

Grounding and Electromagnetic Compatibility of PLC Systems Basic Principles and Measures User Manual

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Document Set

Presentation

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-

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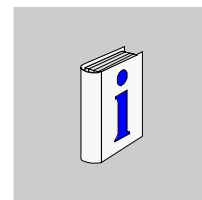
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About the Book



At a Glance

- Document Scope** This manual is intended for users of Schneider Electric PLC systems during configuration and installation and provides information regarding grounding and measures for electromagnetic compatibility (EMC).
- This manual serves the following purposes:
- Provides an overview of general problems regarding grounding and EMC
 - Eases the selection of grounding and EMC measures in the entire system (machine or system)
 - Provides guidelines for configuration and installation of Schneider Electric components regarding grounding and EMC
- Section 1 contains information concerning regulations in the European Union (EU) and in North America. This section also contains references to relevant international standards.
- Section 2 contains basic information concerning grounding and electromagnetic disturbances. You will also find information concerning standard EMC measures listed according to the type of measure.
- Section 3 contains guidelines for EMC and grounding measures in an automated system listed according to system area.
- Sections 4-6 contains special configuration and installation information for the following three Schneider PLC families:
- Quantum
 - Premium
 - Momentum
- Section 7 contains special configuration and installation information for the following network components:
- Modbus Plus
 - Remote I/O
 - PROFIBUS
 - INTERBUS
 - Ethernet
-

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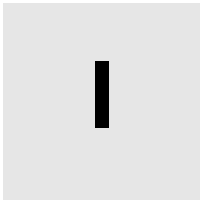
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Regulations and Standards



Overview

Introduction This section contains information concerning regulations for EMC and grounding of systems and machines where PLC systems are used.

What's in this Part? This part contains the following chapters:

Chapter	Chapter Name	Page
1	Using Regulations and Standards in the EU	17
2	International Standards	25

Using Regulations and Standards in the EU

1

Overview

Introduction This chapter provides information concerning the use of regulations and standards in the EU for systems and machines where PLC systems are used.

What's in this Chapter? This chapter contains the following topics:

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Low Voltage Directive	23
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Harmonized Regulations and Standards in the EU

Harmonizing in the EU

Harmonizing in the EU means adjusting the regulations for the individual EU countries so that they match. For technical products, the requirements of the products are standardized to prevent problems with trade. To harmonize the technical requirements, EU guidelines are created to adjust the regulations so that they match. These guidelines define basic requirements that products must meet if they are going to be traded within the EU.

EU Guidelines

The EU guidelines are not regulations because regulations cannot be made at EU level. But this is only a formality because the EU country is required to add the contents of the EU guidelines to the national regulations. Therefore the requirements defined in the EU guidelines – sooner or later – will be regulations throughout the EU.

Examples of EU guidelines are: Machine guidelines, low voltage guidelines, EMC guidelines, guidelines for toys, etc.

Local regulations must be observed!

Note: Inform yourself about local regulations and valid standards in addition to the information provided in this manual. This manual only provides an overview.

Relevant Guidelines for PLC Users

The following guidelines are valid for EMC and the safety of electrical equipment

- Low voltage directive
Guideline 73/23/EEC from the directive of February 19th 1973 to adjust the regulations of the EU countries concerning electrical equipment for use within certain voltage limits
 - Machine directives
Guideline 98/37/EC from the European Parliament and the directive on June 22nd 1998 to adjust the regulations and administrative directives of the EU countries concerning machines
 - EMC guidelines
Guideline 89/336/EEC from the directive on May 3rd 1989 to adjust the regulations of the EU countries concerning electromagnetic compatibility
-

**Conformity
Statement and
CE Mark**

The manufacturer, or whoever trades the product in the EU, must confirm that the requirements of the respective guideline are met in a conformity statement. A CE mark is also required for the products.

Note: The conformity is normally tested and confirmed by the manufacturer. The CE mark is applied to the product by the manufacturer. For certain products with a high potential for danger, the tests must be carried out by an external test lab (e.g. for presses or woodworking systems).

**Harmonized
Standards**

Harmonized European standards are standards created by the European standardization organizations CEN and CENELEC and are recognized by the EU as being harmonized standards. These standards define how the conformity to the requirements of the EU guidelines can be achieved. Each guideline has a group of harmonized standards.

**Role of
harmonized
standards**

If these standards are used, it can be assumed that conformity is guaranteed. However, the standards do not have to be met according to law. If the requirements of the guidelines or the corresponding national regulations are met in other ways, this is also allowed. Using the standards has the advantage that it is easier to create a conformity statement and to confirm conformity in a court of law.

Note: However, using the standards is not enough. The standards are only the minimum requirements. They only represent the level of technology compared to the far reaching state of science and technology

Types of Standards

There are three types of European standard documents:

- European standard (EN...)
A European standard is the basic goal. An EN is a European technical regulation created by CEN or CENELEC in cooperation and with the consent of the parties concerned from the EU countries. European standards must be added to the national standards without being changed. National standards which do not match are to be withdrawn.
- Harmonizing document (HD...)
Harmonizing documents can be created in place of European standards if integration identical national standards is unnecessary, or if the only way to achieve agreement is by permitting national differences.
- European preliminary standard (ENV...)
The European preliminary standard (ENV) was created by CEN and CENELEC to allow definitions to be made quickly which can be used immediately, especially in areas with a high degree of innovation (e.g. IT).

The standards are classified in the following types according to the area of application:

- Type A (general standards)
They contain technical regulations which are not product specific.
- Type B (group standards)
- Type C (product standards)
They contain technical regulations for certain products or product families.
Product standards may only complement - and not override - general standards.

Product Standards

Product standards are valid for certain product groups. A product standard also contains references to the general standards which are valid to the product. Grouping requirements of various types in a document for a certain product group reduces the overhead for the manufacturer.

Note: Requirements from product standards take precedence over requirements from general standards.

Example: The product standard for programmable controllers and peripheral devices is EN 61131.

EMC Directives in the EU

EMC guidelines	The EMC directive for the EU passed in 1989 was used to achieve a harmonization of the regulations for electromagnetic compatibility for technical products in EU countries. The EMC directive was adopted in each EU country as a national EMC regulation.
Requirements	The EMC directive requires that the devices function properly in the electromagnetic environment without causing electromagnetic disturbances which would could disturb the functions of other devices in this environment.
Harmonized Standards	The requirements for protection are met if the devices follow the corresponding harmonized European standards.
Validity	The EMC regulation is valid for devices which can cause electromagnetic disturbances or which can be influenced by such disturbances. This includes all electrical and electronic devices and systems with electrical or electronic components. It defines the conditions of such devices for • sales, • distribution and • operation.
What are the corresponding European standards?	Harmonized standards are standards that use the information published by the European community as the source. The term "corresponding" means that the standards provide information concerning the EMC requirements in general or specially for the product type being used.

Machine Directives in the EU

Machine directives

The machine directive for the EU passed in 1989 and updated in 1998 was used to achieve harmonizing of the regulations for safety of machines in EU countries. The machine directive has been implemented since the 1st of June 1995 in the national laws of every EU country and EU pre-accession country.

Requirements

The machine directive defines basic security and safety requirements for machines and safety equipment which are required for use. These basic security and safety requirements are supplemented by a group of detailed requirements for certain machine types.

Validity

The machine directive is valid for machines and safety equipment.

The term **machine** is a general term and includes a wide range of machines and systems.

- A unit consisting of a group of components or equipment, mostly with at least one moving part, as well as operating machines, control loops, etc., which is used for a certain purpose, such as processing, handling, moving and preparing a material
- A unit consisting of machines which work together in such a manner that they are considered to function as a whole
- Exchangeable equipment used to change the function of machine which can be obtained and added to a machine or a group of machines or a by service personnel, as long as this equipment is not a replacement part or tool

Safety equipment, which is not exchangeable equipment, a component which the manufacturer (or authorized personnel) places on the market with the intent of guaranteeing safety and the failure of this component can danger the security or safety of persons in the work area.

Exceptions

A group of products are excluded from this: People moving equipment, boilers, atomic systems, weapons, etc.

Low Voltage Directive

Full title	The full title of the low voltage directive is: EU Directive 73/23/EEC concerning the safety of electrical equipment
Goal of the low voltage directive	The goal of the low voltage directive (1973) is to harmonize technical safety requirements for low voltage electrical equipment in the EU, in order to do away with business restraints.
Validity	The low voltage directive is valid for electrical equipment that uses a rated voltage of 50 ... 1000 V AC or 75 ... 1500 V DC. Exceptions are: • Electrical equipment for use in an explosive atmosphere • Electro-radiological and electro-medical equipment • Electrical parts of elevators for people and loads • Electricity counter

How to find EU guidelines and harmonized standards

Why only Internet sources?

Many manuals, standard catalogs and other printed materials are available in all countries. However, they have the disadvantage of the fact that you never know if they are out of date. The Internet has developed to the point that it is the best research media for looking up information. That is why only Internet sites are listed here.

Finding EU directives

EU directives can be found in original text on the Internet on the European Commission site. The site is available in all official European languages.

Step	Procedure
1	Go to the EU Commission site http://europa.eu.int/eur-lex
2	Go to the following path on the site: Legislation in force → Industrial policy and internal market .
3	Select Electrical material . Result: You get a list of EU directives for electrical material as well as a direct link to the full-text version of the directive.

Finding harmonized standards

The current list of European harmonized standards for each EU directive can be found on the CENELEC site, the European standards organization for electro-technical products:

Step	Procedure
1	Go to the CENELEC site http://www.cenelec.org .
2	On the site, select Search → Standardization activities . Result: A form appears with fields where you can enter your search criteria.
3	Select a topic from the list of Keywords , for example, EMC .
4	Select an EU directive from the list of Directive(s) , for example 73/23/EEC .
5	Confirm your definitions with OK . Result: You now receive a list of standards according to your search criterion.

Overview

Introduction This chapter provides information concerning international technical standards for systems and machines in which PLC systems are used. It explains the purpose for the standards and their role in relation to the regulations. You will also find concrete references to relevant standards.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Role of the Standards	26
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Relevant Standards for PLC System Users	28

Role of the Standards

Importance of the standards

The components of a PLC system are produced and tested as well as certified or authorized according to the respective regulations and standards for the country where they are being used.

Not only the manufacturer, but also the user of PLC systems must be aware of the regulations and standards. The automated system in which the components of the PLC system are installed is also subject to regulations. To meet the regulations, the use of standards is helpful and essential as they reflect the current state of technology.

Standards and the law

Note: Standards can often provide security concerning product liability, but they are not legal standards. Standardization organizations are not liable for the suitability of the standards. This is tested by the responsible designer through hazard analysis according to machine directives.

What is standardization?

Standardization guarantees uniformity of materials and immaterial things for public use and is carried out according to a plan by interested parties in the community. In addition to company standards, national and international standards are also created.

Standardization serves the following purposes:

- Promotes rationalization and quality assurance for trade, technology and management
 - Improves safety of personnel and material
 - Improves quality in all areas of life
-

International Standards

International standards	In many areas, especially electro technical engineering, there are standards which are valid all over the world. The result of these worldwide efforts are 10,000 international standards which are used directly or can be added to the individual national standards. These international standards are defined by international standardization organizations.
ISO	90 countries work together through their national standardization institute in the International Standards Organization (ISO). A well-known example of ISO's work are the international standards for quality assurance systems ISO 9000 to 9004.
IEC	The International Electro technical Commission (IEC) is responsible for electro technical standards. In this area, there is nearly 100% agreement with the European harmonized standards, which is also evident in the fact that the numbering also matches.
CISPR	CISPR is the International Special Committee on Radio Interference. The goal of CISPR publications and recommendations is to protect radio transmission. CISPR publications mainly contain definitions for test procedures and limit values for radio disturbances for electrical and electronic products.

Relevant Standards for PLC System Users

Introduction

The following standards are a selection of the most important European and international standards which are relevant for PLC system users.

Product Standards

Note: Standards can often provide security concerning product liability, but they are not legal standards. Standardization organizations are not liable for the suitability of the standards. Only the regulations in each individual country are binding.

The following European and international standards define safety and EMC requirements for PLC system users. The selection has been purposefully kept small and mainly contains product standards. Within each individual standard, you will find a list of other standards which refer to certain products and may be valid for your application:

EN-No.	Corresponding IEC No.	Title
EN 61131-4	IEC 61131 -4	Programmable logic controllers – part 4: Guidelines for users
EN 50178	IEC 62103	Electronic equipment for use in power installations
EN 60439 - 1	IEC 60439 -1	Low voltage switching device combinations
EN 60950	IEC 950	Safety of IT equipment

General standards

The following European and international standards define safety and EMC requirements which do not refer to certain products and may be valid for your application:

EN-No.	Corresponding IEC No.	Title
HD 384.4.41	IEC 60364-4-41	Electrical Installations of Buildings - Part 4: Safety measures Chapter 41: Protection against electrical shock
EN 61140	IEC 61140	Protection against electric shock. Common requirements for systems and equipment
EN 60204 -1	IEC 60204 -1	Safety of machines - electrical equipment of machines
EN 50310		Use of measures for equipotential bonding and grounding in buildings with IT equipment
EN 50174 -1		IT - installation of communication cabling – part 1: Specifications and quality assurance
DIN EN 50174-2		IT - installation of communication cabling – part 2: Installation planning and practices in buildings

Grounding and Electromagnetic Compatibility (EMC) - Basics



Overview

Introduction

This section contains basic knowledge concerning the subject area of this manual: Grounding and Electromagnetic Compatibility.

This section consists of terms, definitions and explanations of physical combinations that will be required in understanding some of the measures that will be introduced in subsequent sections.

Planning regulations can be found in *Earth and EMC Measures in Automation Systems - System Guidelines*, p. 89 and Product Specific Grounding and EMC Measures - Guidelines.

What's in this Part?

This part contains the following chapters:

Chapter	Chapter Name	Page
3	Grounding - Basics	33
4	Electromagnetic Disturbance and EMC	45
5	Basic EMC Measures	79

Grounding - Basics



Overview

Introduction This chapter explains the terminology connected with grounding that can be helpful and is sometimes required for understanding grounding procedures for a system or a machine.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Definitions: Earth, ground, reference conductor system	34
Ground Connections in TT, TN and IT Alternating Current Systems	36
Personal Danger through Electrical Current	38
Electric Shock: Causes and preventative measures	39
Classes of Protection for Electrical Equipment	41
Protective Earth	42

Definitions: Earth, ground, reference conductor system

Earth and ground In almost all devices or systems, you should differentiate between the earth (earth conductor) and the common ground (reference conductor system/neutral connection). Earth and common ground are normally connected to each other in a certain place. However, there is a difference:

Note: Earth only conducts fault currents and common ground conducts operational current and is often used as the common conductor for several signal circuits.

Earth Earth is the conductive potential of our earth. The electrical potential of the earth is considered to be zero. Inside a system, earth is understood as being the protective conductor used for protecting people, animals and goods.

Terms used as synonyms for Earth: Equipment grounding conductor, earth, protective earth, chassis or frame ground, station ground

Ground This is the common base for all connected conductive inactive components of electrical equipment and is not a route for operational voltage even when a fault occurs. The common ground is the equipotential offset for a system and is used as a common ground plane for electronic circuits.

The common earth plane is normally connected with the earth (grounded) in a stationary system. Common ground does not necessarily have to be connected with earth ground however (in airplanes for example).

Common ground is found performing the following functions:

- Equipotential plane for the reference conductor system of the electronics
- Equipotential bonding and over voltage protection for all installations of metal, electrical systems, lightning protection system and grounding system
- Protective function for people: Common potential is kept low in relation to earth potential so that a human would not be harmed by coming into contact with parts of the system
- Rerouting over-voltages (caused by faults in the system, lightning)

Terms used as synonyms for Common Ground: Equipotential bonding, neutral, switching ground, signal reference, signal ground, measurement ground, 0 V, reference conductor ground

Common ground examples

Common ground examples:

- Metallic structural elements of a building (framework, piping, etc.)
- Motor housing
- Metal cabinets, unpainted floor plates on housings
- Metallic cable ducts
- Transformer housing, machine bed plate
- Yellow-green wire (PE-PEN) for grounding

Reference conductor, reference conductor systems

The reference conductor for an electronic operation is the reference potential. It is connected with the common ground.

The reference conductor system makes a galvanized connection of all 0 Volt wires that are required in the current loop of the electrical equipment. No voltage differences may exist between the various points of the electronic reference plane otherwise unintended signal voltages can occur.

Normally, several circuits are operated on a common reference conductor system for the exchange of necessary signals.

Terms used as synonyms for Reference Conductor systems: Neutral (system)

Ground Connections in TT, TN and IT Alternating Current Systems

Distribution systems

Ground connections in our alternating current systems (single-phase, three-phase, rotary current systems), these systems can be put into three separate categories (IEC 60364):

System name	Type of ground connection to the energy source (first character)	Type of ground connection to the electric operation (second character)
TN system	A certain point on the neutral conductor, normally close to the feeding current source, is grounded directly.	The body of the electrical equipment is connected with the ground point using a ground conductor.
Variations TN-S system TN-C system TN-C-S system		Depending on the application of the N conductor, TN systems are split into three different types: ● S: Separated neutral and equipment grounding conductors ● C: Combined neutral and equipment grounding conductors (PEN) ● C-S: System with TN-C section(s) and TN-S section(s)
TT system	A certain point on the neutral conductor, normally close to the feeding current source, is connected with a ground connection.	The body of the electrical equipment is connected with other grounding elements, independent of the neutral ground.
IT system	No point in the system is grounded directly.	The body of the electrical equipment is grounded.

Note: Security stipulations for these various systems (cut-off conditions for example) are found in IEC 60364-4-41.

Character definitions

The letters have the following meanings:

Letter	Origin	Meaning
T	French: terre (Earth)	Direct connection of a point to earth
I	isolated	Either all active parts are separated from earth, or one point is connected through an impedance with earth
N	neutral	Body is connected directly to the ground point of the system (In alternating current networks, the grounded point is normally the zero conductor or if none exists then the external conductor.)
S	separate	A conductor is provided for a protective function and is separated from the neutral or the external conductor.
C	English: combined	Neutral and protective function combined in one conductor (PEN conductor)

First and second letter assignment

The identifying letters for the current distribution system are assigned as follows:

- First letter: Indicates the ground connection to the energy source (Transformer for example)
- Second letter: Indicates the ground connection to the electrical equipment

Personal Danger through Electrical Current

Dangerous Body Currents (Electrical Shock)

An electrical shock is the result of current flowing through the human body. Currents of 1 mA can cause reactions in a person of good health which can in turn cause shock to a dangerous degree. Higher levels of current can result in more damage. In dry conditions, voltages to around 42.4 V peak value or 60 V constant voltage are not normally considered dangerous. Components that must be touched or gripped should be connected with protective ground or should be sufficiently insulated.

Energy hazards

Short circuits between neighboring poles of power supply devices of higher current levels or circuits with high capacity can cause arcing or sparking of hot metal particles and result in burns. Even low voltage circuits can be dangerous in this way. Protection is achieved by separation or safety devices.

Burns

A burn can be caused by temperatures that are the result of overloads, component failures, insulation damage or loose connections or those with high transition resistance. The protective measures concern prevention of burns, the selection of materials regarding inflammability, measures for limiting the spreading of burns, etc.

Miscellaneous indirect hazards

Other indirect dangers

- Dangers of heat: Danger of injury caused by touching hot components.
 - Dangers of radiation: Hazardous radiation, e.g., noise, high frequency radiation, infrared radiation, visible and coherent light of high intensity, ultraviolet and ionizing radiation, etc.
 - Chemical hazards: Danger of contact with dangerous chemical materials.
-

Electric Shock: Causes and preventative measures

Dangerous voltages

The following voltages can be dangerous:

- A.C. voltage with a peak value of 42.4 V and higher
- D.C. voltage of 60 V and higher.

Causes

If a person touches a component that is under dangerous voltage, it can cause electric shock. This contact is divided into two categories:

Type of contact	Definition
Direct contact	Contact with components that are supplied with a voltage in undisturbed operation
Indirect contact	Contact with components that are supplied with a voltage caused by a fault

Preventative measures against direct contact

If components carry dangerous voltage, people must be prevented from coming into direct contact and therefore risking injury.

The following measures considered:

- Secure separation between circuits
- Housing or cover
- Insulating active components
- Energy restrictions (capacitor loads, protective impedance)
- Voltage restriction
- Additional fault current protective circuits

Preventative measures for indirect contact

A fault could also occur, in which case preventing people from getting an electric shock (by indirect contact) is also necessary.

The following measures can be considered:

- Doubled/reinforced insulation
 - Basic insulation and protective grounding
 - Additional fault current protective circuits
-

Respective standards

Regulations for protective measures against electric shock are covered in the following standards:

- Safety regulation standard:
IEC 61140: Protection against electric shock. Common requirements for systems and electrical equipment (safety standards)
 - Safety group standards:
IEC 60364-4-41: Electrical Installations of Buildings - Part 4: Protection for Safety, Chapter 41: Protection against electrical shock
 - For systems:
IEC 62103 and EN 50178: Electronic equipment for use in power installations
 - For machines:
IEC 60204: Safety of machines - electrical equipment of machines
-

Classes of Protection for Electrical Equipment

Classes of Protection	Electrical equipment is divided in protection classes 0, I, II and III. These classes of protection are defined by the method in which the protection against electric shock is achieved (IEC 61140). Programmable Logic Controllers and their peripherals must correspond with protective classes I, II or III (according to IEC 61131-2).
Protective Class 0	Electrical equipment for which the protection against dangerous body currents only contacts the basic insulation belongs to protective class 0. This means that no medium for connecting conductive components to the protective conductor (ground conductor) is provided in the permanent wiring of the system. If the basic insulation fails then the surrounding environment is trusted.
Protective Class I	Electrical equipment for which the protection against dangerous body currents does not only contact the basic insulation belongs to protective class I. An additional contact for connecting conductive components to the protective conductor (ground conductor) is provided in the permanent wiring of the system. Components that can be touched are voltage-free if the basic insulation fails in this case.
Protective Class II	Electrical equipment for which the protection against dangerous body currents does not only contact the basic insulation belongs to protective class II. An additional safety feature such as doubled insulation or reinforced insulation is provided but no protective ground.
Protective Class III	Electrical equipment for which the protection against dangerous body currents is achieved by safety extra-low voltage (SELV) supply belongs to protective class II. In this type of electrical equipment, no voltage that is higher than the SELV is produced.
SELV	SELV (Safety extra-low voltage): is defined as a voltage that, measured between conductors or between a conductor and ground, does not exceed 42.4 V peak or constant voltage. The circuits in which these are used must be separated from the power supply by a safety transformer or a similar device.

Protective Earth

Alternatives: Insulation or protective earth

All components of a system or machine that can be applied with a dangerous voltage if a fault occurs must be taken into account. To guarantee safety, these components can either be double insulated or reinforced or they can be equipped with a protective earth.

Protective earth: Definition

Protective earth is the earth that is mainly for guaranteeing the safety of human beings.

The protective earth is a preventative measure for avoiding an electric shock caused by indirect contact, i.e., contact with a component that has been applied with a dangerous voltage as a result of a fault - failure in the basic insulation for example.

Note: The protective earth is clearly separate from the functional earth. The functional earth is not for safety, it is a functional component; it is used as a reference voltage or for rerouting interference current for example.

Grounding arrangements and protective conductors

The precision of the connection to the ground potential depends on the electrical equipment, the components and the type of current distribution (TT, TN, IT system). Some important standard principles for protective earth are:

- The cross section of the protective ground wire must correspond with the maximum expected leakage current.
- Electrical connections must correspond with the loads that are possible in practical operation.
- The protective ground must also be guaranteed operational during service and maintenance work.
- The protective earth overrides the functional earth. It may not e.g. be used to disabled to improve the electromagnetic compatibility.

Note: IEC 60364-5-54 contains requirements for the earth system and protective grounding conductors.

**Protective earth
for PLCs**

Programmable Logic Controllers and their peripherals that belong to protective class I have a protective earth connection.

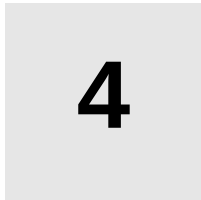
There are two ways of connecting to the earth system:

- The protective conductor is found in the power supply wire directly from the electric supply (mains).
- The device has a protective conductor connection for connecting to an external protective conductor.

All components of the device that a person can come into contact with (e.g. frame, housing, mounts) are connected electrically and are connected with the protective conductor connection so that no dangerous voltage can enter. The protective conductor connection must remain intact when working on the device as long as the supply is connected.

Requirements for the construction of PLCs and their peripherals can be found in IEC 61131-2 ***Programmable Controllers, Part 2: Equipment requirements and tests.***

Electromagnetic Disturbance and EMC



Overview

Introduction

This chapter contains the electronics basics on electromagnetic disturbance. This is based on the following questions:

- What can electromagnetic disturbances in industrial applications actually result in?
- What are the sources of disturbance?
- How can disturbance signals interfere with useful signals?
- What types of coupling mechanisms are there and what measures should be used to avoid problems?

This knowledge is necessary in understanding possible disturbance phenomena and the preventative measures that you can take in the planning and installation of the electrical equipment in an industrial application.

What's in this Chapter?

This chapter contains the following sections:

Section	Topic	Page
4.1	Results, Causes and Types of Disturbance	47
4.2	Overlapping of Interference and Useful Signals on Wires	57
4.3	Interference Coupling	63

4.1 Results, Causes and Types of Disturbance

Overview

Introduction

Electromagnetic disturbance in industrial applications can affect operation to various degrees: From acceptable operational influences right up to damaged system components. The causes of these disturbances lie either within the system or outside of it and can be classified according to various criteria. The disturbances themselves can vary and are also classified according to different criteria. This section is concerned with the results, causes and types of disturbance. It can mainly be used for understanding the terminology and for classification and is therefore required for a complete understanding of the other sections of the document.

What's in this Section?

This section contains the following topics:

Topic	Page
Results of Disturbance to an Industrial Application	48
Principles of Interference Influence - Influence Model	49
Sources of Interference	50
Interference Variables and Interference Signals	53
Effective Parameters	56

Results of Disturbance to an Industrial Application

Degree of effect The effects of undesired voltage and current in industrial applications range from acceptable functional degradation, to unacceptable functionality failures right up to total function failures of individual components or a complete application. These effects are categorized according to degrees:

Degree of effect	Description	Example
Function degradation	A non-significant influence in the functionality that is accepted as being permissible	Minor measurement imprecision is caused by disturbances that occur on a signal wire. These lie within the defined tolerance.
Function fault	The function is influenced to an impermissible degree which ends with a dying out of the amount of disturbance.	An incremental encoder for path measurement is connected with a PLC counter module. A short circuit in a motor supply wire running in parallel is causing an inductive coupling disturbance and is interfering with the useful signals on the wires for the incremental encoder, which is in turn being interpreted as counter pulses by the following circuit. This causes certain machine functions to be executed at the wrong times.
Function failure	An impermissible influence on the function that can only be resolved by technical measures (e.g. repair, exchange)	During a service call, an electrostatically charged technician comes into contact with a module. An electrostatic discharge occurs which damages or destroys components.

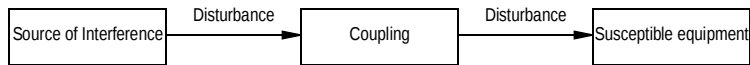
Other examples More examples for the effects of disturbance in a system:

- Individual impulse, i.e. pulse formed over-voltage caused e.g. by switching an inductive consumer such as a motor or valve. These interfere with the functionality of digital systems by setting or clearing registers if the interference threshold of the device is exceeded.
- A building only has one external lightning rod and no protection against lightning inside. When lightning strikes, some of the discharge flows into the building and damages electronic circuits.

Principles of Interference Influence - Influence Model

Influence model The electromagnetic influence of applications happens when a disturbance variable is transferred from an interference source through couplings to susceptible equipment.

The description of the electromagnetic influence follows an influence model consisting of interference source, coupling and susceptible equipment:



Source of interference Interference sources are the origin of disturbance variables. Potential sources of interference are all applications in which electromagnetic energy is transferred. Interference sources can lie within (system internal) or outside of (system external) the system in question.

Coupling The coupling of disturbance variables to susceptible equipment can happen in various ways:

- Galvanic: Coupling through a common circuit
- Capacitive: Coupling through the electric field
- Inductive: Coupling through the magnetic field
- Wave or radiation influence: Coupling through the electromagnetic field

Susceptible equipment Susceptible equipment is any device or component for which the functionality is disturbed by the disturbance variable.

Disturbance (disturbance variable) A disturbance variable (interference) can be electrical voltage, currents, electrical and magnetic fields. They are caused by electromagnetic proceedings, have a broad amplitude and frequency range over varying amounts of time and result in a reduction of functionality in susceptible equipment of varying intensity.

Sources of Interference

Classification of sources of interference

- The following classification for sources of interference can be helpful:
- Natural and technical sources
 - Sources having narrow-band and broad-band frequency spectrums
 - Sources for conductor and radiated disturbance variables
 - Power supply as source of interference
 - Regular and unintended (leakage) sources
 - Continuous and intermittent sources
-

Natural and technical sources of interference

We differentiate between natural and technical sources of interference:

Natural sources of interference	Technical sources of interference
• Lightning • Atmospheric and cosmic noise • Electrostatic discharge	For example: • Thyristor controllers that interfere by steep current slopes • Switching high powered applications on and off • HF Producer • Transmitter • Oven • Local oscillators

Narrow-band interference source

Narrow-band sources of interference are sources having signals with discrete frequencies such as:

- Radio and amateur radio transmitters
- Transmitter receiver devices
- Radar stations
- Industrial HF generators
- Microwave devices
- Energy currents
- Welding machines
- Sound or FX receivers
- Ultrasonic devices
- Power converter circuits

These can generate substantial electromagnetic fields, primarily in the immediate vicinity.

Broad-band interference sources

Broad-band sources of interference of conducted and radiated disturbance variables are feared disruptors in electronic automation systems, since they have very high frequencies in addition to a wide frequency spectrum.

The following belong to the broad-band sources of interference:

- Motors
- Discharge lamps
- Circuit breakers (power switches)
- Isolating switches in energy supplies
- Noise
- Controller circuits with semi-conductors
- Switching devices (relay, contact)
- Electrostatic discharge
- Atmospheric discharge
- Corona
- Nuclear discharge

Sources of conducted interference, power supply (mains)

Conducted influences run through metal conductors (wires or conductive structures), transformers, coils and capacitors. Since conductors effectively work as antennas as well, the interference can also be converted into a radiated disturbance or vice versa.

Examples: Frequency spectrum of conducted disturbances:

Source	Predominant frequency spectrum in MHz
Fluorescent tube	0.1 ... 3
Mercury arc lamps	0.1 ... 1
Data processing systems:	0.05 ... 20
Commutators	2 ... 4
Circuit breaker contacts	10 ... 20
Protection, Relay	0.05 ... 20
Power switch	0.5 ... 25
DC power supply (clocked)	0.1 ... 25
Corona	0.1 ... 10
Vacuum cleaner	0.1 ... 1

Many of the previously mentioned interference sources are connected to the main supply. The respective disturbance variable is sent out onto the supply network and passed on from there. Therefore, the power supply network can itself be the source of continuous and intermittent interference.

**Radiated
sources
Interference**

If the dimensions of the components are small compared to the wave length of the disturbance, then the radiated influence can be monitored separately over the electrical and magnetic fields.

With higher frequencies, the electromagnetic field must be monitored as a whole. This means that all devices, in which higher frequencies are generated and on which components deliberately or accidentally work as antennas, are to be considered as potential sources of interference.

Example: Frequency spectrum of radiated disturbances:

Source	Predominant frequency spectrum in MHz
RF surgery	0.4 ... 5
Bistable latches	0.015 ... 400
Thermostat contacts (Arc)	30 ... 1000
Motor	0.01 ... 0,4
Arcing circuits	30 ... 200
DC power supply	0.1 ... 30
Untreated device housing	0.01 ... 10
Fluorescent tube, arcing	0.1 ... 3
Semiconductor-multiplexer	0,3 ... 0 5
Cam contacts	10 ... 200
Circuits	0.1 ... 300

**Regular and
unintended
(leakage)
sources**

The differences between regular and unintended sources can be helpful in EMC work when monitoring frequency ranges for devices, in taking the appropriate measures for decreasing interference or in searching for unknown interference sources. The emission values of regular sources must be taken into account as part of the planning procedure.

**Continuous or
intermittent
Sources**

Differentiating between continuous or intermittent interference is required if for example, a certain influence should be shut off for timed operations of interference sources and receivers.

Example: Switching off receivers for weather

Interference Variables and Interference Signals

Overview

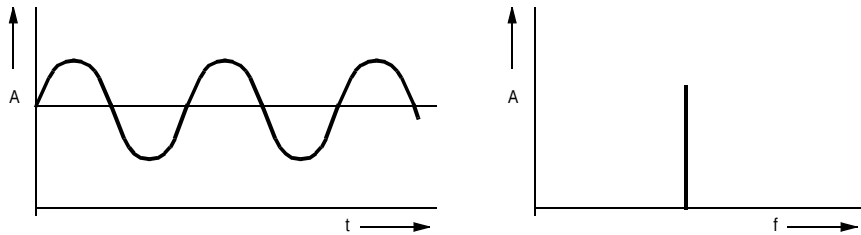
The disturbance variables and the interfering signals that result from them cover a wide frequency and amplitude range. They can occur in many curve forms and be put into many different classifications.

When referring to time, the occurrences are classified as periodical and non-periodic interference variables.

Periodic interference

Periodic interference consists of sinus formed signals. External sinus formed interference sources are radio and television transmitters and radiotelephony. In industrial applications, periodic interference is caused by alternating and rotating current components, power converters, fluorescent lamps, combinational circuit components and PCs. They create continuous distortion in supply voltage, voltage fluctuation, voltage drops and dissymmetry in rotary current supplies.

Periodical interference:



Non-periodic interferences - transients

Non-periodic interferences are short interfering pulses (Transients).

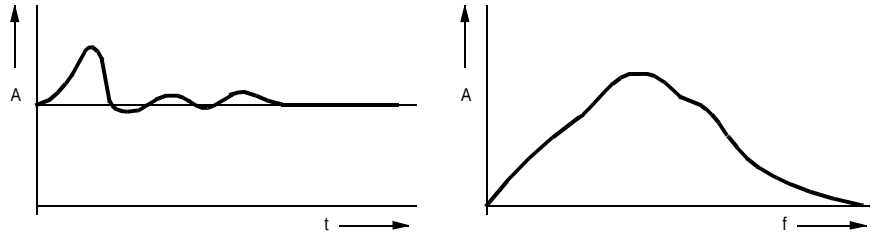
The characteristics of these transients are the rate of change voltage dU/dt and current di/dt fluctuations. In industrial networks, shut-off overvoltage can reach as high as 10 kV with rise time in the nsec. to sec. range and frequencies up to 100 MHz. The voltage increase speeds of these feared bursts lie between 2 and 5 kV/nsec with a pulse duration of 100 nsec to 1 msec.

Transient pulses are noticed especially in digital systems since they can disrupt functionality by setting or clearing memory locations (flags and registers).

Transients and bursts are normally caused by arc charges or switching functions in the following procedures:

- Normal switching and commutation events with high and low voltage switching devices, mainly through mechanical contacts
- Short circuits, voltage surge, lightning discharge

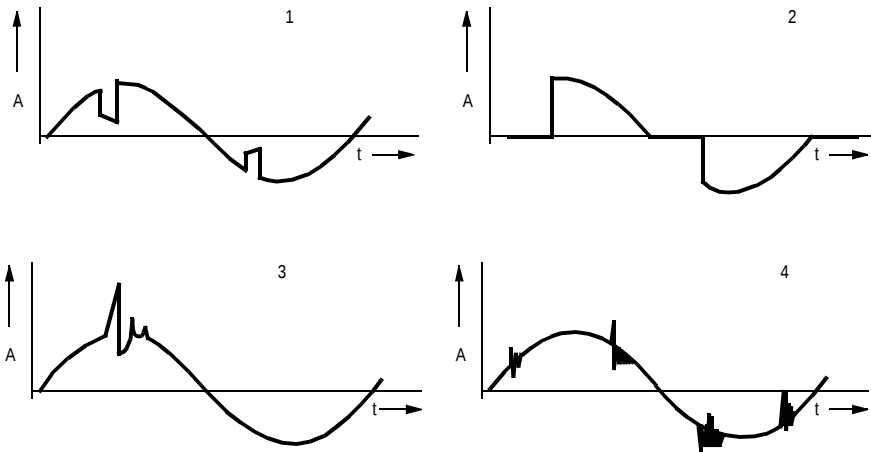
Non-periodical interference:



**Non-periodic
interference to
supply voltages**

Interfering voltages into the kV range can occur because of non-periodical interference to supply and data lines.

Various forms of interference in industrial networks:



- 1 Commutation drop
- 2 Phase controller
- 3 Transient processes
- 4 Burst

Effective Parameters

Interference parameter

Parameters for interference variables are:

- **Rise time:** as a measurement of the duration of the interference
 - **Rate of change** du/dt , di/dt : as a measurement of the intensity of the interference
 - **Peak value:** as a measurement of the energy of the interference
-

Causes of effective interference

Note: Causes of effective interference are **exclusively** amplitude variations in electrical parameters per time unit. The duration of the interference is identical to the duration of the change in the source of interference.

Frequency influence

The frequency spectrum of a disturbance variable is important because the inductive resistance and the capacitive resistance on a conductor depend on the frequency. The higher the frequency of the interference, the higher the interfering signal. Frequent interference signals cause a voltage drop on the inductive resistance of conductors which shows up as interference voltage. This causes a carrier flow on the line capacity that shows up as interference current.

Frequency spectrum of an interference pulse

To simplify matters, an interference pulse can be considered as a rectangular pulse form. This can be calculated as a sum of sinus functions. To recreate this pulse more precisely, i.e. the more slope that is defined for a pulse edge, the more frequent the required voltages must be.

4.2 Overlapping of Interference and Useful Signals on Wires

Overview

Introduction The structure of electrical circuits is important to the way that an interference signal disrupts the useful signals and how well that the interference signal can be separated from the useful signal.

 This section explains the terms symmetric and asymmetric electrical circuits and the common mode interference and the differential mode interference as the principal types of overlaying of interference and useful signals in electrical circuits.

 These basics are required in order to understand the EMC measures for balancing circuits.

What's in this Section?

This section contains the following topics:

Topic	Page
Symmetrically and Asymmetrically Operated Circuits	58
Differential Mode Interference	59
Common Mode Interference	60
Common Mode-Differential Mode-Conversion	62

Symmetrically and Asymmetrically Operated Circuits

Symmetrical circuits

The outgoing and return wires of the reference ground are separated in symmetrically operated circuits. The electrical circuit is connected with the reference ground with a third wire so that a symmetrical circuit makes up a three wire system. The useful signal flows to the device through the outgoing wire and back down the return.

Many interferences can be reduced with a symmetrical connection which is also quite often the reason that they are used.

Typical symmetrical circuit:

- Connections in measurement systems between sensors and electronics
 - Connections for symmetrical data connections (RS422 / V.11)
 - Telephone connections between participants and the central exchange
-

Asymmetrical circuits

In an asymmetrically operated circuit, the circuit is closed with the connection to the earth reference plane. The wanted signal flows to the device through a single wire and back down the earth reference plane.

Note: All connections run through coax cable are asymmetrical connections.

Differential mode and common mode interference

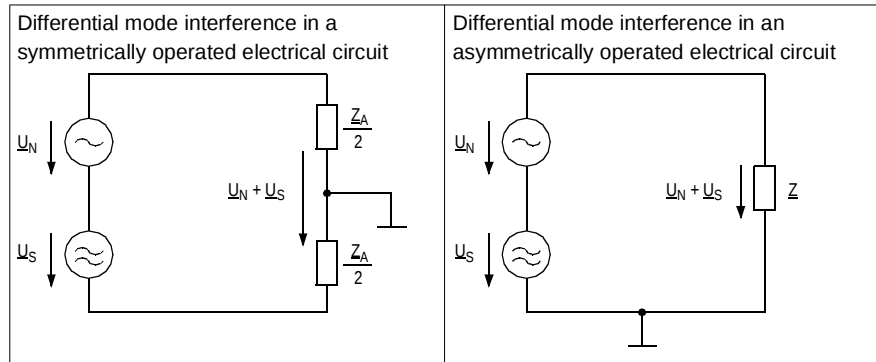
The useful signal is fed into the circuit in differential mode, i.e., the useful current flows in on the feed wire and out on the return wire or the earth reference plane. Interference can also be fed in as a differential mode signal. Interference can however also be fed in as a common mode signal. Common mode interference means that the interfering current flows in the same direction on both branches of the circuit and is returned on the earth reference plane. When the reference ground wire is not connected well, the interfering current caused by the common mode interference can be transmitted to other signal lines that are connected on the same device.

Differential Mode Interference

Differential mode interference

A differential mode interference is caused if an interfering voltage is coupled into one branch of a circuit only. A potential difference is then caused between the outgoing and return wires. Causes are currents in the outward and return conductors to the earth reference plane in opposite directions. The interfering circuit closes exclusively with a galvanic connection.

Circuit diagrams for a symmetrically and an asymmetrically operated electrical circuit with differential mode interference.



Character definitions

Character	Meaning
U_N	Wanted Voltage
U_S	Interference voltage
Z	Impedance (e.g. in measurement device)

Causes

Common mode interferences have many different causes and are coupled either inductive or capacitive:

- Switching frequency and the respective harmonic waves
- Oscillations that can be caused by capacitance or inductance of components or wiring arrangements (parasitic)
- Common mode-differential mode-conversions in unwanted asymmetries on the circuit

Separation of useful and interfering signals

Note: Useful signals and interference signals **cannot** be separated from one another in symmetrical or asymmetrical operations. Therefore, differential mode interference should be avoided.

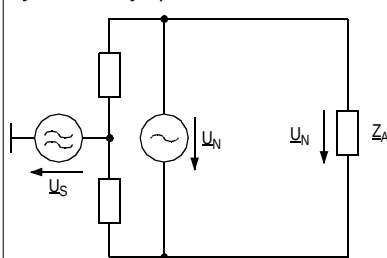
Common Mode Interference

Definition of common mode interference

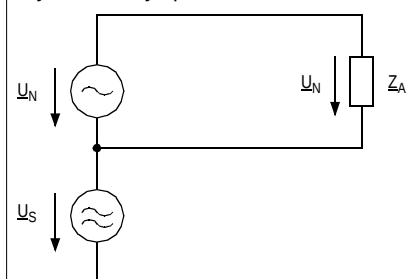
Common mode interference is caused if an interfering voltage is coupled into both branches of a circuit. This increases the potential in the outgoing and return lines. Common mode interference current flows in the same direction as everything else on these lines. The circuit closes with the earth reference plane or with unwanted capacities.

Circuit diagrams for a symmetrically and an asymmetrically operated electrical circuit with common mode interference.

Common mode interference in a symmetrically operated electrical circuit



Common mode interference in an asymmetrically operated electrical circuit



Character definitions

Character	Meaning
U_S	Interference voltage
U_N	Wanted Voltage
Z	Impedance (e.g. in measurement device)

Causes

Common mode interferences have many different causes and are coupled either inductive or capacitive:

- Inductive coupling if electromagnetic fields are found in the area between the symmetrical wire pair and the ground
 - The transmitter of a system sends a common mode signal to a neighboring wire pair which is coupled with other pairs as direct-axis voltage components
 - The switching transistor housing is either at operating voltage potential or at zero depending on the clock pulse; these voltage jumps are coupled to the heat sink and therefore earth reference plane with capacitance
-

Common mode-differential mode-conversion

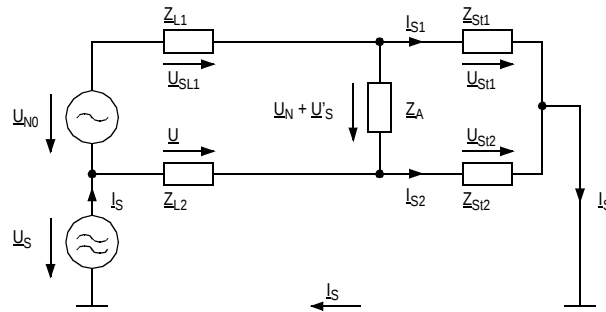
Normally, interference occurs in the form of linear or common mode voltage and only then causes an interfering differential mode signal because of insufficient symmetry. When the impedance of the lines is uneven or if stray capacities are found, a common mode-differential mode-conversion occurs. The asymmetrical ratios then create a differential voltage which is then carried with the useful signal.

As soon as anything asymmetric occurs a coupling of the interference source to the useful load occurs.

Common Mode-Differential Mode-Conversion

Common mode-differential mode-conversion

When the impedance of the lines is uneven or if stray capacitances are found, a common mode-differential mode-conversion occurs. The asymmetrical ratios then create a differential voltage which is then carried with the useful signal. Circuit diagram of common mode-differential mode-conversion with stray impedances Z_{St} between the circuit and reference ground as well as with different line impedances Z_L .



Character definitions

Character	Meaning
U_N	Useful voltage
U_S	Interference voltage at the source interference
U_S'	The signal voltage is overridden by the interference voltage; this part is brought about by the common mode-differential mode-conversion
Z	Impedance (e.g. in measurement device)
$Z_{L\ 1,2}$	Different line impedance in lines 1 and 2
$Z_{St\ 1,2}$	Stray impedances
I_S	Interference current
$I_{S1,2}$	Partial current in both branches of the electrical circuit

4.3 Interference Coupling

Overview

Introduction

Interference has various methods of coupling into the electrical equipment and spreading. The different coupling methods or coupling mechanisms are described in this section. You will also read about which parameters determine the size of the coupled interference signals. At the end of the section you will find a table overview indicating the measures to take for each type of coupling.

A sound knowledge of coupling mechanisms, the influential parameters and the proper basic solutions is necessary for understanding and selecting the proper EMC measures in an industrial application.

What's in this Section?

This section contains the following topics:

Topic	Page
Interference Coupling Mechanisms	64
Galvanic Coupling	66
Inductive Coupling	69
Capacitive Coupling	72
Radiating Coupling	75
Wave Influence	76
Which measures for which type of coupling?	77

Interference Coupling Mechanisms

Overview

To put the proper EMC measures to use during planning and in service, you need to know types, effects and methods of transfer of the coupled interference. This is the only way to effectively combat the problems.

Generally, the physical laws of energy transfer in electromagnetic fields apply for the coupling.

Methods of transfer

The interference can be transferred along a conductive wire (guided) or through space (unguided/radiated). Interferences are normally found together as line guided and radiated interference and are coupled to inputs, outputs, the power supply and data lines.

"Size" Wave lengths

If the wave lengths of the interference variables are greater than the characteristic measurements of the source and receiver, the transfer mechanisms for electrical and magnetic fields are monitored separately.

