Planning Guide 03/2004 Edition

motion control

EMC Installation Guideline
SINUMERIK, SIROTEC, SIMODRIVE
SIMOTION, SINAMICS S120

SIEMENS

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EMC Installation Guideline

Planning Guide

Valid for

SINUMERIK
SIROTEC
SIMODRIVE
SIMOTION
SINAMICS S120

03.2004 Edition

Identification of the documentation

Printing history

Brief details of this edition and previous editions are listed below.

The status of each edition is shown by the code in the "Remarks" columns.

Status code in the "Remarks" column:

A .... New documentation.
B .... Unrevised reprint with new order no.
C .... Revised edition with new status.

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Further information is available on the Internet under:
http://www.siemens.com/motioncontrol

This publicatio was produced with WinWord V 8.0 and Designer V 7.0 and the DocuTool AutWinDoc.

We have checked that the contents of this document corresponds to the hardware and software described. Nonetheless, differences might exist and therefore we cannot guarantee that they are completely identical. The information contained in this documentation is, however, reviewed regularly and any necessary changes will be included in the next edition. We welcome suggestions for improvement.

Subject to change without prior notice

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Preface

What does EMC mean

EMC is the abbreviation for electromagnetic compatibility. Electromagnetic compatibility is defined as the characteristic of a piece of electrical equipment to function satisfactory in a predetermined electromagnetic environment without influencing this environment unduly.

Who is this manual for

- Project managers creating NC and drive system configurations.
- Installers routing the connection lines.
- Service engineers involved in troubleshooting and fault elimination.

Machine manufacturers

The notes indicated in Chapters 2, 4, 5, 6, 7, 9, 10, 11 are primarily directed towards machine manufacturers, who can influence or change the functional behaviour of the complete system by means of the described measures.

Subject matter of this manual

You receive the following information in this Guideline:

- Why are EMC guidelines necessary?
- Which interference sizes have an effect on the control from outside (interference sink)?
- How can EMC malfunctions be prevented?
- Which practical application examples are available for a trouble-free system structure?
- What must be considered when handling electrostatically sensitive assemblies?
- How can a malfunction caused by a deficient EMC be eliminated?

Objectives

These guidelines are not, and do not aim to be, a textbook for EMC. The purpose of these guidelines is to provide the practical person with instructions for securing the EMC.

Compliance with these EMC guidelines are necessary to

a) achieve a minimum noise immunity of the accessories in such a way that they function perfectly in a harsh industrial environment and
b) to not have an undue impact on the environment in terms of radio interference.

These guidelines also describe the necessary measures according to the European Union (EU) directives for compliance with the EMC law or the EMC guidelines.

In installation locations with extremely high interference levels, malfunctions can be caused despite compliance with these EMC Guidelines, although it is very unlikely.

What prior knowledge is required?

Apart from these EMC Guidelines, international and country-specific safety regulations continue to apply.

Good knowledge of the relevant standards and EU regulations is necessary, so that the safety concerns are not impaired when implementing these EMC Guidelines. The implementation of these EMC Guidelines must be performed by qualified personnel.

Qualified personnel

All persons who are entrusted with the installation, assembly, commissioning and operation of the product and who possess the necessary qualifications are to be considered to be qualified personnel.

The authorization to connect circuits and devices in accordance with the approved standards of electrical engineering, to bring them into operation and to remove them from operation applies as a particular qualification.

Hotline

If you have any questions, please get in touch via our hotline:

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Fax form: See the reply form at the end of the document.

Internet addresses

Motion Control Systems: http://www.siemens.com/motioncontrol

Finding your way around

To assist you in your orientation, you have a table of contents and an index.

Safety and warning concept

The following safety and warning information is used in this document.
Explanation of symbols used:

Danger

Indicates an imminently hazardous situation which, if not avoided, **will** result in death or serious injury or in substantial property damage.

Warning

Indicates a potentially hazardous situation which, if not avoided, **could** result in death or serious injury or in substantial property damage.

Caution

This symbol (with a warning triangle) indicates that minor injury or damage to property **may** result if proper precautions are not taken.

Caution

Used without safety alert symbol indicates a potentially hazardous situation which, if not avoided, **may** result in property damage.

Notice

Used without the safety alert symbol indicates a potential situation which, if not avoided, **may** result in an undesirable result or state.

Other information

Important

Important indicates an important or especially relevant item of information.

Note

Note refers to an important item of information about the product, handling of the product or part of the documentation which is particularly relevant in the current context.

Machine manufacturer

This symbol appears in this documentation whenever the machine manufacturer can influence or modify the described functional behavior. Please observe the information provided by the machine manufacturer!

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Contents

1 Introduction

To attain the electromagnetic compatibility (EMC) requested in the EMC Guideline of a complete plant (control and drive engine), EMC measures on the part of the control manufacturer and user (including machine tool manufacturer) are required.

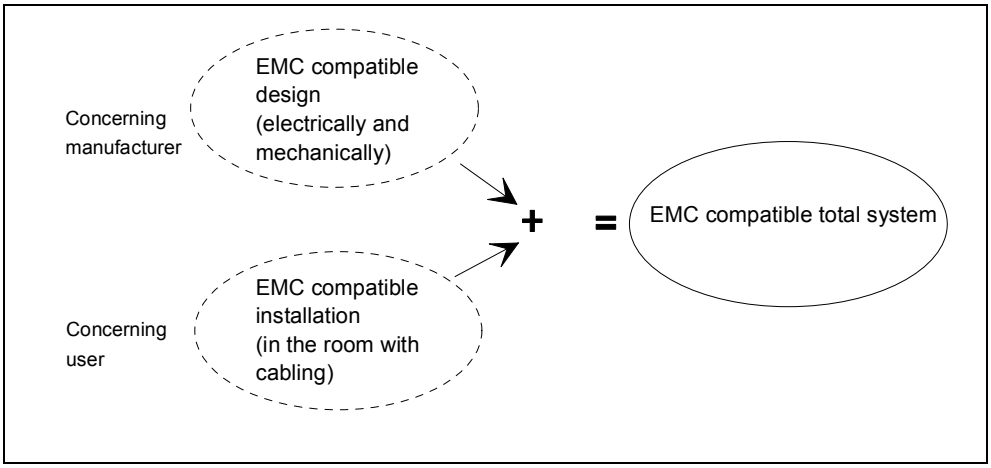

Fig. 1-1 Securing the EMC

Important

To secure the EMC, you must pay attention to the:

- product-specific EMC measures contained in the EMC Guidelines,
- to project or operate only permitted combinations and
- to use the accessories provided in the product-specific documentation (e.g. ready-made wiring) or equivalent.

■

Notes

2 EMC Basic Rules

Mass of metal parts

- Connect all metal parts of the control cabinet flat and well-conducting with each other.
- Connect the cabinet doors via short ground straps (upper, middle, lower) with the cabinet beam.
- Connect the shield bus and potential compensation bus extensively with the cabinet housing.
- Create permanent connections of the metal parts. Perform screw connections on painted and anodized metal parts either by means of special contact discs or permanently remove the insulating protective layer between the parts.
- Do not use any aluminium parts if possible (danger of oxidation).

