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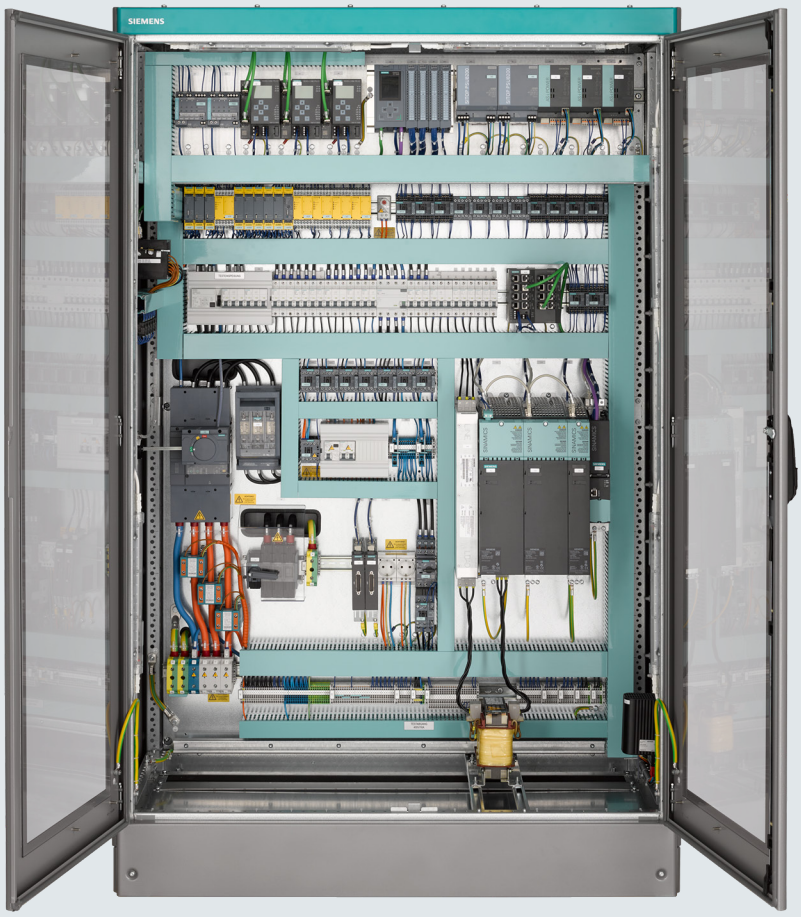

Control Panels

The EMC Directive 2014/30/EU in Practice

Reference Manual

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Control panels

The EMC Directive 2014/30/EU in Practice

Reference Manual

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Legal information

Warning notice system

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

⚠ DANGER

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

⚠ WARNING

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

⚠ CAUTION

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

NOTICE

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

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

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

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Siemens AG
Division Digital Factory
Postfach 48 48
90026 NÜRNBERG
GERMANY

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Preface

History

It was not all that many years ago that the term EMC – Electromagnetic Compatibility - was generally understood to refer primarily to radio frequency interference (RFI). "Radio frequency interference" is generally used to describe the energy that is emitted, radiated or induced by electrical equipment and that has a negative impact on the operation of a radio system.

With this interpretation of EMC, the only relevant issue to be considered in relation to control panels was whether the phenomena described above (radiation, emission or induction) caused by power engineering components in certain equipment would have a negative impact on radio communications.

As the volume of electronic circuitry integrated in electrical equipment (particularly in control panels) rapidly increased, the subject of electromagnetic compatibility took on a whole new meaning.

EMC in the year 2016

When assessing the electromagnetic compatibility of equipment (particularly power engineering systems) in which electronic circuitry is integrated, it is important to consider the totality of all electrical, magnetic and electromagnetic interference.

We need to consider two aspects, i.e. the

- conducted interference, as well as the
- electromagnetically radiated interference

that can reach equipment containing electronic circuitry and have a correspondingly negative effect on its operation.

Objective of the guideline

The intended objective of this guideline is to help users

- understand and ensure compliance with the requirements of the new European EMC Directive 2014/30/EU for control panels,
- understand and put into practice the possibilities and the details of the verification procedure as defined by EN 61439-1,
- acquire a good basic understanding of EMC measures,
- understand and apply practical tips illustrated by an example.

Device-specific technical documentation

The binding document for EMC-compliant configuring and installation is always the device-specific technical documentation. Compliance with the measures described in this documentation is essential in order to ensure adherence to the statutory limit values and proper functioning of equipment.

Disclaimer of liability

The examples and interpretations of directives, standards and guidelines are not binding and do not claim to be complete with respect to configuration, equipment or any other eventuality. They are not customer-specific solutions and are only intended to provide assistance with typical tasks.

Each user of this document is responsible for correct operation of the products described. This document does not exempt you from your obligation to use directives and standards in a proper manner.

By using this document, you agree that Siemens cannot be made liable for possible damage beyond the above-mentioned liability clause.

We reserve the right to make changes and revisions to this document at any time without prior notice.

Some tables and texts included in this description were lifted straight from the relevant directives, standards and technical documentation. All users of this documentation must always check whether or not the quoted passages are still up to date.

The final decision about the appropriateness of applying the relevant directives and standards must be made by the user of this documentation.

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EMC Directive 2014/30/EU

1

1.1 European directives 2014

New directives as of April 2016

As part of its "New Legislative Framework – NLF", the Commission of the European Union issued eight "new" directives to replace existing directives on March 29, 2014. Compliance with and application of these directives has been mandatory since April 20, 2016.

Objectives of the new directives

One of the most important objectives of the "New Legislative Framework" is to promote the implementation of harmonized conditions of competition for the European market and to ensure the protection and safety of consumers. The directives were also revised in order to harmonize them with other directives within the new legislative framework.

Overview of EU directives

The following European directives were revised and republished as part of the NLF:

Table 1- 1 Overview of old and new directives

Directive	Old	New
Lifts Directive	95/16/EC	2014/33/EU
ATEX Directive	94/9/EC	2014/34/EU
Simple Pressure Vessel Directive	2009/105/EC	2014/68/EU
Non-Automatic Weighing Instruments Directive	90/384/EEC	2014/31/EU
Measuring Instruments Directive	2004/22/EC	2014/32/EU
Explosives for Civil Uses	93/15/EEC	2014/28/EU
Low Voltage Directive	**2006/95/EC**	**2014/35/EU**
EMC Directive	**2004/108/EC**	**2014/30/EU**

Effects on control panel engineering

The Low Voltage Directive 2014/35/EU and the EMC Directive 2014/30/EU are of special significance to electrical project management specialists and to manufacturers of control panels and general electrical equipment for machines and installations.

1.2 Definition of terms

Equipment

The purpose of the directive is to ensure the proper functioning of **equipment**. The term "equipment" refers in this case to a single **apparatus** or to **fixed installations**.

Apparatus

An apparatus means "any finished appliance or combination thereof made available on the market as a single functional unit, intended for the end-user and liable to generate electromagnetic disturbance, or the performance of which is liable to be affected by such disturbance" (DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 relating to electromagnetic compatibility, OJ L 96/84, CHAPTER 1, Article 3, par. (1), 2.)

Fixed installation

A fixed installation means "a particular combination of several types of apparatus and, where applicable, other devices, which are assembled, installed and intended to be used permanently at a predefined location" (DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 relating to electromagnetic compatibility, OJ L 96/84, CHAPTER 1, Article 3, par. (1), 3.)

Classification of equipment

To assist with the classification of an item of equipment as an "apparatus" or "fixed installation", the European Commission has issued a "Guide for the EMC Directive 2004/108/EC (8th February 2010)", cf. Chapter 1.1.5, page 15. In this guide you will find examples of items of equipment that belong to the category "Fixed installation", cf. Chapter 1.3.1, page 20.

1.3 Requirements and safety objectives

Validity and scope

The responsibilities of manufacturers, importers and distributors in connection with the sale of **electromagnetic equipment** have been defined in the EMC Directive 2014/30/EU. The directive fulfills the role of defining how devices have to function together in a particular environment

The EMC Directive 2014/30/EU **applies only to apparatus**, but not to electromagnetic fields and their effects, e.g. on people. Radio systems and telecommunications terminal equipment are not covered by the EMC Directive 2014/30/EU, but are dealt with in another directive.

Note

Control panels

In the vast majority of cases, industrial, machine-oriented control panels fall within the scope of the EMC Directive 2014/30/EU since equipment **with electronic circuitry** are required for and therefore generally installed in control panel applications of this kind.

Requirements of the EMC Directive

Correct functioning of equipment is ensured by defining an acceptable level with regard to electromagnetic compatibility. Accordingly, electrical equipment must be designed and manufactured so as to ensure that it possesses the following characteristics:

- The electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended.
- It has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use

The equipment must fulfill the essential requirements of the EMC Directive 2014/30/EU, cf. DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 relating to electromagnetic compatibility, OJ L 96/97, ANNEX I:

1. **General requirements**:
   - Equipment shall be so designed and manufactured, having regard to the state of the art
   - Limitation of interference emission
   - Adequate degree of immunity
2. Specific requirements for **fixed installations**:
   - Installed applying good engineering practices
   - Responsible person keeps the documents for inspection
   - Information on the intended use of its components is respected

1.4 Modifications to 2004/108/EC

The new EMC Directive 2014/30/EU does not contain **any technical changes** in comparison to the previous EMC Directive 2004/108/EC. The EMC Directive 2014/30/EU is the only EU directive that is not **safety-related**.

Modifications to the EMC Directive 2004/108/EC

- The EMC Directive 2014/30/EU clearly stipulates that **documents must be kept for at least 10 years after the apparatus has been placed on the market** and be made available for inspection upon request. In the case of fixed installations, the responsible persons shall keep the document at the disposal of the relevant authorities for inspection for the entire service life of the apparatus.
- The documentation must be written in a **language** that can be easily understood by local authorities and end users of the product.
- The **postal address of the manufacturer** must be stated on the equipment itself wherever possible.
- Manufacturers may also provide the documentation and verification of conformity of the apparatus **in electronic form**.
- All apparatus placed on the EU market must bear the **CE marking** and thus provide the assurance that the apparatus complies with all essential requirements of EU regulations.

Note

Exception: Fixed installations

Equipment does not need to undergo a conformity evaluation if it is placed on the market solely for integration in a specific fixed installation. It must nevertheless comply with the protection requirements of the EMC Directive 2014/30/EU. In other words, the equipment does not require an EU Declaration of Conformity or a CE marking. However, the market surveillance authorities may demand proof of conformity, in particular if there are signs of non-conformity or in the event of complaints.

- Before receiving the CE marking, the manufacturer must perform an **assessment of conformity** and prepare **technical documentation for the equipment**.
- Importers or **distributors** of the product **are responsible for checking** whether the manufacturer has properly carried out the relevant **assessment of conformity procedure**. They are obliged to notify the national market surveillance authorities if they are of the opinion that the equipment does not comply with essential requirements.
- **The technical documentation must be devised such that it allows the product to be assessed against the essential requirements of EU regulations.**
- The documentation must include a **suitable EMC risk analysis and assessment**.
- The EMC Directive 2014/30/EU further defines the responsibility of national authorities to prevent products that do not meet essential requirements from being placed on the market.

1.5 Assessment of conformity

Additional obligations of manufacturers

As a result of the publication of the new EMC Directive, manufacturers now have new obligations to verify that their products conform to the EMC Directive 2014/30/EU. It is no longer sufficient to simply verify the electromagnetic compatibility of equipment on the basis of test reports containing EMC test data or on the basis of expert analysis. The new EMC Directive 2014/30/EU stipulates that the electromagnetic compatibility of an apparatus must be verified by an appropriate risk analysis and assessment.

Note

The European Commission's new "Blue Guide"

You can find further information about the conformity assessment procedure in "The "Blue Guide" on the implementation of EU product rules 2016" recently published by the EU.

Until April 19, 2016

According to the previously applicable directive 2004/108/EC, manufacturers could verify compliance of their products with the EMC Directive 2014/30/EU simply by assessing the electromagnetic phenomena of the equipment and its compatibility. As an alternative, they could apply harmonized standards as a factual equivalent to performing an assessment:

"The manufacturer shall perform an electromagnetic compatibility assessment of the apparatus, on the basis of the relevant phenomena, with a view to meeting the protection requirements set out in point 1 of Annex I. The correct application of all the relevant harmonised standards whose references have been published in the Official Journal of the European Union shall be equivalent to the carrying out of the electromagnetic compatibility assessment." (DIRECTIVE 2004/108/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004, OJ L 390/32, ANNEX II, 1.)

From April 20, 2016

In the recently published EMC Directive 2014/30/EU, the passage cited above concerning the alternative application of European standards was one of the passages deleted in order to harmonize the EMC Directive 2014/30/EU with the New Legislative Framework NLF. Similar to the requirements of the old EMC Directive 2004/108/EC, the new EMC Directive 2014/30/EU also requires manufacturers to assess the electromagnetic compatibility of an apparatus on the basis of electromagnetic phenomena and ascertain whether it fulfills the conditions set out in the EMC Directive 2014/30/EU.

"The manufacturer shall establish the technical documentation. The documentation shall make it possible to assess the apparatus conformity to the relevant requirements, and shall include an adequate analysis and assessment of the risk(s)." (DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 relating to electromagnetic compatibility, OJ L 96/98, ANNEX II, 3., sentence 1)

1.6 New: Risk analysis and assessment

To perform the risk analysis within the scope of the European directives, the European Committee for Electrotechnical Standardization (CENELEC) offers the CENELEC Guide 32:2014 as assistance for operating equipment with low voltage.