- Galvanic coupling with common impedances on the influential electrical circuits (source and receiver)
 - Inductive coupling with the common magnetic field of source and receiver (low pass field coupling)
 - Capacitive coupling with the electrical field between the source and receiver (low pass field coupling)
-

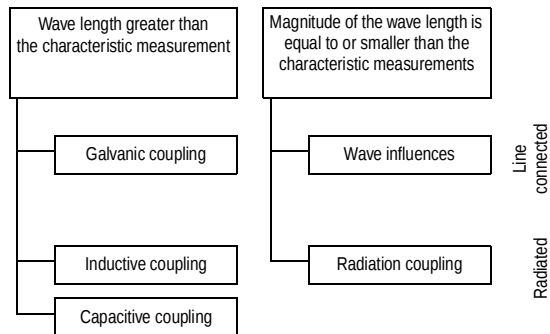
"Small" Wave lengths

If the wave lengths of the interference are the same or are less than the characteristic measurements of the source and receiver, a coupling over the electromagnetic field must be monitored. The following influential mechanisms play a part:

- Wave influence with wave activity on lines
 - Radiated coupling through space
-

Coupling mechanisms

Interference coupling occurs via the following mechanisms:



Galvanic Coupling

Mechanism

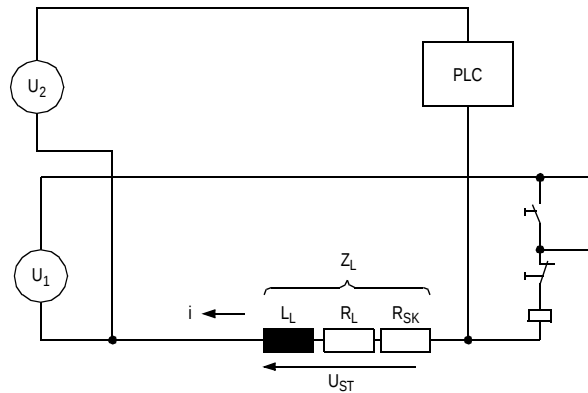
Galvanic coupling is a line guided coupling. This phenomenon occurs if shared line sections belong to different circuits. With every change in current in one of the circuits a voltage change is made on the common line so that the circuits influence each other.

Galvanic coupling typically occurs on the following circuits:

- Coupling of different circuits to the same power supply
- Coupling between operational circuits and grounding circuits (earth circuit coupling)
- Coupling different circuits with a common reference conductor system

Example

The following circuit diagram shows two circuits with a common reference conductor.



Character definitions

Character	Meaning
U_1	Voltage in circuit 1
U_2	Voltage in circuit 2
U_{St}	Interference voltage
Z_L	Impedance of the common line from circuits 1 and 2

When a circuit is wired as seen in the upper diagram then switching the contact in circuit 1 causes a voltage drop on the common line impedance Z_L . This voltage drop overrides the proper signal in circuit 2 as interference.

Size of the interference

The intensity of the interference is determined by the impedance of the common conductor and the size of the change in current.

Note: Especially highly frequent transient interference currents can cause extreme voltage drops.

Voltage drops on a common conductor with a change in current

$$U_{St} = R_L \times \Delta I + R_{SK}(f) \times \Delta I + L_L \times \frac{\Delta I}{\Delta t}$$

Character definitions

Character	Meaning
I	Current fluctuation
U_{St}	Interference voltage
L_L	Self inductivity on the common line (frequency dependent)
R_L	Actual resistance of the common conductor
R_{SK}	Additional resistance on the common conductor caused by skin-effect (frequency dependent)

Actual resistance R_L

The Ohmic DC resistance R_L is effective for currents with frequencies into the Kilohertz range. Utilizing a broad enough cross-section wire generally cures the problem.

Resistance with skin effect R_{SK}

The resistance increase caused by the skin-effect basically rises according to the following formula

$$R_{SK} = R_L \times K \times \sqrt{f}$$

Character definitions

Character	Meaning
K	Geometry factor (less with larger conductive surface)
f	Interference frequency

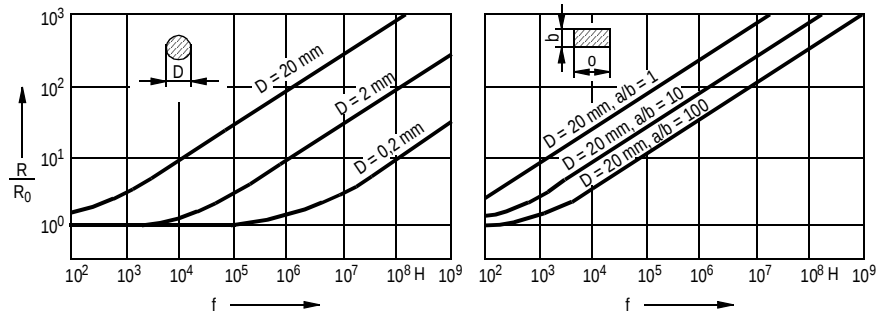
Line inductivity L_L

The self inductance L_L depends on the line geometry and the distance to the ground environment and can be reduced by a factor of 10 by a conductor with a broader surface area. With standard signal lines and wiring, it has approximately the value:

$$L_L \approx 1 \mu \times \frac{H}{m}$$

Influence of line geometry

The effects of line geometry on the frequency dependent effective resistance R are shown in the following diagram. The diagram on the left shows the dependence for a conductor with a round cross section and the one on the right shows the same for a conductor with a rectangular cross section.



R Effective resistance

R0 D.C. resistance

Note: The effective resistance and therefore the influence of high frequency interference currents can be reduced by using broader conductor surface area.

Inductive Coupling

Mechanism

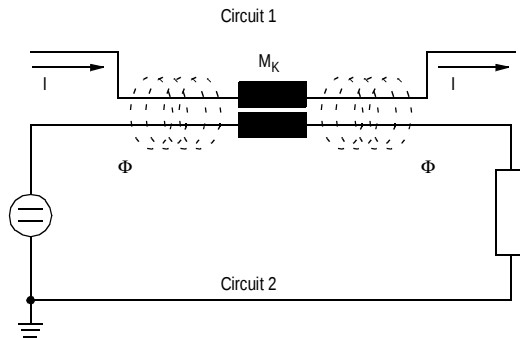
Inductive coupling - or sometimes known as transformer coupling - is a coupling via the magnetic field. This occurs between lines running parallel to one another. Current changes in a wire cause a fluctuation in the magnetic field. The resulting magnetic field lines affect parallel running wires and induce an interference voltage there. A current now flows which overrides the useful signal as an interference signal.

Inductive coupling is caused in parallel running lines in cables, wire harnesses and cable ducts.

Well known sources of interference are:

- Conductors and electrical equipment with high and fluctuating operational and interfering currents (short circuit currents)
- Lightning discharge currents
- Capacity switching
- Welding current generators

The following circuit diagram shows the construction of inductive coupling. Current changes in circuit 1, which are caused by switching large loads or those that are caused by a short circuit, are producing a fluctuation in the magnetic field.



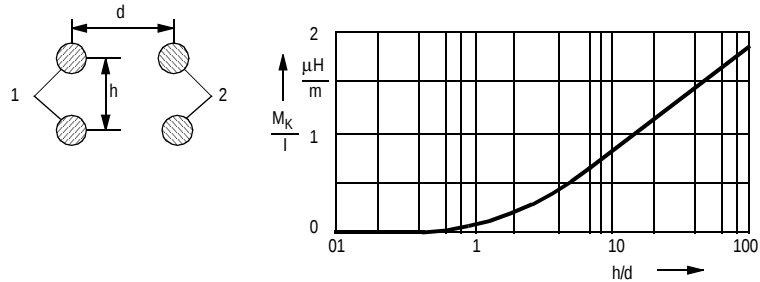
Size of the interference

The interference voltage caused by the inductive coupling depends on the coupling inductivity M_K between the two conductors and the current change time di/dt on the power line:

$$U_{St} = M_K \times \frac{di}{dt}$$

Coupling inductivity M_K

Coupling inductivity M_K is determined by the circuit arrangement. The coupling is at its largest if the circuits lie tight together as with a standard transformer.



1 Circuit 1

2 Circuit 2

h Distance between the outgoing and return lines of the circuit loop or between signal lines and the ground plane.

d Distance between the circuit loops (cable spacing)

l Distance that the lines run in parallel

Realistic example values for the coupling inductivity:

- **Tightly packed cable:** $h = 2 \text{ mm}$, $d = 4 \text{ mm}$
 $M_K = 80 \text{ nH/m}$
- **Cable spacing 10 cm:** $h = 2 \text{ mm}$, $d = 100 \text{ mm}$
 $M_K = 1.5 \text{ nH/m}$

Example: Cable spacing influence

The following calculation example for inductive coupling of two electric circuits shows the influence that cable spacing has on the amount of induced interference voltage: Increasing the space between cables from 4 mm (tightly packed cable) to 10 cm reduces the induced voltage in the disturbed circuit by 98 percent!

- Parallel cable length
 $l = 100\text{m}$
- Switching current in power cable
 $I = 100\text{A}$
- Duration of the current surge:
 $t = 10\mu\text{s}$

The induced voltage in the disturbed circuit depends on

Cable spacing d	Coupling inductivity M_K	Induced voltage in the disturbed circuit U_{St}
4 mm (cable tightly packed)	80 nH/m	80 V
10 cm	1.5 nH/m	1.5 V

Capacitive Coupling

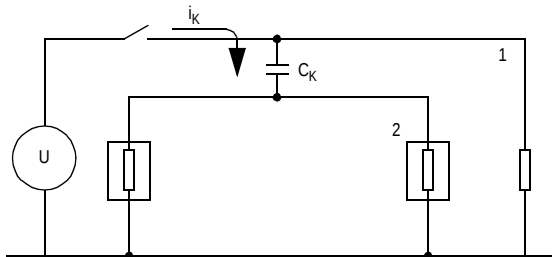
Mechanism

Capacitive coupling is a coupling via the electric field. It occurs between neighboring circuits - such as between high power current and signal lines. A fluctuating potential difference between the two circuits allows electrical current to flow through the insulation medium, air for example, that lies between them. The two lines that are lying next to one another can be considered as electrodes of a capacitor which is indicated by coupling capacity C_K .

Well known sources of interference are:

- Switching off power lines
- Inductivity switching
- Lightning discharges
- Electrostatic discharge

The following circuit diagram shows the construction of capacitive coupling. Circuit 1 indicates a high power line for example and circuit 2 an analog measurement line. When the high power line is switched off, the potential difference between the two neighboring lines is changed. Interference current i_K flows through the coupling capacity:



Character definitions:

Character	Meaning
1	Circuit 1: Interference source (high power cable for example)
2	Circuit 2: Susceptible equipment with impedance Z_2
C_K	Coupling capacity
i_K	Interference current flowing through the coupling capacity

Size of the interference

The amount of interference current I_{St} caused by capacitive coupling depends on coupling capacitance C_K between the two conductors and the duration of the change in voltage du/dt on the power cable.

$$I_{St} = C_K \times \frac{du}{dt}$$

The interference voltage created in the susceptible equipment (circuit 2) depends on:

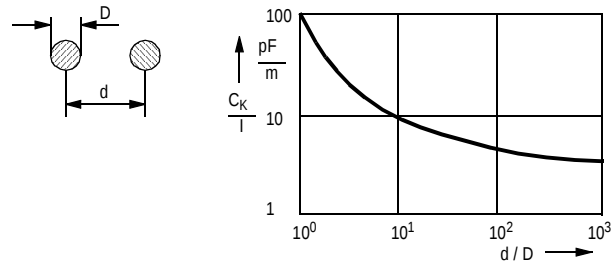
$$U_{St} = C_K \times Z_2 \times \frac{du}{dt}$$

Note: The interference voltage created in the susceptible equipment is proportional to the value of impedance in the susceptible equipment. And the impedance increases with the frequency of the interference signal. This results in the interrelationships.

- High impedance measurement transfer lines are more susceptible to interference than low impedance circuits.
- The interference current increases with the frequency of the voltage that exists in the interference capacity of the "connecting clamps".
- High coupling capacitances create a short circuit between the circuits that influence one another for HF interferences.

Coupling capacitance C_K

Coupling capacitance C_K increases linearly with the distance that the two lines run in parallel and decreases according to a algorithm with the increased cable spacing:



- I Distance that the lines run in parallel
- d Distance of the lines from one another
- D Line diameter

Realistic example values for coupling capacitance C_K with a line diameter of $d = 1$ mm:

- **Tightly packed cable:** C_K up to 100 pF/m
- **Cable spacing 10 cm:** $C_K =$ approx. 5 pF/m

Note: Starting with a distance of $D = 20$ cm, C_K only decreases minimally.

Radiating Coupling

Mechanism

When system components are excited by electromagnetic waves having wave lengths of the measurements of these components, energy is radiated and is transferred across the electromagnetic field to the receivers. Antennas which can be made of loops, dipoles or single ground lines act as susceptible equipment.

Well known sources of interference are:

- Insufficiently shielded high frequency devices
- Radio and television
- Fluorescent lamps
- walkie-talkies, cellular telephones

Size of the interference

The intensity of the excitement and radiation depends on the ratio between measurement and wave length. The amount of received voltage can be estimated at:

$$U_0 = E_0 \times h_{\text{eff}}$$

Character definitions

Character	Meaning
U_0	Received voltage in the susceptible equipment
E_0	Electrical field strength at the receiver
h_{eff}	Effective antenna height

Note:

- The radiating coupling becomes interesting with interference signal frequencies of 30 MHz and higher.
- The interference is at its strongest if the length of the "Antennas" are a multiple of the wave length.

Wave Influence

Mechanism

Wave influence is the combination of capacitive and inductive coupling of parallel lines, if the wave lengths of the signals are within their measurements, i.e. with highly frequent signals.

A progressive wave which creates an electric field and a magnetic field is now the source of interference.

Current and voltage distribution on the line depend among other things on the following values:

- Wave resistance of the line
- Termination resistance of the line

Reflection of the signal occurs on the line or at the end if the wave resistance at the join is changed or if the wave resistance and the termination resistance are not the same size. The reflections override the incoming wave.

Lines within the range of the wandering fields are susceptible equipment. The coupling between the individual lines is done via the respective partial wave resistances.

Size of the interference

The amount of coupled interference voltage depends on the impedances of the disturbed lines. References for ratio calculations have been developed in conductor theory.

Which measures for which type of coupling?

Measures

Depending on the type of spreading (coupling) of the interference, various measures can be taken to decrease or neutralize it. Explanations for the individual measures can be found in the next chapter:

	Galvanic coupling	Inductive coupling	Capacitive coupling	Radiation coupling	Wave influences
Grounding	X				
Electrical isolation	X				
Balancing circuits		X	X	X	
Transposition of outgoing and return lines		X	X	X	
Wiring arrangements		X	X	X	
Device arrangement		X	X	X	
Shielding		X	X	X	
Filtering	X	X	X	X	X
Cable selection	X				X
Wiring layout	X	X	X	X	X

Overview

Introduction Using knowledge about sources of interference and coupling mechanisms, we have the following possibilities to reduce electromagnetic effects:

- Take measures against sources of interference that reduce the transmission of disturbance
- Take measures to limit the spreading of disturbance

This chapter provides detailed descriptions about basic measures to take against sources of interference, and measures to lessen their expansion (coupling). You will need the information given in this chapter to understand EMC measures in a system and for EMC compatible design, and also to understand installation procedures.

A prerequisite for this chapter is knowledge about the types of sources of interference, the superposition of interference and useful signals and about coupling mechanisms.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
EMC Measures for Grounding Systems	80
EMC Compatible Wiring	83
Balancing Circuits	83
Transposition	83
Room Arrangements	84
Cabling Arrangements	84
Shielding	84
Filtering	86

EMC Measures for Grounding Systems

EMC functions of the grounding system

The grounding system has the following tasks with regard to EMC:

- Interference current dissipation
- Prevent couplings
- Maintaining shielding at specific potentials

The grounding system must fulfill these requirements without interfering with the device and wiring.

Note: Green-yellow equipment grounding conductors are not usually suitable for these tasks. Grounding conductors can only dissipate low-frequency signals (50 ...60 Hz), and do not guarantee equipotential bonding for high-frequency signals as their impedance is too high.

Effect of grounding

The galvanic coupling is affected by the ground connection. Disturbances can spread via the grounding system across the entire plant if the grounding system is poorly configured or bad connections are made.

EMC measures for grounding systems

The following EMC arrangements are available for grounding systems:

- Optimal selection and combination of grounding systems (point-to-point or meshed) if necessary
 - Meshed grounding: sufficiently small surface area of the loop between exposed conductive parts
 - Sufficient cross-section of the earth conductors low-resistance and low-inductance lines and therefore an effective equipotential bonding for low and high frequency signals
 - Good chassis connection to decrease the contact resistance
-

Types of grounding systems

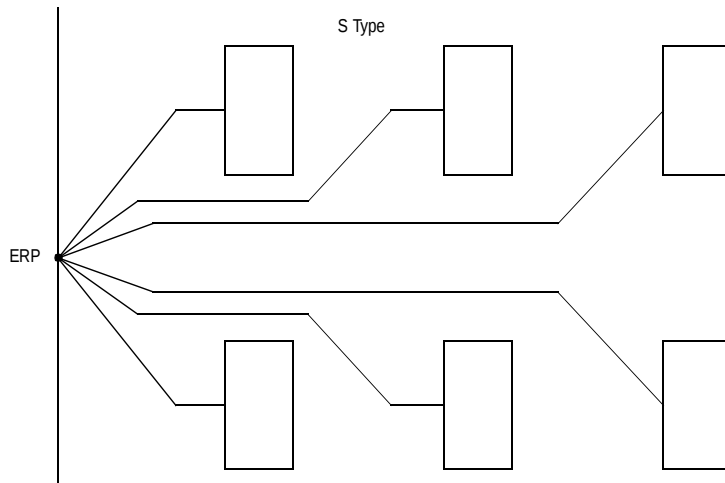
Two types of grounding systems are used:

- S Type: Point-to-point
- M Type: Grid-type

Large plants use both grounding types in combination as they have varying effectiveness depending on the application. The advantages and disadvantages of each system are described below.

S type grounding system

With point-to-point grounding of reference conductors, every reference conductor to be grounded in a circuit is only connected once to ground at a central point.
Point-to-point grounding system

**Advantages and disadvantages of point-to-point grounding**

Advantages of point-to-point grounding for reference conductors

- Reference conductors cannot be coupled and disturbance caused by induced voltages is not possible at low-frequencies
- At low-frequencies, no or only slightly different potential differences between ground and reference conductor can occur.

Disadvantages of point-to-point grounding for reference conductors

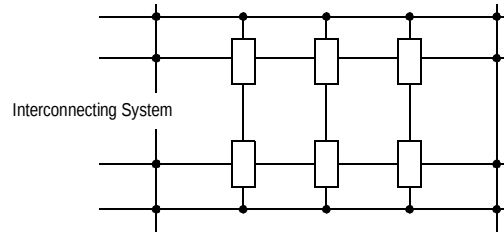
- A point-to-point grounding system can only be achieved at high cost due to additional isolation.
- High-frequency coupling are possible.
- Different conventional reference potentials can occur at high frequencies.
- Isolated arrangement of device chassis is required against the reference conductor.

**Grounding
system type M**

With grid type grounding, the reference conductors are connected multiple times to the chassis connection. This creates a perfectly meshed system.

The connections are arranged between the devices ground, cable runs, existing or under construction metal structures etc. Shielding, filtering devices return conductors, etc. are directly connected to this cable.

Grid-type grounding system



**Advantages and
disadvantages of
meshed
grounding**

Advantages of meshed grounding for reference conductors

- Lower potential difference for high-frequency disturbance within the grounding system
- No isolated arrangement of device chassis is required against the reference conductor.

Disadvantages of meshed grounding for reference conductors

- Galvanic couplings between different circuits via common impedance and currents is possible as a consequence of the induced voltage in the conductor loop.
-

EMC Compatible Wiring

Wiring rules	Electronic wiring must be done according to EMC compatibility. EMC measures include: • Balanced construction and balancing of unbalanced coupled interferences • Low input impedances • Limited working frequency bandwidth • Careful wiring arrangement • Correct chassis connections • Avoidance of internal couplings • EMC domain management of power supplies
---------------------	---

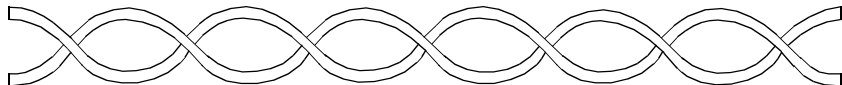
Balancing Circuits

Balancing	The purpose of balancing circuits is to convert unsymmetrical coupled interferences into symmetrical ones. Balanced interferences can therefore be suppressed by differential amplifiers. See also: <i>Overlapping of Interference and Useful Signals on Wires</i>, p. 57.
------------------	--

Wiring possibilities	The following wiring techniques can be used to balance circuits: • Additional resistors • Four conductor bundle • Twisting wires • Twisted
-----------------------------	---

Transposition

Transposition	The transposition of outgoing and return conductors is done to suppress disturbance by creating an inductive coupling in a circuit. Induced voltages in a successive conductor loops are 180° out of sync and neutralize each other.
----------------------	---



Transposition becomes more effective with increasing number of loops. A good figure is 30 loops per meter.

Room Arrangements

Room arrangements from an EMC point of view

Arranging components in a room with regard to EMC basically means that a specified minimum distance between components must be maintained to avoid capacitive, inductive and radiation coupling. This results in groupings of sources of interference and susceptible equipment in a complete system. The field configuration is the decisive factor for the distances required.

Cabling Arrangements

The role of cables in EMC

Cables are used to transfer useful signals. At the same time they can also be an interference source or pass on disturbance they have received. All forms of coupling play a role here.

Principle of cable categories

Cables used in a system are categorized according to the type of signals they carry. The signals EMC performance is the deciding criterion. You can roughly allocate cables into three categories or classes in an industrial environment:

- Sensitive signal
- Insensitive signal, low interference potential
- Signal is an active source of interference

Categorization allows cables with different EMC performance can be laid separately from each other.

There are the following options:

- Maintain distances between different categories
 - Shield cables of different categories from each other
-

Shielding

Use of shields

Shielding is required if susceptible equipment and sources of interference cannot be sufficiently distanced through room rearrangements.

Shield

A shield is a metal component that is placed between the source of interference and the susceptible equipment. It influences the distribution between source and the equipment. The coupling is minimized this way.

Shielding types

There are several different types of shield that can be used:

- Cable shield
- Chassis as shield
- Room shielding
- Partition panel as shield

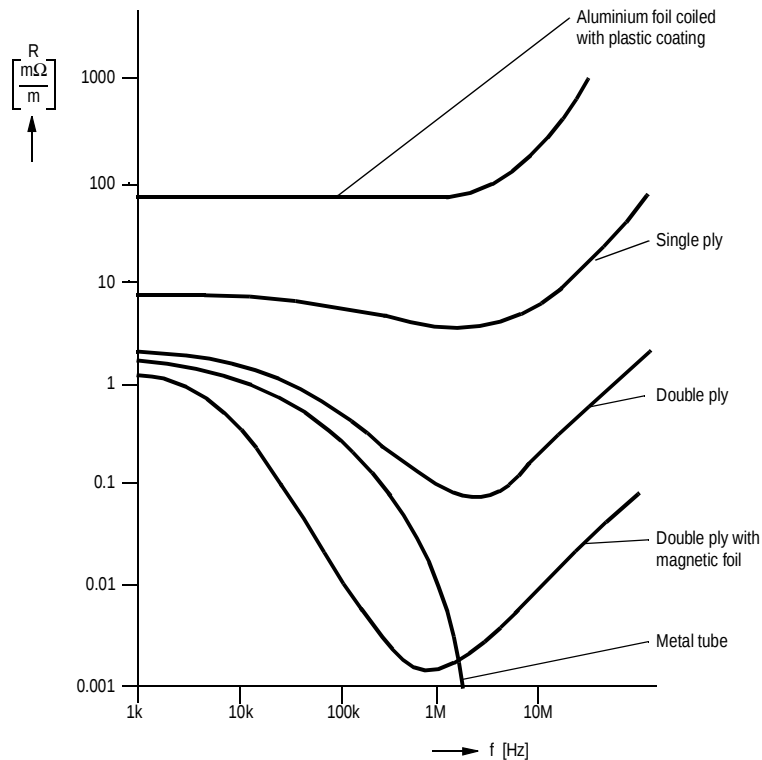
Shielding effectiveness

The effectiveness of the shield depends on its mutual impedance. The mutual impedance must be as small as possible in order to achieve good shielding effectiveness.

The smaller the mutual impedance is, the greater the leakage current can be.

Mutual impedance of different cable shields

The following diagram shows the mutual impedance of different cable shields depending on the frequency:



Shield grounding The shield is connected to ground to dissipate the currents. Sufficiently large cross sections are required for current dissipation since the current discharge can be very large with expanded plant systems.

Double shielding Shielding can be improved by using double shielding. The additional shield is connected to ground at a suitable point.

Driven shield Shielding can be improved by using a driven shield. This maintains the shield at the potential of the signal voltage.
You can achieve this for example, by back coupling a repeater output. This also means capacitive interference currents between the conductor and the internal shield are avoided.

Filtering

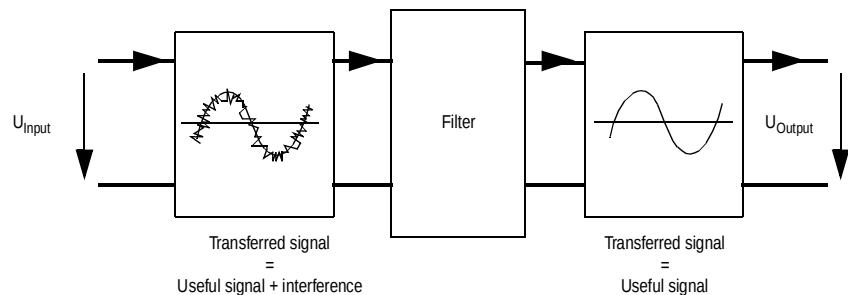
Filter A filter comprises components such as capacitors, chokes or ferrite cores and are integrated in a circuit.

Filters should only let useful signals through and suppress undesired parts of the transferred signal as much as possible.

Filters are used for different purposes:

- To protect the power supply network against interference through the devices
 - Protect devices from interference from the power supply network
 - Protect circuits against interferences from devices within the circuit
-

How filters work Useful signals and undesired signals are superposed at the filters input, only the useful signal is transferred to the output. The filtered out undesired signal is dissipated via the ground connection.



Filter types

There are the following filter types:

- Filter for common-mode interference
 - Filter for differential mode disturbance
 - Combined filter for differential and common-mode interferences
-

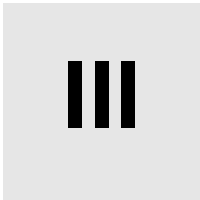
Ferrite cores

Ferrite cores are filters for high frequency common mode interferences. They are made from materials with high magnetic permeability.

Ferrite cores work on two principles:

- Inductivity against common interference currents
 - Absorption of the induced high frequency interference current using simultaneous energy release (warming up)
-

Earth and EMC Measures in Automation Systems - System Guidelines



Overview

Introduction This section contains guidelines for EMC and earth measures in automated systems. The measures are not product specific but generally apply to all modern systems and machines in which PLC systems are used.

What's in this Part? This part contains the following chapters:

Chapter	Chapter Name	Page
6	Measures for the Entire System	91
7	Grounding, Earthing and Lightning Protection System	95
8	Power Supply	115
9	Cabinets and Machines	119
10	Cabling	131

Measures for the Entire System

6

Overview

Introduction This sections contains guidelines for EMC measures that apply to the entire system in which PLCs are used.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Measures to take at Sources of Interference	92
Guidelines for Arranging Devices	92
Protection against Electrostatic Discharge	93

Measures to take at Sources of Interference

Measures to take at Sources of Interference

Measures can be taken against sources of interference to suppress or reduce the interference at its origin.

Measures can include the following:

- Suppressing switched inductive loads
 - Reducing the influence of electrostatic discharges
 - Avoiding influence of walkie talkies
 - Avoiding influence of low frequency magnetic fields
 - Avoiding influence of electron torches
-

Guidelines for Arranging Devices

Arrange devices in zones of differing disturbance climates

Zones of differing disturbances climates must be defined within the plant in which devices are arranged according to their sensitivity or potential for interference.

These include fundamentally different zones:

- Process
 - Control system
 - Data processing with computer work stations
-

PLC system

Separation of the PLC system is enabled by being installed in cabinets or on machine chassis. The guidelines for cabinet setups can be found in *Guidelines for Arranging the Device in the Cabinet or a Machine*, p. 120.

Process

The processing plant with interfering components forms its own zone.

Sensitive cables and devices for process data acquisition and control (that are always in this zone) must be shielded.

Strong interference affects high current equipment above all through their magnetic fields, such as:

- High current equipment in energy supply company systems
 - Melting in chemical plants
 - Transformers
 - Energy distribution from manufacturing plants
-

Computer work stations

Computer work stations should be placed in separate, shielded rooms that are equipped with close-mesh equipotential bonding in the floor, see *Guidelines for the Grounding System in Buildings*, p. 98.

In reality, it is often necessary to install computer work stations near the production line. Monitors near high current equipment can have such large problems with interference that work is no longer possible with them.

If the magnetic fields present exceed the values recommended for monitor use, counter measures must be taken such as:

- Increase the distance from the source of the interference
 - Shielding of the source of interference
 - Use of plasma monitors
 - Shielding of monitor screens
-

Protection against Electrostatic Discharge

How electrostatic charge and discharge works

Computers, central control and operating devices are often installed in rooms with insulated flooring. Dry weather and low relative humidity lead to high electrostatic charge on the operating personnel that can lead to damaging discharges on devices:

- If you wear rubber soled shoes when walking across an insulated carpet of another material (synthetics) an overcharge occurs on the soles of the shoes because two different insulated materials separate from each other.
 - Since the human body can be considered as conductive, an influence charge accumulates on the human body through the charged shoe soles, i.e. positive and negative charge carriers are separated. This charge accumulates with every step.
 - If metal objects or devices are now contacted, a discharge spark with a powerful current pulse is created, whereby the discharged energy is proportional to the square of the electrostatic charge.
-

Guidelines for protection against electrostatic discharges

Observe the following guidelines to avoid damage to operating equipment:

- Use conductive flooring with a contact resistance between 10^5 and 10^9 Ohm.
 - Do not treat smooth surfaces with wax, use anti-static cleaning products instead.
 - Spray carpets with anti-static conditioners.
 - Increase the relative humidity using a humidifier or air conditioning to a value above 50%.
-

Grounding, Earthing and Lightning Protection System

7

Overview

Introduction This sections contains guidelines for the configuration of grounding, earthing and lightning protection systems in a plant in which PLC systems are used.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Combination of Earthing, Grounding and Lightning Protection and Highest Safety Requirements	96
Guidelines for the Grounding System in Buildings	98
Guidelines for Local Grounding for Devices and Machines	100
Guidelines for Installing an Island Grounding System	101
Guidelines for the Earthing System and Grounding System	103
Guidelines for Lightning and Overvoltage Protection	106
Guidelines for Grounding and Earthing for Systems between Buildings	108
Guidelines for Creating Ground Connections	109

Combination of Earthing, Grounding and Lightning Protection and Highest Safety Requirements

Overview

The earthing, grounding and lightning protection systems in a building must be designed together as they are always combined with each other.

The tasks of the three systems are as follows:

- **Grounding system:** The grounding system is responsible for ensuring an equipotential surface for the plant. The connection of the grounding points with the earthing system means the grounding system has an important safety aspect.
 - **Earthing system:** The earthing system creates the electrical connection to earth that serves both as the equipotential bonding for the system and also for safety. Different safety and EMC requirements are required for the different system types TT, TN and IT systems.
 - **Lightning protection system:** The lightning protection system protects the plant and personnel against lightning strikes.
-

Highest safety regulations

The two following safety regulations must be observed when configuring the system:

- Personal injury must be avoided during normal operation and in the event of an error. This means it must be avoided that people can come into contact with components that carry dangerous voltages.

Dangerous voltages are:

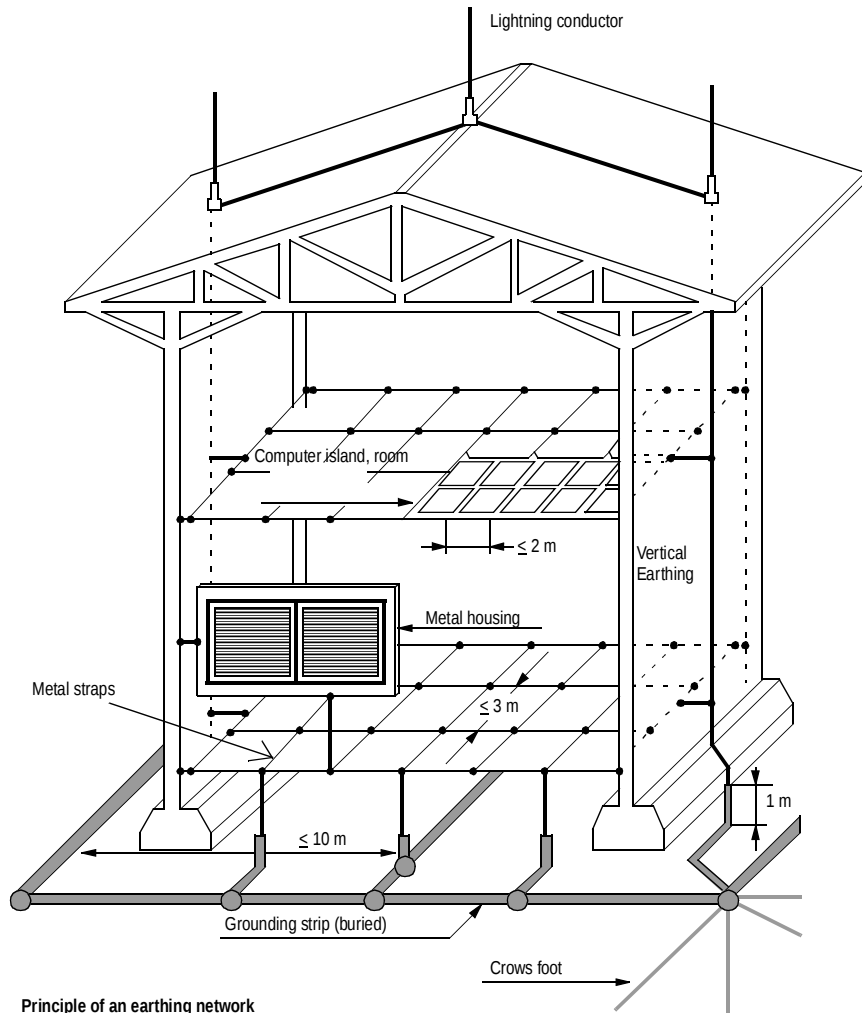
- A.C. voltage with a peak value of 42.4 V and higher
 - D.C. voltage of 60 V and higher.
 - In the event of differing safety and EMC requirements, the safety requirements must always have priority.
-

Safety before EMC!

Note: When configuring the earthing and grounding systems, always give safety requirements priority over EMC if the requirements are conflicting!

Configuration example

The illustration shows an overview of how earthing, grounding and lightning protection systems can be implemented in a building while taking EMC into consideration:



Guidelines for the Grounding System in Buildings

Grounding systems for expanded systems

We differentiate between a main grounding system that incorporates the entire plant and the local equipotential bonding for expanded systems:

- Main system grounding system: Grounding system that incorporates the entire building
 - Local grounding system: Grounding system on the local level (device, machine, cabinet)
-

Guidelines for a building grounding system

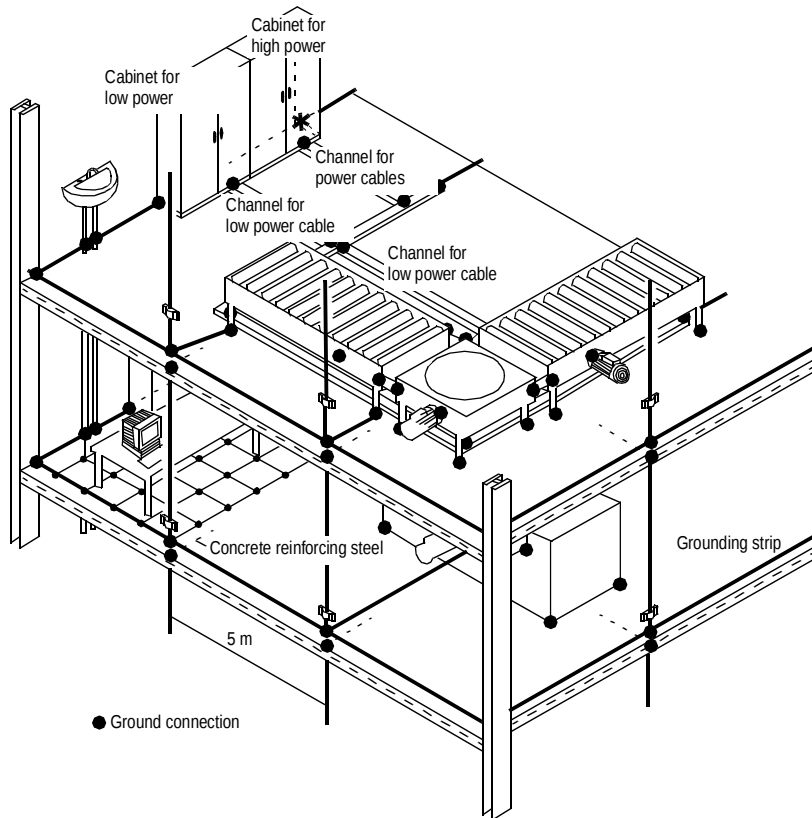
EMC guidelines must be followed for the main grounding system in an expanded system within a building:

- Each floor must have an earth plane as well as a surrounding grounding strip. This includes the following: welded, steel mats in the concrete bed, hollow floors with copper wire grids etc.
- The distance between earth conductors must be greater than the following values:
 - Production hall: 3 ... 5 m
 - Areas with computers and sensitive measuring devices: < 2 m
- All metallic structures within a building should be connected to the network.
 - Metallic framework
 - Concrete reinforcements welded together
 - Metal piping
 - Cable ducts
 - Conveyor belts
 - Metal door frames
 - Grids
 - ...

Note: Earth cables may not be longer than $10/(\text{frequency in MHz})$. Earth cables that are too long cause undefined potentials in the system, unavoidably lead to potential differences between devices and allow undesired currents.

Example: Earth plane in a building

The following illustration shows an example of EMC compatible installation of a grounding system in an industrial building



Guidelines for Local Grounding for Devices and Machines

Local grounding

In addition to the grounding system for the entire system, expanded systems in a plant must also be equipped with local grounding for devices and machines to ensure a good equipotential bonding. The local grounding systems are connected to the plant grounding system.

Guidelines for local grounding

The following guidelines should be observed to achieve a good local equipotential bonding:

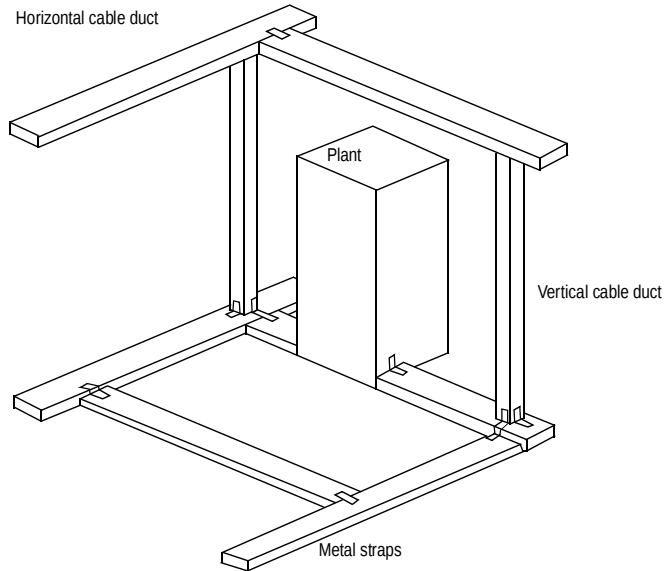
- An unbroken link (daisy chaining) should be made between all metal device and machine structures:
 - Switching cabinet
 - Earth plane plate on cabinet floor
 - Cable duct
 - Pipe and sheathed cable lines
 - Supporting components and metal chassis from machines, motors etc.
 - Special earth conductors may be required to complete the ground connection. Example: Both ends of a cable conductor which is not used are connected to ground.
 - The local ground connection must be connected to the main system network, whereby a maximum number of distributed ground connections should be made.
-

Guidelines for Installing an Island Grounding System

Definition: Island grounding system

A grounding system does not necessarily have to cover the entire building. In an industrial environment the electrical equipment is usually grouped into specific areas or islands.

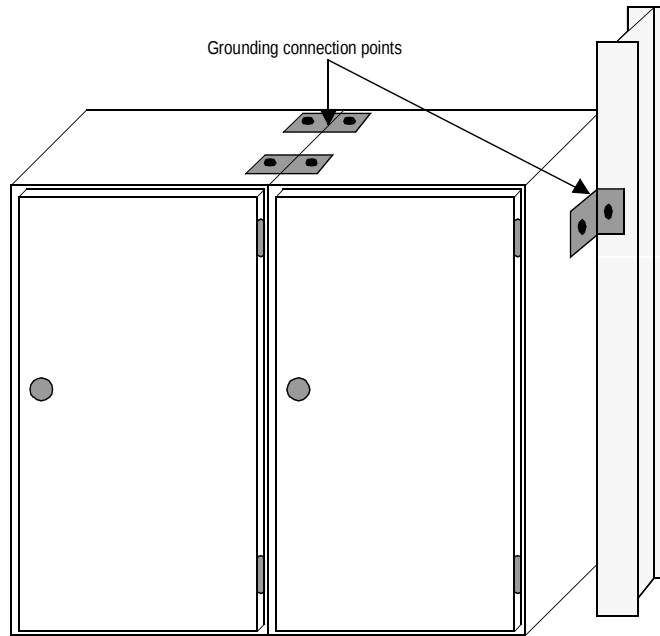
A grounding cell is created by daisy chaining the grounding points. This can be cabinets, machine chassis and metallic cable ducts:



Note: Sensor and actuator cables **outside of** these islands must shielded with great care!

Example of daisy chaining

Example: Two of more cabinets or machine chassis can be connected to an island by daisy chaining their grounding points.
Ground connections for cabinets and constructive components:



Guidelines and recommendations for island grounding systems

Recommendations for creating a grounding cell:

- An island may not be larger than 3 ... 5 m².
 - "Conductive" false floors can be used to create an effective island grounding system. For reasons of practicality only one of three supports needs to be connected. This gives you a cell of 1.80 m².
 - The connections can be made using copper rod, short, fat bolts or with grounding strips.
 - Where possible a direct positive fit contact should be made, for example, for the connection of metal cable ducts.
 - When two chassis or cabinets are installed side by side, they should be connected directly to each other at at least two points, i.e. above and below.
 - Ensure that paint or any other coating does not affect the electrical contact. The use of lock washers is recommended.
 - The grounding components (strips, bolts...) may not be longer than 50 cm.
-

Guidelines for the Earthing System and Grounding System

Scope of the grounding system

The grounding system for an electrical system creates the connection to earth and must meet the following requirements:

- Discharge the voltage from touchable metallic system parts (chassis) to protect people from electric shocks
- Discharge over-currents from direct lightning strikes to earth
- Discharge induced currents from atmospheric discharges between two points of a power transmission line to earth

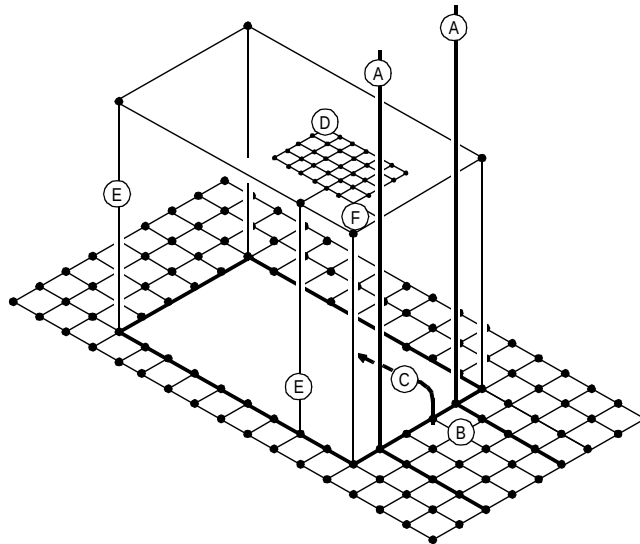
EMC performance and guidelines for the grounding system

System	EMC performance	Guidelines for use
TT	Conditionally suitable Between the ground connection of the primary distribution network and the leakage current from the electrical system, that are caused by ground faults within the system. As with transient currents, potential difference occurs due to the leakage current from devices. These transient currents can lead to faulty couplings or even faults within the system. A corrective measure here is a equipotential bonding conductor between the devices connected directly to earth. These measures basically convert the TT system into a TN-S system.	● ELCB for personnel safety is required ● Surge arresters should be installed (distributed over power transmission lines) ● This type of network requires corresponding measures for devices with high leakage current potential that are located behind the ELCB in the outgoing direction
TN-C TN-C-S	Bad Because the functions and protective earth conductor are combined in TN-C and TN-C-S systems, current feedback occurs on the PEN conductors during normal operation. Current feedback from devices via the PEN conductors can lead to faulty couplings.	● Ensure an unobstructed path for the PEN conductor when expanding the system! ● Because of the high current in the PEN conductor this system is not permitted in areas of particularly dangerous sources. ● If devices with high total harmonic distortion are operated in a system, this type of system is not recommended.

System	EMC performance	Guidelines for use
TN-S	Very good The TN-S system is the best solution from an EMC point of view. The PE conductors have no power in normal operation.	● Ensure an unobstructed path for the PE conductor when expanding the system! ● A 500 mA ELCB must be installed for protection against fire. ● Corresponding measures are required for devices with high leakage current potential that are located behind the ELCB in the outgoing direction.
IT	Bad Note: The IT system is recommended as intrinsically safe for safety matters since no electric arcs can occur.	● Ensure an unobstructed path for the PE conductor when expanding the system! ● Filters for asymmetric interference currents cannot be installed. ● Good EMC is only provided within systems (buildings) where all devices are connected to the same grounding device. ● If circumstances dictate that the system must be divided to limit the cable lengths and leakage currents

**Recommended
grounding
system
connection
scheme**

The following illustration shows a typical connection scheme for a grounding system:



- A** Lightning arrester down-lead
- B** Underground meshed earthing system with reinforcement at foot of the down-lead
- C** System ground connection, connected to the equipotential bonding strip, to which the PE conductor or PEN conductor are connected in turn
- D** Earthing system for a system section with integral metallic structures or additional ground connections (E)
- E** Interconnection between the lightning arrester down-lead and the earthing system as well as other metal structures in the vicinity

Note: A single, specifically laid ground connection is required for every electrical system and is in itself sufficient.

Guidelines for Lightning and Overvoltage Protection

Definition: External and internal lightning protection

We can make a differentiation between external and internal lightning protection for a building containing an electrical system:

- **External lightning protection:** External lightning protection is the installation of air terminations that discharge the lightning current to the earth via a suitable earthing system.
- **Internal lightning protection, overvoltage protection:** Internal lightning protection comprises measures taken against the effects of the lightning strike and its electrical and magnetic fields on metal installations and electrical systems. This means primarily the measures taken against equipotential bonding and overvoltage protection.

Guidelines for lightning protection

The following guidelines should be observed for lightning and overvoltage protection:

- The system should be divided into lightning protection zones with staggered protective measures, see table below.
- All conductive parts that enter a zone should be connected to one another and with equipotential bonding strip at the edges of the individual zones.
- The shielding for the zones should also be connected to these strips.
- In addition, a connection to equipotential bonding strips to higher and lower priority protection zones.

