EcoStruxure Machine Expert - Basic

Operating Guide

Original instructions

EIO0000003281.04
09/2025

www.se.com

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The information provided in this document contains general descriptions, technical characteristics and/or recommendations related to products/solutions.

This document is not intended as a substitute for a detailed study or operational and site-specific development or schematic plan. It is not to be used for determining suitability or reliability of the products/solutions for specific user applications. It is the duty of any such user to perform or have any professional expert of its choice (integrator, specifier or the like) perform the appropriate and comprehensive risk analysis, evaluation and testing of the products/solutions with respect to the relevant specific application or use thereof.

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Table of Contents

Safety Information

Important Information

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, service, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠ DANGER

DANGER indicates a hazardous situation which, if not avoided, **will result in** death or serious injury.

⚠ WARNING

WARNING indicates a hazardous situation which, if not avoided, **could result in** death or serious injury.

⚠ CAUTION

CAUTION indicates a hazardous situation which, if not avoided, **could result** in minor or moderate injury.

NOTICE

NOTICE is used to address practices not related to physical injury.

Please Note

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction and operation of electrical equipment and its installation, and has received safety training to recognize and avoid the hazards involved.

About the Document

Document Scope

This guide describes how to use the EcoStruxure Machine Expert - Basic software to configure, program, and commission applications for supported logic controllers.

Validity Note

This document has been updated for the release of EcoStruxure™ Machine Expert - Basic V1.4.

Product Related Information

⚠WARNING

LOSS OF CONTROL

- Perform a Failure Mode and Effects Analysis (FMEA), or equivalent risk analysis, of your application, and apply preventive and detective controls before implementation.
- Provide a fallback state for undesired control events or sequences.
- Provide separate or redundant control paths wherever required.
- Supply appropriate parameters, particularly for limits.
- Review the implications of transmission delays and take actions to mitigate them.
- Review the implications of communication link interruptions and take actions to mitigate them.
- Provide independent paths for control functions (for example, emergency stop, over-limit conditions, and error conditions) according to your risk assessment, and applicable codes and regulations.
- Apply local accident prevention and safety regulations and guidelines.[1]
- Test each implementation of a system for proper operation before placing it into service.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

[1] For additional information, refer to NEMA ICS 1.1 (latest edition), *Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control* and to NEMA ICS 7.1 (latest edition), *Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems* or their equivalent governing your particular location.

⚠WARNING

UNINTENDED EQUIPMENT OPERATION

- Only use software approved by Schneider Electric for use with this equipment.
- Update your application program every time you change the physical hardware configuration.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

General Cybersecurity Information

In recent years, the growing number of networked machines and production plants has seen a corresponding increase in the potential for cyber threats, such as unauthorized access, data breaches, and operational disruptions. You must, therefore, consider all possible cybersecurity measures to help protect assets and systems against such threats.

To help keep your Schneider Electric products secure and protected, it is in your best interest to implement the cybersecurity best practices as described in the Cybersecurity Best Practices document.

Schneider Electric provides additional information and assistance:

- Subscribe to the Schneider Electric security newsletter.
- Visit the Cybersecurity Support Portal web page to:
  - Find Security Notifications.
  - Report vulnerabilities and incidents.
- Visit the Schneider Electric Cybersecurity and Data Protection Posture web page to:
  - Access the cybersecurity posture.
  - Learn more about cybersecurity in the cybersecurity academy.
  - Explore the cybersecurity services from Schneider Electric.

Available Languages of the Document

The document is available in these languages:

- English (EIO0000003281)
- French (EIO0000003282)
- German (EIO0000003283)
- Spanish (EIO0000003284)
- Italian (EIO0000003285)
- Chinese (EIO0000003286)
- Portuguese (EIO0000003287)
- Turkish (EIO0000003288)

Related Documents

Title of Documentation	Reference Number
EcoStruxure Machine Expert - Basic Generic Functions - Library Guide	EIO0000003289 (ENG) EIO0000003290 (FRE) EIO0000003291 (GER) EIO0000003292 (SPA) EIO0000003293 (ITA) EIO0000003294 (CHS) EIO0000003295 (POR) EIO0000003296 (TUR)
Modicon M221 Logic Controller Advanced Functions - Library Guide	EIO0000003305 (ENG) EIO0000003306 (FRE) EIO0000003307 (GER) EIO0000003308 (SPA) EIO0000003309 (ITA) EIO0000003310 (CHS) EIO0000003311 (POR) EIO0000003312 (TUR)
Modicon M221 Logic Controller - Programming Guide	EIO0000003297 (ENG) EIO0000003298 (FRE) EIO0000003299 (GER) EIO0000003300 (SPA) EIO0000003301 (ITA) EIO0000003302 (CHS) EIO0000003303 (POR) EIO0000003304 (TUR)
Modicon M221 Logic Controller - Hardware Guide	EIO0000003313 (ENG) EIO0000003314 (FRE) EIO0000003315 (GER) EIO0000003316 (SPA) EIO0000003317 (ITA) EIO0000003318 (CHS) EIO0000003319 (POR) EIO0000003320 (TUR)
Modicon TMC2 Cartridge - Programming Guide	EIO0000003329 (ENG) EIO0000003330 (FRE) EIO0000003331 (GER) EIO0000003332 (SPA) EIO0000003333 (ITA) EIO0000003334 (CHS) EIO0000003335 (POR) EIO0000003336 (TUR)

Title of Documentation	Reference Number
Modicon TMC2 Cartridge - Hardware Guide	EIO0000003337 (ENG) EIO0000003338 (FRE) EIO0000003339 (GER) EIO0000003340 (SPA) EIO0000003341 (ITA) EIO0000003342 (CHS) EIO0000003343 (POR) EIO0000003344 (TUR)
Modicon TM3 Expansion Modules - Programming Guide (EcoStruxure Machine Expert - Basic)	EIO0000003345 (ENG) EIO0000003346 (FRE) EIO0000003347 (GER) EIO0000003348 (SPA) EIO0000003349 (ITA) EIO0000003350 (CHS) EIO0000003351 (POR) EIO0000003352 (TUR)
Modicon TM3 Digital I/O Modules - Hardware Guide	EIO0000003125 (ENG) EIO0000003126 (FRE) EIO0000003127 (GER) EIO0000003128 (SPA) EIO0000003129 (ITA) EIO0000003130 (CHS) EIO0000003424 (POR) EIO0000003425 (TUR)
Modicon TM3 Analog I/O Modules - Hardware Guide	EIO0000003131 (ENG) EIO0000003132 (FRE) EIO0000003133 (GER) EIO0000003134 (SPA) EIO0000003135 (ITA) EIO0000003136 (CHS) EIO0000003426 (POR) EIO0000003427 (TUR)
Modicon TM3 Expert Modules - Hardware Guide	EIO0000003137 (ENG) EIO0000003138 (FRE) EIO0000003139 (GER) EIO0000003140 (SPA) EIO0000003141 (ITA) EIO0000003142 (CHS) EIO0000003428 (POR) EIO0000003429 (TUR)

Title of Documentation	Reference Number
Modicon TM3 Safety Modules - Hardware Guide	EIO0000003353 (ENG) EIO0000003354 (FRE) EIO0000003355 (GER) EIO0000003356 (SPA) EIO0000003357 (ITA) EIO0000003358 (CHS) EIO0000003359 (POR) EIO0000003360 (TUR)
Modicon TM3 Transmitter and Receiver Modules - Hardware Guide	EIO0000003143 (ENG) EIO0000003144 (FRE) EIO0000003145 (GER) EIO0000003146 (SPA) EIO0000003147 (ITA) EIO0000003148 (CHS) EIO0000003430 (POR) EIO0000003431 (TUR)
Modicon TM2 Expansion Modules Configuration - Programming Guide	EIO0000003432 (ENG) EIO0000003433 (FRE) EIO0000003434 (GER) EIO0000003435 (SPA) EIO0000003436 (ITA) EIO0000003437 (CHS)
Modicon TM2 Digital I/O Modules - Hardware Guide	EIO0000000028 (ENG) EIO0000000029 (FRE) EIO0000000030 (GER) EIO0000000031 (SPA) EIO0000000032 (ITA) EIO0000000033 (CHS)
Modicon TM2 Analog I/O Modules - Hardware Guide	EIO0000000034 (ENG) EIO0000000035 (FRE) EIO0000000036 (GER) EIO0000000037 (SPA) EIO0000000038 (ITA) EIO0000000039 (CHS)
SR2MOD02 and SR2MOD03 Wireless Modem - User Guide	EIO0000001575 (ENG)

To find documents online, visit the Schneider Electric download center (www.se.com/ww/en/download/).

