SIEMENS

SIMATIC

Process Control System PCS 7 Compendium Part E - Hardware Installation (V9.0)

Operating Manual

Security information 1

Preface 2

General rules for lines and connection technology 3

Configuration and design of control cabinets 4

Plant concept for earthing, potential equalization and lightning protection 5

Rules for S7 automation systems 6

Bus systems 7

Emergency off 8

Service and support 9

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Legal information

Warning notice system

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

⚠ DANGER

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

⚠ WARNING

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

⚠ CAUTION

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

NOTICE

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

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

Qualified Personnel

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

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Disclaimer of Liability

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

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Table of contents

1 Security information 5
2 Preface 6
3 General rules for lines and connection technology 8
3.1 Line selection and connection technology 8
3.2 Line routing through cable channels and control cabinets. 10
3.3 Insulation resistances 11
3.4 Connectors and module slots 12
3.5 Redundant plant configuration 12
4 Configuration and design of control cabinets 14
4.1 General requirements 14
4.2 Place of installation 15
4.3 Environmental conditions and air conditioning 16
4.4 Operator protection 17
4.5 EMC and shielding 19
4.6 Using line filters and interference suppressors 22
4.7 Overload protection systems 24
4.8 Earthing concept for control cabinet components 25
4.9 Wiring unused module inputs 26
4.10 Lightning and overvoltage protection 27
5 Plant concept for earthing, potential equalization and lightning protection 29
5.1 Earthing, potential equalization and lightning protection 29
5.2 Plant-wide earthing 30
5.3 Plant-wide potential equalization 34
5.4 Plant-wide lightning protection 35
6 Rules for S7 automation systems 36
6.1 SIMATIC S7 controls 36
6.2 PC hardware 38
6.3 Redundant servers 38

7 Bus systems 39

7.1 PROFIBUS 39
7.1.1 General rules 39
7.1.2 Bus cable 41
7.1.3 Termination 42
7.1.4 Permitted network structures for PROFIBUS DP 43
7.1.5 Line lengths for PROFIBUS DP 44
7.1.6 Permitted network structures for PROFIBUS PA 45
7.1.7 Earthing and shielding of PROFIBUS components 46
7.1.8 Lightning protection 47

7.2 FOUNDATION Fieldbus H1: 48
7.2.1 Fieldbus 48
7.2.2 Permitted network structures for FOUNDATION Fieldbus 48
7.2.3 Earthing, shielding, and lightning protection 49

7.3 PROFINET 49
7.3.1 General rules 50
7.3.2 Lightning protection 51

7.4 Industrial Ethernet 51
7.4.1 General rules 52
7.4.2 Lightning protection 53

8 Emergency off 55

9 Service and support 56

Security information

1

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. You can find more information about Industrial Security at https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed at https://www.siemens.com/industrialsecurity.

Preface

2

Subject of the manual

As a distinctly open system, SIMATIC PCS 7 can be flexibly adapted to a wide range of customer needs. The system software provides the configuration engineer with a great deal of freedom in terms of project configuration, as well as in the design of the program and visualization.

Experience has shown that subsequent modernization or plant expansion work is made much easier if the project is configured "in conformance with PCS 7" as far as possible right from the start. This means users must adhere to certain basic rules to ensure that the provided system functions will offer optimum usability in the future.

This manual serves as a compendium in addition to the product documentation for SIMATIC PCS 7. The basic tasks for creating and assigning parameters to the project are described in the form of instructions with numerous illustrations.

The compendium directly reflects the recommended method for configuration, which is based on the results of a great deal of practical experience. The description relates to working with the project and the parameter settings of the components it contains but not the application itself.

The compendium contains the following parts:

- Configuration guidelines including checklist
- Process safety including two checklists
- Equipment phases with SFC types
- Operation and maintenance including checklist
- Hardware installation including checklist
- Industrial Security

Subject of Part E "Hardware Installation"

Part E is devoted to defining and describing test points for the hardware installation of process-related production facilities.

Particular attention is paid to the following topics in this regard:

- Lines and connection technology
- Configuration and design of control cabinets
- Earthing, potential equalization and lightning protection
- Bus lines

Note

For matters regarding the products of third parties, contractual obligations are to be performed by the respective manufacturer and not Siemens AG. Siemens AG can therefore not accept any liability for the products of third parties, even if this documentation contains references to such products of associated manufacturers.

Checklists

You can download the checklists for the SIMATIC PCS 7 compendium part E as a zip file via the "Appendix" button in the Industry Online Support Portal.

Validity

This documentation applies to the software package:
- SIMATIC PCS 7 V9.0

SIMATIC PCS 7 in Industry Online Support

An overview of the most important technical information and solutions for SIMATIC PCS 7 is available at http://www.siemens.com/industry/onlinesupport/pcs7 (http://www.siemens.com/industry/onlinesupport/pcs7).

SIMATIC PCS 7 documentation

Full PCS 7 documentation is available to you free of charge and in multiple languages in PDF format at www.siemens.de/pcs7-dokumentation (http://www.siemens.com/pcs7-documentation).

General rules for lines and connection technology 3

3.1 Line selection and connection technology

General rules for line selection

The lines required for connecting to devices and modules are to be selected based on maximum current load, adequate mechanical stability and corrosion resistance. Only if the selected lines stand up to the requirements, both under normal conditions of operation and in the event of faults, shall they be deemed suitable.

For connections to SIMATIC modules, lines may be used that are permitted for those particular modules. The guidelines on usage must be adhered to in such instances.

When selecting suitable lines, protection against the gnawing of rodents must be considered.

General rules for connection technology

Through connection technology that is suitable for lines and modules, it is to be ensured that contacts are permanently failure-free, durable and of a low impedance. When setting up connections the following points must be considered:

- The connections of current-carrying parts may not become unduly altered from rises in temperature under normal operating conditions, changes to the insulating material or shocks that may arise under certain conditions of operation. The following influencing factors must be considered in this regard:
  - The effects of thermal expansion.
  - Electrolytic effects with various metals.
  - The effects on the stability of the materials from temperatures that may arise.
- The connections between current-carrying parts must ensure sufficient and long-lasting contact pressure.
- The screw connections must be tightened correctly to avoid poor contacts and the crushing of lines or contact materials.

For the screw connections of current-carrying parts, the following tightening torques applies:

Screw diameter	Tightening torque
M3	0.8 Nm
M4	1.8 Nm
M5	3.0 Nm
M6	6.0 Nm
M8	13.0 Nm
M10	25.0 Nm
M12	50.0 Nm
A plus tolerance of 30% applies to the tightening torque values.	

Note

In addition to the tightening torques, also be aware of the manufacturers' instructions regarding the setting up of clamps/terminals.

- Non-compliance with the requirements for the screw connections of current-carrying parts leads to a significant increase in contact resistance. This could possibly lead to fires from overheating or electric arcs.
- Surfaces of connections that come into contact must be clear, free of lubricants or films of oil, colorings or anodization and corrosion.
- Cables and lines must not have any soldering joints or mends between two contact points.
- Only one wire may be connected to a terminal. The connecting of two or more wires is only permitted if the terminals are designed for this purpose.
- For inherently safe lines, the requirements pertaining to EN 60079-14 are to be adhered to.

Note

Take note of the cable manufacturers' instructions when working with hot air guns or blowpipes, as insulation materials and wires may become unduly altered due to the effects of excessive heating.

Additional information

For additional information, refer to the "Automation System S7-400 Hardware and Installation (https://support.industry.siemens.com/cs/ww/en/view/1117849)" manual.

3.2 Line routing through cable channels and control cabinets.

Introduction

What follows below are rules for the routing of lines through cable channels and control cabinets, which, if followed correctly, can lead to improvements in electromagnetic compatibility (EMC) and plant availability.

Attaching lines and cables

The following rules apply for the attachment of lines and cables:

- All lines and cables must be marked or labeled clearly.
- Lines and cables must be fed in separate bundles or channels depending on their type (three-phase lines, power supply lines, signal lines, data lines, etc.).
- Lines, cables and insulation must not be damaged, kinked or crushed when laid.
- The minimum and maximum temperatures for transportation, laying and operation specified for the lines may not be undershot or exceeded, in order not to negatively influence the electrical and mechanical properties of the lines.
- No line twisting or torsional stress is allowed to arise during the laying of the lines and cables.
- The minimum bending radius specified by the manufacturer may not be undershot either with copper cables or with fiber-optic cables.
- Lines and cables must be installed in the cable channels provided in a proper and sufficiently fixed manner.
- Wire ends must be insulated or connected to a ground reference.
- Unnecessary wires of lines and cables must be intercepted and fixed properly.
- Unnecessary cable lengths and reserve loops should be avoided.
- Sufficient strain relief must be ensured. The shield connection for control cabinet entry may not be used for this purpose.
- Cable ducts must be set out in such a way that lines and cables are not damaged.

Trailing and daisy-chain cable

For trailing and daisy-chain cable only the cable types permitted by the manufacturer may be used. There must be sufficient free room available for movement in the control cabinet for trailing and daisy-chain cables so that these do not become damaged by structural parts or other cables.

Fiber-optic cable (FoC)

Care must be taken to ensure that fiber-optic cables do not incur any mechanical damage. Damage can result from excessive tensile forces or from crushing during the later laying of additional cable, for example. Fiber-optic cables must be provided with protective covers to protect them from contamination.