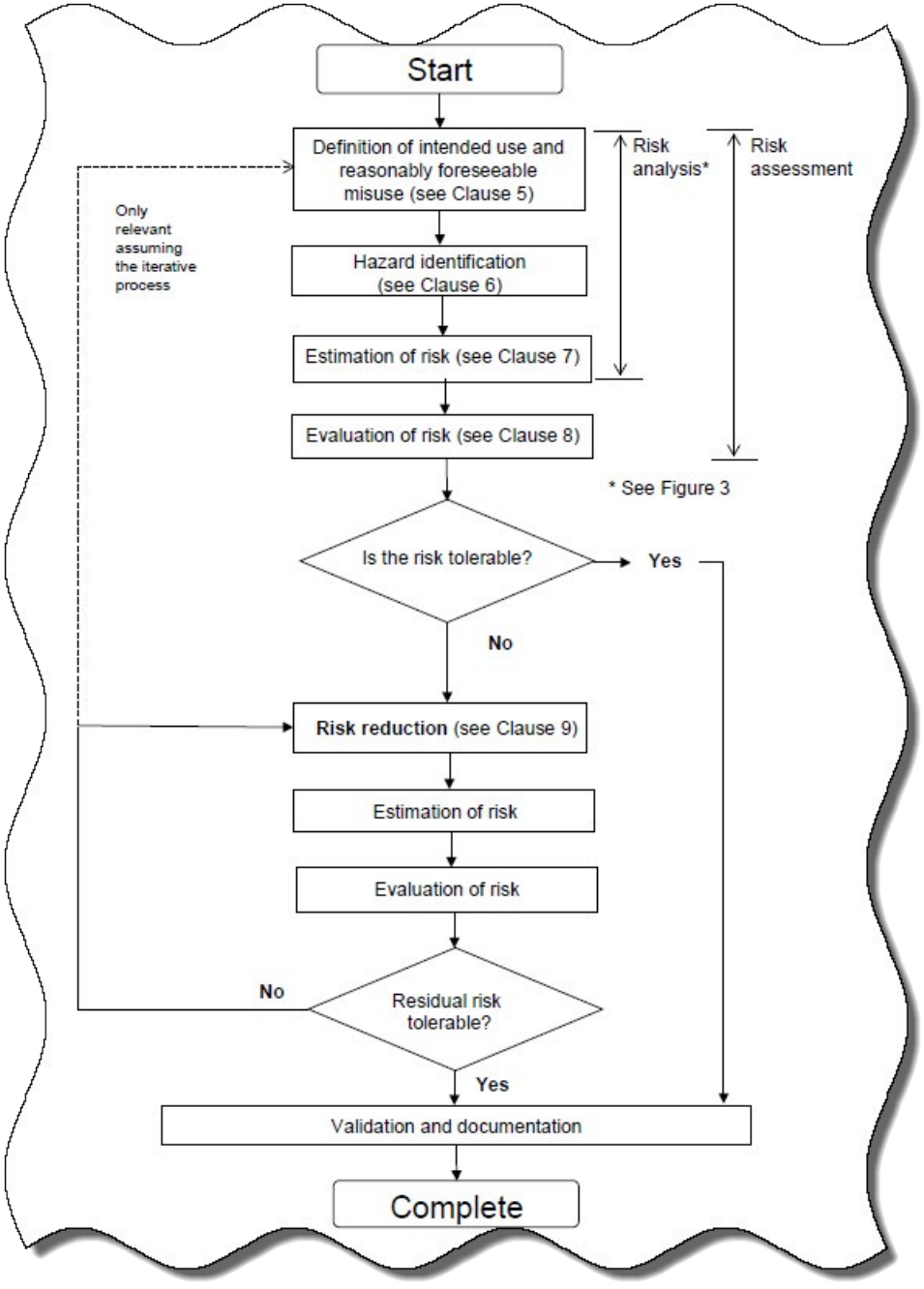


Figure 1-1 CENELEC Guide 32:2014, page 14: Risk assessment and reduction

Harmonized EMC standards

2

2.1 Correlation between directives and standards

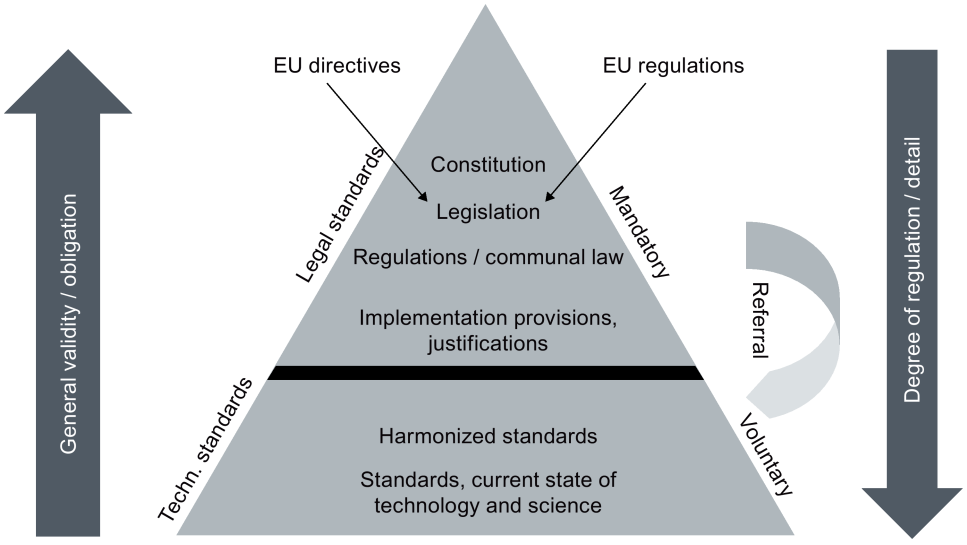


Figure 2-1 Correlation between directives, regulations, legislation and standards

European legislation

As a general rule, **European directives** are anchored in the national laws of individual EU countries.

By contrast, **EU regulations** apply directly in the EU member states.

Note

Responsibility of the manufacturer

Individual manufacturers are responsible for deciding which directive, and accordingly, which standard they need to apply in order to achieve the safety objectives for their application. The currently harmonized standards can be found in the Official Journals of the European Union, see Chapter Official Journals of the EU (Page 18).

2.2 Official Journals of the EU

The official journals that publish European directives list the various harmonized standards that make it possible to fulfill each respective directive's safety objectives (presumption of conformity). Every manufacturer is responsible for checking that the standards applied are still up to date.

In an excerpt from the Official Journal of the European Union (2015/C 014/16 ff) published on January 16, 2015, you will find a selection of EMC standards that apply to control panels:

ESO (1)	Reference and title of the standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard Note 1
(1)	(2)	(3)	(4)
Cenelec	EN 61439-1:2011 Low-voltage switchgear and controlgear assemblies — Part 1: General rules IEC 61439-1:2011	EN 61439-1:2009 Note 2.1	Date expired (23.9.2014)

16.1.2015 EN Official Journal of the European Union C 14/17

(1)	(2)	(3)	(4)
Cenelec	EN 61439-1:2009 Low-voltage switchgear and controlgear assemblies — Part 1: General rules IEC 61439-1:2009 (Modified)	EN 60439-1:1999 Note 2.1	Date expired (1.11.2014)
	EN 61439-1:2009/AC:2013		
EN 61439-1:2009 does not give presumption of conformity without another part of the standard.			
Cenelec	EN 61439-2:2011 Low-voltage switchgear and controlgear assemblies — Part 2: Power switchgear and controlgear assemblies IEC 61439-2:2011	EN 61439-2:2009 Note 2.1	Date expired (23.9.2014)
Cenelec	EN 61439-2:2009 Low-voltage switchgear and controlgear assemblies — Part 2: Power switchgear and controlgear assemblies IEC 61439-2:2009		
Cenelec	EN 61439-3:2012 voltage switchgear and blies — Part 3: boards		

Figure 2-2 Excerpt from the Official Journal of the European Union (2015/C 014/16 ff)

2.3 Equipment-specific EMC standards

Selection of standards applicable to control panel manufacture (not comprehensive)

Different standards can apply to different types of equipment. Listed below is a small selection of the EMC standards that may be applicable to control panels:

Standard	Title
EN 61439-...	**Low-voltage switchgear and controlgear assemblies** • Part 1: **General rules** Conformity according to EN 61439-1 can only be declared in conjunction with one of the relevant parts, e.g. Part 2. • Part 2: **Power switchgear and controlgear assemblies**
EN 61000-6-...	**Electromagnetic compatibility (EMC)** • Part 6-1: Generic standards - **Immunity** for **residential**, commercial and light-industrial environments • Part 6-2: Generic standards - **Immunity** for **industrial environments** • Part 6-3: Generic standards – **Emission standard** for **residential**, commercial and light-industrial environments • Part 6-4: Generic standards – **Emission standard** for **industrial environments**
EN 61800-3	**Adjustable speed electrical power drive systems** - Product standard • Part 3: EMC - requirements and specific test methods
EN 55011 / CISPR11	Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement

2.4 Definition of EMC environments

Standard-specific definitions

Most EMC standards distinguish between two different types of EMC environment: industrial environments and residential environments. However, the terms used to refer to these areas vary from standard to standard.

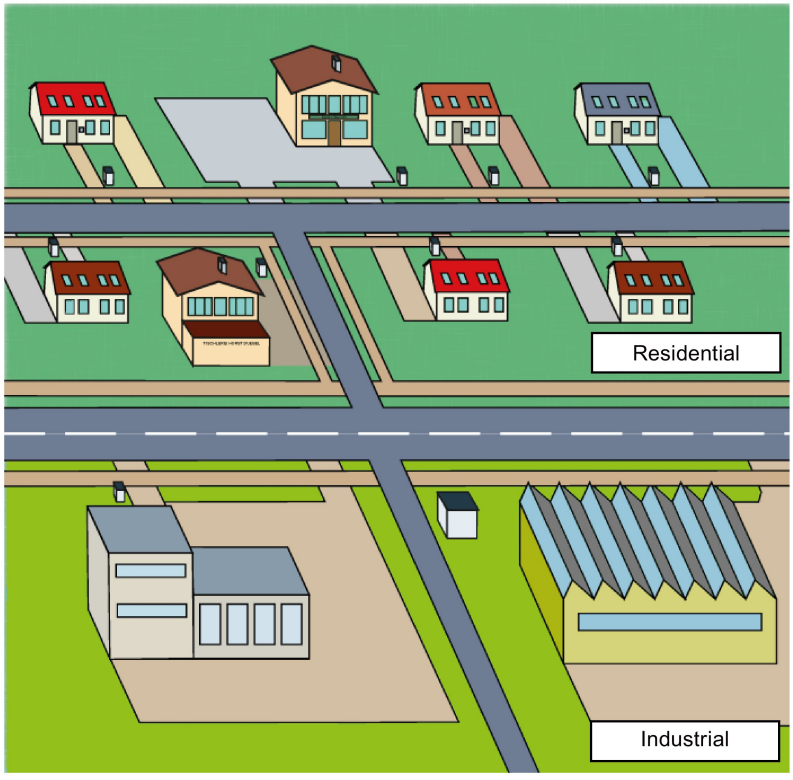


Figure 2-3 EMC environments

Table 2- 1 Standard-specific definitions for EMC environments

EMC environment	EN 61439	EN 61000-6	EN 61800-3	CISPR11 / EN 55011
Industrial environments	Environment A	Industrial environments	Second environment	Class A
Residential environments	Environment B	Residential environments	First environment	Class B

Note

Different limit values

Please note that the limit values applicable to EMC environments of the same kind might differ depending on the specific product standards.

Assessment of conformity for switchgear and controlgear assemblies

3

3.1 Possible methods of assessing conformity

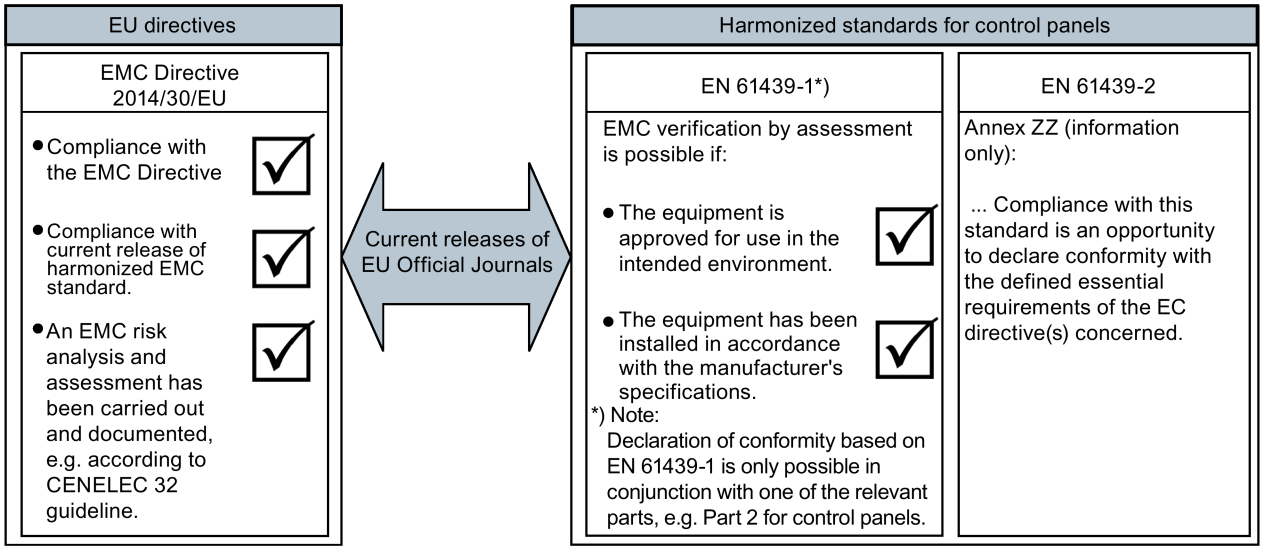


Figure 3-1 Possible methods of assessing conformity

Possible methods of assessing conformity

It is possible to declare the conformity of control panels to the EMC Directive 2014/30/EU in conjunction with the harmonized standards EN 61439-1 and EN 61439-2 by **verifying the following**.

