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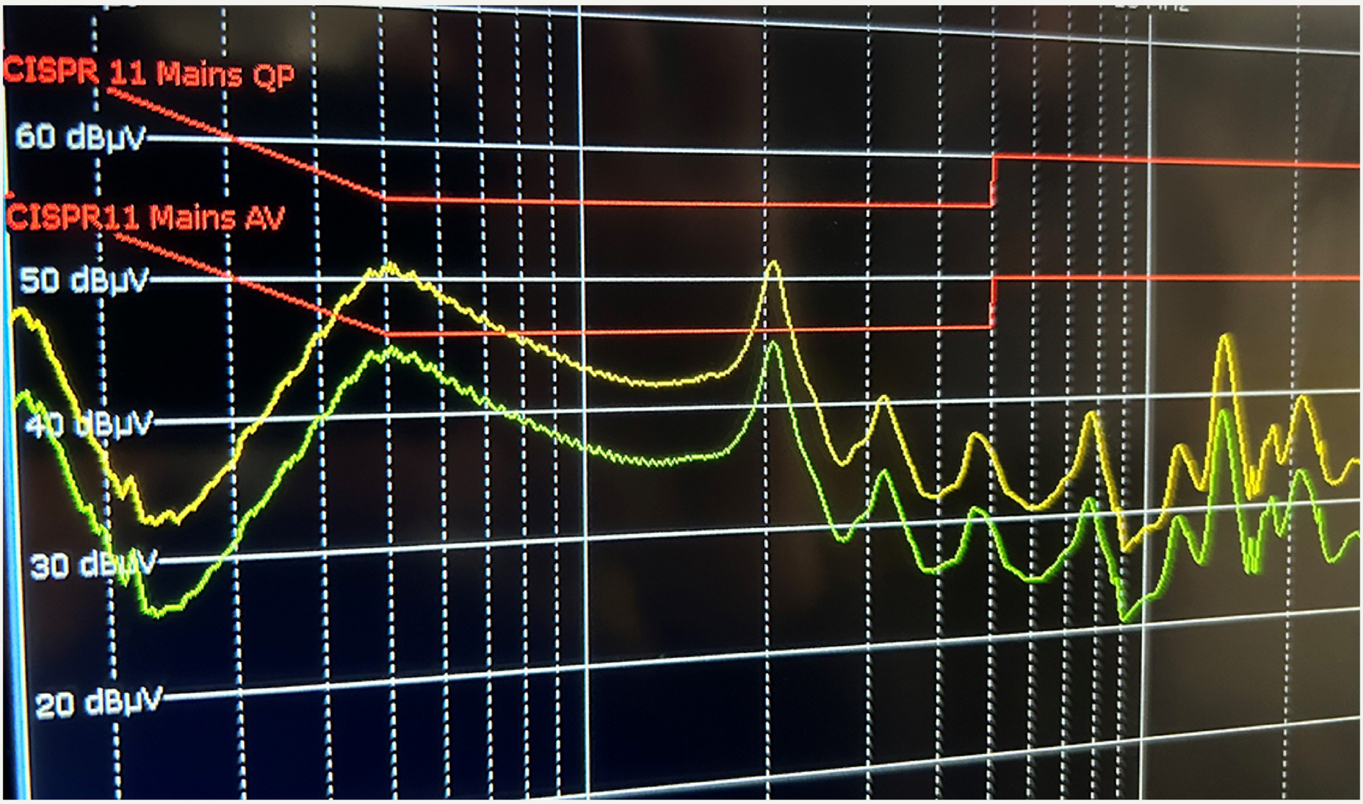

Edition 07/2024

CONFIGURATION MANUAL

SINAMICS

EMC - electromagnetic compatibility

For SINAMICS

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SINAMICS

EMC - electromagnetic compatibility

Configuration Manual

2024/07

A5E53667239B AC

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

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Table of contents

1 Introduction

EMC (electromagnetic compatibility) means that the devices function satisfactorily without interfering with other devices and without being disrupted by other devices. Electromagnetic compatibility applies when the interference (emission levels) and the immunity are matched with each other.

The instructions in this manual concern compliance with the following points:

- Interference-free function of all devices
- EMC standards and guidelines in force at the place of use

1.1 Intended use

Description and measures

The SINAMICS converters described in this manual, together with software, accessories and options, form a power drive module intended to feed low-voltage three-phase motors. The converters are for professional use in fixed systems or machines in industrial, light-industrial and commercial applications. The converters are not plug-in devices and are not mobile equipment.

The converters are generally suitable for supply from non-public (industrial) low-voltage networks. There are additional requirements for supply from a public network and use in residential areas and in commercial or light-industrial applications.

- Consult the manuals to make sure that the product family and product type you selected are suitable for these applications.

The converters must be mounted, put into operation and maintained by trained staff.

- Adhere to the EMC measures described in this document and in the manuals of the relevant product line.
- Implement the EMC measures according to the generally accepted rules of engineering practice.

The converters are used as part of a machine or system.

Before using the product,

- ensure electromagnetic compatibility with suitable measures concerning the arrangement and integration of the machine or system
- assess the risk of the application as a whole.

The EU Declaration of Conformity under EMC Directive 2014/30/EU is valid if the components described in the associated technical user documentation are used, are installed in accordance with the installation guidelines, and are used for their intended purpose. Otherwise the EU Declaration of Conformity must be prepared again by the supplier of these products.

1.2 Definition of terms

Description

Definition of terms used in the manual:

Term	Meaning
Equipotential bonding	Provision of electrical connections between conductive parts, intended to achieve equal potential
Equipotential bonding system	All of the equipotential bonding equipment
Protective conductor	Electrical conductor for safety purposes, for example to protect against electric shock
Grounding	All of the resources and measures to establish an adequate conductive connection to ground
Grounding bar	Metal bar providing equipotential bonding to ground of all metal structures and equipment in a building which are connected to the bar
High-frequency compatible equipotential bonding	Equipotential bonding for conducted disturbances with frequency components greater than the line frequency
Combined bonding system	All of the equipment which simultaneously ensures protection against electric shock and against electromagnetic disturbances

1.3 Definition of power drive system

Description

A power drive system (PDS) comprises the following components:

- Converter
- All components belonging to the converter on the line side and at the power output of the converter, e.g. line filter or line reactor
- All motors connected to the converter
- All encoders mounted on the motors
- All connecting cables between converter, motors and encoders

Example

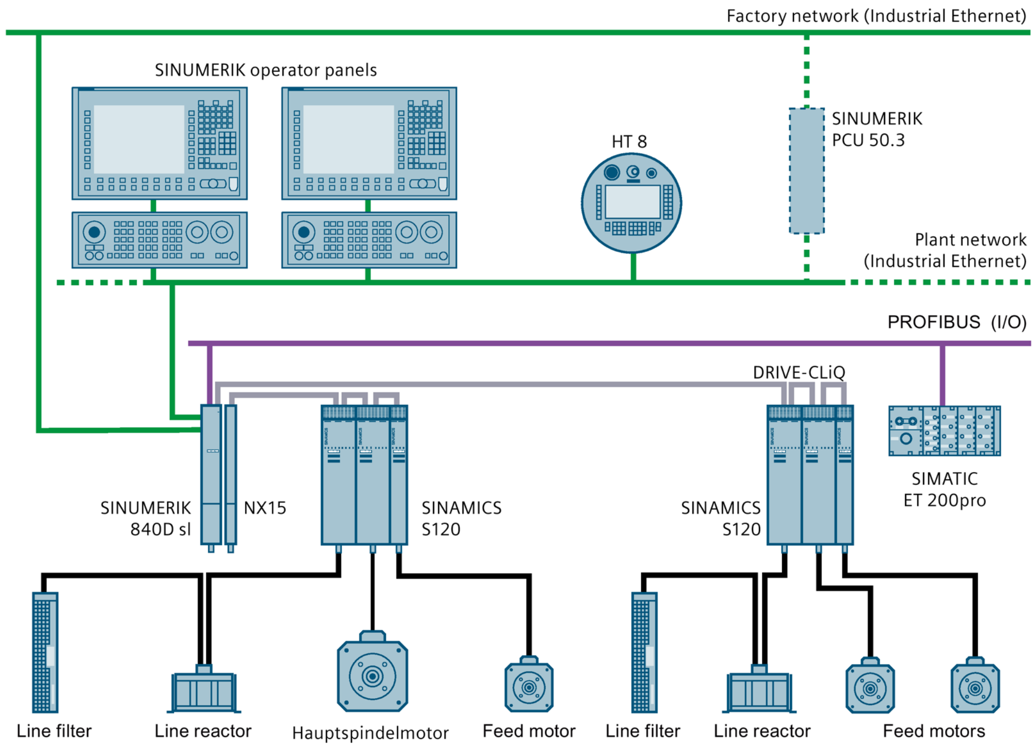


Figure 1-1 2 SINAMICS S120 power drive systems with higher-level SINUMERIK control (the SINUMERIK is not part of the power drive system)

1.4 About EMC (electromagnetic compatibility)

Description

Sources of interference and susceptible devices in electrical power drive systems influence each other.

