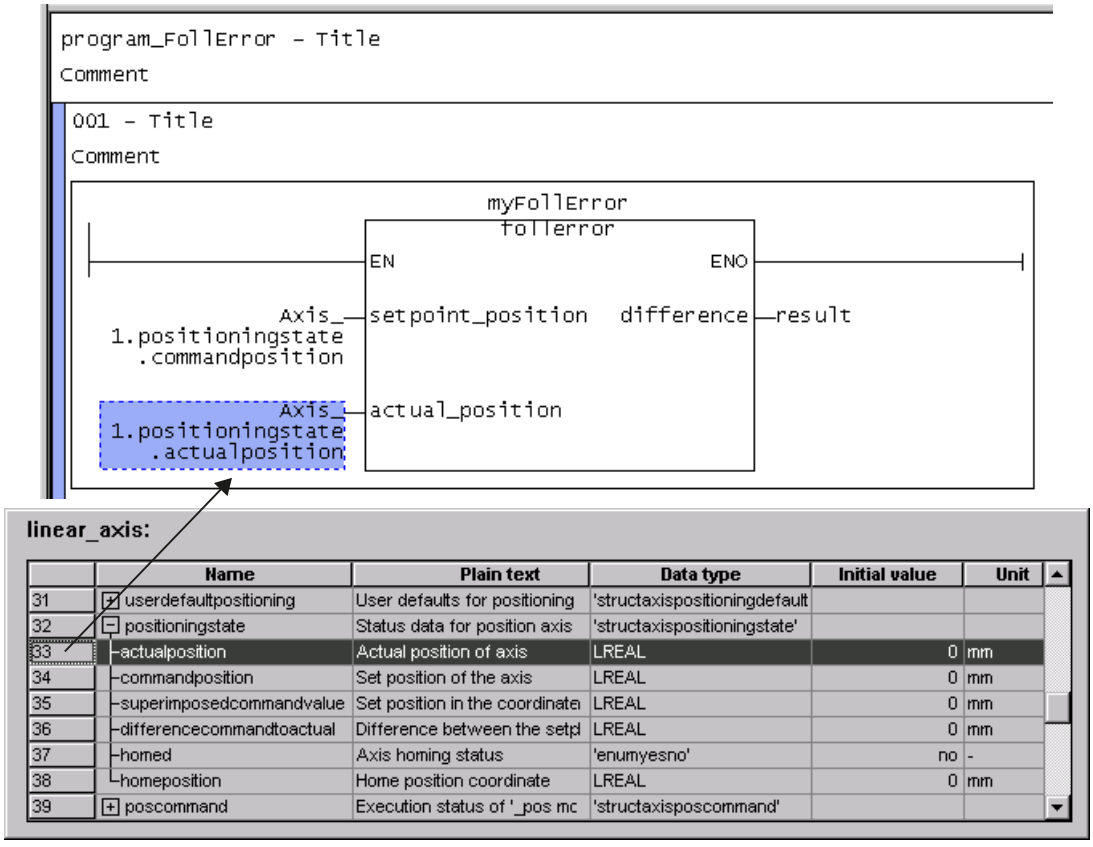


Figure 4-49 Assigning system variables from the detail view to the transfer parameters using drag-and-drop

5. Confirm with **OK**.

Note

The term "LAD/FBD program" is a generic term and may refer to a program, a function (FC), or a function block (FB).

Note

Saving a project in a format older than Version V4.2 of SIMOTION SCOUT

Pay attention to the order of the LAD/FBD programs in the LAD/FBD unit. A subroutine (function, function block, or program ("program in program")) must be defined before it is used. This is the case when the LAD/FBD program of the subroutine appears in the project navigator above the LAD/FBD program in which it is used.

As far as the example described here is concerned, the LAD/FBD program with the function block (FB) must appear in the project navigator above the LAD/FBD program containing the program with the subroutine call.

In other words, the **distance** function block must be positioned above the **program_distance** program in the project navigator. If necessary, reorder the LAD/FBD programs by selecting the relevant LAD/FBD program in the project navigator, then selecting the **Down** or **Up** command in the context menu.

See also: Subroutine call of the function (FC) (Page 176).

4.18.4.5 Opening the function block (FB) directly from the subroutine call

You can open subprograms directly from their respective subprogram call by using the context menu:

- This works regardless of the programming language (ST, MCC, LAD/FBD) used to create the subprogram.
- The subprogram opens in a separate editor or an editor already opened for the subprogram is moved to the foreground.

A subprogram may be a:

- User-defined function (FC)
- User-defined function block (FB)
- User-defined program called as a subprogram ("program in program")
- Library function
- Library function block
- Library program called as a subprogram ("program in program")

Procedure

To open the FB directly from the subprogram call, proceed as follows:

1. In the LAD/FBD network, select the subprogram call used to call the FB.
2. Select the **Open called block** command in the context menu (Ctrl+Alt+O shortcut).

The FB opens in a separate editor or an editor already opened for the FB is moved to the foreground.

Note

If the called FB has not yet been created, the **Open called block** command appears inactive (grayed out) in the context menu.

Note

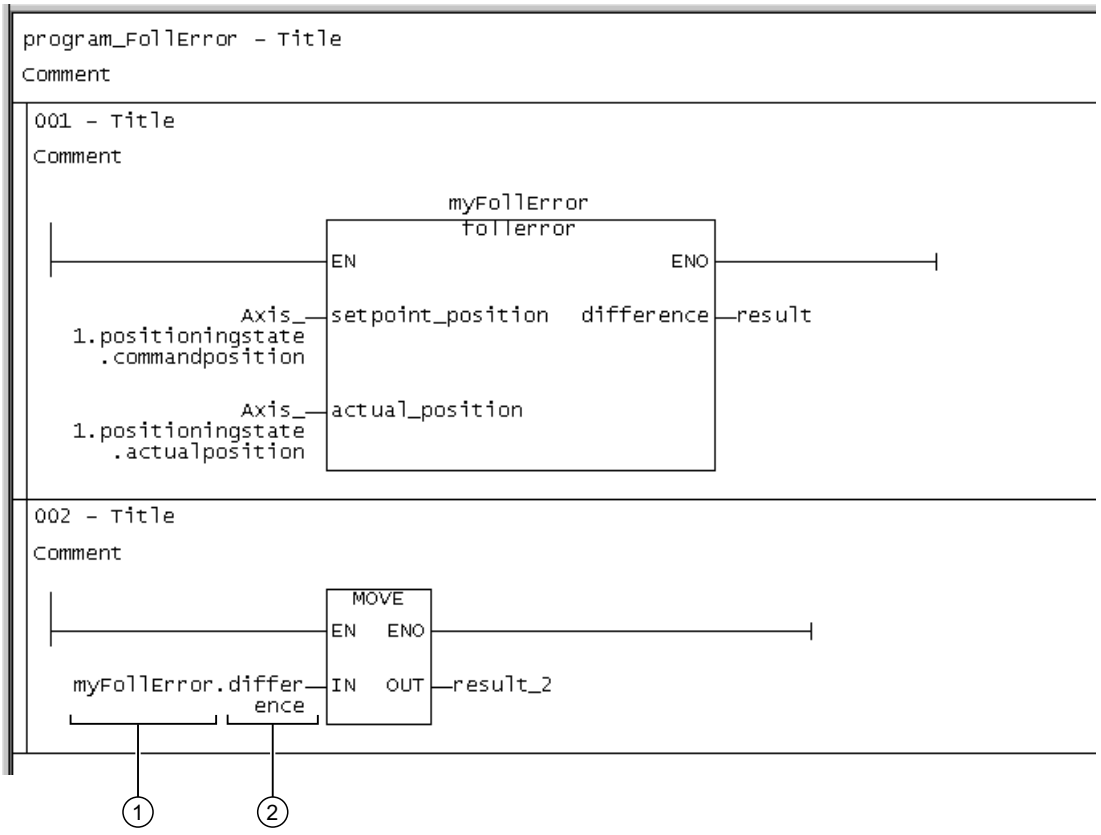
If the called FB is in a program source with know-how protection, the same steps that apply when opening the protected program source directly also apply here (see Know-how protection for LAD/FBD units (Page 48)).

4.18.4.6 Accessing the output parameters of the function block retrospectively

After an instance of the function block has been executed, the static variables of the function block (including the output parameters) are retained. You can access the output parameters at any point in the calling program.

If you have defined the FB instance as VAR_GLOBAL, you can also access the output parameter in other LAD/FBD programs.

1. Insert the **MOVE** command into the LAD/FBD program.
2. Program the command (see figure).



① Name of the FB instance ② Output parameter

Figure 4-50 Programming a variable assignment

4.18.5 Example: Method

4.18.5.1 Example: Methods

In LAD/FDB programs you can call up public methods which have been defined in ST source files within classes and function blocks.

You can use methods in function blocks irrespective of the SIMOTION Kernel version.

Methods in classes can only be used in SIMOTION Kernel as of version V4.5.

No classes or methods can be defined in the LAD/FBD programming language itself. The same applies to methods within function blocks.

Requirements

In an ST source file the COUNTER class is defined with both public methods UP and DOWN: Both methods increment or decrement an internal counter variable until either the maximum value or minimum value is reached.

- The UP method has the following interface:
  - Input parameter INC with data type INT and initial value 1.
    You enter the increment here (standard = 1).
  - Output parameter QU with data type BOOL and initial value FALSE.
    The maximum value is reached when QU = TRUE.
  - Return value with data type INT.
    The return value shows the latest status for the internal counter variables.
- The DOWN method has the following interface:
  - Input parameter DECC with data type INT and initial value 1.
    You enter the increment here (standard = 1).
  - Output parameter QU with data type BOOL and initial value TRUE.
    The minimum value is reached when QU = FALSE.
  - Return value with data type INT.
    The return value shows the latest status for the internal counter variables.

The maximum value and minimum value for the counting range are stipulated in the private variables MAX_Val and MIN_Val for the class. They are pre-assigned with 100 or 0 respectively as standard. However, the initial values can be overwritten with the declaration of an instance for this class.

4.18.5.2 Subprogram call of the method

The method is called from a program in the example.

1. Generate an LAD/FBD program as a program (see Inserting a new LAD/FBD program).
2. Create an instance for the higher-level class.
   - In the LAD/FBD source or LAD/FBD program, declare the instances of the class along with the variables.

   Note that the validity range of the instance and variables is dependent on the declaration location (see Define variables).
3. Call the method:
   - Program the **Subroutine call** command.
4. Accept and compile the program.

You have now finished programming the subroutine call.

4.18.5.3 Creating an instance for the class or the function block

Before you can use a method, you must define an instance for the higher-level class or the higher-level function block. Each instance of a class or FB is independent of the others; once an instance has ended, its static variables remain stored.

Instances of a class or of an FB are defined in the declaration tables of the LAD/FBD source or of the LAD/FBD program. The scope of the instance declaration is dependent on the location of the declaration:

- In the interface section of the declaration table of the LAD/FBD source:
  The instance behaves like a unit variable; it is valid for the entire LAD/FBD source; all LAD/FBD programs (programs, function blocks, and functions) within the LAD/FBD source can access the instance.
  The instance is also available:
  - On HMI devices.
  - In other LAD/FBD source files (or other units) once connected, see “How to define connections to other units (program sources)” (Page 165).

  The total size of all unit variables in the interface section is limited to 64 Kbytes.
- In the implementation section of the declaration table of the LAD/FBD source:
  The instance behaves like a unit variable which is only valid in the LAD/FBD source; all LAD/FBD programs (programs, function blocks, and functions) within the LAD/FBD source can access the instance.
- In the declaration table of the LAD/FBD program (for programs and function blocks only):
  The instance behaves like a local variable; it can only be accessed within the MCC chart in which it is declared.

Proceed as follows (the LAD/FBD source or the LAD/FBD program with the declaration table is open, see “Opening an existing LAD/FBD source” (Page 46) or “Opening an existing LAD/FBD program” (Page 61)):

1. Select the declaration table and, if applicable, the section of the declaration table for the desired scope.
2. Select the **Parameters** tab.
3. Enter or select the following:
   - **Name** of instance (variable name – see Rules for identifiers (Page 97))
   - **Variable type** VAR or VAR_GLOBAL, depending on the declaration location (in LAD/FBD program or LAD/FBD source respectively)
   - Designation of the function block as **data type**.
4. Declare the other variables.

4.18.5.4 Programming the subprogram call of the method

1. From the project navigator drag the **UP** method from the **COUNTER** class to the network for the LAD/FBD program **KOP/FUP_1**.
2. Select the **counter.up** method inserted and select the **Display > All box parameters** command from the shortcut menu.
   All input/output parameters for the **UP** method inserted are displayed.

Note

Mandatory parameters are marked with "???” in the LAD/FBD network and optional parameters with "...".

3. Select the inserted **counter.up** method followed by the **Assign parameters to a call** command from the shortcut menu.
4. Assign parameters to the subroutine call in the **Enter Call Parameter** parameter screen form:
   - Enter the instance **C1** defined in the declaration table in the **Instance** field.
   - Select the **CountOut** variable in the return value field defined in the declaration table.

   Note

   Mandatory parameters are marked with "<???>" and optional parameters with "...".

5. Assign the current values to the transfer parameters:
   - Input parameters: Variable or expression
   - In/out parameter: Directly readable/writable variable
   - Output parameter (optional): Variable
     In the example for the output parameters **QU** in the **Value** column select the variable **UpValReached**.

   You can use drag-and-drop to assign unit variables and system variables from the detail view to the input, output, or in/out parameters of the instance of the **counter.up** method inserted into the LAD/FBD network.
6. Confirm with **OK**.

Note

The term "LAD/FBD program" is a generic term and may refer to a program, a function (FC), or a function block (FB).

Note

Saving a project in a format older than Version V4.5 of SIMOTION SCOUT

Projects which include classes and methods cannot be saved in a format older than Version V4.5 of SIMOTION SCOUT.

4.18.5.5 Opening the method directly from the subprogram call

You can open subprograms directly from their respective subprogram call by using the context menu:

- This works regardless of the programming language (ST, MCC, LAD/FBD) used to create the subprogram.
- The subprogram opens in a separate editor or an editor already opened for the subprogram is moved to the foreground.

A subprogram may be a:

- User-defined function (FC)
- User-defined function block (FB)

- User-defined program called as a subprogram ("program in program")
- Library function
- Library function block
- Library program called as a subprogram ("program in program")

Procedure

To open the method directly from the subprogram call, proceed as follows:

1. In the LAD/FBD network, select the subprogram call used to call the method.
2. Select the **Open called block** command in the context menu (Ctrl+Alt+O shortcut).

The method opens in the ST editor or the ST editor opened for the method is placed in the foreground.

Note

If the called method is in a program source with know-how protection, the same steps that apply when opening the protected program source directly also apply here, see Know-how protection for LAD/FBD sources (Page 48).

4.18.6 Limitations with advance signal switching

An output from an LAD/FBD element can only be connected in advance of an LAP/FBD element input if both the input and output are of data type BOOL. As a result, only Boolean advance signal switching is possible in a network.

An output parameter from an FB or a return value from an FC cannot be switched to an input parameter of a different FB/FC, i.e. Boolean advance signal switching is not possible here either.

Non-Boolean advance signal switching and output/input parameter switching with the FB/FC can be implemented with the aid of an additional network and a temporary variable. If the output from an LAD/FBD element cannot be assigned directly to the input of the other LAD/FBD element, then the former LAD/FBD element is added to this additional network. The same temporary variable is assigned to both output and input, and so the output and input are switched via the temporary variable.

Alternatively, this can also be implemented with just one network and a temporary variable, with the result that both LAD/FBD elements are in the same network.

Example of output/input parameter switching with FB/FC

In the ST programming language, with TO commands from the commands library the "commandid" input parameter can be assigned directly with the *_getcommandid* function.

This output/input parameter switch with FB/FC can be implemented in the LAD/FBD programming language with an additional network for the *_getcommandid* function and a temporary variable.

The *_getcommandid* function is added to the upper network, and the temporary variable "var_commandid" is assigned to its output "OUT". The TO command *_pos* is added to the lower network, and the temporary variable "var_commandid" is likewise assigned to its input "commandid". The switching of the output "OUT" of *_getcommandid* and of the input "commandid" of *_pos* is thus effected using the temporary variable.

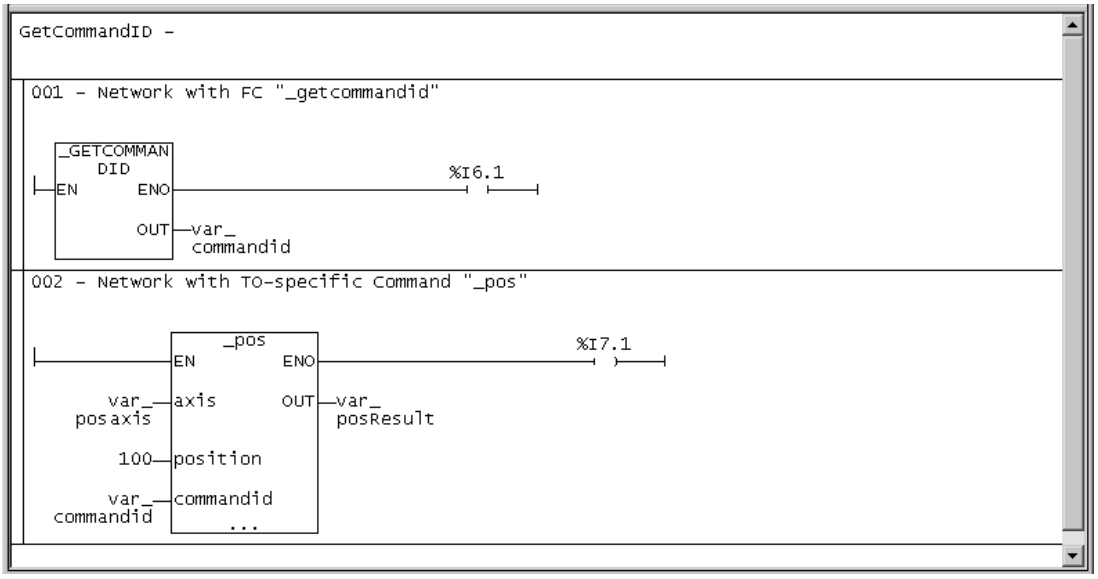


Figure 4-51 Output/input parameter switching with FB/FC

4.18.7 Interface adjustment with FB/FC

If the properties of an FB/FC that has been added to the network are modified, then in the following cases there will be an interface adjustment:

1. One or more new input/output parameters are added
2. One or more unused input/output parameters are deleted
3. One or more used input/output parameters are deleted

In cases 1 and 2 the network is updated immediately when it is opened in the LAD/FBD editor, or immediately after it is opened.

In case 3 the FB/FC call is shown in red in the network, and a manual update must be carried out. An existing Boolean advance switching of a deleted input parameter is not deleted; instead it is merely separated off and, for instance, shown in the LAD display as an as an open ladder diagram in the network.

Manual update of a specific FB/FC call

To manually update a particular FB/FC call, follow these steps:

1. Click on the desired FB/FC call.
2. Select the **Update call** command in the context menu.
   The FB/FC call is shown with the input/output parameters which are currently present, i.e. without the deleted input/output parameters.

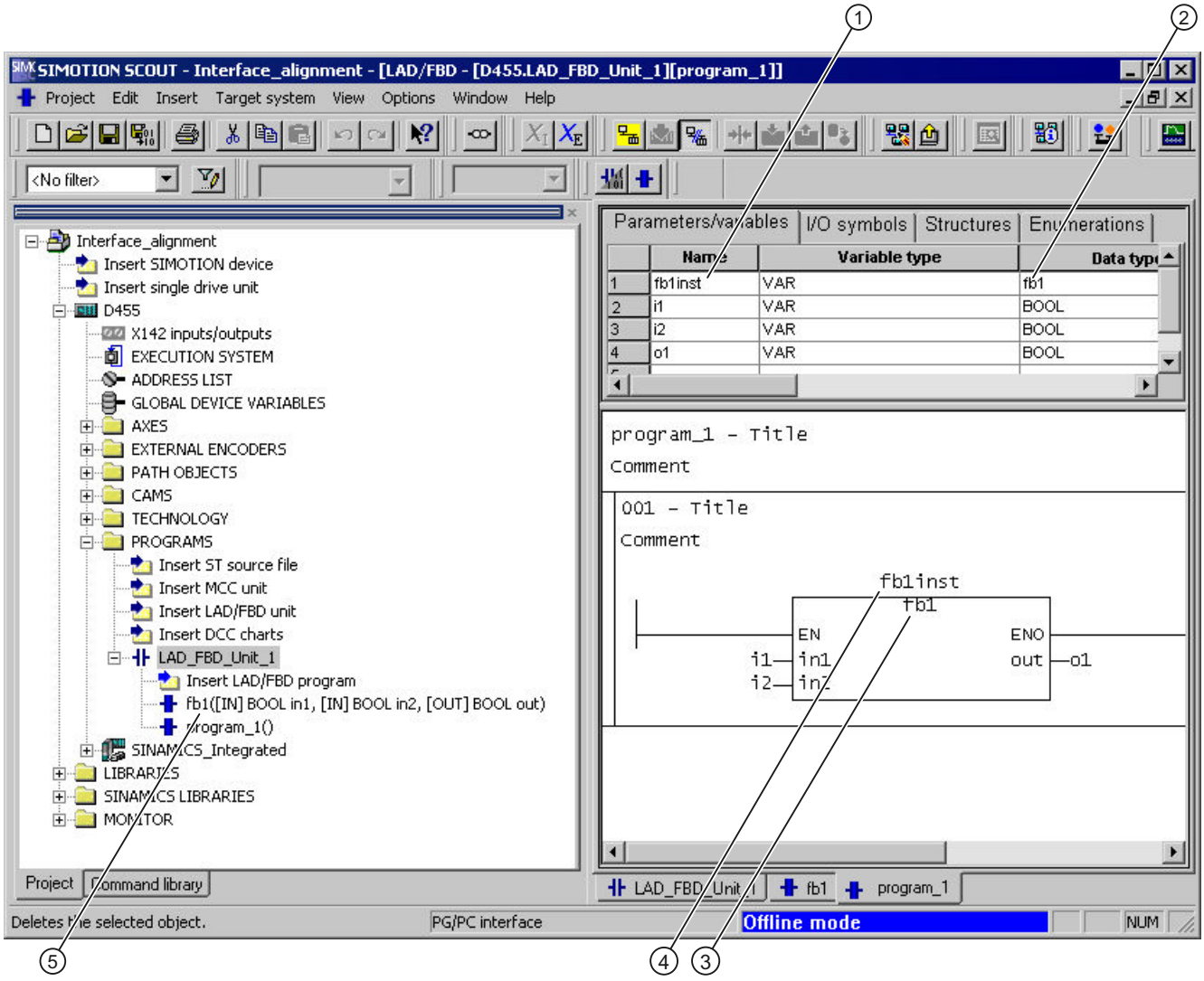
Manually updating all FB/FC calls

To manually update all the FB/FC calls for the program organization unit (POU) currently displayed in the working area, follow these steps:

1. Click on an empty position in the network.
2. Select the **Update all calls for all networks** command in the context menu.
   The FB/FC calls are shown with the input/output parameters which are currently present, i.e. without the deleted input/output parameters.

For the following cases there is no interface adjustment available, and so updating must be performed by entering data manually or with Find/Replace (Page 205):

- Changing the name of the instance variable (only for FBs)
- Changing the name, the data type of the box type of the FB/FC call



① Instance variable (instance name)
Only used with FBs.
In the declaration table an FB instance is declared by specifying the instance variable with the name of the FB as the data type. This instance variable (instance name) is used for calling up the FB.

② Data type
The relevant FB is assigned to the instance variable as its data type.
In order for an FB call to work correctly, the data type and box type must be identical, otherwise the FB call will be displayed in red in the network.

③ Box type, consisting of:

- The type name, e.g. MOVE, ADD etc. or the names of user programs/FBs/FCs
- The type, i.e. the selected creation type (program, FB or FC) of the LAD/FBD program

④ Instance variable (instance name)
Only for FBs.

⑤ Name of the FB/FC (type of a (user-defined) FB/FC)
FB: The name of the FB is used as the data type in the FB instance declaration in the declaration table.
FC: The name of the FC is used as the box type.

Figure 4-52 Overview of FB/FC terms used

Display in the Detail view

Only in case 3 are the deleted input/output parameters and the deleted variables assigned to them displayed in the Detail view in the **Compile/check output** window immediately after a manual update. Deleted input parameters with Boolean advance switching are not displayed because the advance switching is merely separated off and therefore continues to exist in the network.

4.19 Reference data

The reference data provide you with an overview of:

- on utilized identifiers with information about their declaration and use (Cross-reference list (Page 197)).
- on function calls and their nesting (Program structure (Page 201))
- on the memory requirement for various data areas of the program sources (Code attributes (Page 203))

4.19.1 Cross reference list

The cross-reference list shows all identifiers in program sources (e.g. ST source files, MCC units):

- Declared as variables, data types, or program organization units (program, function, function block)
- Used as previously defined types in declarations
- Used as variables in the statement section of a program organization unit.

4.19.1.1 Generating and updating a cross-reference list

Initially, the cross-reference list is generated automatically when opening. Open a cross-reference list, e.g. after selecting an ST source file or library via the **Edit > Display reference data > Cross-references** menu. After changes, the update is partly performed automatically and can always be triggered manually in the detail view via the  button. When updating via the button, a check is performed as to whether a compilation is required. If a compilation is required, this is indicated by a yellow triangle next to the button.

Update of the cross-reference list when selecting a program

The list is updated automatically when opening the selected program. The local defined identifiers are therefore up-to-date.

External identifiers in the program are not updated when opening.

The opened cross-reference list is also updated automatically when compiling the program.

Update of the cross-reference list when selecting a tree (CPU, project, library, program folder)

The cross-reference list is generated automatically when opening the first time. There is no automatic update when opened again.

Note

An error-free compilation is required for a correct, consistent display of the reference data. If required, compile the project, the CPU, the program or the library first.

4.19.1.2 Content of the cross-reference list

The cross-reference list contains all the identifiers assigned to the element selected in the project navigator. The applications for the identifiers are also listed in a table:

Details of how to work with the cross-reference list are provided in the section titled "Working with the cross-reference list (Page 200)".

Table 4-34 Meanings of columns and selected entries in the cross-reference list

Column	Entry in column	Meaning
Name		Identifier name
Type		Identifier type
	Name	• Data type of a variable (e.g. REAL, INT) • POU type (e.g. PROGRAM, FUNCTION)
	DERIVED	Derived data type
	DERIVED ANY_OBJECT	TO data type
	ARRAY …	ARRAY data type
	ENUM …	Enumerator data type
	STRUCT …	STRUCT data type
Declaration		Location of declaration
	Name (UNIT)	Declaration in the program source *name*
	Name (LIB)	Declaration in the library *name*
	Name (TO)	System variable of the technology object *name*
	Name (TP)	Declaration in the default library specified: • Technology package *name* • std_fct = IEC library • device = device-specific library
	Name (DV)	Declaration on the SIMOTION device *name* (e.g. I/O variable or global device variable)
	_project	Declaration in the project (e.g. technology object)
	_device	Internal variable on the SIMOTION device (e.g. TaskStartInfo)
	_task	Task in the execution system
Use		Use of identifier
	CALL	Call as subprogram (static binding)

Column	Entry in column	Meaning
	CALL VTAB	Call of a method of the dynamic binding
	ENUM *name*	As element when declaring the enumerator data type *name*
	I/O	Declaration as I/O variable
	R	Read access
	R (TYPE)	As data type in a declaration
	R/W	Read and write access
	STRUCT *name*	As component when declaring the structure *name*
	TYPE	Declaration as data type or POU
	Variable type (e.g. VAR, VAR_GLOBAL)	Declaration as variable of the variable type specified
	W	Write access
Path specification		Path specification for the SIMOTION device or program source
	Name	SIMOTION device *name*
	Name1|*Name2*	• Program source *name2* on SIMOTION device *name1* • Program source *name2* in library *name1*
	Name/taskbind.hid	Execution system of the SIMOTION device *name*
Range		Range within the SIMOTION device or program source
	INTERFACE	Interface section of the program source
	POE type name (i.e. CLASS *name*, FUNCTION *name*, FUNCTION_BLOCK *name* INTERFACE *name* PROGRAM *name*)	Program Organization Unit (POU) *Name* within the program source. • In an MCC chart: Additional serial numbers for the command (block numbers) • In a LAD/FBD program: Additional serial numbers of the network
	I/O address	I/O variable
	METHOD *Name_1*::*Name_2*	Method *Name_2* within the class or the function block *Name_1*
	TASK *name*	Assignment for the task *name*
	UNIT	Implementation section of the program source, additional specification as POU to be made public in the interface section of the program source
	UNIT - IMPLEMENTATION	Implementation section of the program source
	_device	Global device variable
Language		Programming language of the program source
Line/Block		• In an ST source: Line number within the program source • In an MCC or LAD/FBD source: Relative line number within the command (block) or network. **Note** The absolute line number within the program source, which you need, for example, for the trace function "Trigger to code point", is obtained as follows: – Press the **Determine program line** button. – In the dialog box, press the button **Copy program line to the clipboard**.

Note

Single-step tracking and trace diagnostic functions in MCC programming

Additional variables and functions are created or used for these diagnostics functions:

- The variables TSI#dwuser_1 and TSI#dwuser_2 of the TaskStartInfo are used for the single-step tracking diagnostic function.
- Various internal functions and variables, whose identifier begins with an underscore, are automatically created by the compiler for the trace diagnostic function. The TSI#currentTaskId variable of the TaskStartInfo is also used.

With activated diagnostic function, these variables and functions are used for the control of the diagnostics function. These variables and functions must not be used in the user program.

4.19.1.3 Working with a cross-reference list

In the cross-reference list you are able to:

- Sort the column contents alphabetically:
  - To do this, click the header of the appropriate column.
- Search for an identifier or entry:
  - Click the "Search" button and enter the search term.
- Filter (Page 200) the identifiers and entries displayed.
- Copy contents to the clipboard in order to paste them into a spreadsheet program, for example.
  - Select the appropriate lines and columns.
  - Press the CTRL+C shortcut.
- Print the content (**Project > Print**).
- Open the referenced program source and position the cursor on the relevant line of the ST source file (or MCC command or LAD/FBD element):
  - Double-click on the corresponding line in the cross-reference list.
    or
  - Place the cursor in the corresponding line of the cross-reference list and click the "Go to application" button.

Further details about working with cross-reference lists can be found in the online help.

4.19.1.4 Filtering the cross-reference list

You can filter the entries in the cross-reference list so that only relevant entries are displayed:

1. Click the "Filter settings" button.
   The "Filter Setting for Cross References" window will appear.
2. Activate the "Filter active" checkbox.

3. If you also want to display system variables and system functions:
   – Deactivate the "Display user-defined variables only" checkbox.
4. Set the desired filter criterion for the relevant columns:
   – Select the relevant entry from the drop-down list box or enter the criterion.
   – If you want to search for a character string within an entry: Deactivate the "Whole words only" checkbox.
5. Confirm with **OK**.

The contents of the cross-reference list will reflect the filter settings selected.

Note

A filter is automatically activated after the cross-reference list has been created.

4.19.2 Program structure

The program structure contains all the function calls and their nesting within a selected element.

You can display the program structure selectively for:

- An individual program source (e.g. ST source file, MCC unit, LAD/FBD source file)
- All program sources of a SIMOTION device
- All program sources and libraries of the project
- Libraries (all libraries, single library, individual program source within a library)

Proceed as follows:

1. In the project navigator, select the element for which you want to display the program structure.
2. Select the **Edit > Display reference data > Program structure** menu command.
   The cross-reference tab is replaced by the program structure tab in the detail view.

Note

The display data is updated every time the program structure is opened.

You can update the detail view of an opened program structure with the F5 key.

4.19.2.1 Content of the program structure

A tree structure appears, showing:

- as base respectively
  - the program organization units (programs, functions, function blocks) declared in the program source, or
  - the execution system tasks used
- below these, the subroutines referenced in this program organization unit or task.

For structure of the entries, see table:

Table 4-35 Elements of the display for the program structure

Element	Description
Base (declared POU or task used))	List separated by a comma • Identifier of the program organization unit (POU) or task The specification *Name_1::Name_2* means: Method *Name_2* within the class or the function block *Name_1*. • Identifier of the program source in which the POU or task was declared, with add-on [UNIT] • Minimum and maximum stack requirement (memory requirement of the POU or task on the local data stack), in bytes [Min, Max] • Minimum and maximum overall stack requirement (memory requirement of the POU or task on the local data stack including all called POUs), in bytes [Min, Max]
Referenced POU	List separated by a comma: • Identifier of called POU The specification *Name_1::Name_2* means: Method *Name_2* within the class or the function block *Name_1*. • Optionally: Identifier of the program source / technology package in which the POU was declared: Add-on (UNIT): User-defined program source Add-on (LIB): Library Add-on (TP): System function from technology package • with function blocks or methods only: Identifier of the instance of the function block or the higher-level class • with function blocks or methods only: Identifier of program source in which the instance of the function block or of the higher-level class was declared: Add-on (UNIT): User-defined program source Add-on (LIB): Library • Number of the line in the (compiled) source in which the POE is called; several line numbers are separated by “/".

4.19.3 Code attributes

You can find information on or the memory requirement of various data areas of the program sources under code attribute.

You can display the code attributes selectively for:

- An individual program source (e.g. ST source file, MCC unit, LAD/FBD source file)
- All program sources of a SIMOTION device
- All program sources and libraries of the project
- Libraries (all libraries, single library, individual program source within a library)

Proceed as follows:

1. In the project navigator, select the element for which you want to display the code attributes.
2. Select the **Edit > Display reference data > Code attributes** menu command.
   The **Cross-references** tab is now replaced by the **Code attributes** tab in the detail view.

Note

The display data is updated every time the code attributes are opened.

You can update the detail view of the opened code attributes with the F5 key.

4.19.3.1 Code attribute contents

The following are displayed in a table for all selected program sources:

- Identifier of program source,
- Memory requirement, in bytes, for the following data areas of the program source:
  - **Dynamic data**: All unit variables (retentive and non-retentive, in the interface and implementation sections),
  - **Retain data**: Retentive unit variables in the interface and implementation section,
  - **Interface data**: Unit variables (retentive and non-retentive) in the interface section,
- the **Code size** during the last compilation in bytes,
- the **Number of referenced sources**:
  The maximum number of connected sources is displayed (including system libraries), regardless of whether they are downloaded to the target system at a later date.

4.19.4 Reference to variables

If you have selected the identifier of a variable in the open Editor window for each programming language, you can use the other places of use over the context menu to list or to skip these variables.

You select the identifier of a variable:

- In SIMOTION ST: In the Editor window of an ST source.
- In SIMOTION MCC: In the input field on the parameter screen of an open MCC command within an MCC chart
- In SIMOTION LAD/FBD: In the Editor window of a LAD/FBD program

An identifier is recognized as a variable under the following conditions:

1. The identifier is declared as a variable. The scope of the variable includes the respective window (ST source, MCC chart, LAD/FBD program).
2. The program source is compiled.
3. The variable is selected as follows (in an open parameter screen within an MCC chart):
   - The identifier is fully marked
     or
   - The cursor is within the identifier.

Note

In arrays and structures, only the variable can be selected, not a single element.

Using the **Go to** context menu, you have the following options:

- To jump to the next local place of use:
  Select the context menu **Go to > Local use >>**.
  The next place of use of the variables within the same Editor window (ST source, MCC chart, LAD/FBD program) is selected. In an MCC chart, the corresponding MCC command opens.
- Jump to the previous local place of use:
  Select the context menu **Go to > Local use <<**.
  The previous place of use of the variables within the same Editor window (ST source, MCC chart, LAD/FBD program) is selected. In an MCC chart, the corresponding MCC command opens.
- Jump to the declaration position:
  Select the context menu **Go to > Declaration position**.
  The declaration position of the variables is selected. The corresponding program source is opened, if necessary.
- List all places of use
  Select the context menu **Go to > Places of use ...**.
  In the detailed view, all places of use of the variables within their scope (including the declaration position) are listed The structure of this list is similar to the List of cross references (Page 198).
  This is how you jump to a preferred place of use:
  - Double-click on the corresponding line.
    or
  - Place the cursor in the corresponding line and click the "Go to application" button.

4.20 Find and replace

The following options are available when searching for a given piece of text or for variables only:

- Find or find and replace in the entire project (project-wide search).
  This is described in detail in the Online help.

  Note

  Following a find and replace operation in the whole project, it may be necessary to compile the project, so as to update all symbol information.

- Find or find and replace in a certain program source or their subprograms (local search).
  The following is described in this manual:
  - Finding in an LAD/FBD unit or an LAD/FBD program (Page 205)
  - Finding and replacing in an LAD/FBD unit or an LAD/FBD program (Page 206)

  See the respective manuals for a description of the local search in the other programming languages.

4.20.1 Find in LAD/FBD unit or LAD/FBD program

Range of the local search

With local searching, only the contents of the window (LAD/FBD unit or LAD/FBD program) in which the local search was triggered are searched.

- The following are searched in an LAD/FBD unit:
  - All tabs of the declaration table (INTERFACE and IMPLEMENTATION)

  The assigned LAD/FBD programs are **not** searched.
- The following are searched in an LAD/FBD program:
  - All tabs of the declaration table
  - Program title and comment
  - All networks (title, comment, LAD/FBD elements with parameter labelling)

The dialog box open during the local search is assigned to the respective window and is hidden when changing to another window and displayed again when returning.

Procedure

If you want to conduct local searching for arbitrary text in an LAD/FBD unit or LAD/FBD program, proceed as follows:

1. Open the desired LAD/FBD unit (Page 46) or the LAD/FBD program (Page 61).
2. In the menu, select **Edit > Find** (shortcut Ctrl+F).
   The **Find** dialog box opens.
   A character string selected in the LAD/FBD editor is automatically taken as a search term.

3. Enter the required search term in the **Find** input field.
   Wildcards such as "*" or "?" are not permitted.
4. If required, select a search option as well as the search direction (**Up**/**Down**).
   - If you activate the **Whole words only** checkbox, only a whole word is searched for.
   - If you activate the **Match case** checkbox, the search takes upper- and lower-case into account.
   - If you activate the **Variables only** checkbox, the search is performed only in fields that contain identifiers of variables.
5. Click the **Find next** button (shortcut F3).
   The search is started in the selected direction. The first matching text pattern is highlighted.
6. Click the **Find next** button again to display the next matching text pattern.

Note

You can also continue searching with F3 even when the dialog box is closed.

Displaying search results

- The relevant tab is automatically activated in a declaration table and the found search term is highlighted.
- The found search term is highlighted in the LAD/FBD program.

The respective editor window can also be edited when the dialog box is open.

4.20.2 Find and replace in LAD/FBD unit or LAD/FBD program

The process of finding and replacing on a local basis works like local finding (Page 205), but also makes it possible to specify an expression to replace a search term once found.

Procedure

If you want to conduct local searching for arbitrary text in an LAD/FBD unit or LAD/FBD program, proceed as follows:

1. Open the desired LAD/FBD unit (Page 46) or the LAD/FBD program (Page 61).
2. In the menu, select **Edit > Replace** (shortcut Ctrl+H).
   The **Replace** dialog box opens.
   A character string selected in the LAD/FBD editor is automatically taken as a search term.
3. Enter the required search term in the **Find** input field.
   Wildcards such as "*" or "?" are not permitted.

4. If required, select a search option.
   - If you activate the **Whole words only** checkbox, the search looks for a whole word.
   - If you activate the **Match case** checkbox, the search takes upper- and lower-case into account.
   - If you activate the **Variables only** checkbox, the search is performed only in fields that contain identifiers of variables.
5. Enter the expression that should replace the search term in the **Replace with** input field.
6. Click the **Find next** button (shortcut F3).
   The search begins in the **Down** direction and the first matching text pattern is highlighted. The **Replace** button also becomes active if a replacement is permitted at this position, see Rules for replacing.
   - If you want to replace the search term found, click the **Replace** button.
     The search term found, now selected and displayed, is replaced and the next length of text to match the criteria is displayed.
   - If you do not want to replace the search term found, click the **Find next** button.
     The next length of text to match the criteria is displayed.

