SIEMENS

SIMATIC

Automation System S7-400 Hardware and Installation

Installation Manual

Preface, Contents

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B Guidelines for Handling Electrostatically-Sensitive Devices (ESD)

Glossary, Index

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Safety Guidelines

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 to property damage only have no safety alert symbol. The notices shown below are graded according to the degree of danger.

Danger

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

Warning

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

Caution

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

Caution

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

Notice

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

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

Qualified Personnel

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

Prescribed Usage

Note the following:

Warning

This device and its components may only be used for the applications described in the catalog or the technical description, and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens.

Correct, reliable operation of the product requires proper transport, storage, positioning and assembly as well as careful operation and maintenance.

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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.

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Preface

Purpose of the Manual

The manual contains reference information on operator actions, descriptions of functions and technical specifications of the central processing units, power supply modules and interface modules of the S7-400.

How to configure, assemble and wire these modules (and other) in an S7-400 system is described in the installation manuals for each system.

Required Basic Knowledge

You will need general knowledge of automation to understand this manual.

Prerequisite is also sufficient knowledge in the use of computers or PC-type equipment (programming devices, for example) with Windows 2000 or XP operating system. The S7-400 system is configured in STEP 7 standard software. You should therefore have sufficient knowledge of this standard software. This knowledge is provided in the “Programming with STEP 7” manual.

Please note the information on the safety of electronic control systems in the appendix of this manual, in particular when operating an S7-400 in safety-relevant areas.

Scope of this Manual

The manual applies to the S7-400 automation system.

Approvals

You can find details on approvals and standards in the “Module Data” reference manual.

Place of this Documentation in the Information Environment

This manual is part of the documentation package for S7-400.

System	Documentation Package
S7-400	• *S7-400 Programmable Controller*; *Hardware and Installation* • *S7-400 Programmable Controllers; Module Data* • *Automation System S7-400; CPU Data* • *S7-400 Instruction List*

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Navigating

The manual offers the following access help to make it easy for you to find specific information:

- At the start of the manual you will find a complete table of contents and a list of the diagrams and tables that appear in the manual.
- An overview of the contents of each section is provided in the left column on each page of each chapter.
- You will find a glossary in the appendix at the end of the manual. The glossary contains definitions of the main technical terms used in the manual.
- At the end of the manual you will find a comprehensive index which gives you rapid access to the information you need.

Recycling and Disposal

The S7-400 is low in contaminants and can therefore be recycled. To recycle and dispose of your old device in an environment-friendly manner, please contact a disposal company certified for disposal of electronic waste.

Further Support

If you have any technical questions, please get in touch with your Siemens representative or responsible agent .

You will find your contact person at:

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

You will find a guide to the technical documentation offered for the individual SIMATIC Products and Systems here at:

`http://www.siemens.com/simatic-tech-doku-portal`

The online catalog and order system is found under:

`http://mall.automation.siemens.com`

Training Centers

Siemens offers a number of training courses to familiarize you with the SIMATIC S7 automation system. Please contact your regional training center or our central training center in D 90327 Nuremberg, Germany for details:

Telephone: +49 (911) 895-3200.

Internet: `http://www.sitrain.com`

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You can reach the Technical Suport for all A&D products

- Via the Web formula for the Support Request
  `http://www.siemens.com/automation/support-request`
- Phone: + 49 180 5050 222
- Fax:+ 49 180 5050 223

Additional information about our Technical Support can be found on the Internet pages:
`http://www.siemens.com/automation/service`.

Service & Support on the Internet

In addition to our documentation, we offer our Know-how online on the internet at:

`http://www.siemens.com/automation/service&support`

where you will find the following:

- The newsletter, which constantly provides you with up-to-date information on your products.
- The right documents via our Search function in Service & Support.
- A forum, where users and experts from all over the world exchange their experiences.
- Your local representative for Automation & Drives.
- Information on field service, repairs, spare parts and more under “Services”.

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Product Overview

1

Overview of the S7-400

The S7-400 is a programmable logic controller. Almost any automation task can be implemented with a suitable choice of S7-400 components.

S7-400 modules have a block design for swing-mounting in a rack. Expansion racks are available to extend the system.

In this chapter, we show you the most important components with which you can assemble an S7-400.

Features of the S7-400

The S7-400 programmable controller combines all the advantages of the previous system with those of a new system and new software. These are:

- A graded CPU platform
- Upwardly-compatible CPUs
- Enclosed modules of rugged design
- Convenient terminal system for the signal modules
- Compact modules with a high component density
- Optimum communication and networking facilities
- Convenient incorporation of operator interface systems
- Software parameter assignment for all modules
- Extensive choice of slots
- Operation without fans
- Multicomputing in the non-segmented rack

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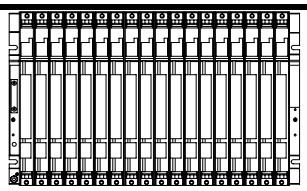
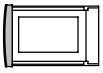
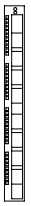
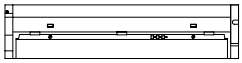
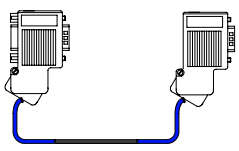
S7-400 components

The most important components of the S7-400 and their functions are given in the following tables:

Components	Function	Illustration
Racks (UR: Universal Rack) (CR: Central Rack) (ER: Expansion Rack)	... provide the mechanical and electrical connections between the S7-400 modules.	
Power Supply Modules (PS = Power Supply) Accessories: Backup battery	... convert the line voltage (120/230 VAC or 24 VDC) to the 5 VDC and 24 VDC operating voltages required to power the S7-400.	
CPUs Central Processing Units (CPUs)	... execute the user program; communicate via the multipoint interface (MPI) with other CPUs or with a programming device (PG).	
Memory cards	... store the user program and parameters.	
IF 964-DP interface module	... used to connect distributed I/Os via PROFIBUS-DP	
Signal Modules (SM = Signal Module) (digital input modules, digital output modules, analog input modules, analog output modules) Accessories: Front connector with three different terminal systems	... match the different process signal levels to the S7-400. ... form the interface between PLC and process.	
Interface modules (IM = Interface Module) Accessories: Connecting cable Terminator	... interconnect the individual racks of an S7-400.	
Cable ducts	...are used for routing cables and as ventilation.	
PROFIBUS bus cables	...connect CPUs to programming devices.	

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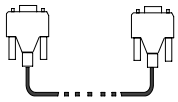
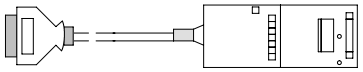
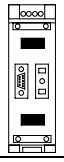
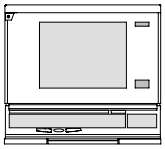
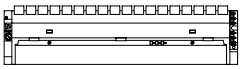
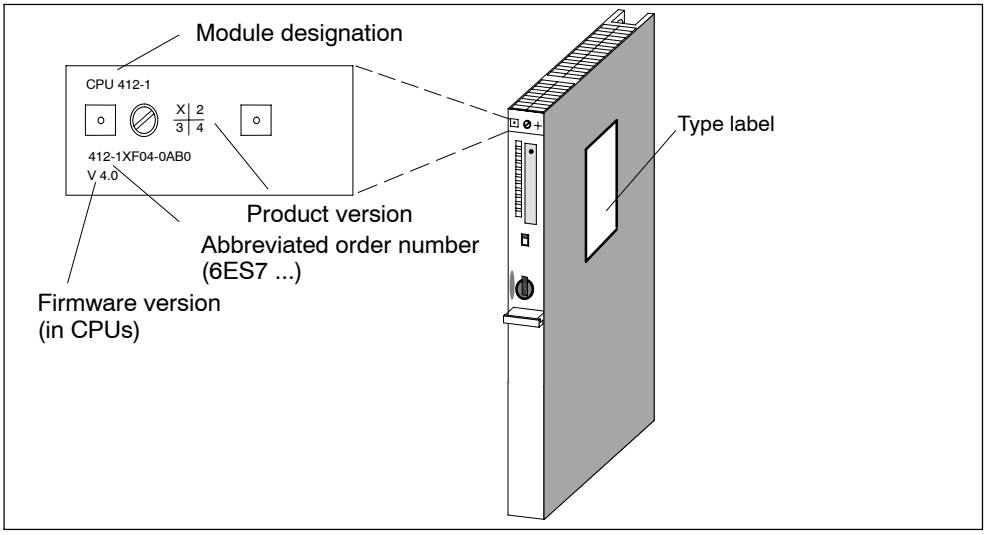
Components	Function	Illustration
PG cables	...connect a CPU to a programming device.	
PROFIBUS components for example, PROFIBUS bus terminal	... connect the S7-400 to other S7-400 devices or programming devices.	
RS 485 repeaters	...amplify data signals on bus lines and links bus segments.	
Programming device (PG) or PC with the STEP 7 software package	...configures, programs, debugs, and assigns parameters to the S7-400.	
Fan subassemblies (for special areas of application)	...ventilates modules in special cases; can be operated with or without a filter.	

Additional components of the S7-400 such as communications processors, function modules, etc., are described in separate manuals.

Location of the order number and product version

The order number and product version are printed on every module of the SIMATIC S7-400. The firmware version is also printed on the CPUs. The following figure shows their locations on a module.

For the product version, an X is entered instead of the valid number. The following figure shows a module with Product Version 1.



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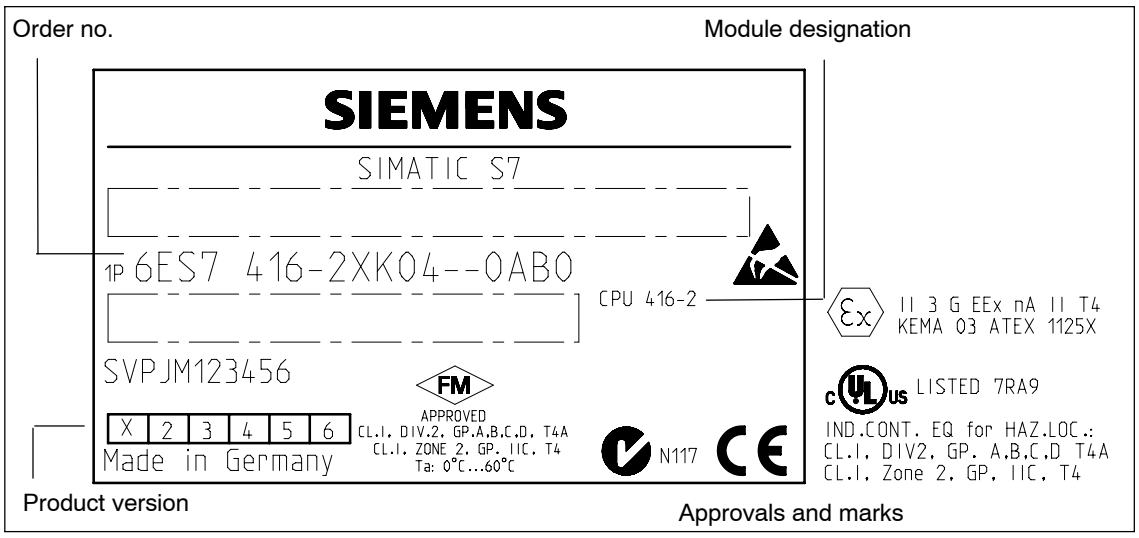
Example of a rating plate



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Installing the S7-400

2

Chapter Overview

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2.1 S7-400 Installation

Introduction

An S7-400 programmable controller consists of a central rack (CR) and one or more expansion racks (ERs), as required. You can add ERs to compensate for lack of slots for your application or operate signal modules at remote locations (e.g. in the immediate vicinity of your process).

When using ERs, you need interface modules (IMs) as well as the additional racks, and additional power supply modules if necessary. When using interface modules, you must always use the appropriate partners: you insert a send IM in the CR, and the matching receive IM in each connected ER (see *Reference Manual*, Chapter 6).

Central Rack (CR) and Expansion Rack (ER)

The rack containing the CPU is known as the central rack (CR). The racks containing modules in the system and connected to the CR are the expansion racks (ERs).

Shown in Figure 2-1 is a rack with 18 slots configured as a CR.

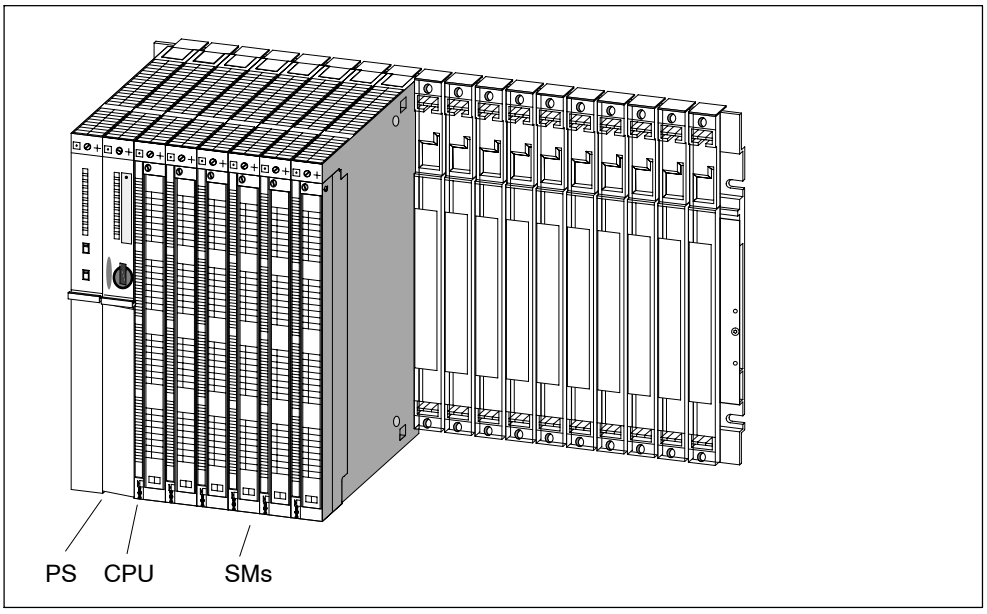

Figure 2-1 Rack Fitted with Modules in the S7-400 System

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Connecting the CR and ER(s)

To connect one or more ERs to a CR, you must fit one or more send IMs in the CR.

The send IMs have two interfaces. You can connect one chain of up to four ERs to each of the two interfaces of a send IM in the CR.

Different IMs are available for local connection and remote connection.

Connecting with a 5 V Supply

For a local connection with the IM 460-1 and IM 461-1, the 5 V supply voltage is also transferred via the interface modules. There must therefore be no power supply module inserted in an ER connected to an IM 460-1/IM 461-1.

Up to 5 A may flow through each of the two interfaces of an IM 460-1. This means that each ER connected via an IM 460-1/461-1 can be powered with a maximum of 5 A at 5 V. For further details, see the *Reference Manual,* Chapter 6.

Overview of the Connections

Observe the connection rules at the end of this section.

	Local Connection		**Remote Connection**	
Send IM	460-0	460-1	460-3	460-4
Receive IM	461-0	461-1	461-3	461-4
Max. number of connectable EMs per chain	4	1	4	4
Max. distance	5 m	1.5 m	102.25 m	605 m
5 V transfer	No	Yes	No	No
Max. current transfer per interface	–	5 A	–	–
Communication bus transmission	Yes	No	Yes	No

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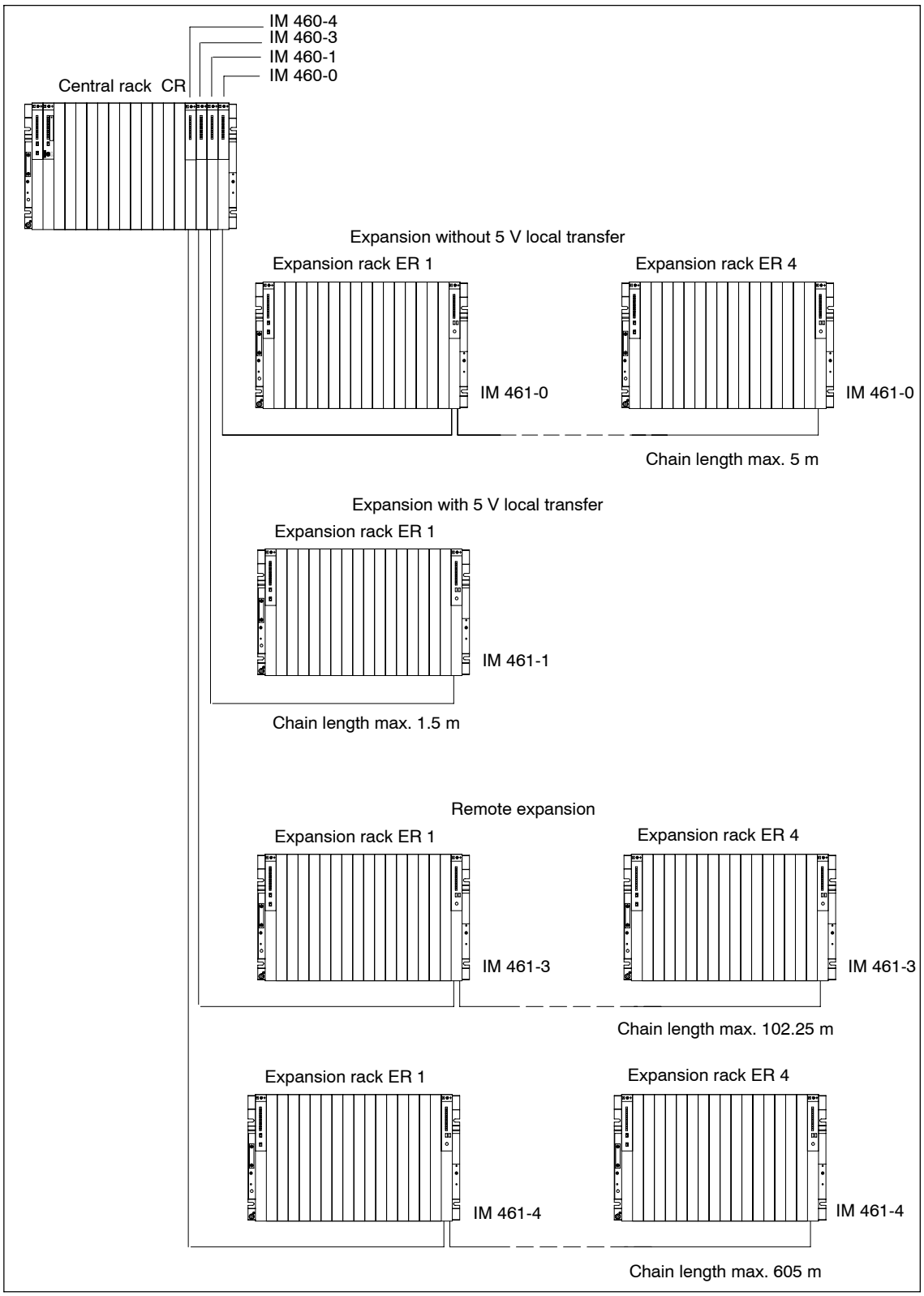
Ways of Connecting Central and Expansion Racks



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Rules for Connection

When you connect a central rack to expansion racks, you must observe the following rules:

- You can connect up to 21 ERs of the S7-400 to one CR.
- The ERs are assigned numbers to identify them. The rack number must be set on the coding switch of the receive IM. Any rack number between 1 and 21 may be assigned. Numbers must not be duplicated.
- You may insert up to six send IMs in one CR. However, only two send IMs with 5 V transfer are allowed in one CR.
- Each chain connected to the interface of a send IM can comprise up to four ERs (without 5 V transfer) or one ER (with 5 V transfer).
- The exchange of data via the communication bus is limited to 7 racks, meaning the CR and ER numbers 1 to 6.
- The maximum (total) cable lengths specified for the type of connection must not be exceeded.

Type of Connection	Maximum (Total) Cable Length
Local connection with 5 V transfer via IM 460-1 and IM 461-1	1.5 m
Local connection without 5 V transfer via IM 460-0 and IM 461-0	5 m
Remote connection via IM 460-3 and IM 461-3	102.25 m
Remote connection via IM 460-4 and IM 461-4	605 m

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2.2 Installing the Central Rack (CR) and Expansion Rack (ER)

Function of the Racks

The racks of the S7-400 system form the basic framework which accepts the individual modules. The modules exchange data and signals and are powered via the backplane bus. The racks are designed for wall mounting, for mounting on rails, and for installation in frames and cabinets.

Racks in the S7-400 System

Rack	No. of Slots	Available Buses	Application	Characteristics
UR1	18	I/O bus Communication bus	CR or ER	Rack for all module types in the S7-400.
UR2	9			
ER1	18	Restricted I/O bus	ERs	Racks for signal modules (SMs), receive IMs, and all power supply modules. The I/O bus has the following restrictions: • Interrupts from modules have no effect because no interrupt lines exist. • Modules are not supplied with 24 V, i.e. modules requiring 24 V cannot be used (see technical data of the modules). • Modules are neither backed up by the battery in the power supply module nor by the voltage applied externally to the CPU or receive IM (EXT.BATT. socket).
ER2	9			
CR2	18	I/O bus, segmented Communication bus, continuous	Segmented CR	Rack for all module types in the S7-400 except receive IMs. The I/O bus is subdivided into 2 I/O bus segments of 10 and 8 slots respectively.
CR3	4	I/O bus Communication bus	CR in standard systems	Racks for all S7-400 module types except receive IMs. CPUs 41x-H only in stand-alone operation.
UR2-H	2*9	I/O bus, segmented Communication bus, segmented	Subdivided CR or ER for compact installation of a fault–tolerant system	Rack for all S7-400 modules except send IMs. The I/O bus and communication bus are divided into 2 bus segments, each with 9 slots.

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Electrical Supply

The modules inserted in the rack are supplied with the required operating voltages (5 V for logic, 24 V for interfaces) via the backplane bus and base connector, by the power supply module fitted in the slot on the extreme left in the rack.

For local connections, ERs can also be supplied with power via the IM 460-1 / IM 461-1 interface modules.

5 A may flow through each of the two interfaces of a send IM 460-1, meaning each ER in a local connection can be supplied with up to 5 A.

I/O Bus

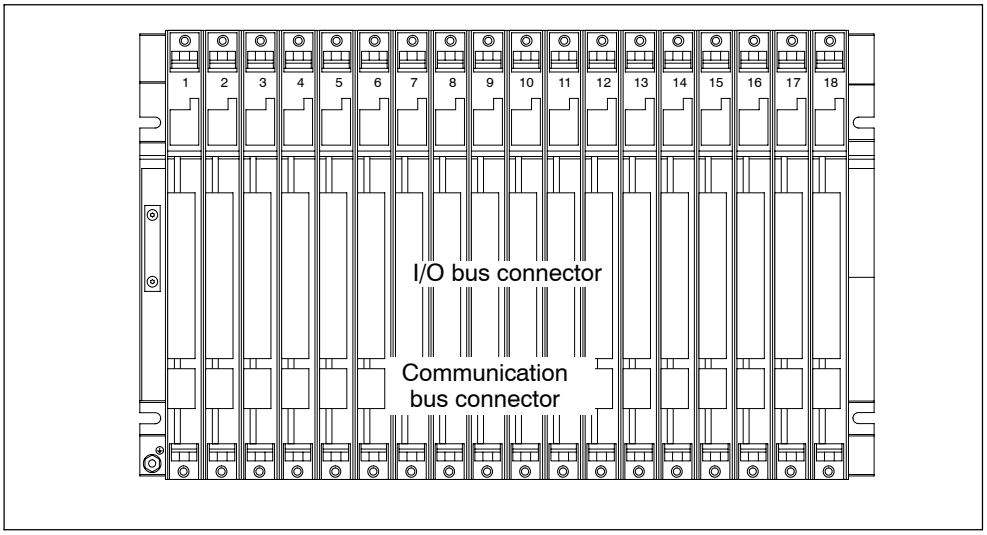
The I/O bus is a parallel backplane bus designed for the fast interchange of I/O signals. Each rack has an I/O bus. Time-critical operations to access the process data of the signal modules take place via the I/O bus.

Communication Bus (C Bus)

The communication bus (C bus) is a serial backplane bus designed for the fast exchange of large volumes of data parallel to the I/O signals. Except for racks ER1 and ER2, each rack has a communication bus.

Rack with I/O Bus and Communication Bus

The following figure shows a rack with an I/O bus and a communication bus. The I/O bus connector and communication bus connector can be seen at each slot. When the rack is delivered, these connectors are protected by a cover.



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2.3 Segmented CR

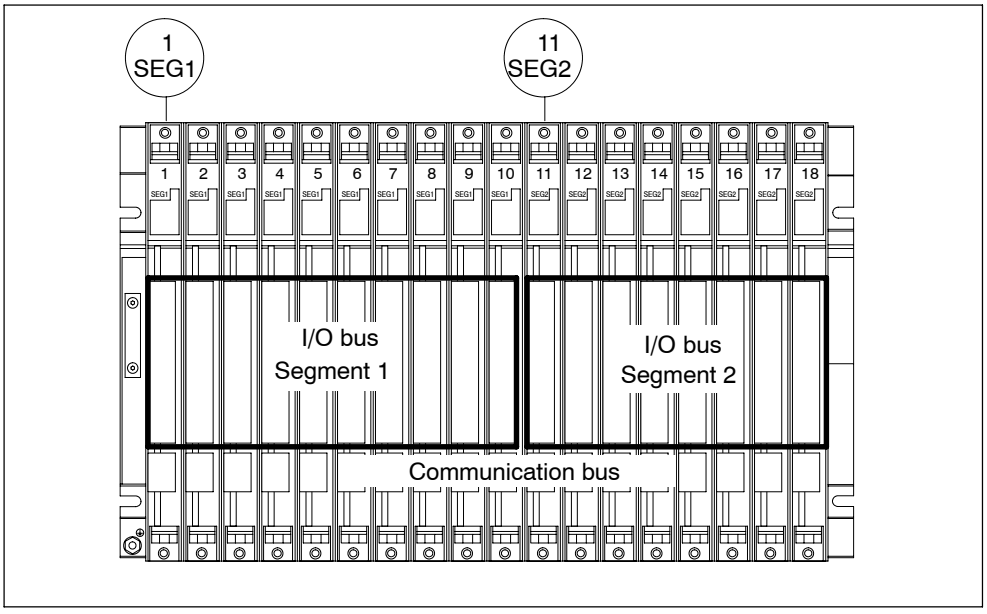
Properties

The “segmented” characteristic relates to the configuration of the CR. In the (non-segmented) CR the I/O bus is continuous and interconnects all 18 or 9 slots; in the segmented CR, however, the I/O bus consists of two I/O bus segments.

A segmented CR has the following important characteristics:

- The communication bus is continuous (global), whilst the I/O bus is divided into two I/O bus segments of 10 and 8 slots respectively.
- One CPU can be inserted per local bus segment.
- The two CPUs in a segmented CR may be in different operating states.
- The two CPUs can communicate with each other via the communication bus.
- All the modules inserted in a segmented CR are powered by the power supply module at slot 1.
- Both segments have a common backup battery.

The following figure shows a segmented CR with divided I/O bus and continuous communication bus.



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2.4 Subdivided CR

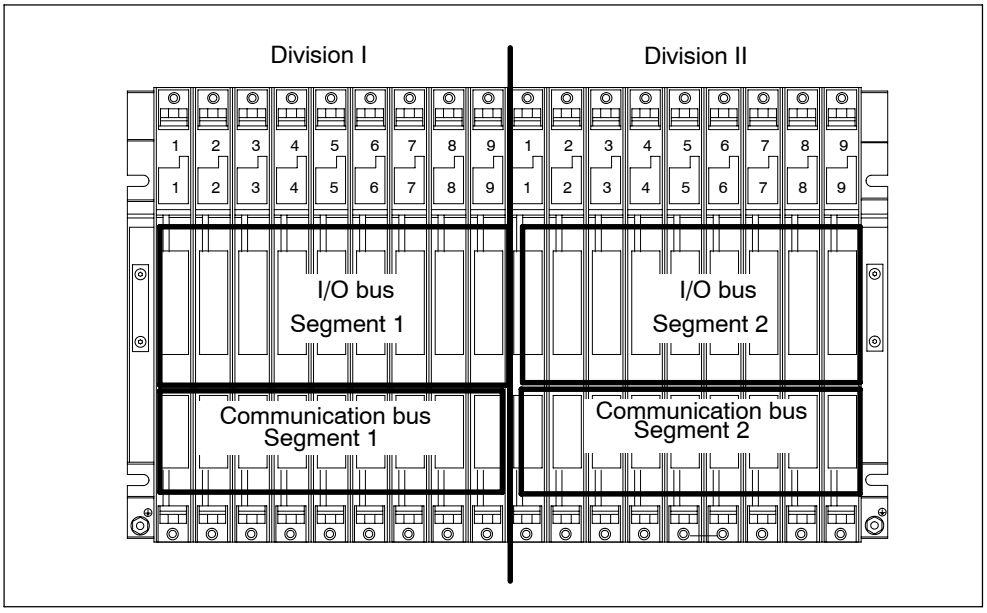
Characteristics

The “subdivided” characteristic relates to the configuration of the CR. In the (non-divided) CR the I/O bus and communication bus are continuous and interconnect all the slots; in the subdivided CR, however, the I/O bus and communication bus consist of two segments each. The UR2-H rack used here functions as two electrically isolated UR2 racks on the same rack profile.

A subdivided CR has the following important characteristics:

- The communication bus and I/O bus are subdivided into two segments with 9 slots each.
- Each segment represents a self-contained CR.

The following figure shows a divided CR with a divided I/O bus and communication bus.



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2.5 Mounting and Grounding the Racks

Important Notes on Installation

The S7-400 racks are designed for wall mounting, mounting on rails, and for installation in frames and cabinets. Their mounting dimensions are compliant with DIN 41 494.

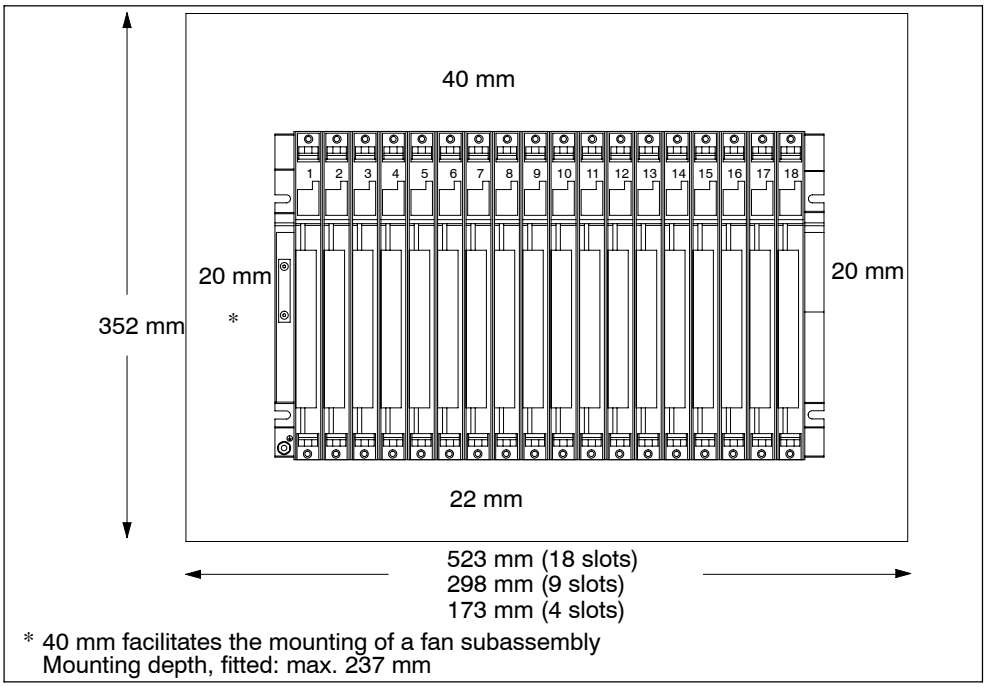
According to the UL/CSA and the EU Directive 73/23/EEC (low-voltage directive), installation in a cabinet, a casing, or a closed operations room is necessary in order to fulfil the requirements for electrical safety (see *Reference Manual*, Chapter 1).

Step 1: Retaining Distances Between Devices

You must observe the minimum distances between the rack and neighboring devices. You need these minimum clearances during installation and operation.

- For fitting and removing modules
- For fitting and disconnecting the module front connectors
- To ensure the air flow required for cooling the modules during operation

The following figure shows the minimum space you must provide for a rack.



* 40 mm facilitates the mounting of a fan subassembly
Mounting depth, fitted: max. 237 mm

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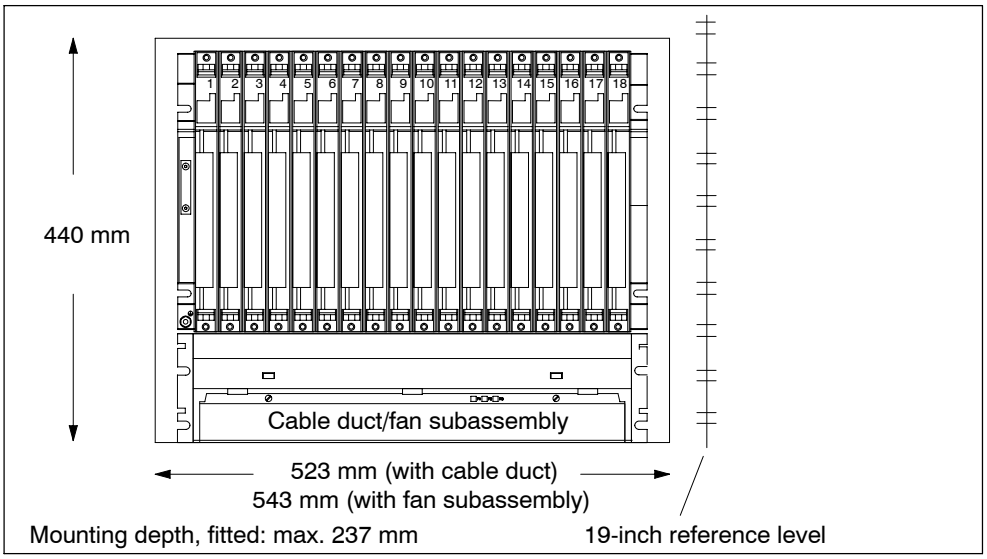
Space Required When Using Cable Channels and Fan Subassemblies

A cable duct or fan subassembly must be installed in the 19-inch pitch immediately below the rack. Additional space for cable routing must be provided on both sides.

The following figure shows how much space you need to allow for when using a cable duct or fan subassembly.



Dimensions of the Racks

The following figure shows the dimensions for racks with 18, 9 and 4 slots and the positions of cutouts for screw mounting.

The cutouts are arranged according to the 19-inch standard.

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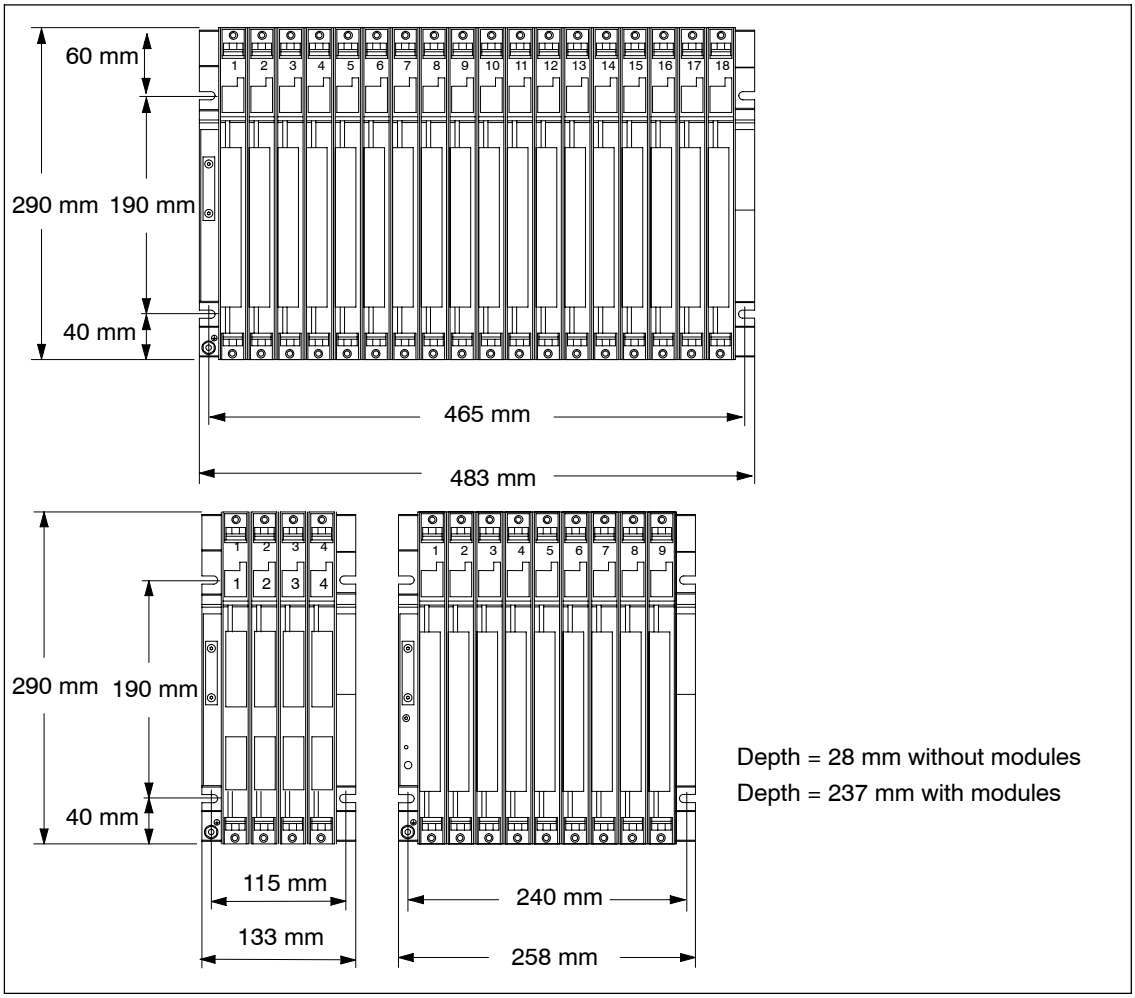

Step 2: Mounting the Rack

Screw the rack onto the mounting panel.

When mounting the equipment on a metal mounting plate, make sure to establish a low-impedance connection. On varnished or anodized metals, for example, wlayws use a suitable contact agent or special contact washers.

Special measures need not be taken if you do not use this type of panel.

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Mounting Screws

You have a choice of the following types of screw for securing a rack:

Screw Type	Explanation
M6 cylinder-head screw to ISO 1207/ISO 1580 (DIN 84/DIN 85)	Choose the screw length according to your assembly. You also need “6.4” washers to ISO 7092 (DIN 433).
M6 hex. screw to ISO 4017 (DIN 4017)	

Step 3: Connecting the Rack to the Chassis Ground

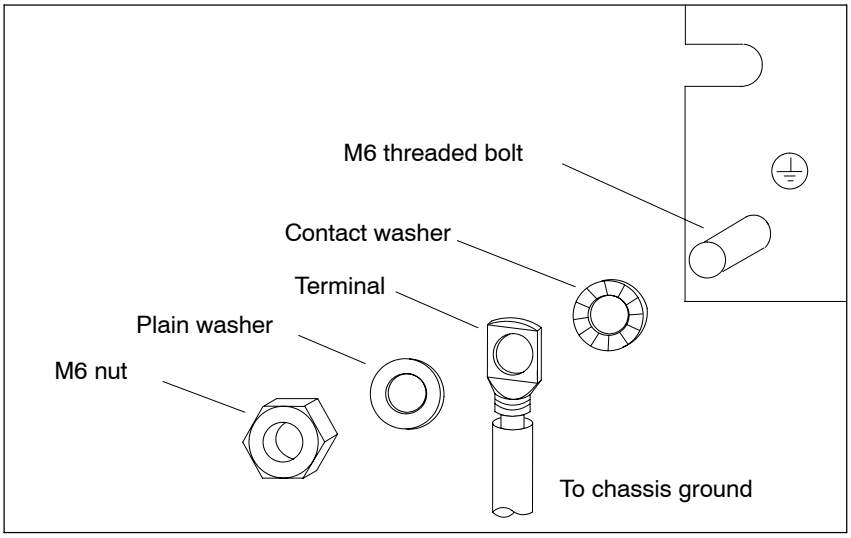
Connect the rack to the chassis ground. A threaded bolt is provided for this purpose on the bottom left of the rack.

Minimum cross-section of the conductor to the chassis ground: 10 mm^2.

If the S7-400 is mounted on a mobile rack, you must provide a flexible conductor to the chassis ground.

Note

Always ensure that there is a low-impedance connection to the chassis ground (see the figure below). You achieve this with the shortest possible, low-resistance conductor with a large surface to establish large-area contact.



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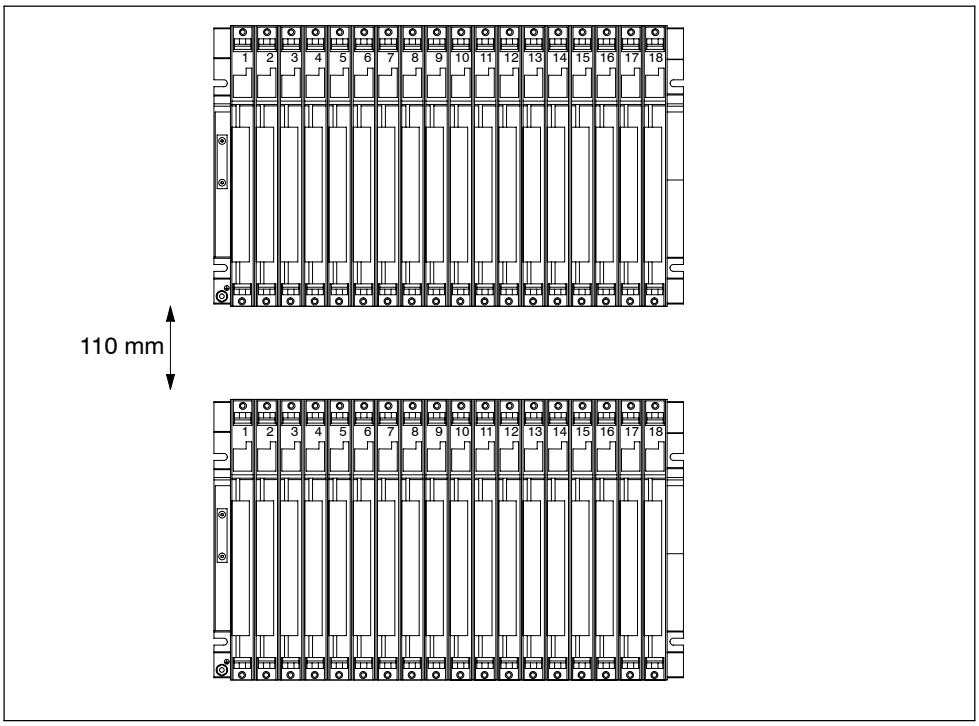
Step 4: Mounting Additional Racks

For S7-400 assemblies containing two or more racks, make allowances for additional clearance between the racks for installing a fan subassembly or cable duct.

The figure below shows the clearance you must allow between two racks of the S7-400 during installation.



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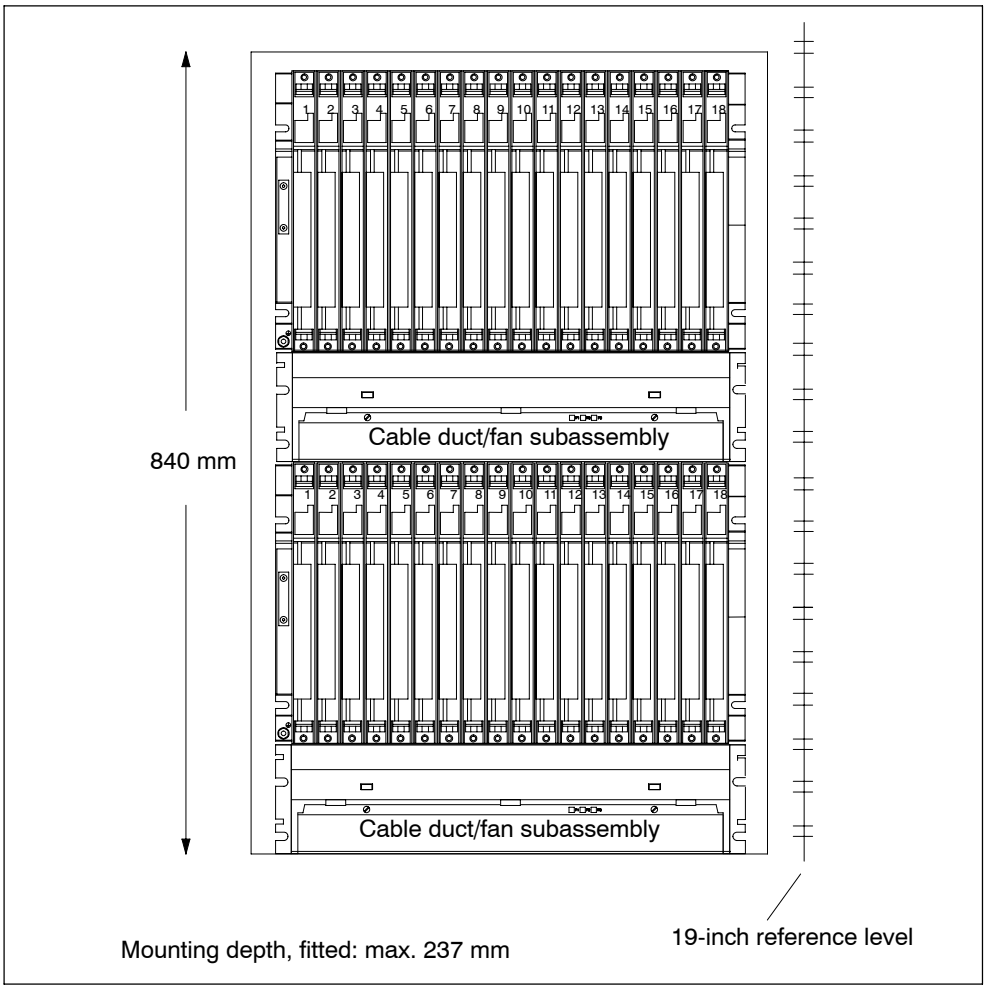
The figure below shows how much space you must allow for when assembling an S7-400 from two racks with a cable duct or fan subassembly. This requirement is increased by a height of 400 mm for each additional rack with a cable duct or fan subassembly.



Note

A minimum clearance as shown in the above figure between rack and cable duct or fan subassembly must not be provided, but is essential between two adjacent racks and between racks and other equipment.

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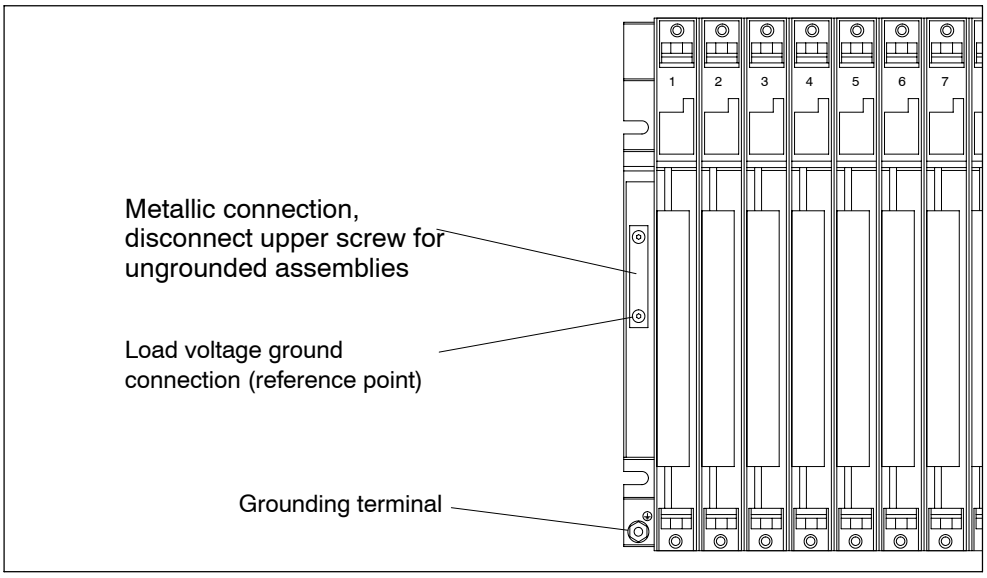
2.6 Chassis Terminal Connection in the Non-Isolated Configuration

Reference Point

The racks offer the option of connecting the 24-V load voltage ground in the non-isolated configuration to the 5-V ground (reference potential M, logic ground).

Connect the chassis ground to the reference point for non-isolated modules. The reference point is metallically connected to the reference potential M.

The following figure shows the position of the reference point on a rack.