Typical sources of interference are:

- Converters
- Switch mode power supplies
- Wireless telephones
- Electrostatic discharge
- Lightning
- Switching operations

Susceptible devices are devices with high susceptibility to interference. Typical susceptible devices are:

- Open-loop control systems
- Closed-loop control systems
- Sensor technology
- Radio receivers

Electromagnetic disturbances can be transmitted as follows:

- Electrically (potential differences, current flow over cable connections)
- Capacitively (electric fields, voltage changes)
- Inductively (magnetic fields, current changes)
- Electromagnetically (radiation)

Electromagnetic disturbances occur throughout the entire frequency range. In practice, radiated coupling is relevant for high frequencies in the MHz range. Below the MHz range, the disturbances are predominantly conducted.

Line harmonic distortions caused by harmonic components are a special aspect of electromagnetic compatibility, and they distort the supply voltage compared to the ideal sine shape – the concept of "power quality" is often used here. Non-linear loads and power electronic devices (such as converters) cause line harmonic distortions. If other devices are operated at the same supply voltage, line harmonic distortions may interfere with, damage or overheat the other devices.

General installation guidelines

2

2.1 Mesh common bonding system (mesh CBN)

Description

High-frequency compatible equipotential bonding between all conductive parts of an electrical machine or system is one of the most effective measures to improve electromagnetic compatibility.

For high-frequency disturbances, protective conductors do not provide sufficient equipotential bonding for the following reasons:

- High-frequency compensation currents only flow near the surface of cables (skin effect).
- Single cores have a large induction surface area and therefore exhibit a high impedance.

This is why it is important to create a common bonding network (CBN) which combines the protective function in the presence of insulation faults with protection against electromagnetic influences.

A mesh CBN reduces the impedances more effectively than a star CBN.

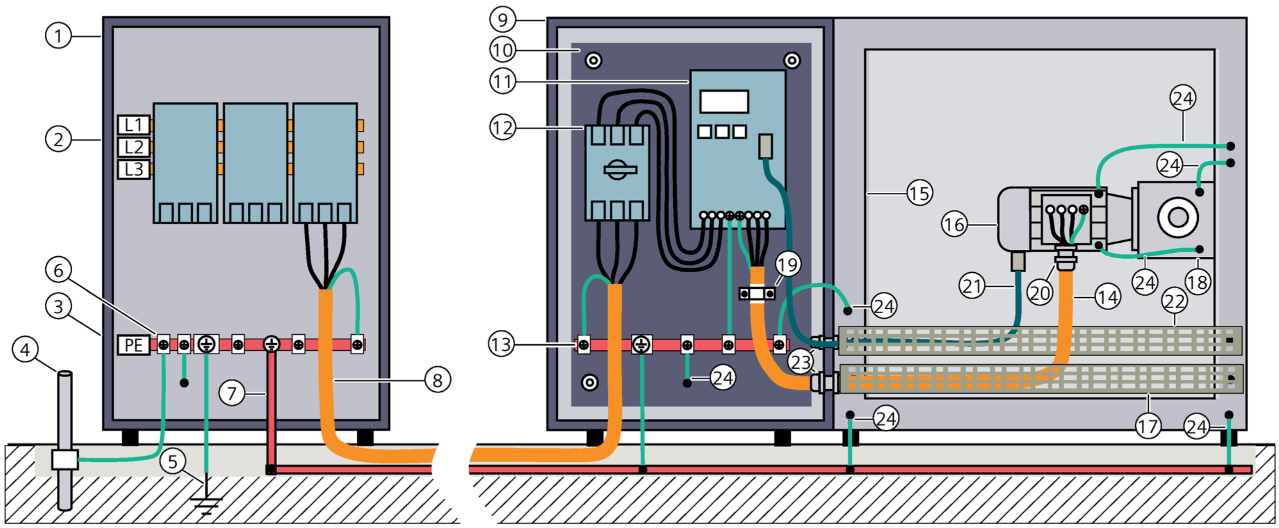
Measures

- Use short braided grounding straps to keep the impedance of the connections low for high-frequency disturbances.

Figure 2-1 Braided grounding strap for high-frequency compatible equipotential bonding

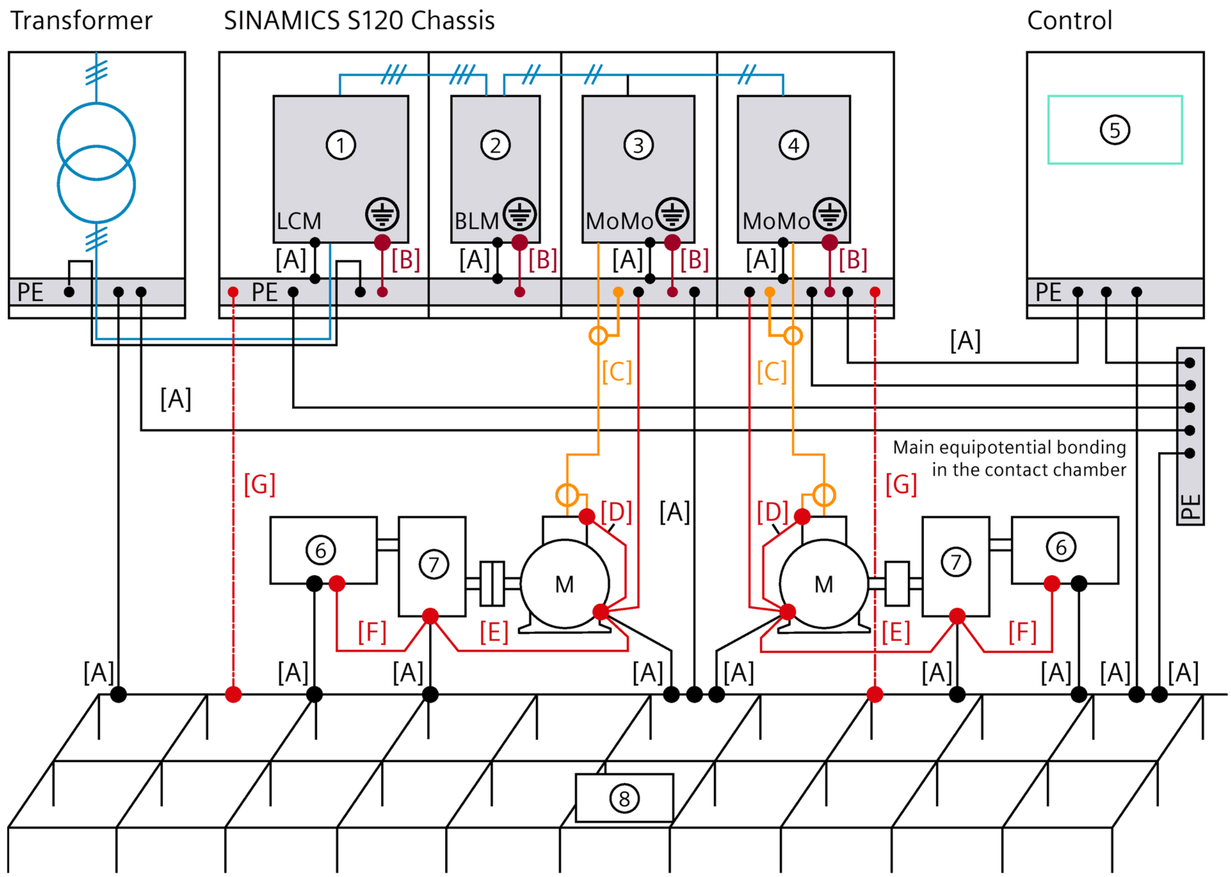
- Create a mesh CBN by connecting all electrically conductive parts of a machine or system within themselves and also with each other in multiple places, e.g. devices, racks, control cabinets, pipes and frames.

Example



(1)	Main distribution cabinet (metal)	(13)	Grounding bar of control cabinet
(2)	Supply network connection	(14)	Motor cable (shielded)
(3)	Supply network PE connection	(15)	Machine frame (metal)
(4)	Conductive parts of the building such as pipes, steel frames, cable racks	(16)	Electric motor
(5)	Foundation ground	(17)	Power cable duct (metal)
(6)	Grounding bar in main distribution cabinet	(18)	Conductive structural part, e.g. gear unit
(7)	Bus bar for grounding	(19)	Shield connection (shielded)
(8)	Mains power input for machine	(20)	EMC cable gland
(9)	Control cabinet (metal)	(21)	Encoder cable (shielded)
(10)	Mounting plate (metal)	(22)	Signal cable duct (metal)
(11)	Converter with integrated line filter	(23)	Cabinet bushing (shielded)
(12)	Circuit breaker	(24)	High-frequency compatible equipotential bonding

Figure 2-2 Mesh CBN at machine level



①	Line Connection Module (LCM)	⑤	SIMATIC
②	Basic Line Module (BLM)	⑥	Driven machine
③	Motor Module (MoMo)	⑦	Gear unit
④	Motor Module (MoMo)	⑧	Foundation ground or meshed network

[A] The protective conductors (black) connect the power drive components to the foundation ground and the grounding bar. The protective conductors provide operator protection but are not high-frequency compatible.

[B] The cables inside the control cabinet (dark red) provide a high-frequency compatible connection between the metal enclosure of the converter components and the control cabinet grounding bar. For a large surface area connection using the metal structure of the cabinet unit, the contact surfaces must be bare metal and each contact point must have a minimum cross-section of several hundred mm^2. Alternatively, connections can be made with short, finely stranded, braided copper wires with a large cross-section (> 95 mm^2).

