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# **DS800 Development Suite Software**

## **User Manual**

# Revision Tracking Sheet

## March 2009

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# Workbench

*The DS800 software suite supports both the ROC800-Series and the FloBoss 107 flow computers from Remote Automation Solutions (RAS). To simplify usage, this documentation refers to both devices as the "RAS device." If there is a situation where we restrict functionality to either the ROC800-Series or the FB107, we note it.*

The Workbench is the environment in which you develop multi-process control projects made up of virtual machines running on hardware components, called target nodes. The development process consists of creating projects made up of configurations, representing, individual target nodes, on which one or more instances of resources, i.e., virtual machines, are downloaded. At runtime, the virtual machines run on these target nodes.

Projects can be developed using any of the five languages of the IEC 61131 standard: SFC: Sequential Function Chart (or Grafcet), FBD: Function Block Diagram, LD: Ladder Diagram, ST: Structured Text, and IL: Instruction List. You can also use the Flow Chart language. When building, resources are compiled to produce very fast "target independent code" (TIC) or "C" code.

Within resources, you can declare variables using standard IEC 61131 data types (i.e., Boolean, integer, real, etc.) or user-defined types such as arrays or structures. For defined variables, you can set up alarms, events, and trending. Furthermore, field communications allow you to connect variables to field equipment. Resources can share variables using internal bindings or external bindings. Internal bindings are between resources within the same project. External bindings are between resources belonging to different projects.

You develop projects on a Windows development platform, in the Workbench and language editors. The Workbench graphically represents and organizes configurations, resources, POUs, and networks within a project from multiple views:

- link architecture
- hardware architecture
- dictionary
- I/O wiring
- bindings

Libraries made up of configurations and resources enable you to define functions and function blocks for reuse throughout projects.

Individual resources, from the configurations making up a project, are downloaded, using the ETCP or ISARSI (serial link) network, onto target RAS device nodes running real-time operating systems. Communication between configurations can be implemented using the TCP/IP network. You can choose to implement any other network.

You can choose to simulate the running of a project, after building a project, using high-level debugging tools, before actually downloading the resources making up configurations to the target nodes.

You can set four levels of access control in a Workbench application:

- password protection and read-only mode for a complete project
- password protection and read-only mode for individual resources
- password protection for individual POUs
- password protection for a target

# Appearance

Title bar

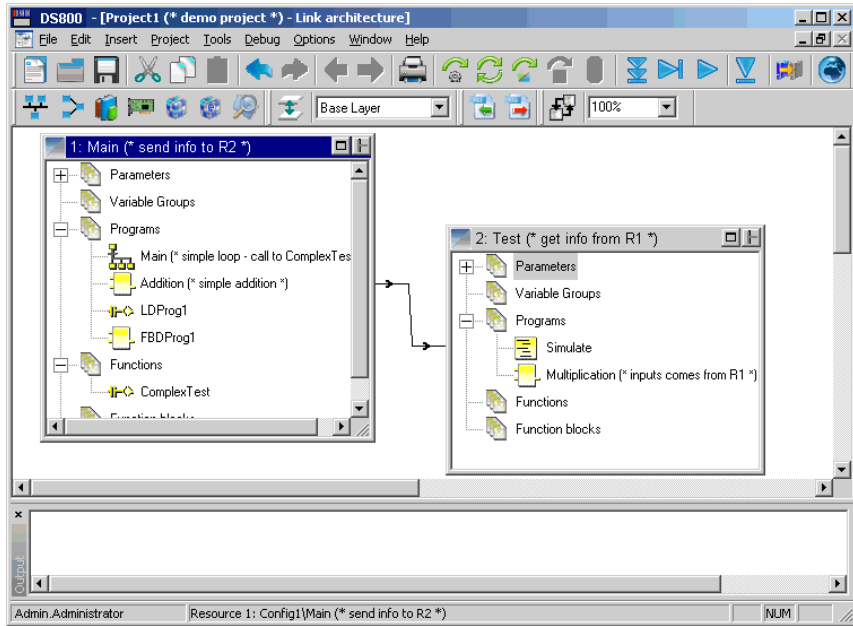
Menu bar

Tool bars

Workspace

Output window

Status bar



## **Title Bar**

For help locating the Title Bar, see the Appearance diagram. The Title Bar displays the application name and the filename of the active project, if any are open, along with the current view (Hardware Architecture, Link Architecture, Dictionary or I/O Wiring).

### **Control Icon**

At the left end of the Title Bar is the Control Icon, which is used to access the Control Menu (see following section). Double-clicking on the Control Icon closes the Workbench.

### **Control Menu**

Clicking on the Control icon opens the Control Menu. The Control Menu is used to position the Main Window or to exit.

### **Window Buttons**

The standard window buttons appear at the right end of the Title Bar. Use these to resize or close the Window.



## Menu Bar

The options available from the menu bar differ slightly for the hardware architecture and link architecture views of a project. Some options are available as keyboard commands.

File	New Project/Library	Ctrl+N	creates a new project or library
	Open Project/Library	Ctrl+O	opens an existing project or library
	Save Project/Library	Ctrl+S	saves the current project or library
	Rename Project/Library		renames the current project or library
	Project Properties		sets project access control
	Import		imports three types of information: - PLC definitions using text files generated with the Target Definition Builder - Workbench elements (projects, configurations, resources, and POU's) - Variables data
	Export		exports Workbench elements (projects, configurations, resources, and POU's) or variables data
	Print	Ctrl+P	accesses the Document Generator
	Exit	Ctrl+Q	leaves the Workbench

Edit	Open	Alt+N	opens the item selected from a resource. This option is only available in the link architecture view.
	Undo	Ctrl+Z	cancels the last action
	Redo	Ctrl+Y	restores the last cancelled action
	Cut	Ctrl+X	removes the selected item and places it on clipboard
	Copy	Ctrl+C	takes a copy of the selected item and places it on the clipboard. For the link architecture view, this option appears as Copy Program where it copies an entire selected program.
	Paste	Ctrl+V	inserts the contents of the clipboard into the selected item
	Delete	DEL	removes the selected item from the selected item
	Find / Replace in POUs	Ctrl+F	finds and replaces text in a project, a configuration, a resource, or a POU
	Select All	Ctrl+A	selects all items in the active view
	Properties		accesses the properties for the selected item
	Move to lower level		sets the selected FC or SFC program as a sub-program of the next program in the resource. This option is only available in the link architecture view.
	Move to upper level		sets the selected FC or SFC program as a parent program of the previous program in the resource. This option is only available in the link architecture view.

Insert	Configuration	inserts a configuration in the workspace. This option is only available in the hardware architecture view.
	Resource	inserts a resource. For the hardware architecture view of a project, you insert resources in selected configurations. For the link architecture view, you insert resources in the workspace.
	Network	inserts a network in the workspace. This option is only available in the hardware architecture view.
	Add Variable Group	adds a variable group to the selected resource. This option is only available in the link architecture view.
	Add Program	adds a program to the selected resource. This option is only available in the link architecture view.
	Add SFC Sub-program	adds an SFC sub-program to the selected program. When an FC program is selected, adds an FC sub-program. This option is only available in the link architecture view.

Project	Types	Ctrl+3	accesses the Types Tree of the Dictionary view
	Variables	Ctrl+G	accesses the Variables Tree of the Dictionary view
	Function /Function Block Parameters		accesses the Parameters Tree of the Dictionary view. This option is only available in the link architecture view.
	External Binding List	Ctrl+0	accesses the External Binding list window where you can define external variable bindings between producer variables of a source resource in a given project with consumer variables of a destination resource in a different project
	Internal Binding List	Ctrl+1	accesses the Binding List window for the selected binding. This option is only available in the link architecture view.
	Defined Words	Ctrl+2	accesses the Defined Words Tree of the Dictionary view
	I/O Wiring		
	Build Project/Library		compiles the current project or library
	Rebuild Project/Library		recompiles the complete current project
	Clean Project/Library		removes files created during the last build of the current project or library
	Build Resource		compiles the selected resource
	Clean Resource		removes files created during the last build of the selected resource
	Build Program		compiles the selected program. This option is only available in the link architecture view.
	Stop Build		stops a build in progress

Tools	Compact Database		optimizes the current project's database
	Edit Project Description	Ctrl+K	accesses the description editor for the current project or library
	Edit Description		accesses the description editor for the selected item
	Unlock Resource		unlocks a resource currently locked by another user. This option is only available when editing a project in normal mode and one or more resources of the project are opened in single-resource editing mode by other users.
	Add/Remove Dependencies		accesses the Add/Remove Dependencies window where you define the libraries used by a project
	Browser	Ctrl+B	accesses the cross references browser listing and localizing all instances of global variables (cross references) and I/Os declared in a project
	Check-in		Checks in a project, configuration, resource, or POU definition not having the read-only attribute into a version source control database
	View History		Views the history of a project, configuration, resource, or POU that has been checked in repeatedly to a version source control database
	Events Viewer		accesses the Events Viewer

Debug	Download	Ctrl+M	accesses the Download editor from where you download resources onto target nodes
	Debug Target	Alt+F6	starts the project in debug mode
	Simulation	Alt+F7	starts the project in simulation mode
	On-line Change: Download		downloads only the changes made since the last download for the selected running resource. The download includes the symbol table (complete or reduced as selected in the resource's compilation options).
	On-line Change: Update		updates a resource running on a target to use the latest on-line change download code. For use when you chose to update the resource code later.
	Start		starts the selected resource, while in run mode
	Stop		stops the selected resource, while in run mode
	Start from code saved on Target		restarts the selected resource using the code saved on the target node
	Save Code on target		saves the code of the running resource (including changes)
	Clean Stored Code		removes code previously saved on a target
	Diagnosis		accesses the Diagnosis window displaying general and status information for the selected resource
	Refresh Status		updates the resource status information, appearing in the title bar, for all resources

Debug (cont)	Real Time / Cycle to Cycle		switches between real time and cycle to cycle mode for the selected resource
	Execute one cycle	Alt+F10	executes one cycle at a time, while in cycle to cycle mode
	Change Cycle timing		accesses the Cycle Time editor where you set the cycle time for the selected resource
	Step	Alt+F8	executes the current line then steps to the next line
	Step Into	Alt+F9	executes the current line then steps into the next line
	Show Current Step		shows the current step
Options	Layout		accesses the Layout editor where you specify which toolbars to display and the magnification of the workspace area
	Customize	Ctrl+U	accesses the customization properties for Workbench views and editors
	Hide Links		enables hiding or showing of the different types of binding links between resources. This option is only available in the link architecture view.

Window	Cascade		sets the different views of the project to appear in a cascading manner
	Tile		sets the different views of the project to appear in a tiled manner
	Show Spy List		accesses the Spy List window where you specify variables whose values are displayed while in test mode
	Show Project Contents		displays the project structure and enables accessing aspects of the currently opened project
	Show Output Window	Ctrl+4	displays the output window below the workspace
	Clear Output Window		clears the contents of the output window
Help	Contents	F1	accesses the online help
	Search Help On...		not currently supported
	About		displays product and version information
	Support Info		not currently supported

**Note:** When no projects are open, only the File and Help menus are visible.

#### Using the Menus:

1. Open a menu by clicking on it, or by pressing (**Alt**) plus the letter that is underlined in the menu's title. For example, to open the File Menu, you press (**Alt**) + (**F**) (shown in this User's Guide as (**ALT+F**)).
2. Choose a menu selection by clicking on it, by pressing its underlined letter, or by using the cursor keys to highlight it and then pressing (**Enter**). Menu selections that appear in grey are not currently available.



## **Control Icon**

When a project is open and not displayed in Cascade or Tile mode, the menu bar has a Control Icon on the left. This icon indicates the current view.

## **Control Menu**

Clicking on the Control Icon opens the Control Menu. The Control Menu is used to position the Window or to alternate between views (see Window Buttons Toolbar).

## **Window Buttons**

The standard window buttons appear at the right end of the menu bar.

# Toolbars

Many toolbars performing different tasks are available for use in the hardware and link architecture views:

- Standard Toolbar
- Debug Toolbar
- Window Buttons Toolbar
- Layers Toolbar
- Version Source Control Toolbar
- Options Toolbar
- I/O Wiring Toolbar

While performing I/O wiring tasks in the I/O Wiring view, the I/O Wiring toolbar becomes available.

## To show or hide toolbars

You can choose to show as many toolbars as required.

1. From the Options menu, choose **Layout**.

The Layout editor appears.

2. To show toolbars, check the required toolbars then click **OK**.
3. To hide toolbars, uncheck the toolbars then click **OK**.

## To move a toolbar

Toolbars can be placed anywhere on the screen, their position is retained until the next change.

1. Point the cursor at the toolbar's title bar or main panel. Do not point at the control icon or one of the window's buttons.

2. Press and hold the left mouse-button.
3. Drag the toolbar by moving the mouse.
4. Release the mouse-button.

## Docking toolbars

- Dock a toolbar to a side of the Workspace by positioning it at the Workspace's edge. Switch back and forth between a toolbar's floating and docked states.

## Standard Toolbar



Creates a project



Opens a project



Saves the current project



Cuts the selection and places it on the clipboard



Copies the selection and places it on the clipboard















Pastes the contents of the clipboard



Undoes the last operation



Redoes the previously undone operation

-  Moves to upper level on currently selected SFC or FC program
-  Moves to lower level on currently selected SFC or FC program
-  Accesses the document generator where you can print different parts of a project
-  Builds the current project/library
-  Rebuilds the current project/library
-  Builds the current resource
-  Builds a program
-  Stops a build
-  Downloads resource code to targets
-  Switches an application to debug mode
-  Switches an application to simulation mode
-  Performs an Online Change: Download



Adds/removes dependencies



Accesses the web site

## Debug Toolbar

The Debug toolbar is accessible when you run a project in either Debug or simulation mode.



Starts all stopped resources



Starts a stopped resource



Stops all running resources



Stops a running resource



Switches an application to real-time mode



Switches an application to cycle-to-cycle mode



Executes one cycle



Steps to the next **line of code or rung**



Steps into the next **line of code or rung**



Locates the current step



Sets the cycle timing



Sets or removes a breakpoint. For LD programs only.



Removes breakpoints. For LD programs only.



Shows/Hides output values. For FBD programs only.



Debugs a function block



Displays the spy variable list



Stops the debug/simulation mode



Refreshes the status of resources



Clears the output window

## Window Buttons Toolbar



Switches the Workbench to the Hardware Architecture view



Switches the Workbench to the Link Architecture view



Switches the Workbench to the Dictionary view



Accesses the I/O Wiring view



Accesses the Binding window where you can create data links between resources and define the variable bindings using these links



Accesses the External Binding list window where you can define external variable bindings between producer variables of a source resource in a given project with consumer variables of a destination resource in a different project

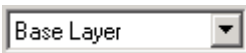


Accesses the cross references browser

## Layers Toolbar



Toggles between the link architecture view and the distribution view.



Sets the project layer to display. The available layers are Base Layer (link architecture view or hardware architecture) and 1499 Layer ( distribution view).

## Version Source Control Toolbar



Checks in a project, configuration, resource, or POU definition not having the read-only attribute into a version source control database

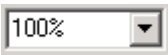


Views the history of a project, configuration, resource, or POU that has been checked in repeatedly to a version source control database

## Options Toolbar



Shows or hides the data links between resources



Sets the magnification factor for the workspace

## I/O Wiring Toolbar



Opens a device



Saves the I/O Wiring



Accesses the document generator



Adds a device



Deletes a device





Undoes the last operation



Redoes the last operation



Frees all I/O device channels



Frees an I/O device channel



Real/Virtual I/O device



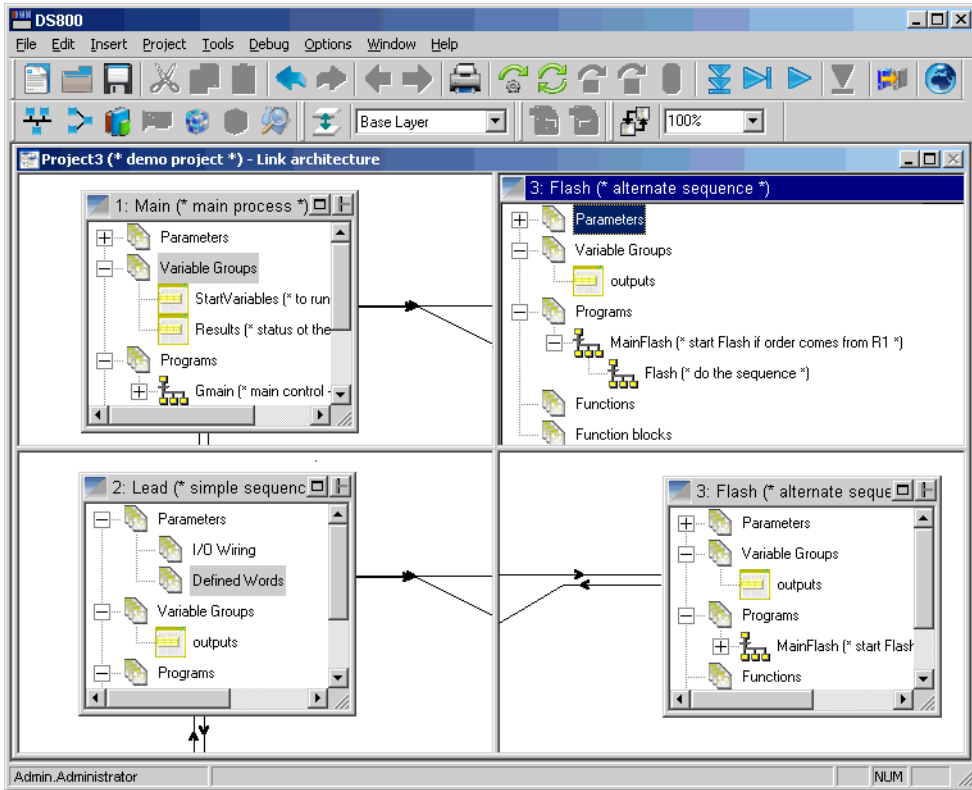
Maps logical and physical channels



Accesses help on selected I/O device in Tree view

# Workspace

The Workspace can be split into a maximum of four simultaneous views:



**Note:** Sub-windows are zoomed independently.

## To split the workspace

- Drag and drop the handles to the required positions:



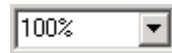
## Zoom

You can adjust the magnification factor, i.e., zoom, for the workspace. Elements appear with more detail as the zoom level increases. You can set the zoom from the Options toolbar or in the Layout editor. You access the Layout editor by choosing **Layout** from the Options menu.

When editing SFC, FC, LD, and FBD POU's, you can also adjust the magnification factor for the language editor's workspace.

### To adjust the zoom level

1. On the Options toolbar, click the arrow of the magnification window
2. Choose a magnification factor from the list.

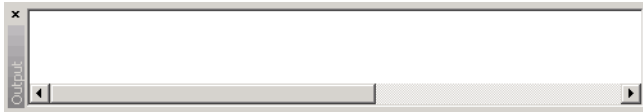


The workspace is displayed using the new magnification factor.

## Output Window

The output window displays information resulting from builds of projects, resources, and programs. It also displays Workbench run-time errors. When building a program, the output window is automatically displayed. The Output window is also available from the language editors.

You can copy to the clipboard the information displayed in the output window.



### To view the Output Window

- ▶ From the Window menu, choose **Show Output Window**.

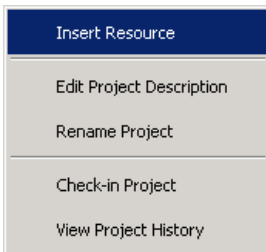
### To clear the contents of the output window

- ▶ From the Window menu, choose **Clear Output Window**.

## Contextual Menus

Contextual menus are displayed by right-clicking in the workspace of the various tools and applications. From the Hardware Architecture view, you can access a contextual menu for configurations or resources. For configurations, you access it by right-clicking a configuration's title bars. For resources, you access it by clicking a resource's name in the configuration window. From the Link Architecture view, you can access a contextual menu for resources by right-clicking a resource's title bar.

### Example



## Status Bar

A status bar appears at the bottom of the main window displaying information about commands, operations, and projects.

### To show or hide the status bar

1. From the Options menu, choose **Layout**.  
The Layout editor appears.
2. To show the status bar, check **Status Bar** then click **OK**.
3. To hide the status bar, uncheck **Status Bar** then click **OK**.

# Customization

You can choose to customize the colors and fonts for many aspects of the Workbench as well as set working preferences. You can customize the colors and fonts for the following items:

- For the dictionary, you can set the font and the colors used for text, scope, and instances
- For the ST and IL editors, you can set the font and the colors used for background and text (basic syntax)
- For the FBD editor, you can set the font and the colors used for background, text, connection and element outline lines, line shadows, and selected elements as well as the fill for main elements
- For the LD, FC, and SFC editors, you can set the font and the colors used for background and text as well as the fill for main elements
- For the FBD and LD editors, you can set the color for comments and for Boolean values (TRUE and FALSE) displayed while in debug mode.

You can also set the colors for resource data links used with bindings.

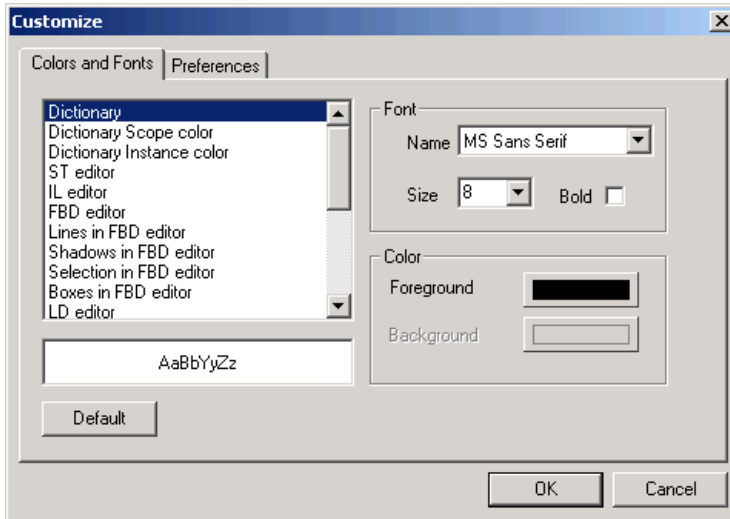
You can set the following working preferences:

- The number of recent project files to display in the File menu
- Reload the last project at startup
- Always prompt before saving changes to the project

## To customize colors and fonts

Resetting the default for an item restores the colors and fonts to those when the Workbench was installed.

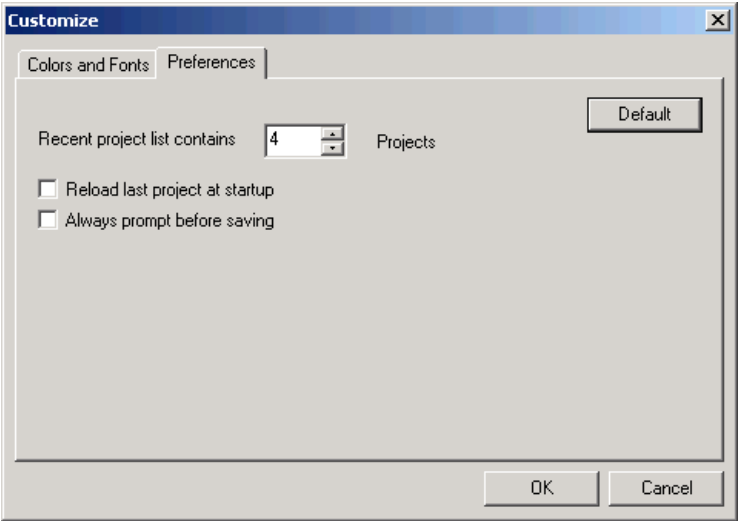
1. From the Options menu, choose **Customize**.



2. On the Customize editor, select the Colors and Fonts tab, then select the item to modify.
3. To change the font used, select a font and size. You can choose to bold the font.
4. To change the foreground or background colors, click the respective button, then from the color editor, choose a pre-defined color or specify a custom color.

### To set working preferences

1. From the Options menu, choose **Customize**.
2. On the Customize editor, select the Preferences tab.



























3. Make the desired changes.










# Directory Structure

The installation process creates the following directory structure:

 Emerson	Root directory for all Emerson products
 DS800 2.1	DS800 Workbench files
 Bin	Executable files
 Simul	Simulator target files
 Tmp	Temporary files
 User	User profile files
 Projects	Emerson projects
 DS800 2.1	DS800 Workbench projects
 Prj	Projects
 <project>	Individual Project Directories
 <configuration>	A directory per hardware configuration
 <resource>	A directory per resource
 Tpl	DS800 templates
 EmptyLibmonoresource	EmptyLibmonoresource templates
 <configuration>	A directory per hardware configuration
 <resource>	A directory per resource

	EmptyLibmultiresource	EmptyLibmultiresource templates
	 <configuration>	A directory per hardware configuration
	 <resource>	A directory per resource
	EmptyPrjmonoresource	EmptyPrjmonoresource templates
	 <configuration>	A directory per hardware configuration
	 <resource>	A directory per resource
	EmptyPrjmultiresource	EmptyPrjmultiresource templates
	 <configuration>	A directory per hardware configuration
	 <resource>	A directory per resource
	Libmonoresource	Libmonoresource templates
	 <configuration>	A directory per hardware configuration
	 <resource>	A directory per resource
	Libmultiresource	Libmultiresource templates
	 <configuration>	A directory per hardware configuration
	 <resource>	A directory per resource
	Prjmonoresource	Prjmonoresource templates
	 <configuration>	A directory per hardware configuration
	 <resource>	A directory per resource

		Prjmultiresource	Prjmultiresource templates		
			<configuration>	A directory per hardware configuration	
				<resource>	A directory per resource
		Shared		Common files shared by Emerson products	
		Error Reporting		Solobug files for use when reporting errors on Emerson products	
		Help 2.1		Online help files for Emerson products	
		Sentinel		Sentinel driver files for use with hardware keys	

Projects are stored in the Projects directory, as MS-Access database (.MDB) files:

`<drive>:\Emerson\Projects\DS800 2.1\Prj\<project name>\PRJLIBRARY.MDB`

For details on the project architecture, see page 368.

**Note:** Existing projects can be manually moved or copied to the "tpl" directory to create new project templates.

### Example

The *panel* resource in the *main* configuration within the *proj1* project is stored in the directory:

`<drive>:\Emerson\Projects\DS800 2.1\Prj\proj1\main\panel\`

# Working with Projects

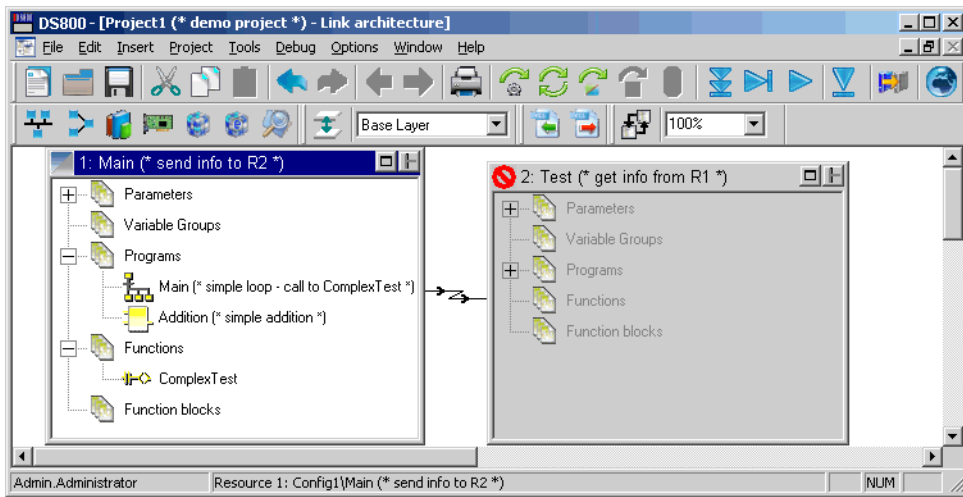
You can work with **DS800 Development Suite** projects in one of two project editing modes:

- Normal
- Single-resource

The normal mode provides access for a single user to all resources and POUs making up a project. While in the normal mode, no other users can access the project or its resources. Before opening a project in normal mode, multiple users can access the individual resources of the project for editing purposes, i.e., single-resource editing mode. The single-resource mode limits access for an individual user to one resource and its POUs. Other users can access other resources of the same project.

**Note:** Make sure to build the complete project in normal mode before editing single resources. Otherwise, a build while in single-resource mode may generate errors.

Only one user can access a resource at any given time; while in use, a resource remains locked to all other users. For instance, when editing a project in normal mode, all resources making up the project are automatically locked for your use except for those resources currently open in single-resource mode. The currently open resources are displayed in the workspace but remain locked. Locked resources appear gray with a lock symbol in their title bar.



You can unlock resources currently open in single-resource mode by another user by selecting the resource, then choosing **Unlock Resource** from the Tools menu.

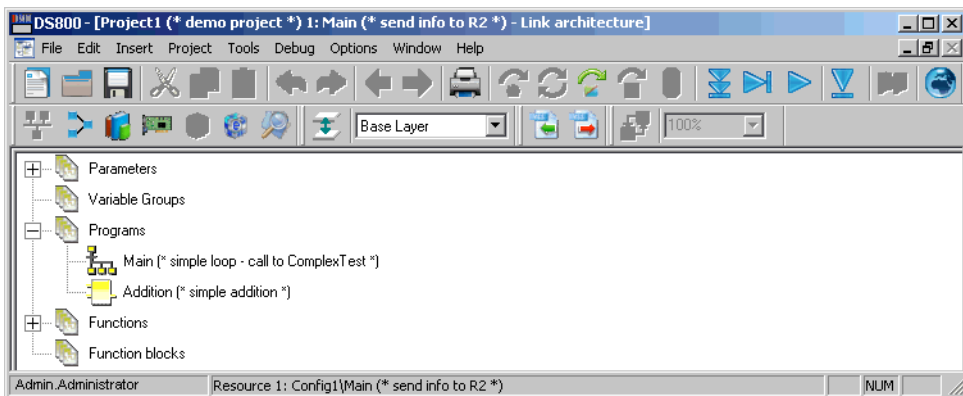
**Warning:** The Unlock Resource option should only be used when necessary. When unlocking resources currently opened by another user, make sure the remote Workbench is no longer running.

The Workbench automatically assigns a user name to a project, when running on a network. The user name is displayed in the status bar and in the access control properties of the resources. The assigned user name depends on the editing mode:

- In normal mode, the user name is always *UserName.Administrator*
- In single-resource mode, the user name is the Windows login user name of the user editing the resource

Resources currently opened by another user hold the name of that user in their properties.

In single-resource mode, a project is displayed in the link architecture view with the project and resource identification in the title bar of the single resource. The hardware architecture view and binding list are not available. In the dictionary view and the I/O wiring view, only the variables and wiring defined for the resource are displayed. Variables bound to other resources as well as types and defined words are in read-only mode. While in single-resource mode, you can switch a project to debug or simulation mode.



While in normal mode, you can perform the following tasks:

- Creating Projects
- Renaming Projects
- Adding a Project Description

While in the normal or single-resource project editing mode, you can perform the following tasks with limitations depending on the mode:

- Opening and Closing Projects
- Saving Projects
- Printing Projects

You can also control access to projects.

## Creating Projects

When you create projects, you use one of four templates:

- SingleROC800, SingleROC800E, and SingleFB107, containing one resource in one configuration
- MultipleROC800E, containing two resources in two different configurations linked by an Ethernet network. This template is not available for use with non-networked versions of the Workbench.

The SingleROC800, SingleROC800E, and MultipleROC800E templates are all RAS device target specific. The LibSingleROC800, LibMultipleROC800, and LibSingleFB107 templates are available for use with libraries.

### To create a new project

1. From the File menu, choose **New Project <Ctrl+N>**.
2. Enter the project name (max 128 characters).

3. Enter comments (optional).
4. Choose a template.
5. Click **OK**.

The project is created using the chosen **template** and the link architecture view is displayed.

You can only open one project at any given time. When changes have been made to an open project, you will automatically be prompted to save the changes before creating a new one.

## Opening and Closing Projects

In the Workbench, you can only open one project at any given time. If changes have been made to an open project, the system automatically prompts you to save changes before closing a project or opening another. You can open projects in one of two project editing modes: normal and single-resource.

Project filenames are always PRJLIBRARY.MDB, the project directory name represents the given project name. When you open a project or create a new project, the hardware architecture view and the link architecture view are cleared. When a project has been relocated, you need to redefine its links within the Workbench before opening it.

When opening a project in single-resource editing mode, you need to select the project, then choose a resource from the list of resources defined for the project. In the list of resources, resources appear with icons indicating their security state or non-availability:



Resource unavailable, currently open by another user

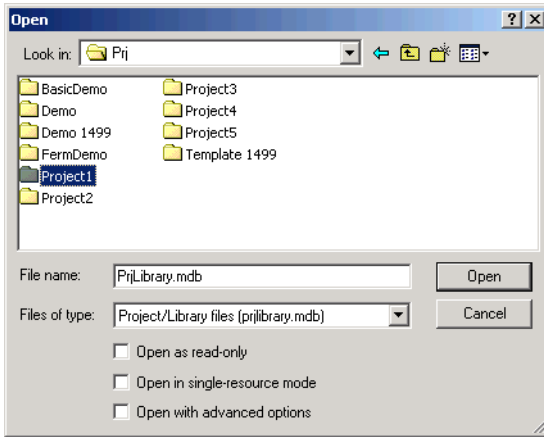
When the advanced options are installed on your computer, you can choose to open a project without the advanced options features such as alarms and events, trends, field communications.

### To open an existing project

1. From the File menu, choose **Open**.

The **Open Project** dialog box is displayed:



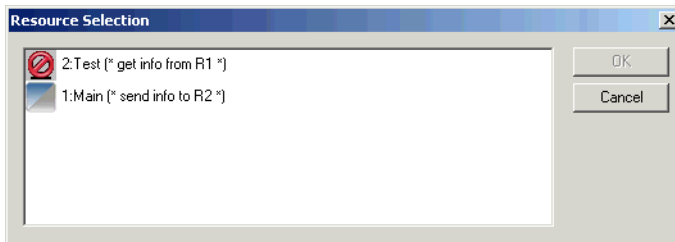


2. Locate the required project **file name**.
3. Do one of the following:
  - To open the project in normal editing mode, click **Open**.

The project is open in the normal editing mode having access to all resources and POUs.

- To open the project in single-resource editing mode, check **Open in single-resource mode**, then click **Open**.

The Resource Selection window is displayed with all project resources showing their security states or non-availability.



4. From the list of available resources, select the resource to open, then click **OK**.

The project is open in the single-resource editing mode where only the selected resource is editable.

### To open a project using a command line

You can open projects in single-resource editing mode or in read-only mode using a command line.

- ▶ To open the project in single-resource editing mode from a command line, use the following syntax:

```
DPM.exe project_path -res resource_name
```

**Note:** For command lines, resource names are case sensitive. You can also use the resource number to identify the resource.

When manually starting the Workbench, you may need to provide the location of the Workbench project. The Workbench needs to be started in its location directory. For example:

```
"C:\Program Files\Emerson\DS800\Bin\DPM.exe" "C:\Emerson\Projects/  
DS800/Prj/Project1" -res Lead
```

- ▶ To open the project in read-only mode from a command line, use the following syntax:

```
DPM.exe project_path -readonly
```

When manually starting the Workbench, you may need to provide the location of the Workbench project. The Workbench needs to be started in its location directory. For example:

```
"C:\Program Files\Emerson\DS800\Bin\DPM.exe" "C:\Emerson\Projects/  
DS800/Prj/Project1" -readonly
```

## Saving Projects

The project name is used to create a unique directory structure. Saving the project saves it in the MS-Access database of the project root directory. Other files related to the project are also updated in this directory structure. When editing a project in single-resource mode, changes are only saved for the edited resource.

### To save a project

- ▶ From the File menu, choose **Save Project**.

**Note:** When a project is saved, the undo/redo history is cleared.

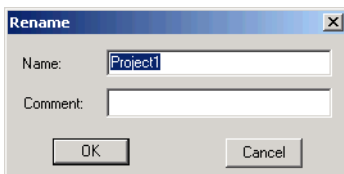
## Renaming Projects

You can rename projects and edit their comments. You cannot rename projects while in single-resource editing mode. Before renaming projects, make sure to close all Workbench windows such as language editors and browsing tools.

### To rename a project

1. From the File menu, choose **Rename Project**.

The Rename Project dialog box appears:



2. Change the name and comment as required.
3. Click **OK**.

The directory structure containing the project is renamed when you save changes to the project.

## **Adding a Project Description**

You can include a text description for a project.

### **To edit the project description**

- ▶ From the Tools menu, choose **Edit Project Description**.

## **Printing Projects**

You can print projects using the Document Generator. For details on the Document Generator, see page 337.

### **To print the current Project**

- ▶ From the File menu, choose **Print**.

The document generator appears with a standard list of elements to be printed for a complete project.

# Project Access Control

For project security, you can control access using a password. You can also apply the read-only mode to the entire project. In read-only mode, users not having the password will have read-only access to the project. When opening a project in read-only mode, all resources and POU's making up the project are set to read-only mode. However, individual resources and POU's making up projects can have their own access control. For instance, a resource having its own password without the read-only option remains locked and cannot be viewed without its password. While in read-only mode, you cannot build a project. When importing and exporting projects having access control, password definitions are retained.

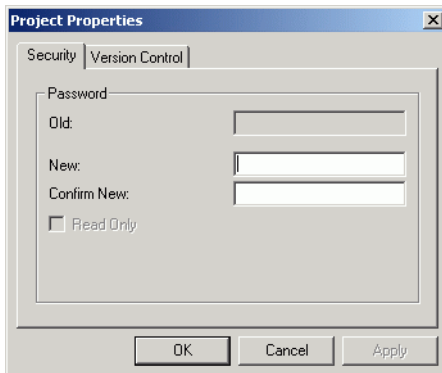
The DS800 Workbench enables monitoring a project, i.e., debugging as well as viewing TLP variables and parameters when a project is opened with access control or in read-only mode. You can open projects in read-only mode when opening the Workbench or open projects in read-only mode using a command line. While in monitoring mode, a banner indicating this mode is displayed above the status bar.

## To set access control for a project

When a password is set for a project, you can choose to enable users not having the password to open the project in read-only mode. The read-only mode for a project is applied to all resources and POU's making up the project. However, individual resources and POU's may have their own access control.

1. From the File menu, choose **Project Properties**.

The Project Properties Security editor is displayed.



2. In the New field, enter the password for the project.
3. In the Confirm New field, reenter the password.
4. To enable users not having the password to open the project in read-only mode, check **Read Only**.

# Importing and Exporting Workbench Elements

You can import and export Workbench elements, i.e., projects, configurations, resources, and POUs, from one project to another. When exporting an element, you copy the element from the project and create a compressed exchange file (.PXF) holding all data except for spy lists and step-by-step debug information. Therefore, enabling you to copy and paste elements from one project to another. When importing and exporting elements having access control, password definitions are retained.

## To export a Workbench element

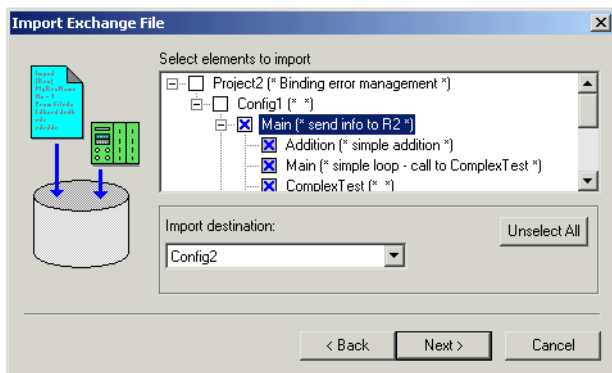
1. Depending on the element type, do one of the following steps:
  - For projects, from the File menu, choose **Export**, then **Project**.
  - For configurations, resources, and POUs, select the element (either from the link architecture or hardware architecture view), from the File menu, choose **Export**, then the element type.
2. In the Export window, select a directory in which to store the compressed exchange file, then click **Start**.
3. To close the window when the export is complete, click **Close**.

## To import a Workbench element

You can only import Workbench elements that have previously been exported and stored as compressed exchange files. You cannot import elements having the same name as those in a project. Before importing an element, you can choose to create an automatic backup of your project.

1. From the File menu, choose **Import**, then **Exchange File**.
2. In the Import Exchange File window, select the *Import from file* option, then click **Next**.
3. Click **Browse** to locate the compressed exchange file (.PXF file), then click **Next**.
4. In the list at the top of the window, select the file name, then click **Next**.

- From the contents of the exchange file, select the element to import. For resources and POU's, you also need to select the import destination.



- Click **Next**.
- Assign a name to the new element that will be created.

**Note:** Before importing elements, you should make a back-up copy of your project so that you could restore it if the resulting import is unsatisfactory.

- To create a backup copy of the project, check **Create a backup copy of the project before importing element**.

The <prjlibrary.BAK> file is created in the project folder. If the results of the import are unsatisfactory, you can choose to restore the project.

- Click **Next**.

The element import begins.

- When the import is complete, do one of the following:
  - To import another element from the exchange file, click **Next**.
  - To exit the dialog, click **Close**.



### To restore a project from a backup

1. Close the workbench.
2. Replace PrjLibrary.mdb with PrjLibrary.bak.
3. Remove (or rename) the *<element\_name>* directory.
4. Rename *<element\_name.BAK>* directory into *<element\_name>* directory.

# Uploading Workbench Elements from Targets

You can upload Workbench elements from any project into another when the resources' code has been stored on the target (if non-volatile storage exists for the platform). The element source file is compressed and contains all data for the element. The file is in the same format, compressed exchange file (.PXF), used when importing and exporting Workbench elements from one project to another. For details on importing and exporting elements, see page 43.

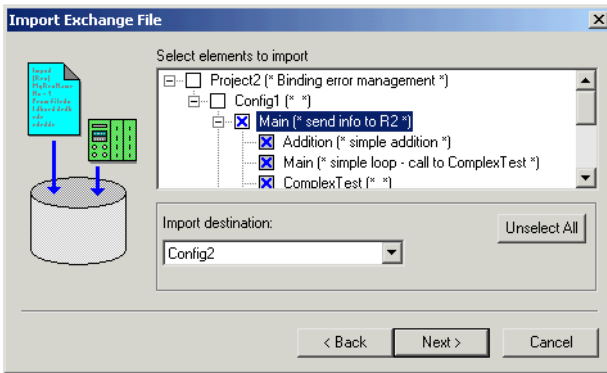
Before uploading an element's source file, you need to download its source code onto the target. Furthermore, when setting up the resource's Compilation Options properties, you need to check the **Embed Zip Source** option and select the element type.

## To upload an element from sources on a target

The element upload process consists of uploading the source file containing the element from the target onto the local computer for access, then importing the element into the project from the source file. Before importing an element from an uploaded source file, you can choose to create an automatic backup for your project.

1. In the project, make sure that the configuration (in which to upload the element) is connected to the correct network with the correct connection parameters (IP Address for ETCP).
2. From the File menu, choose **Import**, then **Exchange File**.
3. In the Import Exchange File window, select the *Upload from target* option, then click **Next**.
4. From the list of available configurations, select the configuration where the required sources are located, then click **Next**.
5. From the list of available sources, select the one to upload, then click **Next**.
6. When the upload is complete, click **Next**.

- From the contents of the exchange file, select the element to import (for resources and POUs, you also need to select the import destination), then click **Next**.



- Assign a name to the new element that will be created.

**Note:** Before importing elements, you should make a back-up copy of your project so that you could restore it if the resulting import is unsatisfactory.

- To create a backup copy of the project, check **Create a backup copy of the project before importing element**.

The <prjlibrary.BAK> file is created in the project folder. If the results of the import are unsatisfactory, you can choose to restore the project.

- Click **Next**.

The element import begins.

- When the import is complete, do one of the following:

- To import another element from the exchange file, click **Next**.
- To exit the dialog, click **Close**.

# Link Architecture View



The **link architecture** view graphically displays the resources of a Project and the resource data links between them. This is the default view of the Workbench providing a main entry point to all editors. In the link architecture view, you manage many aspects of a project:

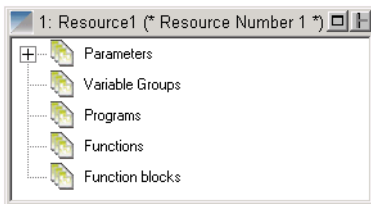
- creating resources
- linking resources (data links for bindings between resources)
- defining variable groups
- creating and manipulating POUs (Program Organization Units)
- setting up I/O wiring

## To access the link architecture view

- ▶ From the Window menu, choose *project\_name-Link Architecture*.

## Resources

Each resource is displayed as a separate **window** within the link architecture view. The resource window title bar includes:



- An icon indicating the operative state and security state of the resource
- The resource name and comment

- A Windows control button to maximize or restore the resource window
- A Data Link button enabling you to graphically create data links between resources

The operative state of a resource is indicated by the color of the upper triangle in the resource icon:



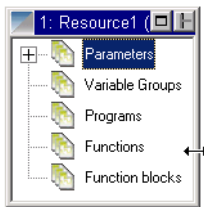
Blue. The resource is in editing mode.



Green. The resource is in real-time mode (running), debug mode, or simulation mode.




You can access the contextual menu from a resource by right-clicking in its title bar. Double-clicking the title bar minimizes/restores a resource window.

You can also resize resource windows by placing the cursor over an edge or corner until it shows double arrows and dragging:



## Resource Window Workspace

The **Workspace** displays a graphical representation of the various components of each resource.

- +  Parameters
-  Variable Groups
-  Programs



Functions



Function Blocks

### To expand / collapse any branch of the hierarchy

- ▶ Click '+' ('-' to collapse).

**Note:** Selecting one of the components changes the menu items available on the menus of the Workbench. For example, if a function is selected, the Insert menu includes the Add Function option. The contextual menus are also affected by selections within the resource window.

## Creating Resources

When you create resources in the link architecture view, these resources are automatically assigned to the first configuration. You can also choose to create, i.e., insert resources directly in configurations while in the hardware architecture view. After having created resources, you can move them. For details on moving resources, see page 113.

### To create a new resource

You can create resources using the main menu or a contextual menu, accessed by right-clicking the empty area of the link architecture view's workspace.

- ▶ From the Insert menu, choose **Resource**.

## Renaming Resources

You can rename an existing resource by editing its properties. When a resource is selected, the Properties option is available from the main menu or a contextual menu. From the resource's Properties window, you can also edit the comments for the resource.

### To rename a resource

1. Select the resource.
2. From the Edit menu, choose **Properties**.

The Resource Properties dialog box appears - on the General Tab.

3. Edit the resource name as required.
4. Edit the comment as required.
5. Click **OK**.

## Copying Resources

You can copy a resource and place it on the clipboard. When copying resources, password definitions are copied, whereas, step-by-step debug information is not copied. When copying resources having The copy command is available from the main menu, the **Ctrl+C** keyboard command, the main toolbar, or a contextual menu.

**Note:** Before copying, click in a blank area inside the resource window to deselect individual programs or groups.

### To copy a resource from the link architecture view

You can access the contextual menu by right-clicking the title bar of the resource.

1. Click on the title bar of the resource.
2. From the Edit menu, choose **Copy**.

### **To copy a resource from the hardware architecture view**

You can access the contextual menu by right-clicking the resource in the configuration window.

1. Select the resource.
2. From the Edit menu, choose **Copy**.

## **Pasting Resources**

You can paste a resource into the workspace of the link architecture view or into a configuration, in the hardware architecture view. When pasting resources, password definitions are also pasted, whereas, step-by-step debug information is not pasted. The paste resources using the main menu, the **Ctrl+V** keyboard command, the main toolbar, or a contextual menu.

### **To paste a resource in the link architecture view**

You can access the contextual menu by right-clicking the title bar of the resource.

1. Click on an empty area of the link architecture view.
2. From the Edit menu, choose **Paste Resource**.

### **To paste a resource in the hardware architecture view**

You can access the contextual menu by right-clicking the resource in the configuration window.

1. Select a configuration to paste the resource into.
2. From the Edit menu, choose **Paste Resource**.

**Note:** Links coming from or arriving to a resource are not copied and pasted.



## Deleting Resources

You can delete a resource from the workspace of the link architecture view or from a configuration, in the hardware architecture view. The delete command is available from the main menu, the **Delete** keyboard command, the main toolbar, or a contextual menu.

**Note:** Before deleting, click in a blank area inside the resource window to deselect individual programs or Groups.

### To delete a resource

You can access the contextual menu by right-clicking the resource title bar.

1. Select the resource.
2. From the Edit menu, choose **Delete**.

## Editing Resource Properties

You need to define several properties at the resource level, intimately linked to targets (and their implementation). These properties determine the behavior of the programs and hardware such as the type of code generated, the timing, and Hardware specific properties. **To access the Resource Properties window**

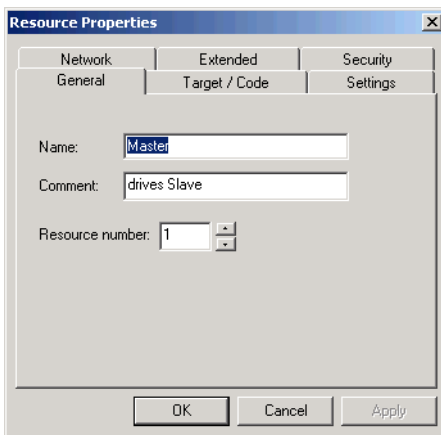
1. From the Window menu, choose *project\_name*-**Link Architecture**.
2. Select a resource.
3. From the Edit menu, choose **Properties**.

The Resource Properties window is displayed.

## Resource Identification

The resource identification properties of a resource include its name, comments, and a resource identification number. The resource number is automatically assigned. You can choose to change this number. However, when changing this number, you need to assign a number that is unique within the project. The resource number identifies the Virtual Machine that will run the resource code. Comments appear in the resource's title bar, next to its name.

You define resource identification properties on the General tab of the Resource Properties window:



## Compilation Options

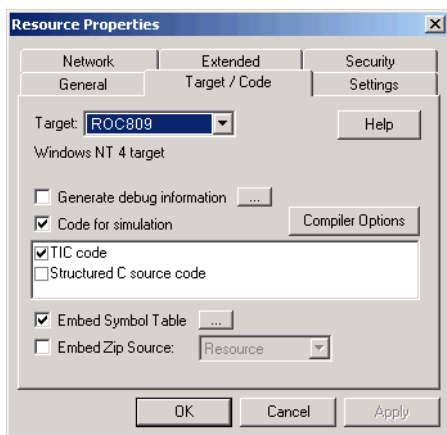
The compilation options of a resource define many aspects of a resource's run-time and simulation options:

- The target operating system on which the resource will run
- The generation of debug information
- The type of code to generate and compiler options
- The symbol table

- Embedded zip of the source files

You can also choose the target type at the configuration level. However, changing the target for a configuration affects all resources attached to it. For details on configuration properties, see page 114.

You specify a resource's compilation options on the Target/Code tab of the Resources Properties window:




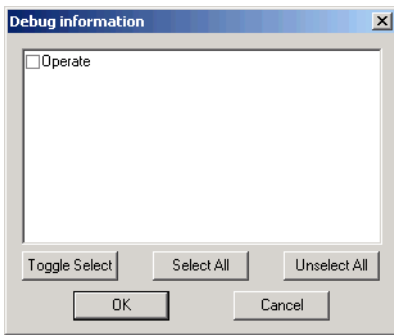
## Generate Debug Information

When using the step-by-step mode, for debugging purposes, you need to generate debug information for a resource and its ST, IL, and LD POU. For details on step-by-step mode, see page 299. When setting up debug information, you also need to specify the individual POU for which to generate debug information. Debug information includes call stack information which tracks stepping between POU and called functions. You can only generate debug information for resources producing TIC code.

**Note:** The first time you choose to generate debug information for a resource, the complete resource is compiled when you build the resource. Subsequently, when you add or remove individual POU, only those POU are compiled when you build the project.

## To generate debug information for ST, IL, and LD programs

1. To generate call stack information for use while stepping in POU's, check **Generate debug information**.
2. To generate debug information, click .
3. In the Debug Information window, check individual POU's, select all POU's, or unselect all POU's, then click **OK**.



## Target Code and Compiler Options

You can specify the generation of three types of code for use in simulation or run time:

- Code for simulation, code required when running the application in simulation. To run the Simulator, you must check **Code for Simulation** to produce the application code.
- TIC Code, the indication of whether Target Independent Code is produced by the compiler. TIC code can be executed on **DS800 Development Suite** virtual machines.
- Structured C source code, the indication of whether structured C source code is produced by the compiler. Structured C source code can then be compiled and linked with **DS800 Development Suite** libraries to produce embedded executable code.

You can also define compiler options for individual resources. For details on compiler options, see page 349.

## Symbol Table

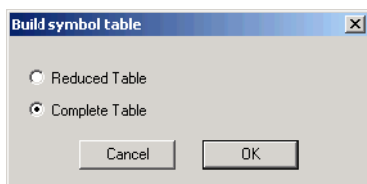
You can specify whether to download the symbol table to the Virtual Machine with the resource code. The symbol table groups the variable names of the resource. You can also choose to download the complete symbol table or the reduced symbol table.

**Note:** The Complete Table must be selected. The **reduced symbol table** contains only names of variables for which the 'Address' cell had been completed. For details on the variables grid, see page 142.

### To change the Build Symbol Table

1. Click **Options**.

The Build Symbol Table dialog box appears.



2. Choose the type of symbol table to download.

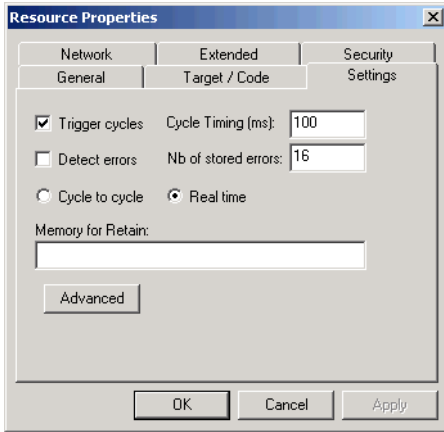
## Embed Zip Source

You can embed, on the target, an exchange file (.PXF) holding all data from Workbench elements. This exchange file is the same as the file created when exporting an element.

## Run-time Settings

The run-time settings include the cyclic and behavior definitions of a resource when the resource is executed. For information about execution rules, see page 376.

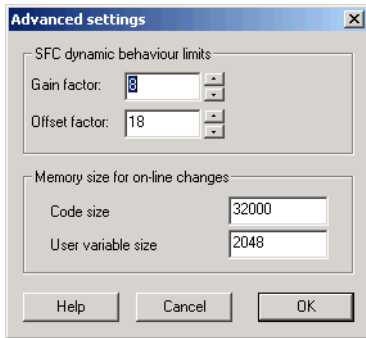
You specify a resource's run-time settings on the Settings tab of the Resources Properties window:



- **Trigger cycles**, enables you to specify the cycle timing, i.e., the amount of time given to each cycle. If a cycle is completed within the cycle time, the system waits until the cycle time has elapsed before starting a new cycle. The cycle consists of scanning the physical inputs of the process to drive, executing the POU's of the Workbench resource, then updating physical outputs. The virtual machine executes the resource code according to the execution rules. For details about the execution rules, see page 376.
- **Detect errors**, enables the storing of errors. You need to define the number of entries, i.e., the size of the queue (FIFO) in which detected errors are stored.
- **Cycle to Cycle / Real Time**, indicates whether programs are executed during the cycle or not. For Cycle to Cycle, inputs are read but the code is not executed during the cycle time. This option is useful for testing I/Os.
- **Memory for Retain**, indicates the location where retained values are stored (the required syntax depends on the implementation)

You can also specify advanced settings for resources:

- SFC dynamic behavior limits
- Memory size for online changes



### To access advanced settings

- ▶ Click **Advanced**.

### SFC Dynamic Behavior Limits

The SFC dynamic behavior limits determine the amount of memory, allocated by the target at initialization time, to manage SFC dynamic behavior (i.e. token moving). The amount of allocated memory is calculated as a linear relation with the number of SFC POUs:

$$\text{Alloc Mem (bytes)} = N * \text{NbElmt} * \text{sizeof}(\text{typVa})$$

$$\text{NbElmt} = \text{GainFactor} * \text{NbOfSFC} + \text{OffsetFactor}$$

Where:

$N = 5$  (constant linked to SFC engine design)

$\text{typVa} = 16$  bits in the medium memory model (32 bits in the large memory model)

$\text{NbElmt}$  represents for each executed cycle:

- The maximum number of transitions that can be valid. That is to say transitions with at least one of their previous steps being active.



A simpler, but more approximate definition is:

- The maximum number of steps that can be active.
- The maximum number of actions that can be executed.

Here, an action refers to an N, P1 or P0 action linked to a step.

If the available memory is not enough at a specific moment:

- If the target is generated with check mode (ITGTDEF\_SFCEVOCHECK defined in dsys0def.h), The target kernel generates a warning to signal an SFC token moving error or an action execution error and the resource is set in ERROR mode (i.e. cycles are no longer executed). Otherwise, kernel behavior may be unpredictable.

## **Memory Size for Online Changes**

The memory size for online changes defines the amount of memory that is reserved on the PLC for managing online changes:

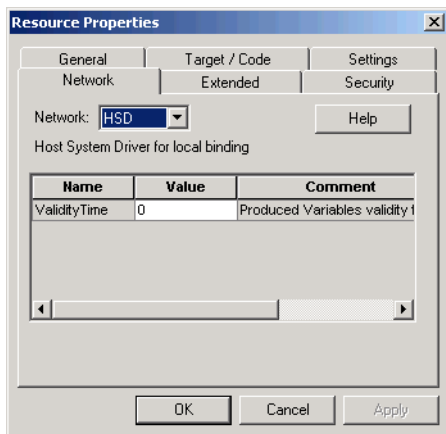
- Code Size, the amount of memory reserved for code sequence changes
- User Variable Size, the amount of memory reserved for adding variables data. When generating symbol monitoring information for a POU, the same amount of memory is also reserved for the POU.

When performing downloads and online changes, parts of the User Variable Size memory space is used to store project data such as variables values. This memory space becomes free when you clean the project.

## Resource Network Parameters

You need to define network parameters attached to the resource for each available network.

You specify a resource's network parameters on the Network tab of the Resources Properties window:



**Note:** The parameters appearing in the list reflect those attached to the resource. Some parameters are read-only. However, when a resource is attached to a network not requiring parameters, the list appears empty.

You can also access the online help by clicking **Help**.

### For the HSD network, the current definition is the following:

The consumer computes the time elapsed between production and consumption and tests if it less than the 'ValidityTime' parameter specified for the producer resource in the workbench. The user must be careful when specifying this value to take into account the cycle time of the producer resource. This resource cannot emit values at a period shorter that its cycle time.

If this time-out is detected, the consumer sets the error variable to ISA\_HSD\_KVB\_ER\_TIMEOUT value.

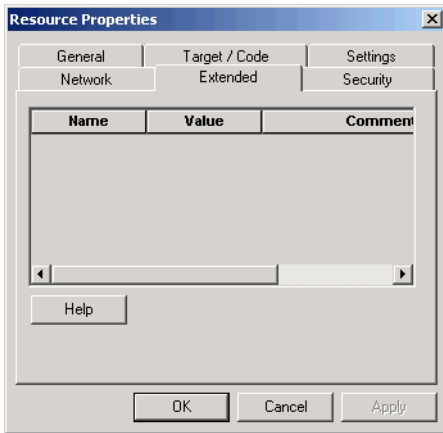
**For the ETCP network, the current definition is the following:**

On the consumer side, if no data is received during the time specified in the Timeout parameter value, then the error variable is set to ETCP\_KVB\_ERR\_TIMEOUT value.

## Custom Resource Parameters

You can define specific **OEM** options for a resource that may be implemented in your target.






**Note:** **DS800 Development Suite** standard targets do not have extended parameters. Contact your target supplier for specific details.



## Resource Access Control

For resource security, you can control access using a password and you can choose to apply the read-only mode to an entire resource. When resources are password-protected, users not having the password can change resource properties, wire and bind variables, modify the memory for retain, and add devices to wired variables. POU's in a resource can have their own level of access control. For instance, a POU having its own password remains locked and cannot be viewed without entering its password. However, a POU using its resource's password also inherits the resource's security properties such as the read-only attribute.

The security state of a resource is indicated by the color of the lower triangle in the resource title bar icon. The resource can also be currently opened by another user.

Resource Icon	Security State
	Gray. The resource has no access control. All users have read and write access in the resource. POU's in the resource may have individual access control.
	Red. The resource is locked. Users not having the resource password cannot access the resource or its POU's; these users do not have read or write capabilities. These users can change resource properties, wire and bind variables, modify the memory for retain, and add devices to wired variables.
	Cyan. The resource is in read-only mode. Users not having the resource password can view the resource and its POU's; these users only have read capabilities. These users can change resource properties, wire and bind variables, modify the memory for retain, and add devices to wired variables. POU's in the resource may have individual access control.
	Green. The resource is unlocked. User can access the resource and its POU's; this user has read and write capabilities. However, POU's in the resource may have individual access control.
	The resource is currently opened by another user in single-resource project editing mode. User can only access the resource properties in read-only mode.

**Note:** While in debug mode or performing builds, unlocked resources as well as resources having no access control switch to read-only mode. Locked resources remain locked.

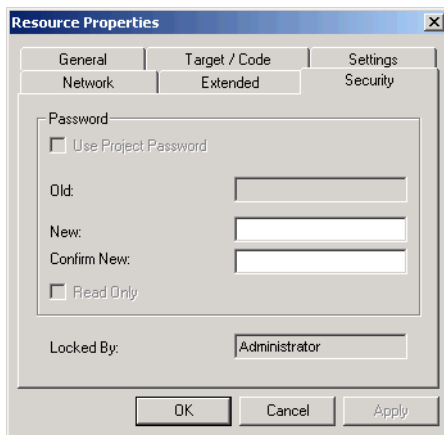
For projects having read-only access control, the resources and POU's making up the project are also set to the read-only mode except for those having individual access control.

When copying, pasting, importing, and exporting resources having access control, password definitions are retained.

When editing a project, resources making up the project are automatically locked by you except for those resources where another user set password protection or that are currently in use by another user in the single resource editing mode.

### To set access control for a resource

You set access control for a resource in its properties' Security tab.



1. Specify a password:
  - To use an unique password, in the New field, enter a password then reenter it in the Confirm New field.
  - To use the same password as set for the project, check **Use Project Password**.
2. To enable all users to access the resource in read-only mode, check **Read Only**.

### To unlock a resource

When entering a password while in debug mode or performing a build, the resource is only unlocked after stopping the debug mode or when the build is completed.

1. Right-click the resource's title bar, then from the contextual menu, choose **Enter Password**.
2. In the Security dialog box, enter the password for the resource.



The resource is unlocked.

## Resource Description

You can include a free-format text description for a resource.

### To edit the resource description

1. Select the resource.
2. From the Tools menu, choose **Edit Description**.
3. Edit the description as required.

## Variable Bindings

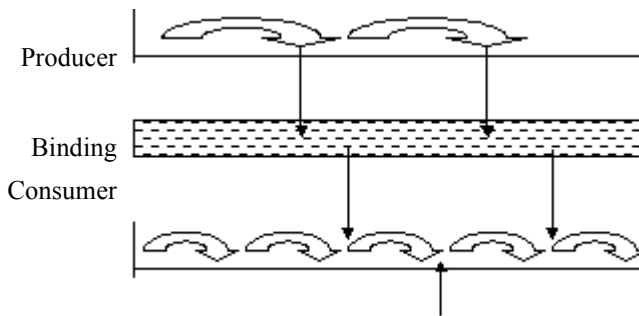
Bindings are directional links, i.e., access paths, between variables located in different resources. One variable is referred to as the producing variable and the other as the consuming variable. The value stored in the producing variable is transferred to the consuming variable. The Workbench enables two types of bindings: internal bindings and external bindings. Internal bindings are between resources within the same project. External bindings are between resources belonging to different projects.

**Note:** Online changes are possible as long as internal and external binding definitions remain the same.

**Binding** the variable V1 from resource R1 to the variable V2 of resource R2 means that V1 is periodically copied to V2 using memory sharing or network exchanges.

Variables coming from bindings (consumed variables) are refreshed in the resource at the beginning of the cycle, each time the producing resource sends them, i.e. on each end of the producing resource cycle.

The variable is not updated in the consuming resource until the producing resource sends them through the binding media. For example:



No update of the variable on that cycle

**DS800 Development Suite** does not impose the read-only accessibility for consumed variables. However, it is highly recommended to declare consumed variables with read-only attribute in order to avoid conflicts between Binding and execution of POUs.

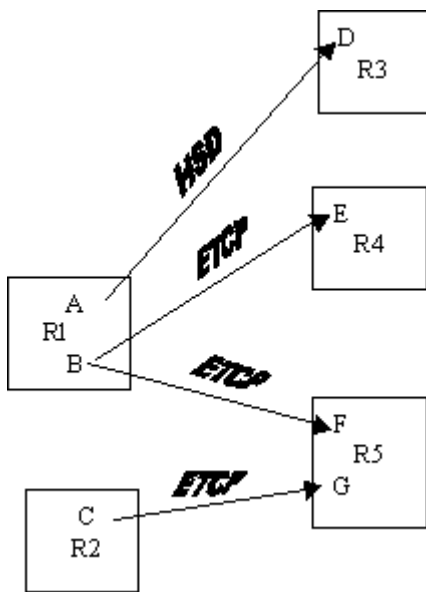
This behavior is applied in both HSD and ETCP Binding drivers. This behavior may change when using other network drivers implemented according to different conventions.

## Binding error variables

Binding error variables enable the management of binding errors at the consumer resource level; one error variable for one consumer resource for each resource that produces to this resource. The virtual machine gives specific values to these error variables.

**Note:** DS800 does not support producer error variables.

## Example



### Production errors

The variable 'A' of the R1 resource represents the producer error variable for all binding links starting from R1 and using the HSD driver (in the example only link from R1 to R3).

The variable 'B' of the R1 resource represents the producer error variable for all all binding links starting from R1 and using the ETCP network (links from R1 to R4 and from R1 to R5).

### Consumption errors

The variable 'F' of the R5 resource represents the consumer error variable for the unique binding link that comes from R1 and using ETCP.

The variable 'G' of the R5 resource represents the consumer error variable for the unique binding link that comes from R2 and using ETCP.

Depending on the driver used the error variables can take different values with different meanings.



**Warning:** Once the error variable is set to a non-zero value, it has to be reset to 0 by user or by Programs.

To test globally that there is a binding error, you can test the value of the following system variables:

- `__SYSVA_KVBPERR`: for a production error. It is a Boolean variable. If it is true it means there is a production error. DS800 does not support the `__SYSVA_KVBPERR` system variable.
- `__SYSVA_KVBCERR`: for a consumption error. It is a Boolean variable. If it is true it means there is a consumption error.

### **For HSD:**

To test values of one binding error variable, you should create the following defined words in the dictionary of your project:

The 0 value in the error variable indicates there is no error.

<code>ISA_HSD_KVB_ER_MUTEX</code>	1	An error occurred with semaphore management
<code>ISA_HSD_KVB_ER_SPACE</code>	2	An error occurred with memory space access
<code>ISA_HSD_KVB_ER_NOKERNEL</code>	3	The bound producer is stopped (not running). This error happens only for consumer resources.
<code>ISA_HSD_KVB_ER_TIMEOUT</code>	4	Variable was not refreshed within the maximum time allowed (ValidityTime). This error happens only for consumer resources.
<code>ISA_HSD_KVB_ER_BAD_CRC</code>	5	Producer and consumer have different CRC.
<code>ISA_HSD_KVB_ER_INTERNAL</code>	6	Internal error

## For ETCP:

To test values of binding error variables, you should create the following defined words in the dictionary of your Project:

A value of 0 in the error variable indicates no error.

ETCP_KVB_ERR_BINDING_IN_PROCESS	1	The binding initialization process is on its way.
ETCP_KVB_ERR_NO_PRODUCER	2	The remote producer is not currently running. This error happens only for consumer resources.
ETCP_KVB_ERR_BAD_CRC	3	Producer and consumer have different CRC.
Obsolete error value	4	The producer has been stopped. This error happens only for consumer resources.
ETCP_KVB_ERR_DATA_DIFFUSION	5	Error during diffusion process.
ETCP_KVB_ERR_TIMEOUT	6	ETCP server does not answer quickly enough (TimeOut). This error happens only for consumer resources.
ETCP_KVB_ERR_IMPOSSIBLE_TO_BIND	7	Impossible to bind.

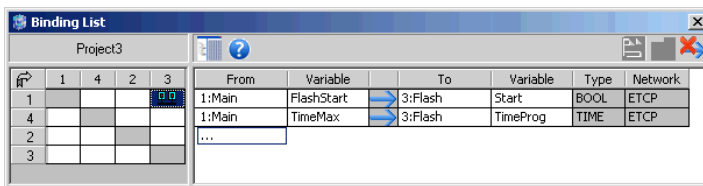
## Internal Bindings

Internal variable bindings are bindings between variables of resources belonging to the same project. Before creating internal bindings for variables, you need to link the resources holding them using data links.

You manage resource data links and internal variable bindings in the Bindings List window. You can also manage resource links directly from the link architecture view.

The Bindings window displays the resource links and internal variable bindings defined for a project. The window is divided into three parts:

- The Resource-binding grid
- The Variable-binding grid
- The Binding List window toolbar




### To access the Binding List window

1. From the Window menu, choose *project\_name*-**Link Architecture**.






The link architecture view appears displaying existing resources and their data links.

2. Do one of the following:

- Click .
- Double-click a data link joining two resources.

## Resource-binding Grid

The Resource-binding grid, on the left side of the Binding List window, displays the data links between resources. The first column and the top row display the available resource's numbers. The resource display order depends on their configuration numbers.





	1	2
1		
2		

When working in the Resource-binding grid, you can perform various tasks using the mouse or keyboard commands:

Description	Mouse	Keyboard
Move into the grid	Select cells	Arrows keys
Select an entire row	Select a row header	Shift+space bar
Select an entire column	Select a column header	Ctrl+space bar
Select the entire grid	Select an arrow on the top left of the grid	Shift+Ctrl+space bar
Switch to the Variable-binding grid	Click on the Variable-binding grid	Tab

## Variable-binding grid

The Variable-binding grid, on the right side of the window, enables you to manage variable bindings. The variable-binding grid manages the bindings between variables. The grid shows where a binding comes from and where it goes to, the type of the variable, and the network used for communicating.

From	Variable		To	Variable	Type	Network
1:Main	LeadStart		2:Lead	Start	BOOL	ETCP
1:Main	TimeMax		2:Lead	TimeProg	TIME	ETCP
1:Main	FlashStart		3:Flash	Start	BOOL	ETCP
1:Main	TimeMax		3:Flash	TimeProg	TIME	ETCP

The column between the variable information indicates the status of the binding:



The binding does not have parameters and the status is OK



The binding does not have parameters but the status is bad



The binding has parameters and the status is OK



The binding has parameters but the status is bad

A bad status occurs when the types, string sizes, or dimensions of variables don't correspond or if the network, used for the binding, doesn't exist.

When working in the Variable-binding grid, you can perform various tasks using the mouse or keyboard commands:

Description	Mouse	Keyboard
Move into the grid	Select cells	Arrows keys
Switch to the Resource-binding grid	Click in the Resource-binding grid	Tab

### Binding List Toolbar

The Binding List window toolbar enables you to perform many resource link and variable binding operations:



Hides the resource-binding grid



Accesses the online help



Creates a new binding variable



Edits an existing binding variable. This operation is only available for use in the variable-binding grid.






Deletes selected cells, rows, or columns

**Note:** If the two resources are distant, they must be located in configurations that are attached to the same target. Heterogeneous bindings are not yet supported.

## Linking Resources

You need to link resources before binding variables belonging to them. Data links between resources are directional. All bindings using a data link must use the same network. You can link resources from the Binding List window. You can also link resources from the link architecture view.

In the Resource-binding grid, you create links between resources by locating the resource holding the producing variable in the first column and the resource holding the consuming variable in the top row, then selecting the grid cell where both meet.

	1	2
1		
2		

In the grid, resource links appear as one of two types:



The linked resources belong to the same configuration




The linked resources belong to different configurations

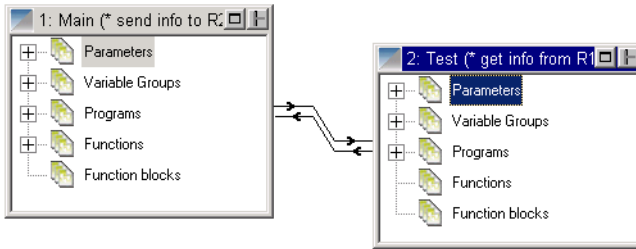
In the link architecture view, you create links by physically joining the resource holding the producing variable with the resource holding the consuming variable. In this view, data links appear as directional arrows linking the resources. The color of data links depend on the type of bindings using it:

Black      The data link is only used for internal bindings

Blue      The data link is used for internal bindings

When bindings have an error, the  symbol is displayed on the data link used by the binding.

You can customize the colors of resource data links.



### To link resources from the Binding List window

You can access the Binding list window from the main menu or the Windows toolbar.


1. From the Project menu, choose **Binding List**.

The Binding List window appears.

2. In the first column of the Resource-binding grid, locate the resource number of the resource holding the producing variable.
3. In the top row of the Resource-binding grid, locate the resource number of the resource holding the consuming variable.
4. Double-click the grid cell where both resource numbers meet.

An icon appears in the grid cell indicating whether the link is between resources from the same or different configurations.

### To link resources from the link architecture view

1. On the resource holding the producing variable, click and hold the Data Link button , located on its title bar.
2. Drag the link to the resource holding the consuming variable.
3. Release the mouse button.


The data link is displayed graphically.

## Deleting Resource Links

You can delete links between resources, i.e., data links, from within the Binding list window. You can also delete links from the link architecture view.

**Note:** Deleting a resource link also deletes the variable bindings using it.

### To delete a resource link from the Binding List window

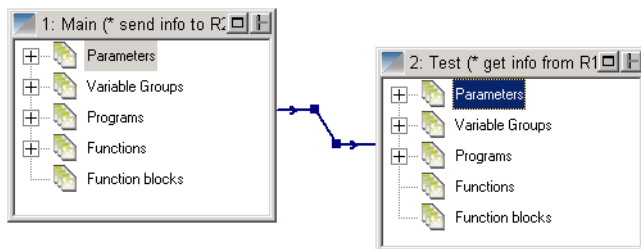
1. In the Resource-binding grid, select the grid cell holding the resource link to delete.
2. Do one of the following:
  - From the Binding List window's toolbar, click .
  - Press **Delete**.

The grid cell appears blank.

### To delete a resource link from the link architecture view

1. In the link architecture view, click on the resource link.

The selected data link appears highlighted:



2. Do one of the following:
  - From the Edit menu, choose **Delete**.
  - Press **Delete**.



## Viewing the Internal Bindings Defined for Resources

You can view all producing variable bindings or all consuming variables defined for a resource at the same time. You can also choose to view all bindings defined for all resources, i.e., the entire project. However, when viewing bindings, you cannot edit their definitions.


### To view the producing variable bindings for a resource

- ▶ In the first column of the Resource-binding grid, click the corresponding resource number.

### To view the consuming variable bindings for a resource

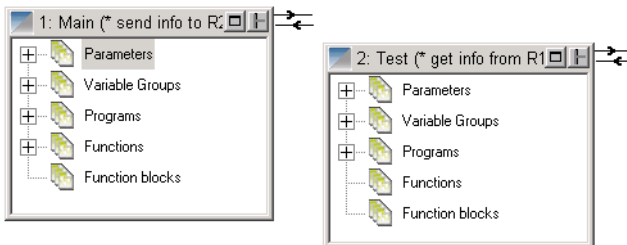
- ▶ In the top row of the Resource-binding grid, click the corresponding resource number.

### To view the bindings defined for a project

- ▶ In the Resource-binding grid, click .

## Hiding and Showing Resource Links

In the link architecture view, you can choose to show or hide the data links between resources. In hidden mode, links cannot be activated or selected. Links appear as short arrows, indicating their direction, sticking out from the top right corner of resources:



### To hide or show data links

You can hide or show data links using the main menu or the Options toolbar.

- ▶ From the Options menu, choose **Hide/Show Links**.

## Defining Internal Variable Bindings

Before defining bindings between variables, you must first link the resources to which they belong. For bindings, one variable is known as the producing variable and the other as the consuming variable.

You can only define bindings between variables of a same type. Producing variables can have any direction attribute, i.e., input, output, and internal. Whereas, consuming variables can only have the output or internal attribute and must also have the Free attribute.

You instantiate variable bindings in the Variable-binding grid of the Binding List window.

From	Variable	To	Variable	Type	Network
1:Main	LeadStart	2:Lead	Start	BOOL	ETCP
1:Main	TimeMax	2:Lead	TimeProg	TIME	ETCP
1:Main	FlashStart	3:Flash	Start	BOOL	ETCP
1:Main	TimeMax	3:Flash	TimeProg	TIME	ETCP

You define variable bindings in the Binding editor. When defining a binding, you need to indicate a producing variable and a consuming variable, and the network used for communicating. The producing variable serves as input for the binding. Whereas, the consuming variable serves as output. You can choose to specify a default value to use in the event of a communication error. You can also choose to specify a binding error variable (producer error variables are not supported in DS800).

The Producing Variable selection list contains all variables of the producer resource. The Consuming Variable selection list contains all variables which do not have the INPUT direction and are not already used as a consumed variable in an existing binding.


The network selection list contains the networks that are supported by the target of the configuration of the first resource and the target of the configuration of the second resource.

The Binding Parameters list displays the parameters to be defined for the variables bound on the selected network. This list may be empty depending on the network used by the binding. For example: ETCP does not need any parameters at this level. You define parameters by double-clicking on a parameter line to display the Binding Parameter dialog box (available only when the parameter is editable). Some parameters are read-only.

The Binding Error Variables section contains two selection lists for selecting a variable (Global / Memory of the DINT type) in each resource to receive binding error values (producer error variables are not supported in DS800). Producer error variables and consumer error variables can be used in the resource's POUs to trap and act upon errors. The default value is None.

### **To create a binding between variables**

1. In the Variable-binding grid, select the next available field.

2. From the Binding List window's toolbar, click .

The Binding editor appears.

3. In the Producing Variable field, select the producing variable.

4. In the Consuming Variable field, select the consuming variable.

5. In the Network field, select the network used for communicating.

6. To set a default value for use in the event of a communication error, select **Use Default Value**, then enter a value in the field.


7. To use a binding error variable, indicate it in the Binding Error Variables section (producer error variables are not supported in DS800).

8. Click **OK**.

## Editing Internal Variable Bindings

You can change the contents of existing variable bindings. You edit bindings from the Variables-binding grid of the Binding List window.

### To edit the contents of an existing binding

1. In the Variable-binding grid, select the variable binding.
2. From the Bindings List window's toolbar, click  .


The Binding editor appears.

3. Make the necessary changes, then click **OK**.

## Deleting Internal Variable Bindings

You delete variable bindings from the variable-binding grid of the Bindings List window.