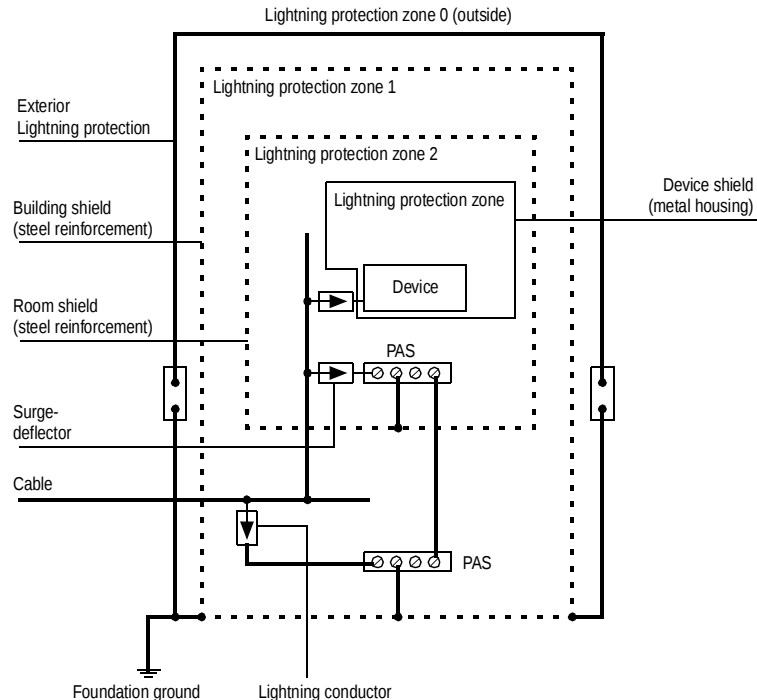
Note: All lines going in and out of the system to be protected must be connected to the earthing system directly via spark gaps or protective devices (lightning arrestors). In the event of a lightning strike the potential of the system struck increases temporarily but no dangerous potential difference occurs within the system.

Lightning protection zones

Dividing the system into lightning protection zones with staggered protective measures is done as follows:

Zone	Definition	Measures
0	All objects are exposed to a direct lightning strike.	External lightning protection via surge arresters and down-leads to the earthing system
1	The objects are not exposed to direct lightning strikes, the magnetic field dampened depending on the shielding present.	Building shield (steel reinforcement)
2 and additional zones ⁽¹⁾	The objects are not exposed to direct lightning strikes, the magnetic field is better dampened, dissipated currents are reduced further.	Room shield using steel mash mat Device shield (metal housing) Lightning conductor
1: If necessary, additional zones with further reduced currents and electromagnetic fields must be installed.		

The following illustration shows an example of the division of a building into lightning protection zones



Guidelines for Grounding and Earthing for Systems between Buildings

Problems that arise with systems that encompass more than one building

A system is not always accommodated within one building, but can stretch across two or more buildings. This means there are power and/or signal cables going from one building to another.

If both buildings have independent ground connections and grounding systems, it can lead to an interfering potential difference between the end points of a line running between buildings.

In the event of a lightning strike on one of the buildings this potential difference can become so high that destructive transient currents can be sent down the line. People and animals can also be endangered if parts of the buildings can be touched simultaneously.

Guidelines for grounding and earthing between buildings

When a system is installed across more than one building the following guidelines for grounding and earthing must be observed:

- Earthed parts that can be touched simultaneously must be connected to the same earth connection.
- A suitable potential compensation lead must be installed between the buildings grounding systems that is capable of dissipating transient currents caused by lightning strikes.

Note: All lines going in and out of the system to be protected must be connected to the earthing system directly via spark gaps or protective devices (lightning arrestors). In the event of a lightning strike the potential of the system struck increases temporarily but no dangerous potential difference occurs within the system.

Guidelines for Creating Ground Connections

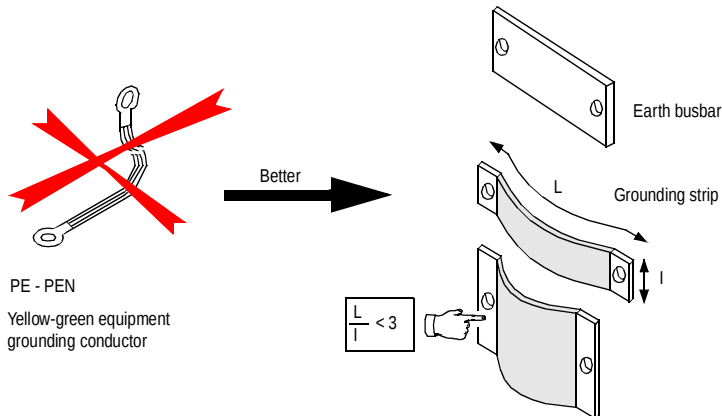
Guidelines for a good ground connection

The following guidelines should be followed when creating ground connections:

- Ground connections must be made with great care and the operating demands of the system must not be impaired.
- High contact resistance with the ground connection must be avoided by taking the following measures:
 - Galvanized mounting plates and fixing components must be used
 - Remove painted or coatings from contact points and protect from corrosion with electrically conductive special grease
 - Bolt on metal pieces directly, without additional electrical conductors, e.g. cable ducts
 - Daisy chaining of earth busbars and welded or bolted on grounding strips (instead of flexible grounding cables)

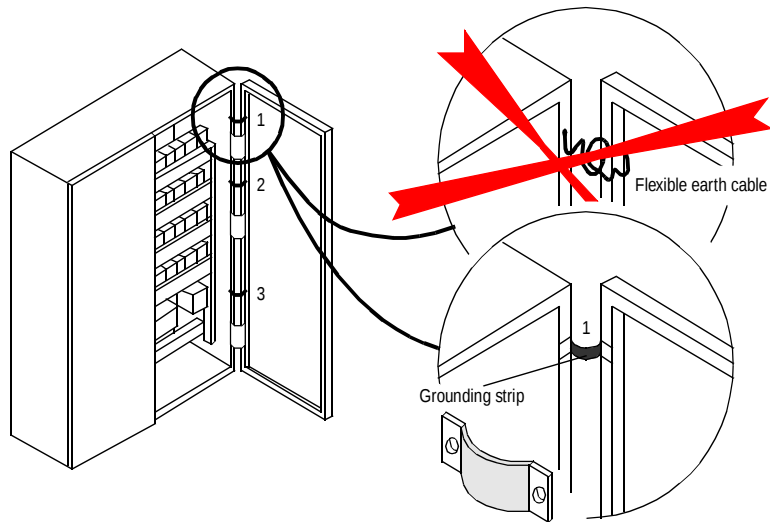
Install earth busbars, grounding strips

Daisy chaining of earth busbars and welded or bolted on grounding strips (instead of flexible grounding cables)



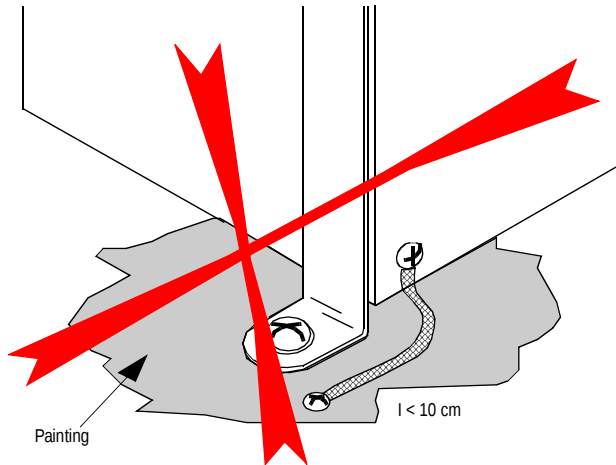
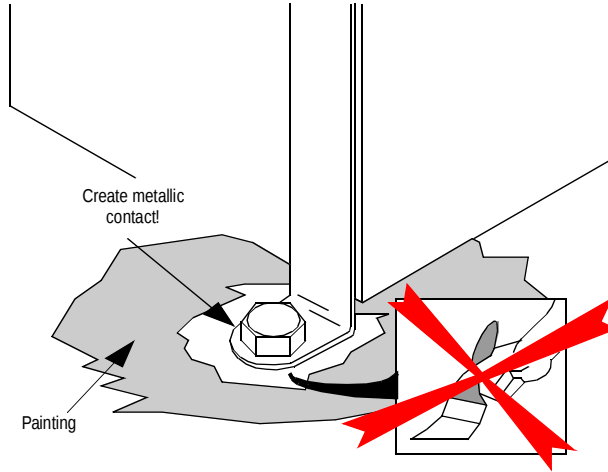
Example:
Cabinet door

Use grounding strips instead of a flexible earth cable for the connection between the cabinet door and the cabinet housing



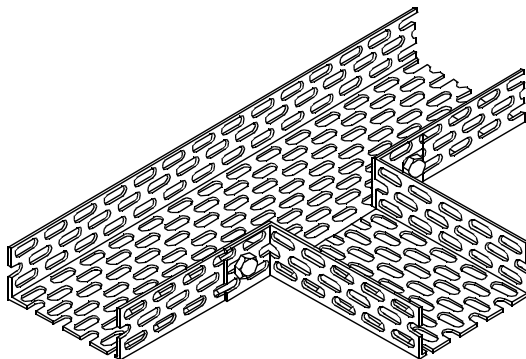
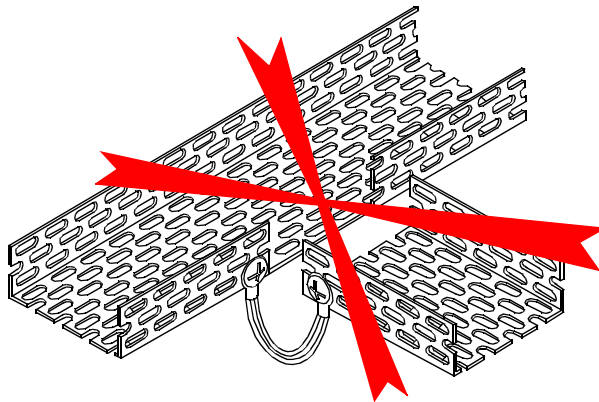
Remove all coatings

Remove painted or coatings from contact points and protect from corrosion with electrically conductive special grease



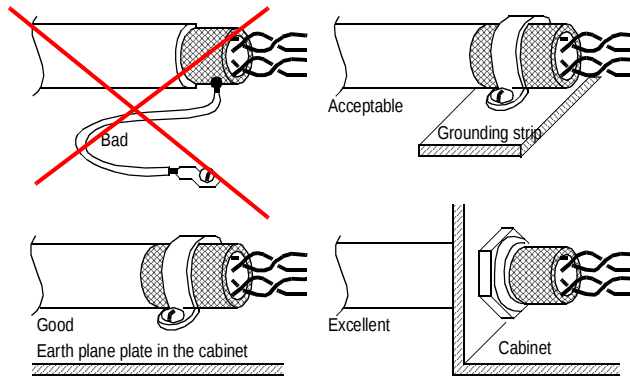
**Direct bonding
by bolted
fastening for
metallic parts**

Bolt on metal pieces directly, without additional electrical conductors, e.g. cable ducts



Ground connection for cable shields

The following illustration shows how to create a ground connection for cable shields.



Note: The ground connection for cable shields must always run through the entire cable.

Power Supply

8

Overview

Introduction This sections contains guidelines for the configuration and layout of the power supply for a system in which PLC systems are used.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
How to Plan the Power Supply Plant	116
Guidelines for the Power Supply	117

How to Plan the Power Supply Plant

Potential disturbances in the power supply network

The power supply network can itself be the source of continuous and intermittent interference. Disturbances in the power supply can already be present in open networks at the entry to the system. Further disturbances can be introduced by devices in the system that are connected to the power supply.

Procedure for meeting technical specifications

Proceed as follows to create the technical specifications for the power supply:

Step	Action
1	Categorize the potential upstream circuit disturbance (characteristics, strength, frequency).
2	Catalog the different devices to be powered as well as the types of disturbance created by them that can affect the functioning of the system.
3	Assess the effects of the disturbance on the system.
4	Evaluate the effects (are the consequences bearable?).
5	The evaluation of the effects of disturbances is then used to create the technical specifications for the power supply. This enables you to determine required properties of the electrical power supply to be installed.

Guidelines for the Power Supply

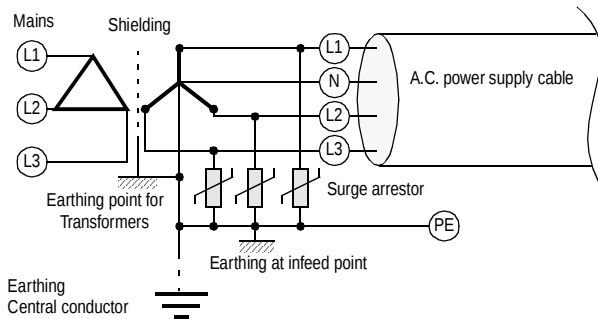
General guidelines

The following guidelines should be observed regarding the power supply:

- A surge limiter must be installed at the junction where the flex enters the building.
- Disturbances to the mains power are dampened by industrial line filters installed at the entrance to the system.
- Sensitive devices are protected by surge limiters and surge arresters at the input feed.
- Transformers can also be used as filters. For high frequency disturbances the transformer must be equipped with single, or preferably double, shielding.

Example: Solution for the power supply

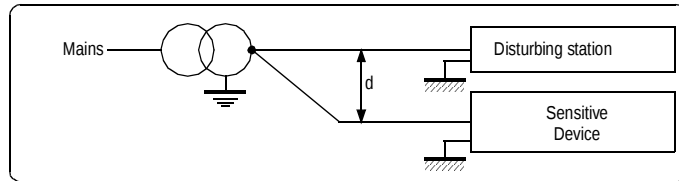
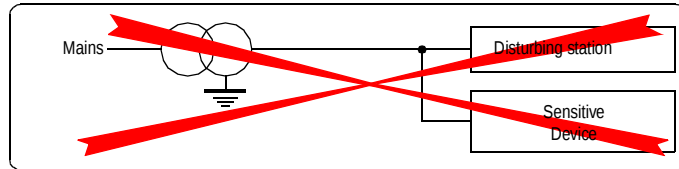
The following illustration shows an example of filtering the mains power by using a double isolated transformer:



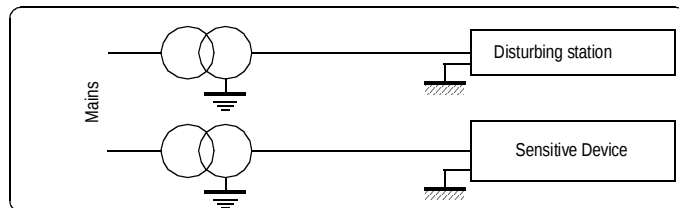
Note: A good ground connection is vital when installing transformers. The transformer housing must be bolted to a conductive earth plane.

Guidelines for partitioning in the system

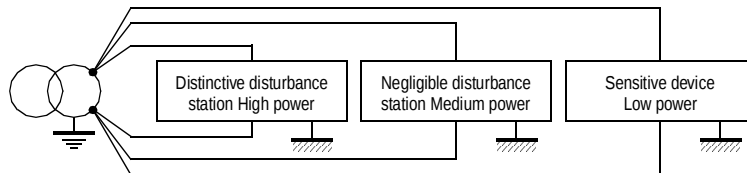
The power supplies for the individual devices should be wired as point-to-point from the line entry:



Separate power supplies must be provided if extremely sensitive and high interference devices are used concurrently in the same power supply system:



Devices with high inference capabilities must be connected as close as possible to the line entry and sensitive devices connected at a distance from the line entry:



Overview

Introduction This section contains guidelines for the setup of cabinets from an EMC point of view, and for the installation of specific components. Some of the guidelines are also applicable for machines that are equipped with PLC controllers, whereby the machine housing can be equated with cabinet housing.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Guidelines for Arranging the Device in the Cabinet or a Machine	120
Guidelines for Grounding and Earthing in the Cabinet	122
Guidelines for the Reference Conductor System in the Cabinet	125
Guidelines for Cabling in the Cabinet	126
Guidelines for Materials and Lighting in the Cabinet	127
Guidelines for Installing Filters in the Cabinet	128

Guidelines for Arranging the Device in the Cabinet or a Machine

EMC Domain

Sensitive and interfering electrical components and cables must be kept separate. This is possible by housing them in separate cabinets or by using shielded partition panels.

The cabinet must be divided into EMC domains:

- Areas of different interference levels (EMC domains) must be made in the cabinet. This means that sources of interference and susceptible equipment must be kept separate.
- The EMC domains must be decoupled.

Note: For machines:

NC controllers, PLCs and drives can be installed in a cabinet or machine housing under the following circumstances:

- The drive cable must be shielded.
- The guidelines for cabling must be observed, see *Cabling*, p. 131.

Isolation of Inductances

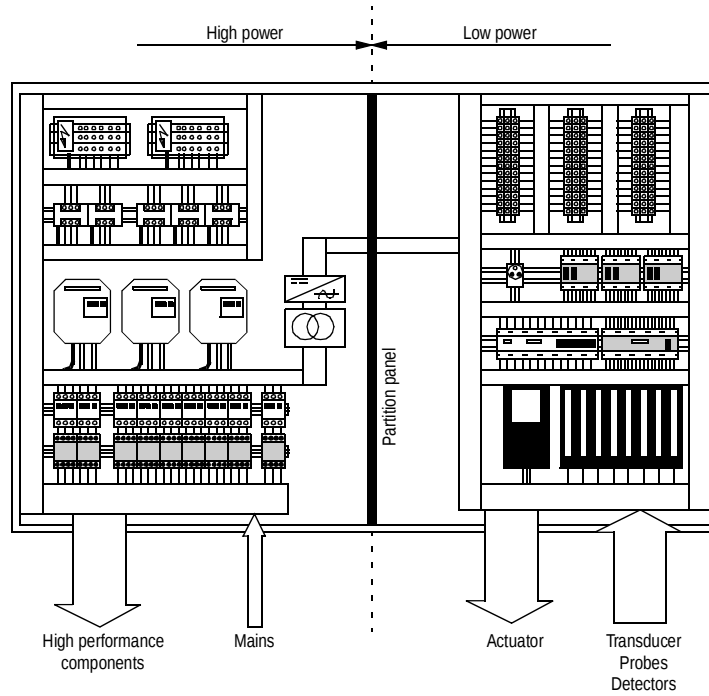
Isolation by using partition panels is necessary for the part of the cabinet where sources of inductance are mounted. The partition panel must have a good connection to the cabinet (ground).

Examples of such sources of inductance are:

- Transformers
 - Valves
 - Contactors
-

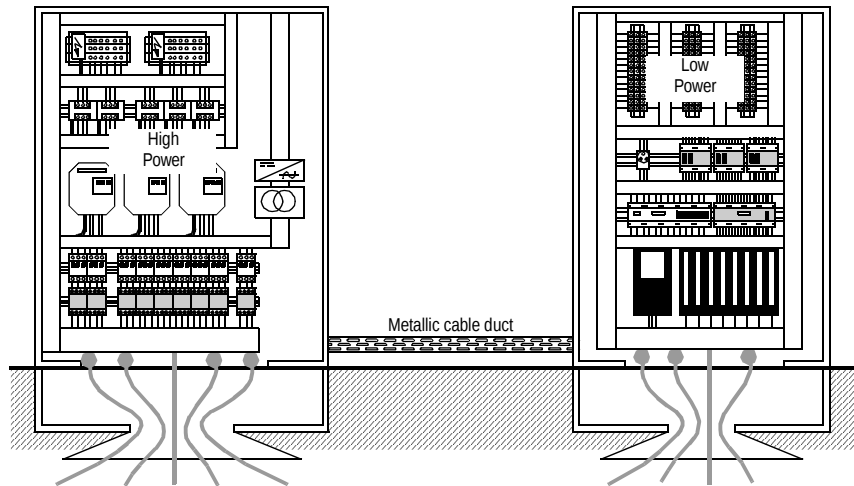
Example: EMC domains separated by partition panels

Example for setting up small cabinets: partitioning using partition panels that are connected to ground at several points, reduces interference influences



Solution: EMC domains in two cabinets

Example for setting up large cabinets: A separate cabinet is provided for the power and control sections; cable connections are made in a metal cable channel:



Guidelines for Grounding and Earthing in the Cabinet

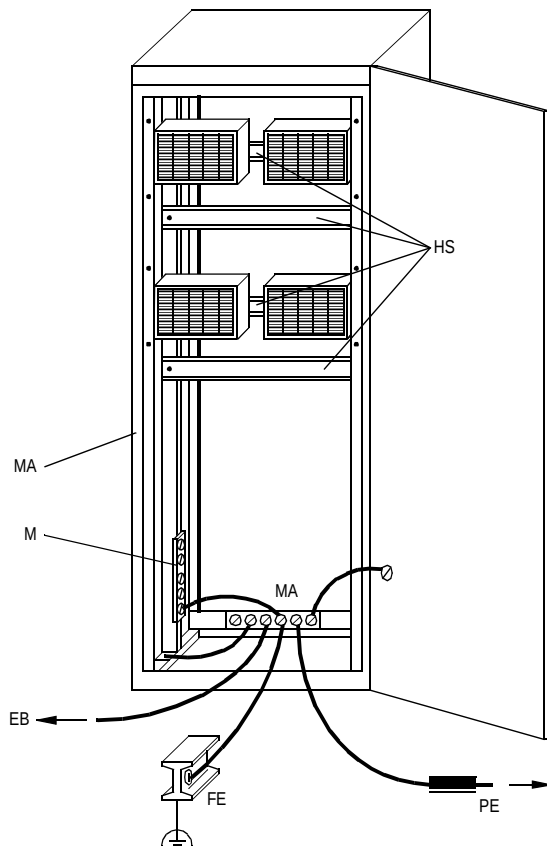
Guidelines for Earthing and Grounding in the Cabinet

The following guidelines should be observed when grounding a cabinet:

- An unpainted earth reference plane or rail must be installed on the floor of the cabinet for the conventional reference potential.
 - All metal parts of the cabinet are connected with each other.
 - The metal housing of the cabinet must be integrated in the higher level earthing system.
 - All protective grounding conductor must be earthed.
-

Constructing earth and ground in the cabinet

The following illustration shows how the earth and grounding system is constructed in the cabinet.



EB Adjacent cabinet or jig

FE The functional earth, e.g. the iron beam of the hall, water or heating supply pipes, or neutral earthing for the hall

HS Mounting rail for installing the module backplane or the installation accessories

M Reference conductor system or reference conductor rail (massive copper busbar or bridged terminal block)

MA Grounding (earth reference plane or rail) that is used as the functional earth

PE Protective earth PE, via protective earth choke

**Guidelines for
installing a
ground
connection in the
cabinet**

The following guidelines should be observed when installing a ground connection in a cabinet:

- An unpainted earth reference plane or rail must be installed on the floor of the cabinet for the common reference potential.
 - The sheet or metal grid that acts as the earth reference plane or rail is connected to the cabinets metal housing at several points that is integrated with the systems ground connection.
 - All electrical components (filters etc.) are bolted directly to this earth reference plane or rail.
 - All cables are fixed straight through this earth reference plane/rail.
 - The all-around contact of the cable shield is created using locknuts that are bolted straight through the earth reference plane/rail.
 - All these electrical connections should be made with utmost care to achieve a low resistance connection.
-

Guidelines for the Reference Conductor System in the Cabinet

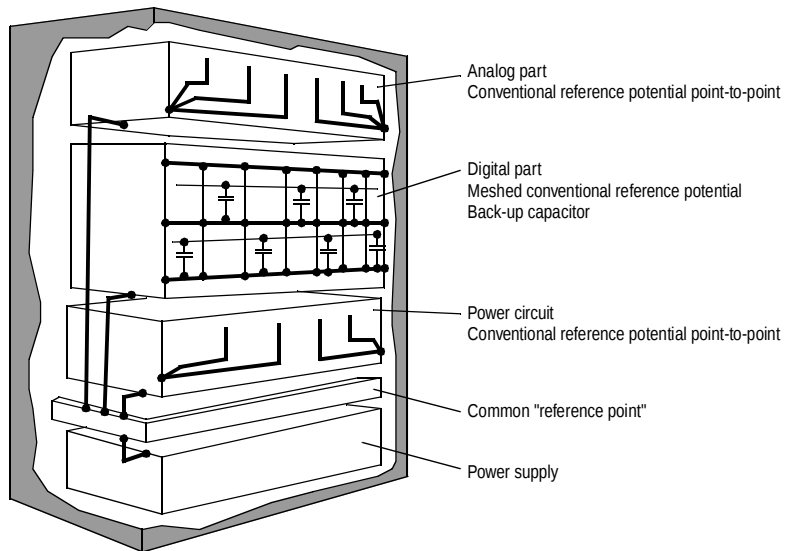
Reference conductor system

The cabinet contains different reference conductor systems that are connected to one another:

- An unpainted earth reference plane must be installed on the floor of the cabinet as the common reference potential.
- The reference conductor system for the following areas must be separated from one another:
 - Analog part (with point-to-point arranged reference conductors)
 - Digital part (with meshed reference conductors)
 - Power circuit (usually with point-to-point arranged reference conductors)
- The galvanic coupling for the reference conductor system must be minimized.

Example: Reference conductor system

Example of partitioning the reference conductor system and its galvanic isolation:



Guidelines for Cabling in the Cabinet

Guidelines for Cabling

The following guidelines apply when cabling the cabinet:

- As with external cabling, the cabling guidelines also apply to cables inside the cabinet, *Cabling*, p. 131.
- Conductive coupling between the interference current dissipation of filters and cable shields with the reference conductor system must be avoided.
- For analog process signals, shielded twisted outgoing and return conductors should be selected.

Guidelines for cable ducts in the cabinet

The following guidelines must be observed when running and combining cables in the cable ducts:

- 115/230 VAC mains and signal lines and 24/60 VDC signal lines must be laid in different cable ducts. The distance between the ducts must be at least 100 mm. Unavoidable crossing must be at right angles.
- Digital signal lines (24/50 VDC) may be unshielded in a common cable channel.
- The following cables can be combined in a cable duct:
 - Shielded bus cable
 - Shielded analog process signal cable
 - Unshielded 24/60 VDC signal lines

Guidelines for installing cables

The following guidelines should be observed when installing cables in cabinets:

- The selection of the housing lead through must be made very carefully as this ensures connection with the earthing system.
- Interfering cables must be filtered before entering the cabinet.

Guidelines for filters

The following guidelines should be observed when using filters:

- The filter must have a good conductive ground connection.
- The filters input line may not be laid together with the filters output line or with other signal and supply lines.
- When mounting the filter near a cable entrance (distance from floor or wall < 100 mm), the line to the filter is only twisted.
- When mounting a filter further than 100 mm away from the cable entrance, the line through the cabinet must be twisted and shielded.

Guidelines for Materials and Lighting in the Cabinet

Guidelines for materials

Suitable metal combinations must be used to ensure a long term highly conductive connection between the metal parts that form the cabinet:

The metals to be connected should be selected according to the electro-chemical series of metals, to reduce the potential differences to a maximum of 0.5 V. This also applies when selecting the connection components such as screws, stay washers, rivets etc).

Guidelines for Lighting

Fluorescent tubes may not be used in series to light cabinets.

The following lights can be used:

- Light bulbs
 - Energy saving lamps
 - Fluorescent tubes with electronic starters
-

Guidelines for Installing Filters in the Cabinet

Installation guidelines for filters

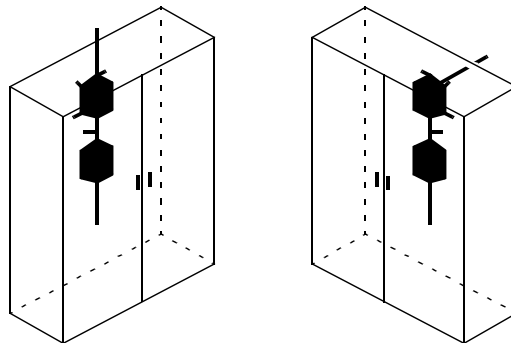
The following guidelines should be observed when installing filters in a cabinet:

- Filter should be installed directly to the cable input in the cabinet if possible.
- Filters are screwed directly to the unpainted wall or to the earth reference plane on the base of the cabinet.
- The filters input and output leads may **not** be installed in parallel.
- The filters cable must be wired directly across the cabinet wall or floor.

Note: Pay attention to leakage current from the filter! Special safety measures must be taken for leakage currents above AC 3.5 mA/DC 10 mA. Refer to the standards that apply in your country.

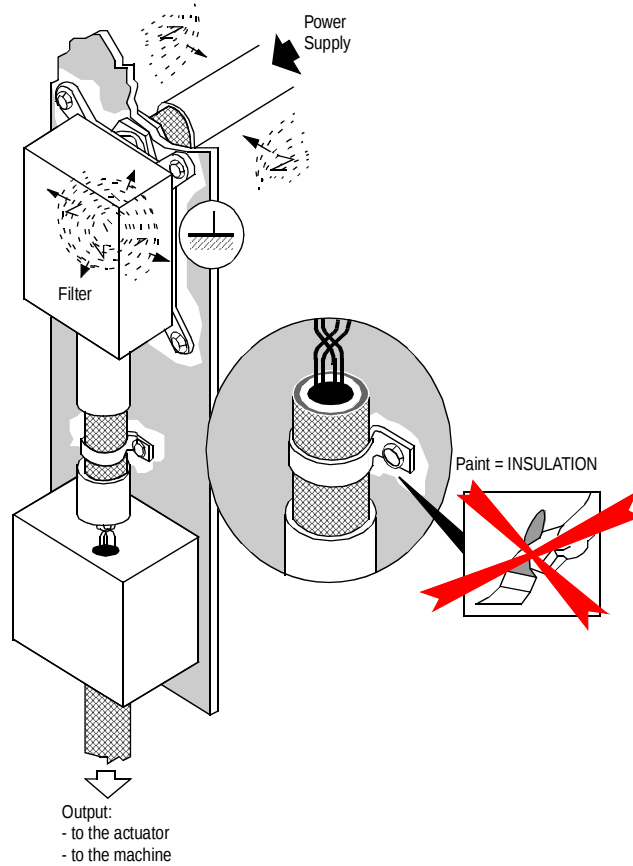
Example: Excellent Installation Locations

The following illustration shows two good solutions for installing a filter in a cabinet:



**Example:
Excellent
Installation**

The following illustration shows an excellent filter installation:



Overview

Introduction This sections contains guidelines for cabling systems in which PLC systems are used.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Classification of Signals according to their EMC Performance	132
Guidelines for Selecting Cables	133
Guidelines for Combining Signals in Cables, Conductor Bundles and Connectors	134
Guidelines for Laying Cables in Parallel and Crossing Cables	135
Guidelines for Creating the Ground Connection for Cable Shielding	136
Guidelines for Grounding Unused Conductors	139
Guidelines for Installing Cables	139
Guidelines for Cable Ducts	141
Guidelines for Cables between Buildings	144

Classification of Signals according to their EMC Performance

Reasons for the classification

In an industrial environment, signals are classified in four categories according to their EMC performance. This classification is required for the application of cabling rules.

Classification of signals

The following table shows the classification of signals according to their EMC performance:

Classification	EMC performance	Example of a circuit or device with cables in this class
Class 1 Sensitive	Signal is very sensitive.	● Low level circuits with analog output, instrument transformer ... ● Measuring circuit (probes, instrument transformer ...)
Class 2 Slightly sensitive	Signal is sensitive. Can disturb class 1 cables.	● Low-level digital circuits (bus ...) ● Low-level circuits with digital output, (instrument transformer ...) ● Control circuit for resistive load ● Low-level d.c. power supplies
Class 3 Slightly interfering	Signal disturbs class 1 and 2 cables	● Control circuit for inductive loads (relay, contactor, coils, inverters ...) with corresponding protection ● A.C. power supplies ● Main power supplies for high power devices
Class 4 Interfering	Signal disturbs other classes signals	● Welding machine ● Power circuits in general ● Electronic speed controller, switching power supplies ...

Guidelines for Selecting Cables

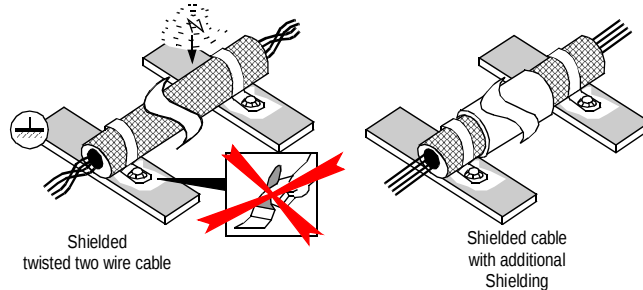
Guidelines for Selecting Cables

The following guidelines should be observed when selecting cables for use in an industrial environment:

- Use cables with twisted outgoing and return conductors.
- For analog signals, cables with shielded out and return conductors and braided shields should be used.
Use cables with double shielding for analog process signals outside of buildings.
- For high frequency radiated interference (5-30 Mhz), use cables with braided shields.
- Use shielded cables for interfering signals (class 4); additional shielding by installing cables through metal tubes or metal cable channels.

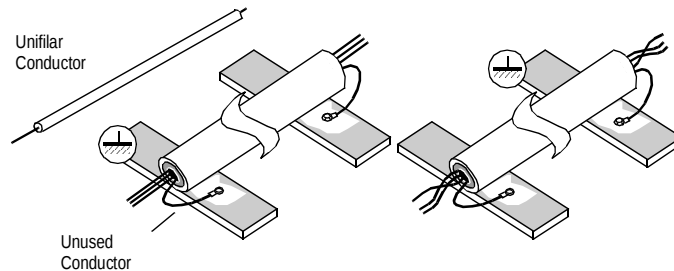
Example for class 1 signals

Example for the implementation of cables for class 1 signals (sensitive)



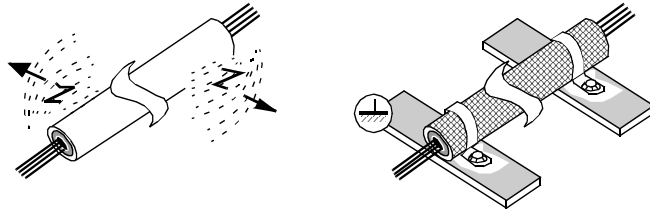
Example for class 2 signals

Example for the implementation of cables for class 2 signals (slightly sensitive):



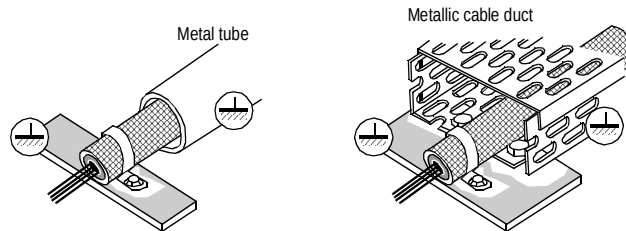
**Example for
class 3 signals**

Example for the implementation of cables for class 3 signals (slightly interfering):



**Example for
class 4 signals**

Example for the implementation of cables for class 4 signals (interfering):



**Guidelines for Combining Signals in Cables, Conductor Bundles
and Connectors**

**Combination of
signals in cables
and conductor
bundles**

Only signals of the same class may be combined in a cable or conductor bundle.

**Combination of
signals in
connectors**

The same connector may not be used for signals from different classes. Analog and digital signals can be combined in a connector if a row of pins with 0 V connections is present between them.

Guidelines for Laying Cables in Parallel and Crossing Cables

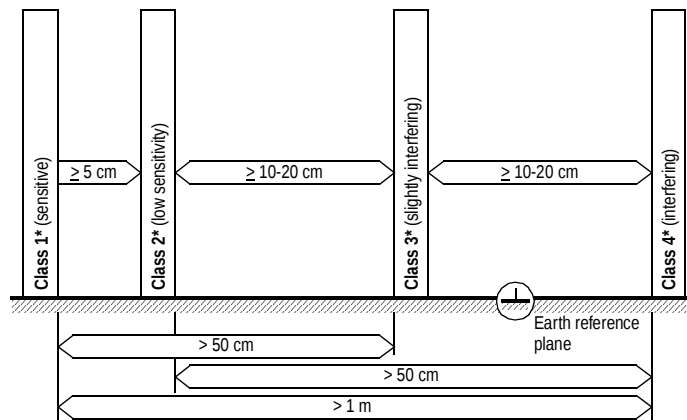
Guidelines for Parallel Cabling

The following guidelines should be observed for parallel cabling with signals of different classes:

- Unshielded cables with signals from different classes should only be installed over the shortest distance possible.
- Parallel cabling of unshielded cables with signals from different classes should be installed with the largest possible working clearance.
- Shielded cables should be used if cables with different signal classes are to be installed in parallel over distances of more than 30 m, or if the working clearance can not be guaranteed.

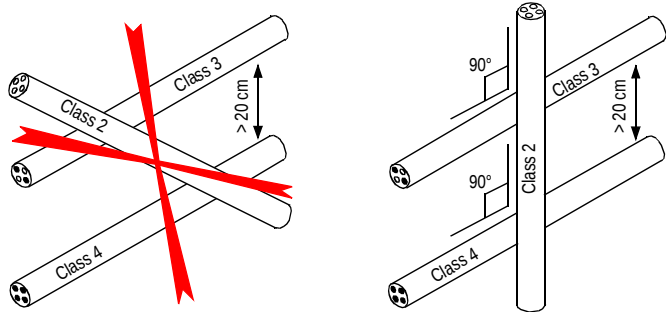
Recommended working clearances

The following illustration shows the recommended working distances between shielded cables with signals from different classes for parallel installation up to 30 m. The longer the distance for the parallel cabling, the greater the working distance to be selected.



Guidelines for crossing cables

Cables that carry different class signals must cross at right angles.



Guidelines for Creating the Ground Connection for Cable Shielding

Guidelines for selecting the method of connection

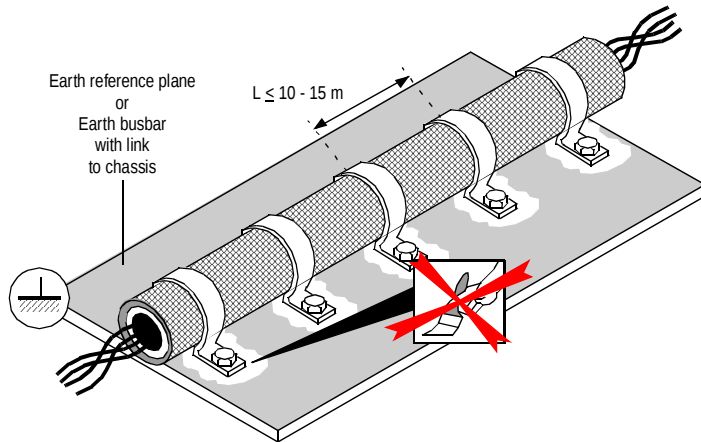
Note: Always avoid cable shielding without a ground connection. This type of connection is practically useless from an EMC point of view and cannot be permitted for safety reasons if contact protection is not provided.

The table shows how the cable shield should be connected to ground depending on the application:

Application	Cable shield ground connection
Shielded analog measuring circuit in the cabinet	● Ground connections are usually found on one side of the cabinet outlet ● Both ends of the cable shielding ground for extreme levels of disturbance
Shielded analog measuring circuits outside of cabinets in closed buildings	● If only capacitive electrical interference is to be reckoned with: single cable shielding ground connection ● If the signal line is setup with high-frequency influences: double sided cable shielding ground connection ● If the signal line is long: in addition to double ground connections along the cable length, further ground connections at intervals from 10 ... 15 m

Long lines

For long shielded lines, several ground connections at intervals of 10 ... 15 m along the length of the cable are recommended:



**Characteristics
of the connection
methods**

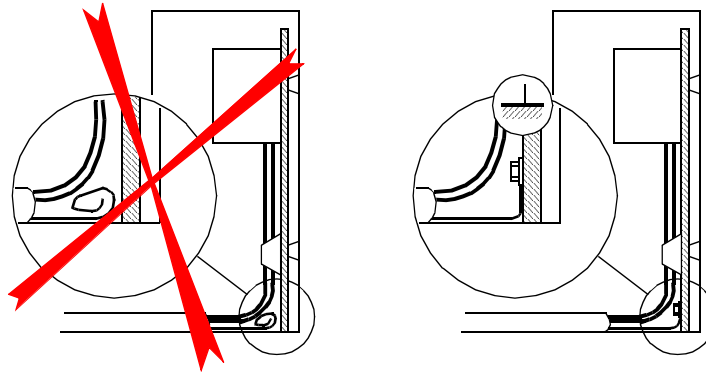
The shielding ground connection is very important for the shielding effectiveness. The following ground connection options have differing effectiveness:

Cable shield ground connection	Effectiveness and advantages	Restrictions
Ground connection on both ends of the cable Extremely effective	• Very effective against external disturbances (high and low-frequency) • Very good shielding effectiveness also against resonance frequency on the cable • No potential difference between cable and ground • Enables common laying of cables that feed different class signals • Very good suppression of high-frequency disturbances	• Ground-fault current can be induced in high-frequency signals with high interference-field strength for long cables (>50 m).
Ground connection on only one end of the cable Average shielding effectiveness	• Enables protection of isolated lines (instrument transformer, ...) against low-frequency electric fields • Enables buzz to be avoided (= low-frequency disturbance)	• Ineffective against external disturbances caused by high-frequency electric fields • The shielding can cause resonance due to the antenna effect. This means the disturbance is greater than when shielding is present! • Potential difference between the shielding and the ground connection at the unearthed end; danger in the event of contact!
Shielding without ground connection Not recommended	• Limits the capacitive coupling	• Ineffective against external disturbances (all frequencies) • Ineffective against magnetic fields • Potential difference between the shielding and the ground connection; Danger in the event of contact!

Guidelines for Grounding Unused Conductors

Guidelines for unused conductors

Free or unused cable conductors must be connected to ground at both ends. The following illustration shows how unused conductors can be connected to ground.

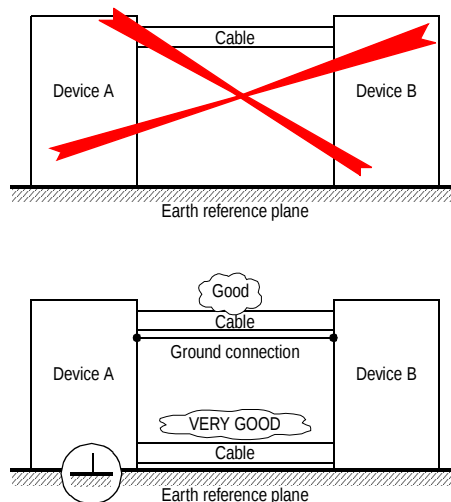


Guidelines for Installing Cables

Avoiding loops between exposed conductive parts

To avoid loop between exposed conductive parts all cables must be installed near ground connections or ground cables.

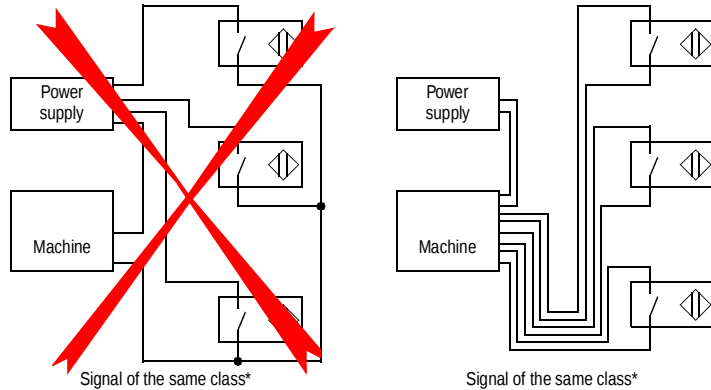
The illustration shows an example of how cables are installed near ground connections:



Installing outgoing and return conductors next to each other

Outgoing and return conductors must always be installed close to each other. The smallest possible intervals are guaranteed across the total run length by using 2-wire twisted wire cables.

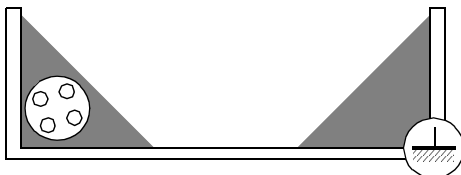
The illustration shows how out and return conductors are installed closely next to each other. Parallel installation is only possible for signals of the same class.



Guidelines for Cable Ducts

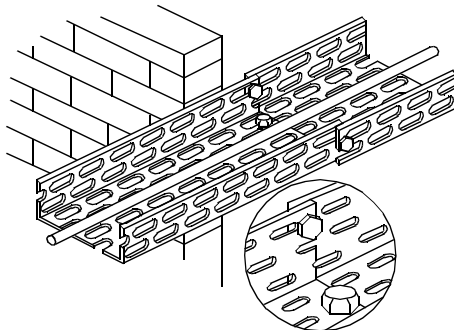
Guidelines for arranging the cables in cable channels

Sensitive cables (classes 1 and 2) must be installed in the corners of the cable duct:



Guidelines for connecting cable ducts

Connecting cable ducts must be carried out when necessary i.e. direct bonding by bolted fastening.



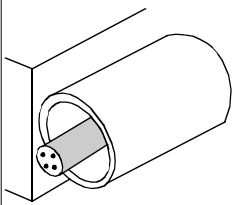
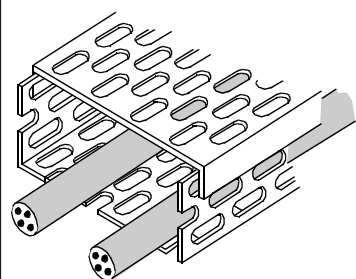
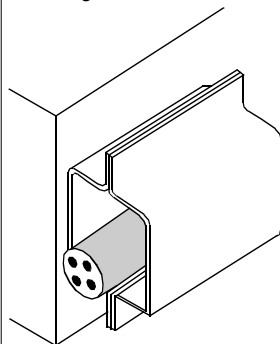
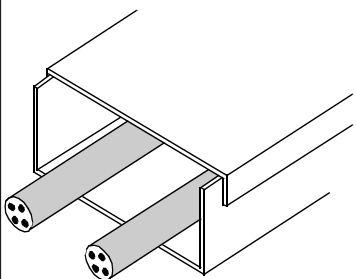
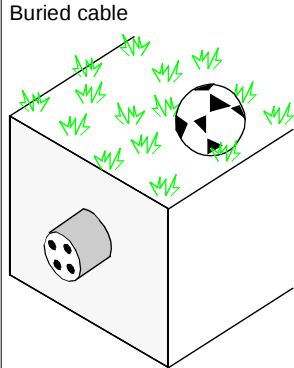
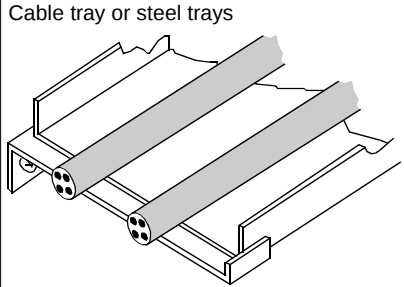
Note: The earthing of cable ducts must be carried out when necessary, see *Direct bonding by bolted fastening for metallic parts*, p. 112.