For SINAMICS S120 Booksize and S220 Booksize, the protective connection can instead be established through mounting on a grounded mounting plate.

[C] The shield of the motor cable (orange) provides the high-frequency compatible equipotential bonding between the converter and the motor terminal box. For cables with poor high-frequency properties of the shield or with poor grounding, the high-frequency compatible equipotential bonding is improved if finely stranded, braided copper wire (red) is laid alongside them.

[D], [E], [F] The cables shown in red provide a high-frequency compatible connection between the motor enclosure and the motor terminal box, gear unit and driven machine.

[G] The cables (red) provide a high-frequency compatible connection between the grounding bar and the foundation ground.

Figure 2-3 Mesh CBN at system level

2.2 Cable installation

Description and measures

The following measures reduce interference and interference coupling:

- Lay all cables as close as possible to the high-frequency compatible equipotential bonding system, e.g. on mounting plates or on the machine frame.
- Always lay the cables at least 200 mm away from devices emitting strong magnetic fields such as transformers or reactors.
  Or
  Shield the magnetic field with metal sheets which are connected in multiple places to the high-frequency compatible equipotential bonding system.
- Avoid unnecessarily long connecting cables.
- Always lay single cores of the mains power input bundled together. Lay the single cores of the mains power input so that there are no structural parts such as beams and crossbars between them.

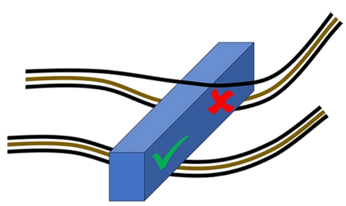


Figure 2-4 Laying single cores of the mains power input

2.3 Separation of power cables and signal cables

Description

A frequent cause of electromagnetic influences is cross-coupling from faulty power cables to sensitive signal cables and unshielded mains power inputs.

Measures

Avoid electromagnetic influences with the following measures:

- Separate the cables into relevant cable groups – power cables and signal cables and unshielded mains power inputs.
- Only bundle cables of the same cable group together.
- Always lay the signal cables at least 200 mm away from power cables and unshielded mains power inputs.
  Or
  Use separating metal sheets which are connected in multiple places to the equipotential bonding system.
- Always lay the unshielded mains power inputs at least 200 mm away from power cables.
  Or
  Use separating metal sheets which are connected in multiple places to the high-frequency compatible equipotential bonding system.
- If it is impossible to avoid crossing cables, make sure they cross at right angles.

2.4 Shielded cables

Description

Shielded cables prevent the emission of electromagnetic disturbances through the cable to the surroundings and protect the signals from the coupling of electromagnetic disturbances from outside.

For cables inside control cabinets, as an alternative to shielded cables, measures are permitted that achieve comparable results to shielded cables:

- Routing behind mounting plates
- Routing in metal cable ducts
- Suitable physical separation

Measures

- The following cables should always be shielded:
  - Motor cables from the converter to the motor
  - Cables from the converter to the motor holding brake contactor
  - Cables from the converter to the braking resistor
  - DC link connecting cables (from about 1 m in length)
  - Cables from the external line filter to the converter
  - Bus cables, e.g. PROFINET, DRIVE-CLiQ, Ethernet
  - Analog signal cables, e.g. +/-10 V, temperature sensors
  - Digital supply cables (24 V I/O signals) outside control cabinets
  - 24 V supply cables outside control cabinets
- Do not interrupt the cable shields.
- Twist all conductors of the same electric circuit with each other within the same cable.
- Connect the unused cores to ground.
- At both ends, connect the shield over a large surface area.
  Use the shield connecting surfaces provided.

  With the bus interfaces (e.g. PROFINET, DRIVE-CLiQ, Ethernet) and encoder interfaces, the shield connection is provided via the plug-in connectors.
- Observe the information about the permissible cable lengths in the manuals and operating instructions of the SINAMICS converters and SIMOTICS motors.

Further measures

Shielded motor cables

- Only use motor cables in which integrated brake cables are shielded separately.
- For the cables to low and medium power motors, it is preferable to use MOTION-CONNECT cables.
- If you use the SINAMICS S120 and S220 Booksize systems with SIMOTICS servo motors, only use pre-assembled MOTION-CONNECT cables.
  The shield connection at the motor is realized with the prepared metal sheets for shield connection and the pressure plate on the module.
  The MOTION-CONNECT cables are also available with integrated and separately shielded cables for the motor holding brake.

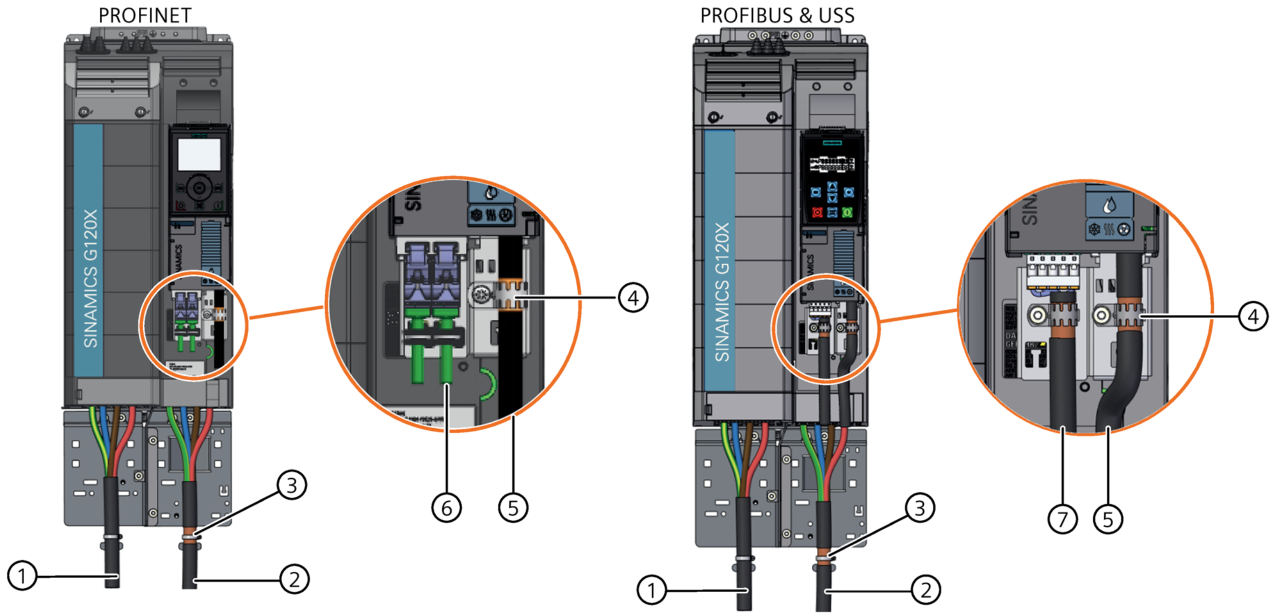
Figure 2-5 SINAMICS S120 (example)

OCC (One-Cable-Connection) is available for the SINAMICS S210 system.

Figure 2-6 SINAMICS S210 with OCC (example)

Correct shield connection

- Connect the cable shields at the designated places on the converter.



①	Unshielded power supply cable	⑤	Shielded control cable
②	Shielded motor cable	⑥	Shielded communication cable
③	Hose clamp	⑦	Shielded communication cable
④	Toothed tape		

Figure 2-7 Connect cable shields (example for converter G120X IP20 FSD)

Cables with a low service capacitance

- In the power range of the SINAMICS devices with the chassis format and cabinet units, use a cable with a low service capacitance, e.g. a symmetrically arranged three-phase cable with 3 protective conductors.

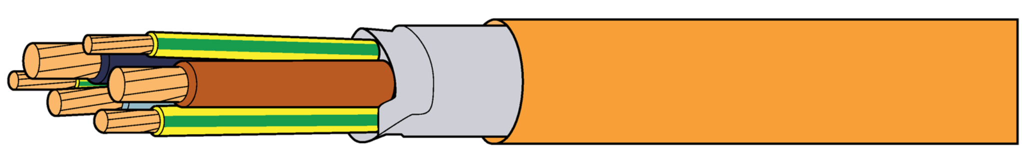


Figure 2-8 Shielded, symmetrically arranged three-phase cable with 3 protective conductors, e. g. PROTOFLEX EMV-FC 2XSLCY-J 0.6/1 kV from Prysmian.