Information on Non-Inclusive or Insensitive Terminology

As a responsible, inclusive company, Schneider Electric is constantly updating its communications and products that contain non-inclusive or insensitive

terminology. However, despite these efforts, our content may still contain terms that are deemed inappropriate by some customers.

Terminology Derived from Standards

The technical terms, terminology, symbols and the corresponding descriptions in the information contained herein, or that appear in or on the products themselves, are generally derived from the terms or definitions of international standards.

In the area of functional safety systems, drives and general automation, this may include, but is not limited to, terms such as *safety*, *safety function*, *safe state*, *fault*, *fault reset*, *malfunction*, *failure*, *error*, *error message*, *dangerous*, etc.

Among others, these standards include:

Standard	Description
IEC 61131-2:2007	Programmable controllers, part 2: Equipment requirements and tests.
ISO 13849-1:2023	Safety of machinery: Safety related parts of control systems. General principles for design.
EN 61496-1:2020	Safety of machinery: Electro-sensitive protective equipment. Part 1: General requirements and tests.
ISO 12100:2010	Safety of machinery - General principles for design - Risk assessment and risk reduction
EN 60204-1:2006	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
ISO 14119:2013	Safety of machinery - Interlocking devices associated with guards - Principles for design and selection
ISO 13850:2015	Safety of machinery - Emergency stop - Principles for design
IEC 62061:2021	Safety of machinery - Functional safety of safety-related electrical, electronic, and electronic programmable control systems
IEC 61508-1:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems: General requirements.
IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems: Requirements for electrical/electronic/programmable electronic safety-related systems.
IEC 61508-3:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems: Software requirements.
IEC 61784-3:2021	Industrial communication networks - Profiles - Part 3: Functional safety fieldbuses - General rules and profile definitions.
2006/42/EC	Machinery Directive
2014/30/EU	Electromagnetic Compatibility Directive
2014/35/EU	Low Voltage Directive

In addition, terms used in the present document may tangentially be used as they are derived from other standards such as:

Standard	Description
IEC 60034 series	Rotating electrical machines
IEC 61800 series	Adjustable speed electrical power drive systems
IEC 61158 series	Digital data communications for measurement and control – Fieldbus for use in industrial control systems

Finally, the term *zone of operation* may be used in conjunction with the description of specific hazards, and is defined as it is for a *hazard zone* or *danger zone* in the *Machinery Directive* (*2006/42/EC*) and *ISO 12100:2010*.

NOTE: The aforementioned standards may or may not apply to the specific products cited in the present documentation. For more information concerning the individual standards applicable to the products described herein, see the characteristics tables for those product references.

Getting Started with EcoStruxure Machine Expert - Basic

What's in This Part

System Requirements and Supported Devices

What's in This Chapter

System Requirements

Overview

In order to operate EcoStruxure Machine Expert - Basic on a PC, the computer must meet the following minimum requirements:

Component	Minimum Requirement
Processor	Intel Core 2 Duo processor or greater
RAM	2 GB RAM
Display resolution	1280 x 768 pixels or greater
Operating system	Microsoft Windows 11 (64-bit processor) or Microsoft Windows 10 (64-bit processor)
Microsoft .NET Framework	Microsoft .NET Framework 4.7.2 or greater

Supported Devices

M221 Logic Controllers

For more information about the M221 logic controller configuration, refer to the following programming and hardware guides:

Logic Controller Type	Hardware Guide	Programming Guide
M221 Logic Controllers	Modicon M221 Logic Controller Hardware Guide	Modicon M221 Logic Controller Programming Guide

TM3 Expansion Modules

For more information about module configuration, refer to the following programming and hardware guides of each expansion module type:

Expansion Module Type	Hardware Guide	Programming Guide
TM3 Digital I/O Expansion Modules	TM3 Digital I/O Expansion Modules Hardware Guide	TM3 Expansion Modules Programming Guide
TM3 Analog I/O Expansion Modules	TM3 Analog Modules Hardware Guide	
TM3 Expert I/O Expansion Modules	TM3 Expert I/O Modules Hardware Guide	
TM3 Safety Modules	TM3 Safety Modules Hardware Guide	
TM3 Transmitter and Receiver Modules	TM3 Transmitter and Receiver Modules Hardware Guide	

TM2 Expansion Modules

For more information about module configuration, refer to the programming and hardware guides of each expansion module type:

Expansion Module Type	Hardware Guide	Programming Guide
TM2 Digital I/O Modules	TM2 Digital I/O Modules Hardware Guide	TM2 Expansion Modules Programming Guide
TM2 Analog I/O Modules	TM2 Analog I/O Modules Hardware Guide	

TMC2 Cartridges

For more information about cartridge configuration, refer to the following programming and hardware guides:

Cartridge Type	Hardware Guide	Programming Guide
TMC2 Cartridges	TMC2 Cartridges Hardware Guide	TMC2 Cartridges Programming Guide

TMH2GDB Remote Graphic Display

For information about the Remote Graphic Display installation, compatibility, configuration, and operation, refer to the following guide:

Display Type	User Guide
Remote Graphic Display	TMH2GDB Remote Graphic Display User Guide

Supported Programming Languages

Overview

A programmable logic controller reads inputs, writes outputs, and solves logic based on a control program. Creating a control program for a logic controller consists of writing a series of instructions in one of the supported programming languages.

EcoStruxure Machine Expert - Basic supports the following IEC-61131-3 programming languages:

- Ladder Diagram language
- Instruction List language
- Grafcet (List)
- Grafcet (SFC)

EcoStruxure Machine Expert - Basic User Interface Basics

What's in This Chapter

Creating Projects With EcoStruxure Machine Expert - Basic

Overview

EcoStruxure Machine Expert - Basic is a graphical programming tool designed to help configure, develop, and commission programs for logic controllers.

Some Essential Terminology

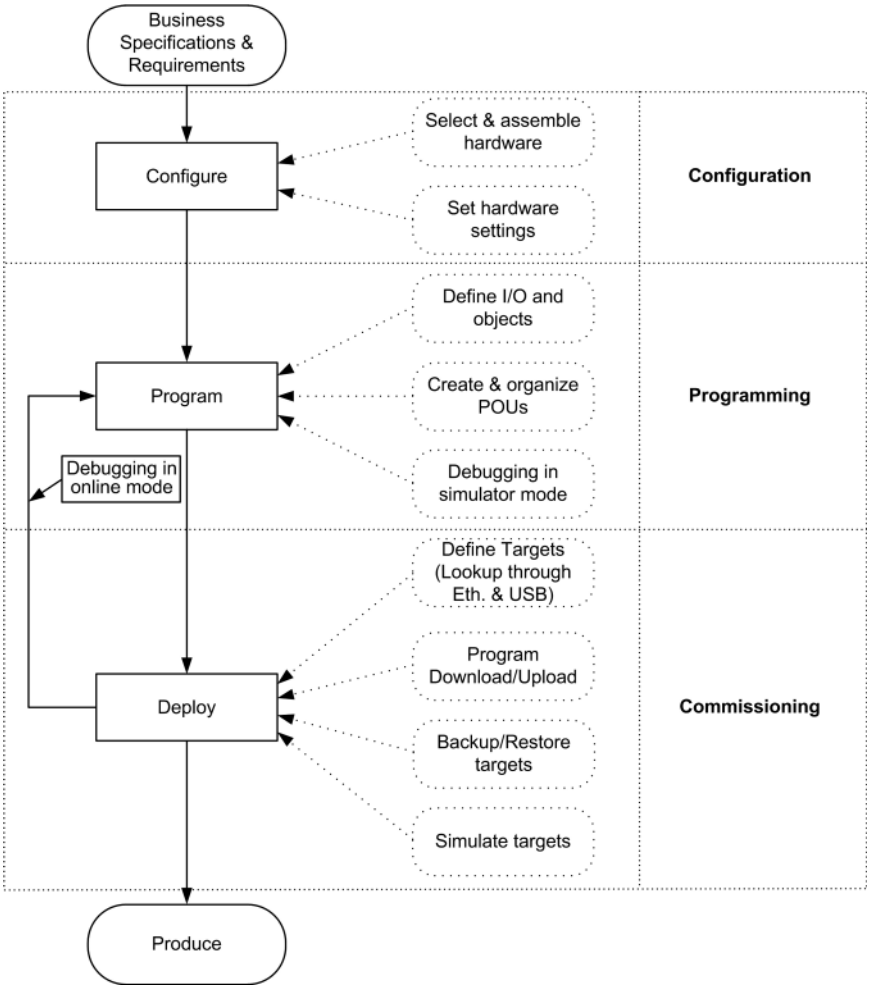
EcoStruxure Machine Expert - Basic uses the following terms:

- **Project**: An EcoStruxure Machine Expert - Basic project contains details about the developer and purpose of the project, the configuration of the logic controller and associated expansion modules targeted by the project, the source code of a program, symbols, comments, documentation, and other related information.
- **Application**: Contains the parts of the project that are downloaded to the logic controller, including the compiled program, hardware configuration information, and non-program data (project properties, symbols, and comments).
- **Program**: The compiled source code that runs on the logic controller.
- **POU** (program organization unit): The reusable object that contains a variable declaration and a set of instructions used in a program.

