AMIKON TECHNICAL DOCUMENTATION

Installation Instructions

Siemens 6ES7214-1AF40-0XB0

CPU 1214FC DC/DC/DC

SUPPLY	STANDARD I/O	ANALOG	CPU TYPE
24 V DC	**14 DI / 10 DQ**	**2 x 0-10 V**	**1214FC**

For qualified personnel only. Isolate the equipment and follow the complete manufacturer and site safety procedures. This reference does not replace the approved project design or the full installation manual.

01 PREPARATION AND WIRING CHECKS

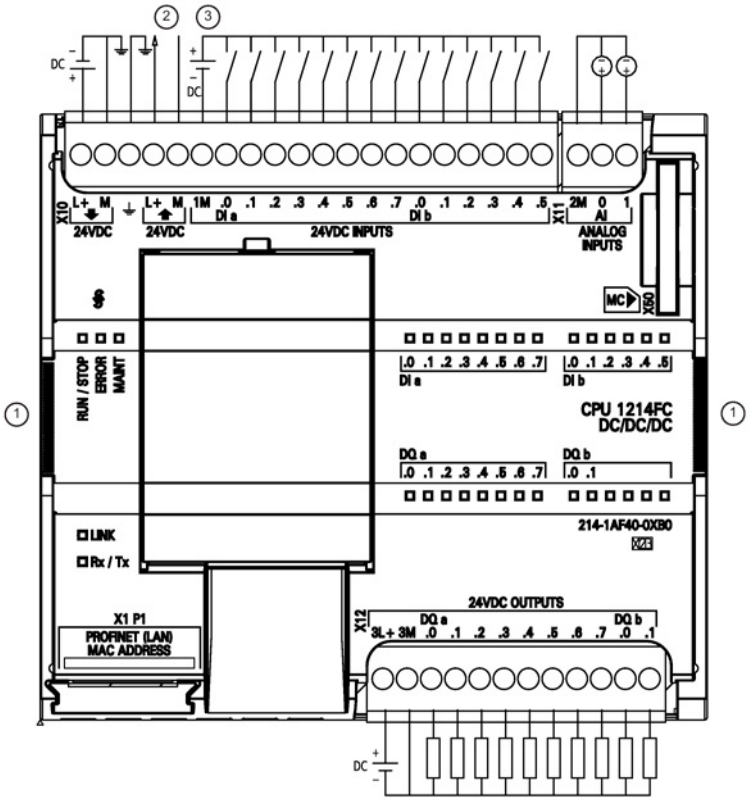
- Use qualified personnel and the applicable SIMATIC Safety configuring/programming manual; this 2015 excerpt is not a complete safety commissioning procedure.
- The CPU onboard I/O is standard, not fail-safe. Keep safety field signals on the required F-I/O modules and validated safety design.
- Disconnect all CPU and related field power before installation or removal; retain correct module identity, orientation and order.
- Use suitable SELV/PELV supplies with the specified fault-voltage limitations and common-reference/isolation arrangement.
- Do not parallel separate supplies; calculate expansion and sensor power budgets.
- Use original AF40 drawing and full pin table; X11 analog connector must be gold and unused analog inputs should be shorted as documented.
- Maintain clearance and enclosure protection, external circuit protection and correct terminal engagement.
- Do not operate standard or safety functions until safety-related commissioning is complete.

02 ORIGINAL WIRING REFERENCE

Original source PDF pages 158, 1, 2, 3, 4, 5, 13, 14, 79, 80, 81, 82, 83, 84, 85, 86, 89, 90, 91, 92, 93, 98, 99, 100, 101, 102, 103, 104, 149, 152, 153, 154, 155, 159. The following pages retain the original Siemens drawings and printed page numbers.

Siemens original installation documentation

Table A- 24 CPU 1214FC DC/DC/DC (6ES7 214-1AF40-0XB0)



①	The two rectangular areas are yellow. These are only on the fail-safe CPUs.
②	24 VDC Sensor Power Out For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.
③	For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".
Note: X11 connectors must be gold. See Appendix B, Spare Parts for article number.	

Table A- 25 Connector pin locations for CPU 1214FC DC/DC/DC (6ES7 214-1AF40-0XB0)

Pin	X10	X11 (gold)	X12
1	L+ / 24VDC	2 M	3L+
2	M / 24VDC	AI 0	3M
3	Functional Earth	AI 1	DQ a.0
4	L+ / 24VDC Sensor Out	--	DQ a.1
5	M / 24VDC Sensor Out	--	DQ a.2
6	1M	--	DQ a.3
7	DI a.0	--	DQ a.4
8	DI a.1	--	DQ a.5
9	DI a.2	--	DQ a.6
10	DI a.3	--	DQ a.7
11	DI a.4	--	DQ b.0
12	DI a.5	--	DQ b.1
13	DI a.6	--	--
14	DI a.7	--	-
15	DI b.0	--	--
16	DI b.1	--	--

SIEMENS

SIMATIC

S7
S7-1200 Functional Safety Manual

Manual

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Legal information

Warning notice system

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

⚠ DANGER

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

⚠ WARNING

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

⚠ CAUTION

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

NOTICE

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

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

Qualified Personnel

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

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

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

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Preface

Purpose of the manual

The S7-1200 series is a line of programmable logic controllers (PLCs) that can control a variety of automation applications. Compact design, low cost, and a powerful instruction set make the S7-1200 a perfect solution for controlling a wide variety of applications. The S7-1200 models and Windows-based programming tools give you the flexibility you need to solve your automation problems.

This manual provides information about using, installing, and programming the S7-1200 Fail-Safe PLCs and is designed for engineers, programmers, installers, and electricians who have a general knowledge of programmable logic controllers.

Required basic knowledge

To understand this manual, it is necessary to have a general knowledge of automation and programmable logic controllers.

Scope of the manual

This manual describes or references the following products:

- STEP 7 Basic V13 SP1 or later with:
  - STEP 7 Safety Basic V13 SP1 or later
  - STEP 7 Safety Advanced V13 SP1 or later
- STEP 7 Professional V13 SP1 or later with:
  - STEP 7 Safety Advanced V13 SP1 or later
- S7-1200 fail-safe CPU firmware release V4.1 or later
- S7-1200 fail-safe signal modules (SM) firmware release V2.0 or later

For a complete list of the S7-1200 products described in this manual, refer to the technical specifications article numbers for fail-safe CPUs (Page 193) and fail-safe SMs (Page 193).

WARNING

The "SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" in the current version is the authoritative source for Functional Safety-related information concerning configuring and programming.

Siemens identifies the "SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en) as the authoritative and/or original source in the case of discrepancies between the manuals.

All warnings in the "SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" have to be observed.

Certification, CE label, C-Tick, and other standards

Refer to the technical specifications (Page 144) for more information.

Glossary

The definitions in the glossary are provided to give the reader an easy first reference for understanding the terms as used in this manual. Some terms have detailed formal definitions in IEC 61508, ISO EN 13849, IEC 61784-3-3, and associated standards, and must be understood in terms of broad safety concepts detailed in these standards.

Another reference for more exact definitions is the "SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

Service and support

In addition to our documentation, we offer our technical expertise on the Internet on the customer support web site (http://www.siemens.com/automation/).