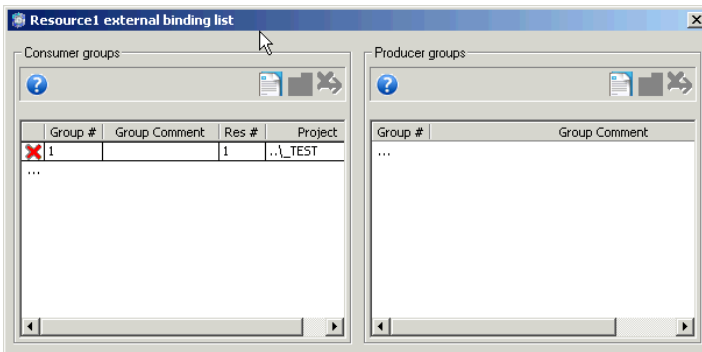
### To delete a variable binding

1. In the Variable-binding grid, select the variable binding.
2. Do one of the following:
  - From the Binding List window's toolbar, click  .
  - Press **Delete**.

## External Bindings

External variable bindings are bindings between variables of resources belonging to different projects. When defining external variable bindings, you need to define groups of producer variables in the producer project, then in the consumer project, link the consumer resource with the producer resource, then define the external bindings between the producer variables and the consumer variables.

You define external bindings from the External Bindings List. This list is made up of the Consumer groups and Producer groups sections. The Consumer groups section lists the groups holding external producer variables having bindings with consumer variables defined in the project. The Producer groups section lists the groups holding outgoing producer variables for consumption in external bindings defined in another project.



When defining producer groups of variables, you group variables of a resource to be consumed by consumer variables of one or more resources located in other projects. Individual variables of a resource can belong to a one or more producer groups.

For producer groups and external bindings, **X** indicates errors that can occur for different situations such as the following:

- Producer groups
  - The project of a producer group cannot be found
  - The producer group cannot be found within the specified project
  - A conflict exists between the consumer and producer resources
  - One of the bound producer variables no longer exists
- External bindings
  - The producer variable used in the binding no longer exists
  - The project holding the producer variable cannot be accessed

## External Binding List Toolbar

The External Binding List window toolbar enables you to perform many external binding operations. The operations performed by the toolbar items differ depending on whether these are in the Consumer or Producer groups sections.



Accesses the online help



In the Consumer groups section, accesses the Consumer Binding list where you define links between resources and define external bindings from the Bindings editor.

In the Producer groups section, accesses the Producer Binding list where you define groups of producer variables for use in bindings with consumer variables of other projects.



In the Consumer groups section, edits an existing external variable binding.


In the Producer groups section, edits an existing group of producer variables.



In the Consumer groups section, deletes an external variable binding.

In the Producer groups section, deletes a group of producer variables.

### To access the External Binding list

1. From the link architecture view, select the resource for which to create producer groups.
2. From the Project menu, choose External Binding List or click , from the Window Buttons toolbar.

## Defining Producer Variable Groups

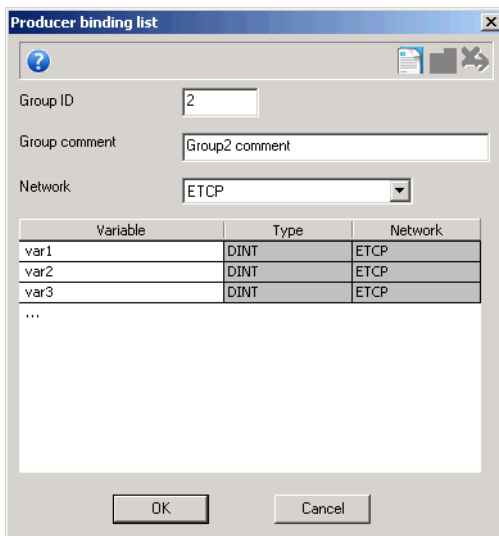
You define producer groups of variables for resources of a project to enable accessing them when defining external variable bindings in consumer resources of other projects. Producer groups hold producer variables of a resource to be consumed by consumer variables of one or more resources located in other projects.

### To define a producer variable group

You define producer variable groups from the External Binding List.

1. In the Producer Groups list, double-click ...

The Producer Binding List editor is displayed:



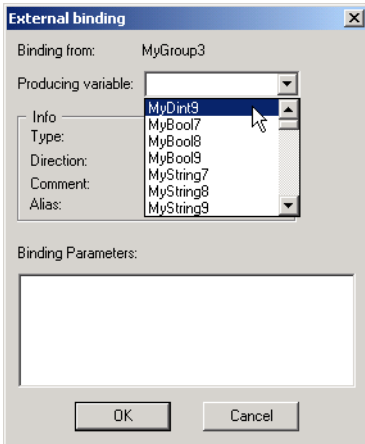
Variable	Type	Network
var1	DINT	ETCP
var2	DINT	ETCP
var3	DINT	ETCP
...		

2. Enter a unique Group ID and optional comment.
3. Specify the network used for the bindings.

4. Specify each variable making up the producer variable group:

a) In the variable list, click ...

The External Binding editor is displayed.



b) In the Producing variable field, select the variable to include in the group.

The selected variable's information is displayed as well as the default network binding parameters. You can edit the values for the network binding parameters.


c) Click **OK**.



## Editing Producer Variable Groups

You edit the contents of an existing producer variable groups from their originating resource.


### To edit the contents of an existing producer variable group

1. In the Producer Groups list, select a producer group.
2. From the Producer's Group binding list toolbar, click .
3. In the Producer Binding List editor, make the necessary changes, then click **OK**.

## Deleting Producer Variable Groups

When deleting producer groups having producer variables used in external bindings, in the consumer project, the link between the consumer and producer resource shows an error (✗).

### To delete a producer group

- ▶ In the Producer Groups list, select the producer group to remove, then from the Producer's Group binding list toolbar, click .

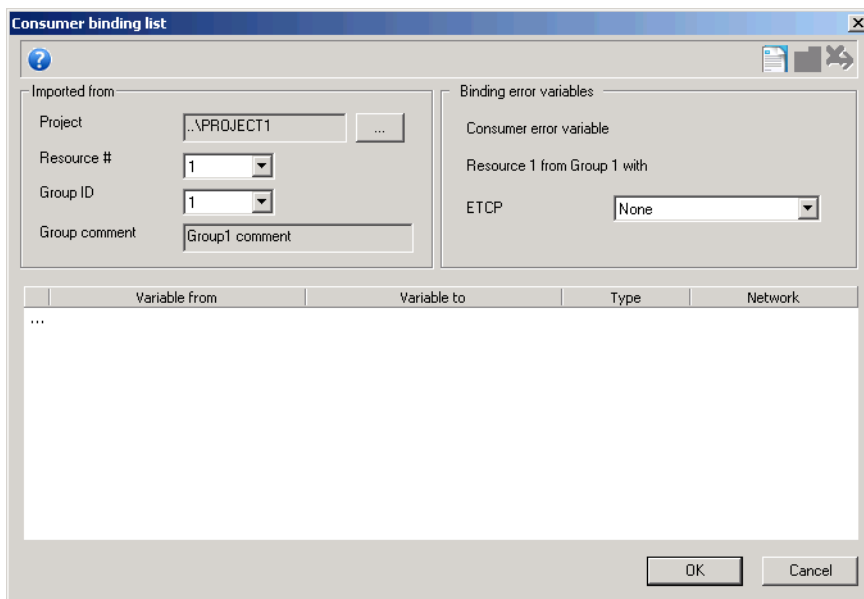
## Linking Resources for External Bindings

Before defining external variable bindings between resources, you need to link the consumer and producer resources. You link these resources from the consumer resource by identifying the project, resource, and producer group of variables, holding the producer variables whose values are conveyed to the consumer variables. A link between resources flows in one direction. You can choose to use binding error variables.

### To link resources for external variable bindings

1. From the External Binding List window, double-click ... in the Consumer Groups section.

The Consumer Binding List is displayed.



2. Define the source of the producer group of variables used for the external bindings.
  - a) Browse for the project holding the producer group to include in the bindings.


- b) Specify the resource and producer group ID of the producer group.

The resource number, producer group ID, and network used for linking the resources are displayed in the Binding error variables section.

- 3. To indicate a binding error variable, select one from the available variables.

## Editing External Resource Links

You can edit resource links for existing external bindings from the consumer resource.

**Warning:** Editing the linking information for a specified producer group, resource, or project sets all defined external variable bindings in the list in error (  ).

### To edit a link between resources of different projects

You edit links between resources from the Consumer Binding List editor.

- ▶ In the Consumer Binding List, make the necessary changes to the project, resource, or producer group information, then click **OK**.

## Defining External Variable Bindings

Before defining external variable bindings, for the producer resources, you need to define producer groups, holding the producer variables for consumption by the consumer resources, and link the consumer and producer resources.

### To define an external variable binding

You define external variable bindings from the consumer resource.

1. In the Consumer Binding List, double-click ...

The External Binding editor is displayed.

External binding

Binding from group: MyGroup1  
Producing variable: MyDint1

Info  
Type: DINT  
Direction: INTERNAL  
Comment:  
Alias:

Network: ETCP

Binding parameters:

to resource: Resource2  
Consuming variable: MyDint9

Info  
Type: DINT  
Direction: INTERNAL  
Comment:  
Alias:

Consumption error behavior  
 Use last value issued from binding  
 Use default value

Default value: 10



OK Cancel

2. Specify the producing variable and consuming variable from their respective lists of available variables.
3. Indicate whether to use the last value issued from the binding or a default value. When using a default value, specify the value to use.
4. Click **OK**.

## Editing External Variable Bindings

You edit the contents of existing external variable bindings from the consumer resource.



### To edit an existing external binding

1. In the External Binding List window, select the binding link to edit in the Consumer groups section.
2. From the Consumer Group's binding list toolbar, click .
3. In the Consumer Binding List editor, select an external binding from the list, then click .
4. In the Binding editor, make the necessary changes.

## Deleting External Variable Bindings




You delete external bindings from the consumer resource.

### To delete an existing external binding

1. In the External Binding List window, select the binding link to edit in the Consumer groups section.
2. From the Consumer Group's binding list toolbar, click .
3. In the Consumer Binding List editor, select an external binding from the list, then click .

# Parameters

The 'Parameters' component contains the IO Wiring and 'Defined words' sub-components. For details on I/O Wiring, see page 155. For details on the Defined Words Tree, see page 130.

-  Parameters
  -  I/O Wiring
  -  Defined Words

I/O Wiring      Double-clicking on this item opens the I/O Wiring Tool to select I/O devices and connect variables to them.

Defined Words      Double-clicking on this item opens the Dictionary on the Defined Words Tree.

## Variable Groups

Variables Groups provide a method of managing variables and logically sorting them within a resource. The variable groups are shown in the Variables Tree, their contents are defined within the Dictionary Variables grid. For information on the variables tree, see page 127.

### Creating Variable Groups

You create variable groups from within the link architecture view. You can rearrange the order of defined variable groups by dragging and dropping within the variable groups section of a resource window. The group order affects the printing order.

#### To create a new variable group

1. From the Window menu, choose *project\_name*-**Link Architecture**.

The link architecture view appears displaying all resources and data links defined for a project.

2. Select a resource.
3. From the Insert menu, choose **Add Variable Group**.

### Opening Variable Groups

Opening a variable group opens the Dictionary with the grid showing variables of that group. You open variable groups from within the link architecture view. For information on the Dictionary, see page 125.

#### To open a variable group from the link architecture view

1. Select a group.

2. Do one of the following steps:
  - From the Edit menu, choose **Open**.
  - Within a resource window, double-click on the required variable group name.
  - Select a group name then press **Enter**.

**To open a variable group from the Dictionary view**

1. Select the Variables Tree.
2. Double-click the resource name to which the group belongs.
3. Click on the variable group name.

The grid displays the variables for that particular group.



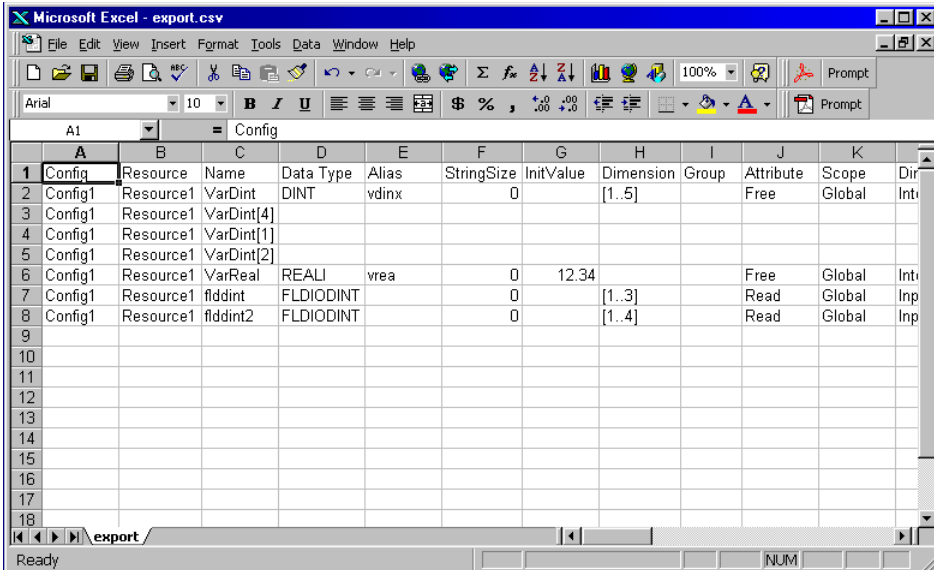
## Importing or Exporting Variables

You can choose to import or export variables data such as hundreds of trends, alarms, or events using either a comma-separated (CSV) file in a text editor or a Microsoft Excel spreadsheet. To include comments in your data, surround them with quotation marks (").

When using a text editor, you must separate each piece of information from the others with a comma; each line must end with a carriage return; the resulting file can have either the .csv or .xls extension. When using a spreadsheet, enter each piece of information in a separate cell; leave empty cells if an item is to be omitted; save the file under the CSV or XLS format. These requirements are automatically followed by the export facility; you must respect them if you build a file to be imported. For variables data, i.e., alarms or events, and trends, imported data must include the configuration, resource, and variable names to which it belongs; default values will appear for all other values that remain empty. You need to define variables before proceeding to defining alarms, events, and trends.

**Note:** The XLS file format is only available when Microsoft Excel is installed on your computer.

An example of an Excel file holding variables data is:



The screenshot shows a Microsoft Excel window titled "Microsoft Excel - export.csv". The spreadsheet contains a table with the following data:

	A	B	C	D	E	F	G	H	I	J	K	L
	Config	Resource	Name	Data Type	Alias	StringSize	InitValue	Dimension	Group	Attribute	Scope	Dir
1	Config1	Resource1	VarDint	DINT	vdinx		0	[1..5]		Free	Global	Int
2	Config1	Resource1	VarDint[4]									
3	Config1	Resource1	VarDint[1]									
4	Config1	Resource1	VarDint[2]									
5	Config1	Resource1	VarReal	REALI	vrea		0	12.34		Free	Global	Int
6	Config1	Resource1	fiddint	FLDIODINT			0	[1..3]		Read	Global	Inp
7	Config1	Resource1	fiddint2	FLDIODINT			0	[1..4]		Read	Global	Inp
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												



2. Do one of the following steps:

- To add the imported data to the Workbench project's database, click **Append**.
- To replace the contents of the Workbench project's database with the imported data, click **Replace**.

**Warning:** When replacing, the Workbench deletes all existing variables for the given resource before importing the data. When appending, the Workbench adds all new variables and inquires about replacing existing variables for the given resource.

The Import window appears.

3. Click **Set File** to locate the file to import, then click **Open**.

The contents of the selected file are displayed in the browser.

### **To export variables data**

1. From the Tools menu, choose **Export Variables**.

The Export window appears.

2. Do one of the following:

- If you are using a template, load the template.
- In the browser, check the data fields to export. To create a template using the selected fields, in the Export Templates section, click **Save**.

3. Click **Set File** to locate the file (.xls or .csv format) to which to export the data, then click **Open**.

4. Select the resource from which to export the fields. You can also select all resources.

5. Click **Export**.

The defined field data is stored in the specified file.

## POUs (Program Organization Units)

A POU (Program Organization Unit) is a set of instructions written in one of the following languages: SFC, FC, IL, ST, FBD, and LD. POU's can be programs, functions, or function blocks.

You can perform many tasks when managing POU's:

- Creating POU's
- Manipulating POU's
- Creating FC Sub-programs
- Creating SFC Child POU's
- Changing Hierarchy Level
- Controlling Access to POU's

## Programs

Programs constitute the target Cycle. Programs are also known as POU's. POU's defined as Programs are executed on the Target system respecting the order shown in the Program section. You need to respect the hierarchy of programs within resources.

Available graphical programming languages are Sequential Function Chart, Flow Chart, Functional Block Diagram, and Ladder Diagram. Available literal programming languages are Structured Text and Instruction List. The language of each program is shown as an icon beside the program name:







Sequential Function Chart (SFC)

SFC Editor



Flow Chart (FC)

FC Editor

	Structured Text (ST)	Multi-language Editor
	Ladder Diagram (LD)	Multi-language Editor
	Function Block Diagram (FBD)	Multi-language Editor
	Instruction List (IL)	Multi-language Editor

Within a resource there are certain restrictions on the relative positions of programs within the hierarchy:

- All SFC and FC programs must be adjacent within the hierarchy.
- SFC Child or FC Sub-programs must use the same language as their parent.

When using SFC programs in a resource, you may need to change the SFC dynamic behavior factors defined for the resource. For details on the SFC dynamic behavior factors, see page 60.

You can move or copy programs written in ST, LD, and FBD to the Functions section and programs written in SFC, ST, LD, and FBD to the Function Blocks section. You can also move or copy functions and function blocks to the Programs section. When moving or copying a program to the Function or Function Blocks sections, all local variables defined in the program are converted to function or function block parameters respectively.

**Note:** To call a POU written with a different language from SFC or FC program, call a function or function block (written in ST, LD, FBD or IL).

## Functions

Any program can call a Function. Functions are also known as POUs. Functions can only be programmed in ST, LD, or FBD. In all cases, the return parameter of a function must be assigned. You can only declare local variables in functions. However, these local variables cannot be function block instances. Also, you cannot retain the values of variables declared in functions.

Each time a function is executed, its local variables are reset to their initial values (zero when none is provided in the dictionary). When a large structure or array is declared as local variable for a function, the compiler generates code to reset the initial values of each simple variable contained in the structure or array.

The order in which functions appear within their section is not important; functions are called from a POU.

You can move or copy functions to the Function Blocks and Programs sections. You can also move or copy function blocks and programs written with languages supported by functions to the Functions section. When moving or copying a program to the Functions section, all local variables defined in the program are converted to function parameters.

### Example

if F1 is programmed as:

```
if (in1) then
F1 := 10;
end_if;
```

in the case in1 is FALSE, F1 will not be assigned, and it can take any value.

in the calling program:

```
MyVar := F1 (TRUE) ; leads to MyVar := 10; this is OK
MyVar2 := F1 (FALSE) ; you can not predict what will be the value of MyVar2
```

## Function Blocks

Any program or function block can call a function block. A function cannot call a function block. Function blocks are also known as POU. Function blocks are written in SFC, ST, LD, or FBD. SFC function blocks can have SFC child function blocks. The order in which function blocks appear within their section is not important; function blocks are called from a POU.

When using SFC function blocks and SFC child blocks, you need to specify the maximum number of tokens for each one in their individual properties.

You can move or copy all function blocks to the Programs section and all but the SFC function block to the Functions section. You can also move or copy functions and programs, written with languages supported by function blocks, to the Functions section. When moving or copying a program to the Function Blocks section, all local variables defined in the program are converted to function block parameters.

## Creating POU

You create, i.e., add, POU (programs, functions, and function blocks) in resources while in the link architecture view. You add POU using the main menu or a contextual menu accessed by right-clicking the respective component (Program, Function, or Function Block) within a resource. After having created a POU, you can drag and drop it to a new position in its section, to another section, or to another resource. POU belonging to a same section must have different names. POU names must begin with a letter.

For SFC programs and SFC child programs, you may need to change the SFC dynamic behavior factors for the resource. For details on the SFC dynamic behavior factors, see page 60. For each SFC function block and SFC child block, you may need to adjust the maximum number of tokens.

### To create a POU

1. In the resource window, select the POU component to create.

2. From the Insert menu, choose **Add Program**, then the desired language.

The new component appears at the end of its respective section with its name ready to edit.

3. Type a name for the component.
4. For SFC POUs, do one of the following:
  - For an SFC program or SFC child program, make sure the dynamic behavior factors defined for the resource are sufficient by selecting the resource, then from the Edit menu, choosing Properties, then the Settings tab, then clicking **Advanced Settings**.
  - For an SFC function block or SFC child function block, specify the maximum number of tokens by selecting the block, then from the Edit menu, choosing Properties, then the Settings tab.

## Manipulating POUs

You can move, cut, copy, paste, and delete POUs, with certain exceptions, within their sections, to other sections, and from one resource to another. You can only move or copy POUs between sections supporting the same language. For instance, you cannot move or copy an SFC program or function block to the Functions section.

You can move programs to change their order of execution or to change them to functions or function blocks. You can move functions to change them to programs or function blocks and move function blocks to change them to programs or functions. Changing a function or function block's order within its section has no effect on its execution since it is called.

**Note:** Before manipulating POUs, you should save the changes made to your project.

### To move a POU

1. Select the POU in the resource window.
2. Drag and drop the POU to its new location.



**Note:** You can only move POU's between sections supporting the same language. You cannot move a program (Child SFC or FC) to change its hierarchy level; you can only move it to change its position as a child within the same level. To change the hierarchical level of an SFC or FC program to become a child, see “Changing Hierarchy Level” on page 103.

### **To cut, copy, or paste a POU**

The cut, copy, and paste commands use the clipboard as temporary storage. Once copied (or cut), a POU can be pasted more than once. You can only paste POU's between sections supporting the same language. SFC programs are pasted at the same hierarchical level as the selected program. When copying and pasting POU's having access control, password definitions are retained.

1. In the resource window, select the POU.
2. From the Edit menu, choose **Cut <Ctrl+X>** or **Copy <Ctrl+C>** (or use the contextual menu).
3. Select the new location, i.e. the Program, Function, or Function Block section within the same or different resource.
4. From the Edit menu, choose **Paste <Ctrl+V>** (or use the contextual menu).

### **To delete POU's**

1. Select the POU.
2. From the Edit menu, choose **Delete <DEL>**.

### **To copy POU's from a project to another**

1. In the destination project, create a program having the same name and language as the program in the original project.
2. From the original project directory of the program's resource, copy the *POU\_name.stf* file, then paste the file in the destination project's resource directory.
3. In the destination project, redeclare local and global variables needed for the POU.

## Creating FC Sub-programs




Flow Chart (FC)



Flow Chart (FC) Sub-program

### To create an FC sub-program

You can create FC sub-programs using the main menu options or a contextual menu accessed by right-clicking the FC program component within a resource.

1. In the resource window hierarchy, select an existing FC program .
2. From the Insert menu, choose **Add FC Sub-Program**.

## Creating SFC Child POUs



Sequential Function Chart (SFC)



Child Sequential Function Chart (SFC)

### To create a child SFC POU



You can create child SFC POUs using the main menu options or a contextual menu accessed by right-clicking an SFC POU within a resource.

1. Select the existing SFC POU  in the resource window hierarchy.
2. From the Insert menu, choose **Add Child SFC**.

## Changing Hierarchy Level

You can promote or demote child SFC (FC) POU's, depending on their relative position in the hierarchy.

### To change the level of an SFC (FC) POU

1. Select the SFC (FC) POU.
2. Do one of the following:
  - From the Edit menu, choose **Move to lower Level** or **Move to upper Level**.
  - From the Main toolbar, click  to move the program to a lower level or  to move it to the upper level.

### Example

Consider the following two SFC POU's:



Sequential Function Chart (SFC)



Sequential Function Chart (SFC)

Selecting the second SFC POU and moving it down a level would produce:



Sequential Function Chart (SFC)



Child Sequential Function Chart (SFC)

Selecting the Child SFC POU and moving it up a level would result in:



Sequential Function Chart (SFC)







Sequential Function Chart (SFC)

## Controlling Access to POUs

You can control access to user-defined POUs using a password. When you set a project with the read-only access control, the resources and POUs making up the project are also set to the read-only mode except for those having individual access control. For instance, a POU having its own password remains locked and cannot be viewed without entering its password. When moving or copying a POU using its resources password, the POU retains this password.

The security state of a POU is indicated by its icon color in the resource:

<b>POU Icon Color</b>	<b>Security State</b>
	Yellow. The POU has no access control. All users have read and write access in the POU. In the dictionary view, local variables and parameters are visible and editable.
	Red. The POU is locked. Users not having the POU password cannot access the POU; these users do not have read or write capabilities. In the dictionary view, local variables and parameters are visible but not editable.
	Blue. The POU is in read-only mode. Users not having the resource password can view the POU; these users do not have write capabilities. The read-only mode for the POU is inherited from the resource to which it belongs. In the dictionary view, local variables and parameters are visible but not editable.
	Green. The POU is unlocked. User can access the POU; this user has read and write capabilities. In the dictionary view, local variables and parameters are visible and editable.

**Note:** While in debug mode or performing builds, unlocked POUs as well as POUs having no access control switch to read-only mode. Locked POUs remain locked.

You can build POU's of all security states.

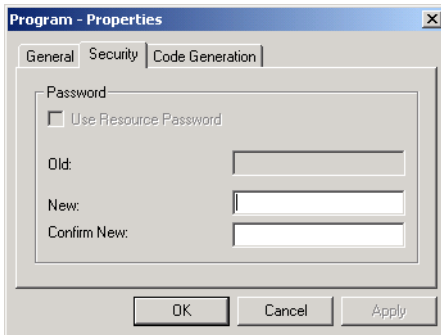
When copying, pasting, importing, and exporting POU's having access control, password definitions are retained.

### To set access control for a POU

You set access control for a POU by setting a password.

1. In the resource window, select the POU for which to set access control.
2. From the Edit menu, choose **Properties**.

The Program Properties window is displayed showing the Security tab.



3. Specify a password:
  - To use a unique password, in the New field, enter a password then reenter it in the Confirm New field.
  - To use the same password as set for the resource to which the POU belongs, check **Use Resource Password**.

## To unlock a POU

When entering a password while in debug mode or performing builds, the POU is only unlocked after stopping the debug mode or when the build is completed.

1. In the resource window, right-click the POU, then from the contextual menu, choose **Enter Password**.
2. In the Security dialog box, enter the password for the POU.

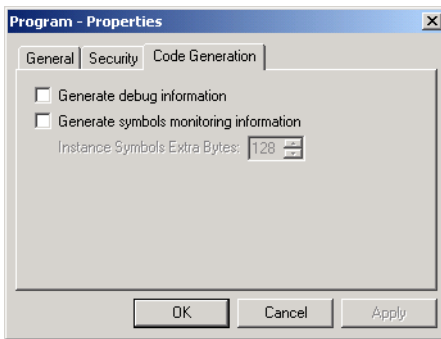


The POU is unlocked.

## Generating Debug and Monitoring Information

You can choose to generate debug and symbols monitoring information for POU's. Debug information is available for ST, IL, and LD POU's (programs, functions, and function blocks) for use when debugging using the step-by-step mode. Symbols monitoring information is available for ST, IL, FBD and LD programs and function blocks for use when debugging or simulating to graphically display the output values of functions and function blocks. For details on the graphical display of output values, see page 295.

You set the generation of debug and symbols monitoring information for a POU on the Code Generation tab of the Program Properties window:



When generating symbols monitoring information for function blocks, you also need to specify the instance symbols extra bytes. This indicates the size of memory reserved for each function block instance for adding symbols monitoring information during online changes. Note that a string-type output takes up 260 bytes.

You can change the default value for the *Generate symbols monitoring information* option as well as the *Instance Symbols Extra Bytes* size. Their values are specified in the *FunctionMonitoringSupportDefault* and *MonitoringSpaceDefault* parameters of the *Settings* section of the *Diamond.ini* file, located in the *Bin* folder. For details on the location of the *bin* folder, see page 29.

The symbols information generated for graphically monitoring output values requires a significant amount of memory space. Therefore, when compiling, an error message stating that the memory limit has been reached may be displayed in the output window. In such a case, to enable compiling, you need to either disable monitoring for the POU, remove elements from the POU, or clean the project.

### **To generate debug information for a POU**

You can also generate debug information for POUs at the resource level.

1. In the resource window, select the POU for which to generate debug information.
2. From the Edit menu, choose **Properties**.

The Program Properties window is displayed showing the Code Generation tab.

3. Check **Generate debug information**.

### **To generate monitoring information for a POU**

1. In the resource window, select the POU for which to generate monitoring information.
2. From the Edit menu, choose **Properties**.

The Program Properties window is displayed showing the Code Generation tab.

3. Check **Generate symbols monitoring information**.
4. For function blocks, specify the size of Instance symbols extra bytes.

## **Editing a POU Description**

You can add a free-format text description for a POU.

### **To edit the POU Description**

1. Select a POU.
2. From the Tools menu, choose **Edit Description**.
3. Edit the description as required.



# Hardware Architecture View



The hardware architecture view graphically displays the configurations of a Project and the network links between them. From the hardware architecture view, you manage many aspects of a project:

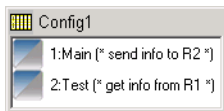
- creating configurations
- attaching targets to configurations
- inserting resources into configurations
- moving resources between configurations
- creating networks
- connecting configurations and networks
- defining configuration connection properties
- defining resource network properties
- setting up I/O wiring

## To switch to the hardware architecture view

- From the Window menu, choose *project\_name*-**Hardware Architecture**.

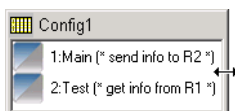
# Configurations

A configuration represents a hardware definition:



When creating a new project, a default configuration is automatically created. Subsequent configurations must be manually inserted.


You can resize configuration windows by placing the cursor over an edge or corner until it shows double arrows and dragging:



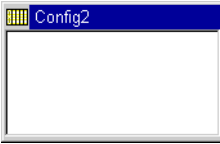
## Creating Configurations

You can create configurations using the main menu or a contextual menu, accessed by right-clicking within the workspace. Following the creation of a configuration, the Configuration Properties dialog box automatically appears where you attach it to a target. Choosing a target leads to the accessibility of network, I/O devices, and RAS device functions and function blocks supported by this target.

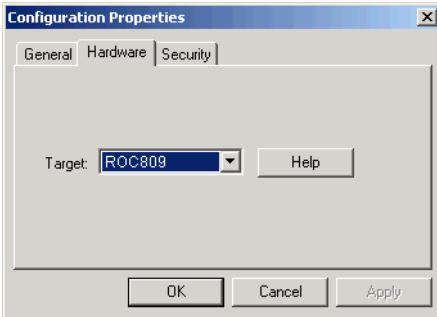
### To create a configuration

1. Switch to hardware architecture View .
2. From the Insert menu, choose **Configuration**.

An empty configuration is created using a default name, then the Configuration Properties dialog box appears:




3. On the Hardware Tab, choose a Target to attach to the configuration:



## Deleting Configurations

You can delete configurations using the main menu or a contextual menu, accessed by right-clicking a configuration's title bar. You cannot delete the last configuration of a project; projects must have at least one configuration.

### To delete a configuration

1. Select the hardware architecture view .
2. Select a configuration.

**Note:** To deselect resources in the configuration window, click an empty space in the configuration window.

3. From the Edit menu, choose **Delete <DEL>**.

## Moving Configurations

When you move configurations, the hardware architecture view is re-drawn to tidy-up the display. Fixed-sized gaps are placed between network and configurations.

### To move a configuration

1. Select the configuration.

The selected configuration's title bar is highlighted.

2. Drag and drop the configuration as desired.

## Inserting Resources

You can choose to insert, i.e., create, resources directly in a configuration while in the hardware architecture view of your project. You can also create resources in the link architecture view. However, in the link architecture, new resources are automatically assigned to the first configuration.

### To insert a resource in a configuration

You can insert resources using the main menu or a contextual menu, accessed by right-clicking the empty space in the configuration's window.

1. Select a configuration.
2. From the Insert menu, choose **Resource**.

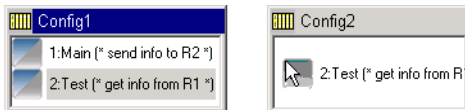
## Moving Resources Between Configurations

When moving resources from one configuration to another, you need to make sure several aspects of the destination configuration are compatible with those of the source configuration:

- Network Information, when both configurations are connected to the same networks, resource information remains intact. Otherwise, you will need to change the binding network information for the moved resource.
- C function or C function block calls, when the list of available C functions or function blocks is different for both configurations, when proceeding to build the resource, some errors may occur when the functions called do not point to the functions declared in the target.
- I/O Wiring, when the I/O device list is different for both configurations, the I/O wiring of the moved resource is deleted.

### To move a resource from one configuration to another

1. Click and hold the mouse button on the required resource.
2. Drag and drop the resource to the new configuration.



## Configuration Properties

Configuration properties are defined from the hardware architecture view.

### To access the Configuration Properties window

1. From the Window menu, choose *project\_name*-**Hardware Architecture**.

The hardware architecture view appears displaying all configurations defined for a project.

2. Select a configuration.
3. From the Edit menu, choose **Properties**.

The Configuration Properties window appears.

## Configuration Link to ROCLINK Configuration File

The configuration general properties enable you to assign a meaningful name to a configuration and link the configuration to a ROCLINK 800 configuration file. You need to link a configuration to a ROCLINK 800 configuration file before defining TLP variables in the dictionary. When the configuration is linked to a configuration file, the name and location of the configuration file is automatically entered in the Comment field. Comments appear within (\* \*) next to the name of the configuration in its title bar.

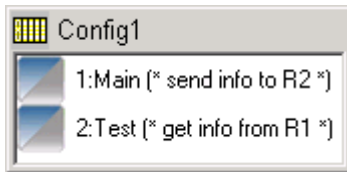
**Note:** The ROCLINK 800 Configuration Software must be installed on the same computer running the DS800 Workbench.

You can choose to replace the configuration representation in the hardware architecture view with a custom bitmap by checking the Use bitmap option, then browsing to locate the bitmap.

Standard Configuration Representation

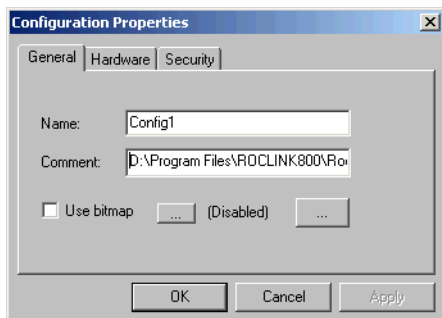
Sample Bitmap Representation

---




When using a custom bitmap for configurations, a copy of the bitmap is automatically placed in the configuration folder and renamed to use the configuration's name.

You specify the configuration general properties in the General tab of the Configuration Properties window:



### To link a configuration to a ROCLINK 800 configuration file

1. Click  .
2. In the *Select ROCLINK 800 Configuration File* browser, locate the configuration file to link.
3. Click **Open**.

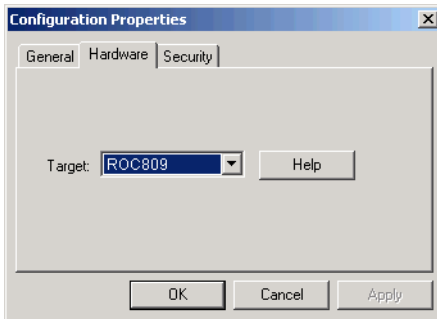
DS800 extracts the IP address of the RAS device target from the ROCLINK 800 configuration file and automatically creates the network connection. The configuration file name and location is indicated in the Comment field.



## Configuration Target Definitions

The configuration target definition property enables you to attach a target to the configuration. Changing targets for a configuration affects all resources attached to the configuration.

You specify the configuration target definition property in the Hardware tab of the Configuration Properties window:



The selection of the target determines:

- the network on which you can connect the configuration and that can be used in Binding definition.
- the I/O devices that you will be able to use in the I/O Wiring Tool
- the list of C functions and function blocks that you will be able to call in your programs.

**Warning:** Changing the target of a configuration may lead to the destruction of the I/O wiring of all resources within the configuration and connections to networks. You should assign targets to configurations as a first step in your project development.




When the advanced options are installed, you can choose whether to download the advanced options features such as alarms and events definitions, trends definitions, events server configuration, and trends server configuration.

You can also choose to add a help file using the Help button.

## Target Access Control

For configuration security, you can control access to a target by setting a password. This password is embedded on the target and can only be set or changed while running in real-time or debug mode. The configuration access control prevents the connection of all IXL clients not having the target's password.

At run time, the security state of a configuration is indicated by its title bar icon:

Configuration Icon	Security State
	The configuration has no access control. All IXL clients can access the target.
	The configuration is not accessible; the target does not recognize the password. IXL clients not having the target password cannot access the target.
	The configuration is accessible; the target recognizes the password. IXL clients having the target password can access the target.

### To specify access control for a configuration

You set access control for a configuration in the configuration's Security properties.



- ▶ In the Password field, enter the password for the configuration, then reenter the password in the Confirm Password field.

**Note:** You can only change a password while in real-time or debug mode. Otherwise, the password embedded on the target remains unchanged.

## **Configuration Description**

A free-format text description of the configuration.

### **To edit the configuration description**

1. Right-click on the configuration title bar.

The contextual menu appears.

2. Choose **Edit Description**.
3. Edit the description as required.

## Networks

Networks provide the means for communication between configurations. Configurations need to communicate when bindings have been defined within them. Configurations are connected to the network. The target attached to the configuration must support the network the configuration is connected to. You define network properties when you create them.

When you create DS800 projects, networks are automatically inserted.

Networks are represented in the hardware architecture view as a horizontal 'bar':



Name

### Notes:

- A project can contain an unlimited number of networks.
- If the network is not implemented in the target, it is the responsibility of the integrator to develop and implement a driver for that particular network. Creating a Network.
- The default network is ETCP.
- ISaRSI is only used to connect the Workbench to the RAS device target. ISaRSI does not support projects with multiple configurations.


## Creating Networks

You define network properties at the time of creation. You need to specify the protocol (also called Network Driver) to use for communications between configurations when bindings are defined. The parameters defining the network appear in the grid. Some parameters may be read-only (greyed). Not all networks require parameters at this level, e.g., ETCP for Ethernet.

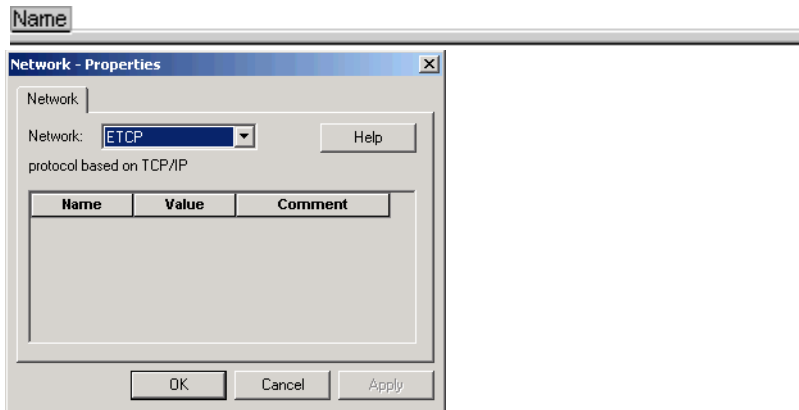
When you create DS800 projects, networks are automatically inserted.

You can choose to integrate help using the Help button.

## To create a network

1. Switch to the hardware architecture view .
2. From the Insert menu, choose **Network**.

A new Network is created and the Network Properties dialog box from which you select a protocol. The available protocols are ETCP and ISaRSI.



**Note:** ISaRSI is only used to connect the Workbench to the RAS device device. ISaRSI does not support projects with multiple configurations.

## Moving Networks

The Network can be moved vertically within the workspace. This facility is simply a method of providing a preferred view for the user, usually the default view is preferred.

### To move a network

1. Select the network.

The selected network is highlighted.

2. Drag and drop the network as required.

**Note:** The hardware architecture view is re-drawn to 'tidy-up' the display. Fixed-sized gaps are placed between network and configurations.

## Connections

Connections between networks and configurations enable communications to flow. DS800 automatically creates connections when creating projects. When you link a configuration to a ROCLINK 800 configuration file, the IP address is automatically assigned. A configuration can be linked to many networks. Similarly, a network can be linked to many configurations.



## Creating Connections

When creating a connection, make sure to not select the configuration or network. Click elsewhere in the workspace to deselect these items. In the connection's properties, you need to specify the IP address of the target, for example:

192.168.2.36

**Note:** DS800 automatically creates connections when creating projects. When you link a configuration to a ROCLINK 800 configuration file, the IP address is automatically assigned.

The list of available parameters depends on the network to which the configuration is connected. This list may be empty. Some parameters may be read-only (displayed greyed). For the ETCP (Ethernet) network driver, only the IP address of the configuration is required.

**Note:** A connection may fail if the network protocol is not supported by the configuration's target.

## To connect a configuration and network

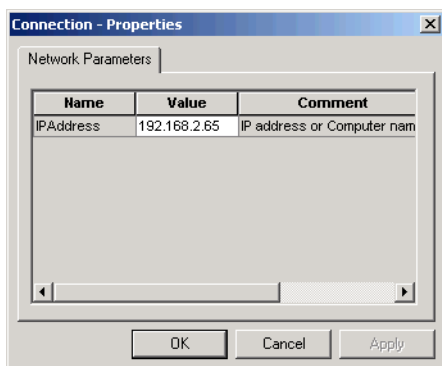
1. Click and hold the mouse button on the title bar of the configuration to connect.

The mouse becomes a network connection cursor:



2. Drag and drop the mouse cursor to the required network.

The connection is created and the Connection Properties dialog box is displayed.



3. In the Value field, enter the IP address, then click **OK**.

## Deleting Connections

You can remove existing connections between configurations and networks.

### To delete a connection between a configuration and network

1. Select the connection.
2. Do one of the following:
  - From the Edit menu, choose **Delete Connection**.
  - Press **Delete**.



# Dictionary View



The Dictionary is an editing tool using tree views and grids for the declaration of the variables, functions, and function block parameters, user types and defined words of the project.

The various components are sorted in a tree-like hierarchy, e.g., by resource or by Type. The Tree name is displayed on the window title bar. The four dictionary tree views are:



Variables Tree



Parameters Tree



Types Tree




Defined Words Tree

**Note:** You need to declare variables before proceeding with the I/O Wiring process.

## To switch to the Dictionary view


- ▶ Do one of the following steps:
  - From the Project menu, choose either **Types**, **Variables**, **Function/Function Block Parameters**, or **Defined Words**.

**Note:** The choices available differ depending on whether you are in the hardware architecture or link architecture views.

- On the Window Buttons toolbar, click .
- Open a variable group.

## To switch to the Dictionary view from a language editor

Opening the Dictionary from an Editor opens the Variable Tree and grid for the POU being edited.

- ▶ Do one of the following steps:
  - From the File menu, choose **Dictionary**.
  - On the Standard Buttons toolbar, click .

## Appearance

The Dictionary view is displayed maximized in the workspace. The menus and toolbar now reflect Dictionary options only.

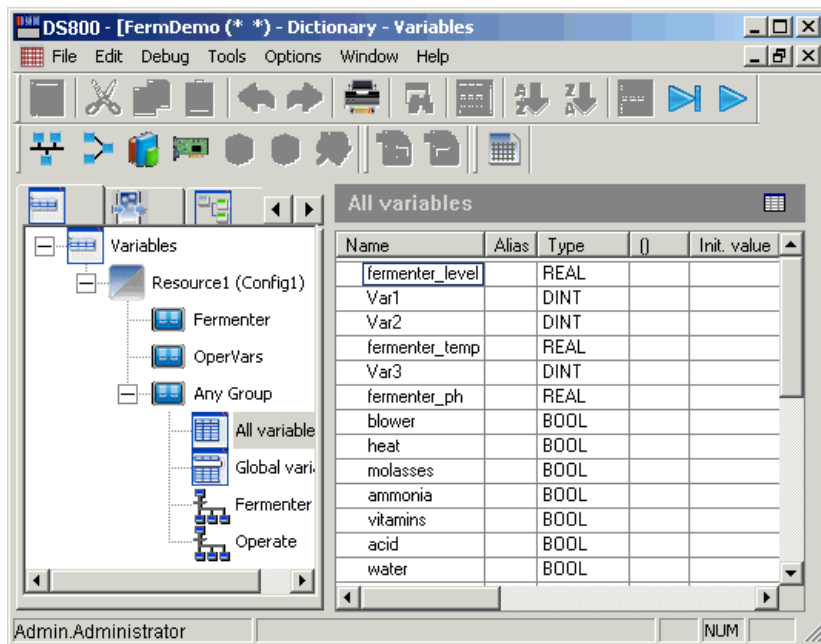
The left of the dictionary workspace is a tree-like hierarchical structure of either variables, parameters, types, or defined words. The right side of the workspace displays a grid-like table.

Titlebar

Menu Bar

Toolbars

Workspace



Status Bar

# Variables Tree

The branches provide different ways to access the variables of each resource:



Top Level



Resources



Variable Group

Grid displays only variables in that group.



Any Group



All Variables

Grid contains all variables in the resource



Global Variables

Grid contains all global variables



Programs

Grid contains global variables and variables local to the program



Functions

Grid contains global variable and variables local to the function

**Note:** When the cursor is positioned over an item, the full name and comments are displayed in the ToolTip.

# Parameters Tree

The branches in each resource show all functions and function blocks, in order to define their parameters in the corresponding grid.



Top Level



Resources



Functions



Function

Grid displays the parameters of the function



Function Blocks



Function Block

Grid displays the parameters of the function block

**Note:** When the cursor is positioned over an item, the full name and comments are displayed in the ToolTip

# Types Tree

The various tree levels are represented using the following icons:



Top Level



Arrays



Structures

Level



Structures

Individual Structures

When the cursor is positioned over an item, the full name and comments are displayed in the ToolTip.

Types have a Common Scope, they can be used as a type or any variable of any resource.

## Creating Structures

### To create a structure

1. Right-click on the 'Structures' top of tree.
2. From the Edit menu, choose **Add Structure**.

A structure has been created at the end of the tree. Its name is displayed and ready for editing.

**Note:** In addition to a name, you can include a comment, e.g., StructName (\* comment \*).

## Renaming Structures

You can rename a structure using the main menu or a contextual menu, accessed by right-clicking a structure.

### To rename a structure

1. Right-click on the structure to rename.
2. From the Edit menu, choose **Rename Structure**.
3. Enter a name and comment in the dialog box.

## Deleting Structures

You can delete structures using the main menu or a contextual menu, accessed by right-clicking the structure.

### To delete a structure

1. Select the structure in the tree.
2. From the Edit menu, choose **Delete Structure**.

## Defined Words Tree

There is no Tree for defined words, these are entered in the grid. Defined words have a Common Scope, they can be used in any POU of any resource. For information on the Defined Words grid, see page 145.

## Working with the Grids

Grids display characteristics and values for components corresponding to the selected Tree View. You create, manipulate, and make changes for variables, functions, and function block parameters, user types and defined words directly in the grids. The grid is a table formatted database. You can use one of two editing modes while working in the grids:

- Grid, where you can access individual cells. In this mode, a grid outlines individual cells:

Name	Alias	Type	()	Init. value
⊕ din		BOOL		

- Line, where you can access complete rows, i.e., lines. The information contained in the line appears in a dialog box where you can change it. In this mode, no grid appears:


Name	Alias	Type	()	Init. value
⊕ din		BOOL		

Keyboard shortcuts enable navigating throughout the grid. The behavior of the shortcuts differs depending on the editing mode of the grid.

Shortcut	Grid Mode	Line Mode
Tab	Moves from one grid cell to the next from left to right. When editing the contents of a cell, the edition mode is retained in the next cells.	Moves from one line to the next from top to bottom
Shift+Tab	Moves from one grid cell to the next from right to left. When editing the contents of a cell, the edition mode is retained in the next cells.	Moves from one line to the next from bottom to top
End	Moves to the bottom of the variables list	Moves to the line at the bottom of the variables list
Home	Moves to the top of the variables list	Moves to the line at the top of the variables list

**Note:** When defining TLP variables, you need to set the variables grid to the line editing mode.

### To switch editing modes

- ▶ Directly above the grid, click .

## Resizing Columns

You can resize columns or rows.

### To resize a column (or row)

1. Click and hold a cell header divider:

Name	Alias	Type	()	Init. value
		BOOL	0	

2. Drag and drop it as required (drag to the left in the above example to shrink the Name column).

## Selecting Rows and Elements

You can select either rows or individual cells in the grid depending on the selected editing mode:

### To select rows

- ▶ While in the Line editing mode, click on the row.
- ▶ While in the Grid editing mode, click the left-most edge of the row.

### To select items in the grid

While in the Line editing mode, you can select one or more items in the grid.

1. To select a single item, click the item.
2. To select more than one consecutive item, click the first item, then while holding down the <SHIFT> key, click the last one.

All the elements between the first and last are selected.

3. To select many individual items, click each one while holding down the <Ctrl> key.



## Editing the Contents of the Grid

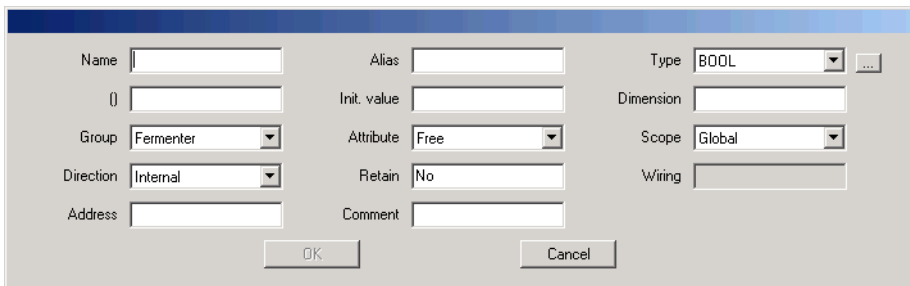
You can edit the contents of individual cells or complete rows depending on the selected editing mode. **To edit the contents of a cell**

- ▶ While in Grid mode, double-click an element within the row.

### To edit the contents of a row

1. While in Line mode, double-click a row.

The variable dialog is displayed.



The image shows a variable dialog box with the following fields and controls:

Name	<input type="text"/>	Alias	<input type="text"/>	Type	BDDL <input type="button" value="..."/>
()	<input type="text"/>	Init. value	<input type="text"/>	Dimension	<input type="text"/>
Group	Fermenter <input type="button" value="v"/>	Attribute	Free <input type="button" value="v"/>	Scope	Global <input type="button" value="v"/>
Direction	Internal <input type="button" value="v"/>	Retain	No <input type="text"/>	Wiring	<input type="text"/>
Address	<input type="text"/>	Comment	<input type="text"/>		
		<input type="button" value="OK"/>		<input type="button" value="Cancel"/>	

2. Make the necessary changes to the variable fields. For the Type field, you can also access the Select Data Types browser by clicking  .

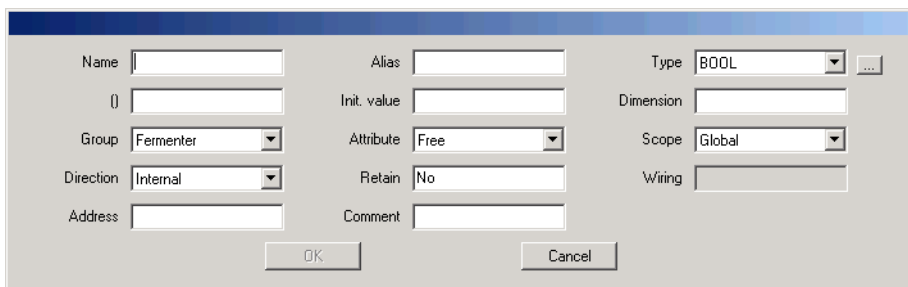
## Adding or Inserting Rows

You can edit the contents of existing rows, add rows at the end of the grid, or insert rows at a specific location in the grid. You can perform these tasks from the main menu or a contextual menu, accessed by right-clicking in the grid.

### To add a row

- ▶ From the Edit menu, choose **Add Row**.

The grid dialog box appears:



Name	<input type="text"/>	Alias	<input type="text"/>	Type	<input type="text" value="BOOL"/> ...
()	<input type="text"/>	Init. value	<input type="text"/>	Dimension	<input type="text"/>
Group	<input type="text" value="Fermenter"/>	Attribute	<input type="text" value="Free"/>	Scope	<input type="text" value="Global"/>
Direction	<input type="text" value="Internal"/>	Retain	<input type="text" value="No"/>	Wiring	<input type="text"/>
Address	<input type="text"/>	Comment	<input type="text"/>		

Some fields have pull-down menus, showing the options available for that field. The Type field also enables access to the Select Data Types browser.

**Note:** The group name is automatically asserted when a variable group is selected in the Variable Tree.

### To insert a row in the grid

1. Select a row in the grid.
2. From the Edit menu, choose **Insert Row**.

When the Line editing mode is selected, a row is inserted in the grid. When the Grid editing mode is selected, grid dialog box appears.

## Moving Rows

You can change the position of a variable or a parameter in the grid, by dragging the line to a new position.

**Note:** You cannot undo row-moving operations.

## Expanding or Collapsing Grid Components

Variables with user types (Arrays and Structures) are initially displayed 'collapsed', i.e. only the variable definition row is displayed, with a + sign in the row header cell. Clicking on the row header cell expands or collapses that variable.

For example, the variable `In1` of type `arr1`, where `arr1` is defined in the Dictionary as an Array of `[1..3]` Booleans, is initially displayed as:

+	in1		None	Arr1		Free	Gk
---	-----	--	------	------	--	------	----

When expanded, the complete definition of `in1` is shown:

-	in1		None	Arr1		Free	Gk
	in1[1]			BOOL			
	in1[2]			BOOL			
	in1[3]			BOOL			

## Cutting, Copying, and Deleting Elements

You can cut, copy, or delete either rows or individual cells in the grid depending on the selected editing mode. The Cut command removes selected elements and places them on the clipboard. The Copy command places the selected item on the clipboard. The clipboard holds only one item at a time.

### To cut elements

1. Select an element.
2. From the Edit menu, choose **Cut <Ctrl+X>**.

### To copy elements

1. Select an element.
2. From the Edit menu, choose **Copy <Ctrl+C>**.

### Deleting elements

- ▶ Select an element then press **Delete**.

## Finding and Replacing Elements

You can search for and replace elements in the grid. , however, you can only replace the following elements in the respective grids:

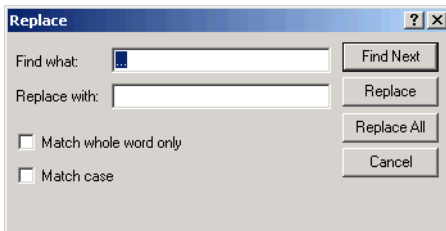
Variables	Parameters	Types	Defined Words
Name	Name	Name	Word
Alias	Short Name	()	Equivalent
()	Comment	Comment	Comment
Init.Value	()		
Dimension	Dimension		
Address			
Comment			

To differentiate between upper and lower case characters during a search, check **Match Case**.

### To search or replace an element (a character, word or phrase):

1. From the Edit menu, choose 'Find / Replace' <Ctrl + F>.

The Find / Replace dialog is displayed.




2. To search for an element, in the Find what field, enter the element to search for, then click **Find Next**.
3. To replace an element, in the Replace with field, enter the element, then click **Replace**. To replace all occurrences of the element, click **Replace All**.

## Pasting Elements

You can paste the contents of the clipboard above the currently selected row(s), if one or more rows have been copied or cut.

### To paste

1. Click on the required insertion point.
2. From the Edit menu, choose **Paste** <Ctrl+V> or on the Standard toolbar, click  ..



OR

1. Right-click the required insertion point.
2. From the contextual menu, choose **Paste**.

## Sorting the Grid

You can sort the contents of individual columns of the grid from the main menu, from the toolbar, or by clicking the individual column headers.


### To sort the grid

1. Do one of the following:
  - From the Tools menu, choose **Sort Ascending** or **Sort Descending**.
  - On the toolbar, click  to sort in an ascending manner or  to sort in a descending manner.
2. In the Sorting dialog box, choose the criteria (column) to use for sorting, then click **OK**.

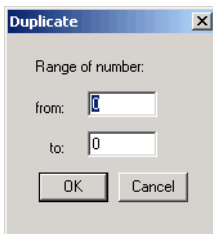
## Duplicating Rows

You can duplicate rows, automatically generating sequentially numbered 'name' copies.

### To duplicate a row

1. Select the row to Duplicate.
2. Do one of the following:
  - From the Tools menu, choose **Duplicate <Ctrl+U>**.
  - On the Standard toolbar, click .

The Duplicate dialog box is displayed:



3. Enter the From and To numbers to use for the automatic generation of names.
4. Click **OK**.

The newly created rows are inserted below the selected row.

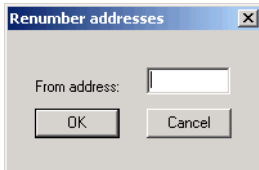
## Renumbering Addresses

Renumbering addresses automatically generates contiguous addresses within a selected range of the grid. Renumbering is only available in the variables grid. When renumbering, certain cells such as a function block instances are ignored since they have no address.

The reduced symbol table contains the set of variables with addresses.

### To renumber addresses

1. Select the rows to renumber their address
2. From the Tools menu, choose **Renumber Addresses**.



3. In the Renumber Addresses dialog, enter the 'From Address' (hexadecimal value ranging from : 1 to FFFF).
4. Click **OK**.

### Example

- If A1 is entered as a Start Address, A1, A2, A3, A4... are generated.
- If AA is entered as a Start Address, AA, AB, AC, AD... are generated.



## Printing a Grid

You can choose to print the current grid. This command launches the Document Generator with the standard list of elements to be printed for a grid. For information on the Document Generator, see page 337.

### To print the current grid

- From the File menu, choose **Print**.

# Variables Grid

The variables grid allows the definition of variables for each resource created in the project.

The columns of the variables grid are:

Column	Details
Name	Variable name: limited to 128 characters, conforming to the IEC 61131 standard
Alias	Any name. Used in LD Editor
Group	Group name or "None"
Type	BOOL, SINT, USINT, BYTE, INT, UINT, WORD, DINT, UDINT, DWORD, LINT, ULINT, LWORD, REAL, LREAL, TIME, DATE, STRING, Array Types, Structure Types, Function Blocks. See Glossary.
( )	if Type is STRING this represents the string length (max. 255 characters)
Dimension	For example: [1..4,1..7]. See Glossary.
Attribute	For example: READ-ONLY. See Glossary.
Scope	Global or local to a program or function. see Glossary.
Direction	of I/O Wiring; Input, Output or Internal.
Init.value	Numeric or Textual. See Glossary.
Wiring	Read-only cell, generated by the I/O Wiring tool. Uses syntax of Directly Represented Variable
Comment	User comments: Free format
Retain	Yes or No. See Glossary and Resource Settings Properties.
Address	Hexadecimal value in the range 1 to FFFF.

## Parameters Grid

The Parameters grid defines the interface of the functions and function blocks created in the project resources. The columns for parameters are:

Column	Details
Name	Parameter name: Limited to a maximum of 128 characters and must conform to the IEC 61131 Standard.
Short Name	Short name used in the FBD and LD Editors for display only (max. 4 chars).
Type	BOOL, SINT, USINT, BYTE, INT, UINT, WORD, DINT, UDINT, DWORD, LINT, ULINT, LWORD, REAL, LREAL, TIME, DATE, STRING, Array Type, Structure Type, Function Block Type. see Glossary
( )	If Type is STRING, ( ) is the length (max. 255 chars).
Dimension	Example [1..4,1..7] for a two dimensional Array. see Glossary
Direction	Input Parameter, Output Parameter or Local
Comment	User comments: Free format

**Note:** Parameters are sorted within the database; "Input", then "Output", then "Local". Functions have only one output parameter which must be a simple type (i.e., no arrays or structures). Function block instances can only be defined as local parameters of function blocks. To call a function block in a function block (nested function blocks), you may create the instance of the called function block as a local parameter of the calling function block. This enables you to spy the local parameters of the called block .

# Types Grid

In the Types grid, you create complex types that will then be available for variable declaration, i.e., new types will appear in the 'Type' selection in all grids. The columns for types are:

- Arrays:

Column	Details
--------	---------

Name	Array name: maximum 128 characters, conforming to the IEC 61131 Standard
Element Type	Array Element Type: BOOL, SINT, USINT, BYTE, INT, UINT, WORD, DINT, UDINT, DWORD, LINT, ULINT, LWORD, REAL, LREAL, TIME, DATE, STRING, User Arrays, Structures
( )	If Type is STRING, this represents the length (maximum 255 characters)
Dimension	Example: [1..10] for a one dimensional Array, [1..4,1..7], for a two dimensional Array. The dimension must be defined as a positive double integer (DINT) value.
Comment	User comments: Free format

- Structures:

Column	Details
--------	---------

Name	Element name: maximum 128 characters, conforming to the IEC 61131 Standard
Element Type	Element Type: BOOL, SINT, USINT, BYTE, INT, UINT, WORD, DINT, UDINT, DWORD, LINT, ULINT, LWORD, REAL, LREAL, TIME, DATE, STRING, User Arrays, Structures
( )	If type is STRING, this represents the length (maximum 255 characters)
Comment	User comments: Free format

**Notes:**

- To create a structure with an element with a dimension, first create an array, then create a structure with an element of type <Array name>.
- Type recursive use is not allowed, e.g., one field of 'str1' cannot use the 'str1' type

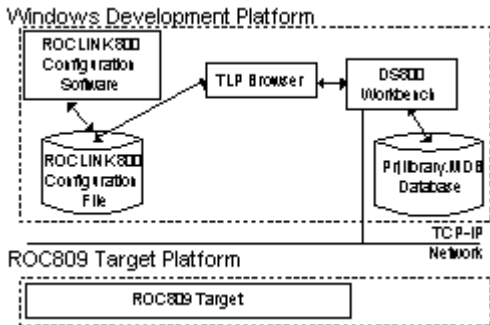
## Defined Words Grid

The columns for defined words are:

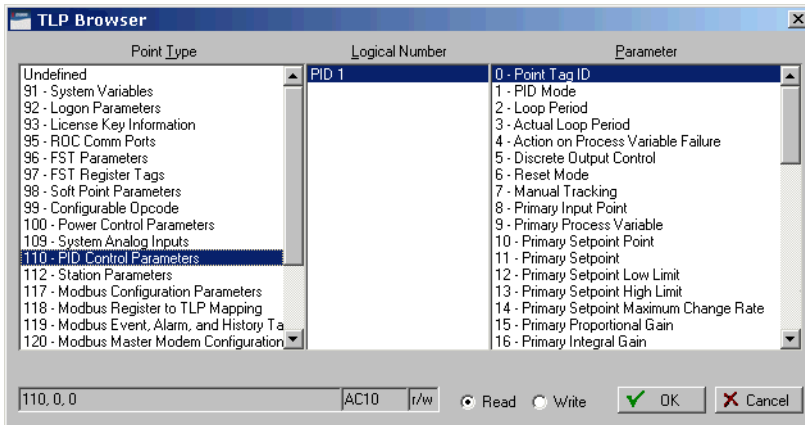
<b>Column</b>	<b>Details</b>
Word	Name used in ST source files: first character must be a letter, following characters must be letters, digits or underscore ( '_' ).
Equivalent	String according to ST syntax, that replaces the defined word during compiling. Example: Word = PI, Equivalent = 3.14159
Comment	User comments: Free format

## Defining TLP Variables

The TLP browser enables the selection of TLP numeric point locations from the **ROCLINK 800** configuration file for use as TLP variables in the DS800 environment. Before defining TLP variables, you need to link the configuration to a ROCLINK 800 configuration file and set the configuration target definition property to the applicable RAS device target. DS800 automatically performs the wiring from defined TLP variables to TLP devices. Each TLP variable is assigned a TLP device.



In the TLP browser, you select three parameters to define point locations:



- Point Type (T) - The point type opens a list of logical numbers and parameters belonging to that Point Type.

- Logical Number (L) - In the configuration screens, the Logical Number is generally referred to as Point Number or Number.
- Parameter (P) - These are usually called by the same term as the Tag on the configuration screen.

The display field at the bottom left of the TLP browser displays the numeric point location of the TLP point and its data type as well as the point's read/write attribute. You also set the read/write attribute of the TLP variable for the DS800 Workbench.

The **ROCLINK 800** data types are matched to the corresponding DS800 data type:

#### Correspondence of Data Types

<b>ROCLINK 800</b>	<b>DS800</b>
FL	REAL
UINT8	DINT
UINT16	DINT
INT16	DINT
UINT32	DINT
ACx	STRING(x)
TIME	STRING(22)
TLP	tlpAddress
HOURMI	DINT
BIN	DINT
Softpoint	Softpoint

In the dictionary, the Comment field indicates the TLP numeric point definition and location


DS800 automatically generates the correct wiring for TLP variables entered in the dictionary. When a TLP variable is deleted from the dictionary, its assigned device is also deleted. Also, when a TLP device is deleted, its wired TLP variable is also deleted. When importing TLP variables, the automatic wiring is not executed.

When selecting a Softpoint Parameter point type with the 0 parameter, the TLP variable has the Softpoint structure type. For a Softpoint structure, you may need to disable the write permission for its individual fields; by default, Softpoint structure fields have the write permissions.

To disable the write permission for a structure field, in the I/O wiring view, select the corresponding field, then in the I/O Parameter dialog, set the parameter's field to FALSE.

### **To define TLP variables in the dictionary**

You access the TLP browser from the dictionary's variables grid while in the line editing mode.

1. Select a row in the variables grid, then from the Edit menu, choose **Add Row**.
2. In the grid dialog, click  .
3. In the TLP browser, to define the point location, select the point type, logical number, and parameter, then indicate the read/write permissions for the device assigned to the TLP variable and click **OK**.

The TLP variable's attributes are displayed in the grid dialog.

4. To enter the TLP variable in the variable grid, click **OK**.

When you save changes in the dictionary, DS800 automatically performs the wiring from the TLP variable to a TLP device. The assigned TLP device's directly represented variable naming is displayed in the Wiring field of the variable grid.

### **To disable the write permission for a Softpoint structure field**

1. In the dictionary's Wiring field, identify the TLP device index to which the Softpoint structure is wired.

The TLP device index is indicated in the directly represented variable naming used in the Wiring grid of the dictionary's variable grid. For example, the %QU19.0 means that the TLP device index is 19.



2. In the I/O Wiring view, locate and expand the TLP device having the corresponding index.

The TLP device index is the number appearing at the left in a device's name. In the following example, the device index is 19:

19:DS800:TLP:TLP\_SOFT\_POINT\_WRITE(\* \*)

3. Expand the Parameters element, then double-click any field.
4. In the I/O Parameters dialog, locate the field for which to disable the write permission, then set its Value to FALSE.
5. Click **OK**.

The selected SoftPoint structure field's write permission is disabled.

## Initial Values

Initial values can only apply to variables. If no initial value is entered in the variables grid, a value of 0 (or FALSE) is used by default.

The initial values are:

Variable	Default	Possible Values
BOOL	FALSE	TRUE or FALSE
SINT	0	any other short integer value
USINT	0	any other unsigned short integer value
BYTE	0	any byte value
INT	0	any other integer value
UINT	0	any other unsigned integer value
WORD	0	any other word value
DINT	0	any other double integer value
UDINT	0	any other unsigned double integer value
DWORD	0	any other double word value
LINT	0	any other long integer value
ULINT	0	any other unsigned long integer value
LWORD	0	any other long word value
REAL	0.0	any other float value (not double). Scientific format 1.2E+10 can be entered
LREAL	0.0	any other float value. Scientific format 1.2E+10 can be entered
TIME	t#0s	any other timer value using the following syntax: t#WhXmYsZms or t#Z  0 <= W: number of hours 0 <= X: number of minutes 0 <= Y: number of seconds 0 <= Z: number of milliseconds <b>Note:</b> The h, m, s, and ms fields are optional. If t#100 is entered, it corresponds to t#100ms.

DATE	d#1970-01-01	any other date value ranging from 1970-01-01 to 2038-01-18 using the following syntax: d#yyyy-mm-dd
STRING	empty	any set of characters contained within single quotes, for example, 'hello'
Array initialization	0 or FALSE	you need to initialize each element of an array*
Structure initialization	0 or FALSE	you need to initialize each field in a structure*

\* When initializing the values of elements for arrays or structures, the total number of characters, including commas automatically inserted to separate the initial values defined for each element, cannot exceed 482. In the Dictionary window, the Initial Value field at the root of the array or structure displays this cumulation.

All variables					
Name	Alias	Type	()	Init. value	Dimensi...
Temperature		DINT		1,2,3,2(4),5,10,75,45,175,25,86,32,5000	[1..25]
Temperature[1]		DINT		1	
Temperature[2]		DINT		2	
Temperature[3]		DINT		3	
Temperature[4]		DINT		4	
Temperature[5]		DINT		4	
Temperature[6]		DINT		5	
Temperature[7]		DINT		10	
Temperature[8]		DINT		75	
Temperature[9]		DINT		45	
Temperature[10]		DINT		175	
Temperature[11]		DINT		25	
Temperature[12]		DINT		86	
Temperature[13]		DINT		32	
Temperature[14]		DINT		5000	

### To initialize the elements of an array

You initialize an array one element at a time.

1. Set the dictionary to grid mode.
2. Expand the array by clicking the '+' sign.
3. Double-click the array element's Init Value column.
4. Enter a value corresponding to the element type.

### **To initialize the fields of a structure**

The first line, with the structure's name, displays the list of each field's values. You initialize a structure one field at a time.

1. Set the dictionary into the grid mode.
2. Expand the structure by clicking on the '+' sign.
3. Double-click on the structure field, in the 'Initial Value' column.
4. Enter the value that corresponds to the field's type.

The first line, with the structure's name, displays the list of field's values. The parenthesis display a list of values that correspond to the array's elements.

## Validation

Validation is performed at all levels of input and use of the grid.

When an error is detected, a message box with an error description appears.

### Cell-level Validation

The system processes cell-level validation:

- IEC 61131 compliance checks of:
  - Variable, Array and Structure names
  - Dimensions
  - Initial values
  - Text length (for example, Comments, Alias)
- Variable, Array, and Structure names cannot be the same as Reserved Keywords
- Validity and range checks of Addresses

### Row-level Validation

The system validates the rows (records) at grid-level. When editing a row, the system checks:

- Retain variables cannot be Input/Output
- If Type is not of type String, the "(" column must be empty Direction checks:
  - Internal: Wiring must be empty
  - Input: Wiring must begin with %I
  - Output: Wiring must begin with %Q

- Attribute checks:
  - Can only be "Read-only" for Inputs
  - Can only be "Write" or "Free" for Outputs
- Inputs cannot have an initial value
- Retain variables cannot have an initial value

## **Database-level Validation**

The system validates the database. When saving, the system checks:


- IEC 61131 functions have one (and only one) Output parameter, named as the function
- Function and function block parameter names are not duplicated
- Parameters are ordered (Input then Outputs)
- Variable names are not duplicated within a resource
- Local variable names:
  - are not duplicated within a POU
  - do not have the same name as a global variable
- within a Structure, a field is not repeated
- the Maximum number of function and function block parameters respects target capabilities

# I/O Wiring View

I/O wiring enables you to define links between the variables defined in a project and the channels of the devices existing on the target system. Wiring is performed at the resource level, therefore, I/O wiring is only available when a resource is selected in either the link architecture or hardware architecture views and when a target has been attached to the current configuration.

After creating variables in the Dictionary, you perform I/O wiring in the I/O wiring tool by adding I/O devices, setting device parameters and I/O filters, then wiring the channels of the devices to variables in the grid. You can also define the mapping of logical channels to physical channels.

## To open the I/O wiring tool from the link or hardware architecture view

1. Select a resource.
2. Do one of the following:
  - From the Project menu, choose **I/O wiring**.
  - On the Window Buttons toolbar, click  .

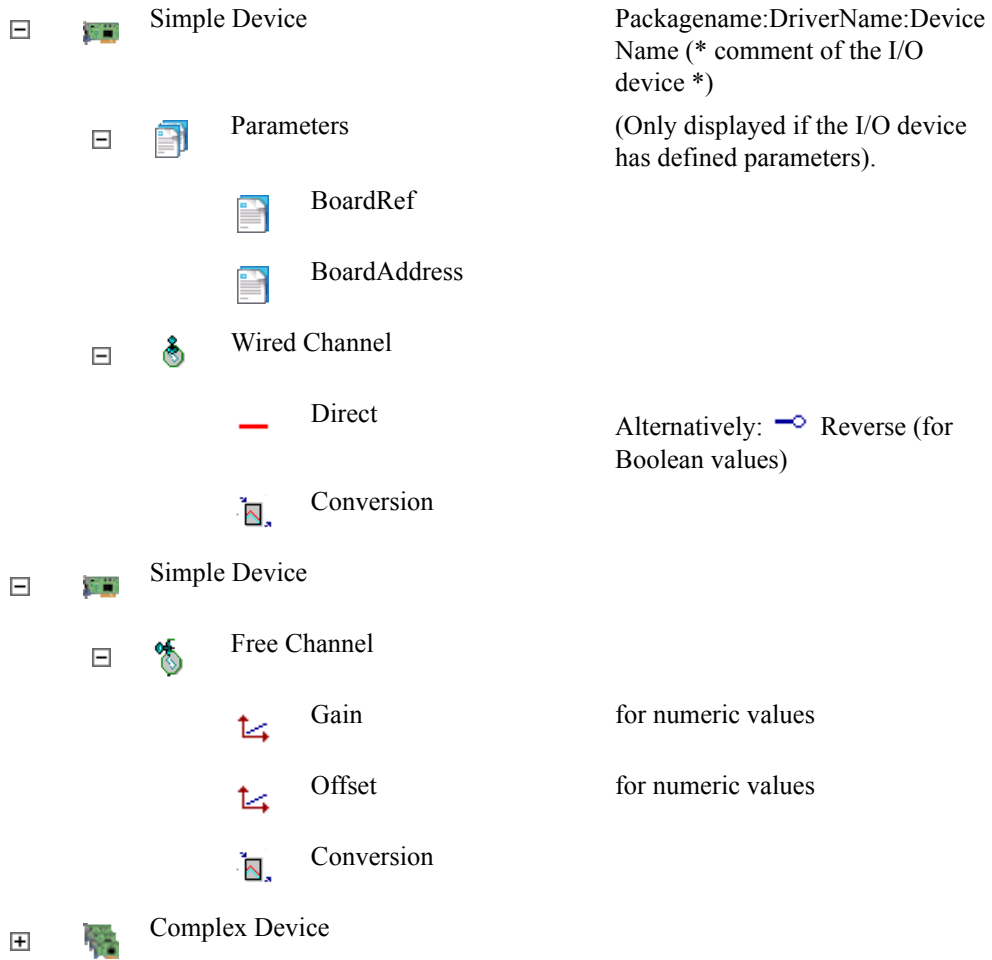
## To open the I/O wiring tool from the link architecture view

- ▶ Within a resource window, open the parameters component, then the I/O wiring component.





## I/O Wiring Tree View



When a device has been added, you can use Direct Variable Representation (%IX1.1) to access IO values. This syntax is shown in the Tree. You can also wire variables that you have already declared in the Dictionary to the device channels, and use these Variable names in your programs to access channel values. The diagram above shows examples of certain simple devices in the I/O Wiring Tree view.

## Parameters

- Double-click on any parameter in the tree to open a dialog box that allows you to modify its value.

## Direct/ Reverse

For a boolean IO channel, you can switch between the original value (direct) or its negation (reverse). Simply double click on 'Direct' or 'Reverse' to swap from one choice to another.

## Gain/Offset

For a numerical channel, you can apply a gain and an offset to a channel value.

For inputs, the original value (coming from the input device) is multiplied by the gain, and the offset value is added. This gives the value used by the programs of the resource.

For outputs, the value of the variable resulting from the execution of the program is multiplied by the gain and the offset value added, before updating the output device.

- Double-click 'Gain' or 'Offset' in the tree to open a dialog box that allows you to modify the values.

**Note:** Gain is composed of a multiplier factor and a divider factor.

The conversion formula applied is as follows:

$$\text{NewValue} = (\text{Value} * \text{MultFactor}) / \text{DivFactor} + \text{Offset}$$

For details on specific implementations, contact your supplier.

## Conversions

Conversions can be applied to any kind of channels. The list of available conversions depends on the target implementation. Please contact your supplier for more information on conversions they provide.

Simply double click on 'Conversion' in the tree to open a dialog box that allows you to select the desired conversion for the channel.

## I/O Wiring Grid View

The Grid view displays a read-only list of the available (non-wired) variables of the resource that match the type and direction of the device selected in the Tree View.

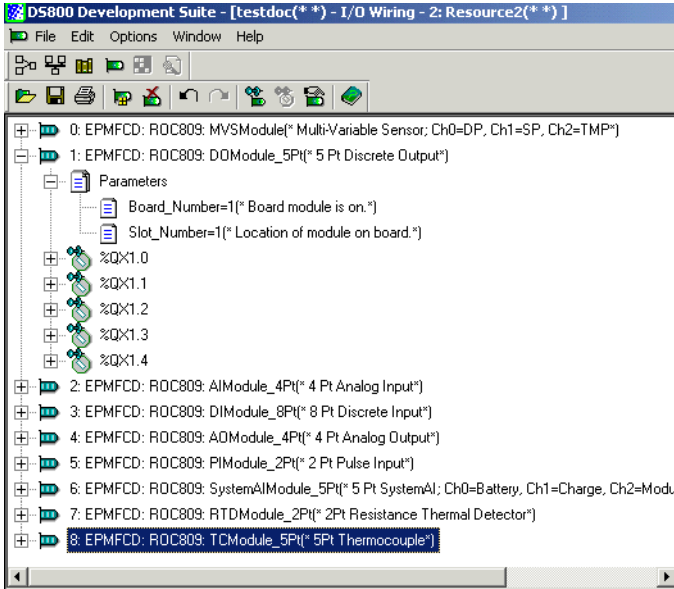
Unwired variables			
Name	Alias	Comment	
StartProduction	PSTA	User order to start	
StopProduction	PSTD	User order to stop	
HeatOK	HOK	No error on temperature	
PressureOK	POK	No error in pressure	
SpeedOK	SOK	No error in speed	

## Working with the I/O Wiring Tool

When defining the I/O Wiring the first time, the Tree and Grid views are empty. After an I/O device is added, the Grid view lists all the variables of the current resource that correspond to the device type and direction. Example: all Boolean inputs for an I/O device: BOOL - Input.

The I/O devices correspond to I/O modules in the RAS device unit:

- Analog Input
- Analog Output
- Discrete Input
- Discrete Output
- MVS Input
- Pulse Input
- RTD Input
- System Analog Input
- Thermocouple Input



## TLP Devices (Automatic Wiring)

When you define TLP variables in the dictionary, these are automatically wired to TLP devices. You may need to modify the write permissions for the fields of Softpoint structures. While modifying the permissions for these fields, avoid interfering with the automatic wiring.

**Note:** The DS800 TLP I/O device drivers require ROC800-Series firmware 2.10 or greater.

The following devices are available for automatic wiring:

TLP\_DINT\_READ

TLP\_DINT\_WRITE

TLP\_REAL\_READ

TLP\_REAL\_WRITE

TLP\_STRING\_READ

TLP\_STRING\_WRITE

TLP\_SOFT\_POINT\_READ

TLP\_SOFT\_POINT\_WRITE

TLP\_REGISTER\_READ

TLP\_REGISTER\_WRITE

## **Analog Input - 4 Point**

This Wiring is set in the I/O Wiring View. The parameters are Board number and Slot number. Board number is always set to 1, and the Slot number refers to the slot in the RAS device housing in which the AI module resides. The I/O module wiring in DS800 software is NOT self-identifying, as it is in ROCLINK 800 software.