Rules for replacing

When replacing, a check is made as to whether the resulting term after replacement is permitted in principle at this position, for example:

- For identifiers of variables and data types, a check is made as to whether the Rules for identifiers (Page 97) have been observed.
- For selection fields (combo boxes), a check is made whether the resulting term is available as a selection option. Some examples are shown below:
  - In the declaration table of an LAD/FBD unit, VAR_GLOBAL cannot be replaced by VAR or VAR_TEMP.
  - The LAD/FBD element ADD can be replaced by other mathematical functions, but not, for example, by MAX or a comparison operator.
  - A comparison operator can only be replaced by another comparison operator, but not, for example, by a mathematical or logical function.
- Generally, the following cannot be replaced:
  - Wildcards, such as "..." or "???"
  - The elements listed in the command library under "LAD elements" and "FBD elements".

Note

If an item cannot be replaced at a particular position, the **Replace** button appears inactive (grayed out).

Further checks are not made, for example

- Whether variables or data types have already been defined.
- Whether there are further dependencies between fields and will be violated by the replacement.

In declaration tables, some columns are generally blocked for replacing, for example:

- The **Absolute identifier** column in the **I/O symbols** tab
- The **Type** column in the **Connections** tab

4.21 Execution order

4.21.1 Non-optimized execution order

Requirements

The non-optimized execution order is active for LAD networks by default. In the "Global settings of the compiler" (Page 53), the **Optimize execution order (LAD/FBD)** checkbox is inactive.

Calculation of the non-optimized execution order

The LAD network is calculated in the following order:

1. At the end of the last parallel branching (at ① in the example), the lower parallel branches are calculated first in the order 2 - 3 - 4 … before the top parallel branch is calculated.
2. The elements are calculated from left to right within a parallel branch.
3. Within the lower parallel branches, further parallel branches (at ② in the example) are calculated in the normal order from top to bottom.
4. In the top parallel branch, further parallel branches (at ③ in the example) are calculated in the order described in 1.

This produces the specified order (1 … 7) in the following example.

Example of a non-optimized execution order

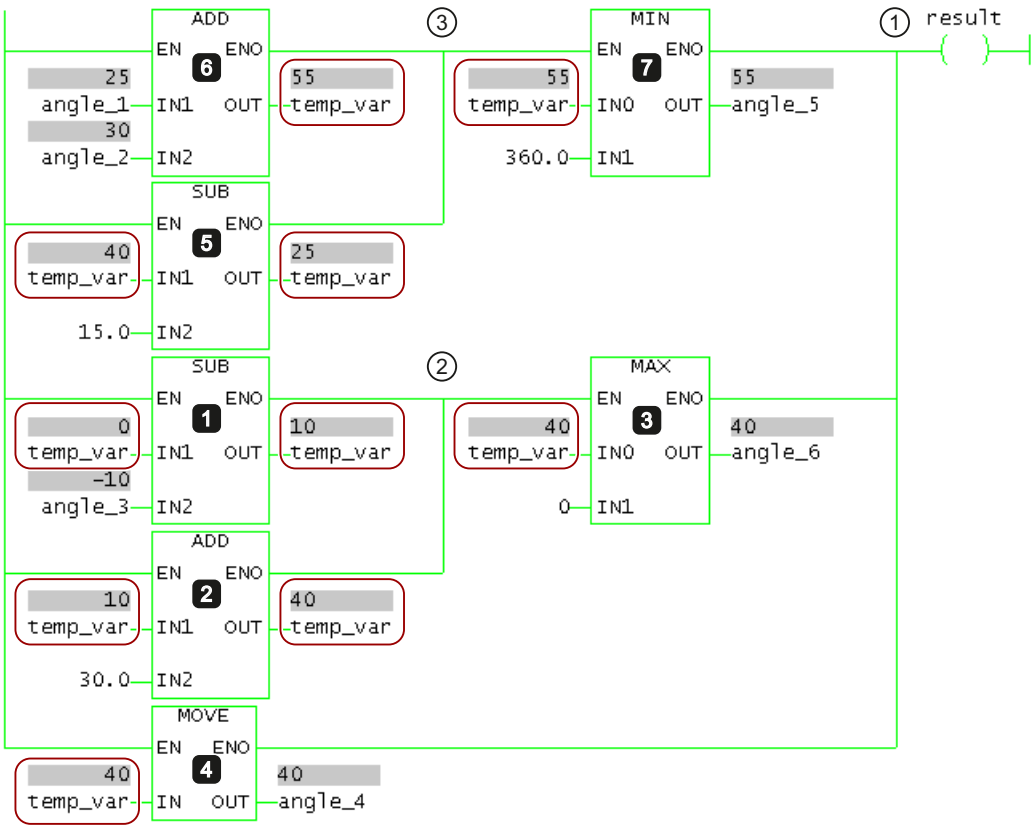


Figure 4-53 Example of a non-optimized execution order

4.21.2 Optimized execution order

Requirements

The setting for the optimized execution order is made globally for the entire project in the "Global compiler settings" (Page 54). The **Optimize execution order (LAD/FBD)** checkbox is active.

Note

Note when saving the project in the old project format: In project formats up to version V4.2, the optimized execution order is not taken into account.

Calculation for the optimized execution order

The LAD network is calculated in the following order:

1. At the end of parallel branching (at ① in the example), the parallel branches are calculated from top to bottom.
2. The elements are calculated from left to right within a parallel branch.
3. Within the parallel branches, further parallel branches (at ② or ③ in the example) are calculated from top to bottom.

This produces the specified order (1 … 7) in the following example.

Example of an optimized execution order

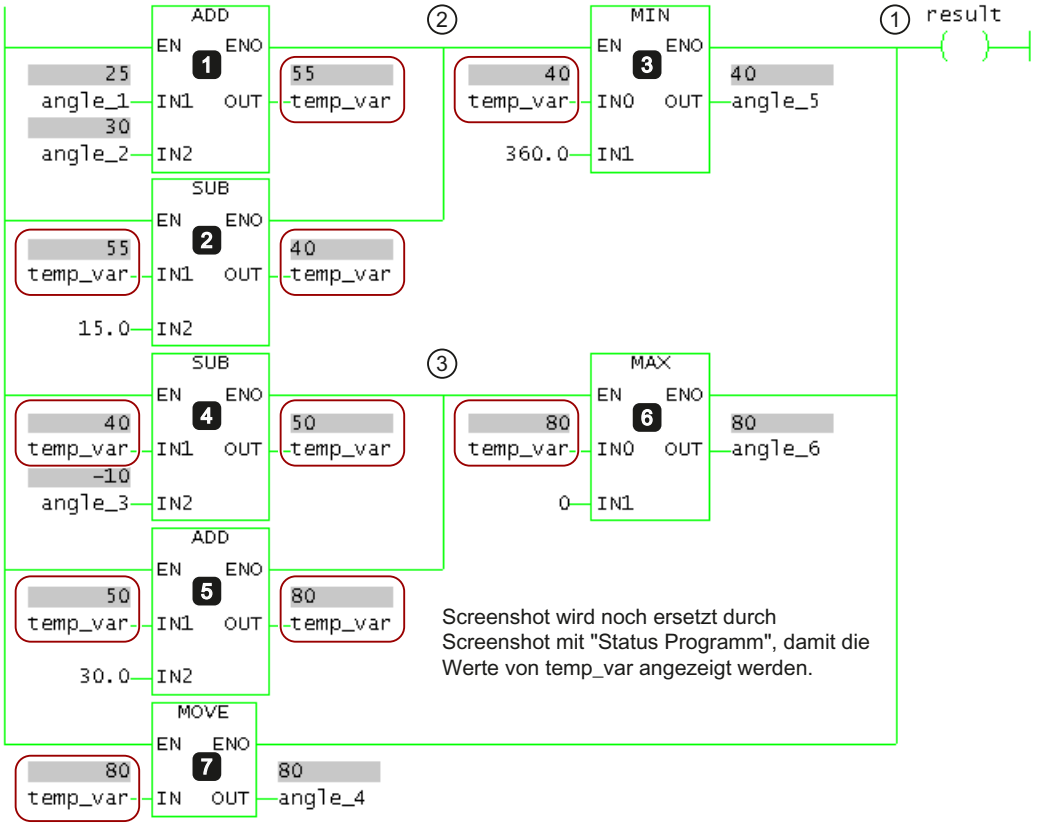


Figure 4-54 Example of an optimized execution order

Functions

5

This chapter provides a detailed description of the commands with the parameters. The commands described are applicable to both the LAD editor and the FBD editor. Examples are provided to illustrate individual commands in the LAD and FBD editors. Where there are differences such as bit logic, you should refer to the relevant LAD bit logic instructions (Page 211) editor.

Note

Functions not described in this section can be found in the Function Descriptions of the ST programming language.

5.1 LAD bit logic instructions

Bit logic operations work with the numbers **1** and **0**. These numbers form the basis of the binary system and are called binary digits or bits. In connection with AND, OR, XOR and outputs, a **1** stands for logic YES and a **0** for logic NO.

The bit logic operations interpret the signal states **1** and **0** and link them according to boolean logic.

The following bit logic operations are available:

- ---| |--- NO contact
- ---| / |--- NC contact
- XOR Linking EXCLUSIVE OR
- ---( ) Relay coil, output
- ---(#)--- Connector
- ---|NOT|--- Invert signal state

The following operations react to a signal state of **1**:

- ---(S) Set output
- ---(R) Reset output
- SR Prioritize set flip-flop
- RS Prioritize reset flipflop

Some operations react to a rising or falling edge change, so that you can perform one of the following operations:

- --(N)-- Scan edge 1 -> 0
- --(P)-- Scan edge 0 -> 1

- NEG edge detection (falling)
- POS edge detection (rising)

5.1.1 ---| |--- NO contact

Symbol

<Operand>

---| |---

Parameter	Data type	Description
<Operand>	BOOL	Scanned bit

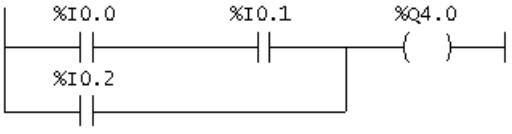
Description

---| |--- (NO contact) is closed if the value of the scanned bit, saved at the specified **<Operand>**, is equal to **1**.

Otherwise, if the signal state at the specified **<address>** is "0", the contact is open.

With series connections, the **---| |---** contact is linked by AND. With parallel connections, the contact is linked by OR.

Example



Output %Q 4.0 is **1**, if (%I 0.0 = **1** AND %I 0.1 = **1**) OR %I 0.2 = **1**.

5.1.2 ---| / |--- NC contact

Symbol

<Operand>

—| / |—

Parameter	Data type	Description
<Operand>	BOOL	Scanned bit

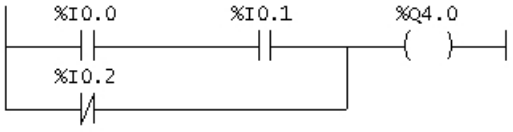
Description

---| / |--- (NC contact) is closed if the value of the scanned bit, saved at the specified **<Operand>**, is equal to **0**.

Otherwise, if the signal state at the specified **<address>** is "1", the contact is open.

With series connections, the **---| / |---** contact is linked bit for bit by AND. With parallel connections, the contact is linked by OR.

Example

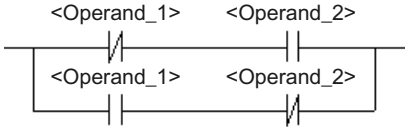


Output %Q 4.0 is **1**, if (%I 0.0 = **1** AND %I 0.1 = **1**) OR %I 0.2 = **0**.

5.1.3 XOR Linking EXCLUSIVE OR

Symbol

For the function **XOR**, a network of NC contacts and NO contacts must be created:

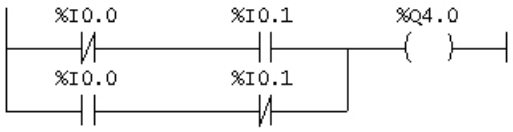


Parameter	Data type	Description
<Operand_1>	BOOL	Scanned bit
<Operand_2>	BOOL	Scanned bit

Description

The value of an **XOR** (Link EXCLUSIVE OR) link is **1** if the signal states of both specified bits are different.

Example



Output %Q 4.0 is **1** if (%I 0.0 = 0 AND %I 0.1 = 1) OR (%I 0.0 = 1 AND %I 0.1 = 0).

5.1.4 ---|NOT|--- Invert signal state

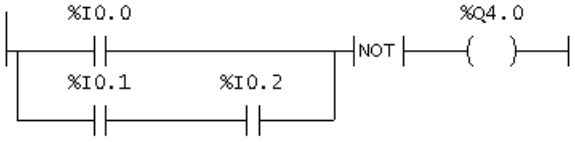
Symbol

---|NOT|---

Description

---|NOT|--- (Invert signal state) inverts the signal bit.

Example



Output %Q 4.0 is **0**, if %I 0.0 = **1** OR (%I 0.1 = **1** AND %I 0.2 = **1)**.

5.1.5 ---( ) Relay coil, output

Symbol

<Operand>

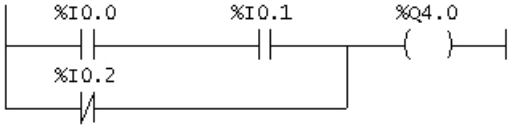
---( )

Parameter	Data type	Description
<Operand>	BOOL	Assigned bit

Description

--- ( ) (Relay coil, output) works like a coil in a circuit diagram. If current flows to the coil, the bit at the **<Operand>**is set to **1**. If no current flows to the coil, the bit at the **<Operand>** is set to **0**. An output coil can only be positioned at the right-hand end of a ladder diagram line in a ladder logic. A negated output can be created with the operation ---|NOT|---.

Example



Output %Q 4.0 is **1**, if (%I 0.0 = **1** AND %I 0.1 = **1**) OR %I 0.2 = **0**.

5.1.6 ---(#)--- Connector (LAD)

Symbol

<Operand>

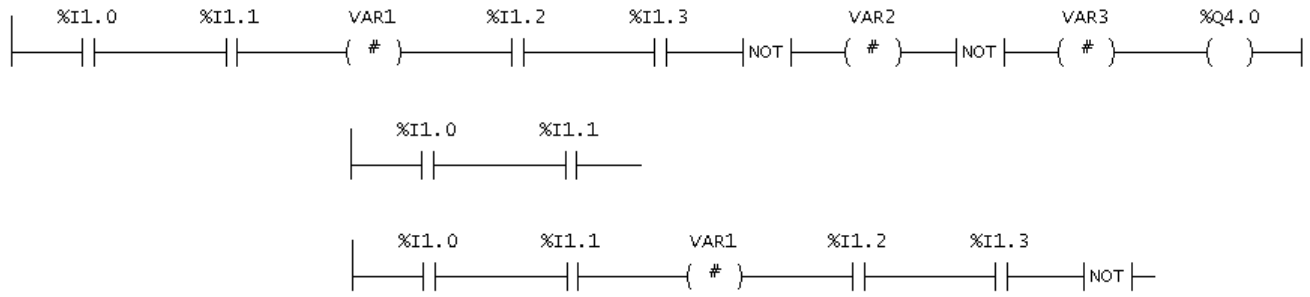
---(#)---

Parameters	Data type	Description
<Operand>	BOOL	Assigned bit

Description

---(#)--- (Connector) is an interposed element with assignment function which saves the current signal state of the signal flow at a specified **<Operand>**. This assignment element saves the bit logic of the last opened branch in front of the assignment element. If connected in series with other elements, the **---(#)---**operation is pasted in as a contact. The **---(#)---** element can never be connected to the conductor bar, nor positioned directly behind a branch, nor used as the end of a branch. A negated element **---(#)---** can be created with the element ---|NOT|--- (Invert signal state).

Example



5.1.7 ---(R) Reset output (LAD)

Symbol

<Operand>

---(R)

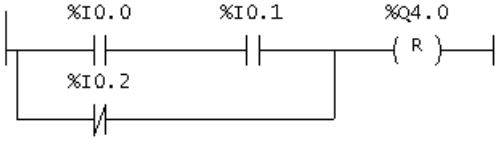
Parameter	Data type	Description
<Operand>	BOOL	Assigned bit

Description

---(R) (Reset output) is executed only if the signal state of the previous operations is **1** (signal flow at the coil). If the signal state is **1**, the specified **<Operand>** of the element is set to **0**.

A signal state of **0** (no signal flow at the coil) has no effect, so that the signal state of the operand of the specified element is not changed.

Example



Output %Q 4.0 is set to **0**, if (%I 0.0 = **1** AND %I 0.1 = **1**) OR %I 0.2 = **0**.

If the signal state is **0**, the signal state of %Q 4.0 remains the same.

5.1.8 ---(S) Set output (LAD)

Symbol

<Operand>

---(S)

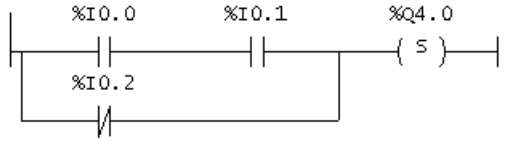
Parameter	Data type	Description
<Operand>	BOOL	Set bit

Description

---(S) (Set output) is executed only if the signal state of the previous operations is **1** (signal flow at the coil). If the signal state is **1**, the specified **<Operand>** of the element is set to **1**.

A signal state = 0 has no effect, so that the current signal state of the specified element's operand is not changed.

Example

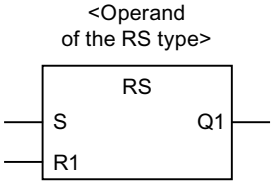


Output %Q 4.0 is set to **1**, if %I 0.0 = **1** AND %I 0.1 = **1**) OR %I 0.2 = **0**.

If the signal state is **0**, the signal state of %Q 4.0 remains the same.

5.1.9 RS Prioritize reset flipflop

Symbol



Parameters	Data type	Description
<Operand>	RS	Instance variable of FB type RS
S	BOOL	Set

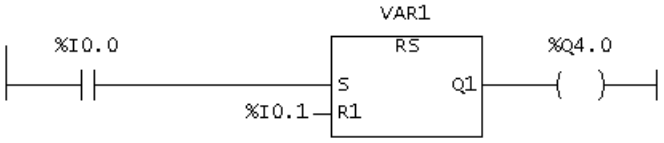
Parameters	Data type	Description
R1	BOOL	Reset
Q1	BOOL	Signal state of <address>

Description

RS (Prioritize reset flip-flop) is reset if the state at input R1 is 1. For the state at output Q1, this means:

- Q1 = 0, if input R1 has state 1 irrespective of the state at the S input.
- Q1 = 1, if input S has state 1 and input R1 has state 0.
- Q1 unchanged, if both R1 and S inputs have state 0.

Example



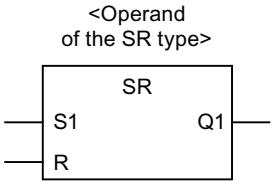
VAR1 is declared as a variable of data type RS and is used as instance of the function block. The I/O addresses %I 0.0 and %I 0.0 (process image of the inputs) are connected to the inputs S and R1 of the function block. Output Q1 of the function block is connected to I/O address %Q 4.0 (process image of the outputs).

The following applies for the signal state at output address %Q 4.0 depending of the signal state at input addresses %I 0.0 and %I0.1:

- %I 0.0 = 1 and %I 0.1 = 1 ⇒ %Q 4.0 = 0.
- %I 0.0 = 1 and %I 0.1 = 0 ⇒ %Q 4.0 = 1.
- %I 0.0 = 0 and %I 0.1 = 1 ⇒ %Q 4.0 = 0.
- %I 0.0 = 0 and %I 0.1 = 0 ⇒ %Q 4.0 remains the same.

5.1.10 SR Prioritize set flipflop

Symbol



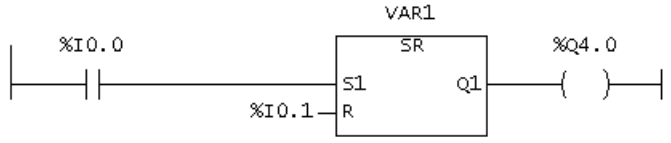
Parameters	Data type	Description
<Operand>	SR	Instance variable from FB type SR
S1	BOOL	Set
R	BOOL	Reset
Q1	BOOL	Signal state of <address>

Description

SR (Prioritize set flip-flop) is set if input S1 has state **1**. For the state at output Q1, this means:

- Q1 = **1**, if input S1 has state **1** irrespective of the state at the R input.
- Q1 = **0**, if input R has state **1** and input S1 has state **0**.
- Q1 unchanged, if both R and S1 inputs have state **0**.

Example



VAR1 is declared as a variable of data type SR and is used as instance of the function block. The I/O addresses %I 0.0 and %I 0.0 (process image of the inputs) are connected to the inputs S1 and R of the function block. Output Q1 of the function block is connected to I/O address %Q 4.0 (process image of the outputs).

The following applies for the signal state at output address %Q 4.0 depending of the signal state at input addresses %I 0.0 and %I0.1:

- %I 0.0 = **1** and %I 0.1 = **1** ⇒ %Q 4.0 = **1**.
- %I 0.0 = **1** and %I 0.1 = **0** ⇒ %Q 4.0 = **1**.
- %I 0.0 = **0** and %I 0.1 = **1** ⇒ %Q 4.0 = **0**.
- %I 0.0 = **0** and %I 0.1 = **0** ⇒ %Q 4.0 remains the same.

5.1.11 --(N)-- Scan edge 1 -> 0 (LAD)

Symbol

<Operand>

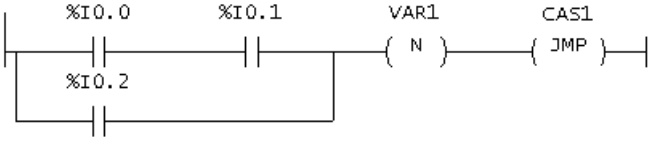
---(N)---

Parameters	Data type	Description
<Operand>	BOOL	N connector bit, saves the previous signal state

Description

---(N)--- (Scan edge 1 -> 0) recognizes a signal state change in the operand from **1** to **0** and displays this after the operation with signal state = 1. The current signal state is compared to the signal state of the operand, the N connector. If the signal state of the operand is **1** and the signal state before the operation is **0**, then the signal after the operation is **1** (pulse), in all other cases **0**. The signal before the operation is saved in the operand.

Example



The N-connector saves the signal state of the result of the entire bit logic.

If the signal state changes from **1** to **0** the jump to the CAS1 jump label is performed.

5.1.12 --(P)-- Scan edge 0 -> 1 (LAD)

Symbol

<Operand>

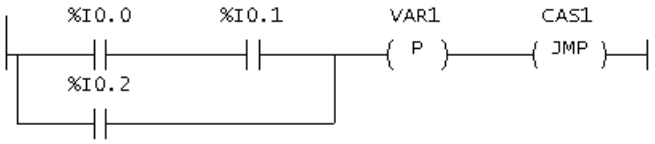
---(P)---

Parameters	Data type	Description
<Operand>	BOOL	P connector bit, saves the previous signal state

Description

---(P)--- (Scan edge 0 -> 1) recognizes a signal state change in the operand from **0** to **1** and displays this after the operation with signal state = 1. The current signal state is compared to the signal state of the operand, the P connector. If the signal state of the operand is **0** and the signal state before the operation is **1**, then the signal after the operation is **1** (pulse), in all other cases **0**. The signal before the operation is saved in the operand.

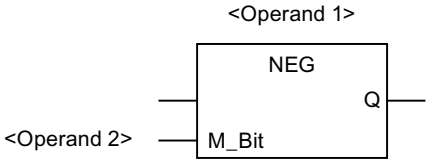
Example



The P-connector saves the signal state of the result of the entire bit logic. If the signal state changes from **0** to **1** the jump to the CAS1 jump label is performed.

5.1.13 NEG edge detection (falling)

Symbol

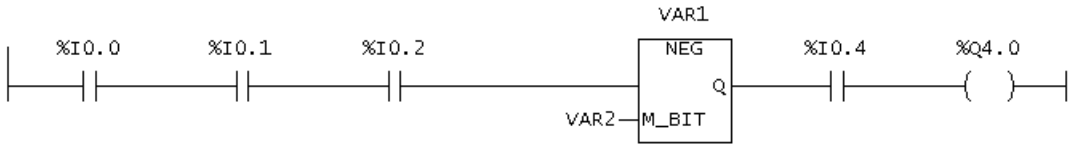


Parameters	Data type	Description
<Operand1>	BOOL	Scanned signal
<Operand2>	BOOL	Connector bit, saves the previous signal state from <Operand1>
Q	BOOL	Signal change detection

Description

NEG (edge detection) compares the signal state of **<Operand1>** with the signal state of the previous scan, which is saved in **<Operand2>**. If the current state of the signal is **0** and the previous state was **1** (detection of a falling edge), output Q is **1** after this function, in all other cases **0**.

Example

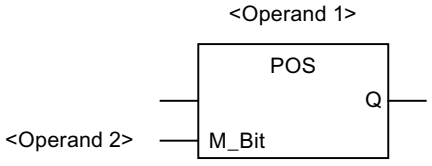


Output %Q 4.0 is **1** if:

(The state at %I 0.0 AND at %I 0.1 AND at %I 0.2 = **1**) AND VAR1 has a falling edge AND the state at %I 0.4 = **1**.

5.1.14 POS edge detection (rising)

Symbol

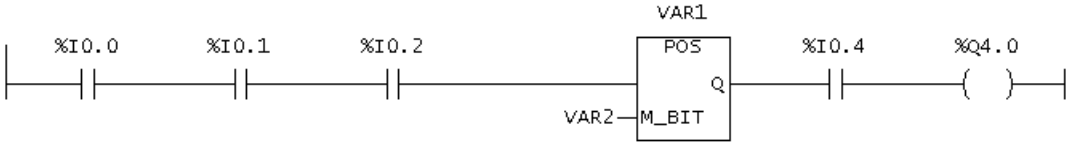


Parameters	Data type	Description
<Operand1>	BOOL	Scanned signal
<Operand2>	BOOL	Connector bit, saves the previous signal state from <Operand1>
Q	BOOL	Signal change detection

Description

POS (edge detection) compares the signal state of **<Operand1>** with the signal state of the previous scan, which is saved in **<Operand2>**. If the current state of the signal is **1** and the previous state was **0** (detection of a rising edge), output Q is **1** after this operation, in all other cases **0**.

Example



Output %Q 4.0 is **1** if:

(The state at %I 0.0 AND at %I 0.1 AND at %I 0.2 = **1**) AND VAR1 has a rising edge AND the state at %I 0.4 = **1**.

5.1.15 Open branch

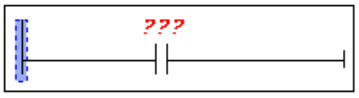
Parallel branches are opened downward.

Parallel branches are always opened behind the selected LAD element.

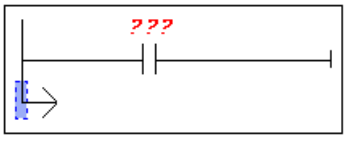
Procedure

To open a parallel branch downward, follow these steps:

1. Use the cursor to select the position where the branch is to be opened.



2. Click the button (shortcut Shift+F8) on the LAD editor toolbar.
   The branch is opened behind the selected element.



5.1.16 Close branch

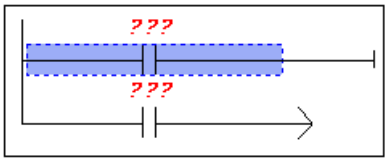
Parallel branches are closed upward.

Parallel branches are always closed behind the selected LAD element.

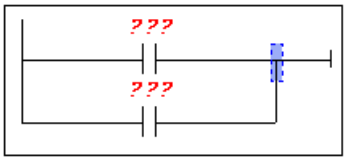
Procedure

To close a parallel branch upward, follow these steps:

1. Use the cursor to select the position where the branch is to be closed.

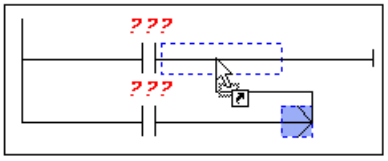


2. Click the button (shortcut Shift+F9) on the LAD editor toolbar.
   The branch is closed behind the selected element.

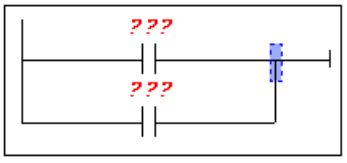


Or:

1. Using the cursor, select the parallel branch to be closed.
2. Holding down the left mouse button, move the selected branch to the position at which it is to be closed.



3. Release the left mouse button.
   The branch is closed at the selected position.



5.2 FBD bit logic instructions

FBD bit logic instructions

Bit logic operations work with the numbers **1** and **0**. These numbers form the basis of the binary system and are called binary digits or bits. In connection with AND, OR, XOR and outputs, a **1** stands for logic YES and a **0** for logic NO.

The bit logic operations interpret the signal states **1** and **0** and link them according to boolean logic.

The following bit logic operations are available in the FBD editor:

- & AND box
- >=1 OR box
- XOR Exclusive OR box
- [=] Assignment
- [#] Connector

The following operations react to a signal state of 1:

- [R] Reset assignment
- [S] Set assignment
- RS Prioritize reset flipflop
- SR Prioritize set flip-flop

Some operations react to a rising or falling edge change, so that you can perform one of the following operations:

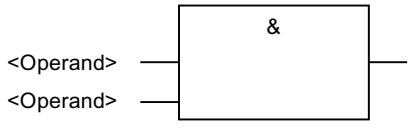
- [N] Scan edge 1 -> 0
- [P] Scan edge 0 -> 1
- NEG edge detection (falling)
- POS edge detection (rising)

The other operations directly affect the signal states:

- --| Inserting a binary input
- --o| Negating a binary input

5.2.1 & AND box

Symbol

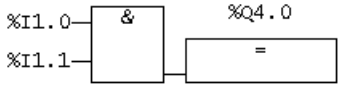


Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

Description

With the **AND** operation, you can scan the signal states of two or more specified operands at the inputs of an AND box. If the signal status of all operands is **1**, the condition is fulfilled and the result of the operation is **1**. If the signal status of one operand is **0**, the condition is not fulfilled and the operation returns a result of **0**.

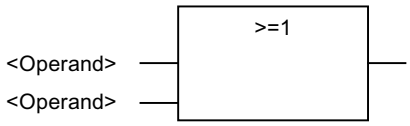
Example



Output %Q 4.0 is set when the signal state at input %I 1.0 AND %I 1.1 is **1**.

5.2.2 >=1 OR box

Symbol

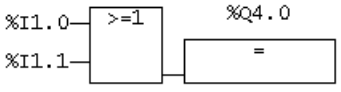


Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

Description

With the **OR** operation, you can scan the signal states of two or more specified operands at the inputs of an OR box. If the signal status of one of the operands is **1**, the condition is fulfilled and the result of the operation is **1**. If the signal status of all operands is **0**, the condition is not fulfilled and the operation returns a result of **0**.

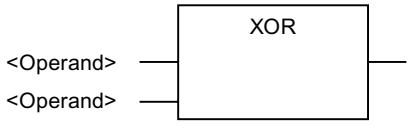
Example



Output %Q 4.0 is set when the signal state at input %I 1.0 OR %I 1.1 is **1**.

5.2.3 XOR EXCLUSIVE OR box

Symbol

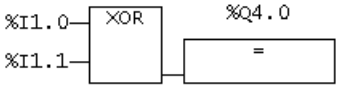


Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

Description

In an **EXCLUSIVE OR** box, the signal state is **1** if the signal state of one of the two specified operands is **1**.

Example



At output %Q 4.0, the signal state is **1** if the signal state is **1** either EXCLUSIVELY at input %I 0.0 OR at input %I 0.1.

5.2.4 --| Inserting a binary input

Symbol

<Operand>

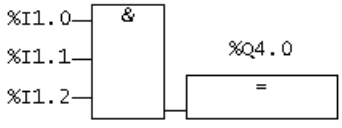
---|

Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

Description

The **Insert binary input** operation inserts a binary input in an AND, OR, or XOR box behind the selection mark.

Example



Output % Q 4.0 is **1** when the state %I 1.0 AND %I 1.1 AND %I 1.2 = 1.

5.2.5 --o| Negating a binary input

Symbol

<Operand>

–o|

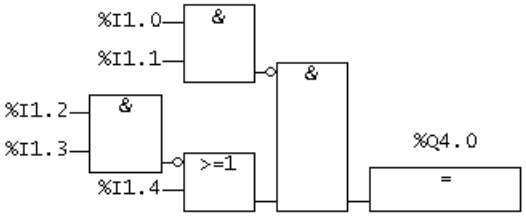
Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

Description

The **Negate binary input** operation negates the signal state.

All binary inputs of any elements can be negated.

Example

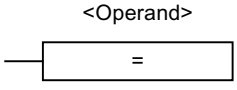


Output %Q 4.0 is **1** if:

- The signal state at %I 1.0 AND %I 1.1 is NOT 1
- AND the signal state at %I 1.2 AND %I 1.3 is NOT 1
- OR the signal state at %I 1.4 = 1.

5.2.6 [=] Assignment

Symbol



Parameters	Data type	Description
<Operand>	BOOL	Assigned bit

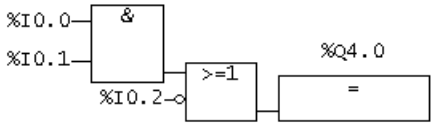
Description

The **Assignment** operation supplies the value. The box at the end of the logic operation carries a signal of 1 or 0 according to the following criteria:

- The output carries a signal of 1 when the conditions of the logic operation are fulfilled before the output box.
- The output carries a signal of 0 when the conditions of the logic operation are not fulfilled before the output box.

The FBD logic operation assigns the signal state to the output that is addressed by the operation. If the conditions of the FBD logic operation are fulfilled, the signal state at the output box is **1**. Otherwise, the signal state is **0**.

Example

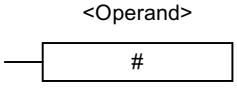


Output %Q 4.0 is **1** if:

- At inputs %I 0.0 AND %I 0.1, the signal state is 1,
- OR %I 0.2 = 0.

5.2.7 [#] Connector (FBD)

Symbol

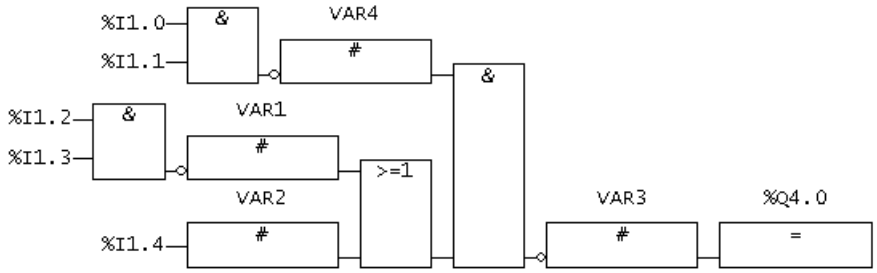


Parameters	Data type	Description
<Operand1>	BOOL	Assigned bit

Description

The **Connector** operation is an intermediate assignment element that stores the signal state. Specifically, this assignment element saves the bit logic of the last opened branch in front of the assignment element.

Example



Connectors store the following logic operation results:

VAR4 saves the negated signal state of

%I1.0

%I1.1

VAR1 saves the negated signal state of

%I1.2

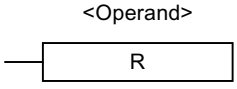
%I1.3

VAR2 saves the negated signal state of %I 1.4.

VAR3 saves the negated signal state of the entire bit logic operation.

5.2.8 [R] Reset assignment (FBD)

Symbol

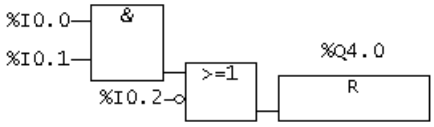


Parameters	Data type	Description
<Operand>	BOOL	Assigned bit

Description

The **Reset assignment** operation then is only performed when the signal state = 1. If the signal state = 1, the specified operand is reset to **0** by the operation. If the signal state = 0, the operation does not affect the specified operand. The operand remains unchanged.

Example



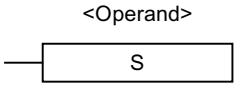
The signal state at output %Q 4.0 is only reset to **0** if:

- The signal state is 1 at inputs %I 0.0 AND %I 0.1
- OR the signal state at input %I 0.2 = 0

If the signal state of the branch = 0, the signal state at output %Q 4.0 is not changed.

5.2.9 [S] Set assignment (FBD)

Symbol

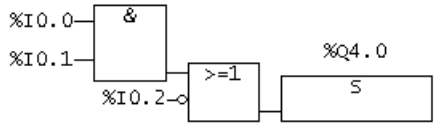


Parameters	Data type	Description
<Operand>	BOOL	Set bit

Description

The **Set assignment** operation is only performed when the signal state = 1. If the signal state = 1, the specified operand is reset to **1** by the operation. If the signal state = 0, the operation does not affect the specified operand. The operand remains unchanged.

Example



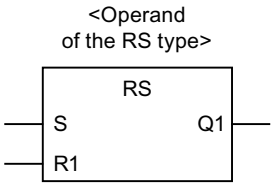
The signal state at output %Q 4.0 is only reset to **1** if:

- The signal state is 1 at inputs %I 0.0 AND %I 0.1
- OR the signal state at input %I 0.2 = 0

If the signal state of the branch = 0, the signal state of %Q 4.0 is not changed.

5.2.10 RS Prioritize reset flipflop

Symbol



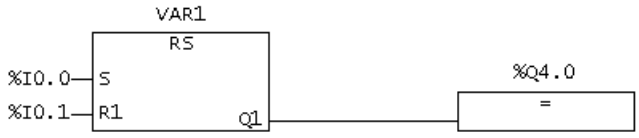
Parameters	Data type	Description
<Operand>	RS	Instance variable of FB type RS
S	BOOL	Enable set
R1	BOOL	Enable reset
Q1	BOOL	Signal state of <address>

Description

The **Prioritize reset flipflop** operation only performs operations such as Set assignment (S) or Reset assignment (R1) if the signal state = 1. A signal state of 0 has no effect on these operations; the operand specified in the operation is not changed.

Prioritize reset flipflop is reset when the signal state at input R1 = 1 and the signal state at input S = 0. The flipflop is set when input R1 = 0 and input S = 1. If the signal state at both inputs is **1**, the flipflop is reset.

Example

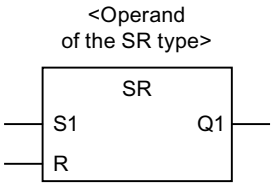


If the state at input %I 0.0 = **1** and at input %I 0.1 = **0**, the variable VAR1 is set and output %Q 4.0 is **1**. Otherwise, if the signal state at input %I 0.0 = **0** and the signal state at input %I 0.1 = **1**, the variable VAR1 is reset and %Q 4.0 is **0**.

If both signal states are **0**, nothing is changed. If both signal states are **1**, the reset operation has priority. VAR1 is reset and %Q 4.0 is **0**.

5.2.11 SR Prioritize set flipflop

Symbol



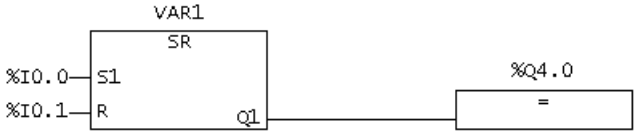
Parameters	Data type	Description
<Operand>	SR	Instance variable from FB type SR
S1	BOOL	Enable set
R	BOOL	Enable reset
Q1	BOOL	Signal state of <address>

Description

The **Prioritize set flipflop** operation only performs operations such as Set (S1) or Reset (R) if the signal state = 1. A signal state of **0** has no effect on these operations; the operand specified in the operation is not changed.

Prioritize set flipflop is set when the signal state at input S1 = 1 and the signal state at input R = 0. The flipflop is reset when input S1 = 0 and input R = 1. If the signal state at both inputs is **1**, the flipflop is set.

Example

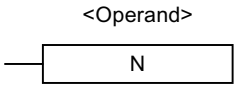


If the state at input %I 0.0 = **1** and at input %I 0.1 = **0**, the variable VAR1 is set and output %Q 4.0 is **1**. Otherwise, if the signal state at input %I 0.0 = 0 and the signal state at input %I 0.1 = 1, the variable VAR1 is reset and %Q 4.0 is **0**.

If both signal states are **0**, nothing is changed. If both signal states are **1**, the set operation has priority. VAR1 is set and %Q 4.0 is **1**.