Additional information

You can find additional information in the following manuals:

- Automation System S7-400 Hardware and Installation (https://support.industry.siemens.com/cs/ww/en/view/1117849)
- SIMATIC Process Control System PCS 7 Engineering System (https://support.industry.siemens.com/cs/ww/en/view/109746533)
- SIMATIC NET Industrial Ethernet / PROFINET Passive Network Components - System Manual (https://support.industry.siemens.com/cs/ww/en/view/72887082)

3.3 Insulation resistances

Requirements

For a safe and fault-free plant operation it is necessary that all cables, lines and housings of the installed components and the insulation and cable jackets are undamaged.

Checking insulation resistance

The following instructions must be observed when checking insulation resistance:

- If a high voltage test is performed in the system with alternating voltage, an available line filter must be disconnected in order to achieve a correct measurement result.
- Anti-interference capacitors that lie between active parts and housings may not be disconnected and must withstand the test voltage.
- One must take note of the maximum permitted test voltages, deviating from 500 V DC, specified by the manufacturer as well as the country-specific standards (e.g. for SIMODRIVE max. 1.8 kV DC phase-PE).
- The testing of insulation resistance is only possible in a voltage-free state. To do this, the control cabinet and its components must be disconnected from the supply voltage.
- For a ground potential-free installation, the resistance between live components and ground potential during plant operation must be continuously monitored (ground-fault monitoring).

Additional information

You can find information on insulation testing, protection classes and protection grades in the "SIMATIC S7-400 Automation Systems S7-400 Module Data" (https://support.industry.siemens.com/cs/ww/en/view/1117740) manual.

3.4 Connectors and module slots

Rules for installing connectors and module slots

The following rules are to be adhered to when installing connectors and module slots in order to prevent faults and failures from high contact resistances or bad or unstable contacts:

- Connectors are to be installed and screwed without errors.
- Connectors are to be screwed together with modules.
- Modules are to be screwed together with module racks.
- Module slots and connectors that are not in use must be provided with dummy connectors or protective covers for protection against contamination and damage.

For additional information, refer to the "Automation System S7-400 Hardware and Installation" (https://support.industry.siemens.com/cs/ww/en/view/1117849) manual.

3.5 Redundant plant configuration

Rules for a redundant plant configuration

Hardware redundancy is employed to increase plant availability. Redundant hardware can only be put to full use if it is configured with the following guidelines having been observed:

- Redundant assemblies must be supplied from separate power sources and secured independently.
- In order to exclude simultaneous damage from the same event, redundant bus lines and redundant lines are principally to be laid on separate routes.
- Redundant components are to be laid out in such a way that they function independently of one another. This means that if an associated partner component fails, the full functionality of the plant is secured. Every component must be capable of handling the full load.
- The failure of a redundant partner must be reported.

Note

Take note of the manufacturer-specific instructions on parallel connections of power supplies (redundant configuration).

Additional information

You can find more information and examples of parallel connections in the following manuals:

- SIMATIC NET Industrial Ethernet / PROFINET Passive Network Components - System Manual (https://support.industry.siemens.com/cs/ww/en/view/72887082)
- Automation System S7-400 Hardware and Installation (https://support.industry.siemens.com/cs/ww/en/view/1117849)

Configuration and design of control cabinets 4

4.1 General requirements

General requirements

Control cabinets and their components must fulfill the following general requirements:

- Control cabinets, key-operated switches and mechanical actuating elements are not impaired and are in a fully functional condition.
- The space for all lines must be sufficient in the control cabinets and cable channels.
- In the covers or doors of control cabinets, the supply lines to devices and measuring instruments must be attached in such a way that they cannot be damaged when moved.
- The edge protection – e.g. on metal edges and transit positions of cable channels and rubber sleeves at cabinet entry – must be sufficient to prevent any damage being caused to cables or lines.
- Control cabinets and their components are kept free of contamination – e.g. from oils, lubricants or coolants – which can impede functionality.
- Control cabinets and their components are kept free of foreign substances – e.g. drilling swarf or residue from installation work.
- Control cabinets and their components are kept free of condensation and moisture.
- Control cabinets and their components are kept free of deposits that are thermally insulating or which have electrical conductivity, such as salt or other substances, which accrue during plant operation (e.g. cement dust in the grinding mill of a cement plant).
- All components of a control cabinet are adequately fixed and screwed down with a mounting plate or to a cabinet frame.
- All components (e.g. modules, power supplies, protective components, etc.) are tested and permitted by the relevant standards.
- The SIMATIC components used are contained in the list of the modules permitted for each respective PCS 7 version.

Additional information

You can find more information in the following manuals:

- Automation System S7-400 Hardware and Installation (https://support.industry.siemens.com/cs/ww/en/view/1117849)
- SIMATIC Process Control System PCS 7 Engineering System (https://support.industry.siemens.com/cs/ww/en/view/109746533)

4.2 Place of installation

Guidelines on the place of installation of a control cabinet

The place of installation and its environmental conditions must be taken into consideration when selecting a control cabinet. A control cabinet that is closed during operation and correctly designed offers protection against the following influences:

- Electromagnetic interference
- Electric shocks – e.g. from direct contact with, or from the ingress of, solid foreign substances or liquids
- Contamination
- Damp/moisture/humidity
- Overheating
- The spreading of electric arcs
- Fire
- Damage from small animals (e.g. rodents)

The environmental conditions (temperature, moisture/humidity, dust, chemical influences, risk of explosion) at the control cabinet's place of installation determines the type of protection (IP xx) necessary for the cabinet.

The following guidelines are to be observed:

- S7-400 modules can be used in ambient temperatures of between 0 and 60 °C, where temperatures may change by a maximum of 10 °C per hour.
  CPU 410 supports ambient temperatures of 0 - 70 °C during operation.
- S7-400 modules can be employed where there is relative humidity of 95% at an ambient temperature of 25° C.
- The permitted air pressure and the permitted pollutant concentration must be considered at the locations where the S7-400 modules are used.

Additional information

You can find additional information in the following manuals:

- SIMATIC S7-400 Automation Systems S7-400 Module Data (https://support.industry.siemens.com/cs/ww/en/view/1117740)
- Automation System S7-400 Hardware and Installation (https://support.industry.siemens.com/cs/ww/en/view/1117849)

4.3 Environmental conditions and air conditioning

Air conditioning of control cabinets

Due to the advancing miniaturization of electronic components and increasing packing densities, the sensitivity of electrical systems to influences such as dust, humidity and temperature is increasing. To ensure a plant's long life cycle, great significance must therefore be attached to the correct dimensioning and air conditioning of control cabinets.

Ambient temperature

A control cabinet should be set up in such a way as to ensure that the maximum and minimum ambient air temperatures for all the components contained within it are neither exceeded nor undershot.

The interior temperature of control cabinets in which temperature-sensitive components are located must be monitored.

Air conditioning measures

The devices used for air conditioning must be arranged in such a way that the cold air in the control cabinet is not fed directly to the modules. This will prevent modules accumulating condensation. Also, it must be ensured that any condensate that may potentially develop can be caught and then drained out using appropriate measures.

In order to guarantee maximum cooling through natural convection, passively cooled modules and devices (with the exception of PCs and possibly other IT devices) must be installed in a vertical mounting position. If vertical installation is not realized, additional measures must be taken to achieve cooling.

Note

Approx. 50W/m² of free control cabinet surface is dissipated through convection in the event of a difference in temperature of 10 °C between the control cabinet and the surrounding environment. Further heat dissipation must be achieved using additional measures.

Ventilation

The following rules apply to the ventilation of control cabinets:

- A minimum clearance of 200 to 400 mm must be maintained between the air inlets and the air outlets. Suitable air convection can be ensured with air deflectors as an alternative to this.
- All the components in a control cabinet must be installed in such a way that ventilation clearance above and below the modules is maintained.
- In the control cabinet, free air circulation must be ensured. The circulation of air must not be impeded by control cabinet components such as cables, for example.
- The circulation of air must be monitored regularly.
- The ventilation slots must not be covered by modules.
- The ingress of dust must be prevented (e.g. through filter mats).

Additional information

You can find more detailed information on venting in control cabinets in the section "Installing the S7-400" in the "Automation System S7-400 Hardware and Installation" (https://support.industry.siemens.com/cs/ww/en/view/1117849) manual.

4.4 Operator protection

Operator protection

Control cabinets also provide protection for people against the direct or indirect effects of electrical currents. Optimum protection is achieved by way of a combination of technical protective equipment and sound constructional measures. Ease of service and installation can also be included here, which provide protection to maintenance and plant personnel, too.

Protection against electric shock

To protect against electric shocks from direct contact, sufficient insulation or covers of active, live parts must be ensured for switchgear assemblies for which occasional access to certain components is necessary during operation – e.g. for replacing fuse links or lamps. In this regard, the removal, opening or disassembly of protective covers or enclosures must only be possible with an appropriate key or tool, or only after isolation. Active components which conform to safety extra-low voltage (SELV) requirements must not be covered or insulated.

Actuators – such as handles or hand wheels, for example – must either be connected to electrically conductive parts which are themselves connected to a protective conductor safely and durably, or be provided with additional insulation against other conductive parts of the switchgear assembly. This insulation must at least be assessed for the largest rated insulation voltage of the associated device.