Contact your Siemens distributor or sales office for assistance in answering any technical questions, for training, or for ordering S7 products. Because your sales representatives are technically trained and have specific knowledge about your operations, processes, and industry, as well as the individual Siemens products that you are using, they can provide the fastest and most efficient answers to any problems you might encounter.

Documentation and information

S7-1200 and STEP 7 provide a variety of documentation and other resources for finding the technical information that you require.

- The *S7-1200 Functional Safety Manual* presents an overview of the Siemens Safety software and fail-safe CPUs and SMs and a Getting Started configuration and programming example. However, the focus of the manual is the S7-1200 fail-safe SMs. SM installation, configuration, diagnostics, applications, and technical specifications are emphasized.

  The English version of the *S7-1200 Functional Safety Manual* is the authoritative (original) language for Functional Safety-related information. All translated manuals refer back to the English manual as the authoritative and/or original source. Siemens identifies the English manual as the authoritative and/or original source in the case of discrepancies between the translated manuals.

- The *Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* provides information that enables you to configure and program SIMATIC Safety fail-safe systems. In addition, you will obtain information on acceptance testing of a SIMATIC Safety fail-safe system. Before configuring and programming an actual live fail-safe operation, it is essential that you refer to this manual.

- The *S7-1200 Programmable Controller System Manual* provides specific information about the operation, programming, and the specifications for the complete S7-1200 product family. In addition to the system manual, the *S7-1200 Easy Book* provides a more general overview to the capabilities of the S7-1200 family.

- The *S7-1200 Functional Safety Manual; SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual; S7-1200 Programmable Controller System Manual*; and the *S7-1200 Easy Book* are available as electronic (PDF) manuals. The electronic manuals can be downloaded from the customer support web site and can also be found on the companion disk that ships with every S7-1200 CPU.

- The TIA portal STEP 7 online help information system provides immediate access to the conceptual information, specific instructions, and error code event IDs that describe the operation and functionality of the programming package and basic operation of SIMATIC CPUs.

- My Documentation Manager accesses the electronic (PDF) versions of the SIMATIC documentation set, including the system manual, the Easy Book, and the information system of STEP 7. With My Documentation Manager, you can drag and drop topics from various documents to create your own custom manual.

  The customer support entry portal (http://support.automation.siemens.com) provides a link to My Documentation Manager under mySupport.

- Siemens also provides online comprehensive support for your use of safety technology. A Safety Evaluation Tool assists you in determining required safety levels, Functional Examples guide you in your safety applications, and SITRAIN classes offer training in safety standards and products. Visit the following web sites to access these support activities:

  – Safety Evaluation Tool (http://www.siemens.com/safety-evaluation-tool)

  – Functional examples (http://www.siemens.com/safety-functional-examples)

  – SITRAIN (http://www.siemens.com/sitrain-safetyintegrated)

1.2 Hardware and software components

S7-1200 Fail-Safe CPUs and SMs

There are four fail-safe CPUs and three fail-safe signal modules (SM) in conjunction with the S7-1200 V4.1 or later release:

- CPU 1214FC DC/DC/DC
- CPU 1214FC DC/DC/RLY
- CPU 1215FC DC/DC/DC
- CPU 1215FC DC/DC/RLY
- SM 1226 F-DI 16 x 24 VDC
- SM 1226 F-DQ 4 x 24 VDC
- SM 1226 F-DQ 2 x Relay

An S7-1200 fail-safe system requires a fail-safe CPU and fail-safe SMs. The integrated I/O on the CPU is not fail-safe, but can be used to complete other control functions.

The S7-1200 standard signal modules (SM), communication modules (CM), and signal boards (SB) can be used in the same system with fail-safe SMs to complete your application control functions that do not require a rated Safety Integrity Level (SIL). Standard SMs that are supported for use with fail-safe SMs have the article numbers (6ES7 --- ---32 0XB0) or later.

The S7-1200 fail-safe CPUs do not support PROFIBUS or PROFINET distributed fail-safe I/O.

Required software components

You require one of the following software combinations:

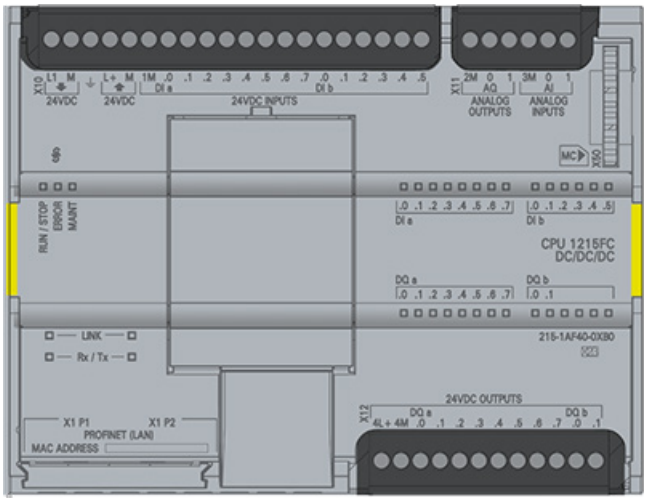
- STEP 7 Basic V13 SP1 or later with STEP 7 Safety Basic V13 SP1 or later
- STEP 7 Professional V13 SP1 or later with STEP 7 Safety Advanced V13 SP1 or later

STEP 7 Safety Advanced V13 SP1 or later and STEP 7 Safety Basic V13 SP1 or later are the configuration and programming software packages for the SIMATIC Safety fail-safe system. In both software packages, you receive the following:

- Support for configuring the fail-safe CPUs and SMs in the hardware and network editor of the TIA portal
- Support for creating the safety program using LAD and FBD and integrating error detection functions into the safety program
- Instructions for programming your safety program in LAD and FBD, which you are familiar with from the standard user programs
- Instructions for programming your safety program in LAD and FBD with special safety functions

1.3 S7-1200 Fail-Safe CPUs

The fail-safe CPU executes your safety program along with standard applications programs. Communication between the fail-safe CPU and the fail-safe signal modules is verified using the PROFIsafe protocol.



Safety program

You can create a safety program using the program editor. You can program fail-safe function blocks (FB) and functions (FC) in the Function Block Diagram (FBD) or Ladder Logic (LAD) programming languages and create fail-safe data blocks (DB).

The fail-safe system performs a dual execution using coded processing. The fail-safe system automatically performs safety checks and inserts additional fail-safe logic for error detection and error response when the safety program compilation occurs. This ensures the detection of failures and faults and appropriate execution of reactions to maintain the fail-safe system in the safe state or bring it to a safe state.

In addition to the safety program, you can run a standard user program on the fail-safe CPU. A standard program can coexist with a safety program in a fail-safe CPU. The fail-safe CPU protects the safety-related data of the safety program from the unintentional effects of the data of the standard user program.

⚠ WARNING

You cannot put an S7-1200 Fail-Safe system that provides safety-related functions into operation after installation or modification until after you successfully commission the safety-related functionality.

Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.

