SafePLC²

Programming Manual

English

Read and follow the programming manual before initial startup/ integration of the module.

Follow all safety instructions!

Keep this manual for future use!

Programming manual for BBH Product devices

Status: 06/2024

NOTICE

The German version is the original version of the programming manual.

- Contact the manufacturer immediately if the manual is missing!
- Always keep the manual at hand
- Make sure that the manual is complete!
- Obtain this manual only through the original publisher!

Subject to modification.

The content of this documentation has been compiled extremely carefully according to our current level of information.
Nevertheless, we indicate that this document cannot always be updated simultaneously with the technical progress.

Information and specifications can be changed at any time. For the current version, please consult www.bbh-products.de.

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INFORMATION	Before programming the unit, the unit must be completely installed and put into operation. For this purpose, all connected components must be installed and put into operation, and the connections must be connected. For installing, putting into operation and connecting, please read and observe the SCU installation manual.

INFORMATION	The documentation (installation manual, programming manual) are disposable via the download of BBH Products GmbH.

Table of contents

1 General information

SafePLC2

The program SafePLC² is a graphically oriented editor for the creation of a PLC-based monitoring program for an SMX-system.

This program editor allows the graphical preparation of sequencing programs using the functional block method, as well as the parameterization of sensor, actuators and other technological functions used.

About This Getting Started Manual

In this manual, you will get to know the basics of SafePLC². This manual will show you the most important screen dialog boxes and the procedures to follow using practical exercises, which are structured so that you can start with almost any chapter. Previous experience of working with the mouse, window handling, pull-down menus, etc. would be useful, and you should preferably be familiar with the basic principles of programmable logic control.

1.1 Terms

PLC

Programmable **L**ogic **C**ontroller, equals the German designation for **S**peicher**p**rogrammierbare **S**teuerung (SPS). The term PLC is exclusively used within the SMX system.

SafePLC2

Program editor for the graphical preparation of sequential programs using the function block method, as well as the parameterization of sensors, actuators and other technological functions used.

SMX

Modular fail-safe control system with integrated technological functions. The behaviour of the SMX system is defined by a user configuration and the associated logic operations.

Function block (functional block)

Block in a PLC-control that influences the program sequence of a PLC-program either physically or logically. A physical (hardware) function block is e.g. a push button or an output on the SMX block. However, a function block is also the logic operation (e.g. AND or OR) of input and output signals within the PLC.

Function block diagram (function block language)

Graphically oriented, function block based, descriptive "programming language" acc. to IEC 1131, serving the purpose of visualizing logic operations of inputs and outputs on function blocks of a PLC control. The function block diagram shows the function blocks and their logic operations in a graphical form (engl. Function Block Diagram FBD).

Input / Output

Location on a function block where a logic operation to other function blocks can be set up.

Logic operation

A named connection between:
a.) a function block output and a function block input.
b.) a PLC input and a function block input.
c.) a function block output and the PLC output.

Connector

Connecting point between the beginning and the end of a logic operation with an input and an output of a function block.

Attribute

Non-graphical feature of a function block. An attribute consists of a designator and a value.

Routes

Horizontal and vertical alignment of logic operations in a function block diagram, so that intersections with function blocks are avoided and logic operations with identical connector are merged at an early stage (related to distance to the target function block).

Signal list

Signal lines into and out of the PLC, represented in a table.

Signal cell

Selectable area within the signal list, which can be provided with a comment.

PLC input signal list

Signal lines entering into the PLC, represented in form of a table. In ***SafePLC²*** the PLC inputs can be designated by the user. They have an unambiguous number and must be assigned to the inputs of a function block.

PLC output signal list

Signal lines leaving the PLC, represented in form of a table. In ***SafePLC²*** these outputs can be designated by the user and, just like the inputs, have an unambiguous identification number.

Instruction list (IL)

Assembler-like programming language that can be loaded into a central SMX module. The duty of ***SafePLC²*** is the generation of an instruction list based on defined function blocks, as well as their attributes and linkages.

Compilation

Compilation and verification of the function block diagram created in ***SafePLC²*** and the associated parameters.

Function block group

Classification of function blocks according to their positioning ability in the function block diagram (input, output, logic).

Function block types

More detailed identification of function blocks within a group. (e.g. "Emergency Stop")

Message window

Multi-line output window, embedded in a Windows Toolbar element. This display window is used for the output of errors, warnings and information from the program to the user. The message window can be switched on and off.

Configuration

Configuration is the generic term for a monitoring program and the associated parameter for permissible deviations or minimum and maximum values. In this context it is important to note that a monitoring program always comes with further data, the program can refer to.

1.2 Structure of safety inforamtion

1.2.1 Symbols and signal words

The following symbols and signal words are used in this documentation. The combination of a pictogram and a signal word classifies the respective safety note. The symbol may vary depending on the type of hazard.

	Symbol	Signal word	Description
Death		**DANGER**	This signal word must be used if death or irreversible damage to health can occur if the hazard warning is ignored.
Injury + property damage		**WARNING**	This signal word indicates personal injury and property damage, including serious injury, accident and health risks.
		**CAUTION**	This signal word indicates a risk of material damage. There is also a low risk of injury.
Material damage		**ATTENTION**	This signal word warns of malfunctions and damage to the drive or its surroundings.
No damage		**NOTICE**	This signal word indicates useful information and tips that can make handling and operation easier.
		**SAFETY NOTICE**	Informs you about the handling and effects of safety information.

1.2.2 Safety information

The safety information applies not only to one specific action, but to several actions within a topic. The pictograms used indicate either a general or specific hazard.

Structure of a safety notice:

SIGNALWORD

Description of the hazard source

Type and danger of the source.

Possible consequences in case of disregard.

2 Installation

This chapter describes installation procedure and with the installation procedure connected requisites.

2.1 System requirements

There are the following system requirements in order to install the program:

Minimum System Requirements:
OS: Windows XP, Windows Vista, Windows 7, Windows 8 or higher (32 Bit / 64 Bit)
Processor: Intel® Pentium® 4 or AMD Athlon™ Dual Core, 3.0 GHz or higher
Memory: 2GB
HDD: 500MB free space

Recommended System Requirements:
Processor: Intel® Core™ i3 or AMD Quad Core, 3.0 GHz or higher
Memory: 4GB or more

Program uses .Net Framework 3.5 and 4.0, but the installer will install it if they are missing. .Net installation can use local files in „components" folder or files from Internet. If there is no Internet connection, program will be installed, but installation of .Net 3.5 and 4.0 will need to be installed by user.

Installer installs VC 2010 redistribution files.
Installer also installs following drivers:

- Matrix-USB Driver (drivers for hardlock
- FTDI's CDM drivers (RS485 - USB) – for connection between PC and PLC to transfer programm from SafePLC to PLC hardware

2.2 Installation Procedure

Administrative privileges are requested only for installing. Normal user can use the installed program.

Program installation starts by double mouse left click on file SetupBBHSafePLC2_X.X.X.XXXX.exe. Then appears the following window:
By rolling down the menu you can choose installation language (English or German).

NOTICE

Installer language window

This windows appear only for the first installation procedure.

For the next time, the choosen language will be remembered and License Agreement window will appear as first. This Installer language window sets up just the installation language and not language for ***SafePLC²*** user interface.

After language choice press button "OK" to continue the installation. If you click button Cancel, installation will finish without program installing.

After pressing button "OK" there will appear next window with license agreement.

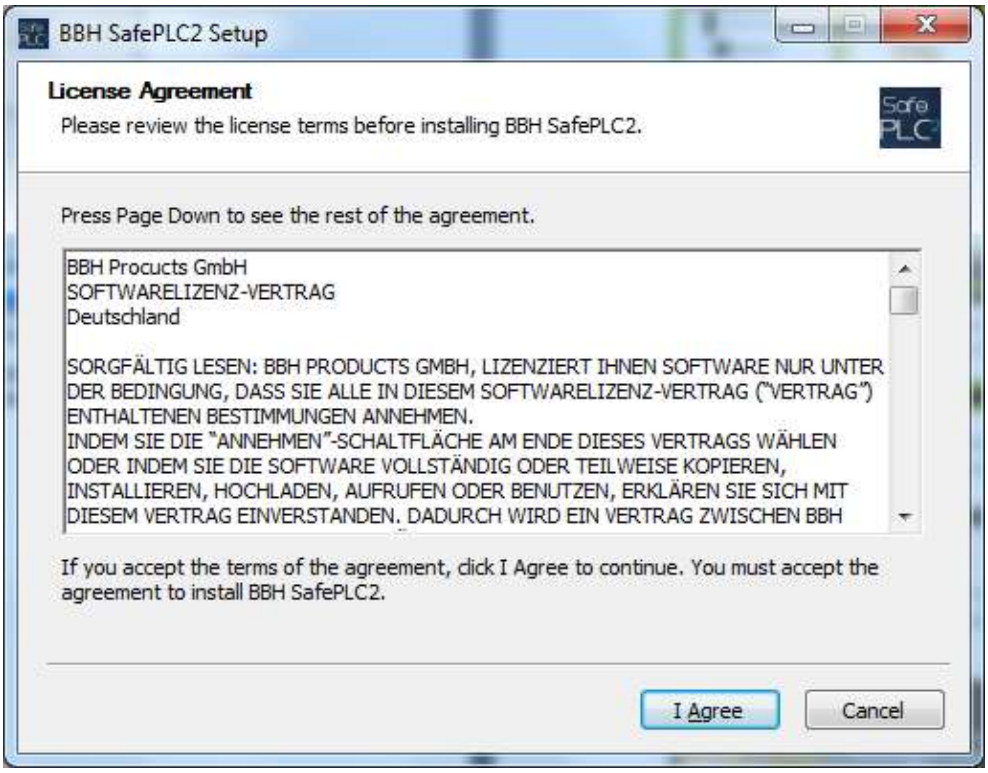


Fig. 1: License Agreement window

To continue in program installation press button "I Agree". If you do not agree with License Agreement press button "Cancel". Installation will finish without program installing.

After pressing button "I Agree" there will appear a window with possibility to set the destination folder where program will be installed.

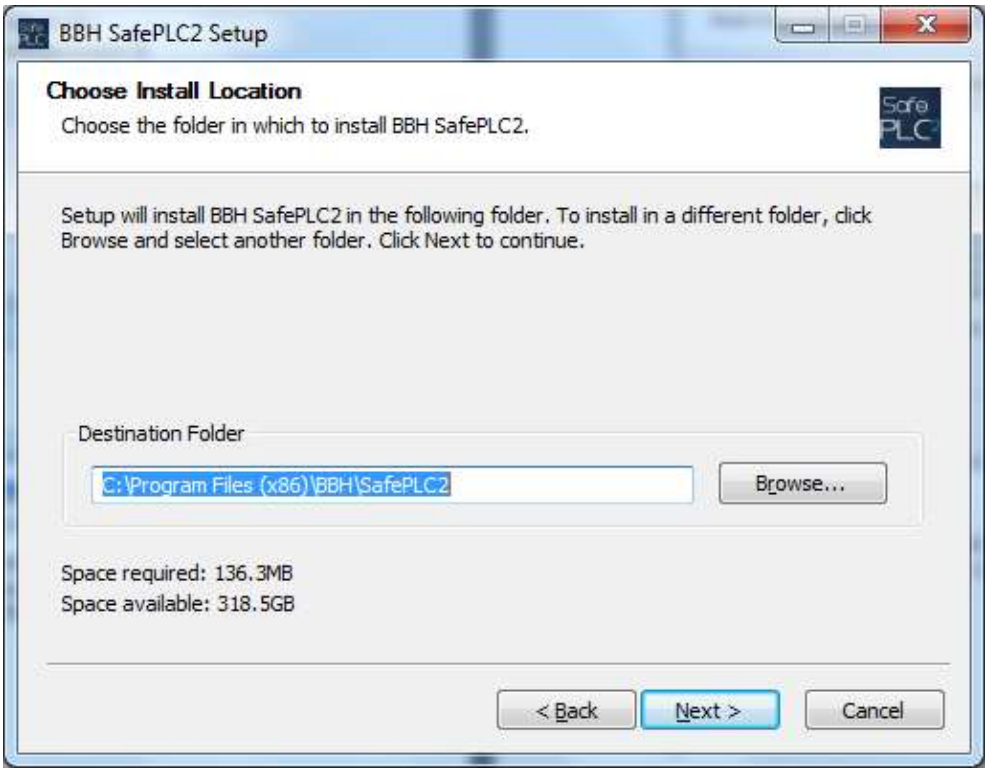


Fig. 2: Choose install location

After pressing button "Next" there will appear window to choose Start Menu folder for BBH SafePLC^2 program's shortcut. There is also possibility to create shortcut in Start Menu program. If you choose this possibility there will be created an icon for starting program only at computer's Desktop.

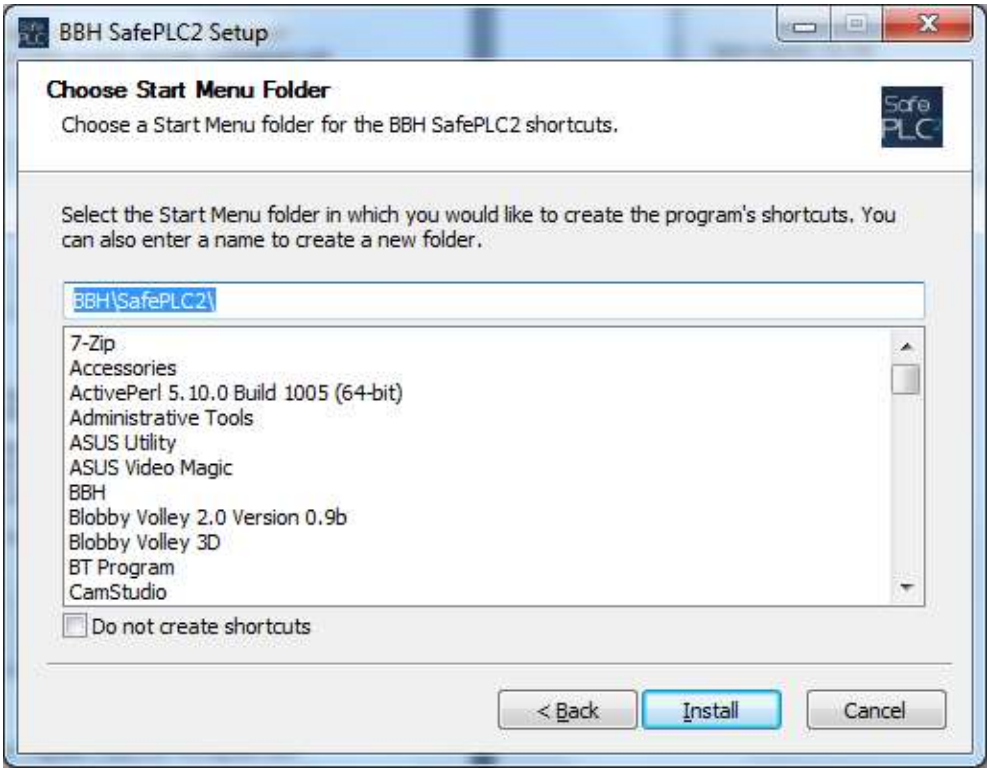


Fig. 3: Choose start menu folder

After pressing button "Install", installation will start.

If during installation there appear Windows security allert click ‚Install' to install Matrix-USB Driver (drivers for hardlock) and FTDI's CDM drivers (RS485 - USB) – for connection between PC and PLC to transfer programm from **SafePLC²** to PLC hardware.

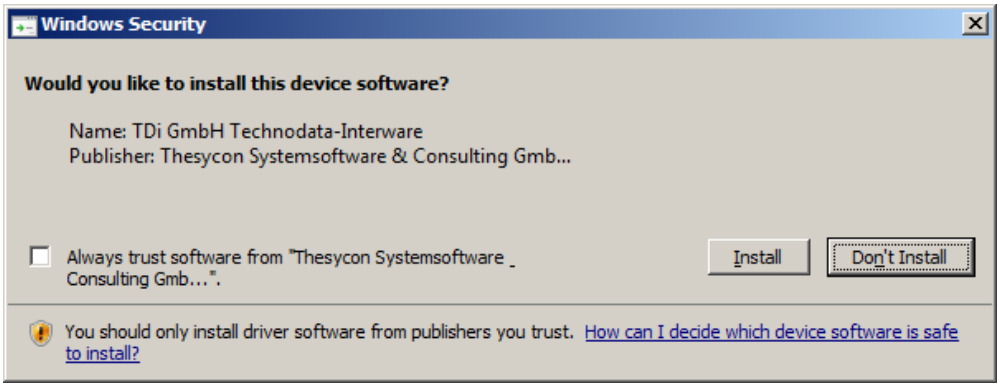


Fig. 4: Windows security notice during the installation process

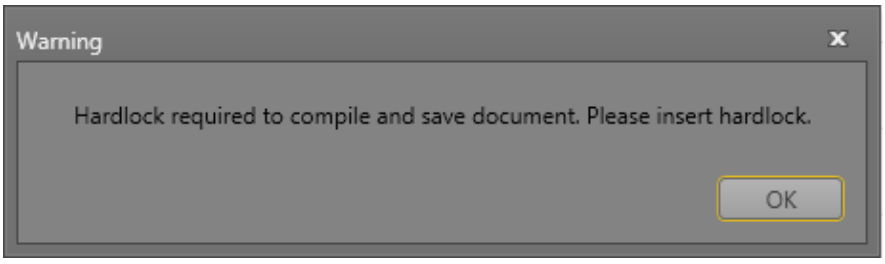
Tip: During installation of USB drivers, click on "Skip searching for Windows updates" for a faster installation.
After finishing installation there will appear window.

Fig. 5: Completing the installation

By clicking check box it is possible to choose if you want run program immediatelly or not. When check box is marked after click on button "Finish", the dialog window will be closed and the program will start.
During the installation the desktop icon for strating the program will be created. You can use this icon to start the program any time. If during installation there was created shortcut in Start Menu Folder it is possible to start program from Shortcut created in this folder.

2.3 Hardlock

For a proper functionality of **SafePLC²** you need Hardlock. If you start program without Hardlock there will appear the following message:



Press button "OK" and insert Hardlock to USB port. Hardlock will be detected and **SafePLC²** will be fully functioned.

CAUTTION

Removing the Hardlock

If you remove Hardlock during working with **SafePLC²**, there will be lost of full functionality and you will be not able to compile and save created program. Insert Hardlock to USB port and full functionality will be recovered.

2.4 Uninstall

To uninstall **SafePLC²** you can use shortcut in Start Menu programm or function Uninstall program in Windows Control Panell.
If you want to install program again with possibility to change Installation Language, it is necessary to delete registry key "Installer Language" in branch HKEY_CURRENT_USER\Software\BBH\SafePLC2.

2.5 Running Application

To Run application double click on icon on desktop or choose program from start menu.

NOTICE

If your setup file is marked as "user login" after application start there appears "Login dialog" and you can work with application after inserting User name and Password.

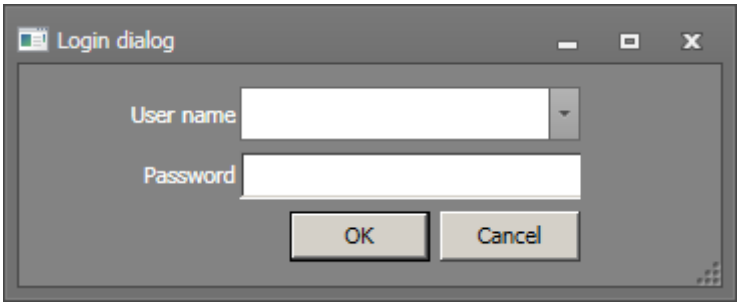


Fig. 6: User login after starting the application

3 User Interface

3.1 Main Window

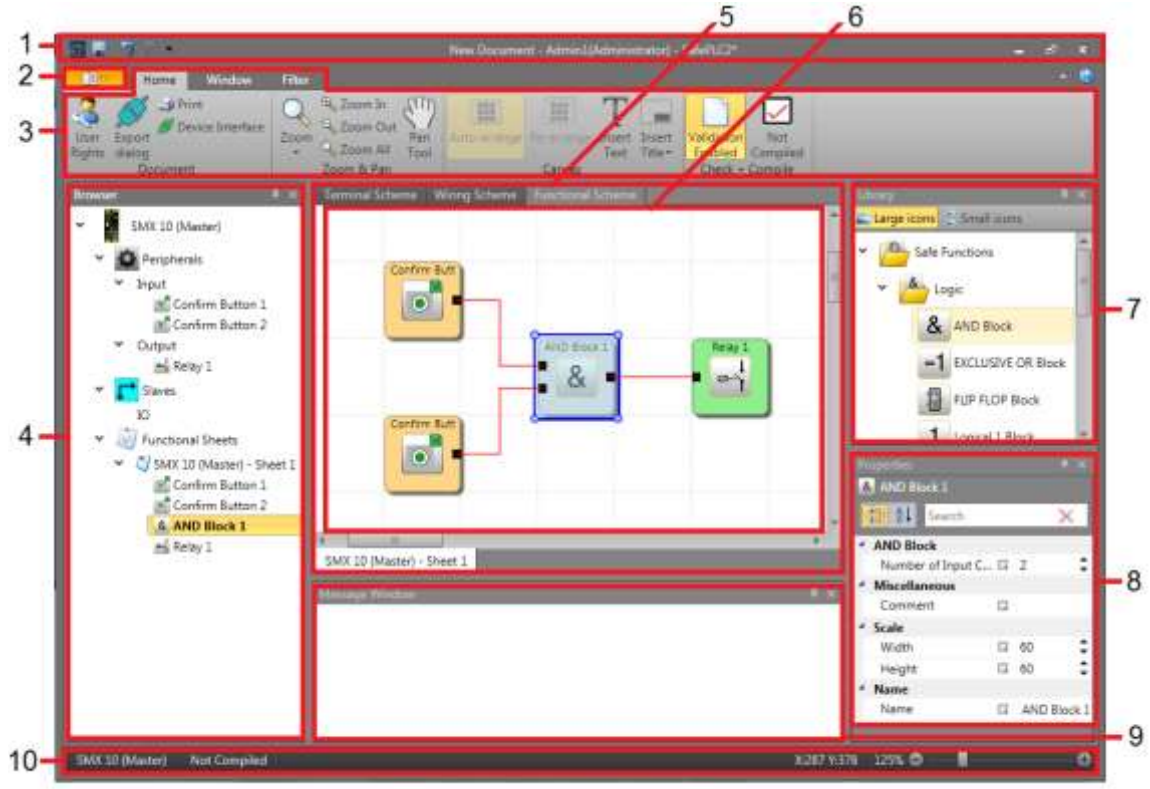


Fig. 7: Layout of the main window

Application window is the root window of SafePLC^2 application. Window can be resized, minimized, maximized or closed through window mode handling buttons. It is divided on following elements:

1. Title bar with Quick Access toolbar
2. Start Menu
3. Ribbon Menu (Tabs (**Start, Window, Filter**) with respective Groups)
4. Browser
5. Document tab control with Schemes tabs placed at the top and sheet tabs at the bottom
6. Canvas
7. Library window
8. Property Grid
9. Message windows
10. Status bar

3.1.1 Adjusting the Main Window

3.1.1.1 Reset Layout

User can reset application layout to defaults by clicking on Reset Layout button located in Window ribbon page. Note that this operation will erase user layout and there is no option to restore user layout.

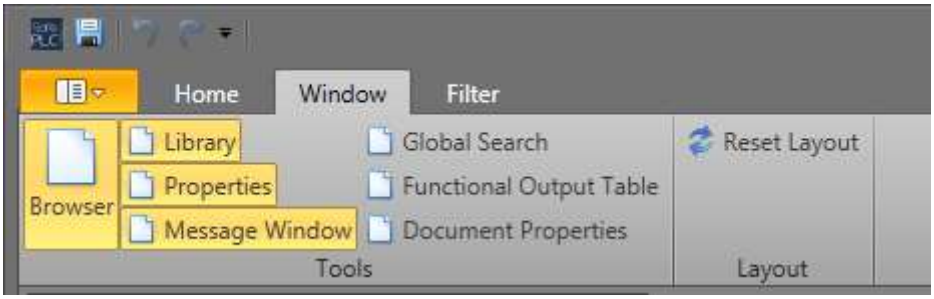


Fig. 8: Tab "window", reset of the layout

3.1.1.2 Docking

Docking provides useful way to customize application layout. Every panel (except Schemes and Sheets) can be dragged out of application window by holding down the left mouse button and can be dropped into other panel or tab group.

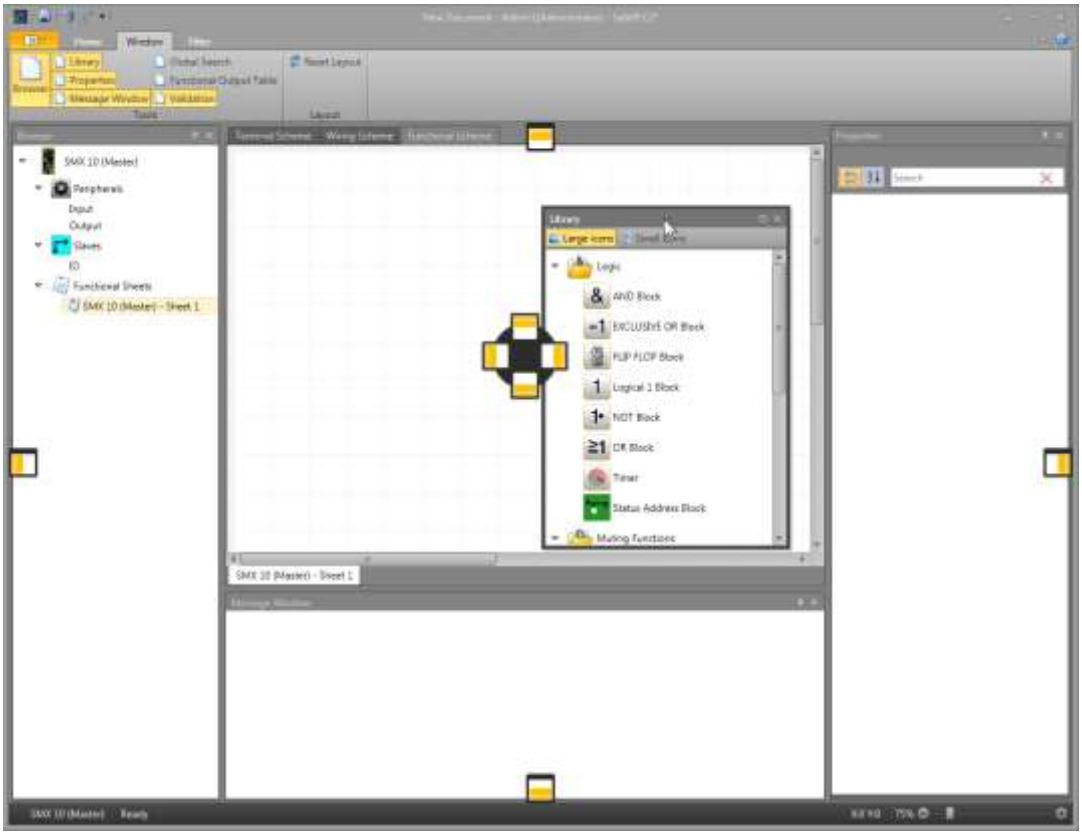


Fig. 9: Customize the application window by docking

When you drag out the desired area, the possible locations for dropping are displayed.

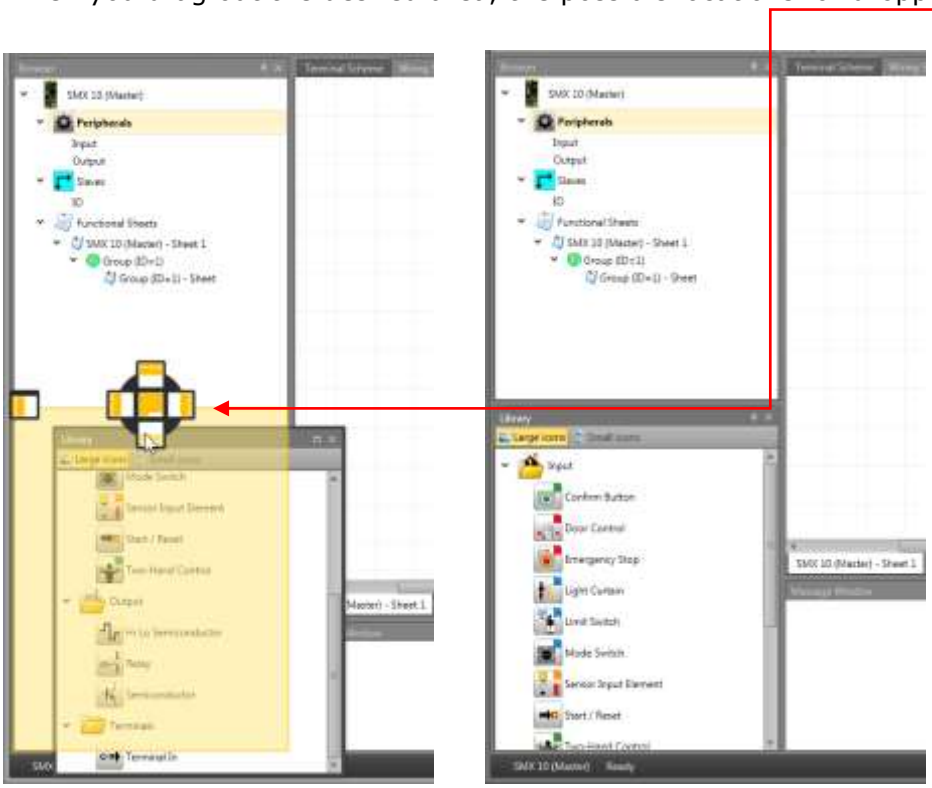


Fig. 10: Example Docking: library is placed under browser window

3.1.1.3 Automatic Hiding

Every panel with Auto Hide icon can be switched to auto hide mode. User can disable auto hide mode and restore panel to its previous position by clicking again on Auto Hide icon .

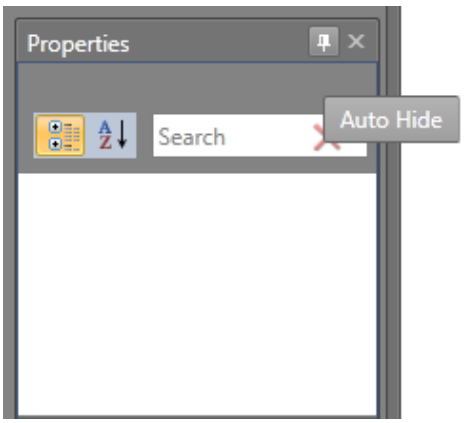
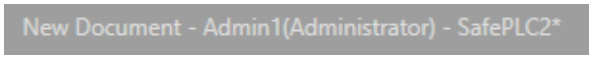


Fig. 11: Panel with selection option for automatic hiding

3.1.2 Title Bar

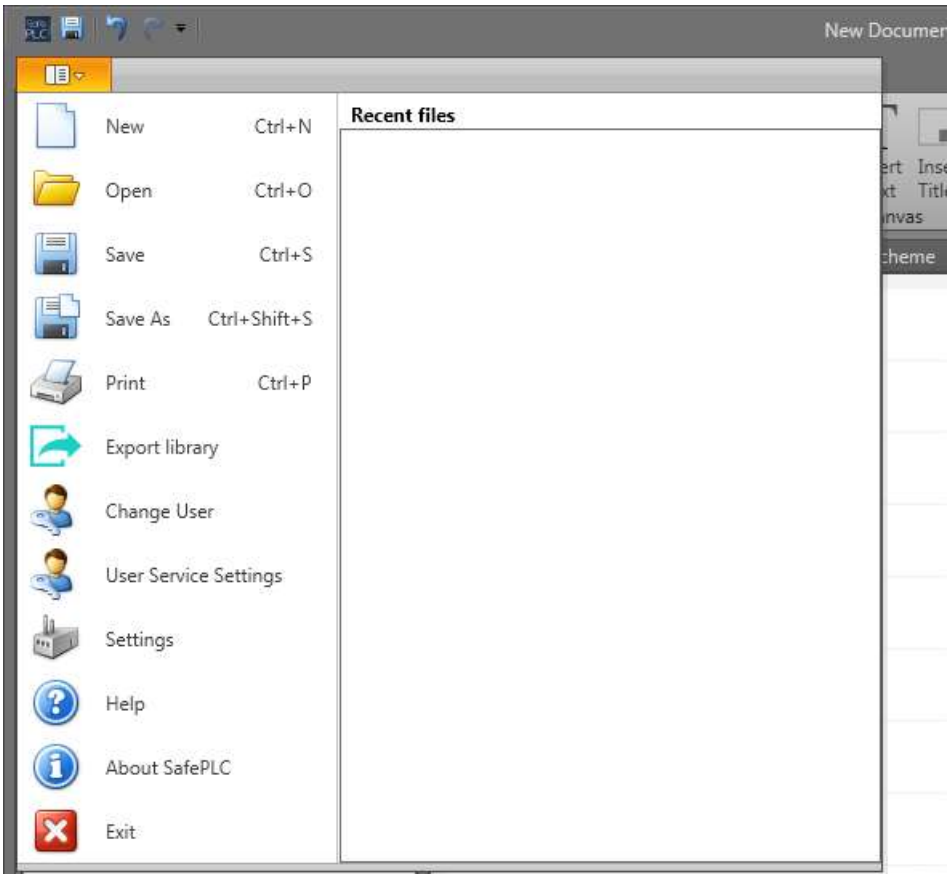
Title bar located on top of application window contains application icon, quick access buttons and application title. Quick access buttons consist of Save button  (also available through keyboard shortcut Ctrl+S), Undo button  (Ctrl+Z) and Redo button  (Ctrl+Y).

Application title 

consists of current document name, name of user currently logged in and application name with asterisk indicating there is at least one unsaved change.
User can display application window context menu by clicking on application icon. Context menu provides well known window functionality.

Fig. 12: Context menu of application window

3.1.3 Start Menu



Start menu provides basic document and application functionality, such as New document, Save document, Print, User management, Settings etc.
Recent files list contains documents recently opened (latest first).

New
Create blank new project. If the corrent project is opened, program will ask if user want save changes to old document.

Open
Opens existing SafePLC^2 document or document with entire library. If the current project is opened, program will ask if user want save changes to old document.

Save
Save document to selected location. In the case of new project, the extended save functions windows appear (like a Save as).

Save as
Save document and select name, type and location of document. If the folder contains the document with the same parameters, the program will ask user if want to replace it.

Print
Shows the print menu. For description of function see chapter "3.10 Print"

Export library
Export SafePLC² library to *.splib file.

Change user
Change user allows user to log in or log off. See chapter "4.13 Change user".

User service settings
Allow changing users.

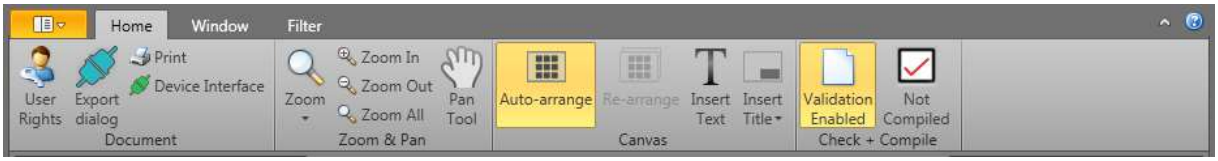
Settings
Settings window allows user to change application settings. See chapter "4.11 settings".

Help
Opens SafePLC2 help window.

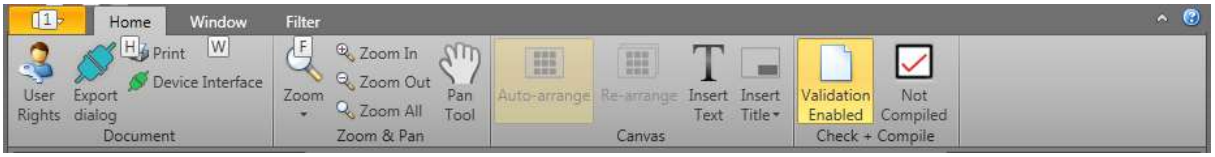
About SafePLC
"About SafePLC" show brief information about Windows system, application build and compilation information.

Exit
Close the whole program.

3.1.4 Ribbon Menu

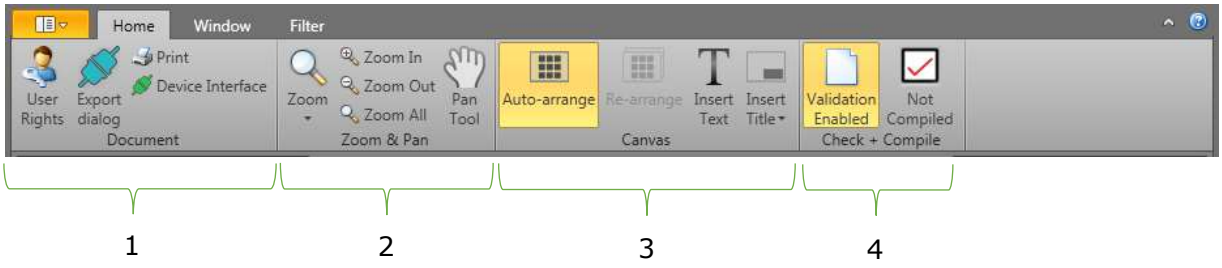


Ribbon menu is part of main window and consists of several ribbon pages. User can toggle ribbon mode (Expanded-Compact) by clicking on  button in top-right corner of menu. When ribbon menu is in Compact mode user has to click on ribbon page name to expand page and page gets automatically collapsed when it loses focus. User can access any ribbon page by pressing Alt key and then desired key regarding the tooltips appeared in ribbon.



Afterwards additional tooltips appear next to each operation in ribbon menu. Next to Toggle ribbon mode button isHelp button  that will show help dialog.

3.1.4.1 Home



1 Document group

- **User Rights** button shows dialog where user can define rights for users.
- **Device Interface** button shows device dialog.
- **Export dialog** button shows export dialog.
- **Print** button shows print menu.

2 Zoom & Pan group

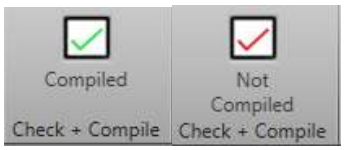
- **Zoom** dropdown list provides quick access to specific zoom values.
- **Zoom In** button increases current zoom value by 25%.
- **Zoom Out** button decreases current zoom value by 25%.
- **Zoom All** button scales canvas so that it fits entire canvas container.
- **Pan Tool** toggle button toggles pan mode. When enabled user is able to pan the canvas by either left mouse button or middle mouse button.

3 Canvas group

- **Auto-arrange** toggle button toggles auto-arrange mode. When enabled elements are automatically arranged. Not all scheme types support arranging.
- **Re-arrange** button arranges elements instantly and does not apply in future. Not all scheme types support arranging.
- **Insert Text** toggle button switches on Text dropping. When enabled user can drop text to canvas by clicking left mouse button.
- **Insert Title** dropdown menu lists available titles. After clicking on one of titles selected title is immediately inserted to all sheets across whole document.

4 Check + Compile group

- **Compile** button compiles current document. When compilation is successful button shows „Compiled" text with green check mark . Otherwise „Not Compiled" text and red check mark are showed.



- **Lock** toggle button locks or unlocks document. When document is locked user cannot edit document. Although user is still able to select elements, switch scheme or sheet.

3.1.4.2 Window

User can show or hide windows by toggling desired toggle button.

- **Browser** toggle button – turns on and off Browser window in user interface.
- **Library** toggle button – turns on and off Library window in user interface.
- **Properties** toggle button – turn on and off Properties grid.
- **Global search** button – turn on window for Global search. More information about this function is in chapter 3.9.

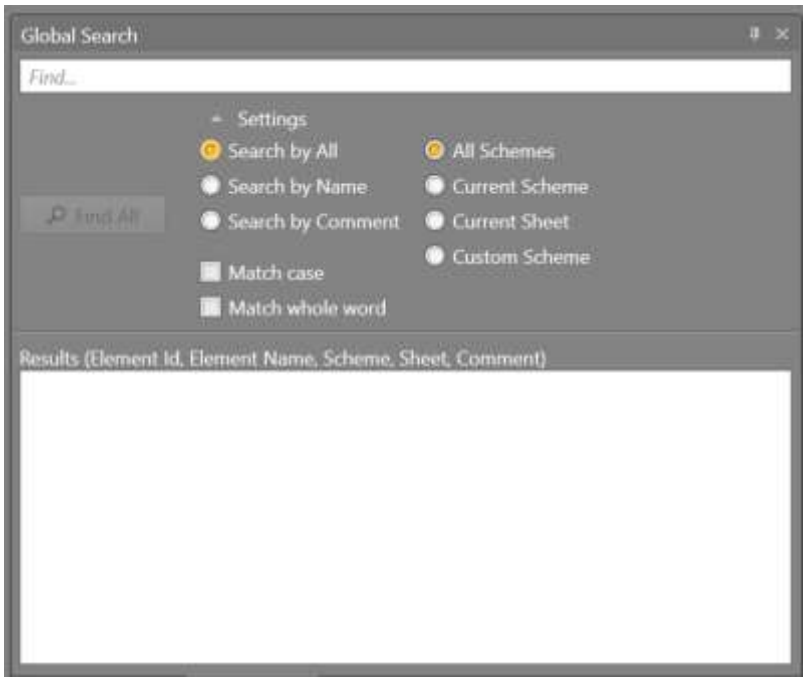
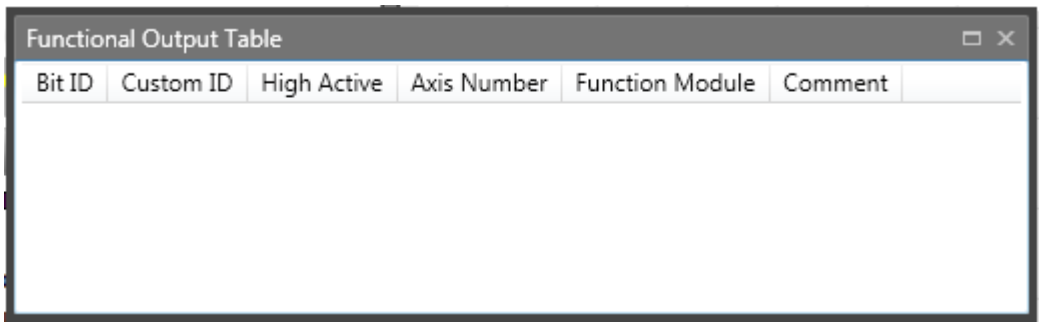


Fig. 13: Results (Element Name, Element Id, Scheme, Sheet, Comment)

- **Functional Output Table** button - shows table (see next figure).



- **Document properties** toggle button – document management information window.

Fig. 14: Document properties window

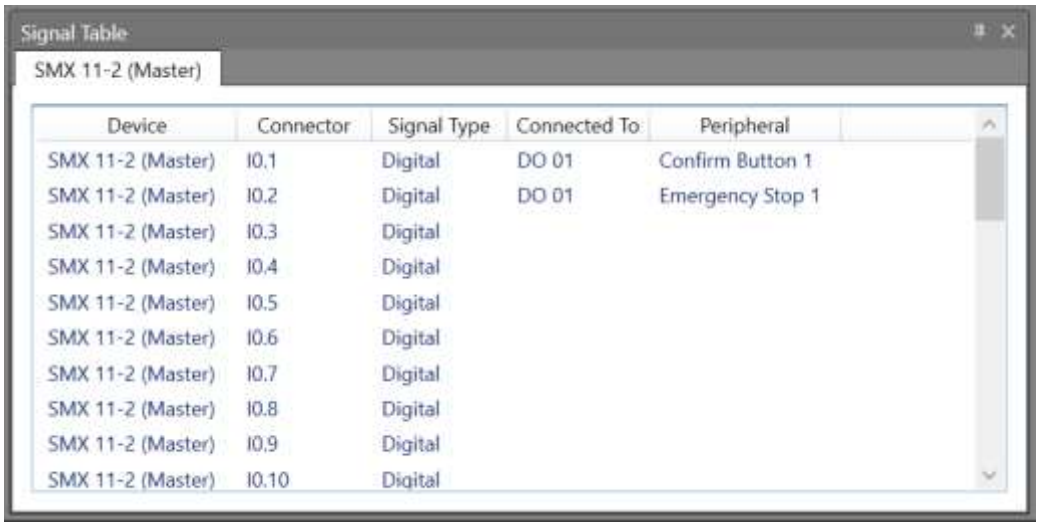
This window contains of Document tab and Device tab. The Document tab consist of:

- Password - This password is used to lock the project and can be unlocked again.
- Lock - This button can be used to lock and unlock documents. If a document is locked, the user cannot edit the document. But the user can select elements and switch between plans or sheets.
- Developer Name - Name of the responsible programmer/developer.
- Comment - This input field provides a descriptive field for the input of any text. Here one can document e.g. program or parameter changes during the life cycle of the currently used device.

Device tab consist of information fields and connection settings.

- Device information – For more information about edited fields see chapter 5 "Configuration Report".
- Connection settings – For more information see chapter 4.8 "Transfering the program on the device".
- Report settings – Choose format (Pdf or Excel) for generated report.

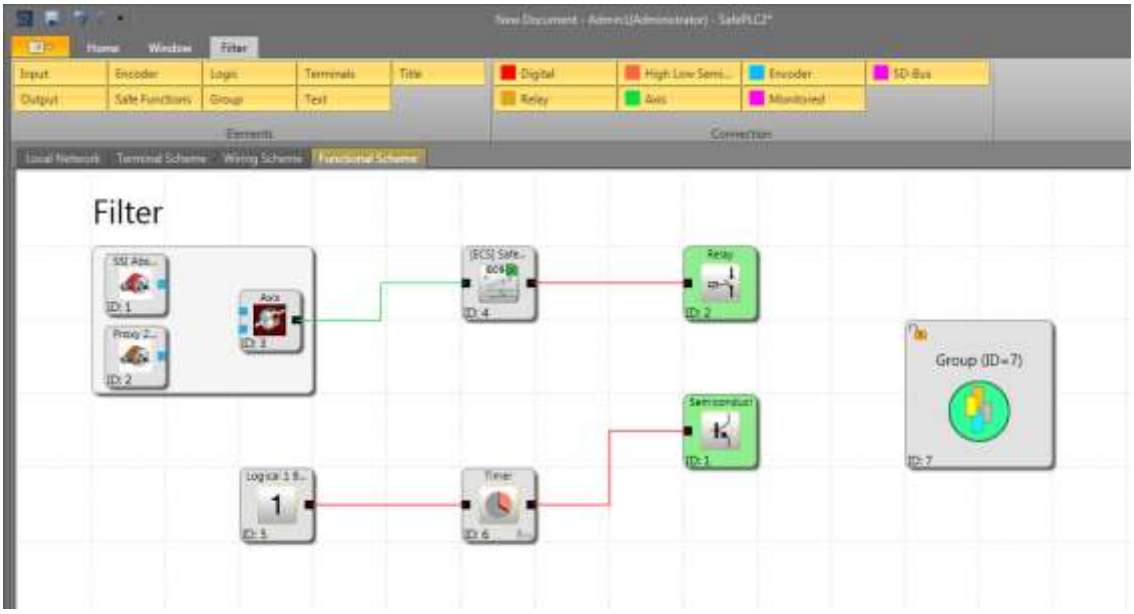
- **Signal Table** – press the button to show or hide the following window:

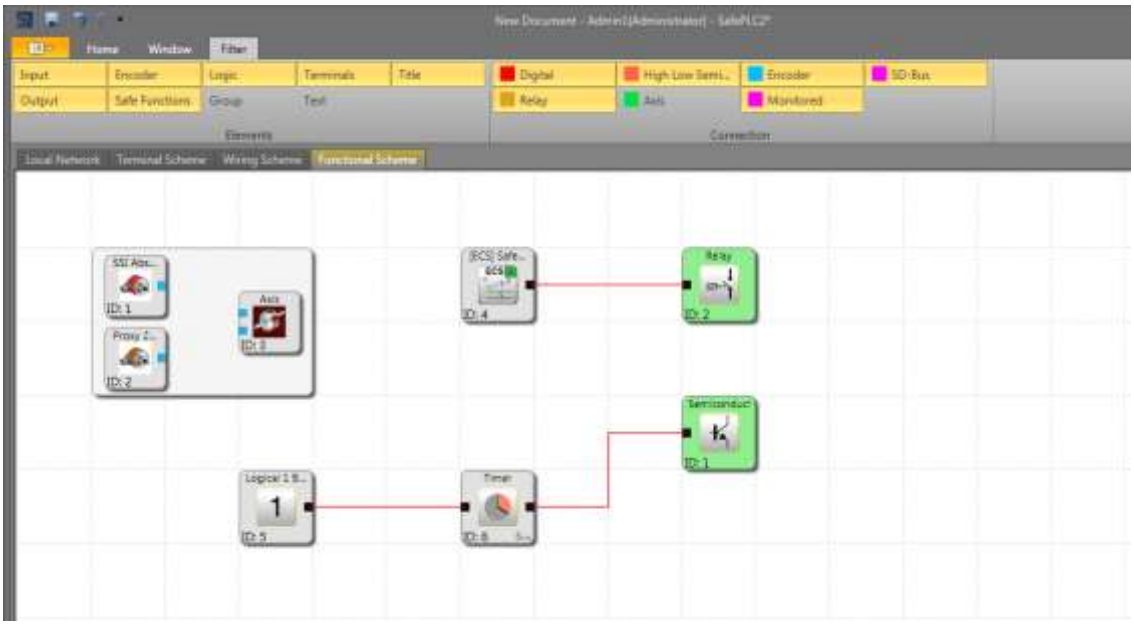


- **Reset layout** button - resets application layout to its defaults.

3.1.4.3 Filter

Filter provides great tool to maintain canvas readability by hiding desired element type or connection type. Filter consists of two filter category: Elements and Connection. Each group contains several filters. By disabling, the filter elements (or connections) that belong to given filter are hidden from canvas.





3.1.5 Status Bar

Status bar belongs to main window and is composed of current master device name and action mode aligned to the left side and cursor position in canvas, canvas zoom slider and resizing icon aligned to to the right side. Resizing icon symbolizes that user can change size of main window. Action mode will show current action that user is performing in canvas.

3.2 Mouse and Keyboard Commands

3.2.1 Mouse Dependent Actions

- Left mouse button click on a function block (de)selected given block.

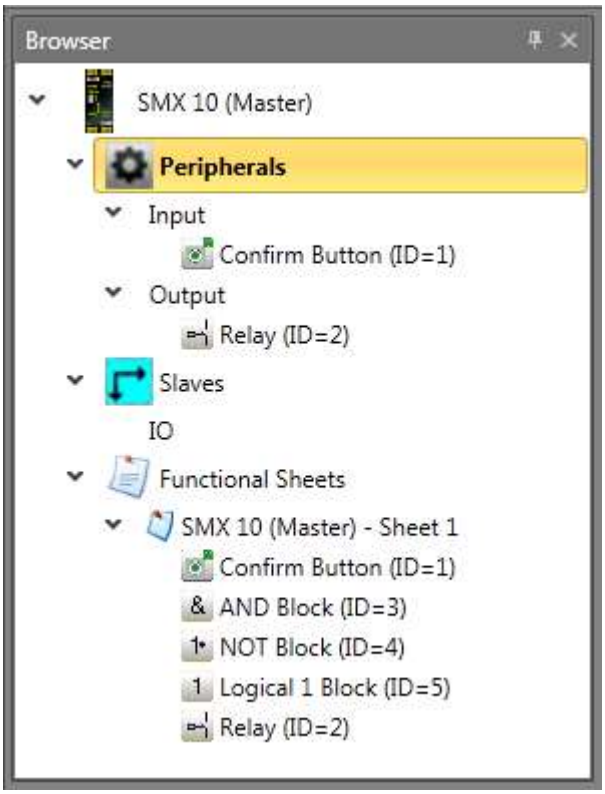
  NOTICE: Multiple selection can be achieved by holding Shift key (adds block to selection) or Ctrl key (inverts selection on block)

- Cursor hover over the block or connection: Highlights the block or connection
- Shift + Left mouse button on function block: Adds block to selection
- Ctrl + Left mouse button on function block: Inverts selection of given block
- Delete key: Deletes the elements incurrent selection including connections
- Right mouse button on object: Displays context menu
- Left mouse button on connection: Highlights the existing connection wire
- Scrolling the scroll wheel on the mouse: Scrolls canvas up/down
- Middle mouse button and mouse move:Pans the canvas
- Shift + Scrolling the scroll wheel on the mouse: Scrolls canvas left/right
- Ctrl + Scrolling the scroll wheel on the mouse: Dynamic zooming of the canvas
- Clicking left mouse button, holding the button and moving mouse pointer: move element on the canvas

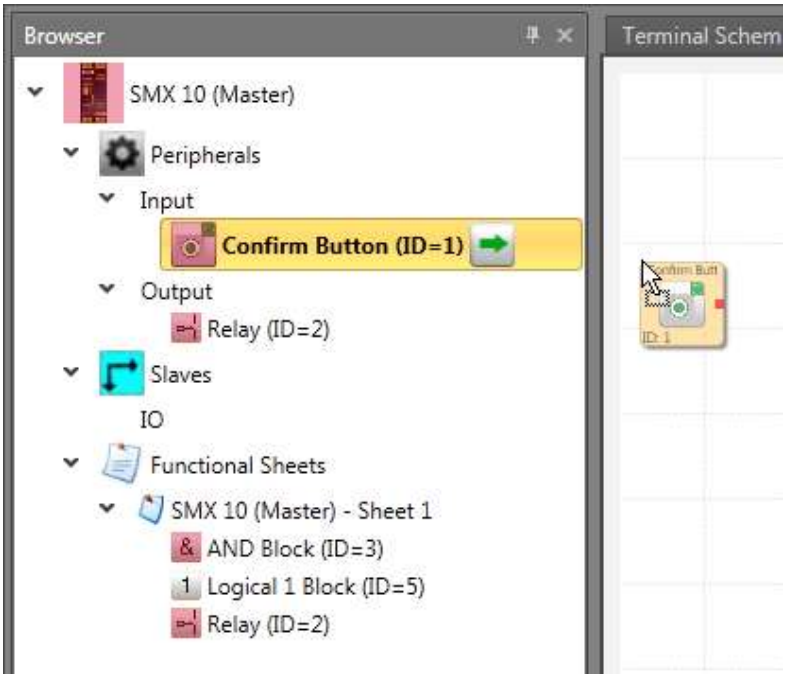
3.2.2 Keyboard Commands

- Ctrl + N: New document command
- Ctrl + O: Open document command
- Ctrl + S: Save document command
- Ctrl + Shift + S: Save As document command
- Ctrl + P: Print command
- Ctrl + R: Open most recent document command
- Ctrl + Z: Undo command
- Ctrl + A: Select All command
- Ctrl + Del: Delete command
- Ctrl + C: Copy selected item(s) command
- Ctrl + X: Cut selected item(s) command
- Ctrl + V: Paste selected item(s) command
- Esc: Cancel command
- Backspace: Remove previous connection point command during drawing connection
- Ctrl + F: Show Global Search command
- Ctrl + F: Show Find dialog command (only when Message Window has focus)
- Shift + F11: Create new sheet command
- Crtl + Tab: Toggle between schemes
- F1: Show the SafePLC^2 Help (on specific window the Help will opened on an appropriate chapter).

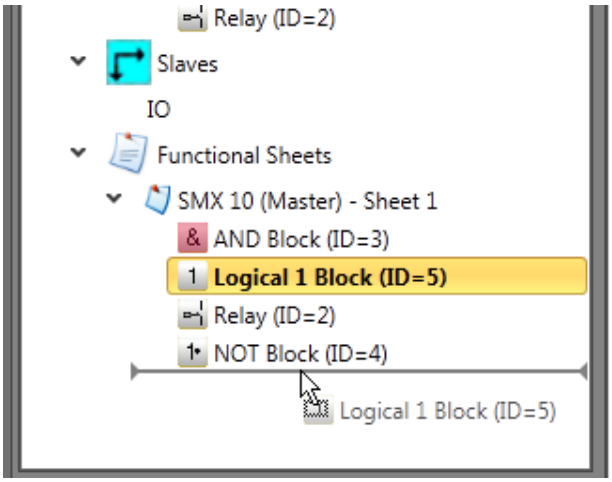
3.3 Browser



Browser panel provides overview of entire document. Devices, Elements and Functional sheets are represented as nodes within a treeview. Library panel adjusts its content automatically regarding the currently selected item in Browser. Each node in Browser can be expanded or collapsed. User can rename any node either by 2nd click on node or by context menu. Multiselection is supported and can be achieved by holding Ctrl or Shift key. Selection in browser is synchronized with selection in canvas.
When Functional scheme is selected and there is any Input or Output or Sensor element that has not yet been inserted into Functional scheme then such items contains green arrow indicating these items can be dragged and dropped to Functional scheme.



Order of children items within parent node typically can be adjusted by user by dragging and dropping element on desired place.



3.4 Document tab control

Following schemes are known within SafePLC2:

- Global Network
- Local Network
- Terminal Scheme
- Wiring Scheme
- Functional Scheme
- Groups
- SD Bus Groups

Each scheme and sheet is represented by single tab within document tab control. Document tab control allows user to switch amongs scheme types and sheets. Schemes tabs are placed on top of panel and Sheet tabs are placed to the bottom of panel. Note that by default only Terminal, Wiring and Functional Scheme tabs are visible. Rest of types (Networks, Groups, SD Bus Groups) will be showed only in certain circumstances. Each sheet belongs to one device. In case Slave device is selected in browser then only schemes and sheets belonging to this slave device are visible. In order to show sheets of other device user has to select desired device in Browser.

NOTICE Keyboard command “Crtl + Tab” toggle between schemes.

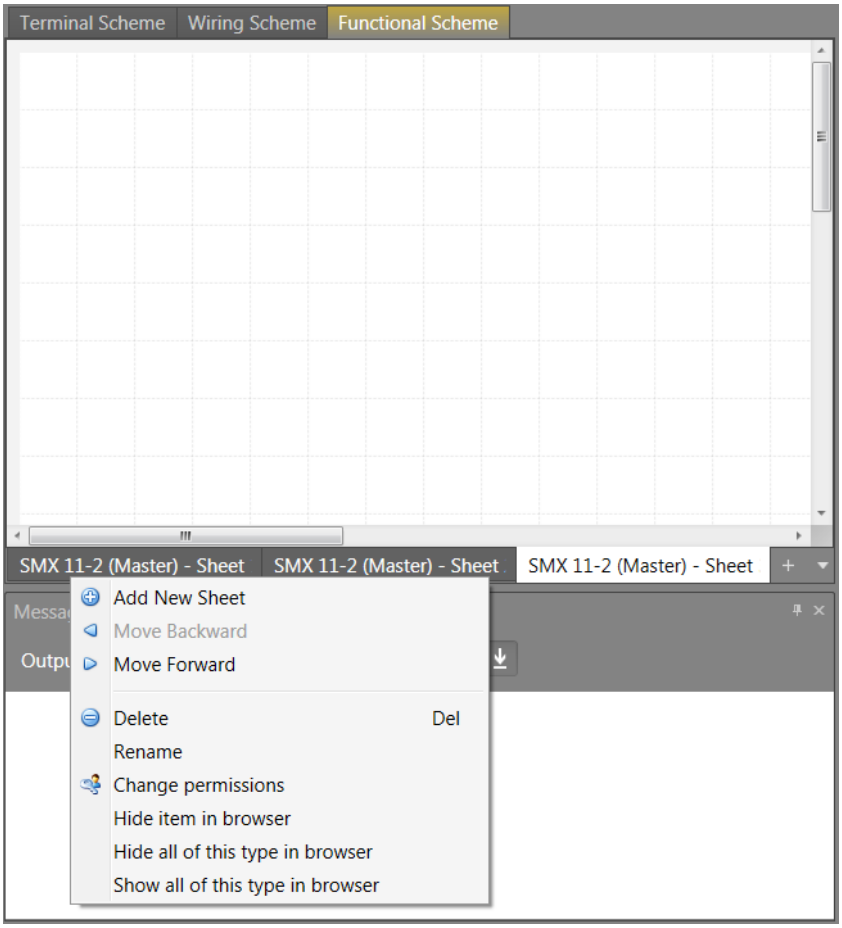


Fig. 15: Sheet context menu

- **Add New Sheet** adds new sheet to current scheme.
- **Move Left** moves current sheet one position to the left.
- **Move Right** moves current sheet one position to the right.
- **Delete** removes current sheet. This command is not available when there is only one sheet left.
- **Rename** renames current sheet.
- **Change permissions** shows permissions dialog.

3.4.1 Scheme types

Each scheme and sheet is represented by single tab within document tab control.

3.4.1.1 Terminal scheme

The terminal scheme represents the simplified scheme with selected devices and peripherals of the SMX-system.

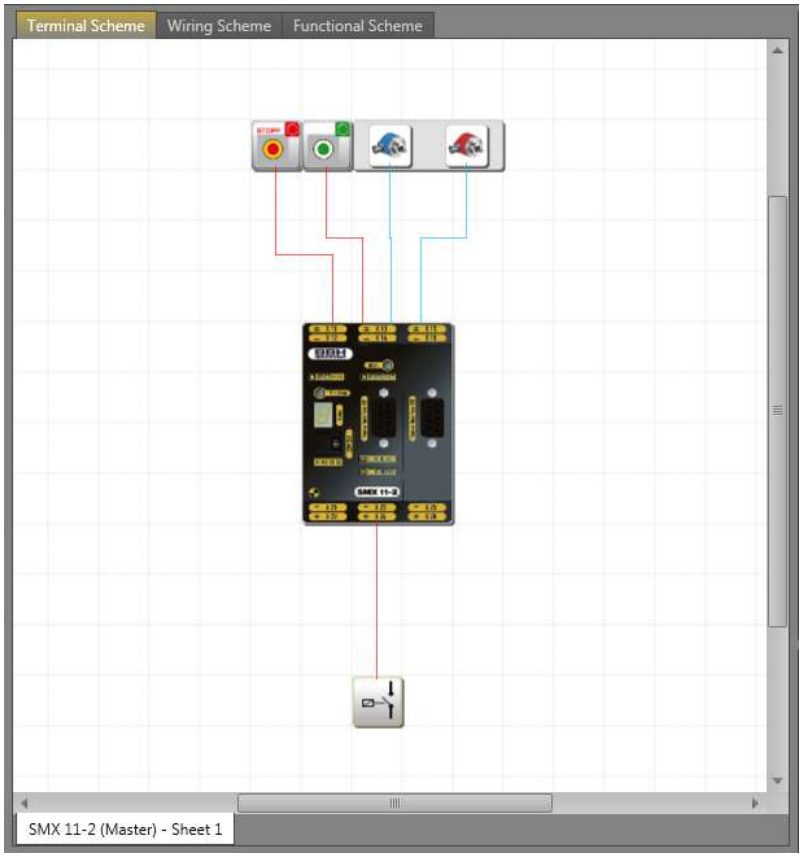


Fig. 16: Terminal Scheme view

Terminal scheme: If function blocks are inserted into the terminal diagram, the elements will be automatically paired with device. In the case of several devices in terminal scheme, user must add peripherals to appropriate device. Otherwise the selection device dialog appear.

3.4.1.2 Wiring scheme

The wiring scheme describes the external port assignments in an SMX-system to the chosen sensors and actuators. When creating a new project (Menu>New...) the scheme shows all available inputs and outputs, as well as further sensor interfaces (encoders, analogue sensors). Even though auto-arrange is enabled, in some instances it may happen, that the connections are unfavourably displayed. However, this does not affect the function! When moving the corresponding block, the connecting wiring will be redrawn and may appear more distinctly.

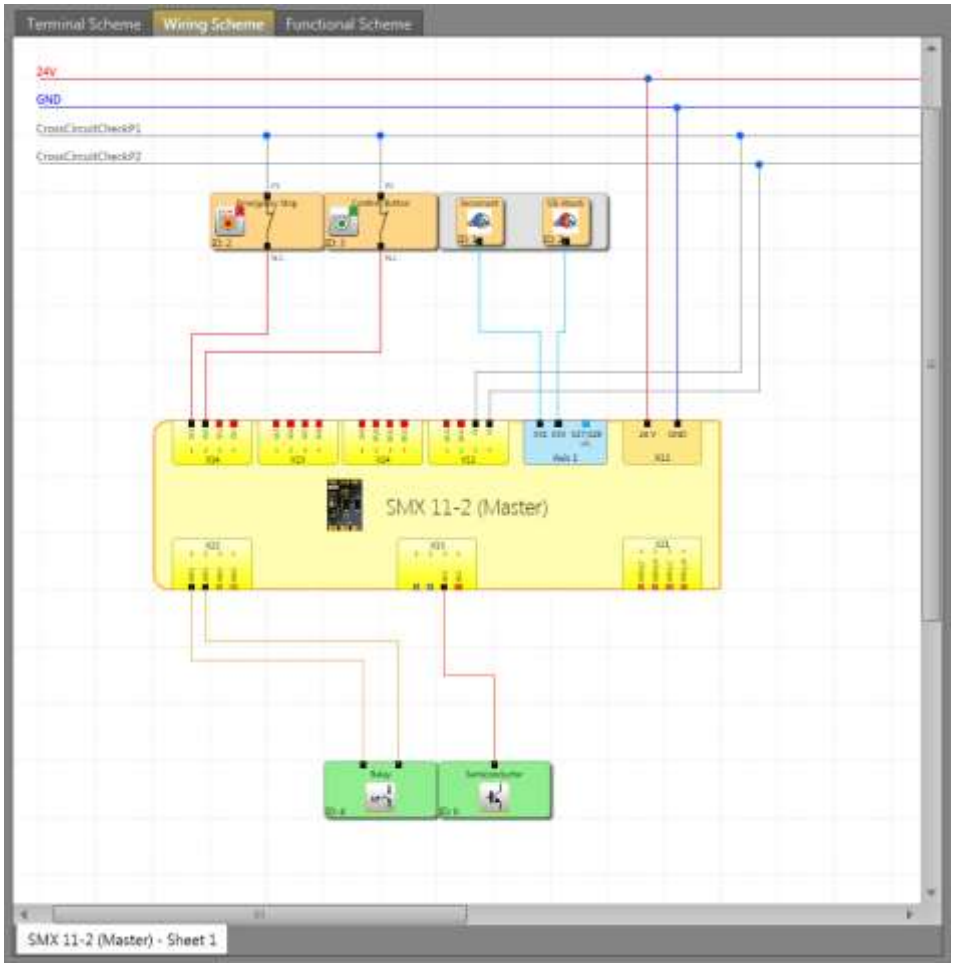


Fig. 17: Wiring scheme view

24V:	This wire represents permanently 24 voltage power. SMX module requires 24VDC power supply.
GND:	This wire represents permanently ground serves as a (reasonably) constant potential reference against which other potentials can be measured.
CrossCircuitCheck T1/T2:	Wiring with T1/T2 pulse circuits.

NOTICE

No logic elements must be defined in this view, the corresponding commands are accessible in the Functional scheme.

3.4.1.3 Functional scheme

In the function block diagram linkages take place between input, monitoring, output and logic blocks.

In this respect the output connectors on the input elements correspond with the input data of the function block diagram. In the same way the input connectors of the output elements must be viewed as output data of the function block diagram.

In order to be able to create a clearly structured function block diagram, one can define so-called terminals. These represent a named connection between input and output connectors of function blocks. One or several marker-output blocks (output terminals) can be defined for one marker setting block (input terminal). (see chapter Terminal)

Tip: Use the comment field on property grid for connecting point inputs. This information simplifies the use of complementary connecting point outputs. This contributes to clarity!

3.4.1.4 Group scheme

Group scheme includes one group sheet for each group block from functional scheme. This scheme is available after cretaing group block in Functional scheme. For more infromation about creating Groups see chapter: "10.3.8 Groups".

3.4.1.5 Global Network

All networks are showing in this schema. Master connections and also connections with slaves, Fieldbus and SD-Bus groups are showing there. For more information see chapter: "9 Networks".

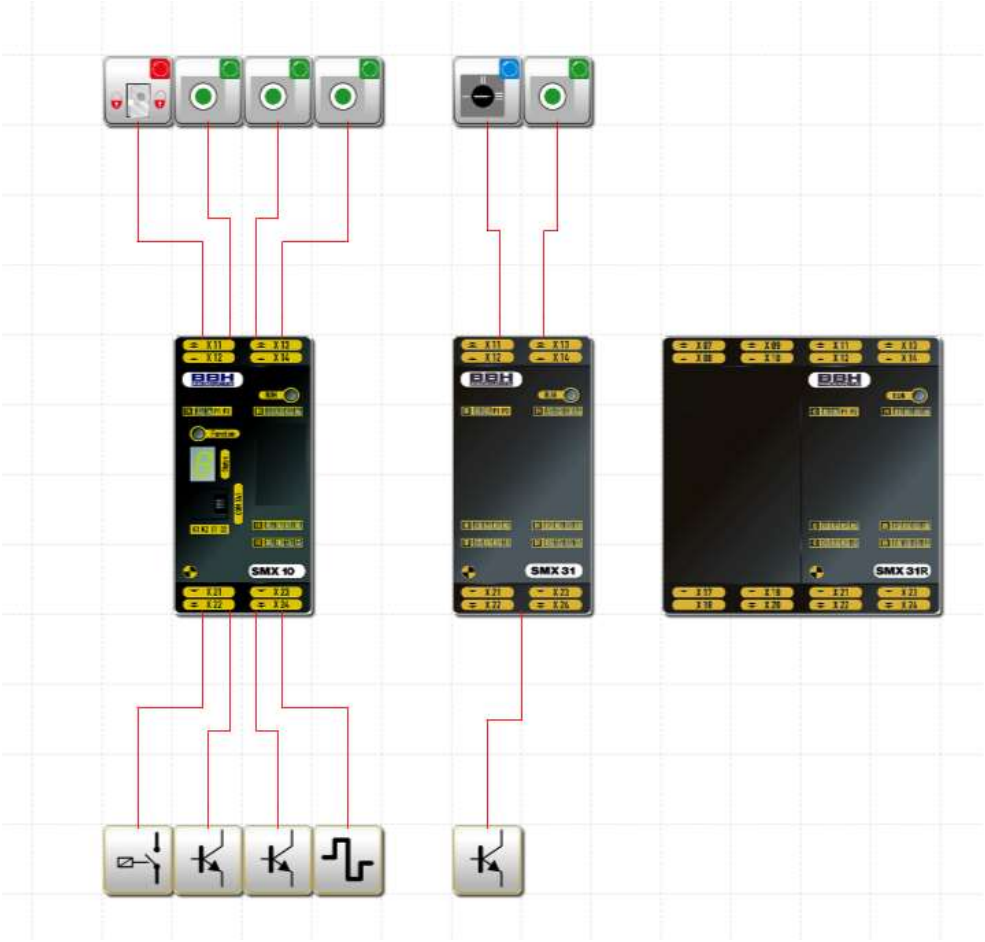
3.4.1.6 Local Network

The other network types are device dependent and it have its own schema which is showing special for that device. This schema called "Local Network".

3.4.1.7 SD-Bus Group

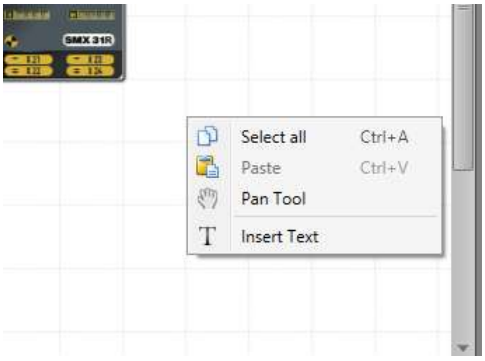
By using a device which supports SD-Bus and activating that the SD-Bus groups can be assigned to that device. A SD-Bus group acting likes an input element with two outputs (like light curtain element). It is possible to assign up to 31 group for a SD-Bus supporting device.

3.5 Canvas



Canvas represents the base drawing tool. Each sheet is represented by its canvas. Useful tips:

- User can pan the canvas by pressing middle mouse button regardless Pan mode is enabled or not.
- Zoom level can be changed by scrolling the mouse wheel while Ctrl key is pressed.
- User can scroll canvas vertically by scrolling mouse wheel.
- User can scroll canvas horizontally by scrolling mouse wheel while Shift key is pressed.
- Each canvas stores its own zoom level.



