SIEMENS

SIMOTION

SIMOTION SCOUT
SIMOTION LAD/FBD

Programming and Operating Manual

05/2009

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.

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

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

⚠CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The device/system may only be set up and used in conjunction with this documentation. Commissioning and operation of a device/system may only be performed by **qualified personnel**. Within the context of the safety notes in this documentation qualified persons are defined as persons who are authorized to commission, ground and label devices, systems and circuits in accordance with established safety practices and standards.

Proper use of Siemens products

Note the following:

⚠WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be adhered to. The information in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of the Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

Siemens AG
Industry Sector
Postfach 48 48
90026 NÜRNBERG
GERMANY

Table of contents

Preface

1

1.1 Scope

This document is part of the SIMOTION Programming documentation package.

This document is valid for product version V4.1, Service Pack 4 of SIMOTION SCOUT (the engineering system of the SIMOTION product family) in conjunction with:

- a SIMOTION device with the following versions of the SIMOTION kernel:
  - V4.1 SP4
  - V4.1 SP2
  - V4.1 SP1
  - V4.0
  - V3.2
  - V3.1
  - V3.0
- The relevant version of the following SIMOTION Technology Packages, depending on the kernel
  - Cam
  - Path (kernel V4.1 and higher)
  - Cam_ext (kernel V3.2 and higher)
  - TControl
  - Gear, Position and Basic MC (only for kernel V3.0).

1.2 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.

1.3 SIMOTION Documentation

An overview of the SIMOTION documentation can be found in a separate list of references.

This documentation is included as electronic documentation with the supplied SIMOTION SCOUT.

The SIMOTION documentation consists of 9 documentation packages containing approximately 80 SIMOTION documents and documents on related systems (e.g. SINAMICS).

The following documentation packages are available for SIMOTION V4.1 SP4:

- SIMOTION Engineering System
- SIMOTION System and Function Descriptions
- SIMOTION Service and Diagnostics
- SIMOTION Programming
- SIMOTION Programming - References
- SIMOTION C
- SIMOTION P350
- SIMOTION D4xx
- SIMOTION Supplementary Documentation

1.4 Hotline and Internet addresses

Siemens Internet address

The latest information about SIMOTION products, product support, and FAQs can be found on the Internet at:

- General information:
  - **http://www.siemens.de/simotion** (German)
  - **http://www.siemens.com/simotion** (international)
- Downloading documentation
  Further links for downloading files from Service & Support.
  http://support.automation.siemens.com/WW/view/en/10805436
- Individually compiling documentation on the basis of Siemens contents with the My Documentation Manager (MDM), refer to **http://www.siemens.com/mdm**

  My Documentation Manager provides you with a range of features for creating your own documentation.
- FAQs
  You can find information on FAQs (frequently asked questions) by clicking **http://support.automation.siemens.com/WW/view/en/10805436/133000**.

Additional support

We also offer introductory courses to help you familiarize yourself with SIMOTION.

For more information, please contact your regional Training Center or the main Training Center in 90027 Nuremberg, Germany.

Information about training courses on offer can be found at:

www.sitrain.com

Technical support

If you have any technical questions, please contact our hotline:

	Europe / Africa
Phone	+49 180 5050 222 (subject to charge)
Fax	+49 180 5050 223
€0.14/min from German wire-line network, mobile phone prices may differ.	
Internet	http://www.siemens.com/automation/support-request

	Americas
Phone	+1 423 262 2522
Fax	+1 423 262 2200
E-mail	mailto:techsupport.sea@siemens.com

	Asia / Pacific
Phone	+86 1064 757575
Fax	+86 1064 747474
E-mail	mailto:support.asia.automation@siemens.com

Note

Country-specific telephone numbers for technical support are provided under the following Internet address:

http://www.automation.siemens.com/partner

Questions about this documentation

If you have any questions (suggestions, corrections) regarding this documentation, please fax or e-mail us at:

Fax	+49 9131- 98 2176
E-mail	mailto:docu.motioncontrol@siemens.com

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.

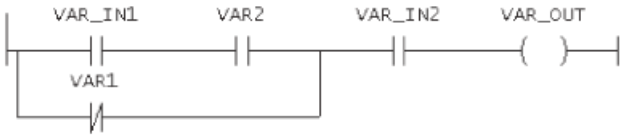


Figure 2-1 Representation of a network in LAD

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.

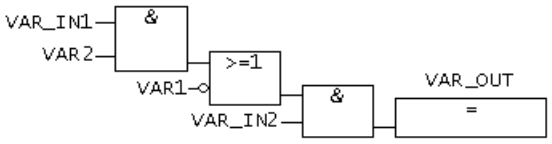


Figure 2-2 Representation of a network in FBD

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.

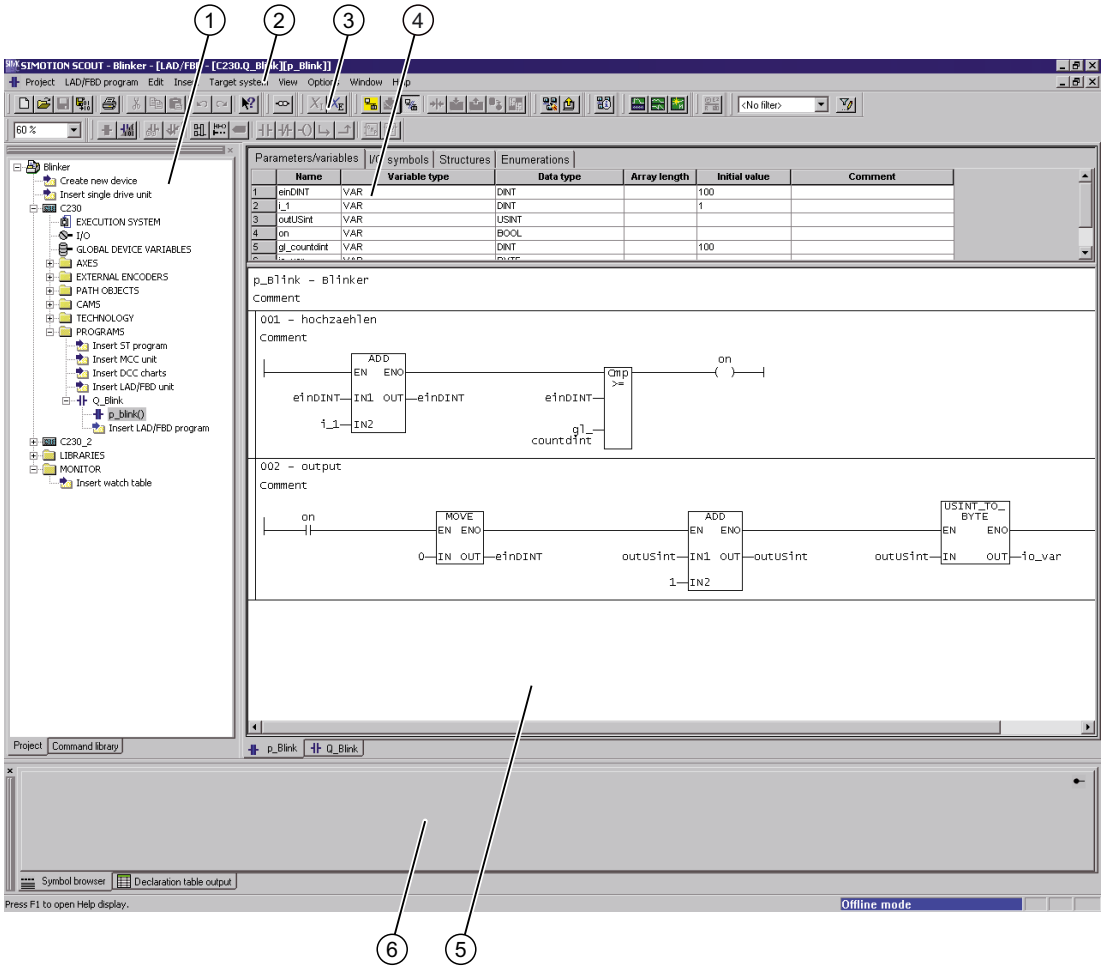


Figure 3-1 Elements of the workbench in a LAD/FBD program

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.

- (5) Working area

  In this area, you carry out job-specific operations. 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 and reducing the editor area for the graphical display

The size of the graphical area of the LAD/FBD editor (i.e. the size of the elements in this area) can be changed using the **Zoom** list on the **Zoom factor** toolbar or using the **View > Zoom in** or **View > Zoom out** menu commands.

Select a factor from the **Zoom** list, or enter an integer value of your own choice. This change always applies to the active LAD/FBD editor.

This setting is not saved when a save operation is performed.

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:

1. Select the appropriate tab below the working window

   or

   Select the appropriate program name in the Window menu.

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
- Text and variables can be dragged from the project navigator, declaration tables, symbol browser or command library and dropped into the input fields.

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.

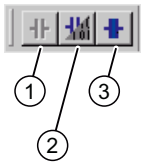
3.7.4 Toolbars

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.

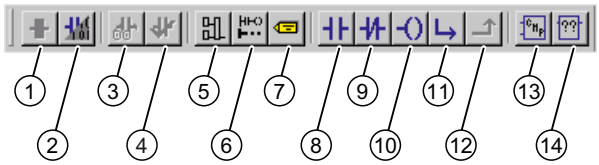
The toolbars can be positioned as required within the Workbench. Once moved, they can be shown or hidden using **View > Toolbars**.

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.



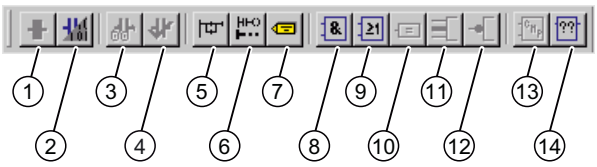
① Insert LAD/FBD unit
② Accept and compile
③ Insert LAD/FBD program

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



① Insert LAD/FBD program
② Accept and compile
③ Program status
④ Symbol check and type update
⑤ Switch to FBD
⑥ Insert network
⑦ Jump label ON/OFF
⑧ Insert NO contact
⑨ Insert NC contact
⑩ Insert coil
⑪ Open branch
⑫ Close branch
⑬ Insert comparator
⑭ Insert an empty box

Figure 3-3 View of the LAD editor toolbar



①	Insert LAD/FBD program	⑧	Insert AND box
②	Accept and compile	⑨	Insert OR box
③	Program status	⑩	Insert assignment
④	Symbol check and type update	⑪	Binary input
⑤	Switch to LAD	⑫	Negate binary input
⑥	Insert network	⑬	Insert comparator
⑦	Jump label ON/OFF	⑭	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. The shortcuts (Page 327) available in the LAD/FBD editor are listed in the Appendix.

3.7.6 Drag&Drop of variables

Variables can be moved from the detail view (**Symbol browser** tab) to the input field using a drag-and-drop operation.

To insert 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 depressed, drag the line number into the input field of the parameter screen form.
3. Release the left mouse button. The variable is inserted 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 insert 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 inserted 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 inserted into the LAD/FBD network from the project navigator (**Command library** tab) using drag-and-drop.

To insert 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 inserted at the selected position.

3.7.10 Command call drag&drop

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

For exceptions, see "Unusable command library functions (Page 84)".

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.

See also

Unusable command library functions (Page 84)

3.7.11 Drag&Drop of command names

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

To insert **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 inserted 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 units can be inserted 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 insert 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 inserted.

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

1. To change the settings, select the **Options > Settings > LAD/FBD editor** menu command.

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 22)

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 unit and/or from LAD/FBD programs within the LAD/FBD unit are changed.

  The symbol check/type update takes place for an LAD/FBD program belonging to the LAD/FBD unit 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.

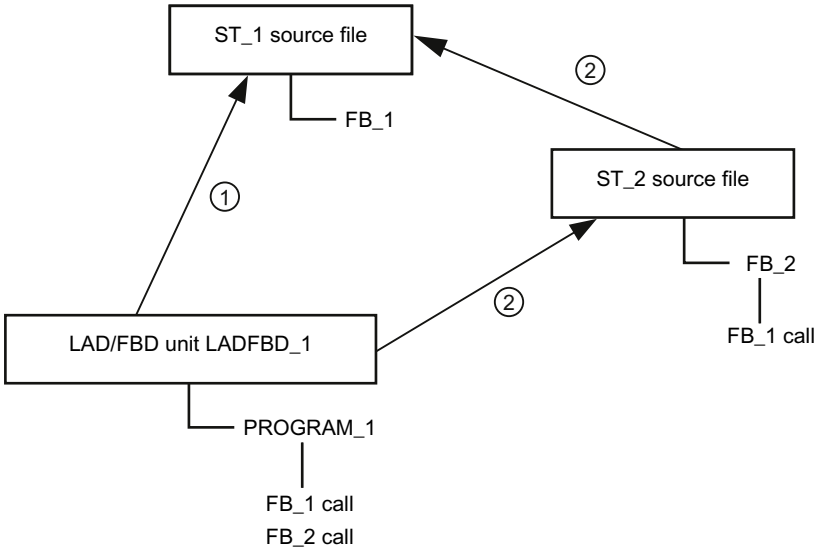
Initial situation

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 135) 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 135) 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 135) 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 3-5 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 158)) 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 136) 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 source files.

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

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

Note

If the automatic symbol check is deactivated, the display may sometimes be inaccurate, e.g. after an external call-up has been inserted, the call-up 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** symbol has been clicked, or the corresponding menu selected.

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:

1. Select the **LAD/FBD program > Automatic symbol check and type update** menu item.

   or

   Click the **Check symbols** icon.

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 Modifying the operand and comment fields

Use the following procedure to modify the display options for the operand and comments:

1. Select the **Options > Settings** menu command.
2. Select the **LAD/FBD editor** tab.
3. Enter the **Number of characters per line** for the operand and comment fields.
4. Enter the **Number of lines** for the operand and comment fields.
5. Confirm with**OK**.

3.8.9 Changing fonts

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

1. Select the **Options > Settings** menu command.
2. Select the **LAD/FBD editor** tab.
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.

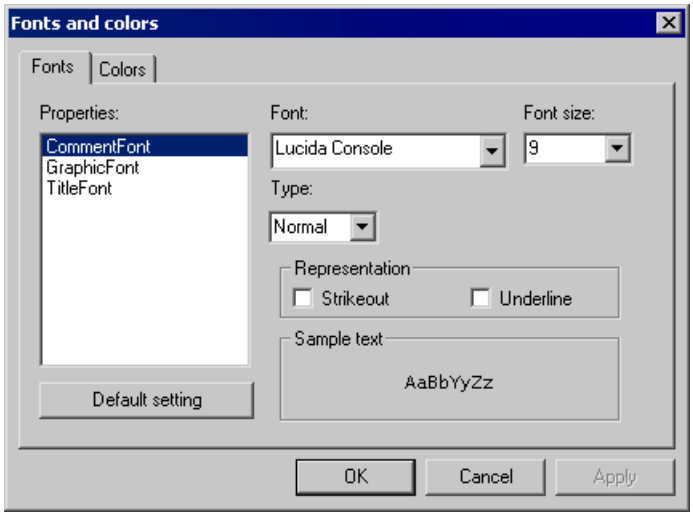


Figure 3-6 Fonts and colors dialog box

5. Confirm with **OK**.

3.8.10 Changing colors

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

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

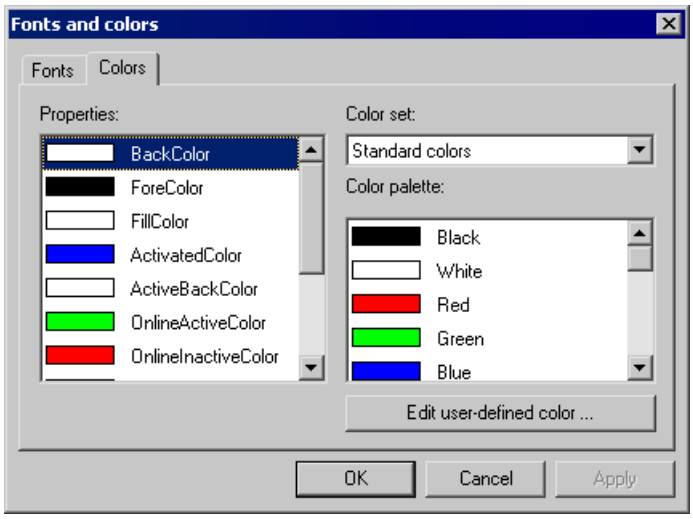


Figure 3-7 Fonts and colors dialog box

6. Confirm with **OK**.

3.8.11 Activating on-the-fly variable declaration

When variable declaration is activated, a dialog box appears when an unknown symbol is entered in the LAD or FBD diagram.

To activate on-the-fly variable declaration, proceed as follows:

1. Select the **Options > Settings** menu command.
2. Select the **LAD/FBD editor** tab.
3. Activate the **on-the-fly variable declaration** checkbox.
4. Confirm with **OK**.

3.8.12 Setting the default language

To set the default language, proceed as follows:

1. Select the **Options > Settings** menu item.
2. Select the tab **LAD/FBD editor**.
3. Select the default language, e.g. **LAD**.
4. Confirm with **OK**.

   When a new LAD/FBD program is created, the selected **LAD** language is set.

3.8.13 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

The LAD/FBD units are assigned to the SIMOTION device on which they will subsequently be run (e.g. SIMOTION C230). They are stored in the project navigator under the SIMOTION device in the PROGRAMS folder or in libraries.

The individual program organization units (POU) are stored under a LAD/FBD source file.

Note

ST source files or MCC source files are also stored.

There is a description of the programming languages ST (Structured Text) and MCC (Motion Control Chart) in the SIMOTION ST and SIMOTION MCC Programming Manuals.

4.2.1 Inserting a new LAD/FBD source file

There are several ways of how to insert a new LAD/FBD source file.

To insert a LAD/FBD source file, proceed as follows:

1. In the project navigator, double-click the **Insert LAD/FBD source file** element in the **PROGRAMS** folder.

   - or -

   Select the **Insert > Program > Insert LAD/FBD source file** menu item.

   - or -

   In the context menu (PROGRAM folder must be selected), select **Insert new object > Insert LAD/FBD unit.**

2. Enter the name of the LAD/FBD unit.

   The names of program sources must comply with the rules for identifiers: They consist of letters (A to Z, a to z), numbers (0 to 9), or single underscores (_) in any order, whereby the first character must be a letter or an underscore. No distinction is made between uppercase and lowercase letters.

   The permissible length of the name depends on the SIMOTION Kernel version:

   – SIMOTION Kernel Version V4.1 and higher: maximum 128 characters.

   – SIMOTION Kernel Version V4.0 and lower: maximum 8 characters.

   Names must be unique within the SIMOTION device. Protected or reserved identifiers (Page 329) are not allowed. The LAD/FBD programs already available are displayed.

3. In the **Compiler** tab, activate checkbox **Permit program status** to use the online status display.

4. You can also enter an author, version, and a comment.

5. Select the **Open editor automatically** checkbox.

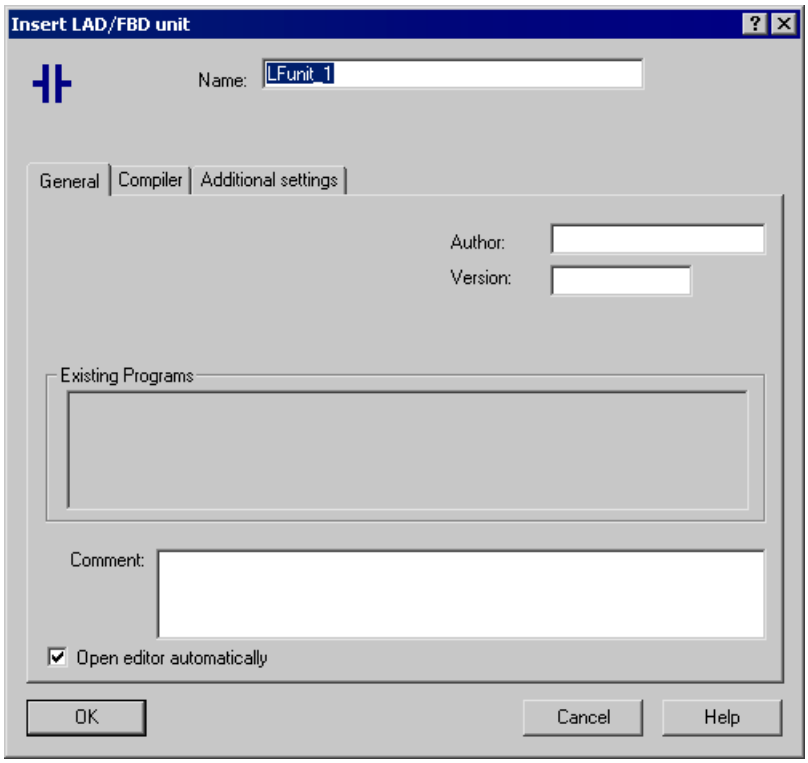


Figure 4-1 Insert LAD/FBD source file dialog box

6. Confirm with **OK**.

   The Declaration tables dialog box is displayed.

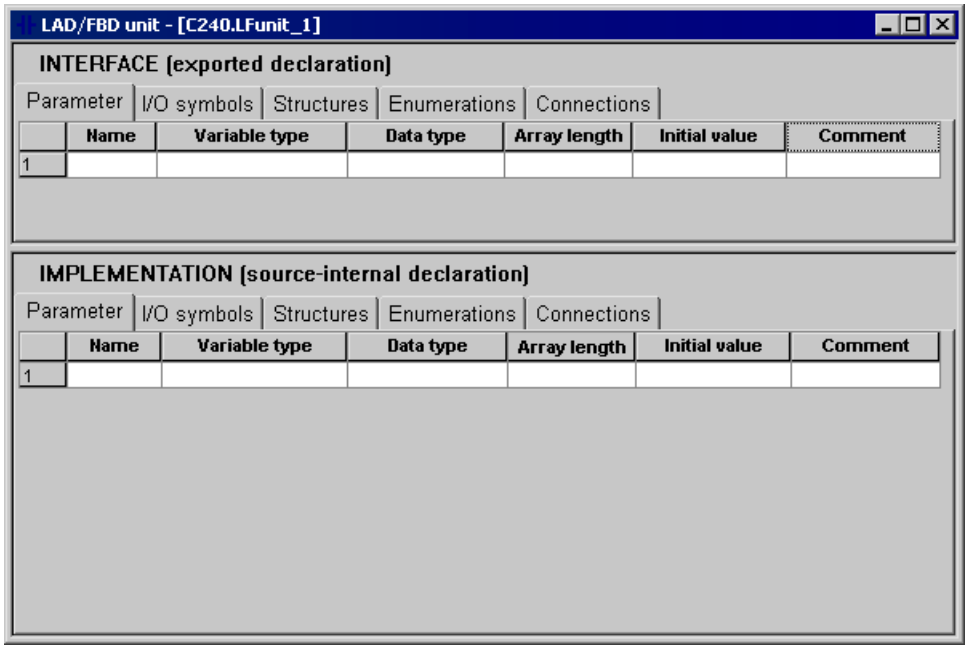


Figure 4-2 Declaration tables for exported and source-internal declarations

4.2.2 Opening an existing LAD/FBD source file

All existing LAD/FBD source files are stored in the PROGRAMS folder in the project navigator.

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

1. Double-click the name of the source file

   or

   Select the LAD/FBD source file and select the **Open** menu item in the context menu.

   The LAD/FBD source file (declaration tables) is opened in the workspace. Several LAD/FBD source files can be opened at the same time.

4.2.3 Saving and compiling a LAD/FBD source file

Prerequisites:

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

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

1. Select the **Save and compile** symbol in the LAD/FBD editor toolbar.

   - or -

   Select the **LAD/FBD source file > Save and compile** menu item.

   - or -

   Select the LAD/FBD source file or a LAD/FBD program in the project navigator and select **Save and compile** in the context menu.

Note

Save and compile only applies the changes to LAD/FBD source files and associated LAD/FBD programs in the project. The data are not saved to disk, together with the project, unless you select **Project > Save** or **Project > Save and compile all**.

A LAD/FBD source file 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 source file 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 source file

   or

   Select the **LAD/FBD source file > Close** menu item.

   or

   Select **Windows > Close all windows** menu item.

   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 inserted in the same or another SIMOTION device.

It is not possible to insert 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 47)

4.2.6 Inserting a cut or copied LAD/FBD source file

To insert a cut or copied LAD/FBD source file:

1. Under the SIMOTION device, select the **PROGRAMS** folder.
2. In the context menu, select **Insert**.

   The LAD/FBD source file is inserted 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 viewed with a password.

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

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

Note

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

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 source file in XML format:

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

Note

LAD/FBD units with know-how protection can also be exported in XML format. The know-how protection is retained during the import.

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 Version V4.1 and higher. 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. Select the directory for the XML export and confirm with **OK**.

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

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

1. In the project navigator, select the required LAD/FBD unit.
2. Select the context menu **Experts > Export as .EXP**.
3. Enter the path and the name for the EXP export.
4. Click **Save**.
   An EXP file is saved under the specified name in the specified path.

4.3.6 Importing EXP data into a LAD/FBD source file

To import EXP data into a LAD/FBD source:

1. In the project navigator, select the required LAD/FBD program.
2. Select the context menu **Expert > Import from .EXP**.
3. Select the EXP file to be imported.

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

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

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

1. In the project navigator, select the required LAD/FBD source file.
2. From the context menu, select **Properties**.

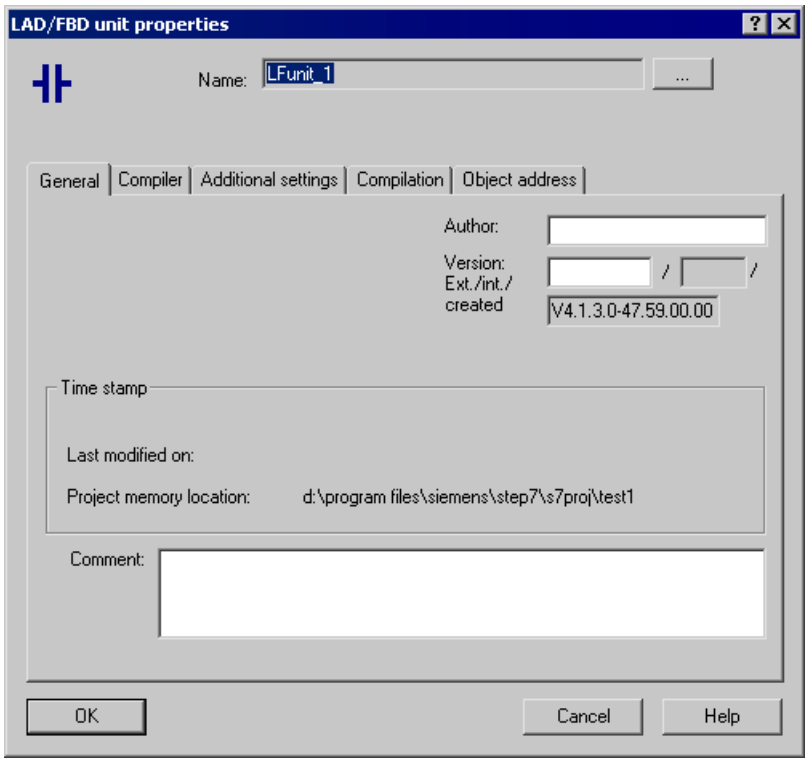


Figure 4-3 Properties of a LAD/FBD source file

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, applicable to all programming languages, see Global compiler settings (Page 48)
- locally for an individual LAD/FBD source within the SIMOTION project, see Local compiler settings (Page 49)

4.4.3.1 Global compiler settings

The global setting are valid for all programming languages within the SIMOTION project.

Procedure

1. Select the menu **Tools > Settings**.
2. Select the **Compiler** tab.
3. Define the settings according to the following table.
4. Confirm with **OK**.

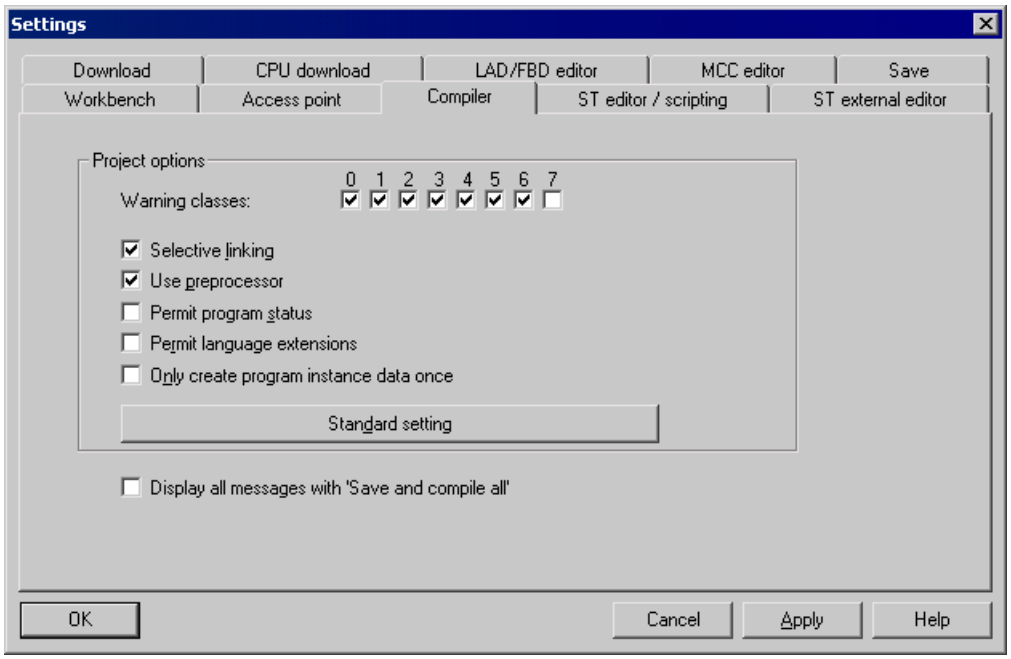


Figure 4-4 Global compiler settings

Parameters

For more information about the parameter description of global compiler settings, see the SIMOTION ST Programming and Operating Manual.

4.4.3.2 Local compiler settings

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

Procedure

To select the compiler options, proceed as follows:

1. Open the property view for the LAD/FBD unit (see Defining the properties of an LAD/FBD unit (Page 47)).
2. Select the **Compiler** tab.
3. Enter settings.
4. Confirm with **OK**.

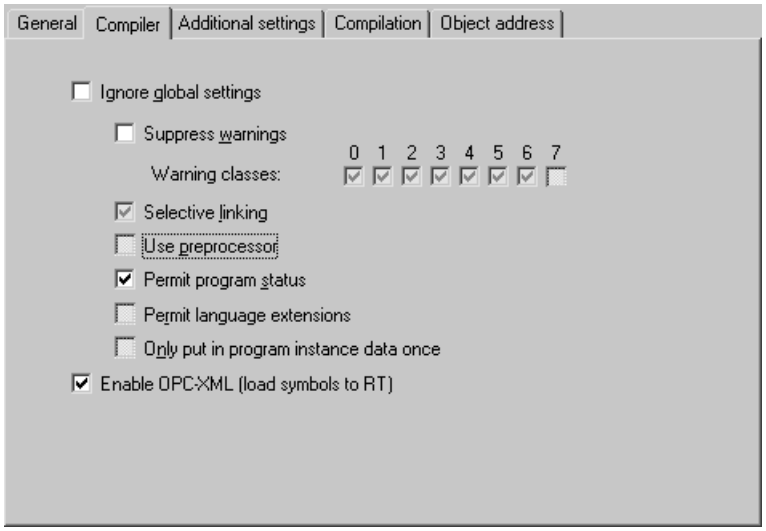


Figure 4-5 Local compiler settings for LAD/FBD source files in the Properties window

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 additional information on what the compiler options mean.

Table 4- 1 Local compiler settings

Parameters	Description
Ignore global settings	See the description under Effectiveness of global or local compiler settings.
Suppress warnings	In addition to error messages, the compiler can output warnings. You can set the scope of the warning messages to be output: **Active**: The compiler outputs the warning messages according to the selection in the global settings of the warning classes. The checkboxes of the warning classes can no longer be selected. **Inactive**: The compiler outputs the warning messages according to the warning classes selected.
Warning classes[1]	Only for Suppress warnings = inactive. **Active**: The compiler outputs warning messages of the selected class. **Inactive**: The compiler suppresses warning messages of the respective class. **Grey background**: The displayed global setting is adopted (only for Ignore global settings = inactive). For the meanings of warning classes, see the SIMOTION ST Programming and Operating Manual. **Note**: If "Suppress warnings" is active, the checkboxes can no longer be selected and show as activated against a gray background.
Selective linking[1]	**Active**: Unused code is removed from the executable program. **Inactive**: Unused code is retained in the executable program. **Grey background**: The displayed global setting is adopted (only for Ignore global settings = inactive).
Use preprocessor[1]	**Active**: The preprocessor is used (see SIMOTION ST Programming Manual). **Inactive**: Preprocessor is not used. **Grey background**: The displayed global setting is adopted (only for Ignore global settings = inactive).
Enable program status[1]	**Active**: Additional program code is generated to enable monitoring of program variables (including local variables) (see Program status (monitor program execution) (Page 269)). **Inactive**: Program status not possible. **Grey background**: The displayed global setting is adopted (only for Ignore global settings = inactive).
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 example for ST programming language) • Accessing the input parameter of a function block when outside the function block (see example for ST programming language). • Calling a program while in a different program (see example for ST programming language) **Inactive**: Only language elements are permitted that comply with IEC 61131-3. **Grey background**: The displayed global setting is adopted (only for Ignore global settings = inactive).

Parameters	Description
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 for calling a program while inside a different program. **Inactive**: The local variables of a program are stored according to the task assignment in the user memory of the respective task. **Grey background**: The displayed global setting is adopted (only for Ignore global settings = inactive). See Memory areas of the variable types.
Enable OPC-XML	**Active:** Symbol information for the unit variables of the ST source file is available in the SIMOTION device (required for the *_exportUnitDataSet* and *_importUnitDataSet* functions, see the *SIMOTION Basic Functions* Function Manual). **Inactive:** Symbol information is not created.
[1] Global setting is also possible (**Options > Settings > Compiler** menu), see Global compiler settings (Page 48). Please also refer to the description of the effectiveness of global or local compiler settings.	

See also

Meaning of warning classes

Defining the properties of a LAD/FBD source file (Page 47)

Program status (monitoring program execution) (Page 269)

Global compiler settings (Page 48)

Direct bit access to variables of a bit data type

Effectiveness of global or local compiler settings

Accessing the input parameter of a function block when outside the function block

Calling a program while in a different program

Memory ranges of the variable types

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

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 source file.
3. Double-click the entry **Insert LAD/FBD program**.
4. Enter the name of the program in the **Insert LAD/FBD program** dialog box.

   The names must be unique within a source file. Protected or reserved identifiers (Page 329) are not allowed. LAD/FBD programs already available in the same source are displayed.
5. Select Program, Function, or Function block as the **Creation type**. See also Changing the LAD/FBD program creation type (Page 58).
6. Enter the name of the LAD/FBD program.

   The name of an LAD/FBD program can contain a maximum of 25 characters. The name of the program organization unit (POU) implemented in the LAD/FBD program object can, therefore, also be entered in accordance with this same restriction. Only one program organization unit per program object is permissible in the LAD/FBD program.
7. For the Function creation type only:

   Select Return value data type as the Return type

   (<--> for no return value).
8. Activate **Exportable** if you want the LAD/FBD program to be accessible from other program sources (LAD/FBD, MCC or ST sources) or from the execution system.
9. Select the **Open editor automatically** checkbox.
10. Confirm with **OK**.

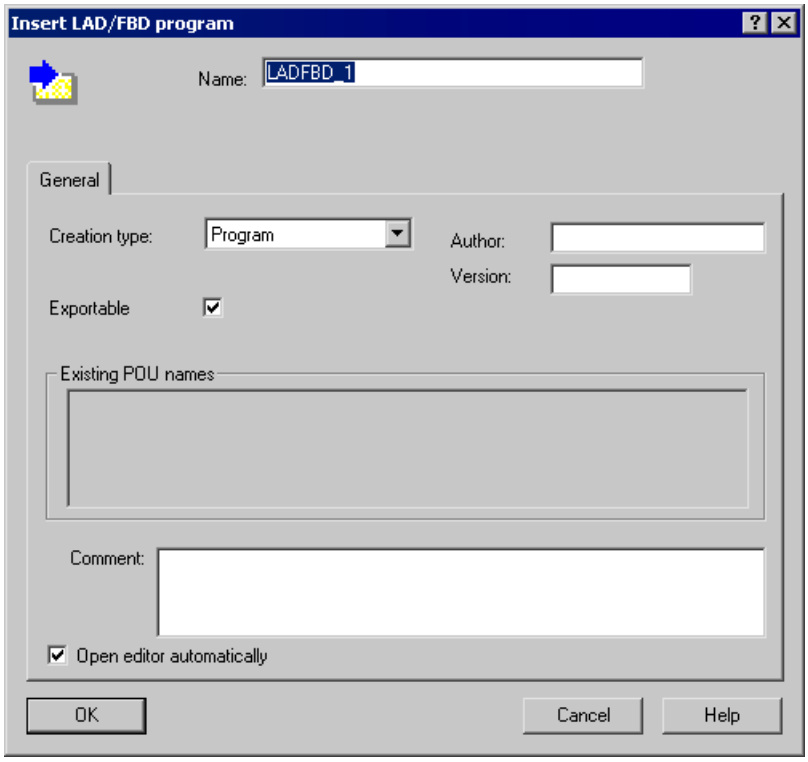
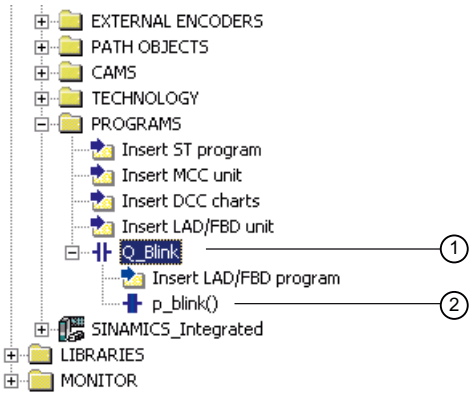


Figure 4-6 Insert LAD/FBD program dialog box



① Name of the LAD/FBD unit

② Name of the LAD/FBD program

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

4.5.2 Opening an existing LAD/FBD program

All LAD/FBD programs belonging to a LAD/FBD source file are located in the project navigator underneath the LAD/FBD source file.