Filter

- Filter must usually be mounted directly at the place where the line to be filtered enters the cabinet.
- Specific filters such as e.g. the SIMODRIVE filter module or the STEPDRIVE filter must be placed, mounted and connected according to the manufacturers' documentation.
- Filters must be fastened in such a way that they lie flat and have a good, durable, conductive connection to the cabinet housing (assembly plate).
- The lines running to the filters must be separated from the lines exiting the filters. Filtered lines must be run separately from unfiltered lines.

Cable running

- Route the signal-/data lines spatially separated from the power current-/power supply lines (avoid coupling routes). Minimum distance in the control cabinet: 20 cm. Use an earthed separating plate, if necessary.
- Twist unshielded lines of the same circuit (forward and return conductor) if possible or minimize the distance between the forward and return conductor.
- Route the lines as close as possible to metallic housing parts (e.g. assembly plate, supporting beams, metal rails).
- Route signal lines and the appropriate potential compensation line as close as possible to each another.
- Never route signal lines on devices which produce strong magnetic fields. (e.g. motors, transformers).
- If possible, insert the signal/data lines at only one level (e.g. only from below) into the cabinet.

- Avoid unnecessary line lengths (also with spare lines).
- Signal lines in particular nominal and actual value lines should be routed without breaks. Ensure continuous shielding at the dividing points.

Fastening the line shields

- Earth the shields of the data lines, analog signal lines and power lines on both sides extensively and well conducting.
- Line shields should be inserted directly after the entry of the line into the cabinet onto a shield bus and routed up to the component. The shield contact is ensured by screwing the plug to the component housing via the product-specific, ready-made lines.
- Only metallic or metallized plug housings must be used for shielded lines.

Remedy of possible interference sources

- The coils of contactors, relays, solenoid valves and other inductors in the cabinet, also perhaps in adjacent environment must be wired. Wiring is performed, for example with RC elements, varistors, etc., directly on the respective coil.
- Use light bulbs as possible for the lighting of cabinets. Avoid the use of fluorescent lamps.

Uniform system reference potential

- If system components are housed in different cabinets, then they must be connected via e.g. an equipotential bonding conductor.
- Adequately-sized equipotential bonding lines must be used against potential differences between system parts.

Measures against the effects of lightning strikes

Measures must be taken in buildings, rooms and electrical devices for the protection of the electrical appliances against overvoltage, caused by lightning strikes. Therefore we recommend you to contact your Siemens office or the relevant specialist firms.

Handling of components susceptible to electrostatic damage

- Wear an electrostatic wristband when working with components susceptible to suffering damage due to electrostatic discharge.
- Use storage surfaces suitable for electrostatically damageable components and packaging made of electrostatically safe materials, e.g. uncoated cardboard boxes.
- See also Chapter 9.

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3 Interference Spreading

Electromagnetic interference sizes have only an effect on a control or system when the following three components are available:

- Interference source
- Coupling path
- Interference sink

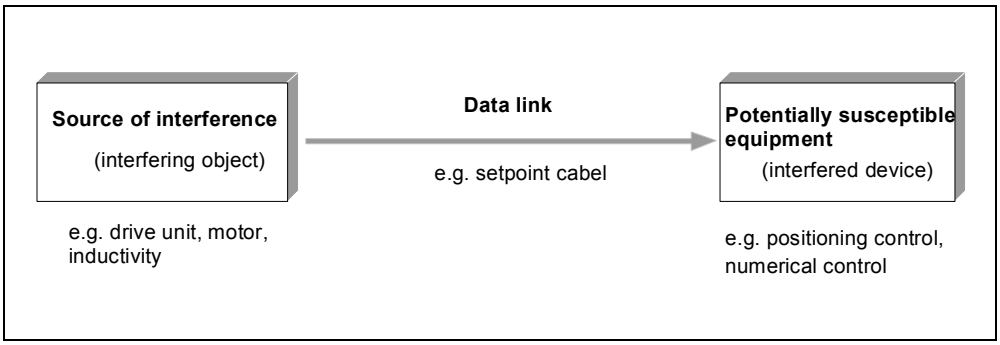


Fig. 3-1 Electromagnetic environment

3.1 Interference sources

The initiator of the interference is described as the interference source. The noise levels generated by the interference sources or their effects must be eliminated or at least dampened by appropriate measures.

Table 3-1 Typical interference sources and their effects on interference sinks

Interference source	**Interference generated by…**	**Effect**
Switched inductors such as e.g. contactors, relays, electronic valves	- Contacts - Coils	- System disturbances - Electromagnetic fields - Magnetic fields
Electrical motors	- Collectors - Coils	- Electromagnetic fields - Magnetic fields
Sparking machines such as e. g. electrical welding equipment, electrical discharge machines	- Contacts - Transformers	- Electromagnetic fields - System disturbances - Compensating currents - Magnetic fields
Power supply units	- Circuits - Switching components	- Electromagnetic fields - System disturbances
High-frequency appliances	- Circuits	- Electromagnetic fields
Transmitters	- Antennas	- Electromagnetic fields
Earth or reference potential differences	- Voltage differences	- Compensating currents
Operator	- Discharges of static electricity	- Electrical discharge currents - Electrical fields
Power lines	- Current flows - Fuse cases	- Power break-ins, power overvoltages - Electrical and magnetic fields
Transmission lines	- Voltage differences - Corona discharges	- Electromagnetic fields - Electrical fields
Current converters, power electronics	- Circuits	- Overvoltages - Compensating currents

3.2 Interference sinks

An interference sink is an electrical device, whose function can be influenced by interference sizes.

Table 3-2 Typical interference sinks and their reaction on interferences

Interference sinks	**are sensitive against…**	**Reaction**
Microprocessor-controlled systems, bus systems	Pulse-shaped noise levels (e.g. switching operations) and electromagnetic fields	Sporadic processor shutdown, transmission errors
Analog circuits	Low-frequency noise levels (e.g. potential differences)	Superimposition of the effective signal on the noise level (e.g. 50 Hz hum on setpoint)
Electron beam monitors	low-frequency magnetic fields (> 1.5 A/m)	Flickering screen or image, colour distortion
Telephones	Mains second harmonics	Whistling is audible
Fax machines, power supply units	Mains second harmonics	Fuse case or defect in the power supply unit, whistling is audible

3.3 Coupling paths

The coupling path is the transmission path for the noise levels generated by an interference source. Through them, the noise levels can spread from the interference source to the interference sink. Different coupling mechanisms exist for the interference coupling:

Table 3-3 Coupling mechanisms and their typical interference sources

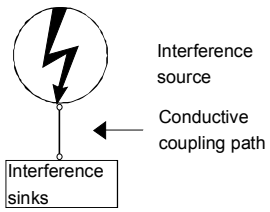
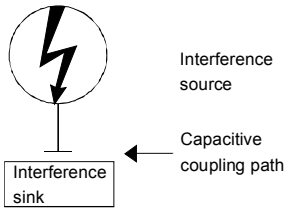
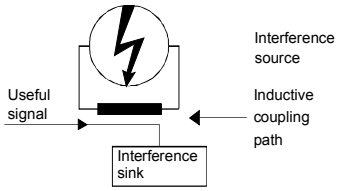
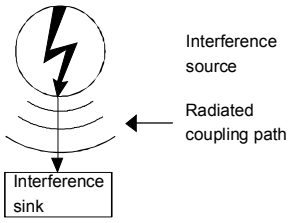
Coupling mechanism		Interference sources
Galvanic coupling 	Galvanic or metallic coupling always occurs when two circuits jointly use a conductor (e.g. joint earth line).	• Cycled appliances (mains influence by converter and external power supply units) • Starting motors • Different potential of component housings with common power supply
Capacitive coupling 	Capacitive or electrical coupling occurs between mutually insulated conductors which are on a different potential.	• Interference coupling by parallel running line • Static discharge of the operator • Contactors
Inductive coupling 	Inductive or magnetic coupling occurs between conductor loops of those at least one is live. The magnetic flows linked with the currents induce interference voltages.	• Transformers, motors, electrical welding equipment • Parallel running power line • Lines with switched currents • Signal line with high frequency • Non-switched solenoids
Radiation coupling 	Radiation coupling is present if an electromagnetic wave hits a line formation. The hit of the electromagnetic wave induces currents and voltages.	• Adjacent transmitter (e.g. walkie-talkies) • Spark paths (spark plugs, collectors of electric motors, welding equipment)

