SIEMENS

SIMATIC

S7-1500

S7-1500 Automation system

System manual

Edition   02/2014

Answers for industry.

SIEMENS

SIMATIC

S7-1500
S7-1500 Automation System

System Manual

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Legal information

Warning notice system

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

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

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

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

NOTICE
indicates that property damage can result if proper precautions are not taken.

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

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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Disclaimer of Liability

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

Preface

Purpose of the documentation

This documentation provides important information on configuring, installing, wiring and commissioning the S7-1500 automation system.

Basic knowledge required

A basic knowledge of automation technology is required to understand the documentation.

Scope of validity of the documentation

This documentation applies to all products from the S7-1500 product family.

Conventions

STEP 7: In this documentation "STEP 7" is used as synonym for all versions of "STEP 7 (TIA Portal)" and the configuration and programming software.

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

The products can be recycled due to the low pollutant content of their components. For environmentally compliant recycling and disposal of your electronic waste, please contact a company certified for the disposal of electronic waste.

Additional support

- Information about technical support can be found in the appendix to this documentation.
- The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

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For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

Table of contents

Documentation guide

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Introduction

The documentation of the SIMATIC products has a modular structure and covers a range of topics concerning your automation system.

The complete documentation for the S7-1500 system consists of a system manual, function manuals and device manuals.

The STEP 7 information system (online help) also helps you to configure and program your automation system.

Overview of documentation for the S7-1500 automation system

The following tables list the documentation for the S7-1500 automation system.

Table 1- 1   System manual for the S7-1500 product family

Topic	Documentation	Most important contents
System description	S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning • Maintenance
Description of the SIMATIC Safety F-system	SIMATIC Industrial Software SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)	• Configuring • Programming • Approvals

Table 1- 2   Function manuals for the S7-1500 product family

Topic	Documentation	Most important contents
Analog value processing	Analog value processing (http://support.automation.siemens.com/WW/view/en/59193559)	• Basics of analog technology • Description / explanation of key topics, such as conversion and cycle time, basic and operational error limits, temperature sensors, connection of sensors in 2-, 3- and 4-conductor technology
Memory concept	Structure and use of the CPU memory (http://support.automation.siemens.com/WW/view/en/59193101)	• Structure • Application
System diagnostics	System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Hardware/software diagnostics evaluation
Motion Control	S7-1500 Motion Control (http://support.automation.siemens.com/WW/view/en/59381279)	• Basics • Configuring
Communication	Communication (http://support.automation.siemens.com/WW/view/en/59192925)	• Basics of communication
	PROFIBUS with STEP 7 (http://support.automation.siemens.com/WW/view/en/59193579)	• PROFIBUS basics • PROFIBUS functions • PROFIBUS diagnostics
	PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856)	• PROFINET basics • PROFINET functions • PROFINET diagnostics
	Communications module PtP - Configurations for point-to-point links (http://support.automation.siemens.com/WW/view/en/59057093)	• Basics • Functions • Operation
	Web server (http://support.automation.siemens.com/WW/view/en/59193560)	
Counting and measuring	Counting and measuring (http://support.automation.siemens.com/WW/view/en/59709820)	• Counting and measuring basics

Topic	Documentation	Most important contents
Designing interference-free controllers	Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection • Housing selection
Cycle and reaction times	Cycle and reaction times (http://support.automation.siemens.com/WW/view/en/59193558)	• Basics • Calculations

Table 1- 3   Manuals for the S7-1500 product family

Topic	Documentation	Most important contents
CPU	CPU 1511-1 PN (http://support.automation.siemens.com/WW/view/en/68020492)	• Block diagram • Wiring • Parameter assignment/addressing • Interrupts, diagnostics, error, and system messages • Technical specifications • Dimension drawings
	CPU 1513-1 PN (http://support.automation.siemens.com/WW/view/en/59186494)	
	CPU 1515-2 PN (http://support.automation.siemens.com/WW/view/en/81162167)	
	CPU 1516-3 PN/DP (http://support.automation.siemens.com/WW/view/en/59191914)	
	CPU 1518-4 PN/DP (http://support.automation.siemens.com/WW/view/en/81164632)	
	CPU 1516F-3 PN/DP (http://support.automation.siemens.com/WW/view/en/56926947/133200)	
	CPU 1518F-4 PN/DP (http://support.automation.siemens.com/WW/view/en/56926947/133200)	
Digital modules	DQ 32x24VDC/0.5A BA digital output module (http://support.automation.siemens.com/WW/view/en/83500404)	
	DQ 16x24VDC/0.5A BA digital output module (http://support.automation.siemens.com/WW/view/en/83500415)	
	DQ 32x24VDC/0.5A ST digital output module (http://support.automation.siemens.com/WW/view/en/59193400)	

Topic	Documentation	Most important contents
	DQ 16x24VDC/0.5A ST digital output module (http://support.automation.siemens.com/WW/view/en/59193401)	
	DQ 8x230VAC/2A ST digital output module (http://support.automation.siemens.com/WW/view/en/59193088)	
	DQ 8x230VAC/5A ST digital output module (http://support.automation.siemens.com/WW/view/en/59192915)	
	DQ 8x24VDC/2A HF digital output module (http://support.automation.siemens.com/WW/view/en/59193089)	
	DI 16x24VDC BA digital input module (http://support.automation.siemens.com/WW/view/en/83501190)	
	DI 32x24VDC BA digital input module (http://support.automation.siemens.com/WW/view/en/83499481)	
	DI 16x230VAC BA digital input module (http://support.automation.siemens.com/WW/view/en/59193398)	
	DI 16x24VDC HF digital input module (http://support.automation.siemens.com/WW/view/en/59193001)	
	DI 16x24VDC SRC BA digital input module (http://support.automation.siemens.com/WW/view/en/59191844)	
	DI 32x24VDC HF digital input module (http://support.automation.siemens.com/WW/view/en/59192896)	
	DI 16x24VDC/DQ 16x24VDC/0.5A BA digital input/output module (http://support.automation.siemens.com/WW/view/en/83501523)	
Analog modules	AQ 8xU/I HS analog output module (http://support.automation.siemens.com/WW/view/en/59193551)	
	AQ 4xU/I ST analog output module (http://support.automation.siemens.com/WW/view/en/59191850)	
	AI 8xU/I HS analog input module (http://support.automation.siemens.com/WW/view/en/59193206)	
	AI 8xU/I/RTD/TC ST analog input module (http://support.automation.siemens.com/WW/view/en/59193205)	

Topic	Documentation	Most important contents
Communication modules	CM PtP RS232 BA communication module (http://support.automation.siemens.com/WW/view/en/59057152)	
	CM PtP RS232 HF communication module (http://support.automation.siemens.com/WW/view/en/59057160)	
	CM PtP RS422/485 BA communication module (http://support.automation.siemens.com/WW/view/en/59057390)	
	CM PtP RS422/485 HF communication module (http://support.automation.siemens.com/WW/view/en/59061372)	
	CM 1542-1 communication module (http://support.automation.siemens.com/WW/view/en/80582078)	
	CM 1542-5 communication module (http://support.automation.siemens.com/WW/view/en/67746513)	
	CM 1542-5 communication module (http://support.automation.siemens.com/WW/view/en/78355628)	
	CM 1543-1 communication module (http://support.automation.siemens.com/WW/view/en/67653729)	
Technology modules	TM Count 2x24V technology module (http://support.automation.siemens.com/WW/view/en/59193105)	
	TM PosInput2 technology module (http://support.automation.siemens.com/WW/view/en/61777657)	
System power supplies	PS 25W 24V DC power supply module (http://support.automation.siemens.com/WW/view/en/59193552)	
	PS 60W 24/48/60V DC power supply module (http://support.automation.siemens.com/WW/view/en/59192919)	
	PS 60W 120/230V AC/DC power supply module (http://support.automation.siemens.com/WW/view/en/59193004)	
Load power supplies	PM 70 W 120/230VAC (http://support.automation.siemens.com/WW/view/en/68036174)	
	PM 190 W 120/230 VAC (http://support.automation.siemens.com/WW/view/en/68022506)	

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

CAx-Download-Manager

With the CAx-Download-Manager you generate your own CAx data types for your individual shopping cart. Select the necessary help for your process from the Siemens CAx data types in order to allow easy use in your CAD or CAE system. You will find the CAx Download Manager on the Internet (http://www.siemens.com/automation/service&support).

Product overview

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2.1   What is the S7-1500 Automation System?

Introduction

The SIMATIC S7-1500 is the further development of the SIMATIC S7-300 and S7-400 automation systems.

Through the integration of numerous new performance features, the S7-1500 automation system offers the user excellent operability and the highest performance.

The new performance features are:

- Increased system performance
- Integrated Motion Control functionality
- PROFINET IO IRT
- Integrated display for machine-oriented operation and diagnostics
- STEP 7 language innovations with retention of proven functions

Field of application

The S7-1500 automation system offers the required flexibility and performance for high bandwidth controller applications in machine and plant design. The scalable configuration allows you to adapt your control system to the specific local requirements.

The S7-1500 automation system complies with IP20 degree of protection and is intended for installation in a control cabinet.

Configuration

The S7-1500 automation system is installed on a mounting rail and can comprise up to 32 modules. The modules are connected to each other with U connectors.

Configuration example

The following figure shows a configuration example of an S7-1500 automation system.
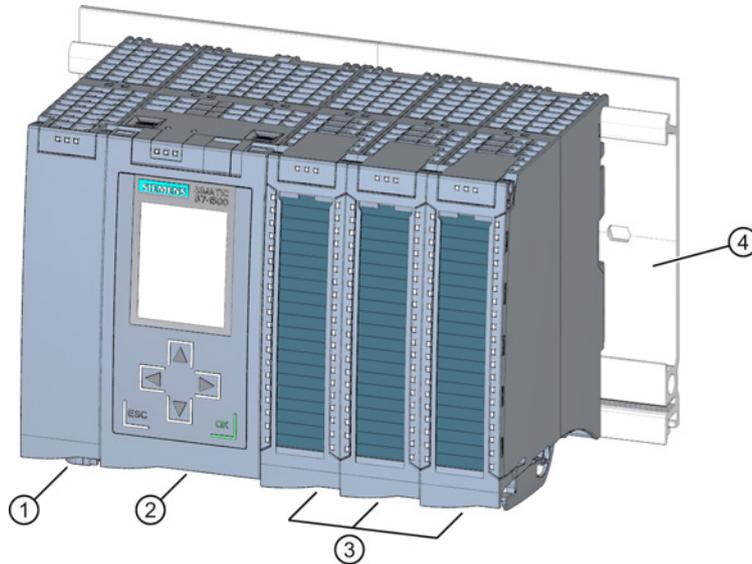
① System power supply module
② CPU
③ I/O modules
④ Mounting rail with integrated top-hat rail profile

Figure 2-1   Example configuration of an S7-1500 automation system

2.2 Components

Components of the S7-1500 automation system

The following table provides an overview of the most important components of the S7-1500 automation system:

Table 2- 1   Components of the S7-1500 automation system

Components	Function	Diagram
Mounting rail	The mounting rail is the rack of the S7-1500 automation system. Additional components (modules from the S7-1200 and ET 200SP ranges, terminals, circuit breakers, small contactors or similar components) can be mounted directly on the integrated standard mounting rail in the lower part of the mounting rail. You can use the entire length of the mounting rail in the assembly (marginless assembly). The mounting rails may be ordered as accessories (Page 212).	
PE connection element for mounting rail	The set of screws is threaded into the mounting rail's T-profile groove, and is required for grounding the mounting rail. The set of screws is contained in the scope of delivery of the mounting rails in the standard lengths (160 to 830 mm), and may be ordered as an accessory (Page 212).	
System power supply (PS)	The system power supply is a diagnostics-capable power supply module, that can be connected with the backplane bus using a U connector. A system power supply is required, if the power fed from the CPU into the backplane bus is not sufficient to supply the connected modules with power. System power supplies are available in various models: • PS 25W 24V DC • PS 60W 24/48/60V DC • PS 60W 120/230V AC/DC A power cable connector with coding element and a U connector are included in the scope of delivery of the system power supply, and may be ordered as a spare part (Page 212).	
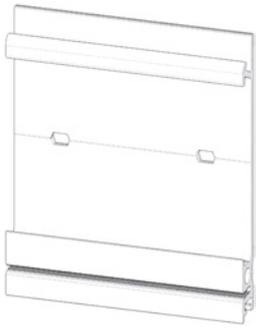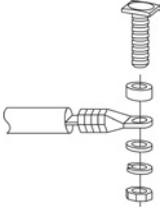
Components	Function	Diagram
CPU	The CPU executes the user program and uses the integrated system power supply to supply the electronics of the modules via the backplane bus. Further features and functions of the CPU: • Communication via Ethernet • Communication via PROFIBUS / PROFINET • HMI communication • Integrated web server • Integrated technology • Integrated system diagnostics • Integrated Industrial Security functions • Safety mode (CPU 1516F-3 PN/DP and CPU 1518F-4 PN/DP)	
I/O module	The I/O modules form the interface between the controller and the process. The controller detects the current process state via the connected sensors and actuators, and triggers the corresponding reactions. I/O modules are classified into the following types of modules: • Digital input (DI) • Digital output (DQ) • Digital input/Digital output (DIQ) • Analog input (AI) • Analog output (AQ) • Technology module (TM) • Communication module (CM) • Communication processor (CP) A U connector is included in the scope of delivery for each I/O module.	
U connector	The modules of the S7-1500 automation system are connected using the U connector. The U connector provides the mechanical and electrical connection between the modules. The U connector is included in the scope of delivery of all modules (exception: CPU) and may be ordered as a spare part (Page 212).	
Front connectors	The purpose of the front connectors is to wire the I/O modules. The front connectors for technology and analog modules must be supplemented with a shielding bracket, power supply element, and shielding clamp. These components are included in the scope of delivery of the technology and analog modules, and may be ordered as accessories (Page 212). The front connectors are available for 35 mm modules with screw terminals and push-in terminals and for 25 mm modules with push-in terminals. Four potential bridges and one cable tie are included in the scope of delivery of the front connectors for 35 mm modules. The front connectors for 25 mm modules have no potential bridges.	

Components	Function	Diagram
Potential bridges for front connector	Two terminals can be bridged with potential bridges. The potential bridges are included in the scope of delivery of the front connector, and may be ordered as a spare part (Page 212). The front connectors for 25 mm modules have no potential bridges. Therefore, you should also observe the information in the manual for the respective analog module.	
Shielding bracket	The shielding bracket is an insertable bracket for modules with EMC-critical signals (e.g., analog modules, technology modules), and (together with the shielding clamp) permits the low impedance application of shielding with minimal installation times. The shielding bracket is included in the scope of delivery of the analog and technology modules, and may be ordered as an accessory (Page 212).	
Shield clamp	The shield clamps are used to attach cable shielding to the shielding bracket. The shield clamp is included in the scope of delivery of the analog and technology modules, and may be ordered as an accessory (Page 212).	
Power supply element	The power supply element is inserted in the front cable connector, and serves to supply power to modules with EMC-critical signals (analog modules, technology modules). The power supply element (connection technology: screw terminal) is included in the scope of delivery of the analog and technology modules, and may be ordered as an accessory (Page 212).	
Labeling strips for the exterior of the front cover of the I/O modules	You can insert labeling strips for the system-specific labeling of modules. You can label the labeling strips using a machine. The labeling strips are available in various colors. The labeling strips are included in the scope of delivery of the I/O modules. Additional labeling strips may be ordered as Accessories (Page 212).	

Components	Function	Diagram
4-pole connection plug for supply voltage of the CPU	In the delivery condition of each CPU a 4-pole connection plug is plugged on the CPU.	
Load current supply (PM)	The system power supply (PS), central modules (CPU), input and output circuits of the I/O modules are supplied with 24 VDC through the load current supply (PM). A load current supply does not occupy a slot in the configuration and is not included in the system diagnostics. If you are using load current supplies, we recommend the devices from our SIMATIC series. These devices can be mounted on the mounting rail. The load current supply can be configured using STEP 7. Load current supplies are available in various models: • PM 70W 120/230V AC • PM 190W 120/230V AC	
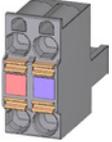
2.3   Properties

Introduction

The most important properties of the S7-1500 automation system are described in the following tables.

Properties of the configuration

Table 2- 2   Properties of the configuration

Properties of the configuration	Explanation
Scalable configuration	• Space-saving because modules can be installed in any order • Configuration over the entire length of the mounting rail (marginless assembly possible) • Significant reduction of configuration and documentation effort
Wide range of modules	• Universal and flexible area of application
Configuration with U connectors	• Fast and simple connection of the modules • Simple extension of the system configuration
Realization of power segments	• Simple system extension by the insertion of additional system power supplies

Properties of the connection system

Table 2- 3   Properties of the connection system

Properties of the connection system	Explanation
Twistable front connector	• Rapid module exchange during maintenance (cable duct remains closed)
Pre-wiring position	• More user-friendly, because the module wiring is easily accessible • No loosening of the wiring when replacing a module • No electrical damage to the module is possible, because it is not yet electrically connected
Development of potential groups by the insertion of potential bridges	• Reduced wiring effort on the front cable connector
Integrated EMC concept (power supply element, shielding bracket, and terminal element)	• Reduction of the interference emission and optimization of the interference immunity
Two snap-in positions of the front cover	• Flexible cable storage space
Automatic coding of the I/O modules and front cable connectors	• Safe replacement of modules
Large label	• Sufficient space for clear identification and user-specific labeling, e.g. symbolic addresses

Module overview

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The following tables summarize the essential properties of the available modules. This overview should make it easier for you to select the module that is suited to your task.

3.1 Central processing units

Overview of properties

The tables below show the essential properties of the central processing units (CPUs).

Table 3- 1   Central processing units (CPUs with small display)

Part number:	6ES7511-1AK00-0AB0	6ES7513-1AL00-0AB0
Short description	CPU 1511-1 PN	CPU 1513-1 PN
Supply voltage, permissible range	19.2 VDC to 28.8 VDC	19.2 VDC to 28.8 VDC
Number of blocks	2000	2000
Data work memory	1 MB	1.5 MB
Code work memory	150 KB	300 KB
Interfaces	1 x PROFINET IO (2-port switch)	1 x PROFINET IO (2-port switch)
Number of PROFINET ports	2	2
Web server supported	Yes	Yes
Isochronous operation supported	Yes	Yes

Table 3- 2   Central processing units (CPUs with large display)

Part number:	6ES7515-2AM00-0AB0	6ES7516-3AN00-0AB0	6ES7518-4AP00-0AB0
Short description	CPU 1515-2 PN	CPU 1516-3 PN/DP	CPU 1518-4 PN/DP
Supply voltage, permissible range	19.2 VDC to 28.8 VDC	19.2 VDC to 28.8 VDC	19.2 VDC to 28.8 VDC
Number of blocks	6000	6000	6000
Data work memory	3 MB	5 MB	10 MB
Code work memory	500 KB	1 MB	3 MB
Interfaces	1 x PROFINET IO (2-port switch) 1 x PROFINET	1 x PROFINET IO (2-port switch) 1 x PROFINET 1 x PROFIBUS	1 x PROFINET IO (2-port switch) 2 x PROFINET 1 x PROFIBUS
Number of PROFINET ports	3	3	4
Web server supported	Yes	Yes	Yes
Isochronous operation supported	Yes	Yes	Yes

Reference

You can find additional information on the technical specifications of the CPUs in the respective manuals.

3.2 Digital input modules

Overview of properties

The table below shows the essential properties of the digital input modules.

Table 3- 3   Digital input modules (35 mm)

Part number:	6ES7521-1BH00-0AB0	6ES7521-1BL00-0AB0	6ES7521-1BH50-0AA0	6ES7521-1FH00-0AA0
Short description	DI 16x24VDC HF	DI 32x24VDC HF	DI 16x24VDC SRC BA	DI 16x230VAC BA
Number of inputs	16	32	16	16
Electrical isolation between channels	No	Yes	No	Yes
Number of potential groups	1	2	1	4
Rated input voltage	24 VDC	24 VDC	24 VDC	120/230 VAC
Diagnostics interrupt	Yes	Yes	No	No
Hardware interrupt	Yes	Yes	No	No
Isochronous operation supported	Yes	Yes	No	No
Input delay	0.05 ms to 20 ms	0.05 ms to 20 ms	3 ms	25 ms

Table 3- 4   Digital input modules (25 mm)

Part number:	6ES7521-1BL10-0AA0	6ES7521-1BH10-0AA0
Short description	DI 32x24VDC BA	DI 16x24VDC BA
Number of inputs	32	16
Electrical isolation between channels	Yes	No
Number of potential groups	2	1
Rated input voltage	24 VDC	24 VDC
Diagnostics interrupt	No	No
Hardware interrupt	No	No
Isochronous operation supported	No	No
Input delay	1.2 ms to 4.8 ms	1.2 ms to 4.8 ms

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

3.3   Digital output modules

Overview of properties

The table below shows the essential properties of the digital output modules.

Table 3- 5   Digital output modules (35 mm)

Part number:	6ES7522-1BH00-0AB0	6ES7522-1BL00-0AB0	6ES7522-1BF00-0AB0
Short description	DQ 16x24VDC/0.5A ST	DQ 32x24VDC/0.5A ST	DQ 8x24VDC/2A HF
Number of outputs	16	32	8
Type	Transistor	Transistor	Transistor
Electrical isolation between channels	Yes	Yes	Yes
Number of potential groups	2	4	2
Rated output voltage	24 VDC	24 VDC	24 VDC
Rated output current	0.5 A	0.5 A	2 A
Diagnostics interrupt	Yes	Yes	Yes
Isochronous operation supported	Yes	Yes	No

Table 3- 6   Digital output modules (35 mm)

Part number:	6ES7522-5HF00-0AB0	6ES7522-5FF00-0AB0
Short description	DQ 8x230VAC/5A ST	DQ 8x230VAC/2A ST
Number of outputs	8	8
Type	Relay	Triac
Electrical isolation between channels	Yes	Yes
Number of potential groups	16	8
Relay coil supply voltage	24 VDC	---
Rated output voltage	230 VAC	230 VAC
Rated output current	5 A	2 A
Diagnostics interrupt	Yes	No
Isochronous operation supported	No	No

Table 3- 7   Digital output modules (25 mm)

Part number:	6ES7522-1BL10-0AA0	6ES7522-1BH10-0AA0
Short description	DQ 32x24VDC/0.5A BA	DQ 16x24VDC/0.5A BA
Number of outputs	32	16
Type	Transistor	Transistor
Electrical isolation between channels	Yes	Yes
Number of potential groups	4	2
Rated output voltage	24 VDC	24 VDC
Rated output current	0.5 A	0.5 A
Diagnostics interrupt	No	No
Isochronous operation supported	No	No

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

3.4 Digital input/output module

Overview of properties

The table below shows the most important properties of the digital input/output module.

Table 3- 8   Digital input/output module 25 mm

Part number:	6ES7523-1BL00-0AA0
Short description	DI 16x24VDC / DQ16x24V/0.5A BA
DI	
Number of inputs	16
Electrical isolation between channels	No
Number of potential groups	1
Rated input voltage	24 VDC
Diagnostics interrupt	No
Hardware interrupt	No
Isochronous operation supported	No
Input delay	1.2 ms to 4.8 ms
DQ	
Number of outputs	16
Type	Transistor
Electrical isolation between channels	Yes
Number of potential groups	2
Rated output voltage	24 VDC
Rated output current	0.5 A
Diagnostics interrupt	No
Hardware interrupt	No
Isochronous operation supported	No

Reference

Additional information on the technical specifications of the module is available in the manual.

3.5 Analog input modules

Overview of properties

The table below shows the essential properties of the analog input modules.

Table 3- 9   Analog input modules

Part number:	6ES7531-7KF00-0AB0	6ES7531-7NF10-0AB0
Short description	AI 8xU/I/RTD/TC ST	AI 8xU/I HS
Number of inputs	8	8
Resolution	16 bits (including sign)	16 bits (including sign)
Measurement type	Voltage Current Resistor Thermal resistor Thermocouple	Voltage Current
Electrical isolation between channels	No	No
Rated supply voltage	24 VDC	24 VDC
Maximum potential difference between inputs (UCM)	10 VDC	10 VDC
Diagnostics interrupt	Yes, high and low limit	Yes, high and low limit
Hardware interrupt	Yes	Yes
Isochronous operation supported	No	Yes
Conversion time (per channel)	9/23/27/107 ms	125 µs, per module, regardless of number of activated channels

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

3.6 Analog output modules

Overview of properties

The table below shows the essential properties of the analog output modules.

Table 3- 10   Analog output modules

Part number:	6ES7532-5HD00-0AB0	6ES7532-5HF00-0AB0
Short description	AQ 4xU/I ST	AQ 8xU/I HS
Number of outputs	4	8
Resolution	16 bits (including sign)	16 bits (including sign)
Output type	Voltage Current	Voltage Current
Electrical isolation between channels	No	No
Rated supply voltage	24 VDC	24 VDC
Diagnostics interrupt	Yes	Yes
Isochronous operation supported	No	Yes

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

3.7 System power supply modules

Overview of properties

The table below shows the essential properties of the system power supply modules.

Table 3- 11   System power supply modules

Part number:	6ES7505-0KA00-0AB0	6ES7505-0RA00-0AB0	6ES7507-0RA00-0AB0
Short description	PS 25W 24V DC	PS 60W 24/48/60V DC	PS 60W 120/230V AC/DC
Rated input voltage	24 VDC	24 VDC, 48 VDC, 60 VDC	120 VAC, 230 VAC 120 VDC, 230 VDC
Output power	25 W	60 W	60 W
Electrical isolation from the backplane bus	Yes	Yes	Yes
Diagnostics interrupt	Yes	Yes	Yes

Reference

Further information on the technical specifications of the system power supply modules may be found in the respective product manuals.

3.8 Load current supply modules

Overview of properties

The table below shows the essential properties of the load current supplies.

Table 3- 12   Load current supply modules

Part number:	6EP1332-4BA00	6EP1333-4BA00
Short description	PM 70W 120/230V AC	PM 190W 120/230V AC
Rated input voltage	120/230 VAC, with automatic switchover	120/230 VAC, with automatic switchover
Output voltage	24 VDC	24 VDC
Rated output current	3 A	8 A
Power consumption	84 W	213 W

Reference

Further information on the technical specifications of the load current supply modules may be found in the respective manuals.

3.9　　　　Technology modules

Overview of properties

The table below shows the essential properties of the technology modules.

Table 3- 13　　Technology modules

Part number:	6ES7550-1AA0-0AB0	6ES7551-1AB00-0AB0
Short description	TM Count 2x24V	TM PosInput 2
Supported encoders	Incremental encoder for signals, 24 V asymmetric, Pulse encoder with/without direction signal, Pulse encoder up/down	Incremental encoder for signals to RS422 (5 V differential signal), Pulse encoder with/without direction signal, Pulse encoder up/down, Absolute encoder (SSI)
Max. count frequency	200 kHz 800 kHz with four-fold pulse	1 MHz 4 MHz with four-fold pulse
Integrated DI	3 DIs per counter channel for start, stop, capture, synchronization	2 DIs per counter channel for start, stop, capture, synchronization
Integrated DQ	2 DQs for comparators and limit values	2 DQs for comparators and limit values
Counting functions	Comparator, Adjustable counting range, Incremental position detection	Comparator, Adjustable counting range, Incremental and absolute position detection
Measuring functions	Frequency, Period, Velocity	Frequency, Period, Velocity
Diagnostics interrupt	Yes	Yes
Hardware interrupt	Yes	Yes
Isochronous operation supported	Yes	Yes

Reference

Further information on the technical specifications of the modules may be found in the respective manuals.

3.10 Communication modules

Overview of properties

The table below shows the essential properties of the communication modules.

Table 3- 14   Communication modules for point-to-point linking

Part number:	6ES7540-1AD00-0AA0	6ES7540-1AB00-0AA0	6ES7541-1AD00-0AB0	6ES7541-1AB00-0AB0
Short description	CM PtP RS232 BA	CM PtP RS422/485 BA	CM PtP RS232 HF	CM PtP RS422/485 HF
Interface	RS232	RS422/485	RS232	RS422/485
Data transmission rate	300 to 19 200 bps	300 to 19 200 bps	300 to 115 200 bps	300 to 115 200 bps
Frame length, max.	1 KB	1 KB	4 KB	4 KB
Diagnostics interrupt	Yes	Yes	Yes	Yes
Hardware interrupt	No	No	No	No
Isochronous operation supported	No	No	No	No
Supported protocols	Freeport, 3964 (R)	Freeport, 3964 (R)	Freeport, 3964 (R), Modbus RTU master, Modbus RTU slave	Freeport, 3964 (R), Modbus RTU master, Modbus RTU slave

Table 3- 15   Communication modules for PROFIBUS and PROFINET

Part number:	6GK7 542-1AX00-0XE0	6GK7542-5FX00-0XE0	6GK7542-5DX00-0XE0	6EGK543-1AX00-0XE0
Short description	CM 1542-1	CP 1542-5	CM 1542-5	CP 1543-1
Bus system	PROFINET	PROFIBUS	PROFIBUS	Industrial Ethernet
Interface	RJ45	RS485	RS485	RJ45
Data transmission rate	10/100 Mbps	9600 bps to 12 Mbps	9600 bps to 12 Mbps	10/100/1000 Mbps
Functionality and supported protocols	TCP/IP, ISO-on-TCP, UDP, S7 communication, IP-Broadcast/Multicast, SNMPv1	DPV1 master/slave, S7 communication, PG/OP communication	DPV1 master/slave, S7 communication, PG/OP communication, Open User communication	TCP/IP, ISO, UDP, S7 communication, IP-Broadcast/Multicast, Security, Diagnostics SNMPV1/V3, DHCP, FTP client/server, E-mail, IPV4/IPV6
Diagnostics interrupt	Yes	Yes	Yes	Yes
Hardware interrupt	Yes	Yes	Yes	No
Isochronous operation supported	No	No	No	No

Reference

> Further information on the technical specifications of the modules may be found in the respective manuals.

Application planning 4

4.1 Hardware configuration

Introduction

The configuration of an S7-1500 automation system consists of a single-row configuration, in which all modules are installed on a mounting rail. The modules are connected by means of U connectors, and thus form a self-assembling backplane bus.

Rule

An S7-1500 automation system consists of a maximum of 32 modules, which occupy slots 0 to 31. The S7-1500 automation system supports a single-row configuration in which all modules are installed on a mounting rail.
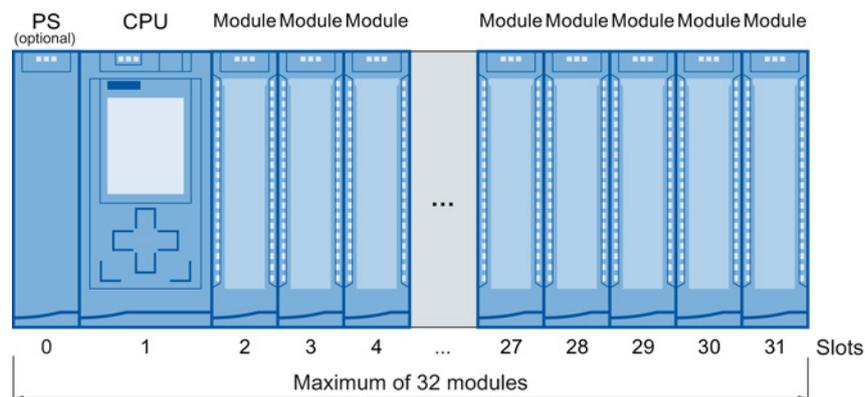
Figure 4-1   Configuration of an automation system with up to 32 modules

Note

Placing load current supplies

Load current supplies do not have a connection to the backplane bus of the S7-1500 automation systems and therefore do not use a configurable slot. Load current supplies can be mounted to the left or right of the configured setup. If you mount a load current supply on the right of the configured setup, the heat development of the load current supply may make a gap to the configured setup necessary. For additional information, refer to the relevant manuals. The number of load current supplies that can be used is unlimited.

Appropriate modules

The following table shows which modules may be used in the various slots:

Module type	Permissible slots	Maximum number of modules
System power supply (PS)	0; 2 - 31	3
CPU	1	1
I/O modules	2 - 31	30
Point-to-point modules	2 - 31	30
Technology modules	2 - 31	30
PROFIBUS/PROFINET modules:		
• When a CPU 1511-1 PN is used	2 - 31	4
• When a CPU 1513-1 PN is used	2 - 31	6
• When a CPU 1515-2 PN is used	2 - 31	6
• When a CPU 1516-3 PN/DP is used	2 - 31	8
• When a CPU 1518-4 PN/DP is used	2 - 31	8

Special feature of the load current supply

To supply 24 VDC to the described max. 32 modules and the input and output circuits, we recommend the load current supplies from the SIMATIC series PM 70W 120/230V AC or PM 190W 120/230V AC. The number of load current supplies is unlimited.

Load current supplies can be mounted on the "S7-1500 mounting rail" but do not have a connection to the backplane bus.

Observe the installation rules and specified installation distances in the manuals of the load current supplies.

Note

Alternative 24 V supply of the modules from the control cabinet

The modules can also be supplied with 24 VDC from the control cabinet provided a secure electrical isolation (SELV/PELV to IEC 60364-4-41) is ensured.

4.2 System and load power supply

In the S7-1500 automation system, you must make a distinction between two different power supplies:

● System power supply (PS)

The system power supply has a connection to the backplane bus (U-connector) and supplies solely the internally required system voltage for the backplane bus. This system voltage supplies parts of the module electronics and the LEDs. A system power supply can also supply CPUs or interface modules if these are not connected to a 24 VDC load current supply.

● Load current supply (PM)

The load current supply feeds the module's input and output electric circuits. In addition, you need a load current supply in order to supply the CPU and the system power supply with 24 VDC. The supply of the CPU with 24 VDC is optional if you supply the voltage for the backplane bus via a system power supply.

If you are using load current supplies, we recommend the devices from our SIMATIC series PM 70W 120/230V AC or PM 190W 120/230V AC. These devices can be mounted on the mounting rail.

The load current supplies listed below have been technically adapted especially to the S7-1500 automation system. Use of the listed load current supplies (PM 70W 120/230V AC and PM 190W 120/230V AC) is not imperative because a SITOP module, for example, can be used as an alternative.

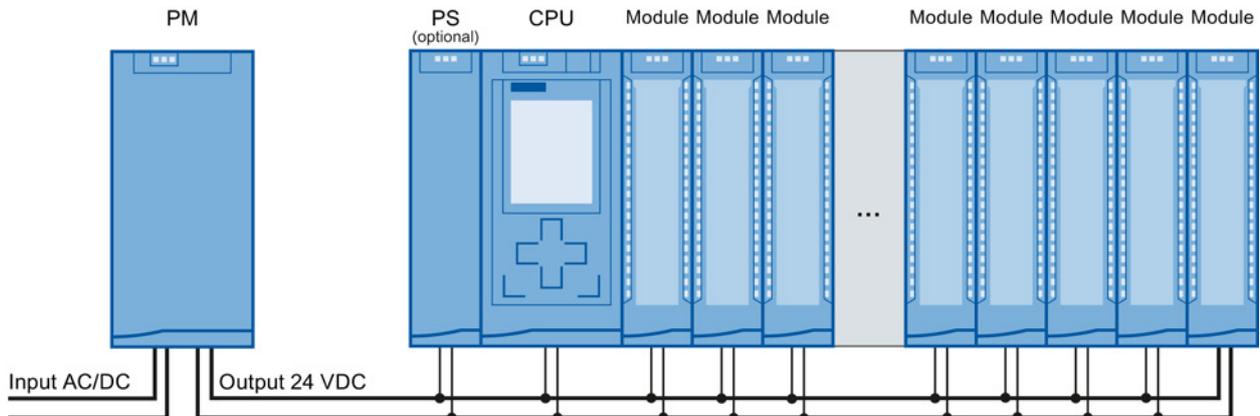Figure 4-2   Total configuration with load current supply (PM) and system power supply (PS)

Optionally, you can insert up to two system power supplies (PS) in the slots to the right of the CPU (power segments).

System power supplies

● PS 25W 24V DC: Supply with 24 VDC and 25 W of power

● PS 60W 24/48/60V DC: Supply with 24/48/60 VDC and 60 W of power

● PS 60W 120/230V AC/DC: Supply with 120/230 VAC and 60 W of power

Load power supplies

- PM 70W 120/230 V AC: Supply with 120/230 VAC and 70 W of power
- PM 190W 120/230 V AC: Supply with 120/230 VAC and 190 W of power

4.2.1 Use of system power supplies

System power supplies are required, if the power fed from the CPU into the backplane bus is not sufficient to supply all connected modules with power. In addition, you can use the system power supply with 120/230 VAC and supply the CPU through the backplane bus. The CPU then does not have to be supplied with 24 VDC.

Whether you need an additional system power supply for your configuration depends on the power that the modules consume from the backplane bus. The power provided by the CPU and the system power supplies via the backplane bus must be greater than the power required by the I/O modules.

When planning with STEP 7, the supplied and required power are compared. If the required power is too high, you receive a corresponding message from STEP 7.

Using system power supplies

The following slots may be used for system power supplies:

- A system power supply in slot 0 to the left of the CPU
- Up to 2 system power supplies in the slots to the right of the CPU (power segments)

Power segment

By using additional system power supplies on the right, next to the CPU, you divide the configuration into power segments.

Configuration variants

Figure 4-3   Configuration variants with 3 power segments
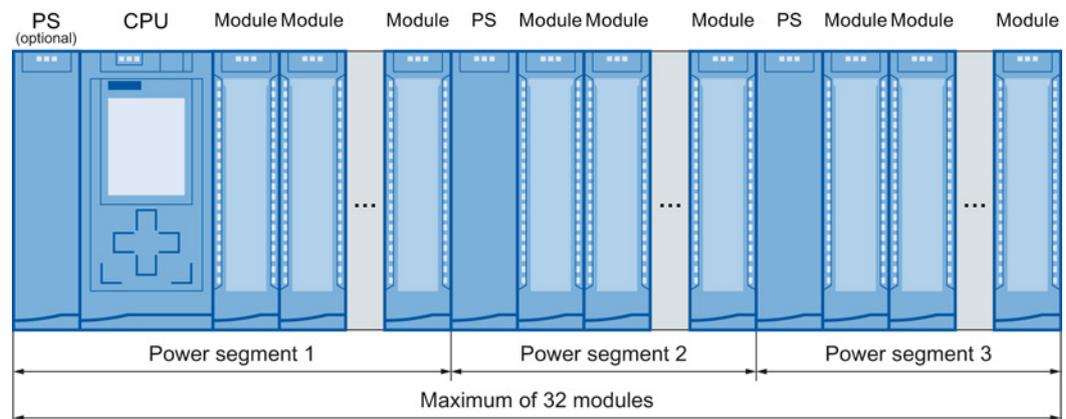
Reference

Information about the required cables is available in the section Power balance calculation (Page 43).

Further information on the performance values (power feed, power consumption) of the CPU, of the system power supply, and of the I/O modules can be found in the Manuals (http://support.automation.siemens.com/WW/view/en/57251228) of the respective modules.

4.2.2   Special considerations for the use of a system power supply in the first power segment

There are three options for the infeed of the required system voltage in the backplane bus:

- Infeed via CPU
- Infeed via CPU and system power supply
- Infeed via system power supply only

Infeed via CPU

Infeed via the CPU generally suffices for small and medium hardware configurations. The power consumption of the connected modules must not be greater than 10 or 12 W (depending on the CPU used).

In this configuration variant, supply the CPU with 24 VDC from a load current supply.

Parameter assignment of the CPU: In STEP 7, select the "Connection to supply voltage L+" option in the "Properties" tab in the "System power supply" area navigation so that STEP 7 can calculate the balance correctly.

Figure 4-4   Supply voltage via CPU only

Infeed via CPU and system power supply

For larger hardware configurations, infeed into the backplane bus by the CPU alone no longer suffices. If modules consume more than 10 or 12 W in total (depending on the CPU used), insert an additional system power supply.

Supply the system power supply with the permissible supply voltage and the CPU with 24 VDC from a load current supply.

Both the system power supply and the CPU feed current into the backplane bus. The supplied power is summed.

Power addition: "Infeed power of the system power supply" + "Infeed power of the CPU"

Parameter assignment of the CPU: In STEP 7, select the "Connection to supply voltage L+" option in the "Properties" tab in the "System power supply" area navigation so that STEP 7 can calculate the balance correctly.
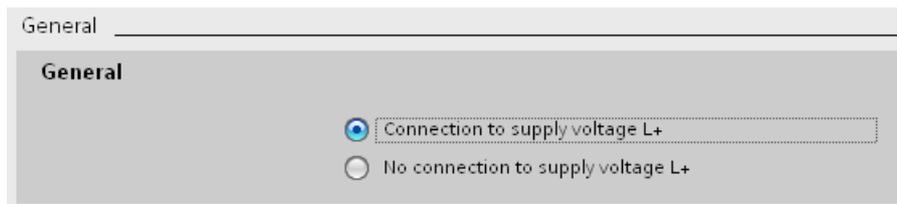

Figure 4-5   Supply voltage via the CPU and system power supply

Infeed via system power supply only

As a further possibility you can feed the required power into the backplane bus using only a system power supply. In this case, the CPU is not supplied with 24 VDC, and draws its supply from the backplane bus. Insert the system power supply next to the CPU, on the left.