5.2.12 [N] Scan edge 1 -> 0 (FBD)

Symbol

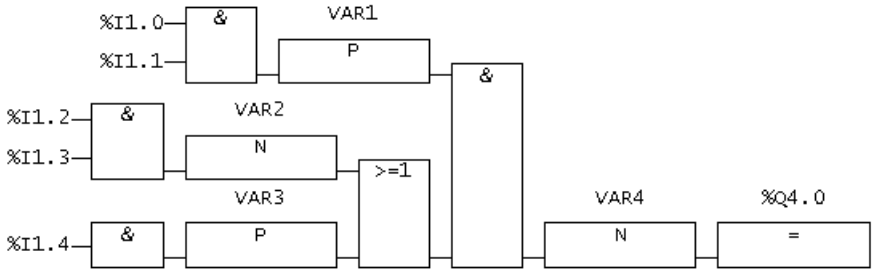


Parameters	Data type	Description
<Operand>	BOOL	N connector bit, saves the previous signal state

Description

The **Scan edge 1 -> 0** recognizes a signal state change in the specified operands from **1** to **0** (falling edge) and displays this after the operation with signal state = 1. The current signal state is compared to the signal state of the operand, the edge variable. If the signal state of the operand is **1** and the signal state before the operation is **0**, then the signal after the operation is **1** (pulse), in all other cases **0**. The signal state before the operation is saved in the operand.

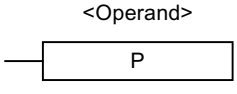
Example



The VAR4 variable saves the signal state.

5.2.13 [P] Scan edge 0 -> 1 (FBD)

Symbol

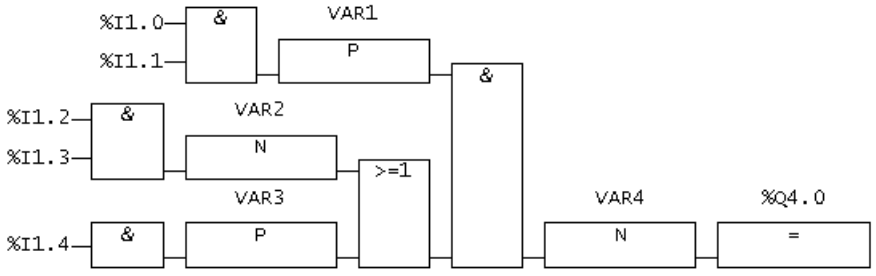


Parameters	Data type	Description
<Operand>	BOOL	P connector bit, saves the previous signal state

Description

The **Scan edge 0 -> 1** recognizes a signal state change in the specified operands from **0** to**1** (rising edge) and displays this after the operation with signal state = 1. The current signal state is compared to the signal state of the operand, the edge variable. If the signal state of the operand is **0** and the signal state before the operation is **1**, then the signal state after the operation is 1, in all other cases **0**. The signal state before the operation is saved in the operand.

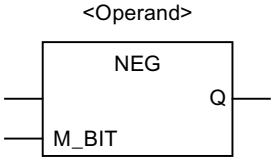
Example



The VAR1 variable saves the signal state.

5.2.14 NEG edge detection (falling)

Symbol

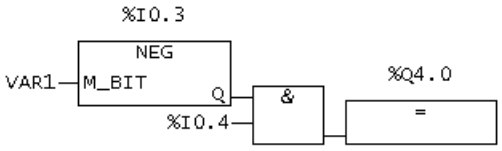


Parameters	Data type	Description
<Operand1>	BOOL	Scanned signal
M_BIT	BOOL	The M-BIT operand indicates the variable in which the previous signal state of NEG is saved.
Q	BOOL	Signal change detection

Description

The **Edge detection** (falling) operation compares the signal state of <Operand1> with the signal state of the previous scan, which is saved in M_BIT. If a change has occurred from **1** to **0**, then output Q = **1**, in all other cases **0**.

Example

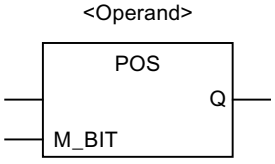


Output %Q 4.0 is **1** if:

- Input %I 0.3 has a falling edge
- AND the signal state at input %I 0.4 = 1.

5.2.15 POS edge detection (rising)

Symbol

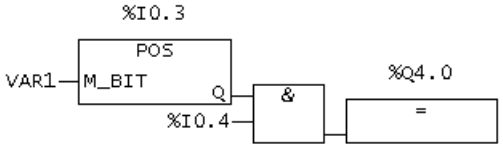


Parameters	Data type	Description
<Operand1>	BOOL	Scanned signal
M_BIT	BOOL	The M-BIT operand indicates the variable in which the previous signal state of POS is saved.
Q	BOOL	Signal change detection

Description

The **Edge detection** (rising) operation compares the signal state of <Operand1> with the signal state of the previous scan, which is saved in M_BIT. If a change has occurred from **0** to **1**, then output Q = **1**, in all other cases **0**.

Example



Output %Q 4.0 is **1** if:

- Input %I 0.3 has a rising edge
- AND the signal state at input %I 0.4 = 1.

5.3 Relational operators

5.3.1 Overview of comparison operations

Description

The inputs IN1 and IN2 are compared using the following comparison methods:

= IN1 is equal to IN2
<> IN1 is not equal to IN2
> IN1 is greater than IN2
< IN1 is less than IN2
>= IN1 is greater than or equal to IN2
<= IN1 is less than or equal to IN2

The following comparison operation is available:

- CMP comparator

5.3.2 CMP Compare numbers

Icons

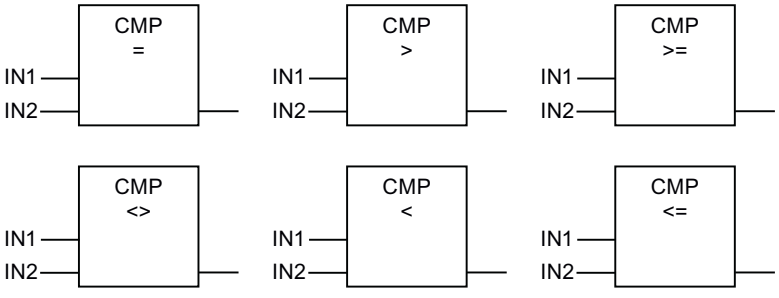


Table 5-1 Parameters for CMP <, CMP > CMP >=, CMP <=

Parameter	Data type	Description
Box output	BOOL	Result of the comparison, processing is only continued if the signal state at the box input = 1.
IN1	ANY_NUM[1] ANY_BIT DATE TIME_OF_DAY (TOD) DATE_AND_TIME (DT) TIME STRING[2]	First comparison value
IN2	ANY_NUM[1] ANY_BIT DATE TIME_OF_DAY (TOD) DATE_AND_TIME (DT) TIME STRING[2]	Second comparison value
The first and second comparison values must be of the same data type, e.g. ANY_NUM and ANY_NUM, DATE and DATE, STRING and STRING. [1] It must be possible to convert both comparison values into the most powerful data type by means of implicit conversion. [2] Variables of the STRING data type can be compared irrespective of the declared length of the string.		

Table 5-2 Parameter for CMP =, CMP <>

Parameter	Data type	Description
Box output	BOOL	Result of the comparison, processing is only continued if the signal state at the box input = 1.
IN1	ANY_NUM[1] ANY_BIT DATE TIME_OF_DAY (TOD) DATE_AND_TIME (DT) TIME STRING[2] Enumeration[3] Array[3] Structure[3] STRUCTTASKID STRUCTALARMID ANYOBJECT	First comparison value

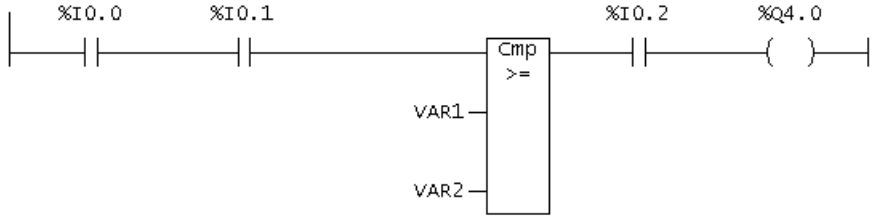
Parameter	Data type	Description
IN2	ANY_NUM[1] ANY_BIT DATE TIME_OF_DAY (TOD) DATE_AND_TIME (DT) TIME STRING[2] Enumeration[3] Array[3] Structure[3] STRUCTTASKID STRUCTALARMID ANYOBJECT	Second comparison value
The first and second comparison values must be of the same data type, e.g. ANY_NUM and ANY_NUM, DATE and DATE, STRING and STRING. [1] It must be possible to convert both comparison values into the most powerful data type by means of implicit conversion. [2] Variables of the STRING data type can be compared irrespective of the declared length of the string. [3] The data type specifications (see the SIMOTION ST Programming and Operating Manual) must be identical for both comparison values.		

Description

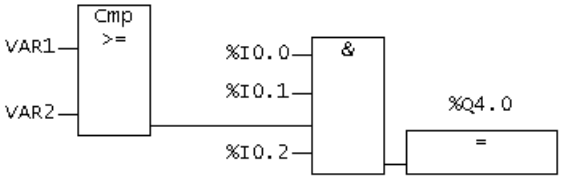
CMP (Compare numbers) can be used like a normal contact. The box can be used at the positions where a normal contact can also be positioned. IN1 and IN2 are compared with the comparison method selected by you.

If the comparison is true, then the value of the operation is **1**. The value of the whole ladder diagram line is linked by AND if the comparison element is connected in series or by OR if the box is connected in parallel.

Example



Representation in the LAD editor



Representation in the FBD editor

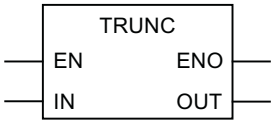
%Q 4.0 is set when:

- VAR1 >= VAR2
- AND the signal state at input %I 0.0 is (1).
  AND the signal state at input %I 0.1 is (1).
  AND the signal state at input %I 0.2 is (1).

5.4 Conversion instructions

5.4.1 TRUNC Generate integer

Symbol

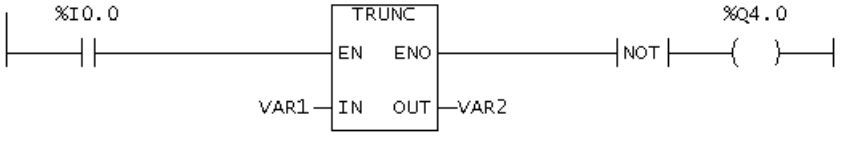


Parameters	Data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
IN	ANY_REAL	Number which is to be converted
OUT	ANY_INT	Integral part of the value from IN

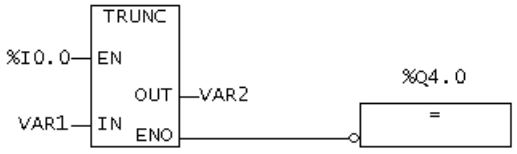
Description

TRUNC (generate integer) reads the contents of the IN parameter as a floating-point number and converts this value to an integer (32-bit). The result is the integral part of the floating-point number which is output by the OUT parameter.

Example



Representation in the LAD editor



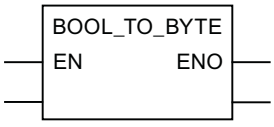
Representation in the FBD editor

If %I 0.0 = 1, the contents of VAR1 are read as a floating-point number and converted to an integer (32-bit). The result is the integral part of the floating-point number which is saved in VAR2.
Output %Q 4.0 is **1** if an overflow occurs or the statement is not processed (%I 0.0 = 0).

5.4.2 Generating numeric data types and bit data types

Symbol

e.g. BOOL_TO_TYPE



Description

You can carry out the explicit data type conversion with the standard functions listed in the tables below.

- Input parameters
  Each function for the conversion of a data type has exactly one input parameter.
- Function value
  The function value is always the return value of the function. The table shows the rules with which a data type can be converted.
- Naming
  Because the data types of the input parameter and the function value come from the respective function name, they are not listed specially in the table "Functions for conversion of numerical data types and bit data types": E.g. with function BOOL_TO_BYTE, the data type of the input parameter is BOOL, the data type of the function value BYTE.

Table 5-3 Functions for conversion of numerical data types and bit data types

Function name	Conversion rule	Implicit okay
BOOL_TO_BYTE	Accept as least significant bit and fill the rest with 0.	yes
BYTE_TO_BOOL	Accept the least significant bit.	no
BYTE_TO_SINT	Accept bit string as SINT value.	no

Function name	Conversion rule	Implicit okay
BYTE_TO_USINT	Accept bit string as USINT value.	no
BYTE_TO_WORD	Accept least significant bit and fill the rest with 0.	yes

Table 5-4 Functions for conversion of numerical data types and bit data types

Function name	Conversion rule	Implicit okay
DINT_TO_DWORD	Accept value as bit string.	no
DINT_TO_INT	Cut off two most significant bytes.	no
DINT_TO_LREAL	Accept value.	yes
DINT_TO_REAL	Accept value (accuracy may be lost).	no
DINT_TO_UDINT	Accept value as bit string.	no
DINT_TO_UINT	Cut off two most significant bytes.	no
DINT_TO_WORD	Cut off two most significant bytes.	no

Table 5-5 Functions for conversion of numerical data types and bit data types

Function name	Conversion rule	Implicit okay
DWORD_TO_DINT	Accept bit string as DINT value.	no
DWORD_TO_INT	Accept the two least significant bytes as INT value.	no
DWORD_TO_REAL	Accept bit string as REAL value (validity check of the REAL number is **not** carried out!).	no
DWORD_TO_UDINT	Accept bit string as UDINT value.	no
DWORD_TO_UINT	Accept the two least significant bytes as UINT value.	no
DWORD_TO_WORD	Accept the two least significant bytes of the bit string.	no

Table 5-6 Functions for conversion of numerical data types and bit data types

Function name	Conversion rule	Implicit okay
INT_TO_DINT	Accept value.	yes
INT_TO_LREAL	Accept value.	no
INT_TO_REAL	Accept value.	yes
INT_TO_SINT	Cut off the most significant byte.	no
INT_TO_UDINT	Accept value as bit string; the two most significant bytes are filled with the most significant bit of the input parameter.	no
INT_TO_UINT	Accept value as bit string.	no
INT_TO_WORD	Accept value as bit string.	no

Table 5-7 Functions for conversion of numerical data types and bit data types

Function name	Conversion rule	Implicit okay
LREAL_TO_DINT	Round off to integer part.	no
LREAL_TO_INT	Round off to integer part.	no
LREAL_TO_REAL	Accept value (accuracy may be lost).	no
LREAL_TO_UDINT	Round off to integer part.	no
LREAL_TO_UINT	Round off to integer part.	no

Table 5-8 Functions for conversion of numerical data types and bit data types

Function name	Conversion rule	Implicit okay
REAL_TO_DINT	Round off to integer part.	no
REAL_TO_DWORD	Accept bit string.	no
REAL_TO_INT	Round off to integer part.	no
REAL_TO_LREAL	Accept value.	yes
REAL_TO_UDINT	Round off to integer part.	no
REAL_TO_UINT	Round off to integer part.	no

Table 5-9 Functions for conversion of numerical data types and bit data types

Function name	Conversion rule	Implicit okay
SINT_TO_BYTE	Accept bit string.	no
SINT_TO_INT	Accept value.	yes
SINT_TO_USINT	Accept bit string.	no

Table 5-10 Functions for conversion of numerical data types and bit data types

Function name	Conversion rule	Implicit okay
UDINT_TO_DINT	Accept bit string.	no
UDINT_TO_INT	Cut off numerical sequence (2 most significant bytes).	no
UDINT_TO_DWORD	Accept bit string.	no
UDINT_TO_LREAL	Accept value.	yes
UDINT_TO_REAL	Accept value (accuracy may be lost).	no
UDINT_TO_UINT	Cut off numerical sequence (2 most significant bytes).	no
UDINT_TO_WORD	Cut off numerical sequence (2 most significant bytes).	no

Table 5-11 Functions for conversion of numerical data types and bit data types

Function name	Conversion rule	Implicit okay
UINT_TO_DINT	Accept value.	yes
UINT_TO_DWORD	Accept bit string, fill rest with zeros.	no
UINT_TO_INT	Accept bit string.	no
UINT_TO_LREAL	Accept value (accuracy may be lost).	no
UINT_TO_REAL	Accept value.	yes
UINT_TO_UDINT	Accept value.	yes
UINT_TO_USINT	Cut off numerical sequence (most significant byte).	no
UINT_TO_WORD	Accept bit string.	no

Table 5-12 Functions for conversion of numerical data types and bit data types

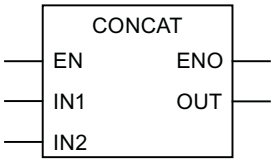
Function name	Conversion rule	Implicit okay
USINT_TO_BYTE	Accept bit string.	no
USINT_TO_INT	Accept value.	yes
USINT_TO_DINT	Accept value.	no
USINT_TO_SINT	Accept bit string.	no
USINT_TO_UINT	Accept value.	yes

Table 5-13 Functions for conversion of numerical data types and bit data types

Function name	Conversion rule	Implicit okay
WORD_TO_BYTE	Cut off most significant byte.	no
WORD_TO_DINT	Accept bit string, fill rest with zeros.	no
WORD_TO_DWORD	Accept the two least significant bytes and fill the rest with 0.	yes
WORD_TO_INT	Accept bit string and interpret this as an integer.	no
WORD_TO_UDINT	Accept bit string, fill rest with zeros.	no
WORD_TO_UINT	Accept bit string.	no

5.4.3 Generating date and time

Symbol



Description

The table below shows the standard functions for date and time data types:

Table 5-14 Standard functions for date and time

Function name	Data type of input parameter	Data type of function value	Description
CONCAT	1: DATE 2: TIME_OF_DAY	DATE_AND_TIME	Compress DATE and TIME_OF_DAY to DATE_AND_TIME.
DT_TO_TOD	DATE_AND_TIME	TIME_OF_DAY	Accept time of day.
DT_TO_DATE	DATE_AND_TIME	DATE	Accept date.

Note

Data type TIME can be converted to numerical data types as follows:

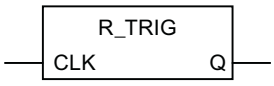
- To data type UDINT:
  Divide it by a standardization factor of data type TIME.
  Multiply the reconversion by the same standardization factor.

5.5 Edge detection

System function block R_TRIG can be used to detect a rising edge; F_TRIG can detect a falling edge. You can use this function, for example, to set up a sequence of your own function blocks.

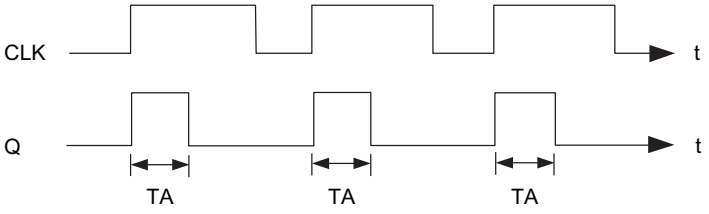
5.5.1 Detection of rising edge R_TRIG

Symbol



Description

If a rising edge (R_TRIG, Rising Trigger), i.e. a status change from 0 to 1, is present at the input, 1 is applied at the output for the duration of one cycle.



TA Cycle time

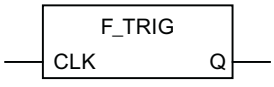
Figure 5-1 Mode of operation of R_TRIG (rising edge) function block

Table 5-15 Call parameters for R_TRIG

Identifier	Parameter	Data type	Description
CLK	Input	BOOL	Input for edge detection
Q	Output	BOOL	Status of edge

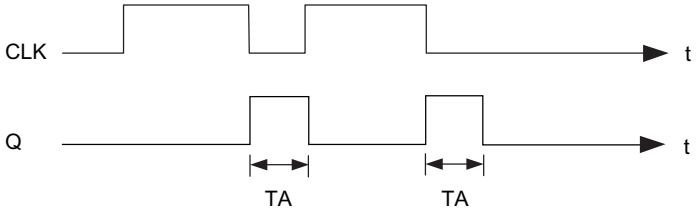
5.5.2 Detection of falling edge F_TRIG

Symbol



Description

When a falling edge (F_TRIG, falling trigger), i.e. a status change from 1 to 0, occurs at the input, the output is set to 1 for the duration of one cycle time.



TA Cycle time

Figure 5-2 Mode of operation of F_TRIG (falling edge) function block

Table 5-16 Call parameters for F_TRIG

Identifier	Parameter	Data type	Description
CLK	Input	BOOL	Input for edge detection
Q	Output	BOOL	Status of edge

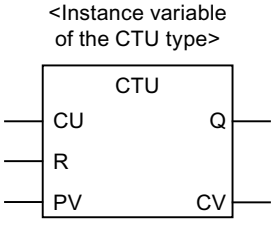
5.6 Counter operations

5.6.1 Overview of counter operations

Every call-up of the function block and the function should be recorded in a counter.

5.6.2 CTU up counter

Symbol



Description

The CTU counter allows you to perform upward counting operations:

- If the input is R = TRUE when the FB is called up, then the CV output is reset to 0.
- If the CU input changes from FALSE to TRUE (0 to 1) when the FB is called (positive edge), then the CV output is incremented by 1.
- Output Q specifies whether CV is greater than or equal to comparison value PV.

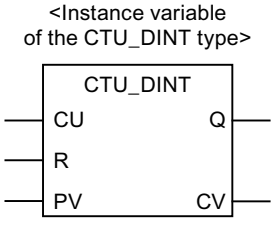
The CV and PV parameters are both INT data types, which means that the maximum counter reading possible is 32767 (= 16#7FFF).

Table 5-17 Parameters for CTU

Identifier	Parameter	Data type	Description
CU	Input	BOOL	Count up if value changes from FALSE to TRUE (positive edge)
R	Input	BOOL	Reset the counter to 0
PV	Input	INT	Comparison value
Q	Output	BOOL	Status of counter (CV >= PV)
CV	Output	INT	Counter value

5.6.3 CTU_DINT up counter

Symbol



Description

The method of operation is the same as for the CTU incrementer except for the following:

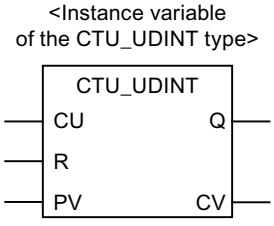
The CV and PV parameters are both DINT data types, which means that the maximum counter reading possible is 2147483647 (= 16#7FFF_FFFF).

Table 5-18 Parameters for CTU_DINT

Identifier	Parameter	Data type	Description
CU	Input	BOOL	Count up if value changes from FALSE to TRUE (positive edge)
R	Input	BOOL	Reset the counter to 0
PV	Input	DINT	Comparison value
Q	Output	BOOL	Status of counter (CV >= PV)
CV	Output	DINT	Counter value

5.6.4 CTU_UDINT up counter

Symbol



Description

The method of operation is the same as for the CTU incrementer except for the following:

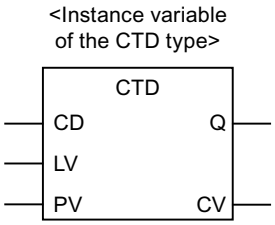
The CV and PV parameters are both UDINT data types, which means that the maximum counter reading possible is 4294967295 (=16# FFFF_FFFF).

Table 5-19 Parameters for CTU_UDINT

Identifier	Parameter	Data type	Description
CU	Input	BOOL	Count up if value changes from FALSE to TRUE (positive edge)
R	Input	BOOL	Reset the counter to 0
PV	Input	UDINT	Comparison value
Q	Output	BOOL	Status of counter (CV >= PV)
CV	Output	UDINT	Counter value

5.6.5 CTD down counter

Symbol



Description

The CTD counter allows you to perform downward counting operations.

- If the LD input = TRUE when the FB is called, then the CV output is reset to start value PV.
- If the CD input changes from FALSE to TRUE (0 to 1) when the FB is called (positive edge), then the CV output is decremented by 1.
- Output Q specifies whether CV is less than or equal to 0.

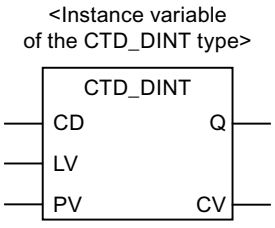
The CV and PV parameters are both INT data types, which means that the minimum counter reading possible is -32,768 (= 16#8000).

Table 5-20 Parameters for CTD

Identifier	Parameter	Data type	Description
CD	Input	BOOL	Count down if value changes from FALSE to TRUE (positive edge)
LD	Input	BOOL	Reset the counter to start value
PV	Input	INT	Start value of counter
Q	Output	BOOL	Status of counter (CV <= 0)
CV	Output	INT	Counter value

5.6.6 CTD_DINT down counter

Symbol



Description

The method of operation is the same as for the CTD up counter except for the following:

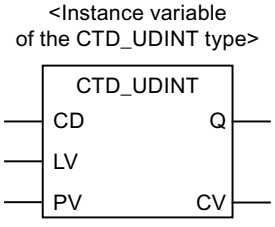
The CV and PV parameters are both DINT data types, which means that the minimum counter reading possible is -2147483648 (= 16#8000_0000).

Table 5-21 Parameters for CTD_DINT

Identifier	Parameter	Data type	Description
CD	Input	BOOL	Count down if value changes from FALSE to TRUE (positive edge)
LD	Input	BOOL	Reset the counter to start value
PV	Input	DINT	Start value of counter
Q	Output	BOOL	Status of counter (CV <= 0)
CV	Output	DINT	Counter value

5.6.7 CTD_UDINT down counter

Symbol



Description

The method of operation is the same as for the CTD up counter except for the following:

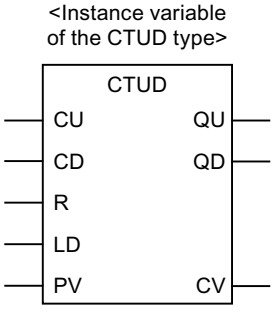
The CV and PV parameters are both UDINT data types, which means that the minimum counter value possible is 0.

Table 5-22 Parameters for CTD_DINT

Identifier	Parameter	Data type	Description
CD	Input	BOOL	Count down if value changes from FALSE to TRUE (positive edge)
LD	Input	BOOL	Reset the counter to start value
PV	Input	UDINT	Start value of counter
Q	Output	BOOL	Status of counter (CV <= 0)
CV	Output	UDINT	Counter value

5.6.8 CTUD up/down counter

Symbol



Description

The CTUD counter allows you to perform both upward and downward counting operations.

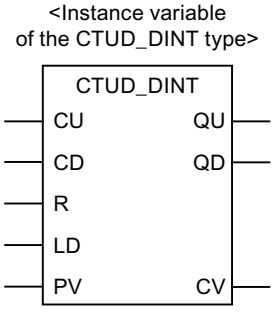
- Reset the CV count variable:
  - If the input is R = TRUE when the FB is called up, then the CV output is reset to 0.
  - If the LD input = TRUE when the FB is called, then the CV output is reset to start value PV.
- Count:
  - If the CU input changes from FALSE to TRUE (0 to 1) when the FB is called (positive edge), then the CV output is incremented by 1.
  - If the CD input changes from FALSE to TRUE (0 to 1) when the FB is called up (positive edge), then the CV output is decremented by 1.
- Counter status QU or QD:
  - Output Q specifies whether CV is greater than or equal to comparison value PV.
  - Output QD specifies whether CV is less than or equal to 0.

Table 5-23 Parameters for CTUD

Identifier	Parameters	Data type	Description
CU	Input	BOOL	Count up if value changes from FALSE to TRUE (positive edge)
CD	Input	BOOL	Count down if value changes from FALSE to TRUE (positive edge)
R	Input	BOOL	Reset the counter to 0 (up counter)
LD	Input	BOOL	Reset the counter to PV start value (down counter)
PV	Input	INT	Comparison value (for up counter) Start value (for down counter)
QU	Output	BOOL	Status as up counter (CV >= PV)
QD	Output	BOOL	Status as down counter (CV <= 0)
CV	Output	INT	Counter value

5.6.9 CTUD_DINT up/down counter

Symbol



Description

The method of operation is the same as for the CTUD up counter except for the following:

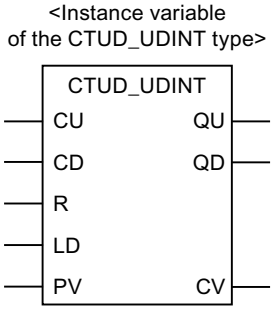
The CV and PV parameters are both DINT data types.

Table 5-24 Parameters for CTD_DINT

Identifier	Parameters	Data type	Description
CU	Input	BOOL	Count up if value changes from FALSE to TRUE (positive edge)
CD	Input	BOOL	Count down if value changes from FALSE to TRUE (positive edge)
R	Input	BOOL	Reset the counter to 0 (up counter)
LD	Input	BOOL	Reset the counter to PV start value (down counter)
PV	Input	DINT	Comparison value (for incrementer) Start value (for decrementer)
QU	Output	BOOL	Status as up counter (CV >= PV)
QD	Output	BOOL	Status as down counter (CV <= 0)
CV	Output	DINT	Counter value

5.6.10 CTUD_UDINT up/down counter

Symbol



Description

The method of operation is the same as for the CTUD up counter except for the following:

The CV and PV parameters are both UDINT data types.

Table 5-25 Parameters for CTD_DINT

Identifier	Parameter	Data type	Description
CU	Input	BOOL	Count up if value changes from FALSE to TRUE (positive edge)
CD	Input	BOOL	Count down if value changes from FALSE to TRUE (positive edge)
R	Input	BOOL	Reset the counter to 0 (up counter)
LD	Input	BOOL	Reset the counter to PV start value (down counter)
PV	Input	UDINT	Comparison value (for incrementer) Start value (for decrementer)
QU	Output	BOOL	Status as up counter (CV >= PV)
QD	Output	BOOL	Status as down counter (CV <= 0)
CV	Output	UDINT	Counter value

5.7 Jump instructions

5.7.1 Overview of jump operations

Description

Jump operations can be used in all logic blocks, e.g. programs, function blocks (FBs), and functions (FCs).

Jump label as operand

The operand of a jump operation is a jump label. The jump label specifies the point to where the program is to jump.

Enter the jump label via the JMP coil. The jump label consists of up to 480 characters. The first character must be a letter, the other characters can be either letters or numbers (e.g. SEG3).

Jump label as target

The target jump label can be at the start of a network.

See also

Showing/hiding a jump label (Page 73)

5.7.2 ---(JMP) Jump in block if 1 (conditional)

Symbol

<jump label>

---(JMP)

Description

---(JMP) (Jump in block if 1) functions as a conditional jump if the pending signal of the previous logic operation is **1**.

There must also be a target (LABEL) for every ---(JMP).

The operations between the jump operation and the jump label are not executed!

Note

An unconditional jump is created by hanging the --(JMP) element directly on the power rail.

5.7.3 ---(JMPN) Jump in block if 0 (conditional)

Symbol

<jump label>

---(JMPN)

Description

---(JMPN) (Jump in block if 0) functions as a conditional jump if the pending signal of the previous logic operation is **0**.

There must also be a target (LABEL) for every ---(JMPN).

The operations between the jump operation and the jump label are not executed!

5.7.4 LABEL Jump label

Symbol

Description

LABEL marks the target of a jump operation. It can have a maximum of 80 characters. The first character must be a letter, the other characters can be letters or numbers, e.g. CAS1.

There must be a target (LABEL) for every ---(JMP) or ---(JMPN).

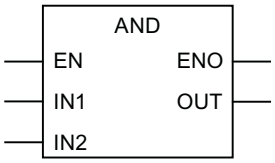
Note

Only alphanumeric characters are allowed during input. The jump label is deleted if it contains an error and cannot be corrected.

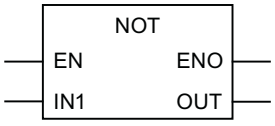
5.8 Non-binary logic

Symbol

e.g. AND



e.g. NOT



Description

Logic operations (AND, OR, XOR, NOT) are also provided as boxes with EN/ENO for non-binary values in the LAD/FBD editor.

The logical operations are listed in the table below.

There is only one operand for **NOT**.

Note

In the Command library tab of the project navigator, the elements **AND**, **XOR**, and **OR, NOT** are represented in the **Logic** entry.

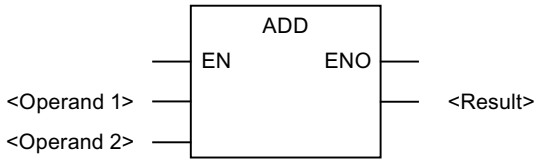
Table 5-26 Non-binary logic

Operator Parameters	AND	XOR	OR	NOT
IN1	ANY_BIT	ANY_BIT	ANY_BIT	ANY_BIT
IN2	ANY_BIT	ANY_BIT	ANY_BIT	
EN	BOOL	BOOL	BOOL	BOOL
ENO	BOOL	BOOL	BOOL	BOOL
OUT	ANY_BIT	ANY_BIT	ANY_BIT	ANY_BIT

5.9 Arithmetic operators

Symbol

e.g. addition



Description

An arithmetic expression is composed of arithmetic operators. These expressions allow numerical data types to be processed.

The divide operators DIV and MOD require that the second operand is not equal to zero.

Note

In the Command library tab of the project navigator, the elements **ADD**, **SUB**, **MUL**, and **DIV** are represented as **+**, **-**, *****, and **/**.

The execution of a network, for example, is simply aborted in the event of an overflow, and the relevant/assigned event-triggered task (ExecutionFaultTask) is started.

The table below contains a list of the arithmetic operators:

Table 5-27 Arithmetic operators

Instruction	Operator	1. Operand (IN1)	2. Operand (IN2)	Result (OUT)
Addition	ADD	ANY_NUM	ANY_NUM	ANY_NUM[1]
		BYTE	BYTE	BYTE
		WORD	WORD	WORD
		DWORD	DWORD	DWORD
		TIME	TIME	TIME[2]
		TOD	TIME	TOD[2]
		DT	TIME	DT[3]
Multiplication	MUL	ANY_NUM	ANY_NUM	ANY_NUM[1]
		BYTE	BYTE	BYTE
		WORD	WORD	WORD
		DWORD	DWORD	DWORD
		TIME	ANY_INT	TIME

Instruction	Operator	1. Operand (IN1)	2. Operand (IN2)	Result (OUT)
Subtraction	SUB	ANY_NUM	ANY_NUM	ANY_NUM[1]
		BYTE	BYTE	BYTE
		WORD	WORD	WORD
		DWORD	DWORD	DWORD
		TIME	TIME	TIME
		TOD	TIME[4]	TOD
		TOD	TOD	TIME[5]
		DT	TIME	DT
		DT	DT	TIME[5]
Division	DIV	ANY_NUM	ANY_NUM[6]	ANY_NUM[1]
		BYTE	BYTE[6]	BYTE
		WORD	WORD[6]	WORD
		DWORD	DWORD[6]	DWORD
		TIME	ANY_INT[6]	TIME
		TIME	TIME[6]	UDINT
Modulo division.	MOD	ANY_INT	ANY_INT[6]	ANY_INT[1]
		BYTE	BYTE[6]	BYTE
		WORD	WORD[6]	WORD
		DWORD	DWORD[6]	DWORD

[1] The data types of the operands and of the result must be identical.

[2] Addition, possibly with overflow.

[3] Addition with date correction.

[4] Restriction of TIME to TOD before calculation.

[5] These operations are based on the modulo of the maximum value of the TIME data type.

[6] The second operand must not be equal to zero.

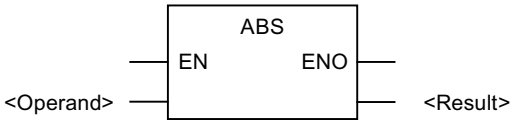
5.10 Numeric standard functions

Every numeric standard function has an input parameter. The result is always the function value.

5.10.1 General numeric standard functions

Symbol

e.g. absolute value



Description

General numeric standard functions are used for:

- Calculation of the absolute value of a variable
- Calculation of the square root of a variable

The table below shows the general numeric standard functions:

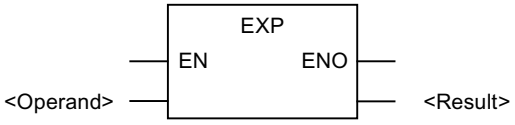
Table 5-28 General numeric standard functions

Function name	Input parameter data type (IN)	Function value data type (OUT)	Description
ABS	ANY_NUM	ANY_NUM[1]	Absolute value
SQRT	ANY_REAL	ANY_REAL[1]	Square root
[1] Identical to the data type of the input parameter IN			

5.10.2 Logarithmic standard functions

Symbol

e.g. exponential value



Description

Logarithmic standard functions are functions for calculating an exponential value or a logarithm of a value.

The table below shows the logarithmic standard functions:

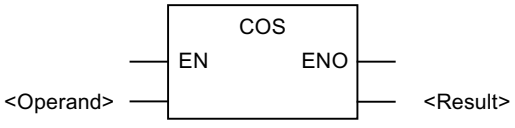
Table 5-29 Logarithmic standard functions

Function name	Input parameter data type (IN)	Data type of function value (OUT)	Description
EXP	ANY_REAL	ANY_REAL[1]	e^x (natural exponential function)
EXPD	ANY_REAL	ANY_REAL[1]	10^x (decimal exponential function)
EXPT	ANY_REAL (IN1) ANY_NUM (IN2)	ANY_REAL[2]	Exponentiation
LN	ANY_REAL	ANY_REAL[1]	Natural logarithm
LOG	ANY_REAL	ANY_REAL[1]	Common logarithm
[1] Identical to the data type of the input parameter IN [2] Identical to the data type of the input parameter IN1			

5.10.3 Trigonometric standard functions

Symbol

e.g. COS



Description

The trigonometric standard functions listed in the table expect and calculate variables of angles in radian measure.

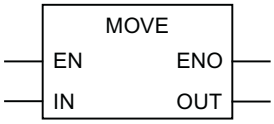
Table 5-30 Trigonometric standard functions

Function name	Input parameter data type	Data type of function value	Description
ACOS	ANY_REAL	ANY_REAL	Arc cosine (main value)
ASIN	ANY_REAL	ANY_REAL	Arc sine (main value)
ATAN	ANY_REAL	ANY_REAL	Arc tangent (main value)
COS	ANY_REAL	ANY_REAL	Cosine (radian measure input)
SIN	ANY_REAL	ANY_REAL	Sine (radian measure input)
TAN	ANY_REAL	ANY_REAL	Tangent (radian measure input)

5.11 Move

5.11.1 MOVE Transfer value

Symbol



Parameters	Data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
IN	ANY	Source value
OUT	ANY	Destination address

Description

MOVE (Assign a value) is activated by the enable input EN. The value specified by the IN input is copied to the value specified in the OUT output. ENO has the same signal state as EN.

5.12 Shifting operations

5.12.1 Overview of shifting operations

Description

The contents of input IN can be moved bit-by-bit to the left or right using shifting operations. A shift of n bits to the left multiplies the contents of input IN by 2 to the power of n; a shift of n bits to the right divides the contents of input IN by 2 to the power of n. If, for example, you move the binary equivalent of the decimal value 3 by 3 bits to the left, this gives the binary equivalent of the decimal value 24. Shift the binary equivalent of the decimal value 16 by 2 bits to the right, this gives the binary equivalent of the decimal value 4.

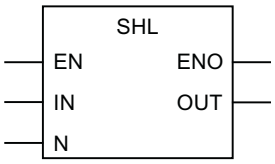
The number that you specify at input N indicates the number of bits by which to shift. The places which become free as a result of the shifting operation are filled up with zeroes.

The following shifting operations are available:

- shift bit to the left
- shift bit to the right

5.12.2 SHL Shift bit to the left

Symbol



Parameters	Data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
IN	ANY_BIT	Value to be shifted
N	USINT	Number of bit positions to be shifted
OUT	ANY_BIT	Result of shifting operation

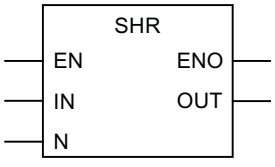
Description

SHL (e.g. shift left by 32 bits) is activated if the enable input (EN) has the signal state **1**. The operation SHL shifts the bits 0 to 31 of the input IN bit-by-bit to the left. Input N specifies the number of bit positions to be shifted. If N is greater than 32, the command writes a **0** in the OUT output. The same number (N) of zeros is shifted from the right in order to occupy the positions which have become free. The result of the shifting operation can be queried at output OUT.

ENO has the same signal state as EN.