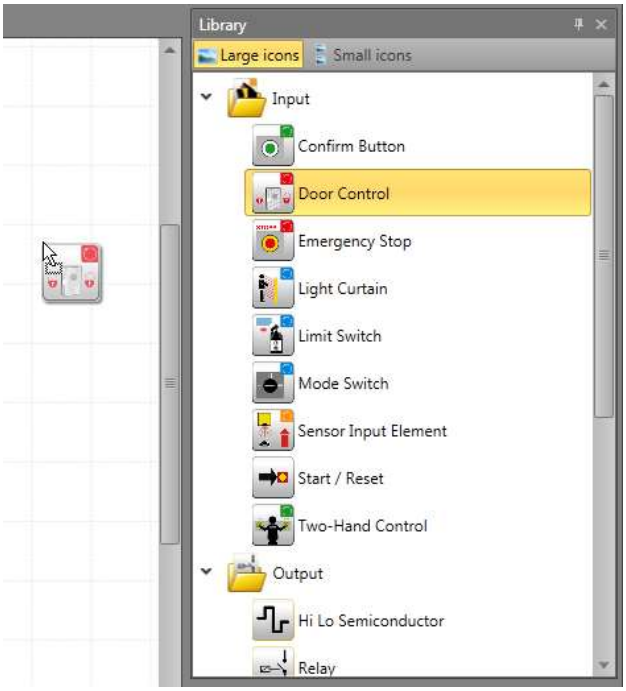
Canvas context menu

- **Select All** selects all elements and connections within canvas.
- **Paste** pastes elements and connections from clipboard (if present).
- **Pan Tool** toggles Pan Tool mode.
- **Insert Text** inserts texts to current mouse pointer position on canvas.

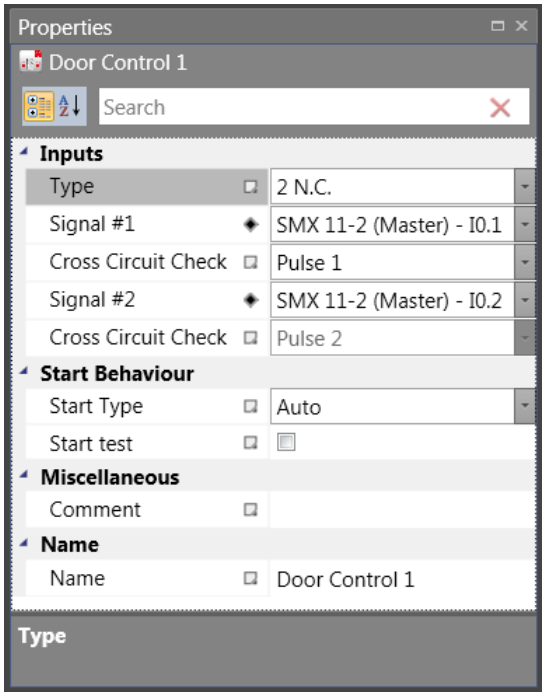
3.6 Library window

Library window represents main tool for user how to insert elements to document. Library window consists of collapsable folders. Each folder contains one or more elements. Folders and elements are filtered regarding to current scheme, current sheet a and currently selected element in browser or canvas. There are two buttons on top of window that allow user to toggle between element size views.

In order to insert element to document user has to drag element from library window and drop it onto canvas.



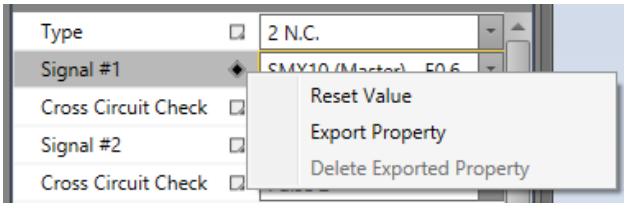
3.7 Property Grid



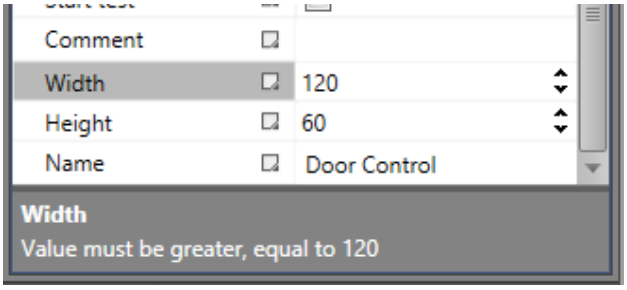
Property grid allows user to change property values of elements. Content of property grid is automatically refreshed and reflects currently selected element. By default properties are grouped into categories. By clicking on Alphabetical button  properties can be sorted alphabetically. To switch back user has to click on Categorized button  .

Search block 

provides fast and easy tool to find desired property.
When property value is set to its default then there is white icon next to property name. When value is set to value other than its default then icon becomes black. After clicking on this icon user can reset value to its default.

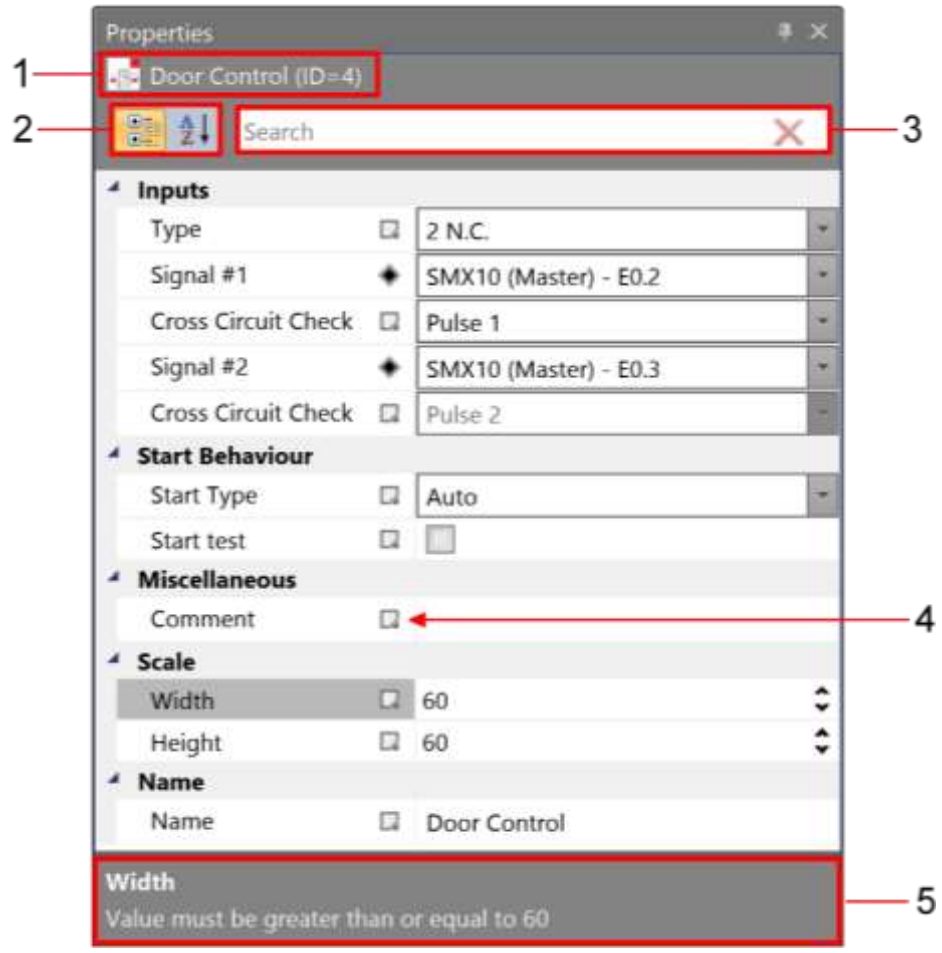


Bottom bar of property grid shows additional information about currently selected property.



The Property grid is where you can view and modify the properties of an selected object. The panel displays different types of editing fields, depending on the needs of a particular property. These edit fields include edit boxes, drop-down lists, and links to custom editor dialog boxes. You can open property grid by pressing the Properties button in the Window tab of the ribbon.

Tip: The Comment field can be in more lines. User can switch to next line by pressing Enter on keyboard.



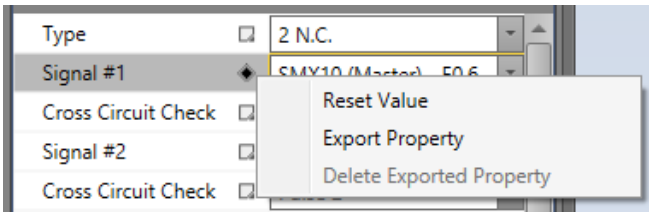
Property grid.

1. The name of the selected object.
2. Toggle buttons for changing arrangement of the property list:
   - Categorized - Lists all properties and property values for the selected object, by category. You can collapse a category to reduce the number of visible properties. Categories are listed alphabetically.
   - Alphabetical - Alphabetically sorts all properties for selected objects.
3. The search box for filtering the properties that are displayed by the text that is entered.
4. The button for opening the Advanced options pop-up menu.
5. The description of the selected property.

3.7.1 Advanced options menu

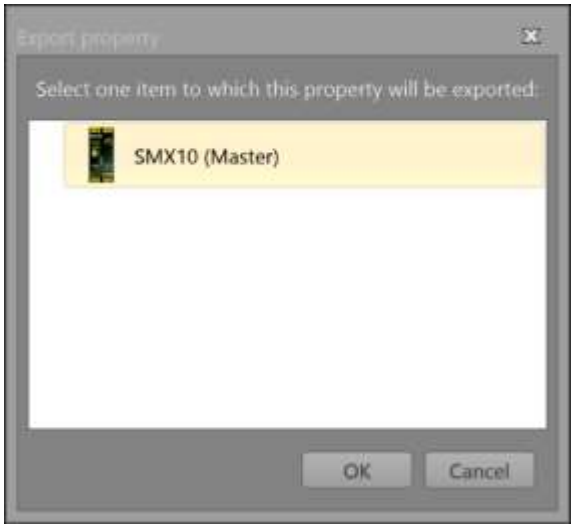
The advanced options menu allows users to invoke property-specific commands.

1. Reset value – Allows user to reset the property to a default value.



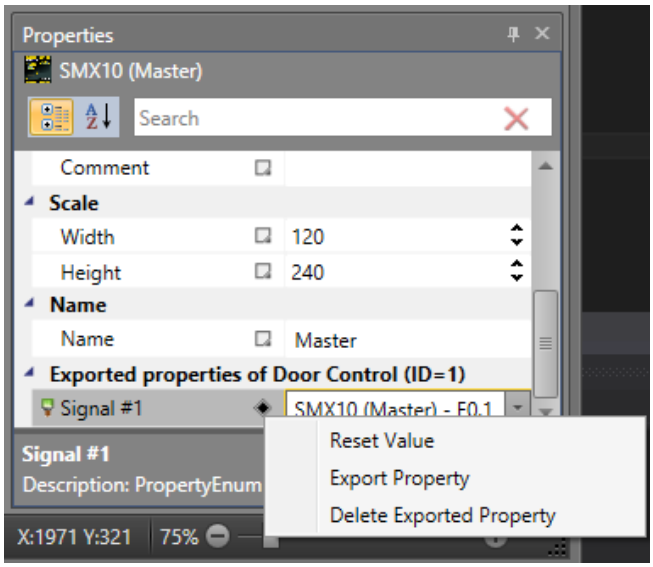
Advanced options menu

2. Export property – Allows user to export the property to any element, that is higher in hierarchy.



Export property dialog

3. Delete Exported Property – Removes exported property from the element.

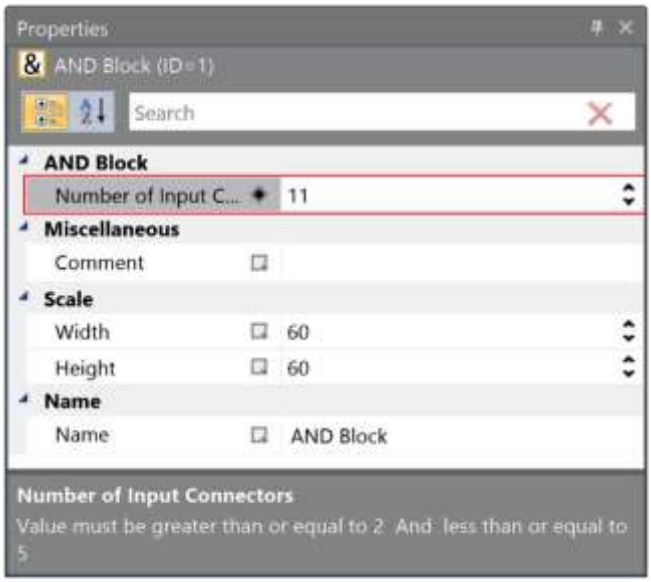


Exported property on a master device

3.7.2 Property validation

3.7.2.1 Input validation

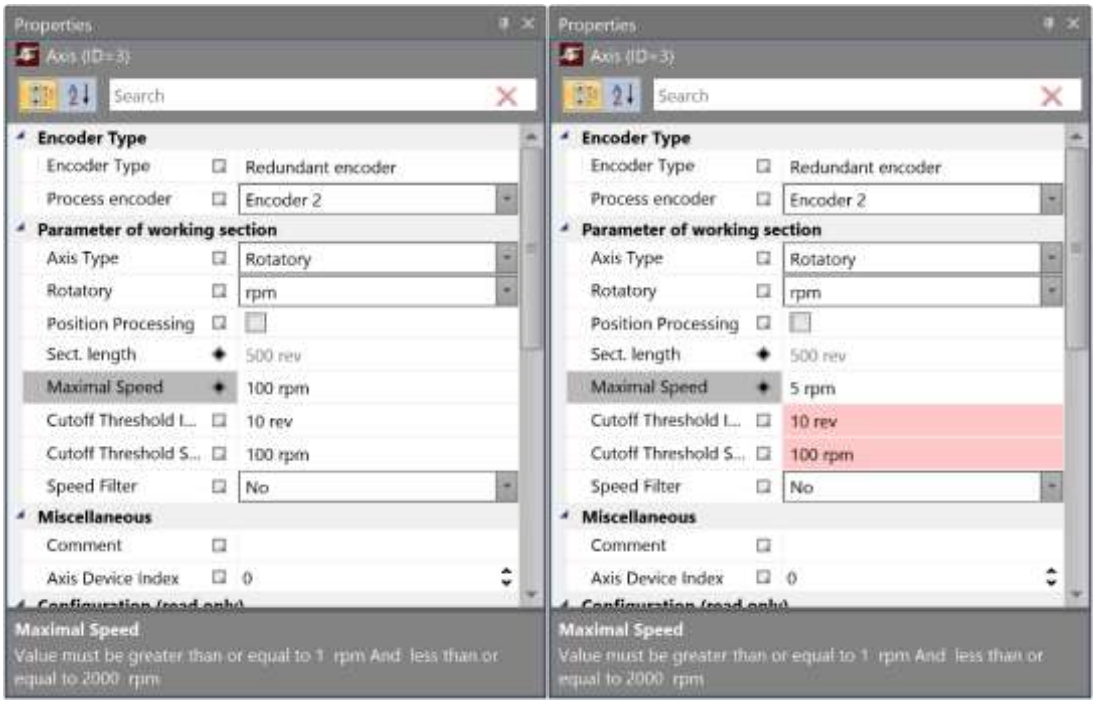
Input validation checks if an editor value is within a range specified by the property and if the value does not contain any illegal characters. If the value is invalid, a red rectangle is drawn around the editor.



Example of input validation. Value of the Number of Input Connectors property is out of range

3.7.2.2 Value validation

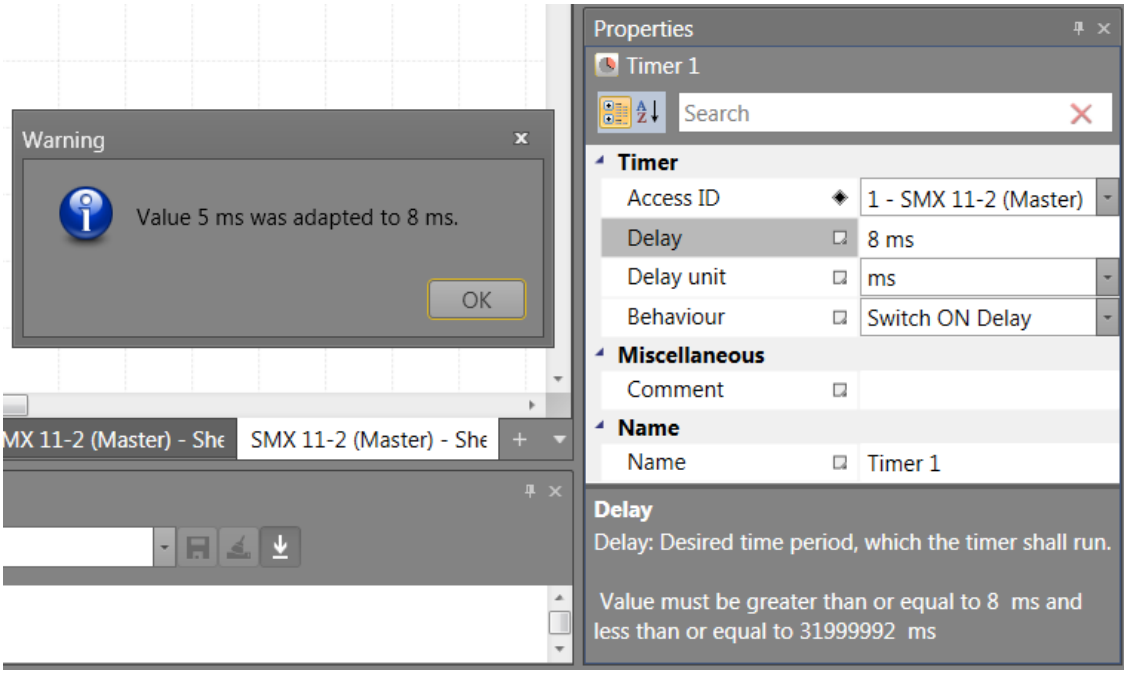
Value validation checks if an editor value meets the constraints defined by other properties. If the value will become invalid, the background of the editor will turn red.



Example of value validation. After changing value of Maximal speed property to 5, Cutoff Threshold properties became invalid

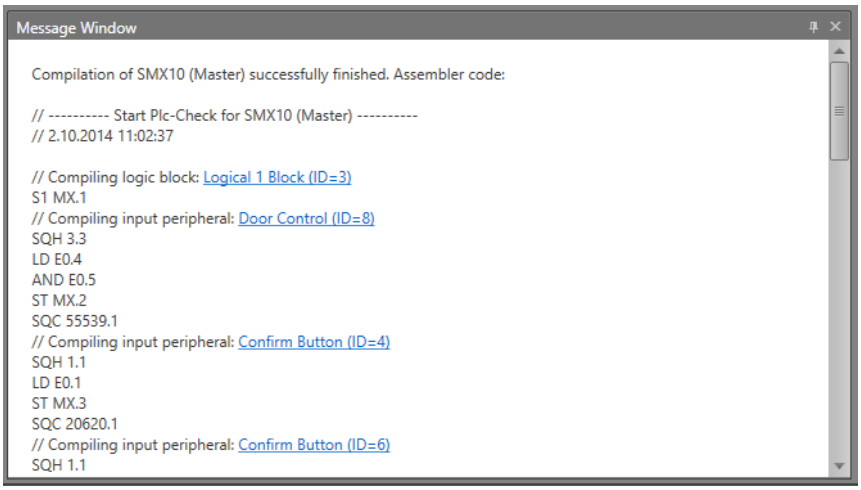
3.7.2.3 Adaptation function

Adaptation function is a special kind of validation, when an adaptation function of a property is used to evaluate the property value. If the value does not meet constraints defined in the function, the function will update the value and display a message box with a description about why the value was invalid.



Example of adapation function. After changing the value of the Delay property to 5, the value was evaluated by adaptation function and was changed to 8.

3.8 Message window



Besides the output of status and error messages as well as the display of results from the examination of the Functional scheme, the messages window also is a powerful tool for checking function block data within their context.

Quick Jump

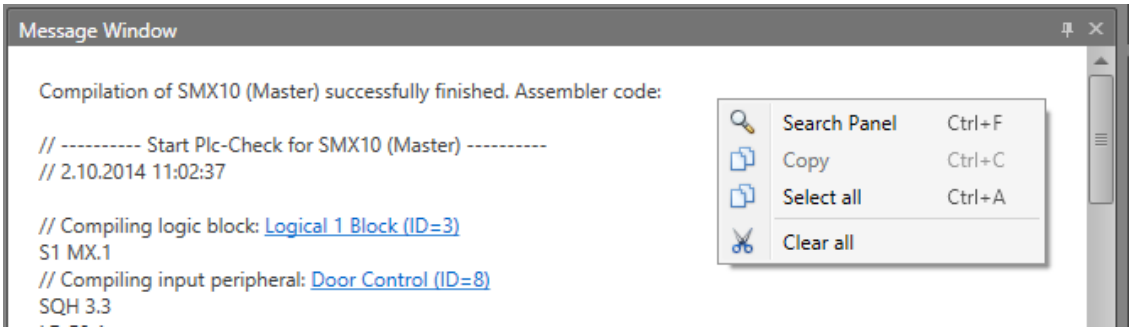
By clicking on the colored BlockID's in the message window one can navigate to given element so that canvas scrolls to proper position to ensure element is visible.

Search Panel

Search Panel is available through keyboard shortcut Ctrl+F. Take into account that this shortcut works only when message window is focused. Second way to show Search Panel is via context menu.

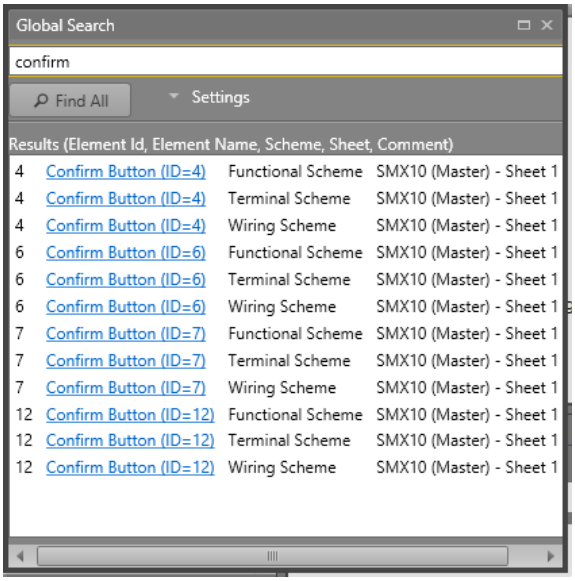
Search Panel allows user to search through compiled code. To find next occurrence one has to click on Find next button  also available through F3 key. By clicking on Settings one can expand or collapse additional settings. By checking the checkboxes user can determine the search method.

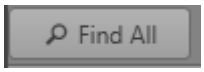
Context menu in message window



Search Panel toggles search panel visibility.
Copy currently selected text into clipboard, making the text available for pasting.
Select all selects whole text.
Clear all deletes whole text.

3.9 Global search



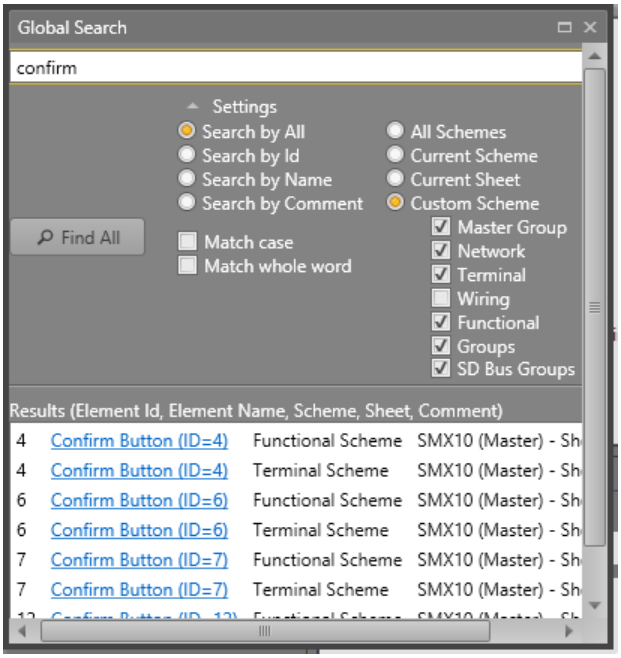
Global Search is a powerful search tool. Text entered into search box will be searched based on settings. To find all occurrences of given text one has to click on "Find All" button 

or press Enter key.

Search Settings

By default search settings section is collapsed and one has to click on Settings expander 

.

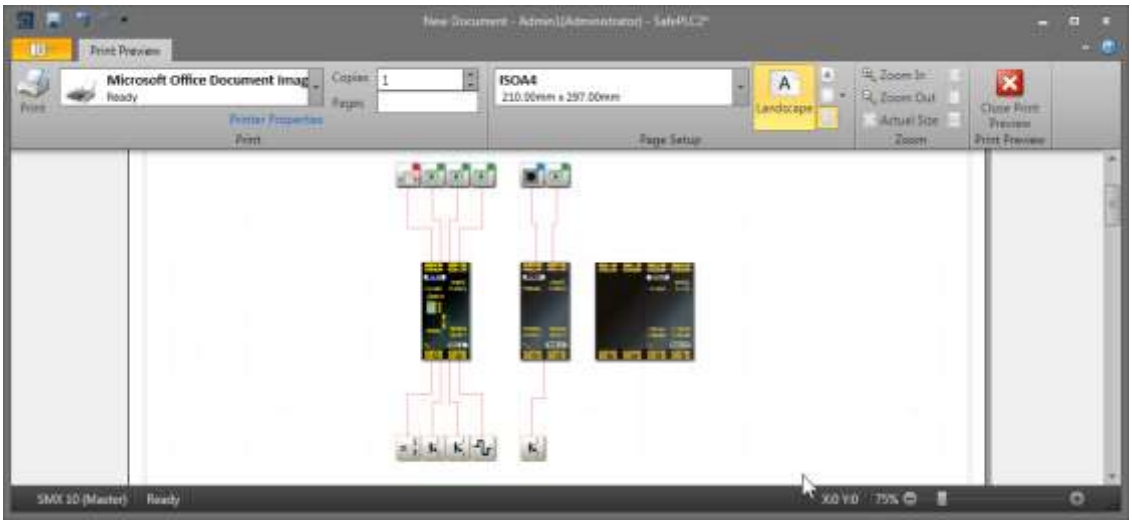


Besides well known settings such as Match case or Match whole word Global Search also provides user to search by Id, by Name or by Comment. In addition one can determine from which schemes results should be displayed.

Quick Jump

By clicking on Block name user gets immediately navigated to block.

3.10 Print



Print allows to print created scheme on paper. It is possible to select printer and set printer properties. You can set how many copies should be printed and set range of pages which should be printed.

Page setup menu group:

There it is possible to set paper size, orientation (Landscape, Portrait), paper margins (Left, Right, Top, Bottom) and it is possible by using Print Grid toggle button turn of and on grid on the paper.

Zoom menu group:

Zoom In – Zoom in content in preview window (+10%).
Zoom Out – Zoom out content in preview window (-10%).
Actual Size – Zoom content to 100% size.
Page Width – Shows page full width.
Whole page – Shows whole page in preview window.
Two pages – shows two pages at the same time.

Scheme selection menu group:

Terminal Scheme toggle button – sets whether the terminal scheme will be printed or not.
Wiring Scheme – sets whether the wiring scheme will be printed or not.
Functional Scheme – sets whether the functional scheme will be printed or not.
Close Print Preview – close window for print preview.

To print scheme from document:

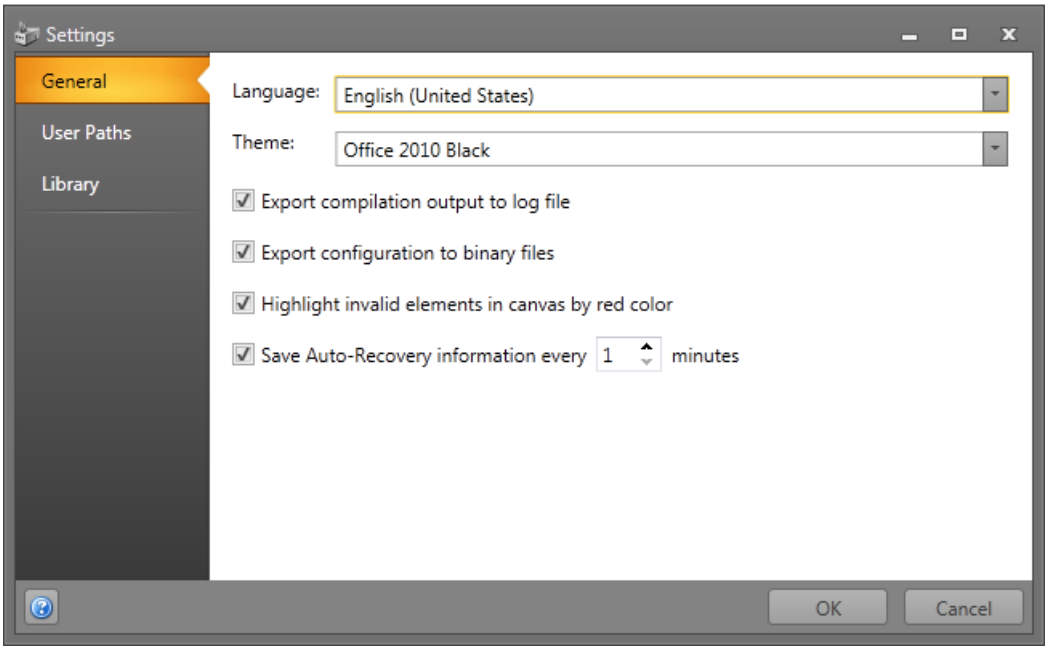
1. Click on print button via home group tab (or click on print on the quick access toolbar or use keyboard combination Ctrl+P).
2. Check the printing preview for terminal,wiring and/or functional schemes before printing.
3. Select the printer from list with ready status.
4. Set the Number of copies and pages.
5. Set Page setup properties such as paper size, orientation, margins and you can switch on or off Print Grid.
6. In Page setup group you can set paper size, orientation, margins and you can switch on or off Print Grid. For Advanced printer properties click on Printer properties.
7. Click on print button 

. When you want edit scheme or continue work close print preview 

.

In Zoom group it is possible to set zoom for print preview.

3.11 Settings

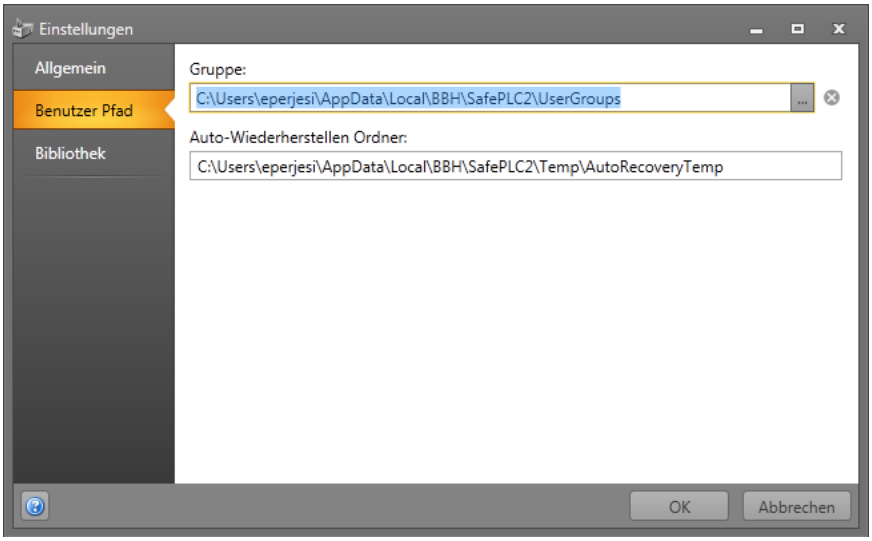


Settings window allows user to change application settings. To switch the category one has to click on desired tab on the left of the program.

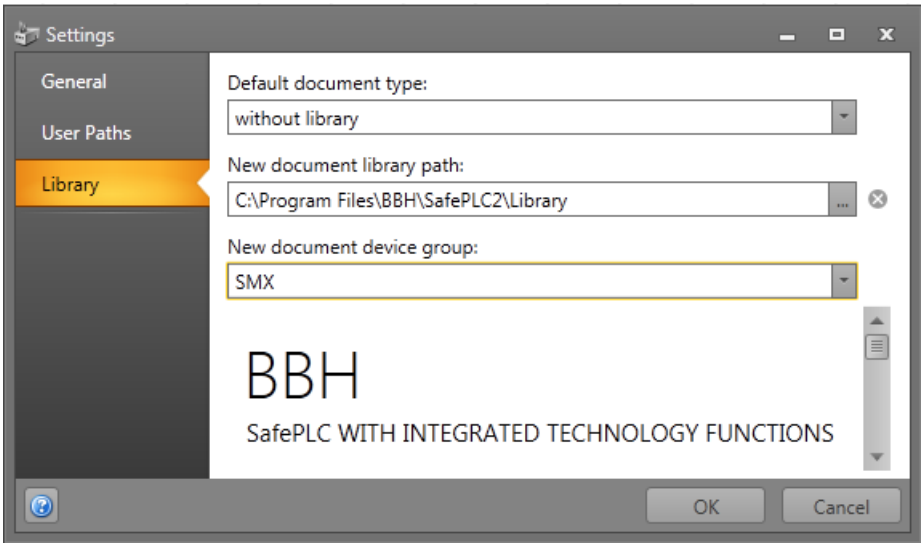
General:
Language selection - setting German, English
Theme - Setting the color scheme of the interface (light or dark).
Check-on or Off - Setting and activation of the following functionalities:

- Saving the compilation result in a log file
- Saving the configuration in a binary file
- "Highlighting of invalid canvas elements in the workspace with red color" to activate the validation in the workspace
- Setting the auto restore function every X minutes

User paths: Save destination of groups and Auto-Recovery folder.



Library: Library settings and path to *.splib file. There is also possible to set device Group.



Default document type:

A selection of the document type can be made::

- Without library *.spl2:
- File size is very small. Program can be opened with the same or newer SafePLC2 with the same range of functions.
- With library *.spl2l:
  File size is very large. Program can be opened with the same or newer SafePLC2 regardless of functionality.

NOTICE

All necessary libraries are saved here. This ensures that the functions are identical even though a new version may have been changed.

New document library path:

Einstellung des Speicherort der Bibliotheksdatei * .splib.

New docuent device group:

If multiple device groups have been created, these can be preset.

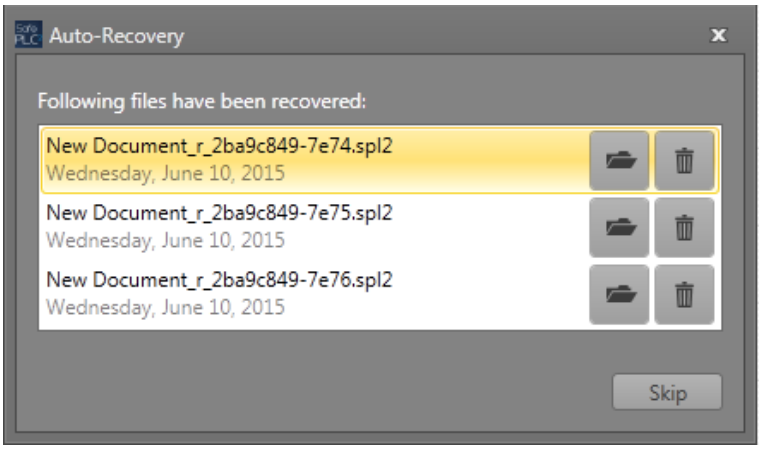
NOTICE

Device group change require restart application to be taken in account.

3.11.1 Auto-Recovery function

SafePLC²has a built-in Auto-Recovery function. This feature saves document process of opened file at a user-definable fixed interval (1 to 60 minutes). The files can be recovered if program closes unexpectedly, for example, during a power failure or unexpected crashing. This ***SafePLC²***function saves the document process in the temporary file directory whitch path is in User Paths tab.

Restarting *SafePLC²*
After crashing allow user to select Auto-Recovery saves, delete save or click skip to pass the selection to the next start ***SafePLC²***. However, this does not saves protect data when ***SafePLC²***closes normally.



Open file – This will allow to continue process with selected recovery file. Other saved recovery files remains to next restarting ***SafePLC²***.

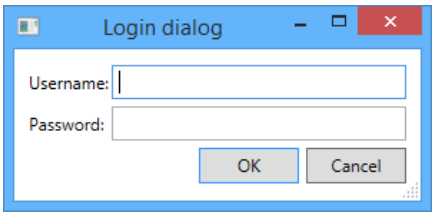
Delete file – Delete recovery file and program continue with blank document. If only one recovery file is available, next selection is not necessary.

Skip – Skips the recovery selection and continue program with blank document. Recovery selection keep files to next restart ***SafePLC²***.

3.12 About the program

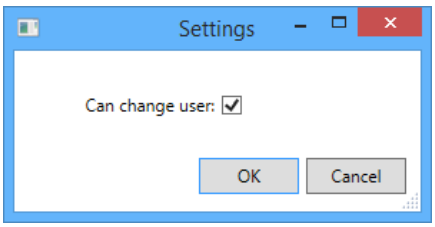
"About the Program" window shows brief information about Windows system, application build and compilation information. Below these is typically placed vendor information and web url.

3.13 Change user

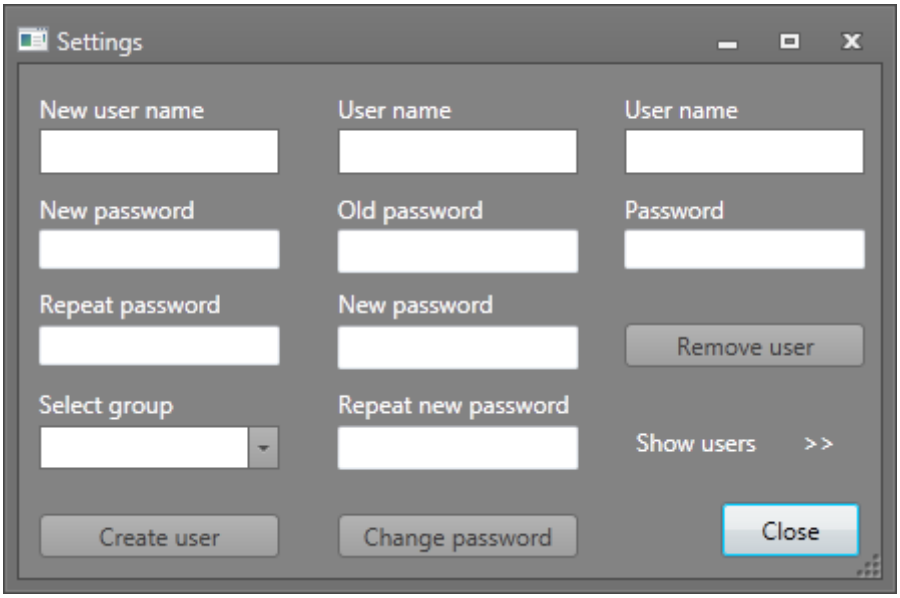


Change user window allows user to log in or log off. This window and its functionality is highly vendor dependent.

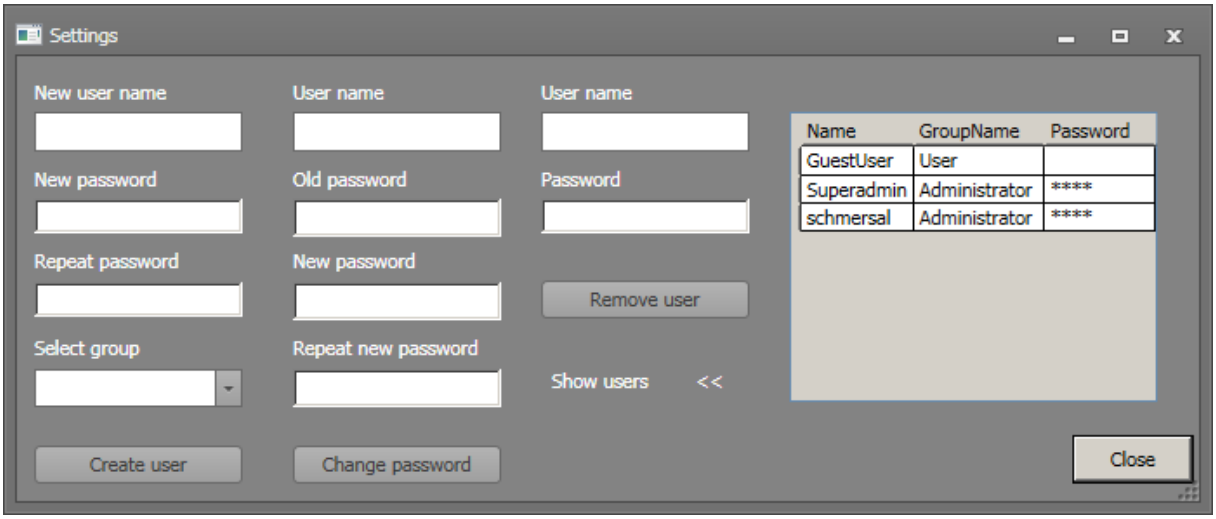
3.14 User Service Setting



Similar to Change User window its functionality is highly vendor dependent.
Via this dialog is possible to manage users (create new users, change password for existing users and remove users).



First column serve for create new user. Second column for change password for existing user and third for remove user. To see defined users click on „Show users".



Similar to Change User window its functionality is highly vendor dependent.

NOTICE	The update of the changes of user database only take place after restarting the application.

3.15 User rights dialog

The user rights dialog allows an administrator to change user permissions for every object in a scheme. The application implements three specific permissions that apply to each object:

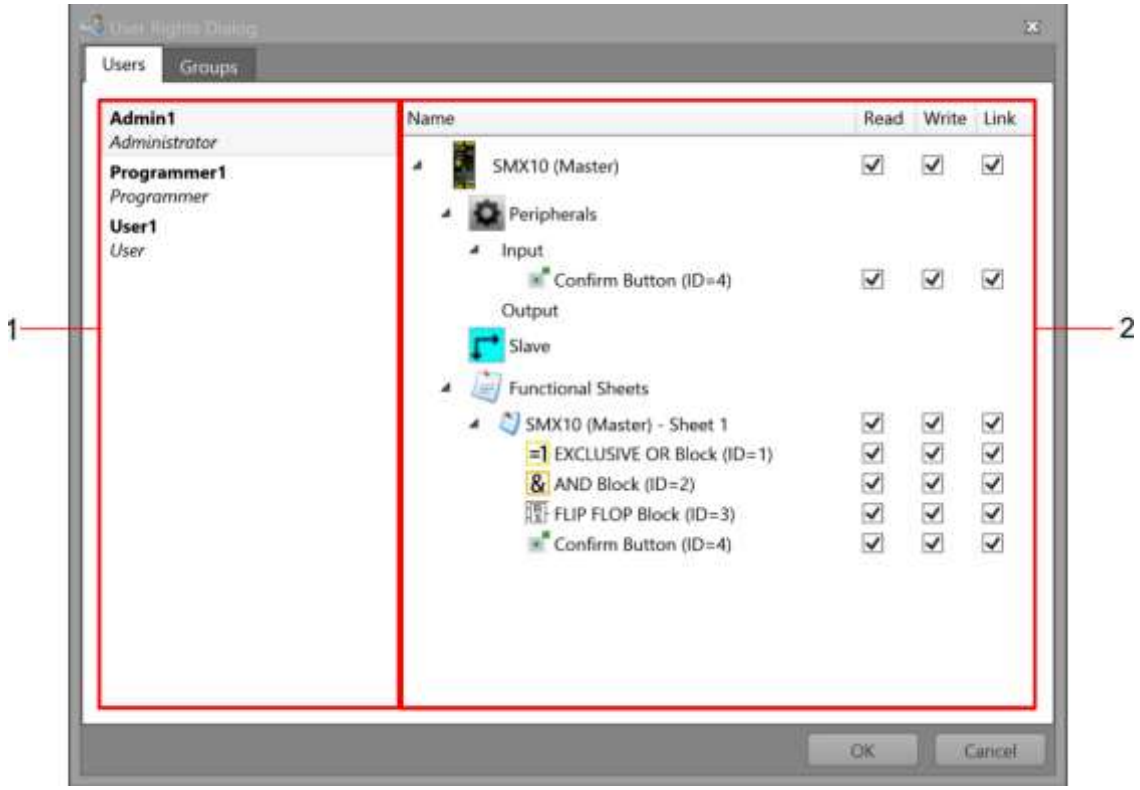
1. The Read permission grants the ability to read the properties of an object.
2. The Write permission grants the ability to modify the properties of an object.
3. The Link permission grants the ability to link an object with another objects.

NOTICE

The dialog is accessible only to administrators.The dialog can opened by pressing the User Rights button on the Home tab. The dialog consist of Users and Groups tabs.

3.15.1 Tab "users"

On the users tab an administrator is able to modify permissions for every other user.



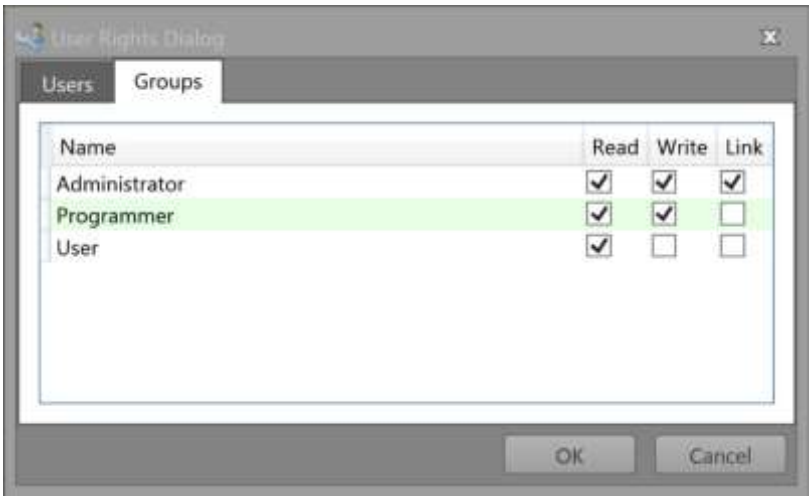
Users tab of the User rights dialog.

1. List of users along with the name of the user group to which they belong (e.g. Administrator). Each user employs a default set of permissions, unless overriden, which he inherits from the user group
2. The list of elements along with the permissions of the currently selected user.

NOTICE

User can change permission for every block or group independently by right mouse button and selecting change permission option.

3.15.2 Tab "Groups"



Groups tab of the User rights dialog

The Group tab allows an administrator to change the default permissions of individual user groups.

4 Procedure

The program ***SafePLC²*** is a graphically oriented software for creating a PLC-based monitoring program for the SMX module. This device enables reliable monitoring of drive motors. The procedure described hereafter has been found most effective for the programming of the SMX devices, whereby it is not strictly prescribed.

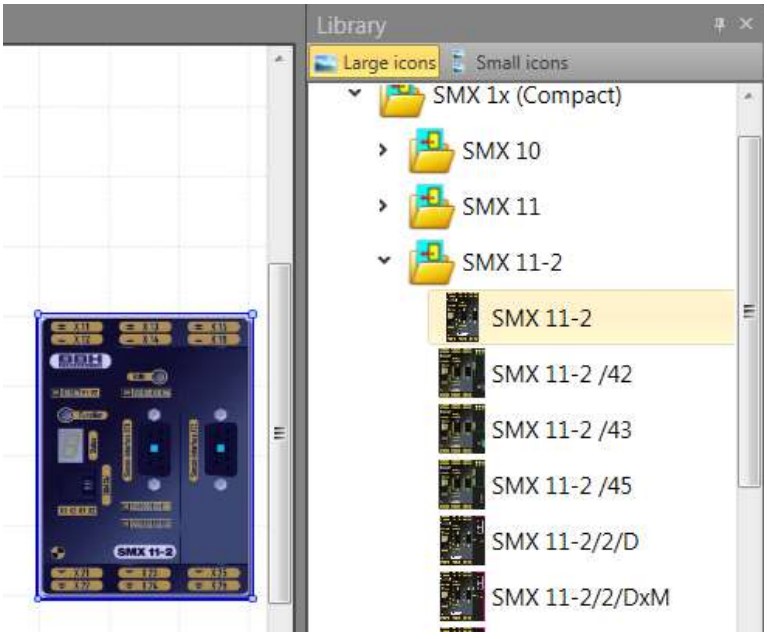
General note:

The program requires write and read rights of the user logged in to the PC that is used for programming. Missing access rights can lead to side effects in Functional scheme debugging or cause problems when saving logic diagrams to directories with limited rights.

4.1 General Workflow

Drag an icon in the library or a menu option and Drop it to the canvas to insert in selected scheme. If it is possible the item will automatically add a block in canvas. The proposed process steps correspond with the considerations, which should be executed when planning a safety related monitoring of a drive axis.

"Drag & Drop"



To add a block or device simply use "Drag & Drop".

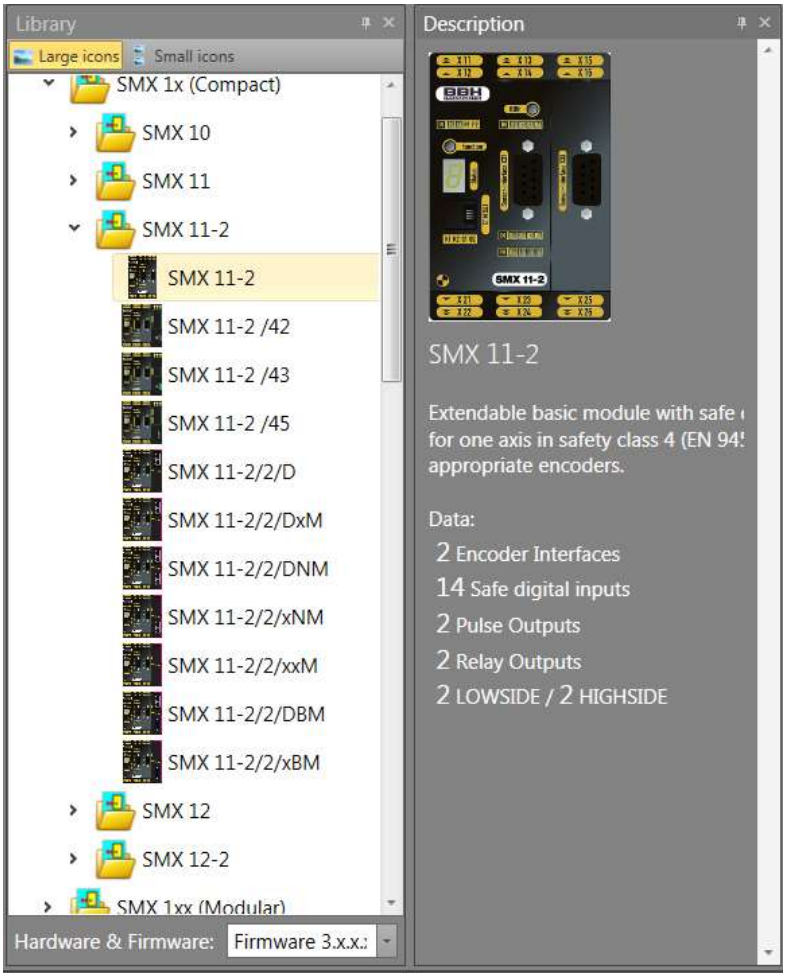
The basic sequence involved in drag and drop is:

- Move the pointer to the object
- Press, and hold down, the button on the mouse or other pointing device, to "grab" the object. The “Esc”-key cancels this mode.
- "Drag" the object to the desired location by moving the pointer to this one
- "Drop" the object by releasing the button

Please proceed as follows to create an application:

1. Selection of the device type to be programmed

Once ***SafePLC²*** has been started, or if a new logic plan is to be created, the blank canvas will appear. All available devices are in library. Clicking on appropriate mudule the description window shows the modul preview and data such as: programming interface, safe monitoring or number of sensor interfaces, digital I/Os, outputs, inputs etc. The desired modul can be added via Drag &Drop.

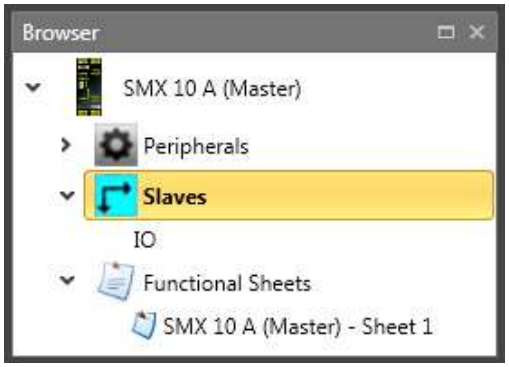


Device preview description

To add In a first step the system device must be selected to continue procedure.

Adding slave device:

If the master device is added to terminal scheme, to add secondary device must be in browser tree selected slave device. Otherwise the master device will be replaced. The program will show replace alert message.



NOTICE

Due to the associated resources and their management in the programming environment, the changing the equipment type at later date are not recommended.

The following property grid can be used to assign a name and to choose the parameters "Cycle Time" for each input cluster.
The setting "Cycle Time" is changeable to 16ms, 24ms and 32ms.

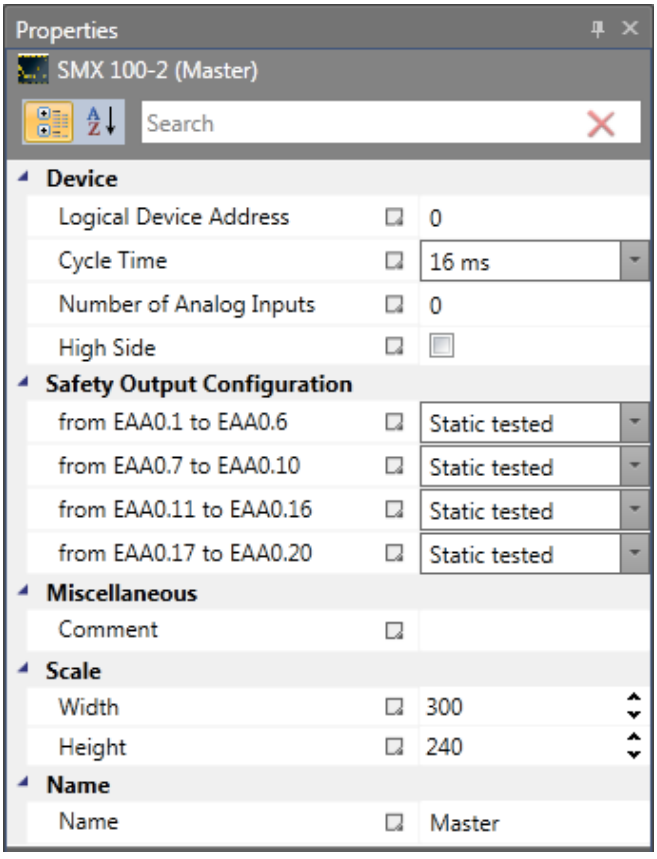


Fig. 18: Device property grid

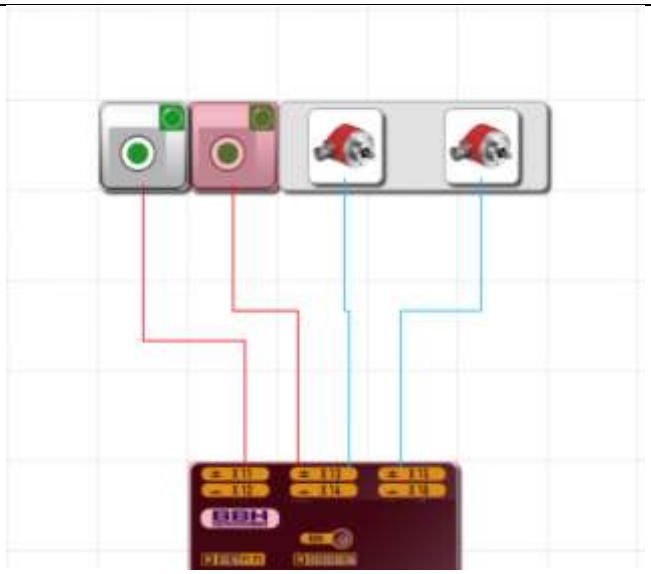
2. Determination of peripheries in terminal scheme

The terminal scheme represents the simplified scheme with selected devices, encoders, inputs and outputs of the SMX-system. The required modules are automaticly linked after inserting to it.

The following procedure is recommended:

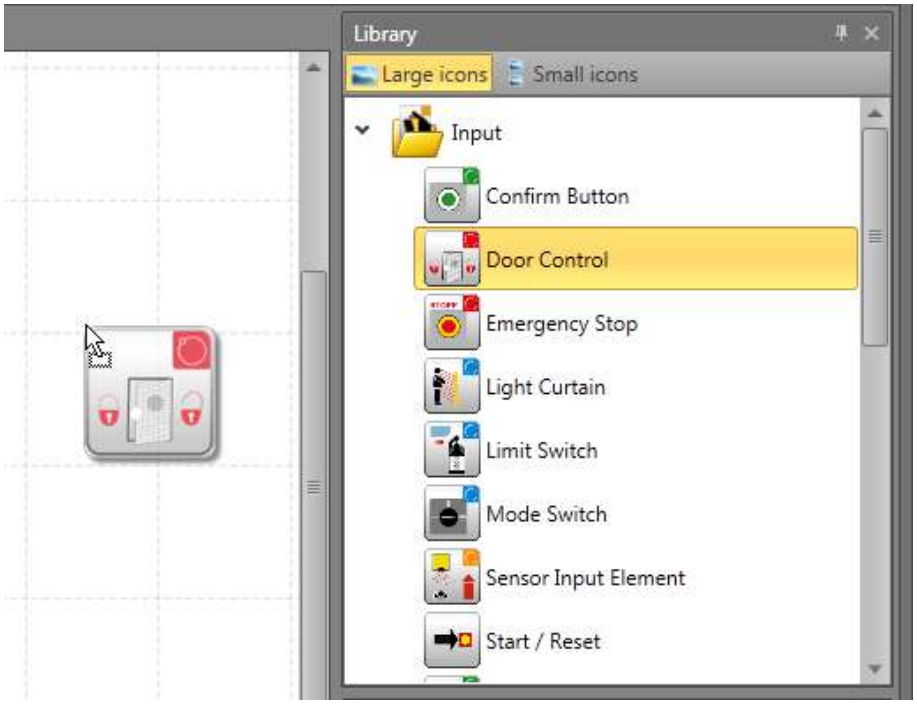
- Select appropriate peripherals type in browser tree.
- Choose module from library.
- For modules with speed and position monitoring the definitions of encoders used and their parameters are required.

NOTICE A red icon indicates the missing parameterization.



Confirm button with missing parametrization (red)

For a module with analog processing the interfaces used must be parameterized.
Selection of input and periphery modules (Confirm Button, Door Control, Emergency Stop, Light Curtain, etc.) via the library "Input elements"



Equally add required output modules (Semiconductor, Relay , etc.)
The wiring scheme represents the connections to sensors and actuators of the SMX-system with displayed connectors. After choosing the required peripherals, these are subsequently linked with each other.

NOTICE

The program matches the first and the last control point to the associated function block connector. The input and output connector is not considered a control point and does therefore not need to be specified.

3. Definition of peripherals in the functional scheme

The functional scheme shows the logic modules and their internal linkage Peripherals that has not yet been inserted into Functional scheme then such items contains green arrow indicating these items can be dragged and dropped to Functional scheme

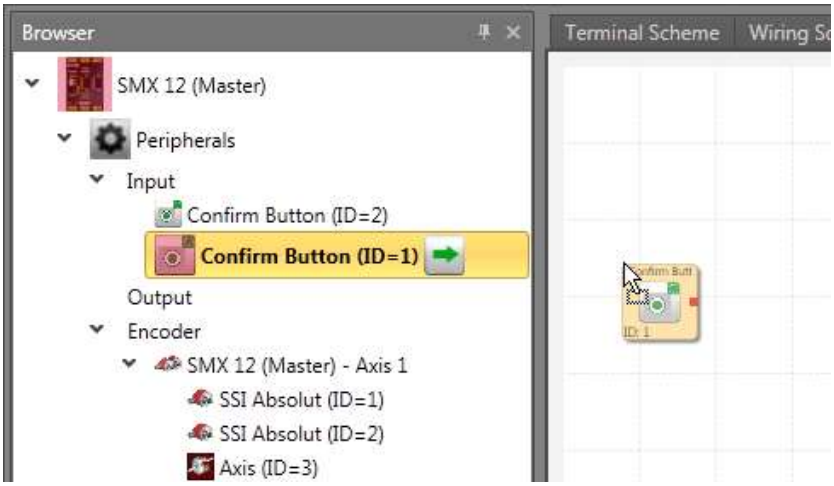


Fig. 19: Inserting the input block

4. Definition of monitoring functions and logic modules in the functional scheme

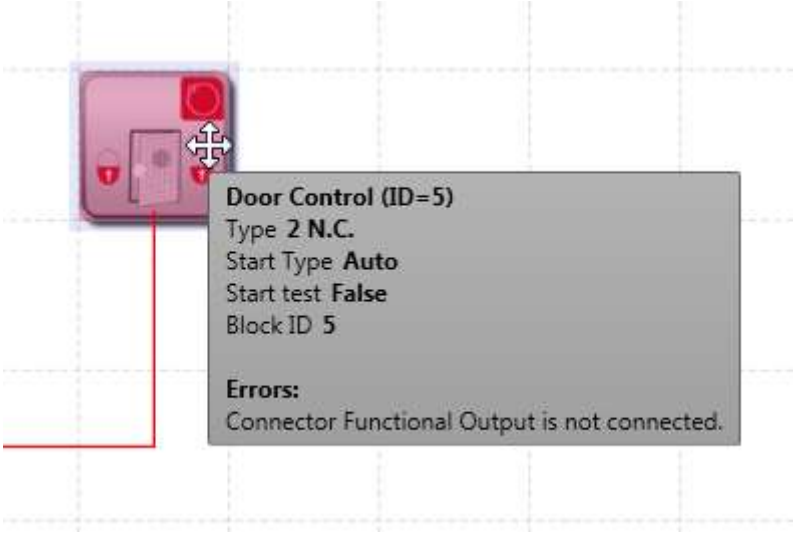
The functional scheme shows the logic modules and their internal linkage

Programming of the functional scheme by using:

- Logical and processing elements.
- Timers, flip-flops (trigger elements) and terminal blocks.
- Monitoring modules for drive monitoring (this is only possible, if the associated sensors had been defined).

After choosing the required modules, these are subsequently linked with each other.

For this purpose drag the mouse pointer across a "start connector".First press the left mouse button in start connector, and then by second clicking connect a "target connector" For more info see chapter „Wiring".



Info display

5. Compilation of monitoring program

After completion of the programming process the functional scheme is compiled and transformed into a machine readable format.
This process consists of:

- Examination for open connectors in the logic diagram
- Examination of boundary conditions for the monitoring functions
- Examination of the correct distribution of cross-circuit pulse numbers
- Generation of a transferable OP programming code for the SMX module

6. Program transfer to basic SMX by clicking on device interface 

After opening device interface dialog window, the program automaticaly compile the program. Process of transfering program consist of:

- Setting the COM output
- Transfer of the machine program
- Testing the program on the SMX module
- Disabling the logic plan after approval
- Preparation of the configuration report and validation of the configuration

4.2 Adding Input elements

The input elements create the digital connection between one or several connected sensors and/or further lower-level switching devices in the ***SMX System***. Each input element, except the mode selector switch, provides one logic output signal "0" or "1" for further processing in the PLC.
The input elements are automatically added and edited in the "Terminal scheme" or "Wiring scheme" view. In the "Terminal scheme" the Input blocks are inserted from browser.

The resource control of the function block elements for the SMX-system manages the available elements, the number of which may be limited.
If no further elements are available when programming the terminal scheme, blocks for adding the corresponding modules or function blocks is not available. The available blocks shows in library. These resources can be released again by deleting the corresponding function blocks. To delete block select the block from browser or canvas and by right mouse button select Delete or press Del.

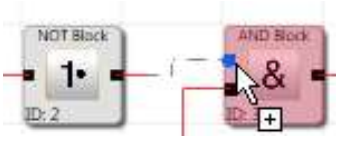
4.3 Inserting output elements

The output elements create the digital connection between one or several connected external switching circuits in the ***SMX System***. This logic diagram element exerts a direct influence on the drive to be monitored. Moreover, one can also specify how external switchgear is to be monitored. Each output element is triggered by a logic input signal "0" or "1" via the functional scheme.
The output elements are added in the "Terminal scheme" or "Wiring scheme" view. Edit the Output elements in "Functional scheme".
In the "Terminal scheme" the Output blocks are dragged and dropped from browser.
The automatic monitoring of resources of the function block elements for the SMX-module has the effect, that only the available elements are enabled in the program. If there are no resources available for the monitoring program in the SMX-module, the commands for inserting the corresponding components or function blocks will be disabled (library options is not available). This is e.g. the case when all digital outputs of the SMX module are occupied. These resources can be released again by deleting the corresponding function blocks.

4.4 Logic modules

These modules form the basis for creating a program for the safety application. They enable the logic linkage of the input with monitoring functions with and the outputs.
Inserting logic modules is only possible in the "Functional scheme" view, otherwise the associated menu commands are disabled. This is the case when the resources for a module are already exhausted, e.g. after all timer modules have been inserted.
For description of each Logic module see chapter „Logic functions"

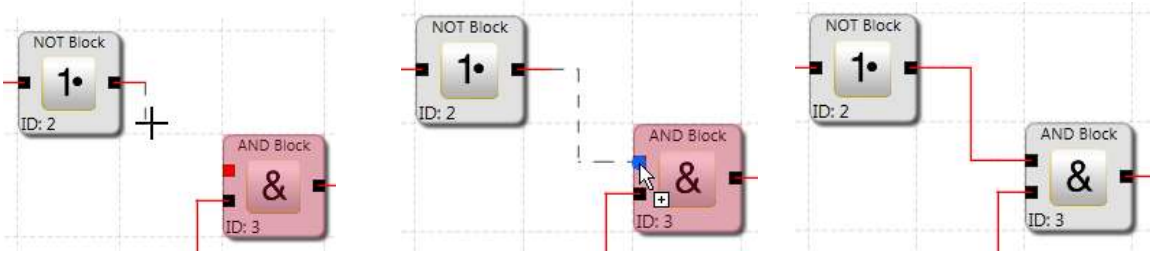
4.5 Wiring



The assignments in the functional scheme are created by linking the input and output connectors of the functional modules. An output of a module may, if necessary, be multiply connected with inputs on other modules, whereby any input must only be assigned once. Apart from this, certain module groups cannot be interconnected for technical reasons. In case of an invalid connection the program will display a corresponding message.
Only orthogonal control points can be generated, i.e. the connecting lines will always run horizontally or vertically.

Connection set-up:

1. First press left mouse button to select a start connector.
2. User can define rout by simply clicking the clear area to define breakpoints.
3. Second click to select target connector.
4. If Auto-arrange is enabled the connection and block will be automatically arranged.



NOTICE

Connections can only be selected with a mouse and deleted by Del button.

Tip: If all connections of a module are to be deleted, one should delete the associated function block. The connected connections will in this case be automatically deleted.

The program routes a new connection in Terminal or Wiring scheme automatically. The program draws the connection by inserting additional control points (breakpoints) based on a bisectioning algorithm.
The graphics display can be varied and the overall presentation optimized by simply moving the function blocks(if auto arrange is disabled). In complex diagrams it may happen that a connecting line will intersect with a function block. This behaviour has no influence on the internal function of the linkage.

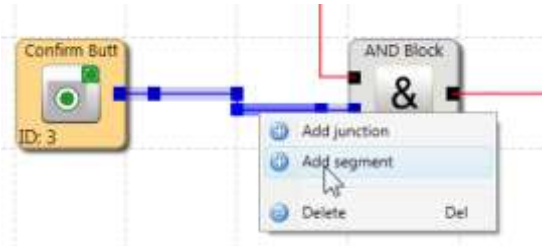
NOTICE

Not all scheme types created connection automatically.

Support of drawing of user defined connecting lines is additionally available. These will remain existent, until the dislocation of an associated function block forces the recalculation of the control points (see arrange buttons).

Add segment

To adding segment in the connection line press the right mouse button and select add segment.



To add junction doubleclick on connection line or press the right mouse button and select Add segment.

User can define connection by selecting the connection and each segment can be modified.

NOTICE

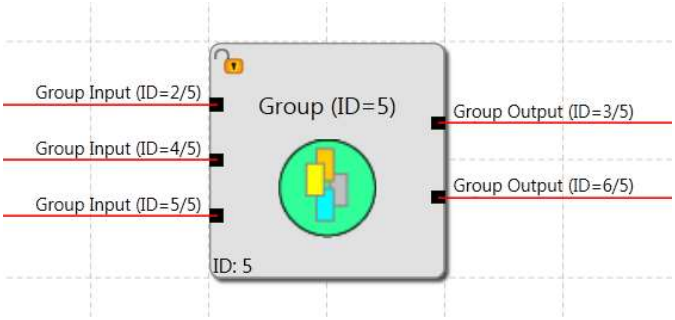
If segments of connection are aligned they are automatically unified.

Input of control points for orthogonal connecting lines , i.e. the connecting lines always run horizontally and vertically. The program connects the entered points, until the drawing command is terminated.

Tip: Visual corrections to the logic diagram should only be made just before the logic digram is blocked. Only then the layout is complete and the blocks do not need to be displaced any more.

4.6 Using groups

Function groups connect several functional blocks to a superordinate logic structure. This matching group of blocks is created inside the function group and connected via this block.



This grouping gives the function block diagram a much clearer structure and, with the export / import functionality, enables the creation of an own function library.

4.7 Program creation

After the program has been finished, the compilation process can be started by invoking the compiler . The results are displayed in the message window witch is automaticlly switched on when compilation is created. After starting the compiler, the compilation process will run in the stages described below. The results are displayed in the message window, which is automatically switched on when the compiler is started.

Verifying for open connectors

SafePLC² makes sure that all connections between function blocks can be opened. Unconnected connectors are recognized as faults.

Verifying for unreferenced "Terminal In" and „Terminal Out"

SafePLC² makes sure that all terminal blocks inserted in the logic diagram are used. Unsolved references are recognized as faults.

Verifying the value ranges of the monitoring functions

Before creating the IL, ***SafePLC²*** checks whether the parameters of the monitoring functions are inside the value ranges of the current encoder configuration. In case of a modification of the encoder settings with a monitoring functionality that had already been determined, an unnoticed area overflow may otherwise occur.

Creation of the instruction list (IL)

The IL-code created on basis of the function blocks is output in the message window, where it can also be verified, The code segments associated with the function blocks are identified by the corresponding BlockID.

Creating the OP code

Generation of a machine readable code for the SMX-system, which is then transferred together with the parameter data.

Message window

All results of the compilation process are reported in the message window. Should faults be found, the message window will automatically pop up.

***Tip*:** Use the "Quick Jump" feature to be able to jump directly to the associated block in the diagram by simply double-clicking on a displayed *BlockID* in the message window. This way one can easily identify the corresponding function block in case of fault messages.

Backup CRCs

After a successful compiler run a total of three CRC-signatures is made:

- Equipment configuration CRC: Signature concerning program and parameter data
- Parameter CRC: Signature concerning parameter data
- Program CRC: Signature concerning the program

NOTICE When an existing SafePLC program is opened with a later version of SafePLC, this program will be ported. In order to ensure a complete portation another step is strictly required.