1. The equipment is approved for use in the intended environment.
2. The equipment will be installed in accordance with the manufacturer's specifications.
3. The equipment conforms to the currently valid harmonized standards.
4. An analysis and assessment of the EMC risks have been carried out.
5. The manufacturer has complied with the formal requirements of the EMC Directive 2014/30/EU, e.g. obligations to supply documentation.

The individual steps are explained in more detail in the following chapters.

3.2 Design verification according to EN 61439-1

Requirement of the standard

Standard EN 61439-1 is the basic standard applicable to low-voltage switchgear and controlgear assemblies. According to the standard, a large number of design and routine verification processes must be carried out in order to verify design, assembly and functionality. For this purpose, standard EN 61439-1 provides a summary of the design verification processes (including the available verification methods) that can be selected in order to furnish the required verification, cf. EN 61439-1:2011, Annex D, page 102. The verification of electromagnetic compatibility (EMC) is also included in this summary as criterion no. 12.

Two equally valid, alternative verification options are available:

- Verification by testing
- Verification by assessment

Validity

Control panels with integral electronic circuitry must fulfill the requirement of the relevant applicable EMC product or generic standard. Electronic circuits include, for example, switch mode power supplies or circuits that contain high-frequency microprocessors. **Components with electronic circuits** must be suitable for the intended EMC environment. They must be installed and wired up in accordance with the equipment manufacturer's instructions.

Exceptions

Control panels are not susceptible to electromagnetic interference if they do not contain any equipment with electronic circuits. **Equipment without electronic circuits** include, for example, contactors (without electronic actuator). They do not therefore need to undergo interference immunity tests. Interference caused by supply conditions such as, for example, voltage fluctuations, dips or interruptions, is already taken into account in the equipment design, or can be eliminated by the inclusion of suitable circuit elements. The voltage strength of the equipment when it is loaded by transient surge voltages is assured by coordinated insulation measures.

Implementation in practice

Standards committees held detailed discussions and expressed controversial opinions as to how the suitability of control panels and EMC conditions should be determined and verified.

In view of the fact that control panels are usually manufactured on behalf of a client and, when the individual choice of equipment and the variations in ambient conditions and fields of application are also taken into account, are almost always a unique design, it was eventually agreed that **verification by testing is practically impossible**. This is true not only for technical verification reasons, but for economic reasons as well.

As a result, the principle option remaining is to test individual items of equipment that are relevant in terms of EMC (e.g. circuit breakers with electronic tripping unit, electronic controllers, soft starters, frequency converters, etc.) for their electromagnetic compatibility and suitability for use for the intended application, and to take into consideration the usual wiring methods, clearances and manufacturer-specific information relating to individual items of equipment when it is installed in control panels.

3.3 EMC verification by assessment

The only circumstances under which EMC testing for interference immunity and interference emissions does not need to be carried out on final assemblies of control panels are if the following two conditions are fulfilled and verification by assessment can take place, cf. EN 61439-1:2011, Annex J.9.4.2, page 123:

- The incorporated devices and components are in compliance with the requirements for EMC for the stated environment as required by the relevant product or generic EMC standard.
- The internal installation and wiring is carried out in accordance with the devices and components manufacturer’s instructions.

3.4 EMC verification by testing

If these two basic requirements for verification by assessment are not fulfilled, then the equipment must be tested to verify its compliance with the relevant electromagnetic compatibility requirements. These test procedures are described in Chapter "J.10.12 Tests for EMC" of standard EN 61439-1:2011.

Only in cases in which it is not possible to adhere to the equipment manufacturer's specifications or when an equal balance between emissions and immunity cannot be achieved is it necessary to verify electromagnetic compatibility by testing in accordance with the standard EN 61439-1.

In this case, **interference emission and interference immunity tests** must be carried out in conformance with the relevant EMC standard. Where required, the control panel manufacturer must specify supplementary measures (e.g. use of dwell times) that must be taken for the purposes of verification. In the context of EMC, the term dwell time refers to the time that the EUT (equipment under test) requires to complete all functions, i.e. has reached a "settled state", during EMC level measurements. The minimum dwell time is 0.5 s or 1 s.

Practical significance

EMC testing is generally an extremely time-consuming, expensive process. With regard to control panels, EMC testing is worthwhile only if a large number of completely identical control panels are to be manufactured, or produced on a large scale. This is the case, for example, if standardized modules are installed in a large number of panels for different applications and if it is necessary to deviate from the specifications of the manufacturer of these modules for important reasons (such as space requirements, device selection).

But even in instances where the panel manufacturer wishes to rely completely on the device manufacturer's specifications, it is advantageous to at least be aware of fundamental EMC-related problems and to understand why it is necessary to adhere to specific installation and wiring regulations in order to comply with EMC requirements.

3.5 Compliance with EMC Directive

Switchgear and controlgear assemblies can be declared compliant with the EMC Directive if the requirements of standard EN 61439-2 are fulfilled. Standard EN 61439-2 contains the following relevant note:

"Coverage of essential requirements of EU Directive 2004/108/EC. This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and within its scope the standard covers all relevant essential requirements as given in Article 1 of Annex I of the EU Directive 2004/108/EC. Compliance with this standard provides one means of conformity with the specified essential requirements of the Directives concerned.

WARNING Other requirements and other EU Directives may be applicable to the products falling within the scope of this standard."[1)]

Note

Risk analysis and assessment

EU Directive 2004/108/EC will be superseded by EU Directive 2014/30/EU on April 20, 2016.

By contrast with the old EMC Directive, the new one stipulates that the electromagnetic compatibility of an apparatus must be verified by an **appropriate risk analysis and assessment**.

[1)]Source: EN 61439-2:2011, Annex ZZ, page 26

Reproduction approved by DKE (DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik/German Commission for Electrical, Electronic & Information Technologies) on June 13, 2016. It is essential that the latest edition of the standard is applied. The latest edition can be purchased from the VDE VERLAG GmbH (www.vde-verlag.de) and the Beuth Verlag GmbH (www.beuth.de).

Fundamental principles of EMC

4

4.1 Electromagnetic compatibility

EMC (electromagnetic compatibility) means that the devices function satisfactorily without interfering with other devices and without being disrupted by other devices. This is true when the emitted interference (emission level) and the interference immunity are matched with each other.

Electromagnetic compatibility is the branch of electrical engineering concerned with the malfunctioning of electrical or electronic equipment caused by, for example, electrical, magnetic or electromagnetic fields or phenomena. A key factor in ensuring the electromagnetically compatible operation of electrical equipment is the proper construction and design of the equipment.

EMC interference emissions and interference immunity are regulated worldwide by standards, guidelines and legislation.

In the case of devices that are supplied ready to use, it normally suffices to install and operate them in accordance with the manufacturer's documentation in order to observe the EMC limit values and to achieve a satisfactory function. The binding document for configuring the respective device types is always the device-specific technical documentation. It is absolutely essential to follow the safety instructions given in the documentation.

4.2 EMC phenomena and causes

EMC phenomena

Electromagnetically-induced interference can have various effects in electrical installations:

- Unstable control systems
- Sporadic faults
- Measuring equipment malfunctions
- Communication equipment malfunctions
- Failure of or irreparable damage to devices and plant sections

Causes of interference

- Bouncing of mechanical contacts
- Switching on and off of fluorescent lamps
- Connection of open-circuited cables
- Ignition process with arc-welding equipment
- Disconnection of inductive loads, transformers, reactors, etc. that are installed in parallel to the voltage source
- High-frequency switching devices (frequency converters, power supply units, etc.)
- High-frequency control electronics (e.g. LCD screens)
- 50 Hz alternating supply voltage
- Changes in potential on the power supply leads to electronic circuitry
- Signal changes on control and data leads
- High-frequency and low-frequency clock signals
- Phenomena associated with de-energization of inductive loads, e.g. reed relays on printed circuit boards
- Magnetic fields induced by storage drives
- Spark discharges when contacts open and close
- Resonance effects when contacts close

4.3 Sources and victims of interference

The identification of potential sources and victims of interference is a crucial aspect of the risk analysis and assessment stipulated by the EMC Directive 2014/30/EU. A list of the typical interference sources and victims in control panel engineering can be found below.

Typical interference sources

- Contactor, electronic valves
- Frequency converter
- Electric motor
- Power supply unit, switched-mode
- High-frequency appliances
- Transmitters (e.g. radio system)
- Differences in ground or reference potential
- Operators (static charge)
- Power cables

Typical interference victims

- Sensors
- Controllers
- Measuring equipment
- Signal interfaces
- Communication equipment

Categorization of cables

Table 4- 1 Categorization of cables into interference sources and victims

Category	Cables
Interference victims	
Extremely sensitive	• Analog signals • Instrument leads
Sensitive	• Digital signals • Sensor cables • 24 V DC switching signals • Communication signals
Interference sources	
Interference source	• Control cables for inductive loads • Unswitched power cables • Motor brakes • Contactors
Strong interference source	• Frequency converter output cables • Welding equipment supply cables • Switched power cables

4.4 Interference propagation and countermeasures

Coupling paths

Electromagnetic interference can be propagated along a variety of different coupling paths until it reaches the "victim".

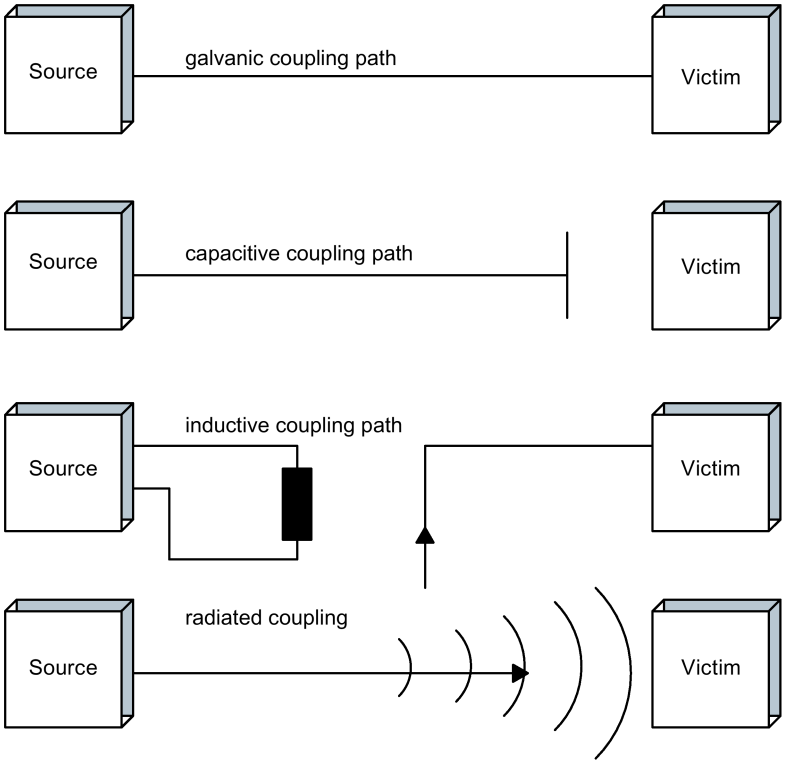


Figure 4-1 Coupling paths between sources and victims

Interference suppression measures

Table 4- 2 Coupling paths und possible interference suppression measures

Coupling path / interference sources	Possible interference suppression measures
Galvanic coupling, e.g. • Ground cable / ground connection shared by several devices • Two circuits share a common cable • Switched-mode devices (power supply network influenced by converters and external power supply units) • Motors during starting • Deviations in potential between enclosures of components with a common power supply	• Keep the length of the common conductor as short as possible • Use cables with a larger cross-section if the common impedance is largely ohmic in character • Use a separate supply and return conductor for each circuit
Capacitive coupling, e.g. • A motor cable and an unshielded signal cable are routed in parallel and in close proximity over a significant distance in a cable rack • Difference in potential between conductors • Interference coupling via signal cables routed in parallel • Static discharge from the operator	• Route the "source" cable and the "victim" cable at the largest possible distance from one another • Keep the distance over which cables are routed in parallel as short as possible, cross cables at right angles • Wherever possible, use signal cables that are shielded along their entire length and install low-inductance shield supports with large contact area: – The shield of digital signal cables is always bonded at both ends. – Low-frequency interference (ground loops) can develop on analog signal cables if the shield is bonded at both ends. In this case, only one end of the shield may be bonded at the converter. The other end of the shield should be grounded via a capacitor of type MKT with approximately 10 nF/100 V.

Coupling path / interference sources	Possible interference suppression measures
Inductive coupling, e.g. • Mutual interference between live conductor loops. Disturbance voltages are induced by the magnetic fields associated with the currents. • Transformers, motors, electric welding devices • Mains cables routed in parallel • Cables carrying switched currents • High-frequency signal cables • Unsuppressed coils	• Keep the distance between the conductor loops as large as possible • Keep the surface area of the conductor loops as small as possible, i.e. route the supply and return conductors in parallel and in the closest possible proximity to one another, or use twisted wires for signal cables • Use shielded signal cables; it is essential that the shield is bonded at both ends
Electromagnetic coupling (radiation coupling), e.g. • Mobile communication devices • Contactors and switches when switching contacts open • A group of cables is exposed to an electromagnetic wave. Currents and voltages are induced in the cables when the wave meets them. • Adjacent transmitters (e.g. radio telephones) • Spark gaps (spark plugs, collectors of electric motors, welding equipment)	• Use metal control cabinets in which the connections between individual components (cabinet frame, walls, doors, etc.) are electrically conductive • Use metal enclosures for devices and modules which have electrically conductive connections to one another and to the cabinet frame • Use cables that are shielded with a finely stranded braid designed to provide immunity against high-frequency noise

Note

Note the manufacturer's specifications

The generally known EMC measures do not always have the desired effect in every application. Whether the shield of analog signal cables should be bonded at one or both ends, for example, depends on the interference source and / or the coupling path.