In general you can use system power supplies with AC or DC infeed for the configuration. If the first power segment is to be supplied directly with 230 VAC, an infeed via only one system power supply makes sense, for example if no 24 VDC supply voltage is available.

Parameter assignment of the CPU: In STEP 7, select the "Connection to supply voltage L+" option in the "Properties" tab in the "System power supply" area navigation so that STEP 7 can calculate the balance correctly.
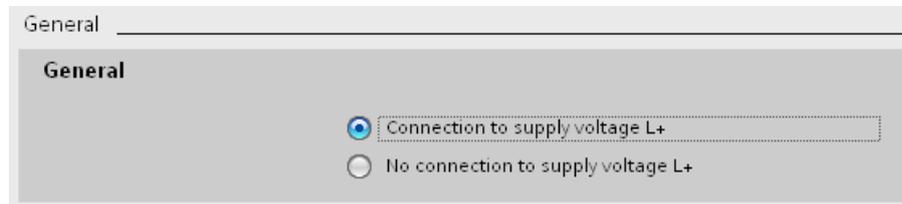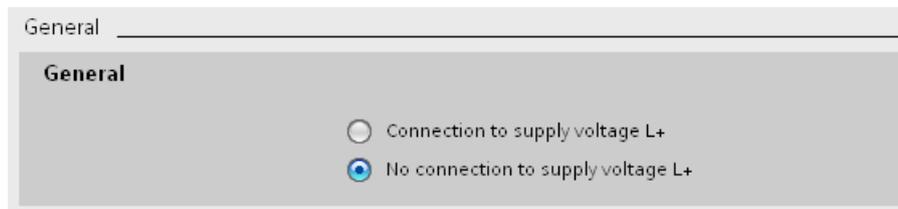

Figure 4-6   No infeed into the backplane bus through the CPU

4.3   Power balance calculation

Introduction

In order to ensure the supply of the modules from the backplane bus, the infed power is compared with the required power. The power balance checks whether the power provided by the system power supplies including CPU is greater than or equal to the power used by the consumers (modules).

In order to operate the configuration with its used modules, the power balance must be positive for each power segment in use.

Negative power balance: The infeed power is less than the power consumed by the modules in the power segment.

Positive power balance: The infed power is greater than the power consumed by the modules in the power segment.

Take care even during planning, that the power fed into the backplane bus is always greater than or equivalent to the power drawn.

The power fed into the backplane bus from the CPU and system power supply is listed in the technical data of the CPU in the corresponding Manual (http://support.automation.siemens.com/WW/view/en/57251228).

The power drawn from the backplane bus by an I/O module or the CPU is listed in the technical data of the CPU in the corresponding Manual (http://support.automation.siemens.com/WW/view/en/57251228).

The power balance calculation is performed:

● During planning with STEP 7

● During operation by the CPU

Power balance calculation during planning with STEP 7

STEP 7 checks compliance with the power balance during the configuration.

Proceed as follows to evaluate the power balance calculation:

1. Configure the configuration of the S7-1500 with all the required modules.

2. In the network view, select the CPU or the system power supply.

3. Open the "Properties" tab in the inspector window.

4. Select the "System power supply" entry in the area navigation.

5. Check the "Power balance calculation" table, so see whether the power balance is positive. If the power balance is negative, the underpowered modules will be marked in red.

Power segment overview

Module	Slot	Supply/consumption
PS 25W 24V DC_1	0	25.00W
PLC_1	1	-8.30W
DI 32x24VDC HF_1	2	-1.10W
DQ 8x230VAC/5A ST_1	3	-0.80W
AI 8xU/I/RTD/TC ST_1	4	-0.70W
AQ 4xU/I ST_1	5	-0.60W
	Summary	13.50W

Figure 4-7   Example of a power balance calculation with STEP 7

Power balance check by the CPU for overload

Compliance with a positive power balance is monitored by the CPU:

- At every POWER ON
- At every change of the installed hardware

Causes for overload

An overload can still occur despite a positive power balance during planning. The cause for overload can be a hardware configuration that does not correspond to the configuration in STEP 7, for example:

- More I/O modules are inserted in the actual configuration than were planned
- A system power supply that is necessary for operation is not inserted
- A system power supply that is necessary for operation is not switched on (power cable connector and on/off switch)
- A system power supply that is necessary for operation has no U connector inserted

Response to negative power balance or failure of power supplies

As soon as a negative power balance/overload is detected by the CPU in a power segment, the following actions are executed:

- CPU stores the retentive data
- CPU enters the event in the diagnostics buffer
- CPU carries out a restart and repeats this until the cause of the negative power balance is resolved

4.4 Use of load power supplies

The system power supply (PS), central modules (CPU), input and output circuits of the I/O modules are supplied with 24 VDC through the load current supply (PM).

The load current supply (PM) is available in the following versions:

- PM 70W AC 120/230 V (automatic switchover), 24 VDC / 3 A
- PM 190W AC 120/230 V (automatic switchover), 24 VDC / 8 A

Several load current supplies (PM) can be used as follows for higher output currents:

- Parallel connection of two load current supplies
- Every load current supply feeds independent 24 VDC load lines.

Alternatively an external 24 V power supply from the SITOP spectrum can be used.

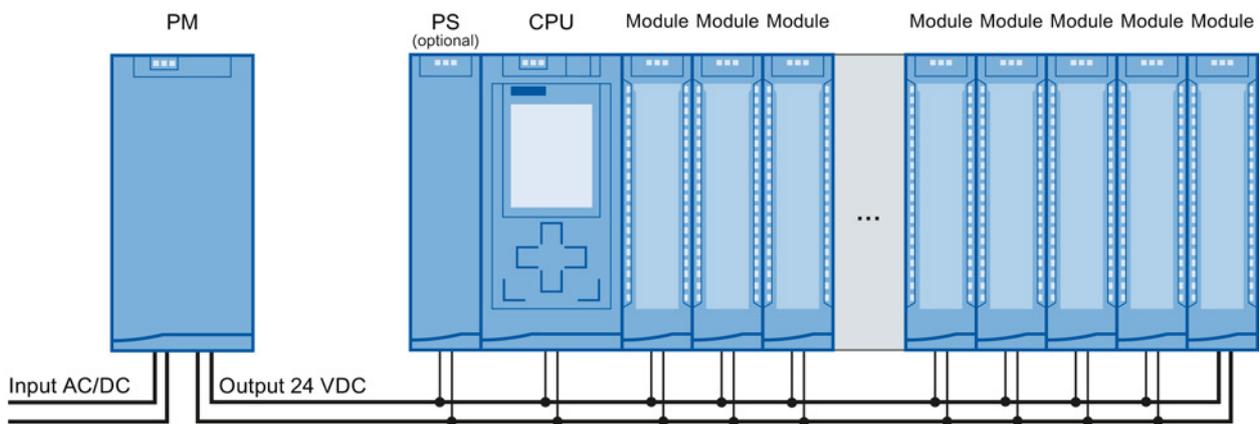Figure 4-8   Supply of the modules from 24 VDC load power supply

Reference

Further information on load power supplies can be found on the Internet (http://www.siemens.com/industrymall) in the online catalog and/or in the online ordering system.

Installation 5

5.1 Basics

Introduction

All modules of the S7-1500 automation system are unenclosed equipment. This means that you may only install this system in housings, cabinets or electrical operating rooms. These housings, cabinets or electrical operating rooms must only be accessible with a key or tool. Access may only be possible for instructed or authorized personnel.

Installation position

The S7-1500 automation system can be used in a horizontal installation for ambient temperatures up to 60 °C and in vertical installation for ambient temperatures up to 40 °C. Additional information can be found in the chapter Mechanical and climatic ambient conditions (Page 190).

Mounting rail

In addition to the S7-1500 modules, other components can be mounted on the S7-1500 mounting rail; for example, modules from the S7-1200 and ET 200SP range, terminals, circuit breakers, small contactors or similar components.

These components can influence the installation dimensions for the cable duct.

Modules can be mounted up to the outer edge of the mounting rail (marginless assembly).

These mounting rails are available in various lengths. You can order them via the online catalog or the online ordering system. The available lengths and part numbers can be found in the Accessories/spare parts (Page 212) section.

Minimum clearances

Modules can be mounted up to the outer edge of the mounting rail. Maintain the following minimum clearances at the top and bottom when installing or removing the S7-1500 automation system.
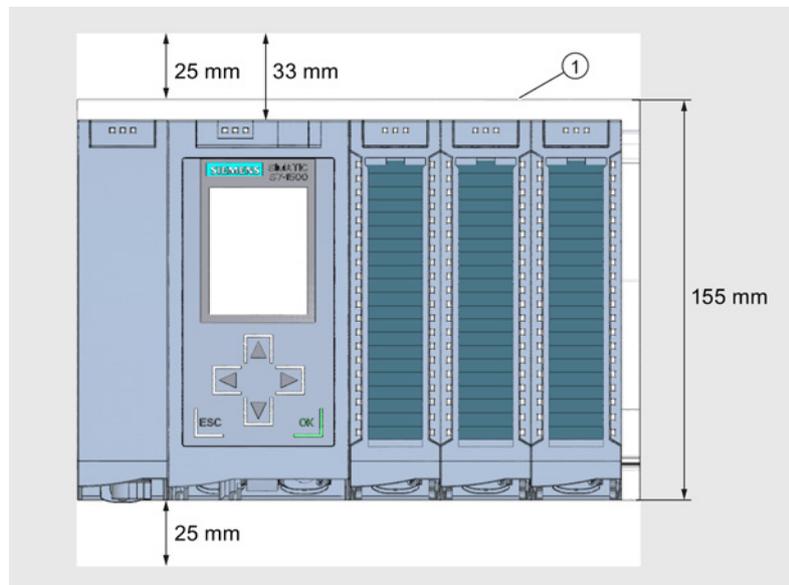
①   Upper edge of the mounting rail

Figure 5-1   Minimum clearances in the control cabinet

Installation rules

- The installation begins on the left side with a CPU, or a power supply module.
- The modules are connected to each other with U connectors.
- Note that no U connector protrudes from the first and last module.

Note

Only insert modules when the power is switched off.

5.2   Installing the mounting rail

Introduction

The mounting rails are delivered in five lengths:

- 160 mm
- 482.6 mm (19 inches)
- 530 mm
- 830 mm
- 2000 mm

The part numbers can be found in the Accessories/spare parts (Page 212) section.

The mounting rails (from 160 to 830 mm) come with two drill holes for fixing screws. A set of screws for grounding the mounting rail is provided.

The 2000 mm mounting rail is provided for assemblies with special lengths and does not have holes for fixing screws. No set of screws for grounding is enclosed with the mounting rail (can be ordered as an accessory (Page 212)).

The specifications of the maximum offsets between two drill holes can be found in the table, "Dimensions for the drill holes".

Tools required

- Commercially available hacksaw
- Drill $\varnothing$ 6.5 mm
- Screwdriver
- Size 10 adjustable screw-wrench or socket wrench for grounding cable connection
- Adjustable screw-wrench, matching the selected fixing screws
- Stripping tool and crimp tool for the grounding cable

Required accessories

You can use the following screw types for fastening of the mounting rails:

Table 5- 1   Required accessories

For ...	you can use ...	Explanation
• outer fixing screws • additional fixing screws (for mounting rails > 482.6 mm)	M6 fillister head screws according to ISO 1207/ISO 1580 (DIN 84/DIN 85)	Choose a suitable screw length for your assembly.
	M6 hexagon head screws according to ISO 4017 (DIN 4017)	You also need washers for cylinder head screws with an internal diameter of 6.4 mm and an external diameter of 11 mm in accordance with ISO 7092 (DIN 433).

Dimensions for the drill holes

The following table contains the dimensions for the mounting rail drill holes.

Table 5- 2   Dimensions for the drill holes

"Standard" mounting rails	"Longer" mounting rails

Length of the mounting rail	Distance a	Distance b
160 mm	10 mm	140 mm
482.6 mm	8.3 mm	466 mm
530 mm	15 mm	500 mm
830 mm	15 mm	800 mm

## Additional fixing screws (for mounting rails > 530 mm)

For mounting rails > 530 mm, we recommend setting additional fixing screws at intervals of ≤ 500 mm on the identification groove.

Preparing the 2000 mm mounting rail for installation

1. Cut the 2000 mm mounting rail to the required length.

2. Mark the holes. The necessary dimensions can be found in the above-mentioned table "Dimensions for the drill holes":

   – Two drill holes at the beginning and end of the mounting rail

   – Additional drill holes at equal intervals of 500 mm maximum, along the identification groove

3. Drill the marked holes according to the selected type of fastening.

4. Ensure that there are no burrs or shavings on the mounting rail.

Note

In order to ensure a secure installation of the modules, make sure that the drill holes are located centrally on the identification groove, and that only screws of the maximum size are used (see the above-mentioned table).

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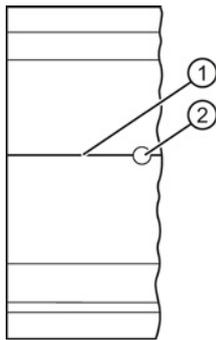
① Identification groove for additional drill holes
② Additional drill hole

Figure 5-2   Preparing the 2000 mm mounting rail for installation

Installing the mounting rail

Place the mounting rail such that sufficient space remains for installation of and heat dissipation from the modules. Note the figure Minimum clearances in the control cabinet (Page 47).

Screw the rail onto the mounting surface.

Attaching the protective conductor

The S7-1500 automation system has to be connected to the protective conductor system of the electrical system to ensure electrical safety.

1. Strip the grounding conductor with a minimum diameter of 10 mm² and attach a ring terminal for size M6 bolts with the crimping pliers.

2. Slide the enclosed bolt into the T profile groove.

3. Insert the spacer, ring terminal with the grounding connector, flat washer, and lock washer onto the bolt (in that order). Thread the hexagon head nut, and fasten the components in place with the nut (torque 4 Nm).

4. Connect the opposite end of the grounding cable to the central grounding point / protective conductor busbar (PE).
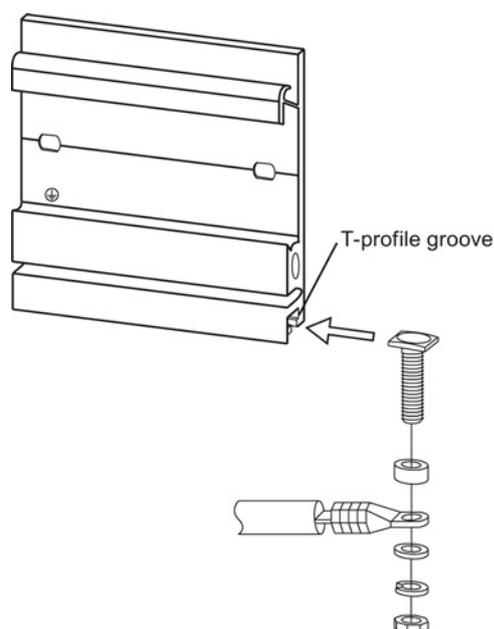

Figure 5-3   Attaching the protective conductor

Note

Alternative grounding of the mounting rail

If it is ensured that the mounting rail is permanently connected to the protective conductor system using an equivalent installation that complies with standards, for example, by permanent attachment to a grounded control cabinet wall, grounding via the grounding screw can be omitted.

Reference

Additional information on the precise dimensions of the mounting rails can be found in the Dimension drawings of the mounting rails (Page 194) section.

5.3 Mounting a system power supply module

Introduction

The system power supply module has a connection to the backplane bus and supplies the configured modules with the internal supply voltage.

Requirements

The mounting rail is installed.

Tools required

Screwdriver with 4.5 mm blade

Mounting a system power supply module

1. Insert the U-connector into the back of the system power supply.

2. Install the system power supply on the mounting rail.

3. Swivel the system power supply to the rear.
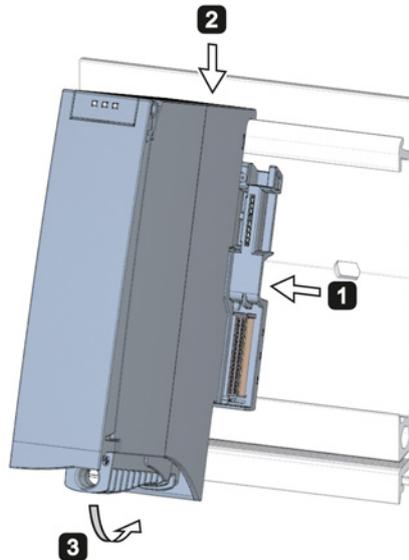
Figure 5-4   Mounting a system power supply module

4. Open the front cover.

5. Disconnect the power cable connector from the system power supply.

6. Screw the system power supply tight (torque 1.5 Nm).

7. Insert the already wired-up power cable connector into the system power supply.

For a description on how to wire the power cable connector refer to the section Wiring the system power supply and load current supply modules (Page 69).

Dismantling a system power supply module

The system power supply is wired up.

1. Turn off the fed supply voltage.

2. Open the front cover.

3. Shut down the system power supply.

4. Disconnect the power cable connector, and remove the connector from the system power supply.

5. Undo the power supply module's fixing screw(s).

6. Swivel the system power supply out of the mounting rail.

Reference

Further information can be found in the Manuals for the system power supplies.

5.4 Mounting a load current supply module

Introduction

Load current supplies do not have a connection to the backplane bus of the S7-1500 automation systems and therefore do not use a configurable slot. The system power supply, CPU, and input and output circuits of the I/O modules are supplied with 24 VDC through the load current supply.

Requirements

The mounting rail is installed.

Tools required

Screwdriver with 4.5 mm blade

Mounting a load current supply module

1. Install the load current supply on the mounting rail.

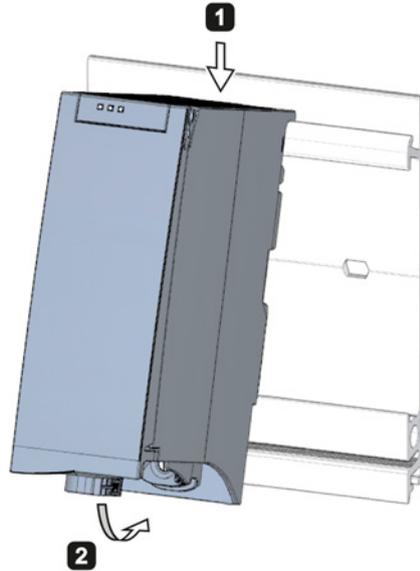2. Swivel the load current supply to the rear.

Figure 5-5   Mounting a load current supply module

3. Open the front cover.

4. Disconnect the power cable connector from the load current supply.

5. Screw the load current supply tight (torque 1.5 Nm).

6. Insert the already wired-up power cable connector into the load current supply.

For a description on how to wire the power cable connector refer to the section Wiring the system power supply and load current supply modules (Page 69).

Note

Load current supplies can be mounted to the left or right of the configured setup. If you mount a load current supply on the right of the configured setup, the heat development of the load current supply may make a gap to the configured setup necessary. For additional information, refer to the relevant manuals. The number of load current supplies that can be used is unlimited.

Dismantling the load current supply

The load current supply is wired up.

1. Turn off the fed supply voltage.

2. Open the front cover.

3. Shut down the load current supply.

4. Disconnect the power cable connector, and remove the connector from the load current supply.

5. Undo the power supply module's fixing screw(s).

6. Swivel the load current supply out of the mounting rail.

Reference

Further information can be found in the Manuals for the load current supplies.

5.5 Installing the CPU

Introduction

The CPU executes the user program and uses the integrated system power supply to supply the electronics of the modules via the backplane bus.

Requirements

The following preconditions have to be fulfilled to mount a CPU:

● The mounting rail is installed.

● In a system power supply located on the left next to the CPU, a U connector is inserted on the back right.

Note

Protective film

Note that a protective film is applied to the display in the delivery state of the CPU. You can remove the protective film as required.

Tools required

Screwdriver with 4.5 mm blade

Installing the CPU

1. Insert a U-connector into the back right on the CPU.

2. Install the CPU on the mounting rail and slide the CPU up to the left-hand system power supply.

3. Ensure that the U-connector is inserted at the system power supply. Swivel the CPU in to the rear.
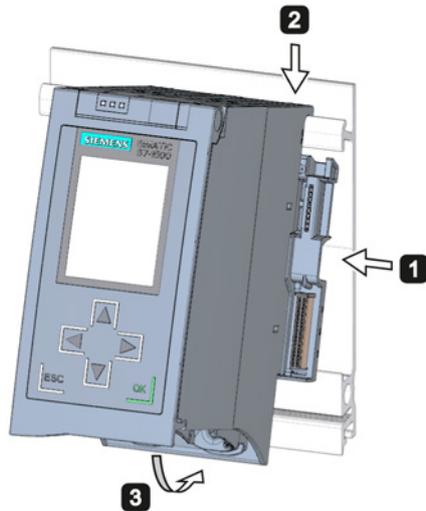
4. Fasten the CPU (torque 1.5 Nm).

Figure 5-6   Installing the CPU

Uninstalling the CPU

The CPU is wired, and is followed by additional modules.

1. Open the front cover.

2. Switch the CPU into STOP mode.

3. Turn off the fed supply voltage.

4. Pull off the connector for the supply voltage.

5. Loosen the bus connectors for PROFIBUS/PROFINET with the screwdriver, and remove them from the CPU.

6. Undo the CPU's fixing screw(s).

7. Pivot the CPU out of the mounting rail.

5.6 Installing I/O modules

Introduction

The I/O modules are installed following the CPU. I/O modules form the interface between the controller and the process. The controller detects the current process state via the connected sensors and actuators, and triggers the corresponding reactions.

Requirements

The following preconditions have to be fulfilled to mount an I/O module:

- The mounting rail is installed.
- The CPU is installed.
- In the module / CPU located on the left next to the I/O module, a U-connector is inserted on the back right.

Tools required

Screwdriver with 4.5 mm blade

Installing I/O modules

Proceed as follows to install an I/O module:

1. Insert a U connector into the back right on the I/O module.
   Exception: the last I/O module in the assembly

2. Install the I/O module on the mounting rail and slide the I/O module up to module on the left.

3. Pivot the I/O module towards the back.
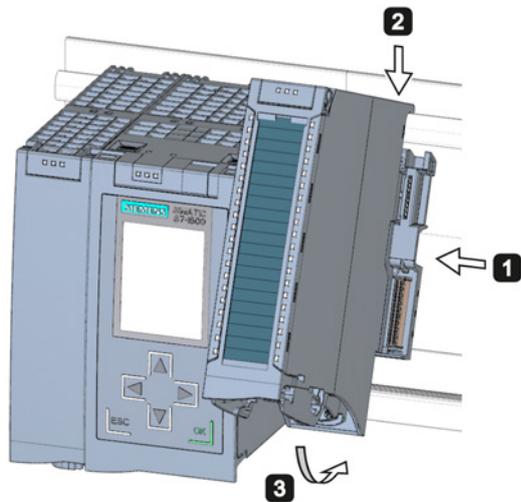
4. Fasten the I/O module (torque 1.5 Nm).

Figure 5-7   Installing I/O module

Uninstalling I/O modules

The I/O module is wired.

Proceed as follows to dismantle an I/O module:

1. Turn off all fed supply voltages.

2. Open the front cover.

3. For communication modules: Loosen and remove the connector from the module.

   At I/O modules: Pull the front connector out of the I/O module using the unlocking strap.

4. Loosen the fixing screw of the I/O module.

5. Pivot the I/O module out of the mounting rail.

Wiring

6

6.1   Rules and regulations for operation

Introduction

As part of plants and/or systems, the S7-1500 automation system requires adherence to special rules and regulations, depending on the field of application.

This section provides an overview of the most important rules that must be observed for the integration of the S7-1500 CPU in a plant or system.

Specific application

Please observe the safety and accident prevention regulations applying to specific applications (e.g., machine protection guidelines).

EMERGENCY-STOP devices

EMERGENCY OFF equipment to IEC 60204 (corresponds to DIN VDE 0113) must remain effective in all operating modes of the plant or system.

Excluding hazardous plant states

Hazardous operating states must not occur when:

- The CPU starts up again after a voltage dip or a power failure.
- The bus communication is resumed after a fault.

If necessary, EMERGENCY-STOP must be forced.

An uncontrolled or undefined startup is not permitted after the EMERGENCY STOP is unlocked.

Line voltage

Below is described, what you must pay attention to with respect to the supply voltage (see the section Statements on insulation tests, protection classes, degree of protection, and rated voltage (Page 192)):

- For fixed plants or systems without multipole circuit breaker, a mains disconnection device (multipole) must be available in the building installation.
- For load power supplies, the configured rated voltage range must correspond to the local line voltage.
- For all power circuits of the S7-1500 CPU, the fluctuation/deviation of the line voltage from the rated value must be within the permitted tolerance.

24 VDC supply

The following describes what you must pay attention to in terms of the 24 VDC supply:

- Power supply units for the 24 VDC supply must have a safe electrical isolation in accordance with IEC 60364-4-41.

- Overvoltage arresters are to be used as protection against lightning and overvoltages.

  Suitable components for the lightning and overvoltage protection are specified in the Defining interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual.

Protection against electrical shock

The mounting rail of the S7-1500 automation system has to be connected conductively with the protective conductor as protection against electrical shock.

Protection against external electrical influences

The following describes what you must pay attention to in terms of protection against electrical influences and/or faults:

- For all plants or systems in which an S7-1500 CPU is integrated, you must ensure that the plant or the system is connected to a protective conductor with sufficient cross-section for conducting electromagnetic disturbances.

- For supply, signal and bus lines, you must ensure that the laying of the lines and the installation is correct.

- For signal and bus lines, you must ensure that a wire/cable breakage or a cross-wire does not lead to undefined states of the plant or system.

Reference

Additional information can be found in the function manual, Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566).

6.2 Operating the S7-1500 on grounded infeed

Introduction

The following provides information on the overall configuration of an S7-1500 on a grounded infeed (TN-S network). The specific subjects discussed are:

● Disconnecting devices, short-circuit and overload protection to IEC 60364 (corresponding to DIN VDE 0100) and IEC 60204 (corresponding to DIN VDE 0113)

● Load power supplies and load circuits

Grounded infeed

In the case of grounding incoming supplies (TN-S system) the neutral conductor (N) and the protective conductor (PE) are each grounded. Both conductors form a part of the overvoltage concept. When a plant is in operation, the current flows across the neutral conductor. When a fault occurs, for example a single ground fault between a live conductor and ground, the current flows through the protective conductor.

Safe electrical isolation (SELV/PELV in accordance with IEC 60364-4-41)

Load current supply modules / power supply modules with safe electrical isolation are necessary for operating the S7-1500. This protection is designated as SELV (Safety Extra Low Voltage)/PELV (Protective Extra Low Voltage) in accordance with IEC 60364-4-41.

Reference potential of the controller

The reference potential of the S7-1500 automation system is connected with the mounting rail through a high-resistance RC combination. In this way, high-frequency interference currents are conducted and electrostatic charges are avoided. Despite the grounded mounting rail, the reference potential of the S7-1500 automation system has to be considered as ungrounded due to the high-resistance connection.

If you want to configure the S7-1500 automation system with grounded reference potential, connect the reference potential of the controller (M connection of the CPU) galvanically with the protective conductor.

A simplified representation of the potential relationships is available in the chapter Electrical configuration of the S7-1500 (Page 64).

Short-circuit and overload protection

Various measures as protection against short-circuits and overloads are required for setting up a full installation. The nature of the components and the degree to which the required measures are binding depends on the IEC (DIN VDE) regulation applicable to your plant configuration. The table refers to the following figure and compares the IEC (DIN VDE) regulations.

Table 6- 1   Components and required measures

	Reference to following figure	IEC 60364 (DIN VDE 0100)	IEC 60204 (DIN VDE 0113)
Shut-off device for control system, sensors, and actuators	①	Main switch	Disconnector
Short-circuit and overload protection: In groups for sensors and actuators	② ③	Single-pole protection of circuits	• With grounded secondary circuit: fuse **unipolar** • otherwise: fuse **all poles**
Load power supply for AC load circuits with more than five electromagnetic devices	④	Galvanic isolation by transformer **recommended**	Galvanic isolation by transformer **recommended**

S7-1500 in the overall configuration

The figure below shows the overall configuration of the S7-1500 (load voltage supply and grounding concept) with infeed from a TN-S network.
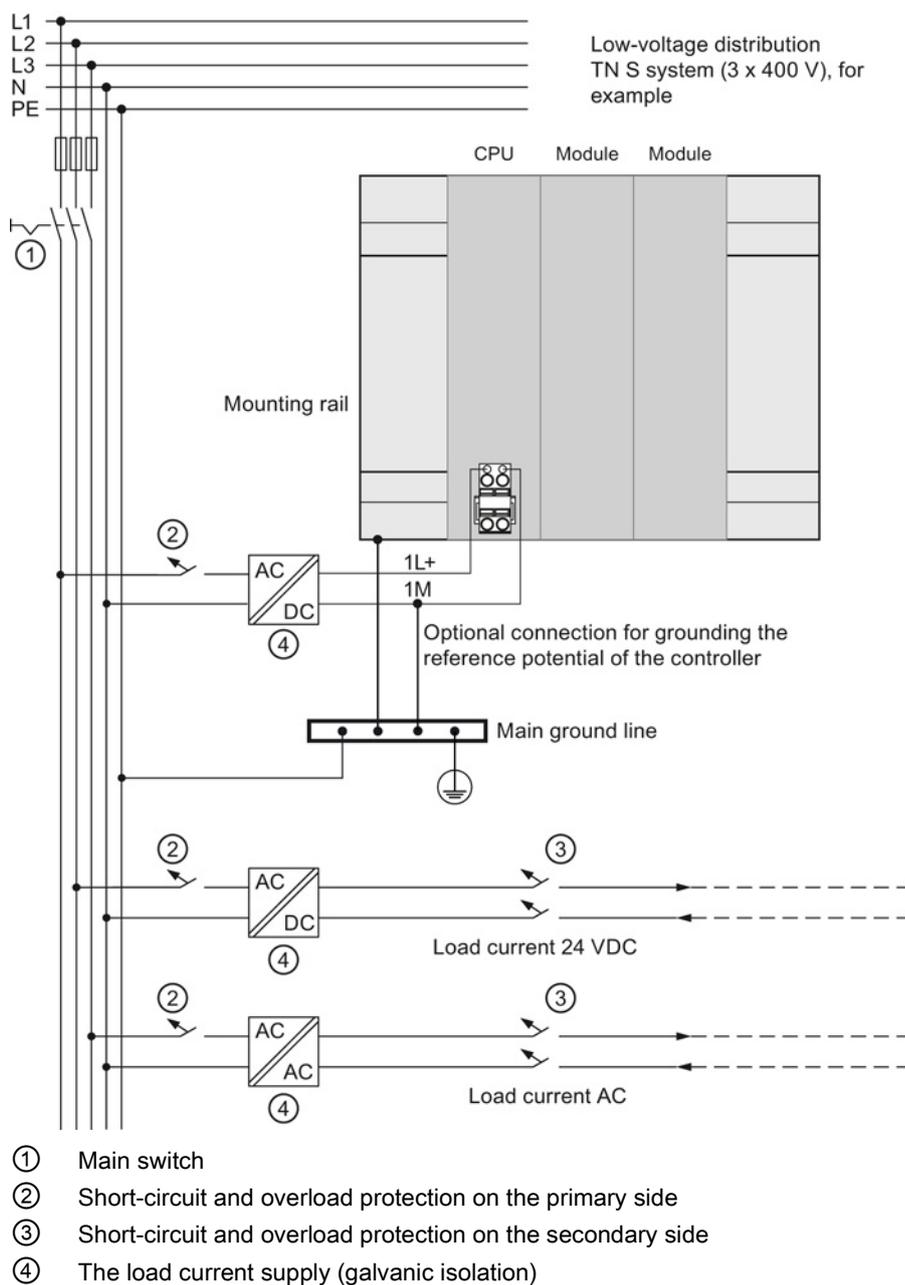

①   Main switch

②   Short-circuit and overload protection on the primary side

③   Short-circuit and overload protection on the secondary side

④   The load current supply (galvanic isolation)

Figure 6-1   Operating the S7-1500 with grounded reference potential

6.3 Electrical configuration of the S7-1500

Electrical isolation

With the S7-1500, there is galvanic isolation between:

- The primary side of the system power supply (PS) and all other circuit components

- The (PROFIBUS/PROFINET) communication interfaces of the CPU and all other circuit components

- The load circuits / process electronics and all other circuit components of the S7-1500 components

High-frequency interference currents are conducted and electrostatic charges are avoided through integrated RC combinations or integrated capacitors.

The following figure shows a simplified representation of the potential relationships of the S7-1500 automation system.
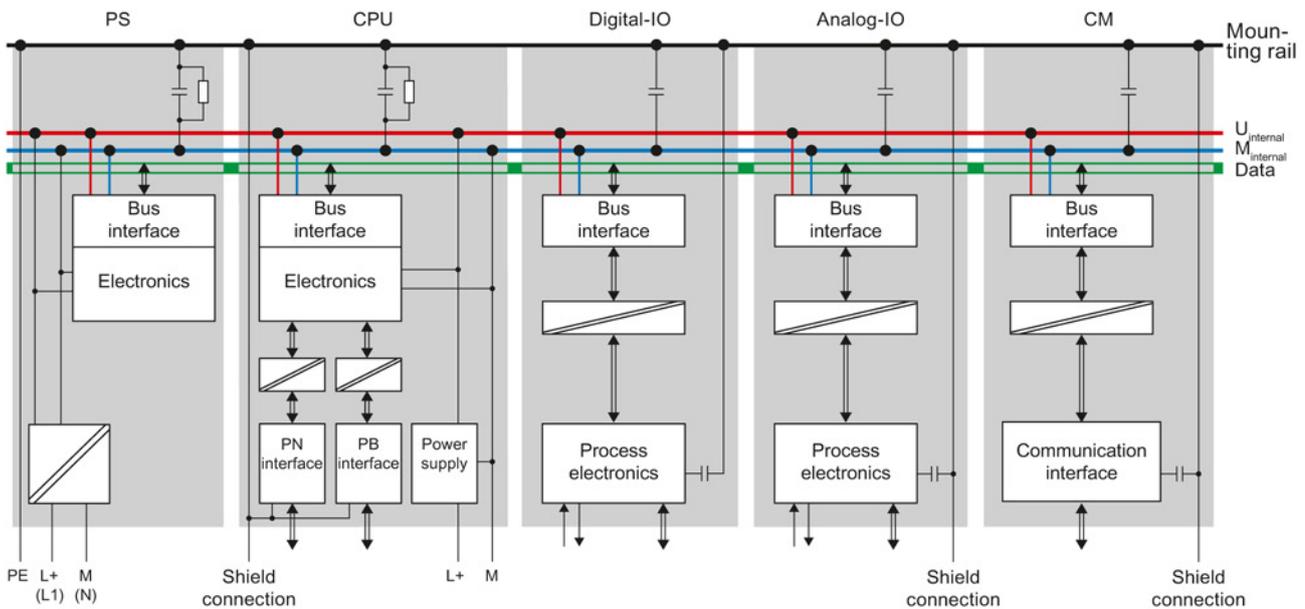
Figure 6-2   Potential relationships for S7-1500 with CPU 1516-3 PN/DP

6.4 Wiring rules

Wiring rules

Table 6- 2   Wiring rules

Wiring rules for...		CPU	System power and load current supply
Connectible conductor cross-sections for solid wires		-	-
		-	-
Connectible conductor cross-sections for stranded wires	Without end sleeve	0.25 to 2.5 mm^2	1.5 mm^2
		AWG[*]: 24 to 16	AWG[*]: 16
	With end sleeve	0.25 to 1.5 mm^2	1.5 mm^2
		AWG[*]: 24 to 16	AWG[*]: 16
Number of wires per connection		1	1
Length of stripped wires		10 to 11 mm	7 to 8 mm
End sleeves according to DIN 46228	without plastic sleeve	Design A, 10 mm long	Design A, 7 mm long
	with plastic sleeve 0.25 to 1.5 mm^2	Design E, 10 mm long	Design A, 7 mm long
Sheath diameter		-	8.5 mm
Tool		3 to 3.5 mm screwdriver, conic design	3 to 3.5 mm screwdriver, conic design
Connection system		Push-in terminal	Screw terminal
Tightening torque		-	from 0.5 Nm to 0.6 Nm

[*] American Wire Gauge

Table 6- 3   Wiring rules

Wiring rules for...		40-pin front connector (screw terminal, for 35 mm module)	40-pin front connector (push-in terminal, for 35 mm module)	40-pin front connector (push-in terminal, for 25 mm module)
Connectible conductor cross-sections for solid wires		up to 0.25 mm²	up to 0.25 mm²	up to 0.25 mm²
		AWG[*]: up to 24	AWG[*]: up to 24	AWG[*]: up to 24
Connectible conductor cross-sections for stranded wires	Without end sleeve	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2 (max. 40 x 0.75 mm^2)
		AWG[*]: 24 to 16	AWG[*]: 24 to 16	AWG[*]: 24 to 16 mm^2 (max. 40 x 0.75 mm^2)
	With end sleeve	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2 (max. 32 x 0.75 mm²; 8 x 1.5 mm²)
		AWG[*]: 24 to 16	AWG[*]: 24 to 16	AWG[*]: 24 to 16 (max. 32 x AWG 19; 8 x AWG 16)

| Wiring rules for...		40-pin front connector (screw terminal, for 35 mm module)	40-pin front connector (push-in terminal, for 35 mm module)	40-pin front connector (push-in terminal, for 25 mm module)
Number of wires per connection		1 or combination of 2 wires up to 1.5 mm^2 (total) in the same end sleeve	1 or combination of 2 wires up to 1.5 mm^2 (total) in the same end sleeve	1 or combination of 2 wires up to 1.5 mm^2 (total) in the same end sleeve
Length of stripped wires		10 to 11 mm	8 to 11 mm (corresponding to length of end sleeve[**]: 8 mm, 10 mm)	8 to 11 mm (corresponding to length of end sleeve[**]: 8 mm, 10 mm)
End sleeves according to DIN 46228	without plastic sleeve	Design A, 10 mm and 12 mm long	Design A, 10 mm long	Design A, 10 mm long
	with plastic sleeve 0.25 to 1.5 mm^2	Design E, 10 mm and 12 mm long	Design E, 8 mm and 10 mm long	Design E, 8 mm and 10 mm long
Sheath diameter		-	-	-
Tool		3 to 3.5 mm screwdriver, conic design	3 to 3.5 mm screwdriver, conic design	3 to 3.5 mm screwdriver, conic design
Connection system		Screw terminal	Push-in terminal	Push-in terminal
Tightening torque (screw terminal)		from 0.4 Nm to 0.7 Nm	-	-
Max. actuation force for complete opening of the push-in terminal		-	40 N	40 N

* American Wire Gauge

** End sleeve

6.5 Connect supply voltage to the CPU

Introduction

The supply voltage of the CPU is supplied by means of a 4-pole cable connector, which is located on the front of the CPU.

Connection for supply voltage

The connections of the 4-pole connector have the following meaning:
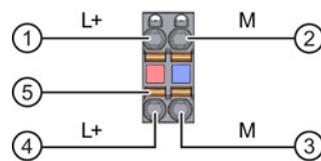
① + 24 V DC of the supply voltage
② Mass of the supply voltage
③ Mass of the supply voltage for looping (current limited to 10 A)
④ + 24 V DC of the supply voltage for looping (current limited to 10 A)
⑤ Spring opener (one spring opener per terminal)

Figure 6-3   Connection for supply voltage

The maximum connector cross-section is 1.5 mm². The cable connector offers you the option of looping the supply voltage uninterrupted, even when it is unplugged.

Requirements

• Only wire the cable connector when the supply voltage is turned off.
• Follow the wiring rules (Page 65).

Tools required

3 to 3.5 mm screwdriver

Tool-free connection of cables: multi-wire (stranded), with end sleeve or ultrasonic compressed

1. Strip 8 to 11 mm of the wires.
2. Seal or crimp the wire with end sleeves.
3. Insert the wire into the push-in terminal as far as it will go.
4. Push the wired connection plug into the plug socket of the CPU.

Connection of wires: multi-wire (stranded), without end sleeve, unprocessed

1. Strip 8 to 11 mm of the wires.

2. Using a screwdriver, press the spring release and insert the wire into the push-in terminal as far as it will go.

3. Pull the screwdriver out of the spring release.

4. Push the wired connection plug into the plug socket of the CPU.

Loosening a wire

Push with the screwdriver as far as it will go into the spring release. Remove the wire.

Uninstalling the connection plug

To uninstall the connection plug, you need a screwdriver. With the screwdriver, pry the connection plug out of the CPU.

6.6   Wiring the system power supply and load current supply modules

Introduction

In the delivery state of the system power supply and load current supply modules, power connectors are inserted. The modules and the associated power connectors are coded. The coding is effected by means of two coding elements - one coding element is located in the module, and the other in the power connector. The system power supply and load current supply modules use identical power connectors for the voltage connection.

The coding element prevents the insertion of a power connector into a different type of power supply module / load current supply module.

Tools required

3 to 3.5 mm screwdriver

Wiring the supply voltage to the system power supply and load current supply modules

You can find a video clip on connecting the supply voltage at the following link (http://cache.automation.siemens.com/media/67462859_connecting_supply_web_en/start.htm):

To connect the supply voltage, follow these steps:

1. Swing the front cover of the module up until the front cover latches.

2. Press down the unlocking button of the power cable connector (Figure 1). Remove the power cable connector from the front of the module.