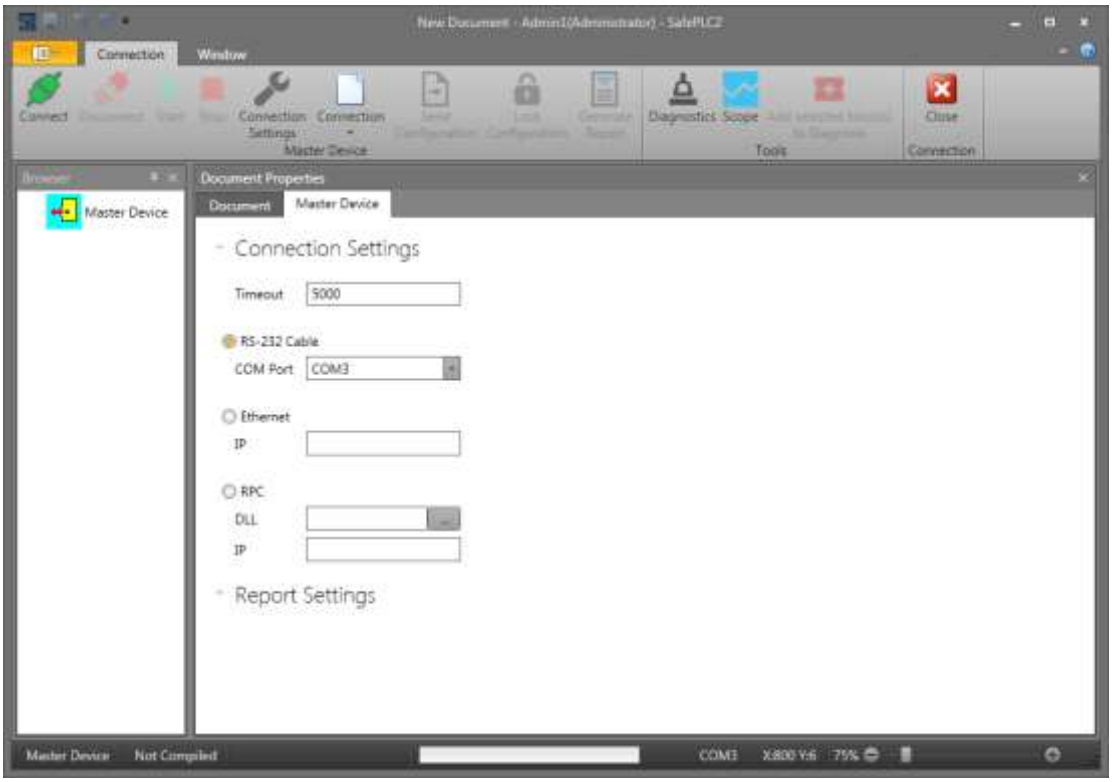
IMPORTANT This display is only informative and must not be used for the safety related documentation!

4.8 Transfering the program on the device

This paragraph describes the data and program transfer to a basic SMX module. Once the interface has been started(via device dialog button Device Interface), the Device interface toolbar will appear. Toolbar contains connection and transfer tools for communication with device. Description of device interface in Device Interface chapter.
Connection settings tool open the Document management window with document and device tab.

NOTICE

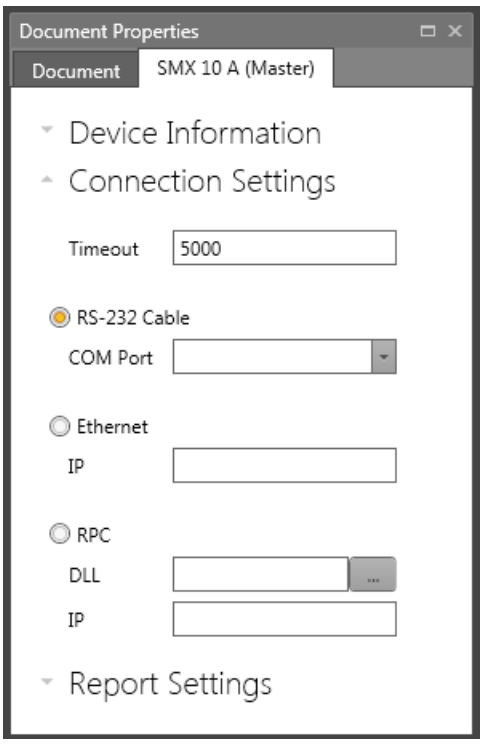
In case of multiple devices each device has one separately tab. Document tab allow user to add developer name and write comment. Device tab consist of Device Information and Connection settings. This window is available also via Document properties switch from Window Ribbon Menu.



More accurate current transfer states or possibly occurring faults are displayed in the message window. Due to the limited space this window is not automatically activated with each message, so that as much of the logic diagram can be displayed in the diagnose.

NOTICE

The connection between PC and SMX-system is based on a USB/RS485 interface. This requires fault-free installation of the correct driver. This driver is included in the scope of delivery and is located in the installation directory of the ***SafePLC²*** programming environment (directory `RS485_USB_Treiber`).



Connection settings

Connection settings:

Timeout

The time in milisecond for communication timeout can be set.

RS-232 Cable

The COM interface used by the Windows driver must be set.

Ethernet

The IP adress must be set.

RPC (Remote Procedure Call)

Browse for a DLL file for communication with PLC. In empty field bellow DLL field it is possible to write parameters (arguments) for choosen DLL file.

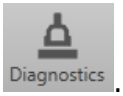
Disconnecting on the PC-side:

At the latest after 5s the system will detect that the connection no longer exists and will also not be re-established automatically, if the connection is to be set up again.

Disconnecting on the SMX-side:

At the latest after 10s the system will detect that there is no connection. However, the connection will be automatically set up again, if the physical connection is re-established.

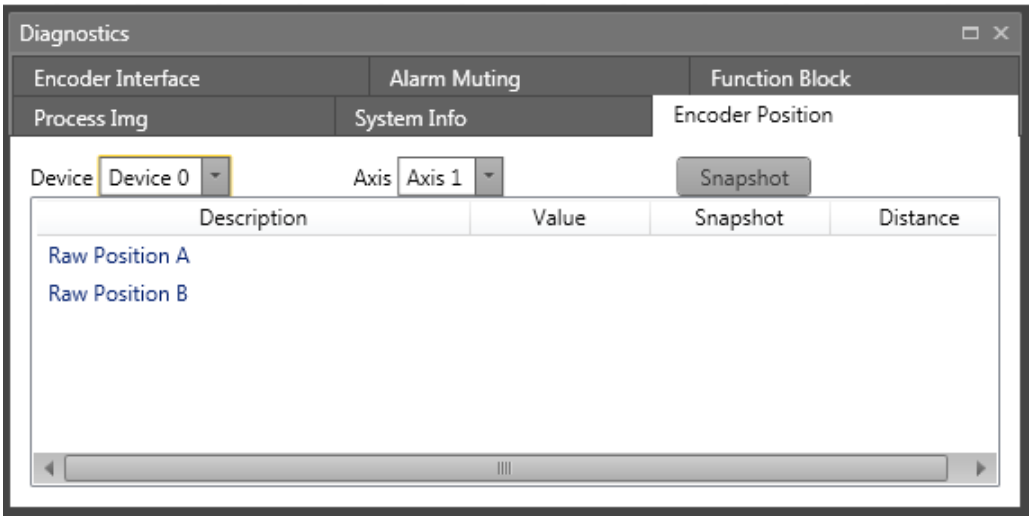
4.9 Diagnostics

After activate the Device Interface there is available Diagnostics button tool 

. When clicking on the Diagnostics button the Diagnostics window will appear. Diagnostic function can not be running simultaneously with Scope function window.

NOTICE

A correct diagnose requires the adjustment of data between functional scheme and equipment configuration. A missing logic diagram or a discrepancy between the available logic scheme and the equipment configuration only permits a limited diagnose. The functionality "Diagnose function modules" is in this case not available.



Diagnostics window consist of following sheets:

Process Image: Display of the states of all addresses of the input and output image in the SMX module. The CRC of the active configuration is displayed together with the status of an internal transfer counter. This counter is incremented during each transfer action to the SMX module and can be used as reference for the purpose of documentation.

System Info: System information about the SMX-module. As follows:

Parameters	Description
Overall – CRC	CRC signature concerning program and parameter data
Configuration - CRC	CRC signature concerning the parameters
Program CRC	CRC concerning the program
Transfer counter	Status of an internal transfer counter This counter is incremented during each transfer action to the SMX-system and can be used as reference for the purpose of documentation.
Serial number	Current serial number of the equipment
Version number	Firmware version number

Encoder Position: Shows the position values for encoder A and encoder B which have actually been transferred by the encoders. User can mark the actual l position via snapshot button. The program will show the distance parameter from the registered position.

Encoder Interface: Shows the voltage differential of the driver modules and the status of the input jumpers in the encoder interface. If one of the values for the voltage condition is 0, the encoder is defective or not connected. The value for the input jumper must be interpreted differently.

In case of incremental encoders:

0 := Jumper OK
1 := Fault

In case of SSI encoders:

0 := Listener operation
1 := SSI encoder operation

Alarm Muting: Show active alarm muting functions.

Function Block: Enables selective monitoring of memory states of pre-selected function blocks. To select function blocks for diagnostics from Canvas use button Add selected block(s) to Diagnostics. This tab allow to see logic condition "0" or "1" in the functional scheme.

4.9.1 Procedure for function block diagram diagnose

The main condition to run diagnostics is that program is Started i.e. Start button in Connection toolbar is gray shaded.

4.9.1.1 Diagnostics in Canvas

Diagnostics in Canvas works only when user select in Diagnostics window Function Block Tab. After selecting Functional Block Tab diagnostics start automatically.

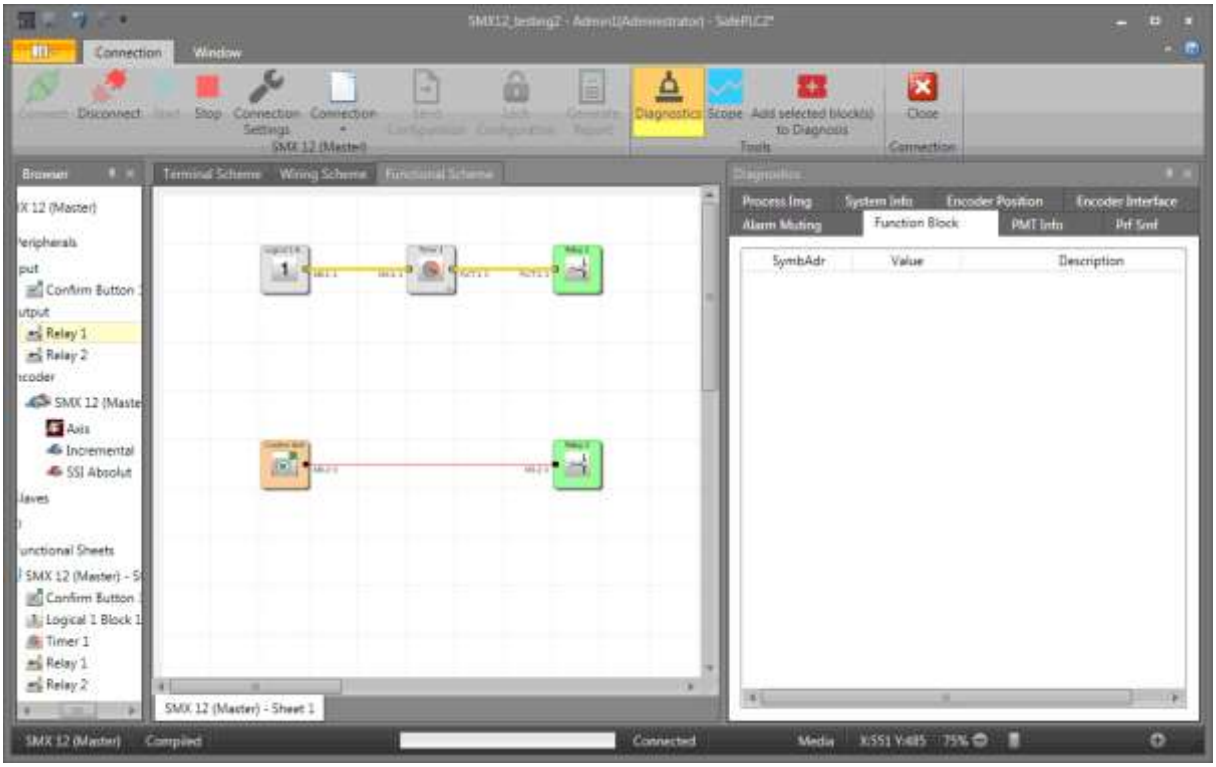


Fig. 20: Running diagnostics in canvas

When running a Canvas diagnose, the current input and output states are displayed in scheme according to their logic condition "0" (red color line) or "1" (yellow color line). The logic condition is also showed in Canvas next to Connector ID.
If the "Tab" of the Diagnostics window is changed from "Functional Block" to another diagnose mode i.e. another Tab (e.g. "Encoder Position"), a diagnostics information disappear from Canvas.

4.9.1.2 Diagnostics in Function Block Tab

It is possible to run diagnostics for selected blocks.

Selecting the data to be displayed

If one has changed to the Functional Block Tab it is possible to select function blocks, the status of which is to be monitored. Functions blocks can be selected in Canvas and after selection press "Add selected block(s) to Diagnosis" 

button. By pressing this button, the blocks are taken over into the monitoring list.

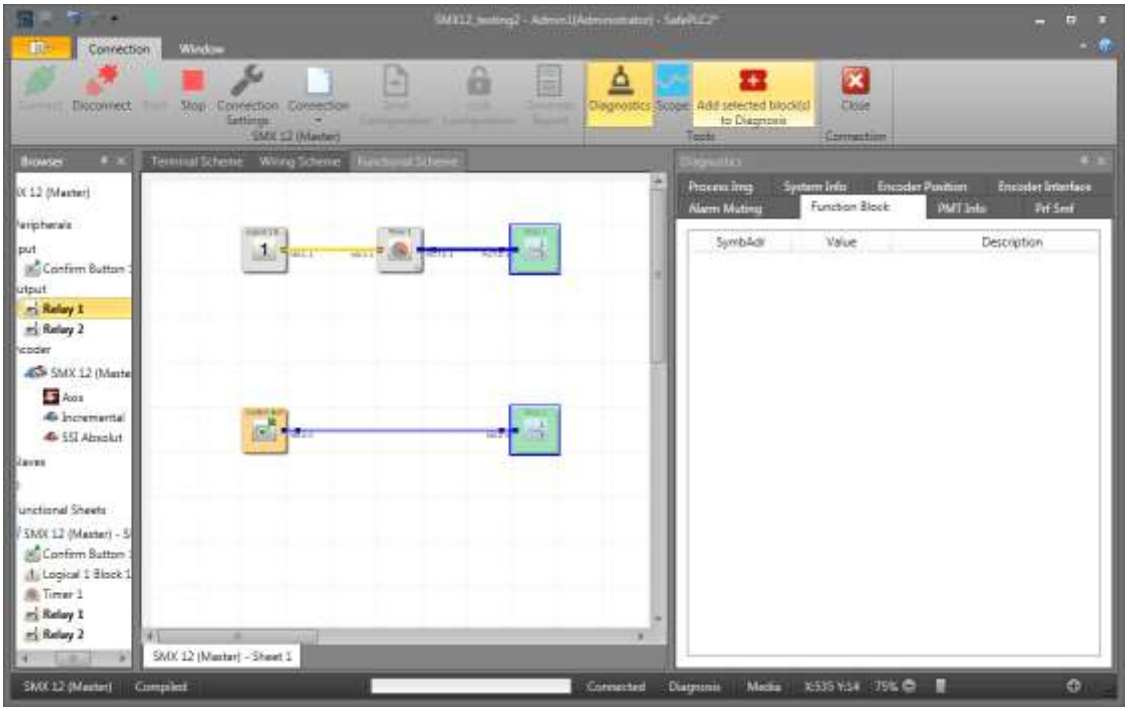
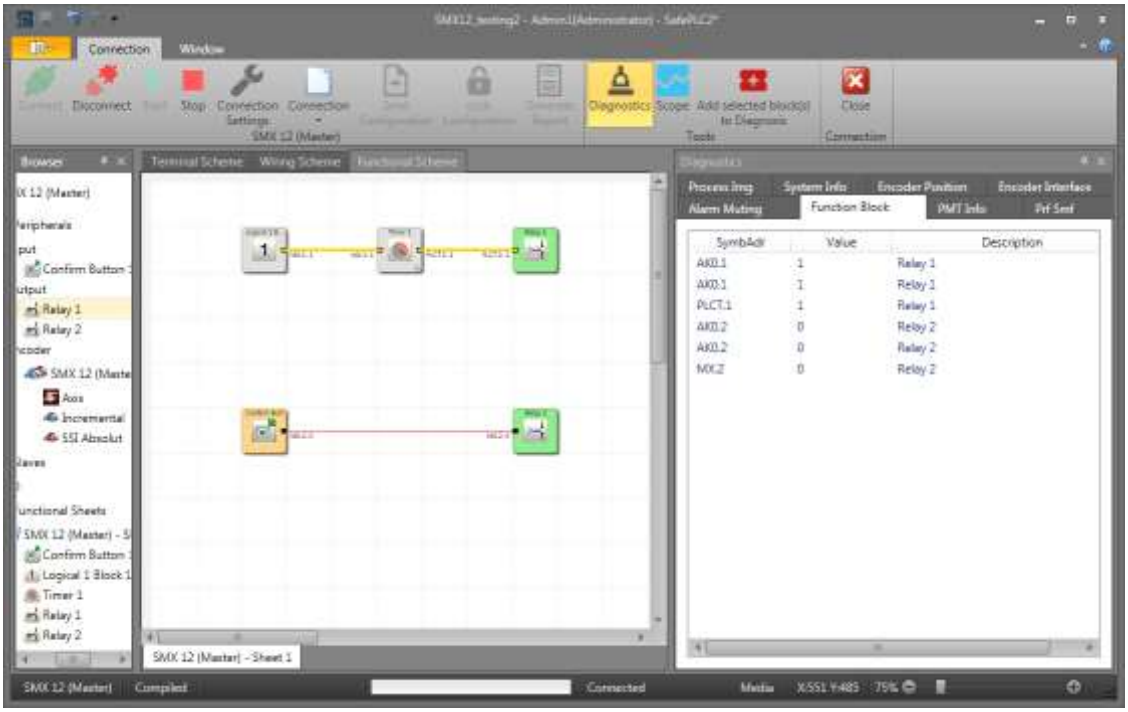


Fig. 21: Selected blocks in Canvas

In monitoring list, there appear Symbol Address, Logic Value and Description for each added block. When running a Functional Block diagnose, the current input and output states of the function blocks are displayed according to their logic condition "0" or "1" on the selected block.



To remove block from monitoring list it is possible by marking block and pressing „Del" button.

Double-clicking on a list entry shows the associated Function block in scheme.

NOTICE

The symbol addresses shown in the list are also used in the compilation and in the validation report.

Tip: The "Select all" command from the context menu (right mouse button) can be used to select all data from the Functional scheme.

The selected data can only be diagnosed if the information in the functional scheme corresponds with the information in the actively connected SMX-system.

NOTICE

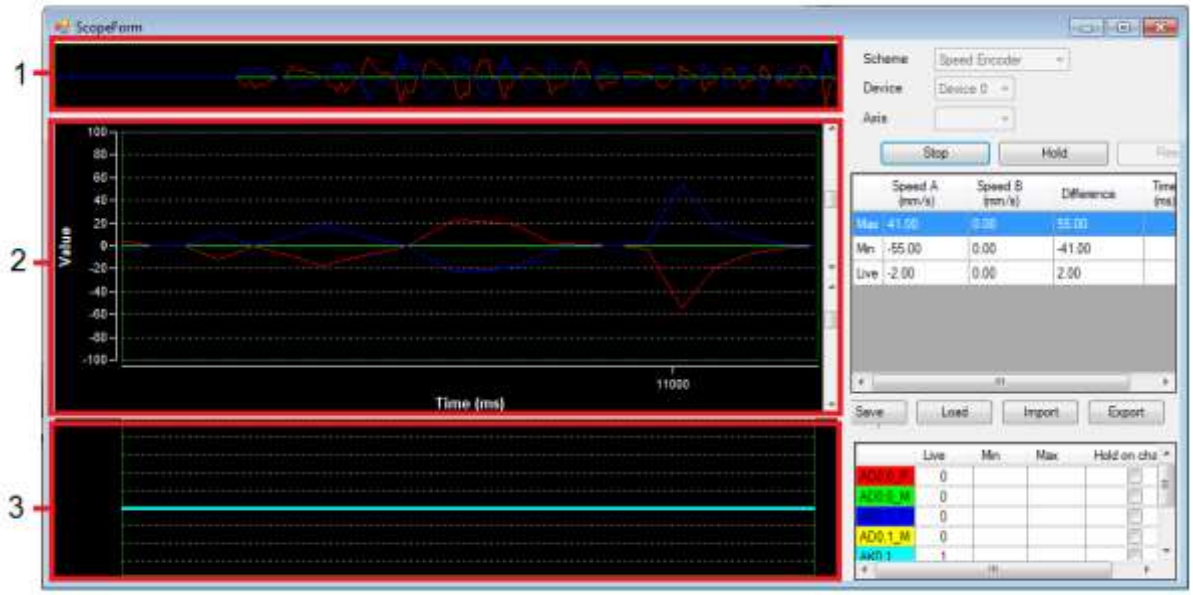
The implemented debugging function requires intensive data transfer between SMX-system and SafePLC2. This results in a temporally delayed display of data. Quick status changes on module outputs may therefore not be detectable.

ATTENTION

If the SMX module changes to a state of alarm, the process representation is no longer updated. Changing input levels no longer have any effect and will also no longer be shown in the diagnose.

4.10 Scope monitoring

Parameterization of drive monitoring requires exact knowledge of process data from the point of view of the SMX-system. Knowledge about the temporal course of speed, acceleration and position is of outmost importance. Only this enables the setting of correct threshold values and limiting parameters.
Scope function is available in Device Interface dialog. Select the scope monitor function by activating the „Scope“  button. If diagnostics button  is enabled clicking on Scope button will be immediately canceled.



Device interface Scope view

- **1-** Overview scroll bar
- **2-** Main diagram window
- **3-** Signal output window

All available graphics functions read the required process data ONLINE from the active basic SMX-group through the communication interface for time-based representation. Up-to-date values are inserted at the right border of the Scope Monitor, moved further to the left during recording, until they finally disappear at the left border of the screen. Although these data have disappeared from the visible window, they are still maintained in a buffer memory and can still be moved back into the visible area by sliding the scroll bar beyond the main diagram window.

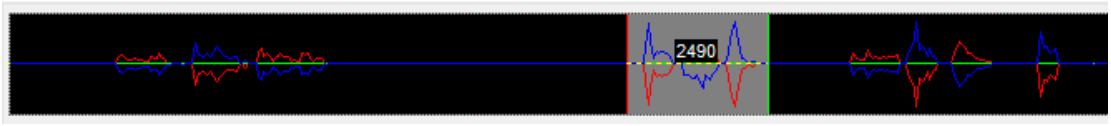


Fig. 22: Overview scroll bar for main diagram

Scheme: The "Scheme" function is used to select the current context for the desired visualization. Depending on the „scheme" selection from the selection list, the context of the displayed graphs will change. These are assigned via the colour specified in the legend.

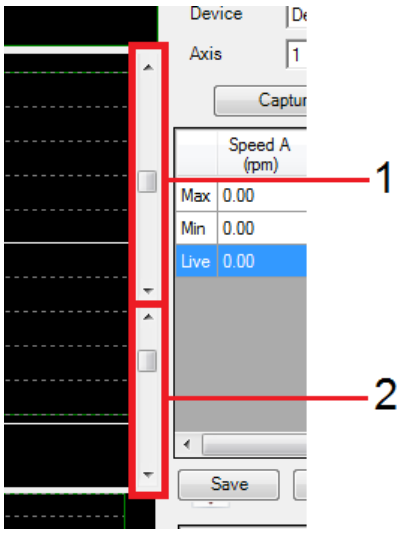
The following is available:

- Encoder data
- Speed Encoder
- Data SSX1 Block
- Data SSX2 Block
- Data SSX3 Block
- Data SSX4 Block
- SEL (Time Based)
- SLS Filter
- SCA Filter
- Sensor Pass
- Encoder Position
- Analog filter
- Analog Adder

Depending on whether the scheme shows time or position dependent values, the X-axis is used to show the progressing Tick Time, or the measuring length configured in the encoder. The Y-values refer to the selected scheme.
Changing the scheme during a progressing measurement is blocked.

Device: Selection of device.

Axis: When using several identical functions, these can be selected and displayed separately via this selection. The values of these measuring data are displayed for each relevant cursor position



Scaling diagram using Slide bars
Scaling the displayed diagram function enables the adaptation of the Y-values in the individual graphs by Slide bar1/2.

Slide bar1: change the Y-values visible area on diagram.
Slide bar2: Change the maximum displayed Y- value range of the diagram.

Capture / Stop: Start or stop recording.

Hold: Press the Hold button to stop displayed values in main diagram with data still maintained in a buffer memory.

Reset: Reset the diagram values and process data.

Tip: Double clicking in main diagram window will insert pointer at that position. This will add the Cursor in value table for optional measurement.

Hold on change: If the switch "Hold on change" is set, recording will stop 2 seconds after an edge change of the specified output (see above). This function enables long-term recording and fault analysis with no operator present.

Save: Once the Scope has stopped, there is a possibility to save the current recording in a file. The Scope data are written in a file as ASCII values. The individual values have XML - tags assigned, so that the recording can be used for the purpose of documentation of for the analysis associated with the encoder configuration. The data can also be viewed with the current Microsoft Explorer or with any other XML-viewer.

Load: With this control button one can load a measurement saved in a Scope XML-file into the Scope. The Scope dialog will in this case change to viewer mode. Due to the possible difference of the encoder configuration of the viewed measurement to the current program and the deviations in the scaling of position and speed values resulting from this, the "Start" button and the scheme selection list are disabled, after data have been loaded for display. Measurements remain disabled, until the Scope is restarted.

Import: Import measurement from .ScpXml files.

Export: Export the measurement of one selected output to .ScpXml file.

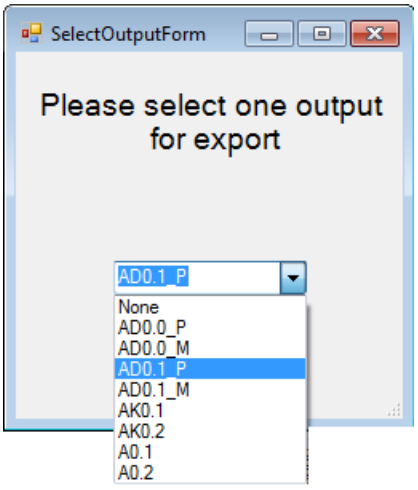


Fig. 23: Selecting output for export

4.10.1 Procedure when measuring with the scope

After the Scope dialog has been opened it is still in "Stop" mode, i.e. no cyclic process data are read-in from the SMX-system. In order to be able to perform a more or less fault-free measurement, you should proceed as described below.

NOTICE

Note: All Internet or LAN based applications (e.g. mail program), which run in the background, should be closed before the measurement.

4.10.2 Preparing the measurement

Choose the desired measuring scheme: In case of a speed oriented measurement the running tick time of the SMX module is displayed on the X-axis. It must be considered as a continuously incrementing counter for the system ticks of the SMX module. The measurement data for the graph are continuously updated and maintained in the buffer memory. The recording memory is approx. 15 minutes.
The measuring process is automatically stopped when the buffer memory is full. The previous measurement is automatically saved under "ScopeTempData.ScpXml".
With position oriented measurement the configured measuring range of the set axis is displayed on the X-axis.

NOTICE

Note: When changing the scheme, any recorded data from previous measurements will be lost. When changing the dialog size the display data must be rescaled. This requires position oriented measuring and resetting the data buffer (SSX).

4.10.3 "Start" measurement

The control button "Capture" for starting measurement is only available in case of an active connection to the SMX-system. After clicking on this control button the data will be cyclically transferred to the buffer memory and displayed in the diagram from left to right. Active recording can be stopped with the "Stop" control button.

4.10.4 "Stopping" a measurement and viewing data

After completion of the measurement the data can be analysed by moving the slide controllers accordingly.

4.10.5 Measuring schemes

4.10.5.1 Encoder data

Functionality	• Recording of scaled position values of system A and system B over the course of time. • Recording of process values for speed and acceleration over the course of time. ***Note:*** After reciprocal comparison of the two channel values, the process value of the position is generated from one channel.
Application	• Scaling of the encoder systems A and B in case of position monitoring. In case of a correctly scaled encoder system there should be no significant deviation between positions A and B, or the deviation should not exceed the "permissible deviation" set in the encoder dialog. • Analysis and course of encoder signal for diagnostic purposes (e.g. trouble shooting, etc.) • Acceleration and speed behaviour of the drive. • Detection of thresholds.
Output	• Acceleration in [rev/min/s] in red • Position A in [rev] in green • Position B in [rev] in yellow • Speed in [rev/min] in blue • Selectable output on SMX in grey • Two cursor values – positionable ***Note:*** The assigned colours can be optionally adapted.

4.10.5.2 Speed Encoder

Functionality	• Recording the current speed of system A and system B over the course of time. • Recording the difference of speed signals from system A and system B over the course of time. ***Note:*** After reciprocal comparison of the two channel values, the process value of the position is internally generated from one channel.
Application	• Scaling of the encoder systems A and B in case of speed monitoring. In case of a correctly scaled encoder system there should be no significant deviation between speeds A and B, or the deviation should not exceed the permissible "speed threshold" set in the encoder dialog. • Analysis and course of encoder signal for diagnostic purposes (e.g. trouble shooting, etc.).
Output	• Speed A in [rev/min] in red • Speed B in [rev/min] in green • Speed difference in [rev/min] in yellow • Selectable output on SMX in grey • Two cursor values – positionable ***Note:*** The assigned colours can be optionally adapted

4.10.5.3 Data SSX1 – SSX4 Block

Functionality	• Recording of process data for speed and acceleration over the course of time. • Recording of upper and lower speed limits for the monitoring function over the course of time.
Application	• The diagram shows the dynamic behaviour of the drive via the visualization of speed and acceleration. • With the SSX not activated, the limiting speed remains zero. • When activating the SSX-function, the limiting speeds and the current speed are taken on and represented over the course of time. • If the drive with its current speed remains below the limiting speed, the system will not be shut down.
Output	• Acceleration in [rev/min/s] in red • Lower limiting speed in [rev/min] in green • Upper limiting speed in [rev/min] in yellow • Current speed in [rev/min] in blue • Selectable output on SMX in grey • Two cursor values – positionable ***Note:*** The assigned colours can be optionally adapted

4.10.5.4 SEL (Time Based)

Functionality	• Recording of process data for speed and acceleration over the position or the course of time. • Visualization of current position in form of the parallel moving cursor. • Visualization of the current stopping distance in form of a trailing pointer.
Application	• The diagram shows the dynamic stopping distance value as minimum value for the braking distance. • Examination of the set parameter values in the SEL-function, examination of the available reserve for shut-down.
Output	• Current position in [rev] in red • Speed in [rev/min] in green • Acceleration in [rev/min/s] in yellow • Stop distance in [rev] in blue • Selectable output on SMX in grey • Two cursor values – positionable ***Note:*** The assigned colours can be optionally adapted

4.10.5.5 SLS Filter

Functionality	• Monitoring the maximum speed or rotational speed of a drive • Recording of process data for speed and over position or course of time. • Visualization of current position in form of the parallel moving cursor. • Visualization of the integrated measurands over speed as position value approximation
Application	• The graph shows the current speed with reference to the set limiting speed. • Checking the shut-down when exceeding the limiting speed. • Display of the integrated speed • Control of functions, which work in dependence on the limiting speed
Output	• Limiting speed in [rev/min] in red • Limit in [rev/min] in green • Integral in yellow • Status of function in blue • Selectable output on SMX in grey • Two cursor values – positionable

(The limit indicates the limiting speed)

4.10.5.6 SCA Filter

Functionality	• Monitoring a parameterizable position range with assigned minimum and maximum values and maximum rotary speed / speed • Recording of process data for speed and over position or course of time. • Visualization of current position in form of the parallel moving cursor.
Application	• The graph shows the current speed with reference to the set limiting speed – as well as the determined position by integrating the speed. • Checking the shut-down when exceeding the limiting speed or when leaving the permitted range between minimum and maximum value • Control of functions, which work in dependence on the position range and a limiting speed
Output	• Limiting speed in [rev/min] in red • Limit in [rev/min] in green • Integral in yellow • Status of function in blue • Selectable output on SMX in grey • Two cursor values – positionable

Sensor Pass

Encoder Position

Analog Filter

Analog Adder

5 Configuration Report

SafePLC² uses the validation function (Device Interface->Generate Report 

) to create a configuration report for the equipment configuration. This function is only available in case of an active connection to an SMX-system. This function can be activated also via check box Generate Validation Report or via icon in toolbar.
Writing or editing informations and description for Generated report are in Document Properties window.

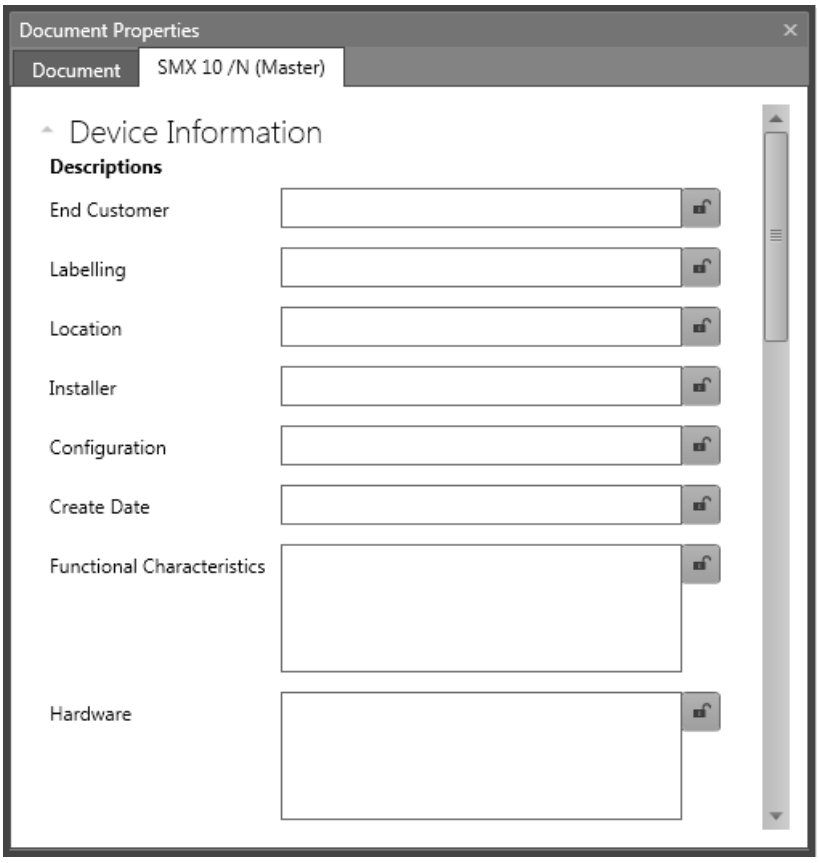


Fig. 24: Device information fields for Configuration Report

Each field has lock function.

The report is saved in a file and can subsequently be edited.

ATTENTION 

The printed file serves as <u>template</u> for the <u>safety related examination</u>!

NOTICE The report can be created only after saving the configuration file (functional scheme). The created file (*.pdf`) has the same name and is situated in the same list as the corresponding functional scheme.

5.1 Processing steps

1. Step: Editing the report header

The following fields can be edited in the header.

End customer: The name of customer
Labelling: The project label
Configuration: The configuration name
Comments: Any comments which can be useful e.g. File name of logic diagram

2. Step: Filling Acceptance

Inspector 1: Inspector's name
Date: Date of inspection
Sign: Place for inspector's sign
Inspector 2: Inspector's name
Date: Date of inspection
Sign: Place for inspector's sign

3. Step: Filling Contact Details

Version: Document version
Installation: Installation place description
Customer: Operator of equipment
Supplier: Manufacturer of machine / equipment
Installer: Information about commissioning of equipment

For fields Installation, Customer, Supplier and Installer there can be filled also Phone number and Fax number.

4. Step: Filling Description

Installer: Person who installed devices
Labelling: Identification of hardware
Location: describes the exact location of the equipment
End customer: Operator of equipment
Configuration: safety related equipment features to be monitored by the safety module
Create Date: Date when report was cerated
Functional characteristics: describes the functionality or field of application of the equipment
Comments: safety related equipment features
Hardware: Code designation of equipment

5. Step: Individual check of each system component

In this area there are check boxes, which should be checked if information mentioned there are correct.
Visual inspection for mechanical damage and correct mounting:
Component documentation is present:
Visual inspection for deviation from installation guidelines:

Device type:	Write device type here e.g. SMX 10, SMX 100, etc.
Serial number:	Serial-number of the safety module (sticker)
CRC Device Config:	Signature concerning program and parameter data
CRC Parameter:	Signature concerning parameter data
CRC Program:	Signature concerning the program
Extension Devices:	Description of extension devices
Transfer Counter:	This field can be also edited.
Number of axes:	Number of all axes

Checking the correct function:

The correct program and parameter data must be loaded to be able to generate the validation report!

The test engineer must once again validate all configured data in the printed report by providing evidence of the programmed functions on the equipment / machine.
All parameterized limiting values of the monitoring functions used must be checked for correctness. Attention must be paid to the response times mentioned in the installation manual.

A successfully executed validation should be completed by clicking on the control button "Lock validation".

NOTICE	If a new configuration is loaded to the SMX-system, the system LED will, in case of fault-free operation, subsequently light *YELLOW*. This signalizes a non-validated application! When actuating the control button "Lock validation" while actively connected with the module, the LED will subsequently flash *GREEN*.

6 User Management

With the User Management the logic diagrams can be disabled against unintended or unauthorized modifications. Here one can disable or enable access to the function blocks in the current logic diagram. This means, that in a disabled logic diagram all menu options and toolbars for adding function blocks appear in grey (= disabled). Moreover, parameters in function blocks, that had already been added, cannot be changed.
"Unlocking" requires a password. The configured values and the functional modules of a disabled diagram may in this case be viewed, but cannot be modified. This functionality make sure that no changes can be made to the logic diagram by unauthorized persons.

NOTICE	Logic diagrams can only be unlocked using the password that was applied when the diagram was disabled. A disabled logic diagram can no longer be compiled! However, access to the SMXxxx-module is still possible.

7 Device interface

Device interface is Device dialog window. This window allow the extended communication dialog such as program transfer, Diagnosis and Scope monitoring with connected SMX devices. If Device interface dialog is opened, program automatically start the compilation process. This dialog consist of device interface tools.

Icon tools for Device dialog:

Fig. 25: Icon tools in the Device Interface – disconnected

Fig. 26: Icon tools -connected

Connect: Starts the connection to the SMX-system.

Disconnect: Cancels an active connection.

Start: Starts the sequencing program in „connected" mode.

Stop: Stops the sequencing program in „connected" mode

Connection settings: Open document properties window with connection settings. In order to be able to set up a connection with a SMX-system, the transfer parameters must be set accordingly.

Connection: Allow to send or read actual configuration to file. This function is not possible with opened Diagnostics or Scope window.

Send configuration: Transmits the configuration of the function block diagram to the SMX-system. This is only possible in "Stop" mode.

Lock configuration: After each transfer of configuration data to an SMX-system, these data are marked as "not validated". The basic group signalizes this by means of yellow flashing of the status LED. The command "Disable configuration" disables access to the configuration data in the basic block. This is indicated by a green flashing status LED.

Generate report: Creates an PDF or Excel file of the current SMX configuration for the connected device. The text file lists the parameters of the configured modules and the IL program. The printout must be confirmed and released within the framework of the TÜV-approval and in accordance with the demanded regulations.

Diagnostics: Open diagnostics window. See chapter „Diagnostics"

Scope: Opens the „Scope" monitor dialog. This enables the representation of various process data.

Add selected block(s) to Diagnosis: This button adds selected elements to Function block tab within Diagnostics window Device dialog. This button is enabled only when Device dialog is showed.

Close: Close Device Interface dialog.

Device interface status bar:

1) Compilation indicator
   a. **Compiled** – compiled current file
   b. **Not compiled** – current file is not compiled

2) Progress status
   a. **None** – gray shaded indicates no configuration sequence
   b. **Sending configuration** – transmitting the configuration of the logic diagram to the SMX module.
   c. **Reading configuration** – reads out the current SMX device configuration

3) Connection status with indicator bar
   a. **Connected** – active connection to the COM interface of a SMX monitoring unit
   b. **Disconnected** – no active connection

4) Program status
   a. **Idle** – program has completed all tasks in Control tab
   b. **Upload** – program is uploading to SMX system
   c. **DownloadBinary** – program is downloading Configuration from device
   d. **Diagnosis** – program uses diagnostic tools in Diagnosis tab.
   e. **Scope** – program monitoring the time dependent courses of speed, acceleration and position in Scope tab.

5) Device status
   a. **Stop** – stops the transferred program
   b. **Run** – starts transferred program
   c. **Init** – program initializing device
   d. **None** – no connected device (only disconnected status

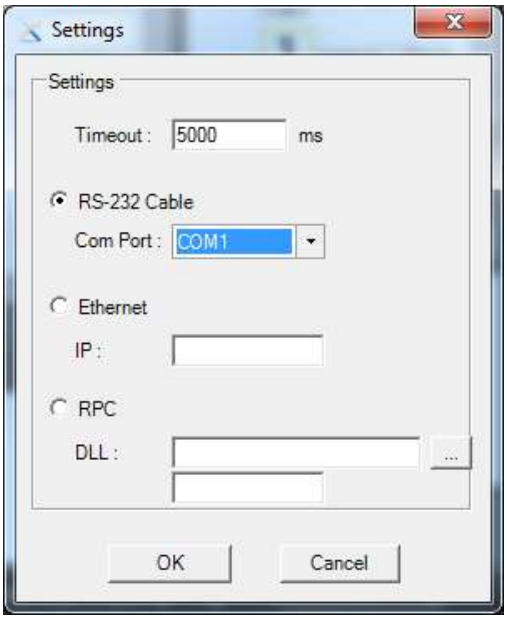
6) Alarm status : Only in case of alarm
   a. **Alarm** – Case of alarm with number of error

7) Connected COM port

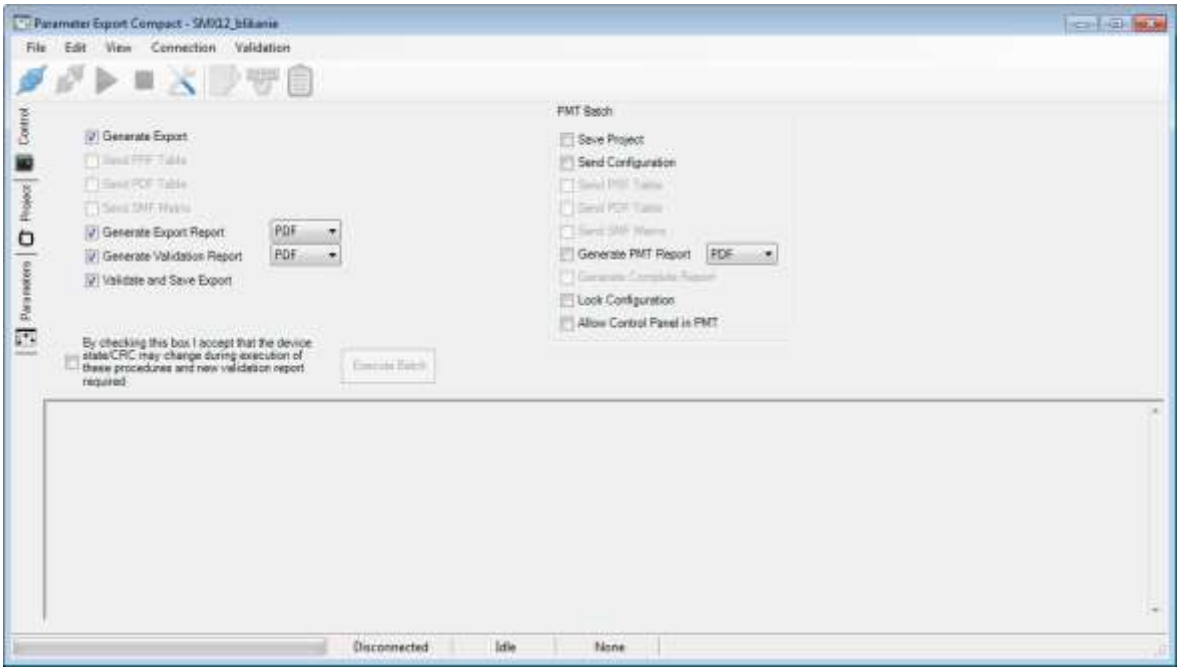
NOTICE	Diagnostic function is described chapter „Diagnostics". For more information about Scope see chapter „The Scope monitor".

8 Export dialog

Export dialog function serve to export parameters and configurations. After pressing button there appear dialog window to set connection among PC and PLC unit.

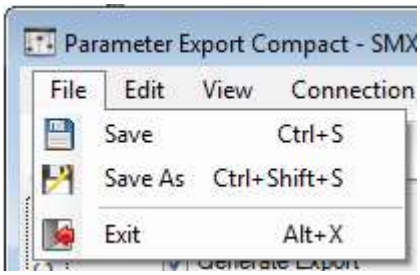


NOTICE	Connection settings are described in chapter 4.8 After connection set an pressing button OK there appear the main window for parameters export – Control Tab.

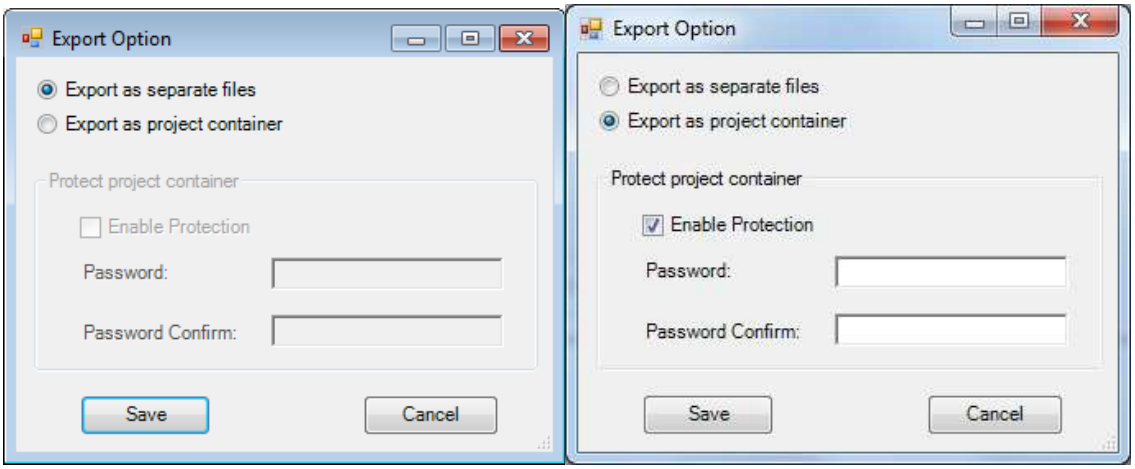


There are following menus: **File**, **Edit**, **View**, **Connection** and **Validation**.

File menu commands:

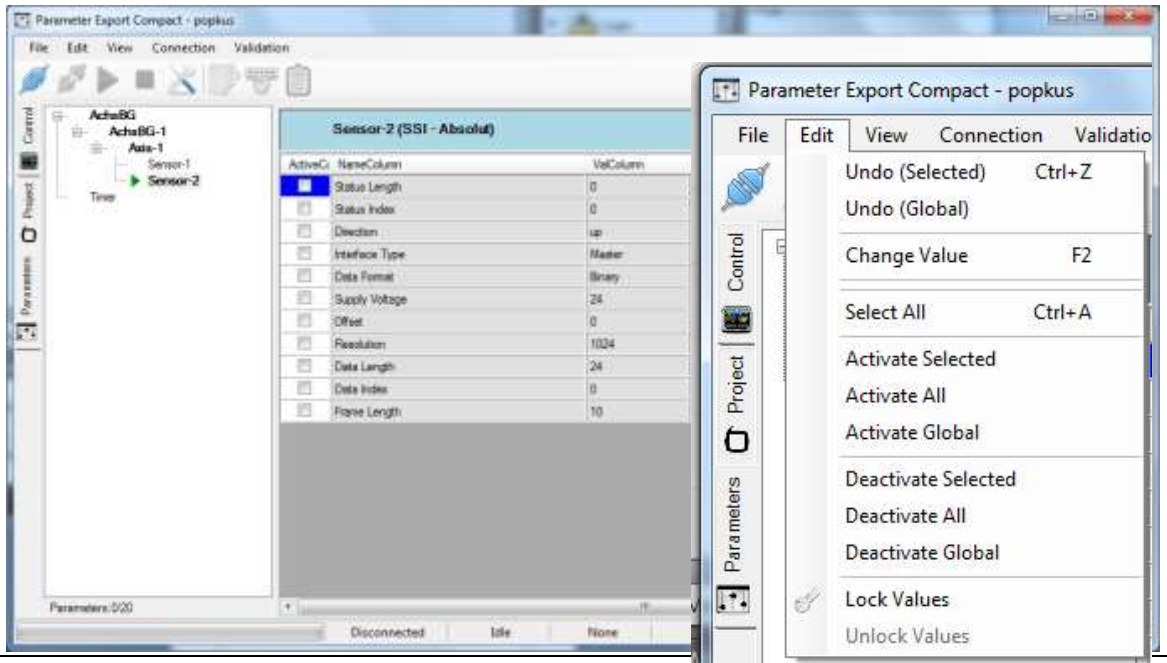


Save – save export parameters.
Save As – it sets the way how are data exported. They can be exported as a separate files, or as a project container (PMT Package file). Project container can be protected by password. To do it so check in box „Enable Protection" and write Password.

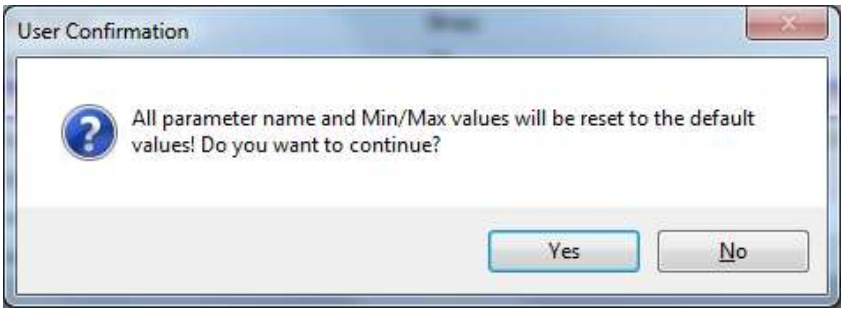


Exit – close Parameter Export window

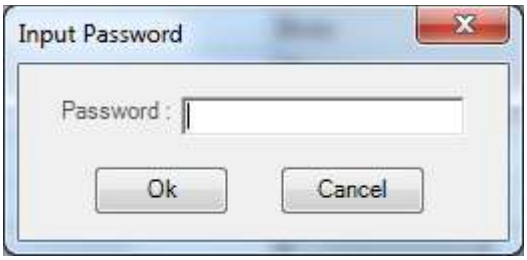
Edit menu commands: Comands in this menu are designated for working in „Parameters" Tab.



Undo (Selected) – return the selected value to the default value.
Undo (Global) – return all changes in all parameters to the default values.



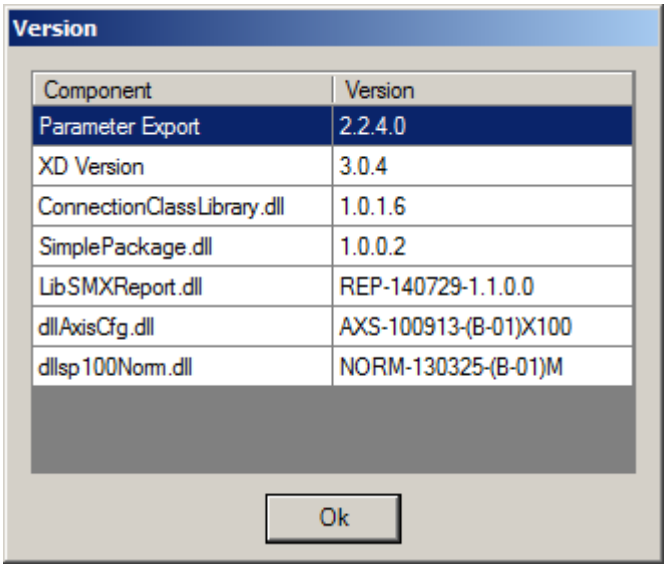
Change Value – it allows to change selected value. The same action can be activated by double left button mouse click on value.
Select All – select all parameters in Parameters Tab for choosen element e.g. Encoder.
Activate Selected – activate selected parameter (row) in Parameters Tab.
Activate all – activate all parameters (rows) for selected element e.g. Encoder.
Activate Global – activate all parameters (rows) for all used elements.
Deactivate Selected – deactivate selected parameter (row) in Parameters Tab.
Deactivate all – deactivate all parameters (rows) for selected element e.g. Encoder.
Deactivate Global – activate all parameters (rows) for all used elements.
Lock values – it allows to lock selected value. There appears dialog window for insert password. These locked values are locked for use in other separate programm.



Unlock values – Unlock value, which were locked befor by command Lock. I does not ask password, because in this environment you are administrator who set password.

View menu commands:

Languages – change language used for user interface and parameters names in Parameters Tab. (English/German).
Version – Show information about Parameters export version.



Always On Top – pin Export dialog Window on top.

Connection menu commands:

Appearance of this menu depend on it, if is SMX connected or not.

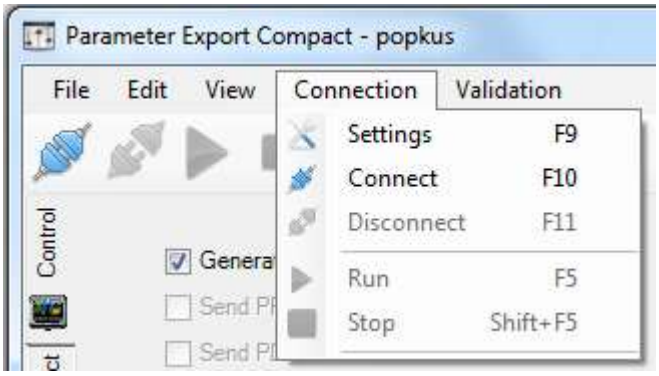


Fig. 27: Appearance if SMX is disconnected.

Fig. 28: Appearance if SMX is connected and running.

Settings – Open connection settings window. In order to be able to set up a connection with a SMX-system, the transfer parameters must be set accordingly.

Connect – Starts the connection to the SMX-system.

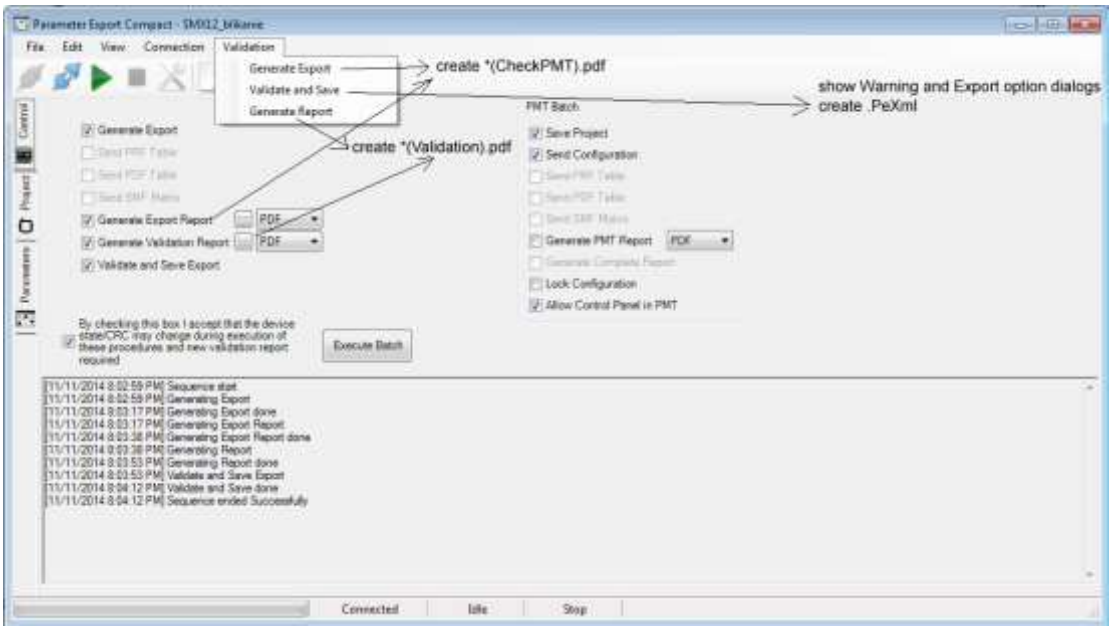
Disconnect – Cancel an active connection.

Run – Starts the sequencing program in „connected" mode.

Stop – Stops the sequencing program in „connected" mode.

Validation menu commands:

Generate Export – this function joins two functions together - Generate export and Generate Export Report.
Validate and Save – Validate parameters and save them.
Generate Report – Creates an PDF or Excel file of the current SMX configuration for the connected device. The text file lists the parameters of the configured modules and the IL program. The printout must be confirmed and released within the framework of the TÜV-approval and in accordance with the demanded regulations.
The same functions it is possible to activate via Control Tab by check in the appropriate check box. See picture below.



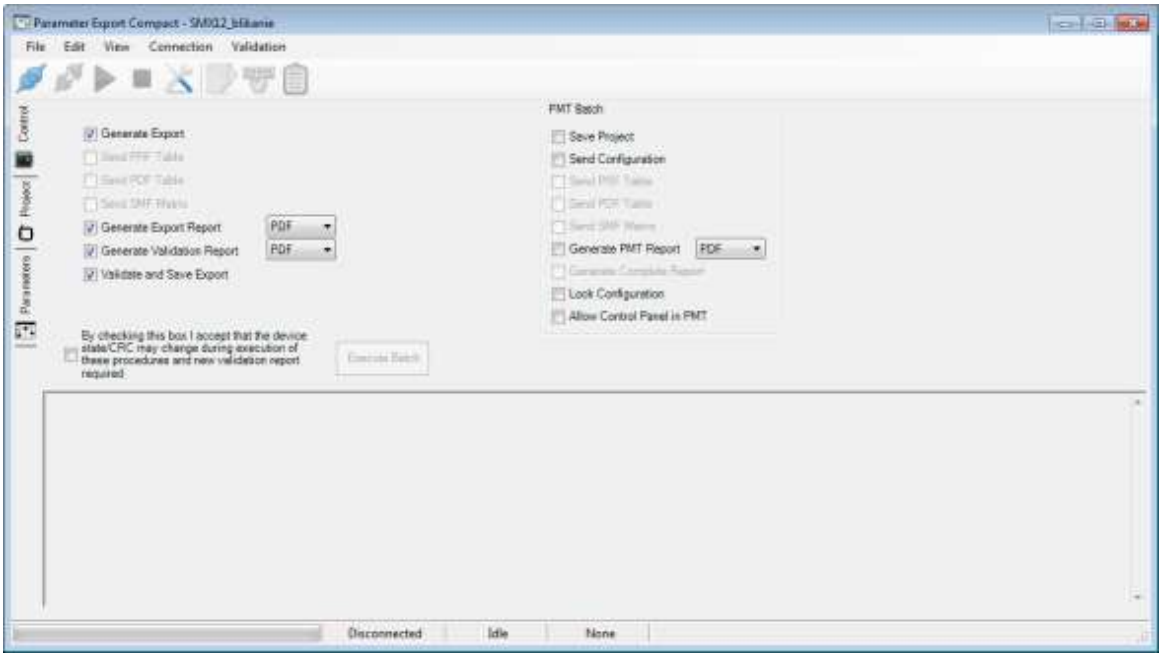
Icon tools for Parameter Export dialog:

Fig. 29: Icon tools in the Device Interface – disconnected

Fig. 30: Icon tools - connected

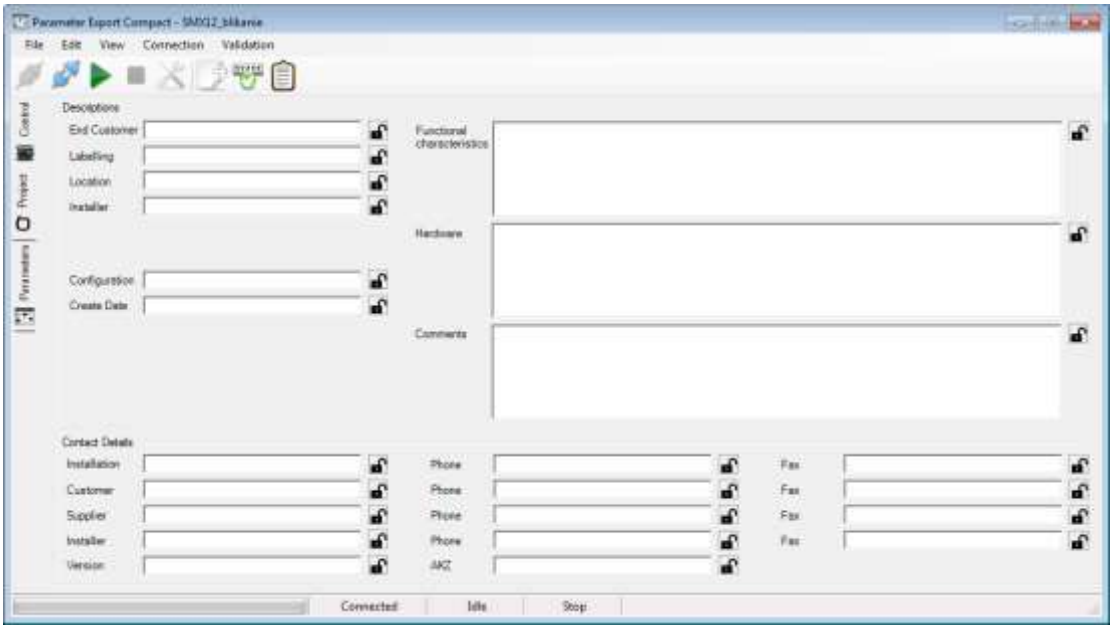
Connect: Starts the connection to the SMX-system.
Disconnect: Cancels an active connection.
Run: Starts the sequencing program in „connected" mode.
Stop: Stops the sequencing program in „connected" mode
Settings: Open connection settings window. In order to be able to set up a connection with a SMX-system, the transfer parameters must be set accordingly.
Generate Export: Generate export.
Validate and Save: Validate parameters and save them.
Generate report: Creates an PDF or Excel file of the current SMX configuration for the connected device. The text file lists the parameters of the configured modules and the IL program. The printout must be confirmed and released within the framework of the TÜV-approval and in accordance with the demanded regulations.

Control Tab



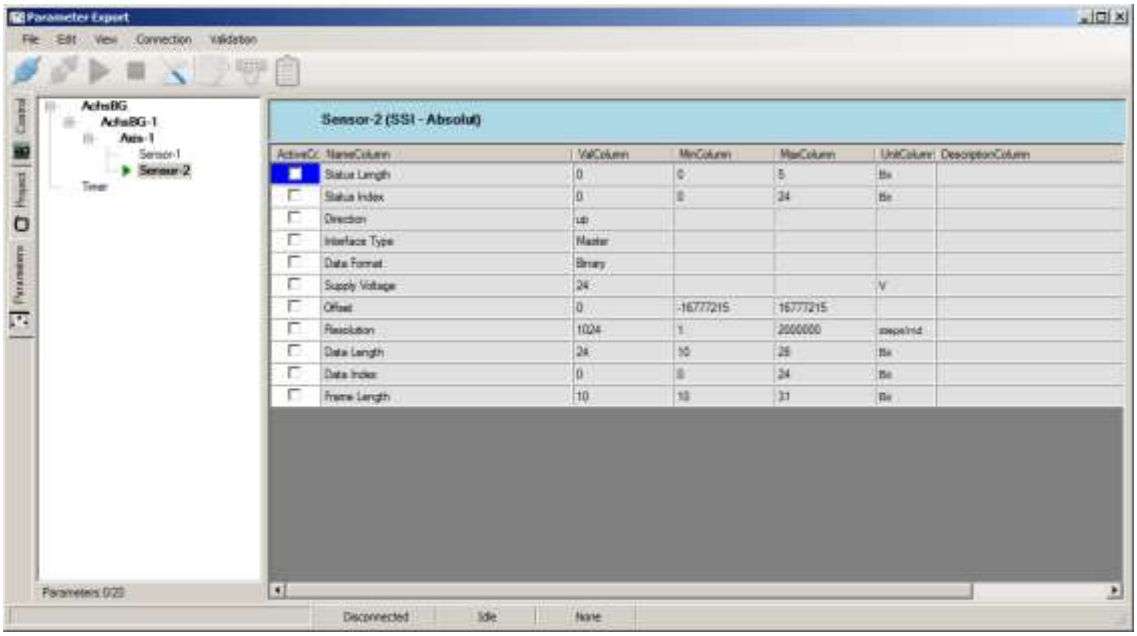
Send PRF (**P**osition **R**eference **F**unction) **Table**: Transfers all data required when using the PRF-function, e.g. the position table. For more information about PRF function see chapter 10.3.3.7 and "TD-37350-820-11-xxF PRF Description of application".
Send SMF (Safe Matrix Function) **Matrix**: Transfers position data of the coordinate matrix. For more information about SMF function see "TD-37350-820-11-xxF Monitoring function SMF".
SafePMT
Further parameterizing tool, see "HB-37350-820-21-xxF-EN SMX Manual SafePMT"

Project Tab
In this tab it is possible to fill text fields and export these information with exported parameters. It is also possible to lock these fields. Locked fields are after exporting and opening in other separate programm impossible to edit.



Parameters Tab

There is possible to see all Parameter, their values and after activate parameters it is possible to change them. Working with parameters use commands in menu Edit or mouse click.



9 Networks

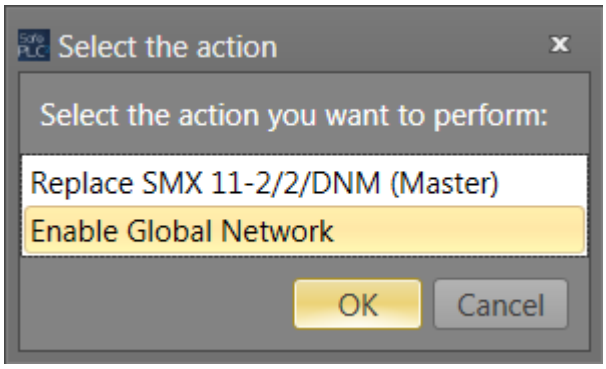
9.1 Master to Master (SMMC)

9.1.1 Description

It is global network with a **SMMC s**afe **m**aster to **m**aster **c**omunication. Minimum are 2 masters, maximum are 4.

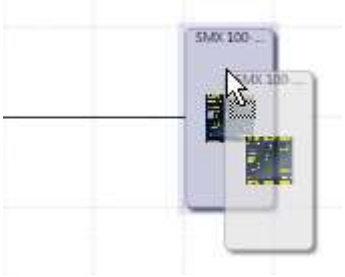
9.1.2 Creating

1. User need to insert master which support **SMMC**
2. If user insert second master which support **SMMC**, user get dialog:



Choosing "Enable Global Network" and press button OK. Second master is added and Global Network scheme Tab appears.

After creating **SMMC** network with minimum 2 master devices, if there will be added next master device with **SMMC** support the dialog above do not appears, and device is automatically added to Global Network (up to max. 4 devices). If you want replace master device with another, you have to drag new device from Library and pull it exactly at icon of device which you want replace. The mouse cursor must point at icon of device which you want to replace (see picture below).



Deactivating – automatically, if other master are deleted and there left only one Master.

Appearance in “Global Network”

9.1.3 Configuration

9.1.3.1 Shared configuration

If user click at SMMC line in Global Network scheme,

Fig. 31: SMMC line selection in „global network"

or select SMMC in browser,

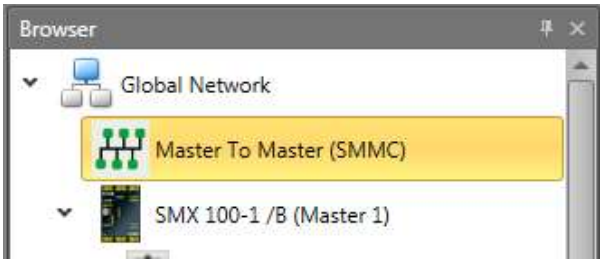


Fig. 32: SMMC selcetion in browser

then there appear properties for SMMC in property Grid.

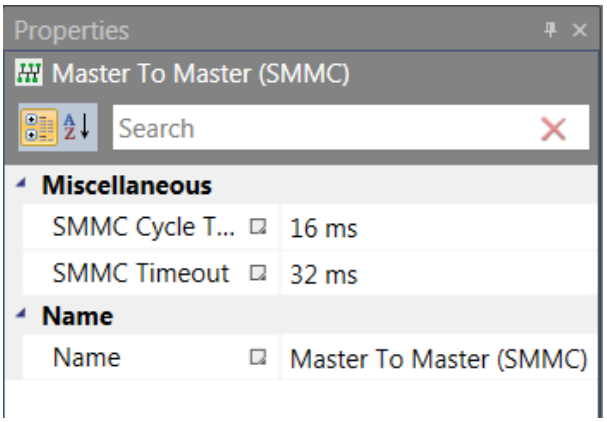


Fig. 33: SMMC in property window

There is possible to set SMMC Cycle Time in ms.

9.1.3.2 Individual configuration of masters

After clicking at each master device in SMMC network, in property grid appear properties which allow to configure these devices individually.

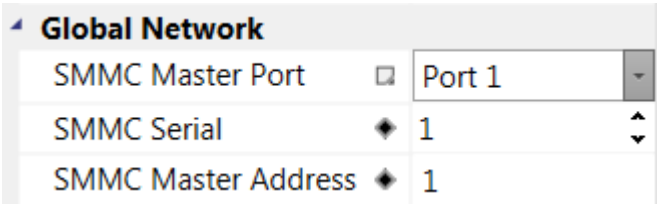


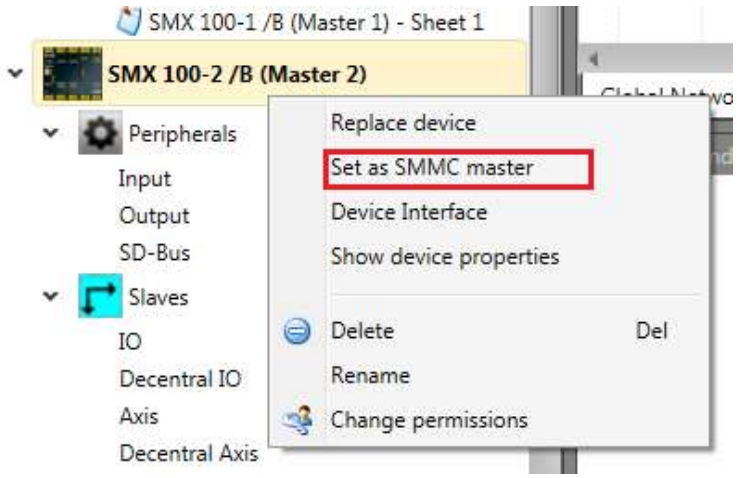
Fig. 34: Configuartion settings of the master devices in SMMC network

SMMC Master Port – select port which will be used for SMMC communication.

SMMC MAC – device MAC address – need to be read from device label and write to program. This address is in hexadecimal code.

SMMC Master Address – it is address of device in SMMC network. SMMC Master device has address 0. Order in scheme and Master address are connected. First device (in top-down direction) is Master and has address 0. Second device has address 1, third has address 2 and last one has address 3. If in Global network scheme user change order of devices by drag&drop function, Master address will be changed according to above mentioned principle (First device = Master address 0, etc.).

After right mouse click button at Master device in browser there is possibility to set selected device as a master. After setting selected device as a master, in Global network scheme this device will be moved at first place and other devices will be moved down and their Master address will be changed.

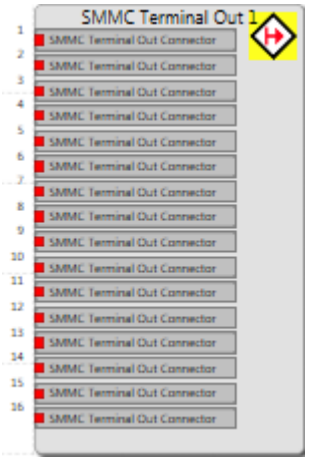


9.1.4 Use

Each device can write 16 bits as output to SMMC. These bits are defined by connection to SMMC Terminal Out connectors.