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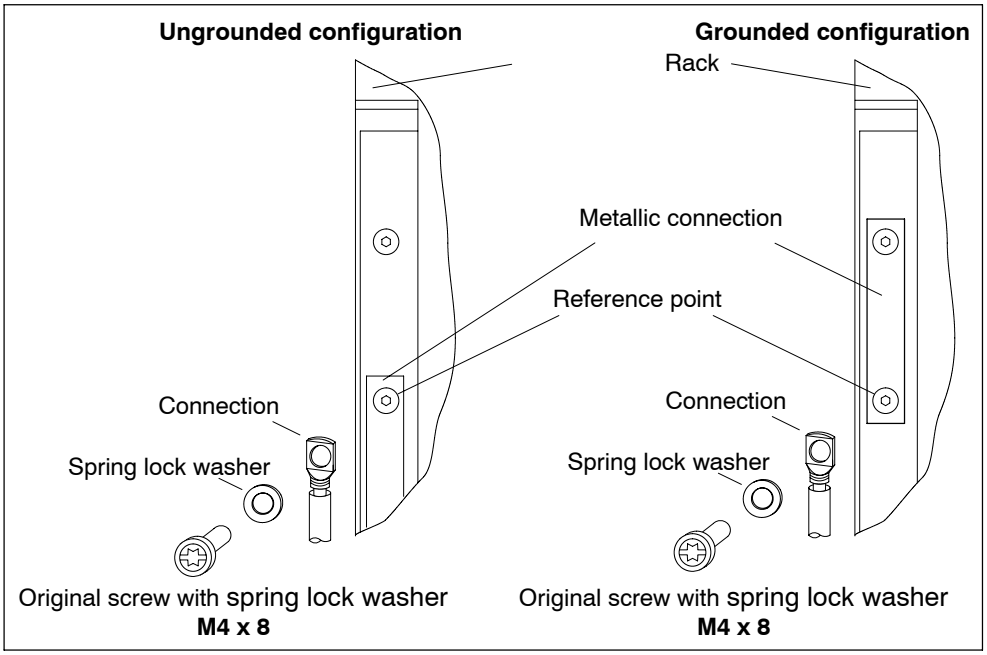
Connection to the Reference Point

For the connection to the reference point, use a cable lug for M4, a suitable spring lock washer (for example, clamping washer to DIN 6796) and the cylinder-head screw supplied.

Ungrounded assembly: Undo the fixing screws of the metallic connection on the rack. Tilt the connection downwards. For the connection to the reference point, use the original M4 x 8 supplied. Use the tilted metallic connection as a washer.

Grounded assembly: Leave the metallic connection on the rack. For the connection to the reference point, use the original M4 x 8.



Note

Do not use any cylinder-head screws that are longer than 6 mm for the connection to the reference point. Otherwise, you may create an undesired connection between the reference point and the rack profile behind it and therefore the connection for the chassis ground. For this reason as well, leave the metallic connection on the rack and use it as a washer in an ungrounded configuration.

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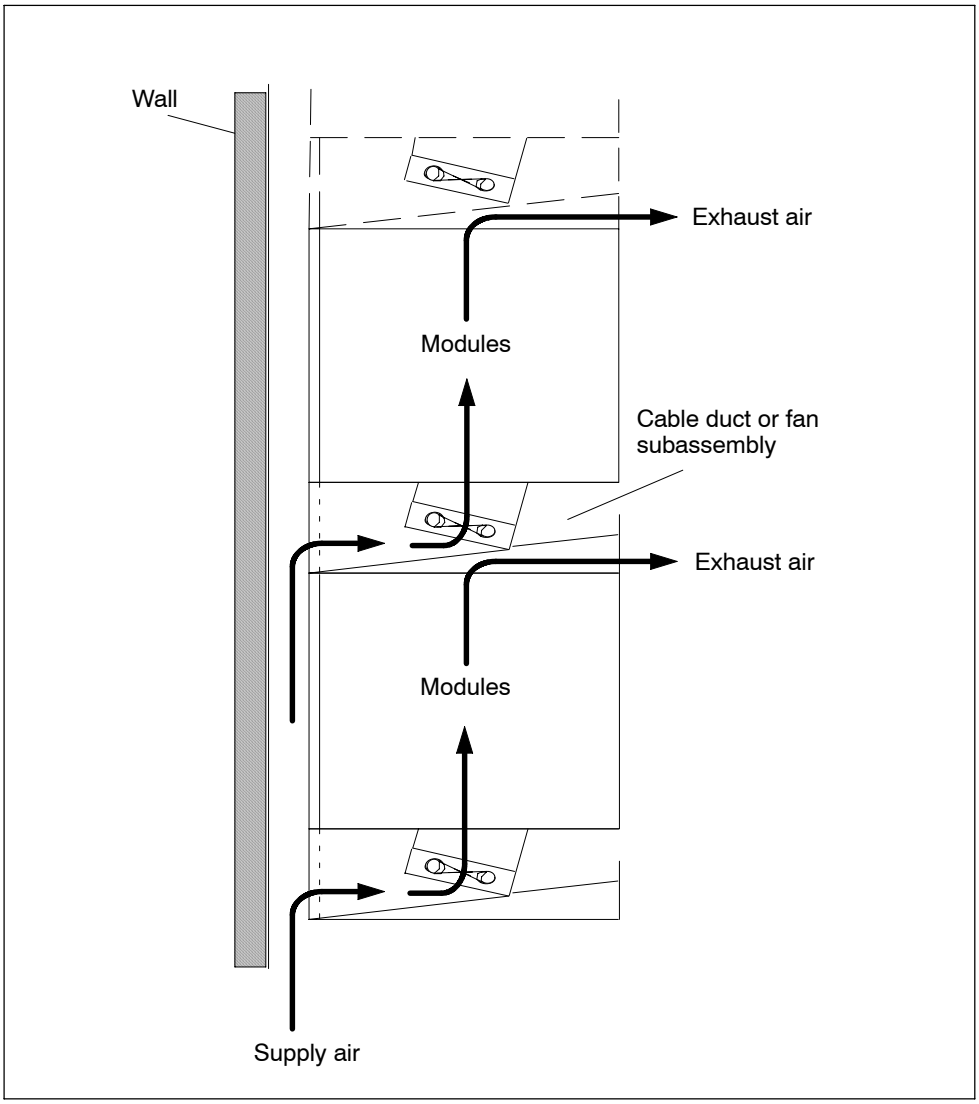
2.7 Methods of Ventilation

Methods of Ventilation

Under extreme ambient conditions, particularly when operating S7-400 modules in cabinets, you can use the cable duct or fan subassembly to optimize ventilation.

There are two methods of supplying air to the modules. You draw in air either from the back or from below. The cable duct and fan subassembly can be converted for this purpose.

The following figure shows the ventilation when air is drawn in from the back.



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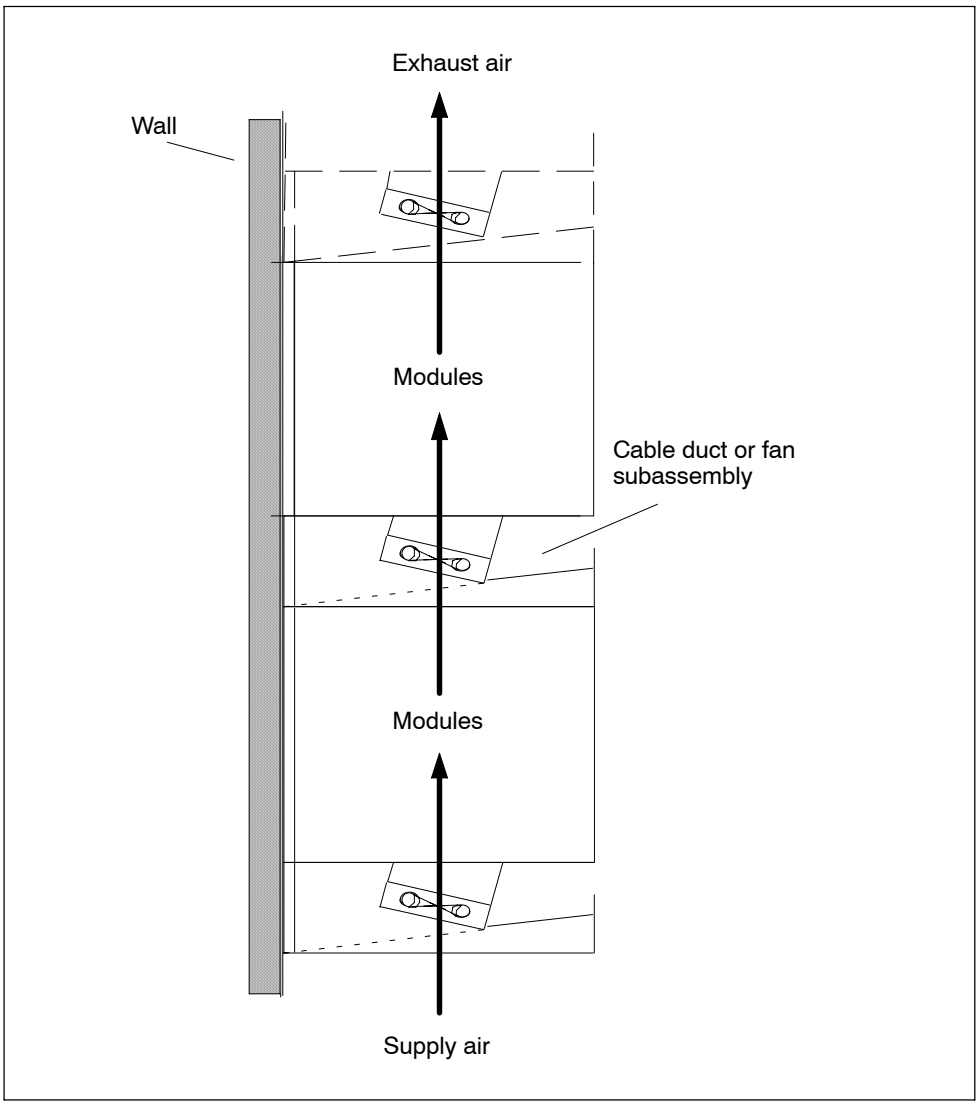
The following figure shows the ventilation when air is drawn in from the bottom.



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2.8 Changing the Ventilation with the Cable Duct and Fan Subassembly

Changing the Ventilation

At the base of the cable duct and the fan subassembly, there is a cover that you can move in order to modify the air duct. To do this, proceed as follows:

1. Using a screwdriver, make a quarter turn counter-clockwise to open the two quick-release locks at the front of the cable duct or fan subassembly.
2. Grasp the base with both hands; press it gently downward and pull it fully out of the cable duct or fan subassembly.
3. The base cover is secured with clips. Firmly press down the cover in the clip areas to remove it.
4. Snap the cover into the snap-in hinges at the rear edge of the base, rougly at a right angles to the base.
5. Slide the base in again and push it up.
6. Use a screwdriver to make a quarter turn clockwise and close the two quick-release locks.

The following figure shows both methods of selecting the ventilation by appropriately fitting the cover in the base of the cable duct or fan subassembly.

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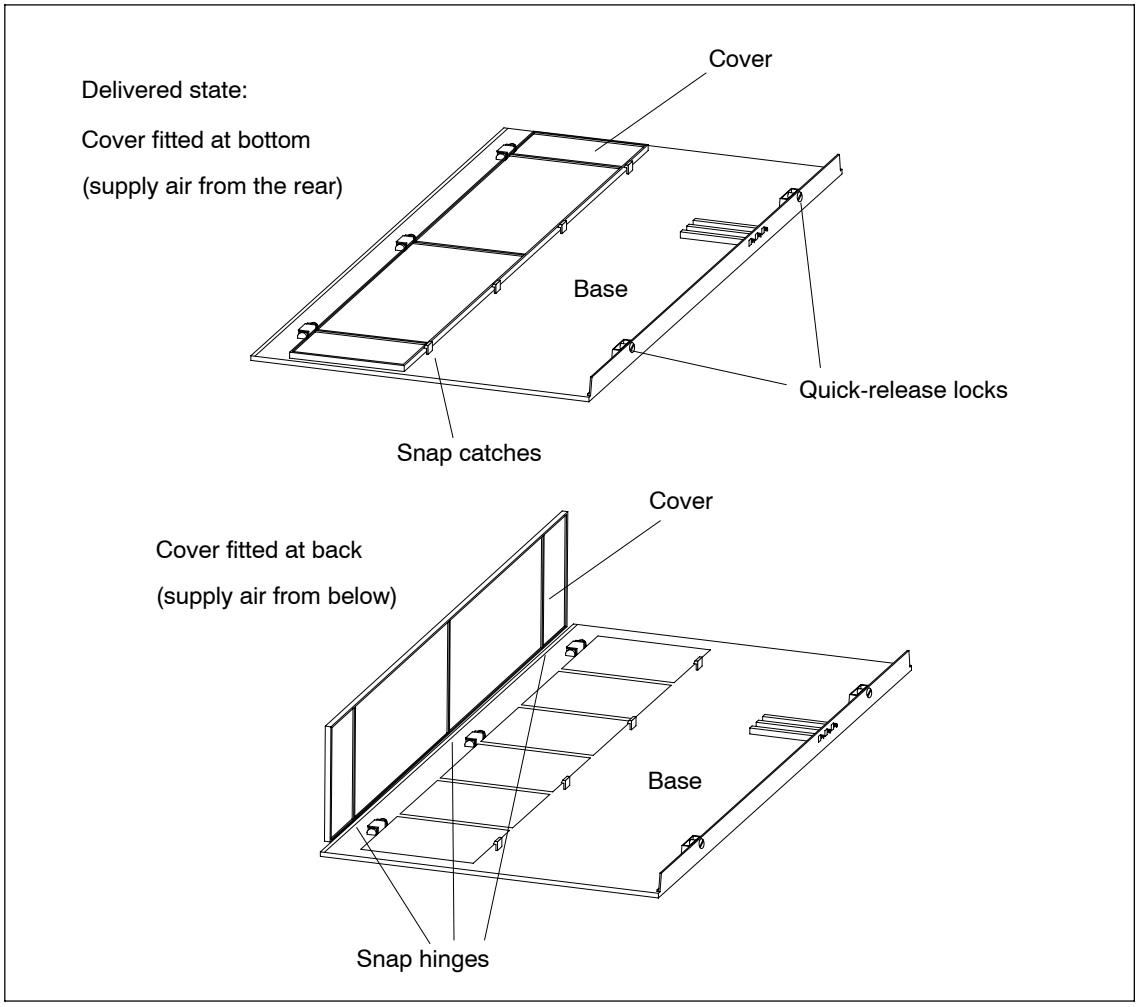

Shipping state

The cover is fitted in the base of the cable duct or fan subassembly. Air is supplied from the back.

Filter Mat (Optional)

To filter the air supply, you can fit a filter mat for the cable duct and fan subassembly. The filter mat is optional and is not part of the cable duct or fan subassembly.

Like the cover, the filter mat can be inserted flat in the base or at its rear edge in the corresponding snap hinges or quick-release locks.

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2.9 Installing the Fan Subassembly

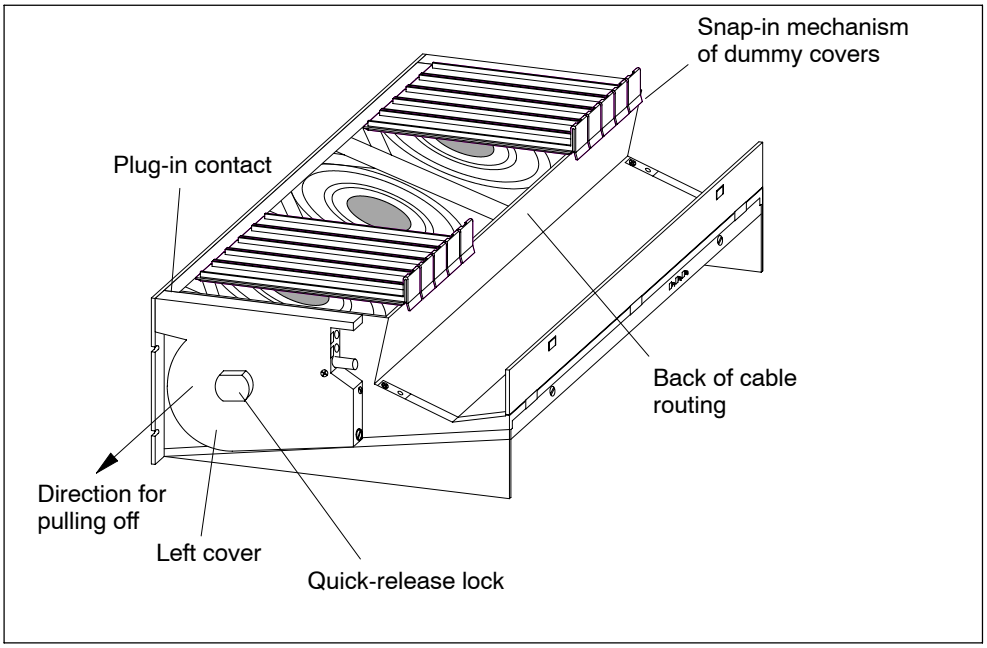
Procedure

1. Remove the left cover from the fan subassembly.

   Using a 17 mm open-ended wrench, slacken the quick-release lock a quarter turn.

   Pull out the left cover of the fan subassembly. To do this, move the left cover parallel to the fan subassembly in order to avoid damaging the plug-in contact on the other side.

   The following figure shows you how to remove the left cover.



Note

Provide the fan subassembly with dummy plates beneath free slots, this will ensure optimum ventilation.

The fan subassembly is supplied with 18 dummy plates, arranged as 2 units, each with 9 individual dummy plates. By breaking at one of the rupture joints, you can split up the individual plates as required.

2. Remove the dummy plates which are not required by slackening the snap-in mechanisms of the covers and pulling them off.
3. Break off as many dummy plates as required.

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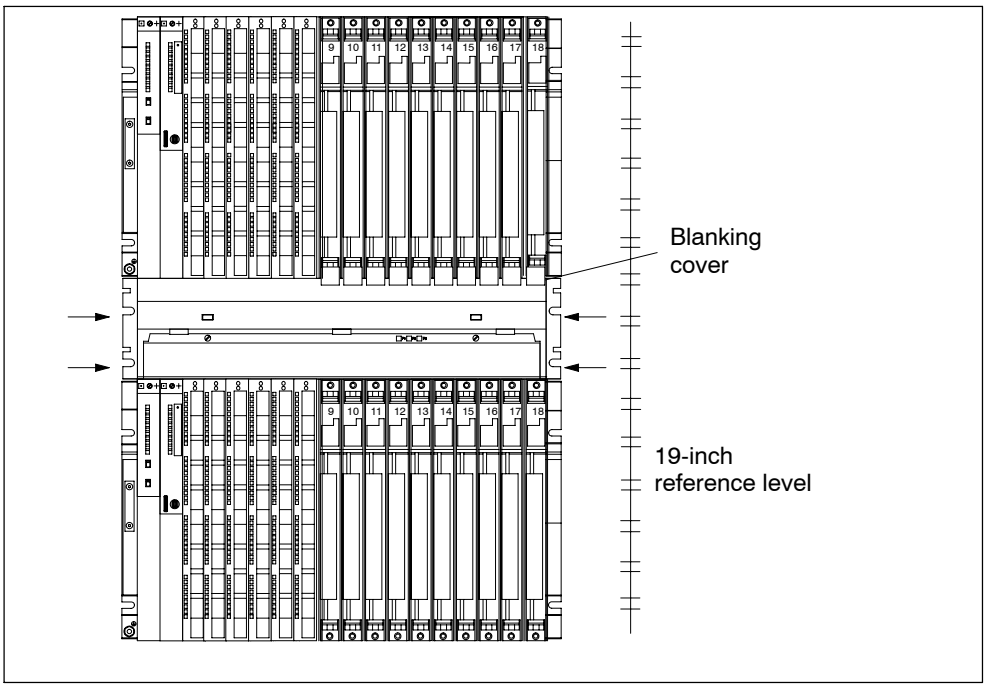
4. Attach the dummy plates to the free slots:
   - Place the dummy plates on the rear wall of the cable routing,
   - Push the dummy plates back so that the noses of the dummy plates will fit into the cutouts provided,
   - Push the dummy plates in until the snap-in mechanism engages in the openings on the back of the cable routing.
5. Then install the fan assembly in the 19-inch pitch directly under the rack or between two racks. Use M6 size screws for mounting.

   The following figure shows how to mount the fan subassembly between two racks.



6. Refit the left cover.
7. Secure the left cover with the quick-release lock.

Monitoring the Fan Subassembly

To monitor the functioning of the fan subassembly via your program, connect the outputs to a digital module.

Further details on the monitoring concept can be found in the *Reference Manual*, Chapter 9.

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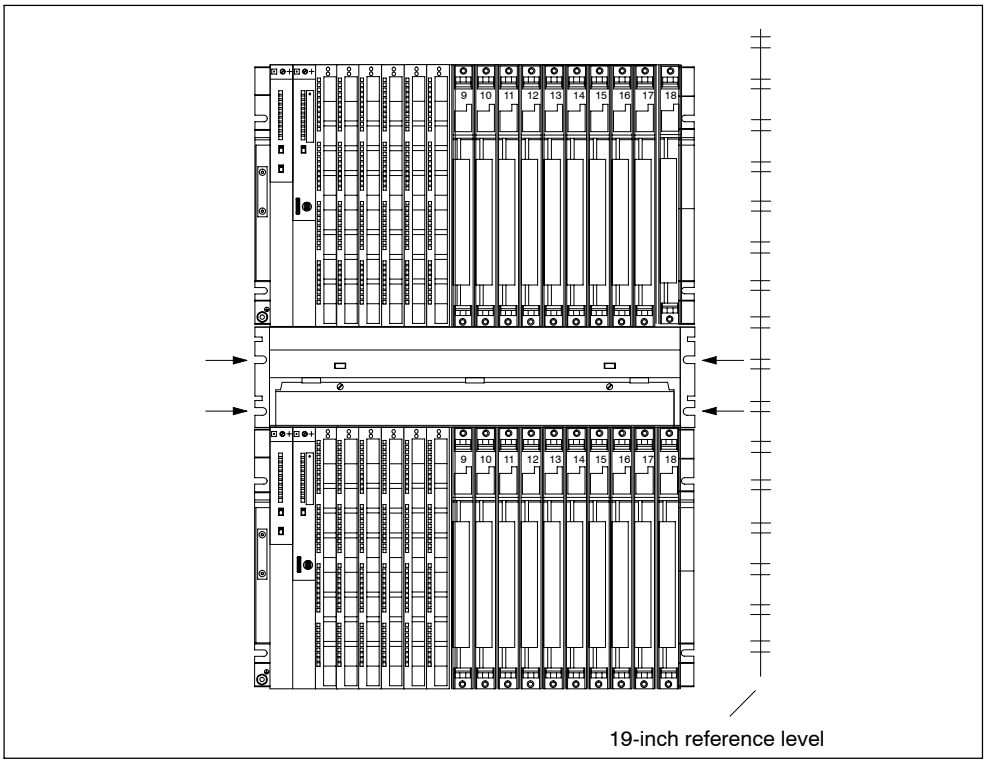
2.10 Installing the Cable Duct

Procedure

1. Install the cable duct in the 19-inch pitch directly under the rack or between two racks. Use M6 size screws for mounting.

The following figure shows how to mount the cable duct between two racks.



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2.11 Choosing and Setting up Cabinets with the S7-400

Why Cabinets are Required

With larger installations and in an environment subject to interference or pollution, you can install the S7-400 in cabinets. The requirements of UL/CSA are met, for example, by an installation in cabinets.

Types and Dimensions of Cabinets

Observe the following criteria when selecting cabinet types and their dimensions:

- Ambient conditions at the point of installation of the cabinet
- Required clearances for the racks
- Total power dissipation of components contained by the cabinet

The ambient conditions at the point of installation of the cabinet (temperature, humidity, dust, effects of chemicals, explosion hazard) govern the required degree of protection of the cabinet (IP xx). Further information on degrees of protection can be found in IEC 529 and DIN 40050.

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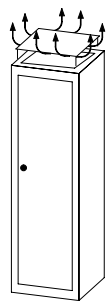
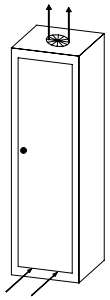
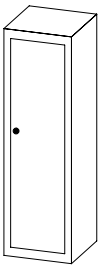
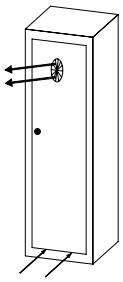
Table 2-1 provides an overview of the most common types of cabinet. You will also find the principle of heat removal, as well as the estimated, maximum achievable power loss removal and the degree of protection.

Table 2-1 Cabinet types

Open Cabinets		**Closed Cabinets**		
Through-ventilation by natural convection	Increased through-ventilation	Natural convection	Forced circulation using fan subassembly, enhanced natural convection	Forced circulation using heat exchanger, external ventilation inside and outside
				
Heat removal primarily by natural thermal convection, small portion via the cabinet wall	Increased heat removal through increased air movement	Heat removal only through the cabinet wall; only low power dissipation permissible. Heat accumulation usually occurs in the top of the cabinet.	Heat removal only through the cabinet wall. Forced ventilation of the internal air results in improved heat removal and prevention of heat accumulation.	Heat removal through exchange between heated internal air and cold external air. The increased surface of the folded-area sectional wall of the heat exchanger and forced circulation of internal and external air permit good heat output.
Degree of protection IP 20	Degree of protection IP 20	Degree of protection IP 54	Degree of protection IP 54	Degree of protection IP 54
Typical removable power dissipation under the following boundary conditions: • Cabinet size 2200 x 600 x 600 mm • Difference between external and internal temperature of the cabinet: 20° C (for other temperature differences, you must refer to the temperature characteristics of the cabinet manufacturer)				
up to 700 W	up to 2700 W (1400 W with very fine filter)	up to 260 W	up to 360 W	up to 1700 W

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Removable Power Dissipation from Cabinets (Example)

The removable power dissipation from a cabinet is governed by the type of cabinet, its ambient temperature, and the arrangement of equipment in the cabinet.

Figure 2-2 shows a diagram with guide values for the permissible ambient temperature of a cabinet measuring 600 x 600 x 2000 mm as a function of power dissipation. These values only apply if you observe the specified installation dimensions and clearances for racks. Further information can be found in Siemens catalogs NV21 and ET1.

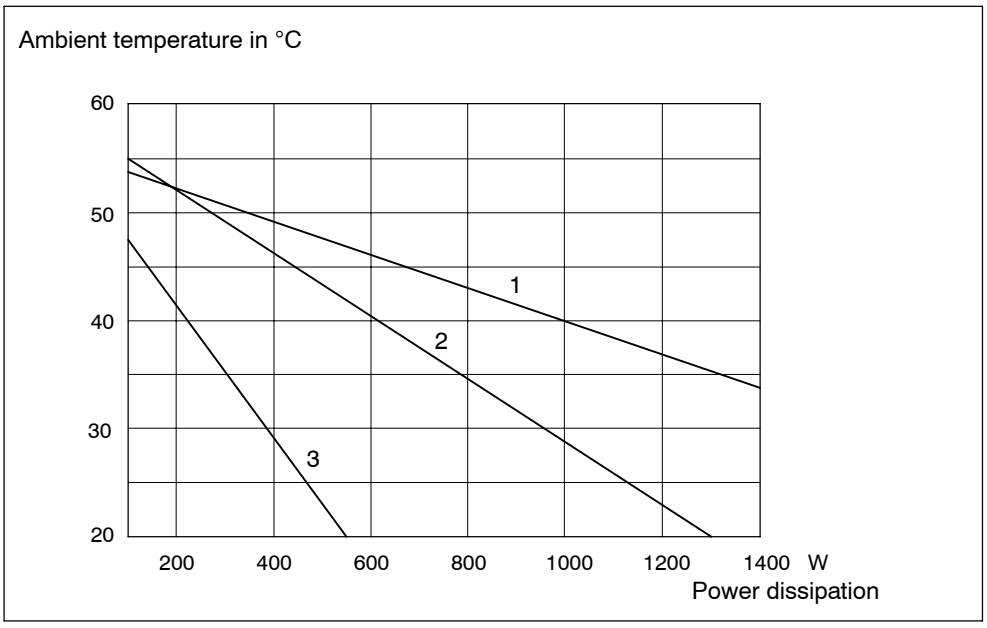

Figure 2-2 Max. Cabinet Ambient Temperature as a Function of Power Dissipation of Equipment in the Cabinet

Legend for Figure 2-2:

1. Closed cabinet with heat exchanger;
   heat exchanger size 11/6 (920 x 460 x 111 mm)
2. Cabinet with through-ventilation by natural convection
3. Closed cabinet with natural convection and forced circulation by equipment fans

Warning

Risk of damage to the modules.

Modules may be damaged as a result of excess ambient temperature.

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Example of selecting the cabinet type

The example below clarifies the maximum permissible ambient temperature at a particular power loss for various cabinet types.

Equipment suitable for installation in a cabinet:

1 central rack	150 W
2 expansion racks, 150 Watts each	300 W
1 load current power supply under full load	200 W
Accumulated power loss	650 W

Permissible ambient temperatures at an accumulated power loss as shown in Figure 2-2:

Type of Cabinet	Max. Permissible Ambient Temperature
Closed, with natural convection and forced circulation (Curve 3)	(no operation possible)
Open, with through-ventilation (Curve 2)	approx. 38° C
Closed, with heat exchanger (Curve 1)	approx. 45° C

Cabinet dimensions

Vital dimensional design factors for an S7-400 cabinet

- Space requirement of the racks
- Minimum clearance between racks and cabinet walls
- Minimum clearance between racks
- Space requirement of cable ducts or fan subassemblies
- Locations of rails

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2.12 Rules for the Arrangement of Modules

Arrangement of the Modules

You only need to observe two rules for rack mounting of the modules:

- In all racks, the power supply module must always be inserted on the extreme left (beginning with slot 1). In the UR2-H from slot 1 in both segments.
- The receive IM in the ER must always be inserted on the extreme right. In the UR2-H at slot 9 once per segment.

Note

Establish whether there are additional regulations applying to all modules not described in this manual.

The following table shows which modules can be used in the different racks:

Table 2-2 Modules in the different racks

Modules	Racks	Racks			
	UR1, UR2 UR2-H as CR	UR1, UR2 as ER	UR2-H as ER*	CR2, CR3	ER1, ER2
Power Supply Modules	●	●	●	●	●
CPUs	●			●	
Send IMs	●			●	
Receive IMs		●	●		●
Signal Modules	●	●	●	●	●

* No IM 463-2, no adapter module, no power supply module along with the IM 461-1.

Space Requirement of the Racks

In the S7-400 system, there are modules occupying one, two, or three slots (width 25, 50, or 75 mm). Refer to the technical specifications of the module under the keyword “dimensions” to see how many slots a module occupies.

The mounting depth of a rack fitted with modules is 237 mm maximum.

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2.13 Installing Modules in a Rack

Introduction

All modules are installed using the same procedure.

Caution

Modules and racks can be damaged.

Do not apply any undue force when installing the modules in a rack, because you will more than likely damage the devices.

Carefully follow the steps described below for the installation sequence.

Tool

The tool needed to install the modules is a cylindrical screwdriver with 3.5 mm blade width.

Installation Sequence

To install modules in a rack:

1. Remove the dummy plates from the slots at which you intend to insert modules. Grasp the dummy plate at the points marked and pull it forward and off.

   With double and triple-width modules, you must remove the dummy plates from all the slots to be covered by the relevant module.
2. Remove the cover, if applicable, from the module (see Figure 2-3).
3. Disconnect the power supply connector at the power supply module.
4. Attach the first module and swing it downwards (see Figure 2-4).

   If you feel a resistance when swinging the module down, raise it slightly and then continue.
5. Tighten the module screws top and bottom with a torque of 0.8 to 1.1 N/m (see Figure 2-5). Triple-width modules are secured with two screws at the top and at the bottom.
6. Refit the module cover, if applicable.
7. Fit the remaining modules in the same way.

The individual steps for installation are explained below.

The method of removing modules is described in Chapter 7.

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Removing the Cover

With modules which have a cover (for example, power supply modules and CPUs), you remove this before installing the module in the rack. Proceed as follows:

1. Push the interlock lever down (1).
2. Swing the cover forward and off (2).

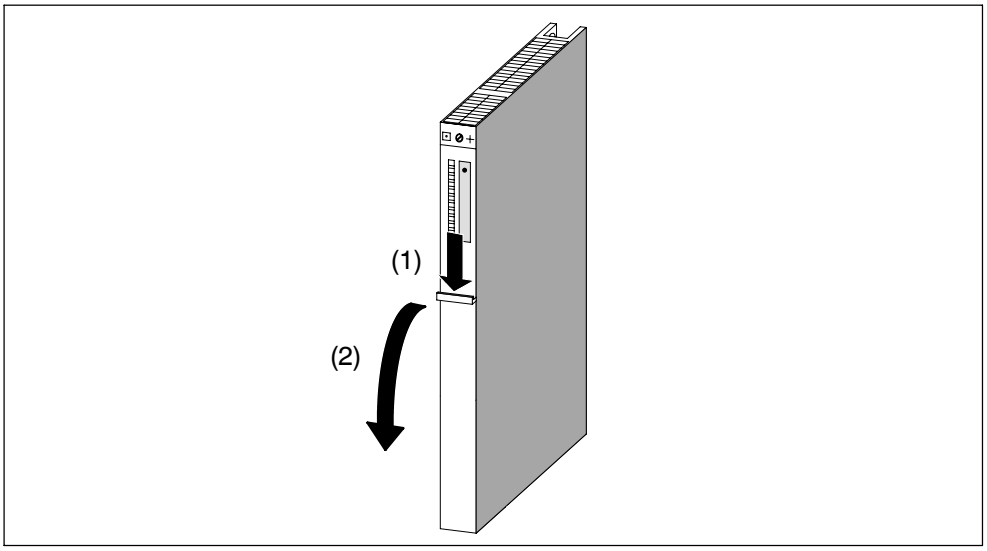

Figure 2-3 Removing the Cover

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Attaching the Modules

Attach the modules one by one (1) and swing them carefully downwards (2). If you feel a resistance when swinging the module down, raise it slightly and then continue.

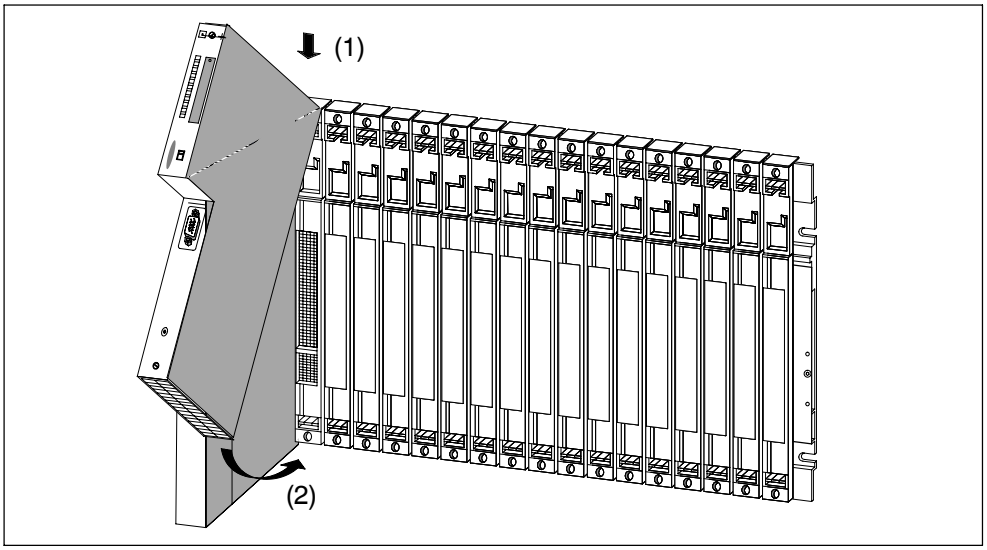

Figure 2-4 Attaching the Modules

Screwing the Modules in Place

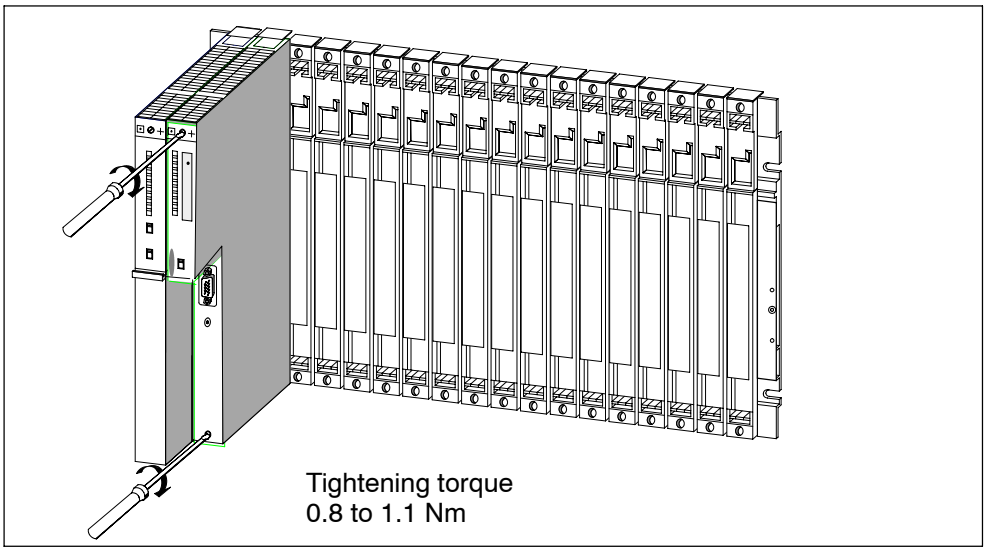

Figure 2-5 Screwing the Modules in Place

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2.14 Marking the Modules with Slot Labels

Slot Number

Once the modules are installed, you should mark each one with its slot number to avoid the risk of mixing up modules during operation. If modules do get mixed up, you may have to reconfigure the assembly.

The slot number is printed on the rack.

Double-width modules occupy two slots and are assigned the consecutive slot numbers of both slots.

Triple-width modules occupy three slots and are assigned the consecutive slot numbers of these three slots.

Fitting Slot Labels

You use slot labels to mark a module with its slot number. The slot labels are provided with the rack as a “number wheel”.

To attach the slot labels:

1. Hold the “number dial” on the module and rotate it to the slot number for the module inserted at this slot.
2. Use your finger to press the slot label into the module. The label will break away from the “number wheel”.

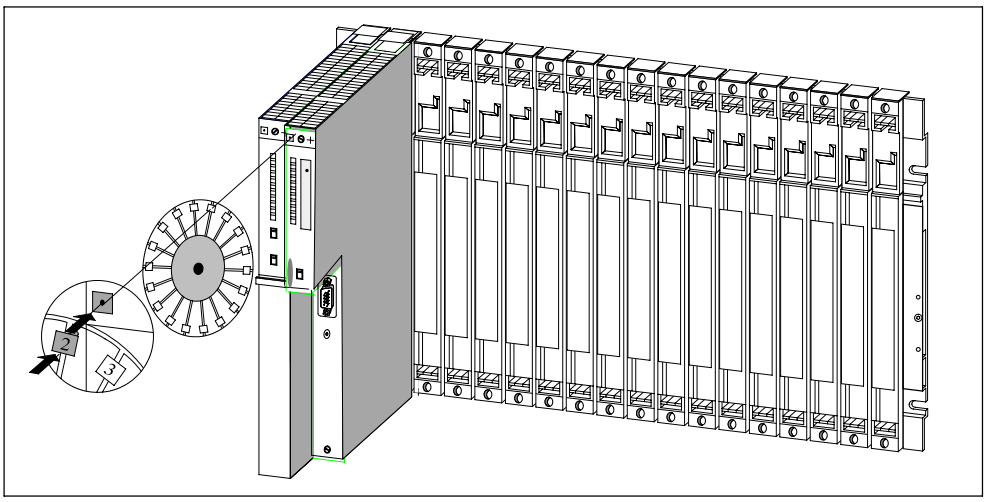

Figure 2-6 Fitting a Slot Label

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2.15 Methods of Expansion and Networking

Introduction

Apart from the structures mentioned in this chapter, other expansions are possible, for example, by connecting distributed I/Os or by networking.

Distributed I/Os

When an S7-400 is configured with a distributed I/O system, the inputs/outputs operate in a distributed local arrangement and are directly connected via PROFIBUS DP to a CPU.

One of the master-capable CPUs of the S7-400 is used.

You can use the following devices, for example, as slaves, i.e. as local inputs/outputs:

- ET 200M
- ET 200S
- ET 200X
- ET 200eco
- All DP standard slaves

Networking

You may connect your S7-400 to various subnets:

- via Simatic Net CP Ethernet to an Industrial Ethernet subnet
- via Simatic Net CP Profibus to a Profibus DP subnet
- via the integrated MPI interface to an MPI subnet
- via the integrated Profibus DP interface to a PROFIBUS DP subnet

See Chapter 5 for further details.

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2.16 Accessories

Accessories

Some of the accessories needed for fitting the modules in the rack are provided in the packaging of the modules and racks. The front connectors of the signal modules must always be ordered separately. There are also optional accessories for some modules.

The accessories for modules and racks are listed and briefly explained in Table 2-3. A list of spare parts for SIMATIC S7 can be found in the *Reference Manual*, Appendix C as well as in the current CA 01 catalog.

Table 2-3 Accessories for Modules and Racks

Module	Accessories Supplied	Accessories Not Supplied	Purpose of the Accessory
Rack (UR, CR, ER)	Number wheel with slot labels	–	For identifying the modules with slot labels
Power Supply Module (PS)	–	1 or 2 backup batteries	For central backup of RAM areas in the CPU
CPU	–	Memory cards	Load memories required for the CPU
Signal Module (SM)	2 labels	–	For labeling the inputs and outputs on the front connector
	Plate with pinout	–	To identify the pinout of the front connectors
	–	Front connector with strain relief for screw, crimp or spring-type terminal	For wiring the SMs
	–	Extraction tool (for crimp terminals)	For rewiring SMs with a front connector with crimp terminals
	–	Crimp contacts	
	–	Crimping tool	

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Addressing the S7-400

3

Chapter Overview

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3.1	Geographical and Logical Addresses	3-2
3.2	How to Determine the Default Address of a Module	3-4
3.3	How to Determine the Default Address of a Channel	3-6

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3.1 Geographical and Logical Addresses

Addresses

In order to control a process, you must address the channels (inputs and outputs) of the signal modules from the user program. You must establish a unique assignment between the (geographical) location of a channel and an address in the user program.

Geographical Addresses

The geographical address of a particular channel is permanently assigned. It is governed by the physical location of the input or output. In particular, this depends on the following basic conditions:

- In which rack (0 to 21) is the signal module fitted?
- At which slot (1 to 18 or 1 to 9) in this rack is the signal module inserted?
- Which channel (0 to 31) of this signal module is addressed?

Section 3.2 describes the method of establishing the geographical address of a channel.

Logical Addresses

The logical address of a module and, therefore, of a channel is freely selectable. It is used in the program to address (read or write to) a particular input or output. The physical location of the relevant module need not be known during programming. You establish the assignment between logical and geographical address with STEP 7.

The Two Stages of Addressing

You assign the channel address in two stages:

- Determine the geographical address of the channel from its location in the entire configuration.
- Assign a logical address to the geographical address under STEP 7. This logical address is used for addressing the channel in the user program.

Note

If your S7-400 comprises only a CR without ER, you can also use default addressing.

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Default Addressing

Under certain conditions, the CPU can handle the assignment between logical address and geographical address for you (default addressing). The logical addresses are then permanently assigned to the slots (default address). Distributed I/Os are not taken into account.

Conditions for Default Addressing

The CPU assigns default addresses under the following conditions:

- No multicomputing
- If only signal modules are inserted

  (no IM, CP, FM inserted; no expansion racks connected)
- If signal modules are used with their default settings (measuring ranges, interrupt processing, etc.)
- If modules are inserted in STOP mode or during power off

  (modules inserted while the system is in RUN or during a RUN → STOP → RUN transition will be ignored)

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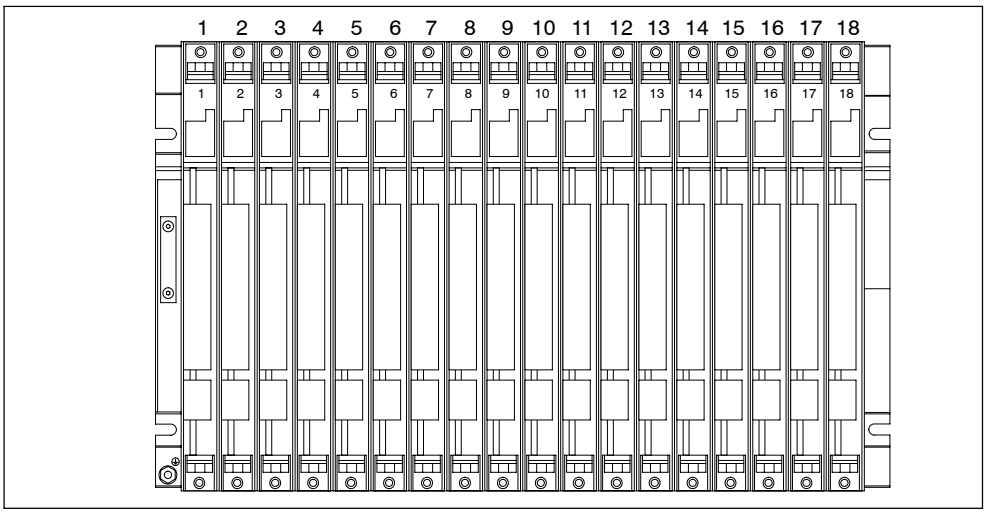
3.2 How to Determine the Default Address of a Module

Default Addressing

You determine the default address of a module from the number of the slot of the module in the CR.

The algorithms used to calculate the default address are different for analog and digital modules.

The following figure shows the numbering of slots in an 18-slot rack. You can also read off the slot numbers directly from the rack.



Default Addresses of Digital Modules

On the S7-400, the default addresses for digital modules start from 0 (First slot in the central rack which is usually occupied by the power supply module) up to 68 (18th slot).

The algorithm used to calculate the default address of a digital module is:

Default address = (slot number - 1) x 4

Example

The default address of a digital module in the 12th slot is as follows:

Default address = (12 - 1) x 4 = 44

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Default Addresses of Analog Modules

On the S7-400, the default addresses for analog modules start from 512 (first slot in the central rack which is usually occupied by the power supply module) up to 1600.

The algorithm used to calculate the default address of an analog module is:

Default address = (slot number - 1) x 64 + 512

Example

The default address of an analog module in the 6th slot is as follows:

Default address = (6 - 1) x 64 + 512 = 832

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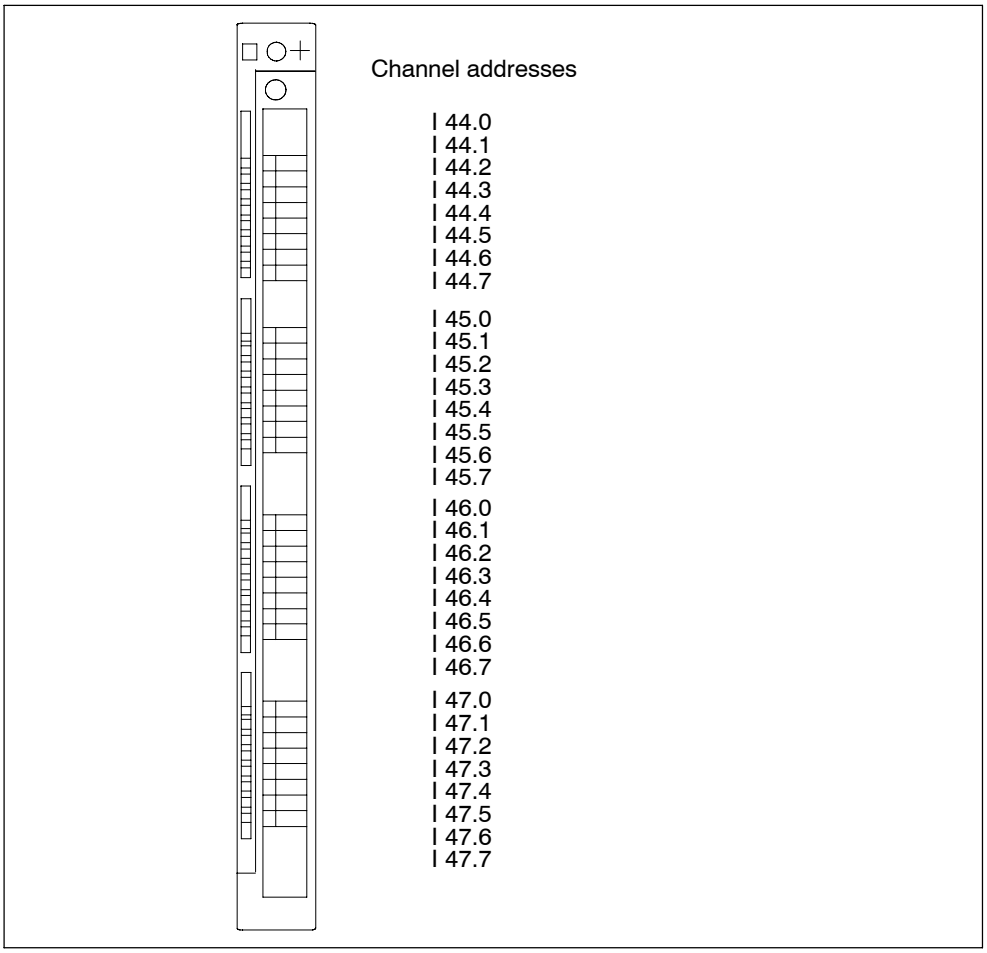
3.3 How to Determine the Default Address of a Channel

Channel on a Digital Module

A channel on a digital module is addressed bit-wise. For a digital input module with 32 inputs, four bytes (starting with the default address of the module) are used to address the inputs, and for a digital input module with 16 inputs, two bytes are used. Bits 0 to 7 in these bytes are then reserved by the individual inputs (from top to bottom).