All contactable, electrically conductive structural parts – such as the housing, for example – must be connected to protective conductors. The structural parts themselves may not be used as protective conductors.

Protective conductors

The following rules apply to protective conductors:

- A protective conductor must be assessed to establish fulfillment of the following criteria:
  - Secure connection to the short-circuit protective device.
  - Sufficient thermal and mechanical stability, even in the event of faults.
- The protective conductor must be easily recognizable from its shape, arrangement, labeling or color. Here, color labels must be bicolor (green/yellow). If an insulated, single-core line is used as a protective conductor, its color labeling must stretch across its entire length where possible.
  In addition, any national regulations concerning the labeling of protective conductors must be adhered to.

Control cabinet configuration

With regard to the configuration of control cabinets, the following rules must be followed:

- All elements that operators or service personnel come into contact with (e.g. push buttons, apparatuses for resetting or unlocking, display devices, etc.) must be installed so as to be easily accessible. As a rule, their center line may not be higher than 2 meters above the floor under the control cabinet.
- The control cabinet doors must be able to be opened sufficiently wide for installation and service tasks (min. 120°).
- Protective covers for manually operated switchgear must be arranged in such a way that people are not at risk from switch arcs. In order to prevent injuries from replacing fuse links, partitions must be used between the phases, provided these are not superfluous due to the design and arrangement of the fuses.
- Parts fasteners that are removed as part of maintenance work must not be missing.

Additional information

For additional information, refer to the "Automation System S7-400 Hardware and Installation" (https://support.industry.siemens.com/cs/ww/en/view/1117849) manual.

4.5 EMC and shielding

Rules for EMC and control cabinet configuration

The availability of the entire plant can be increased through a high degree of EMC resistance of all employed components. To achieve a high degree of electromagnetic compatibility (EMC), the following basic rules apply regarding control cabinet configuration:

1. Prevention of interferences at the source.
2. Prevention of the coupling of interferences or the interruption of coupling paths.
3. Attenuation or diversion of coupled interferences.

For the practical implementation of the basic rules listed above, the following requirements regarding control cabinet construction are to be heeded:

- The control cabinets must be sealed. Only closed, metallic control cabinets offer protection against electromagnetic stray radiation and the unwanted effects of electrical current (e.g. sparks and electromagnetic emissions).
- All metallic components of the control cabinet, mounting plates and metallic module racks must be connected together in an extensively conducting way. In order to ensure a low-impedance connection of all components with the control cabinet ground, non-painted, zinc-coated mounting plates are used which are also extensively connected together to the necessary points and reference ground (e.g. by means of a ground strap). Use screw connections on painted or anodized metal parts either with special contact slides or remove the insulating protective layers from the contact points.
- At cabinet entry, all lines must be attached with strain relief. This should not divert any tensile force onto the line shields. Shield supports are not sufficient as a form of strain relief, because the cable shield becomes impinged with mechanical stress as a result and can thus become damaged.
- Ground structures that are spatially separated from each other must be connected with the protective bonding circuit in a star configuration.
- Ground straps must be used for missing extensive metallic parts.
- Contact surfaces are to be protected from corrosion with suitable greases.
- Supporting beams are to be connected extensively with the cabinet housing.
- There must be an extensive metal connection between supporting beams and module racks.
- The protective conductor rail must be connected with the protective bonding circuit via a separate line (with a minimum cross section of 10 mm^2).
- Sockets in the control cabinet (e.g. for the supply of programming devices) must be supplied from the voltage distribution, whose protective conductor is to be connected to the cabinet. This power supply must be separated from the power supply of the automation technology components of the control cabinet.
- The power supply and power supply parts should preferably be installed near to the power supply infeed.
- Cables and lines must be fed near to the reference potential.
- Conductor loops are to be avoided.

- Connections for incoming and outgoing neutral conductors (N), protective conductors (PE) and PEN conductors must be arranged near to the related outer conductor connection.
- The housing of the sub-D plug connector for the PROFIBUS DP/PA must either be ferrous or metalized.
- For lighting, incandescent lamps or interference-suppressed fluorescent lamps should be used.
- Appropriate cable feeds and screw joints in the control cabinet ensure that the control cabinet remains a closed system. One must pay particular attention that there is careful sealing in areas at risk of explosion or firedamp.
- If there are sources of interference and susceptible equipment in a control cabinet, these should be physically separated from each other (minimum clearance ≥ 20 cm).
- Control cabinet components can be separated by installing earthed plates for sources of interference.
- Sources of interference may not be connected to the same power supply as other components.

Rules for shielding

The following rules for shielding are to be observed with regard to control cabinet configuration:

- The shields of incoming lines must be extensively attached or clamped on the shield bus immediately upon entering the control cabinet. Cable glands with shield earthing or having the cables set up at the cabinet entrance on so-called jagged bus bars would be suitable here. Shield busses must not be painted.
- The cable shield must plainly touch the shield contact area in the connection plug.
- Preferred materials for shielding and earthing are copper or zinc-coated steel, as these allow for good, permanently durable contacting. Aluminum oxidizes readily and is therefore not suited for ground connections.

  The following figure shows an example of a shield connection of an Ethernet cable:



- Shield busses must be connected to the grounding system extensively and with low impedance.
- The lines must run from the shield bus on the cabinet entrance side to the shielded connectors and to the modules without an interruption to the shield. One must ensure that the cable shield does not have any interruptions and none with the contact to the shield bus either.
- The cable shields must be connected directly (i.e. without separately connected lines) to reference ground (e.g. via the metallic connector housing).
- Each component installed in the control cabinet must be independently connected to the potential equalization. A series connection of shields is not permitted. For this purpose, use lines that are as short and low-ohm as possible with large surfaces which can connect with ground potential extensively
- The shield of a signal line is to be attached extensively with cable clips onto the protective conductor bus or an additional shield bus (control room or control cabinet).
- The cable clip must encompass the screening braiding extensively and guarantee good contact.
- The shield bus must be extensively connected to the supporting beams (a metal-metal connection).
- As a component of the shielding, the control cabinet doors must be connected low-impedance to reference earth.

Additional information

You can find further information and examples on the subjects of "EMC" and "Shielding" in the following manuals:

- Automation System S7-400 Hardware and Installation (https://support.industry.siemens.com/cs/ww/en/view/1117849)
- EMC Installation Guidelines (https://support.industry.siemens.com/cs/ww/en/view/60612658)
- SIMATIC NET Industrial Ethernet / PROFINET Passive Network Components – System Manual (https://support.industry.siemens.com/cs/ww/en/view/72887082)

4.6 Using line filters and interference suppressors

Measures for limiting interference voltage using line filters

In industrial plants, high frequency voltages arise from switching operations that become electromagnetically coupled into components and lines. As a result, signals are disturbed and there is increased stress on devices. A well shielding control cabinet does not suffice if an unfiltered line causes interference in the internal space. It is for these reasons that interference voltages are to be limited using suitable measures and attenuated to an appropriate level using line filters. In so doing, interference must be suppressed as close to the source of the disturbance as possible and at the cabinet entrance as the farthest point.

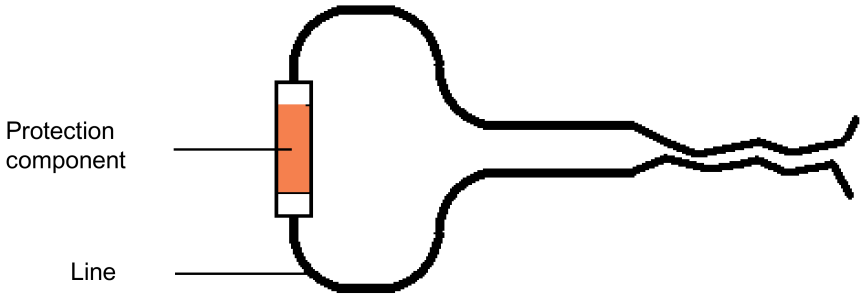
The following measures are to be taken here:

- If the components used in the control cabinet do not have filters or sufficient filters (e.g. SITOP power supplies), all low-voltage lines must be provided with a line filter.
- One must take care that connected inductances (e.g. contactors, relays, solenoid valves, etc.) must be wired with interference suppressing units (e.g. RC elements, varistors, recovery diodes, etc.).
- Line filters and interference suppression units must be placed in immediate proximity to the source of interference, provided this is in the control cabinet. The line filters and interference suppressors must be located directly at the cabinet entrance in the case of inbound or outbound lines that have an interference signal.
- Line filters bond with the device's ground extensively so that the interference current can be fed back to the source.
- The line filter covers all conductors (e.g. L1, L2, L3, N, PE) unless the manufacturer's information states otherwise.
- Each component must be provided with its own separate line filter.

Line routing

When using components for reducing interference, such as surge protection devices and filters, one must ensure that the protected and unprotected line sections are routed separately as far as possible from each other and that a coupling in of interfering signals is prevented.

The following figure shows an example of how this should **not** be arranged: a secured and unsecured line section that are routed next to each other:



4.7 Overload protection systems

Overload protection systems

Two objectives are pursued with overload protection systems:

1. Operator protection
2. Device protection

In the event of faults, protective equipment shuts down operation resources automatically within a set period of time to avoid dangerous touch voltages and to protect devices and lines from overloads.