5.12.3 SHR Shift bit to the right

Symbol



Parameters	Data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
IN	ANY_BIT	Value to be shifted
N	USINT	Number of bit positions to be shifted
OUT	ANY_BIT	Result of shifting operation

Description

SHR (e.g. shift right by 32 bits) is activated if the enable input (EN) has the signal state 1. The operation SHR shifts the bits 0 to 31 of the input IN bit-by-bit to the right. Input N specifies the number of bit positions to be shifted. If N is greater than 32, the command writes a 0 in the OUT output. The same number (N) of zeros is shifted from the left in order to occupy the positions which have become free. The result of the shifting operation can be queried at output OUT.

ENO has the same signal state as EN.

5.13 Rotating operations

5.13.1 Overview of rotating operations

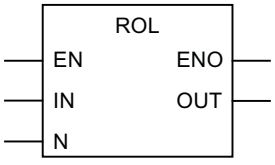
Description

The entire contents of input IN can be rotated bit-by-bit to the left or right using rotating operations. The positions which become free are filled up with the signal states of the bits which have been moved out of the IN input.

At the input N you can specify the number of bits for the rotation.

5.13.2 ROL Rotate bit to the left

Symbol



Parameters	Data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
IN	ANY_BIT	Value to be rotated
N	USINT	Number of bit positions to be rotated
OUT	ANY_BIT	Result of rotation operation

Description

ROL (e.g. rotate left by 32 bits) is activated if the enable input (EN) has the signal state **1**. The operation ROL rotates the entire contents of the IN input bit-by-bit to the left. Input N specifies the number of bit positions by which to rotate. If N is greater than 32, the double word IN is rotated by ((N-1) modulo 32)+1 positions. The bit positions coming from the right are occupied with the signal state of the bits which have been rotated to the left (left rotation). The result of the rotation operation can be queried at output OUT.

ENO has the same signal state as EN.

Example

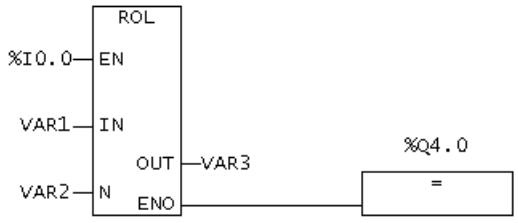


Figure 5-3 Representation in the FBD editor

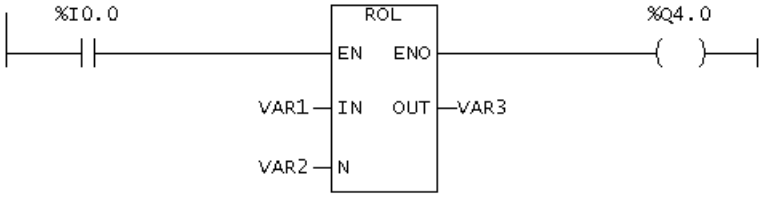
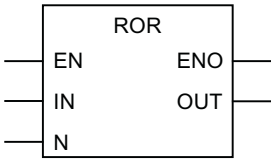


Figure 5-4 Representation in the LAD editor

The ROL box is executed if %I 0.0 = 1. VAR1 is loaded and rotated to the left by the number of bits specified in VAR2. The result is written to VAR3. %Q 4.0 is set.

5.13.3 ROR Rotate bit to the right

Symbol



Parameter	Data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
IN	ANY_BIT	Value to rotate
N	USINT	Number of bit positions to rotate
OUT	ANY_BIT	Result of rotation operation

Description

ROR (e.g. rotate right by 32 bits) is activated if the enable input (EN) has the signal state 1. The operation ROR rotates the entire contents of the IN input bit-by-bit to the right. Input N specifies the number of bit positions by which to rotate. If N is greater than 32, the double word IN is rotated by ((N-1) modulo 32)+1 positions. The bit positions coming from the left are occupied by the signal state of the bits which have been rotated to the right (right rotation). The result of the rotation operation can be queried at output OUT.

ENO has the same signal state as EN.

Example

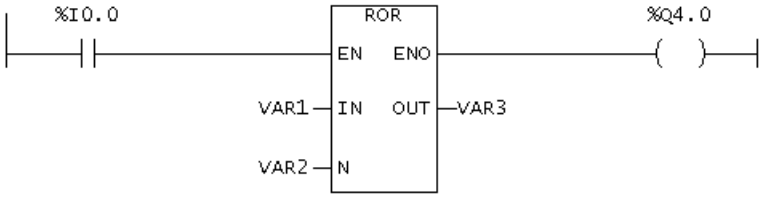


Figure 5-5 Representation in the LAD editor

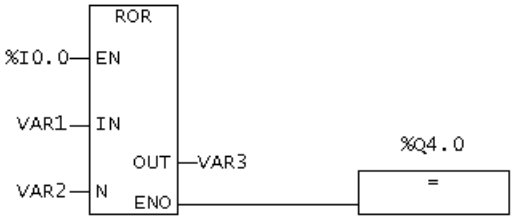


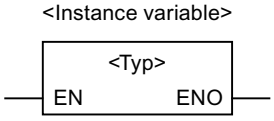
Figure 5-6 Representation in the FBD editor

The ROR box is executed if %I 0.0 = 1. VAR1 is loaded and rotated to the right by the number of bits specified in VAR2. The result is written to VAR3. %Q 4.0 is set.

5.14 Program control instructions

5.14.1 Calling up an empty box

Symbol



Parameters	Data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
<Type>	FB / FC	FC/FB type
<Instance variable>	FB	FB instance variable

Description

The symbol for an empty box depends on the function block/function (according to how many parameters there are). EN, ENO and the name of the FB/FC must be available.

You do not have to specify EN/ENO in the variable declaration. The input and output are automatically allocated by the system.

The EN input can be used to inhibit a block call and redirect the block of the EN input to the ENO output.

It is not possible to control the ENO output in the block itself.

Note

You can use an empty box to insert a call (Page 80). As soon as you enter the type, the box transforms and displays the parameters of the specified FB/FC call.

See also

Inserting LAD/FBD elements (Page 80)

5.14.2 RET Jump back

Symbol

---(RET)

Description

RET (jump back) is used for the conditional exit from blocks. A preceding logic operation is necessary for this output.

Example

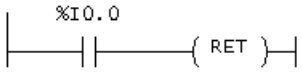


Figure 5-7 Representation in the LAD editor

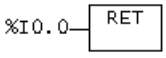


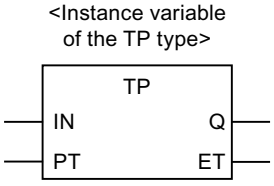
Figure 5-8 Representation in the FBD editor

The operation is executed if %I 0.0 = 1.

5.15 Timer instructions

5.15.1 TP pulse

Symbol



Description

With a signal state change from 0 to 1 at the IN input, time ET is started. Output Q remains at 1 until elapsed time ET is equal to programmed time value PT. As long as time ET is running, the IN input has no effect.

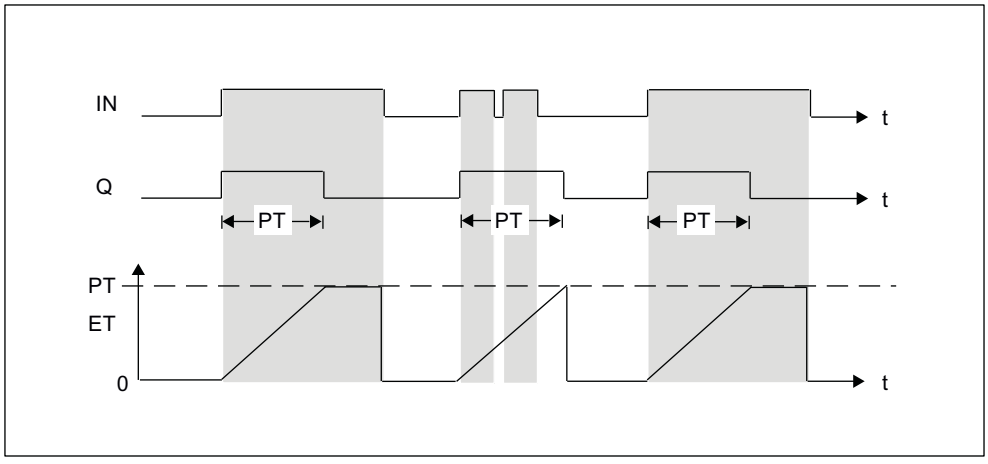


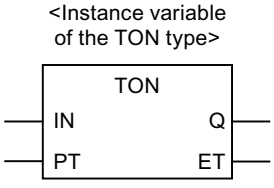
Figure 5-9 Mode of operation of TP pulse timer

Table 5-31 Call parameters for TP

Identifier	Parameters	Data type	Description
IN	Input	Input	Start input
PT	Input	TIME	Duration of pulse
Q	Output	BOOL	Status of time
ET	Output	TIME	Elapsed time

5.15.2 TON ON delay

Symbol



Description

With the signal state change from 0 to 1 at the IN input, time ET is started. The output signal Q only changes from 0 to 1 if the time ET = PT has elapsed and the input signal IN still has the value 1, i.e. the output Q is switched on with a delay. Input signals of shorter durations than programmed time PT do not appear at the output.

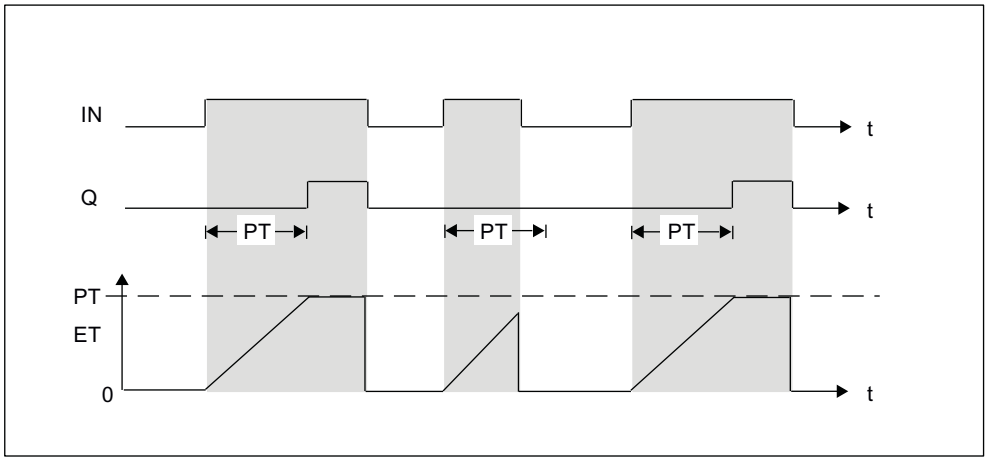


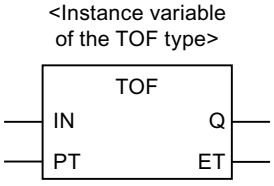
Figure 5-10 Mode of operation of TON on delay timer

Table 5-32 Call parameters for TON

Identifier	Parameters	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration for which the rising edge at input IN is delayed.
Q	Output	BOOL	Status of time
ET	Output	TIME	Elapsed time

5.15.3 TOF OFF delay

Symbol



Description

With a signal state change from 0 to 1 at start input IN, state 1 appears at output Q. If the state at the start input IN changes from 1 to 0, then time ET is started. If a change occurs at input IN from 0 to 1 before time ET has elapsed, then the timer operation is reset. A start is initiated again when the state at input IN changes from 1 to 0. Only after the duration ET = PT has elapsed does output Q adopt a signal state of 0. This means that the output is switched off with a delay.

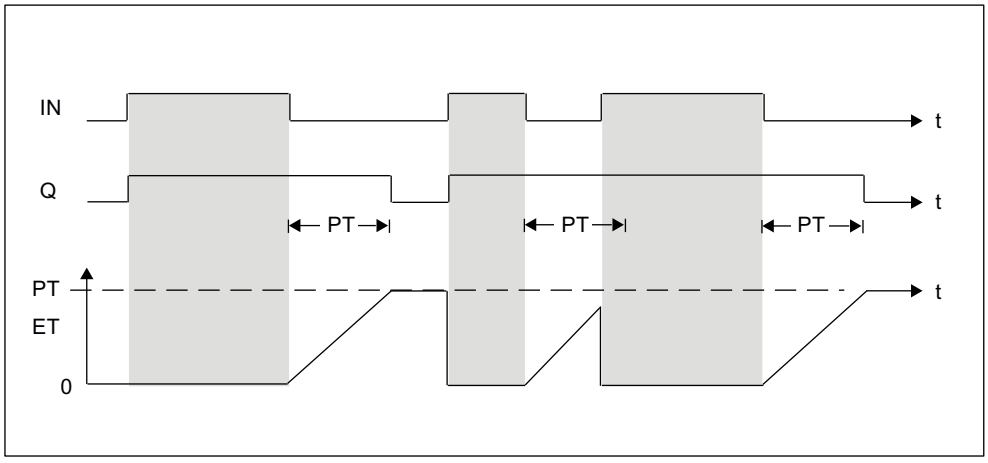


Figure 5-11 Mode of operation of TOF off delay timer

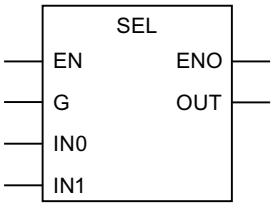
Table 5-33 Call parameters for TOF

Identifier	Parameters	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration for which the falling edge at input IN is delayed.
Q	Output	BOOL	Status of time
ET	Output	TIME	Elapsed time

5.16 Selection functions

5.16.1 SEL Binary selection

Symbol



Parameters	Input parameter data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
G	BOOL	Input parameter
IN0	ANY	Input parameter
IN1	ANY	Input parameter

Description

The function value is one of the input parameters IN0 or IN1, depending on the value of the input parameter G.

The input parameters IN0 and IN1 must be the same data type or must be capable of implicit conversion into the same data type.

The return value is data type ANY.

Selected input parameter

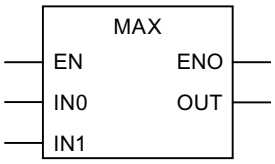
IN0 if G = 0 (FALSE)

IN1 if G = 1 (TRUE)

The data type corresponds to the common data type of the input parameters IN0 and IN1.

5.16.2 MAX Maximum function

Symbol



Parameter	Input parameter data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
IN0	ANY_ELEMENTARY	Input parameter
IN1	ANY_ELEMENTARY	Input parameter

Description

The function value is the maximum value of both input parameters IN0 and IN1.

The input parameters IN0 and IN1 must be the same data type or must be capable of implicit conversion into the most powerful data type.

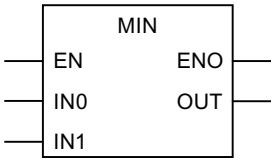
The return value is of data type ANY_ELEMENTARY.

Maximum of the input parameters.

The data type corresponds to the most powerful data type of the input parameters IN0 and IN1.

5.16.3 MIN Minimum function

Symbol



Parameter	Input parameter data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
IN0	ANY_ELEMENTARY	Input parameter
IN1	ANY_ELEMENTARY	Input parameter

Description

The function value is the minimum value of both input parameters IN0 and IN1.

All IN0 and IN1 input parameters must be the same data type or capable of implicit conversion into the most powerful data type.

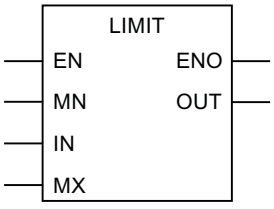
The return value is of data type ANY_ELEMENTARY.

Minimum of the input parameters.

The data type corresponds to the most powerful data type of the input parameters IN0 and IN1.

5.16.4 LIMIT Limiting function

Symbol



Parameters	Input parameter data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
MN	ANY_ELEMENTARY	Input parameter Lower limiting value
IN	ANY_ELEMENTARY	Input parameter Value to be limited
MX	ANY_ELEMENTARY	Input parameter Upper limiting value

Description

The input parameter IN is limited to values lying between the lower limit value MN and the upper limit value MX.

All input parameters must be the same data type or capable of conversion into the most powerful data type by implicit conversion.

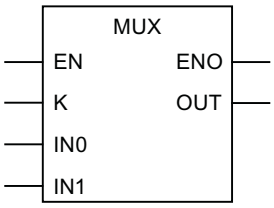
The return value is of data type ANY_ELEMENTARY.

MIN (MAX (IN, MN), MX)

The data type corresponds to the most powerful data type of the input parameters.

5.16.5 MUX Multiplex function

Symbol



Parameters	Input parameter data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
C	ANY_INT	Input parameter
IN0	ANY	Input parameter
IN1	ANY	Input parameter

Description

The function value is one of the two input parameters IN0 or IN1, depending on the value of the input parameter K.

The input parameters IN0 and IN1 must be the same data type or must be capable of implicit conversion into the same data type.

The return value is data type ANY.

The data type corresponds to the common data type of the input parameters IN0 and IN1.

Commissioning (software) 6

6.1 Commissioning

This chapter describes how to assign created programs to the task system of a control unit and how to download them to the target system.

6.2 Assigning programs to a task

Programs must be assigned to a task before they can be downloaded to the target system (the SIMOTION device).

Various tasks are made available by SIMOTION, each with different priorities or system responses (e.g. during initialization).

Further information can be found in the SIMOTION SCOUT Basic Functions Function Manual, and in SIMOTION online help.

Assigning programs to a task:

1. In the project navigator, double-click under the corresponding SIMOTION device the **EXECUTION SYSTEM** element.
   The configuration window for the execution system opens.
2. Select the required task (e.g. MotionTask_1) from the left pane.
3. Select the **Program assignment** tab.
4. Select the program to be assigned from the **Programs** list.

5. Click the button **>>**.
6. Select the **Task configuration** tab to specify additional settings for the task if required.

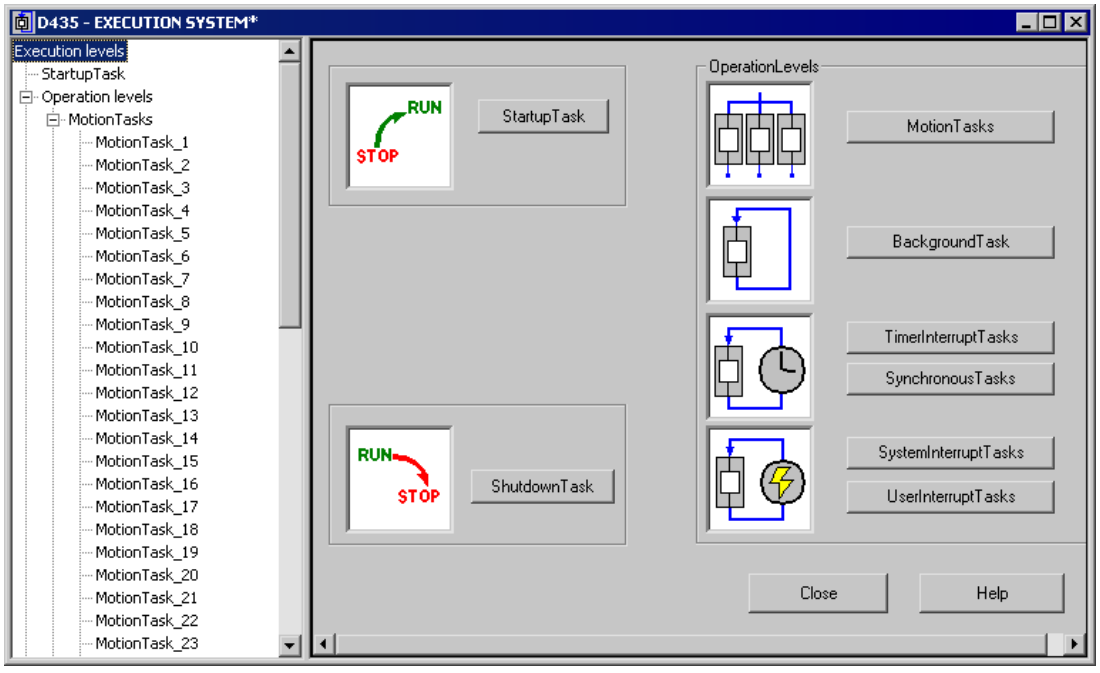


Figure 6-1 Configure execution system

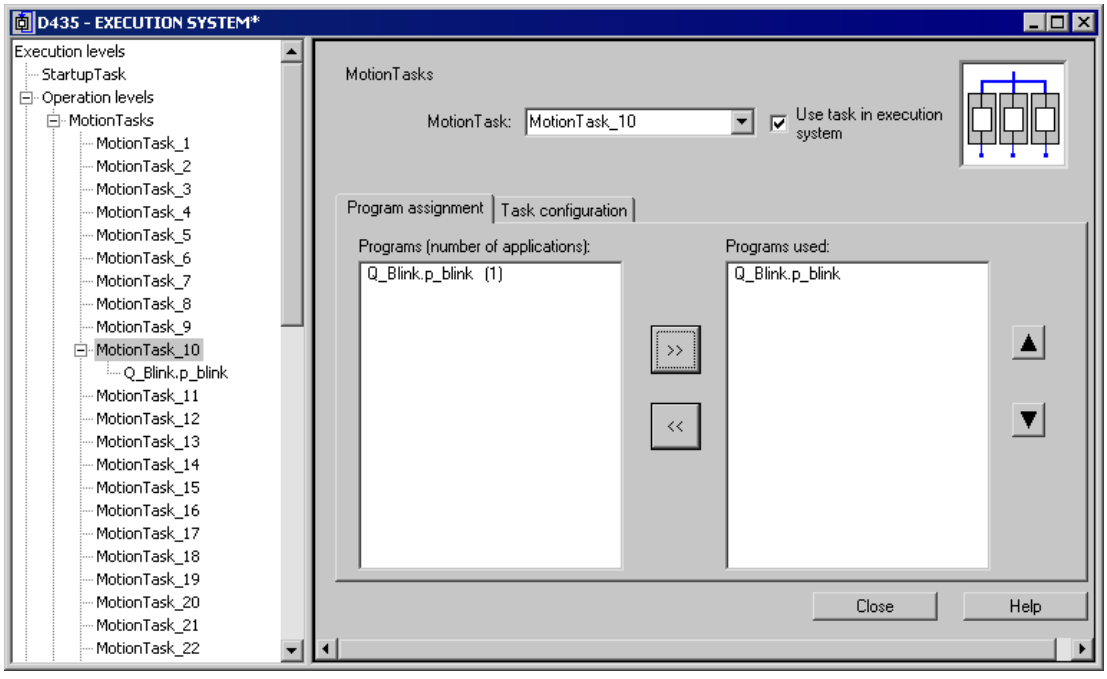


Figure 6-2 Assigning a program to a motion task

6.3 Execution levels and tasks in SIMOTION

Here the execution levels and the tasks assigned are shown in tabular format for an initial overview.

Further information on execution levels and tasks can be found in the SIMOTION Basic Functions Function Manual.

Table 6-1 Description of the execution levels and of the tasks

Execution level	Description
Time-controlled	Cyclic tasks: They are restarted automatically once the assigned programs have been executed.
• SynchronousTasks	Tasks are started periodically, synchronous with specified system cycle clock. • ServoTask_Fast: Synchronous with Servo_fast cycle clock. The Servo_fast cycle clock is a second servo cycle clock and only available: – For D445-2 DP/PN and D455-2 DP/PN as of version V4.2 – For D435-2 DP/PN as of version V4.3. • ServoSynchronousTask: Synchronous with the position control cycle clock • IpoTask_Fast: Synchronous with IPO_fast cycle clock. The IPO_fast cycle clock is the IPO cycle clock for the second servo cycle clock and only available: – For D445-2 DP/PN and D455-2 DP/PN as of version V4.2 – For D435-2 DP/PN as of version V4.3. • IPOsynchronousTask: Synchronous with interpolator cycle clock IPO • IPOsynchronousTask_2: Synchronous with interpolator cycle clock IPO_2 • PWMsynchronousTask: Synchronous with PWM cycle clock (for TControl technology package) • InputSynchronousTask_1: Synchronous with Input1 cycle clock (for TControl technology package) • InputSynchronousTask_2: Synchronous with Input2 cycle clock (for TControl technology package) • PostControlTask_1: Synchronous with Control1 cycle clock (for TControl technology package) • PostControlTask_2: Synchronous with Control2 cycle clock (for TControl technology package)
• TimerInterruptTasks	Tasks are started periodically in a fixed time frame. This time frame must be a multiple of interpolator cycle clock IPO.
Interrupts	Sequential tasks: They are executed once after the start and then terminated.
• SystemInterruptTasks	Started when a system event occurs: • ExecutionFaultTask: Error processing a program • PeripheralFaultTask: Error on I/O • TechnologicalFaultTask: Error on the technology object • TimeFaultBackgroundTask: BackgroundTask timeout • TimeFaultTask: TimerInterruptTask timeout
• UserInterruptTasks	They are started when a user-defined event occurs.

Execution level	Description
Round robin	MotionTasks and BackgroundTasks share the free time remaining after execution of the higher-priority system and user tasks. The proportion of the two levels can be assigned.
• MotionTasks	Sequential tasks: They are executed once after the start and then terminated. Start takes place: • Explicitly via a task control command in a program assigned to another task. • Automatically when RUN operating state is attained if the corresponding attribute was set during task configuration. The priority of a MotionTask can be increased temporarily: • In the MCC programming language with the "Wait for..." commands, see Wait for axis, Wait for signal, Wait for condition. • In the ST programming language with the WAITFORCONDITION statement.
• BackgroundTask	Cyclic task: It is restarted automatically once the assigned programs have been executed. The task cycle time depends on the runtime.
StartupTask	Task is executed once when there is a transition from STOP or STOP U operating state to RUN operating state. SystemInterruptTasks are started by their triggering system event.
ShutdownTask	Task is executed once when there is a transition from RUN operating state to STOP or STOP U operating state. STOP or STOP U operating state is reached by: • Activating the operating state switch • Calling the relevant system function, for example, MCC Change operating state command • Occurrence of a fault with the appropriate error response SystemInterruptTasks and PeripheralFaultTasks are started by their triggering system event.
For information on the behavior of sequential and cyclic tasks: • During initialization of local program variables: See Initialization of local variables (Page 127). • In the event of execution errors in the program: See SIMOTION Basic Functions Function Manual. For information about options for accessing the process image and I/O variables: see Important properties for direct access and process image (Page 141).	

6.4 Task start sequence

When the StartupTask is completed, RUN mode is reached.

The following tasks are then started:

- SynchronousTasks
- TimerInterruptTasks
- BackgroundTask
- MotionTasks with startup attribute.

Note

The sequence in which these tasks are first started after RUN mode has been reached does not conform to the task priorities.

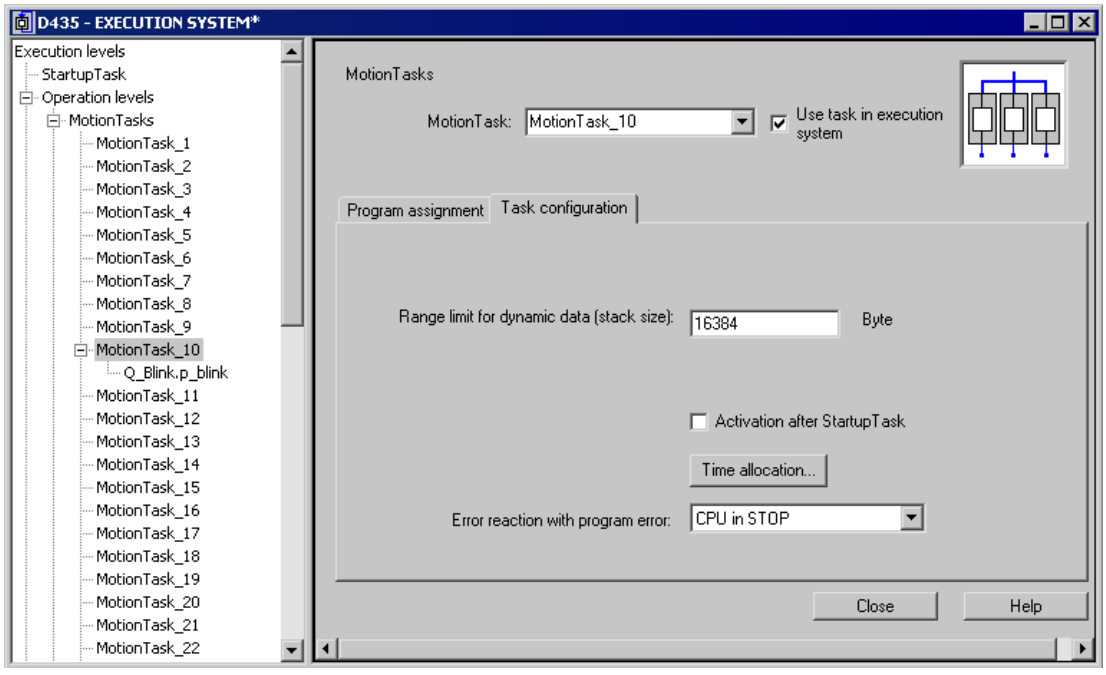


Figure 6-3 Task configuration of a motion task

6.5 Downloading programs to the target system

The program has to be downloaded into the target system, together with the technology objects etc., before being executed.

To download the program to the target system, proceed as follows:

1. Select **Project > Save and recompile all**.
   The project is locally saved on the hard disk and compiled, with due regard for all dependencies.
2. Select the **Project > Check consistency** menu command to check the project for consistency. This is not necessary if the **Check consistency before loading** option is activated under **Options > Settings** on the **Download** tab (this option is activated by default). This means the consistency check is performed automatically during the download to the target system.

3. Select the **Project > Connect to selected target devices** menu command or click  .
   Online mode is activated.
4. Select the **Target system > Load > Download project to target system** menu command or click  .
   The project data (including the sample program) and the data of the hardware configuration are downloaded to the RAM of the target system.

For more information about downloading a program to the target system, see the SIMOTION Basic Functions Function Manual.

Debugging Software / Error Handling 7

7.1 Operating modes for program testing

7.1.1 Modes of the SIMOTION devices

Various SIMOTION device operating modes are available for program testing.

Table 7-1 Operating modes of a SIMOTION device

Operating mode	Meaning
Process mode	Program execution on the SIMOTION device is optimized for maximum system performance. The following diagnostic functions are available, although they may have only restricted functionality because of the optimization for maximum system performance: • Monitor variables in the symbol browser or a watch table • Program status (only restricted): – Restricted monitoring of variables (e.g. variables in loops, return values for system functions). – Maximum of 1 program source (e.g. ST source file, MCC unit, LAD/FBD unit)[1] can be monitored. • Trace tool (only restricted) with measuring functions for drives and function generator, see online help: – Maximum of **1** trace on each SIMOTION device.
Test mode	The diagnostic functions of the process mode are available to the full extent: • Monitor variables in the symbol browser or a watch table • Program status: – Monitoring of all variables possible. – As of version V4.0 of the SIMOTION Kernel: Several program sources (e.g. ST source files, MCC units, LAD/FBD units)[1] can be monitored per task. – For version V3.2 of the SIMOTION Kernel: Maximum of 1 program source (e.g. ST source file, MCC unit, LAD/FBD unit)[1] can be monitored per task. • Trace tool with measuring functions for drives and function generator, see online help: – Maximum of **4** traces on each SIMOTION device. In addition, the following diagnostics function is available: • Trace for monitoring the program execution in program branches which are executed cyclically (only for the MCC programming language and for SIMOTION Kernel V4.2 and higher). **Note** Runtime and memory utilization increase as the use of diagnostic functions increases.

Operating mode	Meaning
Debug mode	In addition to the diagnostic functions of the test mode, you can use the following functions: • Breakpoints Within a program source, you can set breakpoints (Page 302). When an activated breakpoint is reached, selected tasks will be stopped. • Controlling MotionTasks On the "Task Manager" tab of the device diagnostics, you can use task control commands for MotionTasks; see the SIMOTION Basic Functions Function Manual. No more than 1 SIMOTION device of the project can be switched to debug mode. SIMOTION SCOUT is in online mode, i.e. connected to the target system. Observe the following section: Important information about the life-sign monitoring (Page 285).

[1] Each with 1 MCC chart or 1 LAD/FBD program in a program source.

Selecting the operating mode

How to select the operating mode of a SIMOTION device:

1. Make sure a connection to the target system has been established (online mode).
2. Highlight the SIMOTION device in the project navigator.
3. Select the "Operating mode" context menu.
4. Select the required operating mode (see the table above).
   If you have selected "Debug mode":
   – Accept the safety information.
   – Parameterize the sign-of-life monitoring.

   Observe the following section: Important information about the life-sign monitoring (Page 285).
5. Confirm with **OK**.
   The SIMOTION device switches to the selected operating mode (apart from with debug mode; see the explanation below).

Special features with debug mode

Debug mode can only be selected for one SIMOTION device.

If you have selected debug mode, only SIMOTION SCOUT switches to it; the SIMOTION device is in test mode.

- The project navigator indicates that debug mode is activated for SIMOTION SCOUT by means of a symbol next to the SIMOTION device.
- The breakpoints toolbar (Page 307) is displayed.

Debug mode is not enabled for the SIMOTION device until at least one set breakpoint is activated. If all breakpoints are deactivated, debug mode is canceled for the SIMOTION device.

The status bar indicates that debug mode is activated for the SIMOTION device.

7.1.2 Important information about the life-sign monitoring.

⚠ WARNING

Dangerous plant states possible

If problems occur in the communication link between the PC and the SIMOTION device, this may result in dangerous plant states (e.g. the axis may start moving in an uncontrollable manner).

Therefore, use the debug mode or a control panel only with the life-sign monitoring function activated with a suitably short monitoring time!

You must observe the appropriate safety regulations.

The function is released exclusively for commissioning, diagnostic and service purposes. The function should generally only be used by authorized technicians. The safety shutdowns of the higher-level control have no effect.

Therefore, there must be an EMERGENCY STOP circuit in the hardware. The appropriate measures must be taken by the user.

In the following cases, the SIMOTION device and SIMOTION SCOUT regularly exchange life-signs to ensure a correctly functioning connection:

- In debug mode with activated breakpoints.
- When controlling an axis or a drive via the control panel (control priority at the PC):

If the exchange of the life-signs is interrupted longer than the set monitoring time, the following reactions are triggered:

- In debug mode for activated breakpoints:
  - The SIMOTION device switches to the STOP operating state.
  - The outputs are deactivated (ODIS).
- For controlling an axis or a drive using the control panel (control priority for the PC):
  - The axis is brought to a standstill.
  - The enables are reset.

Accept safety notes

After selecting the debug mode or a control panel, you must accept the safety notes. You can set the parameters for the life-sign monitoring.

Proceed as follows:

1. Click the **Settings** button.
   The "Debug Settings" window opens.
2. Read there, as described in the following section, the safety notes and parameterize the life-sign monitoring.

Parameterizing the life-sign monitoring

In the "Life-Sign Monitoring Parameters" window, proceed as described below:

1. Read the warning!
2. Click the **Safety notes** button to open the window with the detailed safety notes.
3. Do not make any changes to the defaults for life-sign monitoring.
   Changes should only be made in special circumstances and in observance of all danger warnings.
4. Click **Accept** to confirm you have read the safety notes and have correctly parameterized the life-sign monitoring.

Note

The life-sign monitoring also responds in the following cases:

- Pressing the spacebar.
- Switching to a different Windows application.
- Too high a communication load between the SIMOTION device and SIMOTION SCOUT (e.g. by uploading task trace data).

The following reactions are triggered:

- In debug mode for activated breakpoints:
  - The SIMOTION device switches to the STOP operating state.
  - The outputs are deactivated (ODIS).
- For controlling an axis or a drive using the control panel (control priority for the PC):
  - The axis or the drive is brought to a standstill.
  - The enables are reset.

⚠ WARNING

Dangerous plant states possible

This function is not guaranteed in all operating states.

Therefore, there must be an EMERGENCY STOP circuit in the hardware. The appropriate measures must be taken by the user.

7.1.3 Life-sign monitoring parameters

Table 7-2 Life-sign monitoring parameter description

Field	Description
Life-sign monitoring	The SIMOTION device and SIMOTION SCOUT regularly exchange life-signs to ensure a correctly functioning connection. If the exchange of the life-signs is interrupted longer than the set monitoring time, the following reactions are triggered: • In debug mode for activated breakpoints: – The SIMOTION device switches to the STOP operating state. – The outputs are deactivated (ODIS). • For controlling an axis or a drive using the control panel (control priority for the PC): – The axis is brought to a standstill. – The enables are reset. The following parameterizations are possible: • Checkbox **active**: If the checkbox is activated, life-sign monitoring is active. The deactivation of the life-sign monitoring is not always possible. • Monitoring time: Enter the timeout. **Prudence** Do not make any changes to the defaults for life-sign monitoring, if possible. Changes should only be made in special circumstances and in observance of all danger warnings.
Safety information	**Please observe the warning!** Click the button to obtain further safety information. See: Important information about the life-sign monitoring (Page 285)

7.2 Editing program sources in online mode

Online editing in process or test mode

If SIMOTION SCOUT is connected to a target system which is in the "process mode" or "test mode" operating mode, program sources (e.g. ST source files, MCC units with MCC charts) can generally be edited, compiled, and loaded to the target system in STOP operating mode. For information on downloading in RUN operating mode, see the corresponding section in the "SIMOTION Basic Functions" Function Manual.

However, you can only activate the "program status", "monitor program execution" (only for MCC), and trace (only for MCC) test functions for a program source or a program organization unit (POU) if the following conditions are met:

1. This program source or any POU of this source (e.g. MCC chart) does not contain any changes which have not been saved.
2. The program source (unit) in SCOUT is consistent with the target system.

Note

If the "program status" test function is activated, editing of the corresponding program source or one of its POUs is disabled.

If an MCC unit or MCC chart is changed and the "monitor program execution" or trace test functions are active for that unit or chart, the test functions are canceled.

Online editing in debug mode

If SIMOTION SCOUT is in debug mode, editing is possible as long as the SIMOTION device is not in debug mode, i.e. no breakpoints are activated.

You can only activate breakpoints and, as a result, switch the SIMOTION device to debug mode if the corresponding program source and all its POUs are saved, compiled so they are up to date, and consistent with the target system.

If you attempt to edit a program source or POU when the SIMOTION device is in debug mode, you are requested to deactivate all breakpoints and, as a result, to switch the SIMOTION device out of debug mode.

Note

If breakpoints have been activated and the SIMOTION device is in debug mode:

Entering a space switches the SIMOTION device to STOP operating mode and deactivates all outputs (ODIS).

7.3 Symbol Browser

7.3.1 Characteristics

In the symbol browser, you can view and, if necessary, change the name, data type, and variable values. You can see the following variables in particular:

- Unit variables and static variables of a program or function block
- System variables of a SIMOTION device or a technology object
- I/O variables or global device variables.

For these variables, you can:

- View a snapshot of the variable values
- Monitor variable values as they change
- Change (modify) variable values

However, the symbol browser can only display/modify the variable values if the project has been loaded in the target system and a connection to the target system has been established.

7.3.2 Using the symbol browser

Requirements

- Make sure that a connection to the target system has been established and a project has been downloaded to the target system (see Download programs to the target system (Page 281)).
- You can run the user program, but you do not have to. If the program is not run, you only see the initial values of the variables.

The procedure depends on the memory area in which the variables to be monitored are stored.

Procedure

Proceed as follows:

1. Select the appropriate element in the project navigator in accordance with the following table.
2. In the detail view, click the **Symbol browser** tab.
   The corresponding variables are displayed in the symbol browser.
3. Select how each variable in the "Display format" column should be displayed.

Table 7-3 Elements in the project navigator and variables to be monitored in the symbol browser

Variables to be monitored in the symbol browser	Element to be selected in the project navigator
Variables in the unit's user memory or in the retentive memory, see SIMOTION ST Programming and Operating Manual: • Retentive and non-retentive unit variables of the interface section of a program source (unit) • Retentive and non-retentive unit variables of the implementation section of a program source (unit) • Static variables of the function blocks whose instances are declared as unit variables. • In addition, if the program source (unit) has been compiled with the "Only create program instance data once" compiler option (Page 53): – Static variables of the programs. – Static variables of the function blocks whose instances are declared as static variables of programs.	Program source (unit)
Variables in the user memory of the task, see SIMOTION ST Programming and Operating Manual: If the program source (unit) was compiled without the "Only create program instance data once" (default) compiler option (Page 53), the user memory of the task to which the program was assigned contains the following variables: • Static variables of the programs. • Static variables of the function blocks whose instances are declared as static variables of programs.	EXECUTION SYSTEM
System variables of a SIMOTION device	SIMOTION device
System variables of a technology object	Instance of the technology object
Global device variables	GLOBAL DEVICE VARIABLES
I/O variables (in the Address list tab of the detail view). The Address list tab of the detail view can be opened by double-clicking the ADDRESS LIST element in the project navigator.	ADDRESS LIST

Note

You can monitor temporary variables (together with unit variables and static variables) with **Program status** (see Properties of the program status (Page 297)).