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 and the desired LAD/FBD source file.
3. Select the required LAD/FBD program.
4. Select **Open** from the context menu.

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

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

LAD/FBD programs in the LAD/FBD unit are compiled and executed in the order in which they are displayed in the project navigator. It is thus sometimes necessary to change the order of the LAD/FBD programs. A POU (e.g., a function) must be defined before it is used.

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 source file, select the POU you want to copy.
2. In the context menu, select **Copy**.
3. Select the LAD/FBD source file which is to be inserted in the POU.
4. In the context menu, select **Paste.**
   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 source file 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 -

   If you want to save and compile all available LAD/FBD programs, select the **Project > Save and compile all** menu item.

   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

The present SCOUT program version supports structures (e.g. several POUs in one source file, advance binary switching) which may not be supported 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.

   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 and the desired LAD/FBD source file under the SIMOTION device.
2. Select the required LAD/FBD program.
3. From the context menu, select **Properties**.

   The **Object properties** dialog box opens.

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.

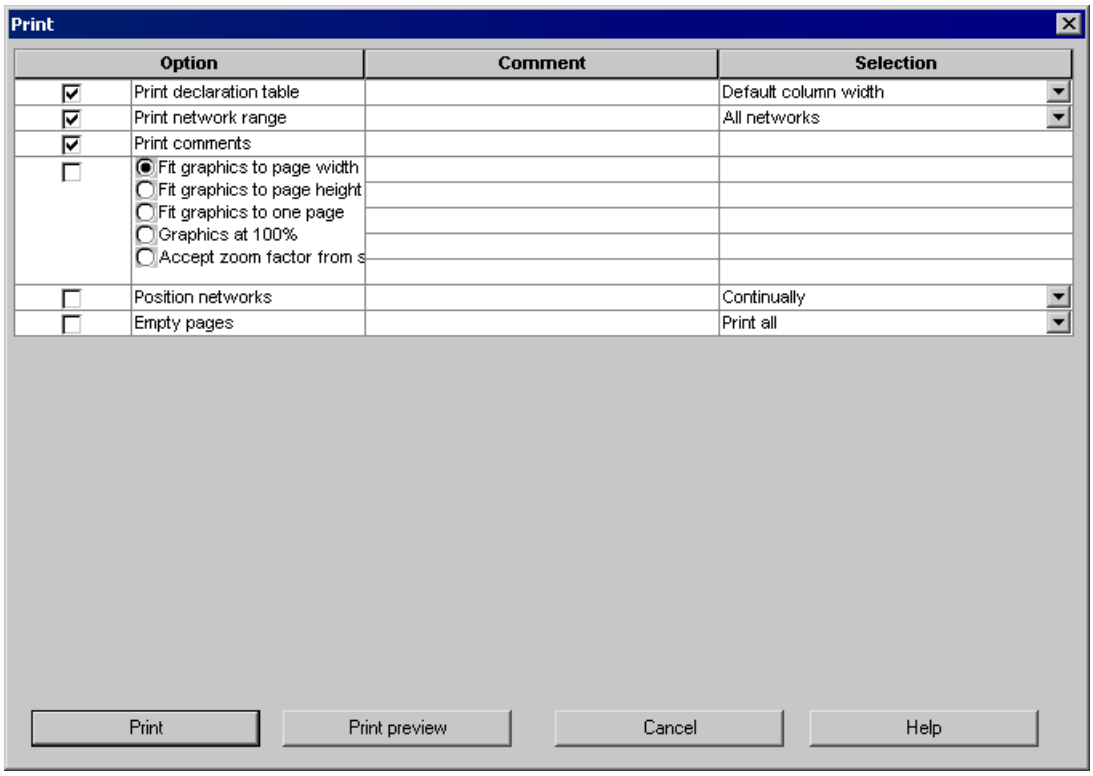


Figure 4-8 Dialog box for setting print options

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 -

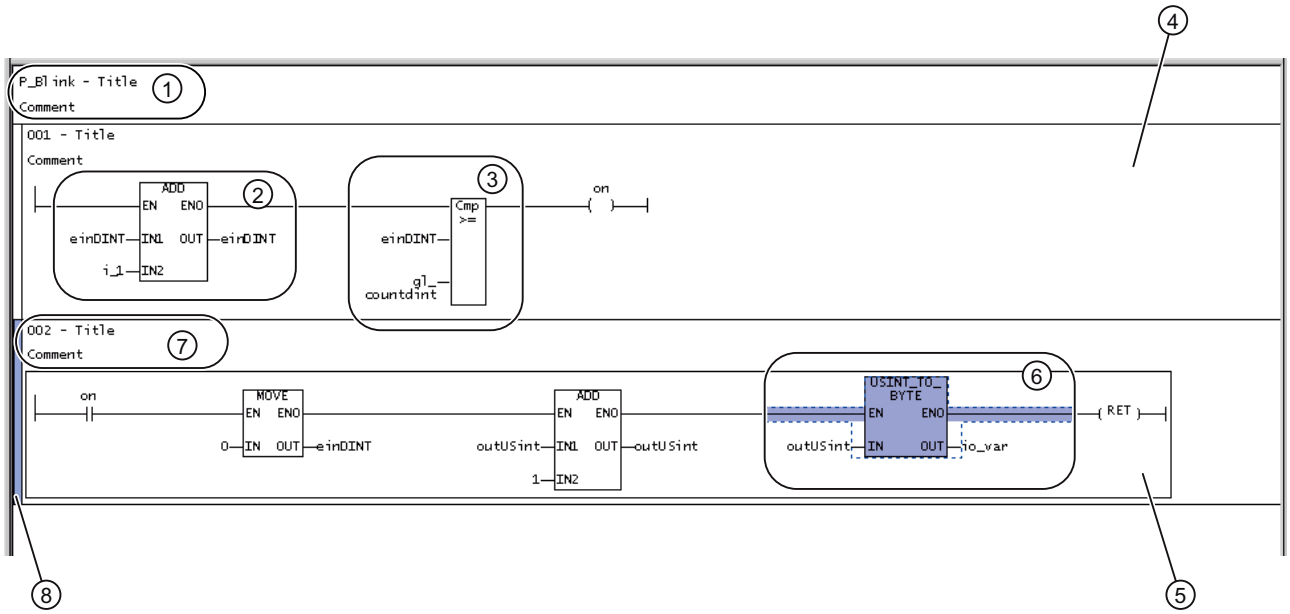
   Select **Omit all**.

   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.



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 4-9 Display of the networks in the LAD/FBD editor

See also

Numbering the networks (Page 65)

4.8.1 Inserting networks

To insert 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 the **LAD/FBD program > Insert network**.

   - or -

   Click the **Insert network** icon.

   The new network is inserted directly after the network which is currently selected. If no network is selected, the new network is inserted at the front.

See also

LAD/FBD networks and elements (Page 63)

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.

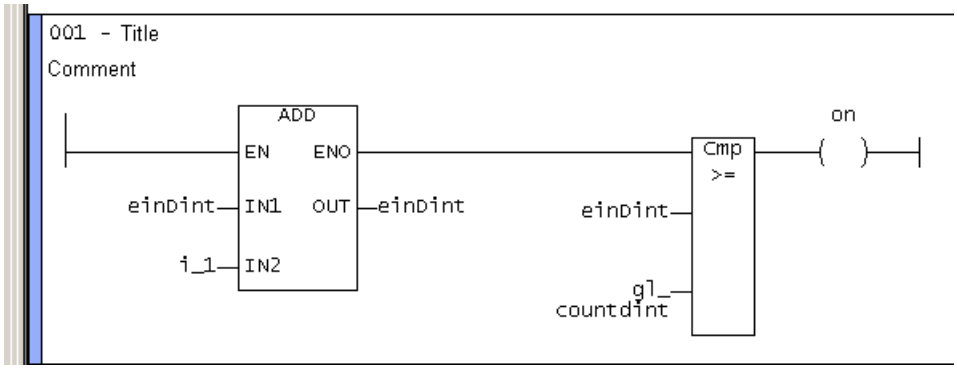


Figure 4-10 Selected network

See also

Settings in the LAD/FBD editor (Page 29)

4.8.3 Numbering the networks

When a network is inserted, 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 63)

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.

   This setting is also saved when storing.

4.8.5 Showing/hiding a jump label

You can insert a jump label in every network.

To insert or hide jump labels, proceed as follows:

1. Select the network in which the jump label is to be inserted.
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 223)

4.8.6 Copying/cutting/pasting networks

If a network is copied or cut, and then inserted 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 inserted again at any place or even in other LAD/FBD programs.

   A new/copied or cut network is always inserted 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.

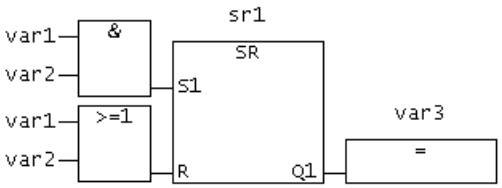


Figure 4-11 FBD with binary preconnection

- &, >=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.

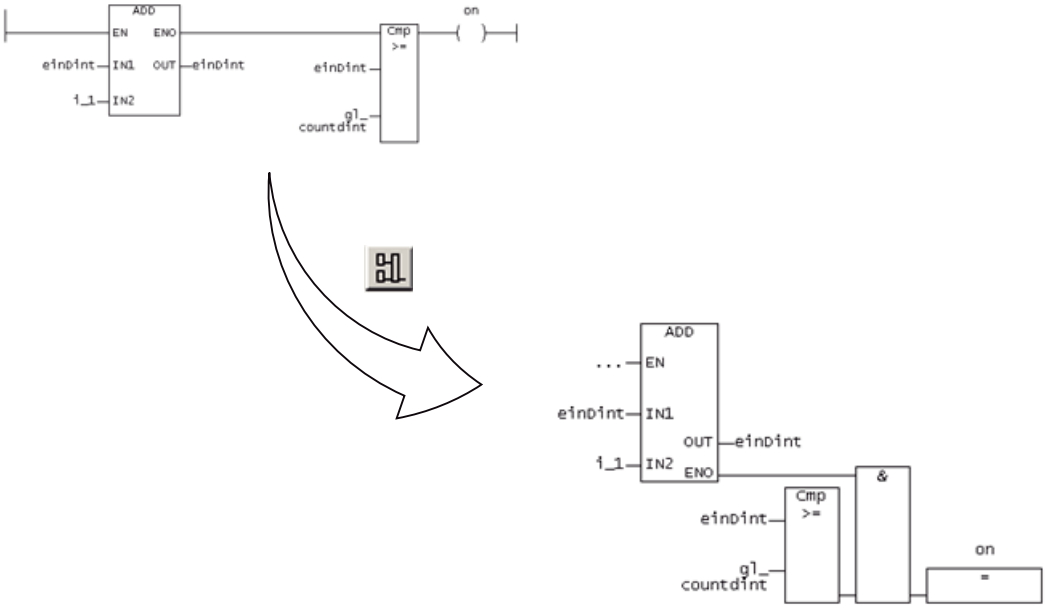


Figure 4-12 Switching from LAD to FBD

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.

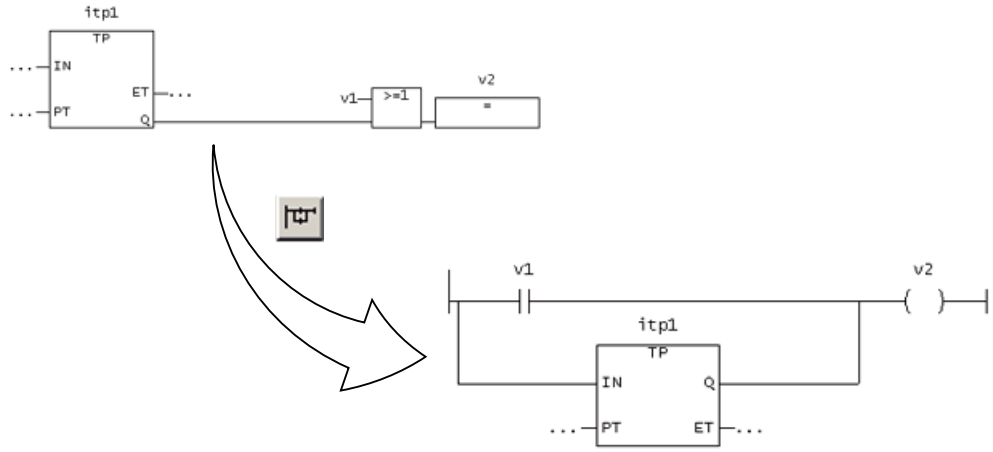


Figure 4-13 Switching from FBD to LAD, example with OR box

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 4-14 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 LAD/FBD elements:

1. Select the position in a network behind which you want to insert a LAD/FBD element.
2. Insert the 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&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 **...** symbol 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

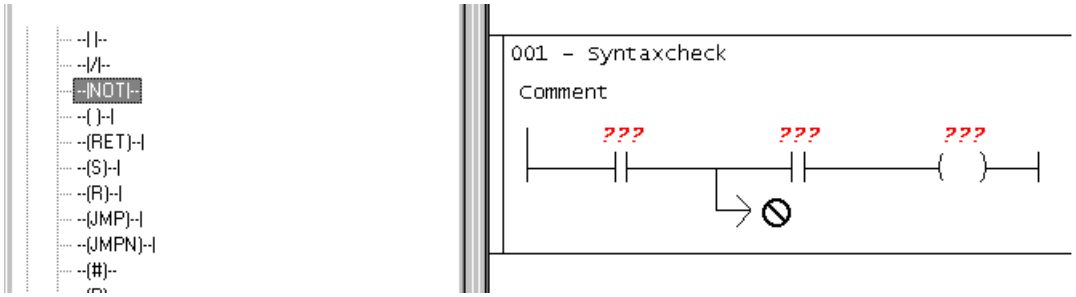


Figure 4-15 Syntax check

4.10.3 Selecting LAD/FBD elements

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

To select LAD elements, proceed as follows:

1. Click the required LAD/FBD element.
   The LAD/FBD element is selected (see following Fig.).

   - or -

   If you want to select several LAD/FBD elements, click the required LAD/FBD elements keeping the **Shift** key depressed.

   Selected LAD/FBD elements are shown with a thick blue outline. You can choose the selection color in the **LAD/FBD editor** tab of the **Settings** dialog box.

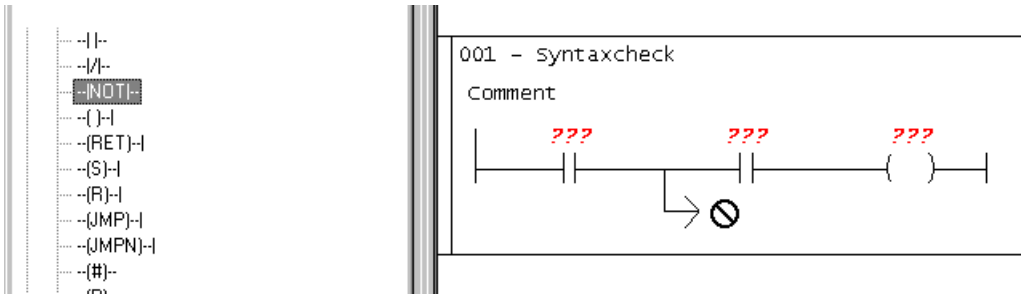


Figure 4-16 Selected LAD/FBD elements

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 79)

Defining global user variables and local variables in the variable declaration dialog box (Page 108)

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 -

   Select the symbol input help with the key shortcut **CTRL+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.

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 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.

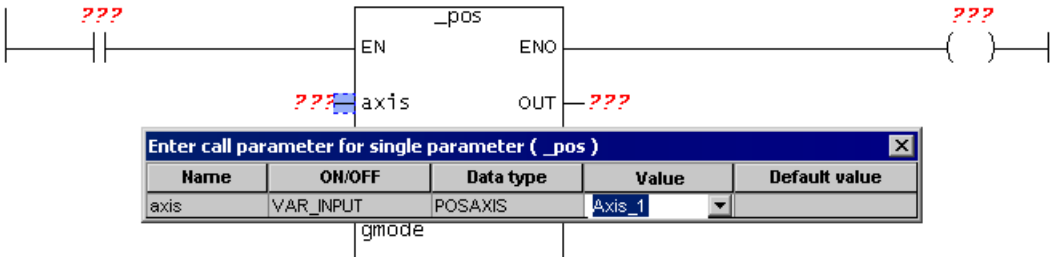


Figure 4-17 Dialog box for setting an individual call parameter

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.

4.10.9 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 context 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.

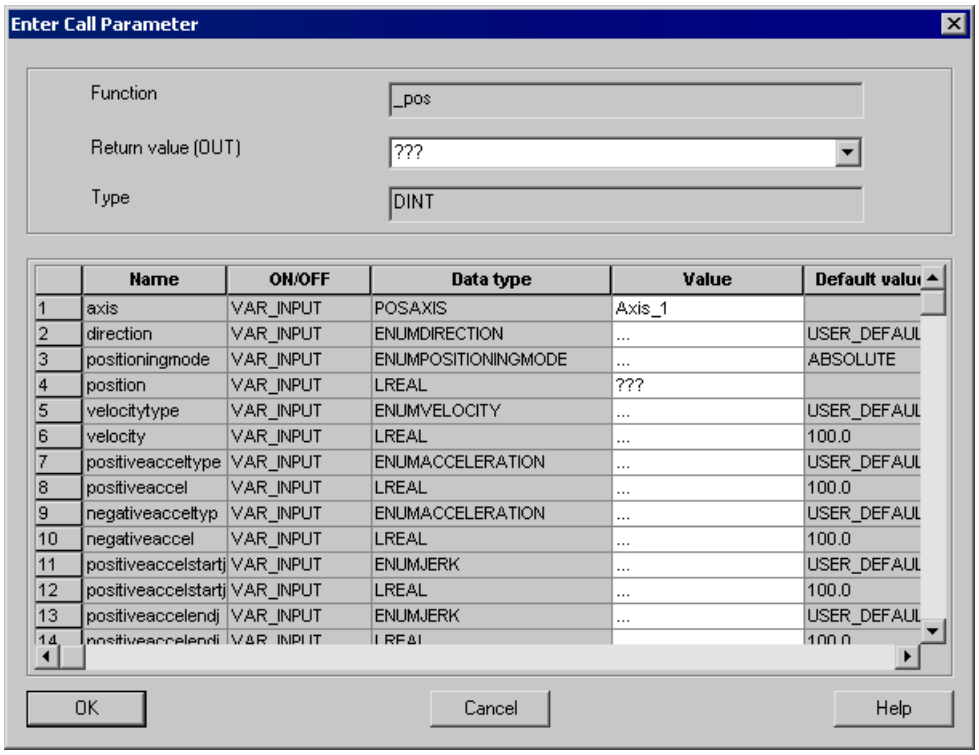


Figure 4-18 Dialog box for setting call parameters

3. Enter:
   - **Return value**

     Here you assign the function return value to a variable of the calling program.
   - **Instance**

     Here, you enter the instance of the function block.
   - **Value**

     Here, you can assign current variables or values to the parameters.
4. Confirm with **OK**.

Note

The **Value** list includes all symbols which are visible 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 type one in yourself.

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

4.10.10 Searching in the project

Searching for elements in the project

To search for elements in a project, proceed as follows:

1. Select the **Search in Project** menu item in the **Edit** menu.
2. The **Search in Project** dialog box opens.
3. Enter your search term.
4. Limit your search, if necessary, using a filter or restrict it to specific objects.
5. Click on the **Search** button to start your search.

   The search result is displayed in the **Search results** table in the workbench.
6. If you double-click on a search result, the located element is displayed in the editor.

4.10.11 Find and replace in a project

Finding and replacing elements in a project

In LAD/FBD, you can replace the following:

- Variable names
- All elements that appear in the Properties dialog box (e.g. an FC return value, etc.)

To search for and replace elements in a project, proceed as follows:

1. Select the **Replace in Project** menu item in the **Edit** menu.
2. The **Replace in Project** dialog box opens.
3. Enter your search term.
4. Enter the expression that should replace the term you are searching for.
5. Limit your search, if necessary, using a filter or restrict it to specific objects.
6. Click on the **Search** button to start your search.

   The search result is displayed in the **Search result** table in the workbench.
   The elements which can be replaced are identified by a check mark.
7. If you wish to replace all marked elements, click on the **Replace** button in the search results.

   All elements are replaced with the expression you entered.
8. If you only wish to replace specific elements, unmark the other elements and then click on the **Replace** button.

   Only the marked elements are replaced.

Note

If you wish to replace an element with an invalid element, LAD/FBD outputs an error message in the output list, which means the element was located and displayed in the list, but not replaced.

You cannot place a checkmark in the checkbox.

Constraints

In general, you cannot replace an element with a new element if the new element cannot be entered (e.g., in the declaration table, you cannot replace VAR_GLOBAL with VAR because you cannot manually enter VAR there).

Constraints in the declaration table:

- VAR, VAR_TEMP and VAR_GLOBAL cannot be freely exchanged for one another

Constraints in the POUs:

- The LAD and FBD elements listed in the command library cannot be freely replaced.
- Comparators can only be exchanged among one another (e.g., "less equal" can be replaced with "more equal" or "equal", but not with a "XOR box", etc.).
- The type of user FBs/FCs can only be replaced with another existing type of user FBs/FCs.
- Mathematic functions can only be replaced with those that can also be entered manually (e.g., sin can be replaced with cos, but not with cmp)
- "..." and "???" are generally not replaced.

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.

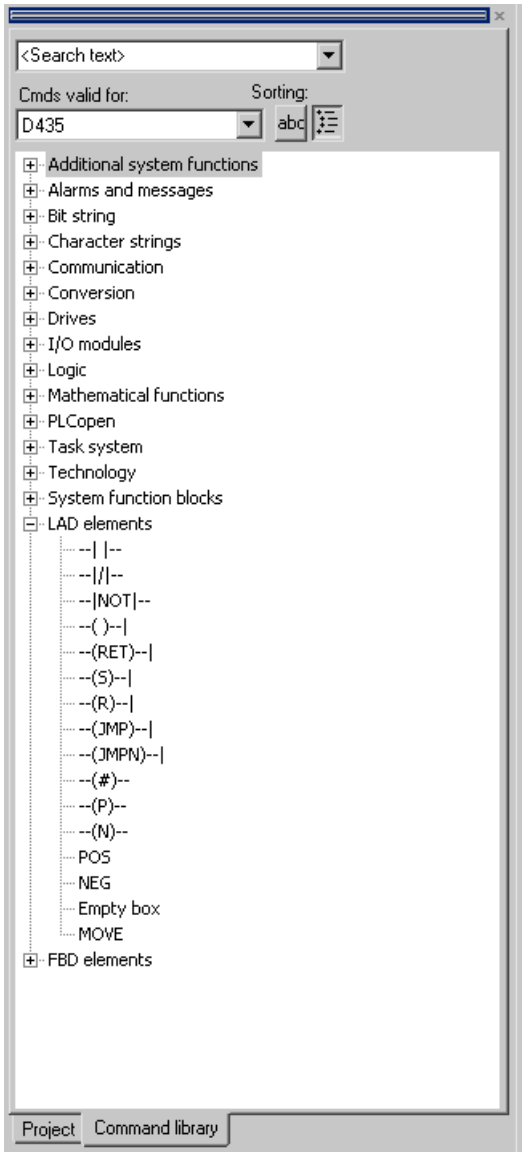


Figure 4-19 Command library tab of the project navigator

4.11.2 Inserting elements/functions from the command library

To insert elements/functions in a programming window, proceed as follows:

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 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).

4.11.3 Unusable command library functions

Not all of the ST programming functions are used in the same way in the LAD/FBD programming language. For this reason, new functions with different parameters have been added ("TaskId" is used instead of "Task") and these are shown in the table below. The new commands are also library-capable. :

The functions in the left column can be used in ST and LAD/FBD. (Extension of the ST function name with "id". Example: _alarmsc becomes _alarmsc**id**).

The ST functions in the right column cannot be used in the LAD/FBD programming language.

These functions are grouped according to call syntax.

Table 4- 2 List of compatible functions

ST and LAD/FBD functions	ST functions
Functions for task control	
_getstateoftaskid	_getstateoftask
_resettaskid	_resettask
_restarttaskid	_restarttask
_resumetaskid	_resumetask

Functions for runtime measurement	
_getmaximaltaskidruntime	_getmaximaltaskruntime
_getminimaltaskidruntime	_getminimaltaskruntime
_getcurrenttaskidruntime	_getcurrenttaskruntime
_getaveragetaskidruntime	_getaveragetaskruntime

Functions for message configuration	
_retriggertaskidcontroltime	_retriggertaskcontroltime
_starttaskid	_starttask
_suspendtaskid	_suspendtask
_alarmsid	_alarms
_alarmsqid	_alarmsq
_alarmscid	_alarmsc

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

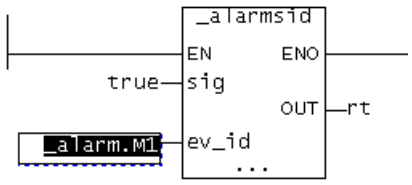


Figure 4-20 Examples for StructAlarmID

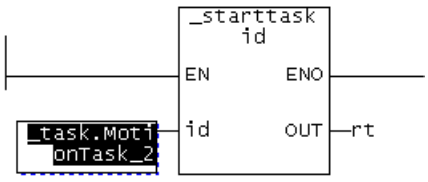


Figure 4-21 Example for StructTaskID

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: After connection (see Define connections (Page 136)), these variables are also available in other units (e.g. MCC units, ST source files, and LAD/FBD source files), as well as on HMI devices (maximum size of the interface section: 64 Kbytes). • In the implementation section: You can access these variables only 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 136)).
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 a row
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).

4.12.4 Frequently used arrays in declarations

4.12.4.1 Array length and array element

An array 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 an array [0...N-1] by entering an array length N.

You have the following options for entering the array 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 array is empty, a single variable is set up rather than an array.

Example definition of an array 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 4-22 Defining the length of a field

Example of use of field elements in a variable assignment

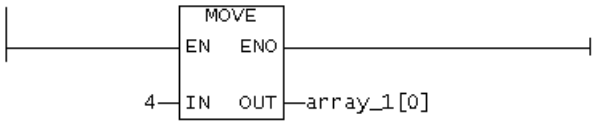


Figure 4-23 Use of array elements in a variable assignment

4.12.4.2 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

Table 4- 3 Preassignment of array elements

10(1)	10 array elements [0 to 9] are preset to the same value "1".
1,2,3,4,5	5 array elements [0..4] are preset to different values "1", "2", "3", "4" and "5".
5(3), 10(99),3(7),2(1)	5 array elements [0..4] are preset to the same value "3". 10 array elements [5..14] are preset to the same value "99". 3 array elements [15..17] are preset to the same value "7". 2 array elements [18..19] are preset to 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 4-24 Definition of the initialization values of an array

Variables with technology object data types are always initialized with TO#NIL.

For variables of data type *followingAxis*, select the associated synchronous object (variable of data type *followingObjectType*).

4.12.4.3 Comments

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

4.13 Data Types

4.13.1 General

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

The following data types are available to the user:

- Elementary data types
- User-defined data types (UDT)
  - Enumerators
  - Structures (Struct)
- Technology object data types
- System data types

4.13.2 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- 4 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).				
	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_96_7295 (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_8E+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_8E+308 Accuracy: 52-bit mantissa (corresponds to 15 decimal places), 11-bit exponent, 1-bit sign.

Type		Reserv. word	Bit width	Range of values
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 two digits for the values day, hour, minute, second and a maximum of three 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 steps 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	All characters with ASCII code $00 to $FF are permitted. Default ' ' (empty string)

NOTICE

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 95)

General data types (Page 96)

Elementary system data types (Page 97)

4.13.2.1 Value range limits of elementary data types

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

Table 4- 5 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			

4.13.2.2 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- 6 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).

4.13.2.3 Elementary system data types

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

Table 4- 7 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. See Function Manual *SIMOTION Basic Functions*. Initialization with STRUCTALARMID#NIL
StructTaskId	32	Data type of the taskId for the project-wide unique identification of the tasks in the execution system. See Function Manual *SIMOTION Basic Functions*. Initialization with STRUCTTASKID#NIL

Table 4- 8 Symbolic constants for invalid values of elementary system data types

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

4.13.3 Derived data types

4.13.3.1 Defining user-defined data types (UDT)

You can create derived data types in source files and programs:

- Structures
- Enumerations

The scope of the data type declaration depends on the location of the declaration.

4.13.3.2 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 **Interface (exported declaration)** source file section of the declaration table:

  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 136)), in other source files (or other units).

- In the **Implementation (source-internal declaration**) source file section of the declaration table:

  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:

  The data type can only be accessed within the program/chart in which it is declared.

4.13.3.3 Defining structures

You define structures in the declaration tables of the source file or the program/chart. The scope (Page 98) 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 element
   - Data type of element
   - Additional characteristics (array length, start value).
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.

4.13.3.4 Defining enumerations

You define **enumerations** in the declaration tables of the source file or the program/chart. The scope (Page 98) 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 there is no initialization entered during the enumeration definition (data type declaration), the first value of the enumeration is assigned to the data type. In this example, **Red** would be used for the initialization because it is defined as the first enumeration element.

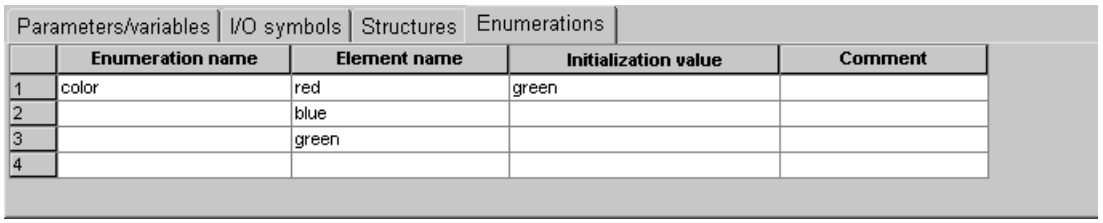


Figure 4-25 Definition of an enumeration data type

4.13.4 Technology object data types

4.13.4.1 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- 9 Data types of technology objects (TO data type)

Technology object	Data type	Contained in the technology package
Drive axis	driveAxis	CAM[1] [2], PATH, CAM_EXT
External encoder	externalEncoderType	CAM[1] [2], PATH, CAM_EXT
Measuring input	measuringInputType	CAM[1] [2], PATH, CAM_EXT
Output cam	outputCamType	CAM[1] [2], PATH, CAM_EXT
Cam track (as of V3.2)	_camTrackType	CAM, PATH, CAM_EXT
Position axis	posAxis	CAM[1] [3], PATH, CAM_EXT
Following axis	followingAxis	CAM[1] [4], PATH, CAM_EXT
Following object	followingObjectType	CAM[1] [4], PATH, CAM_EXT
Cam	camType	CAM, PATH, CAM_EXT
Path axis (as of V4.1)	_pathAxis	PATH, CAM_EXT
Path object (as of V4.1)	_pathObjectType	PATH, CAM_EXT
Fixed gear (as of V3.2)	_fixedGearType	CAM_EXT
Addition object (as of V3.2)	_additionObjectType	CAM_EXT
Formula object (as of V3.2)	_formulaObjectType	CAM_EXT
Sensor (as of V3.2)	_sensorType	CAM_EXT
Controller object (as of V3.2)	_controllerObjectType	CAM_EXT
Temperature channel	temperatureControllerType	TControl
General data type, to which every TO can be assigned	ANYOBJECT	

1) As of Version V3.1, the BasicMC, Position and Gear technology packages are no longer contained.

2) For Version V3.0, also contained in the BasicMC, Position and Gear technology packages.

3) For Version V3.0, also contained in the Position and Gear technology packages.

4) For Version V3.0, also contained in the Gear technology package.

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

Table 4- 10 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 102)

4.13.4.2 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 followingAxis, 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 following 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 following axis or a path axis when calling.

4.13.5 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 enumerator 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 modules (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	Application
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 136)).	FB, FC, program
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, 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
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 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 respective source file.

[2] MCC and LAD/FBD programming languages: in the declaration table of the respective 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 units) 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:
   - Selection of **Retain** checkbox (This declares the variable as retentive, so that its value will be retained after a power failure.)
   - **Array 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 source file. The valid range (scope) 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 source file; all programs/charts (programs, function blocks, and functions) within the source file can access the unit variable.

  In addition, these variables are available on HMI devices and, once connected (see Define connections (Page 136)), 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 (IMPLEMENTATION):

  The unit variable is valid in the source file only; all programs/charts (programs, function blocks, and functions) within the source file can access the unit variable.

Proceed as follows; the source file (declaration table) is open (see Open existing program source file (Page 42)):

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 103)
   - Data type of the variable

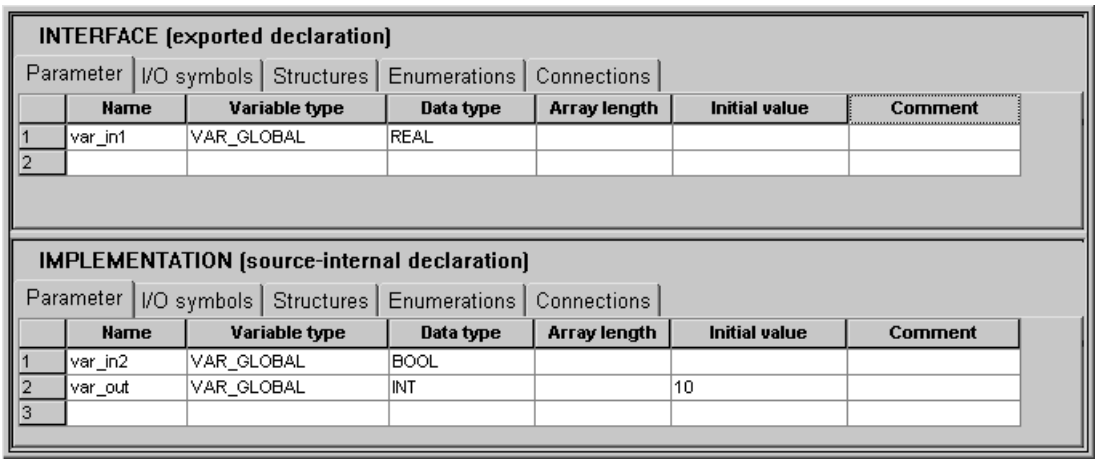
     You can select elementary data types (see Elementary data types (Page 93)); other data types must be entered in the appropriate field.

     See also:

     Defining structures (Page 99)

     Defining enumerations (Page 99)
   - Optional array length (to define the array size)
     See also: Array length and array element (Page 90)
   - Optional initial value (initialization value
     See also: Initial value (Page 91)

The variable is now declared and can be used immediately.



INTERFACE (exported declaration)

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

	Name	Variable type	Data type	Array length	Initial value	Comment
1	var_in1	VAR_GLOBAL	REAL			
2						

IMPLEMENTATION (source-internal declaration)

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

	Name	Variable type	Data type	Array length	Initial value	Comment
1	var_in2	VAR_GLOBAL	BOOL			
2	var_out	VAR_GLOBAL	INT		10	
3						

Figure 4-26 Example: Declaring a unit variable in the source file

Note

The declaration table of the source file is read each time parameters are assigned for a command. Inconsistent data within the declaration table can 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.

Proceed as follows; the program/chart with the declaration table is open (see Open existing program source file (Page 42)):

1. In the declaration table, select the Parameter/Variables tab.
2. Enter:
   - Name of the variable
   - Variable type for variables
     See also: Keywords for variable types (Page 103)
   - You can select elementary data types (see Elementary data types (Page 93)); other data types must be entered in the appropriate field.

     See also:

     Defining structures (Page 99)

     Defining enumerations (Page 99)
   - Optional array length (to define the array size)
     See also: Array length and array element (Page 90)
   - Optional initial value (initialization value
     See also: Initial value (Page 91)

The variable is now declared and can be used immediately.

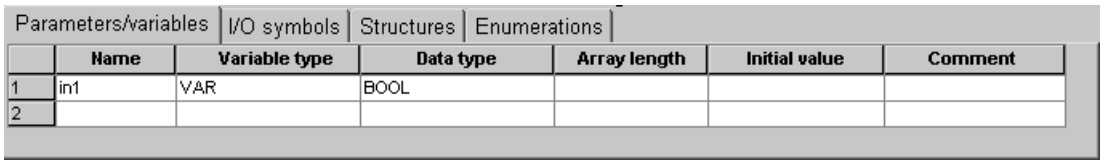


Figure 4-27 Example: Declaring a local variable in the chart/program

Note

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

4.14.2.4 Defining global user variables and local variables in the variable declaration dialog box

As soon as you enter an unknown variable in a LAD/FBD diagram, the **Variable Declaration** dialog box appears.