Rules

The following rules apply to overload protection systems:

- Every I/O module is fused separately with its own element for cutout and separation.
- Power supplies are fused separately with their own element for cutout and separation.
- Safety fuses are only to be used if the following conditions are fulfilled:
  - The short-circuit power is sufficient (approx. 100 times greater than the rated power consumption).
  - The loop impedance is low. Between the input protective conductor and the control cabinet component to be protected, this may not amount to more than 0.1 Ω.
- Parallel configuration of fuses is not permitted.
- One must ensure that the fuses are adequate and selective. A short circuit in any branch is to be switched off by the switching device in the faulty electrical circuit, without this negatively affecting other outgoing units.
- To avoid operating errors, the safety devices must be installed in such a way that a clear assignment between the protection device and the protected electrical current, device or protected component is possible.
- The safety and protection devices employed must clearly display the status of protection (e.g. "live", "intact", "zero-potential", "tripped", etc.).

Note

Ensure the safe accessibility of the monitoring equipment, because this will have to be reset in the event of a fault.

4.8 Earthing concept for control cabinet components

Earthing concept

The earthing of machines or installations is an important protective measure. It influences emitted interference and interference immunity and for this reason also has an impact on EMC.

The following guidelines are to be observed:

- For reasons of operator protection and for diverting electromagnetic interference currents, all passive metal parts not belonging to the operating circuit (e.g. housings, mounting plates and control cabinets) are to be low-impedance connected to earth potential. This also includes the connection of all metallic module racks with earth.
- Protective conductor loops and series connections of several components to protective conductors and similar elements are not permitted, as these can cause harm to people in the event of interruptions.
- With TN or TT networks, protection against electric shocks from discontinuing protective circuits (e.g. ground-fault circuit interrupters [GFCI]) is guaranteed. With an IT network, an unpermitted touch voltage cannot arise with the first fault.
- The connection of electrically conductive, inactive parts (e.g. cable shields, housings, mounting plates, cable racks, etc.) with earth potential is to take place low-impedance independently of the type of network.
- A direct electrical connection between active parts of the electrical equipment (e.g. the M potential of power supplies) and reference earth is only allowed with an earth-connected network configuration (TN and TT networks). This connection is not permitted for ungrounded networks (IT networks).
- Electrical jumpers, such as with SIMATIC S7-400 module racks for example, which establish a low-impedance connection between the internal reference potential M of the modules and the module racks that are to be grounded, must be opened.
- Electrically coupled, high frequency interferences or electrostatic charging are diverted using the integrated RC network.
- If personal injury or material damage could be incurred due to a double fault, insulation resistance monitoring is required.

Note

You can find detailed information and examples on the "earthing concept" in the "Automation System S7-400 Hardware and Installation" (https://support.industry.siemens.com/cs/ww/en/view/1117849) manual.

4.9 Wiring unused module inputs

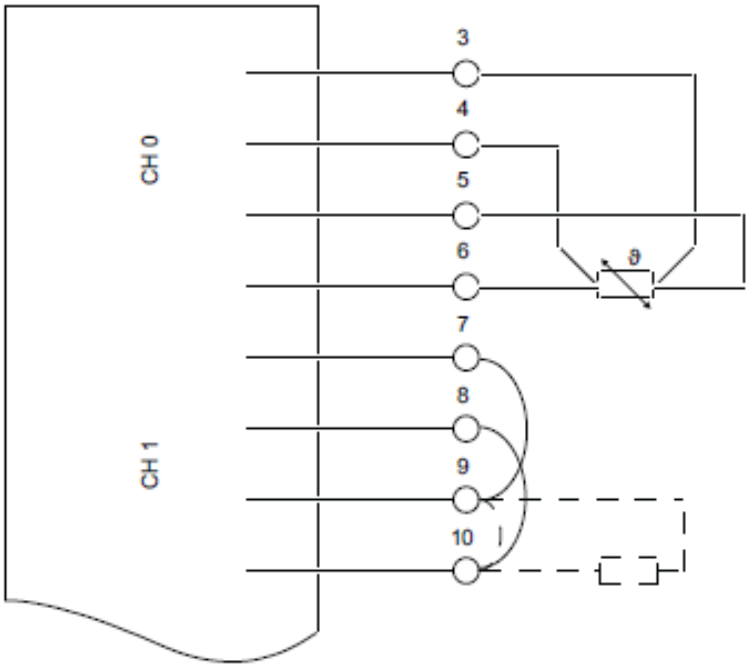
Information regarding the wiring of unused inputs and outputs of modules

The following guidelines must be observed for unused inputs and outputs of modules:

- No disturbances or false alarm messages may be caused by unused inputs and outputs (e.g. reserves) of modules.
- Unused inputs of analog and digital signal modules must be wired correctly so that maximum interference resistance is achieved and channel error messages are avoided.
- For modules with the "measurement type" parameter, these parameters for unused channels must be set to "deactivated" to prevent an unnecessary extension to the cycle time of the module.

Example

The following example applies to the AE module "6ES7 331-7PF01-0AB0". The unused channel 1 can either be short circuited or can be wired with a resistance in the nominal range (e.g. 100 Ω at Pt100 or 200 Ω at Pt200) to prevent diagnostic error messages.



4.10 Lightning and overvoltage protection

Aspects and essentials on procedures for lightning and overvoltage protection

The lightning protection zone concept contained in DIN VDE 0100-534 divides a plant into zones of varying sensitivity of electrical systems with regard to the effects of lightning and provides lightning protection measures for all components of a plant as well as each transition zone. Since the currents and overvoltages that arise vary from zone to zone, the components employed also vary. There are different grades of protection, starting in zone LPZ 0 with primary protection against the direct effects of lighting, including full lightning current and full eletromagnetic interference field, all the way to zone LPZ n, from which only low overvoltages are to be diverted.

All modules and components with electrically conductive connections both inside and outside of the control cabinet must be protected against overvoltages and lightning currents. For control cabinets that are installed in interior spaces, device-related protection in the control cabinet must be undertaken in addition to the protection measures that have already been taken with the transition from the further outlying zones (e.g. at the entrance to the building). If individual components are not included in this protection, one cannot discount damage being incurred (e.g. from overvoltages in the event of a lightning strike).

Note

In order to guarantee operator protection, the network type of the plant (e.g. TN, TT, IT) must also be considered in terms of the concept and the selection of appropriate lightning protection equipment.

Lightning protection for inputs and outputs

The following figure shows an example of a system for overvoltage and overcurrent protection:



Source: Company DEHN + SÖHNE GmbH + Co. KG, Hans-Dehn-Str. 1, 92318 Neumarkt, Germany; Internet: www.dehn.de

Plant concept for earthing, potential equalization and lightning protection

5

5.1 Earthing, potential equalization and lightning protection

Introduction

The term 'grounding-' or 'earthing system' refers to a plant-wide, common resource, low-resistance, low-impedance diversion of lightning currents, overvoltages, fault-related, inadmissible voltages and other interfering electromagnetic signals. Components employed for earthing, potential equalization and lightning protection are connected to each other many times over for this purpose. The extensive network formed as a result of all inactive, metallic plant units constitutes an entire system.

Consequently, a uniform, plant-wide, equal reference potential exists. This improves the EMC resistance of the plant and provides protection from the consequences of an electrical fault for people and objects in equal measure. Connection to an electrical unit also prevents differences in potential developing between equalization systems or dangerous touch voltages emerging from delayed voltages.

When routing extended (electrical) bus systems, one must ensure that this concept is not circumvented here and is, instead, included in the plant-wide system for earthing, shielding and potential equalization.

Examples of elements to be included in this network are foundation earth electrodes, equipotential-bonding cables, concrete reinforcements, metallic water pipes, metallic cable channels, metallic building construction parts and conductor rails.

5.2 Plant-wide earthing

Introduction

Metallic parts with earth potential are mainly connected as a protective measure against an electric shock. Electromagnetic compatibility (EMC) can be improved through earthing (or grounding).

The preconditions for good earthing must be fulfilled during the plant construction stage. Foundation earth electrodes built into the foundation must be combined with below-ground and surface earth electrodes to obtain as low an earth resistance as possible.

The earthing properties can be further improved through multiple connections of the foundation earth electrodes with the reinforcements of the concrete foundation.

The mesh sizes, which should be approx. 20x20 m depending on ground conditions, must be maintained and all grounding conductors must be connected to a closed ring.

When using double-shielded cables, e.g. for transmitting analog video signals, the outer shield must be earthed at both ends. The inner shield can be earthed at one end, preferably at the receiving end.

Optimum shielding effectiveness is achieved when cables and lines are grounded at both ends, i.e. at sender and receiver.

If there is a risk that, due to insufficient potential equalization, compensation currents flow through the cable shield or "ground loops" form, an indirect earthing over the RC network may also be implemented instead of a direct earthing at the sender end.

Guidelines

For plant-wide earthing, the following guidelines must be observed:

- Network structure
  In plants with TT or TN networks, all metallic objects which may be subjected to inadmissible voltages in the event of faults must be earthed. In IT networks this applies equally for all electrically inactive parts.
- Dimensioning

  In order to avoid inadmissible compensation currents over cable shields, sufficient equipotential-bonding cables must be laid. Here, the impedance of the equipotential-bonding cables must be lower than 10% of the shield impedance of the cables being protected.