Developing Programs With EcoStruxure Machine Expert - Basic

Introduction

The following diagram shows the typical stages of developing a project in EcoStruxure Machine Expert - Basic (the **Configuration**, **Programming** and **Commissioning** tabs):



Navigating Within EcoStruxure Machine Expert - Basic

Module Areas

Once you have selected a project to work with, EcoStruxure Machine Expert - Basic displays the main window.

At the top of the main window, a toolbar, page 28 contains icons that allow you to perform common tasks, including opening the **Start Menu**.

Next to the toolbar, the status bar, page 30 displays informational messages about the state of the connection to the logic controller.

Below this, the main window is divided into a number of *modules*. Each module controls a different stage of the development cycle, and is accessible by clicking a tab at the top of the module area. To develop an application, work your way through the modules from left to right:

- **Properties**, page 37

  Set up the project properties
- **Configuration**, page 42

  Define the hardware configuration of the logic controller and associated expansion modules
- **Programming**, page 44

  Develop your program in one of the supported programming languages
- Display (see Modicon M221, Logic Controller, Programming Guide)

  Build an operator interface for the TMH2GDB Remote Graphic Display module
- **Commissioning**, page 158

  Manage the connection between EcoStruxure Machine Expert - Basic and the logic controller, upload/download applications, test, and commission the application.

Operating Modes

Introduction

The operating modes provide control to develop, debug, monitor, and modify the application when the controller is connected or not connected to EcoStruxure Machine Expert - Basic.

EcoStruxure Machine Expert - Basic can operate in the following modes:

- Offline mode
- Online mode
- Simulator mode

Offline Mode

EcoStruxure Machine Expert - Basic operates in offline mode when no physical connection to a logic controller has been established.

In offline mode, you configure EcoStruxure Machine Expert - Basic to match the hardware components you are targeting, then develop your application.

Online Mode

EcoStruxure Machine Expert - Basic operates in online mode when a logic controller is physically connected to the PC.

In online mode, you can proceed to download your application to the logic controller (downloading and uploading application is not possible in the simulator mode because the application is saved in the simulated logic controller). EcoStruxure Machine Expert - Basic then synchronizes the application in the PC memory with the version stored in the logic controller, allowing you to debug, monitor, and modify the application.

You can modify certain elements of a program in online mode. For example, you can add or delete rungs, or modify the values of certain function block parameters.

NOTE: Online program modifications are subjected to the predefined configuration. See Memory Management. Refer to Debugging in Online Mode, page 149 for more information.

Simulator Mode

EcoStruxure Machine Expert - Basic operates in simulator mode when a connection has been established with a simulated logic controller. In simulator mode, no physical connection to a logic controller is established; instead EcoStruxure Machine Expert - Basic simulates a connection to a logic controller and the expansion modules to run and test the program.

For more information, refer to EcoStruxure Machine Expert - Basic Simulator, page 177.

The Start Menu

What's in This Chapter

Introduction to the Start Menu

Overview

The **Start Menu** has the following items:

- **New Project**

  To create a new project.
- **Open Project**, page 23

  To open an existing project.
- **Compare Projects**

  To compare the project to a saved project.
- **Templates**, page 26

  To create a new project using an example project as a template.
- **Help**, page 26

  To display the online help, related documents, training materials, and tutorials.
- **Recent projects**

  To open a recent project.
- **About**

  To display information about EcoStruxure Machine Expert - Basic.
- **Exit**

  To exit from EcoStruxure Machine Expert - Basic.

Registering the EcoStruxure Machine Expert - Basic Software

Overview

You can use the EcoStruxure Machine Expert - Basic software for 30 days before you are required to register the software. When you register, you receive an authorization code to use the software.

Registering your EcoStruxure Machine Expert - Basic software entitles you to receive technical support and software updates.

Registering

To register your EcoStruxure Machine Expert - Basic software:

Step	Action
1	In the **Start Menu**, click **About** > **Register now**.
2	Follow the instructions on the Registration Wizard. Click the **Help** button for more details.

Open Project Window

Overview

Use the **Projects** window to create a new EcoStruxure Machine Expert - Basic project or to open an existing EcoStruxure Machine Expert - Basic, TwidoSoft, or TwidoSuite project to work with.

The right-hand area of the **Projects** window contains links to additional useful information.

Opening an EcoStruxure Machine Expert - Basic Project File

Follow these steps to open a project file:

Step	Action
1	Click the **Start Menu**.
2	Do one of the following: • Click a recent project in the **Recent projects** list. • Click **Open project** and select an existing EcoStruxure Machine Expert - Basic project file (*.smbp) or a sample project file (*.smbe).
3	**Case 1** Optionally, in case the project encryption password is active, a window appears: 1. Type the **encryption password**. 2. Click **Apply** 3. To allow project modifications in the case that the modification password is active: a. Click on the **Properties** tab. **Result:** A window asking you to enter the password appears. b. Type the **modification password**. c. Click **Apply**. **Result**: The project file opens and the **Configuration** tab is displayed. **Case 2** If an error icon is displayed on the **Properties** tab, it means that the project that you want to open was password-protected in a previous version of EcoStruxure Machine Expert - Basic with **View and Download** selected: 1. Click **Properties tab > Project Protection**. 2. Click on the **Properties** tab. 3. Type a password to encrypt the project. You must encrypt the project to be allowed to save it. 4. Click **Apply**. **Case 3** If the **Error** window appears, it means that the project that you want to open was password-protected in a previous version of EcoStruxure Machine Expert - Basic with **Download only** selected: 1. Click **OK** **Result:** The **Properties** tab is displayed. 2. Click **Project Protection**. 3. Click , then enter the **encryption password**. 4. If you want to remove the project protection, select **Inactive** and click **Apply**. If you want to keep the project protection, type the **encryption password**. 5. Click **Apply**.

Opening a TwidoSuite or TwidoSoft Project File

EcoStruxure Machine Expert - Basic allows you to open applications created for Twido programmable controllers and convert them to EcoStruxure Machine Expert - Basic project files.

Follow these steps to open a TwidoSuite or TwidoSoft project file:

Step	Action
1	Click **Open Project** on the **Start Menu**.
2	Click **Open an existing project**, select any of the following in the **Files of type** list, and then browse and select an existing project with respective extension: • TwidoSuite Project Files (*.xpr) • Twido Archive Project Files (*.xar) • TwidoSoft Project Files (*.twd) If the selected Twido project file is open in TwidoSoft, TwidoSoft locks the project file and it is not possible to open it in EcoStruxure Machine Expert - Basic. Close the project in TwidoSoft before opening it in EcoStruxure Machine Expert - Basic. **Result**: The selected project file opens and the **Configuration** tab is displayed.
3	A conversion report window appears. Thoroughly examine the conversion results in order to determine whether there are anomalies that resulted from converting from one controller platform to another. Refer to Converting Twido Projects to EcoStruxure Machine Expert - Basic for help on reconciling any such anomalies.
4	Optionally, change the M221 Logic Controller reference, page 43.

NOTE: TwidoSuite uses `%I0.0.1` (or `%I0.0.7`) as the Pulse input on the Very Fast Counter (%VFC) function block. In EcoStruxure Machine Expert - Basic the equivalent High Speed Counter (%HSC) function block uses `%I0.0` (or `%I0.6`). Make appropriate modifications to your applications after conversion.