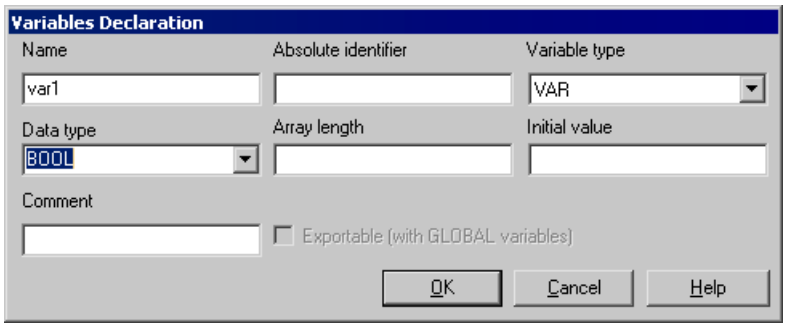


Figure 4-28 Variable declaration dialog box

To define variables in the **Variable Declaration** dialog box, proceed as follows:

1. Enter the name of the variable in the LAD or FBD diagram.
2. Press the **Return** key.
   The **Variable Declaration** dialog box appears.
3. Enter:
   - Another variable name, if required
   - **Absolute identifier**
     The absolute name you entered appears in the I/O symbols tab of the declaration table. As soon as you have entered the **Absolute name**, you can no longer select the **Variable type**, **Array length**, or **Initial value** fields in the **Variable Declaration** dialog box.
   - **Data type** of the variables
     Select the data type from the pull-down menu. If the data type of an I/O symbol is not ANY_BIT or ANY_INT, you may enter an absolute name.
     If you select a global variable (e.g. VAR_GLOBAL) as the type, the Exportable check box is activated.

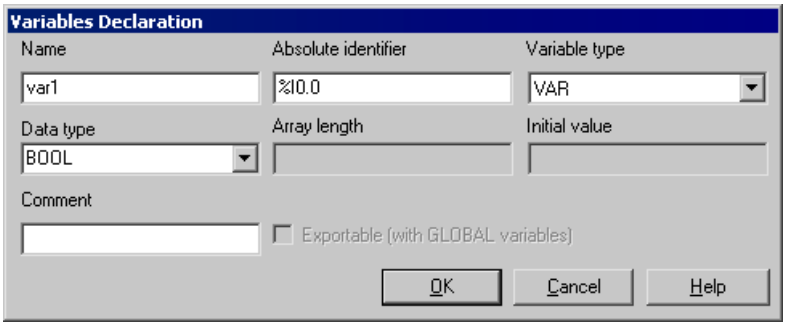


Figure 4-29 Example: Variable declaration (absolute name)

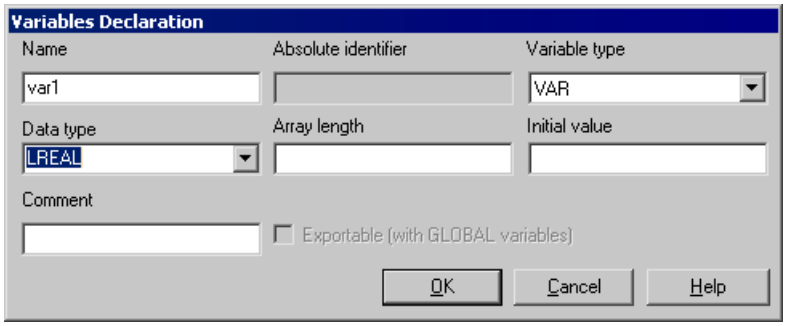


Figure 4-30 Example: Variable declaration

Confirm with **OK**.

The variable is defined and entered in the declaration table of the source file or the program, depending on the selected variable type and **Exportable**.

Note

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

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

4.14.3 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 the firmware is updated.
- When a memory reset (MRES) is performed.
- With the restart function (Del. SRAM) in SIMOTION P350.
- By applying the *_resetUnitData* function (as of kernel V3.2), possible selectively for different data segments of the retentive data.
- When a download is performed according to the following description.

Table 4- 11 Initializing retentive global variables during download

Variable type	Time of the variable initialization
Retentive global device variables	The behavior when downloading depends on the *Initialization of all retentive global device variables and program data* setting[1]: • **Yes**[2]: All retentive global device variables are initialized. • **No**[3]: – As of version V3.2 of the SIMOTION Kernel: **Separate version ID** for retentive global device variables. If the version ID is changed, the retentive global device variables are initialized. – Up to Version V3.1 of the SIMOTION kernel: **Joint version ID** for all global device variables (retentive and non-retentive). If the version ID is changed, all global device variables are initialized. See: Version ID of global variables and their initialization during download (Page 117).
Retentive unit variables	The behavior when downloading depends on the *Initialization of all retentive global device variables and program data* setting[1]: • **Yes**[2]: All retentive unit variables (all units) are initialized. • **No**[3]: – As of version V3.2 of the SIMOTION Kernel: **Separate version ID** for each individual data block (= declaration block)[4] of the retentive unit variables in the interface or implementation section. If the version identification is changed, only the associated data block will be initialized[5]. – Up to Version V3.1 of the SIMOTION kernel: **Common version ID** for all unit variables (retentive and non-retentive, in the interface and implementation section) of a unit. If the version ID is changed, all unit variables of this unit are initialized. See: Version ID of global variables and their initialization during download (Page 117).

[1] Default setting 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] Several data blocks for retentive unit variables in the interface or implementation section can be declared only in the SIMOTION ST programming language. For the SIMOTION MCC and SIMOTION LAD/FBD programming languages, only one data block for retentive unit variables will be created in the interface or implementation section.

[5] Also for the download in RUN, provided the associated prerequisites have been satisfied and the following attribute has been specified in the associated declaration block within a pragma (only for the SIMOTION ST programming language):
{ BlockInit_OnChange := TRUE; }.
For the download in RUN, see the SIMOTION Basic Functions 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:

- For the Initialization of retentive global variables (Page 110), e.g. during a firmware update or general reset (MRES).
- During power up.
- By applying the *_resetUnitData* function (as of kernel V3.2), possible selectively for different data segments of the non-retentive data.
- During the download in accordance with the description on the following table.
- Only as of Version V4.1 of the SIMOTION Kernel and for non-retentive unit variables:

  For transition to the RUN mode when the associated declaration block within a pragma specifies the following attribute (only for SIMOTION ST programming language): { BlockInit_OnDeviceRun := ALWAYS; }

Table 4- 12 Initializing non-retentive global variables during download

Variable type	Time of the variable initialization
Non-retentive global device variables	The behavior when downloading depends on the *Initialization of all non-retentive global device variables and program data* setting[1]: • **Yes**[2]: All non-retentive global device variables are initialized. • **No**[3]: – As of version V3.2 of the SIMOTION Kernel: **Separate version ID** for non-retentive global device variables. If the version ID is changed, the non-retentive global device variables are initialized. – Up to Version V3.1 of the SIMOTION kernel: **Joint version ID** for all global device variables (retentive and non-retentive). If the version ID is changed, all global device variables are initialized. See: Version ID of global variables and their initialization during download (Page 117).
Non-retentive unit variables	The behavior when downloading depends on the *Initialization of all non-retentive global device variables and program data* setting[1]: • **Yes**[2]: All non-retentive unit variables (all units) are initialized. • **No**[3]: – As of version V3.2 of the SIMOTION Kernel: **Separate version ID** for each individual data block (= declaration block)[4] of the non-retentive unit variables in the interface or implementation section. If the version identification is changed, only the associated data block will be initialized[5]. – Up to Version V3.1 of the SIMOTION kernel: **Common version ID** for all unit variables (retentive and non-retentive, in the interface and implementation section) of a unit. If the version ID is changed, all unit variables of this unit are initialized. See: Version ID of global variables and their initialization during download (Page 117).

[1] Default setting 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] Several data blocks for non-retentive unit variables in the interface or implementation section can be declared only in the SIMOTION ST programming language. For the SIMOTION MCC and SIMOTION LAD/FBD programming languages, only one data block for non-retentive unit variables will be created in the interface or implementation section.

[5] Also for the download in RUN, provided the associated prerequisites have been satisfied and the following attribute has been specified in the associated declaration block within a pragma (only for the SIMOTION ST programming language):
{ BlockInit_OnChange := TRUE; }.
For the download in RUN, see the SIMOTION Basic Functions Function Manual.

4.14.3.3 Initialization of local variables

Local variables are initialized:

- For the initialization of retentive unit variables (Page 110).
- For the initialization of non-retentive unit variables (Page 112).
- Also, according to the following description:

Table 4- 13 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 115). • 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 116). • 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 165) 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 "Create program instance data only once" (Page 48) compiler option.

- For the deactivated "Create program instance data only 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 initialized only during transition to RUN mode.

- For the activated "Create program instance data only 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 112).

  – Only as of Version V4.1 of the SIMOTION Kernel:

    In addition, they can be initialized during transition to RUN mode. To do this, the following attribute must be specified in the associated declaration block within a pragma (only SIMOTION ST programming language):
    { BlockInit_OnDeviceRun := ALWAYS; }.

4.14.3.5 Initialization of instances of function blocks (FBs)

The initialization of a function block instance 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 112).

- Local declaration in a program (within VAR / END_VAR):

  Initialization as for static variables of programs, see Initialization of static variables of programs (Page 115).

- 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 165) 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 110) and Initialization of non-retentive global variables (Page 112).

The behavior during the download is shown below for:

- Non-retentive system variables
- Retentive system variables

Table 4- 14 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 setting 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- 15 Version ID of global variables and their initialization during download

Data segment		As of Version V3.2 of the SIMOTION kernel	Up to Version V3.1 of the SIMOTION kernel
Global device variables			
	Retentive global device variables	• **Separate version ID** for each data segment of the global device variables. • The version identification 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 ID does not change on: – Changes in the other data segment – Changes to initialization values[1] • During downloading[2], the rule is: **Initialization of a data segment** only if its version ID has changed. • Use of the functions for data backup and initialization possible.	• **Common version ID** for all data segments of the global device variables. • This version ID changes when the variable declaration is changed in a data segment. • During downloading[2], the rule is: **Initialization of all data segments** if the version ID changes. • Use of the functions for data backup not possible.
	Non-retentive global device variables		

Data segment		As of Version V3.2 of the SIMOTION kernel	Up to Version V3.1 of the SIMOTION kernel
Unit variables of a unit			
	Retentive unit variables in the interface section	• Several data blocks (= declaration blocks)[3] in each data segment possible. • **Own version ID** for each data block. • The version identification of the data block changes for: – Add or remove a variable in the associated 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 ID 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: **Initialization of a data block** only if its version ID has changed.[5] • Functions for data backup and initialization take into account the version ID of the data blocks.	• One data block in each data segment (also for several declaration blocks)[3] • **Common version ID** for all global declarations in a unit. • This version ID changes in response to the following changes: – Variable declaration in a data segment – Declaration of global data types in the unit – Declaration in the interface section of an imported[4] unit. • During downloading[2], the rule is: **Initialization of all data segments** if the version ID changes. • Use of the functions for data backup only possible for: Non-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		

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

[2] If *Initialization of all retentive global device variables and program data* = No and *Initialization of all non-retentive global device variables and program data* = No.
In the case of other settings: See the sections "Initialization of retentive global variables (Page 110)" and "Initialization of non-retentive global variables (Page 112)".

[3] Several declaration blocks per data segment are possible only in the SIMOTION ST programming language. For the SIMOTION MCC and SIMOTION LAD/FBD programming languages, only one declaration block per data segment will be created.

[4] The import of units depends on the programming language, refer to the associated section (Page 136).

[5] Also for the download in RUN, provided the associated prerequisites have been satisfied and the following attribute has been specified in the associated declaration block within a pragma (only for the SIMOTION ST programming language): { BlockInit_OnChange := TRUE; }.
For the download in RUN, see the SIMOTION Basic Functions Function Manual.

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

4.15.1 Overview of access to inputs and outputs

You can access the SIMOTION device inputs and outputs as well as the central and distributed I/O:

- Via direct access with I/O variables

  You define an I/O variable (name and I/O address). The entire address range 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. (

- Via the process image of cyclic tasks using I/O variables

  A memory area in the RAM of the SIMOTION device, on which the address space of the SIMOTION device is mapped. The mirror image is refreshed with the assigned task and is consistent throughout the entire cycle. It 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 area of the SIMOTION device can be used.

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

- Using the fixed process image of the BackgroundTask

  A memory area in the RAM of the SIMOTION device on which a subset of the I/O address space is mapped. The mirror image is refreshed with the BackgroundTask and is consistent throughout the entire cycle. It is used preferentially when programming the BackgroundTask (cyclic programming).

  The address range 0 .. 63 can be used, except for the process image of the cyclic tasks.

Note

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

4.15.2 Important features of direct access and process image access

Table 4- 16 Important features 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). The addresses used must be present in the I/O and appropriately configured.		0 .. 63, except for the addresses used in the process image of cyclic tasks 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.
Updating	• Onboard I/O of SIMOTION devices C230-2, C240, and P350: Update occurs in a cycle clock of 125 µs. • I/O via PROFIBUS DP, PROFINET, P-Bus, and DRIVE-CLiQ as well as Onboard I/O of the D4xx SIMOTION devices: Update occurs in the position control cycle clock. Inputs are read at the start of the cycle clock. Outputs are written at the end of the cycle clock.	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.	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.
Consistency	–	During the entire cycle of the assigned task. **Exception**: Direct access to output occurs.	During the entire cycle of the *BackgroundTask*. **Exception**: Direct access to output occurs.
	Consistency is only ensured for elementary data types. When using arrays, the user is responsible for ensuring data consistency.		
Use	Preferred in MotionTasks	Preferred in the assigned task	Preferred in the BackgroundTask
Declaration as variable	Necessary, for the entire device in the symbol browser		Possible, but not necessary: • For the entire device in the symbol browser, • As unit variable, • As local variable in a program.

	Direct access	Access to process image of cyclic tasks	Access to fixed process image of the BackgroundTask
Write protection for outputs	Possible; **Read only** status can be selected.	Not supported.	Not supported.
Declaration of arrays	Possible.		Not supported.
Responses in the event of an error	Error during access from user program, alternative reactions available: • CPU stop[1] • Substitute value • Last value	Error during generation of process image, alternative reactions available: • CPU stop[1] • Substitute value • Last value	Error during generation of process image, reaction: CPU stop[1]. **Exception**: If direct access has been set up at the same address, the behavior set there applies.
	See Description of Functions SIMOTION Basic Functions		
Use the absolute address	Not supported.		Supported
Access			
• In RUN mode	Without any restrictions.	Without any restrictions.	Without any restrictions.
• During 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.
• During 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] Call of PeripheralFaultTask.			

4.15.3 Direct access and process image of cyclic tasks

Properties

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 (see table below) can be used.

A comparison of the most important properties, also in comparison to the fixed process image of the BackgroundTask (Page 128) is contained in "Important properties of direct access and process image (Page 120)".

Direct access

The direct access is used to directly access the corresponding I/O address. 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 125) without assigning it a task.

Note

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

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 125) and assign it a task.

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

Address range of the SIMOTION devices

The address range of the SIMOTION devices depending on the version of the SIMOTION kernel is contained in the following table. The complete address range can be used for direct access and process image of the cyclical tasks.

Table 4- 17 Address range of the SIMOTION devices depending on the version of the SIMOTION kernel

SIMOTION device	Address range for SIMOTION Kernel version		
	V3.0	V3.1, V3.2	As of V4.0
C230-2	0 .. 1023	0 .. 2047 [4]	0 .. 2047 [4]
C240	–	–	0 .. 4096 [4]
C240 PN [1]	–	–	0 .. 4096 [5]
D410 [2]	–	–	0 .. 16383 [4 5]
D425 [3]	–	0 .. 4095 [4]	0 .. 16383 [4 5]
D435	0 .. 1023	0 .. 4095 [4]	0 .. 16383 [4 5]
D445 [3]	–	0 .. 4095 [4]	0 .. 16383 [4 5]
D445-1 [1]	–	–	0 .. 16383 [4 5]
P350	0 .. 1023	0 .. 2047 [4]	0 .. 4095 [4]

[1] Available with V4.1 SP2 HF4 and higher

[2] Available with V4.1 and higher

[3] Available with V3.2 and higher

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

[5] For distributed I/O (over PROFINET), the transmission volume is restricted to 4096 bytes per PROFINET segment.

Note

Observe the rules for I/O addresses for direct access and the process image of the cyclical tasks (Page 124).

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

NOTICE

You must observe the following rules for the I/O variable addresses for direct access and the process image of the cyclic task (Page 122). 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 must be within an address area configured in HW-config.
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 variables 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 128). These accesses are not taken into account during the consistency check of the project (e.g. during download).

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

You create I/O variables for direct access and a process image of the cyclic tasks 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. In the project navigator of SIMOTION SCOUT, select the I/O element in the subtree of the SIMOTION device.
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.
   - **I/O address** according to the "syntax for entering I/O addresses (Page 127)".
   - 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 128)".
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 cleared.

     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 the behavior in an error situation (see *SIMOTION Basic Functions* Function Manual).
   - **Substitute value** (if array, for each element).
   - **Display format** (if array, for each element), when you monitor the variable in the symbol browser.

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

NOTICE

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 134)".

4.15.3.3 Syntax for entering I/O addresses

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 122), 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- 18 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 version of the SIMOTION kernel, see address range of the SIMOTION devices in "direct access and process image of the cyclical tasks (Page 122)".							
[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 124).

4.15.3.4 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 122). 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- 19 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 127)".

4.15.4 Access to 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. 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).

A comparison of the most important properties in comparison to the direct access and process image of the cyclical tasks (Page 122) is contained in "Important properties of direct access and process image (Page 120)".

NOTICE

I/O addresses that are accessed with the process image of the cyclic tasks must not be used. These addresses cannot be read or written to with the fixed process image of the BackgroundTask.

Note

The rules for I/O addresses for direct access and the process image of the cyclical tasks (Page 124) do **not** apply. The accesses to the fixed process image of the BackgroundTask are 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 130): The absolute PI access identifier contains the address of the input/output and the data type.
- Using a symbolic PI access (Page 131): 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 133): In the symbol browser, you define a valid I/O variable for the entire device that references the corresponding absolute PI access.

NOTICE

Please note that if the inputs and outputs work with the little-endian byte order (e.g. the integrated digital inputs of SIMOTION devices C230-2, C240, or C240 PN) and the following conditions are fulfilled:

1. The inputs and outputs are configured to an address 0 .. 62.
2. An I/O variable for direct access (data type WORD, INT or UINT) has been created for these inputs and outputs.
3. You also access these inputs and outputs via the fixed process image of the BackgroundTask.

then the following is valid:

- Access with the data type WORD supplies the same result via the I/O variable and the fixed process image of the BackgroundTask.
- The access to the individual bytes with 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.

For information on the order of the bytes Little Endian and Big Endian: Please refer to the *SIMOTION Basic Functions* Function Manual.

4.15.4.1 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 128) by directly using the identifier for the address (with implicit data type). The syntax of the identifier (Page 130) 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.

4.15.4.2 Syntax for the identifier for an absolute process image access

For the absolute access to the fixed process image of the BackgroundTask (Page 130), 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 131).
- For the creation of an I/O variables for accessing the fixed process image of the BackgroundTask (Page 133).

Table 4- 20 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] Except for the addresses used in the process image of the cyclic tasks.				

Examples

Input at logic address 62, WORD data type: **%IW62**.

Output at logical address 63, bit 3, BOOL data type: **%Q63.3**.

NOTICE
Addresses that are accessed with the process image of the cyclic tasks must not be used. These addresses cannot be read or written to with the fixed process image of the BackgroundTask.

Note

The rules for I/O addresses for direct access and the process image of the cyclical tasks (Page 124) do **not** apply. The accesses to the fixed process image of the BackgroundTask are 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.

4.15.4.3 Defining symbolic access to the fixed process image of the BackgroundTask

You create symbolic access to the fixed process image of the Background Task in the declaration table of the source file or the 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 (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 130).
   - Data type of symbol (Page 132) (this must agree with the length of the process image access).

4.15.4.4 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 128). 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 131).
- For the creation of an I/O variable (Page 133).

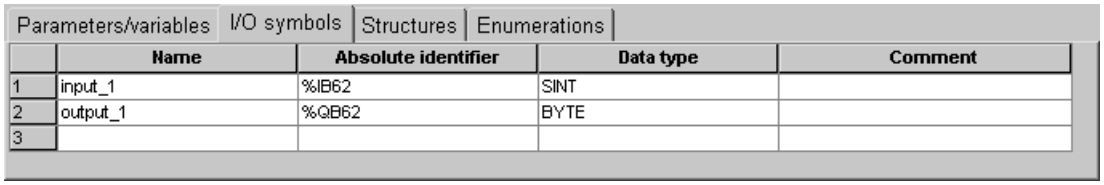
If you assign a numeric data type to the symbolic PI access or to the I/O variables, you can access these variables as integer.

Table 4- 21 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 130)".

4.15.4.5 Example: Defining symbolic access to the fixed process image of the BackgroundTask



Parameters/variables | I/O symbols | Structures | Enumerations

	Name	Absolute identifier	Data type	Comment
1	input_1	%IB62	SINT	
2	output_1	%QB62	BYTE	
3				

Figure 4-31 Example: Defining symbolic access to the fixed process image of the BackgroundTask

4.15.4.6 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. In the project navigator of SIMOTION SCOUT, select the "I/O" element in the subtree of the SIMOTION device.
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.
   - Under **I/O address**, the absolute PI access according to the "syntax for the identifier for an absolute PI access (Page 130)"
     (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 132)".
4. Select optionally the display format used to monitor the variable in the symbol browser.

You can now access this variable using the symbol browser 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 134)".

4.15.5 Accessing I/O variables

You have created an I/O variable for:

- Direct access or process image of the cyclic tasks (Page 122).
- Access to the fixed process image of the BackgroundTask (Page 128).

You can use this I/O variable just like any other variable.

NOTICE
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 namespace, see the "Predefined namespaces" table in "Namespaces").

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.

4.16 Connections to other program source files or libraries

In the declaration table of a source file, you can define connections to:

- LAD/FBD units under the same SIMOTION device
- MCC source files 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 source file:

- In the case of connected program sources, 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
- In the case of connected libraries, the following items which are defined there
  - Functions
  - Function blocks
  - Programs (optional)
  - User-defined data types (structures, enumerations)

Program source files 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).

4.16.1 Defining connections

4.16.1.1 Procedure for defining connections to other units (program source files)

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 file.

- 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 source files (Page 42)):

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.

4.16.1.2 Procedure for defining connections to libraries

Connections to libraries are defined in the declaration table of the source file.

Proceed as follows; the source file (declaration table) is open (see Open existing program source files (Page 42)):

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 137)):

   To do this, enter a name under **Name space**.

Note

When programming the subroutine call command (see Inserting and parameterizing subroutine calls (Page 142)) 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 file; the name of the library is assigned as the name space. You can also change the designation of the name space at a later point in time.

4.16.2 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 137)).

It is important to specify the name space if the current LAD/FBD program/MCC chart or program source file contains variables, data types, functions, or function blocks with the same name as the connected library. The name space will then allow you to specifically access 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/MCC chart, then insert the designation of the name space in front of the variable name, etc., from the library, separated by 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- 22 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 ST Programming Manual.
_device	For device-specific variables (global device user variables, I/O variables, system variables, and system variables of the SIMOTION device)
_direct	By means of direct access to I/O variables. 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
_task	For TaskID: The _task.name variable contains the TaskId of the task with the *name* identifier – see SIMOTION ST Programming and Operating Manual.
_to	For technology objects as well as their system variables and configuration data – see SIMOTION ST Programming and Operating Manual.

4.17 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 116)).

  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 48) and Local compiler settings (Page 49)):
  - "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.

NOTICE
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 insert (create) the function (see Insert function (FC) or function block (FB) (Page 141)).

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 145) and function blocks (Page 150).

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 142)

4.17.1 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 52)).
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 89)).
   – 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.

4.17.2 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.

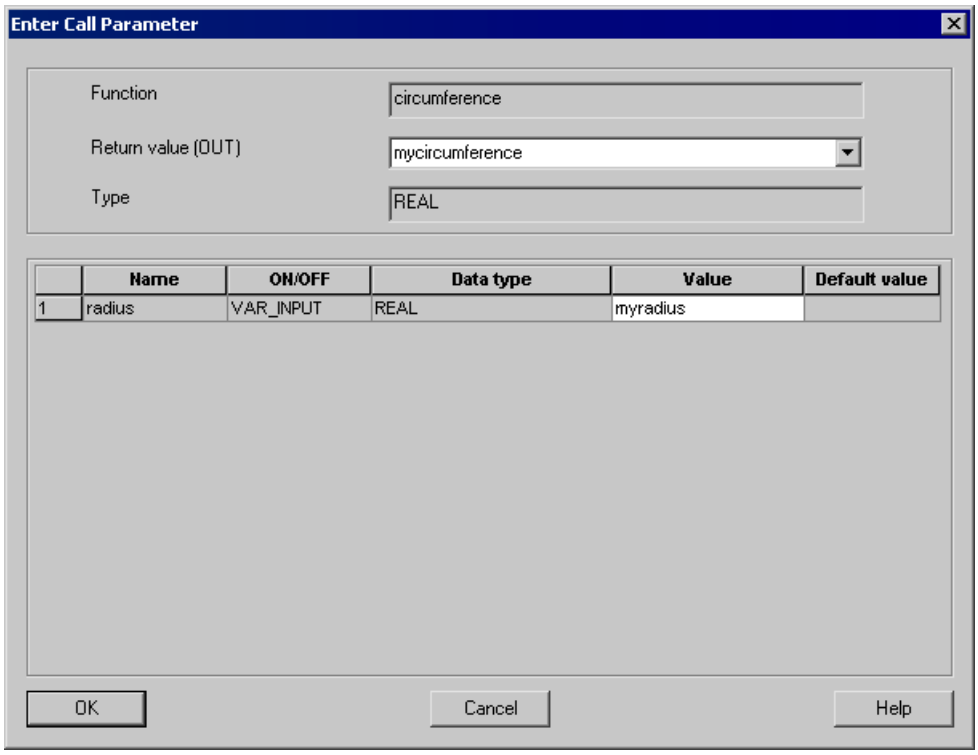


Figure 4-32 Parameterization of a function's subroutine call

NOTICE
Pay attention to the order of the LAD/FBD programs in an LAD/FBD unit. A subroutine (function, function block, or 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 147)

Note

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

4.17.2.1 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**(default value) A function is a calculation subroutine that supplies a defined result as a return value based on the parameter entered. Functions have no memory beyond the call. **Function block** A function block is a subroutine that can have several return values. A function block corresponds to a data type. Instances are defined. They have a memory, that is, they retain instance data of a function block extending over several calls. Return values of the call can also be scanned in the 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 48) and Local compiler settings (Page 49)): • "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.
Return value	In the case of a function-type subroutine: Here, you enter the variable in which the return value is to be stored. The type of variable must match the return value type.

Field/Button	Explanation/instructions
Type	In the case of a function-type subroutine: The data type of the return value is displayed.
Instance	In the case of a function block-type subroutine: 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 unit as VAR_GLOBAL • In the declaration table of the LAD/FBD program as VAR
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 parameter (for functions and function blocks) **VAR_IN_OUT** In/out parameter (for functions and function blocks) **VAR_OUTPUT** Output parameter (for function blocks only)
Data type	The data type of the transfer parameter is displayed here.
Value	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 – for FB only): The assignment of an output parameter to a variable in this parameter screen form is optional; you can also access an output parameter after executing the function block. 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.

4.17.3 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.

4.17.3.1 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**.
   - Confirm with **OK**.
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 4-33 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.

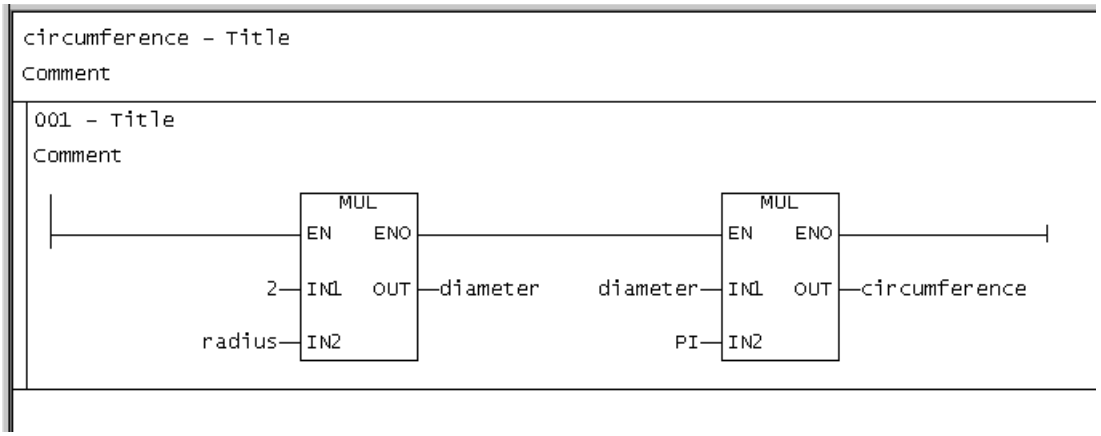


Figure 4-34 Programming the **Circumference** subroutine (e.g. assignment to a return value)

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).

4.17.3.2 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 52)):
   - Enter the name **Program_circumference**.
   - For creation type, select **Program**.
   - Confirm with **OK**.
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 104)).

	Name	Variable type	Data type	Array length	Initial value	Comment
1	mycircum	VAR	REAL			
2	myradius	VAR	REAL			
3						

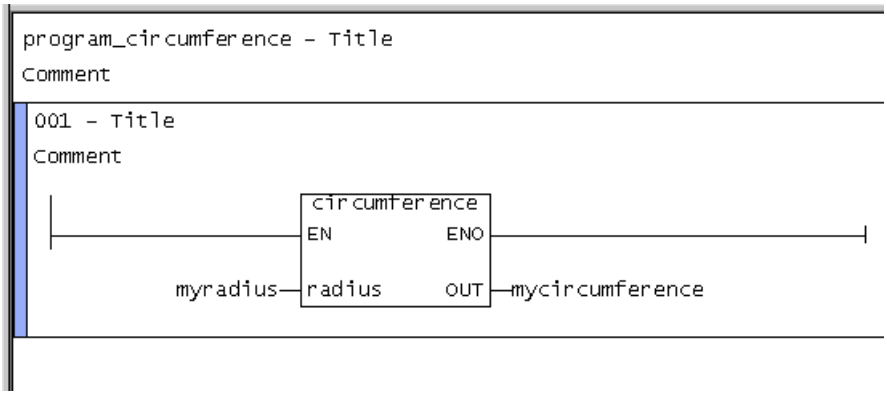
① You can continue to use the myumfang (mycircum) variable in the program.

Figure 4-35 Declaring a variable in the LAD/FBD program

1. Click the **Insert network** button on the LAD editor toolbar.

   A network is inserted into the **Program_circumference** program.
2. Drag the **Circumference** function from the project navigator and drop it into the network of the **Program_circumference** program.
3. Select the inserted function, **Circumference**, 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.



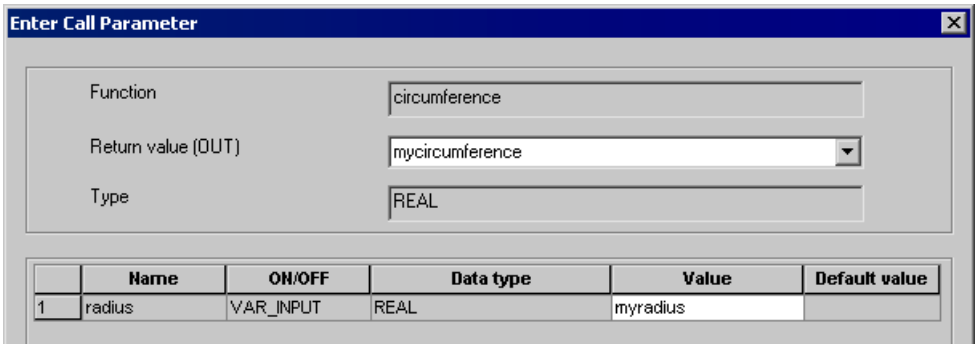
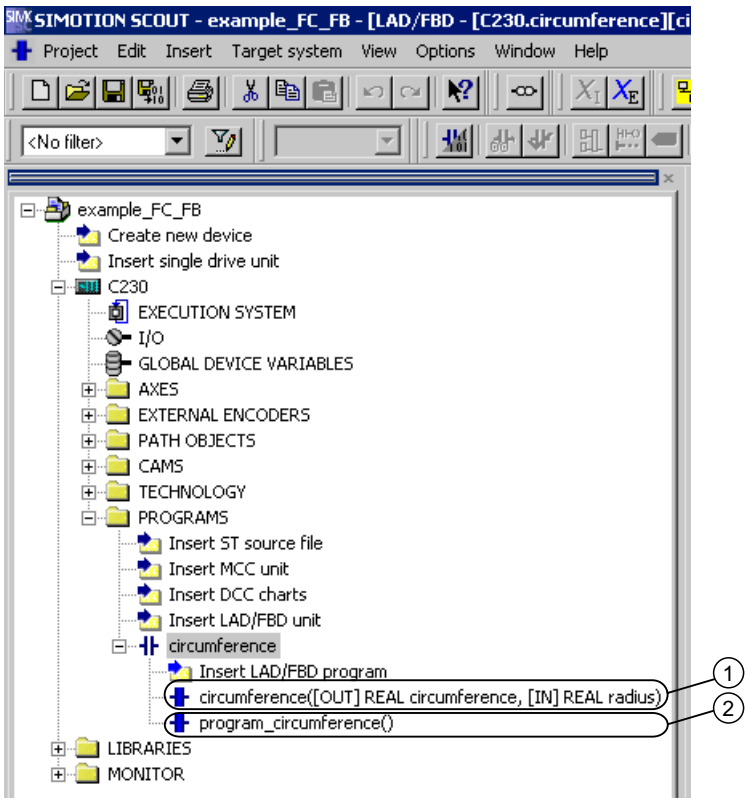


Figure 4-36 Opened parameter screen form for assigning parameters to the subroutine call

5. Pay attention to the order of the LAD/FBD programs in the LAD/FBD unit. The LAD/FBD program with the function (FC) must appear in the project navigator above the LAD/FBD program containing the subroutine call.
   In other words, the **Circumference** function must be positioned in the project navigator above the **Program_circumference** program.
   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

6. 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).

4.17.4 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.

4.17.4.1 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 4-37 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.

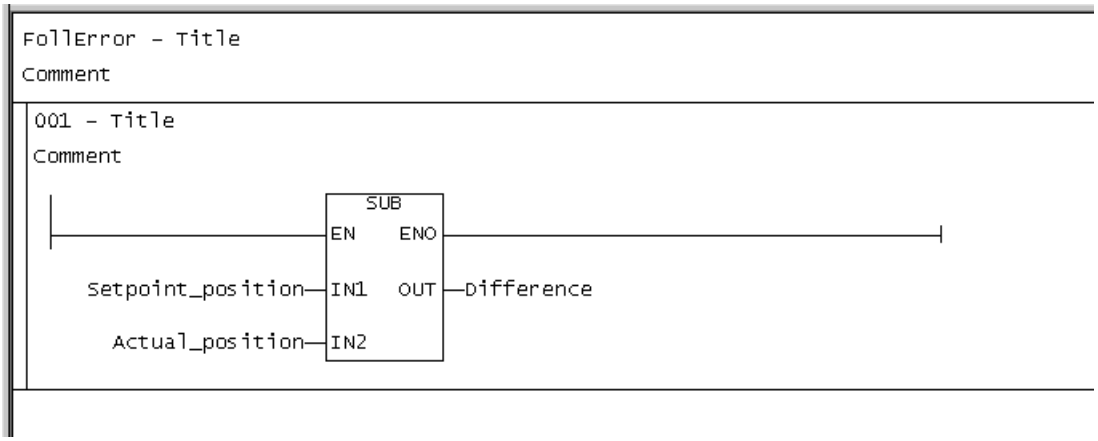


Figure 4-38 Programming the following error calculation

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).

4.17.4.2 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 52)).
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 104)).
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.

4.17.4.3 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 unit 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 unit:

  The instance behaves like a unit variable; it is valid for the entire LAD/FBD unit; all LAD/FBD programs (programs, function blocks, and functions) within the LAD/FBD unit can access the instance.

  In addition, the instance is available on HMI devices and, once connected (see How to define connections to other units (program source files) (Page 136)), in other LAD/FBD units (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 LAD/FBD unit:

  The instance behaves like a unit variable which is only valid in the LAD/FBD unit; all LAD/FBD programs (programs, function blocks, and functions) within the LAD/FBD unit 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 unit or the LAD/FBD program with the declaration table is open (see Open existing LAD/FBD unit (Page 42) or Open existing LAD/FBD program (Page 54)):

1. Select the declaration table and, if applicable, the section of the declaration table for the desired scope.
2. Select the **Parameter** tab.
3. Enter or select the following:
   - **Name** of instance (variable name – see Rules for identifiers (Page 89))
   - **Variable type** VAR or VAR_GLOBAL, depending on the declaration location (in LAD/FBD program or LAD/FBD unit, 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 ② ③ 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 34):

- Only function blocks with the same program source or from connected program sources or libraries
- All function blocks defined in the project

Figure 4-39 Defining an instance of the function block and variables in the LAD/FBD program or the LAD/FBD unit

4.17.4.4 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.
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:
   - In the **Value** column, select the **Result** variable for the **Difference** output parameter.
   - Enter the instance **myfollerror**, defined in the declaration table, in the **Instance** field. The input and in/out parameters of the FB are displayed.