  When assessing the cross sections one must ensure that there is sufficient resistance against mechanical stresses, corrosion and current loads.

  The following recommendations are made from practical experience:

  – Linked ribbon steel cable with a minimum cross section of 100 mm^2 and a minimum thickness of 3 mm.
  – CU cord, plain with a minimum conductor cross-section of 16 mm^2 for cable lengths of up to 200 m.

- Expansion joints and transition positions.

  Due to the EMC, the connection of the reinforcements of the various concrete slabs, which are often not connected at the site of construction (e.g. during ceiling construction) should have a low electrical impedance.

  Foundation earth electrodes should be laid in the concrete of the foundations if there is no high-resistance layer (e.g. thermal insulation from polyurethane foam, bituminous sealing) between the foundations and the earth.

- Contacting

  The contacting of all connections should be low-impedance so that, in the event of a ground fault of a high-current consumer, no inadmissible potential differences emerge and the thermal load of the transition positions remains low.

- Corrosion protection

  Adequate corrosion protection must be ensured by, for example, having an appropriate selection of materials, full integration of the foundation earth electrode in the concreted foundations or special lubricants at the contact points.

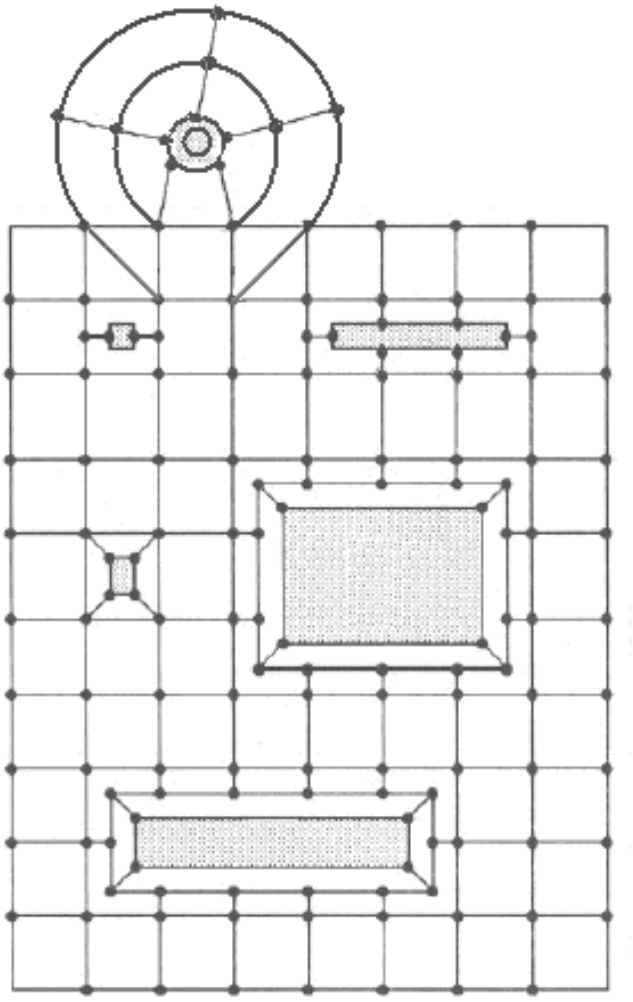
- Connections

  The foundation earth electrode and the connections to the foundation earth electrode must be clearly marked (e.g. with color).

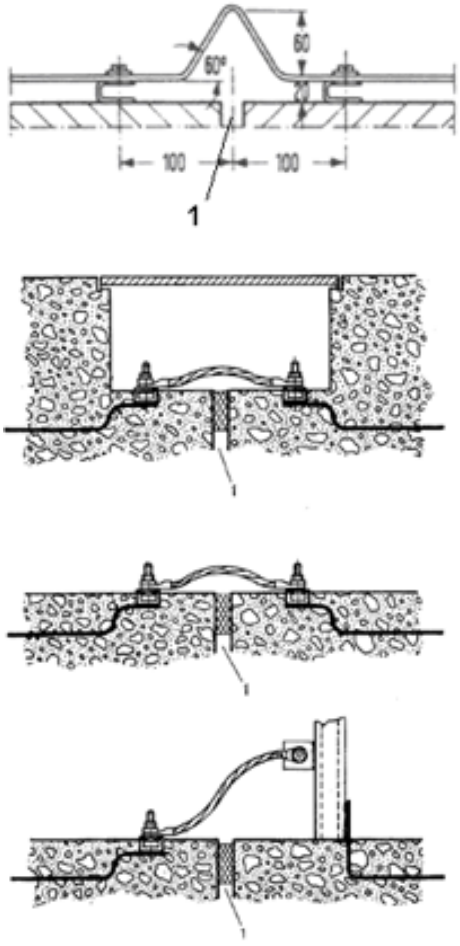
  Control cabinets and metallic control consoles must be connected to the earthing system with low inductive capacity.

Examples

The following figure shows an example of a mesh grounding network which includes different buildings, external installations and a chimney:



The following figures show examples of a suitable layout for a structural joint (1):



5.3 Plant-wide potential equalization

Potential equalization

In addition to its function as a protection measure, potential equalization is primarily sensible from an EMC perspective. In the event of potential differences of plant units connected by cable, compensation currents can flow through cable shields (earthed at both ends) which can lead to an interference with signals. If the difference in potential is too great, compensation currents may flow at a rate that can lead to cable destruction.

The task of a potential equalization system is to divert the interfering currents in such a way that there can be no adverse effects on the plant. To achieve this, all conducting structural components (e.g. foundation reinforcements, wall coverings, door frames, steel constructions, etc.) and all (electrically) inactive metal parts (e.g. metallic housings and machine parts, cable racks, banisters, water pipes, equipotential-bonding cables, etc.) are low-impedance connected together. Plant-wide potential equalization will be ensured as a result.

The lower its impedance, the greater the effectiveness of potential equalization will be. To prevent sparking, potential equalization in areas where there is a danger of explosion is essential.

The following guidelines are to be observed:

- Separated plant units are to be connected with equipotential-bonding cables made from copper or steel (at least 16 mm²).
- Equipotential-bonding cables are to be connected extensively with ground electrodes / protective conductors.
- Equipotential-bonding cables are to be routed in such a way that the space between equipotential-bonding cables and signal lines is as small as possible.
- Conductive, metallic cable channels / cable racks are to be integrated into the potential equalization of the building and between the individual plant units by connecting these as often as possible to the building's grounding grid.
- For two-sided shielding, it is very important to ensure a very high degree of potential equalization.
- Expansion joints and links (e.g. on cable trays) must be additionally bypassed using flexible grounding straps.
- If equalizing currents are to be expected above the shielding, an equipotential bonding line (≥ 10 mm² copper) must be installed parallel with the bus line wherever possible.
- In order to prevent any coupling in, lines must be laid near to plates (ground reference surfaces) which are connected to a potential equalization system. Examples of such plates are the earthed cabinet walls or the earthed cable racks.
- Cable carriers must be low-impedance connected at regular distances (approx. every 30 m) to the potential equalization.

Additional information

You can find additional information in the following manuals:

- Automation System S7-400 Hardware and Installation (https://support.industry.siemens.com/cs/ww/en/view/1117849)
- SIMATIC NET Industrial Ethernet / PROFINET Passive Network Components - System Manual (https://support.industry.siemens.com/cs/ww/en/view/72887082)

5.4 Plant-wide lightning protection

Introduction

The lightning protection zone concept was introduced for the configuration of protection against lightning-related overvoltages. The basic idea of this concept is to organize a plant into zones of the same sensitivity with regards to susceptible equipment located in this area. When defining the individual lightning protection zones (LPZ) the physical boundaries (e.g. walls and floors) are to be taken into account, but these are not in themselves to be considered as guidelines.

The effects of a lightning strike are pulse-shaped lightning currents that are rich in energy and strong electromagnetic fields. By employing suitable lightning current and surge arresters and shielding measures, these effects are reduced during transfer from one lightning protection zone to the next.

Lightning protection

People and electrical installations must be protected against both the direct and indirect effects of lightning, and the operation of the plant must also be secured against lightning strikes.

Adequate protection against the effects of lightning will be achieved if suitable measures are taken at each transition zone.

The following guidelines are to be observed in this regard:

- Since lightning / overvoltage protection devices always work against protective conductors, different circuit types and dimensions are to be observed (DIN VDE 0100-534) for different network types (TN, TT, IT).
- In the case of industrial buildings with steel frame structures in particular, it is to be ensured that there can be no undesired flashovers between the lightning protection's external elements and other electrically conductive parts, e.g. in the building's interior. This is achieved by having sufficient separation distances between the interception system and the lightning rods on the one hand and the metallic parts of the building's electrical installations on the other.
- In areas with a high risk of explosion, one must also ensure that all the elements of the lightning protection system are set up so that no ignitable sparks can arise when lightning current is diverted. Some manufacturers offer special products and assembly materials for this purpose.