In general, the conversion of other controller platforms to the M221 Logic Controller and EcoStruxure Machine Expert - Basic platform is supported to the limits of the differences between those platforms. Inevitably, you must reconcile manually those differences, such as that described in the note above.

⚠WARNING

UNINTENDED EQUIPMENT OPERATION

- Always verify that your application program operates as it did prior to the conversion, having all the correct configurations, parameters, parameter values, functions, and function blocks as required.
- Modify the application as necessary such that it conforms to its previous operation.
- Thoroughly test and validate the newly compiled version prior to putting your application into service.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Project Templates Window

Overview

You can use example projects to form the basis of new EcoStruxure Machine Expert - Basic projects.

Opening a Project Template

Follow these steps to create a new project based on a project template:

Step	Action
1	Select **Templates** on the **Start Menu**.
2	Use the **Search in templates** text field located in the upper left-hand corner of the window to search for projects. As you type, EcoStruxure Machine Expert - Basic searches in the project name, the description of the project available in the lower of the window, and the project properties, page 37. A list of matching projects appears as you type. Select a project template file (*.smbe) in the **Projects** list and click **Open Template**. **Result**: A new project is created as a copy of the selected template. For projects that have a help file linked to the project template, click the **Open Associated Help** button for an **Open associated help** to be opened. If available, the option is highlighted below the **Projects** list. **NOTE:** EcoStruxure Machine Expert - Basic also provides a Vijeo-Designer application file and a System User Guide for some example projects. Read the description of the selected project in the **Description** area to know whether these files are provided with your project or not. If these files are provided, click **Open associated folder** to browse through the project template files (*.smbe) and Vijeo-Designer application files (*.vdz) in Windows Explorer.

Help Window

Overview

This window contains links to additional EcoStruxure Machine Expert - Basic resources:

- The EcoStruxure Machine Expert - Basic online help system
- Related PDF documents, such as System User Guides (SUGs), training materials, Instruction Sheets, and descriptions of example applications
- Tutorials
- Information for converting Twido applications for use with EcoStruxure Machine Expert - Basic.

Developing EcoStruxure Machine Expert - Basic Applications

What's in This Part

The EcoStruxure Machine Expert - Basic Window

What's in This Chapter

Toolbar Buttons

Introduction

The toolbar appears at the top of the EcoStruxure Machine Expert - Basic window to provide an access to frequently-used functions.

Toolbar

The toolbar has the following buttons:

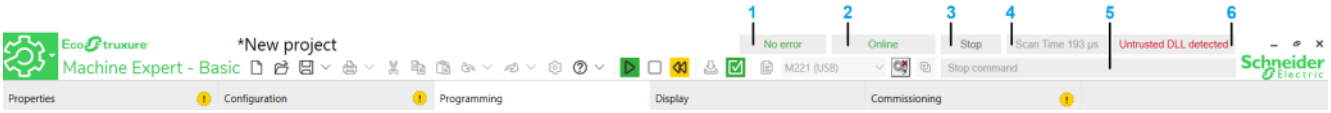
Icon	Description
	Open the Start Menu.
	Create a new project (CTRL+N)
	Open an existing project (CTRL+O)
	Save the project (CTRL+S). Click the down arrow to display a menu with additional options.
	Print a report (CTRL+P). Click the down arrow to select the report to print, page 35 or to configure the report content and format, page 36.
	Cut (CTRL+X)
	Copy (CTRL+C)
	Paste (CTRL+V)
	Undo (CTRL+Z). Click once to undo the most recent action in the program editor. Click the down arrow and select an action from the list to undo all actions up to and including the selected action. You can undo up to 10 actions.
	Redo (CTRL+Y). Click once to cancel the most recent Undo action. Click the down arrow and select an action from the list to redo all actions up to and including the selected action. You can redo up to 10 actions.
	Display the System Settings, page 32 window.

Icon	Description
	Click the down arrow and select an action from the list. Display online help or contextual help, view templates, release notes, and tutorials, or contact Schneider Electric technical support.
	Start the logic controller (CTRL+M). Only available in online mode and when the controller is not already in the *RUNNING* state.
	Stop the logic controller (CTRL+L). Only available in online mode and when the controller is in the *RUNNING* state.
	Initialize the logic controller. Only available in online mode.
	Compile the program.
	Enable (default) automatic program validation; the application is continuously verified for errors and a corresponding message is displayed. Automatic program validation is activated when either the Compile  or Login  button is pressed. Click to disable automatic validation. The icon changes to  . When disabled, instructions in the program are not automatically validated. This can improve the performance of the Ladder editor for large applications. **NOTE:** Automatic program validation cannot be disabled when in online mode or when writing to the SD card.
	Launch the Trace window. **NOTE:** Only available when all the following conditions apply: • A logic controller is connected or the simulator is running. • An animation table is active in the lower part of the **Programming** tab. • At least one object in the animation table has the **Trace** option selected.
	Log in (CTRL+G) to or log out (CTRL+H) from the selected controller. **NOTE:** The name of the selected controller appears to the left of this button.
	Launch (CTRL+B) or stop (CTRL+W) the EcoStruxure Machine Expert - Basic simulator, page 177.

Status Area

Overview

The status area at the top of the main window displays information on the present system status:



1 Program status: Indicates whether:

- The program has detected errors
- The program is incomplete
- The program is under validation

2 Connection status: Indicates the connection status between EcoStruxure Machine Expert - Basic and either the logic controller or the simulated logic controller.

3 Controller status: Indicates the present state of the logic controller (*RUNNING*, *STOPPED*, *HALTED*, and so on).

4 Scan time: Indicates the last scan time.

5 Controller last error detected: Indicates the most recent error detected. Information is extracted from the system bits and system words if the logic controller is in *STOPPED* or *HALTED* state.

6 Untrusted DLL detected: Indicates that DLL verification, page 32 is active and detected an issue.

Status Area Messages

The following messages can appear in the status area:

Message Type	Possible Message	Description
Program status	**[No error]**	No error is detected in the program.
	[Program advisory(ies) detected]	Program is incomplete.
	[Program error(s) detected]	No program or the program contains detected error(s).
	[Validating program nn%]	Program is under validation (nn% indicates the validated program percentage).
Connection status	**[Not connected]**	EcoStruxure Machine Expert - Basic is running in offline mode.
	[Online]	EcoStruxure Machine Expert - Basic is running in online mode.
Controller status (only in online mode)	**[Not Connected]**	Controller is not connected to EcoStruxure Machine Expert - Basic.
	[Halted]	Controller is in *HALTED* state. Controller is stopped due to an application error being detected.
	[Stop]	Controller is in *STOPPED* state. Controller has a valid application which is stopped.
	[Run]	Controller is in *RUNNING* state. Controller is executing the application.
	[Powerless]	Controller is in *POWERLESS* state. Controller is powered only by the USB cable and is ready to download/ upload the firmware by USB.
	[Firmware download]	Controller is downloading the firmware.
	[Firmware Error]	Firmware error detected. Version of the firmware downloading to the controller is older than present firmware version.
	[No Application]	Controller has no application.
	[Power Up]	Controller is starting (*BOOTING*).
Scan time (only in online mode)	**[Scan Time 0 µs]**	The most recent scan time in microseconds.
Controller last detected error (only in online mode)	**[No error(s) detected]**	No system error detected in the controller.
	[Controller could not switch to RUNNING state]	Controller is not OK to run.
	[Battery level low]	Controller battery is low.
	[Run/Stop input]	Controller is stopped due to Run/Stop input command.
	[Stop command]	Controller is stopped due to stop command.
	[Software error detected (exceeding the controller scan)]	Controller is halted due to software detected error. Controller scan time overshoot. Controller scan time is greater than the period defined by the application.
	[Stop due to detected hardware error]	Controller is stopped due to detected error in the hardware.
	[Power outage]	Controller is stopped due to power outage.
	[Controller is configured in 'Start in Stop' mode]	Controller does start in automatic application execution mode due to configuration of the startup behavior.
	[Init command]	Initialization in cold start.
	[Unknown stop reason: {0}]	Indeterminable error detected.

Refer to the programming guide of the logic controller for a complete list of the system bits and system words.

System Settings

Overview

This window allows you to set the language of the EcoStruxure Machine Expert - Basic software, configure DLL verification, customize the Ladder editor, and choose the default logic controller that appears on the **Configuration** tab when you create a new project.