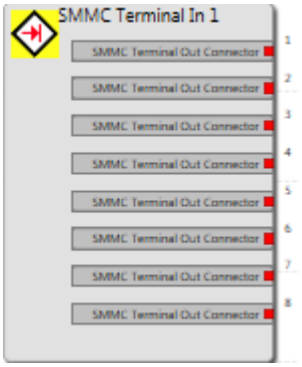
9.1.4.1 SMMC Terminal Out

Each device can write 16 bits as output to SMMC. These bits are defined by connection to SMMC Terminal Out connectors.



9.1.4.2 SMMC Terminal In

Each device can read bits from all other devices and also own bits.



There are limited numbers of configurable shared bits for each device between these master devices that can be assigning to the logic as a “SMMC Terminal Out” and then later can be used in other master’s functional layouts in their logics.

These “SMMC Terminal Out” bits group element will be available in the library as an element that can be dropped for each master separately for input configuring in functional schema and connect to anywhere (Digital connections). Then an instance can be generated as “SMMC Terminal In” from them to be use in other master’s functional schema as a Bridge.
This connector acting as like as normal terminal in except that the related terminal out can be inserted in any master functional schema and can be assigned to their logic. This SMMC

Terminal In will be available after the user configured the related "SMMC Terminal Out" in any functional schema library.

9.2 SD-Bus

9.2.1 Description

The SD-Bus is a proprietary **S**erial **D**iagnostic **B**us (in the following: SD-Bus).

9.2.1.1 Physical perspective

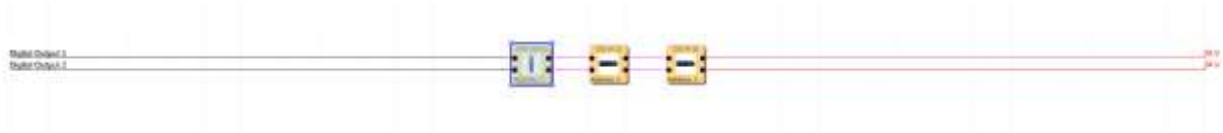
SD-Bus is a single-line bus system which is connected to a master device (universal communication board) or in future to a decentralized device (in the following: only master devices are mentioned).
Because of this single-line character, SD-Bus compatible safety switching devices have an SD-Bus in- and output contact. The master device output contact is connected to the input of the first device, from the first's output to the input of the next device and so on. All these devices must always be connected electrically in series.
From safety perspective each device has additionally 2 safety input and 2 safety output contacts. Groups of devices can be built. A group contains a number (minimum one) of devices which are connected in series within this group (from output to input contacts and so on). The safety output contacts of the first device of each group can be connected to two safety inputs of a master device or of extension modules. The 2 safety input contacts of the last device in each group are connected to 24V.

9.2.1.2 SafePLC^2 (logical) perspective

SD-Bus allows transferring diagnostic information from the SD-Bus compatible safety switching devices to a master device. In the other direction it's possible to affect the behavior of the switching devices sending commands from the master.
SD-Bus elements allow handling SD-Bus compatible safety switching devices inside ***SafePLC²***. The graphical presentation within ***SafePLC²*** is almost identical with the electrical installation. Therefore SD-Bus elements are divided into SD-Bus group and SD-Bus device elements.
SD-Bus group elements act similar as the other input elements (like a light curtain). In ***SafePLC²*** schemes multiple SD-Bus group elements can be connected to a master device or to extension modules.
Because these Group elements are the counterparts of the above mentioned electrical groups they also contain a number (minimum one) of SD-Bus device elements.
These SD-Bus device elements act as the counterparts of the real SD-Bus safety switching devices. Therefrom these elements are also connected in series within such a SD-Bus group. The two outputs of the first SD-Bus device element are the group outputs, the inputs of the last SD-Bus device element are the group inputs which are connected to a logical 24V level (which means that this device generates their own test pulses like a light curtain or a sensor input element).
SD-Bus device elements allow to select the diagnostic data and commands of the real SD-Bus safety switching device which may than be used inside ***SafePLC²***.

9.2.2 Creating

- Insert SD-Bus group is possible from library. If in scheme is inserted at least one SD-Bus group, it is possible to use Copy&Paste function to insert others SD-Bus groups.
- By using a device which supports SD-Bus that the SD-Bus groups can be assigned to that device. A SD-Bus group acting likes an input element with two outputs (like light curtain element). it is possible to assign up to 31 groups for a SD-Bus supporting device.
- SD-Bus for a device can be in more than one group and each of them represents an element in wiring schema. Each group has 2 safe outputs, 24 Volt input and a diagnosis channel input (violet color in scheme means that device is connected to SD-Bus device connector).
- Each group can contain SD-Bus elements inside and a bus can contain up to 31 elements. It means it is possible to have at minimum one group with 31 elements inside or maximum 31 groups with one element for each group. Each group can be configured like the picture bellow.



Appearance

In Global Network scheme the maximum of 3 icons are showed. If there are more than 3 SD-Bus Groups, the connection line among second and the last icon is represented by dashed line.

In Local Network scheme there are all SD-Bus groups visible.

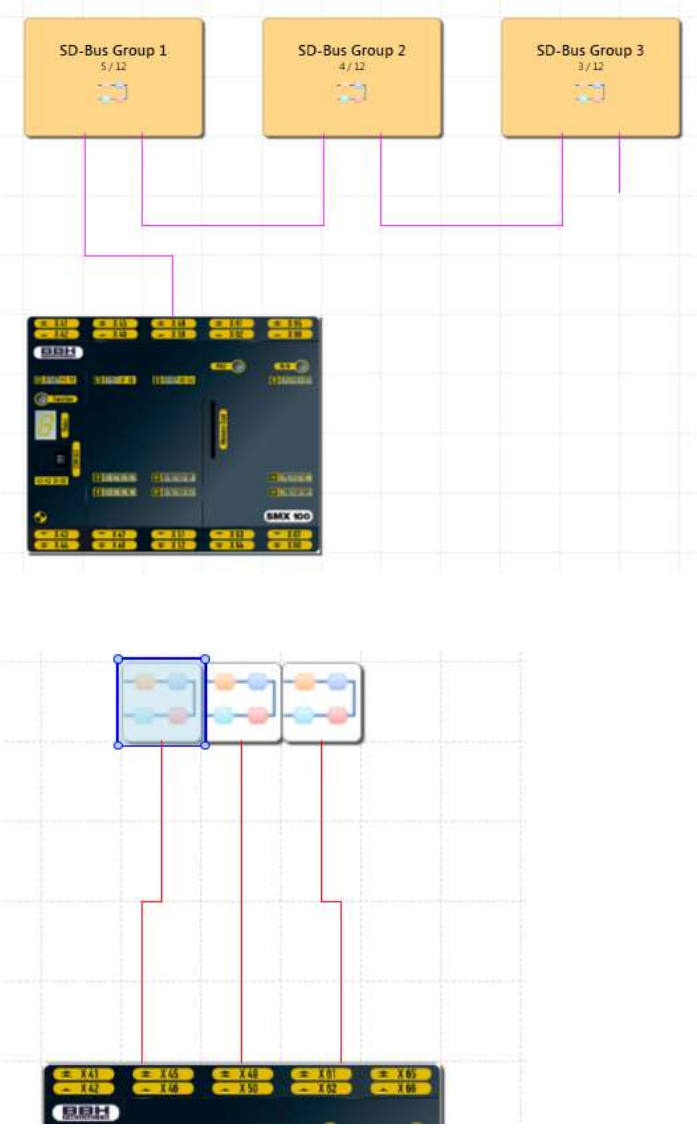


Fig. 35: Fig. 22: SD-Bus appearance in Terminal Scheme

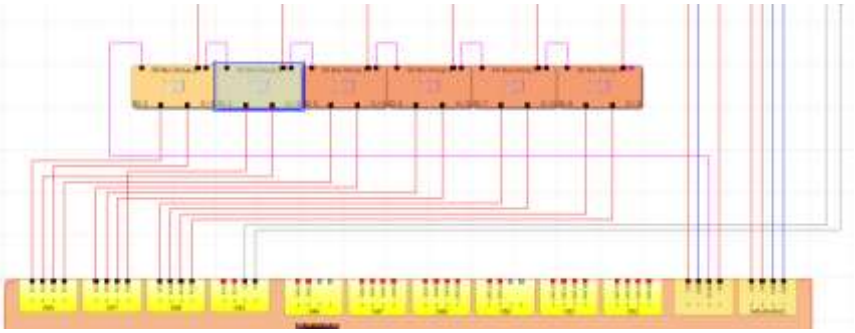
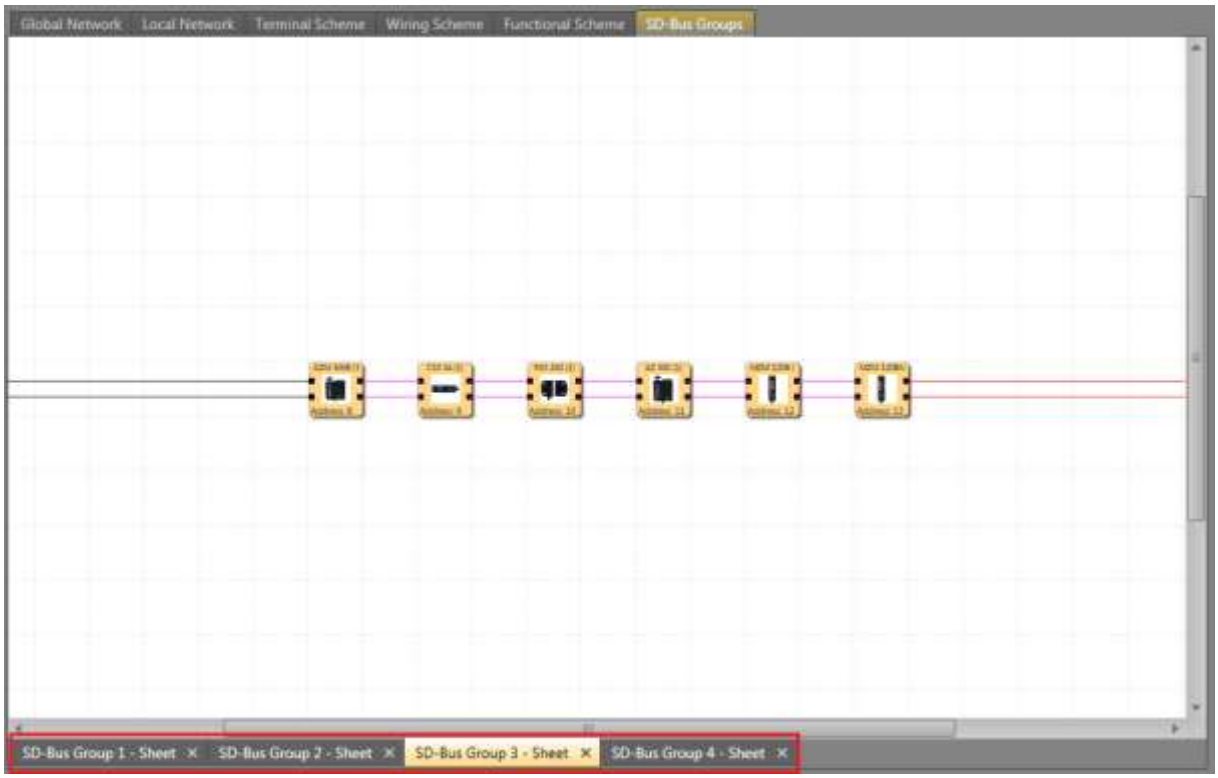


Fig. 36: Fig. 23: SD-Bus appearance in Wiring Scheme

Inserting SD-Bus elements to SD-Bus group

To insert SD-Bus elements to SD-Bus group it is necessary to open SD-Bus Groups Tab in main window. After opening this tab, in library appears SD-Bus elements which is possible insert to scheme by Drag&Drop function. If you select some SD-Bus element, it is also possible to use Copy&Paste function.

SD-Bus group scheme

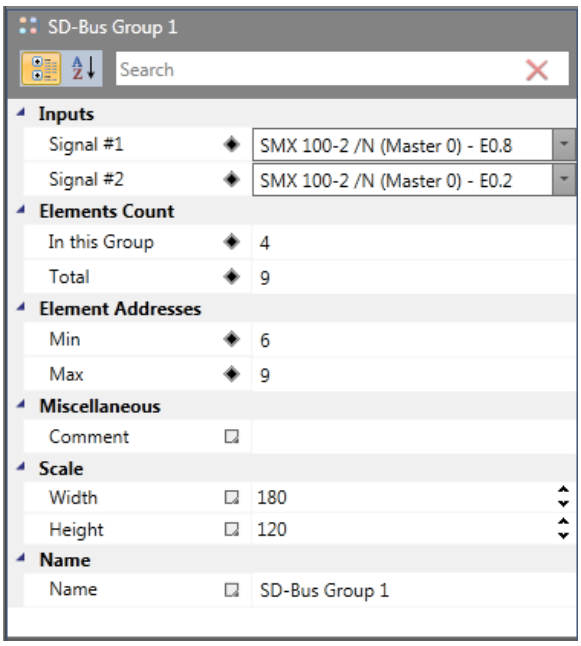


If there is more than one SD-Bus group at the bottom of window are Tabs, which allow to switch among individual SD-Bus groups. After switching to desired SD-Bus Group scheme it is possible insert SD-Bus element to this group.

SD-Bus elements are connected in one row from left to right. Address of SD-Bus element is given by order of element in row. By changing order of elements in row is also changed its address (from 1 to 31). Numbering of elements is going through groups i.e. if you have in first SD-Bus group six elements, they will have addresss from 1 to 6 and in next group will have first element address 7, second 8 etc. Changing order of elements is possible by Drag&Drop function. If you will insert SD-Bus element between existing elements in scheme, all elements on right from place of inserting will be renumbered i.e. their addresses will be changed. If number of SD-Bus elements across the SD-Bus groups for one master will reach number 31, the library window become empty and there is no possibility to insert next SD-Bus element.

9.2.3 Configuration

To configure SD-Bus group is possible in Property Grid. To see properties for SD-Bus Group is neccessary to select SD-Bus Group in Browser or select it in Local Network scheme, Terminal Scheme or Wiring Scheme. The order of SD-Bus groups it is possible to change in Local Network scheme, Terminal Scheme or Wiring Scheme by Drag&Drop function or in Browser window. Remember that, changing order of SD-Bus groups will change also adresses of SD-Bus elements in these groups.



9.2.4 Use

SD-Bus group can be inserted from Browser to Functional Scheme. Every SD-Bus Group will act as like as an input element in functional scheme and the output connector can be connected to safe logics inside functional scheme. Connection can be created by drawing connection line between output connector and desired element as it is showed on picture below, or by setting in Property Grid.

9.3 Fieldbus

9.3.1 Description

Fieldbus is the name of a family of industrial computer network protocols used for real-time distributed control, standardized as IEC 61158.
Fieldbus network protocols:

- Standard networks (non-safe)
  - PROFINET
  - PROFIBUS
  - EtherCAT
  - CANopen
  - DeviceNET
  - EtherNet/IP
  - Modbus/TCP
- Safe networks
  - PROFISAFE (PROFINET, PROFIBUS)
  - FSoE

For available fieldbuses see „HB-37450-810-01-xxF-DE COM Installation manual"

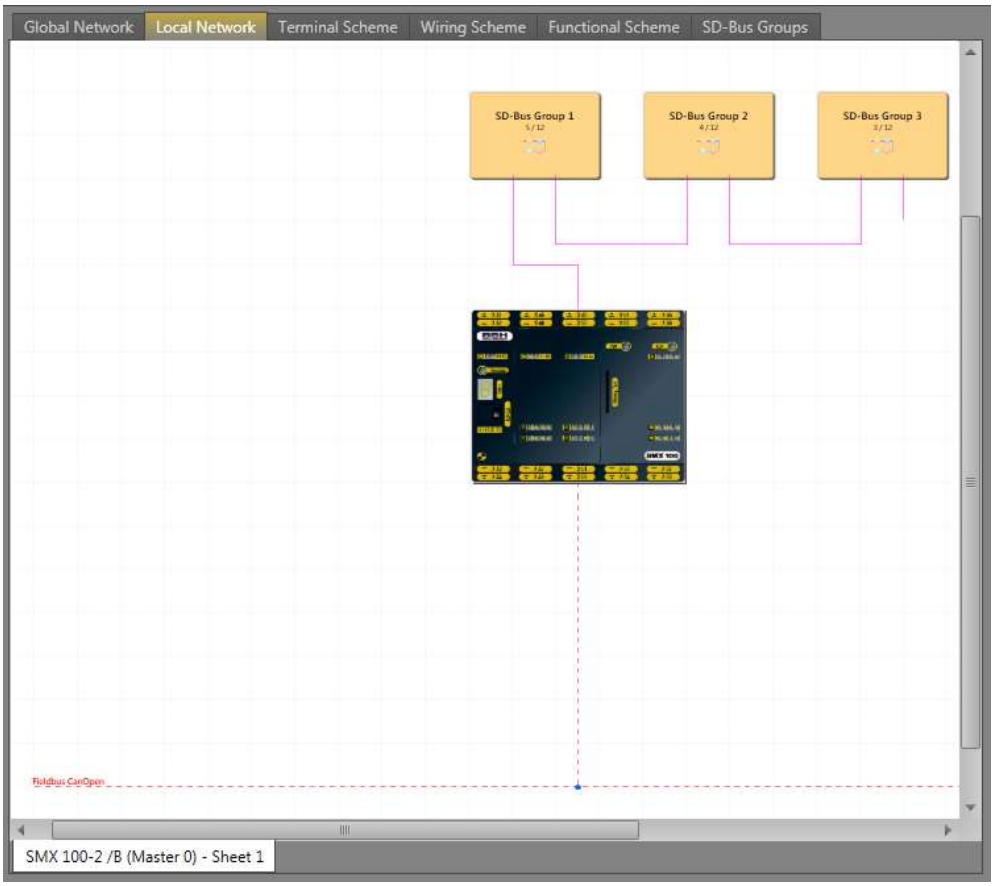
9.3.2 Creating

If device supports Fieldbus, in Property Grid is field Fieldbus. By checking on this property box it is possible to turn on or off Fieldbus.

By activating Fieldbus for each device a network line will be created for that. This fieldbus network will communicate with upper PLC through some ports.

Appearance
In Global Network scheme:

In Local Network scheme:



This schema represents the connection of device with upper PLCs. The Fieldbus is activated in Local Network for each device separately.
The Fieldbus usage can by Safe, Non-Safe and Both. Selecting usage is possible in Property Grid. Appearance of line for Fieldbus will change according to selected usage.

The safe usage is represented by red continuous line:

Non-Safe is represented by red dashed line:

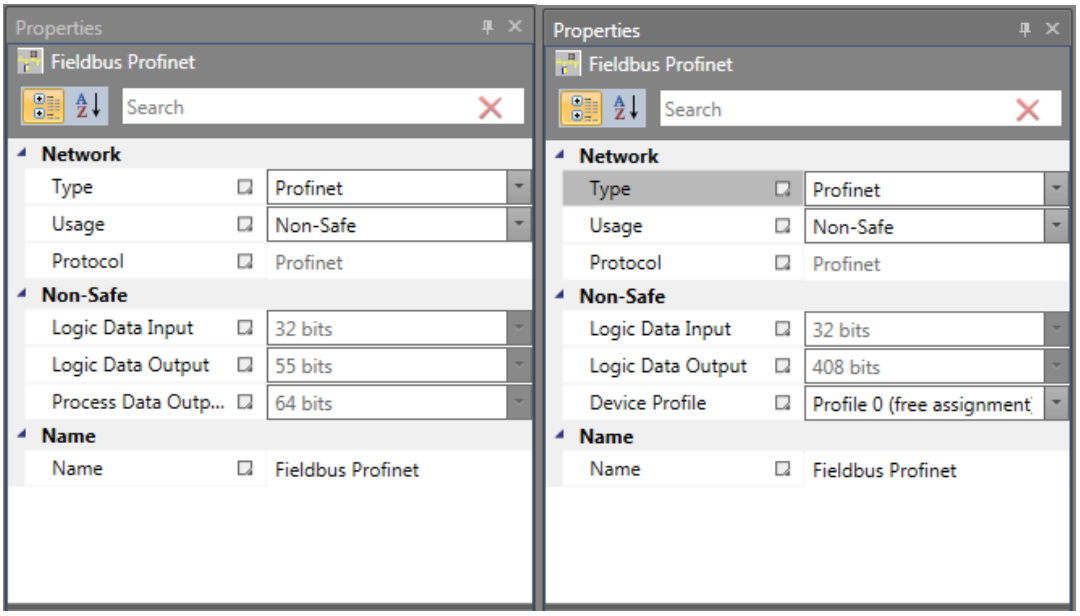
The Both usage is represented by double orange blue line:

9.3.3 Configuration

The properties of this network are configurable when user clicks on the Fieldbus line or selecting Fieldbus in browser through the Property Grid with defined properties in library. The information over this bus has a fixed size for transmission (for example 96 bit in compact series). This information is shared between "process data" like speed, position which each one can be defined as byte, int16, int24 or int32 or even brand defined type and also the other part can be used to transmit the logical information. The way that this network is configures is depend on the pre-defined profiles.

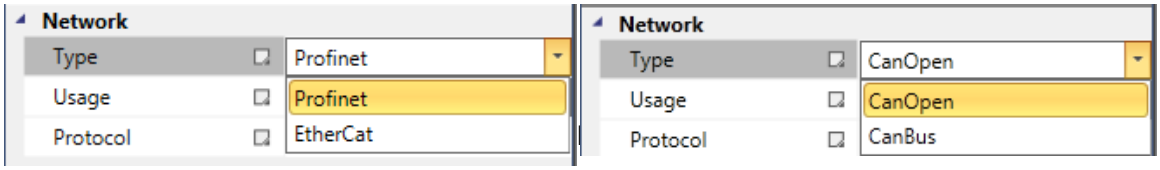
There are different properties for Compact and Modular devices in Fieldbus Property Grid.

Property grid for Compact and Modular series are on pictures below.

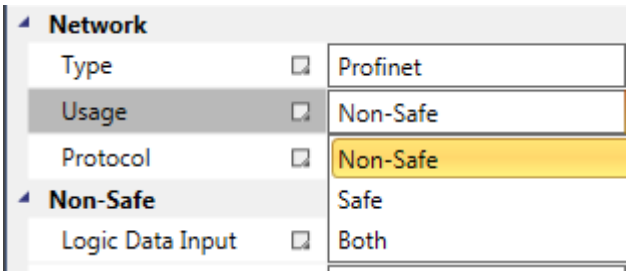


For both series it is possible to set following properties:

Network Type – Profinet and EtherCat can be selected for some devices and CanOpen and CanBus for some other devices.



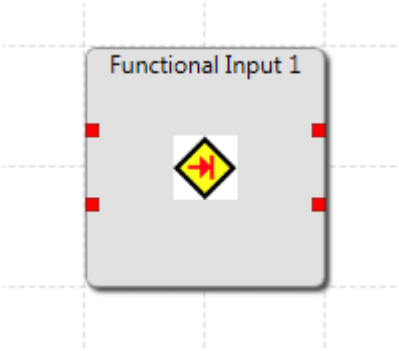
Network usage (prototype) – safe, non-safe and both can be selected

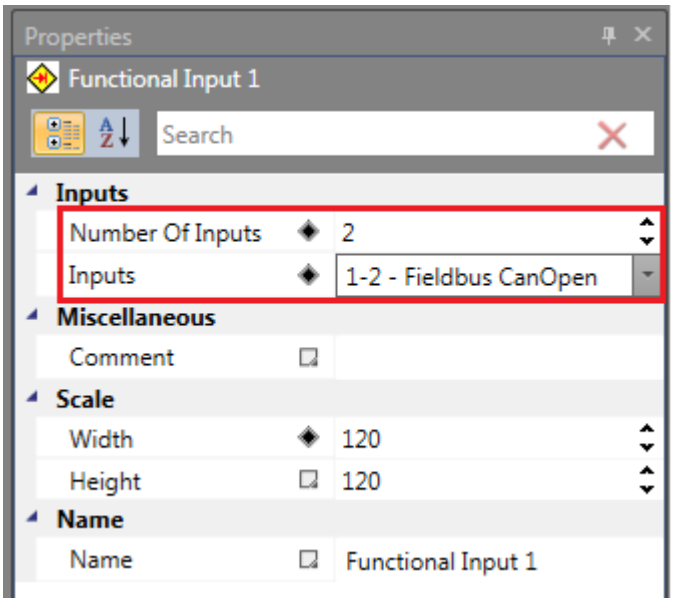


9.3.3.1 Non-Safe Usage

For **Non-Safe** usage both series have Logic Data Input and Output with fixed bits. Difference is in number of bits for Logic Data Output (55 bits in Compact versus 408 bits for Modular). These values define the number of bits used by Functional Input and Fuctional Output.

Functional Input – one bit can be used only once. Each block can configure the Number of Input in range 1 – 32. Then it is possible to set range of Inputs. Functional Input provides non-safe input and it is not allowed to use non-safe input directly, but it is allowed use non-safe input enabled by other safe input. So Functional Input has additional input connector for each non-safe input which enable using of non-safe input.
This checks that this additional input connector is connected to a safe input block. Connection to logic 1 or another logic module is not permitted.





Functional Output - one bit can be used only once. Each block can configure the Number of Outputs in range 1 – 55 for compact series and 1 – 408 for modular series. The figure shows a functional output with 3 outputs. There is configuration for each connector.

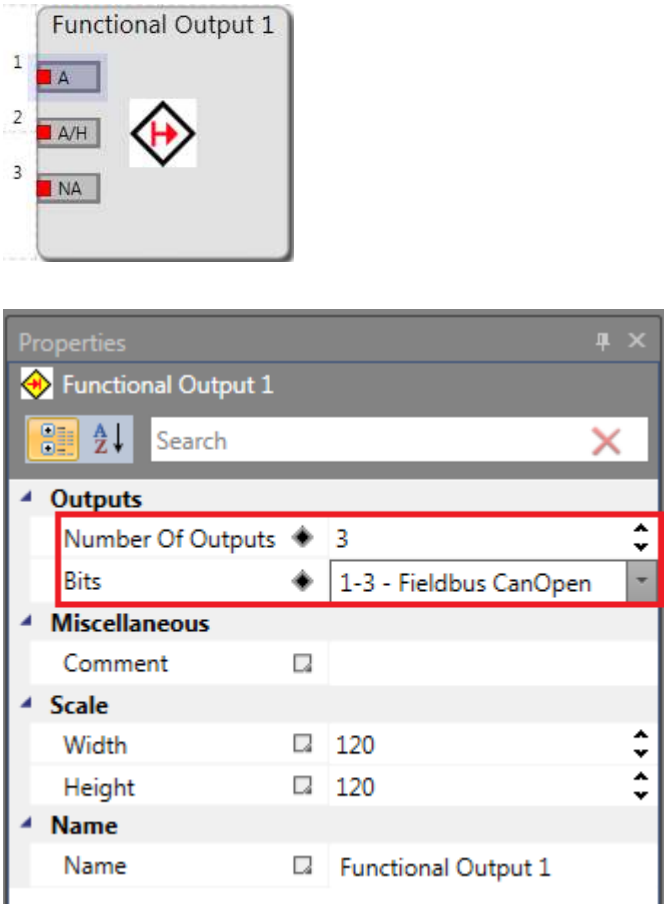
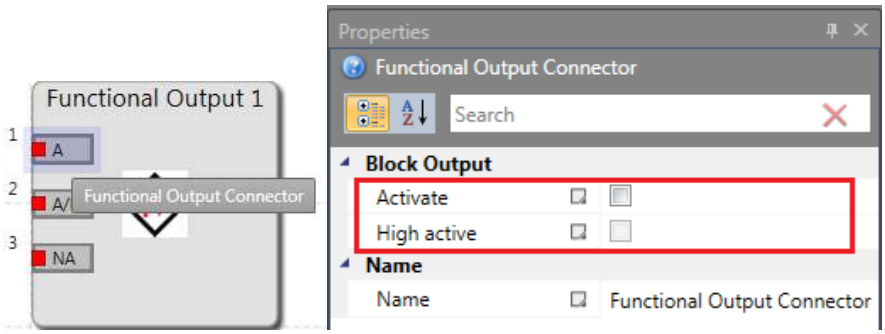


Fig. 37: Property Grid for Functional Output

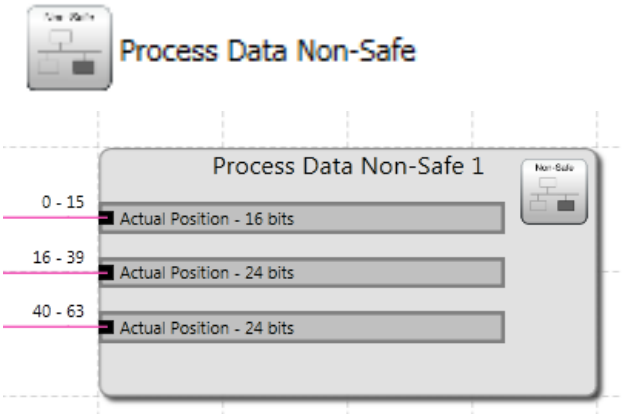
After selecting Functional Output Connector, in Property Grid appear properties for selected connector. There is possible to set Block Output as a:

NA – Non activated (both check boxes are not checked)
A – Activate
A/H – Activate with "High active"

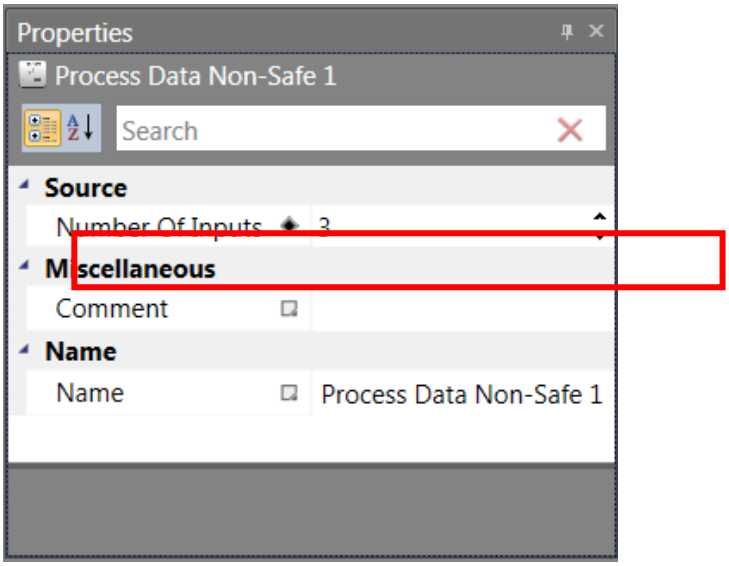


9.3.3.1.1 Process Data for Compact

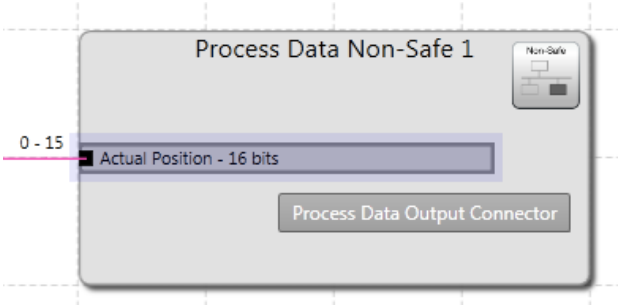
Process Data output

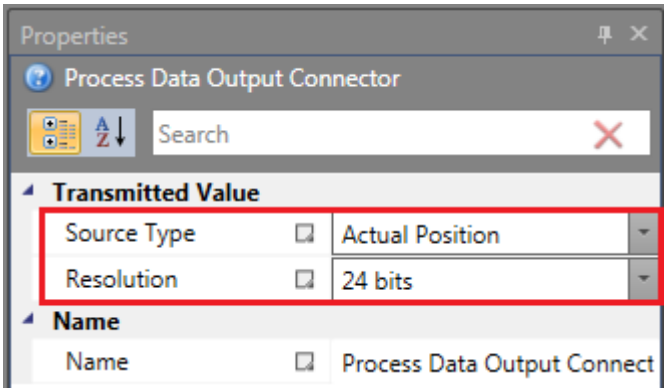


For Process Data Output it is possible to set Number Of Inputs.

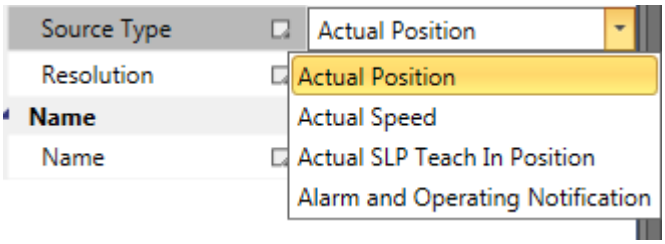


After selecting Process Data output Connector in Property grid it is possible to set Source Type and Resolution.

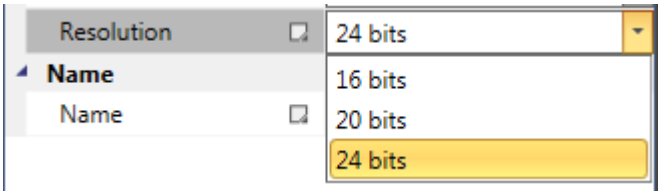




Source Type can be Actual Position, Actual Speed, Actual SLP Teach In Position and Alarm and Operating Notification.



Resolution can be set in different range and it depends on selected Source Type e.g. for Actual Position it can be 16, 20 or 24 bits.



9.3.3.1.2 Process Data for Modular

For Modular series there is possible to set:

Device Profile – There is possible to set 3 Profiles.

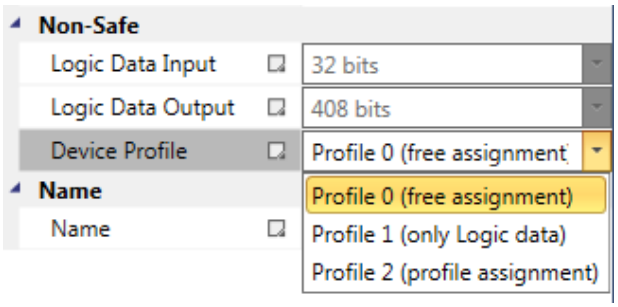


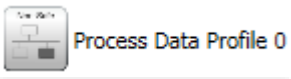
Fig. 38:process data modular; 3 device profiles

Profile 0 (free assignment) - User can insert one Process Data Profile 0 block and can free configure inputs and connect sources to inputs.

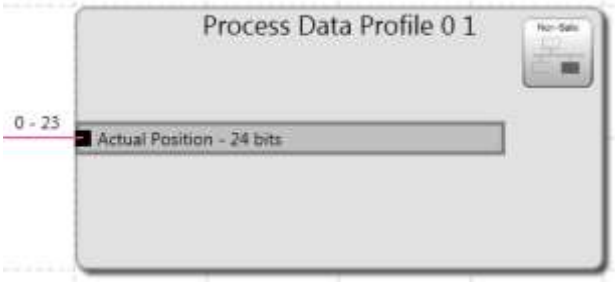
Profile 1 (only Logic data) – no process data.

Profile 2 (profile assignment) – user can choose from predefined profiles showed in library. Some can be configurable other totally fixed.
Process data are configured separately for each axis slave device. Master, IO and Decentral IO slaves don't have process data.
Choosed Profile effects which Process Data Profile blocks are showed in Library.

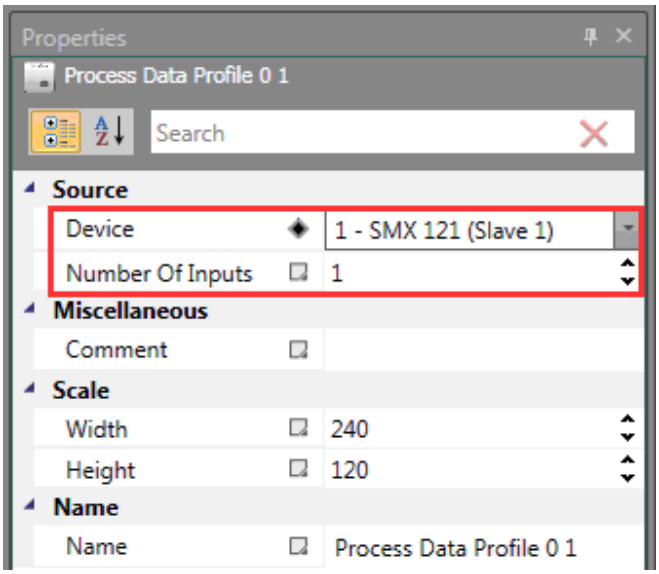
IMPORTANT NOTICE	**To see Process Data Profiles blocks in Library window for, all modular devices it is necessary to insert at least one Axis slave to scheme**.

If **Profile 0** is selected in library appears 

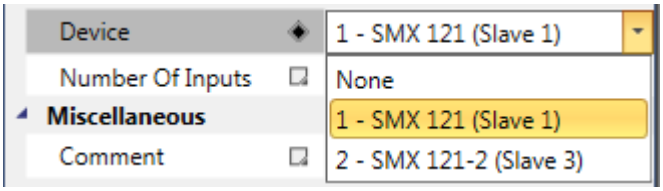
and following configurations are possible:



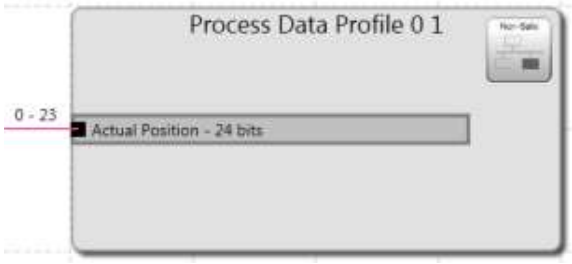
There is possible to set Device and Number of Inputs.



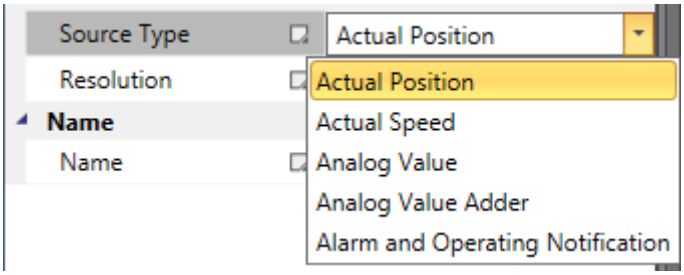
The device can be "None" or some of used devices.

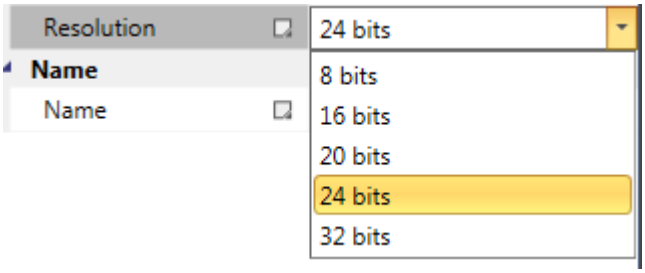


If Input is selected, there is possible to set its properties in Property Grid.



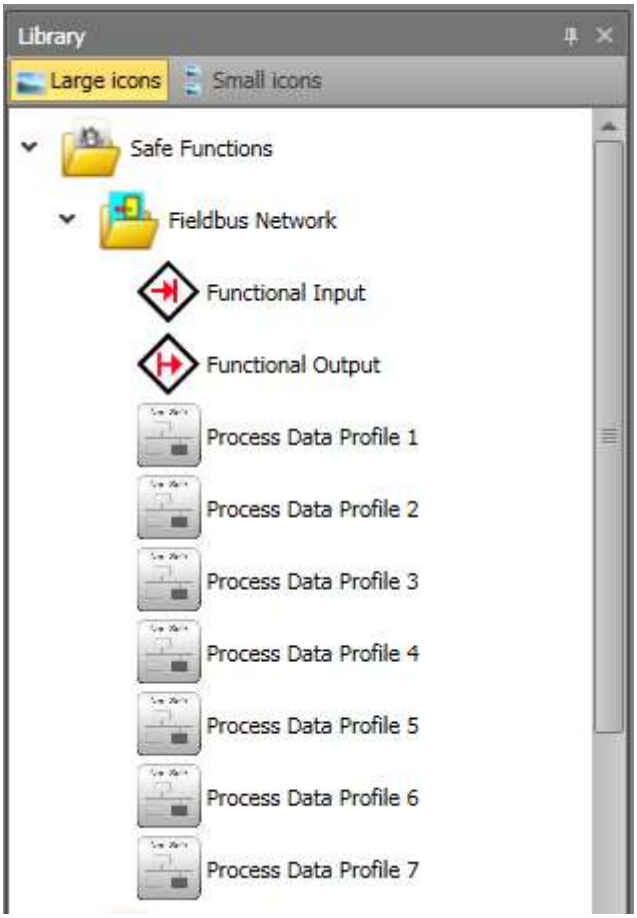
It is possible to set Source Type (Actual Position, Actual Speed, Analog Value, Analog Value Adder, Alarm and Operating Notification) and Resolution. For Analog Value, Analog Value Adder, Alarm and Operating Notification it is not possible to set Resolution.





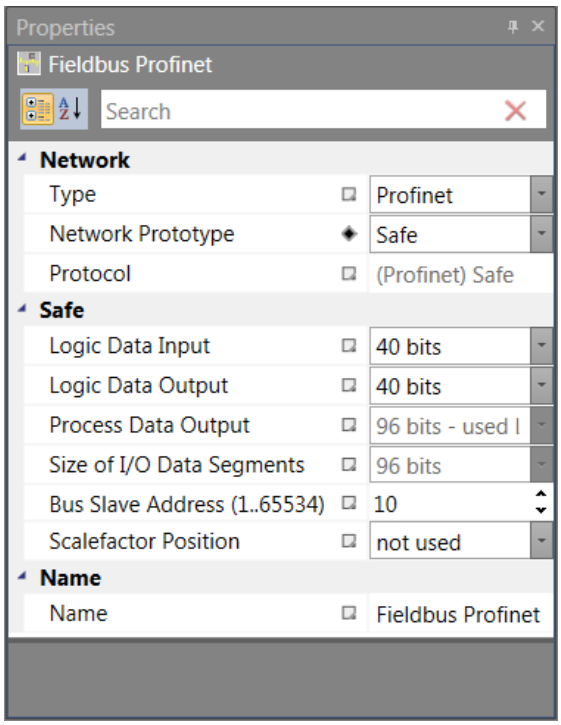
If **Profile 1** is selected, there is no Process Data Profile in Library.
If **Profile 2** is selected, in Library appear predefined profiles. Some predefined functions and values is not possible to change, but for some values changes are alloved.

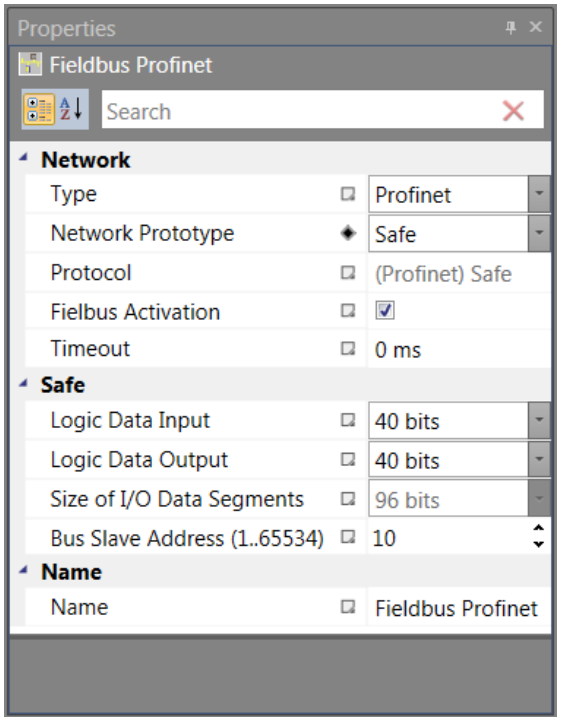
For every axis device it is possible to insert one Process Data Profile block.



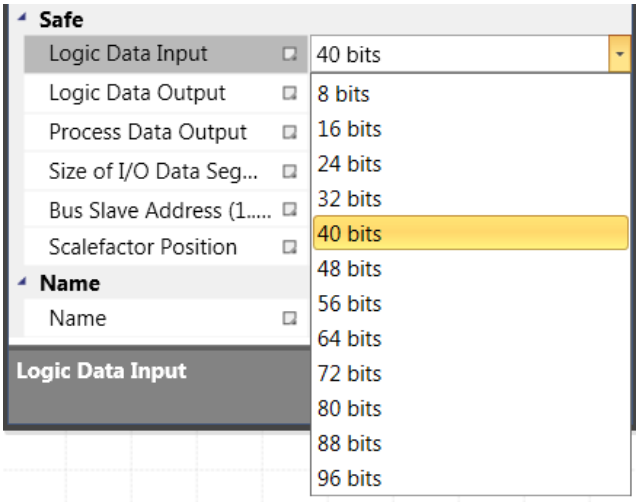
9.3.3.2 Safe Usage

For **Safe** usage Property Grid looks like it is shown on next pictures (Compact series – left, Modular series – right).

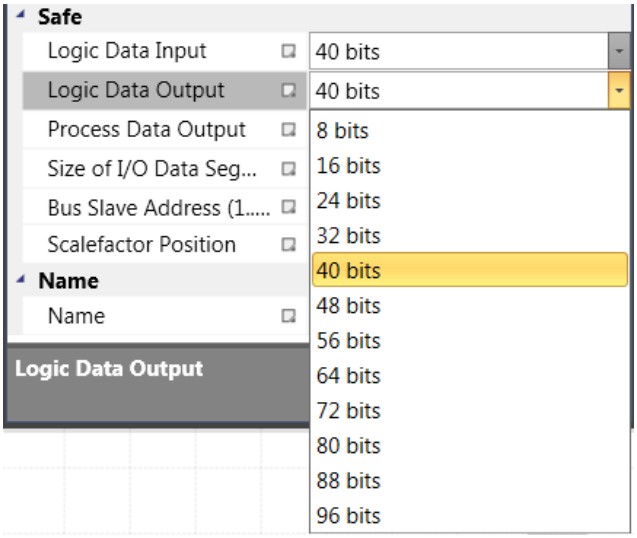




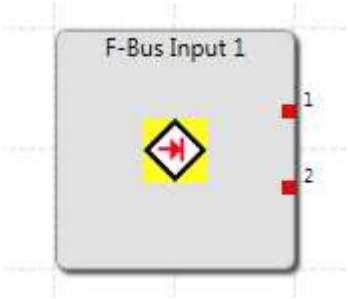
There is possible to set:
Logic Data Input – it is possible to set it from 8 bits to 96 bits.

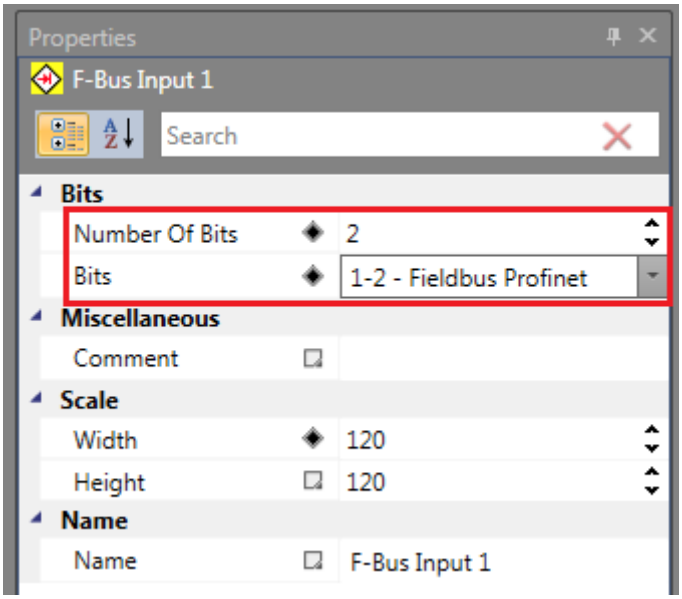


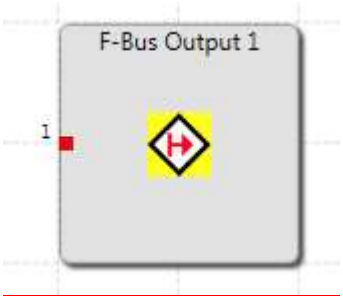
Logic Data Output – it has the same range as input (from 8 bits to 96 bits).

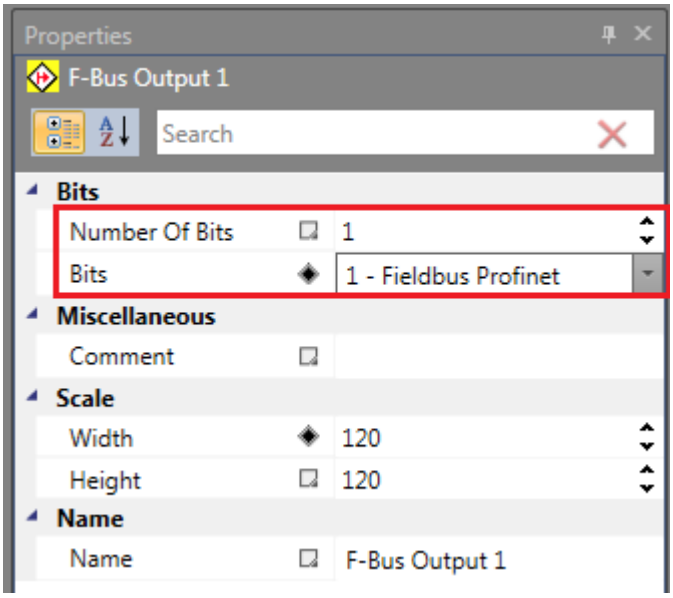


These values define number of bits used by safe terminals: F-Bus Input and F-Bus Output. Safe functions F-Bus Input, F-Bus Output – one bit can be used only once. For each block can be configured the Number Of Bits in range 1 – 32 and also which bit or bits will be used.

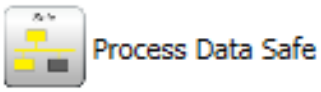




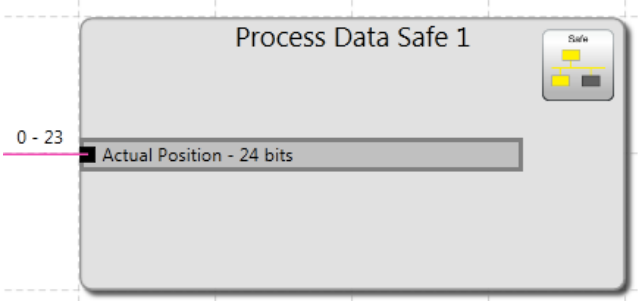


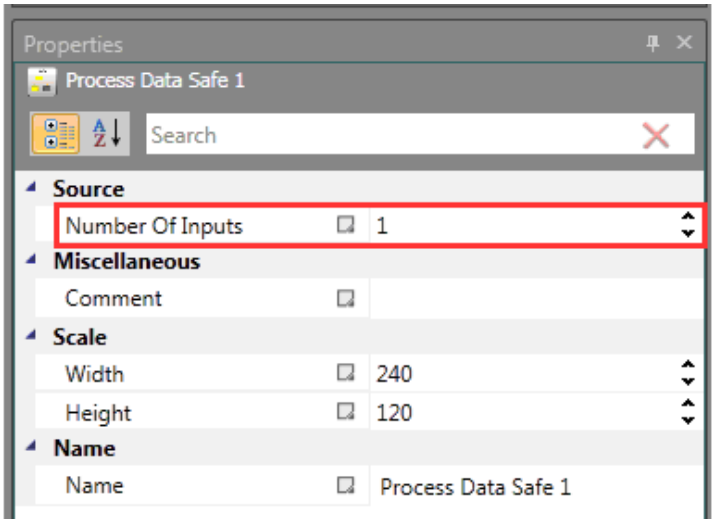


9.3.3.2.1 Process Data Output for compact

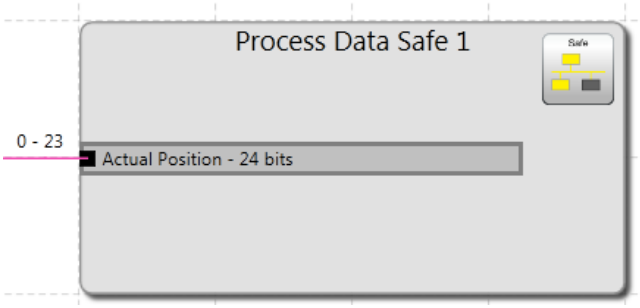


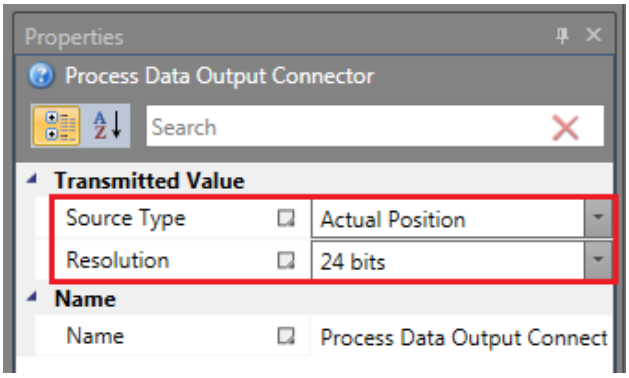
There is possible to set the Number Of Inputs in range from 1 to 7.

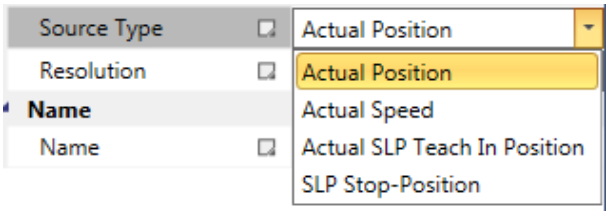


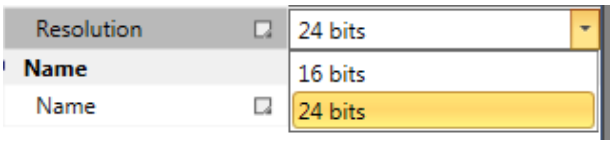


After selecting Input Connector it is possible to set Source Type (Actual Position, Actual Speed, Actual SLP Teach In Position and Alarm and Operating Notification) and Resolution in Property Grid.



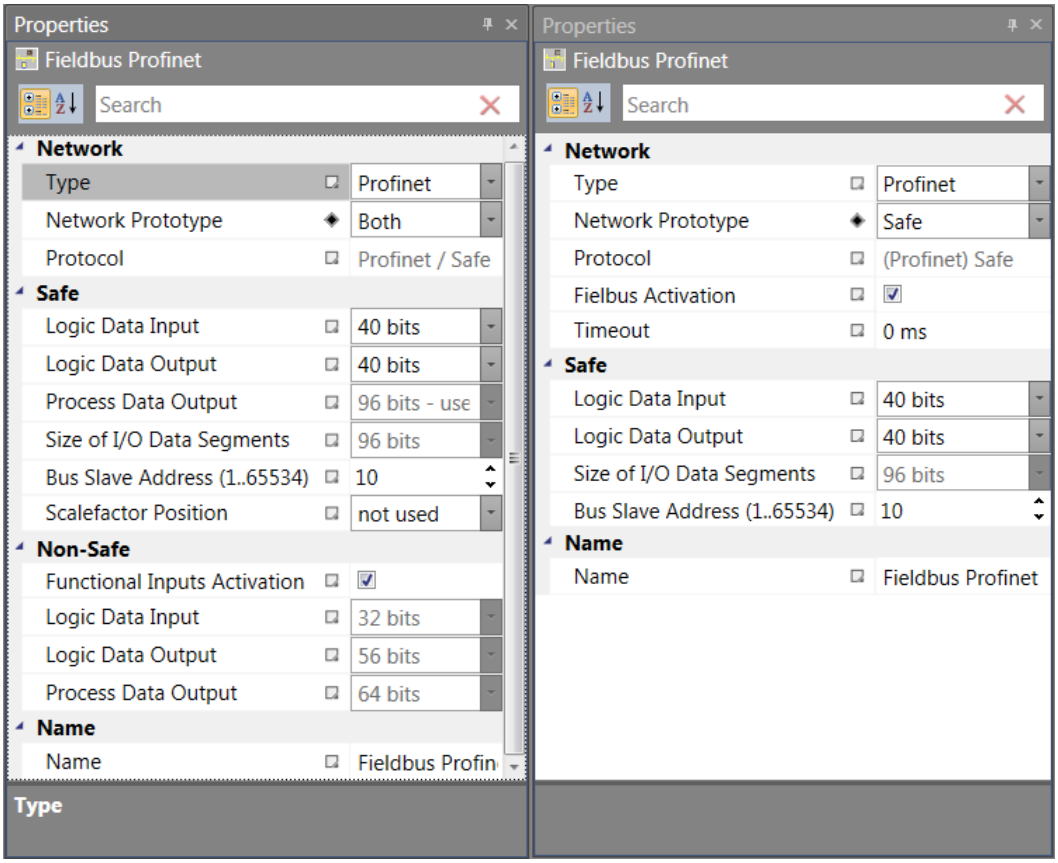






9.3.3.3 Both Usage

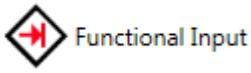
For **Both** usage there is possible to set values for Network and Non safe usage (settings are the same as it is described in chapter 9.3.3.1) and Safe usage (the same settings as it is described in chaper 9.3.3.2). See pictures below for Property Grid for compact and modular series.



9.3.4 Use

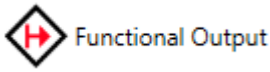
In Functional scheme in Library, there appears Fieldbus Network folder . There are functions connected to Fieldbus. Showed functions depends on choosen device and Usage.

Functional Input



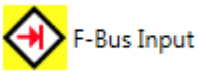
Described in chapter 9.3.3.1.

Functional Output



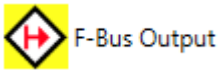
Described in chapter 9.3.3.1.

F-Bus Input



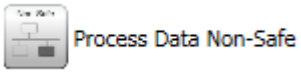
Described in chapter 9.3.3.2.

F-Bus Output



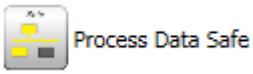
Described in chapter 9.3.3.2.

Process Data Non-Safe



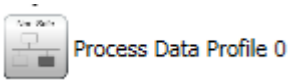
Described in chapter 9.3.3.1.

Process Data Safe



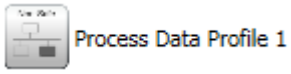
Described in chapter 9.3.3.2.

Process Data Profile 0

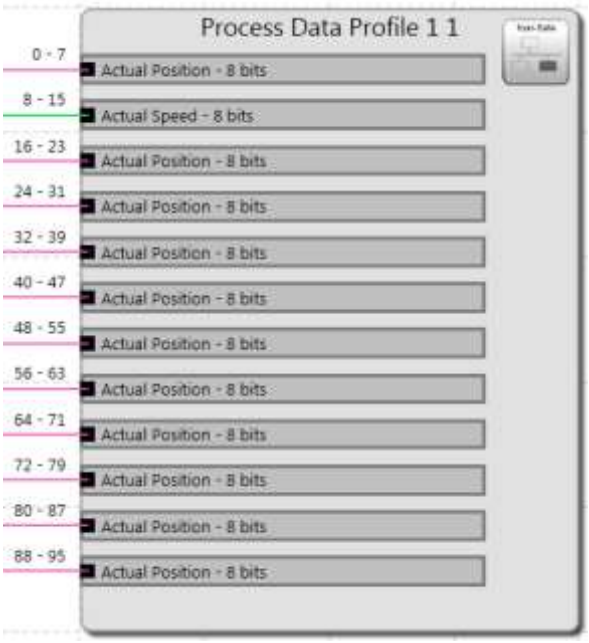


Described in chapter 9.3.3.1.

Process Data Profile 1



It offers from 1 to 12 inputs. It is possible to set Source Type: Actual Position, Actual Speed, Analog Value, Analog Value Adder, Alarm and Operating Notification. For Actual Position and Actual Speed it is possible to set resolution.



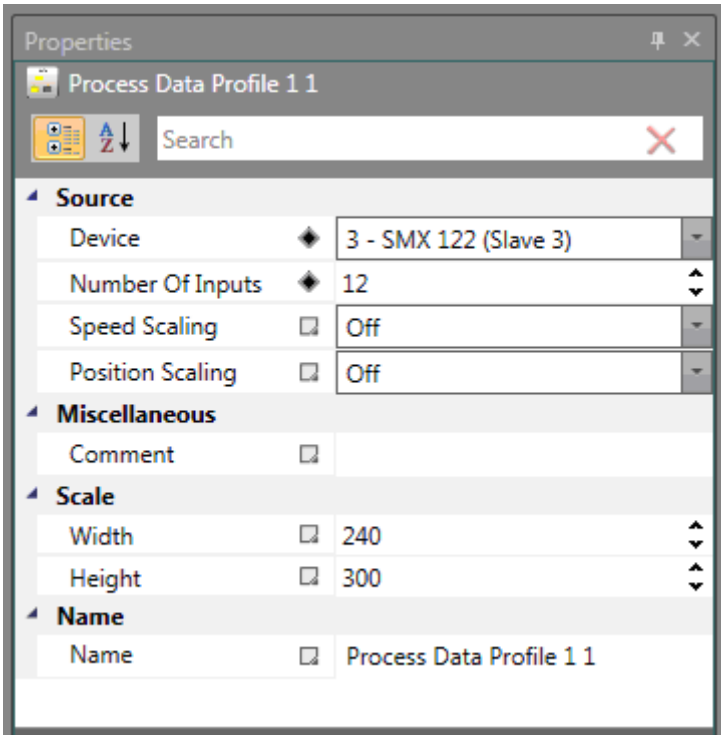
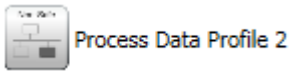
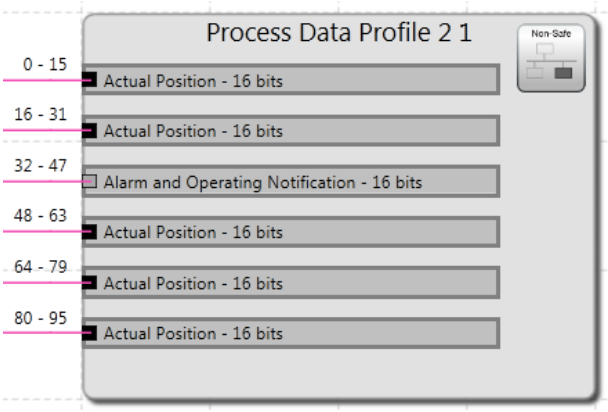


Fig. 39: Property Grid for Process Data Profile 1

Process Data Profile 2



It offers from 1 to 6 inputs. It is possible to set Source Type: Actual Position, Actual Speed, Analog Value, Analog Value Adder, Alarm and Operating Notification. It is possible set resolution only for Actual Position.



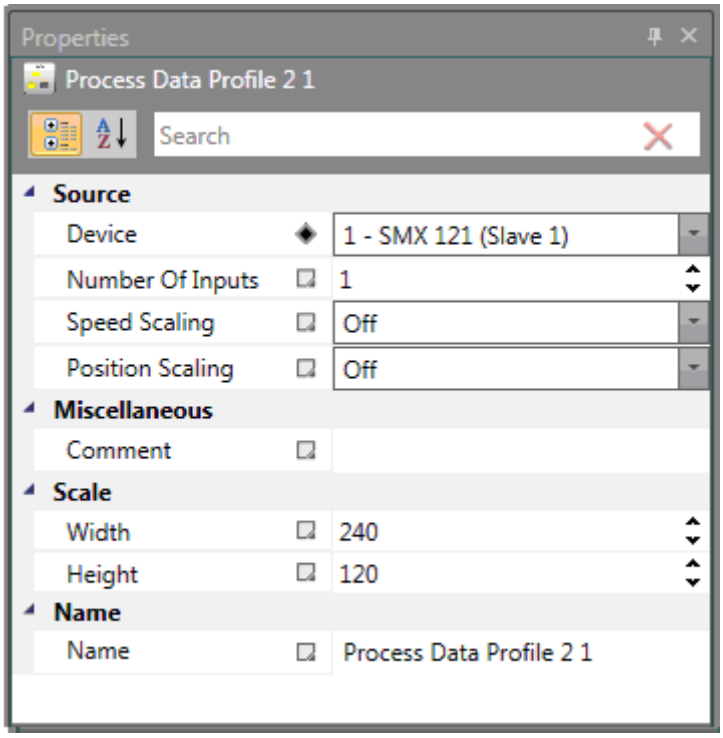
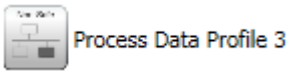
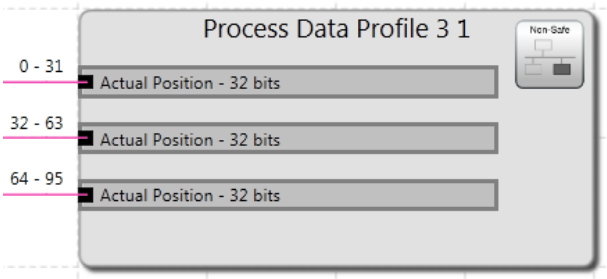


Fig. 40: Property Grid for Process Data Profile 2.

Process Data Profile 3



From one to three Actual Position (32 bit) inputs only. It is not possible to change resolution.



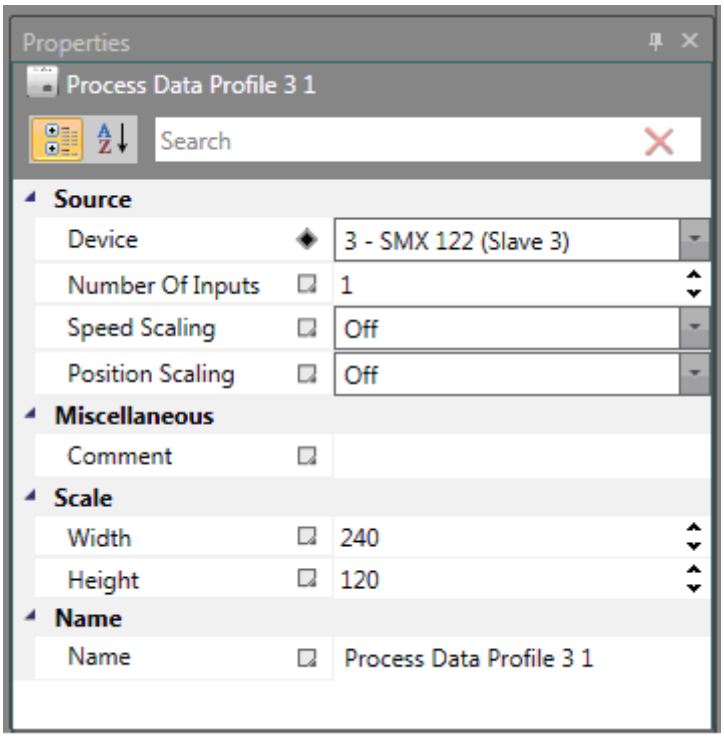
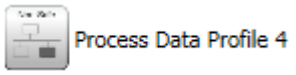
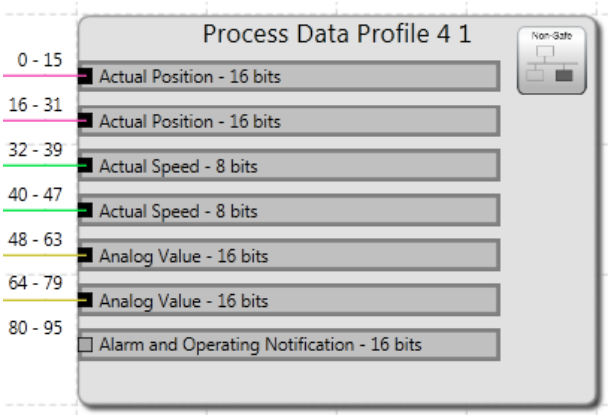


Fig. 41: Property Grid for Process Data Profile 3.

Process Data Profile 4



Fixed 7 inputs with predefined resolution.



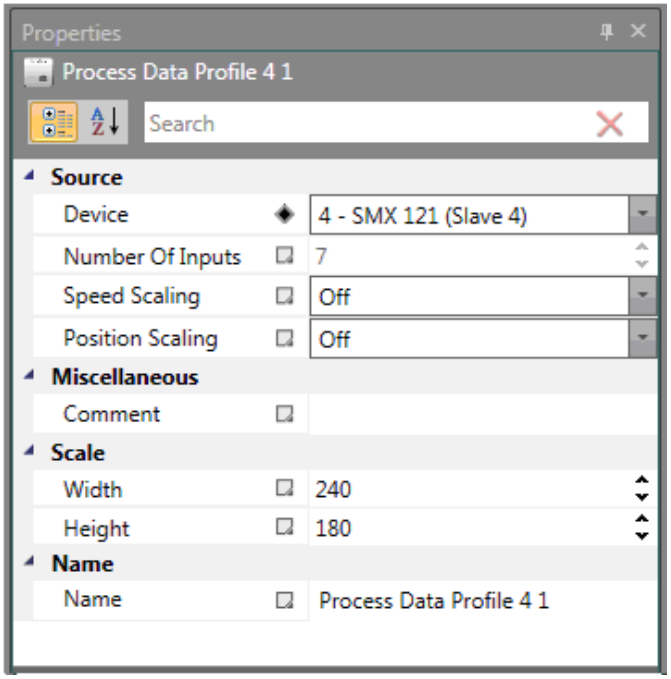
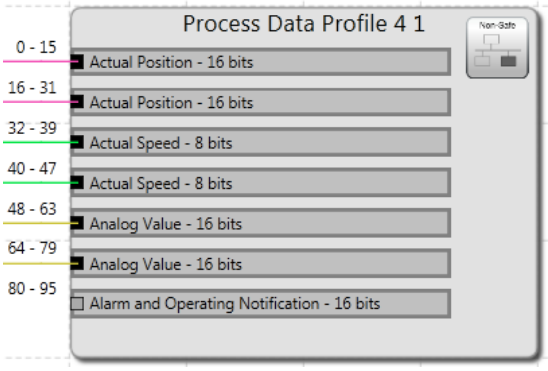
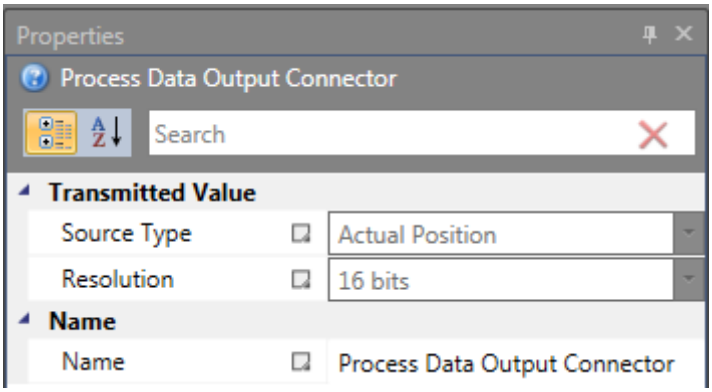


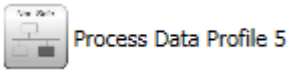
Fig. 42: Property Grid for Process Data Profile 4.

Source Type and Resolution is not possible to change.

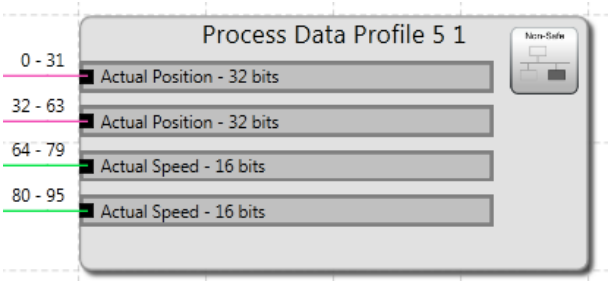




Process Data Profile 5



Fixed 4 inputs with predefined resolution.