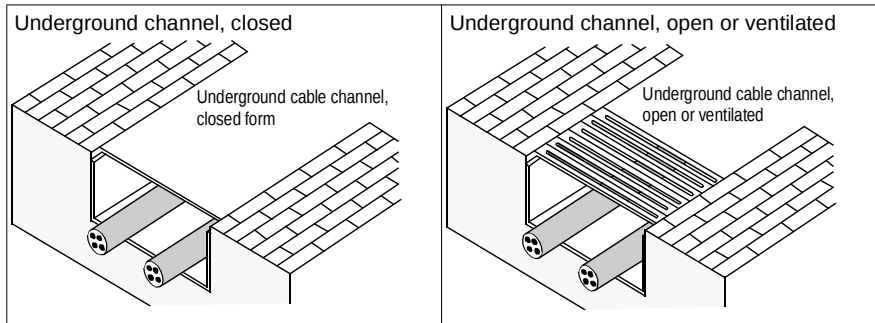
Non metallic cable ducts

Note: Cable ducts that are not electrically conductive such as PVC tubes, plastic skirting boards or similar, are not recommended as they offer no shielding. For example, they can be used in existing systems but only with a maximum run length of 3 m.

**Recommended
cable ducts**

The following cable ducts are recommended:

Steel conduit 	Steel cable duct 
Trunking 	Steel cable duct 
Buried cable 	Cable tray or steel trays 



Guidelines for Cables between Buildings

Problems that can arise with outside cables

If signal cables are laid outside of buildings the following points should be noted:

- A potential difference can exist between buildings that can create an error during transfer.
 - Cables between buildings can carry a higher current in the event of a sudden increase in the potential of a building due to a lightning strike.
-

Guidelines for outside cables

For cables that are laid outside of buildings, the following guidelines should be observed:

- Shielded cables must be used.
- The shield must be capable of carrying the current and must be grounded at both ends.

If the shield cannot carry the current, a relieving line can be installed directly next to the signal cable for current dissipation. The relieving line should have a cross-section of approximately 35 mm².

- Analog signal lines must have double shielded cables, the inside shield must be grounded at one end and the outside shield at both ends.
- Signal lines must be wired with an over-voltage protection element, that is connected at the cable entrance to the building when possible or at the cabinet as a minimum.

Observe the following: *Guidelines for Grounding and Earthing for Systems between Buildings*, p. 108.

Recommended for data transfer between buildings

Fiber optic cables are recommended for data transfer between buildings. This creates no problems with loops between exposed conductive parts in the event of a lightning strike.

Quantum Family

Overview

Introduction This section contains product specific guidelines, installation instructions and information about grounding and EMC for the components of the Quantum product family.
It contains the same information as the documentation provided with the products.

What's in this Part? This part contains the following chapters:

Chapter	Chapter Name	Page
11	Quantum Family	147

Overview

Introduction This chapter contains product specific guidelines, installation instructions and information about grounding and EMC for the components of the Quantum product family.
It contains the same information as the documentation provided with the products.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Batteries as DC power supplies	148
General Information	149
AC Power and Grounding Considerations	150
DC Power and Grounding Considerations	155
Closed System Installation	160

Batteries as DC power supplies

Overview

Power Supplies usually provide the adequate protection from high **and** low frequency RF noise because of filtered outputs. Batteries provide only good filtering abilities against low frequency noise.

To protect battery powered networks, additional RFI filters are required such as:

- CURTIS F2800 RFI filters
 - TRI-MAG, Inc. FL Series Filters or equivalent
-

General Information

Overview

The required power and grounding configurations for AC powered and DC powered systems are shown in the following illustrations. Also shown are power and grounding configurations of AC and DC systems required for CE* compliance.

Note: Each backplane shown has its own ground connection; that is, a separate wire returning to the main grounding point, rather than "daisy chaining" the grounds between power supplies or mounting plates.
The main grounding point is the local common connection of the panel ground, equipment ground, and earth grounding electrode.

CE Compliance

The CE mark indicates compliance with the European Directive on Electromagnetic Compatibility (EMC) (89/336/EEC) and the Low Voltage Directive (73/23/EEC).

Note: In order to maintain CE compliance, the Quantum system must be installed in accordance to these instructions.

Chassis Grounding

A chassis ground wire is required for each backplane. The wire is connected between one of four ground screws (located on the backplane) and the main ground point of the power system. This wire should be green (or green with a yellow stripe) and the AWG rating must be (at a minimum) sized to meet the fuse rating of the supply circuit.

Power Supply Grounding

On each power supply connector there is a ground connection. This connection must be made for safety reasons. The preferred connection is between the power supply connector ground terminal and one of the backplane ground screws. This wire should be green (or green with a yellow stripe) and at a minimum the same AWG rating as the power connections to the supply.

In backplanes with multiple power supplies, each supply should have a ground connection between its input connector and the backplane ground screws.

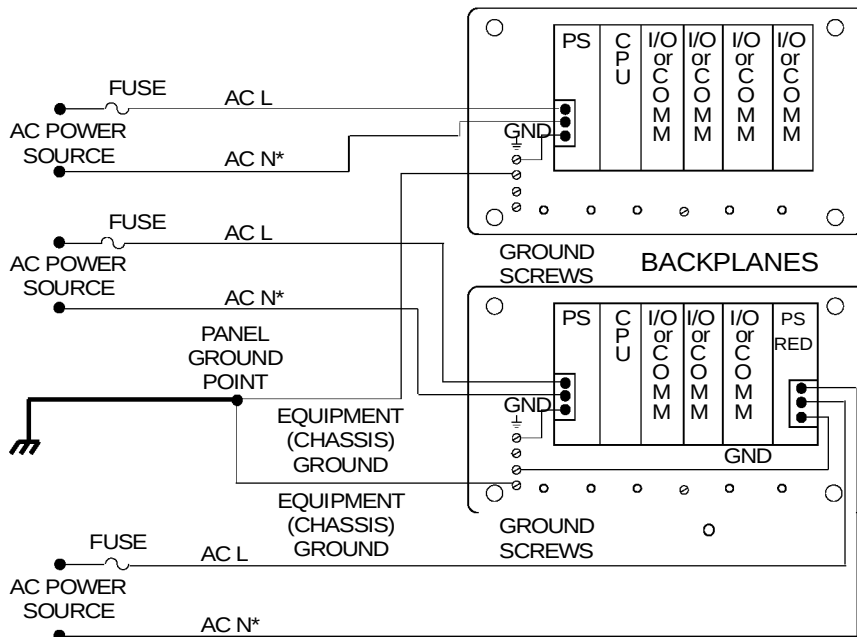
Note: It is recommended that the power supply, feeding the I/O modules, is grounded at the main ground point.

Other Equipment Grounding Other equipment in the installation should not share the grounding conductor of the system. Each piece of equipment should have its own grounding conductor returning to the main grounding point from which the equipment power originates.

Systems with Multiple Power Feeds In systems with multiple power feeds, the grounding should proceed in the same manner as single feed systems. However, a zero volt potential difference must be maintained between the equipment grounding conductors of the separate systems to prevent current flow on communication cables.

AC Power and Grounding Considerations

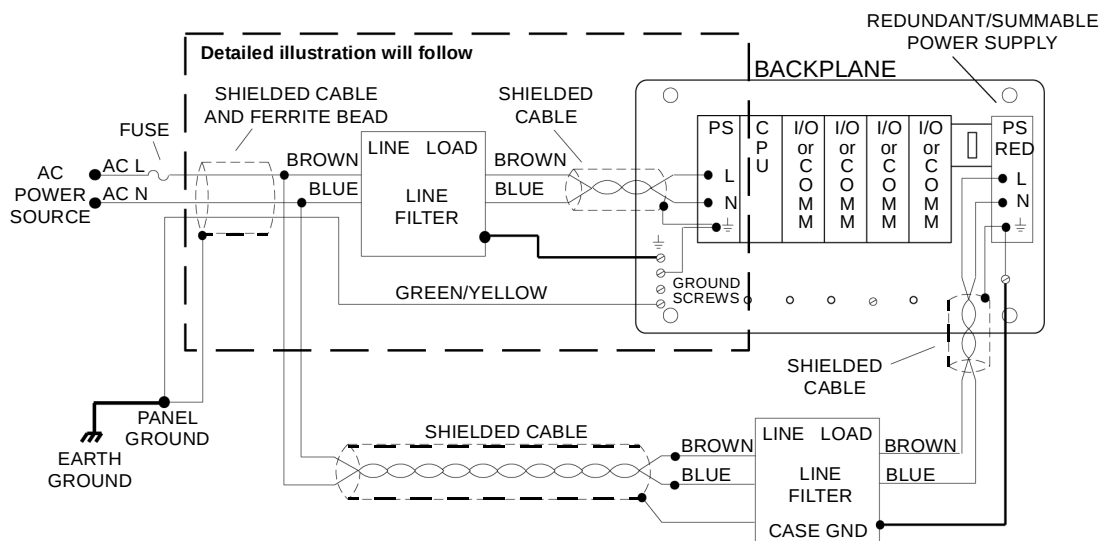
AC Powered Systems Figure The following figure shows the AC powered systems.



Note: *AC N should be earth grounded. If it is not earth grounded, it must be fused (refer to local codes)

AC Powered System for CE Compliance

The following figure shows a AC powered systems for CE compliance.

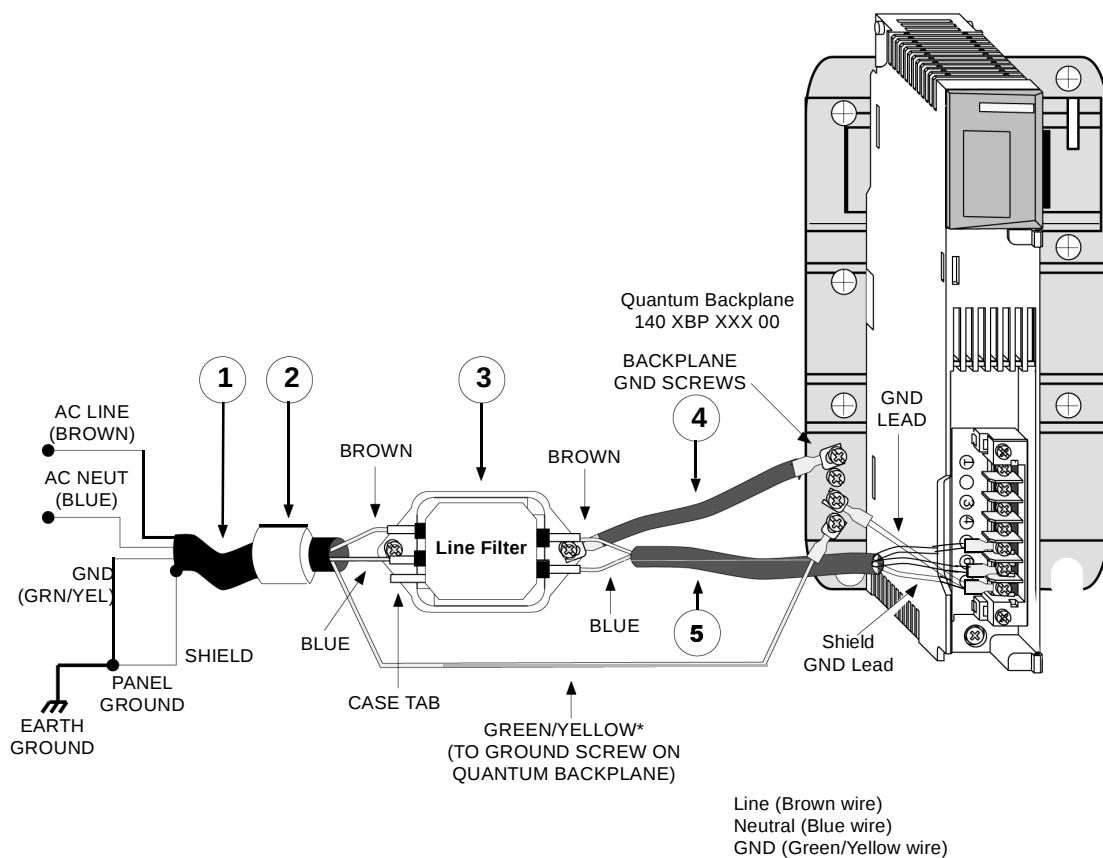


	CAUTION
	European compliance To maintain CE compliance with the European Directive on EMC (89/336/EEC), the AC power supplies must be installed in accordance with these instructions. Failure to follow this precaution can result in injury or equipment damage.

	CAUTION Requirements compliance For installations that must meet "Closed System" requirements, as defined in EN 61131-2 (without relying upon an external enclosure), connector models 140 XTS 00100 and 140 XTS 00500 are required. Also, if an external Line Filter is used, it must be protected by a separate enclosure which meets the "finger safe" requirements of IEC 529, Class IP20. Failure to follow this precaution can result in injury or equipment damage.
---	---

Detailed AC Powered System Figure

The following figure shows the details for the AC powered system for CE compliance.



Note: Only one ground wire per backplane is required. In redundant and summable systems, this lead is not connected for the additional line filter/power supply.

Note: For detailed wiring diagrams, refer to the part Power Supply Modules

Part list

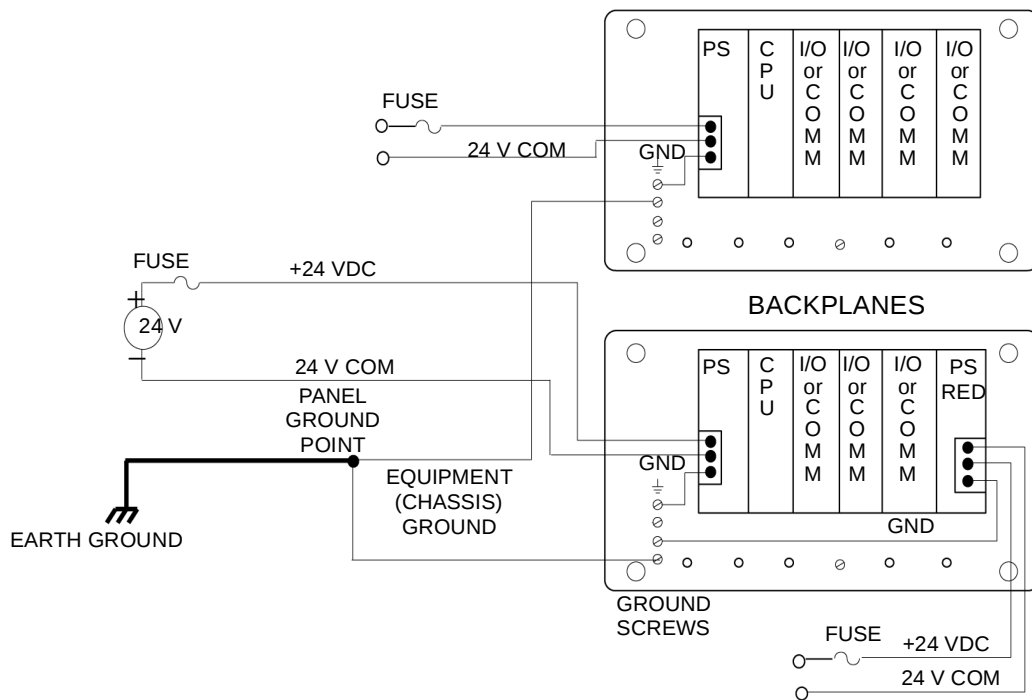
Table of the parts

Callout	Vendor or equivalent	Part Number	Description	Instruction
1	Oflex-Series 100cy	35005	Line Cord	Terminate the shield at panel ground; the filter end of the shield is not terminated.
2	Stewart Fairite	28 B 0686-200 2643665702	Ferrite Bead	Install next to the filter and secure with tie wraps at both ends of the ferrite bead.
3	Schaffner	FN670-3/06	Line Filter (fast on terminals) Dimensions: Length: 3.4" (85 mm) Width: 2.2" (55 mm) Height: 1.6" (40 mm) Mounting Holes: 0.2 in (5.3 mm) dia., 3 in (75 MM) centerline mounted. Fast on terminals: 0.25 in (6.4 mm)	Install next to the power supply.
4	NA	NA	Ground Braid Flat braid 0.5 in (134 mm) with a maximum length of 4" (100 mm)	NA
5	Oflex Series 100cy	35005	Shield Cable The maximum length is 8.5" (215 mm)	Third lead (green/yellow) is not used; terminate the shield at the power supply ground terminal.

DC Power and Grounding Considerations

24 VDC Powered System Figure

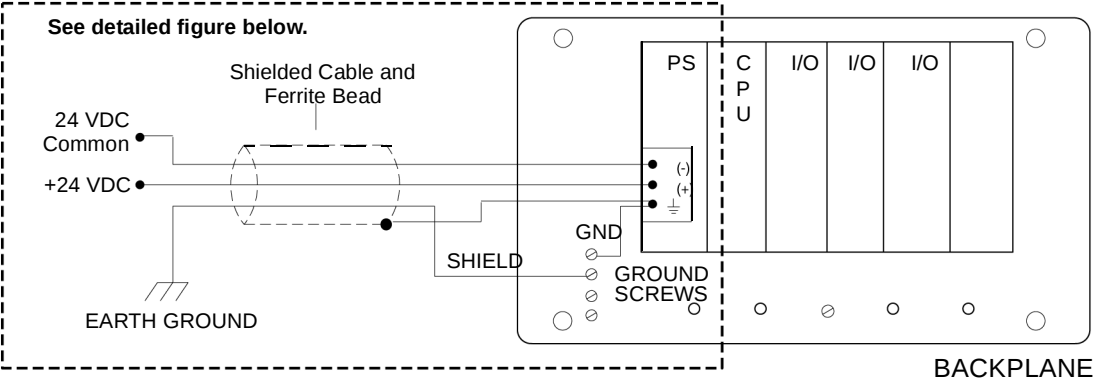
The following figure shows a 24 VDC powered system.



Note: It is recommended to earth ground the 24 VDC power supply.

24 VDC Powered System for CE Compliance

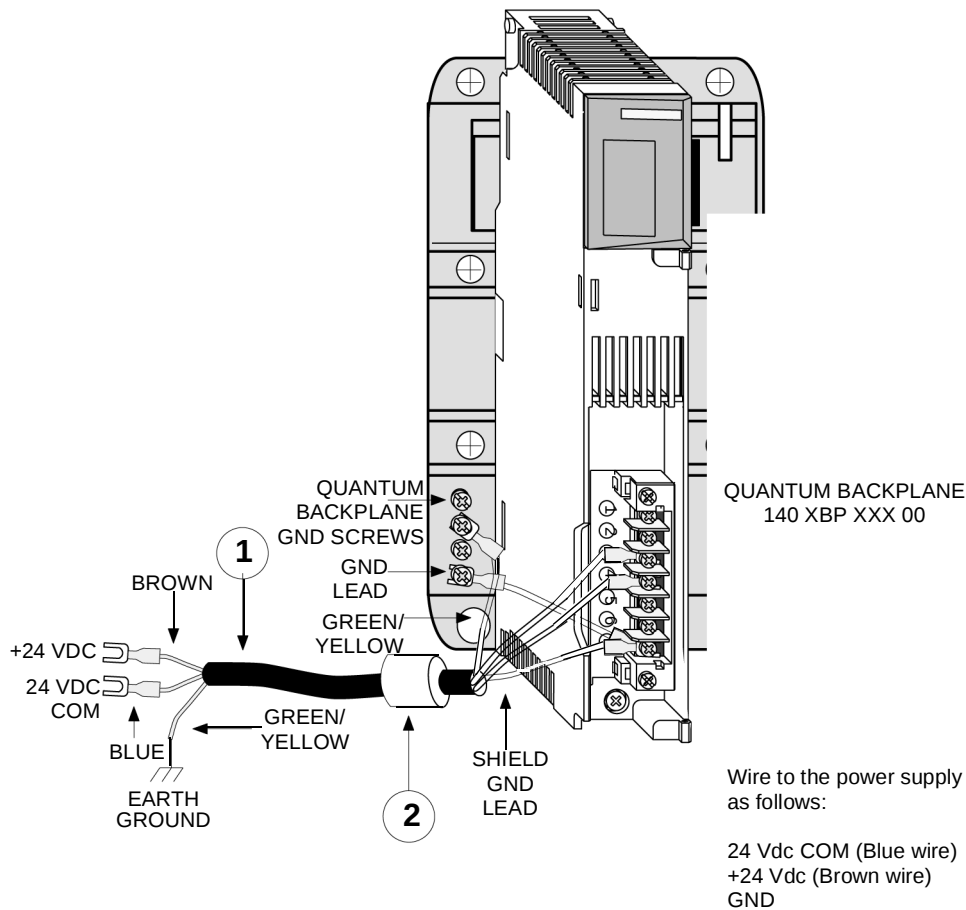
The following figure shows a 3 A, 24 VDC powered system for CE compliance.



	CAUTION
	European compliance To maintain CE compliance with the European Directive on EMC (89/336/EEC) and the Low Voltage Directive (73/23/EEC), the 140 CPS 211 00, the 140 CRA 211 20, and the 140 CRA 212 20 must be installed in accordance with these instructions. Failure to follow this precaution can result in injury or equipment damage.

24 VDC Detailed Figure

The following figure shows the detailed installation of a 3 A, 24 VDC powered system for CE compliance.



Note: For detailed wiring diagrams, refer to the part Power Supply Modules

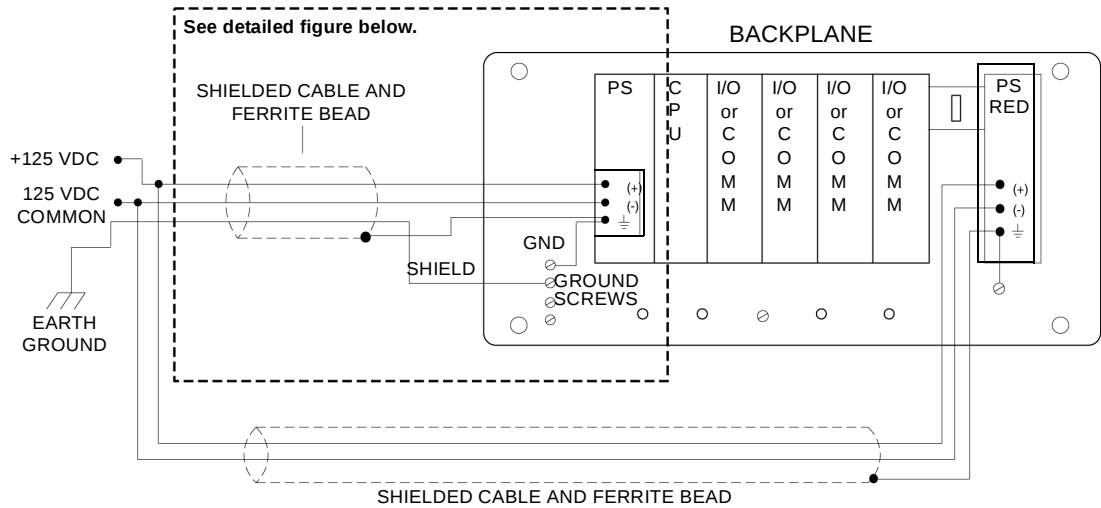
Parts List.

Callout	Vendor (or equivalent)	Part Number	Description	Instruction
1	Offlex Series 100cy	35005	Line Cord	Terminate the shield at the power supply ground terminal

Callout	Vendor (or equivalent)	Part Number	Description	Instruction
2	Seward Fairite	28 BO686-200 2643665702	Ferrite Bead	Install next to the filter and secure with tie wraps at Both ends of the ferrite bead.

**125 VDC
Powered System
Figure**

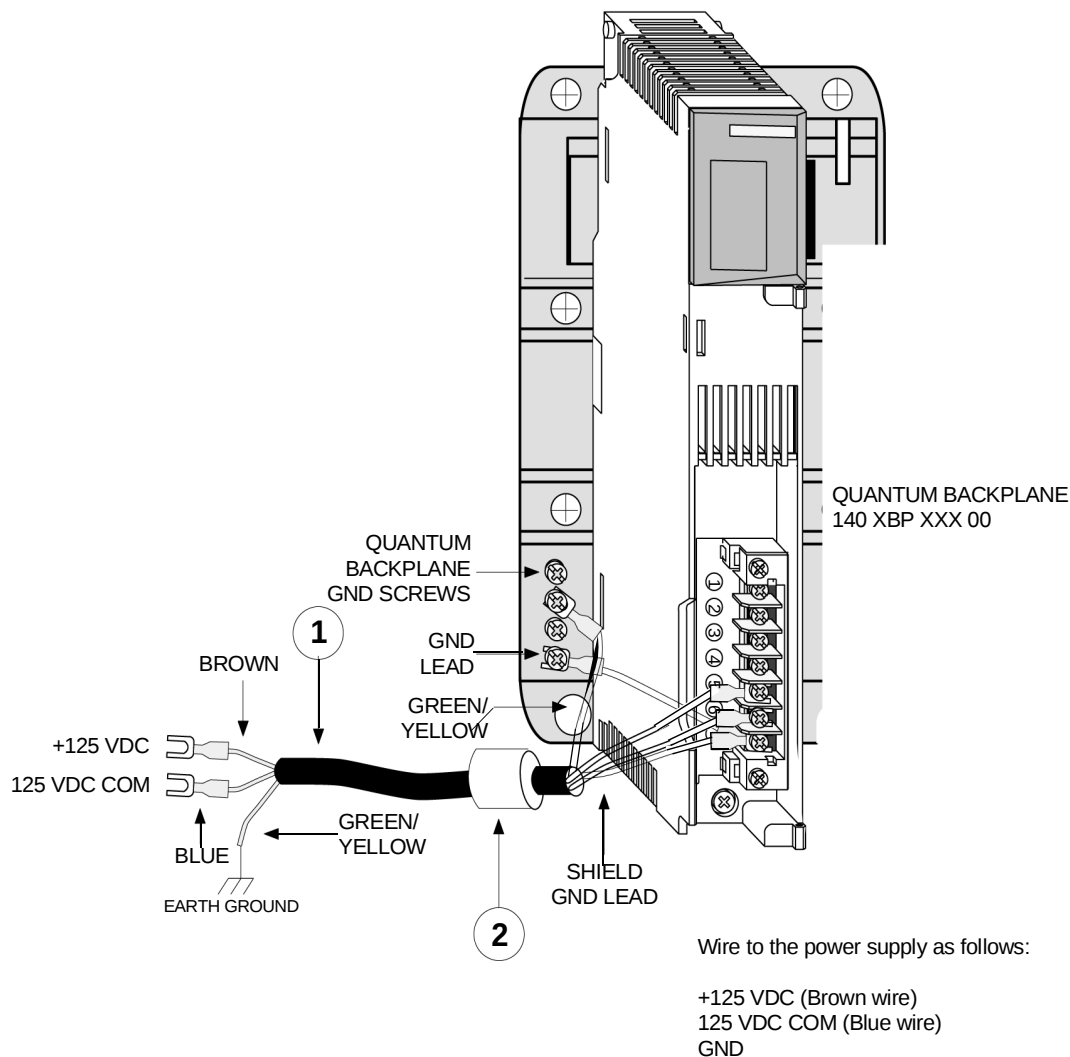
The following figure shows a 125 VDC powered system for CE compliance.



	CAUTION
	European compliance
	To maintain CE compliance with the European Directive on EMC (89/336/EEC) and the Low Voltage Directive (73/23/EEC), the 140 CPS 511 00 and the 140 CPS 524 00 must be installed in accordance with these instructions. Failure to follow this precaution can result in injury or equipment damage.

125 VDC Detailed Figure

The following figure shows the detailed installation for the 125 VDC powered system for CE compliance.



Note: For detailed wiring diagrams of all power supply modules, refer to the part

Parts List.

Callout	Vendor (or equivalent)	Part Number	Description	Instruction
1	Offlex Series 100cy	35005	Line Cord	Terminate the shield at the power supply ground terminal
2	Sreward Fairite	28 BO686-200 2643665702	Ferrite Bead	Install next to the filter and secure with tie wraps at Both ends of the ferrite bead.

	CAUTION
	European compliance To maintain CE compliance with the European Directive on EMC (89/336/EEC) and the Low Voltage Directive (73/23/EEC), the 140 CPS 511 00 and the 140 CPS 524 00 must be installed in accordance with these instructions. Failure to follow this precaution can result in injury or equipment damage.

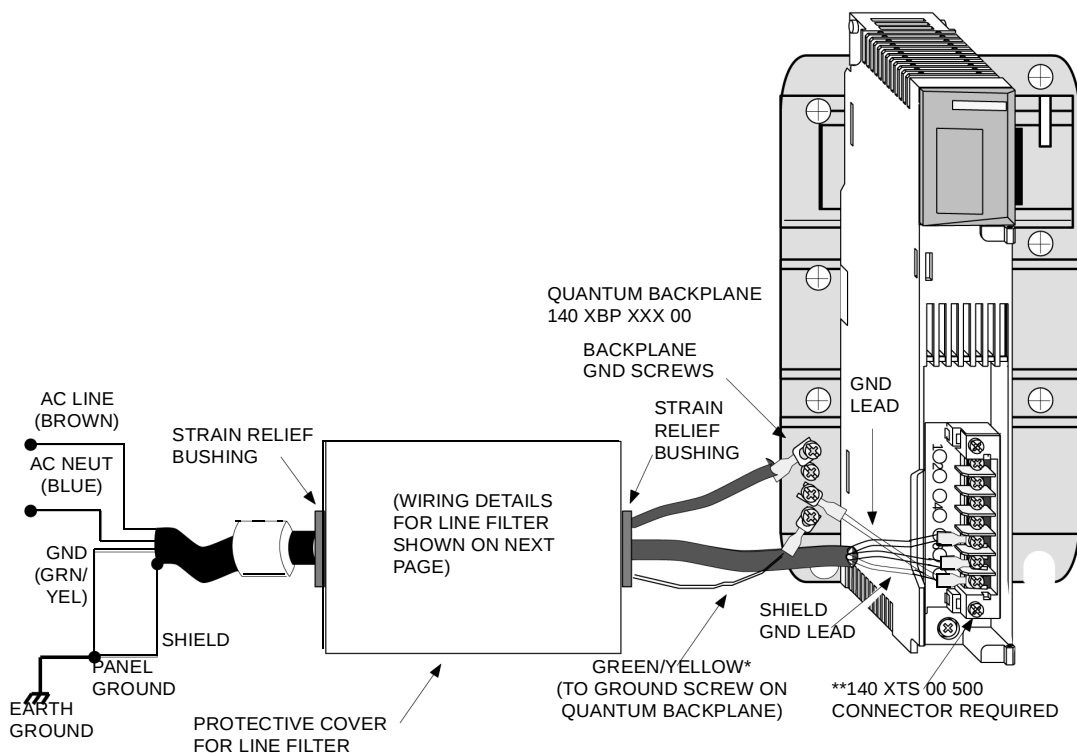
Closed System Installation

Overview

For installations that must meet "Closed System" requirements, as defined in EN 61131-2 (without relying upon an external enclosure) in which an external Line Filter is used, it must be protected by a separate enclosure which meets the "finger safe" requirements of IEC 529, Class IP20.

AC/DC Installation Figure

The following figure shows the detailed installation for the AC and DC powered systems for CE closed system compliance.



Wire to the power supply as follows:

Line (Brown wire)
Neutral (Blue wire)
GND (Green/Yellow wire)

Note: *Only one ground wire per backplane is required. In redundant and summable systems, this lead is not connected for the additional line filter/power supply

**Connectors 140 XTS 005 00 (for all power supplies) and 140 XTS 001 00 (for all I/O modules) must be ordered separately.

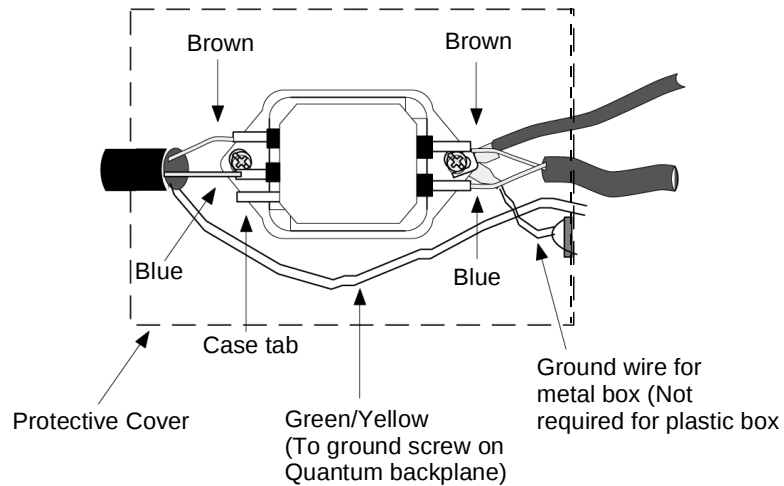
Note: For detailed wiring diagrams, refer to the part Power Supply Modules

Protective Cover

The protective cover must completely enclose the line filter. Approximate dimensions for the cover are 12.5 cm by 7.5 cm. Wire entry/exit shall be through strain relief bushings.

Line Filter Connections Figure

The following figure shows the wiring connections to the enclosed line filter.



Momentum Family



Overview

Introduction This chapter contains product specific guidelines, installation instructions and information about grounding and EMC for the components of the Momentum product family.
It contains the same information as the documentation provided with the products.

What's in this Part? This part contains the following chapters:

Chapter	Chapter Name	Page
12	Momentum Family	165

Overview

Introduction This chapter contains product specific guidelines, installation instructions and information about grounding and EMC for the components of the Momentum product family.
It contains the same information as the documentation provided with the products.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Structuring Your Power Supply System	166
Selecting Power Supplies	167
Single Power Supply Configuration	168
Protective Circuits for DC Actuators	170
Protective Circuits for AC Actuators	171
Suggested Component Values for AC and DC Actuators	172
Grounding Momentum Devices	172
Grounding DIN Rail Terminals and Cabinets	174
Grounding Analog I/O Lines	175

Structuring Your Power Supply System

Overview This section contains guidelines for planning and wiring your power supply system.

Use Separate Power Supply for Outputs Operating voltage and input voltage can be derived from one power supply (PS). We recommend that the output voltage be drawn from a separate power supply (e.g., 10 A or 25 A, referred to as PS1 and PS2).
A separate output voltage supply prevents interferences caused by switching processes from affecting the voltage supply to the electronics. Where larger output currents are involved, provide additional power supplies for the output voltage (PS3, ...).

Use Star Configuration Each I/O base should be fed by the power supply in star configuration, i.e., separate leads from the power supply to each module.

	CAUTION
	POTENTIAL FOR SHORT CIRCUITS AND/OR POWER-UP/POWER-DOWN SPIKES
	Provide external fuses on the operating voltage to protect the module. Appropriate fuse values are shown in the wiring diagrams. An unprotected module may be subject to short circuits and/or power-up/power-down spikes. Failure to follow this precaution can result in injury or equipment damage.

Avoid Induction Loops Do not create any induction loops. (This can be caused by laying out the supply conductors L+/M-, ... in pairs.) As a remedy use twisted-pair wiring.

Avoid Series Connections The series connections often found in automatic circuit breakers should be avoided, since they increase the inductive component in the output-voltage leads.

Potential-Isolated Fieldbus Islands The potential relationships of the bus adapters are designed so that the individual I/O stations form potential-isolated islands (e.g., by isolating the incoming remote bus of InterBus). To decide whether potential balancing is necessary refer to the installation guidelines of the used communication adapter.

Selecting Power Supplies

Introduction This section provides guidelines for selecting power supplies.

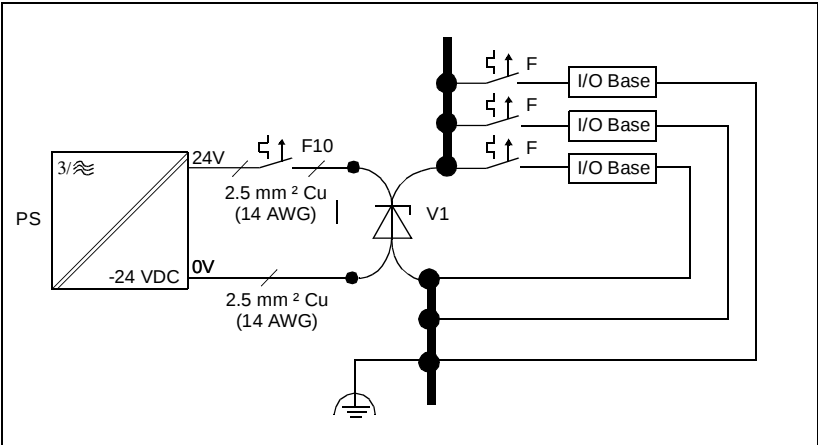
Using Three-Phase Bridges Unfiltered three-phase bridges can be used in 24 VDC power supplies for the I/O bases, the sensors, and the actuators. In view of the maximum permissible ripple of 5%, monitoring for phase failure is necessary. For single-phase rectification, the 24 VDC must be buffered to ensure conformance to the specifications in *System Specifications* on page 595 (20...30V; max. ripple 5 %).

	CAUTION
	POTENTIAL FOR DANGEROUS VOLTAGE LEVELS You must electrically isolate the AC-to-DC converter between the input (primary) and output (secondary). Otherwise, dangerous voltage levels can be propagated to the output if the AC-to-DC converter fails. Failure to follow this precaution can result in injury or equipment damage.

Provide Reserve Capacity Startup transients, extra long cables, and low cross-sectional efficiency can lead to voltage supply breakdowns. You should therefore select power supplies with enough reserve capacity and select the proper cable lengths and cross sections.

Single Power Supply Configuration

Introduction	This section contains illustrations of a sample circuit layout, potential bundling and potential isolation for a single power supply configuration.
Fusing in Circuit Layout	Each of the following circuit branches must be fuse-protected (F in the figure below). In the case of long lines, the circuit branch must be provided with a suppressor circuit OVP 001/OVP 248. This protection selectively shuts off a circuit branch through the associated fuse even if the diode is short-circuited.
Illustration	The following illustration shows a sample circuit layout for a single power supply configuration.

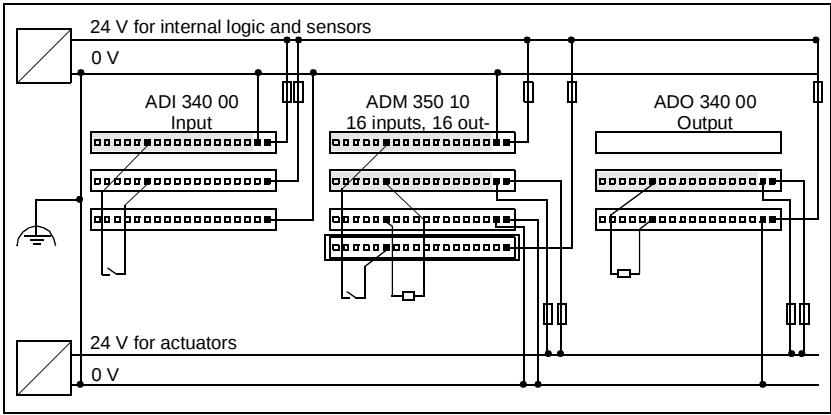


- F** Automatic circuit breaker or fuse (see appropriate field wiring illustration in I/O base description)
- F10** Optional circuit breaker (with over-voltage protection)
- PS** Power Supply 24 VDC, max. 25 A
- V1** Overvoltage protection circuit OVP 001, OVP 002

Fusing in Wiring Illustrations	The fuses shown in the illustrations below must be selected on the basis of the type and number of the sensors and actuators used.
---------------------------------------	--

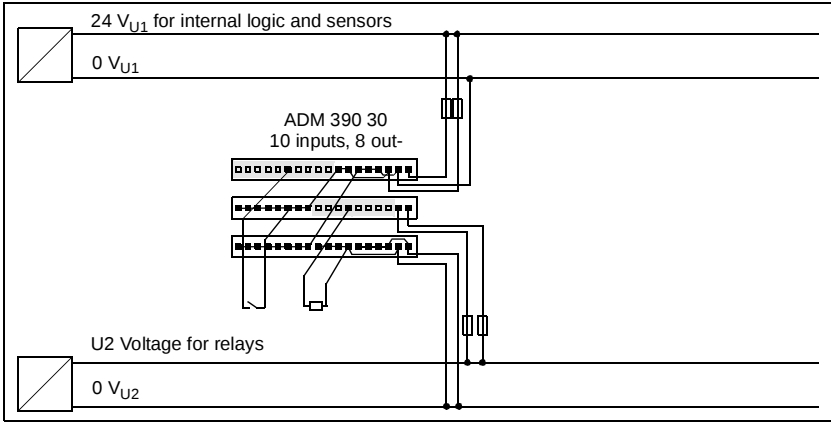
Potential Bundling

In this example, the output voltage is drawn from a separate power supply.



Potential Isolation

In this example, the output voltage is drawn from a separate power supply



Protective Circuits for DC Actuators

Overview

This section discusses specific cases when inductive loads at output points require additional protective circuits (directly on the actuator) and provides two examples or protective circuitry.

Case 1

When there are contacted circuit elements (e.g. for safety interlocks) in the output conductors.

Case 2

When the leads are very long.

Case 3

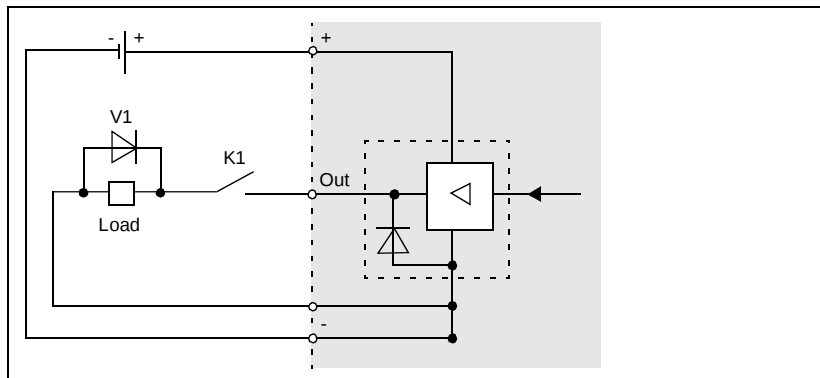
Where inductive actuators are operated via relay contacts of the I/O base. (To extend contact life and for EMC considerations.)

Protective Circuit Types

In all three cases, the protective circuit may be a clamping diode, a varistor or an RC combination.

Example 1

An example of a protective circuit for inductive DC actuators is illustrated below:

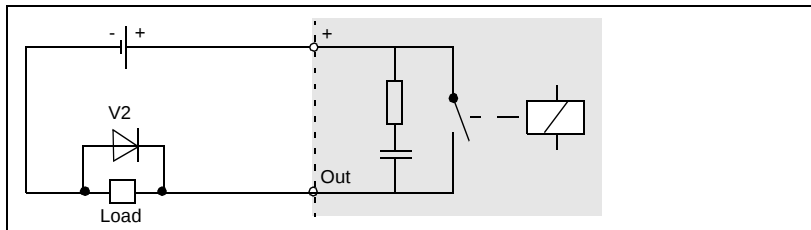


K1 Contact, e.g., for safety interlocks

V1 Clamping diode as the protective circuit

Example 2

Another example of a protective circuit for inductive DC actuators is illustrated below:



V2 Clamping diode as the protective circuit

See *Suggested Component Values for AC and DC Actuators*, p. 172.

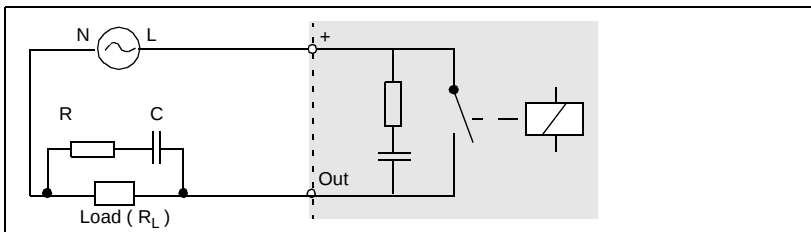
Protective Circuits for AC Actuators

Overview

To reduce noise potentials and for EMC considerations you may need to equip the inductive actuators with varistors or noise suppressors, e.g., anti-interference capacitors, at the point of interference.

Example

An example of a protective circuit for inductive AC actuators is illustrated below:



L, N Phase (L1, L2, L3) and Reference Conductor

RC RC Combination as the Protective Circuit (rated per manufacturer's specifications)

RL Inductance Load

See *Suggested Component Values for AC and DC Actuators*, p. 172.

Suggested Component Values for AC and DC Actuators

**Suggested
Values Only**

The clamping diode forward current rating must be equal to or greater than load current. Diode PIV rating must be three or four times greater than supply voltage at 24 VDC and 8 ... 10 times greater than supply voltage at 110 VAC. The unpolarized (AC) snubb
Values may be:

Load Inductance	Capacitance
25 ... 70 mH	0.50 microF
70 ... 180 mH	25 microF
180 mH	10 microF

Snubber resistors may be 1 ... 3 Ohms, 2 W. Resistor values should be increased up to 47 Ohms/5 W for R_L exceeding 100 Ohms.

Grounding Momentum Devices

Overview

This section describes how to provide two types of grounding for assembled Momentum devices:

- Functional earth (FE), used to discharge high frequency disturbances, guaranteeing proper EMC behavior
- Protective earth (PE), used for protection against personal injuries according to IEC and VDE.

**Grounding
Momentum
Devices**

Momentum devices consist of an I/O base assembled with a Communications Adapter or a Processor Adapter and possibly an Option Adapter. The PE of the adapters is electrically connected with the PE of the I/O base; you do not have to provide any further grounding of the adapter.

**Grounding
Guidelines**

Follow these guidelines:

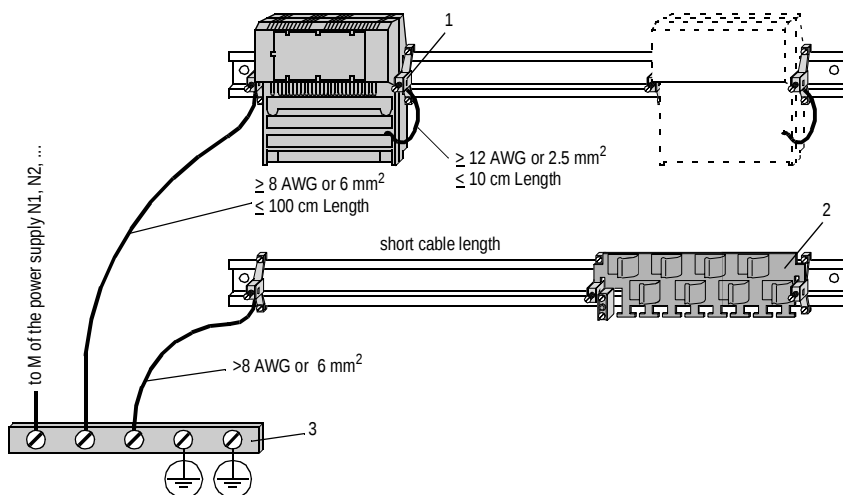
- Be sure you establish good ground contacts.
- Connect the grounding screw to protective earth (PE) for AC and DC modules.

**Cable
Specifications**

When you are using ground cable up to 10 cm (4 in) long, its diameter should be at least 12 AWG (or 2.5 mm²). When longer cables are used, larger cable diameters are required, as shown in the following illustration

Grounding Scheme

The illustration below illustrates properly grounding modules and tracks.



- 1 Grounding clamp, such as EDS 000
- 2 Cable Grounding Rail (CER 001), an optional component for grounding lines close to PE/FE rail
- 3 PE/FE rail in the cabinet or PE/FE screw in terminal cabinet

Note: The lower DIN rail shows a Cable Grounding Rail (CER 001), an optional component for grounding analog lines. For a procedure for grounding analog I/O lines, see *Grounding Analog I/O Lines*, p. 175.