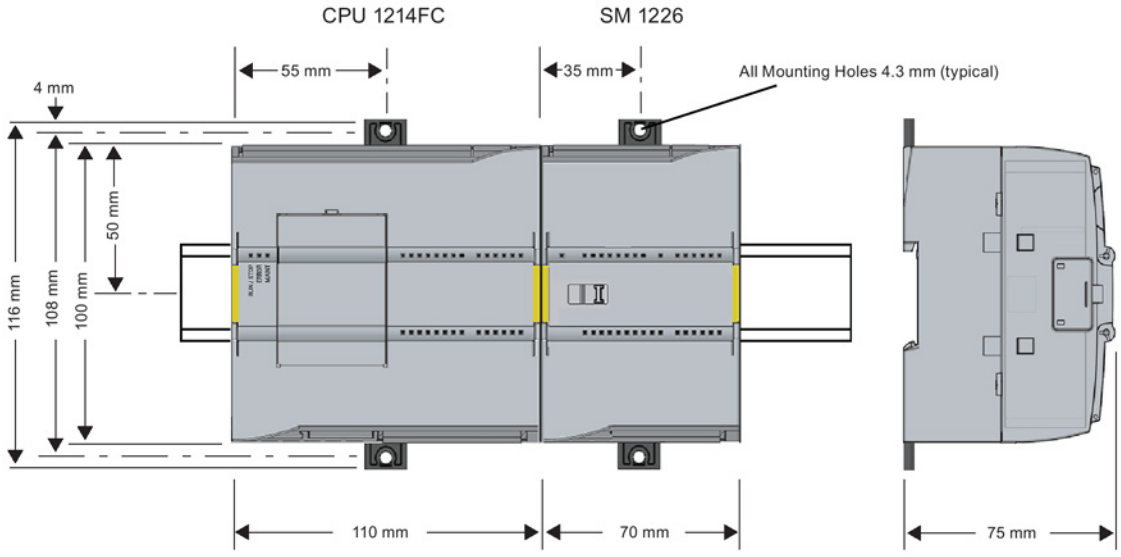
An S7-1200 Fail-Safe system that provides both safety-related functions and standard (non safety-related) functions must not be put into operation in order to use the standard functions before you successfully commission the safety-related functions, even if all fail-safe signal modules go to the error state and thus remain safe.

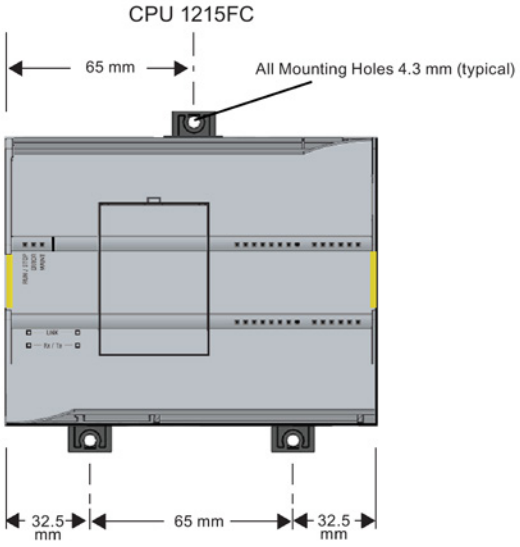
Fail-Safe CPU and signal module (SM) installation

4

4.1 S7-1200 Fail-Safe modules installation and removal

4.1.1 Mounting dimensions for S7-1200 Fail-Safe modules





4.1.2 Guidelines for installing S7-1200 Fail-Safe devices

The S7-1200 equipment is designed to be easy to install. You can install an S7-1200 either on a panel or on a standard rail. The S7-1200 assembly can be oriented either horizontally or vertically. The small size of the S7-1200 allows you to make efficient use of space.

Expansion module installation rules:

- Standard and fail-safe signal modules (SM) are installed on the right side of a CPU. Fail-safe CPUs allow a maximum of 8 signal modules, if the total of all expansion module CPU loads does not exceed the CPU's 5 VDC and 24 VDC power supply load limits. Fail-safe and standard modules may be intermixed on the right side of the CPU.
- Communication modules (CM), are installed on the left side of the CPU. Fail-safe CPU's allow a maximum of 3 communication modules, if the total of all expansion module loads does not exceed the CPU's 5 VDC and 24 VDC power load limits.
- Signal boards (SB), communications boards (CB), and battery boards (BB) are installed on top of the CPU. A maximum of 1 signal board, communication board, or battery board is allowed for any CPU.

The S7-1200 standard signal modules (SM), communication modules (CM), and signal boards (SB) can be used in the same system with fail-safe SMs to complete your application control functions that do not require a rated Safety Integrity Level (SIL). Standard SMs that are supported for use with fail-safe SMs have the MLFB numbers (6ES7 --- ---32 0XB0).

The S7-1200 fail-safe CPUs do not support PROFIBUS or PROFINET distributed fail-safe I/O.

Electrical equipment standards classify the SIMATIC S7-1200 system as Open Equipment. You must install the S7-1200 in a housing, cabinet, or electric control room. You should limit entry to the housing, cabinet, or electric control room to authorized personnel.

The installation should provide a dry environment for the S7-1200. SELV/PELV circuits are considered to provide protection against electric shock in dry locations.

The installation should provide mechanical and environmental protection that is approved for open equipment in your particular location category according to applicable electrical and building codes.

Conductive contamination due to dust, moisture, and airborne pollution can cause operational and electrical faults in the PLC.

If you locate the PLC in an area where conductive contamination may be present, the PLC must be protected by an enclosure with appropriate protection rating. IP54 is one rating that is generally used for electronic equipment enclosures in dirty environments and may be appropriate for your application.

⚠ WARNING

Improper installation of the S7-1200 can result in electrical faults or unexpected operation of machinery.

Electrical faults or unexpected machine operation can result in death, severe personal injury, and/or property damage.

All instructions for installation and maintenance of a proper operating environment must be followed to ensure the equipment operates safely.

Separate the S7-1200 devices from heat, high voltage, and electrical noise

As a general rule for laying out the devices of your system, always separate the devices that generate high voltage and high electrical noise from the low voltage, logic devices such as the S7-1200.

When designing the layout of an S7-1200 inside your panel, consider the heat generating devices and locate electronic devices in the cooler areas of your cabinet. Reducing the exposure to a high temperature environment extends the operating life of any electronic device.

Consider also the routing of the wiring for the devices in the panel. Avoid placing low voltage signal wires and communications cables in the same tray with AC power wiring and high energy, rapidly switched DC wiring.

Provide adequate space for cooling and wiring

S7-1200 devices are designed for natural convection cooling. For proper cooling, you must provide a clearance of at least 25 mm above and below the devices. Also, allow at least 25 mm of space between the front of the modules and the inside of the enclosure.