Before wiring, each variable must be defined in the Dictionary View Variables Grid. Select the appropriate variable from the unwired variables list. The Name should identify the I/O module. The direction can be set three ways. If defined as I (Input) then the variable will have to be wired to an Input module, if defined as O (Output) then the variable will have to be wired to an Output module, or if defined as Internal then it can not be wired to a ROC I/O module. The Attribute should be R (read for Inputs), W (write for Outputs), or Free (for Inputs or Outputs that will be used as Inputs in other locations in the algorithm).

## **Analog Output - 4 Point**

This Wiring is set in the I/O Wiring View. The parameters are Board number and Slot number. Board number is always set to 1, and the Slot number refers to the slot in the RAS device housing in which the AO module resides. The I/O module wiring in DS800 software is NOT self-identifying, as it is in ROCLINK 800 software.

Before wiring, each variable must be defined in the Dictionary View Variables Grid. Select the appropriate variable from the unwired variables list. The Name should identify the I/O module. The direction can be set 3 ways. If defined as I (Input) then the variable will have to be wired to an Input module, if defined as O (Output) then the variable will have to be wired to an Output module, or if defined as Internal then it can not be wired to a ROC I/O module. The Attribute should be R (read for Inputs), W (write for Outputs), or Free (for Inputs or Outputs that will be used as Inputs in other locations in the algorithm).

## **Discrete Input - 8 Point**

This Wiring is set in the I/O Wiring View. The parameters are Board number and Slot number. Board number is always set to 1, and the Slot number refers to the slot in the RAS device housing in which the DI module resides. The I/O module wiring in DS800 software is NOT self-identifying, as it is in ROCLINK 800 software.

Before wiring, each variable must be defined in the Dictionary View Variables Grid. Select the appropriate variable from the unwired variables list. The Name should identify the I/O module. The direction can be set 3 ways. If defined as I (Input) then the variable will have to be wired to an Input module, if defined as O (Output) then the variable will have to be wired to an Output module, or if defined as Internal then it can not be wired to a ROC I/O module. The Attribute should be R (read for Inputs), W (write for Outputs), or Free (for Inputs or Outputs that will be used as Inputs in other locations in the algorithm).

## **Discrete Output - 5 Point**

This Wiring is set in the I/O Wiring View. The parameters are Board number and Slot number. Board number is always set to 1, and the Slot number refers to the slot in the RAS device housing in which the DO module resides. The I/O module wiring in DS800 software is NOT self-identifying, as it is in ROCLINK 800 software.

Before wiring, each variable must be defined in the Dictionary View Variables Grid. Select the appropriate variable from the unwired variables list. The Name should identify the I/O module. The direction can be set 3 ways. If defined as I (Input) then the variable will have to be wired to an Input module, if defined as O (Output) then the variable will have to be wired to an Output module, or if defined as Internal then it can not be wired to a ROC I/O module. The Attribute should be R (read for Inputs), W (write for Outputs), or Free (for Inputs or Outputs that will be used as Inputs in other locations in the algorithm).



## Multi-Variable Sensor Input - 6 Point

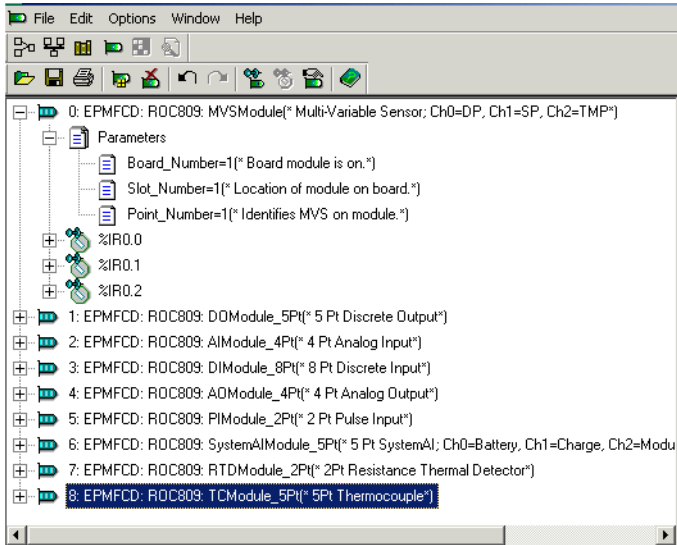
This Wiring is set in the I/O Wiring View. The three channels refer to the three points received from the MVS Sensor:

- Differential Pressure (DP)
- Static Pressure (SP)
- Temperature

For more information on these points, refer to the ROCLINK 800 Configuration Software User Manual.

The parameters are Board number, Slot number, and Point number. Board number is always set to 1. The Slot number refers to the slot in the RAS device housing in which the MVS module resides. The Point number refers to which of the 6 MVS sensor points is being used. The I/O module wiring in DS800 software is NOT self-identifying, as it is in ROCLINK 800 software.

Before wiring, each variable must be defined in the Dictionary View Variables Grid. Select the appropriate variable from the unwired variables list. The Name (tag) should identify the I/O module. The direction can be set three ways. If defined as I (Input) then the variable will have to be wired to an Input module, if defined as O (Output) then the variable will have to be wired to an Output module, or if defined as Internal then it cannot be wired to a ROC I/O module. The Attribute should be R (read for Inputs), W (write for Outputs), or Free (for Inputs or Outputs that will be used as Inputs in other locations in the algorithm).



## Pulse Input - 2 Point

This Wiring is set in the I/O Wiring View. The parameters are Board number and Slot number. Board number refers to which RAS device PI Module is being wired (as more than 1 PI module may be used), and the Slot number refers to the slot in the RAS device housing in which the PI module resides. The I/O module wiring in DS800 software is NOT self-identifying, as it is in ROCLINK 800 software.

Before wiring, each I/O module must be defined as a variable in the Dictionary View Variables Grid. The Name should be A (Analog), D (Discrete), P (Pulse), MVS, RTD, SA (System Analog), or TC, the direction should be I (Input), O (Output), or Internal (for System AI). The Attribute should be R (read), W (write), or Free.

## **RTD Input - 2 Point**

This Wiring is set in the I/O Wiring View. The parameters are Board number and Slot number. Board number is always set to 1, and the Slot number refers to the slot in the RAS device housing in which the RTD module resides. The I/O module wiring in DS800 software is NOT self-identifying, as it is in ROCLINK 800 software.

Before wiring, each variable must be defined in the Dictionary View Variables Grid. Select the appropriate variable from the unwired variables list. The Name should identify the I/O module. The direction can be set 3 ways. If defined as I (Input) then the variable will have to be wired to an Input module, if defined as O (Output) then the variable will have to be wired to an Output module, or if defined as Internal then it can not be wired to a ROC I/O module. The Attribute should be R (read for Inputs), W (write for Outputs), or Free (for Inputs or Outputs that will be used as Inputs in other locations in the algorithm).

## **System Analog Input - 5 Point**

This Wiring is set in the I/O Wiring View. The 5 points (channels) refer to inputs for:

- +/- BATT (supply from Battery to power supply module is low)
- +/- CHG (Supply to solar Charge is low)
- Module V (Voltage monitor from power supply module to I/O and Comm modules)
- One point that is not used
- Board Temperature (monitor of thermistor on CPU)

For more information on these points, refer to the ROCLINK 800 Configuration Software User Manual.

The parameters are Board number and Slot number. Board number is always set to 1, and the Slot number is fixed (non-configurable) as it has no physical location in the RAS device housing. The I/O module wiring in DS800 software is NOT self-identifying, as it is in ROCLINK 800 software.

Before wiring, each variable must be defined in the Dictionary View Variables Grid. Select the appropriate variable from the unwired variables list. The Name should identify the I/O module. The direction can be set three ways. If defined as I (Input) then the variable will have to be wired to an Input module, if defined as O (Output) then the variable will have to be wired to an Output module, or if defined as Internal then it cannot be wired to a ROC I/O module. The Attribute should be R (read for Inputs), W (write for Outputs), or Free (for Inputs or Outputs that will be used as Inputs in other locations in the algorithm).

## **Thermocouple Input - 5 Point**

This Wiring is set in the I/O Wiring View. The parameters are Board number and Slot number. Board number is always set to 1, and the Slot number refers to the slot in the RAS device housing in which the T/C module resides. The I/O module wiring in DS800 software is NOT self-identifying, as it is in ROCLINK 800 software.

Before wiring, each variable must be defined in the Dictionary View Variables Grid. Select the appropriate variable from the unwired variables list. The Name should identify the I/O module. The direction can be set 3 ways. If defined as I (Input) then the variable will have to be wired to an Input module, if defined as O (Output) then the variable will have to be wired to an Output module, or if defined as Internal then it can not be wired to a ROC I/O module. The Attribute should be R (read for Inputs), W (write for Outputs), or Free (for Inputs or Outputs that will be used as Inputs in other locations in the algorithm).

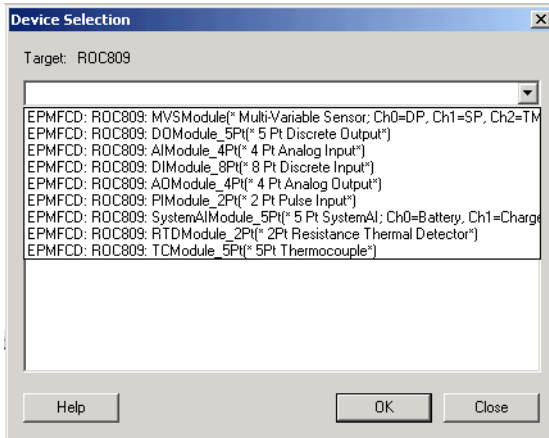
## Adding I/O Devices

You can add simple and complex devices to the I/O wiring tree. Available devices for a target are displayed in the device selection list. When adding complex devices, the number of channels, i.e., device size, of individual simple devices making up a complex device varies depending on the definition of the complex device in the target.

### To add an I/O device

1. From the Edit menu, choose **Add I/O Device** or click  on the I/O Wiring toolbar.

The Device Selection dialog box appears:




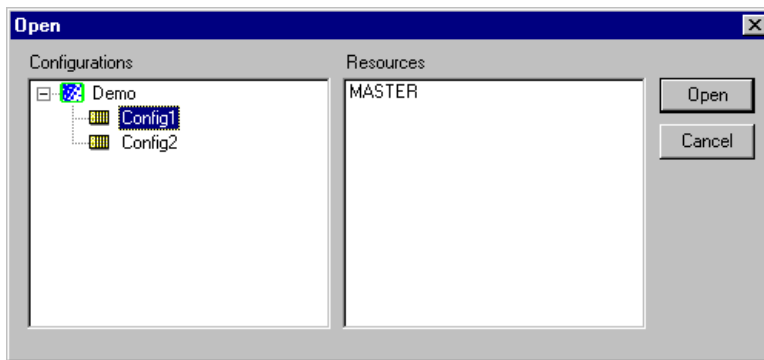
2. Choose the device from the pull-down menu.
3. Change the device index and number of channels (if required and available).
4. Click **OK**.

## Opening Devices

You can open existing devices defined for any resource of a project.

### To open an existing device

1. From the File menu, choose **Open Device** or click  on the I/O Wiring toolbar.
2. In the Open window, browse to select the resource holding the device, then click **Open**.



The devices defined for the selected resource are displayed in the I/O Wiring View.

## Deleting Devices and Conversions

You can delete devices and conversions from the I/O wiring view. You cannot delete Parameter, Gain, or Offset elements. You remove a current conversion by replacing it with "None". You can also disconnect variables attached to selected channels.

When deleting devices, all variables are unwired from the device (as with Free I/O device channels).

### To delete a device or conversion


You can delete devices or conversions using the main menu or the I/O Wiring toolbar.


- ▶ From the Edit menu, choose **Delete Device** or click  on the I/O Wiring toolbar.

## Setting the Real or Virtual Attribute

This command sets the Real/Virtual attribute for the currently selected device.

### To toggle the Real/Virtual attribute:

1. Select the device in the Tree View.
2. From the Edit menu, choose **Real / Virtual I/O Device** or click  on the I/O Wiring toolbar.

The Tree View icon for a virtual device is .

In Real Mode, I/O variables are directly linked to the corresponding I/O devices. Input or Output operations in the programs correspond directly to the input or output conditions of the actual I/O device fields. In virtual mode, I/O variables are processed as internal variables. They can be read or updated by the Debugger so that the user can simulate the I/O processing, but no actual connection is made.

## Wiring Channels

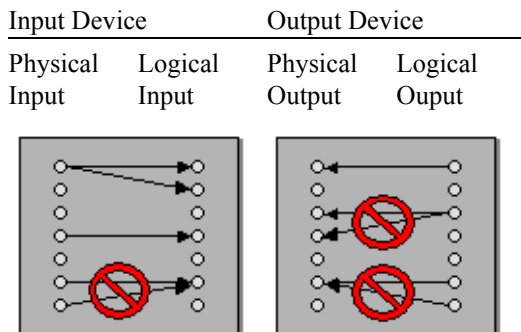
You wire variables to channels by selecting a channel in the Tree, then double-clicking or pressing **<Return>** on a variable in the grid. If the channel is already wired, the existing variable is unwired and replaced by the one in the grid.

After a connection, the variable is removed from the grid and the next channel is selected; only variables available for wiring appear in the grid.

**Note:** If no channel is selected, nothing happens.

## Mapping Channels

You can define the mapping of logical channels to physical channels. When mapping channels, only one link can send to or receive from a logical channel. For an input device, you can map a physical input to one or more logical inputs. Whereas, you cannot map more than one physical input to a logical input. For an output device, you can only link one logical output to one physical output:



When performing online changes, you can modify channel mappings.

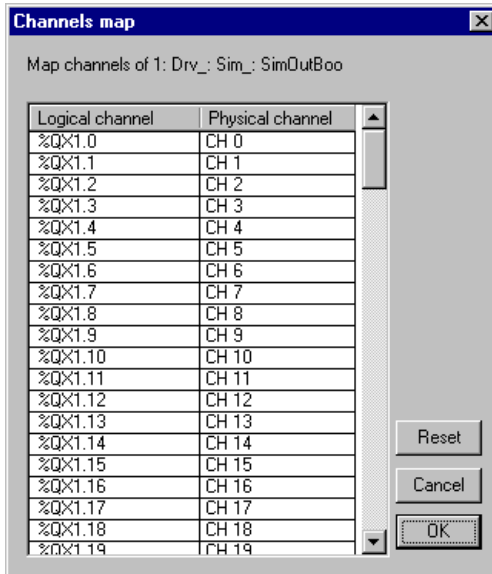
### To map logical and physical channels for a device

1. In the I/O wiring tool, select the device.



- From the Edit menu, choose **Map Channels** or click  on the I/O Wiring toolbar.

The Map Channels editor displays the current mapping of channels for the device:




- For each logical channel to map, locate and double-click its corresponding physical channel, then from the drop-down list assign the new physical channel by double-clicking it.
- Click **OK**.


## Freeing Channels

You can unwire one or all variables for a selected device.

### To free one channel

1. Select a wired channel in the tree view.
2. Do one of the following:
  - From the Edit menu, choose **Free I/O device channel**.
  - From the I/O wiring toolbar, click  on the I/O Wiring toolbar.
  - Press **Delete**.

### To free all channels

1. Select a device in the tree view.
2. Do one of the following:
  - From the Edit menu, choose **Free all I/O device channels**.
  - From the I/O wiring toolbar, click .

# Run-time System Events

You can log run-time system events on the Windows platform using the Events Logger and view these events using the Events Viewer.

You access the Events Logger and Events Viewer from the Workbench. You can also start the logger and viewer from command lines.

## Logging Events

The Events Logger receives events from DS800 targets. You can view these events using the Events Viewer. Events are stored in a log file, in Unicode format, located in the Events Logger folder of the current project's directory. A new log file is automatically created each day at 00:00:00 hours.

The name of the log file is `Events_YYYYMMDD.txt` where *YYYY* is the year, *MM* is the month, and *DD* is the day on which the file is created.

You can open the log file in text format using a text editor.

When starting the Events Viewer from the Workbench while an application is running, the Events Logger automatically points towards the application's project and the logger is started. You can also choose to start the Events Logger from a command line.

### To start the Events Logger from a command line

You can set the Events Logger to start for a given Workbench project from a command line using the following syntax:

```
EventsLogger -P"full_directory_path"
```

The executable file for the Events Logger is installed in the following location:

```
Program Files\Emerson\DS800\bin\EventsLogger.exe
```

When manually starting the Events Logger, you may need to provide the location of the Workbench project. The Events Logger needs to be started in its location directory. For example:

```
C:> cd "Program Files\Emerson\DS800\Bin"  
C:> EventsLogger -P"Program Files\Emerson\Projects\DS800\  
Prj\MyProject"
```

You can also start the Events Viewer from a command line.

### **To open a log file**

You can view the log of events as a text file by opening the log in a text editor such as Notepad. The default location for the log file is in the Events Logger folder of the current project's directory.

- ▶ Locate and double-click the .txt file.

The file opens in the associated text editor.

## **Viewing Events**

The Events Viewer displays run-time system events logged with the Events Logger.

The Events Viewer displays the contents of the log file, created daily by the Events Logger. In the viewer, events appear as they occur. You can sort events according to the categories at the top of the viewer window:

- Date and time when the event took place
- Level, the level of the event. Possible values include Error, Warning, and Info.
- Module, the module sending the event
- Sub-module, the sub-module sending the event
- Error, the code number of the error
- Description, a textual description of the event

- Value, a number relating to target development values
- Configuration, the name of the configuration running on the target that sent the event. When the event is related to a resource, the resource name is added to the configuration name, for example, Config1.Res1.

You can choose to view events for a day other than the current day. You can also view events for a day in a different month and year as long as the log file for the specified date is available. Furthermore, you can sort the contents of the viewer according to individual columns in ascending or descending order by clicking a column heading a first time for ascending order and a second time for descending order.

When viewing events, you can access more detailed information for specific messages by pressing F1.

**Note:** The Events Logger only logs target errors; Simulator errors are not displayed in the Events Viewer.

### **To access the Events Viewer**

When starting the Events Viewer while running an application, the Events Logger automatically points towards the application's project and is started.

- ▶ In the Workbench, from the Tools menu, choose **Events Viewer**.

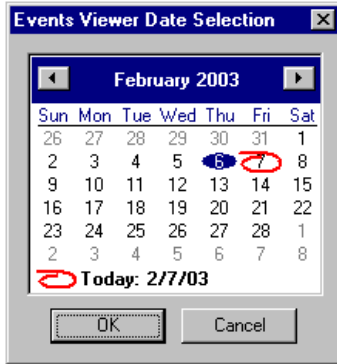
### **To sort events in the Events Viewer**




- ▶ At the top of the window, click a category heading. To inverse sorting order, click the category heading a second time.

### **To view events for another day**

1. At the top of the window, click the date.

The Events Viewer Date Selection window appears:



2. To view the events for another day, click the day on the calendar.
3. To view the dates for another month, do one of the following:
  - Click  or  to scroll through the previous or following months.
  - Click on the month at the top of the calendar, then choose one from the list.
4. To change the year, click the year at the top of the calendar, then choose one from the list.
5. To return to viewing events for the current day, click  below the calendar.

### To start the Events Viewer from a command line

You can set the Events Viewer to start for a given Workbench project from a command line using the following syntax:

```
EventsViewer -P"full_directory_path"
```

The executable file for the Events Viewer is installed in the following location:

Program Files\Emerson\DS800\bin\EventsViewer.exe

The Events Viewer needs to be started in its location directory. For example:

```
C:> cd "Program Files\Emerson\DS800\Bin"  
C:> EventsViewer -P"Program Files\Emerson\Projects\DS800\  
Prj\MyProject"
```

You can also start the Events Logger from a command line.





# Language Editors

The Workbench holds several language editors, having some Common Editor Features, for use with the many supported languages.

SFC Editor

FC Editor

Multi-language Editor

Composite IEC 61499 Editor

## Common Editor Features

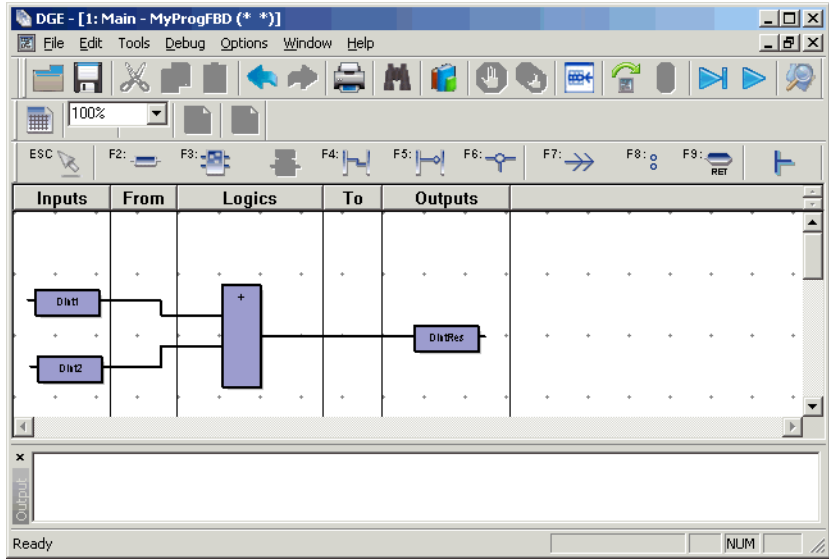
Each Editor in the Workbench has a similar and consistent interface using standard Windows layout and functionality (for example, menus, toolbars).

The Dictionary, listing variables that can be used in the current POU, or used to declare new variables, can be opened from any Editor. Building POU Code and starting Test Mode can also be performed from all the Editors.

Printing from an Editor launches the Document Generator with elements specific to that Editor.

# Appearance

title bar  
menu bar  
toolbars  
  
workspace  
  
output window  
status bar



## Title Bar

For help locating the title bar, see the Appearance diagram. The title bar displays the application name and filename of the active Program.

## Control Icon

At the left end of the title bar is the Control Icon, which is used to access the Control Menu (see following section). Double-clicking on the Control Icon closes the Editor.

## Control Menu

Clicking on the Control icon opens the Control Menu. The Control Menu is used to position the Main Window or to exit.

## Window Buttons

The standard window buttons appear at the right end of the title bar. Use these to resize or close the Window.

## Menu Bar

The Menu Bar contains the Editor's menus. For help locating the menu bar, see the Appearance diagram. Each menu lists a "family" of selections, each selection performs a specific action.

**Note:** Menus that are not currently available are temporarily removed from the menu bar. Menu Items not available are displayed in gray.

## Using the Menus

1. Open a menu by clicking on it, or by pressing <Alt> plus the letter that is underlined in the menu's title. For example, to open the File Menu, you press <Alt> + <F> (shown in this User's Guide as ALT+F).
2. Choose a menu selection by clicking on it, by pressing its underlined letter, or by using the cursor keys to highlight it and then pressing <Enter>. Menu selections that appear in grey are not currently available.

## Control Icon

When a Program is open, the menu bar has a Control Icon on the left.

## Control Menu

Clicking on the Control Icon opens the Control Menu. The Control Menu is used to position the Window or to alternate between them.

## Window Buttons

The standard window buttons appear at the right end of the menu bar.

## Toolbars

The language editors holds toolbars performing various functions.

### Displaying the toolbars

#### To show or hide a toolbar

1. From the Options Menu, choose **Layout**.

The Layout Dialog Box appears.

2. Check / uncheck the names of the toolbars to show / hide.

### Moving toolbars

The toolbars can be placed anywhere on the screen.

#### To move a toolbar

1. Point the cursor at the toolbar's title bar or main panel.

**Note:** Do not point at the control icon or one of the window's buttons.

2. Press and hold the left mouse-button.
3. Drag the toolbar by moving the mouse.

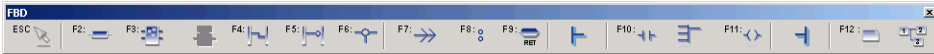


4. Release the mouse-button.

## Docking toolbars

- Dock a toolbar to a side of the Workspace by positioning it at the Workspace's edge, this toggles between a toolbar's floating and docked states.

The toolbar shown above appears as follows in its floating state:



## Standard Toolbar



Opens a POU



Saves the current POU



Cuts the selection and places it on the clipboard



Copies the selection and places it on the clipboard



Pastes the contents of the clipboard



Undoes the last operation












Redoes the last operation




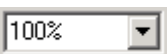
Accesses the document generator



Finds and replaces items

-  Accesses the Dictionary view
-  Sets or removes a breakpoint
-  Removes breakpoints
-  Inserts identifiers
-  Builds the current POU
-  Stops a build
-  Switches the application to debug mode
-  Switches an application to simulation mode
-  Accesses the cross references browser

### Options Toolbar

-  Displays the grid
-  Adjusts the zoom



Increases the X to Y Ratio (LD Only) Cells are displayed wider



Decreases the X to Y Ratio (LD Only) Cells are displayed narrower

## Debug Toolbar

The Debug toolbar is accessible when you run a POU in either debug or simulation mode.



Starts all stopped resources



Starts a stopped resource



Stops all running resources



Stops a running resource



Switches the application to Real-time mode



Switches the application to cycle-to-cycle mode



Executes one cycle



Steps to the next **line of code or rung**



Steps into the next **line of code or rung**



Locates the current step



Sets the cycle timing



Sets or removes a breakpoint. For LD programs only.



Removes breakpoints. For LD programs only.



Shows/Hides output values. For FBD programs only.



Debugs a function block



Displays the spy variable list



Stops the debug/simulation mode



Refreshes the status of resources



Clears the output window



## SFC Breakpoints Toolbar



Sets a breakpoint on step activation



Sets a breakpoint on step deactivation



Sets a breakpoint on transition



Removes a breakpoint



Removes all breakpoints



Clears a transition

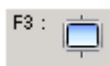
## SFC Tools



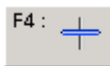
Select



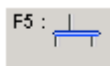
Insert Initial Step



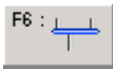
Add a Step



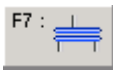
Add a Transition



Add an OR Divergence



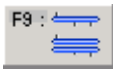
Add an OR Convergence



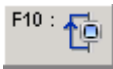
Add an AND Divergence



Add an AND Convergence



New Branch



Add a Link



Jump



Renumber



Add Action Block



Move Action Block Up

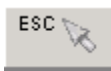


Move Action Block Down

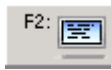


Delete Action Block

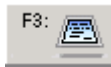
## Flow Chart Tools



Select



Insert Action



Insert I/O Specific Action



Insert Test



Insert Flow



Insert Connector



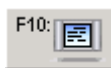
IF-THEN-ELSE



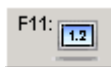
DO-WHILE



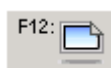
WHILE-DO



Insert Sub-Program



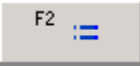



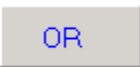

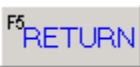
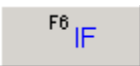
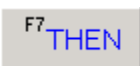


Renumber Flow Chart






Insert Comment

## ST Tools

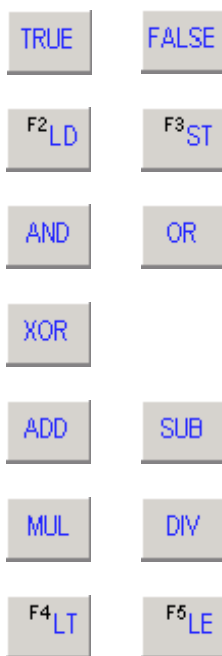
This toolbar is displayed when editing an ST POU, an Action, or a test of an FC or SFC POU written in ST. Clicking on one button of this toolbar inserts the corresponding word, at the caret position, in the text of the current POU.

	Assignment
	Boolean True
	Boolean False
	Boolean AND operator
	Boolean OR operator
	Boolean XOR operator
	RETURN statement
	IF Statement
	THEN Statement
	ELSIF Statement
	ELSE Statement

	END_IF Statement
	CASE Structure
	END_CASE Structure

## IL Tools

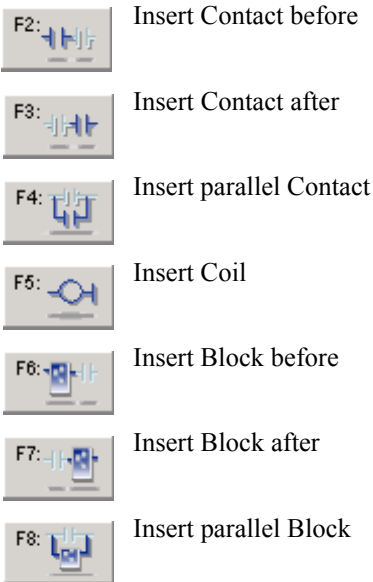
This toolbar is displayed when editing an IL POU or an action or a test of an FC or SFC POU written in IL. Clicking on a button of this toolbar inserts the corresponding word, at the caret position, in the text of the current POU.

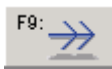




## LD Tools

This toolbar is displayed when editing an LD POU or an Action or a test of an FC or SFC POU written in LD.





Insert a Jump



Insert RETURN



Change Coil/Contact Type (pressing the **<spacebar>** has the same effect)



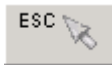
Insert link



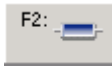
Align coils

## FBD Tools

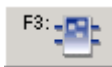
The FBD tools bar is displayed when editing a POU written in the FBD language.



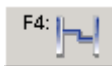
Selects items



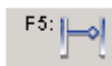
Adds a variable



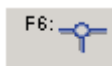
Adds a function block



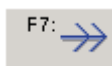
Draws a link



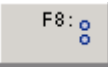
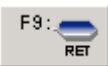

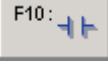

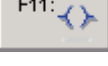




Draws a link with negation



Adds a corner



Inserts a jump to label

	Inserts a label
	Inserts a return
	Adds a left power bar
	Adds a contact
	Adds an LD vertical connection
	Adds a coil
	Change Coil/Contact Type (pressing the <b>&lt;spacebar&gt;</b> has the same effect)
	Adds a right power bar
	Adds a comment
	Shows or hides the execution order

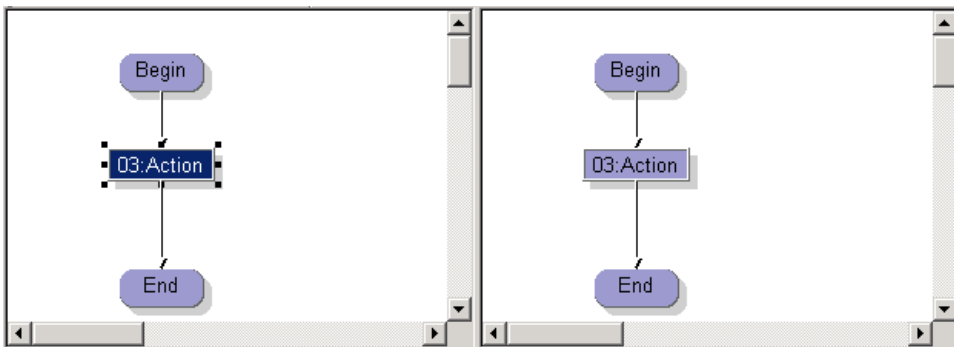


## Workspace

When you open a POU, it appears in a window. This windows appear within the Editor's Workspace.

For the FBD and LD language editors, you can also change the foreground and background colors.

The Workspace of the FC (Flow Chart) and SFC Editors can be sub-divided into two simultaneous views:



Each view can be zoomed independently.


### To split the workspace

1. From the Window menu, choose **Split**.
2. Drag and drop the vertical division to the required position.

### Grid

The editing grid shows matrix cells. An editor option allows the user to show or hide the grid during development. The grid is very useful for placing new elements.

### To toggle (display / hide) the grid



- From the Layout sub-menu of the Options Menu, choose **Grid** or click  on the Options toolbar.

**Note:** The grid visibility does not affect its use to position elements, simply whether or not it can be seen.

### X-Y Ratio

The x-y ratio determines the relative width spacing of the grid compared to the height of each grid 'cell'. This is a display property only, it has no effect on the definition or execution of the Program.

### To change the x-y ratio

- From the Options Menu, choose **Layout** OR use the buttons (  ,  ) on the Options toolbar.

**Note:** The X-Y ratio features are only available when editing LD.

## Contextual Menus

The Contextual Menus are displayed by clicking the right mouse-button in the Editor Workspace.

The commands on the Contextual Menu are generally available in the Edit Menu.

### Example



## Output Window

### To view the output window

- From the Window Menu, choose **Show Output Window**.

The output window appears, docked to the status bar:



**Note:** The output window is moved like a toolbar. It is automatically displayed when Building and Debugging a Program. Compilation errors are displayed in the output window.

### **To clear the output window**

- From the Window Menu, choose **Clear Output Window**.

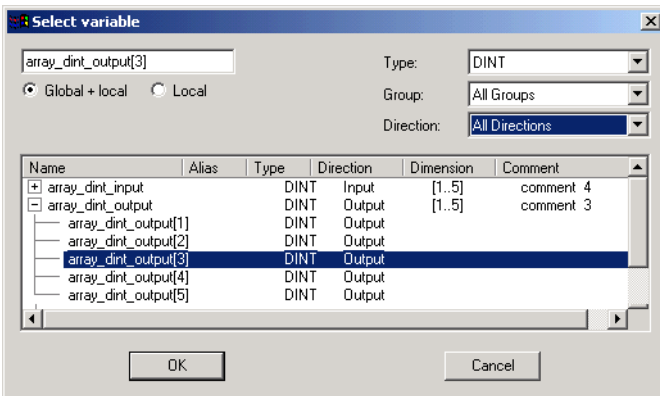
### **Status Bar**

The Status Bar appears at the bottom of the Main Window. Information about commands, operations and POUs is given on the Status Bar.

## Inserting Identifiers

You can insert identifiers, i.e., variables, previously declared in the Dictionary. You can also create new variables and enter constant values into a POU as well as access the parameters of functions or function blocks. When creating a new variable, you need to assign a unique name (not corresponding to an existing variable) as well as specify its type and scope: global or local to the POU. These variables are added to the project database with default values for their other attributes (Internal, Free). For new variables of the STRING type, a string of 80 characters is automatically defined.

You insert identifiers using the Select Variable dialog. You can list all types of variables or individual standard IEC 61131 types as well as defined words, arrays, and structures. You can also list variable groups and variable directions. When editing functions or function blocks, the parameters option appears in this list. When typing identifier names, the selector automatically searches for the first item in the list matching the entered criteria.



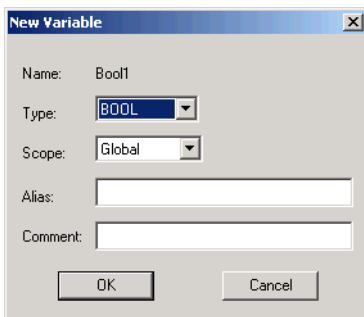
**Note:** Arrays must be declared in the Dictionary View before using them in Functional Block Diagrams (FBD).

### To insert an identifier in a POU

1. From the Edit menu, choose **Insert Identifier** or click  from the Standard toolbar.

The Select Variable dialog box is displayed.

2. To reduce the number of variables appearing in the list, select a type, variable group, and direction of the identifiers to list. To list the parameters for functions and function blocks, select the Parameters option.
3. Do one of the following:
  - To use a previously declared variable, select a variable from the list or type the name of the variable in the field at the top left.
  - To create a new variable, in the top left field, type a unique name and click **OK**, then in the New Variable dialog box, specify the type and scope for the new variable (optionally an alias and comment). To specify the local scope, select the name of the currently edited POU.



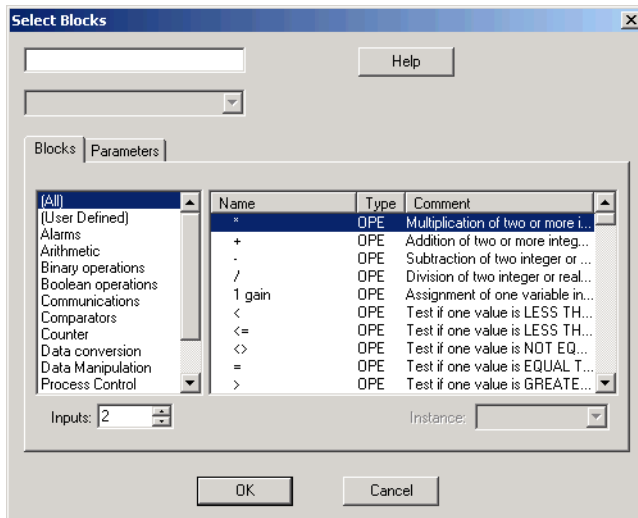
- To enter a constant value, type the value in the field at the top left.

4. Click **OK**.

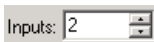
The identifier is inserted in the currently edited POU at the current position.

## Inserting Blocks

You insert blocks, i.e. operators, functions, and function blocks into programs from the Select Blocks window. The items displayed in the list depend on the program type. For SFC, FC, ST, LD, FBD, and IL programs, the available items are operators (OPE), standard functions (SFU), standard function blocks (SFB), user IEC 61131 Functions (IFU), user IEC 61131 Function Blocks (IFB) and all "C" Functions (CFU) and Function Blocks (CFB) supported by the target attached to the current resource.



- The block identifier field (top left) indicates the selected operator, function, or function block. When an instance is selected, the instance name is displayed.
- The Blocks list enables you to display all or various types of operators, functions, and function blocks.
- Inputs are only available for operators such as +, \*, and AND to define the number of input connections for the block.



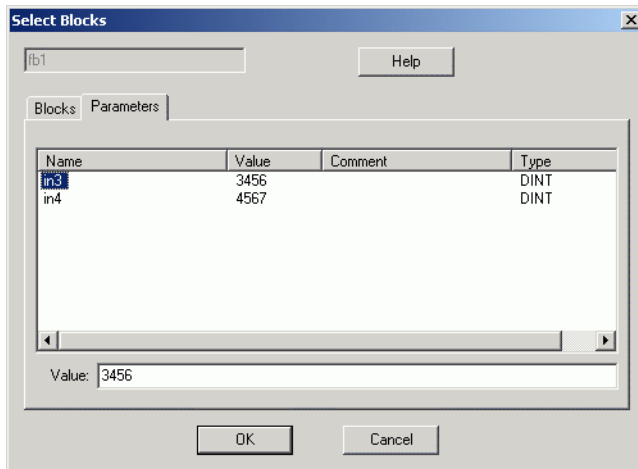
- For FBD 61131 programs, the Instance field is only available when the currently selected Block is a declared instance. The Instance field enables you to select the Instance name to

insert into the POU. When the field is left blank, an automatic instance is created for the function block.

Instance:

The Help button displays the description of the Block or Function or the associated help if it exists (C Function or Function Block).

The Parameters tab is significant only for some "C" Functions and Function Blocks. It shows the Parameters that are not shown when inserting the block in the program editor. These Parameters are called "Hidden Parameters". They correspond to Input Parameters of the Block to which you can give a constant value. The Parameters tab allows you to enter a value for these Parameters.




Select the parameter name in the list, and enter its value in the "Value" edit box, press Enter to assign the value.



## Printing POU's

You can choose to print a standard list of elements for a POU from the Document Generator. For information about the Document Generator, see page 337.


### To print the current POU

- From the File menu, choose **Print** or click  on the Standard toolbar.

## Opening the Dictionary

From a language editor, you can open the Dictionary filtered for the current POU.


### To open the Dictionary

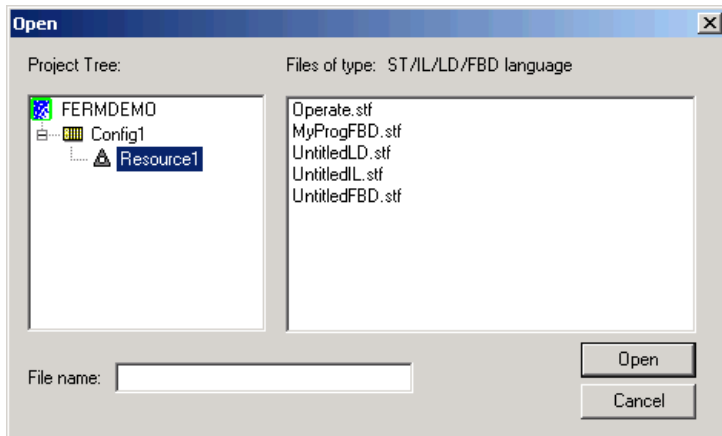
- From the File menu, choose **Dictionary** or click  on the Standard toolbar.

## Opening Another POU

From a language editor, you can open another POU written with the language supported by the current editor from any resource.

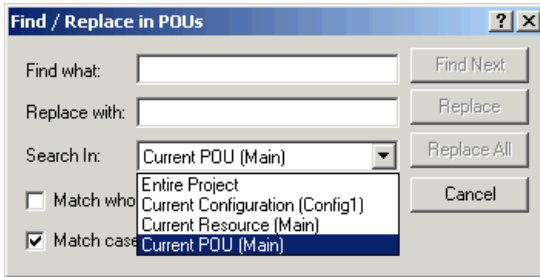
### To open another POU from a language editor

1. From the file menu, choose Open or click  on the Standard toolbar.
2. In the Open dialog box, from the project tree, select the resource holding the POU to open, then the file from the list of available files.



## Finding and Replacing in POUs

You can find and replace text throughout all POUs. You can specify to search an entire project, a configuration, a resource, or a POU.



Searches include level 2 code of SFC and FC POUs as well as action block names of steps. The Find / Replace in POUs utility is not case-sensitive, for instance, FIND is the same as FinD.

To find a step or transition name in an SFC chart or an action or test name in an FC chart, use the Goto command in the Edit menu from the respective editor.

### To find an item (characters, word, or phrase)

Searches are performed from top to bottom and from left to right.

1. From the Edit menu, choose **Find / Replace in POUs** <Ctrl+F> or click  on the toolbar.

**Note:** While in the Dictionary view, the toolbar element accesses the Dictionary grid Find/Replace utility and the shortcut key for the Find/Replace In POUs menu item is Ctrl+Shift+F.

2. Enter the item to search for. To perform a case sensitive search, check **Match Case**.
3. To find the next occurrence of the item, click **Find Next**.

4. To replace found items, in the Replace field, enter the text to replace, then do one of the following:
  - To replace the found occurrence, click **Replace**.
  - To replace all occurrences of an item, click **Replace All**.

## SFC Editor




The **SFC (Sequential Function Chart) Editor** is launched automatically when an SFC program is opened from the Workbench. The SFC language is used to describe operations of a sequential process. It uses a simple graphic representation for the different steps of a process, and conditions that enable the change of active steps. An SFC Program is entered by using the graphical SFC editor.

SFC is the core of the IEC 61131-3 standard. The other languages (except Flow Chart) usually describe the actions within the steps and the logical conditions for the transitions. The SFC editor allows the user to enter complete SFC programs. It combines graphic and text editing capabilities, thus allowing the entry of both the SFC chart, and the corresponding actions and conditions.

The SFC editor is automatically opened when an SFC program is edited.

**Note:** Before creating new programs, you need to close the Dictionary.

### To subsequently open another program from the SFC Editor

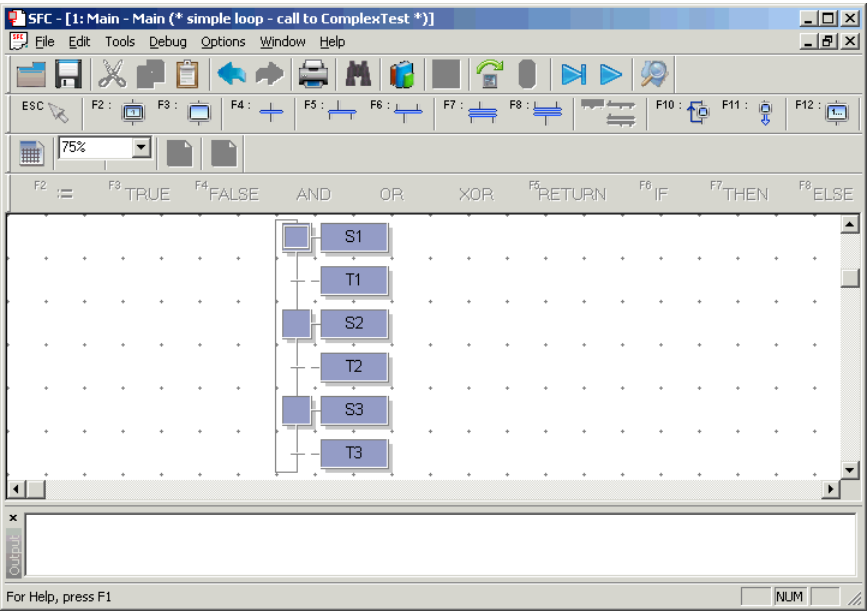
- From the File Menu, choose **Open (CTRL+O)** or click , on the Standard toolbar.

# Appearance

Title Bar  
Menu Bar  
Toolbar

Workspace

Output Window  
Status Bar



## Menu Bar

Some options are available as keyboard commands.

File	Open	Ctrl+O	opens an existing POU
	Close	Alt+F4	closes the POU
	Save	Ctrl+S	saves the current POU
	Build Program	Alt+F3	builds the code for the current POU
	Stop Build Program		stops the build in progress for the current POU
	Dictionary	Ctrl+D	opens the dictionary filtered for the current POU
	Description	Ctrl+K	accesses the program description
	Print	Ctrl+P	prints the current POU
	Exit	Ctrl+Q	leaves the language editor
	Edit	Cut	Ctrl+X
Copy		Ctrl+C	takes a copy of the selected item and places it on the clipboard
Paste		Ctrl+V	inserts the contents of the clipboard into the selected item
Delete		DEL	removes the selected item
Undo		Ctrl+Z	cancels the last action
Redo		Ctrl+Y	restores the last cancelled action
Find / Replace in POUs		Ctrl+F	finds and replaces text in a project, a configuration, a resource, or a POU
Go to		Ctrl+G	jumps to the indicated step or transition number
Rename Step/Transition		Ctrl+R	renames the element
ReNUMBER			renumbers all elements in the chart in sequential order
Add Action Block		add an action block	

Edit	Delete Action Block		deletes an action block
(Continued)	Edit Level 2	Enter	opens the level 2 programming for an element
	Edit Level 2 in Separate Window	Ctrl+Enter	opens the level 2 programming for an element in a separate window
	Insert/Set Identifier	Ctrl+I	accesses the Select Variable dialog box where you can insert a variable
	Insert New Rung	Ctrl+R	inserts a rung
Tools	Browser	Ctrl+B	accesses the Cross References browser listing and localizing all instances of global variables and I/Os declared in a project
Debug	Debug	Alt+F6	switches the application to debug mode
	Simulation	Alt+F7	switches the application to simulation mode
	Debug FB	F11	opens a selected function block in the language editor with its instantiation values
Options	Set Level 2 Language		sets the programming language used for level 2 programming. For programs, possible languages are ST, IL, and LD. For function blocks, possible languages are ST and LD.
	Customize	Ctrl+U	accesses the customization properties for Workbench views and editors
	Target/Code Settings		accesses the compilation options for the POU



Window	Cascade		sets the different views of the project to appear in a cascading manner
	Tile		sets the different views of the project to appear in a tiled manner
	Split		splits the workspace into two simultaneous views
	Show Output Window	Ctrl+4	displays the output window below the workspace
	Clear Output Window		clears the contents of the output window
Help	Contents	F1	accesses the online help
	Search Help On...		not currently supported
	About		displays product and version information
	Support Info		not currently supported

## Working with the Editor

The SFC language is used to represent sequential processes. The SFC programming is usually separated into two different levels:

- Level 1 shows the graphic chart, the reference names of the steps and the transitions, and the comments.
- Level 2 is the ST, LD or IL programming of the actions within the steps, or the conditions attached to the transitions. Actions or conditions may refer to functions written in other languages (FBD, LD, ST or IL). The level 2 programming of a step includes action blocks programmed in ST, LD or IL. The level 2 programming of a transition describes a Boolean condition entered in ST, LD or IL.

Individual elements are automatically linked if the SFC editor considers them to be in a valid position.

From the editor, you can:

- Build the current program code to check your program and prepare the code for building the resource code.
- Print your program.
- Launch the Dictionary.

### **You can also enter a description to document your Program**

- From the File menu, choose **Description**.

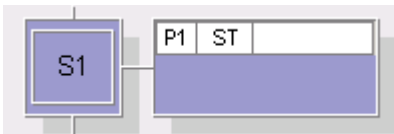
## SFC Elements

To draw an SFC chart, you simply introduce the significant components of the chart. The SFC editor automatically draws most of the single lines joining two elements (horizontally or vertically). Lines (or links) can be drawn manually.

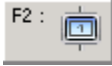
To place an SFC component on the chart, the user has to select the type of the component in the editor toolbar and then click in the edition workspace at the desired position. If the mouse button is kept depressed, a "ghost" of the element is shown in order not to place it blindly. When the symbol is placed, links can be created automatically depending on the element position regarding the existing elements. The editor may not accept the placement of the element. For example, you cannot place an element over an existing element.

### Initial Step

Every SFC program must have an **Initial Step**. Initial steps are double bordered. For information about initial steps, see page 396.

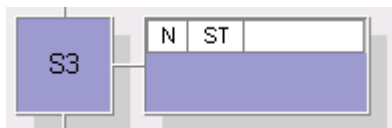


### To place an Initial Step


1. On the SFC toolbar, click  .
2. Click in the workspace at the desired position.

## Step

Steps are given sequentially numbered default names, e.g. S1, S3, S5... For information about steps, see page 396.



### To place a Step

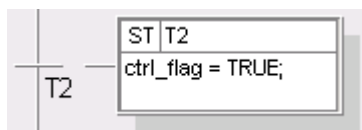
1. On the SFC toolbar, click  .
2. Click in the Workspace at the desired position.

**Note:** To link a step to an existing transition, place the mouse cursor on the grid cell above or below the transition.

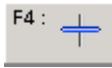


## Transition

Transitions are given sequentially numbered default names, e.g. T2, T4, T6... For information about transitions, see page 397.

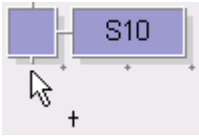


## To place a Transition



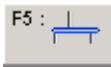
1. On the SFC toolbar, click .
2. Click in the workspace at the desired position.

If you want to link the transition to an existing step, click the mouse with the cursor on the grid cell above or below the step.

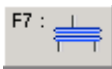
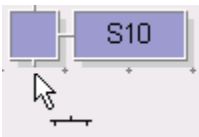


## Divergence/Convergence

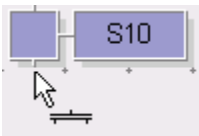
To place a **divergence**, click on the button on the SFC Toolbar then click in the chart workspace at the desired position.



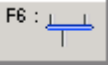
- To link an OR divergence ( ) to an existing step, place the mouse cursor on the grid cell below the step.

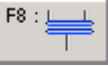


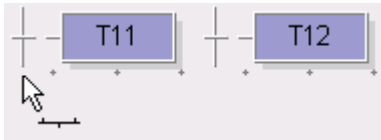
- To link an AND divergence ( ) to an existing transition, click grid cell below the transition:



- To place a **convergence** and attach it to previous elements, click the left-most branch. OR

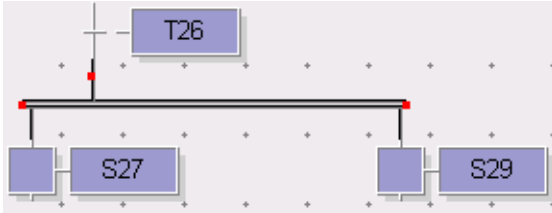
convergences (  ) are attached to the preceding transitions, AND convergences

(  ) are attached to preceding steps.



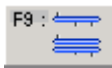
## Creating New Branches

Inserting a new branch creates an alternative routing for connections.



### To insert a new branch on a divergence or convergence

1. Select a divergence / convergence.



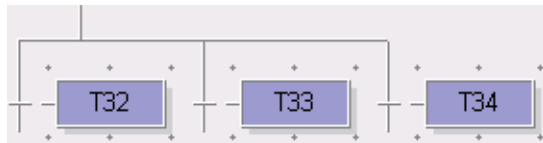
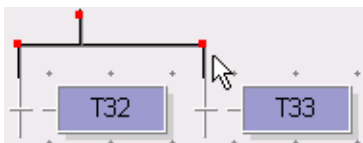
2. On the SFC toolbar, click .

**Note:** Moving the upper handles, on the left or right of a divergence or convergence, automatically causes a new branch to be created.

To create a branch next to existing branches, select the divergence (OR divergence for transitions, AND divergence for steps), then press F9 or click the new branch icon and add an element (transition or step).

### Example

Right-click or press F9 to add a branch Add element on new branch

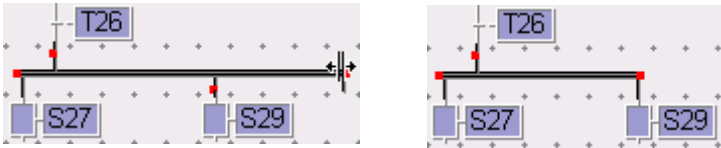


### Deleting Branches

Moving non-connected branches back onto the nearest connected branch deletes 'extra' branches.

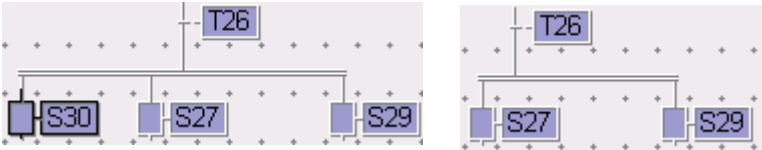
Select the divergence, place the cursor on the upper-right handle (red square), then drag the branch onto the branch with S29:

Select branch end and move towards existing element	Branch is removed from divergence
<hr/>	



Deleting an element removes the branch directly above it.

Select and delete element	Element and branch are removed
<hr/>	



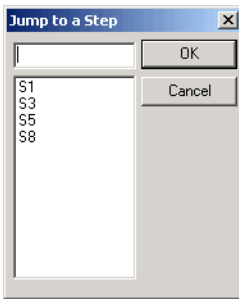


## Link

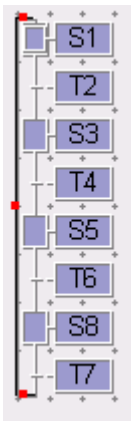
Drawing a **link** is a drag and drop operation linking one element to another. Links always move from a step to a transition or from a transition to a step. Links can be moved using drag and drop operations on the handles (red squares), displayed when the link is selected. For information about oriented links, see page 398.

### To insert a link

Inserting a link with a single click on the link origin, or dropping the link in an empty area of the workspace, displays the Jump to a Step dialog. The "Jump to a Step" dialog is only displayed when the link origin is a transition.



- Choose the required step name then click **OK**.



## Jump

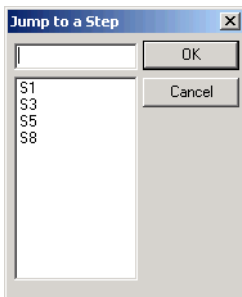
You can insert jumps between transitions and steps. For information about jumps to steps, see page 398.

### To insert a jump

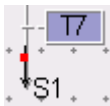
1. On the SFC toolbar, click  .

The cursor changes to a 'Jump' cursor.

2. Click on the workspace, immediately below the transition to jump 'from'.
3. In the Jump to a Step dialog, select the required step name then click **OK**.



The step name is indicated next to the jump symbol.

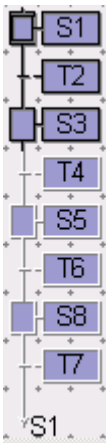


## Managing Elements

SFC elements can be cut, copied, and pasted within a Sequential Function Chart or, if more than one is open, between different charts. When an element is moved, removed or added, the chart is automatically refreshed, elements are placed according to the grid and links are redrawn.

### Select

To select an item simply click on it with the left mouse-button. Multiple selections are made by clicking a blank area of the workspace then drag and drop until the required items are highlighted. Alternatively, multiple items are selected by holding down (**CTRL**) or (**SHIFT**) then clicking elements to add to the selection.



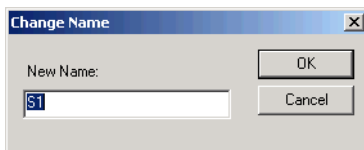
## Rename

You can rename steps and transitions.

### To rename elements

1. Select the element to rename.
2. From the Edit menu, choose **Rename Step (Transition)** OR right-click on the element to display the contextual menu.

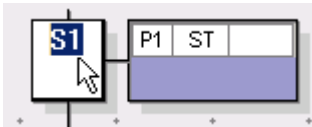
The Change Name dialog box appears:



3. Edit the name then click **OK**.

OR

1. Select the element to rename.
2. Click on the name to edit.
3. Edit the name directly in the program element:



4. When finished, click elsewhere in the workspace.

## Move


### To move elements

1. Select the element(s) to move.
2. Drag the 'ghost' to a valid location.
3. Drop the elements as required.

## Cut

Use the cut command to remove selected elements and move them to the clipboard, replacing the clipboard's current contents.


### To cut elements

- ▶ Select the element(s) to cut, then from the Edit menu, choose **Cut (CTRL+X)** or click  , on the Standard toolbar.

## Copy

Use the copy command to copy selected elements and place them on the clipboard, replacing the clipboard's current contents.

### To copy elements

- ▶ Select the element(s) to copy, then from the Edit menu, choose **Copy (CTRL+C)** or click  , on the Standard toolbar.


## Paste

Use the **Paste** command to place the contents of the clipboard at the insertion point. Pasted elements are automatically assigned sequentially numbered names.

### To paste elements

1. From the Edit menu, choose **Paste (CTRL+V)**.
  2. Position the 'ghost'.
  3. Click to paste at the new location
- OR



1. On the Standard toolbar, click  .
2. Position the 'ghost'.
3. Click to paste at the new location

## Delete

### To delete elements

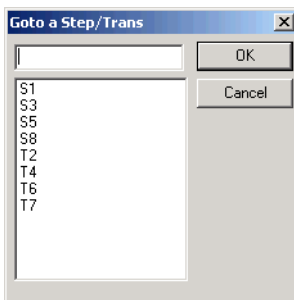
- ▶ Select the element(s), then from the Edit menu, choose **Delete** <Delete>.

## Goto

The step / transition is selected in the level 1.

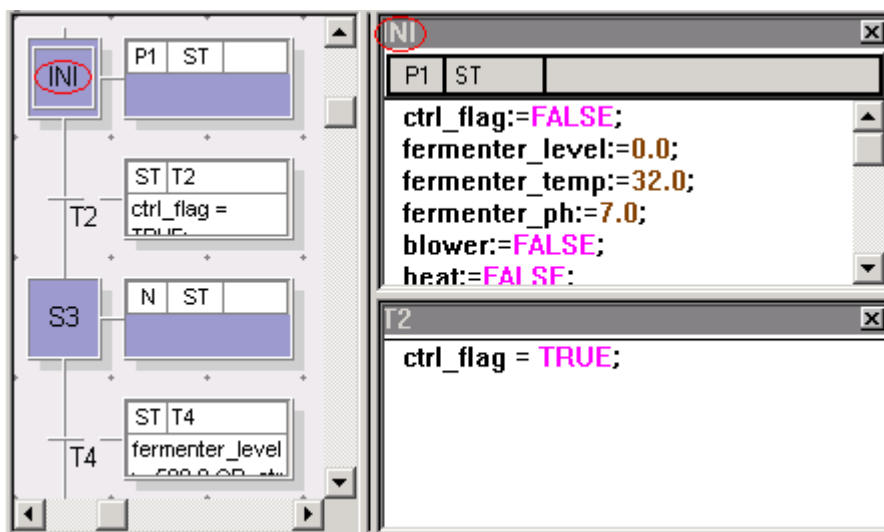
### To go to a step or transition in the current SFC program

1. From the Edit menu, choose **Goto**.
2. In the Goto Step/Transition dialog, select the element from the list then click **OK**.



## Level 2

The **Level 2** window displays the coding for steps and transitions. For steps, the window displays the defined action blocks. For transitions, the window displays the defined conditions. You can also display a second level 2 window for another step or transition. When first coding steps, you need to add action blocks.



### To edit the Level 2

The Edit Level 2 option is available from the main menu and the contextual menu accessed by right-clicking a step or transition.

1. Select the step or transition.
2. From the Edit menu, choose **Edit Level 2**.
3. To display a second level 2 window for another step or transition, do one of the following:
  - Right-click an element (without selecting it), then choose **Edit Level 2 in separate window** from the contextual menu
  - Drag to select an element, then press Ctrl+Enter



## Coding Action Blocks for Steps

You attach **action blocks** to steps by adding them in the level 2 window, then defining their name, comment (optional), type, and qualifier. Comments are displayed after the action block name in the level 2 window for a step, for example, InitAction (\* initialize all \*). When changing the type of an action block, the code zone must be empty. For details on actions within steps, see page 404.

You can specify the ST, IL, or LD language for use as default for the level 2 programming of steps.

The available action block types are the following:

- Boo
- IL
- LD
- SFC child
- ST

Boo action blocks require the selection of a Boolean variable from the variable selector. These action blocks take the name of the selected variable. SFC child action blocks require assigning the name of the SFC child to the action block. You cannot program Boo or SFC-child action blocks.

The available qualifiers for all action block types are None Store Action (N), Set (S), and Reset (R). The qualifiers for IL, LD, and ST action block types also include the Pulse on Deactivation Action (P0) and Pulse On Activation Action (P1).

### To add action blocks to steps

You can add action blocks using the main menu, the SFC toolbar, or a contextual menu accessed by right-clicking in the level 2 window.

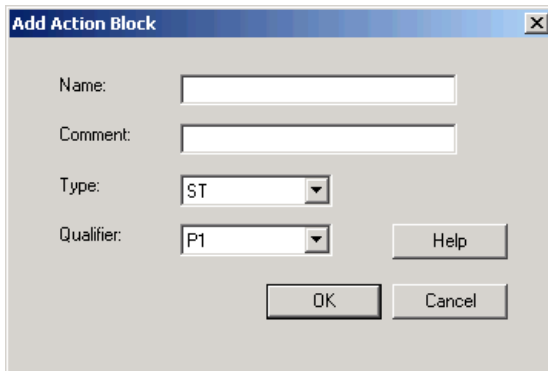
1. In the SFC chart, select the step for which to add an action block, then from the Edit menu choose **Edit Level 2**.

2. Click in the level 2 window, then from the Edit menu, choose **Add Action Block** or click



, from the SFC toolbar.

3. In the Add Action Block dialog, enter a name and comment (optional), then select a type and qualifier for the action block. For the Boo type, the selected variable's name is automatically entered in the Name field. For the SFC child type, enter the name of the SFC child in the Name field.

The image is a screenshot of a dialog box titled "Add Action Block". It has a standard Windows-style title bar with a close button (X) in the top right corner. The dialog contains four input fields: "Name:" (a text box), "Comment:" (a text box), "Type:" (a dropdown menu with "ST" selected), and "Qualifier:" (a dropdown menu with "P1" selected). To the right of the "Qualifier:" dropdown is a "Help" button. At the bottom of the dialog are three buttons: "OK", "Cancel", and "Help".

4. Click **OK**.
5. In the editor window, enter the code for the action block. You cannot program Boo and SFC child action blocks.

### To specify the default programming language for steps

- From the Options menu, choose Set Default Level 2 Language, then Step, then the desired programming language.

## Coding Conditions for Transitions

You attach conditions to transitions by programming these in the level 2 window. Only one condition can be attached to a transition. When defining conditions, you indicate a name, a comment (optional), and the programming language (type). The available programming languages for transitions are LD and ST. When changing the programming language of a transition, the code zone must be empty. For details on conditions attached to transitions, see page 410.

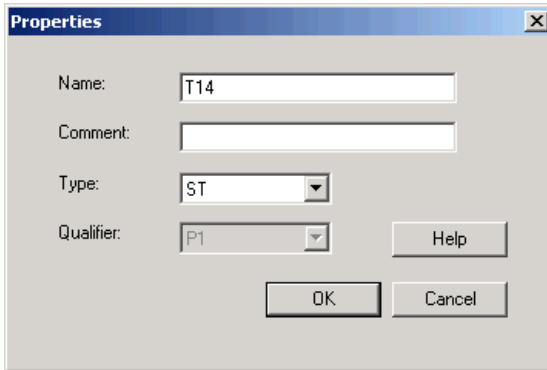
You can specify the ST or LD language for use as default for the level 2 programming of transitions.

### To attach conditions to transitions

1. In the SFC chart, select the transition for which to attach a condition, then from the Edit menu choose **Edit Level 2**.

The level 2 window is displayed with the transition's name and set for programming in the ST language.

2. To change the name or programming language for the transition, double-click the level 2 window title bar, then in the Properties dialog, make the necessary changes and click **OK**.




### To specify the default programming language for transitions

- From the Options menu, choose Set Default Level 2 Language, then Transition, then the desired programming language.


## Moving Action Blocks Up or Down

You can change the order of the action blocks in a step. The displayed order is used during execution.

### To move an action block up

1. Select the step in the SFC chart, then from the Edit menu, choose **Edit Level 2**.
2. In the level 2 window, click the action block to move up, then do one of the following:
  - Right-click the action block, then from the contextual menu, choose **Move Up**.
  - On the SFC toolbar, click  .

### To move an action block down

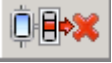
1. Select the step in the SFC chart, then from the Edit menu, choose **Edit Level 2**.
2. In the level 2 window, click the action block to move up, then do one of the following:
  - Right-click the action block, then from the contextual menu, choose **Move Down**.
  - On the SFC toolbar, click  .

## Deleting an Action Block

You delete action blocks from a step from within the level 2 window.

### To delete an action block

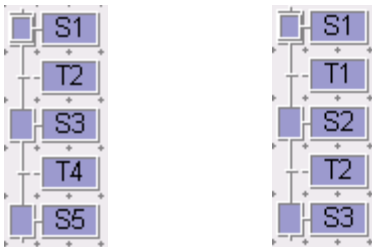
1. Select the step in the SFC chart, then from the Edit menu, choose **Edit Level 2**.
2. In the level 2 window, click the action block to delete, then do one of the following:
  - From the Edit menu, choose **Delete Action Block**.

- From the SFC toolbar, click  .

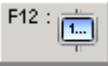
## Renumbering Charts

**Renumbering** of SFC elements takes place from top to bottom, then from left to right. Renumbering is only applied to steps and transitions having the standard default names (Sx and Tx).

Before Renumbering      After Renumbering



### To renumber a chart

- From the Edit menu, choose **Renumber** or click  , on the SFC toolbar.



## FC Editor



The **FC (Flow Chart) editor** is launched automatically when an FC program is edited from the Workbench.

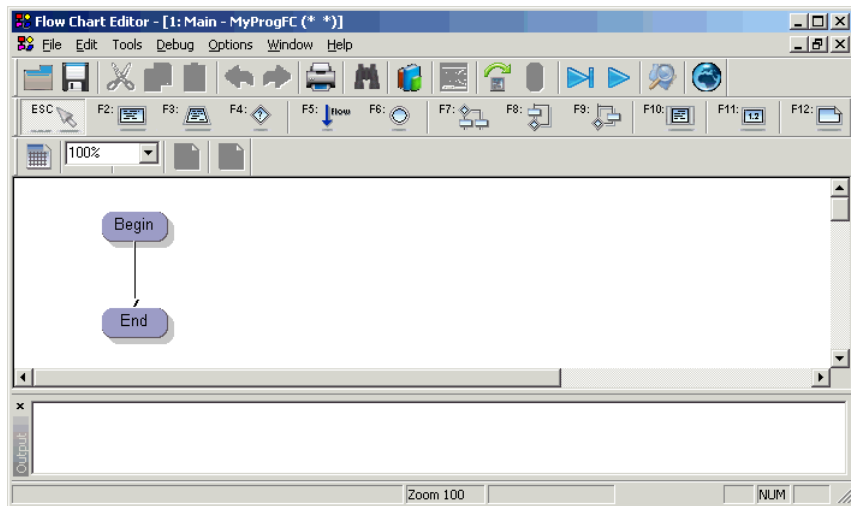
**Note:** Before creating new programs, you need to close the Dictionary.

**To subsequently open another program, from the FC editor**

- From the File menu, choose **Open (CTRL+O)** or click , on the Standard toolbar.

## Appearance

Title Bar  
Menu Bar  
Toolbar  
Workspace  
Output Window  
Status Bar



## Menu Bar

Some options are available as keyboard commands.

File	Open	Ctrl+O	opens an existing POU
	Close	Alt+F4	closes the POU
	Save	Ctrl+S	saves the current POU
	Build Program	Alt+F3	builds the code for the current POU
	Stop Build Program		stops the build in progress for the current POU
	Dictionary	Ctrl+D	opens the dictionary filtered for the current POU
	Description	Ctrl+K	accesses the program description
	Print	Ctrl+P	prints the current POU
	Exit	Ctrl+Q	leaves the language editor
	Edit	Undo	Ctrl+Z
Redo		Ctrl+Y	restores the last cancelled action
Cut		Ctrl+X	removes the selected item and places it on clipboard
Copy		Ctrl+C	takes a copy of the selected item and places it on the clipboard
Paste		Ctrl+V	inserts the contents of the clipboard into the selected item
Delete		DEL	removes the selected item
Find / Replace in POUs		Ctrl+F	finds and replaces text in a project, a configuration, a resource, or a POU
Go to		Ctrl+G	jumps to the indicated element number
Renumber			renumbers all elements in the chart in sequential order
Edit Level 2		Enter	opens the level 2 programming for an element



Edit (Continued)	Edit Level 2 in Separate Window	Ctrl+Enter	opens the level 2 programming for an element in a separate window
	Insert/Set Identifier	Ctrl+I	accesses the Select Variable dialog box where you can insert a variable in the current POU
	Insert New Rung	Ctrl+R	inserts a rung
	Change Yes/No Direction		changes the direction of an IF-THEN-ELSE structure
Tools	Browser	Ctrl+B	accesses the Cross References browser listing and localizing all instances of global variables and I/Os declared in a project
Debug	Debug	Alt+F6	switches the application to debug mode
	Simulation	Alt+F7	switches the application to simulation mode
	Debug FB	F11	opens a selected function block in the language editor with its instantiation values
Options	Set Level 2 Language		sets the programming language used for level 2 programming. Possible languages are LD, ST, and IL.
	Layout		accesses the Layout editor where you specify options such as the toolbars to display, the magnification of the workspace area, and other level 2 options
	Customize	Ctrl+U	accesses the customization properties for Workbench views and editors
	Target/Code Settings		accesses the compilation options for the POU

Window	Cascade		sets the different views of the project to appear in a cascading manner
	Tile		sets the different views of the project to appear in a tiled manner
	Split		splits the workspace into two simultaneous views
	Show Output Window	Ctrl+4	displays the output window below the workspace
	Clear Output Window		clears the contents of the output window
Help	Contents	F1	accesses the online help
	Search Help On...		not currently supported
	About		displays product and version information
	Support Info		not currently supported

## Working with Flow Charts

Flow Chart programs are created in a resource in the link architecture view of the Workbench. After having opened the program, you can create / insert new elements in the Level 1 (diagram) or modify / move existing elements.

Every Flow Chart must have a BEGIN and an END, these are automatically inserted when a new Flow Chart is created from the link architecture view. These elements can be moved, but not deleted.

Level 2 programming of each action and test using ST, LD or IL syntax is also performed within the Flow Chart editor.

### To save the current flow chart

- From the File menu, choose **Save (CTRL+S)** or click  , on the Standard toolbar.

From the editor, you can:

- Build the current program code to check your program and prepare the code for building the resource code.
- Print your program.
- Launch the Dictionary.

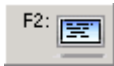
### To include a description documenting your program

- From the File menu, choose **Description**.

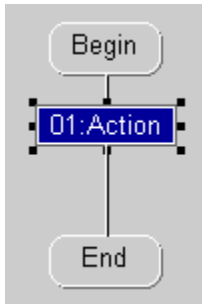
## Flow Chart Elements

Most common operations are performed with the mouse: insertion, selection and drag and drop of elements. Moving an element also moves all the elements directly linked below. Elements are individually re-sizable.

### Action



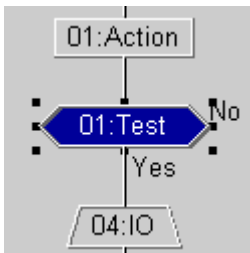
Insert FC **action** creates a new action each time the mouse button is pressed. Actions are automatically linked by the Flow Chart editor. An action number is automatically generated, sequentially for each new action. For details about FC actions, see page 420.



### Test



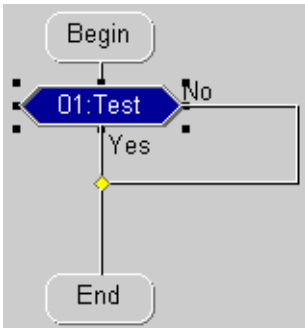
Insert a test to branch between sections of the program that are executed conditionally. Double-clicking the Yes or No text, swaps their position. For details about FC conditions, see page 420.



## IF-THEN-ELSE

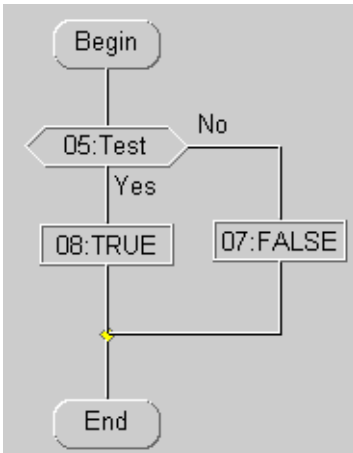


This generates a standard **IF-THEN-ELSE** structure in the Flow Chart. Examples of Flow Chart complex structures are available on page 425.



Actions can be added on both Branches before the Connection.

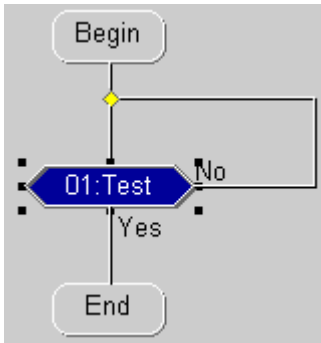
### Example



## DO-WHILE

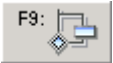


This generates a standard **DO-WHILE** structure in the Flow Chart. Examples of Flow Chart complex structures are available on page 425.

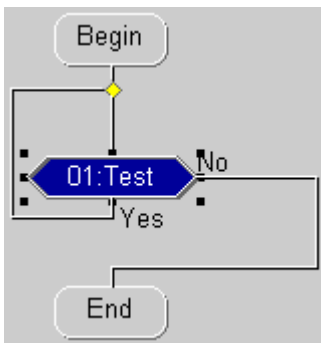


**Note:** The difference between this structure and the WHILE-DO is the location of the action(s) to repeat.

## WHILE-DO



This generates a standard **WHILE-DO** structure in the Flow Chart. The difference between this structure and the DO-WHILE is the location of the action(s) to repeat. Examples of Flow Chart complex structures are available on page 425.




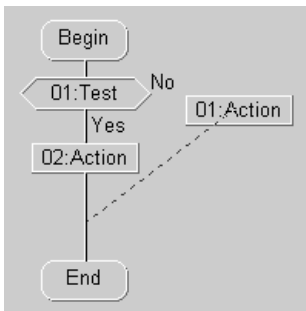
## Flow



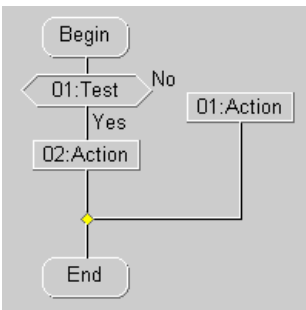
A **Flow** indicates a link between two elements. For details about FC flow links, see page 419.

### To insert a flow

1. On the Flow Chart Tools toolbar, click  .
2. Click on the elements to flow from.
3. Drag the link to a point on another link or a non-connected element.



4. Drop the Flow link.

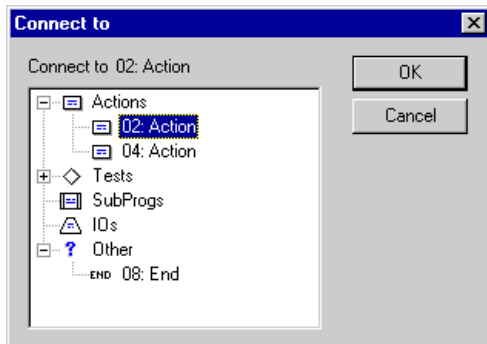




## Connector



A **Connector** is used to link to an element, without specifically 'drawing' the link. For details about FC connectors, see page 424.

The Connect To Dialog Box is automatically displayed:

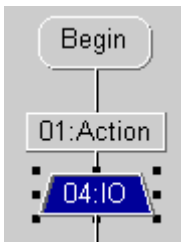


1. Expand (or collapse) sections in the tree by clicking on the  (or ) Buttons.
2. Select an element then click **OK**.

## I/O Specific

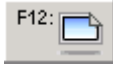


An **I/O Specific action** is one that contains hardware dependent code, they must be re-written for different I/Os. For details about FC I/O specific actions, see page 423.





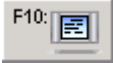
## Comment



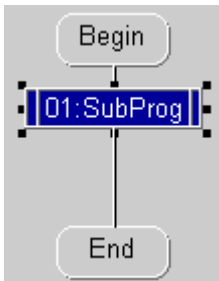
Comments are free format text inserted anywhere in the Flow Chart for documentation purposes only. For details about FC comments, see page 424.



## Sub-Program



When inserting a Sub-program symbol, a dialog box is displayed to select the Sub-program from the list within the current program. For details about FC sub-programs, see page 422.



**Note:** Double-clicking on a **Sub-program** opens the selection dialog box to change the sub-program reference

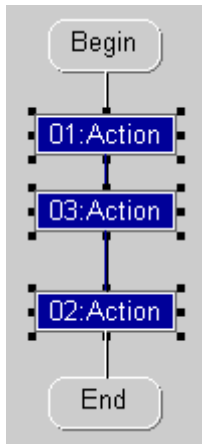
## Managing Elements

Flow Chart elements can be cut, copied and pasted within a Flow Chart or, if more than one Flow Chart is open, between different Flow Charts. When an element is moved, removed or added, the chart is automatically refreshed, elements are placed according to the grid and links are redrawn.

### Select



To **Select** an item, simply click on it with the left mouse-button. Multiple selections are made by clicking a blank area of the workspace then drag and drop until the required items are highlighted. The shift key, combined with a mouse click, selects multiple, distant, elements.



## Cut


Use the cut command to remove selected elements and move them to the clipboard, replacing the clipboard's current contents.

### To cut elements

1. Select the element(s) to cut.
2. From the Edit menu, choose **Cut (CTRL+X)**.

OR

1. Select the element(s) to cut.

2. On the Standard toolbar, click  .

## Copy


Use the **copy command** to copy selected elements and place them on the clipboard, replacing the clipboard's current contents.

### To copy elements

1. Select the element(s) to copy.
2. From the Edit menu, choose **Copy (CTRL+C)**.

OR


1. Select the element(s) to copy.

2. On the Standard toolbar, click  .

## Paste

Use the **Paste** command to place the contents of the clipboard at the insertion point. Any existing selected items are automatically unselected.

### To paste elements

1. From the Edit menu, choose **Paste (CTRL+V)** or click  , on the Standard toolbar.
2. Position the 'ghost'.
3. Click to paste at the new location

## Delete

### To delete elements

1. Select the element(s).
2. From the Edit menu, choose **Delete** OR press <Delete>.

## Move

All elements linked directly below a 'moved' element are automatically moved and their flow links re-drawn.