Changing the User Interface Language

Follow these steps to change the user interface language:

Step	Action
1	Choose **System Settings** > **General** on the **System Settings** window.
2	Select the language to use in the **Language** list. The default language is English.
3	Click **Apply** and close the **System Settings** window.
4	Close and restart EcoStruxure Machine Expert - Basic to view the user interface in the new language.

Configuring DLL Verification

Each time EcoStruxure Machine Expert - Basic is launched, Dynamic Link Library (DLL) verification is performed to detect potential security threats.

If modifications to Schneider Electric-certified DLLs are detected, the message **Untrusted DLL detected** appears in the status area.

Proceed as follows to configure the response:

Step	Action
1	Choose **System Settings** > **General** on the **System Settings** window.
2	Choose the **Verification level**: • **Silent**. EcoStruxure Machine Expert - Basic ignores the potential threat and starts up as normal. • **Advisory** (default). A popup window is displayed for each detected threat and you can choose to either continue launching EcoStruxure Machine Expert - Basic, or to exit immediately. • **Error**. A popup window is displayed and you must exit immediately.
3	Click **Apply** and close the **System Settings** window.

Changing Shortcuts for Help

Follow these steps to change the keyboard shortcut to access contextual or general help:

Step	Action
1	Choose **System Settings** > **General** on the **System Settings** window.
2	Select **F1** or **Shift + F1** for contextual help. The shortcut for **General help** is automatically updated.

Customizing Auto-Save

Follow these steps to change project auto-saving:

Step	Action
1	Choose **System Settings** > **General** on the **System Settings** window.
2	To activate **Automatic project backup**, click **Yes** and set interval delay (in minutes). To deactivate **Automatic project backup**, click **No**.
3	Click **Apply** and close the **System Settings** window.

NOTE: In case of unintentional closing of EcoStruxure Machine Expert - Basic, backup projects are available to be reopened when EcoStruxure Machine Expert - Basic is started again.

Multiple Data Properties Views

Follow these steps to display multiple data properties views in the lower part of the **Programming** tab:

Step	Action
1	Choose **System Settings** > **General** on the **System Settings** window.
2	To activate the **Support multiple windows** option, click **Yes**. Up to 3 properties windows can be opened and displayed simultaneously. To deactivate the **Support multiple windows** option, click **No**. Only one data properties window can be displayed (the default).

Configuring the Simulator

Follow these steps to configure the simulator:

Step	Action
1	Choose **System Settings** > **General** on the **System Settings** window.
2	Enter the new value for **Ethernet port**. **Result:** The Modbus server of the simulator monitors using this port.

Customizing the Ladder Editor

Follow these steps to customize the Ladder editor:

Step	Action
1	Choose **System Settings** > **Ladder Editor** on the **System Settings** window.
2	Choose the **Grid lines style** for the Ladder editor. • **Dots** (default) • **Dashed Lines** • **Lines**
3	Set the **Number of columns** (11...30) for the cells in the Ladder editor. The default value of number of cells is 11. For more information, refer to Programming Principles for Ladder Diagrams, page 114.
4	Set the **Rung cache size** (25…200) to define the number of rendered rungs in memory. The default cache size is 25 rungs. Larger cache sizes help improve rung loading experience but uses more memory resources.
5	Under **Tool Selection Conservation**, select: • **Keep selected tool**: After selecting and placing a graphic element in a rung, the most recently selected graphic element remains selected. This allows you to place the same element in a rung again without reselecting it. Press the ESC key or right-click an empty cell in the rung to select the pointer tool  . • **Reset to pointer**: (default) After selecting and placing a contact or a coil in a rung on a new or unmodified installation, the pointer tool  is automatically selected. To insert the same contact or coil element again, select it in the toolbar.
6	Choose the **Shortcuts and toolbar style** setting for the Ladder Editor: • **Machine Expert - Basic set** (default) • **Asian set 1** • **Asian set 2** • **European set** • **American set** For the selected style, the table displays a list of keyboard shortcuts for each of the toolbar buttons displayed.
7	Click **Apply** and close the **System Settings** window to view the changes in the Ladder editor.

Choosing a Default Logic Controller

Follow these steps to choose a default logic controller:

Step	Action
1	Choose **System Settings** > **Configuration** on the **System Settings** window.
2	Click **Preferred controller** and choose a logic controller from the list.
3	Click **Apply** and close the **System Settings** window.
4	Close and restart EcoStruxure Machine Expert - Basic to view the new default logic controller in the **Configuration** tab when a new project is created.

Print Reports

Presentation

You can generate customizable reports to print or to save in PDF format on the PC.

The **Print** button provides the following options:

- **Print Project Report** to print a customized report which can include the listing of the hardware components, the application architecture and the contents of the project, program, and application.
- **Print Bill Of Material** to print a listing of the hardware components used in the project configuration.
- **Settings** to customize the project report, allowing you to select which elements to include and the page layout.

Printing the Project Report

To print the project report:

Step	Action
1	Click the down arrow to the right of the **Print** button  on the toolbar and choose the **Print Project Report** menu command, or press CTRL+P. The **Print Preview** window is displayed.
2	• Click  on the toolbar of the **Print Preview** window to print the project report. • Click  on the toolbar of the **Print Preview** window to save the project report as a PDF file on the PC.

Printing the Bill Of Material

To print the **Bill Of Material**:

Step	Action
1	Click the down arrow to the right of the **Print** button  on the toolbar and choose the **Print Bill Of Material** menu command. The **Print Preview** window is displayed.
2	• Click  on the toolbar of the **Print Preview** window to print the **Bill Of Material**. • Click  on the toolbar of the **Print Preview** window to save the **Bill Of Material** as a PDF file on the PC.

Customizing the Project Report

To select which items to include in the project report and configure its layout:

Step	Action
1	Click the down arrow to the right of the **Print** button  on the toolbar and choose the **Settings** menu command. The **Settings** window is displayed.
2	Click the **Report** node to configure the format settings of the report (paper size, margins, and orientation).
3	Select the items to include in the project report: • **Description** is the project description as in the **Project Information** window. • **Bill Of Material** is the listing of the hardware components used in the project configuration. • **Hardware Configuration** is a listing of the hardware devices used in the configuration: ◦ **IO Bus** is a list of the I/O expansion modules used. ◦ **Cartridges** is a list of the cartridges used. ◦ **Bus Coupler** is a list of the TM3 Bus Couplers used. • **Software Configuration** is to include/exclude the following items: ◦ **Constant words** is a list of constant word (%KW) objects used in the project. ◦ **Network objects** is a list of objects used to communicate with Ethernet/IP or Modbus TCP devices. ◦ **Software Objects** lists the software objects used in the program, such as timers and counters. ◦ **Drives** lists Drive objects used in the program. ◦ **PTO objects** lists PTO function blocks used in the program. ◦ **Communication Objects** lists the communication objects used in the program. • **Program** is to include/exclude the following items: ◦ **Behavior** is the settings configured in the **Behavior** window. ◦ **Memory consumption** is the amount of controller memory used by the application, program, and associated user data. ◦ **Application architecture** is the settings configured in the **Master Task** and **Periodic Task** windows. ◦ **POU** is a listing of the POUs used in the program. • **Display** is a report section containing information about the Remote Graphic Display: ◦ **General properties** is the general parameters that appear on the **Display** tab. There is an option to print the password in your report. ◦ **Alarm View** displays a list of triggered alarms. ◦ **Pages** is a list of operator interface pages created on the **Display** tab. • **Symbols** is a list of all symbols or of the symbols used in the project. • **Cross-reference** is a table containing the used addresses, objects, rungs, and the line of code in which they are used. • **Animation table** is a table containing the objects added to animation tables in the project.
4	Close the window.