3. Loosen the screw on the front of the connector. This loosens the housing latch and the cable relief. With a tightened screw the connector's cover can't be removed (Figure 2).

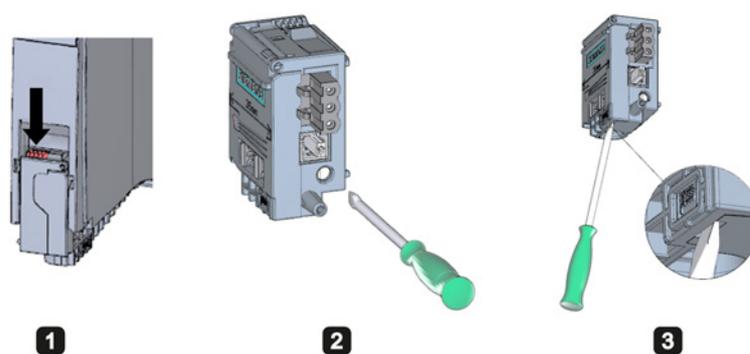4. Pry off the connector cover using a suitable tool (Figure 3).

Figure 6-4   Wiring the supply voltage to the system power supply and load current supply modules (1)

5. Strip the cable sheathing to a length of 35 mm and the conductors to a length of 7 to 8 mm, and bring them up to the end sleeves.

6. Connect the wires in the connector according to the connection diagram (Figure 4).

7. Close the cover (Figure 5).

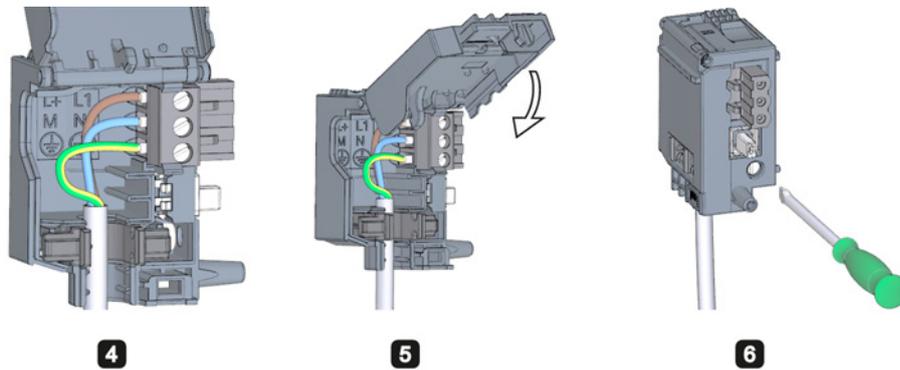8. Retighten the screw (Figure 6). This effects a strain relief on the lines.

Figure 6-5   Wiring the supply voltage to the system power supply and load current supply modules (2)

9. Insert the power connector into the module, until the latch engages.

Reference

Further information about connecting the 24 VDC output voltage of the load voltage supply modules is available in the Manuals of the corresponding modules.

6.7   Connect interfaces for communication

Communication interfaces of the S7-1500 modules are connected using standardized connectors.

Use prefabricated connecting cables for the connection. If you want to prepare communication cables yourself, the interface assignment is specified in the Manuals of the corresponding modules. Observe the mounting instructions for the connectors.

# 6.8 Front connector for the I/O modules

6.8.1 Characteristics of the front connector

Introduction

The sensors and actuators of your plant are connected to the S7-1500 automation system by means of front connectors. Wire the sensors and actuators to the front connector and then plug it into the I/O module. You can either wire the front connector in the "pre-wiring position" that makes convenient wiring possible, or completely, before you insert it into the I/O module.

You can remove the front connector easily from the I/O module with the wiring attached. This means it is not necessary to loosen the wiring when you replace the module.

Properties of the front connectors
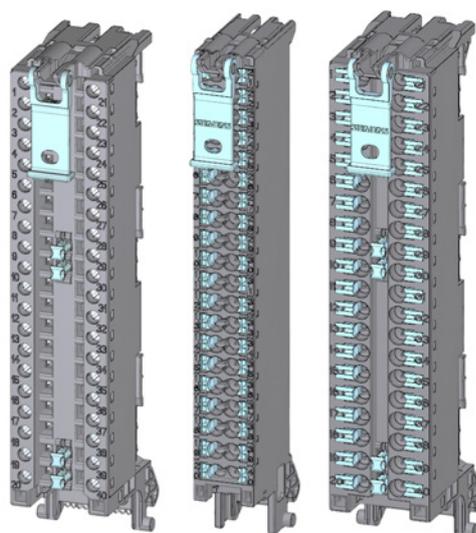
① Front connector 35 mm with screw terminals
② Front connector 25 mm with push-in terminals
③ Front connector 35 mm with push-in terminals

The three different front connectors are characterized as follows:

- 40 clamping points each

- Connection technology: Screw terminal (for 35 mm modules only) or push-in terminal

- Module width: 35 mm or 25 mm

- If you want to supply load groups with the same potential (non-isolated), use the potential bridges supplied for the front connector. In four locations: 9 and 29, 10 and 30, 19 and 39, 20 and 40, the terminals can be bridged by means of potential bridges. Advantage: Reduction of the wiring effort.

Note

Note that the potential bridges may only be deployed with a maximum rated voltage of 24 VDC! The current capacity per potential bridge is 8 A maximum.

Note that potential bridges are not available for front connectors for a module width of 25 mm.

- In the delivery state a coding element is located in the module. When the front connector is first inserted into the I/O module, a part of the coding element clips onto the front connector. When the front connector is removed from the I/O module, one half of the coding element remains in the front connector, and the other part of the coding element remains in the I/O module. The insertion of a front connector that is not suited to the module is thereby mechanically prevented. Thus, for example, the front connector with the coding element for a digital module cannot be inserted on an analog module. Additional information on the coding element can be found in section Coding element at the I/O module and at the front connector (Page 130).

Reference

Further information on the use of the potential bridges can be found in the manual for the respective I/O module.

6.8.2 Wiring front connectors for I/O modules without shield contact element

Requirement

- The I/O modules are installed on the mounting rail.
- The supply voltages are turned off.
- The wires are prepared according to the utilized clamping technology, take the wiring rules (Page 65) into account for this purpose.

Tools required

- Stripping tool
- 3 to 3.5 mm screwdriver

Preparing and wiring front connectors for I/O modules without shield contact element

Proceed as follows to wire the front connector:

1. As needed, switch off the load power supply.
2. Place the included cable strain relief (cable tie) for the cable harness into the front connector (Figure 1).
3. Swing the front cover of the wired I/O module up until the front cover latches (Figure 2).

4. Bring the front connector into the pre-wiring position. To do this, hook the front connector into the bottom of the I/O module and swivel the front connector upward until the front connector latches (Figure 3).

    Result: In this position, the front connector still protrudes from the I/O module (Figure 4). However, front connector and I/O module are not yet electrically connected. By means of the pre-wiring position, you can easily wire the front connector.
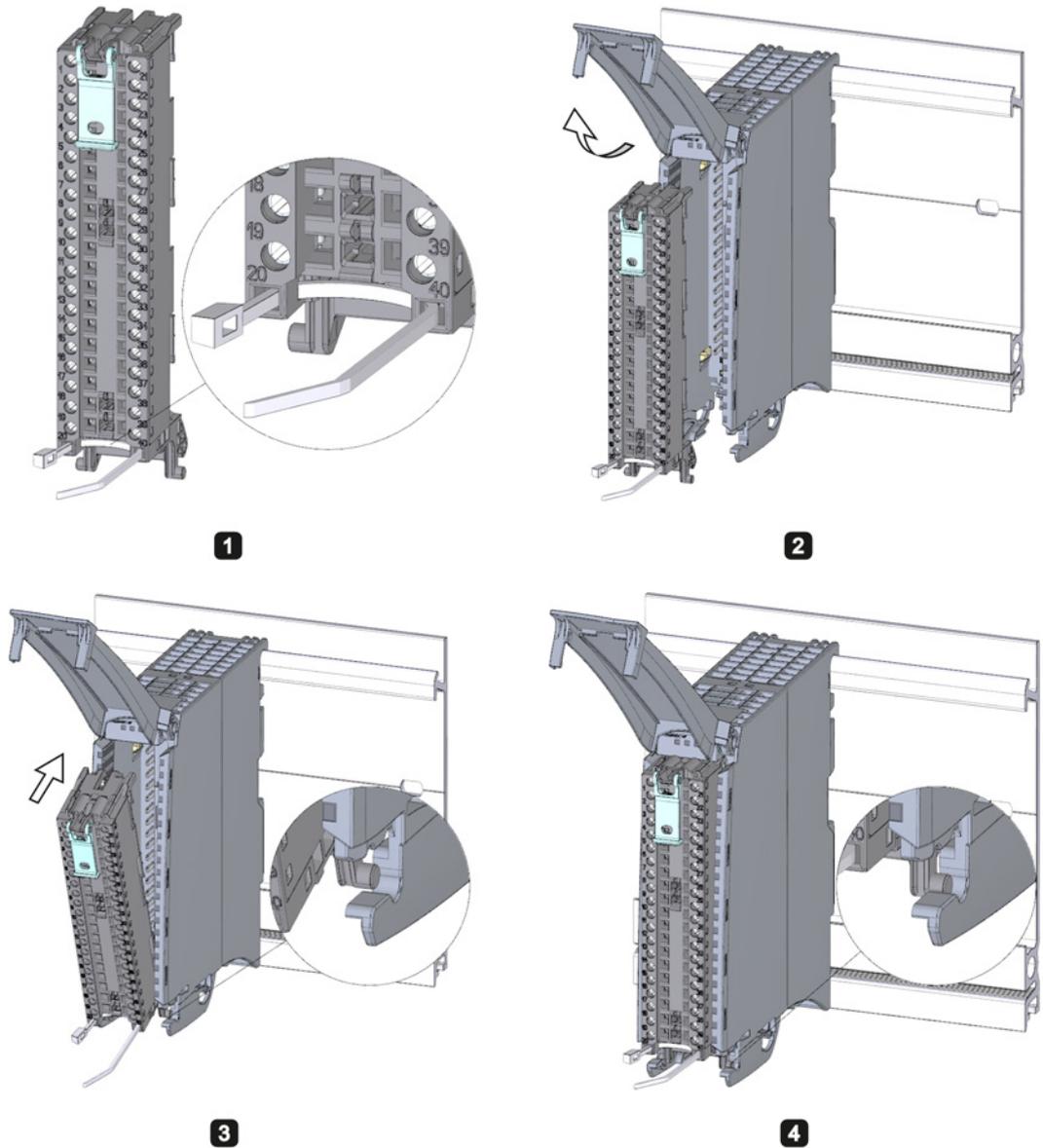

Figure 6-6   Wiring front connectors for I/O modules without shield contact element

5. Begin to completely wire the front connector.

6. Put the strain relief around the cable harness, and pull the strain relief for the cable harness tight.

Use of the potential bridges at digital modules

With the delivered potential bridges, for digital modules with a maximum rated voltage of 24 V DC, you can bridge the terminals for the voltage supply and thus reduce the wiring effort. The bridges are used to connect respectively the facing terminals 9 and 29, 10 and 30, 19 and 39 as well as 20 and 40.

Reference

Further information on wiring the inputs and outputs can be found in the manuals for the I/O modules.

6.8.3 Wiring front connectors for I/O modules with shield contact element

Requirement

- I/O modules are installed on the mounting rail.
- The supply voltage is turned off.
- Wires are prepared according to the clamping technology used. To do this, follow the wiring rules (Page 65).

Tools required

- Stripping tool
- 3 to 3.5 mm screwdriver
- Flat pliers

Details view

The shielding bracket, the power supply element, and the shielding clamp are included in the scope of delivery for the analog and technology modules.

The following figure shows the details view of a front connector with shield connection element:

①	Shield clamp	⑥	Power supply element
②	Cable sheathing removed (approx. 20 mm)	⑦	Shielding bracket
③	Strain relief (cable tie)	⑧	Supply lines
④	Signal cables	①+⑦	Shield contact
⑤	Front connectors		
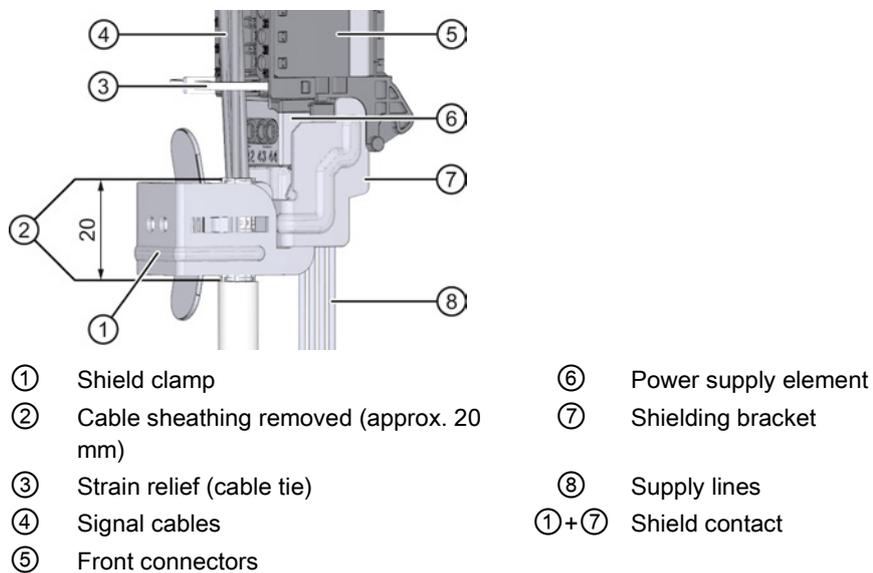
Figure 6-7   Details view for front connectors with shield connection elements

Preparing front connectors for I/O modules with shield contact element

You can find a video clip on the preparation all the way to wiring the front connector at the following link
(http://cache.automation.siemens.com/media/67462859_wiring_shield_web_en/start.htm):

To prepare the front connector for wiring, follow these steps:

1. Remove the connection separator from the lower part of the connector (Figure 1).

2. Insert the power supply element (Figure 2).

3. Insert the shielding bracket from below into the guiding groove of the front connector until it latches into place (Figure 3).

4. Place the included cable strain relief (cable tie) for the cable harness into the front connector (Figure 4).
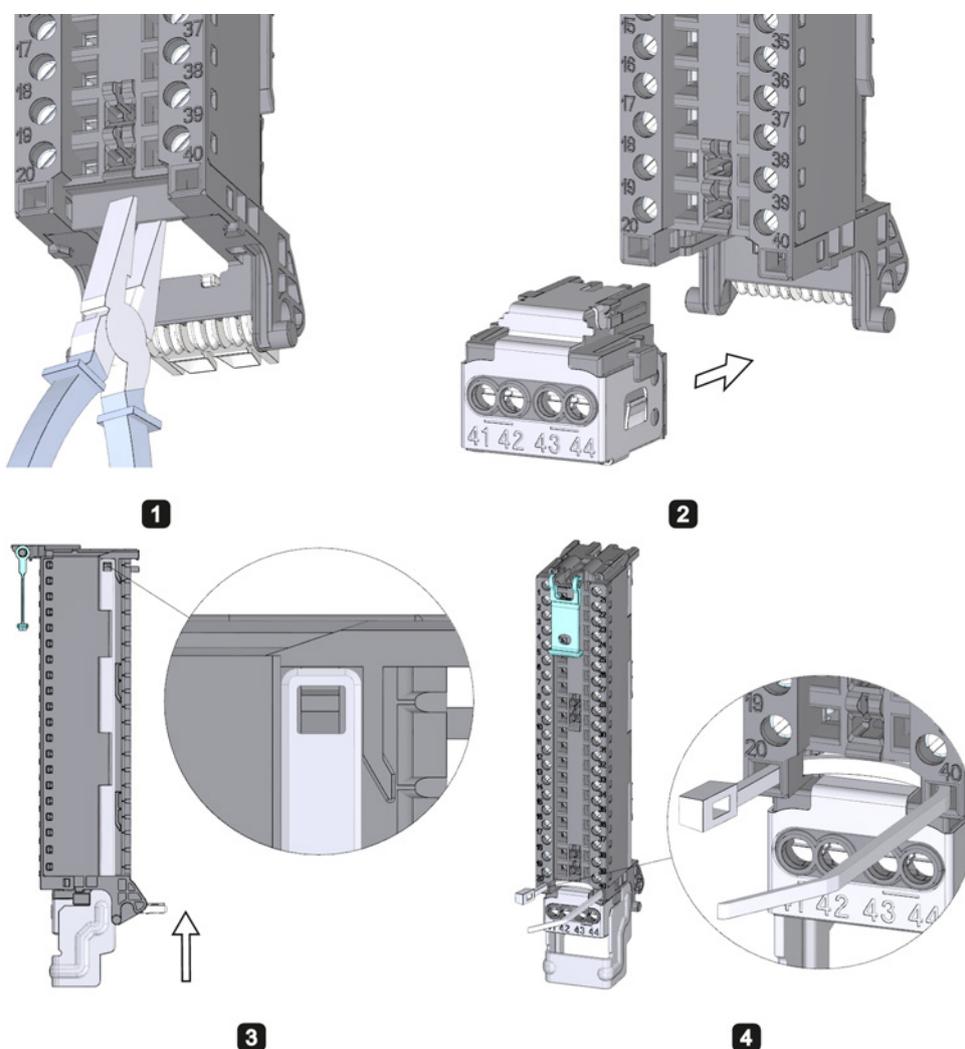
Figure 6-8   Preparing front connectors for I/O modules with shield contact element (1)

5. Swing the front cover up until the front cover latches (Figure 5).

6. Bring the front connector into the pre-wiring position. To do this, hook the front connector into the bottom of the I/O module and swivel it upwards until the front connector latches (Figure 6).

Result: In this position, the front connector still protrudes from the I/O module (Figure 7). However, front connector and I/O module are not yet electrically connected.
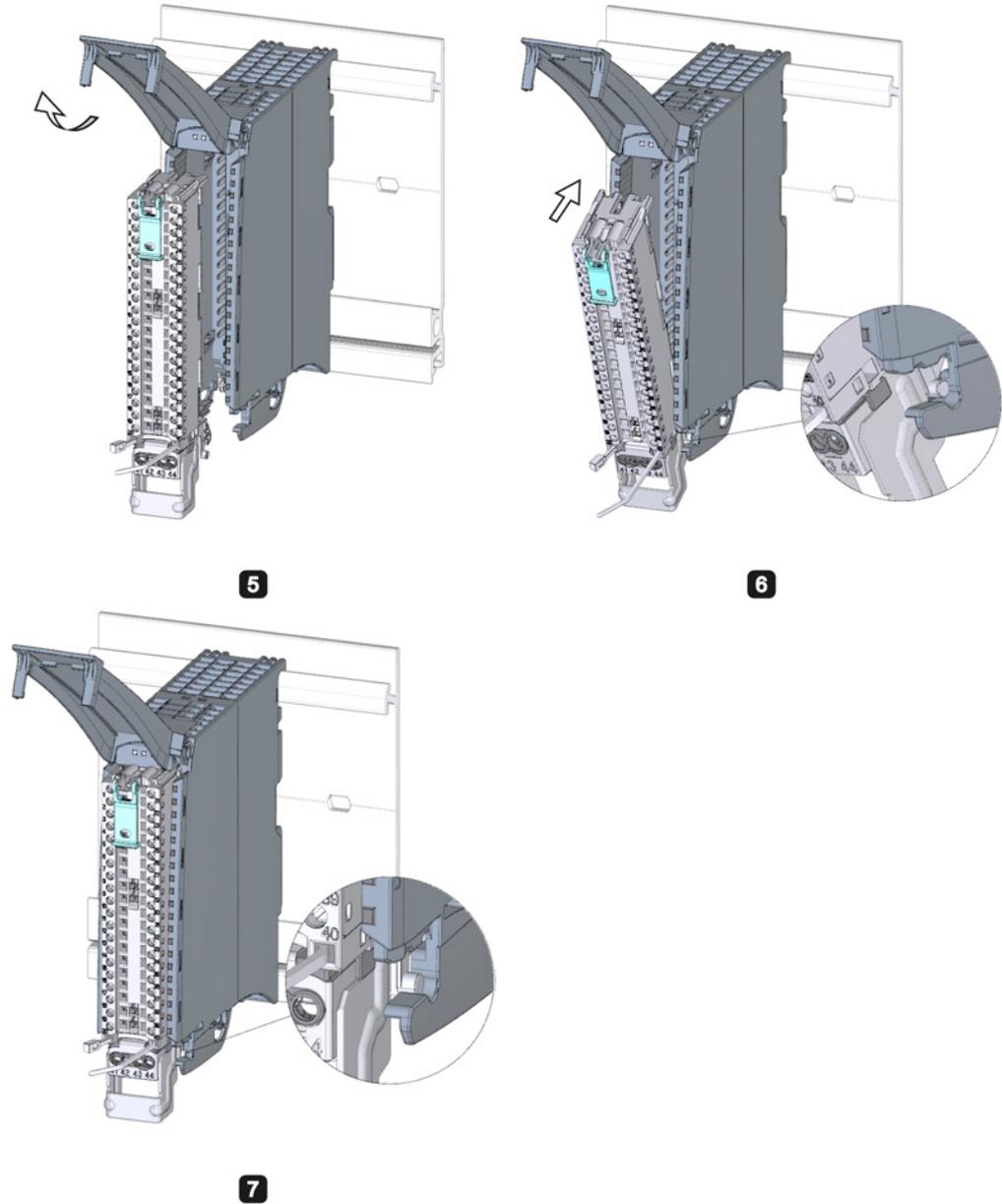

Figure 6-9   Preparing front connectors for I/O modules with shield contact element (2)

7. Wire the power supply element (Figure 8).
   Terminals 41/42 and 43/44 are galvanically connected to each other. If you connect the supply voltage to 41 (L+) and 44 (M), you can then loop-through the potential to the next module with terminals 42 (L+) and 43 (M).
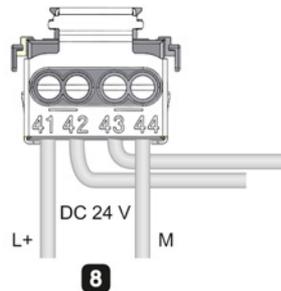

Figure 6-10   Preparing front connectors for I/O modules with shield contact element (3)

Wiring front connectors for I/O modules with shield contact element
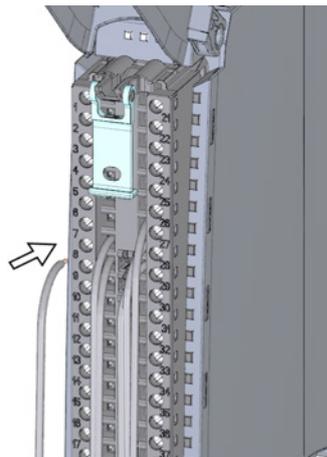
1. Strip the cable shielding.

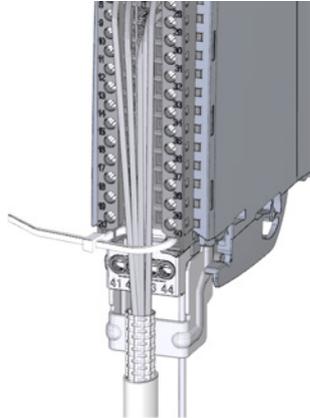2. Begin to completely wire the front connector (Figure 1).

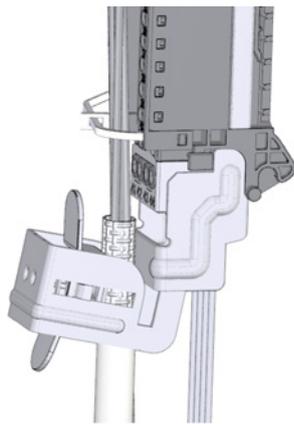Figure 6-11   Wiring front connectors for I/O modules with shield contact element (1)

3. Put the strain relief (cable tie) around the cable harness, and pull the strain relief for the cable harness tight (Figure 2).

Figure 6-12   Wiring front connectors for I/O modules with shield contact element (2)

4. Insert the shield clamp from below into the shielding bracket in order to connect the cable shielding (Figure 3).

Figure 6-13   Wiring front connectors for I/O modules with shield contact element (3)

Functions of the shield contact

The shield contact:

● Is needed to apply cable shields (e.g., for analog modules)

● Interference currents on cable shields are diverted from the shield connection to ground via the mounting rail. The shielding connection is not required at cable entry into the switchboard.

Reference

Further information on wiring the inputs and outputs can be found in the manuals for the I/O modules.

6.8.4 Bringing the front connector into final position

Bring the front connector from the pre-wiring position into final position

Proceed as follows to bring the front connector from the pre-wiring position into final position:

1. Grip the front connector by the unlocking strap.

2. Pull on the strap until the front connector is released from its latched position.

3. Tilt the top section of the front connector and raise it slightly. The front connector slides over the guide channel into its final position.
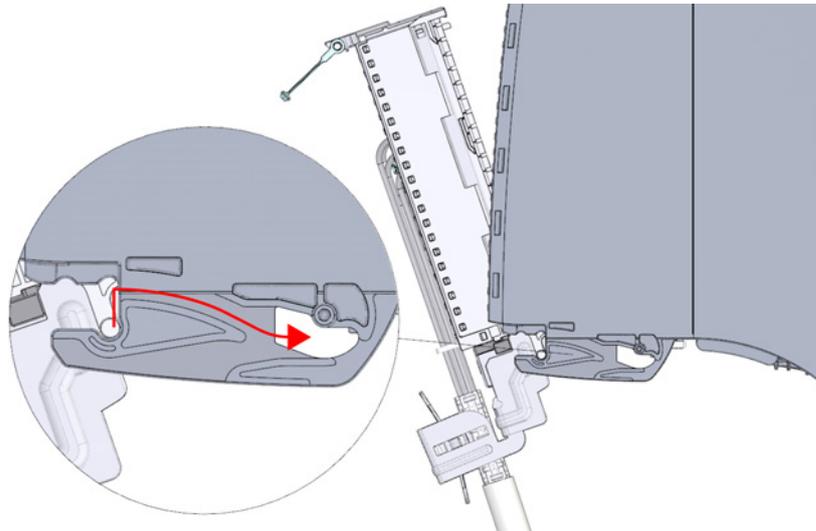
Figure 6-14   Bring the front connector from the pre-wiring position into final position

4. Push the front connector back into the I/O module until it latches. The front connector is now electrically connected with the I/O module.

5. Swivel the front cover down into place. Depending on the space requirement of the cable harness, various latch positions are possible so that the required cable storage space can grow as needed.

Bringing the front connector directly into final position

Proceed as follows to bring the front connector directly into final position:

1. Grip the front connector by the unlocking strap.

2. Push the guide pin of the front connector into the guide channel that has been displaced downwards. The front connector slides over the guide channel into its final position.
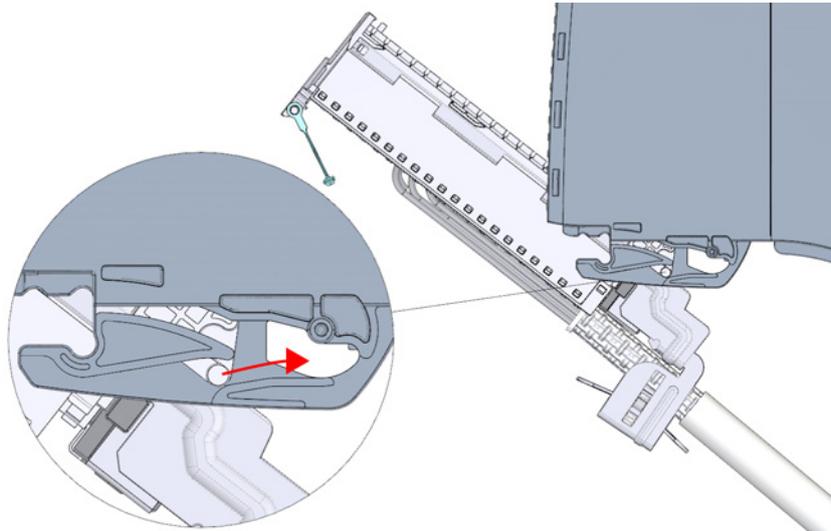

Figure 6-15   Bringing the front connector directly into final position

3. Tilt the front connector and press it into the I/O module until it latches. The front connector is now electrically connected with the I/O module.

4. Swivel the front cover down into place. Various latch positions are possible depending on the space requirement of the cable harness so that the required cable storage space can grow as needed.

6.9 Marking the I/O modules

6.9.1 Labeling strips

Introduction

Mark the pin assignment of the I/O modules using labeling strips. You can label the labeling strips as desired and slide them into the outside of the front cover.

The labeling strips are available in the following models:

- Pre-prepared strips that are included with the I/O module as delivered.
- DIN A4 sheets, pre-perforated strips for machine printing, see chapter Accessories/Spare parts (Page 212)

Preparing and installing the labeling strip

Proceed as follows to prepare and install the labeling strips:

1. Label the labeling strip.

2. With a pre-perforated strip: Separate the labeling strip from the sheet.

3. Slide the labeling strip into the outside of the front cover.
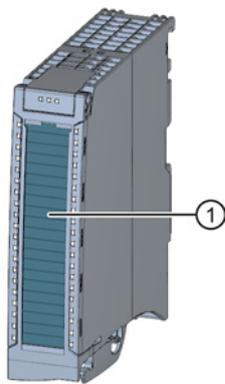
① Labeling strips

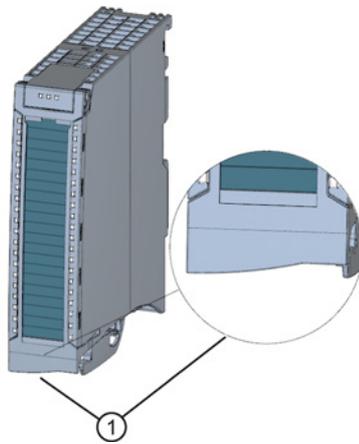Figure 6-16   Marking with labeling strips

6.9.2 Optional marking

Introduction

On the I/O modules there is free space on the front cover, that permits an additional labeling or marking on the part of the customer.

Optional marking

The front cover provides about 30 mm x 10 mm of space in its lower part for an optional identifier label.

①   Free space for example for equipment identifiers

Figure 6-17   Optional marking

Configuring

7

You transfer the configuration (preset configuration) and mode of operation to the S7-1500 automation system by configuring, parameterizing and connecting the individual hardware components. The work needed for this is undertaken in the device and network view in STEP 7.

"Configuring" is understood to mean arranging, setting and networking devices and modules within the device or network view. Modules and module carriers are graphically represented. Just like "real" module carriers, the device view allows the insertion of a defined number of modules.

When the modules are plugged, STEP 7 automatically assigns the addresses and a unique hardware identifier. The addresses can be changed subsequently. However, the hardware identifiers cannot be changed.

When the automation system is started, the CPU compares the configured planned configuration with the system's actual configuration. You can carry out parameter assignment of the response of the CPU to errors in the hardware configuration.

"Parameter assignment" is understood to mean setting the properties of the components used. The hardware parameters and the settings for data exchange are thereby assigned:

● Properties of the modules to which parameters can be assigned

● Settings for data exchange between components

The parameters are loaded into the CPU and transferred to the corresponding modules when the CPU starts up. Modules can be replaced with ease since the parameters set are automatically loaded into the new module during startup.

Reading out the configuration of an existing station

When a connection exists to a CPU, you can load the configuration of this CPU (including possibly present modules) from the device into your project.

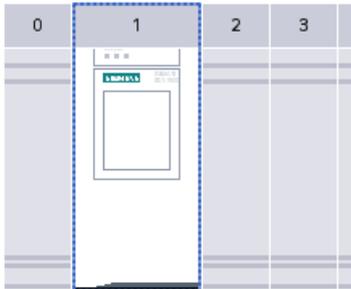To do this, create a new project and configure an "Unspecified CPU".

Figure 7-1   Unspecified S7-1500 CPU in the device view

In the device view (or in the network view), select the "Hardware detection" command in the "Online" menu.
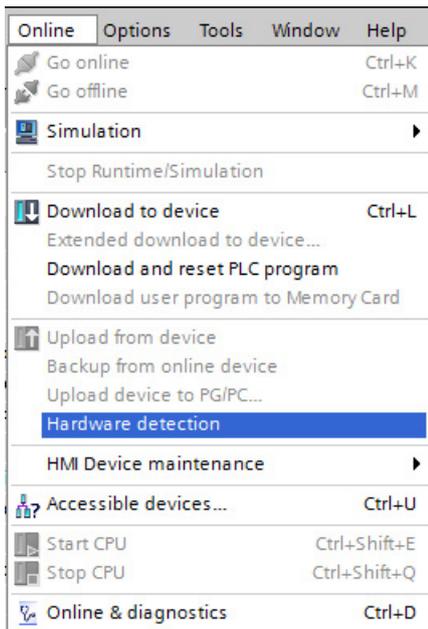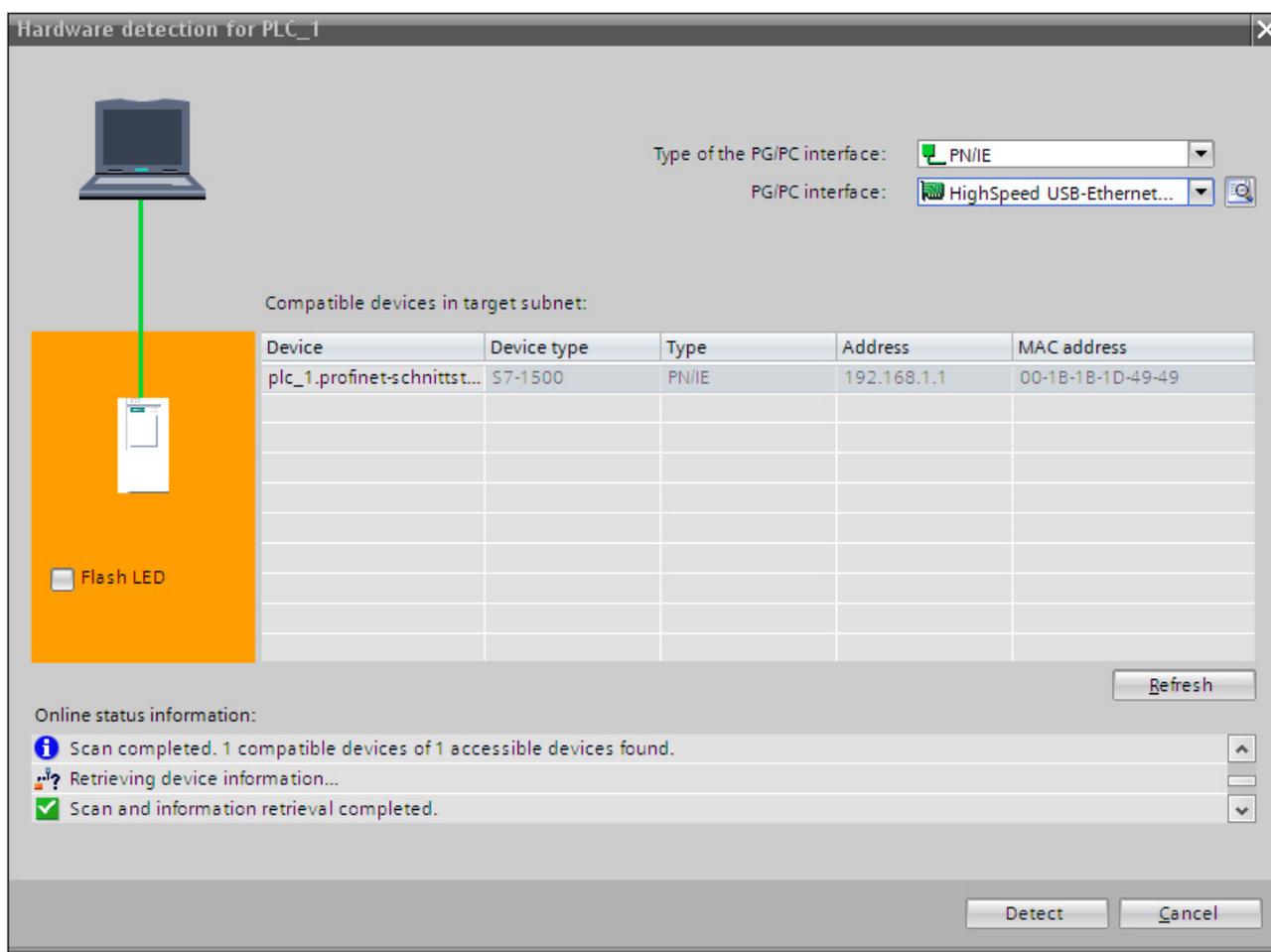

Figure 7-2   Hardware detection in the Online menu

Or double-click the CPU and click "detect" in the message.

The device is not specified.
→ Please use the Hardware catalog to specify the CPU,
→ or detect the configuration of the connected device.

Figure 7-3   Message for hardware detection in the device view

After you have selected the CPU in the "Hardware detection for PLC_x" dialog and have clicked the "Detect" button, STEP 7 loads the hardware configuration including the modules from to the CPU into your project.

Hardware detection for PLC_1

Type of the PG/PC interface: PN/IE
PG/PC interface: HighSpeed USB-Ethernet...

Compatible devices in target subnet:

Device	Device type	Type	Address	MAC address
plc_1.profinet-schnittst...	S7-1500	PN/IE	192.168.1.1	00-1B-1B-1D-49-49

Flash LED

Refresh

Online status information:
- Scan completed. 1 compatible devices of 1 accessible devices found.
- Retrieving device information...
- Scan and information retrieval completed.
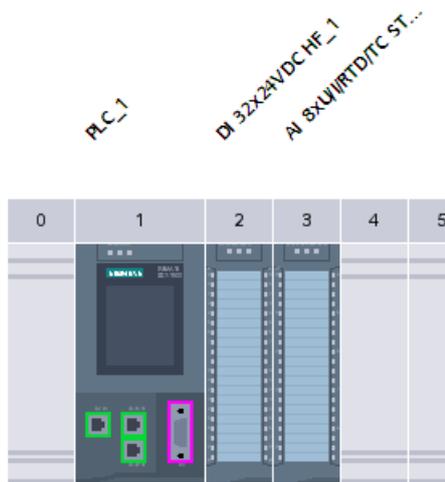
Detect   Cancel

Figure 7-4   Result of the hardware detection in the device view

STEP 7 assigns a valid default parameter assignments for all modules. You can change the parameter assignment subsequently.

Properties of central modules

The properties of the CPUs have special significance for system behavior. You can set the following, for example, at a CPU in STEP 7:

• Startup behavior

• Parameter assignment of the interface(s), for example IP address, subnet mask

• Web server, e.g., activation, user administration, and languages

• Cycle times, e.g., maximum cycle time

• Properties for the operation of the display

• System and clock memory

• Protection level for access protection with assigned password parameter

• Clock time settings (daylight saving time/standard time)

The properties that can be set and the respective value ranges are specified by STEP 7. Fields that cannot be edited are grayed out.

Reference

Information about the individual settings can be found in the online help and in the manual of the respective CPU.

7.1 Address assignment

7.1.1 Addressing - overview

Introduction

In order to address the automation components or I/O modules, unique addresses must be assigned to them. The various address areas are explained below.

I/O address

I/O addresses (input/output addresses) are required to read inputs and set outputs in the user program.

Input and output addresses are assigned automatically by STEP 7 when modules are inserted. Each module uses a continuous area in the input and/or output addresses corresponding to its volume of input and output data.

Module	Rack	Slot	I address	Q address	Type	Order no.
	0	0				
▶ PLC_1	0	1			CPU 1516-3 PN/DP	6ES7 516-3AN00-0AB0
DI 16x24VDC HF_1	0	2	0...1		DI 16x24VDC HF	6ES7 521-1BH00-0AB0
DQ 32x24VDC/0.5A ST_1	0	3		0...3	DQ 32x24VDC/0.5A...	6ES7 522-1BL00-0AB0
AI 8xU/I HS_1	0	4	2...17		AI 8xU/I HS	6ES7 531-7NF10-0AB0
AQ 8xU/I HS_1	0	5		4...19	AQ 8xU/I HS	6ES7 532-5HF00-0AB0

Figure 7-5   Example with input / output addresses from STEP 7

The address areas of the modules are assigned by default to the process image partition 0 ("Automatic updating"). This process image partition is updated in the main cycle of the CPU.

Device address (e.g., Ethernet address)

Device addresses are addresses of programmable modules with interfaces to a subnet (e.g., IP address or PROFIBUS address). They are required in order to address the various devices on a subnet, e.g., in order to download a user program.

Hardware identifier

In addition to the I/O addresses, a hardware identifier (Hardware identifier), which is used to identify the module, is assigned automatically by STEP 7. Such a Hardware identifier is also assigned to submodules.