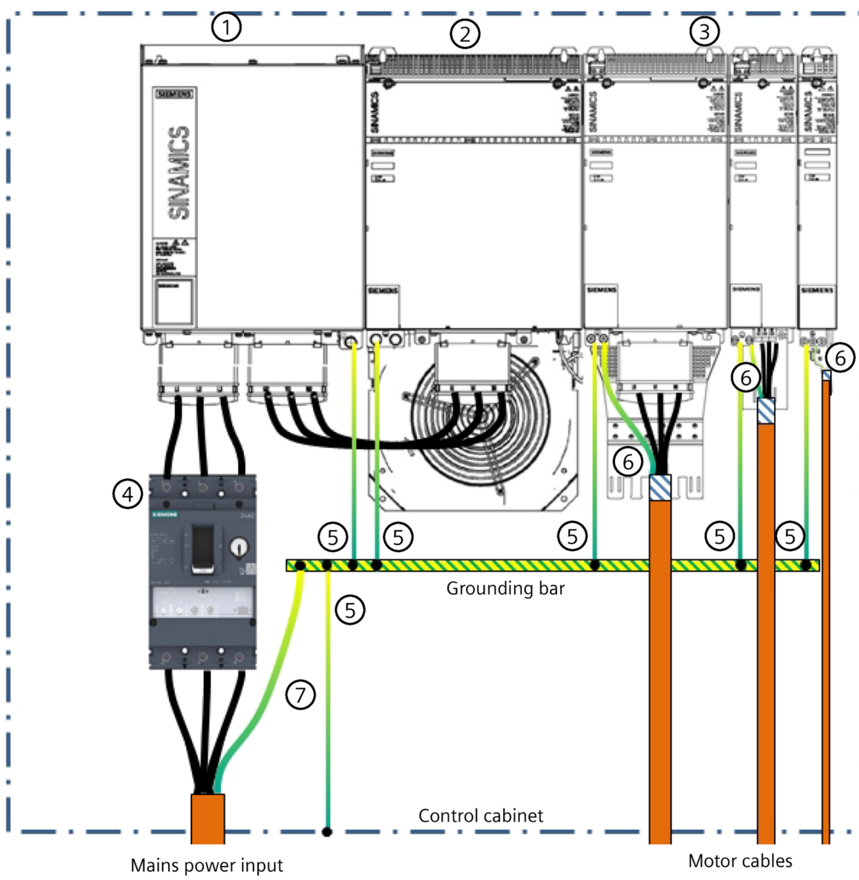
Installation guidelines for industrial control cabinets

3

3.1 High-frequency compatible equipotential bonding at control cabinet level

Description

To achieve good electromagnetic compatibility, it is essential to provide high-frequency compatible equipotential bonding within the control cabinet as a whole.



①	Active Interface Module	⑤	High-frequency compatible equipotential bonding to the equipment and to the mounting plate
②	Active Line Module	⑥	Protective conductors to the motors
③	Motor Modules	⑦	Protective conductor (PE) for the control cabinet
④	Overcurrent protection devices		

Figure 3-1 Protective connection concept, SINAMICS S120 Booksize (example)

Measures

- Use control cabinets made of metal.
- Mount all DIN rails and electrical components directly onto a bare metal mounting plate which is as uniform as possible.
- Make sure that the connecting surfaces of the electrical components are bare metal.
- Connect all control cabinet parts and enclosure parts to each other over a large surface area to establish a good electrical connection.
- Ensure that the points of contact are unpainted. Alternatively, you can also use toothed contact discs.
- Use short braided grounding straps to connect moving parts such as doors.
- Use a continuous grounding bar and connect it to the mounting plate over a large surface area to establish a good electrical connection.
- Connect the protective conductors of all electrical equipment to the grounding bar. Alternatively you can connect all protective conductors to the mounting plate.
- If there is more than one mounting plate inside a control cabinet, connect the mounting plates to each other and to the grounding bar in multiple places.

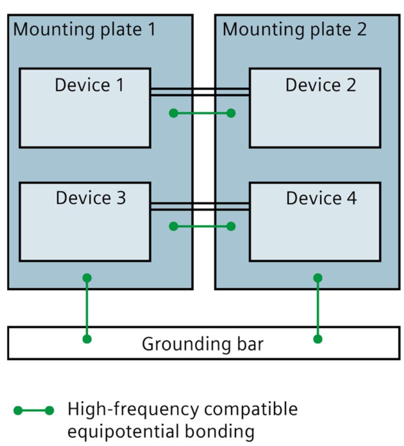
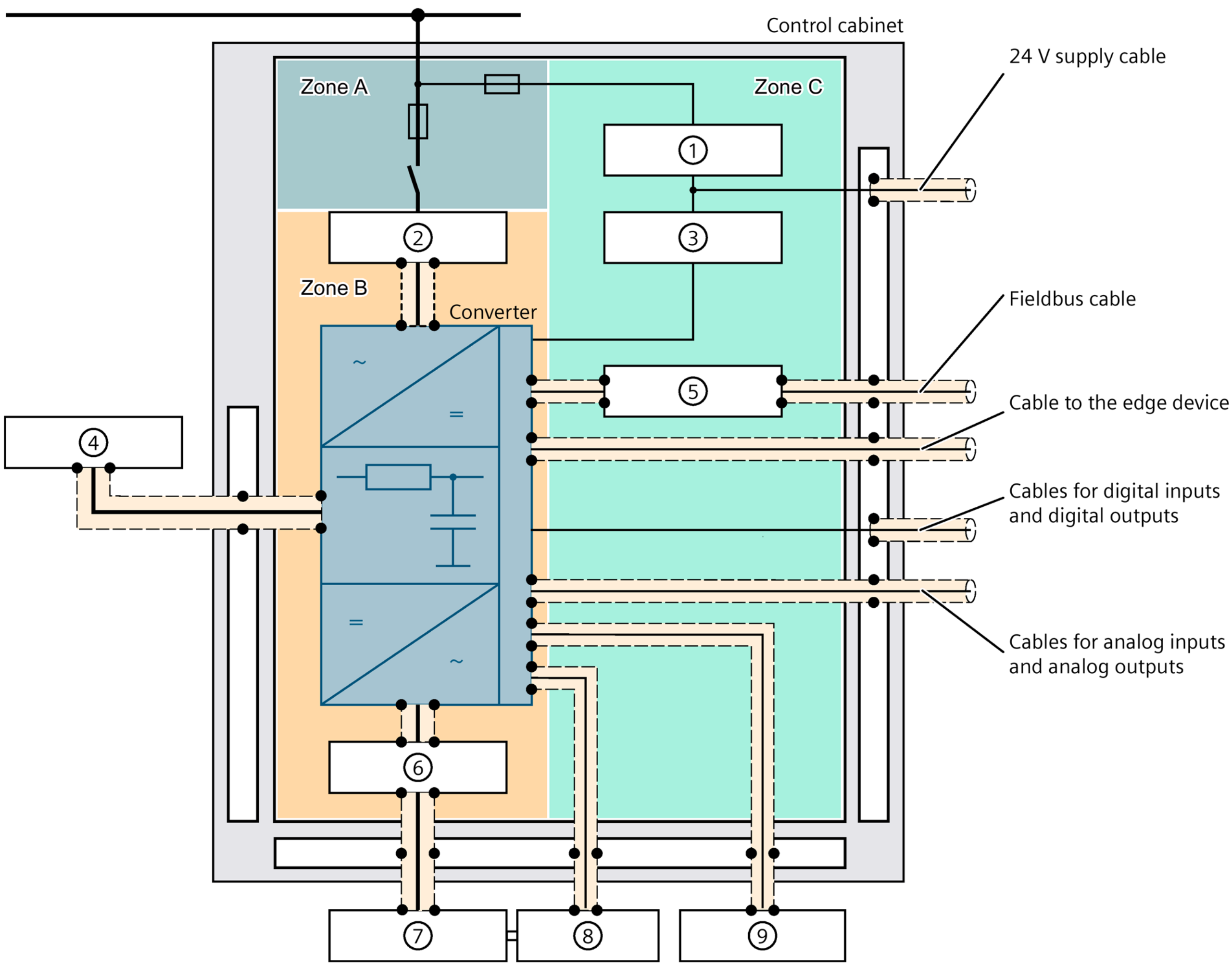


Figure 3-2 High-frequency compatible equipotential bonding in the control cabinet

- In large control cabinets, bolt the individual cabinet elements to each other in multiple places. Use toothed contact discs.

3.2 Zone concept within the control cabinets

Description



Zone A	Point of coupling
Zone B	Area with high interference, e.g. with converter, braking resistor, components on the motor side and power cables
Zone C	Area with high susceptibility, e.g. with open-loop and closed-loop electronics, sensor technology and signal cables

①	24 V power supply	⑥	Components on the motor side
②	External line filter	⑦	Motor
③	Surge protection device	⑧	Encoder
④	Braking resistor	⑨	Temperature sensor
⑤	Bus coupler	●●	Shield connection

Figure 3-3 Zone concept in the control cabinet (example)

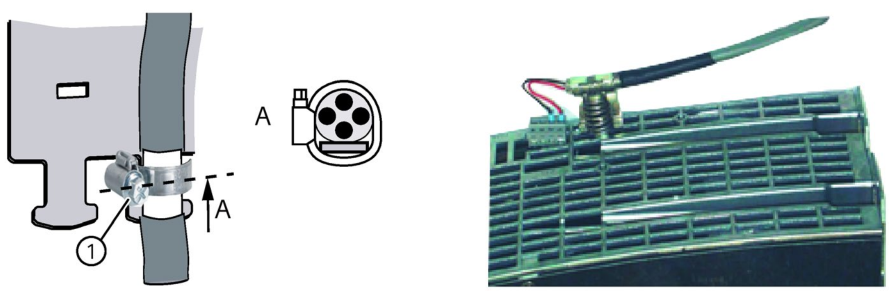
Measures

- Divide the control cabinet into different EMC zones:
  - Zones with high interference, e.g. power electronics
  - Zones with high susceptibility, e.g. control systems and sensor technology
- Decouple the zones using physical separation (about 200 mm) or shield plates which are grounded over a large surface area.
- Avoid routing cables of different EMC zones together in cable ducts.
- If necessary, use filters and disconnector modules at the interfaces between the zones.
- If necessary, also use separate 24 V power supplies for control systems and converters.