Properties

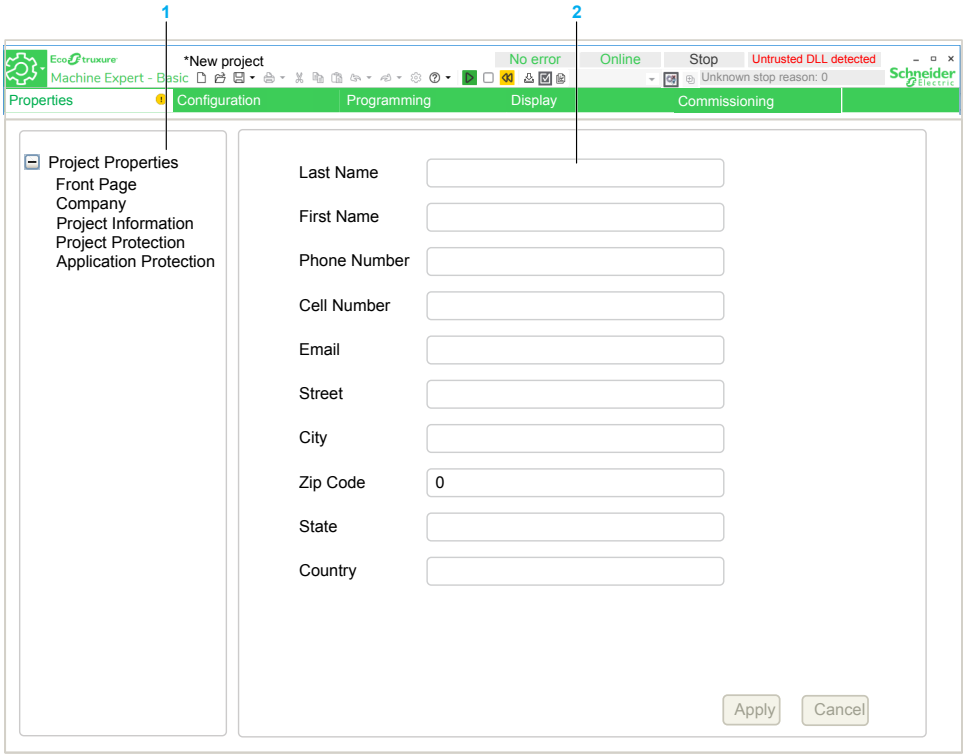
What's in This Chapter

The Properties Window

Overview

The **Properties** tab allows you to specify information about the project and whether it is to be password-protected:

- Details about the developer and the company developing the project.
- Information about the project itself.
- If the project is to be password protected, the password that must be entered correctly to open the project in EcoStruxure Machine Expert - Basic.
- If the application stored in the logic controller is to be password protected, the password that must be entered correctly to upload the application into an EcoStruxure Machine Expert - Basic project.



1 The left hand area displays a list of the available properties.

2 The right hand area displays the properties of the item that is selected in the left hand area.

Project Properties

Overview

Use the **Properties** window to provide details about the user of EcoStruxure Machine Expert - Basic, the company developing the application, and the project. In this window, you can also password protect the project file and the application when stored in the logic controller.

Specifying Application Developer Properties

To specify the application developer properties:

Step	Action
1	Display the **Properties** tab and click **Project Properties** > **Front Page**.
2	Complete the information.
3	Click **Apply**.

NOTE: This information appears in the Windows Explorer properties window when you right-click on an EcoStruxure Machine Expert - Basic project file.

Specifying Company Properties

To specify the company properties:

Step	Action
1	Display the **Properties** tab and click **Project Properties** > **Company**.
2	Complete the information. To upload the company logo image, click **Change** then browse to select the file to upload. Click **Remove** to delete the current image.
3	Click **Apply**.

Specifying Project Information

To specify project information:

Step	Action
1	Display the **Properties** tab and click **Project Properties** > **Project Information**.
2	Complete the information. To upload an image, such as a photograph or CAD image of the instrumented machine, click **Change** then browse to select the file to upload. Click **Remove** to delete the current image.
3	Click **Apply**.

Password-Protecting a Project

It is possible to encrypt and password-protect a project file.

If a project is encrypted, you are prompted for the **encryption password** whenever you try to open the project.

If the project is protected against modifications, by default you can only view the project. To modify the project, type the **modification password**.

Follow these steps to encrypt and password-protect a project file:

Step	Action
1	Display the **Properties** tab and click **Project Properties** > **Project Protection**.
2	Select the **Active** option. Required items of information are marked with an asterisk (*).
3	Type the password and type it again as confirmation to encrypt the project.
4	Optionally, type a password and the confirmation to protect the project from modifications.
5	Click **Apply**.

If you want to prevent a program from being modified, create an encrypted and password-protected project file and then restore it to controller, page 171.

Removing Password Protection from a Project

Follow these steps to remove password protection from a project:

Step	Action
1	Display the **Properties** tab and click **Project Properties** > **Project Protection**.
2	Select the **Inactive** option.
3	Click **Apply**. **NOTE:** If prompted to provide the **modification password**, type it and click **Apply**.

Password Protecting an Application

EcoStruxure Machine Expert - Basic allows an application stored in the logic controller to be protected with a password. This password controls uploading of the application from the logic controller into an EcoStruxure Machine Expert - Basic project.

Follow these steps to read-protect an application:

Step	Action
1	Display the **Properties** tab and click **Project Properties** > **Application Protection** > **Read protection**.
2	Choose the level of read protection: • Select **Active** and leave **Password** blank to disable application upload from the logic controller to the PC. • Select **Active** and type the same password in the **Password** and **Confirmation** fields to password protect the application. You must then enter this password when prompted before uploading the application from the logic controller to the PC.
3	Click **Apply**.

⚠WARNING

UNAUTHORIZED DATA ACCESS

- Do not expose the device or device network to public networks and the Internet as much as possible.
- Immediately change the default password to a new secure password.
- Do not distribute passwords to unauthorized or otherwise unqualified personnel.
- Restrict access to unauthorized personnel.
- Use additional security layers like VPN for remote access and install firewall mechanisms.
- Validate the effectiveness of these measurements regularly and frequently.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

NOTE: A secure password is one that has not been shared or distributed to any unauthorized personnel and does not contain any personal or otherwise obvious information. Further, a mix of upper and lower case letters and numbers offer greater security. You should choose a password length of at least ten characters.

Removing Read Protection from an Application

Follow these steps to remove password protection from an application:

Step	Action
1	Display the **Properties** tab and click **Project Properties** > **Application Protection** > **Read protection**.
2	Select the **Inactive** option.
3	Click **Apply**.

Restricting Modifications of an Application

EcoStruxure Machine Expert - Basic allows an application stored in the logic controller to be protected by restricting changes and/or modifications. This restriction controls modifying the logic controller application or downloading of a new application from EcoStruxure Machine Expert - Basic into the logic controller.

Follow these steps to restrict changes to an application:

Step	Action
1	Display the **Properties** tab and click **Project Properties** > **Application Protection** > **Write protection**.
2	Choose the level of write protection: • Select **Active** and leave **Password** blank to disable application download or modification from EcoStruxure Machine Expert - Basic into the logic controller. • Select **Active** and type the same password in the **Password** and **Confirmation** fields to password protect any application modification. You must then enter this password when prompted before modifying the application in the logic controller or downloading an application into the logic controller.
3	Click **Apply**.

Removing Modification Protection of an Application

Follow these steps to remove modification protection of an application:

Step	Action
1	Display the **Properties** tab and click **Project Properties** > **Application Protection** > **Write protection**.
2	Select the **Inactive** option.
3	Click **Apply**.

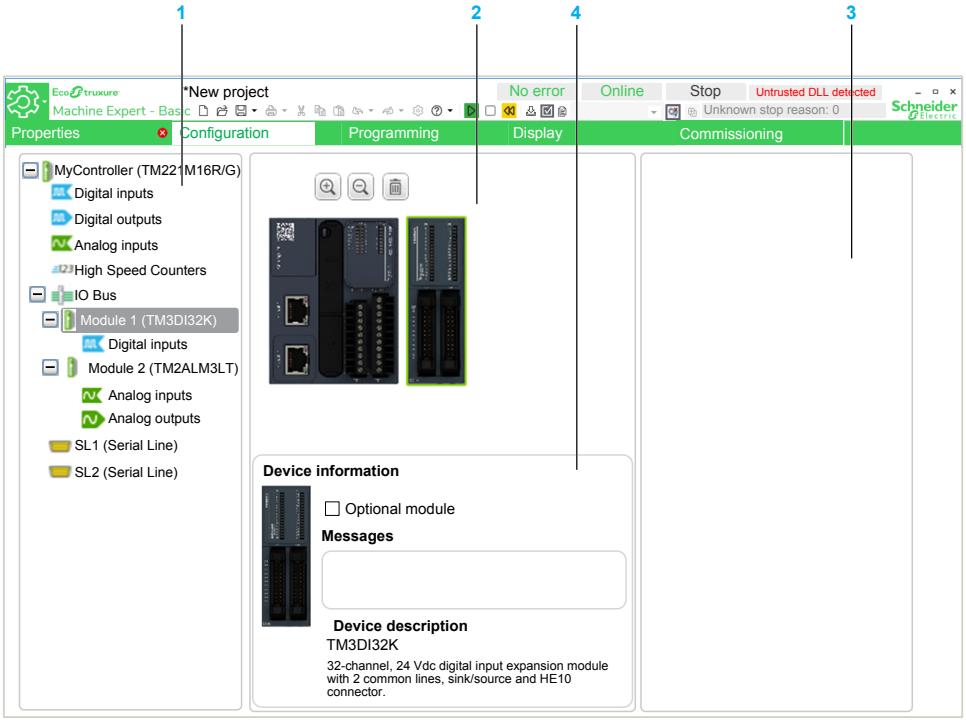
Configuration

What's in This Chapter

Overview of the Configuration Window

Introduction

Use the **Configuration** window to recreate the hardware configuration of the logic controller and expansion modules to be targeted by the program.