### To move elements

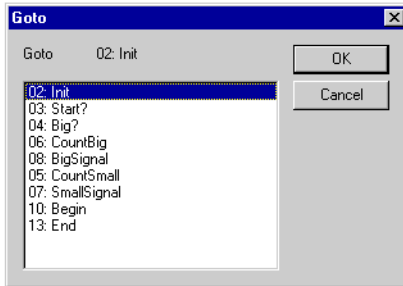
1. Select the element(s) to move.
2. Drag the 'ghost' to a valid location.
3. Drop the elements as required.

## GoTo

### To go to a symbol in the current FC program

1. From the Edit menu, choose **GoTo**.

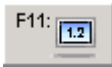
The GoTo dialog box appears:



2. Select the element from the list then click **OK**.

The Action / Test Level 1 is selected.

## Renumber

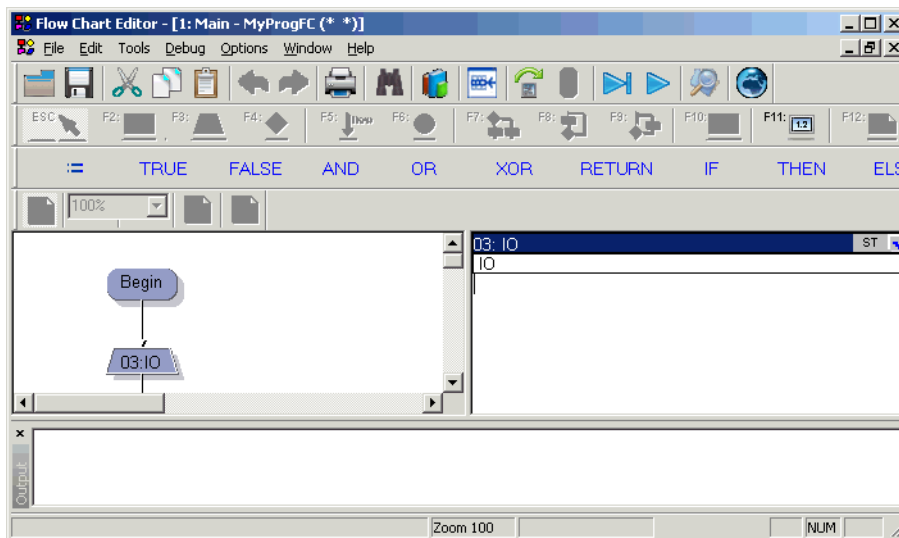


Two elements cannot have the same logical number within one Flow Chart. In this case, a renumber facility is provided to automatically generate sequential numbers. The order in which the chart is renumbered is based on each element's position, from top to bottom, then from left to right.

## Level 2

### To view the Level 2 window of an FC Element (action or test)

1. Select an FC element.
2. Do one of the following:
  - From the Edit menu, choose **Edit Level 2**.
  - Double-click an FC element.



**Note:** The FC Level 2 is also shown within the corresponding element representation in the Level 1 Workspace.

To view the Level 2 of another element, follow the instructions above, in which case the new Level 2 will replace the one displayed, or open the new Level 2 in a separate window.

## To open the Level 2 in a separate window

1. Select an FC element.
2. Do one of the following:
  - From the Edit menu, choose **Edit Level 2 in separate window**.
  - Press **<Ctrl+Return>**.

You can close level 2 windows by clicking on the close icon on the right of their title bar.

## Level 2 Window

When the Edit Level 2 command is used:

- If no Level 2 window exists, a level 2 window is opened.
- If one level 2 window is already open, it is replaced by the level 2 of the current element.  
(The Level 2 of the FC window is sub-divisible).
- If there are two level 2 windows, the level 2 window that had the focus is replaced by the level 2 of the currently selected element.



A maximum of two separate windows (elements) can be opened for simultaneous editing.

## **Edit the Level 2**

ST is the default language of the level 2. You can change the language to LD or IL with the list displayed on the right of the title bar of the level 2 window.

You can set the default language for the level 2 programming from the menu by choosing Options, then Set Level 2 Language, then the desired default language.


- In a test only one condition can be written; In the case of editing in LD, there is only one coil without any variable attached. The coil value corresponds to the value of the test.
- In a test, no pulse is permitted, i.e. neither positive, nor negative contacts can be used.

## **Related Topics**

Multi-language Editor



## Multi-language Editor

 The **Multi-language editor** has editing functions for graphical and textual languages. These editing functions are automatically launched when an FBD, ST, IL, or LD program is opened from the Workbench.

The editor only allows new elements to be inserted if the current position is valid. Use the mouse or cursor keys to move the current position around within the Workspace.

From the editor, you can perform several tasks:

- Build the current Program code (to check your Program and prepare the code for building the Resource code)
- Print programs
- Launch the Dictionary

**Note:** Before creating new programs, you need to close the Dictionary.

When printing programs, the fonts used in the diagram are the same as for the editor. The FBD and LD diagrams are scaled to fit the width of the printed page format (portrait or landscape). To adjust the font for printed diagrams, you need to modify the font used for the editor.

### To subsequently open another program, from the Multi-language editor

- From the File menu, choose **Open (CTRL+O)**.

### To add a description to a program

- From the File menu, choose **Description**.

# Appearance

Title Bar

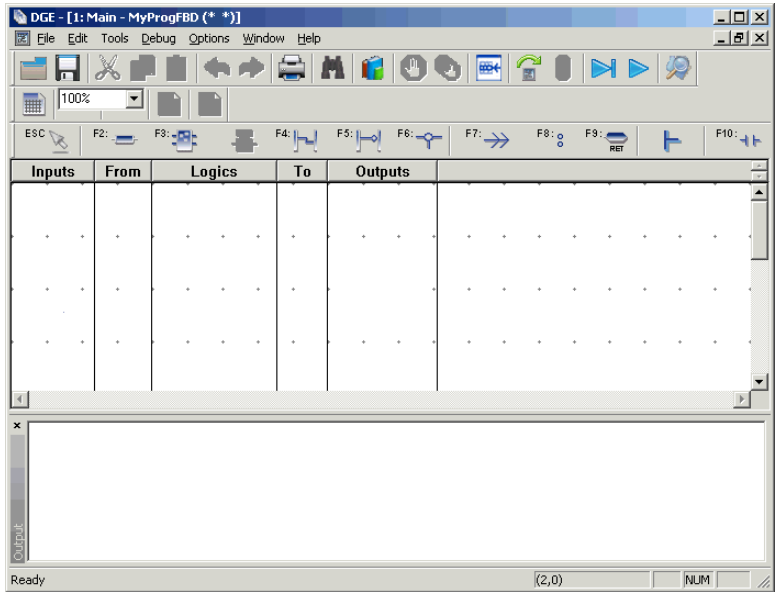
Menu Bar

Toolbars

Workspace  
with or  
without  
Guidelines

Output  
Window

Status Bar



**Note:** The Language toolbar contains tools for LD, ST, IL, or FBD.

## Workspace

You can arrange the workspace of the FBD editor to show guideline areas. These areas divide the workspace into logical sections: Inputs, From, Logics, To, and Outputs. Elements move independently of the area guidelines. You can choose to hide individual areas and resize the areas. You can also choose to restore the default area sizes.

When moving the cursor across the FBD or LD editor, the cursor's coordinates are displayed in the status bar. These coordinates refer to grid areas. For instance, the top-leftmost grid area is coordinate (0,0) and the grid area to its immediate right is coordinate (1,0). The grid coordinates remain the same whether the zoom or cell width changes.

### **To manage the guidelines**

You access the Areas layout options window from the menu or by right-clicking an area titlebar.

1. To show or hide the guideline areas, from the Tools menu, choose **Show/Hide Areas**, then in the areas layout window, check the areas to display.
2. To resize an area, drag the boundary on the left or right side of the heading until the area is the width you want.
3. To return the area guidelines to their initial widths, click **Restore Default Area Sizes**.

## Menu Bar

The options available differ depending on the POU's programming language. Some options are available as keyboard commands.

File	Open	Ctrl+O	opens an existing POU
	Close	Alt+F4	closes the POU
	Save	Ctrl+S	saves the current POU
	Build Program	Alt+F3	builds the code for the current POU
	Stop Build Program		stops to build in progress for the current POU
	Dictionary	Ctrl+D	opens the dictionary filtered for the current POU
	Description	Ctrl+K	accesses the program description
	Print	Ctrl+P	prints the current POU
	Exit	Ctrl+Q	leaves the language editor
	Edit	Undo	Ctrl+Z
Redo		Ctrl+Y	restores the last cancelled action
Cut		Ctrl+X	removes the selected item and places it on clipboard
Copy		Ctrl+C	takes a copy of the selected item and places it on the clipboard
Paste		Ctrl+V	inserts the contents of the clipboard into the selected item
Special Paste			places the contents of the clipboard in a specified position
Delete		DEL	removes the selected item
Select All		Ctrl+A	selects all items in the active view
Find / Replace in POUs		Ctrl+F	finds and replaces text in a project, a configuration, a resource, or a POU
Find Matching Name		Alt+F2	finds and selects matching variable names in the current POU

Edit (Continued)	Find Matching Coil	Alt+F5	finds and selects matching variable names for coils in the current POU
	Go to Line	Ctrl+G	jumps to the indicated line number
	Insert/Set Identifier	Ctrl+I	accesses the Select Variable dialog box where you can insert a variable in the current POU
	Insert/Set Block	Ctrl+R	accesses the list of all available functions and function blocks to insert in the current POU
	Insert Rung	Ctrl+R	inserts a rung
	Change Coil/Contact Type	Space	changes the selected coil or contact type
	Insert Comment		inserts a comment above a rung in LD diagrams
Tools	Browser	Ctrl+B	accesses the Cross References browser listing and localizing all instances of global variables and I/Os declared in a project
	Show/Hide Execution Order	Ctrl+W	shows or hides the execution order of FBD diagrams
	Show/Hide Areas		accesses the areas layout window where you check the areas to display in the FBD editor workspace
	Show/Hide Output Values		shows or hides the output values of blocks (operators, functions, and function blocks) in the FBD and LD editors, while in debug or simulation mode
Debug	Debug	Alt+F6	switches the application to debug mode
	Simulation	Alt+F7	switches the application to simulation mode
	Spy Selection		adds a selected variable to the Spy List while in Debug mode

Debug (Continued)	Debug FB	F11	opens a selected function block in the language editor with its instantiation values
	Toggle Breakpoint	F10	sets or removes a breakpoint for step-by-step mode
	Breakpoints		removes a breakpoint for step-by-step mode
	Real Time		switches the application to real-time mode
	Cycle to Cycle		switches the application to cycle-to-cycle mode
	Execute One Cycle	Alt+F10	executes one cycle
	Step	Alt+F8	executes the current line then steps to the next line
	Step Into	Alt+F9	executes the current line then steps into the next line
	Show Current Step		shows the current step
	Options	Layout	
Customize		Ctrl+U	accesses the customization properties for Workbench views and editors as well as working preferences
Tab Setting			sets the number of spaces for the Tab character
Show Coils/Contacts			sets the display of the name, alias, or name and alias for coils and contacts
Target/Code Settings			accesses the compilation options for the POU
Auto Input			assigns a variable name or block when inserting elements

Options (Continued)	Manual Input		assigns a variable name or block at any time
	Numerical Display		sets the numerical display of values
	Show I/O Variable Comments		in the FBD editor, displays comments for I/O variables, entered in the dictionary
	Hide I/O variable Comments		in the FBD editor, hides comments for I/O variables
	Show Internal Variable Comments		displays comments for I/O variables, entered in the dictionary
	Hide Internal Variable Comments		hides comments for I/O variables
	Window	Cascade	
Tile			sets the different views of the project to appear in a tiled manner
Show Spy List			accesses the Spy List window where you specify variables whose values are displayed while in test mode
Show Output Window		Ctrl+4	displays the output window below the workspace
Clear Output Window			clears the contents of the output window
Show Call Stack			displays the call stack window
Help		Contents	F1
	Search Help On...		not currently supported
	About		displays product and version information
	Support Info		not currently supported

## Multi-Language Elements

The language used for the Program currently edited determines the elements that can be inserted. This is reflected in the menu commands and toolbar buttons.

- ST/IL Elements
- LD Elements
- FBD Elements

**Note:** Arrays must be declared in the Dictionary View before inserting them in Functional Block Diagrams (FBD).

## ST/IL Elements

The main keywords of the ST or IL language are available in the Language toolbar. When entering ST or IL syntax, basic coding is black while other items are displayed using color:

- Keywords are pink
- Numbers are brown
- Comments are green

Inserting a variable name can be done directly by typing it or by using the Insert Identifier command from the Edit menu. To insert block instances or to get help on a block, use the Insert Block command from the Edit menu.




## LD Elements


When editing an LD POU, you can place elements by using the keyboard. Keyboard shortcuts are indicated on the LD toolbar. Alternatively, use the mouse to select the element to insert from the toolbar. The element is inserted at the current position in the diagram.

The current position is the cell that is marked in black.

To attach a variable to a coil or a contact, double-click on it or press **<Return>** when it is selected. The Select Variable dialog box is displayed. You can also use the Insert identifier

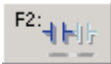
button  on the Standard toolbar.

To attach a block type to a block, double-click on it or press **<Return>** when it is selected.

The Select Block dialog box is displayed. You can also use the Insert Identifier button  on the Standard toolbar.

If you want to enter a variable name or block type when you place the element, check "Auto input" in the Option menu. If you want to do it at a later time, uncheck this option.

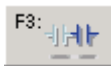
### Contact on the Left



The contact is inserted to the left of the current position (highlighted in black).

**Note:** Pressing F2 on the keyboard has the same effect.

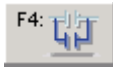
### Contact on the Right



The contact is inserted to the right of the current position (highlighted in black).

**Note:** Pressing F3 on the keyboard has the same effect.

## Parallel Contact



Inserts a contact, parallel to the current selection.

**Note:** Pressing F4 on the keyboard has the same effect.

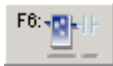
## Coil



Inserts a coil on the current rung.

**Note:** Pressing F5 on the keyboard has the same effect.

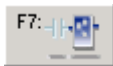
## Block on the Left



The block is inserted to the left of the current position (highlighted in black).

**Note:** Pressing F6 on the keyboard has the same effect.

## Block on the Right



The block is inserted to the right of the current position (highlighted in black).

**Note:** Pressing F7 on the keyboard has the same effect.

## Parallel Block



Inserts a block, parallel to the current selection.

**Note:** Pressing F8 on the keyboard has the same effect.

## Jump



Inserts a jump to a label.

**Note:** Pressing F9 on the keyboard has the same effect.

## Label

In Ladder, the label identifies a rung.

### To enter a label identifying a rung

1. Press Enter or double-click the header-cell of the rung
2. In the dialog box, enter a name for the label.
3. Press OK to confirm.

## Return



Inserts a return symbol.

**Note:** Pressing Shift+F9 on the keyboard has the same effect.


## Change Coil/Contact Type



The available types of coils and contacts are listed in the Language Reference.

For LD elements in FBD diagrams, you can also change the type of contact or coil.

### To change the type of a coil or a contact

1. Select the coil or contact.
2. Do one of the following:
  - From the Edit menu, choose Change coil/contact type.
  - On the LD toolbar, click .
  - Press the **<space bar>**.

## Insert New Rung

### To insert a rung between two existing rungs


- From the Edit menu, choose **Insert New Rung**.

The new rung is inserted above the rung that contains at least one selected element. The rung is composed of one contact and one coil.

When you press any button on the LD toolbar at the end of the diagram, a new rung is created.

## Other Operations

### To insert a link

1. Select the desired part of the rung by clicking on it.
2. On the right hand side of the LD toolbar, click .

The new link is inserted to the left of the position highlighted in black.

### To align coils on all rungs



"justifies" the coils on each rung so that coils are aligned vertically on the right.

## FBD Elements

When programming in FBD, choose the element to be inserted from the FBD toolbar and place it in the Program Workspace.

Place all elements (blocks and variables), then link them by using links. An element is automatically linked to another element if it is placed next to it such that their connectors meet. When wiring intersects or diverges, the junction is indicated by a dot.

Before using arrays in FBD, these must be declared in the Dictionary View. Ladder elements are also available for use in FBD programs.

### To show the order of execution of an FBD program

You can show the order of execution in the form of numerical tags for the following elements in an FBD program: coils, returns, jumps, instances of function blocks (declared or not), and variables where a value is assigned in the program. When the order cannot be determined, the tags display question marks (?). You can perform this task from the menu bar, the toolbar, or keyboard shortcut (Ctrl+W).

- ▶ From the Tools menu, choose **Show/Hide Execution Order** or click  on the Standard toolbar.

### To assign a name to a variable or block graphic symbol

- ▶ Select the graphic symbol, then on the Standard toolbar, click  or select the graphic symbol, then double-click it.

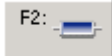
### To assign variable names or block types when placing an element

- ▶ In the Options menu, choose **Auto Input**.

### To assign variable names or block types at any time

- ▶ In the Options menu, choose **Manual Input**.

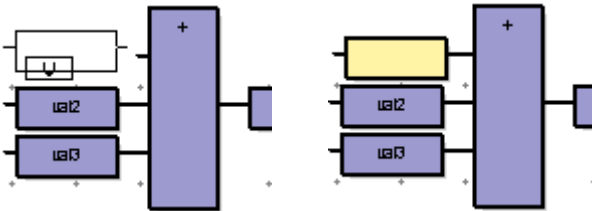
## Variable



Accesses the variable selector enabling the insertion of a variable or constant into the workspace.

To connect a new symbol to an existing one (another variable, a block input, or a block output), keep the mouse button depressed (the cursor becomes a "ghost" symbol) and drag the element until its connecting line on the left (or right) overlaps an existing connecting point. When the mouse is released, the new symbol is automatically created and linked.

Drag to place the element:      Release the mouse button. The new variable is automatically connected:



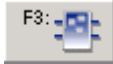
For input and output variables, you can choose to display comments entered in the dictionary directly below the variable by choosing **Show I/O Variable Comments** from the Options menu. You hide comments by choosing **Hide I/O Variable Comments**. When moving the cursor over a selected variable, its data type and hidden comment is displayed as a tooltip.



When entering variable blocks, you can choose to have the Workbench automatically prompt you to enter a constant or select a variable from the Select Variable dialog by choosing **Auto Input** from the Options menu. You can also choose to enter variable names manually by choosing **Manual Input**.

You can resize variable blocks.

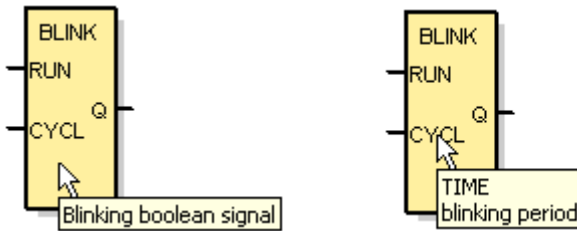
## Function Block



Accesses the block selector enabling the insertion of a block into the workspace. Blocks can be function blocks ("RAS device" or IEC 61131), functions ("RAS device" or IEC 61131) or operators.

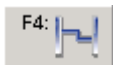
Inputs and outputs can be connected to variables, contacts or coils, or other block inputs or outputs. Formal parameter short names are displayed inside the block.

When moving the cursor over a selected function block or instance of a function block, its comment is displayed as a tooltip. Furthermore, when moving over a parameter, its data type and comment is displayed as a tooltip.

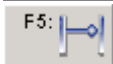


You can resize function blocks.

## Link



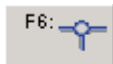
Connection links are drawn between elements in the diagram.



Negation connection links are equivalent to placing a NOT block on a direct link.

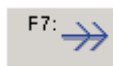
Both direct links and negated links are always drawn from an output to an input point (in the direction of the data flow).

## Corner



User-defined points may be inserted in the diagram that determine the routing of links. First, place a corner, then add links to and from this point. If no corner is placed, the editor uses a default routing algorithm.

## Jump



Inserts a jump in the workspace.

A dialog box containing a list of labels to jump to is displayed. Alternatively, by entering a new name in the edit box, then clicking OK, a Jump is created to a new Label (the corresponding Label symbol must then be placed in the diagram).

A Jump symbol must be linked to a Boolean point. When this Boolean (left) connection is TRUE, the execution of the diagram Jumps directly to the target Label.

**Note:** Backward jumps may lead to a blocking of the PLC loop in some cases.

## Label



Inserts a label in the workspace.

The Jump Label dialog box is displayed to enter and create a Label name. Alternatively, if a Jump symbol was previously inserted, and a new Label name was entered in the edit box, the Label name specified when creating that Jump can be chosen from the list.

Labels can be placed anywhere in an FBD diagram. They are used as a target for Jump instructions, to change the execution order of the diagram. Labels are not connected to other elements.

**Note:** It is highly recommended to place Labels on the left of the diagram in order to increase diagram readability.

For more details about labels, see page 431.



## Return



Inserts a return symbol in the workspace.

If the connection line (to the left of the Return symbol) has the Boolean state TRUE, the Program ends - no further part of the diagram is executed.

No connection can be put on the right of a RETURN symbol.

For more details about return statements, see page 431.

## LD Elements

The LD elements available for use in Function Block Diagrams are the following:

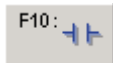
### Left Power Bar



Contacts of the Ladder Diagram language must be connected, on the left, to a left power bar which represents the initial "TRUE" state. The editor also allows the connection of any Boolean symbol to a left power bar.

You can resize the height of a left power bar.

### Contacts



A contact can be connected, on the left, to a left power bar or another contact. A contact can be connected, on the right, to any other Boolean point; another contact, a coil, a Boolean input of a block...

By default, a direct contact is inserted. To change the contact type, select the contact and press the <spacebar>. Repeatedly pressing the <spacebar> cycles between all contact types.

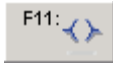
### LD Vertical "OR" Connection



LD vertical connection accepts several connections on the left and several connections on the right. Each connection on the right is equal to the OR combination of the connections on the left.

You can resize the height of an OR Connection.

## Coils



A coil represents an Action. It must be connected on the left to a Boolean symbol, such as a contact or the Boolean output of a block. By default, a coil is inserted with a small Right Power Bar. If a link is inserted, from the right of a coil to a Right Power Bar, this small Bar is removed.

Before linking to a Right Power Bar:



After linking to a Right Power Bar:



By default, a direct coil is inserted. To change the coil type, select the coil and press the <spacebar>. Repeatedly pressing the <spacebar> cycles between the all coil types.

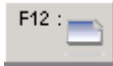
## Right Power Bar



Coils may be connected, on the right, to a right power bar. This is optional. If a coil is not connected on the right, a small right power bar is included. For details about multiple connections, see page 437. For details about basic LD contacts and coils, see page 439.

You can resize the height of a right power bar.

## Comment



Press this button, on the Language toolbar, then click in the Workspace to insert a comment. **Comments** are free format text inserted anywhere in the FBD POU, for documentation puposes only.

After entering text, click elsewhere in the Workspace to 'validate' the comment.

You can also resize comments.

## Managing Elements

Programming elements can be cut, copied and pasted within a program or, if more than one is open, between different programs. When an element is moved, removed or added, the chart is automatically refreshed, elements are placed according to the grid and links are redrawn.

### Select



Selections can contain text, graphics or both.

#### To make a selection

- Click the cursor on an element to make / change a selection.

#### To select multiple elements in LD or ST or IL

- Drag the cursor to highlight multiple elements in the workspace.

OR

- Hold down **SHIFT** then use the cursor keys to extend the current selection.

#### To select multiple elements in FBD

- Click in a blank area of the workspace then drag to enclose the required elements.

OR

- Hold down **CTRL** or **SHIFT**, then use the mouse, to add to the current selection.

**Note:** In the FBD editor, **ESC** removes the current selection. If the editor is in 'element insertion' mode, **ESC** returns to 'select' mode.

## Resize

The dimensions of individual programming elements can be changed. Resizing elements in the Multi-language editor is only valid for FBD POU's.

### To resize an element

1. Select the element to resize.
2. Click and hold the cursor over on the edge of the selected element.
3. Drag the edge to the desired position.

The cursor changes during a resize.



4. Release the mouse button to complete the operation.

**Note:** Elements cannot be resized so that they overlap other elements, you may need to move elements prior to resizing.

## Undo/Redo

The Multi-language editor provides a multi-level Undo / Redo facility (*limited to only one action for ST and IL*).

### To Undo (Redo) the previous action

- From the Edit menu, choose **Undo (Redo)** or click  or , on the Standard toolbar.

## Move

Moving elements in the Multi-language editor is only valid for FBD IEC 61131 POU's. You can drag individual elements to a new position in the workspace without first selecting them. However, to drag multiple elements, you need to select each element.

### To move elements

- To move a single element, click the element and while holding down the mouse drag the element to its new position, then release the mouse.
- To move multiple elements, select all elements and while holding down the mouse drag the elements to their new position, then release the mouse.

## Cut


Use the Cut command to remove selected Elements and move them to the clipboard, replacing the clipboard's current contents.

### To cut elements

1. Select the element(s) to cut.
2. From the Edit menu, choose **Cut (CTRL+X)**.

OR

1. Select the element(s) to cut.

2. On the Standard toolbar, click  .

## Copy


Use the Copy command to copy selected elements and place them on the clipboard, replacing the clipboard's current contents.

### To copy elements

1. Select the element(s) to copy.
2. From the Edit menu, choose **Copy (CTRL+C)**.

OR

1. Select the element(s) to copy.

2. On the Standard toolbar, click  .

## Paste

Use the **Paste** command to place the contents of the clipboard at the insertion point.

- For ST and IL, if text is selected before a paste, it is replaced by the contents of the clipboard.
- For LD, the elements on the clipboard are pasted in parallel with selected elements. To paste before or after a selection, use the Paste Special command. The Paste command may fail when placing a coil in parallel with a contact or a contact in parallel with a coil
- For FBD, using the ghost (keeping the mouse button depressed) enables moving pasted elements to the desired position.

### To paste elements

- From the Edit menu, choose **Paste (CTRL+V)** or click  , on the Standard toolbar.



## Paste Special

This command is only valid for LD POU's. The Paste Special command places the contents of the clipboard in a specified position.

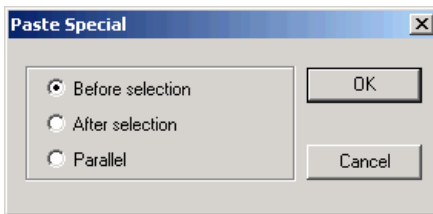
### Notes:

- The standard Paste command has the same effect as a Parallel Paste Special command.
- The Paste command may fail because: *a coil can not be put in parallel with a contact, or a contact can not be put in parallel with a coil.*

### To paste elements

1. From the Edit menu, choose Paste Special.

A dialog box appears, to choose the paste location:



2. Choose the desired paste location.
3. Click OK.

## Delete

### To delete elements

1. Select the element(s).
2. From the Edit menu, choose Delete.

## Select All

All the elements in the current Program are simultaneously selected with the Select All command.

### To Select All elements

- From the Edit menu, choose **Select All (CTRL+A)**

## Find Matching Name

For LD only. Find Matching Name finds and selects matched variable names within the current POU. You can also find matching names for function blocks or rung labels.

### To find a matching variable name

1. Select a variable with the name to match.
2. To select the next element with the same variable name as the current selection, press **<ALT+F2>**.

## Find Matching Coil

For LD only. Find Matching Coil finds and selects matched variable names within the current POU. This feature is mainly used while in debug mode, to quickly find rungs forcing suspicious variables.

### To find a matching coil

1. Select a variable name to match.
2. To select the next coil with the same variable name as the current selection, press **<ALT+F5>**.

## Go to Line

The Go To Line command is only valid when editing ST and IL POU's. In the Multi-language editor, you access it from the File menu by choosing Go To Line.

You enter a line number, for the current POU, indicating the line to which to move the cursor.

## Display/Hide Comments

You specify displaying or hiding variable comments at the language editor level. However, you can also choose to display or hide individual variable comments. For instance, you can choose to display all internal variable comments, then hide the comment for a specific internal variable. You can also choose to hide all I/O variable comments, then display the comment for a specific I/O variable. The display/hide setting for individual comments overrides the display/hide setting at the editor level (for either I/O variable or internal variable comments).

### To display/hide comments defined for I/O variables

You display or hide all comments defined for I/O variables at the editor level from the main menu.

- ▶ To display comments for I/O variables, from the Options menu, choose **Show I/O Variable Comments**.
- ▶ To hide comments for I/O variables, from the Options menu, choose **Hide I/O Variable Comments**.

### To display/hide comments defined for internal variables

You display or hide all comments defined for internal variables at the editor level from the main menu.

- ▶ To display comments for internal variables, from the Options menu, choose **Show Internal Variable Comments**.
- ▶ To hide comments for internal variables, from the Options menu, choose **Hide Internal Variable Comments**.

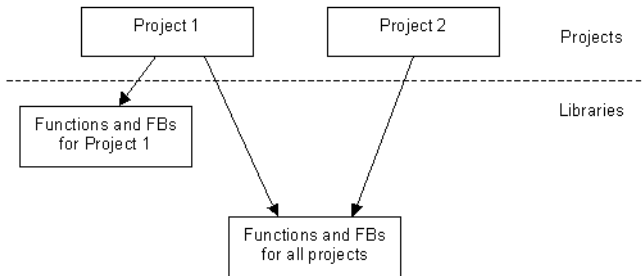
### To display/hide individual comments defined for variables

You display or hide individual comments defined for I/O variables and internal variables at the comment level from a contextual menu. You can also reset individual variable comments to use the display/hide setting defined for a given type of variable comments.

- ▶ To display the variable comment, select the comment, then right-click and choose **Show Comment**.
- ▶ To hide the variable comment, select the comment, then right-click and choose **Hide Comment**.
- ▶ To set the variable comment to use the display/hide setting specified for the variable type, select the comment, then right-click and choose **Reset Default**.

# Libraries

Libraries are special projects made up of configurations and resources in which you define functions and function blocks for reuse throughout **DS800 Development Suite** projects. Libraries also enable you to modularize projects and to isolate functions and function blocks so that these can be validated separately.



Functions and function blocks can be written using the IEC 61131 languages (FBD, LD, ST, or IL). Libraries can also contain POU's, global variable definitions, and any other item used for testing functions and function blocks.

Before using libraries, you need to create them.

## Creating Libraries

You create libraries much the same as you create projects. You base a library on a template then develop its elements, i.e., configurations, resources, programs, functions, and function blocks. Libraries are stored in the same location as projects and are also MS-Access database (.MDB) files:

```
<root directory>/prj/<library name>/PRJlibrary.MDB
```

Three templates are available for use with libraries:

- LibSingleROC800 and LibSingleFB107, containing one resource in one configuration
- LibMultipleROC800, containing two resources in two different configurations linked by an Ethernet network

Furthermore, the target type of a library resource affects the usability of functions and function blocks throughout projects using the library. Functions and function blocks can only be used in resources referring to the same target type except when they use the SIMULATOR target type. When library resources use the SIMULATOR target type, all of their functions and function blocks can be used in any project resource regardless of its target type. Below are examples of possible combinations of resource target types:

<b>Target in library</b>	<b>Target in project</b>	<b>Usage</b>
SIMULATOR	ROC809	OK
ROC809	ROC809	OK

Library functions and function blocks must have unique names. When they have the same names as those defined in a project in which they are used, only those from the project will be recognized. Furthermore, you do not need to compile functions and function blocks in the library before using them in projects. They are compiled in the calling project space, in order to take care of the compiling options defined for the project.

### **To create a library**

1. From the File menu, choose **New Project\Library**.
2. Enter a name for the library.
3. Select a template.
4. Click **OK**.

## **Using Libraries in a Project**

Projects can use functions and function blocks from one or more libraries. You need to create libraries before using them. Furthermore, you need to define a project's dependencies, i.e., the set of libraries the project will use, before using a library's defined elements. A project can depend on more than one library.

You can also add dependencies to third-party library projects. However, to enable their use, you need to license third-party library projects. Otherwise, their dependency appears invalid.

Library functions and function blocks can refer to some global defined words or data types defined in the library. In such a case, these defined words and data types from the library can also be used in the project.

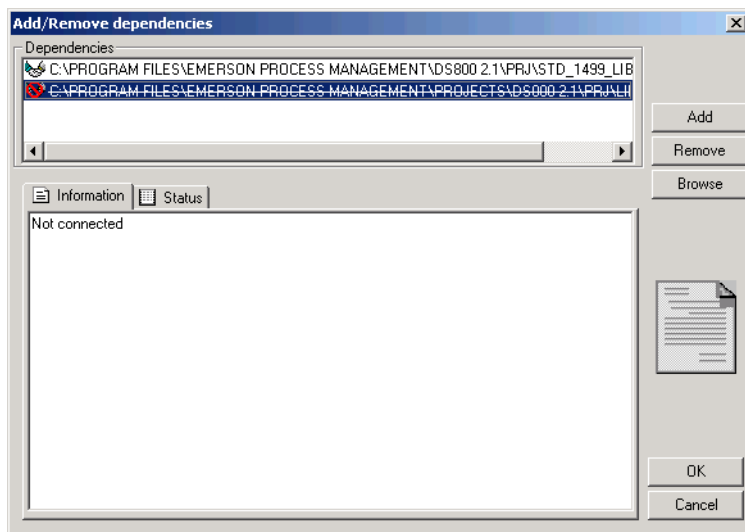
A library cannot use functions and function blocks from another library. In other words, you cannot define external dependencies for a library. However, a function or function block from a library can call other functions or function blocks from the same library. Furthermore, functions or function blocks from libraries can call 'C' written functions and function blocks defined for the corresponding target.

All functions and function blocks within a project, including those coming from libraries, must have unique names. When more than one uses the same name, the following conditions apply:

- If the functions or function blocks come from different libraries, warnings are generated at compilation and only the first definition is recognized
- If one function or function block is defined in the project and the other from a library, only the one defined in the project is recognized. The other is ignored.

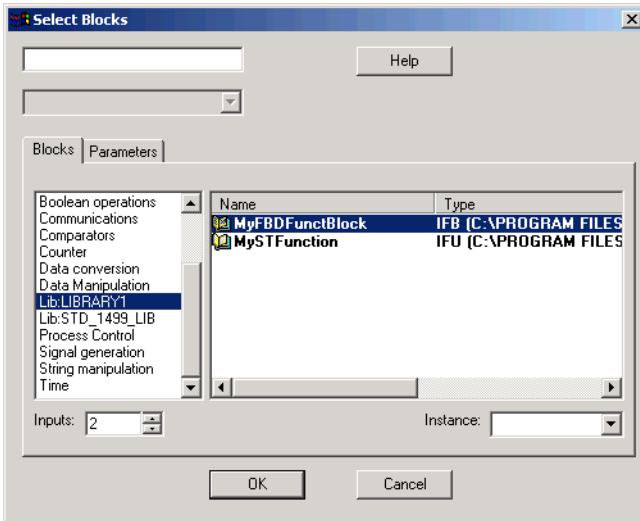
Furthermore, when the same name is used for several types or several defined words having different definitions in a project and attached libraries, an error is generated at compilation time. However, when a data type or defined word is defined several times with the same contents or definition, a warning is reported but the project can be compiled.

You specify a project's dependencies in the Add/Remove Dependencies window. This window is divided into the Dependencies list and the Information and Status areas. The Dependencies list displays the full pathnames of all libraries used by the project. The Information area shows the description of the library currently selected in the Dependencies list. The Status area shows the status of the library.

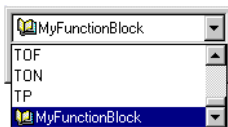


Once a project's dependencies are set up, you can access the functions and function blocks contained in the specified libraries from the Select Blocks dialog box, available in the ST, LD, and FBD editors. In this dialog box, library items appear with the IFB or IFU types and the source library's path. The IFB type indicates an IEC Function Block and the IFU type indicates an IEC Function.





In the dictionary, when declaring an instance of a function block from a library, the pathname of the library is also displayed together with the function block's type:



When a project has dependencies, an icon indicating the status of its dependencies appears at the bottom right-hand corner of both the hardware and link architecture views:



The status of the project's dependencies is OK



The project dependencies refer to an invalid library. This can happen if a library has been removed, renamed or moved.

When a project has a dependency on an invalid library, to retain all associations between the project and library upon renaming or moving, you need to reestablish the library path. Upon deleting a library, all associations are broken.

### **To define a project's dependencies**

You can access the Add/Remove Dependencies window from the menu or the main toolbar. You can only define the dependencies for the currently opened project.

1. From the Tools menu, choose **Add/Remove Dependencies**.

The Add/Remove Dependencies window appears.

2. To add a new library to the list of dependencies:

- a) Click **Add**.
- b) In the file browser, locate the library's PRJlibrary.MDB file.
- c) Click **Open**.

3. To remove a library from the list of dependencies:

- a) From the Dependencies list, select the library to remove.
- b) Click **Remove**.

### **To reestablish an invalid library path**

You reestablish an invalid library path for a renamed or moved library from the Add/Remove Dependencies window. Reestablishing a library path restores all associations between a project and library.

1. From the Tools menu, choose **Add/Remove Dependencies**.

The Add/Remove Dependencies window appears.

2. From the Dependencies list, select the invalid library to reestablish.
3. Click **Browse**, then locate and select the library.

### **To license a third-party library project**

You can choose to license third-party library projects while adding them as dependencies or at any other time. You initiate licensing for these library projects in the Add/Remove Dependencies window, then complete the process in the License Manager.

1. Make sure the third-party library project is copied onto your disk, then from the Tools menu, choose **Add/Remove Dependencies**.
2. In the Add/Remove Dependencies window, add the third-party library project to the list of dependencies:

- a) Click **Add**.

- b) In the file browser, locate the library's PRJlibrary.MDB file.

- c) Click **Open**.

A message stating that the library is not licensed is displayed.

- d) Click **OK**.

The License Manager is displayed

3. Do one of the following:

- To license the third-party library project at this time, click **Send** in the License Manager, then include all required information and send the email.
- To license the third-party library project at a later time, click **Cancel** in the License Manager. You can launch the licensing process at any time by selecting the unlicensed third-party library project, then clicking **Browse** to locate, select, and open the library's PRJlibrary.MDB file.

The original setup code and user codes as well as a Registration Key 1 and Registration Key 2 will be returned via e-mail.

4. Upon reception, make sure the setup and user codes are the same as those in the License Manager window, then copy and paste the registration keys in their respective fields.

The third-party library project is enabled for use.

# Debug

When developing an application, you can choose to debug, i.e., detect and remove errors, from a project using one of two methods:

- Simulation mode. In this case, inputs and outputs are not managed by the target virtual machine. The rest (i.e. Binding exchanges and execution of the POU's of each resource) is executed by the standard Windows platform. Each resource will be executed by one virtual machine on the PC running the Workbench.
- Online mode. In this case, each resource is executed by one **DS800 Development Suite** virtual machine on the real platform. A download operation is required, to download the code of each resource to the corresponding platform. For details on downloads, see page 293.

**Note:** To enable the debugging of a Project, you must first build it using the Build Project command. For details on building projects and resources, see page 347.

Before simulating a resource, the code for the simulation has to be generated for each resource. By default, this option is checked in a resource's compilation options. For details on compilation options, see page 55.

When switching an application to Debug mode, the Workbench verifies the coherency between the current resource definitions and the resources' compiled code. The Workbench also verifies the coherency between all versions of the resource code. You can access version information for a resource.

While in debug mode, the security state of unlocked resources and resources having no access control switches to read-only mode. The security state of unlocked POU's and POU's having no access control also switches to read-only mode. Locked resources and locked POU's remain locked.

To test a resource "online", its TIC code must be produced and downloaded to the target system, otherwise, the corresponding virtual machine may have been generated with the "C" code of the application.

## Status Information

When running a project in Debug mode, status information for resources from the target is updated at a regular interval, indicated by the debug refresh rate. The status information is displayed in resource title bars as:

- resource icons
- text information

You can also choose to refresh the status information for resources at any time.

The debug refresh rate applies to all resource data including variables and status information while in debug mode; its default value is 300 milliseconds. You set the refresh rate in the DefaultRefreshTime property in the [REFRESH] section of the Dta.ini file located in the Workbench's Bin folder. You can also set refresh rates for individual resources by adding the following entry for a resource in the same section: RefreshTime(X)=YYY, where X indicates the resource number and YYY indicates the refresh time in milliseconds.

**Note:** For a project in normal editing mode, refreshing the status of resources will not refresh the status of resources previously opened by other users for single-resource editing. To refresh the displayed status for these resources, you need to reopen the Workbench project.

### Resource Icons

The resource icons appear in the left-most corner of the title bar:

Icon	Description
------	-------------



The resource belongs to the current project and is running on the configuration.



The resource belongs to the current project and is either running on the configuration but with a different version or it is not running on the configuration but the code of the resource is available on the configuration.

## Icon Description



The resource belongs to the current project and is not running on the configuration and no code is available on the configuration.



The resource does not belong to the current project but is running on the configuration. In this case, a new empty resource appears with this icon in the link architecture and hardware architecture views of the project.

Resource icons also display the security state of a resource.

## Text Information

The state of the resource appears next to the resource icon before the resource's name, in the title bar.

Resource State	Description
RUN	The resource is running ( real-time mode). You can switch the resource to cycle-to-cycle mode.
STOP	The resource is in cycle-to-cycle mode. Possible operations are: <ul style="list-style-type: none"><li>- switch the resource to real-time mode</li><li>- execute one cycle</li><li>- go to the next step (only when step-by-step mode is instantiated)</li></ul>
BREAK	The resource is in break point mode (SFC POU's). Possible operations are: <ul style="list-style-type: none"><li>- switch the resource to real-time mode</li><li>- execute one cycle</li><li>- go to the next step (only when step-by-step mode is instantiated)</li></ul>
ERROR	The resource is in error. Possible operations are: <ul style="list-style-type: none"><li>- switch the resource to real-time mode</li><li>- execute one cycle</li><li>- go to the next step (only when step-by-step mode is instantiated)</li></ul>

<b>Resource State</b>	<b>Description</b>
STEPPING	<p>The resource is in step-by-step mode.</p> <p>Possible operations are:</p> <ul style="list-style-type: none"> <li>- switch the resource to cycle-to-cycle mode returning the resource to the start of its cycle without executing the remaining code</li> <li>- execute one cycle</li> <li>- execute the current step and go to the next one</li> <li>- locate the current step</li> <li>- switch the resource to real-time mode</li> </ul>
STEPPING_ERROR	<p>The resource is in stepping error mode. This state is caused when an invalid operation occurs such as a division by 0 or a bound check error.</p> <p>Possible operations are:</p> <ul style="list-style-type: none"> <li>- locate the current step to debug it</li> <li>- switch the resource to cycle-to-cycle mode returning the resource to the start of its cycle without executing the remaining code</li> </ul>

The BREAK, STOP, and ERROR states are possible while in cycle-to-cycle mode. I/Os and bindings are done, but POU's are not executed. A complete cycle is executed when you execute one cycle. The STEPPING and STEPPING\_ERROR states are possible while in step-by-step debugging mode.

The existence of code on the configuration is indicated with the following text:

CODE	The resource is not running but the code exists (disk or PROM) on the configuration.
NOCODE	The code does not exist on the configuration.

On a running resource, when the version of code in the project differs from the code on the corresponding virtual machine of the configuration, a message is displayed.

### **To refresh the status of resources**

- ▶ From the Debug menu, choose **Refresh Status**.

The status information displayed in the title bars of all resources is updated.



## Download

When simulating a project, you do not need to perform a download operation. You perform a download operation for each resource having code to send to a target.

The Download window shows the list of resources making up a project. In this list, resources are displayed next to the name of the configuration to which they are attached. When the resource code contains debug information generated for ST, IL, or LD programs, the word "debug" appears in comments.

**Note:** Each time you perform a download operation, the Workbench verifies the coherency between the current resource definitions and the resources' code to download. The Workbench also verifies the coherency between all versions of the resource code. You can access version information for a resource.

### Conditions necessary to download a resource:

1. The code (corresponding to the resource available on the hardware configuration) must first be generated by building the project or resource. By default, TIC code is generated for a DS800 virtual machine.
2. Verify that the Power Switch parameter in the DS800 screen of ROCLINK 800 is set to on.
3. The computer where the Workbench is installed must be connected to the configuration through a network supported by the Debugger. The standard network used by the Workbench is Ethernet. If downloading a project with a single configuration, then you may also choose to use the ISaRSI network.

In the Download window, select the resources to download by clicking on their name in the list (click again to unselect). You can click **Toggle** to select or unselect a selected resource. You can also choose to select all or unselect all resources.

### Download options:

- Start after download, indicates that the virtual machine executes the resource code upon reception

- Save after download, indicates that the virtual machine saves the resource code on the configuration platform upon reception. The code can be saved to a disk, if the platform has one, or another storage method, depending on the platform and the implementation of the virtual machine.

### **To download the code of project resources**

At anytime during a download operation, you can abort the operation by clicking **Abort**.

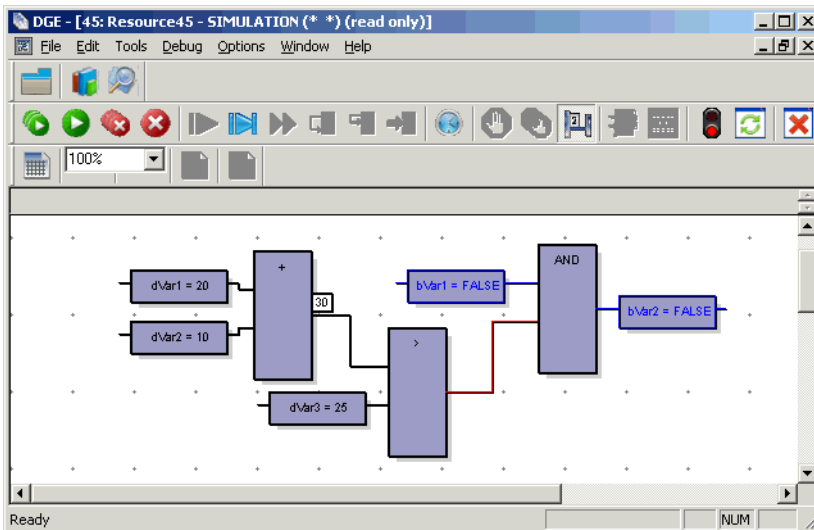
- From the Debug menu, choose **Download** or click  on the Standard Toolbar.

## Debug/Simulate

You can test a project using one of two modes:

- Debug, where you test resources online. The debugger establishes the connections with remote configurations. Execution errors and warnings can appear in the Output Window.
- Simulation, where you simulate the running of the project. The Configuration manager and a virtual machine for each resource is launched. The Simulate I/Os Panel is displayed.

While in debug or simulation mode, for FBD and LD programs and function blocks, you can choose to graphically monitor the block (operator, function, or function block) output values. You can temporarily resize variables to enable viewing their output values. Resized variables return to their original size upon quitting debug or simulation mode.



- Output values of boolean type are displayed using color. The output value color continues to the next input. The default colors are red when True and blue when False. You can customize the colors used for the boolean items.
- Output values of SINT, USINT, BYTE, INT, UINT, WORD, DINT, UDINT, DWORD, LINT, ULINT, LWORD, REAL, LREAL, TIME, DATE, and STRING type are displayed

as a numeric or textual value in a label directly above the output. When the output is a structure type, the displayed value is the selected member.

When the output value is unavailable, the ??? text is displayed in the output label.

To enable the graphic display of output values, you need to generate the symbols monitoring information for individual FB and LD programs and function blocks before building. You can choose to show or hide the output display values.

### To start Debug mode

You can start Debug mode from the link architecture view, hardware architecture view, or from a language editor.

- ▶ From the Debug menu, choose **Debug Target** or click  , on the Standard toolbar.

### To start Simulation mode

You can start Simulation mode from the link architecture view, hardware architecture view, or from a language editor.

- ▶ From the Debug menu, choose **Simulation** or click  , on the Standard toolbar.

### To show or hide output values


You can choose to display the values of non-boolean outputs in the FBD and LD editors.

- ▶ From the Tools menu, choose **Show/Hide Output Values** or click  , on the Debug toolbar.

### To stop Debug or Simulation mode

- ▶ From the Debug menu, choose **Stop Debug/Simulation**.

Or

- ▶ On the Debug toolbar, click  .


## Start / Stop a Resource

The "Start" command on the Debug menu enables you to start a resource which has been stopped. It launches the DS800 virtual machine on the RAS device system and the resource is executed. The resource code must be available on the RAS device system.


**To stop the execution of a resource and kill the corresponding** virtual machine

- ▶ From the Debug menu, choose **Stop**.

Or

- ▶ On the Debug toolbar, click  .

**To stop all resources of the project**

- ▶ On the Debug toolbar, click  .

## Resource Execution Mode

You can execute a resource in one of three possible execution modes:

- Real-time
- Cycle-to-cycle
- Step-by-step


When defining a resource's Settings properties, you can set it to automatically start in real-time or cycle-to-cycle execution mode prior to code generation. By default, resources start in real-time mode.

### Real-time Mode

Real-time mode is the run time normal execution mode where target cycles are triggered by the programmed cycle timing. While in real-time mode, you can switch the resource to cycle-to-cycle mode. When debug information is generated for POUs in a resource, the resource automatically switches to step-by-step mode when the application encounters a breakpoint.

A resource where real-time mode is activated is in the RUN state.

#### To activate real-time mode


- ▶ On the Debug toolbar, click  .

## Cycle-to-cycle Mode

In cycle to cycle mode, the virtual machine loads the resource code but does not execute it until you execute one cycle or activate real-time mode. When debug information is generated for POU's in a resource, the resource automatically switches to step-by-step mode when the application encounters a breakpoint. You can also switch to step-by-step mode by stepping.


A resource where cycle-to-cycle mode is activated can be in one of three states: STOP, BREAK, and ERROR.

### To activate cycle-to-cycle mode

- ▶ On the Debug toolbar, click  .

### To execute one cycle

Cycle-to-cycle mode must be activated before executing individual cycles.

- ▶ On the Debug toolbar, click  .

## Step-by-step Mode

You can instantiate step-by-step mode for ST, IL, and LD POU's. For ST and IL POU's, you set breakpoints to specific lines of code. For LD POU's, you set breakpoints to rungs. When you run an application in Debug mode, the application stops when it encounters a breakpoint. At this time, depending on the state of the resource, you can choose to perform various operations:

- Step to the next line of code or rung
- Step into the next line of code or rung
- Execute one cycle
- Switch to cycle-to-cycle mode
- Switch to real-time mode

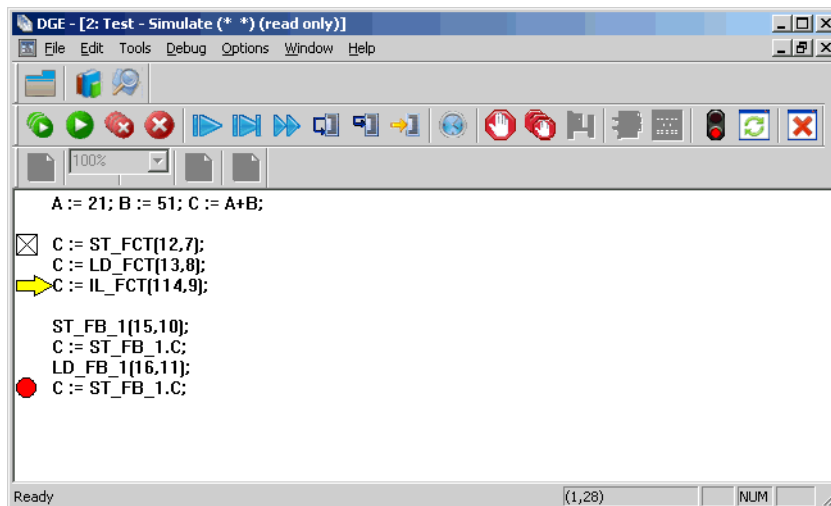
A resource where step-by-step mode is activated is in the STEPPING state. When the resource encounters a stepping error, the resource is in the STEPPING\_ERROR state. When stepping within a resource reaches the end of its cycle, the resource automatically switches to cycle-to-cycle mode in the STOP state.

**Note:** You can only set breakpoints for resources producing TIC code; you cannot set breakpoints for resources producing C source code. Furthermore, you cannot set or remove SFC breakpoints while a resource is in the STEPPING state.

Before setting up step-by-step mode for ST, IL, and LD POU's, you need to specify the generation of debug information for the resource and the individual POU's.

When switching an application to debug mode, to use step-by-step mode, defined breakpoints are sent to the target. When you stop debug mode, you can choose to remove the breakpoints from the target. Breakpoints remaining on a running target may interfere with its cycle.

In the language editor, while in step-by-step mode, defined breakpoints that have been successfully sent to the target appear as red circles to the left of the line of code or rung; breakpoints that are disabled on the target appear as . The current line is indicated with a yellow arrow at its left. When stepping passes beyond the last line or rung of a POU, the arrow points downward (↓). A Call Stack window shows stepping information such as the name of the POU from which a Step Into command jumped from upon execution.






## Setting Breakpoints

You set breakpoints for ST, IL, and LD POU's in the POU editor. Before setting breakpoints in a POU, you need to specify the generation of debug information for the resource and the individual POU's. For details on generating debug information, see page 56.

**Note:** You can only set breakpoints for resources producing TIC code; you cannot set breakpoints for resources producing C source code.

### To set a breakpoint in an ST, IL, or LD POU

1. Click in the line of code or rung on which to set the breakpoint.


2. On the toolbar, click .

A breakpoint appears to the left of the line of code or rung.


## Removing Breakpoints

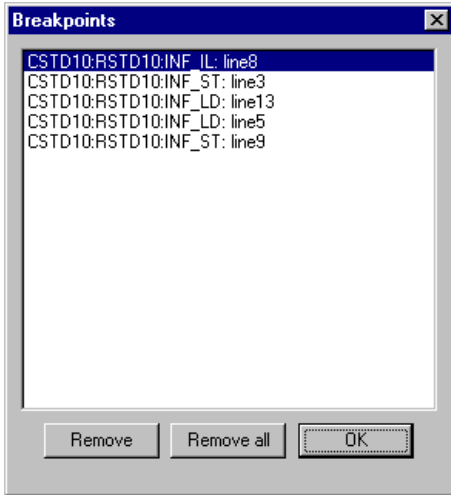
You can remove breakpoints set for ST, IL, and LD POU's for step-by-step mode.

### To remove breakpoints

- ▶ To remove a breakpoint while in its POU, click in the line of code or rung with the breakpoint, then click  on the toolbar.

The breakpoint is removed from the line of code or rung.

- ▶ To remove a breakpoint from any POU in a resource, click  on the toolbar, then select the breakpoint from the list and click **Remove**. You can also remove all breakpoints set in all POU's of the resource by clicking **Remove All**.



The individual or multiple breakpoints are removed from their POUs.

## Stepping in POUs

While a resource is in the STEPPING state, you can step in a POU ( ST, IL, and LD for which you generated debug information) once its execution is interrupted by encountering a breakpoint. You can execute one of two types of steps:

- Step, executes the current line of code or rung then steps to the next line or rung
- Step into, executes the current line of code or rung then steps into the next line of code or rung. When the next line includes a call to a function, stepping continues in the called function then returns to the next line of code or rung in the POU.


When a resource holds POUs for which debug information is generated, stepping is also available while the resource is in either the STOP, BREAK, or ERROR state. However, in these states, stepping jumps to the first line or rung of the first POU for which debug information is generated.

When stepping in POUs, you can locate the current step from within any POU.

### To step to the next line of code or rung

1. Select the POU to step in.




2. From the Debug toolbar, click  .

The POU executes the current line of code or rung then steps to the next one.

### To step into the next line of code or rung


1. Select the POU to step in.



2. From the Debug toolbar, click  .

The POU executes the current line of code or rung then steps into the next one and stepping continues in any called function before returning to the next line of the POU.

### To locate the current step in a resource

- ▶ From the Debug toolbar, click  .



## Set Cycle Time

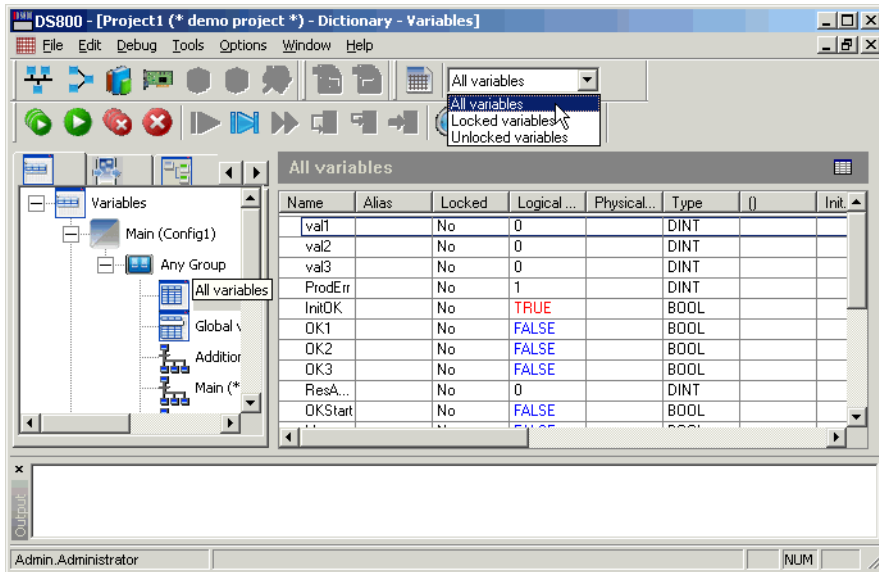
While in debug mode, you can change the cycle time of a resource. You can also set the cycle time before building the code for the resource in the run time settings for the resource. To view the current value of the resource cycle time, from the Debug menu, choose **Diagnosis**.

### To change the Cycle Time of the resource

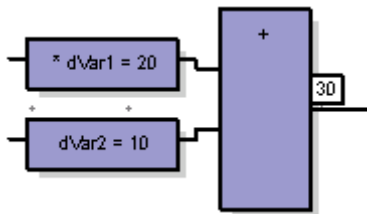
1. Select the resource.
2. From the Debug Menu, choose **Change Cycle Timing**.

## Write / Lock / Unlock

While in debug or simulation mode, you can view the values and lock status of variables from within the dictionary view, LD editor, and FBD editor. In the dictionary view, the Locked column indicates whether a variable is locked. You can also choose to display all variables, locked variables, or unlocked variables.



In the LD and FBD editors, the \* symbol displayed at the left of a variable name indicates a locked variable.



You lock and unlock variables, and force the values of variables from the dictionary view, LD editor, and FBD editor. You can also unlock variables from the Diagnosis window.



- From the LD or FBD editors, double-click the variable, then in the dialog, click **Lock**.

### **To unlock variables**

- From the dictionary view, double-click the variable's corresponding cell in the Locked column, then in the dialog, click **Unlock**.
- In the LD or FBD editors, double-click the variable, then in the dialog, click **Unlock**.

You can also unlock variables from the Diagnosis window.

### **To force the values of variables**

- From the dictionary view, double-click the variable's corresponding cell in the Logical column, then in the dialog, enter a value and click **Write**.
- From the LD and FBD editors, double-click the variable, then in the dialog, enter a value and click **Write**.

## Diagnosis

You can access diagnostic information for individual resources while running an application in simulation mode. This information is divided into five categories:

- Timing
- System Variables
- Locked Variables
- Breakpoints
- Version Information

For details on run-time settings for resources, see page 59.

### To access diagnostic information for a resource

1. While the application runs in simulation mode, select a resource for which to obtain diagnostic information.
2. From the Debug menu, choose **Diagnosis**.

The Diagnosis window displays the diagnostic information for the resource.

### Timing

Timing information holds the current values of specific system variables for a selected resource. The timing information is:

- Programmed cycle time, the defined cycle time for the resource
- Current cycle time, the time of the last executed cycle
- Maximum cycle time, the longest period of time used for a cycle, since the resource was started
- Overflow, the number of cycles having exceeded the programmed cycle time

- State, the current state of the resource. Possible states are RUN (real-time mode), STOP, BREAK, ERROR, STEPPING, and STEPPING\_ERROR.
- Code, the indication of whether the code has been saved on the target system

For details on setting the cycle time of a resource, see page 303.

## System Variables

System variables hold the current values of all system variables for the resource. You can read from or write to system variables. These variables are defined in the **dsys0def.h** file. The system variables are:

Variable Name	Type	Read/Write	Description
__SYSVA_RESNAME	STRING	Read	Resource name (max length=255)
__SYSVA_SCANCNT	DINT	Read	Input scan counter
__SYSVA_CYCLECNT	DINT	Read	Cycle counter
__SYSVA_KVBPERR	BOOL	Read/Write	Kernel variable binding producing error (production error). Not supported in DS800.
__SYSVA_KVCERR	BOOL	Read/Write	Kernel variable binding consuming error (consumption error)
__SYSVA_TCYCYCTIME	TIME	Read/Write	Programmed cycle time
__SYSVA_TCYCURRENT	TIME	Read	Current cycle time
__SYSVA_TCYMAXIMUM	TIME	Read	Maximum cycle time since last start
__SYSVA_TCYOVERFLOW	DINT	Read	Number of cycle overflows



Variable Name	Type	Read/Write	Description
__SYSVA_RESMODE	SINT	Read	Resource execution mode. Possible modes are: -1: Fatal error 0: No resource available 1: Stored resource available NOT USED (CMG) 2: Ready to run 3: Run in real time 4: Run in cycle by cycle 5: Run with SFC breakpoint encountered 7: Stopped in stepping mode
__SYSVA_CCEXEC	BOOL	Write	Execute one cycle when application is in cycle to cycle mode
__SYSVA_WNGCMPTNM	STRING	Read	Warning component name
__SYSVA_WNGCMD	SINT	Read/Write	Warning command. Set it to 1 to get next warning
__SYSVA_WNGARG	DINT	Read	Warning Argument
__SYSVA_WNGNUM	DINT	Read	Warning Number

**Warning:** For the `__SYSVA_CCEXEC` system variable, its use in an ST program is not significant because resources run in cycle-to-cycle mode. Therefore, programs are not executed.

### Locked Variables

Locked variables are input, output, and internal variables that have been locked. When deleting locked variables through an online change, these deleted locked variables remain displayed but are preceded by the `_DEL_` prefix. To remove these variables from the list, you need to unlock them.

You can unlock variables in the Diagnostic window. You can also unlock variables from the from the dictionary view, LD editor, and FBD editor.

When viewing locked unwired IO channels, these are displayed with their directly represented variable naming.

### To unlock variables

- To unlock a single variable, select its name in the list then click **Unlock**.
- To unlock all variables, click **Unlock All**.

### Breakpoints

You can view a list of all breakpoints defined for ST, IL, and LD POU's of a resource, for use with the step-by-step mode.

```
IL_prg: line 10  
IL_prg: line 21  
LD_prg: line 6  
ST_prg: line 8
```

### Version Information

You can view version information including the compilation version number, the compilation date, and the CRC (Cyclic Redundancy Checking) of the data the resource works on for three sources of resource code:

- the compiled code for the resource in the Workbench project
- the code for the resource running on the target
- the code for the resource stored on the target

Version	Date	CRC
Compiled		
5	14:33:39 21-Feb-2003	F23EAFAC
Running		
4	14:31:35 21-Feb-2003	166EE91A
Stored		
4	14:31:35 21-Feb-2003	166EE91A

## SFC Breakpoints

While in Debug mode, you can place SFC breakpoints on SFC steps or transitions. When a breakpoint is encountered, the resource is set to the BREAK state. This mode is equivalent to the cycle-to-cycle mode. Then to overpass the breakpoint, you can choose either to execute one cycle or switch real-time mode. When a resource is in the BREAK state and step-by-step debugging is activated for ST, IL, or LD POU's within the resource, you can also step to the first line of the first POU of the resource for which debug information is generated.

**Note:** You can only set breakpoints for resources producing TIC code; you cannot set breakpoints for resources producing C source code. Furthermore, you cannot set or remove SFC breakpoints while a resource is in the STEPPING state.

Four types of SFC breakpoints are available:



Breakpoint on Step Activation



Breakpoint on Step Deactivation



Breakpoint on Transition



Transition Clearing Forcing

### To set a breakpoint command on a step or transition

You can set breakpoint commands from the Breakpoints toolbar or from the contextual menu.

- ▶ Right-click on the step or transition, then from the contextual menu choose the desired breakpoint command.

Once the breakpoint is reached, you can execute one cycle or switch real-time mode to continue the execution.

### To remove breakpoints from steps

You can remove breakpoints from the Breakpoints toolbar or from the contextual menu.

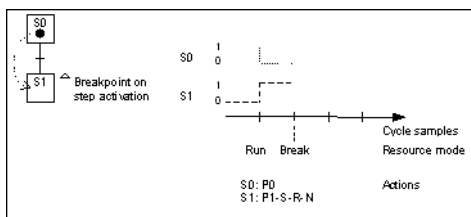
1. To remove a single breakpoint, right-click on the step, then from the contextual menu choose **Remove Breakpoint**.
2. To remove all breakpoints, right-click on a step, then from the contextual menu choose **Remove All Breakpoints**.

## Breakpoint on Step Activation

When the step goes from the inactive (no token) to the active (token) state, then breakpoint mode is set for the next cycle. The current cycle goes on executing normally. In particular around the step where the breakpoint is placed, before breakpoint mode is really set:


- All P0 actions, linked to all previous steps that become inactive, are executed.
- All P1 – S – R – N actions, linked to the step that becomes active, are executed.

The following illustrates cycle execution when a breakpoint on step activation is encountered.



### To set a breakpoint on step activation

You can set breakpoint commands from the Breakpoints toolbar or from the contextual menu.

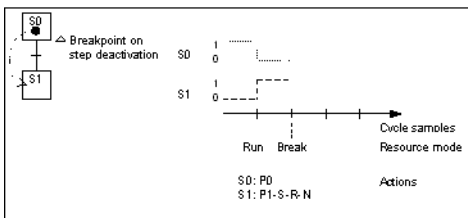
- Select the step, then from the toolbar, click  .

## Breakpoint on Step Deactivation

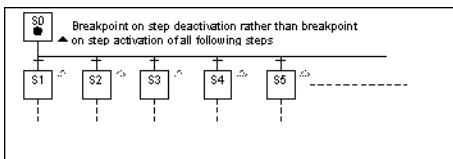
When the step goes from the active (token) to the inactive (no token) state, then breakpoint mode is set for the next cycle. Current cycle goes on executing normally. In particular around the step where the breakpoint is placed, before breakpoint mode is really set:

- All P0 actions, linked to the step that becomes inactive, are executed.
- All P1 – S – R – N actions, linked to all successor steps that become active, are executed.

The following illustrates cycle execution when a breakpoint on step de-activation is encountered.




The behaviors of setting a breakpoint on step activation is the same as step de-activation. These are both available to avoid setting multiple breakpoints as shown below.



**Note:** On a given step, you cannot set both a breakpoint on step activation and a breakpoint on step de-activation.

### To set a breakpoint on step deactivation

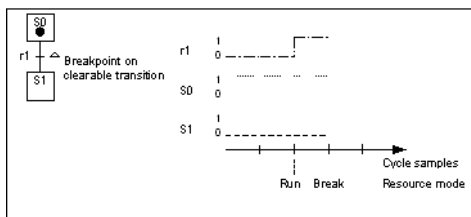
You can set breakpoint commands from the Breakpoints toolbar or from the contextual menu.

- ▶ Select the step, then from the toolbar, click  .

## Breakpoint on Transition


When a transition becomes clearable (transition is valid i.e. all previous steps are active, and its receptivity is true) then breakpoint mode is set for the next cycle. The current cycle goes on executing normally except that the transition is not cleared and therefore related tokens are not moved.

The following illustrates cycles execution when a breakpoint on transition is encountered.



### To set a breakpoint on a transition

You can set breakpoint commands from the Breakpoints toolbar or from the contextual menu.

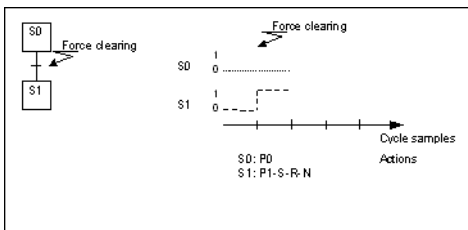
- ▶ Select the transition, then from the toolbar, click  .

## Transition Clearing Forcing

This debug command allows to force the clearing of a transition whether the latter is valid or not (i.e all previous steps are active or not). Tokens are moved and actions are executed as for a usual transition clearing.

More precisely, tokens of all predecessor steps are removed, if any. Tokens of all successor steps are created. All P0 actions linked to all predecessor steps are executed (even if no token was placed). All P1 – S – R – N actions linked to all successor steps are executed.


The following illustrates cycles execution when clearing of a transition is forced.



**Warning:** Clearing a transition may lead to abnormal behavior of your chart since it may create several tokens.

### To clear a transition

You can clear transitions from the Breakpoints toolbar or from the contextual menu.

- ▶ Select the transition, then from the toolbar, click  .

## Spying Variables

While in Debug mode, you can choose to spy on selected variables, i.e., view the changes of values for these variables. You spy on variables by adding them to a spy list.

### To access the Spy List window

You can access the Spy List window from either the link architecture, hardware architecture, or dictionary views as well as the language editors.

- ▶ From the Window menu, choose **Show Spy List**.

## Adding Variables to the Spy List

You can add variables to the spy list from the Spy List window, from the dictionary view, and from ST, LD, FBD, or IL programs.

### To add a variable from the Spy List window

1. Within the Spy List window, in the Name column double-click ...
2. From the list of available resources, select the resource holding the variable to spy on.
3. Using the keyboard arrows or the mouse, move to the Name cell, then press **Enter**.

The list of variables available for the resource appears (you may need to resize the Name column to display complete names).

4. Using the keyboard arrows, move within the list of variables to the desired variable, then press **Enter**.

### To add a variable from the dictionary view

- ▶ In the dictionary view, select then drag a variable from the dictionary grid to the Spy List window.




### To add a variable from ST, LD, FBD, or IL programs

In the language editors, you can add variables to the spy list using the menus, toolbars, or contextual menus.

1. Start the project in Debug mode.
2. Double-click the program.

The editor is launched displaying the program in read-only mode.

3. Select a variable to spy on.

4. From the editor's toolbar, click  .

### Selecting Variables in the Spy List

You can select one or more variables in the spy list.

#### To select variables in the spy list

1. To select a single variable, click at the beginning of the line holding the variable.
2. To select more than one line contiguous lines, select the lines holding the variables while holding down the **Shift** key.
3. To select more than one line non-contiguous lines, select the lines holding the variables while holding down the **Ctrl** key.

## Removing Variables from the Spy List

You remove variables from the Spy List window

### To remove a variable from the spy list

1. In the Spy List window, select the variable by clicking on the very beginning of the line.
2. Press **Delete**.

## Rearranging the Spy List

You can change the position of a variable within the spy list.

### To change the position of a variable in the spy list

- ▶ In the Spy List window, select the variable, then drag and drop it to its new position.

## Saving a Spy List

You can save a spy list created for your projects. These lists are saved with the .SPY extension.

### To save a spy list

1. In the Spy List window, right-click in the grid.
2. From the contextual menu, choose **Save Spy list**.
3. In the dialog box, enter a name for the file and choose a location then click **Save**.

**Warning:** You need to save your list each time you make changes.

## Opening an Existing Spy List

You can choose to open a previously created spy list.

### To open a previously created spy list

1. Within the Spy List window, right-click in the grid.
2. From the contextual menu, choose **Load Spy List**.

## Forcing the Value of a Spy List Variable

You can force, i.e., change, the value of a variable in the spy list.

### To force the value of a spy list variable

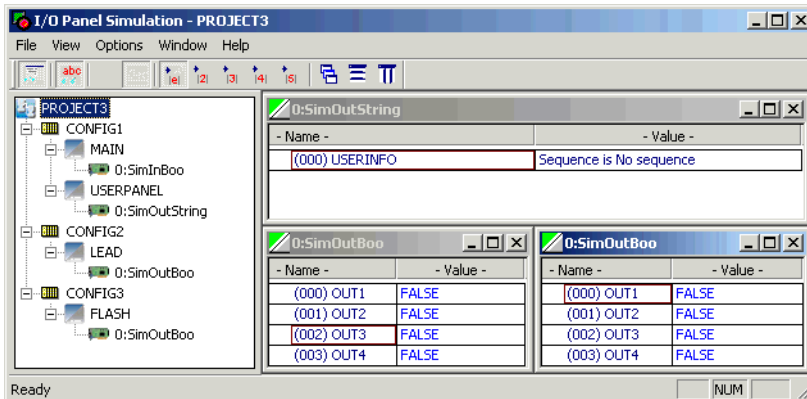
1. Double-click the Value cell of the variable.
2. Enter an new value.

## Simulate a Panel of I/Os

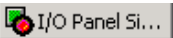
You can simulate a panel of I/Os, i.e., display the values of inputs and outputs defined for a project, in their I/O devices. When testing a project in simulation mode, the Simulator (I/O Panel Simulation) is automatically launched. The Simulator is automatically closed when the test mode is stopped. You can perform the following tasks from the Simulator:

- Opening and closing I/O device windows
- Forcing the values of input device channels

The following example shows the Simulator displaying two I/O devices for the "Project3" project:



### To display the Simulator

- ▶ While the application runs in Test mode, in the Windows task bar, click .

### **To open and close I/O device windows**

You can choose to open individual I/O devices or all I/O devices belonging to items in a project's structure, i.e. resources, configurations, and projects.

1. From the browser, double-click an item in the structure. You can also drag and drop items into the Simulator's workspace.
2. To close I/O device windows, on the individual windows title bars, click the 'Close Window' button.

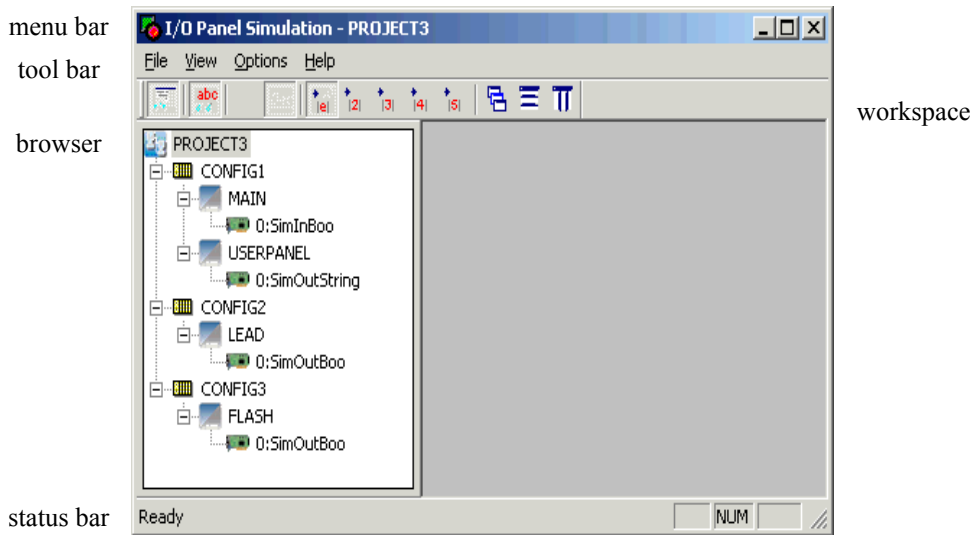
### **To force the value of an input device channel**

You can force, i.e., change, the value of BOOL, numeric-type, and STRING input device channels. For BOOL input devices, forcing the value means changing a TRUE value to FALSE and a FALSE value to TRUE. For numeric-type (SINT, USINT, BYTE, INT, UINT, WORD, DINT, UDINT, DWORD, LINT, ULINT, LWORD, REAL, LREAL, TIME, DATE) or STRING input devices, this means entering a new value. A value cell is any cell in the 'value column' of an 'I/O device' window.

1. Double-click the value cell of the required input device channel.
2. For numeric-type and STRING input devices, press **Enter**.

## Appearance

The Simulator is the environment where you can simulate a panel of I/Os. Its window is divided into two parts: a browser and a workspace.



The browser, located on the left side of the window, displays the defined project items in a tree-like structure, with the project as root. The workspace, to the right of the window, enables you to display the I/O devices defined for the items selected in the browser. Each I/O Device appears in a separate window showing the resource and configuration to which the I/O Device belongs. You can customize many aspects of the Simulator including:

- Resizing and moving individual I/O device windows
- Moving and hiding the browser
- Displaying I/O device window headers

## Menu Bar

Some options are available as keyboard commands.

File	Open I/O Device	Ctrl+O	creates a new project
	Exit	Alt+F4	leaves the Simulator
View	Toolbar		shows or hides the Simulator's toolbar
	Status Bar		shows or hides the Simulator's status bar
	Tree Bar		shows or hides the Simulator's browser
Option	Auto Vertical Tile Windows		sets the I/O device windows to automatically tile vertically
	Auto Horizontal Tile Windows		sets the I/O device windows to automatically tile horizontally
	Auto Cascade Windows		sets the I/O device windows to automatically display in a cascading manner
	Display Header		displays a header at the top of I/O device windows
	Display Name		displays the variable names associated with each channel in all I/O devices
	Numerical Display		sets the numerical display of values
	Auto Save when Exit		activates or deactivates the automatic saving of changes to the Simulator including the position and look of all I/O device windows. These changes are saved in the current project directory

Window	Cascade	displays the I/O device windows in a cascading manner
	Tile	displays the I/O device windows in a tiling manner
Help	Contents	accesses the online help
	Search for Help On	not currently supported
	About	displays product and version information
	Support Info	not currently supported

## Toolbar



shows or hides the Simulator's browser



display the variable names associated with each channel in all I/O devices



displays integer values in the hexadecimal format



displays integer values in the decimal format



sets real values to be rounded off to one digit after the decimal point. Otherwise, values appear in scientific notation (1.0E+2) format



sets real values to be rounded off to two digits after the decimal point



sets real values to be rounded off to three digits after the decimal point



sets real values to be rounded off to four digits after the decimal point



sets real values to be rounded off to five digits after the decimal point





sets the I/O device windows to appear in a cascading manner



sets the I/O device windows to appear in a horizontal tiling manner



sets the I/O device windows to appear in a vertical tiling manner

## Contextual Menu

A contextual menu, accessed by right-clicking within an I/O device window, enables you to change the numeric presentation of values, the display options (I/O window header and variable name), and split the window.

## Displaying I/O Device Window Headers

In the Simulator, you can choose to display a header at the top of device I/O windows in the following format:

```
<Resource number>:<Resource name> (<configuration name>)  
'Direction:' <'Input' / 'Output'> '- Type:' <type-name>  
1: C1_R1 (Config C1)  
Direction: Input - Type: BOOL
```

### To display window headers

- From the Option menu, choose **Display Header**.

## Moving or Hiding the Browser

You can move, resize, or hide the Simulator's browser. To undock it, click on the 'double line' and drag the window. You can move it to the top, bottom, left, and right of the workspace or completely outside of the Simulator window.

### To move or hide the browser

1. To move the browser, click its frame then drag it to the new location.
2. To hide the browser, from the View menu, choose **Treebar**.

## Online Changes

You can modify a resource while it runs. This is sometimes necessary for chemical processes where any interruption may jeopardize production or safety. When performing online changes, you can choose to update a running resource at the time of download or at a later time. However, online changes should be used with care. **DS800 Development Suite** may not detect all possible conflicts generated by user-defined operations as a result of these online changes.

### To perform an online change

- ▶ From the Debug menu, choose **Online Change: Download**, then choose the desired option.

## Code Sequences

A sequence of code is a complete set of ST, IL, LD, FBD 61131, or FBD 61499 instructions executed in a row. In a cyclic program, a code sequence is the entire list of instructions written in the program. In an SFC or FC program, a code sequence is the level 2 programming of one step / action or transition / test.