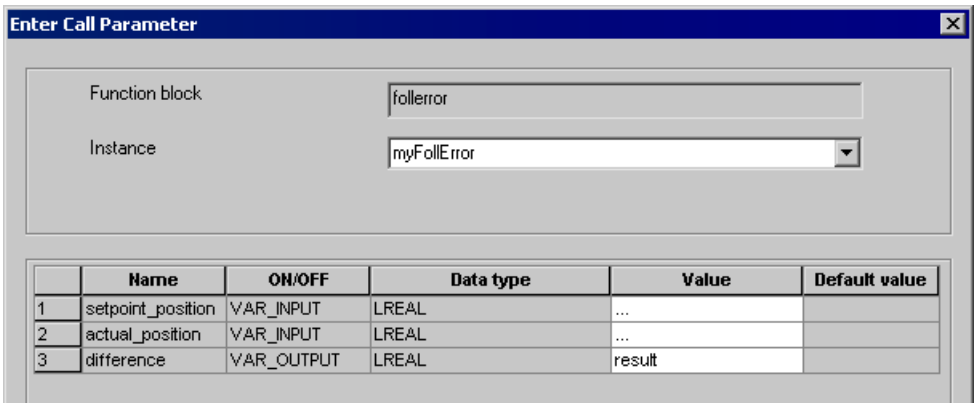


Figure 4-40 Opened parameter screen form for assigning parameters to the subroutine call

5. Confirm with **OK**.
6. Assign the current values to the transfer parameters:
   - Input parameters: Variable or expression
   - In/out parameter: Directly readable/writable variable
   - Output parameter (optional): Variable

   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.

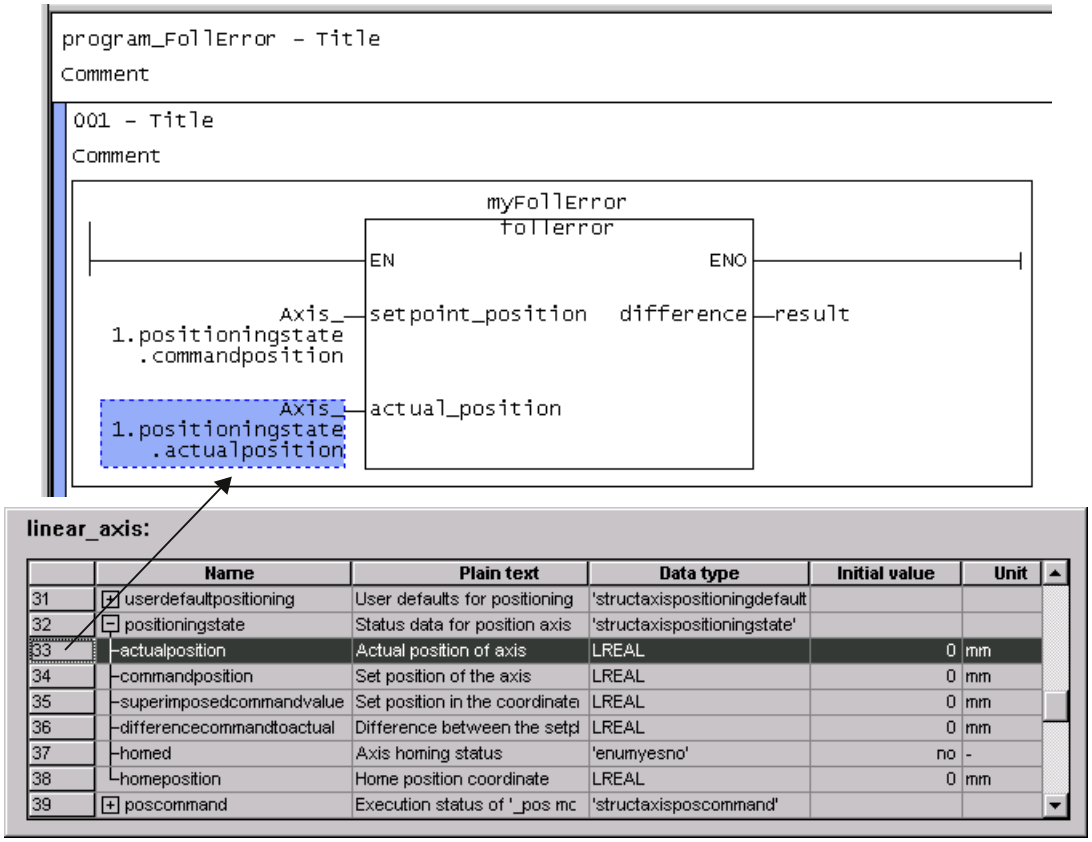


Figure 4-41 Assigning system variables from the detail view to the transfer parameters using drag-and-drop

7. Pay attention to the order of the LAD/FBD programs in the LAD/FBD unit. The LAD/FBD program with the function block must appear in the project navigator above the LAD/FBD program containing the program with the subroutine call.
   In other words, the **FollError** function block must be positioned in the project navigator above the **Program_FollError** program.
   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 147)

Note

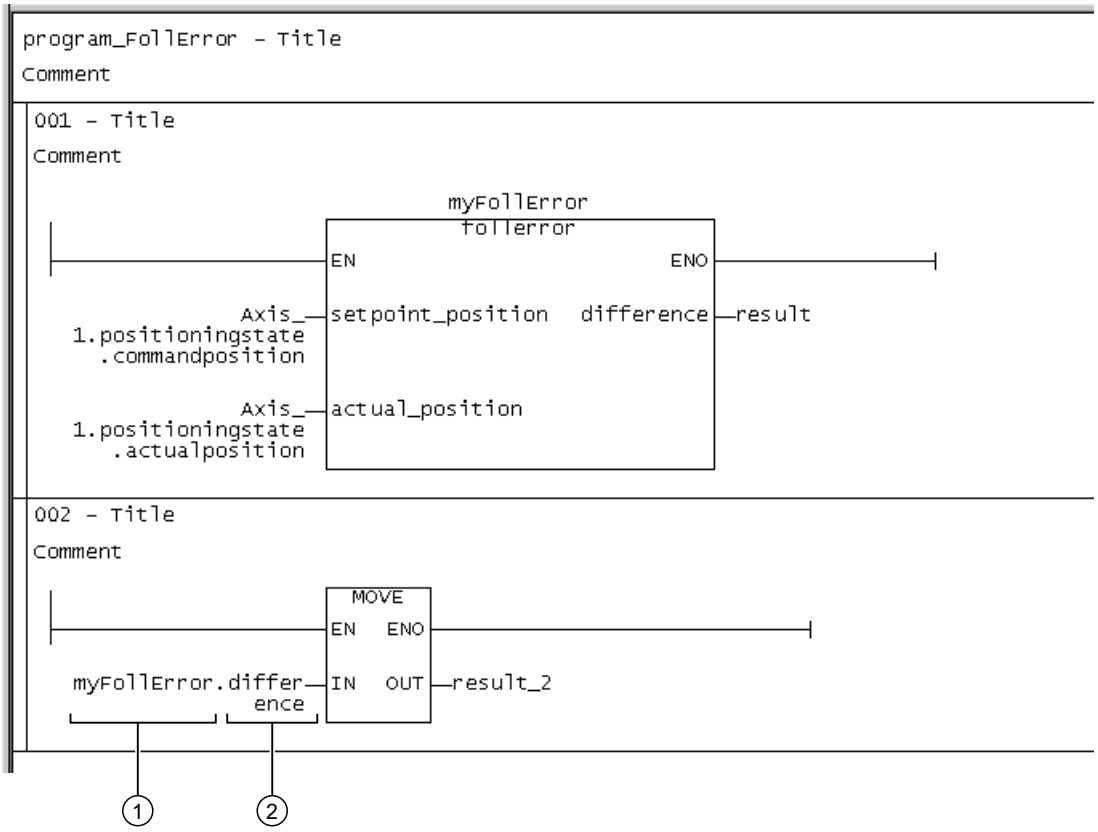
The term "LAD/FBD program" is a generic term and may refer to a program, a function (FC), or a function block (FB).

4.17.4.5 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 4-42 Programming a variable assignment

4.17.5 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.

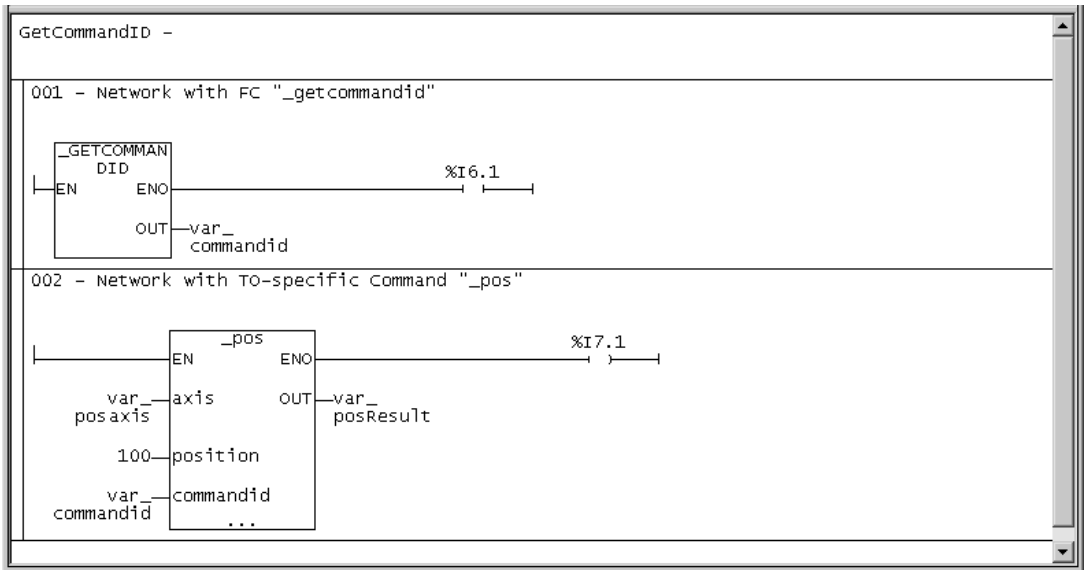


Figure 4-43 Output/input parameter switching with FB/FC

4.17.6 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

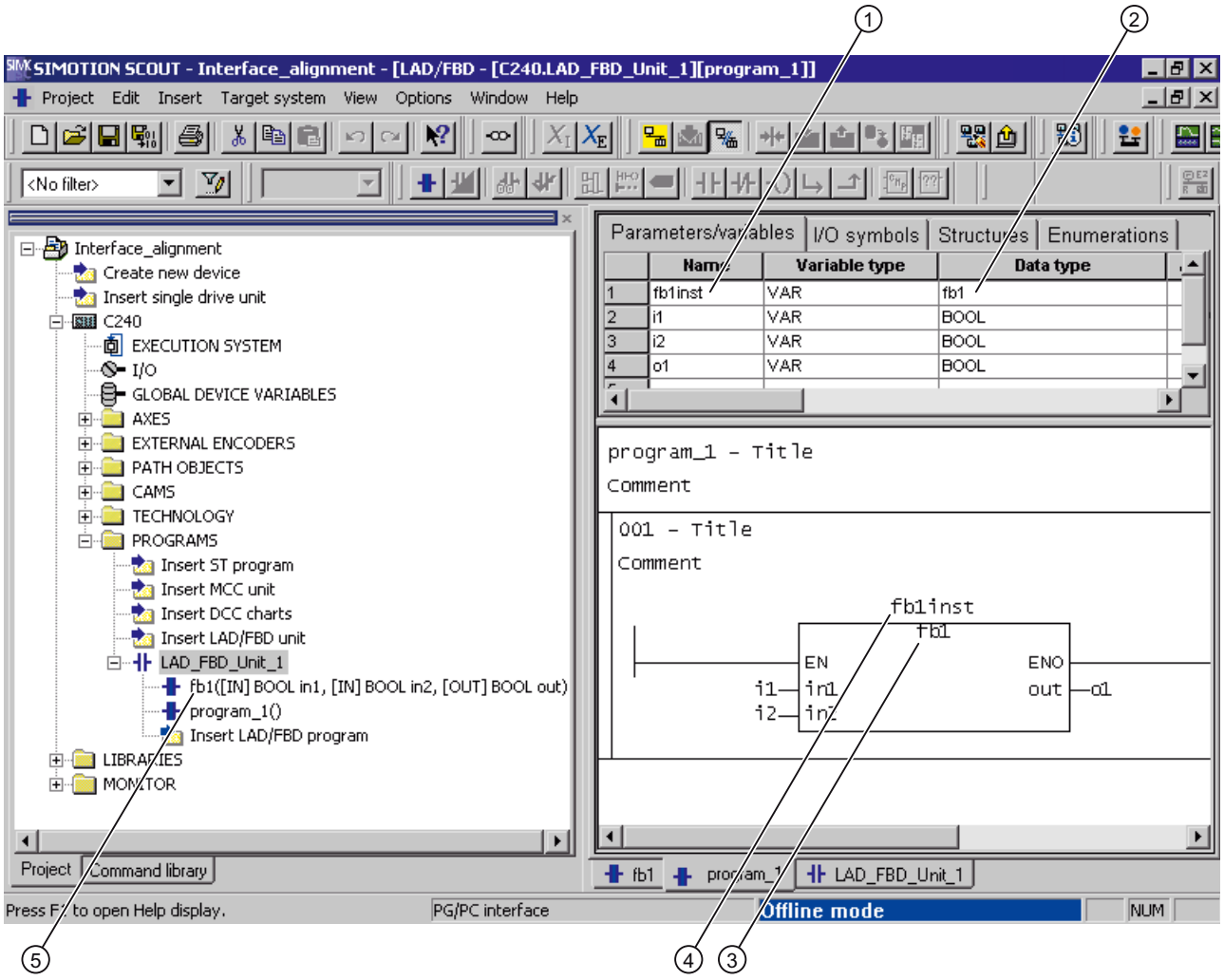
To manually update all the FB/FC calls for the program organization unit (POU) currently displayed in the work area, follow these steps:

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 entering data manually or with Find/Replace (see restrictions under Find/Replace in a Project (Page 81)):

- 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 4-44 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.

4.18 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 161)).
- on function calls and their nesting (Program structure (Page 165))
- on the memory requirement for various data areas of the program sources (Code attributes (Page 166))

4.18.1 Cross reference list

The cross-reference list shows all identifiers in program sources (e.g. ST source files, MCC source files):

- 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.

You can generate the cross-reference list selectively for:

- An individual program source (e.g. ST source file, MCC source file, LAD/FBD source)
- All program sources of a SIMOTION device
- All program sources and libraries of the project
- Libraries (all libraries, single library)

4.18.1.1 Creating a cross-reference list

To create the cross-reference list:

1. In the project navigator, select the element for which you want to create a cross-reference list.
2. Select the menu **Edit > Reference data > Create**.

The cross-reference list is displayed in its own tab in the detail view.

Note

The generated cross-reference list is saved automatically and can be displayed selectively after selecting the appropriate element in the project navigator. To display the cross-reference list, select the **Edit > Reference data > Display > Cross-Reference List** menu command.

When a cross-reference list is recreated, it is updated selectively (corresponding to the selected element in the project navigator). Other existing cross-reference data are retained and displayed, if applicable.

4.18.1.2 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 described in the section "Working with the cross-reference list (Page 164)".

Table 4- 23 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 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
Usage		Use of identifier
	CALL	Call as subroutine
	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

Column	Entry in column	Meaning
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
	IMPLEMENTATION	Implementation section of the program source
	INTERFACE	Interface section of the program source
	POU type name (e.g. FUNCTION *name*, PROGRAM *name*)	Program organization unit (POU) *name* within the program source (also MCC chart, LAD/FBD program)
	I/O address	I/O variable
	TASK *name*	Assignment for the task *name*
	_device	Global device variable
Language		Programming language of the program source
Line/Block		Line number of the program source (e.g. ST source file) With MCC units or MCC charts, the following is also shown: • Number: serial numbers for the command (block numbers) or • DT: declaration table

Note

Activated single-step monitoring in MCC programming

Each task is assigned two variables TSI#dwuser_1 and TSI#dwuser_2, which can be written and read.

When single step monitoring is activated, the compiler uses these variables to control single step monitoring if at least one MCC chart is assigned to the relevant task. The user then cannot use these variables, because their contents are overwritten by single step monitoring and may cause undesirable side effects.

4.18.1.3 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 164) the identifiers and entries displayed.
- Copy contents to the clipboard in order, for example, to paste them into a spread-sheet program
  - Select the appropriate lines and columns.
  - Press the CTRL+C shortcut.
- Print the contents ("Project" > "Print" menu).
- 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.

4.18.1.4 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.

4.18.2 Program structure

The program structure contains all the function calls and their nesting within a selected element.

When the cross-reference list has been successfully created, you can display the program structure selectively for:

- An individual program source (e.g. ST source file, MCC source file, LAD/FBD source)
- 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)

Follow these steps:

1. In the project navigator, select the element for which you want to display the program structure.
2. Select the menu **Edit > Reference data > Display > Program structure**.

   The cross-reference tab is replaced by the program structure tab in the detail view.

4.18.2.1 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- 24 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 • 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 • 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 • Only for function blocks: Identifier of instance • Only for function blocks: Identifier of program source in which the instance was declared: Add-on (UNIT): User-defined program source Add-on (LIB): Library • Line of (compiled) source in which the POU is called; several lines are separated by "|".

4.18.3 Code attributes

You can find information on or the memory requirement of various data areas of the program sources under code attribute.

When the cross-reference list has been successfully created, you can display the code attributes selectively for:

- An individual program source (e.g. ST source file, MCC source file, LAD/FBD source)
- 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)

Follow these steps:

1. In the project navigator, select the element for which you want to display the code attributes.
2. Select the **Edit > Reference data > Display > Code attributes** menu.

   The **Cross-references** tab is now replaced by the **Code attributes** tab in the detail view.

4.18.3.1 Code attribute contents

The following are displayed in a table for all selected program source files:

- Identifier of program source file,
- Memory requirement, in bytes, for the following data areas of the program source file:
  - **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,
- Number of referenced sources.

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 169) 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>

---| |---

Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

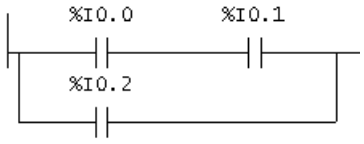
Description

---| |--- (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



Current can flow if:
The state at the inputs %I 0.0 AND %I 0.1 = **1** OR the state at input %I 0.2 = **1**.

5.1.2 ---| / |--- NC contact

Symbol

<Operand>

—| / |—

Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

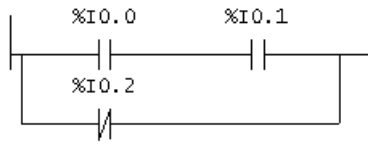
Description

---| / |--- (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

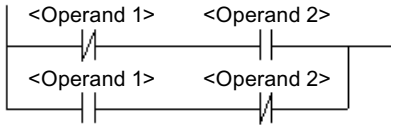


Current can flow if:
The state at the inputs %I 0.0 AND %I 0.1 = **1** OR the state at input %I 0.2 = **0**.

5.1.3 XOR Linking EXCLUSIVE OR

Symbol

For the function **XOR**, a network of NC contacts and NO contacts must be created:

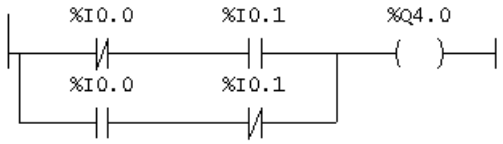


Parameters	Data type	Description
<Operand>	BOOL	Scanned bit
<Operand>	BOOL	Scanned bit

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

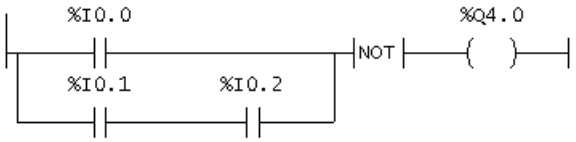
Symbol

---|NOT|---

Description

---|NOT|--- (Invert signal state) inverts the signal bit.

Example



Output %Q 4.0 is **0** if:

The state at input %I 0.0 = **1** OR the state at %I 0.1 AND %I 0.2 = **1**.

5.1.5 ---( ) Relay coil, output

Symbol

<Operand>

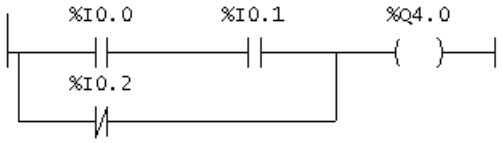
---( )

Parameters	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:

(The state at input %I 0.0 AND %I 0.1 = **1**) OR the state at input %I 0.2 = **0**.

5.1.6 ---(#)--- Connector (LAD)

Symbol

<Operand>

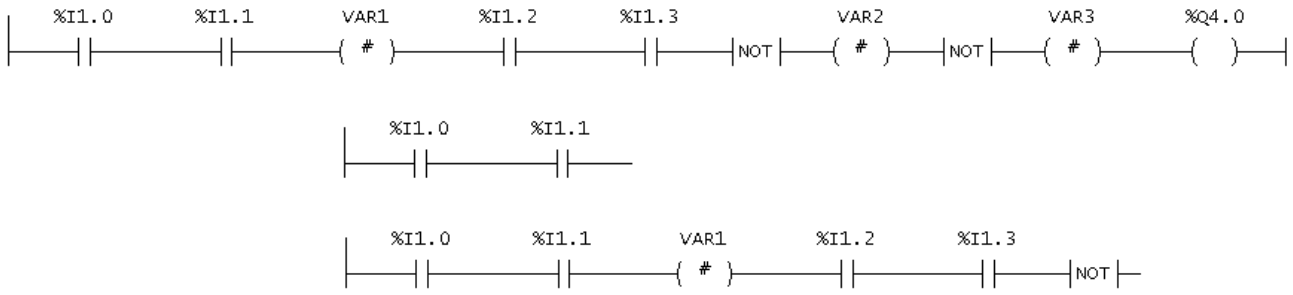
---(#)---

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 inserted 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)

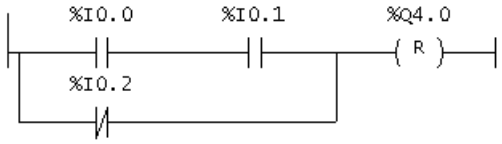
Parameters	Data type	Description
<Operand>	BOOL	Assigned bit

Description

---(R) (Reset output) is executed only if the signal state of the previous operations is **1** (signal flow at the coil). If current flows to the coil (signal state is **1**), the specified **<Operand>** of the element is then 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 only reset if:

(The state at input %I 0.0 AND at input %I 0.1= **1**) OR the state at input %I 0.2 = **0**.

5.1.8 ---(S) Set output (LAD)

Symbol

<Operand>

---(S)

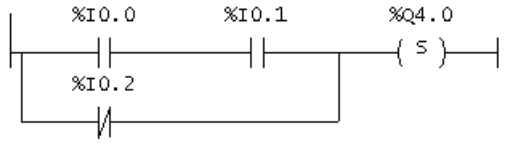
Parameters	Data type	Description
<Operand>	BOOL	Set bit

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



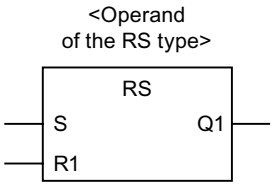
Output %Q 4.0 is only set to **1** if:

(The state at input %I 0.0 AND %I 0.1 = **1**) OR the state at input %I 0.2 = **0**.

If the signal state is **0**, the signal state of output %Q 4.0 remains the same.

5.1.9 RS Prioritize reset flipflop

Symbol



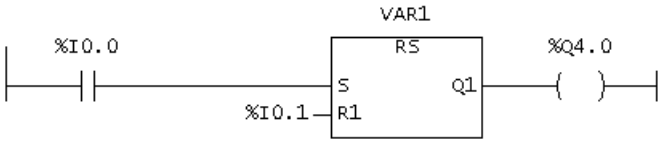
Parameters	Data type	Description
<Operand>	RS	Instance variable of FB type RS
S	BOOL	Enable set
R1	BOOL	Enable reset
Q1	BOOL	Signal state of <address>

Description

RS (Prioritize reset flipflop) is reset if the state at input R1 is **1**, and **0** at input S. Otherwise, if input R1 has state **0** and input S has state **1**, the flipflop is set.

The operations S (set) and R1 (reset) are executed only if the pending signal = 1. If the pending signal = 0, these operations are not affected and the specified operand is not changed. If the pending signal at both inputs is **1**, the RS is reset.

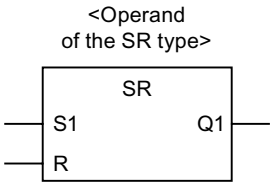
Example



If the state at input %I 0.0 = **1** and at input %I 0.1 = **0**, the state flag VAR1 is set and %Q 4.0 is **1**. Otherwise, if the signal state at input %I 0.0 = **0** and the state at input %I 0.1 = **1**, the state flag VAR1 is reset and %Q 4.0 is **0**. If both signal states are **0**, nothing is changed. If both signals are **1**, the reset operation has priority. VAR1 is reset and %Q 4.0 is **0**.

5.1.10 SR Prioritize set flipflop

Symbol



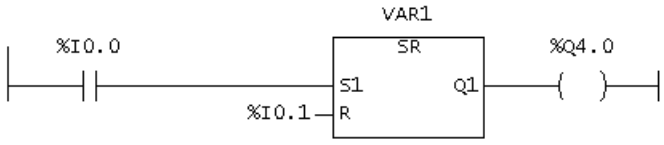
Parameters	Data type	Description
<Operand>	SR	Instance variable from FB type SR
S1	BOOL	Enable set
R	BOOL	Enable reset
Q1	BOOL	Signal state of <address>

Description

SR (Prioritize set flipflop) is set if input S1 has state **1** and input R has state **0**. Otherwise, if input S1 has state **0** and input R has state **1**, the flipflop is reset.

The operations S1 (set) and R (reset) are executed only if the pending signal = 1. If the pending signal = 0, these operations are not affected and the specified operand is not changed. If the pending signal at both inputs is **1**, then SR is set.

Example



If the state at input %I 0.0 is **1** and at input %I 0.1 = **0**, the state flag VAR1 is set and %Q 4.0 is **1**. Otherwise, if the state at input %I 0.0 = 0 and the state at input %I 0.1 = 1, the state flag VAR1 is reset and %Q 4.0 is **0**. If both signal states are **0**, nothing is changed. If both signals are **1**, the set operation has priority. VAR1 is set and %Q 4.0 is **1**.

5.1.11 --(N)-- Scan edge 1 -> 0 (LAD)

Symbol

<Operand>

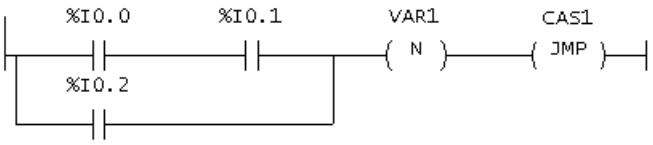
---(N)---

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>

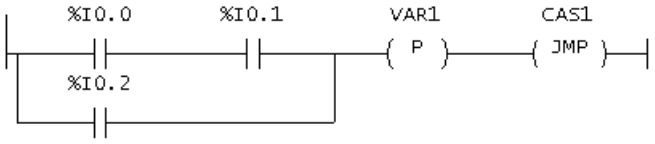
---(P)---

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.

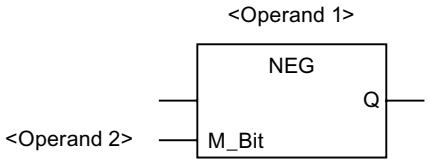
Example



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

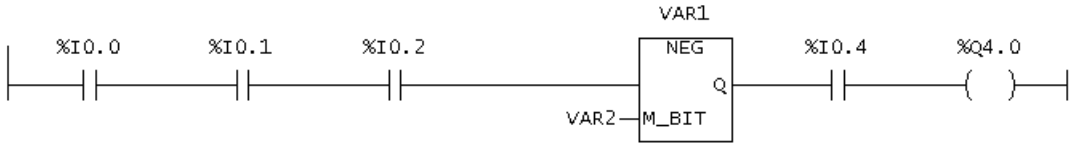


Parameters	Data type	Description
<Operand1>	BOOL	Scanned signal
<Operand2>	BOOL	Connector bit, saves the previous signal state from <Operand1>
Q	BOOL	Signal change detection

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

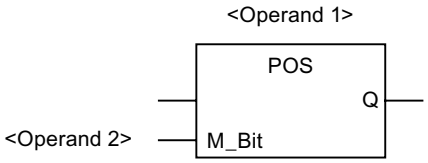


Output %Q 4.0 is **1** if:

(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

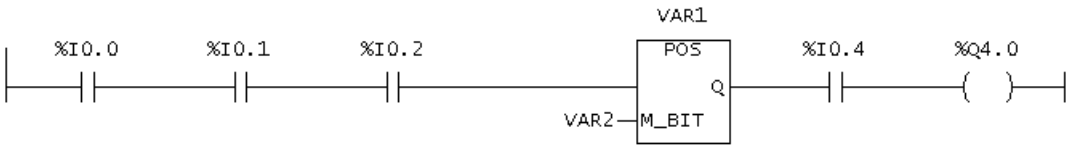


Parameters	Data type	Description
<Operand1>	BOOL	Scanned signal
<Operand2>	BOOL	Connector bit, saves the previous signal state from <Operand1>
Q	BOOL	Signal change detection

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

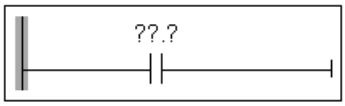
Parallel branches are opened downward.

Parallel branches are always opened behind the selected LAD element.

Procedure

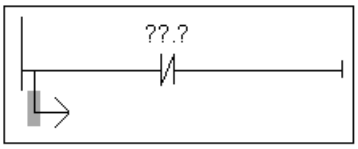
To open a parallel branch downward, follow these steps:

1. Use the cursor to select the position where the branch is to be opened.



2. Click the  button (shortcut F8) on the LAD editor toolbar.

   The branch is opened behind the selected element.



5.1.16 Close branch

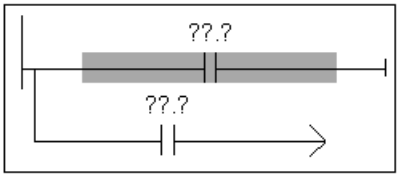
Parallel branches are closed upward.

Parallel branches are always closed behind the selected LAD element.

Procedure

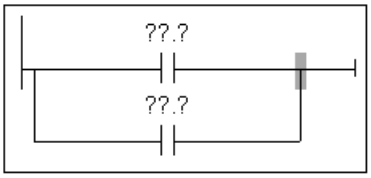
To close a parallel branch upward, follow these steps:

1. Use the cursor to select the position where the branch is to be closed.



2. Click the  button (shortcut F9) on the LAD editor toolbar.

   The branch is closed behind the selected element.



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:

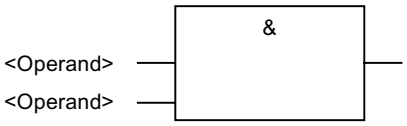
- [N] Scan edge 1 -> 0
- [P] Scan edge 0 -> 1
- NEG edge detection (falling)
- POS edge detection (rising)

The other operations directly affect the signal states:

- --| Inserting a binary input
- --o| Negating a binary input

5.2.1 & AND box

Symbol

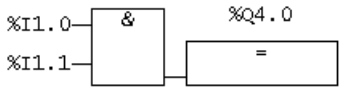


Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

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**.

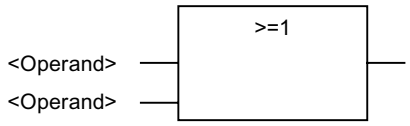
Example



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

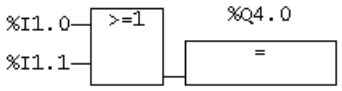


Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

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**.

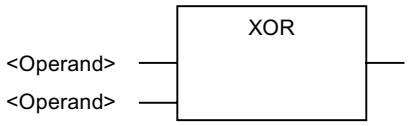
Example



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

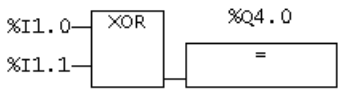


Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

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>

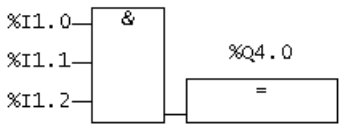
---|

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|

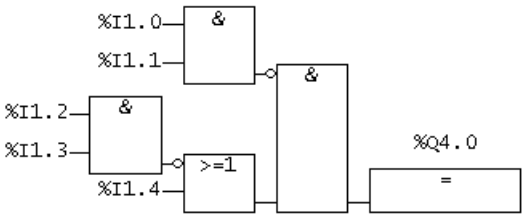
Parameters	Data type	Description
<Operand>	BOOL	Scanned bit

Description

The **Negate binary input** operation negates the signal state.

All binary inputs of any elements can be negated.

Example

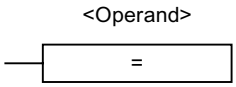


Output %Q 4.0 is **1** if:

- 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

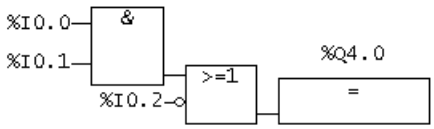
Description

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

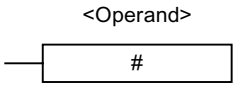


Output %Q 4.0 is **1** if:

- 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

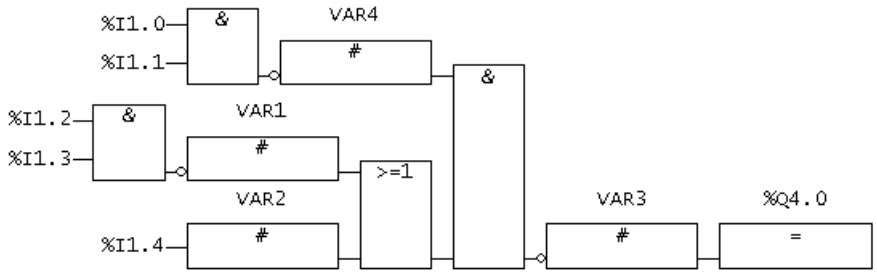


Parameters	Data type	Description
<Operand1>	BOOL	Assigned bit

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

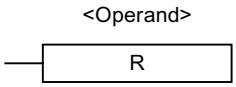
%I1.3

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

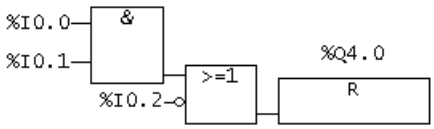


Parameters	Data type	Description
<Operand>	BOOL	Assigned bit

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



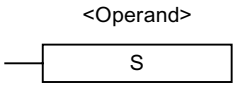
The signal state at output %Q 4.0 is only reset to **0** if:

- 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

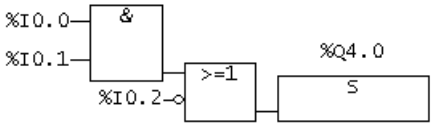


Parameters	Data type	Description
<Operand>	BOOL	Set bit

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



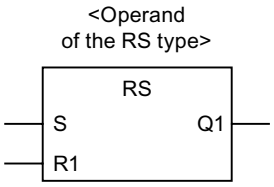
The signal state at output %Q 4.0 is only reset to **1** if:

- 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



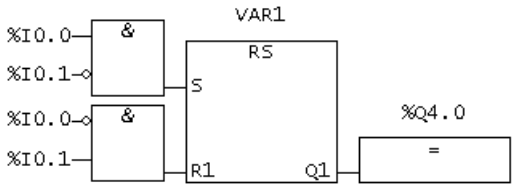
Parameters	Data type	Description
<Operand>	RS	Instance variable of FB type RS
S	BOOL	Enable set
R1	BOOL	Enable reset
Q1	BOOL	Signal state of <address>

Description

The **Prioritize reset flipflop** operation only performs operations such as Set assignment (S) or Reset assignment (R) only if the signal state = 1. A signal state of 0 does not affect these operations: The operand specified in the operation is not changed.

Prioritize reset flipflop is reset when the signal state at input R = 1 and the signal state at input S = 0. The flipflop is set when input R = 0 and input S = 1. If the signal state at both inputs is **1**, the flipflop is reset.

Example

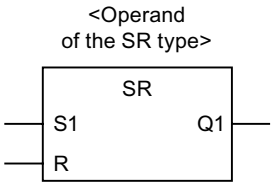


If %I 0.0 = **1** and %I 0.1 = **0**, the VAR1 variable is set and output %Q 4.0 is **1**. If %I 0.0 = **0** and %I 0.1 = **1**, the VAR1 variable is reset and output %Q 4.0 is **0**.

If both signal states are **0**, a change occurs. If both signal states are **1**, the reset operation has priority due to the sequence. VAR1 is reset and %Q 4.0 is **0**.

5.2.11 SR Prioritize set flipflop

Symbol



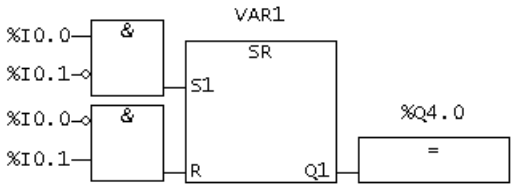
Parameters	Data type	Description
<Operand>	SR	Instance variable from FB type SR
S1	BOOL	Enable set
R	BOOL	Enable reset
Q1	BOOL	Signal state of <address>

Description

The **Prioritize set flipflop** operation performs operations such as Set (S) or Reset (R) only 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 S = 1 and the signal state at input R = 0. The flipflop is reset when input S = 0 and input R = 1. If the signal state at both inputs is **1**, the flipflop is set.

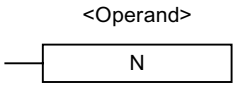
Example



If %I 0.0 = 1 and %I 0.1 = 0, the VAR1 variable is set and %Q 4.0 is **1**. If %I 0.0 = 0 and %I 0.1 = 1, the VAR1 is reset and %Q 4.0 is **0**. If both signal states are **0**, nothing is changed. If both signals 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

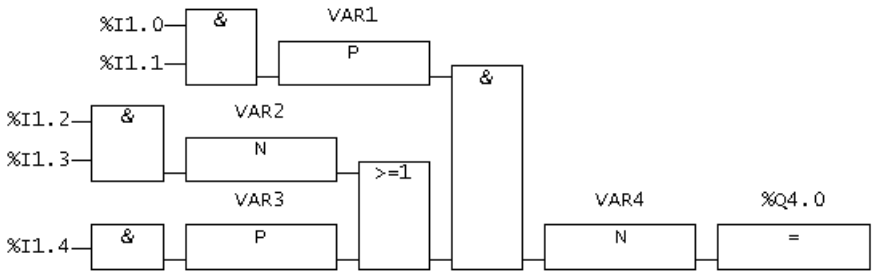


Parameters	Data type	Description
<Operand>	BOOL	N connector bit, saves the previous signal state

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.