Table 3-4 Examples for coupling paths

Coupling path	Cause
Lines	• Incorrect or inappropriate laying • Missing or incorrectly connected shield • Inappropriate spatial arrangement of the lines (incl. equipotential bonding line) • Unsuitable lines
Control cabinet or housing of the controls	• Missing or incorrectly wired compensation line • Missing or incorrect earthing • Inappropriate spatial arrangement • Components not mounted securely • Unfavourable cabinet structure

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4 Equipotential Bonding

Note

Equipotential bonding must not be confused with protection against electric shock by means of a protective line system. This protective measure must be performed according to the appropriate standards and guidelines and is not a constituent part of these EMC Guidelines.

Why is equipotential bonding necessary?

Basic principle:
Control components between which a signal connection exists also require a potential connection. System malfunctions of the electrical components are prevented by equipotential bonding between the electrical components among each other and the earth.

Where is equipotential bonding required?

a) Between all control components which are also interconnected to each other via signals.
b) Between control components and the central earthing bar.

Note

The central earthing bar is a bus bar for all earth, equipotential bonding and protective conductors of a control cabinet. The external protective conductor or the building earthing system is also connected to this bus.

Exception:
A potential connection is not necessary for control components with potential-free signal transmission (e. g. via light wave conductor), in many cases it is also not permissible.

No direct potential connection line is required (applicable to all digital signal transmissions between the central appliance and the cabinet external components) for control components, for which the signal transmission is conditionally potential-free, i.e. it is only potential-free up to a certain voltage level. Here a short potential connection to the respective earth (reference potential) is sufficient.

4.1 Equipotential bonding in built-in cabinets

Equipotential bonding via meshing

The equipotential bonding between the individual control components among each other and the central earthing bar within a metallic housing (cabinet) should preferably be performed by meshing.

Meshing is understood to mean the conducting connection of several components, whereby a direct conducting connection exists between all components. (See Section 4.2, Fig. 4-1).

Points to bear in mind:

- Components with metal housings must be bolted onto the cabinet housing (assembly plate). Ensure an large-surface conducting connection.

Note

This direct galvanized connection of the metal housing to the cabinet rear via the component fastening bolts is only possible if the terminal at the control components (designation: ⏚ or ⏚) for the equipotential bonding line has a large-surface galvanic connection with the fastening bearing surface of the components.

In the event that the control components have an insulated housing fastening or the fastening facing consists of metallized (galvanized) plastics, the connection between the equipotential bonding terminal of the component and the cabinet housing must be provided $\geq$ via a short equipotential bonding line 10 mm^2 Cu (see Section 4.2 Fig. 4-1, component 3).

- The connection between the central earthing bar and the cabinet housing must be low-resistance, short and with a large surface area.
- All contact surfaces for earth connections must be metallically bare. It is absolutely essential to remove the oxide and colour coat permanently.
- The corrosion resistance of the earth connections must be ensured, particularly in respect of contact corrosion and resistance against external influences.

Equipotential bonding by equipotential bonding lines

If no meshed connection is possible via the cabinet housing between control components and the central earthing bar (e.g. because of a control cabinet with an insulated rear panel), the equipotential bonding can also be provided between components and the central earthing bar by means of equipotential bonding lines (see Section 4.2, Fig. 4-2).

Points to bear in mind:

- Create the potential connections in a star shape. The neutral point of the equipotential bonding lines may be:
  - central earthing bar or
  - separate equipotential bonding bus (see Section 4.2, Fig. 4-2).
- Equipotential bonding lines of power components such as drives, machines, load power supply units, relay adjusting parts, etc., are basically connected to the central earthing bar. A jointly equipotential bonding line for power and non-power components may not be used.
- If the equipotential bonding is performed on power parts with analog regulation by means of the equipotential bonding lines, then:
  - The electronic earth must be connected only with the NC equipotential bonding terminal.
  - The SL terminal must be connected to the central earthing bar.
- The line lengths of the equipotential bonding lines must be as short as possible.
- Cross-section of the equipotential bonding lines $\geq 10mm^2$ Cu.

4.2 Equipotential bonding of external components

Control components in different cabinets

If the control cabinets (e.g. control panel, DMP modules) are not housed in the same cabinet as the associated central device, then the potentials of the cabinets or the respective central earthing bars must be interconnected:

a) Through a good conducting screw connection of the cabinet housing with each other or, if this is not possible
b) Through connection of the respective central earthing bars by means of an equipotential bonding conductor.

Points to bear in mind:

- Cross-section of the equipotential bonding lines ≥ 10mm^2 Cu.
- The distance between the equipotential bonding line and signal connection lines must be as short as possible (bundle the lines).