The Hardware identifier consists of an integer and is output at diagnostics alarms by the system. This identifies the faulty module or the functional unit.
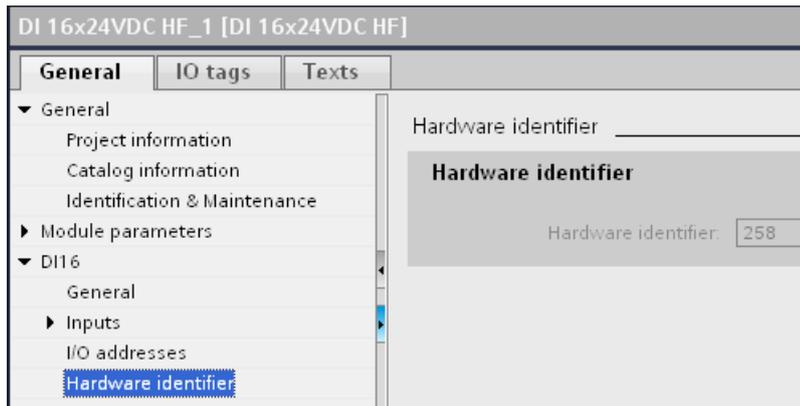

Figure 7-6   Example of a Hardware identifier from STEP 7

You also use the Hardware identifier for a series of instructions in order to identify the module to which the instruction should be applied.

The HW identifier is assigned automatically by STEP 7 and cannot be changed by the user.

The Hardware identifier is assigned automatically when components are inserted in the device or network view, and entered in the "Default tag table" of the PLC tags. A name is also assigned automatically for the Hardware identifier. These entries in the "Default tag table" of the PLC tags cannot be changed either.

Figure 7-7   Example of a default tag table from STEP 7

7.1.2   Addressing digital modules

Introduction

The addressing of digital modules is described below. In your user program, you require the addresses of the channels of the digital module.

Digital module addresses

The address of a digital module's input or output is composed of the byte address and the bit address. The channels of the digital module are assigned bit addresses.

If you enable the value status for a digital module, then additional bytes are allocated in the input address area. Each bit is assigned to a channel and returns information about the validity of the digital value (0 = incorrect value).

The value status is a binary additional information of a digital input signal. The value status is entered simultaneously with the process signal in the process image input and provides information about the validity of the signal.

Example: **I 1.2**

The example consists of:

I	Input	-
1	Byte address	The byte address depends on the module start address
2	Bit address	You read the bit address from the module

When you insert a digital module into a free slot, STEP 7 assigns a default address. You can change the proposed default address in STEP 7.

Example for the assignment of channel addresses (digital module)

The following figure shows how the addresses of the individual channels of the digital input module (e.g., 6ES7521-1BL00-0AB0) are determined.
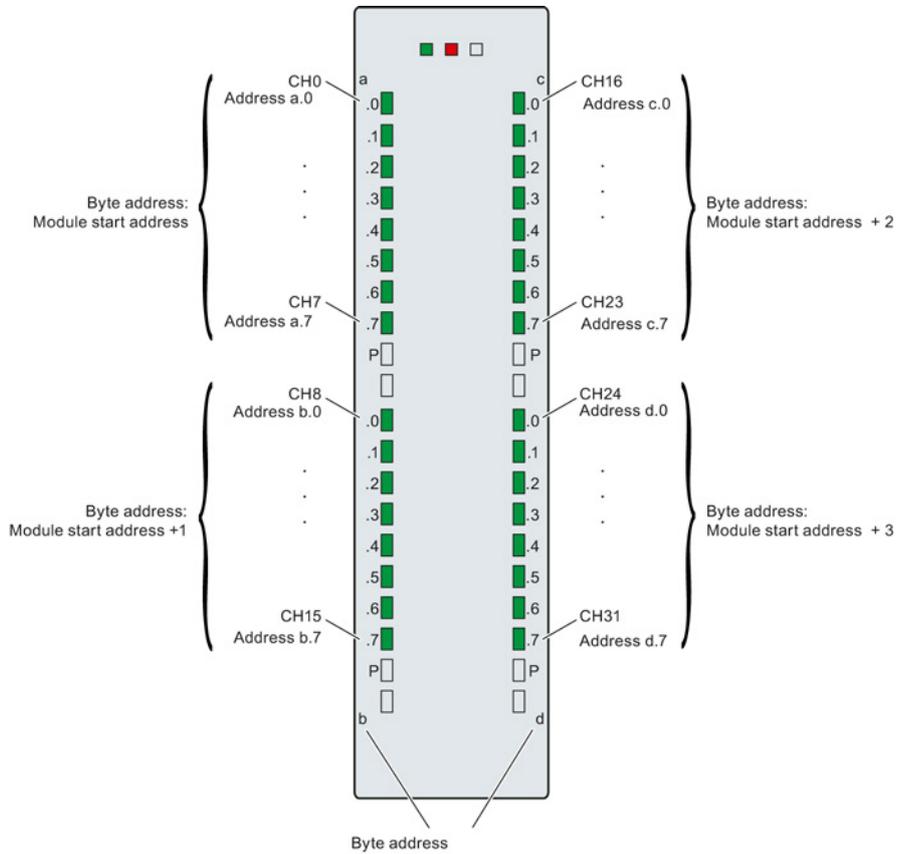

Figure 7-8   Example for the assignment of channel addresses (digital module)

Note

You can also assign symbolic names to the addresses in the STEP 7 PLC tag table.

Reference

Additional information on addressing and address allocation with value status can be found in the manuals of the digital modules, and in the online help for STEP 7.

7.1.3   Addressing analog modules

Introduction

The addressing of analog modules is described below. In your user program, you require the addresses of the channels of the analog module.

Analog module addresses

The address of an analog channel is always a word address. The channel address depends on the module start address. The channel addresses are automatically assigned during configuration in STEP 7. Based on the module start addresses, the assignment of the channel addresses occurs in increasing sequence (in the following figure, the module start address is 256).

When you insert an analog module into a free slot, STEP 7 assigns a default address. You can change the assigned default address in STEP 7.

If you enable the value status for an analog module, then additional bytes are allocated in the input address area. Each bit in this byte is assigned to a channel and returns information about the validity of the analog value (0 = incorrect value).

Example for the assignment of channel addresses (analog module)

The following figure shows how the addresses of the of the individual channels of the analog input module (e.g., 6ES7531-7NF10-0AB0) are determined, when the module has the start address 256.
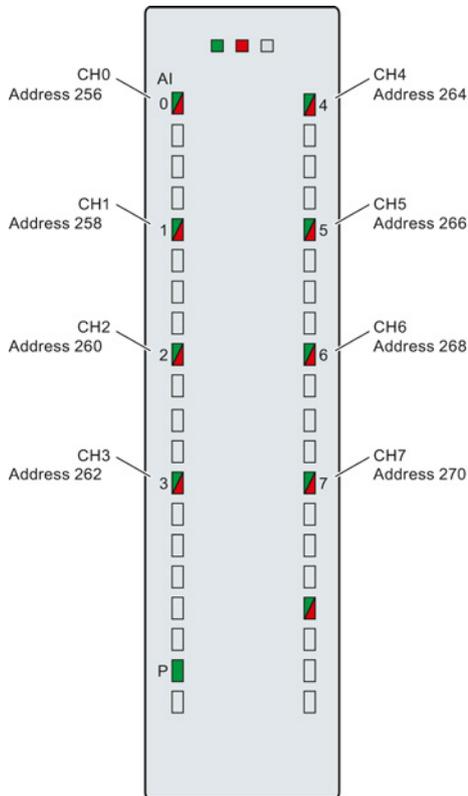

Figure 7-9   Example for the assignment of channel addresses (analog module)

Note

Names are assigned to the addresses in STEP 7's PLC tag table.

Reference

Additional information on addressing and address allocation with value status can be found in the manuals of the analog modules, and in the online help for STEP 7.

7.2 Process images and process image partitions

7.2.1 Process image - overview

Process image of the inputs and outputs

When the user program addresses the input (I) and output (O) operand areas, it does not query the signal states directly from the I/O modules. Instead, it accesses a memory area of the CPU. This memory area contains an image of the signal states and is called the process image.

Advantages of the process image

A process image offers the advantage that you can access a consistent image of process signals during cyclic program execution. If a signal state at an input module changes during program processing, the signal state is retained in the process image. The process image is not updated until the next cycle.

You can only assign the addresses of a module to a single process image partition.

32 process image partitions

In the S7-1500 automation system, the overall process image is subdivided into up to 32 process image partitions (PIP).

PIP 0 (automatic update) is automatically updated in each program cycle and is assigned to OB 1.

Process image partitions PIP 1 through PIP 31 can be assigned to the other OBs. In STEP 7, this assignment occurs during configuration of the I/O modules.

7.2.2 Automatically update process image partitions

One process image partition can be assigned to each organization block. In this case, the process image partition is automatically updated. The exceptions are PIP 0 and isochronous OBs.

Update process image partition

The process image partition is divided into two parts:

● Process image partition of the inputs (PIPI)

● Process image partition of the outputs (PIPQ)

The process image partition of the inputs (PIPI) is always read in/updated before the processing of the associated OB. The process image partition of the outputs (PIPQ) is always output at the end of the OB.

The following figure illustrates the updating of the process image partitions.
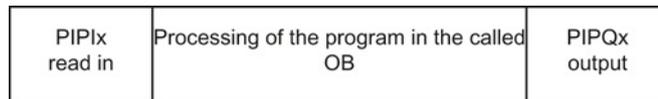
PIPIx read in	Processing of the program in the called OB	PIPQx output

Figure 7-10   Update process image partitions

7.2.3 Update process image partitions in the user program

As an alternative to the automatic updating of process image partitions, you can update process images with the "UPDAT_PI" instruction or the "UPDAT_PO" instruction. In STEP 7, these instructions are available on the "Instructions" Task Card under "Extended instructions" and may be called from any point in the program.

Requirements for updating process image partitions with the "UPDAT_PI" and "UPDAT_PO" instructions:

● The process image partitions may not be assigned to any OB, i.e. they may not be automatically updated.

● PIP 0 (automatic update) can likewise not be updated with the "UPDAT_PI" and "UPDAT_PO" instructions.

UPDAT_PI: Update the process image partition of the inputs

With this instruction you read the signal states from the input modules into the process image partition of the inputs (PIPI).

UPDAT_PO: Update the process image partition of the outputs

With this instruction you transmit the process image partition of the outputs to the output modules.

Direct I/O access to the inputs and outputs of the module

In the case of the S7-1500 you still have direct read and write access to the I/O, as an alternative to access via the process image, if this direct access is required for programming reasons.

Reference

Additional information on process image partitions is available found in the function manual, Cycle and response times (http://support.automation.siemens.com/WW/view/en/59193558).

Flexible automation concepts 8

8.1 Shared commissioning of projects

Team Engineering

In Team Engineering several users from various engineering systems work on a project at the same time and access one S7-1500 CPU.

The editors can work on separate parts of a master project independently of each other at the same time. The changes of the other editors are displayed in a synchronization dialog during the loading of the configuration in the CPU and synchronized automatically, if possible.

Certain online functions can also be executed at the same time from several engineering systems on the shared CPU, for example:

- Monitoring blocks on the CPU
- Controlling blocks on the CPU
- Trace functions

You can find detailed information on the topic of Team Engineering in the STEP 7 online help.

8.2 Standard machine projects

Using standard machine projects

Standard machine projects can be a useful solution, for example, when:

- The automation solution (machine) is used multiple times by a customer.
- The machine is used in different plants by various customers.

Advantages of standard machine projects

- A centrally maintained project (configuration and program) can be loaded to various machines of the same type without changes.
- Only a few easy adaptations are needed locally to integrate the machine into an existing network infrastructure.

Additional information

For detailed information on standard machine projects, refer to the PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) manual.

8.3 Configuration control

8.3.1 Important information regarding configuration control

Operating principle

Configuration control enables you to configure the installation of a controller and to operate versions (options) that differ from this configuration.

A control data record you have programmed in the startup program notifies the CPU as to which modules are missing in the real installation as compared to the configuration or which modules are located on a different slot as compared to the configuration. The configuration control does not have an impact on the parameter assignment of the modules.

Configuration control gives you the flexibility to vary the central installation as long as the real configuration can be derived from the set maximum configuration.
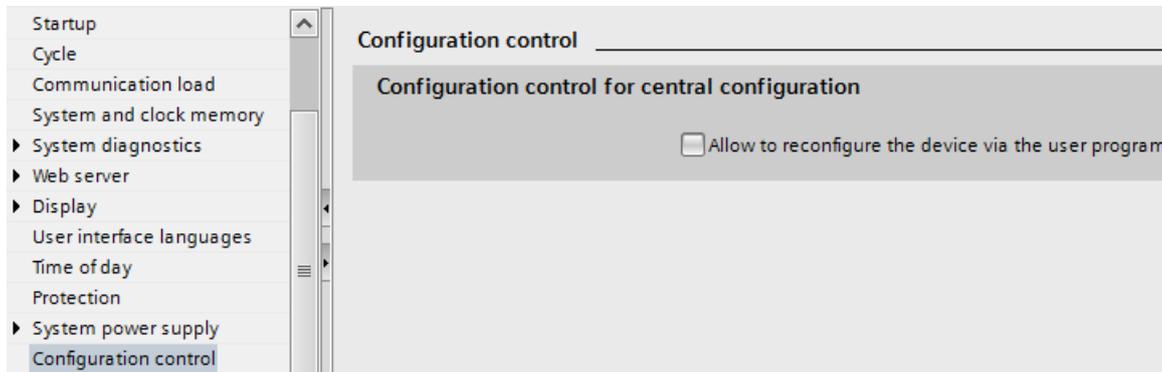
Below you will find a description of how to activate configuration control (CPU parameter assignment) and how to structure the required data record.

Requirement

- STEP 7 Professional Version V13 or higher

- CPU S7-15XX as of firmware version V1.5

- Recommendation: Before you load a new program with a modified control data record, perform a memory reset. This action will prevent errors that occur if an incompatible control data record is present.
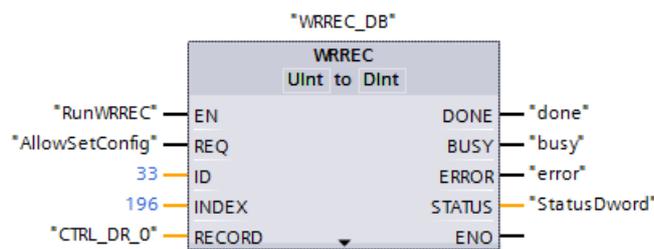
Required steps

- Enable the "Enable reconfiguration of device with user program" parameter when configuring the CPU ("Configuration control" area).

Startup
Cycle
Communication load
System and clock memory
▶ System diagnostics
▶ Web server
▶ Display
User interface languages
Time of day
Protection
▶ System power supply
Configuration control

Configuration control

Configuration control for central configuration

☐ Allow to reconfigure the device via the user program

- Create a control data record (in a data block, for example) according to the current configuration based on the sample described below for the control data record. The control data record has the number 196.

		Name	Data t...	Start v..	Retain	Accessi...	Visibl...	Setpoint	Comment
1		▼ Static	📋		☐	☐	☐	☐	
2	▪	Block_length	Byte	9	☑	☑	☑	☐	4+number of slots
3	▪	Block_ID	Byte	196	☑	☑	☑	☐	Data record number
4	▪	Version	Byte	4	☑	☑	☑	☐	
5	▪	Subversion	Byte	0	☑	☑	☑	☐	
6	▪	slot_0	Byte	16#0	☑	☑	☑	☐	configured slot 0 < real slot 0
7	▪	slot_1	Byte	16#1	☑	☑	☑	☐	configured slot 1 < real slot 1
8	▪	slot_2	Byte	16#2	☑	☑	☑	☐	configured slot 2 < real slot 2
9	▪	slot_3	Byte	16#FF	☑	☑	☑	☐	configured slot 3 < not used
10	▪	slot_4	Byte	16#3	☑	☑	☑	☐	configured slot 4 < real slot 3

- In the startup OB, call the extended WRREC (Write data record) instruction and transfer the created control data record.

```
                          "WRREC_DB"
                    ┌──────────────────┐
                    │      WRREC        │
                    │   UInt to DInt    │
     "RunWRREC" ────┤ EN          DONE ├──── "done"
"AllowSetConfig" ───┤ REQ         BUSY ├──── "busy"
             33 ────┤ ID         ERROR ├──── "error"
            196 ────┤ INDEX     STATUS ├──── "StatusDword"
    "CTRL_DR_0" ────┤ RECORD   ▼   ENO ├
                    └──────────────────┘
```

The configuration control is not ready for operation if a valid control data record is not transferred in the startup OB. The CPU returns from startup to STOP in this case.

Arrangement of the modules

The following table shows the slot number assignment:

Slot	Modules	Remark
0	Power supply module (optional)	Before the CPU
1	CPU	Slot 1 is always the CPU
2 - 31	I/O modules/system power supply modules, depending on the configuration version	After the CPU

Control data record

A control data record 196 containing a slot assignment is defined for the configuration control.

Byte	Element	Code	Explanation
0	Block length	4 + number of slots	Header
1	Block ID	196	
2	Version	4 (for central I/O)	
3	Version	0	
4	Assignment of configured slot 0	Real slot 0	Control element Describes in each element which real slot in the device is assigned to the configured slot.
5	Assignment of configured slot 1	Real slot 1 (always 1, because the CPU is always in slot 1)	
:	:	:	
4 + (max. slot number)	Assignment of configured maximum slot	Real slot	

Control element

Each element of the control data record must contain the following information about the slot:

● Assignment of configured slot ⇔ real slot

Byte	Bit	Meaning
Assignment of configured slot (e.g. in byte 5)	0 to 7	11111111: Module not present 00000000 up to maximum slot: Real slot

Rules

Observe the following rules:

- The central configuration must not contain a CP/CM, e.g., no CM 1542-5 (DP master or DP slave). You cannot load the configuration if you have configured a module of this type and configuration control is enabled.

- If you have enabled configuration control, the CPU is not ready for operation without a control data record. The CPU returns from startup to STOP if a valid control data record is not transferred in the startup OB. The central I/O is not initialized in this case. The cause for the STOP mode is entered in the diagnostics buffer.

- For addressing the WRREC instruction, use the HW identifier 33 (decimal, for the LADDR block parameter) to write the control data record.

  The HW identifiers can be found, for example, under **PLC tags > Default tag table > System constants** or in the "System constants" tab in the Inspector window of the CPU.

- The control data record is saved retentively in the CPU, which means that it is not necessary to write the control data record 196 again at a restart if the configuration is unchanged. Prior to commissioning, we recommend that a memory reset be performed for the CPU in order to delete any control data record that is present.

- Slot entries in the control data record outside the configured preset configuration are ignored.

- The control data record can be shortened. It must contain the entries up to the last slot of the current preset configuration.

- Each real slot may only be present once in the control data record.

- A real slot may only be assigned to one configured slot.

- System power supply modules (PS) can also be subject to configuration control. For a system power supply module (PS) on slot 0, we recommended that you avoid reconfiguration.

Note

Modified configuration

The writing of a control data record with a modified configuration triggers the following automatic reaction by the CPU: Memory reset with subsequent startup with this modified configuration.

As a result of this reaction, the retentively saved original data record 196 is deleted and the new data record 196 is saved retentively.

Behavior during operation

Effect of the discrepancy between the configured configuration and real configuration:

- For the online display and for the display in the diagnostics buffer (module OK or module faulty), the hardware configuration is always used and not the differing real configuration.

  Example: A module outputs diagnostics data. This module is configured in slot 4, but is really inserted in slot 3 (missing module; see example in the next section). In the online view, a configured slot 4 is indicated as faulty. In the real configuration, the module at slot 3 indicates an error via an LED display.

If modules are entered as missing in the control data record, the automation system behaves as follows:

- Modules designated as not present in the control data record do not supply diagnostics and their status is always OK. The value status is OK.

- Direct writing access to the outputs or writing access to the process image of outputs that are not present: Remains without effect; no access error is signaled.

- Direct read access to the inputs or read access to the process image of inputs that are not present: Value "0" is supplied; no access error is signaled.

- Write data record to module that is not present: Remains without effect; no error is signaled.

- Read data record from module that is not present: An error is signaled because a valid data record cannot be returned.

Error messages

The following error messages are returned if an error occurs during writing of the control data record:

Table 8- 1   Error messages

Error code	Meaning
80B1$_H$	Invalid length; the length information in data record 196 is not correct.
80B5$_H$	Configuration control parameters not assigned.
80E2$_H$	Data record was transferred in the wrong OB context. The data record must be transferred in the startup program.
80B8$_H$	Parameter error; module signals invalid parameters.

8.3.2 Example of a configuration control

A configuration consisting of a system power supply, CPU, and three I/O modules is configured in the following section.
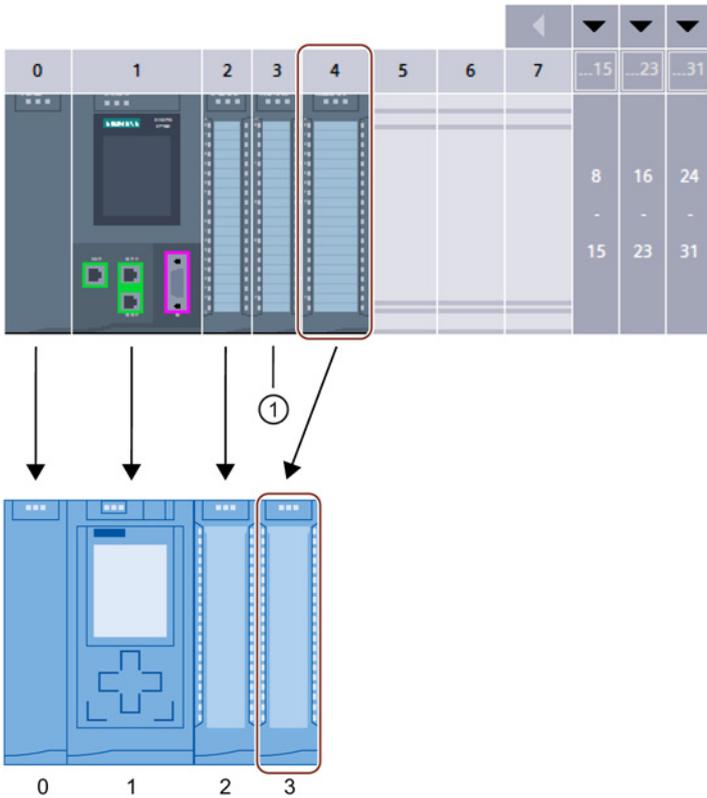
The module at slot 3 is not present in the first configuration expansion and is "hidden" by the configuration control.

In the second configuration expansion, the module that was initially hidden is located in the last slot. The added slot is made known to the CPU by a modified control data record.

Actual configuration with missing module

The specified configuration contains all modules that can be present in a final expansion stage.

The module that is inserted in slot 3 in the specified configuration is missing in the real expanded configuration. For this reason, slot 3 must be coded in the control data record accordingly with "FF $_H$" (= not present).

		Name		Data t...	Start v..	Retain	Accessi...	Visibl...	Setpoint	Comment
1		▼ Static				☐	☐	☐	☐	
2			Block_length	Byte	9	☑	☑	☑	☐	4+number of slots
3			Block_ID	Byte	196	☑	☑	☑	☐	Data record number
4			Version	Byte	4	☑	☑	☑	☐	
5			Subversion	Byte	0	☑	☑	☑	☐	
6			slot_0	Byte	16#0	☑	☑	☑	☐	configured slot 0 < real slot 0
7			slot_1	Byte	16#1	☑	☑	☑	☐	configured slot 1 < real slot 1
8			slot_2	Byte	16#2	☑	☑	☑	☐	configured slot 2 < real slot 2
9			slot_3	Byte	16#FF	☑	☑	☑	☐	configured slot 3 < not used
10			slot_4	Byte	16#3	☑	☑	☑	☐	configured slot 4 < real slot 3

①   Module is missing in the real configuration

Actual configuration with subsequently added module

The module present in slot 3 in the specified configuration is added to the back of the real configuration by inserting it as the last module in slot 4.

The control data record is adapted accordingly.
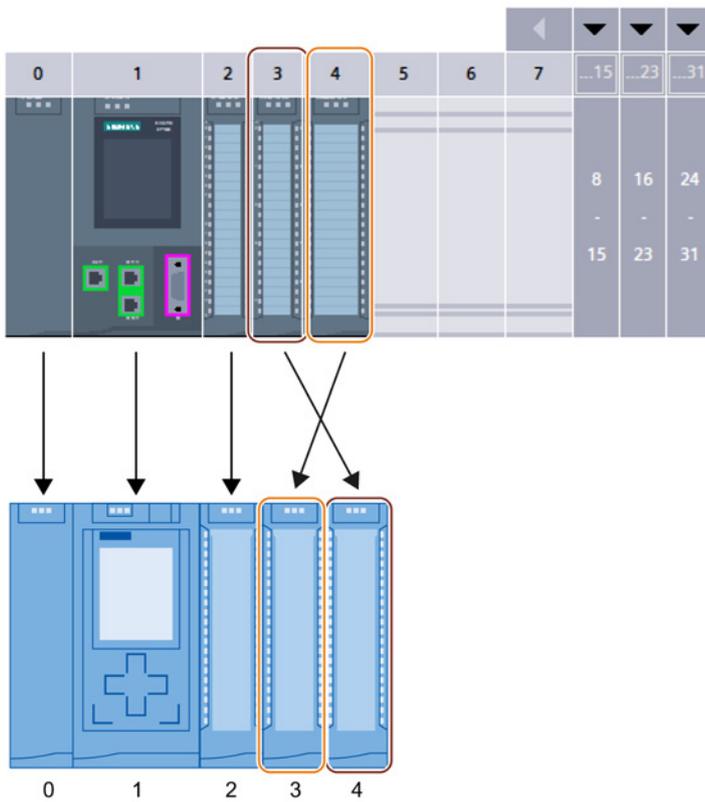
		Name	Data type	Start value	Retain	Acc...	Visi...	Setpo...	Comment
1		▼ Static			☐	☐	☐	☐	
2		Block_length	Byte	9	☑	☑	☑	☐	4+number of slots
3		Block_ID	Byte	196	☑	☑	☑	☐	Data record number
4		Version	Byte	4	☑	☑	☑	☐	
5		Subversion	Byte	0	☑	☑	☑	☐	
6		slot_0	Byte	16#0	☑	☑	☑	☐	configured slot 0 < real slot 0
7		slot_1	Byte	16#1	☑	☑	☑	☐	configured slot 1 < real slot 1
8		slot_2	Byte	16#2	☑	☑	☑	☐	configured slot 2 < real slot 2
9		slot_3	Byte	16#4	☑	☑	☑	☐	configured slot 3 < real slot 4
10		slot_4	Byte	16#3	☑	☑	☑	☐	configured slot 4 < real slot 3

Commissioning

<div style="text-align: right; font-size: 3em;">9</div>

9.1 Commissioning S7-1500 - overview

Introduction

In this section you will find summary information about the necessary steps for commissioning an S7-1500.

Commissioning requirements

Note

You must ensure the safety of your plant. Therefore, you must perform a complete functional test and the necessary safety checks before commissioning a plant.

Also allow for any possible foreseeable errors in the tests. In this way, you avoid endangering persons or plants during operation.

9.2 Check before powering on for the first time

Check before powering on for the first time

Before the first power-on, check the installation and the wiring of the S7-1500 automation system.

Questions for the check

The following questions provide guidance for the review of your S7-1500 automation system in the form of a checklist.

Racks

- Are the mounting rails firmly installed on the wall, in the framework, or in the cabinet?
- Are the cable ducts correctly installed?
- Have the minimum clearances been observed?

Grounding and chassis concept

- Is the mounting rail connected to the protective conductor?
- Has the connection between reference ground and ground been correctly made on all mounting rails?
- Are the required equipotential bonding cables connected with low impedance to the affected analog parts?

Module installation and wiring

- Are all the modules inserted / installed in accordance with the mounting plan and corresponding to the configuration with STEP 7 and screwed firmly to the mounting rail?
- Are all the front connectors wired according to the circuit diagram, in the final position, and inserted on the correct module?
- Are the correct modules installed and connected to each other with U connectors?
- Are U connectors projecting either at the left-hand or right-hand over the outer modules at the S7-1500 automation system?

System power supply or load current supply

- Are all the system power supply and load current supply modules switched off?
- Is the power cable connector correctly wired?
- Has the connection to line voltage been made?

9.3 Commissioning procedure

Requirement

The following requirements must be met:

- CPU that is in the "Factory settings" state or has been reset to Factory settings (Page 139)

- SIMATIC memory card that is in the delivered condition and formatted

Commissioning procedure

For the first commissioning of an S7-1500 automation system, we recommend the following procedure:

Action	Remark
Configure hardware in STEP 7 and perform power balance calculation (see also "Special considerations: CPU as bus device")	See the section Power balance calculation (Page 43).
Create user program	See the STEP 7 online help
Insertion of all required modules	See the Installation (Page 46) section
Wiring of the assembly (power supply modules, front connectors, ...)	See the Wiring (Page 59) section
Insertion of the SIMATIC memory card into the CPU	See the section, Insertion/removal of the SIMATIC memory card (Page 110)
First power-on	Switch on the CPU and power supply module. See the First power-on (Page 112) section
LED check	Notes on the meaning of the LEDs can be found in the manuals of the modules, and in the System Diagnostics Function Manual (http://support.automation.siemens.com/WW/view/en/59192926).
Evaluate information on the CPU's display	See the section, Display of the CPU (Page 156)
Configure hardware in STEP 7 and upload to the CPU	See Online and Diagnostics functions in STEP 7
Test the inputs and outputs	The following functions are helpful: Monitoring and controlling tags, testing with program status, forcing, controlling the outputs in STOP mode. See the Test functions and fault resolution (Page 143) section

Special considerations: CPU as bus device

For the operation of a CPU, the following requirements must be noted:

- PROFIBUS interface (for CPU 1516-3 PN/DP and CPU 1518-4 PN/DP)

    – The integrated PROFIBUS interface of the CPU is configured using STEP 7 (participant IP address and bus parameters configured).

    – The CPU is connected to the subnet.

    – The terminating resistors at the segment boundaries are switched on.

    See the PROFIBUS Function Manual (http://support.automation.siemens.com/WW/view/en/59193579)

- PROFINET interface

    – The integrated PROFINET interface of the CPU is configured using STEP 7 (IP address and device name configured).

    – The CPU is connected to the subnet.

    See the PROFINET Function Manual (http://support.automation.siemens.com/WW/view/en/49948856)

9.3.1 Removing/inserting the SIMATIC memory card

Requirement

The CPU only supports pre-formatted SIMATIC memory cards. As applicable, delete all previously stored data before using the SIMATIC memory card. Additional information about deleting the contents of the SIMATIC memory card can be found in the section, SIMATIC memory card - overview (Page 149).

In order to work with the SIMATIC memory card, first ensure that the SIMATIC memory card is not write-protected. For this purpose, slide the slider out of the lock position.

If the inserted SIMATIC memory card is write-protected, the CPU's display outputs the ⚠ symbol in the "Memory card" category and writes a corresponding alarm in the lower level of the category.

Insertion of the SIMATIC memory card

1. Open the front cover of the CPU.
2. Ensure that the CPU is either switched off, or in the STOP mode.
3. Insert the SIMATIC memory card, as depicted on the CPU, into the slot for the SIMATIC memory card.
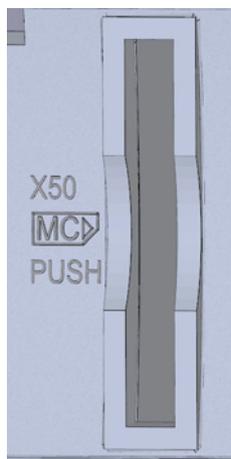

Figure 9-1   Slot for the SIMATIC memory card

4. Insert the SIMATIC memory card with light pressure into the CPU, until the SIMATIC memory card latches.

Removal of the SIMATIC memory card

1. Open the front cover.

2. Switch the CPU into STOP mode.

3. Press the SIMATIC memory card into the CPU with light pressure. After audible unlatching of the SIMATIC memory card, remove it.

Reactions after removing/inserting the SIMATIC memory card

Inserting and removing the SIMATIC memory card in STOP, STARTUP or RUN mode triggers a re-evaluation of the SIMATIC memory card. The CPU hereby compares the content of the configuration on the SIMATIC memory card with the backed-up retentive data. If the backed-up retentive data matches the data of the configuration on the SIMATIC memory card, the retentive data is retained. If the data differs, the CPU automatically performs a memory reset (which means the retentive data is deleted) and then goes to STOP.

The CPU evaluates the SIMATIC memory card, and indicates this by flashing the RUN/STOP LED.

Reference

Additional information on the SIMATIC memory card can be found in the SIMATIC memory card (Page 149) section.

9.3.2 First power-on

Introduction

The following procedure describes the commissioning of the CPU.

Requirements

- An S7-1500 automation system is installed and wired
- SIMATIC memory card has been inserted into the CPU

First power-on of a CPU

Switch on the system power supply and load power supply.

Result:

The CPU executes a flash test:

- All LEDs flash at 2 Hz
- RUN/STOP LED flashes alternately yellow/green
- ERROR LED flashes red
- MAINT LED flashes yellow

This is followed by system initialization with evaluation of the SIMATIC memory card:

- RUN/STOP LED flashes yellow at 2 Hz

After the system initialization has been completed, the CPU goes to STOP mode:

- The RUN/STOP LED lights up yellow

9.4 Operating modes

9.4.1 Basic principles of the operating modes

Introduction

Operating modes describe the states of the CPU. The following operating states are possible via the mode selector:

- STARTUP
- RUN
- STOP

In these operating modes, the CPU can communicate, e.g. via the PN/IE interface.

The status LEDs on the front side of the CPU indicate the current operating mode.

Reference

You can find additional information in the STEP 7 online help.

9.4.2   Operating mode transitions

Operating modes and operating mode transitions

The following figure shows the operating modes and the operating mode transitions:
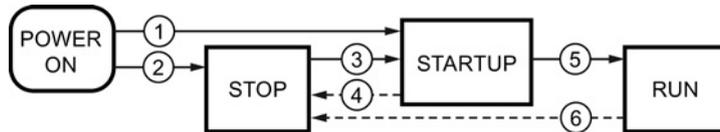
Figure 9-2   Operating modes and operating mode transitions

The following table shows the conditions under which the operating modes change:

Table 9- 1   Operating mode conditions

No.	Operating mode transitions	Conditions
①	POWER ON → STARTUP	After switching on, the CPU switches to "STARTUP" mode if: • The hardware configuration and program blocks are consistent. • The start-up type "Warm restart RUN" is set or the startup type "Warm restart operating mode before POWER OFF" is set and was in RUN mode before POWER OFF. Non-retentive memory is cleared, and the content of non-retentive DBs is reset to the start values of the load memory. Retentive memory and retentive DB contents are retained.
②	POWER ON → STOP	After switching on, the CPU goes to "STOP" mode if: • The hardware configuration and program blocks are consistent or • the "No restart" startup type is set. Non-retentive memory is cleared, and the content of non-retentive DBs is reset to the start values of the load memory. Retentive memory and retentive DB contents are retained.

No.	Operating mode transitions	Conditions
③	STOP → STARTUP	The CPU switches to "STARTUP" mode if: • The hardware configuration and program blocks are consistent. • The CPU is set to "RUN" by the programming device or via the display and the operating mode switch is in the RUN position or • the operating mode switch is switched from STOP to RUN. Non-retentive memory is cleared, and the content of non-retentive DBs is reset to the start values of the load memory. Retentive memory and retentive DB contents are retained.
④	STARTUP → STOP	The CPU returns to the "STOP" mode in the following cases of "STARTUP": • An error is detected during start-up. • The CPU is set to "STOP" mode via the programming device, the display or the operating mode switch. • A STOP command is executed in the Startup OB.
⑤	STARTUP → RUN	The CPU goes to the "RUN" mode in the following cases of "START-UP": • The CPU has initialized the PLC tags. • The CPU has executed the startup blocks successfully.
⑥	RUN → STOP	The CPU returns to the "STOP" mode in the following cases of "RUN": • An error is detected that prevents continued processing. • A STOP command is executed in the user program. • The CPU is set to "STOP" mode via the programming device, the display or the operating mode switch.

Setting the startup behavior

Proceed as follows to set the startup behavior:

1. Select the CPU in the device view of the STEP 7 hardware network editor.

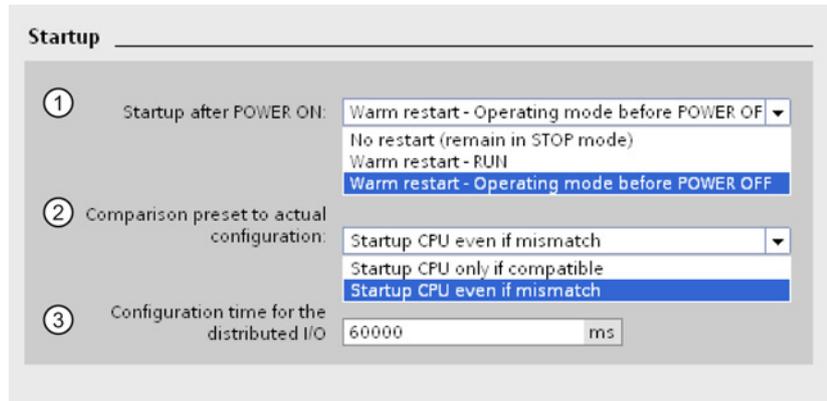2. In the properties under "General" select the "Startup" area.

Figure 9-3   Setting the startup behavior

① Sets the startup type after POWER ON

② Defines the startup behavior for the case where a module in a slot does not correspond to the configured module. This parameter applies to the CPU and to all the modules for which no other setting was selected.

- Startup CPU only if compatible: In this setting a module on a configured slot has to be compatible with the configured module.

- Startup CPU even if mismatch: At this setting the CPU starts up irrespective of the type of module plugged.

For locally used modules you can configure the hardware compatibility in the parameter "Comparison preset to actual module" individually for each slot. When you change the setting of the hardware compatibility for a module, the setting made at the CPU does not apply for this module.

③ Specifies a maximum period (default: 60000 ms) in which the central and distributed I/O must be ready for operation. The CMs and CPs are supplied with voltage and communication parameters during the CPU startup. This parameter assignment time grants a period, within which the I/O modules connected to a CM or CP must be operationally ready.
The CPU goes into RUN mode when the central and the distributed I/O is operationally ready within the parameter assignment time.

If the central and distributed I/O is not ready for operation within the configuration time, the startup characteristics of the CPU depends on the setting of the hardware compatibility.

Hardware compatibility

Compatible means that the module matches the number of inputs and output and must match with respect to its electrical and functional properties. A compatible module must be fully able to replace a configured module; it may be more capable, but not less capable.

In case of the "Startup CPU only if compatible" setting the CPU only starts up if the configured module or a compatible module is inserted. The CPU does not start up if an incompatible module is inserted.

Example for the "Startup CPU only if compatible" setting:

The input module DI 32x24VDC HF with 32 digital inputs is a compatible replacement for the input module DI 16x24VDC HF with 16 digital inputs, because the pin assignment and all the electrical and functional properties match.

Example for the "Startup CPU even if mismatch" setting:

Instead of a configured digital input module, an analog output module is inserted or no module is present in this slot and thus in all subsequent slots. Although the configured inputs cannot be accessed, the CPU starts up.

Note in this case that the user program cannot function correctly, so take the appropriate measures!

9.4.3 "STARTUP" mode

Function

Before the CPU starts to execute the cyclic user program, a startup program is executed.

By suitably programming startup OBs, you can specify initialization tags for your cyclic program in the startup program. That is, you can set up one or several startup OBs in your program, or none at all.

Special features during startup

Note the following points regarding the "STARTUP" mode:

- All outputs are disabled or react according to the parameter settings for the respective module: They provide a substitute value as set in the parameters or retain the last value output and bring the controlled process to a safe operating mode.

- The process image is initialized.

- The process image is not updated.
  In order to read the current state of inputs during STARTUP, you can access inputs by direct I/O access.
  In order to initialize outputs during STARTUP, values can be written via the process image or via direct I/O access. The values are output at the outputs during the transition to the RUN mode.

- The CPU always starts up in a warm restart.

  – The non-retentive bit memories, timers and counters are initialized.

  – The non-retentive tags in data blocks are initialized.

- During startup, no cycle time monitoring is running yet

- The startup OB are executed in the sequence of the startup OB numbers. All startup OBs that you have programmed are executed, regardless of the selected startup mode.

- The following OBs can be started during startup, if a corresponding event occurs:

  – OB 82: Diagnostics interrupt

  – OB 83: Pull/plug interrupt for modules

  – OB 86: Rack error

  – OB 121: Programming error (only for global error handling)

  – OB 122: Time-out (for global error handling only)
    You can find a description of how to use global and local error handling in the STEP 7 online help.

All other OBs cannot be started until after the transition to "RUN" mode.

Response when expected and actual configurations do not match

The expected configuration is represented by the configuration loaded into the CPU. The actual configuration is the actual configuration of the automation system. If the expected configuration and actual configuration deviate from one another, the CPU's behavior is specified by the setting of the hardware compatibility. For additional information about the hardware compatibility, see the section Operating mode transitions (Page 114).

Canceling a startup

If errors occur during startup, the startup is canceled and the CPU returns to "STOP" mode.

Under the following conditions, a startup will not be performed or will be canceled:

● If no SIMATIC memory card is inserted or an invalid one is inserted.

● If no hardware configuration has been downloaded.