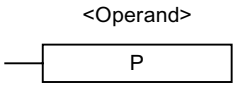
Example



The VAR4 variable saves the signal state.

5.2.13 [P] Scan edge 0 -> 1 (FBD)

Symbol

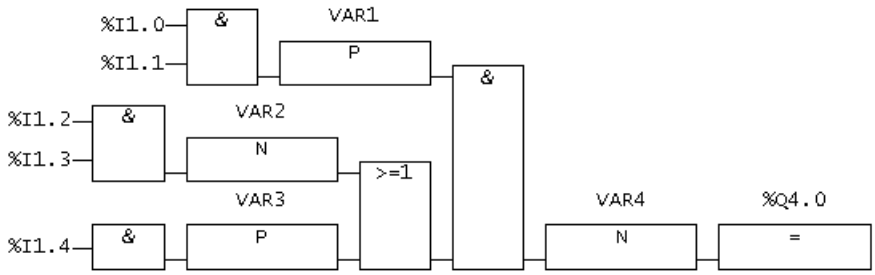


Parameters	Data type	Description
<Operand>	BOOL	P connector bit, saves the previous signal state

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.

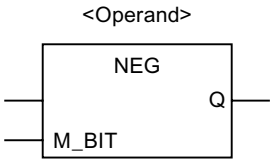
Example



The VAR1 variable saves the signal state.

5.2.14 NEG edge detection (falling)

Symbol

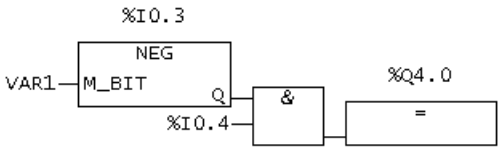


Parameters	Data type	Description
<Operand1>	BOOL	Scanned signal
M_BIT	BOOL	The M-BIT operand indicates the variable in which the previous signal state of NEG is saved.
Q	BOOL	Signal change detection

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

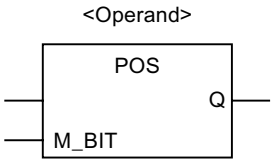


Output %Q 4.0 is **1** if:

- 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

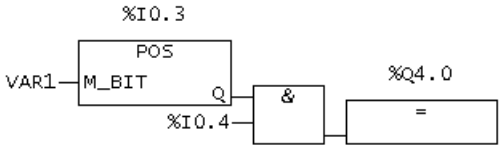


Parameters	Data type	Description
<Operand1>	BOOL	Scanned signal
M_BIT	BOOL	The M-BIT operand indicates the variable in which the previous signal state of POS is saved.
Q	BOOL	Signal change detection

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

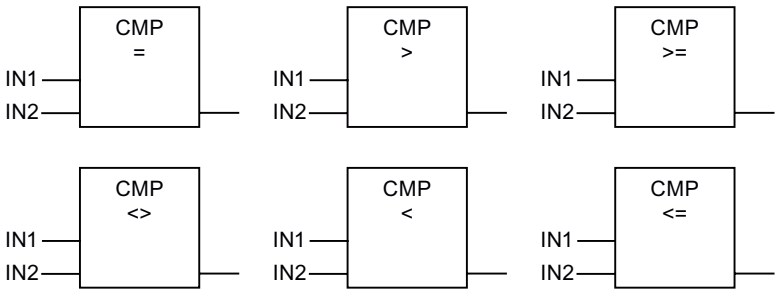


Table 5- 1 Parameters for CMP <, CMP > CMP >=, CMP <=

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 <>

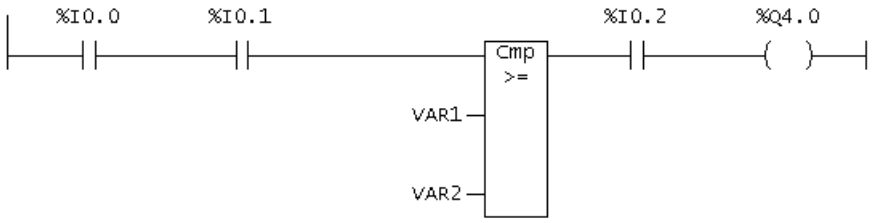
Parameter	Data type	Description
Box output	BOOL	Result of the comparison, processing is only continued if the signal state at the box input = 1.
IN1	ANY_NUM[1] ANY_BIT DATE TIME_OF_DAY (TOD) DATE_AND_TIME (DT) TIME STRING[2] Enumeration[3] Array[3] Structure[3] STRUCTTASKID STRUCTALARMID ANYOBJECT	First comparison value
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

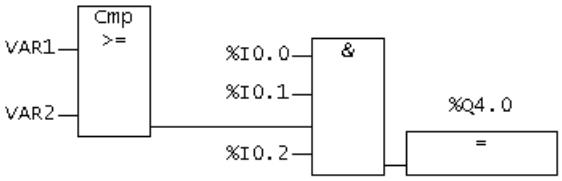
CMP (Compare numbers) can be used like a normal contact. The box can be used at the positions where a normal contact can also be positioned. IN1 and IN2 are compared with the comparison method selected by you.

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

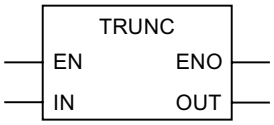
%Q 4.0 is set when:

- 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

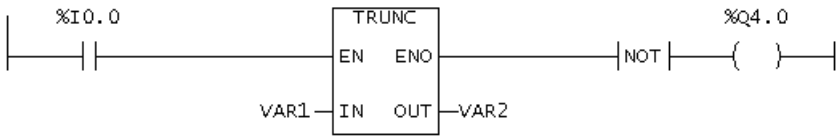


Parameters	Data type	Description
EN	BOOL	Enable input
ENO	BOOL	Enable output
IN	ANY_REAL	Number which is to be converted
OUT	ANY_INT	Integral part of the value from IN

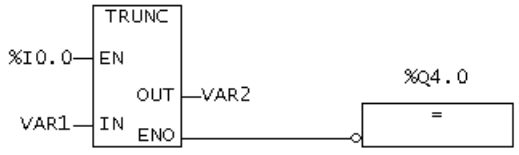
Description

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



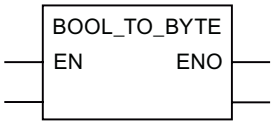
Representation in the FBD editor

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
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

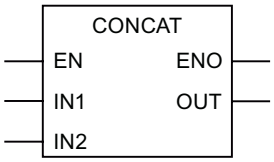
Function name	Conversion rule	Implicit okay
USINT_TO_BYTE	Accept bit string.	no
USINT_TO_INT	Accept value.	yes
USINT_TO_DINT	Accept value.	no
USINT_TO_SINT	Accept bit string.	no
USINT_TO_UINT	Accept value.	yes

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:

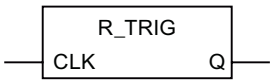
- To data type UDINT:
  Divide it by a standardization factor of data type TIME.
  Multiply the reconversion by the same standardization factor.

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.

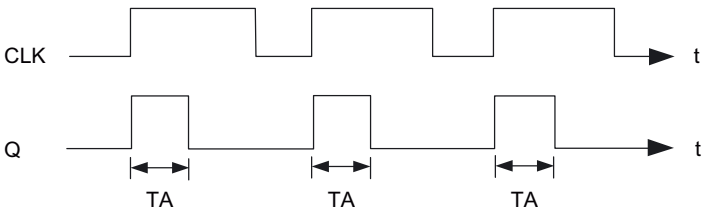
5.5.1 Detection of rising edge R_TRIG

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

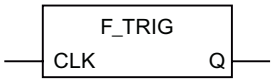
Figure 5-1 Mode of operation of R_TRIG (rising edge) function block

Table 5- 15 Call parameters for R_TRIG

Identifier	Parameters	Data type	Description
CLK	Input	BOOL	Input for edge detection
Q	Output	BOOL	Status of edge

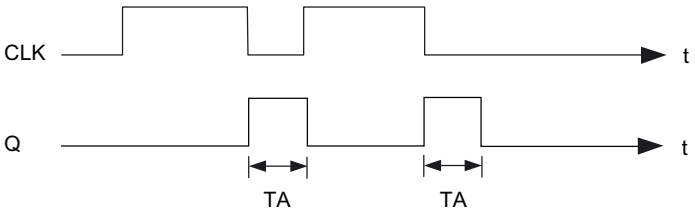
5.5.2 Detection of falling edge F_TRIG

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	Parameters	Data type	Description
CLK	Input	BOOL	Input for edge detection
Q	Output	BOOL	Status of edge

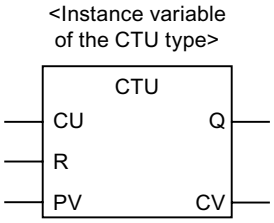
5.6 Counter operations

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.

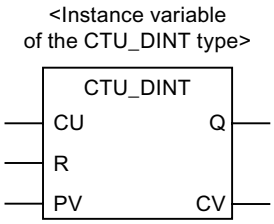
The CV and PV parameters are both INT data types, which means that the maximum counter reading possible is 32767 (= 16#7FFF).

Table 5- 17 Parameters for CTU

Identifier	Parameters	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:

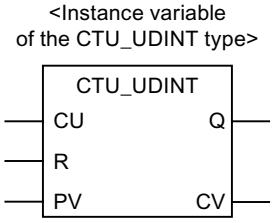
The CV and PV parameters are both DINT data types, which means that the maximum counter reading possible is 2147483647 (= 16#7FFF_FFFF).

Table 5- 18 Parameters for CTU_DINT

Identifier	Parameters	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:

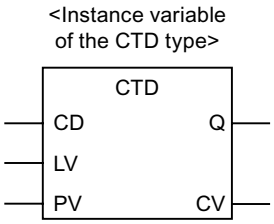
The CV and PV parameters are both UDINT data types, which means that the maximum counter reading possible is 4294967295 (=16# FFFF_FFFF).

Table 5- 19 Parameters for CTU_UDINT

Identifier	Parameters	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.

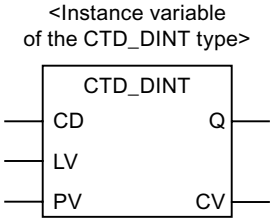
The CV and PV parameters are both INT data types, which means that the minimum counter reading possible is -32,768 (= 16#8000).

Table 5- 20 Parameters for CTD

Identifier	Parameters	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:

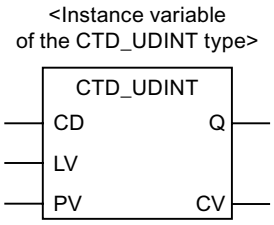
The CV and PV parameters are both DINT data types, which means that the minimum counter reading possible is -2147483648 (= 16#8000_0000).

Table 5- 21 Parameters for CTD_DINT

Identifier	Parameters	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:

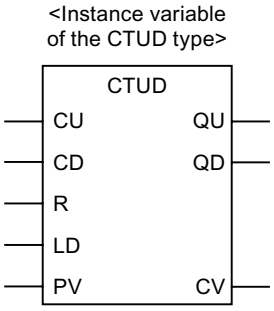
The CV and PV parameters are both UDINT data types, which means that the minimum counter value possible is 0.

Table 5- 22 Parameters for CTD_DINT

Identifier	Parameters	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.

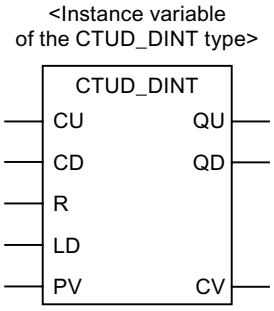
- Reset the CV count variable:
  - If the input is R = TRUE when the FB is called up, then the CV output is reset to 0.
  - If the LD input = TRUE when the FB is called, then the CV output is reset to start value PV.
- Count:
  - If the CU input changes from FALSE to TRUE (0 to 1) when the FB is called (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:

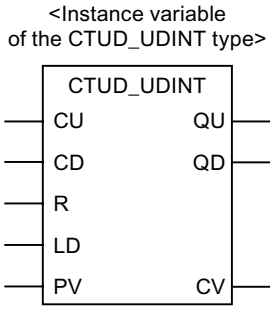
The CV and PV parameters are both DINT data types.

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	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	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 67)

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).

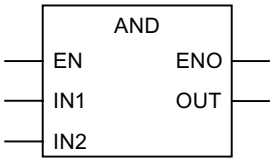
Note

Only alphanumeric characters are allowed during input. The jump label is deleted if it contains an error and cannot be corrected.

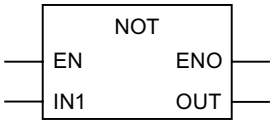
5.8 Non-binary logic

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.

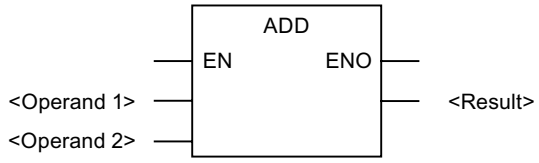
Table 5- 26 Non-binary logic

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
Subtraction	SUB	ANY_NUM	ANY_NUM	ANY_NUM[1]
		BYTE	BYTE	BYTE
		WORD	WORD	WORD
		DWORD	DWORD	DWORD
		TIME	TIME	TIME

Instruction	Operator	1. Operand (IN1)	2. Operand (IN2)	Result (OUT)
		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.

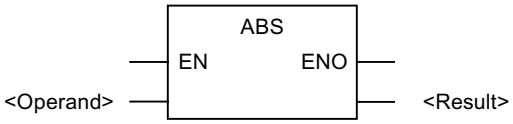
5.10 Numeric standard functions

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:

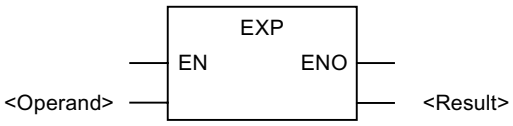
Table 5- 28 General numeric standard functions

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:

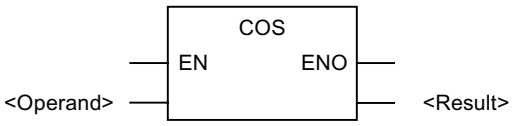
Table 5- 29 Logarithmic standard functions

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.

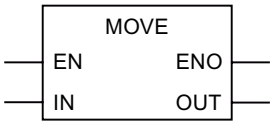
Table 5- 30 Trigonometric standard functions

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.

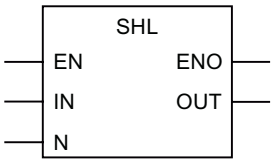
The number that you specify at input N indicates the number of bits by which to shift. The places which become free as a result of the shifting operation are filled up with zeroes.

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

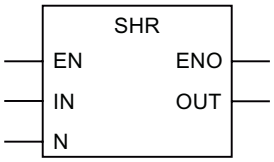
Description

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

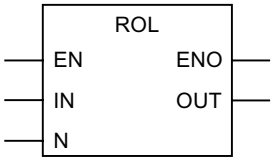
Description

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

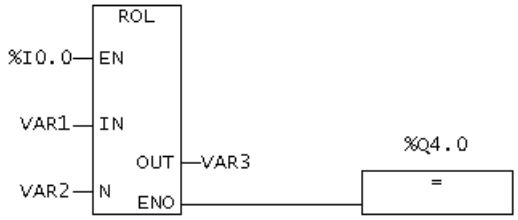


Figure 5-3 Representation in the FBD editor

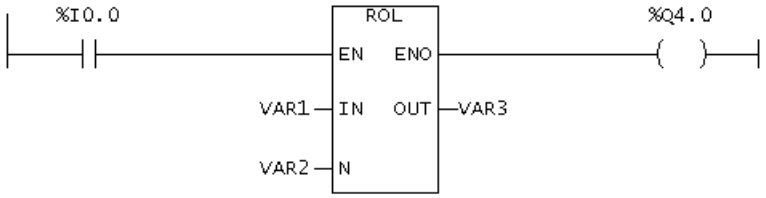
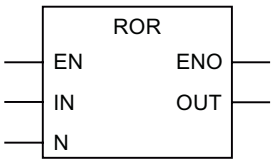


Figure 5-4 Representation in the LAD editor

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

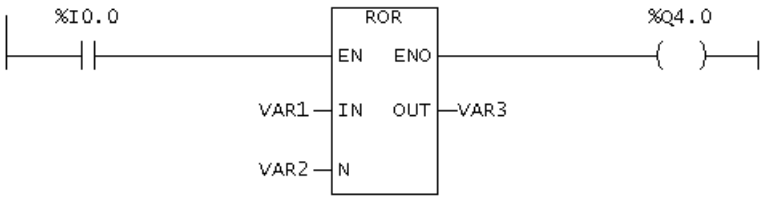


Figure 5-5 Representation in the LAD editor

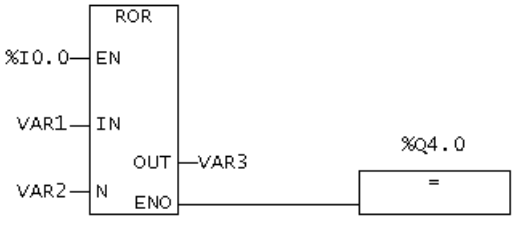


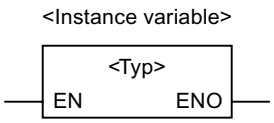
Figure 5-6 Representation in the FBD editor

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 74). 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 74)

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

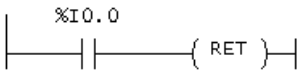


Figure 5-7 Representation in the LAD editor

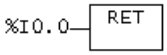


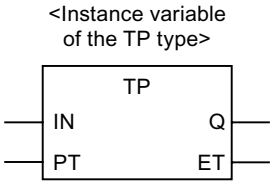
Figure 5-8 Representation in the FBD editor

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.

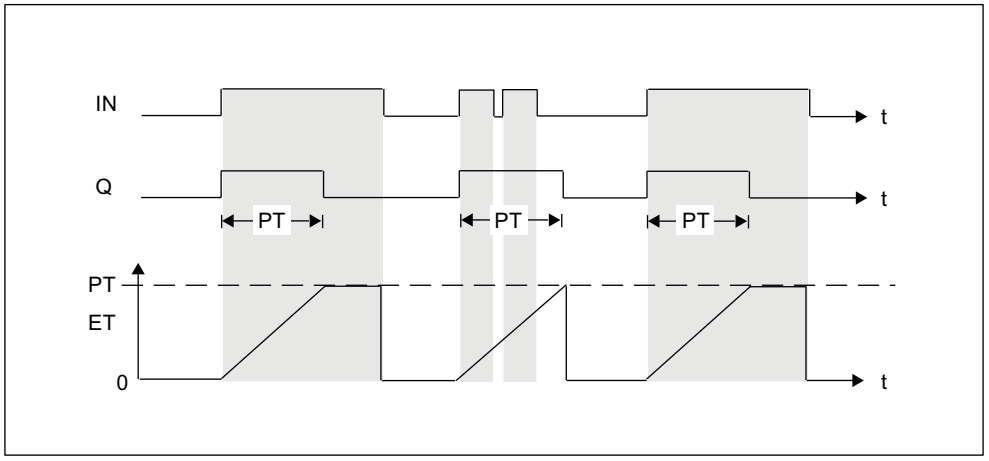


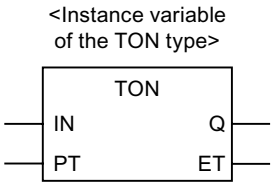
Figure 5-9 Mode of operation of TP pulse timer

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.

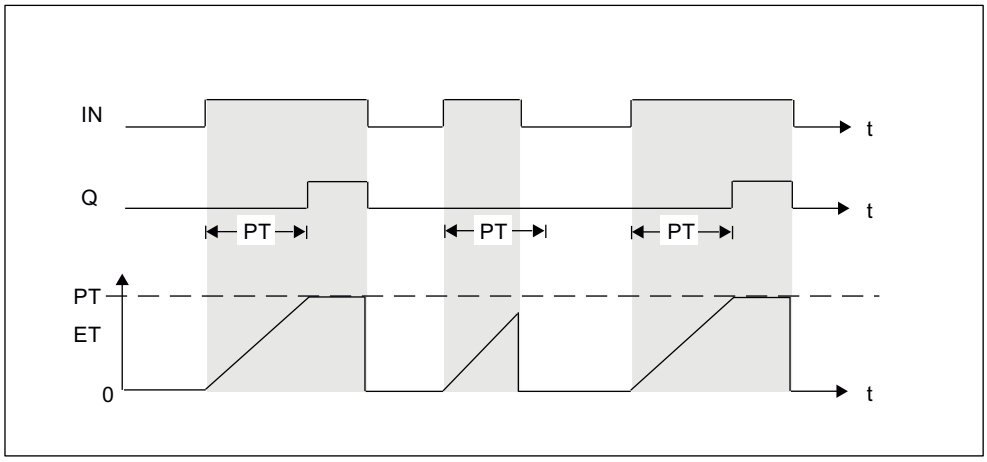


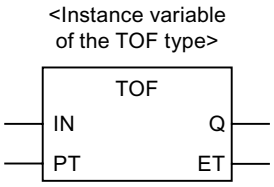
Figure 5-10 Mode of operation of TON on delay timer

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.

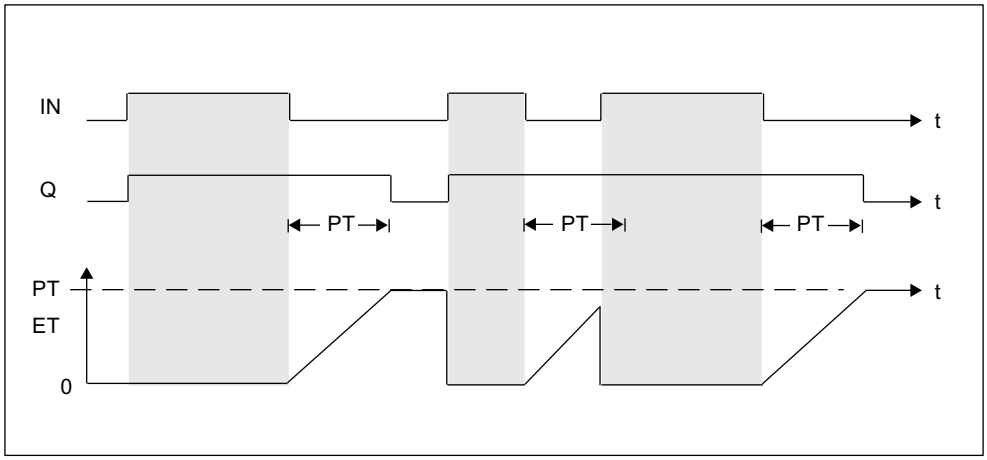


Figure 5-11 Mode of operation of TOF off delay timer

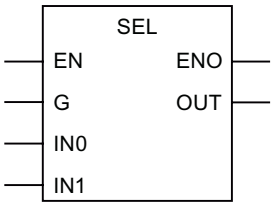
Table 5- 33 Call parameters for TOF

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

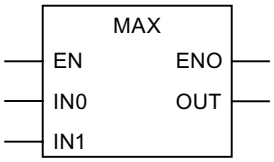
IN0 if G = 0 (FALSE)

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.

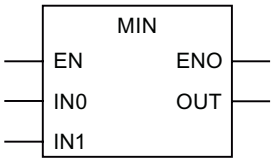
The return value is of data type ANY_ELEMENTARY.

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.

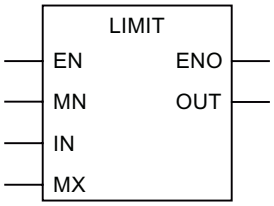
The return value is of data type ANY_ELEMENTARY.

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.

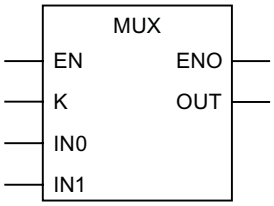
The return value is of data type ANY_ELEMENTARY.

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.

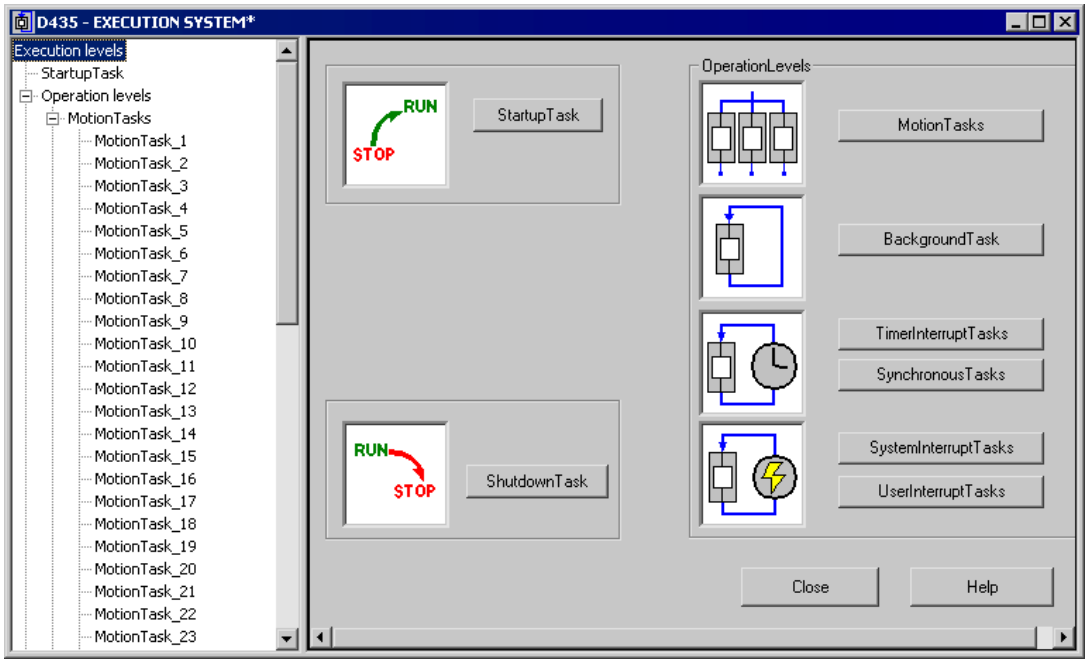


Figure 6-1 Configure execution system

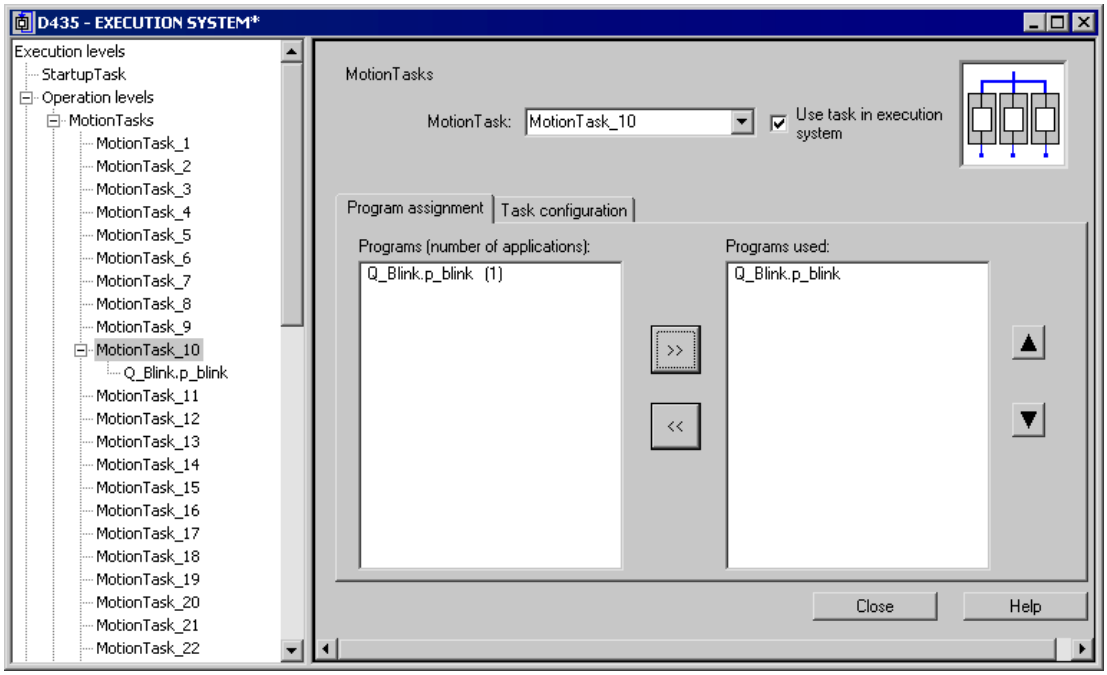


Figure 6-2 Assigning a program to a motion task

6.3 Execution levels and tasks in SIMOTION

Table 6- 1

Execution level	Description
Time-controlled	Cyclic tasks: automatically restarted once assigned programs have been executed.
• SynchronousTasks	Tasks are started periodically, synchronous with specified system cycle clock. • ServoSynchronousTask: Synchronous with position-control cycle clock • 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: executed once after 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: executed once after start and then terminated. Start takes place: • Explicitly via a task control command in a program assigned to another task. • Automatically when RUN mode is attained if the corresponding attribute was set during task configuration. The priority of a MotionTask can be temporarily increased using the Wait for... functions (see Wait for axis , Wait for signal , Wait for condition).
• BackgroundTask	Cyclic task: automatically restarted once 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 mode to RUN mode. SystemInterruptTasks are started by their triggering system event.
ShutdownTask	Task is executed once when there is a transition from RUN mode to STOP or STOP U mode. STOP or STOP U mode is reached by: • Activating the operating mode switch • Calling the relevant system function, for example, MCC Change operating mode command • Occurrence of a fault with the appropriate error response SystemInterruptTasks and PeripheralFaultTasks are started by their triggering system event.
For information on behavior of sequential and cyclic tasks: • During initialization of local program variables: See Initialization of local variables (Page 114). • In the event of processing errors in the program: Please refer to the SIMOTION Basic Functions Function Manual. For information about access options for the process image and I/O variables: Please refer to Important features of direct access and process image (Page 120).	

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.

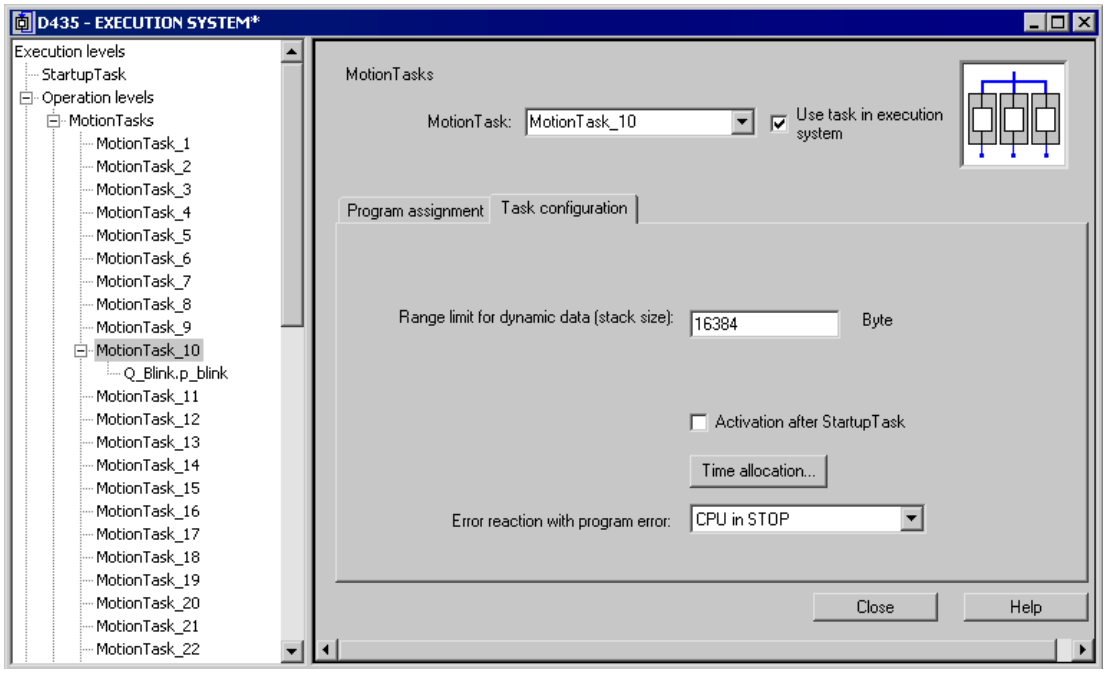


Figure 6-3 Task configuration of a motion task

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 compile 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 option **Check consistency before loading** is activated in menu option **Options > Settings** in the **Download** tab (the default for this option is to be activated). This means that the consistency check is performed automatically during **Download**.

3. Select the **Project > Connect to target system** menu command or click  .

   The Online mode is activated.

4. Select the **Target system > Connect 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 Modes for program testing

7.1.1 Modes of the SIMOTION devices

Various SIMOTION device modes are available for program testing.

How to select the mode of a SIMOTION device:

1. Highlight the SIMOTION device in the project navigator.
2. Select the "Test mode" context menu.
3. Select the required mode (see following table).

   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 257).
4. Confirm with "OK".

   The SIMOTION device switches to the selected mode.

   When the SIMOTION device switches to "Debug mode":

   – A connection to the target system will be established automatically (online mode) if SIMOTION SCOUT is currently in offline mode.

   – The activated debug mode is indicated in the status bar.

   – The breakpoints toolbar (Page 278) is displayed.

Table 7- 1 Modes of a SIMOTION device

Setting	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). – As of version V4.0 of the SIMOTION kernel: No more than one program source (e.g. ST source, MCC source, LAD/FBD source) can be monitored **per task**. – Up to version V3.2 of the SIMOTION kernel: No more than one program source (e.g. ST source, MCC source, LAD/FBD source) can be monitored. • Trace tool (only restricted) with measuring functions for drives and function generator, see online help: – No more than **one** 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 sources, MCC sources, LAD/FBD sources) can be monitored per task. – Up to version V3.2 of the SIMOTION kernel: No more than one program source (e.g. ST source, MCC source, LAD/FBD source) can be monitored **per task**. • Trace tool with measuring functions for drives and function generator, see online help: – No more than **four** traces on each SIMOTION device. **Note** Runtime and memory utilization increase as the use of diagnostic functions increases.
Debug mode	This mode is available in SIMOTION kernel as of V3.2. In addition to the diagnostic functions of the test mode, you can use the following functions: • Breakpoints Within a program source file, you can set breakpoints (Page 272). When an activated breakpoint is reached, selected tasks will be stopped. • Controlling MotionTasks In 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 one SIMOTION device of the project can be switched to debug mode. SIMOTION SCOUT is in online mode, i.e. connected with the target system. Observe the following section: Important information about the life-sign monitoring (Page 257).

7.1.2 Important information about the life-sign monitoring.

⚠ WARNING

You must observe the appropriate safety regulations.

Use the debug mode or a control panel only with the life-sign monitoring function activated with a suitably short monitoring time! Otherwise, if problems occur in the communication link between the PC and the SIMOTION device, the axis may start moving in an uncontrollable manner.

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.

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 parameterization 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.

NOTICE

Pressing the spacebar or switching to a different Windows application causes:

- In debug mode for activated breakpoints:
  - The SIMOTION device switches to STOP mode.
  - 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

This function is not guaranteed in all operating modes. 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-sign signals to ensure a correctly functioning connection. If the exchange of the life-sign is interrupted longer than the set monitoring time, the following response occurs: • In debug mode for activated breakpoints: – The SIMOTION device switches to STOP mode. – 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: • **Active** check box: If the check box is selected, 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 257)

7.2 Symbol Browser

7.2.1 Characteristics

In the symbol browser, you can view and, if necessary, change the name, data type, and variable values. In particular, you can: see the following variables:

- 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.

7.2.2 Using the symbol browser

Enabling symbol browser

To enable the symbol browser, proceed as follows:

1. Make sure that a connection to the target system has been established and that the sample program has been downloaded to the target system (see Download programs to the target system (Page 254)). You can run the program, but you don't have to. If the program is not run, you only see the initial values of the variables.
2. If you have not already done so, select a LAD/FBD unit in the project navigator.
3. Click the **Symbol browser** tab.

   All of the unit variables used in the program are displayed.

In the **Status value** column, the current variable values are displayed and periodically updated.

Variables in the user memory of the unit or in the retentive memory

In the symbol browser, you can monitor the variables contained in the user memory of the unit or in the retentive memory:

- 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 "Create program instance data only once" compiler option (Page 48):
  - Static variables of the programs.
  - Static variables of the function blocks whose instances are declared as static variables of programs.

Follow these steps:

1. Select the program source file in the project navigator.
2. In the detail view, click the **Symbol browser** tab.

In the symbol browser, you can see all the variables of the program source contained in the user memory of the unit or in the retentive memory.

- All unit variables of the program source.
- Only if the program source has been compiled with the "Create program instance data only once" compiler option: The programs of the program source file and below their static variables (including instances of function blocks).

Variables in the user memory of the task

You can use the symbol browser to monitor the variables contained in the user memory of the associated task:

If the program source (unit) was compiled **without** the compiler option (Page 48) "Create program instance data only once" (default), 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.

Follow these steps:

1. In the project navigator of SIMOTION SCOUT, select the **EXECUTION SYSTEM** element in the subtree of the SIMOTION device.
2. In the detail view, click the **Symbol browser** tab.