1 The Hardware Tree - a structured view of the hardware configuration.

2 The configuration - a logic controller and expansion modules.

3 Catalog references of the supported logic controller and expansion module hardware components. To add a component to the hardware configuration, drag and drop it onto the configuration.

4 The properties of the component selected in the configuration, or the properties of the selected item in the Hardware Tree.

Building a Configuration

Replacing the Default Logic Controller

When you create a new EcoStruxure Machine Expert - Basic project, a logic controller reference appears in the central area of the **Configuration** window.

Step	Action
1	Click the **Configuration** tab.
2	Expand the logic controller category in the catalog area on the right, if it is not already displayed.
3	Select a logic controller reference. A short description of the physical properties of the logic controller appear in the **Device description** area.
4	Drag the logic controller reference over the image of the existing logic controller in the central area of the window and drop it.
5	Click **Yes** when prompted to confirm replacing the logic controller reference.

NOTE: The default controller reference is specified in the **System Settings** window, page 32.

Configuring the Logic Controller

Use the **Configuration** window to configure the logic controller.

Refer to the *Programming Guide* of the logic controller used in the configuration for details.

Configuring Expansion Modules

Use the **Configuration** window to add and configure expansion modules.

Refer to the *Programming Guide* of the expansion module used in the configuration for details.

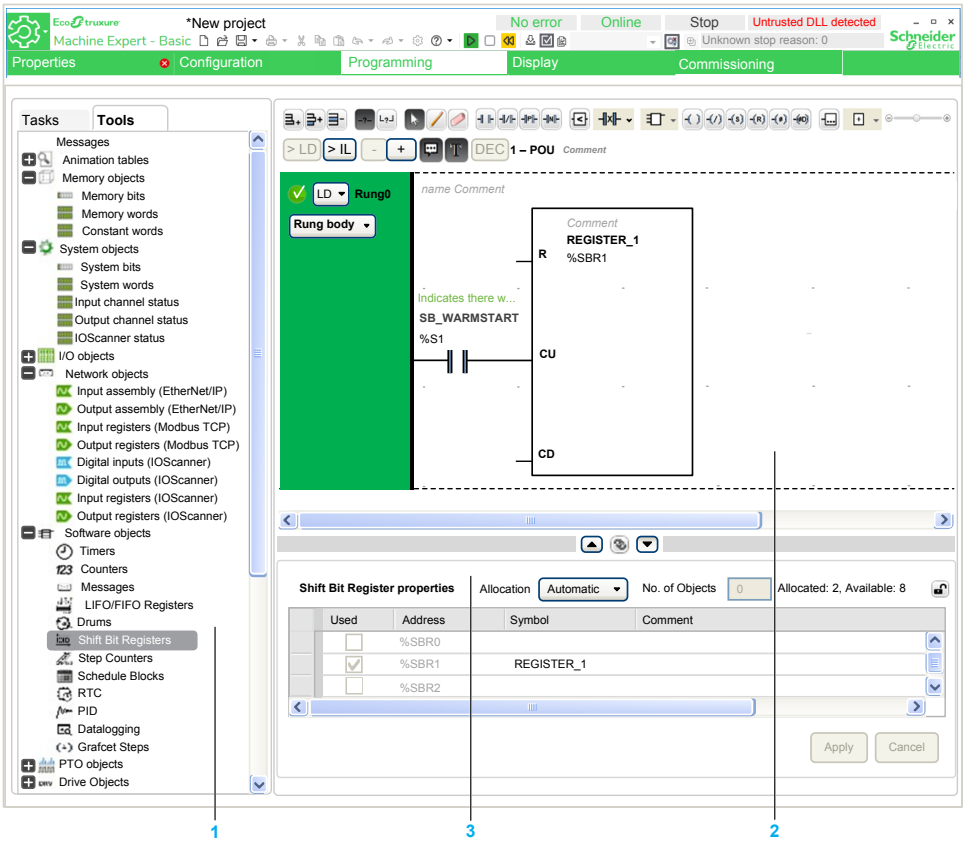
Programming

What's in This Chapter

Overview of the Programming Workspace

Overview

The **Programming** tab is split into 3 main areas:



1 The Programming Tree allows you to select the properties of the program and its objects, and functions, as well as a number of tools which you can use to monitor and debug the program.

2 The upper central area is the programming workspace where you enter the source code of your program.

3 The lower central area allows you to view and configure the properties of the item selected in the programming workspace or the Programming Tree.

Special Functions

Objects

Overview

In EcoStruxure Machine Expert - Basic, the term *object* is used to represent an area of logic controller memory reserved for use by an application. Objects can be:

- Simple software variables, such as memory bits and words
- Addresses of digital or analog inputs and outputs
- Controller-internal variables, such as system words and system bits
- Predefined system functions or function blocks, such as timers and counters.

Controller memory is either pre-allocated for certain object types, or automatically allocated when an application is downloaded to the logic controller.

Objects can only be addressed by a program once memory has been allocated. Objects are addressed using the prefix *%*. For example, *%MW12* is the address of a memory word, *%Q0.3* is the address of an embedded digital output, and *%TM0* is the address of a *Timer* function block.

Symbolic Addressing

Introduction

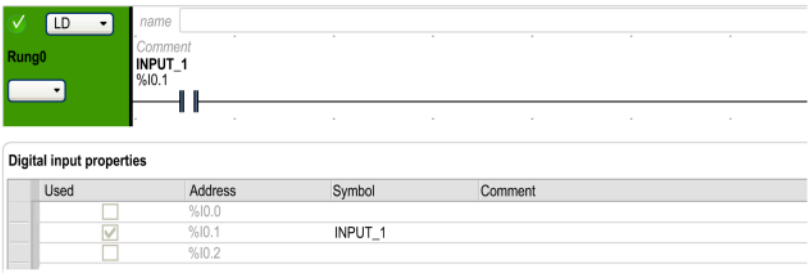
EcoStruxure Machine Expert - Basic supports the symbolic addressing of language objects; that is, the indirect addressing of objects by name. Using symbols allows for quick examination and analysis of program logic, and simplifies the development and testing of an application.

Example

For example, `WASH_END` is a symbol that could be used to identify an instance of a *Timer* function block representing the end of a wash cycle. Recalling the purpose of this name is easier than trying to remember the role of a program address such as `%TM3`.

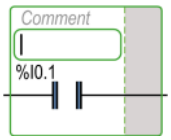
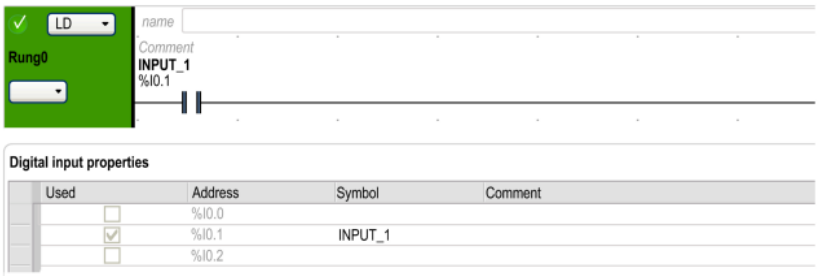
Defining a Symbol in the Properties Window

To define a symbol in the properties window:

Step	Action
1	Select the **Tools** tab in the left-hand area of the **Programming** window.
2	Select the type of object with which to define a symbol, for example **I/O objects > Digital inputs**, to display the properties of digital inputs. The properties window of the object type appears in the lower central area of the **Programming** window.
3	Double-click in the **Symbol** column of the properties table and type the symbol to define for a particular item, for example `Input_1` for the input `%I0.2` 
4	Click **Apply**.