Rules for S7 automation systems

6

6.1 SIMATIC S7 controls

Fix and earth modules

When fixing and earthing modules the following guidelines are to be observed:

- The minimum clearances between the module racks and other equipment must be maintained.
- The module rack is to be connected to local ground (10 mm² GN/GE).
- If the reference potential is earthed (standard) the "removable jumper" must be firmly inserted.
- If the reference potential is not earthed the "removable jumper" does not have to be firmly inserted.

For additional information, refer to the "Automation System S7-400 Hardware and Installation" (https://support.industry.siemens.com/cs/ww/en/view/1117849) manual.

Backup batteries

The use of correct backup batteries is essential for the secure operation of the plant. The backup batteries must be used in accordance with SIMATIC specifications, and the battery monitoring must be activated by means of the battery monitoring switch.

You can find further rules and information regarding the use of backup batteries in the "Automation System S7-400 Hardware and Installation" (https://support.industry.siemens.com/cs/ww/en/view/1117849) manual.

The set-up of redundant hardware

Increased plant availability is achieved through the setting up of redundant hardware.

With regard to the setting up of redundant hardware, the following guidelines must be observed:

- The hardware configuration for the two redundant subsystems of a fault-tolerant system must be identical. This means that the central modules, external DP master interfaces (redundant) or communication modules must be integrated at the same slots in each case.
- In an H system, all four synchronization submodules must be of the same type.
- External DP master interfaces for redundant DP master systems may only be inserted into the central devices and not into expansion devices.
- Redundantly used modules (e.g. CPUs, distributed I/O) must have identical article numbers and the same firmware version.
- The installation of redundant PROFINET configurations R1 for redundant connection of ET 200SP HA requires CPU 410 Firmware V8.2 or higher und SIMATIC PCS 7 V9.0 or higher. Furthermore, an additional license (PN RED) that is transferred to the CPU in the System Expansion Card (SEC) is needed for the redundant connection of PROFINET devices.
- For the central modules of an H system to be able to work redundantly, they must be connected to each other via two synchronization submodules respectively. The two upper and the two lower synchronization submodules of the two CPU modules are connected in the process. Different cable lengths can be used for the synchronization cable depending on the type of synchronization submodule employed.
- Depending on the cable length, separate specifications apply regarding the fiber-optic cable permitted (see system manual "Fault-tolerant Systems S7-400H" (https://support.industry.siemens.com/cs/ww/en/view/82478488))
- For CPUs ≥ V4.0, the rack number (0 or 1) is set via a switch on the back of the module. For CPUs < V4.0, the rack number is set via a switch on the respective synchronization modules.
- If the availability of the power supply is increased, then a redundant power supply can be installed in each subsystem. This must consist of the types PS405 R / PS407 R.
- If there are long synchronization cables the cycle time can be extended.
- You can find the modules released for redundant operation in function manual "PCS 7 High Availability Process Control Systems" (https://support.industry.siemens.com/cs/ww/en/view/109746538).
- If a channel of redundantly installed I/O devices reports an overflow or underflow, the module or channel is immediately passivated. To prevent this, unwired inputs must be deactivated via the "measurement type" parameter.

You can find more information on the redundant hardware design in function manual "PCS 7 High Availability Process Control Systems" (https://support.industry.siemens.com/cs/ww/en/view/109746538).

6.2 PC hardware

PC hardware requirements

Safe operation of the plant is only made possible by selecting suitable visualization and HMI devices.

The minimum requirements of the various PCs of a PCS 7 system depend on a computer's purpose of use. For monitors a minimum resolution of 1,280 x 1,024 is recommended.

You can find additional information and examples in the following documentation:

- Manual "SIMATIC IPC647D" (https://support.industry.siemens.com/cs/ww/en/view/87514778)"
- Manual "SIMATIC Process Control System PCS 7 - PC Configuration" (https://support.industry.siemens.com/cs/ww/en/view/109749317)

6.3 Redundant servers

Introduction

Increased plant availability is achieved through the use of redundant servers.

The following rules must be adhered to:

- The PCs used in a redundant server pair must be identical computers with the same hardware.
- Additionally, the computers of a redundant server pair must be connected to each other directly ("redundant connection") to know the status of the other partner PCs.

Redundancy connection

The following options exist for the redundancy connection:

- With SIMATIC BATCH servers:

  Network cable to an additional Ethernet network adapter. When using PCs as a BATCH server, this is the only type of redundancy connection permitted. The "zero-modem cable" connection option is not supported by redundant BATCH servers.

- With OS servers and route control servers:

  Null-modem cable to the COM interface or network cable to an additional Ethernet network adapter.

Take note of the maximum cable length for the connection of the redundant server.

You can find additional information on redundancy connections in the SIMATIC Process Control System PCS 7 Fault-tolerant Process Control Systems (https://support.industry.siemens.com/cs/ww/en/view/109746538) manual.

Bus systems

7

In order to prevent unintended damage to bus lines, these should be clearly visible and laid separately from all other lines and cables.

Special requirements are to be fulfilled when laying redundant bus lines. Redundant lines are to be laid on separate routes to exclude simultaneous damage being incurred from the same event.

7.1 PROFIBUS

7.1.1 General rules

The PROFIBUS must be installed in accordance with the PROFIBUS user organization and standards specifications, and it must have a permitted network structure. All devices connected to the bus must be certified as per PROFIBUS specifications.

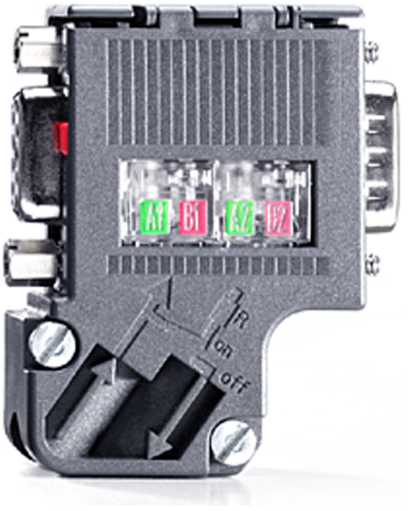
The following rules must be adhered to:

- Taking the type of cable employed into account, the segment lengths must conform to the PROFIBUS specification.
- The cable specification for bending radii must be adhered to.
- The bus segments must be terminated in accordance with the specification.
- Metallic bus connectors or bus connectors with inner-lying shield plates must be used exclusively, which establish an extensive connection of the shield braiding with earth potential.
- Bus connectors with a diagnostic interface are to be employed.
- All bus connectors must be screwed to the bus node.
- All devices employed on the bus (standard and safety) must show a PROFIBUS certificate or a corresponding manufacturer's declaration. Furthermore, a certificate of notified bodies (e.g. TÜV, BIA, HSE, INRS, UL, etc.) must be shown for all safety devices.

You can find more information in manual "SIMATIC NET PROFIBUS Network Manual" (https://support.industry.siemens.com/cs/ww/en/view/35222591).

Example

The following figure shows a bus connector with diagnostic interface:



7.1.2 Bus cable

PROFIBUS cables

In addition to guidelines on cables and the laying of cables, the following rules are to be adhered to with regard to PROFIBUS configuration:

- Only permitted cables may be used. The notes on usage must be considered here.
- The maximum segment length must be considered.
- The temperature range specified for the cable must be adhered to.
- The maximum cable lengths specified only apply to uncut or unspliced lines. Line attenuation is increased through optical couplings, for example. The permitted lengths are reduced.
- When laying bus cables, general instructions are:
  - Do not twist bus cables.
  - Do not stretch bus cables.
  - Do not press bus cables.
- When using optical link modules (OLMs), one must ensure that only OLMs of the same wavelength are connected to each other.
- Along the course of a redundant ring configured from OLMs, only lines with fiber-optic cables may be used. No segment may consist of RS 485 bus lines.
- With redundant optical rings, the value of the HSA (Highest Station Address) parameter must be set for all terminal devices so that between the bus address "0" and the "HSA" value at least one address in the network is not occupied by a bus node. An address gap of at least one must be present.

Additional information

You can find information on the properties of the PROFIBUS DP bus cable in the "Automation System S7-400 Hardware and Installation" (https://support.industry.siemens.com/cs/ww/en/view/1117849) manual.

You can find information on RS 485 bus lines for PROFIBUS in the "SIMATIC NET PROFIBUS" (https://support.industry.siemens.com/cs/ww/en/view/35222591) network manual.

You can find information on bus lines for PROFIBUS PA in the "SIMATIC NET PROFIBUS" (https://support.industry.siemens.com/cs/ww/en/view/35222591) network manual.

You can find information on bus lines when using OLMs in manual "SIMATIC NET Network Components/PROFIBUS Optical Link Module" (https://support.industry.siemens.com/cs/ww/en/view/109476821).

7.1.3 Termination

Notes on termination

To prevent reflections, PROFIBUS segments must be terminated. The following rules apply here:

- Bus lines are terminated at the end of the segment at both ends.
- Branch lines are not terminated.
- In order to always ensure a termination independent of the bus nodes when swapping devices at the two end segments of the RS 485 PROFIBUS line, we recommend performing the bus termination using the active SIMATIC NET PROFIBUS terminator. One must also ensure that there is an independent power supply for the terminator. The following figure shows an example of a PROFIBUS terminator:



You can find additional information and examples in manual "SIMATIC NET PROFIBUS Network Manual (https://support.industry.siemens.com/cs/ww/en/view/35222591)".