The symbol browser shows all tasks used in the execution system together with the assigned programs. The associated variables contained in the user memory of the task are listed below.

Note

You can monitor temporary variables (together with unit variables and static variables) with **Program status** (see Program status (Page 269)).

System variables and global device variables

You can also monitor the following variables in the symbol browser:

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

Follow these steps:

1. Select the appropriate element in the SIMOTION SCOUT project navigator.
2. In the detail view, click the **Symbol browser** tab.

The corresponding variables are displayed in the symbol browser.

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 check box in this column
3. Click the **Immediate control** button.

The values you entered are written to the selected variables.

NOTICE
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.

Fixing the display

You can fix the display of the symbol browser for the active object:

1. To do so, click the **Maintain display** symbol in the right upper corner of the symbol browser. The displayed symbol changes to .

   The variables of this object are still displayed and updated in the symbol browser even if another object is selected in the project navigator.
2. To remove the display, click the symbol again. The displayed symbol changes back to .

Display invalid floating-point numbers

Invalid floating-point numbers are displayed as follows in the symbol browser (independently of the SIMOTION device):

Table 7- 3 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

7.3 Watch tables

7.3.1 Monitoring variables in watch table

Watch table options

With the symbol browser you can view the variables belonging to one object in your project; with the program status you can view the variables belonging to a selected 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.

NOTICE
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.

Fix the display of the watch table

You can fix the display of the active watch table:

- To do so, click the **Retain display** icon in the right upper corner of the Watch table tab in the detail view. The displayed symbol changes to .

  This watch table is still displayed even if another one is selected in the project navigator.
- To remove the display, click the icon again. The displayed symbol changes back to .

7.4 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.

7.5 Program run

7.5.1 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 268)" 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 source files:

Table 7- 4 SIMOTION RT program source files

Name	Meaning
taskbind.hid	Execution system
stdfunc.pck	IEC library
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

7.5.2 Parameter call stack program run

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- 5 Parameter description call stack program run

Field	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 file, 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 file, 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 267)".

7.5.3 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- 6 Program run toolbar

Symbol	Meaning
	Display program run Click this button 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 267)

7.6 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 modes of a SIMOTION device.

Note

In the process mode, the program status can be called only once for a LAD/FBD program, FB or FC.

In the test mode, the program status can be called for a maximum of four LAD/FBD programs, FB or FC.

If you do not observe the restriction, error message 25023 "No resources in the runtime" will appear.

7.6.1 Starting and stopping the program execution monitoring

Starting and stopping program status

You can call up information on network status in two different ways using the 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.

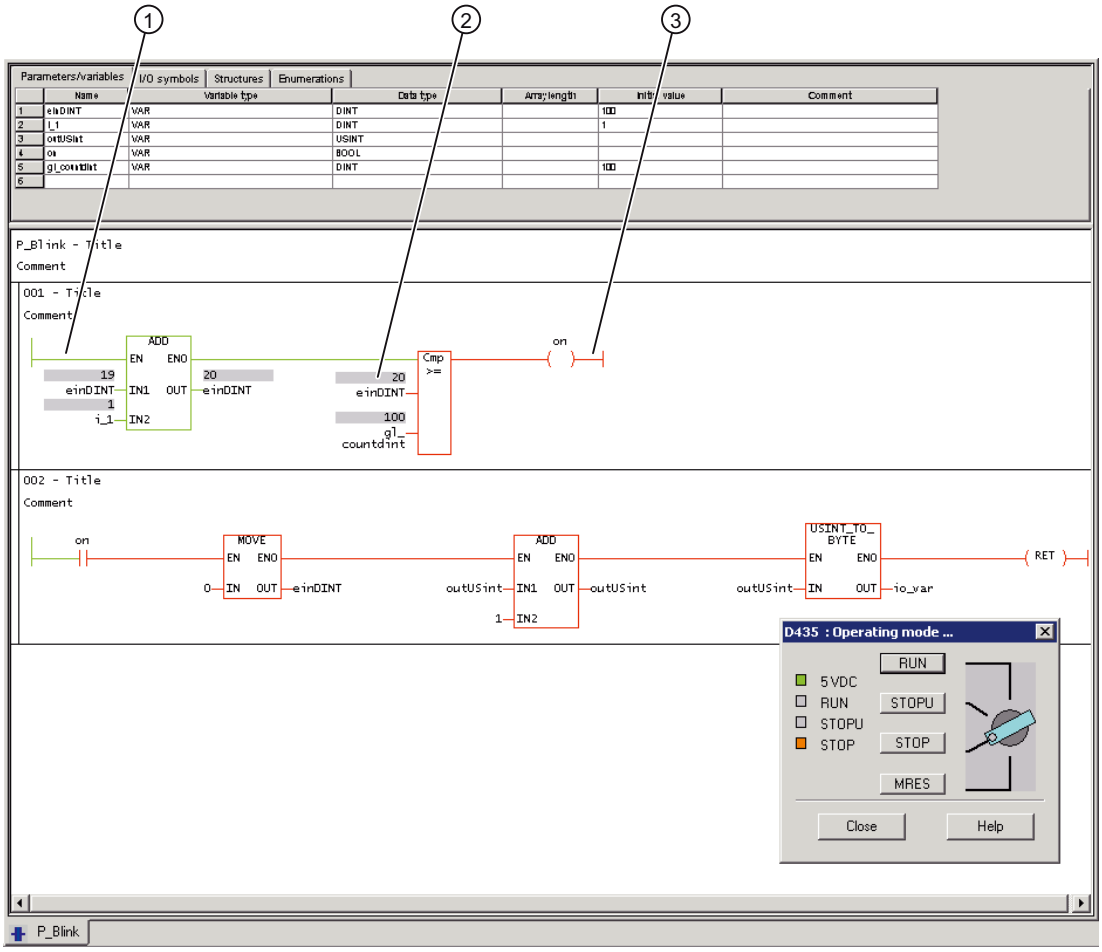
To start/stop Program status, proceed as follows:

1. Make sure that the LAD/FBD unit generates the additional debug code during compilation:

   Select the LAD/FBD unit in the project navigator and select the **Edit > Object properties** menu command.

   Select the **Compiler** tab, activate the **Permit program status** checkbox and confirm with OK.
2. Open the LAD/FBD unit and recompile it with **LAD/FBD unit > Save and compile**.
3. Download and start the program in the usual way. Make sure that the target system is in STOP mode.
4. Click the **Program status** button to start the test mode.
5. To stop the program execution monitoring, click the **Program status** icon.

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: 1, True

② Gray background: Non-binary value

③ Red: 0, False

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.

Monitoring of the program execution is started by means of the **Program status** icon.

In order to be able to monitor several programs simultaneously with the program status, the following conditions must be fulfilled:

- Mark the required LAD/FBD unit in the project navigator, select the **Properties** command in the context menu and mark the **Permit program status**checkbox in the **Compiler** tab.
- Mark the required SIMOTION device in the project navigator, select the **Test mode** command in the context menu and enable the **Test mode** option.

7.7 Breakpoints (WS)

7.7.1 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.

Proceed as follows

Follow these steps:

1. Select "Debug mode" for the associated SIMOTION device, see Set debug mode (Page 273).
2. Specify the debug task group, see Specifying the debug task group (Page 274).
3. Set breakpoints, see Setting breakpoints (Page 276).
4. Define the call path, see Defining a call path for a single breakpoint (Page 279).
5. Activate the breakpoints, see Activating breakpoints (Page 283).

7.7.2 Setting the debug mode

⚠WARNING

You must observe the appropriate safety regulations.

Use the debug mode only with activated life-sign monitoring (Page 257) with a suitably short monitoring time! Otherwise, if problems occur in the communication link between the PC and the SIMOTION device, the axis may start moving in an uncontrollable manner.

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.

To set the debug mode, proceed as follows:

1. Highlight the SIMOTION device in the project navigator.
2. Select **Test mode** from the context menu.
3. Select **Debug**mode (Page 255).
4. Accept the safety information
5. Parameterize the sign-of-life monitoring.

   See also section: Important information about the life-sign monitoring (Page 257).
6. Confirm with **OK**.

   If no connection has been established with the target system (offline mode), the online mode will be established automatically.

   The activated debug mode is indicated in the status bar.

   The breakpoints toolbar (Page 278) is displayed.

Note

You cannot change the program sources in debug mode!

NOTICE

Pressing the spacebar or switching to a different Windows application causes in debug mode for activated breakpoints:

- The SIMOTION device switches to STOP mode.
- The outputs are deactivated (ODIS).

⚠WARNING

This function is not guaranteed in all operating modes. Therefore, there must be an EMERGENCY STOP circuit in the hardware. The appropriate measures must be taken by the user.

7.7.3 Define the debug task group

On reaching an activated breakpoint, all tasks that are assigned to the debug task group are stopped.

Requirement

- The relevant SIMOTION device is in debug mode.

Proceed as follows

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 mode): 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 HALT mode): 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.

NOTICE
Note the different behavior when an activated breakpoint is reached, see the following table.

Table 7- 7 Behavior at the breakpoint depending on the tasks to be stopped in the debug task group.

Properties		Tasks to be stopped	
		Single selected tasks (debug task group)	**All tasks**
Behavior on reaching the breakpoint			
	Operating mode	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 mode	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 released after another download of the project.
	Technology	Closed-loop control active	

Note

You can only make changes to the debug task group if no breakpoints are active.

Proceed as follows:

1. Set breakpoints (see Setting breakpoints (Page 276)).
2. Define the call path (see Defining a call path for a single breakpoint (Page 279)).
3. Activate the breakpoints (see Activating breakpoints (Page 283)).

7.7.4 Setting breakpoints

Requirements:

1. The program source with the POU (e.g. ST source file, MCC chart, LAD/FBD program) is open.
2. The relevant SIMOTION device is in debug mode,
see Setting debug mode (Page 273).
3. The debug task group is defined, see Defining the debug task group (Page 274).

Proceed as follows

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. Alternative:
   - 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. Alternative:
   - 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:

- Alternative:
  - 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".

Set breakpoints remain saved also after leaving the "debug mode", they are displayed only in debug mode.

You can use the program status (Page 269) diagnosis functions and breakpoints together in a program source file 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 279).
2. Activate the breakpoints, see Activating breakpoints (Page 283).

7.7.5 Breakpoints toolbar

This toolbar contains important operator actions for setting and activating breakpoints:

Table 7- 8 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 276).
	Activate/deactivate breakpoint Click this icon to activate or deactivate the breakpoint at the selected code position. See: Activating breakpoints (Page 283).
	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 279), Defining the call path for all breakpoints (Page 281).
	Activate all breakpoints Click this icon to activate all breakpoints in the current program source or POU (e.g. ST source file, MCC chart, LAD/FBD program). See: Activating breakpoints (Page 283).
	Deactivate all breakpoints Click this icon to deactivate all breakpoints in the current program source or POU (e.g. ST source file, MCC chart, LAD/FBD program). See: Activating breakpoints (Page 283).
	Remove all breakpoints Click this icon to remove all breakpoints in the current program source or POU (e.g. ST source file, MCC chart, LAD/FBD program). See: Setting breakpoints (Page 276).
	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 285).
	Resume Click this icon to continue the program execution after reaching an activated breakpoint. See: Activating breakpoints (Page 283), Displaying the call stack (Page 285).

7.7.6 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. The relevant SIMOTION device is in debug mode,
   see Setting debug mode (Page 273).
3. The debug task group is defined, see Defining the debug task group (Page 274).
4. Breakpoint is set, see Setting breakpoints (Page 276).

Proceed as follows

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 file, 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 283).

Note

You can use the "Display call stack (Page 285)" 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 281)

7.7.7 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

- The program source with the POU (e.g. ST source file, MCC chart, LAD/FBD program) is open.
- The relevant SIMOTION device is in debug mode,
  see Setting debug mode (Page 273).
- The debug task group is defined, see Defining the debug task group (Page 274).

Proceed as follows

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 file, 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 283).

Note

You can use the "Display call stack (Page 285)" 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 279)

7.7.8 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. The relevant SIMOTION device is in debug mode,
see Setting debug mode (Page 273).
3. The debug task group is defined, see Defining the debug task group (Page 274).
4. Breakpoints are set, see Setting breakpoints (Page 276).
5. Call paths are defined, see Defining a call path for a single breakpoint (Page 279).

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.
   - 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. Alternative:
   - 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:

- Alternative:
  - Select the **Debug > Activate all breakpoints** menu command.
  - Click the  button in the Breakpoints toolbar.

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.

Behavior at the activated breakpoint

On reaching an activated breakpoint (possibly using the selected call path (Page 279)), 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 274)". The breakpoint is highlighted.

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 260).

You can use the "Display call stack (Page 285)" 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

How to resume program execution:

- Alternative:
  - Select the **Debug > Continue** menu command (shortcut CTRL+F8).
  - Click the  button on the Breakpoint toolbar to "Continue".

Deactivate breakpoints

To deactivate a single breakpoint, proceed as follows:

1. Select the code position with the activated breakpoint.
2. Alternative:
   - 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:

- Alternative:
  - Select the **Debug > Deactivate all breakpoints** menu command.
  - Click the  button in the Breakpoints toolbar.

7.7.9 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 274) have been stopped.

Proceed as follows

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) in 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.

For names of the SIMOTION RT program sources, refer to the table in "Program run (Page 267)".

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/FBDsource file using the shortcut menu:

1. Select the **PROGRAMS** folder of the relevant SIMOTION device in the project navigator.
2. Double-click the entry **Insert LAD/FBD unit**.

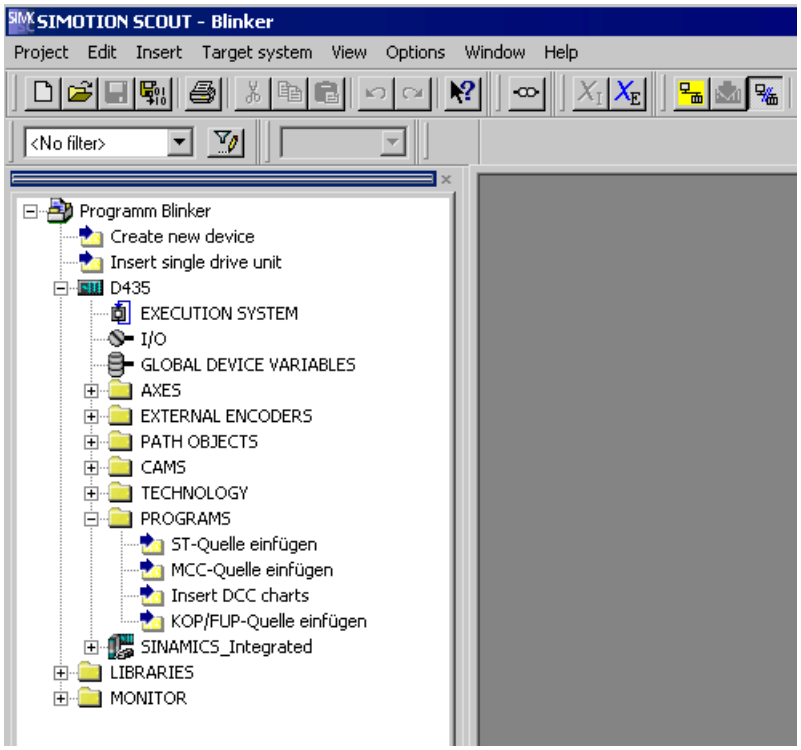


Figure 8-1 Project folder

The **Insert LAD/FBD unit** dialog box appears.

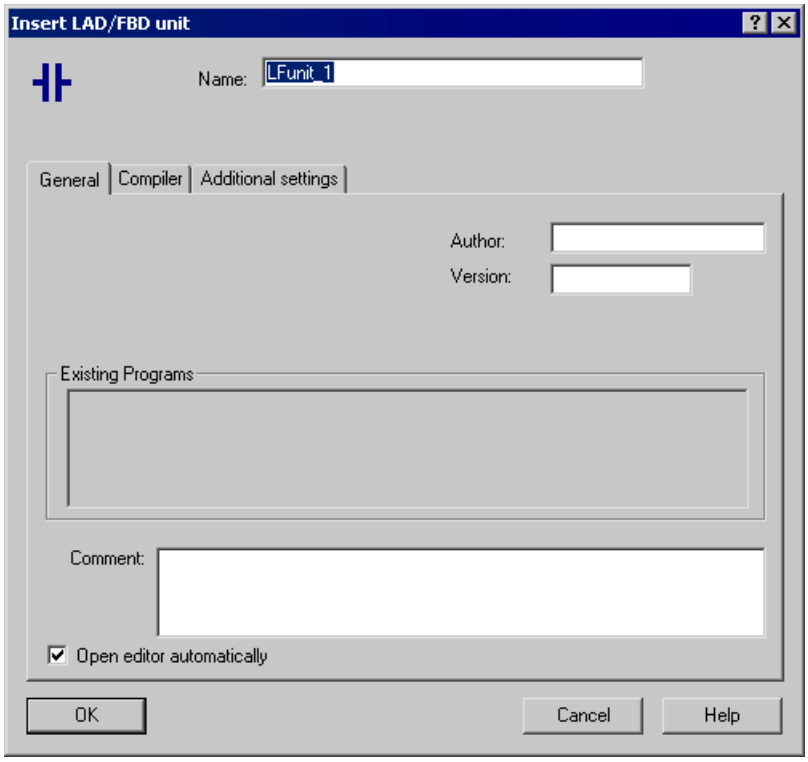


Figure 8-2 Insert LAD/FBD unit dialog box

3. Enter the name of the LAD/FBD unit.

   The names of program sources must comply with the rules for identifiers: They consist of letters (A to Z, a to z), numbers (0 to 9), or single underscores (_) in any order, whereby the first character must be a letter or an underscore. No distinction is made between uppercase and lowercase letters.

   The permissible length of the name depends on the SIMOTION Kernel version:

   – SIMOTION Kernel Version V4.1 and higher: maximum 128 characters.
   – SIMOTION Kernel Version V4.0 and lower: maximum 8 characters.

   Names must be unique within the SIMOTION device. Protected or reserved identifiers (Page 329) are not allowed. The LAD/FBD programs already available are displayed.

4. In the **Compiler** tab, activate checkbox **Permit program status**, to use the online status display later.
5. You can also enter an author, version, and a comment.

6. Select the **Open editor automatically** checkbox.
7. 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.

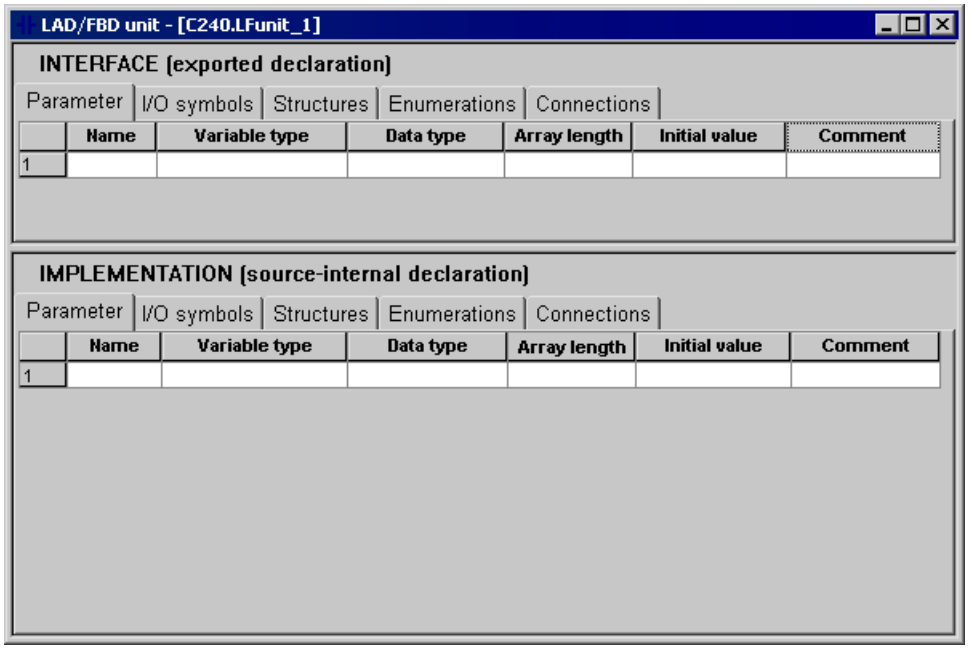


Figure 8-3 Declaration tables for exported and source-internal declarations

8.3.2 Insert LAD/FBD program

To insert an LAD/FBD program, proceed as follows:

1. In the **PROGRAMS** folder within 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.

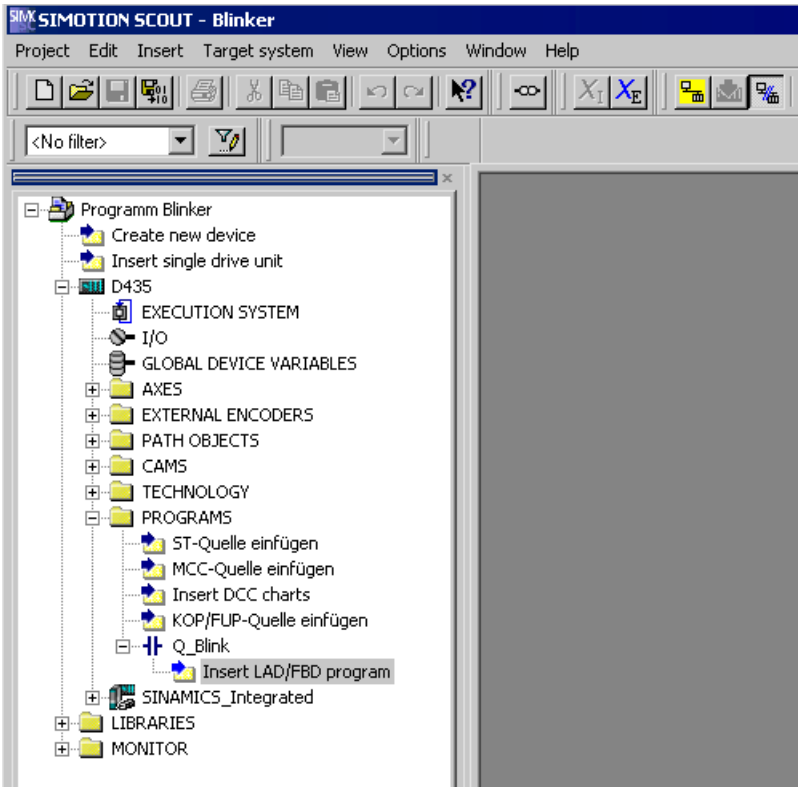


Figure 8-4 Opening a project folder

The **Insert LAD/FBD program** dialog box appears.

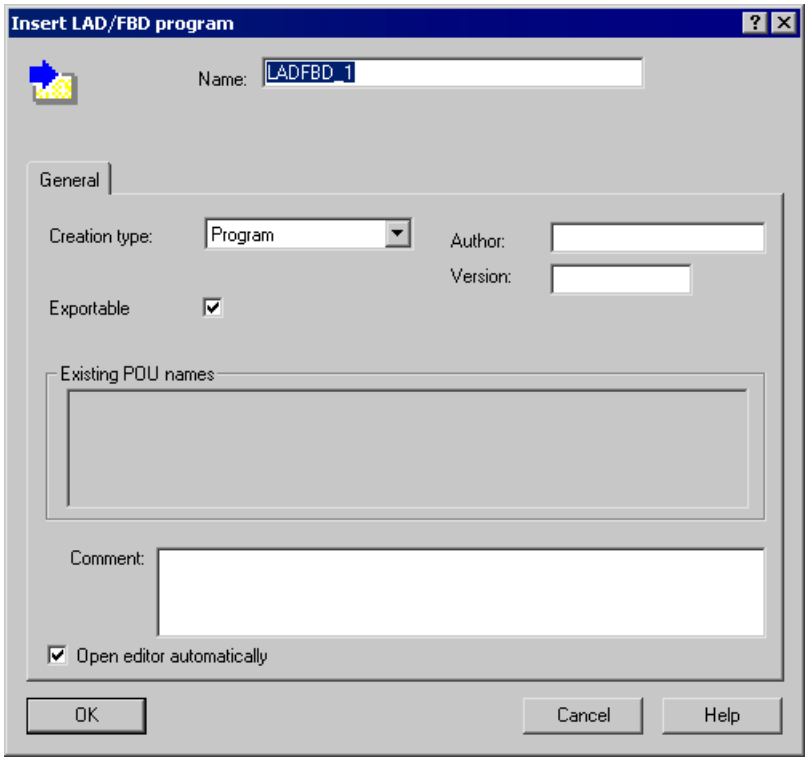


Figure 8-5 Insert LAD/FBD program dialog box

Enter the name of the program in the **Insert LAD/FBD program** dialog box.

The names must be unique within a source file. Protected or reserved identifiers (Page 329) are not allowed.

The following appear:

- all POUs from its own program source
- the exportable POUs (e.g. LAD/FBD programs, MCC charts) from other program sources

3. For **Creation type**, select program.
4. Where necessary, activate **Exportable** if you want the LAD/FBD program to be accessible from other program sources (LAD/FBD, MCC or ST source files) or from the execution system.
5. Select the **Open editor automatically** checkbox.
6. Confirm with **OK**.

   A blank LAD/FBD program is opened.

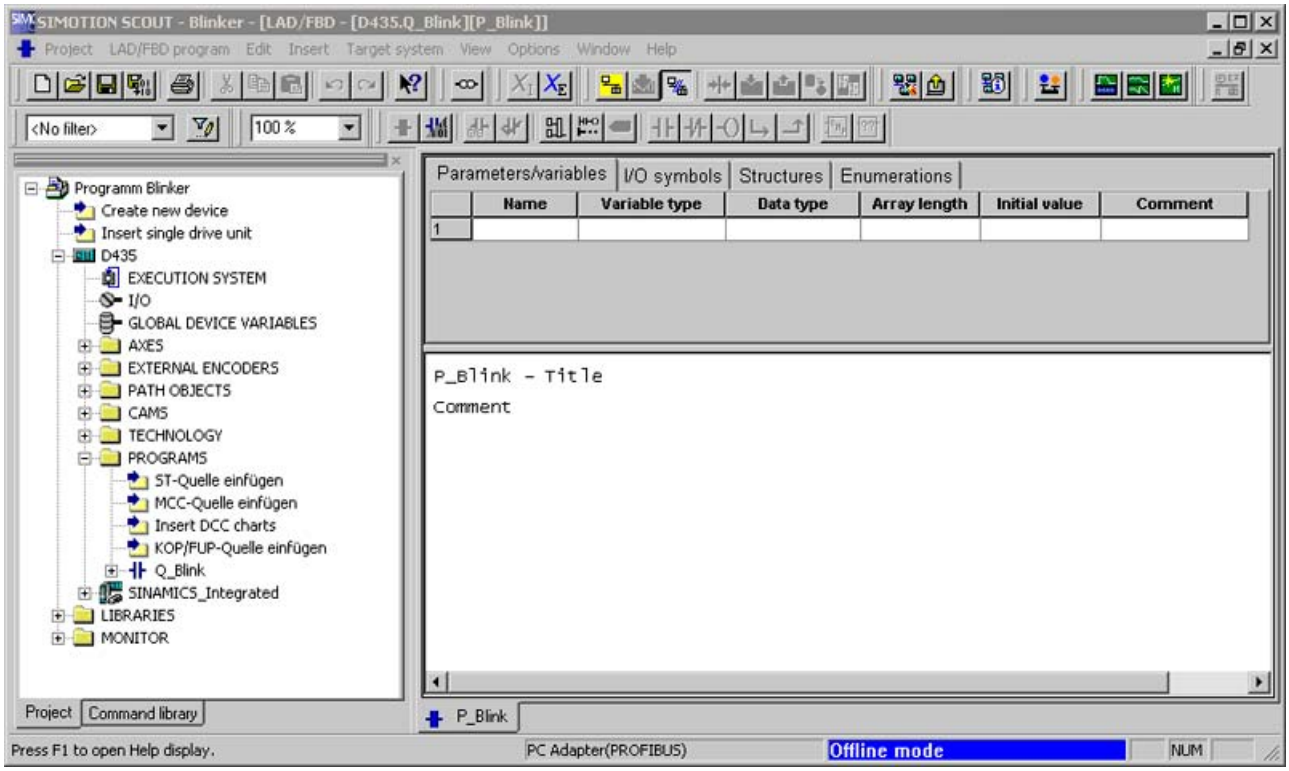


Figure 8-6 Open LAD/FBD program

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.

Parameters/variables | I/O symbols | Structures | Enumerations

	Name	Absolute identifier	Data type	Comment
1	io_var	%QB4	BYTE	
2				

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.

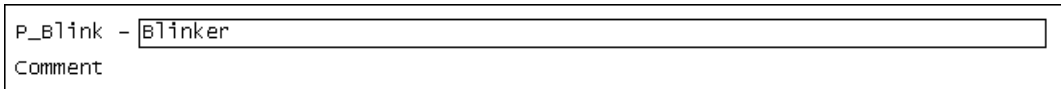


Figure 8-9 Program title

8.3.5 Inserting network

To insert a network:

1. Select **LAD/FBD program > Insert network** menu item.

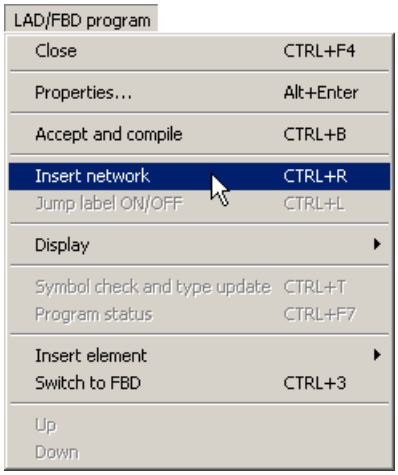


Figure 8-10 Menu selection

2. Click in the title line.
3. Enter the network name in the window.

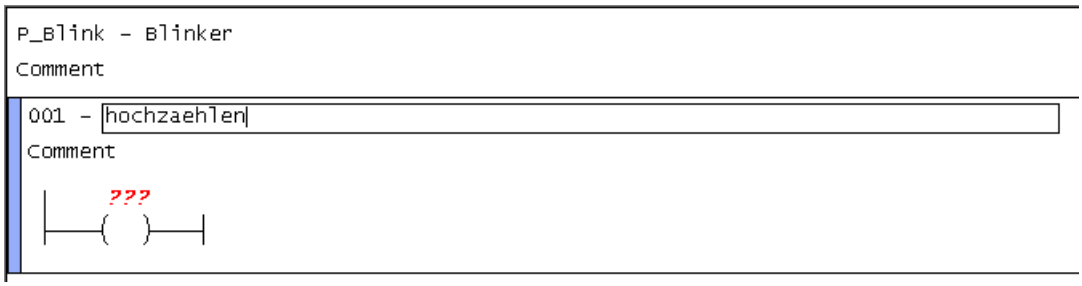


Figure 8-11 Network with entered name

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.

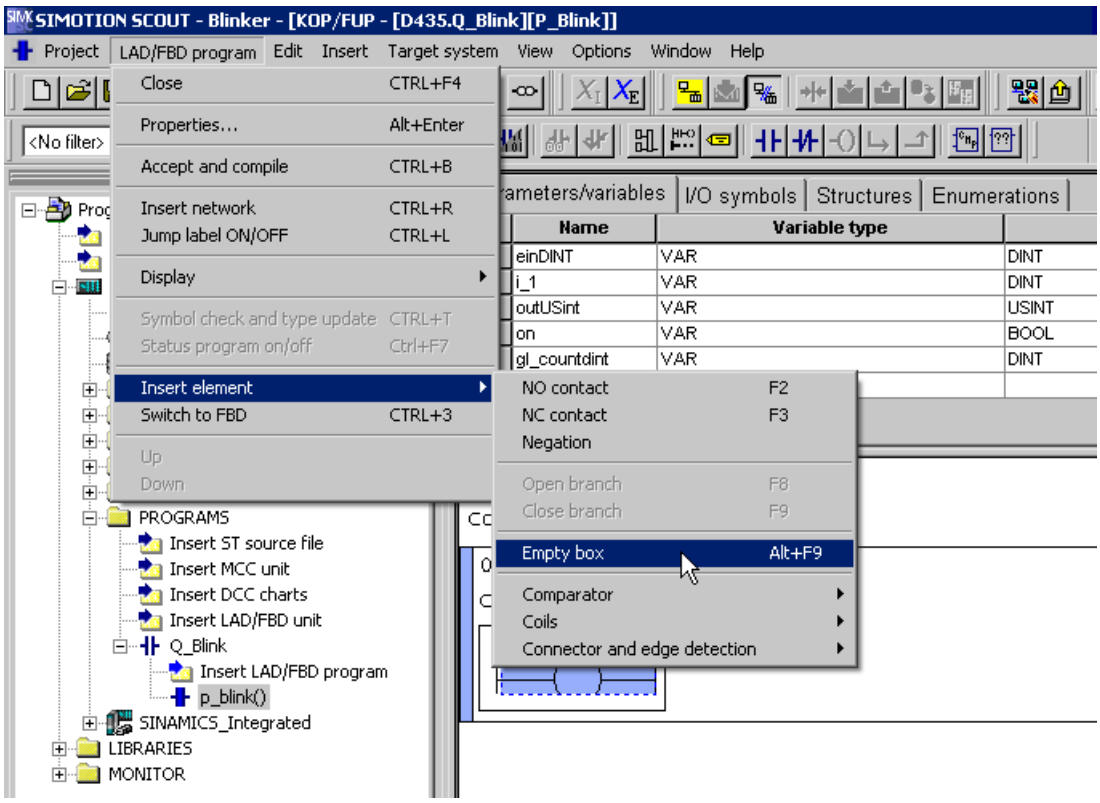


Figure 8-12 Insert an empty box

An empty box is inserted.

Mandatory parameters in a network are identified by **???**, optional parameters by **...** .

8.3.7 Selecting box type

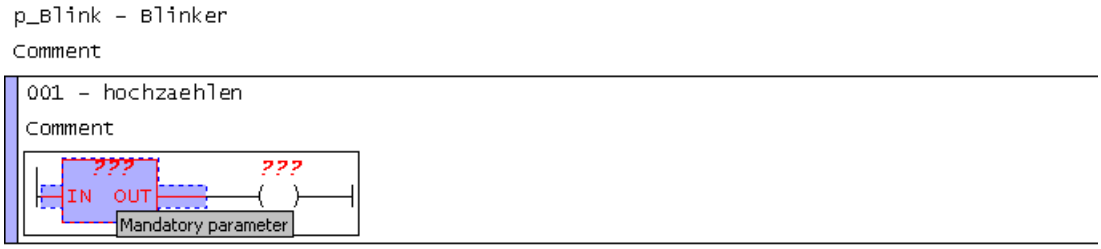


Figure 8-13 Empty box

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 appropriate box type from the drop-down menu and confirm your selection by pressing the **Enter key**.

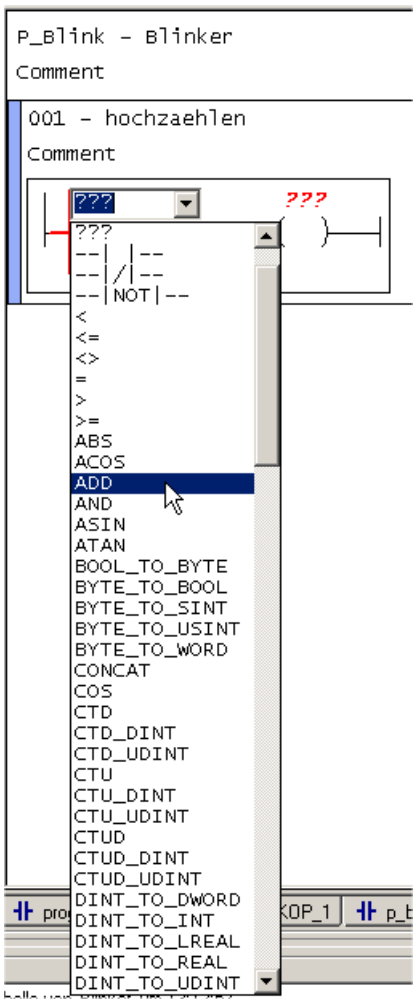


Figure 8-14 Selection of box type

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 **???**.