An online change consists in replacing one or more code sequences, without stopping the PLC execution cycle. Therefore, you cannot add, delete, or rename any POU. Note that in such a case, no compiler warning is generated and the changes will be denied at download step.

### Particular case of SFC

Since the control of SFC tokens is very critical, you cannot modify an SFC structure or add, renumber, or remove a step or transition.

The switch occurs between two cycles:

- In the case of a step that was already active, if the new code of the step contains non-stored boolean or SFC child actions or P1 actions, then such actions are not updated. Afterwards when the step becomes inactive, the Boolean is reset / the SFC child is killed / P0 actions are executed.

- In the case of a step that becomes inactive, if its code sequence has changed, then the new one is used (P0 actions are executed).

Code sequence for receptivity equation of a transition is changed if it is required and it will be evaluated when the transition is valid.

### **Particular case of IEC 61131 function blocks**

You can make changes to the body of an IEC 61131 function block but cannot change its definition. That is to say you cannot change:

- The number of parameters.
- Parameters name, type, direction (input, local, output), dimension for arrays, and string size for string type.

Therefore, in case of graphic languages you cannot add/remove nested blocks ('C' block or IEC 61131 block calls) because they lead to automatic instances and therefore number of parameters modifications. For same reasons you cannot add/remove a 'pulse' variable.

### **Particular case of calls to Functions**

You can add a call to a standard IEC 61131 function. You cannot add a call to a specific RAS device function if it is its first use.

### **Particular case of calls to Function Blocks**

When adding calls to IEC 61131 function blocks, you need to respect the particularities of function block instances. For details on the particularities of function block instances, see page 330.

## Variables

As the variable database is a critical part of the resource, it can be accessed at any time by other processes (via multitasking PLC). It is also possible to modify variable values from the Debugger. Therefore, you cannot add, rename, or remove a variable online. However, you can modify the way a variable is used in the application. You can also reserve "unused" internal or I/O variables in the first version of the resource, so that future modifications can make use of them.

Target databases contain different styles of variables each having their own limitations.

## Declared Variables

Declared variables are declared using the Dictionary. You can add new variables with or without initial values and you can remove variables. You cannot:

- Add a variable with the name of a previously removed variable
- Add/Remove an I/O variable
- Change the definition of an existing variable

The definition of a variable refers to many aspects:

- Name
- Type
- Scope
- Dimension (arrays)
- String size (for string type)
- Direction (Input / Output / Internal)
- Address
- Retain attribute

## Notes:

- Renaming variables has the same effect as removing and adding them, i.e., their values will be lost in the RAS device
- During code generation, the Workbench linker keeps information about removed and added variables in the PLC data memory map. Therefore, before performing complete downloads instead of online changes, you should clean the project before building it.
- When the initial value of an existing variable is changed, no warning message appears but the modification is not taken into account by the target at online change stage. If changes have been saved, the new initial value take effect at the next 'Stop' / 'Start'.

## Function Block Instances

Each instance of IEC 61131 or RAS device written function corresponds to data stored in **DS800 Development Suite** virtual machine real time database. You cannot add new automatic instances of IEC 61131 function blocks or of standard 'C' function blocks with or without initial values. To enable online changes, you need to work with function block instances declared in the Dictionary.

You cannot add any user RAS device Function Blocks instances.

## Compiler Allocated Hidden Variables

The compiler generates "hidden" temporary variables to solve complex expressions. The compiler forces a minimum number of temporary variables to be allocated for each program, even if not used for compiling the first version of the resource. As long as a new compiling of the resource gives a number of allocated temporary variables lower than this minimum, the online change will be possible.

## **I/O Devices**

Since the I/O system is very open, required modifications should be implemented by an integrator, using specific features of the corresponding hardware.

For simple or complex I/O devices, when supported by the driver, you can perform online changes for OEM parameters. For I/O channels, also when supported by the driver, you can perform online changes for the Gain, Offset, Direct, and Conversion parameters as well as the mapping of logical and physical channels. You cannot add, connect, or remove an I/O variable, or modify the description of an I/O device online. Operations such as modifying device parameters may be available using specific functions provided by the integrator.

## **Memory Requirements**

In order to support the "Online Change" capability, the target PLC must have free memory space to enable the storage of:

- The modified version of the code sequences. Original code and modified code have to be stored in PLC memory.
- The addition of new data variables

Online changes will be denied if there is not enough memory space. You specify the available memory for online changes in the Advanced settings for resource properties. For details about advanced settings for resources, see page 59.

## **Miscellaneous Limitations**

As described before, you can change code sequences and add or remove variables with some limitations. However, you cannot change the descriptions of I/O devices. Other limitations exist for various items of a project:

- Types, you cannot add, remove, or change types definitions. When required, you could define extra types. Such extra types could then be used for future changes.

- Bindings, for some changes made to bindings, no warning message appears during compilation and modifications are not taken into account by the target at online change.
- Resource properties, for some changes made to other options, no warning message appears and the modification is not taken into account by the target at on line change.

During compilation, changes that are not allowed are detected result in the generation of warning outputs. Online changes are denied. The target also does some extra checks. However this function should be used with care. **DS800 Development Suite** may not detect all possible conflicts generated by user-defined operations as a result of these online changes.

## Operations

Modifying a running resource consists of the following operations:

1. Modifying the resource source code on the Workbench
2. Generating the new resource code
3. Downloading the new resource code using "Online change: download" command on the Debug menu (instead of "download")
4. Switching from the old resource code to the new one in between PLC execution cycles, using the "Online change: update" command on the Debug menu

This procedure guarantees that the RAS device Target always has a complete and reliable running resource, and enables you to control the timing of the sample operations in a very safe and efficient way. It also enables the user to modify the project when required.


Regardless to the process itself, the "Online Change" is essentially the same as a normal "stop, download and start" set of commands. The only differences are that no variable state is lost and the switching time is very short (usually 1 or 2 cycle duration). During the switch, no variable is modified, and all internal, input, or output variables keep the same value before and after the resource modification. During the switch, no action is performed, and SFC tokens are not moved.



Detailed operations:

1. Before making any change on a running application, it is highly recommended to make a copy of the current project under another name.
2. Before editing any program, you should edit the description of each POU that will be modified and indicate the current date and the nature of the modification, to ease future program maintenance. Select the POU and use the "Tools / Edit Description" command.
3. When one or more allowed changes have been made, the code of the new resource must be generated on the workbench before downloading. Use the Project / Build Resource

command  .

4. Use the "Debug / Online Change: Download" command  . In the dialog box displayed, check the options as desired:
  - Update and Save after download
  - Update after download
  - Update later

The modified code is downloaded by selecting the "Download" button. This may slightly slow down the RAS device target during transfer.

To save your change later, once it is validated, use the command "Debug / Save code on target". This command saves the code of the running resource (including changes). To update your change later, use the command "Debug / On-line change: Update".

**If you did not update the change after download (above option):**

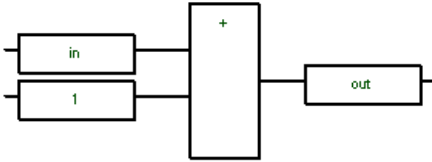
- Using the Debugger, connect the RAS device target and perform any operation which can make the resource update faster, or more safely, then run the "Debug / On-line change: update" command

A message is displayed in the Output window to indicate the success of the switch. If unsuccessful, the existing running application remains as is.

## Debug Function Block Instances

You can visually debug instances of function blocks. Function blocks can be written in SFC, ST, FBD 61131, FBD 61499, or LD language. Visual debugging consists of animating the source code of the function block body with the data of a specified instance of the block.

Below is an example of a very simple function block programmed in FBD. The `LIB_FB1` function block has the `in` input and the `out` output and a constant having a value of 1:



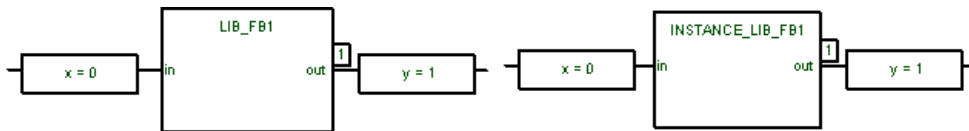
You can distinguish two types of instances of function blocks:

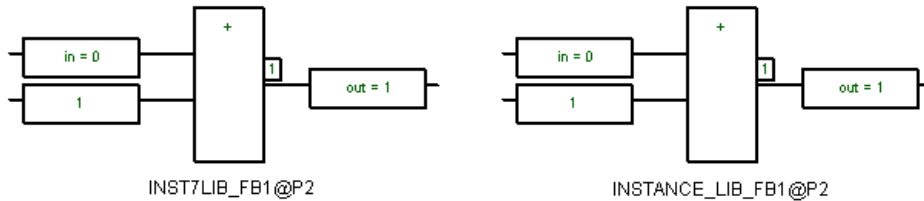
- Declared instances declared in the variable dictionary. These instances are considered as variables.
- Automatic instances created in LD or FBD diagrams. The compiler automatically assigns a unique identifier to each automatic instance. This identifier consists of the `__INST` prefix and a sequential number before the function block's name.

At debug time, you can select instances within a program to open and visualize their diagram. The following examples show the `LIB_FB1` function block used as an automatic instance and a declared instance in the `P2` program. The upper diagrams show the instances in the program, whereas, the lower diagrams show the individual instances open.

### Automatic Instance

### Declared Instance





The automatic instance is assigned the INST7LIB\_FB1@P2 name and the declared instance retains its defined name, INSTANCE\_LIB\_FB1@P2. For automatic and declared instances, a suffix consisting of the @ symbol and scope is added to the instance name.

### To debug declared instances of function blocks

You can debug variables declared instances of function blocks either from the dictionary, in the LD and FBD diagrams, and in the resource window. However, when declared instances are from a library, you can only debug these from the dictionary or from the LD and FBD diagrams.

**Note:** You cannot debug function block instances declared as parameters of function blocks.

- ▶ To debug a declared instance do one of the following:
  - From the dictionary view, select the block then from the Debug menu, choose **Debug FB**.
  - In the function blocks section of a resource window, locate the block then double-click it.
  - In the LD or FBD diagram, locate the block then double-click it.

### To debug automatic instances of function blocks

You can only debug automatic instances of function blocks from the LD and FBD diagrams.

- ▶ Open the LD or FBD diagram where the instance is inserted then double-click it.

## **Clean Stored Code**

If you have downloaded a resource with the "Save" option checked in the Download dialog box, the resource's code is stored on the target system. Then if the target RAS device system restarts, it will load this code and start a virtual machine to run this code.

**Note:** If you want to clean (i.e. remove) this code from the target and avoid restarting on it, from the Debug menu, choose **Clean Stored Code**.

# Document Generator


You can build and print the complete or partial documentation for the current project from within the Document Generator.

You can access the Document Generator from the hardware architecture view, link architecture view, dictionary view, or any of the language editors. The Document Generator window has three tabs:

- Table, showing a table (or tree) representing all items that can be printed for the current project
- Options, showing a list of printing options
- Preview, displaying a preview of the project to print

## To print the documentation for a project

You can choose to print from any tab of the Document Generator.

1. From the File menu, choose **Print** or click  on the Standard toolbar.

The Document Generator is displayed.

2. On the Table tab, select the project items to print.
3. On the Options tab, set the desired printing options for the project documentation.
4. On the Preview tab, review the appearance of the documentation print job.
5. Click **Print**.

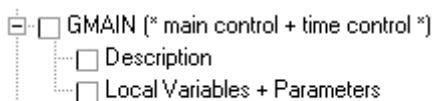
Building and formatting a project's documentation may take a few minutes. Before running other commands in the Workbench, you should wait until the printing task is completed. Building the whole documentation may require a large space on the hard disk. If the disk is full, an error message is displayed, then you need to either free up disk space by removing files or reduce the size of the print task.

## Table of Items

The table of items displays all items available for printing for a project. The items preselected for printing differ depending on the location from which printing is initiated. For example, when you initiate printing from the link architecture view where the Main resource is selected, all items defined for this resource appear selected in the Document Generator. When you initiate printing from a program, only the items defined for the program appear selected in the Document Generator. You can always choose to select other items for printing.

You expand or collapse a branch of the tree, by clicking the  /  symbol before an item.

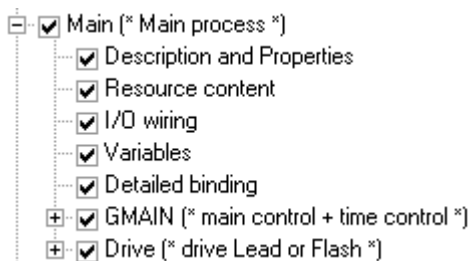
Clicking here collapses GMAIN sub-tree



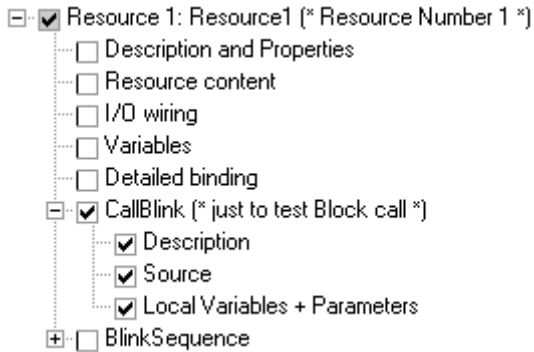
Clicking here expands Drive sub-tree



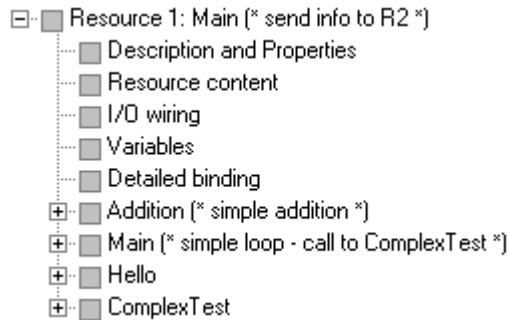
You select items for printing by checking the box at their left. You deselect items by unchecking them. Checking an item at the top of a sub-tree automatically selects all items below it for printing. In the following example, only the Main resource was checked for printing:



When some (but not all) items within a tree are selected, the check box at the top of the structure is grayed:



When items such as projects, resources, or POU's are password-protected (locked), these are unavailable for printing and appear grayed:

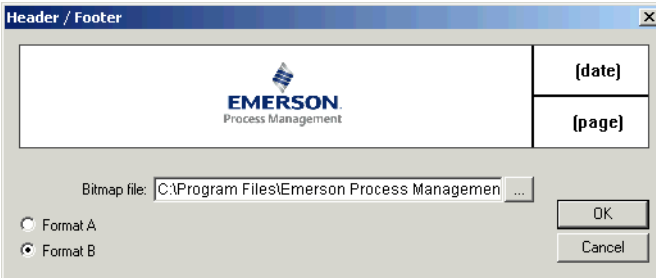
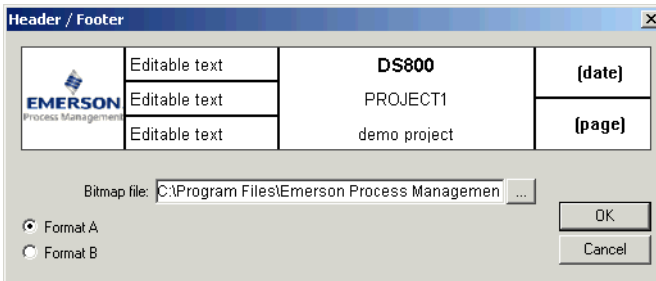


# Printing Options

Project documentation uses the default printer settings specified for your computer. However, you can define many other printing options. You can choose to place each item on a new page. You can also choose to print diagrams in landscape orientation. This option sets the printing of all FBD and LD diagrams using the landscape orientation while printing all other items using the portrait orientation. FBD and LD diagrams including guideline areas are automatically scaled to fit the width of the printed pages. You can also specify printing options for the following documentation aspects:

- **Header / Footer.** You can choose to display document information including the date and page count as a header at the top of each page or as a footer at the bottom of each page. You can also choose to have no headers or footers. You can modify the contents of the displayed header or footer by clicking Edit in the Header/Footer section of the printing options.

You can choose to use one of two formats as header/footer. One format provides three fields where you can enter text. In both formats, you can change the logo by entering the path and filename of a bitmap (.bmp) file. Click "... " to browse and select your file.





When replacing the bitmap for the format B option, you need to use one consistent with the resolution of your printer. For example, the default bitmaps are consistent with a 600 dpi printer.

- **Page numbering.** You can specify the page numbering method used for the project document printing: page count (#/total number of pages), page number (#), or section number (###.###).

For page count, the page section in the header/footer displays the page number out of the total number of pages and the table of contents starts count at 1.

For page number, the page section in the header/footer displays the page number and the table of contents starting count at the Start Page value. When no value is specified, page numbering begins at 1.

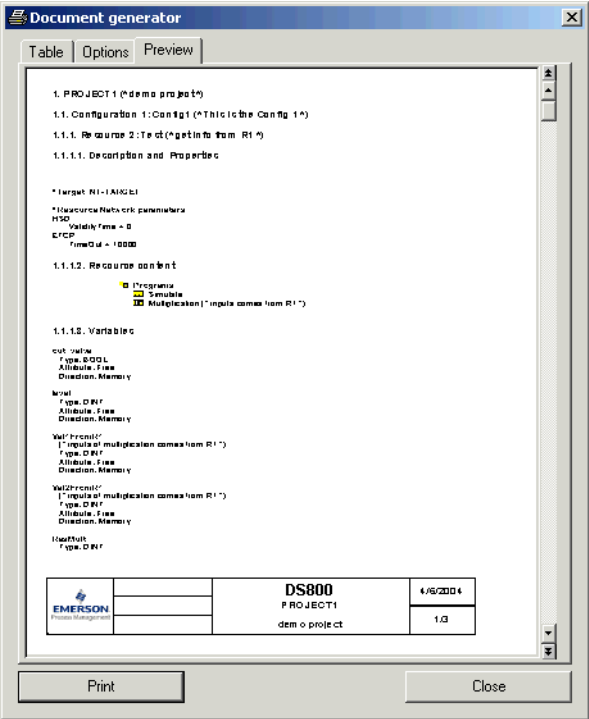
For section number, the page section in the header/footer displays the page number and the table of contents starting count at the Start Section value after the table of contents page; the header and table of contents pages use the lower-case Roman numerals i and ii, then section numbering begins. When no value is specified, section numbering begins at 1.

You can only include page numbering in a header or footer.

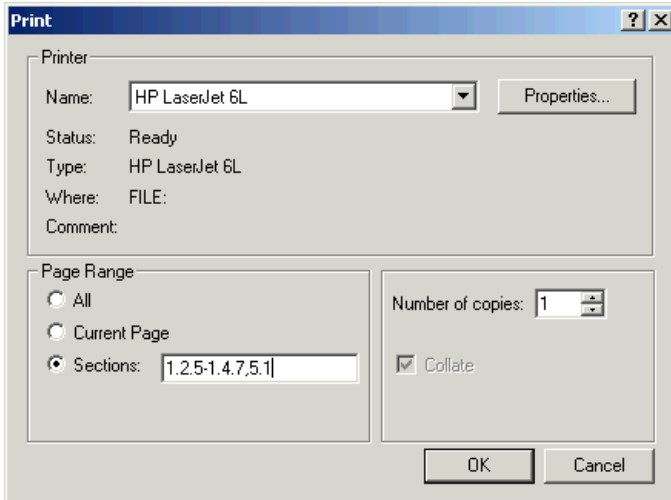
- **Cover page.** You can choose to include the header or footer on the cover page of the project documentation. You can also choose to add a printing history. When the printing starts up, a dialogue box is displayed where you can enter a note describing the actual print command. Such notes are stored in a history file and are printed on the first page of any future document (including the present one).
- **Margins.** You can choose to include visible margins on all pages. When checked, the width of each margin (top, bottom, left, right) is user-definable, using the corresponding edit boxes.
- **Fonts.** You can change the font used to print text by clicking Text font and making the desired changes. You can change the font used to print all titles (corresponding to items listed in the table) by clicking Title font and making the desired changes.

# Preview

You can choose to preview a document with the selected items before printing. You can scroll the complete document. You can also print previewed pages.



While printing pages, you can choose to print all of a document, the current page, or specific sections of the document. When defining the printing of a range between sections, you need to specify the start and end section.



Since pagination for project documentation is set using the default paper dimensions specified for your computer, when changing the paper dimensions from the Print dialog, the pagination for project documentation differs from the preview.



# Code Generator

The Code Generator is launched with the "Build ..." commands of the Workbench and editors. The Code Generator shows compilation errors in the output window.

You can build the code of a single POU, a complete resource, or a whole Project.

**Warning:** Before building code, you should save all programs currently being editing. Furthermore, for each resource, you could also verify the target type and the type of code to generate.

## Build

Before downloading code onto your RAS device target systems, you must first build the code of the whole project. This operation builds the code of all resources of the project, and builds information used to recognize your systems on networks. You cannot build projects open in the read-only mode.

Once a project has been built, subsequent builds only recompile the parts of the project needing recompilation. You can choose to rebuild a project, i.e., recompiling a whole project, to ensure that the complete compiled version is up-to-date with the current Workbench project. You can rebuild projects following a date change on a system or relocation of a project onto a different computer.

You can choose to clean projects. However, after cleaning a project, you cannot perform online changes. Therefore, to retain the ability to perform online changes, you can rebuild a project rather than cleaning then building it.

While performing builds, the security state of unlocked resources and resources having no access control switches to read-only mode. The security state of unlocked POUs and POUs having no access control also switches to read-only mode. Locked resources and locked POUs remain locked.

### To build the project

- From the Project menu, choose **Build Project** or click  on the Standard toolbar.

If the hardware architecture view is not changed, building resource code is enough to update one Virtual Machine.

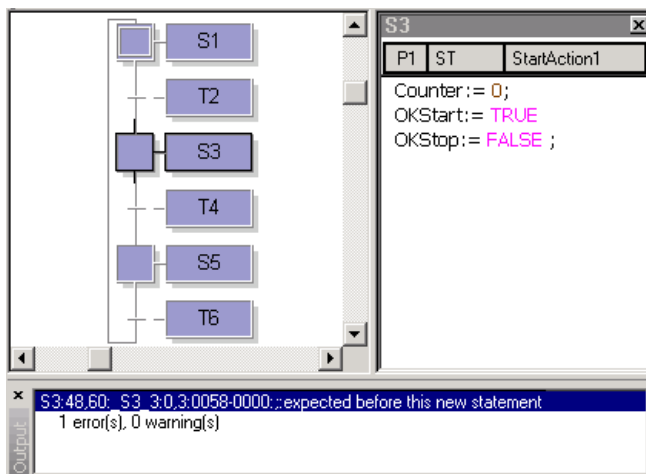
### To rebuild a project

- From the Project menu, choose **Rebuild Project** click  on the Standard toolbar.

### Build a POU

While editing a POU, the "Build program" command allows you to verify programming syntax errors for the current program.

Error messages are displayed in the Output window. Double-clicking on the error message places the caret on the error or, for graphic programs, selects the erroneous graphic element.



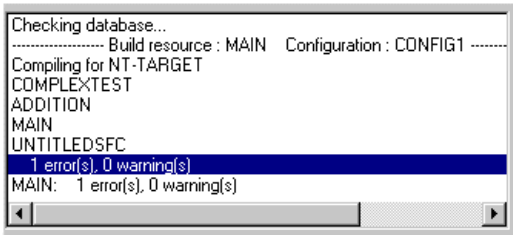
The Build program command verifies the current program even if it has not been modified since its last verification.

While performing builds, the security state of unlocked POU's and POU's having no access control switches to read-only mode. Locked POU's remain locked.

## Building Resources / Projects

The "Build Resource" or "Build Project" command displays the number of the error detected in all POU in the Output window.

Double-clicking on the number of **errors** of a POU opens the corresponding editor for corrections to be made.



```
Checking database...
----- Build resource : MAIN   Configuration : CONFIG1 -----
Compiling for NT-TARGET
COMPLEXTTEST
ADDITION
MAIN
UNTITLED$FC
1 error(s), 0 warning(s)
MAIN: 1 error(s), 0 warning(s)
```

The "Build Project" performs the "Build Resource" command for all resources of the project and builds information used to recognize configurations on networks.

**Note:** While in single resource mode, you cannot build a resource having links to libraries located on a different computer.

The "Build Resource" command constructs the entire code of the resource. Before generating anything, this command checks the syntax of the declarations and programs of each resource. Errors that cannot be detected during single program compiling are detected using these commands. For example, the IO Wiring and Binding Links are checked.

While performing builds, the security state of unlocked resources and resources having no access control switches to read-only mode. Locked resources remain locked.

Programs which have already been checked (with no errors detected) and have not been modified since their last "Build program" operation are not re-compiled. Variable declaration verification and coherence checking are always performed.


## Stopping Builds

You can stop a build, i.e. compilation, in progress for a project, resource, or POU. This feature is not available when using a PROPI interface. When a build process is stopped, it can be restarted without affecting the incremental or full compilation. After a build is stopped, online changes can be performed since a copy of the last build is kept until a complete new one is generated.

### To stop a build

- ▶ From the Project menu, choose **Stop Build**.

Or

- ▶ On the Standard toolbar, click  .

You can also abort build operations by pressing the **<ESCAPE>** key.

## Cleaning Projects

The "Clean Project" or "Clean Resource" commands (on the Project menu of the Workbench) simulate a modification of all the project's (or resource's) programs, so that they are all verified during the next "Build Project" or "Build Resource" operation.

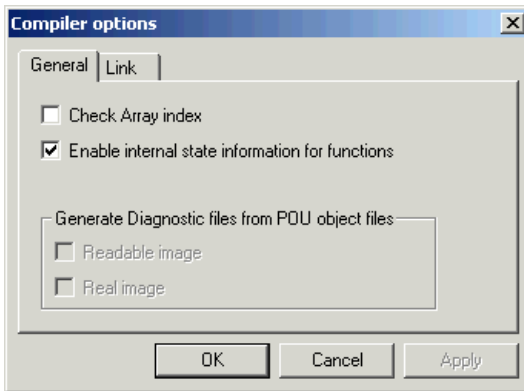
**Note:** After cleaning a project, you cannot perform online changes. Cleaning projects or resources actually deletes all files generated during the last "Build" command. Therefore, to retain the ability to perform online changes, you can rebuild a project rather than cleaning then building it.



## Compiler Options

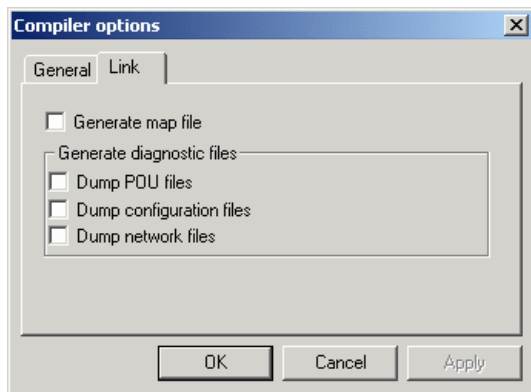
Compiler options are defined for each resource. These options enable setting up the parameters used by the Code Generator to build and optimize the target code. In the Compilation Options of a resource, you select the type of code to generate according to corresponding targets and set up the optimizer parameters according to the expected compilation and run-time requirements. For details on resource compilation options, see page 55.

The general compiler options are the following:



- Check array index, enables the verification of array indices
- Enable internal state information for functions. Functions containing no internal state information denotes that the invocation of a function with the same arguments always yields the same values.
- Generate Diagnostic files from POU object files, *To be defined*

The link compiler options are the following:



- *To be defined*

### To access the compiler options for a resource

The general and link compiler options are accessed for individual resources from the resources properties window.

1. From the Window menu, choose *project\_name-Link Architecture*.
2. Select a resource.
3. From the Edit menu, choose **Properties**.

The Resource Properties window is displayed.

4. On the Target/Code tab, click **Compiler Options**.

The Compiler Options dialog is displayed.

## C Source Code

The workbench compiler produces, by default, TIC code (Target Independent Code) that can be executed by virtual machines. The compiler also enables the production of code in "C". You select code production in the Compilation Options of a resource. For details on resource compilation options, see page 55.

POUs written in FC (Flow Chart), FBD, LD, ST, IL and action blocks and conditions of SFC POUs are generated in "C" source code format.

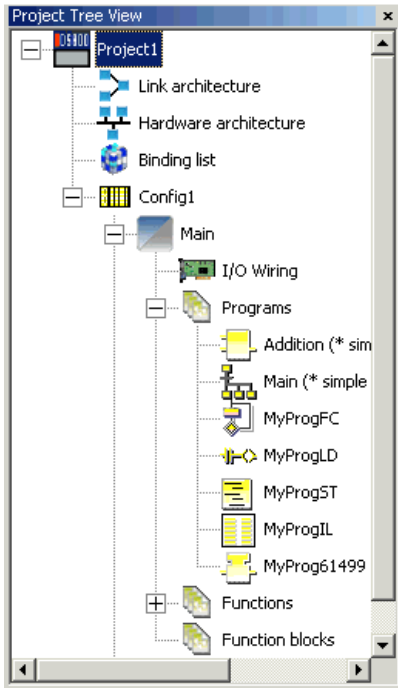
The "C" source files must be compiled and linked to the target libraries in order to produce the final executable code. For further information about recommended implementation techniques, refer to the "I/O Development Toolkit User's Guide".

**Note:** Some debugging features such as downloading the resource code, online modification, and breakpoints are not available when the resource is compiled using the "C" language.



# Project Tree View

The Project Tree View displays the project structure and enables accessing most aspects of the currently opened project. For instance, you can access the link or hardware architecture views, the internal binding list, elements (programs, functions, and function blocks) defined for resources and I/O wiring. You can also access utilities such as the events viewer, trends logger, and driver monitor.



Contextual menus enabling tasks such as locating and opening project elements are available by right-clicking these elements.

## To access the Project Tree View

- ▶ From the **Window** menu, choose **Show Project Tree View**.

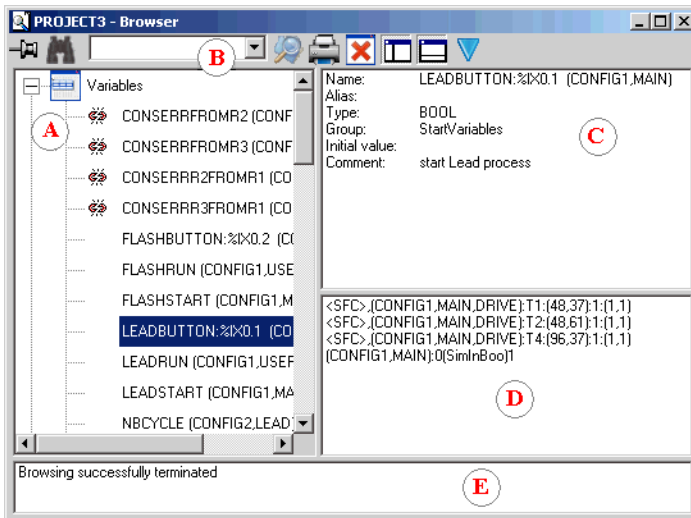



# Cross References Browser

The Cross References Browser is a tool that finds in the POU's of a project all references to global variables, i.e., cross references, defined in a project. It provides a total view of the declared variables in the programs of the project and where these are used. The aim of the browser is to list all the global variables, I/Os, and instances declared in the project, and to localize, in the source of each program the parts of source code where those variables are used. The browser is very useful for a global view of one variable life cycle. This helps localize side effects, and reduce the time to understand the project during maintenance.

The browser is divided into five sections:

- A, the list of global objects declared in a project
- B, the search field where you enter a name to search in the list of objects
- C, the description of the object selected in the list
- D, the locations of the object selected in the list in the project POU's. For variables, the description includes the direction, i.e., READING FROM, WRITING TO.
- E, an output window where messages and error messages are displayed



When viewing global objects in the browser, the  symbol indicates that the object is not used in any POUs.

You can perform many tasks from the Browser's toolbar:



keeps the browser always on top



locates the name entered in the Find field (B) from the list of global objects declared in the project (A)



browses, i.e., parse the POUs to re-calculate the cross references



prints the cross references



clears the output window



shows or hides the list of declared objects



shows or hides the output window



accesses the available options for the calculation of cross references

### To access the browser

You can access the browser using the menu, the toolbars, or from a contextual menu, available by right-clicking in a language editor.

- ▶ From the Tools menu, choose Browser or from the Window Buttons toolbar, click






## Calculating Cross References

When you calculate cross references, these are stored in a cross references file. Such a file is automatically created for each resource of a project. These files eliminate the need to parse POUs each time the browser is closed and re-opened. When files are missing or invalid due to changes in the project, messages are displayed in the output window. The cross reference files are deleted when you clean a project.

When cross references are out of date, the  icon appears in the browser's title bar.

### To calculate cross references

- ▶ From the Browser's toolbar, click .

## Browsing the POUs of a Project

Occurrences of a selected object in the source files of an open project appear in the locations section of the browser. Double-clicking an occurrence opens the program directly where the object appears.

## Defining Search Options

You can define the search options used when finding cross references. The options consist of three types: the global object to search for during the next scan, the objects to list in the browser window, and the exact set of configurations and resources in which to search for selected objects. You can choose to scan the cross references for one or more resources in order to shorten calculation time.

The options for the global object to search for are:


Variables	all global variables and I/Os
Programs	program names (SFC or FC names can be used in parent programs)
Functions	all functions declared in the project or in attached libraries, plus "C" and standard functions available for the corresponding RAS device target
Function Blocks	all function blocks declared in the project or in attached libraries, plus "C" and standard function blocks available for the corresponding RAS device target
Defined Words	aliases defined in the "Defined Words" section of the dictionary, in the project or in attached libraries

The options specifying what objects to listed in the browser window are:

Unused	list unused variables
Used	list variables used in POUs

### To define search options

Changes only take effect during the next scan.

1. From the Browser's toolbar, click .
2. In the list of available options, check the desired options.

# Version Source Control

You can manage the changing versions of Workbench elements including projects, configurations, resources, and POUs by saving them to a version source control database. Saving these elements to a control database enables you to retrieve older versions of the elements at a later time. The information saved in the database also includes advanced options definitions such as alarms and events, field communications, fail-over mechanisms, trending, and Web HMI data servers. Version source control also applies to projects opened in single-resource mode.

You save version source control information to a repository using one of two modes:

- file mode where you specify a path for a local or remote computer
- client/server mode where you specify login information and server location. Before setting this mode, the repository project must exist.

The default uses the file mode and saves this information in a VSC folder in the project folder. A repository folder, defined by the path, can hold multiple version source control projects. You can choose to clear the version source control status for a project. Clearing the version source control status for a project means disabling the version source control for the project. The version source control repository must be removed manually.

Workbench elements are always editable. Therefore, you do not need to check these out of the control database to modify them. At any time, you can check in, i.e., save, changes made to elements in the control database. When you check in an element, all of its descendants are also checked in. For instance, when you check in a project, all of its configurations, resources, and POUs are checked in. You can only check in or get elements available for edition: you cannot check in or get elements having the read-only attribute. However, you can view the history of read-only elements.

When you retrieve, i.e., get, a Workbench element from the control database, this element is automatically updated to the current version. Therefore, a local element containing more current definitions could be overwritten. Before using a retrieved project or configuration, you need to recompile the entire project. Before using a retrieved resource or POU, you need to recompile the resource.

Deleting or renaming previously checked in Workbench elements detaches these from their history in the control database. For instance, before retrieving any part of a deleted resource's history, you need to recreate a new instance of the resource having the same name.

When performing a check in, individual elements are placed in four file types within the control database. For example, a project is split into a project file, a configuration file for each configuration, a resource file for each resource, and a POU file for each POU. The project file contains a list calling its configurations, resources, and POUs. The information retained in each type of file varies:

Element Type	Retained in Control Database File
POU	POU properties, local variables, symbols, and advanced options definitions as well as a list of contained child POUs
Resource	Resource properties, global variables, internal/external bindings, I/O devices, variable groups, and advanced options definitions as well as a list of contained POUs
Configuration	Configuration settings, network connections, and advanced options definitions as well as a list of contained resources
Project	Project settings, types, and advanced options definitions as well as a list of contained configurations, and resources

Stored element files do not retain information such as imported target definitions, compilation output files, driver definitions, and protocols. Each POU also has a second file holding the code and instructions (*POU\_name.stf*).

The version control status of an element is indicated in the Workbench. For a project, the status is indicated in textual format in the title bar: Up-to-date or Locally modified. For a configuration or resource, the status is displayed as an icon at the left-hand corner of its title bar. For a POU, the status is applied directly to the POU icon.



Up-to-date. The file is identical to the latest version in the source control database or to its retrieved version.



Locally modified. The file differs from the latest version in the source control database or from its retrieved version. A modification at any level affects the upwards status of the project elements. For instance, when modifying a resource, the status of the resource as well as the configuration and project to which it belongs become locally modified.

When using version source control with your projects, you can perform the following tasks:

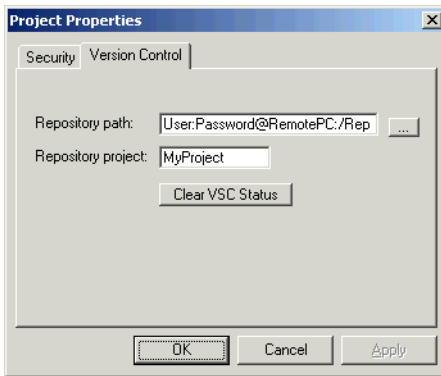
- Performing a Check in of a Workbench Element
- Viewing the History of Workbench Elements

Results and errors for version source control operations are displayed in the output window.

### To define a version source control repository

You can choose to save version source control information for a project using the file mode or the client/server mode.

1. With the project open in the Workbench, from the File menu, choose **Project Properties**.
2. In the Project Properties window, select the Version Control tab.



3. In the Repository path and Repository Project field, specify the location in which to save the version source control information by clicking **...** to browse the path.

The syntax to specify a server repository path on a remote computer is as follows:

*UserName:Password@RemoteComputer*

where *UserName* and *Password* represent the logon information for the remote computer, *RemoteComputer* represents the name or IP address of the computer.

### **To clear version source control status for a project**

1. With the project open in the Workbench, from the File menu, choose **Project Properties**.
2. In the Project Properties window, select the Version Control tab.
3. Make sure the repository path is the correct one for the project, then click **Clear VSC status**.

The version source control information is disabled for the project.

## Performing a Check in of a Workbench Element

You can check in, i.e., save, project, configuration, resource, and POU definitions not having the read-only attribute into a version source control database. For elements having access control, the check-in process encrypts the element in the version source control database making them accessible upon entering a valid password.

### To check in a project

1. With the project open in the Workbench, from the Tools menu, choose **Check In**, then **Project**.
2. In the Check In dialog, enter a comment (optional), then click **OK**.

The project definitions including all of its configurations, resources, and POUs is saved in the version source control database.

### To check in a configuration, resource, or POU

You can check in configurations and resources from the hardware architecture view. You can check in resources and POUs from the link architecture view. You can check in configurations, resources, or POUs using the main menu or from a contextual menu, available by right-clicking the element.

1. In the applicable view, select the element to check in.
2. From the Tools menu, choose **Check In**, then the respective option.
3. In the Check In dialog, enter a comment (optional), then click **OK**.

The element's definitions are saved in the version source control database. For configurations, these definitions include all of its resources and POUs. For resources, these definitions include all of its POUs.

## Viewing the History of Workbench Elements

You can view the history of projects, configurations, resources, and POU's that have been checked in repeatedly to the version source control database. Each checked in version appears as a separate entry.

### To view the history of a project

- ▶ With the project open in the Workbench, from the Tools menu, choose **View History**, then **Project**.

All previously checked-in versions of the project are displayed.

### To view the history of a configuration, resource, or POU

You can view the history of configurations and resources from the hardware architecture view. You can view the history of resources and POU's from the link architecture view. You can view the history of configurations, resources, or POU's using the main menu or from a contextual menu, available by right-clicking the element.

1. In the applicable view, select the element for which to view the history.
2. From the Tools menu, choose **View History**, then the respective option.

All previously checked-in versions of the element are displayed.



## Getting a Previous Version

When viewing the history of a project, configuration, resource, or POU, you can choose to get, i.e., retrieve, a previously checked in version of the element. For elements having access control, you can access them upon entering a valid password.

**Warning:** Since getting an element from the control database automatically updates a locally held version to the retrieved version, a local element or its underlying elements containing more current definitions could be overwritten. For example, getting a project from the control database where a resource and POU have been locally modified since the check in causes the resource and POU to be overwritten with their older definitions contained in the control database.

When you delete or rename a Workbench element that was checked in to the control database, you cannot retrieve any part of the history for this element from the database unless you recreate a new instance of this element having the same name.

### To get a previous version of a Workbench element

- ▶ In the History list of elements, select the version to retrieve, then click **Get**.

This older version replaces the current version.

## Comparing Current and Previous Versions

When viewing the history of a project, configuration, resource, or POU, you can choose to compare a previously checked in version of the element with the current version or another checked-in version.

### To compare a previous and current version of an element

- ▶ In the History list of elements, select the version with which to compare, then click **Diff**.

The response indicates whether the files are different or identical. To navigate between File Differences windows and the Workbench, you need to close the History window.

## Accessing Details for a Previous Version

When viewing the history of a project, configuration, resource, or POU, you can access history details on a previously checked in version of the element. These details include the incremental version number, automatically assigned at check in, the date on which the version was checked in, and the identity of the user who checked in the version as well as an optional comment.

### To access the history details of a previous version

- ▶ In the History list of elements, select the version for which to access details, then click **Details**.

The History Details dialog is displayed showing the details for the selected version.

## Creating a History Report

When viewing the history of a project, configuration, resource, or POU, you can choose to create a report of text format (.txt) on the history of the element. This report lists all or selected incremental checked-in versions, the dates of each check in, and the user that performed each check in. A report can also include the differences from one version to the next. Before sending a report to a file, you can choose to preview it.

### To create a history report for an element

1. In the History list of elements, click **Report**.
2. In the History Report dialog, do the following:
  - To include version numbers, check-in dates, and check-in users, check **Include details**.
  - To include the differences between versions, check **Include differences**.
3. To preview the report before sending it to file, click **Preview**.
4. To send the report to file, click **OK**, then choose the location in which to save the file.

---

# Language Reference

This Language Reference is a complete description of all available features for programming ROC applications with this Workbench.

A description of the project architecture, variables and the syntax of each programming language is given, along with a full listing of the standard functions, function blocks and Operators that can be called by programs.

# Project Architecture

A Project is composed of configurations. A configuration is one RAS device unit and is composed of one or more resources. A resource represents a DS800 target Virtual Machine. A resource is divided into several programming units called POU's (Program Organization Unit). The POU's of a resource are linked together in a tree-like architecture. POU's can be described using any of **SFC**, **FC**, **ST**, **IL**, **FBD**, or **LD** graphic or literal languages. POU's can be programs, functions or function blocks.

## Programs

A Program is a logical programming unit, that describes operations between **variables** of the process. Programs describe either **sequential** or **cyclic** operations. Cyclic programs are executed at each target system Cycle. The execution of sequential programs has a Dynamic Behavior.

Programs are linked together in a hierarchy tree. Those placed on the top of the hierarchy are activated by the system. **Child-programs** (lower level of the hierarchy – only for SFC and FC: Child SFC and FC Sub-programs) are activated by their father. A program can be described with any of the available graphic or literal languages:

- **Sequential Function Chart (SFC)**
- **Flow Chart (FC)**
- **Function Block Diagram (FBD)**
- **Ladder Diagram (LD)**
- **Structured Text (ST)**
- **Instruction List (IL)**

The same program cannot mix several languages, except for LD and FBD which can be combined into one diagram.

SFC programs and SFC child programs have dynamic behavior limits which are set at the resource level. Whereas, SFC function blocks and SFC child function blocks each have their own maximum number of tokens which are set in their individual properties.

## Cyclic and Sequential Operations

The hierarchy of POUs is divided into three main sections or groups:

- Program Section** Programs located in this part represent the target cycle. Note that inside this section, SFC and FC programs, which represent sequential operations, are grouped together.
- Function Section** Set of functions that can be called by any program.
- Function Block Section** Set of function blocks that can be called by any program.

Programs before and after SFC and FC programs describe cyclic operations, and are not time dependent. They are called **cyclic programs**. SFC and FC programs describe sequential operations, where the time variable explicitly synchronizes basic operations. These are called **Sequential programs**. Cyclic programs are systematically executed at the beginning of each run time cycle. Main sequential programs (at the top of the hierarchy) are executed according to the SFC and FC dynamic behavior.

POUs of the "Functions" section are programs that can be called by any other program in the project. These are called **functions**. A function can call another function.

POUs of the "Function Block" section are programs that can be called by any other POU in the project. These are called **function blocks**. A function block section can call functions or other function blocks.

Main sequential programs must be described with the SFC or the FC language. Cyclic programs cannot be described with the SFC language, neither with the FC language. Any SFC program may own one or more SFC child. Any FC program can "call" one or more FC sub-program.

Functions can be described with the ST, LD, or FBD languages and function blocks can be described with the SFC, ST, LD, or FBD language. Functions and function blocks can be called from actions or conditions of SFC or FC programs.

Programs located at the beginning of the cycle (before sequential programs) are typically used to describe preliminary operations on input devices to build high level filtered variables. Such variables are frequently used by the programs of the sequential programs. Programs located at the end of the cycle (after sequential programs) are typically used to describe security operations on the variables operated on by sequential programs, before sending values to output devices.

## Child SFC POUs

Any SFC POU may control other SFC POUs. Such low level units are called **child SFC**. A child SFC POU is a parallel unit that can be started, killed, frozen, or restarted by its parent. The **parent POU** and child POU must both be described with the SFC language. A child SFC POU may have local variables.

When a parent POU starts a child SFC, it puts an **SFC token** (activates) into each initial step of the child. This command is described with the **GSTART** statement or with the name of the child with the S qualifier. When a parent POU kills a child SFC, it clears all the tokens existing in the steps of the child. Such a command is described with the **GKILL** statement or with the name of the child and the R qualifier. When a father POU starts a child, the father continues its execution.

When a parent POU freezes a child SFC, it clears all the tokens existing in the child, and keeps their position in memory. Such a command is described with the **GFREEZE** statement. When a parent POU restarts a frozen child SFC, it restores all the tokens cleared when the child was frozen. Such a command is described with the **GRST** statement.

Child SFC function block instances, as their SFC function block fathers, have a maximum number of tokens, unlike SFC programs whose dynamic behavior limits are set at the resource level. You specify the tokens limit for an SFC function block in its setting properties, accessed by selecting the block, then from the Edit menu, choosing Properties, then the Settings tab.

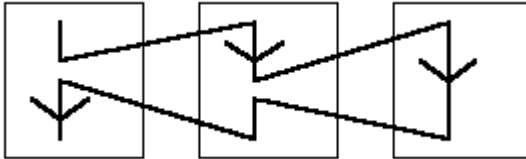
When using an SFC function block with an SFC child, you can access, for read-only purposes, the local values of the child from its father by entering the child's name and the parameter in an action or transition's code. For example, to access the *Local1* parameter of an SFC child named *FB\_Child*, in an action or transition defined for the SFC function block father, you would write the following:

```
FB_Child.Local1
```

## FC Sub-Programs

Any FC program can call one or more FC program. The **FC Sub-program** execution is driven by its **parent program**. The parent FC program execution is suspended until the FC Sub-program execution ends.

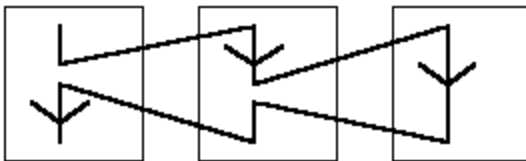
Parent program    FC sub-program    FC sub-program



## Functions

A function execution is driven by its parent program. The execution of the parent program is suspended until the function ends:

Main program    Function    Function



Any program of any Section may call one or more functions. A function may have local variables. The ST, LD, FBD or IL languages can be used to describe a function.

**Warning:** The system does not support recursivity during function calls. A run-time error occurs when a program of the "Functions" Section is called by itself or by one of its called functions. Furthermore, a function does not store the local value of its local variables. A function is not instantiated, therefore, cannot call function blocks.

The interface of a function must be explicitly defined, with a type and a unique name for each of its calling (or Input Parameter) or return parameter (or Output Parameter). In order to support the ST language convention, the return parameter must have the same name as the function. There is only one output parameter.

The following information shows how to set the value of the return parameter in the body of a function, in the various languages:

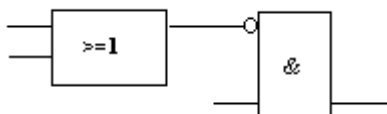
ST: assign the return parameter using its name (the same name as the function):

FunctionName := <expression>;

IL: the value of the current result (IL register) at the end of the sequence is stored in the return parameter:

LD 10  
ADD 20 (\* return parameter value = 30 \*)

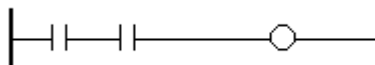
FBD: set the return parameter using its name:



FunctionName

LD: use a coil symbol with the name of the return parameter:

FunctionName





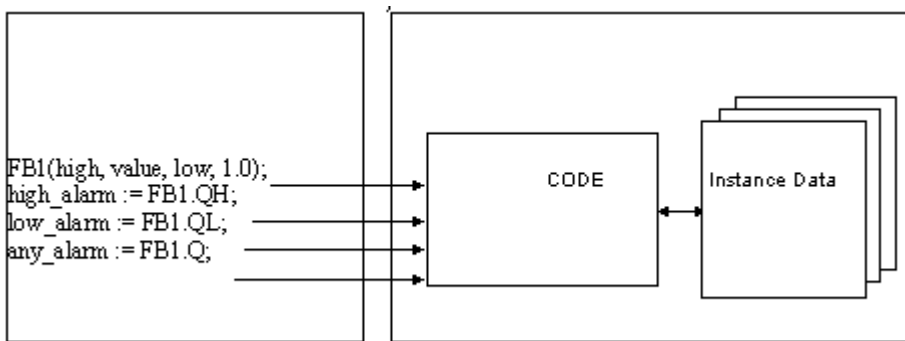
# Function Blocks

Function blocks can use the SFC, ST, LD, or FBD languages. Function blocks are instantiated meaning **local variables** of a function block are copied for each Instance. When calling a function block in a program, you actually call the Instance of the block: the same code is called but the data used are the one which have been allocated for the Instance. Values of the variables of the Instance are stored from one cycle to the other.

(\* ST Programming \*)

Function Block Implementation

(\* FB1 is a declared Instance  
of the SAMPLE Function Block \*)



The interface of a function block must be explicitly defined, with a type and a unique name for each of its calling (or Input Parameter) or return parameters (or output parameters). A function block can have more than one output parameter.

The following information shows how to set the value of an output parameter in the body of a function block, in the various languages:

ST: assign the output parameter using its name concatenated with the function block name

FunctionBlockName.OutputParaName := <expression>;

IL: use LD and ST operator:

LD FunctionBlockName.OutputParaName

ST 20 (\* value of Parameter = 20 \*)

FBD: set the return parameter using its name:

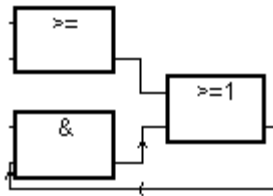
OutputParaName

LD: use a coil symbol with the name of the return parameter:

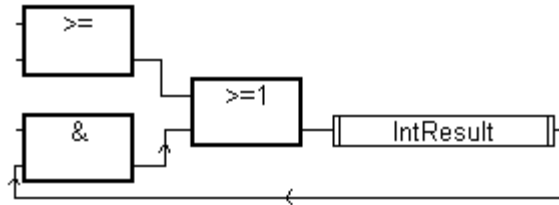
OutputParaName

**Warning:** When you need a loop in your function block, you must use local variable before doing the loop.

This will not work:



This is OK:



SFC function block instances, as their SFC child blocks, have a maximum number of tokens, unlike SFC programs whose dynamic behavior limits are set at the resource level. You specify the tokens limit for an SFC function block in its setting properties, accessed by selecting the block, then from the Edit menu, choosing Properties, then the Settings tab.

# Description Language

A program can be described with any of the following graphic or literal languages:



Sequential Function Chart (SFC) for high level operations



Flow Chart (FC) for high level operations



Function Block Diagram (FBD) for cyclic complex operations



Ladder Diagram (LD) for Boolean operations only



Structured Text (ST) for any cyclic operations



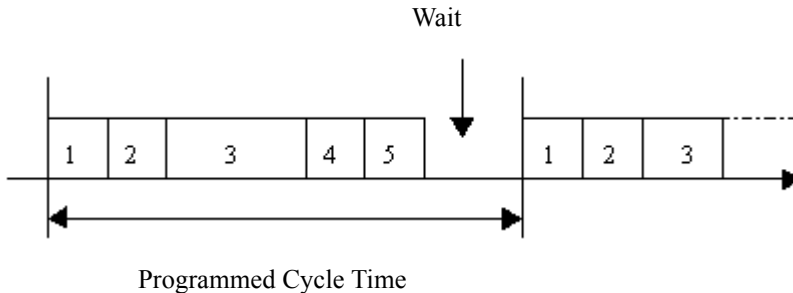
Instruction List (IL) for low level operations

A program cannot contain multiple languages. However, you can combine FBD and LD in a single program. The language used to describe a program is chosen when creating the program and cannot be changed.

## Execution Rules

The system is Synchronous. All operations are triggered by a clock. The basic duration of the clock is called the cycle timing:

1. Scan input variables
2. Consume bound variables
3. Execute POUs
4. Produce bound variables
5. Update output devices



In the case where bindings (Data Links between resources) have been defined, variables consumed by this resource are updated after the inputs are scanned, and the variables produced to other resources are "sent" before updating the outputs.

If a cycle time is programmed, the virtual machine waits until this time has elapsed before starting the execution of a new cycle. The POUs execution time varies depending upon the number of active steps in SFC Programs and on instructions such as Jump, IF and Return...

# Common Objects

These are main features and common **objects** of the programming data base. Such objects can be used in any POU (Program Organization Unit: programs, functions or function blocks) written with any of the **SFC**, **FC**, **FBD**, **IL**, **ST**, or **LD** languages.

## Data Types

Any constant, expression, or variable used in a POU (written in any language) must be characterized by a type. Type coherence must be followed in graphic operations and literal statements.

Types are known by any resource of a Project; types have a common Scope. These types are:

- Standard IEC 61131 Types
- User Types (based on standard IEC 61131 types)

## Standard IEC 61131 Types

You can program objects using 17 standard IEC 61131 types:

- **BOOL**: logic (true or false) value
- **SINT**: short integer continuous value (8 bit)
- **DINT**: double integer continuous value (32 bit)
- **REAL**: real (floating) continuous value (32 bit)
- **TIME**: time values less than one day; these value types cannot store dates (32 bit)
- **STRING**: character string having a defined *size*, representing the maximum number of characters the string can contain. For example, to define `MyString` as a string containing 10 characters, enter `MyString(10)`. For information on using string variables, see page 391.

Based on the above standard IEC 61131 types, you can define new user types. Furthermore, you can define arrays or structures using standard IEC 61131 types, arrays, or other user types.

When creating a variable, a dimension can be given to define an array. The following example shows the `MyVar` variable of type `BOOL` having a dimension defined as follows: `[1..10]`

```
FOR i = 1 TO 10 DO  
MyVar[i] := FALSE;  
END_FOR;
```

## User Types: Arrays

You can define arrays of standard IEC 61131 types or user types. An array has one or more **dimension**. When an array is defined, a variable can be created with this type and a structure can have a field with this type. Array dimensions are positive DINT constant expressions and array indexes are DINT constant expressions or variables.

**Note:** Arrays must be declared in the Dictionary View before using them in Functional Block Diagrams (FBD).

### Example

#### 1. One-dimensional array:

```
MyArrayType is an array of 10 BOOL. Its dimension is defined as follows: [1..10].  
MyVar is of type MyArrayType.  
Ok := MyVar[4];
```

#### 2. Two-dimensional array:

```
MyArrayType2 is an array of DINT. It has two dimensions defined as follows:  
[1..10,1..3]  
MyVar2 is of type MyArrayType2  
MyVar2[1,2] := 100;
```

#### 3. Array of an array:

```
MyVar3 is an array of MyArrayType; Its dimension is defined as follows [1..3]  
FOR I := 1 TO 3 DO  
FOR J := 1 TO 10 DO  
MyVar3[I][J] := FALSE;  
END_FOR;  
END_FOR;
```

## User Types: Structures

Users can define structures using standard IEC 61131 types or user types. A structure is composed of sub-entries called **Fields**. When a structure is defined, a variable can be created with this type.

### Example

MyStruct1 is composed of:

Field1 which is BOOL

Field2 which is DINT

MyStruct2 is composed of:

Field1 which is DINT

Field2 which is BOOL

Field3 which is an array of 10 DINT

Field4 which is of type MyStruct1

MyVar of type MyStruct2 can be used as follows:

```
Value1 := MyVar.Field1; (* Value1 is of type DINT *)
```

```
Ok1 := MyVar.Field2; (* Ok1 is of type BOOL *)
```

```
Tab[2] := MyVar.Field3[5]; (* Tab is an array of DINT *)
```

```
Value2 := MyVar.Field3[8]; (* Value2 is of type DINT *)
```

```
Ok2 := MyVar.Field4.Field1; (* Ok2 is of type BOOL *)
```



## Constant Expressions

**Constant expressions** are relative to one type. The same notation cannot be used to represent constant expressions of different types.

### Boolean Constant Expressions

There are only two Boolean constant expressions:

- **TRUE** is equivalent to the integer value 1
- **FALSE** is equivalent to the integer value 0

"True" and "False" keywords are not case-sensitive.

### Short Integer Constant Expressions

Short integer constant expressions represent signed integer (8 bit) values:

from **-128 to +127**

Short integer constants may be expressed with one of the following **Bases**. Short integer constants must begin with a **Prefix** that identifies the Bases used:

<b>Base</b>	<b>Prefix</b>	<b>Example</b>
DECIMAL	(none)	19
HEXADECIMAL	"16#"	16#A1
OCTAL	"8#"	8#28
BINARY	"2#"	2#0101_0101

The underscore character ('\_') may be used to separate groups of digits. It has no particular significance other than to improve constant expression readability.

## Double Integer Constant Expressions

Double integer constant expressions represent signed double integer (32 bit) values:

from **-2147483648** to **+2147483647**

Double integer constants may be expressed with one of the following **Bases**. Double integer constants must begin with a **Prefix** that identifies the Bases used:

<b>Base</b>	<b>Prefix</b>	<b>Example</b>
DECIMAL	(none)	-908
HEXADECIMAL	"16#"	16#1A2B3C4D
OCTAL	"8#"	8#1756402
BINARY	"2#"	2#1101_0001_0101_1101_0001_0010_1011_1001

The underscore character ('\_') may be used to separate groups of digits. It has no particular significance other than to improve constant expression readability.

## Real Constant Expressions

Real constant expressions can be written with either **Decimal** or **Scientific** representation. The decimal point ('.') separates the Integer and Decimal parts. The decimal point must be used to differentiate a Real constant expression from an Integer one. The scientific representation uses the letter 'E' to separate the mantissa part and the exponent. The exponent part of a real scientific expression must be a signed integer value from -37 to +37. A real variable has six significant digits.

### Example

3.14159	-1.0E+12
+1.0	1.0E-15
-789.56	+1.0E-37

The expression "**123**" does not represent a Real constant expression. Its correct real representation is "**123.0**".

## Timer Constant Expressions

Timer constant expressions represent time values from 0 to 1193h2m47s294ms. The lowest allowed unit is a millisecond. Standard time units used in constant expressions are:

Hour	The "h" letter must follow the number of hours
Minute	The "m" letter must follow the number of minutes
Second	The "s" letter must follow the number of seconds
Millisecond	The "ms" letters must follow the number of milliseconds

The time constant expression must begin with "**T#**" or "**TIME#**" prefix. Prefixes and unit letters are not case sensitive. Some units may not appear.

### Example

**T#1H450MS** 1 hour, 450 milliseconds  
**time#1H3M** 1 hour, 3 minutes

The expression "**0**" does not represent a time value, but an Integer constant.

## String Constant Expressions

String constant expressions represent character strings. Characters must be preceded by a quote and followed by an apostrophe. For example:

**'THIS IS A MESSAGE'**

**Warning:** The apostrophe "'" character cannot be used within a string constant expression. A string constant expression must be expressed on one line of the program source code. Its length cannot exceed 255 characters, including spaces.

Empty string constant expression is represented by two apostrophes, with no space or tab character between them:

**" (\* this is an empty string \*)**

The dollar ('\$') special character, followed by other special characters, can be used in a string constant expression to represent a non-printable character:

<b>Sequence</b>	<b>Meaning</b>	<b>ASCII (hex)</b>	<b>Example</b>
\$\$	'\$' character	16#24	'I paid \$\$5 for this'
\$'	apostrophe	16#27	'Enter '\$Y\$' for YES'
\$L	line feed	16#0a	'next \$L line'
\$R	carriage return	16#0d	' llo \$R He'
\$N	new line	16#0d0a	'This is a line\$N'
\$P	new page	16#0c	'lastline \$P first line'
\$T	tabulation	16#09	'name\$Tsize\$Tdate'
\$hh (*)	any character	16#hh	'ABCD = \$41\$42\$43\$44'

(\*) "**hh**" is the hexadecimal value of the ASCII code for the expressed character.

# Variables

**Variables** can be **LOCAL** to one program or **GLOBAL** to a resource. Local variables can be used by one program only. Global variables can be used in any program of the resource. Local or Global information is called the Scope **of the variable**.

**Variable names** must conform to the following rules:

- Names cannot exceed 128 characters
- The first character must be a letter
- The following characters can be letters, digits or the underscore character

## Reserved Keywords

A list of the reserved keywords is shown below. Such Identifiers cannot be used to name a POU or a variable:

- A** ABS, ACOS, ADD, ANA, AND, AND\_MASK, ANDN, ARRAY, ASIN, AT, ATAN,
- B** BCD\_TO\_BOOL, BCD\_TO\_INT, BCD\_TO\_REAL, BCD\_TO\_STRING, BCD\_TO\_TIME, BOO, BOOL, BOOL\_TO\_BCD, BOOL\_TO\_INT, BOOL\_TO\_REAL, BOOL\_TO\_STRING, BOOL\_TO\_TIME, BY, BYTE,
- C** CAL, CALC, CALCN, CALN, CALNC, CASE, CONCAT, CONSTANT, COS,
- D** DATE, DATE\_AND\_TIME, DELETE, DINT, DIV, DO, DT, DWORD,
- E** ELSE, ELSIF, EN, END\_CASE, END\_FOR, END\_FUNCTION, END\_IF, END\_PROGRAM, END\_REPEAT, END\_RESSOURCE, END\_STRUCT, END\_TYPE, END\_VAR, END\_WHILE, ENO, EQ, EXIT, EXP, EXPT,
- F** FALSE, FIND, FOR, FUNCTION,
- G** GE, GFREEZE, GKILL, GRST, GSTART, GSTATUS, GT,
- I** IF, INSERT, INT, INT\_TO\_BCD, INT\_TO\_BOOL, INT\_TO\_REAL, INT\_TO\_STRING, INT\_TO\_TIME,

**J** JMP, JMPC, JMPCN, JMPN, JMPNC,  
**L** LD, LDN, LE, LEFT, LEN, LIMIT, LINT, LN, LOG, LREAL, LT, LWORD,  
**M** MAX, MID, MIN, MOD, MOVE, MSG, MUL, MUX,  
**N** NE, NOT,  
**O** OF, ON, OR, OR\_MASK, ORN,  
**P** PROGRAM  
**R** R, READ\_ONLY, READ\_WRITE, REAL, REAL\_TO\_BCD, REAL\_TO\_BOOL,  
 REAL\_TO\_INT, REAL\_TO\_STRING, REAL\_TO\_TIME, REPEAT, REPLACE,  
 RESSOURCE, RET, RETAIN, RETC, RETCN, RETN, RETNC, RETURN,  
 RIGHT, ROL, ROR,  
**S** S, SEL, SHL, SHR, SIN, SINT, SQRT, ST, STN, STRING, STRING\_TO\_BCD,  
 STRING\_TO\_BOOL, STRING\_TO\_INT, STRING\_TO\_REAL,  
 STRING\_TO\_TIME, STRUCT, SUB, SUB\_DATE\_DATE, SYS\_ERR\_READ,  
 SYS\_ERR\_TEST, SYS\_INITALL, SYS\_INITANA, SYS\_INITBOO,  
 SYS\_INITTMR, SYS\_RESTALL, SYS\_RESTANA, SYS\_RESTBOO,  
 SYS\_RESTTMR, SYS\_SAVALL, SYS\_SAVANA, SYS\_SAVBOO,  
 SYS\_SAVTMR, SYS\_TALLOWED, SYS\_TCURRENT, SYS\_TMAXIMUM,  
 SYS\_TOVERFLOW, SYS\_TRESET, SYS\_TWRITE, SYSTEM,  
**T** TAN, TASK, THEN, TIME, TIME\_OF\_DAY, TIME\_TO\_BCD,  
 TIME\_TO\_BOOL, TIME\_TO\_INT, TIME\_TO\_REAL, TIME\_TO\_STRING,  
 TMR, TO, TOD, TRUE, TYPE,  
**U** UDINT, UINT, ULINT, UNTIL, USINT,  
**V** VAR, VAR\_ACCESS, VAR\_EXTERNAL, VAR\_GLOBAL, VAR\_IN\_OUT,  
 VAR\_INPUT, ,VAR\_OUTPUT  
**W** WHILE, WITH, WORD  
**X** XOR, XOR\_MASK, XORN

All keywords beginning with an underscore ('\_') character are internal keywords and must not be used in textual instructions.

## Directly Represented Variables

The system enables the use of directly represented variables in the source of the programs to represent a free Channel. Free Channels are the ones which are not linked to a declared I/O variable. The identifier of a directly represented variable always begins with "%" character.

The naming conventions of a directly represented variable for a channel of a single I/O device. "s" is the slot number of the I/O device. "c" is the number of the Channel:

<b>%IXs.c</b>	free Channel of a Boolean input I/O device
<b>%IBs.c</b>	free Channel of a Short integer input I/O device
<b>%IDs.c</b>	free Channel of a Double integer input I/O device
<b>%IRs.c</b>	free Channel of a Real input I/O device
<b>%ITs.c</b>	free Channel of a Time input I/O device
<b>%ISs.c</b>	free Channel of a String input I/O device
<b>%QXs.c</b>	free Channel of a Boolean output I/O device
<b>%QBs.c</b>	free Channel of a Short Integer output I/O device
<b>%QDs.c</b>	free Channel of a Double integer output I/O device
<b>%QRs.c</b>	free Channel of a Real output I/O device
<b>%QTs.c</b>	free Channel of a Time output I/O device
<b>%QSs.c</b>	free Channel of a String output I/O device

The naming conventions of a directly represented variable for a Channel of a complex device. "s" is the slot number of the device. "b" is the index of the single I/O device within the complex device. "c" is the number of the Channel:

<b>%IXs.b.c</b>	free Channel of a Boolean input I/O device
<b>%IBs.b.c</b>	free Channel of a Short Integer input I/O device
<b>%IDs.b.c</b>	free Channel of a Double integer input I/O device
<b>%IRs.b.c</b>	free Channel of an Real input I/O device

<b>%ITs.b.c</b>	free Channel of a Time input I/O device
<b>%ISs.b.c</b>	free Channel of a String input I/O device
<b>%QXs.b.c</b>	free Channel of a Boolean output I/O device
<b>%QBs.b.c</b>	free Channel of a Short Integer output I/O device
<b>%QDs.b.c</b>	free Channel of a Double integer output I/O device
<b>%QRs.b.c</b>	free Channel of a Real output I/O device
<b>%QTs.b.c</b>	free Channel of a Time output I/O device
<b>%QSSs.b.c</b>	free Channel of a String output I/O device

### **Example**

**%QX1.6** 6th channel of the I/O device #1 (boolean output)

**%ID2.1.7** 7th channel of the I/O device #1 in the device #2 (integer input)



## Information on Variables

All variables have an Attribute and a Direction.

Variables can have one of the following Attributes:

- Free** Variable which can be used for reading or writing, with an initial value
- Read** Read-only variable with an initial value
- Write** Write-only variable with an initial value

They also have a direction:

- Internal** Internal variable updated by the programs
- Input** Variable connected to an input device (refreshed by the system)
- Output** Variable connected to an output device

**Note:** Some variables cannot be input or output (Timers for example). Each restriction is indicated in the corresponding section.

Variables of standard IEC 61131 types can be given an Initial Value. The default initial value is 0 or FALSE. The initial value is the value of the variable when the Target starts the first Cycle.

## Boolean Variables (BOOL)

Boolean means Logic. Such variables can take one of the Boolean values: **TRUE** or **FALSE**. Boolean variables are typically used in Boolean expressions.

## Short Integer Variables (SINT)

Short Integer variables are 8-bit signed integers from -128 to +127.

A **bit of a short integer** variable can be accessed using the following syntax:

`MyVar.i`

If MyVar is a short Integer.

MyVar.i is a Boolean. "i" must be a constant value from 0 to 7.

## Double Integer Variables (DINT)

Double Integer variables are 32-bit signed integers from -2147483648 to +2147483647.

A **bit of a double integer** variable can be accessed using the following syntax:

`MyVar.i`

If MyVar is an Integer.

MyVar.i is a Boolean. "i" must be a constant value from 0 to 31.

## Real Variables (REAL)

Real variables are standard IEEE 32-bit floating values (single precision).

1 sign bit + 23 mantissa bits + 8 exponent bits

The exponent value cannot be less than **-37** or greater than **+37**. A real variable has six significant digits.

## **Timer Variables (TIME)**

Timer means **clock** or **counter**. Such variables have time values and are typically used in Time expressions. A Timer value cannot exceed **1193h2m47s294ms** and cannot be negative. Timer variables are stored in 32 bit words. The internal representation is a positive number of milliseconds.

## **String Variables (STRING)**

String variables contain character strings. The length of the string can change during process operations. The length of a string variable cannot exceed the capacity (maximum length) specified when the variable is declared. String capacity is limited to 255 characters excluding the terminating null character (0).

String variables can contain any character of the standard ASCII table (ASCII code from **0** to **255**). The null character (**0**) can exist in a character string, however, it indicates the end of the string.

Strings have a **size** representing the maximum number of characters that the string can contain. For example, to define the `MyString` string containing 10 characters, you would write `MyString(10)`.

## Comments

Comments may be freely inserted in literal languages such as ST and IL. A comment must begin with the special characters "(" and terminate with the characters ")". Comments can be inserted anywhere in a ST program, and can be written on more than one line.

### Example

```
counter := ival; (* assigns the main counter *)  
  
(* this is a comment expressed  
on two lines *)  
  
c := counter (* you can put comments anywhere *) + base_value + 1;
```

Interleave comments cannot be used. This means that the "(" characters cannot be used within a comment.

**Warning:** The IL language only accepts comments as the last component of an instruction line.

## Defined Words

The system allows the re-definition of constant expressions, true and false Boolean expressions, keywords or complex **ST** expressions. To achieve this, an identifier name, called a **defined word**, has to be given to the corresponding expression. Defined words have a Common Scope: they can be used in any POU of any resource of the Project.

### Example

```
YES is TRUE  
PI is 3.14159  
OK is (auto_mode AND NOT (alarm))
```

When such an equivalence is defined, its **identifier** can be used anywhere in an ST program to replace the attached expression. This is an example of ST programming using defines:

```
If OK Then
angle := PI / 2.0;
isdone := YES;
End_if;
```

**Warning:** When the same identifier is defined twice with different ST equivalencies, the last defined expression is used. For example:

```
Define:          OPEN is FALSE
                OPEN is TRUE
means:          OPEN is TRUE
```

Naming defined words must conform to following rules:

- name cannot exceed 128 characters
- first character must be a letter
- following characters can be letters, digits or underscore ('\_') character

**Warning:** A defined word can not use a defined word in its definition, for example, you can not have:

```
PI is 3.14159
PI2 is PI*2
```

write the complete equivalence using constants or variables and operations:

```
PI2 is 6.28318
```



# SFC Language

**Sequential Function Chart (SFC)** is a graphic language used to describe **sequential operations**. The process is represented as a set of well defined **Steps**, linked by Transitions. A Boolean Condition is attached to each Transition. A set of Actions are attached to each Step. For programs, Conditions and Actions are detailed using three other languages: ST, IL, or LD. For function blocks, Conditions and Actions are detailed using only two other languages: ST or LD. From Conditions and Actions, any Function or Function Block in any language can be called.

## SFC Main Format

An SFC Program is a graphic set of Steps and Transitions, linked together by oriented **Links**. Multiple connection Links are used to represent divergences and convergences. The basic graphic rules of the SFC are:

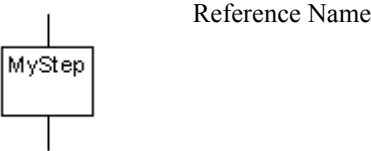
- SFC Programs must have at least one Initial Step
- A Step cannot be followed by another Step
- A Transition cannot be followed by another Transition

# SFC Basic Components

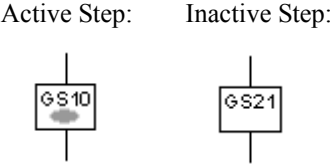
The basic components (graphic symbols) of the SFC language are: Steps and Initial Steps, Transitions, Oriented Links, and Jumps to a Step.

## Steps and Initial Steps

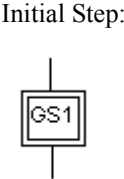
A step is represented by a single square. Each step is referenced by a name, written in the step square symbol. The above information is called the level 1 of the step:



At run time, a token indicates that the step is active:



The initial situation of an SFC program is expressed with initial steps. An initial step has a double bordered graphic symbol. A token is automatically placed in each initial step when the program is started.





An SFC program must contain at least one initial step.

These are the attributes of a step. Such fields may be used in any of the other languages:

**StepName.x activity** of the Step (Boolean value)

**StepName.t activation duration** of the Step (time value)

(where **StepName** is the name of the step)

When reading a child active step or duration from a father:

**ChildName.\_\_S1.x activity** of the Step (Boolean value)

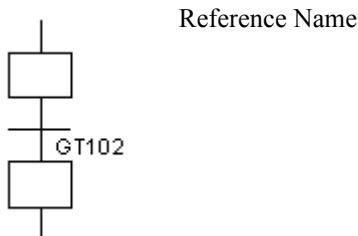
**ChildName.\_\_S1.t activation duration** of the Step (time value)

(where **ChildName** is the name of the child. Note that S1 is preceded by two underscore (\_) characters)

For details about ST extensions, see page 467.

## Transitions

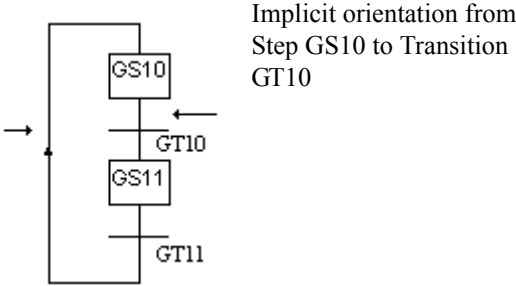
Transitions are represented by a small horizontal bar that crosses the connection link. Each transition is referenced by a name, written next to the transition symbol. The above information is called the level 1 of the transition:



# Oriented Links

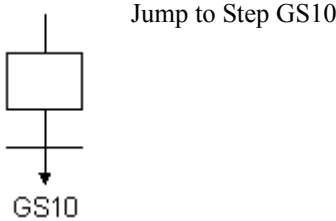
Single lines are used to link steps and transitions. These are oriented links. When the orientation is not explicitly given, the link is oriented from the top to the bottom.

Explicit orientation from Transition GT11 to Step GS10



# Jump to a Step

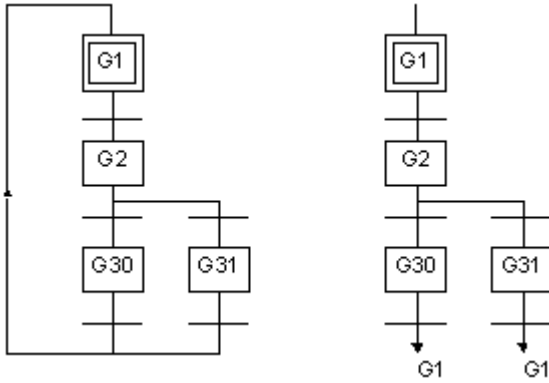
Jump symbols may be used to indicate a connection link from a transition to a step, without having to draw the connection line. The jump symbol must be referenced with the name of the destination step:



A Jump symbol cannot be used to represent a Link from a Step to a Transition.

## Example

The following charts are equivalent:



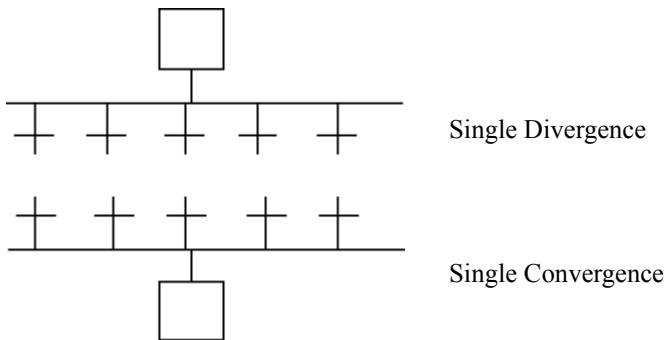
## Divergences and Convergences

Divergences are multiple connection links from one SFC symbol (step or transition) to many other SFC symbols. Convergences are multiple connection links from more than one SFC symbols to one other symbol. Divergences and convergences can be single or double.

### Single Divergences (OR)

A single divergence is a multiple link from one step to many transitions. It allows the active token to pass into one of a number of branches. A single convergence is a multiple link from many transitions to the same step. A single convergence is generally used to group the SFC branches which were started on a single divergence.

Single divergences and convergences are represented by single horizontal lines.

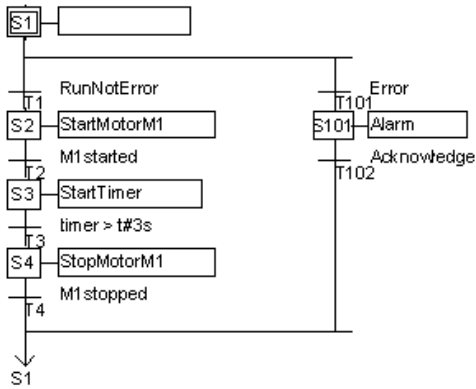


**Warning:** The conditions attached to the different Transitions at the beginning of a single divergence are **not implicitly exclusive**. The exclusivity has to be explicitly detailed in the conditions of transitions to ensure that only one Token progresses in one Branch of the divergence at run time.