Equipotential bonding by meshing via the rear panel of the cabinet

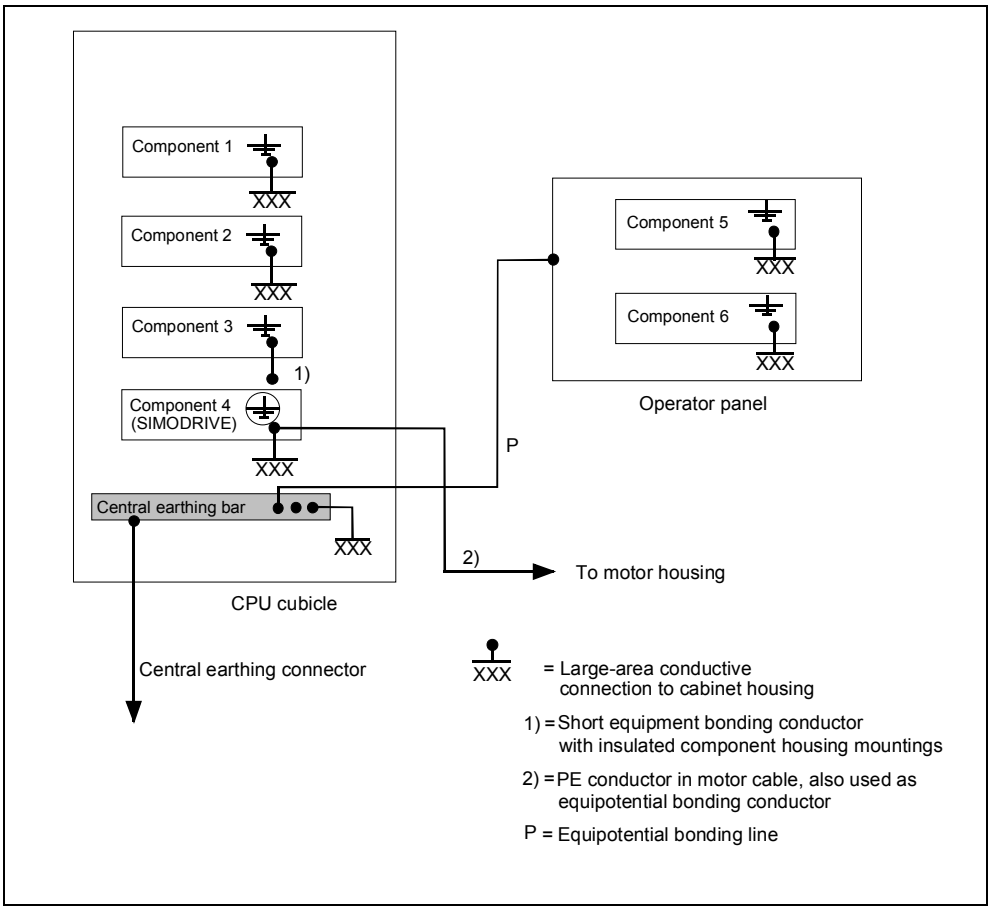

Fig. 4-1 Equipotential bonding by meshing

Equipotential bonding by means of equipotential bonding lines

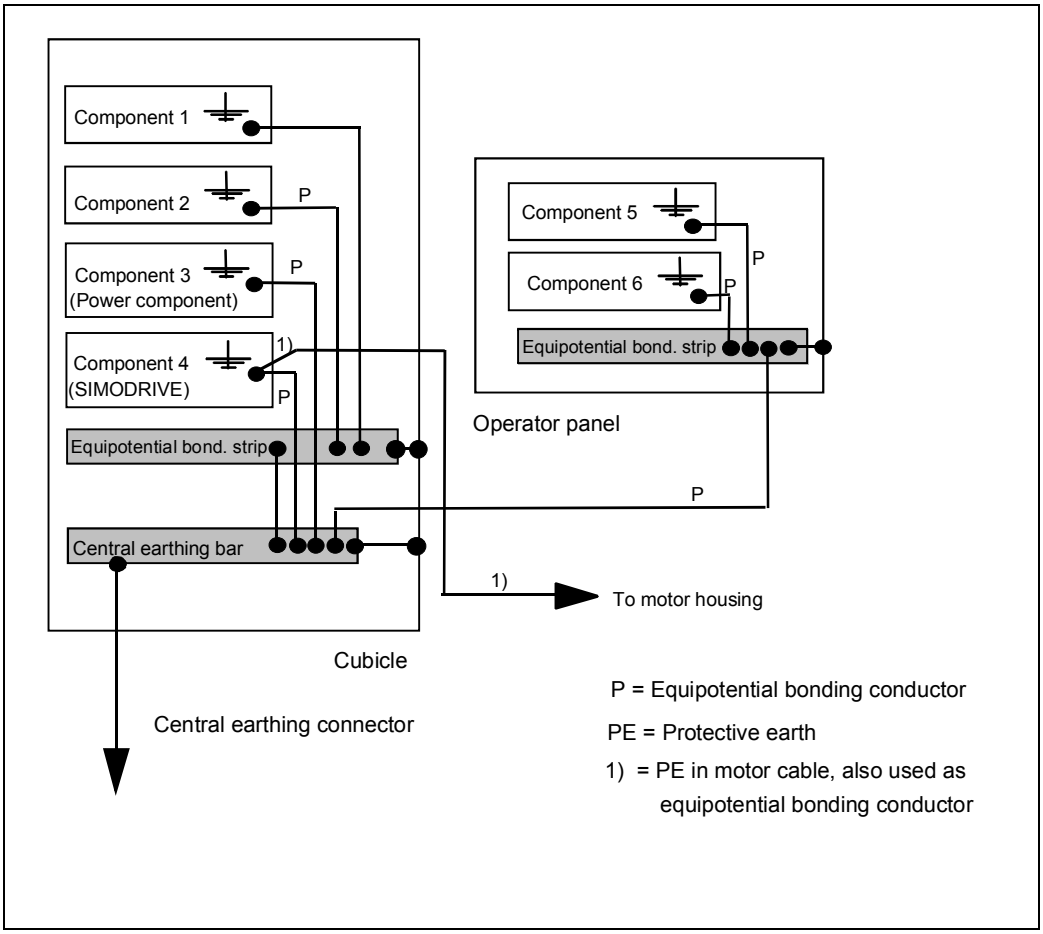

Fig. 4-2 Equipotential bonding by means of equipotential bonding lines

Arrangement:
The distance between the signal lines (forward and return conductor) or between signal lines and the appropriate equipotential bonding lines must be as short as possible (bundle the lines!). The interference surface between the lines must be kept as small as possible.

Cross-section:
Cross-section of the equipotential bonding lines ≥ 10mm^2 Cu.

Grouping:
With an insulated component structure or when connecting equipotential bonding lines of cabinet external components, the equipotential bonding lines must be arranged separately from the power components and signal-sensitive components. The equipotential bonding lines must be arranged in groups.