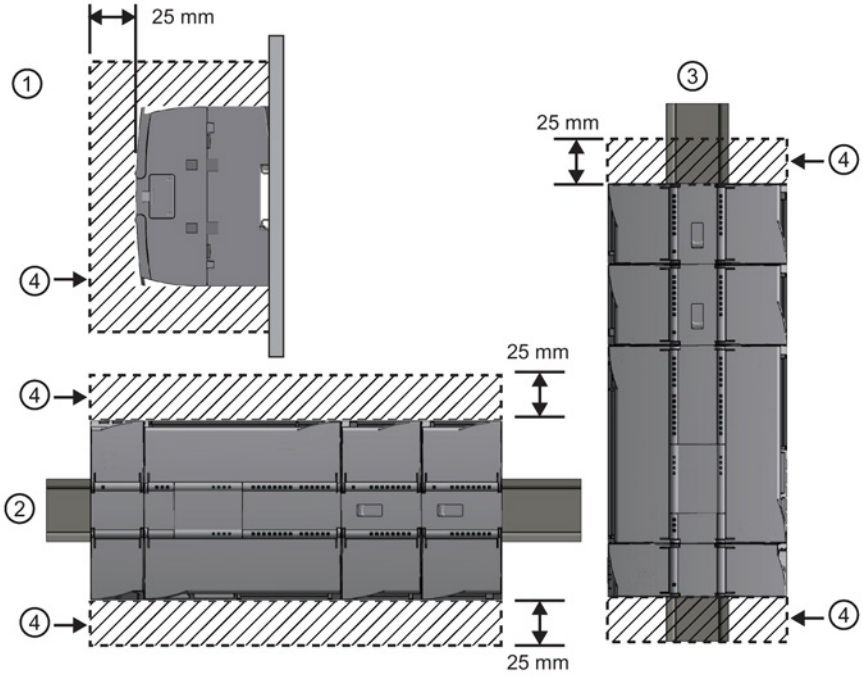
⚠ CAUTION

For vertical mounting, the maximum allowable ambient temperature is reduced by 10 degrees C.

Orient a vertically mounted S7-1200 system as shown in the following figure.

Ensure that the S7-1200 system is mounted correctly.

When planning your layout for the S7-1200 system, allow enough clearance for the wiring and communications cable connections.

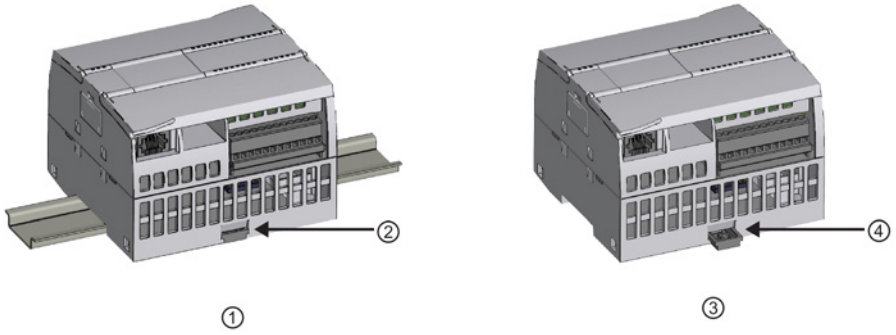


① Side view
② Horizontal installation
③ Vertical installation
④ Clearance area

4.1.3 Installation and removal safety rules

Installing and removing the S7-1200 devices

The CPU can be easily installed on a standard DIN rail or on a panel. DIN rail clips are provided to secure the device on the DIN rail. The clips also snap into an extended position to provide a screw mounting position for panel-mounting the unit.



① DIN rail installation
② DIN rail clip in latched position
③ Panel installation
④ Clip in extended position for panel mounting

Before you install or remove any electrical device, ensure that the power to that equipment has been turned off. Also, ensure that the power to any related equipment has been turned off.

⚠ WARNING

Installation or removal of S7-1200 or related equipment, with the power applied, could cause electric shock or unexpected operation of equipment.

Failure to disable all power to the S7-1200 and related equipment during installation or removal procedures could result in death, severe personal injury and property damage due to electric shock or unexpected equipment operation.

Always follow appropriate safety precautions and ensure that power to the S7-1200 is disabled before attempting to install or remove S7-1200 CPUs and related equipment.

Always ensure that whenever you replace or install an S7-1200 device you use the correct module or equivalent device.

WARNING

Incorrect installation of an S7-1200 module may cause the program in the S7-1200 to function unpredictably.

Failure to replace an S7-1200 device with the same model, orientation, or order could result in death, severe personal injury and property damage due to unexpected equipment operation.

Replace an S7-1200 device with the same model, and be sure to orient and position the module correctly.

WARNING

Do not disconnect equipment when a flammable or combustible atmosphere is present.

Disconnection of equipment when a flammable or combustible atmosphere is present may cause a fire or explosion which could result in death, serious injury and property damage.

Always follow appropriate safety precautions when a flammable or combustible atmosphere is present.

Note

Electrostatic discharge can damage the device or the receptacle on the CPU.

Make contact with a grounded conductive pad or wear a grounded wrist strap whenever you handle the device.

4.1.4 Installing and removing an S7-1200 FC CPU

You can install the CPU on a panel or on a DIN rail.

Note

Attach any communication modules to the CPU and install the assembly as a unit. Install signal modules separately after the CPU has been installed.

Set up the CPU rail clips:

- **For DIN rail mounting**, make sure the upper DIN rail clip is in the latched (inner) position and lower DIN rail clip is in the unlatched (extended) position, for both CPU and attached CMs.
  - After installing the devices on the DIN rail, move the lower DIN rail clips to the latched position to lock the devices on the DIN rail.
- **For panel mounting**, make sure the DIN rail clips are pushed to the extended position.

To install the CPU on a panel, follow these steps:

1. Locate, drill, and tap the mounting holes (M4), using the dimensions shown in the mounting dimensions table (Page 79).
2. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power.
3. Extend the mounting clips from the module. Make sure the DIN rail clips on the top and bottom of the CPU are in the extended position.
4. Secure the module to the panel, using a pan head M4 screw with spring and flat washer. Do not use a counter-sink screw with beveled head. Apply only enough torque to flatten the spring washer.

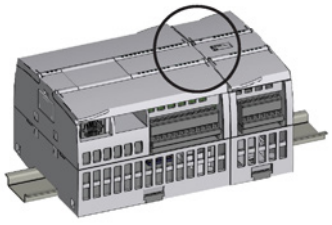
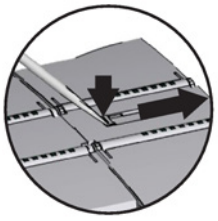
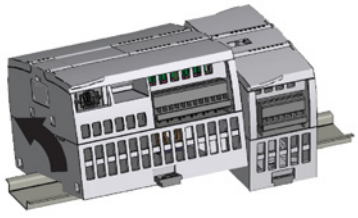
Note

If your system is subject to a high vibration environment or is mounted vertically, then panel mounting the S7-1200 is recommended.

Table 4- 1 Installing the CPU on a DIN rail

Task	Procedure
	1. Install the DIN rail. Secure the rail to the mounting panel every 75 mm. 2. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power. 3. Hook the CPU over the top of the DIN rail. 4. Pull out the DIN rail clip on the bottom of the CPU to allow the CPU to fit over the rail. 5. Rotate the CPU down into position on the rail. 6. Push in the clips to latch the CPU to the rail.
	

Table 4- 2 Removing the CPU from a DIN rail

Task	Procedure	
		1. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power. 2. Disconnect the I/O connectors, wiring, and cables from the CPU. Refer to the terminal block removal instructions (Page 89). 3. Remove the CPU and any attached communication modules as a unit. All signal modules should remain installed. 4. If an SM is connected to the CPU, then retract the bus connector: – Place a screwdriver beside the tab on the top of the signal module. – Press down to disengage the connector from the CPU. – Slide the tab fully to the right. 5. Remove the CPU: – Pull out the DIN rail clip to release the CPU from the rail. – Rotate the CPU up and off the rail, and remove the CPU from the system.
		