Parameter assignment of startup behavior

You can assign parameters for the behavior of the CPU in the "Startup" group of the CPU properties. Additional information on configuring the startup behavior can be found in the Operating mode transitions (Page 114) section.

9.4.4 "STOP" mode

Function

In "STOP" mode, the user program is not executed.

All outputs are disabled or react according to the parameter settings for the respective module: They provide a substitute value as set in the parameters or retain the last value output and thus hold the controlled process in a safe operating mode.

9.4.5   "RUN" mode

Function

In "RUN" mode the cyclic, time-driven, and interrupt-driven program execution is performed. Addresses that are in the "Automatic Update" process image are automatically updated in each program cycle. See also the Process images and process image partitions (Page 95) section.

Execution of the user program

Once the CPU has read the inputs, the cyclic program is executed from the first instruction to the last instruction.

If you have configured a minimum cycle time, the CPU will not end the cycle until this minimum cycle time is up even if the user program is completed sooner.

A maximum cycle time is set which you can adjust according to your requirements. This ensures that the cyclic program is completed within a specified time. If the cyclic program has not finished running within this time, the system responds with a time error.
Further events such as hardware interrupts and diagnostic interrupts can interrupt the cyclic program flow and prolong the cycle time.

Reference

Further information about cycle and response times is available in the Function Handbook Cycle and response times (http://support.automation.siemens.com/WW/view/en/59193558).

9.5 Memory reset

Basics of a memory reset

A memory reset on the CPU is possible only in the STOP mode.

When memory is reset, the CPU is changed to a so-called "initial status".

This means that:

- An existing online connection between your programming device/PC and the CPU is terminated.

- The content of the work memory and the retentive and non-retentive data (applies only to manual memory reset by the user) are deleted.

- The diagnostics buffer, time of day, and IP address are retained.

- Subsequently the CPU is initialized with the loaded project data (hardware configuration, code and data blocks, force jobs). These data are copied from the load memory to the work memory.

  Result:

  – If an IP address was set in the hardware configuration ("Set IP address in the project" option) and a SIMATIC memory card with the project is in the CPU, this IP address is valid after the memory reset.

  – Data blocks no longer have current values but rather their configured start values.

  – Force jobs remain active.

How can I tell if the CPU is performing a memory reset?

The RUN/STOP LED flashes yellow at 2 Hz. After completion the CPU goes into STOP mode, and the RUN/STOP LED is switched on (unchanging yellow).

Result after memory reset

The following table provides an overview of the contents of the memory objects after memory reset.

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Certain retentive tags from technology objects (for example, adjustment values of absolute encoders)	Retained
Diagnostics buffer entries (retentive area)	Retained
Diagnostics buffer entries (non-retentive area)	Initialized
Counter readings of the runtime meters	Retained
Time of day	Retained

9.5.1   Automatic memory reset

Possible cause of automatic memory reset

The CPU executes an automatic memory reset, if an error occurs that prevents normal further processing.

Causes for such errors can be:

- User program is too large, and can't be completely loaded into work memory.

- The project data on the SIMATIC memory card are damaged, for example because a file was deleted.

- If the SIMATIC memory card is removed or inserted and the backed-up retentive data differs in structure from that of the configuration on the SIMATIC memory card.

9.5.2 Manual memory reset

Reason for manual memory reset

Memory reset is required to reset the CPU to its "original state".

Options for performing memory reset on a CPU

There are three options for performing a memory reset on the CPU:

- Using the operating mode switch
- Using the display
- Using STEP 7

Procedure using the operating mode switch

Note
Memory reset ↔ Reset to factory settings

The selector operation described below also reflects the procedure for a memory reset:
- Selector operation with inserted SIMATIC memory card: Memory reset is executed
- Selector operation without inserted SIMATIC memory card: Reset to factory settings is executed

---

Proceed as follows to reset the CPU memory using the mode selector switch:

1. Set the operating mode switch to the STOP position.

   Result: The RUN/STOP LED lights up yellow.

2. Set the operating mode switch to the MRES position. Hold the selector in this position until the RUN/STOP LED lights up for the 2nd time and remains continuously lit (this takes three seconds). After this, release the selector.

3. Within the next three seconds, switch the operating mode switch back to the MRES position, and then back to STOP again.

Result: The CPU executes memory reset.

Procedure using the display

To navigate to the desired "Memory reset" menu command, select the following sequence of menu commands and confirm after each selection with "OK".

- Settings → Reset → Memory reset

Result: The CPU executes memory reset.

Procedure using STEP 7

To perform a memory reset of the CPU using STEP 7, follow these steps:

1. Open the "Online Tools" task card of the CPU.

2. Click the "MRES" button in the "CPU control panel" pane.

3. Click "OK" in response to the confirmation prompt.

Result: The CPU is set to STOP mode and performs memory reset.

9.6 Identification and maintenance data

9.6.1 Reading out and entering I&M data

Introduction

Identification and maintenance data (I&M data) is data saved on the module as read-only (I data) or read/write (M data) information.

Identification data (I&M0): Manufacturer information about the module that can only be read and is in part also printed on the housing of the module, e.g., part number and serial number.
Maintenance data (I&M1, 2, 3): system-specific information, e.g. the installation location. Maintenance data for the S7-1500 are created during configuration and loaded into the automation system.

All modules of the S7-1500 support identification data (I&M0 through I&M3).

The I&M identification data supports you in the following activities:

- Checking the plant configuration

- Locating hardware changes in a plant

- Correcting errors in a plant

Modules can be clearly identified online using the I&M identification data.

You can read out the identification data with STEP 7 (see online help for STEP 7).

Options for reading out I&M data

- via the user program

- via the CPU's display

- via the CPU's web server

- via STEP 7 or HMI devices

Procedure for reading I&M data via the user program

To read the modules' I&M data in the user program, use the RDREC instruction.

The record structure for centrally inserted modules as well as for distributed modules that are accessible via PROFINET IO/PROFIBUS DP, is described in the chapter Record structure for I&M data (Page 127).

Procedure for reading I&M data via the display

To read the I&M data "Plant designation" or "Location identifier" of the CPU via the display, follow these steps:

1. Navigate to the "Overview/PLC" menu on the display of the CPU.

2. Select "Plant designation" or "Location identifier" and confirm with "OK".

To read the I&M data "Plant designation" or "Location identifier" of a centrally used module, follow these steps:

1. Navigate to the "Modules" menu on the display of the CPU.

2. Select the menu command "Local modules" and confirm with "OK".

3. Select the slot of the module (e.g., slot 3: DI 32 x 24VDC HF) and confirm with "OK".

4. Select the "Status" and confirm with OK.

5. Select "Plant designation" or "Location identifier" and confirm with "OK".

To read the I&M data "Plant designation" or "Location identifier" of a module used in distributed mode, follow these steps:

1. Navigate to the "Modules" menu on the display of the CPU.

2. Select the corresponding distributed I/O system (for example PROFINET IO system) and confirm with "OK".

3. Select the corresponding device (for example ET 200SP-Station_1) and confirm with "OK".

4. Select the slot of the module (e.g., slot 1: DI 16 x DC24V ST_1) and confirm with "OK".

5. Select the "Status" and confirm with OK.

6. Select "Plant designation" or "Location identifier" and confirm with "OK".

Procedure for reading I&M data via the Web server

The procedure is extensively described in the Identification section of the Web Server Function Manual (http://support.automation.siemens.com/WW/view/en/59193560).

Procedure for reading I&M data via STEP 7

Requirement: There must be an online connection to the CPU.

1. In the project tree, select the CPU and go to "Online & diagnostics".

2. In the "Diagnostics" folder, select the "General" area.

Procedure for entering maintenance data via STEP 7

The default module name is assigned by STEP 7. You can enter the following information:

- Plant designation (I&M 1)
- Location identifier (I&M 1)
- Installation date (I&M 2)
- Additional information (I&M 3)

1. In the device view of the STEP 7 device configuration, select the CPU or a module.

2. In the properties under "General" select the "Identification & Maintenance" area, and enter the data.

During the loading of the hardware configuration, the maintenance data (I&M 1, 2, 3) are also loaded.

Reference

The description of the instructions can be found in the STEP 7 online help.

9.6.2 Record structure for I&M data

Reading I&M records (centrally and distributed via PROFINET IO)

To directly access specific identification data for a module, use **Read record** ("RDREC" instruction). Under the associated record index you obtain the corresponding part of the identification data.

The records are structured as follows:

Table 9- 2   Basic record structure for I&M identification data

Contents	Length (bytes)	Coding (hex)
Header information		
BlockType	2	I&M0: 0020_H I&M1: 0021_H I&M2: 0022_H I&M3: 0023_H
BlockLength	2	I&M0: 0038_H I&M1: 0038_H I&M2: 0012_H I&M3: 0038_H
BlockVersionHigh	1	01
BlockVersionLow	1	00
Identification data		
Identification data (see table below)	I&M0/Index $AFF0_H$: 54 I&M1/Index $AFF1_H$: 54 I&M2/Index $AFF2_H$: 16 I&M3/Index $AFF3_H$: 54	- - - -

Table 9- 3   Record structure for I&M identification data

Identification data	Access	Example	Explanation
Identification data 0: (record index $AFF0_H$)			
VendorIDHigh	read (1 bytes)	0000_H	Vendor name ($002A_H$ = SIEMENS AG)
VendorIDLow	read (1 bytes)	$002A_H$	
Order_ID	read (20 bytes)	6ES7516-3AN00-0AB0	Part number of the module (e.g. CPU 1516-3 PN/DP)
IM_SERIAL_NUMBER	read (16 bytes)	-	Serial number (device-specific)
IM_HARDWARE_REVISION	read (2 bytes)	1	corresponds to hardware version (e.g. 1)
IM_SOFTWARE_REVISION	read	Firmware version	Provides information about the firmware version of the module (e.g. V1.0.0)
• SWRevisionPrefix	(1 byte)	V	
• IM_SWRevision_Functional_ Enhancement	(1 byte)	0000_H - $00FF_H$	
• IM_SWRevision_Bug_Fix	(1 byte)	0000_H - $00FF_H$	

Identification data	Access	Example	Explanation
• IM_SWRevision_Internal_ Change	(1 byte)	0000$_H$ - 00FF$_H$	
IM_REVISION_COUNTER	read (2 bytes)	0000$_H$	Provides information about parameter changes on the module (not used)
IM_PROFILE_ID	read (2 bytes)	0000 $_H$	Generic Device
IM_PROFILE_SPECIFIC_TYPE	read (2 bytes)	0001$_H$	CPU
		0003$_H$	I/O modules
IM_VERSION	read	0101$_H$	Provides information on the ID data version (0101$_H$ = Version 1.1)
• IM_Version_Major	(1 byte)		
• IM_Version_Minor	(1 byte)		
IM_SUPPORTED	read (2 bytes)	000E$_H$	provides information about the available identification and maintenance data (I&M1 to I&M3)
Maintenance data 1: (Record index AFF1$_H$)			
IM_TAG_FUNCTION	read/write (32 bytes)	-	Enter an identifier for the module here, that is unique plant-wide.
IM_TAG_LOCATION	read/write (22 bytes)	-	Enter the installation location of the module here.
Maintenance data 2: (Record index AFF2$_H$)			
IM_DATE	read/write (16 bytes)	YYYY-MM-DD HH:MM	Enter the installation date of the module here.
Maintenance data 3: (Record index AFF3$_H$)			
IM_DESCRIPTOR	read/write (54 bytes)	-	Enter a comment about the module here.

Reading I&M records with record 255 (distributed configuration via PROFIBUS)

The modules also support standardized access to the identification data via record 255 (index 65000 through 65003). For further information on the DS 255 data structure, refer to the specifications of the PROFIBUS Guideline - Order No. 3.502.

Maintenance

<div style="text-align: right; font-size: 3em; font-weight: bold;">10</div>

10.1 Removing and inserting I/O modules

Front connectors and I/O modules must only be inserted or removed when the voltage is switched off.

NOTICE
Physical damage can occur
If you install or uninstall front connectors and/or I/O modules with switched-on voltage, this can lead to undefined conditions in your plant.
Physical damage to the S7-1500 automation system may occur as a result.
Therefore only install/uninstall front connectors and/or I/O modules with switched-off voltage.
Therefore during the planning of a plant always make sure to comply with the necessary, pertinent standards and safety guidelines.

10.2 Replacement of I/O modules and front connectors

10.2.1 Coding element on the I/O module and on the front connector

Introduction

All front connectors for the I/O modules of the S7-1500 automation system are identical. The coding element prevents a front connector from being inserted on a module with a different electrical pin assignment.

In the delivery state, the coding element is located in the I/O module.
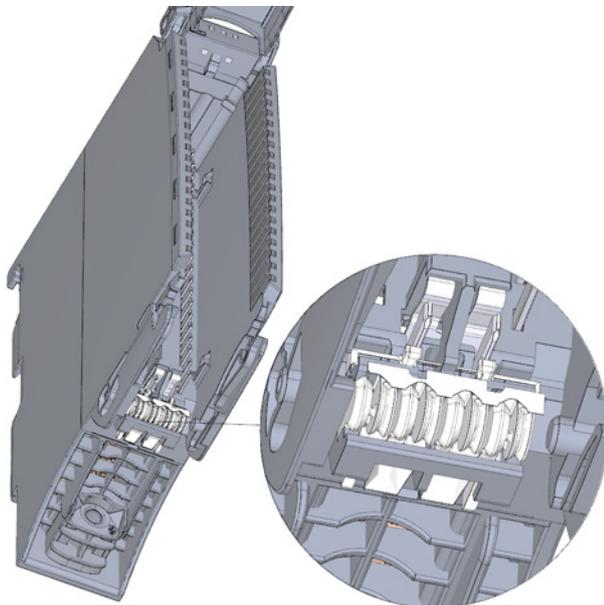
Figure 10-1   Coding element in the I/O module (delivery condition)

When the front connector is inserted into the I/O module for the first time, one half of the coding element latches into the front connector. When the front connector is removed from the I/O module, this half of the coding element remains in the front connector, while the other half remains in the I/O module.

I/O module with separated coding element

Front connector with separated coding element
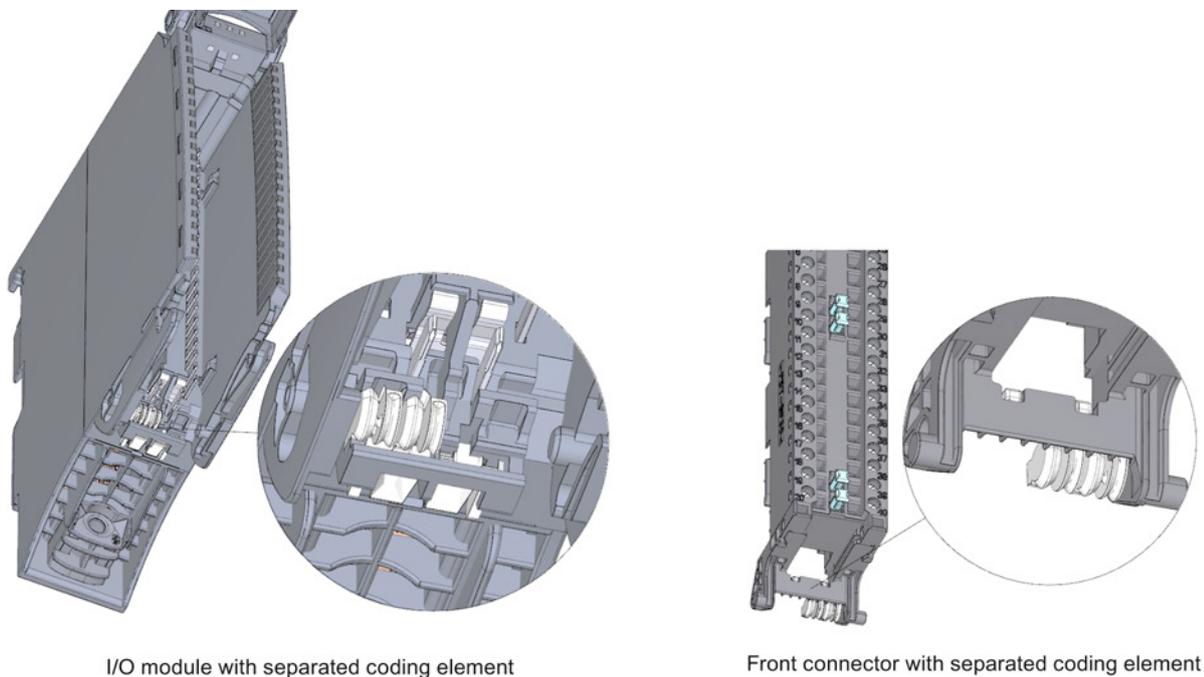
Figure 10-2   Coding element in the I/O module/front connector

A coded front connector can be inserted on modules with the same electrical pin assignment.

Please note the Application Planning (Page 35) section.

NOTICE
Physical damage can occur
If the coding element is changed or removed, it will be possible to insert the front connector on modules in which the electrical connection is not properly wired.
This can destroy the module and/or the connected sensors and actuators. Even hazardous plant states are possible.
Do not change the coding element unless you want to use the front connector on a different module and you change the process wiring accordingly.

Use cases for replacing the coding element

- Replacing an I/O module, for example due to a defect or to incorrect assembly
- Replacing a front connector

10.2.2   Replacing an I/O module

Introduction

When the front connector is first inserted into the I/O module, a part of the coding element clips onto the front connector. When you replace an I/O module with the same type of module, the correct coding element is already present in the front connector.

Replacing an I/O module

You have already uninstalled the I/O module.

1. With a new I/O module, use a screwdriver to break out the half of the coding element that is designated for the front connector.
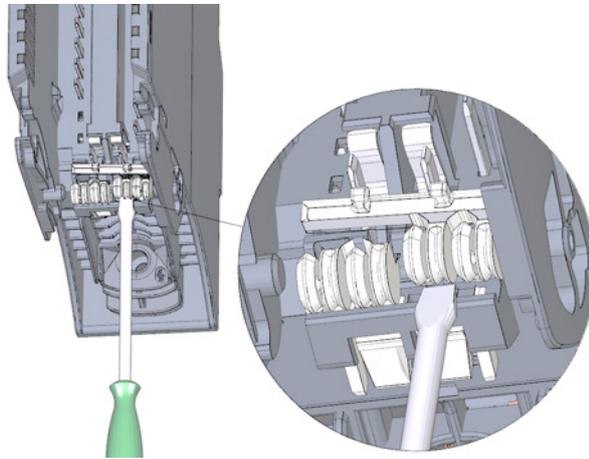
Figure 10-3   Breaking the coding element out of the I/O module

2. Insert the old front connector into the new I/O module (same module type) until your hear it click into place.

10.2.3   Replacing a front connector

Introduction

When the front connector is first inserted into the I/O module, a part of the coding element clips onto the front connector. When you replace a defective front connector with a new front connector, then you must transfer the coding element into the new front connector.

Replacing a front connector

You have already removed the front connector from the module and loosened the wiring. If you are using the front connector for an analog module, you also need to remove the power supply element and shield element. Proceed as follows to replace the front connector:

1. Carefully remove the coding element from the front connector. Take care not to damage the coding element.
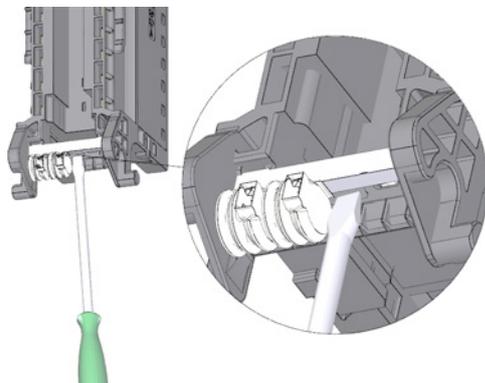
Figure 10-4   Removing the coding element from the front connector

2. Insert the removed coding element into the new front connector.
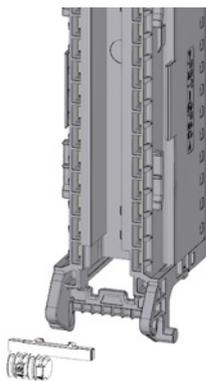
Figure 10-5   Inserting the coding element into the front connector

3. Insert the new front connector into the existing I/O module, until your hear it click into place.

4. Wire the new front connector.

10.3 Replacing the coding element at the power connector of the system power and load current supply

Introduction

The coding consists of a 2-part coding element.

Ex factory a part of the coding element is inserted into the back side of the power connector. The other part is firmly inserted in the system power supply or load current supply module.

This prevents the insertion of a power connector of a system power supply or load current supply module into a supply module of a different type.

> ⚠ **DANGER**
>
> **Do not manipulate the coding element, or leave it off**
>
> - If you undertake changes to the coding element or replace it, then this can lead to dangerous conditions in your plant.
> - In order to prevent damage, you must not change or replace the coding.
> - The coding element may not be left off.

Replacement parts scenario

Insertion of the coding element into a new power connector in the case of a replacement part.

> ⚠ **DANGER**
>
> **Dangerous voltage**
>
> When installing the coding element, you must take into account the supply voltage of the power supply module, 24 VDC, 24/48/60 VDC or 120/230 VAC/DC.
>
> Only install the coding element with switched-off voltage.
>
> You must insert the coding element in such a way that the power connector matches the power supply module in terms of voltage.

Procedure

1. Orient yourself to the labeling on the power cable connection.
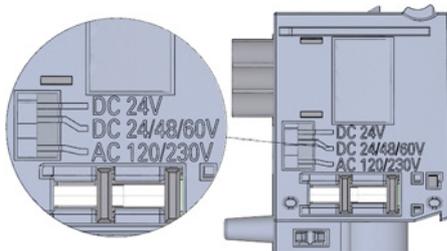
Figure 10-6   Labeling on the power connector

2. Orient yourself to the red marking on the coding element.

3. The coding element has 3 red markings. Turn the coding element in such a way that one of the 3 red markings corresponds to the voltage indicated on the connector.

4. Insert the coding element into the back side of the power cable connector, until you hear it click into place. The figure below shows you how to insert a coding element into a power cable connector for 24 VDC.
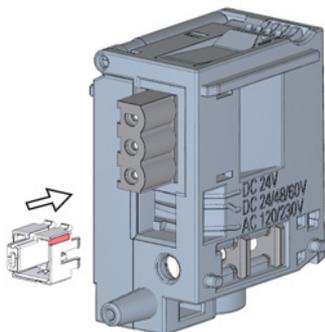
Figure 10-7   Inserting a coding element into a power connector

10.4   Firmware update

Introduction

During operation it may be necessary to update the firmware (for example due to functional enhancements).

Update the firmware of the CPU, display, and I/O modules using firmware files. The retentive data is retained after the execution of the firmware update.

Requirement

- You have downloaded the file(s) for the firmware update from the Customer Support (http://www.siemens.com/automation/) web site.

  On this web site, select: Automation technology > Automation systems > SIMATIC industrial automation system > Controllers > SIMATIC S7 modular controllers > SIMATIC S7-1500.

  From there, navigate to the specific type of module that you want to update. To continue, click on the link for "Software downloads" under "Support". Save the desired firmware update files.

- Ensure before installing the firmware update, that the modules are not being used.

Options for the firmware update

There are three options for performing a firmware update.

- via STEP 7 (online)
- via SIMATIC memory card (possible for CPU, display, and all centrally inserted modules)
- via the integrated Web server

Note

Firmware files of the CPU

An update of the S7-1500 CPU is only possible with STEP 7 (TIA Portal V12 or higher). An update of the I/O modules is possible with both STEP 7 (TIA Portal V12 or higher) and STEP 7 (V5.5). When you select the firmware files, make sure to use the files for STEP 7 (TIA Portal V12 or higher).

Installation of the firmware update

> ⚠️ **WARNING**
>
> **Impermissible plant states possible**
>
> Due to the installation of the firmware update, the CPU enters the STOP mode, which can impact the operation of an online process or a machine.
>
> Unexpected operation of a process or a machine can lead to fatal or severe injuries and/or to material damages.
>
> Ensure before installing the firmware update, that the CPU is not executing any active process.

Procedure using STEP 7

Proceed as follows to perform an online firmware update via STEP 7:

1. Select the CPU or the module in the device view.

2. Select the "Online & diagnostics" command from the shortcut menu.

3. In the "Functions" folder, select the "Firmware update" group.
   For a CPU, you can select whether you want to update the CPU or the CPU's display.

4. In the "Firmware update" area, click the "Browse" button to select the path to the firmware update files.

5. Select the matching firmware file. The table in the firmware update area lists all modules for which an update is possible with the selected firmware file.

6. Click the "Run update" button. If the selected file can be interpreted by the module, the file is downloaded to the module. If the operating mode of the CPU needs to be changed for this purpose, you will be prompted to do this by means of dialogs.

Updating the firmware

The "Run firmware after update" check box is always selected.

After a successful loading process the CPU includes imports the firmware and subsequently operates with the new firmware.

Insertion of the SIMATIC memory card

Proceed as follows perform a firmware update via the SIMATIC memory card:

Step 1: Load the firmware update onto the SIMATIC memory card

Step 2: Installation of the firmware update

Load the firmware update onto the SIMATIC memory card

1. Insert a SIMATIC memory card into an SD card reader of your programming device / computer.

2. In order to save the update file onto the SIMATIC memory card, select the SIMATIC memory card in the project tree under "Card reader/USB memory", and then in the "Project" menu select the command "Card reader/USB memory > Create firmware update memory card".

   Use a file selection dialog to navigate to the firmware update file. In a further step you can decide whether the content of the SIMATIC memory card is to be deleted or whether firmware update files are to be added to the SIMATIC memory card.

Special feature at a firmware update of analog modules

If you want to carry out a firmware update for analog modules, you have to supply 24 VDC load supply to the module through the power supply element.

Procedure

1. Remove any inserted SIMATIC memory card.

2. Insert the SIMATIC memory card with the firmware update files into the CPU.

3. The firmware update begins shortly after the SIMATIC memory card has been plugged.

   The display indicates that the CPU is in STOP mode, and that a firmware update is being executed (STOP [FW UPDATE]). It displays the progress of the firmware update. Possibly occurring errors during the firmware update will likewise be displayed on the display.

4. After a completed firmware update, the display indicates that you can remove the SIMATIC memory card.
   The RUN LED on the CPU lights up yellow, the MAINT LED flashes yellow.

If you then use the SIMATIC memory card as program card, delete the firmware update files manually.

Note

If your hardware configuration contains several modules to which a firmware update from the SIMATIC memory card can be applied, the CPU updates all affected module in the slot sequence, which means in ascending order of the module position in the STEP 7 device configuration.

Procedure using the Web server

The procedure is described in the Web server
(http://support.automation.siemens.com/WW/view/en/59193560) Function Manual.

Reference

Further information on the procedure can be found in the STEP 7 online help.

10.5 Resetting the CPU to factory settings

With "Reset to factory settings" the CPU is restored to the "as-delivered condition". This means that all data that were internally stored in the CPU have been deleted.

Recommendation:

If you want to remove a PROFINET CPU and use it elsewhere with a different program, or put it into storage, then the CPU should be restored to the as-delivered condition. When restoring factory settings, remember that the IP address parameters are also deleted.

Options for resetting a CPU to factory settings

There are three options for resetting the CPU to the as-delivered condition:

- Using the operating mode switch
- Using the display
- Using STEP 7

Procedure using the operating mode switch

Make sure that there is no SIMATIC memory card in the CPU and that the CPU is in STOP mode (the display of the CPU shows the STOP mode or RUN/STOP LED lights up yellow).

Note

Reset to factory settings ↔ Memory reset

The selector operation described below also reflects the procedure for a memory reset:

- Selector operation with inserted SIMATIC memory card: Memory reset is executed
- Selector operation without inserted SIMATIC memory card: Reset to factory settings is executed

---

Perform a reset to factory settings, when there is no SIMATIC memory card inserted, as follows:

1. Set the operating mode switch to the STOP position.

   Result: The RUN/STOP LED lights up yellow.

2. Set the operating mode switch to the MRES position. Hold the operating mode switch in this position until the RUN/STOP LED lights up for the 2nd time and remains continuously lit (this takes three seconds). After this, release the selector.

3. Within the next three seconds, switch the operating mode switch back to the MRES position, and then back to STOP again.

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, then the CPU has been reset to factory settings, and is in the STOP mode. The "Reset to factory settings" event is entered into the diagnostics buffer.

Note

The IP address of the CPU is also deleted when the CPU is reset to the factory settings through the operating mode switch.

Procedure using the display

Make sure that there is no SIMATIC memory card in the CPU and that the CPU is in STOP mode (CPU shows the STOP mode or RUN/STOP LED lights up yellow).

To navigate to the desired "Factory settings" menu command, select the following sequence of menu commands and confirm after each selection with "OK".

● Settings → Reset → Factory settings

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, then the CPU has been reset to factory settings, and is in the STOP mode. The "Reset to factory settings" event is entered into the diagnostics buffer.

Note

The IP address of the CPU is also deleted when the CPU is reset to the factory settings through the display.

Procedure using STEP 7

Make sure there is an online connection to the CPU that is to be reset to the factory settings.

1. Open the Online and Diagnostics view of the CPU.

2. In the "Functions" folder, select the "Reset to factory settings" group.

3. Select the "Retain IP address" option button if you want to retain the IP address, or the "Reset IP address" option button if you want to delete the IP address.

4. Click the "Reset" button.

5. Click "OK" in response to the confirmation prompts.

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, then the CPU has been reset to factory settings, and is in the STOP mode. The "Reset to factory settings" event is entered into the diagnostics buffer.

Result after resetting to factory settings

The following table provides an overview of the contents of the memory objects after the reset to factory settings.

Table 10- 1   Result after resetting to factory settings

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Certain retentive tags from technology objects (for example, adjustment values of absolute encoders)	Initialized
Diagnostics buffer entries (retentive area)	Initialized
Diagnostics buffer entries (non-retentive area)	Initialized
Counter readings of the runtime meters	Initialized
Time of day	Initialized

If a SIMATIC memory card was inserted prior to the reset to factory settings, the configuration contained on the SIMATIC memory card (hardware and software) is downloaded to the CPU. A configured IP address then becomes valid again.

Reference

Additional information on "Reset to factory settings" can be found in the Function Manual Structure and use of the CPU memory (http://support.automation.siemens.com/WW/view/en/59193101) in the section on memory areas and retentivity, and in the online help for STEP 7.

Test functions and fault resolution $\quad$ 11

11.1 $\quad$ Test functions

Introduction

You have the option of testing the operation of your user program on the CPU. You can then monitor signal states and values of tags and can assign values to tags to simulate specific situations in the running of the program.

Note

Using test functions

The use of test functions can influence the program execution time and thus the cycle and response times of the controller to a slight extent (a few milliseconds).

Requirement

The following requirements must be met:

- There is an online connection to the relevant CPU.
- There must be an executable program in the CPU.

Test options

The following test options are available:

- Testing with program status
- Testing with a watch table
- Testing with a force table
- Testing with the LED flash test
- Testing with the trace and logic analyzer function

Testing with program status

The program status allows you to monitor the execution of the program. You can display the values of operands and the results of logic operations (RLO) allowing you to recognize and fix logical errors in your program.

Testing with watch tables

The following functions are available in the watch table:

- Monitoring of tags

  This allows the current values of the individual tags of a user program or a CPU to be monitored on the programming device / PC or on the display of the CPU.

  The following operand areas are possible:

  – Inputs and outputs (process image) and bit memory

  – Contents of data blocks

  – Peripheral inputs and peripheral outputs

  – Timers and counters

- Modifying tags

  You can use this function to assign fixed values to the individual tags of a user program or CPU. Modifying is also possible with Test with program status .

  The following operand areas are modifiable:

  – Inputs and outputs (process image) and bit memory

  – Contents of data blocks

  – Peripheral inputs and peripheral outputs (for example, %I0.0:P, %Q0.0:P)

  – Timers and counters

- "Enable peripheral outputs" and "Modify now"

  These two functions enable you to assign fixed values to individual peripheral outputs of a CPU in the STOP mode. You can also use them to check your wiring.

Testing with the force table

The following functions are available in the force table.

- Monitoring of tags

  This allows the current values of the individual tags of a user program or a CPU to be displayed on the programming device / PC or on the display of the CPU. Tags can be monitored with or without a trigger frequency.

  The following tags can be monitored:

  – Bit memory

  – Contents of data blocks

  – Peripheral inputs (e.g. %I0.0:P)

- Forcing of peripheral inputs and peripheral outputs

  You can force individual peripheral inputs or peripheral outputs.

  – Peripheral inputs: Forcing of peripheral inputs (for example %I0.0:P) is a "bypassing" of sensors / inputs by the specification of fixed values to the program. Instead of the actual input value (via process image or via direct access) the program receives the force value.

  – Peripheral outputs: Forcing of peripheral outputs (for example %Q0.0:P) is a "bypassing" of the complete program by the specification of fixed values to the actuators.

Difference between modifying and forcing

The fundamental difference between the modifying and forcing functions consists in the storage behavior:

- Modifying: Modifying of tags is an online function and is not stored in the CPU. You can end modifying of tags in the watch table or by disconnecting the online connection.

- Forcing: A force job is written to the SIMATIC memory card and is retained after a POWER OFF. An active force job is indicated in the display of the S7-1500 CPU through a corresponding symbol. You can only end the forcing of peripheral inputs and peripheral outputs in the force table.

Testing with the LED flash test

In many online dialogs, you can perform an LED flash test. This function is useful, for example, when you are not sure which device in the hardware configuration corresponds to the station currently selected in the software.

When you click the "Flash LED" button, an LED flashes at the currently selected station. On the CPU, the following LEDs flash: RUN/STOP LED, ERROR LED and MAINT LED. The LEDs continue to flash until you terminate the flash test.

Testing with the trace and logic analyzer function

The trace function is used to record the CPU tags, depending on the settable trigger conditions. Tags are, for example, drive parameters or system and user tags of a CPU. The recorded data are saved on the CPU and, when required, can be displayed and read out with STEP 7.

The trace function can be called from the CPU's folder in the project tree, under the name "Traces".

Simulation

With STEP 7 you can run and test the hardware and software of the project in a simulated environment. Start the simulation using the menu command "Online" > "Simulation" > "Start".

Reference

Further information on the test functions can be found in the STEP 7 online help.

Further information about testing with trace and logic analyzer functions is available in the Function Manual Using the trace and logic analyzer function (http://support.automation.siemens.com/WW/view/en/64897128).

11.2 Reading out/saving service data

Introduction

In addition to the contents of the diagnostics buffer, the service data contain numerous additional data points about the internal status of the CPU. If a problem with the CPU should occur, that cannot otherwise be resolved, please send the service data to our Service & Support. The service data allow Service & Support to analyze problems that have occurred rapidly.

Requirement

Service data can be read out via the Web server, via STEP 7 or via the SIMATIC memory card.

Procedure using the Web server

1. Open a web browser that is suitable for communication with the CPU.

2. Enter the following address in the address bar of the web browser:
   https://<CPU IP address>/save_service_data.html, e.g.,
   https://172.23.15.3/save_service_data.html

3. The service data page will appear on your screen, with a button for saving the service data.

Figure 11-1   Reading out service data via the web server

4. Save the service data locally on your PC/programming device, by clicking "Save ServiceData".

Result: The data are saved in a .dmp file with the following naming convention:
"<Part number> <serial number> <time stamp>.dmp". The file name can be changed.

Procedure using STEP 7

A description of how to save service data is available under the keyword "Save service data" in STEP 7 online help.

Procedure via the SIMATIC memory card

If it is no longer possible for technical reasons to communicate with the CPU via Ethernet, you can also read out the service data via the SIMATIC memory card. To do this, proceed as follows:

1. Insert the SIMATIC memory card into the card reader of your PC / programming device.

2. Open the job file S7_JOB.S7S in an editor.

3. Overwrite the entry PROGRAM with the string DUMP in the editor.
   (Do not use any spaces/line breaks/quotation marks to ensure that the file size is exactly 4 bytes)

4. Save the file under the existing file name.

5. Make sure that the SIMATIC Memory Card is not write protected and insert it in the slot on the CPU.
   (for the CPU 1518-4 PN/DP, you need a card ≥ 2 GB and for the CPU 1511-1 PN, CPU 1513-1 PN, CPU 1515-2 PN, and CPU 1516-3 PN/DP a card ≥ 32 MB)

Result: The CPU writes the service data file DUMP.S7S to the SIMATIC memory card and remains in STOP mode.

The transfer of the service data has been completed as soon as the STOP LED stops flashing and lights up continuously. If the transfer was successful, only the STOP LED lights up. If the transfer was not successful, the STOP LED lights up and the ERROR LED flashes. In case of an error, the CPU stores a text file with a note on the error that occurred in the DUMP.S7S folder.

Use the SIMATIC memory card to read out the service data only if you are no longer able to communicate with the CPU via Ethernet. In all other cases it is preferable to read out the service data via the Web server or STEP 7.

SIMATIC memory card

<div align="right" style="font-size:3em">12</div>

12.1 SIMATIC memory card - overview

Introduction

The S7-1500 automation system uses a so-called SIMATIC memory card as the program memory. The SIMATIC memory card is a preformatted memory card compatible with the Windows file system. The memory card is available in different memory sizes and can be used for the following purposes:

- Transportable data carrier
- Program card
- Firmware update card
- Service data cards

A commercially available SD card reader is required to write / read the SIMATIC memory card with the programming device / PC. This allows, for example, files to be copied directly to the SIMATIC memory card using the Windows Explorer.

A SIMATIC memory card is absolutely required in order to operate the CPU.

Note

Memory size of the SIMATIC memory card

Please note that a SIMATIC memory card with a memory size of 24 MB is not sufficient for a firmware update of the CPU 1518-4 PN/DP.

Therefore, select a SIMATIC memory card with more memory space (e.g. 2 GB) for the firmware update of a CPU 1518-4 PN/DP.

Insertion of the SIMATIC memory card
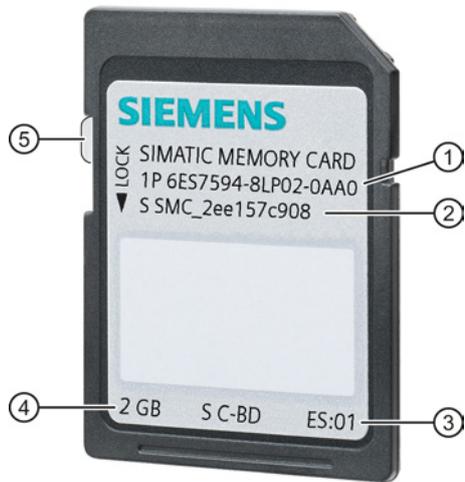
①   Part number
②   Serial number
③   Product version
④   Memory size
⑤   Slider for enabling write protection:

- Slider up: not write-protected
- Slider down: write-protected

Figure 12-1   Insertion of the SIMATIC memory card

Folders and files on the SIMATIC memory card

The following folders and files can be found on the SIMATIC memory card:

Table 12- 1   Folder structure

Folder	Description
FWUPDATE.S7S	Firmware update files for CPU and I/O modules
SIMATIC.S7S	User program, i.e. all blocks (OBs, FCs, FBs, DBs) and system blocks, project data of the CPU
SIMATIC.HMI	HMI-relevant data
DataLogs	DataLog files
Recipes	Recipe files

Table 12- 2   File structure

File type	Description
S7_JOB.S7S	Job file
SIMATIC.HMI\Backup*.psb	Panel backup files
SIMATICHMI_Backups_DMS.bin	Protected file (required to use panel backup files in STEP 7)
__LOG__	Protected system file (required in order to use the card)
crdinfo.bin	Protected system file (required in order to use the card)
DUMP.S7S	Service data file
*.pdf, *.txt, *.csv, ...	Further files with different formats that you can also store in folders of the SIMATIC memory card

Use the serial number for copy protection

You can set up copy protection for CPUs, which binds execution of the block to a specific SIMATIC memory card. Configuration is carried out in STEP 7 in the properties of the block "Bind to serial number of the SIMATIC memory card".

The block can then only be executed if it is on the SIMATIC memory card with the specified serial number.

Removing the SIMATIC memory card

Only remove the SIMATIC memory card in the POWER OFF or STOP operating modes of the CPU. Ensure that no writing functions (e.g. loading/deleting a block) are active in STOP mode, or were active in POWER OFF mode. For this purpose, disconnect the communication connections.

If the SIMATIC memory card is removed during a write process, the following problems can occur:

- The data contents of a file are incomplete

- The file is no longer readable, or no longer exists

- The entire data contents are defective

Removing the SIMATIC memory card from the CPU in STOP, STARTUP or RUN mode triggers a re-evaluation of the SIMATIC memory card. The CPU hereby compares the content of the configuration on the SIMATIC memory card with the backed-up retentive data. If the backed-up retentive data matches the data of the configuration on the SIMATIC memory card, the retentive data is retained. If the data differs, the CPU automatically performs a memory reset (which means the retentive data is deleted) and then goes to STOP.

Removing the SIMATIC memory card from Windows computers

If you are using the card in a commercially available card reader under Windows, use the "Eject" function before you remove the card from the card reader. Otherwise data loss can arise.

Deleting the contents of the SIMATIC memory card

You have the following options for deleting the contents of the SIMATIC memory card:

- delete files using Windows Explorer

- format with STEP 7

Note

If you format the card with Windows utilities, you will render the SIMATIC memory card unusable as a storage medium for a CPU.