Note

Trace diagnostic function for MCC programming

Various internal variables, whose identifier begins with an underscore, are automatically created by the compiler for the trace diagnostic function. These variables are displayed in the symbol browser.

With activated diagnostic function, these variables are used for the control of the diagnostics function. These variables must not be used in the user program.

Status and controlling variables

In the **Status value** column, the current variable values are displayed and periodically updated.

You can change the value of one or several variables. Proceed as follows for the variables to be changed:

1. Enter a value in the **Control value** column.
2. Activate the checkbox in this column
3. Click the **Immediate control** button.

The values you entered are written to the selected variables.

⚠ WARNING

Dangerous plant states possible

You assign the entered values to the variables during control. This can result in dangerous plant states, e.g. unexpected axis motion.

Note

Note when you change the values of several variables:

The values are written sequentially to the variables. It can take several milliseconds until the next value is written. The variables are changed from top to bottom in the symbol browser. There is therefore no guarantee of consistency.

Working with the symbol browser

The functions of the symbol browser and how you work with them are described in detail in the online help.

Display invalid floating-point numbers

Invalid floating-point numbers are displayed as follows in the symbol browser (independently of the SIMOTION device):

Table 7-4 Display invalid floating-point numbers

Display	Meaning
1.#QNAN -1.#QNAN	Invalid bit pattern in accordance with IEEE 754 (NaN Not a Number). There is no distinction between signaling NaN (NaNs) and quiet NaN (NaNq).
1.#INF -1.#INF	Bit pattern for + infinity in accordance with IEEE 754 Bit pattern for – infinity in accordance with IEEE 754
-1.#IND	Bit pattern for indeterminate

7.4 Watch tables

7.4.1 Monitoring variables in watch table

Watch table options

With the symbol browser, you see only the variables of an object within the project. With program status, you see only the variables for a freely selectable monitoring area in the program

With watch tables, by contrast, you can monitor selected variables from different sources as a group (e.g. program sources, technology objects, SINAMICS drives - even on different devices).

You can see the data type of the variables in offline mode. You can view and also modify the value of the variables in online mode.

Creating a watch table

Procedure for creating a watch table and assigning variables:

1. In the project navigator, open the **Monitor** folder.
2. Double-click the **Insert watch table** entry to create a watch table and enter a name for it. A watch table with this name appears in the **Monitor** folder.
3. In the project navigator, click the object from which you want to move variables to the watch table.
4. In the symbol browser, select the corresponding variable line by clicking its number in the left column.
5. From the context menu, select **Add to watch table** and the appropriate watch table, e.g. **Watch table_1**.
6. If you click the watch table, you will see in the detail view of the **Watch table** tab that the selected variable is now in the watch table.
7. Repeat steps 3 to 6 to monitor the variables of various objects.

If you are connected to the target system, you can monitor the variable contents.

Status and controlling variables

In the **Status value** column, the current variable values are displayed and periodically updated.

You can change the value of one or several variables. Proceed as follows for the variables to be changed:

1. Enter a value in the **Control value** column.
2. Activate the checkbox in this column
3. Click the **Immediate control** button.

The values you entered are written to the selected variables.

⚠ WARNING

Dangerous plant states possible

You assign the entered values to the variables during control. This can result in dangerous plant states, e.g. unexpected axis motion.

Note

Note when you change the values of several variables:

The values are written sequentially to the variables. It can take several milliseconds until the next value is written. The variables are changed from top to bottom in the watch table. There is therefore no guarantee of consistency.

Working with the watch table

The functions of the watch table and how you work with them are described in detail in the Online help.

Display invalid floating-point numbers

Invalid floating-point numbers are displayed as follows in the watch table (independently of the SIMOTION device):

Table 7-5 Display invalid floating-point numbers

Display	Meaning
1.#QNAN -1.#QNAN	Invalid bit pattern in accordance with IEEE 754 (NaN Not a Number). There is no distinction between signaling NaN (NaNs) and quiet NaN (NaNq).
1.#INF -1.#INF	Bit pattern for + infinity in accordance with IEEE 754 Bit pattern for – infinity in accordance with IEEE 754
-1.#IND	Bit pattern for indeterminate

7.5 Variable status

"Variable status" enables you to monitor the current value for an individual variable, selected using the cursor, in an open program source or program organization unit (e.g. ST source file, MCC chart, LAD program).

Requirements

- Make sure that a connection to the target system has been established and a project has been downloaded to the target system. For information on loading a project, see "Downloading programs to the target system (Page 281)".
- The program source containing the program organization unit (POE) whose variables you want to monitor must be consistent with the target system.
- The associated source (e.g. ST source file, MCC chart, LAD program) must be open.
- With the MCC programming language only: The parameter screen form for the command in which the variable you want to monitor is being used must be open.
- You can run the user program, but you do not have to. If the program is not run, you only see the initial values of the variables.

Procedure

To monitor an individual variable using variable status:

1. Position the cursor above the identifier for a variable.
   - With the ST programming language: in the open ST source file
   - With the ST programming language: within an input field in the open parameter screen form
   - With the LAD/FBD programming language: within a network of the LAD/FBD program
2. Briefly position the cursor above the identifier.

The tool tip shows the current value of the variable. If you keep the cursor above the identifier for a longer period, the value is updated on an ongoing basis.

Note

With "variable status", the current value for the variable is displayed, wherever the selected variable is being used.

The "variable status" function enables you to monitor all those variables you are also able to monitor in the symbol browser (Page 289) or the address list. These are:

- System variables of SIMOTION devices
- System variables of technology objects
- Global device variables
- Retentive and non-retentive unit variables of the interface section of a program source (unit)
- Retentive and non-retentive unit variables of the implementation section of a program source (unit)
- Static variables of the programs
- Static variables of the function blocks whose instances are declared as unit variables

- Static variables of the function blocks whose instances are declared as static variables of programs
- I/O variables

7.6 Trace

Trace options

Trace allows you to record and save signal characteristics of inputs/outputs or the variable values. This allows you to document the optimization, for example, of axes.

You can set the recording time, display up to four channels with eight values each in the test or debug mode, select trigger conditions, parameterize timing adjustments, select between different curve displays and scalings, etc.

The SIMOTION online help provides additional information on the trace tool.

7.7 Program run

7.7.1 Program run: Display code location and call path

You can display the position in the code (e.g. line of an ST source file) that a MotionTask is currently executing along with its call path.

Follow these steps:

1. Click the Show program run button on the Program run toolbar.
   The "Program run call stack (Page 296)" window opens.
2. Select the desired MotionTask.
3. Click the Update button.

The window shows:

- The position in the code being executed (e.g. line of the ST source file) stating the program source and the POU.
- Recursively positions in the code of other POUs that call the code position being executed.

The following names are displayed for the SIMOTION RT program sources:

Table 7-6 SIMOTION RT program sources

Name	Meaning
taskbind.hid	Execution system
stdfunc.pck	IEC library

Name	Meaning
device.pck	Device-specific library
tp-name.pck	Library of the *tp-name* technology package, e.g. cam.pck for the library of the CAM technology package

7.7.2 Program run parameters

You can display the following for all configured tasks:

- the current code position in the program code (e.g. line of an ST source file)
- the call path of this code position

Table 7-7 Program run parameter description

Array	Description
Selected CPU	The selected SIMOTION device is displayed.
Refresh	Clicking the button reads the current code positions from the SIMOTION device and shows them in the open window.
Calling task	Select the task for which you want to determine the code position being executed. All configured tasks of the execution system.
Current code position	The position being executed in the program code (e.g. line of an ST source file) is displayed (with the name of the program source, line number, name of the POU).
is called by	The code positions that call the code position being executed within the selected task are shown recursively (with the name of the program source, line number, name of the POU, and name of the function block instance, if applicable).

For names of the SIMOTION RT program sources, refer to the table in Program run (Page 295).

7.7.3 Program run toolbar

You can display the position in the code (e.g. line of an ST source file) that a MotionTask is currently executing along with its call path with this toolbar.

Table 7-8 Program run toolbar

Symbol	Meaning
	Display program run Click this symbol to open the Program run call stack window. In this window, you can display the currently active code position with its call path. See: Program run: Display code position and call path (Page 295)

7.8 Program status (monitoring program execution)

Monitoring the program execution

Monitoring the program execution does not affect the actual execution of the program, but does increase the communication load. This has an impact on the execution of MotionTasks and the BackgroundTask.

Program status can be switched on and off during all operating modes of a SIMOTION device (Page 283).

Note

In the process mode, the program status can be called only once for a LAD/FBD program, FB or FC. If you do not observe the restriction, error message 25023 "No resources in the runtime" will appear.

In the test mode, the program status can be called simultaneously for several LAD/FBD programs, FB or FC. The maximum possible number depends on the utilization of the SIMOTION device.

The values of the following variables are displayed:

- Simple data type variables (INT, REAL, etc.)
- Individual elements of a structure, provided an assignment is made
- Individual elements of an array, provided an assignment is made
- Enumeration data type variables

Note

The values of constants are not displayed.

Due to the restricted buffer capacity and the requirement for minimum runtime tampering, the following variables cannot be displayed:

- Complete arrays
- Complete structures

Individual array elements or individual structure elements are displayed, however, provided an assignment is made in the ST source file.

7.8.1 Starting and stopping program status (monitoring program execution)

You can call up information on network status in two different ways using program status:

- You can select specific networks to display their status. Multiple selection (Shift key) and the selection of all networks (Ctrl+A) is possible. The boxes will be displayed in the same color as the corresponding output.
  The left-hand border of a selected network is highlighted in blue.
- If you do not select a network, the status is displayed for those networks that are visible on the screen. If you scroll down, the status of those visible networks is now displayed.

Preparing program status

Before you can work with program status, additional code must be generated during compilation:

1. Select the **Project > Connect to selected target devices** menu command or click the  button.
   Online mode is activated.
2. Select the SIMOTION device, followed by **Operating mode** in the context menu.
3. Select **Test mode**.
   Program status is available in this operating mode without restrictions, see Operating modes for SIMOTION devices (Page 283).
4. Open the Properties window for the LAD/FBD unit, see Defining the properties of an LAD/FBD unit (Page 51).
5. Activate the **Permit program status** compiler option on the **Compiler** tab as the local compiler setting (Page 54) for this LAD/FBD unit.

   Note

   Alternatively, select **Options > Settings > Compiler**, then activate the **Permit program status** compiler option as the global compiler setting (Page 53) for all program sources (ST, MCC and LAD/FBD units).

6. Select the **LAD/FBD unit > Accept and compile** menu command.
   The LAD/FBD unit is compiled.

   Note

   If the **Permit program status** global compiler option is changed, you need to select **Project > Save and compile changes** to compile all the program sources affected by the change.

7. Select the **Target system > Load > Project to target system** menu command or click the  button.
   The programs are downloaded to the target system. Make sure that the target system is in STOP mode.

Starting the Status program

Requirement

- The corresponding LAD/FBD program is opened.
- The LAD/FBD program does not contain any unsaved changes.
- The LAD/FBD unit in SCOUT must be consistent with the target system.

Procedure

To start program status, proceed as follows:

1. Select the **LAD/FBD program > Program status on/off** menu command or click the button  for **Program status** (Ctrl+F7 shortcut) to start this test mode.
2. If the LAD/FBD program is assigned to more than one task, the **Call path/task selection Program status** dialog box opens:
   – In this dialog box, select the task in which you want to monitor the program.

   The 

   symbol on the tab for the open LAD/FBD program indicates that program status has started, as does the symbol for the respective combination of the currently activated test functions (program status, breakpoints).

Note

Start program status for multiple windows for each SIMOTION device

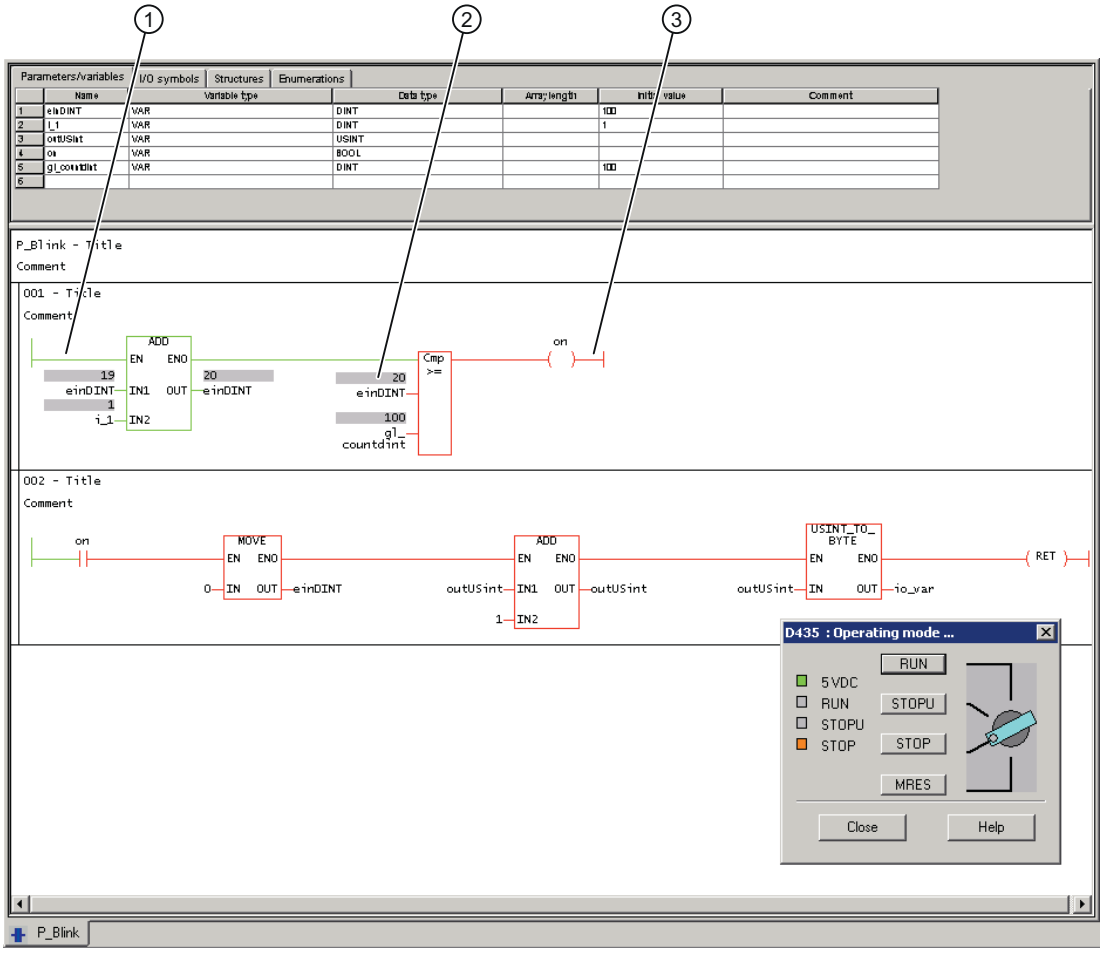
A window can be an open ST source file, an open LAD/FBD program or an open MCC chart. An active window is located in the foreground and the current status values are displayed (MCC: open MCC command).

In **Process mode**, program status can only be started for one window.

In **Test mode**, program status can be started simultaneously for several windows per task. The maximum possible number depends on the utilization of the SIMOTION device.

If program status is started for an additional window (**Process mode**) or starting it causes the maximum possible number to be exceeded (**Test mode**), program status is automatically deactivated for the currently active window (**Process mode**) or the oldest active window (**Test mode**), i.e. momentarily paused, but not stopped. If a window with deactivated program status is brought to the foreground (MCC: open MCC command), program status is automatically reactivated and the current status values are displayed again.

If the program execution monitoring is activated, the ladder diagram lines/signal paths of the selected networks or the networks displayed on the screen are colored according to the current values:



① Green: Lines: Value = TRUE (Data type BOOL)

Boxes: Result = TRUE or box is activated (enable input EN = TRUE).
Non-binary connections are shown in green.
Binary connections are displayed according to their values (green or red).

② Gray: Only when boxes are active: Non-binary values are shown on gray background.

③ Red: Lines: Value = FALSE (Data type BOOL)

Boxes: Result = TRUE or box is activated (enable input EN = TRUE).
Non-binary connections are shown in red.
When the boxes are inactive, binary connections are shown in cyan.

Figure 7-1 Online display in the LAD/FBD editor

Note

When a constant is used in a network, the current value of the constant is also displayed during program execution.

A constant which is not included is colored turquoise.

Stopping program status

To stop program status, proceed as follows:

1. Select the **LAD/FBD program > Program status on/off** menu command or click the button for **Program status** (Ctrl+F7 shortcut).
   Program status is stopped.

Disabling program status

Disabling program status frees up CPU resources.

To disable program status, proceed as follows:

1. First, stop the program status function, see Stopping program status.
2. Open the Properties window for the LAD/FBD unit, see Defining the properties of an LAD/FBD unit (Page 51).
3. Deactivate the **Permit program status** compiler option on the **Compiler** tab as the local compiler setting (Page 54) for this LAD/FBD unit and confirm by clicking **OK**.

   Note

   If the **Permit program status** compiler option is activated as the global setting for the compiler (Page 53), you can deactivate this for either one LAD/FBD unit by deactivating the relevant **Use global settings** checkbox, see Local compiler settings (Page 54) or for all the program sources by selecting **Options > Settings > Compiler**.

4. Select the SIMOTION device, followed by **Operating mode** in the context menu.
5. Select **Process mode**.
   Program execution is optimized for this operating mode to ensure maximum performance, see Operating modes for SIMOTION devices (Page 283).
6. Recompile the program and download it to the target system.

Note

If the **Permit program status** global compiler option is changed, you need to select **Project > Save and compile changes** to compile all the program sources affected by the change.

7.9 Breakpoints

7.9.1 General procedure for setting breakpoints

You can set breakpoints within a POU of a program source (e.g. ST source, MCC chart, LAD/FBD source). On reaching an activated breakpoint, the task in which the POU with the breakpoint is called is stopped. If the breakpoint that initiated the stopping of the tasks is located in a program or function block, the values of the static variables for this POU are displayed in the "Variables status" tab of the detail display. Temporary variables (also in/out parameters for function blocks) are not displayed. You can monitor static variables of other POUs or unit variables in the symbol browser.

Requirement:

- The program source with the POU (e.g. ST source file, MCC chart, LAD/FBD program) is open.

Procedure

Follow these steps:

1. Select "Debug mode" for the associated SIMOTION device; see Setting debug mode (Page 303).
2. Specify the tasks to be stopped, see Specifying the debug task group (Page 304).
3. Set breakpoints, see Setting breakpoints (Page 306).
4. Define the call path, see Defining a call path for a single breakpoint (Page 309).
5. Activate the breakpoints, see Activating breakpoints (Page 312).

7.9.2 Setting the debug mode

⚠ WARNING

Dangerous plant states possible

If problems occur in the communication link between the PC and the SIMOTION device, this may result in dangerous plant states (e.g. the axis may start moving in an uncontrollable manner).

Therefore, use the debug mode only with activated life-sign monitoring (Page 285) with a suitably short monitoring time!

You must observe the appropriate safety regulations.

The function is released exclusively for commissioning, diagnostic and service purposes. The function should generally only be used by authorized technicians. The safety shutdowns of the higher-level control have no effect!

Therefore, there must be an EMERGENCY STOP circuit in the hardware. The appropriate measures must be taken by the user.

Requirement

1. A connection to the target system must have been established (online mode)
2. Debug mode must not be selected for any SIMOTION device.

Procedure

To set the debug mode, proceed as follows:

1. Highlight the SIMOTION device in the project navigator.
2. Select **Operating mode** from the context menu.
3. Select **Debug** mode (Page 283).
4. Accept the safety information
5. Parameterize the sign-of-life monitoring.
   See also section: Important information about the life-sign monitoring (Page 285).
6. Confirm with **OK**.

SIMOTION SCOUT switches to debug mode for this device; the SIMOTION device itself remains in "test mode", as long as at least one breakpoint is activated:

The project navigator indicates that debug mode is activated for SIMOTION SCOUT by means of a symbol next to the SIMOTION device.

The breakpoints toolbar (Page 307) is displayed.

As long as no breakpoints are activated, you can edit program sources in debug mode (Page 287).

Debug mode is not enabled for the SIMOTION device until at least one set breakpoint is activated. If all breakpoints are deactivated, debug mode is canceled for the SIMOTION device. The status bar indicates that debug mode is activated for the SIMOTION device.

Note

Pressing the spacebar or switching to a different Windows application causes the following to happen if the SIMOTION device is in debug mode (breakpoints activated):

- The SIMOTION device switches to the STOP operating state.
- The outputs are deactivated (ODIS).

⚠ WARNING

Dangerous plant states possible

This function is not guaranteed in all operating states.

Therefore, there must be an EMERGENCY STOP circuit in the hardware. The appropriate measures must be taken by the user.

7.9.3 Define the debug task group

On reaching an activated breakpoint, all tasks that are assigned to the debug task group are stopped.

Requirement

1. A connection to the target system must have been established (online mode).
2. SIMOTION SCOUT is in debug mode for the corresponding SIMOTION device; see Setting debug mode (Page 303).

Procedure

How to assign a task to the debug task group:

1. Highlight the relevant SIMOTION device in the project navigator.
2. Select **Debug task group** from the context menu.
   The Debug Task group window opens.
3. Select the tasks to be stopped on reaching the breakpoint:
   - If you only want to stop individual tasks (in RUN operating state): Activate the **Debug task group** selection option.
     Assign all tasks to be stopped on reaching a breakpoint to the **Tasks to be stopped** list.
   - If you only want to stop individual tasks (in HOLD operating state): Activate the **All tasks** selection option.
     In this case, also select whether the outputs and technology objects are to be released again after resumption of program execution.

Note

Note the different behavior when an activated breakpoint is reached, see the following table.

Table 7-9 Behavior at the breakpoint depending on the tasks to be stopped in the debug task group.

Property		Tasks to be stopped	
		Single selected tasks (debug task group)	All tasks
Behavior on reaching the breakpoint			
	Operating state	RUN	STOP
	Stopped tasks	Only tasks in the debug task group	All tasks
	Outputs	Active	Deactivated (ODIS activated)
	Technology	Closed-loop control active	No closed-loop control (ODIS activated)
	Runtime measurement of the tasks	Active for all tasks	Deactivated for all tasks
	Time monitoring of the tasks	Deactivated for tasks in the debug task group	Deactivated for all tasks
	Real-time clock	Continues to run	Continues to run
Behavior on resumption of program execution			
	Operating state	RUN	RUN
	Started tasks	All tasks in the debug task group	All tasks
	Outputs	Active	The behavior of the outputs and the technology objects depends on the **'Continue' activates the outputs (ODIS deactivated)** checkbox. • Active: ODIS will be deactivated. All outputs and technology objects are released. • Inactive: ODIS remains activated. All outputs and technology objects are only enabled for one STOP-RUN transition.
	Technology	Closed-loop control active	

Note

You can only make changes to the debug task group if no breakpoints are active.

The settings of the debug task group are retained after exiting "Debug mode".

Proceed as follows:

1. Set breakpoints (see Setting breakpoints (Page 306)).
2. Define the call path (see Defining a call path for a single breakpoint (Page 309)).
3. Activate the breakpoints (see Activating breakpoints (Page 312)).

7.9.4 Setting breakpoints

Requirements:

1. The program source with the POU (e.g. ST source file, MCC chart, LAD/FBD program) is open.
2. A connection to the target system must have been established (online mode).
3. SIMOTION SCOUT is in debug mode for the corresponding SIMOTION device; see Setting debug mode (Page 303).
4. The tasks to be stopped are specified, see Specifying the debug task group (Page 304).

Procedure

How to set a breakpoint:

1. Select the code location where no breakpoint has been set:
   - SIMOTION ST: Place the cursor on a line in the ST source file that contains a statement.
   - SIMOTION MCC: Select an MCC command in the MCC chart (except module or comment block).
   - SIMOTION LAD/FBD: Set the cursor in a network of the LAD/FBD program.
2. Perform the following (alternatives):
   - Select the **Debug > Set/remove breakpoint** menu command (shortcut F9).
   - Click the  button in the Breakpoints toolbar.

To remove a breakpoint, proceed as follows:

1. Select the code position with the breakpoint.
2. Perform the following (alternatives):
   - Select the **Debug > Set/remove breakpoint** menu command (shortcut F9).
   - Click the  button in the Breakpoints toolbar.

To remove all breakpoints (in all program sources) of the SIMOTION device, proceed as follows:

- Perform the following (alternatives):
  - Select the **Debug > Remove all breakpoints** menu command (shortcut CTRL+F5).
  - Click the  button in the Breakpoints toolbar.

Note

You cannot set breakpoints:

- For SIMOTION ST: In lines that contain only comment.
- For SIMOTION MCC: On the module or comment block commands.
- For SIMOTION LAD/FBD: Within a network.
- At code locations in which other debug points (e.g. trigger points) have been set.

You can list the debug points in all program sources of the SIMOTION device in the debug table:

- Click the  button for "debug table" in the Breakpoints toolbar.

In the debug table, you can also remove all breakpoints (in all program sources) of the SIMOTION device:

- Click the button for "Clear all breakpoints".

The breakpoints set also remain saved after leaving debug mode; they are displayed in debug mode only.

You can use the program status (Page 298) diagnosis functions and breakpoints together in a program source or POU. However, the following restrictions apply depending on the program languages:

- SIMOTION ST: For version V3.2 of the SIMOTION Kernel, the (marked) ST source file lines to be tested with program status must not contain a breakpoint.
- SIMOTION MCC and LAD/FBD: The commands of the MCC chart (or networks of the LAD/FBD program) to be tested with program status must not contain a breakpoint.

Proceed as follows

1. Define the call path, see Defining a call path for a single breakpoint (Page 309).
2. Activate the breakpoints, see Activating breakpoints (Page 312).

7.9.5 Breakpoints toolbar

This toolbar contains important operator actions for setting and activating breakpoints:

Table 7-10 Breakpoints toolbar

Symbol	Meaning
	Set/remove breakpoint Click this icon to set at breakpoint for the selected code position or to remove an existing breakpoint. See: Setting breakpoints (Page 306).
	Activate/deactivate breakpoint Click this icon to activate or deactivate the breakpoint at the selected code position. See: Activating breakpoints (Page 312).

Symbol	Meaning
	Edit the call path Click this icon to define the call path for the breakpoints: • If a code position **with** breakpoint is selected: The call path for this breakpoint. • If a code position **without** breakpoint is selected: The call path for all breakpoints of the POU. See: Defining the call path for a single breakpoint (Page 309), Defining the call path for all breakpoints (Page 311).
	Activate all breakpoints of the active POU Click this symbol to activate all breakpoints in the active program source or POU (e.g. ST source file, MCC chart, LAD/FBD program). See: Activating breakpoints (Page 312).
	Deactivate all breakpoints of the active POU Click this symbol to deactivate all breakpoints in the active program source or POU (e.g. ST source file, MCC chart, LAD/FBD program). See: Activating breakpoints (Page 312).
	Remove all breakpoints of the active POU Click this symbol to remove all breakpoints from the active program source or POU (e.g. ST source file, MCC chart, LAD/FBD program). See: Setting breakpoints (Page 306).
	Debug table Click this icon to display the debug table. See: Debug table parameters.
	Display call stack Click this icon after reaching an activated breakpoint to: • View the call path at the current breakpoint. • View the code positions at which the other tasks of the debug task group have been stopped together with their call path. See: Displaying the call stack (Page 315).
	Resume Click this icon to continue the program execution after reaching an activated breakpoint. See: Resuming program execution (Page 315), Displaying the call stack (Page 315).
	Next step (SIMOTION Kernel as of version V4.4) Only available for the MCC and LAD/FBD programming languages: Click this icon to resume the program execution until the next MCC command or LAD/FBD network is reached. See: Resume program execution in single steps (Page 316).
	Step through the subprogram (SIMOTION Kernel as of version V4.4) Only available for the MCC programming language. Click this icon to jump to the called subprogram and stop at the first command. The subprogram must be created in the MCC or LAD/FBD programming language. See: Resume program execution in single steps (Page 316).

7.9.6 Defining the call path for a single breakpoint

Requirements:

1. The program source with the POU (e.g. ST source file, MCC chart, LAD/FBD program) is open.
2. A connection to the target system must have been established (online mode).
3. SIMOTION SCOUT is in debug mode for the corresponding SIMOTION device; see Setting debug mode (Page 303).
4. The tasks to be stopped are specified, see Specifying the debug task group (Page 304).
5. Breakpoint is set, see Setting breakpoints (Page 306).

Procedure

To define the call path for a single breakpoint, proceed as follows:

1. Select the code location where a breakpoint has already been set:
   - SIMOTION ST: Set the cursor in an appropriate line of the ST source.
   - SIMOTION MCC: Select an appropriate command in the MCC chart.
   - SIMOTION LAD/FBD: Set the cursor in an appropriate network of the LAD/FBD program.
2. Click the  button for "edit call path" in the Breakpoints toolbar.
   In the Call path / task selection breakpoint window, the marked code position is displayed (with the name of the program source, line number, name of the POU).
3. Select the task in which the user program (i.e. all tasks in the debug task group) will be stopped when the selected breakpoint is reached.
   The following are available:
   - **All calling locations starting at this call level**
     The user program will always be started when the activated breakpoint in any task of the debug task group is reached.
   - The individual tasks from which the selected breakpoint can be reached.
     The user program will be stopped only when the breakpoint in the selected task is reached. The task must be in the debug task group.
     The specification of a call path is possible.

4. Only for functions and function blocks: Select the call path, i.e. the code position to be called (in the calling POU).
   The following are available:
   - **All calling locations starting at this call level**
     No call path is specified. The user program is always stopped at the activated breakpoint if the POU in the selected tasks is called.
   - Only when a single task is selected: The code positions to be called within the selected task (with the name of the program source, line number, name of the POU).
     The call path is specified. The user program will be stopped at the activated breakpoint only when the POU is called from the selected code position.
     If the POU of the selected calling code position is also called from other code positions, further lines are displayed successively in which you proceed similarly.
5. If the breakpoint is only to be activated after the code position has been reached several times, select the number of times.

Note

You can also define the call path to the individual breakpoints in the debug table:

1. Click the  button for "debug table" in the Breakpoints toolbar.
   The "Debug table" window opens.
2. Click the appropriate button in the "Call path" column.
3. Proceed in the same way as described above:
   - Specify the task.
   - Define the call path (only for functions and function blocks).
   - Specify the number of passes after which the breakpoint is to be activated.

Proceed as follows:

- Activate the breakpoints, see Activating breakpoints (Page 312).

Note

You can use the "Display call stack (Page 315)" function to view the call path at a current breakpoint and the code positions at which the other tasks of the debug task group were stopped.

See also

Defining the call path for all breakpoints (Page 311)

7.9.7 Defining the call path for all breakpoints

With this procedure, you can:

- Select a default setting for all future breakpoints in a POU (e.g. MCC chart, LAD/FBD program or POU in an ST source file).
- Accept and compare the call path for all previously set breakpoints in this POU.

Requirements

1. The program source with the POU (e.g. ST source file, MCC chart, LAD/FBD program) is open.
2. A connection to the target system must have been established (online mode).
3. SIMOTION SCOUT is in debug mode for the corresponding SIMOTION device; see Setting debug mode (Page 303).
4. The tasks to be stopped are specified, see Specifying the debug task group (Page 304).

Procedure

To define the call path for all future breakpoints of a POU, proceed as follows:

1. Select the code location where **no** breakpoint has been set:
   - SIMOTION ST: Set the cursor in an appropriate line of the ST source.
   - SIMOTION MCC: Select an appropriate command in the MCC chart.
   - SIMOTION LAD/FBD: Set the cursor in an appropriate network of the LAD/FBD program.
2. Click the  button for "edit call path" in the Breakpoints toolbar.
   In the "Call path / task selection all breakpoints for each POU" window, the marked code position is displayed (with the name of the program source, line number, name of the POU).
3. Select the task in which the user program (i.e. all tasks in the debug task group) will be stopped when a breakpoint in this POU is reached.
   The following are available:
   - **All calling locations starting at this call level**
     The user program will always be started when an activated breakpoint of the POU in any task of the debug task group is reached.
   - The individual tasks from which the selected breakpoint can be reached.
     The user program will be stopped only when a breakpoint in the selected task is reached.
     The task must be in the debug task group.
     The specification of a call path is possible.

4. Only for functions and function blocks: Select the call path, i.e. the code position to be called (in the calling POU).
   The following are available:
   - **All calling locations starting at this call level**
     No call path is specified. The user program is always stopped at an activated breakpoint when the POU in the selected tasks is called.
   - Only when a single task is selected: The code positions to be called within the selected task (with the name of the program source, line number, name of the POU).
     The call path is specified. The user program will be stopped at an activated breakpoint only when the POU is called from the selected code position.
     If the selected calling code position is in turn called by other code positions, further lines are displayed successively in which you proceed similarly.
5. If a breakpoint is only to be activated after the code position has been reached several times, select the number of times.
6. If you want to accept and compare this call path for all previously set breakpoints in this POU:
   - Click **Accept**.

Proceed as follows:

- Activate the breakpoints, see Activating breakpoints (Page 312).

Note

You can use the "Display call stack (Page 315)" function to view the call path at a current breakpoint and the code positions at which the other tasks of the debug task group were stopped.

See also

Defining the call path for a single breakpoint (Page 309)

7.9.8 Activating breakpoints

Breakpoints must be activated if they are to have an effect on program execution.

Requirements

1. The program source with the POU (e.g. ST source file, MCC chart, LAD/FBD program) is open.
2. A connection to the target system must have been established (online mode).
3. SIMOTION SCOUT is in debug mode for the corresponding SIMOTION device; see Setting debug mode (Page 303).
4. The tasks to be stopped are specified, see Specifying the debug task group (Page 304).

5. Breakpoints are set, see Setting breakpoints (Page 306).
6. Call paths are defined, see Defining a call path for a single breakpoint (Page 309).

Activating breakpoints

How to activate a single breakpoint:

1. Select the code location where a breakpoint has already been set:
   - SIMOTION ST: Set the cursor in an appropriate line of the ST source file.
   - SIMOTION MCC: Select an appropriate command in the MCC chart.
   - SIMOTION LAD/FBD: Set the cursor in an appropriate network of the LAD/FBD program.
2. Perform the following (alternatives):
   - Select the **Debug > Activate/deactivate breakpoint** menu command (shortcut F12).
   - Click the  button in the Breakpoints toolbar.

To activate all breakpoints (in all program sources) of the SIMOTION device, proceed as follows:

- Perform the following (alternatives):
  - Select the **Debug > Activate all breakpoints** menu command.
  - Click the  button in the Breakpoints toolbar.

Once the first breakpoint has been activated, the SIMOTION device switches to debug mode. It remains in this mode until the last breakpoint is deactivated.

In the Task status function bar, (Page 317) the tasks with activated breakpoints are highlighted in gray ( ).

Note

Breakpoints of all program sources of the SIMOTION device can also be activated and deactivated in the debug table:

1. Click the  button for "debug table" in the Breakpoints toolbar.
   The "Debug Table" window opens.
2. Perform the action below, depending on which breakpoints you want to activate or deactivate:
   - Single breakpoints: Check or clear the corresponding checkboxes.
   - All breakpoints (in all program sources): Click the corresponding button.

The following applies up to version V4.3 of the SIMOTION Kernel:

- In the case of activated breakpoints, the "Single step" test function of the SIMOTION MCC programming language cannot be used.

The following applies as of version V4.4 of the SIMOTION Kernel:

- The "Single step" test function of the SIMOTION MCC programming language is not available in the Debug mode.

Breakpoints cannot be activate if the control priority is at the axis control panel. Conversely, you cannot fetch the control priority for the axis control panel when a breakpoint activated.

Behavior at the activated breakpoint

On reaching an activated breakpoint (possibly using the selected call path (Page 309)), all tasks assigned to the debug task group will be stopped. The behavior depends on the tasks in the debug task group and is described in "Defining a debug task group (Page 304)". The breakpoint is highlighted.

In the Task status function bar, (Page 317) the task in which the breakpoint was reached is highlighted in red ( ).

The following applies to the programming languages MCC or LAD/FBD: If the debug task group is stopped by a breakpoint, then the user has the option to change to another task, belonging to the debug task group, in the combo box. Always the breakpoint of the currently selected task is visualized.

If the breakpoint that initiated the stopping of the tasks is located in a program or function block, the values of the static variables for this POU are displayed in the "Variables status" tab of the detail display. Temporary variables (also in/out parameters for function blocks) are not displayed. You can monitor static variables of other POUs or unit variables in the symbol browser (Page 289).

You can use the "Display call stack (Page 315)" function to:

- View the call path at the current breakpoint.
- View the code positions with the call path at which the other tasks of the debug task group have been stopped.

Resuming program execution

You can resume the execution of the stopped tasks, see "Resuming program execution" (Page 315).

As of version V4.4 of the SIMOTION Kernel, you can resume the task in single steps that has been stopped at the activated breakpoint in the MCC and LAD/FBD programming languages, see Resuming program execution in single steps (Page 316).

Deactivate breakpoints

To deactivate a single breakpoint, proceed as follows:

1. Select the code position with the activated breakpoint.
2. Perform the following (alternatives):
   - Select the **Debug > Activate/deactivate breakpoint** menu command (shortcut F12).
   - Click the button in the Breakpoints toolbar.

To deactivate all breakpoints (in all program sources) of the SIMOTION device, proceed as follows:

- Perform the following (alternatives):
  - Select the **Debug > Deactivate all breakpoints** menu command.
  - Click the button in the Breakpoints toolbar.

Once the last breakpoint has been deactivated, the SIMOTION device switches to "test mode"; SIMOTION SCOUT continues to run in debug mode.

7.9.9 Display call stack

You can use the "Display call stack" function to:

- View the call path at the current breakpoint.
- View the code positions with the call path at which the other tasks of the debug task group have been stopped.

Requirement

The user program is stopped at an activated breakpoint, i.e. the tasks of the debug task group (Page 304) have been stopped.

Procedure

To call the "Display call stack" function, proceed as follows:

- Click the  button for "display call stack" in the Breakpoints toolbar.
  The "Breakpoint call stack" dialog opens. The current call path (including the calling task and the number of the set passes) is displayed.
  The call path cannot be changed.

To use the "Display call stack" function, proceed as follows:

1. Keep the "Breakpoint call stack" dialog open.
2. To display the code position at which the other task was stopped, proceed as follows:
   – Select the appropriate task. All tasks of the debug task group can be selected.

   The code position, including the call path, is displayed. If the code position is contained in a user program, the program source with the POU (e.g. ST source file, MCC chart, LAD/FBD program) will be opened and the code position marked.
3. How to resume program execution:
   – Click the  button for "resume" (Ctrl+F8 shortcut) on the Breakpoint toolbar.

   When the next activated breakpoint is reached, the tasks of the debug task group will be stopped again. The current call path, including the calling task, is displayed.
4. Click **OK** to close the "Breakpoint call stack" dialog box.

For names of the SIMOTION RT program sources, refer to the table in "Program run (Page 295)".

7.9.10 Resuming program execution

How to resume program execution:

- Perform the following (alternatives):
  – Select the **Debug > Continue** menu command (shortcut CTRL+F8).
  – Click the  button on the Breakpoint toolbar (Page 307) to "Continue".

The stopped task is continued until the next active breakpoint is reached.

7.9.11 Resuming program execution in single steps (as of Kernel V4.4)

This function is available as of SIMOTION Kernel version V4.4.

In the MCC and LAD/FBD programming languages you can resume the task in single steps that was stopped at an activated breakpoint (Page 302).

The current MCC command or the current LAD/FBD network and all stopped tasks of the debug task group are executed.

All tasks that are assigned to the debug task group are stopped at the following MCC command or LAD/FBD network or the next activated breakpoint within the debug task group.

Next step

To execute the current MCC command or the current LAD/FBD network at which the program has been stopped, proceed as follows:

- Perform the following (alternatives):
  - Select the **Debug > Next step** menu command (shortcut CTRL+F10).
  - Click the  button for "Next step" in the Breakpoints toolbar (Page 307).