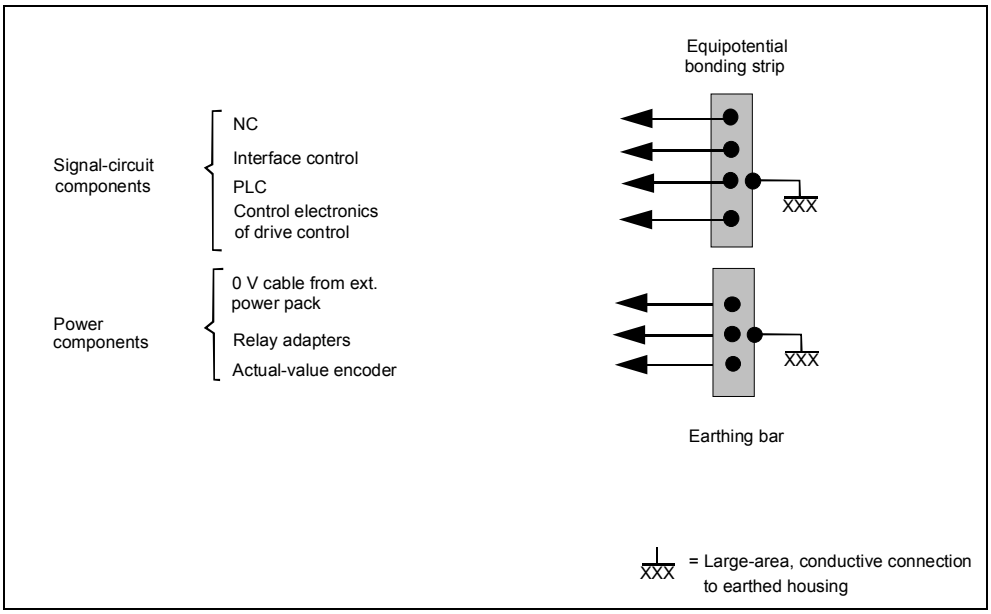

Fig. 4-3 Arrangement of equipotential bonding lines in groups

4.3 Examples of equipotential bonding

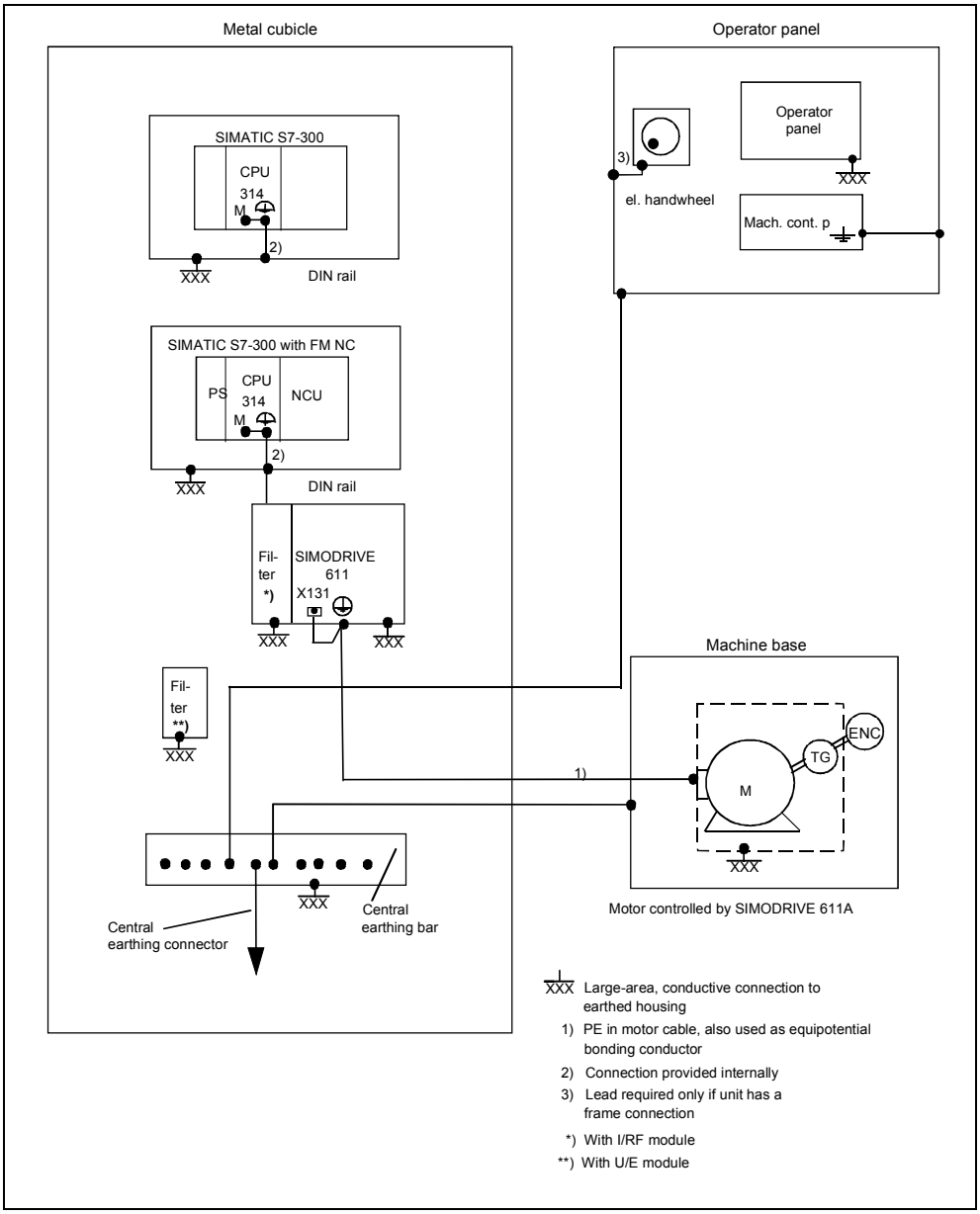

Fig. 4-4 Equipotential bonding in the SINUMERIK FM NC with SIMODRIVE 611

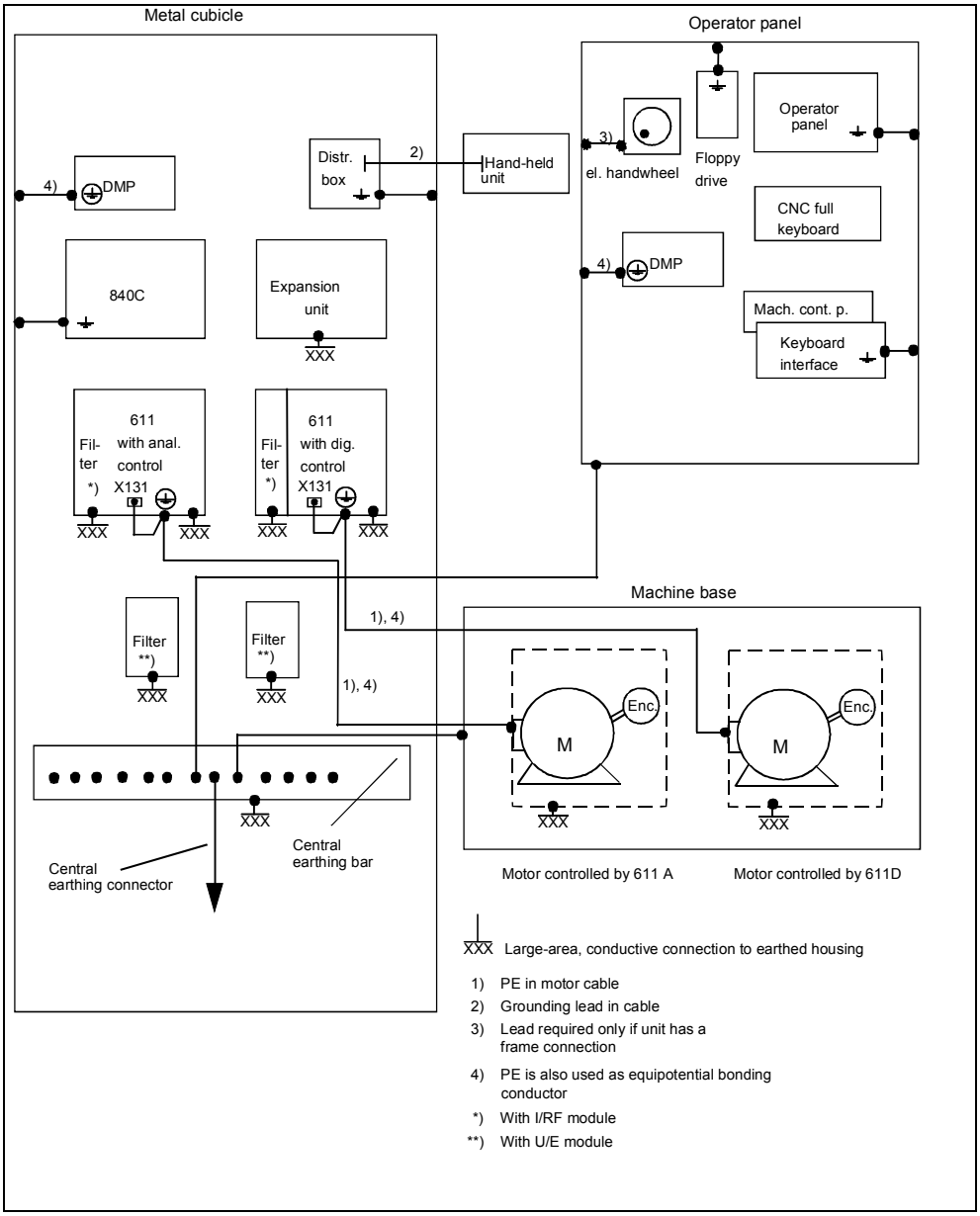

Fig. 4-5 Equipotential bonding in the SINUMERIK 840C with SIMODRIVE 611

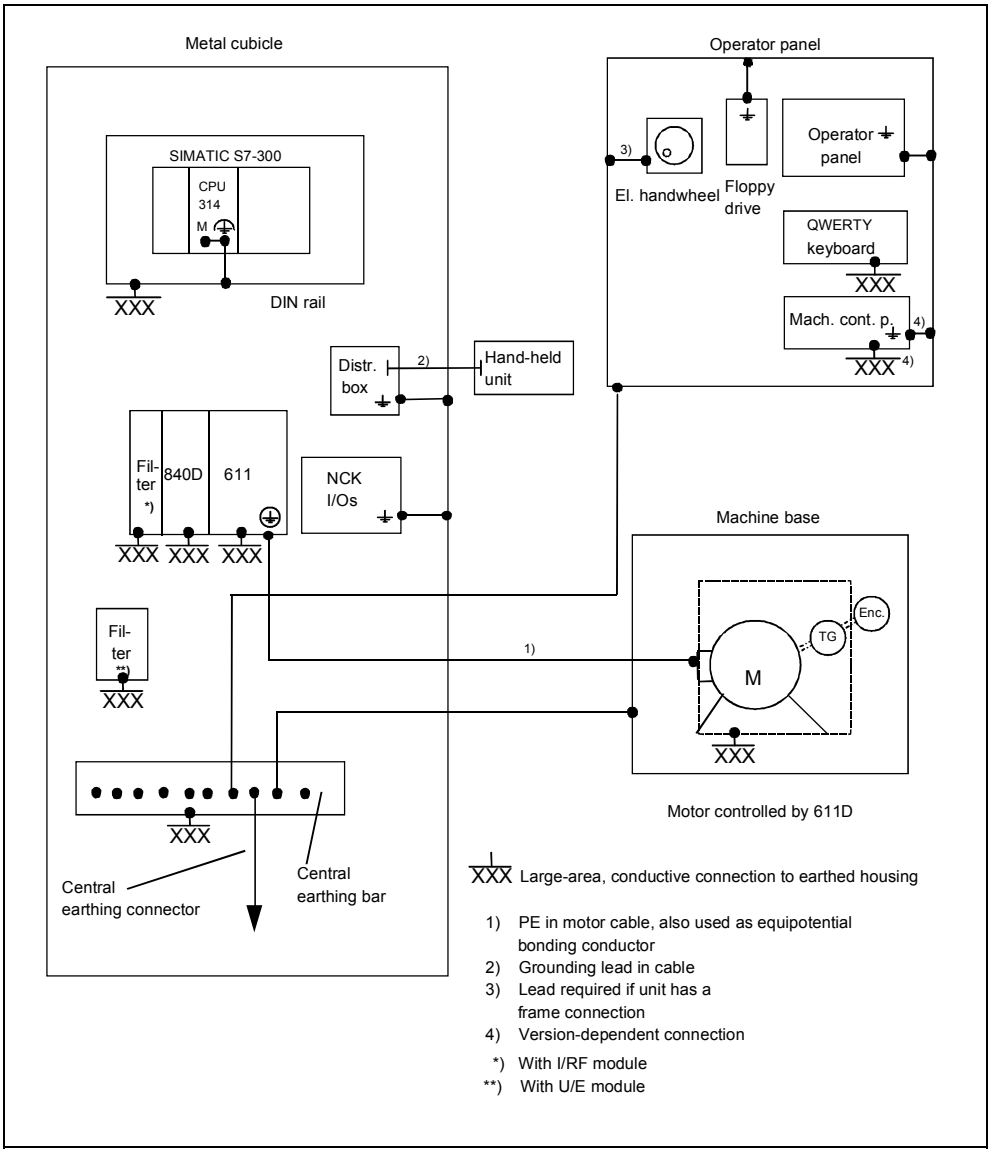