The following therefore applies:

The technical documentation supplied with the devices or components used is always the binding document with respect to EMC measures. Follow the instructions contained in this documentation relating to EMC-compliant installation, operation and accessories (shielded cables, for example).

Take these manufacturer specifications as well as general EMC measures into account in the risk analysis and assessment.

4.5 Functional grounding

Electromagnetic interference

Electromagnetic interference can cause large deviations in potential between individual components and areas of the control cabinet. The high compensating currents that develop as a result can have undesirable effects in the control cabinet:

- Malfunctions
- Damage
- Irreparable damage
- Burn damage to shields that are bonded at both ends

To ensure problem-free interaction between the components in a complex system, a good system of equipotential bonding (functional grounding) is required. This must be effective for (high) frequencies of up to 10 MHz and above.

Functional grounding (FE)

The purpose of a functional grounding system is to enhance electromagnetic compatibility:

- It defines a common reference potential for signals
- It discharges interference currents and therefore limits their voltage drops on ground cables that cause interference voltages
- Shields are connected to this potential in order to prevent interference coupling

⚠ DANGER

Hazardous touch voltage

Functional grounding (FE) is not designed to provide electrical safety and is not identical to protective grounding (PE).

When grounding an electrical installation, take appropriate measures to protect personnel in accordance with DIN VDE 0100.

EMC in the control panel (example) 5

5.1 Basic rules of EMC

EMC-compliant installation

If you follow the basic rules stated below, they will help you to achieve a control panel design that is EMC-compliant. If you adhere to these rules and observe the specifications in the device-specific technical documentation, you can feel confident that your design will comply with EMC limit values and also function satisfactorily.

Basic rules of EMC

1. Separation of sources and victims of interference
   - EMC zoning
   - Separate routing of cables
2. Functional grounding and equipotential bonding
3. Use of shielded cables
4. Filters and suppressor circuits

Note

Note the manufacturer's specifications

The generally known EMC measures do not always have the desired effect in every application. Whether the shield of analog signal cables should be bonded at one or both ends, for example, depends on the interference source and / or the coupling path.

The following therefore applies:

The technical documentation supplied with the devices or components used is always the binding document with respect to EMC measures. Follow the instructions contained in this documentation relating to EMC-compliant installation, operation and accessories (shielded cables, for example).

Take these manufacturer specifications as well as general EMC measures into account in the risk analysis and assessment.

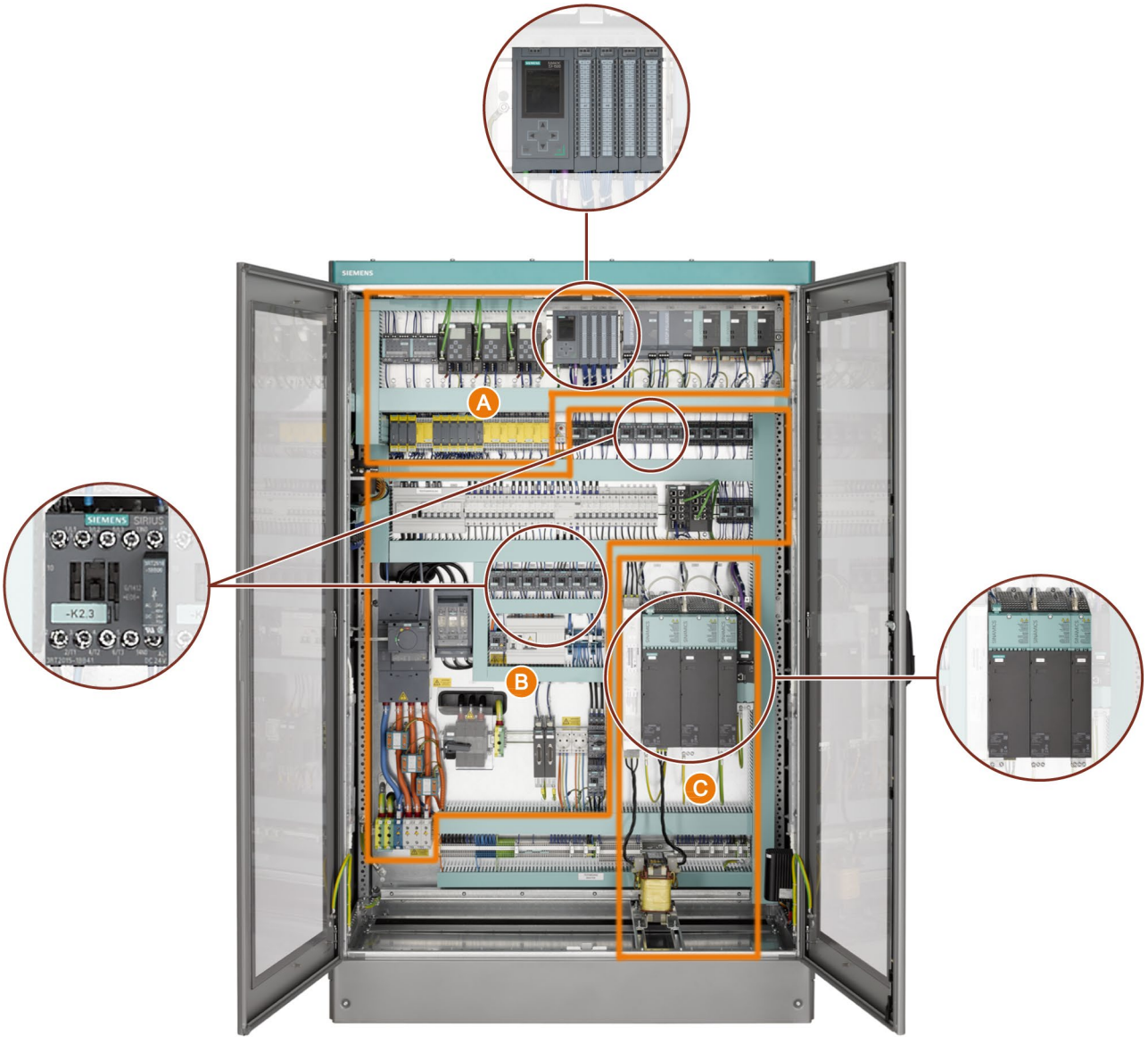
5.2 EMC zoning

Separation of sources and victims of interference

The easiest way to implement interference suppression measures within the control panel is to ensure that interference sources and interference victims are spatially separated.

1. Categorize each device as either an interference source or an interference victim.
2. Divide the entire control panel into EMC zones and assign the devices to these zones.
3. Prevent the interference sources from emitting interference:
   - Equipotential bonding
   - Shielding
   - Filters and suppressor circuits
4. Provide protection for interference victims:
   - Equipotential bonding
   - Shielding

EMC zoning of a control panel



Zone A **Control system and sensors (victims)**
e.g. SIMATIC, safety relays, sensor evaluation equipment

Zone B **Controls and mains connection (sources and victims)**
e.g. SIRIUS, fuses, switches, contactors, mains connection

Zone C **Power electronics (sources)**
e.g. SINAMICS converter comprising a rectifier, braking module, inverter and motor-end circuit breakers, reactors and filters

Figure 5-1 EMC zoning of a control panel

5.3 Zone A: "Control system and sensors (victims)"

5.3.1 SIMATIC S7-1500 automation system

We will assign devices that are susceptible to interference to zone A of our control cabinet. The S7-1500 automation system is an example of one of the devices assigned to zone A.

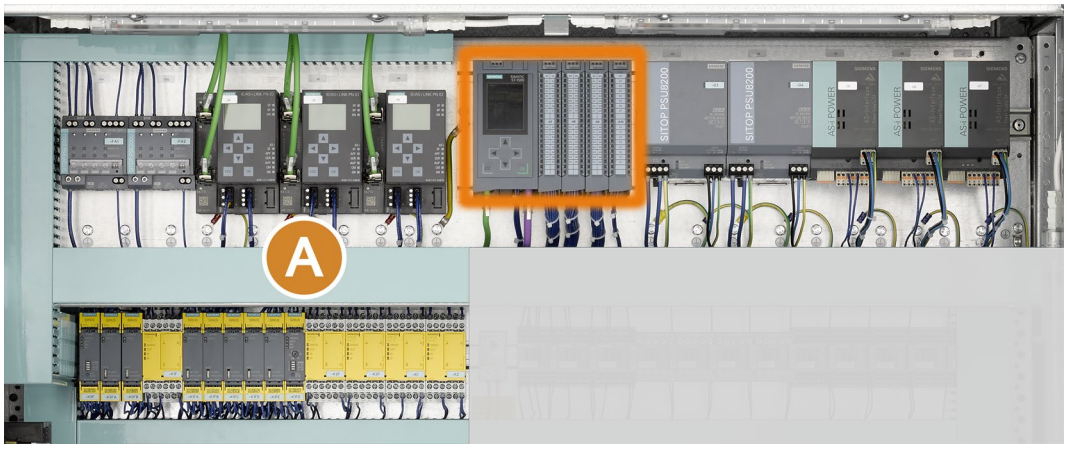


Figure 5-2 Section from the control cabinet (zone A)

Note

Power supply unit as an interference source

Zone A in our example also contains a SITOP power supply unit. Power supply units are sometimes a source of substantial interference owing to their pulsed DC voltage. It does not make sense to install them in a separate location, however, because it would then be necessary to route 24 V cables through the entire cabinet.

Note the information about EMC-compliant installation in the technical documentation supplied with the devices.

S7-1500 automation system

Figure 5-3 Example of an S7-1500 automation system

The SIMATIC S7-1500 automation system in our example consists of a CPU 1516-3 PN/DP and a number of digital modules.

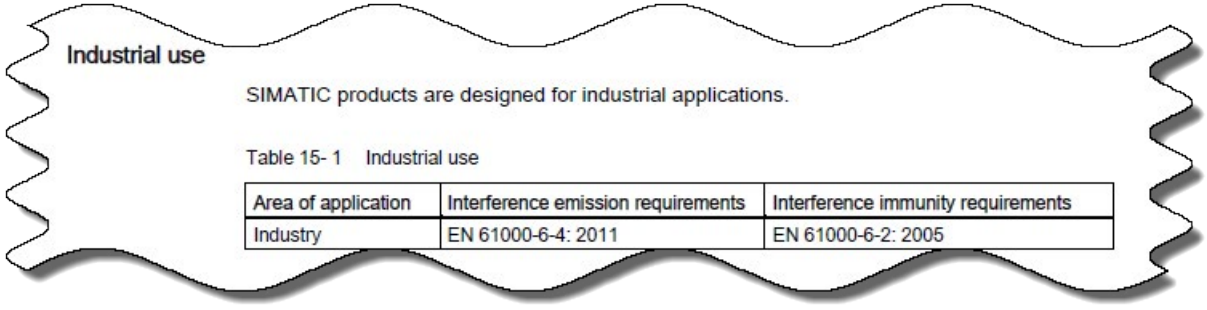
The CPU 1516-3 PN/DP is a standard CPU with a large program and data memory for complex applications. It executes the user program and networks the controller with other automation components.

5.3.2 EMC environment for SIMATIC S7-1500

Permissible EMC environment for SIMATIC S7-1500

In order to furnish verification of electromagnetic compatibility, you must first check whether the equipment is approved for use in the intended environment.

The permissible EMC environment is defined as follows according to the specific EMC standards in the documentation of the SIMATIC S7-1500 automation system:



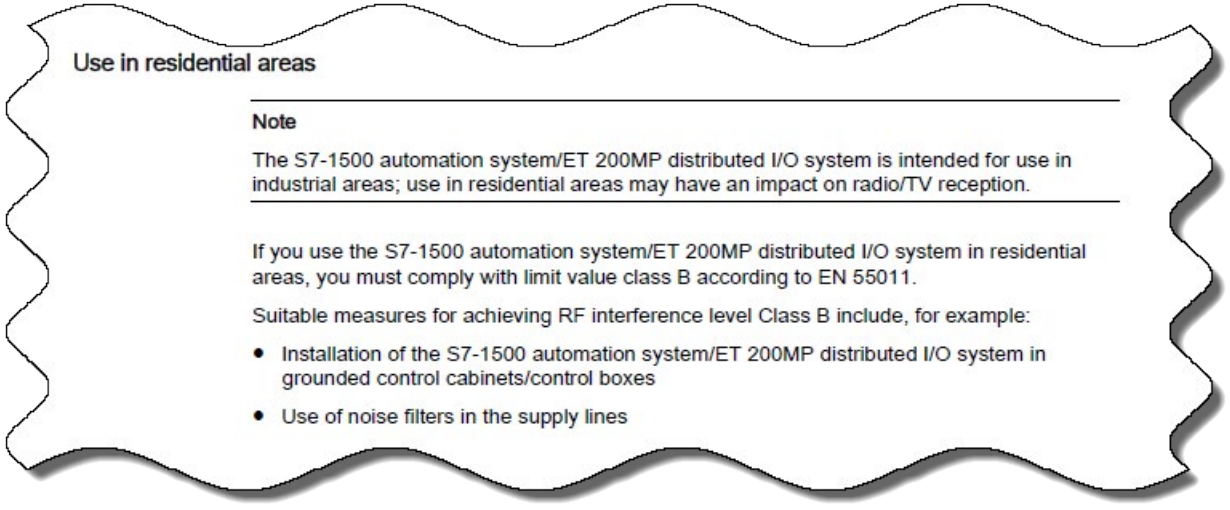
Industrial use

SIMATIC products are designed for industrial applications.