## Example

(\* SFC Program with single divergence and convergence \*)

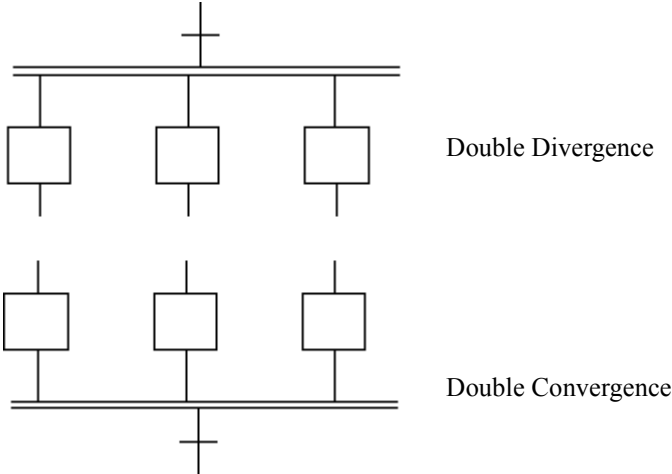
Normal OR divergence:



# Double Divergences (AND)

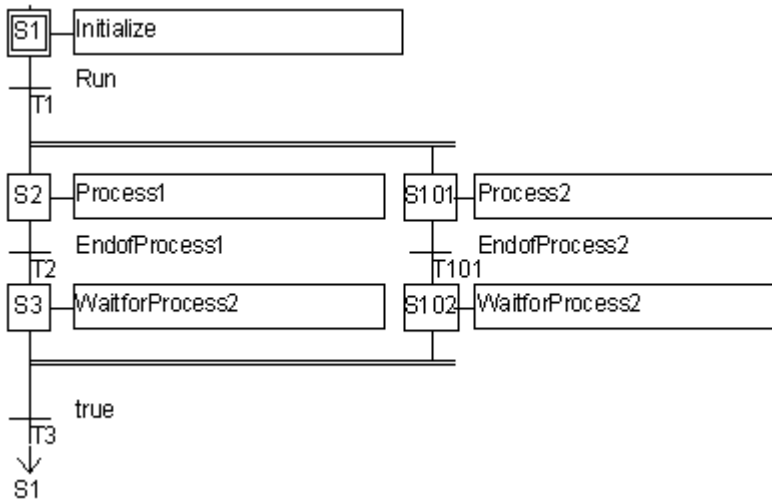
A double divergence is a multiple link from one transition to many steps. It corresponds to parallel operations of the process. A double convergence is a multiple link from many steps to the same transition. A double convergence is generally used to group the SFC branches started on a double divergence.

Double divergences and convergences are represented by double horizontal lines.



## Example

(\* SFC program with double divergence and convergence \*)



## Actions Within Steps

The level 2 of an SFC step is the detailed description of the actions executed during the step activity. This description is made by using SFC literal features, and other languages such as Structured Text (ST) or Ladder Diagram(LD). The basic types of Actions are:

- Boolean actions with Set, Reset or Non-Stored Qualifier.
- List of instructions programmed in ST, LD or IL with Pulse or Non-Stored Qualifier
- SFC Actions (management of SFC children) with Set, Reset or Non-Stored Qualifier.

Several Actions (with same or different types) can be described in the same Step.

The special feature that enables the use of any of the other language is calling Functions and Function blocks (written in ST, LD, and FBD)

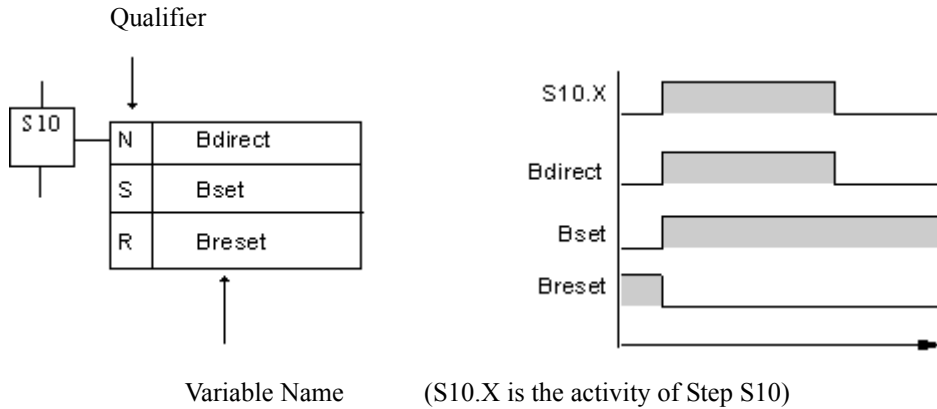
## Boolean Actions

Boolean Actions assign a Boolean Variable with the activity of the Step. The Boolean Variable can be an output or a memory Variable. It is assigned each time the Step activity starts or stops. This is the meaning of the basic Boolean Actions:

- |                                |   |
|--------------------------------|---|
| <b>N on a Boolean Variable</b> | assigns the Step activity signal to the Variable                        |
| <b>S on a Boolean Variable</b> | sets the Variable to TRUE when the Step activity signal becomes TRUE    |
| <b>R on a Boolean Variable</b> | resets the Variable to FALSE when the Step activity signal becomes TRUE |



The Boolean Variable must be an OUTPUT or a MEMORY variable. The following SFC programming leads to the indicated behavior:



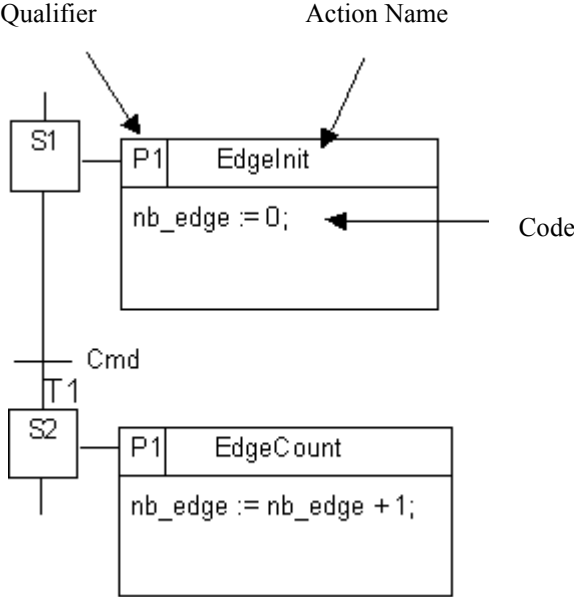
## Pulse Actions

A pulse action is a list of instructions, which are **executed only once at the activation of the Step: P1 Qualifier, or executed only once at the deactivation of the Step: P0 Qualifier**. Instructions are written using the ST, IL or LD syntax.

The following shows the results of a pulse Action with the P1 Qualifier:



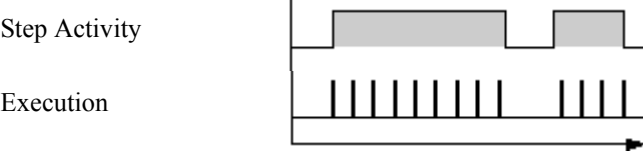
### Example



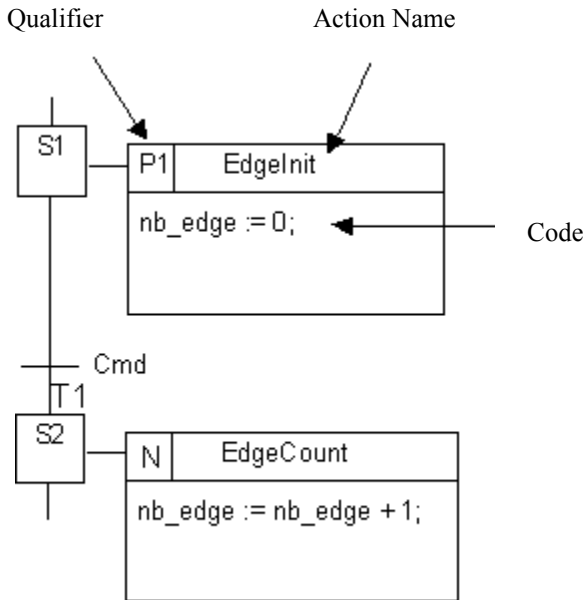
### Non-stored Actions

A non-stored (normal) action is a list of ST, IL or LD instructions which are executed **at each** cycle during the whole **active** period of the step. Instructions are written according to the used language syntax. Non-stored actions have the "N" qualifier.

The following is the results of a non-stored Action:



## Example



## SFC Actions

An SFC action is a child SFC sequence, started or killed according to the change of the step activity signal. An SFC action can have the **N** (Non stored), **S** (Set), or **R** (Reset) Qualifier. This is the meaning of the actions on SFC child:

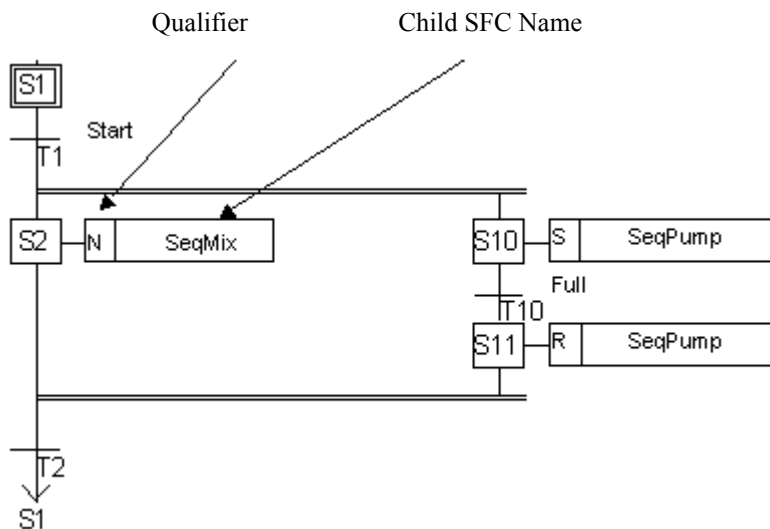
- N on a child** starts the child sequence when the Step becomes active, and kills the child sequence when the Step becomes inactive
- S on a child** starts the child sequence when the Step becomes active. nothing is done when the Step becomes inactive
- R on a child** kills the child sequence when the Step becomes active. nothing is done when the Step becomes inactive

The SFC sequence specified as an Action must be a **child SFC Program** of the program currently being edited. Note that using the **S** (Set) or **R** (Reset) Qualifiers for an SFC Action has exactly the same effect as using the **GSTART** and **GKILL** statements, programmed in an **ST** pulse Action.

### Example

(\* SFC Program using SFC Actions \*)

The main SFC Program is named **Father**. It has two SFC children, called **SeqMlx** and **SeqPump**. The SFC programming of the father SFC Program is:



### List of Instructions

Actions corresponding to several operations can be written as a program using **ST**, **IL** and **LD** syntax. Such actions can have **N**, **P0** or **P1** qualifiers.

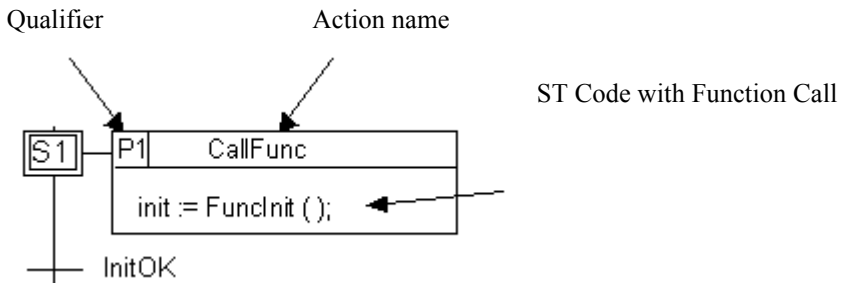
## Calling Functions and Function Blocks

Functions (written in ST, LD, or FBD) or Function Blocks (written in SFC, ST, LD, or FBD) or "C" Functions and "C" Function Blocks, can be directly *called from* an SFC action block, based on the syntax of the language used in the action block.

Detailed syntax can be found in the corresponding language section.

### Example

(\* SFC program with a Function call in an Action Block \*)



## Conditions Attached to Transitions

At each Transition, a Boolean expression is attached that conditions the clearing of the Transition. The condition is usually expressed with ST or LD language. This is the Level 2 of the Transition. Ways to program a condition:

- Conditions programmed in ST or LD
- Calling Function from a Transition

**Warning:** When no expression is attached to the Transition, the default condition is **TRUE**.

### Condition Programmed in ST

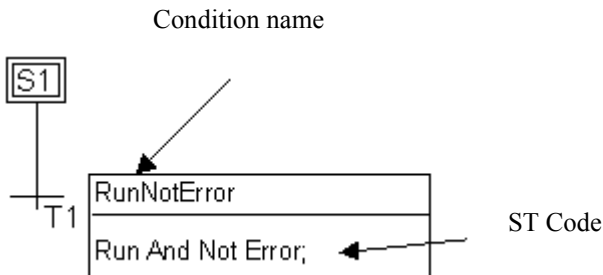
The Structured Text (ST) language can be used to describe the condition attached to a Transition. The complete expression must have Boolean type and may be terminated by a semi colon, according to the following syntax:

`< boolean_expression > ;`

The expression may be a TRUE or FALSE constant expression, a single input or an internal Boolean Variable, or a combination of Variables that leads to a Boolean value.

### Example

(\* SFC Program with ST programming for Transitions \*)

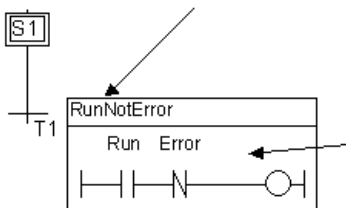


## Condition Programmed in LD

The Ladder Diagram (LD) language can be used to describe the condition attached to a transition. The diagram is composed of only one rung with one coil. The coil value represents the transition's value.

### Example

(\* SFC Program with LD programming for transitions \*)



## Condition Programmed in IL

Instruction List (IL) programming may be directly used to describe an SFC **condition**, according to the following syntax:

<IL instruction>

<IL instruction>

....

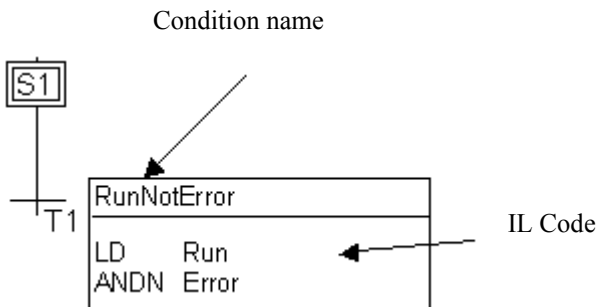
The value contained by the **current result** (IL register) at the end of the IL sequence causes the resulting of the condition to be attached to the Transition:

**current result = 0 or FALSE** -> **condition is FALSE**

**current result <> 0 or TRUE** -> **condition is TRUE**

## Example

(\* SFC program with a condition programmed in IL \*)



## Calling Functions from a Transition

Any Function (written in ST, LD, or FBD), or a "C" Function can be called to evaluate the condition attached to a **Transition**, according to the following syntax in ST:

< function > ( ) ;

The value returned by the Function must be Boolean and yields the resulting condition:

return value = **FALSE**    ->    condition is **FALSE**

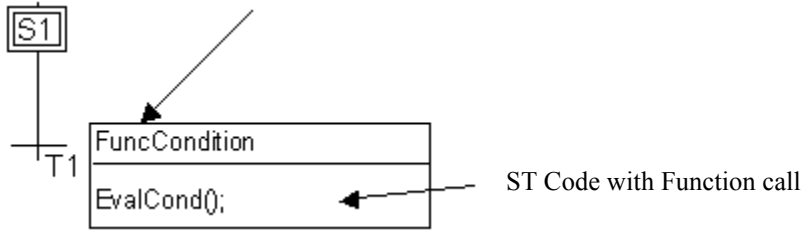
return value = **TRUE**     ->    condition is **TRUE**

## Example

(\* SFC program with function call for transitions \*)

Condition name





**Note:** The syntax of Function call for LD and IL is given in the corresponding language section.

## Calling Function Blocks from a Transition

It is not recommended to call a Function Block in an SFC condition for the following reasons:

- A Function Block should be called at each Cycle, typically in a cyclic Program. For example, counting blocks make incremental operation at each Cycle, Trigger Blocks need to store value of a Boolean at each Cycle to test rising or falling edges...
- An SFC condition is evaluated only when all its preceding Steps are active (not at each Cycle)

# SFC Dynamic Behavior

The dynamic behaviors of the SFC language are:

## Initial situation

The **Initial Situation** is characterized by the **Initial Steps** which are, by definition, in the active state at the beginning of the operation. **At least one** Initial Step must be present in each SFC Program.

## Clearing of a transition

A Transition is either **enabled** or **disabled**. It is said to be enabled when all immediately preceding Steps linked to its corresponding Transition symbol are **active**, otherwise it is disabled. A Transition cannot be **cleared** unless:

- it is enabled, and
- the associated Transition condition is TRUE

## Changing of state of Active Steps

The clearing of a Transition simultaneously leads to the **active** state of the immediately following Steps and to the inactive state of the immediately preceding Steps.

## Simultaneous clearing of Transitions

All Transitions (of all SFC Programs) that can be cleared (enabled and condition to true), are cleared simultaneously.

## SFC Program Hierarchy

The system enables the description of the vertical structure of SFC Programs. SFC Programs are organized in a **hierarchy tree**. Each SFC Program can control (start, kill...) other SFC Programs. Such Programs are called **children** of the SFC Program which controls them. SFC Programs are linked together into a main **hierarchy tree**, using a "**father - child**" relationship:

**Father** Program



The basic rules implied by the hierarchy structure are:

- SFC Programs which have no father are called "main" SFC Programs
- Main SFC Programs are activated by the system when the application starts
- A Program can have several child Programs
- A child of a Program cannot have more than one father
- A child Program can only be controlled by its father
- A Program cannot control the children of one of its own children

The basic actions that a father SFC Program can take to control its child Program are:

Start (**GSTART**)

Starts the child Program: activates each of its Initial Steps.  
Children of this child Program are not automatically started.

Kill (**GKILL**)

Kills the child Program by deactivating each of its active Steps.  
All the children of the child Program are also killed.

Freeze (**GFREEZE**)

Deactivates each of the active Steps of the Program, and memorizes them so the program can be restarted. All the children of the child Program are also frozen.

Restart (**GRST**)

Restarts a frozen SFC Program by reactivating all the suspended Steps. Children of the Program are not automatically restarted.

Get status (**GSTATUS**)

Gets the current status (active, inactive or frozen) of a child Program.

Refer to "SFC Actions" or to the ST sub-sections "GSTART" "GKILL" "GFREEZE" "GRST" and "GSTATUS" for more details.

# FC Language

**Flow Chart (FC)** is a graphic language used to describe **sequential operations**. A Flow Chart diagram is composed of **actions** and **tests**.

Between actions and test are **oriented links** representing data flow.

Actions and tests can be described with ST, LD or IL languages. Functions and Function blocks of any language (except SFC) can be called from actions and tests.

A Flow Chart program can call another Flow Chart program. The called FC program is a **sub-program** of the calling FC program.

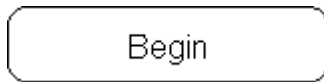
## FC Basic Components

The basic components of the Flow Chart language are:

- beginning of chart
- ending of chart
- actions
- tests (conditions)
- oriented links and connectors

## FC BEGIN

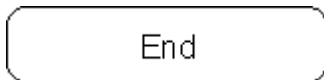
A "**Begin**" symbol must appear at the beginning of a Flow Chart program. It is unique and cannot be omitted. It represents the initial state of the chart when it is activated. Below is the drawing of a "Begin" symbol:



The "Begin" symbol always has a connection (on the bottom) to the other objects of the chart. A flow chart is not valid if no connection is drawn from "Begin" to another object.

## FC END

An "**End**" symbol must appear at the end of a Flow Chart program. It is unique and cannot be omitted. It represents the final state of the chart, when its execution has been completed. Below is the drawing of an "End" symbol:



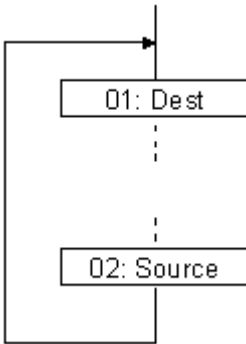
The "End" symbol generally has a connection (on the top) to the other objects of the chart. A flow chart may have no connection to the "End" object (always looping chart). The "End" object is still visible at the bottom of the chart in this case.

## FC Flow Links

A flow link is a line that represents a flow between two points of the diagram. A link is always terminated by an arrow. Below is the drawing of a flow link:



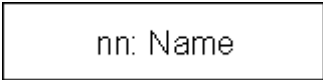
### Example



Two links cannot be connected to the same source connection point.

# FC Actions

An **action** symbol represents actions to be performed. An action is identified by a number and a name. Below is the drawing of an "Action" symbol:



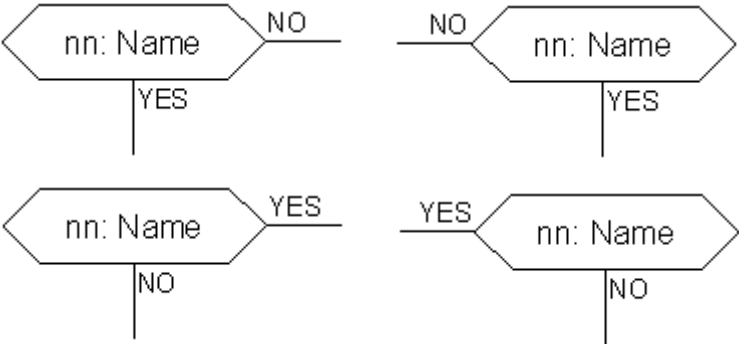
Two different objects of the same chart cannot have the same name or logical number.

Programming language for an action can be ST, LD or IL.

An action is always connected with links, one arriving to it, one starting from it.

# FC Conditions

A **Condition** represents a Boolean **test**. A Condition is identified by a number and a name. According to the evaluation of attached ST, LD or IL expression, the flow is directed to "YES" or "NO" path. Below are the possible drawings for a Condition symbol:



Two different objects of the same chart cannot have the same name or logical number.



The programming of a test is either:

- an expression in ST, or
- a single rung in LD, with no symbol attached to the unique Coil, or
- several instructions in IL. The IL register (or current result) is used to evaluate the Condition.

When programmed in ST text, the expression may optionally be followed by a semi-colon.

When programmed in LD, the unique coil represents the condition value.

A condition equal to:

- 0 or FALSE directs the flow to NO
- 1 or TRUE directs the flow to YES

A test is always connected with an arriving link, and both forward connections must be defined.

## Other FC Components

In addition to basic components, more complex flow charts are built using **FC sub-programs**.

You can also use Connectors instead of flow links. This leads to more readable charts, when too many flow links "cross" many elements.

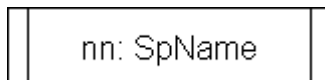
## FC Sub-Program

The system enables the description of the vertical structure of FC programs. FC programs are organized in a **hierarchy tree**. Each FC program can call other FC programs. Such a program is called a **child program** of the FC program which calls them. FC programs which call FC sub-programs are called **father programs**. FC programs are linked together into a main hierarchy tree, using a "Father - Child" relation:

**Father Program**



A **sub-program** symbol in a Flow Chart represents a call to a Flow Chart sub-program. Execution of the calling FC program is suspended till the sub-program execution is complete. A Flow Chart sub-program is identified by a number and a name, as other programs, Functions or Function Blocks. Below is the drawing of a "Sub-Program call" symbol:



Two different objects of the same chart cannot have the same logical number.

The basic rules implied by the FC hierarchy structure are:

- FC programs which have no father are called **main FC programs**.
- Main FC programs are activated by the system when the application starts

- A program can have several child programs
- A child of a program cannot have more than one father
- A child program can be called only by its father
- A program cannot call the children of one of its own children

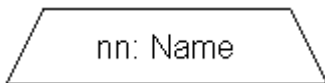
The same sub-program may appear several times in the father chart.

A Flow Chart sub-program call represents the complete execution of the sub chart. The father chart execution is suspended during the child chart is performed.

The sub-program calling Blocks must follow the same Connection rules as the ones defined for an action.

## FC I/O Specific Actions

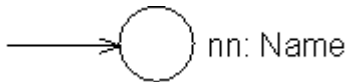
An **I/O specific action** symbol represents actions to be performed. As other actions, an I/O specific action is identified by a number and a name. The same semantic is used on standard actions and I/O specific actions. The aim of I/O specific actions is only to make the chart more readable and to give focus on non-portable parts of the chart. Using I/O specific actions is an optional feature. The drawing of an "I/O Specific Action" symbol is:



I/O specific actions have exactly the same behavior as standard actions. This covers their properties, ST, LD or IL programming, and connection rules.

## FC Connectors

**Connectors** are used to represent a link between two points of the diagram without drawing it. A Connector is represented as a circle and is connected to the source of the flow. The drawing of the Connector is completed, on the appropriate side (depending on the direction of the data flow), by the identification of the target point (generally the name of the target symbol). Below is the standard drawing of a connector:



A Connector always targets a defined Flow Chart symbol. The destination symbol is identified by its logical number.

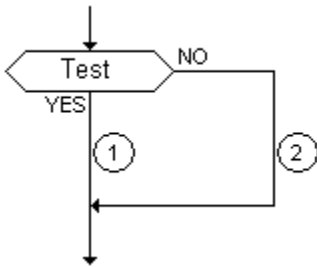
## FC Comments

A **Comment** Block contains text that has no sense for the semantic of the chart. It can be inserted anywhere on an unused space of the Flow Chart document window, and is used to document the program. Below is the drawing of a "Comment" symbol:



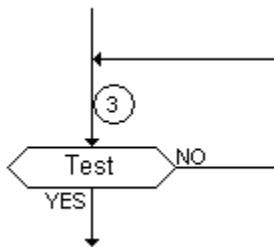
## FC Complex Structure Examples

This section shows **Complex Structure** examples that can be defined in a Flow Chart diagram. Such Structures are combinations of basic objects linked together.



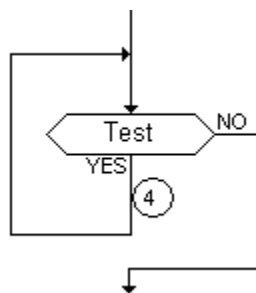
### IF / THEN / ELSE

- (1) place for "THEN" actions to be inserted
- (2) place for "ELSE" actions to be inserted



### REPEAT / UNTIL

- (3) place for repeated actions to be inserted



### WHILE / DO

- (4) place for repeated actions to be inserted

## FC Dynamic Behavior

The execution of a Flow Chart diagram can be explained as follows:

- The Begin symbol takes one Target Cycle
- The End symbol takes one Target Cycle and ends the execution of the chart. After this symbol is reached, no more actions of the chart are executed.
- The flow is broken each time an item (action, decision) is encountered that has already been reached in the same Cycle. In such a case the flow will continue on the next Cycle.

**Note:** Contrary to SFC, an action is not a stable state.

## FC Checking

Apart from attached ST, LD, or IL programming, some other syntactic rules apply to Flow Chart itself. The following are the main rules:

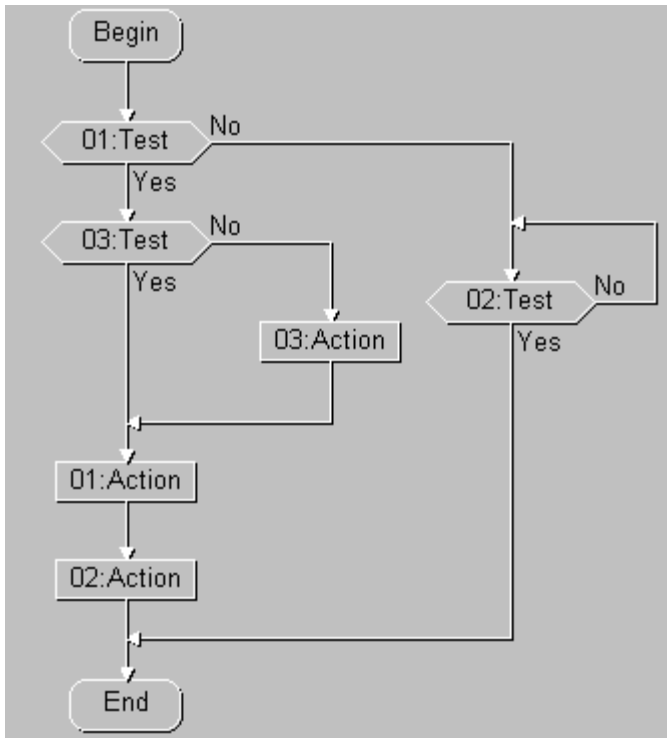
- All "connection" points of all symbols must be wired (connection to "End" symbol may be omitted)
- All symbols must be linked together (no isolated part should appear)
- All connectors should have valid destinations

## FC Examples

Two examples of Flow Chart are provided.

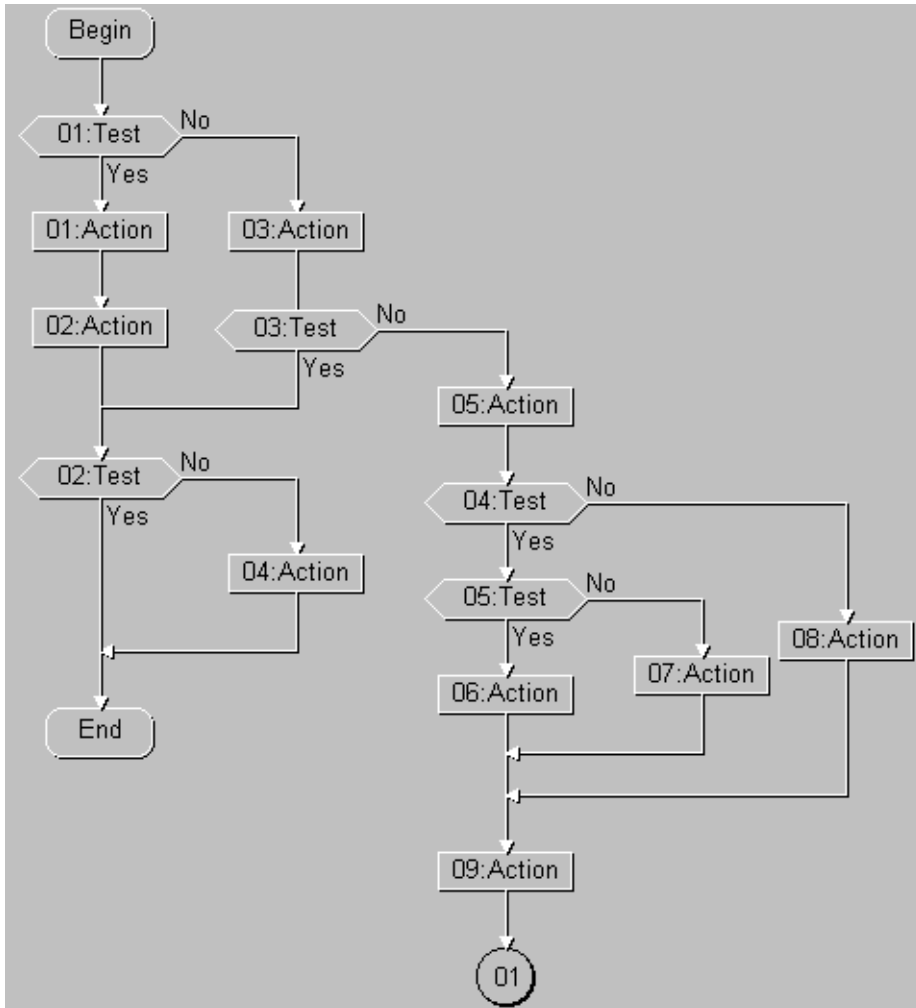
### A structured chart using IF/THEN/ELSE and REPEAT/UNTIL structures

This first example shows a structured chart using IF/THEN/ELSE and REPEAT/UNTIL Structures:



### A non-structured chart using a Connector

This example shows a non-structured chart using a Connector. The use of Connectors in such a case avoid the drawing of very long links that could be hard to follow in the case of a large chart, when source and destination of a link cannot be visible together on the screen:



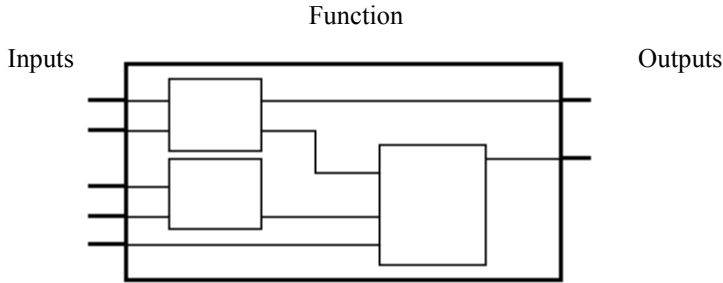


# FBD Language

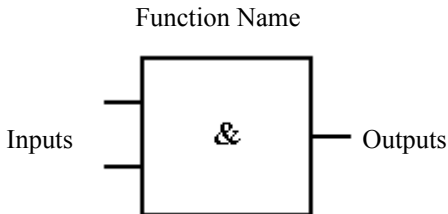
The **Functional Block Diagram (FBD)** is a graphic language. It allows the programmer to build complex procedures by taking existing functions from the standard library or from the function or function block section.

## FBD Diagram Main Format

FBD diagram describes a function between **input variables** and **output variables**. A function is described as a set of elementary blocks. Input and output variables are connected to blocks by connection lines. An output of a block may also be connected to an input of another block.



An entire function operated by an FBD program is built with standard elementary **blocks** from the standard library or from the function or function block section. Each block has a fixed number of input connection points and a fixed number of output connection points. A block is represented by a single rectangle. The inputs are connected on its left border. The outputs are connected on its right border. An elementary block performs a single function between its inputs and its outputs. The name of the function to be performed by the block is written in its rectangle symbol. Each input or output of a block has a well defined type.



Input variables of an FBD program must be connected to input connection points of blocks. The type of each variable must be the same as the type expected for the associated input. An input for FBD diagram can be a Constant Expression, any internal or input variable, or an output variable. For information on constant expressions, see page 381.

Output variables of an FBD program must be connected to output connection points of blocks. The type of each variable must be the same as the type expected for the associated block output. An output for FBD diagram can be any internal or output variable, or the name of the Function (for functions only). When an output is the name of the currently edited function, it represents the assignment of the return value for the function (returned to the calling program).

Input and output variables, inputs and outputs of the blocks are wired together with connection lines, or **links**. Single lines may be used to connect two logical points of the diagram:

- An input variable and an input of a block
- An output of a block and an input of another block
- An output of a block and an output variable

For information on variables, see page 389.

The connection is oriented, meaning that the line carries associated data from the left end to the right end. The left and right ends of the connection line must be of the same data type.

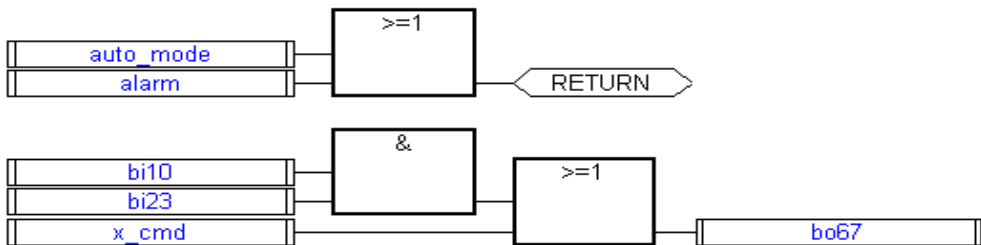
Multiple right connection, also called **divergence** can be used to broadcast an information from its left end to each of its right ends. All the ends of the connection must be of the same data type.

For information on data types, see page 377.

## RETURN Statement

The "<RETURN>" keyword may occur as a diagram output. It must be connected to a Boolean output connection point of a block. The RETURN statement represents a **Conditional End** of the program: if the output of the box connected to the statement has the Boolean value **TRUE**, the end (remaining part) of the diagram is not executed.

### Example



(\* ST equivalence: \*)

```
If auto_mode OR alarm Then
Return;
End_if;
bo67 := (bi10 AND bi23) OR x_cmd;
```

## Jumps and Labels

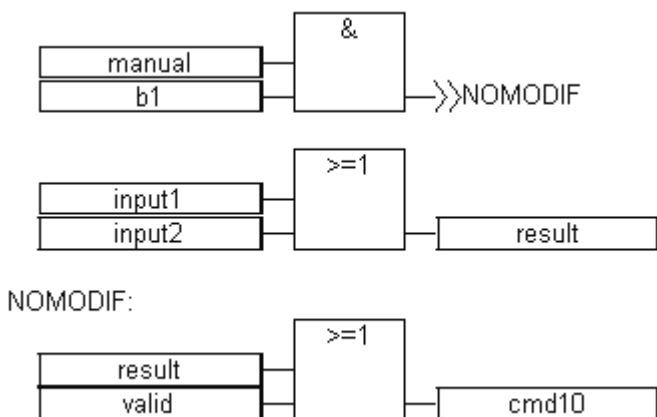
**Labels** and **jumps** are used to control the execution of the diagram. No other object may be connected on the right of a jump or label symbol. The following notation is used:

**>>LAB** Jump to a label (label name is "LAB")

**LAB:** Definition of a label (label name is "LAB")

If the connection line on the **left** of the jump symbol has the Boolean state **TRUE**, the execution of the program directly jumps to after the corresponding label symbol.

## Example



(\* IL Equivalence: \*)

```
                ld      manual1
                and     b1
                jmpc   NOMODIF
                ld      input1
                or      input2
                st      result
NOMODIF:        ld      result
                or      valid
                st      cmd10
```

## Boolean Negation

A single connection line with its right end connected to an input of a block can be terminated by a **Boolean negation**. The negation is represented by a small circle. When a Boolean negation is used, the left and right ends of the connection line must have the **BOOL** type.

### Example

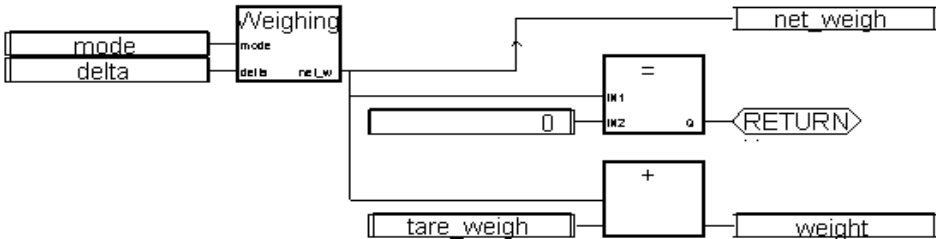


## Calling Functions and Function Blocks

The FBD language enables the **calling of functions or function blocks**. A Function or Function Block is represented by a box. The name written in the box is the name of the function or function blocks.

In the case of a function, the return value is the only output from the box. Function blocks can have more than one output.

### Example



(\* ST Equivalence – in ST, we have to define an intermediate variable: net\_weight \*)

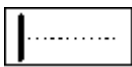
```
net_weight := Weighing (mode, delta); (* call function *)
```

```
If (net_weight = 0) Then Return; End_if;
```

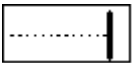
```
weight := net_weight + tare_weight;
```

# LD Language

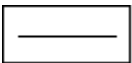
**Ladder Diagram (LD)** is a graphic representation of Boolean equations, combining **Contacts** (input arguments) with **Coils** (output results). The LD language enables the description of tests and modifications of **Boolean** data by placing graphic symbols into the program chart. LD graphic symbols are organized within the chart exactly as an electric Contact diagram. LD diagrams are connected on the left side and on the right side to vertical **Power Rails**. These are the basic graphic components of an LD diagram:



Left vertical power rail



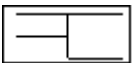
Right vertical power rail



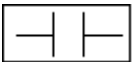
Horizontal connection line



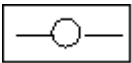
Vertical connection line



Multiple connection lines (all connected together)



Contact associated with a variable

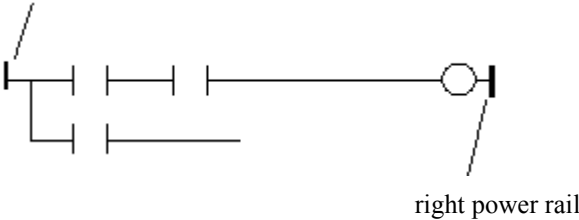


Coil associated to an output or to an internal variable

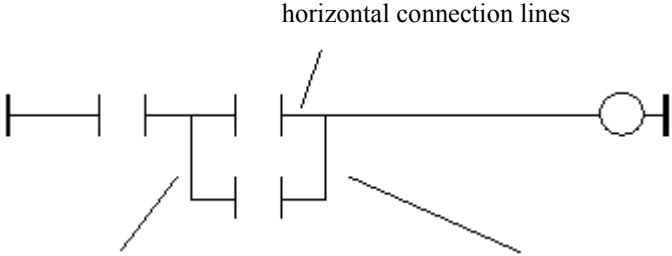
# Power Rails and Connection Lines

An LD diagram is limited on the left and right side by vertical lines, named **left power rail** and **right power rail** respectively.

left power rail



LD diagram graphic symbols are connected to power rails or to other symbols by connection lines, or **links**. Connection lines are horizontal or vertical.



vertical connection lines

vertical connection lines with OR meaning

Each line segment has a boolean state **FALSE** or **TRUE**. The Boolean state is the same for all the segments directly linked together. Any horizontal line connected to the left *vertical power rail* has the **TRUE** state.

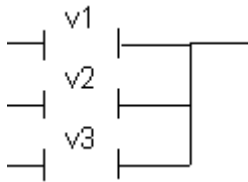


## Multiple Connections

The Boolean state given to a single horizontal connection line is the same on the left and on the right ends of the line. Combining horizontal and vertical connection lines enables the building of **multiple connections**. The Boolean state of the ends of a multiple connection follows logic rules.

A *multiple connection on the left* combines *more than one* horizontal lines connected on the *left* side of a vertical line, and *one* line connected on its *right* side. The Boolean state of the right end is the LOGICAL OR between all the left extremities.

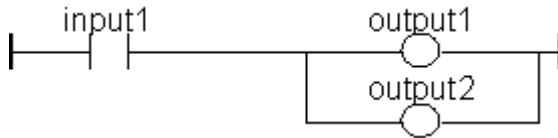
(\* Example of multiple LEFT connection \*)



(\* right end state is (v1 OR v2 OR v3) \*)

A **multiple connection on the right** combines *one* horizontal line connected on the *left* side of a vertical line, and *more than one* line connected on its *right* side. The Boolean state of the left end is propagated into each of the right ends.

(\* Example of multiple RIGHT connection \*)

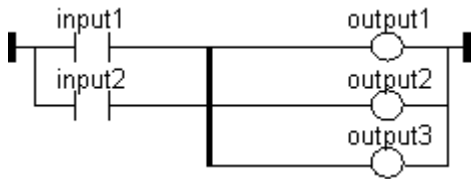


(\* ST equivalence: \*)

```
output1 := input1;  
output2 := input1;
```

A *multiple connection on the left and on the right* combines *more than one* horizontal line connected on the **left** side of a vertical line, and *more than one* line connected on its right side. The Boolean state of each of the right ends is the LOGICAL OR between all the left ends.

(\* Example of multiple LEFT and RIGHT connection \*)



(\* ST Equivalence: \*)

```
output1 := input1 OR input2;  
output2 := input1 OR input2;  
output3 := input1 OR input2;
```

## Basic LD Contacts and Coils

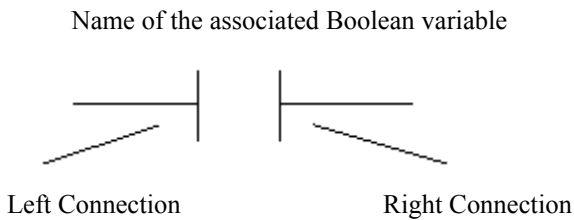
Several symbols are available for input **contacts**:

- Direct Contact
- Inverted Contact
- Contact with Rising Edge Detection
- Contact with Falling Edge Detection

Several symbols are available for output **coils**:

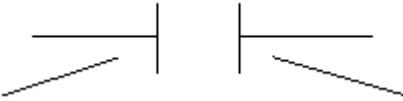
- Direct Coil
- Inverted Coil
- SET Coil
- RESET Coil
- Coil with Rising Edge Detection
- Coil with Falling Edge Detection

The name of the variable is written above any of these graphic symbols:



# Direct Contact

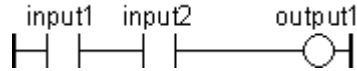
A **Direct Contact** enables a *Boolean operation* between a *connection line state* and a *Boolean variable*.



Left Connection      Right Connection

The state of the connection line on the right of the Contact is the Logical AND between the state of the left connection line and the value of the variable associated with the Contact.

# Example



(\* ST Equivalence: \*)

```
output1 := input1 AND input2;
```

# Inverted Contact

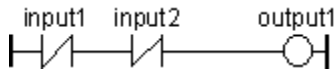
An **Inverted Contact** enables a *Boolean operation* between a *connection line state* and the Boolean negation of a *Boolean variable*.



Left Connection      Right Connection

The state of the connection line on the right of the Contact is the Logical AND between the state of the left connection line and the *Boolean negation* of the value of the variable associated with the Contact.

### Example

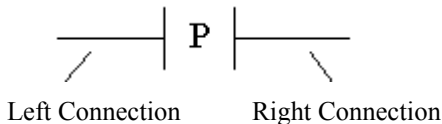


(\* ST Equivalence: \*)

output1 := NOT (input1) AND NOT (input2);

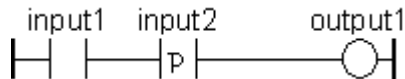
### Contact with Rising Edge Detection

A Contact with rising edge detection (positive) enables a Boolean operation between a connection line state and the rising edge of a Boolean variable.



The state of the connection line on the right of the contact is set to TRUE when the state of the connection line on the left is TRUE, and the state of the associated variable rises from FALSE to TRUE. It is reset to FALSE in all other cases.

### Example



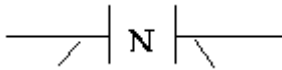
(\* ST Equivalence: \*)

```
output1 := input1 AND (input2 AND NOT (input2prev));
```

(\* input2prev is the value of input2 at the previous cycle \*)

## Contact with Falling Edge Detection

A Contact with **Falling Edge** detection (negative) enables a *Boolean operation* between a *connection line* state and the falling edge of a *Boolean variable*.

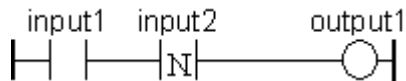


Left Connection

Right Connection

The state of the connection line on the right of the Contact is set to **TRUE** when the state of the connection line on the left is **TRUE**, and the state of the associated variable *falls* from TRUE to FALSE. It is reset to FALSE in all other cases.

### Example



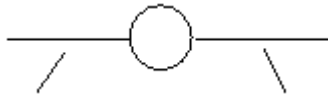
(\* ST Equivalence: \*)

```
output1 := input1 AND (NOT (input2) AND input2prev);
```

(\* input2prev is the value of input2 at the previous cycle \*)

## Direct Coil

**Direct Coils** enable a Boolean output of a connection line Boolean state.



Left Connection

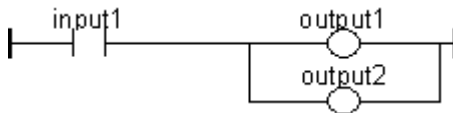
Right Connection

The associated variable is assigned with the Boolean *state of the left connection*. The state of the left connection is propagated into the right connection. The right connection may be connected to the right vertical Power Rail. For information on variables, see page 389.

The associated Boolean variable must be OUTPUT or MEMORY.

The associated name can be the name of the program (for Function only). This corresponds to the assignment of the return value of the function.

### Example

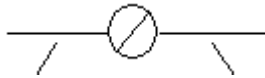


(\* ST Equivalence: \*)

```
output1 := input1;  
output2 := input1;
```

## Inverted Coil

**Inverted Coils** enable a Boolean output according to the Boolean negation of a connection line state.



Left Connection

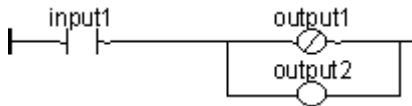
Right Connection

The associated variable is assigned with the Boolean *negation* of the *state of the left connection*. The state of the left connection is propagated into the right connection. Right connection may be connected to the right vertical power rail. For information on variables, see page 389.

The associated Boolean variable must be OUTPUT or MEMORY.

The associated name can be the name of the program (for Function only). This corresponds to the assignment of the return value of the function.

### Example



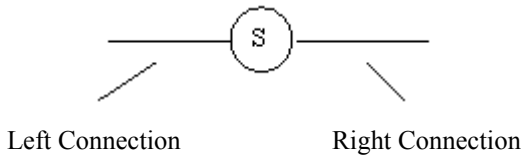
(\* ST Equivalence: \*)

```
output1 := NOT (input1);  
output2 := input1;
```



## SET Coil

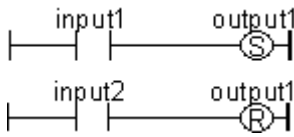
"Set" Coils enable a Boolean output of a connection line Boolean state.



The associated variable is SET TO TRUE when the boolean state of the left connection becomes TRUE. The output variable keeps this value until an inverse order is made by a "RESET" coil. For information on variables, see page 389. The state of the left connection is propagated into the right connection. Right connection may be connected to the right vertical power rail.

The associated Boolean variable must be OUTPUT or MEMORY.

### Example

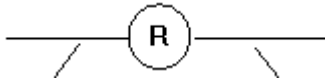


(\* ST Equivalence: \*)

```
IF input1 THEN
    output1 := TRUE;
END_IF;
IF input2 THEN
    output1 := FALSE;
END_IF;
```

## RESET Coil

"Reset" Coils enable Boolean output of a connection line Boolean state.



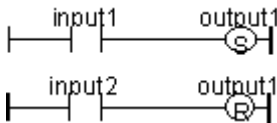
Left Connection

Right Connection

The associated variable is RESET TO FALSE when the Boolean *state of the left connection* becomes **TRUE**. The output variable keeps this value until an inverse order is made by a "SET" coil. For information on variables, see page 389. The state of the left connection is propagated into the right connection. Right connection may be connected to the right vertical Power Rail.

The associated Boolean variable must be OUTPUT or MEMORY.

### Example



(\* ST Equivalence: \*)

```
IF input1 THEN
  output1 := TRUE;
END_IF;
IF input2 THEN
  output1 := FALSE;
END_IF;
```

## Coil with Rising Edge Detection

Coils with rising edge detection or "Positive" coils enable Boolean output of a connection line Boolean state.



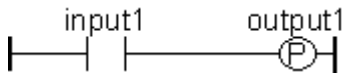
Left Connection

Right Connection

The associated variable is set to **TRUE** when the Boolean *state of the left connection* rises from FALSE to TRUE. The output variable resets to FALSE in all other cases. For information on variables, see page 389. The state of the left connection is propagated into the right connection. Right connection may be connected to the right vertical power rail.

The associated Boolean variable must be OUTPUT or MEMORY.

### Example



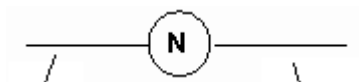
(\* ST Equivalence: \*)

```
IF (input1 and NOT(input1prev)) THEN
    output1 := TRUE;
ELSE
    output1 := FALSE;
END_IF;
```

(\* input1prev is the value of input1 at the previous cycle \*)

## Coil with Falling Edge Detection

Coils with falling edge detection or "Negative" coils enable Boolean output of a connection line Boolean state.



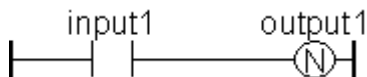
Left Connection

Right Connection

The associated variable is set to **TRUE** when the Boolean *state of the left connection* falls from TRUE to FALSE. The output variable resets to FALSE in all other cases. For information on variables, see page 389. The state of the left connection is propagated into the right connection. Right connection may be connected to the right vertical power rail.

The associated Boolean variable must be OUTPUT or MEMORY.

### Example



(\* ST Equivalence: \*)

```
IF (NOT(input1) and input1prev) THEN
  output1 := TRUE;
ELSE
  output1 := FALSE;
END_IF;
```

(\* input1prev is the value of input1 at the previous cycle \*)

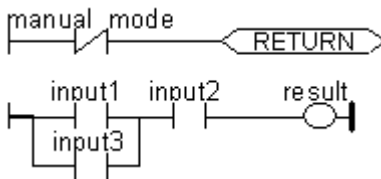
## RETURN Statement

The **RETURN** label can be used as an output to represent a conditional end of the program. No connection can be put on the right of a RETURN symbol.

If the *left connection* line has the **TRUE** Boolean state, the program ends without executing the equations entered on the following lines of the diagram.

When the LD program is a function, its name has to be associated with an output coil to set the return value (returned to the calling program).

### Example



(\* ST Equivalence: \*)

```
If Not (manual_mode) Then RETURN; End_if;
result := (input1 OR input3) AND input2;
```

## Jumps and Labels

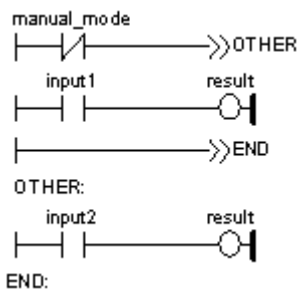
Labels, conditional and unconditional jumps symbols, can be used to control the execution of the diagram. No connection can be put on the right of the label and jump symbol. The following notations are used:

>>LAB    jump to label named "LAB"

LAB:        definition of the label named "LAB"

If the *connection on the left* of the jump symbol has the TRUE Boolean state, the program execution is driven after the label symbol.

### Example



(\* IL Equivalence: \*)

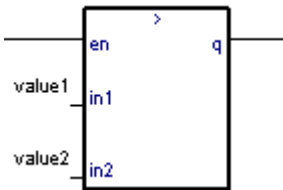
```
      ldn    manual_mode
      jmpc   OTHER
      ld     input1
      st     result
      jmp    END
OTHER:  ld     input2
      st     result
END:    (* end of program *)
```

## BLOCKS in LD

Using the LD editor, you connect function boxes to Boolean lines. A function can actually be an operator, a function block or a function. As all blocks do not have always a Boolean input and/or a Boolean output, inserting blocks in an LD diagram leads to the addition of new parameters **EN**, **ENO** to the block interface.

### The "EN" input

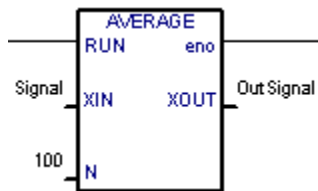
On some operators, functions or function blocks, the first input does not have Boolean data type. As the first input must always be connected to the rung, another input is automatically inserted at the first position, called "EN". The block is executed only if the EN input is TRUE. Below is the example of a comparison operator, and the equivalent code expressed in ST:



```
IF rung_state THEN
q := (value1 > value 2);
ELSE
q := FALSE;
END_IF;
(* continue rung with q state *)
```

### The "ENO" output

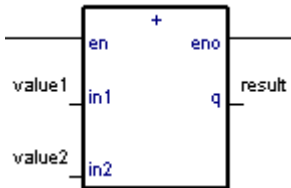
On some operators, functions or function blocks, the first output does not have Boolean data type. As the first output must always be connected to the rung, another output is automatically inserted at the first position, called "ENO". The ENO output always takes the same state as the first input of the block. Below is an example with AVERAGE function block, and the equivalent code expressed in ST:



```
AVERAGE(rung_state, Signal, 100);
OutSignal := AVERAGE.XOUT;
eno := rung_state;
(* continue rung with eno state *)
```

## The "EN" and "ENO" parameters

On some cases, both **EN** and **ENO** are required. Below is an example with an arithmetic operator, and the equivalent code expressed in ST:



```
IF rung_state THEN
  result := (value1 + value2);
END_IF;
eno := rung_state;
(* continue rung with eno state *)
```



# ST Language

**ST (Structured Text)** is a high level structured language designed for automation processes. This language is mainly used to implement complex procedures that cannot be easily expressed with graphic languages. ST language can be used for the description of the actions within the Steps and conditions attached to the Transitions of the SFC or the Actions and Tests of the FC Language.

## ST Main Syntax

An ST program is a list of ST **statements**. Each statement ends with a semi-colon (";") separator. Names used in the source code (variable identifiers, constants, language keywords...) are separated with **inactive separators** (space character, end of line or tab stops) or by **active separators**, which have a well defined significance (for example, the ">" separator indicates a "greater than" comparison. **Comments** may be freely inserted into the text. A comment must begin with "(" and ends with "\*". These are basic types of ST statements:

- assignment statement (variable := expression;)
- function call
- function block call
- selection statements (IF, THEN, ELSE, CASE...)
- iteration statements (FOR, WHILE, REPEAT...)
- control statements (RETURN, EXIT...)
- special statements for links with other languages such as **SFC**

When entering ST syntax, basic coding is black while other items are displayed using color:

- Keywords are pink
- Numbers are brown
- Comments are green

Inactive separators may be freely entered between active separators, constant expressions and identifiers. ST inactive separators are: *Space* (blank) character, *Tabs* and *End of line* character. Unlike line-formatted languages such as IL, end of lines may be entered anywhere in the program. The rules shown below should be followed when using inactive separators to increase ST program readability:

- Do not write more than one statement on one line
- Use tabs to indent complex statements
- Insert comments to increase readability of lines or paragraphs

## Example

### Low Readability

```
imax := max_ite; cond := X12;
if not(cond (* alarm *))
then return; end_if;
for i (* index *) := 1 to max_ite
do if i <> 2 then Spcall();
end_if; end_for;

(* no effect if alarm *)
```

### High Readability

```
(* imax : number of iterations *)
(* i: FOR statement index *)
(* cond: process validity *)

imax := max_ite;
cond := X12;
if not (cond) then
return;
end_if;

(* process loop *)

for i := 1 to max_ite do
if i <> 2 then
Spcall ();
end_if;
end_for;
```

## Expressions and Parentheses

ST expressions combine ST *operators* and variable or constant *operands*. For each single expression (combining operands with one ST operator), the type of the operands must be the same. This single expression has the same data type as its operands, and can be used in a more complex expression. For example:

(boo_var1 AND boo_var2)	has BOOL type
not (boo_var1)	has BOOL type
(sin (3.14) + 0.72)	has REAL type
(t#1s23 + 1.78)	is an invalid expression

For information on data types, see page 377.

**Parentheses** are used to isolate sub parts of the expression, and to explicitly order the priority of the operations. When no parentheses are given for a complex expression, the operation sequence is implicitly given by the default *priority* between ST operators. For example:

$2 + 3 * 6$	equals $2+18=20$	because multiplication operator has a higher priority
$(2 + 3) * 6$	equals $5*6=30$	priority is given by parenthesis

## Functions or Function Block Calls

Standard ST function calls may be used for each of following objects:

- Functions and function blocks written in IEC 61131 languages
- "C" functions and function blocks

## Calling Functions

### Calling Functions from ST:

- Name:** name of the called function written in IEC 61131 language or in "C"
- Meaning:** calls a ST, IL, LD or FBD Functions or a "C" function and gets its return value
- Syntax:** `<variable> := <funct> (<par1>, ... <parN>);`
- Operands:** The type of return value and calling parameters must follow the interface defined for the function.
- Return value:** value returned by the function

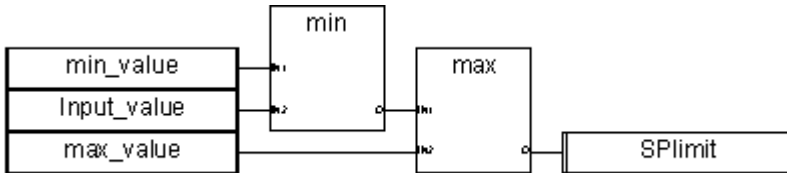
Function calls may be used in any expression.

### Example

Example1: IEC 61131 function call

```
(* Main ST program *)
(* gets an integer value and converts it into a limited time value *)
ana_timeprog := SPLimit ( tprog_cmd );
appl_timer := ANY_TO_TIME (ana_timeprog * 100);
```

(\* Called FBD function named 'SPlimit' \*)



Example2: "C" function call – same syntax as for IEC 61131 function calls

(\* Functions used in complex expressions: min, max, right, mlen and left are standard "C" functions \*)

```
limited_value := min (16, max (0, input_value) );
```

```
rol_msg := right (message, mlen (message) - 1) + left (message, 1);
```

## Calling Function Blocks

### Calling Function Blocks from ST:

**Name:** name of the function block instance

**Meaning:** calls a function block from the standard library or from the user's library and accesses its return parameters

**Syntax:** (\* call of the function block \*)  
<blockname> (<p1>, <p2> ... );  
(\* gets its return parameters \*)  
<result> := <blockname>. <ret\_param1>;  
...  
<result> := <blockname>. <ret\_paramN>;

**Operands:** parameters are expressions which match the type of the parameters specified for that function block

**Return value:** See Syntax to get the return parameters.

Consult the 'Standard Function Blocks' section to find the meaning and type of each function block parameter. The function block instance (name of the copy) must be declared in the dictionary

## Example

```
(* ST program calling a function block *)  
  
(* declare the instance of the block in the dictionary: *)  
(* trigb1 : block R_TRIG - rising edge detection *)  
  
(* Function block activation from ST language *)  
trigb1 (b1);  
(* return parameters access *)  
If (trigb1.Q) Then nb_edge := nb_edge + 1; End_if;
```

## ST Operators

Standard operators such as AND, NOT, OR, XOR, etc. are described in the Standard Operators section.

## ST Basic Statements

### Assignment

**Name:** :=

**Meaning:** Assigns a variable to an expression

**Syntax:** <variable> := <any\_expression> ;

**Operands:** Variable must be an internal or output variable and the expression must have the same type

The expression can be a call to a function.

### Example

```
(* ST program with assignments *)
(* variable <=> variable *)
bo23 := bo10;
(* Variable <=> expression *)
bo56 := bx34 OR alrm100 & (level >= over_value);
result := (100 * input_value) / scale;
(* assignment with function call *)
limited_value := min (16, max (0, input_value) );
```

## RETURN Statement

**Name:** RETURN

**Meaning:** terminates the execution of the current program

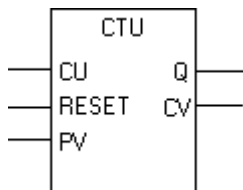
**Syntax:** RETURN ;

**Operands:** (none)

In an SFC action block, the RETURN statement indicates the end of the execution of that block only.

### Example

(\* FBD specification of the program: programmable counter \*)



(\* ST implementation of the program, using RETURN statement \*)

```
If NOT (CU) then
  Q := false;
  CV := 0;
  RETURN; (* terminates the program *)
end_if;

if RESET then
  CV := 0;
else
  if (CV < PV) then
    CV := CV + 1;
  end_if;
end_if;
Q := (CV >= PV);
```



## IF-THEN-ELSIF-ELSE Statement

**Name:** IF ... THEN ... ELSIF ... THEN ... ELSE ... END\_IF

**Meaning:** executes one of several lists of ST statements  
selection is made according to the value of a Boolean expression

**Syntax:** IF <Boolean\_expression> THEN  
    <statement> ;  
    <statement> ;  
    ...  
    ELSIF <Boolean\_expression> THEN  
        <statement> ;  
        <statement> ;  
        ...  
    ELSE  
        <statement> ;  
        <statement> ;  
        ...  
END\_IF;

The ELSE and ELSIF statements are optional. If the ELSE statement is not written, no instruction is executed when the condition is FALSE. The ELSIF statement may be used more than once. The ELSE statement, if used, must appear only once at the end of the 'IF, ELSIF...' sequence.

### Example

```
(* ST program using IF statement *)  
  
IF manual AND not (alarm) THEN  
    level := manual_level;  
    bx126 := bi12 OR bi45;  
ELSIF over_mode THEN  
    level := max_level;  
ELSE  
    level := (lv16 * 100) / scale;  
END_IF;
```

```
(* IF structure without ELSE *)
If overflow THEN
  alarm_level := true;
END_IF;
```

## CASE Statement

**Name:** CASE ... OF ... ELSE ... END\_CASE

**Meaning:** executes one of several lists of ST statements  
selection is made according to an integer expression

**Syntax:** CASE <integer\_expression> OF  
    <value> : <statements>;  
    <value>, <value> : <statements>;  
    ...  
ELSE  
    <statements>;  
END\_CASE;

Case values must be integer constant expressions. Several values, separated by commas, can lead to the same list of statements. The ELSE statement is optional.

### Example

```
(* ST program using CASE statement *)

CASE error_code OF
  255: err_msg := 'Division by zero';
fatal_error := TRUE;
  1: err_msg := 'Overflow';
  2, 3: err_msg := 'Bad sign';
ELSE
  err_msg := 'Unknown error';
END_CASE;
```

## WHILE Statement

**Name:** WHILE ... DO ... END\_WHILE

**Meaning:** iteration structure for a group of ST statements  
the "continue" condition is evaluated BEFORE any iteration

**Syntax:** WHILE <Boolean\_expression> DO  
    <statement>;  
    <statement>;  
    ...  
END\_WHILE;

**Warning:** Since the virtual machine is a **synchronous** system, input variables are not refreshed during WHILE iterations. The change of state of an input variable cannot be used to describe the condition of a WHILE statement.

### Example

```
(* ST program using WHILE statement *)  
  
(* this program uses specific "C" functions to read characters *)  
(* on a serial port *)  
  
string := ''; (* empty string *)  
nbchar := 0;  
  
WHILE ((nbchar < 16) & ComIsReady ( )) DO  
    string := string + ComGetChar ( );  
    nbchar := nbchar + 1;  
END_WHILE;
```

## REPEAT Statement

**Name:** REPEAT ... UNTIL ... END\_REPEAT

**Meaning:** iteration structure for a group of ST statements  
the "continue" condition is evaluated AFTER any iteration

**Syntax:** REPEAT  
    <statement>;  
    <statement>;  
    ...  
    **UNTIL** <Boolean\_condition>  
    **END\_REPEAT** ;

**Warning:** Because the virtual machine is a **synchronous** system, input variables are not refreshed during REPEAT iterations. The change of state of an input variable cannot be used to describe the ending condition of a REPEAT statement.

### Example

```
(* ST program using REPEAT statement *)  
  
(* this program uses specific "C" functions to read characters *)  
(* on a serial port *)  
  
string := ''; (* empty string *)  
nbchar := 0;  
IF ComIsReady ( ) THEN  
  REPEAT  
    string := string + ComGetChar ( );  
    nbchar := nbchar + 1;  
  UNTIL ( (nbchar >= 16) OR NOT (ComIsReady ( )) )  
  END_REPEAT;  
END_IF;
```

## FOR Statement

**Name:** FOR ... TO ... BY ... DO ... END\_FOR

**Meaning:** executes a limited number of iterations, using an integer index variable

**Syntax:** FOR <index> := <mini> TO <maxi> BY <step> DO  
    <statement> ;  
    <statement> ;  
END\_FOR;

**Operands:** **index:** internal integer variable increased at each loop  
**mini:** initial value for index (before first loop)  
**maxi:** maximum allowed value for index  
**step:** index increment at each loop

The [ BY step ] statement is optional. If not specified, the increment step is 1

**Warning:** Because the virtual machine is a **synchronous** system, input variables are not refreshed during FOR iterations.

This is the "WHILE" equivalent of a FOR statement:

```
index := mini;
while (index <= maxi) do
    <statement> ;
    <statement> ;
    index := index + step;
end_while;
```

### Example

```
(* ST program using FOR statement *)
(* this program extracts the digit characters of a string *)

length := mlen (message);
target := ''; (* empty string *)
FOR index := 1 TO length BY 1 DO
    code := ascii (message, index);
    IF (code >= 48) & (code <= 57) THEN
        target := target + char (code);
    END_IF;
END_FOR;
```

## EXIT Statement

**Name:** EXIT

**Meaning:** exit from a FOR, WHILE or REPEAT iteration statement

**Syntax:** EXIT;

The EXIT is commonly used within an IF statement, inside a FOR, WHILE or REPEAT block.

### Example

```
(* ST program using EXIT statement *)
(* this program searches for a character in a string *)

length := mlen (message);
found := NO;
FOR index := 1 TO length BY 1 DO
  code := ascii (message, index);
  IF (code = searched_char) THEN
    found := YES;
    EXIT;
  END_IF;
END_FOR;
```

## ST Extensions

The following statements and functions are available to control the execution of the SFC child programs. They may be used inside action blocks written in ST in SFC steps.

GSTART	starts an SFC program or function block
GKILL	kills an SFC program
GFREEZE	freezes an SFC program
GRST	restarts a frozen SFC program or function block
GSTATUS	gets current status of an SFC program

**Warning:** These functions are not in the IEC 61131 standard.

Easy equivalents can be found for GSTART and GKILL using the following syntax in the SFC step:

- child\_name with the S qualifier (\* equivalent to GSTART(child\_name); \*)
- child\_name with the R qualifier (\* equivalent to GKILL(child\_name); \*)

The following fields can be used to access the status of an SFC step or child (from its father):

StepName.x	Boolean value that represents the <b>activity of the Step</b>
StepName.t	time elapsed since the last activation of the step: <b>activity duration</b> ("StepName" represents the name of the SFC step)
ChildName.__S1.x	Boolean value that represents the <b>activity of the child</b>
ChildName.__S1.t	time elapsed since the last activation of the step: <b>activity duration</b> ("ChildName" represents the name of the SFC child)

## **GSTART Statement in SFC Action**

<b>Name:</b>	<b>GSTART</b>
<b>Meaning:</b>	Starts an SFC child program or function block by placing a token into each of its initial Steps. The abbreviated syntax is equivalent to an SFC Child action block having the S qualifier. The extended syntax only applies to SFC child function blocks.
<b>Syntax:</b>	<b>GSTART</b> ( < <i>child_name</i> > ); or <b>GSTART</b> ( < <i>child_name,step_name,input1,input2,...inputn</i> > ) where <i>child_name</i> represents the name of the SFC child POU <i>step_name</i> represents the name of the active step. <i>step_name</i> must be preceded by two underscore characters (e.g., __S1) <i>input1,input2,...inputn</i> indicate the values of the input parameters of the SFC child POU
<b>Operands:</b>	the specified SFC program must be a child of the one in which the statement is written
<b>Return value:</b>	(none)

Children of the child program are not automatically started by the GSTART statement. For details about SFC actions, see page 407.

**Note:** Since GSTART is not in the IEC 61131 standard, it is preferable to use the S qualifier attached to the child name.



## **GKILL Statement in SFC Action**

**Name:** GKILL

**Meaning:** Kills a child SFC program by removing the Tokens currently existing in its Steps. The syntax is equivalent to an SFC Child action block having the R qualifier.

**Syntax:** GKILL (<*child\_name*>);  
where  
*child\_name* represents the name of the SFC child POU

**Operands:** the specified SFC program must be a child of the one in which the statement is written

**Return value:** (none)

Children of the child program are automatically killed with the specified program. For details on SFC actions, see page 407.

**Note:** Since GKILL is not in the IEC 61131 standard, it is preferable to use the R qualifier attached to the child name.

### **Example**

See GSTART

## GFREEZE Statement in SFC Action

**Name:** GFREEZE

**Meaning:** freezes a child SFC (program or function block); suspends its execution. The suspended SFC POU can then be restarted using the GRST statement.

**Syntax:** GFREEZE ( <child\_name> );  
where  
*child\_name* represents the name of the SFC child POU

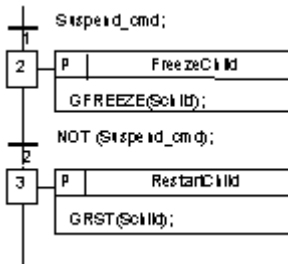
**Operands:** the specified SFC program must be a child of the one in which the statement is written

**Return value:** (none)

Children of the child program are automatically frozen along with the specified program.

**Note:** GFREEZE is not in the IEC 61131 standard.

### Example



## GRST Statement in SFC Action

**Name:** GRST

**Meaning:** restarts a child SFC program frozen by the GFREEZE statement: all the Tokens removed by GFREEZE are restored. The extended syntax only applies to SFC child function blocks.

**Syntax:** GRST ( <*child\_name*> );  
or  
GRST ( <*child\_name,input1,input2,...inputn*> );  
where  
*child\_name* represents the name of the SFC child POU  
*inputn* indicates the value of the input parameter of the SFC child POU

**Operands:** the specified SFC program must be a child of the one in which the statement is written

**Return value:** (none)

Children of the child program are automatically restarted by the GRST statement.

GRST is not in the IEC 61131 standard.

## GSTATUS Statement in SFC Action

**Name:** GSTATUS

**Meaning:** returns the current status of an SFC program

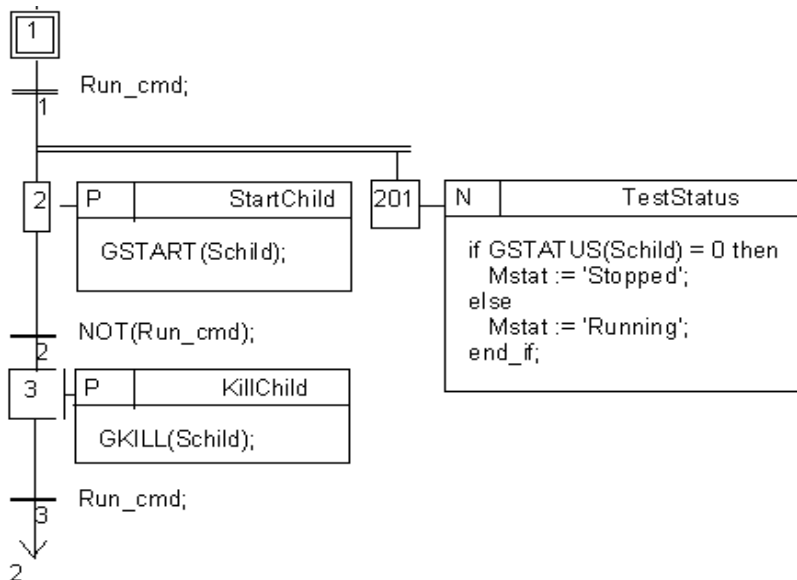
**Syntax:** `<var> := GSTATUS ( <child_name> );`  
where  
*child\_name* represents the name of the SFC child POU

**Operands:** the specified SFC program must be a child of the one in which the statement is written

**Return value:** 0 = Program is inactive (killed)  
1 = Program is active (started)  
2 = Program is frozen

**Note:** GSTATUS is not in the IEC 61131 standard.

### Example



# IL Language

**Instruction List**, or **IL** is a low level language. Instructions always relate to the **current result** (or **IL register**). The operator indicates the operation that must be made between the current value and the operand. The result of the operation is stored again in the current result.

## IL Main Syntax

An IL program is a list of **instructions**. Each instruction must begin on a new line, and must contain an **operator**, completed with optional **modifiers** and, if necessary, for the specific operation, one or more **operands**, separated with commas (','),. A **label** followed by a colon (':') may precede the instruction. If a **comment** is attached to the instruction, it must be the last component of the line. Comments always begin with '(\*' and ends with '\*)'. Empty lines may be entered between instructions. Comments may be placed on empty lines. Furthermore, when entering IL syntax, basic coding is black while other items are displayed using color:

- Keywords are pink
- Numbers are brown
- Comments are green

### Example

Label	Operator	Operand	Comments
Start:	LD	IX1	(* push button *)
	ANDN	MX5	(* command is not forbidden *)
	ST	QX2	(* start motor *)

## Labels

A **label** followed by a colon (':') may precede the instruction. A label can be put on an empty line. Labels are used as operands for some operations such as jumps. Labels must conform to the following naming rules:

- name cannot exceed **16** characters
- first character must be a **letter**
- following characters must be **letters, digits** or **'\_'** character

The same name cannot be used for more than one label in the same IL program. A label can have the same name as a Variable.

## Operator Modifiers

The available operator **modifiers** are shown below. The modifier character must complete the name of the operator, with no blank characters between them:

<b>N</b>	Boolean negation of the operand
<b>(</b>	delayed operation
<b>C</b>	conditional operation

The **'N'** modifier indicates a Boolean negation of the operand. For example, the instruction **ORN IX12** is interpreted as: **result := result OR NOT (IX12)**.

The parenthesis **'(** modifier indicates that the evaluation of the instruction must be delayed until the closing parenthesis **)** operator is encountered.

The **'C'** modifier indicates that the attached instruction must be executed only if the current result has the Boolean value TRUE (different than 0 for non-Boolean values). The **'C'** modifier can be combined with the **'N'** modifier to indicate that the instruction must be executed only if the current result has the Boolean value FALSE (or 0 for non-Boolean values).

## Delayed Operations

Because there is only one IL register (**current result**), some operations may have to be **delayed**, so that the execution order of the instructions can be changed. Parentheses are used to indicate delayed operations:

'(' is a modifier indicates the operation to be delayed  
)' is an operator executes the delayed operation

The opening **parenthesis** '(' modifier indicates that the evaluation of the instruction must be delayed until the closing parenthesis ')' operator is encountered.

### Example

```
AND ( IX12  
OR IX35  
)
```

is interpreted as:

**result := result AND ( IX12 OR IX35 )**

## IL Operators

The following table summarizes the standard operators of the IL language:

<b>Operator</b>	<b>Modifier</b>	<b>Operand</b>	<b>Description</b>
LD	N	Variable, constant	Loads operand
ST	N	Variable	Stores current result
S		BOOL variable	Sets to TRUE
R		BOOL variable	Resets to FALSE
AND	N (	BOOL	Boolean AND
&	N (	BOOL	Boolean AND
OR	N (	BOOL	Boolean OR
XOR	N (	BOOL	exclusive OR
ADD	(	Variable, constant	Addition
SUB	(	Variable, constant	Subtraction
MUL	(	Variable, constant	Multiplication
DIV	(	Variable, constant	Division
GT	(	Variable, constant	Test: >
GE	(	Variable, constant	Test: >=
EQ	(	Variable, constant	Test: =
LE	(	Variable, constant	Test <=
LT	(	Variable, constant	Test <
NE	(	Variable, constant	Test <>
CAL	C N	Function block instance name	Calls a function block
JMP	C N	Label	Jumps to label
RET	C N	Label	Returns from function
)			Executes delayed operation



In the next section, only operators which are specific to the IL language are described, other standard operators can be found in the section "standard operators, Function Blocks and Functions".