Deletion of files and folders is permitted, with the exception of the "__LOG__" and "crdinfo.bin" system files. These are required by the CPU. If you delete these files, then you will no longer be able to use the SIMATIC memory card with the CPU.

If the "__LOG__" and "crdinfo.bin" system files have been deleted, format the SIMATIC memory card as described in the following section.

Formatting a SIMATIC memory card

Note

Formatting of a SIMATIC memory card may only be carried out in a CPU. Otherwise the SIMATIC memory card cannot be used in the S7-1500 CPUs.

If you want to format the SIMATIC memory card using STEP 7, an online connection to the relevant CPU must exist. The relevant CPU is in the STOP mode.

Proceed as follows to format a SIMATIC memory card:

1. Open the Online and Diagnostics view of the CPU (either from the project context or via "Accessible devices").

2. In the "Functions" folder, select the "Format memory card" group.

3. Click the "Format" button.

4. Click "Yes" in response to the confirmation prompt.

Result:

- The SIMATIC memory card is formatted for use in S7-1500 CPUs

- The data on the CPU are deleted with the exception of the IP address

Service life of a SIMATIC memory card

The service life of a SIMATIC memory card depends essentially on the following factors:

- The number of delete or write processes

- External influences, e.g., ambient temperature

With an ambient temperature of up to 60 °C, at least 100,000 delete/write processes are possible on the SIMATIC memory card.

12.2   Setting the card type

Setting the card type

You can use the SIMATIC memory card as a program card or as a firmware update card.

To set the card type, insert the SIMATIC memory card in the programming device's card reader, and select the "SIMATIC Card Reader" folder in the project tree.

In the properties of the selected SIMATIC memory card, specify the card type:

- **Program card**

  You use a program card as an external load memory for the CPU. It contains the entire user program for the CPU. The user program is transferred from the load memory to the work memory and runs there. If the SIMATIC memory card with the user program is removed, the CPU goes into STOP mode.

  The following folder is created on the SIMATIC memory card: SIMATIC.S7

- **Firmware update card**

  Firmware for the CPU, for a display and for I/O modules can be stored on a SIMATIC memory card. It is thus possible to perform a firmware update with the help of a specifically prepared SIMATIC memory card.

  The following folder is created on the SIMATIC memory card: FWUPDATE.S7S

Reference

You can find additional information in the STEP 7 online help.

12.3   Data transfer with SIMATIC memory cards

Transferring objects from the project to a SIMATIC memory card

When the SIMATIC memory card is inserted into the programming device or into an external card reader, you can transfer objects as follows from the project tree (STEP 7) to the SIMATIC memory card:

- Individual blocks (multiple selection possible)

  In this case a consistent transfer is available, i.e. the dependencies between blocks due to block calls are taken into account.

- CPU folder

  In this case, all runtime-relevant objects including blocks and the hardware configuration are transferred onto the SIMATIC memory card - just as when downloading.

To perform a transfer, you can transfer the objects by dragging and dropping, or use the "Card Reader/USB memory > Write to memory card" command in the "Project" menu.

Firmware update via SIMATIC memory card

You can find information on how to perform a firmware update via SIMATIC memory card in the Firmware update (Page 136) section.

Reference

For additional information about the SIMATIC memory card, refer to the STEP 7 online help.

Display of the CPU 13

The section below gives an overview of the mode of operation of the CPU display. Detailed information on the individual options, a training course and a simulation of the selectable menu items is available in the SIMATIC S7-1500 Display Simulator (http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started_simatic-s7-1500/disp_tool/start_en.html).

Introduction

The S7-1500 CPU has a front cover with a display and operating keys. Control data and status data can be displayed in various menus on the display, and numerous settings can be configured. You use the operating keys to navigate through the menus.

Benefits

The display of the CPU offers the following advantages:

- Reduced downtimes through diagnostics alarms in plain text
- Changing of the interface settings on site without programming device
- Password assignment for display operation is possible via STEP 7
- Shorter downtimes due to read access to watch and force tables.
  This allows the current values of the individual tags of a user program or a CPU to be monitored by the watch and force tables. You can find additional information on the watch and force tables in the section Test functions and fault correction (Page 143) and in the STEP 7 online help.
- IP addresses of CPU and connected CP/CMs are adjustable

Operating temperature for the display

To increase the service life of the display, the display switches off when the permitted operating temperature is exceeded. When the display has cooled down again, it switches on automatically again. The status of the CPU continues to be indicated via the LEDs while the display is switched off.

Further information about the temperatures at which the display switches off and back on again is available in the technical data of the manuals of the CPUs.

Display

The figures below show an example view of the displays of a CPU 1515-2 PN, CPU 1516-3 PN/DP or CPU 1518-4 PN/DP on the left and a CPU 1511-1 PN or CPU 1513-1 PN on the right.
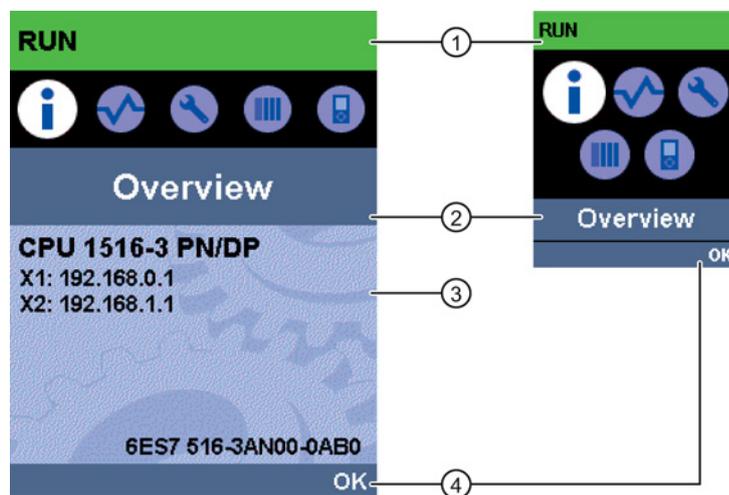
①   CPU status data
②   Submenu names
③   Data display field
④   Navigation aid, e.g. OK/ESC or the page number

Figure 13-1   Example views of the displays

Regarding ①: CPU status data

The following table shows the CPU status data that can be retrieved via the display.

Table 13- 1   CPU status data

Color and icons for the status data	Meaning
green	• RUN • RUN with alarm
yellow	STOP
red	ERROR
white	• Connection establishment between CPU and display • Firmware update of the display
🔒	Protection level configured
⚠️	Interrupt (at least one interrupt is active in the CPU)
⛔	Fault (at least one fault is active in the CPU)
F	Force table is active in the CPU
🔴	EMERGENCY OFF active (only for CPU 1516F-3 PN/DP and CPU 1518F-4 PN/DP)
〰️	Fail-safe CPU (only for CPU 1516F-3 PN/DP and CPU 1518F-4 PN/DP)

Regarding ②: Submenu names

The following table shows the available submenus of the display.

Table 13- 2   Submenu names

Main menu items	Meaning	Description
	Overview	The "Overview" menu contains information about the properties of the CPU and the properties of the inserted SIMATIC memory card.
	Diagnostics	The "Diagnostics" menu contains information about diagnostics alarms, the diagnostics description, a read access to monitoring and force tables, and the display of the interrupts. Additionally there is information about the network properties of each of the CPU's interfaces.
	Settings	In the "Settings" menu, IP addresses of the CPU are assigned, the date, time of day, time zones, operating modes (RUN/STOP) and protection levels are set, a memory reset and reset to factory settings can be performed on the CPU, and the status of firmware updates displayed.
	Modules	The "Modules" menu contains information about the modules that are used in your configuration. The modules can be centrally or peripherally deployed. Peripherally deployed modules are connected to the CPU via PROFINET and/or PROFIBUS. You can set the IP addresses for a CP/CM here.
	Display	In the "Display" menu you can configure settings related to the display, such as language setting, brightness and energy-saving mode. The energy-saving mode darkens the display. The standby mode switches the display off.

Menu icons

The following table shows the icons that are displayed in the menus.

Table 13- 3   Menu icons

Icon	Meaning
🖉	Editable menu item
🌐	Select the desired language here.
⚠	There is an alarm in the next lower level object.
🔴	There is a fault in the next lower level object.
▶	Navigate to next sublevel, or alternatively: navigate using "OK" and "ESC"
↕	In edit mode you make the selection using two arrow keys: • down/up: jumps to a selection, or serves for selecting desired digits / options
◆	In edit mode you make the selection using four arrow keys: • down/up: jumps to a selection, or serves for selecting desired digits • left/right: jumps one spot forward or backward

Handling the front cover

The front cover is removable and can be taken off or replaced during operation (RUN). Removing or replacing of the displays does not have any influence on the running CPU.

The front cover is removed from the CPU as follows:

1. Flip up the front cover until the front cover stands at a 90° angle to the front of the module.

2. In the upper area of the front cover simultaneously press on the anchor(s) and pull the front cover forward and away.

Note

The removal and insertion of the display is also possible during operation (RUN).

The figure below shows an exemplary view of the CPU 1516-3 PN/DP.
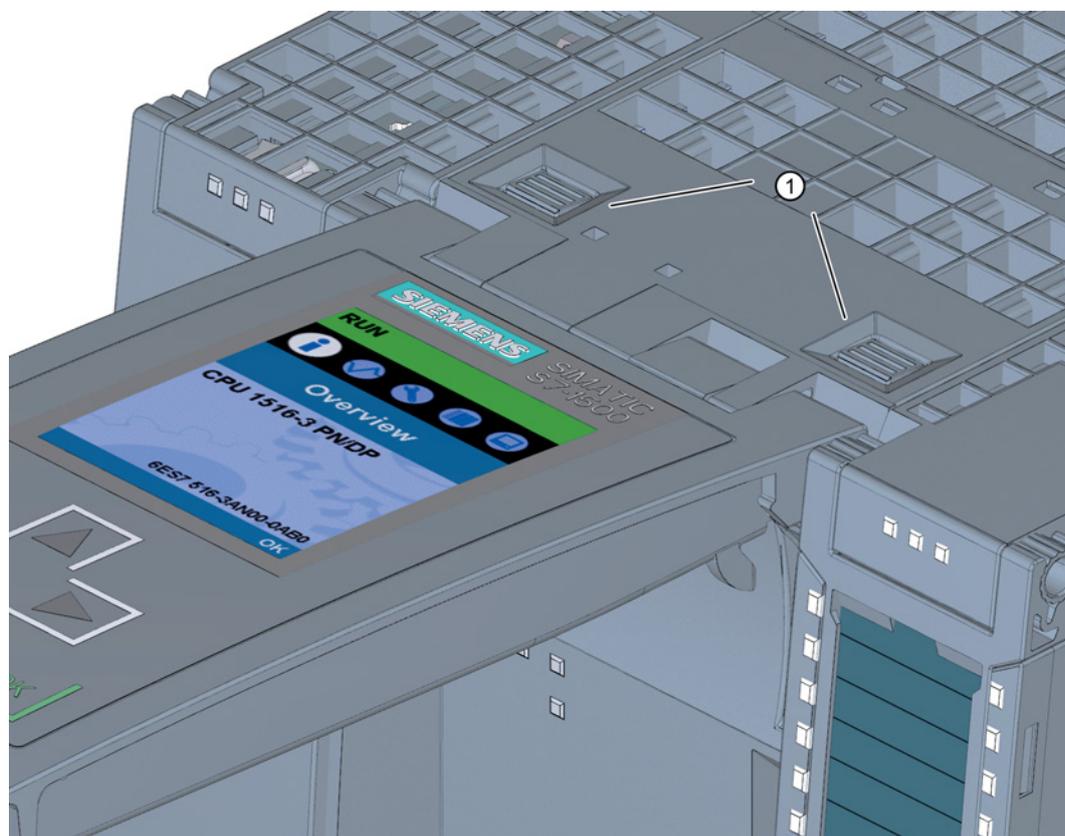
①   Fasteners for removing and fitting the front panel

Figure 13-2   Removing and fitting the front panel

> ⚠️ **WARNING**
>
> **Personal injury and damage to property may occur**
>
> Personal injury or material damage can occur in hazardous are zone 2 if you remove or fit the front panel while the S7-1500 automation system is running.
>
> Before you remove or fit the front panel, always switch off the power supply to the S7-1500 automation system in hazardous area zone 2.

Control keys

The following keys are available on the CPU's display:

- Four arrow buttons: "up", "down", "left", "right"
- One ESC key
- One OK key
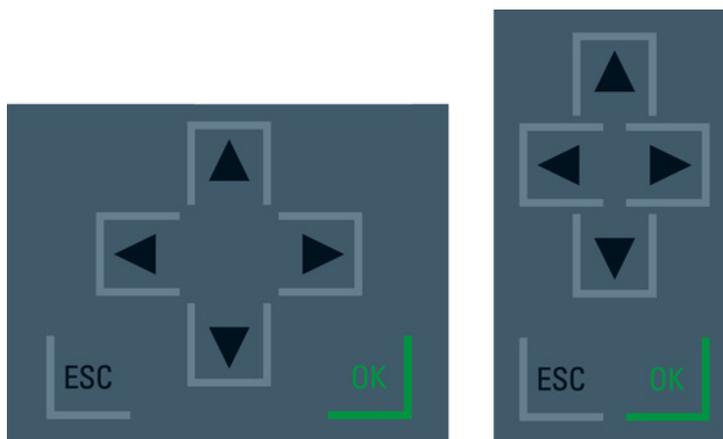
Figure 13-3   Control keys

Note

If the display is in energy-saving mode or in standby mode, this mode can be exited by pressing any key.

Functions of the "OK" and "ESC" keys

- For menu commands in which an entry can be made:
  - OK → valid access to the menu command, confirmation of input, and exit from the edit mode
  - ESC → set the original content (which means changes are not saved) and exit from edit mode

- For menu commands in which no entry can be made:
  - OK → to next submenu command
  - ESC → back to previous menu command

Tooltips

Some of the values shown on the display (e.g., station name, plant designation, location identifier, PROFINET device name, etc.) can exceed the available display width. This applies in particular to the display of the CPU 1511-1 PN or CPU 1513-1 PN. A tooltip appears when you focus on the respective value on the display and then press the "Left" arrow key. The tooltip shows the name of the value in complete length.
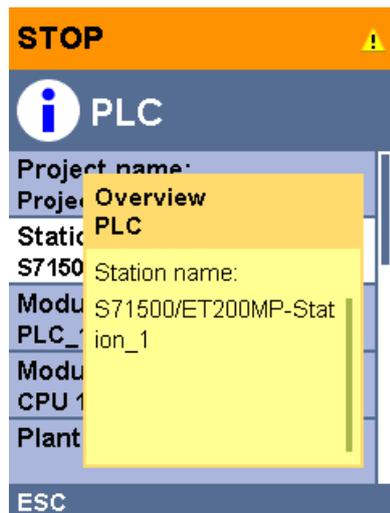
Figure 13-4   Tooltip function

Uploading image to CPU

You can use the "User-defined logo" function under "Display" in the device view of the CPU to load an image from your file system into the display of the CPU via STEP 7. To correctly show the aspect ratio of the uploaded image, use the following dimensions depending on the CPU images.

CPU	Dimensions	Supported formats
CPU 1511-1 PN	128 x 120 pixels	Bitmap, JPEG, GIF, PNG
CPU 1513-1 PN	128 x 120 pixels	Bitmap, JPEG, GIF, PNG
CPU 1515-2 PN	240 x 260 pixels	Bitmap, JPEG, GIF, PNG
CPU 1516-3 PN/DP	240 x 260 pixels	Bitmap, JPEG, GIF, PNG
CPU 1518-4 PN/DP	240 x 260 pixels	Bitmap, JPEG, GIF, PNG

If the uploaded image exceeds the specified dimensions, only a section of the image is displayed in the size of the specified dimensions. The "Adjust logo" provides you with the option of scaling the image to the specified dimensions. However, note that the original aspect ratio of the image is not retained in such cases.

To display the uploaded image on the display of the CPU, keep the ESC key pressed briefly in the main screen of the display. When you upload a image and are located on the main screen, the image is displayed automatically after 60 seconds. To hide the image again, press any key on the display.
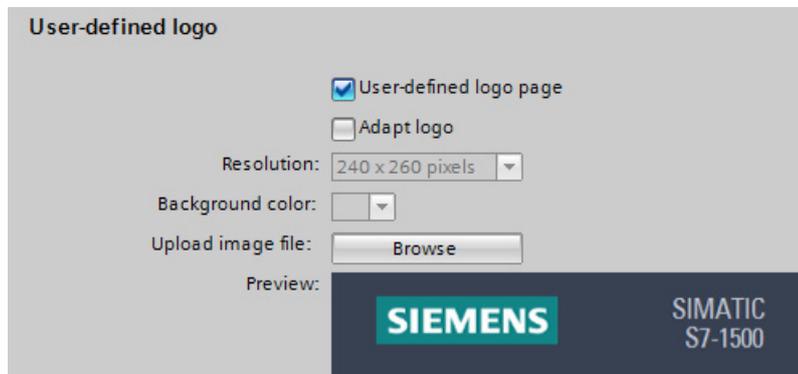
Available language settings

You can set the following languages separately for menu and message texts:

- Chinese
- German
- English
- French
- Italian
- Japanese
- Korean
- Portuguese
- Russian
- Spanish
- Turkish

You select the required language directly at the display in the "Display" menu or in STEP 7 in the hardware configuration of the CPU under User interface languages".

To display alarm texts on the display, these have to be loaded into the CPU as a software component. To do so, select the "Consistent download" option under "Text libraries" in the "Load preview" dialog.

Basics of program processing

14

14.1 Events and OBs

Start events

The occurrence of a start event results in the following reaction:

- If the event comes from an event source to which you have assigned an OB, this event triggers the execution of the assigned OB. This means that the event is positioned in a queue that corresponds to its priority.

- If the event comes from an event source to which you have not assigned an OB, the default system reaction is executed.

Note

Some event sources, such as startup, pull/plug, exist even if you do not configure them.

The table below provides an overview of the start events, including the possible values for OB priority, possible OB numbers, default system reaction and number of OBs. The table is sorted in ascending order by OB numbers.

Types of event sources	Possible priorities (default priority)	Possible OB numbers	Default system reaction*	Number of OBs
Startup**	1	100, ≥ 123	Ignore	0 to 100
Cyclic program**	1	1, ≥ 123	Ignore	0 to 100
Time-of-day interrupt**	2 to 24 (2)	10 to 17, ≥ 123	not applicable	0 to 20
Time-delay interrupt**	2 to 24 (3)	20 to 23, ≥ 123	not applicable	0 to 20
Cyclic interrupt**	2 to 24 (8 to 17, frequency dependent)	30 to 38, ≥ 123	not applicable	0 to 20
Hardware interrupt**	2 to 26 (18)	40 to 47, ≥ 123	Ignore	0 to 50
Status interrupt	2 to 24 (4)	55	Ignore	0 or 1
Update interrupt	2 to 24 (4)	56	Ignore	0 or 1
Manufacturer-specific or profile-specific interrupt	2 to 24 (4)	57	Ignore	0 or 1
Isochronous mode interrupt	16 to 26 (21)	61 to 64, ≥ 123	Ignore	0 to 2
Time error***	22	80	Ignore	0 or 1
Maximum cycle time exceeded once			STOP	
Diagnostics interrupt	2 to 26 (5)	82	Ignore	0 or 1
Pull/plug interrupt for modules	2 to 26 (6)	83	Ignore	0 or 1
Rack error	2 to 26 (6)	86	Ignore	0 or 1

Types of event sources	Possible priorities (default priority)	Possible OB numbers	Default system reaction*	Number of OBs
MC servo interrupt	17 to 26 (25)	91	not applicable	0 or 1
MC interpolator interrupt	16 to 26 (24)	92	not applicable	0 or 1
Programming error (only for global error handling)	2 to 26 (7)	121	STOP	0 or 1
I/O access error (only for global error handling)	2 to 26 (7)	122	Ignore	0 or 1

* If OB was not configured

** For these event sources, besides the permanently assigned OB numbers (see column: possible OB numbers), you can also assign OB numbers from the range ≥ 123 in STEP 7.

*** If the cycle monitoring time was exceed twice within a cycle, the CPU always switches to STOP, regardless of whether OB80 was configured.

Assignment between event source and OBs

The type of OB determines where you make the assignment between OB and event source:

- With hardware interrupts and isochronous mode interrupts, the assignment is made during the configuration of the hardware or when the OB is created.

- STEP 7 automatically assigns OBs 91/92 to the MC-Servo interrupt and MC-Interpolator interrupt, as soon as an "S7-1500 Motion Control" technology object is added.

- For all other types of OB, the assignment is made when the OB is created, where applicable after you have configured the event source.

For hardware interrupts, you can change an assignment which has already been made during runtime with the instructions ATTACH and DETACH. In this case, only the actually effective assignment is changed, not the configured assignment. The configured assignment takes effect after loading, and upon each startup.

Hardware interrupts are ignored if no OB was assigned by their configuration or if they occur after the DETACH instruction. The check as to whether an OB is assigned to an event does not take place when the associated event occurs, but only when the hardware interrupt actually has to be executed.

OB priority and runtime behavior

If you have assigned an OB to the event, the OB has the priority of the event. S7-1500 CPUs support the priority classes 1 (lowest) to 26 (highest). Events are executed with a defined priority. The following items are essential to the execution of an event:

- the call of the assigned OB
- the update of the process image partition of the assigned OB
- the execution of the assigned OB.

The OBs are executed exclusively on a priority basis. This means that the OB with the highest priority will be executed first when multiple OB requests occur at the same time. If an event occurs that has a higher priority than the currently active OB, this OB is interrupted. Events of the same priority are processed in order of occurrence.

Note

Communication

Communication always has priority 15. This makes it possible to assign a priority greater than 15 to OBs so that these OBs are not interrupted by the communication.

Reference

Further information on organization blocks is available in the STEP 7 online help.

14.2   CPU overload behavior

Principle of CPU overload behavior

For the event scenarios considered in the following section, it is assumed that you have assigned an OB to each event source and that these OBs have the same priority. The second condition, in particular, is only for the sake of a simplified representation.

When an event occurs, the execution of the associated OB is triggered. Depending on the OB priority and the current processor load, a time delay may occur before the OB is executed when there is an overload. The same event can therefore occur once or several times before the OB belonging to the preceding event is processed. Such a situation is handled by the CPU as follows: In the order of their occurrence, the operating system positions the events into the queue associated with their priority.

To control temporary overload situations, you can limit the number of pending events that are linked from the same source. The next event is discarded as soon as the maximum number of pending start events of a specific cyclic interrupt OB, for example, is reached.

An overload occurs when events which originate from the same source occur faster than they can be processed.

More detailed information is provided in the following sections.

Discarding similar events or fetching them later

Below, the term "similar events" refers to events from a single source, such as start events for a specific cyclic interrupt OB.

The OB parameter "Events to be queued" is used to specify how many similar events the operating system places in the associated queue and therefore post-processes. If this parameter has the value 1, for example, exactly one event is stored temporarily.

Note

Post-processing of cyclic events is often not desirable, as this can lead to an overload with OBs of the same or lower priority. Therefore, it is generally advantageous to discard similar events and to react to the overload situation during the next scheduled OB processing. If the value of the "Events to be queued" parameter is low, this ensures that an overload situation is mitigated rather than aggravated.

If the maximum number of start events is reached in the queue for a cyclic interrupt OB (Cyclic interrupt), for example, each additional start event is only counted and subsequently discarded. During the next scheduled execution of the OB, the number of discarded start events is made available (in the start information) in the "Event_Count" input parameter. You can then react appropriately to the overload situation. The CPU then sets the counter for lost events to zero.

If the CPU, for example, first discards a start event for a cyclic interrupt OB, its further behavior depends on the OB parameter "Report event overrun into diagnostics buffer": If the check box is selected, the CPU enters the event DW#16#0002:3507 once in the diagnostics buffer for the overload situation at this event source. Additional diagnostics buffer entries of the event DW#16#0002:3507 that refer to this event source are suppressed until all events from this source have been post-processed.

Threshold mechanism for time error OB request

The cyclic interrupt OB parameter "Enable time error" is used to specify whether the time error interrupt should be called when a specific overload level is reached for similar events. You can find the OB parameter "Enable time error" in the properties of the OB in the "Attributes" category.

If yes (check box selected), you use the OB parameter "Event threshold for time error" to specify the number of similar events in the queue at which the time error interrupt should be called. If this parameter has the value 1, for example, the event DW#16#0002:3502 is entered once in the diagnostics buffer and the time error interrupt is requested when the second event occurs. Additional diagnostics buffer entries of the event DW#16#0002:3502 that refer to this event source are suppressed until all events from this source have been post-processed.

In the event of an overload, you therefore have the option of programming a reaction well before the limit is reached for similar events and thus before the events are discarded.

The following value range applies to the "Event threshold for time error" parameter:
1 ≤ "Event threshold for time error" ≤ "Events to be queued".

Protection

15

15.1 Overview of the protective functions of the CPU

Introduction

This chapter describes the following functions for protecting the S7-1500 automation system against unauthorized access:

- Access protection
- Know-how protection
- Copy protection
- Protection by locking the CPU

Further measures for protecting the CPU

The following measures additionally increase the protection against unauthorized access to functions and data of the S7-1500 CPU from external sources and via the network:

- Deactivation of the Web server
- Deactivation of the time synchronization via an NTP Server
- Deactivation of the PUT/GET communication

When the Web server is used, you protect your S7-1500 automation system against unauthorized access by setting password-protected access rights for specific users in the user management.

15.2 Configuring access protection for the CPU

Introduction

The CPU offers four access levels, in order to limit access to specific functions.

By setting up the access levels and the passwords for a CPU, you limit the functions and memory areas that are accessible without entering a password. The individual access levels as well as the entry of their associated passwords are specified in the object properties of the CPU.

Access levels of the CPU

Table 15- 1   Access levels of the CPU

Access levels	Access restrictions
Complete access (no protection)	The hardware configuration and the blocks can be read and changed by all users.
Read access	With this access level, read-only access to the hardware configuration and the blocks is possible without entering a password, which means you can download hardware configuration and blocks to the programming device. In addition, HMI access and access to diagnostics data is possible. Without entering the password, you cannot load any blocks or hardware configuration into the CPU. Additionally, the following are **not** possible without the password: Writing test functions and firmware update (online).
HMI access	With this access level only HMI access and access to diagnostics data is possible without entering the password. Without entering the password, you can neither load blocks and hardware configuration into the CPU, nor load blocks and hardware configuration from the CPU into the programming device. Additionally, the following are **not** possible without the password: Test functions which write, changing the operating mode (RUN/STOP), and firmware update (online).
No access (complete protection)	When the CPU is completely protected, no read or write access to the hardware configuration and the blocks is possible. HMI access is also not possible. The server function for PUT/GET communication is disabled in this access level (cannot be changed). Authentication with the password will again provide you full access to the CPU.

Each access level allows unrestricted access to certain functions without entering a password, e.g. identification using the "Accessible devices" function.

The CPU's default setting is "No restriction" and "No password protection". In order to protect access to a CPU, you must edit the properties of the CPU and set up a password. In the default access level "Full access (no protection)" every user can read and change the hardware configuration and the blocks. A password is not set and is also not required for online access.

Communication between the CPUs (via the communication functions in the blocks) is not restricted by the protection level of the CPU, unless PUT/GET communication is deactivated.

Entry of the right password allows access to all the functions that are allowed in the corresponding level.

Note

Configuring an access level does not replace know-how protection

Configuring access levels offers a high degree of protection against unauthorized changes to the CPU by restricting the rights to download the hardware and software configuration to the CPU. However, blocks on the SIMATIC memory card are not write- or read-protected. Use know-how protection to protect the code of blocks on the SIMATIC memory card.

Parameterizing the procedure at access levels

To configure the access levels of an S7-1500 CPU, follow these steps:

1. Open the properties of the S7-1500 CPU in the Inspector window.

2. Open the "Protection" entry in the area navigation.

   A table with the possible access levels appears in the Inspector window.

Figure 15-1 Possible access levels

3. Activate the desired protection level in the first column of the table. The green check marks in the columns to the right of the respective access level show you which operations are still available without entering the password.

4. In the "Enter password" column, specify a password for the access level "Full access" in the first row. In the "Confirm password" column, enter the selected password again to guard against incorrect entries.

   Ensure that the password is sufficiently secure, in other words, that is does not follow a pattern that can be recognized by a machine!

5. Assign additional passwords as needed to other access levels if the selected access level allows you to do so.

6. Download the hardware configuration to the CPU, so that the access level will take effect.

The CPU logs the entry of the correct or incorrect password and any changes in the configuration of the access levels by a corresponding entry in the diagnostics buffer.

Behavior of a password-protected CPU during operation

The CPU protection takes effect after the settings are downloaded in the CPU.

Before an online function is executed, the necessary permission is checked and, if necessary, the user is prompted to enter a password. The functions protected by a password can only be executed by one programming device/PC at any one time. Another programming device/PC cannot log on.

Access authorization to the protected data is in effect for the duration of the online connection, or until the access authorization is manually rescinded with "Online > Delete access rights".

Access to a password-protected CPU in the RUN mode can be limited locally in the display so that access with a password is also not possible.

Access level for F-CPUs

For the fail-safe CPUs (CPU 1516F-3 PN/DP and CPU 1518F-4 PN/DP) there is an additional access level in addition to the four described access levels. For additional information on this access level, refer to the description of the fail-safe system SIMATIC Safety Programming and Operating Manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

15.3 Using the display to set additional access protection

Introduction

On the display of an S7-1500, you can block access to a password-protected CPU (local lock). The access lock is only in effect, when the operating mode switch is in the RUN position.

The access block requires a configured protection level in STEP 7. The access block is effective regardless of the password protection. This means that even if someone accesses the CPU via a connected programming device and has entered the correct password, access to the CPU remains disabled.

The access block can be set separately for each access level on the display, so that, for example, read access is allowed locally, but write access is not allowed locally.

Procedure

If an access level with a password is configured in STEP 7, access can be blocked using the display.

Proceed as follows to set the local access protection for an S7-1500 CPU on the display:

1. On the display, select Settings > Protection menu.

2. Confirm the selection using "OK", and configure for each access level, whether access at the RUN operating mode switch is allowed or not:

   Allow: Access to the CPU is possible, provided the corresponding password is entered in STEP 7.

   Disabled in RUN: When the operating mode switch is in the RUN position, no more users with privileges for this access level can log in to the CPU, even if they know the password. In STOP mode, access is possible with password entry.

Access protection for the display

A password can be configured for the display in STEP 7 in the properties of the CPU so that the local access protection is protected by a local password.

15.4 Using the user program to set additional access protection

Access protection by means of the user program

In addition to restricting access to the display you can also restrict access to a password-protected CPU in STEP 7 using the block SFC 110. You can find a description of this block in the online help under the keyword "ENDIS_PW: Limit and enable password legitimation".

15.5 Know-how protection

You can use know-how protection to protect one or more blocks of the OB, FB, FC type and global data blocks in your program from unauthorized access. You can enter a password in order to restrict access to a block. The password offers high-level protection against unauthorized reading or manipulation of the block.

If a block is know-how protected, only the following data is readable without the correct password:

● Block title, comments and block properties

● Block parameters (INPUT, OUTPUT, IN, OUT, RETURN)

● Call structure of the program

● Global tags without information on the point of use

Further actions that can be carried out with a know-how protected block:

● Copying and deleting

● Calling in a program

● Online/offline comparison

● Load

Global data blocks and array data blocks

You cannot provide global data blocks (global DBs) with know-how protection. Users who do not possess the valid password can read the global data block but not change it.

You cannot provide array data blocks (array DBs) with know-how protection.

Setting up block know-how protection

1. Open the properties of the respective block.

2. Select the "Protection" option under "General".
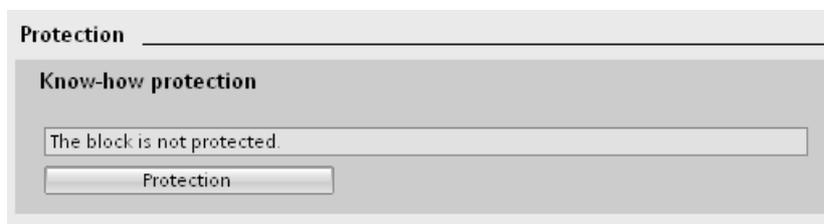
Figure 15-2   Setting up block know-how protection (1)

3. Click the "Protection" button to display the "Know-how protection" dialog.

Figure 15-3   Setting up block know-how protection (2)

4. Click the "Define" button to open the "Define password" dialog.
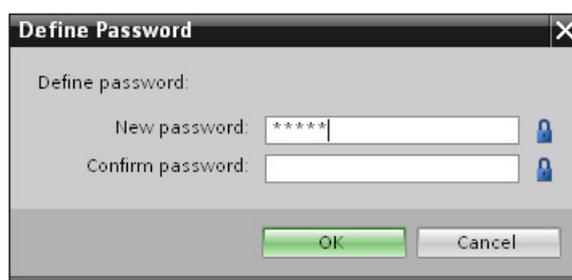
Figure 15-4   Setting up block know-how protection (3)

5. Enter the new password in the "New password" field. Enter the same password in the "Confirm password" field.

6. Click "OK" to confirm your entry.

7. Close the "Know-how protection" dialog by clicking "OK".

Result: The blocks selected will be know-how-protected. Know-how protected blocks are marked with a lock in the project tree. The password entered applies to all blocks selected.

Opening know-how protected blocks

1. Double-click the block to open the "Access protection" dialog.

2. Enter the password for the know-how protected block.

3. Click "OK" to confirm your entry.

Result: The know-how-protected block will open.

Once you have opened the block, you can edit the program code and the block interface of the block for as long as the block or STEP 7 is open. The password must be entered again the next time the block is opened. If you close the "Access protection" dialog with "Cancel", the block will open but the block code will not be displayed and you will not be able to edit the block.

The know-how protection of the block is not removed if, for example, you copy the block or add it to a library. The copies will also be know-how-protected.

Removing block know-how protection

1. Select the block from which you want to remove know-how protection. The protected block may not be open in the program editor.

2. In the "Edit" menu, select the "Know-how protection" command to open the "Know-how protection" dialog.

3. Clear the "Hide code (Know-how protection)" check box.

Figure 15-5   Removing block know-how protection (1)

4. Enter the password.

Figure 15-6   Removing block know-how protection (2)

5. Click "OK" to confirm your entry.

Result: Know-how protection will be removed from the block selected.

15.6 Copy protection

Copy protection allows you to bind the program or the blocks to a specific SIMATIC memory card or CPU. Through the linking of the serial number of a SIMATIC memory card or of a CPU the use of this program or of this block is only possible in combination with a specific SIMATIC memory card or CPU. With this function a program or block can be sent electronically (e.g. by e-mail) or by shipping a memory module.

When you set up such a copy protection for a block, also assign know-how-protection to this block. Without know-how protection, anyone can reset the copy protection. You must, however, set up copy protection first as the copy protection settings are read-only if the block is already know-how-protected.

Setting up copy protection

1. Open the properties of the respective block.

2. Select the "Protection" option under "General".

Figure 15-7   Setting up copy protection (1)

3. In the "Copy protection" area, select either the "Bind to serial number of the CPU" entry or the "Bind to serial number of the memory card" entry from the drop-down list.
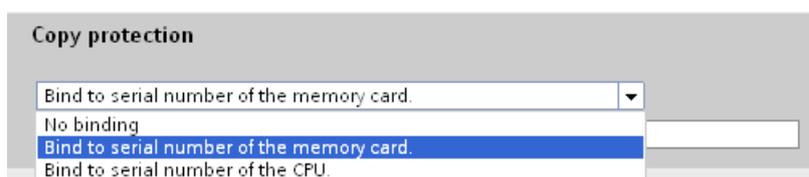
Figure 15-8   Setting up copy protection (2)

4. Enter the serial number of the CPU or the SIMATIC memory card.
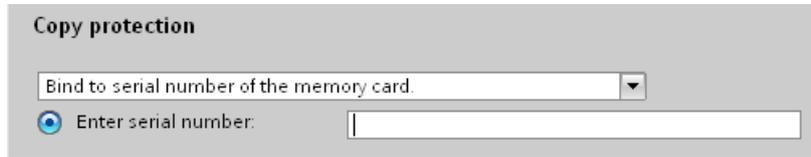
Figure 15-9   Entering the serial number

5. You can now set up the know-how protection for the block in the "Know-how protection" area.

Note

If you download a copy protected block to a device that does not match the specified serial number, the entire download operation will be rejected. This means that blocks without copy protection will also not be downloaded.

Removing copy protection

1. Remove any existing know-how protection (Page 176).

2. Open the properties of the respective block.

3. Select the "Protection" option under "General".

4. In the "Copy protection" area, select the "No binding" entry from the drop-down list.
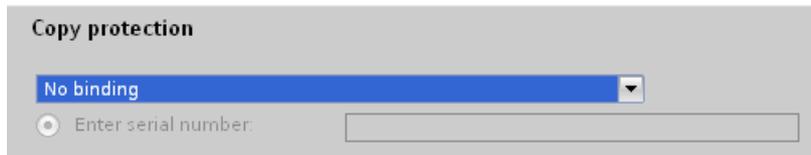
Figure 15-10 Removing copy protection

15.7 Protection by locking the CPU

Protect your CPU from unauthorized access using a sufficiently secured front cover.

You have e.g. the following options:

- affix a seal
- secure the front cover with a lock (shackle diameter: 3 mm)
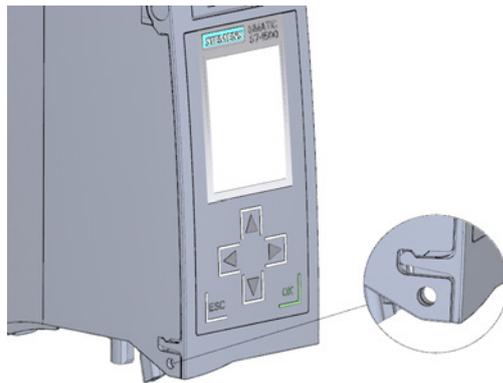
Figure 15-11 Locking latch on the CPU

Technical specifications 16

16.1 Standards and Approvals

Introduction

Contents of general technical specifications:

- The standards and test values that the modules of the S7-1500 automation system comply with and fulfill.

- The test criteria according to which the S7-1500 automation system was tested.

Note

Information on the components of the S7-1500 automation system

The current valid markings and approvals are printed on the components of the S7-1500 automation system.

Technical specifications for the modules

The technical specifications of the individual modules can be found in the manuals of respective modules. In the event of deviations between the statements in this document and the manuals, the statements in the product manuals take priority.

Reference

The certificates for the markings and approvals can be found on the Internet under Service&Support (http://www.siemens.com/automation/service&support).

Safety information

> ⚠ **WARNING**
>
> **Personal injury and damage to property may occur**
>
> In hazardous areas, injury to persons and material damage may occur if you disconnect plug-in connections during operation of an S7-1500 automation system.
>
> Always switch off the power to the S7-1500 automation system when disconnecting plug-in connections in potentially explosive atmospheres.

> ⚠ **WARNING**
>
> **Explosion hazard**
>
> If you replace components, compliance with Class I, DIV. 2 could be compromised.

> ⚠ **WARNING**
>
> **Deployment requirements**
>
> This device is only appropriate for use in Class I, Div. 2, Group A, B, C, D, or in non-hazardous areas.

CE mark

C E

The S7-1500 automation system meets the requirements and protection targets of the following EC guidelines and complies with the harmonized European standards (EN) for programmable logic controllers published in the official gazettes of the European Community:

- 2006/95/EC "Electrical Equipment Designed for Use within Certain Voltage Limits" (LowVoltage Directive)

- 2004/108/EC "Electromagnetic Compatibility" (EMC Directive)

- 94/9/EC on "equipment and protective systems for use in hazardous areas" (explosion protection directive)

The EC declaration of conformity is held on file available to competent authorities at:

Siemens Aktiengesellschaft
Industry Sector
I IA AS FA WF AMB
Postfach 1963
D-92209 Amberg, Germany

These files are also available for download on the Customer Support Internet pages, under the keyword "Declaration of Conformity".

cULus approval

Underwriters Laboratories Inc. in accordance with

- UL 508 (Industrial Control Equipment)
- C22.2 No. 142 (Process Control Equipment)

OR

cuLus HAZ LOC approval

Underwriters Laboratories Inc. in accordance with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

Installation Instructions for cULus haz.loc.

- WARNING - Explosion Hazard - Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.
- These products need to be connected by means of the front connector Cat. No. 6ES7592-1AM00-0XB0

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

FM approval

Factory Mutual Research (FM) according to

- Approval Standard Class Number 3611, 3600, 3810
- ANSI/ISA 82.02.01 (IEC 61010-1)
- CSA C22.2 No. 213
- CSA 22.2 No. 1010.1

APPROVED for use in Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

ATEX approval

In accordance with EN 60079-15 (Electrical apparatus for potentially explosive atmospheres; Type of protection "n") and EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements)

II 3 G Ex nA IIC Tx Gc
DEKRA 12ATEX0004X

IECEx approval

According to IEC 60079-15 (Explosive atmospheres - Part 15: Equipment protection by type of protection "n") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements)

IECEx Ex nA IIC Tx Gc
IECEx DEK 13.0010X

Tick mark for Australia and New Zealand

The S7-1500 automation system meets the requirements of the standard AS/NZS CISPR 16.