Table 15- 1 Industrial use

Area of application	Interference emission requirements	Interference immunity requirements
Industry	EN 61000-6-4: 2011	EN 61000-6-2: 2005

Figure 5-4 Source: System manual: SIMATIC S7-1500, ET 200MP automation system, page 219



Use in residential areas

Note

The S7-1500 automation system/ET 200MP distributed I/O system is intended for use in industrial areas; use in residential areas may have an impact on radio/TV reception.

If you use the S7-1500 automation system/ET 200MP distributed I/O system in residential areas, you must comply with limit value class B according to EN 55011.

Suitable measures for achieving RF interference level Class B include, for example:

- Installation of the S7-1500 automation system/ET 200MP distributed I/O system in grounded control cabinets/control boxes
- Use of noise filters in the supply lines

Figure 5-5 Source: System manual: SIMATIC S7-1500, ET 200MP automation system, page 220

Evaluation for EMC verification

EMC environment	Information in the documentation of the S7-1500 automation system		Evaluation for EMC verification
	EN 61000-6-2 / EN 61000-6-4	EN 55011	
Industrial environments	Industrial environments	Class A	The equipment may be used in industrial environments.
Residential environments	-	Class B if the following conditions are fulfilled: • Installation in grounded control cabinets/control boxes • Use of filters in electrical supply lines	Equipment may be used in residential environments under certain conditions.

Source of verification and documentation

You can find documentation and detailed information about SIMATIC S7-1500 control systems for verification purposes on the Internet at:

- System manual: SIMATIC S7-1500, ET 200MP automation system

  Link (https://support.industry.siemens.com/cs/ww/de/view/59191792)
- Product manual: SIMATIC S7-1500 CPU 1516-3 PN/DP

  Link (https://support.industry.siemens.com/cs/ww/en/view/59191914)

5.3.3 EMC phenomena associated with controllers

SIMATIC products and their components have been developed for use in industrial environments and fulfill all legal EMC requirements (EMC - Electromagnetic Compatibility). Before you install your controller, however, you still need to conduct an EMC assessment in order to identify any potential sources of interference so that you can take them into consideration.

Electromagnetic interference is coupled into the automation system by various different paths. The major forms of interference and its causes are listed below:

- Electromagnetic fields that have a direct effect on the system
- Interference that is coupled into the system via bus signals (e.g. PROFINET)
- Interference that is coupled in via process wiring
- Interference that reaches the system via the power supply and/or the protective ground

The figure below shows the possible coupling paths for electromagnetic interference.

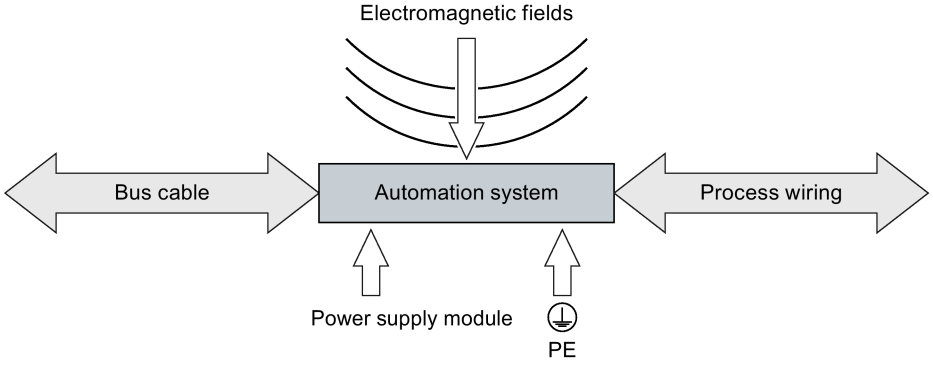


Figure 5-6 Sources of electromagnetic interference affecting a controller

5.3.4 EMC measures for controllers

Interference-proof cable routing

Interference can reach the automation system via various different coupling mechanisms depending on the propagation medium and the distance between the interference source and the victims.

- Assign cables to different categories depending on their sensitivity to coupled interference and emitted interference. The greater the distance you can maintain between the different categories of cable, the lower the level of mutual interference between cables due to capacitive and inductive coupling.
- When you bring cables into the control cabinet, do not route them in parallel past shield supports.
- If you install the cables in metal cable ducts, you can position the cable ducts directly adjacent to one another.
- If you intend to install cables from different categories in the same cable duct, then use metal cable ducts with a metal partition.
- Connect metallically conductive cable ducts to the equipotential bonding system.
- If you cannot avoid crossing cables, then place them at an angle of 90° at crossing points wherever possible in order to minimize interference caused by electrical fields.

Shielding of cables

The purpose of shielding cables is to attenuate (dampen) magnetic, electrical or electromagnetic interference fields. Interference currents on cable shields are discharged to ground via the shield connection. To ensure that these interference currents cannot become a source of interference themselves, it is particularly important to provide a low-impedance connection to the protective conductor.

- Use cables with a braided shield wherever possible. The shield must make more than 80 % contact at the contact point.
- Always connect cable shields to ground at both ends of the cable. It is only by connecting the shield to ground at both ends that low-frequency and high-frequency interference can be reduced.
- If there is a potential difference between grounding points, a compensating current can flow across the shield grounded at both ends. In this case, install an additional equipotential bonding cable.
- If you don't have the option of installing an equipotential bonding cable (e.g. in a large-scale plant), connect one end of your shield to ground via a capacitive coupling. This solution is only effective at reducing high-frequency interference.
- A special concept for connecting the shield of signal cables has been developed for the S7-1500 automation system and the ET 200MP distributed I/O system. The following types of shield connection have proven successful for use on devices that are not equipped with special shield clamps:
  - Use metal cleats to secure the braided shields of the cables. The cleats must provide a good electrical contact and a large-surface connection to the shield.
  - Attach the shield to a shield bar directly after the cable entry point into the cabinet. If you take the shield further up to the module, do not connect it to ground at any other point before it reaches the module or else you will create grounding loops! The diagram below shows commonly used types of shield connection.

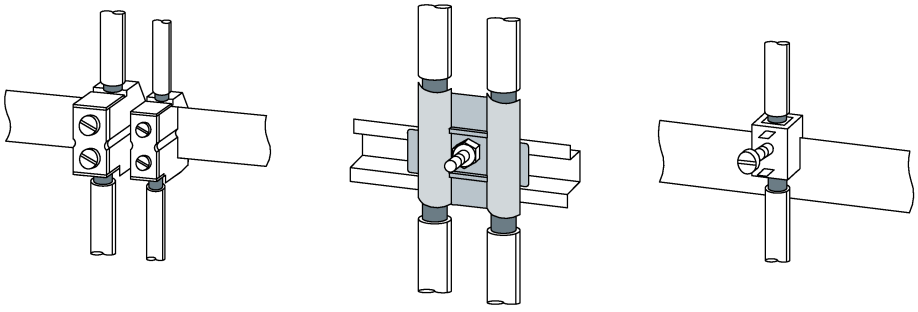


Figure 5-7 Cable shield connection

Equipotential bonding

Electromagnetic interference can cause large deviations in potential between individual components and areas of the control cabinet. The high compensating currents that develop as a result can have undesirable effects (e.g. malfunctions or damage) on the components inside the cabinet:

- Connect equipotential bonding cables over a large contact area to ground.
- Protect the connection points against corrosion.
- Do not create grounding loops.
- Route the equipotential bonding cables as close as possible to the signal cables.
- The lower the impedance of the equipotential bonding cable, the greater the equipotential bonding effect. The impedance of the additionally installed equipotential bonding cable must not exceed 10 % of the shield impedance.
- In order to prevent the formation of grounding loops, equipotential bonding cables are routed in parallel and, whenever possible, close to the signal/bus cable. This will minimize the size of the area between the two cables.

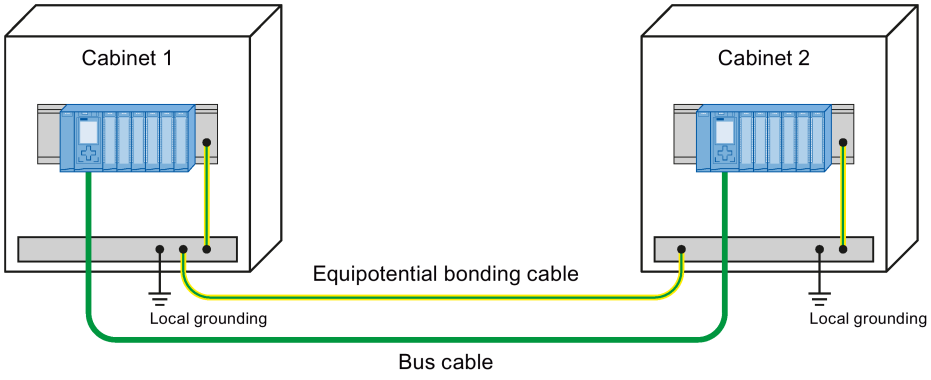


Figure 5-8 Installation of equipotential bonding cables

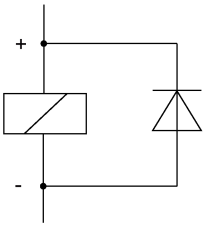
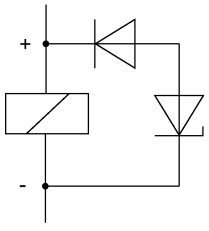
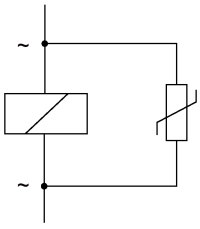
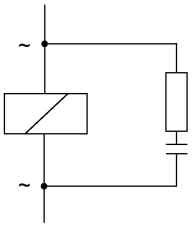
Connecting snubber elements to inductive loads

Under ideal conditions, it is not necessary to connect external snubber elements to inductive loads (e.g. contactor or relay coils) that are controlled by SIMATIC. The snubber elements required are already integrated in the modules.

However, if the SIMATIC output power circuit can also be interrupted by built-in contacts (e.g. relay contacts for EMERGENCY STOP), the snubber elements integrated in the modules will no longer work effectively. In this case, you must connect snubber elements to the inductive loads.

Equip the inductive loads with elements such as freewheeling diodes, varistors or RC suppressors.

Table 5- 1 Protective circuit for inductive loads

Protective circuit for DC-operated inductive loads		Protective circuit for AC-operated inductive loads	
with diode	with Z diode	with varistor	with RC element
			

Detailed information

You can find detailed information about designing electromagnetically compatible SIMATIC S7-1500 controllers and the special shield concept on the Internet:

- Function manual: SIMATIC S7-1500, ET 200MP, ET 200SP, ET 200AL Designing interference-free controllers

  Link (https://support.industry.siemens.com/cs/ww/en/view/59193566)

5.4 Zone B: "Controls and mains connection (interference sources and victims)"

5.4.1 3RT2 contactors and contactor assemblies

The mains connection components are assigned to zone B of our control cabinet. The 3RT2015 interference-proof contactors are an example of one component from zone B.

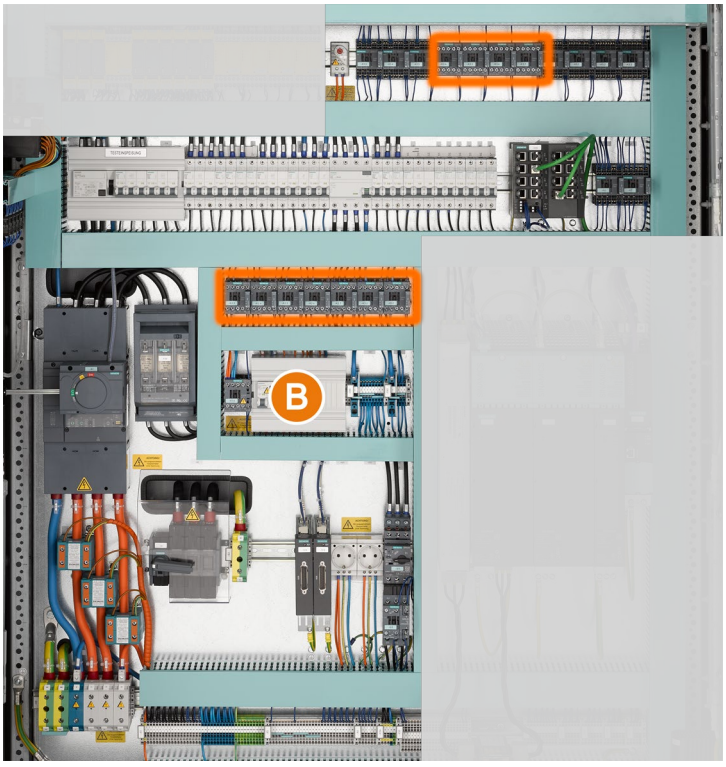


Figure 5-9 Section from the control cabinet (zone B)

3RT2015-1BB41 coupling relays

The SIRIUS coupling relays for switching motors as well as auxiliary and control circuits are specially designed for operation with electronic controllers. The key characteristics of these coupling relays are their low power consumption and extended solenoid coil operating range. The excellent contact reliability of the auxiliary contacts guarantees that no spurious signals are generated, even at low switching capacities. An integral system of overvoltage damping protects sensitive output stages against coil opening surges.

3RT2916-1BB00-Z surge suppressor (varistor)

All 3RT2 contactors and 3RH2 contactor relays can be retrofitted with RC elements or varistors for damping opening surges in the coil. Diodes or diode combinations (comprising noise suppression diodes and Zener diodes for short break times) can be used.

5.4.2 EMC environment for 3RT2 contactors

EMC verification

In order to furnish verification of EMC compliance, you must first check whether the equipment is approved for use in the intended environment according to the specific product technical standard.