The current MCC command or the current LAD/FBD network is executed. The program is stopped at the following MCC command or the current LAD/FBD network.

A subprogram call is executed without interruption as long as no breakpoint is activated within the subprogram. If a

Stepping through the subprogram (MCC only)

If the program execution has been stopped at the "Subprogram call" command in the MCC programming language, you can jump to the subprogram and run through it in single steps. The subprogram must have been created in the MCC or LAD/FBD programming language.

- Perform the following (alternatives):
  - Select the **Debug > Step through subprogram** menu command (shortcut CTRL+SHIFT +F10).
  - Click the  button on the Breakpoint toolbar (Page 307) to "Step through subprogram".

The appropriate MCC chart or LAD/FBD program is opened and the program execution stopped at the first MCC command or LAD/FBD network.

Note

Stepping is not possible in MCC charts and LAD/FBD programs whose sources are in libraries.

Stepping is not possible in ST source files.

You can only open MCC charts and LAD/FBD programs with know-how protection if you have the required authorization (e.g. password).

7.10 Task status function bar

In a combo box, the Task status function bar displays all tasks of the active SIMOTION device, to which a program is assigned.

They are displayed under the following conditions:

1. SIMOTION SCOUT is in online mode.
2. The affected SIMOTION device is active, e.g.
   - In the project navigator, the SIMOTION device or an element in its subtree is selected (such as program source, technology object).
   - In the working area, an open window is active that belongs to an element in the subtree of the SIMOTION device.
3. The SIMOTION device is consistent.

A background color highlights the occurrence of specific events in the affected task, see the following table. The task in question is displayed in the combo box of the function bar according to the event priority.

Table 7-11 Meaning of background colors in the Task status function bar

Background color	Meaning	Priority
Cyan	The affected task waits for a command at the "Single step" test function (only for SIMOTION MCC programming language).	Highest
Red	The affected task is located at a breakpoint (Page 312).	
Blue	In the affected task, the "Single step" test function is activated (only for SIMOTION MCC programming language)	
Gray	In the affected task, at least 1 breakpoint (Page 312) is activated.	
Yellow	In the affected task, the "Monitoring" test function is activated (only for SIMOTION MCC programming language).	
White	In the affected task, none of the above-mentioned test functions are activated.	Lowest

Note

A selection of a task in the combo box is only possible:

- For the following test functions of the SIMOTION MCC programming language:
  - Monitoring
  - Single step
  - Trace
- at activated breakpoints (Page 312) in the MCC or LAD/FBD programming languages.

7.11 Project comparison

SIMOTION SCOUT has a **project comparison** function (start this via the **Start object comparison**  button) for comparing objects within the same project and/or objects from different projects (online or offline).

Project comparison allows you to establish any differences and, if necessary, run a data transfer to rectify them.

Objects are devices and their sub-objects, programs, technology objects (TOs) or drive objects (DOs), and libraries. Comparing projects is useful if you need to carry out service work on the system.

Further information on project and detail comparisons can be found in the SIMOTION Project Comparison Function Manual.

Application Examples 8

8.1 Examples

You will be given an introduction to the LAD and FBD programming languages using two simple examples.

8.2 Creating sample programs

Requirements for program creation

The project is the highest level in the data management hierarchy. SIMOTION SCOUT saves all data which belongs, for example, to a production machine, in the project directory.

This means that the project therefore brackets together all SIMOTION devices, drives, etc., belonging to one machine.

Within the project, the hardware used must be made known to the system, including:

- SIMOTION device
- Centralized I/O (with I/O addresses)
- Distributed I/O (with I/O addresses)

A SIMOTION device must be configured before you can insert and edit LAD/FBD sources.

Sample programs

We will create two short programs (position blinker program, axis program) that demonstrate all the work steps from the creation through to the start and testing of a program.

8.3 Blinker program

Prerequisites

A project must have been created and the hardware used in the project must be known to the system.

Task specification

Output of a cyclically changing bit pattern after exceeding a limit value.

This task is divided into the following parts:

- Insert LAD/FBD source file
- Insert LAD/FBD program
  Network one
  A program variable is incremented and compared to a reference value
  Network two
  When the reference value is exceeded, the program variable is reset and a bit pattern is output
- Compiling
- Insert program in a task
- Download program onto target device

You can observe the result of your program at the outputs of your target system.

This example deals only with the LAD programming aspect.

8.3.1 Insert LAD/FBD source file

To insert a new LAD/FBD unit using the context menu:

1. Select the **PROGRAMS** folder of the relevant SIMOTION device in the project navigator.
2. Double-click the entry **Insert LAD/FBD unit**.

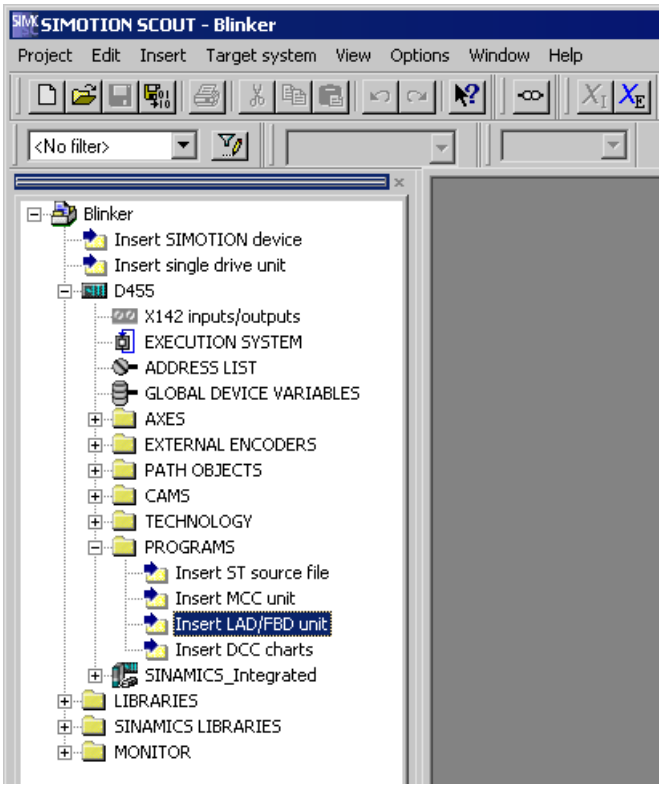


Figure 8-1 Project folder

The **Insert LAD/FBD Unit** dialog box appears.

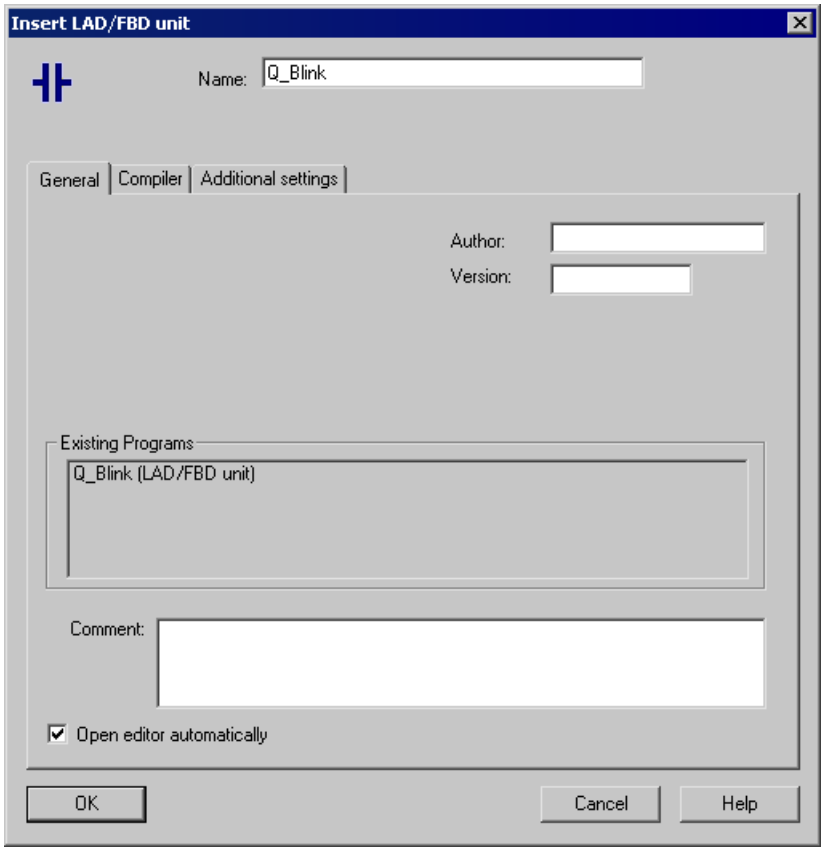


Figure 8-2 Insert LAD/FBD Unit dialog box

3. Enter the name of the LAD/FBD unit.
   The names of program sources must comply with the rules for identifiers (Page 97): They are made up of letters (A … Z, a … z), numbers (0 … 9), or single underscores (_) in any order, whereby the first character must be a letter or underscore. No distinction is made between upper- and lower-case letters.
   The permissible length of the name depends on the SIMOTION Kernel version:
   – SIMOTION Kernel as of version V4.1: Maximum 128 characters.
   – SIMOTION Kernel up to version V4.0: Maximum 8 characters.

   Names must be unique within the SIMOTION device. Protected or reserved identifiers (Page 361) are not permitted.
   Existing program sources (e.g. LAD/FBD units, ST source files) are displayed.
4. Activate the **Permit program status** compiler option to be able to use the online status display later:
   – Deactivate the associated checkbox in the "Global settings" column.
   – Activate the associated checkbox in the "Current settings" column.
5. In the **Compiler** tab, activate the **Permit program status** checkbox
6. You can also enter an author, version, and a comment.

7. Activate the **Open editor automatically** checkbox.
8. Confirm with **OK**.
   The declaration tables for exported and source-internal variables appear in the working area.
   No variables are defined here in the sample program.

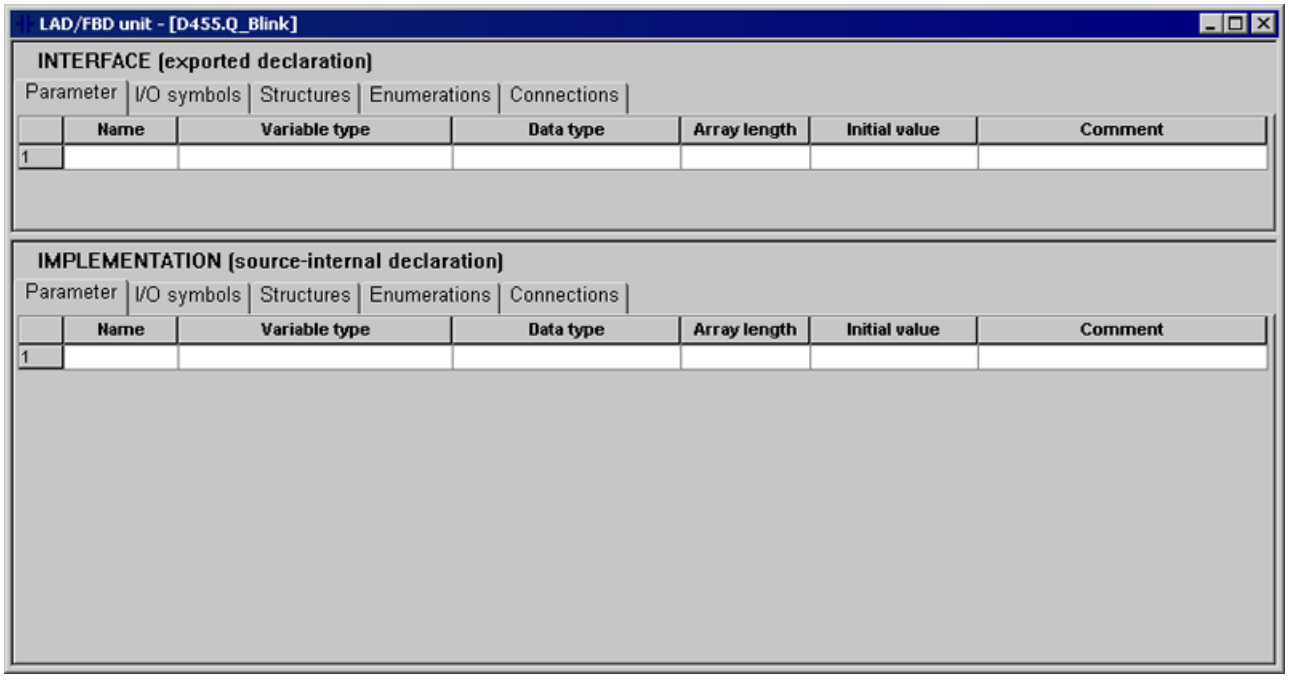


Figure 8-3 Declaration tables for exported and source-internal declarations

8.3.2 Insert LAD/FBD program

To insert an LAD/FBD program, proceed as follows:

1. In the **PROGRAMS** folder in the project navigator, open the LAD/FBD unit you just inserted.
2. Double-click the entry **Insert LAD/FBD program** in the LAD/FBD unit.

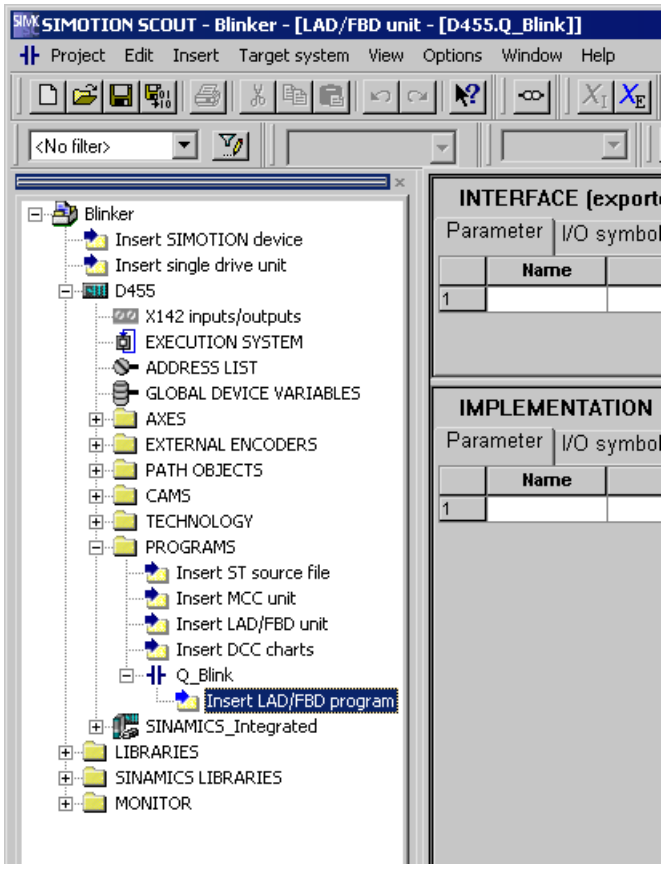


Figure 8-4 Opening a project folder

The **Insert LAD/FBD Program** dialog box appears.

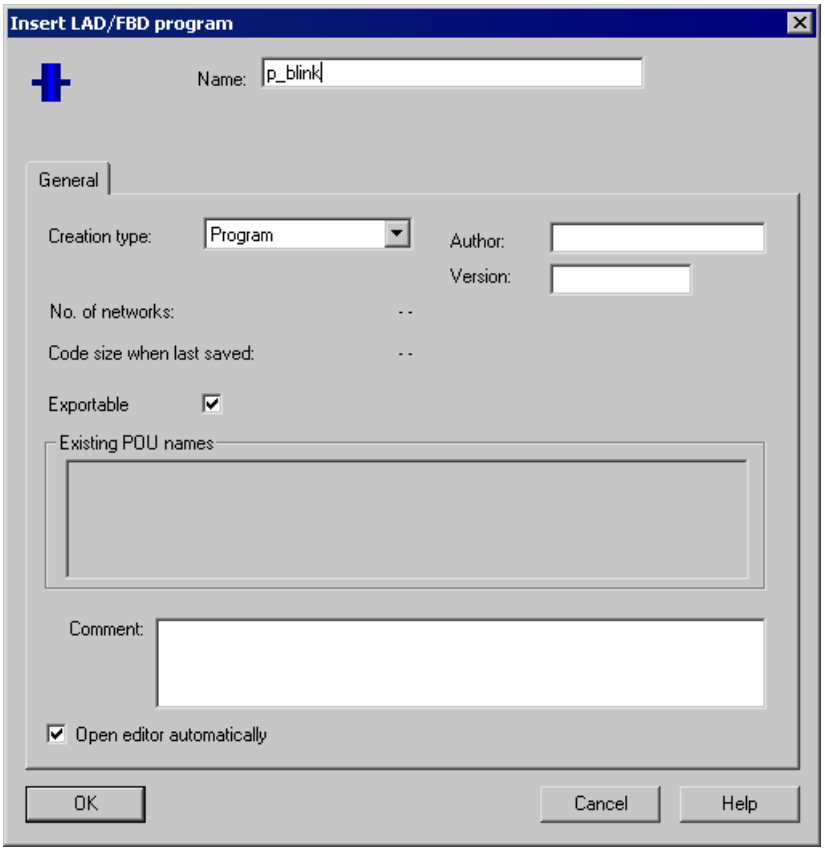


Figure 8-5 Insert LAD/FBD Program dialog box

3. Enter the name of the program in the **Insert LAD/FBD Program** dialog box.
   Names for LAD/FBD programs must comply with the Rules for identifiers (Page 97): They are made up of letters (A … Z, a … z), numbers (0 … 9), or single underscores (_) in any order, whereby the first character must be a letter or underscore. No distinction is made between upper- and lower-case letters. Protected or reserved identifiers (Page 361) are not permitted.
   The permissible length of the name is 25 characters.
   The names must be unique within the LAD/FBD unit. The names of all exportable program organization units (POUs) must also be unique within the SIMOTION device. The names of all LAD/FBD programs of the program source as well as the names of all exportable POUs of the device are displayed.
4. For **Creation type**, select program.
5. Activate the **Exportable** checkbox that must be available for the LAD/FBD program in the execution system.
6. Activate the **Open editor automatically** checkbox.
7. Confirm with **OK**.

A blank LAD/FBD program is opened.

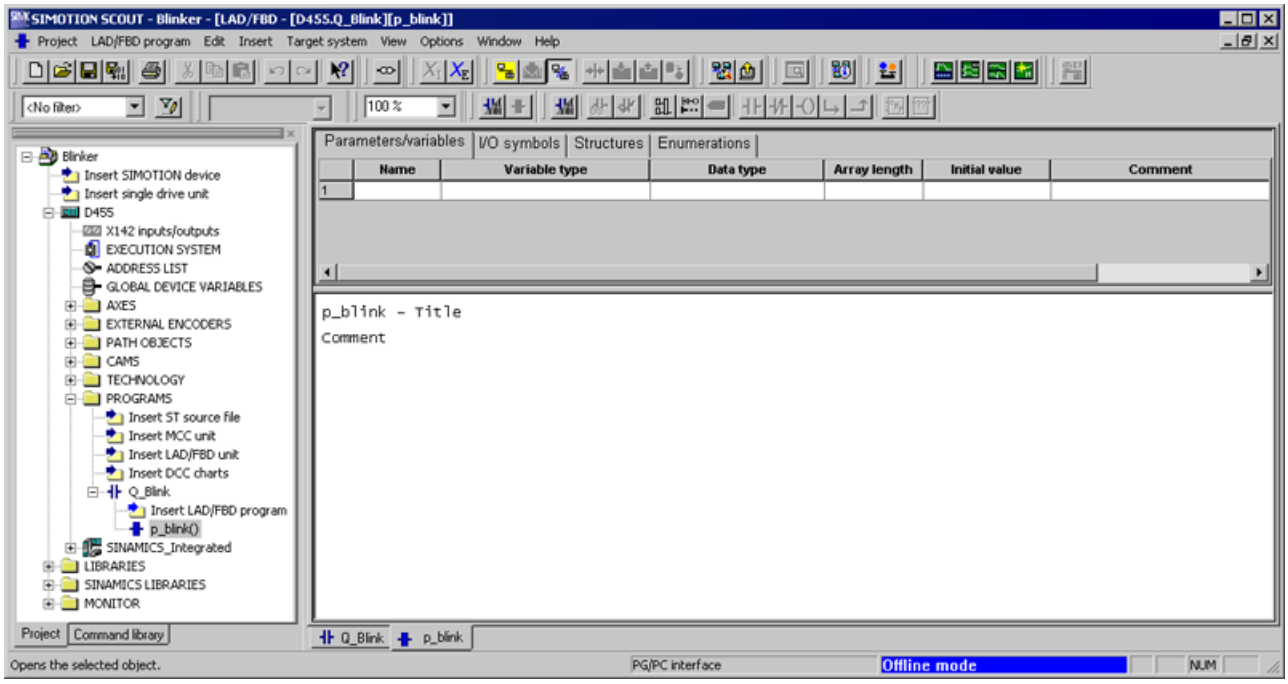


Figure 8-6 Open LAD/FBD program

8.3.3 Entering variables in the declaration table

To enter variables, proceed as follows:

1. Select the **Parameters/variables** tab.
2. Enter name, variable type, data type and/or start value in the declaration table (as shown in the figure below).

Parameters/variables | I/O symbols | Structures | Enumerations

	Name	Variable type	Data type	Array length	Initial value	Comment
1	einDINT	VAR	DINT		100	
2	i_1	VAR	DINT		1	
3	outUSint	VAR	USINT			
4	on	VAR	BOOL			
5	gl_countdint	VAR	DINT		100	
6						

Figure 8-7 Variables in the declaration table

3. Select the **I/O Symbols** tab.
4. Enter the name and absolute identifier (in accordance with the figure below).
   The **data type** is entered automatically.

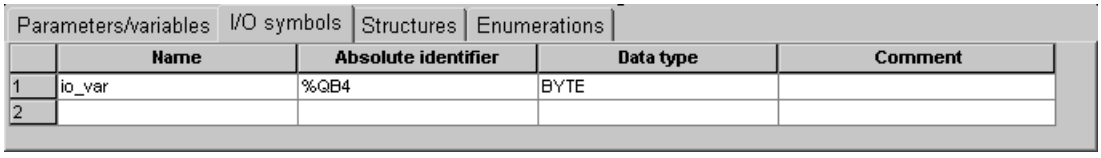


Figure 8-8 I/O symbols in the declaration table

8.3.4 Entering a program title

To enter a program title, proceed as follows:

1. Click in the title line.
2. Enter the program name in the window.

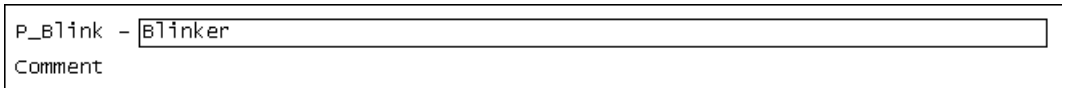


Figure 8-9 Program title

8.3.5 Inserting network

To paste in a network:

1. Select **LAD/FBD program > Insert network**.

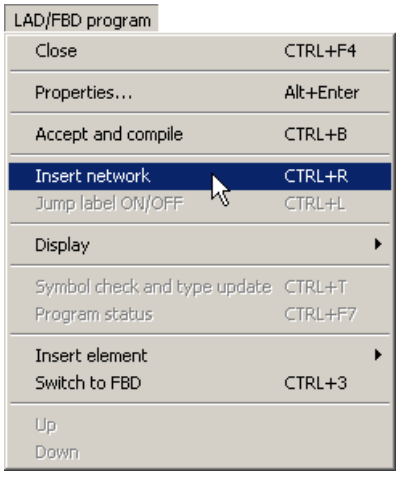


Figure 8-10 Menu selection

2. Click in the title line.

3. Enter the network name in the window.

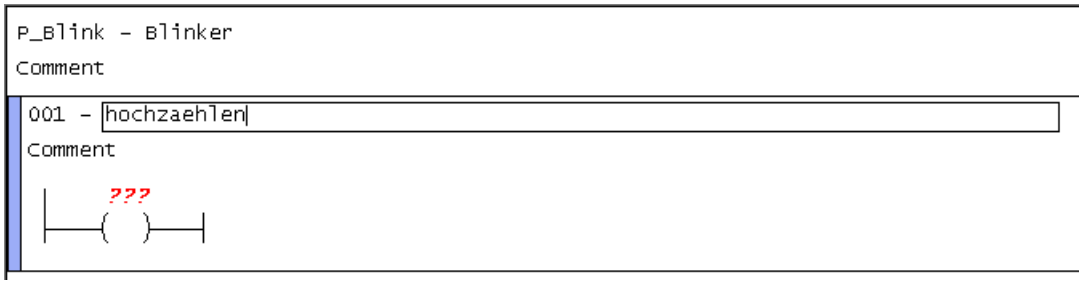


Figure 8-11 Network with entered name

4. Click the power rail to the left of the coil.

8.3.6 Inserting an empty box

To insert an empty box, proceed as follows:

1. From the menu, select the **LAD/FBD program > Insert element > Empty box** menu item.

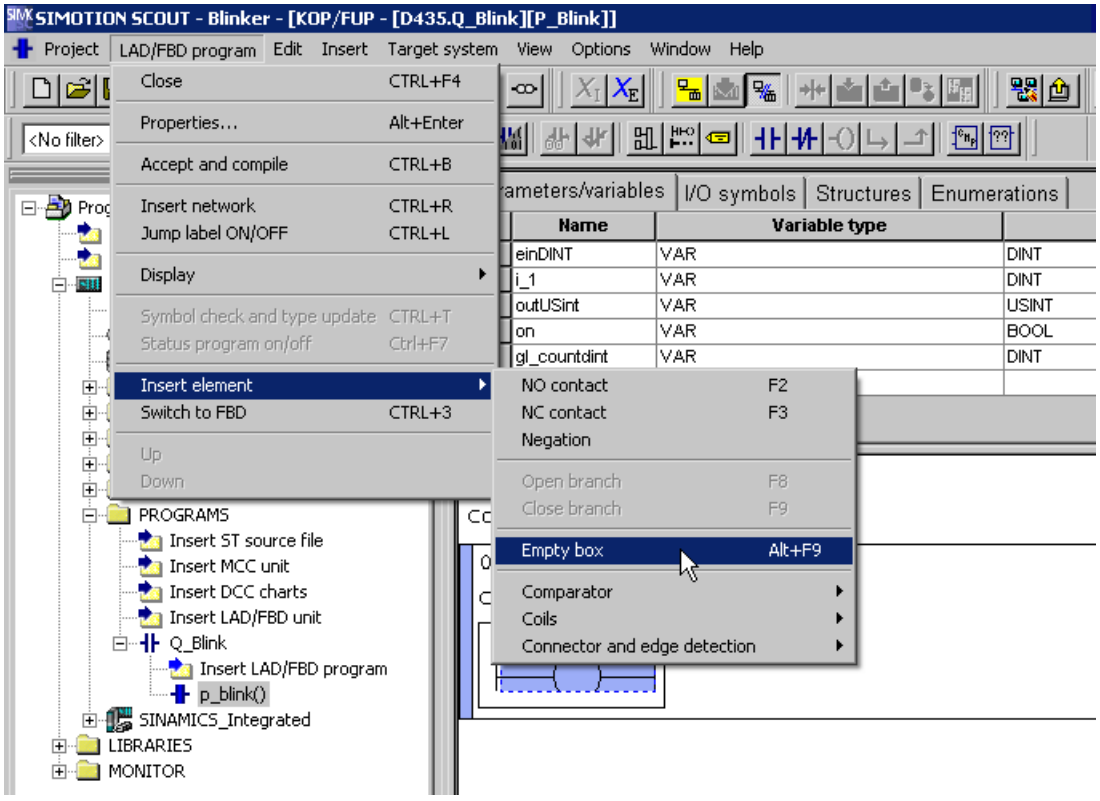


Figure 8-12 Insert an empty box

An empty box is inserted.

Mandatory parameters in a network are identified by **???**, optional parameters by **...** .

8.3.7 Selecting box type

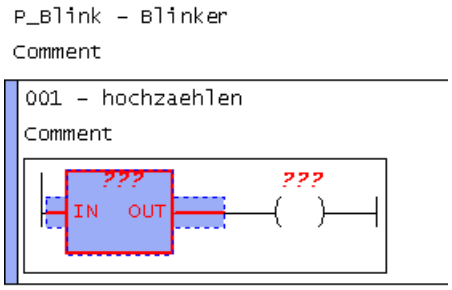


Figure 8-13 Empty box

To select a box type, proceed as follows:

1. Press the **Enter key** in the selected empty box.
   A drop-down menu appears.
2. Select the **ADD** box type from the drop-down menu and confirm your selection by pressing the **Enter key**.

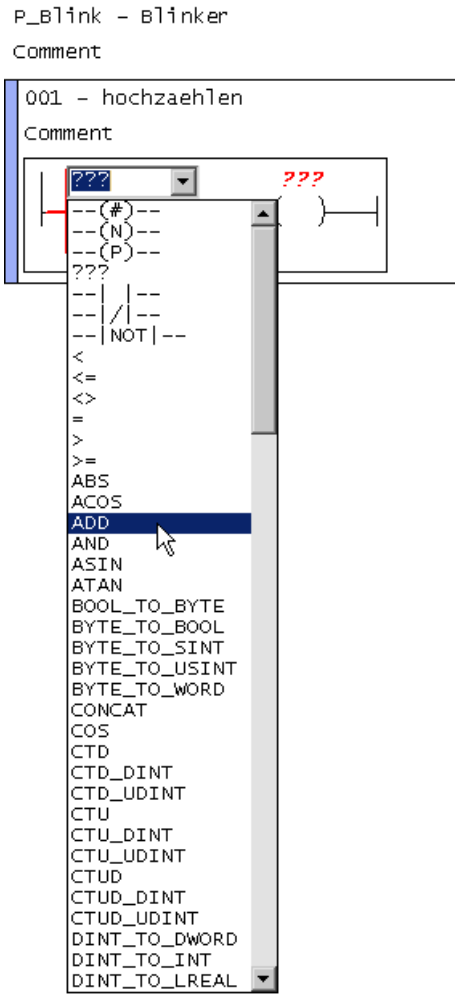


Figure 8-14 Selection of box type

8.3.8 Parameterizing the ADD call-up

To parameterize the ADD call-up, proceed as follows:

1. Click in the other mandatory input fields **???**.

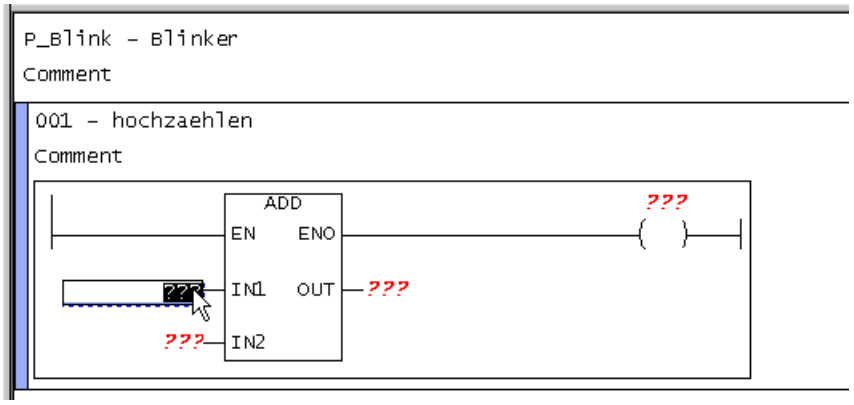


Figure 8-15 ADD box

2. Enter the appropriate values.

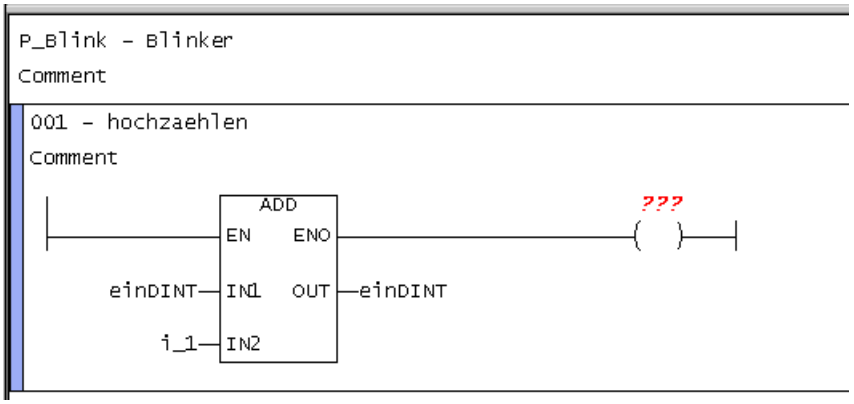


Figure 8-16 Parameterized ADD box

8.3.9 Inserting comparator

To insert a comparator, proceed as follows:

1. Select the ADD box.

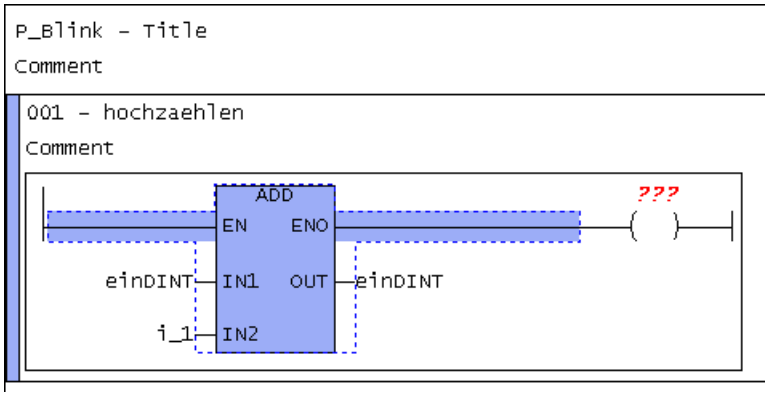


Figure 8-17 Selected ADD box

2. Select **LAD/FBD program > Insert element >Comparator > > =**.

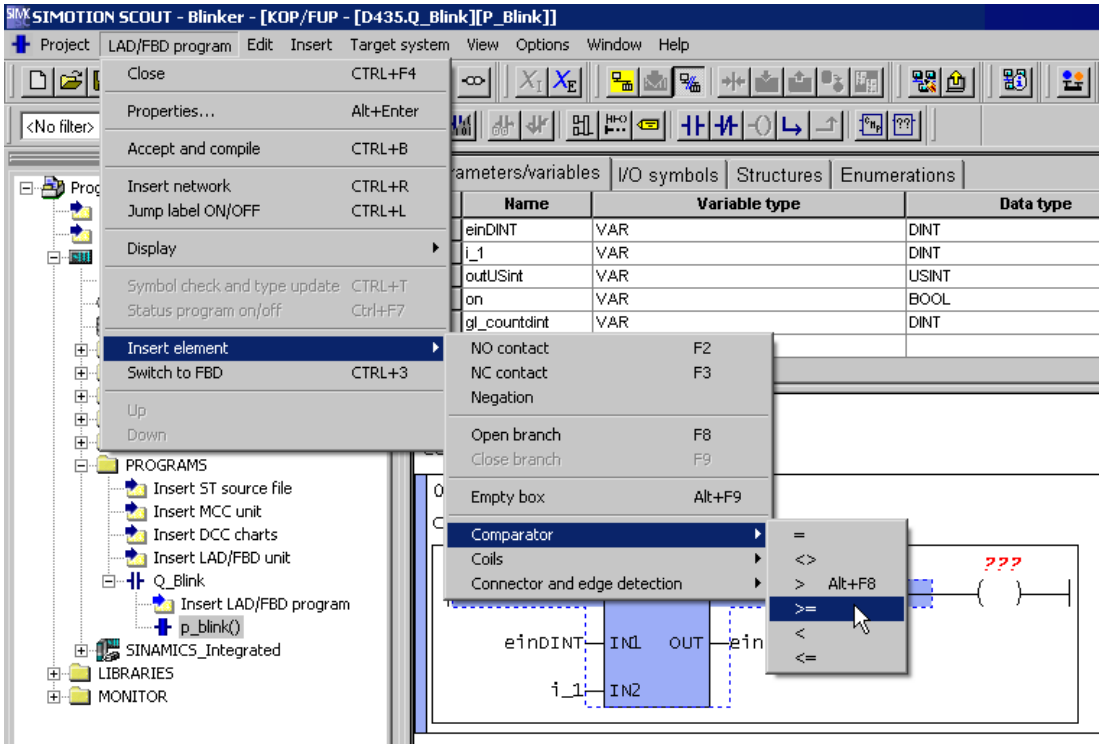


Figure 8-18 Select comparator

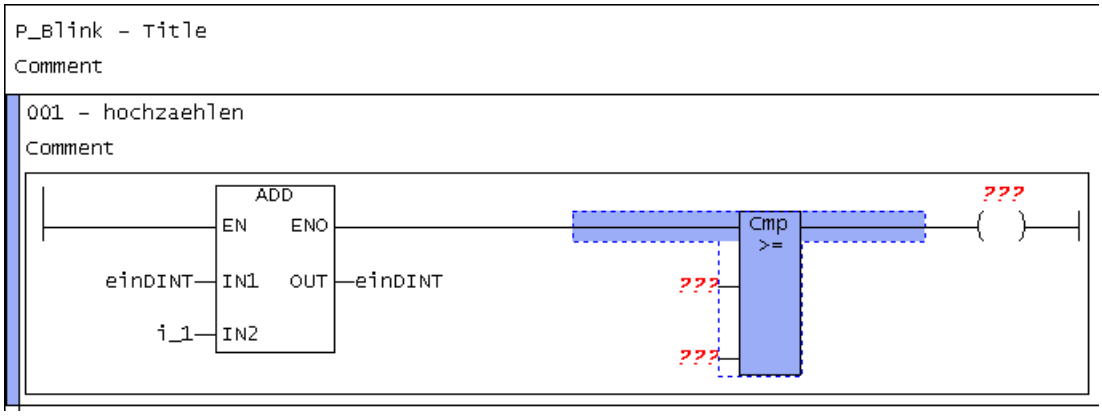


Figure 8-19 Inserted comparator

8.3.10 Labeling the comparator

To label the comparator, proceed as follows:

1. Click each comparator input field individually.
2. Enter the appropriate values for the comparator.

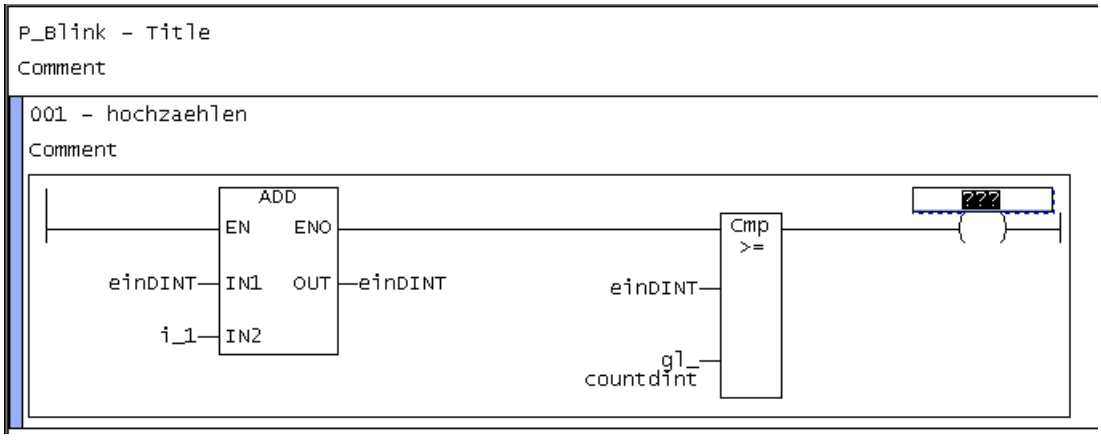


Figure 8-20 Labeled comparator

8.3.11 Initializing a coil

To initialize a coil, proceed as follows:

1. Click in the input field **???** of the coil.
2. Enter the appropriate variable.

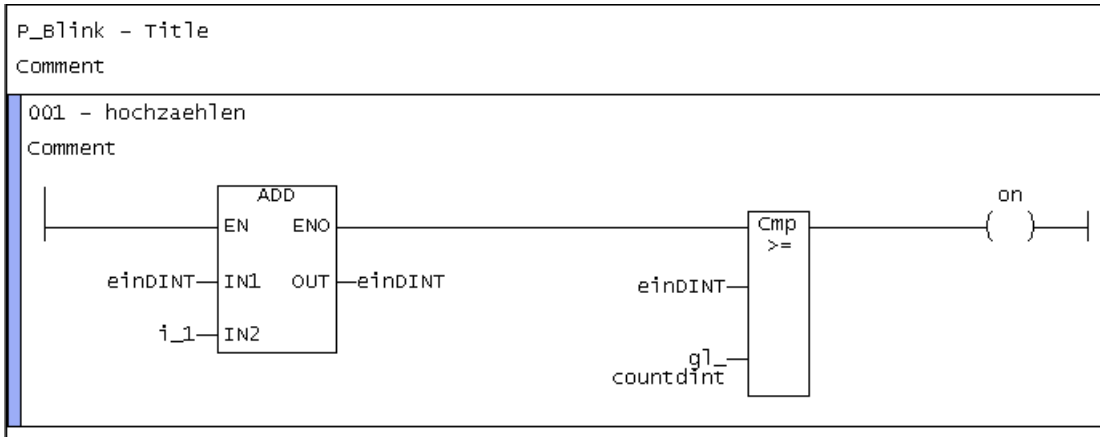


Figure 8-21 Initialized coil

8.3.12 Inserting next network

To paste in another network, proceed as follows:

1. To paste in the second network, repeat the steps used to paste in the first network.

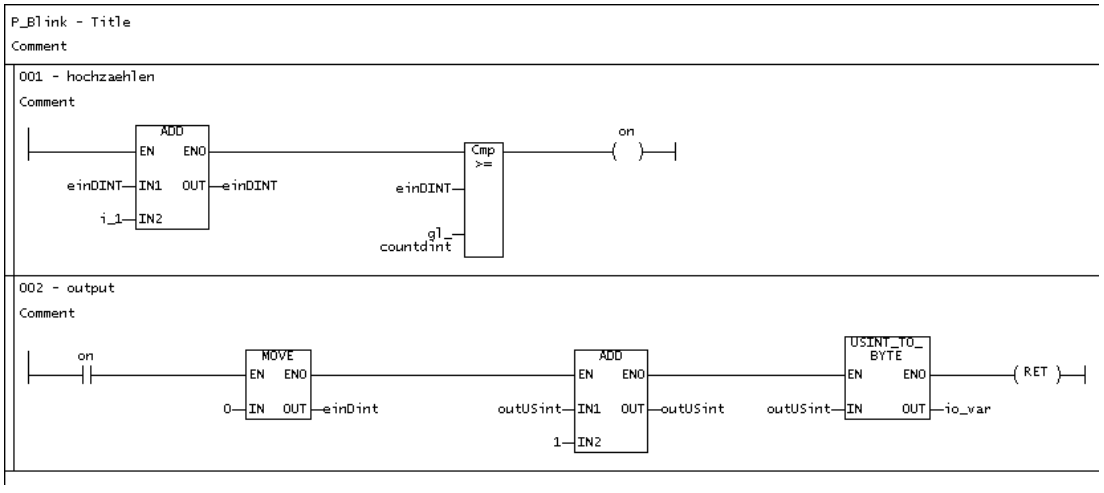


Figure 8-22 Project with two networks

8.3.13 Details view

To show the detail view, proceed as follows:

1. Select the **View > Detail view** menu command.
   Information, e.g. compiler messages, will be displayed during the compilation of a program.