4.1.6 Removing and reinstalling the S7-1200 terminal block connector

CPUs, signal boards (SB) and signal modules (SM) have removable connectors to make wiring easy.

Table 4- 5 Removing terminal blocks (CPU example)

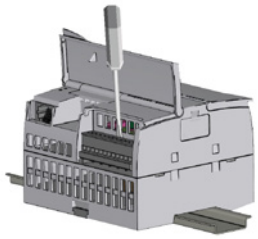
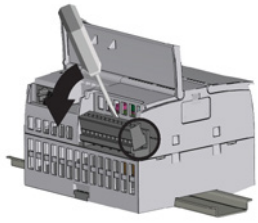
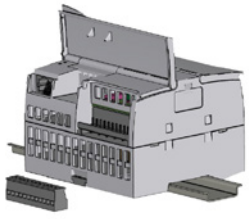
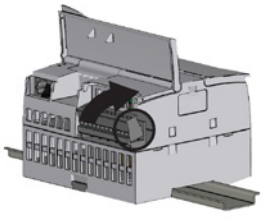
Task	Procedure
 	Prepare the system for terminal block connector removal by removing the power from the CPU and opening the cover above the connector. 1. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power. 2. Inspect the top of the connector and locate the slot for the tip of the screwdriver. 3. Insert a screwdriver into the slot. 4. Gently pry the top of the connector away from the CPU. The connector releases with a snap. 5. Grasp the connector and pull away from the CPU.

Table 4- 6 Installing the connector

Task	Procedure
 	Prepare the components for terminal block installation by removing power from the CPU and opening the cover for connector. 1. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power. 2. Align the connector with the pins on the unit. 3. Align the wiring edge of the connector inside the rim of the connector base. 4. Press firmly down and rotate until the connector snaps into place. Check carefully to ensure that the connector is properly aligned and fully engaged.

4.2 Fail-Safe system electrical design rules

4.2.1 Safe functional extra low voltage requirement (power supplies and other system components)

⚠ WARNING

Fail-safe modules must be operated with safe functional extra-low voltage (SELV, PELV) power sources.

To maintain safe S7-1200 low voltage circuits, external connections to communications ports, analog circuits, 24 VDC nominal power supplies, and I/O circuits must be powered from approved sources that meet the requirements of SELV, PELV, Class 2, Limited Voltage, or Limited Power according to various standards.

The external power supply should limit the maximum voltage to 35 VDC even under fault conditions. Please consult the manufacturer's data for the power supplies that you use.

Maximum applied voltage to S7-1200 Fail-Safe devices

- Operational voltage: The fail-safe CPU and fail-safe signal modules operational voltage is 20.4 VDC - 28.8 VDC, 35 VDC surge for 0.5 second. Operation of the unit to specifications is assured by design and testing. Defined transients from defined source impedances per EN 61000-4-2, 61000-4-4, 61000-4-6, as specified in the data sheet for each product, may be imposed on this voltage without disrupting operation or causing damage. Sustained operation in the range of 28.8 - 35 VDC can result in unacceptable temperature rise and thermal damage, causing the product to become inoperable.
- Absolute maximum rating regarding supply voltage: The absolute maximum rating to prevent module damage and to ensure the functional safety of the modules is 35 VDC. Only use SELV / PELV power supplies, connected directly or through field devices, with the fail-safe CPU and fail-safe signal modules. These power supplies must be specified by the manufacturer to limit the output voltage to 35 VDC or less under fault conditions. Otherwise, external protection must be supplied that will reliably open the circuit or limit the output voltage to less than 35 VDC to the CPU and signal modules.
- Surge immunity: Wiring systems subject to surges from lightning strike coupling must be equipped with external protection. This protection must be sufficient to clamp surge voltages and/or open the supply circuit to assure the PLC system is not exposed to voltages greater than 35 VDC. One specification for evaluation of protection from lightning type surges is found in EN 61000-4-5, with operational limits established by EN 61000-6-2. S7-1200 DC fail-safe CPUs and fail-safe signal modules require external protection to maintain safe operation when subject to surge voltages defined by this standard. Refer to Appendix A.1: "General technical specifications (Page 132)", "Surge immunity" for further information.

WARNING

All power supply and fail-safe signal module circuits must be connected together to a common voltage reference or must be isolated SELV circuits.

The power supply M terminals on the fail-safe CPU and the fail-safe SMs must be connected together or isolated as SELV. Failure to do so can result in unexpected machine or process operation, which may cause death or serious injury to personnel, and/or damage to equipment.

Connecting all M terminals together or isolating with approved SELV isolation prevents unwanted current flows in the event of a single fault in the CPU to SM isolation boundary.

4.2.2 Power budget

4.2.2.1 Connecting power to the S7-1200 system

Fail-safe CPUs require an external SELV/PELV 24 VDC power supply for the CPU's 24 VDC power input (the 24 VDC L+ and M terminals, with an **arrow pointing into** the CPU module). The external 24 VDC supply powers the CPU's internal 5 VDC supply that provides power for the CPU, signal modules (SM), signal board (SB), and communication modules (CM). 24 VDC power is available at the CPU's 24 VDC power output (the 24VDC L+ and M terminals, with an **arrow pointing out of** the CPU module).

Note

Sensor supply connections for safety inputs

If you want to use a sensor supply source from the PLC for safety inputs, you should use the sensor supply provided on the fail-safe DI signal modules.

The purpose of a power budget calculation is to ensure that the power requirements of all CPU powered elements (fail-safe CPU, fail-safe SM, standard SM, and CM) do not exceed the available CPU power:

- You may not be able to connect the maximum number of signal modules and communication modules, if you exceed the CPU's 5 VDC power output capability.
- You may need to use external 24 VDC power for some system elements, if you exceed the CPU's 24 VDC power output capability.

Note

Power limits for 5 VDC and 24 VDC supplied from a fail-safe CPU.

Exceeding the power budget of the CPU may result in not being able to connect the allowed maximum number of add-on modules.

Refer to the technical specifications for information about power input requirements (CPUs, SMs, SBs, and CMs) and CPU power output limits (5 VDC and 24 VDC).

Refer to the "Calculating a power budget" (Page 94) to determine CPU power output capability.

Expansion module installation rules:

- Standard and fail-safe signal modules (SM) are installed on the right side of the CPU. Fail-safe CPUs allow a maximum of 8 signal modules, if the total of all add-on module CPU loads does not exceed the CPU's 5 VDC and 24 VDC power supply load limits. Fail-safe and standard modules may be intermixed on the right side of the CPU.
- Communication modules (CM), are installed on the left side of the CPU. A maximum of 3 communication modules is allowed for a Fail-safe CPU, if the total of all add-on module CPU loads does not exceed the CPU's 5 VDC and 24 VDC load limits.
- Signal boards (SB), communications boards (CB), and battery boards (BB) are installed on top of the CPU. A maximum of one signal board, communication board, or battery board is allowed for any CPU.

⚠ WARNING

Do not connect separate power supplies directly in parallel.

This can cause a conflict between the power supplies, as each supply tries to establish its preferred output voltage level.

The result of this conflict can be shortened lifetime or the immediate failure of one or both power supplies, with consequent unpredictable operation of the PLC system. Unpredictable operation could result in death, severe personal injury and property damage.