Since contactors do not contain any electronic circuitry, they are not susceptible to electromagnetic interference and are not therefore subject to any EMC product standard or generic standard. It is not therefore necessary to carry out interference immunity tests for these components and no specifications pertaining to testing are included in the documentation.

Note

Exception

The contactors with solid-state operating mechanism developed for Environment A according to IEC/EN 60947-1, IEC/EN 60947-4-1, or Class A according to CISPR 11, EN 55011 are an exception, cf. Catalog IC 10 - 2016, page 3/15.

Owing to the opening surges associated with contactors that can affect electronic controllers, however, they must nevertheless be taken into consideration in the evaluation of EMC phenomena and measures and therefore included in the EMC risk analysis and assessment.

5.4.3 EMC phenomena associated with contactors

Surge voltages

Surge voltages occur when contactor coils are de-energized (inductive loads). Voltage peaks of up to 4 kV can occur at a rate of rise of voltage of 1 kV/microsecond (shower discharges). This leads to:

- Substantial erosion and, as a result, premature wear of the contacts which switch the coil.
- Injection of interference signals which lead to spurious signals in electronic controllers.

Therefore, all contactor coils should be equipped with damping elements to attenuate opening surge voltages, particularly when the coils are operating in conjunction with electronic controllers.

Furthermore, the high rate of rise of the voltage waveforms generated can lead to the capacitive coupling of significant interference signals with adjacent systems. They necessitate an RC circuit directly at the location where the source of interference originated, i.e. at the contactor coil. This prevents overvoltages from occurring directly at the place of origin and protects the electronic components which are sensitive to voltage too. It also prevents the capacitive coupling of interference signals with the control cables of electronic circuits.

Coil without RC circuit

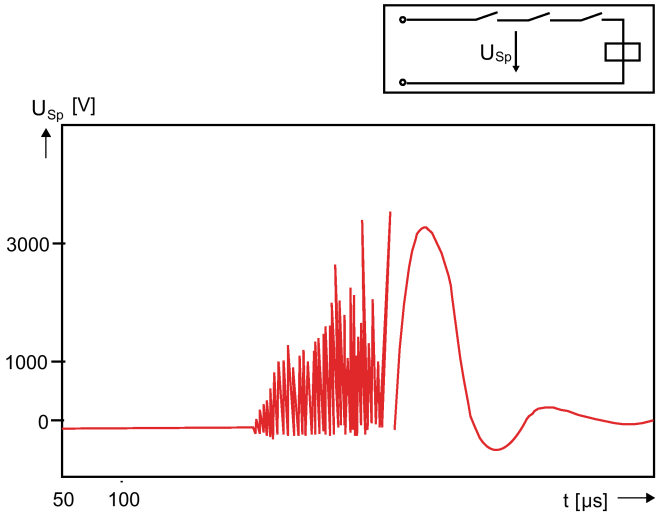


Figure 5-10 Disconnection of a contactor coil without RC circuit

Oscillogram of the disconnection of a contactor relay coil; the coil does not have an RC circuit: Shower discharges are clearly visible (voltage peaks up to around 4 kV). Once the disconnection process has started, the shower discharges occur for about 250 µs; after that, the vibration is simply damped.

5.4.4 EMC measures for contactors

Damping methods

The following RC circuit elements are commonly used to damp overvoltages; they are connected in parallel with the contactor coil:

- Freewheeling diode
- Diode combination
- Varistors
- Suppressor diode
- RC element

All 3RT2 contactors and 3RH21 contactor relays can be subsequently connected to RC elements or varistors for damping opening surges in the coil. Diodes or diode combinations can also be used.

Coupling relays, on the other hand, do not require any additional surge suppressor elements and can be used directly with electronic controls.

RC circuit with varistor

Varistors (voltage-dependent resistors) limit the maximum level of the overvoltage, as they become conductive above a certain threshold voltage. Shower discharges occur up to that level, in a similar way to those seen with the magnet coil without an RC circuit, but they do not last as long overall. Varistors can be used for DC- and AC-operated contactors.

Note

Varistors extend the contactor's OFF time by around 2 to 5 ms.

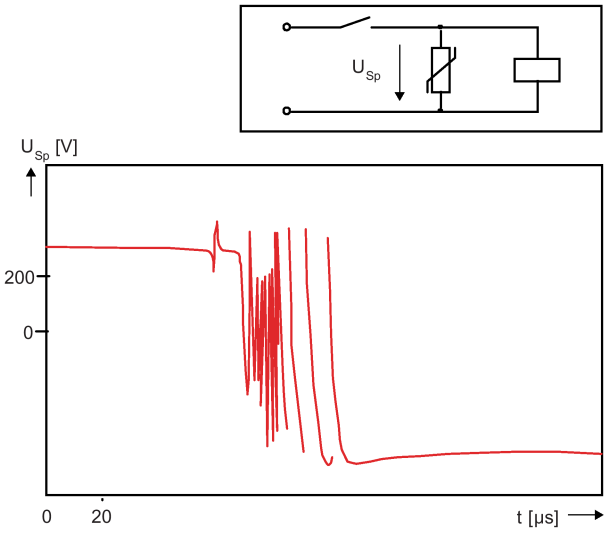


Figure 5-11 RC circuit with varistor (AC/DC operation)

Voltage peaks still occur. They are truncated at around 400 V and do not last as long overall (approximately 50 µs).

Note

Oscillogram is truncated; voltage drops to zero after around 3 ms.

Detailed information

You can find detailed information about electromagnetically-compatible operation of contactors on the Internet.

- Product manual: SIRIUS Innovations - SIRIUS 3RT2 Contactors / Contactor Assemblies

  Link (https://support.industry.siemens.com/cs/ww/en/view/60306557)
- Reference manual: Basics of Low-Voltage Controls and Distribution

  Link (https://support.industry.siemens.com/cs/ww/de/view/34973099)

5.5 Zone C: "Power electronics (sources)"

5.5.1 SINAMICS S120 converter

Zone C of our control cabinet contains the power electronics equipment and in our example, this is the SINAMICS S120 drive system.

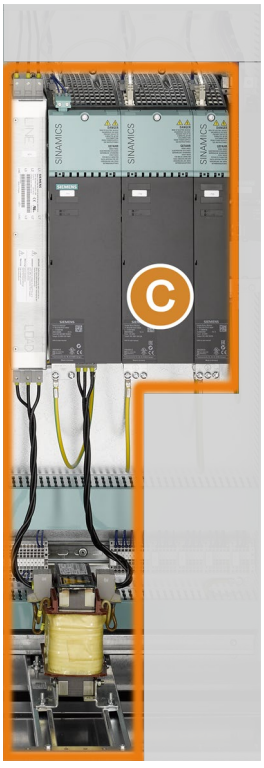


Figure 5-12 Section from the control cabinet (zone C)

SINAMICS S120 drive system

Figure 5-13 SINAMICS S120 drive system

The modular SINAMICS S120 drive is the modular system for high-performance motion control applications in industrial plant and machinery construction. Customized solutions can be implemented based on a wide range of components and functions that are optimally coordinated with one another. For instance, high-performance single-motor drives and coordinated drives (multi-axis applications) with vector or servo functionality. Users of the SINAMICS S120 drive will benefit from a system that offers higher performance, enhanced productivity and improved flexibility.

5.5.2 EMC environment for SINAMICS S120 converters

In order to furnish verification of electromagnetic compatibility, you must first check whether the equipment is approved for use in the intended environment. The permissible EMC environment is defined as follows according to the specific standards in the documentation of the SINAMICS S120 drive system.

Table 3- 1 Environments and categories in accordance with EMC product standard IEC 61800-3

	Variable-speed PDS drive system			
Environment	1. Environment (residential and commercial areas) (public grid)		2. Environment (industrial area) (industrial network decoupled with an isolating transformer)	
Category	C1[1]	C2[2]	C3[3]	C4[4]
Voltage, current	< 1,000 V			≥ 1,000 V or ≥ 400 A
Line system	TN, TT			TN, TT, IT
Expert	No request	Installation and commissioning must be performed by authorized personnel.		

1) No products are on offer for category C1.

2) Drive systems installed by qualified personnel can be used in the first environment category C2 in accordance with EMC product standard IEC 61800-3.

3) The drive systems described in this document with the associated filters in accordance with EMC product standard IEC 61800-3 can be used in the second environment category C3.

4) To ensure the EMC in the category C4, it is necessary that the plant manufacturer and the plant operators agree an EMC plan that specifies individual, plant-specific measures. If prescribed by the product description, drive systems can also be used in non-grounded systems (IT systems) in accordance with EMC product standard IEC 61800-3.

Figure 5-14 Source: Configuration Manual EMC Installation Guidelines / Basic System Requirements, page 16

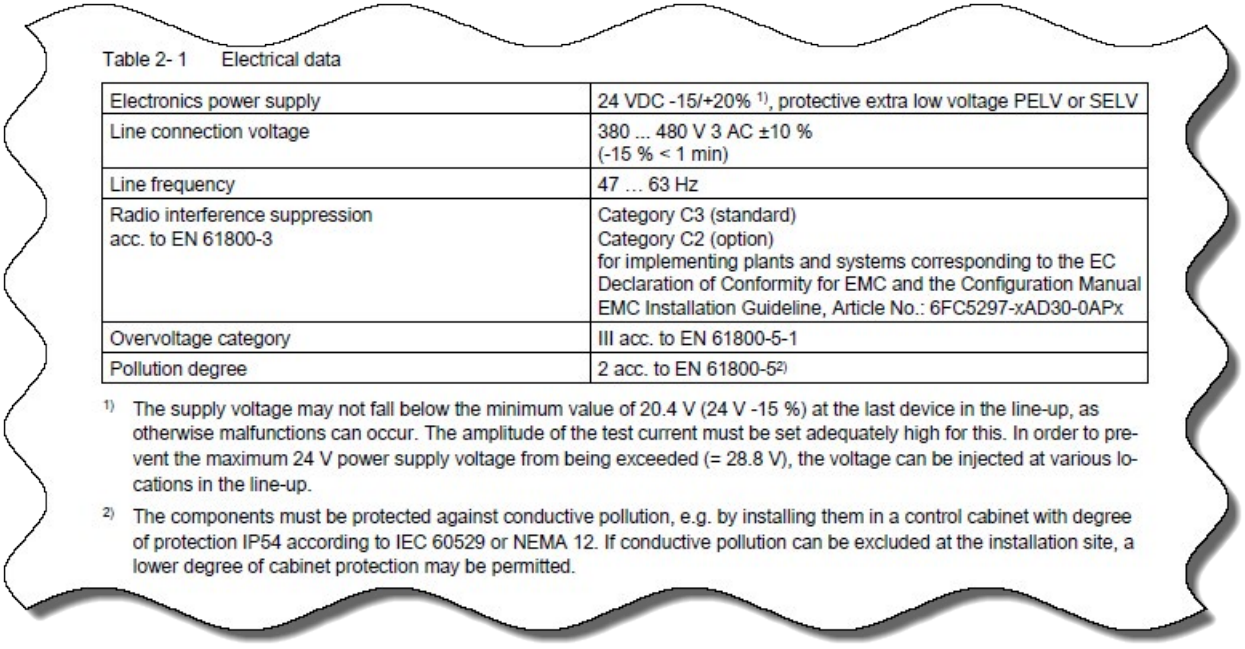


Table 2- 1 Electrical data

Electronics power supply	24 VDC -15/+20% [1], protective extra low voltage PELV or SELV
Line connection voltage	380 ... 480 V 3 AC ±10 % (-15 % < 1 min)
Line frequency	47 … 63 Hz
Radio interference suppression acc. to EN 61800-3	Category C3 (standard) Category C2 (option) for implementing plants and systems corresponding to the EC Declaration of Conformity for EMC and the Configuration Manual EMC Installation Guideline, Article No.: 6FC5297-xAD30-0APx
Overvoltage category	III acc. to EN 61800-5-1
Pollution degree	2 acc. to EN 61800-5[2]

1) The supply voltage may not fall below the minimum value of 20.4 V (24 V -15 %) at the last device in the line-up, as otherwise malfunctions can occur. The amplitude of the test current must be set adequately high for this. In order to prevent the maximum 24 V power supply voltage from being exceeded (= 28.8 V), the voltage can be injected at various locations in the line-up.

2) The components must be protected against conductive pollution, e.g. by installing them in a control cabinet with degree of protection IP54 according to IEC 60529 or NEMA 12. If conductive pollution can be excluded at the installation site, a lower degree of cabinet protection may be permitted.

Figure 5-15 Source: Manual Control Units and Additional System Components, page 35

EMC verification

EMC environment	**Comparison of relevant standards** **SINAMICS S120 drive system** **EN 61800-3**	**Evaluation for EMC verification**
Industrial environments	Fulfilled with Category C3 (standard)	The equipment may be used in industrial environments if it is installed and commissioned by specialist personnel.
Residential environments	Conditionally fulfilled with Category C2 (option)	Use in residential areas is permissible subject to fulfillment of the following conditions: • Equipment is installed and commissioned by specialist personnel. • A line filter has been installed to ensure compliance with the limit values defined according to EN 61800-3, Class C2.

Source of verification and documentation

You can find further information about the EMC requirements of the SINAMICS S120 drive system in the relevant documentation:

- Configuration manual: EMC Installation Guidelines / Basic System Requirements

  Link (https://support.industry.siemens.com/cs/ww/en/view/60612658)
- Product manual: S120 Control Units and Additional System Components

  Link (https://support.industry.siemens.com/cs/ww/en/view/109478725)
- Product manual: S120 Booksize Power Units

  Link (https://support.industry.siemens.com/cs/ww/en/view/68042012)

5.5.3 EMC phenomena associated with SINAMICS S120 converters

Frequency converters are powerful sources of electromagnetic interference. The following phenomena can occur as soon as the converter drive is running. The following list does not claim to be complete.