Fig. 4-6 Equipotential bonding in the SINUMERIK 840D with SIMODRIVE 611

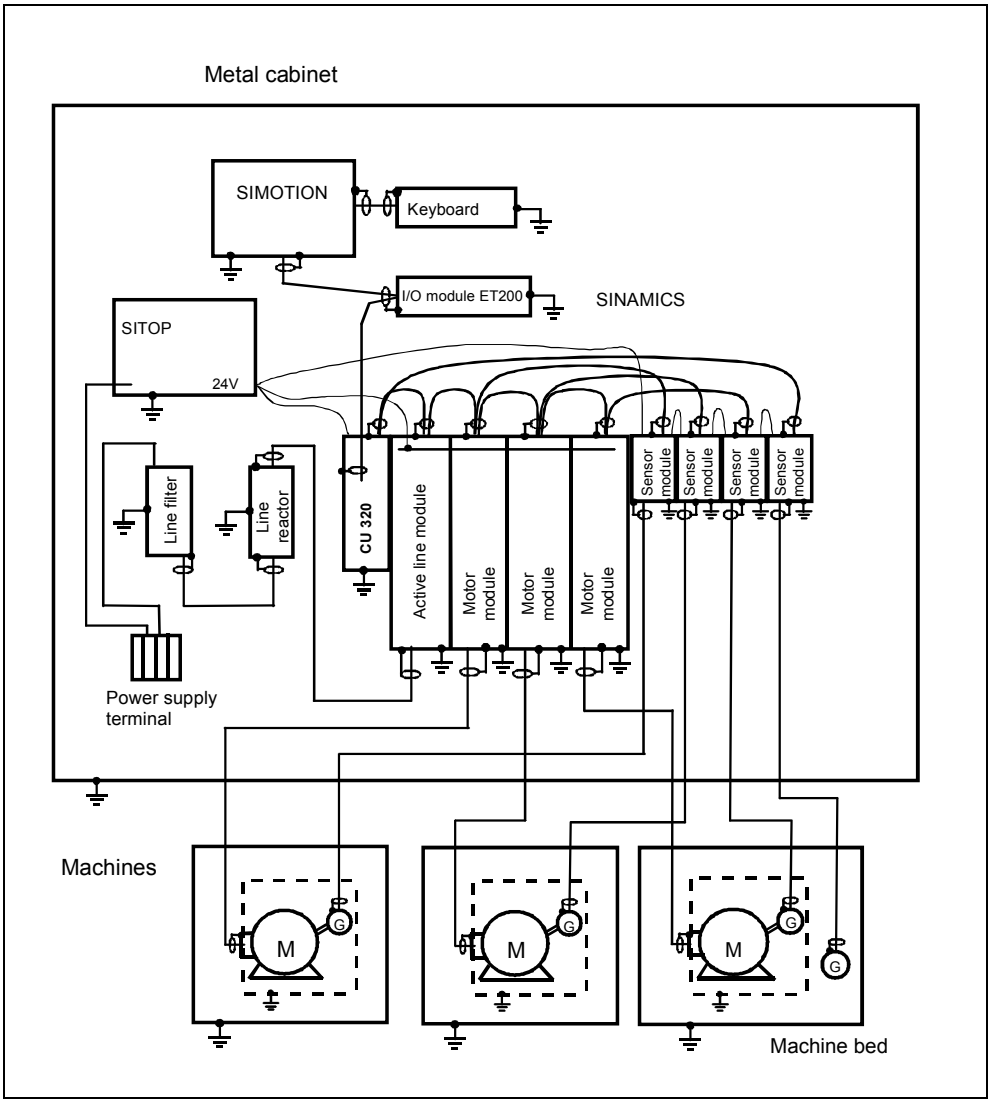

Fig. 4-7 Equipotential bonding in the SIMOTION P350 and SINAMICS

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5 Control Cabinet Structure

5.1 Design and assembly of the cabinet

5.1.1 Earthing of control cabinet components

The following measures improve the shielding effect of a control cabinet:

- Connect all metallic parts of the control cabinet flat and with good conduction between each other.
- Cabinet covers as side plates, rear panels, roof and bottom plates should be contacted with a sufficiently small distance.
- Side, rear panel, assembly and roof plates must be connected extensively to the cabinet framework.
- The mounting angle for the component holders must have a large surface-area metal-metal-connection to the cabinet framework.
- All screw connections on painted and anodized metal parts must either be executed by means of special contact discs or the insulating protective layers between the parts must be removed before assembly.
- If protective layers are extensively removed for a good metal-to-metal connection, then long-term corrosion protection (e. g. contact grease) must be ensured by taking additional measures.
- The material of the parts to be connected including the connection elements (screws, toothed washers, rivets, etc.) should lie close together in the electrochemical voltage series.

5.1.2 Breakdowns in the control cabinet wall

The shielding effect of the control cabinet is impaired by the attachment of ventiducts, installation of inspection windows and operating devices.

Warning

If an opening in the control cabinet wall reaches the size of the half wavelength of the interference signal, then the shielding effect is practically neutralized, since the breakdown can act as an antenna.

Example: Interference signal = 500 MHz ⇒ ½ wavelength = 30 cm
Interference signal = 1000 MHz ⇒ ½ wavelength = 15 cm

Ventilation slots

If ventilation openings are integrated into the control cabinet, then offset boreholes or HF grids are basically better than slots, since slots conduct high-frequency signals into the interior of the control cabinet.

Many small boreholes are more favourable than few large boreholes.

Operating devices

When installing operating devices and control panels, pay particular attention to good all-round contact with metallic assembly frames by tightening the fastening elements with the torques indicated in the product documentation.

Bushings

The best way of ensuring the earthing of shields are bushings which have good all-round contact with the shield and connect the housing (cabinet wall) with HF-tightness. This measure also prevents the interference fields from arising in the cabinet and being emitted outwards via the shielded line. For this reason, the external shield at the cabinet inlet must be connected to the cabinet housing at all shielded lines with an extensive and good conduction.

With coated cabinet housings (e.g. painted or powder-coated), the insulating protective layer must be removed around the breakdown to ensure a perfect contact with the bushing. Contact corrosion can be avoided by the selection of suitable metals.

The connection of the shielding braid at the lead-through and/or at the plug should be done in accordance with the assembly guidelines of the lead-through or plug manufacturer. The correct connection of the shield is essential for the EMC quality of the entire system.

EMC control cabinets from Siemens

The Siemens department A&D offers EMC executions of control cabinets. These cabinets have a shield damping of approx. 60 dB, over a frequency range of 10 kHz to 1 GHz.

More detailed information on these EMC cabinets can be found in catalogue NV 21.

Note

At this point, we would like to point out that the expenditure to increase the shield effect of a cabinet at a later date far exceeds the purchase cost of a new EMC cabinet.

5.2 Assembly of the components in the control cabinet

Basically, the following applies:

- The effect of the interference size decreases with an increasing distance between interference source and interference sink.
- An additional decrease of the interferences can be achieved by the installation of earthed shielding plates.
- All components must be connected extensively and with good conduction to each other.

Modules

When installing the components (assemblies, modules, circuitboards etc.), ensure that these are firmly connected with the support bar (module assembly frame, etc.), to ensure the correct functioning of the assembly. The recommended torque must be observed for the fastening bolts.

Control panels with monitors

It must be ensured that no lines or devices with solenoids are arranged next to the monitors which generate strong magnetic fields, e.g. power lines, contactors, relays, solenoid valves, transformers, etc.

Power and control components

Power components (transformers, driving appliances, load power supply units, etc.) should basically be arranged separately from the control components (relay control parts, digital controls, programmable controls, e.g. SIMATIC etc.). This does not apply, however, to power components which are provided by the manufacturer already for the common structure (e.g. SIMODRIVE 611 and SINUMERIK 840D).

The metal housing of all components, particularly the housing of converters and the appropriate filter modules must be connected at a low resistance to the control cabinet for high-frequency interference currents. The modules are to be mounted for this ideally on a conductive blank metal plate and must be connected extensively to it. Painted control cabinet walls as well as hat bars or similar assembly aids with a small contact surface do not meet these requirements.

SINUMERIK FM components are attached to the assembly bar of the SIMATIC system S7-300. This assembly bar must be connected via extensive conduction to the control cabinet.

Filter modules for converters

Filter modules are necessary for compliance with the EMC thresholds. They reduce the coupling of device-internal interferences of the converters to the power line. These filter modules are functionally mounted directly adjacent to the feed/feedback module (see following figure). Optionally, assembly in direct proximity to the control cabinet mains feed is also possible.

Filter modules from A&D are suitable only for the interference suppression of A&D converters.

Additional mains filter

If an additional mains filter is to be used for further users in the control cabinet (see Planning guide Converter), the following must be observed:

- Attach the main filter in proximity to the cabinet feed.
- Connect the mains filter via extensive conduction to the cabinet housing.

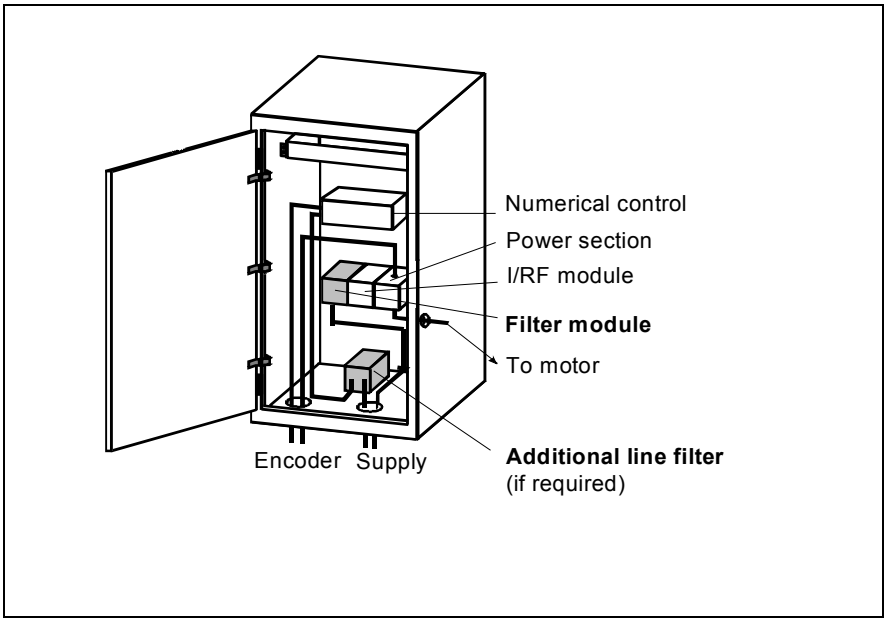


Fig. 5-1 Example for a filter module and mains filter assembly (diagrammatic sketch)

Shield buses

The shield bus must be connected extensively to the supporting beams for putting on the line shields.