This is clarified by the following figure with the example of a digital input module with 32 channels at slot 12 (default address 44). With a digital output module, the first character is a Q instead of an I.



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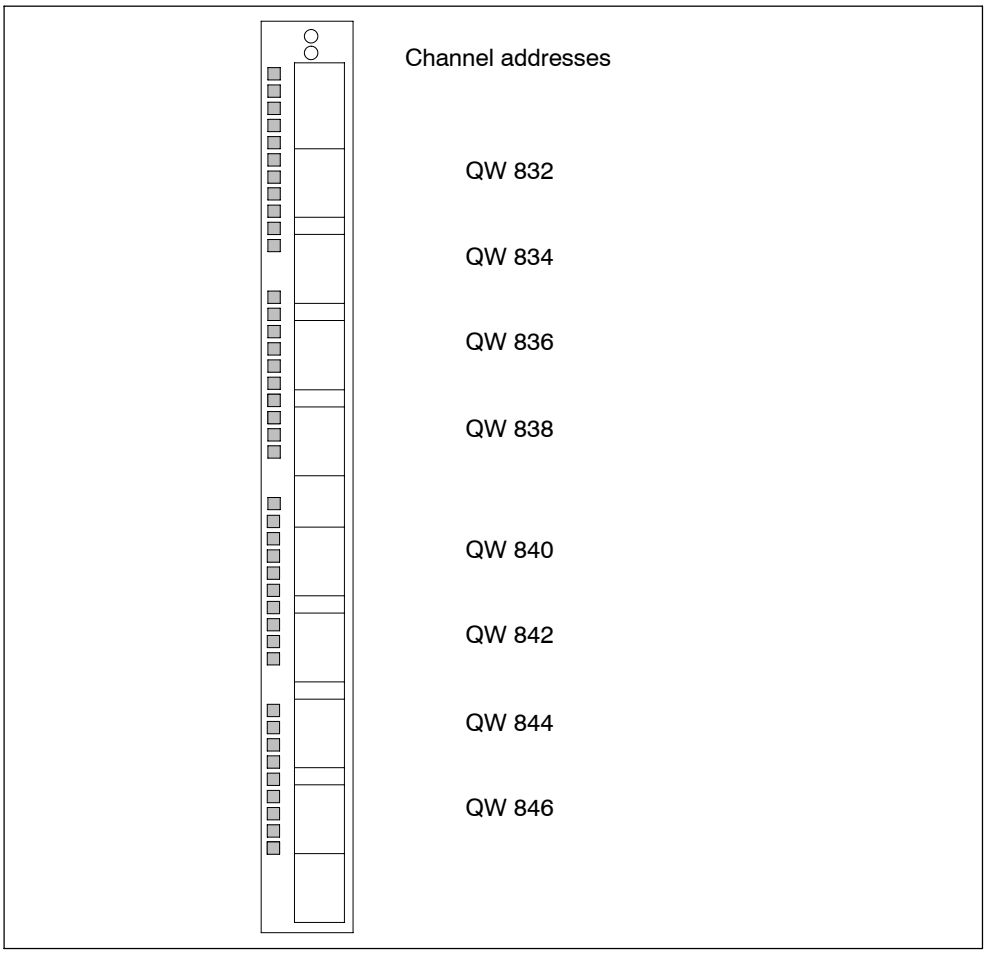
Channel on an Analog Module

Channels on analog modules are addressed word-wise.

Starting with the default address of the module, which also represents the address of the uppermost channel of the module, the addresses of the individual channels (from top to bottom) increase by two bytes (= one word).

This is clarified by the following figure with the example of a digital input module with 8 channels at slot 6 (default address 832). With an analog input module, the first characters are IW instead of QW.



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Wiring the S7-400

4

Chapter Overview

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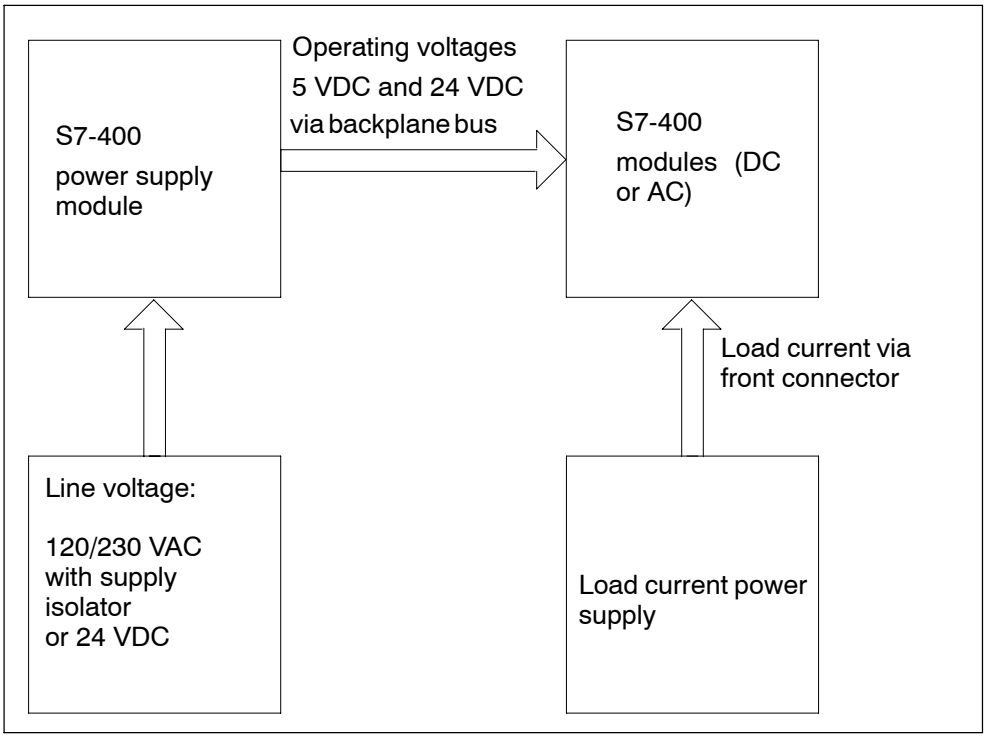
4.1 Supplying Power to Modules

Power Supply Modules and Load Current Power Supplies

The modules of the S7-400 system are supplied with all the required operating voltages by a power supply module, via the backplane bus of the rack. Which power supply module you use in a rack depends on your system requirements (line voltage, current consumption of the modules used).

You must provide load voltages and currents via external load current power supplies.

The following figure shows how the individual modules of the S7-400 are supplied with current and voltage.



Note

The power supply modules must not be connected in parallel on their secondary sides.

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4.2 Choosing the Power Supply Module

Estimating the Power Requirement

You should make an estimate of the power requirement for each rack of your S7-400 system in order to select the appropriate power supply module for the rack. Current consumption and power dissipation of the individual modules can be found in the relevant data sheets.

Calculation Example

The following modules are to be fitted in a CR with 18 slots:

- 1 CPU 414-1
- 3 analog input modules SM 431;AI 16 x 16 bits
- 5 digital input modules SM 421;DI 32 x 24 VDC
- 6 digital input modules SM 422;DO 32 x 24 VDC/0.5A
- 1 send IM, IM 460-0

You can calculate Current Consumption I in this rack as follows, with the data from the individual data sheets:

Module	Quantity	+5 VDC (Max. Current Consumption Values)	
		I / Module	I Total
CPU 417-4	1	2600 mA	2600 mA
SM 431; AI 16 x 16 bits	3	700 mA	2100 mA
SM 421;DI 32 x 24 VDC	5	30 mA	150 mA
SM 422;DO 32 x 24 VDC/0.5A	6	200 mA	1200 mA
IM 460-0	1	140 mA	140 mA
Total			6190 mA

From the data in the table, you can see that you must install a power supply module PS 407 10A (for connection to 120/230 VAC) or PS 405 10A (for connection to 24 VDC) in the rack, to cover the current consumption calculated here.

Note

If you wish to connect an ER to the CR via a send IM with current transfer, you must also take the current consumption of this ER into account when choosing the power supply module.

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4.3 Choosing the Load Current Power Supply

Choosing the Load Current Power Supply

The input and output circuits (load current circuits) as well as sensors and actuators are powered by the load current power supply. Listed in the following are the characteristics of the load current power supplies required in special applications for choosing the load current power supplies.

Characteristics of the Load Current Power Supply	Required for ...	Remarks
Safe isolation	Modules which must be supplied with voltages ≤ 60 VDC or ≤ 25 VAC.	The Siemens SITOP power load current supplies have this characteristic.
	24 VDC load circuits	
Tolerances of the output voltages: 20.4 V to 28.8 V 40.8 V to 57.6 V 51 V to 72 V	 24 VDC load circuits 48 VDC load circuits 60 VDC load circuits	If the output voltage tolerances are exceeded, you should provide an energy storage capacitor. Rating: 200 μF per 1 A load current (with bridge rectification).

Load Current Power Supplies

The DC load current power supply must meet the following requirements:

Only a safe, isolated extra-low voltage of ≤ 60 VDC may be used as the load current supply. Isolation may be implemented according to the requirements of the following, amongst other publications:
VDE 0100-410 / HD 384-4-41 S2 / IEC 60364-4-41
(as a functional extra-low voltage with isolation) or
VDE 0805 / EN 60950 / IEC 60950
(as a safety extra-low voltage SELV) or VDE 0106 Part 101.

Determining the Load Current

The required output load current is determined by the accumulated current of all sensors and actuators connected to the outputs.

IN the case of a short-circuit, a current of two to three times the rated output current flows briefly at DC outputs before the switched electronic short-circuit protection becomes effective. When selecting the load current power supply, therefore, you must ensure that the increased short-circuit current is available. With unregulated load current power supplies, this excess current is generally ensured. With regulated load current power supplies, particularly at low output levels (up to 20 A), you must ensure a suitable excess current.

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4.4 Assembling an S7-400 with Process I/Os

Definition of a Grounded Supply (TN-S Network)

In grounded supplies, the neutral conductor of the system is grounded. A single fault between a live conductor and ground or a grounded part of the installation results in tripping of the protective devices.

Components and Protective Measures

Various components and protective measures are specified for assembling a full installation. The types of components and whether the protective measures are mandatory or recommended depends on the VDE specification applying to your installation, VDE 0100 or VDE 0113. The following table relates to Figure 4-1.

Table 4-1 VDE Specifications for Assembling a Programmable Controller

Compare ...	Ref. to Figure 4-1, page 4-6	VDE 0100	VDE 0113
Disconnection element for control system, sensors, and actuators	1	... Part 460: Main switches	... Part 1: Isolating switches
Short-circuit and overload protection: in groups for sensors and actuators	2	... Part 725: Single-pole protection of circuits	... Part 1: • With grounded secondary circuit: **single-pole** protection • Otherwise: **all-pole** protection
Load current PS for AC power circuits with more than five items of electromagnetic apparatus	3	Isolation by transformer is **recommended**	Isolation by transformer is **required**

Rule: Grounding the Load Current Circuits

Load current circuits must be grounded.

Reliable functional safety is provided by the common reference potential (ground). Provide a detachable connection to the protective ground conductor at the load current power supply (Terminal L- or M) or on the isolating transformer (Figure 4-1, 4). In the event of faults in the power distribution, this will facilitate the locating of ground faults.

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S7-400 in the Overall Installation

Shown in Figure 4-1 is the position of the S7-400 in the overall installation (load current power supply and grounding concept) with supply from a TN-S system.

Note: The arrangement of supply terminals shown is not the actual arrangement; it has been chosen for reasons of clarity.

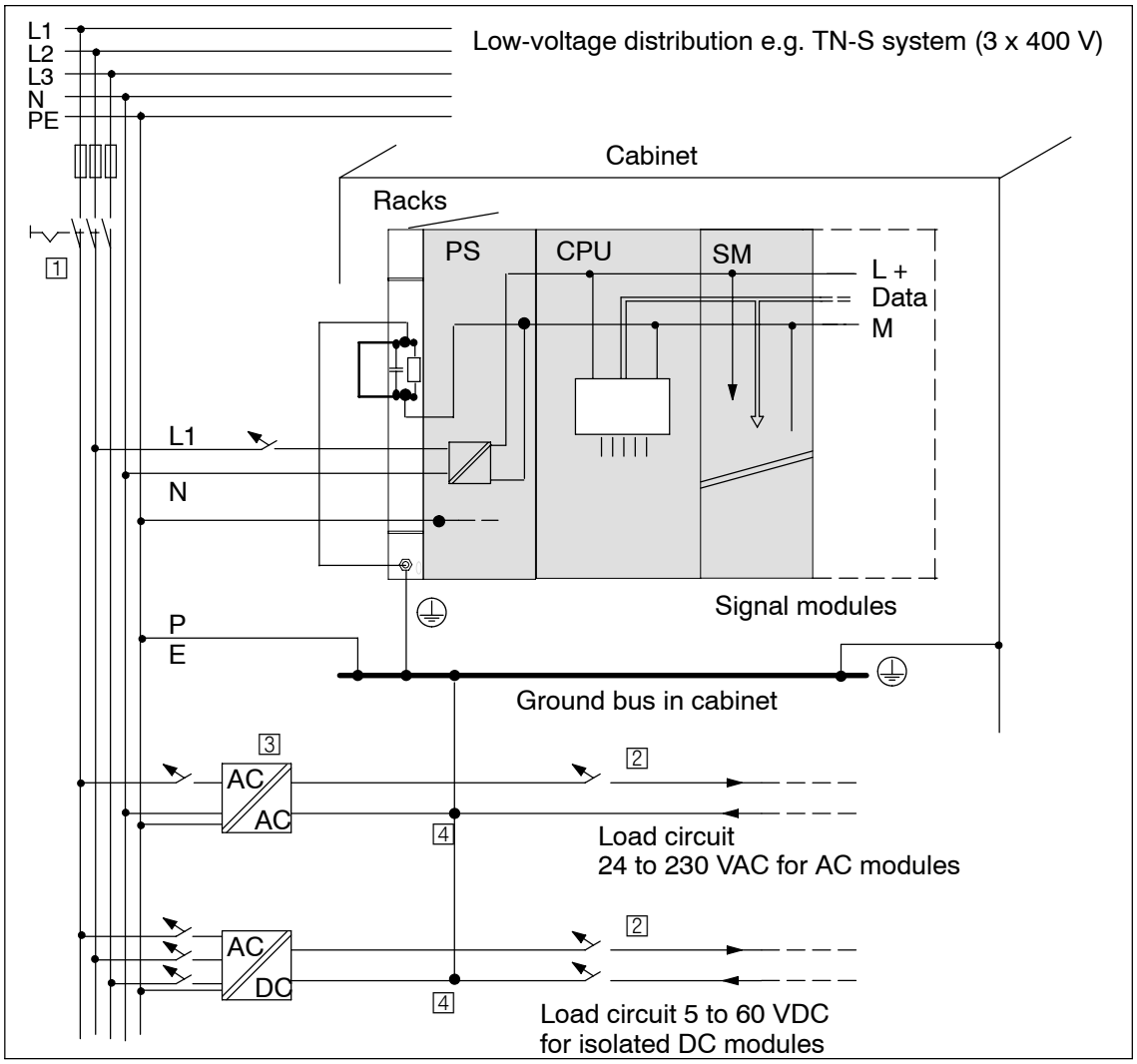

Figure 4-1 Operating the S7-400 from a Grounded Supply

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4.5 Assembling an S7-400 with Grounded Reference Potential (M)

Application

You use an S7-400 with grounded reference potential in machines or industrial plants.

Discharge of Interference Currents

When the S7-400 is configured with a grounded reference potential, any interference currents are discharged to the chassis ground.

Terminal Connection Model

When delivered, the racks have a detachable metallic connection between the internal reference potential M of the modules and the frame element of the racks. Situated behind this connection is an RC network which is placed in the circuit for the ungrounded configuration. This connection is located at the left edge of the rack. The terminal for the chassis ground also has an electrical connection to the frame element.

Shown in Figure 4-2 is an S7-400 configured with grounded reference potential. To ground the reference potential M, you must connect the chassis ground terminal to the chassis ground and you must not remove the jumper between reference potential M and the frame element terminal on the rack.

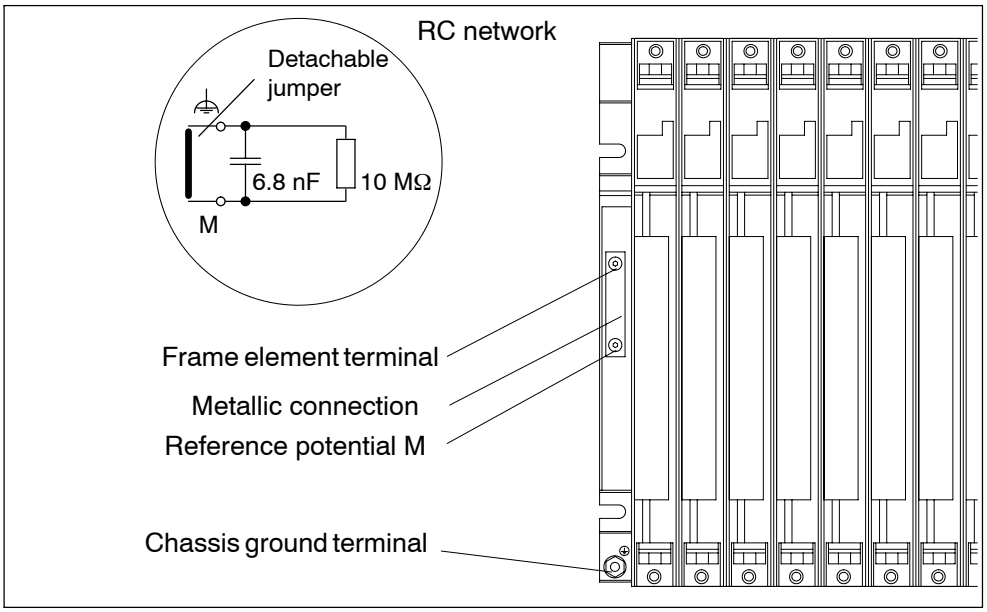

Figure 4-2 An S7-400 Configured with Grounded Reference Potential

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4.6 Assembling an S7-400 with Ungrounded Reference Potential (Ungrounded Configuration)

Application

In large installations, it may be necessary to configure the S7-400 with an ungrounded reference potential, for example, for ground fault monitoring. This is the case in the chemical industry or in power plants, for example.

Discharge of Interference Currents

With the S7-400 in an ungrounded configuration, any interference currents are discharged to the chassis ground via an RC network integrated in the rack.

Terminal Connection Model

Shown in Figure 4-3 is an S7-400 configured with ungrounded reference potential. In this case you must remove the jumper between reference potential M and the frame element terminal on the rack. The reference potential M of the S7-400 is then connected via the RC network to the chassis ground terminal. When you connect this terminal to the chassis ground, RF interference currents will be discharged and static charges will be avoided.

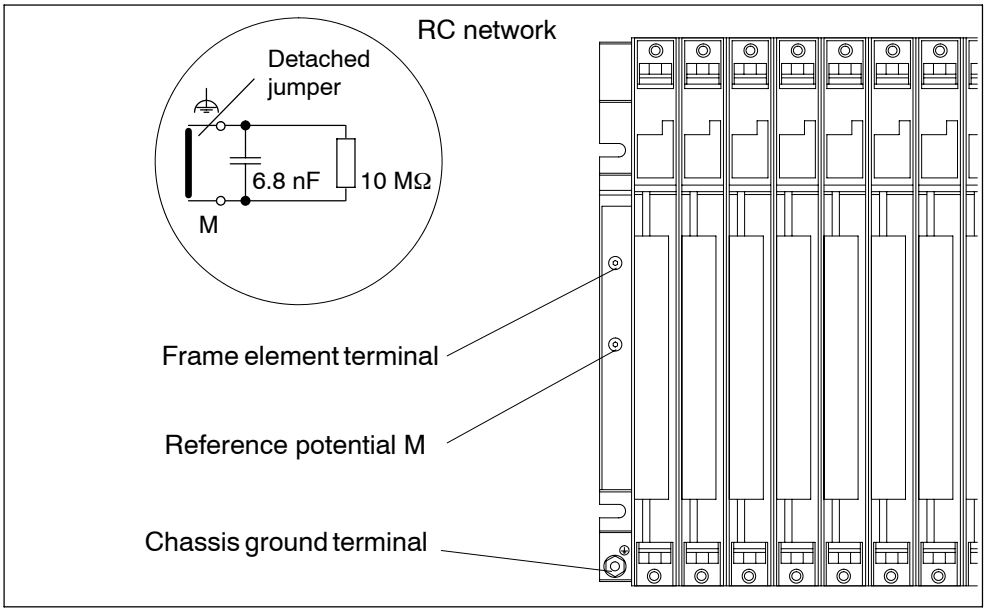

Figure 4-3 An S7-400 Configured with Ungrounded Reference Potential

Power Supply Units

When using power supply units, ensure that the secondary winding is not connected to the protective ground conductor.

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Filtering the 24 VDC Supply

When you power the S7-400 from a battery with the ungrounded configuration, you must provide interference suppression for the 24 VDC supply. Use a Siemens power cable filter, such as the B84102-K40.

Insulation Monitoring

If a double fault could cause a hazardous state in the installation, you must provide insulation monitoring.

Example of Ungrounded Operation

If you have configured an S7-400 with a local connection and you only wish to ground the overall installation at the CR, you can operate the ERs in an ungrounded configuration.

Note

If you connect an ER via a local connection with 5 V transfer, ungrounded operation is mandatory for the ER.

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4.7 Assembling an S7-400 with Isolated Modules

Definition

In a configuration with isolated modules, the reference potentials of the control circuit ($M_{internal}$) and the load circuit ($M_{external}$) are isolated (see also Figure 4-4).

Application

Isolated modules are used for:

- All AC load circuits
- DC load circuits with a separate reference potential

  Examples of load circuits with a separate reference potential:

  - DC load circuits whose sensors have different reference potentials (for example, when grounded sensors are used far from the programmable controller and equipotential bonding is not possible).
  - DC load circuits whose positive terminal (L+) is grounded (battery circuits).

Isolated Modules and Grounding Concept

You can use isolated modules, regardless of whether or not the reference potential of the programmable controller is grounded.

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Configuration with Isolated Modules

Shown in Figure 4-4 are the potentials of an S7-400 configured with isolated input and output modules.

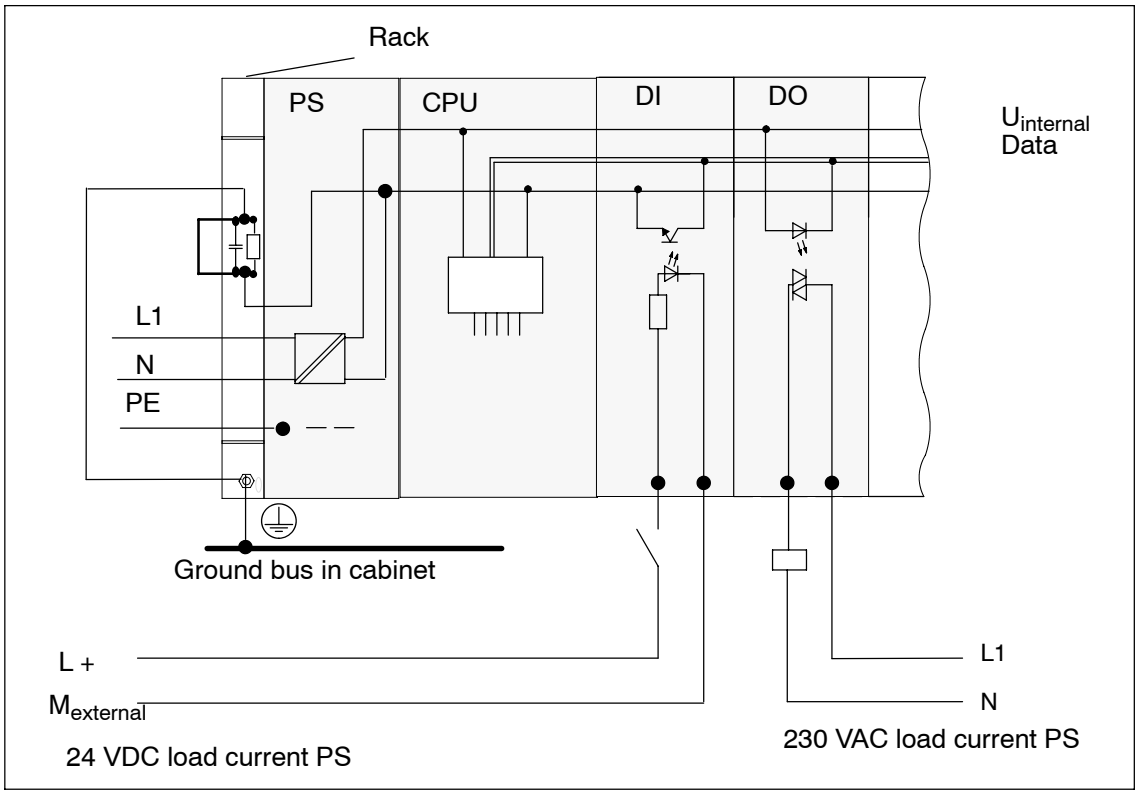

Figure 4-4 Simplified Representation of Configuration with Isolated Modules

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4.8 Parallel Wiring of Digital S7-400 Outputs

Parallel Wiring of a Digital Output with Different Rated Load Voltages

The parallel wiring of a digital output (rated load voltage 1L+) with another digital output (rated load voltage 2L+) or a rated load voltage 3L+ is only possible using series diodes.

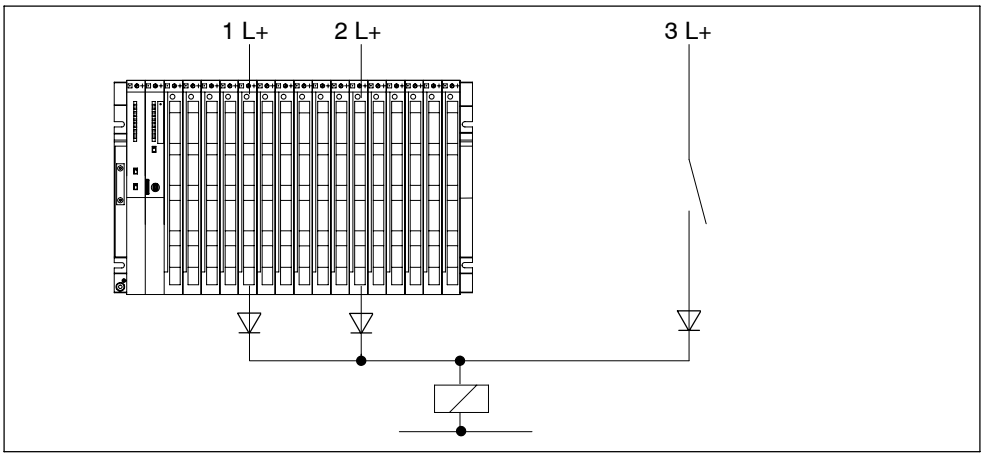

Figure 4-5 Parallel Wiring of a Digital Output with Different Rated Load Voltages

Parallel Wiring of a Digital Output with Identical Rated Load Voltages

If the L+ supplies of the digital output modules and the L+ voltage connected in parallel to the output are always the same **(difference < 0.5 V)**, there is no need to use diodes, see figure 4-6.

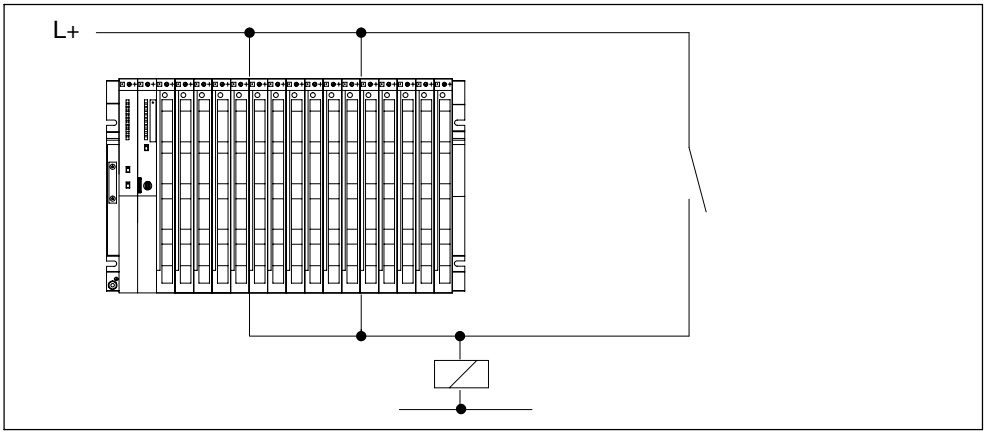

Figure 4-6 Parallel Wiring of a Digital Output with Identical Rated Load Voltages

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4.9 Grounding

Introduction

Grounding in accordance with regulations and conscientiously implemented is the prerequisite for proper functioning of a programmable controller.

Each individual component of the S7-400 and of the controlled system must be properly grounded.

Ground Connections

Low-resistance ground connections reduce the risk of electric shock in the event of a short-circuit or faults in the system. Moreover, proper grounding (low-impedance connections: large surface area, wide-area bonding) together with the effective shielding of lines and devices reduces the effect of interference on the system and the interference signal emissions.

Note

Always ensure that operating currents do not flow via ground.

Protective Ground

All equipment of Safety Class I and all large metal parts must be connected to the protective ground. This is essential to ensure that the user of the installation is reliably protected from electric shock.

Furthermore, this serves to discharge interference transferred via external power supply cables, signal cables, or cables to I/O devices.

Shown in Table 4-2 are the grounding methods required for the individual components.

Table 4-2 Methods of Protective Grounding

Device	Grounding Method
Cabinet/frame	Connection to central ground point, e.g. ground bus, via cable with protective conductor quality
Racks	Connection to central ground point via cable with 10 mm^2 min. cross-section, when racks are not installed in a cabinet and not interconnected via large metal parts
Module	None; automatically grounded via backplane bus when fitted
I/O device	Grounded via power plug
Shields of connecting cables	Connection to rack or central ground point (avoid ground loops)
Sensors and actuators	Grounding according to specifications applying to the system

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Connecting the Load Voltage Ground

Many output modules require an additional load voltage to switch the actuators. Two different modes are possible for this load voltage:

- Non-isolated operation
- Floating operation

The following table shows how the load voltage ground is connected in the individual modes.

Table 4-3 Grounded connection load voltage

Mode	Connection of Load Voltage
Non-isolated operation	
• Grounded configuration	to the reference point of the rack; metallic connection between frame element and chassis ground must be fitted.
• Ungrounded configuration	to the reference point of the rack; metallic connection between frame element and chassis ground must be fitted.
Floating operation	
• Grounded and ungrounded configuration	Left open or to any point, but not to protective ground or reference potential M of operating voltages

The following figure shows how the load voltage ground is connected for non-isolated operation.

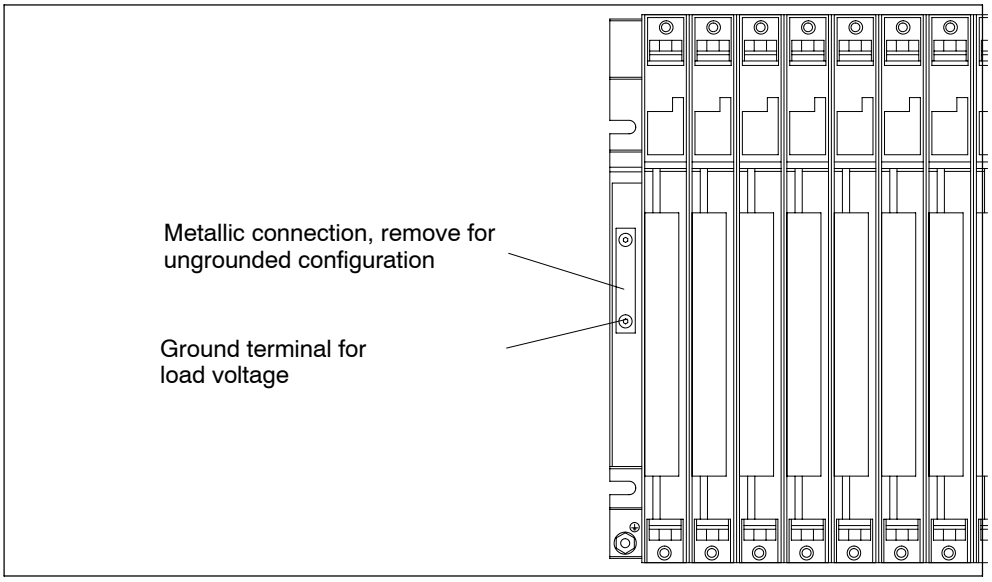

Figure 4-7 Grounded connection load voltage

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4.10 Interference-Free Configuration for Local and Remote Connections

Use only Approved Components

Note

If you use components which are not approved for setting up local and remote connections, interference rejection may be impaired.

Interference-Free Configuration for Local Connections

If you connect the CR and ER via suitable interface modules (send IM and receive IM), no particular shielding and grounding need be implemented. Ensure, however, that

- All racks must have a low-impedance connection to each other
- The racks in a grounded arrangement must have a star grounding configuration
- The contact springs of the racks must be clean and may not be bent and will therefore ensure the discharge of interference currents.

Interference-Free Configuration for Remote Connections

If you connect the CR and ER via suitable interface modules (send IM and receive IM), normally no particular shielding and grounding need be implemented.

Special shielding and grounding may become necessary if you operate your system in an environment with an extremely high level of interference. In that case, observe the following points:

- In the cabinet, connect the cable shields to the shield bus immediately after entry.
  - Strip the outer cable insulation in the region of the shield bus without damaging the braided shield.
  - Ensure that the braided shield has the greatest possible contact area on the shield bus, for example, with metal hose clamps surrounding the shield over a large area.
- Connect the shield bus(es) over a large area to the frame or cabinet wall.
- Connect the shield bus(es) to the chassis ground.

In a remote connection, ensure that the VDE regulations for laying the protective ground are not infringed.

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Figure 4-8 shows the methods described here. If the permissible potential difference between grounding points is exceeded, you must install an equipotential bonding conductor (copper conductor with a cross-section of $\geq$ 16 mm^2).

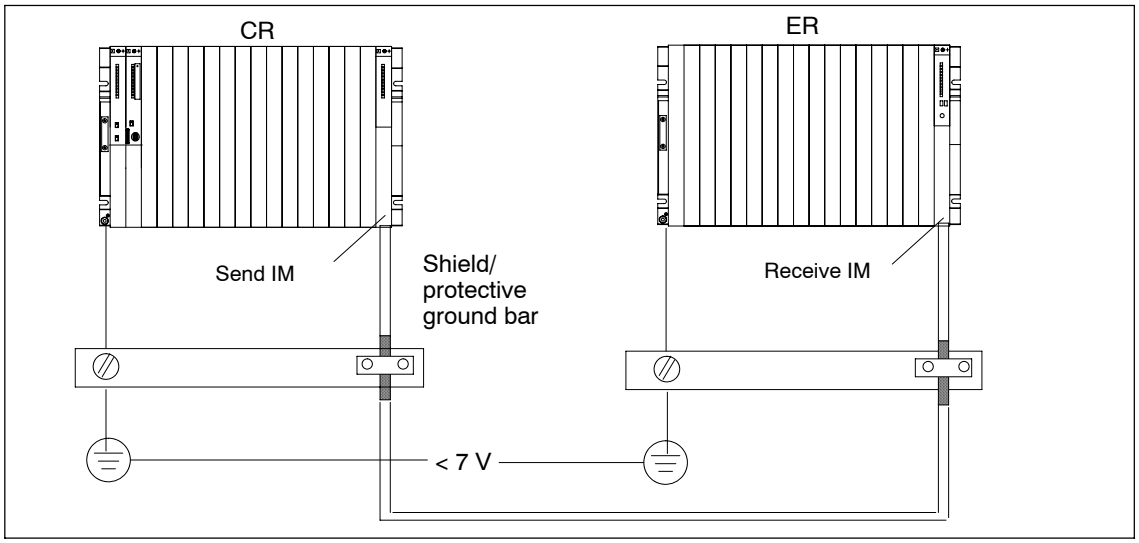

Figure 4-8 Shielding and Grounding the Connecting Cable for a Remote Connection

Special Cases

For remote connections, you must use precut/preassembled connecting cables of fixed length. When the connecting cables are laid, therefore, there may be excess lengths. These must be coiled with a bifilar winding and deposited.

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4.11 Wiring Rules

Lines and Tools

For wiring the S7-400 modules, there are some rules for the cables and tools to use.

Rules for	... Power Supply	... Front Connectors		
		Crimp terminal	Screw-type terminal	Spring-type terminal
Conductor cross-sections:				
Outer diameter:	3 to 9 mm			
Flexible cond. without wire end ferrule	no	0.5 to 1.5 mm^2	0.25 to 2.5 mm^2	0.08 to 2.5 mm^2
Flexible cond. with wire end ferrule	**230 VAC:** flexible sheathed cable 3 x 1.5 mm^2 **24 VDC:** flexible sheathed cable 3 x 1.5 mm^2 or individual wires 1.5 mm^2	no	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2
No. of conductors per terminal	1	1	1 *	1 *
Stripping length of single conductors	7 mm	5 mm	8 to 10 mm without ferrule 10 mm with ferrule	8 to 10 mm without ferrule 10 mm with ferrule
Wire end ferrules	**230 VAC:** with insulating collar to DIN 46228 E1,5-8 **24 VDC**: without insulating collar to DIN 46228, shape A, short version	-	with or without insulating collar to DIN 46228 Part 1 or 4, Shape A, normal version	with or without insulating collar to DIN 46228 Part 1 or 4, Shape A, normal version
Blade width and shape of the screw driver	3.5 mm (cylindrical shape)	-	3.5 mm (cylindrical shape)	0.5 mm x 3.5 mm DIN 5264
Tightening torque: for connecting conductors	0.6 to 0.8 Nm	-	0.6 to 0.8 Nm	-

* You can also connect a combination of two conductors of up to 1.0 mm each to a screw-type or spring-loaded terminal. You must use special wire end ferrules for this purpose. Two types and manufacturers of such ferrules are given below:

- Phoenix TWIN Type no. 32 00 81 0, for 2 x 1 mm^2
- AMP Order no. 966 144-4, for 2 x 1 mm^2

Note

You must use shielded cables for the analog modules (see Section A.5).

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4.12 Wiring the Power Supply Module

Power Supply Connector

You use the power supply connector to connect a power supply module to your supply. When delivered, the power supply connector is plugged into the power supply module. There are two versions (AC and DC) of power supply connector. The two versions are coded, meaning an AC connector can only be plugged into an AC power supply module, and a DC connector can only be plugged into a DC power supply module.

Disconnecting the Power Supply Connector

Before wiring, you must unplug the power supply connector from the power supply module.

1. Open the cover of the power supply module.
2. Detach the connector by levering it off with a suitable tool, for example, a screwdriver, at the opening provided (1).
3. Pull the connector forward and out of the power supply module (2).

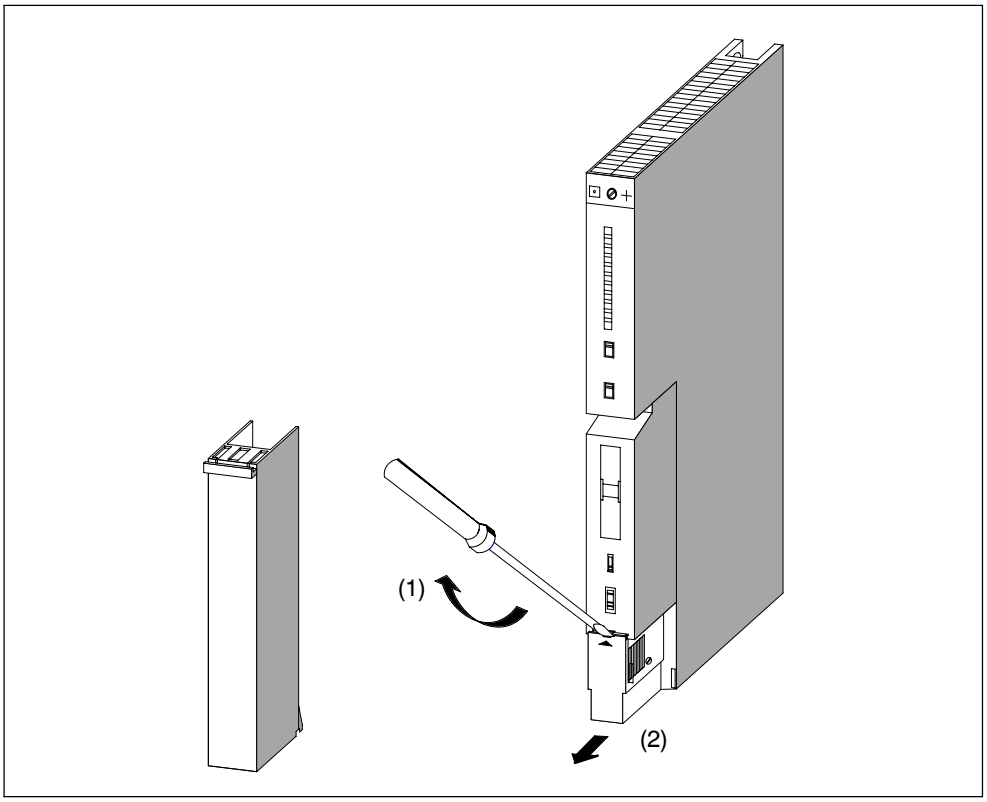

Figure 4-9 Disconnecting power supply connector

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Wiring the Power Supply Connector

To wire the power supply connector, follow the steps outlined below:

Warning

There is a risk of personal injury.

If you wire the connector with voltage applied, you may suffer a shock and personal injury.

Only wire the connector with power disconnected.

1. Switch off the line voltage at your VAC supply disconnector.

Note

The standby switch of the power supply module does not disconnect the power supply module from the supply.

2. Are you using a flexible sheathed cable with outer insulation (with 230 VAC)?

   If so: Strip the outer insulation over a length of 70 mm. Note that an overall cable diameter of between 3 mm and 9 mm must be present under the strain relief after connection.

   If not: Wrap the cores with insulating tape so that an overall cable diameter of between 3 mm and 9 mm will be present under the strain relief after connection. As an alternative to insulating tape, you can use a shrink-on sleeve.
3. Shorten the two cores which are not needed for connection to protective ground (PE) by 10 mm.
4. Strip the cores over a length of 7 mm.
5. Slacken the screw in the cover of the power supply connector and open the connector.

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6. Slacken the screw of the strain relief and insert the cable.
7. Connect the cores according to the illustration on the cover of the power supply connector. Connect the longer core to PE. Screw on the cores with a torque of 0.6 to 0.8 N/m.

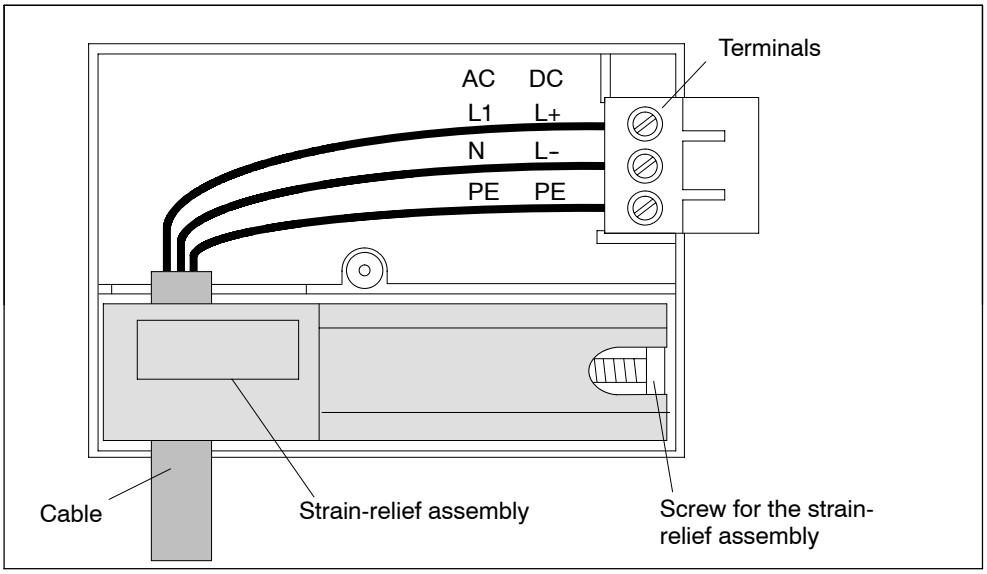

Figure 4-10 Wiring the power supply connector

8. Tighten the screw of the strain relief, so that the cable is secured properly.
9. Close the power supply connector and screw on the cover.

Caution

The power supply module or power supply connector can be damaged.

If you plug in or disconnect the connector with voltage applied, the power supply module or the connector may be damaged.

Only plug in or disconnect the power supply connector with power removed.

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Plugging In the Power Supply Connector

You can only plug in the connector when the power supply module is installed (lower mounting screw tightened).

To plug the wired power supply connector into the power supply module, follow the steps outlined below:

1. Open the cover of the power supply module.
2. Insert the power supply connector into the guide groove in the module housing.
3. Slide the power supply connector into the power supply module as far as it will travel.
4. Close the cover of the power supply module.

The following figure shows how to plug the power supply connector into the power supply module.

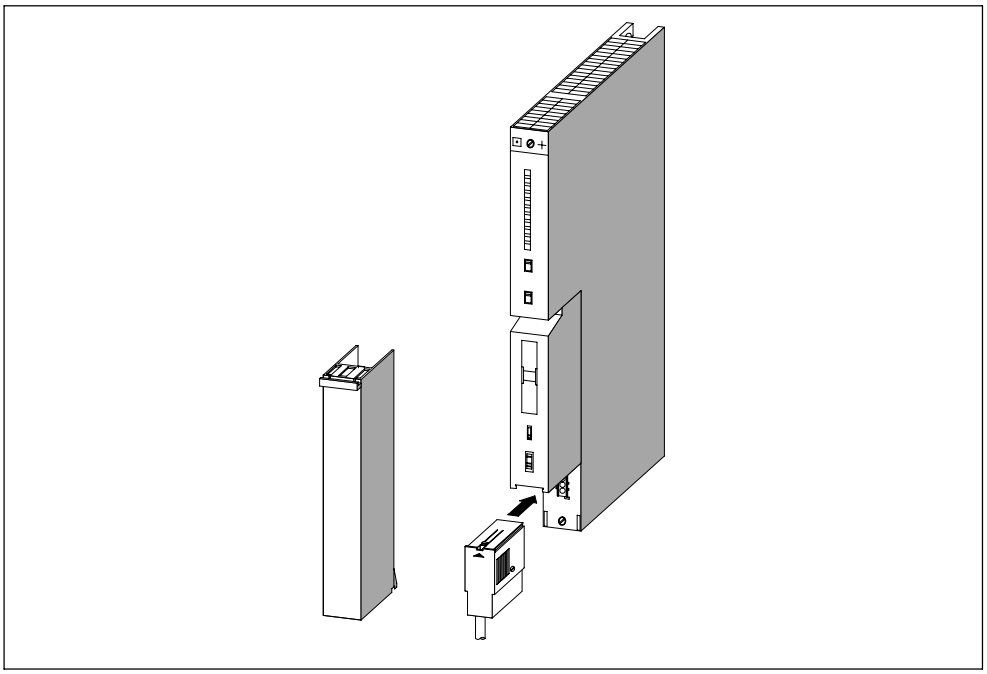

Figure 4-11 Plugging the power supply connector

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4.13 Wiring the Signal Modules

Procedure

How to connect your sensors and actuators to the S7-400 signal modules:

1. Wire the front connector.
   This includes all incoming and outgoing connections of the sensorsan actuators.
2. Install the front connector on the module.

The Three Types of Front Connector

Three types of front connector are available for the S7-400 signal modules:

- Front connector with crimp terminals
- Front connector with screw terminals
- Front connector with spring loaded terminals.

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Preparing to Wire the Front Connector

1. Insert a screwdriver at the point marked on the bottom left of the front connector, then lever off the lower corner of the cover.
2. Open the cover completely.
3. Pull the opened cover forward at the bottom and swing it up.