- Sudden malfunctions of machines and equipment, IT and telephone systems without a discernible cause
- Erroneous tripping of protective switches or circuit breakers
- Frequent failures of switched-mode power supplies, e.g. in IT systems
- Destruction of the capacitors, in reactive power compensation systems and filter systems, for example
- Overheating of cables, motors and equipment that are directly connected to the mains supply and equipment such as fuses, contactors, etc.
- Noise development (humming), for example in switches, motors and transformers that are connected directly to the mains supply
- Excessive load on the neutral conductor, e.g. in building technology when many single-phase converters/devices are operating on the mains supply with B2 rectifiers (3rd harmonic)

In addition to the direct effects, **long-term effects** can also present problems:

- Rapid device aging for capacitors and windings, e.g. in reactive power compensation systems and electronic devices (e.g. controllers, computers, cash register systems)
- Poor power factor with increased system losses

5.5.4 EMC measures for SINAMICS S120 converters

EMC zoning concept - planning guide

- Assign all of the devices that are to be installed in the control cabinet to the category "interference source" or "interference victim".
- When you have finished categorizing the individual devices, divide the entire area of the plant or control cabinet into EMC zones.
- Take measures to decouple the zones electromagnetically.
  Such decoupling measures include, for example, large spatial distances (approx. 20 cm).

  Better and more space-saving is decoupling using separate metal enclosures or large metal partitions.
- Install all of the components on a bare and highly conductive metallic mounting plate. Connect the mounting plate so that it is electrically conductive and flush with the side rails of the cabinet, the grounding rail and EMC shielding rail, e.g. using braided copper bands
- The previous statement also applies if you are installing mounting plates or individual components to side plates, rear panels, top and bottom plates.
  Also connect the cabinet doors to the cabinet side rails with a braided copper band for improved discharge of high-frequency interference.
- Ground the entire control cabinet/box in an EMC-compliant manner. In case of doubt, also connect it to ground using a braided copper band.

Note

Use of inductive loads (coils):

If connections are made using mechanical switching contacts, e.g. for the contactor, relay or output contacts of a PLC or converter, equip all of the connected actuators, contactor coils, solenoid valves, holding brakes, etc., with surge suppression elements, e.g. RC elements or varistors, directly at the interference source if possible. This prevents switching overvoltages.

EMC-compliant cabling

General information

- All of the communication and analog signal cables and the motor cable (cable, not individual conductors) from the converter must be shielded inside and outside the cabinet.
- The supply cable of the converter must be shielded downstream of the filter to the converter.

Notes on EMC-compliant cable routing in the control cabinet and the system

- Keep all cables in the control cabinet as short as possible.
- Route shielded and unshielded power and signal cables separately (except for short sections of cable) and with a minimum distance between them of 20 cm.
  It is permissible to cross cables.
- Do not route cables from different zones in shared cable harnesses or cable ducts.

Notes on shielding

Carefully comply with the following information about attaching cable shields.

- Always connect the shield at both ends using a 360° bonding shield support. When the potential conditions, e.g. between the converter and motor, are unknown, route an equipotential bonding cable parallel to the motor cable. This is usually not required for short cables.
- If possible, connect shielded cables to the device without intermediate terminals.
- Always attach the shield in the control cabinet and at the motor, for example, so that it has a 360° bond with the shield support or mounting plate.
- Clamp the shield down firmly using, for example, shield clamps, cable ties or metallic hose clamps (motor cable).
- The shields of cables for analog signals must be connected at both ends. Good equipotential bonding between output and input is required.

Line reactors and line filters

The drive line filter that belongs to the converter system is tailored exclusively to the converter system and should only be used for this. For other loads, a commercially available line filter must be installed downstream of the main switch and fuses as close as possible to the cabinet entry point. Other loads are supplied via this line filter.

Detailed information

You can find detailed information about the SINAMICS S120 drive system on the Internet.

- Configuration manual: EMC Installation Guidelines

  Link (https://support.industry.siemens.com/cs/ww/de/view/60612658/en)

- Configuration manual: SINAMICS G130, G150, S120 Chassis, S120 Cabinet Modules, S150 (Supplement to Catalogs D 11 and D 21.3)

  Link (http://w3app.siemens.com/mcms/infocenter/content/en/Pages/order_form.aspx?nodeKey=key_516849&infotype=catalogs&linkit=b6e260e1-c2ea-449a-842c-4fbc73128084)

- Product manual: S120 Booksize Power Units

  Link (https://support.industry.siemens.com/cs/ww/en/view/68042012)

- Product manual: S120 Control Units and Additional System Components

  Link (https://support.industry.siemens.com/cs/ww/en/view/109478725)

- Brochure: EMC - Electromagnetic Compatibility

  Link (https://support.industry.siemens.com/cs/ww/en/view/103704610)

Practical tips for dealing with EMC

6

6.1 Cabinet configuration

Shielding by enclosure

Metal enclosures can be used to guard equipment that is susceptible to interference ("victim") against the effects of magnetic and electrical fields, and electromagnetic waves. The easier it is for the induced interference current to flow, the greater the degree of self-weakening of the interference field. It is for this reason that the connections between all enclosure panels or plates in the cabinet must be highly conductive.

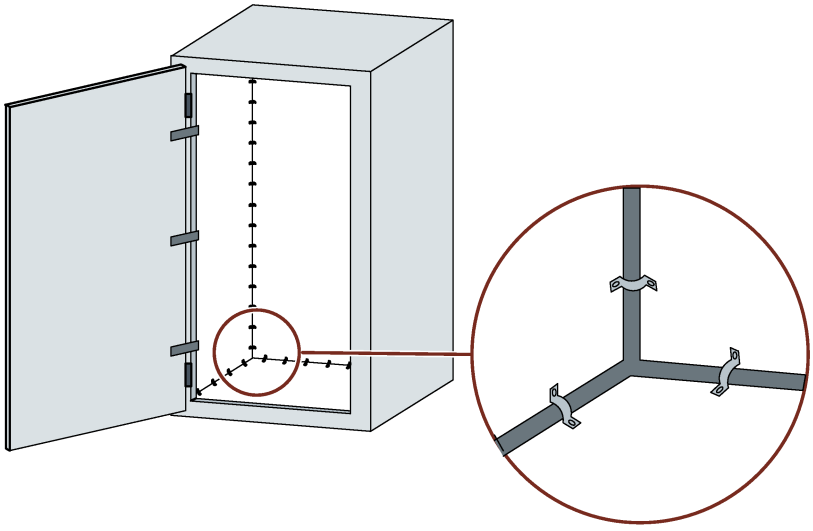


Figure 6-1 Shielding by enclosure

If the cabinet panels are mutually insulated, a connection that conducts high-frequency interference can be created using flat straps and high-frequency shield clamps, or HF conductive paste. The larger the surface area of the connection, the greater its ability to conduct high-frequency interference. This kind of connection cannot be achieved with simple wires.

Preventing interference by implementing an optimum equipment design (EMC zones)

Interference can be discharged effectively by installing equipment on conductive mounting plates (bare metal). It is easy to protect equipment against the effects of interference if the control cabinet is designed in accordance with the relevant guidelines. Power components (transformers, drive systems, load power supply units) should be spatially separated from control components (relay control unit, SIMATIC S7).

The following always applies:

- The effects of interference diminish as the distance between the interference source and the victim increases.
- Interference can be further reduced by the installation of shield plates.
- Load cables and power cables must be installed at a distance of at least 10 cm from signal cables.

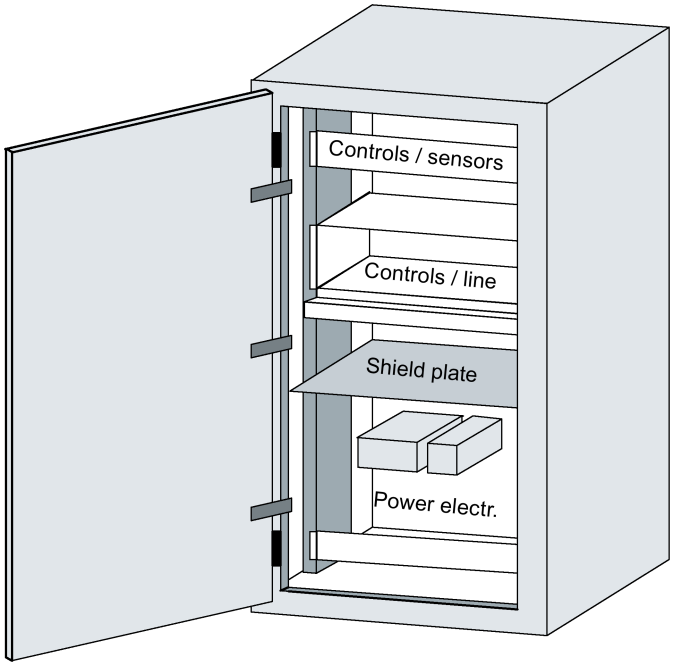


Figure 6-2 Preventing interference by implementing an optimum equipment design

Filtering the supply voltage

Installing line filters prevents external interference from the supply system from reaching the equipment. In addition to proper dimensioning of the filters, it is also essential to install them in the correct position. Line filters must always be mounted directly at the cabinet entry point. This ensures that an interference current is not allowed to pass through the cabinet, but is filtered out early at the cabinet entry point.

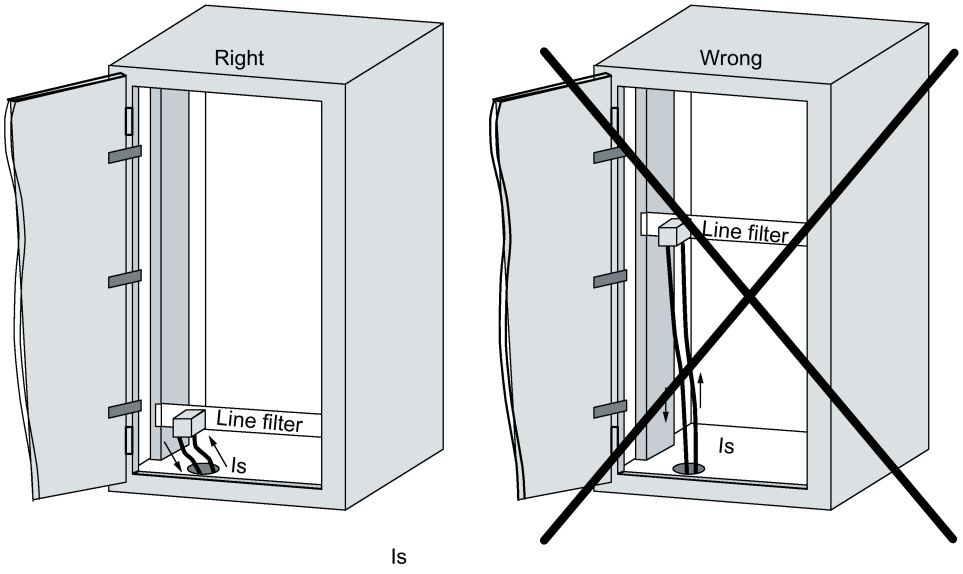


Figure 6-3 Filtering the supply voltage

6.2 Equipotential bonding

Differences in potential can develop between different sections of an installation owing to variations in system design and voltage levels. If the different sections are interconnected by signal cables, then compensating currents will flow along these cables. These compensating currents can falsify signals.

It is therefore essential to implement proper equipotential bonding.

- The cross section of the equipotential bonding cable must be sufficiently large (at least 10 mm^2).
- The distance between the signal cable and its equipotential bonding cable must be as small as possible (antenna effect).
- A finely stranded cable must be used (to conduct high-frequency interference more effectively).
- Equipotential bonding cables must be connected to the central equipotential busbar (EB) according to groupings of "power components" and "non-power components".
- Each of the equipotential bonding cables of the individual modules must be routed directly to the EB (equipotential busbar). When the cabinet includes sources of high-frequency interference, the mounting plate is also often used as a central EB.

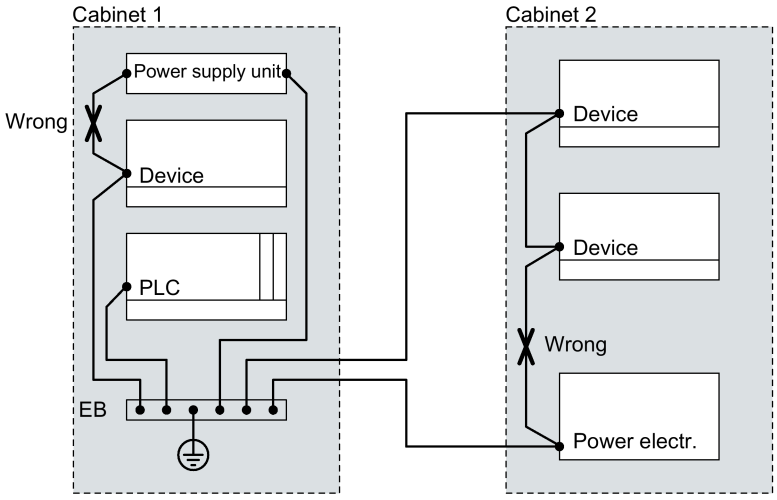


Figure 6-4 Equipotential bonding (EB = equipotential busbar)

The more effective the equipotential bonding system in an installation, the lower the risk of interference induced by fluctuations in potential.

The equipotential bonding system must not be confused with protective grounding. The protective grounding system is designed to prevent the occurrence of high touch voltages in the event of equipment faults, while equipotential bonding prevents differences in potential.

6.3 Cable shielding

Signal cables must be shielded to protect them against interference coupling.