Korea Certification

KC registration number: KCC-REM-S49-S71500

Please note that this device corresponds to limit value class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

IEC 61131

The S7-1500 automation system meets the requirements and criteria of the standard IEC 61131-2 (programmable logic controllers, Part 2: Equipment requirements and tests).

Marine approval (applied for)

Classification societies:

- ABS (American Bureau of Shipping)

- BV (Bureau Veritas)

- DNV (Det Norske Veritas)

- GL (Germanischer Lloyd)

- LRS (Lloyds Register of Shipping)

- Class NK (Nippon Kaiji Kyokai)

Industrial use

SIMATIC products are designed for industrial applications.

Table 16- 1   Industrial use

Area of application	Interference emission requirements	Interference immunity requirements
Industry	EN 61000-6-4: 2011	EN 61000-6-2: 2005

Use in residential areas

Note

The S7-1500 automation system is intended for use in industrial areas; use in residential areas may have an impact on radio/TV reception.

If you want to use the S7-1500 automation system in residential areas, you must ensure that its radio interference emission complies with limit value class B in accordance with EN 55011.

Suitable measures for achieving RF interference level Class B include, for example:

- Installation of the S7-1500 automation system in grounded switchboards/control cabinets

- Use of noise filters in the supply lines

16.2 Electromagnetic compatibility

Definition

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

Among other things, the S7-1500 automation system also meets the requirements of the EMC legislation for the European single market. The prerequisite for this is that the S7-1500 system complies with the requirements and guidelines relating to electrical equipment.

EMC in accordance with NE21

The S7-1500 automation system meets the EMC specifications of the NAMUR guideline NE21.

Pulse-shaped disturbances

The following table shows the electromagnetic compatibility of the S7-1500 automation system with regard to pulse-shaped disturbances.

Table 16- 2   Pulse-shaped disturbances

Pulse-shaped disturbance	Test voltage	corresponds with degree of severity
Electrostatic discharge in accordance with IEC 61000-4-2.	Air discharge: ±8 kV	3
	Contact discharge: ±6 kV	3
Burst pulses (high-speed transient disturbances) in accordance with IEC 61000-4-4.	±2 kV (power supply lines) ±2 kV (signal lines > 30 m) ±1 kV (signal lines < 30 m)	3 3
High-energy single pulse (surge) in accordance with IEC 61000-4-5 External protective circuit required (not for 230 V modules) (see the Defining interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) Function Manual)		3
• asymmetric coupling	±2 kV (power supply lines) DC with protective elements	
	±2 kV (signal/data line only > 30 m), with protective elements	
• symmetric coupling	±1 kV (power supply lines) DC with protective elements	
	±1 kV (signal/data line only > 30 m), with protective elements	

Sinusoidal disturbances

The following table shows the electromagnetic compatibility of the S7-1500 automation system with regard to sinusoidal disturbances (RF radiation).

Table 16- 3   Sinusoidal disturbances with RF radiation

RF radiation in accordance with IEC 61000-4-3/NAMUR 21 Electromagnetic RF field, amplitude-modulated		corresponds with degree of severity
80 to 1000 MHz; 1.4 to 2 GHz	2.0 GHz to 2.7 GHz	
10 V/m	1 V/m	3
80 % AM (1 kHz)		

The following table shows the electromagnetic compatibility of the S7-1500 automation system with regard to sinusoidal disturbances (RF coupling).

Table 16- 4   Sinusoidal disturbances with RF coupling

RF coupling in accordance with IEC 61000-4-6	corresponds with degree of severity
from 10 kHz	
10 V_{rms}	3
80 % AM (1 kHz)	
150 Ω source impedance	

Emission of radio interference

Interference emission of electromagnetic fields in accordance with EN 55016: Limit value class A, group 1 (measured at a distance of 10 m).

Table 16- 5   Interference emission of electromagnetic fields

Frequency	Interference emission
30 MHz to 230 MHz	< 40 dB (µV/m) QP
230 MHz to 1000 MHz	< 47 dB (µV/m) QP

Table 16- 6   Interference emission via the AC power supply

Frequency	Interference emission
0.15 MHz to 0.5 MHz	< 79 dB (µV/m)Q
	< 66 dB (µV/m) M
0.5 MHz to 30 MHz	< 73 dB (µV/m)Q
	< 60 dB (µV/m) M

Interference emission via the AC power supply in accordance with EN 55016: Limit value class A, Group 1.

16.3   Shipping and storage conditions

Introduction

With respect to transportation and storage conditions, the S7-1500 automation system fulfills the requirements in accordance with IEC 61131-2. The following statements apply to modules that are transported and stored in the original packaging.

Shipping and storage conditions for modules

Table 16- 7   Shipping and storage conditions for modules

Type of condition	Permissible range
Free fall (in shipping package)	≤ 1 m
Temperature	from -40 °C to +70 °C
Barometric pressure	1080 hPa to 660 hPa (corresponds to an altitude of -1000 m to 3500 m)
Relative humidity	5% to 95%, without condensation
Sinusoidal vibrations in accordance with IEC 60068-2-6	5 - 9 Hz: 3.5 mm 9 - 500 Hz: 9.8 m/s^2
Shock in accordance with IEC 60068-2-27	250 m/s^2, 6 ms, 1000 shocks

16.4 Mechanical and climatic ambient conditions

Operating conditions

The S7-1500 automation system is suitable for use in weather-proof, fixed locations. The operating conditions exceed requirements according to DIN IEC 60721-3-3:

- Class 3M3 (mechanical requirements)
- Class 3K3 (climatic requirements)

Test of mechanical ambient conditions

The table below provides important information with respect to the type and scope of the test of ambient mechanical conditions.

Table 16- 8   Test of mechanical ambient conditions

Condition tested	Test Standard	Remark
Vibration	Vibration test according to IEC 60068-2-6 (Sinus)	Type of oscillation: Frequency sweeps with a rate of change of 1 octave/minute.
		5 Hz ≤ f ≤ 8.4 Hz, constant amplitude 7 mm
		8.4 Hz ≤ f ≤ 150 Hz, constant acceleration 2 g
		Duration of oscillation: 10 frequency sweeps per axis, along each of the 3 mutually perpendicular axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine
		Shock intensity: 15 g max., duration 11 ms
		Direction of shock: 3 shocks each in (+/-) direction, along each of the 3 mutually perpendicular axes
Continuous shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine
		Shock intensity: 250 m/s^2 peak value, 6 ms duration
		Direction of shock: 1000 shocks each in (+/-) direction, along each of the 3 mutually perpendicular axes

Reduction of vibrations

If your S7-1500 automation system is exposed to severe shock or vibration, take appropriate measures to reduce the acceleration or the amplitude.

We recommend the installation of the S7-1500 automation system on damping materials (for example, rubber-bonded-to-metal mounting).

Climatic ambient conditions

The S7-1500 automation system may be used in the following climatic ambient conditions:

Table 16- 9   Climatic ambient conditions

Ambient conditions	Permissible range	Comments
Temperature: horizontal mounting position: vertical mounting position:	0 °C to 60 °C 0 °C to 40 °C	To increase the service life of the display, the display switches off when the permitted operating temperature is exceeded. Further information about the temperatures at which the display switches off and back on again is available in the technical data of the manuals of the CPUs.
Temperature variation	10 K/h	-
Relative humidity	from 10 % to 95 %	Without condensation, corresponds to relative humidity (RH) class 2 in accordance with IEC 61131 part 2
Barometric pressure	from 1080 hPa to 795 hPa	corresponds to an altitude of -1000 m to 2000 m
Concentration of pollutants	SO_2: <0.5 ppm; RH <60%, no condensation H_2S: < 0.1 ppm; RH < 60 %, no condensation	-
	ISA-S71.04 severity level G1; G2; G3	-

16.5 Information on insulation tests, protection class, degree of protection and rated voltage

Insulation

The insulation is designed in accordance with the requirements of EN 61131-2: 2007.

Note

For modules with 24 VDC supply voltage, the electrical isolation is designed for max. 60 VAC / 75 VDC and basic insulation is designed according to EN 61131-2: 2007.

Contamination level/overvoltage category according to IEC 61131-2: 2007

- Pollution degree 2
- Overvoltage category: II

Protection class in accordance with IEC 61131-2: 2007

Protection class I or III, depending on module type

Degree of protection IP20

Degree of protection IP20 in accordance with IEC 60529 for all modules of the S7-1500 automation system, i.e.:

- Protection against contact with standard test finger
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

Rated voltage for operation

The S7-1500 automation system works with the rated voltages and corresponding tolerances listed in the following table.

Note the supply voltage of each module when selecting the rated voltage.

Table 16- 10 Rated voltage of all modules of the S7-1500 automation system, for operation

rated voltage	Tolerance range
24 VDC	19.2 VDC to 28.8 VDC [1]
48 VDC	40.8 to 57.6 VDC
60 VDC	51.0 to 72.0 VDC
120 VAC	93 VAC to 132 VAC
230 VAC	187 VAC to 264 VAC

[1]   Static value: Creation as functional extra-low voltage with safe electrical isolation in accordance with IEC 60364-4-41.

16.6   Use of the S7-1500 in Zone 2 potentially explosive atmospheres

See product information Deployment of the modules in zone 2 potentially explosive atmospheres (http://support.automation.siemens.com/WW/view/en/19692172).

Dimension drawings

A

A.1 Minimum clearances

Modules on the mounting rail

Modules can be mounted up to the outer edge of the mounting rail.

Note

Minimum clearances

Observe the minimum clearances of 25 mm above and below the mounting rail as described in the section Mounting (Page 46).

A.2 Dimension drawings of the mounting rails

In this appendix you will find the dimension drawings of the mounting rails.

Mounting rail 160 mm
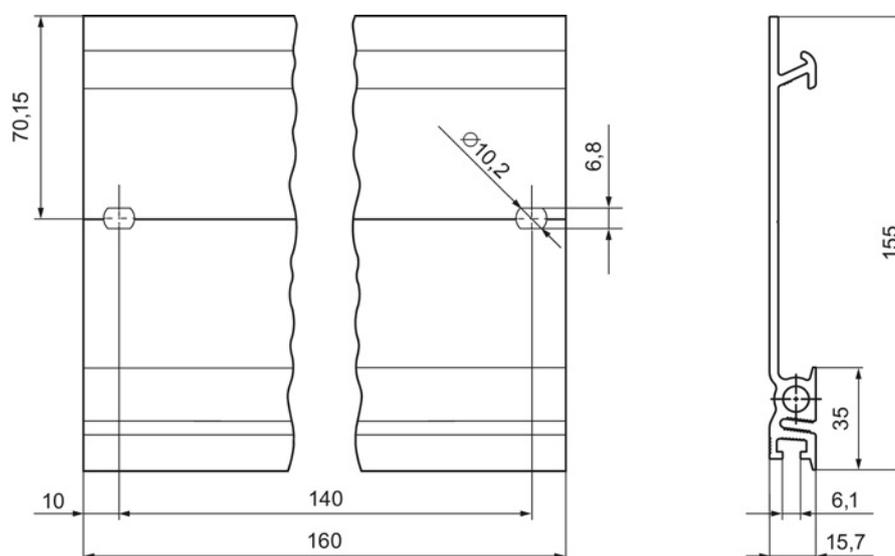
Figure A-1   Mounting rail 160 mm

Mounting rail 482.6 mm
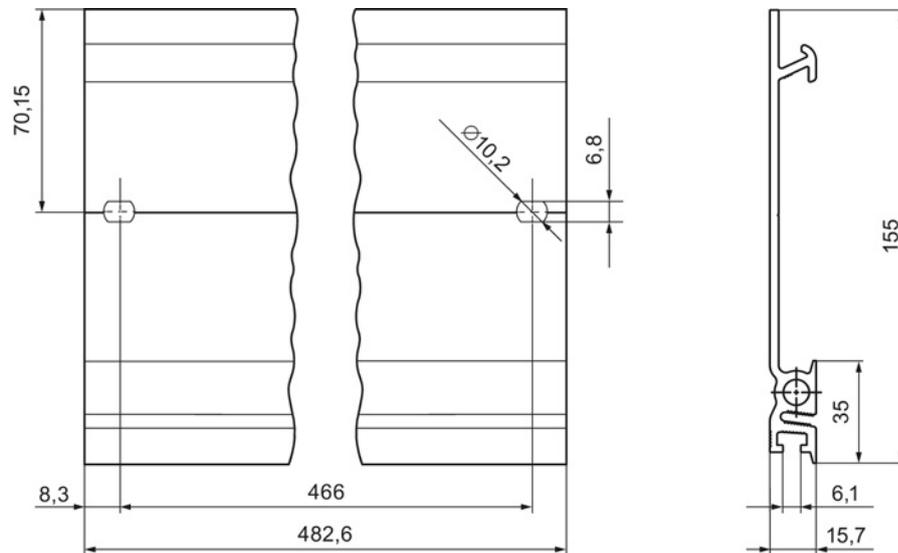
Figure A-2   Mounting rail 482.6 mm

Mounting rail 530 mm
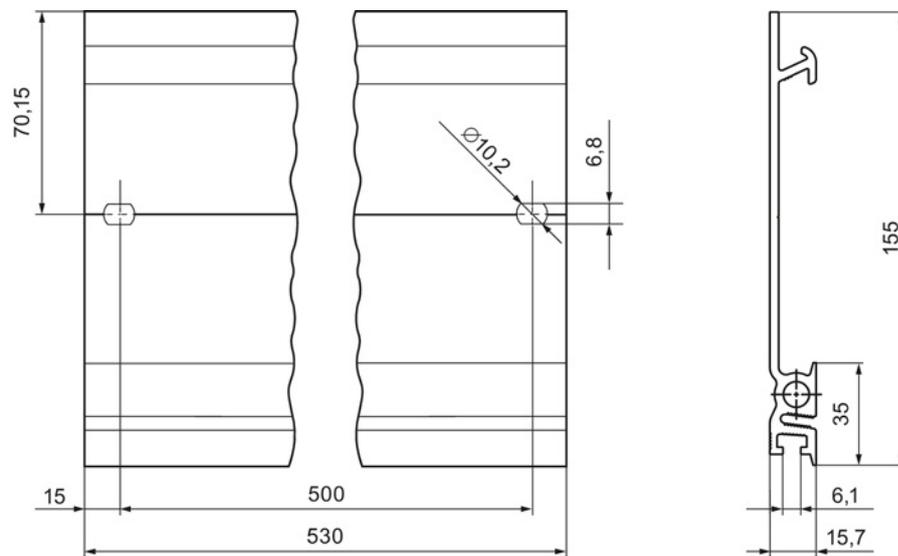
Figure A-3   Mounting rail 530 mm

Mounting rail 830 mm
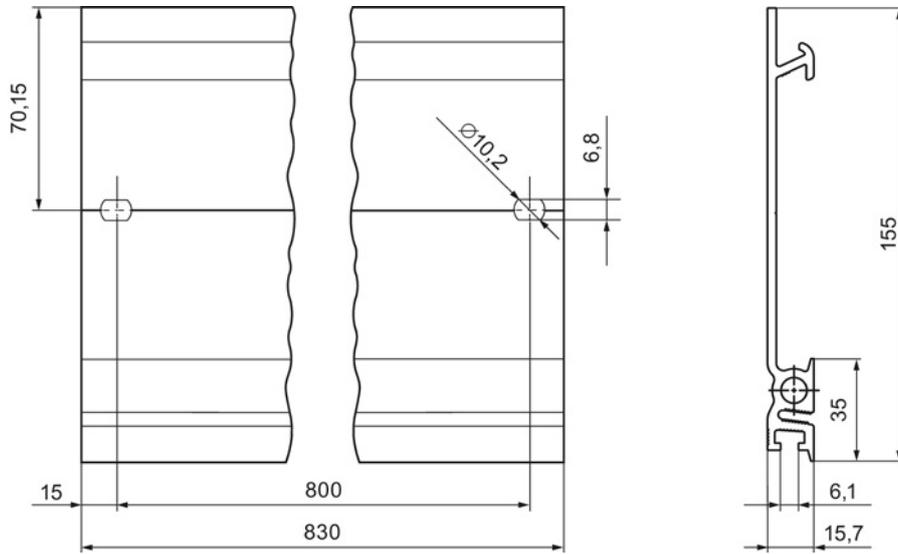
Figure A-4   Mounting rail 830 mm

Mounting rail 2000 mm
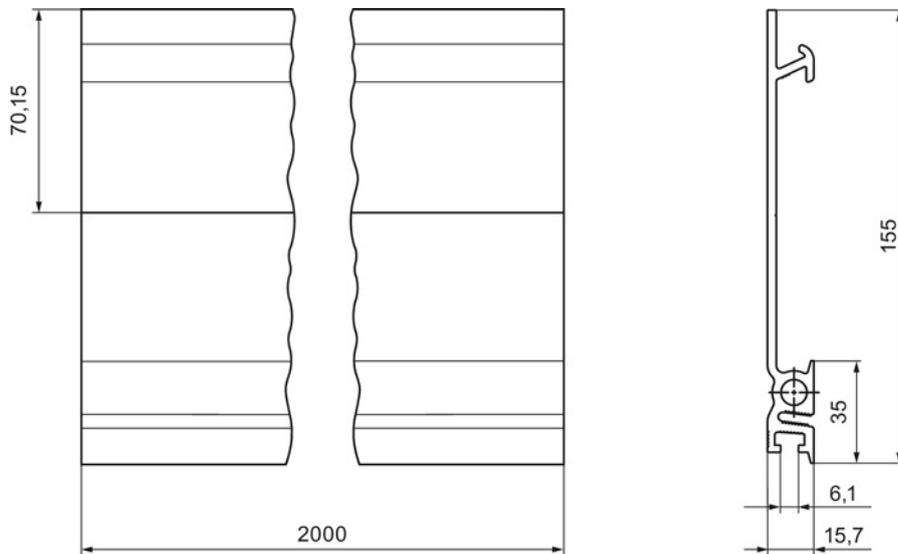
Figure A-5   Mounting rail 2000 mm

A.3 Dimension drawing of CPU, 35 mm wide

In this appendix you will find the dimension drawing of the CPU installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
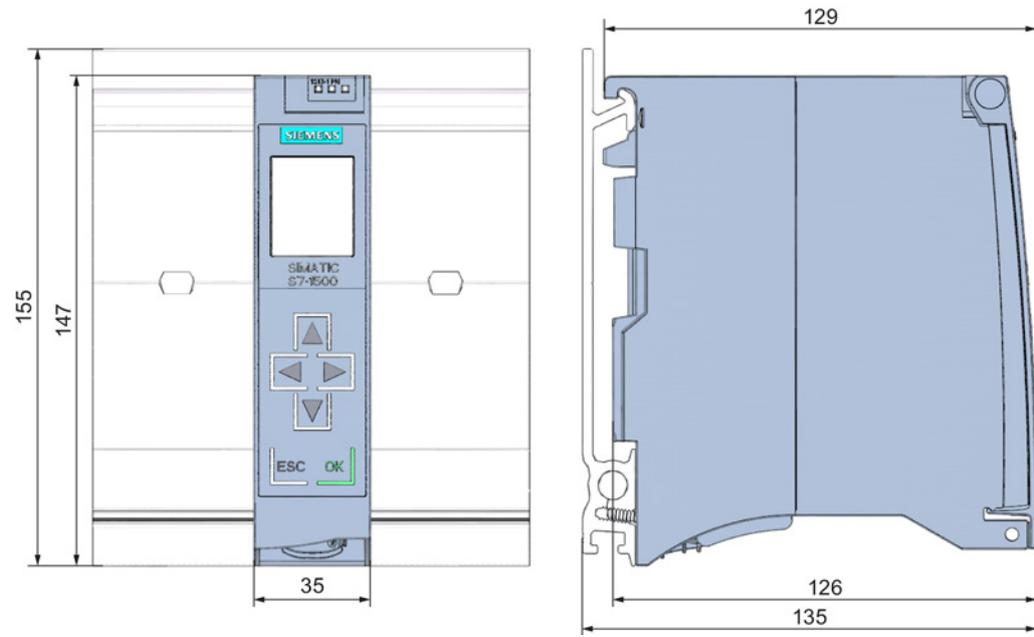
Figure A-6   Dimension drawing of CPU (35 mm wide), front and side views
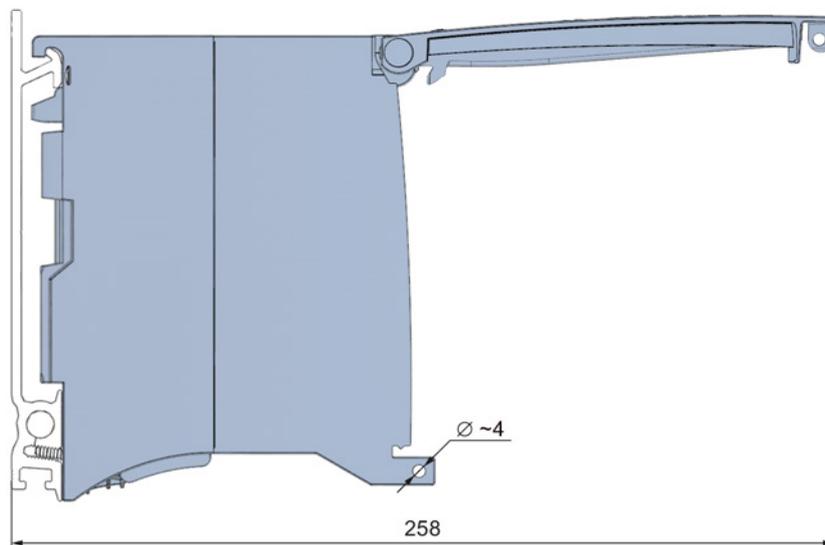
Figure A-7   Dimension drawing of CPU (35 mm wide), side view with open front cover

See also

Basics (Page 46)

A.4 Dimension drawing of CPU, 70 mm wide

In this appendix you will find the dimension drawing of the CPU installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
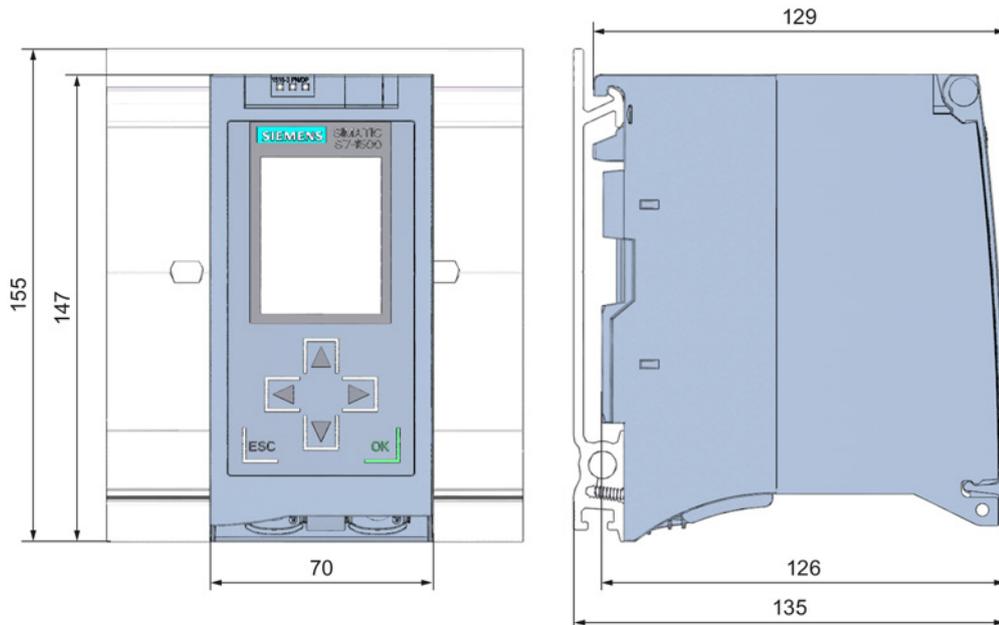

Figure A-8   Dimension drawing of CPU (70 mm wide), front and side views
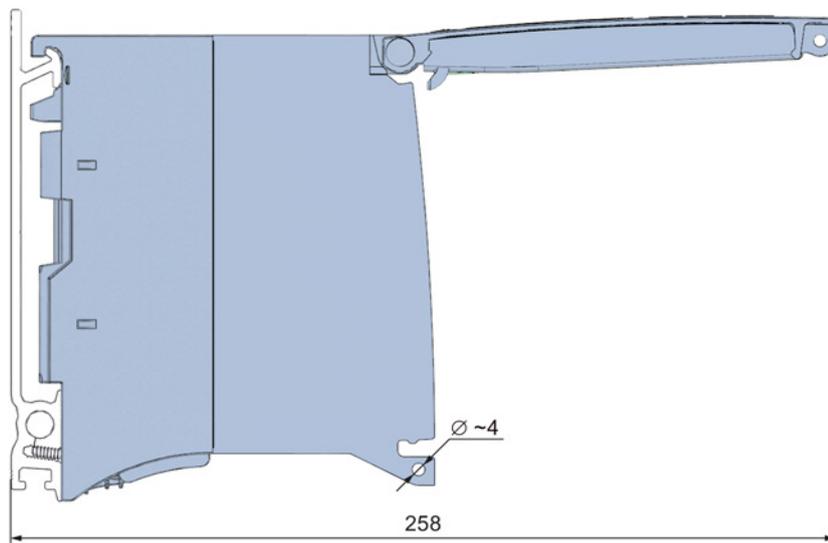
Figure A-9   Dimension drawing of CPU (70 mm wide), side view with open front cover

See also

Basics (Page 46)

A.5 Dimension drawing of CPU, 175 mm wide

In this appendix you will find the dimension drawing of the CPU installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
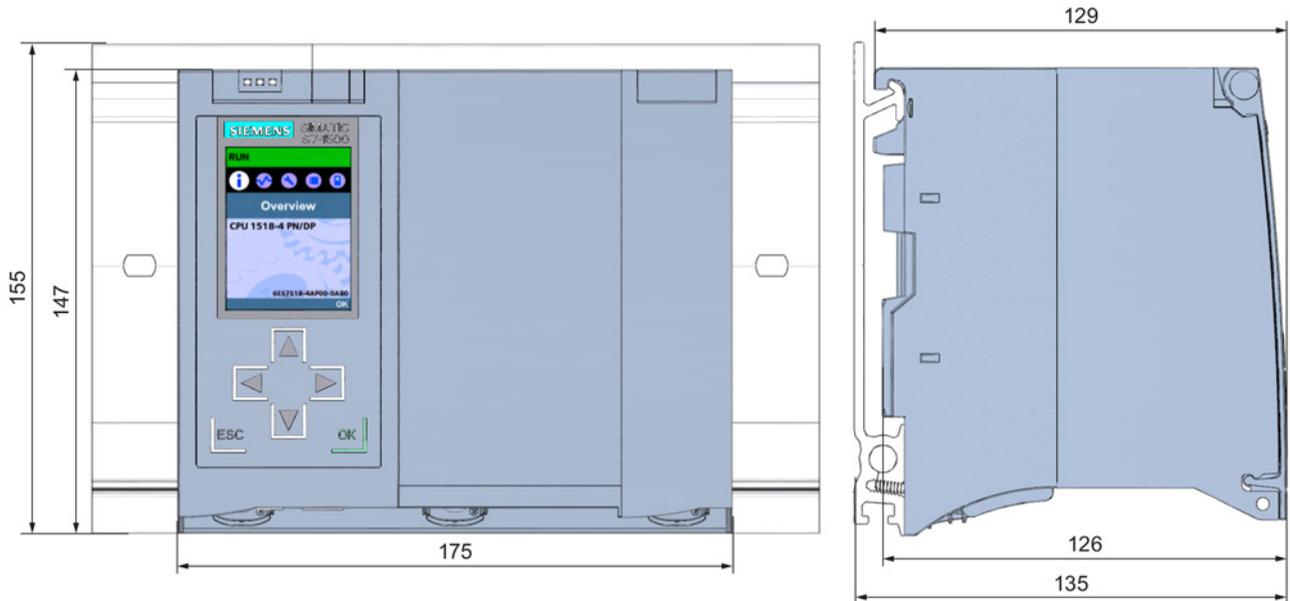
Figure A-10   Dimension drawing of CPU 1518-4 PN/DP, front and side view
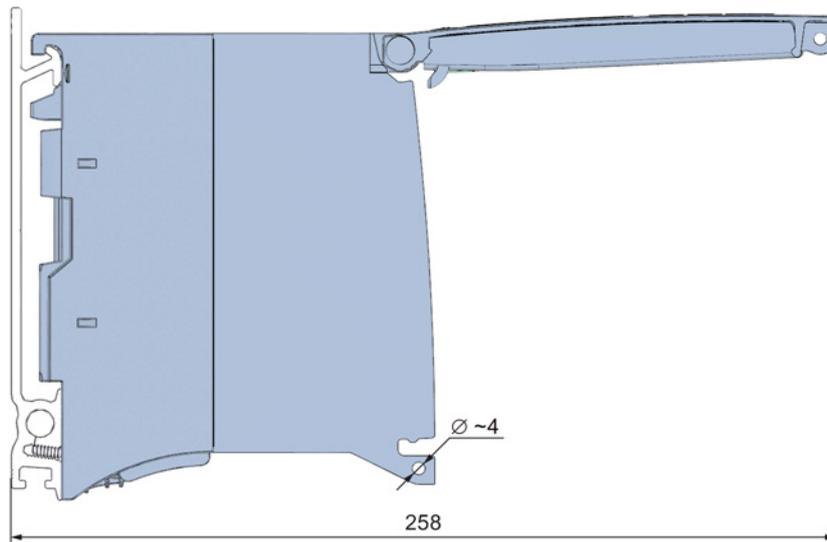
Figure A-11   Dimension drawing of CPU (175 mm wide), side view with open front cover

A.6 Dimension drawing I/O module, 25 mm wide

In this appendix you will find the dimension drawing of the I/O module installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
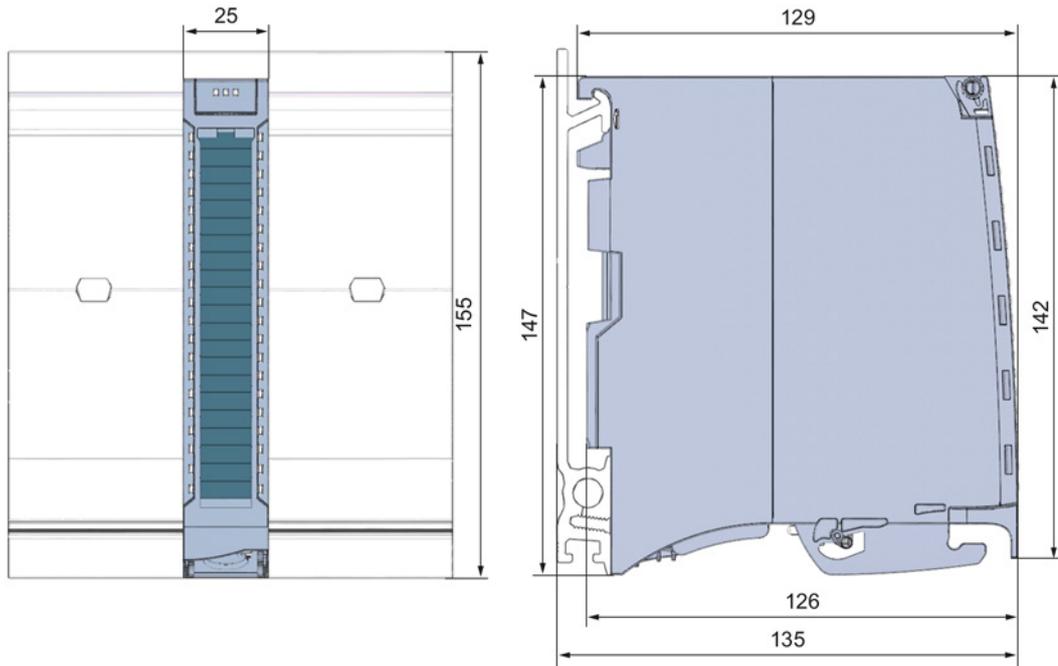
Figure A-12   Dimension drawing of I/O module, front and side views
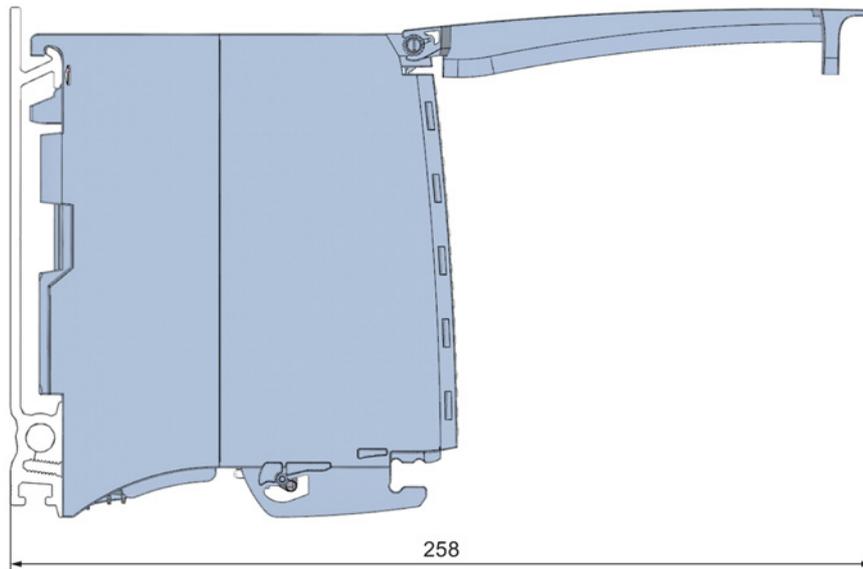
Figure A-13   Dimension drawing of I/O module, side view with open front cover

A.7 Dimension drawing I/O module, 35 mm wide

In this appendix you will find the dimension drawing of the I/O module installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
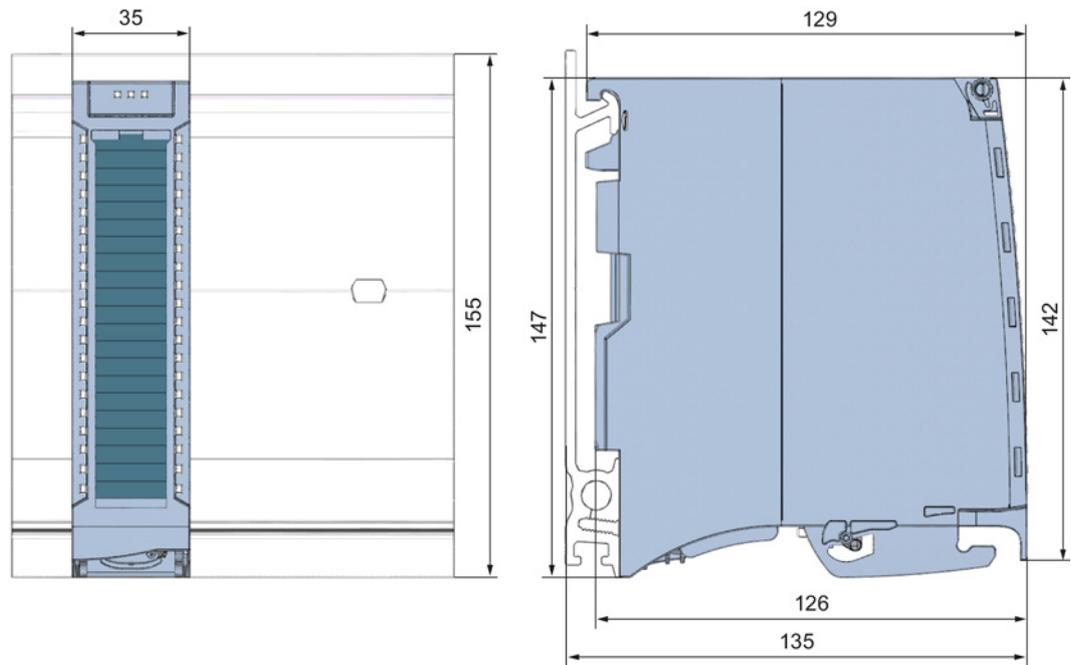
Figure A-14   Dimension drawing of I/O module, front and side views
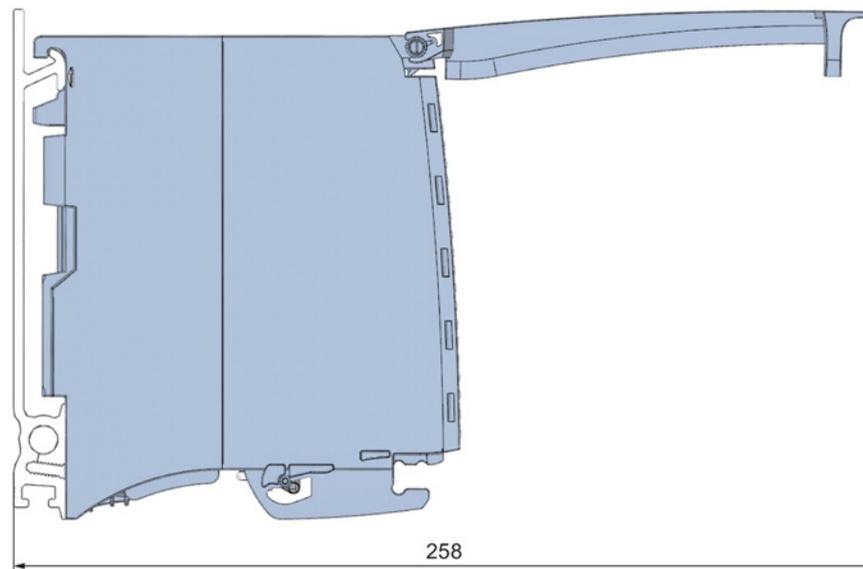
Figure A-15   Dimension drawing of I/O module, side view with open front cover

See also

Basics (Page 46)

A.8 Dimension drawing I/O module, 35 mm wide

In this appendix you will find the dimension drawing of the I/O module installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
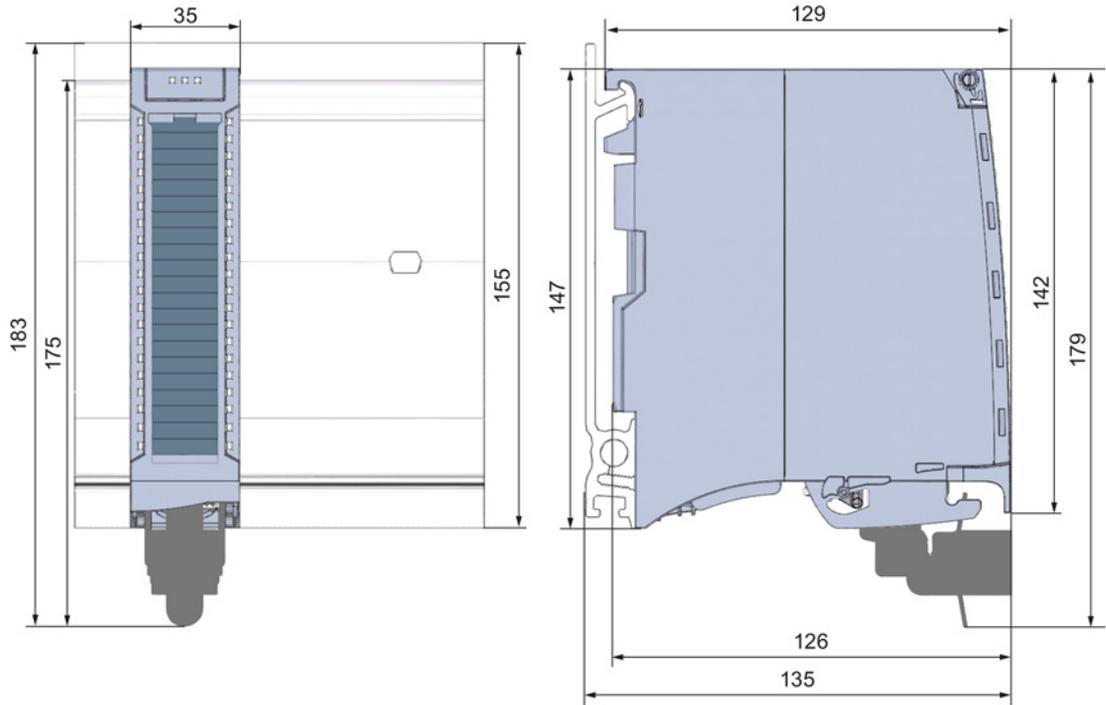
Figure A-16   Dimension drawing of I/O module with shield connection element, front and side views
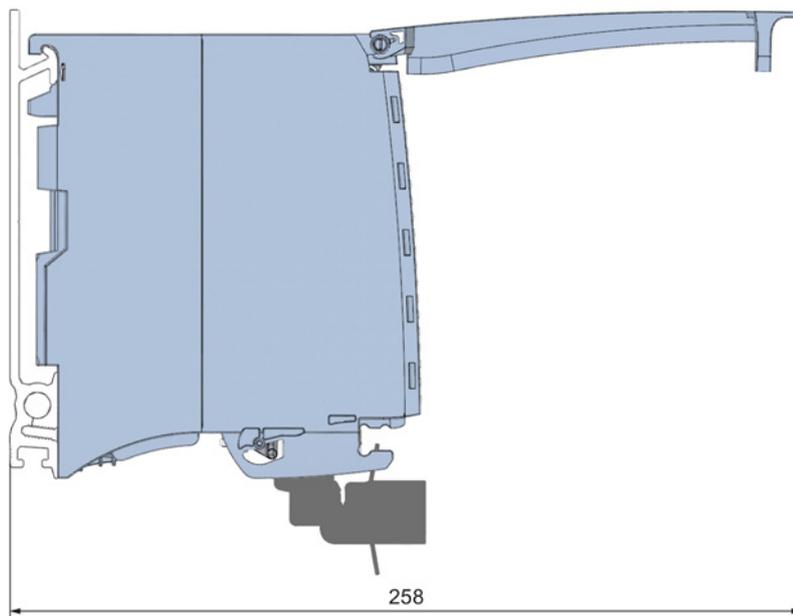
Figure A-17   Dimension drawing of I/O module with shield connection element, side view with open front cover