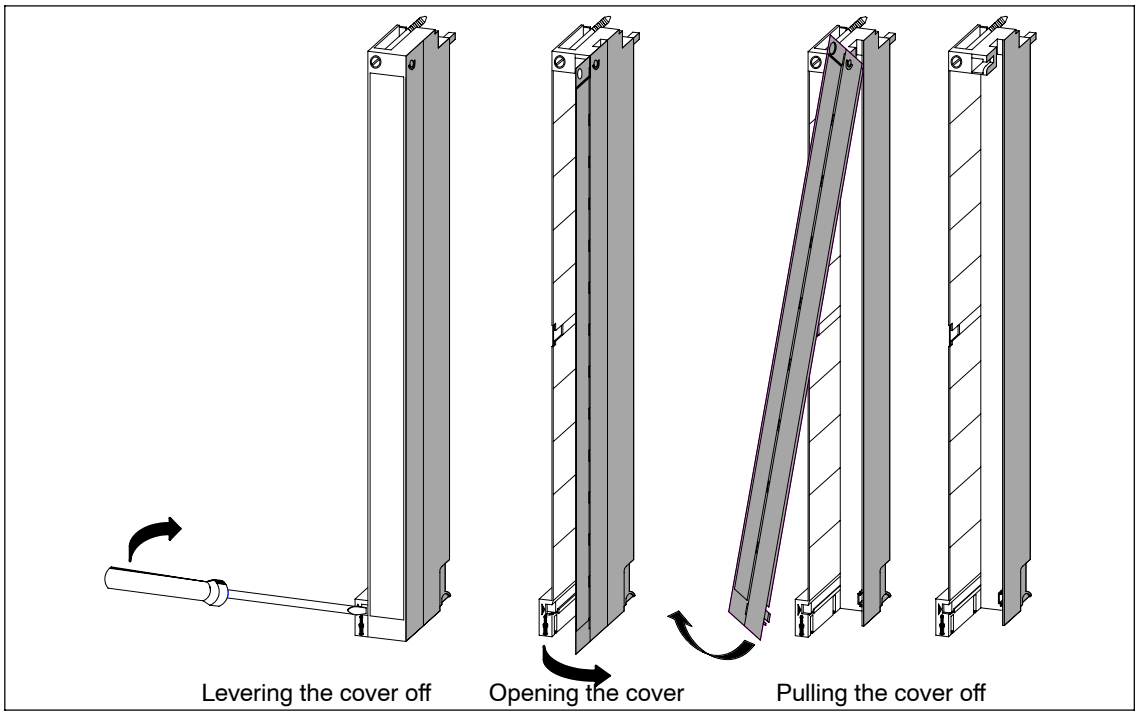

Figure 4-12 Preparing to wire the front connector

4. Cut the wires to length. Avoid any loops in the front connector after wiring.
5. Strip the wires according to the table in Section 4.11.

Note

The front connector contains a jumper which is required to enable specific functions on certain signal modules. Do not remove this jumper.

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4.14 Wiring the Front Connector, Crimping

Procedure

To wire the prepared front connector:

1. Strip the conductors at a length of approx. 5 mm.
2. Crimp the contacts onto the conductors. A crimptool is aailable on order as an accessory for your signal modules.
3. Insert the crimp contacts into the recesses of the front connector, starting at the bottom.

   The order number for crimp contacts is found in Appendix C of the Reference Manual.

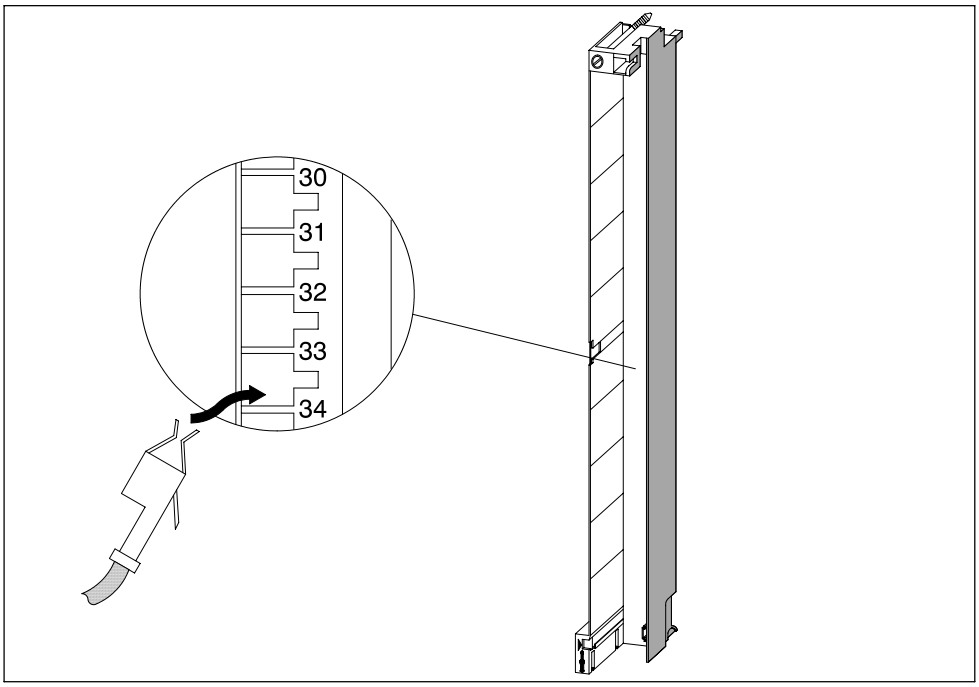

Figure 4-13 Wiring a Front Connector with Crimp Terminals

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4.15 Wiring the Front Connector, Screw Terminals

Procedure

To wire the prepared front connector:

1. Are you using wire ferrules?

   If yes: Strip the conductors at a length of 10 mm. Press-fit the wire end ferrules onto the conductors.

   If not: Strip the conductors at a length of 8 to 10 mm.

2. Terminate the wires, starting at the bottom of the front connector.
3. Screw the ends of the conductors onto the front connector (tightening torque = 0.6 to 0.8 N/m. Also tighten the unwired terminals.

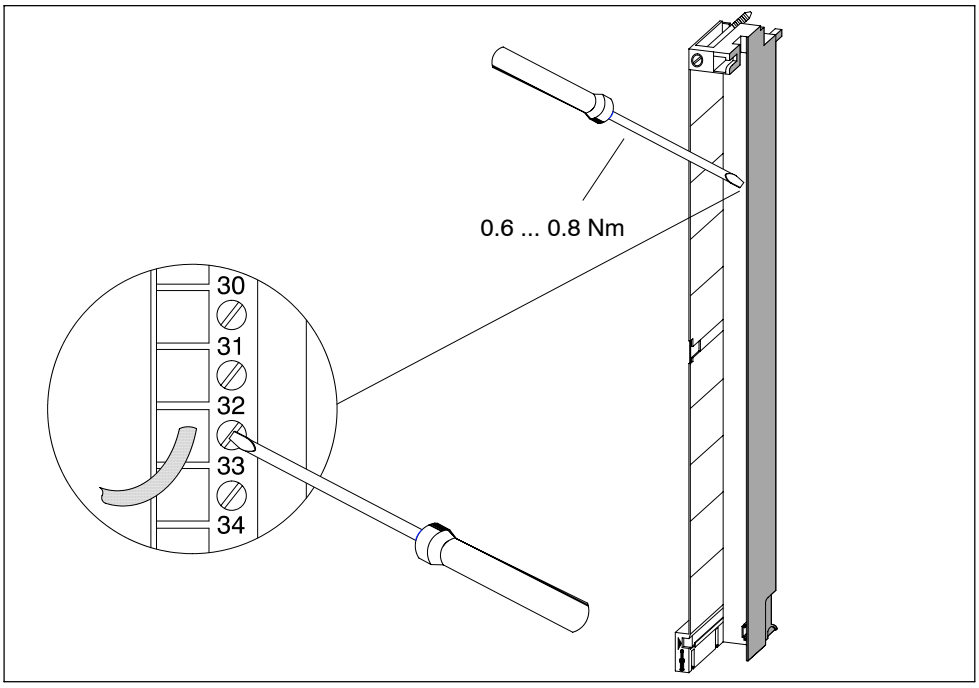

Figure 4-14 Wiring a Front Connector with Screw-Type Terminals

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4.16 Wiring the Front Connector, Spring-Type Terminals

Procedure

To wire the prepared front connector, follow the steps outlined below:

1. Are you using wire end ferrules?

   If so: Strip the conductors over 10 mm. Press-fit the wire end ferrules onto the conductors.

   If not: Strip the conductors over 8 to 10 mm.

2. Use a screwdriver (0.5 x 3.5 mm DIN 5264) to release the spring contact of the first terminal. Start at the bottom of the front connector.

   You can release the individual spring contacts at three points: from the front, from the side or from the back (see Figure 4-15).

3. Push the first wire into the released spring contact and withdraw the screwdriver.

4. Repeat steps 3 and 4 for all other wires.

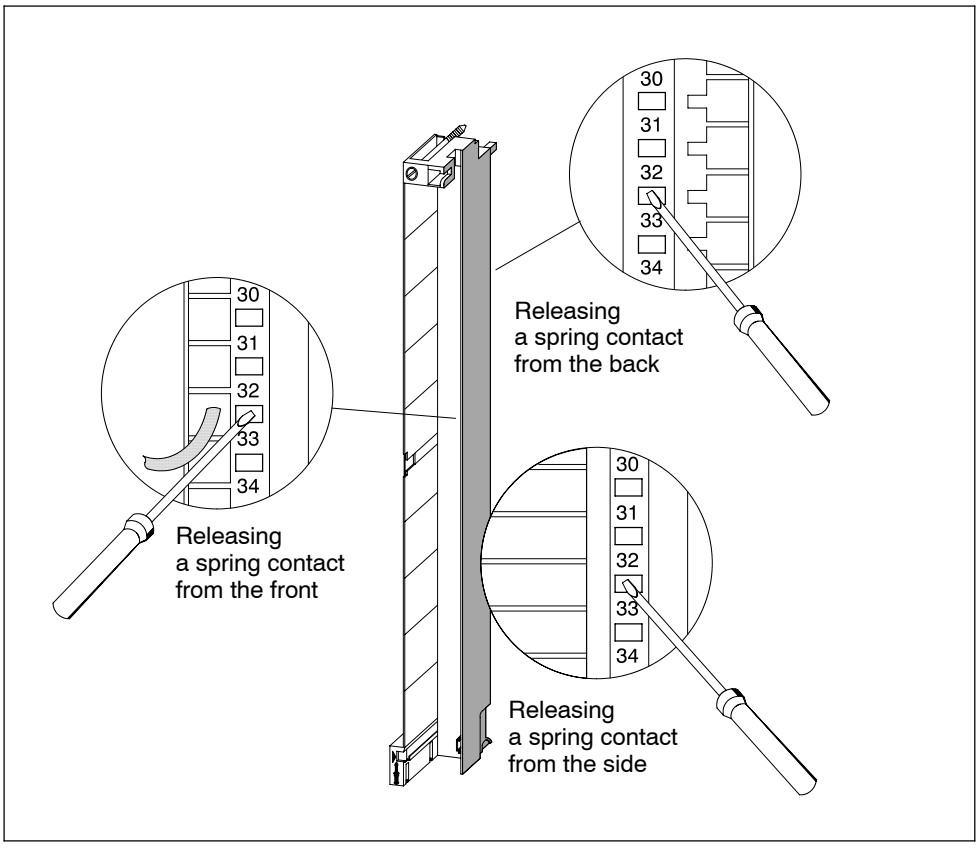

Figure 4-15 Wiring a Front Connector with Spring-Type Terminals

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Principle of the spring loaded terminal

The following figure shows the principle of spring contacts. Releasing and engaging from the front is illustrated.

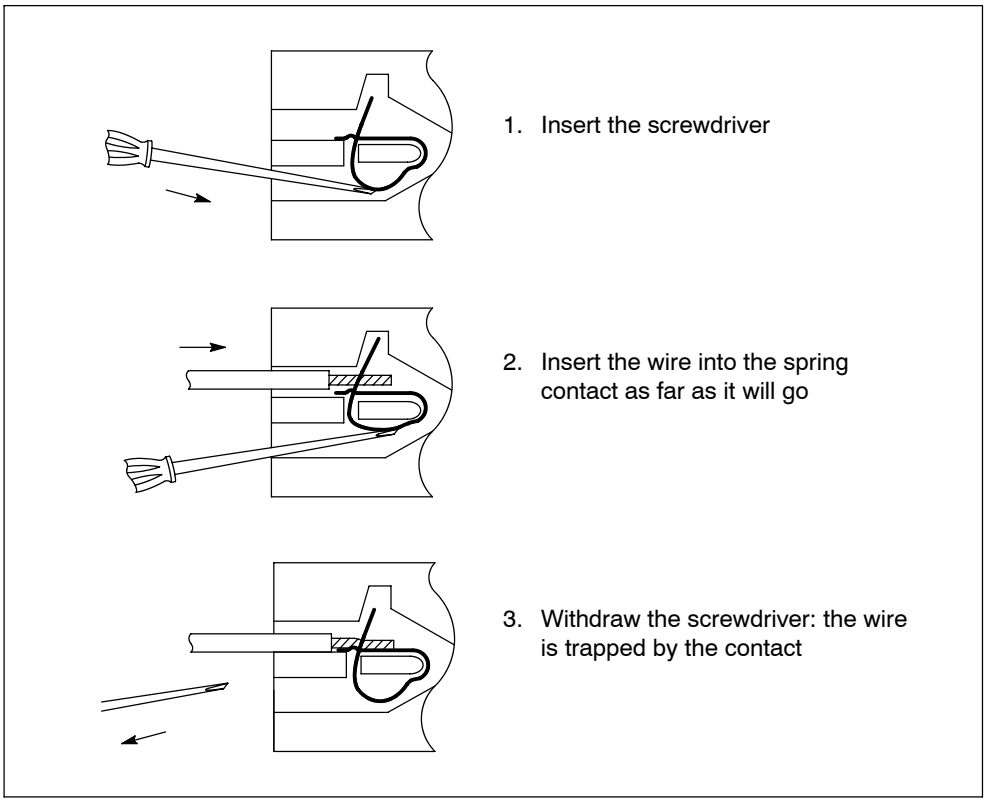

Figure 4-16 Principle of the spring contact

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4.17 Fitting the Strain Relief

Cable Ties as Strain Relief

When you have wired the front connector, the cable tie provided should be fitted at the bottom of the front connector as a strain relief for the connected cable.

There are three ways of fitting the strain relief, according to the thickness of the cable. Three openings are provided at the bottom of the front connector.

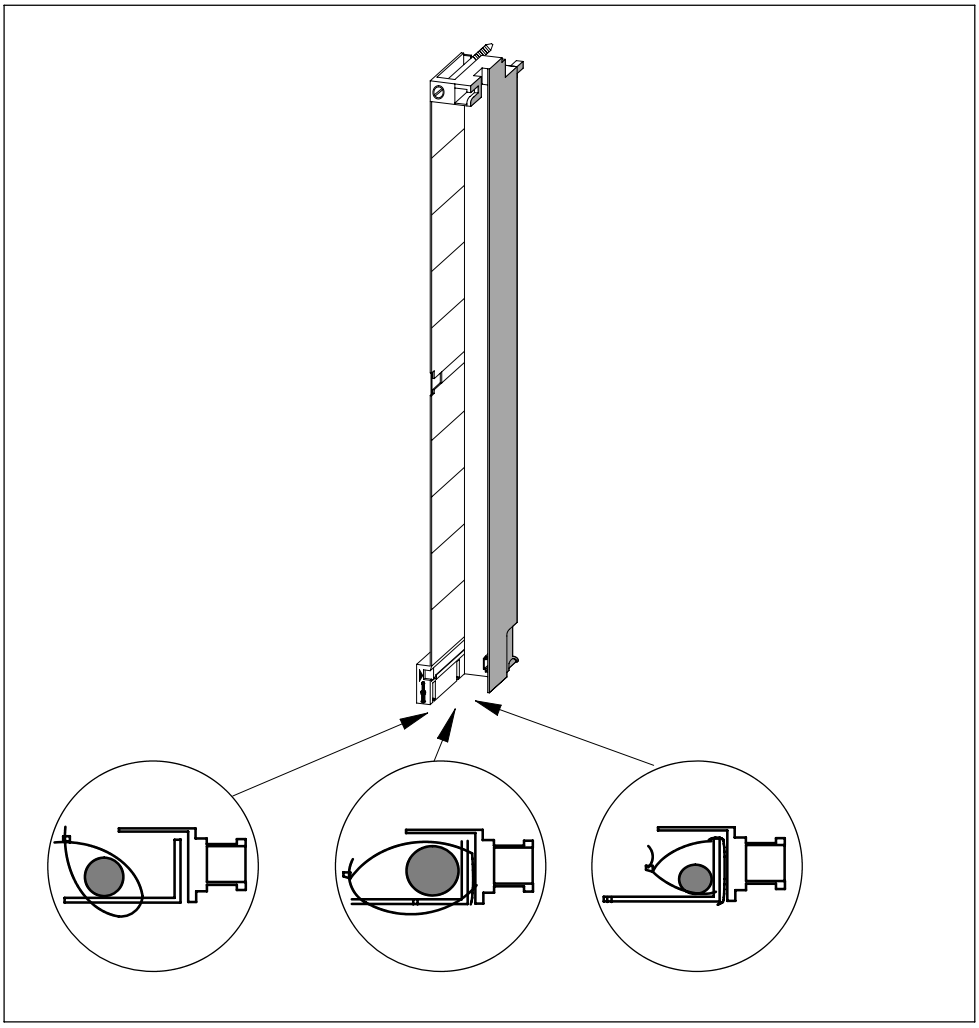

Figure 4-17 Fitting a Strain Relief (Viewed from Below)

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4.18 Labeling a Front Connector

Labels and Terminal Diagram

Each signal module is provided with three labels: two blank labels and one printed label showing the terminal diagram for inputs and outputs.

Figure 4-18 shows the locations for fitting the individual labels on the front connector.

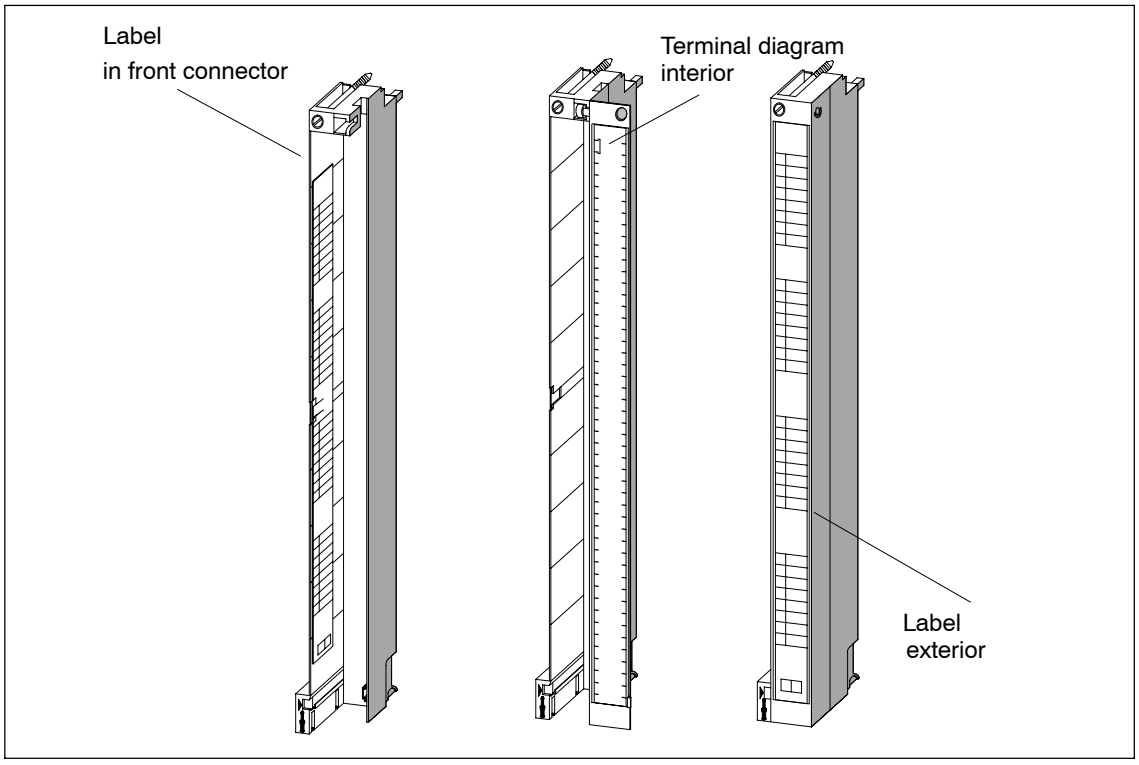

Figure 4-18 Fitting the Labels on the Front Connector

To label a front connector, follow the steps outlined below:

1. Enter the addresses of the individual channels on the two labels. Note the slot numbers on the labels to record the assignment of front connector to module.
2. Place a label on the left of the opened front connector. The label has a T-shaped blank in the middle with which you can fix the label onto the front connector housing. Bend the blank slightly to one side and push it behind the corresponding cutout of the front connector whilst sliding in the label (see Figure 4-19).
3. Refit the cover on the front connector.
4. Slide the label with the terminal diagram of the inputs or outputs into the interior of the cover of the front connector.
5. Slide a label externally into the cover of the front connector.

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Figure 4-19 shows details for fitting a label in the front connector.

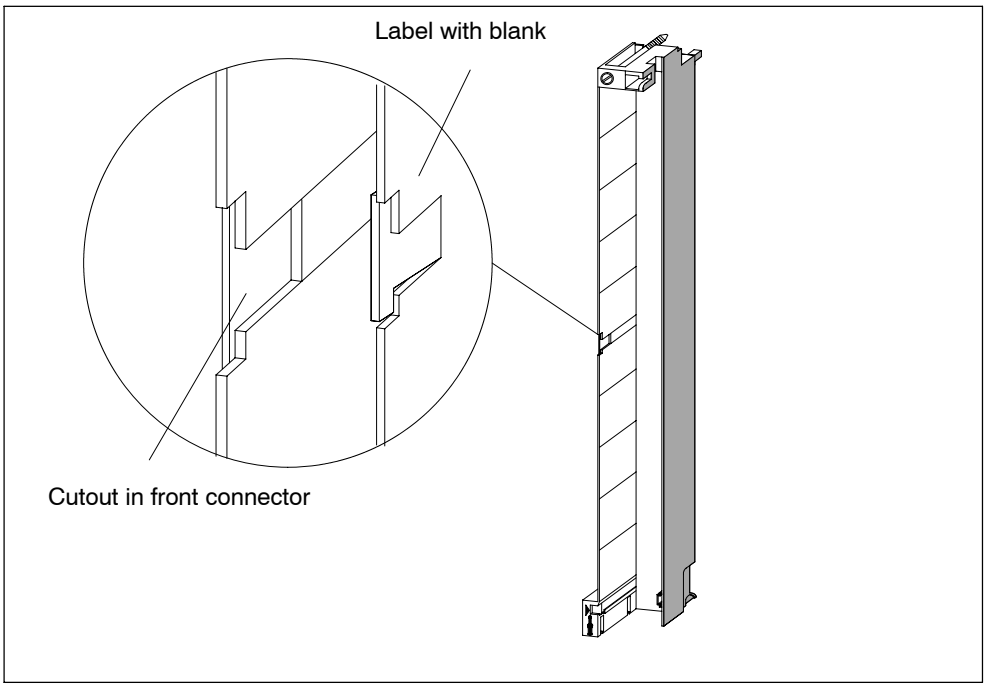

Figure 4-19 Fitting a Label in the Front Connector

Labels

- Print labels are prerequisite for professional, convenient labeling of your SIMATIC S7-400 signal modules, including FMs modules.
- The perforated labeling strips are available on DIN A4 sheets and can be easily separated without the use of a tool. This makes them easy to use and ensures a clean cut.
- The single-color labels are tear-proof and dirt-resistant. They are available in petrol, light beige, red, and yellow.
- SIMATIC S7-400 I/O modules can be easily labeled application-specifically by machine using a standard laser printer in one of the following two ways:
  - Use the print templates you can download free of charge from the Internet
  - Use the “S7-SmartLabel” add-on tool for SIMATIC STEP 7

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Notes on Ordering Labeling Sheets for S7-400

Order Number	Description
	SIMATIC S7-400, 10 A4 label sheets, 4 labeling strips / sheets for signal modules. Material: film, perforated, for laser printers. 10 sheets per package.
6ES7492-2AX00-0AA0	Petrol
6ES7492-2BX00-0AA0	Light–beige
6ES7492-2CX00-0AA0	Yellow
6ES7492-2DX00-0AA0	Red

How to Label S7-400 Modules

Method 1: Using Templates

1. Find the templates on the Internet
   You can download the templates from the Internet free of charge. Search for the templates on the Customer Supports homepage under article ID 11765788.
2. Download
   The download contains templates for the labeling of S7-400 modules.

   The templates for S7-400 make the labeling strips available for the outside of the front connector cover and the terminal diagrams for the inside of the front connector cover.
3. How to Print the Labeling Sheets Using the Templates

   The idea is to use the templates to print directly onto the foil sheets. You can use a laser printer to label the foil sheets. Proceed as follows:

   a) Select page layout view in WORD to edit the template forms.

   b) Label the module by clicking in the text boxes and entering the application-specific designation.

   c) Always print a preview of the form on white paper, and compare the layout with the original labeling sheets. Because there are differences between the different printers and printer drivers and their accuracy, the dimensions may vary and adjustment may be necessary. If the line and column spacing is not set correctly, you can adjust the position of the entire template under “Header>Graphics>Position” and “File>Page Setup>Margins”.

   d) When some templates are printed, a message reporting that the margins are outside of the printable area appears. This message can be ignored.

   e) Once you have printed the film sheets, make sure that you fold the labeling strips along the perforation before separating them. This will ensure that the edges of the strips are even. You can then apply the labeling strips to the corresponding module.

Method 2: Using the “S7-SmartLabel” Add-On Tool for SIMATIC STEP 7

You can derive the labeling directly from the STEP 7 project. The basis for application-specific labeling is the symbol table in STEP 7. Detailed information is available on the Internet under: http://www.s7-smartlabel.de/.

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4.19 Fitting the Front Connector

Principle of a Coding Key

To reduce the risk of a wired front connector being plugged into the wrong type of module after rewiring or module replacement, the signal modules have a coding key for front connectors.

A coding key comprises two parts: one part is permanently connected to the module; the second part is still connected to the first part when delivered (see Figure 4-20).

When you plug in a front connector, the second part of the coding key engages in the connector, becoming detached from the part connected to the signal module. Both parts of the coding key are mating elements and a front connector with the wrong mating element cannot be plugged into this signal module.

Front Connector Coding on the Signal Modules

Shown in the following table is the allocation between the different front connector coding keys and individual signal modules.

Table 4-4 Front connector coding elements

Signal Modules	Color of Front Connector Coding Key		
	red	yellow	green
Digital inputs, outputs > 60 VDC or > 50 VAC	●		
1. Digital inputs, outputs ≤ 60 VDC or ≤ 50 VAC		●	
Analog inputs, outputs			●

Plugging In the Front Connector

You can only plug in the connector when the power supply module is installed (lower mounting screw tightened).

Caution

Modules can be damaged.

If, for example, you plug the front connector of a digital input module into a digital output module, the module can be damaged. If, for example, you plug the front connector of an analog input module into an analog output module, the module can be damaged.

When plugging in the front connector, ensure that the module and front connector are matched.

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To plug in the front connector, follow the steps outlined below:

1. Hold the front connector horizontally and engage the front connector with the coding key. After an audible click, the front connector will engage with the mount and can be swung upwards.
2. Swing the front connector upwards. The two parts of the coding key will then be separated.
3. Screw the front connector on.

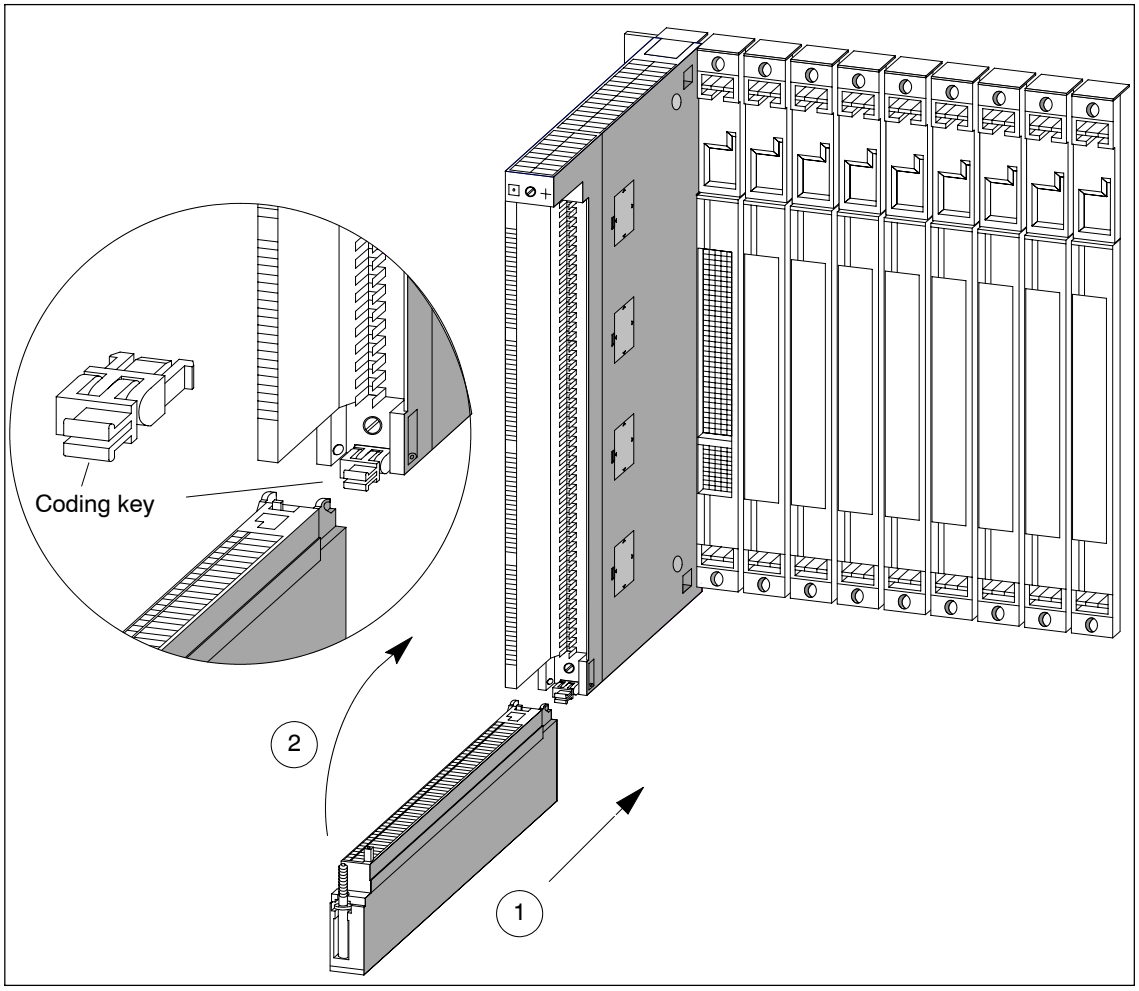

Figure 4-20 Attaching the Front Connector

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Figure 4-21 shows how to screw on the front connector.

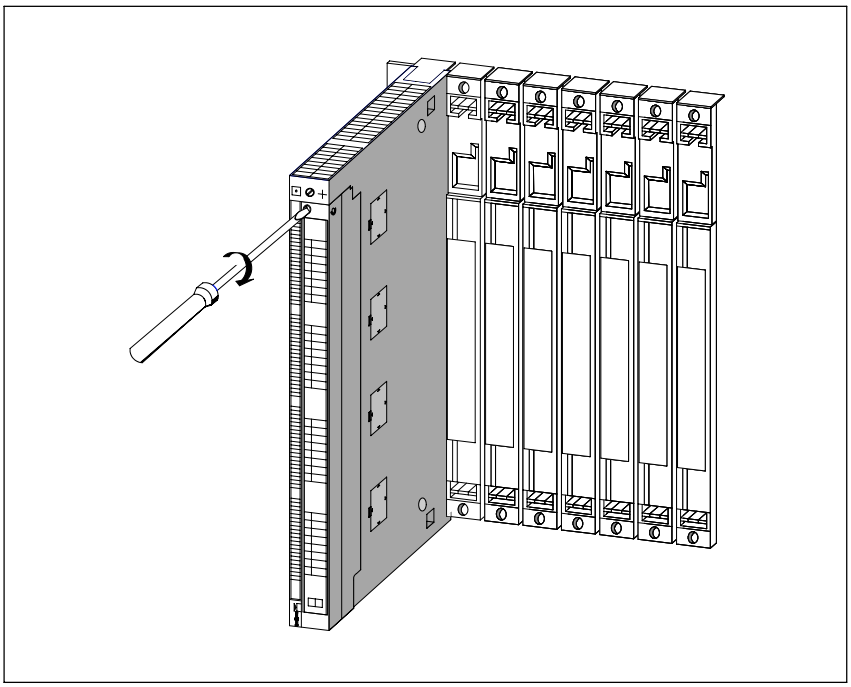

Figure 4-21 Screwing On the Front Connector

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4.20 Interconnecting the CR and ER(s)

Interconnecting the Interface Modules

When you assemble an automation system comprising a CR and one or more ERs, you connect the racks via the connecting cables of the interface modules.

To interconnect the interface modules:

1. Ensure that all the connecting cables needed for the programmable controller are ready. Allow for the maximum cable lengths permitted for your assembly (see Chapter 2) and check that you have the correct cables (see *Reference Manual Module Specifications*, Chapter 6).
2. Start with the send IM (the interface module in the central rack).
3. Open the cover of the send IM.
4. Plug the male connector of the first connecting cable into one of the female connectors of the send IM and screw-tighten it.

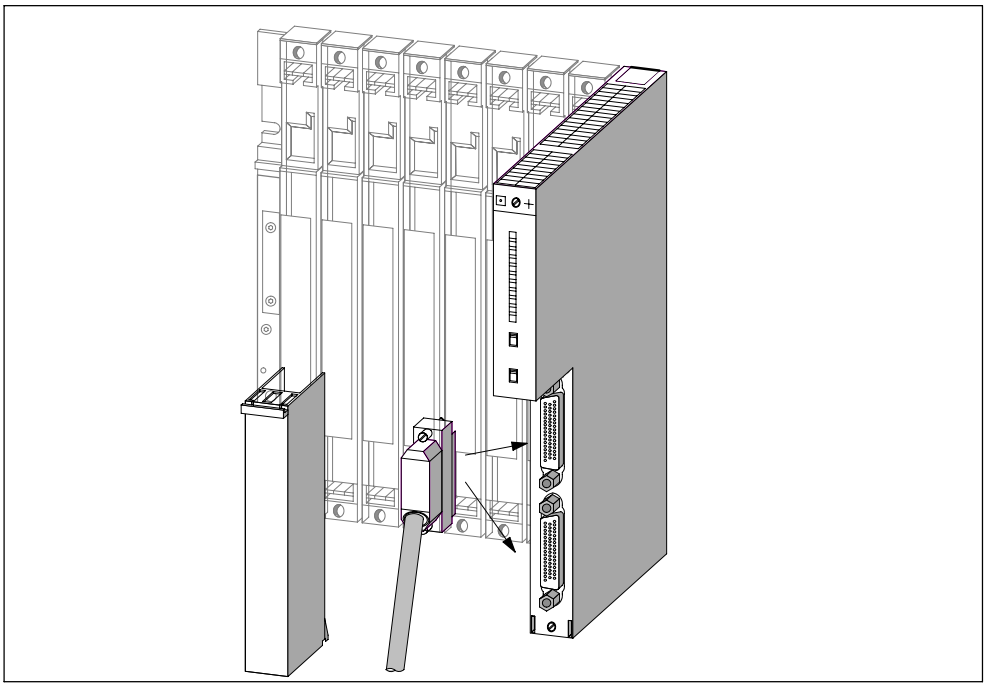

Figure 4-22 Plugging a Connecting Cable into a Send IM

5. If you wish to interconnect two ERs segments to this send IM, plug the connector of the second connecting cable into the second port of the send IM.
6. Close the cover of the send IM.

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7. Open the cover of the first receive IM (interface module in the ER).
8. Plug the free end of the connecting cable into the upper male connector (receive interface) of the receive IM and screw the connector on.
9. Connect the remaining receive IMs by connecting one send interface (lower female connector X2) to one receive interface (upper male connector X1) in each case.

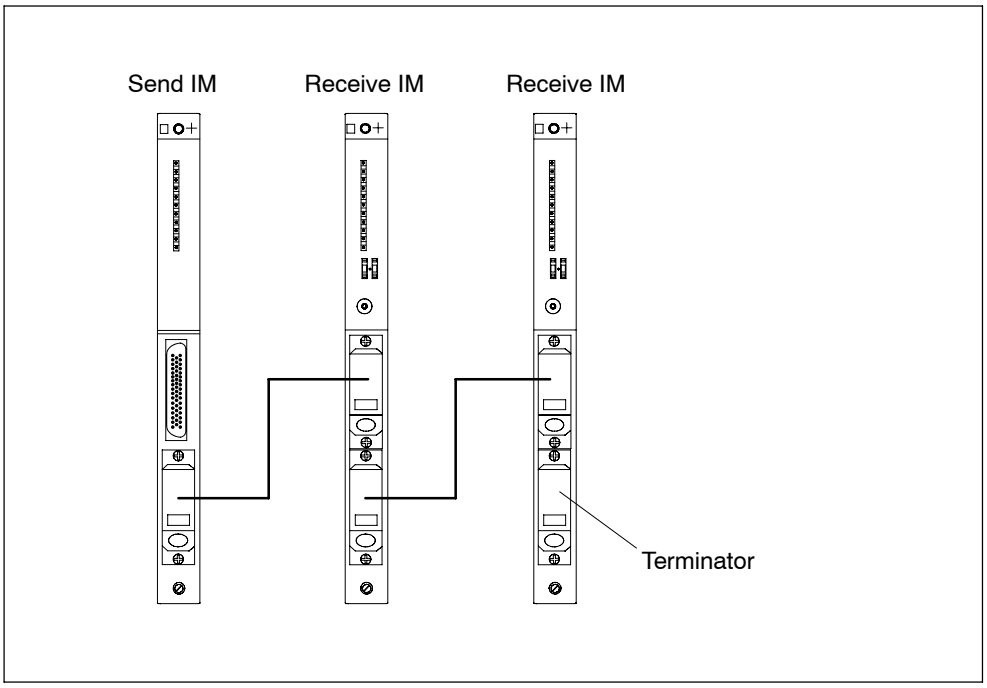

Figure 4-23 Connection Between a Send IM and Two Receive IMs

10. Plug the terminator into the lower female connector of the receive IM in the last ER of the chain (see *Reference Manual Module Specifications*, Chapter 6).

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4.21 Setting the Fan Subassembly to the Line Voltage and Wiring It

Setting the Fan Subassembly to the Line Voltage

Check whether the voltage selector switch in the fan subassembly is set to your line voltage (see Figure 4-24).

Fuse

The fan subassembly has two standard fuses:

- A 250 mA slow blow fuse for the 120 V range
- A 160 mA slow blow fuse for the 230 V range.

The fuse for the 230 V range is fitted before delivery.

Note

If you change the voltage range, you must also fit the fuse for this voltage range in the fan subassembly. Replacing the fuse is described in Chapter 7.

Wiring the Fan Subassembly

1. Strip the cables of the power cable. Press-fit wire end ferrules onto the conductors.
2. Insert the wires in the power terminals of the fan subassembly. Use a suitable screwdriver to release the spring contacts of the power terminals.
3. The small cover serves as a strain relief for the power cable. Choose one of the three sizes provided to suit your cable cross-section.
4. Screw the strain relief on.

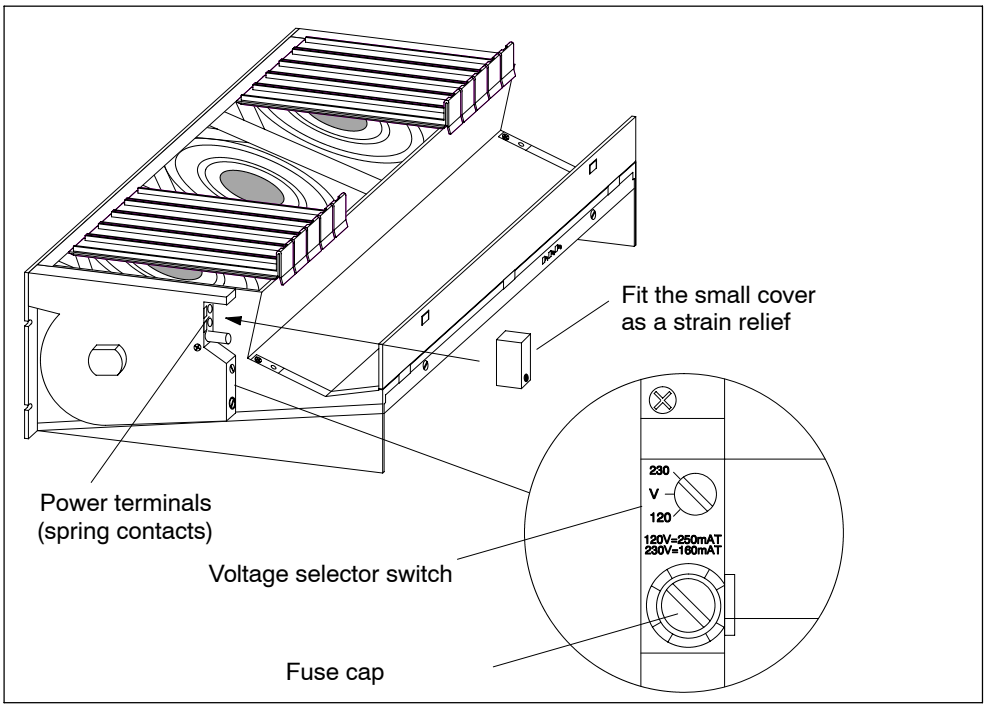

Figure 4-24 Wiring the Fan Subassembly

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4.22 Cable routing in cable ducts or fan subassemblies

Cable Routing

Depending on the number of cables and plug-in lines merging at the particular rack, the cross-section of the cable duct or fan subassembly may not be sufficient to accept all cables.

You should therefore route half the cables toward each side via the cable duct or fan subassembly.

Securing Cables

There are eyes for securing cables on both sides of the cable duct or fan subassembly (see *Reference Manual Module Specifications*, Chapter 6). You can secure the cables to these eyes with cable ties, for example.

Shield Contact

The cable duct and fan subassembly offer the facility of electrical contact for cable shields. You can use the shield clamps provided
(see *Reference Manual Module Specifications*, Chapter 9).

To establish contact for the cable shields, strip the outer insulation in the region of the shield clamp, and trap the cable shield under the shield clamp.

4.23 Routing Fiber-Optic Cables

Cable Routing

Indoor fiber-optic cables (for example, for connecting synchronization submodules) are permitted for use in buildings, cable ducts, and channel trunking.

The maximum strain load when assembling is 1000 N and during operation 150 N.

Bending Radius

Minimum bending radius of the cables:

- At the connector: 55 mm
- Otherwise: 30 mm

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Networking

5

Chapter Overview

Section	Description	Page
5.1	Configuring a Network	5-2
5.2	Fundamentals	5-3
5.3	Rules for Configuring a Network	5-7
5.4	Cable Lengths	5-15
5.5	PROFIBUS-DP Bus Cables	5-18
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5.7	RS 485 Repeater / Diagnostics Repeater	5-21
5.8	PROFIBUS-DP Network with Fiber-Optic Cables	5-22

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5.1 Configuring a Network

Subnets

You can connect an S7-400 device to various subnets:

- Via Simatic Net CP Ethernet to an Industrial Ethernet subnet
- Via Simatic Net CP PROFIBUS to a PROFIBUS-DP subnet
- Via the integrated MPI interface to an MPI subnet
- Via the integrated PROFIBUS-DP interface to a PROFIBUS DP subnet

Same Configuration

We recommend you use the same bus components as for a PROFIBUS DP network configuration when configuring an MPI network. The same configuration rules apply.

Multipoint Interface (MPI)

This interface of the CPU uses a Simatic S7-specific protocol for the communication with programming devices (by means of STEP 7), operator panels, and other S7 CPUs. The bus structure corresponds to PROFIBUS.

Configuring Communication

In order that the individual nodes of an MPI or PROFIBUS-DP network can communicate with each other, you must assign MPI or PROFIBUS-DP addresses to them. The Manual *Configuring Hardware and Communication Connections STEP 7* describes how to assign these addresses and what you must take into account.

All the CPU-related data you need to know to configure communication can be found in the *Reference Manual CPU Data*.

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5.2 Fundamentals

Station = Node

Declaration: All the stations you connect in a network are referred to as nodes in the following.

Segment

A segment is a bus cable between two terminating resistors. A segment can contain up to 32 nodes. Furthermore, a segment is limited by the permissible cable length according to the transmission rate.

Baud Rate

The baud rate (transmission rate) is the speed at which data is transmitted, expressed in terms of bits per second.

- Baud rates of 19.2 kbps to 12 Mbps are possible for interfaces of the type MPI/DP.
- Transmission rates of 9.6 kbps to 12 Mbps are possible for interfaces of the type PROFIBUS-DP.

Note

If you change the parameter assignment of the MPI/DP interface transmission rate, the new transmission rate remains set even after memory reset, voltage failure or removing/inserting the CPU.

Connectable Nodes

MPI	PROFIBUS DP
Programming devices (PGs)	Programming devices (PGs)
Operator interfaces (SIMATIC-OP), WinCC	Operator panels (OPs)*
S7-400	PROFIBUS-DP master, PROFIBUS-DP slaves
S7-300	PROFIBUS-DP slaves

* Not recommended in DP operation

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Number of Nodes

MPI	PROFIBUS DP	
127	127 *	
(default: 32)	of which:	1 master (reserved)
1 PG port (reserved)		1 PG port (reserved)
		125 slaves or other masters

* Observe the CPU-specific maximum numbers in the *Reference Manual CPU Data*

MPI/PROFIBUS-DP Addresses

In order for all nodes to be able to communicate with one another, you must assign them an address:

- In the MPI network, an MPI address
- A PROFIBUS-DP address in the PROFIBUS-DP network

Default MPI Addresses

The following table shows the default MPI address and the max. MPI address with which the devices are shipped:

Node (Device)	Default MPI Address	Default Highest MPI Address
Programming device	0	31
OP	1	31
CPU	2	31

Note

If you change the parameter assignment of the highest MPI address of the MPI/DP interface, the new address remains set even after memory reset, voltage failure or removing/inserting the CPU.

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Rules for MPI Addresses

Observe the following rules before assigning MPI addresses:

- All MPI addresses in an MPI network must be different.
- The highest possible MPI address must be equal to or higher than the highest actual MPI address and must be set to the same value for all nodes. (Exception: connecting a programming device to two or more nodes.)

PG / OP – Module communication without MPI

If one of the programming devices or operator panels connected to a multipoint interface (MPI) communicates with an S7-400 module which does not have an MPI connection (for example, SIMATIC NET CPs, FM 456 etc.), this module can be reached via the CPU to whose MPI the programming device or operator panel is connected. In this case, the CPU simply acts as an intermediary for the transfer. This type of connection between a programming device or operator panel and a module only communicating via the communication bus occupies two connection resources in the CPU.

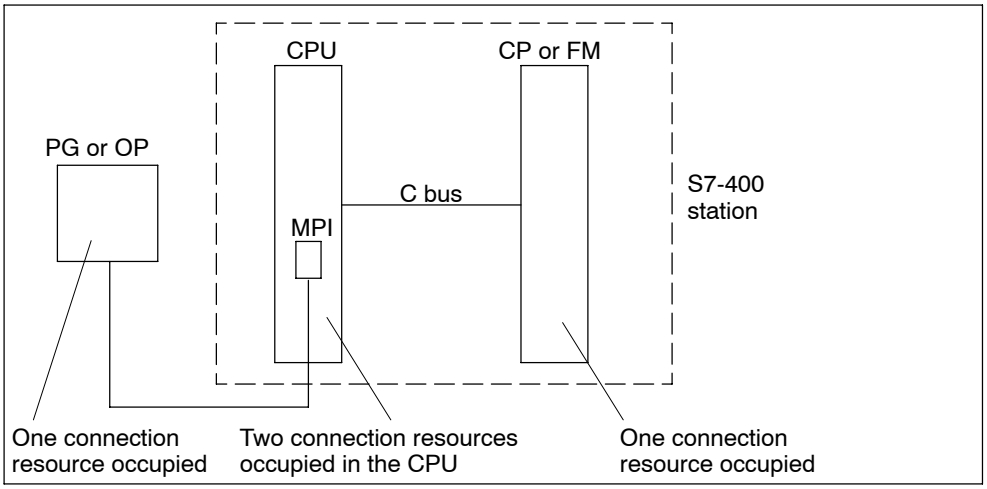

Figure 5-1 Communication between Programming Device/Operator Panel and a Module without MPI

Maximum Number of Connections via MPI

When configuring the connections of a CPU 41x via MPI, remember to include the PG connection in the maximum number of possible connections.

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PG Access

A CPU exchanges data with other systems using communication mechanisms, for example with other programmable controllers, with operator interface stations (OP, OS) or with programming devices (see Figure 5-2).