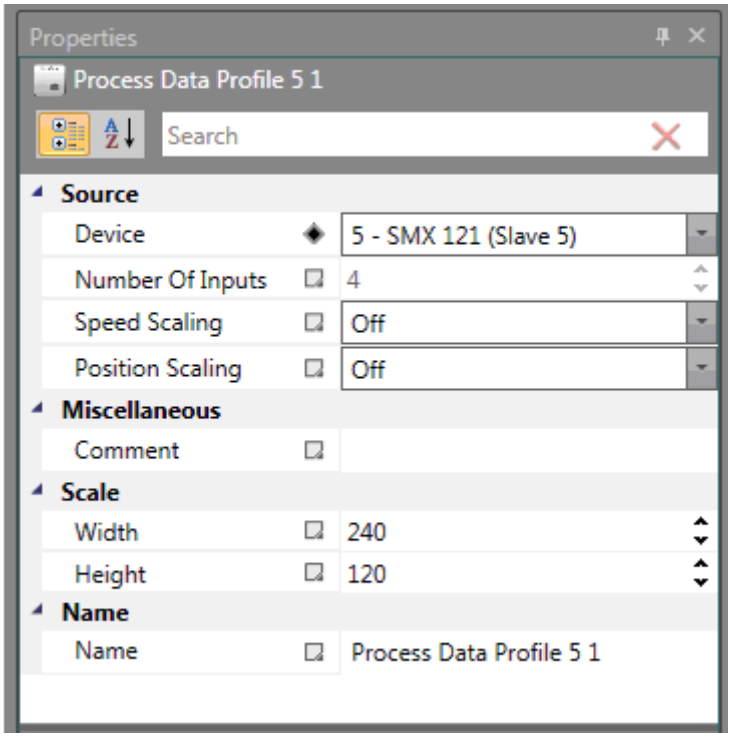
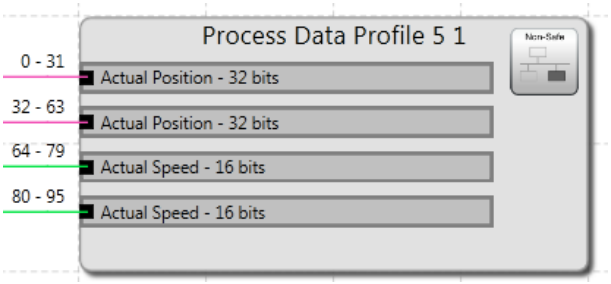
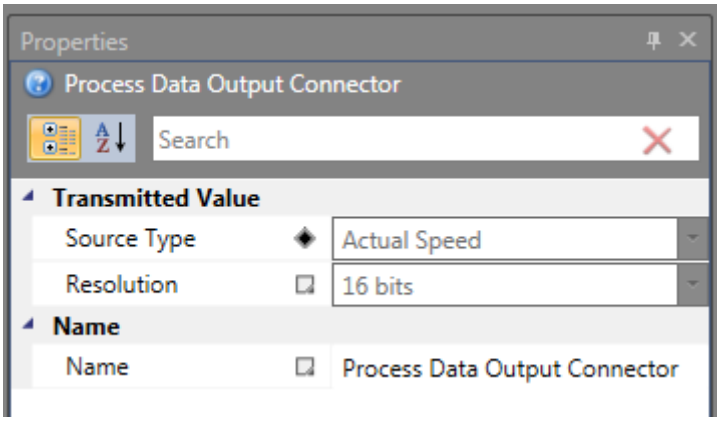


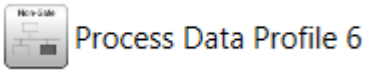
Fig. 43: Property Grid for Process Data Profile 5.

Source Type and Resolution is not possible to change.

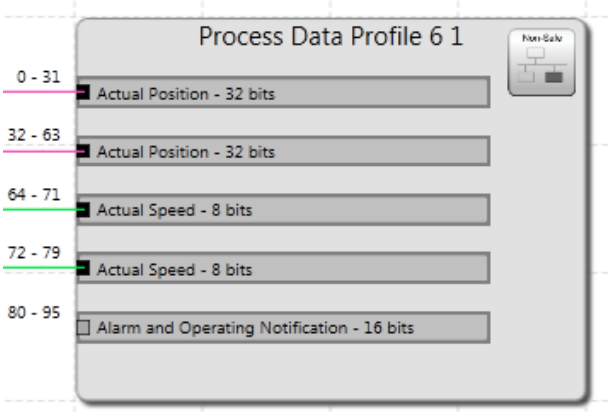




Process Data Profile 6



Fixed 5 inputs with predefined resolution. Source Type and Resolution is not possible to change.



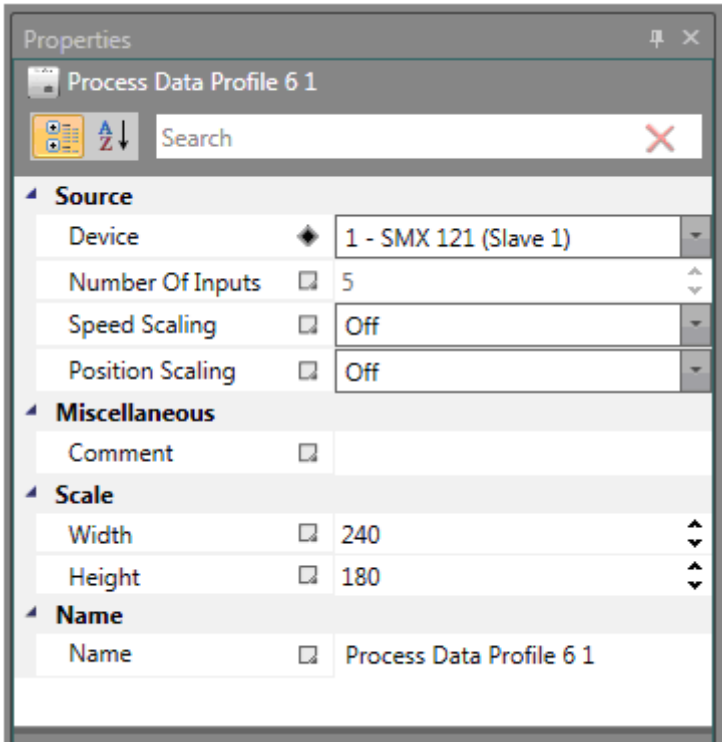
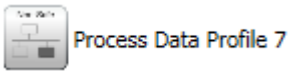
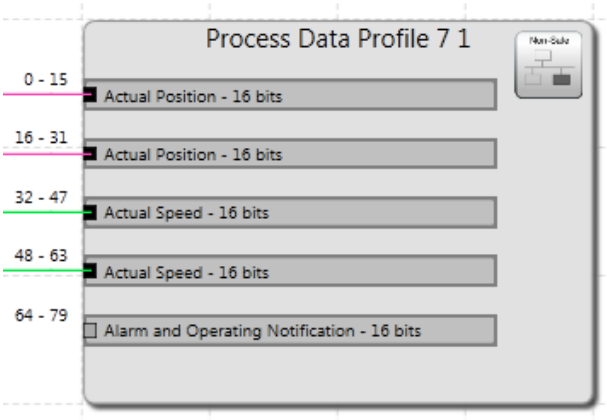


Fig. 44: Property Grid for Process Data Profile 6.

Process Data Profile 7



Fixed 5 inputs with predefined resolution. Source Type and Resolution is not possible to change.



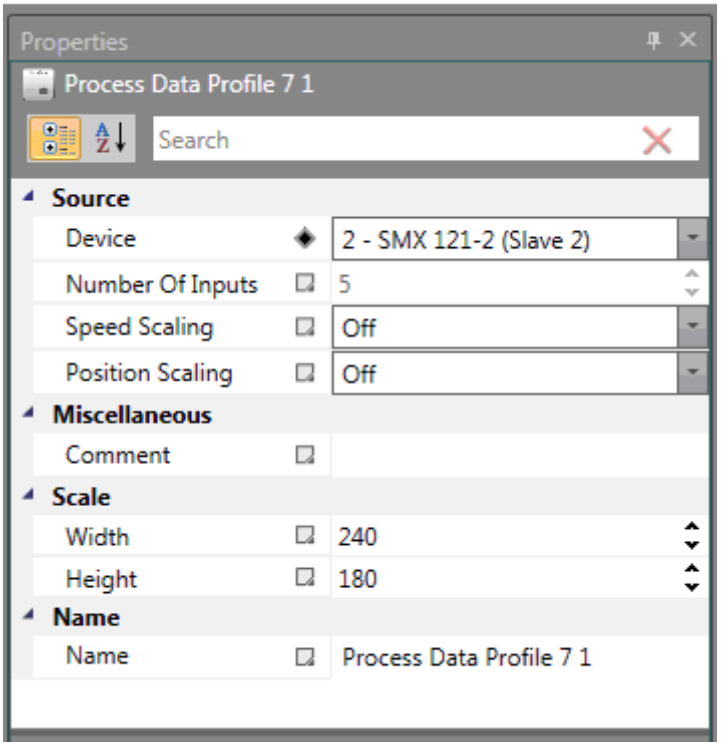
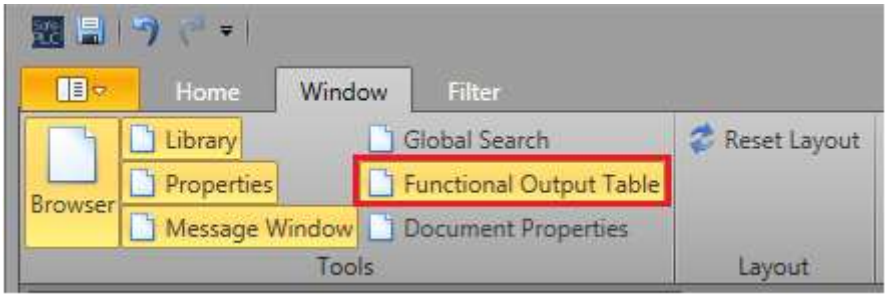


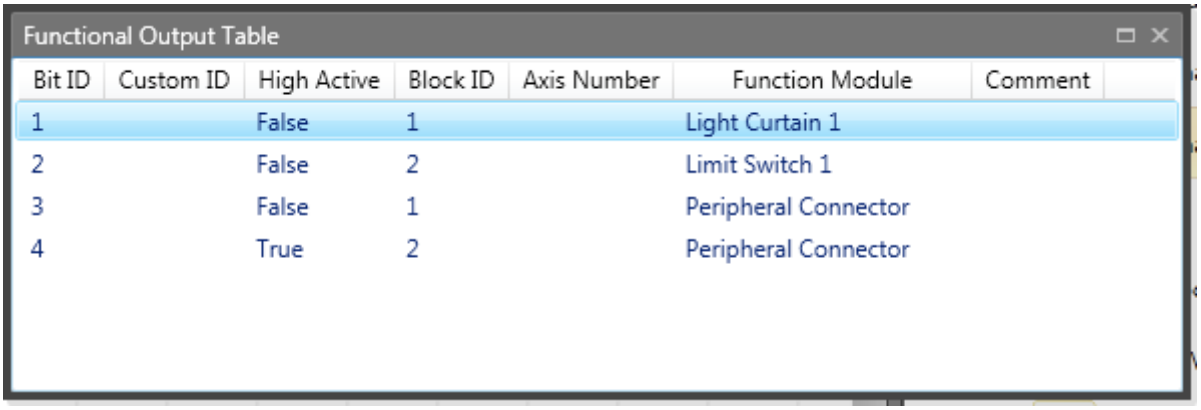
Fig. 45: Property Grid for Process Data Profile 7.

Functional Output Table

In Tab Window there is table which contain all connected functional output connectors - Functional Output Table.



Functional Output Table:

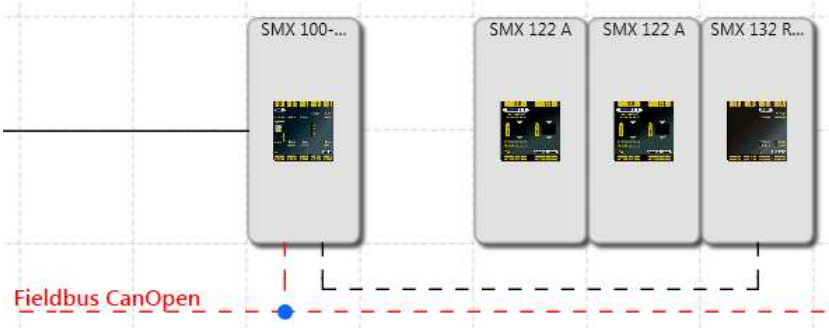


9.4 Decentral
9.4.1 Creating

If device support Decentral devices then there is showed Decentral IO folder in browser and there are slaves showed in library. User can Drag and Drop.

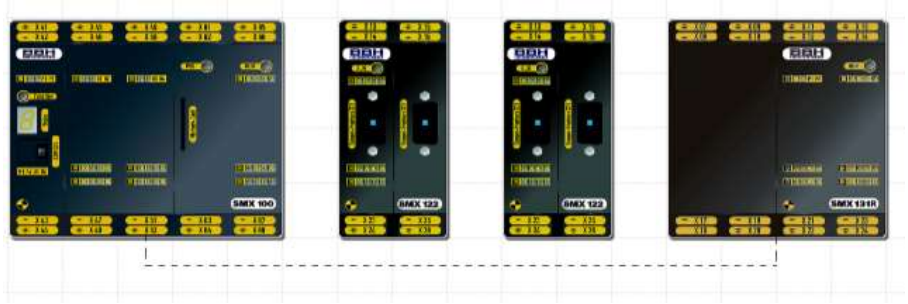
Appearance

In Global Network scheme:



Local Network scheme:

Terminal Scheme:



10 Library Content

Library window offers all available building blocks to build desired block diagrams.
It shows only the elements which can be used in the selected scheme.
The blocks can be added to the scheme view by Drag&Drop and edited in Properties window.

Fig. 46: Library view – Terminal scheme selected

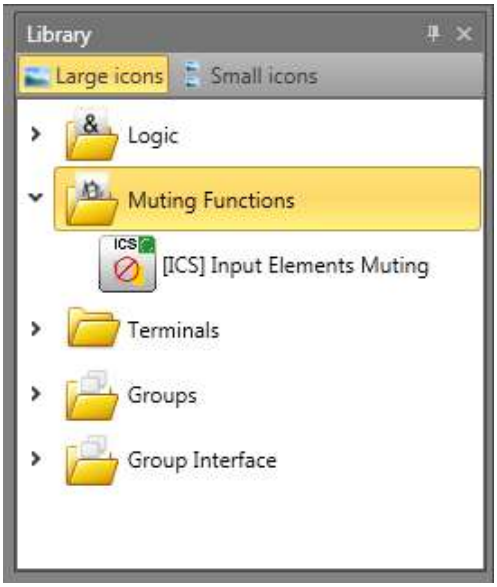


Fig. 47: Library view – Functional scheme selected

The resource control of block elements for the SMX-system manages the available elements, the number of which may be limited.
The automatic monitoring of resources of the block elements for the SMX module has the effect, that only the available elements are enabled in the program. This, above all, concerns the time-monitored peripheral devices.

Some of them are dependent on other blocks, so they are available only when these blocks are already present in the scheme.

If there are no resources (memory) available for the monitoring program in the SMX module, the components or function blocks are no longer listed in the Library view. This is e.g. the case when all digital ports of an SMX module are occupied or all timer modules have been used.
These resources can be released again by deleting the corresponding function blocks.

10.1 Device modules

10.1.1 Master devices

Master device is base module for programming. There are compact or modular series of master devices based on slave (extension) modules which can be used.

- for the compact series can be configured only IO-extensions,
- for the modular series can be used IO-extensions or Axis extensions up to maximum number of slave devices allowed by the master device.

One SafePLC2 document can contain programs for more master devices of different kinds. The master devices which have this ability can communicate to each other using SMMC network.

NOTICE	I/O devices can be configured in modular series to maximum number of slave devices.

10.1.2 Slave devices

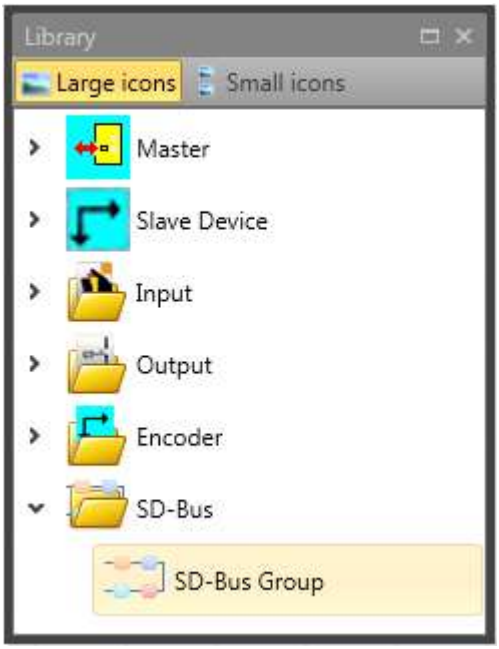
Slave device is extension module which provides more I/O connectors or allows to control more axes. There are two kinds of slave devices:

- IO-extensions extend the number of inputs and outputs.
- Axis extension modules can be used to control additional axes. The axes extension modules provide also additional inputs and outputs.

If the IO or Axis extensions are connected with their master via SMMC network, they are listed in the document browser in Decentral IO or Decentral axis folder.

10.1.3 SD-Bus Group

SD-Bus groups connect several SD-Bus elements to transferring diagnostic information to master device. If device support SD-Bus it is possible to insert SD-Bus group from the library. User can add multiple SD-Bus group. Each group must contain at least one SD-Bus Element. Number of SD-Bus group is limited by maximum of 31 SD-Bus Eelements. Every SD-Bus Group will act as like as an input element in functional scheme and the out port connector can be connected to safe logics inside functional scheme. For more information see chapter ”9.2 SD-Bus”.



10.2 Peripherals

They represent external building blocks connecting to in/out ports on SMX modules, providing Input or Output signals.
They can be placed to Terminal or Wiring scheme, where are automatically connected to corresponding available ports of SMX devices.
When added, the corresponding functional block is created, which can be used (in Functional scheme) with other Functional blocks to configure desired functionality of the system.

10.2.1 Input Blocks

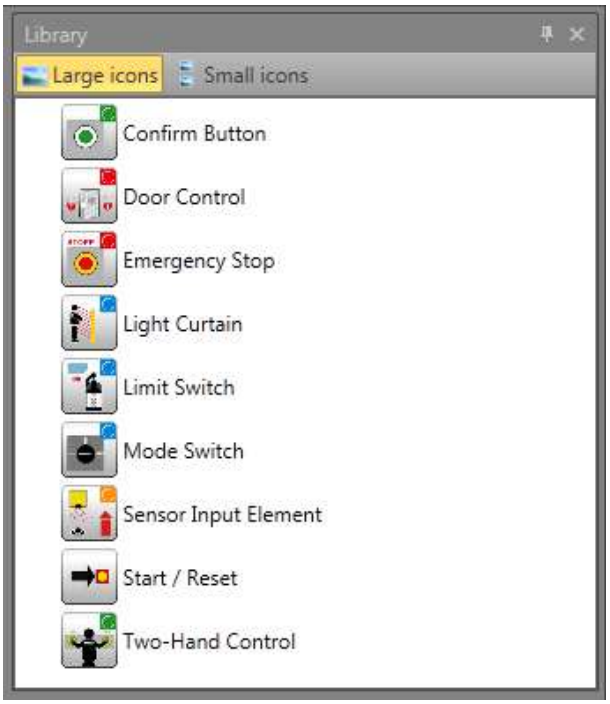


Fig. 48: List of Input blocks

The Input elements create the digital connection between one or several connected sensors and/or further lower-level switching devices in the ***SMX System***. They deliver the data about operating status of the plant monitored by the SMX module. These components, which, from the point of view of the SMX module, are outside the device, can only be inserted and configured in the Terminal or Wiring scheme. Each Input element, except the Mode Switch, provides one logic Output signal "0" or "1" for further processing in the PLC. The elements are structured according to use and Input signal type, enabling targeted resource monitoring of the SMX module. The input elements are structured according to their application (example enable button).
The following paragraphs list details to this type (e.g. Confirm button).

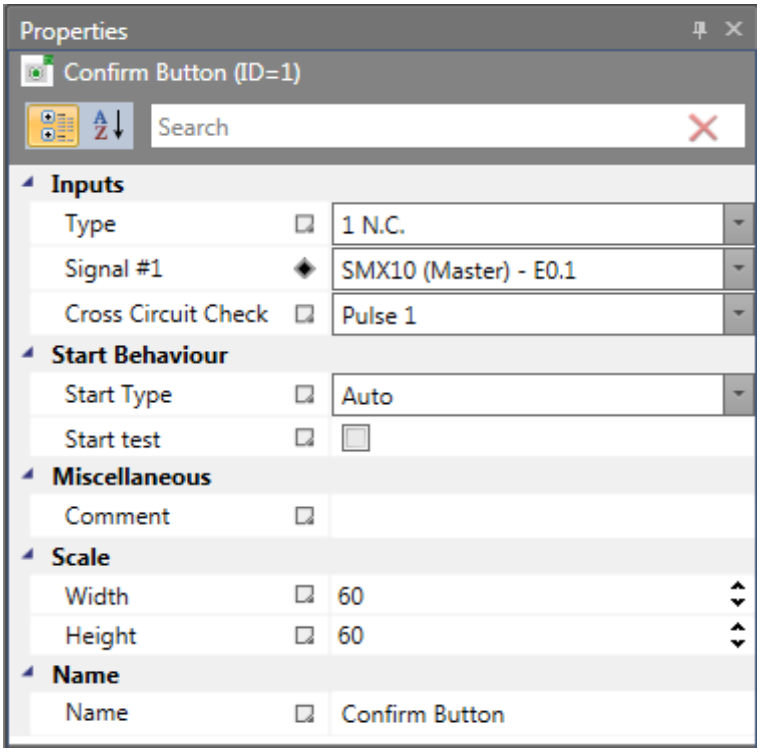


Fig. 49: Confirm button properties view.

NOTICE

- The configuration of the Input block has a significant effect to the performance level. See installation manual.
- Not used Inputs are always assigned to puls 1 (default configuration)
- Not used Inputs are listed into the configuration report anyway with the "default configuration".

The configuration of the digital Inputs is always based on the same process:

Switch type

Switch type used for the component that is connected to the SMX module. The number of associated Input signals and the monitoring behaviour of the SMX module changes in dependence on the selection.

With time monitored switch elements another signal change must take place with t=3s after the first signal. If this is not true, a malfunction is recognized.

Signal-No.

Assignment number of the external signal at the digital Input of the SMX module. This selection list shows the still unused Input signal designators (e.g. "E.1") of the SMX module. These are assigned by the user. A double assignment of Input signals is not permitted. If the resources of the SMX module are almost exhausted and the selection of the switch type would use up too many Input signals, the selection list will remain empty. Here a switch type with less connections must be used.

Cross-circuit check

Source of the Input signal used. Two signal pulses, Pulse1 and Pulse2, are available. The "OFF" option can be alternatively selected.

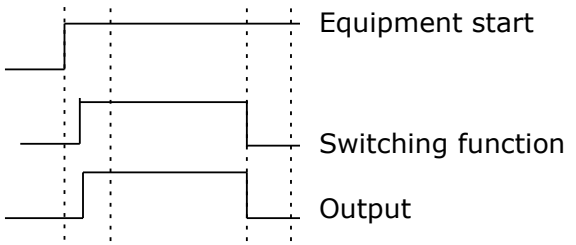
In order to ensure reliable monitoring for short-circuit or line breakage, Inputs next to each other on the SMX module, should have different pulse numbers assigned. If this is not true, a warning will be issued.

Start behaviour

With this setting you specify the way the peripheral devices should behave when switching on or resetting the system.

Automatic

This preset type of starting enables the booting of the SMX module without the necessity of any feedback from the user.

Start type	Function	Scheme
Automatic start	Automatic start after equipment reset. Output of the input element becomes "1" when the safety circuit is closed/active acc. To the definition of the switch type	

Monitored

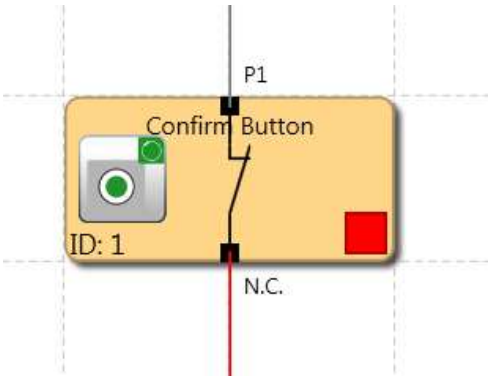
Release of the monitored Input element in case of descending edge on the specified monitoring Input. This is required at any time when the monitored Input element is to be switched.

Example: Start of a drive only after this has been confirmed by the operating personnel. With monitored starting mode an additional connector for linking with a Start element is provided. Here one can configure the continuous behaviour for monitoring the Input element during the start phase.

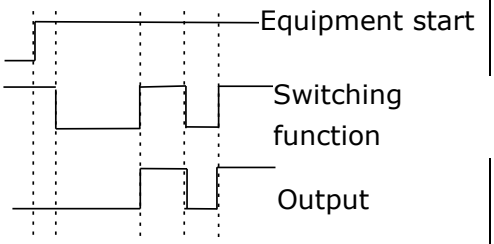
Start test

Manual starting after equipment reset or interruption of the defined safety circuit, including testing of the connected monitoring equipment. The monitoring equipment must trigger once in monitoring direction and switch back on again. Followed by normal operation. This non-recurrent triggering of the Input element when starting (or resetting) the monitored equipment ensures the function of the Input element at the time of starting. A start test can be performed for all Input elements, except the mode selector switch.

An activated start test is indicated by a red rectangle on an added function block.



Each Input block has the ability for running an automatic function test (= start-up test). Altogether two switch elements can be configured with start-up test.

Start type	Function	IL	Scheme
Start test	Manual staring after a new start or an alarm reset, including testing of the connected monitoring equipment. The monitoring equipment must trigger once in monitoring direction and switch back on again. Followed by normal operation. E1: Switching function y1: auxiliary marker	LD E1 ST MX.y1 LD NOT MX.y1 ST MEAA_EN.1 LD MX.y1 ST MEAA_EN.2 LD MEA.1 AND MX.y1 ST MX.2	

Comment

A text to be displayed on the block. You can enter own comment text.

10.2.1.1 Confirm Button

Switch type	Designation	Comment
1 (1 N.C.)	1 normally closed	Enable switch standard
2 (1 N.O.)	1 normally open	Enable switch standard
3 (2 N.C.)	2 normally closed	Enable switch increased request
4 (2 N.C. Time Monitored)	2 normally closed time monitored	Enable switch monitored

10.2.1.2 Emergency Stop

Switch type	Designation	Comment
1 (1 N.C.)	1 normally closed	Emergency Stop standard
3 (2 N.C.)	2 normally closed	Emergency stop higher requirements
4 (2 N.C. Time Monitored)	2 normally closed time monitored	Emergency Stop monitored

10.2.1.3 Door Control

Switch type	Designation	Comment
3 (2 N.C.)	2 normally closed	Door monitoring higher requirements
4 (2 N.C. Time Monitored)	2 normally closed time monitored	Door monitoring monitored
5 (1 N.O. 1 N.C.)	1 normally open + 1 normally closed	Door monitoring higher requirements
6 (1 N.O. 1 N.C. Time Monitored)	1 normally open + 1 normally closed time monitored	Door monitoring monitored
7 (2 N.O. 2 N.C.)	2 normally open + 2 normally closed	Door monitoring higher requirements
8 (2 N.O. 2 N.C. Time Monitored)	2 normally open + 2 normally closed time monitored	Door monitoring monitored
9 (3 N.C.)	3 normally closed	Door monitoring higher requirements
10 (3 N.C. Time Monitored)	3 normally closed time monitored	Door monitoring monitored

10.2.1.4 Two-Hand Control

Switch type	Designation	Comment
11 (2 Toggle Switches)	2 normally open + 2 normally closed	Two-hand button higher requirements type III C
12 (2 N.O.)	2 normally open	Two-hand button monitored type IIIA

Note: With these Input elements a fixed pulse assignment takes place, which cannot be influenced by the user!

10.2.1.5 Limit Switch

Switch type	Designation	Comment
1 (1 N.C.)	1 normally closed	Enable switch standard
2 (1 N.O)	1 normally open	
3 (2 N.C.)	2 normally closed	Enable switch higher requirements
4 (2 N.C. Time Monitored)	2 normally closed time monitored	Enable switch monitored

10.2.1.6 Master Switch

10.2.1.7 Light Curtain

Switch type	Designation	Comment
3 (2 N.C.)	2 normally closed	Light curtain higher requirements
4 (2 N.C. Time Monitored)	2 normally closed time monitored	Light curtain monitored
5 (1 N.O. 1 N.C.)	1 normally open + 1 normally closed	Light curtain higher requirements
6 (1 N.O. 1 N.C. Time Monitored)	1 normally open + 1 normally closed time monitored	Light curtain monitored

10.2.1.8 Mode Switch

Switch type	Designation	Comment
13 (N.C. N.O.)	Selector switch normally closed/normally open	Mode selector switch monitored
14 (3 Phase)	Selector switch 3 steps	Mode selector switch monitored
15 (4 Phase)		

Note: When changing the status of the switch, the SafePLC program to be created must ensure that the Outputs of the module are deactivated (note: Standard 60204-Part1-Paragraph 9.2.3).

10.2.1.9 Sensor

Switch type	Designation	Comment
1 (1 N.C.)	1 normally closed	Sensor Input standard
2 (1 N.O.)	1 normally open	Sensor Input standard
3 (2 N.C.)	2 normally closed	Sensor Input higher requirements
4 (2 N.C. Time Monitored)	2 normally closed time monitored	Sensor Input monitored
5 (1 N.O. 1 N.C.)	1 normally open + 1 normally closed time monitored	Sensor Input monitored

10.2.1.10 Start / Reset Element

This Input element offers both extended monitoring functionality, as well as the possibility to reset an occurring alarm.

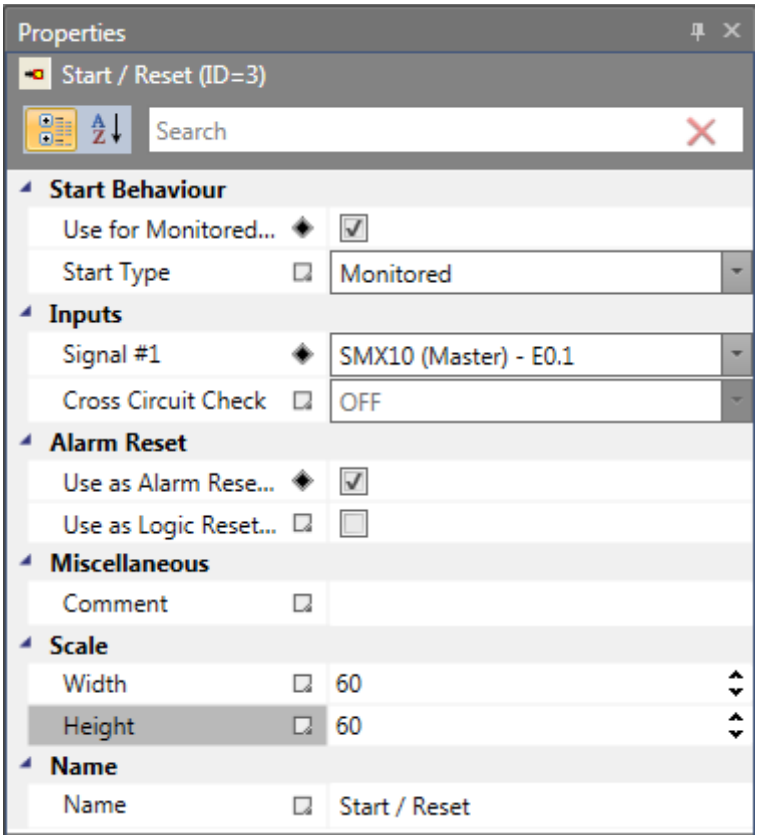
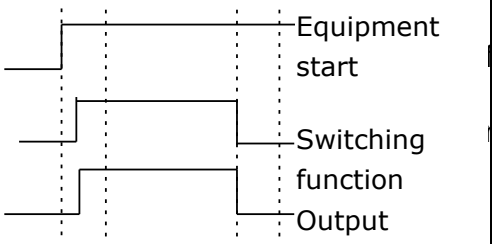
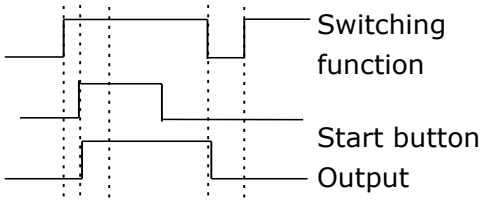


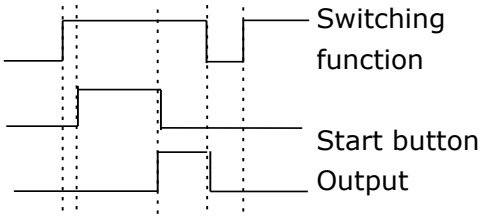
Fig. 50: Start / Reset properties view

Use for Monitored Start Up

With start monitoring activated, special IL code segment for monitoring an assigned Input segment during a restart or an alarm reset of the equipment/machine to be monitored is automatically generated.

This function related testing of a periphery element (e.g. actuation of the emergency stop switch) is intended to ensure its functionality when the equipment is started.

Start type	Function	IL	Scheme
Auto	Automatic start after equipment reset or activation of the Input. Output of the Input element becomes "1" when the safety circuit is closed/active acc. to the definition of the switch type		
Manual start (by hand)	Manual start after equipment reset. Output of the Input element becomes 1 when the safety circuit is closed/active acc. to the definition of the switch type and the start button has been pressed 1 x. Output becomes 0 after safety circuit is open. E1: Switching function E2: Start button M.(X1): Auxiliary marker 1	LD E.1 AND E.2 S M.(X1) LD NOT E.1 R M.(X1) LD M.(X1) AND E.1 ST IE.X	

Start monitored	Manual start after equipment reset with monitoring of start circuit for static 1-signal. Output of the Input element becomes 1 when the safety circuit is closed/active acc. to the definition of the switch type and the start button has been pressed 1 x and released again. Output becomes 0 after safety circuit is open. E1: Switching function E2: Start button M.(X1): Auxiliary marker 1 M.(X2): Auxiliary marker 2	LD E.1 AND E.2 S M.(X1) LD NOT E.1 R M.(X1) LD M.(X1) AND E.1 AND NOT E.2 S M.(X2) LD NOT E.1 R M.(X2) LD M.(X2) AND E.1 ST IE.X	

List of starting types by means of a enable button

The monitoring Input of the start element must be connected to the Output of the Input elements labelled "Start element". Several elements can be monitored.

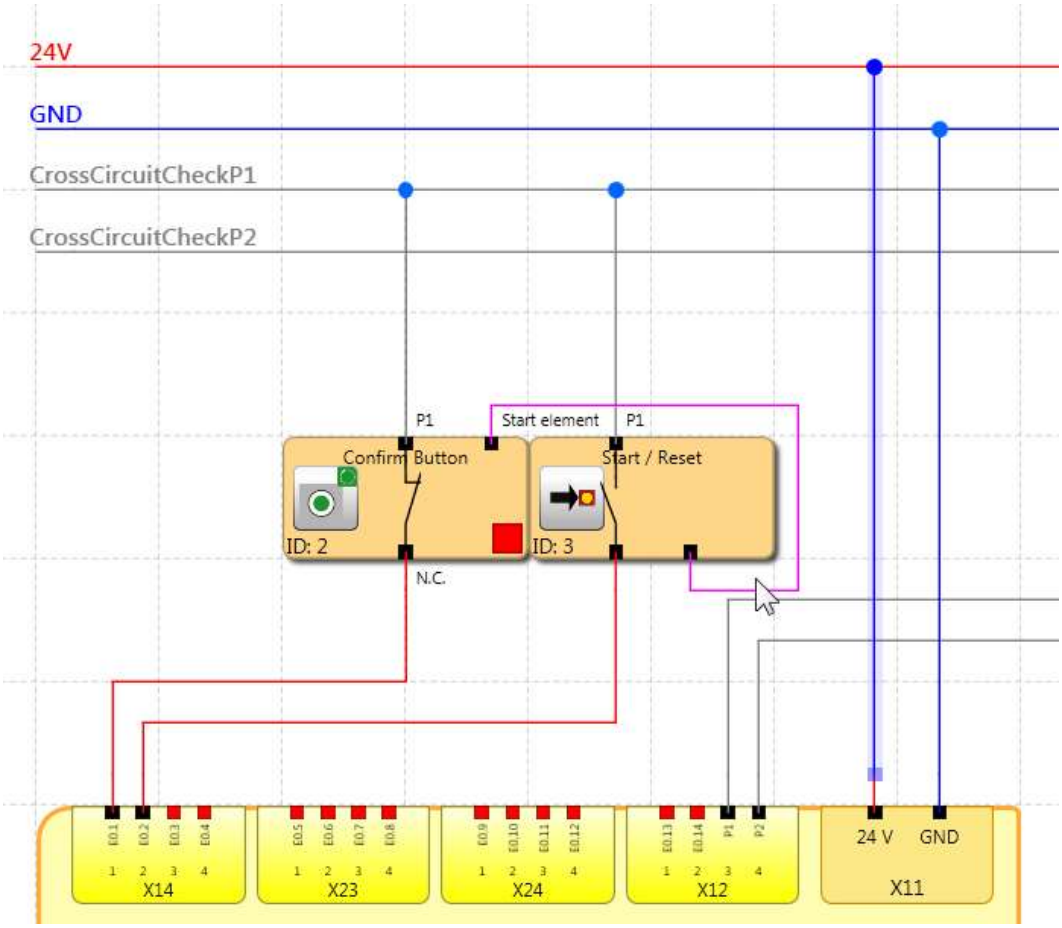


Fig. 51: Start/Reset block connected with Monitored start type

NOTICE	When editing the associated input element, the connection with the start element is deleted and cannot be restored automatically. It must subsequently be supplemented manually.

Input: Signal No. 1

As with the Input elements, this selection list is used to determine the Input on the SMX module to which the button for for the start element is to be connected. This Input is internally limited to the assignment to a basic module (I0.1 to I0.14).

Use as Alarm Reset (normally open)

If this option is set, the associated button can be used to reset (acknowledge) a fault that may occur during operation. The user is thus not forced to reset an occurring fault with the "Func" button on the SMX module. No special program code is generated, but this Input is directly processed by the SMX module in case of an alarm. Only one Alarm reset can be used.

NOTICE	If a reset element is used, no cross-circuit monitoring can be processed for this Input. The cross-circuit check, in this case, is set to "OFF".

The following table shows an overview of all monitoring functions and their acknowledgement in triggered state.

Safety modules	Reset necessary
SEL	yes
SLP	yes
SCA	no
SLA	yes
SSR	no
SSM	no
SSX	yes
SLI	yes
SDI	yes
SLS	yes
SAR	yes
SOS	yes
SAC	no
SMT	no
SLT	no
STR	no
ECS	yes

Resettable safety module

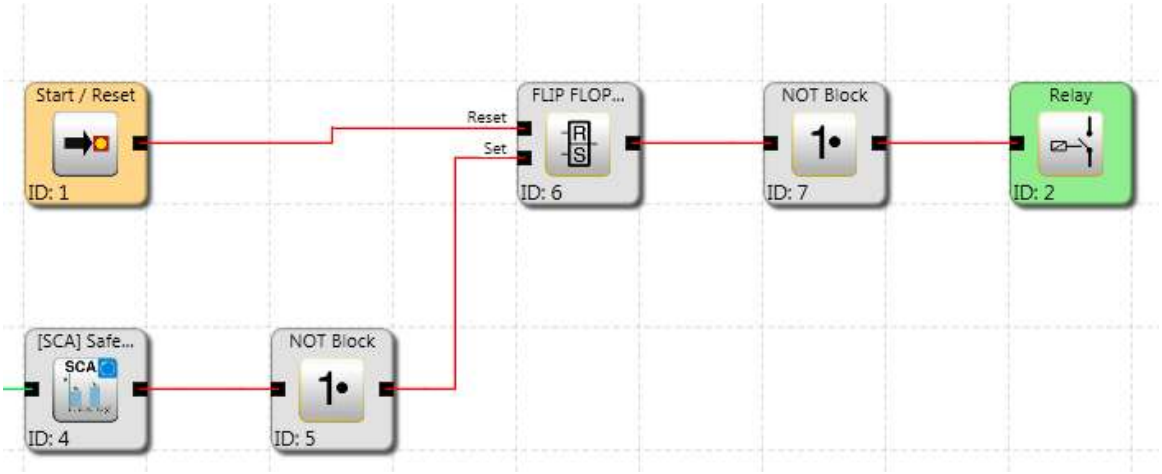
Note:

- The same functionality is achieved when using the "Function" button of the basic SMX module.
- Error messages of type "FatalError" require a restart of the basic SMX module.
- The alarm reset Input can be operated with 24V continuous voltage and is edge triggered.

Use as Logic Reset (normally open)

This option makes the reset-acknowlegement functionality in the logic diagram available for further processing. In this case, the Output of the function block is automatically generated, and can be used for linkage with a logic functionality. This logic reset signal is normally used for the acknowledgement of RS-FlipFlops.

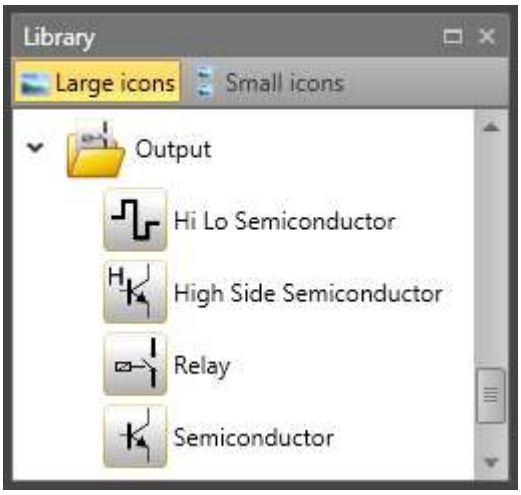
This is intended for the case that an occurring SCA fault is permanently set in an RS-module and can only be reset by pressing the reset button on the RS-module.



Start/Reset used to save and reset errors of SCA module via RS-FlipFlop

Switch type	**Comment**	**Classification category**	**Classification SIL**
1 normally open	Alarm reset standard (evaluation of edge)	--	--
1 normally open	Logic reset standard	Category 3	SIL 2
1 normally open	Start monitoring standard (optional function)	--	--

10.2.2 Output blocks



The Output blocks create the digital connection between one or several connected external switching circuits in the ***SMX System***. Each block is triggered by a logic Input signal "0" or "1" via the functional scheme.

EMU Monitoring

The multiplication of contacts and power normally requires additional switching devices, which are triggered through the shut-down circuits of the ***SMX-system***. EMU monitoring realizes the "Safety relay" function by processing an external feedback circuit.
Applications with higher safety requirements (category 4 of EN 954-1) among others require functional monitoring for these types of switching devices. For this purpose the switching devices must be equipped with positively driven auxiliary contacts. Details can be found in the "SMX Installation Guidelines".
Contacts to be monitored are switched in series and are closed when in idle state. It is verified whether all contacts are closed in idle state and open in active state. Time related expectations can be parameterized. The same sources as for the Inputs are also used to supply the contacts to be monitored. The contacts to monitor must be supplied through the fixed assigned cycle lines.

NOTICE	Details to this subject can be found in the circuitry examples of the installation manual.

Loop Back Circuit
Switch to activate EMU monitoring

Operating Time
Variable time slot (closing delay) for testing the safety contacts
Min{T_{EMU}} = 8 msec
Max{T_{EMU}} = 3000 msec

Releasing Time

Variable time slot (release delay) for testing the safety contacts

Min{T_{EMU}} = 8 msec

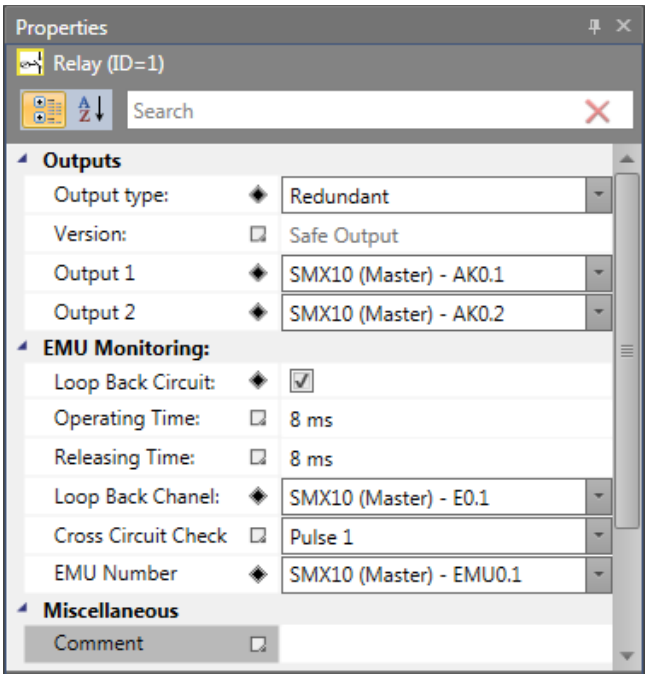
Max{T_{EMU}} = 3000 msec

Loop Back Channel

Digital Input of the feedback circuit. The Outputs for activation of the external switching function and the feedback circuit are located on the same **SMX-system** module (basic module or expansion module).

NOTICE	The result of EMU function of the master device is routed in the PLC code to the configured Output. EMU function in the slave device generates in case of an error an alarm event on the master device.

10.2.2.1 Relay



Output type

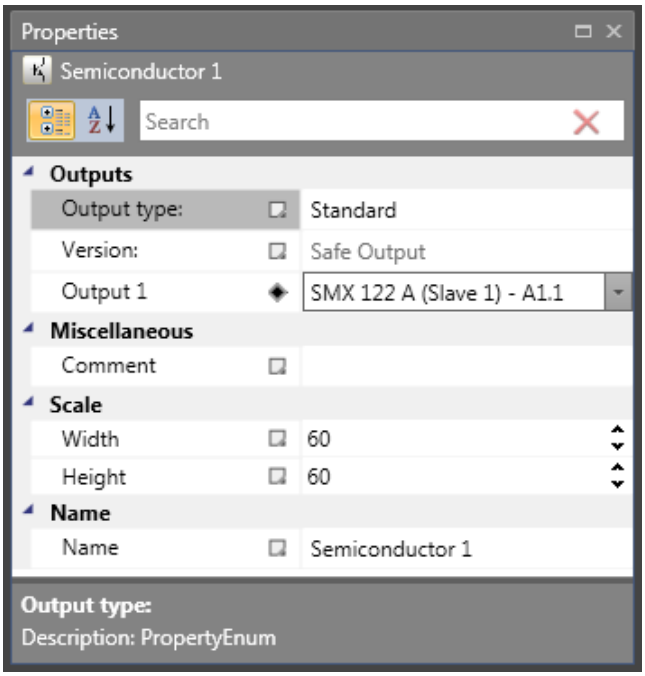
Standard*:* 2 single relays (K1 to K2) can be selected independently from each other.

Redundant: Two relay Outputs are combined and always switched together.

NOTICE	Follow the explanations in the installation manual when using relay in safety applications.

For EMU Monitoring see chapter “EMU Monitoring”.

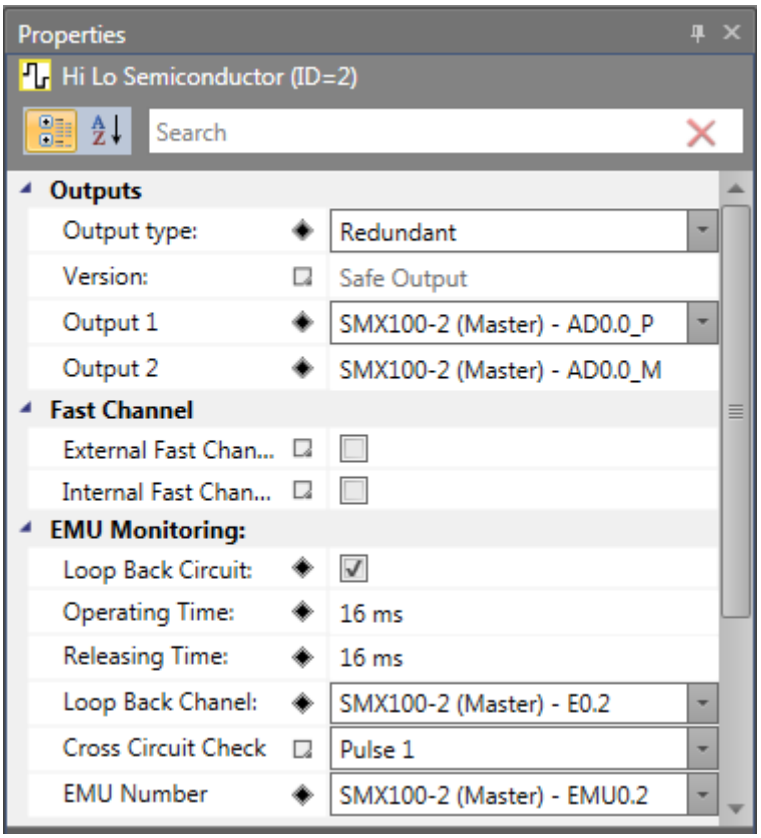
10.2.2.2 Semiconductor



Output as Auxiliary Output

Certain semi-conductor Outputs can solely be used as auxiliary Outputs and are thus not suitable for safety applications (refer to the installation manual for details).

10.2.2.3 Hi Lo Semiconductor



Output type

Standard: "HISIDE" (= P-switching) or "LOSIDE" (= M-switching) can be selected as standard Output. The use of single standard Outputs is not suitable for safety Outputs.
Redundant: This option compellingly specifies a combination of "HISIDE" and "LOSIDE" Outputs.

Output as Auxiliary or Safety Output

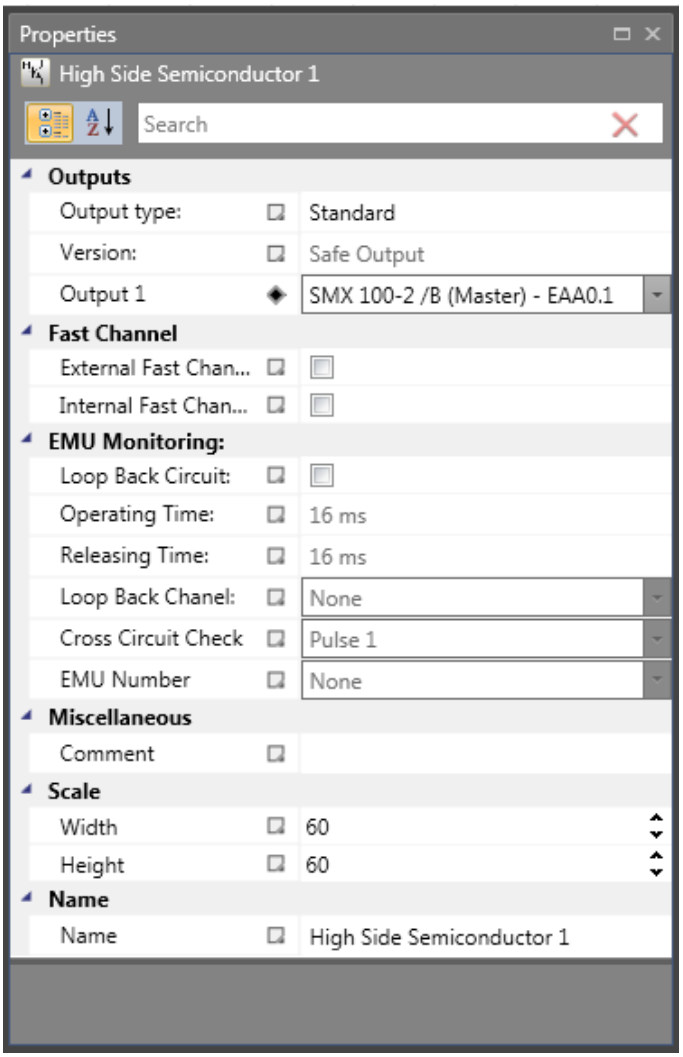
HiLo semi-conductor Outputs can be used individually as standard Outputs and grouped as safety Outputs (refer to the installation manual for details).
For exact contact monitoring see chapter EMU function.

Fast Channel (applies only for SMX100 series)

Only "Redundant" Output type can be configured to a Fast Channel.
A master device Output can use "External" or/and "Internal" Fast Channel of an axis slave device.
The safety functions SLS and SOS can trigger a Fast Channel event.

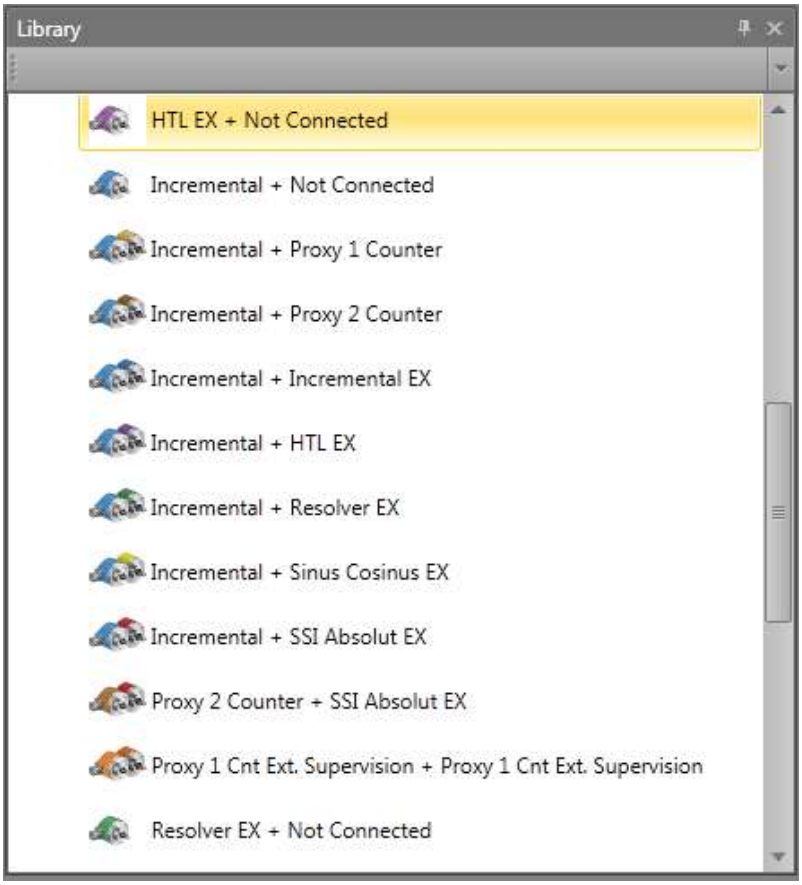
NOTICE Only one Fast Channel event can be created, i.e. all Outputs configured with Fast Channel will be switched off. For Reaction time see installation manual.

10.2.2.4 High Side Semiconductor



10.2.3 Encoder combination

Encoder combination is listed in library window and selection is available in library by Drag&Drop to terminal scheme. It shows only combination which can be used with selected SMX devices. Each Encoder combination has two encoder types.



NOTICE

The parameterization of encoders must always be related to one common axis. If the two encoders are connected to different mechanical positions, and these positions are linked e.g. by an intermediate gear, the measuring section must be fixed to one of the two encoder positions and for the other encoder the transmission ratio in between must be accounted for.

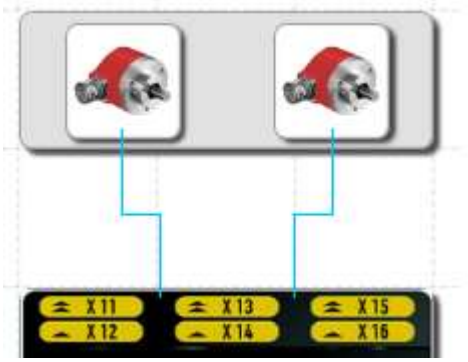


Fig. 52: Encoder combination view in Terminal scheme

10.2.3.1 Encoder type

Fig. 53: Adding encoder by Drag&Drop

Selection of function type of encoder:

- **Incremental**

  Position and speed are detected via pulses / distance.

- **SIN / COS**

  Position and speed are detected via Sine and Cosine / distance.

- **Absolute**

  Absolute encoder, i.e. the position is detected absolute and remanent. By activating the position processing in the axis area, the Input field "Offset" can be additionally enabled.

- **Proxi Switch 1Z**

  Position and speed are recorded by one pulse counter.

- **Proxi Switch 2Z 90°**

  Position and speed are recorded by two pulse counters.

- **Not connected**

  No secondary Encoder.

NOTICE

For position monitoring at least one of the two encoders must be designed as absolute encoder. If none of the two sensors is of the "Absolute" type, the position Input fields in all other Input masks of the monitoring function are inactive.

If an absolute encoder has been selected, the system will show the data format area in property window for further selection.
With the "Incremental" type an impulse multiplication takes place inside the device. The resolution of the encoder must always be entered via "Resolution" calculate button as pulses per revolution (PPR). The multiplication depends on the set encoder configuration and runs internally automatically. Further information can be found in the installation manual.

10.2.3.2 Parameterization Encoder area

Parameterization of both encoders for position and speed detection can be defined in properties window by clicking on appopriate encoder child area on functional scheme or browser.

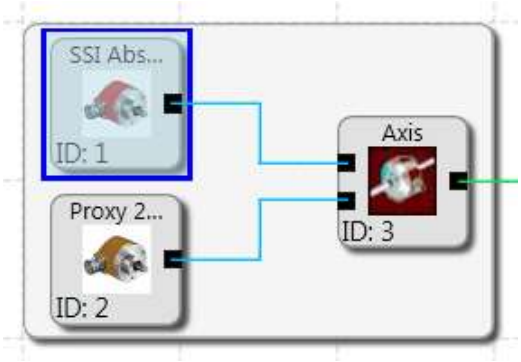


Fig. 54: Encoder child area in encoder combination – Functional scheme

The configuration solely effects the encoder control software. For correct functioning an extended hardware parameterization of the encoder interface is required. Details to this subject can be found in the SMX module "Installation Manual".

Encoder area properties: Parameters depends on encoder type.

Parameter	***description***	***value***
Direction	Selection of sensor counting direction	Up / Down
Supply Voltage	Encoder power supply	5 V, 8V, 10V, 12V, 20V, 24V
Resolution (i) (i)=double click open calculation dialog	Encoder resolution referring to the measuring axis in the pre-defined context (linear or rotational)	1 – 2 000 000 inkr/1000 oder inkr/U
Offset (i) (i)=double click open calculation dialog	Offset value for position encoder. Usable if "Position Processing" is activated	0 – 268435455 Inkr
Encoder type (SinCos EX)	Activation high resolution mode for slow counting SinCos Encoder.	Simple -> no high resolution HighRes -> high resolution
SSI-Interface (Absolutencoder)		
Interface Type	SSI Ausführung	SSI-Masterclock, SSI-Listener
Data Format	Format of position data	Binär, Graycode
Frame Length	Length of whole SSI frame	10 – 31 Bits

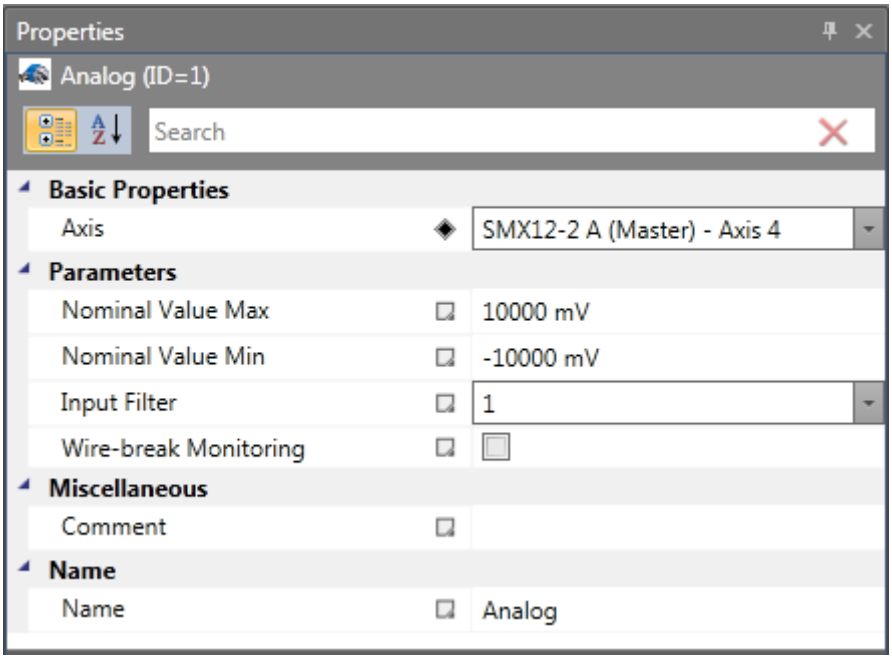
Data Length	Length SSI-Daten starting with MSB. In this data field no e.g. status bits are allowed (only SSI data).	10 – 28 Bits
Data Index	Start-index for bit information encoder data.	Integer value: Bit position starting at LSB
Status Length	Length status infprmation (e.g.: error bit, status bits)	Integer value: Length starting at LSB
Status Index	Index, where a status information (bit index) is listed	Integer value: Bit position starting at LSB
Status Mask Err	Not used	
Status Mask Def	Not used	
Resolver type (Resolver)		
Formfaktor	Formfactor des Resolvers	Off, Sinus, Triangle
Resolver Ratio	Resolver ratio	2:1, 3:2, 4:1, Pattern1 (Amplitude Check: Off), Pattern2 (Frequency Check: Off), Pattern3 (Frequency&Amplitude Check: Off)
Polpaire	Number of pole pairs	1 – 8 Pole pairs
Interface Type	Resolver type	Master, Listener
Listener Frequency	Frequency listener mode	4 kHz – 12 kHz, 14 kHz, 16 kHz

Configuration (read only): Displayed result data related to the currently used encoders.

Colum name	***Meaning***
Class-ID	Unambiguous ID of encoder configuration
General flags	BIT-coded assignment D0: 1= shows that this encoder Input is activated
Modes	BIT-coded assignment for SSI-Interface, data format and sense of rotation D0: 1= SSI-Listener 0= SSI-Standard D1: 1= SSI-Binary 0= SSI-GrayCode D2: 1= Rising0= Falling D3: not used D4: 1= WCS
EXT-Modes	BIT-coded assignment for Encoder voltages D0: 1= 5V D1: 1= 12 V D2: 1= 24 V
V_Standardization	Standardization value for speed (internal calculation value)
PosStandardization	Standardization value for position (internal calculation value)
ShiftvalPos	Interger exponent for basis 2. Internal calculation value for position standardization.
ShiftvalSpeed	Interger exponent for basis 2. Internal calculation value for speed standardization.
Offset	Offset between the encoder value and the position in the measuring section.
Resolution	Resolution of the encoder related to the measuring axis in steps/m or steps/rev.
FilterTime	Not used
Data width	Field with data width in encoder interface
Cycle time	Specifies the cycle time of the SMX module
V_max	The maximum speed that can be entered for the parameterization of the monitoring dialogs. Is defined via “Encoder dialog maximum speed” * Factor 1.5
V_minused	Internal minimum speed for standardization calculation
V_min	The minimum speed that can be entered for then parameterization of the monitoring dialogs.
Measuring length	Entered measuring length.
Pos_Minused	Internal minimum position for standardization calculation
Pos_min	The maximum position that can be entered for the parameterization of the monitoring dialogs.

Analog encoder combination

If an analog encoder combination has been selected, the system will show the data format area in property window for further selection.
Parameters enable scaling of the applied analogue sensor signals. The encoder combination signals encoder1 and encoder2 are used by the ***SMX System*** to generate a secure analogue information AIN1 for further processing by special monitoring blocks. There is also the possibility to use the sensor signals Sensor 3 and Sensor 4 to calculate the secure standardized analogue information AIN2. SMX uses a calculation method which transfers an analogue Input information in a standardized image area ranging from 0 to 100% (see chapter Analog adder). The physical analog Inputs S1/S2 and S3/S4 are assumed to belong together as pairs.



Analog encoder properties: Following parameters for analogue encoders are possible.

Nominal value minimum:	Lower limit of the Input signal in millivolt. After standardization this signal level has a value of 0%.
Nominal value maximum:	Upper limit of the Input signal in millivolt. After standardization this signal level has a value of 100%.
Input filter:	Low-pass filter for the assigned Input signal.

NOTICE

The filter response times specified in the installation manual must be taken into account!

10.2.3.3 Parameterization Axis properties

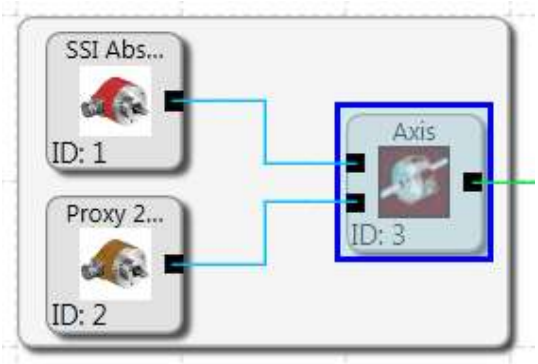
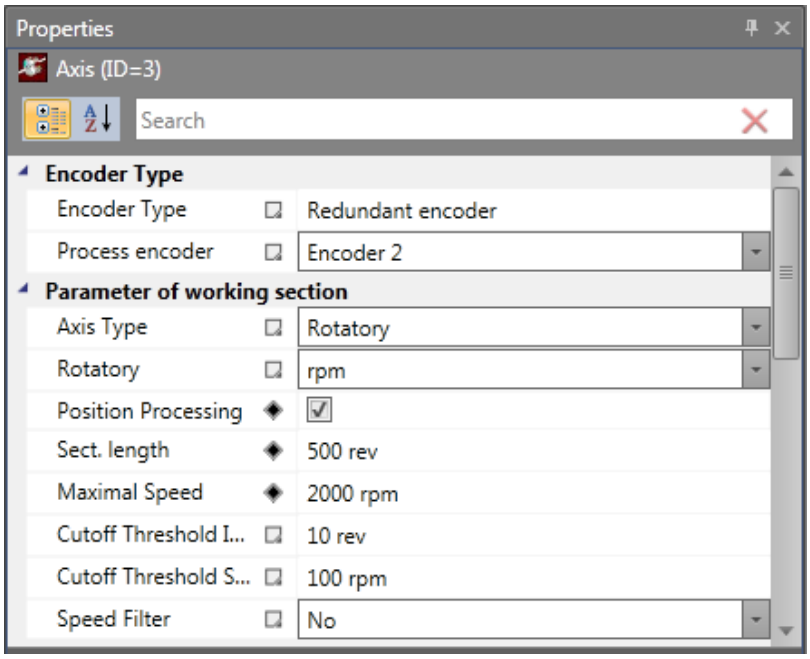


Fig. 55: Axis area in encoder combination – Functional scheme

Parametrization of the following options and Inputs are possible on property window by selecting Axis area in Encoder combination.



Parameterization of the working section

Linear: The measuring section has a linear characteristic. The unit for the position in this case is "mm" and the speed can be given either in "mm/sec" or in "m/sec".

Rotatory: The measuring section has a rotational characteristic, i.e. the movement is a rotation. The position is processed in "mgrd" or in "revolutions", the speed in "mgrd/sec", "revolutions/sec" or in "revolutions/min".

Activating position processing:

Processing of an absolute measuring section. This functionality is only available for selection if an absolute encoder has been parameterized beforehand!
With position processing activated all position related monitoring functions are enabled.

Measuring length:

Specification of the max. measuring length for the position in mm, m or mgrd, rev. With position processing activated, the application must always maintained within the limits of the set measuring length. Each actual position outside the defined measuring length causes an alarm of the SMX axis.

Maximum speed:

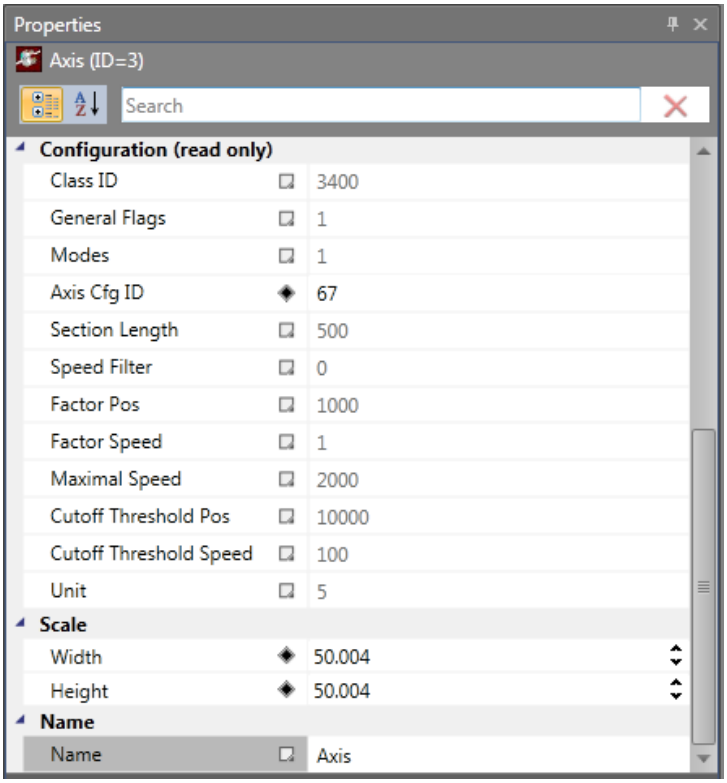
Specification of the max. speed of the reference axis given in the currently selected unit.

The permissible maximum speed describes the highest speed that can possibly be reached with the current technological system configuration. Here one should enter the max. value that may possibly be reached by the axis to be monitored. This may, under certain circumstances, only refer to a theoretical maximum speed of the actual application. The parameterized value does not refer to the safety-related shut-down (e.g. shut-down via SLS), but to the reliability, i.e. consistency of encoders or consistency of the mechanical situation. Exceeding this value triggers an alarm with shut-down and error / alarm status. This is no planned shut-down because of safety-relevant speeding, but the reliability of the encoders or the mechanical situation is in doubt (encoder fault, electric power converter fault,...), because this speed can normally not be achieved under drive technological aspects.
Should this occur, the SMX-module will change into alarm state and switch off all Outputs.
This means, that the "maximum speed" must always be higher than the shut-down speed of a safety function. It serves the purpose of detecting a fault on the safe axis by means of measuring systems.
The value that is entered into this field, at the same time changes the dimensioning of the encoder consistency in regard to the "Increment shut-down threshold" and the "Speed shut-down threshold". A higher maximum speed permits higher shut-down thresholds between the encoders. The maximum value should therefore not be chosen too high, as otherwise the shut-down thresholds could be to high for the reliability of the encoders amongst each other. Configuration (read only) properties value

table shows these calculated limiting values for the variables V_max, V_min.

Shut-down thresholds: The shut-down threshold defines the tolerable speed/position deviation between the two detection channels / encoder channels. It may be dependent on the arrangement of the sensors and the maximum mechanical play (e.g. gearbox and spring rate) between the two detection locations. The lowest possible value, at which monitoring is not yet triggered in normal operation, should be chosen, under due consideration of the dynamic processes (e.g. load/play in gearbox).

Speed filter: Average filter covering the detected speed values of the encoder to dampen peak speeds in case of low resolution or variance of the connected sensor With the filter switched on the specified response time of the overall system will increase by the set time. The filter has an effect on the speed related parameters of the monitoring modules.



Configuration (read only): Displayed result data related to the currently used encoders.

Column name	***Meaning***
Class-ID	Unambiguous ID of axis configuration
General flags	BIT-coded assignment D0: 1= shows that this axis Input is activated
Modes	BIT-coded assignment for Position processing and type of measuring section D0: 1= Position processing active 0= inactive D1: 1= Linear 0= Rotary
Axis CFG ID	Unambiguous ID for both encoder configurations
Measuring length	The measuring length for the position from the main dialog
PosFactor	Factor for position calculation (Standardization)
FactorSpeed	Factor for speed calculation (Standardization).
MaxSpeed	Maximum standardized speed.
Shut.down threshold Pos	Value of shut-down threshold incr. but non-standardized
Shut.down threshold Speed	Value of shut-down threshold speed, but non-standardized
Unit	Unit for the displayed values 1 = UNIT_MM 2 = UNIT_M 3 = UNIT_MDEG 4 = UNIT_REV_SEC 5 = UNIT_REV_MIN

NOTICE

The displayed values serve the purpose of technical support of the encoder configuration and are used for the standardization calculation in the SMX-block!