A CPU 24 VDC supply and any external power supply should provide power to different load points.

For improved electrical noise protection, the commons (M) of the different power supplies should be connected.

Some of the 24 VDC power inputs in an S7-1200 system are interconnected, with a common logic circuit connecting multiple M terminals. For example, the following circuits are interconnected when designated as "not isolated" in the technical specifications: the 24 VDC power supply of the CPU, the power input for the relay coil of an SM, or the power supply for a non-isolated analog input. All non-isolated M terminals must connect to the same external reference potential.

⚠ WARNING

Connecting non-isolated M terminals to different reference potentials will cause unintended current flows that may cause damage or unpredictable operation in the PLC and any connected equipment.

Failure to comply with this guideline could cause damage or unpredictable operation which could result in death or severe personal injury and property damage.

Always ensure that all non-isolated M terminals in an S7-1200 system are connected to the same reference potential.

4.3 Control system wiring guidelines

4.3.1 Guidelines for grounding and wiring

Proper grounding and wiring of all electrical equipment is important to provide electrical noise protection for your application and the S7-1200. Refer to the technical specifications (Page 132) for the S7-1200 wiring diagrams.

Prerequisites

Before you ground or install wiring to any electrical device, ensure that the power to that equipment has been turned off. Also, ensure that the power to any related equipment has been turned off.

Ensure that you follow all applicable electrical codes when wiring the S7-1200 and related equipment. Install and operate all equipment according to all applicable national and local standards. Contact your local authorities to determine which codes and standards apply to your specific case.

⚠ WARNING

Installing or wiring the S7-1200 or related equipment with power applied could cause electric shock or unexpected operation of equipment.

Failure to disable all power to the S7-1200 and related equipment during installation or removal procedures could result in death, severe personal injury, and damage due to electric shock or unexpected equipment operation.

Always follow appropriate safety precautions and ensure that power to the S7-1200 is disabled before attempting to install or remove the S7-1200 or related equipment.

Always take safety into consideration as you design the grounding and wiring of your S7-1200 system. Electronic control devices, such as the S7-1200, can fail and cause unexpected operation of the equipment that is being controlled or monitored:

- On-board I/O on the fail-safe CPU and signal modules (SM) other than fail-safe SM: Single point dangerous failures of electronics or software can occur on these devices. You should never depend on these devices as the only protection against personal injury or unacceptable property damage.
- Fail-safe SM: Internal dangerous failures can occur on these devices with a probability as reflected in the SIL rating, PFD, and PFH as stated in this manual.
- Each control's installation: Common cause failure threats can occur such as overvoltage, over-temperature, electrical faults, EMC interference, and fire, water, or mechanical damage to the installation.

You must evaluate every control point for the threat level and consequences of failure. Your installation can require safeguards that are independent of the S7-1200 to achieve an appropriate level of risk for personal injury or equipment damage.

⚠ WARNING

Control devices can fail in an unsafe condition, resulting in unexpected operation of controlled equipment.

Such unexpected operations could result in death, severe personal injury, and property damage.

When using fail-safe I/O, design safety-related control functions to account for the probability of faults, including redundancy to achieve an appropriate level of risk for the consequences of failure.

When using standard I/O, always include an emergency stop function, electromechanical overrides, or other redundant safeguards when a failure could cause personal injury or significant property damage.

4.3.2 Grounding an S7-1200 system

Guidelines for grounding the S7-1200

The best way to ground your application is to ensure that all the common and ground connections of your S7-1200 and related equipment are grounded to a single point. This single point should be connected directly to the earth ground for your system.

All ground wires should be as short as possible and should use a large wire size, such as 2 mm^2 (14 AWG).

When locating grounds, consider safety-grounding requirements and the proper operation of protective interrupting devices.

4.3.3 Wiring an S7-1200 system

Guidelines for wiring the S7-1200 system

When designing the wiring for your S7-1200, provide a single disconnect switch that simultaneously removes power from the fail-safe CPU power supply, from all input circuits, and from all output circuits. Provide over-current protection, such as a fuse or circuit breaker, to limit fault currents on supply wiring. Consider providing additional protection by placing a fuse or other current limit in each output circuit.

Install appropriate surge suppression devices for any wiring that could be subject to lightning surges.

Avoid placing low voltage signal wires and communications cables in the same wire tray with AC wires and high energy, rapidly switched DC wires. Always route wires in pairs, with the neutral or common wire paired with the hot or signal-carrying wire.

Note

The standard I/O channels integrated in the S7-1200 fail-safe CPUs are not designed to be used for the fail-safe I/O function

In your project, you can use the integrated fail-safe CPU I/O with standard code blocks, but you must use the S7-1200 fail-safe DI and DQ signal modules as the fail-safe digital I/O channels with safety code blocks.

Use the shortest wire possible and ensure that the wire is sized properly to carry the required current. The CPU and SM connectors accept wire sizes from 2 mm^2 to 0.3 mm^2 (14 AWG to 22 AWG). Wire strip length is 6.4 mm.

Wire and cable should have a temperature rating 30 °C higher than the ambient temperature around the S7-1200 (for example, a minimum of 85 °C-rated conductors for 55 °C ambient temperature). You should determine other wiring type and material requirements from the specific electrical circuit ratings and your installation environment.

Use shielded wires for optimum protection against electrical noise. Typically, grounding the shield at the S7-1200 gives the best results. You should ground communication cable shields to S7-1200 communication connector shells using connectors that engage the cable shield, or by bonding the communication cable shields to a separate ground. You should ground other cable shields using clamps or copper tape around the shield to provide a high surface area connection to the grounding point.

When wiring input circuits that are powered by an external power supply, include an overcurrent protection device in that circuit. External protection is not necessary for circuits that are powered by the 24 VDC sensor supply from the S7-1200 because the sensor supply is already current-limited.

All S7-1200 modules have removable connectors for user wiring. To prevent loose connections, ensure that the connector is seated securely and that the wire is installed securely into the connector. To avoid damaging the connector, be careful that you do not over-tighten the screws. The maximum torque for the CPU and SM connector screw is 0.56 N-m (5 inch pounds).

To help prevent unwanted current flows in your installation, the S7-1200 provides isolation boundaries at certain points. When you plan the wiring for your system, you should consider these isolation boundaries. Refer to the technical specifications (Page 132) for the amount of isolation provided and the location of the isolation boundaries. Circuits rated for AC line voltage include safety isolation to other circuits. Isolation boundaries between 24 VDC circuits are functional only, and you should not depend on these boundaries for safety.

4.3.4 Guidelines for lamp loads

Guidelines for lamp loads

Lamp loads are damaging to relay contacts because of the high turn-on surge current. This surge current is 10 to 15 times the steady state current for a tungsten filament lamp. A replaceable interposing relay or surge limiter is recommended for lamp loads that are switched a large number of times during the lifetime of the application.

4.3.5 Guidelines for inductive loads

Guidelines for inductive loads

Use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off. Suppressor circuits protect your outputs from premature failure caused by the high voltage transient that occurs when current flow through an inductive load is interrupted.