Defining a Symbol in the Ladder Editor

To define a symbol within the Ladder editor:

Step	Action
1	In the Ladder editor, click the **Symbol** line of a graphic element, for example a latch or function block. A cursor appears: 
2	Type the symbol to use, for example `Input_1` and press **Enter**. The following rules apply to symbols: • A maximum of 32 characters. • Letters (A-Z), numbers (0-9), or underscores (_). • First character must be a letter. You cannot use the percentage sign (%). • Symbols are not case-sensitive. For example, `Pump1` and `PUMP1` are the same symbol and can only be used uniquely for any given object; that is, you cannot assign the same symbol to different objects.
3	If the graphic element is not yet associated with an object, the **Remark** window appears. Select an object to associate with the symbol and click **OK**. Otherwise, click **Yes** when prompted to associate the symbol with the object.
4	Double-click either the symbol or object of the graphic element to display the symbol in the **Symbol** column of the properties window: 

Displaying All Defined Symbols

Choose **Tools > Symbol list** to display a list of all defined symbols, page 107.

Storing Symbols

Symbols are a part of non-program data. They are stored in the logic controller as part of an EcoStruxure Machine Expert - Basic application.

Memory Allocation

Introduction

EcoStruxure Machine Expert - Basic allows you to pre-allocate (reserve) blocks of logic controller memory for use by certain object types used in a program, including simple objects (memory words, constant words) and software objects (function blocks).

Allocation Modes

In offline mode, you can specify the memory allocation mode for each object type. When configuring these objects (**Programming > Tools**), the following window then appears above the list of configurable objects:

Choose the memory allocation mode to use:

- **Automatic**. All objects from offset 0 to the highest memory address used in the program, or associated with a symbol, are automatically allocated in logic controller memory. For example: if the memory word `%MW20` is used in the program, all objects from `%MW0` to `%MW20` inclusive (21 objects) are automatically allocated in memory.

  If you later switch to online mode, you cannot allocate new memory objects with addresses higher than the highest address that was used before you went online.
- **Manual**. Specify a number of objects to be allocated in memory in the **No. of Objects** box. When you switch to online mode, you can add new contacts, coils, or equations in your program (up to the limit of memory allocated) without having to log out from the logic controller, modify the program, log in, and download the application again.

  EcoStruxure Machine Expert - Basic displays the number of objects you specified.

EcoStruxure Machine Expert - Basic displays the total number of **Allocated** memory objects and the number of memory objects **Available** in the logic controller.

If you specified the number of objects, only these objects appear in the table.

To use the multi-operand instructions, 20 `%MW` are needed and another 20 `%MW` if using the periodic task.

Ladder/List Reversibility

Introduction

EcoStruxure Machine Expert - Basic supports conversion of rungs from Ladder Diagram to Instruction List and from Instruction List back to Ladder Diagram. This is called *program reversibility*.

In EcoStruxure Machine Expert - Basic, you can toggle rungs between programming languages at any time as required. You can therefore display a program with some rungs in Ladder Diagram and other rungs in Instruction List.

> **NOTE:** You cannot convert Ladder and Instruction List programs to Grafcet (SFC), or Grafcet (SFC) programs to Ladder or Instruction List, or Grafcet (IL) to Grafcet (SFC).

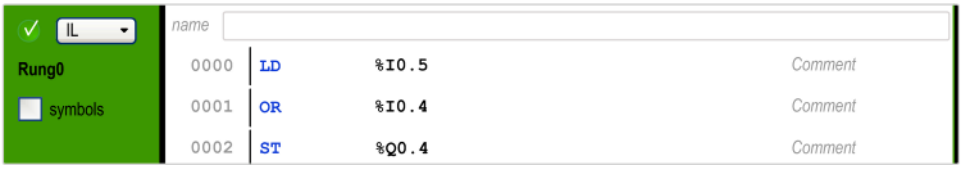
Understanding Reversibility

A key to understanding program reversibility is examining the relationship between a Ladder Diagram rung and the associated Instruction List rung:

- **Ladder Diagram rung**: A collection of Ladder Diagram instructions that constitute a logical expression.
- **List sequence**: A collection of Instruction List programming instructions that correspond to the Ladder Diagram instructions and represents the same logical expression.

The following illustration displays a common Ladder Diagram rung and its equivalent program logic expressed as a sequence of Instruction List instructions.

Equivalent Instruction List instruction:



A program is stored internally as Instruction List instructions, regardless of whether it is originally written in the Ladder Diagram or Instruction List language. EcoStruxure Machine Expert - Basic takes advantage of the program structure similarities between the 2 languages and uses this internal Instruction List image of the program to display it either as an Instruction List program, or graphically as a Ladder Diagram.

Instructions Required for Reversibility

The structure of a reversible function block in Instruction List language requires the use of the following instructions:

- *BLK* marks the block start, and defines the beginning of the rung and the start of the input portion to the block.
- *OUT_BLK* marks the beginning of the output portion of the block.
- *END_BLK* marks the end of the block and the rung.

The use of these reversible function block instructions is not mandatory for a properly functioning Instruction List program.

Programming Situations and IL/Ladder Reversibility

The following table lists programming situations for the Ladder or IL languages which, if left untreated, generate advisories or errors and a possible loss of reversibility.

Situation	IL	Ladder	Rung reversible
Jump to a label which has not been defined	Error	Error	Yes
Call to undefined subroutine	Error	Error	Yes
Activate or deactivate an undefined Grafcet step	Error	Error	Yes
Jump instruction between parentheses	Error	-	No
Label between parentheses	Error	-	No
Subroutine between parentheses	Error	-	No
More than 32 nested parentheses	Error	-	No
Closing parenthesis without opening parenthesis	Error	-	No
Unbalanced parentheses	Error	-	No
BLK without *END_BLK*	Error	-	No

Situation	IL	Ladder	Rung reversible
OUT_BLK or *END_BLK* without *BLK*	Error	-	No
Label definition not followed by *LD* or *BLK*	Error	-	No
Subroutine definition not followed by *LD* or *BLK*	Error	-	No
More than 11 nested *MPS*	Error	-	No
MRD without *MPS*	Error	-	No
MPP without *MPS*	Error	-	No
Use Grafcet instruction in *POST*	Error	Error	Yes
Grafcet definition not followed by *BLK* or *LD*	Error	-	No
Unbalanced stack operations	Error	-	No
Duplicate label	Error	Error	Only LD->IL
Duplicate Subroutine	Error	Error	Only LD->IL
Duplicate Grafcet step	Error	Error	Only LD->IL
Duplicate *POST*	Error	Error	Only LD->IL
Nested FB	Error	-	No
OUT_BLK between *BLK* and *END_BLK*	Error	-	No
BLK not followed by *LD*	Error	-	No
LD of FB output not in *OUT_BLK*	Error	-	No
FB outputs used outside their respective FB structure	Error	-	No
FB outputs repeated or out of order	Error	-	No
FB inputs not in *BLK* before *OUT_BLK*	Error	-	No
FB inputs used outside their respective FB structure	Error	-	No
FB inputs repeated or out of order	Error	-	No
Label declared in *BLK*	Error	-	No
Subroutines declared in *BLK*	Error	-	No
Grafcet steps declared in *BLK*	Error	-	No
Attempted *LD* of a non FB output in *OUT_BLK*	Error	-	No
FB output used between *BLK* and *END_BLK*	Error	-	No
Nested subroutines	Error	Error	No
Subroutine call between *MPS* and *MPP*	Error	Error	No
Subroutine call between parentheses	Error	-	No
First instruction of program not a rung delimiter	Error	-	No
Jump instruction between *MPS* and *MPP*	Error	Error	No
Rung contains syntax error	Error	-	No
Program instructions following *JMP* or *END* unconditional instructions	Error	-	No
Rung beginning with *LD* instruction does not terminate with a conditional action instruction	Advisory	-	No
Action instruction between parentheses	Error	-	No
Stack instruction between parentheses	Error	-	No
Direct-access instructions for FB (ex: *""CU %C0""*)	Advisory	-	No
Action instructions in the input section of a FB	Error	-	No
Instructions after *END_BLK*	Error	-	No
FB outputs used with *AND* and *OR* instructions	Advisory	-	No
OR instruction inside a FB output not between parentheses	Advisory	-	No