## LD Operator

**Operation:** loads a value in the current result

**Allowed modifiers:** N

**Operand:** constant expression  
internal, input or output Variable

### Example

```
LDex:  LD      false      (* result := FALSE Boolean constant *)
        LD      true       (* result := TRUE Boolean constant *)
        LD      123        (* result := integer constant *)
        LD      123.1      (* result := real constant *)
        LD      t#3ms      (* result := time constant *)
        LD      boo_var1   (* result := Boolean Variable *)
        LD      ana_var1   (* result := integer Variable *)
        LD      tmr_var1   (* result := timer Variable *)
        LDN     boo_var2   (* result := NOT ( Boolean Variable ) *)
```

## ST Operator

- Operation:** stores the current result in a variable.  
The current result is not modified by this operation.
- Allowed modifiers:** N
- Operand:** internal or output Variable

### Example

```
STboo:      LD      false
            ST      boo_var1  (* boo_var1 := FALSE *)
            STN     boo_var2  (* boo_var2 := TRUE  *)
STana:      LD      123
            ST      ana_var1  (* ana_var1 := 123 *)
STtmr:      LD      t#12s
            ST      tmr_var1  (* tmr_var1 := t#12s *)
```

## S Operator

- Operation:** stores the Boolean value TRUE in a Boolean Variable, if the current result has the Boolean value TRUE. No operation is processed if current result is FALSE. The current result is not modified by this operation
- Allowed modifiers:** (none)
- Operand:** output or internal Boolean Variable

## Example

```
SETex:  LD    true      (* current result := TRUE *)
        S     boo_var1 (* boo_var1 := TRUE *)
                               (* current result is not modified *)
        LD    false     (* current result := FALSE *)
        S     boo_var1 (* nothing done - boo_var1 unchanged *)
```

## R Operator

**Operation:** stores the Boolean value FALSE in a Boolean Variable, if the current result has the Boolean value TRUE. No operation is processed if current result is FALSE. The current result is not modified by this operation

**Allowed modifiers:** (none)

**Operand:** output or internal Boolean Variable

## Example

```
RESETex: LD    true      (* current result := TRUE *)
        R     boo_var1  (* boo_var1 := FALSE *)t
                               (* current result is not modified *)
        ST    boo_var2  (* current result is not modified *)
        LD    false     (* current result := FALSE *)
        R     boo_var1  (* nothing done - boo_var1 unchanged *)
```

## JMP Operator

**Operation:** jumps to the specified label

**Allowed modifiers:** C N

**Operand:** label defined in the same IL program

### Example

(\* the following example tests the value of an integer selector (0 or 1 or 2) \*)

(\* to set one from 3 output Booleans. \*)

(\*Test "is equal to 0" is made with the JMPC operator \*)

```
JMPex:  LD          selector      (* selector is 0 or 1 or 2 *)
        ANY_TO_BOOL          (* conversion to Boolean *)
        JMPC       test1        (* if selector = 0 then *)
        LD          true
        ST          bo0         (* bo0 := true *)
        JMP        JMPend      (* end of the program *)

test1:  LD          selector
        SUB         1          (* decrease selector: is now 0
                               or 1 *)
        ANY_TO_BOOL          (* conversion to Boolean *)
        JMPC       test2        (* if selector = 0 then *)
        LD          true
        ST          bo1         (* bo1 := true *)
        JMP        JMPend      (* end of the program *)

test2:  LD          true        (* last possibility *)
        ST          bo2         (* bo2 := true *)

JMPend:                               (* end of the IL program *)
```

## RET Operator

**Operation:** ends the current IL program. If the IL sequence is a Function, the current result is returned to the calling program

**Allowed modifiers:** C N

**Operand:** (none)

### Example

(\* the following example tests the value of an integer selector (0 or 1 or 2) \*)  
(\* to set one from 3 output Booleans. \*)  
(\*Test "is equal to 0" is made with the JMPC operator \*)

```
JMPex:  LD          selector      (* selector is 0 or 1 or 2 *)
        ANY_TO_BOOL              (* conversion to Boolean *)
        JMPC       test1        (* if selector = 0 then *)
        LD          true
        ST          bo0         (* bo0 := true *)
        RET                               (* end - return 0 *)
                                           (* decrease selector *)

test1:  LD          selector
        SUB         1           (* selector: is now 0 or 1 *)
        ANY_TO_BOOL              (* conversion to Boolean *)
        JMPC       test2        (* if selector = 0 then *)
        LD          true
        ST          bo1         (* bo1 := true *)
        LD          1           (* load real selector value *)
        RET                               (* end - return 1 *)
                                           (* last possibility *)

test2:  RETNC                      (*returns if the selector has *)
```

```

                ST          bo2          (* bo2 := true *)
:              LD          2            (* load real selector value *)
                                                (* end - return 2 *)

```

## ) Operator

**Operation:** executes a delayed operation. the delayed operation was notified by "("

**Allowed modifiers:** (none)

**Operand:** (none)

### Example

(\* The following program interleaves delayed operations: \*)  
 (\* res := a1 + (a2 \* (a3 - a4) \* a5) + a6; \*)

```

Delayed:  LD      a1      (* result := a1; *)
          ADD(   a2      (* delayed ADD - result := a2; *)
          MUL(   a3      (* delayed MUL - result := a3; *)
          SUB    a4      (* result := a3 - a4; *)
          )      (* execute delayed MUL - result := a2 *
                  (a3-a4); *)
          MUL    a5      (* result := a2 * (a3 - a4) * a5; *)
          )      (* execute delayed ADD *)
                  (* result := a1 + (a2 * (a3 - a4) * a5); *)
          ADD    a6      (* result := a1 + (a2 * (a3 - a4) * a5) + a6;
                          *)
          ST     res     (* store current result in variable res *)

```

## Calling Functions

A **Function call from IL** (written in any of the ST, LD, FBD, or "C" language), uses its name as an operator.

**Operation:** executes a Function - the value returned by the function is stored into the IL current result

**Allowed modifiers:** (none)

**Operand:** The first calling parameter must be stored in the current result before the call. The following ones are expressed in the operand field, separated by commas.

### Example

(\* Calling Function : converts an integer value into a time value \*)

```
Main: LD          bi0
      MYFUNC      bi1,bi2  (* call function to get integer value
                          *)
      ST          result  (* result := value returned by
                          function *)
      GT          vmax    (* test value overflow *)
      RETC        (* return if overflow *)
      LD          result
      MUL         1000    (* converts seconds in milliseconds
                          *)
      ANY_TO_TIME (* converts to a timer *)
      ST          tmval   (* stores converted value in a timer
                          *)
```

(\* Called Function named MYFUNC : evaluates the integer value \*)

(\* given as a binary value on three Boolean inputs: in0, in1, in2 are the three Boolean input parameters of the Function \*)

```

LD          in2
ANY_TO_DINT          (* result = ANY_TO_DINT (in2); *)
MUL          2          (* result := 2*ANY_TO_DINT (in2); *)
ST          temporary (* temporary := result *)
LD          in1
ANY_TO_DINT
ADD          temporary (* result := 2*ANY_TO_DINT (in2) +
                       ANY_TO_DINT (in1); *)
MUL          2          (* result := 4*ANY_TO_DINT (in2) +
                       2*ANY_TO_DINT (in1); *)
ST          temporary (* temporary := result *)
LD          in0
ANY_TO_DINT
ADD          temporary (* result := 4*ANY_TO_DINT (in2) +
                       2*ANY_TO_DINT (in1)+ANY_TO_DINT (in0); *)

```



## Calling Function Blocks: CAL Operator

- Operation:** calls a function block
- Allowed modifiers:** C N
- Operand:** Name of the function block instance.

The input parameters of the blocks must be assigned before the call using LD/ST operations sequence.

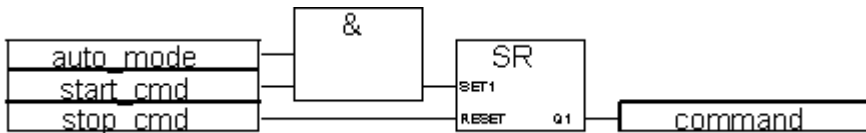
Output parameters are known if used.

### Example

(\* Calling function block SR : SR1 is an instance of SR \*)

```
LD    auto_mode
AND   start_cmd
ST    SR1.set1
LD    stop_cmd
ST    SR1.reset
CAL   SR1
LD    SR1.Q1
ST    command
```

(\* FBD equivalent : \*)



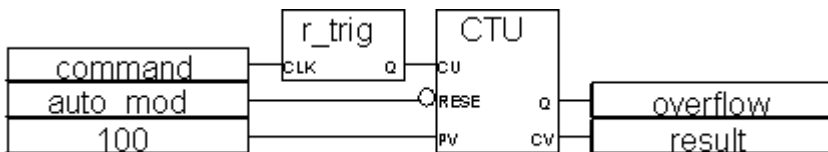
(\*We suppose R\_TRIG1 is an instance of R\_TRIG block and CTU1 is an instance of CTU block\*)

```

LD    command
ST    R_TRIG1.clk
CAL   R_TRIG1
LD    R_TRIG1.Q
ST    CTU1.cu
LDN   auto_mode
ST    CTU1.reset
LD    100
ST    CTU1.pv
CAL   CTU1
LD    CTU1.Q
ST    overflow
LD    CTU1.cv
ST    result

```

(\* FBD equivalent: \*)



# Standard Operators

The following are **Standard Operators** of the IEC languages:

<b>Arithmetic operations</b>	Addition	Adds two or more variables
	Division	Divides two variables
	Multiplication	Multiplies two or more variables
	Subtraction	Subtracts a variable from another
	1 GAIN	Assigns one variable into another
	NEG	Integer negation
<b>Boolean operations</b>	AND	Boolean AND
	OR	Boolean OR
	XOR	Boolean exclusive OR
	NOT	Boolean negation
<b>Comparator</b>	Less Than	Tests if one value is less than another
	Less Than or Equal	Tests if one value is less than or equal to another
	Greater Than	Tests if one value is greater than another
	Greater Than or Equal	Tests if one value is greater than or equal to another
	Equal	Tests if one value is equal to another
	Not Equal	Tests if one value is not equal to another
<b>Data conversion</b>	ANY_TO_BOOL	Converts to Boolean
	ANY_TO_SINT	Converts to Short integer
	ANY_TO_DINT	Converts to Double integer
	ANY_TO_REAL	Converts to Real
	ANY_TO_TIME	Converts to Time
	ANY_TO_STRING	Converts to String



(\* IL equivalence: \*)

```
LD      ai101
MUL     ai102
ST      ao10
LD      ai51
MUL     ai52
MUL     ai53
ST      ao5
```

**+**



**Note:** For this **Operator**, the number of inputs can be extended to more than two.

Arguments:

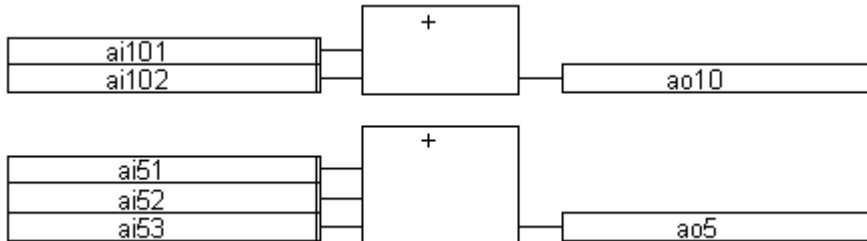
(inputs)	SINT - DINT - REAL - TIME - STRING	can be of any integer, real, TIME, or STRING format (all inputs must have the same format)
output	SINT - DINT - REAL - TIME - STRING	<b>addition</b> of the input terms

Description:

Addition of two or more integer, real, TIME, or STRING variables.

## Example

(\* FBD example with Addition Operators \*)



(\* ST equivalence: \*)

```
ao10 := ai101 + ai102;
```

```
ao5 := (ai51 + ai52) + ai53;
```

(\* IL equivalence: \*)

```
LD    ai101
```

```
ADD   ai102
```

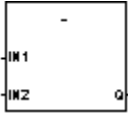
```
ST    ao10
```

```
LD    ai51
```

```
ADD   ai52
```

```
ADD   ai53
```

```
ST    ao5
```



Arguments:

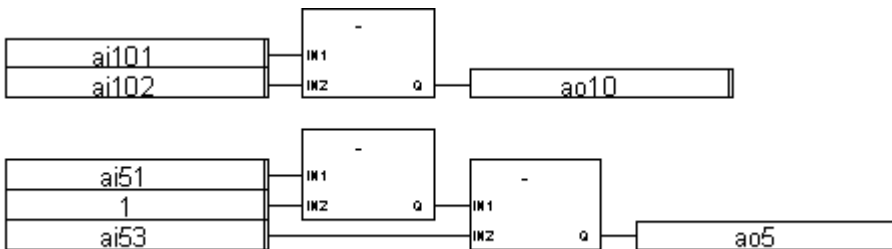
IN1	SINT - DINT - REAL - TIME	can be of any integer, real, or TIME format
IN2	SINT - DINT - REAL - TIME	(IN1 and IN2 must have the same format)
Q	SINT - DINT - REAL - TIME	subtraction (first - second)

Description:

**Subtraction** of two integer, real, or TIME variables (first - second).

### Example

(\* FBD example with Subtraction Operators \*)



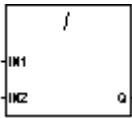
(\* ST equivalence: \*)

```
ao10 := ai101 - ai102;
ao5 := (ai51 - 1) - ai53;
```

(\* IL equivalence: \*)

```
LD    ai101
SUB   ai102
ST    ao10
LD    ai51
SUB   1
SUB   ai53
ST    ao5
```

/



Arguments:

IN1	SINT - DINT - REAL	can be of any integer or real format (operand)
IN2	SINT - DINT - REAL	non-zero integer or real value (divisor) (IN1 and IN2 must have the same format)
Q	SINT - DINT - REAL	integer or real <b>division</b> of IN1 by IN2

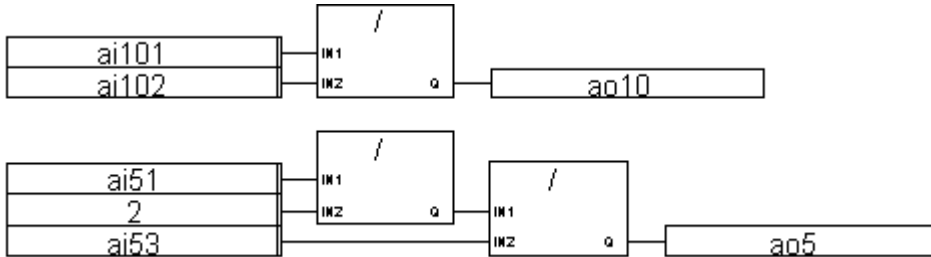
Description:

Division of two integer or real variables (the first divided by the second).



## Example

(\* FBD example with Division Operators \*)



(\* ST Equivalence: \*)

```
ao10 := ai101 / ai102;
```

```
ao5 := (ai5 / 2) / ai53;
```

(\* IL equivalence: \*)

```
LD    ai101
```

```
DIV   ai102
```

```
ST    ao10
```

```
LD    ai51
```

```
DIV   2
```

```
DIV   ai53
```

```
ST    ao5
```

# 1 GAIN



Arguments:

IN SINT - DINT - REAL - TIME - STRING

Q SINT - DINT - REAL - TIME - STRING IN and Q must have the same format

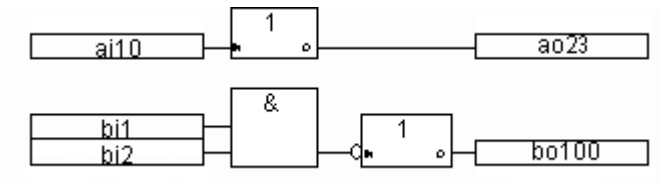
Description:

**assignment** of one variable into another one

This Block is very useful to directly link a diagram input and a diagram output. It can also be used (with a Boolean negation line) to invert the state of a line connected to a diagram output.

## Example

(\* FBD example with assignment Operators \*)



(\* ST equivalence: \*)

```
ao23 := ai10;
```

```
bo100 := NOT (bi1 AND bi2);
```

(\* IL equivalence: \*)

```
LD ai10
```

```
ST ao23
```

```
LD bi1
```

AND     bi2  
STN     bo100

## AND



**Note:** For this Operator, the number of inputs can be extended to more than two.

Arguments:

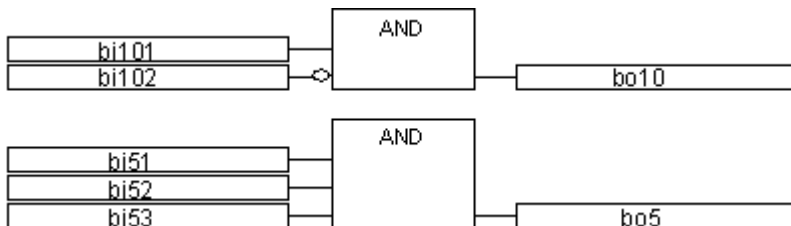
(inputs)    BOOL  
output      BOOL     Boolean AND of the input terms

Description:

Boolean **AND** between two or more terms.

### Example

(\* FBD example with "AND" Operators \*)



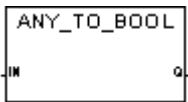
(\* ST equivalence: \*)

```
bo10 := bi101 AND NOT (bi102);  
bo5  := (bi51 AND bi52) AND bi53;
```

(\* IL equivalence \*)

```
LD      bi101    (* current result := bi101 *)
ANDN    bi102    (* current result := bi101 AND not(bi102) *)
ST      bo10     (* bo10 := current result *)
LD      bi51     (* current result := bi51; *)
&       bi52     (* current result := bi51 AND bi52 *)
&       bi53     (* current result := (bi51 AND bi52) AND bi53 *)
ST      bo5      (* bo5 := current result *)
```

## ANY\_TO\_BOOL



Arguments:

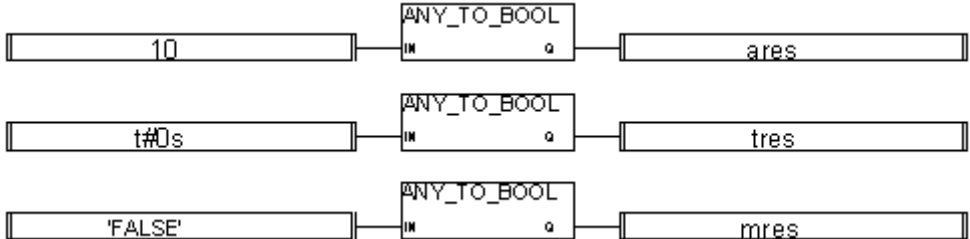
IN	SINT - DINT - REAL - TIME - STRING	any non-Boolean value
Q	BOOL	TRUE for non-zero numerical value FALSE for zero numerical value TRUE for 'TRUE' string FALSE for 'FALSE' string

Description:

Converts **any variable** to a **Boolean variable**

## Example

(\* FBD example with "Convert to Boolean" Operators \*)



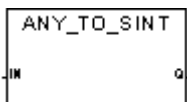
(\* ST Equivalence: \*)

```
ares := ANY_TO_BOOL (10);          (* ares is TRUE *)
tres := ANY_TO_BOOL (t#0s);       (* tres is FALSE *)
mres := ANY_TO_BOOL ('FALSE');    (* mres is FALSE *)
```

(\* IL equivalence: \*)

```
LD          10
ANY_TO_BOOL
ST          ares
LD          t#0s
ANY_TO_BOOL
ST          tres
LD          'FALSE'
ANY_TO_BOOL
ST          mres
```

# ANY\_TO\_SINT



Arguments:

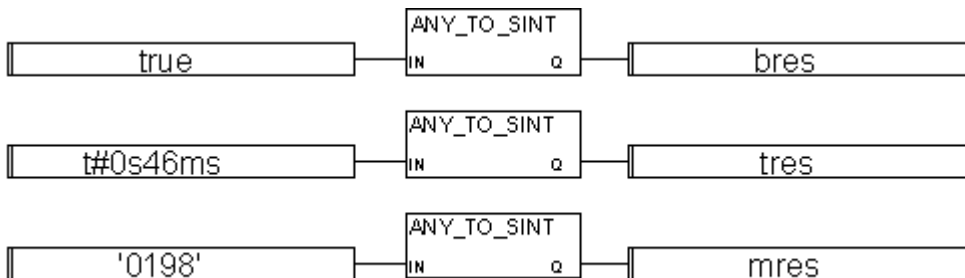
IN	BOOL - DINT - REAL - TIME - STRING	any value other than a short integer
Q	SINT	0 if IN is FALSE / 1 if IN is TRUE number of milliseconds for a timer integer part for real decimal number represented by a string

Description:

Converts **any variable** to a **Short integer variable** (8-bit)

## Example

(\* FBD example with "Convert to Short Integer" Operators \*)



(\* ST Equivalence: \*)

```

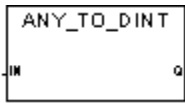
bres := ANY_TO_SINT (true);           (* bres is 1 *)
tres := ANY_TO_SINT (t#0s46ms);      (* tres is 46 *)
mres := ANY_TO_SINT ('0198');        (* mres is 198 *)

```

(\* IL equivalence: \*)

```
LD          true
ANY_TO_SINT
ST          bres
LD          t#1s46ms
ANY_TO_SINT
ST          tres
LD          '0198'
ANY_TO_SINT
ST          mres
```

## ANY\_TO\_DINT



Arguments:

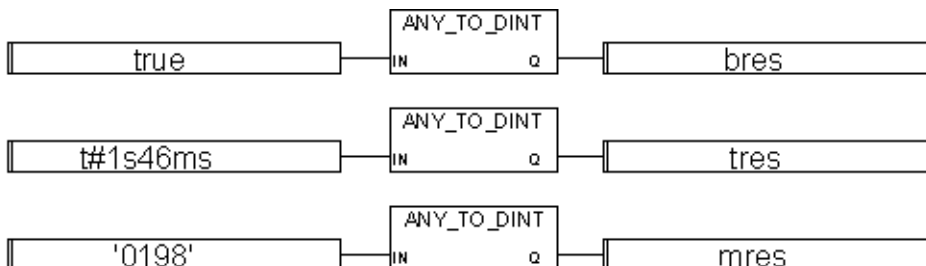
IN	BOOL - SINT - REAL - TIME - STRING	any value other than a double integer
Q	DINT	0 if IN is FALSE / 1 if IN is TRUE number of milliseconds for a timer integer part for real decimal number represented by a string

Description:

Converts **any variable** to a **double integer variable** (32-bit)

## Example

(\* FBD example with "Convert to Double Integer" Operators \*)



(\* ST Equivalence: \*)

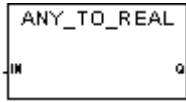
```
bres := ANY_TO_DINT (true);           (* bres is 1 *)
tres := ANY_TO_DINT (t#1s46ms);      (* tres is 1046 *)
mres := ANY_TO_DINT ('0198');        (* mres is 198 *)
```

(\* IL equivalence: \*)

```
LD          true
ANY_TO_DINT
ST          bres
LD          t#1s46ms
ANY_TO_DINT
ST          tres
LD          '0198'
ANY_TO_DINT
ST          mres
```



# ANY\_TO\_REAL



Arguments:

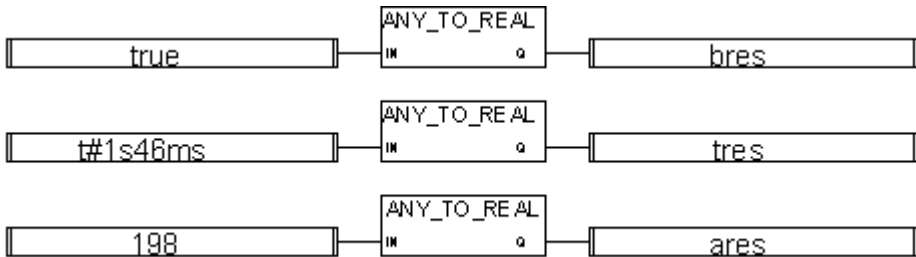
IN	BOOL - SINT - DINT - TIME - STRING	any value other than a real
Q	REAL	0.0 if IN is FALSE / 1.0 if IN is TRUE number of milliseconds for a timer equivalent number for integer

Description:

Converts **any variable** to a **real variable**

## Example

(\* FBD example with "Convert to Real" Operators \*)



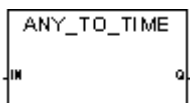
(\* ST Equivalence: \*)

```
bres := ANY_TO_REAL (true);           (* bres is 1.0 *)  
tres := ANY_TO_REAL (t#1s46ms);      (* tres is 1046.0 *)  
ares := ANY_TO_REAL (198);           (* ares is 198.0 *)
```

(\* IL equivalence: \*)

```
LD          true
ANY_TO_REAL
ST          bres
LD          t#1s46ms
ANY_TO_REAL
ST          tres
LD          198
ANY_TO_REAL
ST          ares
```

## ANY\_TO\_TIME



Arguments:

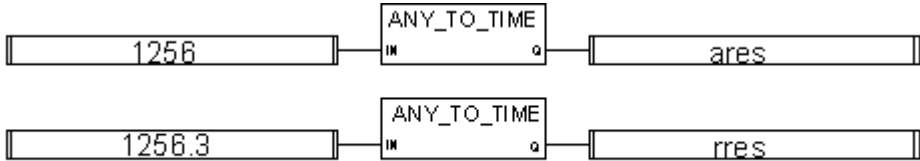
IN	BOOL - SINT - DINT - REAL - STRING	any positive value other than a time and date format IN (or integer part of IN if it is real) is the number of milliseconds STRING (number of milliseconds, for example, a value of 300032 represents 5 minutes and 32 milliseconds)
Q	TIME	time value represented by IN. A value of 1193h2m47s295ms indicates an invalid time.

Description:

Converts **any variable other than a time or date type** to a **timer variable**. The SUB\_DATE\_DATE function enables the conversion of a date type to a time format. For details on the SUB\_DATE\_DATE function, see page 567.

## Example

(\* FBD example with "Convert to Timer" Operators \*)



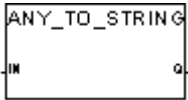
(\* ST Equivalence: \*)

```
ares := ANY_TO_TIME (1256);           (* ares := t#1s256ms *)  
rres := ANY_TO_TIME (1256.3);       (* rres := t#1s256ms *)
```

(\* IL equivalence: \*)

```
LD          1256  
ANY_TO_TIME  
ST          ares  
LD          1256.3  
ANY_TO_TIME  
ST          rres
```

# ANY\_TO\_STRING



Arguments:

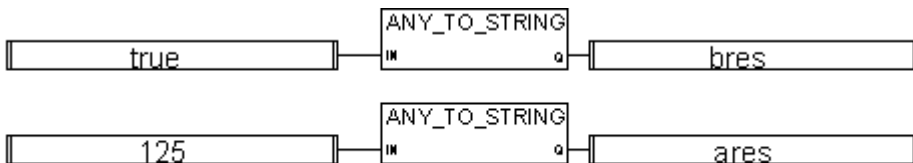
- IN    BOOL - SINT - DINT - REAL - any non-string value  
      TIME
- Q     STRING  
      If IN is a Boolean, 'FALSE' or 'TRUE'  
      If IN is an integer or a real, decimal representation  
      If IN is a TIME:  
      TIME time1  
      STRING s1  
      time1 :=13 ms;  
      s1 :=ANY\_TO\_STRING(time1);  
      (\* s1 = '0s13' \*)

Description:

Converts **any variable** to a **string variable**

## Example

(\* FBD example with "Convert to string" Operators \*)



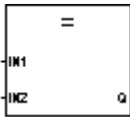
(\* ST Equivalence: \*)

```
bres := ANY_TO_STRING (TRUE);    (* bres is 'TRUE' *)  
ares := ANY_TO_STRING (125);    (* ares is '125' *)
```

(\* IL equivalence: \*)

```
LD          true
ANY_TO_STRING
ST          bres
LD          125
ANY_TO_STRING
ST          ares
```

## Equal



Arguments:

IN1	BOOL - SINT - DINT - REAL - TIME - STRING	Both inputs must have the same format. The TIME input only applies to the ST and IL languages. The BOOL input is not accepted in the IL language.
IN2	BOOL - SINT - DINT - REAL - TIME - STRING	
Q	BOOL	TRUE if IN1 = IN2

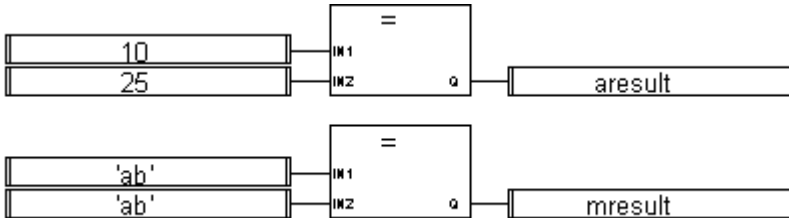
Description

Test if one value is **EQUAL TO** another one (on integer, real, time, date, and string variables)

**Note:** The equality test on a TIME variable is not recommended for testing output of TIME blocks such as TON, TP, TOF, BLINK and for testing StepName.t in SFC chart.

## Example

(\* FBD example with "Is Equal to" Operators \*)



(\* ST Equivalence: \*)

```
areult := (10 = 25); (* areult is FALSE *)
```

```
mresult := ('ab' = 'ab'); (* mresult is TRUE *)
```

(\* IL equivalence: \*)

```
LD 10
```

```
EQ 25
```

```
ST areult
```

```
LD 'ab'
```

```
EQ 'ab'
```

```
ST mresult
```

# Greater Than or Equal



Arguments:

IN1	SINT - DINT - REAL - TIME - STRING	Both inputs must have the same type.
IN2	SINT - DINT - REAL - TIME - STRING	The TIME input only applies to the ST and IL languages.
Q	BOOL	TRUE if IN1 >= IN2

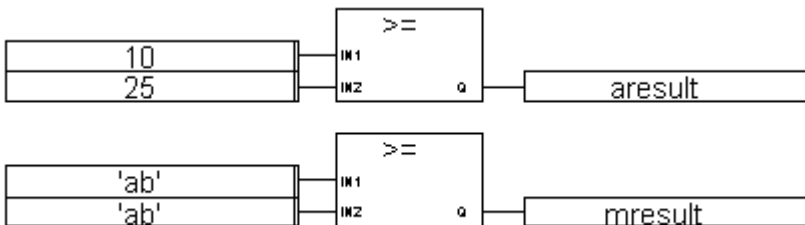
Description:

Test if one value is **GREATER THAN or EQUAL TO** another one (on integers, reals, times, dates, or strings)

**Note:** The equality test on a TIME variable is not recommended for testing output of TIME blocks such as TON, TP, TOF, BLINK and for testing StepName.t in SFC chart.

## Example

(\* FBD example with "Greater or Equal to" Operators \*)



(\* ST Equivalence: \*)

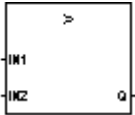
```
aresult := (10 >= 25); (* aresult is FALSE *)
```

```
mresult := ('ab' >= 'ab'); (* mresult is TRUE *)
```

(\* IL equivalence: \*)

```
LD  10
GE  25
ST  arestult
LD  'ab'
GE  'ab'
ST  mresult
```

## Greater Than



Arguments:

IN1	SINT - DINT - REAL - TIME - STRING	Both inputs must have the same type
IN2	SINT - DINT - REAL - TIME - STRING	
Q	BOOL	TRUE if IN1 > IN2

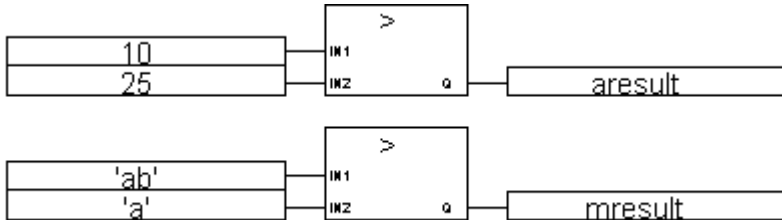
Description:

Test if one value is **GREATER THAN** another one (on integers, reals, times, dates, or strings)



## Example

(\* FBD example with "Greater than" Operators \*)



(\* ST Equivalence: \*)

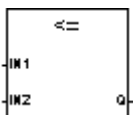
```
areult := (10 > 25); (* areult is FALSE *)
```

```
mresult := ('ab' > 'a'); (* mresult is TRUE *)
```

(\* IL equivalence: \*)

```
LD  10
GT  25
ST  areult
LD  'ab'
GT  'a'
ST  mresult
```

## Less Than or Equal



Arguments:

IN1	SINT - DINT - REAL - TIME - STRING	Both inputs must have the same type.
IN2	SINT - DINT - REAL - TIME - STRING	The TIME input only applies to the ST and IL languages.
Q	BOOL	TRUE if IN1 <= IN2

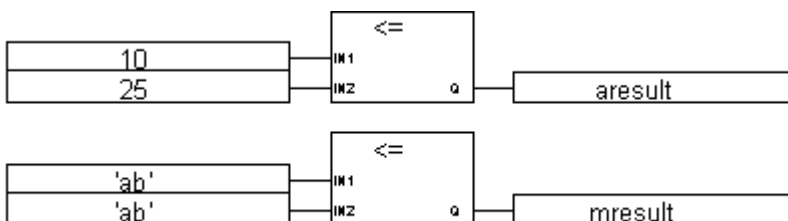
Description:

Tests if one value is **LESS THAN or EQUAL TO** another one (on integers, reals, times, dates, or strings)

**Note:** The equality test on a TIME variable is not recommended for testing output of TIME blocks such as TON, TP, TOF, BLINK and for testing StepName.t in SFC chart.

### Example

(\* FBD example with "Less or equal to" Operators \*)



(\* ST Equivalence: \*)

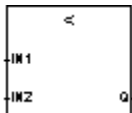
```
areult := (10 <= 25); (* areult is TRUE *)
```

```
mresult := ('ab' <= 'ab'); (* mresult is TRUE *)
```

(\* IL equivalence: \*)

```
LD  10
LE  25
ST  arestult
LD  'ab'
LE  'ab'
ST  mresult
```

## Less Than



Arguments:

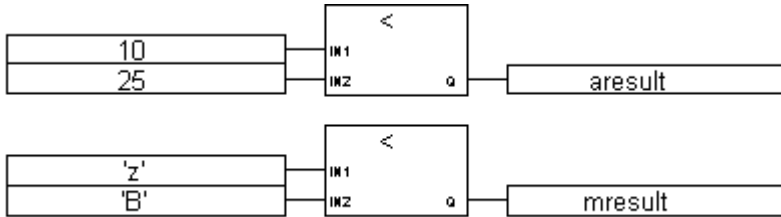
IN1	SINT - DINT - REAL - TIME - STRING	Both inputs must have the same type
IN2	SINT - DINT - REAL - TIME - STRING	
Q	BOOL	TRUE if IN1 < IN2

Description:

Test if one value is **LESS THAN** another one (on integers, reals, times, dates, or strings)

## Example

(\* FBD example with "Less than" Operators \*)



(\* ST Equivalence: \*)

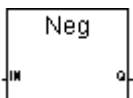
```
areult := (10 < 25); (* areult is TRUE *)
```

```
mresult := ('z' < 'B'); (* mresult is FALSE *)
```

(\* IL equivalence: \*)

```
LD    10
LT    25
ST    areult
LD    'z'
LT    'B'
ST    mresult
```

## NEG



Arguments:

IN SINT - DINT - REAL

Input and output must have the same format

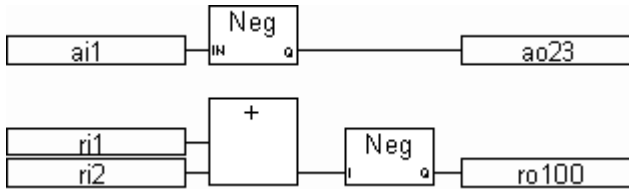
Q SINT - DINT - REAL

Description:

Assignment of the **negation** of a variable.

### Example

(\* FBD example with Negation Operators \*)



(\* ST equivalence: \*)

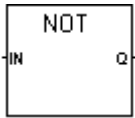
```
ao23 := - (ai10);
```

```
ro100 := - (ri1 + ri2);
```

(\* IL equivalence: \*)

```
LD    ai10
MUL   -1
ST    ao23
LD    ri1
ADD   ri2
MUL   -1.0
ST    ro100
```

# NOT



Arguments:

IN: Any Boolean variable or complex expression

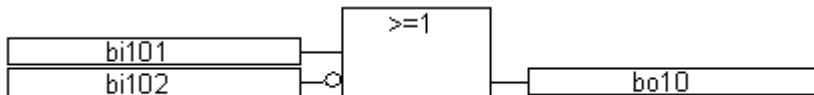
Q: TRUE when IN is FALSE  
FALSE when IN is TRUE

Description:

Returns the negation of a complete Boolean expression.

## Example

(\* FBD example with "NOT" Operator \*)



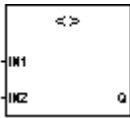
(\* ST equivalence: \*)

```
bo10 := bi101 XOR NOT (bi102);
```

(\* IL equivalence: \*)

```
LD    bi101
XORN  bi102
ST    bo10
```

## Not Equal



Arguments:

IN1    BOOL - DINT - REAL - TIME - STRING    both inputs must have the same type

IN2    BOOL - DINT - REAL - TIME - STRING

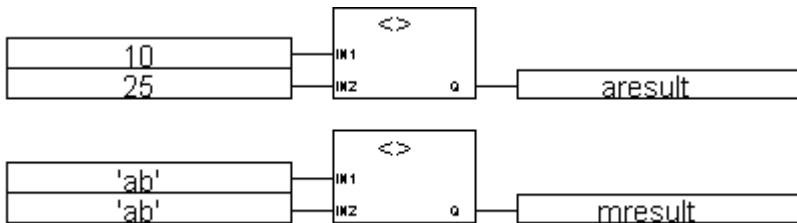
Q      BOOL                                    TRUE if first  $\neq$  second

Description:

Test if one value is **NOT EQUAL TO** another one (on integer, real, time, date, and string variables)

### Example

(\* FBD example with "Is Not Equal to" Operators \*)



(\* ST Equivalence: \*)

```
areult := (10 <> 25); (* areult is TRUE *)
```

```
mresult := ('ab' <> 'ab'); (* mresult is FALSE *)
```

(\* IL equivalence: \*)

```
LD    10
```

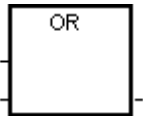
```
NE    25
```

```

ST   aresult
LD   'ab'
NE   'ab'
ST   mresult

```

## OR



**Note:** For this Operator, the number of inputs can be extended to more than two.

Arguments:

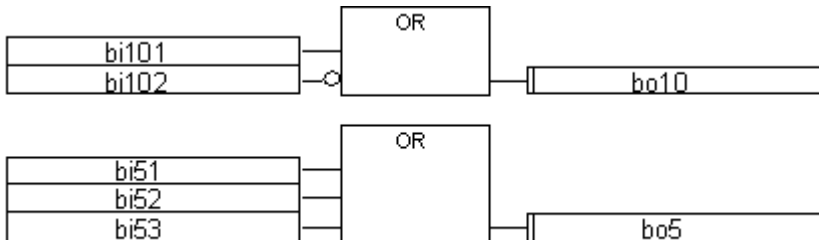
(inputs)      BOOL  
output        BOOL            Boolean **OR** of the input terms

Description:

Boolean OR of two or more terms.

### Example

(\* FBD example with "OR" Operators \*)





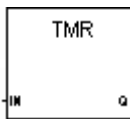
(\* ST equivalence: \*)

```
bo10 := bi101 OR NOT (bi102);  
bo5  := (bi51 OR bi52) OR bi53;
```

(\* IL equivalence: \*)

```
LD    bi101  
ORN   bi102  
ST    bo10  
LD    bi51  
OR    bi52  
OR    bi53  
ST    bo5
```

## TMR



Arguments:

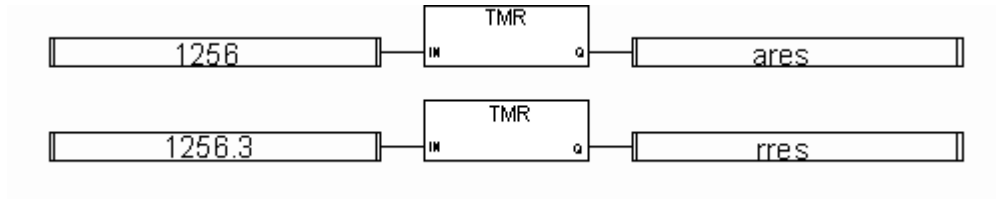
IN	DINT	A non-TIME value IN (or integer part of IN if it is real) is the number of milliseconds
Q	TIME	Time value represented by IN

Description:

Converts an integer or real variable to a time one.

## Example

(\* FBD example with "Convert to Timer" Operators \*)



(\* ST Equivalence: \*)

```
ares := TMR (1256);           (* ares := t#1s256ms *)
rres := TMR (1256.3);        (*rres := t#1s256ms *)
```

(\* IL equivalence: \*)

```
LD          1256
TMR
ST          ares
LD          1256.3
TMR
ST          rres
```

## XOR



Arguments:

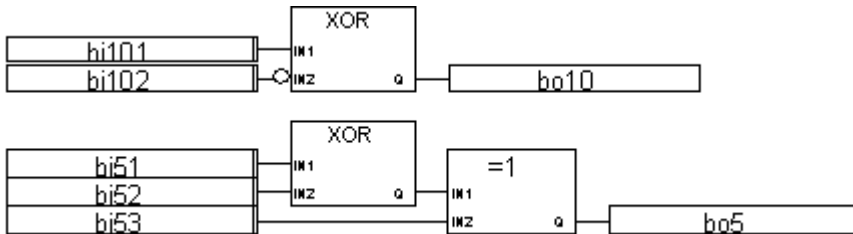
```
IN1  BOOL
IN2  BOOL
Q    BOOL    Boolean exclusive OR of the two input terms
```

Description:

Boolean exclusive OR between two terms.

### Example

(\* FBD example with "XOR" operators \*)



(\* ST equivalence: \*)

```
bo10 := bi101 XOR NOT (bi102);
```

```
bo5 := (bi51 XOR bi52) XOR bi53;
```

(\* IL equivalence: \*)

```
LD    bi101
XORN  bi102
ST    bo10
LD    bi51
XOR   bi52
XOR   bi53
ST    bo5
```



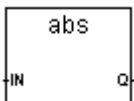
# Standard Functions

The following are the standard functions supported by the system:

<b>Arithmetic Operations</b>	ABS	Absolute value of a real value
	EXPT, POW	Exponent, power calculation of real values
	LOG	Logarithm of a real value
	MOD	Modulo
	SQRT	Square root of a real value
	RAND	Random value
	TRUNC	Truncate decimal part of a real value
	ACOS, ASIN, ATAN	Arc cosine, Arc sine, Arc tangent of a real value
	COS, SIN, TAN	Cosine, Sine, Tangent of a real value
<b>Binary operations</b>	AND_MASK	Integer bit-to-bit AND mask
	OR_MASK	Integer bit-to-bit OR mask
	XOR_MASK	Integer bit-to-bit Exclusive OR mask
	NOT_MASK	Integer bit-to-bit negation
	ROL, ROR	Rotate Left, Rotate Right an integer value
	SHL, SHR	Shift Left, Shift Right an integer value
<b>Boolean operations</b>	ODD	Odd parity
<b>Data manipulation</b>	MIN, MAX, LIMIT	Minimum, Maximum, Limit
	MUX4, MUX8	Multiplexer (4 or 8 entries)
	SEL	Binary selector
<b>String manipulation</b>	ASCII	Character -> ASCII code
	CHAR	ASCII code -> Character
	MLEN	Get string length
	DELETE, INSERT	Delete sub-string, Insert string
	FIND, REPLACE	Find sub-string, Replace sub-string
LEFT, MID, RIGHT	Extract left, middle or right of a string	

<b>Time operations</b>	CURRENT_ISA_DATE	Gets the current date
	SUB_DATE_DATE	Compares two dates and gives the difference in TIME format

## ABS



Arguments:

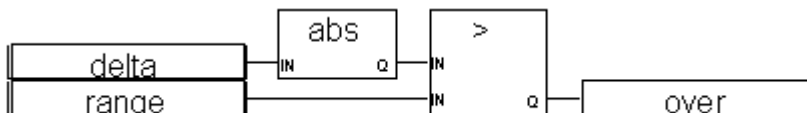
IN REAL Any signed real value  
 Q REAL Absolute value (always positive)

Description:

Gives the absolute (positive) value of a real value.

### Example

(\* FBD Program using "ABS" Function \*)



(\* ST Equivalence: \*)

```
over := (ABS (delta) > range);
```

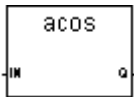
(\* IL Equivalence: \*)

```
LD delta
ABS
```

GT range

ST over

## ACOS



Arguments:

IN REAL Must be in set [-1.0 .. +1.0]

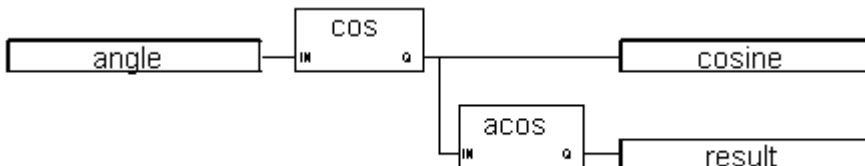
Q REAL Arc-cosine of the input value (in set [0.0 .. PI])  
= 0.0 for invalid input

Description:

Calculates the Arc cosine of a real value.

### Example

(\* FBD Program using "COS" and "ACOS" Functions \*)



(\* ST Equivalence: \*)

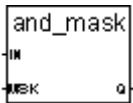
```
cosine := COS (angle);
```

```
result := ACOS (cosine); (* result is equal to angle *)
```

(\* IL Equivalence: \*)

LD     angle  
COS  
ST     cosine  
ACOS  
ST     result

## AND\_MASK



Arguments:

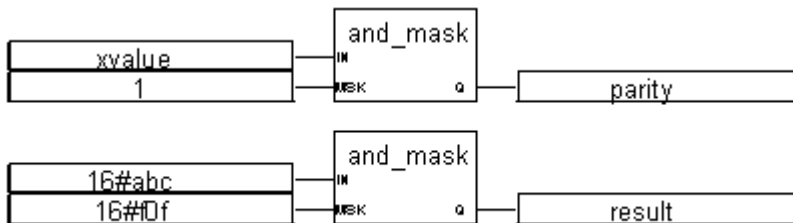
IN     DINT     Must have integer format  
MSK   DINT     Must have integer format  
Q     DINT     Bit-to-bit logical **AND** between IN and MSK

Description:

Integer AND bit-to-bit mask.

### Example

(\* FBD example with AND\_MASK Operators \*)





(\* ST Equivalence: \*)

```
parity := AND_MASK (xvalue, 1); (* 1 if xvalue is odd *)
```

```
result := AND_MASK (16#abc, 16#f0f); (* equals 16#a0c *)
```

(\* IL equivalence: \*)

```
LD      xvalue
```

```
AND_MASK 1
```

```
ST      parity
```

```
LD      16#abc
```

```
AND_MASK 16#f0f
```

```
ST      result
```

## ASCII



Arguments:

IN     STRING   Any non-empty string

Pos    DINT     Position of the selected character in set [1.. len] (len is the length of the IN string)

Code   DINT     Code of the selected character (in set [0 .. 255])  
                  returns 0 is Pos is out of the string

Description:

Gives the ASCII code of one character in a string.

### Example

(\* FBD Program using "ASCII" Function \*)



(\* ST Equivalence: \*)

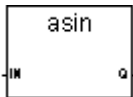
```
FirstChr := ASCII (message, 1);
```

(\* FirstChr is the ASCII code of the first character of the string \*)

(\* IL Equivalence: \*)

```
LD    message
ASCII 1
ST    FirstChr
```

## ASIN



Arguments:

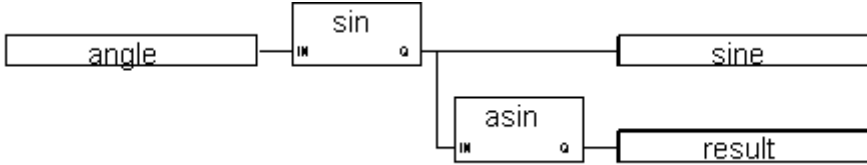
IN	REAL	Must be in set [-1.0 .. +1.0]
Q	REAL	Arc-sine of the input value (in set [-PI/2 .. +PI/2]) = 0.0 for invalid input

Description:

Calculates the Arc sine of a real value.

### Example

(\* FBD Program using "SIN" and "ASIN" Functions \*)



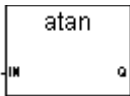
(\* ST Equivalence: \*)

```
sine := SIN (angle);
result := ASIN (sine); (* result is equal to angle *)
```

(\* IL Equivalence: \*)

```
LD    angle
SIN
ST    sine
ASIN
ST    result
```

## ATAN



Arguments:

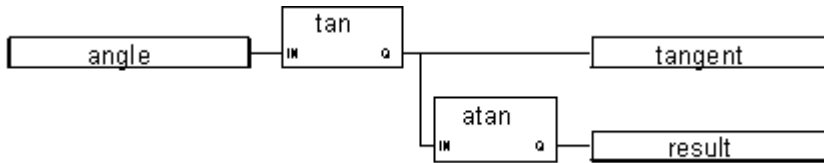
- IN REAL Any real value
- Q REAL Arc-tangent of the input value (in set  $[-\pi/2 .. +\pi/2]$ )  
= 0.0 for invalid input

Description:

Calculates the arc tangent of a real value.

## Example

(\* FBD Program using "TAN" and "ATAN" Function \*)



(\* ST Equivalence: \*)

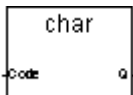
```
tangent := TAN (angle);
```

```
result := ATAN (tangent); (* result is equal to angle*)
```

(\* IL Equivalence: \*)

```
LD    angle
TAN
ST    tangent
ATAN
ST    result
```

## CHAR



Arguments:

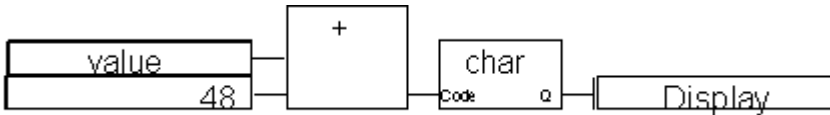
Code	DINT	Code in set [0 .. 255]
Q	STRING	One character string the character has the ASCII code given in input Code (ASCII code is used modulo 256)

Description:

Gives a one character string from a given ASCII code.

### Example

(\* FBD Program using "CHAR" Function \*)



(\* ST Equivalence: \*)

```
Display := CHAR ( value + 48 );
```

```
(* value is in set [0..9] *)
```

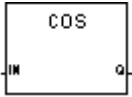
```
(* 48 is the ascii code of '0' *)
```

```
(* result is one character string from '0' to '9' *)
```

(\* IL Equivalence: \*)

```
LD    value
ADD   48
CHAR
ST    Display
```

# COS



Arguments:

IN REAL Any REAL value

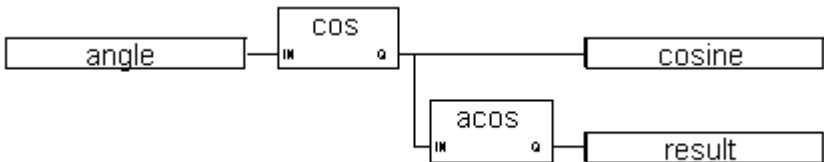
Q REAL Cosine of the input value (in set [-1.0 .. +1.0])

Description:

Calculates the cosine of a real value.

## Example

(\* FBD Program using "COS" and "ACOS" Functions \*)



(\* ST Equivalence: \*)

```
cosine := COS (angle);
```

```
result := ACOS (cosine); (* result is equal to angle *)
```

(\* IL Equivalence: \*)

```
LD angle
```

```
COS
```

```
ST cosine
```

```
ACOS
```

```
ST result
```

# CURRENT\_ISA\_DATE



Arguments:

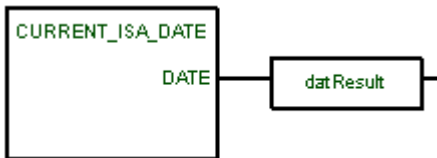
DATE DATE      The current date

Description:

Gets the current date. The ANY\_TO\_DINT function enables the conversion of DATE to the number of seconds since 1970/01/01 00:00:00:000 GMT (Greenwich Mean Time).

## Example

(\* FBD Program using "CURRENT\_ISA\_DATE" Function \*)



(\* ST Equivalence: \*)

```
datResult := CURRENT_ISA_DATE();
```

(\* IL Equivalence: \*)

CURRENT\_ISA\_DATE

ST                      datResult

# DELETE



Arguments:

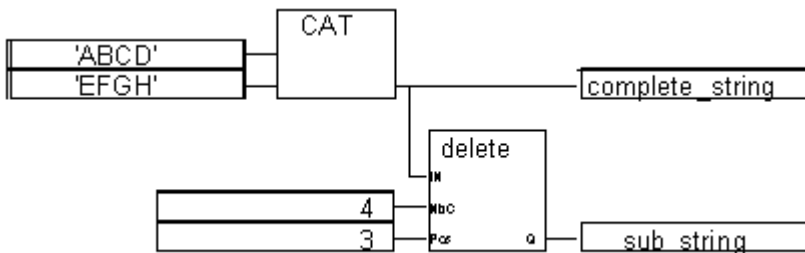
IN	STRING	Any non-empty string
NbC	DINT	Number of characters to be deleted
Pos	DINT	Position of the first deleted character (first character of the string has position 1)
Q	STRING	modified string empty string if Pos < 1 initial string if Pos > IN string length initial string if NbC <= 0

Description:

Deletes a part of a string.

## Example

(\* FBD Program using "DELETE" Function \*)





(\* ST Equivalence: \*)

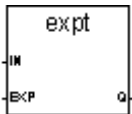
```
complete_string := 'ABCD' + 'EFGH'; (* complete_string is 'ABCDEFGH' *)
```

```
sub_string := DELETE (complete_string, 4, 3); (* sub_string is 'ABGH' *)
```

(\* IL Equivalence: \*)

```
LD      'ABCD'  
ADD     'EFGH'  
ST      complete_string  
DELETE  4, 3  
ST      sub_string
```

## EXPT



Arguments:

IN REAL Any signed real value

EXP DINT Integer exponent

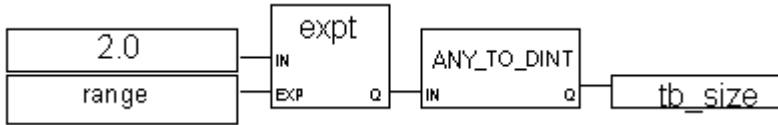
Q REAL (IN<sup>EXP</sup>)

Description:

Gives the real result of the operation: (base<sup>exponent</sup>) 'base' being the first argument and 'exponent' the second one.

## Example

(\* FBD Program using "EXPT" Function \*)



(\* ST Equivalence: \*)

```
tb_size := ANY_TO_DINT (EXPT (2.0, range) );
```

(\* IL Equivalence: \*)

```
LD          2.0
EXPT        range
ANY_TO_DINT
ST          tb_size
```

## FIND



Arguments:

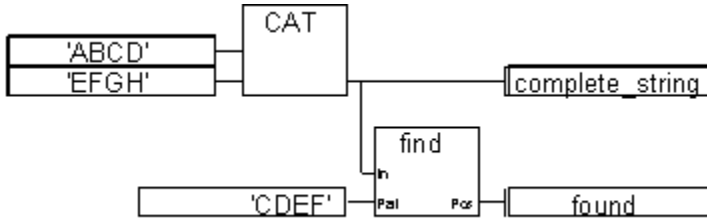
In	STRING	Any string
Pat	STRING	Any non-empty string (Pattern)
Pos	DINT	= 0 if sub string Pat not found = position of the first character of the first occurrence of the sub-string Pat (first position is 1) this function is <b>case sensitive</b>

Description:

Finds a sub-string in a string. Gives the position in the string of the sub-string.

### Example

(\* FBD Program using "FIND" Function \*)



(\* ST Equivalence: \*)

```
complete_string := 'ABCD' + 'EFGH'; (* complete_string is 'ABCDEFGH' *)
```

```
found := FIND (complete_string, 'CDEF'); (* found is 3 *)
```

(\* IL Equivalence: \*)

```
LD    'ABCD'  
ADD   'EFGH'  
ST    complete_string  
FIND  'CDEF'  
ST    found
```

# INSERT



Arguments:

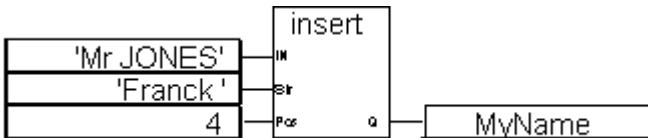
IN	STRING	Initial string
Str	STRING	String to be inserted
Pos	DINT	Position of the insertion the insertion is done before the position (first valid position is 1)
Q	STRING	Modified string empty string if Pos <= 0 concatenation of both strings if Pos is greater than the length of the IN string

Description:

Inserts a sub-string in a string at a given position.

## Example

(\* FBD Program using "INSERT" Function \*)



(\* ST Equivalence: \*)

```
MyName := INSERT ('Mr JONES', 'Frank ', 4);
```

(\* MyName is 'Mr Frank JONES' \*)

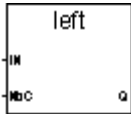
(\* IL Equivalence: \*)

```
LD      'Mr JONES'
```

```
INSERT  'Frank ',4
```

```
ST      MyName
```

## LEFT



Arguments:

IN     STRING     Any non-empty string

NbC    DINT       Number of characters to be extracted. This number cannot be greater than the length of the IN string.

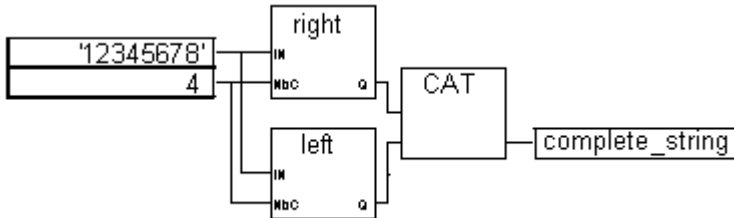
Q       STRING     Left part of the IN string (its length = NbC)  
          empty string if NbC <= 0  
          complete IN string if NbC >= IN string length

Description:

Extracts the left part of a string. The number of characters to be extracted is given.

## Example

(\* FBD Program using "LEFT" and "RIGHT" Functions \*)



(\* ST Equivalence: \*)

```
complete_string := RIGHT ('12345678', 4) + LEFT ('12345678', 4);
```

(\* complete\_string is '56781234'

the value issued from RIGHT call is '5678'

the value issued from LEFT call is '1234'

\*)

(\* IL Equivalence: First done is call to LEFT \*)

```
LD      '12345678'  
LEFT    4  
ST      sub_string (* intermediate result *)  
LD      '12345678'  
RIGHT   4  
ADD     sub_string  
ST      complete_string
```

# LIMIT



Arguments:

MIN	DINT	Minimum allowed value
IN	DINT	Any signed integer value
MAX	DINT	Maximum allowed value
Q	DINT	Input value bounded to allowed range

Description:

Limits an integer value into a given interval. Whether it keeps its value if it is between minimum and maximum, or it is changed to maximum if it is above, or it is changed to minimum if it is below.

## Example

(\* FBD Program using "LIMIT" Function \*)



(\* ST Equivalence: \*)

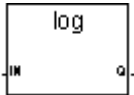
```
new_value := LIMIT (min_value, value, max_value);
```

(\* bounds the value to the [min\_value..max\_value] set \*)

(\* IL Equivalence: \*)

```
LD      min_value
LIMIT  value, max_value
ST      new_value
```

## LOG



Arguments:

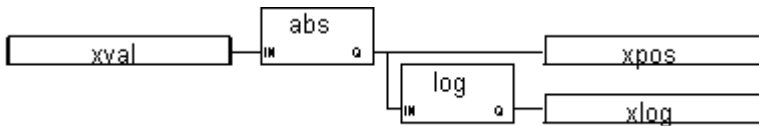
IN REAL Must be greater than zero  
Q REAL Logarithm (base 10) of the input value

Description:

Calculates the logarithm (base 10) of a real value.

### Example

(\* FBD Program using "LOG" Function \*)



(\* ST Equivalence: \*)

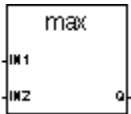
```
xpos := ABS (xval);
xlog := LOG (xpos);
```



(\* IL Equivalence: \*)

LD     xval  
ABS  
ST     xpos  
LOG  
ST     xlog

## MAX



Arguments:

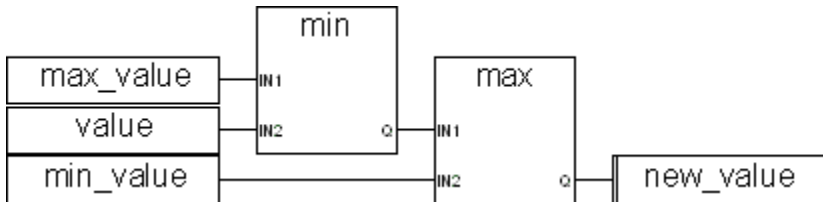
IN1   DINT   Any signed integer value  
IN2   DINT   (cannot be REAL)  
Q     DINT   Maximum of both input values

Description:

Gives the maximum of two integer values.

## Example

(\* FBD Program using "MIN" and "MAX" Function \*)  
)



(\* ST Equivalence: \*)

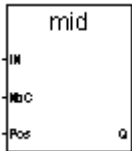
```
new_value := MAX (MIN (max_value, value), min_value);
```

(\* bounds the value to the [min\_value..max\_value] set \*)

(\* IL Equivalence: \*)

```
LD      max_value
MIN     value
MAX     min_value
ST      new_value
```

## MID



Arguments:

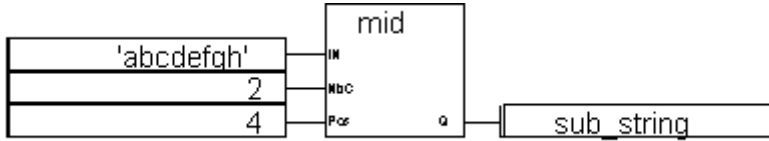
IN	STRING	Any non-empty string
NbC	DINT	Number of characters to be extracted cannot be greater than the length of the IN string
Pos	DINT	Position of the sub-string the sub-string first character will be the one pointed to by Pos (first valid position is 1)
Q	STRING	Middle part of the string (its length = NbC) empty string if parameters are not valid

Description:

Extracts a part of a string. The number of characters to be extracted and the position of the first character are given.

## Example

(\* FBD Program using "MID" Function \*)



(\* ST Equivalence: \*)

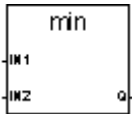
```
sub_string := MID ('abcdefgh', 2, 4);
```

(\* sub\_string is 'de' \*)

(\* IL Equivalence: \*)

```
LD    'abcdefgh'
MID   2, 4
ST    sub_string
```

## MIN



Arguments:

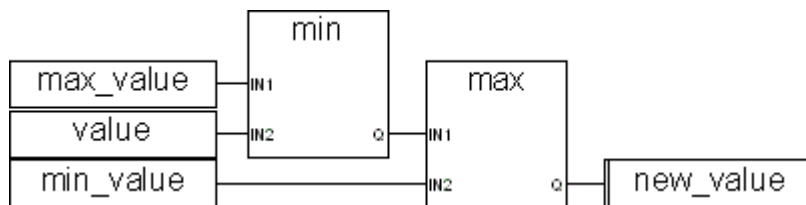
IN1 DINT Any signed integer value  
IN2 DINT (cannot be REAL)  
Q DINT Minimum of both input values

Description:

Gives the minimum of two integer values.

## Example

(\* FBD Program using "MIN" and "MAX" Function \*)



(\* ST Equivalence: \*)

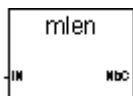
```
new_value := MAX (MIN (max_value, value), min_value);
```

(\* bounds the value to the [min\_value..max\_value] set \*)

(\* IL Equivalence: \*)

```
LD    max_value
MIN   value
MAX   min_value
ST    new_value
```

## MLEN



Arguments:

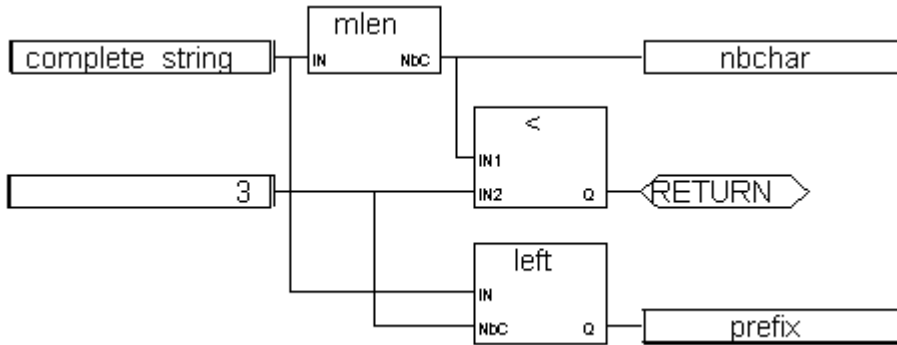
IN	STRING	Any string
NbC	DINT	Number of characters in the IN string

Description:

Calculates the length of a string.

## Example

(\* FBD Program using "MLEN" Function \*)



(\* ST Equivalence: \*)

```
nbchar := MLEN (complete_string);
If (nbchar < 3) Then Return; End_if;
prefix := LEFT (complete_string, 3);
```

(\* this program extracts the 3 characters on the left of the string and put the result in the prefix string variable

nothing is done if the string length is less than 3 characters \*)

(\* IL Equivalence: \*)

```
LD    complete_string
MLEN
ST    nbchar
LT    3
RETC
LD    complete_string
LEFT  3
ST    prefix
```

# MOD



Arguments:

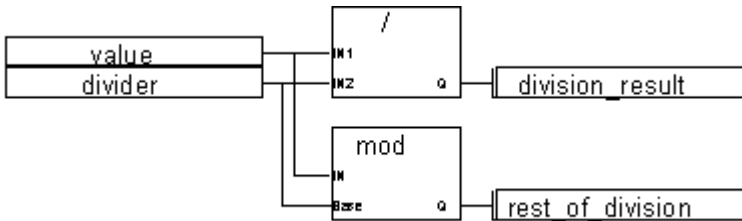
IN	DINT	Any signed INTEGER value
Base	DINT	Must be greater than zero
Q	DINT	Modulo calculation (input MOD base) returns -1 if Base <= 0

Description:

Calculates the modulo of an integer value.

## Example

(\* FBD Program using "MOD" Function \*)



(\* ST Equivalence: \*)

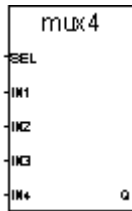
```
division_result := (value / divider); (* integer division *)
```

```
rest_of_division := MOD (value, divider); (* rest of the division *)
```

(\* IL Equivalence: \*)

```
LD    value
DIV   divider
ST    division_result
LD    value
MOD   divider
ST    rest_of_division
```

## MUX4



Arguments:

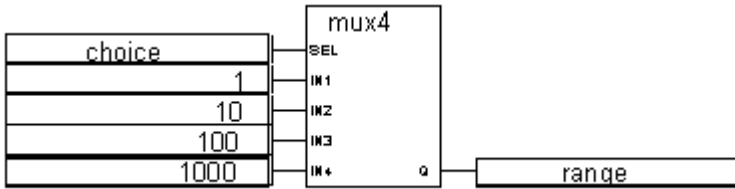
SEL	DINT	Selector integer value (must be in set [0..3])
IN1..IN4	DINT	Any integer values
Q	DINT	= value1 if SEL = 0 = value2 if SEL = 1 = value3 if SEL = 2 = value4 if SEL = 3 = 0 for all other values of the selector

Description:

Multiplexer with four entries: selects a value between four integer values.

## Example

(\* FBD Program using "MUX4" Function \*)



(\* ST Equivalence: \*)

```
range := MUX4 (choice, 1, 10, 100, 1000);
```

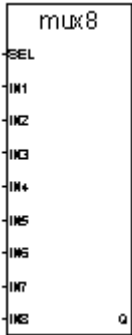
(\* select from 4 predefined ranges, for example, if choice is 1, range will be 10 \*)

(\* IL Equivalence: \*)

```
LD    choice
MUX4  1,10,100,1000
ST    range
```



# MUX8



Arguments:

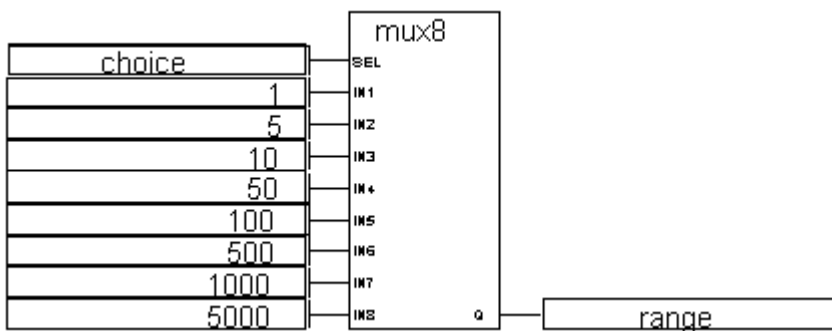
SEL	DINT	Selector integer value (must be in set [0..7])
IN1..IN8	DINT	Any integer values
Q	DINT	= value1 if selector = 0 = value2 if selector = 1 ... = value8 if selector = 7 = 0 for all other values of the selector

Description:

Multiplexer with eight entries: selects a value between eight integer values.

## Example

(\* FBD Program using "MUX8" Function \*)



(\* ST Equivalence: \*)

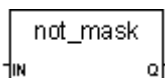
```
range := MUX8 (choice, 1, 5, 10, 50, 100, 500, 1000, 5000);
```

(\* select from 8 predefined ranges, for example, if choice is 3, range will be 50 \*)

(\* IL Equivalence: \*)

```
LD      choice
MUX8    1,5,10,50,100,500,1000,5000
ST      range
```

## NOT\_MASK



Arguments:

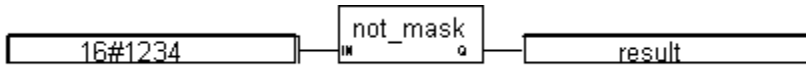
IN DINT Must have integer format  
Q DINT Bit-to-bit negation on 32 bits of IN

Description:

Integer bit-to-bit negation mask.

### Example

(\* FBD example with NOT\_MASK Operators \*)



(\*ST equivalence: \*)

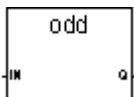
```
result := NOT_MASK (16#1234);
```

(\* result is 16#FFFF\_EDCB \*)

(\* IL equivalence: \*)

```
LD          16#1234
NOT_MASK
ST          result
```

### ODD



Arguments:

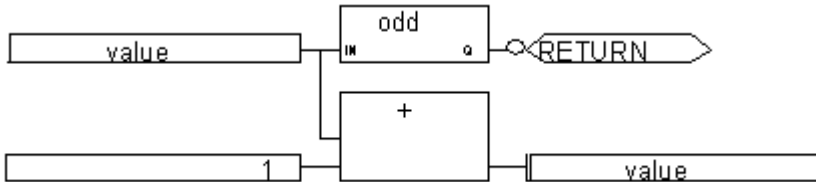
IN	DINT	Any signed integer value
Q	BOOL	TRUE if input value is odd FALSE if input value is even

Description:

Tests the parity of an integer: result is odd or even.

## Example

(\* FBD Program using "ODD" Function \*)



(\* ST Equivalence: \*)

```
If Not (ODD (value)) Then Return; End_if;
```

```
value := value + 1;
```

(\* makes value always even \*)

(\* IL Equivalence: \*)

```
LD    value
```

```
ODD
```

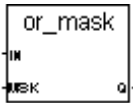
```
RETNC
```

```
LD    value
```

```
ADD    1
```

```
ST    value
```

## OR\_MASK



Arguments:

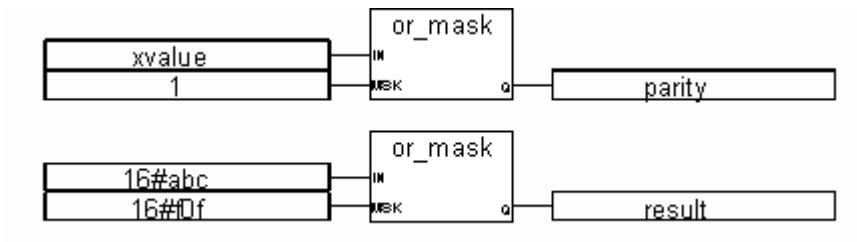
IN	DINT	Must have integer format
MSK	DINT	Must have integer format
Q	DINT	Bit-to-bit logical <b>OR</b> between IN and MSK

Description:

Integer OR bit-to-bit mask.

### Example

(\* FBD example with OR\_MASK Operators \*)



(\* ST Equivalence: \*)

```
parity := OR_MASK (xvalue, 1); (* makes value always odd *)
```

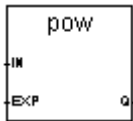
```
result := OR_MASK (16#abc, 16#f0f); (* equals 16#fbf *)
```

(\* IL equivalence: \*)

```
LD      xvalue
OR_MASK 1
ST      parity
```

```
LD      16#abc
OR_MASK 16#f0f
ST      result
```

## POW



Arguments:

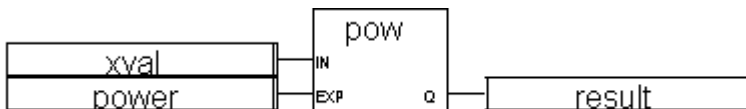
IN	REAL	Real number to be raised
EXP	REAL	Power (exponent)
Q	REAL	( $IN^{EXP}$ ) 1.0 if IN is not 0.0 and EXP is 0.0 0.0 if IN is 0.0 and EXP is negative 0.0 if both IN and EXP are 0.0 0.0 if IN is negative and EXP does not correspond to an integer

Description:

Gives the real result of the operation: (base<sup>exponent</sup>) 'base' being the first argument and 'exponent' the second one. The exponent is a real value.

### Example

(\* FBD Program using "POW" Function \*)



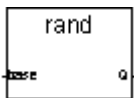
(\* ST Equivalence: \*)

```
result := POW (xval, power);
```

(\* IL Equivalence: \*)

```
LD    xval
POW   power
ST    result
```

## RAND



Arguments:

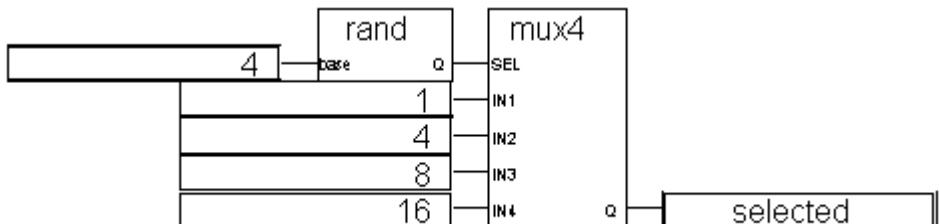
base    DINT    Defines the allowed set of number  
Q       DINT    Random value in set [0..base-1]

Description:

Gives a random integer value in a given range.

### Example

(\* FBD Program using "RAND" function \*)



(\* ST Equivalence: \*)

```
selected := MUX4 ( RAND (4), 1, 4, 8, 16 );
```

(\*

random selection of 1 of 4 pre-defined values

the value issued of RAND call is in set [0..3],

so 'selected' issued from MUX4, will get 'randomly' the value

1 if 0 is issued from RAND,

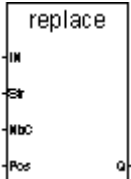
or 4 if 1 is issued from RAND,

or 8 if 2 is issued from RAND,

or 16 if 3 is issued from RAND,

\*)

## REPLACE



Arguments:

IN	STRING	Any string
Str	STRING	String to be inserted (to replace NbC chars)
NbC	DINT	Number of characters to be deleted



Pos    DINT        Position of the first modified character  
                      (first valid position is 1)

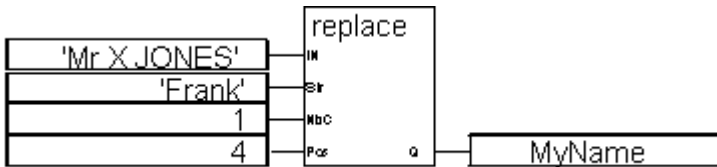
Q        STRING    Modified string:  
                      - NbC characters are deleted at position Pos  
                      - then substring Str is inserted at this position  
                      returns empty string if Pos <= 0  
                      returns strings concatenation (IN+Str) if Pos is greater than the length of  
                      the IN string  
                      returns initial string IN if NbC <= 0

Description:

Replaces a part of a string by a new set of characters.

### Example

Replaces a part of a string by a new set of characters.



(\* ST Equivalence: \*)

```
MyName := REPLACE ('Mr X JONES', 'Frank', 1, 4);
```

(\* MyName is 'Mr Frank JONES' \*)

(\* IL Equivalence: \*)

```
LD            'Mr X JONES'
REPLACE      'Frank', 1, 4
ST            MyName
```

# RIGHT



Arguments:

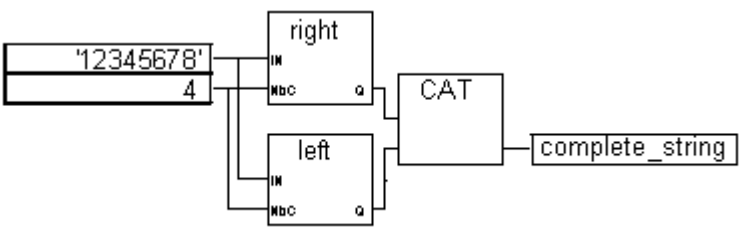
- IN STRING Any non-empty string
- NbC DINT Number of characters to be extracted. This number cannot be greater than the length of the IN string.
- Q STRING Right part of the string (length = NbC)  
empty string if NbC <= 0  
complete string if NbC >= string length

Description:

Extracts the right part of a string. The number of characters to be extracted is given.

## Example

(\* FBD Program using "LEFT" and "RIGHT" Functions \*)(\* ST Equivalence: \*)



```
complete_string := RIGHT ('12345678', 4) + LEFT ('12345678', 4);
```

(\* complete\_string is '56781234'

the value issued from RIGHT call is '5678'

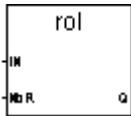
the value issued from LEFT call is '1234'

\*)

(\* IL Equivalence: First done is call to LEFT \*)

```
LD      '12345678'  
LEFT   4  
ST      sub_string (* intermediate result *)  
LD      '12345678'  
RIGHT  4  
ADD     sub_string  
ST      complete_string
```

## ROL

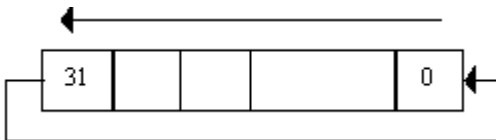


Arguments:

IN DINT Any integer value  
NbR DINT Number of 1 bit rotations (in set [1..31])  
Q DINT Left rotated value  
              no effect if NbR <= 0

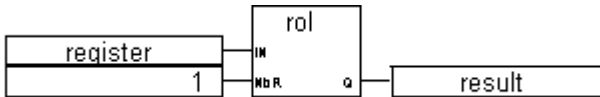
Description:

Make the bits of an integer rotate to the left. Rotation is made on 32 bits:



## Example

(\* FBD Program using "ROL" Function \*)



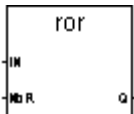
(\* ST Equivalence: \*)

```
result := ROL (register, 1);
(* register = 2#0100_1101_0011_0101*)
(* result = 2#1001_1010_0110_1010*)
```

(\* IL Equivalence: \*)

```
LD    register
ROL   1
ST    result
```

## ROR

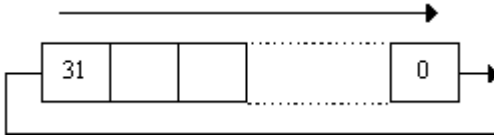


Arguments:

IN	DINT	Any integer value
NbR	DINT	Number of 1 bit rotations (in set [1..31])
Q	DINT	Right rotated value no effect if NbR <= 0

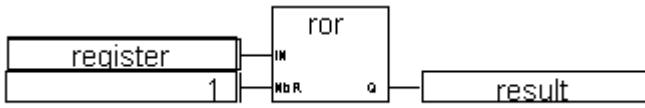
Description:

Make the bits of an integer rotate to the right. Rotation is made on 32 bits:



### Example

(\* FBD Program using "ROR" Function \*)



(\* ST Equivalence: \*)

```
result := ROR (register, 1);
```

(\* register = 2#0100\_1101\_0011\_0101 \*)

(\* result = 2#1010\_0110\_1001\_1010 \*)

(\* IL Equivalence: \*)

```
LD    register
ROR   1
ST    result
```

# SEL



Arguments:

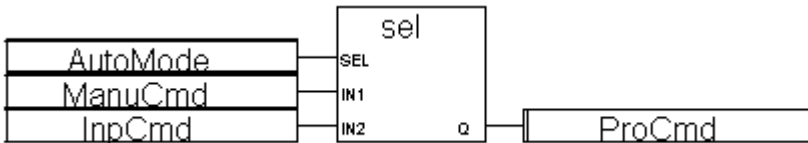
SEL	BOOL	Indicates the chosen value
IN1, IN2	DINT	Any integer values
Q	DINT	= IN1 if SEL is FALSE = IN2 if SEL is TRUE

Description:

Binary selector: selects a value between two integer values.