3.3 Shielded cables in the control cabinet

Measures

1. Use the connection features on the device to connect the shield.



① Shield clamp

Figure 3-4 Examples of correctly executed shield connections

2. Take suitable measures to prevent tensile loads at the shield connection.
3. If using devices without suitable shield connection features, connect the cable shield to the grounded mounting plate over a large surface area, close to the device.

4. Execute the shielding without interruptions.

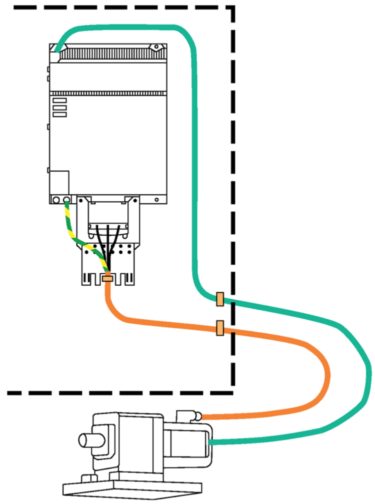


Figure 3-5 Example of an uninterrupted cable routing from the motor to the converter

5. If shielded cables exit the control cabinet, also connect the shield to the control cabinet enclosure over a large surface area at the exit point.

3.4 Limitation of transient overvoltages at the 24 V interfaces

Description

Transient overvoltages are brief, high voltage peaks caused by the switching of inductive loads or by coupling into long cables.

Wiring for inductive loads

High voltage peaks are produced when inductive loads are switched off, potentially interfering with or damaging other devices.

The 24 V digital outputs of the converters have an integrated voltage limitation with rapid demagnetization.

Measure for correct wiring

- Use suitable components to wire the inductive loads at switches or relay outputs:
  – Freewheeling diodes
  – Suppressor diodes
  – Varistors

Limitation of overvoltage in cables over 30 meters in length.

The longer the 24 V supply cables and signal cables become, the more likely transient overvoltages are to occur.

The product documentation of the various SINAMICS product lines describes whether the total length of the supply and signal cables can exceed 30 m and if so, what additional measures are necessary (e.g. surge suppressor).

Measures to limit overvoltage

- Follow the instructions in the manual concerning the use of 24 V supply and signal cables over 30 meters in length.
- Make sure that the 24 V supply cables and signal cables outside control cabinets are shielded.

Interference from converters

4

4.1 Typical harmonic behavior of different converter topologies

4.1.1 Voltage distortion at the point of coupling

Description

Non-sinusoidal currents generated by converters with a line-commutated input rectifier can distort the line voltage at the point of coupling.

- Point of common coupling: PCC
- In-plant point of coupling: IPC

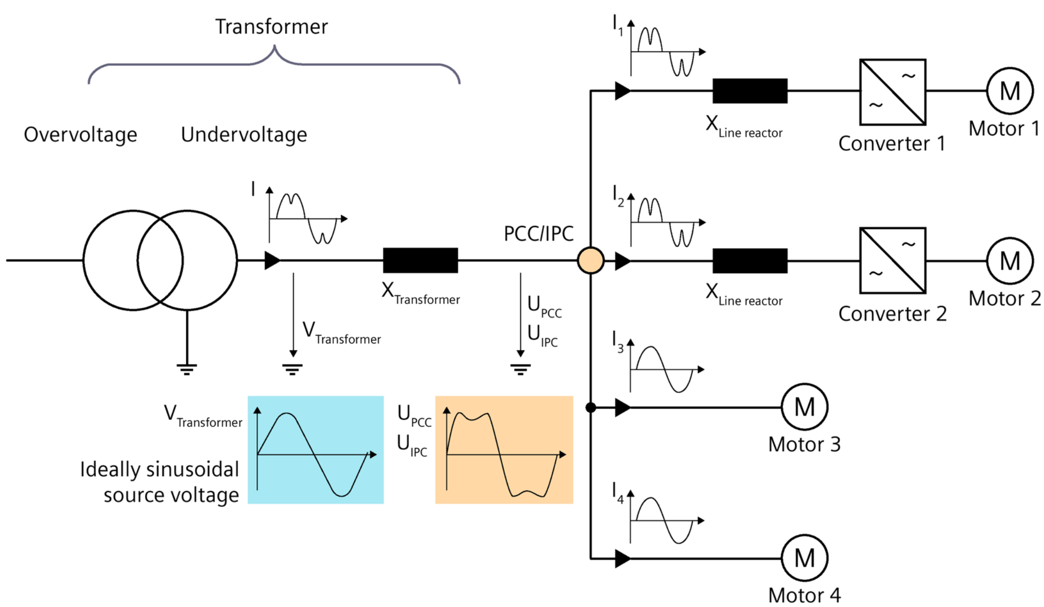


Figure 4-1 A low-voltage network supplied via a transformer with sinusoidal source voltage

The non-sinusoidal quantities at the point of coupling can be broken down into sinusoidal components:

- Fundamental component
- Harmonic components

The higher the harmonic components, the larger the deviations from the desired sinusoidal shape.

The current harmonics are predominantly defined by the type of rectifier circuit.

Converters are in the category of non-linear loads, in which the supply current deviates from the ideal sinusoidal shape. Due to line impedance, these current harmonics distort the supply voltage. In networks with high impedance, lower current harmonics and higher voltage harmonics occur. The line voltage distortion can negatively affect devices connected to the same network or damage them.

The type of line rectifier (AC/DC converter) has a crucial bearing on the current harmonics.

The line impedance significantly influences the short-circuit ratio Rsce. The Rsce is calculated from the ratio of the three-phase short-circuit power at the point of common coupling and the rated apparent power of the equipment (IEC 61000-3-12).

4.1.2 Converters for a single-phase point of coupling with diode rectifier

Description

Converters for a single-phase point of coupling with diode rectifier have a line rectifier with B2 diode bridge and are not suitable for regenerative feedback operation.

- Converters SINAMICS V20, G120 PM240-2 (FSA-B)
- Servo drives SINAMICS V90, S200, S210

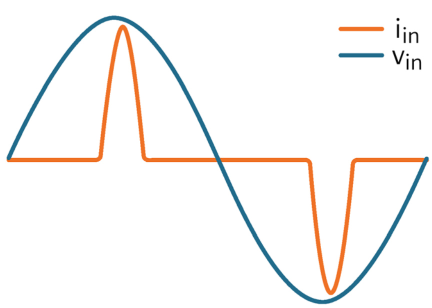


Figure 4-2 Typical progression of the input current of a single-phase converter

The product documentation contains typical harmonic currents as a percentage of the rated input current.

Example for V20:

Table 4- 1 Current harmonics of V20 FSA-C for an Rsce = 25

h	3	5	7	9	11	13	17	19
I_h	53%	42%	31%	23%	16%	11%	3%	2%

h = harmonic number, I_h = harmonic component

Measures

- If using single-phase converters on a three-phase network, note that the current harmonics with the harmonic number 3 and multiples of 3 add up in the neutral conductor and can overload it.
- Follow the recommendations for sizing the neutral conductor in IEC 60364-5-52:2019, Section 524.
- If no more detailed information is available, size the neutral conductor for 1.45 times the current-carrying capacity of the line conductor.

4.1.3 Converters for a three-phase point of coupling with diode rectifier or thyristor rectifier

Description

Converters for a three-phase point of coupling with diode rectifier have a line rectifier with B6 diode bridge and are not suitable for regenerative feedback operation. Converters for a three-phase point of coupling with thyristor rectifier have a thyristor bridge and are not suitable for regenerative feedback operation.

- Standard drives SINAMICS V20, G120 PM240-2, G120C, G120X, G130, G150, G220
- Servo drives SINAMICS V90, S200, S210
- SINAMICS S120 Basic Line Modules (BLM)

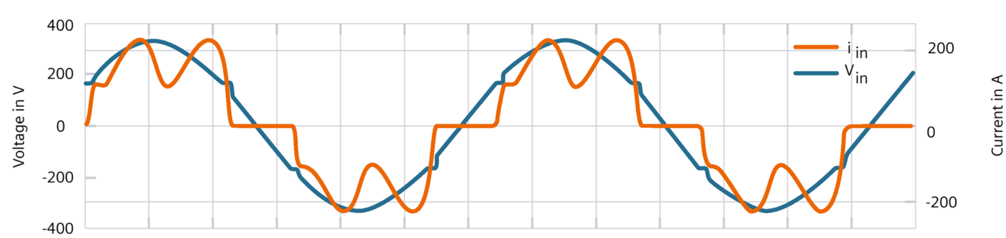


Figure 4-3 Typical progression of the input current of a three-phase converter

The product documentation contains typical harmonic currents as a percentage of the rated input current.