7.1.4 Permitted network structures for PROFIBUS DP

Requirements

Permitted topologies are line, tree and ring structures. The following boundary conditions are to be observed when configuring a PROFIBUS line:

- Maximum line length up to 1,000 m, with RS485 technology (also less depending on the baud rate and type of media).
- Maximum of 32 nodes per segment.

  If more than 32 stations, or greater network expansion is required to a PROFIBUS, a repeater must be employed.
- Maximum of 9 RS 485 repeaters.
- Maximum total of 126 nodes.
- An optical line may contain a maximum of 32 integrated optical interfaces in sequence.
- Several lines from up to 32 integrated optical interfaces may be connected via Optical Bus Terminals (OBT).
- In optical networks (lines, stars, rings) which only contain OLMs, the number of OLMs is limited to 122.
- The quantity of all the optical components (integrated interfaces, OBTs, OLMs) in the optical PROFIBUS network is to be specified in the configuration tool under "OLM, OBT quantity" and may not exceed 122.

Note

A repeater is "transparent". This only provides the signal regeneration and does not count towards the number of nodes in a segment.

Conversely, a diagnostics repeater is a DP slave and thus reduces the maximum number of slaves that can still be wired to the connected bus segments to 31.

Additional information

You can find additional information in manual "SIMATIC NET PROFIBUS Network Manual (https://support.industry.siemens.com/cs/ww/en/view/35222591)".

7.1.5 Line lengths for PROFIBUS DP

Introduction

Depending on the segment length of the PROFIBUS, there is a maximum permitted baud rate for a PROFIBUS line. The determining factor is the shortest segment of a PROFIBUS line.

The following conditions apply to the segment lengths:

Baud rate	Maximum line length of a segment (m)
9.6 to 187.5 kBd	1000
500 kBd	400
1.5 MBd	200
3 to 12 MBd	100

Length of branch lines

Branch lines also count as segments in this assessment. Branch lines (formed from T connectors, for example) are offshoots within a PROFIBUS segment. The maximum bit rate of the complete PROFIBUS line is influenced by branch lines.

Bit rates of up to a maximum of 1.5 MBd

In principle, branch lines are not allowed if baud rates of over 1.5 MBd are used. The maximum lengths of bus segments (including branch lines) must be observed with baud rates up to a maximum of 1.5 MBd. In intrinsically safe areas, a maximum branch line length of 30 m is permitted. Branch lines are not terminated (e.g. with a bus termination resistor).

Baud rate	Maximum length of a branch line	Quantity of nodes with a branch line length of:		Maximum total length of all branch lines per segment
		1.5 or 1.6 m	3 m	
9.6 to 93.75 kBd	3 m	32	32	96 m
187.5 kBd	3 m	32	25	75 m
500 kBd	3 m	20	10	30 m
1.5 MBd	3 m	6	3	10 m

Baud rate over 1.5 MBd

For baud rates of over 1.5 MBd, one must use connectors that have been designed especially for this purpose. Serial inductances can be installed within these connectors to compensate for connector capacity.

The following rules apply for baud rates over 1.5 MBd:

- Branch lines are not permitted at bit rates of over 1.5 MBd.
- The maximum segment length is restricted to 100 m.
- A minimum cable length of 1 m between two stations is recommended.

Additional information

For additional information, refer to the "Automation System S7-400 Hardware and Installation" (https://support.industry.siemens.com/cs/ww/en/view/1117849) manual.

7.1.6 Permitted network structures for PROFIBUS PA

Network configuration

The following points are to be considered with regard to the network configuration:

- The maximum line length
- The maximum number of nodes per segment (32 nodes/segment)
- The maximum current load per coupler

Topologies

Permitted topologies are line, tree and ring structures, taking certain criteria into account. You can find further information on this in the "SIMATIC NET PROFIBUS Network Manual" (https://support.industry.siemens.com/cs/ww/en/view/35222591).

The planning of PROFIBUS lines is easier if there is just one power source per segment and all components have FISCO approval.

It is prerequisite that the bus cable fulfill the following requirements:

- R´= 15 … 150 Ω/km
- L´= 0.4 … 1 mH/km
- C´= 80 ... 200 nF/km

Applicable in this case is that:

- The maximum cable length is 1,000 m for explosion protection type *i*, category *a*, and

1,900 m for explosion protection type *i*, category *b*.

- The replacement of devices or the expansion of bus segments via "Plug&Play" is possible without recalculation and also in hazardous areas.

7.1.7 Earthing and shielding of PROFIBUS components

Rules for PROFIBUS cables

PROFIBUS cables must be included within the plant-wide earthing and lightning protection plan.

Shielding will be improved and EMC issues will be minimized if the following guidelines are observed:

- PROFIBUS cable shields are earthed at both ends. If potential equalization is not secured, one side will be earthed directly and one side indirectly.
- Non-grounded (i.e. fault-prone) cable sections and already grounded (i.e. low-fault) PROFIBUS cables should not be laid next to each other in parallel (e.g. in the area between the cabinet entrance and the shield connection).
- The impact of the shield will be improved if the cables are laid next to shielding equipotential-bonding cables or grounded plates.
- To minimize problems with potential equalization and lightning protection, fiber-optic bus cables should be used for bus segments that connect different plant units.
- If fiber-optic cable plug connectors become contaminated, one must ensure that they only work in a limited way. All unused fiber-optic cable slots must be fitted with protective caps.
- When laying cable in the ground, you must ensure that the cable in question is approved for such use by the manufacturer.

Additional information

You can find information on electrical isolation and earthing in the "DP/DP coupler" (https://support.industry.siemens.com/cs/ww/en/view/1179382) manual.

You can find information on non-grounded operation of the RS 485 repeater in the "SIMATIC NET PROFIBUS" (https://support.industry.siemens.com/cs/ww/en/view/35222591) network manual.

7.1.8 Lightning protection

Lightning protection measures

Lightning protection measures are necessary, especially for PROFIBUS expansion across an entire building. As overvoltages can also result within buildings from the effects of lightning, measures for protecting against overvoltages must be taken.

A distinction is made here between primary and secondary lightning protection. Primary protection is intended to prevent damage resulting from lightning currents and is therefore installed near to where the bus cable enters the building. Secondary protection involves surge suppression and is installed near to devices/bus partners that are to be protected.

Primary and secondary protection are each to be considered together, like a node within bus planning.

If there is a risk that inadmissible compensation currents may flow over the PROFIBUS cable shield with the shield set up at both ends (e.g. setup in building A and also at the entrance to building B), the use of two different elements of primary protection is recommended. A protective component with direct grounding should thus be set at one end, and one should be set at the other with indirect grounding.

Additional information

You can find additional information on lightning protection for bus lines in the "SIMATIC NET PROFIBUS Network Manual" (https://support.industry.siemens.com/cs/ww/en/view/35222591).

7.2 FOUNDATION Fieldbus H1:

7.2.1 Fieldbus

The FOUNDATION Fieldbus works according to the standard IEC 61158-2. Both communication and the voltage supply of the bus nodes is performed through a single shielded two-wire cable. A maximum of 32 bus nodes is possible on one field bus segment (FF Link + maximum 31 field devices).

FF devices are connected to PROFIBUS DP via a Compact FF Link. The Compact FF Link is a DP slave with respect to the automation system and an FF Link Master with respect to FF devices.

FF devices can communicate via the FF segment without participation of the automation system. The name of this function is "Control in the field" (CIF).

7.2.2 Permitted network structures for FOUNDATION Fieldbus

Line lengths

The following points are to be considered with regard to the network configuration:

- The maximum line length per FF segment is 1900 m (the specification only applies when suitable cables are used). Spur lines should also be taken into account when calculating the bus line to the FF field devices.
- The maximum permitted length of a branch line is 120 m (depending on cable type)

Number of branch lines (longer than 1 m)	Maximum branch line length
1-12	120 m
13-14	90 m
15-18	60 m
19-24	30 m
25-31	1 m

- With an intrinsically safe configuration, the maximum length of a branch line is limited to 60 m.

Note

You can optimize performance by using shielded bus cables (type A) as this reduces the sensitivity to interference.

Topologies

In case of connection to a non-redundant automation system (non-redundant DP master system), the Foundation Fieldbus can be configured as a line topology. In case of connection to a redundant automation system (redundant DP master system and two Compact FF Links), the Foundation Fieldbus can be configured as a line structure using coupler redundancy (with Active Field Splitter (AFS)) or as a ring structure using ring redundancy (with Active Field Distributor (AFD)).

7.2.3 Earthing, shielding, and lightning protection

The same earthing, shielding, and lightning protection measures generally apply to the FOUNDATION Fieldbus as they do for the PROFIBUS:

- Earthing and shielding of PROFIBUS components (Page 46)
- Lightning protection (Page 47)

7.3 PROFINET

Introduction

PROFINET is a combination of the established PROFIBUS DP and Industrial Ethernet. PROFINET is based on switched Ethernet with full duplex operation and a transmission rate of 100 Mbps. The switches used must be certified for PROFINET (e.g. support of VLAN tag with priority).

With PROFINET, a switching technology is used which allows any node to access the network at any time. The network can thus be used considerably more effectively with simultaneous data transmission. Simultaneous sending and receiving of data is enabled by the full duplex operation of the switched Ethernet.