## Example

(\* FBD Program using "SEL" Function \*)



(\* ST Equivalence: \*)

```
ProCmd := SEL (AutoMode, ManuCmd, InpCmd);
```

(\* process command selection \*)

(\* IL Equivalence: \*)

```
LD    AutoMode
SEL   ManuCmd, InpCmd
ST    ProCmd
```

# SHL



Arguments:

IN	DINT	Any integer value
NbS	DINT	Number of 1 bit shifts (in set [1..31])
Q	DINT	Left shifted value no effect if NbS <= 0 0 is used to replace lowest bit

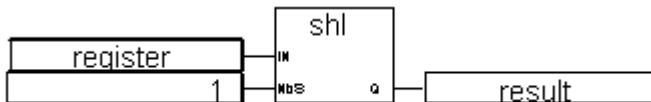
Description:

Make the bits of an integer shift to the left. Shift is made on 32 bits:



## Example

(\* FBD Program using "SHL" Function \*)



(\* ST Equivalence: \*)

```
result := SHL (register,1);
```

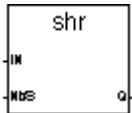
```
(* register = 2#0100_1101_0011_0101 *)
```

```
(* result = 2#1001_1010_0110_1010 *)
```

(\* IL Equivalence: \*)

```
LD    register
SHL   1
ST    result
```

## SHR

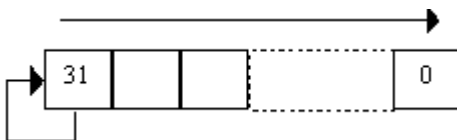


Arguments:

IN	DINT	Any integer value
NbS	DINT	Number of 1 bit shifts (in set [1..31])
Q	DINT	Right shifted value no effect if NbS <= 0 highest bit is copied at each shift

Description:

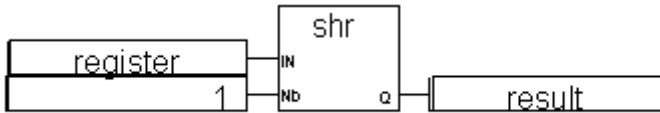
Make the bits of an integer shift to the right. Shift is made on 32 bits:





## Example

(\* FBD Program using "SHR"Function \*)



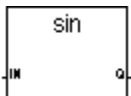
(\* ST Equivalence: \*)

```
result := SHR (register,1);  
(* register = 2#1100_1101_0011_0101 *)  
(* result = 2#1110_0110_1001_1010 *)
```

(\* IL Equivalence: \*)

```
LD    register  
SHR   1  
ST    result
```

## SIN



Arguments:

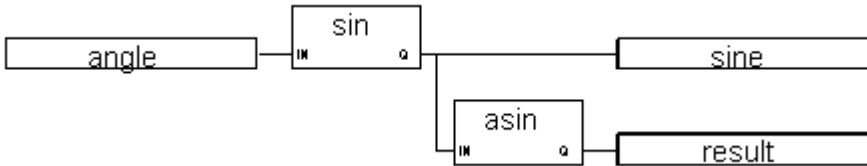
IN REAL Any REAL value  
Q REAL Sine of the input value (in set [-1.0 .. +1.0])

Description:

Calculates the Sine of a real value.

## Example

(\* FBD Program using "SIN" and "ASIN" Functions \*)



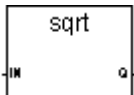
(\* ST Equivalence: \*)

```
sine := SIN (angle);  
result := ASIN (sine); (* result is equal to angle *)
```

(\* IL Equivalence: \*)

```
LD   angle  
SIN  
ST   sine  
ASIN  
ST   result
```

## SQRT



Arguments:

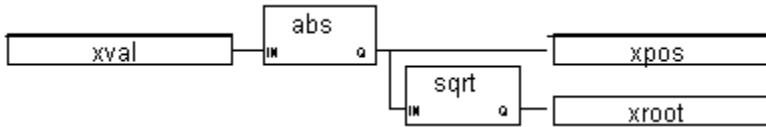
IN	REAL	Must be greater than or equal to zero
Q	REAL	Square root of the input value

Description:

Calculates the square root of a real value.

## Example

(\* FBD Program using "SQRT" Function \*)



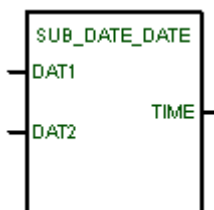
(\* ST Equivalence: \*)

```
xpos := ABS (xval);  
xroot := SQRT (xpos);
```

(\* IL Equivalence: \*)

```
LD    xval  
ABS  
ST    xpos  
SQRT  
ST    xroot
```

## SUB\_DATE\_DATE



Arguments:

DAT1    DATE    First date in a comparison

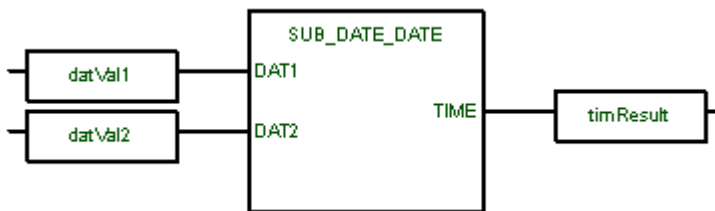
DAT2	DATE	Second date in a comparison
TIME	TIME	Difference in TIME format between DAT1 and DAT2. The possible date difference values range from t#0h to t#1193h2m47s294ms inclusively. A value of 1193h2m47s295ms indicates an error for either of the following conditions: - DAT1 is less than DAT2 - The difference between DAT1 and DAT2 is greater than 1193h2m47s294ms

Description:

Compares two dates and gives the difference in TIME format.

### Example

(\* FBD Program using "SUB\_DATE\_DATE" Function \*)



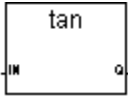
(\* ST Equivalence: \*)

```
timResult := SUB_DATE_DATE (datVal1, datVal2);
```

(\* IL Equivalence: \*)

```
LD          datVal1
SUB_DATE_DATE datVal2
ST          timResult
```

# TAN



Arguments:

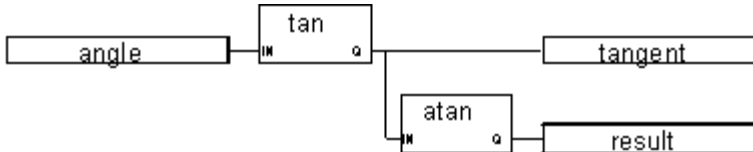
IN REAL Cannot be equal to  $\pi/2$  modulo  $\pi$   
Q REAL Tangent of the input value  
=  $1E+38$  for invalid input

Description:

Calculates the Tangent of a real value.

## Example

(\* FBD Program using "TAN" and "ATAN" Functions \*)



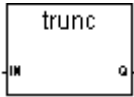
(\* ST Equivalence: \*)

```
tangent := TAN (angle);  
result := ATAN (tangent); (* result is equal to angle*)
```

(\* IL Equivalence: \*)

```
LD    angle  
TAN  
ST    tangent  
ATAN  
ST    result
```

# TRUNC



Arguments:

IN REAL Any REAL value

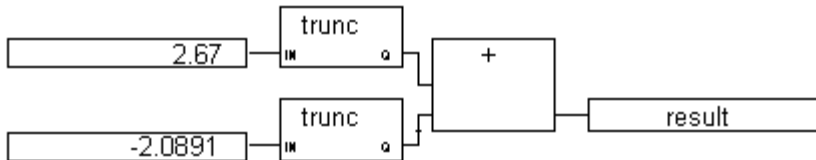
Q REAL If IN>0, biggest integer less or equal to the input  
If IN<0, least integer greater or equal to the input

Description:

Truncates a real value to have just the integer part.

## Example

(\* FBD Program using "TRUNC" Function \*)



(\* ST Equivalence: \*)

```
result := TRUNC (+2.67) + TRUNC (-2.0891);
```

(\* means: result := 2.0 + (-2.0) := 0.0; \*)

(\* IL Equivalence: \*)

```
LD      2.67
```

```
TRUNC
```

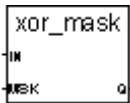
```
ST      temporary      (* temporary result of first TRUNC *)
```

```
LD      -2.0891
```

```
TRUNC
```

ADD        temporary  
ST        result

## XOR\_MASK



Arguments:

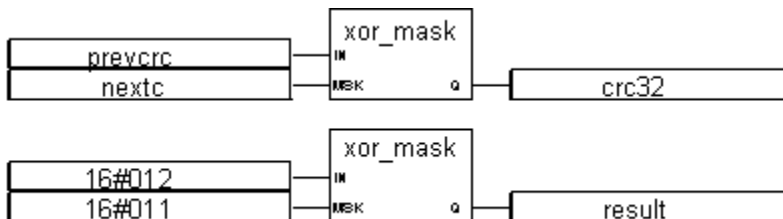
IN        DINT    Must have integer format  
MSK      DINT    Must have integer format  
Q        DINT    Bit-to-bit logical **Exclusive OR** between IN and MSK

Description:

Integer exclusive OR bit-to-bit mask

### Example

(\* FBD example with XOR\_MASK Operators \*)



(\* ST Equivalence: \*)

```
crc32 := XOR_MASK (prevcrc, nextc);  
result := XOR_MASK (16#012, 16#011); (* equals 16#003 *)
```

(\* IL equivalence: \*)

LD	prevcrc
XOR_MASK	nextc
ST	crc32
LD	16#012
XOR_MASK	16#011
ST	result



# Standard Function Blocks

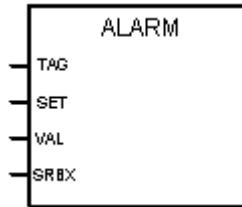
DS800 Development Suite supports the following standard function blocks:

<b>Alarm and event operations</b>	ALARM	Places a time-stamped alarm in the alarm log of a device.
<b>Warning:</b> These function blocks are available only on ROC800-Series devices.	EVENT	Places a time-stamped event in the event log of a device.
<b>Boolean operations</b>	SR	Set dominant bistable
	RS	Reset dominant bistable
	R_TRIG	Rising edge detection
	F_TRIG	Falling edge detection
<b>Communications</b>	CONNECT	Connection to a resource
	USEND_S	Sending of a message to a resource
	URCV_S	Reception of a message from a resource
<b>Comparator</b>	CMP	Full comparison Function Block
<b>Counters</b>	CTU	Up counter
	CTD	Down counter
	CTUD	Up-down counter
<b>Database commands</b>	DBG_CLR_GET_ERR	Clears error set by TLP_GET_xxx functions
<b>Warning:</b> These function blocks are available only on ROC800-Series devices.	DBG_CLR_SET_ERR	Clears error set by TLP_SET_xxx functions
	DBG_GET_ERR	Indicates error with TLP_GET_xxx functions
	DBG_SET_ERR	Indicates error with TLP_SET_xxx functions
	SOFT_POINT_READ	Reads entire contents of a soft point and writes the data to an output value
	SOFT_POINT_WRITE	Writes data to a specified soft point
	TLP_GET_DINT	Returns TLP data as a DINT

	TLP_GET_REAL	Returns TLP data as a REAL
	TLP_GET_SINT	Returns TLP data as an SINT
	TLP_GET_STRING	Returns TLP data as a STRING
	TLP_GET_TLP	Reads the TLP from a specified TLP
	TLP_SET_DINT	Writes a DINT to a TLP
	TLP_SET_REAL	Writes a REAL to a TLP
	TLP_SET_SINT	Writes a SINT to a TLP
	TLP_SET_STRING	Writes a STRING to a TLP
<b>Data manipulation</b>	AVERAGE	Running average over N samples
<b>License request and operating system priority</b>	REQUEST_LICENSE	Requests a license from the license server.
	SET_PRIORITY	Sets the priority of the operating system.
<b>Warning:</b> These function blocks are available only on ROC800-Series devices.		
<b>Process control</b>	DERIVATE	Differentiation according to time
	HYSTER	Boolean hysteresis on difference of reals
	INTEGRAL	Integration over time
	STACKINT	Stack of integer
<b>Signal generation</b>	BLINK	Blinking Boolean signal
	SIG_GEN	Signal generator
	TON	On-delay timing
	TOF	Off-delay timing
	TP	Pulse timing

**Note:** When new function blocks are created, these can be called from any language.

## ALARM



**Warning:** This function block is available only on ROC800-Series devices.

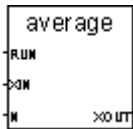
Arguments:

TAG	STRING	A brief textual description of the alarm
SET	BOOL	TRUE enables alarm, FALSE disables alarm
VAL	REAL	Numerical value associated with the alarm
SRBX	BOOL	Alarm is a spontaneous report by exception alarm

Description:

The ALARM function places a time stamped alarm in the alarm log of the device. Setting the SET input to TRUE logs an “alarm set”, whereas, setting this input to false logs an “alarm clear”. The SRBX input allows for the device to contact a host to report an alarm condition. Further setup is required in ROCLINK if this input is set to TRUE.

## AVERAGE



Arguments:

RUN	BOOL	TRUE=run / FALSE=reset
XIN	REAL	Any real Variable
N	DINT	Application defined number of samples

XOUT REAL Running average of XIN value

**Note:** When setting or changing the value for N, you need to set RUN to FALSE, then set it back to TRUE.

Description:

Stores a value at each cycle and calculates the average value of all already stored values. Only the N last values are stored.

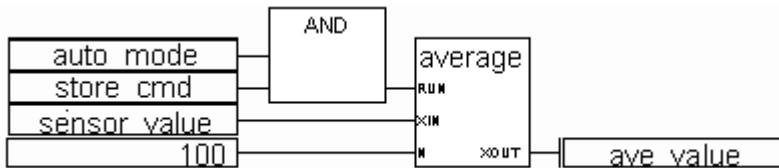
The number of samples N cannot exceed **128**.

If the "RUN" command is **FALSE** (reset mode), the output value is equal to the input value.

When the maximum N of stored values is reached, the first stored value is erased by the last one.

### Example

(\* FBD Program using "AVERAGE" Block: \*)

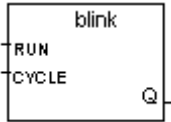


(\* ST Equivalence: AVERAGE1 instance of AVERAGE block \*)

```
AVERAGE1((auto_mode & store_cmd), sensor_value, 100);
```

```
ave_value := AVERAGE1.XOUT;
```

# BLINK



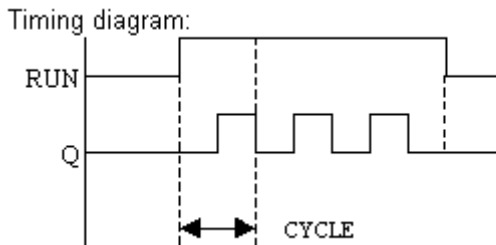
Arguments:

RUN	BOOL	Mode: TRUE=blinking / FALSE=reset the output to false
CYCLE	TIME	Blinking period. Possible values range from 0ms to 23h59m59s999ms.
Q	BOOL	Output blinking signal

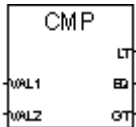
Description:

Generates a blinking signal.

Timing diagram:



# CMP



Arguments:

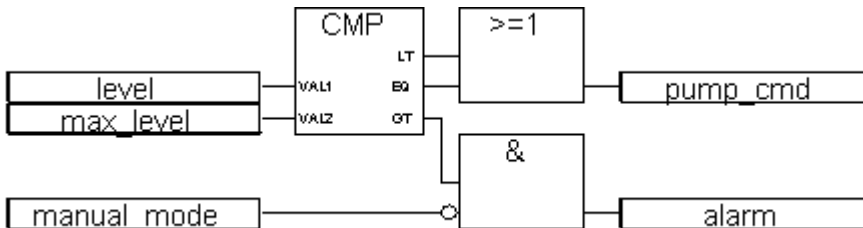
VAL1	DINT	Any signed integer value
VAL2	DINT	Any signed integer value
LT	BOOL	TRUE if val1 is Less Than val2
EQ	BOOL	TRUE if val1 is Equal to val2
GT	BOOL	TRUE if val1 is Greater Than val2

Description:

Compare two values: tell if they are equal, or if the first is less or greater than the second one.

## Example

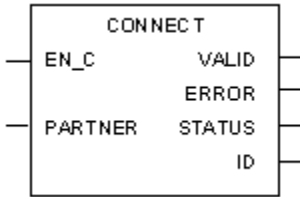
(\* FBD Program using "CMP" Block \*)



(\* ST Equivalence: We suppose CMP1 is an instance of CMP block \*)

```
CMP1(level, max_level);  
pump_cmd := CMP1.LT OR CMP1.EQ;  
alarm := CMP1.GT AND NOT(manual_mode);
```

# CONNECT



Arguments:

EN_C	BOOL	Enable connection.
PARTNER	STRING	Name of the remote communication partner.
VALID	BOOL	If TRUE, connection ID is valid.
ERROR	BOOL	If TRUE, new non-zero status received.
STATUS	DINT	Last detected status.
ID	DINT	Identification of the communication Channel.

Description:

Creates a connection with a remote or local Resource (of current Project or another Project) and manages the exchanges (for blocks USEND\_S and URCV\_S). For details on the USEND\_S block, see page 613. For details on the URCV\_S block, see page 612.

It creates a communication channel identifier (ID).

This identifier is required in all others communication function blocks (URCV\_S or USEND\_S).

PARTNER parameter is a string with the following format:

```
'ResourceNumber@Address'
```

## Example

```
'1@123.45.67.89'
```

Connection with the ETCP driver to Resource 1 at address 123.45.67.89.

If the Resource is on the same Configuration, its number is enough to identify it (e.g. '1').

On a rising edge of EN\_C parameter, the CONNECT Block establishes the communication with the remote partner.

The VALID parameter is set to TRUE until the communication is available.

Every time the status changes, the output parameter ERROR is set to TRUE during one cycle and the new status is set in the STATUS parameter.

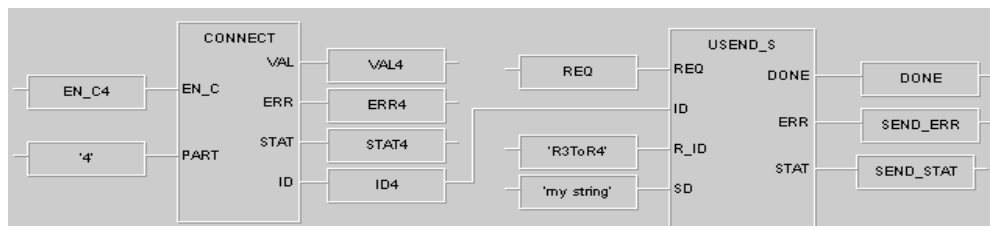
STATUS can take following values:

STATUS	Description
0	Connection successfully completed.
1	Waiting for reply
2	Too many CFB connect
3	Not ready for a new connection
4	Connect failed
5	Bad partner

If the connection failed, a new connection is not automatically done, a rising edge must be detected on EN\_C parameter.

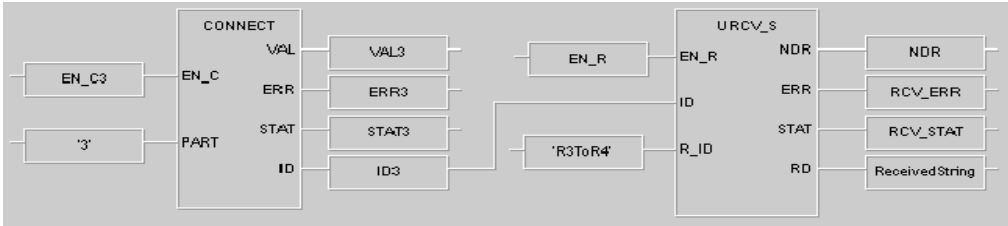
### Example

The following is a program of Resource 3 that sends a string to Resource 4 on the same Configuration:

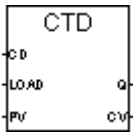




The following is the corresponding program in Resource 4 that receives the string:



## CTD



Arguments:

CD	BOOL	Counting input (down-counting when CD is TRUE)
LOAD	BOOL	Load command (dominant) (CV = PV when LOAD is TRUE)
PV	DINT	Programmed initial value
Q	BOOL	Underflow: TRUE when CV <= 0
CV	DINT	Counter result

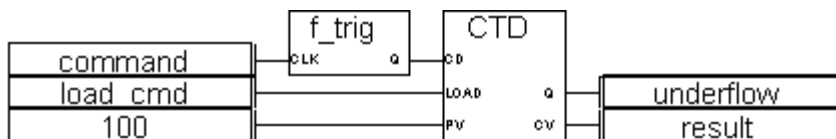
**Warning:** The CTD Block does not detect the rising or falling edges of the counting input (CD). It must be associated with an "R\_TRIG" or "F\_TRIG" block to create a pulse counter.

Description:

Count (integer) from a given value down to 0 1 by 1

## Example

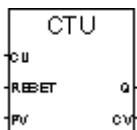
(\* FBD Program using "CTD" Block \*)



(\* ST Equivalence: We suppose F\_TRIG1 is an instance of F\_TRIG block and CTD1 is an instance of CTD block\*)

```
F_TRIG1(command);  
CTD1(F_TRIG1.Q,load_cmd,100);  
underflow := CTD1.Q;  
result := CTD1.CV;
```

## CTU



Arguments:

CU	BOOL	Counting input (counting when CU is TRUE)
RESET	BOOL	Reset command (dominant)
PV	DINT	Programmed maximum value
Q	BOOL	Overflow: TRUE when $CV \geq PV$
CV	DINT	Counter result

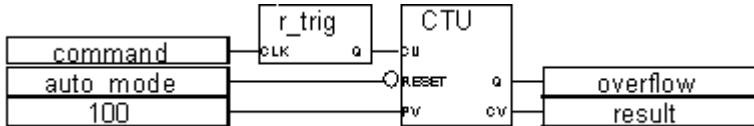
**Warning:** The CTU Block does not detect the rising or falling edge of the counting input (CU). It must be associated with an "R\_TRIG" or "F\_TRIG" block to create a pulse counter.

Description:

Count (integer) from 0 up to a given value 1 by 1

### Example

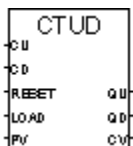
(\* FBD Program using "CTU" Block \*)



(\* ST Equivalence: We suppose R\_TRIG1 is an instance of R\_TRIG block and CTU1 is an instance of CTU block\*)

```
R_TRIG1 (command) ;  
CTU1 (R_TRIG1.Q, NOT (auto_mode) , 100) ;  
overflow := CTU1.Q ;  
result := CTU1.CV ;
```

## CTUD



Arguments:

CU	BOOL	Up-counting (when CU is TRUE)
CD	BOOL	Down-counting (when CD is TRUE)
RESET	BOOL	Reset command (dominant) (CV = 0 when RESET is TRUE)
LOAD	BOOL	Load command (CV = PV when LOAD is TRUE)

PV	DINT	Programmed maximum value
QU	BOOL	Overflow: TRUE when CV >= PV
QD	BOOL	Underflow: TRUE when CV <= 0
CV	DINT	Counter result

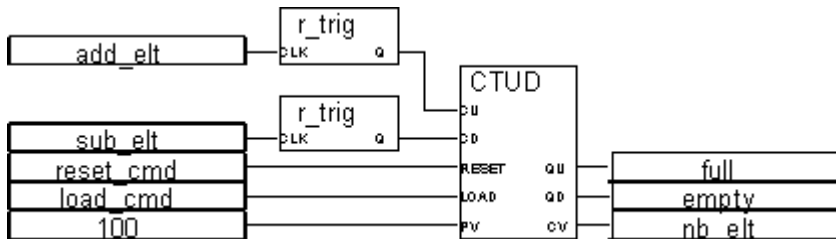
**Warning:** The CTUD Block does not detect the rising or falling edge of the counting inputs (CU and CD). It must be associated with an "R\_TRIG" or "F\_TRIG" Block to create a pulse counter.

Description:

Count (integer) from 0 up to a given value 1 by 1 or from a given value down to 0 1 by 1

### Example

(\* FBD Program using "CTUD" Block \*)



(\* ST Equivalence: We suppose R\_TRIG1 and R\_TRIG2 are two instances of R\_TRIG Block and CTUD1 is an instance of CTUD block\*)

```

R_TRIG1(add_elt);
R_TRIG2(sub_elt);
CTUD1(R_TRIG1.Q, R_TRIG2.Q, reset_cmd, load_cmd,100);
full := CTUD1.QU;
empty := CTUD1.QD;
nb_elt := CTUD1.CV;

```

## **DBG\_CLR\_GET\_ERR**

DBG\_CLR\_GET\_ERR

**Warning:** This function block is available only on ROC800-Series devices.

Arguments:

This function has no arguments.

Description:

This function clears the errors that were encountered with any of the TLP\_GET\_xxx functions.

## **DBG\_CLR\_SET\_ERR**

DBG\_CLR\_SET\_ERR

**Warning:** This function block is available only on ROC800-Series devices.

Arguments:

This function has no arguments.

Description:

This function clears the errors that were encountered with any of the TLP\_SET\_xxx functions.

## DBG\_GET\_ERR



**Warning:** This function block is available only on ROC800-Series devices.

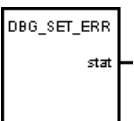
Arguments:

status (stat)    BOOL    TRUE=error/FALSE=no error

Description:

This function is intended as an aid for debugging your DS800 application. Returns TRUE if an error has been encountered with any of the TLP\_GET\_XXX functions. Errors occur if the TLP does not exist, or if the TLP references a data type that is incompatible with the return type of the function. The error remains set until DBG\_CLR\_GET\_ERR is called.

## DBG\_SET\_ERR



**Warning:** This function block is available only on ROC800-Series devices.

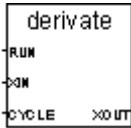
Arguments:

status (stat)    BOOL    TRUE=error/FALSE=no error

Description:

This function is intended as an aid for debugging your DS800 application. Returns TRUE if an error has been encountered with any of the TLP\_SET\_XXX functions. Errors occur if the TLP does not exist, or if the TLP references a data type that is incompatible with the data type of the value it is being set to. The error remains set until DBG\_CLR\_SET\_ERR is called.

# DERIVATE



Arguments:

RUN	BOOL	Mode: TRUE=normal / FALSE=reset
XIN	REAL	Input: any real value
CYCLE	TIME	Sampling period. Possible values range from 0ms to 23h59m59s999ms.
XOUT	REAL	Differentiated output

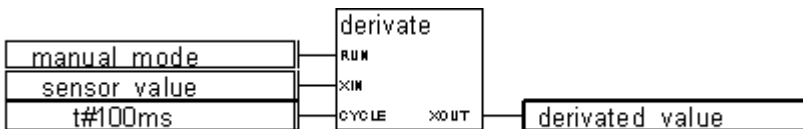
Description:

Differentiation of a real value.

If the "CYCLE" parameter value is less than the cycle timing of the execution of the resource in the target, the sampling period is forced to this cycle timing.

## Example

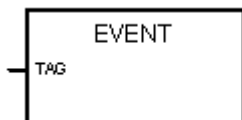
(\* FBD Program using "DERIVATE" Block: \*)



(\* ST Equivalence: DERIVATE1 instance of DERIVATE block \*)

```
DERIVATE1(manual_mode, sensor_value, t#100ms);  
derivated_value := DERIVATE1.XOUT;
```

## EVENT



**Warning:** This function block is available only on ROC800-Series devices.

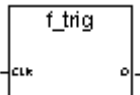
Arguments:

TAG      STRING    A brief textual description of the event

Description:

The EVENT function places a time-stamped user event in the event log of the device.

## F\_TRIG



Arguments:

CLK      BOOL      Any Boolean Variable

Q        BOOL      TRUE when CLK changes from TRUE to FALSE  
          FALSE if all other cases

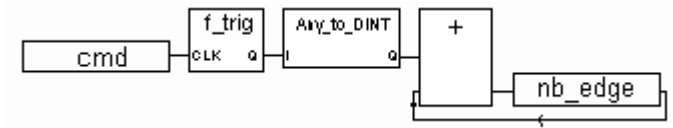
Description:

Detects a falling edge of a Boolean Variable



## Example

(\* FBD Program using "F\_TRIG" Block \*)

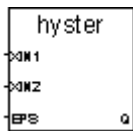


(\* ST Equivalence: We suppose F\_TRIG1 is an instance of F\_TRIG block \*)

```
F_TRIG1 (cmd) ;
```

```
nb_edge := ANY_TO_DINT(F_TRIG1.Q) + nb_edge;
```

## HYSTER



Arguments:

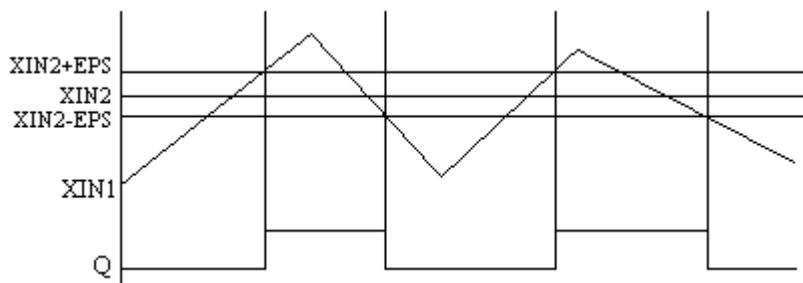
XIN1	REAL	Any real value
XIN2	REAL	To test if XIN1 has overpassed XIN2+EPS
EPS	REAL	Hysteresis value (must be greater than zero)
Q	BOOL	TRUE if XIN1 has overpassed XIN2+EPS and is not yet below XIN2-EPS

Description:

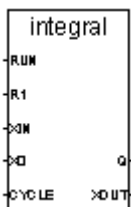
Hysteresis on a real value for a high limit.

## Example

Example of a timing diagram:



## INTEGRAL



Arguments:

RUN	BOOL	Mode: TRUE=integrate / FALSE=hold
R1	BOOL	Overriding reset
XIN	REAL	Input: any real value
X0	REAL	Initial value
CYCLE	TIME	Sampling period. Possible values range from 0ms to 23h59m59s999ms.
Q	BOOL	Not R1
XOUT	REAL	Integrated output

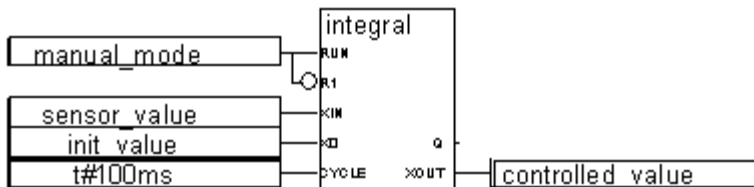
Description:

Integration of a real value.

If the "CYCLE" parameter value is less than the cycle timing of the execution of the resource in the target, the sampling period is forced to this cycle timing.

## Example

(\* FBD Program using "INTEGRAL" Block: \*)

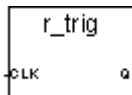


(\* ST Equivalence: INTEGRAL1 instance of INTEGRAL block \*)

```
INTEGRAL1(manual_mode, NOT(manual_mode), sensor_value, init_value,
t#100ms);
```

```
controlled_value := INTEGRAL1.XOUT;
```

## R\_TRIG



Arguments:

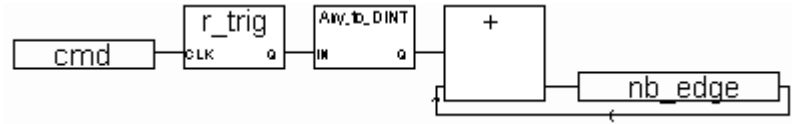
CLK	BOOL	Any Boolean Variable
Q	BOOL	TRUE when CLK rises from FALSE to TRUE FALSE in all other cases

Description:

Detects a Rising Edge of a Boolean Variable

## Example

(\* FBD Program using "R\_TRIG" Block \*)

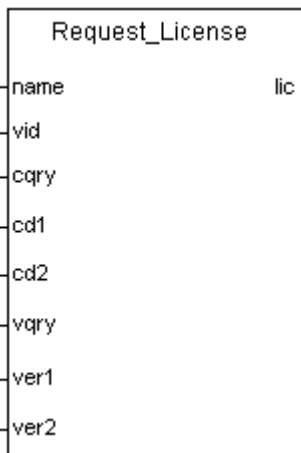


(\* ST Equivalence: We suppose R\_TRIG1 is an instance of R\_TRIG Block \*)

```
R_TRIG1 (cmd) ;
```

```
nb_edge := ANY_TO_DINT(R_TRIG1.Q) + nb_edge;
```

## REQUEST\_LICENSE



**Warning:** This function block is available only on ROC800-Series devices.

Arguments:

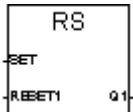
name	STRING	Name of application to request license for
vid	DINT	Vendor ID

cqry	DINT	Query options for application code
cd1	DINT	Application code 1
cd2	DINT	Application code 2
vqry	DINT	Query options for version
ver1	STRING	Version 1
ver2	STRING	Version 2
lic	LicenseInfo	Identifies license returned

Description:

The REQUEST\_LICENSE function requests a license from the license server.

## RS



Arguments:

SET	BOOL	If TRUE, sets Q1 to TRUE
RESET1	BOOL	If TRUE, resets Q1 to FALSE (dominant)
Q1	BOOL	Boolean memory state

Description:

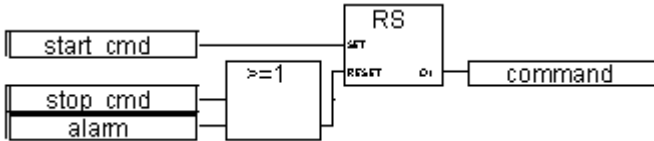
Reset dominant bistable:

Set	Reset1	Q1	Result Q1
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1

1	0	1	1
1	1	0	0
1	1	1	0

## Example

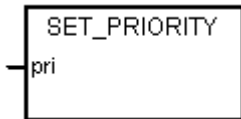
(\* FBD Program using "RS" Block \*)



(\* ST Equivalence: We suppose RS1 is an instance of RS block \*)

```
RS1(start_cmd, (stop_cmd OR alarm));
command := RS1.Q1;
```

## SET\_PRIORITY



**Warning:** This function block is available only on ROC800-Series devices.

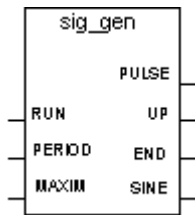
Arguments:

pri        DINT     Priority of the operating system. Possible values range between 10 and 31.

Description:

Sets the priority of the operating system.

## SIG\_GEN



### Arguments:

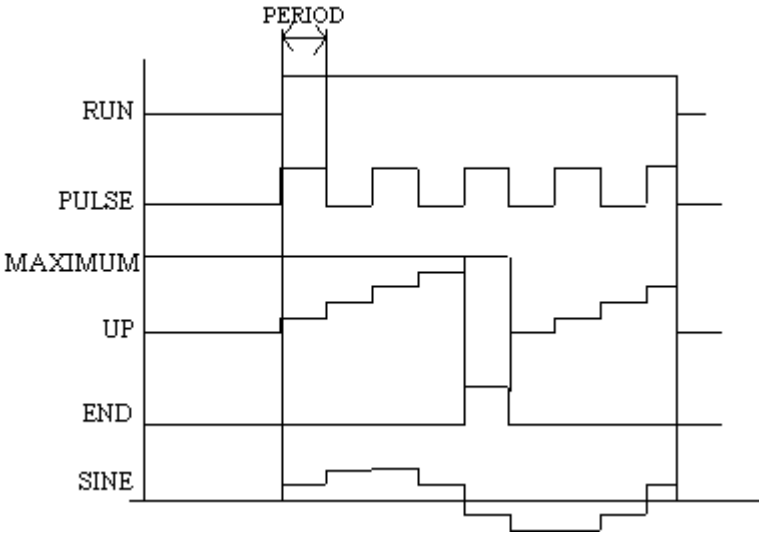
RUN	BOOL	Mode: TRUE=running / FALSE=reset to false
PERIOD	TIME	Duration of one sample. Possible values range from 0ms to 23h59m59s999ms.
MAXIMUM	DINT	Maximum counting value
PULSE	BOOL	Inverted after each sample
UP	DINT	Up-counter, increased on each sample
END	BOOL	TRUE when up-counting ends
SINE	REAL	Sine signal (period = counting duration)

### Description:

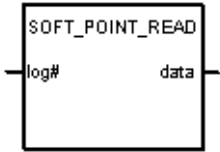
Generates various signal: blink on a boolean, a integer counter-up, and real sine wave.

When counting reaches maximum value, it restarts from 0 (zero). So END keeps the TRUE value only during 1 PERIOD.

Timing diagram:



## SOFT\_POINT\_READ



**Warning:** This function block is available only on ROC800-Series devices.

Arguments:

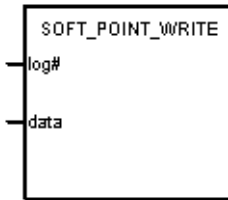
- log\_num ( log# )      DINT      Identifies the logical number of a soft point to read from.
- data                      SoftPoint      Stores contents of specified soft point

Description:

Reads entire contents of a soft point and writes the data to an output value.



## SOFT\_POINT\_WRITE



**Warning:** This function block is available only on ROC800-Series devices.

Arguments:

log_num ( log# )	DINT	Identifies the logical number of a soft point to write to.
data	SoftPoint	Contains data to be written to soft point.

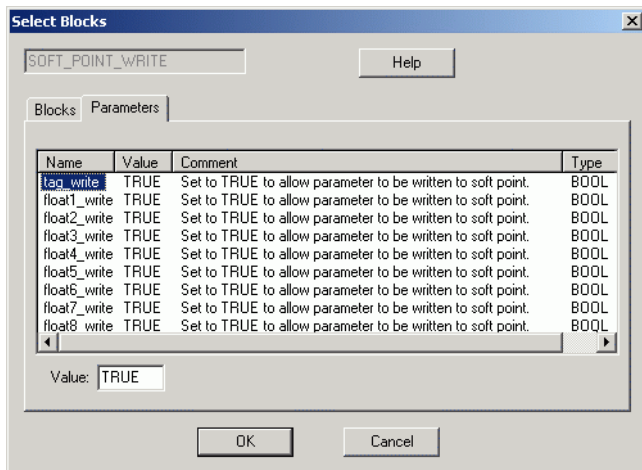
Description:

Writes data to a specified soft point.

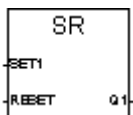
Hidden Parameters:

This function block has hidden parameters that correspond to each parameter in a soft point. These hidden parameters can be used to control which parameters in the input data actually get written to the soft point. The hidden parameters are of type BOOL. The default value for each parameter is TRUE, changing this value to FALSE prevents the corresponding soft point parameter from getting over-written with the input data.

Double-clicking the function block in the Function Block Diagram opens up a dialog box from which you access the hidden parameters. Click on the "Parameters" tab to display the hidden parameters.



## SR



Arguments:

SET1	BOOL	If TRUE, sets Q1 to TRUE (dominant)
RESET	BOOL	If TRUE, resets Q1 to FALSE
Q1	BOOL	Boolean memory state

Description:

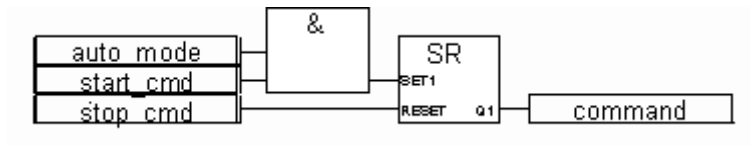
Set dominant bistable:

Set1	Reset	Q1	Result Q1
0	0	0	0

0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

### Example

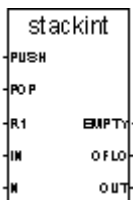
(\* FBD Program using "SR" Block \*)



(\* ST Equivalence: We suppose SR1 is an instance of SR block \*)

```
SR1((auto_mode & start_cmd), stop_cmd);
command := SR1.Q1;
```

# STACKINT



Arguments:

PUSH	BOOL	Push command (on Rising Edge only) add the IN value on the top of the stack
POP	BOOL	Pop command (on rising edge only) delete in the stack the last value pushed (top of the stack)
R1	BOOL	Resets the stack to its empty state
IN	DINT	Pushed value
N	DINT	Application defined stack size
EMPTY	BOOL	TRUE if the stack is empty
OFLO	BOOL	Overflow: TRUE if the stack is full
OUT	DINT	Value at the top of the stack

Description:

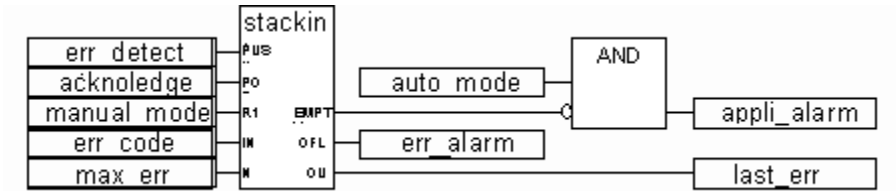
Manage a stack of integer values.

The "STACKINT" Function Block includes a rising edge detection for both PUSH and POP commands. The maximum size of the stack is **128**. The application defined stack size **N** cannot be less than 1 or greater than 128.

**Note:** OFLO value is valid only after a reset (R1 has been set to TRUE at least once and back to FALSE).

## Example

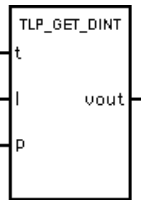
(\* FBD Program using "STACKINT" Block: error management \*)



(\* ST Equivalence: We suppose STACKINT1 is an instance of STACKINT Block \*)

```
STACKINT1(err_detect, acknowledge, manual_mode, err_code, max_err);
appli_alarm := auto_mode AND NOT(STACKINT1.EMPTY);
err_alarm := STACKINT1.OFLO;
last_error := STACKINT1.OU;
```

## TLP\_GET\_DINT



**Warning:** This function block is available only on ROC800-Series devices.

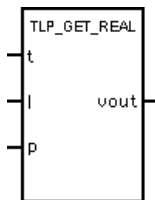
Arguments:

point_type ( t )	DINT	Refers to point type that contains the parameter to be read
logical ( l )	DINT	Instance of specified point type
parameter ( p )	DINT	Parameter to get
vout	DINT	Value of specified TLP

Description:

Gets parameter referenced by a TLP. The specified TLP may be any numerical data type. Parameter is converted to a DINT before being written to the output value.

## TLP\_GET\_REAL



**Warning:** This function block is available only on ROC800-Series devices.

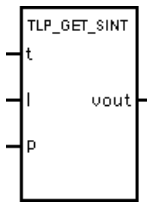
Arguments:

point_type ( t )	DINT	Refers to point type that contains the parameter to be read
logical ( l )	DINT	Instance of specified point type
parameter ( p )	DINT	Parameter to get
vout	REAL	Value of specified TLP

Description:

Gets parameter referenced by a TLP. The specified TLP may be any numerical data type. Parameter is converted to a REAL before being written to the output value.

## TLP\_GET\_SINT



**Warning:** This function block is available only on ROC800-Series devices.

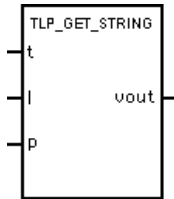
Arguments:

point_type ( t )	DINT	Refers to point type that contains the parameter to be read
logical ( l )	DINT	Instance of specified point type
parameter ( p )	DINT	Parameter to get
vout	SINT	Value of specified TLP

Description:

Gets parameter referenced by a TLP. The specified TLP may be any numerical data type. Parameter is converted to a SINT before being written to the output value.

## TLP\_GET\_STRING



**Warning:** This function block is available only on ROC800-Series devices.

Arguments:

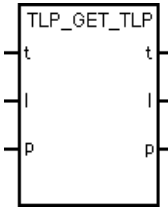
point_type ( t )	DINT	Refers to point type that contains the parameter to be read
logical ( l )	DINT	Instance of specified point type
parameter ( p )	DINT	Parameter to get
vout	STRING	Value of specified TLP

Description:

Gets parameter referenced by a TLP. The specified TLP must be a string. The string is truncated if it is too large to fit in the return value.



## TLP\_GET\_TLP



**Warning:** This function block is available only on ROC800-Series devices.

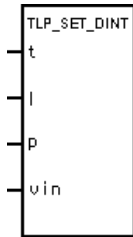
Arguments:

point_type ( t )	DINT	Refers to point type that contains the parameter to be read
logical ( l )	DINT	Instance of specified point type
parameter ( p )	DINT	Parameter to get
rpoint_type ( t )	DINT	Specified point type
rlogical ( l )	DINT	Specified instance of point type
rparameter ( p )	DINT	Specified parameter

Description:

Reads the TLP from a specified TLP.

## TLP\_SET\_DINT



**Warning:** This function block is available only on ROC800-Series devices.

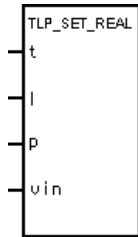
Arguments:

point_type ( t )	DINT	Refers to point type that contains the parameter to be set
logical ( l )	DINT	Instance of specified point type
parameter ( p )	DINT	Parameter to set
vin	DINT	New value for specified parameter

Description:

Sets parameter referenced by a TLP. Any numerical data type can be set with this function. Vin is converted to the data type of specified TLP before parameter is set.

## TLP\_SET\_REAL



**Warning:** This function block is available only on ROC800-Series devices.

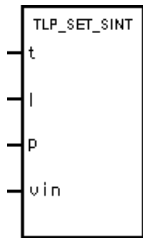
Arguments:

point_type ( t )	DINT	Refers to point type that contains the parameter to be set
logical ( l )	DINT	Instance of specified point type
parameter ( p )	DINT	Parameter to set
vin	REAL	New value for specified parameter

Description:

Sets parameter referenced by a TLP. Any numerical data type can be set with this function. Vin is converted to the data type of specified TLP before parameter is set.

## TLP\_SET\_SINT



**Warning:** This function block is available only on ROC800-Series devices.

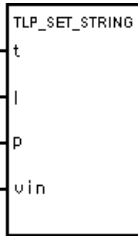
Arguments:

point_type ( t )	DINT	Refers to point type that contains the parameter to be set
logical ( l )	DINT	Instance of specified point type
parameter ( p )	DINT	Parameter to set
vin	SINT	New value for specified parameter

Description:

Sets parameter referenced by a TLP. Any numerical data type can be set with this function. Vin is converted to the data type of specified TLP before parameter is set.

## TLP\_SET\_STRING



**Warning:** This function block is available only on ROC800-Series devices.

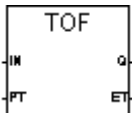
Arguments:

point_type ( t )	DINT	Refers to point type that contains the parameter to be set
logical ( l )	DINT	Instance of specified point type
parameter ( p )	DINT	Parameter to set
vin	STRING	New value for specified parameter

Description:

Sets parameter referenced by a TLP. Any string type can be set with this function. String will be padded with spaces if vin is shorter than string being set. String will be truncated if vin is longer than string being set.

## TOF



Arguments:

IN	BOOL	If Falling Edge, starts increasing internal timer If Rising Edge, stops and resets internal timer
PT	TIME	Maximum programmed time

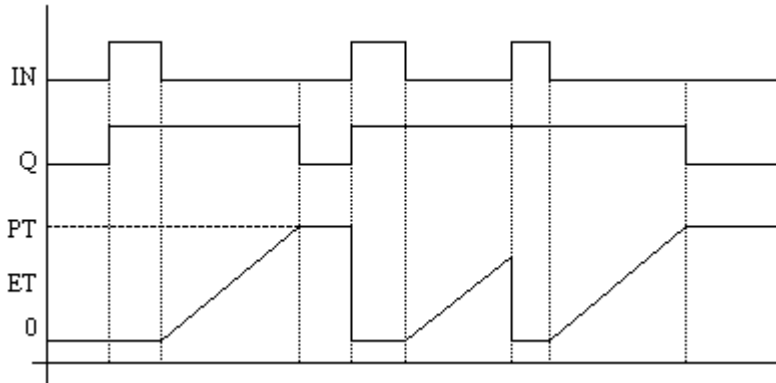
Q    BOOL    If TRUE: total time is not elapsed

ET   TIME    Current elapsed time

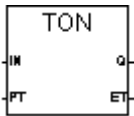
Description:

Increase an internal timer up to a given value.

Timing diagram:



## TON



Arguments:

IN    BOOL    If Rising Edge, starts increasing internal timer  
              If Falling Edge, stops and resets internal timer

PT    TIME    Maximum programmed time

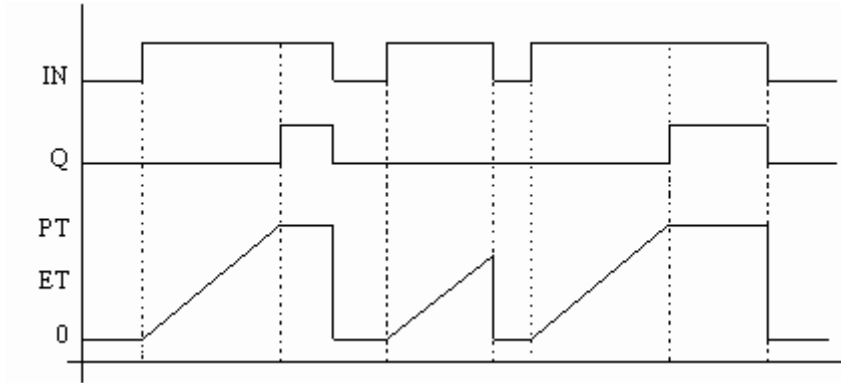
Q    BOOL    If TRUE, programmed time is elapsed

ET    TIME    Current elapsed time. Possible values range from 0ms to 23h59m59s999ms.

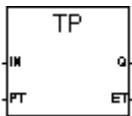
Description:

Increase an internal timer up to a given value.

Timing diagram:



## TP



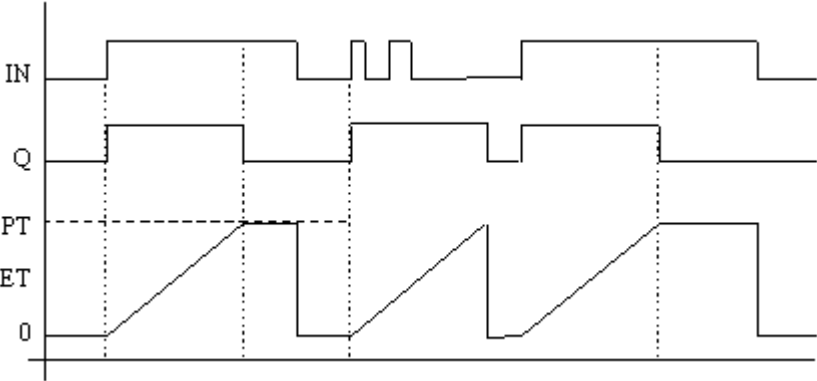
Arguments:

- IN    BOOL    If Rising Edge, starts increasing internal timer (if not already increasing)  
              If FALSE and only if timer is elapsed, resets the internal timer  
              Any change on IN during counting has no effect.
- PT    TIME    Maximum programmed time
- Q     BOOL    If TRUE: timer is counting
- ET    TIME    Current elapsed time. Possible values range from 0ms to 23h59m59s999ms.

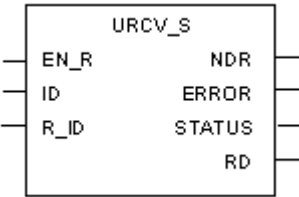
Description:

Increase an internal timer up to a given value.

Timing diagram:



## URCV\_S



Arguments:

EN_R	BOOL	Enable to receive data
ID	DINT	Identification of the communication Channel
R_ID	STRING	Identification of the remote SFB inside the Channel
NDR	BOOL	If TRUE, new string received in RD
ERROR	BOOL	If TRUE, new non-zero STATUS received
STATUS	DINT	Last detected status
RD	STRING	Received string



Description:

Receive a string from a remote or local resource (of current Project or another Project).

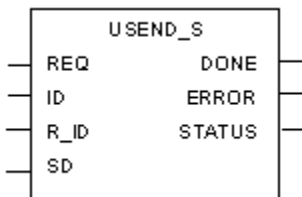
**Warning:** Connect block must have been called in current cycle before the URCV\_S call. This CFB receives a string from one USEND\_S instance. Previously received string is overwritten. If string is successfully received then NDR is set to TRUE during one cycle. If an error occurs, the ERROR output parameter is set to TRUE and the status is set in the STATUS parameter.

STATUS can have the following values:

STATUS	Description
0	Receive successfully completed
1	Waiting for message
2	Invalid identifier
3	Not ready for receive
6	Waiting for message
7	Dialog has failed

See example in the description of the CONNECT Block.

## USEND\_S



Arguments:

REQ	BOOL	Send request on rising edge
ID	DINT	Identification of the communication channel
R_ID	STRING	Identification of the remote CFB inside the channel

SD	STRING	String to send
DONE	BOOL	If TRUE, function performed successfully
ERROR	BOOL	If TRUE, new non-zero STATUS received
STATUS	DINT	Last detected status

Description:

Send a string to a remote or local Resource (of current Project or another Project).

**Warning:** Connect block must have been called in current cycle before the USEND\_S call. This CFB sends a string to one URCV\_S instance on rising edge of REQ. If string is successfully sent then DONE is set. If an error occurs, the output parameter ERROR is set to TRUE and the status is set in the STATUS parameter.

STATUS can have the following values:

STATUS	Description
0	Send successfully completed
1	Send in progress
2	Invalid identifier
3	Not ready to send
6	Dialog has failed
7	Send has failed

If the send failed, a new send is not automatically done, a rising edge must be detected on REQ parameter.

See example in the description of the CONNECT block.

# Glossary

The Glossary contains terms used in the Workbench and their definitions.

<b>Access Control</b>	The use of password-protection to control access to projects, resources, POU's, and targets. For projects, resources, and POU's, access control can also limit access to read-only mode.
<b>Access Method</b>	Methods to access the Virtual Machine database from a client application (programmed in C): SMA, MIB, SID.
<b>Action</b>	In SFC: an action can be on a Boolean variable or a child SFC, or a collection of operations (written in ST, IL, LD) to perform with an associated SFC step. The action is executed when the Step (SFC) is active. In FC: an action is a collection of operations (written in ST, IL, LD) to perform.
<b>Activity of a Step</b>	Attribute of a Step (SFC) which is activated by an SFC token.
<b>Address</b>	Optional hexadecimal address freely defined for each variable. This address can be used by an external application to access the value of the variable when the resource is executed by the Target.
<b>Alias</b>	The property of a variable indicating a short name for a variable. For FBD and LD diagrams, aliases indicate the parameters in functions and function blocks.
<b>Array</b>	Set of elements of the same type referenced by one or more indexes enclosed in square brackets and separated by commas. The index is an integer. Examples: tabi[2] or tabij[2,4].
<b>Attribute</b>	The property of a variable indicating whether a variable is read-only, write-only, or free (read and write).
<b>Automatic Instance (of a function block)</b>	A function block having no assigned instances. Automatic instances of function blocks cannot be added to a POU during online changes.  See also Declared Instance (of a function block)

<b>Binding</b>	Bindings are directional links, i.e., access paths, between variables located in different resources. The Workbench enables two types of bindings: internal bindings and external bindings. Internal bindings are between resources within the same project. External bindings are between resources belonging to different projects.
<b>Binding Error Variable</b>	Variables enabling the management of binding errors at the consumer resource level.
<b>Boolean (Bool)</b>	Basic type that can be used to define a variable, a Parameter (POU) or a device. A Boolean can be TRUE (1) or FALSE (0).
<b>Boolean Action</b>	SFC Action: a Boolean variable is assigned with the activity of a Step (SFC).
<b>Breakpoint</b>	SFC POU: Mark placed by the user at debug time, on an SFC Step (SFC) or Transition. The Target system stops when an SFC token is moved on a breakpoint. Step-by-step mode: For ST and IL POU's, you set breakpoints to specific lines of code. For LD POU's, you set breakpoints to rungs. When running an application in Debug mode, the application stops when it encounters a breakpoint.
<b>C Function</b>	Function written with the "C" language, called from POU's, in a synchronous manner.
<b>C Language</b>	High level literal language used to access particularities of the target system. C language can be used to program C functions, function blocks and conversion functions.
<b>Call Stack</b>	Information which tracks stepping between POU's and called functions. Debug information includes call stack. You can only generate debug information for resources producing TIC code.
<b>Cell</b>	Elementary area of the graphic matrix for graphic languages such as SFC, FBD or LD or for the Dictionary Grid View.
<b>CFB</b>	Indicates a C function block
<b>CFU</b>	Indicates a C function

<b>Channel</b>	A channel of a device represents a hardware I/O point. It can be an input or an output. A variable is generally connected to a channel in order to be used in POU's. Directly represented variables can also be used in POU's.
<b>Check In</b>	Sending the contents of Workbench elements including projects, configurations, resources, and POU's for storage in a version source control database. Checked-in elements can be recovered at a later time.
<b>Child</b>	For SFC and FC, program which is activated by its father. The child has only one father. Only its father can start or kill it. A father can have more than one child.
<b>Clearing a Transition</b>	The forcing of the clearing of a transition whether the latter is valid or not (i.e all previous steps are active or not). Tokens are moved and actions are executed as for a usual transition clearing. All tokens existing in the preceding steps are removed. A token is created in each of the following steps.
<b>CMG</b>	Short name for the configuration manager
<b>Coil</b>	Graphic component of an LD Program representing the assignment of an output or an internal variable.
<b>Common Scope</b>	Scope of a declaration applying to all POU's within a Project. (Only defined words and types can have common scope).
<b>Complex Equipment</b>	See I/O Complex Device.
<b>Condition</b>	A Boolean expression attached to an SFC Transition or an FC test. In case of an SFC transition, the transition cannot be cleared when its condition is false.
<b>Configuration</b>	A software object made up of one or more resources. A configuration becomes a RAS device target when it is downloaded onto a target.
<b>Configuration Manager</b>	(ConfigurationManager.exe) The executable file providing communication services between the Workbench and target. Responsible for launching, killing, and giving the status of running virtual machines.
<b>Connection</b>	The link between networks and configurations, displayed in the hardware architecture view.

<b>Constant Expression</b>	Literal expression used to describe a constant value.
<b>Consumer Group</b>	A group holding external producer variables having bindings with consumer variables defined in the project.
<b>Consumption Error Behavior</b>	Indication of the value to use when an error occurs for an internal binding. Possible values are either the last value issued from the binding or a specified default value.
<b>Contact</b>	Graphic component of an FBD or LD diagram. Depending on the type of contact, it represents the value or function of an input or an internal variable.
<b>Contextual Menu</b>	Menu that is displayed under the mouse cursor by right-clicking the mouse.
<b>Convergence</b>	Multiple connection link from multiple SFC symbols (steps or transitions) to a single symbol. Convergences can be single or double. A single convergence (OR) is a multiple link from multiple transitions to the same step. A double convergence (AND) is a multiple link from multiple steps to the same transition.
<b>Conversion</b>	Filter attached to an input or output variable. The conversion is automatically applied each time the input variable is read or the output variable is refreshed.
<b>Conversion Function</b>	"C" written Function which describes a conversion. Such a conversion can be attached to any input or output, integer or real variable.
<b>CRC</b>	Cyclic redundancy checking
<b>Cross References Browser</b>	A tool that finds all references to variables, i.e., cross references, defined in the POU's of a project. The browser provides a total view of the declared variables in the programs of the project and where these are used.
<b>CSV File Format</b>	(Comma Separated Values) A delimited data format having each piece of information separated by commas and each line ending with a carriage return. The CSV file format can be used for importing or exporting variables data.
<b>Current Result (IL)</b>	Result of an instruction in an IL POU. The current result can be modified by an instruction, or used to set a variable.

<b>Cycle</b>	The Virtual Machine executes the programs of a resource as a cycle. All programs of the resource are executed following the order defined by the user, from the first program to the last and again and again. Before the execution of the first program, inputs are read. After the execution of the last program, the outputs are refreshed.
<b>Cycle Time</b>	The time between two input scans on the target. It represents the time to execute one cycle. The cycle time can differ at each cycle if none is programmed. When the cycle time is shorter, the Virtual Machine waits until this time has elapsed. When the cycle time is longer, the Virtual Machine immediately scans the inputs but signals with the "overflow" that the programmed time has been exceeded. When the cycle time is 0, the Virtual Machine does not wait to start a new cycle.
<b>Cycle-to-cycle Mode</b>	Execution mode: In this mode, cycles are executed one by one, according to the orders given by the user of the debugger.
<b>Database</b>	The collection of definitions making up a Workbench project. The version source control feature stores checked-in information in a separate database.
<b>Data Link</b>	A directional link between resources across which variable bindings data is conveyed.
<b>Debug Information</b>	For use when debugging using the step-by-step mode with ST, IL, and LD POU's (programs, functions, and function blocks). Debug information includes call stack information which tracks stepping between POU's and called functions. You can only generate debug information for resources producing TIC code.
<b>Declared Instance (of a function block)</b>	A function block having assigned instances, i.e., declared in the dictionary. Declared instances of function blocks can be added to a POU during online changes.
	See also Automatic Instance (of a function block)
<b>Defined Word</b>	Word that is an expression. This word can be used in POU's. At compiling time the word is replaced by the expression. A defined word can not use a defined word.

<b>Delayed Operation (IL)</b>	Operation of an IL Program, executed when the ")" instruction occurs, later in the Program.
<b>Dependency (on a library)</b>	The state where a project uses, i.e., depends, on functions or function blocks defined in a library.
<b>Device</b>	See I/O device.
<b>Dictionary</b>	The view displaying the variables, function and function block parameters, types, and defined words used in the programs of a Project.
<b>Dimension</b>	The size (number of elements) of an array. For example: [1..3,1..10] - represents a two-dimensional array containing a total of 30 elements.
<b>Direction</b>	Variables and devices have a direction. For the property of a variable, direction indicates whether a variable is an input, output, or internal. The direction of a device can be input or output.
<b>Directly Represented Variable</b>	A variable is generally declared before its use in one POU. Inputs and outputs can be used without any declaration respecting a defined syntax. It corresponds to direct represented variables. Example: %QX1.6, %ID8.2
<b>Divergence</b>	Multiple connection link from a single SFC symbol (steps or transitions) to multiple SFC symbols. Divergences can be single or double. A single divergence (OR) is a multiple link from one step to many transitions. A double divergence (AND) is a multiple link from one transition to many steps.
<b>Double Integer (DINT)</b>	Signed double integer 32-bit format. Basic type that can be used to define a variable, a Parameter (POU) or a Device.
<b>Driver</b>	See IO driver, Network Driver.
<b>Edge</b>	See Falling Edge, Rising Edge.
<b>ETCP</b>	(ETCP.exe) <b>DS800 Development Suite</b> network driver that uses the TCP / IP stack.
<b>Events Logger</b>	A logger that receives events from <b>DS800 Development Suite</b> targets. You view these events using the Events Viewer. Events are stored in a log file, in Unicode format. A new log file is automatically created each day at 00:00:00 hours



<b>Events Viewer</b>	A viewer that displays run-time system events logged with the Events Logger.
<b>Execution Mode</b>	The mode in which a resource is executed: real-time, cycle-to-cycle, and step-by-step.
<b>External Binding List</b>	The list of consumer groups, holding external producer variables having bindings with consumer variables defined in the project, and producer groups, holding outgoing producer variables for consumption in external bindings defined in another project.
<b>Expression</b>	Set of operators and identifiers.
<b>Falling Edge</b>	A falling edge of a Boolean variable corresponds to a change from TRUE (1) to FALSE (0).
<b>Father Program</b>	For SFC and FC, program which controls other programs, called its children. See Child.
<b>FBD</b>	Function Block Diagram. Programming language.
<b>FC</b>	Flow Chart. Programming language.
<b>Function</b>	POU which has input parameters and one output parameter. A function can be called by a program, a function or a function block. A function has no instance. It means that local data are not stored, and are generally lost from one call to the other. A function can be written in ST, IL, LD, FBD and "C".
<b>Function Block</b>	POU which has input and output parameters and works on internal data (parameters). A program can call an instance of a function block. A function block instance can not be called by a function (no internal data for a function). A function block can call another function block (instantiation mechanism is extended to the function blocks called). A function block can be written in ST, IL, LD, FBD and "C".
<b>Global Scope</b>	Scope of a declaration applying to all POUs of one resource.
<b>Global Variable</b>	A variable whose scope is global.
<b>Hardware Architecture</b>	The view graphically displaying the configurations of a project and the network links between them.

<b>Hidden Parameter</b>	Input parameters of a function block that are not displayed in FBD diagrams. Hidden parameters are set in the Parameters tab of the Select Block dialog.
<b>Hierarchy</b>	Architecture of a Project, divided into several POUs. The hierarchy tree represents the links between father programs and children programs. See Father Program, Parent Program.
<b>Identifier</b>	Unique word used to represent a variable or a constant expression in the programming.
<b>IFB</b>	Indicates an IEC 61131 function block
<b>IFU</b>	Indicates an IEC 61131 function
<b>IL</b>	Instruction List. Programming language.
<b>Initial Situation</b>	Set of the initial steps of an SFC Program, which represents the context of the program when it is started.
<b>Initial Step</b>	Special Step (SFC) of an SFC Program, which is activated when the program starts.
<b>Initial Value</b>	Value which has a variable when the Virtual Machine starts the execution of the resource. The initial value of a variable can be the default value, a value given by the user when the variable is defined or the value of the retain variable after the Virtual Machine has stopped.
<b>Input</b>	Direction of a variable or a Device. An input variable is connected to an input channel of an input Device.
<b>Input Parameter</b>	Input argument of a function or a function block. These parameters can only be read by function or function block. A parameter is characterized by a type.
<b>Instance (of a Function Block)</b>	Copy of the internal data of a function block which persists from one call to the other. This word is used, by extension, to say that a program calls a function block instance and not the function block itself.
<b>Instruction</b>	Elementary operation of an IL program, entered on one line of text.
<b>Internal</b>	Attribute of a variable, which is not linked to an input or output device. Such a variable is called an internal variable.

<b>Internal Binding List</b>	The view displaying the resource links and internal variable bindings defined for a project.
<b>I/O Binding</b>	A virtual connection between two software elements.
<b>I/O Channel</b>	See Channel.
<b>I/O Complex Device</b>	Element grouping several "simple devices". This provides the means for manufacturers to mix types and directions. The implementation of the I/O Driver of a complex device corresponds to the implementation of the drivers of all the devices composing it. Parameters are also attached to a complex device, OEM parameters.
<b>I/O Simple Device</b>	Element grouping several channels of the same type and same direction (INPUT, OUTPUT). An Array can be connected to a device if all elements are connected to contiguous channels, the type of the array must be the type of the Device. Variables of the same type can also be connected to channels of a device. A device corresponds to a hardware device and an I/O Driver in (or linked to) the Virtual Machine. Parameters are also attached to a device: the OEM parameters. I/O devices are defined by the integrator.
<b>I/O Driver</b>	"C" code which makes the interface between a Virtual Machine and the hardware devices. The driver can be statically linked to the Virtual Machine or in a separate DLL (such as for the Windows NT target). Two types of drivers are available for use in the Workbench: generic and advanced.
<b>IO Variable</b>	Variable connected to an input or output device. An IO variable must be connected on a channel of an IO device.
<b>IO Wiring</b>	Definition of the links between the variables of the Project and the channels of the devices existing on the Target system.
<b>ISaRSI</b>	(IsaRSI.exe) Enhanced serial port driver. The network driver that provides communication with the workbench on a serial port. Similar to ETCP.
<b>ITA</b>	Indicates an array
<b>ITS</b>	Indicates a structure

<b>IXLSma Server</b>	(IxLSmaServer.exe) Provides service for performing IXL read operations, using the HSD driver with the SMA method. This method is independent from the virtual machine cycle and is thus faster.
<b>Jump to a Step</b>	SFC graphic component representing a link from a Transition to a Step (SFC). The graphic symbol of a jump is an arrow, identified with the reference of the destination step.
<b>Keyword</b>	Reserved identifier of the language.
<b>Label</b>	For FBD, IL, or LD, identifier identifying an instruction. Labels can also be used for jump operations.
<b>LD</b>	Ladder Diagram. Programming language.
<b>Level 1 of the FC</b>	Main description of an FC program. Level 1 groups the chart (actions and tests), and the attached comments.
<b>Level 1 of the SFC</b>	Main description of an SFC program. Level 1 groups the chart (steps and transitions), and the attached comments.
<b>Level 2 of the FC</b>	Detailed description of an FC program. It is the description of the actions and tests. Level 2 programming for FC elements can be developed with ST or LD.
<b>Level 2 of the SFC</b>	Detailed description of an SFC program. It is the description of the actions within the steps, and the Boolean conditions attached to the transitions. Level 2 programming for SFC elements can be developed with ST or LD or call an SFC child.
<b>Library</b>	Special projects made up of configurations and resources in which you define functions and function blocks for reuse throughout <b>DS800 Development Suite</b> projects. Libraries also enable you to modularize projects and to isolate functions and function blocks so that these can be validated separately.
<b>Link</b>	For FBD, SFC, or LD diagrams, a graphic component connecting elements in a diagram.
<b>Link Architecture</b>	The view graphically displaying the resources of a project and the resource data links, used for internal bindings, between them. This is the default view of the Workbench providing a main entry point to all editors.
<b>Literal</b>	A lexical unit that directly represents a value.

<b>Local scope</b>	Scope of a declaration applying to only one POU.
<b>Locked I/O</b>	Input or output variable, disconnected logically from the corresponding I/O device, by a "Lock" command sent by the user from the debugger.
<b>Maximum time</b>	Time of the longest cycle since the Virtual Machine has started the execution of the programs of a resource.
<b>Memory for Retain</b>	Run-time setting for a resource indicating the location where retained values are stored (the required syntax depends on the implementation).
<b>Message</b>	See STRING.
<b>Method</b>	See Access Method.
<b>Modifier (IL)</b>	Single character put at the end of an IL operation keyword, which modifies the meaning of the operation.
<b>Network</b>	The means of communication between configurations and their clients.
<b>Network Driver</b>	"C" code which makes the interface between the Target network layer and the network.
<b>Non-stored Action</b>	SFC Action: it is a list of statements, executed at each Target cycle, when the corresponding Step (SFC) is active.
<b>OEM</b>	Original Equipment Manufacturer
<b>OEM Parameter</b>	Parameters attached to an IO device or an I/O Complex Device. A parameter is characterized by a type. An OEM parameter is defined by the designer of the Device. It can be a constant, or a variable parameter entered by the user during the I/O connection.
<b>Operand (IL)</b>	Variable or constant expression processed by an elementary IL instruction.
<b>Operation (IL)</b>	Basic instruction of the IL language. An operation (or operator) is generally associated to an operand in an instruction.
<b>Operator</b>	Basic logical operation such as arithmetic, boolean, comparator, and data conversion.
<b>Output</b>	Direction of a variable or a device. An output variable is connected to an output channel of an output Device.

<b>Output Parameter</b>	Output argument of a function or function block. These parameters can only be written by a function or function block. A function has only one output parameter. A parameter is characterized by a type.
<b>Overflow</b>	Integer value which corresponds to the number of times the cycle time has been exceeded. Always 0, if cycle time is 0.
<b>Parameter (POU)</b>	See Input Parameter, Output Parameter, OEM Parameter, and Hidden Parameter
<b>Parent Program</b>	It can be a Father Program or an FC program that call an FC Sub-program.
<b>PLC</b>	Programmable Logic Controller
<b>POU</b>	Program Organization Unit: set of instructions written in one of the following languages: SFC, FC, IL, ST, FBD, LD. A POU can be a program, a function or function block.
<b>Power Rail</b>	Main left and right vertical rails at the extremities of a ladder diagram.
<b>Producer Group</b>	A group holding outgoing producer variables for consumption in external bindings defined in another project.
<b>Program</b>	See POU. A program belongs to a resource. It is executed by the Virtual Machine, depending on its location (order) in the resource.
<b>Project</b>	Set of configurations and links between their resources.
<b>Project Updater</b>	A program allowing to convert projects developed using previous versions for use within the latest version. Each time you upgrade to a newer version, you need to update projects.
<b>PROPI</b>	PROPI is an interface enabling you to send commands directly to the Workbench via a custom application. For instance, you could use the PROPI interface when using the Workbench in the background.
<b>Pulse Action</b>	SFC Action: it is a list of statements executed only once when the corresponding Step (SFC) is activated.
<b>Qualifier</b>	Determines the way the action of a step is executed. The qualifier can be N, S, R, P0 or P1.

<b>Real</b>	Type of a variable, stored in a floating IEEE single precision 32-bit format. Basic type that can be used to define a variable, a Parameter (POU) or a Device.
<b>Real Device</b>	I/O Device physically connected to an I/O device on the target machine. See Virtual Device.
<b>Real Time Mode</b>	Run time normal execution mode: the Target cycles are triggered by the programmed cycle timing.
<b>Reference Name (SFC)</b>	Name which identifies an SFC Step (SFC) or Transition in an SFC program.
<b>Register (IL)</b>	Current result of an IL sequence.
<b>Resource</b>	The POU's and definitions making up a Virtual Machine.
<b>Resource Name</b>	The unique identifier of a resource within a configuration.
<b>Retain</b>	Attribute of a variable. The value of a retain variable is saved by the Virtual Machine at each cycle. The value stored is restored if the Virtual Machine stops and restarts.
<b>Return</b>	Graphic component of an LD program representing the conditional end of a program.
<b>Return Parameter</b>	See Output Parameter.
<b>Rising Edge</b>	A rising edge of a Boolean variable corresponds to a change from FALSE (0) to TRUE (1).
<b>Rung</b>	Graphic component of an LD program representing a group of circuit elements leading to the activation of a coil in an LD diagram.
<b>Run-time Error</b>	Application error detected by the Target system at run time.
<b>Scope</b>	See Global Scope, Common Scope, Local scope.
<b>Section</b>	Program, function and function block sections are where are localized POU of a resource. POU's located in the Program section are executed by the Virtual Machine.
<b>Security State</b>	The indication of the level of access control that is applied to a resource, a POU, or a target.

<b>Selection List</b>	Also known as a 'combo-box'.  When a Selection List is provided for a particular cell, clicking on its right part (down arrow), displays the available choices. To make a selection, perform one of the following operations: - click on the item (use the scroll bar first if the required choice is not visible) - move in the list using the cursor keys and press Enter - type the first letter (if more than one item starts with this letter, press the letter again to select the next occurrence).
<b>Separator</b>	Special character (or group of characters) used to separate the identifiers in a literal language.
<b>Sequential</b>	Attribute of a program. A sequential program gives an order to operations of a process and conditions between operations. Generally, it is programmed with SFC or FC.
<b>Server</b>	Part of the target that receives requests from IXL to retrieve information about the resource run by the Virtual Machine.
<b>SFB</b>	Indicates a standard function block
<b>SFC</b>	Sequential Function Chart. Programming language.
<b>SFU</b>	Indicates a standard function
<b>Short Integer (SINT)</b>	Signed integer 8-bit format. Basic type that can be used to define a Variable, a Parameter (POU) or a Device.
<b>Single Resource Mode</b>	The project editing mode limiting access for an individual user to one resource and its POU's. Other users can access other resources of the same project.
<b>SIT</b>	Indicates a Standard IEC 61131 type.
<b>ST</b>	Structured Text. Programming language.
<b>Standard IEC 61131 Types</b>	Boolean (Bool), Short Integer (SINT), Double Integer (DINT), Real, Timer (TIME), STRING. See Type.
<b>Statement</b>	Basic ST complete operation.



<b>Step (SFC)</b>	Basic graphic component of the SFC language. A step represents a steady situation of the process, and is drawn as a square. A step is referenced by a name. The activity of a step is used to control the execution of the corresponding actions.
<b>Step (FC)</b>	The word step may be used for Flow Chart actions.  See Action.
<b>Step-by-step Mode</b>	A mode used while debugging ST, IL, and LD POU's where you set breakpoints at specific lines of code or rungs causing the application to stop when reached.
<b>STRING</b>	Character string. Basic type that can be used to define a Variable, a Parameter (POU) or a Device.
<b>Structure</b>	Corresponds to a type which has previously been specified to be a data structure, i.e. a type consisting of a collection of named elements (or fields). Each field can be a basic type, a basic structured type, a structure or an array. A field of a variable with a structure type can be accessed using the following syntax: VarName.a, VarName.b[3], VarName.c.d
<b>Sub-program</b>	Programs written in SFC or FC language and called by a father program. A sub-program is also called a child program. To call sub-programs written in another language, use a function. A function can be called by any POU.
<b>Symbol Table</b>	The file corresponding to the variables and function blocks defined for a resource. This file is downloaded onto the target. The symbol table is set to one of two formats: complete table or reduced table. The complete table contains all defined variables, whereas, the reduced symbol table only contains the names of variables having a defined Address cell.
<b>Symbols Monitoring Information</b>	When debugging or simulating, code required to enable graphically displaying the output values of functions and operators in FBD and LD diagrams.
<b>System Events</b>	Events occurring on the development platform. Such events can be logged using the Events Logger and viewed using the Events Viewer.

<b>System Variable</b>	System variables hold the current values of all system variables for a resource. You can read from or write to system variables. These variables are defined in the dsys0def.h file. For example, the current cycle time is a system variable that can only be read by a program.
<b>Target</b>	The hardware platform on which Virtual Machines run resources of a project. You download configurations (Configs), onto a RAS device target.
<b>Target Definition Builder</b>	The Target Definition Builder enables the description of targets (main definition and options of the embedded software), complex data types (such as defined in IEC languages), "C" functions, function blocks and conversion functions, I/O devices or network drivers for IXL communication and/or data binding.
<b>TIC Code</b>	Target Independent Code produced by the <b>DS800 Development Suite</b> compiler for execution on virtual machines.
<b>Timer (TIME)</b>	Unit of a timer is the millisecond. Basic type that can be used to define a Variable, a Parameter (POU) or a Device.
<b>Token (SFC)</b>	Graphical marker used to show the active steps of an SFC program.
<b>Top Level Program</b>	Program put at the top of the hierarchy tree. A top level program is activated by the system. See also Parent Program, Father Program.
<b>Transition</b>	Basic graphic SFC component. A transition represents the condition between different SFC steps. A transition is referenced by a name. A Boolean Condition is attached to each transition.
<b>Type</b>	Data types are defined for many items in <b>DS800 Development Suite</b> projects: <ul style="list-style-type: none"> <li>- variables</li> <li>-function or function block parameters</li> <li>- devices</li> </ul> See Standard IEC 61131 Types, Basic Structured Types, User Types.

<b>User Data</b>	User Data are any data of any format (file, list of values) which have to be merged with the generated code of the resource in order to download them into the RAS device target. Such data are not directly operated by the Virtual Machine and is commonly dedicated to other software installed on the target PLC.
<b>User Types</b>	Types that the user can define using basic types or other user types. User types can be arrays or structures.
<b>Validity of a Transition</b>	Attribute of a Transition. A transition is validated (or enabled) when all the preceding steps are active.
<b>Variable</b>	Unique identifier of elementary data which is used in the programs of a Project.
<b>Variable Binding</b>	See Binding
<b>Variable Group</b>	Grouping of variables enabling managing and logically sorting these within a resource. Variable groups are displayed in the dictionary's variables tree.
<b>Variable Name</b>	A unique identifier, defined in the Workbench, for a storage location containing information used in exchanges between resources.
<b>Version Information</b>	The information indicating the compilation version number, the compilation date, and the CRC of the data the resource works on for three sources of resource code: <ul style="list-style-type: none"> <li>- the compiled code for the resource in the Workbench project</li> <li>- the code for the resource running on the target</li> <li>- the code for the resource stored on the target</li> </ul>
<b>Version Source Control</b>	A tool that manages the changing versions of Workbench elements including projects, configurations, resources, and POUs by saving them to a version source control database. Saving these elements to a control database enables you to retrieve older versions of the elements at a later time.
<b>Virtual Device</b>	I/O Device which is not physically connected to an I/O device of the Target machine. See Real Device.
<b>Virtual Machine</b>	(IsaVM.exe) The instantiation of a resource on a Target.

**Wiring**

The property of a variable indicating the I/O channel to which the variable is wired.

**Zip Source**

An exchange file (.PXF) holding all data from Workbench elements. From the compilation options for a resource, you can choose to embed a zip source file for resources, configurations, or projects onto the target. This source file can be uploaded from the target at a later time.

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