Example for G120 PM240-2:

Table 4- 2 Current harmonics of G120 PM240-2 FSD 400 V with RSC = 120

h	5	7	11	13	17	19	23	25
I_h	37%	21%	7%	5%	4%	3%	3%	2%

h = harmonic number, I_h = harmonic component

Measures

Note

Line reactors limit the dynamic response of the motion control of servo drives.

Do not use line reactors with servo drives SINAMICS V90 or S200.

- For converters SINAMICS G120 PM240-2 FSA-FSC, G120C and V20, use the optional line reactors if possible. Place the line reactors close to the converter.
- Only operate the SINAMICS S120 Booksize BLM and Chassis BLM (Basic Line Module) with the associated line reactor.

4.1.4 Converters with diode rectifier and pared-down DC link

Description

Converters with diode rectifier and pared-down DC link are not suitable for regenerative feedback operation and have a line rectifier with B6 diode bridge and a DC link with low-capacitance film capacitors. If film capacitors are used, the capacitance in the DC link is much less than with classic converters with electrolytic capacitors.

Lower current harmonics occur in the frequency range up to 2 kHz. The higher current harmonics in the frequency range above 2 kHz increase the risk of resonance effects on the line side.

The converters are G120P, G110D, or G115D.

Table 4- 3 Current harmonics for converters G120P FSA FSF

h	5	7	11	13	17	19	23	25
I_h	20%	14%	9.1%	7.7%	5.9%	5.3%	4.3%	4.0%

h = harmonic number, I_h = harmonic component

Measure

- Only operate converters with a pared-down DC link in networks with Rsce ≥ 100.

4.1.5 Converters with F3E infeed

Description

Converters with F3E infeed have a capacitive filter on the line side and a B6 IGBT bridge, meaning that they are suitable for infeed operation and regenerative feedback operation. The DC link is executed without significant capacitance.

- SINAMICS G120 PM250 and G120D.

Lower current harmonics occur in the frequency range up to 2 kHz. In unfavorable system configurations, higher current harmonics in the frequency range above 2 kHz and the relatively high capacitance of the line-side filter increase the risk of resonance effects on the line side.

Measures

- Only operate converters with F3E infeed in networks with RSC ≥ 100.
- If multiple converters are connected in parallel, note that the load adds up with capacitive reactive currents.

4.1.6 Converters with smart infeed

Description

Converters with smart infeed have a B6 IGBT bridge on the line side and a 4% reactor, meaning that they are suitable for infeed operation and regenerative feedback operation. The DC link is executed with electrolytic capacitors.

- SINAMICS S120 and S220 Smart Line Modules (SLM)

In infeed operation, the smart infeed behaves exactly the same as a classic diode infeed with 4% line reactor. In regenerative feedback operation, the shape of the current changes, with the current harmonic components I_h moving to higher harmonic numbers.

Table 4- 4 Typical current harmonics for SINAMICS with smart infeed in infeed operation with line reactor UK = 4%

h	5	7	11	13	17	19	23	25	THD(I)
I_h	30.6%	8.6%	5.7%	3.1%	2.1%	1.6%	1.2%	1.1%	32.6%

h = harmonic number, I_h = harmonic component

Table 4- 5 Typical current harmonics for SINAMICS with smart infeed in regenerative feedback operation with line reactor UK = 4%

h	5	7	11	13	17	19	23	25	THD(I)
I_h	20%	16%	11%	8%	7%	6%	5%	4%	32%

h = harmonic number, I_h = harmonic component

Measure

- Only operate the SINAMICS S120 Booksize SLM and Chassis SLM with the associated line reactor.

4.1.7 Converters with active infeed

Description

Converters with active infeed have an active, controlled line rectifier with line reactor, B6 IGBT bridge (Active Line Modules only) and DC link with electrolytic capacitors.

Devices with active infeed have a virtually sinusoidal current consumption from the network.

S120 ALMs are suitable for regenerative feedback operation, and an AIM containing the line reactor, the line filter and a switching frequency filter is necessary for operation.

G220 CPDs are not suitable for regenerative feedback operation and contain all components necessary for operation.

Note

In the lower frequency range (2 kHz to 150 kHz), active infeeds generate greater line harmonic distortions than converters with line-commutated infeed.

Measures

- Only operate the S120 ALMs with the associated AIMs.
- Follow the instructions in the product documentation about the minimum permissible line short-circuit power.

4.2 Line-side filters to reduce the current harmonics

Description

Passive low harmonics filters are LC filters which mainly filter the 5th and 7th harmonics in the line current of 6-pulse rectifiers. The passive low harmonics filters reduce the line harmonic distortions at the point of coupling.

Passive low harmonics filters are only suitable for applications with virtually constant load using the following converters:

- SINAMICS G120X
- SINAMICS G130
- SINAMICS G150

Passive low harmonics filters are not suitable for:

- Servo converters, e.g. SINAMICS V90, S200, S210
- Converters with pared-down DC link, e.g. SINAMICS G110D, G115M, G120D, G120P, G120 PM250
- Converters with smart infeed, e.g. SINAMICS S120 SLM, G220 Regenerative Drive

There is more information about the operating principles and the usage constraints in the passive low harmonics filter manuals.

4.3 High-frequency interference

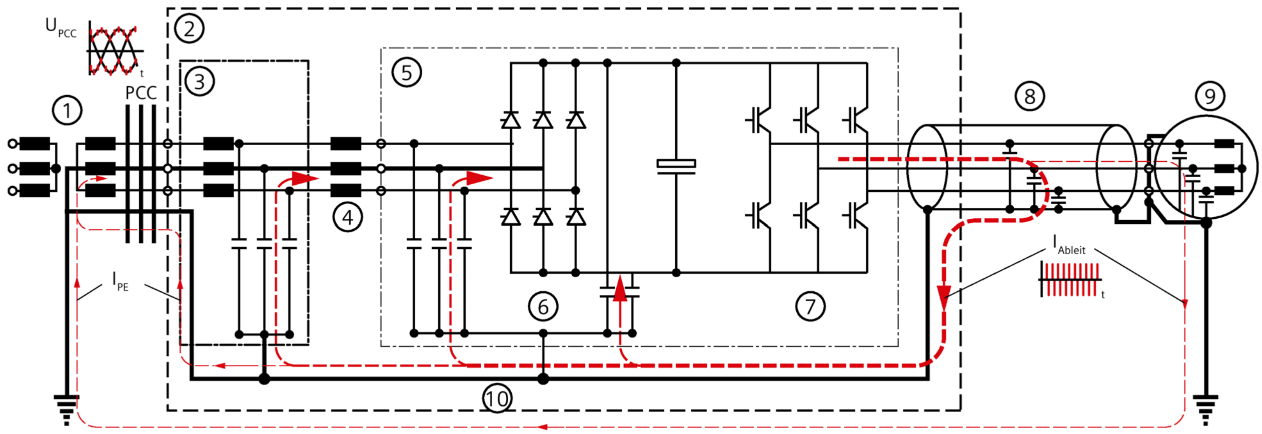
Description

Converters generate high-frequency interference currents that may cause radio-frequency interference.

4.4 Line filters to limit high-frequency interference

Description

Line filters reduce the conducted interference from the drive to the supplying network in the 150 kHz to 30 MHz frequency range to the permissible limit values set out in IEC 61800-3.



①	Transformer	⑥	Line filter category C3
②	Converter cabinet unit	⑦	IGBT inverter
③	Line filter category C2 (optional)	⑧	Motor cable
④	Line reactor	⑨	Motor
⑤	Converter chassis unit	⑩	Grounding bar

Figure 4-4 Reduction of high-frequency interference with line filters

The IGBT inverter generates capacitive leakage currents (red). Line filters return these leakage currents directly to the converter, reducing the interference into the supplying network.

Note

For operation on the public network in residential environments and in commercial and light-industrial applications, additional measures to reduce radio-frequency interference may be necessary. There is more information in High-frequency interference in commercial and light-industrial applications (Page 49) and High-frequency interference in residential environments (Page 49)

Measures

- For converters without an integrated line filter, use the optional external line filters.
- Place the external line filters close to the converter.

4.5 Filter components on the motor side

Description

Line filters combined with shielded motor connection cables limit the high-frequency interference. The product documentation of the individual product lines sets out the types of shielded motor cables that should be used and the lengths up to which the specified limit values are respected.

Filter components on the motor side are appropriate in the following use cases:

- Longer cable lengths
- Protection of motor insulation
- Reduction of motor bearing currents

Examples of filter components on the motor side:

- Motor reactors
- du/dt filters with voltage peak limiters
- Sine-wave filters

The engineering of the filter components on the motor side is covered by this documentation.

Measures

- For the modular power drive systems S120 and S220, also follow the instructions concerning the maximum permissible total cable lengths.
- Use motor connection cables without shielding only if a sine-wave filter is also used.
- Place the filter components on the motor side as close as possible to the converter.

4.6 Fieldbus interfaces

Description

Within a system, fieldbuses such as PROFINET or PROFIBUS connect field devices (actuators and sensors) in order to communicate with a programmable controller such as SIMATIC.