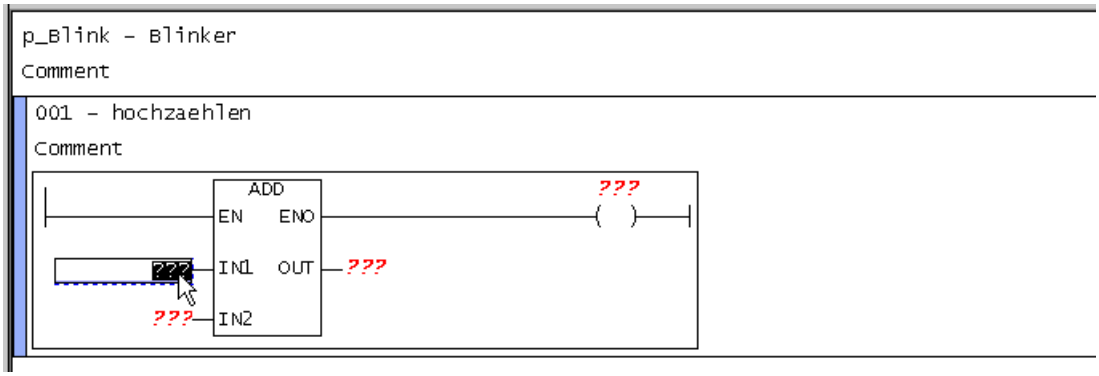


Figure 8-15 ADD box

2. Enter the appropriate values.

8.3.9 Inserting comparator

To insert a comparator, proceed as follows:

1. Select the ADD box.

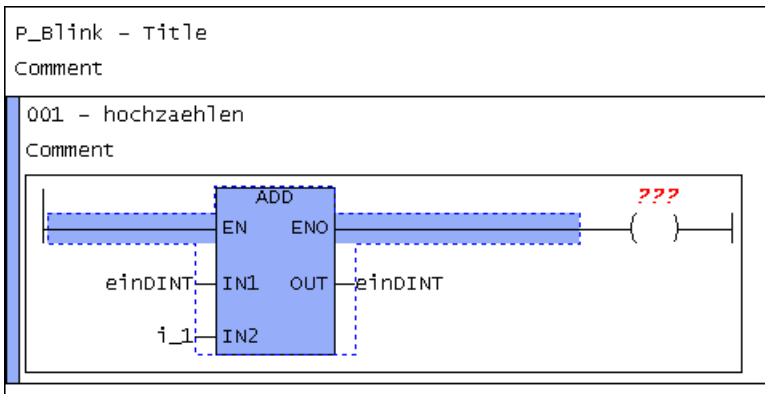


Figure 8-16 Selected ADD box

2. Select **LAD/FBD program > Insert element >Comparator > > =**.

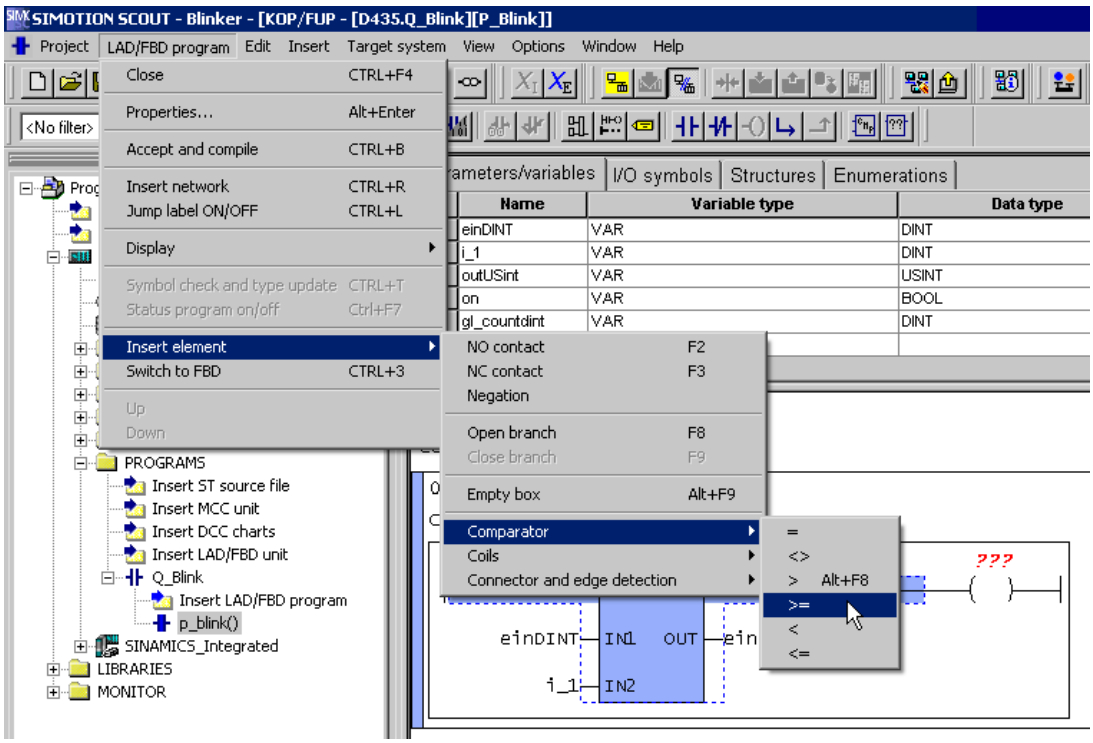


Figure 8-17 Select comparator

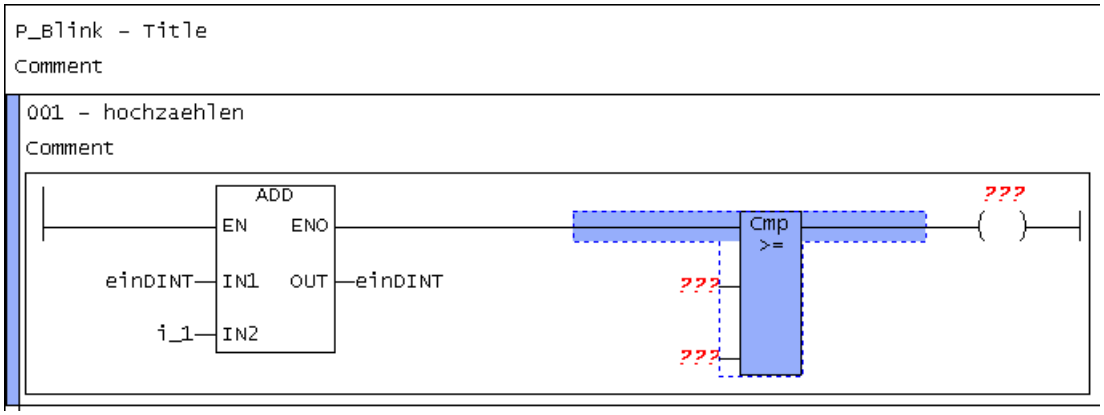


Figure 8-18 Inserted comparator

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.

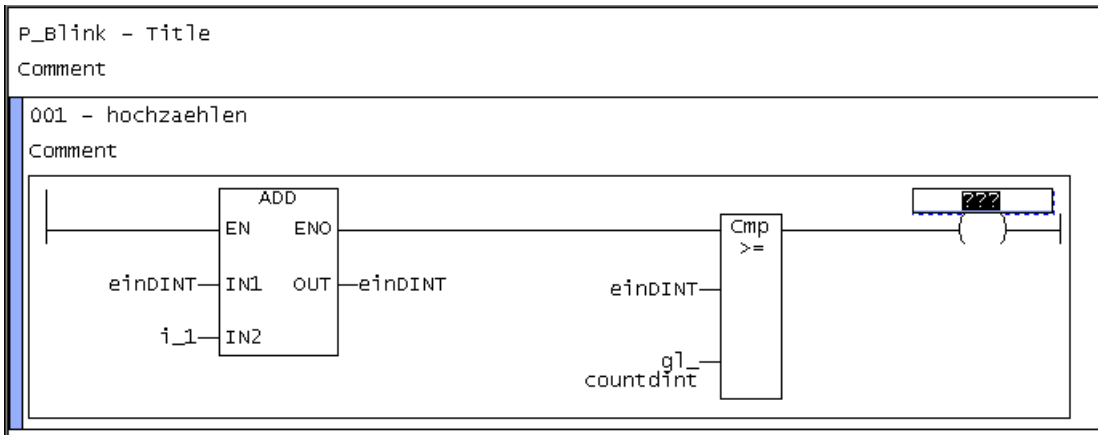


Figure 8-19 Labeled comparator

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.

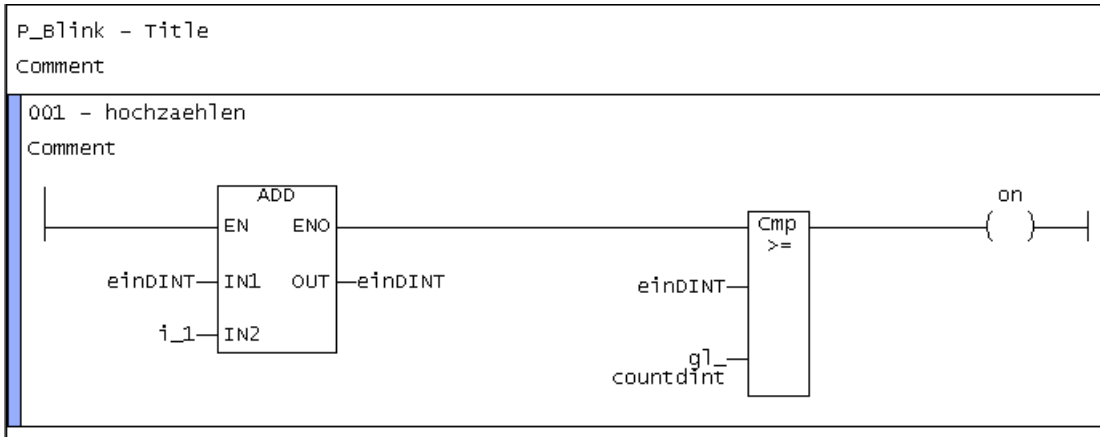


Figure 8-20 Initialized coil

8.3.12 Inserting next network

To insert another network, proceed as follows:

1. To insert the second network, repeat the steps used to insert the first network.

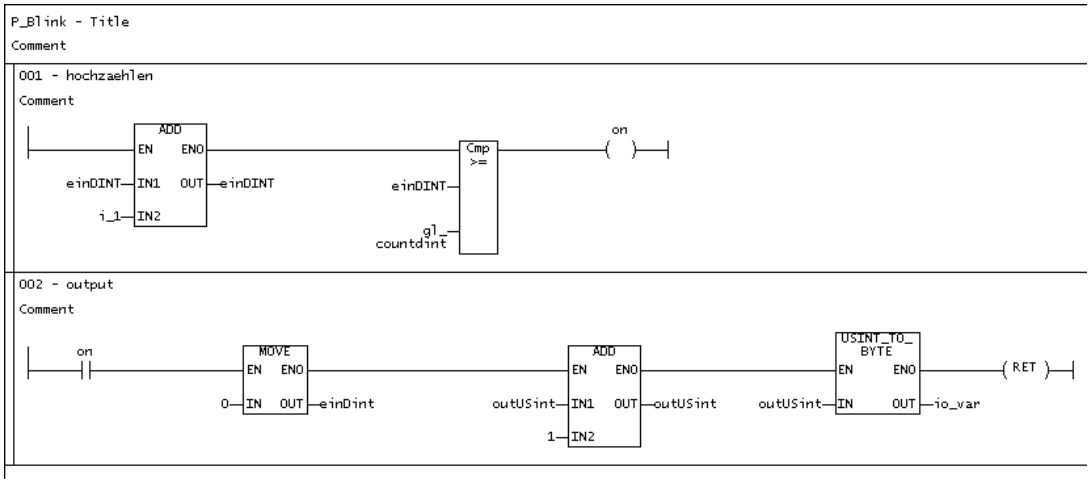


Figure 8-21 Project with two networks

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.

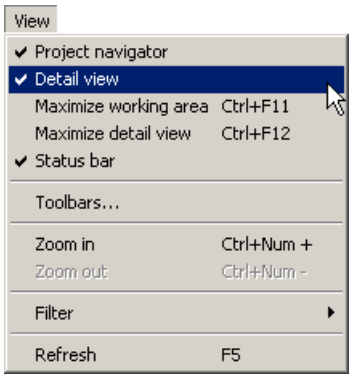


Figure 8-22 Detail view menu selection

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.

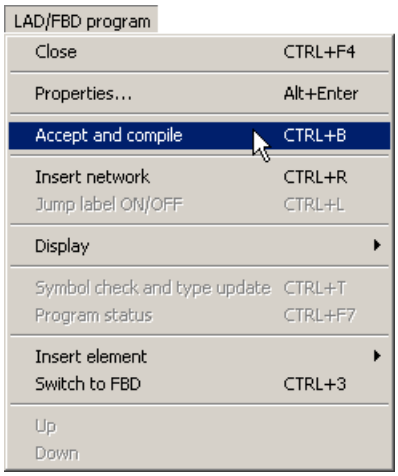


Figure 8-23 Save and compile menu selection

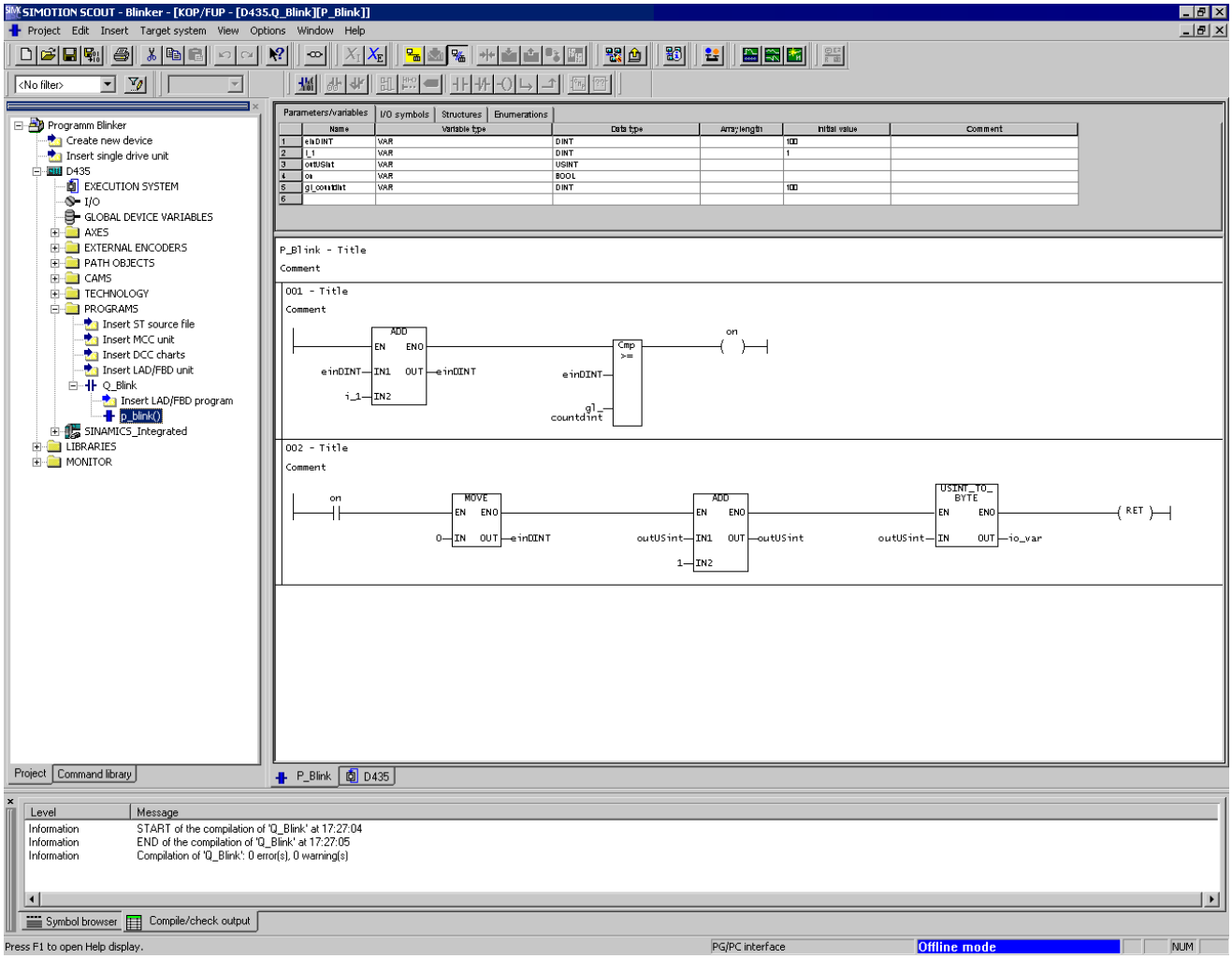


Figure 8-24 Compiled project with compiler information in the detail view

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 **>>**.

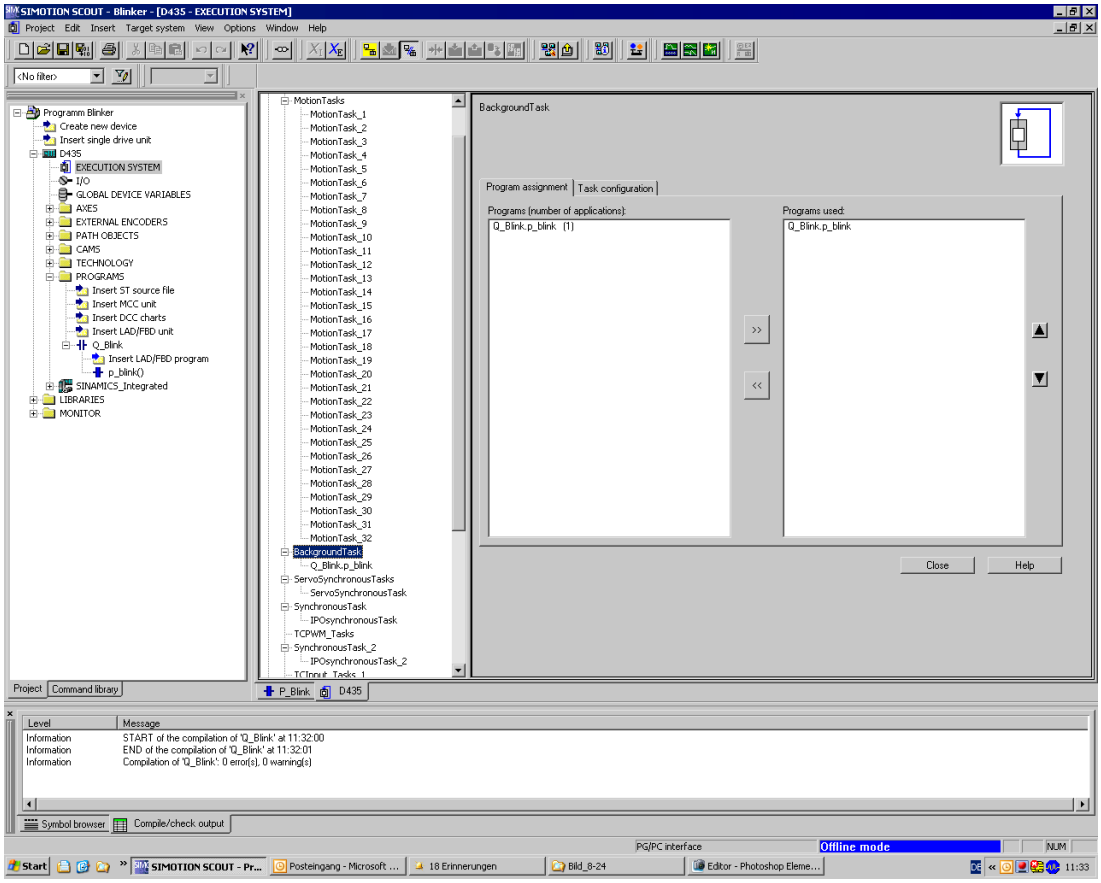


Figure 8-25 Assigning a program to the BackgroundTask

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. Select **Project > Save and compile all**

   The project is locally saved on the hard disk and compiled.

2. Select the **Project > Connect to target system** menu command or click  .

   The Online mode is activated.

3. Select the **Target system > Connect 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.

4. Mark both networks and click the **Program status** button (shortcut CTRL+F7) in the LAD editor toolbar (Page 25) to confirm.

   Monitoring the program execution (Page 269) is switched on.

5. 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.

6. 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 269).

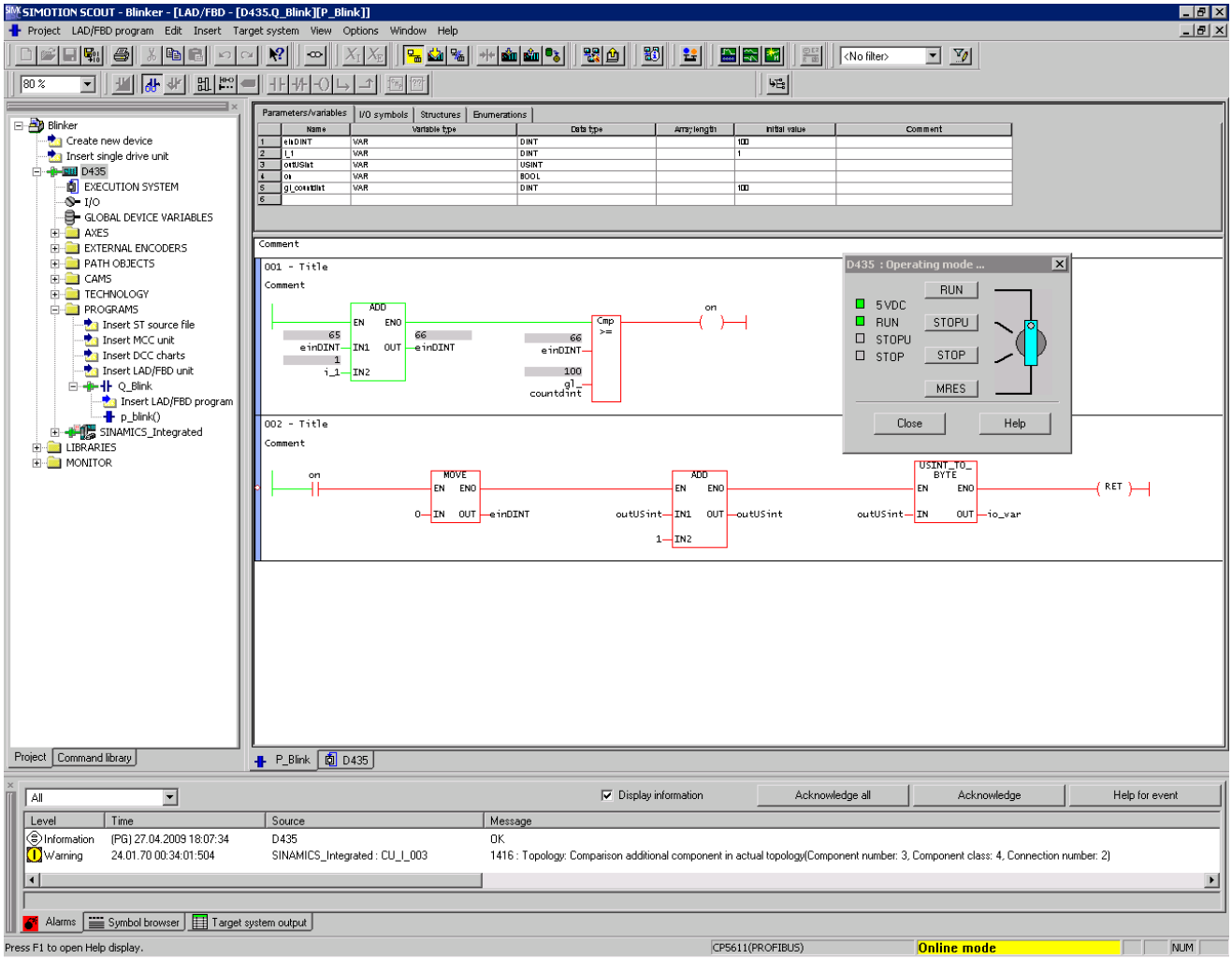


Figure 8-26 Sample program is started

8.4 Position axis program

Prerequisites

A project, a CPU and a virtual position axis must be created.

Task specification

An axis is to be traversed at a velocity of 100 mm/s from the current position 1000 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 = 1000, speed = 100 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 288) 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: They consist of letters (A to Z, a to z), numbers (0 to 9), or single underscores (_) in any order, whereby the first character must be a letter or an underscore. No distinction is made between uppercase and lowercase letters.

   The permissible length of the name depends on the SIMOTION Kernel version:

   – SIMOTION Kernel Version V4.1 and higher: maximum 128 characters.

   – SIMOTION Kernel Version V4.0 and lower: maximum 8 characters.

   Names must be unique within the SIMOTION device. Protected or reserved identifiers (Page 329) are not allowed.

   Existing program sources (e.g. ST source files, MCC units) are displayed.
4. In the **Compiler** tab, activate checkbox **Permit program status**, to use the online status display later.
5. You can also enter an author, version, and a comment.
6. Select the **Open editor automatically** checkbox.
7. Confirm with **OK**.

   The declaration tables for global and unit-local variables appear in the working area.

See also

Blinker program (Page 288)

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 inserted.
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** window.
   The names must be unique within the SIMOTION device. Protected or reserved identifiers (Page 329) are not allowed.

   The following appear:

   – all POUs from its own program source

   – the exportable POUs (e.g. LAD/FBD program, MCC charts) from other program sources
4. For **Creation type**, select program.
5. Select 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 insert a new network.

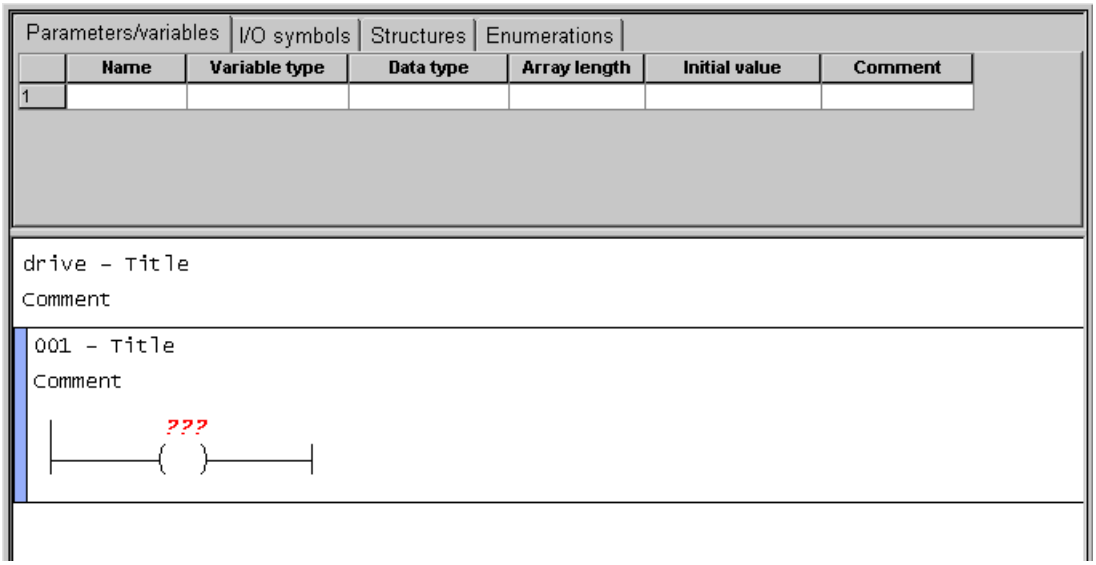


Figure 8-27 Inserted network

Note

Mandatory parameters in a network are identified by **???**, optional parameters by **...** .

8. Mark the inserted box and select **Delete** in the context menu.

   The box is removed from the network.

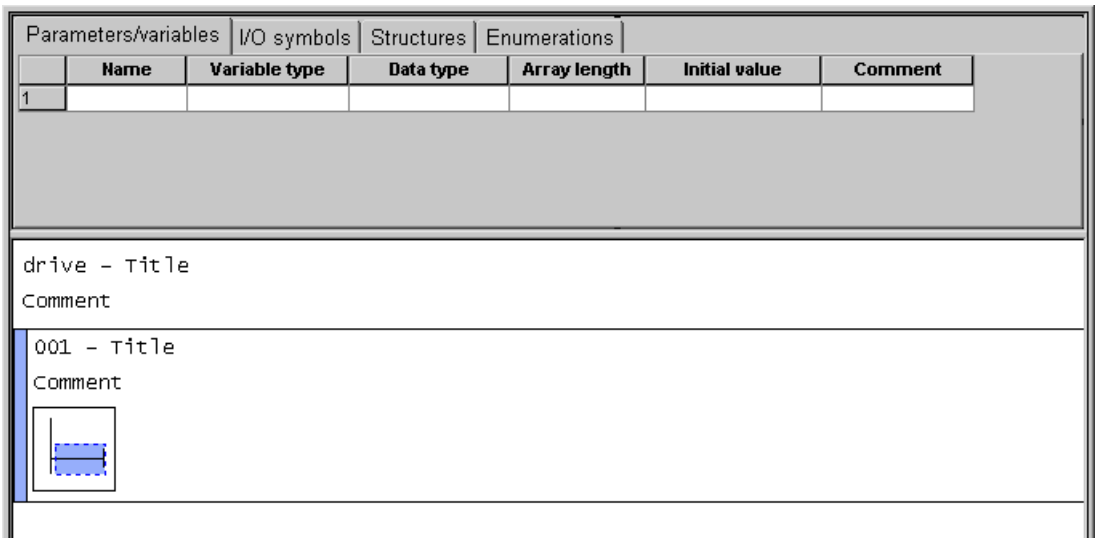


Figure 8-28 Inserted network without a box

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&drop the **_mc_power** command into the network (see Network with RET assignment).

   This command serves to enable the command.

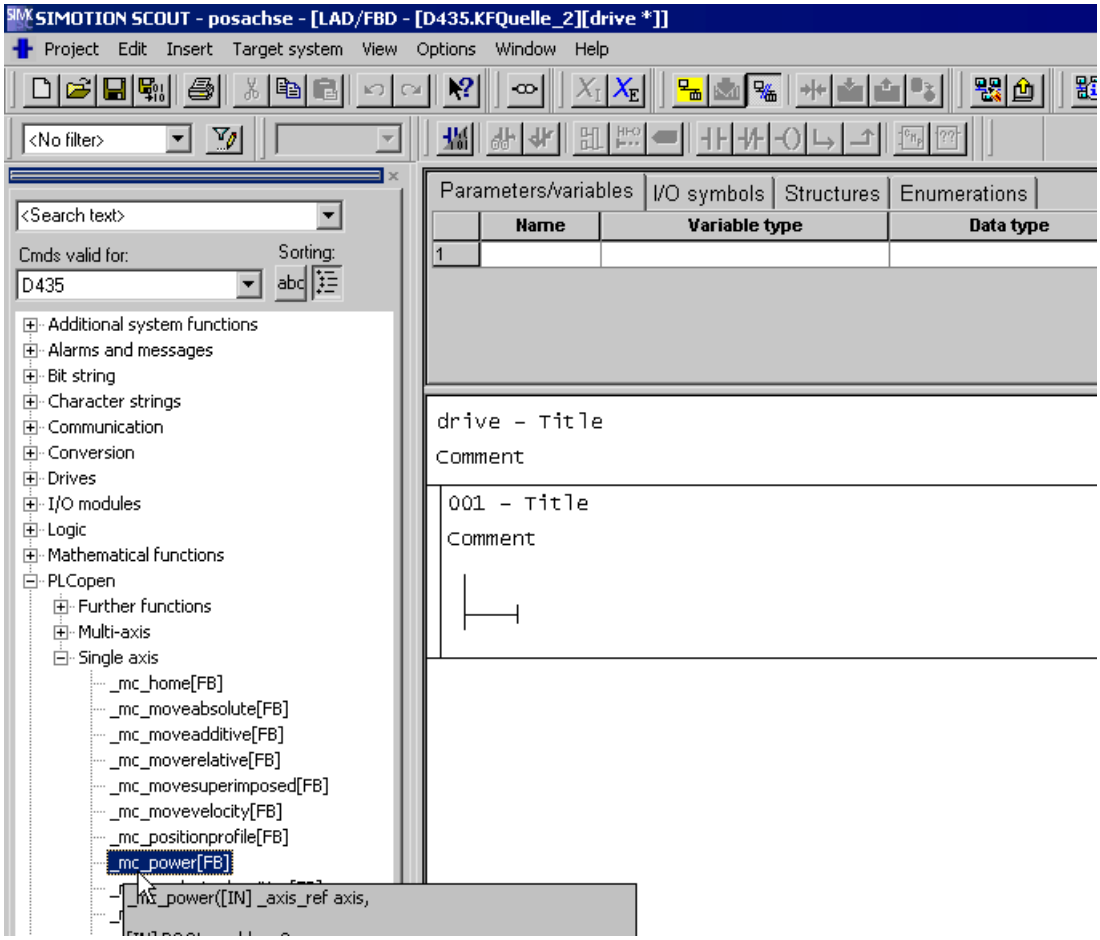


Figure 8-29 TO-specific command (_mc_power) from the command library

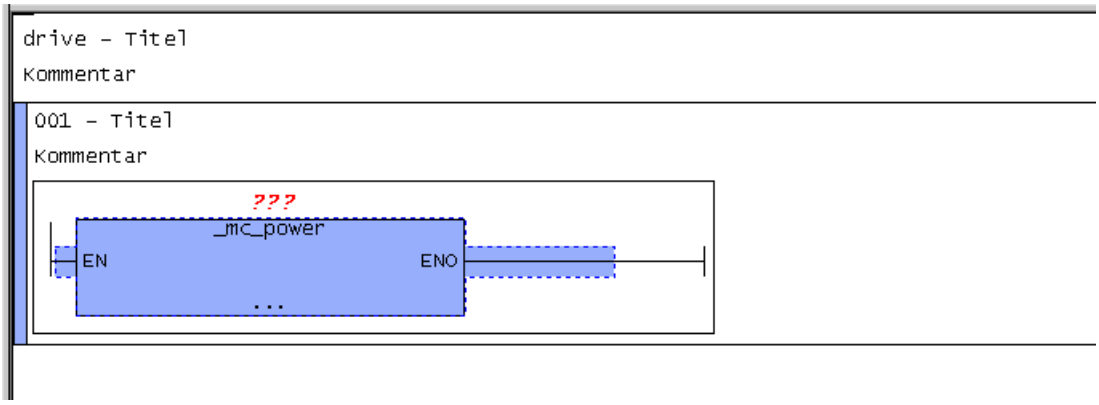


Figure 8-30 Network with inserted _mc_power box

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&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.

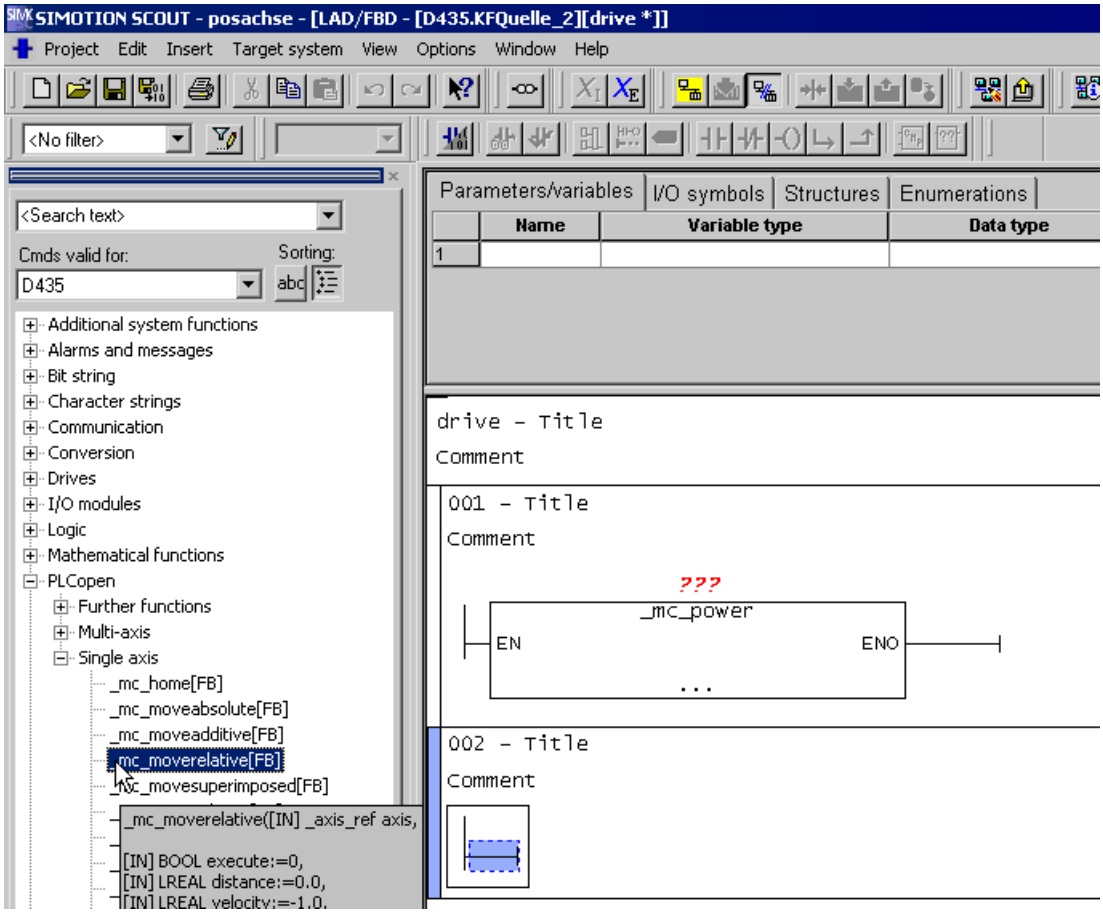


Figure 8-31 TO-specific command (_mc_moverelative) from the command library

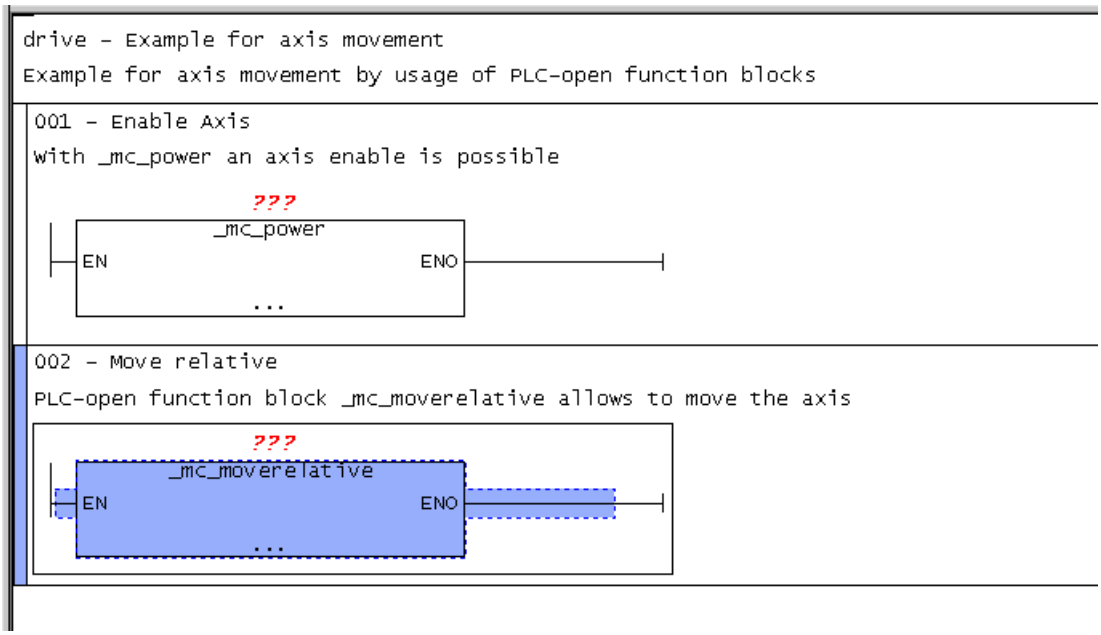


Figure 8-32 Network with inserted _mc_moverelative box

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 the working area and select **Display > Alle 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&drop the **NO contact** LAD element to the **enable** input of the **_mc_power** function block.