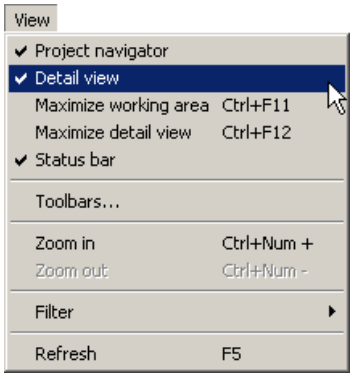


Figure 8-23 Detail view menu selection

8.3.14 Compiling

To compile the created program, proceed as follows:

1. Select the program in the project navigator.
2. Open the **LAD/FBD program** menu and select **Accept and compile**.
   The source file and its POUs are saved and compiled.
   During the compilation process, messages on the successful compilation status are displayed in the detail view. Should any error occur during compilation, they will be displayed in plain text there.

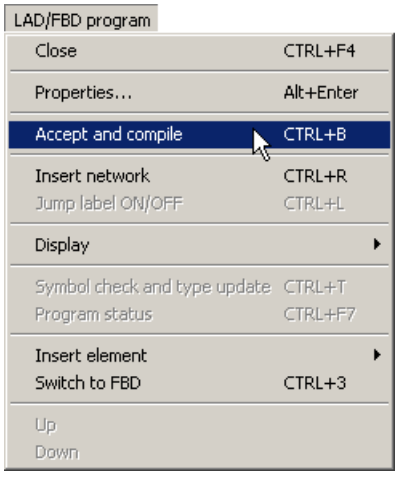


Figure 8-24 Save and compile menu selection

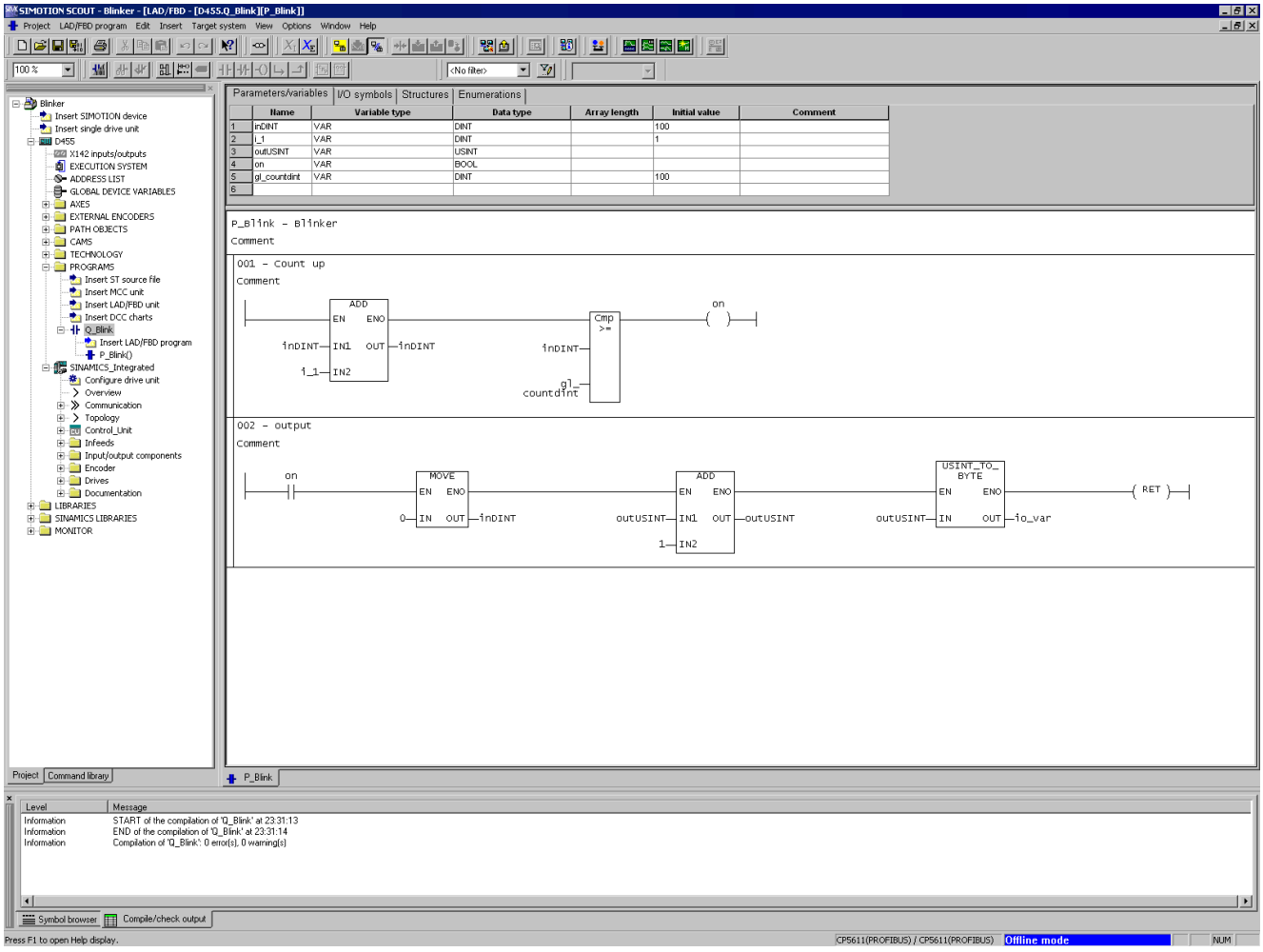


Figure 8-25 Compiled project with compiler information in the detail view

8.3.15 Assigning a sample program to an execution level

To assign a program to an execution level, proceed as follows:

1. Double-click the **EXECUTION SYSTEM** folder in the project navigator.
2. Click **BackgroundTask**.
3. Click the **Program assignment** tab.
4. Select the program **Q_blink.p_blink**.

5. Click the button **>>**.

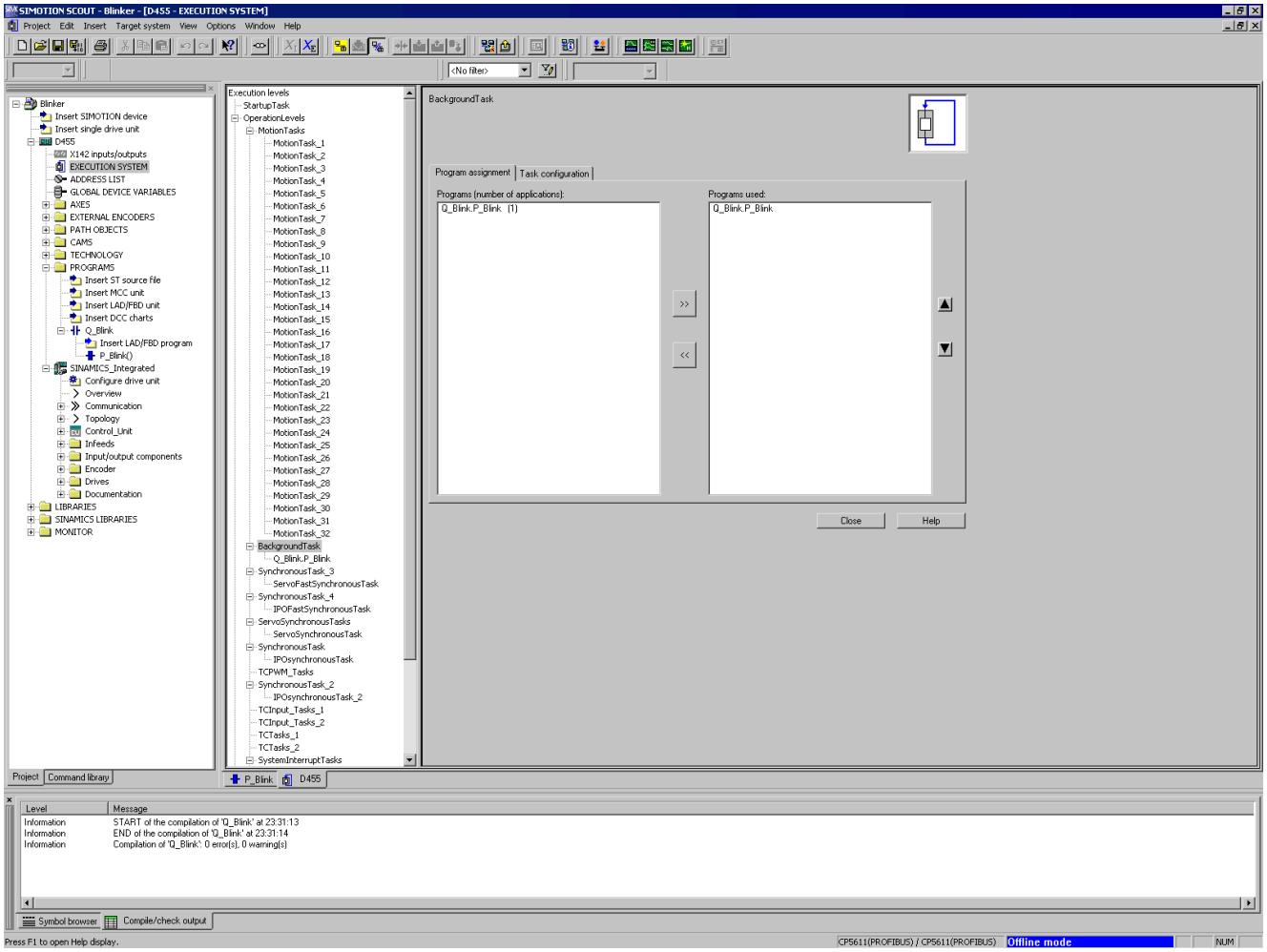


Figure 8-26 Assigning a program to the BackgroundTask

6. Click **Close** and acknowledge the message saying the execution system has changed by clicking **Yes**.
   The changes are accepted into the project.

8.3.16 Starting sample program

To start a program, proceed as follows:

1. Make sure the LAD/FBD unit creates the additional debug code for **program status** during compilation:
   Open the Properties window for the LAD/FBD unit (see Defining the properties of an LAD/FBD unit (Page 51)).
2. Activate the **Permit program status** compiler option on the **Compiler** tab as the local compiler setting (see Local compiler settings (Page 54)) for this LAD/FBD unit.
   See also the description relating to Effectiveness of local or global compiler settings (see the SIMOTION ST Programming and Operating Manual).

3. Select **Project > Save and recompile all**.
   The project is locally saved on the hard disk and compiled.
4. Select the **Project > Connect to selected target devices** menu command or click .
   Online mode is activated.
5. Select the **Target system > Load > Download project to target system** menu command or click .
   The project data (including the sample program) and the data of the hardware configuration are downloaded to the RAM of the target system.
6. Select both networks and click the button for **program status** (Ctrl+F7 shortcut) in the LAD editor function bar (Page 26).
   Monitoring the program execution (Page 297) is switched on.
7. Mark the SIMOTION device in the project navigator and select **Target device > Operating mode** in the context menu.
   The **Operating mode** window with the software switch for modes opens.
8. Click the **RUN** button in the software switch.
   The SIMOTION device is in **RUN** mode. The sample program is run and the current paths/signal paths are color-coded in accordance with the current signal values (Page 297).

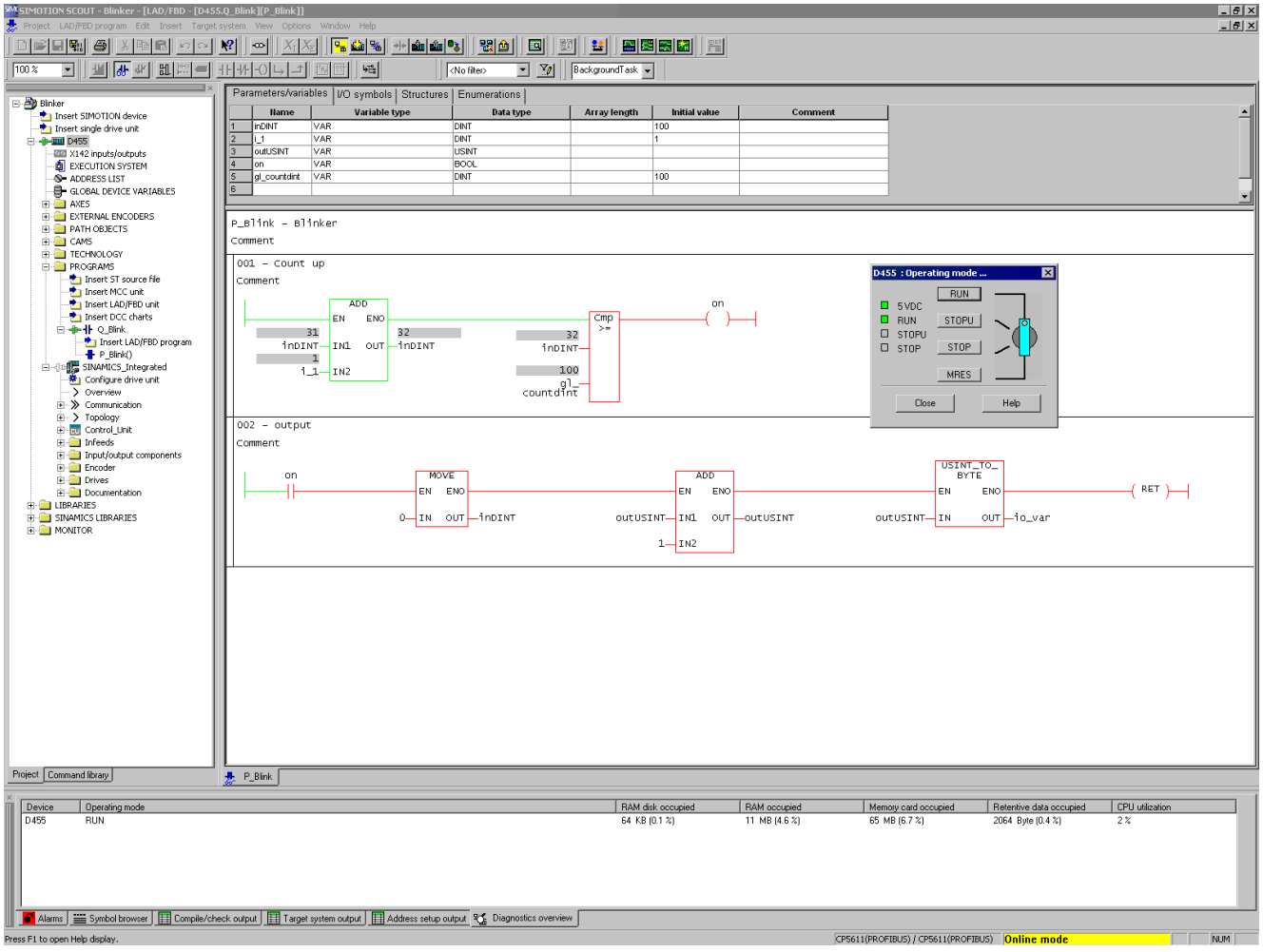


Figure 8-27 Sample program is started

8.4 Position axis program

Requirements

A project must be created. In the project, a CPU and a virtual position axis must be created (name of the axis: posAxis).

Task specification

An axis is to be traversed at a velocity of 10 mm/s from the current position 100 mm in the negative direction.

This task is divided into the following parts:

- Insert LAD/FBD unit
- Insert LAD/FBD program
  - Insert network
  - Set axis enable signals
  - Traverse axis to position
  - Remove axis enable
- Compile program
- Insert program in a task
- Download program onto target device

PLCopen blocks are used for the programming. The PLCopen blocks are designed for use in cyclic programs/tasks and enable motion control programming in a PLC environment. They are used primarily in the LAD/FBD programming language.

PLCopen blocks are available as standard functions (directly from the command library).

You can find further information about PLCopen blocks in the SIMOTION PLCopen Blocks Function Manual.

There is a TO-specific command available for the aforementioned subtasks **Set axis enable** and **Traverse axis to position/Remove axis enable**. Each command is represented by a box in LAD/FBD. The parameters for individual commands (position = 100, speed = 10 etc.) are entered

via the **Variable declaration** dialog box.

- or -

via the **Enter call parameters** dialog box

- or -

by entering the values in the input fields on each connector.

The task is implemented using LAD programming.

8.4.1 Insert LAD/FBD source file

To insert an LAD/FBD unit (for details of how to insert the unit and program, see also the blinker program (Page 319) example), proceed as follows:

1. Open the **PROGRAMS** folder of the relevant SIMOTION device in the project navigator.
2. Double-click the entry **Insert LAD/FBD unit**.
   The **Insert LAD/FBD Unit** dialog box appears.
3. Enter the name of the LAD/FBD unit.
   The names of program sources must comply with the rules for identifiers (Page 97): They are made up of letters (A … Z, a … z), numbers (0 … 9), or single underscores (_) in any order, whereby the first character must be a letter or underscore. No distinction is made between upper- and lower-case letters.
   The permissible length of the name depends on the SIMOTION Kernel version:
   – SIMOTION Kernel as of version V4.1: Maximum 128 characters.
   – SIMOTION Kernel up to version V4.0: Maximum 8 characters.

   Names must be unique within the SIMOTION device. Protected or reserved identifiers (Page 361) are not permitted.
   Existing program sources (e.g. ST source files, MCC units) are displayed.
4. In the **Compiler** tab, activate the **Permit program status** checkbox, to use the online status display later.
5. You can also enter an author, version, and a comment.
6. Activate the **Open editor automatically** checkbox.
7. Confirm with **OK**.
   The declaration tables for global and unit-local variables appear in the working area.

8.4.2 Insert LAD/FBD program

To insert an LAD/FBD program, proceed as follows:

1. In the **PROGRAMS** folder within the project navigator, open the LAD/FBD unit you just pasted in.
2. Double-click the entry **Insert LAD/FBD program** in the LAD/FBD unit.
   The **Insert LAD/FBD Program** dialog box appears.
3. Enter the name of the program in the **Insert LAD/FBD Program** dialog box.
   Names for LAD/FBD programs must comply with the Rules for identifiers (Page 97): They are made up of letters (A … Z, a … z), numbers (0 … 9), or single underscores (_) in any order, whereby the first character must be a letter or underscore. No distinction is made between upper- and lower-case letters. Protected or reserved identifiers (Page 361) are not permitted.
   The permissible length of the name is 25 characters.
   The names must be unique within the LAD/FBD unit. The names of all exportable program organization units (POUs) must also be unique within the SIMOTION device. The names of all LAD/FBD programs of the program source as well as the names of all exportable POUs of the device are displayed.
4. For **Creation type**, select program.

5. Activate the **Open editor automatically** checkbox.
6. Confirm with **OK**.
   A blank LAD/FBD program is opened.
7. Click the working area and select **LAD/FBD program > Insert network** from the menu to paste in a new network.

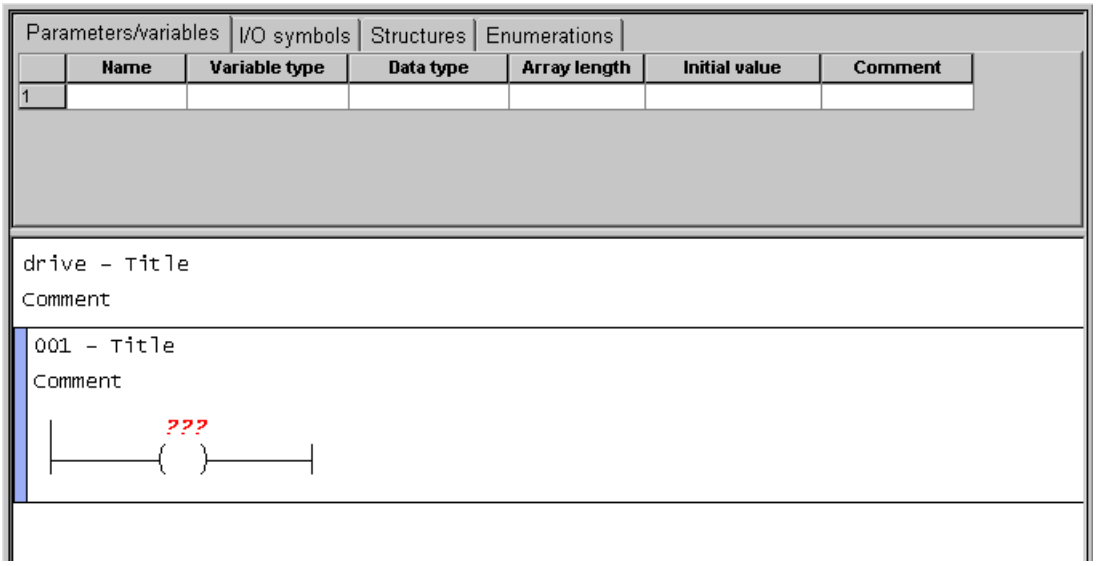


Figure 8-28 Pasted network

Note

Mandatory parameters in a network are identified by **???**, optional parameters by **...** .

8. Select the pasted box and select **Delete** in the context menu.
   The box is removed from the network.

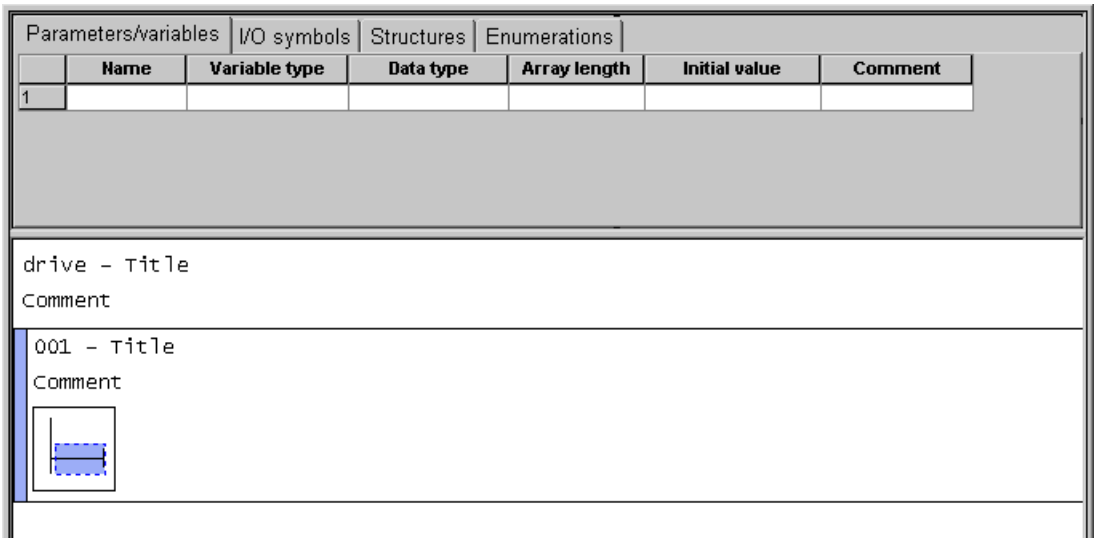


Figure 8-29 Pasted network without a box

8.4.3 Inserting a TO-specific command

To insert a **TO-specific command**, proceed as follows:

1. To enhance the display in the working area, open the shortcut menu of the network and select **Display > Mandatory and assigned box parameters**.
2. Select the **Command library** tab in the project navigator.
   The command groups appear.
3. Click the relevant plus sign to open the **PLCopen > SingleAxis** command group.

4. Drag and drop the **_MC_Power** command into the network (see Network with RET assignment).
   This command serves to enable the command.

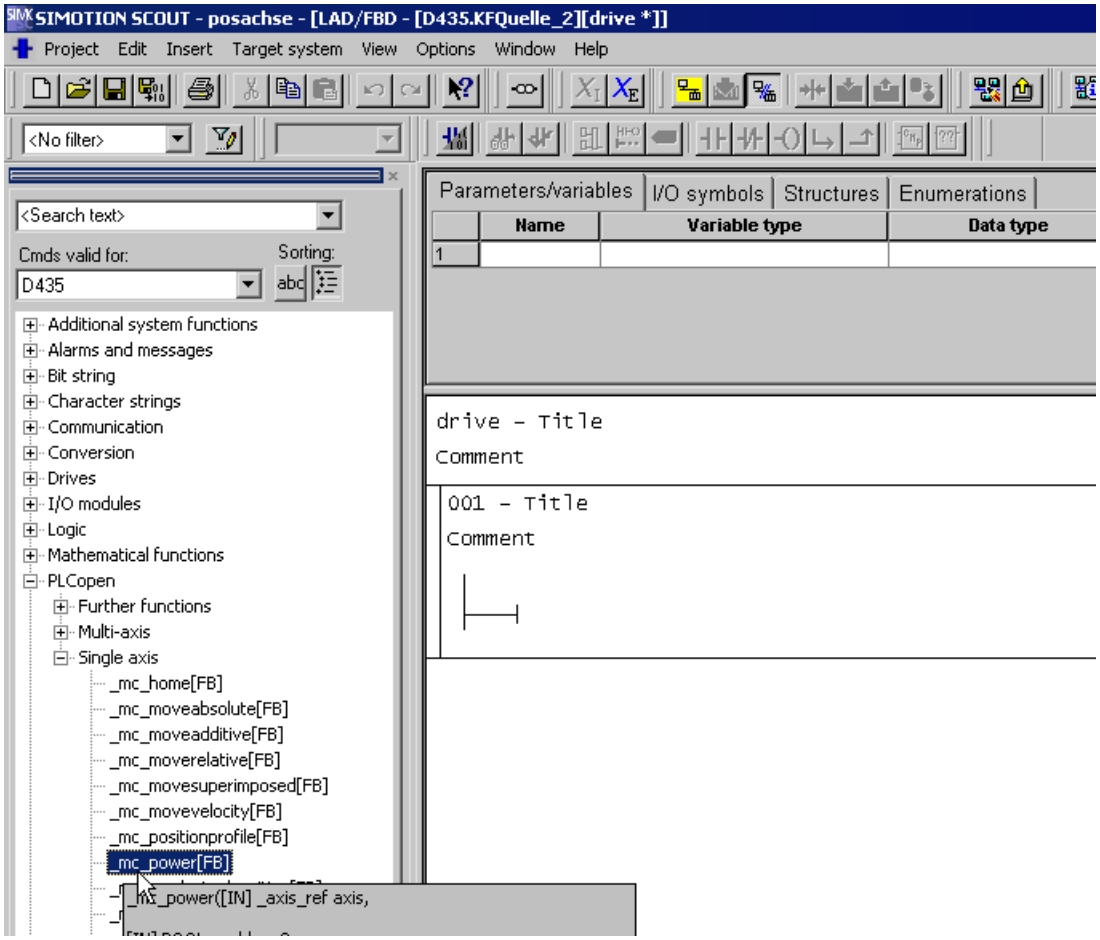


Figure 8-30 TO-specific command (_MC_Power) from the command library

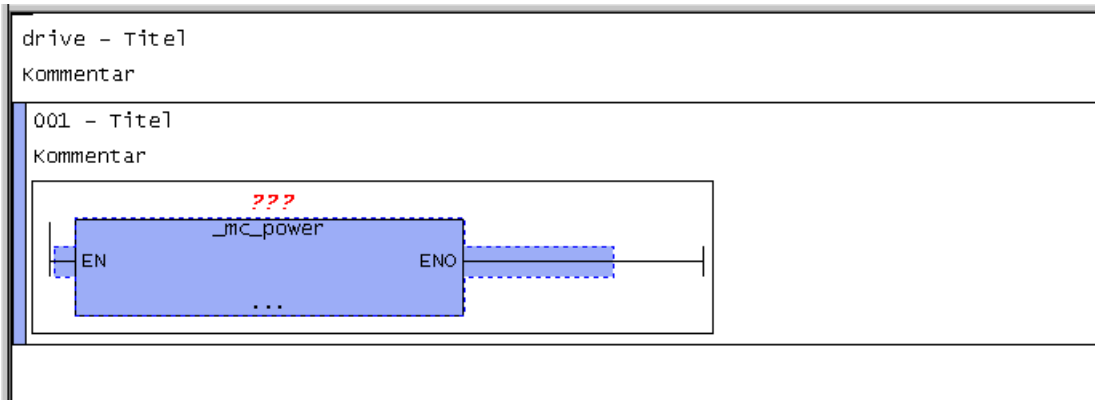


Figure 8-31 Network with inserted _MC_Power Box

5. Mark the network and select **LAD/FBD program > Insert network** from the menu to insert a second network.

6. Mark the inserted box from the second network and select **Delete** in the context menu.
   The box is removed from the network.
7. Drag and drop the **_MC_MoveRelative** command from the command library to the marked position in the second network.
   The axis is positioned at the specified speed with this command.

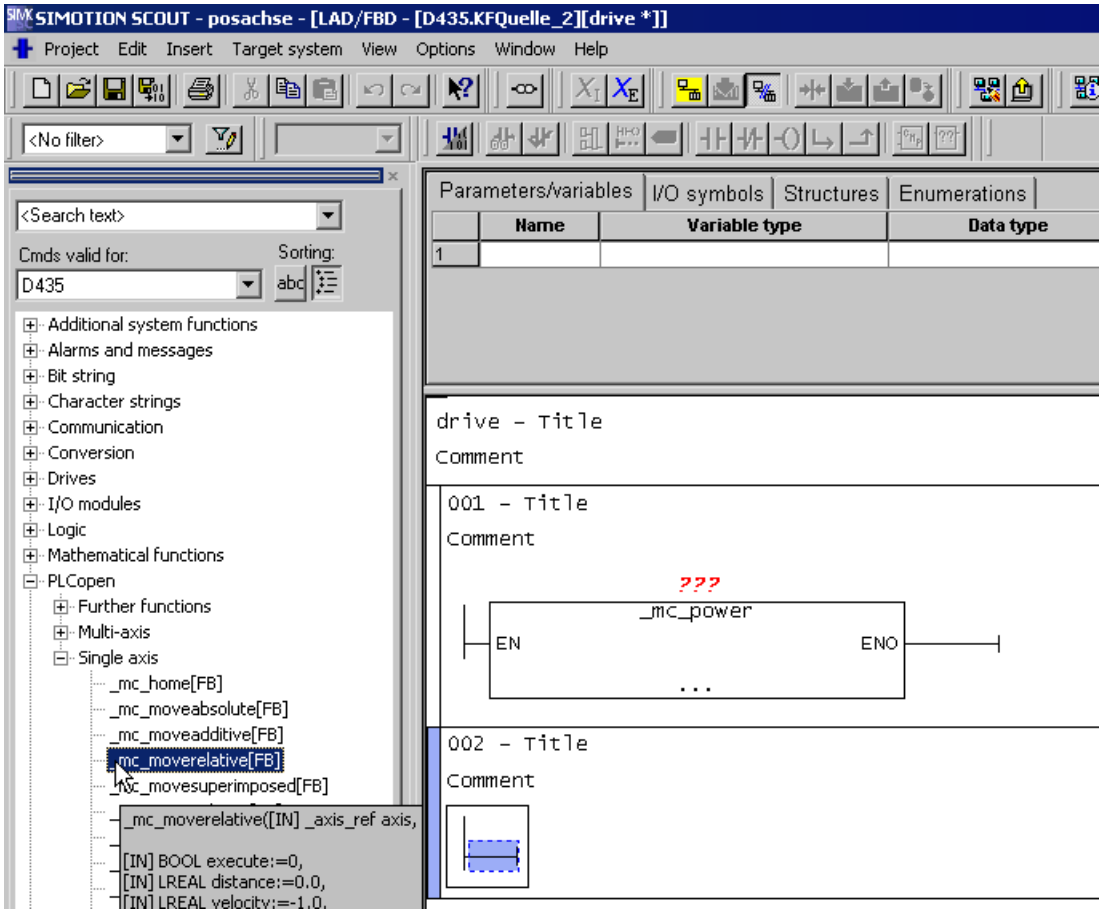


Figure 8-32 TO-specific command (_MC_MoveRelative) from the command library

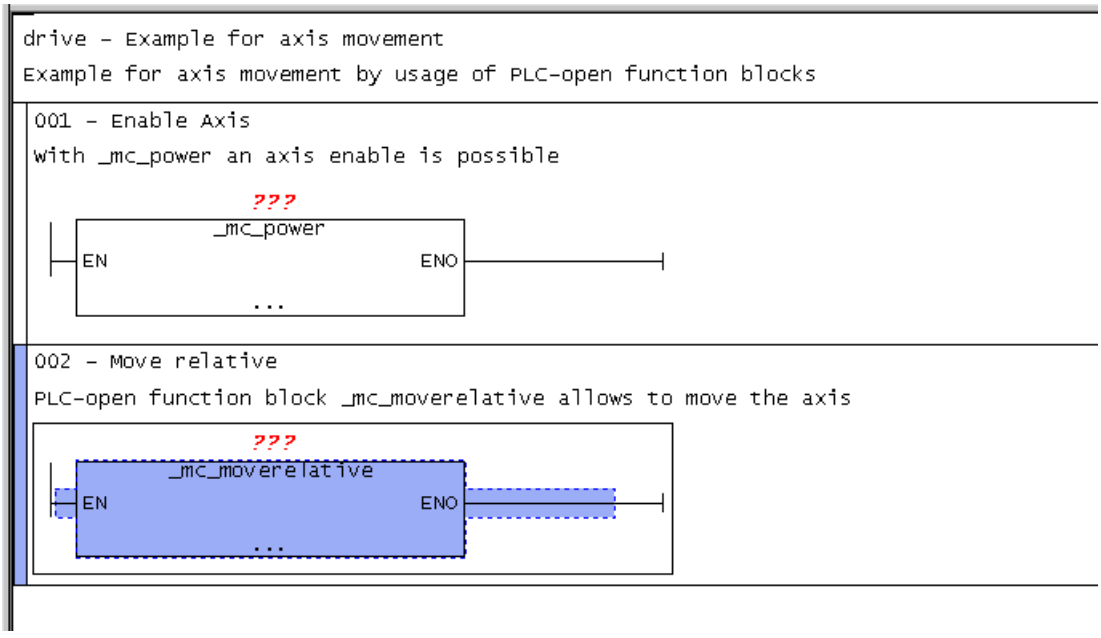


Figure 8-33 Network with inserted _MC_MoveRelative box

8.4.4 Connecting the enable inputs

The **enable** input for the **_MC_Power** command and the **execute** enable input for the **_MC_MoveRelative** command still have to be connected to NO contacts.

How to insert the NO contacts:

1. Click in the working area and select **Display > All box parameters** in the context menu. All the inputs and outputs of the boxes are shown.
2. Select the **Command library** tab in the project navigator. The command groups appear.
3. Click the plus symbol to open the command group **LAD elements**.