PROFINET is realized through the PROFINET standard for automation devices IEC 61158-x-10.

You can find an overview of all relevant information for realization of PROFINET solutions in SIMATIC PCS 7 in Entry "PROFINET in Process Automation with SIMATIC PCS 7 (https://support.industry.siemens.com/cs/ww/en/view/72887082)".

7.3.1 General rules

The following information applies to the structure of the PROFINET fieldbus:

- Permitted structures for the fieldbus with PROFINET are line, star, tree, and ring structures.
- When rings are configured based on MRP (Media Redundancy Protocol), a maximum of 50 nodes are permitted. In this process, a reconfiguration time of less than 0.2 s is achieved.
- The maximum length for the electrical transmission between PROFINET nodes is 100 m. Larger distances are possible with optical transmission.
- A mixture of electrical and optical bus segments is possible.
- The use of Fast Connect RJ45 plugs is recommended, because unlike standard RJ45 connectors, they have all-round shielding and improved EMC properties, due to their metal enclosure.

You can find more information for planning and configuring the PROFINET fieldbus in the following documents:

- You can find recommended and tested topologies as PROFINET blueprints in application example "PROFINET in SIMATIC PCS 7 – Guidelines and Blueprints (https://support.industry.siemens.com/cs/ww/en/view/72887082)".
- Observe the installation guideline "PROFINET of PROFIBUS & PROFINET International (PI) (http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/)".
- You can find information on cable lengths in the product manuals and in manual "SIMATIC NET Industrial Ethernet / PROFINET Passive Network Components - System Manual (https://support.industry.siemens.com/cs/ww/en/view/84922825)".

7.3.2 Lightning protection

Lightning protection measures

Lightning protection measures are necessary, especially for bus expansion across an entire building. There is a distinction here between primary and secondary protection.

Primary protection is intended to prevent damage resulting from lightning currents and is therefore installed near to where the bus cable enters the building. Secondary protection provides surge suppression and is installed near to devices/bus partners that are to be protected.

If fiber-optic technology is employed for busses spanning entire buildings, bus-specific usage of primary protection measures is not necessary. Because overvoltages can also occur within buildings from the effects of lightning, appropriate secondary protection measures are to be taken.

The following guidelines are to be observed:

- The shield is connected at both ends of the twisted pair line via the connected connector/outlet extensively and with good conductivity to the housing of the connected terminal device or the network component.
- If there is a risk of non-permissible compensating currents flowing over the cable shield of the bus due to connection of the shield at both ends (e.g. connection in building A and also at the entrance to building B), then fiber-optic cables must be used instead of a bus segment consisting of copper cables.

7.4 Industrial Ethernet

Introduction

The plant bus connects the automation systems with one another. OS servers and engineering stations also have a connection to the plant bus.

With the terminal bus, the communication between the servers and the clients is achieved. Engineering stations also have a connection to the terminal bus.

Both busses are based on the Ethernet Standard in accordance with IEEE 802.3, which, when expanded for use in industrial environments, is also referred to as Industrial Ethernet

Wireless radio networks can only be configured when taking spatial conditions into account. The special requirements, planning aspects and recommended components and accessories of radio networks are described in great detail in the "SIMATIC NET Industrial Ethernet" manual.

See also

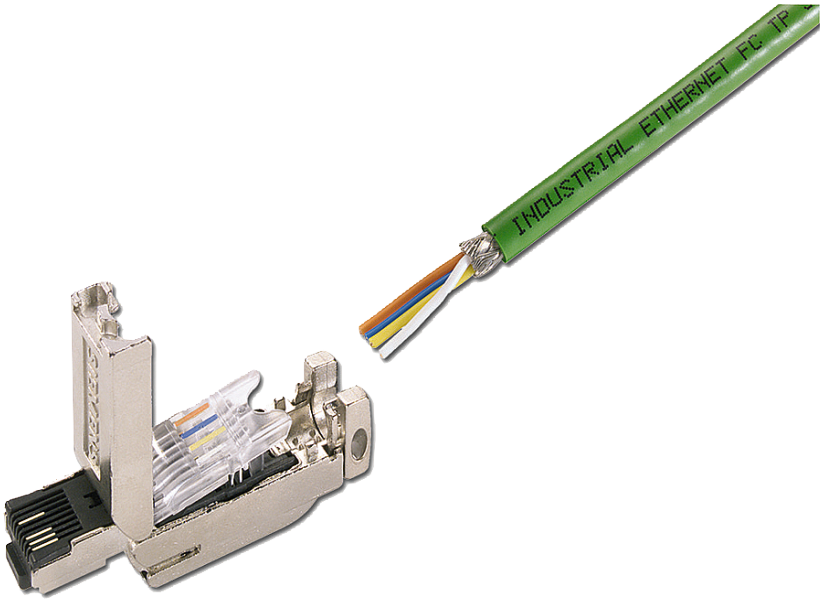
PROFINET in Process Automation with SIMATIC PCS 7
(https://support.industry.siemens.com/cs/ww/en/view/72887082)

7.4.1 General rules

The following information applies to the structure of the plant bus and terminal bus:

- Permitted structures for the plant, and terminal busses are lines, stars, trees or rings.
- When employing a redundancy manager, one must ensure that this function is also released and parameterized on the device and the correct ports are used for the ring connection.
- The standby coupling of two rings is possible when the HRP standby function is used and available.
- At most 100 SCALANCE X are permitted in a ring. In this process, a reconfiguration period of less than 0.3 s with HRP (Highspeed Redundancy Protocol) is achieved.
- With Fast Ethernet (100 Mbps), 4-wire twisted pair cable is used for electrical transmission. With Gigabit Ethernet (1000 Mbps), 8-wire twisted pair cable is used. The maximum length for the electrical transmission between two devices is 100 m. Larger distances are possible with optical transmission. Depending on the modules and cables, distances up to 200 km (Fast Ethernet and single-mode cable) can be spanned.
- A mixture of electrical and optical bus segments is possible.
- In industrial environments, the use of Fast Connect RJ45 plugs is recommended, because, unlike standard RJ45 connectors, they have all-round shielding and improved EMC properties, due to their metal enclosure. The FastConnect RJ45 plug is available in different variants (different cable outlet angles), which enables configuration of a stable connection with strain relief.

The following figure shows a Fast Connect RJ45 plug:



You can find more information on Industrial Ethernet in the following documents:

- You can find network architectures for the plant bus and terminal bus in manual "SIMATIC PCS 7 Standard Architectures (https://support.industry.siemens.com/cs/ww/en/view/109739629)".
- You can find general information in manual "SIMATIC NET Industrial Ethernet – System Manual (https://support.industry.siemens.com/cs/ww/en/view/27069465)".
- You can find Information about cable types (e.g. halogen-free, trailing for ground cable, for use in ship building) in manual "SIMATIC NET Industrial Ethernet / PROFINET Passive Network Components - System Manual (https://support.industry.siemens.com/cs/ww/en/view/84922825)".

7.4.2 Lightning protection

Lightning protection measures

Lightning protection measures are necessary, especially for bus expansion across an entire building. This can be broken down here into primary and secondary protection.

Primary protection is intended to prevent damage resulting from lightning currents and is therefore installed near to where the bus cable enters the building. Secondary protection provides surge suppression and is installed near to devices/bus partners that are to be protected.

If fiber-optic technology is employed for busses spanning entire buildings, bus-specific usage of primary protection measures is not necessary. Because overvoltages can also occur within buildings from the effects of lightning, appropriate secondary protection measures are to be taken.

The following guidelines are to be observed:

- The shield is connected at both ends of the twisted pair line via the connected connector/outlet extensively and with good conductivity to the housing of the connected terminal device or the network component.
- If there is a risk that inadmissible compensation currents may flow over the bus cable shield with the shield set up at both ends (e.g. setup in building A and at the entrance to building B), then fiber-optic cables are to be used in place of a bus segment consisting of copper cables.
- Lightning protection from radio network components must be considered, especially for use in external areas.

Examples

The following figure shows an example for surge arresters:



Source: Company DEHN + SÖHNE GmbH + Co. KG, Hans-Dehn-Str. 1, 92318 Neumarkt, Germany; Internet: www.dehn.de

The following figure shows an example of an arrester for data racks with a larger number of incoming and outgoing patch cables (e.g. for switches with RJ45 plugs) as surge arrester inserts:



Source: Company DEHN + SÖHNE GmbH + Co. KG, Hans-Dehn-Str. 1, 92318 Neumarkt, Germany; Internet: www.dehn.de

Emergency off

8

Requirements

The following minimum requirements apply to setting up emergency off systems:

- The emergency off mechanisms of the plant must function at all times, regardless of operating modes.
- It must be ensured that the emergency off mechanisms are always easily accessible (height of installation between 800 and 1600 mm above the floor).

Ensure that disturbances to the communication connections or line or wire breakages cannot lead to danger.

Note

The plant must not be allowed to enter uncontrollable or undefined states or be able to run autonomously following the unlocking or release of the emergency off mechanism.

You can find wiring examples, for example, in the "Fail-safe Digital Modules – SIMOCODE pro Safety" (https://support.industry.siemens.com/cs/ww/en/view/50564852) system manual.

Service and support

9

Industry Online Support

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