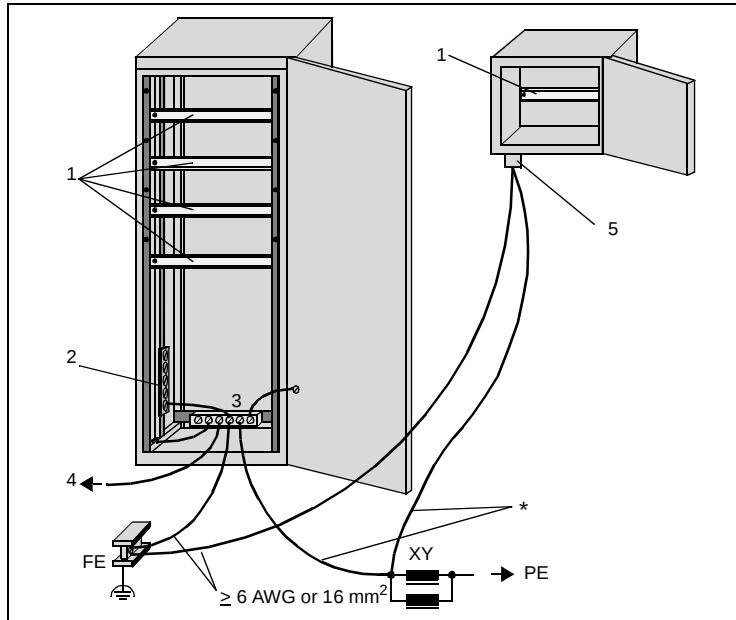
Grounding DIN Rail Terminals and Cabinets

Overview

This section shows how to ground DIN rail terminals and cabinets.

Illustration

The following illustration shows how to ground DIN rail terminals and cabinets:



- 1 DIN rail for connecting the Momentum device and its accessories
 - 2 Reference conductor system or rail (solid copper or connected terminals)
 - 3 Grounding bar in the cabinet
 - 4 Next cabinet
 - 5 Grounding screw (PE/FE) in cabinet
- FE** Functional earth
PE Protective earth
XY Protective earth choke
 * Conductor cross section depends on the load of the system

Grounding Analog I/O Lines

Overview

Analog wires must be grounded directly when entering the cabinet. You may use commercial cleats or clamps or an analog cable grounding rail. This section describes both approaches.

Principle

High frequency interference can only be discharged via big surfaces and short cable lengths.

Guidelines

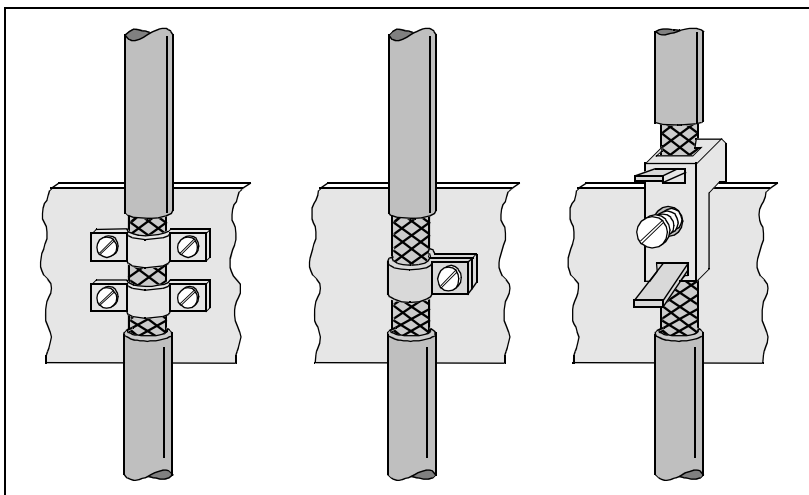
Follow these wiring guidelines:

- Use shielded, twisted-pair cabling
- Expose the shielding on one side (for instance, at the console exit)
- Make sure the track is properly grounded (see *Grounding Momentum Devices*, p. 172)

Grounding of the bus cable is determined by the bus adapter used. Look for details in your *bus adapter manual*.

Using Cleats or Clamps

Cleats or clamps can be mounted directly on the ground rail (PE/FE rail) in the cabinet, as shown in the illustration below. Be sure the cleats or clamps make proper contact.





Overview

Introduction This chapter contains product specific guidelines, installation instructions and information about grounding and EMC for the components of the Premium product family.
It contains the same information as the documentation provided with the products.

What's in this Part? This part contains the following chapters:

Chapter	Chapter Name	Page
13	Standards Conformity and EMC Characteristics	179
14	Basic elements: Backplane RKY, power supply PSY	189
15	Power Supply for the Process and AS-i SUP	203
16	Discrete I/O Modules DEY/DSY	219
17	Safety Modules PAY	231
18	Counter Modules CTY	237
19	Axis Control Modules CAY	245
20	Stepper Motor Control Modules CFY	247
21	Electronic Cam Module CCY 1128	251
22	Analog Modules AEY/ASY	263
23	Weighing Module ISPY100/101	265

Standards Conformity and EMC Characteristics

13

Introduction

Introduction This section provides an overview of the standards that Premium Hardware Products conform to, and also includes EMC standards. It also includes exact information about the products disturbance immunity and emitted disturbance.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Standards and Certification	180
Operating conditions and environmental conditions to be avoided	181

Standards and Certification

General

Premium TSX/PMX/PCX PLCs have been developed to conform to the principal national and international standards for industrial electronic PLC equipment.

- Programmable PLCs: specific requirements: functional characteristics, resistance, safety etc.
IEC 61131-2, CSA 22.2 N° 142, UL 508
 - Merchant navy requirements of the major international organisations:
ABS, BV, DNV, GL, LROS, RINA, RRS, CCS etc.
 - Adhering to European Directives:
Low Voltage: 73/23/EEC amendment 93/68/EEC
Electromagnetic Compatibility: 89/336/EEC amendments 92/31/EEC and 93/68/EEC
 - Electric qualities and self-extinguishability of insulating materials: UL 746C, UL 94
 - Danger Zones Cl1 Div2 CSA 22.2 N° 213
"THIS EQUIPMENT IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C AND D OR NON-HAZARDOUS LOCATIONS ONLY"
WARNING: "EXPLOSION HAZARD - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS AREA IS KNOWN TO BE NON-HAZARDOUS"
-

Operating conditions and environmental conditions to be avoided

Operating temperature/ hygrometry/ altitude

Data table:

Ambient temperature when operative	0°C to +60°C (IEC 1131-2 = +5°C to +55°C)
Relative humidity	10% to 95% (without condensation)
Altitude	0 to 2000 meters

Power supply voltages

Data table:

Voltage	nominal	24 VDC	48 VDC	100 to 240VAC	100...120/200...240 VAC
	limit	19 to 30 VDC	19...60VDC (1)	90 to 264 VAC	90 to 140/190 to 264VAC
Frequency	nominal	-	-	50/60 Hz	50/60 Hz
	limit	-	-	47/63 Hz	47/63 Hz
Brown-outs	duration	≤ 1 μs	≤ 1 μs	≤ 1/2 period	≤ 1/2 period
	repetition	≥ 1 s	≥ 1 s	≥ 1 s	≥ 1 s
Harmonic rate		-	-	10%	10%
Residual ripple included		5%	5%	-	-

(1) Possible up to 34 VDC, limited to 1 hour every 24 hours.

For PSY 1610 and PSY 3610 power supplies, and when using relay output modules, this scope is reduced to 21.6V...26.4V.

Human and material safety

Data table:

Test Designation	Norms	Levels	
Dielectric rigidity and Isolation resistance *	IEC 61131-2 UL 508 CSA 22-2 N°142 IEC 60950	24 - 48 V Power supply 100 -220 V Power supply < 48V Discrete I/Os > 48V Discrete I/Os > 10 MΩ	1500 Vrms 2000 Vrms 500 Vrms 2000 Vrms
Maintaining ground connections*	IEC 61131-2 UL 508 CSA 22-2 N°142	< 0.1 Ω / 30 A / 2 min	
Leakage Current *	CSA 22-2 N°142 IEC 60950	< 3.5 mA fixed device	
Enclosures for protection *	IEC 61131-2 CSA 22-2 N°142 IEC 60950	IP 20	
Impact Resistance	CSA 22-2 N°142 IEC 60950	Drop / 1.3 m / 500 g Sphere	
Legend			
*: Tests required by EC directives			

Note: The devices must be installed and wired according to the directions in the DG KBL• manual.

Resistance of devices to power supply L.F. turbulence

Data table:

Test Designation	Norms	Levels
Voltage and frequency Variation *	EN 50082-1	Un 15% / Nf 5% 30 min x 2 Un 20% / Nf 10% 5 s x 2
Continuous voltage variation *	EN 50082-1	0.85 Un - 1.2 Un 30 + 30 min + 5% ripple maximum
Harmonic 3 *	IEC 61131-2	10% Un 0° / 5 min - 180° / 5 min
Momentary Interruptions *	IEC 61131-2	AC 10 ms DC 1 ms
Voltage peaks and troughs *	IEC 61131-2	Un-0-Un; Un / 60s 3 cycles separated by 10 s Un-0-Un; Un / 5s 3 cycles separated by 1 to 5 s Un-0.9-Un; Un / 60s 3 cycles separated by 1 to 5 s
Legend		
Un: Nominal Voltage Nf: Nominal Frequency Ud: Power-on detection level		
*: Tests required by EC directives		

Note: The devices must be installed and wired according to the directions in the DG KBL• manual.

**Resistance to
H.F. turbulence**

Data table:

Test Designation	Norms	Levels
Amortized oscillatory wave *	IEC 61131-2 IEC 61000-4-12	AC / DC 1 kV SM 24 V Discrete I/Os 1 kV SM
Fast transients (bursts) *	EN 50082-1 IEC 61000-4-4	AC / DC Power Supply 2 kV WM / CM 48 V > Discrete I/Os 2 kV CM other ports 1 kV CM
Hybrid shockwave	IEC 61000-4-5	AC / DC Power Supply 2 kV WM / 1 kV SM AC Discrete I/Os 2 kV WM / 1 kV SM DC Discrete I/Os 2 kV WM / 0.5 kV SM Shielded Cable 1 kV CM
Electrostatic Discharge *	IEC 61131-2 IEC 61000-4-2	6 kV contact 8 kV air
Electromagnetic Field *	EN 50082-2 IEC 61000-4-3	10 V/m, 80MHz - 2 GHz Sinusoidal modulation amplitude 80% / 1kHz
Conduit Turbulence *	EN 50082-2 IEC 61000-4-6	10 V 0.15 MHz - 80 MHz Sinusoidal modulation amplitude 80% / 1kHz
Legend		
SM: Serial mode CM: Common Mode WM: Wire Mode		
*: Tests required by EC directives		

Note: The devices must be installed and wired according to the directions in the DG KBL• manual.

**Electromagnetic
Emissions**

Data table:

Test Designation	Norms	Levels
Conduction Limits *	EN55022/55011 EN50081-2	Class A 150 kHz - 500 kHz quasi-peak 79 dB mV average 66 dB mV 500 kHz -30 kHz quasi-peak 73 dB mV average 60 dB mV
Emission Limits *(1)	EN55022/55011 EN50081-2	Class A d = 10 m 30 kHz -230 kHz quasi-peak 30 dB mV/m 230 kHz -1 kHz quasi-peak 37 dB mV/m
Legend		
(1) This test is carried out outside the casing, with the devices secured to a metallic grill and wired as shown in the DG KBL• Manual.		
*: Tests required by EC directives		

Note: The devices must be installed and wired according to the directions in the DG KBL• manual.

Resistance to climatic variation

Data table:

Test Designation	Norms	Levels
Dry heat	IEC60068-2-2 Bd	60°C / 16h (E.O) 40°C / 16h (E.F)
Cold	IEC60068-2-1 Ad	0°C / 16h
Continuous humid heat	IEC60068-2-30 Ca	60°C / 93% Hr /96h (E.O) 40°C / 93% Hr /96h (E.F)
Cyclical humid heat	IEC60068-2-30 Db	(55°C E.O / 40°C E.F); - 25°C / 93-95% Hr 2 cycles: 12 o' clock - 12h o' clock
Cyclical temperature variations	IEC60068-2-14 Nb	0°C; -60°C / 5 Cycles: 6 o'clock-6 o'clock (E.O.) 0°C; -40°C / 5 Cycles: 6 o'clock-6 o'clock (E.F)
Temperature Rise	IEC61131-2 UL508 CSA22-2 N°142	Ambient temperature: 60°C
Legend		
E.O: Device open E.F: Device closed Hr: Relative Humidity		

Resistance to mechanical constraints

Data table:

Test Designation	Standards	Levels
Sinusoidal vibrations	IEC60068-2-6 Fc	3 Hz - 100 Hz / 1 mm amplitude / 0.7 Gn Endurance: rf / 90 min / axis (Q limit) < 10 3 Hz - 150 Hz / 1.5 mm / 2 Gn Endurance: 10 cycles (1 octave / min)
Half-sinus shocks	IEC60068-2-27 Ea	15 Gn x 11 ms 3 shocks / direct. / axis
Legend		
rf: Resonance Frequency Q: Amplification Coefficient		

Resistance to climatic variation

Data table:

Test Designation	Standards	Levels
Dry heat whilst inoperative	IEC60068-2-2 Bb	70°C / 96h
Cold whilst inoperative	IEC60068-2-1 Ab	-25°C / 96h
Humid heat whilst inoperative	IEC60068-2-30 dB	60°C; - 25°C / 93-95% Hr 2 cycles: 12 o' clock - 12h o' clock
Thermal shocks whilst inoperative	IEC60068-2-14 Na	-25°C; -70°C / 2 Cycles: 3 o'clock - 3 o'clock

Resistance to mechanical constraints

Data table:

Test Designation	Standards	Levels
Flat free drop	IEC60068-2-32 Ed	10 cm / 2 drops
Free drop from controlled position	IEC60068-2-31 Ec	30° or 10 cm / 2 drops
Random free drop (conditioned material)	IEC60068-2-32 Method 1	1 m / 5 drops

Basic elements: Backplane RKY, power supply PSY

14

Overview

Introduction This section contains guidelines and information for the configuration and installation of the basic elements of the Premium hardware with regard to grounding and EMC.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Connection of the ground to a RKY rack	190
How to mount processor modules	191
Precautions to be taken when replacing a PCX 57 processor	193
Rules for connecting PSY supply modules	193
Connecting alternating current power supply modules	196
Connecting direct current power supply modules from an alternating current network	198

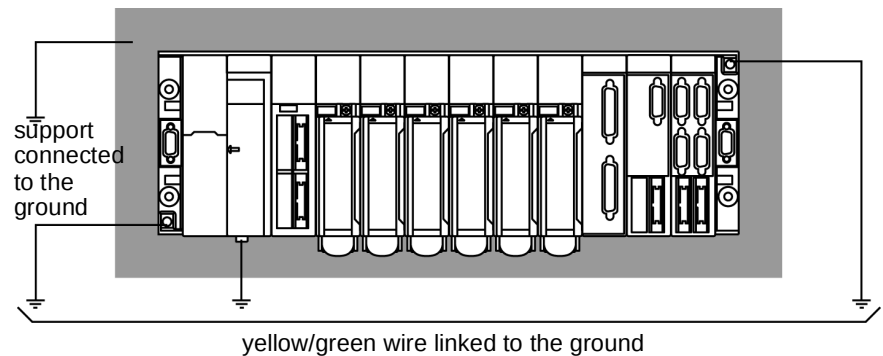
Connection of the ground to a RKY rack

Grounding racks Functional grounding of the racks is guaranteed by the back, which is made of metal. This means that the PLCs can be guaranteed to conform to environmental norms; assuming, however, that the racks are fixed to a metal support that is correctly connected to ground. The different racks which can make up a P57 PLC station must be mounted either on the same support or on different supports, as long as the latter are correctly interlinked.

For people's safety, in every case, each rack's grounding terminal must be linked to the protective ground.

For this, use a green/yellow wire of with a minimum section of 2.5 mm^2 and of the shortest length possible.

Illustration:



Note: The PLC's internal 0V is linked to the ground connection. The ground connection itself being linked to ground.

Maximum lightning moment on the ground connection screw: 2.0 N.m.

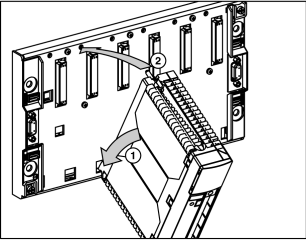
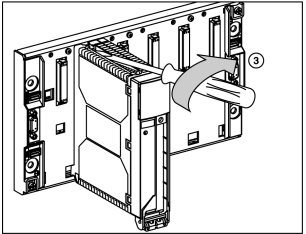
How to mount processor modules

Introduction Mounting and removing processor modules is identical to mounting and removing other modules apart from the fact that **it must not be done when power is switched on**.

Note: when extracting/inserting modules with the power on, the terminal block or HE10 connector must be disconnected. You must also take care to shut off the sensor/preactuator supply if this is over 48V.

Installing a processor module onto a rack

Carry out the following steps:

Step	Action	Illustration
1	Place the pins at the back of the module into the centering holes on the lower part of the rack (number 1, see diagram 1).	
2	Swivel the module to bring it into contact with the rack (number 2).	
3	Fix the processor module to the rack by tightening the screw on the upper part of the module (number 3).	

Note: the mounting of processor modules is identical to the mounting of other modules.

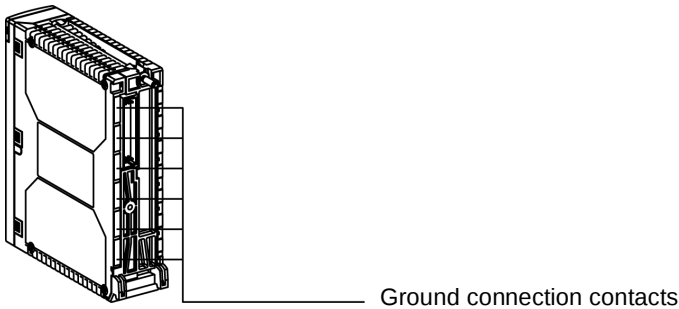
Note: Maximum tightening torque: 2.0N.m.

	CAUTION
	Install with power off A processor module must always be mounted with the rack power supply switched off. Failure to follow this precaution can result in injury or equipment damage.

**Grounding
modules**

Processor modules are grounded using metal plates at the rear of the module. When the module is in place, these metal plates are in contact with the metal of the rack. This ensures the link with the ground connection.

Illustration



Precautions to be taken when replacing a PCX 57 processor

Important

	CAUTION
	Replacing a processor
	If the PCX 57 processor is being replaced by another processor which is not blank (i.e. the processor has already been programmed and contains an application), you must cut the power to all of the PLC station's control units.
	Before restoring power to the control units, check that the processor contains the required application. Failure to follow this precaution can result in injury or equipment damage.

Rules for connecting PSY supply modules

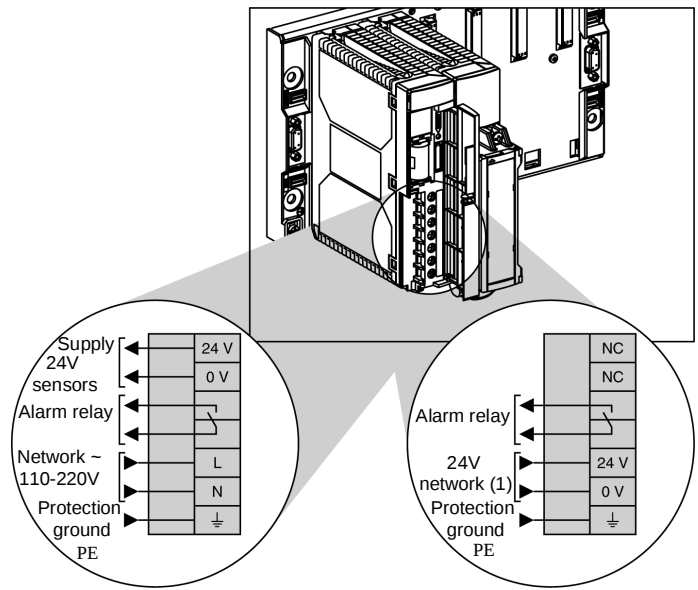
General points

The PSY ••• power supply modules on each rack are equipped with a non-removable terminal block, protected by a flap, which is used to connect the power supply, the alarm relay, the protection ground and, for alternating current supplies, the supply of the 24 VDC sensors.

This screw terminal block is equipped with captive clamp screws which can connect a maximum of 2 wires with a cross-sectional area of 1.5mm^2 with wire end ferrules, or one wire with a cross-sectional area of 2.5mm^2 (maximum tightening torque on screw terminal: 0.8N.m).

The wires come out vertically towards the bottom. These wires can be kept in place with a cable-clip.

Illustration This diagram shows the screw terminal block:



Alternating current supply
TSX PSY 2600/5500/8500

Direct current supply
TSX PSY 1610/3610/5520

(1) 24...48VAC for the PSY 5520 supply module.

	CAUTION
	Positioning the voltage selector
	For the power supply modules PSY 5500/8500, position the voltage selector according to the voltage power used (110 or 220 VAC). Failure to follow this precaution can result in injury or equipment damage.

Provide a protection device and switchgear upstream of the PLC station.
When selecting protection devices, the user should take into account the signaling currents which are defined in the characteristics tables for each supply module.

Note: As direct current supply modules PSY 1610/2610/5520 have a strong signaling current, it is not advisable to use them on direct current networks which protect flood-back current limits.

When a power supply module is connected to a direct current network, it is mandatory to limit the length of the supply cable in order to prevent transmission loss.

- PSY 1610 supply module:
 - length limited to 30 meters (60 meters there and back) with copper wires and a 2.5mm² cross-section,
 - length limited to 20 meters (40 meters there and back) with copper wires and a 1.5mm² cross-section.
- PSY 3610 and PSY 5520 supply modules:
 - length limited to 15 meters (30 meters there and back) with copper wires and a 2.5mm² cross-section,
 - length limited to 10 meters (20 meters there and back) with copper wires and a 1.5mm² cross-section.

Warning

Linking several PLCs supplied by a permissible direct current network not connected to ground.

The 0V and physical ground are linked internally in the PLCs, in the network cabling accessories and in some control consoles.

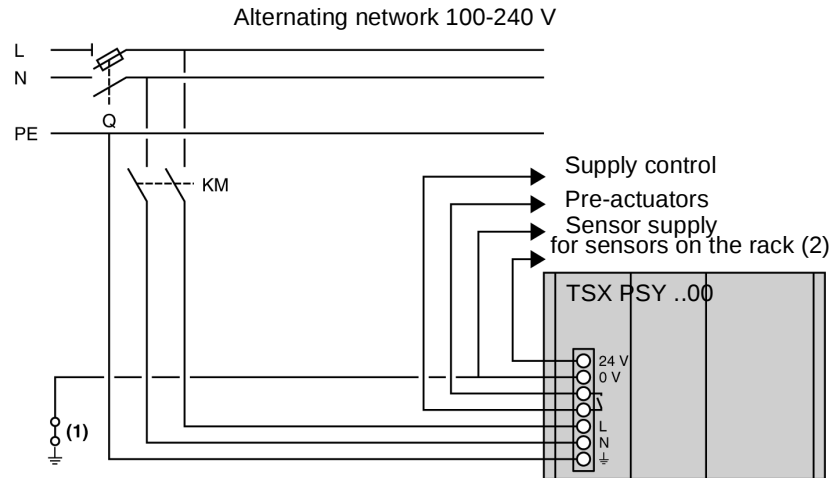
For specific applications which use a "floating" installation, special measures should be taken with connections. These depend on the method used for installation.

In this case, it is mandatory to use insulated direct current power supplies. Please contact us when you are defining the electrical installation.

Connecting alternating current power supply modules

Connecting a single-rack PLC station

Illustration:



Q: general section switch,

KM: circuit contactor-breaker,

(1) insulating connector bar for finding grounding faults

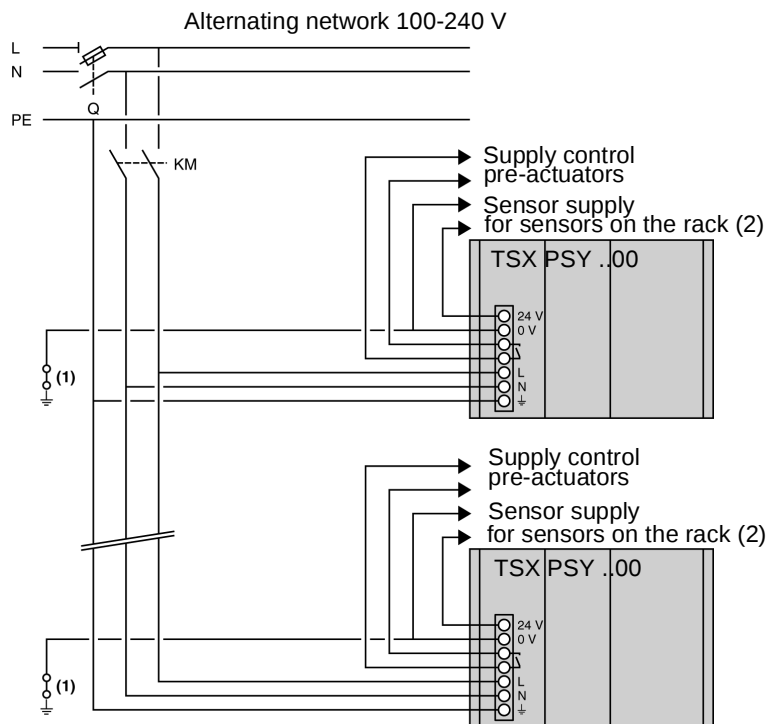
(2) available current:

- 0.6 A with a PSY 2600 power supply module,
- 0.8 A with a PSY 5500 power supply module,
- 1.6 A with a PSY 8500 power supply module,

Note: Protective fuses: alternating current power supply modules PSY 2600/5500/8500 are fitted during manufacture with a protective fuse. This fuse, in series with the L input, is located inside the module and cannot be accessed.

Connecting a PLC station made up of several racks

Illustration:



Note: If there are several PLC stations supplied by the same network, the principles of connection are identical.

Q: general section switch,

KM: circuit contactor-breaker,

(1) insulating connector bar for finding grounding faults

(2) available current:

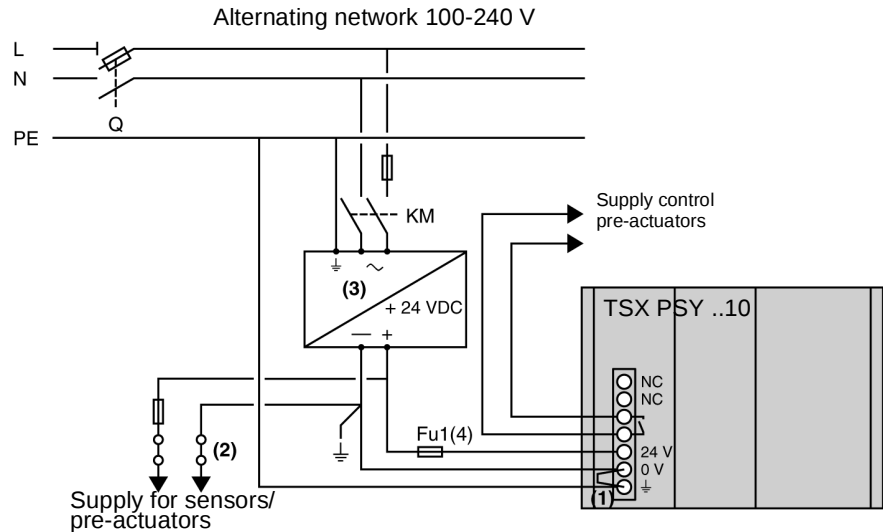
- 0.6 A with a PSY 2600 power supply module,
- 0.8 A with a PSY 5500 power supply module,
- 1.6 A with a PSY 8500 power supply module,

Note: Protective fuses: alternating current power supply modules PSY 2600/5500/8500 are fitted during manufacture with a protective fuse. This fuse, in series with the L input, is located inside the module and cannot be accessed.

Connecting direct current power supply modules from an alternating current network

Non-insulated power supply modules PSY 1610/3610

Connecting a single-rack PLC station with a ground-referenced network:



Q: General section switch,

KM: Circuit contactor-breaker,

(1): External shunt provided with the power supply module,

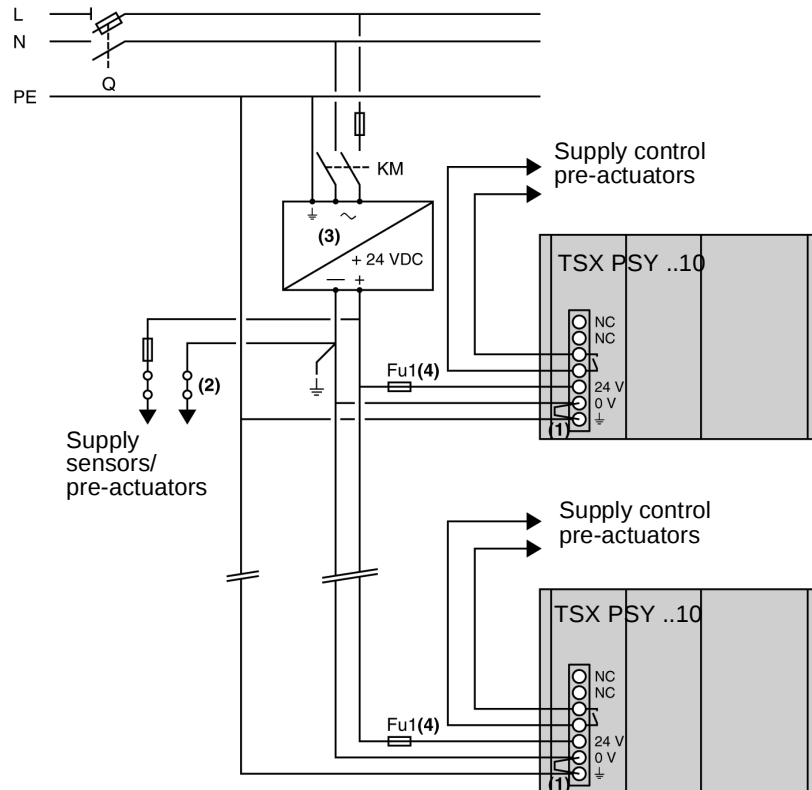
(2): Insulating connector bar for finding grounding faults. In this case, it is necessary to switch off the supply in order to disconnect the network from the ground,

(3): Optional use of a process power supply module,

(4): Protective fuse, (4 A, with time-delay) only necessary with the PSY 3610 power supply module.

The PSY 1610 power supply module is fitted during manufacture with a protective fuse located under the module and in series on the 24V input (3.5 A, 5x20 time-delay fuse).

Connecting a multi-rack PLC station with a ground-referenced network:
 Alternating network 100-240 V



Q: General section switch,

KM: Circuit contactor-breaker,

(1): External shunt provided with the power supply module,

(2): Insulating connector bar for finding grounding faults. In this case, it is necessary to switch off the supply in order to disconnect the network from the ground,

(3): Optional use of a process power supply module,

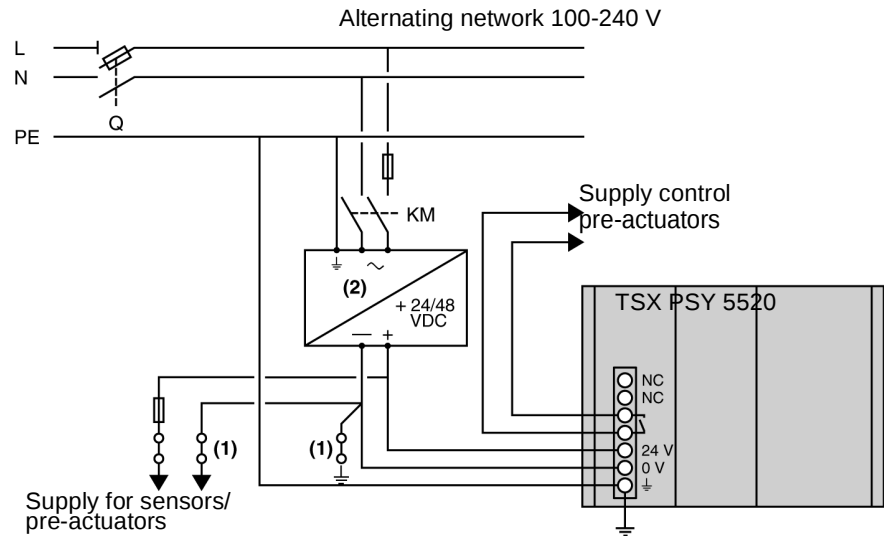
(4): Protective fuse, (4 A, with time-delay) only necessary with the PSY 3610 power supply module.

The PSY 1610 power supply module is fitted during manufacture with a protective fuse located under the module and in series on the 24V input (3.5 A, 5x20 time-delay fuse).

Note: If there are several PLC stations supplied by the same network, the principles of connection are identical.

**PSY 5520
isolated power
supply module**

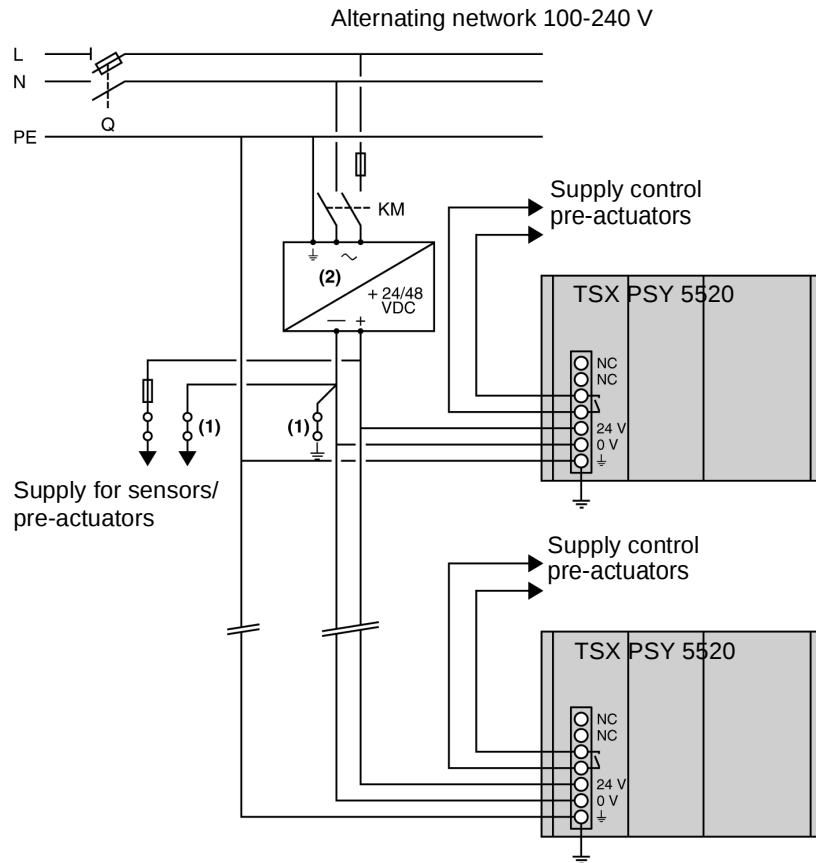
Connecting a single-rack PLC station with a ground-referenced network:



- Q: General section switch,
 KM: Circuit contactor-breaker,
 (1): Insulating connector bar for finding grounding faults,
 (2): Optional use of a process power supply.

Note: Protective fuse: the PSY 5520 power supply modules are fitted during manufacture with a protective fuse. This fuse, in series with the 24/48V input, is located inside the module and cannot be accessed.

Connecting a multi-rack PLC station with a ground-referenced network:



- Q: General section switch,
 KM: Circuit contactor-breaker,
 (1): Insulating connector bar for finding grounding faults,
 (2): Optional use of a process power supply.

Note: Protective fuse: the PSY 5520 power supply modules are fitted during manufacture with a protective fuse. This fuse, in series with the 24/48V input, is located inside the module and cannot be accessed.

Note: If there are several PLC stations supplied by the same network, the principles of connection are identical.

Power Supply for the Process and AS-i SUP

15

Overview

Introduction This section contains guidelines and information for the configuration and installation of the power supply for the Process and AS-i-Bus with regard to grounding and EMC.

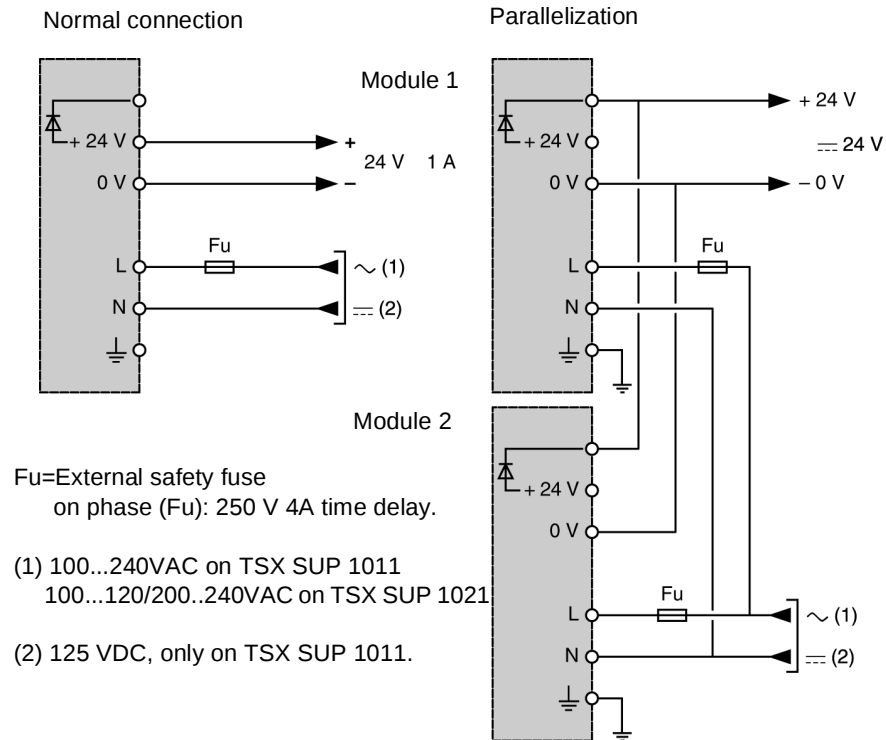
What's in this Chapter? This chapter contains the following topics:

Topic	Page
Connection of SUP 1011/1021 power supplies	204
Connection of SUP 1051 power supplies	206
Connection of SUP 1101 power supplies	208
Connection of SUP A02 power supply modules	211
Connecting SUP A05 supply modules	213
General precautions	217

Connection of SUP 1011/1021 power supplies

Illustration

Connection diagram:



Connection rules **Primary:** if the module is supplied with a 100/240V AC power supply, it is necessary to observe wiring requirements for the phase and neutral when connecting the module. However, if the module is powered by a 125 VDC supply, it is not necessary to respect the polarities.

- an operating voltage ≥ 600 V AC with a cross-section of 1.5 mm^2 for connection to the mains,

	DANGER
	Safety of personnel
	To ensure the safety of personnel, the ground terminal of the module must be connected to the protective earth using a green/yellow wire. Failure to follow this precaution will result in death, serious injury, or equipment damage.

The power supply terminal is protected by a flap which allows access to the wiring terminals. The wires come vertically out of the power supply at its base. These wires can be kept in place with a cable-clip.

Secondary: to comply with isolation requirements for a 24 V SELV isolated voltage, the following wiring is used:

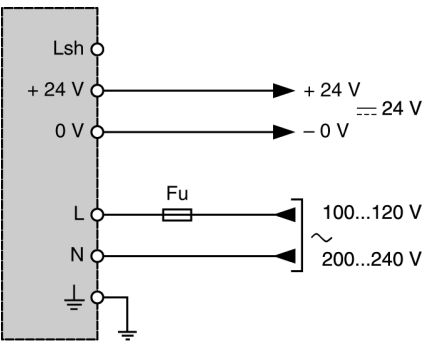
- an operating voltage ≥ 300 V AC with a cross-section of 2.5 mm^2 for the 24 V outputs and the ground.

Connection of SUP 1051 power supplies

Illustration

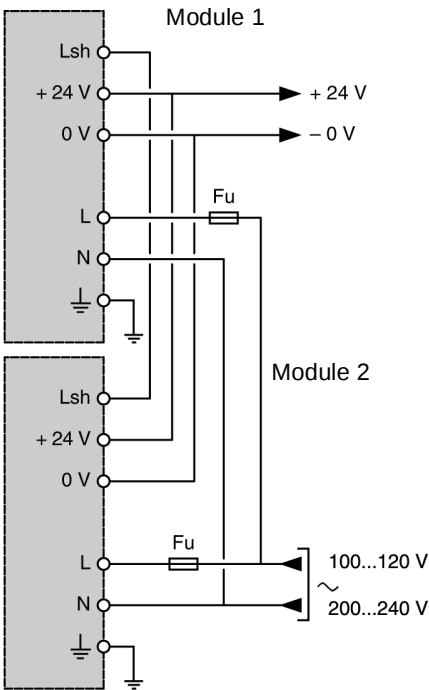
Connection diagram:

Normal connection



Fu=External safety fuse on phase
(Fu): 250V 4A time delay

Parallelization



Connection rules **Primary:** observe the rules concerning phase and neutral when wiring.

- an operating voltage ≥ 600 VAC with a cross-section of 1.5 mm^2 for connection to the mains,

	DANGER
	Safety of personnel
	To ensure the safety of personnel, the ground terminal of the module must be connected to the protective earth using a green/yellow wire. Failure to follow this precaution will result in death, serious injury, or equipment damage.

The power supply terminal is protected by a flap which allows access to the wiring terminals. The wires come vertically out of the power supply at its base. These wires can be kept in place with a cable-clip.

Secondary: to comply with isolation requirements for a 24 V SELV isolated voltage, the following wiring is used:

- an operating voltage ≥ 300 V AC with a cross-section of 2.5 mm^2 for the 24 V outputs and the ground.

Connection of SUP 1101 power supplies

Illustration 1

Normal connection diagram:

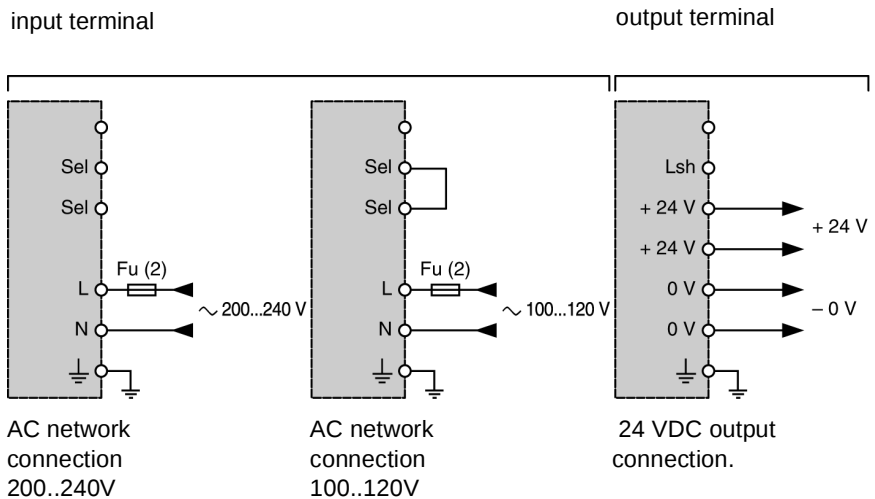
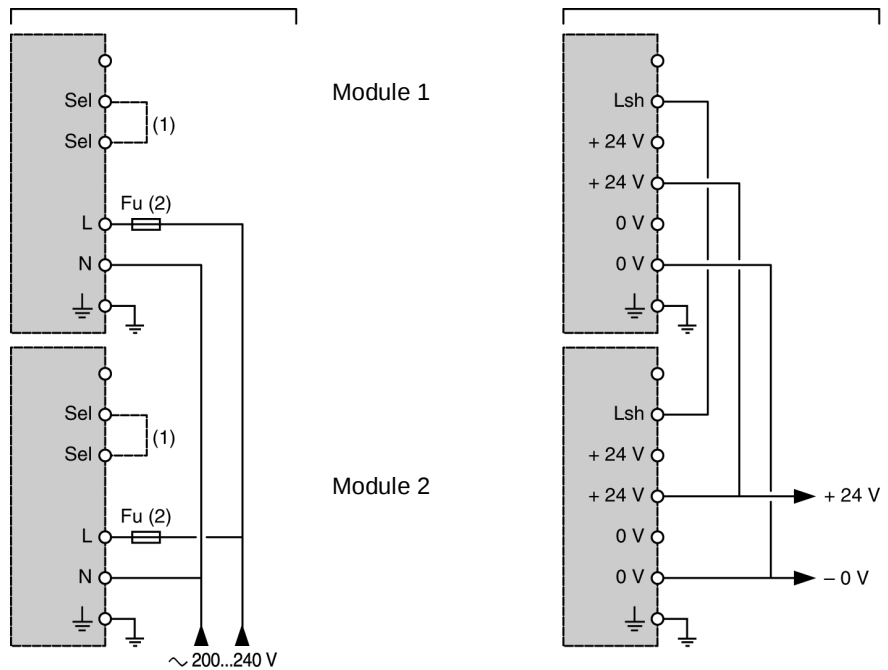


Illustration 2

Parallel connection diagram (parallelization):
input terminals

output terminals



(1) Connection for a 100...120 VAC power supply.

(2) External safety fuse on phase (Fu): 250 V 6.3A time delay.

- Connection rules** **Primary:** Observe the rules concerning phase and neutral when wiring.
- an operating voltage $\geq 600\text{ V AC}$ with a cross-section of 1.5mm^2 or 2.5mm^2 for connection to the mains,

	DANGER
	Safety of personnel
	To ensure the safety of personnel, the ground terminal of the module must be connected to the protective earth using a green/yellow wire. Failure to follow this precaution will result in death, serious injury, or equipment damage.

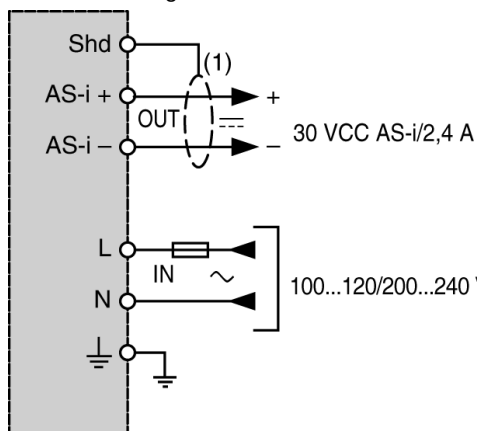
The power supply terminal is protected by a flap which allows access to the wiring terminals. The wires come vertically out of the power supply at its base. These wires can be kept in place with a cable-clip.