In addition, suppressor circuits limit the electrical noise generated when switching inductive loads. High frequency noise from poorly suppressed inductive loads can disrupt the operation of the PLC. Placing an external suppressor circuit so that it is electrically across the load and physically located near the load is the most effective way to reduce electrical noise.

S7-1200 DC outputs include internal suppressor circuits that are adequate for inductive loads in most applications. Since S7-1200 relay output contacts can be used to switch either a DC or an AC load, internal protection is not provided.

A good suppressor solution is to use contactors and other inductive loads for which the manufacturer provides suppressor circuits integrated in the load device, or as an optional accessory. However, some manufacturer provided suppressor circuits may be inadequate for your application. An additional suppressor circuit may be necessary for optimal noise reduction and contact life.

For AC loads, a metal oxide varistor (MOV) or other voltage clamping device may be used with a parallel RC circuit, but is not as effective when used alone. An MOV suppressor with no parallel RC circuit often results in significant high frequency noise up to the clamp voltage.

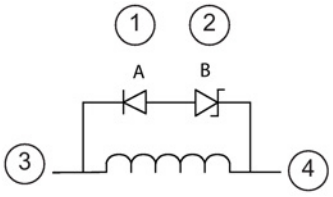
A well-controlled turn-off transient will have a ring frequency of no more than 10KHz, with less than 1KHz preferred. Peak voltage for AC lines should be within +/- 1200V of ground. The data sheets list voltage thresholds for the internal suppression circuits on DC outputs. (Refer to Appendix A: "Technical specifications" for further information.) External suppression should limit the transient to less than this threshold to ensure that the internal suppression circuit does not attempt to suppress an excessive load. Placing an external suppressor circuit so that it is electrically across the load and physically located near the load is the most effective way to reduce electrical noise.

An external suppression circuit connected directly across the load also avoids the hazard of energizing the load if suppression circuit components fail short.

Note

The effectiveness of a suppressor circuit depends on the application and must be verified for your particular usage. Ensure that all components are correctly rated and use an oscilloscope to observe the turn-off transient.

Typical suppressor circuit for DC or relay outputs that switch DC inductive loads



① 1N4001 diode or equivalent

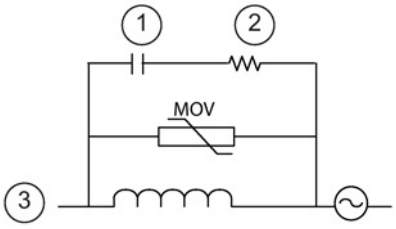
② 8.2 V Zener (DC outputs),
36 V Zener (Relay outputs)

③ Output channel F-DQ (P-switch)
or standard DQ output

④ Output channel F-DQ (M-switch)
or standard DQ common return

In most applications, the addition of a diode (A) across a DC inductive load is suitable, but if your application requires faster turn-off times, then the addition of a Zener diode (B) is recommended. Be sure to size your Zener diode properly for the amount of current in your output circuit.

Typical suppressor circuit for relay outputs that switch AC inductive loads



Ensure that the working voltage of the MOV is at least 20% greater than the nominal line voltage.

Choose pulse-rated, non-inductive resistors, and capacitors recommended for pulse applications (typically metal film). Verify the components meet average power, peak power, and peak voltage requirements.

① See table for C value

② See table for R value

③ Output channel

If you design your own suppressor circuit, the following table suggests resistor and capacitor values for a range of AC loads. These values are based on calculations with ideal component parameters. "I rms" in the table refers to the steady-state current of the load when fully ON.

Table 4- 9 AC suppressor circuit resistor and capacitor values

Inductive load			Suppressor values		
I rms	230 VAC	120 VAC	Resistor		Capacitor
Amps	VA	VA	Ω	W (power rating)	nF
.02	4.6	2.4	15000	.1	15
.05	11.5	6	5600	.25	47
.1	23	12	2700	.5	100
.2	46	24	1500	1	150
.5	115	60	560	2.5	470
1	230	120	270	5	1000
2	460	240	150	10	1500

Conditions satisfied by the table values:

Maximum turn-off transition step < 500V
Resistor peak voltage < 500V
Capacitor peak voltage < 1250V
Suppressor current < 8% of load current (50 Hz)
Suppressor current < 11% of load current (60 Hz)
Capacitor dV/dt < 2 V/µs
Capacitor pulse dissipation : $\int (dv/dt)^2 \, dt < 10000 \, V^2/\mu s$
Resonant frequency < 300 Hz
Resistor power for 2Hz max switching frequency
Power factor of 0.3 assumed for typical inductive load

4.4 Maintenance guidelines

Each S7-1200 module and CPU is a factory-assembled unit that contains no user replaceable components or repairable components, except for removeable terminal blocks and memory cards. Maintenance of an S7-1200 system consists of the following:

- Observation and response to diagnostic reports from the S7-1200
- Replacement of modules with identified failures
- Replacement of modules at 20 years of operating life
- Inspection and monitoring of the installation environment to ensure continued adherence to all specified operating conditions, to include the following:
  - S7-1200 and field wiring electrically and mechanically secure
  - Ventilation continued as designed for installation
  - Continued protection from moisture, dust, and conductive contamination
  - Voltage of connected circuits in proper range
  - Operating temperature of equipment in proper range

The fail-safe signal modules (SMs) monitor the 24 VDC power supplied at L+/M and passivate the module on voltage out-of-range.

The fail-safe SMs monitor internal temperature and passivate the SM on temperature out-of-range.

You must assess your installation safety and determine if you require additional voltage and temperature monitoring.

Note

Associated equipment including sensors, actuators, circuit breakers, and surge protectors are subject to wear and typically require periodic inspections or proof tests according to manufacturer's instructions or standards to maintain a consistent level of safety integrity.

User cleaning or decontamination of an S7-1200: Use vacuum or a dry cloth applied to the outside of the assembly only. High pressure forced air can damage components or carry entrained contaminants. Liquid cleaners of any kind can deposit conductive contamination onto the circuit boards.

A.2.2 CPU 1214FC

A.2.2.1 General specifications and features

Table A- 9 General

Technical data	CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Article number	6ES7 214-1HF40-0XB0	6ES7 214-1AF40-0XB0
Dimensions W x H x D (mm)	110 x 100 x 75	
Shipping weight	435 grams	415 grams
Power dissipation	12 W	
Current available (SM and CM bus)	1600 mA max. (5 VDC)	
Current available (24 VDC)	400 mA max. (sensor power)	
Digital input current consumption (24 VDC)	4 mA/input used	

Table A- 10 CPU features

Technical data		Description
User memory (Refer to "General technical specifications (Page 132), "Internal CPU memory retention".)	Work	125 Kbytes
	Load	4 Mbytes internal, expandable up to SD card size
	Retentive	10 Kbytes
On-board digital I/O		14 inputs/10 outputs
On-board analog I/O		2 inputs
Process image size		1024 bytes of inputs (I)/1024 bytes of outputs (Q)
Bit memory (M)		8192 bytes
Temporary (local) memory		• 16 Kbytes for startup and program cycle (including associated FBs and FCs) • 6 Kbytes for each of the other interrupt priority levels (including FBs and FCs)
Signal modules expansion		8 SMs max.
SB, CB, BB expansion		1 max.
Communication module expansion		3 CMs max.
High-speed counters		Up to 6 configured to use any built-in or SB inputs. (Refer to the *S7-1200 System Manual*. for more information.) • 100/[1]80 kHz (Ia.0 to Ia.5) • 30/[1]20 kHz (Ia.6 to Ib.5)
Pulse outputs[2]		Up to 4 configured to use any built-in or SB outputs • 100 kHz (Qa.0 to Qa.3) • 30 kHz (Qa.4 to Qb.1)
Pulse catch inputs		14