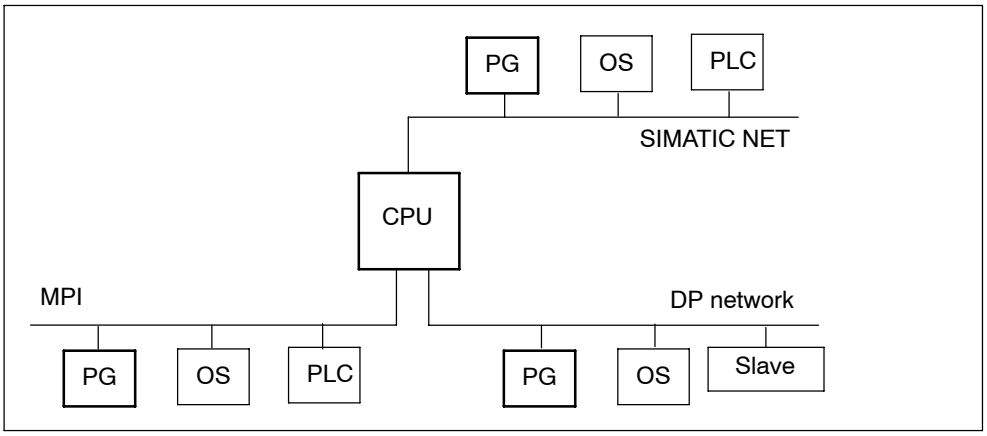

Figure 5-2 Data Exchange

Process communication, including communication services for data exchange between programmable controllers (PLC - PLC) and between programmable controllers and operator interface stations (PLC - OS/OP), has priority in CPUs over communication between programming devices and CPUs.

The CPUs have different characteristics. One of these characteristics is their communication performance. If the communication resources of a CPU are occupied completely by process communication, this can severely hamper access to the CPU from the programming device.

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5.3 Rules for Configuring a Network

Rules

Observe the following rules for connecting the nodes of a network:

- **Before** you interconnect the individual nodes of the network, you must assign to each node the MPI address and the highest MPI address or PROFIBUS-DP address.

  Tip: Mark the address of each node in a network on the housing. To do this, use the adhesive labels enclosed with the CPU. You can then always see which address is assigned to which node in your plant.

- **Before** you insert a new node in the network, you must switch off its supply voltage.

- Connect all the nodes in the network in a row. In other words, include the fixed programming devices and operator panels directly in the network.

  Only use spur lines for connecting the programming devices / OPs to the network which are needed for startup or maintenance.

- If you operate more than 32 nodes in a PROFIBUS-DP network, you must connect the bus segments via RS 485 repeaters.

  In a PROFIBUS-DP network, all bus segments **together** must have at least one DP master and one DP slave.

- You connect ungrounded bus segments and grounded bus segments via RS 485 repeaters (see *Reference Manual CPU Data*, Chapter 10).

- The maximum number of nodes per bus segment decreases with each RS 485 repeater. This means that if there is an RS 485 repeater in a bus segment, there may only be a maximum of 31 other nodes in a bus segment. However, the number of RS 485 repeaters has **no** effect on the maximum number of nodes on the bus.

  Up to ten segments can be connected in series.

- Switch on the terminating resistor at the first and last node of a segment.

  To ensure the bus operates without interference, you should not switch off these nodes.

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Data Packets in the MPI Network

Observe the following feature in the MPI network:

Note

If you connect an additional CPU to the MPI network during operation, data may be lost.

Remedy:

1. Disconnect power from the nodes to be connected.
2. Connect the nodes to the MPI network.
3. Switch on the nodes.

Recommendation for MPI Addresses

Reserve MPI address “0” for a service programming device and “1” for a service OP, which will later be briefly connected to the MPI network as required. Thus you assign different MPI addresses to the programming devices / OPs incorporated in the MPI network.

Reserve MPI address “2” for a new CPU. You thus avoid the duplication of MPI addresses after a CPU with a default setting has been installed in the MPI network (for example, when replacing a CPU). Thus you assign an MPI address higher than “2” to all CPUs in the MPI network.

Recommendation for PROFIBUS-DP Addresses

Reserve PROFIBUS-DP address “0” for a service programming device, which will later be briefly connected to the PROFIBUS-DP network as required. Thus you assign other PROFIBUS-DP addresses to all the programming devices incorporated in the PROFIBUS-DP network.

Components

You connect the individual nodes via bus connectors and the PROFIBUS-DP bus cable. Remember to provide a bus connector with PG female port for nodes into which a programming device may be plugged if required.

Use RS 485 repeaters for the connection between segments and for extending the cable.

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Terminating Resistor on the Bus Connector

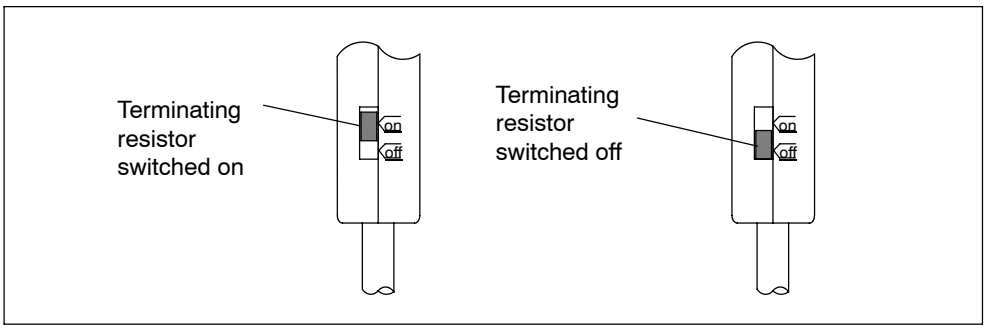

Figure 5-3 Terminating resistor on bus connector

Terminating Resistor on the RS 485 Repeater

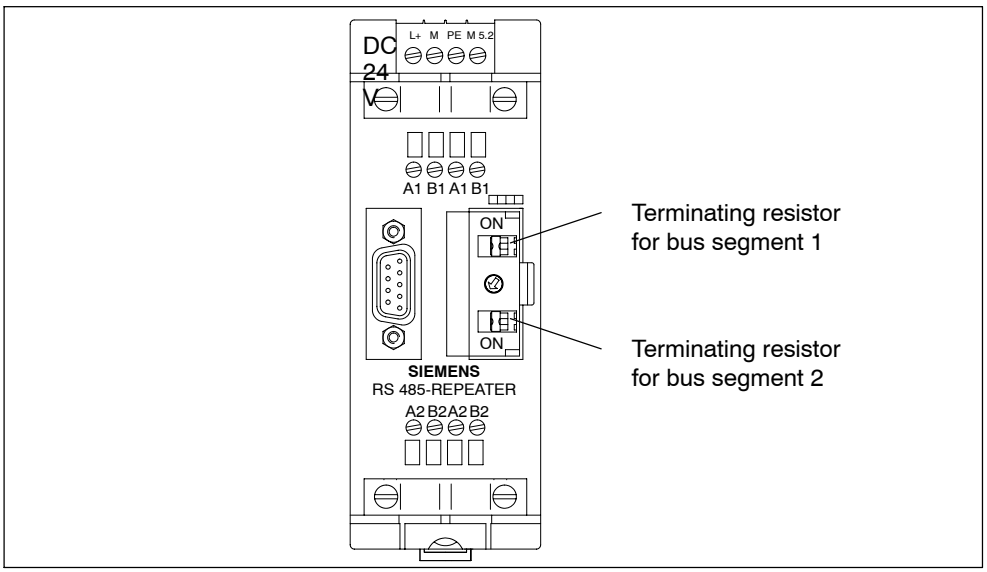

Figure 5-4 Terminating resistor on RS 485 repeater

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Example: Terminating Resistor in the MPI Network

The figure below shows where you have to connect the terminating resistor in a possible configuration for an MPI network.

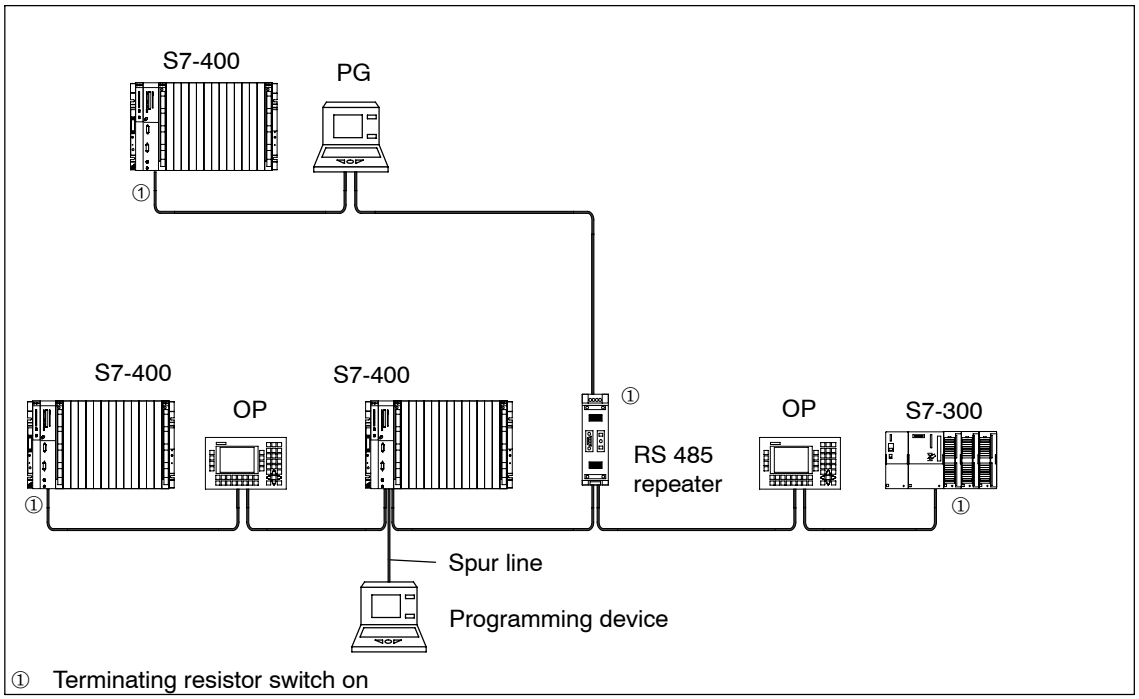

Figure 5-5 Terminating resistor on MPI network

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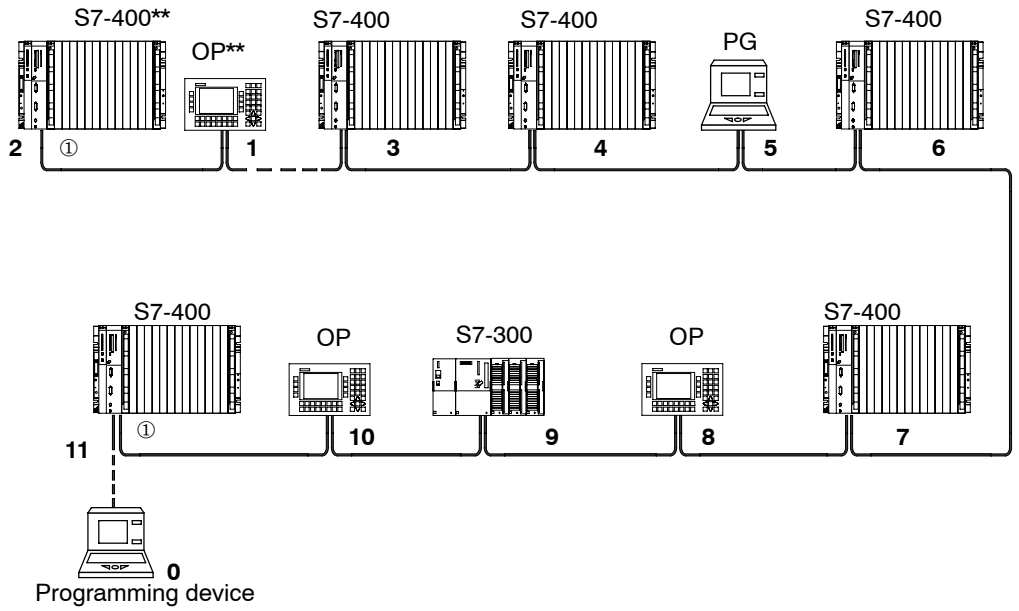
Example of an MPI Network



* Only connected via spur line for startup/maintenance (with default MPI address)
** Connected to the MPI later on (with default MPI address)
0 ... x MPI address of nodes
① Terminating resistor switch on

Figure 5-6 Example of an MPI network

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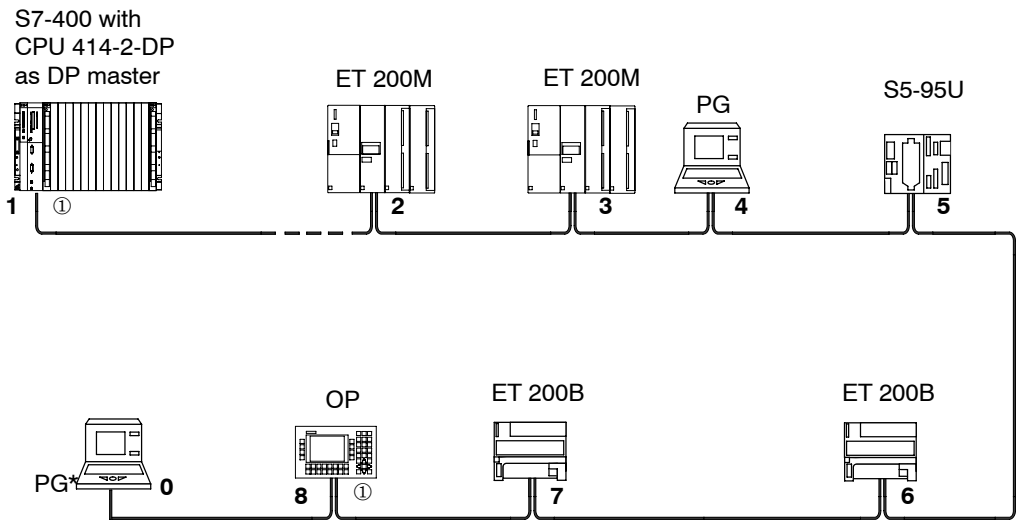
Example of a PROFIBUS-DP Network



***** Only connected via spur line for startup/maintenance (with default PROFIBUS-DP address = 0)

0 ... x PROFIBUS DP addresses of nodes

① Terminating resistor switched on

Figure 5-7 Example of a PROFIBUS DP network

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Example Using a CPU 414-2

The figure below shows an example of a configuration with CPU 414-2 DP which is integrated in an MPI network and simultaneously used as DP master in a PROFIBUS-DP network.

In both networks, the node numbers can be assigned separately without conflicts resulting.

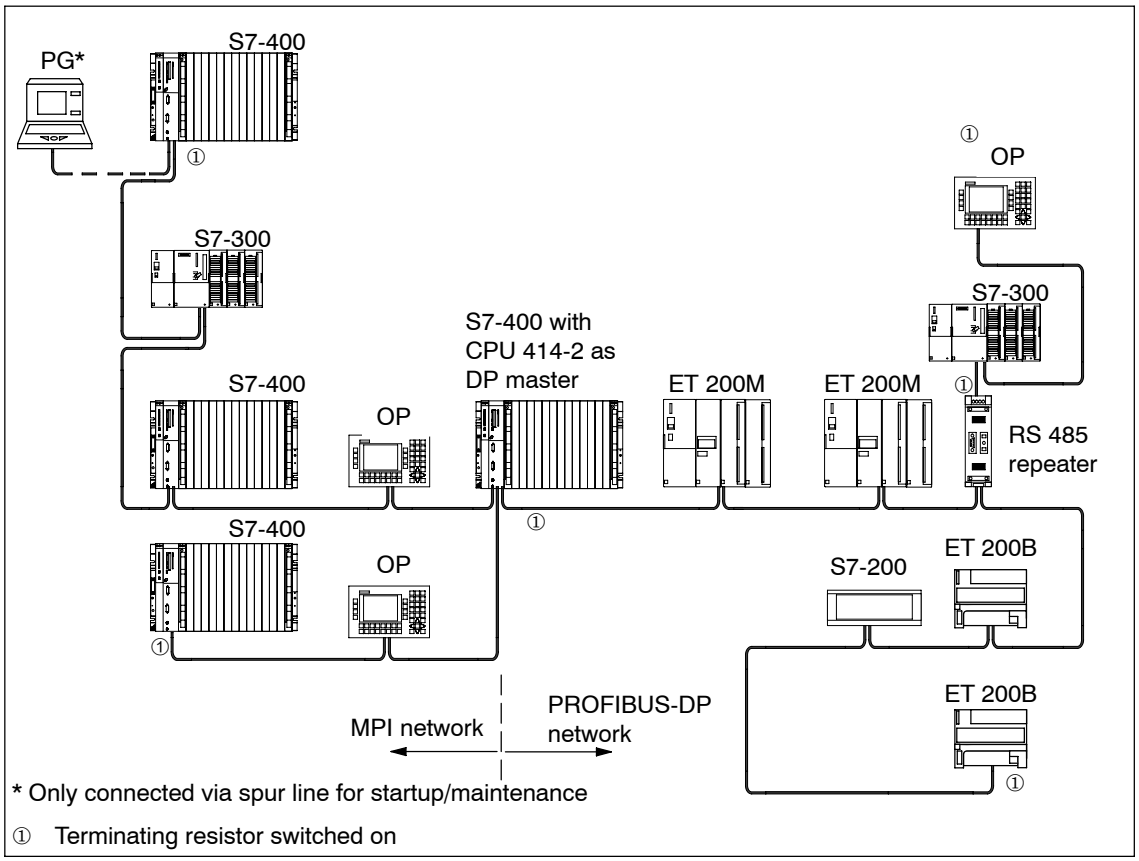

Figure 5-8 Example with CPU 414-2

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Programming Device Access Beyond Network Limits (Routing)

You can access all modules beyond network limits using a programming device.

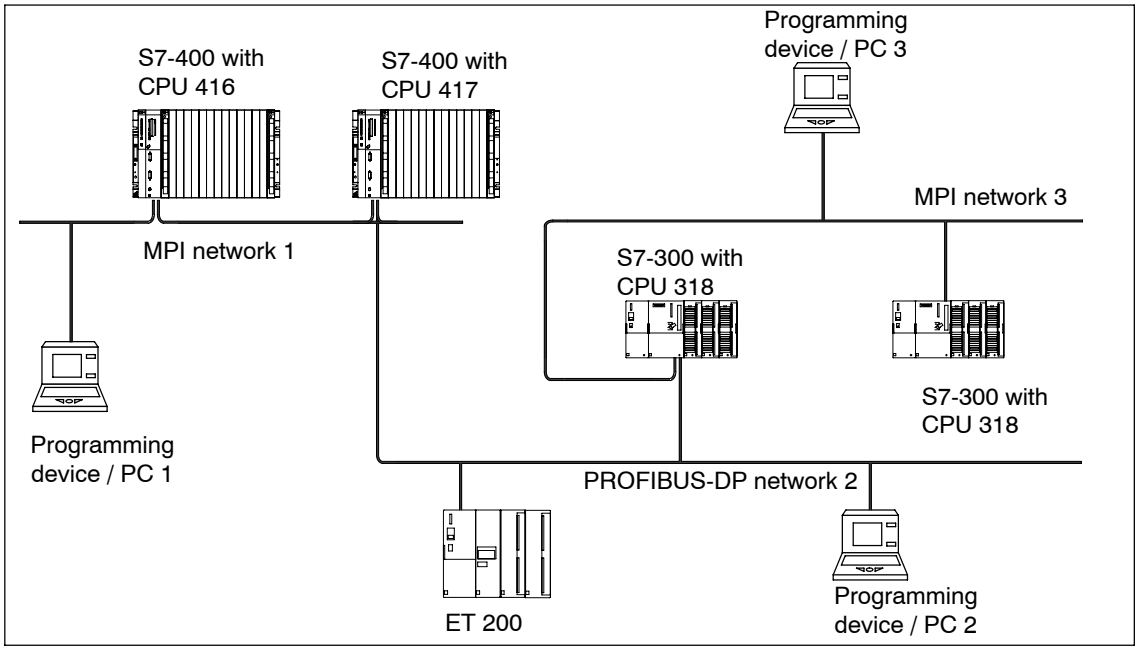

Figure 5-9 Programming device access beyond network limits

Requirements :

- Use STEP 7 from version 5.0 onwards
- Assign STEP 7 to a programming device or PC on the network (SIMATIC Manager, Assign programming device/PC)
- The network limits are bridged by modules with routing capability.

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5.4 Cable Lengths

Segment in the MPI Network

In a segment of an MPI network, you can use cable lengths of up to 50 m. This 50 m applies from the first node to the last node in the segment.

Table 5-1 Permitted Cable Length of a Segment in an MPI Network

Transmission Rate	Maximum Cable Length of a Segment (in m)
187.5 Kbps	50
19.2 Kbps	50
12 Mbps	50

Segment in the PROFIBUS-DP Network

In a segment of a PROFIBUS-DP network, the cable length depends on the transmission rate (see Table 5-2). These lengths only apply if you connect a CPU to a PROFIBUS-DP network via an MPI interface configured as a DP interface.

Table 5-2 Permitted Cable Length of a Segment in the PROFIBUS-DP Network Depending on the Transmisson Rate

Transmission Rate	Maximum Cable Length of a Segment (in m)
9.6 to 187.5 Kbps	1000
500 Kbps	400
1.5 Mbps	200
3 to 12 Mbps	100

Longer Cable Lengths

If you have to implement cable lengths which are longer than permissible in one segment, you must interconnect RS 485 repeaters. The maximum possible cable length between two RS 485 repeaters is the same as the cable length of a segment (see Tables 5-1 and 5-2). With these maximum cable lengths, however, note that **no** other nodes may be situated between the two RS 485 repeaters. You can connect up to ten RS 485 repeaters in series.

Note that you must count an RS 485 repeater as a node of the MPI network in the total number of all nodes to be connected, even if it is not assigned its own MPI number. The use of RS 485 repeaters reduces the number of nodes.

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Lengths of Spur Lines

If you do not fit the bus cable directly at the bus connector (for example, when using a PROFIBUS-DP bus terminal), you must take into account the maximum possible spur line length.

The following table gives the maximum lengths of spur lines allowed per bus segment:

Table 5-3 Lengths of Spur Lines per Segment

Transmission Rate	Maximum Length of a Spur Line	Number of Nodes per Spur Line Length of ...		Maximum Length of Spur Lines per Segment
		1.5 m and 1.6 m	3 m	
9.6 to 93.75 kbps	3 m	32	32	96 m
187.5 kbps	3 m	32	25	75 m
500 kbps	3 m	20	10	30 m
1.5 Mbps	3 m	6	3	10 m

A spur line is not permissible with transmission rates greater than 1.5 Mbps.

To connect a programming device or PC, use the connecting cable for the programming with theorder number 6ES7901-4BD00-0XA0. You can use several connecting cable with this order number for programming devices in one bus configuration.

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Example

The figure below shows a possible configuration of an MPI network. This example clarifies the maximum possible distances in an MPI network.

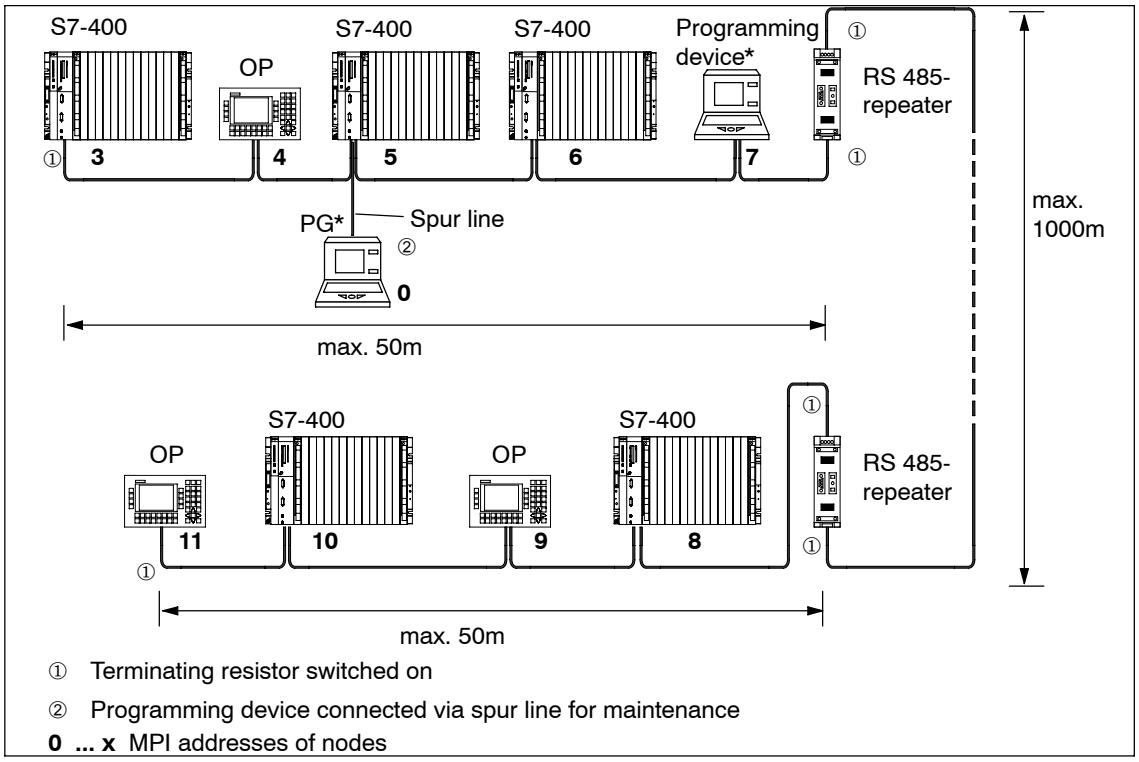

Figure 5-10 Configuration of an MPI network

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5.5 PROFIBUS-DP Bus Cables

PROFIBUS-DP Bus Cables

Siemens supply the following PROFIBUS-DP bus cables (see catalog ST 70):

PROFIBUS-DP bus cable	6XV1830-0AH10
PROFIBUS-DP cable for burying in ground	6XV1830-3AH10
PROFIBUS-DP trailing cable	6XV1830-3BH10
PROFIBUS-DP bus cable with PE sheath (for foodstuffs and luxury food industry)	6XV1830-0BH10
PROFIBUS-DP bus cable festoons	6XV1830-3CH10

Characteristics of the PROFIBUS-DP Bus Cable

The PROFIBUS-DP bus cable is a twisted, shielded pair with the following characteristics:

Characteristics	Values
Impedance	approx. 135 to 160 Ω (f = 3 to 20 MHz)
Loop resistance	≦ 115 Ω/km
Working capacitance	30 nF/km
Attenuation	0.9 dB/100 m (f = 200 kHz)
Permissible core cross-section	0.3 mm^2 to 0.5 mm^2
Permissible cable diameter	8 mm ± 0.5 mm

Rules for Laying Cables

When you lay the PROFIBUS-DP bus cable, you should not:

- Twist it,
- Stretch it, or
- Compress it.

Furthermore, when installing the indoor bus cable, you must observe the following basic conditions (d_A = outer diameter of the cable):

Characteristics	Boundary Conditions
Bending radius for single bend	≥ 80 mm (10 x d_A)
Bending radius for repeated bends	≥ 160 mm (20 x d_A)
Permissible temperature range for installation	– 5 °C to + 50 °C
Storage and stationary operating temperature range	– 30 °C to + 65 °C

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5.6 Bus Connectors

Purpose of the Bus Connector

The bus connector is used to connect the PROFIBUS-DP bus cable to the MPI or PROFIBUS-DP interface. In this way, you establish the connection to other nodes.

There are two different bus connectors:

- Bus connector without PG connector

  6ES7972-0BA12-0XA06

  6ES7972-0BA41-0XA0

  6ES7972-0BA50-0XA0

  6ES7972-0BA60-0XA0

  6ES7972-0BA30-0XA0

- Bus connector with PG connector

  6ES7972-0BB12-0XA0

  6ES7972-0BB41-0XA0

  6ES7972-0BB50-0XA0

  6ES7972-0BB60-0XA0

Appearance (6ES7972-0B.20 ...)

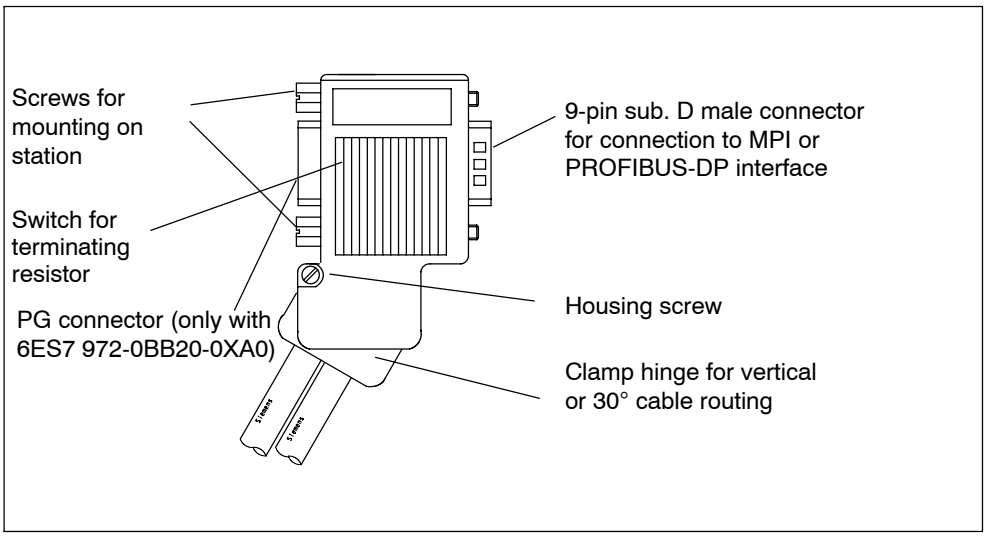

Figure 5-11 Bus connector

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Connecting Bus Cables to Bus Connectors (6ES7972-0B.20 ...)

For detailed information on how to connect a bus cable to a bus connector, refer to the *SIMATIC NET Profibus Networks* manual.

Connecting the Bus Connector

To connect the bus connector, proceed as follows:

1. Plug the bus connector into the module.
2. Screw the bus connector into the module.
3. If the bus connector is located at the beginning or end of a segment, you must switch on the terminating resistor.

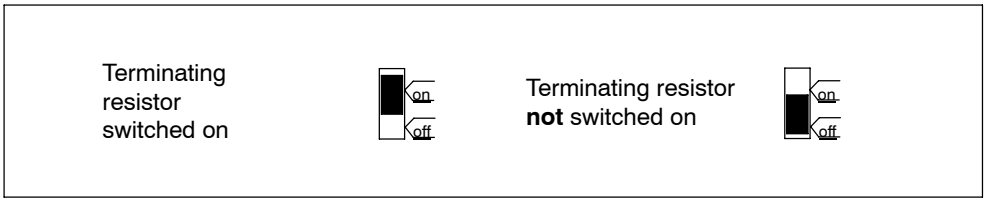

Figure 5-12 Switch on terminating resistant

Ensure that power is always applied to the stations at which the terminating resistor is situated, during startup and operation.

Removing the Bus Connector

With a **looped-through bus cable** you can remove the bus connector from the PROFIBUS-DP interface at any time, without interrupting data traffic on the bus.

Warning

Interference to the data traffic on the bus is possible.

A bus segment must always be terminated with the terminating resistor at both ends. This is not the case, for example, when the last slave with bus connector is not under power. Since the bus connector is powered by the station, the terminating resistor has no effect.

Ensure that the stations at which the terminating resistor is switched on are always under power.

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5.7 RS 485 Repeater / Diagnostics Repeater

Purpose of the Repeater

The RS 485 Repeater / Diagnostics Repeater amplifies data signals on bus cables and couples bus segments.

You need an repeater when:

- More than 32 nodes are connected in the network,
- A grounded segment is to be connected to an ungrounded segment
- The maximum cable length of a segment is exceeded.

Description of the RS 485 Repeater

A detailed description and technical data of the RS 485 repeater can be found in the *Reference Manual Module Specifications*, Chapter 10.

Assembly

You can install the repeater on a 35 mm standard profile rail.

Wiring the Power Supply Unit

To wire the power supply unit of the repeater, proceed as follows:

1. Open the “M” and “PE” screws.
2. Strip the 24 VDC power supply cable.
3. Terminate the cable to “L+” and “M” or “PE”.

Terminal “M5.2”

Terminal “M5.2” should not be wired because it is only needed during maintenance. Terminal “M5.2” is the reference ground you require when measuring the voltage between terminals “A1” and “B1”.

Connecting the PROFIBUS-DP Bus Cable

For detailed information on hwo to connect the PROFIBUS DP bus cable to the RS 485 repeater, refer to the *SIMATIC NET Profibus Networks* manual:

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5.8 PROFIBUS-DP Network with Fiber-Optic Cables

Electrical/Optical Conversion

If you want to use the field bus for larger distances irrespective of the transmission rate, or if the data traffic on the bus is not to be impaired by external interference fields, use fiber-optic cables rather than copper cables.

There are two ways to convert electrical cables to fiber-optic cables:

- PROFIBUS nodes with a PROFIBUS-DP interface (RS 485) are connected to the optical network via an Optical Bus Terminal (OBT) or via the Optical Link Module (OLM).
- PROFIBUS nodes with an integrated fiber-optic cable interface (e.g. ET 200M (IM 153-2 FO), S7-400 (IM 467 FO)) can be directly integrated in the optical network.

How to set up optical networks with the Optical Link Module (OLM) is described in detail in the *SIMATIC NET PROFIBUS Networks* manual. You will find below the most important information on setting up an optical PROFIBUS-DP network with PROFIBUS nodes that have an integrated fiber-optic cable interface.

Benefits and Areas of Application

Fiber-optic cables have the following advantages over electrical cables:

- Electrical isolation of the PROFIBUS-DP components
- Insensitivity to electromagnetic interference (EMC)
- No electromagnetic emission into the environment
- Thus no need for additional grounding and shielding measures
- No adherence to minimum clearances from other cables necessary for EMC
- No need for equipotential bonding conductors
- No need for lightning conductors
- Maximum permissible cable lengths independent of the transmission rate
- Easy installation of the fiber-optic cable connections of the PROFIBUS-DP components by means of standard fiber-optic cable connectors (Simplex connectors)

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Optical PROFIBUS-DP Network in Partyline Topology

The optical PROFIBUS-DP network with nodes that have an integrated fiber-optic cable interface has a **partyline topology**. The PROFIBUS nodes are interconnected in pairs by means of Duplex fiber-optic cables.

Up to 32 PROFIBUS nodes with a fiber-optic cable interface can be series-connected in an optical PROFIBUS-DP network. If a PROFIBUS node fails, as a result of the partyline topology none of the downstream DP slaves can be accessed by the DP master.

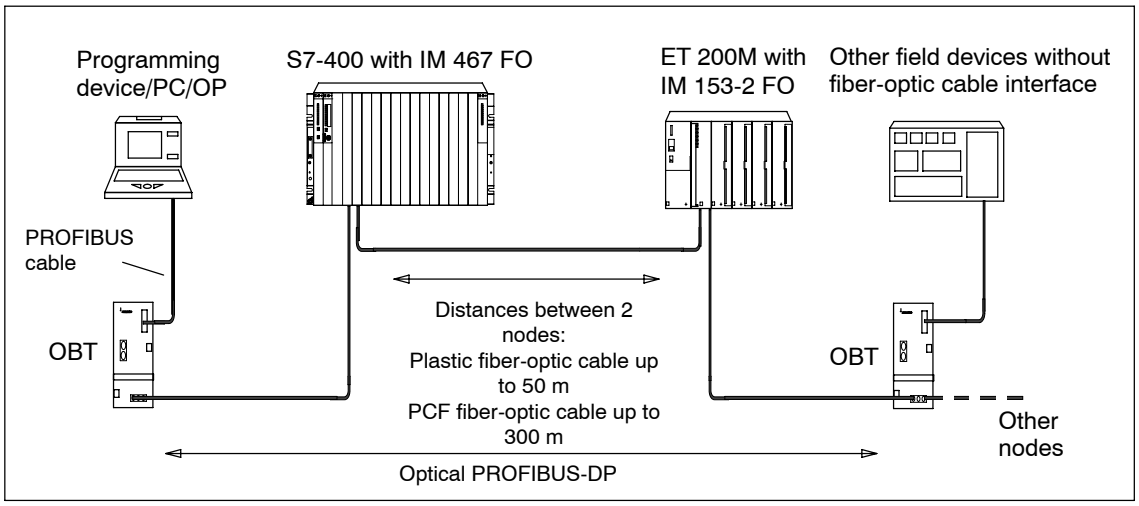

Figure 5-13 Optical PROFIBUS-DP Network with Nodes that have an Integrated Fiber-Optic Cable Interface

Transmission Rate

The following transmission rates are possible when the optical PROFIBUS-DP network is operated with a partyline topology:

- 9.6 kbps
- 19.2 kbps
- 45.45 kbps
- 93.75 kbps
- 187.5 kbps
- 500 kbps
- 1.5 Mbps
- 12 Mbps

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PROFIBUS Optical Bus Terminal (OBT)

A PROFIBUS node can be connected to the optical PROFIBUS-DP network via a PROFIBUS Optical Bus Terminal (OBT) (6GK1 500-3AA00) without an integrated fiber-optic cable interface (e.g. programming devices (PGs) or operator panels (OPs), see Figure 5-13).

The programming device/PC is connected to the RS 485 interface of the OBT by means of the PROFIBUS cable. The OBT is integrated in the optical PROFIBUS-DP line by means of its fiber-optic cable interface.

5.8.1 Fiber-Optic Cables

Features of the Fiber-Optic Cables

Use Siemens plastic and PCF fiber-optic cables with the following features:

Table 5-4 Features of the Fiber-Optic Cables

Description	SIMATIC NET PROFIBUS		
	Plastic Fiber-Optic Duplex Conductor	**Plastic Fiber-Optic Standard Cable**	**PCF Fiber-Optic Standard Cable**
Standard designation	I-VY2P 980/1000 150A	I-VY4Y2P 980/1000 60A	I-VY2K 200/230 10A17+8B20
Field of application	Indoors with a low mechanical load, such as laboratory test assemblies or in cabinets: Cable lengths up to 50 m	Indoor applications: Cable lengths up to 50 m	Indoor applications: Cable lengths up to 300 m
Fiber type	Step-index fiber		
Core diameter	980 µm		200 µm
Core material	Polymethyl methacrylate (PMMA)		Quartz glass
Cladding outer diameter	1000 µm		230 µm
Cladding material	Fluorinated special polymer		
Inner sheath • Material • Color • Diameter	 PVC Gray 2.2 ± 0.01 mm	 PA Black and orange 2.2 ± 0.01 mm	 – (Without inner sheath)
Outer sheath • Material • Color	 –	 PVC Purple	 PVC Purple
Number of fibers	2		
Attenuation at wavelength	≤ 230 dB/km 660 nm		≤ 10 dB/km 660 nm

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Table 5-4 Features of the Fiber-Optic Cables, continued

Description	SIMATIC NET PROFIBUS		
	Plastic Fiber-Optic Duplex Conductor	**Plastic Fiber-Optic Standard Cable**	**PCF Fiber-Optic Standard Cable**
Cable grip	-	Kevlar fibers	Kevlar fibers
Maximum permissible tensile force			
• Short-term	≤ 50 N	≤ 100 N	≤ 500 N
• Continuous	Not suitable for continuous tensile load	Not suitable for continuous tensile load	≤ 100 N (At cable grip only, ≤ 50 N at connector or single conductor)
Resistance to lateral pressure per 10 cm cable length (short-term)	≤ 35 N/ 10 cm	≤ 100 N/ 10 cm	≤ 750 N/ 10 cm
Bend radius			
• Single bend (without tensile force)	≥ 30 mm	≥ 100 mm	≥ 75 mm
• Multiple bends (with tensile force)	≥ 50 mm (flat side only)	≥ 150 mm	≥ 75 mm
Permissible environmental conditions			
• Transport/storage temperature	–30 °C to +70 °C	–30 °C to +70 °C	–30 °C to +70 °C
• Laying temperature	0 °C to +50 °C	0 °C to +50 °C	–5 °C to +50 °C
• Operating temperature	–30 °C to +70 °C	–30 °C to +70 °C	–20 °C to +70 °C
Resistance against			
• Mineral oil ASTM no. 2, grease or water	Conditional[1])	Conditional[1])	Conditional[1])
• UV radiation	Not UV-resistant	Conditional[1])	Conditional[1])
Flame retardance	Flame retardant in accordance with the VW-1 flame test to UL 1581		
Outer dimensions	2.2 4.4 mm ± 0.01 mm	Diameter: 7.8 ± 0.3 mm	Diameter: 4.7 ± 0.3 mm
Weight	7.8 kg/km	65 kg/km	22 kg/km

1) Please ask your Siemens contact about specific applications.

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Order Numbers

You can order the fiber-optic cables under the order numbers specified in Table 5-4.

Table 5-5 Order Numbers - Fiber-Optic Cables

Fiber-Optic Cables	Form	Order Number
SIMATIC NET PROFIBUS plastic fiber-optic, duplex conductor I-VY2P 980/1000 150A Plastic fiber-optic cable with 2 conductors and a PVC sheath, without connectors, for use in environments with low mechanical stress (e.g. in a cabinet or for test assemblies in the laboratory)	50 m ring	6XV1821-2AN50
SIMATIC NET PROFIBUS plastic fiber-optic, standard cable I-VY4Y2P 980/1000 160A Robust round cable with 2 plastic fiber-optic cable conductors, PVC outer sheath and PA inner sheath, without connectors, for use indoors	per meter 50 m ring 100 m ring	6XV1821-0AH10 6XV1821-0AN50 6XV1821-0AT10
SIMATIC NET PROFIBUS PCF fiber-optic, standard cable I-VY2K 200/230 10A17 + 8B20 PCF fiber-optic cable with 2 conductors, PVC outer sheath, fitted with 4 Simplex connectors, whip length 30 cm each, for distances up to 300 m (Other lengths on request)	50 m 75 m 100 m 150 m 200 m 250 m 300 m	6XV1821-1CN50 6XV1821-1CN75 6XV1821-1CT10 6XV1821-1CT15 6XV1821-1CT20 6XV1821-1CT25 6XV1821-1CT30

5.8.2 Simplex Connectors and Connector Adapter

Definition

Simplex connectors allow you to connect the fiber-optic cable to the integrated fiber-optic cable interface on the PROFIBUS device. In some modules (e.g. IM 153-2 FO, IM 467 FO) two Simplex connectors (one for the sender and one for the receiver) are inserted in the module by means of a special connector adapter.

Prerequisite

The PROFIBUS device must be equipped with a fiber-optic cable interface, such as the ET 200M (IM153-2 FO) or the IM 467 FO for S7-400.

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Structure

Two Simplex connectors (a sender and a receiver) and a connector adapter with the following attributes are required for a fiber-optic cable connection:

- Degree of protection IP20
  protection
- Transmission rate 9.6 kbps to 12 Mbps

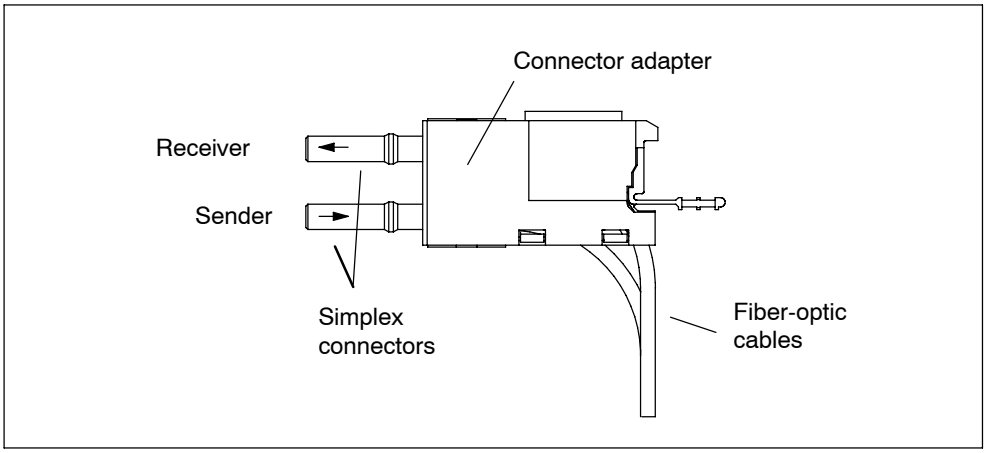

Figure 5-14 Simplex Connectors and a Special Connector Adapter for the IM 153-2 FO and IM 467 FO (installed)

Order Numbers

You can order Simplex connectors and connector adapters unjdedr the following order numbers:

Table 5-6 Order Numbers - Simplex connectors and connector adapters

Accessories	Order Number
SIMATIC NET PROFIBUS plastic fiber-optic Simplex connector/polishing set 100 Simplex connectors and 5 polishing sets for fitting SIMATIC NET PROFIBUS plastic fiber-optic cables with connectors	6GK1901-0FB00-0AA0
Connector adapters Pack of 50 for fitting plastic Simplex connectors with the IM 467 FO and the IM 153-2 FO	6ES7195-1BE00-0XA0

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5.8.3 Connecting a Fiber-Optic Cable to the PROFIBUS Device

Cable Lengths

With fiber-optic cables, the length of the cable segment **does not depend** on the transmission rate.

Each bus node in the optical PROFIBUS-DP network has repeater functionality. The distances specified below are the distances between two neighboring PROFIBUS nodes in the partyline topology.

The maximum cable length between two PROFIBUS nodes depends on the type of the fiber-optic cable used.

Table 5-7 Permissible Cable Lengths on the Optical PROFIBUS-DP Network (Partyline Topology)

SIMATIC NET PROFIBUS Fiber-Optic Cable	Maximum cable Lengths Between Two Nodes (in m)	Projected for 1 Network (= 32 nodes) (in m)
Plastic fiber-optic duplex conductor	50	1.550
Plastic fiber-optic standard cable	50	1.550
PCF fiber-optic standard cable	300	9.300

Mixed Use of Plastic Fiber-Optic and PCF Fiber-Optic Cable

To gain the maximum benefit from the different cable lengths you can mix the plastic and PCF fiber-optic cables.

For example, you can use plastic fiber-optic cable for connections between DP slaves locally (distances $<$50 m) and PCF fiber-optic cable for the connection between the DP master and the first DP slave in the partyline topology (distance $>$50 m).

Laying PCF Fiber-Optic Cable

You can order PCF fiber-optic cables fitted with 2x2 connectors in specific lengths from Siemens.

Lengths and order numbers: See Table 5-5

Laying Plastic Fiber-Optic Cable

You can easily fit connectors to and install plastic fiber-optic cables yourself. Please read the following information on how to do this and on the rules for laying the cable.

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Installation Instructions for Plastic Fiber-Optic Cable (with Photos)

Here you will find detailed installation instructions and a series of photographs on fitting plastic fiber-optic cables with Simplex connectors:

- In the appendix of the *SIMATIC NET PROFIBUS Networks* manual
- On the Internet
  - German: http://www.ad.siemens.de/csi/net
  - English: http://www.ad.siemens.de/csi_e/net

  Click SEARCH on this page, enter the number “574203” under “Entry-ID” and start the search function.
- Enclosed with the Simplex connector/polishing set

Title: *Assembly instructions for SIMATIC NET PROFIBUS Plastic Fiber Optics with Simplex connectors*

Rules for Laying Cable

When you lay plastic fiber-optic cable, please adhere to the following rules:

- Use only the Siemens fiber-optic cables specified in Section 5.8.1
- Never exceed the maximum permissible stresses (tensile load, crushing, etc.) of the cable you are using specified in Table 5-4. Impermissible crushing can occur, for example, when screw clamps are used to fix the cable in place.
- Follow the steps specified in the installation instructions, and use only the tools specified there. Grind and polish the fiber ends carefully.

Note

Polishing the fiber ends of the fiber-optic cable, as described in the installation instructions, reduces attenuation by 2 dB.

- Grind and polish by pressing the connector only lightly against the abrasive paper or polishing foil in order to prevent the connector fusing with the fiber.
- Ensure that you maintain the bend radii specified in Table 5-4 during grinding and polishing, particularly when cables are supported for mechanical strain relief. In this case, ensure an adequate whip length.
- Ensure that there are no loops when cables are cut to length. Under tensile load, loops can cause kinks to form in the cable and thus damage it.
- Ensure that the outer and conductor sheathing of the cable and the fibers are not damaged. Scoring and scratches can let light escape and thus lead to higher attenuation values and line failure.
- Never insert dirty connectors or connectors with protruding fibers in the device sockets. This can destroy the optical sending and receiving elements.

Installing the Connector Adapter

The installation of the cut fiber-optic cable with connector on the PROFIBUS devices is module-specific, and it is therefore described in the manual for the PROFIBUS device with an integrated fiber-optic cable interface.

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Commissioning

6

Chapter Overview

Section	Description	Page
6.1	Recommended Procedure for First Startup	6-2
6.2	Checks Prior to Switching On for the First Time	6-3
6.3	Connecting a Programming Device (PG) to an S7-400	6-5
6.4	Switching On an S7-400 for the First Time	6-6
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6.6	Cold, Warm, and Hot Restarts with the Mode Selector Switch	6-10
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6.8	Inserting a Backup Battery (Option)	6-13
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6.10	Installing Interface Submodules (CPU 414-3, 414-3, 416-3, 417-4 and 417-4H)	6–18

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6.1 Recommended Procedure for First Startup

Recommended Procedure

Due to the modular assembly and the many expansion options, an S7-400 can be very extensive and complex. A first startup of an S7-400 with two or more racks and all modules inserted is therefore not advisable. Instead, a startup in stages is recommended.

When commissioning an H system, you should first start up each subsystem separately, as described in this chapter, before connecting both subsystems together to form a complete system.