See also

Basics (Page 46)

A.9   Dimension drawing of system power supply, 35 mm wide

In this appendix you will find the dimension drawing of the system power supply installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
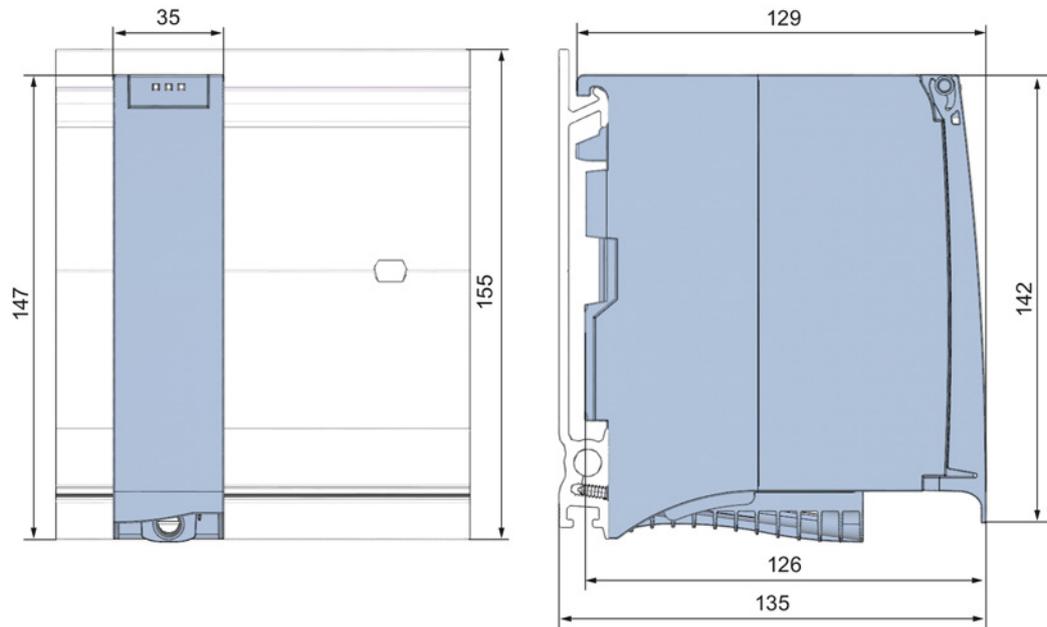
Figure A-18   Dimension drawing of system power supply (35 mm wide), front and side views
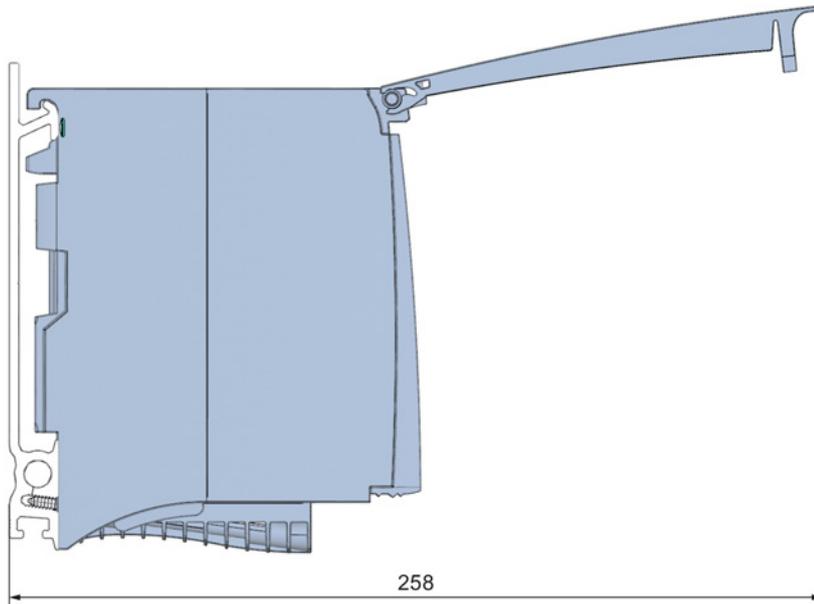
Figure A-19   Dimension drawing of system power supply (35 mm wide), side view with open front
cover

See also

Basics (Page 46)

A.10   Dimension drawing of system power supply, 70 mm wide

In this appendix you will find the dimension drawing of the system power supply installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
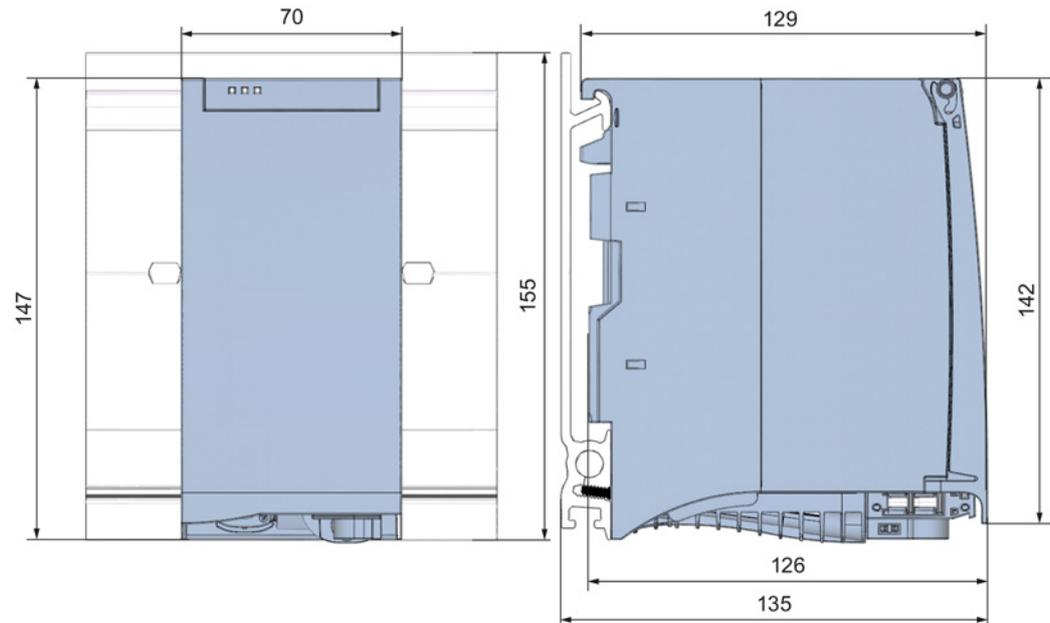
Figure A-20   Dimension drawing of system power supply (70 mm wide), front and side views
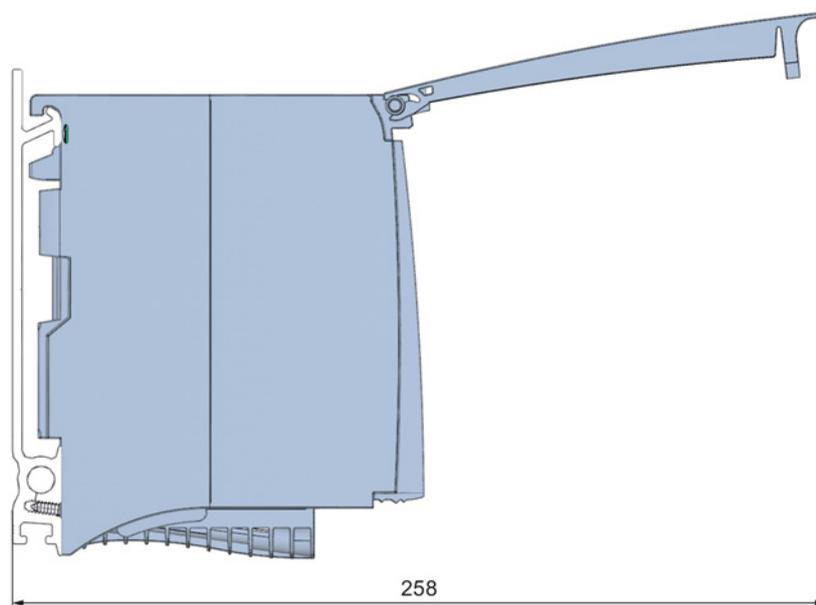
Figure A-21   Dimension drawing of system power supply (70 mm wide), side view with open front cover

See also

Basics (Page 46)

A.11 Dimension drawing of load power supply, 50 mm wide

In this appendix you will find the dimension drawing of the load power supply installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
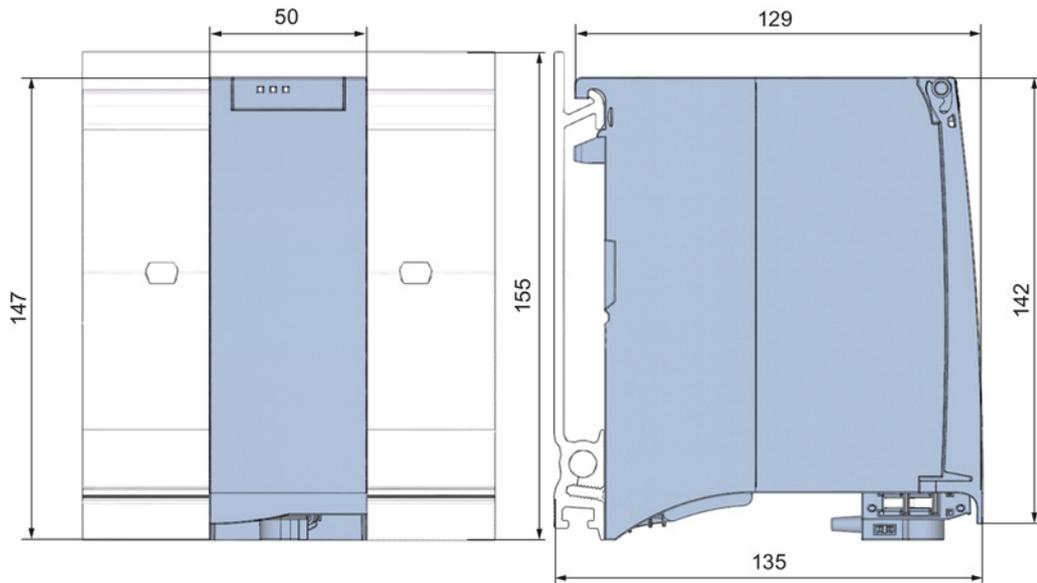
Figure A-22   Dimension drawing of load current supply (50 mm wide), front and side views
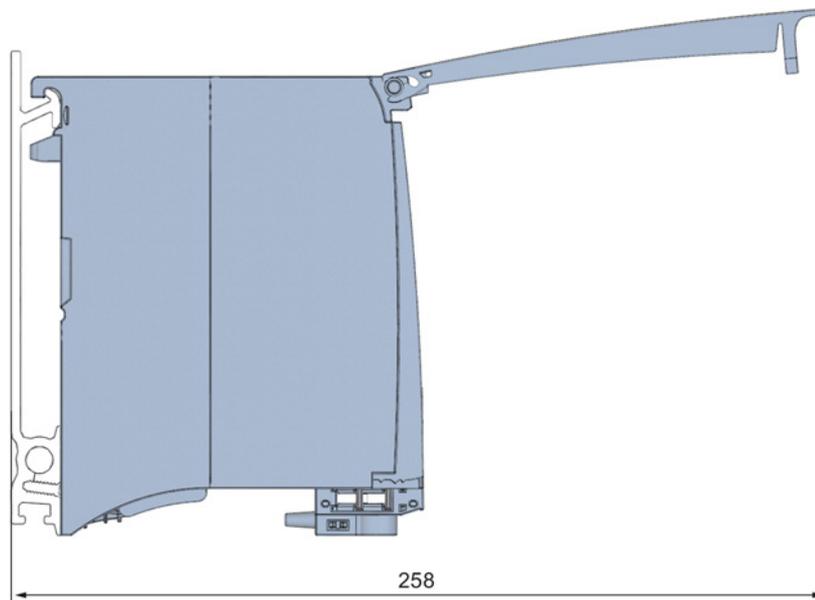
Figure A-23   Dimension drawing of load current supply (50 mm wide), side view with open front cover

See also

Basics (Page 46)

A.12   Dimension drawing of load power supply, 75 mm wide

In this appendix you will find the dimension drawing of the load power supply installed on a mounting rail, as well as a dimension drawing with open front cover. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
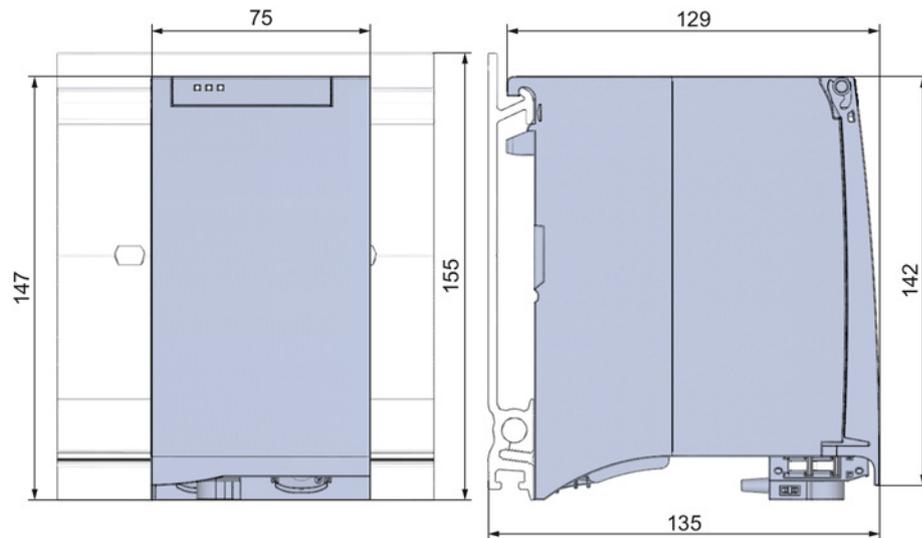
Figure A-24   Dimension drawing of load current supply (75 mm wide), front and side views
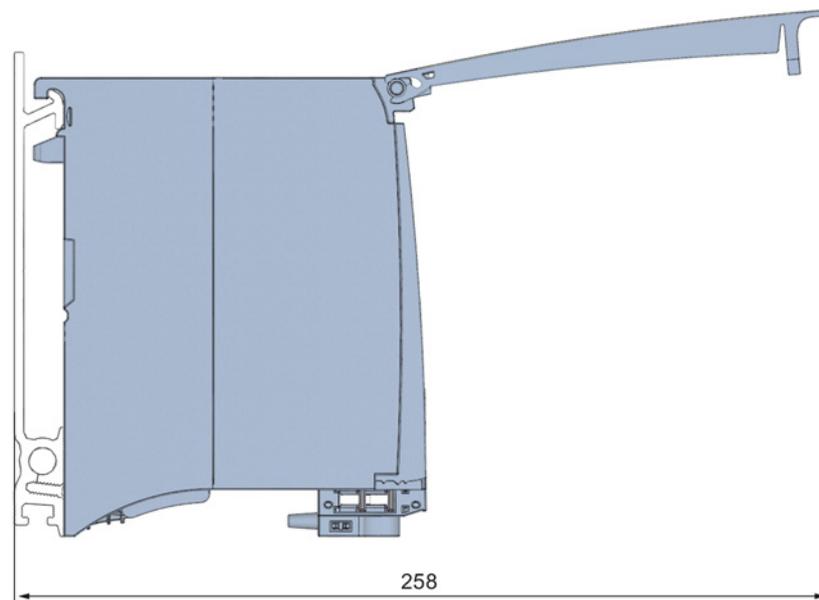
Figure A-25   Dimension drawing of load current supply (75 mm wide), side view with open front cover

See also

Basics (Page 46)

A.13 Dimension drawing of the shielding bracket

In this appendix you will find the dimension drawing of the shielding bracket in front and side view.
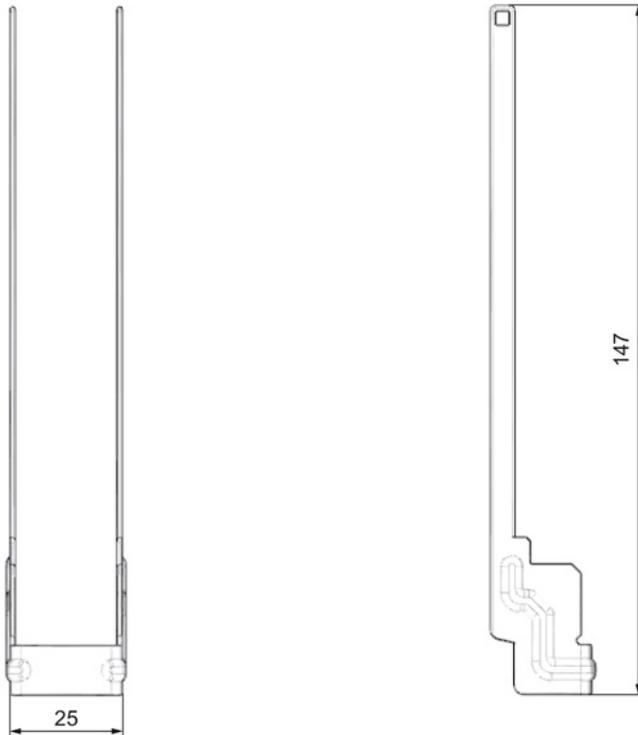
Figure A-26   Dimension drawing of the shielding bracket

A.14 Dimension drawing of the shield clamp

In this appendix you will find the dimension drawing of the shield clamp in front and side view.
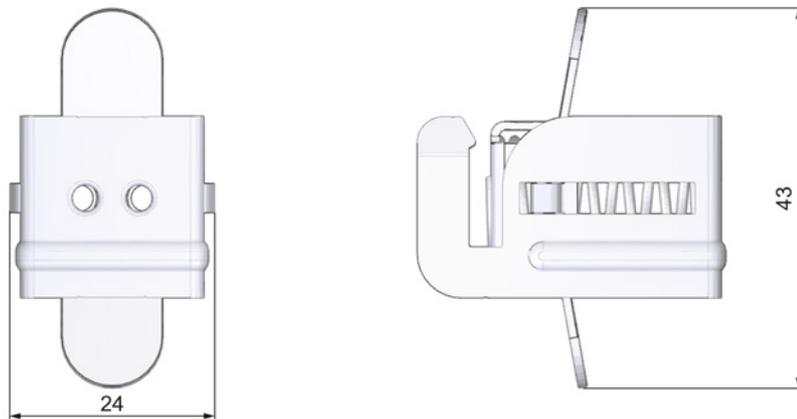
Figure A-27   Dimension drawing of the shield clamp

A.15 Dimension drawing of the power supply element

In this appendix you will find the dimension drawing of the power supply element in front and side view.
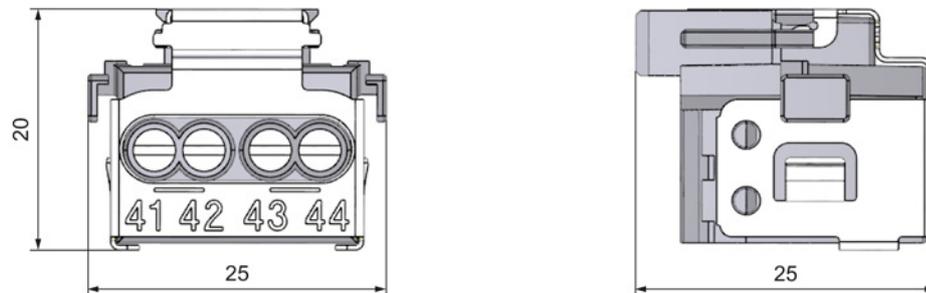
Figure A-28   Dimension drawing of the power supply element

A.16 Dimension drawings of the labeling strips

In this appendix you will find the dimension drawings of the labeling strips.
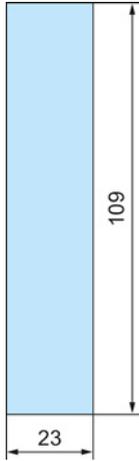
Figure A-29   Dimension drawing labeling strips for 35 mm modules
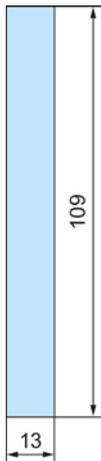
Figure A-30   Dimension drawing labeling strips for 25 mm modules

A.17 Dimensional drawing of communication module

This appendix contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.
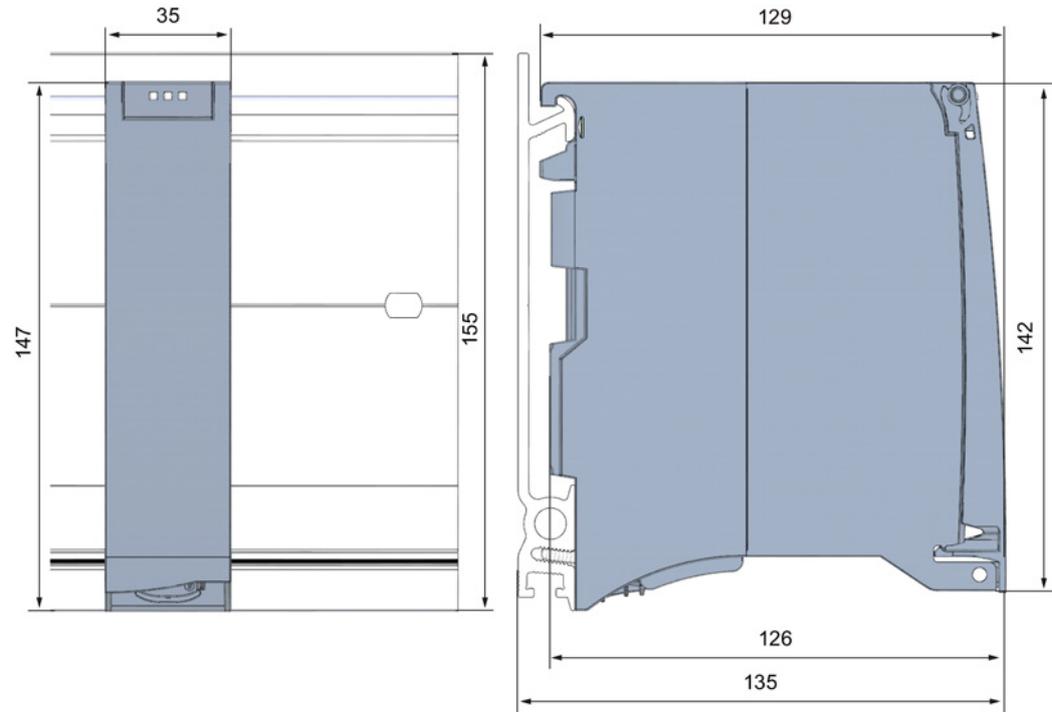
Figure A-31   Dimension drawing of communication module, front and side views
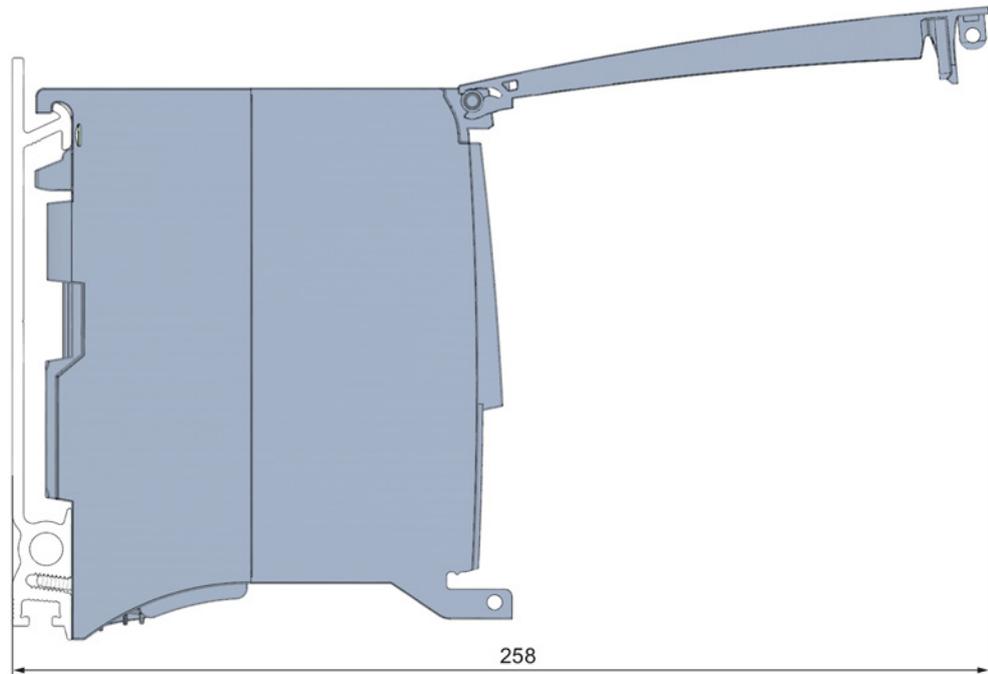
Figure A-32   Dimension drawing of communication module, side view with open front cover

Accessories/spare parts

B

Accessories for the S7-1500 automation system

Table B- 1   Accessories for the S7-1500 automation system

Description	Part number
Mounting rail	
• Mounting rail, 160 mm (with drill holes)	6ES7590-1AB60-0AA0
• Mounting rail, 482 mm (with drill holes)	6ES7590-1AE80-0AA0
• Mounting rail, 530 mm (with drill holes)	6ES7590-1AF30-0AA0
• Mounting rail, 830 mm (with drill holes)	6ES7590-1AJ30-0AA0
• Mounting rail, 2000 mm (without drill holes)	6ES7590-1BC00-0AA0
PE connection element for mounting rail, 2000 mm (spare part), 20 units	6ES7590-5AA00-0AA0
Front connector (incl. four potential bridges, cable tie, and individual labeling strip) for 35 mm modules	
• Screw-type terminals, 40-pin	6ES7592-1AM00-0XB0
Front connector (incl. four potential bridges, cable tie, and individual labeling strip) for 35 mm modules	
• Push-in terminal (40-pin)	6ES7592-1BM00-0XB0
Front connector (incl. cable tie and individual labeling strip) for 25 mm modules	
• Push-in terminal (40-pin)	6ES7592-1BM00-0XA0
4-pole connection plug for supply voltage (spare part), 10 units	6ES7193-4JB00-0AA0
DIN A4 labeling sheet (10 x for labeling the 35 mm I/O modules)	
• pre-perforated, AI gray	6ES7592-2AX00-0AA0
DIN A4 labeling sheet (10 x for labeling the 25 mm I/O modules)	
• pre-perforated, AI gray	6ES7592-1AX00-0AA0
U connector (spare part), 5 units	6ES7590-0AA00-0AA0
I/O shielding set (consists of: power supply element, shielding bracket, and shield clamp), (spare part), 5 units	6ES7590-5CA00-0AA0
U connector (spare part), 10 units	6ES7590-5BA00-0AA0
70 mm display for CPU (spare part)	6ES7591-1BA00-0AA0
35 mm display for CPU (spare part)	6ES7591-1AA00-0AA0
Power cable connector with coding element for power supply module (spare part), 10 units	6ES7590-8AA00-0AA0
Potential bridge for front connector (spare part), 20 units	6ES7592-3AA00-0AA0

Description	Part number
Universal front cover for 35 mm I/O modules (spare part), 5 units	6ES7528-0AA00-7AA0 Consists of: • 5 x front cover • 5 x front labeling strip (per module - part number) • 5 x wiring plan (per module part number)
Universal front cover for 25 mm I/O modules (spare part), 5 units	6ES7528-0AA00-0AA0 Consists of: • 5 x front cover • 5 x front labeling strip (per module - part number) • 5 x wiring plan (per module part number)
Industrial Ethernet FastConnect RJ45 plug 180, 1 unit	6GK1901-1BB10-2AA0
Industrial Ethernet FastConnect RJ45 plug 180, 10 units	6GK1901-1BB10-2AB0
PROFIBUS-FastConnect bus connector without programming device socket, up to 12 MBaud, 1 unit	6ES7972-0BA70-0XA0
PROFIBUS-FastConnect bus connector with programming device socket, up to 12 MBaud, 1 unit	6ES7972-0BB70-0XA0
PROFIBUS FastConnect bus connector without programming device socket, up to 12 MBaud, 1 unit	6ES7972-0BA52-0XA0
PROFIBUS FastConnect bus connector with programming device socket, up to 12 MBaud, 1 unit	6ES7972-0BB52-0XA0

SIMATIC Memory Card

Table B- 2   SIMATIC Memory Card

Part number	Capacity
6ES7954-8LCxx-0AA0	4 MB
6ES7954-8LExx-0AA0	12 MB
6ES7954-8LFxx-0AA0	24 MB
6ES7954-8LP01-0AA0	2 GB

Online catalog

Additional order numbers for the S7-1500 automation system can be found on the Internet (http://www.siemens.com/industrymall) in the online catalog and online ordering system.

Service & Support

C
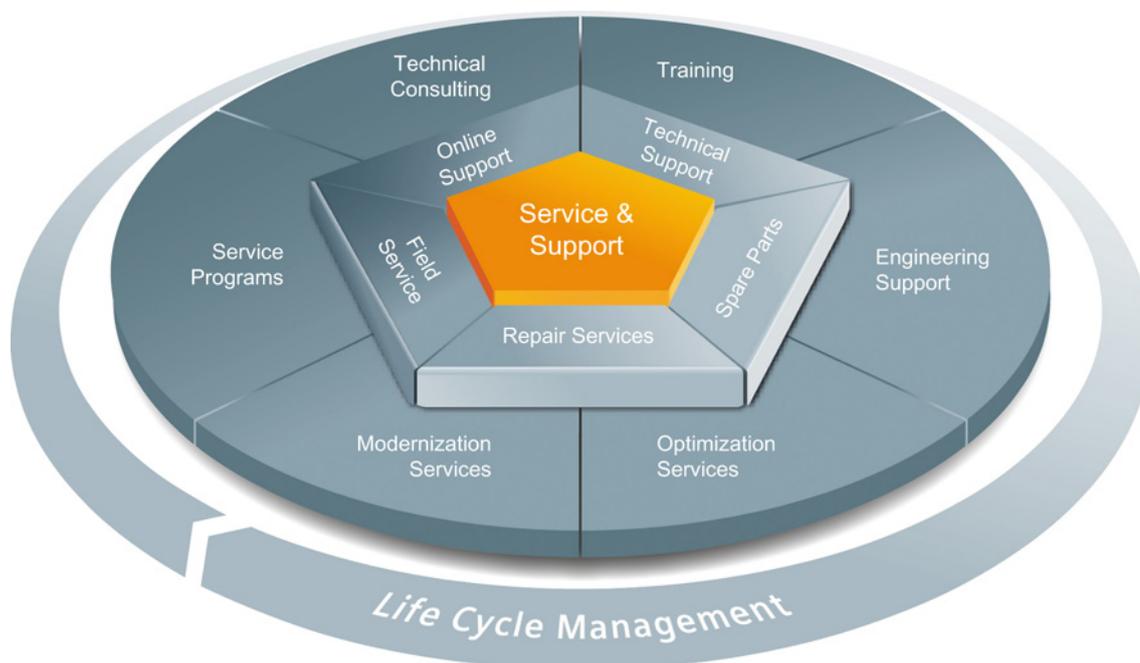
The unmatched complete service for the entire life cycle

For machine constructors, solution providers and plant operators: The service offering from Siemens Industry Automation and Drive Technologies includes comprehensive services for a wide range of different users in all sectors of the manufacturing and process industry.

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Support in planning and designing your project: From detailed actual-state analysis, definition of the goal and consultation on product and system questions right through to the creation of the automation solution.

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Extend your competitive edge – through practical know-how directly from the manufacturer.

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Support during project engineering and development with services fine-tuned to your requirements, from configuration through to implementation of an automation project.

Field Service

Our Field Service offers you services for commissioning and maintenance – to ensure that your machines and plants are always available.

Spare parts

In every sector worldwide, plants and systems are required to operate with constantly increasing reliability. We will provide you with the support you need to prevent a standstill from occurring in the first place: with a worldwide network and optimum logistics chains.

Repairs

Downtimes cause problems in the plant as well as unnecessary costs. We can help you to reduce both to a minimum – with our worldwide repair facilities.

Optimization

During the service life of machines and plants, there is often a great potential for increasing productivity or reducing costs.

To help you achieve this potential, we are offering a complete range of optimization services.

Modernization

You can also rely on our support when it comes to modernization – with comprehensive services from the planning phase all the way to commissioning.

Service programs

Our service programs are selected service packages for an automation and drives system or product group. The individual services are coordinated with each other to ensure smooth coverage of the entire life cycle and support optimum use of your products and systems.

The services of a Service Program can be flexibly adapted at any time and used separately.

Examples of service programs:

- Service contracts
- Plant IT Security Services
- Life Cycle Services for Drive Engineering
- SIMATIC PCS 7 Life Cycle Services
- SINUMERIK Manufacturing Excellence
- SIMATIC Remote Support Services

Advantages at a glance:

- Reduced downtimes for increased productivity
- Optimized maintenance costs due to a tailored scope of services
- Costs that can be calculated and therefore planned
- Service reliability due to guaranteed response times and spare part delivery times
- Customer service personnel will be supported and relieved of additional tasks
- Comprehensive service from a single source, fewer interfaces and greater expertise

Contact

At your service locally, around the globe: your partner for consultation, sales, training, service, support, spare parts... for the entire range of products supplied by Industry Automation and Drive Technologies.

You can find your personal contact in our contacts database at: Internet (http://www.siemens.com/automation/partner).

Glossary

Automation system

Programmable logic controller for the closed-loop and open-loop control of process chains in the process engineering industry and manufacturing technology. The automation system consists of different components and integrated system functions according to the automation task.

Baud rate

Data transmission rate indicates the number of bits transmitted per second (baud rate = bit rate).

Bus

A common transfer route to which all nodes of a field bus system are connected; it has two defined ends.

Bus cable connector

Physical connection between the bus node and the bus cable.

Configuration

Systematic arrangement of the individual modules (configuration).

Crimping

Procedure whereby two components joined together, e.g. wire end ferrule and cable, are connected with one another through plastic strain.

Device names

Before an IO device can be addressed by an IO controller, it must have a device name. This approach was chosen for PROFINET because names are easier to administer than complex IP addresses.

An IO device has no device name upon delivery. An IO device can only be addressed by an IO controller - e.g., for transferring configuration data (including the IP address) during startup, or for user data exchange during cyclic operation - after it has been assigned a device name with the programming device/PC.

Diagnostics

Monitoring functions for the detection, localization, classification, display, and further evaluation of errors, faults, and alarms. They run automatically while the system is in operation. This increases the availability of systems by reducing commissioning times and downtimes.

Distributed I/O system

System with input and output modules that are configured on a distributed basis, far away from the CPU controlling them.

Equipotential bonding

Electrical connection (potential equalization conductor) that brings the bodies of electrical equipment and other conductive bodies to the same or almost the same potential, in order to prevent disruptive or dangerous voltages between these bodies.

Firmware update

Upgrade of firmware for modules, e.g. after functional enhancements, to the newest firmware version (update).

Functional ground

The functional ground is a low-impedance current path between electric circuits and ground. It is not designed as a safety measure but instead, for example, as a measure to improve noise immunity.

Ground

Conductive earth whose electrical potential can be set equal to zero at any point.

All interconnected, inactive parts of a piece of equipment that cannot accept any dangerous contact voltage, even in the event of a fault.

Ground

Conductive earth whose electrical potential can be set equal to zero at any point.

All interconnected, inactive parts of a piece of equipment that cannot accept any dangerous contact voltage, even in the event of a fault.

Grounding

Grounding means connecting an electrically conductive part to a grounding electrode by means of a grounding system.

GSD file

As a Generic Station Description, this file contains all properties of a PROFINET or PROFIBUS device that are necessary for its configuration.

I/O modules

All modules that can be operated with a CPU or an interface module.

Identification data

Information that is saved in modules, and that supports the user in reviewing the system configuration and locating hardware changes.

Interface module

Module in the distributed I/O system. The interface module connects the distributed I/O system to the CPU (IO controller) via a fieldbus, and prepares the data for and from I/O modules.

Isolated modules

In the case of isolated input/output modules, the reference potentials of the control and load circuits are galvanically isolated, e.g. by means of optical isolators, relays or transformers. Input/output circuits can be connected to common potential.

Load current supply

Supply of the module's input and output electric circuits.

MAC address

worldwide, clear device identification, which is already assigned to each PROFINET device in the factory. The 6 bytes of the address consist of a 3-byte manufacturer ID and a 3-byte device ID (serial number). The MAC address is usually clearly legible on the device.

Nodes

Device that can send, receive or amplify data via the bus, e.g., I/O device via PROFINET IO.

Non-isolated modules

In the case of non-isolated input and output modules, the reference potentials of the control and load circuits are electrically connected.

Parameter assignment

Parameter assignment is the transfer of parameters from the IO controller / DP master to the IO device / DP slave.

PELV

Protective **E**xtra **L**ow **V**oltage = grounded extra low voltage with safe isolation

Pre-wiring

Wiring of the electrical system on the front connector before the front connector is used on the I/O module.

Process image (I/O)

The CPU transfers the values from the input and output modules in this memory area. At the start of the cyclic program the signal states of the input modules are transmitted to the process image of the inputs. At the end of the cyclic program the process image of the outputs is transmitted as signal state to the output modules.

PROFIBUS

PROcess **FI**eld **BUS**, process and fieldbus standard that is specified in IEC 61784-1:2010 Ed3 CP 3/1. It specifies functional, electrical and mechanical characteristics for a bit-serial field bus system.

PROFIBUS supports the protocols DP (= Distributed I/O), FMS (= Fieldbus Message Specification), PA (= Process Automation), or TF (= Technological Functions).

PROFIBUS master

When masters are in possession of the token, they can send data to other devices and request data from them (= active device).

PROFINET

PROcess **FI**eld **NET**work, open industrial Ethernet standard which further develops PROFIBUS and industrial Ethernet. A cross-manufacturer communication, automation, and engineering model defined by PROFIBUS International e.V. as an automation standard.

PROFINET component

A PROFINET component includes the entire data of the hardware configuration, the parameters of the modules, and the corresponding user program. The PROFINET component consists of:

- Technological function

  The (optional) technological (software) function comprises the interface to other PROFINET components in the form of interconnectable inputs and outputs.

- Device

  The device is the representation of the physical automation device or field device including the I/O, sensors and actuators, mechanics, and device firmware.

PROFINET IO

Communication concept for the realization of modular, distributed applications within the scope of PROFINET.

PROFINET IO controller

Device used to address connected I/O devices. This means that: The IO controller exchanges input and output signals with assigned field devices. The IO controller often corresponds to the controller in which the automation program is running.

PROFINET IO device

A distributed field device that is assigned to an IO controllers (e.g., remote IO, valve terminals, frequency converters, switches).

Provider-Consumer principle

Principle of data communication on the PROFINET IO: in contrast to PROFIBUS, both parties are independent providers when sending data.

Reference potential

Potential from which the voltages of the circuits involved are observed and/or measured.

SELV

Safety **E**xtra **L**ow **V**oltage = Safety Extra Low Voltage

Slave station

A slave may only exchange data with a master after being requested to by the master.

SNMP

SNMP (Simple Network Management Protocol) is the standardized protocol for performing diagnostics on and assigning parameters to the Ethernet network infrastructure.

In the office setting and in automation engineering, devices from many different vendors support SNMP on the Ethernet.

SNMP-based applications can be operated on the same network in parallel to applications with PROFINET.

The scope of supported functions varies depending on the device type. For example a switch has more functions than a CP 1616.

Switch

PROFIBUS is a linear network. The communication nodes are linked by means of a passive cable - the bus.

By contrast, Industrial Ethernet consists of point-to-point connections: each communication node is interconnected directly with precisely one other communication node.

If a communication node is linked to several communication nodes, this communication node is connected to the port of an active network component - the switch. Additional communication nodes (including switches) can now be connected to the other ports of the switch. The connection between a communication node and the switch remains a point-to-point connection.

A switch thus has the task of regenerating and distributing received signals. The switch "learns" the Ethernet address(es) of a connected PROFINET device or additional switches and only forwards those signals that are intended for the connected PROFINET device or switch.

A switch has a specific number of connections (ports). You connect at most one PROFINET device or additional switch to each port.

System power supply

Supply of the I/O modules via the backplane bus.

Value status

The value status is a binary additional information of a digital input signal. The value status is entered simultaneously with the process signal in the process image input and provides information about the validity of the signal.

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