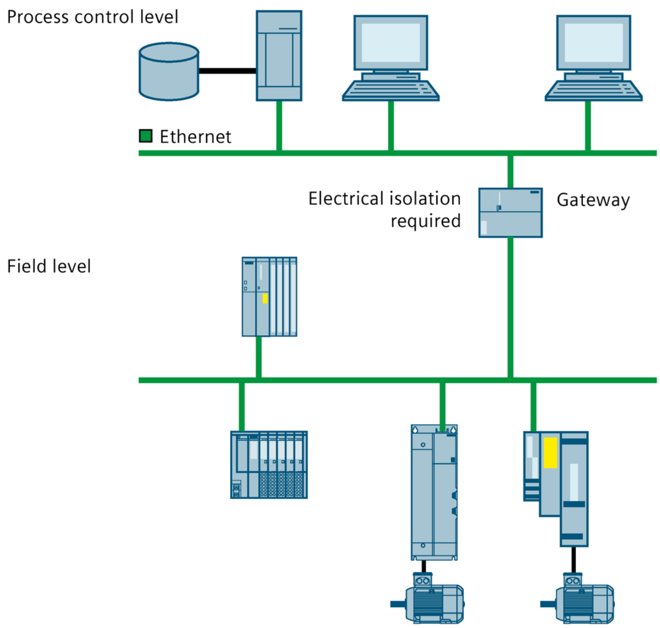


Figure 4-5 Electrical isolation between the process control level and field level

If the process control level and field level of the fieldbus are connected through a gateway, optical or electrical isolation is required in the gateway.

Within the field level, electrical isolation between individual segments of the fieldbus is possible when required.

The integrated power electronics of the SINAMICS converters may cause greater conducted interference. The disturbances are spread from fieldbus cables which exit the control cabinet. Network isolators with electrical separation prevent these disturbances from spreading.

The following are recommended for Ethernet-based fieldbuses (e.g. PROFINET, Ethernet/IP):

- SCALANCE XCM102 IE media converter
- Phoenix Contact, Network Isolator, e.g. FL Isolator 1000-RJ/RJ

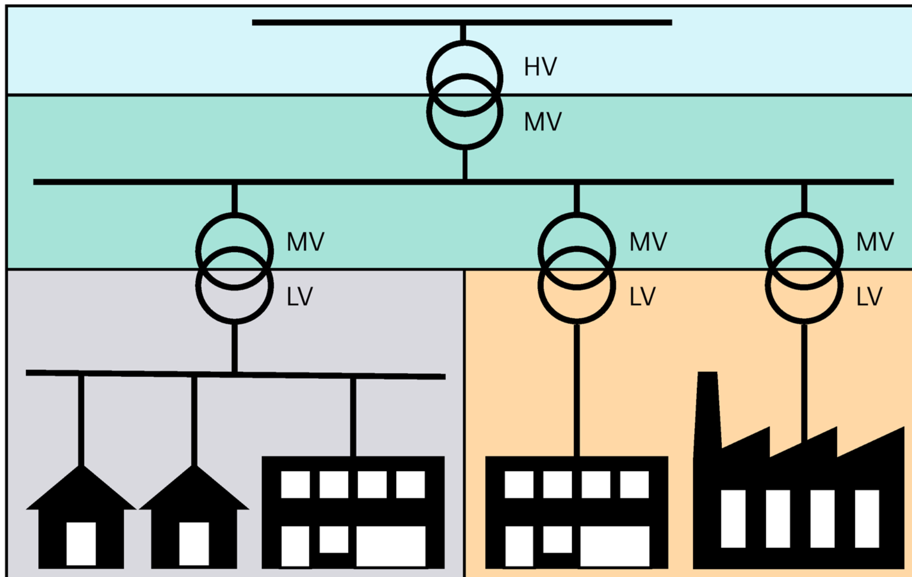
Definition of the different operating environments 5

Description

The various standards concerning EMC and power quality at device level and system level distinguish between the following environments:

- Residential environments supplied by the public low-voltage network.
- Commercial and light-industrial environments supplied by the public low-voltage network, e.g. supermarkets, auto repair workshops.
- Environments for industry and large-scale plants, supplied by a separate power network. The separate power network uses a high voltage transformer or medium voltage transformer designed specifically to supply the plant. The separate power network is also used to supply non-industrial devices such as office equipment.
- Environments for heavy industry, supplied by a separate power network. The separate power network uses a high voltage transformer or medium voltage transformer designed specifically to supply the plant. The separate power network is used exclusively to supply industrial devices such as converters.

The following figure provides an overview of the different operating environments:



Low-voltage network	Public supply network		Non-public and industrial supply networks	
Operating environment	Residential	Commercial/-light industry	Industry/large-scale plants	Heavy industry
High-frequency interference [1]	IEC 61800-3 Category C1	IEC 61800-3 Cat. C1 or C2 [5]	IEC 61800-3 Cat. C2 or C3	IEC 61800-3 Cat. C3 or C4 [6]
Current harmonics [2]	IEC 61000-3-2 (up to 16 A) IEC 61000-3-12 (16 A to 75 A)		-	
Voltage changes, fluctuations and flicker	IEC 61000-3-3 (up to 16 A) IEC 61000-3-11 (16 A to 75 A)		-	
Voltage harmonics [3]	IEC 61000-2-2		IEC 61000-2-4 Class 2 or 3	IEC 61000-2-4 Class 3
Voltage distortions [4]	IEC 61000-2-2		-	
Harmonics in electric power systems [7]	IEEE519			

① Limit values for radio-frequency disturbance voltage 9 kHz to 30 MHz and radio-frequency emitted interference > 30 MHz

② Limit values up to 2 kHz for devices

③ Compatibility level up to 2 kHz at point of coupling of systems

④ Compatibility level 2 kHz to 150 kHz at point of coupling of systems (IEC 61000-2-2:2018 Edition 2.2)

⑤ Category C2 PDSs must be set up and put into operation by trained staff.

⑥ Category C4 is applicable for PDSs with a rated current > 400 A, for use in complex industrial systems or for operation in IT supply systems.

⑦ IEEE 519: Standard for harmonic control in electric power systems

Figure 5-1 Voltage levels in public and non-public/industrial supply networks

Note

The compatibility levels defined in the IEC 61000-2-X series of standards are not limit values, but rather, defined reference levels to coordinate interference limit values in the defined environment. The compatibility levels do not relate to individual devices but to the point of coupling of systems.

Operation on a non-public and industrial network 6

6.1 Operation in non-public and industrial supply networks

Description

According to IEC 61800-3:2022, a separate power network is a characteristic feature of industrial locations. The separate power network uses a high voltage transformer or medium voltage transformer designed specifically to supply the plant. The electromagnetic environment of an industrial location is mainly determined by the devices and systems operating there.

Higher interference levels are permissible in industrial environments than in environments supplied by the public low-voltage network. Devices for use in industrial environments must have correspondingly greater immunity.

All SINAMICS converters are suitable for use in industrial environments.

6.2 Current harmonics

Description and measure

For converters used in industrial environments, IEC 61800-3 does not define any limit values for current harmonics. IEC 61800-3 recommends an assessment of the system as a whole according to IEC/TR 61000-3-14 and IEC 61800-3 Annex B.4.

- Use the SIZER engineering tool to assess the harmonics.
  Download: (https://support.industry.siemens.com/cs/ww/en/ps/13434)

Note

It is often preferable for financial and technical reasons to use collective filters for the system as a whole rather than a large number of individual filters at device level.

6.3 Low-frequency conducted disturbances in industrial plants

Description

IEC 61000-2-4 defines compatibility levels for low-frequency conducted disturbances in industrial plants. The EMC at the in-plant point of coupling (IPC) is considered. The IPC is the in-plant point of coupling to a supply network to which other loads are or could be connected.

Converters are used in two environment classes:

Class 2:
Locations with light industry and large-scale plants in which the following areas are connected to a shared, non-public supply network:

- Areas with industrial power electronic devices, e.g. production areas
- Areas with non-industrial devices, e.g. offices

Class 3:
Locations with heavy industry in which exclusively industrial devices are connected to the non-public supply network.

If converters (apart from converters with active infeed) are used, the compatibility levels for harmonic voltage components up to the 50th order are particularly relevant. You can find additional information on this in IEC 61000-2-4 Table 2.

Measure

- Calculate the line harmonic distortion for the individual system.

6.4 Category C3 high-frequency interference

6.4.1 High-frequency interference

Description

For the industrial use of converters with a rated input current of 400 A, a limitation is necessary for the following disturbances:

- Conducted disturbances
- Radiated electromagnetic disturbances

The defined limit values of IEC 61800-3 Category C3 must be respected.

The standard allows higher interference levels for devices with a rated input current > 100 A. If possible, also use suitable filters for converters with a rated input current > 400 A.

Measures

1. Operate the converters on an industrial TN system or TT system with grounded neutral point.
2. Use converters with an integrated line filter or external C2 line filters or C3 line filters.
3. Follow the instructions concerning the maximum permissible lengths of the motor cables in the relevant manuals.
4. Use shielded motor connection cables with low capacitance.
5. Do not operate the converter with a pulse frequency higher than the factory setting.

6.4.2 Category C4 high-frequency interference

Description

Category C4 is applicable for:

- Converters with a rated current greater than 400 A
- Use in complex industrial systems
- Operation in IT supply systems

Measures

- For Category C4 installations, create an EMC plan describing compliance with EMC requirements for the intended application.
- As part of this, define the EMC characteristics of the environment, including the system as a whole and the surroundings. You must observe the typical interference levels of the converters.
- Avoid excessive disturbances into surrounding low-voltage networks even if they are spread by a medium-voltage network.