The following procedure is recommended for the first startup of an S7-400:

1. Carry out the checks listed in Table 6-1.
2. First start the CR with the power supply module and CPU inserted (see Section 6.4). If you are installing an S7-400 in a segmented rack, you must insert both CPUs for the preliminary commissioning phase.

   Check the LED indicators on the two modules. The meanings of these LED indicators can be found in the *Reference Manual Module Specifications*, Chapter 3 and in the reference manual *CPU Data*.
3. Insert additional modules in the CR, one at a time, and start them up one at a time.
4. If required, connect the CR to ERs by inserting one or more send IMs in the CR and the matching receive IM in the ER.

   In the case of ERs with their own power supply modules, switch them on first and then the power supply module of the CR.
5. Insert additional modules in the ERs one at a time and start them up one after the other.

How to Proceed in the Case of an Error

If an error occurs, you can proceed as follows:

- Check your system by means of the checklist in Section 6.2.
- Check the LED indicators on the modules. Meanings of these indicators can be found in the chapters containing the descriptions of the relevant modules.
- If necessary, remove individual modules to locate faults.

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6.2 Checks Prior to Switching On for the First Time

Checks Prior to Switching On for the First Time

After installing and wiring your S7-400, it is advisable to check the steps carried out so far, before switching on for the first time.

Table 6-1 contains a guide in the form of a checklist for your S7-400, and refers to the chapters containing additional information on the subject.

Table 6-1 Checklist to be Used Before Switching On for the First Time

Points to be Checked	See Installation Manual Chapter	See Reference Manual "Module Specification" Chapter	See Reference Manual "CPU Data" Chapter
Racks			
Are the racks secured on the wall, in the frame or cabinet?	2		
Have the necessary clearances been allowed?	2		
Are cable ducts or fan subassemblies correctly installed?	2		
Is the ventilation in order?	2		
Grounding and Chassis Ground Concept			
Is there a low-impedance connection (large surface, large-area contact) to the chassis ground?	2		
On all racks, is the connection between reference ground and chassis ground correct (metallic connection or ungrounded operation?)	4		
Are all grounds of the non-isolated ded modules and the grounds of the load current power supplies connected to the reference points?	2		
Mounting and Wiring Modules			
Are all modules correctly inserted and screwed on?	2		
Are all front connectors correctly wired, plugged into the right modules, and screwed on?	4		
Are any necessary cable ducts or fan subassemblies fitted correctly?	2		

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Table 6-1 Checklist to be Used Before Switching On for the First Time, continued

Module Settings			
Is the CPU mode switch set to STOP?	6		1
Are the numbers of the racks correctly set on the coding switches of the receive IMs and not duplicated?		7	
If measuring range modules are fitted on the analog input modules, are they correctly set?		5, 6	
Have the rules for connection been observed?	2		
Have the correct cables been used for connections to existing ERs?	2, 4	7	
Is the last receive IM of each connection chain terminated with the right terminator?		7	
Power Supply Module			
Is the power supply connector correctly wired?	4		
On AC PS modules, is the voltage selector switch set to the available line voltage?	4	3	
On fan subassemblies, is the voltage selector switch set to the available line voltage?	4	9	
Are all power supply modules switched off (Standby switch set to ⏻)?		3	
Is the BATT INDIC switch for battery monitoring correctly set (see Table 6-2)?		3	
Has the connection to the supply been made?			
Line Voltage			
Is the available line voltage correct?		3	

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According to the backup concept, Table 6-2 shows how you must set the battery monitoring switch on the different power supply modules.

Table 6-2 Setting the Battery Monitoring Switch

If You ...	...Then
do not use battery monitoring,	set the BATT INDIC switch to OFF.
use battery monitoring with a single-width power supply module,	set the BATT INDIC switch to BATT.
want to monitor a backup battery with a double or triple-width power supply module,	set the BATT INDIC switch to 1BATT.
want to monitor two backup batteries with a double or triple-width power supply module,	set the BATT INDIC switch to 2BATT.

6.3 Connecting a Programming Device (PG) to an S7-400

Connecting a Programming Device (PG) to an S7-400

You must connect the programming device via a connecting cable to the MPI of the CPU. This allows access via the communication bus to all CPUs and programmable modules.

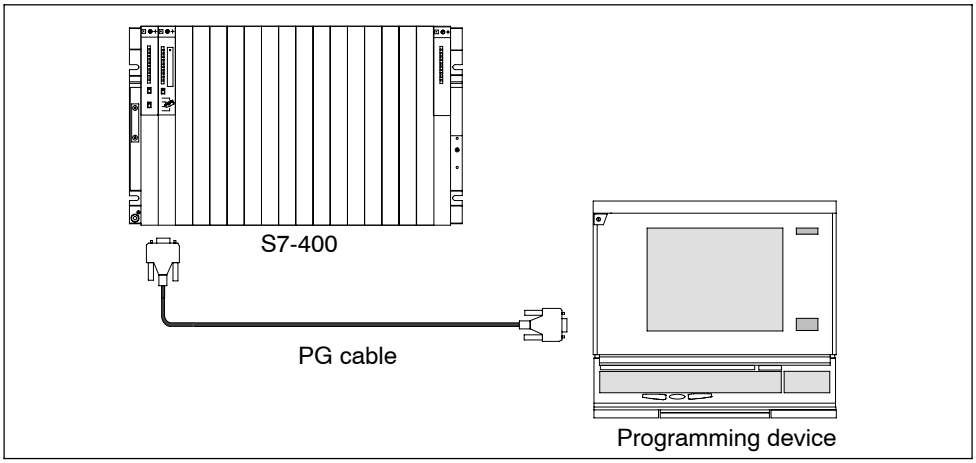

Figure 6-1 Connecting PG to an S7-400

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Communication between Programming Device and CPU

The following conditions apply when communicating between a programming device and a CPU:

- You need a programming device with STEP 7.
- The CPU can communicate with the programming device in the following modes: RUN, STOP, STARTUP, and HOLD.

Operator Control

A description of operator control of communication between CPUs and programming devices can be found in the STEP 7 manuals.

6.4 Switching On an S7-400 for the First Time

Switching On an S7-400 for the First Time

First switch on the power cutout.

Then set the standby switch of the power supply module from the standby setting to the **I** setting (output voltages at rated value).

Result:

- On the power supply module, the green 5 VDC and 24 VDC LEDs light up.
- On the CPU
  - The yellow CRST LED lights up;
  - The yellow STOP LED flashes for three seconds at 2 Hz. During this time the CPU automatically executes a reset.
  - The yellow STOP LED lights up after the automatic reset.

If the red BAF LED and one of the yellow LEDs (BATTF or BATT1F or BATT2F) light up on the power supply module, check the backup battery/batteries, the setting of the BATT INDIC switch, or read the section on controls and indicators of the power supply modules in Chapter 3 of the *Reference Manual, Module Specifications*.

Switching On an H System for the First Time

First switch on the master device and then the standby device. In each case, proceed as described above.

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6.5 Resetting the CPU with the Mode Selector Switch

How to Carry Out a Memory Reset

When you reset a CPU, you place the memories of the CPU in a defined initial state. The CPU also initializes its hardware parameters and some of the system program parameters. If you have inserted a Flash card with a user program in the CPU, the CPU transfers the user program and the system parameters stored on the Flash card into the main memory after the memory reset.

When Should a CPU be Reset?

You must reset the CPU:

- Before transferring a new, complete user program to the CPU.
- When the CPU requests a reset. Your recognize this request by slow flashing of the STOP LED at 0.5 Hz.

How to Perform a Memory Reset

There are two ways of resetting the CPU:

- Reset with the mode selector switch
- Reset from the programming device (see STEP 7)

Resetting the CPU with the mode selector is described in the following section.

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Resetting the CPU with the Mode Selector Switch

The mode selector switch is designed as a toggle switch. The following figure shows all positions of the mode selector switch.

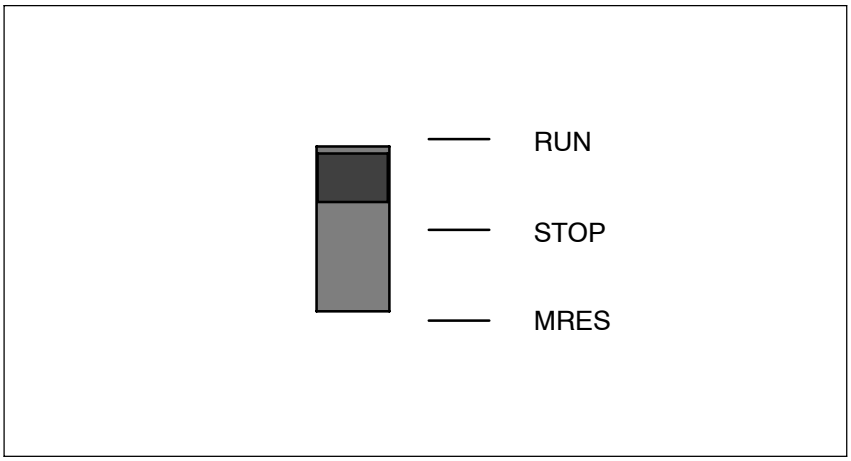

Figure 6-2 Positions of the mode selector switch

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

Case A: You want to transfer a new, complete user program to the CPU.

1. Set the switch to STOP setting.

   Result: The STOP LED lights up.

2. Set the switch to MRES and hold it there.

   Result: The STOP LED is switched off for one second, on for one second, off for one second and then remains on.

3. Turn the switch back to the STOP setting, then to the MRES setting again within the next 3 seconds, and back to STOP.

   Result: The STOP LED flashes for at least 3 seconds at 2 Hz (reset is being executed) and then remains lit.

Case B: The CPU requests a reset by slow flashing of the STOP LED at 0.5 Hz (system reset request, for example, when a memory card has been removed or inserted).

Set the switch to MRES and then back to STOP.

Result: The STOP LED flashes for at least 3 seconds at 2 Hz (reset is being executed) and then remains lit.

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What Happens in the CPU During a Memory Reset

When you carry out a memory reset, the following process occurs in the CPU:

- The CPU deletes the entire user program from the main memory and load memory (integrated RAM and, if applicable, RAM card).
- The CPU clears all counters, bit memory, and timers (except for the time of day).
- The CPU tests its hardware.
- The CPU initializes its hardware and system program parameters, (internal default settings in the CPU). Some programmed default settings will be taken into account.
- If no Flash card is inserted, a reset CPU has a memory utilization level of 0. You can read out the memory utilization level with STEP 7.
- If a Flash card is inserted, the CPU copies the user program and the system parameters stored on the Flash card into the main memory after the reset.

What Remains Following the Memory Reset...

After the CPU has been reset, the following remains:

- The contents of the diagnostic buffer

  The contents can be read out with the programming device using STEP 7.
- Parameters of the MPI (MPI address and highest MPI address). Note the special cases in the section below.
- The time of day
- Status and value of the operating hours counter

Special Case MPI Parameters

The MPI parameters are handled in a special mway during a CPU memory reset. If you haev inserted a Memory Card containing the MPI parameters, the system automatically loads these into the CPU and validates the data.

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6.6 Cold, Warm, and Hot Restarts with the Mode Selector Switch

Restart (warm start)

- A restart resets the process image and the non−retentive flags, timers, times and counters.

  Retentive flags, times and counters retain their last valid value.

  All DBs assigned the “Non Retain” attribute are reset to load values. The remaining DBs retain their last valid value.
- Program execution is restarted at the start position (startup OB or OB 1).
- After a power supply interruption, the warm restart function is only available in backup mode.

Hot restart

- Wihen a hot restart is performed, all data and the process image retain their last valid value.
- Program execution is resumed at the breakpoint.
- The outputs do not change their status until the current cycle is completed.
- After a power supply interruption, the hot restart function is only available in backup mode.

Control sequence for restart (warm restart) / hot restart

1. Set the switch to STOP.

   Result: The STOP LED is lit.
2. Set the switch to RUN.

Whether the CPU executes a restart / hot restart depends on the CPU configuration.

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6.7 Inserting a Memory Card

The Memory Card as Load Memory

You can insert a Memory Card into any S7-400 CPU. This card represents the load memory expansion of the CPU. Depending on the type of memory card, the user program is retained on the memory card even when power is removed.

What Type of Memory Card Should You Use?

There are two types of memory card: RAM cards and Flash cards.

Whether you use a RAM card or a Flash card depends on how you intend to use the memory card.

If You ...	...Then
only intend to expand the integrated load memory of the CPU,	you should use a RAM card.
want to store your user program permanently on the memory card, even with power removed (without backup or outside the CPU),	you should use a Flash card.

Further information on the memory cards can be found in the *CPU Manual*, Chapter 1.

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Inserting a Memory Card

To insert a memory card, follow the steps outlined below:

1. Set the mode selector switch on the CPU to STOP.
2. Insert the memory card in the submodule slot of the CPU and push the memory card in as far as it will go.

   Note the position of the marker dot. You can only insert the memory card in the card slot in the direction shown in Figure 6-3.

   Result: The CPU requests a memory reset by slow flashing of the STOP LED at 0.5 Hz.
3. Perform a memory reset on the CPU by pressing the mode selector switch in MRES position and then resetting it to STOP.

   Result: The STOP LED flashes for at least 3 seconds at 2 Hz (reset is being executed) and then remains lit.

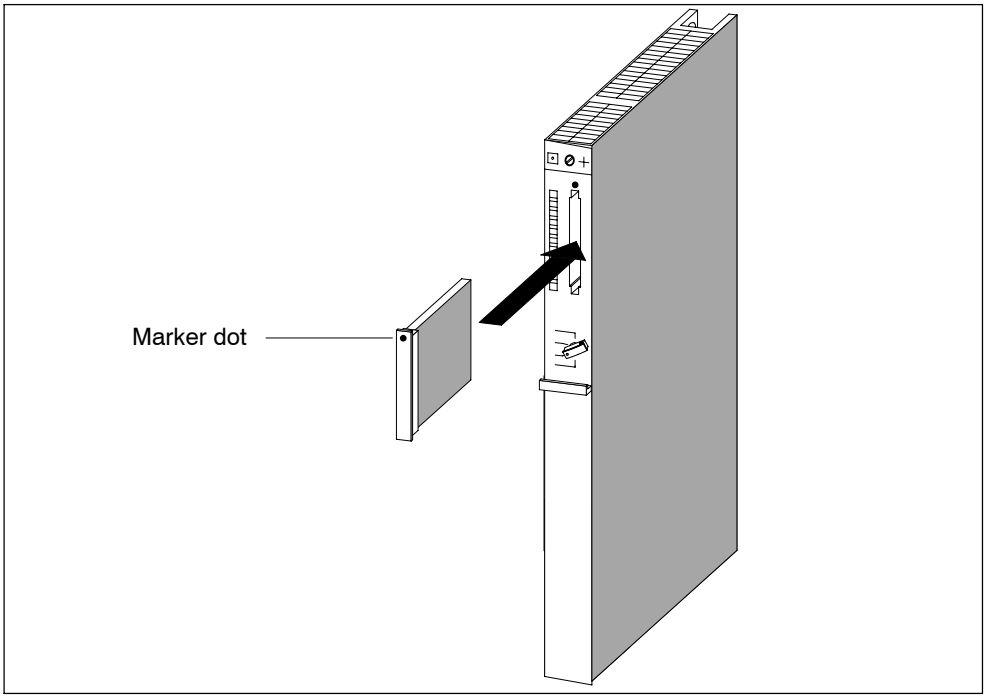

Figure 6-3 Inserting a Memory Card in a CPU

Note

If you insert or remove the memory card with the controller switched on, the CPU inidcates a memory reset request by the slow flashing of the STOP indicator at 0.5 Hz.

If you insert or remove the memory card with the controller switched off, the CPU performs an automatic memory reset after power on.

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6.8 Inserting a Backup Battery (Option)

Backup

Depending on the power supply module, you can use one or two backup batteries:

- To back up a user program and save it without loss in the event of a power failure.
- For retentive storage of bit memory, timers, counters, and system data as well as data in variable data blocks.

You can also provide this backup with an external battery (5 to 15 VDC). You achieve this by connecting the external battery to the EXT. BATT. socket on the CPU (see *Reference Manual*, *CPU Data* Section 1.2). You can also back up modules in an expansion rack via the EXT. BATT socket on the receive IM.

Inserting a Backup Battery

To insert the backup battery (batteries) in the power supply module, proceed as follows:

1. Discharge any static charge by touching a grounded metal part of the S7-400.
2. Open the cover of the power supply module.
3. Insert the backup battery/batteries in the battery compartment.

   Ensure correct polarity of the battery.
4. Switch on battery monitoring with the BATT INDIC slide switch, as shown in the following table.

If You ...	...Then
have a single-width power supply module,	set the BATT INDIC switch to BATT.
have a double or triple-width power supply module and want to monitor a backup battery,	set the BATT INDIC switch to 1BATT.
have a double or triple-width power supply module and want to monitor both backup batteries,	set the BATT INDIC switch to 2BATT.

5. Close the cover.

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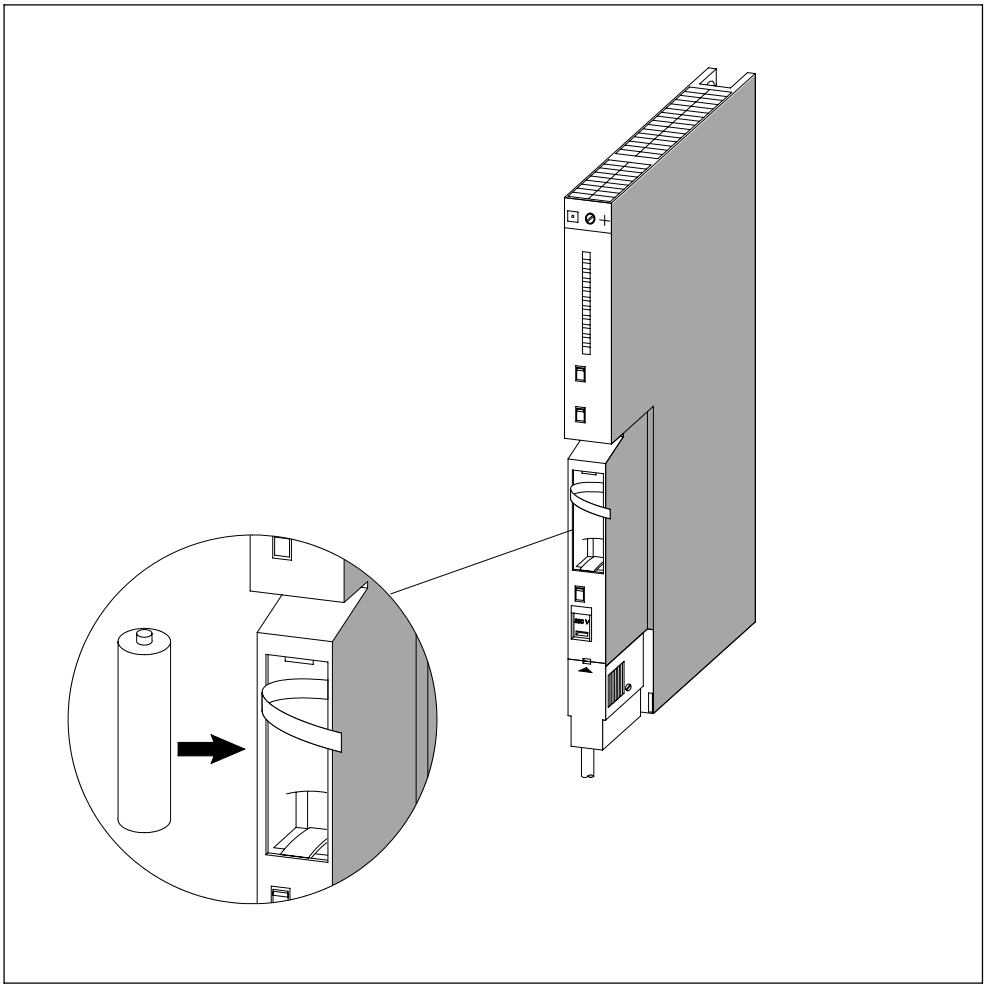
The following figure shows how to insert a backup battery in the single-width power supply module.



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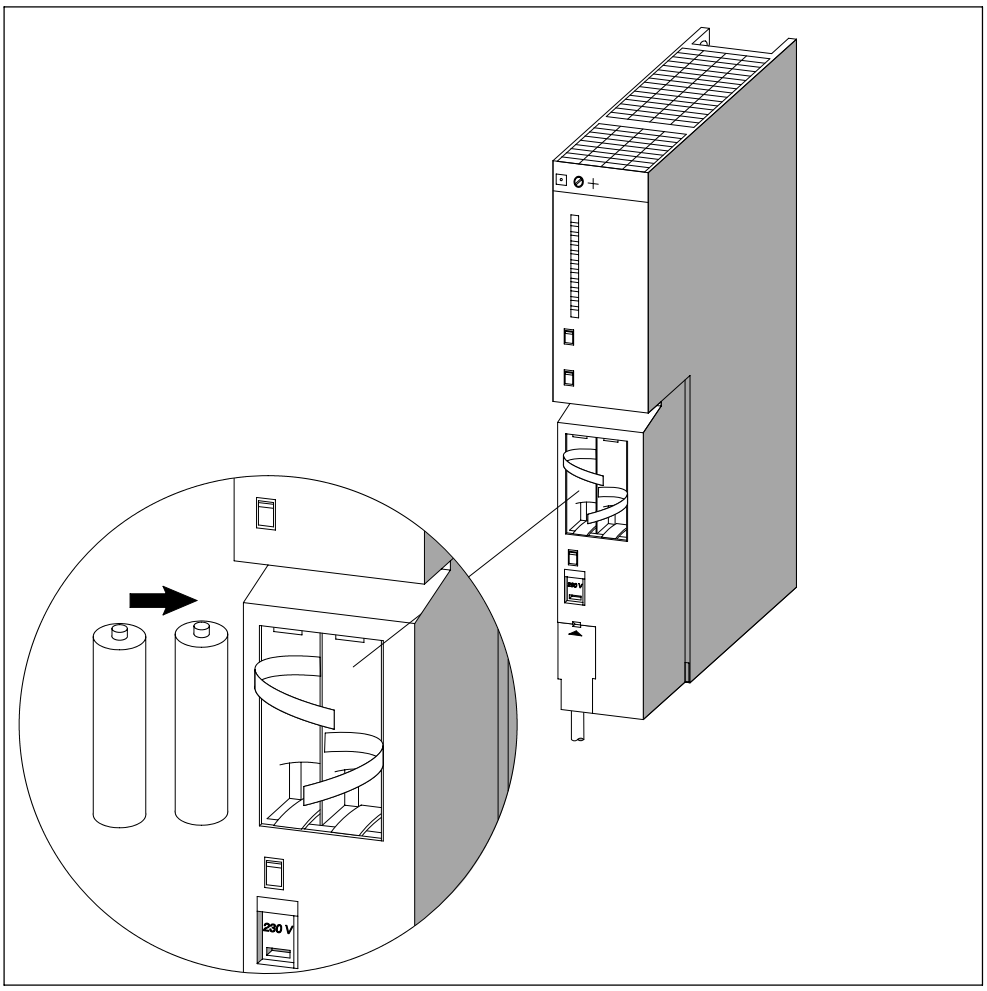
The following figure shows how to insert two backup batteries in a double-width power supply module.



Warning

Hazardous to persons and property, risk of pollutant emission.

A lithium battery can explode if treated incorrectly; improper disposal of old lithium batteries can result in pollutant emission. The following instructions should therefore be observed without fail:

- Do not throw new or discharged batteries into a fire and do not solder onto the cell body (max. temperature 100° C). Do not recharge, there is a risk of explosion. Do not open the battery, and only replace it with one of the same type. Obtain the replacement via Siemens (see the *Reference Manual*, *Module specifications* appendix C for the order number). This will ensure that you have a short-circuit protected type.
- Old batteries should be disposed of with battery manufacturers/recyclers if possible, or as hazardous waste.

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Reducing the Passivation Layer

Lithium batteries (lithium/thionyl chloride) are used as backup batteries for the S7-400. In lithium batteries of this technology, a passivation layer can develop after storage for a very long time, and the immediate functional capability of the battery may not be certain. This may result in an error message when the power supply module is switched on.

The power supply modules of the S7-400 are capable of reducing the passivation layer of the lithium battery with a defined load on the battery. This process may take some minutes. When the passivation layer has been reduced and the lithium battery has reached its rated voltage, the error message of the power supply module can be acknowledged with the FMR button.

Since the storage time of the lithium battery is not usually known, we recommend the following procedure:

- Insert the backup battery/batteries in the battery compartment.
- Acknowledge any battery error message of the power supply module with the FMR button.
- If the battery error cannot be cleared, try again after a few minutes.
- If the battery error still cannot be cleared, remove the battery/batteries and short-circuit it/them for one to three seconds maximum.
- Reinsert the battery/batteries and try to acknowledge with the FMR button again.
- If the battery error message goes off, the battery/batteries is/are operational.
- If the battery error message does not go off, the battery/batteries is/are discharged.

Removing a Backup Battery

Chapter 7 describes how to remove the backup battery (batteries).

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6.9 Starting Up a PROFIBUS-DP Subnet

Introduction

This section describes the procedure for starting up a PROFIBUS-DP subnet with an S7-400 CPU as the DP master.

Requirements

Before you can start up the PROFIBUS-DP subnet, the following requirements must be met:

- The PROFIBUS-DP subnet has been set up (see Chapter 5).
- With STEP 7, you have configured the PROFIBUS-DP subnet and assigned a PROFIBUS-DP address and the address area to all nodes (see manual *Configuring Hardware and Communication Connections with STEP 7*). Note that for some DP slaves, address switches must also be set (see the reference manuals for the particular DP slaves).

Starting Up

1. Use the programming device to load the configuration of the PROFIBUS-DP subnet created under STEP 7 (preset configuration) in the CPU. This procedure is described in the manual *Configuring Hardware and Communication Connections with STEP 7*.
2. Switch on all DP slaves.
3. Switch the CPU from STOP to RUN.

Behavior of the CPU During Startup

During startup, the CPU compares the preset and actual configurations. You set the duration of the test with STEP 7 in the “Startup” parameter block with the “module time limits” parameter. (See also *Reference Manual*, Chapter 1, the manual *Configuring Hardware and Communication Connections with STEP 7*, and the STEP 7 Online Help).

If the preset configuration = actual configuration, the CPU goes into RUN.

If the preset configuration ≠ actual configuration, the CPU’s reaction depends on the setting of the parameter for “Startup if preset configuration ≠ actual configuration”:

Startup if Preset Config. Actual Config. = Yes (Default)	Startup if Preset Config. ≠ Actual Config. = No
CPU goes into RUN	The CPU remains at STOP and, after the timeset in the “module time limits” parameter, the BUSF LED flashes. Flashing of the BUSF LED indicates that at least one slave will not respond. In this case, check whether all slaves are switched on or display the content of the diagnostic buffer (see *Configuring Hardware and Communication Connections with STEP 7*).

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6.10 Installing Interface Modules (CPU 414-2, 414-3, 416-3, 417-4 and 417-4H)

Available Interface Modules

Note

Only use interface submodules that are explicitly released for use in S7-400 devices.

Installing Interface Modules

Warning

The modules can be damaged.

When inserting or removing interface submodules with power applied, the CPU and interface submodules can be damaged (exception: using synchronization submodules in an H system).

Never insert or remove the interface submodules while power is being supplied (exception: synchronization submodules). Always switch off the power supply before inserting or removing interface submodules.

Caution

Danger of damage to persons and property.
Interface submodules contain electronically-sensitive components that may be damaged if they are touched.
The surface temperatures on the components can reach up to 70^{o} C and there is a risk of burning.
For this reason, you should always hold the interface submodules on the longest sides of the front panel.
Observe the ESD guidelines when installing interface submodules.

To fit an interface submodule in a card slot, follow the steps outlined below:

1. Hold the interface submodule on the long sides of the front plate.
2. Insert the PCB end of the interface submodule in the lower and upper guides of the card slot, as shown in Figure 6-4.

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3. Slowly push the interface submodule into the slot until the front plate rests on the frame of the card slot.
4. Important! Secure the front plate with the two fitted, captive M2.5 x 10 slot-head screws on the left frame of the card slot.

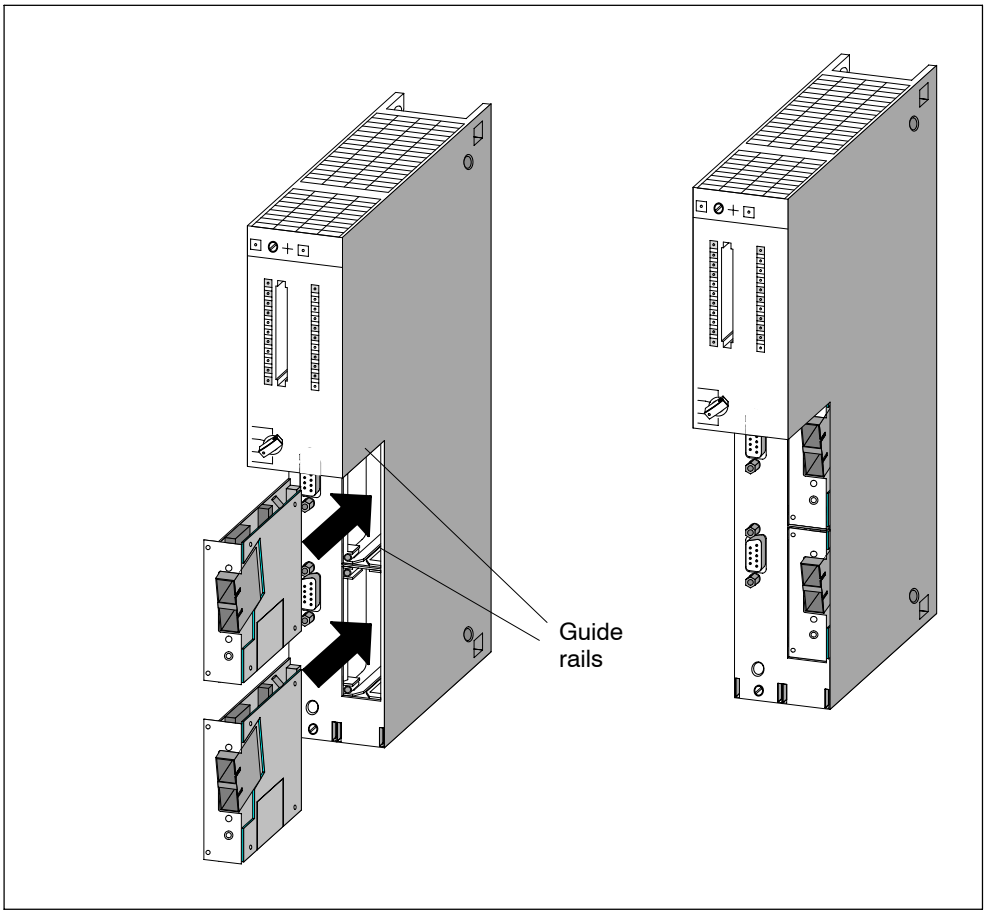

Figure 6-4 Inserting Interface Submodules in the CPU

Covering Unused Submodule Slots

On delivery, all the submodule slots are secured with a submodule cover. The cover is attached to the frame of the card slot with screws.

Leave unused submodule slots secured.

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Maintenance

7

Chapter Overview

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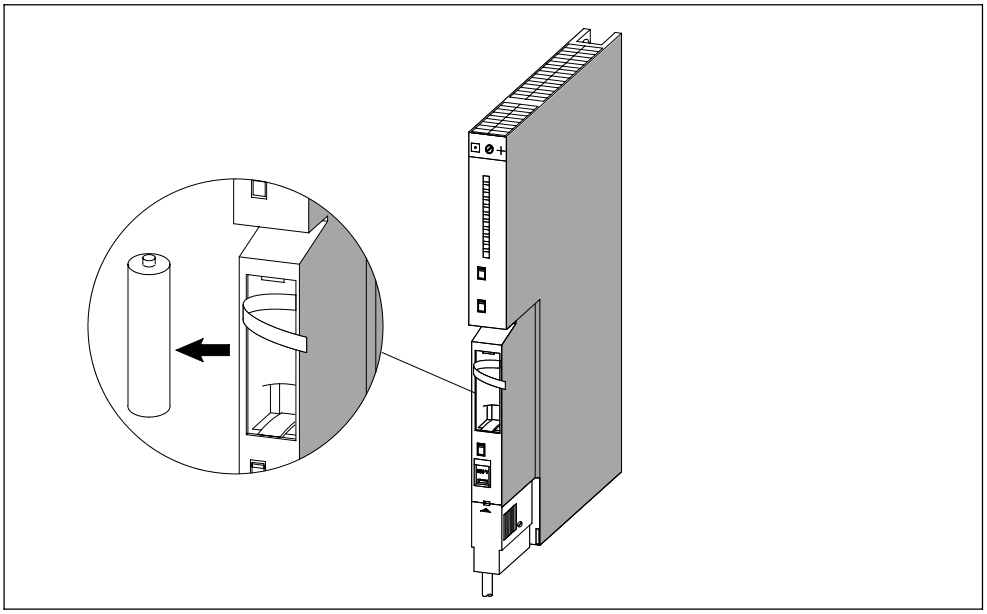
7.1 Replacing the Backup Battery

Replacing the Backup Battery

1. Discharge any static charge by touching a grounded metal part of the S7-400.
2. Open the cover of the power supply module.
3. Using the loop(s), pull the backup battery/batteries out of the battery compartment.



4. Insert the new backup battery/batteries in the battery compartment of the power supply module.

   Ensure correct polarity of the battery/batteries.
5. Switch on battery monitoring with the BATT INDIC slide switch.

If You ...	...Then
have a single-width power supply module,	set the BATT INDIC switch to BATT.
have a double or triple-width power supply module and want to monitor a backup battery,	set the BATT INDIC switch to 1BATT.
have a double or triple-width power supply module and want to monitor both backup batteries,	set the BATT INDIC switch to 2BATT.

6. Press the FMR button.
7. Close the cover of the power supply module.

Note

If you store the batteries for a long period, a passivation layer may form. Please read Section 6.8, Inserting a Backup Battery.

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Using Backup Batteries

You should change the backup battery once a year.

Observe the usual regulations/guidelines for disposing of lithium batteries in your country.

Backup batteries should be stored in a cool, dry place.

Backup batteries can be stored for ten years. If they are stored for a longer period, however, a passivation layer may form.

Rules for the Care of Backup Batteries

You must observe the following rules to avoid hazards in the care of backup batteries:

Warning

Risk of injury, material damage, release of hazardous substances.

Lithium batteries can explode if handled improperly. Their improper disposal may result in the release of hazardous substances. Strictly adhere to the following instructions:

- Do not throw a new or low battery into an open fire and do not perform any soldering work on the cell casing (max. temperature 100 °C). Do not recharge the battery – risk of explosion! Do not open a battery. Replace a faulty battery onoly with the same type. Replacement batteries can be ordered from SIEMENS (for order numbers, refer to the *“Module data” reference manual,* in appendix C). This will insure that your are installing a short circuit-proof type.
- Always try to return low batteries to the manufacturer or deliver these to a registered recycling company.

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7.2 Replacing a Power Supply Module

Slot Numbering

If you have provided the modules in your system with slot numbering, you must remove the number from the old module when replacing it and apply the number to the new module.

Removing the Module (Ignore Steps 1 and 2 When Using Redundant Power Supply Modules)

1. Set the CPU mode switch to STOP.

   When you replace the power supply module in an ER, the CR may remain in the RUN state, depending on CPU programming. You can back up the data in the ER via the EXT. BATT. socket of the receive IM.
2. If you wish to back up the data in the CPU, you can use the EXT. BATT. socket of the CPU (see *Reference Manual*, Chapter 1).
3. Set the standby switch of the power supply module to ⏻ (0 V output voltages).
4. Set the line disconnector to OFF.
5. Remove the cover.
6. Remove the backup battery/batteries if applicable.
7. Disconnect the power supply connector from the power supply module.
8. Loosen the mounting screws of the module.
9. Swing the module out.

Installing a New Module

1. Check the voltage selector switch.
2. Attach the new module of the same type and swing it downwards.
3. Screw the module on.
4. Check that the power disconnector is set to OFF and the standby switch to ⏻ .
5. Plug in the power supply connector at the power supply module.
6. Insert the backup battery/batteries, if applicable.
7. Close the cover.
8. Set the power disconnector to ON.
9. Set the standby switch of the power supply module to I (output voltages at rated value).
10. Set the CPU mode switch to RUN if applicable.

How the S7-400 Behaves after Exchanging Modules

If an error occurs after replacing a module, you can read out the cause of the error from the diagnostic buffer.

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7.3 Replacing CPUs

Slot Numbering

If you have provided the modules in your system with slot numbering, you must remove the number from the old module when replacing it and apply the number to the new module.

Saving the Data

Save the user program including configuration data.

Removing the Module

1. Set the CPU mode switch to STOP.
2. Set the standby switch of the power supply module to ⏻ (0 V output voltages).
3. Remove the cover of the CPU.
4. Disconnect the MPI connector, if applicable.
5. Disconnect the connector at the EXT. BATT. socket, if applicable.
6. Remove the memory card.
7. Loosen the mounting screws of the module.
8. Swing the module out.

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Installing a New Module

1. Attach the new module of the same type and swing it downwards.
2. Screw the module on.
3. If applicable, plug the connector for the external battery supply into the socket.
4. Set the CPU mode switch to STOP.
5. Insert the memory card.
6. Set the standby switch of the power supply module to I (output voltages at rated value).

   The remaining procedure depends on whether you use a Flash card and whether or not you have configured your system for networking.
7. Proceed as follows to operate with a Flash card:

   Transfer the user and configuration data.

   Set the CPU mode switch to RUN.

   Close the cover.
8. If your system is not configured for networking, proceed as follows:

   Transfer the user and configuration data by means of the programming device, via the programming device cable (see Section 6.3).

   Set the CPU mode switch to RUN.

   Close the cover.
9. If your system is configured for networking, proceed as follows:

   Transfer the user and configuration data by means of the programming device, via the programming device cable (see Section 6.3).

   Set up your network by plugging in the MPI connector.

   Set the CPU mode switch to RUN.

   Close the cover.

How the S7-400 Behaves after Exchanging Modules

If an error occurs after replacing a module, you can read out the cause of the error from the diagnostic buffer.

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7.4 Replacing Digital or Analog Modules

Slot Numbering

If you have provided the modules in your system with slot numbering, you must remove the number from the old module when replacing it and apply the number to the new module.

Installing a Module

1. You can replace analog and digital modules in RUN mode. You must have taken the appropriate action in your STEP 7 program to ensure correct responses from your system.

   If you are not sure whether your program will react correctly, set the CPU mode switch to STOP.

Warning

Improper handling of the front connectors can result in injury and damage.

If the front connector is removed and inserted during operation, hazardous voltages of >25 VAC or >60 VDC may be present at the pins of the module.

When such voltages are present at the front connector, modules with power applied may only be replaced by electrical specialists or trained personnel in such a way that the pins of the module are not touched.

2. Loosen the mounting screw of the front connector and pull it off.
3. Loosen the mounting screws of the module.
4. Swing the module out.

Note

In order that the removal and insertion of digital or analog modules can be detected by the CPU, a minimum time of two seconds must elapse between removal and insertion.

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Removing the Front Connector Coding Key

Before fitting the front connector, you must remove (break off) the front part of the coding key, because this part is already fitted in the wired front connector.

Caution

The module can be damaged.

If, for example, you insert a front connector of a digital module in an analog module, the module may be damaged.

Only operate modules with their complete front connector coding key.

Installing a New Module

1. Attach the new module of the same type at the appropriate slot and swing it downwards.
2. Screw the module on with both mounting screws.
3. Fit the front connector.
4. If you have set the CPU to STOP, you must now set it to RUN again.
5. After fitting, each programmable module will be reinitialized by the CPU with parameters.

How the S7-400 Behaves after Exchanging Modules

If an error occurs after replacing a module, you can read out the cause of the error from the diagnostic buffer.

Exchanging the Front Connector

1. Switch off all load power supplies for the module.
2. Loosen the screw of the front connector and pull it off.
3. Remove the labels from the front connector and insert them into the new front connector.
4. Wire the new front connector.
5. Insert the front connector in the module.
6. Screw the front connector on.
7. Switch on the load voltage.

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7.5 Changing the Fuses in the Digital Modules

Modules with Fuses

The following modules have fuses which you can change yourself if they are defective:

- Digital output module SM 422; DO 16 x DC 20–125 V/1,5A (6ES7422-5EH10-0AB0)
- Digital output module SM 422; DO 16 x AC 20-120 V/2A (6ES7422-5EH00-0AB0)
- Digital output module SM 422;DO 8 x AC 120/230 V/5A (6ES7422-1FF00-0AA0)
- Digital output module SM 422;DO 16 x AC 120/230 V/2A (6ES7422-1FH00-0AA0)

Check the Plant

Correct the faults which led to the fuses blowing.

Changing the Fuses

To change the fuses in a digital module, you must remove the front connector from the digital module and remove the module from the rack.

Warning

Improper handling of the digital modules can result in injury and damage.

Hazardous voltages of >25 VAC or >60 VDC may be present below the covers on the right-hand side of the module.

Before you open these covers, ensure that either the front connector for the module is removed or the module is disconnected from the voltage supply.

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Warning

Improper handling of the front connectors can result in injury and damage.

If the front connector is removed and inserted during operation, hazardous voltages of >25 VAC or >60 VDC may be present at the pins of the module.

When such voltages are present at the front connector, modules with power applied may only be replaced by electrical specialists or trained personnel in such a way that the pins of the module are not touched.

To change the fuses:

1. You must have taken the appropriate action in your STEP 7 program to ensure correct responses from your system.

   If you are not sure whether your program will react correctly, set the CPU mode switch to STOP.
2. Loosen the mounting screw of the front connector and pull it off.
3. Loosen the mounting screws of the module.
4. Swing the module out.

Note

In order that the removal and insertion of digital modules can be detected by the CPU, a minimum time of two seconds must elapse between removal and insertion.

5. Remove the covers on the right-hand side of the module by levering them out with a screwdriver.
6. Replace the defective fuses with new fuses of the same type.
7. Place the guides on the covers into the appropriate cutouts in the module casing and close the covers until they click into place.
8. Attach the module onto its slot and swing it down.
9. Screw the module on with both mounting screws.
10. Fit the front connector.
11. If you have switched the CPU to STOP, you must now switch it to RUN again.
12. After fitting, each programmable module will be reinitialized by the CPU with parameters.

How the S7-400 Behaves after Replacing the Fuse

If an error occurs after replacing a fuse, you can read out the cause of the error from the diagnostic buffer.

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7.6 Replacing Interface Modules

Slot Numbering

If you have provided the modules in your system with slot numbering, you must remove the number from the old module when replacing it and apply the number to the new module.

Hot-swapping Modules

Observe the following warning when fitting and removing the interface modules and the corresponding connecting cables.

Caution

Data can be lost or corrupted.

If you remove or insert the interface modules and/or corresponding connecting cables with power applied, data may be lost or corrupted.

Switch off the power supply modules of the CR and ERs on which you are working before carrying out any actions.

Removing Modules / Exchanging Cables

1. If you wish to back up your data in the CPU, you can do this with a backup battery or via an external battery supply at the CPU (see *the CPU Data Reference Manual*, Chapter 1).
2. Set the CPU mode switch to STOP.
3. Set the standby switches of both power supply modules (in the CR and the ER) to ⏻ (0 V output voltages).
4. Remove the cover.
5. Disconnect the connecting cables.
6. Disconnect the terminator, if applicable.
7. Loosen the mounting screws of the module.
8. Swing the module out.

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Installing a New Module

1. Set the number of the rack at receive IMs.
2. Attach the new module of the same type and swing it downwards.
3. Screw the module on.
4. Fit the connecting cables.
5. Plug in the terminator, if applicable.
6. Secure the cover.
7. First switch on the power supply module in the ER.
8. Then switch on the power supply module in the CR.
9. Set the CPU mode switch to RUN mode.

How the S7-400 Behaves after Exchanging Modules

If an error occurs after replacing a module, you can read out the cause of the error from the diagnostic buffer.

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7.7 Replacing the Fuse of the Fan Subassembly

Fuse Type

The fuse of the fan subassembly is a standard 5 x 20 mm cartridge fuse to DIN and not a spare part.

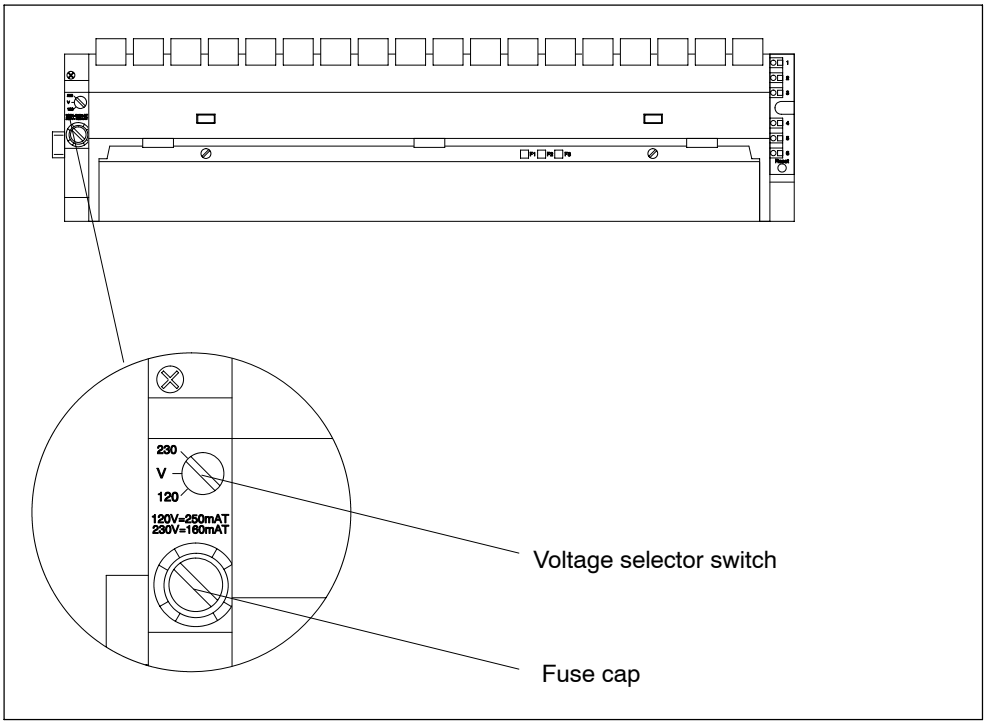
Use the following fuse:

- 160 mA slow blow if the voltage selector switch is set to 230 V
- 250 mA slow blow if the voltage selector switch is set to 120 V

Replacing the Fuse

To replace the fuse of the module, follow the steps outlined below:

1. Disconnect the power cable of the fan subassembly from the supply.
2. Use a screwdriver to unscrew the fuse cap.



3. Remove the blown fuse from the fuse cap.
4. Insert the new fuse in the fuse cap and screw the cap into the fan subassembly.
5. Connect the power cable of the fan subassembly to the supply.

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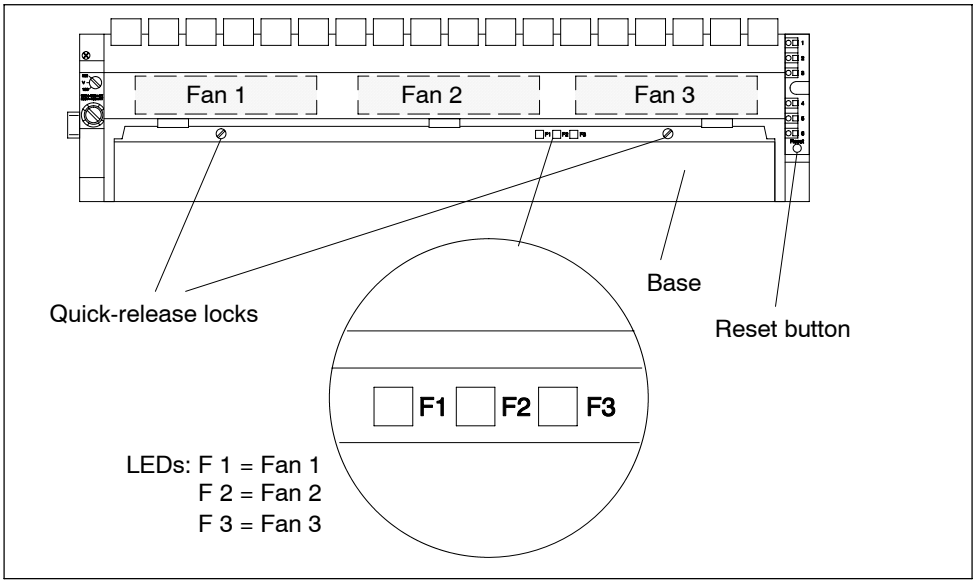
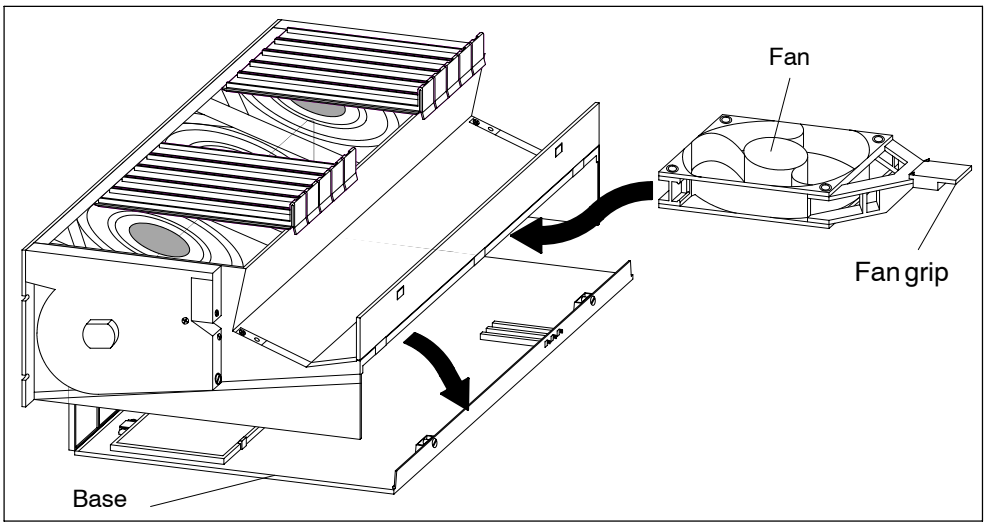
7.8 Replacing Fans in the Fan Subassembly During Operation

Removing the Fans

1. Use a screwdriver to make a quarter turn counter-clockwise and open the two quick-release locks on the front of the fan subassembly.