- Secondary:** To comply with isolation requirements for a 24 V SELV isolated voltage, the following wiring is used:
- an operating voltage $\geq 300\text{ V AC}$ with a cross-section of 2.5 mm^2 for the 24 V outputs and the ground.
 - Wire the two 24V terminals in parallel, or distribute the load over the two 24V outputs when the total current to be supplied is greater than 5A.
-

Connection of SUP A02 power supply modules

Illustration

Connection diagram:

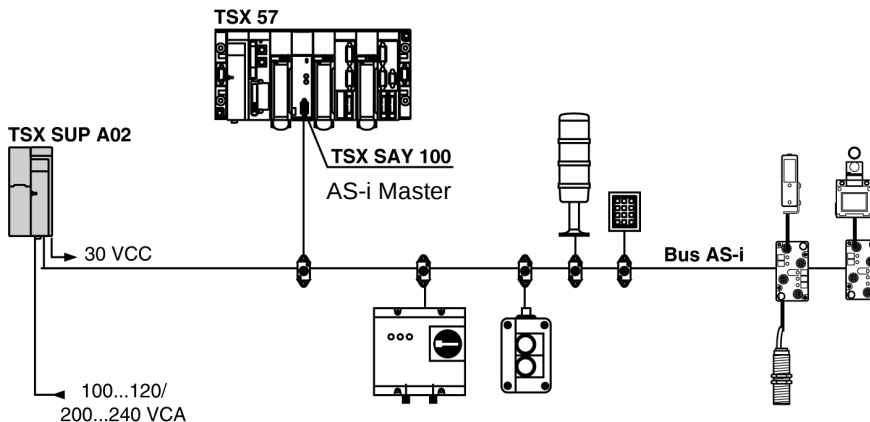


(1) Shielded AS-i cable screen if environment is disturbed.

Fu=External safety fuse on phase (Fu): 250 V 4A time delay.

Connection synoptic

The SUP A02 power supply module is designed to supply the AS-i bus, and the connected slaves (30 VDC/2.4A).



Connection rules **Primary:** observe the rules concerning phase and neutral when wiring.

	DANGER
	Safety of personnel To ensure the safety of personnel, the ground terminal of the module must be connected to the protective earth using a green/yellow wire. Failure to follow this precaution will result in death, serious injury, or equipment damage.

The power supply terminal is protected by a flap which allows access to the wiring terminals. The wires come vertically out of the power supply at its base. These wires can be kept in place with a cable-clip.

To comply with isolation requirements for a 24 V SELV isolated voltage, the following wiring is used:

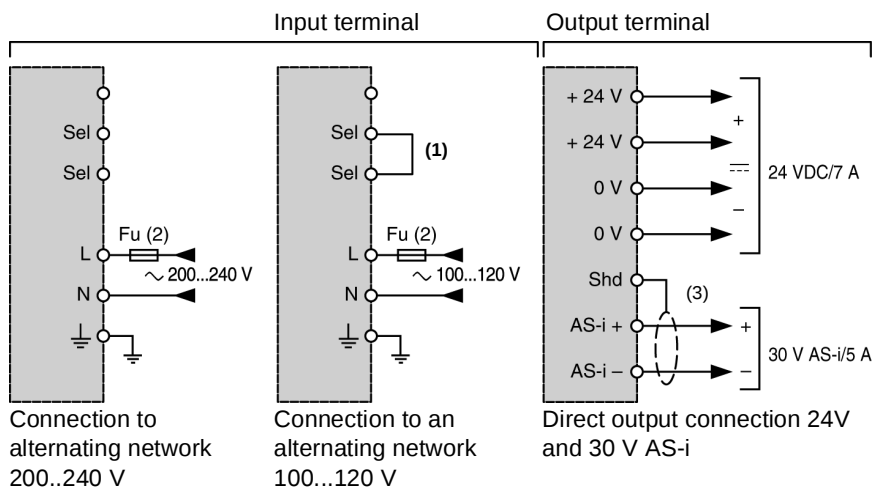
- an operating voltage ≥ 600 VAC with a cross-section of 1.5 mm^2 for connection to the mains,
- an operating voltage ≥ 300 VAC with a cross-section of 2.5 mm^2 for the 24 V outputs and the ground.

It is necessary to use a shielded cable for the AS-i bus only in cases where the installation is subject to very high levels of disturbance in terms of EMC (Electro Magnetic Compatibility).

Connecting SUP A05 supply modules

Illustration

Connection diagram:



(1) Connection if supply is from 100/120V alternating current network.

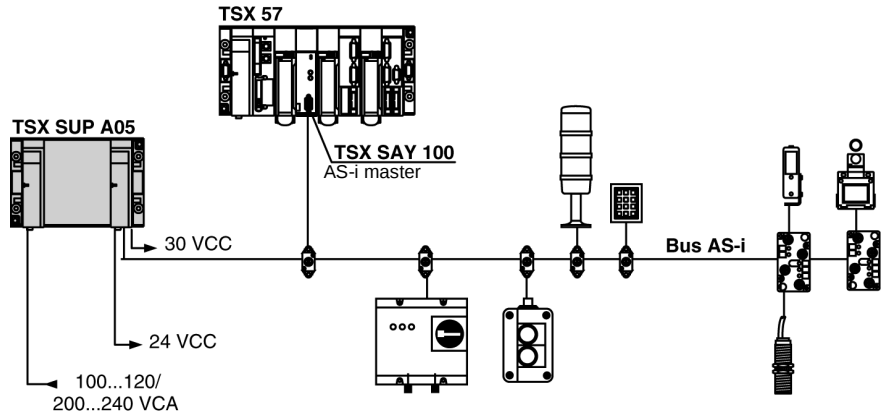
(2) External protection fuse on phase (Fu): 6.3A time delay 250 V.

(3) Shielded AS-i cable screen in case of disrupted surroundings.

**Connection
overview**

The SUP A05 supply module is designed to supply the AS-i bus, including the slaves which are connected to it (30V/5A output). It also has an auxiliary supply (24 VDC/7A) for sensors/actuators which consume large amounts of current. For this, a black AS-i ribbon cable is used.

Principle diagram:



Rules of connection

Primary: observe the rules concerning phase and neutral when wiring.

- an operating voltage ≥ 600 V AC with a cross-section of 1.5mm^2 or 2.5mm^2 for connection to the mains,

	DANGER
	Safety of personnel
	For personnel safety, the module ground terminal must be connected to the protective ground with a green/yellow wire. Failure to follow this precaution will result in death, serious injury, or equipment damage.

The "AC power supply network" and "24V and 30 V DC output" AS-i terminals are protected by a flap allowing access to the wiring terminals. The wires come vertically out of the power supply at its base. These wires can be kept in place with a cable-clip.

Secondary: to comply with isolation requirements for a 24 V SELV isolated voltage, the following wiring is used:

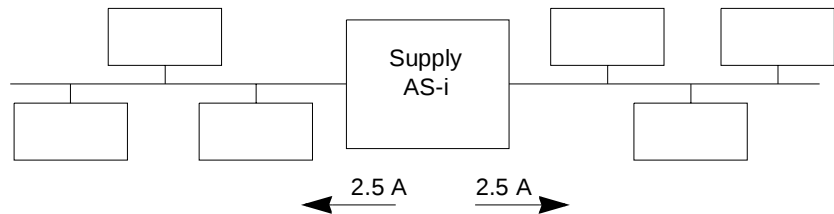
- an operating voltage ≥ 300 V AC with a cross-section of 2.5mm^2 for the 24 V outputs and the ground,
- connect the two 24V terminals in parallel, or distribute the load over the two 24V outputs when the total current to be provided is greater than 5A.

Using a shielded cable for the AS-i bus is only necessary if the installation is overly disrupted in terms of EMC (Electro Magnetic Compatibility).

Given the large current that this supply module provides, its position on the bus is very important.

If the supply module is placed at one of the ends of the bus, it will provide a nominal current (e.g. 5A) for the whole bus. The fall in voltage at the end of the bus is therefore proportional to the 5A.

If it is positioned in the middle of the bus, the voltage drop at the ends is proportional to only 2.5A, assuming that the consumption for both sections of the bus is the same.



If there is no slave which consumes large amounts of power, it would be better to place the supply module in the middle of the installation. Conversely, if the installation has one or several large power consumers, it would be wise to place the supply module close to them.

Note: Where there are large power consumer actuators (contactor, solenoid coils etc.) the SUP A05 supply module can provide the auxiliary 24 VDC, insulated from the AS-i line.

General precautions

Introduction

While installing the yellow AS-i cable, it is essential to place it in a cable track which is separate from the power cables. It is also advisable to place it flat and not twisted. This will help make the two AS-i cable wires as symmetrical as possible. Installing the AS-i cable on a surface connected to the electric potential of the machine (for example, the housing) complies with the requirements of the EMC (Electro Magnetic Compatibility) directive.

The end of the cable, or the ends in the case of a bus with a star-formation, must be protected either:

- by connecting it (them) to a T-derivation,
 - by not allowing them to come out of their last connection point.
-

Important

It is important to distribute power effectively on the AS-i bus, so that each device on the bus is supplied with sufficient voltage to enable it to operate properly. To do this, certain rules must be followed.

Rule 1

Select the caliber of the supply module adapted to the total consumption of the AS-i segment. Available calibers are 2.4A (SUP A02) and 5A (SUP A05). A caliber of 2.4A is generally sufficient based on an average consumption of 65mA per slave for a segment made up of a maximum of 31 slaves.

Rule 2

To minimize the effect of voltage falls and reduce the cost of the cable, you must determine the best position of the supply module on the bus, as well as the minimum size of cable appropriate for distributing power. The voltage fall between the master and the last slave on the bus must not exceed 3V. For that purpose, the table below gives the essential points for selecting the cross-sectional measurement of the AS-i cable.

Table of characteristics:

Cross-section measurement of AS-i cable	0.75 mm ²	1.5 mm ²	2.5 mm ²
Linear resistance	52 milli Ohms/meter	27 milli Ohms/meter	16 milli Ohms/meter
Voltage fall for 1A over 100 meters	5.2V	2.7V	1.6V

The cable which can be used for most applications is the cable with a cross-section of 1.5 mm². This is the standard AS-i bus model (the cable is offered in the SCHNEIDER catalog). Smaller cables can be used when sensors consume very little power.

Note: The maximum length of all the segments making up the AS-i bus without a relay is 100 meters. The lengths of cables which link a slave to a passive distribution box must be taken into account.

Overview

Introduction This section contains guidelines and information for the configuration and installation of the Premium hardware discrete I/O modules with regard to grounding and EMC.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Choice of direct current power supply for sensors and pre-actuators associated with Discrete I/O modules.	220
Precautions and general rules for wiring with Discrete I/O modules	221
Means of connecting Discrete I/O modules: connecting HE10 connector modules	225
Means of connecting Discrete I/O modules: connecting screw terminal block modules	227
Ways of connecting discrete I/O modules: connecting modules to TELEFAST interfaces using an HE10 connector	228

Choice of direct current power supply for sensors and pre-actuators associated with Discrete I/O modules.

At a Glance

The following is a presentation of precautions for choosing sensors and pre-actuators associated with Discrete I/O modules.

External direct current power supplies

When using an external 24 VDC direct current power supply, it is advised to use either:

- regulated power supplies;
- non-regulated power supplies but with the following filtering:
 - 1000 microF/A with full-wave single phase rectification and 500 microF/A with tri-phase rectification;
 - 5% maximum peak to peak ripple;
 - maximum voltage variation: -20% to +25% of the nominal voltage (including ripple).

Note: Rectified power supplies with no filtering are prohibited.

Ni-Cad battery power supplies

This type of power supply can be used to power sensors and pre-actuators and all associated I/Os that have a normal operating voltage of 30 VDC maximum. While being charged, this type of battery can reach, for a duration of one hour, a voltage of 34 VDC. For this reason, all I/O modules with an operating voltage of 24 VDC can withstand this voltage (34 VDC) for up to one hour every 24 hours. This type of operation entails the following restrictions:

- at 34 VDC, the maximum current withstood by the outputs must under no circumstances exceed the maximum current defined for a voltage of 30 VDC;
 - temperature downgrading imposing the following restrictions:
 - 80% of I/Os at 1 at up to 30°C;
 - 50% of I/Os at 1 to 60°C.
-

Precautions and general rules for wiring with Discrete I/O modules

At a Glance

The Discrete I/Os feature protective measures which ensure a high resistance to industrial environmental conditions. Certain rules, shown below, must nevertheless be respected.

External power supplies for sensors and pre-actuators.

External sensor and pre-actuator power supplies associated with Discrete I/O modules must be protected against short circuits and overloads by quick-blow fuses.

For **HE10** connector Discrete I/O modules, the sensor/pre-actuator power supply must be linked to each connector, except in the event where the corresponding channels are not in use and are not assigned to any task.

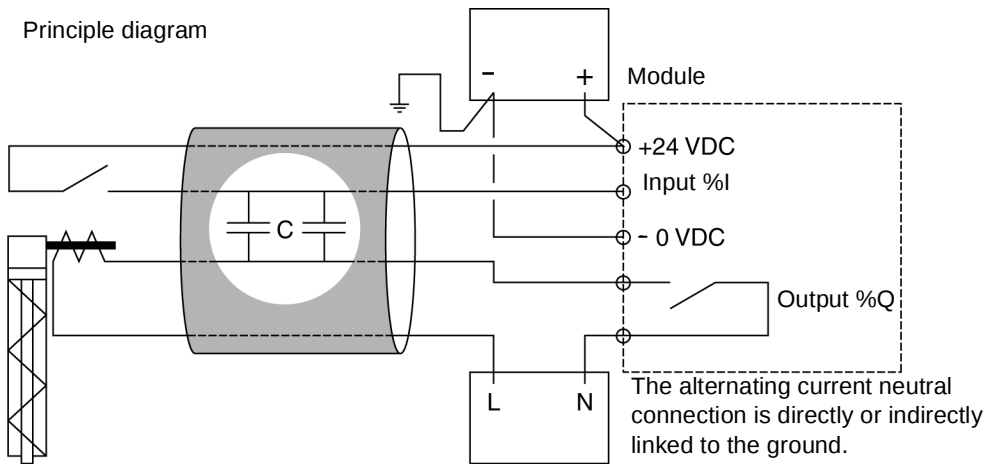
Note: if an I/O module with screw block terminals or HE10 connector is present in the PLC, the sensor/pre-actuator voltage must be connected to the module; otherwise an "external supply" error is signaled and the I/O LED comes on. In the event that the 24 VDC installation is not carried out according to SELV (safety extra low voltage) standards, the 24 VDC power supplies must have the 0V linked to mechanical ground, which is in turn linked to the ground as close as possible to the power supply. This restriction is necessary for personnel safety in the event of a power phase coming into contact with the 24 VDC supply.

Inputs

Recommendations for use concerning Discrete I/O module inputs are as follows:

- for fast input modules (**DEY 16 FK/DMY 28FK/DMY 28RFK**):
 - in the event that 24 VDC direct current inputs are used, it is recommended to adapt the filtering time to the required function;
 - in order for bounces not to be taken into account upon closure of contacts, it is not advisable to use sensors with mechanical contact outputs if the filtering time is reduced to under 3 ms;
 - for faster operation, the use of direct current inputs and sensors is recommended, as alternating current inputs have a much higher response time.
- for 24 VDC inputs and line coupling with an alternating current network:
 - operation can be disturbed if the coupling between cables relaying an alternating current and cables relaying signals intended for direct current inputs is too large. This is illustrated in the following circuit diagram. When the

Principle diagram



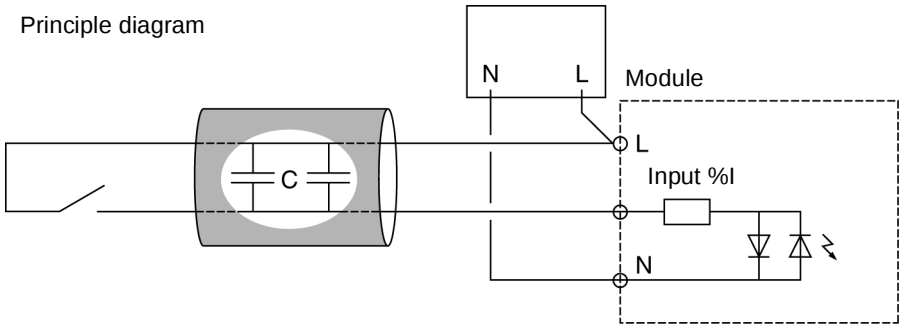
input contact is open, an alternating current exceeding the cable's interference capacities may generate a current in the input which might cause it to be set to 1.

- the line capacity values that must not be exceeded, for a 240 VCA/50 Hz line coupling, are given in the summary table at the end of this paragraph. For a coupling with a different voltage, the following formula can be applied:

$$\text{Acceptable capacity} = (\text{Capacity at 240 VAC} \times 240) / \text{line voltage}$$
- for 24 to 240 VAC inputs and line coupling:

- In this case, when the line that controls the input is open, the current passes according to the coupling capacity of the cable (see circuit diagram below).

Principle diagram



- the line capacity values that must not be exceeded are given in the summary table at the end of this paragraph.

The summary table below shows the acceptable line capacity values.

Module	Maximum coupling capacity
24 VDC inputs	
DEY 32 / DEY 64D2K	25 nF (1)
DEY 16D2	45 nF (1)
DEY 16FK / DMY 28FK / DMY 28RFX	10 nF (1) (2) 30 nF (1) (3) 60 nF (1) (4)
24 to 240 VAC inputs	
DEY 16A2	50 nF
DEY 16A3	60 nF
DEY 16A4	70 nF
DEY 16A5	85 nF
Legend	
(1)	Max. admissible coupling capacity with 240 VAC / 50 Hz line
(2)	Filtering = 0.1 ms
(3)	Filtering = 3.5 ms
(4)	Filtering = 7.5 ms

Outputs

Recommendations for use concerning Discrete I/O module outputs are as follows:

- it is recommended to segment starts, protecting each one with a quick-blow fuse, if currents are high;
 - wires of a sufficient diameter should be used to avoid drops in voltage and overheating.
-

Cable routing

Precautions for use to be taken concerning the wiring system are as follows:

- in order to reduce the number of alternating couplings, power circuit cables (power supplies, power switches, etc.) must be separated from input cables (sensors) and output cables (pre-actuators) both inside and outside the equipment.
 - outside the equipment, cables leading to inputs / outputs should be placed in covers that make them easily distinguishable from those containing wires relaying high energy levels. They should also be placed preferably in separate grounded metal cableways. These various cables must be routed at least 100 mm apart.
-

Means of connecting Discrete I/O modules: connecting HE10 connector modules

At a Glance

HE10 connector modules are connected to sensors, pre-actuators or terminal blocks using a pre-formed cable designed to allow the smooth and direct transition of module inputs/outputs from wire to wire.

Pre-formed cable CDP 301 / 501

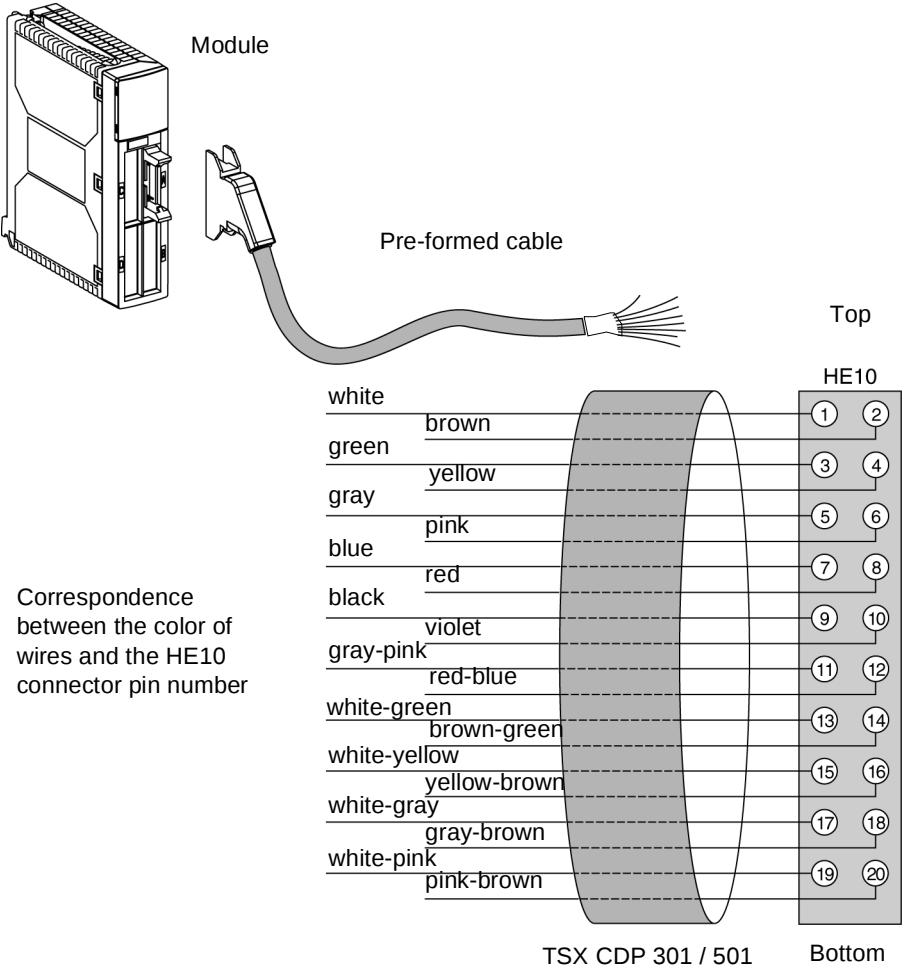
The 3 meter long **CDP 301** or 5 meter long **CDP 501** pre-formed cables are made up of:

- a molded **HE10** connector at one end with 20 protruding sheathed wires with a cross-section of 0.34 mm²;
- free wires at the other end, differentiated by a color code complying with DIN 47100.

Note: A nylon thread built into the cable allows easy-stripping of the sheath.

Note: HE10 connectors must be engaged or disengaged with sensor and pre-actuator voltage switched off.
--

The diagram below shows the connection of the pre-formed cable to the module.



Note: The maximum torque setting for tightening **CDP •** cable connector screws is 0.5 N.m

Means of connecting Discrete I/O modules: connecting screw terminal block modules

At a Glance

Discrete I/O module terminal blocks feature an automatic code transfer device activated on first use. This allows fitting errors to be avoided when replacing a module. This coding guarantees electrical compatibility by module type.

Description of the screw terminal block

Every terminal block can receive bare wires or wires with terminations or spade terminals.

The capacity of each terminal is:

- minimum: 1 x 0.2 mm² wire (AWG 24) without termination;
 - maximum: 1 x 2 mm² wire without termination or 1 x 1.5 mm² with termination.
- Illustration of the termination and the spade terminal.



(1) 5.5 mm maximum.

The maximum capacity of the terminal block is 16 x 1 mm² wires (AWG) + 4 x 1.5 mm² wires (AWG).

Screw clamps come with slots for the following types of screwdriver:

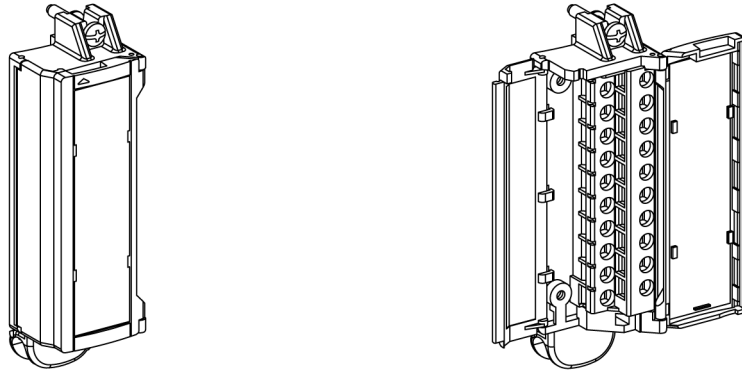
- Pozidriv No. 1;
- 5 mm diameter flat head.

Screw connection terminal blocks feature captive screws. On the supplied blocks, these screws are not tightened.

Note: The maximum torque setting for tightening connection terminal block screws is 0.8 N.m

Note: Screw terminal blocks must be engaged or disengaged with sensor and pre-actuator voltage switched off.

The diagram below shows the method for opening the screw terminal block door.



Ways of connecting discrete I/O modules: connecting modules to TELEFAST interfaces using an HE10 connector

At a Glance

Connecting discrete input/output modules to **TELEFAST** interfaces for connecting and adapting fast wiring **HE10** connectors, is done with the aid of:

- a 28 gage multi-stranded sheathed cable (0.08 mm^2);
- a 22 gage connection cable (0.34 mm^2).

CDP 102/202/302 connection cable

The 28 gage connection cable (0.08 mm^2) comes in three different lengths:

- 3 ft 3.4 in length: **CDP 102**;
- 6 ft 6.8 in length: **CDP 202**;
- 9 ft 10.2 in length: **CDP 302**.

This cable is made up of 2 **HE10** connectors and a multi-stranded sheathed ribbon cable, where each wire has a cross-section area of 0.08 mm^2 .

Given the small area of each of the wires, you are advised to only use it for low current inputs or outputs ($< 100 \text{ mA}$ per input or output).

**CDP 053/103/203/
303 /503
connection cable**

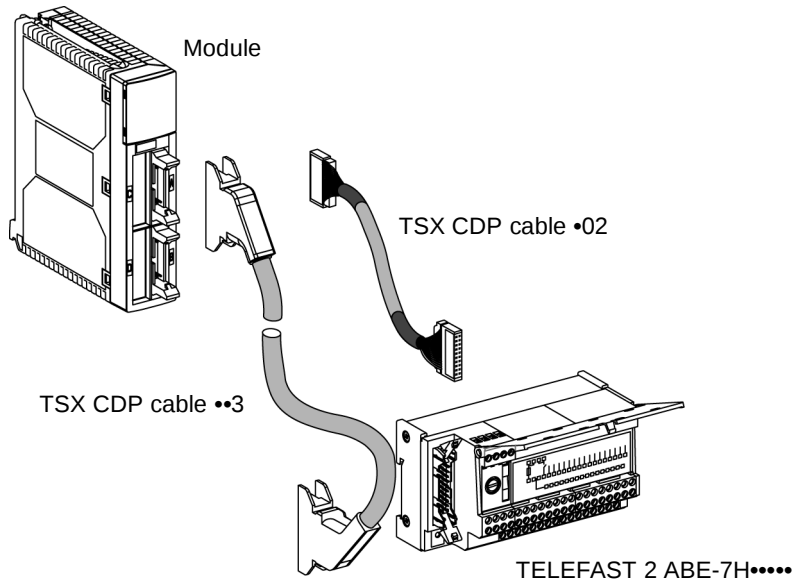
The 22 gage connection cable (0.34 mm^2) comes in five different lengths:

- 1 ft 7.7 in length: **CDP 053**;
- 3 ft 3.4 in length: **CDP 103**;
- 6 ft 6.8 in length: **CDP 203**;
- 9 ft 10.2 in length: **CDP 303**;
- 16 ft 5 in length: **CDP 503**.

This cable is made up of 2 sheathed **HE10** connectors, and a cable with a cross-section of 0.34 mm^2 , which can take higher currents ($> 500 \text{ mA}$).

Illustration

The illustration below shows the two types of connection to the **TELEFAST** interface via multi-strand cable or other cable.



Note: Check the consistency between the rating of the fuse on board the TELEFAST 2 and the fuse which is to be used on the inputs/outputs (see Connecting modules).

Overview

Introduction This section contains guidelines and information for the configuration and installation of the Premium hardware safety modules with regard to grounding and EMC.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
General description of safety modules	232
Wiring precautions	233
Cable dimensions and lengths	234

General description of safety modules

General

The **TSX PAY 2•2** safety modules and their accessories **TSX CPP 301/-02** and **TELEFAST 2 ABE-7CPA13** are used to interrupt one or several category 0 safety or emergency stop control circuits (safety components) in complete safety. The entire safety system is compliant with European standards EN 418 for emergency stops and EN 60204-1 for safety circuits.

These modules also comply with safety requirements regarding the electrical monitoring of position switches activated by protection devices.

The **TSX PAY 2•2** safety modules provide:

- A safety system designed to control the emergency stop circuits of machines in complete safety. The modules are equipped with a wired logic safety block for monitoring emergency stops.
- Full diagnostics of the safety system readable from the status of the position switches and push-buttons of the emergency stop input sequence, the reactivation input, the feedback loop, the control of both output circuits, and the safety system power supply status. All this information is sent to the PLC's CPU in the form of 28-bit Discrete inputs.

Note: The PLC has no effect on the safety modules, and the safety system section is connected to an external power supply.
--

Wiring precautions

General

The safety system must be wired in accordance with EN60204-1. This section gives a description of the rules for 'wiring and mechanically protecting cables.

The 'entire safety system, the ES PBs or PSs, TSX PAY 2•2 modules, protection fuses and auxiliary relays are incorporated in housings with an IP54 minimum protection index as per EN954-1.

Grounding

The module has no grounding terminal on its front panel. Depending on the TSX CPP •02 cable being used, the 0 VDC can be grounded (cf. EN60204-1) directly via the TELEFAST ABE-CPA13.

Note: The TSX CPP 301 cable has no ground connection.

Protection of safety system

Errors within the safety modules can be propagated to the 'outside of the module, particularly to the 'external supply in use: short circuits within the module can cause a supply voltage avalanche 'or a supply malfunction if it is 'not protected. This is why a 1 A (gL) quick-blow fuse ' is placed in the control section of the relays, given that maximum consumption is 200 mA.

Note: This fuse, called F1, is an active element of the safety system.

The module also contains a 'current limiting device set to 750 mA in order to detect inter-channel short circuits on the ES PBs or PSs. The external supply is protected' in the event of this happening, and an error is indicated on the safety system.

In order to guarantee the safety function, it is compulsory 'to use the following:

- On input
 - double contact ES PBs or PSs,
 - the NF contacts of the guided-contact auxiliary relays in the feedback loop,
 - On output
 - two or four guided-contact auxiliary relays,
 - a 4 A gL output protection fuse F2,
 - On the external 'module supply: a 1 A (gL) protection fuse F1.
-

Protection of safety outputs

Output voltages can reach ' 230 VAC or 127 VDC.

Outputs are not protected inside the 'module, though GMOV-type (for a continual load), or RC cell-type (for an alternating load) protection is applied directly to the terminals of the load in use. These protective measures must be adapted to the load.

The 'use of guided-contact auxiliary relays and the feedback loop wiring then make it possible to detect a safety output short circuit.

A 4 A (gL) quick-blow fuse is located in the auxiliary supply circuit 'to protect the module's safety relay contacts and the connected loads: this fuse is identical to that used in PREVENTA modules.

The fuse F2, located on the safety outputs, provides protection against short circuits and overloads. This protection avoids the melting of the safety relay contacts in TSX PAY 2•2 modules.

Cable dimensions and lengths

General points

The length of safety system wires can cause a drop in supply voltage related to the current circulating. This voltage drop is due to sum of the currents circulating on the 0 VDC feedback path of the electrical circuit. It is usual practice to double or triple the 0 VDC wires.

In order to ensure the correct operation of the safety system (reactivation of relays) and a correct reading of diagnostic information, it is important that the voltage measured between terminals A1 and A2 be greater than 19.2 V.

Cross-section of TELEFAST cables

Each TELEFAST ABE-7CPA13 terminal accepts bare wires or ones fitted with terminations, or spade or eye terminals.

The capacity of each terminal is:

- minimum: 1 x 0.28 mm² wire without termination,
- maximum: 2 x 1 mm² wires or 1 x 1.5 mm² wire with termination.

The maximum cross-section dimensions for wires on the terminal block are:

1 x 2.5 mm² wire without termination.

Calculation of cable length

The resistance of each safety system ((+) channel and (-) channel) must not exceed 75 Ohms. The maximum resistance of the channel between an ES PB or PS and the corresponding input of the module must be $\leq 6 \Omega$.

Given the length and cross-section of the cable, its resistance can be calculated as

$$R = \rho \cdot \frac{l}{S}$$

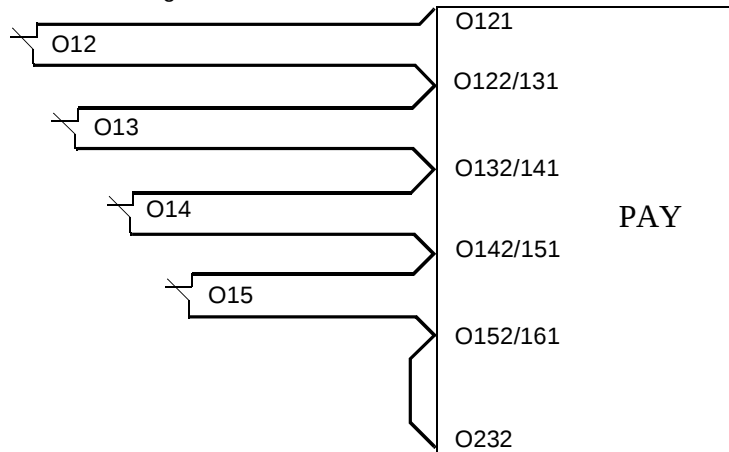
follows:

Equation parameter

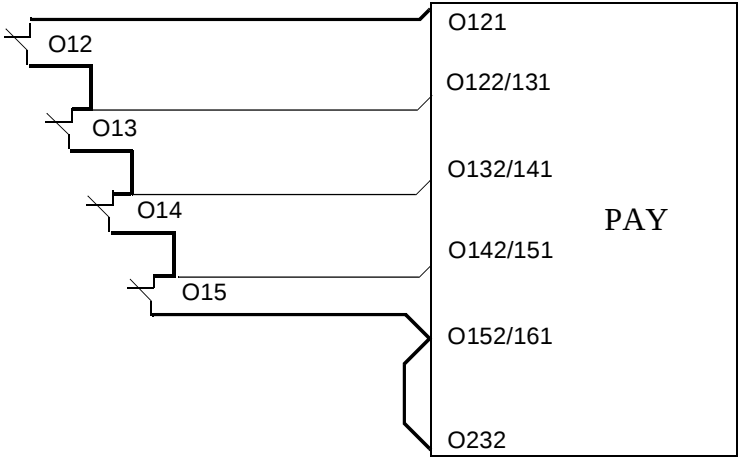
Parameter	Meaning
R	Cable resistance in Ohms
ρ	Resistivity: $1.78 \times 10^{-8} \Omega \cdot m$ for copper
l	Cable length in m
S	Cross-section in m^2

It is possible to wire the system so as to allow a greater distance between the ES PBs or PSs and the module:

Standard wiring:



Optimized length wiring:



— : Length to be taken into account for calculation of the resistance.

Overview

Introduction This section contains guidelines and information for the configuration and installation of the Premium hardware counter modules with regard to grounding and EMC.

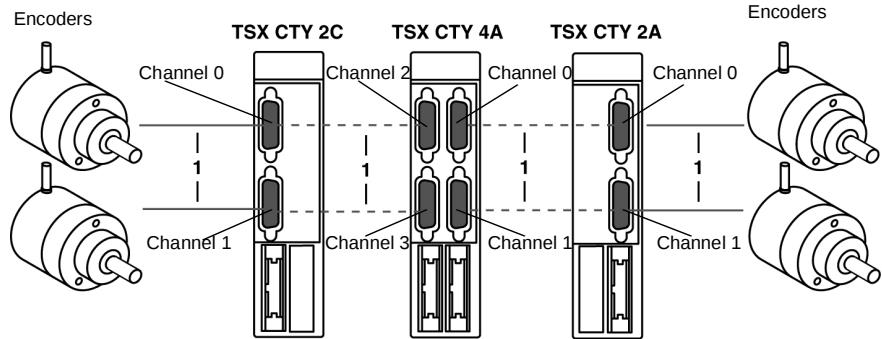
What's in this Chapter? This chapter contains the following topics:

Topic	Page
Process for connecting encoder count sensors	238
General rules for implementation	239
Connecting the encoder supply	241
Wiring precautions	242

Process for connecting encoder count sensors

Illustration

The CTY 4A module wiring is as follows. For a CTY 2A or CTY 2C module, only the elements related to channels 0 and 1 should be connected.



Description of the different connection elements

1 Process for connecting the encoder to the standard 15-pin SUB-D connector, located on the CTY 2A / 4A / 2C module. Given the various encoder types, it is your responsibility to carry out this connection, which consists of:

- a connector for linking to the encoder (determined by the connector on the encoder in use; normally a female 12-pin DIN connector),
- a standard male 15-pin SUB-D connector, to connect to the female 15-pin SUB-D connector on the CTY 2A/4A/2C module. This connector is available under reference CAP S15,
- a cable:
 - with twisted pairs (gauge 26) and shielding for an incremental encoder with standard RS 422 line transmitter outputs or an absolute encoder,
 - multi-conductor (gauge 24) with shielding for an incremental encoder with Totem Pole outputs.

The type of cable shielding should be "braid and foil". The cables should be completely supported to ensure the "braid and foil" is connected to the ground connection of each connector.

Connection of the cable to the two connectors can vary according to the type of encoder supply (5 VDC or 10...30 VDC) and the type of outputs (RS 422, Totem Pole). By way of an example, certain types of connection are described in the following pages.

General rules for implementation

Installation

Connecting or disconnecting the standard 15 pin SUB-D connectors of the CTY 2A/ 4A/ 2C modules to/from the encoder and sensor supplies present is not recommended as this may damage the encoder. Some encoders cannot withstand sudden and simultaneous signal and supply power-ups or outages.

General wiring instructions

Wire sections

Use wires of a satisfactory section to avoid drops in voltage (mainly with 5 V) and overheating.

Example of falls in voltage for encoders supplied with 5 V with a cable length of 100 meters:

Section of the wire	Encoder consumption			
	50 mA	100 mA	150 mA	200 mA
0.08 mm ² (gauge 28)	1.1 V	2.2 V	3.3 V	4.4 V
0.12 mm ² (gauge 26)	-	1.4 V	-	-
0.22 mm ² (gauge 24)	-	0.8 V	-	-
0.34 mm ² (gauge 22)	0.25 V	0.5 V	0.75 V	1 V
0.5 mm ²	0.17 V	0.34 V	0.51 V	0.68 V
1 mm ²	0.09 V	0.17 V	0.24 V	0.34 V

Connection cable

All cables carrying the sensor supply (encoders, proximity sensor etc.) and the counting signals must:

- be at a distance from high voltage cables,
- be shielded with the shielding , which is linked to the protective ground connection on both the PLC and encoder side,
- never carry signals other than counting signals and supplies relating to counting sensors.

The connection cable between the module and encoder should be as short as possible to avoid creating loops, as the circuit capacities can interfere with operation.

Note: If necessary, direct the flow of the signal in the same cable as the supplies. Cables with twisted pairs should preferably be used for this.

**Encoder and
auxiliary sensor
supply**

Encoder supply

This must:

- be reserved exclusively for supplying the encoder to avoid parasitic pulses which could interfere with the encoders, whose electronics are sensitive,
- be placed as close to the TELEFAST 2 base as possible to reduce drops in voltage and coupling with other cables,
- be protected against short circuits and overloads by fast blow fuses,
- work well independently to avoid micro-power outages.

Auxiliary sensor supply

Refer to the general regulations for implementing discrete modules.

Note: The – 0 VDC polarity of the auxiliary encoder and sensor supplies should be grounded as near to the supplies as possible.

The shielding of the cables carrying the voltages should be grounded.

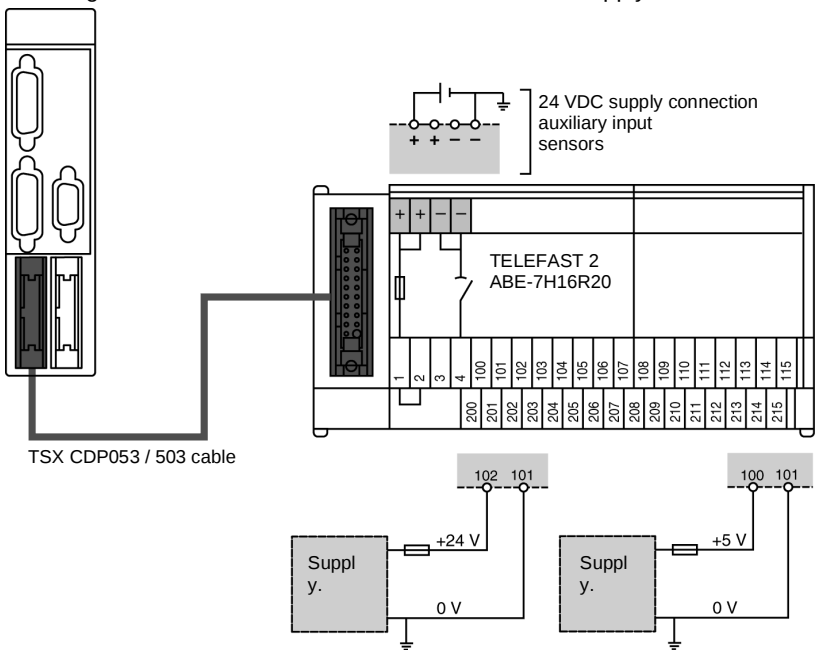
**Software
implementation**

Software implementation and the language objects assigned to the different counting functions are described in the "counting application" manual.

Connecting the encoder supply

Diagram of the principle

This diagram illustrates the connection of the encoder supply:



Cable length:

Cable	Length
CDP 053	0.5 m
CDP 103	1 m
CDP 203	2 m
CDP 303	3 m
CDP 503	5 m

Note: The maximum length of the wire between the supply outputs and the connection points on the TELEFAST should be less than 0.5 m. Only one supply is required if the encoders on the two channels are of the same type.

Fuses

This module integrates several basic protection systems against wiring errors and accidental short circuits on the cable:

- polarity inversions of the supplies,
- inversion of 5 V supplies <--> 10/30 V,
- 10/30 V short circuit on the CLOCK signal of the serial link.

The module cannot tolerate them for very long time, it should therefore have very fast blow fuses. The fuses should therefore be "rapid" and of 1A caliber maximum. Supplies should have a limitation current, such that the blow of the fuse can be correctly executed.

Wiring precautions

General

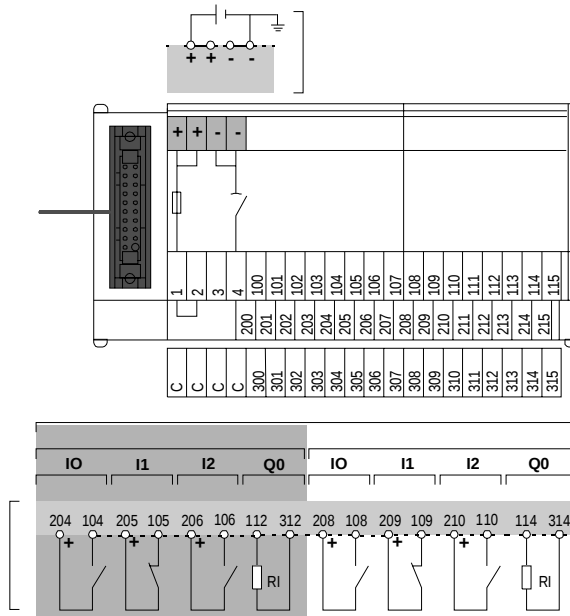
The I0, I1 and I3 inputs are rapid inputs, which should be connected to the sensor using either a twisted wire if it is a dry contact, or using shielded cables if it is a 2 or 3-wire proximity sensor.

The module integrates basic protection against short circuits or voltage inversions. However, the module cannot remain operational for long with an error. You must therefore ensure that the fuses in series with the supply carry out their protective function. These are 1A maximum non-delay fuses, the supply energy must be sufficient to ensure their fusion.

**Important note:
wiring of Q0
static outputs**

The actuator connected to the Q0 output has its shared point at 0 V of the supply. If for any reason (poor contact or accidental unplugging) there is a 0 V outage of the output amplifier supply, when the 0 V of the actuators remains connected to the 0 V supply, there may be enough mA output current from the amplifier to keep low-power actuators locked.

Illustration:



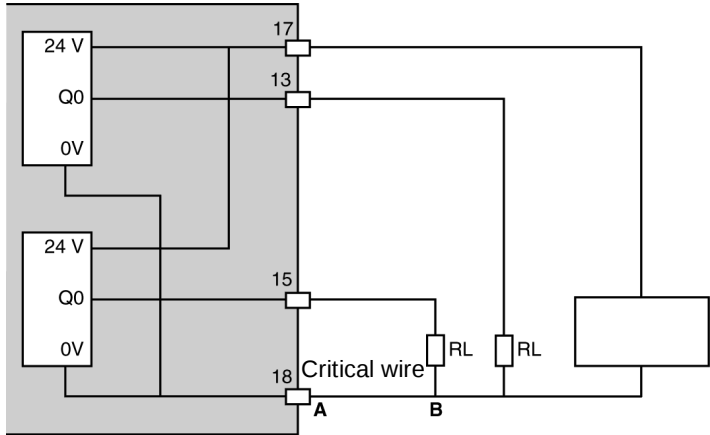
Connection via TELEFAST

This kind of connection provides the most guarantees, on condition that the shared actuators are connected to the bar for shared points 200 to 215 (jumper wire in position 1-2). In this case there can be no outage of the shared module without an outage of the shared actuators.

**Connection
using strips**

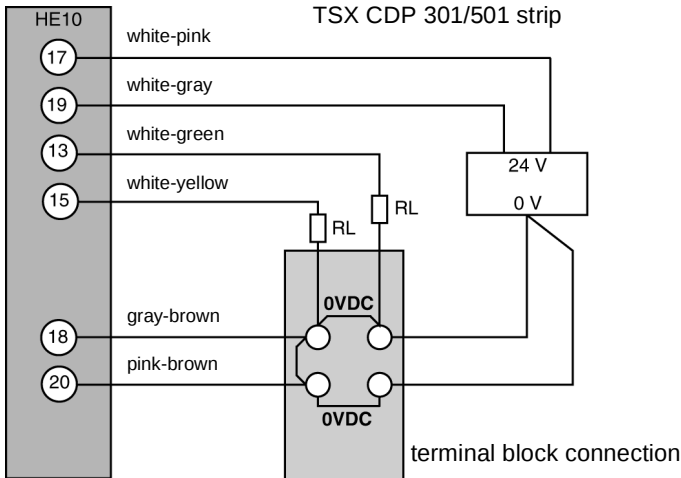
This kind of connection must be carried out with the highest care and attention. It is recommended that you take special care in wiring this cable, for example using cable markers on screw terminals. It may be necessary to double the connections in order to ensure permanent contacts. When the actuator supply is a long distance away from the modules and close to the shared actuators, there may be an accidental break in the link between the latter and the 0 V or modules terminal illustration:

TSX CAY 21/41



If there is a break of the supply section between A and B, there is a risk that the RL actuators may not remain operational. You must, if possible, double connections of 0 V supply to the modules.

Using CDP 301/501 strips:



General precautions for wiring

General

The supplies to sensors and actuators must be protected against overloading or excess voltage by non-delay fuses.

When wiring, use wires of a satisfactory size to avoid on-line drops in voltage and overheating,

Keep sensor and actuator cables away from any source of radiation resulting from high-power electric circuit switches.

All cables which link the incremental or absolute encoders must be shielded. The shielding should be good quality and linked to the protective ground connection on the side of the module and the side of the encoder. Continuity must be ensured throughout connections. Do not introduce any other signals than those of the encoders in the cable.

For reasons of performance, the auxiliary inputs of the module have a short response time. You must therefore make sure that the supply autonomy of these inputs is sufficient to ensure the module continues to operate correctly in the event of short power breaks. It is recommended that you use regulated supplies to ensure more reliable response times from the actuators and sensors. The 0 V supply must be linked to the protective ground connection as near to the supply output as possible.

Stepper Motor Control Modules

CFY

20

Overview

Introduction This section contains guidelines and information for the configuration and installation of the Premium hardware stepper motor control modules with regard to grounding and EMC.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
General precautions for wiring	248
Wiring precautions	248

General precautions for wiring

General

The power supply to sensors and actuators must be protected against overload or overvoltage by fast-blow fuses.