- Determining the characteristic of the measuring length as linear or rotational generally influences all position and speed Inputs in the other properties of the monitoring functions. It generally changes the Input from mm, m or mm/s, m/s to mgrd, rev or mgrd/s, rev/s or rev/min and vice versa.
- The specification of max. measuring length and max. speed is mandatory. A missing or incorrect entry can cause undesired responding of the monitoring functions.
- In general first encoder has the function of a process sensor and second encoder acts as a reference sensor. For the combination of absolute/incremental encoder combination the absolute system is always used as process sensor. If encoder with different resolutions are used, the encoder with the higher resolution should be configured as process sensor.

10.2.3.4 Analogue interface

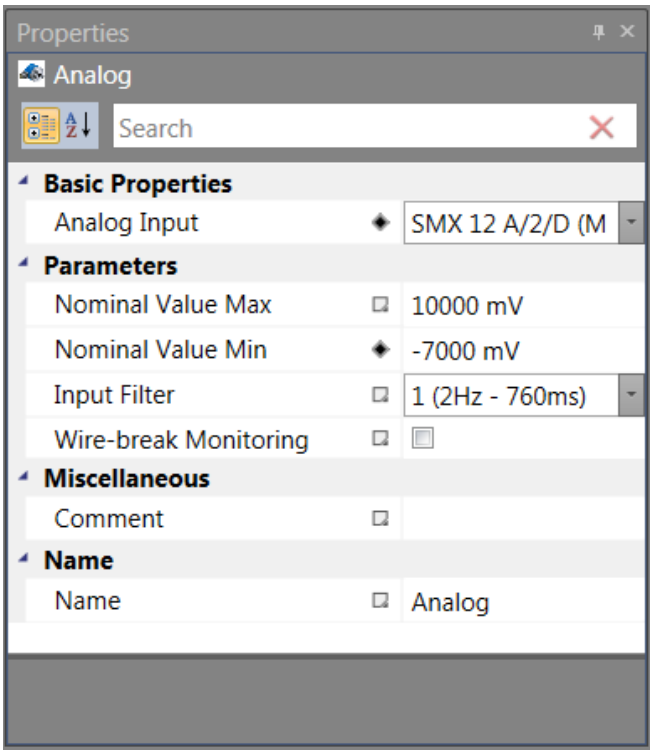
A special parameter editor is available for parameterizing the analogue interface. The associated block symbol in the terminal scheme will appear against a red background, as long as this interface has not been parameterized. After parameterization the background colour changes to green.
For safety tasks two physically analogue input signals each are required. These can be scaled according to their signal characteristics and wired with low-pass filters.

In the terminal scheme the analogue inputs and the associated filter blocks are shown accordingly. Double-clicking opens the editor for the selected element.

Fig. 56: Analog input

10.2.3.4.1 Analogue input AIN1 / AIN2

This dialog enables scaling of the applied analogue sensor signals.
The sensor signals Sensor1 and Sensor2 are used by the ***SMX System*** to generate a secure analogue information AIN1 for further processing by special monitoring blocks.
There is also the possibility to use the sensor signals Sensor 3 and Sensor 4 to calculate the secure standardized analogue information AIN2.
SMX uses a calculation method which transfers an analogue input information in a standardized image area ranging from 0 to 100%.



Perm. deviation sensor 1/2
Max. permissible deviation between the two analogue input signals Sensor 1/Sensor 2 or Sensor 3/Sensor 4 respectively. Default value in percent of the standardized maximum signal range.

Nominal value minimum
Lower limit of the input signal in millivolt. After standardization this signal level has a value of 0%.

Nominal value maximum
Upper limit of the input signal in millivolt. After standardization this signal level has a value of 100%.

Input filter
Low-pass filter for the assigned input signal.

Wire-break Monitoring
If activated the analog input value has to be > 1000mV. If the value is <= 1000mV an alarm will be generated.

NOTICE	The filter response times specified in the installation manual must be taken into account!

Analogue adder

The analogue adder enables weighting of the standardized analogue signals.
Two input signals, which have already been standardized, can be added together in a defined ratio to each other. The corresponding signal components are determined in percent.

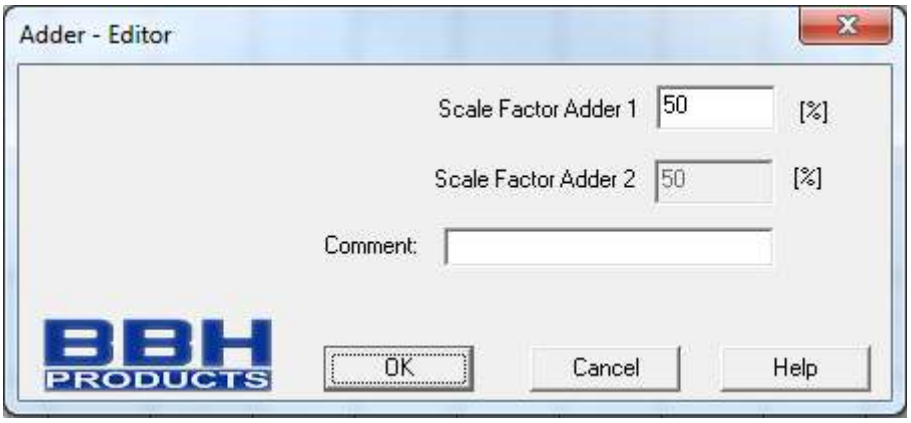


Fig. 57: Analogue input - adder

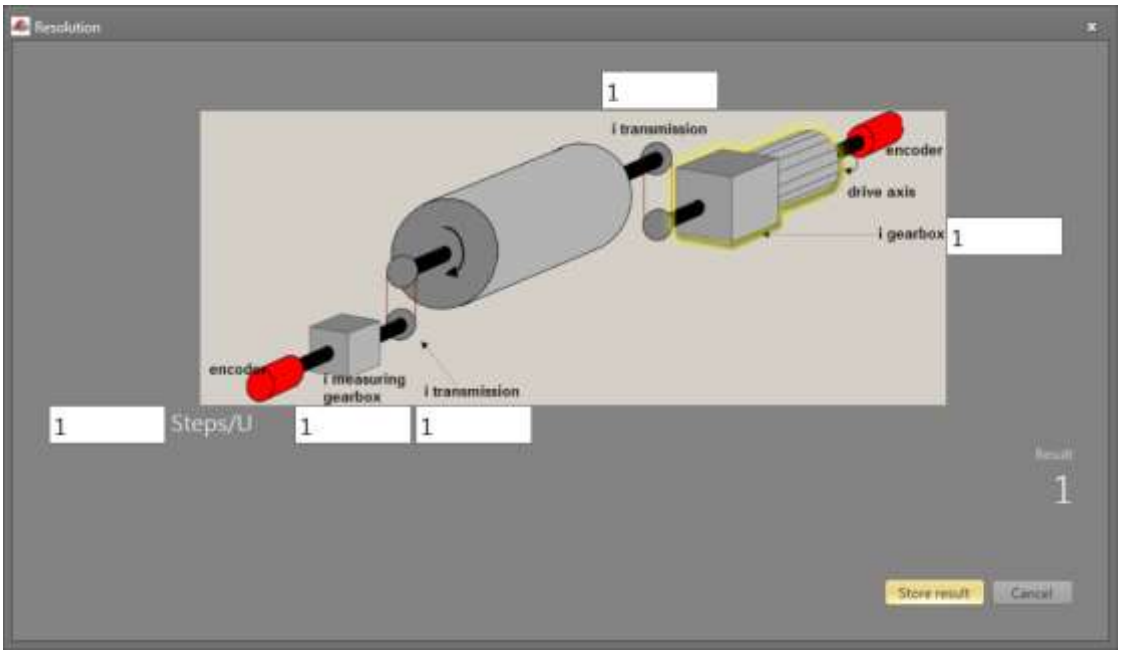
10.2.3.4.2 Analogue sensor test

See "TD-37350-820-12-01F Analogue sensor test"

10.2.4 Determination of the Resolution

Determination of the resolution with regard to different characterized measuring lengths. Determination must always be entered by calculate button in encoder area properties. Encoder resolution referring to the measuring axis in the pre-defined context (linear or rotational). Input data for the determination must be stored for determination.

10.2.4.1 Rotational measuring lengths:



Reference axis	Input values		Resolution related to measuring length
Feed axis (process axis)	Encoder 1: Resolution Gb 1 in measuring gearbox in layshaft assembly	A_Gb1 in [steps/rev] I_MG I_VG	Gb1 = I_MG · I_VG · A_Gb1
	Encoder 2: Resolution Gb 2 in gearbox in layshaft assembly for drive	A_Gb2 in [steps/rev] I_G I_VA	Gb2 = I_G · I_VA · A_Gb2
Motor axis	Encoder 1: Resolution Gb 1 in measuring gearbox in layshaft assembly ∅ measuring gear in gearbox in layshaft assembly	A_Gb1 in [steps/rev] I_MG I_VG D_MR in [mm] I_G I_VA	

Input example 1:
In a manufacturing device the speed of certain manual processes is to be monitored for a safe reduced value, as well as standstill and movement direction. The movement to be actively monitored is a rotary movement. The drive works with an electric motor with integrated motor feedback system and intermediate gear.

Selecting the block or module
Selecting the encoder type: No monitoring of positions requested -> Absolute encoders are not required, speed detection by means of incremental encoders is quite sufficient.

Determination of the measuring length: The axis of rotation of the manufacturing device is selected as reference axis. The following parameters are selected:

- Rotational
- Measuring length unknown
- Reference axis is rotational axis => designation = mgrd

Determination of parameters for Encoder 1: Encoder 1 is directly connected with the Output axis of the gearbox = load axis. A encoder with the data: Pulse generator A/B-track, 5000 pulses/revolution is used.

The following parameters are selected:

- Encoder type incremental
- Resolution:

Encoder 1: Resolution Gb 1 i measuring gearbox i layshaft assembly	 5000 [steps/rev] 1 1

$$Gb1 = I\_MG \cdot I\_VG \cdot A\_Gb1 = 1 \cdot 1 \cdot 5000 = 5000;$$

Determination of parameters for Encoder 2: The existing motor feedback system is used as encoder 2. The motor is connected to the rotational axis of the manufacturing device by means of an intermediate gear.
The encoder interface is connected to the pulse Outputs of the power converter. The sensor data are as follows: Hiperface, 1024 I/rev. According to the data sheet of the power converter manufacturer the sine/cosine tracks of the Hiperface encoder are Output in the form of pulses -> emulated encoder on the pulse Output of the power converter = pulse generator, A/B-track, 1024 I/rev. The following parameters are selected:

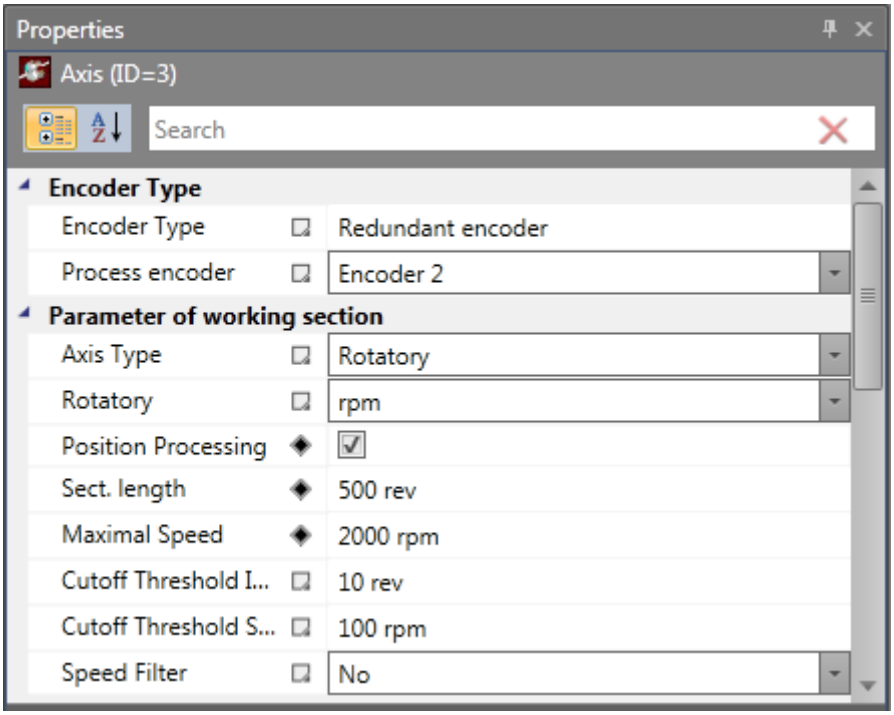
- Encoder type incremental
- Resolution:

Encoder2: Resolution Gb2 i gearbox I layshaft assembly for drive	 1024[steps\rev] 350 1

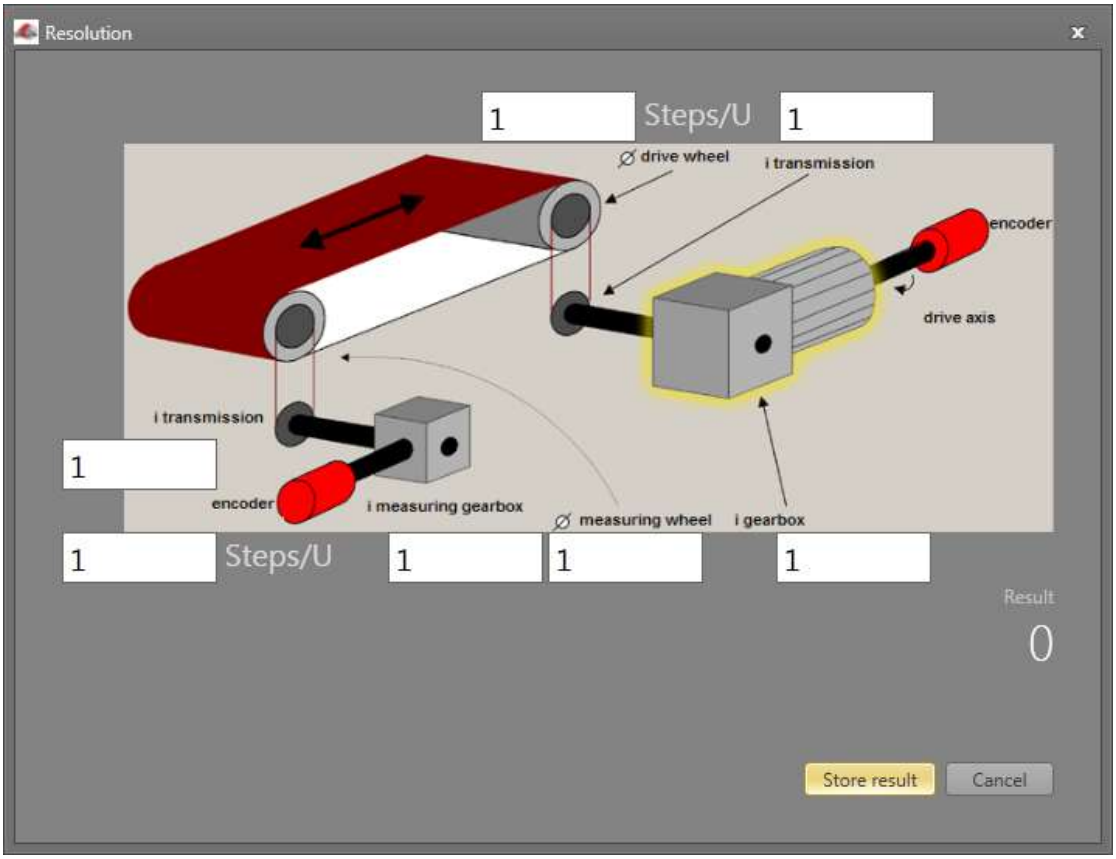
Gb2 = I_G · I_VA · A_Gb2 = 1024 · 350 · 1 = 35840;

Specification of max. speed: The max. speed of the Output axis is derived from the max. motor speed. In rev./s related to the load axis and with Nmax = 1500 rev./min it is (1500 [rev./min] / 60 [s]) / 350 = 0,
Converted to mgrd/s this results in 0.07142 [1/s] * 360 *10³ [mgrd] = 25 714 [mgrd/s]

Input of max. deviation: The empirical measurement reveals a maximum difference between both detection points of 80 mgrd. A value of 100 mgrd is chosen.



10.2.4.2 Linear measuring length



Reference axis	Input values		Resolution related to measuring length
Feed axis (process axis)	Encoder1: Resolution Gb 1 in measuring gearbox in layshaft assembly ∅ measuring gear	A_Gb1 in [steps/rev] I_MG, I_VG, D_MR in [mm]	$Gb1 = \frac{1000}{D\_MR \cdot \pi} \cdot I\_MG \cdot I\_VG \cdot A\_Gb1$
	Encoder 2: Resolution Gb 2 in gearbox in layshaft assembly for drive ∅ drive gear	A_Gb2 in [steps/rev] I_G, I_VA, D_AR in [mm]	$Gb2 = \frac{1000}{D\_AR \cdot \pi} \cdot I\_G \cdot I\_VA \cdot A\_Gb2$
Motor axis	Encoder 1: Resolution Gb 1 in measuring gearbox in layshaft assembly ∅ measuring gear in gearbox in layshaft assembly for drive ∅ drive gear	A_Gb1 in [steps/rev] I_MG, I_VG, D_MR in [mm], I_G, I_VA, D_AR in [mm]	$Gb1 = \frac{\frac{1000}{D\_MR \cdot \pi} \cdot I\_MG \cdot I\_VG \cdot A\_Gb1}{\frac{1000}{D\_AR \cdot \pi} \cdot I\_G \cdot I\_VA \cdot A}$

Input example 2

On a manufacturing machine access to the working area is to be enabled at certain positions of the main feed axis for manual feeding or setup work. The drive remains active in this position and is only monitored for standstill. The limits of the working stroke are variable and are to be monitored electronically in safety-relevant mode, as a replacement of the mechanical safety limit switch. The movement to be actively monitored is a linear movement. An absolute encoder is positively connected with this main drive axis of the linear length measuring system. The drive works with an electric motor with integrated motor feedback system and one intermediate gear. The Output shaft of the intermediate gear is connected with a drive gear ∅ 31.83 mm (= 100 mm circumference).

Selecting the module

Selecting the encoder type: Monitoring of positions is requested -> Absolute encoder required, for the second encoder an incremental detection + reference switch is sufficient.

Determination of the measuring length parameters: The main axis of the machine is selected as reference axis. The following parameters are selected:

- Linear
- Measuring length = 600 mm
- Reference axis is rotational axis => designation = mm

Determination of parameters for encoder 1: Encoder 1 is directly connected to the drive axis. Absolute encoder SSI, 4096 steps/rev. is used.

The following parameters are selected:

- Encoder type absolute
- Data format SSI
- Resolution:

Encoder 1:	
Resolution Gb 1	4096 [steps/rev]
i measuring gearbox	1
i layshaft assembly	1
∅ drive gear	31.83

$$Gb1 = \frac{1000}{D\_MR \cdot \pi} \cdot I\_MG \cdot I\_VG \cdot A\_Gb1 = \frac{1000}{31{,}83 \cdot \pi} \cdot 1 \cdot 1 \cdot 4096 = 40960$$

Determination of parameters for encoder 2: The existing motor feedback system is used as encoder 2. The motor is connected with the drive gear via an intermediate gearbox. The ratio of the gearbox is 4.51 times the Ø of the drive gear 31.831 mm.
The encoder interface is connected to the pulse Outputs of the power converter. The encoder data are as follows: Hiperface, 1024 I/rev. According to the data sheet of the power converter manufacturer the sine/cosine tracks of the Hiperface encoder are Output in the form of pulses -> emulated encoder on the pulse Output of the power converter = pulse generator, A/B-track, 1024 I/rev.

The following parameters are selected:

- Encoder type incremental
- Resolution:

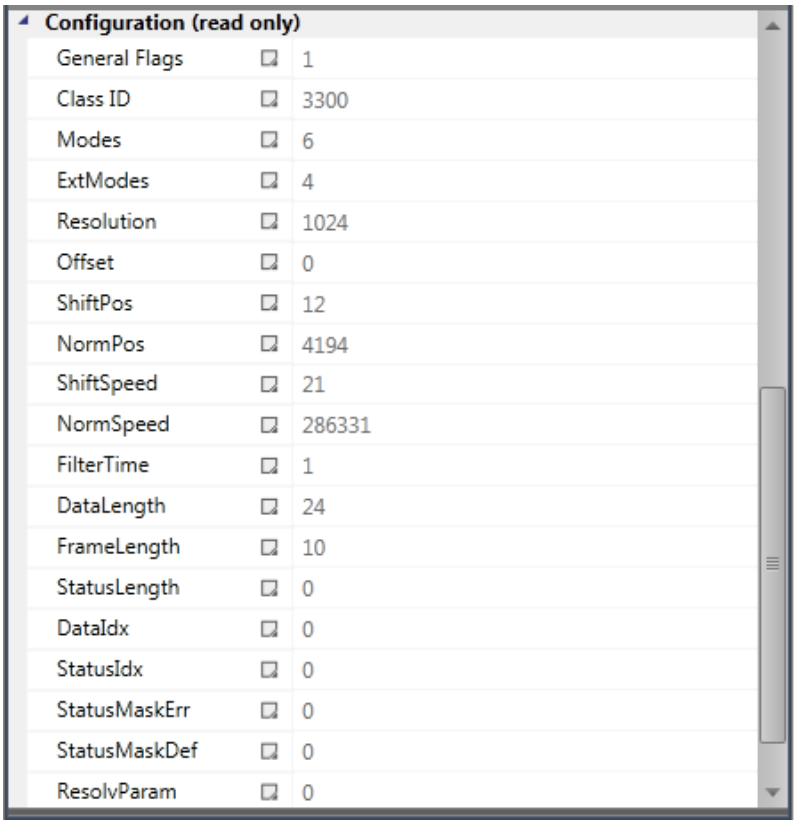
Encoder 1:	
Resolution Gb 2	1024 [steps/rev]
i gearbox	4.51
i layshaft assembly	1
∅ drive gear	31.83

$$Gb2 = \frac{1000}{D\_AR \cdot \pi} \cdot I\_G \cdot I\_AV \cdot A\_Gb2 = \frac{1000}{31{,}83 \cdot \pi} \cdot 4{,}51 \cdot 1 \cdot 1024 = 46182$$

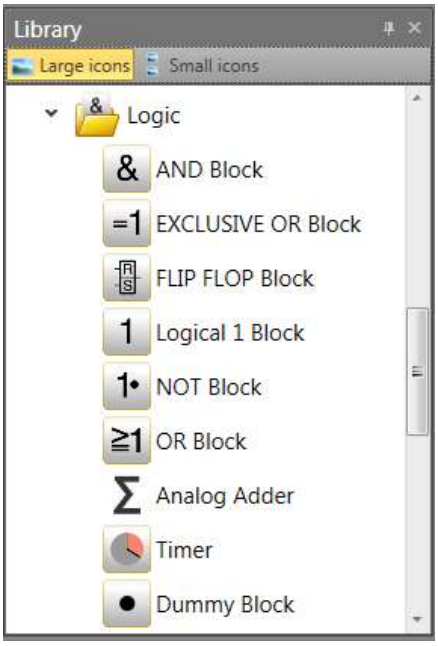
Specification of max. speed: The max. speed of the Output axis is derived from the max. motor speed. In rev./s related to the load axis and with Nmax = 1500 rev./min it is (1500 [rev/min] / 60 [s]) * 0.012 [m] = 0.3 [m/s] = 300 [mm/s].

Input of max. deviation: The empirical measurement reveals a maximum difference of <1 mm between both sensing points on motor axis and movement axis. The value chosen is 1 mm.

The encoder configuration Info obtains:



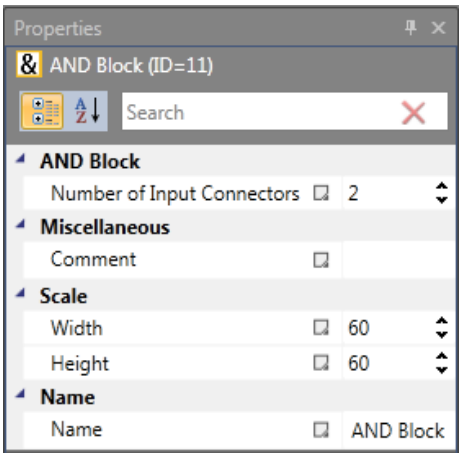
10.3 Function blocks
10.3.1 Logic functions



These blocks form the basis for creating a program for the safety application. They enable the logic linkage of the Inputs with monitoring functions with and the Outputs. Inserting logic blocks is only possible in the "Functional scheme" view, otherwise the associated menu commands are disabled. This is the case when the resources for a module are already exhausted, e.g. after all timer modules have been inserted.

10.3.1.1 AND Block

"AND"-operations of maximum 5 Output signals from other function blocks. The AND-operation provides the signal state "1" for all Input signals "1" as logical result, otherwise "0".

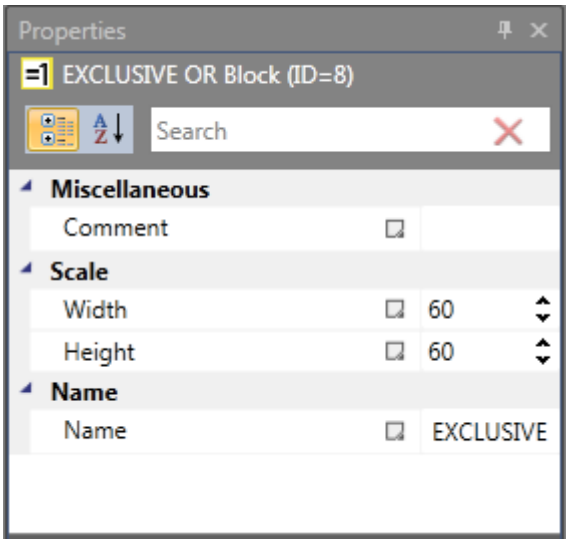


NOTICE

The number of Input Connectors can only be reduced in case of free connectors. If all connectors have linkages assigned, these must be deleted beforehand.

10.3.1.2 EXCLUSIVE OR Block

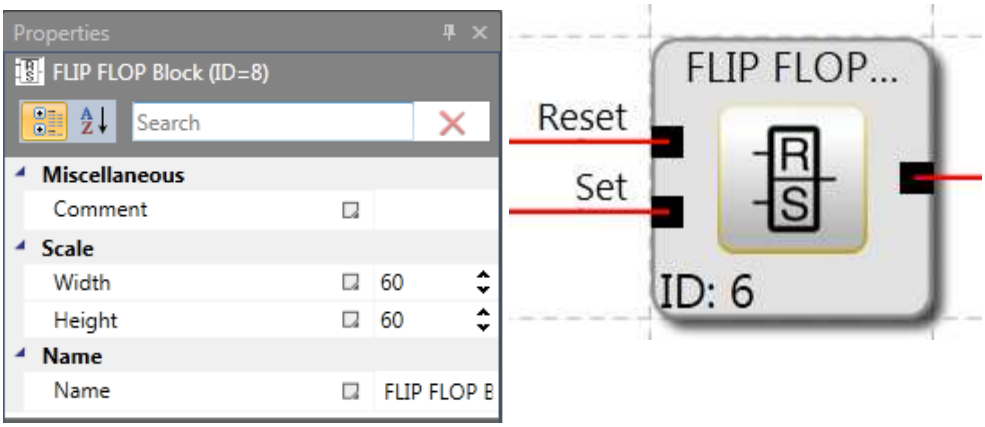
"EXCLUSIVE OR"-operations of 2 Output signals from other function blocks. The XOR-module provides "1" as logic result, if one Input has the Input signal "1" and the Input has the Input signal "0", otherwise "0".



10.3.1.3 FLIP FLOP Block

Set / reset contact element. This switching element shows the following characteristics:

- The logic result during initialization of the element is "0".
- The logic result becomes "1", if an edge change from "0" to "1" takes place at the "Set" Input. The Output remains at "1", even if the state of the "Set" Input changes back to "0".
- The logic result becomes "0", if an edge change from "0" to "1" takes place at the "Set" Input.
- With both Inputs set to "1", the result is "0"!



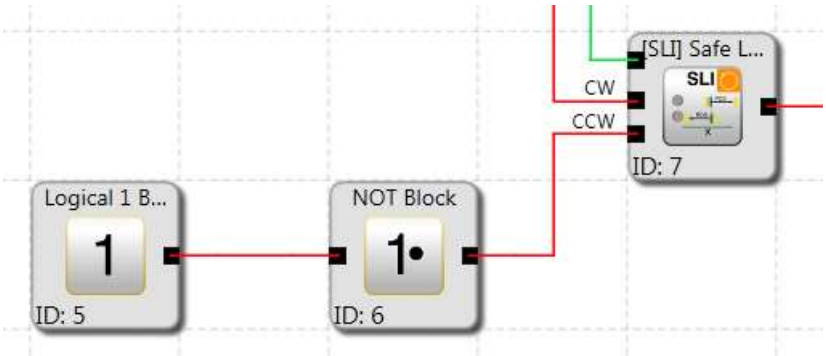
NOTICE

The desired switching state of this element is only achieved by linking as specified in the labelling(reset-set).

10.3.1.4 Logical 1 Block

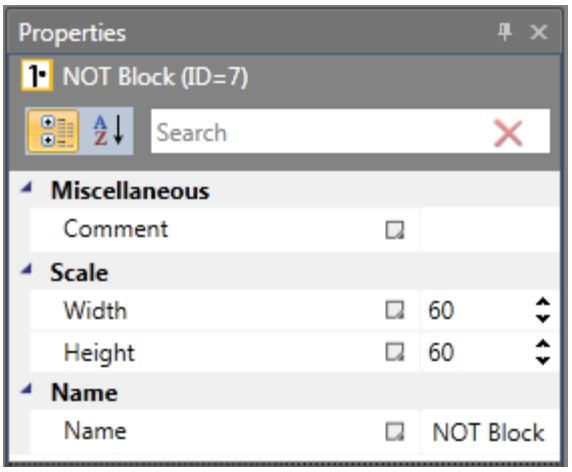
This module constantly provides the value "1". This function can be used to program static states in the functional scheme.

Example: Assignment of an unused Input on a direction dependent SDI



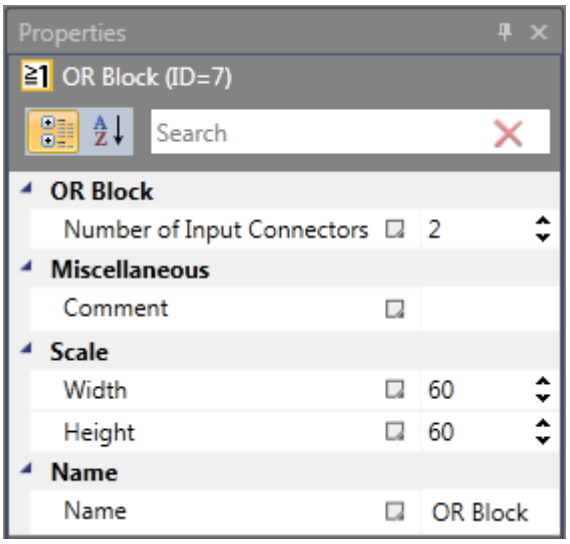
10.3.1.5 NOT Block

The logic result of this function block is the negation of the Input signal. The term negation means that the logic result is reversed (negated).



10.3.1.6 OR Block

"OR"-operations of maximum 5 Output signals from other function blocks. The OR-operation provides the signal state "1" for at least one Input with signal state "1", otherwise "0".

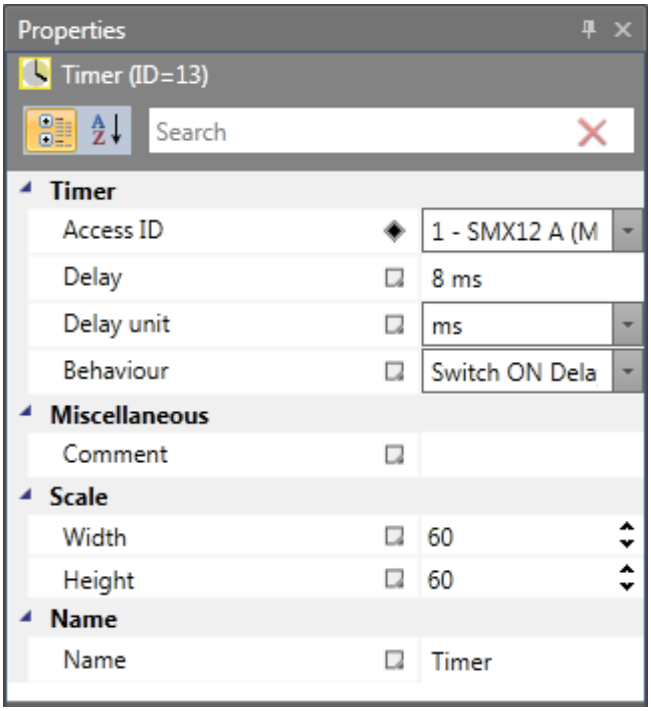


10.3.1.7 Dummy Block

The signal channel enables the functional transfer of data from the process mapping to a connected fieldbus. It consists of two parts: the first part consists of logic data with 56 bits, the second part consists of a process data channel with a width of 64 bits. The data to be transmitted can be freely assigned via a profile generator.

10.3.1.8 Timer

Function block that starts a counter in the event of an edge change. After the specified temporal delay the logic result will become "1" or "0".



Block ID: Number of timer. This can be set when inserting. Once all timers are used up, the timer command will be disabled in the menu.
Delay: Desired period of time the timer should run.
T min = 8 ms (SMX Compact)
T min = 16, 24, 32 ms (SMX Modular)
T max = 533 min (31999992 ms)

NOTICE
Due to the fixed / parametriced cycle times of the SMX module the timer specification must be a multiple of cycle time.

Characteristics

Switch ON delay:

- The timer Output remains "0" as long as no signal is applied to the Input.
- The timer is activated as the edge picks up.
- Once the timer has run out, the Output changes to 1, as long as no edge change has occurred at the Input (the Input remains "1").
- If the Input changes to "0", the Output will immediately also be set to "0".

Switch OFF delay:

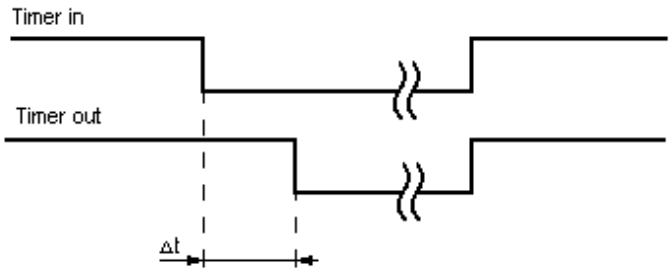
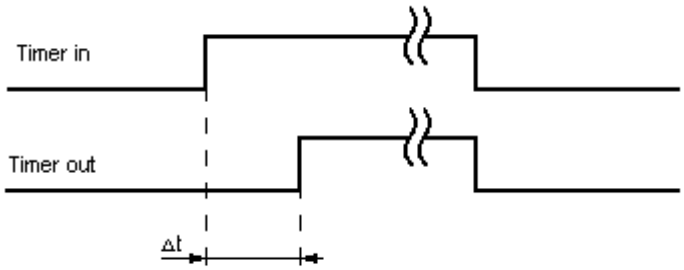
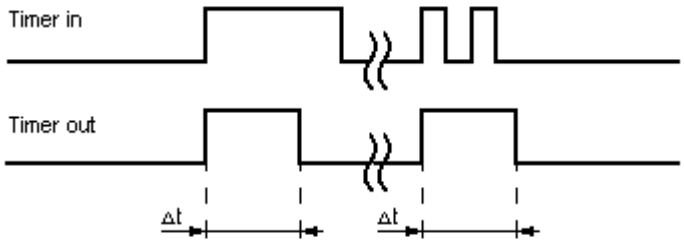
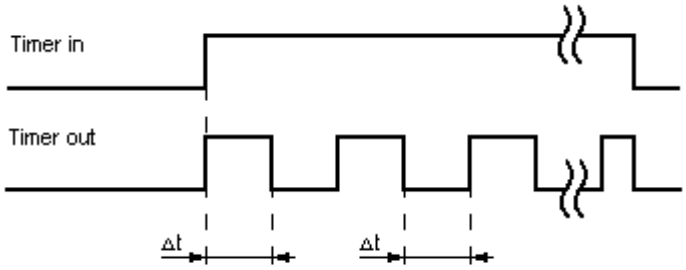
- The timer Output remains "0" as long as no signal is applied to the Input and the timer is not running.
- The timer is activated as the edge drops off. The Output remains 1 over the set time period.
- The timer Output will immediately change to "1" as soon as a signal is applied to the Input.
- The Output changes to 0 after the set time period, if no edge change has occurred at the Input.

Impuls:

- The timer output remains "0", as long as no signal is applied to the input.
- The timer is activated as the edge picks up. The output remains "1" over the set time period, even if no signal is applied to the input.
- The timer output immediately changes to "1" as soon as a signal is applied to the Input.
- The output changes to "0" after the set time, even if a signal is applied to the input or not.

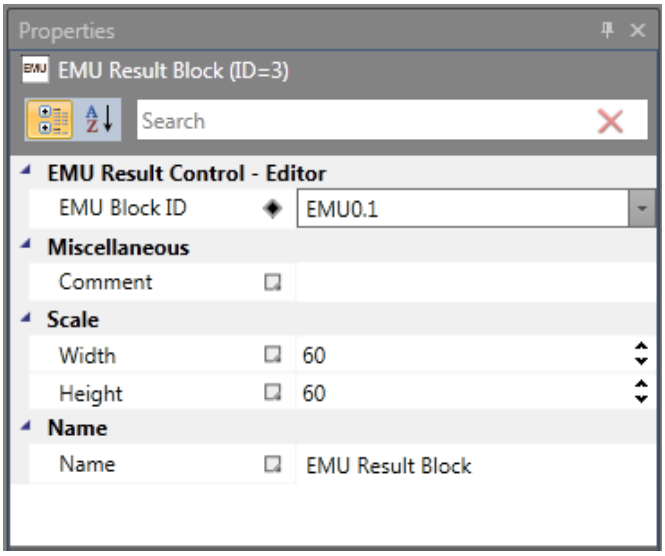
Intermitted:

- The timer output remains "0", as long as no signal is applied to the input.
- The timer is activated when the edge picks up.
- The timer output immediately changes to "1" when a signal is applied to the input.
- The output changes to "0" after the set time and returns to "1" after the same set time if no edge change has occurred at the input.

Function	Activation timer	Timing diagram
Switch OFF Delay	Falling edge	
Switch ON Delay	Rising edge	
Impulse	Rising edge	
Intermitted	Rising edge	

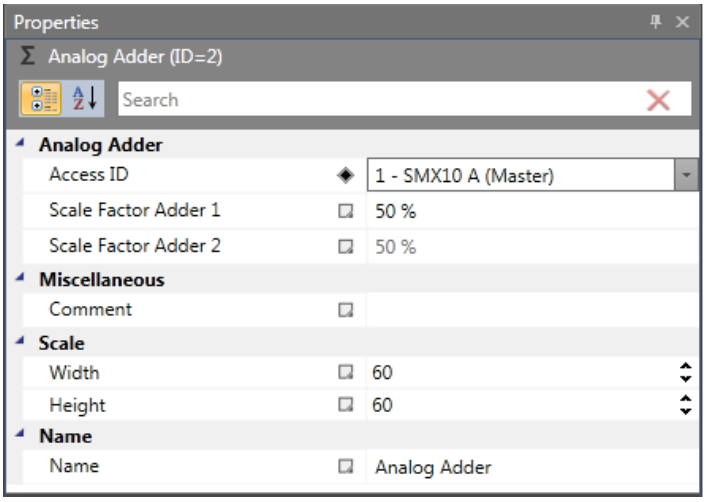
10.3.1.9 EMU Result Block

This module delivers the result of the EMU-function that has been parameterized in the Output module. In OK-condition this value is "1". The module can be used for e.g. visualizing the EMU condition through an Output to the outside.



10.3.1.10 Analog adder

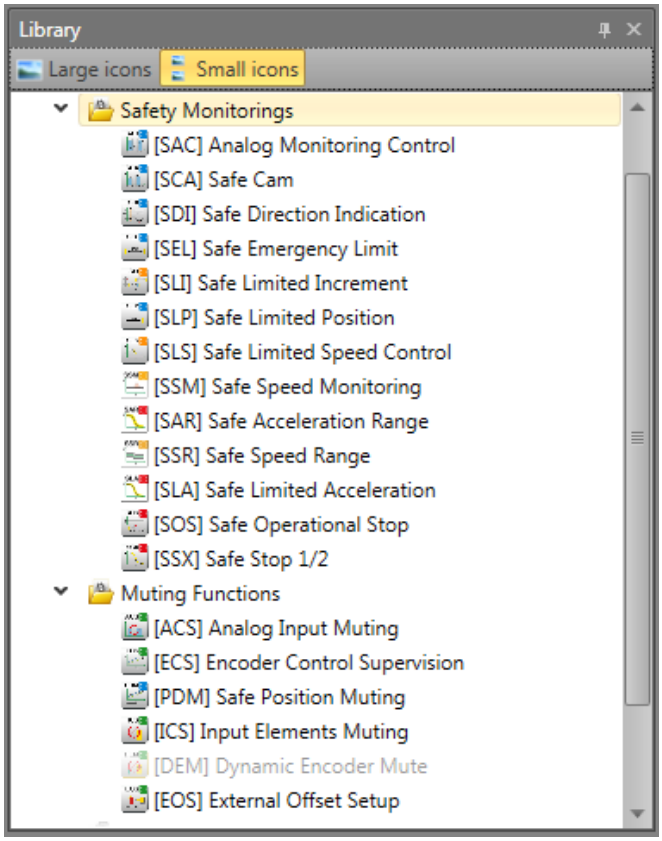
The analog adder enables weighting of the standardized analog signals.
Two Input signals, which have already been standardized, can be added together in a defined ratio to each other. The corresponding signal components are determined in percent.



Scale factor on adder1

Specification of an integer value by which the Input signal 1 of the adder is to be scaled (max. 100%).

10.3.2 Safety functions



The safety functions are an essential functionality of the SMX-system. Pre-defined functions for:

- speed monitoring
- position detection
- monitoring of limits and target positions
- functional emergency monitoring
- standstill monitoring
- direction monitoring
- function monitoring of external shut-down devices
- reset functions
- muting

are available.

The functionality for monitoring position, speed and shut-down is only activated after successful encoder configuration. Once this has been done, the corresponding functions can be inserted as long as there are resources available in the SMX module for this purpose. Once these have all been used, the menu option for the corresponding function block is disabled.

Function named in EN 61800–5–2	Number of blocks for SMX 1x series	Number of blocks for SMX 1xx series
SLS = Safe Limited Speed	8	48
SLA = Safe Limited Acceleration	Resources SLS	Resources SLS
SOS - Safe Operational Stop	1 (per axis)	12 (1 per axis)
SDI = Safe Direction Indication	1 (per axis)	12 (1 per axis)
SSX = Safe Stop 1/2	4	24 (4 per device)
SAR Safe Acceeleration Range	Resources SSX	Resources SSX
SLI = Safe Limited Increment	1 (per axis)	12 (1 per axis)
SCA = Safe Cam	16	64
SSR = Safe Speed Range	Resources SCA	Resources SCA
SEL = Safe Emergency Limit	1 (per axis)	12 (1 per axis)
SLP = Safe Limited Position	2	12 (2 per device)
SAC = Safely Analog Control	8	48
SMT = Safe Motor Temperature	Resources SAC	Resources SAC
SLT = Safe Limited Torque	Resources SAC	Resources SAC
STR = Safe Torque Range	Resources SAC	Resources SAC
EMU – Emergeny Monitoring Unit	2	16
SBC – Safe Breake Control	Resources EMU	Resources EMU
DEM – Dynamic Encoder Muting	X	12 (1 per axis)
ECS – Encoder Control Supervisor	1 (per axis)	1 (per slave device)
ICS – Input Elements Muting	1	1 (per slave device)
ACS – Analolg Input Muting	1	1 (per slave device)
EOS – External Offset Setup	X	1 (per axis)
PDM – Safe Position Muting	1 (per axis)	1 (per axis)

If this switching off by a monitoring function is to be signalized to the outside, e.g. to a control unit, an auxiliary Output may be used for this purpose. Once a 1 is applied to the Outputs of the monitoring functions in OK condition, the result is to be negated as per following example for the feedback.

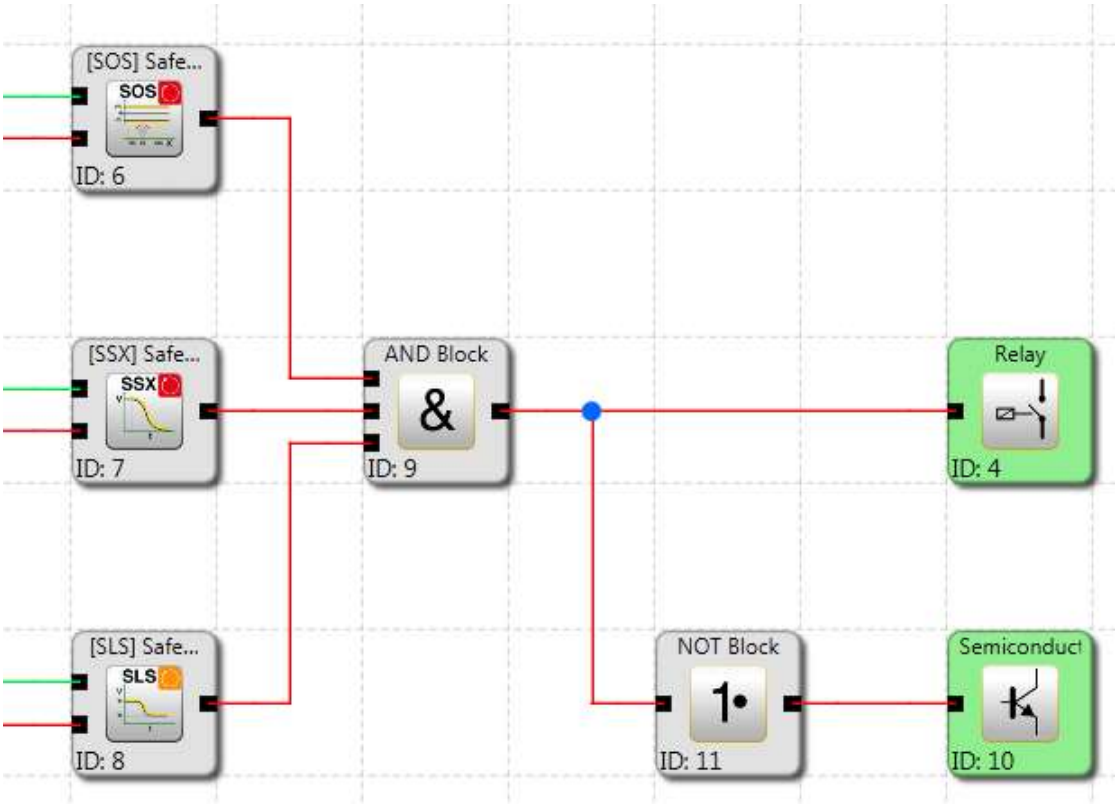


Fig. 58: Example for a logic linkage of monitoring functions.

10.3.2.1 SEL (Safe Emergency Limit)

Monitoring of the maximum movement range

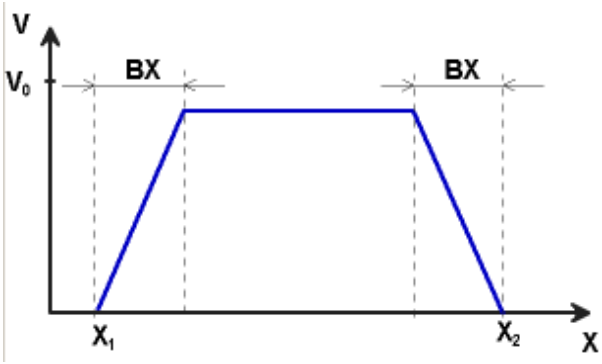
Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Axis assignment:	maximum 1 function per axis
Function:	Monitoring of the permissible speed related to the relative distance to the maximum limit of the movement or adjustment range. This function replaces the conventional safety limit switches!
Input:	Standardized position signal X from the encoder interface.
RESET-function:	The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via: • RESET function in the group of Input elements • Function key on the front side of a basic module • FBus reset element

Description of function:

- Calculation of actual speed V using position signal X
- Determination of the stopping distance related to the current status of acceleration and speed
  => Cyclic determination of the $Stop\_Distanz_{Akt.} = f(V, a)$ with a = acceleration
- Comparison: $Pos_{Akt.} + Stop\_Distanz_{Akt.} < Ziel\_Pos + Overtravel$

A trapezoidal or S-shaped speed profile serves as basis for the calculation. For a trapezoidal speed profile the limit curve is the result of the parameterized acceleration, whereas an S-shaped speed profile additionally uses the change in acceleration for the calculation.

Trapezoidal speed profile:

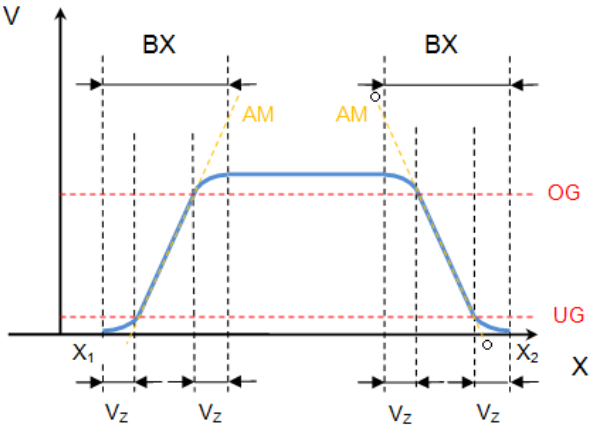


X1 = Min. position
X2 = Max. position
V0 = Maximum speed for (X1 + BX) < X < (X2 – BX)
F= Type of speed profile (trapezoidal or S-shaped)

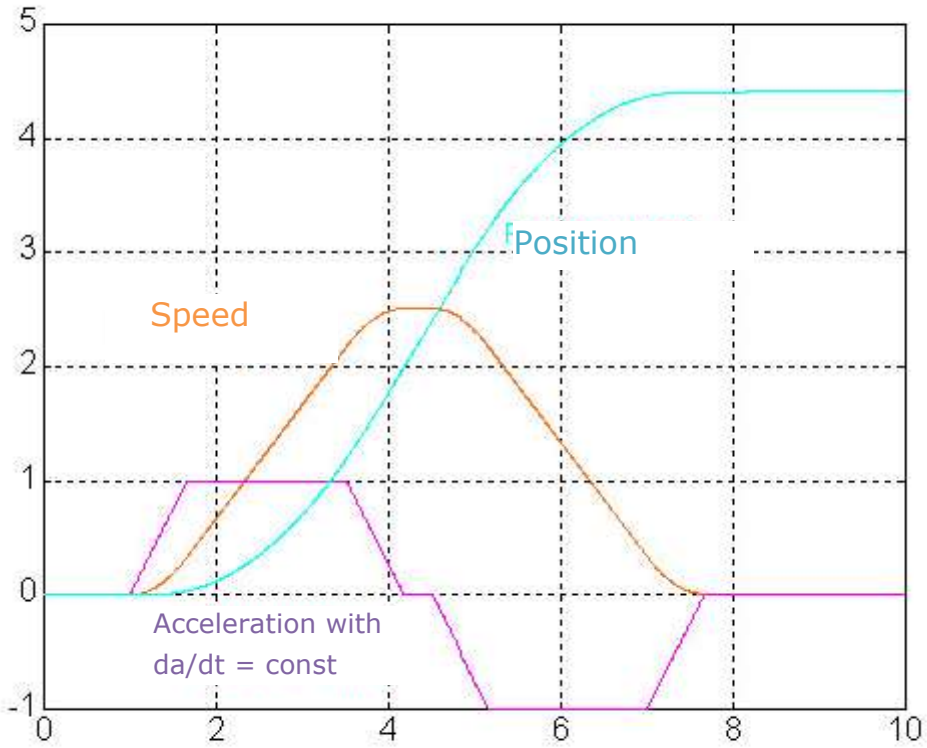
Trapezoidal
BX = Braking/approaching range

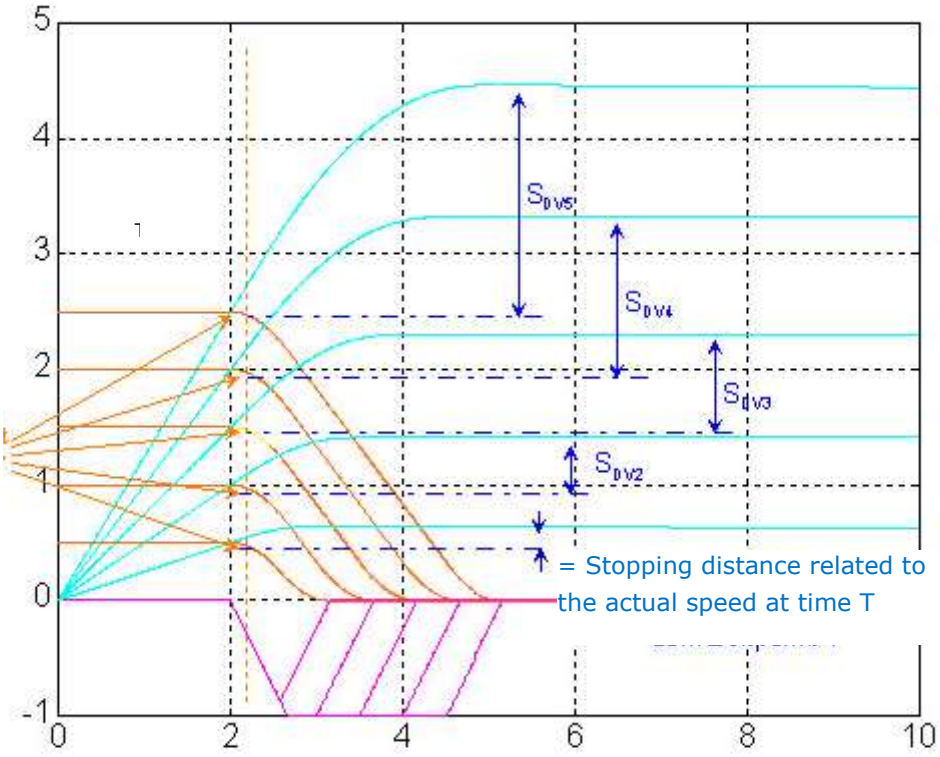
S-shaped
AM= Maximum acceleration
DA = Type of acceleration

S-shaped speed profile



BX = Braking/approaching range
X1 = Min. position
X2 = Max. position
V_Z = S-Scatter time
AM = Max. Acceleration
UG/OG = area of max. acceleration

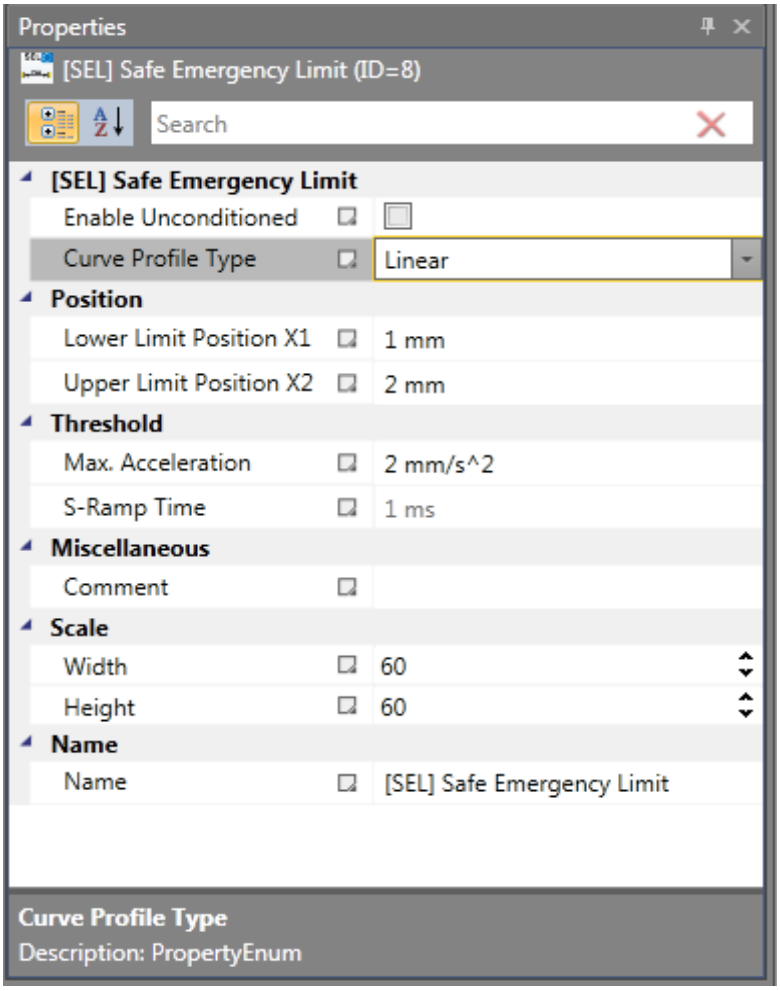

Position
Speed
Acceleration with
da/dt = const


Actual speed
at time T
= Stopping distance related to
the actual speed at time T

Output function:

Range		HI	LO
X < X1 X > X2	OR		X
X >= X1 X <= (X1 + BX) V < Limit curve	AND AND	X	
X >= (X2 – BX) X <= X2 V < Limit curve	AND AND	X	
X >= X1 X <= (X1 + BX) V >= Limit curve	AND AND		X
X >= (X2 – BX) X <= X2 V >= Limit curve	AND AND		X

Limit curve = Speed profile derived from the actual parameterization



Parameters:

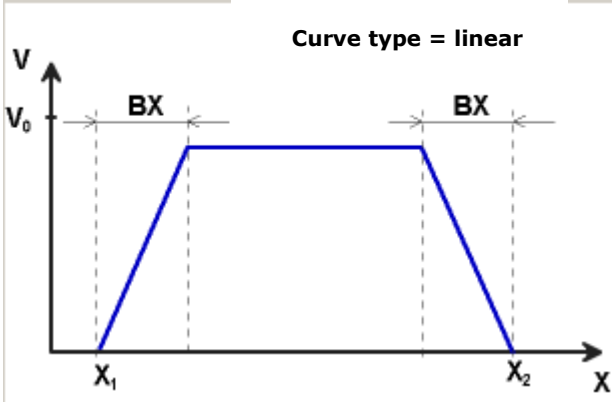
Enable unconditioned

If this option is set, the monitoring function has no Input connector. The function is active right from the start of the device.

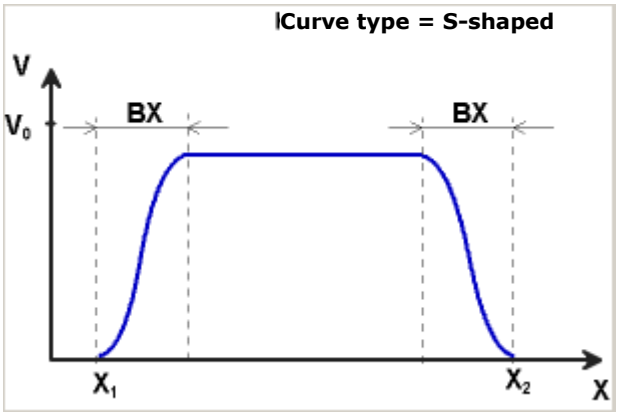
Curve profile type:

- linear

Linear calculation method for the stopping distance with respect to the limit position



- type S-shaped
Square calculation method for the stopping distance with respect to the limit position



Lower limit position X1
Lower limit position

Upper limit position X2
Upper limit position

Max. acceleration
Max. acceleration value within BX

S-Ramp time
Slope time of the acceleration => time from acceleration = 0 until max. acceleration

Input example 1
On a manufacturing machine access to the working area is to be enabled at certain positions of the main feed axis for manual feeding or setup work. The drive remains active in this position and is only monitored for standstill. The limits of the working stroke are variable and are to be monitored electronically in safety-relevant mode, as a replacement of the mechanical safety limit switch. The movement to be actively monitored is a linear movement. An absolute encoder is positively connected with this main drive axis of the linear length measuring system. The drive works with an electric motor with integrated motor feedback system and intermediate gear.

1. Limit position
The reference zero point of the main drive axis is located in the top dead centre The mechanical trailing distance subordinate is = X1 = -5mm.
The lower end position is at 600mm + 5 mm safety limit.
=> X2 = 605mm

2. Form of speed selection

The drive/position controller uses a ramp limitation (jolt limitation) for the acceleration with resultant S-slip of the speed, in order to minimize deviations and processing marks => Select S-form option

3. Limit value selection

All other limit values are taken from the machine parameterization.
Maximum acceleration = 1000 mm/s²
Maximum change of acceleration = 3000 mm/s³

10.3.2.2 SLP (Safe Limited Position)

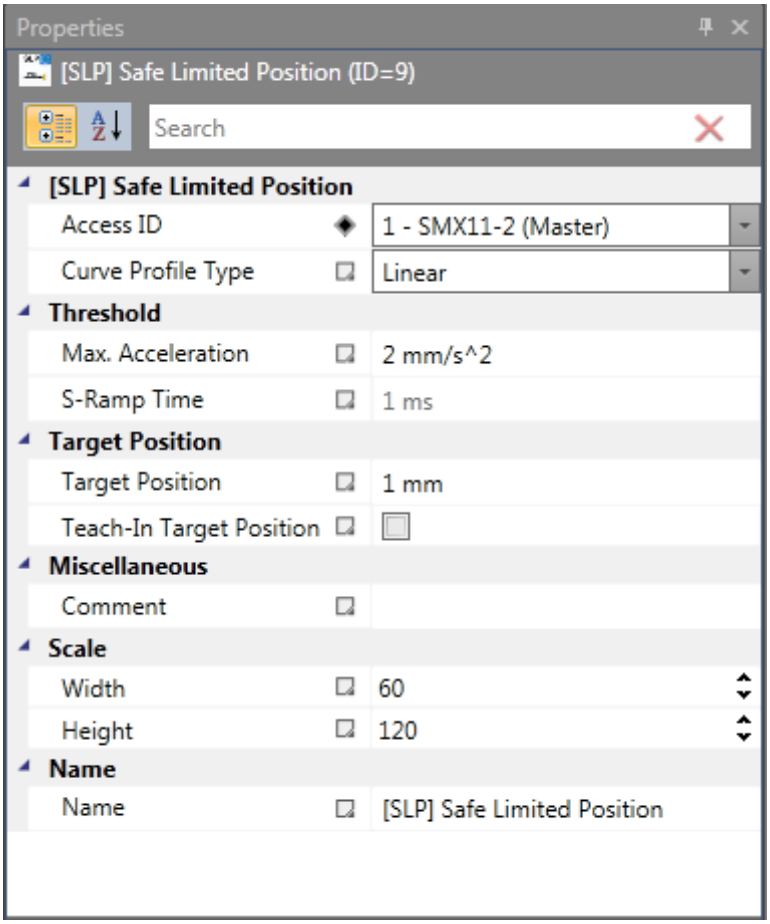
GOTO monitoring

Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Axis assignment:	maximum 1 function per axis
Function:	Monitoring of the permissible speed related to the relative distance to a parameterized Teach-In recorded target position.
Input:	Standardized position signal X from the encoder interface
RESET-function:	The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via: • RESET function in the group of Input elements • Function key on the front side of a basic module • FBus reset element

Description of function:

- Calculation of actual speed V using position signal X
- Determination of the stopping distance related to the current status of acceleration and speed=> Cyclic determination of the $Stop\_Distanz_{Akt.}$ = f (V, a) with a = acceleration
- Comparison: $Pos_{Akt.}$ + $Stop\_Distanz_{Akt.}$ < Ziel_Pos + Overtravel
- Comparison: $Pos_{Akt.}$ - $Stop\_Distanz_{Akt.}$ > Ziel_Pos + Ovetravel
- Direction control cw = clockwise, ccw = counter-clockwise

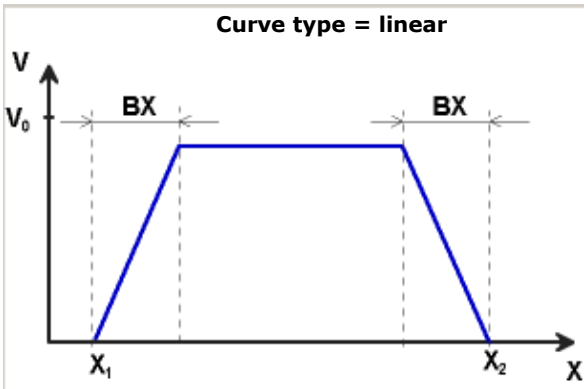
NOTICE If the function will be enabled it's not allowed the Input Signal cw and ccw are enabled at the same time. If both are enabled an alarm will be generated.



Parameters:

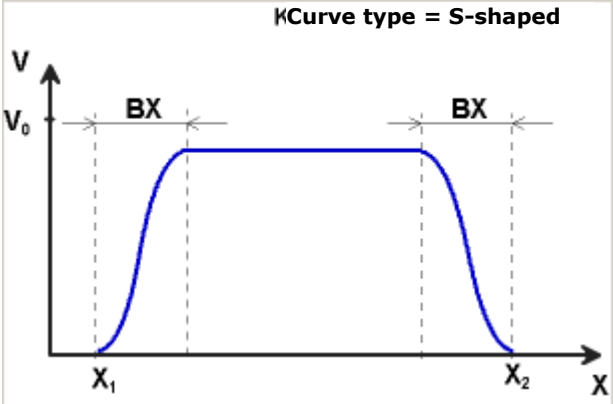
Curve type linear

Linear calculation method for the stopping distance with respect to the target position



Curve type S-shaped

Square calculation method for the stopping distance with respect to the target position



Max. acceleration

Max. acceleration value within BX

Max. change in acceleration

Value of the maximally permitted change in acceleration within BX when using the square calculation method.

Target position

Absolute position value of target position

Recording the target position using Teach-In

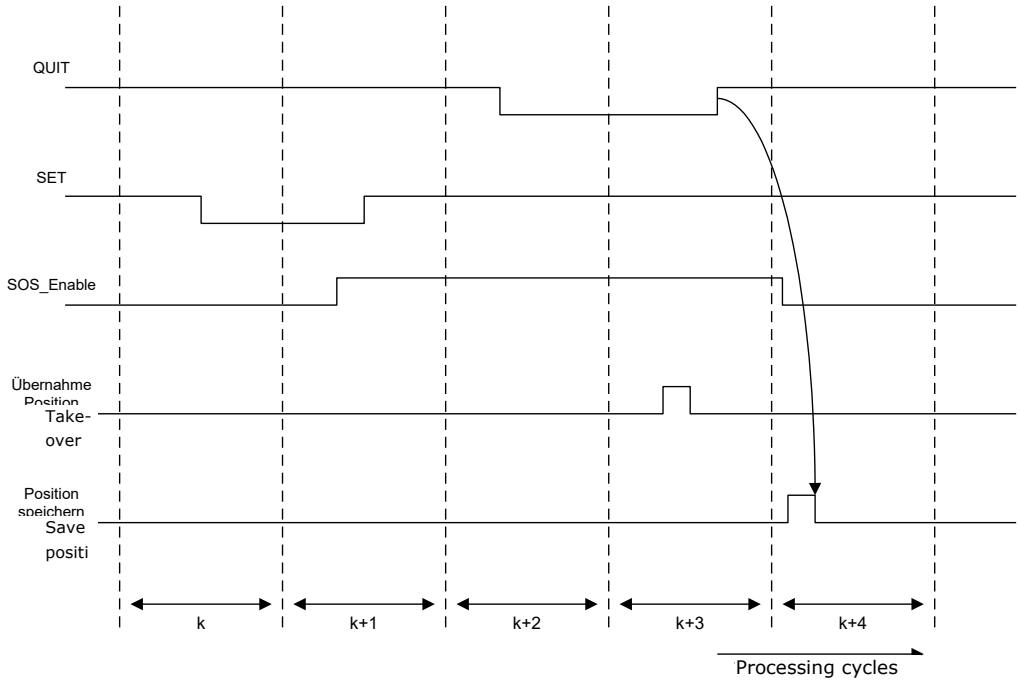
The "Teach-In" option can be used to have the target position recorded by the SMX-system without the need of manual subsequent parameterization. This requires the following steps:

- Activating the switch "Teach-In" changes the Input field "Target position" to "Position tolerance". At same time the Input dialog increases by the SOS-functionality.
- Recording a position using the "Teach-In" option can only take place at standstill, with the SOS-function activated and SLP deactivated.
- Recording a position requires the two signals "SET" and "QUIT". These appear when activating the TEACH-IN option as Input connector of the functional module.
- The „TeachIN" mode activates automatically the SOS-function and evaluates the result of this function. Non-triggering of the SOS-function is pre-condition for an active teach-in cycle.
- Position will only be recorder if the present position is within the defined position range.
- The successfully recorded TeachIN position appears in the process Input image on index 37(SLP 1) respective index 38 (SLP 2).
- The TeachIn position is securely stored . although in case of a power loss.
- The TeachIn position is reset after every configuration upload.

NOTICE

In case of bus versions of the SMX100 module, parameterization of the OLC-function partly takes place directly via the safety bus. The target position is transferred to the SMX100 module under OLC-position (from bit 32 in PAA). The selection of the OLC-range also takes place with bit 6 or bit 7 of the PAA for ranges 1 or 2. The settings for target position and range in the parameterizing mask have no effect in case of bus versions of the SMX100 module!

Time characteristic of the SET/QUIT process:



The sequence is time monitored and triggers an ALARM if the expectations are exceeded.

ATTENTION

The maximum time slot is 3 seconds !

Position Tolerance

Tolerance value for Teach-In position.

cw (enabled) = $Pos_{Akt.}$ + $Stop\_Distanz_{Akt.}$ < Ziel_Pos + Position Tolerance

ccw (enabled) = $Pos_{Akt.}$ - $Stop\_Distanz_{Akt.}$ > Ziel_Pos - Position Tolerance

NOTICE

When using the Teach-In function, the monitoring threshold is extended by the value of the position tolerance. Without the Teach-In functionality the value of the position tolerance is zero.

For the Input "SET" a key switch must be used, or the Input must have two AND-linked position switches assigned. When determining the position tolerance one must consider the permissible maximum position => maximum value of position tolerance = max. position in travel direction – Teach-In position

Parameters of the SOS-dialog: See SOS-function

10.3.2.3 SCA (Safe Cam)

Monitoring of position range with rotational speed/speed monitoring

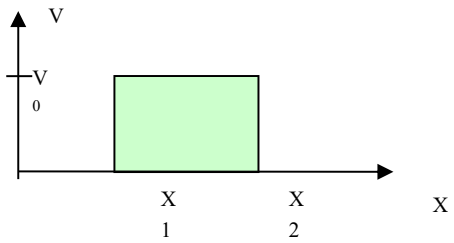
Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Axis allocation:	any
Function:	Monitoring of a parameterizable position range with allocated minimum and maximum limits. Additional monitoring of the maximum rotational speed/speed in the permissible range.
Input:	Standardized position and speed signal X and V from encoder interface
RESET-function:	Violation of the permissible monitoring range is not saved. No RESET acknowledgement required.