2. Grasp the base with both hands, press it down slightly and pull it fully out of the fan subassembly.
3. Release the fan to be replaced by pressing the fan grip away from the housing with your thumb.



4. Pull out the fan to be replaced.

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5. Slide the new fan in until it engages.
6. Slide the base in again and press it up.
7. Use a screwdriver to make a quarter turn clockwise and close the two quick-release locks.
8. Use a pointed object to press the RESET button. The fault LED will go off and the fan will start running.

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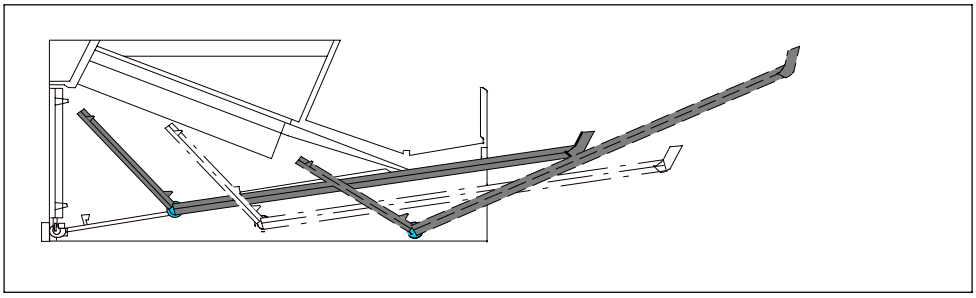
7.9 Replacing the Filter Frame of the Fan Subassembly During Operation

Replacing the Filter Frame

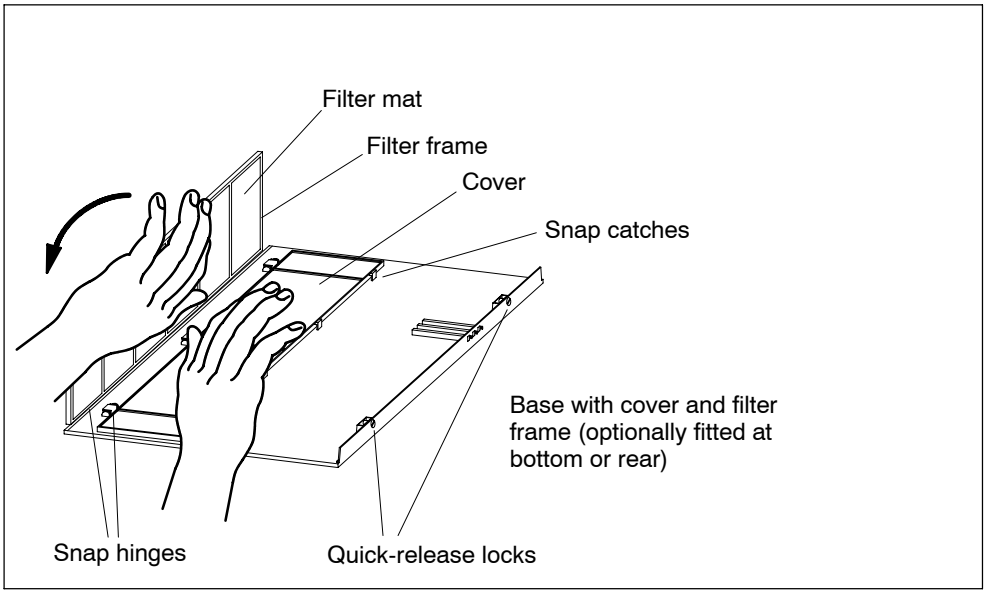
1. Use a screwdriver to make a quarter turn counter-clockwise and open the two quick-release locks on the front of the fan subassembly.
2. Grasp the base with both hands, press it down slightly, pull it first fully forward and then up at an angle out of the fan subassembly.



3. The filter frame is secured either in the bottom of the base or at its rear edge with snap hinges and snap catches. The individual filter mats are joined with the filter frame.

   Remove the filter frame as follows:

   - The filter frame is fitted in the bottom of the base:
     Near the snap catches, press against the filter frame from below and remove the filter frame.
   - The filter frame is secured at the rear edge of the base:
     With the flat of your hand, press the filter frame away from the base of the fan subassembly. This will release the filter frame from the snap hinges.



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4. Fit the new filter frame:
   - Fitting the filter frame at the bottom of the base:
     Insert the filter frame in the snap hinges at the base cutout and engage it with the snap catches.
   - Fitting the filter frame at the rear edge of the base:
     At about a right angle to the base, insert the filter frame in the snap hinges at the rear edge of the base.
5. Slide the base in again and press it up.
6. Use a screwdriver to make a quarter turn clockwise and close the two quick-release locks.
7. Replacing the filter frame will not trigger an interrupt. There is therefore no need to press the RESET button.

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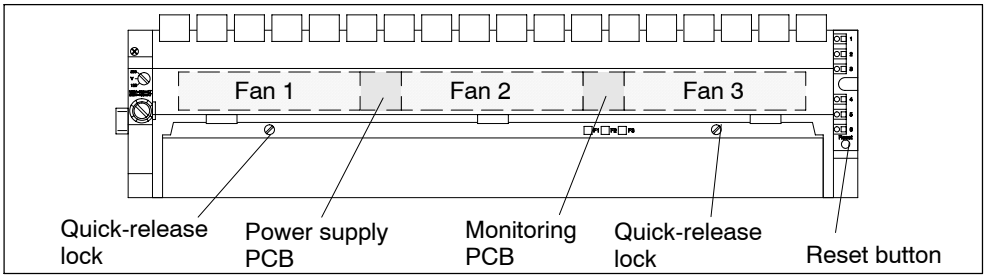
7.10 Replacing the Power Supply PCB and Monitoring PCB of the Fan Subassembly

Exchanging the Mother Board

1. Disconnect the power cable of the fan subassembly from the supply.
2. Use a screwdriver to make a quarter turn counter-clockwise and open the two quick-release locks on the front of the fan subassembly.
3. Remove the base of the fan subassembly (see Section 7.9).

Shown in the following figure is a front view of the fan subassembly. You can also see the locations of the printed-circuit boards (PCBs).



4. Pull the faulty PCB forward and out of the fan subassembly.
5. Slide the new PCB in until it engages.
6. Slide the base in again and press it up.
7. Use a screwdriver to make a quarter turn clockwise and close the two quick-release locks.
8. Connect the power cable of the fan subassembly to the supply.
9. Use a pointed object to press the RESET button. The fans will start running.

Caution

Electronic components can be damaged.

If you do not observe the ESD guidelines when handling printed-circuit boards with electronic components, the components can be damaged by a static discharge.

Observe the ESD guidelines (see Appendix).

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7.11 Replacing Interface Submodules

Available Interface Submodules

Note

Only use interface submodules that are explicitly released for use in S7-400 devices.

Installing Interface Submodules

Warning

The modules can be damaged.

When inserting or removing interface submodules with power applied, the CPU and interface submodules can be damaged (exception: using synchronization submodules in an H system).

Never insert or remove the interface submodules while power is being supplied (exception: synchronization submodules). Always switch off the power supply before inserting or removing interface submodules.

Caution

Danger of damage to persons and property.
Interface submodules contain electronically-sensitive components that may be damaged if they are touched.
The surface temperatures on the components can reach up to 70° C and there is a risk of burning.
For this reason, you should always hold the interface submodules on the longest sides of the front panel.
Observe the ESD guidelines when installing interface submodules.

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You can replace an interface submodule with another one without having to remove the associated CPU from the rack. Follow the steps outlined below:

1. Switch the CPU to STOP (not the synchronization module of a redundant system).
2. Switch off the power supply (not the synchronization module of a redundant system).
3. Loosen the screws of the sub-D-connector and remove all connectors.
4. Loosen the two captive slot-head screws which secure the front plate of the interface submodule to the left frame of the card slot so that the screws can be removed by 6 mm.
5. Carefully remove the interface submodule from the guide support of the card slot (see figure 7-1). Hold the interface module on the long sides of the front plate.

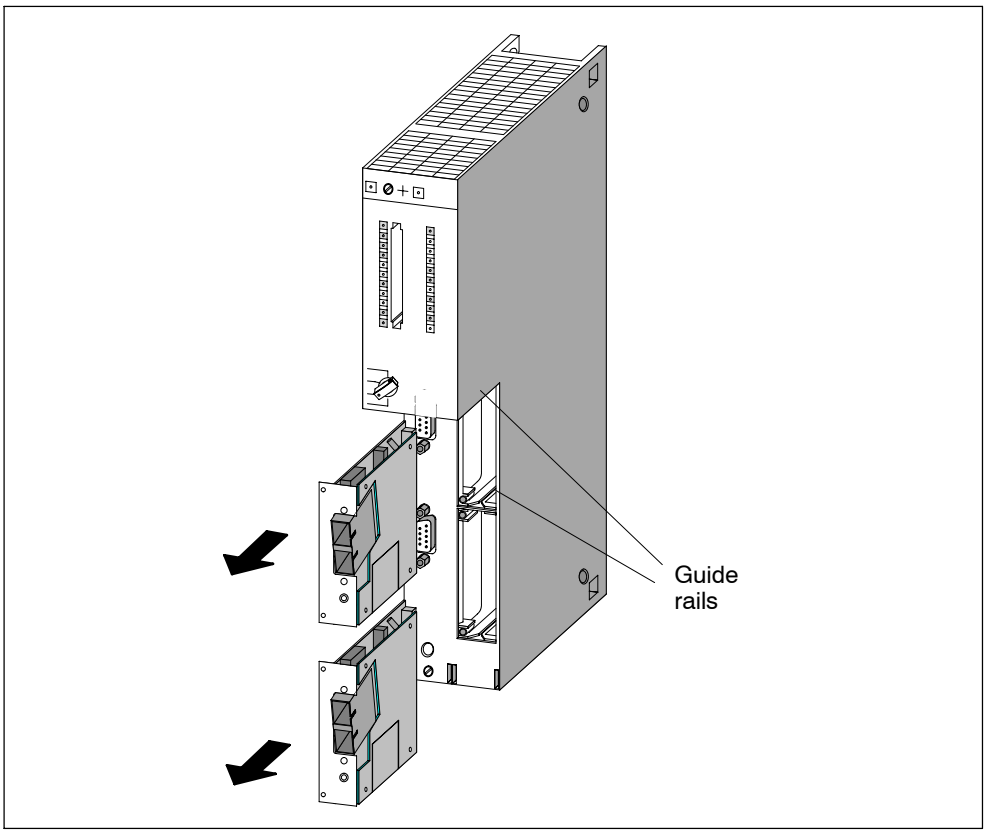

Figure 7-1 Inserting an Interface Submodule in a CPU

Installing Interface Submodules

In order to install an interface submodule, proceed in reverse order. For further information, see section 6.10 ”Installing Interface Submodules”.

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Assembling and Installing Systems

A

Chapter Overview

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A.1 General Rules and Regulations for Operating the S7-400

General Basic Rules

On account of the many possible applications of the S7-400, this chapter can only cover the basic rules for the electrical configuration. You must at least comply with these basic rules to ensure fault-free operation of the S7-400.

Specific Application

Observe the safety and accident prevention regulations applying to specific applications, for example, the Machine Protection Guidelines.

EMERGENCY OFF Devices

EMERGENCY OFF devices complying with IEC 60204-1 (which corresponds to VDE 0113-1) must remain effective in all operating modes of the plant or system.

Reactions of the Plant after Certain Events

The following table shows how you must respond to the reactions of a plant to certain events.

Event	Requirement
Failure of the operating or supply voltage of the S7-400	Hazardous operating states must not occur.
Tripping of the Emergency Off device	Hazardous operating states must not occur.
Restoration of the operating or supply voltage of the S7-400	Hazardous operating states must not occur. No uncontrolled or undefined restart of the system must occur.
Restart after release of the Emergency Off device	Hazardous operating states must not occur. No uncontrolled or undefined restart of the system must occur.

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120/230 VAC Supply

The following table shows which points you must observe when connecting the S7-400 to a 120/230 VAC supply.

With ...	... You Must Ensure ...
buildings	that suitable external lightning protection measures are provided.
supply cables and signal lines	that suitable internal and external lightning protection measures are provided.
stationary equipment and systems without all-pole disconnector	that a supply disconnector (switch) is installed in the building.
load power supplies and power supply modules	that the set line voltage range corresponds to the local line voltage.
all circuits of the S7-400	that fluctuations of line voltage from the rated value are within permissible tolerances (see Technical Data of the modules).
residual-current devices (RCDs)	that the RCD is suitable for the total discharge currents of the power supply module.

24 VDC Supply

The following table shows the points you must observe when connecting the S7-400 to a 24 VDC supply.

With ...	... You Must Ensure ...
buildings	that suitable external lightning protection measures are provided.
24 VDC supply cables and signal lines	that suitable internal and external lightning protection measures are provided.
24 V supply	that the supply voltage produced is an isolated extra-low voltage.
load power supplies	that only isolated load current power supplies are used.

Protection Against External Electrical Effects

The following table shows what you must observe for protection against external electrical effects.

With ...	... You Must Ensure ...
all plants and systems in which the S7-400 is installed	that the plant and all system sections are properly connected to protective ground to discharge electromagnetic interference.
connecting cables and signal lines	that all cables are correctly routed and connected.
signal lines	that an open circuit in a signal line does not place the equipment in an undefined state.

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Protection Against Other Electrical Effects

The following table shows the other external effects against which you must provide protection.

Protection against ...	... by Means of ...
inadvertent actuation of operator controls	a suitable arrangement or covering of keyboard and operator controls or a recessed arrangement of operator controls.
splashing and surging water	suitable protective devices or installation in waterproof housings.
direct solar radiation	suitable shading or installation in appropriately sheltered locations.
mechanical damage	suitable demarcation, protective devices, or installation in rugged housings.

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A.2 Principles of System Installation for EMC

Definition: EMC

EMC (electromagnetic compatibility) describes the capability of electrical apparatus to operate without faults in a given electromagnetic environment, without being affected by the environment and without affecting it in an unacceptable manner.

Introduction

Although the S7-400 and its components were developed for operation in an industrial environment and meet high EMC requirements, you should carry out EMC planning before installing your control system, taking possible interference sources into account and incorporating them in your observations.

Possible Effects of Interference

Electromagnetic interference can affect the programmable controller in different ways:

- Electromagnetic fields which directly affect the system
- Interference picked up via bus signals (PROFIBUS DP, etc.)
- Interference acting via the process wiring
- Interference reaching the system via the power supply and/or protective ground

Figure A-1 shows the possible routes for electromagnetic interference.

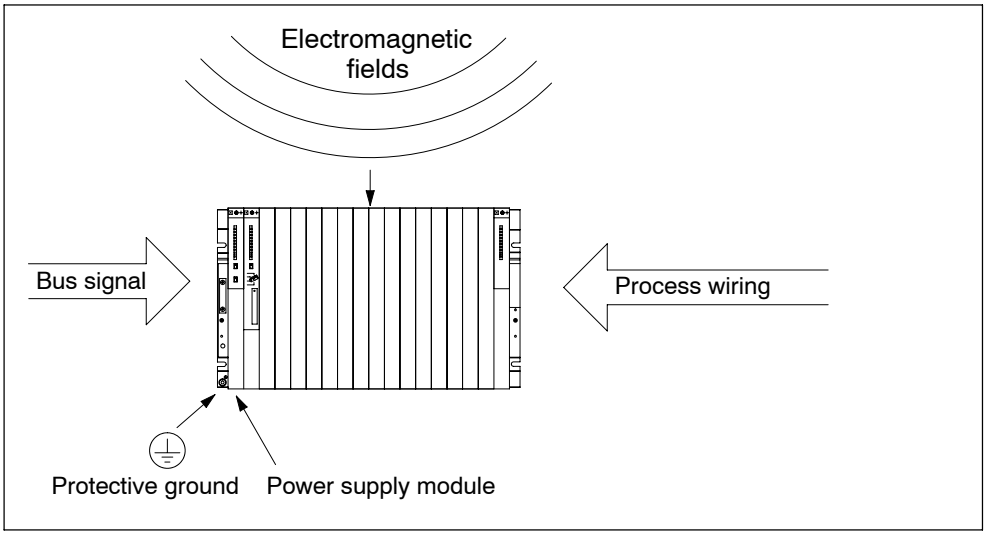

Figure A-1 The Possible Routes for Electromagnetic Interference

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Coupling Mechanisms

Interference can reach the programmable controller via four different coupling mechanisms, depending on the transmission medium (conducted or non-conducted) and distance between interference source and the equipment.

Coupling Mechanism	Cause	Typical Interference Sources
Direct Coupling	Direct or metallic coupling always occurs when two circuits have a common conductor.	• Switched devices (supply affected by inverters and external power supply units) • Motors being started • Different potentials of component cases with a common power supply • Static discharges
Capacitive Coupling	Capacitive or electrical coupling occurs between conductors which are at different potentials. The degree of coupling is proportional to the voltage variation as a function of time.	• Interference pickup via parallel signal cables • Static discharge of the operator • Contactors
Inductive Coupling	Inductive or magnetic coupling occurs between two conductor loops through which current is flowing. Interference voltages are induced by the magnetic fluxes associated with the currents. The degree of coupling is proportional to the current variation as a function of time.	• Transformers, motors, electric welders • Parallel AC supply cables • Cables with switched currents • Signal cables with a high frequency • Unconnected coils
Radiated Interference	There is a radiation path when a conductor is subjected to an electromagnetic wave. Impinging of the wave results in induced currents and voltages.	• Local transmitters (for example, two-way radios) • Spark gaps (spark plugs, collectors of electric motors, welders)

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Five Basic Rules for Ensuring Electromagnetic Compatibility

In many cases, you can ensure electromagnetic compatibility by observing the following five basic rules:

Rule 1: Large Area Grounding

When installing the programmable controllers, provide large-area good quality grounding of the inactive metal parts (see Section A.3).

- Make a large-area low-impedance connection of all inactive metal parts to chassis ground.
- For screw connections on painted or anodized metal parts, either use special contact washers or remove the insulating protective layers from the contact points.
- If possible, do not use aluminum parts for grounding. Aluminum oxidizes easily and is therefore less suitable for grounding.
- Make a central connection between chassis ground and the ground/protective ground conductor system.

Rule 2: Correct Cable Routing

Ensure proper routing of lines when wiring (see Sections A.7 and A.8).

- Arrange the cabling in line groups (AC power cables, power supply cables, signal lines, data lines).
- Always install AC power cables and signal or data lines in separate ducts or bunches.
- Route the signal and data lines as closely as possible to grounded surfaces such as cabinet elements, metal bars and cabinet panels.

Rule 3: Secure Cable Shields

Ensure that cable shields are properly secured (see Section 4.9).

- Only use shielded data lines. The shield must have a large-area connection to ground at each end.
- Analog lines must always be shielded. For the transfer of signals with low amplitudes, it may be advisable to connect the shield to ground at only one end.
- Provide the line shields with a large-area connection to a shield/protective ground bar immediately after the cabinet inlet, and secure the shields with cable clamps. Route the grounded shield as far as the module without interruption, but do not ground it there again.
- There must be a low-impedance connection between shield/protective ground bar and cabinet/housing.
- Use metal or metallized connector cases for shielded data lines.

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Rule 4: Special EMC Measures

Employ special EMC measures for particular applications (see Section 4.11).

- Fit suppressors to all inductors which are not controlled by S7-400 modules.
- Use incandescent bulbs or suppressed fluorescent lamps in the immediate vicinity of your controller for illuminating cabinets or housings.

Rule 5: Standard Reference Potential

Create a standard reference potential; ground all electrical apparatus if possible (see Sections 4.10 and 4.12).

- Install equipotential bonding conductors of sufficient rating when potential differences exist or are expected between sections of your system.
- Use specific grounding measures. Grounding the control system is a protective and functional measure.
- Connect the system sections and cabinets containing central racks and expansion racks to the grounding/protective ground system in a star configuration. This prevents the formation of ground loops.

See also

Cable shielding, page A-13
Cabling outside buildings, page A-19
Cabling inside buildings, page A-17
Mounting of programmable controllers for EMC, page A-9

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A.3 Installation of Programmable Controllers for EMC

Introduction

Measures for suppressing interference are often only applied when the control system is already operational, and the proper reception of a useful signal is found to be impaired.

The cause of such interference is often due to insufficient reference potentials which can be attributed to errors during assembly. This section tells you how to avoid such errors.

Inactive Metal Parts

Inactive parts are all the conductive parts which are electrically isolated from active parts by basic insulation, and can only develop a potential in the event of a fault.

Grounding of Inactive Metal Parts During Installation

When installing the S7-400, ensure large-area grounding of all inactive metal parts. Properly implemented chassis grounding creates a standard reference potential for the control system, and reduces the effects of picked-up interference.

The chassis ground provides the electrical interconnection between all inactive parts. The entirety of all interconnected inactive parts is known as the chassis ground.

Even in the event of a fault, the chassis ground must not develop a dangerous touch potential. It must therefore be connected to the protective ground conductor via an adequate conductor cross-section. To prevent ground loops, locally separated ground elements such as cabinets, structural and machine parts must always be connected to the protective ground system in star configuration.

Ensure the following when chassis grounding:

- Connect the inactive metal parts with the same degree of care as the active parts.
- Ensure low-impedance connections between metal parts, for example, with large-area good quality contact.
- With painted or anodized metal parts, the insulating protective layer must be penetrated or removed at the contact point. Use special contact washers or scratch the layer off fully at the contact point.
- Protect the connection points from corrosion, for example, with suitable grease.
- Use flexible grounding strips to connect movable grounded parts such as cabinet doors. The grounding strips should be short and have a large surface, because the surface is decisive in providing a path to ground for high-frequency interference.

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A.4 Examples of EMC-Compatible Assembly

Introduction

Below you will find two examples of configurations for programmable controllers for EMC.

Example 1: Cabinet Configuration for EMC

Figure A-2 shows a cabinet installation in which the measures described above (grounding of inactive metal parts and connection of cable shields) have been applied. However, this example only applies to grounded operation. Observe the points marked in the figure when installing your system.

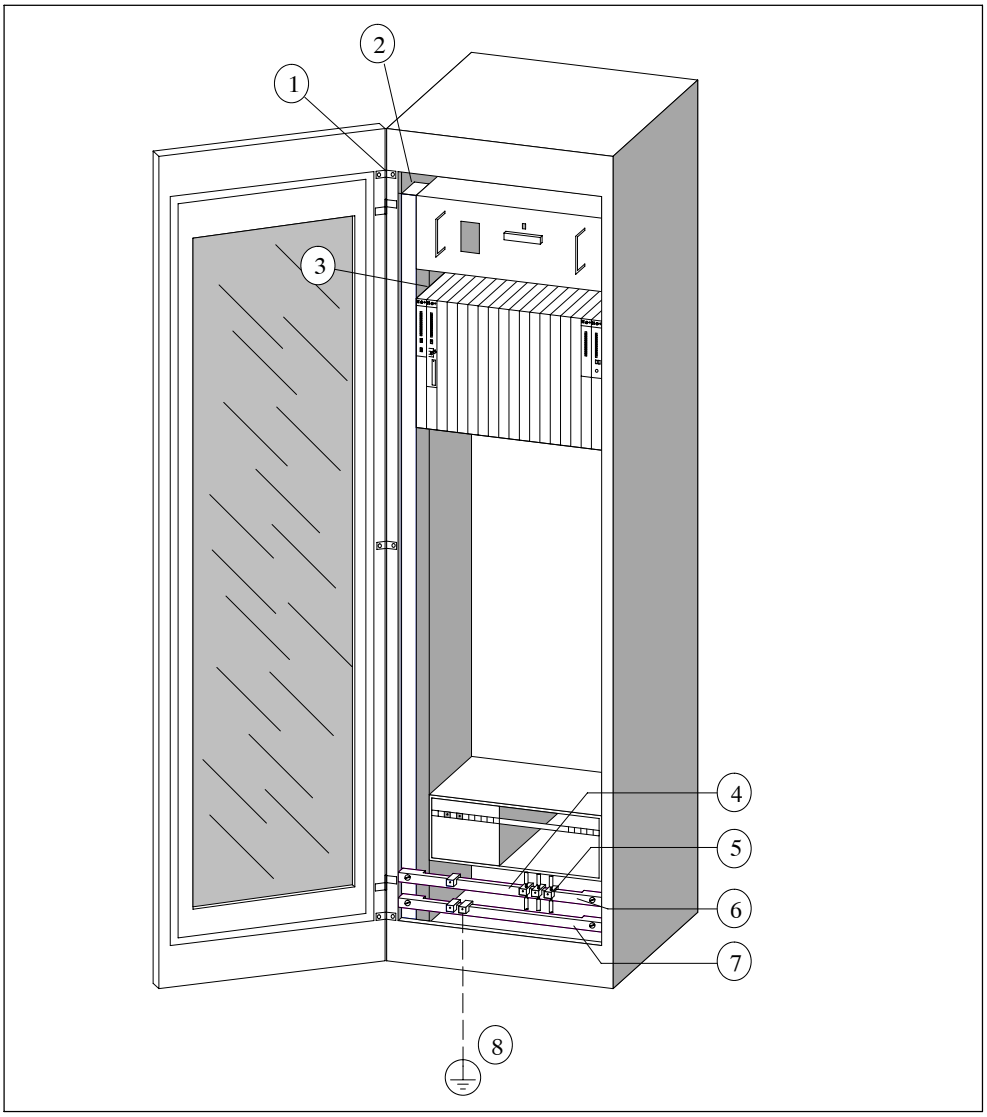

Figure A-2 Example of Cabinet Installation for EMC

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Key for example 1

The numbers in the following list refer to the numbers in Figure A-2.

Table A-1 Key for Example 1

No.	Key	Meaning
1	Grounding strips	If there are no large-area metal-to-metal connections, you must interconnectinactive metal parts such as cabinet doors or support plates via grounding strips or to ground. Use short grounding strips with a large surface.
2	Supporting bars	Connect the supporting bars and the cabinet housing over a large area (metal-to-metal connection).
3	Secure the rack	There must be a large-area metal-to-metal connection between supporting barand rack.
4	Signal lines	Use cable clamps on the protective ground bar or an additional shield bus forlarge-area connection of the shield of signal lines.
5	Cable clamp	The cable clamp must surround the braided shield over a large area and ensuregood quality contact.
6	Shielding bus	Provide a large-area connection between the shield bus and supporting bars (metal-to-metal connection). The cable shields are connected to the shield bus.
7	Protective ground bar	Provide a large-area connection between the protective ground bar and supporting bars (metal-to-metal connection). Connect the protective ground bar to the protective conductor system via a separate conductor (minimum cross-section 10 mm^2).
8	Conductor to the protective conductor system (grounding point)	Provide a large-area connection between the conductor and the protective conductor system (grounding point).

Example 2: EMC-compliant Wall Mounting

If you operate your S7-400 in a low-interference environment in which the permissible ambient conditions are complied with (see the *Module Data reference manual*, Chapter 1), you can mount your S7-400 in frames or on the wall.

Picked-up interference must be given a path to large metal surfaces. You should therefore secure standard mounting channels, shield, and protective ground bars to metal structural elements. For wall mounting in particular, installation on reference potential surfaces made of sheet steel has proved advantageous.

Provide a shield bus for connecting the cable shields if you install shielded cables. The shield bus can simultaneously serve as the protective ground bar.

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Ensure the following for frame and wall mounting:

- Use special contact washers with painted and anodized metal parts, or remove the insulating protective layers.
- Provide large-area, low-impedance metal-to-metal connections when securing the shield/protective ground bar.
- Cover the AC supply conductors in a shockproof arrangement.

Figure A-3 shows an example of wall mounting for EMC

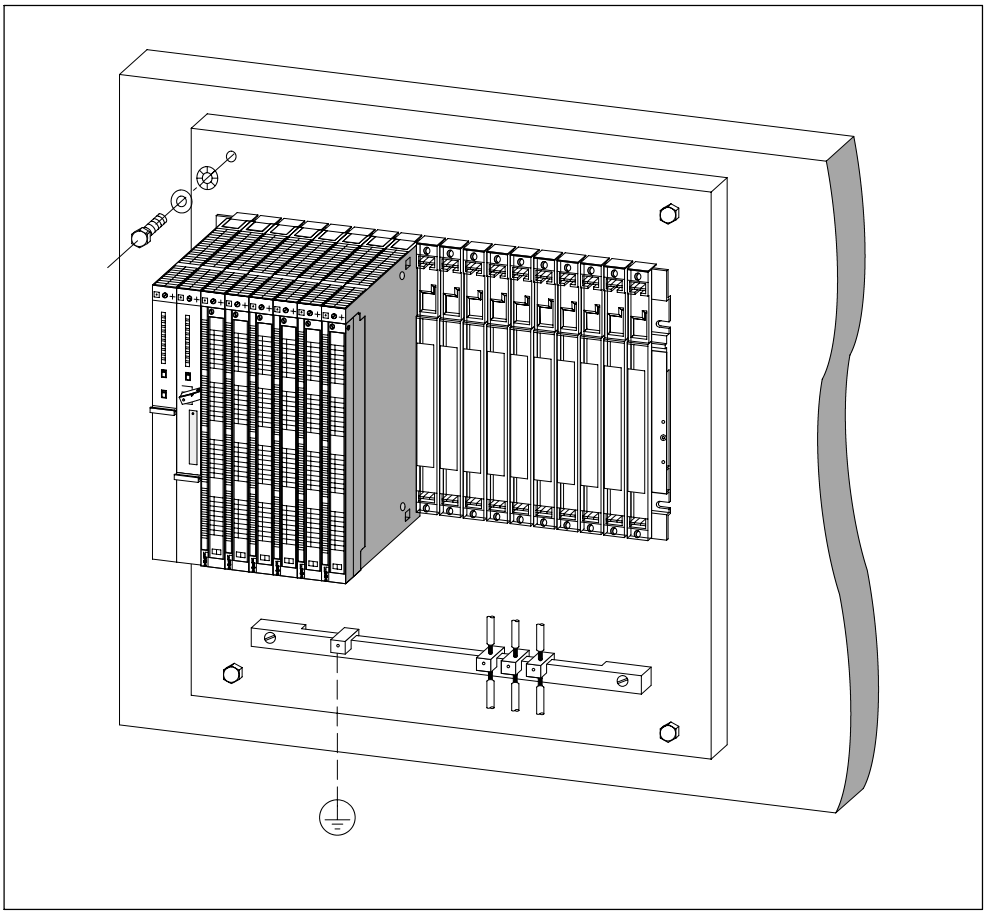

Figure A-3 Wall Mounting an S7-400 for EMC

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A.5 Shielding Cables

Purpose of the Shielding

A cable is shielded to attenuate the effects of magnetic, electrical, and electromagnetic interference on this cable.

Principle of Operation

Interference currents on cable shields are discharged to ground via the shield bus which is electrically connected to the housing. To prevent these interference currents themselves from becoming an interference source, a low-impedance connection to the protective ground conductor is particularly important.

Suitable Cables

If possible, only use cables with a braided shield. The coverage density of the shield should be at least 80%. Avoid cables with a foil shield because the foil can be easily damaged by tensile and compressive stress at the securing points; this can reduce the shielding effect.

Grounding the Cable Shields

Generally, you should always connect both ends of the shield to the chassis ground (that is, at the beginning and end of the cable). Grounding the shields at both ends is essential to achieve a good degA-19A-19A-19A-19ree of suppression of interference in the higher frequency region.

In exceptional cases, you can connect only one end of the shield to the chassis ground (for example, at the beginning or end of the cable). However, you only achieve attenuation of lower frequencies. Single-ended connection of the shield may be advantageous when

- An equipotential bonding conductor cannot be laid
- Analog signals of a few mA or μA are transmitted
- Foil shields (static shields) are used.

For data cables in serial communication, only use metallic or metallized connectors. Secure the shield of the data cable to the connector housing. Do not connect the shield to Pin 1 of the connector.

For stationary operation, you should strip the shielded cable without damaging the shield and connect it to the shield/protective ground bar.

Note

In the event of potential differences between grounding points, a circulating current may flow via the shield connected at both ends. In this case, install an additional equipotential bonding conductor (see Section A.6).

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Handling the Shields

Observe the following points with regard to the shield:

- Only use cable clamps made of metal to secure braided shields. The clamps must surround the shield over a large area and provide good contact.
- Connect the shield to a shield bus immediately after entry of the cable into the cabinet. Route the shield to the module but do not connect it there again to the chassis ground or the shield bus.
- For installation other than in cabinets (for example, wall mounting), you can provide contact between the cable shields and the cable duct.

Shown in the figure A-4 are some methods of securing shielded cables with cable clamps.

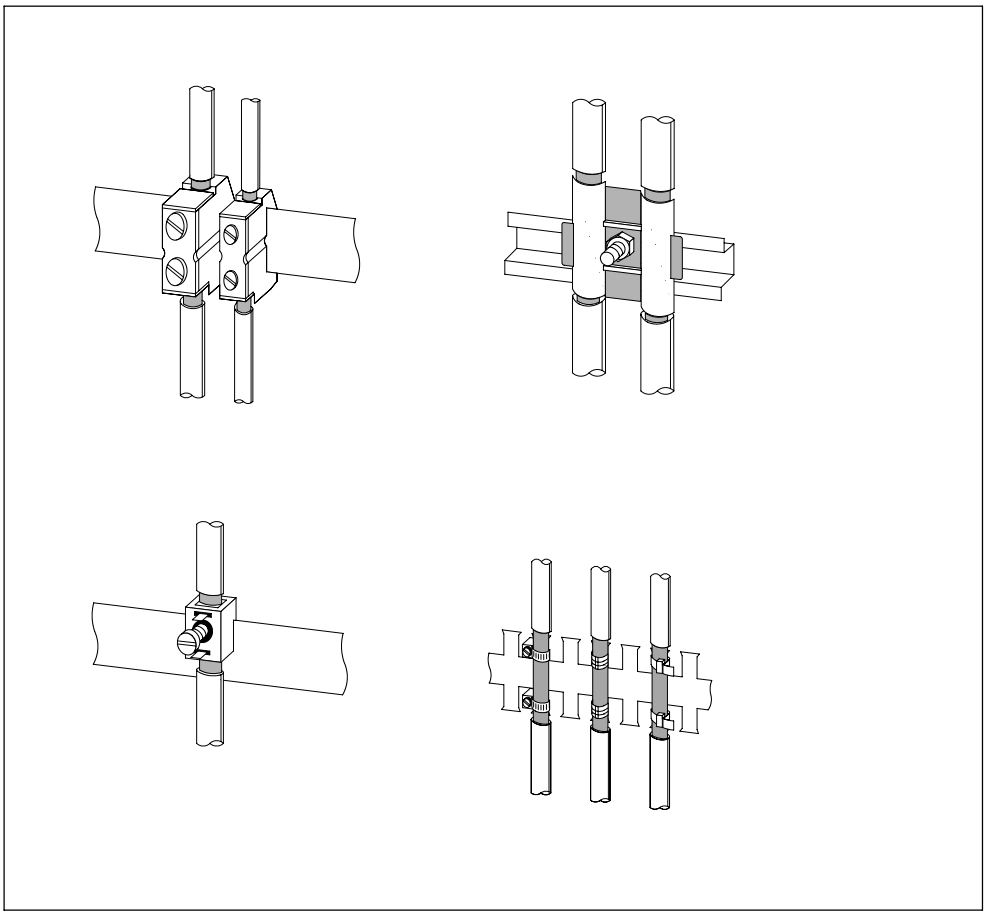

Figure A-4 Mounting Cable Shields

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A.6 Equipotential Bonding

Potential Differences

Potential differences can occur between separate system components, leading to high transient currents; for example, if cable shields are fitted on both sides and grounded at different system components.

Potential differences can be caused by different electrical supplies.

Caution

This can result in damage.

Cable shields are not suitable for equipotential bonding.

Use the prescribed cables exclusively (e.g. those with a 16 mm^2 cross-section). Ensure also that the cable cross-section is adequate when installing MPI/DP networks, since otherwise the interface hardware may be damaged or even destroyed.

Equipotential Bonding Conductor

You must reduce the potential differences by laying equipotential bonding conductors to ensure that the electronic components used function correctly.

Observe the following points for installing an equipotential bonding conductor:

- The lower the impedance of the equipotential bonding conductor, the higher the efficiency of the equipotential bonding.
- Where two sections of an installation are interconnected via shielded signal lines whose shields are connected to the ground/protective conductor at both ends, the impedance of the additional equipotential bonding conductor must not exceed 10% of the shield impedance.
- The cross-section of an equipotential bonding conductor must be rated for the maximum circulating current. In practice, equipotential bonding conductors with a cross-section of 16 mm^2 have proved to be effective.
- Use equipotential bonding conductors made of copper or zinc-plated steel. Provide a large-area contact between the cables and the ground/protective conductor and protect them from corrosion.
- Lay the equipotential bonding conductor in such a way that the surface between the conductor and the signal lines is as small as possible. (see Figure A-5).

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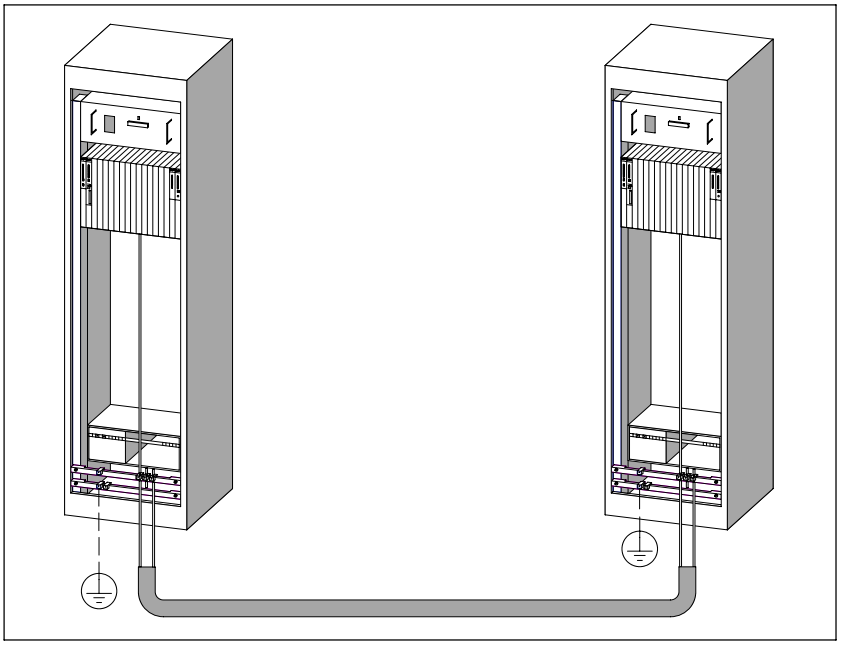

Figure A-5 Routing Equipotential Bonding Conductor and Signal Line

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A.7 Cabling Inside Buildings

Introduction

Inside buildings, clearances must be observed between groups of different cables to achieve the necessary electromagnetic compatibility (EMC). Table A-2 provides you with information on the general rules governing clearances to enable you to choose the right cables.

How to Read the Table

1. Look up the type of the first cable in column 1 (Cables for ...).
2. Look up the type of the second cable in the corresponding field in column 2 (and Cables for ...).
3. Read the routing specifications in column 3 (routing ...).

Table A-2 Cabling Inside Buildings

Connect Cables for ...	and Cables for ...	Run ...
LAN signals, shielded (SINEC L1, PROFIBUS DP) Data signals, shielded (programming devices, operator panels, printers, counter inputs, etc.) Analog signals, shielded DC voltage (≤ 60 V), unshielded Process signals (≤ 25 V), shielded AC voltage (≤ 25 V), unshielded Monitors (coaxial cable)	LAN signals, shielded (SINEC L1, PROFIBUS DP) Data signals, shielded (programming devices, operator panels, printers, counter inputs, etc.) Analog signals, shielded DC voltage (≤ 60 V), unshielded Process signals (≤ 25 V), shielded AC voltage (≤ 25 V), unshielded Monitors (coaxial cable)	in common bundles or cable ducts
	DC voltage (> 60 V and ≤ 400 V), unshielded AC voltage (> 25 V and ≤ 400 V), unshielded	in separate bundles or cable ducts (no minimum clearance necessary)
	DC and AC voltages (> 400 V), unshielded	**Inside cabinets:** in separate bundles or cable ducts (no minimum clearance necessary) **Outside cabinets:** on separate cable racks with a clearance of at least 10 cm (3.93 in.)

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Table A-2 Cabling Inside Buildings, continued

Connect Cables for ...	and Cables for ...	Run ...
DC voltage (> 60 V and ≤ 400 V), unshielded AC voltage (> 25 V and ≤ 400 V), unshielded	LAN signals, shielded (SINEC L1, PROFIBUS DP) Data signals, shielded (programming devices, operator panels, printers, counter inputs, etc.) Analog signals, shielded DC voltage (≤ 60 V), unshielded Process signals (≤ 25 V), shielded AC voltage (≤ 25 V), unshielded Monitors (coaxial cable)	in separate bundles or cable ducts (no minimum clearance necessary)
	DC voltage (> 60 V and ≤ 400 V), unshielded AC voltage (> 25 V and ≤ 400 V), unshielded	in common bundles or cable ducts
	DC and AC voltages (> 400 V), unshielded	**Inside cabinets:** in separate bundles or cable ducts (no minimum clearance necessary) **Outside cabinets:** on separate cable racks with a clearance of at least 10 cm (3.93 in.)
DC and AC voltages (> 400 V), unshielded	LAN signals, shielded (SINEC L1, PROFIBUS DP) Data signals, shielded (programming devices, operator panels, printers, counter inputs, etc.) Analog signals, shielded DC voltage (≤ 60 V), unshielded Process signals (≤ 25 V), shielded AC voltage (≤ 25 V), unshielded Monitors (coaxial cable) DC voltage (> 60 V and ≤ 400 V), unshielded AC voltage (> 25 V and ≤ 400 V), unshielded	**Inside cabinets:** in separate bundles or cable ducts (no minimum clearance necessary) **Outside cabinets:** on separate cable racks with a clearance of at least 10 cm (3.93 in.)
DC and AC voltages (> 400 V), unshielded	DC and AC voltages (> 400 V), unshielded	in common bundles or cable ducts
ETHERNET	ETHERNET	in common bundles or cable ducts
	Others	in separate bundles or cable ducts with a clearance of at least 50 cm (19.65 in.)

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A.8 Cabling Outside Buildings

Rules for EMC

When installing cables outside buildings, the same EMC rules apply as for inside buildings. The following also applies:

- Run cables on metallic cable supports (racks, trays etc.).
- Establish a metallic connection between the joints in the cable supports
- Ground the cable supports
- If necessary, provide adequate equipotential bonding between the various items of equipment connected.
- Take the necessary (internal and external) lightning protection and grounding measures applying to your particular application (see below).

Rules for Lightning Protection Outside Buildings

Lay your cables either:

- In metallic conduits grounded at both ends, or
- In concrete cable ducts with continuous end-to-end armoring

Overvoltage Protection Devices

An individual appraisal of the entire plant is necessary before initiating any lightning protection measures (see Section A.9).

Further Information on Lightning Protection

You will find further information in the following sections.

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A.9 Lightning Protection and Overvoltage Protection

Overview

Failures are very often the result of overvoltages caused by:

- Atmospheric discharge or
- Electrostatic discharge.

First of all, we want to introduce you to the lightning protection zone concept, on which the protection against overvoltage is based.

At the end of this section, you will find rules for the transitions between the individual lightning protection zones.

Note

This section can only provide information on the protection of a **programmable logic controller** against overvoltages.

However, a complete protection against overvoltage is guaranteed only if the whole surrounding building is designed to provide protection against overvoltages. This refers especially to constructional measures for the building already in the planning phase.

If you wish to obtain detailed information on overvoltage protection, we therefore recommend you to address your Siemens contact or a company specialized in lightning protection.

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A.9.1 Lightning Protection Zone Concept

Principle of the Lightning Protection Zone Concept According to IEC 61312-1/DIN VDE 0185 T103

The principle of the lightning protection zone concept states that the volume to be protected, for example, a manufacturing hall, is subdivided into lightning protection zones in accordance with EMC guidelines (see Figure A-6).

The individual lightning protection zones are constituted by the following measures:

The external lightning protection of the building (field side)	Lightning protection zone 0
The shielding of buildings	Lightning protection zone 1
The shielding of rooms	Lightning protection zone 2
The shielding of devices	Lightning protection zone 3

Effects of a Lightning Strike

Direct lightning strikes occur in lightning protection zone 0. The lightning strike creates high-energy electromagnetic fields which can be reduced or removed from one lightning protection zone to the next by suitable lightning protection elements/measures.

Surges

In lightning protection zones 1 and higher, surges can result from switching operations and interference.

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Diagram of the Lightning Protection Zones

The following diagram illustrates a lightning protection zone concept for a detached building.

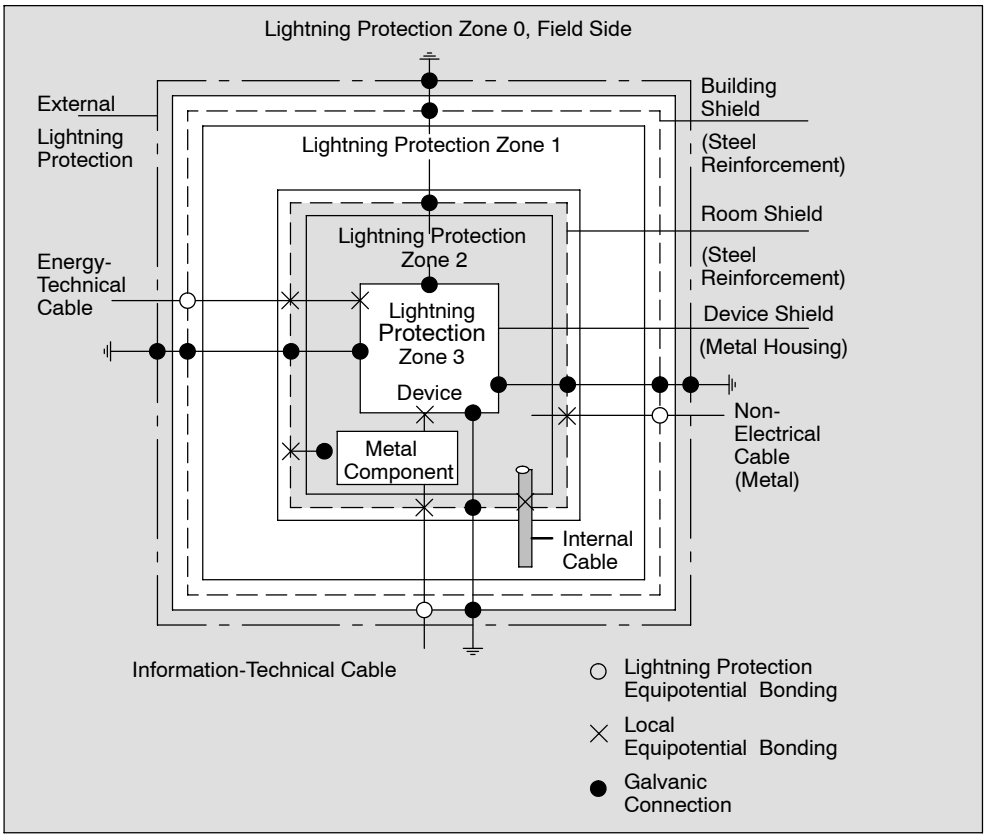

Figure A-6 Lightning Protection Zones of a Building

Principle of Transitions between the Lightning Protection Zones

At the transition points between the lightning protection zones, you must take measures to prevent surges being conducted further.

The lightning protection zone concept also states that all lines at the transitions between the lightning protection zones that can carry lightning stroke current must be included in the lightning protection equipotential bonding.

Lines that can carry lightning stroke current include:

- Metal pipelines (for example, water, gas and heat)
- Power cables (for example, line voltage, 24 V supply)
- Data cables (for example, bus cable).