- when wiring use wires of sufficient size to avoid on-line voltage falls and overheating,
- keep sensor and actuator cables away from any source of radiation resulting from high-power electric circuit switching,
- all cables connecting the translators must be shielded, the shielding must be good quality and connected to the protective ground both for the module and the translator. Continuity must be ensured throughout connections. Do not transmit any other signals in the cable than those for the translators.

For reasons of performance the auxiliary inputs of the module have a short response time. You must therefore make sure that there is enough self-sufficient supply to these inputs to ensure the module continues to operate correctly in the event of a short power break. It is recommended that you use a regulated supply to ensure more reliable response times from the actuators and sensors. The 0 V supply must be connected to the protective ground nearest to the supply module output.

Wiring precautions

General

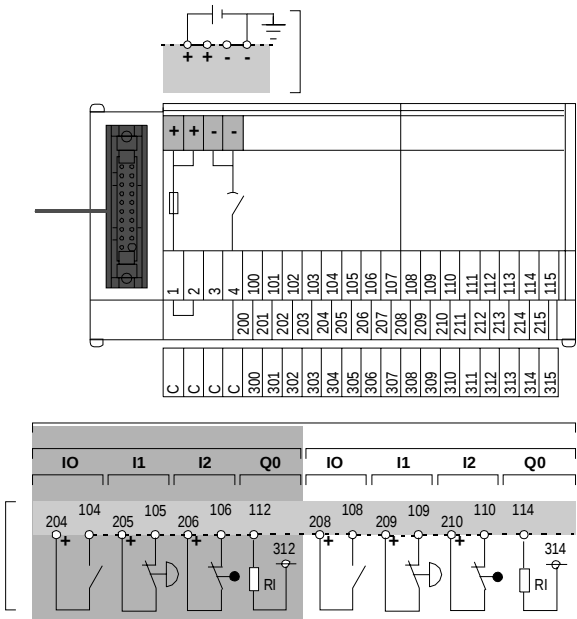
To ensure the best performance, inputs I0 to I5 are rapid inputs. If the actuator is a dry contact, the inputs must be connected by a twisted pair, or by a shielded cable if the sensor is a two or three-wire proximity detector.

The module includes as standard basic protection against short circuits or voltage inversions. However, the module cannot remain operational for long with an error. You must therefore ensure that the fuses in series with the supply carry out their protective function. These are 1A maximum fast-blow fuses, the supply energy must be sufficient to ensure their fusion.

Important note:
wiring of Q0
static outputs

The actuator connected to the Q0 brake output has its shared pin connected to supply 0 V. If for any reason there is a 0 V outage of the output amplifier supply (e.g. poor contact or accidental unplugging), when the 0 V of the actuators remains connected to the 0 V supply, there may be enough mA output current from the amplifier to keep low-power actuators triggered.

Illustration:



Connection via
TELEFAST

This kind of connection is the most guaranteed, on the condition that the shared actuators are connected to the 200 to 215 shared points strip (jumper wire in position 1-2). In this case there can be no outage of the shared module without an outage of the shared actuators.

Overview

Introduction This section contains guidelines and information for the configuration and installation of the Premium hardware electronic cam module CCY 1128 with regard to grounding and EMC.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Installation precautions for the CCY 1128	252
General wiring instructions	253
Selecting and protecting auxiliary power supplies	254
Choice of encoders for the CCY 1128	255
Connecting the encoder supply to the CCY 1128	257
Wiring rules and precautions specific to the TELEFAST	259

Installation precautions for the CCY 1128

Installation

In order to guarantee good working order, it is necessary to take certain precautions during its installation and removal, when plugging and unplugging the connectors on the front panel of the module, and when adjusting its fixing screws and the SUB D 15-pin connector.

Installing and removing the module

The module can be installed or removed without cutting the supply to the rack. The design of the module allows this action to be carried out with the power on in order to ensure the availability of the device.

Plugging and unplugging the connectors on the front panel of the module

It is not recommended that you plug in or unplug the connectors located at the front panel of the module when the sensor/pre-sensor supply is switched on.

Reasons:

- the encoders will not tolerate a simultaneous start-up or outage of the signals and supplies.
 - The track outputs can become damaged if they are in state 1 and connected to an inductive supply
-

Adjusting the screws and locking the HE10 connectors in place

In order to ensure good electrical contact between the devices and by doing so create effective resistance to electrostatic and electromagnetic interference:

- the fixing screws on the module and the SUB D 15-pin connector must be correctly screwed in.
 - tightening on the module's fixing screw: 2.0 N.m
 - tightening on the SUB D 15-pin connector's fixing screw: 0.5 N.m
 - The HE10 connectors must be correctly locked.
-

General wiring instructions

Introduction	In order to guarantee that the automatism operates correctly, it is necessary to respect some basic rules.
Section of wires used	Must be of sufficient size to avoid on-line voltage falls and overheating.
Cable path.	The encoder connector cables, the other sensors and the pre-actuators must be kept away from any source of radiation resulting from high-power electric circuit switches and which could cause malfunctions.
Encoder signal connector cables	The module/encoder connector cables must adhere to the following rules: • They must be shielded using a high quality shielding, • they must only carry related signals to the encoder, • the cable shielding must be linked to the protective ground connection both at the module and the encoder, • the grounding must be continuous throughout the connection.

Selecting and protecting auxiliary power supplies

Introduction	Encoders, sensors and pre-actuators associated with the module require auxiliary power supplies (5VDC and/or 24VDC).
Type of power supply	Only use regulated power supplies to: • ensure optimum reliable response time for sensors and pre-actuators, • increase the reliability of devices by minimum heating of module I/O circuits. These power supplies must be independent enough (> 10ms) to override micro-power outages and ensure the module continues to run effectively.
Protecting power supplies	The power supplies for encoders, other sensors and pre-actuators MUST be protected from overloads and short-circuits by appropriately calibrated fast-blow fuses.
Connection of the 0V supply to the protective ground:	The 0V supply must be connected to the protective ground nearest to the supply module output.
General rules for installing the encoder power supply module	• this must be used only for supplying the encoder, • it must be independent enough to override micro-power outages (> 10ms). • it must be placed as close as possible to the CCY 1128 module to reduce circuit capacities to the maximum.

Choice of encoders for the CCY 1128

Introduction

The CCY 1128 module inputs are able to receive signals from the following encoders:

- incremental,
- absolute with SSI serial outputs,
- absolute with parallel outputs. This last type requires the use of a specific interface TELEFAST ABE-7CPA11.

The user can choose from these encoder types according to the requirements.

Encoder output interface

The table below summarizes the main characteristics of the output interface for the encoder types normally used.

Type of encoder	Supply voltage	Output voltage	Types of interface
Incremental	5 VDC	5 VDC differential	Outputs with line transmitters to RS 422 standard, with 2 outputs per signal A+/A-, B+/B-, Z+/Z-
	10...30 VDC	10...30 VDC	Totem Pole outputs with one output per signal A, B, Z
Absolute with SSI outputs	10...30 VDC	5 VDC differential	Output with line transmitters to RS 422 standard for the data signal (Data SSI) RS 422 compatible input for the clock signal (CLK SSI).
Absolute with parallel outputs	5 VDC or 10...30 VDC	5 VDC or 10...30 VDC	Parallel outputs. Require the use of the Telefast ABE-7CPA11 interface to transform parallel output signals into serial signals.

Encoder supply

The design of the module allows an encoder supply of:

- 5 VDC
- 24 VDC, standardized voltage in the 10...30 VDC format.

The choice of supply voltage is dependent on the encoder supply voltage.

5 VDC encoder supply

For encoders with a 5 VDC supply, voltage falls must be taken into account. These are dependent upon:

- the length of the cable between the module and the encoder (double length),
- the section of wire,
- the encoder consumption.

The acceptable voltage fall for the encoder is generally 10% of the nominal voltage. The table below gives the on-line voltage fall, according to the section of the wire, for a 100 meter length of wire with a given encoder consumption.

Section of wire	Voltage fall for a 100 meter length of wire with an encoder consumption of:			
	50 mA	100 mA	150 mA	200 mA
0.22 mm = gauge 24	0.4 V	-	-	-
0.34 mm = gauge 22	0.25 V	0.5 V	-	-
0.5 mm	0.17 V	0.34 V	0.51 V	-
1 mm	0.09 V	0.17 V	0.24 V	0.34 V



CAUTION

Recommendation for a 5 VDC encoder supply voltage

It is dangerous to raise the supply voltage of the encoder to compensate for an on-line voltage fall. After a break in the supply, there is a risk of an overvoltage at the module inputs.

Failure to follow this precaution can result in injury or equipment damage.

24 VDC encoder supply

Encoders with a supply voltage of 24 VDC are recommended for the following reasons:

- the supply source does not need to be completely accurate. As a general rule, these encoders use a supply format of 10...30 V.
- an on-line voltage fall is of little significance due to a substantial distance between the module and the encoder.

Ground connection continuity

In order to ensure correct operation during interference, it is vital:

- to choose an encoder with a metal casing that is referenced to the protective ground of the connected device.
- that the ground connection is continuous between:
 - the encoder,
 - the shielding of the connector cable,
 - the module.

Connecting the encoder supply to the CCY 1128

Introduction

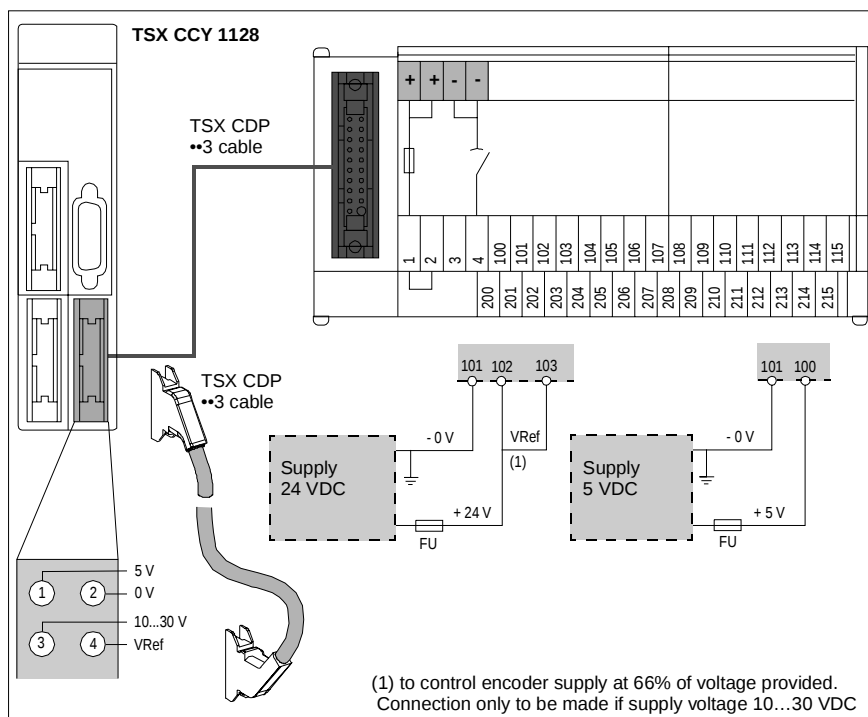
The encoder supply can be connected:

- either by using a TELEFAST ABE-7H16R20 cable interface, which is then connected to the module using a CDP •3 cable.
- or directly, using a CDP •01 pre-wired strand

Process diagram for connecting the encoder supply to the TELEFAST interface

The diagram below shows the process for connecting the encoder supply.

- At 24 VDC for an encoder with a 10...30 VDC supply format,
- and at 5 VDC for an encoder with a 5 VDC supply.



Catalog of CDP ••3 connector cables

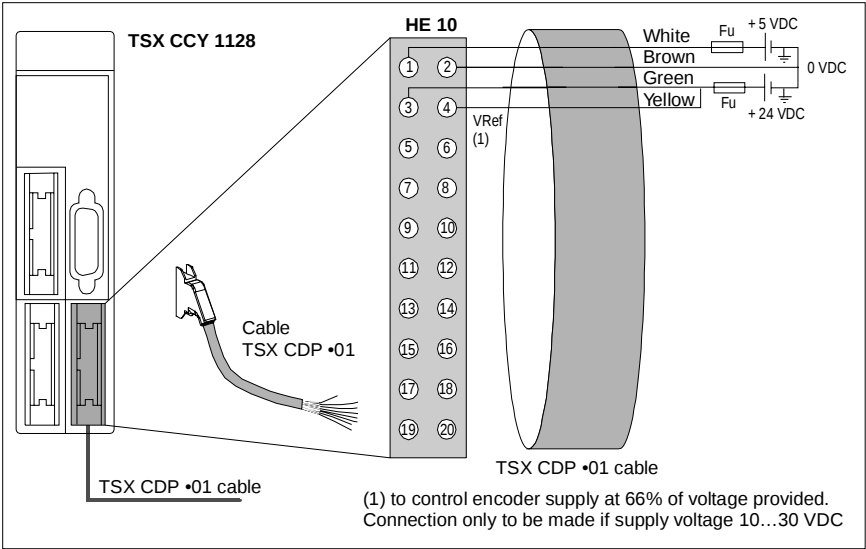
The table below gives the different references for the cables connecting the TELEFAST to the module, and their respective lengths.

Cable references	Cable lengths
CDP 053	0.5 meters
CDP 103	1 meter
CDP 203	2 meters
CDP 303	3 meters
CDP 503	5 meters

Diagram showing the process for connecting the supply using a CDP •01 pre-wired strand

The diagram below shows the process for connecting the encoder supply.

- At 24 VDC for an encoder with a 10...30 VDC supply format,
- and at 5 VDC for an encoder with a 5 VDC supply.



Catalog of CDP •01 connector cables

The table below gives the different references for the cables connecting the TELEFAST to the module, and their respective lengths.

Cable references	Cable lengths
CDP 301	3 meters
CDP 501	5 meters

Recommendations

- Maximum length of wires between the supply outputs and the connection points on the TELEFAST: must be less than 0.5 meters.
- Protection on the + supply: although the module has several built-in protection systems to guard against wiring errors and accidental short-circuits on the cables, it is vital to install a 1A maximum non-delay fuse (Fu) on the + supply.
- Connection of the 0 V supply to the protective ground: must be as close as possible to the supply output.

Wiring rules and precautions specific to the TELEFAST**Connecting or disconnecting the TELEFAST**

You should always connect or disconnect the TELEFAST's connectors and various connection wires when the voltage is SWITCHED OFF:

- connecting or disconnecting the cable connectors linking the module and the TELEFAST connector,
- connecting or disconnecting the wires linking the TELEFAST connector to the encoder.

Length of the connection cable between the module and the TELEFAST

The table below gives the clock frequency of the transmission series according to the distance.

If	then
cable length < to 10 meters	frequency of the transmission series clock: 1 MHz
cable length < to 20 meters	frequency of the transmission series clock: 750 kHz
cable length < to 50 meters	frequency of the transmission series clock: 500 kHz
cable length < to 100 meters	frequency of the transmission series clock: 375 kHz
cable length < to 150 meters	frequency of the transmission series clock: 200 kHz
cable length < to 200 meters	frequency of the transmission series clock: 150 kHz

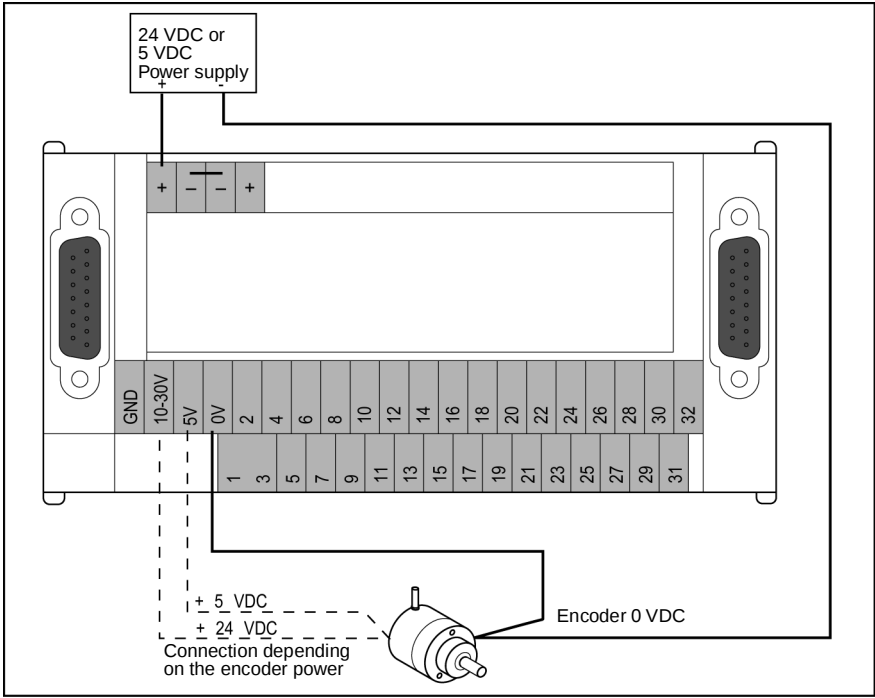
Cross-section of the wire connecting the module and the TELEFAST

In order to reduce the on-line voltage falls as much as possible, please respect the following points:

If	And	Then
The encoder is using a 5VDC supply	The distance from the module to the TELEFAST is < 100m	Use a wire with minimum cross-section 0.08 mm (gage 28)
	The distance from the module to the TELEFAST is > 100m	Use a wire with minimum cross-section 0.34 mm (gage 22)

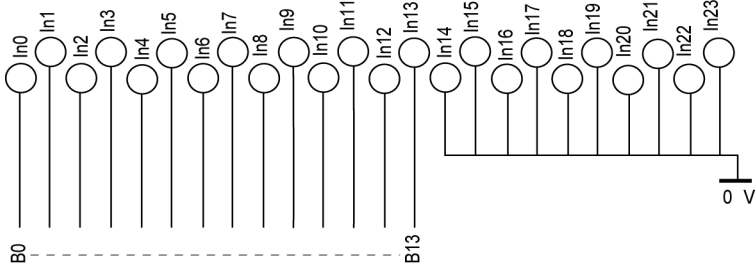
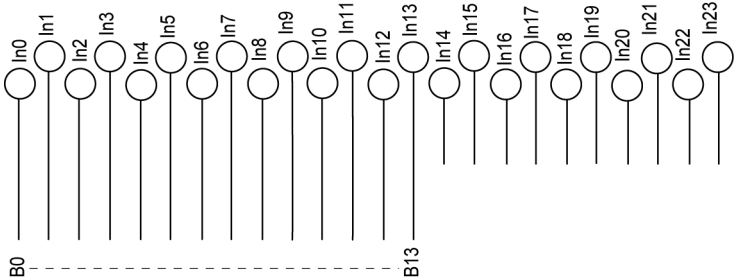
Connecting the encoder supply

In order to limit voltage falls with a 0V, caused by the encoder supply current, we recommend that you wire the 0V as follows:



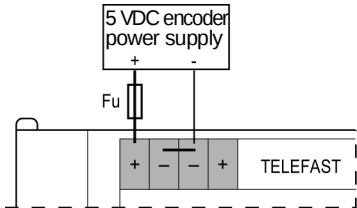
Wiring the encoder outputs on the TELEFAST

If the encoder outputs have positive or negative logic with a number lower than 24, use the following connection procedure:

If	And	Then
the encoder outputs have positive logic	their number is lower than 24	- wire the encoder outputs to the TELEFAST inputs, working from the least significant to the most significant - wire the unused TELEFAST inputs to the 0V terminal
 Example: 14-bit encoder		
the encoder outputs have negative Logic	their number is lower than 24	- wire the encoder outputs to the TELEFAST inputs, working from the least significant to the most significant - do not wire (leave free) the unused TELEFAST inputs.
 Example: 14-bit encoder		

Protecting the encoder supply

According to the encoder supply voltage, the supply should be protected as follows:

If	Then
The encoder supply voltage is 10...30VDC	The protective fuse is built into the TELEFAST: ● size: 1A ● type: fast-blow fusion.
The encoder supply voltage is 5VDC	Provide a series fuse (Fu) for the positive supply: ● calibre: to be determined by the user, dependent upon the TELEFAST and encoder consumption ● type: fast-blow fusion 

Monitoring the encoder supply

If the encoder supply voltage decreases by more than 15%, the default (EPSR signal) is sent back to the module. If the encoder does not have a return supply, do the following:

If	Then
No return encoder supply	Connect the positive and negative EPSR of the TELEFAST: ● the positive EPSR terminal of the TELEFAST to the positive terminal of the encoder supply ● the negative EPSR terminal of the TELEFAST to the negative terminal of the encoder supply

Cabling precautions on analog modules

At a Glance	To protect the signal from external noises induced in serial mode and from noises in common mode, you are advised to take the following precautions.
Kind of conductors	Use shielded twisted pairs of a minimum section of 0.28 mm ² (AWG24 gage).
Cable shielding	- For modules fitted with a screw terminal block (TSX AEY 414 and TSX ASY 410) : Link the cable shields, at each end, to the shield recovery terminals (grounding terminals). - For modules fitted with Sub-D connectors (TSX AEY 16••/8••/420 and TSX ASY 800) : As the number of channels is important, a minimum of a 13 twisted pair cable with a general shield (external diameter 15 mm maximum) will be used, fitted with a 25-pin Sub-D male connector for the direct link to the module. Connect the cable shield to the cover of the Sub-D male connector. The connection to the PLC ground is therefore done using the tightening screws of the Sub-D connector. For this reason, the Sub-D male connector must be screwed onto its female base.
Association of connectors in cables	Grouping into multi-pair cables is possible for signals of the same type and which have the same reference in relation to the ground.
Cable routing	Keep the measurement wires as far as possible from the discrete input/output cables (particularly relay outputs) and the cables which transmit "power" signals.

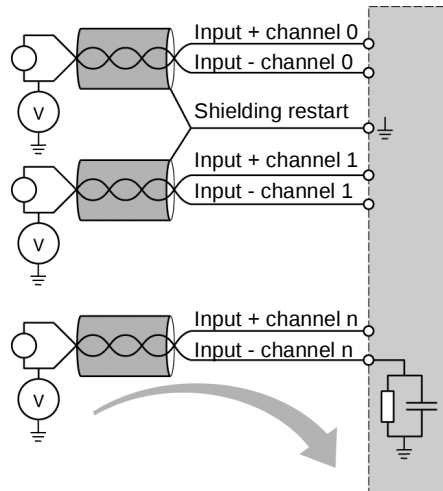
Reference for sensors in relation to the ground

To ensure correct operation of the acquisition device, the following precautions are recommended :

- the sensors must be close to each other (a few meters),
- all the sensors are referenced to the same point which is linked to the module ground.

Use of sensors referenced in relation to the ground

The sensors are connected according to the following diagram :



If the sensors are referenced in relation to the ground, this can in certain cases, return the potential of a remote ground to the terminal block or the Sub-D connector(s). It is therefore **essential** to respect the following rules :

- this potential must be lower than the security voltage: for example, 48 V max. for France,
- connecting a sensor point to a reference potential generates a leakage current. It is therefore necessary to check that the total leakage currents generated do not disrupt the system.

Use of pre-actuators referenced in relation to the ground

There are no particular technical constraints for referencing the pre-actuators to the ground. For security reasons, it is however preferable to avoid returning a remote ground potential to the terminal block , as this can be very different from the local ground potential.

Overview

Introduction This section contains guidelines and information for the configuration and installation of the basic elements of the Premium hardware with regard to grounding and EMC.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Recommendations on how to install a measurement system	266
Cabling precautions on the weighing module	268
Connection of the weighing module discrete outputs	269

Recommendations on how to install a measurement system

General

The quality of the measurement provided by the module may be reduced considerably if the sensor set-up and installation precautions have not been observed. Thus in place of exhaustive information, these few lines should make you aware of some of the precautions which need to be taken.

Dividing up the loads

In a measurement system, the weighing sensors support the following weights :

- the maximum weight to be weighed,
- the weight of the loading receiver and its structures (or metrological tare).

This total weight is divided up between 1, 2, 3, 4, 6, even 8 sensors. The design of the mechanical structures, the shape of the loading receiver and the dividing of the load on or within the receiver, means that the total weight is not always equally divided between all the sensors (except of course in the case of a single sensor).

It is therefore a good idea to make sure that the dimensions of the weighing sensors are calculated in such a way as to be able to support the total weight (maximum weight + tare) to which they will be subjected

Inhibiting interference on the load receiver

As a weighing sensor deflection is very weak (a few tenths of a millimeter), all interference on the load receiver or any friction on the permanent framework will cause an invalid weight measurement and make correct adjustment of the module impossible.

Mechanical installation of the weighing sensors

The sensors in traction or compression must be used vertically respecting their action direction (traction or compression). The maximum admissible tolerance on the installation's verticality is in the region of the degree according to the installation and the required precision.

Protecting the sensors from interference currents

It is recommended that each sensor be provided with a mass flex which plays the role of the electric " shunt " with the aim of protecting sensors from currents capable of circulating in the metallic framework (ground currents, from the terminal to be connected, and electrostatic discharges...).

This flex will be of a sufficient length to not result in mechanical constraints and it will be placed directly next to the sensors, between the permanent framework and the load receiver.

**Contact with
water and
corrosive
products**

Weighing sensors are manufactured as waterproof. It is recommended, however, that they be prevented from coming into contact with water, corrosive products and direct sunlight.

**Preventive
maintenance of
the installation
and accessories**

The weighing module requires no special maintenance. The weighing sensors, however, should be cleaned periodically if used in a difficult environment. It is advisable to periodically test and service the mechanical state of the load receiver.

- Cleaning the receiver and its structures because of a product deposit or various material deposits may result in a noticeable variation of the tare.
- Checking the verticality of the weighing sensors.
- Checking the sensor and actuator states according to their period of use.
- Etc ...

Note: Statistics show that 90% of breakdowns occurring on a weighing/dosing installation are not attributable to the electric command device, but to the installation itself (defective limit switches, mechanical faults...).
--

Cabling precautions on the weighing module

At a Glance

To protect the signal from external noises induced in serial mode and from noises in common mode, you are advised to take the following precautions.

Kind of conductors

Use shielded twisted pairs of a minimum section of 0.28 mm² (AWG24 gage).

Cable shielding

The measurement cable shielding should only be connected to the ground on the module side. If problems arise, if the grounds on either side of the connection are of good quality, then both ends of the shield can be connected to the ground. On the Sub-D connectors connect the cable shield to the cover of the connector, the PLC ground being connected by the tightening screws of the Sub-D connector. For this reason, the male Sub-D connector **must** be screwed onto its female connection base.

Cable routing

Keep the measurement wires as far as possible from the discrete input/output cables (particularly relay outputs) and the cables which transmit "power" signals.

Avoid :

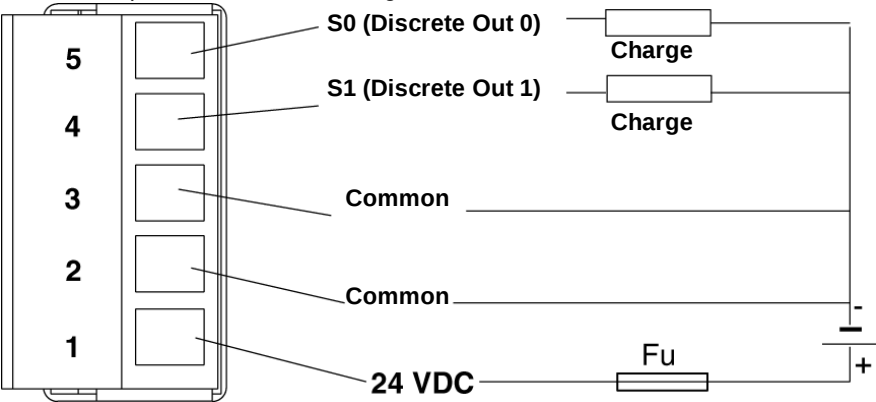
- parallel routing (maintain a distance of at least 20 cm between the cables),
- and cross them at right-angles.

Note: The measurement input is grounded via the module.
--

Connection of the weighing module discrete outputs

General

Weighing module discrete outputs are used to trigger actions on threshold crossing. This functionality is used in the "filling machine" application. Discrete outputs are connected using a screw terminal block :



The common 2 and 3 are linked by the card.

Characteristics of the discrete outputs

The following table shows the characteristics of the discrete outputs of the module TSX ISP Y100/101 :

Discrete output	Characteristics
Number of channels	2
Type	A transistors
Response time	1 ms discrimination. The point where the threshold between two measurements is crossed is calculated by millisecond interpolation
Nominal supply voltage	24 V
Insulation voltage	1500 Veff
Maximum current	500 mA
Protection	Polarity and short-circuit inversion Provide a fuse on the pre-actuators +24 V

Protection

The outputs are galvanically protected by the ground.
Each of the two output channels is protected against:

- short-circuits and overloads
- polarity inversions

Note: In order to best protect against polarity inversions, it is essential **to place** a fast-acting **fuse** on the supply, upstream of the load (shown as Fu in the diagram above).

Overview

Introduction This section contains product specific guidelines, installation instructions and information about grounding and EMC for networks. It contains the same information as the documentation provided with the products.

What's in this Part? This part contains the following chapters:

Chapter	Chapter Name	Page
24	Profibus	273
25	Interbus	285
26	Ethernet	293
27	Modbus Plus Network	323
28	RIO Network	329

Overview

Introduction This chapter contains product specific guidelines, installation instructions and information about grounding and EMC for Profibus components. It contains the same information as the documentation provided with the products.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Wiring	274
Grounding and Shielding for Systems with Equipotential Bonding	275
Grounding and Shielding for Systems without Equipotential Bonding	276
Surge Protection for Bus Leads (lightning protection)	278
Static Discharge in Long PROFIBUS DP Cables	281
Capacitive By-Pass Terminal GND 001	282

Wiring

Guidelines for Bus Segment Installation

The following guidelines apply for wiring bus segments:

- Type "A" bus cable which complies with PROFIBUS standards is to be used the bus.
 - The bus cable may not be twisted, pinched or stretched.
 - A bus segment must be fitted with a termination resistor on both ends.
The corresponding slave must be live at all times so that the termination resistor is effective however.
 - Bus nodes that do not terminate a segment can be separated from the bus without interrupting regular data traffic.
 - Branch lines are not allowed.
-

Wiring in Buildings

In Cabinets

Cable locations play a major role in the resistance to interference. Therefore, the following guidelines are applied:

- Data lines must be separated from all AC and DC power lines ≥ 60 V.
- A minimum spacing of 20 cm is to be kept between data lines and power lines.
- AC and DC feed wires > 60 V and ≤ 230 V must be run separately from AC and DC power feeds > 230 V
Separated means that the cables are in different cable bundles and ducts.
- PG screws with integrated grounding are not allowed.
- Cabinet lighting must be done with EMC safe lights and wiring.

Outside of Cabinets

- Cables must be run in metal cable ducting (lines, troughs, ducts or tubing) wherever possible.
 - Only wires of < 60 V or shielded < 230 V may be run in common cable ducts.
Dividers in metal cable ducts may be used as long as the minimum spacing of 20 cm is kept between wires.
 - PROFIBUS data lines must be run separately in metal cable ducts.
-

Wiring outside of buildings

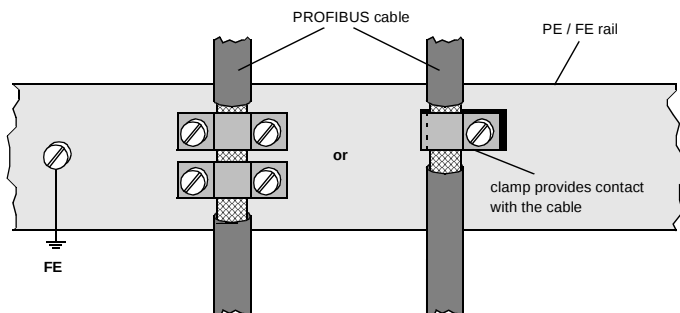
Generally, the same rules apply for running lines outside of buildings as within. However, the following applies to bus cable:

- Run in a suitable plastic tubing.
 - When burying cables, only cable that is specifically designed for this purpose may be used.
Pay special attention to the permitted temperatures.
 - When running cables between buildings, use *Surge Protection for Bus Leads (lightning protection)*, p. 278.
 - For baud rates over 500 kBaud, fiber optics cable is recommended.
-

Grounding and Shielding for Systems with Equipotential Bonding

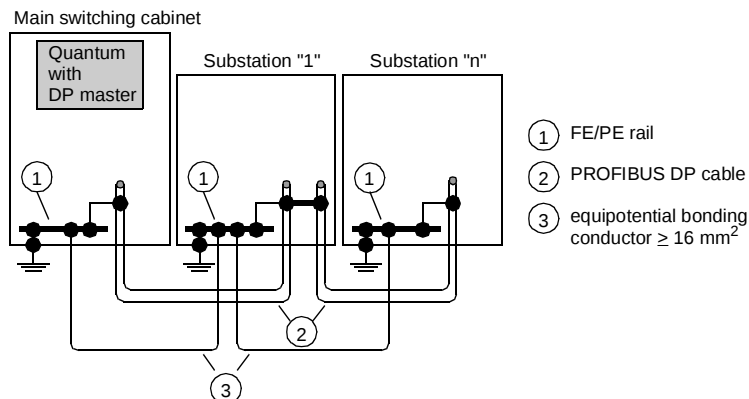
Central Shielding Measures

Each cable shield should be galvanically grounded with the earth using FE/PE grounding clamps immediately after the cable has been connected to the cabinet. This example indicates the shielding connection from the PROFIBUS cable to the FE/PE rail.



Note: An equalization current can flow across a shield connected at both ends because of fluctuations in ground potential. To prevent this, it is imperative that there is potential equalization between all the attached installation components and devices.

This example indicates the system components and devices in a system with equipotential bonding.



Grounding and Shielding for Systems without Equipotential Bonding

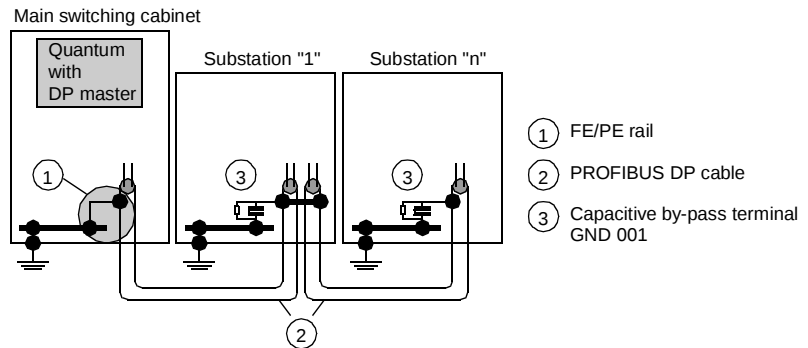
Principle

Note: Basically, grounding and shielding is to be carried out the same as for systems **with** equipotential bonding.

If this is not possible because of system or construction specific reasons however, distributed ground with a capacitive coupling of high frequency interference signals. Procedures

Overview

This representation shows distributed grounding with capacitive coupling



**Distributed
Grounding with
Capacitive
Coupling**

This table shows you the steps in setting up distributed grounding with capacitive coupling.

Step	Action	Comments
1	Galvanically ground the shielding (only) to the end of the bus cable and with as much surface area as possible to the central cabinet	
2	Run the bus cable from there to the last bus node, without any other ground connections	
3	Shielding for all bus nodes should be ground "capacitive only" This is done with e.g. the GND 001 terminal connection.	This is achieve at least one discharge route for high frequency interference Note: A transient current cannot flow without a galvanic connection
4	Refer to the <i>Connection Example</i> , p. 282 and the <i>Making Shielding Connections</i> , p. 283 in the instructions for the corresponding device.	

Surge Protection for Bus Leads (lightning protection)

Surge Protection for Bus Leads up to 12 Mbps Signals

To protect transmission systems from extraneous surges (lightning), the PROFIBUS DP lead should be equipped with suitable surge protection equipment once it extends outside a building.

The nominal discharge current should, in this case, be at least 5 kA.

The following lightning arrestors e.g. **type CT MD/HF5** and **type CT B110** from Dehn und Söhne GmbH & Co KG may be used. Addresses and order numbers for these devices can be found in the appendix under).

For adequate protection of a PROFIBUS DP cable, two sets of protection equipment are required for each building. The first set of protection devices (type B110), located where the cable enters the building, works as a lightning conductor, the second (type MD/HF5), located near the first device, works as a surge protection device.

Connection rules for protection devices

Before connection of the protection devices please observe the following rules:

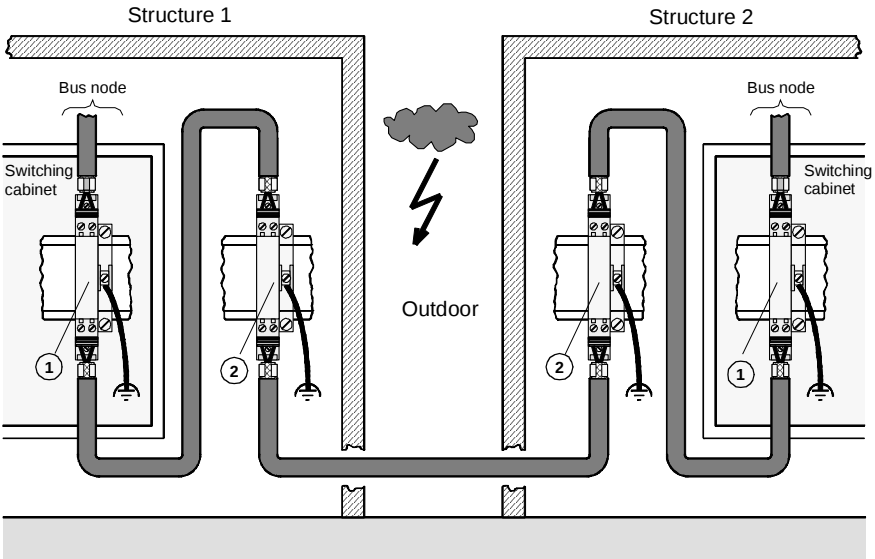
- Install a functional ground (equipotential bonding rail)
- Install the protection equipment near the functional ground, to keep surge current path as short as possible.

Keep the lead to the functional ground as short as possible. (min. 6 mm²)

- The maximum lead length depends on the transfer rate.
 - **At transfer rates up to 500 kBaud** you can configure a maximum of **4 outdoor segments** with 8 pairs of protection devices (CT B110 and CT MD/HF5).
 - **At transfer rates of 1 MBaud** or higher, you may only configure **one outdoor segment** with 2 pairs of protection devices.
 - Do **not** confuse the IN and OUT ends of the lightning arrestor (IN = outdoor end)
 - Make certain that you *Shield grounding with protection devices, p. 280* according to the type of lightning arrestor (CT B110 or CT MD/HF5) that is used.
-

**Protection
device
connection plan**

Protection device connection plan:



Type and number of lightning conductors made by the firm Dehn und Söhne GmbH & Co KG suitable for a PROFIBUS DP cable

No.	Model	Number per group
1	CT MD/HF 5	2
2	CT B110	2

Note: Information about assembly and connection of the cables can be found in the relevant installation instructions that come with lightning arrester.

Shield grounding with protection devices

Direct or indirect shield grounding are offered by the protection devices. An indirect grounding occurs using gas conductors. In both cases EMC spring terminals grasp the input and output sides of the cable shield.

Note: When the system permits it, we recommend you use direct shield grounding.

Types of shield grounding assignment

Type of grounding	Technique
Direct shield grounding	Connect the shield of the incoming cable to the IN terminal, and that of the outgoing cable to the OUT terminal. The shields are now galvanically connected with PE.
Indirect shield grounding using gas conductors	Connection of the shield as described for direct shield grounding. Insert the gas-type surge protector in the rack beneath the cabinet connection terminals on the input side.

Note: Further information about grounding and shield grounding can be found in the relevant installation instructions that come with the lightning arrestor.

Static Discharge in Long PROFIBUS DP Cables

Static Discharge Very long bus cables, which have been laid but not yet connected, are discharged as follows:

Step	Action
1	Select the PROFIBUS DP connector closest to the FE/PE grounding clamp .
2	Touch the metal of the connector housing to the cabinet's FE/PE grounding clamp to discharge any static electricity.
3	Now connect the bus connector to the device.
4	Discharge the other PROFIBUS DP cable connectors as described in steps 2 and 3.

Notes

Note: During mounting, the metal part of the PROFIBUS DP connector is connected internally to the cable shield. When the bus cable connector is inserted into the module's PROFIBUS port, a short connection between the shield and the FE/PE is created automatically.

Capacitive By-Pass Terminal GND 001

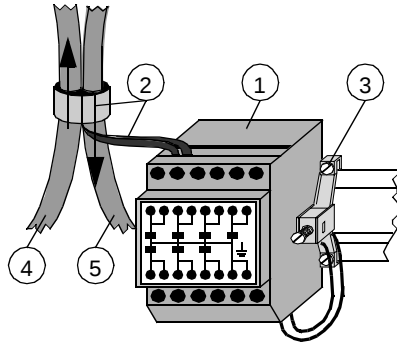
Overview

Distributed grounding with capacitive by-passing is used in systems without equipotential bonding.

Mount the Schneider by-pass terminal (GND 001) as shown in the following representations.

Connection Example

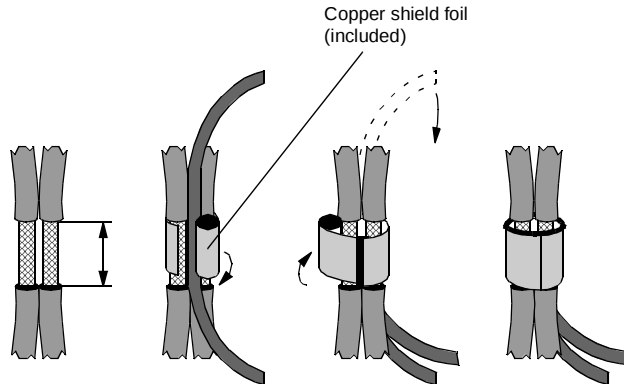
This example shows the connection from the PROFIBUS cable to the by-pass terminal.



- 1 GND 001
 - 2 Shielding
 - 3 Connection to Rail
 - 4 PROFIBUS cable entering switching cabinet
 - 5 PROFIBUS cable exiting switching cabinet
-

Making Shielding Connections

This example shows the shielding connection with the PROFIBUS cable.



Note: The by-pass for the bus ends is to be prepared on **one** cable only

Overview

Introduction This chapter contains product specific guidelines, installation instructions and information about grounding and EMC for Interbus components. It contains the same information as the documentation provided with the products.

What's in this Chapter? This chapter contains the following topics:

Topic	Page
Momentum Communication Adapter Ground Screw Installation	286
Central Shielding Measures for the INTERBUS	288
Overvoltage Protection for Remote Bus Lines (Lightning protection)	289

Momentum Communication Adapter Ground Screw Installation

Overview

Recently revised to meet new Interbus standards for electrical noise immunity, select Momentum products have been updated with an additional ground screw. This second ground screw is being added to all new and upgraded Momentum products. Currently, three communication adapters have been updated. They are:

- Momentum Interbus Communication Adapter (170 INT 110 03), which supports the diagnostic functions of a Generation 4 Interbus Master and is compliant with Interbus certification, version 2
- Momentum Ethernet Communication Adapter (170 ENT 110 01), version 2
- Momentum FIP IO Communication Adapter (170 FNT 110 01), version 5

These communication adapters contain a new grounding system, which was originally required to meet the revised Interbus electrical noise immunity standard (ability to pass a 2.2kv electrical fast transient burst test). This grounding system includes a ground screw in the communication adapter, which is connected to a fixed standoff-ground nut on the printed circuit board and to a standoff on selected Momentum I/O modules.

Note: This electrical noise immunity requirement only applies to systems that require Interbus certification, version 2, and not to any other communication network that Momentum I/O currently uses.

Momentum I/O Modules

The Momentum I/O modules, which include the fixed standoff-ground nut assembly and the male-female standoff, and accept ground screws, are:

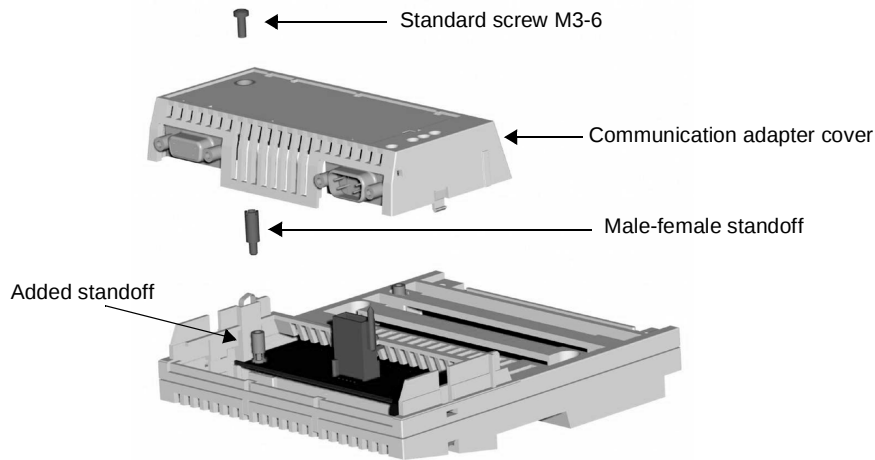
Name	Description
170 ADM 350 10 PV .05	24 VDC 16 Input/16 Output Module
170 ADM 350 11 PV .05	24 VDC 16 Input/16 Output Fast Response Module
170 ADI 340 00 PV .04	24 VDC 16 Input Point Module
170 ADI 350 00 PV .05	24 VDC 32 Input Point Module
170 ADO 340 00 PV .04	24 VDC 16 Point Output Module
170 ADO 350 00 PV .04	24 VDC 32 Point Output Module
170 ADM 370 10 PV .04	24 VDC 16 Input/8 Output @ 2 amps Module
170 AAI 030 00 PV .05	Analog 8 Channel Differential Input Module

Required Tools The only tool required to install the ground screw is a PZ 1 Phillips head screwdriver. The recommended torque on the ground screw is 0.7Nm (.51 ft-lb).

Installation These communication adapters will be shipped with the ground screw attached in a separate plastic bag. The above I/O modules will be shipped with a standoff in a separate plastic bag along with an I/O module label. To install the ground screw, follow the steps below. Refer to the figure below for the screw locations.

Step	Action
1	Install the standoff into the threaded fixed standoff-ground nut assembly, which is located on the I/O module's printed circuit board.
2	Snap the communication adapter onto the I/O module. Follow the same procedure as all other Momentum products. (For more information on communication adapter assembly, refer to Chapter 3 of <i>Modicon Momentum I/O Base User Guide</i> (870 USE 002 00).
3	Install the ground screw through the top of the communication adapter.

Ground screw installation:



**Backward
Compatibility**

The above I/O modules can also be used with any of the Momentum communication or processor adapters that do not include the ground screw.

	CAUTION
	POSSIBLE EQUIPMENT FAILURE When using the new version of the above I/O modules with any communication or processor adapter, do not install the standoff into the fixed standoff-ground nut assembly on the I/O module's printed circuit board. The standoff could touch some of the components on the adapter, which may cause faulty operation or product failure. Failure to follow this precaution can result in injury or equipment damage.

Central Shielding Measures for the INTERBUS

**Central shielding
measures**

For the commissioning phase, a large surface area connection should be made between each cable shield and ground (FE/PE rail) directly after the cable enters the switch cabinet.