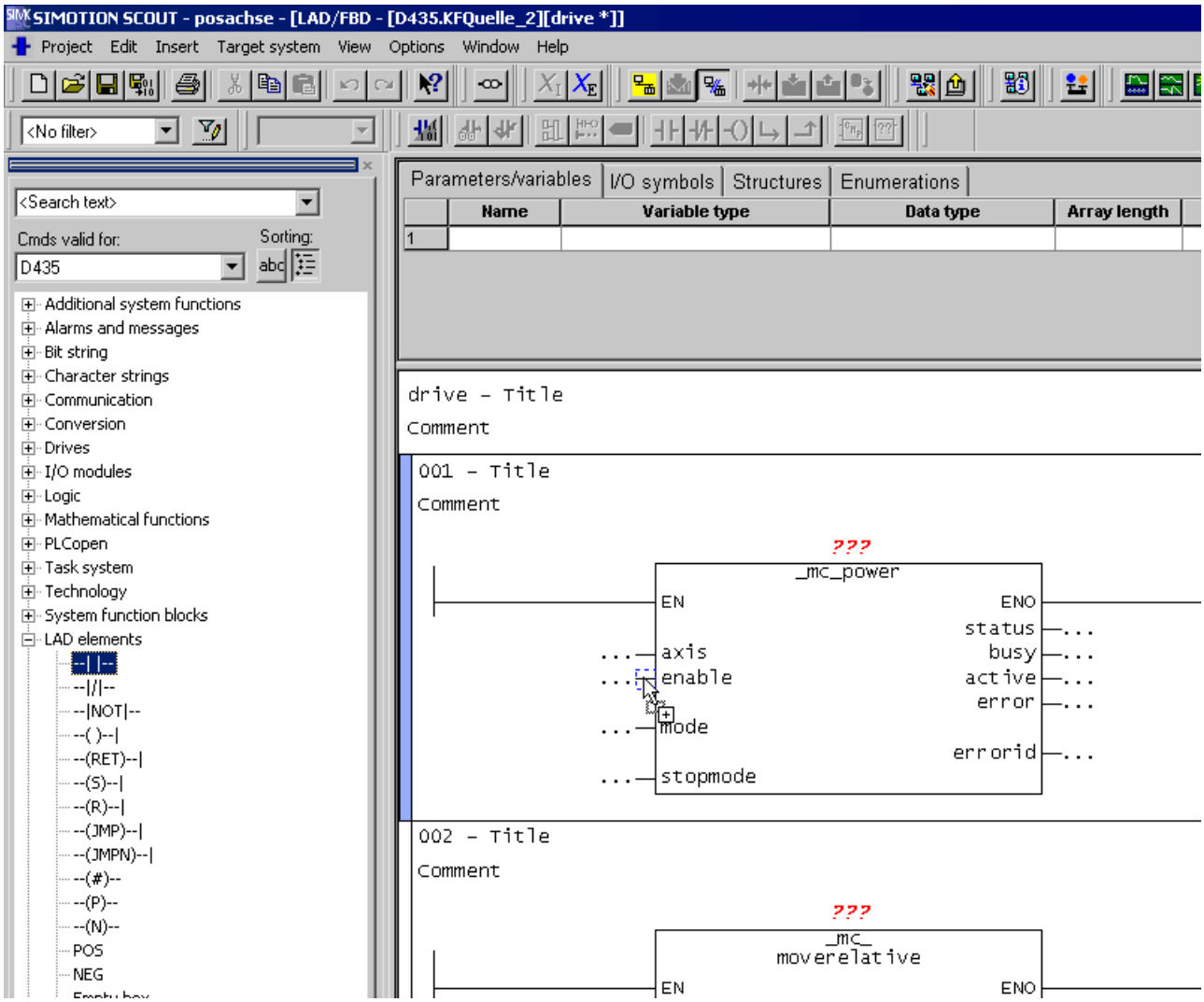


Figure 8-33 Drag&drop the NO contact LAD element to the connector of the enable input

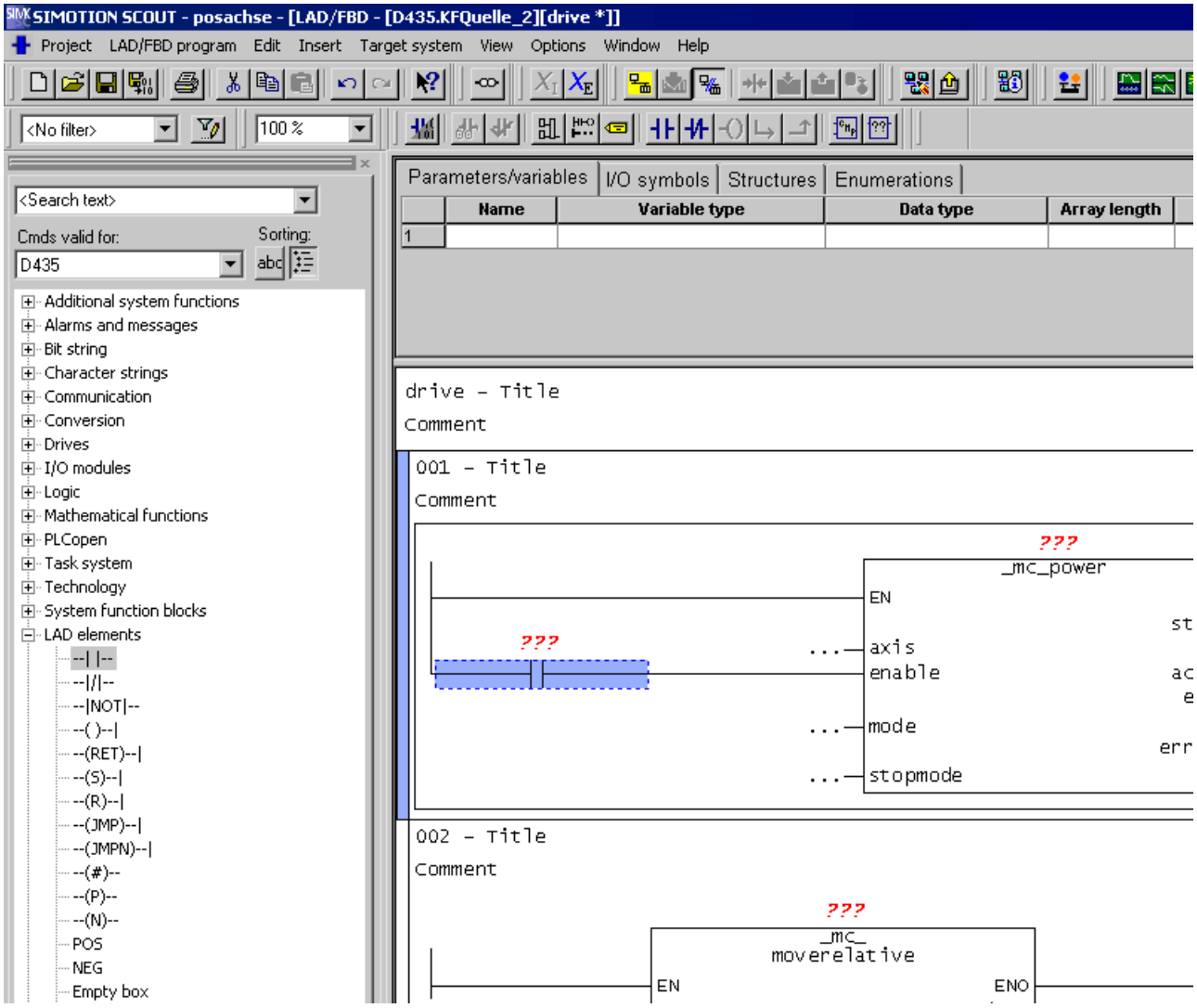


Figure 8-34 Network with a NO contact LAD element inserted

5. Drag&drop two **NO contact** LAD elements to the **execute** enable input of the **_mc_moverelative** function block.

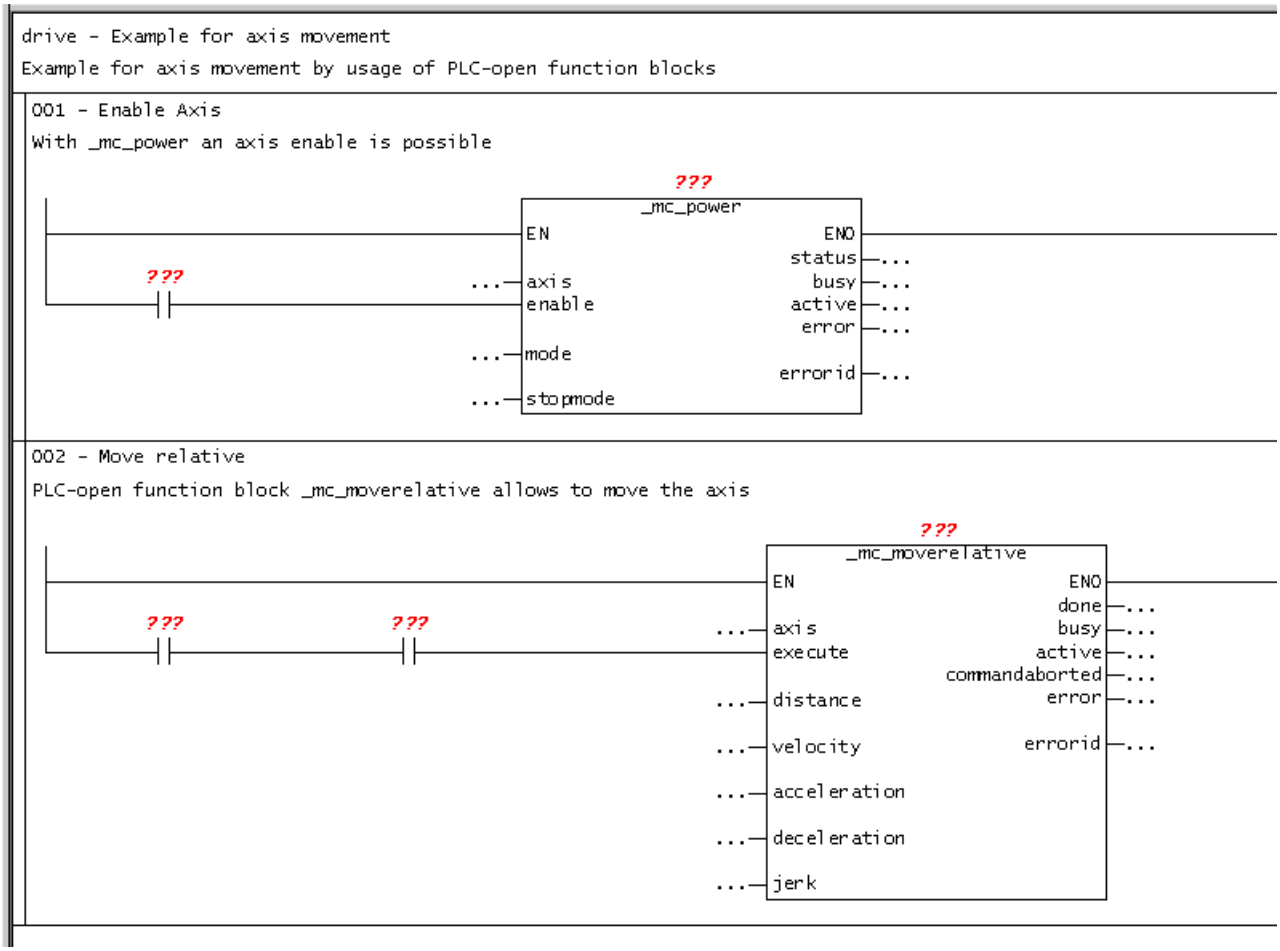


Figure 8-35 Networks with NO contacts inserted

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 block instance for each being used (**_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 150).

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 8-36 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**.

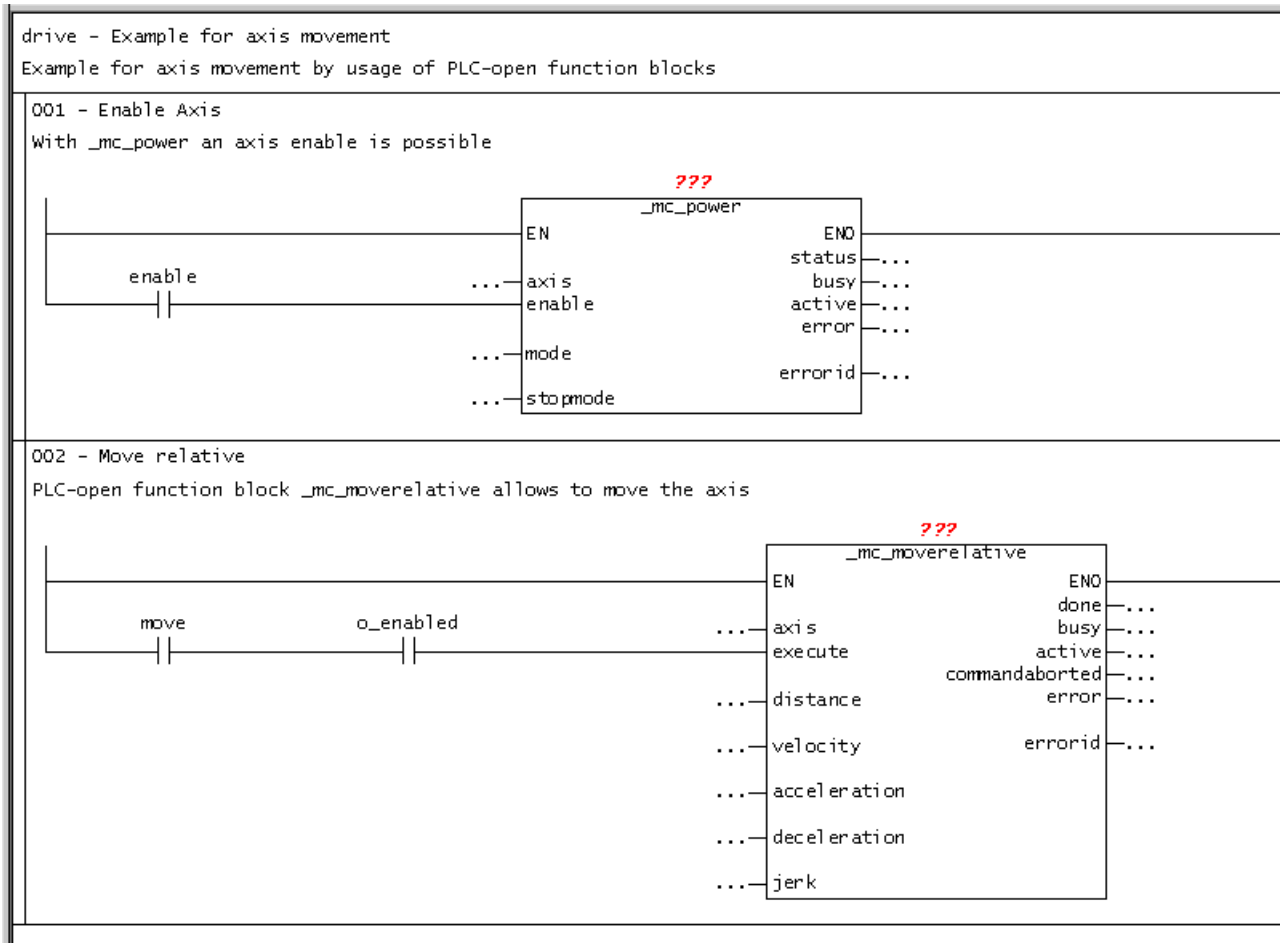


Figure 8-37 Parameterization of the NO contacts

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**.

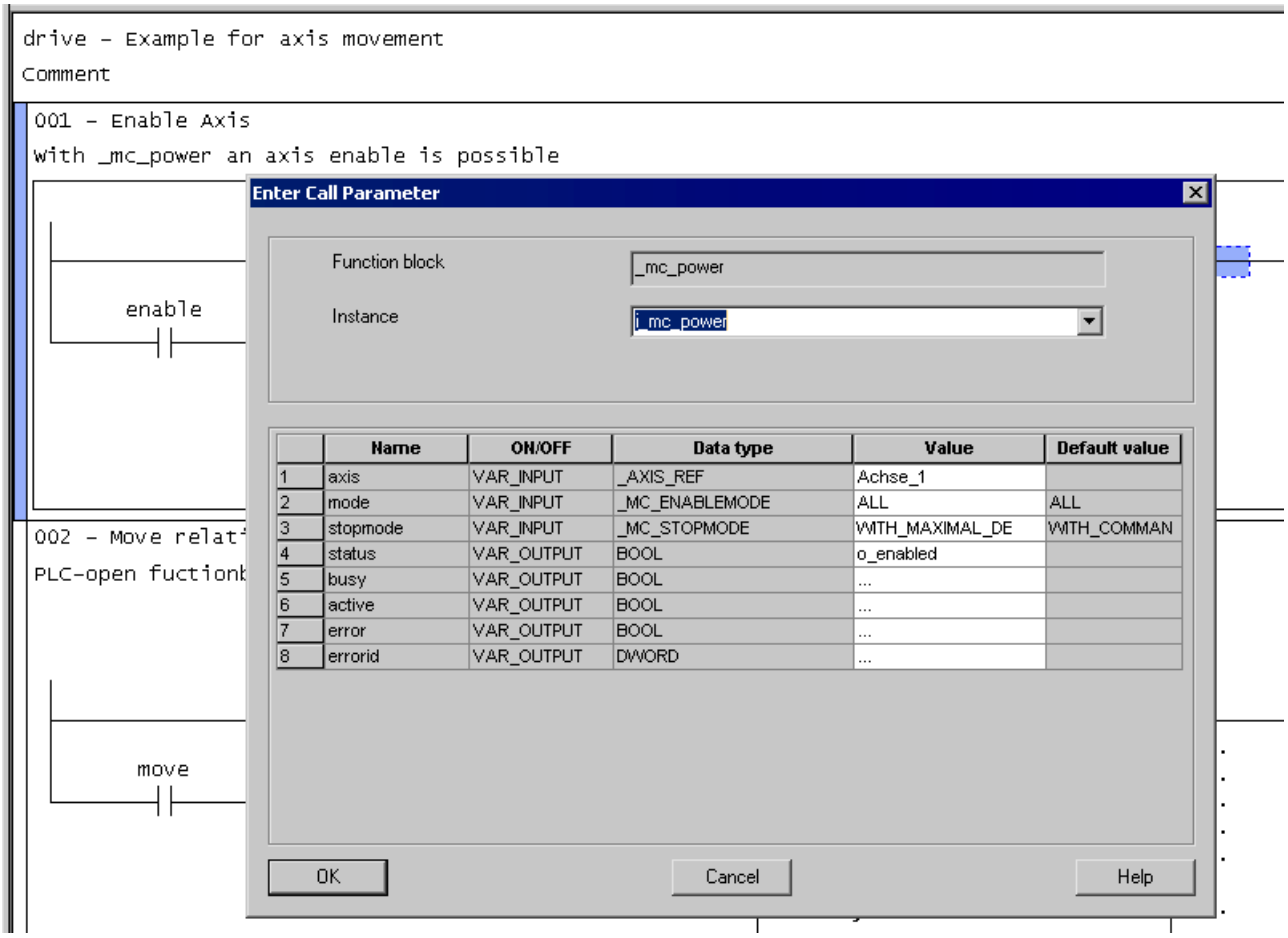


Figure 8-38 Set call parameters for the PLCopen block _mc_power

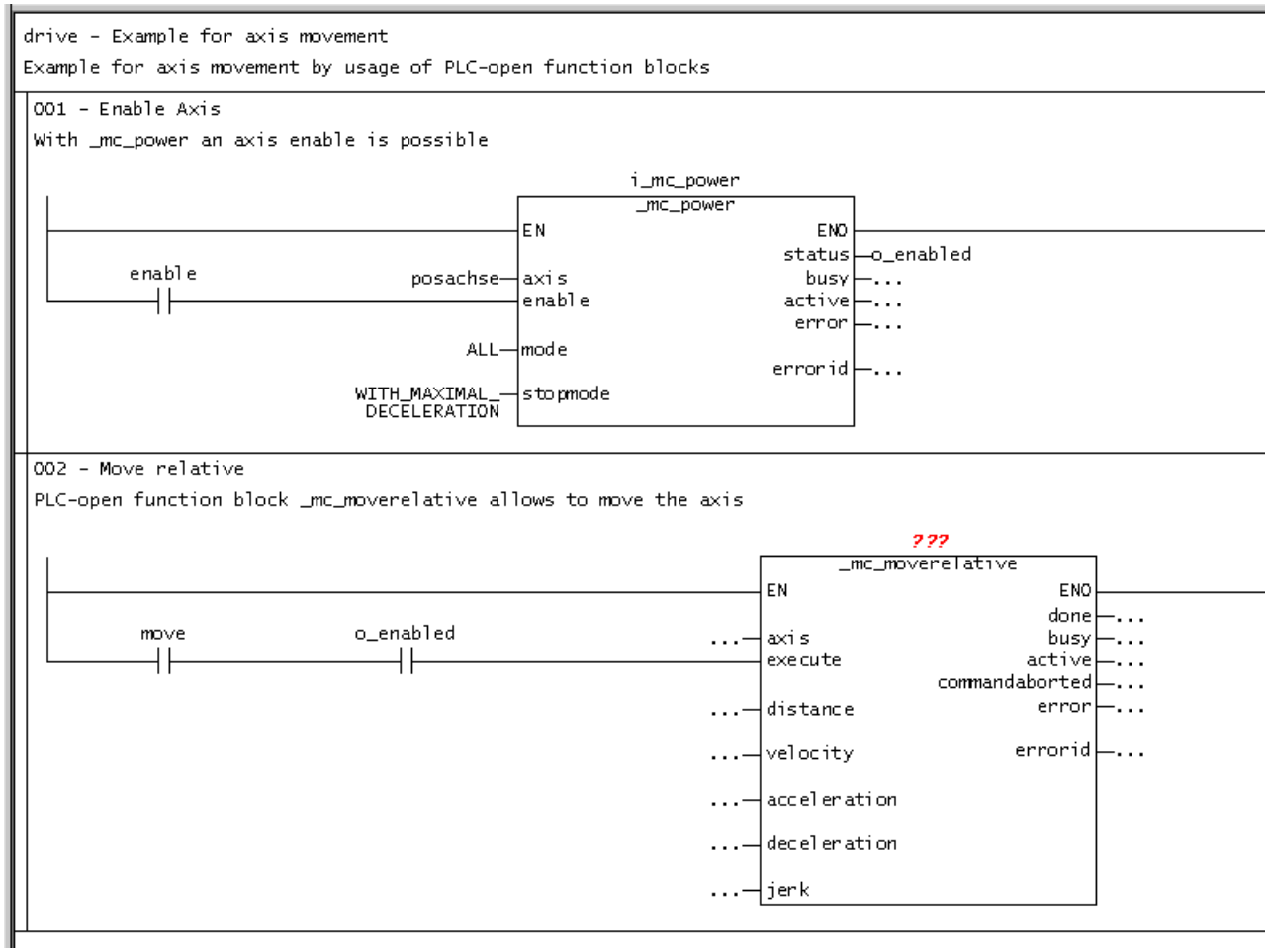


Figure 8-39 Labeled _mc_power box

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**.

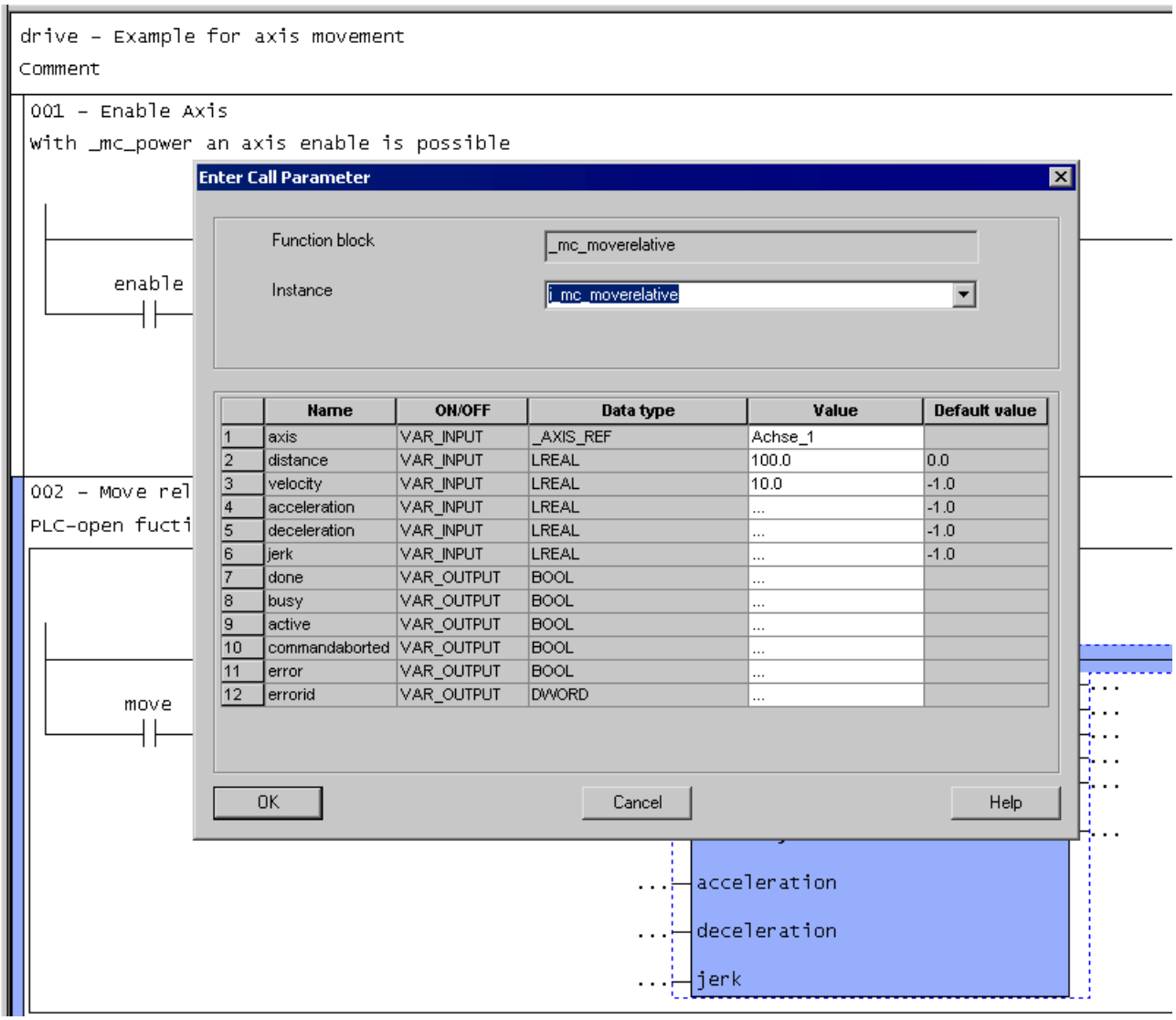


Figure 8-40 Set call parameters for the PLCopen block _mc_moverelative

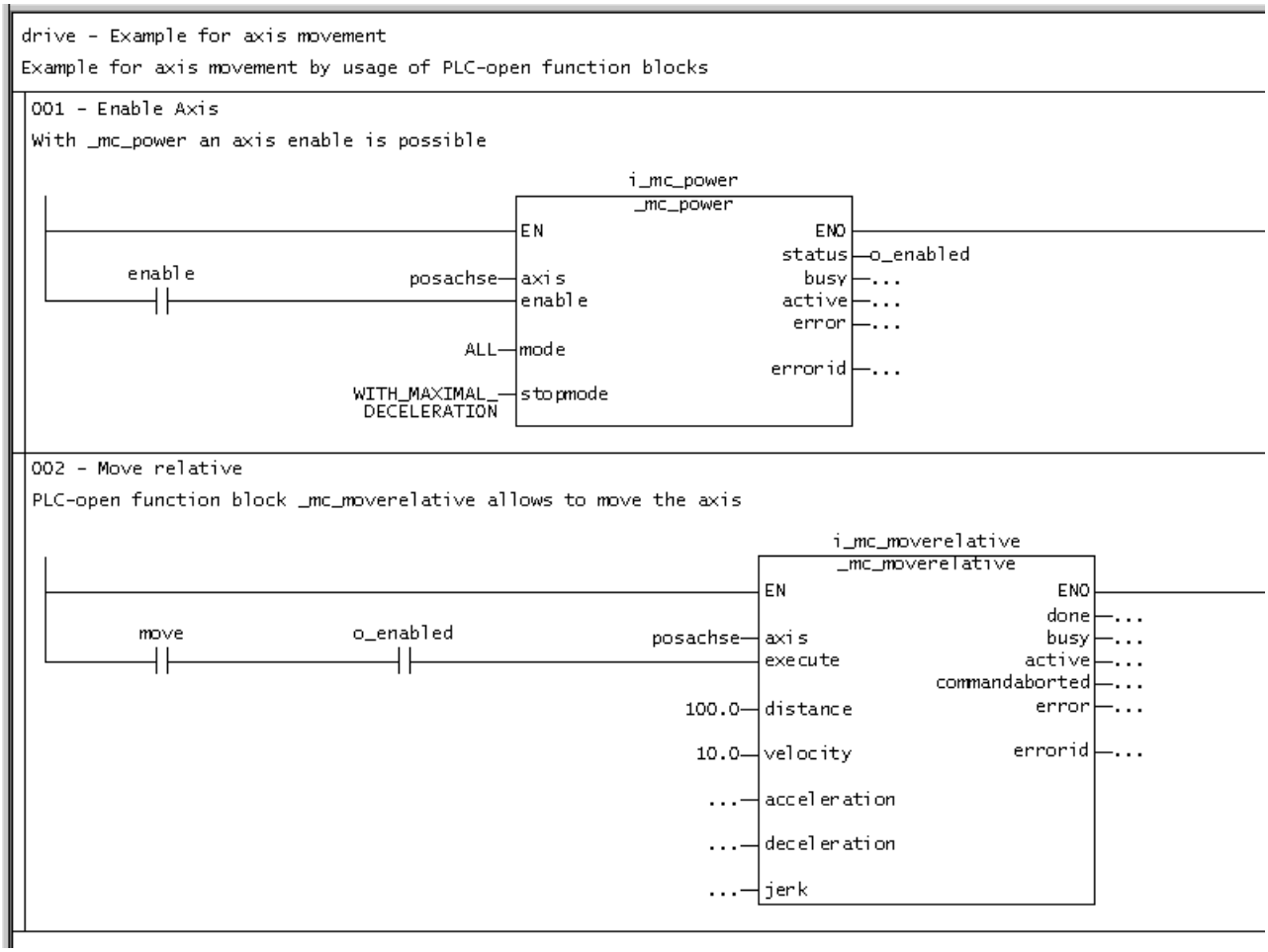


Figure 8-41 Network with entered variables

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 305) 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 305)

8.4.12 Starting sample program

To start a program, proceed as follows:

1. Select **Project > Save and compile all**

   The project is locally saved on the hard disk and compiled.

2. Select the **Project > Connect to target system** menu command or click  .

   The Online mode is activated.

3. Select the **Target system > Connect 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.

4. Mark both networks and click the  button for **program status** (shortcut CTRL+F7) in the LAD editor toolbar (Page 25) to confirm.

   Monitoring the program execution (Page 269) is switched on.

5. 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.

6. 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 269).

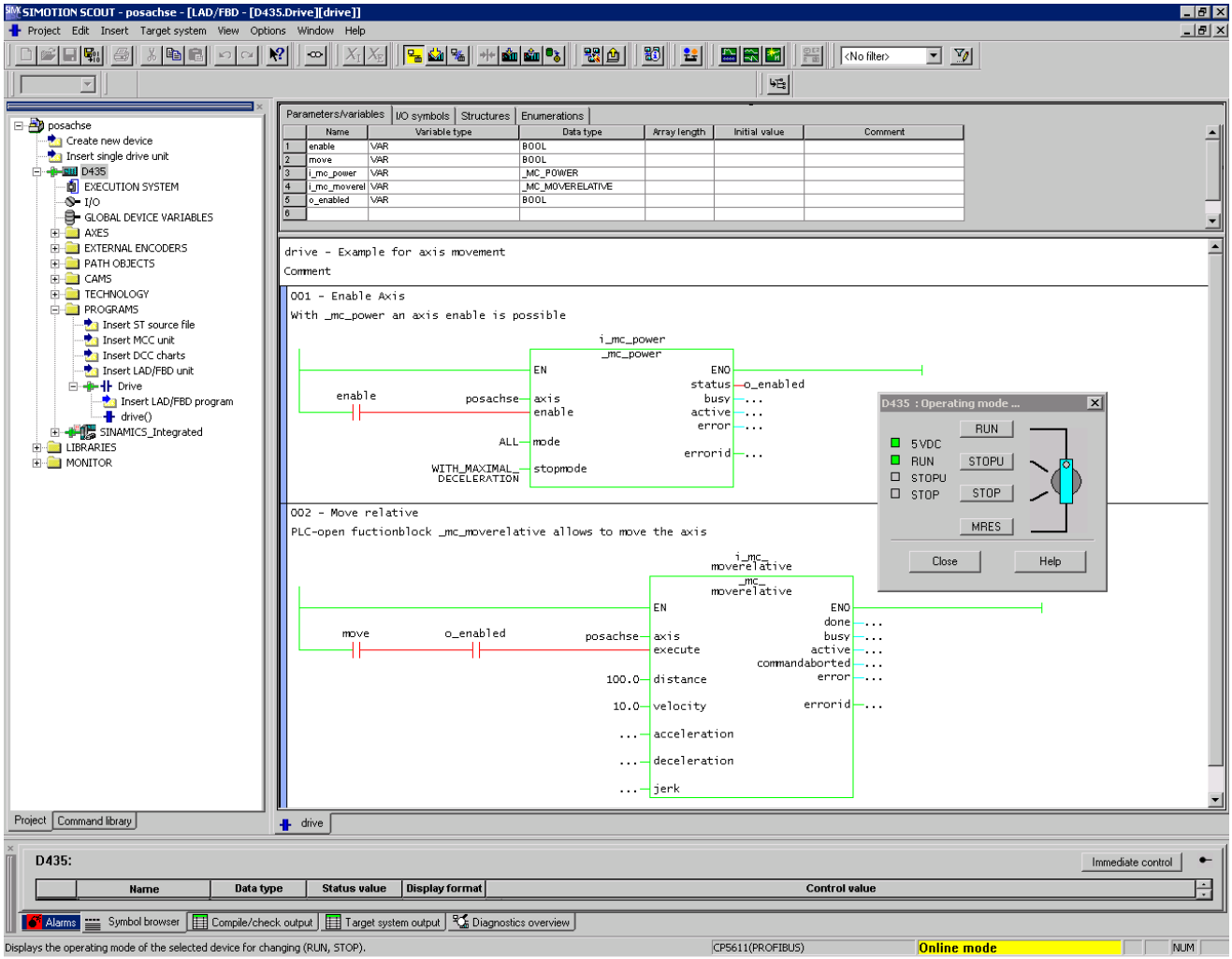


Figure 8-42 Sample program is started

Appendix

A

A.1 Key combinations

The following key combinations are available:

With LAD/FBD editor open	
Cursor keys	With a selected operator: Navigation between the individual operators
Ctrl+CursorUp	Select previous network
Ctrl+CursorDn	Select next network
Page up	Select the network at the start of the visible editor area
Page down	Select 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 edit field of the current operand or confirms the entry made in the edit field
Esc	Aborts the entry while edit field is open

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.
Alt+F4	Closes all windows and ends the application.

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

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
Alt+Enter	Displays the properties of the active/selected object for editing.
Enter	Opens the selected object.
Ctrl+B	Saves and compiles the active/selected object.
Ctrl+A	Selects all objects in the current window
Alt+F8	Insert comparator
Alt+F9	Insert an empty box
Ctrl+R	Inserts a new network
Ctrl+L	Jump label ON/OFF
Ctrl+Shift+K	Show/hide comment line
Ctrl+Z	Undo
Ctrl+Y	Repeat
Ctrl+1	Switches to LAD
Ctrl+3	Switches to FBD
Ctrl+T	Symbol check and type update
Ctrl+Shift+B	Display options for boxes
Shift+F6	Switches between declaration table and editor area

LAD elements	
F2	Insert NO contact
F3	Insert NC contact
F7	Insert coil
F8	Open branch
F9	Close branch

FBD elements	
F2	Insert AND box
F3	Insert OR box
F4	Insert XOR box
F7	Assignment
F8	Insert binary input
F9	Negate binary input

Symbol input help	
Ctrl+H	Opens the symbol input help dialog window

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	

Index

D

E

F

G

I

P

R

S

T

U

V

W