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A.9.2 Rules for the Transition between Lightning Protection Zones 0 and 1

Rule for the Transition 0 <-> 1 (Lightning Protection Equipotential Bonding)

The following measures are suitable for lightning protection equipotential bonding at the transition between lightning protection zone 0 <-> 1:

- Use grounded, spiralled, current-conducting metal strips or metal braiding, for example, NYCY or A2Y(K)Y, as a cable shield at the start and end
- Lay the cables in one of the following ways:
  - in continuous metal pipes that are grounded at the start and end
  - in ducts of armored concrete with continuous armoring
  - on closed metal cable racks grounded at the start and end
- Use fiber-optic cables instead of lightning stroke current-carrying cables.

Additional Measures

If you cannot take the measures listed above, you must install a high-voltage protector at transition 0 <->1 with a relevant lightning conductor. Table A-3 contains the components you can use for high-voltage protection of your plant.

Table A-3 High-Voltage Protection of Cables with the Help of Surge Protection Equipment

Ser. No.	Cables for ...	... equip transition point 0 <-> 1 with:		Order No.
1	3-phase TN-C system	1 piece of	DEHNbloc/3 lightning conductor phase L1/L2/L3 to PEN	900 110* 5SD7 031
	3-phase TN-S system	1 piece of	DEHNbloc/3 lightning conductor phase L1/L2/L3 to PE	900 110* 5SD7 031
		1 piece of	DEHNbloc/1 lightning conductor N to PE	900 111* 5SD7 032
	3-phase TT system	1 piece of	DEHNbloc/3 lightning conductor phase L1/L2/L3 toN	900 110* 5SD7 031
		1 piece of	DEHNgap B/n N-PE lightning conductor N to PE	900 130*
	AC TN-S system	2 pieces of	DEHNbloc/1 lightning conductor phase L1 + N to PE	900 111* 5SD7 032
	AC TN-C system	1 piece of	DEHNbloc/1 lightning conductor phase L to PEN	900 111* 5SD7 032

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Table A-3 High-Voltage Protection of Cables with the Help of Surge Protection Equipment, continued

Ser. No.	Cables for ...	... equip transition point 0 <-> 1 with:		Order No.
	AC TT system	1 piece of	DEHNbloc/1 lightning conductor phase to N	900 111* 5SD7 032
		1 piece of	DEHNgap B/n N-PE lightning conductor N to PE	900 130*
2	24 VDC Power Supply	1 piece of	Blitzductor VT lightning conductor, type A D 24 V –	918 402*
3	MPI bus cable, RS 485, RS 232 (V.24)	1 piece of	Blitzductor CT lightning conductor, type B	919 506* and 919 510*
4	Inputs/outputs of digital modules 24 V		DEHNrail 24 FML	901 104*
5	24 VDC power supply module	1 piece of	Blitzductor VT lightning conductor, type AD 24 V –	918 402* 900 111* 5SD7 032
6	Inputs/outputs of digital modules and 120/230 VAC power supply	2 pieces of	DEHNbloc/1 lightning conductor	900 111* 5SD7 032
7	Inputs/outputs of analog modules up to 12 V +/–	1 piece of	Blitzductor CT lightning conductor, type B	919 506* and 919 510*

* You can order these components directly at:

DEHN + SÖHNE
GmbH + Co. KG
Elektrotechnische Fabrik
Hans-Dehn-Str. 1
D-92318 Neumarkt

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A.9.3 Rules for the Transitions between Lightning Protection Zones 1 <-> 2 and Greater

Rules for Transitions 1 <-> 2 and Above (Local Equipotential Bonding)

for all lightning protection zone transitions 1 <-> 2 and greater:

- Set up local equipotential bonding at each subsequent lightning protection zone transition.
- Include all cables (also metal pipelines, for example) in the local equipotential bonding at all subsequent lightning protection zone transitions.
- Include all metal installations located within the lightning protection zone in the local equipotential bonding (for example, metal part within lightning protection zone 2 at transition 1 <-> 2).

Additional Measures

We recommend you ensure low-voltage protection for the following elements

- for all lightning protection zone transitions 1 <-> 2 and greater

  and

- for all cables that run within a lightning protection zone and are longer than 100 m.

Lightning Protection Element for the 24 VDC Supply

You should only use the lightning conductor KT, type 24 VAD SIMATIC for the 24 VDC power supply of the S7-400. All other surge protection components do not meet the required tolerance range of 20.4 V to 28.8 V of the S7-400's power supply.

Lightning Protection Element for Signal Modules

You can use standard overvoltage protection components for the digital I/O modules. However, please note that these only permit a maximum of 1.15 x V_{Nom} = 27.6 V for 24 VDC nominal voltage. If the tolerance of your 24 VDC power supply is higher, use the surge protection components for 30 VDC nominal voltage.

You can also use the VT lightning conductor, Type AD 24 V SIMATIC. However, this can result in the following restrictions:

- Digital inputs: An increased input current can flow in the case of negative input voltages.
- Digital outputs: Dropout time of contactors can increase significantly.

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Low-Voltage Protection Elements for 1 <-> 2

For the transition points between lightning protection zones 1 <-> 2 we recommend the surge protection components listed in table A-4

Table A-4 Low-Voltage Protection Components for Lightning Protection Zones 1 <-> 2

Ser. No.	Cables for ...	... equip transition point 1 <-> 2 with:		Order No.
1	3-phase TN-C system	3 pieces of	DEHNguard 275 surge arresters	900 600* 5SD7 030
	3-phase TN-S system	4 pieces of	DEHNguard 275 surge arresters	900 600* 5SD7 030
	3-phase TT system	3 pieces of	DEHNguard 275 surge arresters phase L1/L2/L3 to N	900 600* 5SD7 030
		1 piece of	DEHNgap C N-PE surge N to PE	900 131*
	AC TN-S system	2 pieces of	DEHNguard 275 surge arresters	900 600* 5SD7 030
	AC TN-C system	1 piece of	DEHNguard 275 surge arresters	900 600* 5SD7 030
	AC TT system	1 piece of	DEHNguard 275 surge arresters phase L to N	900 600* 5SD7 030
		1 piece of	DEHNgap C, N-PE surge arrester, N to PE	900 131*
2	24 VDC Power Supply	1 piece of	Blitzductor VT lightning conductor, type AD 24 V	918 402*
3	Bus cable			
	• MPI RS 485		• Blitzductor CT surge arrester, type MD/HF	919 506* and 919 570*
	• RS 232 (V.24)	1 piece of	• per conductor pair surge arrester Blitzductor CT type ME 15 V	919 506* and 919 522*
4	Inputs of digital modules 24 VDC	1 piece of	Low-voltage surge arrester, type FDK 2 60 V	919 993*
5	Outputs of digital modules 24 VDC	1 piece of	Low-voltage surge arrester FDK 2D5 24	919 991*
6	Inputs/outputs of digital modules	2 pieces of	Surge arresters	
	• 120 VAC		• DEHNguard 150	900 603*
	• 230 VAC		• DEHNguard 275	900 600*
7	Inputs of analog modules up to 12 V +/–	1 piece of	Surge arrester Blitzductor CT type MD 12 V	919 506* and 919 541*

* You can order these components directly at:

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Low-Voltage Protection Elements for 2<-> 3

For the transition points between lightning protection zones 2 <-> 3 we recommend the surge protection components listed in the table below. This low-voltage protection must be used in S7-400 for CE compliance.

Table A-5 Surge Protection Components for Lightning Protection Zones 2 <-> 3

Ser. No.	Cables for ...	... .. equip transition point 2 <-> 3 with:		Order No.
1	3-phase TN-C-System	3 pieces of	DEHNguard 275 surge arresters	900 600* 5SD7 030
	3-phase TN-S system	4 pieces of	DEHNguard 275 surge arresters	900 600* 5SD7 030
	3-phase TT system	3 pieces of	DEHNguard 275 surge arresters phase L1/L2/L3 to N	900 600* 5SD7 030
		1 piece of	DEHNgap C N-PE surge N to PE	900 131*
	AC TN-S system	2 pieces of	DEHNguard 275 surge arresters	900 600* 5SD7 030
	AC TN-C system	1 piece of	DEHNguard 275 surge arresters	900 600* 5SD7 030
	AC TT system	1 piece of	DEHNguard 275 surge arresters phase L to N	900 600* 5SD7 030
		1 piece of	DEHNgap C N-PE surge N to PE	900 131*
2	24 VDC Power Supply	1 piece of	Blitzductor VT lightning conductor, type AD 24 V	918 402*
3	Bus cable			
	• MPI RS 485		• Blitzductor CT surge arrester, type MD/HF	919 506* and 919 570*
	• RS 232 (V.24)	1 piece of	• per conductor pair low-voltage protection FDK 2 12 V	919 995*
4	Inputs of digital modules			
	• 24 VDC	1 piece of	Low-voltage surge arrester, type FDK 2 60 V on insulated rail	919 993*
		2 pieces of	Surge arresters	
	• 120 VAC		• DEHNrail 120 FML	901 101*
	• 230 VAC		• DEHNrail 230 FML	901 100*
5	Outputs of digital modules 24 VDC	1 piece of	Low-voltage protection FDK 2 D 5 24	919 991*
6	Outputs of analog modules up to 12 V +/–	1 piece of	Low-voltage protection, type FDK 2 12 V on insulated rail connected with M– of the power supply for the modules.	919 995*

* You can order these components directly at:

DEHN + SÖHNE
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A.9.4 Sample of a Surge Protection Circuit for Networked S7-400 PLCs

Sample Circuit

The sample in the figure A-7 shows you how install an effective surge protection for 2 networked S7-400 PLCs:

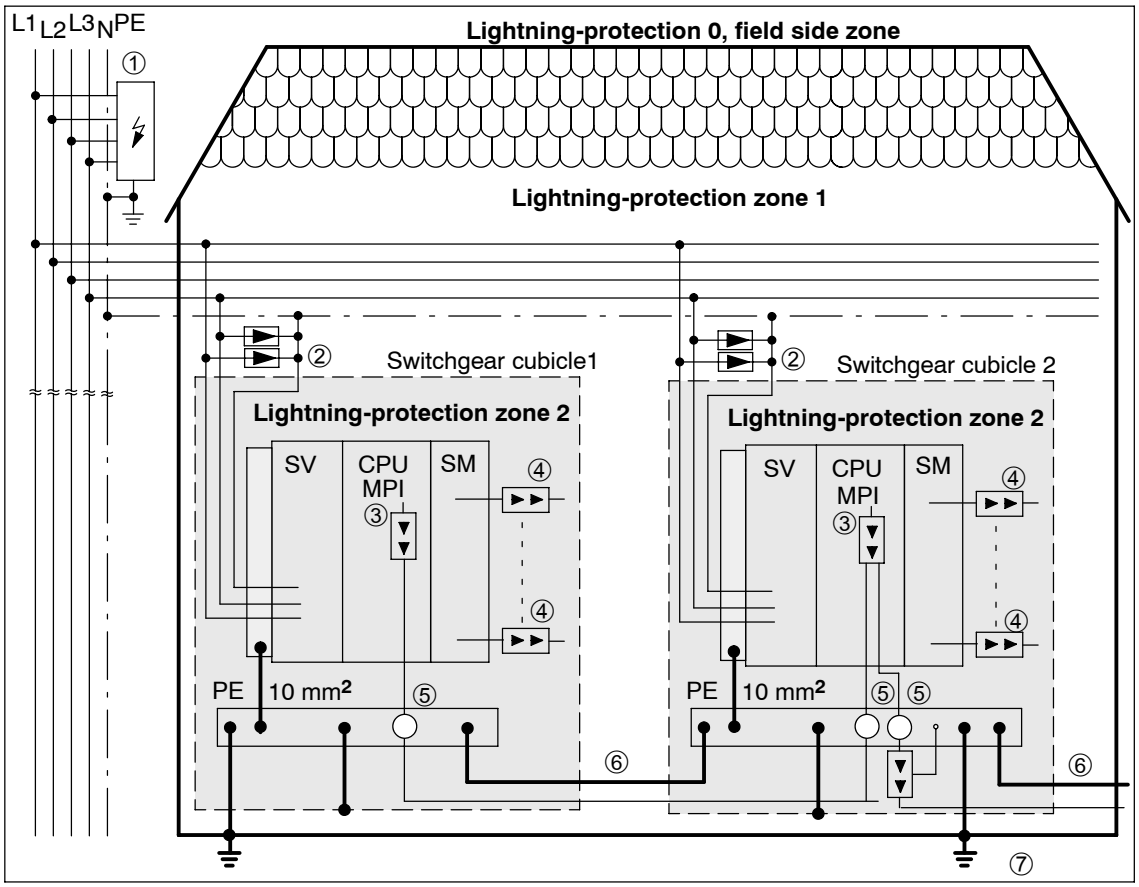

Figure A-7 Sample Circuitry for Networked S7-400 PLCs

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Components in figure A-7

The table A-6 explains consecutive numbers in the figure A-7:

Table A-6 Example of a Circuit Conforming to Lightning Protection Requirements (Legend to Figure A-7)

Ser. No. from figure A-7	Components	Description
1	Lightning arrestor, depending on the mains system, e.g. TN-S system: 1 piece DEHNbloc/3, order number: 900 110* and 1 piece DEHNbloc/1, order number: 900 111*	High-voltage protection against direct lightning strike and surge voltage as of transition 0 <–> 1
2	surge arrestors, 2 pieces DEHNguard 275; order number: 900 600*	High-voltage surge protection at transition 1 <–> 2
3	Surge arrestor, Blitzductor CT type MD/HF, order number: 919 506* and 919 570*	Low-voltage surge protection for RS 485 interfaces at transition 1 <–> 2
4	Digital input modules: FDK 2 D 60 V, order number: 919 993* Digital output modules: FDK 2 D 5 24 V, order number: 919 991* Analog modules: MD 12 V Blitzductor CT, order number: 919 506 and 919 541	Low-voltage surge protection, signal modules I/O at transition 1 <–> 2
5	Bus cable shielding mounting device with EMC spring clamp on the basic unit of Blitzductor CT; order No.: 919 508*	Discharge of interference current
6	Cable for equipotential bonding 16 mm	Standardization of reference potentials
7	Blitzductor CT, type B for building transitions; order number: 919 506* and 919 510*	High-voltage surge protection for RS 485 interfaces at transition 0 <–> 1

* You can order these components directly at:

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A.10 How to Protect Digital Output Modules against Inductive Surge

Inductive Surge Voltage

Overvoltage occurs when inductive devices are switched off. Examples are relay coils and contactors

Integrated Surge Arrester

S7-400 digital output modules are equipped with an integrated surge arrester

Additional Overvoltage Protection

Inductive devices require additional surge arresters only in following cases:

- If SIMATIC output circuits can be switched off by additionally installed contacts (e.g. relay contacts).
- If the inductive loads are not controlled by SIMATIC modules.

Note: Consult the supplier of the inductors for the ratings of surge suppression devices.

Example

Figure A-8 shows an output circuit that requires additional surge arresters.

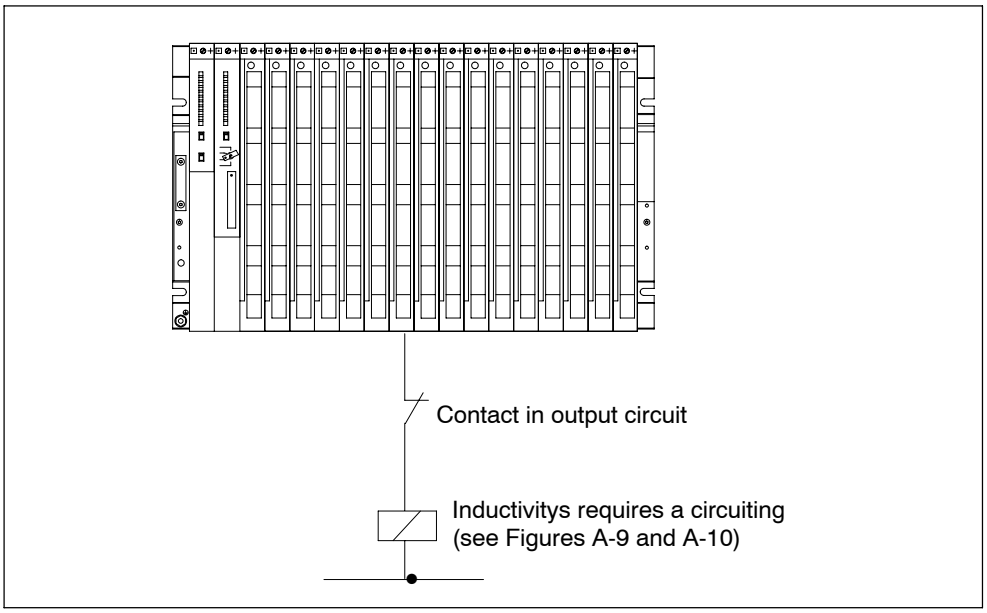

Figure A-8 Relay Contact for EMERGENCY OFF in the Output Circuit

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Suppression for DC-Operated Coils

DC-operated coils are interconnected to diodes or Zener diodes.

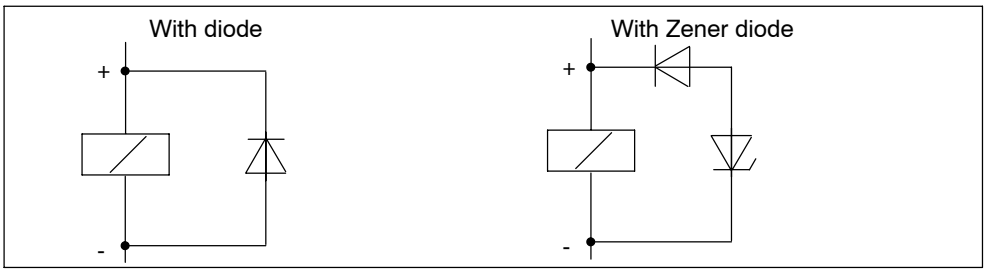

Figure A-9 Suppression for DC-Operated Coils

Suppression with Diodes / Zener Diodes

Suppression with diodes or Zener diodes exhibits the following characteristics:

- Switching overvoltages can be avoided entirely. A Zener diode has a higher turn-off voltage.
- High turn-off delay (6 to 9 times higher than without suppressor circuits)
  The Zener diode switches off more quickly than a diode circuit.

Suppression with AC-Operated Coils

AC-operated coils are suppressed with varistors or RC elements.

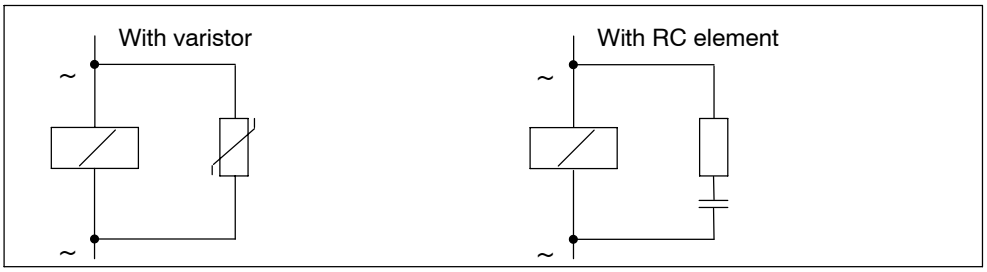

Figure A-10 Suppression with AC-Operated Coils

Suppression with a varistor exhibits the following characteristics:

- The amplitude of the switching overvoltage is limited but not attenuated.
- The steepness of the surge voltage remains the same.
- Low turn-off delay.

Suppression with an RC element exhibits the following characteristics:

- The amplitude and steepness of the switching overvoltage are reduced.
- Low turn-off delay.

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A.11 Safety of Electronic Control Equipment

Intoduction

The notes below apply independent of the type or manufacturer of the electronic control.

Reliability

Maximum reliability of SIMATIC devices and components is achieved by implementing extensive and cost-effective measures during development and manufacture:

- Use of high-quality components;
- Worst-case design of all circuits;
- Systematic and computer-aided testing of all components;
- Birm-in of all large-scale integrated circuits (e.g. processors, memory, etc.);
- Measures preventing static charge when handling MOS ICs;
- Visual checks at different stages of manufacture;
- Continuous heat-run test at elevated ambient temperature ove a period of several days;
- Careful computer-controlled final testing;
- Statistical evaluation of all returned systems and components to enable the immediate initiation of suitable corrective measures;
- Monitoring of major control compoments, using on-line tests (watchdog for the CPU, etc.).

These measures are referred to in safety technology as basic measures. They prevent or rectify a large proportion of possible faults.

Risks

A higher degree of safety standard applies to all applications and situations where there is a risk of material damage or injury upon the event of a failure. Special system-specific regulations are applied to such applications and must be observed on installing the control system (e.g. VDEE 0116 for burner control systems).

For electronic control equipment with a safety function, the measures that have to be taken to avoid or correct faults are based on the risks involved in the installation. As of a certain degree of hazard, the basic measures mentioned above are no longer sufficient. That is, additional measures (e.g. redundant configurations, tests, checksums, etc.) must be implemented and certified for the control equipment (DIN VDE 0801). The prototype of the fail-safe S7-400F and S7-400FH PLCs were tested by TÜV (German Institute for Technological Suirveillance), BIA and G EM III; several certificates have been granted. These are suitable therefore for controlling and monitoring safety-relevant applications.

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Splitting the group into safety-relevant areas and areas which are not savety-relevant

Most plants contain components for handling safety-relevant functions (e.g. EMERGENCY-OFF switch, protective gates, two-hand controls). To avoid the need to examine the entire controller from the aspect of safety, the control system is usually divided into an area that is **safety-relevant** and an area that is **not safety-relevant**. In the non-safety area, no special demands are placed on the safety of the control equipment, because any failure in the electronic system will not influence safety in the installation. In the safety-relevant area, however, it is only allowed to operate controllers or circuits which satisfy the corresponding regulations.

The following divisions are common in practical situations:

- For control equipment with few safety-related functions (e.g. machine controls)

  The conventional PLC is responsible for machine control, whereas safety-related functions are implemented with a fail-safe PLC.

- For controllers with balanced areas (e.g. chemical installations, cable cars)

  In this case also, the area that is not safety-relevant is controlled with a standard PLC, whereas a tested fail-safe controller (S7-400F or S7-400FH) PLC the safety-relevant areas.

  The entire installation is implemented with a fail-safe control system.

- For control equipment with mainly safety-relevant functions (e.g. burner control systems)

  The entire control system is implemented with fail-safe technology

Important Information

Even when electronic control equipment has been configured for maximum design safety – e.g. with a multi-channel structure – it is imperative conform with instructions given in the operating manual. Incorrect handling can render measures intended to prevent dangerous faults ineffective, or generate additional sources of danger.

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A.12 Interference-Free Connection of Monitors

Introduction

You can use control and monitoring interfaces with monitor ports from the WinCC product family. The layout of apparatus and degree of interference are decisive factors for the interference-free connection of monitors to a PLC. A decisive factor in the selection of monitor and video cables is the location of the monitor and PLC, that is, depending on whether these are operated under low-interference or industrial conditions.

Operation under Low-Interference Conditions

Where a monitor and the programmable controller operate in a low-interference environment and there is only a short distance between monitor and programmable controller, they are at almost the same ground potentials. Interference and disturbance by ground loops are therefore not expected.

In these cases, you can use either TTL or analog signals to drive the monitor. Digital cables or single-shielded coaxial cables can be used to transmit the video signals. Note that the braided shield of the coaxial cable serves as the return conductor and must not be connected to the shield bus. The monitor and communications processor (CP) are interconnected without additional shielding and grounding.

Operation under Industrial Conditions

Where the monitor and programmable controller are operated under harsh industrial conditions or there is a great distance between monitor and programmable controller, the apparatus may be at different ground potentials; this, in turn, can result in interference and disturbances caused by ground loops.

In these cases, double-shielded coaxial cable (triaxial cable) must be used to transmit the video signal. The inner braided shield of this cable serves as the return conductor and must not be connected to the shield bus. The outer braided shield serves to discharge interference currents and must be incorporated in shielding and grounding measures.

In order to avoid ground loops, electronics ground and chassis ground of the monitor must be isolated. This is achieved by satisfying the following requirement:

- Electronic and chassis grounds of the monitor are isolated from each other.
- Electronic and chassis grounds of the monitor are interconnected via a voltage-dependent resistor (VDR) fitted by the manufacturer of the monitor.

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Shielding and Grounding under Industrial Conditions

If the monitor and programmable controller are operated under harsh industrial conditions, you must observe the following:

On the side of the programmable controller:

- Connect the cable shields in the cabinet to the shielding busbar immediately behind the cable inlet. The following points are important:
  - Strip the video cables without damaging the conductors.
  - Secure the outer braided shield with the largest possible area to the shielding busbar of the programmable controller (for example, secure the shielding with metal straps or cable clamps).
- Provide large-area contact between the shielding busbars and the frame or cabinet wall.
- Connect the shielding busbar to the central grounding point of the cabinet.

On the side of the monitor:

- Isolate electronic ground and chassis ground from each other. Proceed as follows:
  - Remove the jumper on the monitor to separate the two potentials.
  - Install a contact protection on the video sockets, because with isolated grounding, a shock–hazard voltage of more than 40 V may develop in this area.

Caution

There is a risk of personal injury.

Shock-hazard voltages may be present at the video sockets of the monitor.

Insulate the sockets.

- Connect the ground clamp of the monitor to the chassis ground.
- Connect the cable shields to the ground clamp of the monitor as follows: Proceed as follows:
  - Strip the outer cable insulation of the video cables in the region of the ground clamp of the monitor, without damaging the braided shield.
  - Secure the outer braided shield over a large area to the ground clamp of the monitor.

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Figure A-11 shows a schematic view of the shielding and grounding for your monitor and S7-400.

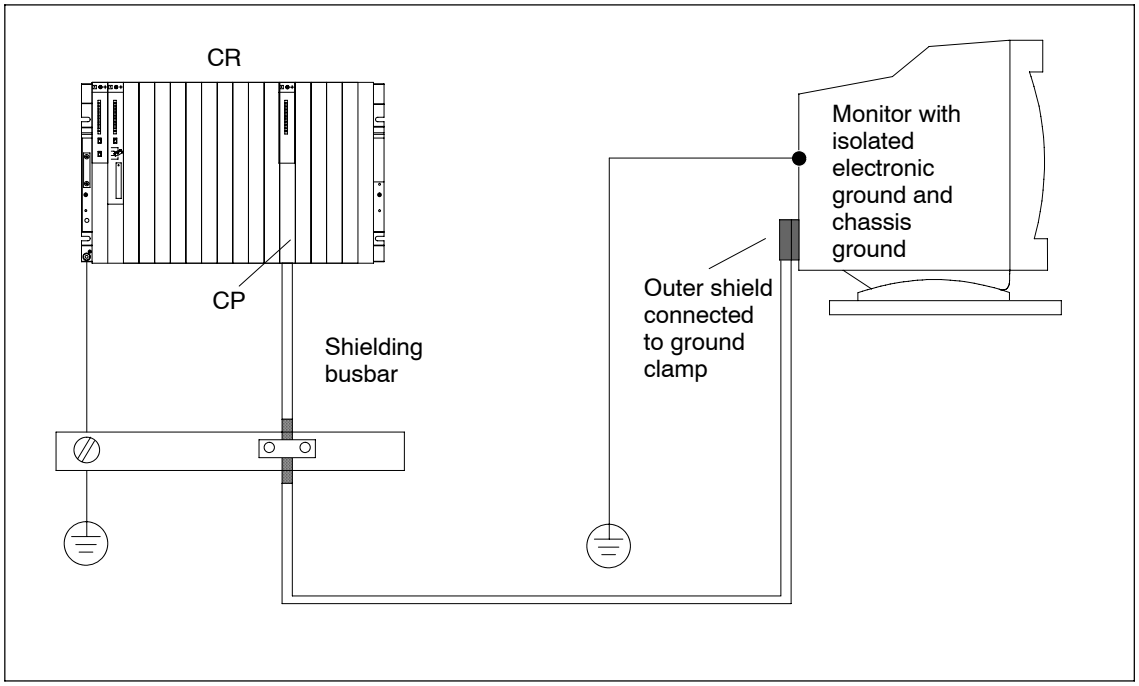

Figure A-11 Shielding and Grounding with a Great Distance between Monitor and Programmable Controller

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Guidelines for Handling Electrostatically-Sensitive Devices (ESD)

B

Chapter Overview

Section	You will find	Page
B.1	What is ESD?	B-2
B.2	Electrostatic Charging of Persons	B-3
B.3	General Protective Measures Against Electrostatic Discharge Damage	B-4

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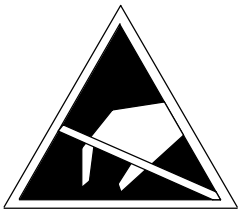
B.1 What is ESD?

Definition:

All electronic modules are equipped with large-scale integrated ICs or components. Due to their design, these electronic elements are very sensitive to overvoltages and thus to any electrostatic discharge.

These **E**lectrostatically-**S**ensitive **D**evices are commonly referred to by the abbreviation **ESD**.

Electrostatically-sensitive devices are labeled with the following symbol:



Caution

Electrostatically-sensitive devices are subject to voltages that are far below the voltage values that can still be perceived by human beings. These voltages are present if you touch a component or the electrical connections of a module without previously being electrostatically discharged. In most cases, the damage caused by an overvoltage is not immediately noticeable and results in total damage only after a prolonged period of operation.

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B.2 Electrostatic Charging of Persons

Charging

Every person with a non-conductive connection to the electrical potential of its surroundings is subject to electrostatic charge.

Figure B-1 shows you the maximum values for electrostatic voltages which can build up on a person coming into contact with the materials indicated in the figure. These values are in conformity with the specifications of IEC 61000-4-2.

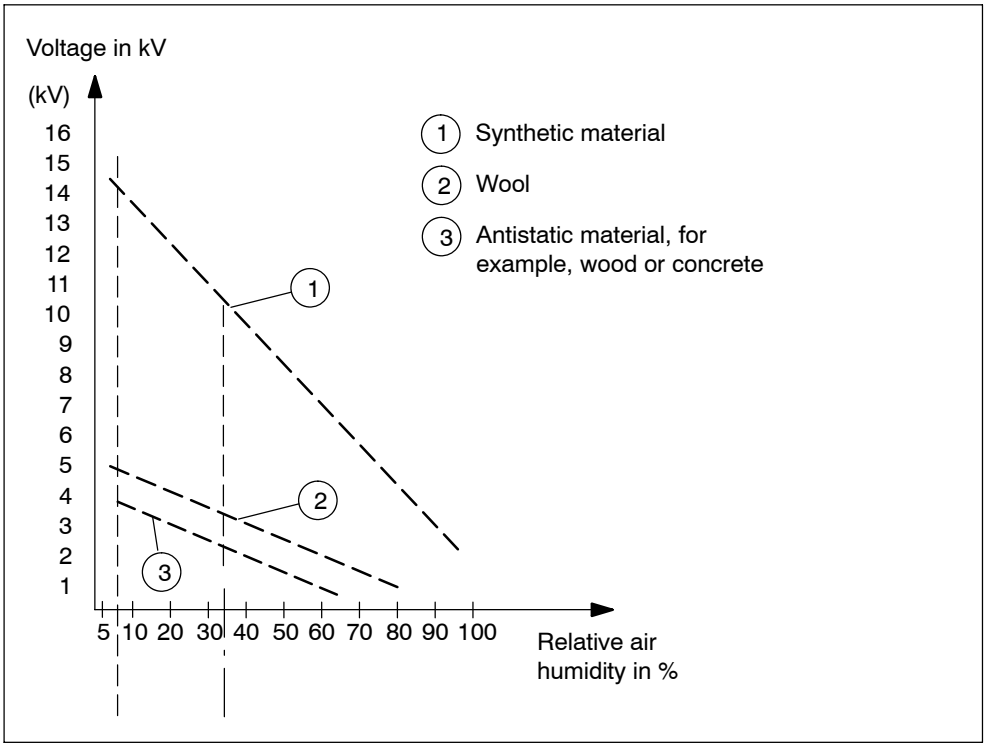

Figure B-1 Electrostatic Voltages which can build up on a person

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B.3 General Protective Measures Against Electrostatic Discharge Damage

Ensure Sufficient Grounding

Make sure that the personnel, working surfaces, and packaging are sufficiently grounded when handling electrostatically-sensitive devices. You thus avoid electrostatic charging.

Avoid Direct Contact

You should touch electrostatically-sensitive devices only if it is unavoidable (for example, during maintenance work). Hold modules without touching the pins of components or printed conductors. In this way, the discharged energy cannot affect the sensitive devices.

If you have to carry out measurements on a module, you must discharge your body before you start the measurement by touching grounded metallic parts. Use grounded measuring devices only.

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Glossary

A

Address

An address is the identifier for a specific area of memory on which an instruction acts.
Examples: Input I 12.1; Memory Word MW24; Data Block DB3.

Analog Module

Analog modules convert analog process variables (for example, temperature) into digital values that can be processed in the CPU or they convert digital values into analog manipulated variables.

B

Backup Battery

The backup battery ensures that the user program in the CPU is not lost in the event of a power failure and that defined data areas, bit memory, timers, and counters are also retained.

Bit Memory (M)

A memory area in the system memory of a SIMATIC CPU. This area can be accessed using write or read access (bit, byte, word, and double word). The bit memory area can be used by the user to store intermediate results. It can be accessed bit by bit, byte by byte, word by word, or double word by double word.

Building Ground

The connection between data processing equipment and ground, whereby no unacceptable functional interference to data processing equipment is caused by external effects, such as interference caused by power systems. The connection must be in the form of a low-noise ground.

Bus segment

Entity of a serial bus system, coupled via repeaters.

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C

Central module

Programmable S7-400 module with MPI interface, controls the automation tasks.

Chassis Ground

The chassis ground comprises all interconnected inactive parts of an apparatus, which even in case of a fault cannot take dangerous touch voltages.

Cold restart

Restart of an automation system and its user program after all dynamic data (tags of the I/O image, internal registers, timers, counters etc. and the corresponding program elements) were reset to default. A cold start may be triggered automatically (for example, due to power failure, loss of dynamic data in memory).

Communications Processor

Communications processors are modules for point-to-point and bus connections.

Compress

The PG online function “Compress” is used to shift all valid blocks in the RAM of the CPU evenly and without any gaps to the beginning of the user memory. All gaps caused by deleting or correcting blocks are thus removed.

Configuration

The configuration is the selection and putting together of the individual components of a programmable logic controller (PLC).

Configuring

Configuring is the assigning of modules to racks or slots and (with signal modules) addresses.

Consistent data

Data associated with each other in the same context and which may not be separated

All values of analog modules must be treated as consistent data, for example. That is, a value read at different times from an analog module may not be corrupted.

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Counters

Counters are an area in the system memory of the CPU. The contents of these counters can be changed using STEP 7 instructions (for example, up counter, down counter).

CP

→ Communications Processor

CPU

Central processing unit of the S7 programmable controller with processor, arithmetic unit, memory, operating system, and programming device interface.

Cycle time

The time a → CPU requires to execute the → user program.

Cyclic Interrupt

A cyclic interrupt is generated by the S7-400 CPU periodically according to a programmable time interval. A corresponding organization block is then executed.

D

Data Block (DB)

Data blocks are areas in the user program which contain user data. There are shared data blocks which can be accessed by all logic blocks, and there are instance data blocks which are associated with a particular function block (FB) call.

Data, Static

Static data are data which are used only within a function block. These data are stored in an instance data block belonging to the function block. The data stored in the instance data block are retained until the next function block call.

Data, Temporary

Temporary data are local data of a block that are stored in the L stack during processing of the block and that are not retained after processing.

Default Setting

A default setting is an expedient basic setting which is always used when no other value is preset by a parameter.

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Diagnostic Buffer

The diagnostic buffer is a retentive area of memory within the S7-400 CPU which stores the diagnostic events in the order they occurred.

Diagnostic Interrupt

Modules with diagnostics capability signal system errors to the S7-400 CPU by means of diagnostic interrupts.

DP Master

A master which is compliant with EN 50170, Part 3.

Interconnects the CPU and the distributed I/O system. Exchanges data via PROFIBUS DP with the distributed I/O and monitors the PROFIBUS DP.

DP Slave

A slave which is operated on PROFIBUS with PROFIBUS DP protocol and compliant with EN 50170, Part 3.

Prepares the data of encoders and actuators locally for their transfer to the CPU via PROFIBUS DP.

DPV1

Enhancement of distributed I/O to EN 50170. The results were incorporated into IEC 61158 / IEC 61784-1:2002 Ed1 CP 3/1. The term DPV1 is used in the SIMATIC documentation. The new version contains enhanced and simplified functionality, for example, the extension of acyclic services with new interrupt functions.

The DPV1 functionality is integrated into IEC 61158/EN 50170, Volume 2, PROFIBUS.

E

Electromagnetic Compatibility (EMC)

Electromagnetic compatibility is understood to mean the capability of electrical apparatus to operate without faults in a given environment, without affecting that environment in an unacceptable manner.

Equipotential Bonding

An electrical connection (equipotential bonding conductor) that ties the exposed conductive parts of an item of electrical equipment and extraneous conductive parts to the same, or approximately the same, potential in order to prevent disturbing or dangerous voltages between these parts.

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Error Display

Error display is one of the possible responses of the operating system to a run-time error. The other possible responses include: error response in the user program, STOP mode of the CPU.

Error Handling via OB

When the operating system detects an error (for example, STEP 7 access error), it calls the specific organization block (error OB) for this error, where the further response of the CPU can be specified.

Error Response

Response to a run-time error. The operating system can respond to the following types: transferring of the programmable controller to STOP mode, calling of an organization block where the user can program a response, or displaying of the error.

F

FB

→ Function Block

FC

→ Function

FORCE

Function which can be used to assign fixed values to specific tags in a user program or CPU (also: I/Os), so that the user program is not able to change or overwrite these values. The function allows users to set defined tag values in the user program for use in specific situations and to test the programmable functions.

Function

According to IEC 61131-3, a function is a code block that does not contains any static data. Temporary tags of functions are stored in the local data stack and will be lost after the FC was executed.

Functions are therefore suitable for storing data in shared DBs. Because FCs are not assigned a memory, you always need to specify their actual parameters. You can not assign initial values to the local data of an FC.

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Functional Grounding

Grounding whose only purpose is to ensure the intended function of the electrical equipment concerned. Functional grounding short-circuits any noise that might otherwise have a detrimental effect on the equipment.

Function Block (FB)

According to IEC 61131-3, a function block (FB) is a code block that contains static data. It is assigned an instance DB as memory. All parameters and static tags passed to the FB are stored in the instance DB. Its temporary data are stored in the local data stack.

Data in the instance DB are retentiveAn FB allows parameters to be passed in the user program. Function blocks are therefore suitable for programming complex functions, e.g. closed-loop controls, mode selections, which are repeated frequently

Function Module (FM)

A programmable module which, in contrast to the CPU, has no multipoint interface and can only be operated as a slave.

G

Global Data Communication

Global data communication is a procedure with which shared data are transferred between CPUs.

Ground

The conductive mass of the ground whose potential can be assumed to be zero at any point.

In the vicinity of ground electrodes, the ground may have a potential other than zero. The term “reference ground” is often used in this situation.

Ground (verb)

To ground means connecting an electrically conductive part via a grounding system to ground (one or more electrically conductive parts that have good contact with the soil).

GSD File

The device master file (GSD file) contains all slave-specific data. The format of GSD files is specified in EN 50170, Volume 2, PROFIBUS.

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H

Hardware Interrupt

Interrupt-triggering modules trigger a hardware interrupt in the case of a certain event in the process. The hardware interrupt is signalled to the CPU. In accordance with the priority of this interrupt, the corresponding organization block is then executed.

I

Instance Data Block

With the S7-400, each call of a function block in the STEP 7 user program is assigned a data block which is generated automatically. In the instance data block, the values of the input, output and in/out parameters as well as the local block data are stored.

Interface, Multipoint

→ Multipoint Interface.

Interrupt, Cyclic

→ Cyclic Interrupt

Isolated

In the case of isolated I/O modules, the reference potentials of the control and load circuits are galvanically isolated from each other, for example, by optocouplers, relay contacts, or transformers. The I/O circuits can be connected to a common potential.

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L

Load Memory

The load memory is part of the S7-400 CPU. It contains objects created by the programming device. It can be either a plug-in memory card or an integrated memory.

Contains the complete user program during runtime, the comments and the symbolic system, additional special information which allows decompilation of the user program, and all module parameters.

Local Data

→ Data, Temporary

Logic Block

In SIMATIC S7, a logic block is a block that contains part of the STEP 7 user program. The other type of block is a data block which contains only data.

M

Manufacturer-specific interrupt

Can be generated by a DPV1 slave. The DPV1 master responds with a call of OB57.

For detailed information on OB57, refer to the *"System Software for S7-300/S7-400 System and Standard Functions"* reference manual.

Measuring Range Submodule

Measuring range submodules are plugged onto the analog input module for adapting to various measuring ranges.

Memory Card

Memory cards are storage media in credit-card format for CPUs and CPs. They are available as RAM or FEPROM.

Module Parameters

Module parameters are used to set the module reactions. A difference is made between static and dynamic module parameters.

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Multipoint Interface (MPI)

The multipoint interface is the programming device interface in SIMATIC S7. It enables the simultaneous operation of a number of nodes (programming devices, text display operator interfaces, and operator panels) from one or more CPUs. Each node is identified by an address (MPI address).

MPI Address

→ Multipoint Interface (MPI)

N

Nesting Depth

A block can be called from another block by means of block calls. The nesting depth is the number of simultaneously called logic blocks.

Network

In communications, a network is the connection between two or more S7-400 CPUs and other terminals such as a programming device, via a connecting cable. Data are exchanged over the network between the connected stations.

Node Number

The node number represents the accessing address of a CPU or programming device or of another intelligent I/O module when they communicate with each other via a network. The node number is assigned by the CPU or programming device using the STEP 7 software.

Non-Isolated

In the case of non-isolated I/O modules, the reference potentials of the control and load circuits are electrically connected to each other.

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O

OB

→ Organization Block

OB Priority

The operating system of the S7-400 CPU differentiates between various priority classes, for example, cyclic program processing, process interrupt-controlled program processing. Each priority class is assigned organization blocks (OBs), where the S7 user can program a reaction. As a standard, the OBs have different priorities to which they are processed when they occur simultaneously or when they interrupt each other.

Operating State

The SIMATIC S7 programmable controllers recognize the following operating states: STOP, STARTUP, RUN.

Operating System of the CPU

The operating system of the CPU organizes all functions and sequences of the CPU which are not connected to a specific control task.

Organization Block (OB)

Organization blocks form the interface between the operating system of the S7-400 CPU and the user program. The sequence in which the user program should be processed is laid down in the organization blocks.

P

Parameter

1. Variable of a STEP 7 logic block
2. Variable for setting the reaction of a module (one or more per module).

Parameters can be static or dynamic.

Parameters, Dynamic

In contrast to static parameters, dynamic parameters of modules can be changed during operation by calling an SFC in the user program, for example, limit values of an analog signal input module.

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Parameters, Static

In contrast to dynamic parameters, static parameters of modules cannot be changed by means of the user program, but only via STEP 7 (not in the RUN state); for example, input delay of a digital signal input module.

PG

→ Programming Device

PROFIBUS DP

Digital, analog and intelligent modules, as well as a wide range of field devices to EN 50170, Part 3, such as drives or valve modules are moved to the local process by the PLC across distances of up to 23 km.

The modules and field devices are interconnected with the PLC via PROFIBUS DP field bus and are addressed in the same way as local I/O.

Priority classes

The S7 CPU operating system provides up to 26 priority classes (or “program execution levels”) which are assigned different OBs. These classes determine which OB can interrupt other OBs. Several OBs belonging to the same priority class do not interrupt each other, and are executed in sequential order.

Process Image

The process image is a component part of the system memory of the S7-400 CPU. At the beginning of the cyclic program, the signal states of the input modules are transferred to the process-image input table (PII). At the end of the cyclic program, the process-image output table (PIQ) is transferred to the output modules as the signal state.

Programming Device (PG)

A personal computer with a special compact design, suitable for industrial conditions. A Siemens programming device is completely equipped for programming the SIMATIC programmable logic controllers.

Protective Ground

Connection via protective conductor to a common ground conductor for the exposed, conductive parts of electrical apparatus which are not normally live, but at which a voltage may be present in the event of a fault, and which are jointly protected via a protective device.

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R

RAM

The RAM (Random Access Memory) is a semiconductor memory with random access (read/write memory). May be used as for storing interim data for later use. This memory is not retentive, that is, its data are lost after power failure.

Reference Ground

→ Ground

Reference Potential

The potential on which the voltages of the various circuits are based and according to which they are measured.

Retentive Data

Retentive data are not lost after a power failure, if a backup battery is provided.

Release version

Used to distinguish products with the same order number. Incremented with each up-compatible functional enhancement, manufacturing-specific change (use of new parts / components) and for bugfixes.

Run-Time Error

Errors that occur in the programmable controller (that is, not in the process) during execution of the user program.

S

Scan Cycle Time

The scan cycle time is the time the CPU takes to run the user program once through.

Shared Data

Shared data can be accessed by any code block (FC, FB, OB). These include bit memory M, inputs I, outputs Q, timers T, counters C, and data blocks DB. Global data can be accessed either absolutely or symbolically.

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Segment

→ Bus segment

SFB

→ System Function Block

SFC

→ System Function

Signal Module

Signal modules (SMs) are the interface between the process and the programmable controller. Signal modules comprise digital input and output modules (I/O module, digital) and analog input and output modules (I/O module, analog).

Slave

A slave may only exchange data when requested by a master.

STARTUP

The CPU goes through the STARTUP state during the transition from STOP to RUN mode. It can be set using the mode selector on the CPU, following power-on, or by an operation on the programming device.

Status interrupt

Can be generated by a DPV1 slave. The DPV1 master responds with a call of OB55.

For detailed information on OB57, refer to the *"System Software for S7-300/S7-400 System and Standard Functions"* reference manual.

STEP 7

Programming language for writing user programs for SIMATIC S7 programmable controllers.

Substitute Value

Substitute values are values which are output to the process in the case of faulty signal output modules or which are used in the user program instead of a process variable in the case of faulty signal input modules. The substitute values can be specified in advance by the user (for example, maintain old value).

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System Diagnostics

System diagnostics is the detection, evaluation, and reporting of errors occurring within the programmable controller. Examples of such errors are: program errors or failures on modules. System errors can be indicated with LED indicators or by STEP 7.

System Function (SFC)

An integral programmable function of the CPU operating system. Can be called in the user program. SFCs are not loaded as part of the program, because they are part of the operating system. SFCs do not have a memory function, same as FCs.

System Function Block (SFB)

An itegral function block of the CPU operating system. SFBs are not loaded as part of the program, because they are part of the operating system. Without memory function, same as SFCs. You need to create instance DBs for these blocks and load them into the CPU as part of the user program.

System Memory

The system memory is integrated in the CPU and executed in the form of RAM. The address areas (timers, counters, bit memory, etc.) and data areas required internally by the operating system (for example, backup for communication) are stored in the system memory.

T

Terminating resistor

Used to terminate data transfer lines in order to avoid reflections on the bus.

Time-Delay Interrupt

The time-delay interrupt belongs to one of the priority classes in SIMATIC S7-400 program processing. It is generated after expiry of a time started in the user program. A corresponding organization block is then executed.

Time-Of-Day Interrupt

The time-of-day interrupt belongs to a priotity class in SIMATIC S7-400 program program execution. It is generated depending on a certain date (or daily) and time of day (for example, 9:50 or hourly, per minute). A corresponding organization block is then executed.

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Timer (T)

Timers are an area in the system memory of the CPU. The contents of these timers are updated by the operating system asynchronously to the user program. You can use STEP 7 instructions to define the exact function of the timer (for example, on-delay timer) and start processing it (Start).

Toggle switch

The mode selector is a toggle switch which can be used to set the CPU from RUN to STOP or reset CPU memory.

Total Current

Sum of currents of all output channels of a digital output module.

U

Ungrounded

Without galvanic connection to ground.

Update interrupt

An update inbterrupt can be generated by a DPV1 slave.
The DPV1 responds with a call of OB56. For detailed information on OB56, refer to the *"System Software for S7-300/S7-400 System and Standard Functions"* reference manual.

User Memory

The user memory contains logic blocks and data blocks of the user program. The user memory can either be intergrated in the CPU or can be plugged in on memory card or memory submodules. In general, however, the user program is executed from the work memory (RAM) of the CPU.

User Program

With SIMATIC a difference is made between the operating system of the CPU and user programs. The latter are generated by means of the STEP 7 programming software in the possible programming languages (Ladder Logic, Statement List, Function Block Diagram) and are stored in logic blocks. Data are stored in data blocks.

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V

Varistor

Voltage-dependent resistor

W

Warm Restart

During a CPU startup and before cyclic program processing starts (OB1), either OB101 (hot restart), or OB100 (restart / warm start), or OB102 is processed first. Prerequisite for the execution of the “hot restart” function is a backup of all CPU data.

The data of all data areas (timers, counters, flags, DBs) are retained. The process-image input table is read in and the STEP 7 user program processed starting at the last breakpoint STOP, power failure).

Watchdog interrupt

Generated cyclically within a configurable time pattern by the S7-400 CPU. Triggers the execution of a corresponding OB. Starting point of the clock cycle is the operational transition from STOP to RUN.

Work Memory

The work memory is the RAM (Random Access Memory) in the CPU to which the STEP 7 user program is automatically reloaded from the load memory. The processor executes the program in the work memory in RUN mode.

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