4. Drag and drop the **NO contact** LAD element to the **enable** input of the **_MC_Power** function block.

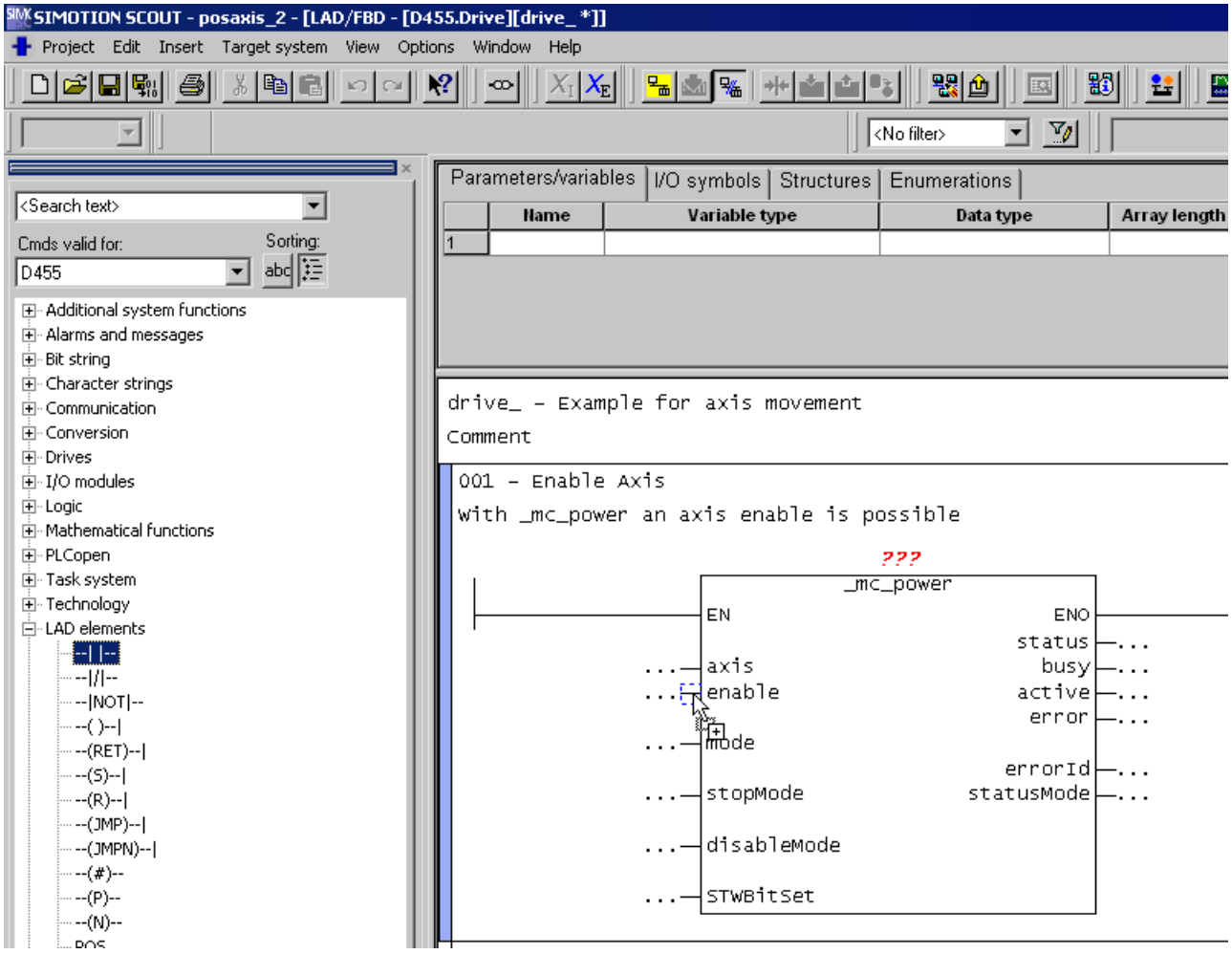


Figure 8-34 Drag&drop the NO contact LAD element to the connector of the enable input

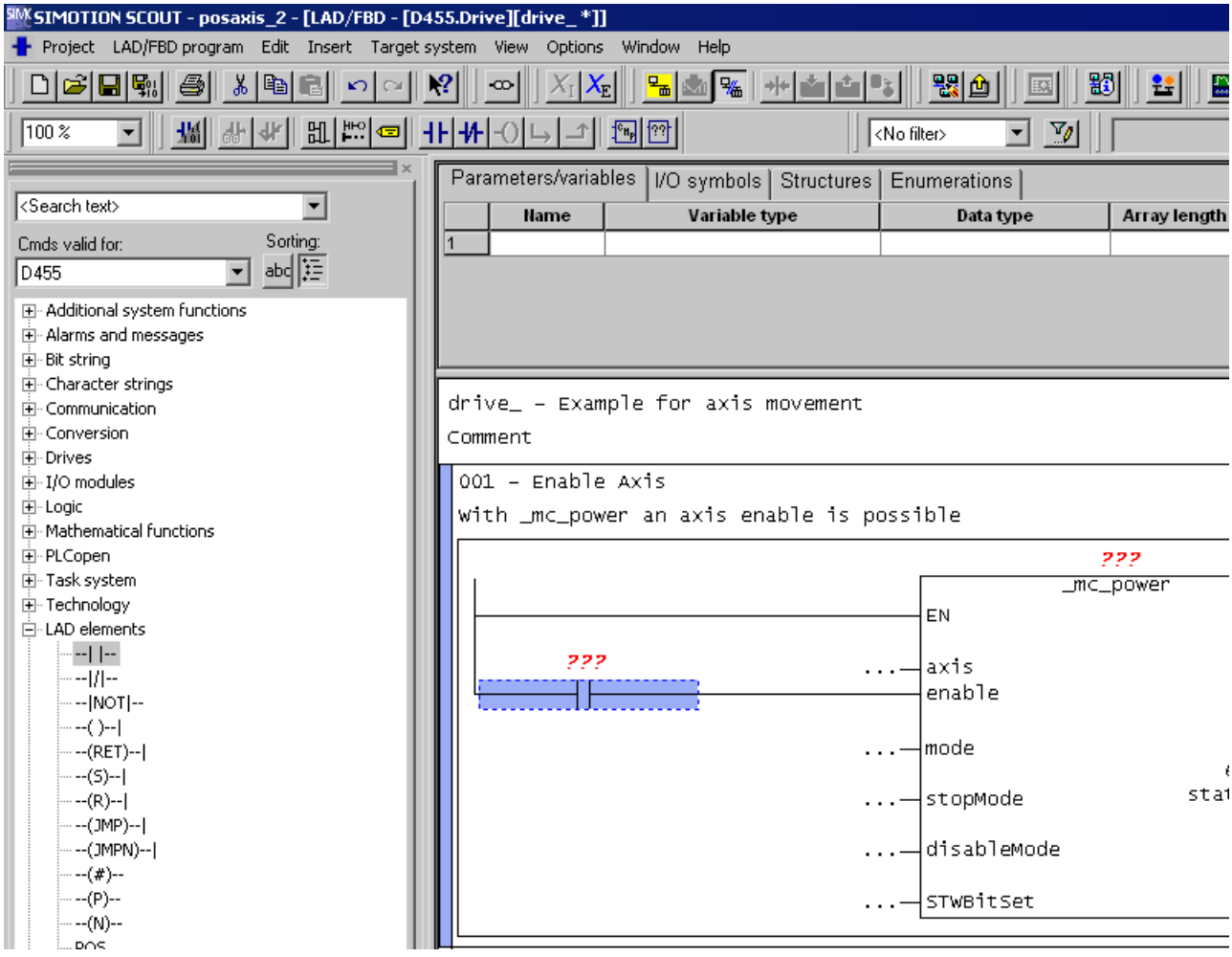


Figure 8-35 Network with a NO contact LAD element inserted

5. Drag and drop two **NO contact** LAD elements to the **execute** enable input of the **_MC_MoveRelative** function block.

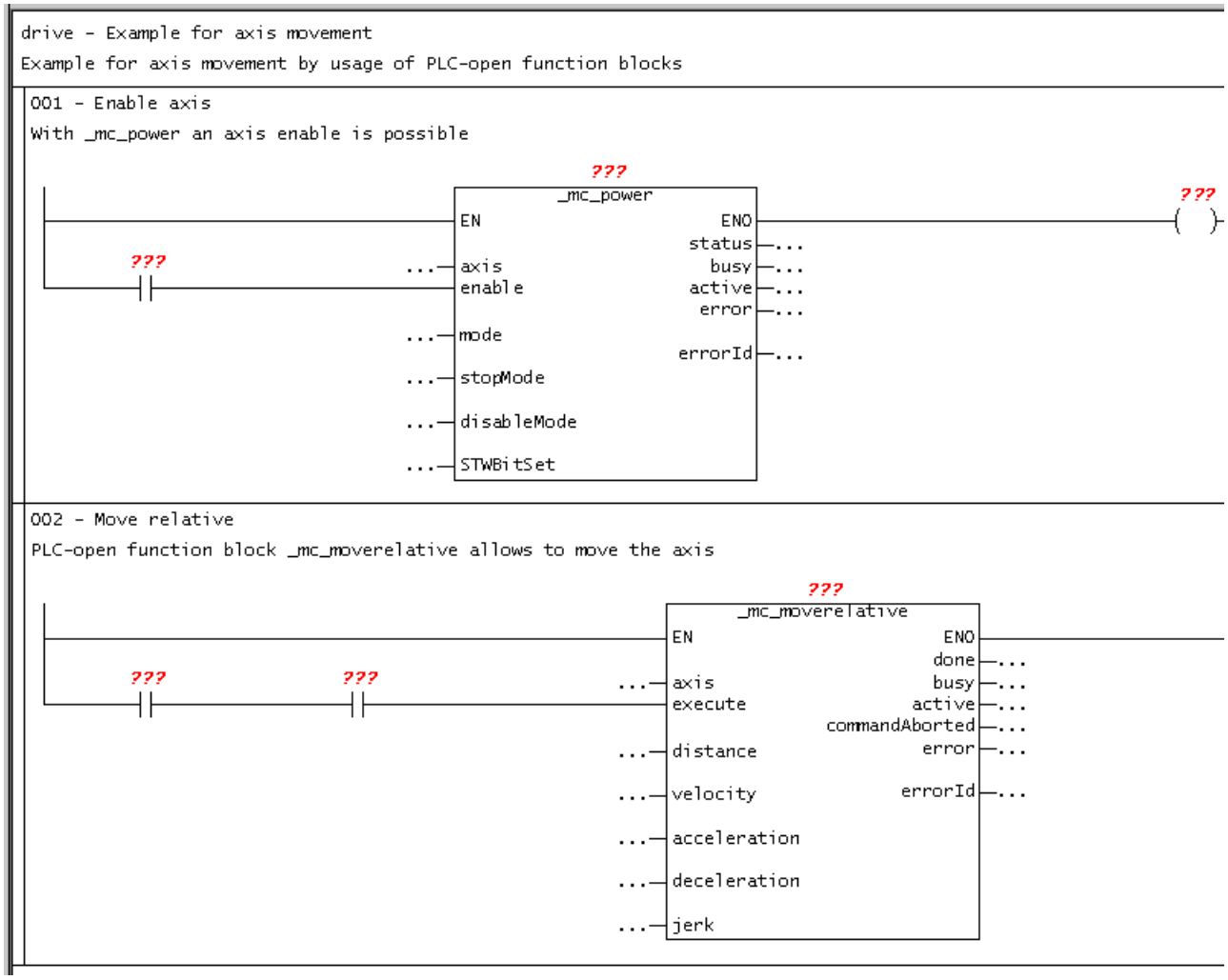


Figure 8-36 Networks with NO contacts inserted

8.4.5 Entering variables in the declaration table

To enter variables, proceed as follows:

1. Select the **Parameters/variables** tab.
2. Enter name, variable type, data type and/or start value in the declaration table (as shown in the figure below).
   In order to use PLCopen blocks, you must create one instance for each the used blocks (**_MC_Power** and **_MC_MoveRelative**). The data type of the instance corresponds to the block name. The variables **i_mc_power** and **i_mc_moverelative** are instance variables for the two function blocks **_MC_Power** and **_MC_MoveRelative**.
   You can find further information about the declaration and use of instance variables in Example: Function block (FB) (Page 179).

Parameters/variables | I/O symbols | Structures | Enumerations

	Name	Variable type	Data type	Array length	Initial value	Comment
1	enable	VAR	BOOL			
2	move	VAR	BOOL			
3	i_mc_power	VAR	_MC_POWER			
4	i_mc_moverelative	VAR	_MC_MOVERELATIVE			
5	o_enabled	VAR	BOOL			
6						

Figure 8-37 Variables in the declaration table

8.4.6 Parameterization of the NO contacts

How to parameterize each of the NO contacts:

1. Click in the input field **???** for the NO contact.
2. Enter the appropriate variable.
3. Press **Enter**.

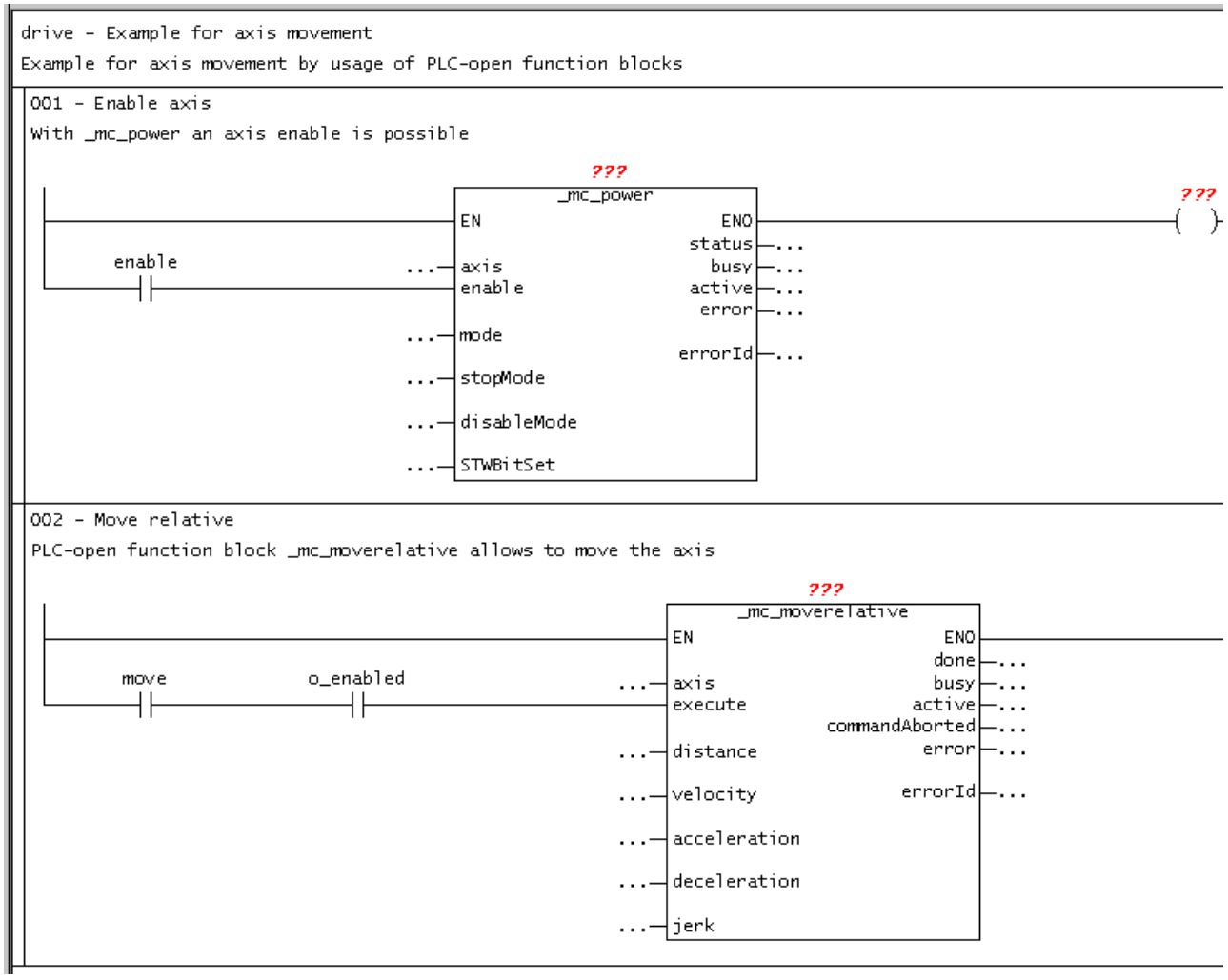


Figure 8-38 Parameterization of the NO contacts

8.4.7 Setting call parameters for the _MC_Power command

Note

The **Enter Call Parameters** dialog box displayed below is available for each SIMOTION command.

To set the call parameters, proceed as follows:

1. Double-click the box.
2. Select the instance, the homing axis, the axis enables to be set, stop mode and enable mode for the axis.
   If you print the project, your parameters appear in the printout according to your settings, e.g. **only allocated box parameters**.
3. Confirm with **OK**.

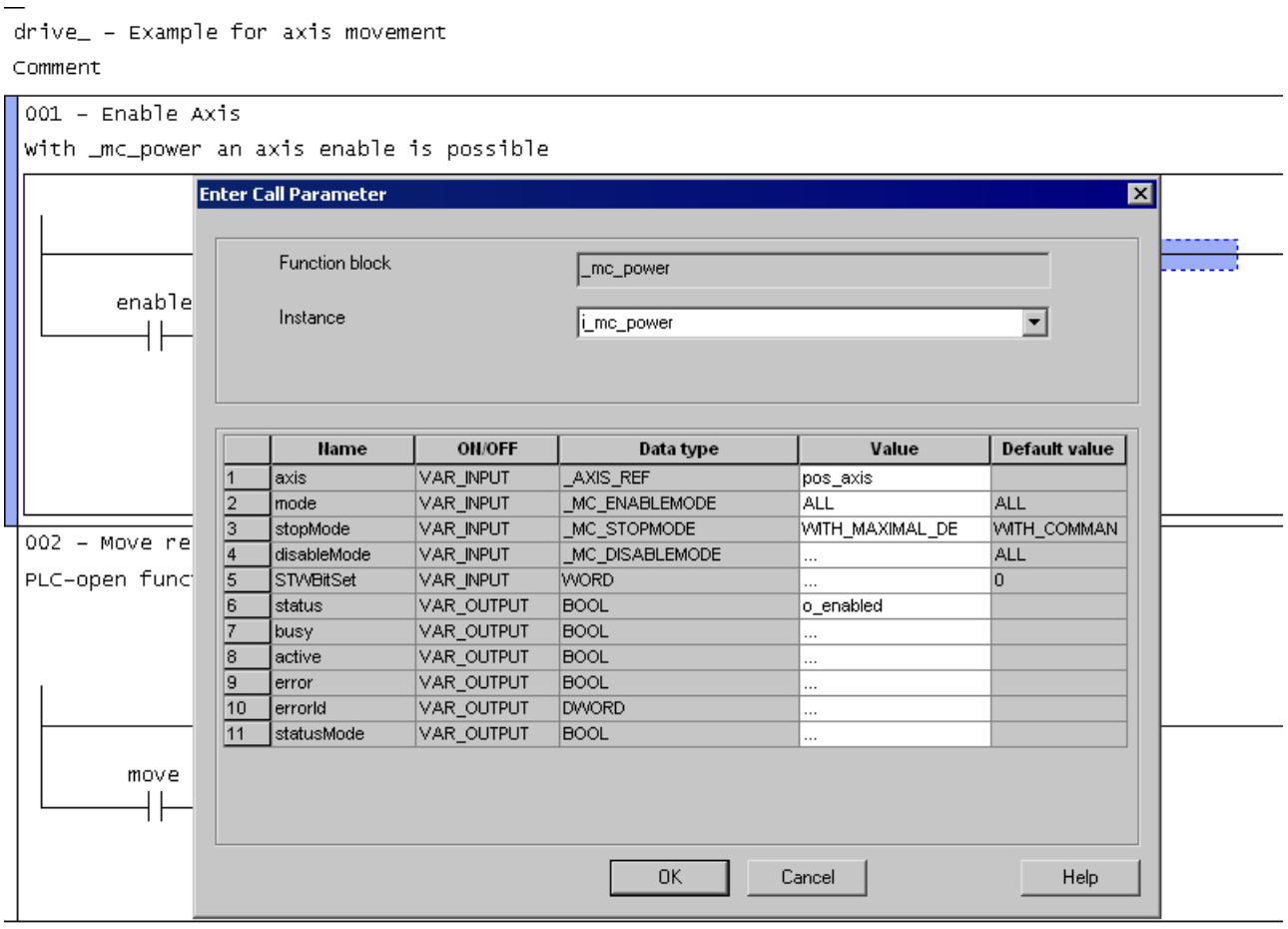


Figure 8-39 Set call parameters for the PLCopen block _MC_Power

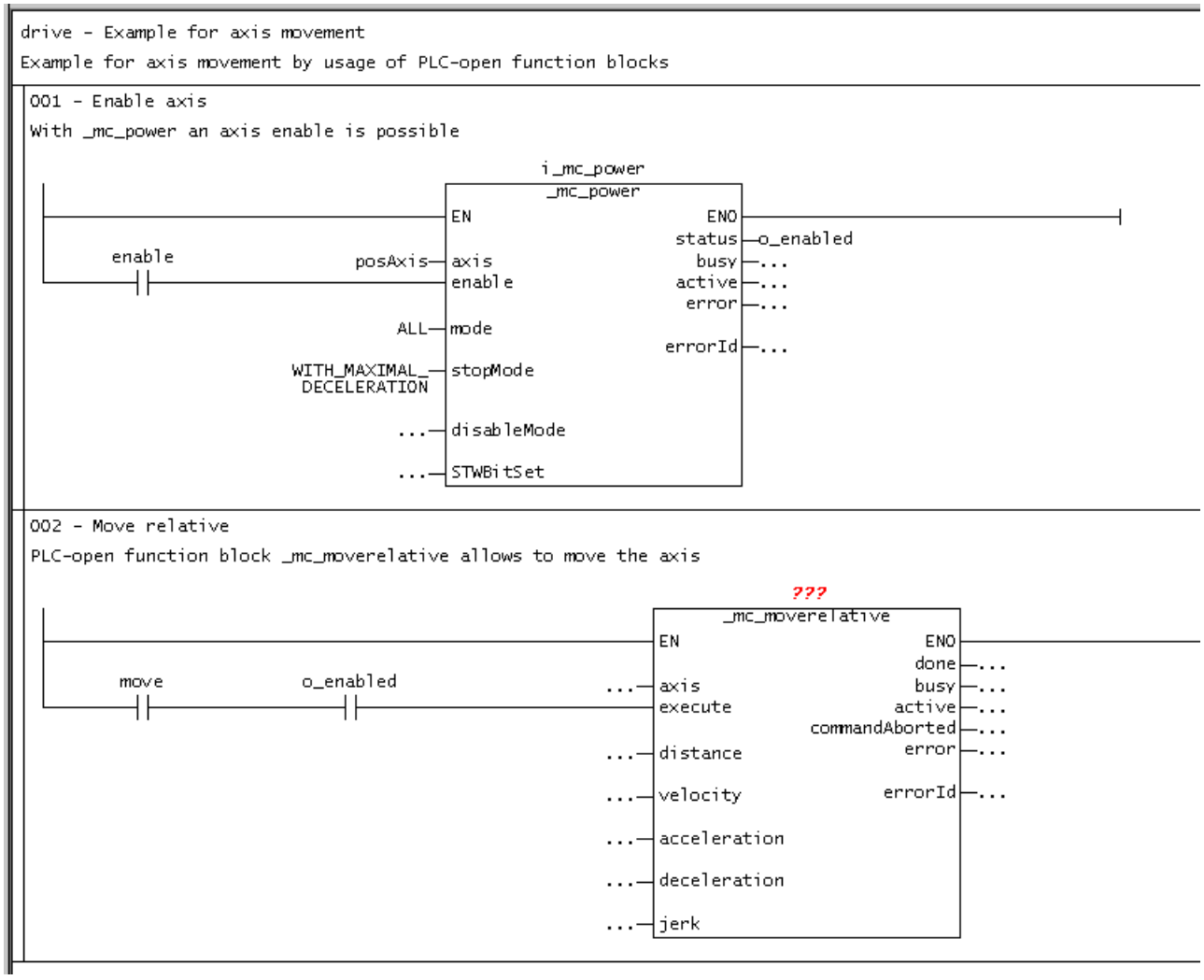


Figure 8-40 Labelled _MC_Power box

8.4.8 Setting call parameters for the _MC_MoveRelative command

To set the call parameters, proceed as follows:

1. Double-click the _mc_moverelative box.
2. Select the instance and the homing axis. Enter values for the difference in distance traveled and for the maximum speed of the axis.
   If you print the project, your parameters appear in the printout according to your settings, e.g. **only allocated box parameters**.
3. Confirm with **OK**.

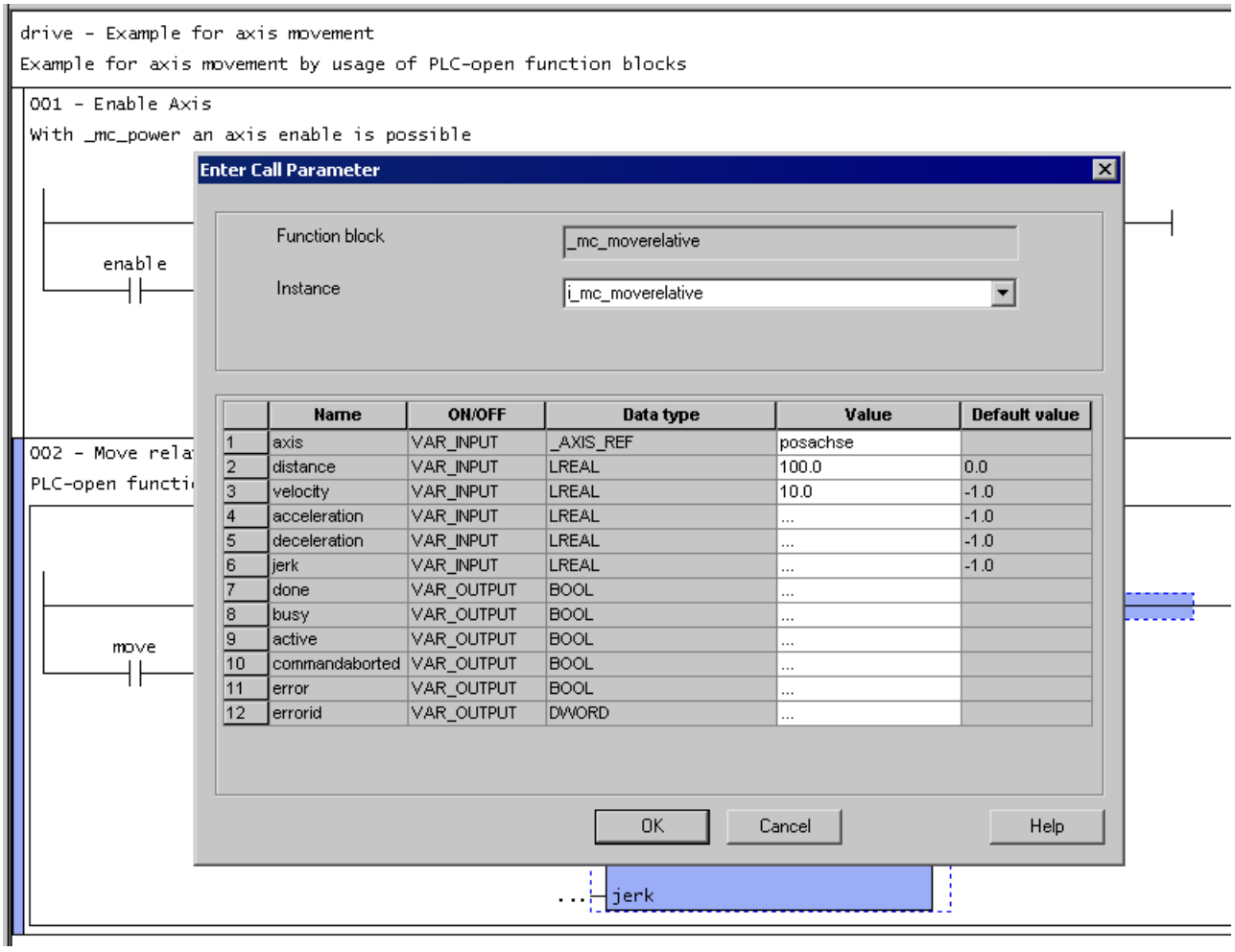


Figure 8-41 Set call parameters for the PLCopen block _MC_MoveRelative

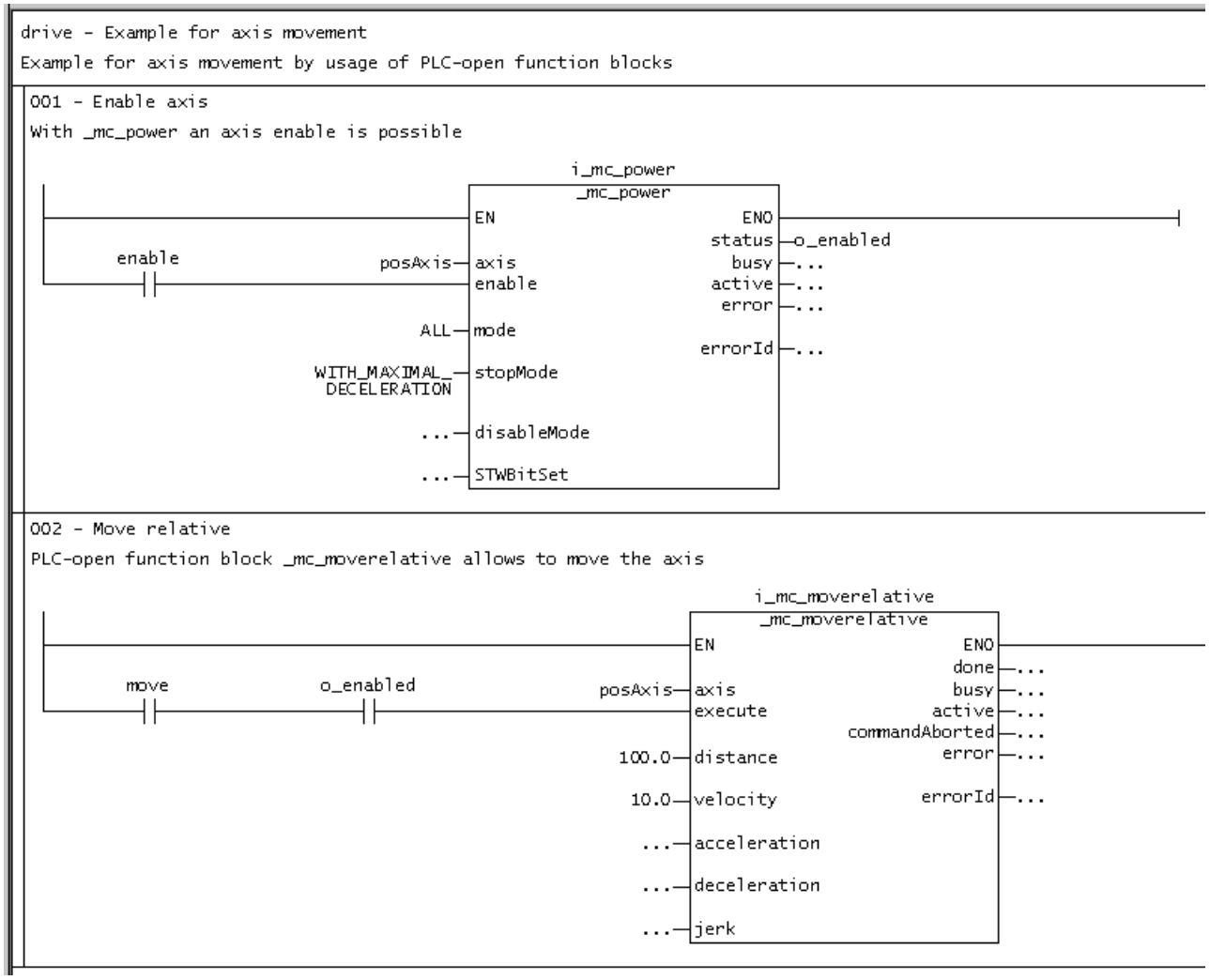


Figure 8-42 Network with entered variables

8.4.9 Details view

To show the detail view, proceed as follows:

1. Select the **View > Detail view** menu item.
   Information, e.g. compiler messages, will be displayed during the compilation of a program.

8.4.10 Compiling

To compile the program, proceed as follows:

1. Select the program in project navigation.
2. Open the **LAD/FBD program** menu and select **Accept and compile**.

During the compilation process, messages on the successful compilation status are displayed in the detail view. Should any error occur during compilation, they will be displayed in plain text there.

8.4.11 Assigning a sample program to an execution level

Before you can run the sample program, you must assign it to an execution level or a task. When you have done this, you can establish the connection to the target system, download the program to the target system, and then start it.

To assign the program to an execution level (see also the blinker program (Page 337) example), proceed as follows:

1. Double-click the **EXECUTION SYSTEM** folder in the project navigator.
2. Mark the **BackgroundTask**.
3. Click the **Program assignment** tab.
4. Select the program.
5. Click the button **>>**.
6. Click **Close**.

See also

Assigning a sample program to an execution level (Page 337)

8.4.12 Starting sample program

To start a program, proceed as follows:

1. Make sure the LAD/FBD unit creates the additional debug code for **program status** during compilation:
   Open the Properties window for the LAD/FBD unit (see Defining the properties of an LAD/FBD unit (Page 51)).
2. Activate the **Permit program status** compiler option on the **Compiler** tab as the local compiler setting (see Local compiler settings (Page 54)) for this LAD/FBD unit.
   See also the description relating to Effectiveness of local or global compiler settings (see the SIMOTION ST Programming and Operating Manual).
3. Select **Project > Save and recompile all**.
   The project is locally saved on the hard disk and compiled.
4. Select the **Project > Connect to selected target devices** menu command or click  .
   Online mode is activated.
5. Select the **Target system > Load > Download project to target system** menu command or click  .
   The project data (including the sample program) and the data of the hardware configuration are downloaded to the RAM of the target system.

6. Select both networks and click the button for **program status** (CTRL+F7 shortcut) in the LAD editor function bar (Page 26).
   Monitoring the program execution (Page 298) is switched on.
7. Mark the SIMOTION device in the project navigator and select **Target device > Operating mode** in the context menu.
   The **Operating mode** window with the software switch for modes opens.
8. Click the **RUN** button in the software switch.
   The SIMOTION device is in **RUN** mode. The sample program is run and the current paths/signal paths are color-coded in accordance with the current signal values (Page 298).

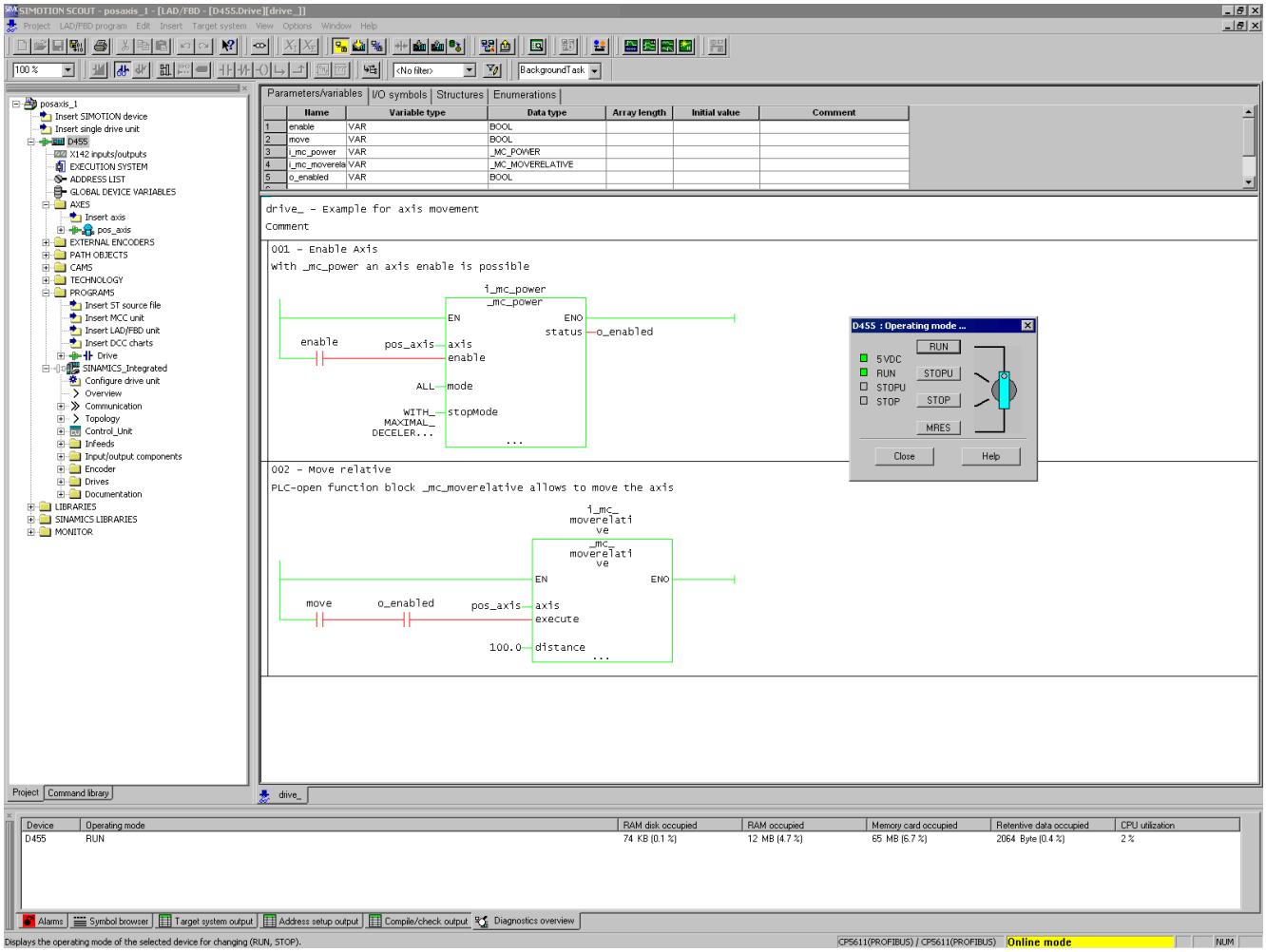


Figure 8-43 Sample program is started

Appendix

A

A.1 Key combinations

The following key combinations are available:

With LAD/FBD editor open	
Left/right arrow buttons Up/down arrow buttons	With a selected operator: Navigation between the individual operators
Ctrl+down arrow button	Selects previous network
Ctrl+up arrow button	Selects next network
Ctrl+F7	Switches the program status (Page 297) function on and off
Ctrl+space	Automatic completion (Autocomplete) (Page 30)
Pg Up	Selects the network at the start of the visible editor area
Pg Dn	Selects the network at the end of the visible editor area
Del	Deletes an operator
Tab / Shift+Tab	Jumps forward to next button / input field / jumps back to previous button / input field
Return	Opens the input field of the current operand or confirms the entry made in the input field
Esc	Aborts the entry while input field is open
Shift+F6	Switches between declaration table and editor area
Ctrl+Alt+H	Opens the symbol input help dialog window

Window menu	
Ctrl+Shift+F5	Rearranges all windows opened in this application in horizontal tiled format
Ctrl+Shift+F3	Rearranges all windows opened in this application in vertical tiled format
Ctrl+Tab	Switches between windows of the working area

View menu	
Ctrl+F11	Maximizes the working area
Ctrl+F12	Maximizes the detail view
Ctrl+Num+	Enlarges the contents of the working area
Ctrl+Num-	Reduces the contents of the working area
F5	Updates the view

LAD/FBD unit menu	
Ctrl+F4	Closes the LAD/FBD unit
Alt+Enter	Displays the properties of the active/selected object for editing
Ctrl+B	Accepts and compiles the active/selected object
Ctrl+R	Inserts a new network

LAD/FBD program menu	
Ctrl+F4	Closes the LAD/FBD program
Alt+Enter	Displays the properties of the active/selected object for editing
Ctrl+B	Accepts and compiles the active/selected object
Ctrl+R	Inserts a new network
Ctrl+L	Jump label ON/OFF
Ctrl+Shift+K	Shows/hides the comment line
Ctrl+Shift+B	Display options for boxes
Ctrl+T	Symbol check and type update
Ctrl+F7	Program status On/Off
Alt+Shift+F8	Inserts a comparator
Alt+Shift+F9	Inserts an empty box
Ctrl+1	Switches to LAD
Ctrl+3	Switches to FBD

Edit menu	
Ctrl+Z	Undoes the last action (except: Save)
Ctrl+Y	Redoes the last action which was undone
Ctrl+X	Cuts a command
Ctrl+C	Copies a command
Ctrl+V	Inserts a command
Del	Deletes selected commands in the LAD editor
F2	Renames the active/selected object
Alt+Enter	Displays the properties of the active/selected object for editing
Ctrl+Alt+O	Opens the selected object
Ctrl+A	Selects all objects in the current window
Ctrl+F	Local search
Ctrl+Shift+F	Find in the project
F3	Find next (for local search)
Ctrl+H	Local find and replace
Ctrl+Shift+G	Find and replace in a project
Ctrl+J	Next position (for search in the project)

Debug menu	
F12	Activates or deactivates a set breakpoint
Ctrl+F8	Continues the program execution at the activated breakpoint
Ctrl+F10	Next step

LAD elements	
Shift+F2	Inserts an NO contact
Shift+F3	Inserts an NC contact

LAD elements	
Shift+F7	Inserts a coil
Shift+F8	Opens a branch
Shift+F9	Closes a branch

FBD elements	
Shift+F2	Inserts an AND box
Shift+F3	Inserts an OR box
Shift+F4	Inserts an XOR box
Shift+F7	Assignment or jump
Shift+F8	Inserts a binary input
Shift+F9	Negates a binary input

A.2 Protected and reserved identifiers

Reserved identifiers may only be used as predefined. You may not declare a variable or data type with the name of a reserved identifier.

There is no distinction between upper and lower case notation.

The ST programming language includes protected and reserved identifiers (see the SIMOTION ST Programming and Operating Manual). The same list also applies to the LAD/FBD programming languages. The LAD/FBD programming language also includes the protected and reserved identifiers listed in the table.

You can find a list of all the identifiers whose meanings are predefined in SIMOTION in the SIMOTION Basic Functions Function Manual.

Table A-1 Protected identifiers applicable only to the LAD/FBD programming language

A	
ANDN	
C	
CAL CALC	CALCN
J	
JMP JMPC	JMPCN
L	
LD	LDN
O	
ORN	
R	
RET RETC	RETCN
S	

ST	STN
X	
XORN	

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