Static discharge

Very long bus cables, which have been laid but not yet connected, are discharged as follows:

Step	Action
1	Begin with the static discharge with the INTERBUS plug nearest to the FE/PE rail.
2	Touch the FE/PE rail of the switch cabinet with the metal of the plug case.
3	Then plug the bus plug into the device, but only after this has been statically discharged.
4	Discharge the cable's other INTERBUS plugs in the same way and then plug these into the device.

**Notes for
connection the
cable shield with
earth**

Note: The metal guide of the INTERBUS plug is internally connected with the cable shield during the construction of the cable. If the bus cable plug is plugged into the module's INTERBUS interface, a short connection is automatically established between the shield and PE.

Overvoltage Protection for Remote Bus Lines (Lightning protection)

Overvoltage protection

To protect the transmission equipment from coupled voltage spikes (lightning strike), overvoltage protection equipment should be used in the remote bus cables, as soon as it is laid outside of buildings.

The nominal discharge current should, in this case, be at least 5kA.

The lightning arrestors **Type VT RS485** and **Type CT B110** from Dehn und Söhne GmbH & Co KG can, for example, be used. For the supplier address and order numbers for protection equipment and accessories, see .

To protect an INTERBUS cable, two protection device groups are required in each building. The first group (Type B110) is positioned where the cable enters the building and is used as the lightning conductor. The second group (Type RS485), close to the first node, is the overvoltage protection device.

Connection rules for protection devices

Before connection of the protection devices please observe the following rules:

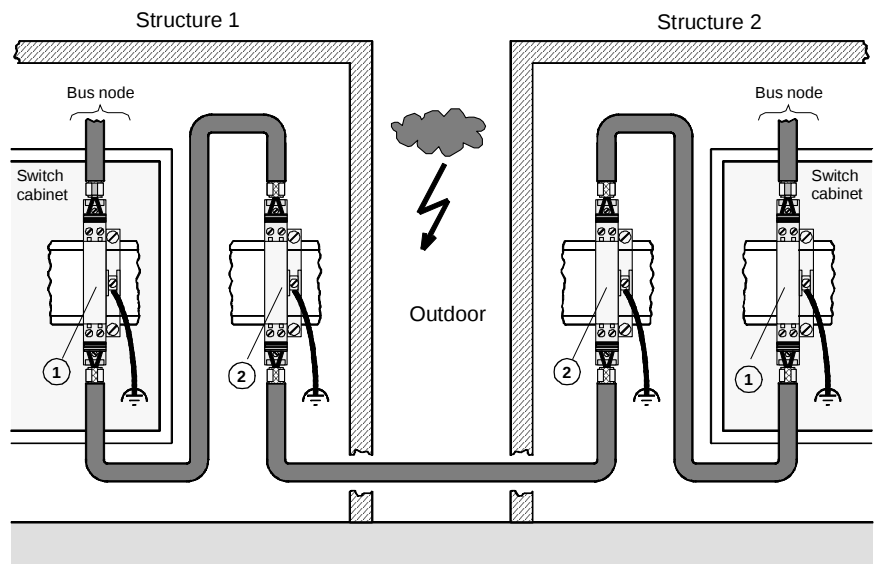
- Install a functional ground (equipotential bonding rail)
- Assemble the protection devices near the building ground, so that the overload current is diverted along the shortest route.

The cable(minimum 6mm²) to the building and functional ground should be as short as possible.

- A maximum of 10 protection devices connected in series with 4 open land sections, for connecting buildings to each other, are allowed in the INTERBUS cables.
 - Perform a Shield grounding (See *Shield grounding with protection devices*, p. 291) of the INTERBUS lead according to the lightning arrestor used (type CT B110 or type VT RS485).
-

Protection
device
connection plan

Protection device connection plan:



Type and number of the lightning arrestors from Dehn und Söhne GmbH &Co KG for a remote bus cable LiYCY (INTERBUS):

No.	Type	Number per group
1	VT RS485	1
2	CT B110	3

Note: Information about assembly and connection of the cables can be found in the relevant installation instructions that come with lightning arrester.

Shield grounding with protection devices

Direct or indirect shield grounding are offered by the protection devices. An indirect grounding occurs using gas conductors.
The construction of the shield grounding depends on the type of lightning arrester.

Lightning arrester type	Direct shield grounding	Indirect shield grounding using gas conductors
CT B110	Connect the shield of the incoming remote bus cable at connection IN and that of the remote bus cable at connection OUT. The shields are now galvanically connected with PE.	Connection of the shield as described for direct shield grounding. Put the gas conductor in the unit underneath the shield connection terminal on the input side.
	EMC cage clamp terminals fasten the remote bus cable shield on the input and output sides.	
VT RS485	Connect the shield of the incoming remote bus cable at connection IN2 and that of the remote bus cable at connection OUT2.	Connect the shield of the incoming remote bus cable at connection IN1, and the remote bus cable shield at connection OUT1. The gas conductor is installed in the device.
	Note: Connect the grounding terminals of the lightning arrester to the PE.	

Note: Further information about grounding and shield grounding can be found in the relevant installation instructions that come with the lightning arrester.

Overview

Introduction This chapter contains product specific guidelines, installation instructions and information about grounding and EMC for Ethernet components. It contains the same information as the "Transparent Factory" product documentation - but is included here as a general information source for Ethernet.

What's in this Chapter? This chapter contains the following sections:

Section	Topic	Page
26.1	Basic rules	295
26.2	Wiring regulations	303
26.3	Using the cable runs	306
26.4	Inter building links	317
26.5	Using optical fiber	320

26.1 Basic rules

Rules and precautions

Introduction The following chapter describes the rules and precautions to be taken to install ethernet cabling under the optimum conditions.

What's in this Section? This section contains the following topics:

Topic	Page
Presentation	296
Earth and ground connections	297
Differential Mode and Common Mode	299
Wiring the ground connections and the neutral	300
Choice of Transparent Factory electric wiring	301
Sensitivity of the different families of cables	302

Presentation

Description

You have to take some precautions before installing a Transparent Factory system. The following explains which cabling to choose, why and how to install it to obtain entire satisfaction.

Principles

- Equipment complying with industrial standards (electromagnetic compatibility or "EMC") works well independently.
- Precautions must be taken when equipment is connected so that it works in its electromagnetic environment depending on its destination.

Exclusive use of Transparent Factory insulated optical fiber cables is the way to get over any EMC problems on these links.

Note: EEC labeling must be used in Europe. This labelling does not guarantee the actual performance of the systems with regard to CEM.

Earth and ground connections

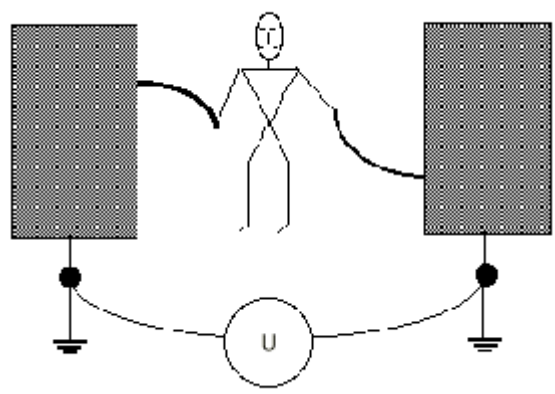
Introduction An earthing network carries leakage current and fault current from equipment, common mode current from external cables (electricity and telecoms mainly) and direct lightning currents into the earth.

Description Physically, weak resistance (relative to a distant earth), does not concern us as much as the local equipotentiality of the building. In fact the most sensitive lines are those that connect equipments together. In order to restrict the circulation of common mode currents on cables which do not leave the building, it is necessary to restrict the voltage between interconnected equipments within the site.
A mechanical ground is any hardware conducting part which is exposed, which is not normally live, but which could be in case of a failure.

	CAUTION
	Simultaneous accessibility of 2 mechanical grounds
	Two mechanical connections which are simultaneously accessible must have a lower contact voltage "U" than the conventional limit contact voltage (25 or 50 V depending on the case). Failure to follow this precaution can result in injury or equipment damage.

Principle

Basically nothing else has any effect on people's safety, in particular the earthing resistance or the method of connecting the mechanical grounds to the earth.



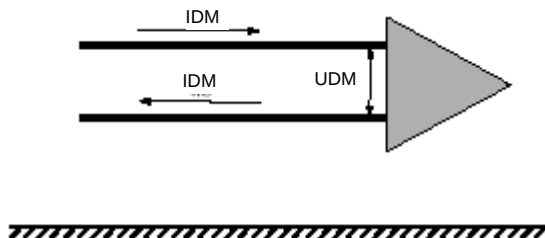
Equipments and electronic systems are interconnected. The best way to ensure that everything works properly is to maintain good equipotentiality between equipments. Besides the safety of the personnel, which is a LF (Low Frequency) constraint, equipotentiality between equipments must be satisfactory, especially for digital equipments even at very high frequencies.

	CAUTION
	Safety regulations In case of dispute, safety regulations take precedence over EMC constraints. If there is a difference between the recommendations of this manual and the instructions of a particular piece of equipment, the equipment instructions take precedence. Failure to follow this precaution can result in injury or equipment damage.

Differential Mode and Common Mode

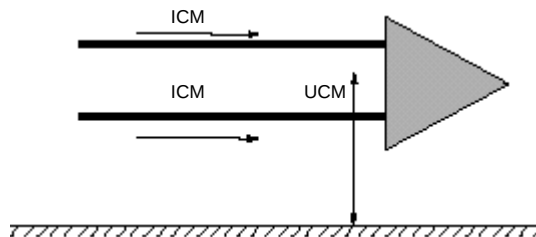
Differential Mode **Differential mode** is the normal way of transmitting electric and electronic signals. The Transparent Factory data in electric form are transmitted in differential mode. The current is propagated on one conductor and returned on the other conductor. The differential voltage is measured between the conductors. When the one way and return conductors are side by side as in Transparent Factory cables and far away from disturbing currents, **the differential mode disturbance is usually not significant.**

Differential Mode



Common Mode

Common mode is an interference mode where the current is propagated in the same direction on all the conductors and returns via the mechanical ground. Common Mode



A mechanical ground (a conducting frame for instance), serves as a potential reference for the electronics and as a return for common mode currents. Any current, even a strong one, coming in one cable, in common mode into a unit which is insulated from the ground connections, comes out through the other cables, including Transparent Factory cables when they exist.

Wiring the ground connections and the neutral

Linking the ground connections

When the ground connections are not linked properly, a cable, bearing a common mode current, disturbs all the others (including the Transparent Factory electric cables). Proper interlinking of ground connections reduces this.

Good methods for wiring the ground connections and therefore for interlinking them, applicable for cabinets and also for machines and buildings, are explained in the DG KBL E manual which can be ordered separately.

Note: HF interference, conducted in common mode cables, is the main problem in EMC.

Wiring the neutral

The TN-C neutral diagram, which confuses the neutral conductor (marked N, which is live) with the shielding conductor (marked PE) allows strong currents to pass through the ground connections.

The TN-C neutral diagram is therefore harmful to the magnetic environment. The TN-S neutral diagram (with or without shielding from residual differential current) is much better.

Note: However, local safety regulations must always be scrupulously observed.

Choice of Transparent Factory electric wiring

Screened cables

The choice of screen quality depends on the type of connection. SCHNEIDER ELECTRIC defines the cables for each field bus and each local network in order to ensure the installation's electromagnetic compatibility.

A screened cable provides excellent protection against electromagnetic disturbance, especially at high frequencies. The efficiency of a screened cable depends on the choice of the screen and, to a greater extent, on how it is implemented.

Note: Transparent Factory cables have a ring and a braid.
--

Ring cables

The problem with ring cables is that they are fragile. The HF protective effect of a ring cable is damaged through the general handling of the cable.

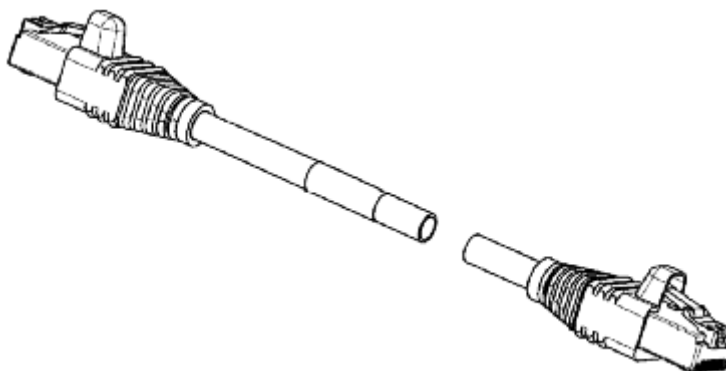
Always reduce any pulling or twisting of Transparent Factory cables to a minimum, especially on installation.

The protective effect can reach several hundreds with a simple braid from a few MHz upwards, when the screen connections are acceptable.

Note: Bilateral connection of the screen to the exposed conductive parts protects against the most severe disturbance.

This is why it is essential to properly equip each end of the Transparent Factory screened cables with RJ45 screened connectors.
--

Twisted pair, screened and ring cables



Sensitivity of the different families of cables

Description

Descriptive table

Family	Cables	Composition	EMC behavior
1	...analog	supply and reading circuits for analog sensors	These signals are sensitive
2	digital and telecomm	digital and data bus circuits including Transparent Factory	These signals are sensitive They are disturbing for family 1 if they are not enough shielded
3	relaying	dry contact circuits with refiring risks	These signals interfere with families 1 and 2
4	...supply	supply and power circuits	These signals cause disturbance

26.2 Wiring regulations

Rules to follow by the fitter

Introduction The fitter must, except if it's not possible, follow the following rules.

What's in this Section? This section contains the following topics:

Topic	Page
First wiring rule	304
Second wiring rule	305
Third wiring rule	305

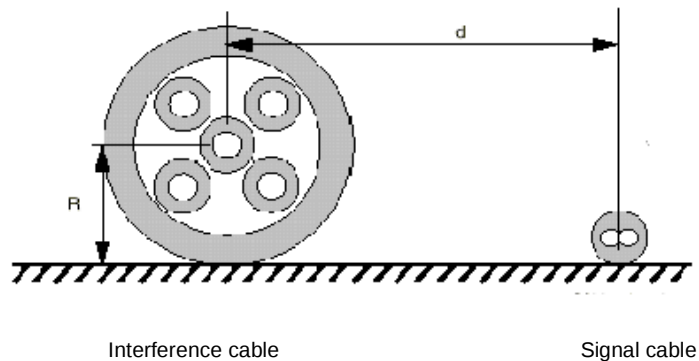
First wiring rule

Principle

It is desirable to flatten any connection against equipotential exposed conducting structures in order to take advantage of the HF protection effects. Using conductor cable runs leads to a satisfactory level of protection in most cases. As a minimum requirement, you should ensure that connecting cables between or inside buildings also have a ground connection: earthing cable or cable run. For internal connections to cabinets and to machines, the cables shall be systematically flattened against the metal supports. To maintain the correct protective effect it is advisable to observe a distance between cables of more than 5 times the radius "R" of the largest one:

$$d > 5R$$

Positioning the cables



Second wiring rule

Principle	Only analog, digital and telecommunication signal pairs can be tight together in one bundle. The relay, variator, supply and power circuits shall be separated from the pairs above. Take special care when setting up the variable speed controllers to separate the power connections from the data connections. Everytime it is possible a duct should be reserved for power connections, even in the cabinets.
------------------	--

Third wiring rule

Principle	The power cables do not need to be shielded if they are filtered. Thus, the power outputs of the variable speed controllers must be either shielded or filtered.
------------------	--

26.3 Using the cable runs

Basics

Introduction This chapter describes the basics about cable runs installation.

What's in this Section? This section contains the following topics:

Topic	Page
Basics on how to use cable runs	307
Verification modes of the length of a homogeneous cable	312
Verification mode of a the length of a heterogeneous cable	314
Other protective effects	315

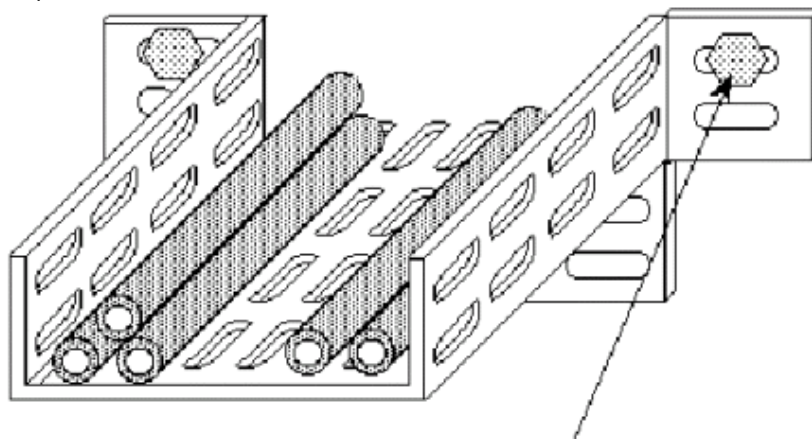
Basics on how to use cable runs

Metal cable runs

Outside the cabinets, beyond a distance of 3 m, the **ducts** must be **metal**. These cable runs must have electrical continuity from end to end via fish plates or foils. It is very important to set up connections using fish plates or foils rather than using a braid or even a round conductor. These cable runs must be connected in the same way to the cabinet and machine connections, if necessary after scraping away the paint in order to ensure contact.

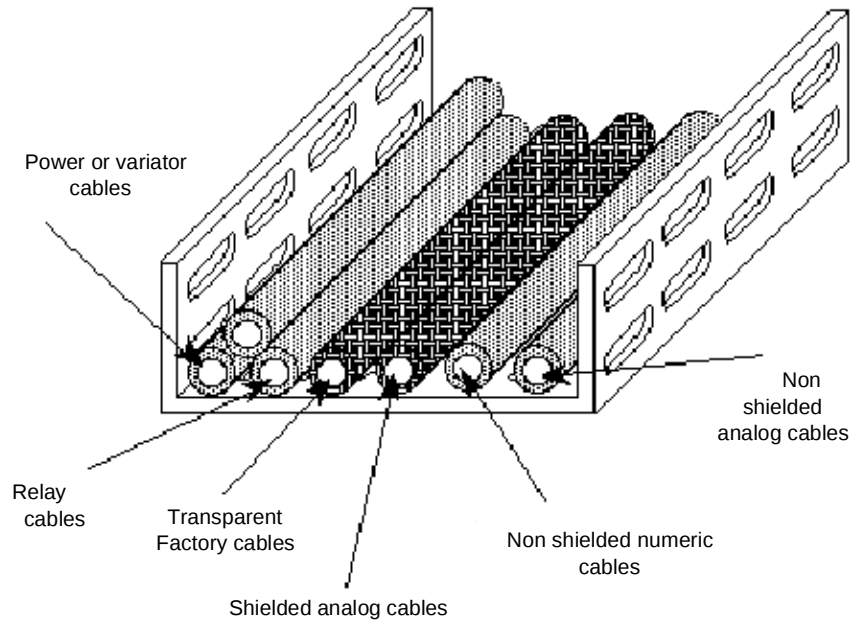
An accompanying cable will only be used when there is no other solution.

Example: Use of a metallic duct



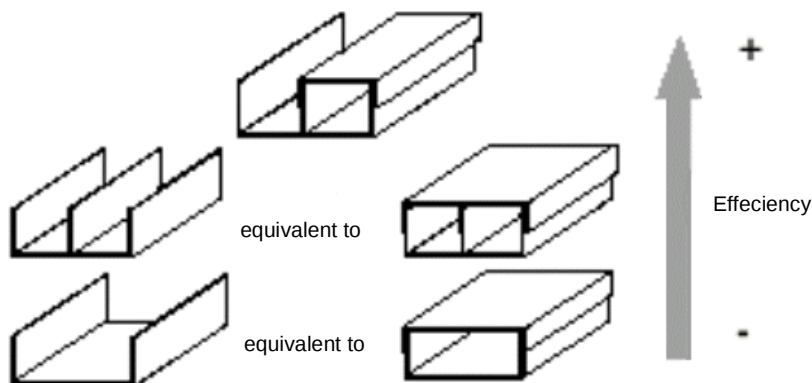
There must be electrical contact with all connections: **SCRAPE OFF** the paint

Non-shielded cables must be fixed in the corners of the ducts as shown in the illustration below.



Future developments

Bear in mind future developments. Vertical separation in the duct avoids mixing incompatible cables. A metal cover on the signals half duct is desirable. You must be aware that a complete metal cover on the duct does not improve the EMC. Efficiency of the various types of ducts



Transparent Factory

For Transparent Factory, as for each communication network, an initial maximum limit for **segment length (without repeater)** must be observed. This limit of **100 metres**, can only be achieved if installation conditions are satisfactory with regard to the EMC (especially: cables placed in metal ducts with end to end electrical continuity connected to frame ground mesh and to earth system).

It is therefore necessary to define a **maximum theoretical length** for electromagnetic compatibility. This second limit is theoretical and is used to optimize installation conditions and must be observed **at the same time** as the previous limit. **The theoretical EMC length is 400 meters for Transparent Factory.**

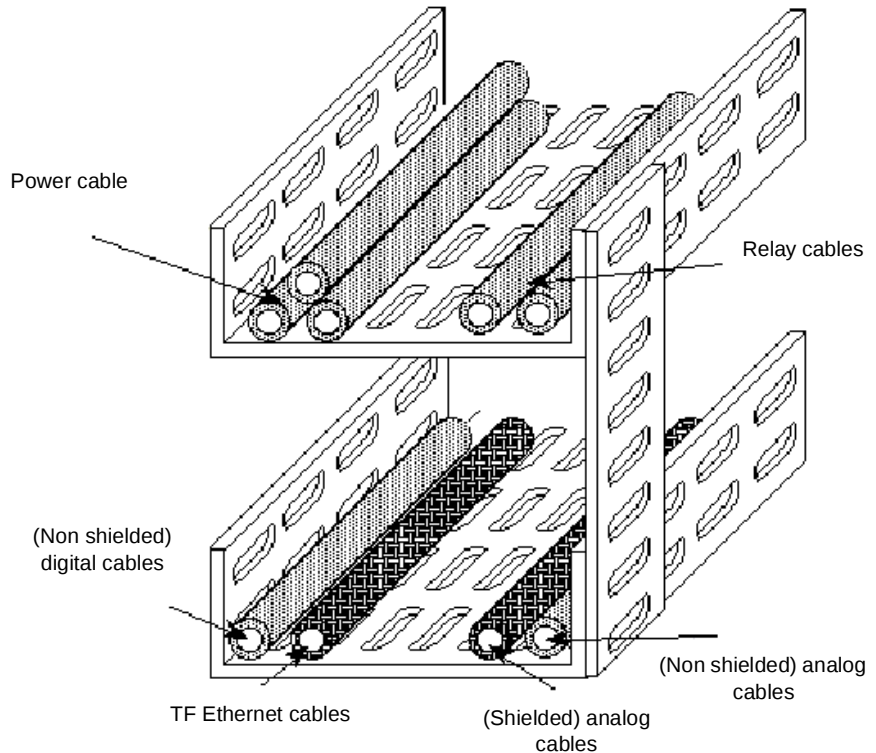
Separating the cables according to their type

Except when it is not possible, **two metal ducts** will be used:

- one reserved for power, relays and variators
- the other for signal cables (sensors, data, telecoms..).

These two ducts can be in contact if they are shorter than 30 m. From 30 to 100 m they shall be spaced 10 cm apart, either side by side or one above the other.

Example of installation with 2 ducts



All these particular limits come from the same EMC Theoretical Length, or "ETL". To reach this ETL it is assumed that the following two optimum conditions have been fulfilled:

- a second duct, at least 30 cm away, is reserved for power and relay cables,
- the ducts are not filled to more than 50% of their capacity.

Ki Coefficient

Depending on the type of communication network this value can be different.

- Everytime one of both conditions is not fulfilled from end to end and in order to observe electromagnetic compatibility, a coefficient must be assigned to the physical duct length. These Ki coefficients, defined in the table below, measure the decrease of the protective effect. The resulting authorized length will then be less than the ETL.
- Similarly, in the case of a single duct for power and signal cables, the coefficient will take into account the lack of a metal separation or metal covering on the signal half duct.

Summary table

Symbol	Condition	Illustration	Coefficient	Total length (1)
			Ki	ETL x 1/Ki
K50	Single duct filled to 50% or more		2	200 m
K10	Ducts 10 cm apart (instead of 30 cm)		2	200 m
K6	Single duct or 2 contiguous ducts with separation and cover on the signal half duct		4	100 m
K8	Single duct or 2 contiguous ducts without cover on the signal half duct		6	60 m
K0	Single duct or 2 contiguous ducts without separation		12	30 m

(1) Maximum total length if it's the unique condition against (with ETL = 400m)

Verification modes of the length of a homogeneous cable

Introduction

There are two ways of using the K_i coefficients.

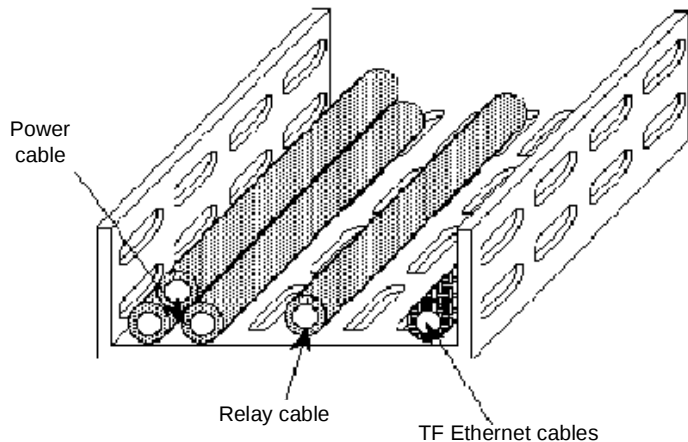
- To obtain the authorized physical length, you take the ETL and divide it by K_i , (examples 1 and 2 below).
- On the contrary, when particular physical lengths are imposed necessary, multiply them by K_i and compare the result with the ETL to check that you are compliant with the EMC requirements (examples 3,4, and 5).

Example 1: Transparent Factory links less than 30m

Wiring can then be done in a single metal run (for ETL = 400 m or more).

If the duct is not filled to more than 50% (bear in mind future developments), only the K_o coefficient must then be taken into account, which gives a maximum length of 400 m: 12×30 m.

The power cables and shielded digital connections shall be fixed in the corners of the duct as shown in the illustration below:



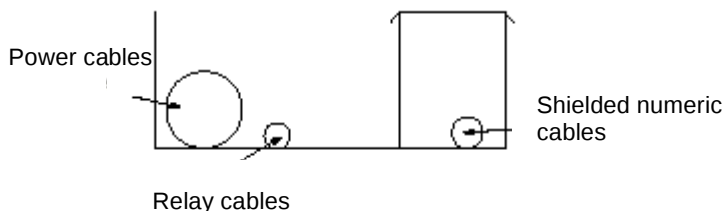
Example 2:
Transparent
Factory links up
to less than 100m

If length calculated in an installation condition is insufficient (30 m in the first example) it will be necessary to improve the EMC aspect of the configuration. Vertical separation in the duct avoids mixing incompatible cables. A metal cover on the half duct of the signal cables restricts signal interference. That's why the coefficient value then goes from 12 (=K0) to only 4 (=K6), which, (with ETL=400) gives the maximum length: $ETL / 4 = 100$ m. The EMC conditions to be observed are then:

- each half duct is filled to 50% max.,
- the separation is metallic and in contact with the duct along the whole length,
- the cover is in contact with the separation along the whole length.

Note: Bear in mind future developments.

Illustration



Example 3: Plan
for laying 30m of
Transparent
Factory cable

It is planned to lay the cable in a single duct filled to 70% without separation, together with a power cable and an analog cable. This installation condition, according to the Ki symbols table, is linked to two coefficients: K0 (=12) et K50 (=2); you must therefore multiply the physical length by 2 and by 12. As the result 720m (30m x12) is greater than ETL=400m, the 30m installed length will not comply with EMC requirements. Example 4 (next §) explains a possible solution.

Verification mode of a the length of a heterogeneous cable

Introduction

When there are multiple installation conditions along the length of a cable run, each physical length of the same laying type must be multiplied by the relevant coefficients following the same rules as above.

The sum of the various results must be less than ETL (Transparent Factory).

Example 4: New laying plan for 30m of Transparent Factory cable

The signal cable in example 3 is laid along 10m according to the laying type above; the remaining 20m are laid 10 cm away from the first one, in a separate duct from the power cable, but placed .

Calculation table

Length	Ki coefficients	Calculations	Results
10 m	K0 (=12) et K50 (=2)	10 m x 24	240 m
20 m	K10 (=2) et K50 (=2)	20 m X 4	80 m
Total (30 m)		240 m + 80 m	320 m

As the resulting 320m is now less than ETL = 400m, the 30 m installed length will comply with EMC requirements.

Example 5: Laying plan for a 1000m FIP cable

The documentation for the system shows that the first limit is observed, provided only if main cable (150 ohms single pair large gage) is used.

The ETL value for this technology is 2000 m.

Let us assume that the 2 optimum conditions are observed for 700m and that for the rest of the length the power duct is:

- filled to more than 50%,
- and only 10cm away from the signal duct.

Calculation table

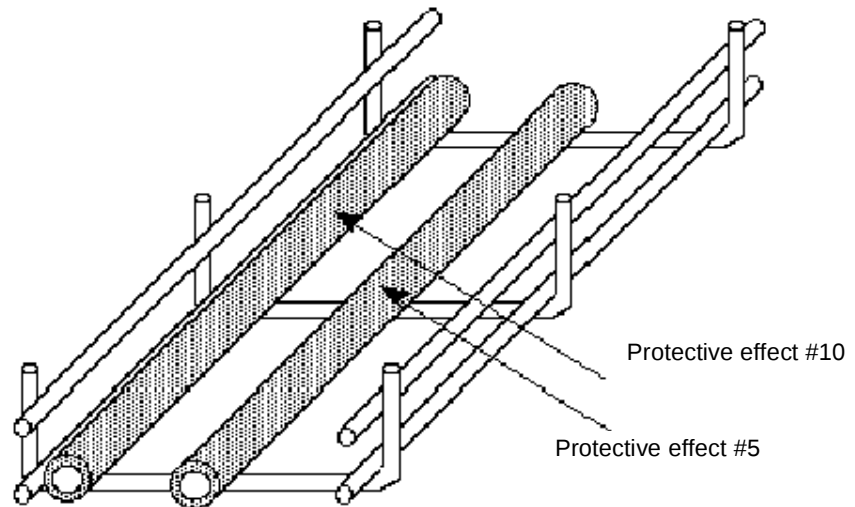
Length	Ki coefficients	Calculations	Results
700 m	no		700 m
300 m	K50 (=2) et K10 (=2)	300 m X 4	1.200 m
Total (1.000 m)		700 m +1.200 m	1.900 m

As the result 1900m is less than ETL=2000m, the installed length will comply with EMC requirements and only the previous contingency remains (no small gage pair).

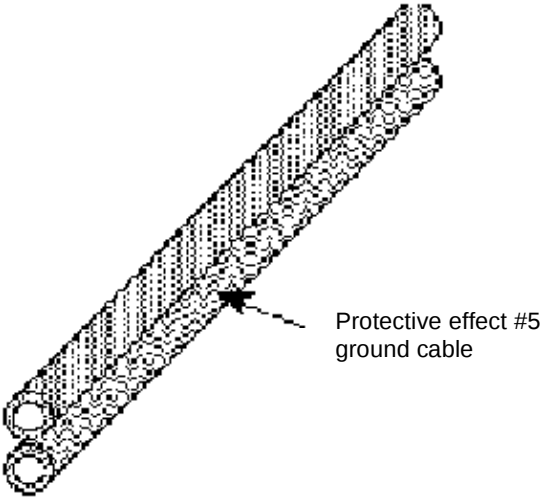
Other protective effects

Introduction

The protective effect of a cable run is about 50 between 1 MHz and 100 MHz. If you cannot use this type of hardware, other protective effects are possible. Soldered wire cable runs "cablofils" are less effective and often more expensive than metal ducts. Cablofil



Grounding cable



26.4 Inter building links

Introduction

Presentation This chapter gives the precautions and recommendations for inter building wiring.

Note: It is strongly recommended to use optical fiber cable for data links and therefore for Transparent Factory between buildings. This type of link is used to eliminate loop problems between buildings.

What's in this Section? This section contains the following topics:

Topic	Page
Wiring electrical connections	318
Protection against intrusion	319

Wiring electrical connections

Principle

Inter building links present two special features that can introduce risks for the installation:

- the poor equipotentiality between installation grounds,
- the large areas of loops between the data cables and the grounds.

Note: Before installing and connecting a data cable between two buildings, you must check that the two ground connections (one at each building) are interconnected.

All the exposed metal parts accessible at the same time must be connected to the same ground connector (or at least to a set of interconnected ground connections). This requirement is fundamental to ensure people's safety.

The second risk associated to inter building connections is the area of loop included between the data cables and the connections.

This loop is particularly critical when there is an indirect blasting of the site. The overvoltage caused in these loops by an indirect blasting is approximately of 100 volts per m.

Note: In order to reduce this risk, all cable runs between two buildings must be doubled up with a large section equipotential line ($\gg 35 \text{ mm}^2$).

Protection against intrusion

Principle

Common mode currents coming from outside must be discharged to the ground network at the entrance to the site in order to limit voltages between equipments.

Note: Any conducting lines (conducting cable, conducting pipework or insulating pipework carrying a conducting fluid), entering in a building must be connected to a ground at the entrance of the building and at the shortest possible distance.

Surge absorbers must be placed on electricity, telecommunications and signal cable (for data, alarms, access checks, video supervision,...) at the entrance to the buildings. The efficiency of such devices is largely influenced by the way they are installed.

The surge absorbers (varistors, discharge gaps etc.) must be connected directly to the ground connection on the electrical panel or to equipments they are protecting. Simply connecting surge absorbers to earth (instead of the mechanical ground) is not efficient.

As far as possible the panels, where the electrical, telecommunications and signal protectors are installed, must be placed close to a grounding strip.

26.5 Using optical fiber

Choosing and Fitting Optical Fiber

Introduction This chapter gives the necessary recommendations for choosing optical fibers.

What's in this Section? This section contains the following topics:

Topic	Page
Choosing the optical connection type	321
Fitting the optical patches	321

Choosing the optical connection type

Choosing the optical fibers

Schneider Electric supplies Transparent Factory equipments with optical ports: modules, hubs and switches. What all those equipments have in common is that it is used to connect **silica multimode fibers**. Each optical connection needs two fibers.

From one end to the other these fibers must be **62.5/125 type** and specified to allow communication on wavelengths **850 nm and 1300 nm**.

Choosing the optical cables

The cable must include a minimal amount and maximal quality of fibers as described in the previous paragraph. Furthermore, it can contain other fibers or electrical conductors.

Its **protection** must be compatible with the installation conditions.

Fitting the optical patches

Definition

The optical strings necessary to connect the Control Intranet modules, hubs and switches are supplied in 5 meter lengths with the options of suitable optical connectors.

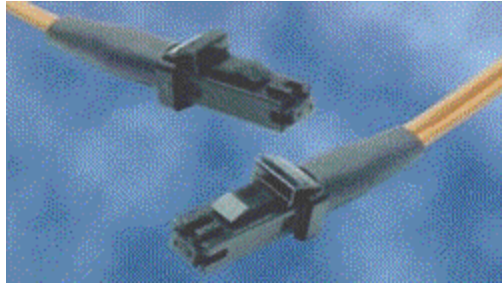
MT-RJ / SC duplex optical patch (490NOC00005)



MT-RJ / ST duplex optical patch (490NOT00005)



MT-RJ / MT-RJ optical patch (490NOR00005)



Two important precautions must be taken by the installer and the user :

- 1. Do not bend these stringss (**the minimum radius is 10 cm**).
- 2. Pull or twist the cable and its connectors as less as possible.

On the other hand, **there is no minimum distance** to be observed between an optical cable and any cable or equipment which could interfere with it. Special cases of strong ionizing rays is not the purpose of this manual.

Overview

Introduction This chapter contains product specific guidelines, installation instructions and information about grounding and EMC for Modbus Plus network components. It contains the same information as the documentation provided with the products.

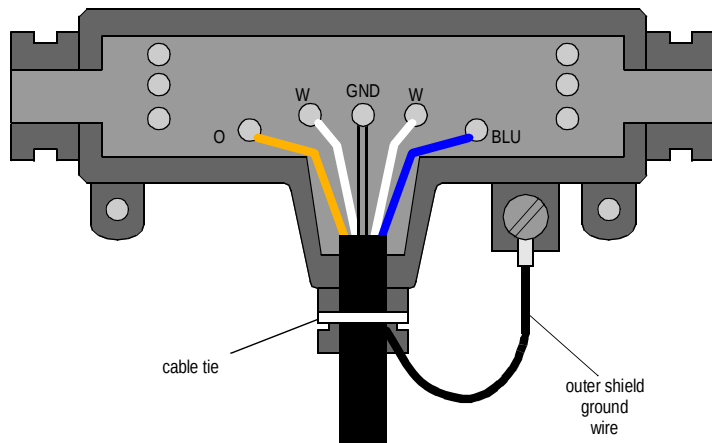
What's in this Chapter? This chapter contains the following topics:

Topic	Page
Modbus Plus Termination and Grounding	324
Fiber Repeaters	327

Modbus Plus Termination and Grounding

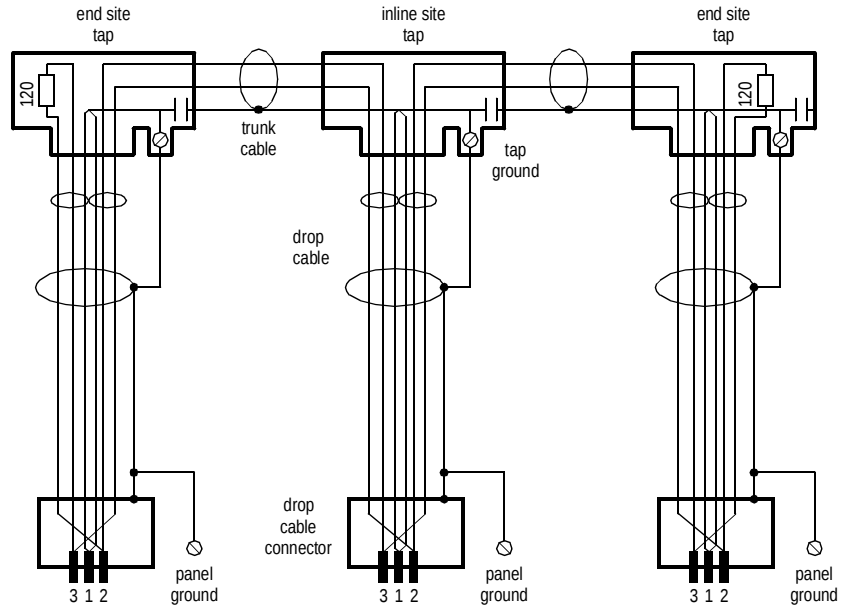
How taps have to be terminated

A tap is required at each site on the trunk cable to provide connections for the trunk cable and drop cable. Each tap contains an internal terminating resistor that can be connected by two jumpers. Two jumper wires are included in the tap package, but are not installed. At the taps at the two ends of a cable section, you must connect both of the jumpers to provide the proper terminating impedance for the network. Taps at inline sites must have both jumpers removed. The impedance is maintained regardless of whether a node device is connected to the drop cable. Any connector can be disconnected from its device without affecting the network impedance. The diagram shows a Modbus Plus Network connection with terminating resistors and grounding.



Grounding at the tap

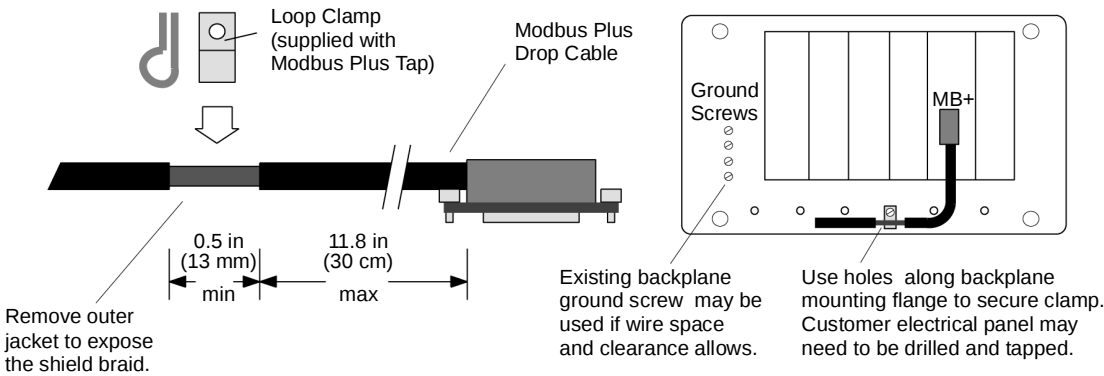
Each tap has a grounding screw for connection to the site panel ground. Modicon drop cables have a grounding lug in the cable package. This must be tightly soldered or crimped on the cable and connected to the grounding screw on the tap. The diagram shows a drop cable, connected and grounded with a tap.



The node device end of the drop cable has a lug which must be connected to the node device's panel ground. The network cable must be grounded through this connection at each node site, even when the node device is not present. The ground point must not be left open. No other grounding method can be used.

Grounding at the device panel

Modbus Plus network drop cables require a ground connection to the backplane. The connection is made by means of a metal loop clamp that grounds the cable shield to the ground point. The following figure shows the Modbus Plus grounding at the device panel.



Note: To maintain CE compliance with the European Directive on EMC (89/336/EEC), the Modbus Plus drop cables must be installed in accordance with these instructions.

Preparing the cable for grounding

This table shows the steps to prepare the cable for grounding

Step	Action
1	Determine the distance from the cable's end connector to the intended ground point on your backplane or panel
2	Stripping of the cable's outer jacket Note: Keep in mind, that the maximum allowable distance from the ground point to the cable's end connector is 11.8 in (30 cm)
3	Remove 0.5 -1 in (13-25 mm) of the cable's outer jacket to expose the shield braid as shown in the figure above.)
4	If the panel has a suitable ground point for mounting the cable clamp, install the clamp at that point

Fiber Repeaters

Grounding

This table shows the steps for grounding a Modbus Plus Fiber Repeater

Step	Action
1	Connect the Repeater to the site ground Result: The Repeater obtains it's ground through the chassis ground screw or DC (-) wire.
2	Use a continuity tester to verify, that the repeater is grounded to the site ground

Connecting AC power

This table shows the steps to supply AC power to the repeater

Step	Action
1	Remove the power at it's source
2	If necessary install a different plug on the cable for the power source at your site Note: The AC power cable supplied with the repeater is keyed for North American 110-120 VAC outlets.
3	Remove the AC power cable from the repeater
4	Set the power selector plug to the 110-120 VAC or 220-240 VAC position for the power source at your site. To do this 1. Remove the power selector plug by prying under it's tab using a small screw driver 2. Set the plug to the proper voltage position as shown on the plug body 3. Reinsert the plug
5	Insert the AC power cable in the rear panel connector
6	Insert the AC power cable into the power source

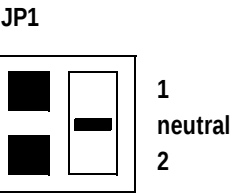
Connecting DC power

This table shows the steps to supply DC power to the repeater

Step	Action
1	Remove the power at it's source
2	Connect the source to the DC power terminals, observing the proper polarity

RIO shield-to-chassis switch

RIO cable shield-to-chassis switch on the rear of the repeater is used to specify the repeater’s relationship to chassis ground.
This diagram shows the shield-to-chassis switch



This table shows the function depending on the switch position

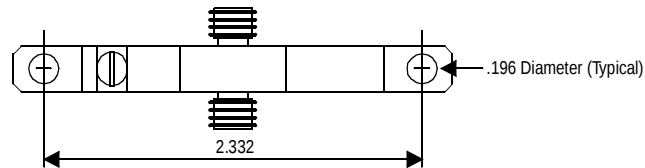
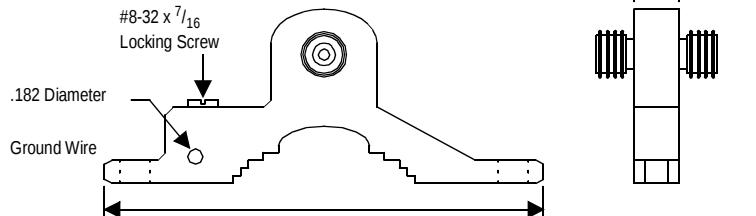
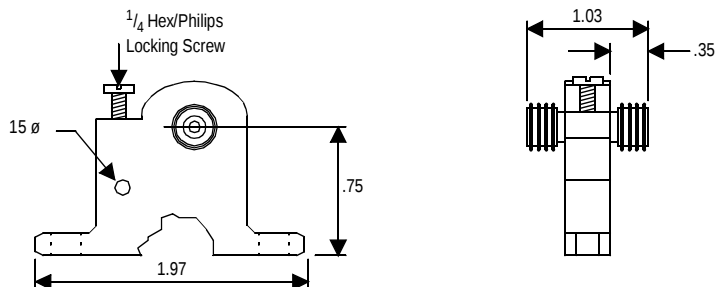
Switch position	Function
1	RIO cable shield is isolated from chassis ground by a capacitor (i.e if low frequency is a problem)
neutral	Repeater is configured as a drop on the optical link (shipped position)
2	RIO cable shield is connected directly to chassis ground (i.e. the same ground as the main RIO head)

Grounding of RIO Networks

Overview	The Remote I/O communication is based on single point grounding, that is located at the head. Coaxial cable and taps have no additional connection to the ground. That eliminates the low frequency ground loops.
Missing grounding	A cable system must be grounded at all times to ensure safety and proper operation of the nodes on the network. The cable system is grounded by the RIO head processor. But if the cable is removed, the ground connection doesn't work anymore.
Ground Blocks	Ground blocks ensure grounding, even if the cable is removed. Additional properties are as follows: • Low insertion loss Only if five or more are used, they have to be consider in the trunk attenuation with 0.2 dB each. The impedance is 75 Ohms and the return loss > 40 dB • Wide application frequency

Ground Block structure

The ground block 60-0545-000 consists of two female in-line F connectors and a separate screw hole binding for attaching a ground wire. The grounding block has two mounting holes, allowing it to be mounted to a flat surface. Two styles of the ground block 60-0545-000 are available and may be used interchangeably. This diagram shows the dimensions of the two available 60-0545-000 grounding blocks.

**Type A****Type B**

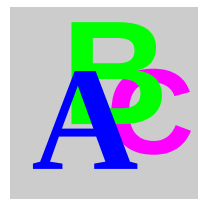
Note: Local building codes may require the cable shield tied to ground, whenever the cable system exits and/or enters a new building (NEC Article 820-33)

Surge protection Surge protection is available for coaxial network trunks that span between buildings and are exposed to lightning. The recommended product has internal gas discharge surge protectors that absorb very high currents induced into the cable system by near-lightning strikes. The device indicated has insertion loss of less than 0.3 dB at the network operating frequency. The unused drop ports must be terminated with a Modicon 52-0402-000 Port Terminator. If desired, shrink tubing may be used to seal the F connections.

The device should be accessible for maintenance, and be protected from the elements if installed outside. The threaded stud should be connected to building ground.

The recommended product is Relcom Inc. p/n CBT-22300G. Contact information is:
Relcom Inc.
2221 Yew Street Forest Grove, Oregon 97116, Tel: 8003823765
www.relcominc.com

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