Element		Description
	Storage	Structure in DB, size dependent upon count type • SInt, USInt: 3 bytes • Int, UInt: 6 bytes • DInt, UDInt: 12 bytes

Table A- 13 Communication

Technical data	Description
Number of ports	1
Type	Ethernet
HMI device	4
Programming device (PG)	1
Connections	• 8 for Open User Communication (active or passive): TSEND_C, TRCV_C, TCON, TDISCON, TSEND, and TRCV • 3 for server GET/PUT (CPU-to-CPU) S7 communication • 8 for client GET/PUT (CPU-to-CPU) S7 communication
Data rates	10/100 Mb/s
Isolation (external signal to PLC logic)	Transformer isolated, 1500 VAC, for short term event safety only
Cable type	CAT5e shielded

Table A- 14 Power supply

Technical data		CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Voltage range		20.4 VDC to 28.8 VDC	
Line frequency		--	
Input current (max. load)	CPU only	500 mA at 24 VDC	
	CPU with all expansion accessories	1500 mA at 24 VDC	
Inrush current (max.)		12 A at 28.8 VDC	
Isolation (input power to logic)		Not isolated	
Ground leakage, AC line to functional earth		-	
Hold up time (loss of power)		10 ms at 24 VDC	
Internal fuse, not user replaceable		3 A, 250 V, slow blow	

Table A- 15 Sensor power

Technical data	CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Voltage range	L+ minus 4 VDC min.	
Output current rating (max.)	400 mA (short-circuit protected)	
Maximum ripple noise (<10 MHz)	Same as input line	
Isolation (CPU logic to sensor power)	Not isolated	

A.2.2.4 Digital inputs and outputs

Table A- 16 Digital inputs

Technical data	CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Number of inputs	14	
Type	Sink/Source (IEC Type 1 sink)	
Rated voltage	24 VDC at 4 mA, nominal	
Continuous permissible voltage	30 VDC, max.	
Surge voltage	35 VDC for 0.5 sec.	
Logic 1 signal (min.)	15 VDC at 2.5 mA	
Logic 0 signal (max.)	5 VDC at 1 mA	
Isolation (field side to logic)	500 VAC for 1 minute	
Isolation groups	1	
Filter times	us settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0	
HSC clock input rates (max.) (Logic 1 Level = 15 to 26 VDC)	100/80 kHz (Ia.0 to Ia.5) 30/20 kHz (Ia.6 to Ib.5)	
Number of inputs on simultaneously	14 inputs at 55 °C horizontal or 45 °C vertical	
Cable length (meters)	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs	

Table A- 17 Digital outputs

Technical data	CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Number of outputs	10	
Type	Relay, mechanical	Solid state - MOSFET (sourcing)
Voltage range	5 to 30 VDC or 5 to 250 VAC	20.4 to 28.8 VDC
Logic 1 signal at max. current	--	20 VDC min.
Logic 0 signal with 10 KΩ load	--	0.1 VDC max.
Current (max.)	2.0 A	0.5 A
Lamp load	30 W DC / 200 W AC	5 W
ON state resistance	0.2 Ω max. when new	0.6 Ω max.
Leakage current per point	--	10 µA max.
Surge current	7 A with contacts closed	8 A for 100 ms max.
Overload protection	No	
Required external overload protection [4]	10 A maximum must be limited to any common	5 A maximum must be limited to any common
Isolation (field side to logic)	1500 VAC for 1 minute (coil to contact) None (coil to logic)	500 VAC for 1 minute
Isolation resistance	100 MΩ min. when new	--
Isolation between open contacts	750 VAC for 1 minute	--

Technical data	CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Isolation groups	2	1
Isolation (group-to-group)	1500 VAC [1]	--
Inductive clamp voltage	--	L+ minus 48 VDC, 1 W dissipation
Switching delay (Qa.0 to Qa.3)	10 ms max.	1.0 µs max., off to on 3.0 µs max., on to off
Switching delay (Qa.4 to Qb.1)	10 ms max.	50 µs max., off to on 200 µs max., on to off
Maximum relay switching frequency	1 Hz	--
Pulse Train Output rate	Not recommended [2]	100 kHz (Qa.0 to Qa.3) [3], 2 Hz min. 20 kHz (Qa.4 to Qb.1) [3]
Lifetime mechanical (no load)	10,000,000 open/close cycles	--
Lifetime contacts at rated load	100,000 open/close cycles	--
Behavior on RUN to STOP	Last value or substitute value (default value 0)	
Number of outputs on simultaneously	10 outputs at 55 °C horizontal or 45 °C vertical	
Cable length (meters)	500 m shielded, 150 m unshielded	

[1] Relay group-to-group isolation separates line voltage from SELV/PELV and separates different phases up to 250 VAC line to ground.

[2] For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

[3] Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) may improve pulse signal quality and noise immunity.

[4] External overload protection is to limit fire hazard. Overload can damage relay or transistor output.

A.2.2.5 Analog inputs

Table A- 18 Analog inputs

Technical data	Description
Number of inputs	2
Type	Voltage (single-ended)
Full-scale range	0 to 10 V
Full-scale range (data word)	0 to 27648
Overshoot range	10.001 to 11.759 V
Overshoot range (data word)	27649 to 32511
Overflow range	11.760 to 11.852 V
Overflow range (data word)	32512 to 32767
Resolution	10 bits
Maximum withstand voltage	35 VDC
Smoothing	None, Weak, Medium, or Strong See the table for step response (ms) for the analog inputs of the CPU (Page 155).
Noise rejection	10, 50, or 60 Hz
Impedance	≥100 KΩ
Isolation (field side to logic)	None
Accuracy (25 °C / 0 to 55 °C)	3.0% / 3.5% of full-scale
Cable length (meters)	100 m, shielded twisted pair

Step response of built-in analog inputs of the CPU

Table A- 19 Step Response (ms), 0 V to 10 V measured at 95%

Smoothing selection (sample averaging)	Rejection frequency (Integration time)		
	60 Hz	50 Hz	10 Hz
None (1 cycle): No averaging	50 ms	50 ms	100 ms
Weak (4 cycles): 4 samples	60 ms	70 ms	200 ms
Medium (16 cycles): 16 samples	200 ms	240 ms	1150 ms
Strong (32 cycles): 32 samples	400 ms	480 ms	2300 ms
Sample time	**4.17 ms**	**5 ms**	**25 ms**

Sample time for the built-in analog ports of the CPU

Table A- 20 Sample time for built-in analog inputs of the CPU

Rejection frequency (Integration time selection)	Sample time
60 Hz (16.6 ms)	4.17 ms
50 Hz (20 ms)	5 ms
10 Hz (100 ms)	25 ms

Pin	X10	X11 (gold)	X12
17	DI b.2	--	--
18	DI b.3	--	--
19	DI b.4	--	--
20	DI b.5	--	--

Note

Unused analog inputs should be shorted.