6.4.3 Special considerations for operation in insulated networks (IT supply systems)

Description

Some branches of industry use ungrounded networks or high-impedance grounded networks (IT supply systems). If ground faults occur, IT supply systems increase the availability of the equipment.

The capacitors to ground (Y capacitors) integrated in the line filters of the converters can be overloaded, causing

- insulation monitors to activate incorrectly
- the converter to be overloaded by capacitive discharge currents during a ground fault

Measures

1. If the converter has an integrated line filter, deactivate the ground connection of the Y capacitor.
2. If the converter does not have an integrated line filter, do not use an external line filter.
3. Create an EMC plan for the Category C4 installation.
4. Use an insulation monitor.
5. Use suitable surge arresters to ground for device protection.
6. Correct any insulation faults immediately.

Operation on a public network 7

7.1 Operation on public low-voltage networks

Description

Public low-voltage networks are used to supply residential areas and commercial and light-industrial areas.

The standards for public low-voltage networks define limit values for electromagnetic disturbances (immunity and interference). Devices and systems that are operated on the public low-voltage supply must respect the limit values for electromagnetic disturbances (immunity and interference) defined in the relevant standards. Industrial power systems are subject to stricter requirements particularly regarding interference. The requirements for operation on the public low-voltage network are explained in more detail below.

The requirements for public low-voltage networks are stricter than for industrial networks. This section describes the requirements for operation on the public low-voltage network.

Note

Observe the technical connection conditions of your grid operator. Requirements may be defined there that exceed the standard requirements described in this document.

The converter series SINAMICS V90, G120 PM250, G130, G150, S120, S200, S210 and S220 are not intended for operation on the public network.

You can operate the converter series SINAMICS V20, G110D, G115M, G120 PM240-2, G120C, G120P, G120X, G220 and G220 Clean Power Drive on the public network subject to the following constraints.

7.2 Immunity to ripple control signals

Description

A ripple control technique is often used as part of network management in public supply networks, in which voltage pulses in the frequency range from 110 Hz to about 2 kHz are superimposed onto the line voltage. The ripple control signals can influence converters, especially converters in V/f mode.

Measure

- It is preferable to operate converters on the public network in vector control or servo control modes.

7.3 Flicker (voltage supply deviation)

Description

Flicker behavior can only be assessed if the drive is considered in conjunction with an application. There is more information about this in IEC/EN 61800-3, section 6.2.4.2.

Load fluctuations in the application are visible on the line side virtually unchanged.

Measure

- Assess the compliance of the installation with the limit values of IEC 61000-3-3 and IEC 61000-3-11.
- Use the characteristics of the load presented before the driven installation.

7.4 Current harmonics of converters on the public network

Description

The EMC product standard IEC 61800-3 for converters refers to compliance with the IEC 61000-3-2 and IEC 61000-3-12 standards for operation on the public network.

- In terms of current harmonics, the converter series SINAMICS G220 Clean Power is suitable for operation on public networks without restriction.

If installations contain multiple converters up to a rated input current of 75 A, the requirements of the IEC 61000-3-2 and IEC 61000-3-12 standards apply to the complete installation.

If installations contain converters with a rated input current > 75 A, IEC 61800-3 recommends an assessment of the system as a whole according to IEC 61000-14 and IEC 61800-3 Annex B.4.

Note

Also observe the technical connection conditions of your local grid operator.

Measures

1. Assess the system as a whole according to IEC 61000-14 and IEC 61800-3 Annex B.4.
2. Use the engineering tool SIZER integrated in TIA Selection Tool to assess the harmonics. Download: TIA Selection Tool - SIZER plugin (https://www.siemens.com/global/en/products/automation/industry-software/automation-software/tia-portal.html)

Use of harmonic filters

If harmonic filters are used, it is often preferable for financial and technical reasons to use collective filters for the system as a whole rather than a large number of individual filters at device level.

Converters with a rating up to 1 kW

Converters with a rating up to 1 kW must respect the limit values for current harmonics according to IEC 61000-3-2 Table 1.

Converters with a rating > 1 kW and an input current ≤ 16 A

IEC 61000-3-2 does not define any limit values for converters in professional use in commercial and light-industrial applications in the range > 1 kW and ≤ 16 A.

1. Ask the relevant power supply company for a connection permit for converters in professional use in the range > 1 kW and ≤ 16 A. (This does not apply to SINAMICS G220 Clean Power) IEC 61000-3-12 contains relevant recommendations.

Converters with an input current in the range > 16 A to 75 A

If the constraints below are respected, the following converters with a rated input current in the range from > 16 A to 75 A meet the requirements of IEC 61000-3-12 for operation on the public network:

Converter	Size	Constraints
G220 Clean Power	All	None
G220	B, C, D	Rsce ≥ 120
G120 PM240-2	D	
G120	D	
G120C	D	
G120X	B, C, D	
V20	C, D, E	Rsce ≥ 120 and line reactor (optionally available)
G120 PM240-2	B, C	
G120C	B, C	
G120 PM230	B, C, D, E	Rsce ≥ 250

7.5 Harmonic voltages in public networks

Description

IEC 61000-2-2, Table 1 defines the following:

- Compatibility levels for harmonic components of voltages at the PCC (Point of Common Coupling) up to the harmonic number 40
- Corresponding compatibility level for the total demand distortion (THD) = 8%

The PCC is the point of coupling to the public network.

For systems in which converters or other non-linear loads are widely used, calculate a line harmonic distortion that takes the individual system configuration into account.

The converter series G220 Clean Power and G120X with upstream line harmonics filters (LHFs) allow adherence to the compatibility levels for voltage harmonics, regardless of what percentage of the overall load is made up by the converter load.

Measures

- Calculate the line harmonic distortion for each system individually.
- Use the engineering tool SIZER integrated in TIA Selection Tool to assess the harmonics. Download:TIA Selection Tool - SIZER plugin (https://www.siemens.com/global/en/products/automation/industry-software/automation-software/tia-portal.html)

7.6 Low-frequency symmetrical voltage distortions

Description

IEC 61000-2-2 defines compatibility levels for low-frequency voltage distortions in the frequency range from 2 kHz to 9 kHz and from 9 kHz to 150 kHz.

Measure

- Assess the voltage distortions of the individual systems. When doing this, take into account the relevant line impedance.

7.7 High-frequency interference in commercial and light-industrial applications

Description

For the commercial and light-industrial use of converters, it is necessary to limit the conducted and radiated electromagnetic disturbances to at least the limit values defined in IEC 61800-3, Category C2.

Measures

- Operate the converters on a TN system or TT system with grounded neutral point.
- Use converters with an integrated line filter or with external line filters of at least Category C2.
- Respect the maximum permissible motor cable lengths from the relevant manuals.
- Use shielded motor connection cables with low capacitance.
- Do not operate the power drive system with a pulse frequency higher than the factory setting.

7.8 High-frequency interference in residential environments

Description

Note

The SINAMICS converters are not intended for use in residential environments and can cause high-frequency disturbances there.

In the case of converters in the SINAMICS G120X series, adherence to the limit values for conducted interference of EMC Category C1 is possible.

Measure

- Respect the constraints in the operating instructions of the G120X for adherence to the limit values for conducted disturbances.

Harmonics at the point of coupling according to IEEE 519

8

Description and measure

IEEE 519 defines limit values for voltage harmonics and current harmonics for all of the loads at the point of common coupling (PCC).

Systems satisfy the limit values of IEEE 519 (without the need to implement special measures) only if the percentage of converters with line-commutated rectifiers and other non-linear loads in the overall load is relatively low.

- Assess each system individually.

For a relative short-circuit power Rsce ≥ 20, the SINAMICS G220 Clean Power G120X converter series with upstream line harmonics filters (LHF) allow all requirements laid down in IEEE 519 to be complied with, independent of the percentage component with respect to the complete system.

Effects of converter operation on the motors 9

Description

The switching operations of the IGBTs in the output of the SINAMICS converters generate voltage swells at the motor connections. The voltage swells place an additional load on the motor insulation and can cause early damage to the winding.

The rapid switching operations also produce a higher current flow in the motor bearings. The higher current flow can cause early bearing damage. This effect can occur mainly in motors with a shaft height of 225 mm and above.

Measures

In certain use cases, the following additional measures are appropriate:

- Motor reactors
- du/dt filters with voltage peak limiters
- Sine-wave filters
- Symmetrical motor connection cable

The measures allow:

- Longer cable lengths
- Protection of motor insulation
- Reduction of motor bearing currents

Note

The engineering of measures to reduce the voltage load and the bearing currents is not covered by this documentation.

You can find more information in the system manual for third-party motors (https://support.industry.siemens.com/cs/ww/en/view/109792187)

- Only use motors with an insulation system that is suitable for converter operation.
- Reduce the effects of rapidly switching power semiconductors as described in the SINAMICS Configuration Manual.
(https://support.industry.siemens.com/cs/ww/en/view/83180185)

Get more information

SINAMICS:
www.siemens.com/sinamics

Industry Mall:
www.siemens.com/industrymall

Industry Online Support:
www.siemens.com/online-support