Description of function:

- Comparison of actual position with the parameterized range limits
- Comparison of actual speed with the parameterized maximum speed range
- Comparison of actual acceleration with the parameterized acceleration range
- Monitoring positon limit with speed profile supervision
- Count direction control
- Enable unconditioned
- Overspeed distance monitoring

Dependencies of the functions

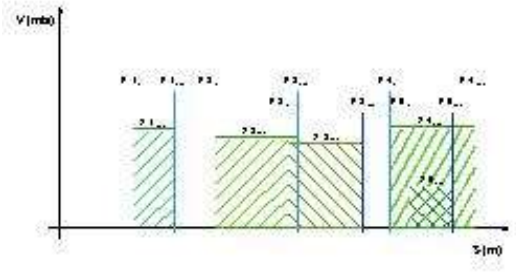
Position tolerance	**Speed tolerance**	**Acceleration monitoring**	**Movement curve monitoring**	**Direction-dependent release**	**Fault distance monitoring**
X	X	X			
X	X				X
X			X		X
X				X	X

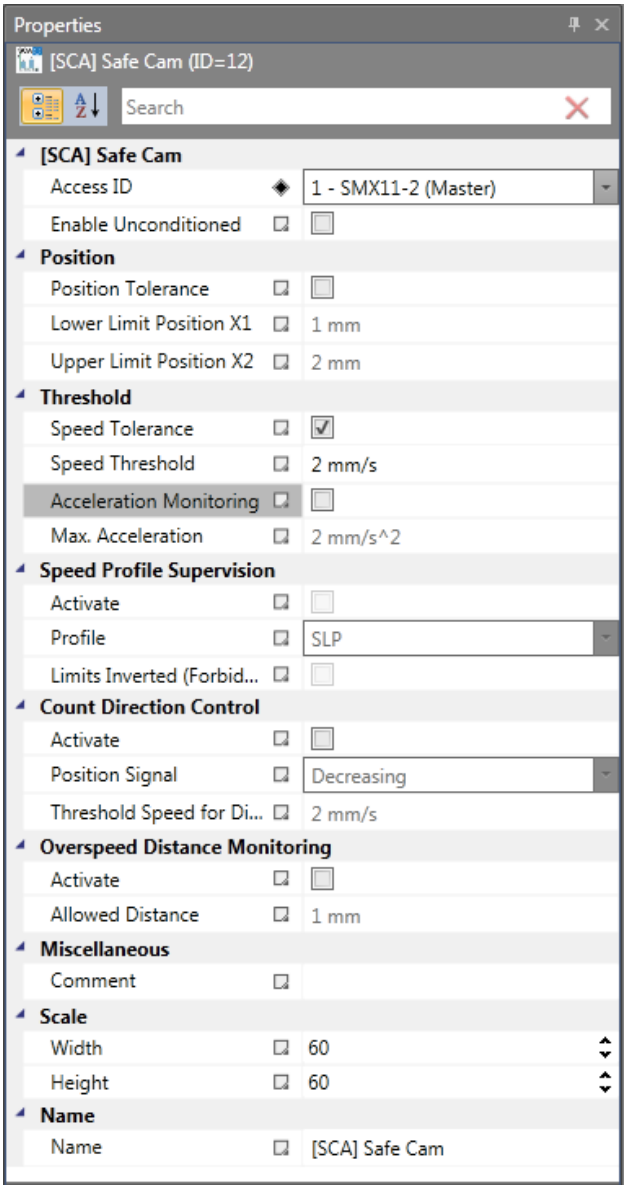


Output function

Range	HI	LO
X < X1 OR X > X2		X
X >= X1 AND X <= X2 AND V < V0	X	
X >= X1 AND X <= X2 AND V >= V0		X

Ranges can be defined as overlapping and nested.





Parameters:

Enable unconditioned

If this option is set, the monitoring function has no Input connector. The function is active right from the start of the device.

Lower limit position X1

Lower limit position

Upper limit position X2

Upper limit position

Speed threshold

Maximum permissible speed in the parameterized position range

Max. acceleration
Maximum permissible acceleration in the parameterized position range

Direction dependent release
Enables the activation of downstream functional modules in dependence on the direction. This functionality can only be utilized without speed and acceleration monitoring.

- **Position signal rising**:
  Functional module delivers the Output value = "1" for a rising position signal

- **Position signal falling:**
  Functional module delivers the Output value = "0" for a falling position signal

- **Activation speed direction release**
  The evaluation of the direction dependent release only takes place from the specified limit. Below this speed threshold the Output value is = 0;

Travel curve monitoring
Monitoring of speed at the limits using the monitoring characteristics parameterized in SEL or SLP.This switch can only be activated with the SLP or SEL function block inserted.

The parameters "Inverted limits (forbidden area)" determines the type of area information.

- Standard (without inverted limits):
  The indication of minimum and maximum value represents the limits for the permissible area, which is located between these limits.
  -----[MIN====MAX]---- (- forbidden area, = permissible area)
- "Inverted limits" inverts the permissible area
  The permissible area is outside the area between minimum and maximum value. Minimum and maximum value now specify the Forbidden area between the values.
  ====]MIN-----MAX[====

Fault distance monitoring
This additional functionality enables filtering of peak speeds in case of irregular travel operation (speed peaks in signal). The path integer is calculated on basis of the difference between the current speed and the parameterized speed monitoring value and compared with the entered value. If the entered value is exceeded the monitoring function is triggered. The function can only be activated if the acceleration monitoring function is switched Off.

ATTENTION	If this functionality is used, the response time of the monitoring function used will be delayed.

Input example:
On a manufacturing machine access to the working area is to be enabled at certain positions of the main feed axis for manual feeding or setup work. The drive remains active in this position and is only monitored for standstill. The limits of the working stroke are variable and are to be monitored electronically in safety-relevant mode, as a replacement of the mechanical safety limit switch. The movement to be actively monitored is a linear movement. An absolute encoder is positively connected with this main drive axis of the linear length measuring system. The main axis serves as reference axis for the SMX-module.

1. Selecting the range

Position monitoring is to be used to monitor the position of the main axis in top zero position. Top zero position also serves as reference zero position in the length measurement of the feed axis. If the range is recognized, a protective device is released for opening.

Range limit X1 = top position = 0mm
Range limit X2 = lower tolerance limit for position = 2 mm
Speed = tolerated speed to maintain position= 3 mm/s
Acceleration = tolerated acceleration to maintain position= 5 mm/s

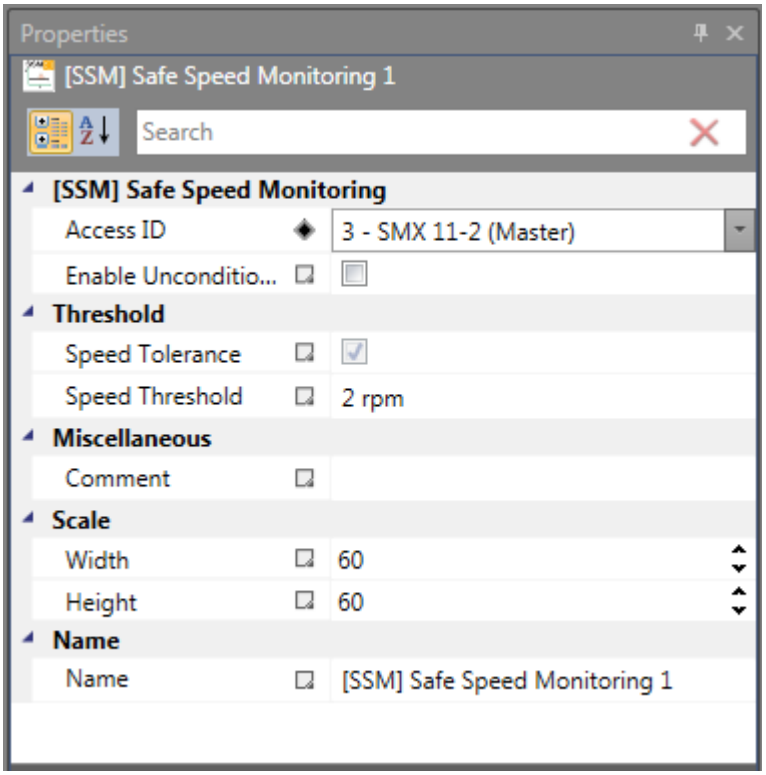
10.3.2.4 SSM (Safe Speed Monitoring)

Monitoring of speed

Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Axis allocation:	any
Function:	Monitoring of a parameterizable speed with allocated maximum limits.
Input:	Standardized position and speed signal X and V from encoder interface
RESET-function:	Violation of the permissible monitoring range is not saved. No RESET acknowledgement required.

Description of function:

- The SSM function warns when the drive is working below a specified speed. As long as it remains below the threshold, the function output is high.



Parameters:

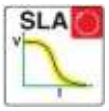
Enable unconditioned
If this option is set, the monitoring function has no Input connector. The function is active right from the start of the device.

Speed Threshold
Corresponds to the speed threshold. This determines the state of the SSM block output.

Example:

- With the SSM function, a safety door can be unlocked if the speed drops below the specified level.

10.3.2.5 SLA (Safe Limited Acceleration)



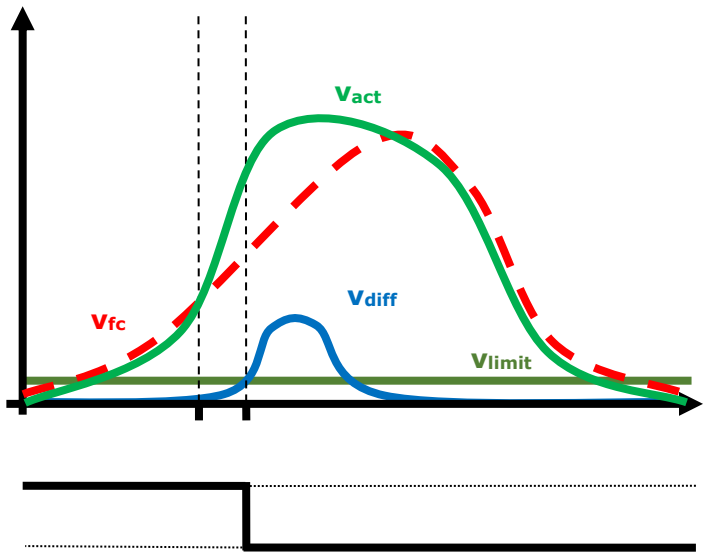
Monitoring of a minimum acceleration

Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Axis allocation:	1 per Axis
Function:	Monitoring of a minimum acceleration
Input:	Logic input enable Standardized speed signal V from encoder interface
Output:	Logic signal high/low acc. logic table
RESET-function:	The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via: ▪ RESET function in the group of Input elements ▪ Function key on the front side of a basic module ▪ F-Bus reset element

Description of function:

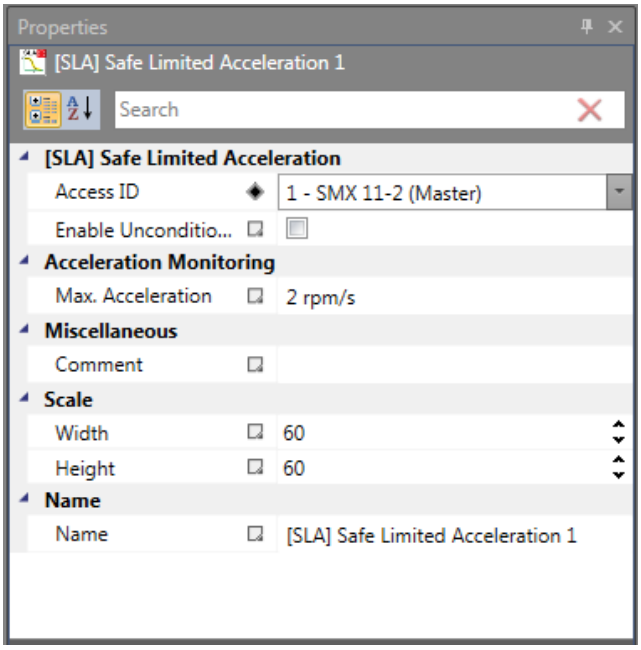
- Acceleration monitoring of a drive
- Calculation of an expected speed value based on actual speed and maximum acceleration
- Comparison of the actual speed with calculated speed via parameterizable speed difference (tolerance window)

Function diagram:



Logic table:

Area		High	Low
$v_{diff} \leq v_{limit}$	Acceleration within permissible limits	X	
$v_{diff} > v_{limit}$	Maximum acceleration exceeded		X



Parameters:

Enable unconditioned

If this option is set, the monitoring function has no Input connector. The function is active right from the start of the device.

Speed tolerance

The "speed threshold" between V_{akt} and V_{fc}.

Max. acceleration

Specification of the max. acceleration

10.3.2.6 SSR (Safe Speed Range)

Monitoring of speed

Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Axis allocation:	any
Function:	Monitoring of the maximum rotational speed/speed in the permissible range.
Input:	Standardized speed signal X and V from encoder interface
RESET-function:	Violation of the permissible monitoring range is not saved. No RESET acknowledgement required.

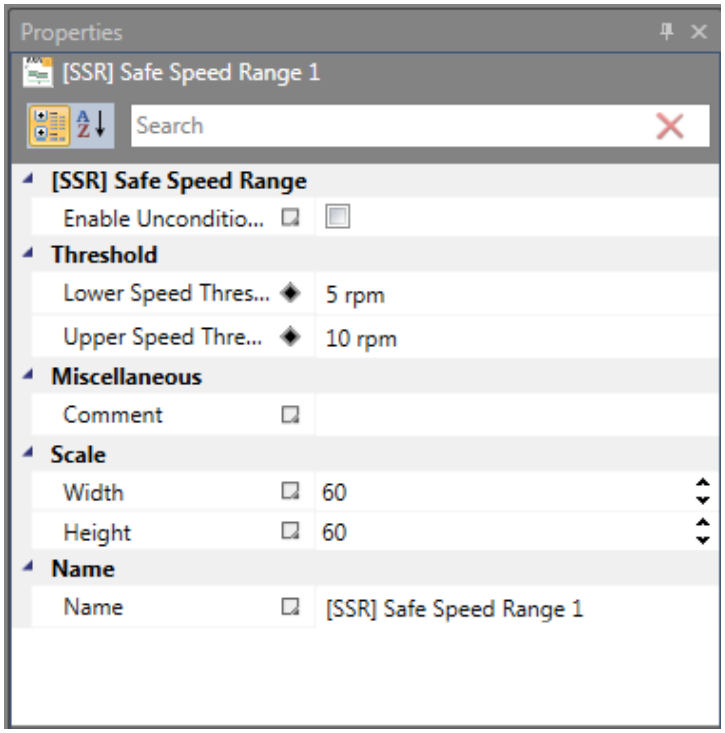
Description of function:

- Comparison of actual speed with the parameterized maximum speed range

Output function

Range		HI	LO
X < X1 X > X2	OR		X
X >= X1 X <= X2 V < V0	AND AND	X	
X >= X1 X <= X2 V >= V0	AND AND		X

Ranges can be defined as overlapping and nested.



Parameters:

Enable unconditioned

If this option is set, the monitoring function has no Input connector. The function is active right from the start of the device.

Upper speed threshold

Upper limit speed in the parameterized speed range

Lower speed threshold

Lower limit speed in the parameterized speed range

10.3.2.7 SSX (Safe Stop 1/2)

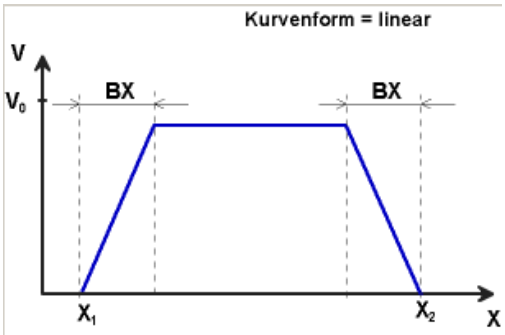
Function monitoring for emergency stop

Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Axis allocation:	any
Function:	Monitoring of an EMERGENCY STOP function
Input:	Standardized position signal X from the encoder interface
RESET-function:	The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via: • RESET function in the group of Input elements • Function key on the front side of a basic module • FBus reset element

Description of function:

Monitoring the sequence of a controlled EMERGENCY STOP by comparing the speed drop with a parameterizable monitoring curve over the course of time. The monitoring curve is a result of latency, max. speed distance to the limit curve, as well as their characteristic, calculated on the basis of acceleration and acceleration change. After activating the monitoring function, the course of the limit curve is calculated on the basis of the current speed.

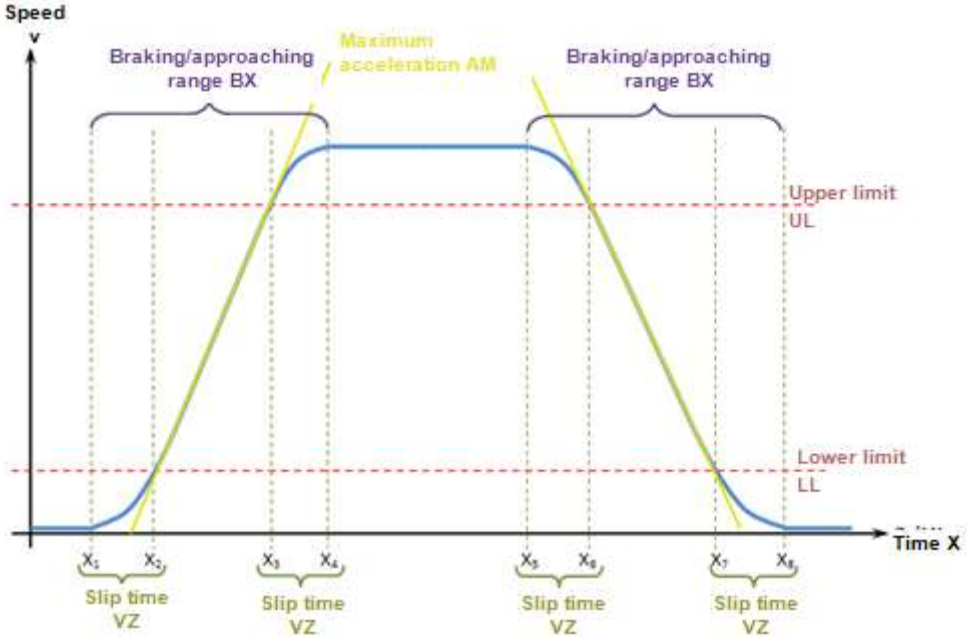
Linear curve type



BX = Braking/approaching range
X_1 / X_2 = Time for a ramp function sequence
V_0 = Start speed of the ramp function

S-shaped speed profile

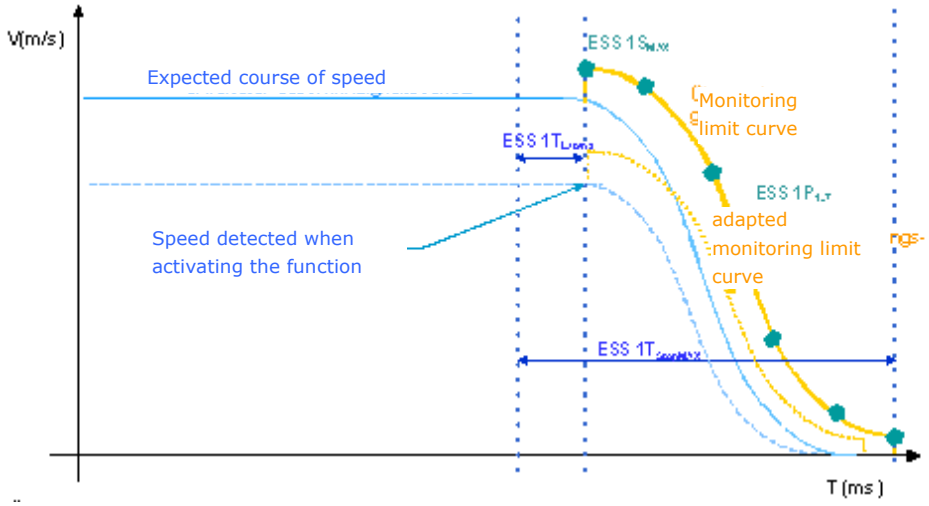
Trapezoidal course of speed



The S-shaped speed profile shows the changes to or the course of speed over time.

Maximum acceleration AM
Max. acceleration value within BX

Slip time VZ
The slip time VZ designates the period of time in which the speed changes in a non-linear fashion, or the time period for changing the acceleration from a=0 to a=a_{max} or vice-versa

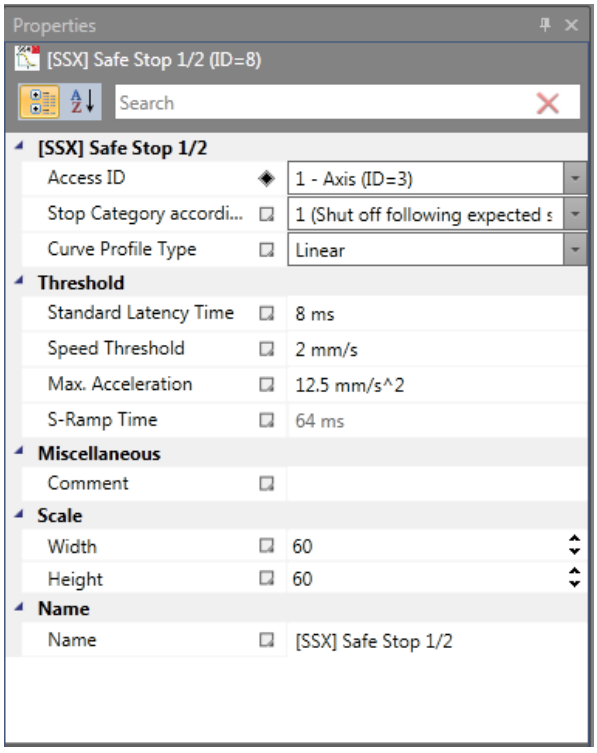


Monitoring limit curves with S-shaped course of speed

Output function

Range	HI	LO
$T < T_{Latency}$	X	
$T > T_{Latency}$ AND $V < V_{Limit\ curve}$	X	
$T > T_{Latency}$ AND $V > V_{Limit\ curve}$		X

Each function block can be parameterized to stop category 1 or 2. In stop category 2 the SOS-function is automatically activated after the expected standstill.



Parameters:

Stop category 1

This option realizes monitoring of the controlled EMERGENCY STOP acc. to EN 60604. According to the normative definition the energy supply should here be disconnected after the drive has come to a halt. This is supported by a transition of the SSX-function Output value from "1" to "0".

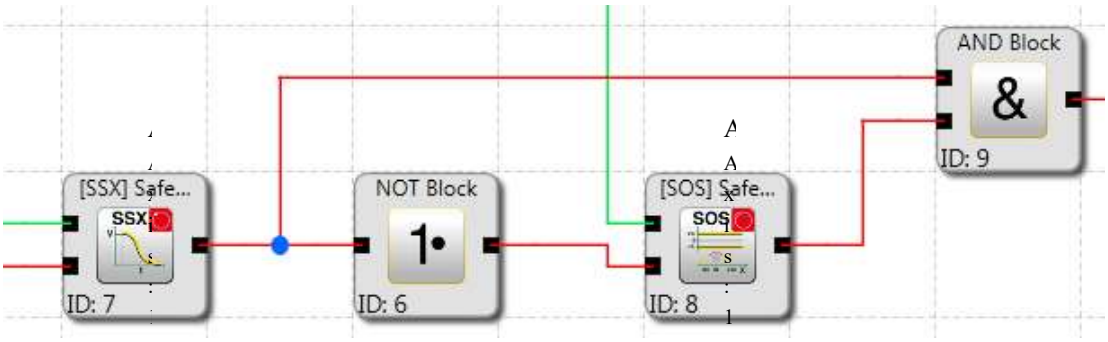
Stop category 2 (SOS after expected standstill)

This option realizes monitoring of the controlled EMERGENCY STOP acc. to EN 60604. After the ramp monitoring has expired, the drive is stopped without disconnection from the energy supply (Safe Operational Stop = Standstill). For this reason the Output value remains art "1" after the SSX-limit curve has expired.

If no SOS-module has yet been defined in the functional scheme, the SSX-dialog is extended by this function. All parameters required for the SOS-function, can thus be entered immediately. If an SOS-element is inserted into the functional scheme at a later date, the dialog in the SSX-mask is omitted.

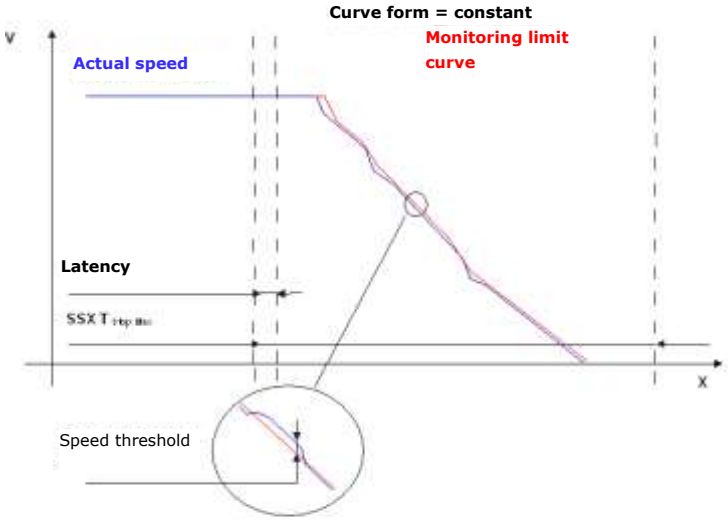
NOTICE

If the SSX-function is used in connection with SOS, the following circuitry must be used. If standstill is detected, the operating system will automatically activate the SOS-monitoring.



Curve type linear

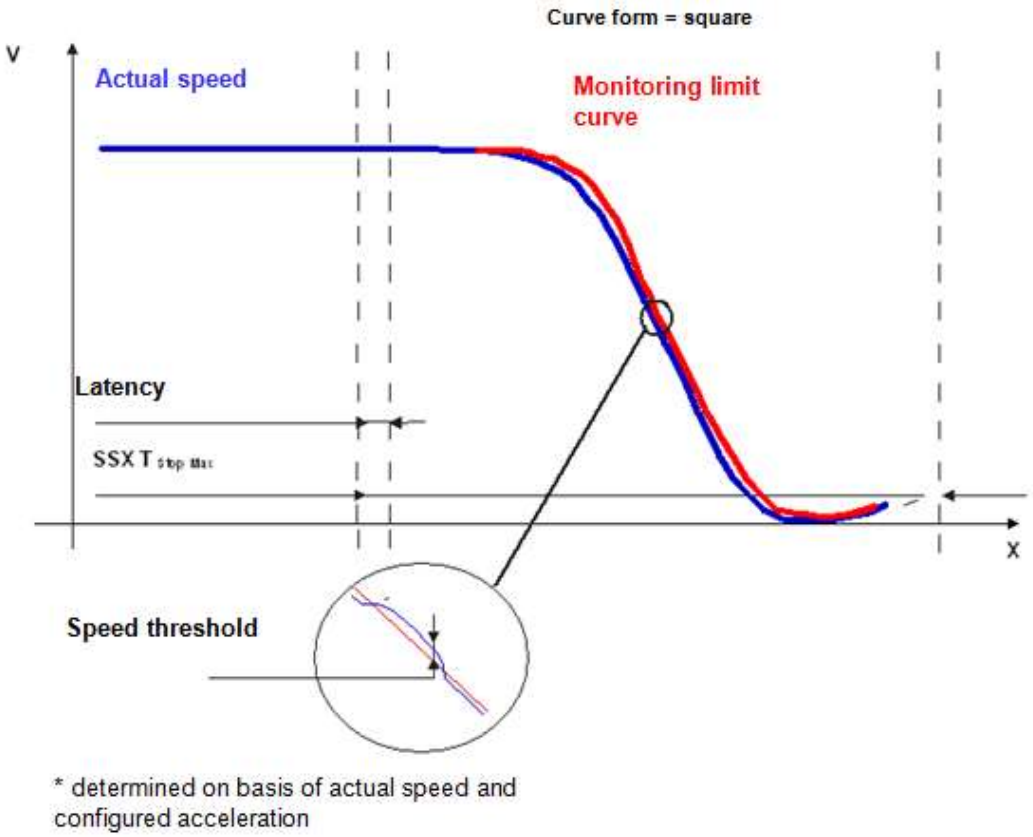
Linear speed and constant acceleration curve for the stop sequence



* determined on basis of actual speed and configured acceleration

Curve type S-shape

S-shape speed and linear acceleration curve for the stop sequence



Standard latency

Latency until the occurrence of active deceleration

Max. speed (speed threshold)

Speed threshold that must not be exceeded during the stopping process, as otherwise the energy supply will be disconnected.

Max. acceleration

Default acceleration value to calculate the limit curve.

Max. acceleration change

Default acceleration change value to calculate the limit curve.

S-Ramp time

Designates the period of time in which the speed changes in a non-linear fashion, or the time period for changing the acceleration from a=0 to a=a_{max} or vice-versa

Axis assignment

Input of axis assignment.

Input example:
On a manufacturing machine access to the working area is to be enabled at certain positions of the main feed axis for manual feeding or setup work. The drive remains active in this position and is only monitored for standstill. The limits of the working stroke are variable and are to be monitored electronically in safety-relevant mode, as a replacement of the mechanical safety limit switch. The movement to be actively monitored is a linear movement. An absolute encoder is positively connected with this main drive axis of the linear length measuring system. The drive works with an electric motor with integrated motor feedback system and intermediate gear.

1. Selecting the stop category
In order to keep times of standstill and restart as short as possible, the stop category 2 acc. to DIN 60604-1 (controlled stop with drive subsequently actively controlled to V=0) is to be used => Selection stop category 2

2. Form of speed selection
The drive/position controller uses a ramp limitation (jolt limitation) for the acceleration with resultant S-slip of the speed, in order to minimize deviations and processing marks => Select S-slip option

3. Limit value selection
For the purpose of monitoring one must enter the worst-case latency starting with the occurrence of the Emergency Stop event, until the start of the braking process, which is executed with the standard control. The program sequence time of the standard control results in: Latency = cycle time*2 = 50 ms

All other limit values are taken from the machine parameterization.
Maximum feed speed = 300 mm/s²
Maximum acceleration = 1000 mm/s²
Maximum change of acceleration = 3000 mm/s³

10.3.2.8 SLI (Safe Limited Increment)

Monitoring of the max. step measurement

Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Axis assignment:	1 per axis
Function:	Monitoring of the max. permitted step measurement
Input:	Standardized position / speed signal V and X from encoder interface. Direction indication LEFT/RIGHT
RESET-function:	The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via: • RESET function in the group of Input elements • Function key on the front side of a basic module • FBus reset element

Description of function:

- Monitoring of the max. permitted step measurement = relative travel range for uninterrupted travelling in jog mode.
- Calculation of the current sense of rotation RX on basis of position / speed signal
- Determination of the relative travel after the start of the movement.
- Monitoring for compliance with the predetermined direction and the max. relative travel

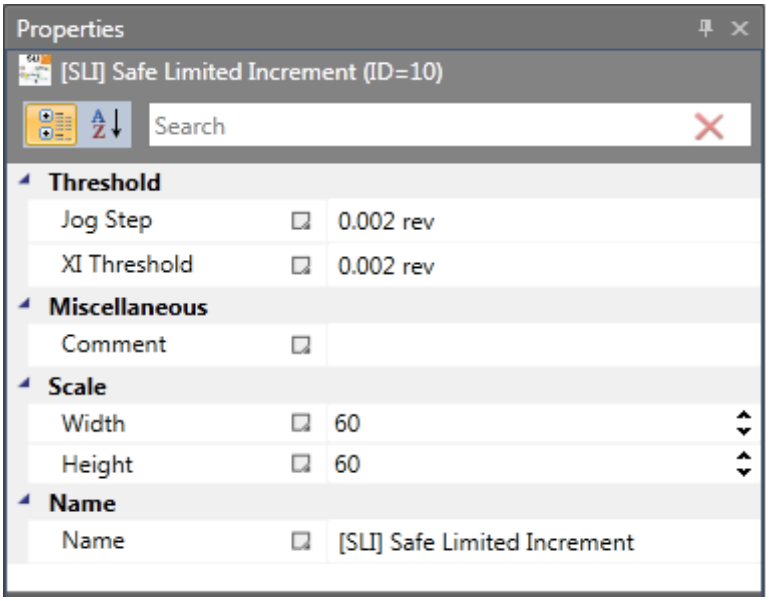
NOTICE

Ports of SLI block has to be set to „0" in case of a reset event. Otherwise the function could not be reset.

If the function will be enabled it's not allowed the Input Signal cw and ccw are enabled at the same time. If both are enabled an alarm will be generated.

Output function

Range	HI	LO
V < 0 AND DIRECTIONMARKER = LEFT AND relative travel < max. step measurement	X	
V >= 0 AND DIRECTION MARKER = RIGHT AND relative travel < max. step measurement	X	
V < 0 AND (DIRECTION MARKER = RIGHT OR relative travel > max. step measurement		X
V > 0 AND (DIRECTIONMARKER = LEFT OR AND relative travel > max. step measurement		X



Parameters:

Jog Step

Step measurement - Maximum relative travel after activating the monitoring function

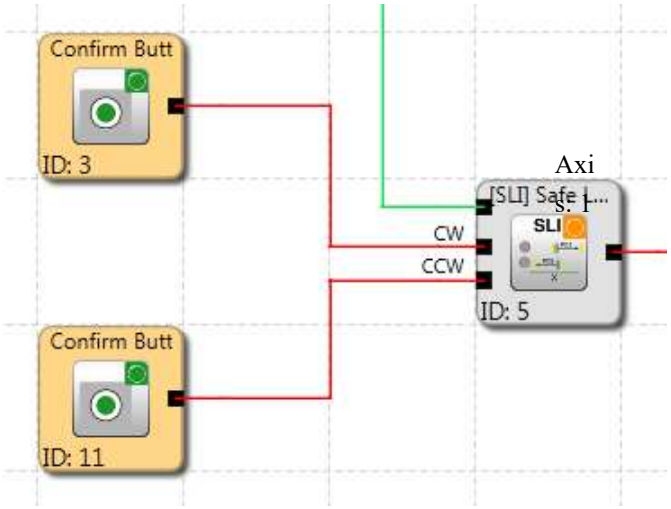
XI threshold

Tolerance threshold for monitoring the travel in opposite direction

Axis assignment

Input of axis assignment. In case of a multi-axis device, the axis to be monitored can be set here. For a single axis device only "Axis 1" is available.

Activation example:



Input example:

The max. travel in the material feed system of a manufacturing facility is to be safely monitored in jog mode. According to the risk analysis this travel is max. 50 mm. A faulty travel in opposite direction is to be monitored.

1. Jog Step

The relative travel (only incremental encoder present) is monitored => Input of the max. permissible travel acc. to risk analysis with tolerance = 55 mm

2. Travel direction monitoring

Tolerable travel in opposite direction (=creeping motion of drive) = 1 mm/s

3. Monitoring Input

The monitoring module has two Inputs to specify the direction. An active direction signal activates the monitoring function.

Once monitoring has been activated, the direction must be specified by a clear signal. => Buttons for direction specification are directly connected with the default Inputs on the SMX100 => selection E 01, E 02

NOTICE	Both Input signals "1" are detected as non-permitted condition, causing an alarm message.

10.3.2.9 SDI (Safe Direction Indication)

Direction detection

Number: see chapter "Safety functions"

Access-ID: Identification of function element

Axis assignment: 1 per axis

Function: Monitoring the pre-defined sense of rotation / direction of movement

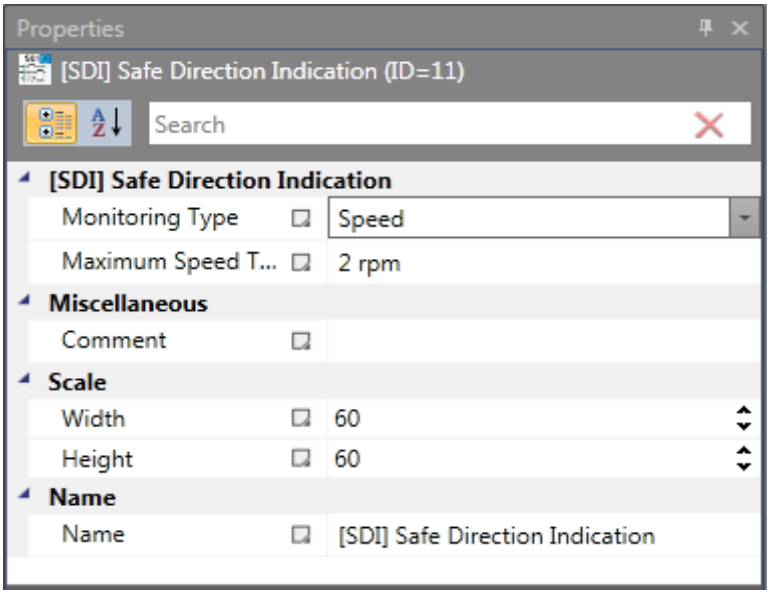
Input: Standardized position / speed signal X from encoder interface. Direction marker LEFT/RIGHT

RESET-function: The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via:

- RESET function in the group of Input elements
- Function key on the front side of a basic module
- FBus reset element

Output function

Range	HI	LO
V < 0 AND DIRECTIONMARKER = LEFT	X	
V >= 0 AND DIRECTION MARKER = RIGHT	X	
V < 0 AND DIRECTION MARKER = RIGHT		X
V > 0 AND DIRECTIONMARKER = LEFT		X

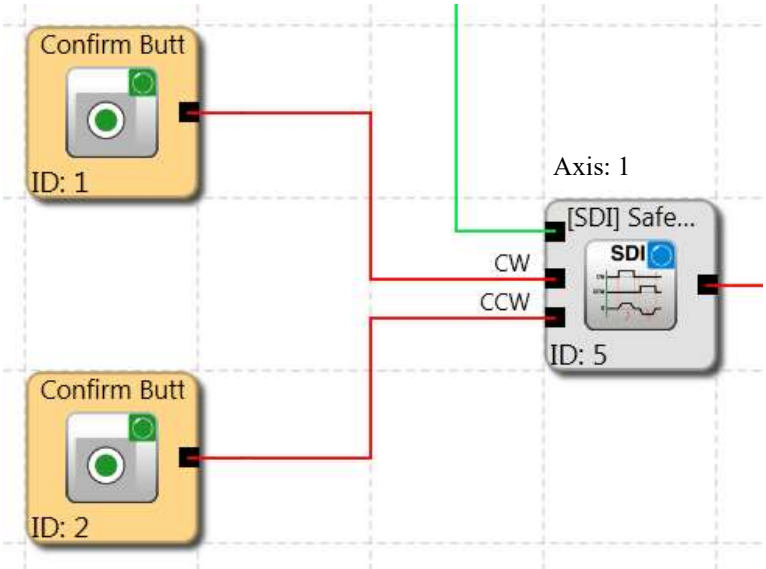


Parameters:

Maximum
Tolerance threshold for position or speed in opposite direction

Axis assignment
Input of axis assignment.

Activation example:



Input example:
In a manufacturing device the speed of certain manual processes is to be monitored for a safe reduced value, as well as standstill and movement direction. The movement to be actively monitored is a rotary movement. The drive works with an electric motor with integrated motor feedback system and intermediate gear.

1. Input for monitoring function
Monitoring of speed (only incremental encoder present)
=> Speed

2. Speed monitoring
Tolerable speed in opposite direction (=Creeping of drive) from machine parameter = 1 mm/s

Monitoring Input
The monitoring module has two Inputs to specify the direction. An active direction signal activates the monitoring function.

NOTICE	Both Input signals "1" are detected as non-permitted condition, causing an alarm message.

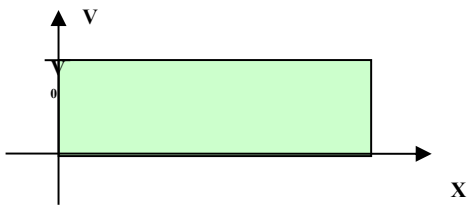
10.3.2.10 SLS (Safe Limited Speed Control)

Monitoring of a minimum speed

Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Axis allocation:	any
Function:	Monitoring of a minimum speed
Input:	Standardized position signal X from the encoder interface
RESET-function:	The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via: ▪ RESET function in the group of Input elements ▪ Function key on the front side of a basic module ▪ FBus reset element

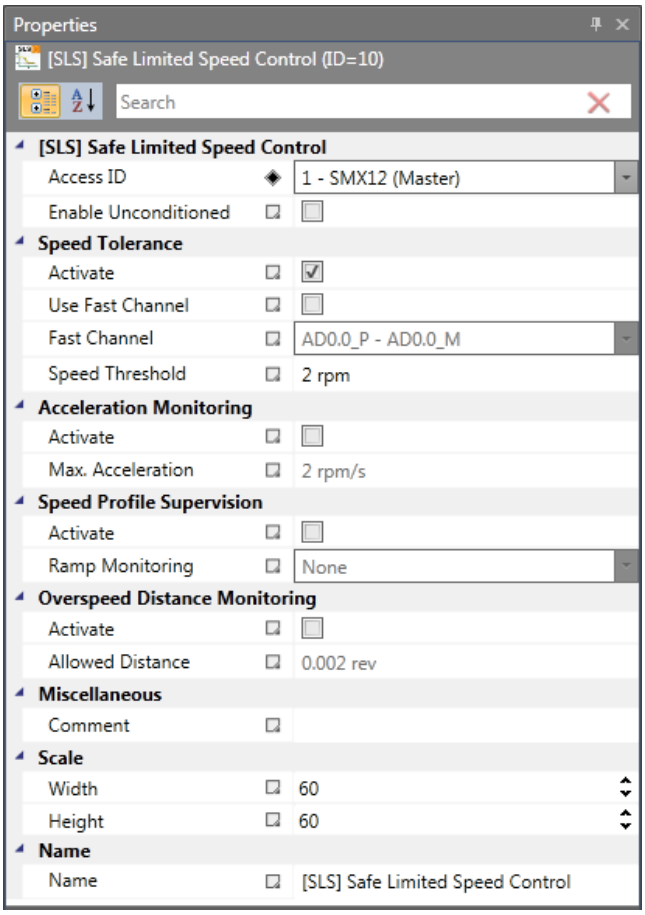
Description of function:

- Monitoring the maximum speed or rotational speed of a drive.
- Calculation of the current speed V on basis of position or digital speed signal X
- Comparison of the actual speed with the parameterized speed threshold
- Monitoring of a speed transition from fast to slow.
- Overspeed distance monitoring



Output function

Range	HI	LO
V < V0	X	
V >= V0		X



Parameters:

Enable unconditioned
If this option is set, the monitoring function has no Input connector. The function is active right from the start of the device.

Speed tolerance
To activate speed monitoring

Use fast channel
The "Fast Channel" option can be used to achieve a shorter response time of the system. The two semi-conductor Outputs can alternatively be chosen in combination as shut-down channel.

ATTENTION **Response time see installation manual !**

Speed threshold
Specification of maximum speed, alternatively max. rotational speed.

Max. acceleration
Specification of the max. acceleration

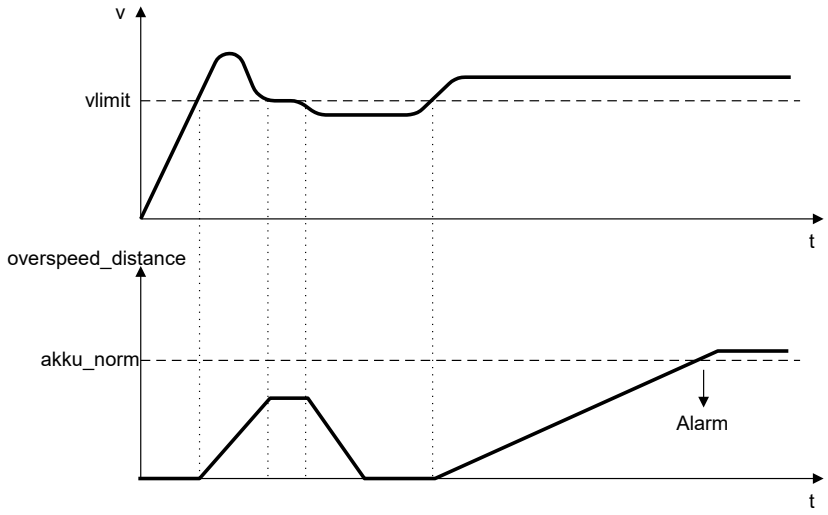
Ramp monitoring
This option monitors the transition of speed from fast to slow by using an SSX-functionality. The selected SSX-element must be available in the functional scheme.

Overspeed distance monitoring
This additional functionality enables filtering of peak speeds in case of irregular travel operation (speed peaks in signal).

The path integer is calculated on basis of the difference between the current speed and the parameterized speed monitoring value and compared with the entered value. If the entered value is exceeded the monitoring function is triggered.
The function can only be activated if the acceleration monitoring function is switched off.

Example of overspeed distance monitoring:

The graph shows an example for overspeed distance monitoring. A drive exceeds the threshold "vlimit", which is parameterized in the SLS-function. By exceeding this value, the speed above the threshold is integrated (= akku_norm). If the current speed drops below the threshold, the integer will also decrease down below the limitation. During the continuing process the speed will rise again and remain above the parameterized threshold. As a consequence the integer will also increase again, triggering an alarm when it exceeds the fault distance (= integrated speed proportion). The course of the fault integrator can be visualized with the SCOPE-function.



ATTENTION

When using this function, the response behaviour of the application will change. In this case strictly follow the explanations in the installation manual.

Reaction time:

The filter function delays the reaction time on the speed limit v0 for the value of **delta_v_filter**. For the specific application the total value of the reaction time Treact=Tdcs + Tfilter has to be considered.

Parameter	Calculation method	Remark
T_{dcs}	Output reaction time	Refer to reaction time in installation manual
T_{filter}	$=\sqrt{2 * XF / a0}$	Filter reaction time
T_{react}	$= Tfilt_{er} + T_{dcs}$	Total reaction time
delta_v_filter	$=\sqrt{2 * XF * a0}$	
v1(k2)	$=\sqrt{2 * XF * a0} + v0 + a0 * T_{dcs}$	Speed at the reaction set point

Note:

Speed limit in SLS — v0 = konstant

Filter value — XF = konstant

Max. acceleration value of the application — a0 = konstant

Input examples:

In a manufacturing device the speed of certain manual processes is to be monitored for a safe reduced value, as well as standstill and movement direction. The movement to be actively monitored is a rotary movement. The drive works with an electric motor with integrated motor feedback system and intermediate gear.

1. Speed monitoring

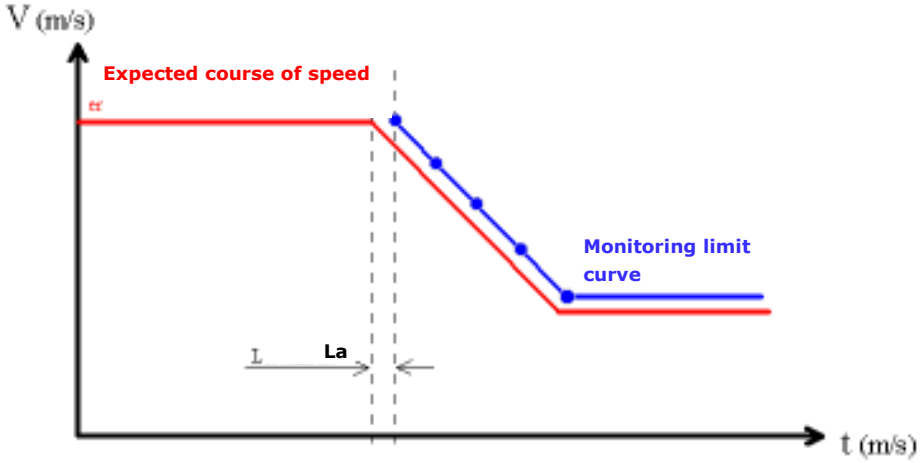
The safely reduced speed in manual mode is to be monitored => speed monitoring active with max. value from machine parameter = 50

2. Acceleration monitoring

The safely reduced acceleration in manual mode is to be monitored => acceleration monitoring active with max. value from machine parameter = 100

3. Ramp monitoring

Speed monitoring and ramp monitoring acc. to SSX must be activated. In this case the SSX used must already be inserted or configured in the project. The transition from a fast to a slower (= parameter max. speed) speed can now be monitored (see graph).



When activating the SLS, the parameterized SSX is automatically activated via the SLS. The SSX monitors the ramp course of the speed. If the actual speed is lower than the SLS threshold, the SLS will take over the further monitoring, until the SLS is deactivated again.

The ramp course can be diagnosed with the SCOPE monitor as a diagnostic function.

NOTICE

- If the SSX used is activated during "SLS ramp monitoring" (i.e. normal EMERGENCY STOP function via SSX-enable), the parameterized SSX-connection is always prioritized.
- The SSX-function is always activated by the SLS, if the current speed is higher than the SLS-threshold.
- The SLS threshold value must be higher than 0, as otherwise an emergency stop will be triggered.
- If the calculated speed profile is exceeded when changing the speed from fast to slow, this is saved in both monitoring functions SLS and SSX.
- If several SLS-functions with ramp monitoring are activated, the lowest parameterized SLS-threshold value is used as threshold value for the SSX-ramp.

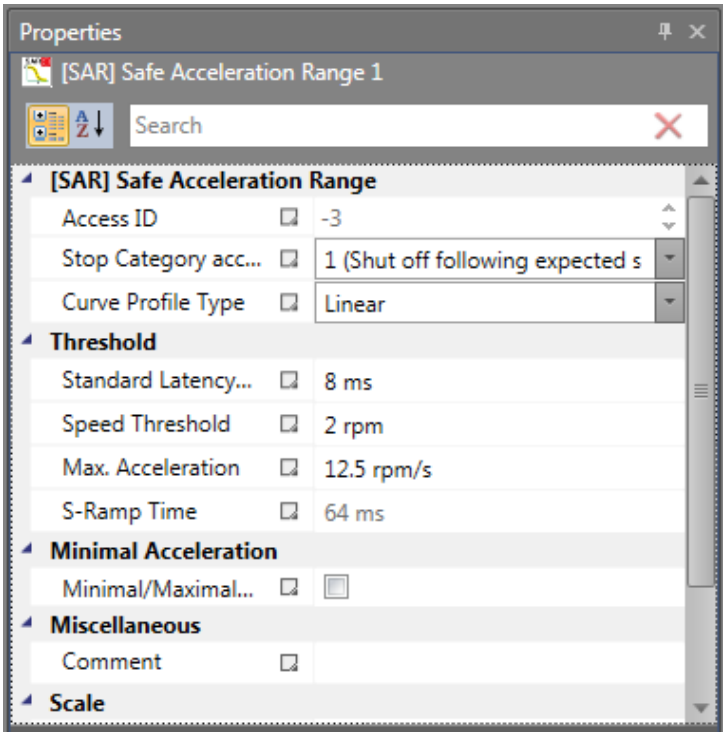
10.3.2.11 SAR (Safe Acceleration Range)

Monitoring of acceleration range

Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Axis allocation:	any
Function:	Monitoring of a parameterizable speed range with allocated minimum and maximum limits.
Input:	Standardized position and speed signal X and V from encoder interface
RESET-function:	The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via: ▪ RESET function in the group of Input elements ▪ Function key on the front side of a basic module ▪ FBus reset element

Description of function:

- The SAR monitors whether an acceleration is in a defined area.



Parameters:

Curve type linear
Linear monitoring limit curve for the stop sequence

Curve type S-shape
S-shape speed and linear acceleration curve for the stop sequence

Standard latency
Latency until the occurrence of active deceleration

Max. speed (speed threshold)
Speed threshold that must not be exceeded during the stopping process, as otherwise the energy supply will be disconnected.

Max. acceleration
Default acceleration value to calculate the limit curve.

Max. acceleration change
Default acceleration change value to calculate the limit curve.

S-Ramp time
Designates the period of time in which the speed changes in a non-linear fashion, or the time period for changing the acceleration from a=0 to $a=a_{max}$ or vice-versa

10.3.2.12 SOS (Safe Operational Stop)

Standstill monitoring

Number: see chapter "Safety functions"

Access-ID: Identification of function element

Axis assignment: 1 per axis

Function: Standstill monitoring

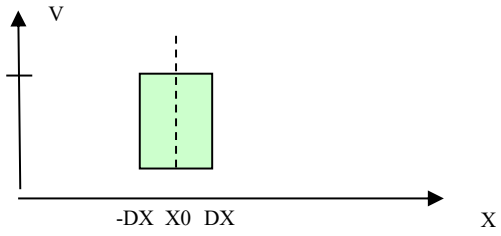
Input: Standardized position / speed signal V and X from encoder interface.

RESET-function: The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via:

- RESET function in the group of Input elements
- Function key on the front side of a basic module
- FBus reset element

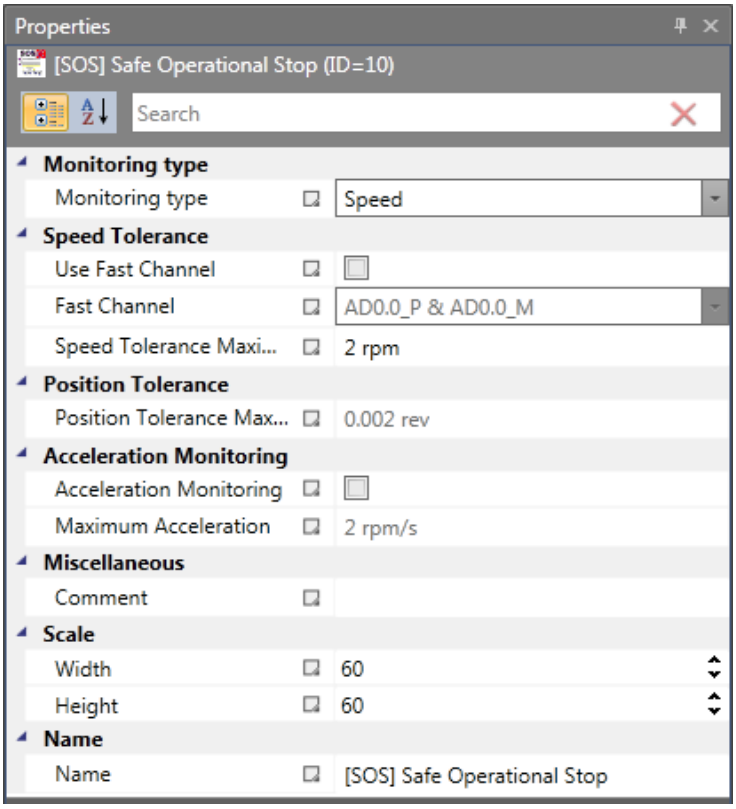
Description of function:

Standstill monitoring of drive at the current position with drive enabled and possibly activated position controller. Calculation of the current speed V on basis of position or digital speed signal X. Comparison of the actual speed with the parameterized monitoring slot



Output function

Range	HI	LO
X > (X0 – DX) AND X < (X0 + DX)	X	
X <= (X0 - DX)		X
X >= (X0 + DX)		X



Type of monitoring
Determination of the monitoring type for standstill to a minimum speed threshold or a position slot

Maximum
Minimum speed or a permissible relative deviation from the actual position at the time when the SOS-functionality is activated.

Use fast channel
The "Fast Channel" option can be used to achieve a shorter response time of the system. The two semi-conductor Outputs can alternatively be chosen in combination as shut-down channel.

ATTENTION **Response time see installation manual !**

Speed tolerance
Maximum permissible speed.

Position tolerance
Tolerance threshold for position

Acceleration monitoring
Optional maximum value for acceleration monitoring during an active SOS-function.

Input example 1:

In a manufacturing device the speed of certain manual processes is to be monitored for a safe reduced value, as well as standstill and movement direction. The movement to be actively monitored is a rotary movement. The drive works with an electric motor with integrated motor feedback system and intermediate gear.

1. Selecting the type

Only the speed is monitored (e.g. by means of incremental encoder) => speed monitoring

2. Speed monitoring

Specification of the tolerable speed monitoring value

Input example 2:

On a manufacturing machine access to the working area is to be enabled at certain positions of the main feed axis for manual feeding or setup work. The drive remains active in this position and is only monitored for standstill. The limits of the working stroke are variable and are to be monitored electronically in safety-relevant mode, as a replacement of the mechanical safety limit switch. The movement to be actively monitored is a linear movement. An absolute encoder is positively connected with this main drive axis of the linear length measuring system. The drive works with an electric motor with integrated motor feedback system and intermediate gear.

1. Selecting the type

The position is monitored (absolute encoder available) => position monitoring

2. Position monitoring

Specification of the tolerable position monitoring value

10.3.2.13 SAC (Safe Analog Monitoring)

Monitoring of an analog Input signal

Number: see chapter "Safety functions"

Access-ID: Identification of function element

Axis allocation: none

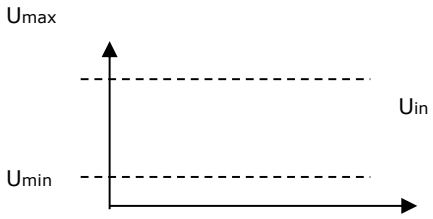
Function: Monitoring of a parametrizable analog range

Input: Standardized Input signals Uin1 and Uin2

RESET-function: The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via RESET function in the group of Input elements

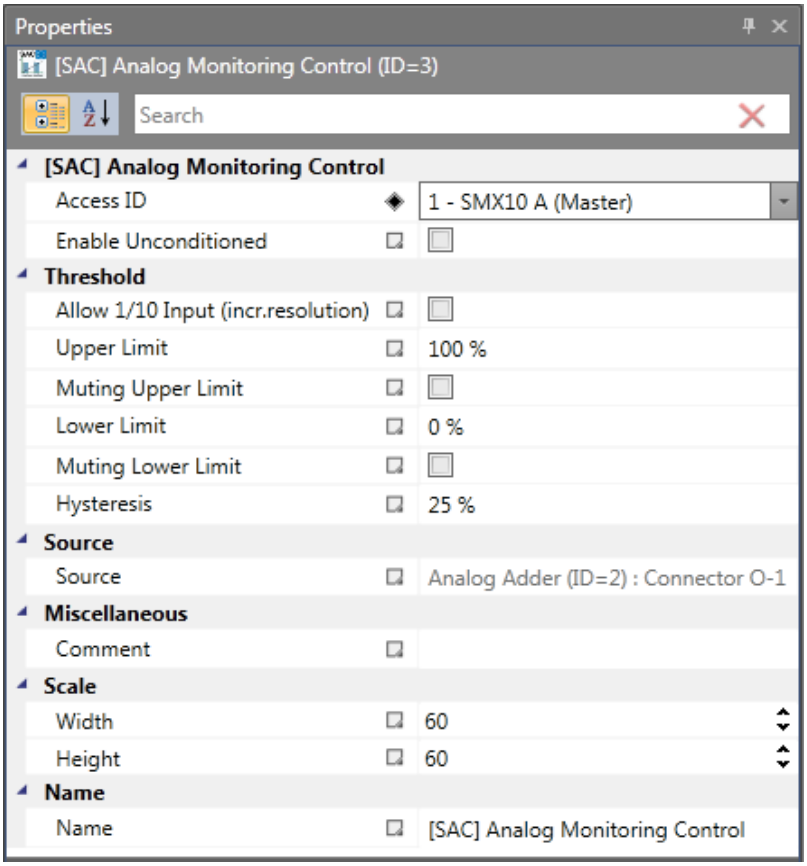
- RESET function in the group of Input elements
- Function key on the front side of a basic module
- FBus reset element

Description of function:



Output function

Range	**HI**	**LO**
Uin > Umin	X	
Uin < Umax	X	
Uin <= Umin OR Uin >= Umax		X



Parameters:

Enable unconditioned

If this option is set, the monitoring function has no Input connector. The function is active right from the start of the device.

Upper limit

Maximum value - threshold

Lower limit

Minimum value - threshold

Allow 1/10 Input

High resolution mode with limited range

Muting

Muting of the monitoring on the two Input values per channel for range and tolerance against each other

Hysteresis

Hysteresis for threshold values

Source

Adjustable analog signal source:

- **Analog signal 1**: Ain1 is made up of Input signals fro encoder 1 and encoder 2 of the interface.
- **Analog signal 2**: Ain2 is made up of Input signals fro encoder 3 and encoder 4 of the interface.
- **Filtered values of analog signals Ain1 and Ain2**: The result of the filter function F1 or F2.
- **Proportionally added input ½:** Result The weighted of the proportional adder.

ATTENTION	**When using filter functions the response times specified in the installation manual must be taken into account !**

10.3.2.14 SLT (Safe Limited Torque)

Torque monitoring over analog Input signal

10.3.2.15 STR (Safe Torque Range)

Torque range monitoring over analog Input signal

10.3.2.16 SMT (Safe Motor Temperature)

Motor temperature monitoring over analog Input signal

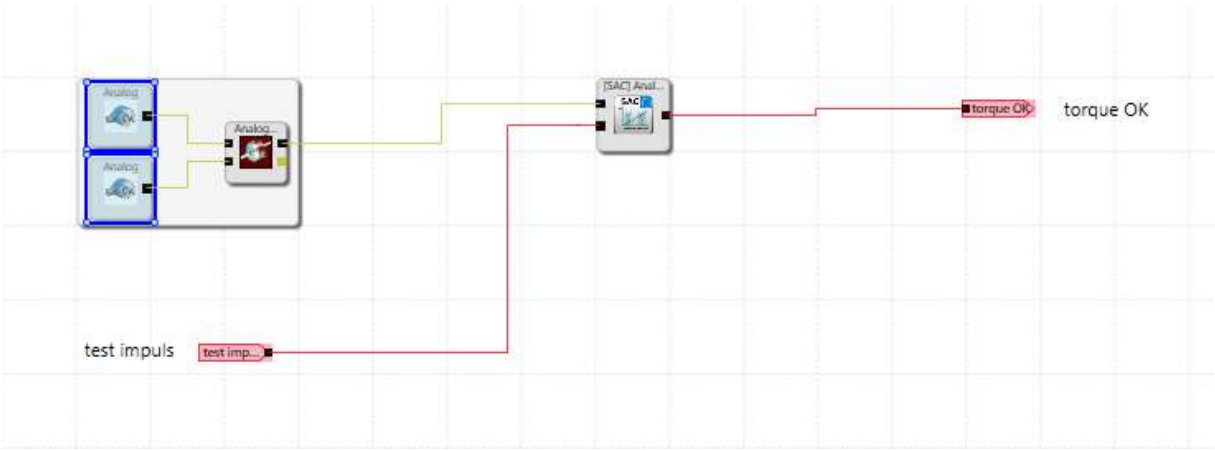
Number:	see chapter "Safety functions"
Access-ID:	Identification of function element (corresponds to the selected SAC ID)
Axis allocation:	none
Function:	Monitoring of a parametrizable analog range
Input:	Standardized Input signals Uin1 and Uin2
RESET-function:	The violation of the permissible monitoring range is saved and requires a RESET acknowledgement. This occurs alternatively via RESET function in the group of Input elements • Reset function in the group of input elements • Function button on the front of a base module • F-bus reset element

Description of function:

- The SLT function prevent that the motor set Torque or applying a linear motor the set exceeds force.
- The SLT and STR and SMT function is identical in operation with the SAC feature.
- Diagnostic function for the torque (SLT, STR).
- Diagnostic function for the temperature (SMT)

Parameters:

- Please read the description of the parameter and the function of the SAC at the chapter **SAC (Safe Analog Monitoring)**



10.3.3 Muting Functions

10.3.3.1 PDM (Position Deviation Muting)

Temporal hiding of the 2-channel encoder evaluation in case of encoder position deviation or an encoder "RESET"

Number: see chapter "Safety functions"

Access-ID: Identification of function element

Axis assignment: maximum 1 function per axis

Function: Hiding (muting) the encoder diagnostics

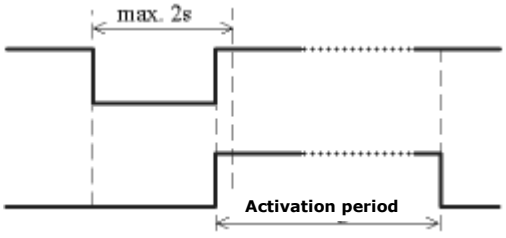
NOTICE **This function may have a considerable effect on the safety of an application. One must make absolutely sure that the use of the PDM-function will not cause any situations that may adversely affect safety!**

Description of function:

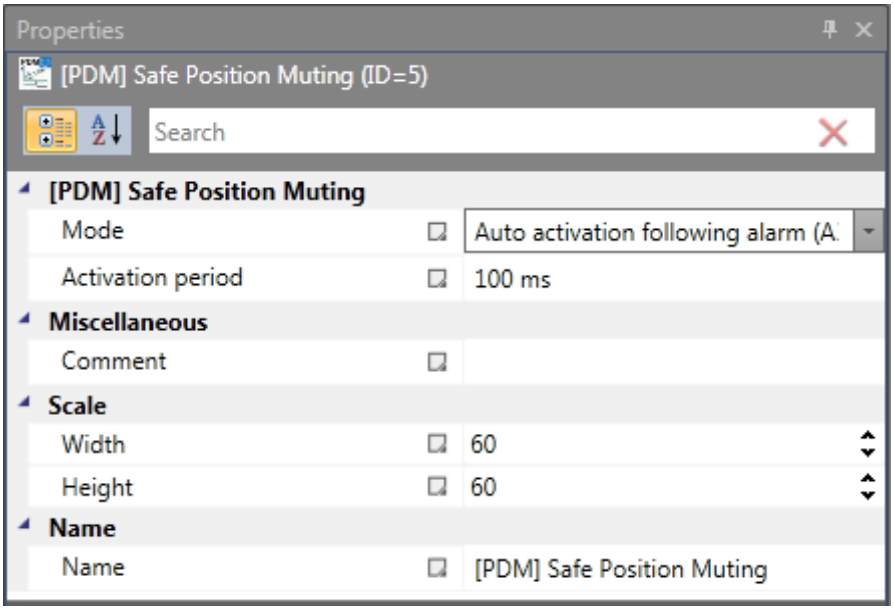
- **Automatic activation in case of an alarm**
  Switching off the encoder diagnostics for an existing A3303/A3304

- **Autom. adjustment of encoder data (in case of Incr./SSI Configr.)**
  The encoder diagnostics is suppressed over the parameterized activation period

Input:
The PDM-function should be activated by means of a safety directed button or a similar facility. In normal condition the activation signal for the PDM-function is "1". The Input is time monitored and needs to execute an edge change from "1" to "0" and from "0" to "1" within two seconds. Only then is the PDM-function available.

Making behaviour	
Input	
Output	

Output:
In deactivated condition this function sends the result "0" and in activated condition a "1" to the process image.



Parameters :

Automatic activation in case of alarm A3303/A3304
Suppression of the plausibility test for speed and position over the duration of the activation time from a fault A3303/A3304.

Application example: e.g. lifting platform with 2 encoder systems

A lifting platform is equipped with two drive systems and assigned encoder systems (both SSI-encoders). The encoders are connected with the SMX-module and monitor the horizontal position of the platform. If the platforms drifts to a slanted position (position deviation of encoders) the alarm triggered by this condition can not be reset. By activating this PDM-function the user is able to bring the platform back to horizontal position.

NOTICE

- Perhaps a speed fault (A3301/A3302) is first detected in case of an encoder deviation. After resetting the fault with the drive at standstill the position deviation fault A3303/A3304 is then displayed.
- When activating this function the encoder monitoring is switched off for the configured period of time. In this case the user must ensure that the moved drive does not pose any danger to persons or property.

Automatic adjustment of encoder data

Suppression of the plausibility test for speed and position over the duration of the activation time without any further pre-conditions.

Application example:

Compensation of position drifting in a friction wheel application.

A drive system is equipped with a position encoder with friction wheel drive. After several operation cycles a difference in form of an incremental feedback occurs between absolute encoder and second channel. The absolute encoder needs to be reset at a defined position, but the drive system is to remain active (= RUN) during that time. Resetting the encoder during operation would possibly result in high speed or acceleration values, which would cause a shut-down, even though the drive is already at rest at the time of the encoder preset.

NOTICE

- The user needs to ensure that the drive is at standstill when the encoder is preset.
- In a "Preset" the encoder can only be set to a value range 0 < x < measuring length!

Activation period

Time in milli-seconds after which the suppression is automatically removed.

Input range: 100ms … 25s

NOTICE

Once the monitoring function can be temporarily deactivated with the help of this function, particular attention must be paid when it is used!

10.3.3.2 ECS (Encoder Control Supervision)

User defined evaluation of encoder status.

Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Function:	Evaluation of the encoder error status in the logic diagram.
Reset characteristic:	This function does not trigger an alarm. The correct behaviour for cases of shut-down and release of the affected Outputs must be assured by the user program.
Input:	The function can be permanently activated or activated through an input.
Function:	Evaluation of the encoder status using the PLC-function
RESET-function:	no RESET required

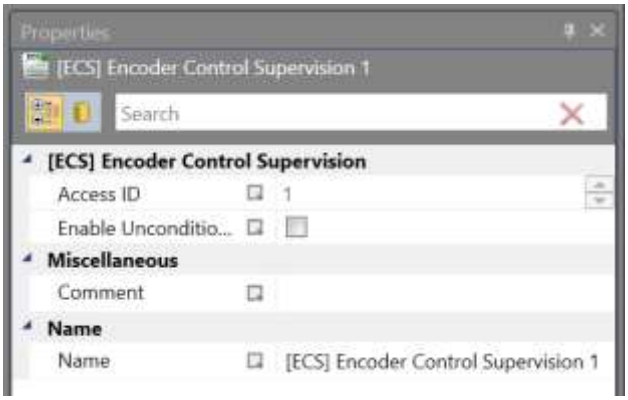
Description of function:
The detection of safe speed and position is based on a multitude of measures and various fault reactions in the form of alarm messages. Without the use of an ECS–element the operating system will switch the SMX-system to status **RUN → ALARM** when a speed/position fault is detected. All Outputs will be blocked immediately.

Inserting an ECS-element into the function block diagram suppresses this state change and the operating system remains in **RUN** condition. The PLC-program now needs to use the status of the ECS-element to trigger the required measures to avoid dangerous conditions in the application. Alarm messages of the encoder interface with identical reference number are identified with the prefix "E".

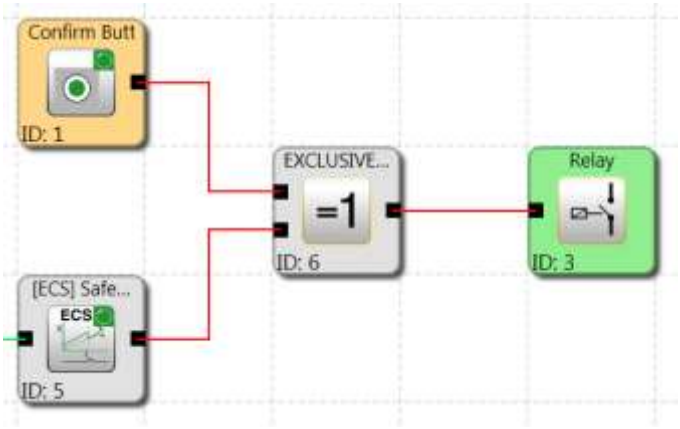
NOTICE

Since this function is critical with respect to safety, the user must check when and how the individual functionalities may be used. He must additionally make sure that the reliability is independent from the application and needs to be individually approved by the TÜV.

ECS can be configured per axis from firmware version 3.0.0.1. Previously only one ECS per module.