Cables can be shielded most effectively by routing them through steel tubes, but this is only necessary if the signal cable is to be routed through an environment that is exposed to significant interference. It is normally sufficient to use cables with braided shields. Whichever of these two shielding methods is used, however, the shielding efficacy is largely dependent on correct bonding of the shield.

Note

A shield that is incorrectly bonded or not bonded at all has no shielding effect.

The following applies: (please refer to product-specific documentation for exceptions)

- In the case of analog signal cables, the shield must be bonded at one end at the receiver device.

  Low-frequency interference (ground loops) can develop on analog signal cables if the shield is bonded at both ends. In this case, only one end of the shield may be bonded at the converter. The other end of the shield should be grounded via a capacitor of type MKT with approximately 10 nF/100 V.
- The shield of digital signal cables must be bonded at both ends to the enclosure.
- Since interference signals are often within the HF range (> 10 kHz), the shield must be bonded using an HF-immune shield connection with large contact area.

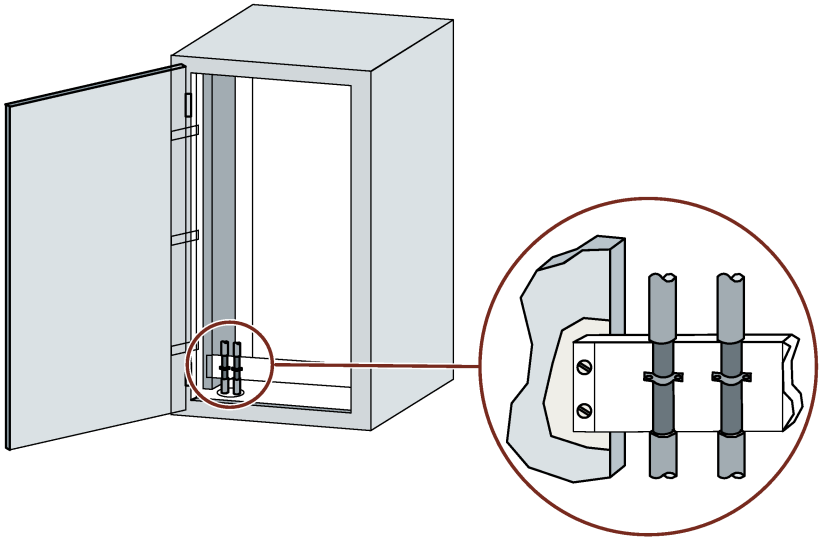


Figure 6-5 Shielding of cables

The shielding bus must be joined to the control cabinet enclosure in a highly conductive connection (over large contact area) and located as close as possible to the cable entry point. The insulation is stripped from the cables which are then clamped to the shielding bus (with high-frequency clamps) or fastened to it with cable ties. The connection between the shielding bus and cables must be highly conductive.

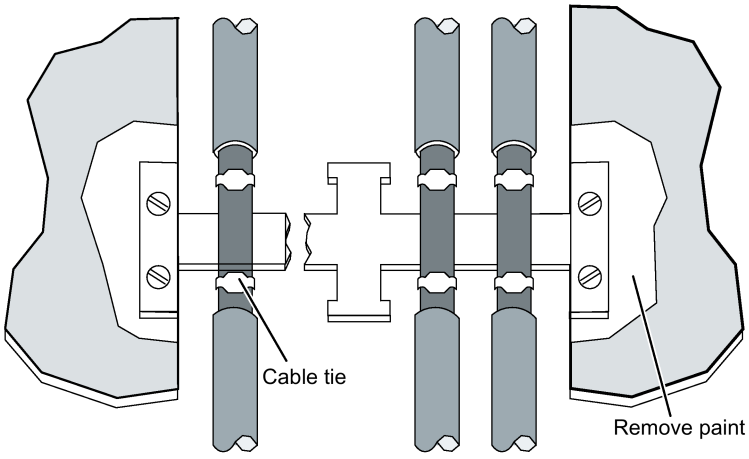


Figure 6-6 Connection of shielding bus

The shielding bus must be connected to the grounding rail.

If it is necessary to interrupt shielded cables, the shield must be continued uninterrupted through the connector casing at the interruption point. The connectors used must be suitable for the purpose, e.g. they must not have a metallized connector casing, but a metal casing for high-frequency currents.

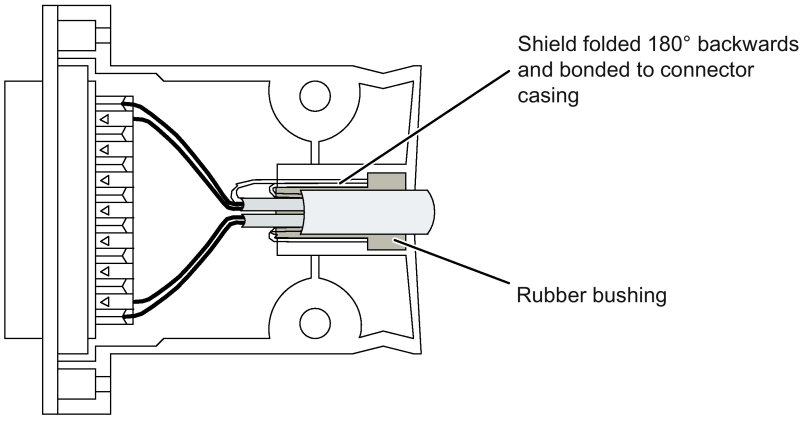


Figure 6-7 Interruption of shielded cables

If adapter plugs or terminals without a suitable shield connection are used, cable clamps must be used to continue the shield uninterrupted at the interruption point in order to provide an HF-conductive connection over a large contact area.

6.4 Prevention of interference sources

In the interests of boosting levels of interference immunity, inclusion of interference sources in an electrical installation must be avoided. Any kind of switched inductive load is a common source of interference.

Suppression of inductive load interference

Relays, contactors, etc. generate interference voltages and must therefore have one of the following interference suppression circuits.

When a 24 V coil is switched, it can generate an interference voltage of up to 800 V (even in a small relay), while the interference voltage produced by a 230 V coil can reach several kVs. Freewheeling diodes or RC circuits can be used to suppress the interference voltage and thus prevent inductive interference in cables that are routed in parallel to the coil cable.

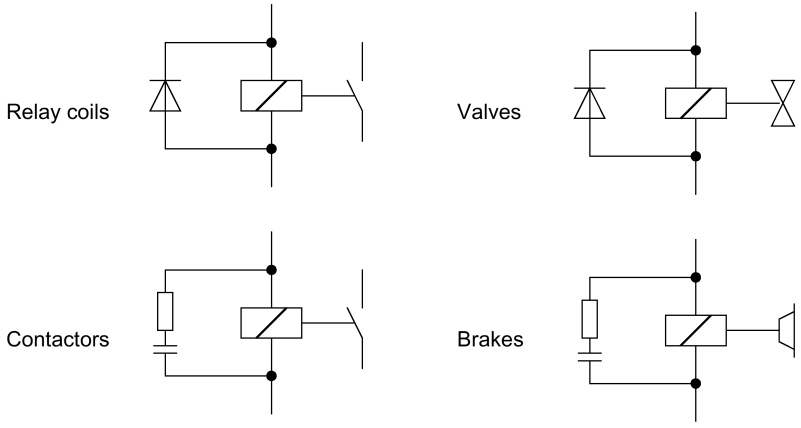


Figure 6-8 Suppression of inductive load interference

Note

All coils in the cabinet must be equipped with interference suppression elements or circuits. Valves and motor brakes are often forgotten. Fluorescent lamps in the control cabinet must undergo special tests.

6.5 Further assistance

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Checklists

A

A.1 EMC verification

Verification of compliance with EMC Directive 2014/30/EU

The procedure outlined below is one possible option for verifying conformance with EMC Directive 2014/30/EU in conjunction with the harmonized standards EN 61439-1 and EN 61439-2. All conditions must be fulfilled and the relevant verifications / documentation must be available to ensure successful verification:

No.	Condition	Where can I find this information?	Assessment		Verification / Documentation	
			Condition met	Condition not met	Available	Not available
1	Is the equipment approved for use in the intended environment?	Documentation of the equipment				
2	Has the equipment been installed in accordance with the manufacturer's specifications?	Documentation of the equipment				
3	Have the most recent editions of harmonized standards been applied?	Standards for control panels: e.g. EN 61439-1 and EN 61439-2				
4	Have an analysis and assessment of the EMC risks been carried out?	e. g. in CENELEC 32				
5	Does the equipment comply with the formal requirements of the EMC Directive 2014/30/EU?	EMC Directive 2014/30/EU				

Note

Note the manufacturer's specifications

The generally known EMC measures do not always have the desired effect in every application. Whether the shield of analog signal cables should be bonded at one or both ends, for example, depends on the interference source and / or the coupling path.

The following therefore applies:

The technical documentation supplied with the devices or components used is always the binding document with respect to EMC measures. Follow the instructions contained in this documentation relating to EMC-compliant installation, operation and accessories (shielded cables, for example).

Take these manufacturer specifications as well as general EMC measures into account in the risk analysis and assessment.

A.2 EMC measures

Separation of sources and victims of interference

No.	Condition	Condition met	Condition not met	Not relevant
1	Does an EMC zone concept exist and has it been applied?			
2	Have appropriate measures (partitions, distances, etc.) been taken to separate sources and victims of interference?			
3	Have appropriate measures (metal cable ducts, distance, etc.) been taken to route power and signal cables separately?			
4	Have the cables been kept as short as possible?			
5	Are the signal cables installed as close as possible to grounded components?			
6	Do cables routed as single cables have twisted supply and return conductors?			

Functional grounding and equipotential bonding

No.	Condition	Condition met	Condition not met	Not relevant
7	Does a grounding concept for equipotential bonding exist and has it been applied?			
8	Are all inactive metal parts including the shielding bus joined over a large area and in a highly conductive connection?			
9	Has the functional grounding been implemented in accordance with the manufacturer's specifications?			

Shielded cables

No.	Condition	Condition met	Condition not met	Not relevant
10	Have appropriate measures (braided shield) been taken to shield signal cables?			
11	Is the shield connection a highly conductive bond with a large contact area? • Analog signal cables with shield bonded at one end unless otherwise specified by the manufacturer, e.g. to prevent ground loops • Digital signal cables with shield bonded at both ends			
12	Are the shields continuous, i.e. with as few interruptions as possible?			
13	Have the cable shields been attached over a large area to the shielding bus at the cabinet entry point unless otherwise specified by the manufacturer, e.g. for motor cables at frequency converters?			
14	Has an equipotential bonding cable been routed in parallel to the shielded signal cable in installations with differences in potential?			

Filters and suppressor circuits

No.	Condition	Condition met	Condition not met	Not relevant
15	Have filters and reactors been installed according to the manufacturer's specifications?			
16	Have inductive loads, e.g. contactor coils, been equipped with snubber elements (overvoltage protection)?			

Plant-specific EMC topics (e.g. manufacturer's equipment specifications)

No.	Condition	Condition met	Condition not met	Not relevant
17				
18				
19				
20				
21				
22				
23				
24				
25				

List of references

B

Siemens list of EMC references

SIRIUS controls

- Reference manual: Basics of Low-Voltage Controls and Distribution

  Link (https://support.industry.siemens.com/cs/ww/de/view/34973099)

- Product manual: SIRIUS Innovations - SIRIUS 3RT2 Contactors / Contactor Assemblies

  Link (https://support.industry.siemens.com/cs/ww/en/view/60306557)

SIMATIC S7-1500 automation system

- Function manual: SIMATIC S7-1500, ET 200MP, ET 200SP, ET 200AL Designing interference-free controllers

  Link (https://support.industry.siemens.com/cs/ww/en/view/59193566)

- System manual: SIMATIC S7-1500, ET 200MP automation system

  Link (https://support.industry.siemens.com/cs/ww/de/view/59191792)

- Product manual: SIMATIC S7-1500 CPU 1516-3 PN/DP

  Link (https://support.industry.siemens.com/cs/ww/en/view/59191914)

SINAMICS S120 drive system

- Configuration manual: EMC Installation Guidelines / Basic System Requirements

  Link (https://support.industry.siemens.com/cs/ww/de/view/60612658/en)

- Brochure: EMC - Electromagnetic Compatibility

  Link (https://support.industry.siemens.com/cs/ww/en/view/103704610)

- Configuration manual: SINAMICS G130, G150, S120 Chassis, S120 Cabinet Modules, S150 (Supplement to Catalogs D 11 and D 21.3)

  Link (http://w3app.siemens.com/mcms/infocenter/content/en/Pages/order_form.aspx?nodeKey=key_516849&infotype=catalogs&linkit=b6e260e1-c2ea-449a-842c-4fbc73128084)

- Product manual: S120 Control Units and Additional System Components

  Link (https://support.industry.siemens.com/cs/ww/en/view/109478725)

- Product manual: S120 Booksize Power Units

  Link (https://support.industry.siemens.com/cs/ww/en/view/68042012)

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- Panel building

  Link (www.siemens.com/panelbuilding)

- Efficient control panel engineering

  Link (http://www.industry.siemens.com/verticals/global/en/panel-building/control-panel/Pages/default.aspx)

- European control panel directives

  Link (http://www.industry.siemens.com/verticals/global/en/panel-building/standards/european-directives/Pages/Default.aspx)

Directives and guidelines

- EU directives

  Link (http://eur-lex.europa.eu/homepage.html)

- CENELEC Guide 32:2014

  Link (https://www.cenelec.eu/membersandexperts/referencematerial/cenelecguides.html)

- "The "Blue Guide" on the implementation of EU product rules 2016"

  Link (http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_type=254&lang=en&item_id=7326)

- Guide for the EMC Directive 2004/108/EC (8th February 2010)

  Link (http://ec.europa.eu/growth/sectors/electrical-engineering/emc-directive/index_en.htm) (in section "Guidance" > "Guides")

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