Example for the use of the ECS-function



The ECS-function mutes encoder alarm functions listed below:

System A	System B	Diagnostics function
3209	3210	Monitoring the encoder voltage X31
3213	3214	Monitoring the encoder voltage X32
3229	3230	Plausibility test for encoder voltage (Dynamic test)
3237	3238	Test of the analogue encoder AIN1
3239	3240	Test of the analogue encoder AIN2
3309	3302	Diagnose speed test of maximum speed (axis 1)
3329	3322	Diagnose speed test of maximum speed (axis 2)
3301	3304	Speed test (comparison) of the two encoders (axis 1)
3321	3324	Speed test (comparison) of the two encoders (axis 2)
3303	3308	Position test (comparison) of the two encoders (axis 1)
3323	3328	Position test (comparison) of the two encoders (axis 2)
3307	3310	Inspection of the measuring length for permissible range (axis 1)
3327	3330	Inspection of the measuring length for permissible range (axis 2)

System A	System B	Diagnostics function
3317	3318	Monitoring of the counting signal for track A
3337	3338	Monitoring of the counting signal for track A X32
3313	3314	Monitoring of the SSI encoder value for impermissible jump (axis 1)
3333	3334	Monitoring of the SSI encoder value for impermissible jump (axis 2)
3407	3408	Difference level monitoring (axis 1)
3409	3410	Difference level monitoring (axis 2)
3411	3412	SIN/COS plausibility monitoring (axis 1)
3413	3414	SIN/COS plausibility monitoring (axis 2)
3415	3416	Level monitoring proxy
3451	3452	Frequency monitoring of the reference signal
3453	3454	Monitoring of the transfer ratio reference signal / measured signal
3457	3458	Monitoring the Uref on the Extended Board
3459	3460	Diagnose of amplitude monitoring
3461	3462	General diagnostic status PIC faulty
3463	3464	Diagnose of signal level
3465	3466	Form factor analysis of the measured signal
3469	3470	Monitoring of the permissible quadrant
3471	3472	Supply voltage monitoring
3473	3474	Signal level Input monitoring
3475	3476	Monitoring of the counting signal separated for track A/B
3551	3552	Fault in 1. status bit of the SSI_Ext encoder (axis 1)
3553	3554	Fault in 2. status bit of the SSI_Ext encoder (axis 1)
3555	3556	Fault in 3. status bit of the SSI_Ext encoder (axis 1)
3557	3558	Fault in 4. status bit of the SSI_Ext encoder (axis 1)
3559	3560	Fault in 5. status bit of the SSI_Ext encoder (axis 1)
3561	3562	Fault in 1. status bit of the SSI_Ext encoder (axis 2)
3563	3564	Fault in 2. status bit of the SSI_Ext encoder (axis 2)
3565	3566	Fault in 3. status bit of the SSI_Ext encoder

		(axis 2)
3567	3568	Fault in 4. status bit of the SSI_Ext encoder (axis 2)
3569	3570	Fault in 5. status bit of the SSI_Ext encoder (axis 2)

System A	**System B**	**Diagnostics function**
3571	3572	Fault in 1. status bit of the SSI encoder
3573	3574	Fault in 2. status bit of the SSI encoder
3575	3576	Fault in 3. status bit of the SSI encoder
3577	3578	Fault in 4. status bit of the SSI encoder
3579	3580	Fault in 5. status bit of the SSI encoder

The number of modules depends on the number of groups. Only one ECS can be used per group. This works on both axes.

Application:
As long as the ECS block is not used, the monitoring unit will change to alarm or fault mode in case of encoder errors and switches the Outputs automatically off. When using the ECS function block, the user takes over the treatment of errors for any cases in which encoder errors are detected. This enables e.g. monitored travel movements by an operator, in order to move the application to a suitable position for fault rectification. The Output of the function block has been set (High), if no encoder related error is present.

10.3.3.3 ACS (Analog Input Muting)

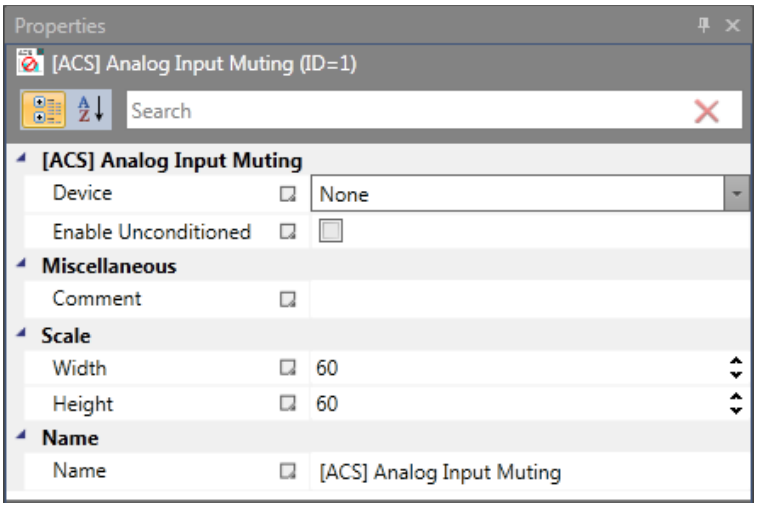
Muting of the monitoring on the analog Inputs

Number: see chapter "Safety functions"

Function: Muting of the monitoring on the analog Inputs for range and tolerance against each other

RESET-Function: not applicable

NOTICE **This function has important influence on the safety level of an application. It has to be analyzed that the use of this function will not reduce the required safety level within the complete operational range of the application!**



Description of the function

By activation of this ACS-element all possible alarms on the monitoring oft he analog Inputs such as:

- Monitoring of the correct range of the 2 Input signals
- Comparison of the 2 signal values against a maximum tolerance value are muted. The system remains in the RUN-state if such an alarm status occurs.

The automatic monitoring of the analog Inputs has to be substitute by an adequate method within the PLC-program by using the Output status of this function block. Detected alarms are shown with the prefix E and the same reference as under normal conditions.

10.3.3.4 ICS (Input Elements Muting)

Muting of the monitoring on the digital Inputs

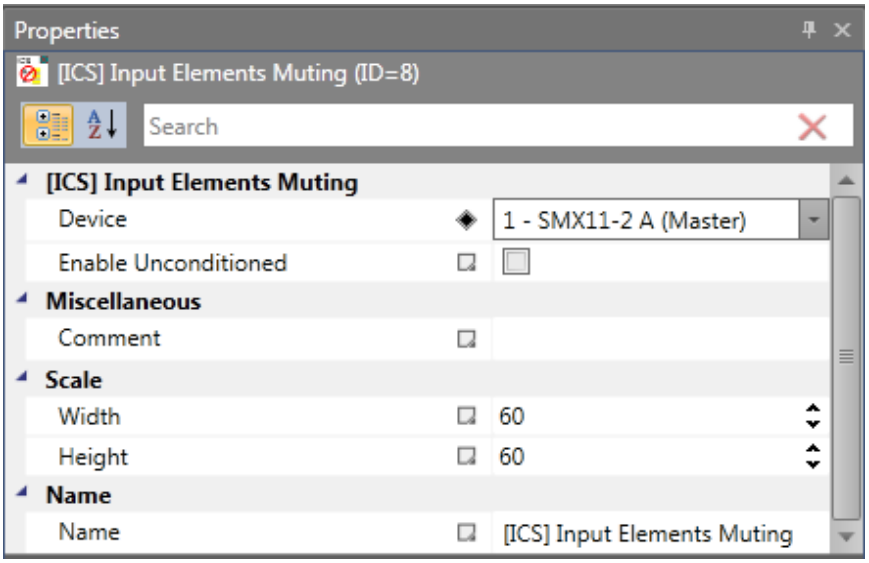
Number: see chapter "Safety functions"

Function: Muting of the monitoring on the digital Inputs for correct puls and Input function as per configuartion

RESET-Function: not applicable

NOTICE

This function has important influence on the safety level of an application. It has to be analyzed that the use of this function will not reduce the required safety level within the complete operational range of the application!



Description of the function:

By activation of this ICS-element all possible alarms on the monitoring of the digital Inputs such as:

- Monitoring of the correct pulse on the Input lines as per specific configuration
- Monitoring of the correct function on the Input lines of one Input as per configuration are muted.

The system remains in the RUN-state if such an alarm status occurs.
The automatic monitoring of the digital Inputs has to be substitute by an adequate method within the PLC-program by using the Output status of this function block.
Detected alarms are shown with the prefix E and the same reference as under normal conditions.

10.3.3.5 DEM (Dynamic Encoder Mute)

Number: see chapter "Safety functions"

Access-ID: Identification of function element

Function: Muting of alarm from encoder diagnose functions starting from a parameterizable limiting speed.

RESET- Function: no reset necessary

NOTICE **DEM-function can only be used for axis parametrized without position processing.**

Operation:

- Alarm muting of encoder diagnostic functions if a parametrizable speed tolerance is exceeded if function is enabled.
- If a safety function with the same axis will be enabled the DEM-function will be disabled.
- The alarm status of encoder diagnostics will be internally saved. Status FALSE (encoder alarm) will be cleared if the speed muting gets inactive.
- The saved alarm status will generate an alarm if a other safety function will be enabled during muting.

Output:

The Output signalized the status (only diagnostic) of this function and will be cleared depending of the muting function if the muting gets inactive.

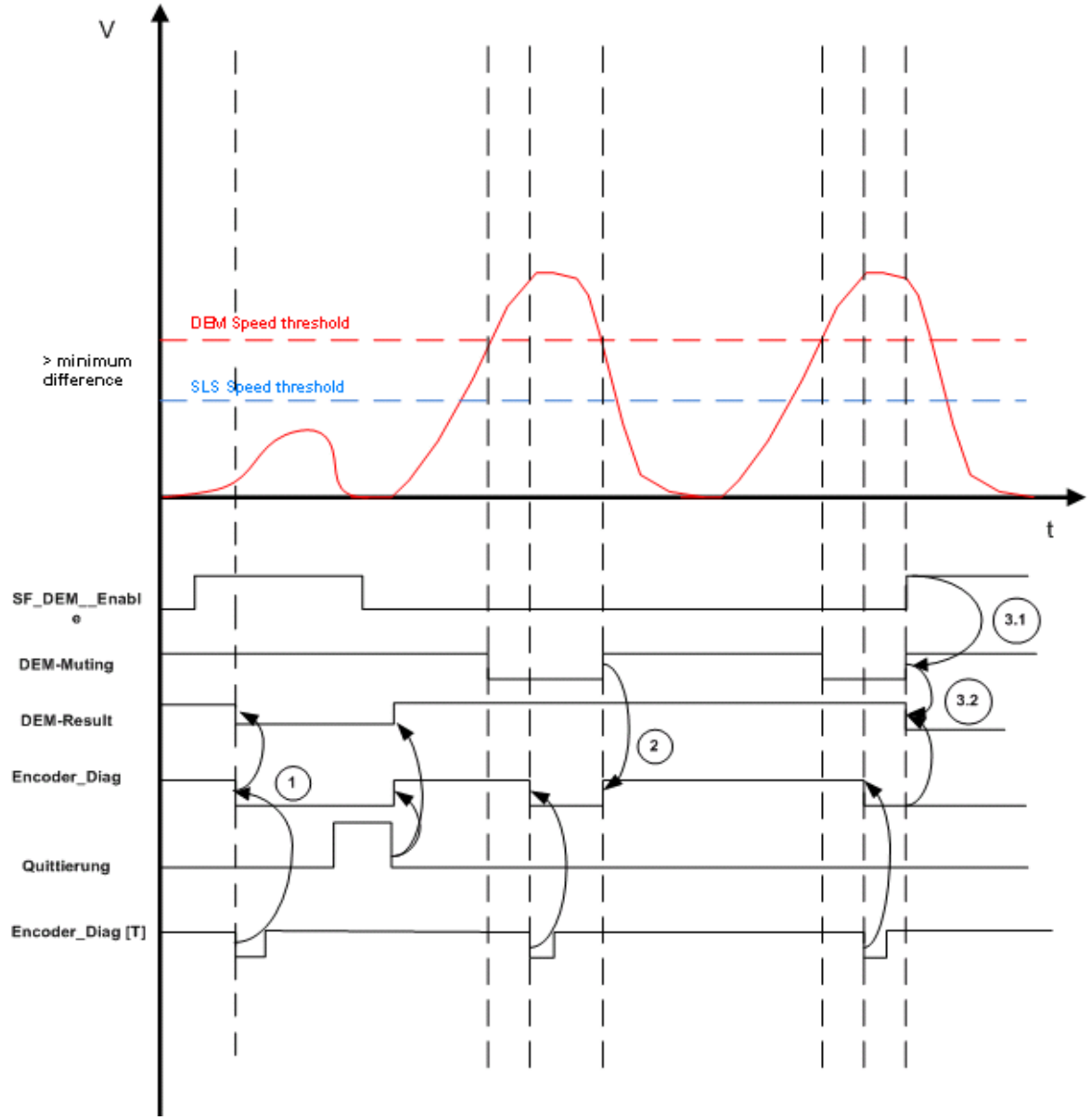
SAFETY ADVICE

- The speed threshold should be always much greater than the speed threshold in other safety functions used the axis number.
- The Output of DEM should be evaluated. The evaluation is not safety related and can be done in a non safe controller.
- The signal used for enable the DEM-function has to be the highest SIL or PL level as the used safety function on the same axis.

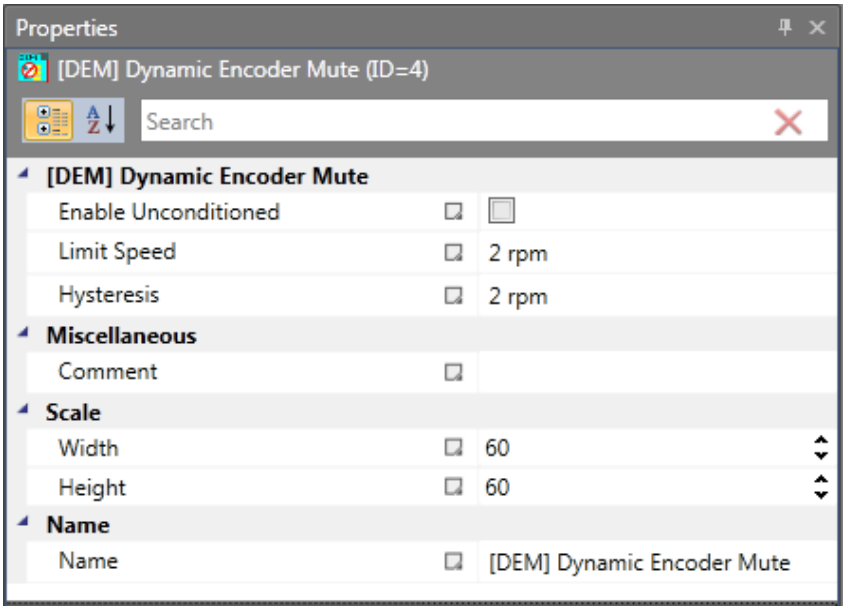
Example: DEM function axis1 with SLS according to Pl_d and SOS according to Pl_e. The activation of DEM will be if door is closed. Closed state will be controlled with a door – monitoring block.

- Highest level Pl = Pl_e, Input signal has to be Pl_e
- Door- monitoring signal has to be Pl_e
- 2-pole
- 2-pole positively driven door contact in electrical and mechanical design accordingly Pl_e, on Input interface SMX100 with activated short circuit monitoring.

Functional timing diagram :



	SF_ Enable (min. one other safety function enabled)	V_System > Speed threshold + hystersis	Input DEM	Encoder_Diag (merker for encoder faults)	Encoder alarm	DEM_Output
Encoder monitoring = True (no alarm occured)	Don't care	Don't care	Don't care	True	True	(1)
	False	Don't care	Don't care	False	True	1
	True	Don't care	Don't care	False	False	0
Encoder monitoring = False (alarm occured)	True	Don't care	Don't care	False	False	0
	False	True	False	False	False	0
	False	True	True	False	True	1
	False	False	Don't care	False	False	0



Parameters:

Enable unconditioned:

If this option is set, the monitoring function has no Input connector. The function is active right from the start of the device.

Limit speed:

If this value will be exceeded the muting function will be enabled.

NOTICE	"Limit Speed" also defines the max. Input values for the speed limits in the functions SLS, SOS, SDI and SCA. Their Input values must always be smaller than the muting speed limit.

Hysteresis:

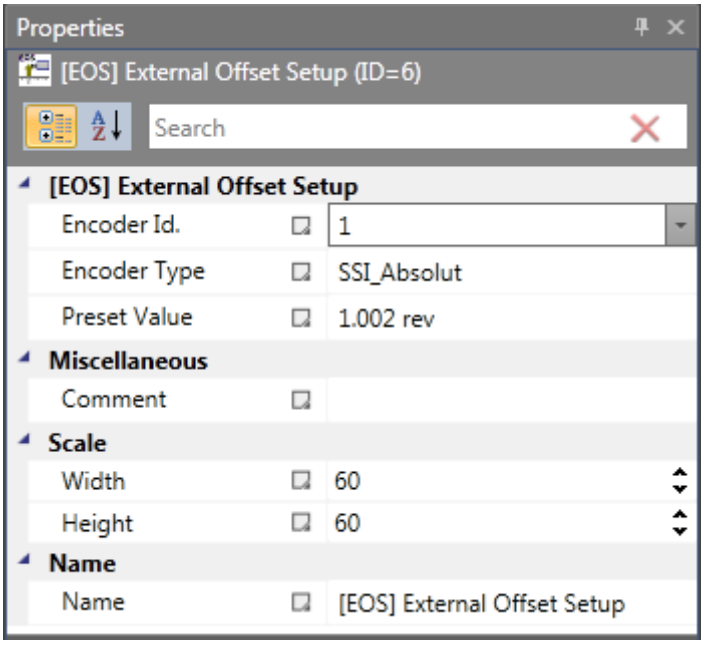
To avoid a toggle in the enable of the function a hysteresis value can be set:

- Enable function: Speed threshold + Hysteresis
- Disable function: Speed threshold

10.3.3.6 EOS (External offset setup)

Sets encoder position to configured position value

Number:	see chapter "Safety functions"
Access-ID:	Identification of function element
Function:	Calculation of an offset value for position encoders based on a parametrizable Set position derived from the current encoder position. By activating the EOS-function the current position value is adapted to a parametrizable preset value by recalculating and setting of the offset value. The offset value is in this case permanently saved.
Input:	**Position signal X** from the encoder interface. Selection module / axis and encoder
Reset function:	no reset necessary
Operation:	Activation of this function starts with a rising edge at the Input of the function. The EOS-function can only be used after position processing has been activated and absolute encoder (e.g. SSI-encoder) has been parameterized on the selected encoder channel.
Parameters:	This module can subsequently be parameterized in the functional scheme. For this purpose the sensor channel is chosen by using via axis and encoder number. The specification of the preset value takes place in the physical unit chosen for the measuring distance.



Encoder Id.: Choice of sensor connected to Encoder A (= 1) or Encoder B (= 2).

Encoder type: Choice of encoder type.

Preset Value: Preset value (set position) for selected encoder.

NOTICE

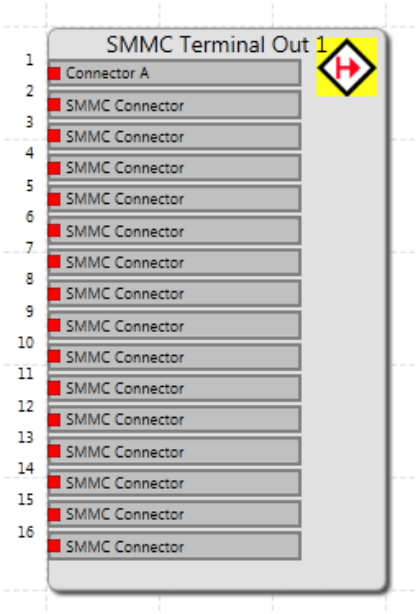
- Max. one EOS-function can be used for an absolute encoder.
- Any operational activation of the EOS-function must be ruled out. The function serves the purpose of service and maintenance. This must be assured by choosing suitable operating means for triggering this function. Suitable operating means are e.g. key switch, only accessible for qualified service and maintenance personnel.
- Suitable organisational measures must be applied to ensure compliance between the physical position of the axis and the Set position.
- The calculated offset value is stored in the device in a voltage protected way.
- ECS-function has to be enabled during the use of EOS-function for correct working.

10.3.4 Global Network Elements

Global network elements include one SMMC terminal Out and adequate Terminal In blocks.

10.3.4.1 SMMC Terminal Out

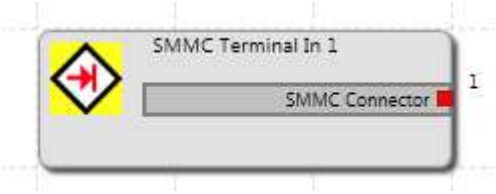
This lock represent Terminal Out for SMMC. Each device can write 16 bits as output to SMMC. These bits are defined by connection to SMMC Terminal Out connectors.



User can change the name of each used Terminal Out connector.

10.3.4.2 SMMC Terminal In

This block represent of terminal In for SMMC will be available after the user configured the related "SMMC Terminal Out" in any functional scheme.



Number Of Bits: Number of bits available for Terminal In. Number must be greater or equal to 1 and less or equal to 16.

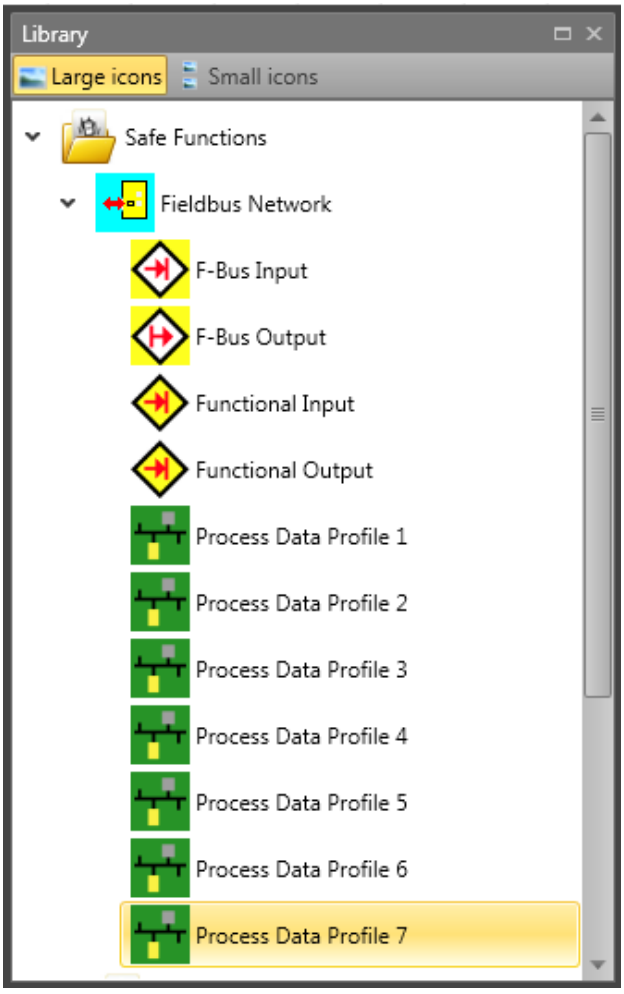
Device: Selection of SMMC device.

Bits: Range of available bits depends of selected number of bits.

Name: User can define name of SMMC terminal.

10.3.5 Fieldbus Network Elements

Fieldbus Network Elements are showed in Library under Fieldbus Network folder if Functional scheme Tab is selected. These Elements are showed on picture below. Showed functions depend on choosen device and Usage. Description of elements is in Chapter 9.3.



10.3.6 SD-Bus Group Elements

SD-Bus device elements are the logical representation of the real SD-Bus compatible safety switching devices.
For this reason each SD-Bus device element is generally identified in the respective scheme by an icon with the associated device type name .

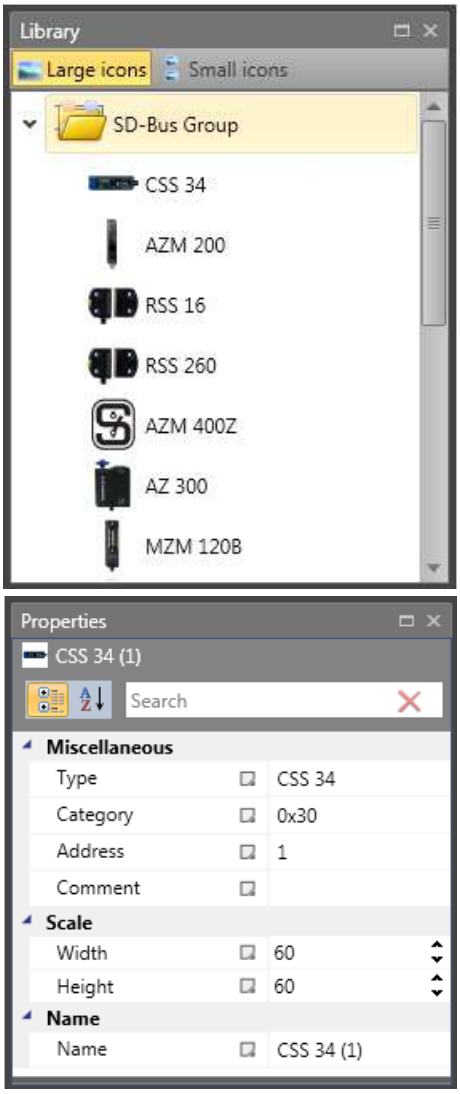


Fig. 59: Properties of SD-Bus device elements

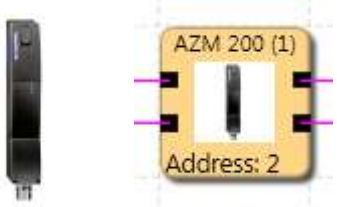
Type:	Type of the SD-Bus element. This category can't be edited.
Category:	the device category identifies the type of switching device. The category is described by a hexadecimal number which is equivalent to the following types. This category can't be edited.
Address:	The Adress is a value between 1 and 31 and can't be edited in property grid. This address depends on SD-Bus chain scheme.
Comment:	A text to be displayed on the block. It is possible to enter own comment text.

10.3.6.1 CSS 34

Safety sensor for series wiring. Series wiring up to 31 components.

10.3.6.2 AZM 200

Selenoid safety interlock. Series wiring up to 31 components.



10.3.6.3 RSS 16

Safety sensor for series wiring. Series wiring up to 31 components.

10.3.6.4 RSS 260

Safety sensor for series wiring. Series wiring up to 31 components.

10.3.6.5 AZM 400Z

Safety interlock, „Z"-type.

10.3.6.6 AZ 300

Safety switch.

10.3.6.7 MZM 120B

Safety interlock, „B"-type.

10.3.6.8 MZM 120BM

Safety interlock, „BM"-type.

10.3.6.9 MZM 120-1BM

Safety interlock, „BM"-type.

10.3.6.10 MZM 100

Safety interlock, „Z"-type.

10.3.6.11 AZ 200

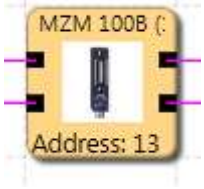
Safety switch.

10.3.6.12 CSS 30S

Safety sensor for series wiring.

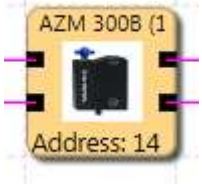
10.3.6.13 MZM 100B

Safety interlock, „B"-type.



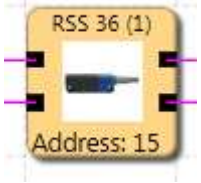
10.3.6.14 AZM 300B

Safety interlock, „B"-type.



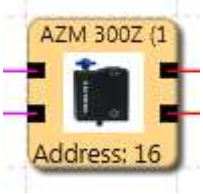
10.3.6.15 RSS 36

Safety sensor for series wiring.



10.3.6.16 AZM 300Z

Safety interlock, „Z"-type.



10.3.7 Terminals

These elements serve the clear representation of functional schemes. These elements provide "Output/Input connecting point" elements. The connection in-between is then drawn.

Terminal In

These elements provide Output connecting point elements. The reference numbers of the connecting points are automatically generated. If an "Input connecting point" block is selected, the associated "Output connecting point" blocks will also be selected, when new Output is selected. Once the Input with relevant number is selected then Output with relevant number can be added. For same multiple connecting points drag the connections from browser window.

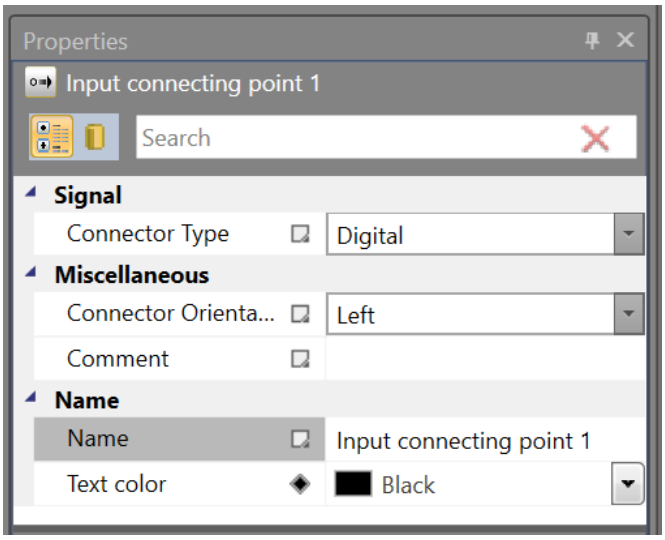


Fig. 60: Terminal properties grid

Terminal number: Identification number of the connecting point.

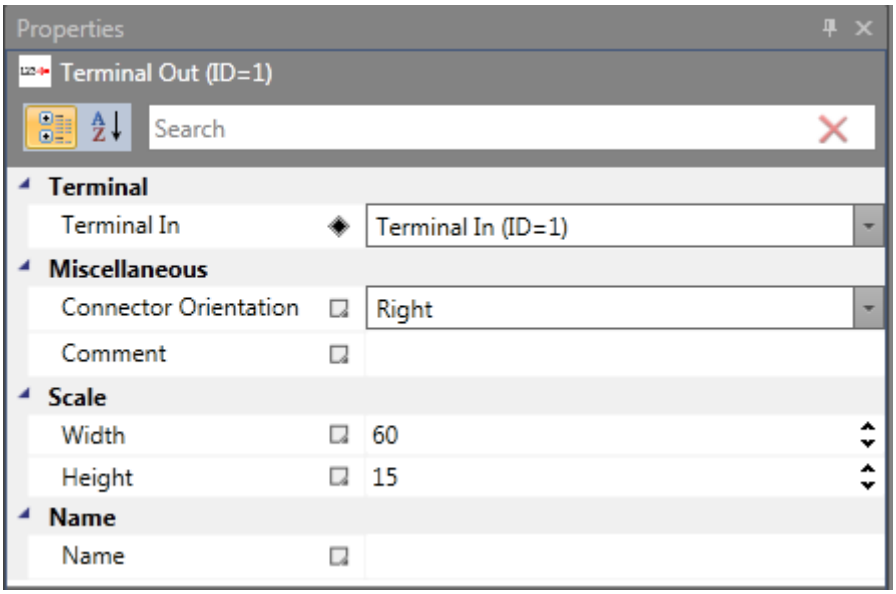
NOTICE

When deleting "Connecting point" elements, which are referenced by "Output" blocks, the user will receive a warning. When confirmed, the dependent function blocks will be deleted. If no associated "Marker Output"block has been defined, this will result in a compiler error: "Unreferenced "Set connecting point" -block.

Tip: Use the comment line. The entered comment will simplifies the assignment of elements.

Terminal Out

This element enables the continuation of a signal, which leads to a "Set connecting point" function block. According to this, these elements can only be inserted after a "Set connecting point" element has been defined.



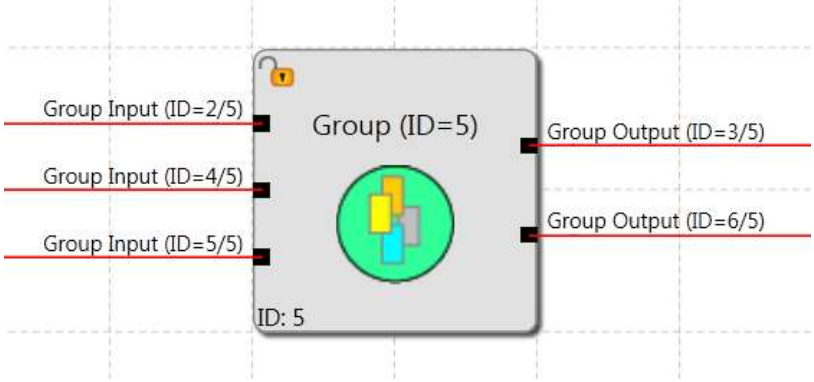
Connector orientation: Selecting orientation of connecting point in canvas.
Terminal In: Identification of the "Set connecting point" connecting point.

NOTICE

Since this element refers to the set "Set connecting point" element, the comment for this element is displayed.

10.3.8 Groups

Function groups connect several functional blocks to a superordinate logic structure. This matching group of blocks is created inside the function group and connected via this block.



This grouping gives the function block diagram a much clearer structure and, with the export / import functionality, enables the creation of an own function library.

10.3.8.1 Creating the Group:

1. Create Group Block

Creating a clear Function Group

Library window contain New Group element. To adding new group, drag New Group  from library window and drop it in functional scheme canvas. Created group has no Inputs/Outputs interface.

Creating a function group from selection

The size of the group elements is determined with the mouse pointer:

1.) First position the mouse pointer with the left mouse button in the left upper corner of the group frame and hold the mouse button depressed.
2.) Then drag the mouse pointer while holding the left mouse button depressed and determine the bottom corner of the group area.
3.) Click right mouse button on selection and create a new group that will insert the group frame and allow to open group tab for editing.

The block types that cannot be contained in a group are filtered out with info display that show filtered blocks.

2. Adding function blocks to the group

The group canvas can optionally be opened by double-clicking in the group frame, or via the group sheet of a browsers tree. Function blocks can be inserted, moved or deleted on this area. The blocks will automatically be accepted in the group, unless the group is in disabled state. The functional blocks in this case additionally show the number of the function group. As long as the group module is enabled, function modules can be added to or deleted from the area of the group frame.

Please note:

- No function blocks can be taken in by simply moving the group block! The modules must be moved into the group sheet instead.
- Only logic modules and monitoring modules can be accepted in the group, Input and Output modules, pre-defined elements such as signal lists, analog modules or encoder modules are not permitted.
- In case of modules with existing connections it may happen, that a connection projects from the group frame during the step-by-step movement of the selection. This is under no circumstances permitted and the connection will be automatically deleted.
- If modules, that have already been connected, are to be added to groups with their connections by moving, you should proceed as follows:
    - The move the group block over the function blocks. The affected connections must all be inside the group sheet.
    - Select the modules and displace them by one grid position inside the group module.

The following block types cannot be contained in a group. They are filtered out when the modules are moved into the frame area.

- Input modules
- Output modules
- All function blocks pre-defined in the functional scheme (e.g. encoders, analog modules, IOs)
- Signal channel module

The maximum number of blocks is determined by sheet size.

Right mouse button on Group will display Export to library option

3. Adding interface Input/Output

Inserting a group interface block with Drag Group Input/Output in the Group Interface library and Dropping on appropriate Group block (alternatively on Group in functional sheet). After placing a block inside a group the group interface is added.
For more info see chapter “Group interface”

4. Create connections

-see chapter “Wiring”

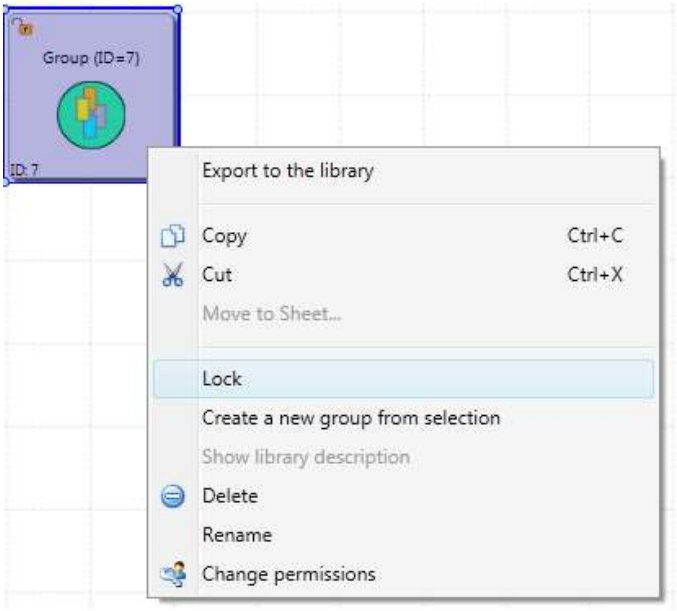
5. Connect Group interface

The functional blocks contained in a group can only be linked with the function elements outside the group frame via the interface blocks described above. In these interface connector type can be set as required, which will demand the same connection constellation when importing the group into another function block diagram. The interface blocks enable a description of the Input and Output of the function group. The description should be documented in the comment field.

Tips:

- The group(s) should remain in enabled condition for as short a time as possible.
- Enable as little groups as possible in the function scheme.
- Refrain from moving groups in the Function scheme.
- If possible, only edit one group in the function block diagram.
- Disable groups before saving.
- Create connections only as late as possible.

10.3.8.2 Setting the group management

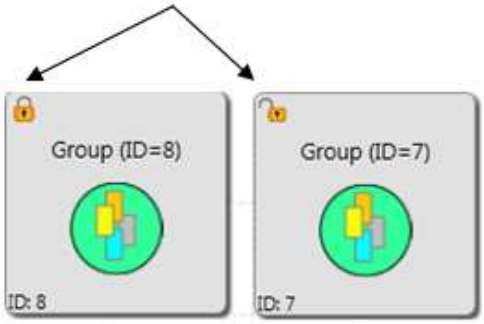


Right mouse button on group will display context menu with lock management function.

With this function block management of the frame is disabled and the blocks are tied to the group:

- Modules can no longer be removed from the group, whereby the configuration of parameters is still permitted.
- Deleting a group frame also deletes all group blocks.
- No new blocks can be added to the group.

The group status "disabled" is indicated by the padlock symbol in the group block at the top left.



Group locked / unlocked

When inserting a New Group block the Lock function is initially not set.

10.3.8.3 Exporting/Importing a function group

Right mouse button on Group will display Export to the library option. The modules of a group can be exported into a library. An exported group can be imported into another group sheet. This enables the creation of a library with pre-defined function groups, which can then be imported into new projects. The Group can't be renamed in library window. User can change the image of exported Groups.

A function group can only by imported using an already inserted group frame via library. The import process includes the verification of the sensor configuration and the still existing resources in the functional scheme. The group can only be imported if the resources for all modules are available. The necessary sensor settings must be checked, particularly in case of position dependent monitoring modules.If a resource is no longer available, this is indicated by an error message.

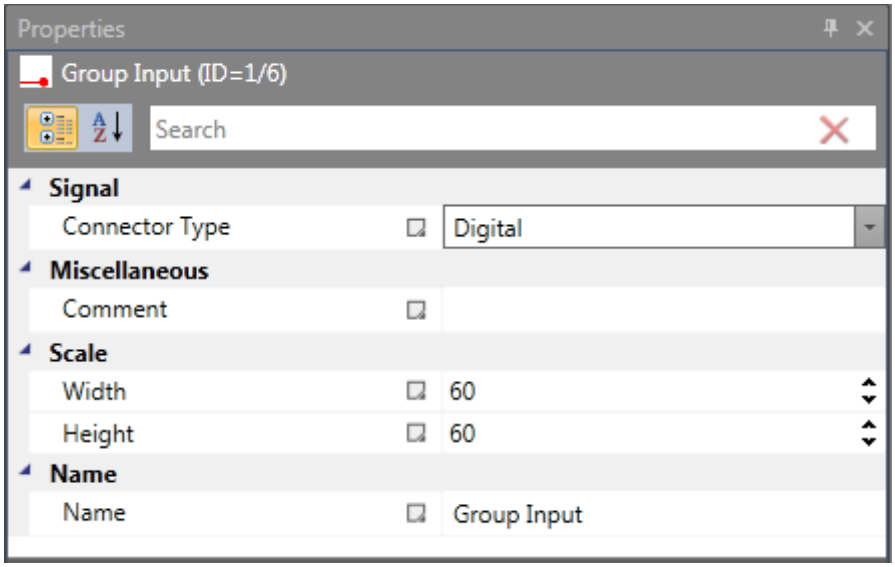
In case of resource errors make sure that the sensor settings comply with the requirements of the group. This is particularly valid if position dependent modules were used in the function groups (SEL, SLP, SCA).

10.3.9 Group interface

The group interface blocks represent the interface of the function group to the elements outside the group. Connections to function blocks outside the group can only be made via Group Interface. Inserting a group interface block with Drag Group Input/Output in the Group Interface library and Dropping on appropriate Group block (alternatively on Group in functional sheet). After placing a block inside a group the group interface is added. In these interface modules connector type can be set as required, which will demand the same connection constellation when importing the group into another Functional scheme.

Connector type: This option can be used to set group Input and group Output elements and prevent impermissible allocations.

Example: Connector type axis is connected to the group interface block. In user mode the group block always expects to be connected with the same connector type.



This setting is used to determine the connection properties of the block as Input or Output.

Group Input

This element represents the connection of function blocks outside the group to the external group elements. The block should be positioned on the left side of the group area, if this is possible. The Output connector must be wired further inside the group.

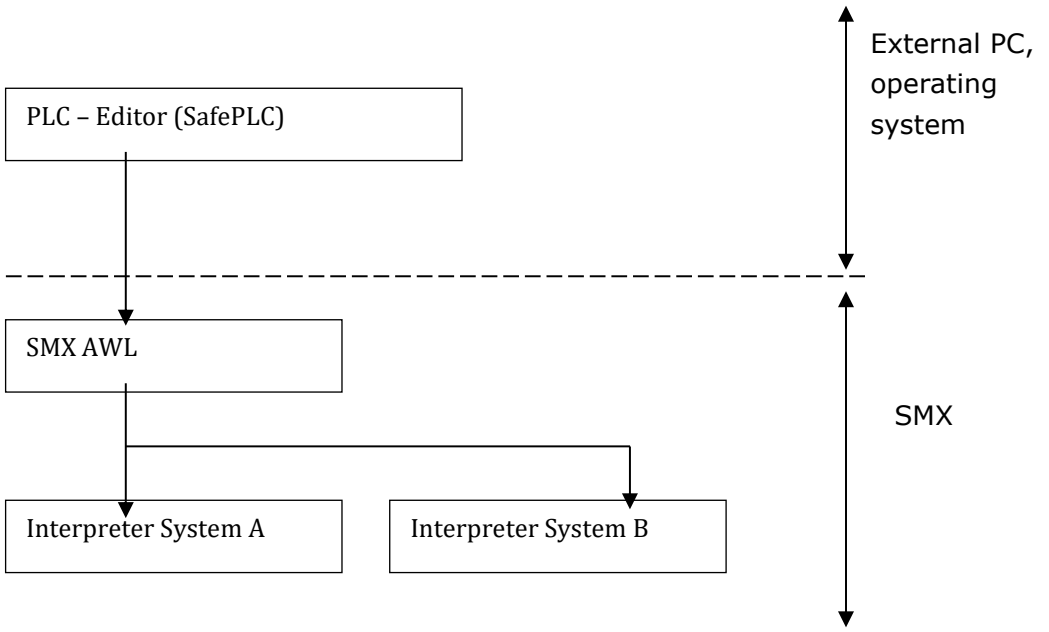
Group Output

This icon transfers a result from the group to externally located function block diagram elements.
Input/Output blocks can be deleted only in Group sheet

11 Appendix Process Image

11.1 Introduction

The SMX-system is able to execute interpreter code saved in the block with PLC-functionality in real-time.
With an external, not safety related PLC-editor (***SafePLC***) a program can be created in function block representation as specified in IEC 61131, compiled and saved in the format **SMXA*WL***. The same program adds the **SMXAWL -** instructions to the configuration data and transmits the data to the block SMX10/11/12/12A.



Evidence of the correct assignment of inputs and outputs must be provided by the user within the scope of a safety documentation (validation report).

The SMX AWL-CODE is executed by both systems in each cycle. For this purpose the input variables used in the program are linked in compliance with the interpreter code. The result of the interpreter run is obtained by:

- Setting/deleting one or several variables in the initial process image
- enabling/disabling monitoring functions
- setting/deleting outputs
- setting/deleting markers
- starting and stopping timers

The AWL-code generated by the compiler must be verified within the validation process. Exceptions are the so-called MACRO-functions, which are internally 2-channel tested by the SMX-system. In the MACRO-function only the connection of inputs must be verified. MACRO-functions refer e.g. to two-hand operation.

11.2 Descriptionof function elements

The following description is required for executing the application validation.

11.2.1 PLC – Commands

The following list contains all commands used within the SMX-system:

Operator	Operand	Description
LD	all input and output operands	Equates current result with operand
LD NOT	all input and output operands	Equates current result with operand and inverts the operand
ST	only output operands	Saves current result to operand address
AND	all input and output operands	Boolean AND
AND NOT	all input and output operands	Negated Boolean AND
OR	all input and output operands	Boolean OR
OR NOT	all input and output operands	Negated Boolean OR
XOR	all input and output operands	Boolean Exclusive OR
NOT	all input and output operands	Inverts the accumulator value
SET MARKER	PLC_MARKER in output image	Sets marker
RESET MARKER	PLC_MARKER in output image	Resets marker
SET	all input and output operands	Sets operand to 1
RESET	all input and output operands	Sets operand to 0
MACRO_INFO	Description of macro element	Operand field: 2 byte for macro identification
MACRO_CRC	CRC the previous macro field	Operand field: 1. Operand: CRC_LO (8 Bit) 2. Operand: CRC_HI (8 Bit)
INFO	Info field	Operand field: 1. Operand: reserved free! 2. Operand: reserved free!

11.2.2 Input variables in functional scheme for compact devices

Note: The output values of the monitoring functions must be considered as inputs in the process image!

Index	*PAE-variable*	*Bit Pos.*	*Bit variable*	*Description*
1	Config_ID			0x3001 fixed
2	DriveBASE	0 1 2 3 4 5		0 .. 2 always "1" 3 Reset monitoring functions 4 ECS result axis 1 5 ECS result axis 2
3	DriveSLI	0 1	SLI.0 SLI.1	Results SLI
4	EA2_In8	0 .. 7	EA2.1 .. EA2.8	Extension inputs
5	DriveEMU	0 1	EMU.1 EMU.2	Results EMU
6	DriveSCA	0 .. 7 0 .. 7	SCA.1 .. SCA.8 SCA.9 .. SCA.16	Results SCA
7	DriveSSX	0 1 2 3	SSX.1 SSX.2 SSX.3 SSX.4	Results SSX
8	DriveSOS	0 1	SOS.1 SOS.2	Results SOS
9	DriveSLP	0 1	SLP.1 SLP.2	Results SLP
10	DriveSEL	0 1	SEL.1 SEL.2	Results SEL
11	DriveSLS	0 .. 7	SLS.1 .. SLS.8	Results SLS
12	DriveSDI	0 1	SDI.1 SDI.2	Results SDI
13	DriveSAC	0 .. 7	SAC.1 .. SAC.8	Results SAC
14	DriveSF	0 1	PDM_EN.1 PDM_EN.2	Results PDM
15	DI8	0 .. 7	E0.1 .. E0.8	Hardware inputs basic block 1 .. 8
16	DI16	0 .. 7	E0.9 .. E0.16	Hardware inputs basic block 9..16
17	DI24	0 .. 7	E1.1 .. E1.8	Hardware inputs SMX31 Extension with log. address 1 inputs 1 – 8
18	DI32	0 .. 7	E1.9 .. E1.12	Hardware inputs SMX31 Extension with log. address 1 inputs 9 – 12 and extension with log. address 2 inputs 9 – 12
19	PLCTimer16	0 .. 7	PLCT.9 .. PLCT.16	Results PLC Timer
20	Reserve1			Reserve
21	StartTimer	0 .. 1 2 .. 3 4 .. 5 6 .. 7	MET.1 MET.2 MET.3 MET.4	Output start element with time
22	Outp2HandTimer	0	MEZ.1	Output two-hand with time
23	Start element	0	MES.1	Output start element
24	Start-up Test	0	MEA.1	Output start-up test

		1	MEA.2	
25	PLC Timer	0 .. 7	PLCT.1 .. PLCT.8	Results PLC_Timer
26	DriveTTS	0 1 2 3	EAE2.7 EAE2.8 EAE2.9 EAE2.10	
27	AIn1			Analogue input 1
28	AIn2			Analogue input 2
29	AIn3			Analogue input 3
30	AIn4			Analogue input 4
31	SysACC Axis1		SysAcc[0]	current system acceleration axis 1
32	SysACC Axis2		SysAcc[1]	current system acceleration axis 2
33	Limit20Axis1		Limit20[0]	Limit for GOTO monitoring axis 1
34	Limit20Axcis2		Limit20[1]	Limit for GOTO monitoring axis 2
35	Pos20Axis1		Position20[0]	Current position axis 1
36	Pos20Axis2		Position20[1]	Current position axis 2
37	BG20Axis1		BG20[0]	Range limit axis 1
38	BG20Axis2		BG20[1]	Range limit axis 2
39	StopDistAxis1		StopDistanz20[0]	Current stop distance axis 1
40	StopDistAxis2		StopDistanz20[1]	Current stop distance axis 2
41	SysSpeed Axis1		SysSpeed[0]	Current speed axis 1
42	SysSpeed Axis2		SysSpeed[1]	Current speed axis 2
43	AnalogAdder			Analogue adder
44	EA_IN8	0 .. 7	EAE1.1 .. EAE1.8	Extension inputs SMX31 with log. address 1
45	EA_IN16	0 .. 7	EAE1.9 .. EAE1.10 EAE2.1 .. EAE2.6	Log. address 1 Log. address 1 Log. address 2 Log. address 2
46	Start element Timer2	0 1 2 3	MET.5 MET.6 MET.7 MET.8	Output start element with time
47	EMU 31 1 1	0 1 2 3 4 5 6 7	EMU31_1.1 EMU31_1.2 EMU31_1.3 EMU31_1.4 EMU31_1.5 EMU31_1.6 EMU31_1.7 EMU31_1.8	EMU results SMX31 with log. address 1
48	EMU 31 1 1	0 1	EMU31_1.9 EMU31_1.10	EMU results SMX31 with log. address 1
49	EMU 31 1 2	0 1 2 3 4 5 6 7	EMU31_2.1 EMU31_2.2 EMU31_2.3 EMU31_2.4 EMU31_2.5 EMU31_2.6 EMU31_2.7 EMU31_2.8	EMU results SMX31 with log. address 2
50	EMU 31 1 2	0 1	EMU31_2.9 EMU31_2.10	EMU results SMX31 with log. address 2
51	Reserve3 PAE			Reserve
52	Reserve			Reserve

53	Reserve			Reserve
54	Reserve 2_0 PAE			Reserve
55	Reserve 2_1 PAE			Reserve
56	Reserve 2_2 PAE			Reserve
57	Reserve 2_3 PAE			Reserve
58	Reserve 2_4 PAE			Reserve
59	Reserve 2_5 PAE			Reserve

11.2.3 Input variables in functional scheme for modular devices

Input variables for the PLC-system are marked by:Output variables for the PLC-system are identified by:

- Affiliation to the system image of the mosular system
- the unambiguously determined address (byte index in system image, bit index in entry of system image).
- by the 1-bit value of the inPort variable (TRUE or FALSE)
- Type of input variables: HW-inputs, RESULT of the monitoring function, RESULT of markers, RESULT of timers
- Access to the input variables always takes place **bit by bit!**

Syntax and addressing:

Idx	PAE name	Description
1	Drive SAC 1-8	Result SAC funktion 1…48
2	Drive SAC 9-16	
3	Drive SAC 17-24	
4	Drive SAC 25-32	
5	Drive SAC 33-40	
6	Drive SAC 41-48	
7	Drive SDI 1-8	Result SDI Function 1-12 Bit 13-16 not used
8	Drive SDI 9-16	
9	Drive SLI 1-8	Result SLI Function 1-12 Bit 13-16 not used
10	Drive SLI 9-16	
11	Drive SEL 1-8	Result SEL Function 1-12 Bit 13-16 not used
12	Drive SEL 9-16	
13	Drive SSX 1-8	Result SSX Function 1-24
14	Drive SSX 9-16	
15	Drive SSX 17-24	
16	Drive Base	DRB_STAT.1 = ESTOP external DRB_STAT.2 = RUNNING DRB_STAT.3 = LOCK DRB_STAT.4 = RESET
17	Drive SLP 1-8	Result SLP Function 1-12 Bit 13-16 not used
18	Drive SLP 9-16	
19	Drive SLS 1-8	Result SLS Function 1-48
20	Drive SLS 9-16	

21	Drive SLS 17-24	
22	Drive SLS 25-32	
23	Drive SLS 33-40	
24	Drive SLS 41-48	
25	Drive SCA 1-8	Result SCA Function 1-64
26	Drive SCA 9-16	
27	Drive SCA 17-24	
28	Drive SCA 25-32	
29	Drive SCA 33-40	
30	Drive SCA 41-48	
31	Drive SCA 49-56	
32	Drive SCA 57-64	
33	Drive SF 1-8	Not used
34	Drive SF 9-16	
35	Drive SOS 1-8	Result SOS Function 1-12 Bit 13-16 not used
36	Drive SOS 9-16	
37	Drive PDM 1-8	Not used
38	Drive PDM 9-16	
39	Drive ECS 1-8	Result ECS Function 1-12 Bit 13-16 not used
40	Drive ECS 9-16	
41	Drive ACS 1-8	Result ACS Function 1-12 Bit 13-16 not used
42	Drive ACS 9-16	
43	Drive EMU 1-8	Result EMU Function 1-16
44	Drive EMU 9-16	
45	PLC Timer 1-8	Result PLC Timer 1 -64
46	PLC Timer 9-16	
47	PLC Timer 17-24	
48	PLC Timer 25-32	
49	PLC Timer 33-40	
50	PLC Timer 41-48	
51	PLC Timer 49-56	
52	PLC Timer 57-64	
53	FunctionalInp 1-8	Functional inPorts 1-32
54	FunctionalInp 9-16	
55	FunctionalInp 17-24	
56	FunctionalInp 25-32	
57	StarteElement Timer 1-8	Results for inPort time monitored 1…64
58	StarteElement Timer 9-16	
59	StarteElement Timer 17-24	
60	StarteElement Timer 25-32	
61	StarteElement Timer 33-40	
62	StarteElement Timer 41-48	
63	StarteElement Timer 49-56	
64	StarteElement Timer 57-64	
65	Anlauftest 1-8	Result of start behaviour monitored
66	Anlauftest 8-16	
67	Anlauftest 17-24	
68	Anlauftest 25-32	
69	Anlauftest 33-40	
70	Anlauftest 41-48	
71	Anlauftest 49-56	
72	Anlauftest 57-64	
73	Ausgang Zweihandtimer 1-8	Result of Two-hand button
74	Ausgang Zweihandtimer 9-16	
75	Digital Inp 1-8	InPort Master E0.1 bis E0.12
76	Digital Inp 9-16	
77	Digital Inp 17-24	InPort Master EAE0.1 bis E0.8
78	Digital Inp 25-32	InPort Master EAE0.9 bis E0.16
79	Digital Inp 33-40	InPort Master EAE0.17 bis E0.24

80	Digital Inp 41-48	InPort Master EAE0.25 bis E0.32
81	Digital Inp 49-56	InPort Master EAE0.33 bis E0.40
82	Digital Inp 57-64	Nicht verwendet
83	Digital Inp 65-72	InPort Slave Adresse 1
84	Digital Inp 73-80	InPort Slave Adresse 1
85	Digital Inp 81-88	InPort Slave Adresse 1
86	Digital Inp 89-96	InPort Slave Adresse 2
87	Digital Inp 97-104	InPort Slave Adresse 2
88	Digital Inp 105-112	InPort Slave Adresse 2
89	Digital Inp 113-120	InPort Slave Adresse 3
90	Digital Inp 121-128	InPort Slave Adresse 3
91	Digital Inp 129-136	InPort Slave Adresse 3
92	Digital Inp 137-144	InPort Slave Adresse 4
93	Digital Inp 145-152	InPort Slave Adresse 4
94	Digital Inp 153-160	InPort Slave Adresse 4
95	Digital Inp 161-168	InPort Slave Adresse 5
96	Digital Inp 169-176	InPort Slave Adresse 5
97	Digital Inp 177-184	InPort Slave Adresse 5
98	Digital Inp 185-192	InPort Slave Adresse 6
99	Digital Inp 193-200	InPort Slave Adresse 6
100	Digital Inp 201-208	InPort Slave Adresse 6
101	Digital Inp 209-216	InPort Slave Adresse 7
102	Digital Inp 217-224	InPort Slave Adresse 7
103	Digital Inp 225-232	InPort Slave Adresse 7
104	Digital Inp 233-240	InPort Slave Adresse 8
105	Digital Inp 241-248	InPort Slave Adresse 8
106	Digital Inp 249-256	InPort Slave Adresse 8
107	Digital Inp 257-264	Not used
108	Digital Inp 265-272	Not used
109	Digital Inp 273-280	Not used
110	Digital Inp 281-288	Not used
111	Digital Inp 289-296	Not used
112	Digital Inp 297-304	Not used
113	Digital Inp 305-312	Not used
114	Digital Inp 313-320	Not used
115	Digital Inp 321-328	Not used
116	Digital Inp 329-336	Not used
117	Digital Inp 337-344	Not used
118	Digital Inp 345-352	Not used
119	Digital Inp 353-360	Not used
120	Digital Inp 361-368	Not used
121	Digital Inp 369-376	Not used
122	Digital Inp 377-384	Not used
123	Digital Inp 385-392	Not used
124	Digital Inp 393-400	Not used
125	Digital Inp 401-408	Not used
126	Digital Inp 409-416	Not used
127	Digital Inp 417-424	Not used
128	Digital Inp 425-432	Not used
129	Digital Inp 433-440	Not used
130	Digital Inp 441-448	Not used
131	SOC Status 1-8	Status information from Slave Adresse1
132	SOC Status 9-16	
133	SOC Status 17-24	
134	SOC Status 25-32	
135	SOC Status 33-40	Status information from Slave Adresse2
136	SOC Status 41-48	
137	SOC Status 49-56	
138	SOC Status 57-64	

139	SOC Status 65-72	Status information from Slave Adresse3
140	SOC Status 73-80	
141	SOC Status 81-88	
142	SOC Status 89-96	
143	SOC Status 97-104	Status information from Slave Adresse4
144	SOC Status 105-112	
145	SOC Status 113-120	
146	SOC Status 121-128	
147	SOC Status 129-136	Status information from Slave Adresse5
148	SOC Status 137-144	
149	SOC Status 145-152	
150	SOC Status 153-160	
151	SOC Status 161-168	Status information from Slave Adresse6
152	SOC Status 169-176	
153	SOC Status 177-184	
154	SOC Status 185-192	
155	SOC Status 193-200	Status information from Slave Adresse7
156	SOC Status 201-208	
157	SOC Status 209-216	
158	SOC Status 217-224	
159	SOC Status 225-232	Status information from Slave Adresse8
160	SOC Status 233-240	
161	SOC Status 241-248	
162	SOC Status 249-256	
163	Meisterschalter Eingang 1-8	Result Master switch
164	Meisterschalter Eingang 9-16	
165	Meisterschalter Eingang 17-24	
166	Meisterschalter Eingang 25-32	
167	DriveDEM 1-8	Result DEM Function 1-12 Bit 13-16 not used
168	DriveDEM 9-16	

Note) Digital inPort Slave x:

- Bit0…11: Ex.1 …Ex.12
  Bit12…21 -> EAEx.1… EAEx.10

11.3 PLC Processing

11.3.1 PLC – Syntax

The PLC-program is CRC-protected and part of the SMX configuration data. Each PLC-command is identically structured as follows:

Syntax of list entry:
Size of list entry = 4 byte

Byte index	0	1	2	3
Assignment	PLC – Command	Byte-Address Operand	Bit-Address	Downcount 0..255

Comment:

Downcount = (number of IL-commands) – (line number of list entries - 1)
At 256 the counter jumps back to 0.

11.3.2 PLC – Commands

Operator	Operand	OPCODE	Description
LD	all input and output operands	02	Equates current result with operand
LD NOT	all input and output operands	04	Equates current result with operand and inverts the operand
ST	only output operands	06	Saves current result to operand address
AND	all input and output operands	08	Boolean AND
AND NOT	all input and output operands	10	Negated Boolean AND
OR	all input and output operands	12	Boolean OR
OR NOT	all input and output operands	14	Negated Boolean OR
XOR	all input and output operands	16	Boolean Exclusive OR
NOT	all input and output operands	18	Inverts the accumulator value
SET MARKER	PLC_MARKER in output image	20	Sets marker
RESET MARKER	PLC_MARKER in output image	22	Resets marker
SET	all input and output operands	24	Sets operand to 1
RESET	all input and output operands	26	Sets operand to 0
MACRO_INFO	Description of macro element	28	Operand field: 2 byte for macro identification
MACRO_CRC	CRC the previous macro field	30	Operand field: 1. Operand: CRC_LO (8 Bit) 2. Operand: CRC_HI (8 Bit)
INFO	Info field	32	Operand field: 1. Operand: reserved free! 2. Operand: reserved free!

11.3.3 PLC – Elements (I/O)

The PLC input and output elements are defined in the document "TS-37350-340-02 Switch Types PLC"!

11.3.3.1 Input elements

I/O	Type
ESwitch_1O	1
ESwitch_1S	2
ESwitch_2O	3
ESwitch_2OT	4
ESwitch_1S1O	5
ESwitch_1S1OT	6
ESwitch_2S2O	7
ESwitch_2S2OT	8
ESwitch_3O	9
ESwitch_3OT	10
TwoHand_2O	n/a
TwoHand_2S	n/a
Mode_1S1O	13
Mode_3Switch	14

11.3.3.2 Output elements

I/O	Type
DO.0_P	1
DO.0_M	1
DO.1_P	1
DO.1_M	1
DO.2_P	1
DO.2_M	1

11.4 Process Data for SMX modular

Idx	PAE name	Description
1	Limit20 Axis:1	Not used
2	Limit20 Axis:2	
3	Limit20 Axis:3	
4	Limit20 Axis:4	
5	Limit20 Axis:5	
6	Limit20 Axis:6	
7	Limit20 Axis:7	
8	Limit20 Axis:8	

9	Limit20 Axis:9	
10	Limit20 Axis:10	
11	Limit20 Axis:11	
12	Limit20 Axis:12	
13	Position20 Axis: 1	Position value axis 1 ... 12
14	Position20 Axis: 2	
15	Position20 Axis: 3	
16	Position20 Axis: 4	
17	Position20 Axis: 5	
18	Position20 Axis: 6	
19	Position20 Axis: 7	
20	Position20 Axis: 8	
21	Position20 Axis: 9	
22	Position20 Axis: 10	
23	Position20 Axis: 11	
24	Position20 Axis: 12	
25	BG20 Axis: 1	TeachIn position value axis 1 ... 12
26	BG20 Axis: 2	
27	BG20 Axis: 3	
28	BG20 Axis: 4	
29	BG20 Axis: 5	
30	BG20 Axis: 6	
31	BG20 Axis: 7	
32	BG20 Axis: 8	
33	BG20 Axis: 9	
34	BG20 Axis: 10	
35	BG20 Axis: 11	
36	BG20 Axis: 12	
37	StopDistanz20 Axis: 1	Not used
38	StopDistanz20 Axis: 2	
39	StopDistanz20 Axis: 3	
40	StopDistanz20 Axis: 4	
41	StopDistanz20 Axis: 5	
42	StopDistanz20 Axis: 6	
43	StopDistanz20 Axis: 7	
44	StopDistanz20 Axis: 8	
45	StopDistanz20 Axis: 9	
46	StopDistanz20 Axis: 10	
47	StopDistanz20 Axis: 11	
48	StopDistanz20 Axis: 12	
49	SysSpeed Axis: 1	Speed value axis 1 ... 12
50	SysSpeed Axis: 2	
51	SysSpeed Axis: 3	
52	SysSpeed Axis: 4	
53	SysSpeed Axis: 5	
54	SysSpeed Axis: 6	
55	SysSpeed Axis: 7	

56	SysSpeed Axis: 8	
57	SysSpeed Axis: 9	
58	SysSpeed Axis: 10	
59	SysSpeed Axis: 11	
60	SysSpeed Axis: 12	
61	SysAcc Axis: 1	Acceleration value axis 1 ... 12
62	SysAcc Axis: 2	
63	SysAcc Axis: 3	
64	SysAcc Axis: 4	
65	SysAcc Axis: 5	
66	SysAcc Axis: 6	
67	SysAcc Axis: 7	
68	SysAcc Axis: 8	
69	SysAcc Axis: 9	
70	SysAcc Axis: 10	
71	SysAcc Axis: 11	
72	SysAcc Axis: 12	
73	AIn Eingang: 1	Analog inPort Ain 1 ... 16
74	AIn Eingang: 2	
75	AIn Eingang: 3	
76	AIn Eingang: 4	
77	AIn Eingang: 5	
78	AIn Eingang: 6	
79	AIn Eingang: 7	
80	AIn Eingang: 8	
81	AIn Eingang: 9	
82	AIn Eingang: 10	
83	AIn Eingang: 11	
84	AIn Eingang: 12	
85	AIn Eingang: 13	
86	AIn Eingang: 14	
87	AIn Eingang: 15	
88	AIn Eingang: 16	
89	AnalogAdder Id: 1	Analog adder 1 … 8
90	AnalogAdder Id: 2	
91	AnalogAdder Id: 3	
92	AnalogAdder Id: 4	
93	AnalogAdder Id: 5	
94	AnalogAdder Id: 6	
95	AnalogAdder Id: 7	
96	AnalogAdder Id: 8	

11.4.1 PLC – Outputs variables

Output variables for the PLC-system are identified by:

- Affiliation to the system image of the SMX-system
- the unambiguously determined address (byte index in system image, bit index in entry of system image).
- PAEOFFS = Size of segment **PAE = 96**
- by the 1-bit value of the input variable (TRUE or FALSE)

Syntax and addressing:

Index	PAE-variable	Bit Pos.	Bit variable	Description
1	Config_ID			0x3002 fixed
2	DriveBASE	0 1 2 3 4 5		DRB_STAT.1 = ESTOP external DRB_STAT.2 = RUNNING DRB_STAT.3 = LOCK DRB_STAT.4 = RESET
3	DriveSLI	0 1	SLI_EN.1 SLI_EN.2	Activation SLI
4	DriveEMU	0 1	EMU_EN.1 EMU_EN.2	Activation EMU
5	DriveSCA	0 .. 7 0 .. 7	SCA_EN.1 .. SCA_EN.8 SCA_EN.9 .. SCA_EN.16	Activation SCA
6	DriveSSX	0 1 2 3	SSX_EN.1 SSX_EN.2 SSX_EN.3 SSX_EN.4	Activation SSX
7	DriveSOS	0 1	SOS_EN.1 SOS_EN.2	Activation SOS
8	DriveSLP	0 1	SLP_EN.1 SLP_EN.2	Activation SLP
9	DriveSEL	0 1	SEL_EN.1 SEL_EN.2	ActivationSEL
10	DriveSLS	0 .. 7	SLS_EN.1 .. SLS_EN.8	Activation SLS
11	DriveSDI	0 1	SDI_EN.1 SDI_EN.2	Activation SDI
12	DriveSAC	0 .. 7	SAC_EN.1 .. SAC_EN.8	Activation SAC
13	DriveSummary	0 1	PDM_EN.1 PDM_EN.2	Activation PDM
14	DO8	0 1 2 3	DO.0_P DO.0_M DO.1_P DO.1_M	Semi-conductor output HISIDE1 Semi-conductor output LOSIDE1 Semi-conductor output HISIDE2 Semi-conductor output LOSIDE2

		4 5 6 7	K.1 K.2 EAA1.9 EAA1.10	Relay K1 Relay K2 Semi-conductor output SMX31 log. addr 1 Semi-conductor output SMX31 log. addr 1
15	HW_Output	0 1 2 3 4 5 6 7	A0.1_O A0.2_O A1.1_O A1.2_O A2.1_O A2.2_O EAA2.9 EAA2.10	Auxiliary outputs SMX Auxiliary outputs SMX Auxiliary output SMX31 log. addr 1 Auxiliary output SMX31 log. addr 1 Auxiliary output SMX31 log. addr 2 Auxiliary output SMX31 log. addr 2
16	PLC_Marker	0 .. 7	M.1 .. M.8	
18	PLCTimer_EN	0 .. 7	PLCT_EN.1 .. PLCT_EN.8	
19 – 64	MX8 MX16 MX24 .. MX368	each 0 .. 7	MX.1 .. MX.368	PLC_MX Marker
65	Diag 17_24	0 .. 7		Diagnostic Bit 16 .. 23
66	Diag25_32	0 .. 7		Diagnostic Bit 24 .. 31
67	EnableEingang Timer	0 1 2 3 4 5 6 7	META_EN.1 METB_EN.1 META_EN.2 METB_EN.2 META_EN.3 METB_EN.3 META_EN.4 METB_EN.4	Activation of input element with time monitoring
68	EnableEingang ZweihandTimer	0 .. 2	MEZ_EN.1 .. MEZ_EN.3	Activation of two-hand button
69	EnableStartele-ment	0 1	MES_EN.1 MES_EN.2	Activation of start element
70	EnableAnlauftest			
71	EAA1_8	0 .. 7	EAA1.1 .. EAA1.8	Extension output SMX31 log. addr 1
72	EAA2_8	0 .. 7	EAA2.1 .. EAA2.8	Extension output SMX31 log. addr 2
73	Diag_1_16			Diagnostic Bit 0 .. 15
74	Diag_33_40			Diagnostic Bit 30..39
75	Diag_41_48			Diagnostic Bit 40..47
76	Diag_49_56			Diagnostic Bit 48..55
77	EnableEingang Timer2	0 1 2 3 4 5 6 7	META_EN.5 METB_EN.5 META_EN.6 METB_EN.6 META_EN.7 METB_EN.7 META_EN.8 METB_EN.8	Activation of input element with time monitoring

78	Reserve1			Reserve
79	Reserve2			Reserve
80	Reserve3			Reserve
81	Reserve4			Reserve
82	Reserve5			Reserve
83	Reserve6			Reserve
84	Reserve7			Reserve
85	Reserve8			Reserve
86	Reserve9			Reserve
87	Reserve10			Reserve
88	Reserve11			Reserve
89	Reserve12			Reserve

11.4.2 PLC – Processing elements

Number = 8

PLC-markers can be set and reset with the commands "S" or "R". PLC-markers are part of the process output image "Outputs". The user can only address markers through the macro "RS-Flipflop".

11.4.2.1 PLC - Timer

The runtime system of PLC-processing holds a total of 8 PLC-timers available. These have the following properties:

- Generation of time events 1…31.999.992ms
- Downwards counter limited to ZERO, starts from configured initial value (part of configuration data)
- In the system image the timers only occupy 2 bits for ENABLE and RESULT (TRUE = timer elapsed, i.e. internal value at ZERO). Start of timer by setting ENABLE. ENABLE = FALSE resets the timer to the initial value (initial value = FALSE).

ENABLE	Timer value	Initial value	Activity
FALSE	Initial value on configuration	FALSE	Counter inactive
TRUE	1 ... < INITIAL VALUE	FALSE	Counter active
TRUE	ZERO	TRUE	Counter inactive

PLC-Timer - ENABLE can only be started or disabled with the command "ST". Release and status of timers are part of the process image. The initial values of the timers are saved in the configuration data in the PLC segment.

11.4.3 PLC – Processing List

The PLC-instruction list consists of a header and a linear list of single PLC-instructions, consisting of operator and operands, in the format specified under 2.2.1.

Contents	Index	Contents	Description
Header	0	ID_PLC	Identification of the PLC-list
	2	CRC	CRC over the structure
	4	Date1	Date of creation/change
	6	Date2	
	8	PLC_Len	Number of AWL-instructions
	10	free	
	12	free	
	14	free	
PLC-Timer	16	Timer 1	
	.....		

	44	Timer 8	Time events from 1 Tcyc to 3.999.999
Reserve	48	free	
	50	free	
	52	free	
	54	free	
AWL – List	56	Instruction 1	AWL acc. to format section 2.2.1)
	....		
	48 + (PLC_Len*4) – 4	Instruction no. PLC_Len	
Reserve	1056	free	
	1058	free	

11.4.4 Assignment of resources

Element	**In**	**Out**	**Qty. MX**	**IN/OUT Process image**	**PLC-Code**	**Qty. IL**
AND2	2	1	1	0	LD x1.y1 AND x2.y2 ST MX.z	3
						…
AND5	5	1	1	0	LD x1.y1 AND x2.y2 AND x3.y3 AND x4.y4 AND x5.y5 ST MX.z	6
OR2 .. OR5					Analogue AND	3 … 6
XOR 2					Analogue AND	3
NOT	1	1	1	0	LD x1,y1 NOT ST MX.z	3
RS-Flipflop	2	1	0	Output = 1	LD x1.y1 (Source S) S M.z LD x2.y2 (Source R) R M.z	4
Timer	1	1	0	Output = 1	Timer enable: LD x1.y1 ST PLCT_EN.z	2
Monitoring functions	1	1	0	Output = 1	Monitoring function enable: LD x1.y1 ST uuu_EN.z	2
Semi-conductor output Single	1	1	0	Output = 1	LD x1.y1 ST DO.x_y	2
Semi-conductor output Redundant	1	2	0	Output = 2	LD x1.y1	3

					ST DO.x_P ST DO.x_M	

Processing of input elements see document TS-37330-340-02 PLC switch types!