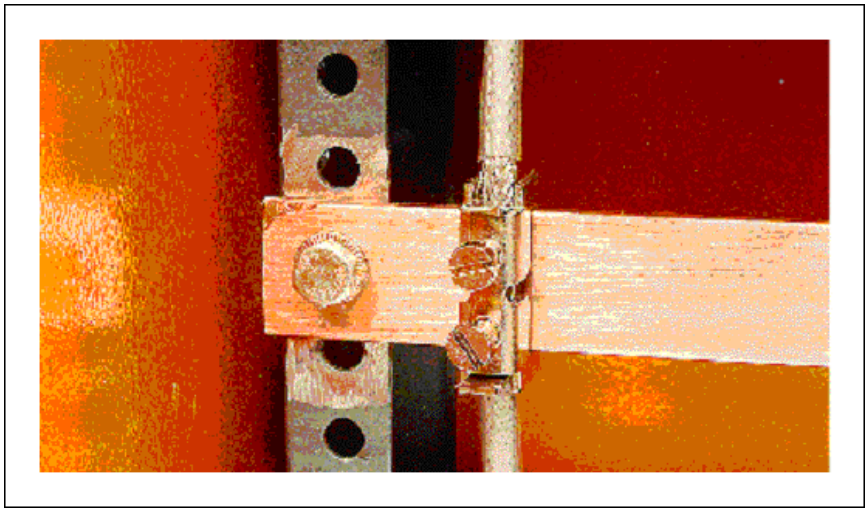


Fig. 5-3 Example: Assembly of the shield bus

Central earthing bar/conductor bar

The central earthing bar or conductor bar must be connected extensively with the supporting beams (metal-to-metal connection) and must be in direct proximity to the cable duct. Beside the central earthing bar must be connected with a line to the conductor system (earthing). Only in this way can error and interference currents that arise be discharged securely.

5.3 Wiring, shielding and earthing

Wiring in groups

Power and signal lines must basically be routed separately. The different lines are divided for this functionally into line groups. The lines of a group can be united in common bundles and the different groups can be connected to each other with the necessary distance (see chapter “cable running and shielding”).

Basic rules for cable running

Power lines must be inserted into the cabinet at the opposite side of the signal lines (24 volts control signals, data lines and analog signals). They should be routed in metal ducts separately from the signal lines.

- Route the control circuits for contactors (AC 230 V) separately from the signal lines if possible.
- Conduct the lines close to the cabinet earth if possible.
- Related lines (forward and return conductor) must be routed together within the cabinet.
- For more detailed information, see the chapter “Wiring and Shielding”.

Basic rules for shielding

- The shield contacting must be performed immediately with the line entry into the cabinet housing if the product-specific documentation does not prescribe a different procedure.
- Special shield buses should be provided for the impedance-poor shield contacting.
- The cable clamp must enclose the shielding braid extensively and contact it to achieve a good conductive connection of the shield to the cabinet earth.
- Do not break the shields.
- For further information, see the chapter “Cable running and shielding”.

■

Notes

6 Wiring and Shielding

Ensure maximum spatial separation between signal and power lines. If sufficient spatial separation is not possible, then shielded lines must be routed in shielded, earthed, metallic cable ducts.

6.1 Cable running

Basic requirements

All lines within the control cabinet must basically be routed as close as possible along metallic housing parts (e.g. control cabinet walls, assembly plates, supporting bars, metal bars). Long routing through the free space can lead to interference couplings (antenna effect).

Requirements for line routing

- Signal and power lines may cross at right angles, but they may never run parallel closely side by side.
- Signal/data lines are to be routed spatially separated from power lines and power supply lines (avoid coupling paths). Minimum distance in the control cabinet: 20 cm. Use an earthed baffle, if necessary.
- Twist unshielded lines of the same circuit (forward and return conductor) if possible or minimize the distance between the forward and return conductor.
- Route signal lines and the appropriate equipotential bonding line as close as possible to one another.
- Signal lines may never be routed through devices which generate strong magnetic fields (e.g. motors, transformers).
- Insert the signal/data lines possibly into the cabinet at only one level (e.g. only from below).
- Avoid unnecessary line lengths (also with spare lines).
- Signal lines, particularly nominal and actual value lines should be routed without breaks. Ensure continuous shielding at the dividing points.
- Ensure a continuous shield connection at the line dividing points of shielded lines.
- Pulse-loaded high-current/high-voltage lines must basically be routed completely separately from all other lines.
- Route the lines on metallic cable bearers.
- Interconnect abutting joints of the cable bearers galvanically.
- Earth the cable bearer.
- Provide lightning protection (internal and external lightning protection) and earthing measures as far as they are applicable to the application case.

Requirements for the line length

- Avoid unnecessary line lengths. Thus coupling capacities and coupling inductivities are kept small.
- Spare lines should be as short as possible.
- Cores of spare lines should at least be put at one line end on a potential, and should preferably be earthed.

Additional requirements

- Basically the ready-made original lines recommended by the manufacturer should be used. Thereby the maximum line length must be adhered to for the respective purpose. Indications of the line length can be found in the product catalogue or in the product-specific documentation. These line lengths refer to the original lines of the manufacturer.
- The lines and plugs must be protected against mechanical damage, e.g. by cable ducts or coverings.
- The penetration of oil, refrigerant or chips into plug-in connections must be prevented.
- The plugs must be attached firmly to the components.
- Use special lines for cable installations which are suitable for this purpose.

6.2 Shielding

6.2.1 Introduction

Shielding of areas

Shielding is understood to mean the measures which decouple two areas in respect of radiation-related sizes. With these measures, the shield effect of the control cabinets, the metallic cable ducts, the plug housings and the line/shielding braid should be considered. The shielding is also used, together with filtration, for the interference-free operation of the system.

What is also required?
The prerequisite for an optimal shielding is a good conductive connection of the shield ends to the cabinet earth or shield bus.

How does the most simple measurement look?
The fundamental recommendation is the use of product-specific original lines as standard, since the adherence of the EMC law and the EMC Guideline has been proven with it. Only the respectively indicated plug types are permitted.

Basically, the standard lines and the lines in combination with the product components possess the necessary shield connection. The connection from shield to housing is executed on both line ends via the plug, with few exceptions. The double-sided shield connection to the earth offers the best shield effect. Special additional measures can be obtained from Chapter 10 of the product-specific documentation.

When is simple shielding sufficient?
In most industrial plants, simple-shielded lines are sufficient for the reliability of the plant. The double-sided connection of the shield to the earth is thereby the most effective shielding measure.

When is double shielding necessary?
Double shielding is advantageous for signal transmission in a particularly interference-prone environment.

Shield bus

The earth bar or if additionally available the equipotential bonding bus, may be used as shield bus. The earth bar is available for protective earthing and the equipotential bonding bus for functional earthing. It is also possible to provide only one earthing bar, which simultaneously serves as the equipotential bonding bus.

Cable intercept bus
The cable intercept bus is necessary for the strain relief of the cables and lines. In the following picture, two possible forms of strain relief can be seen.

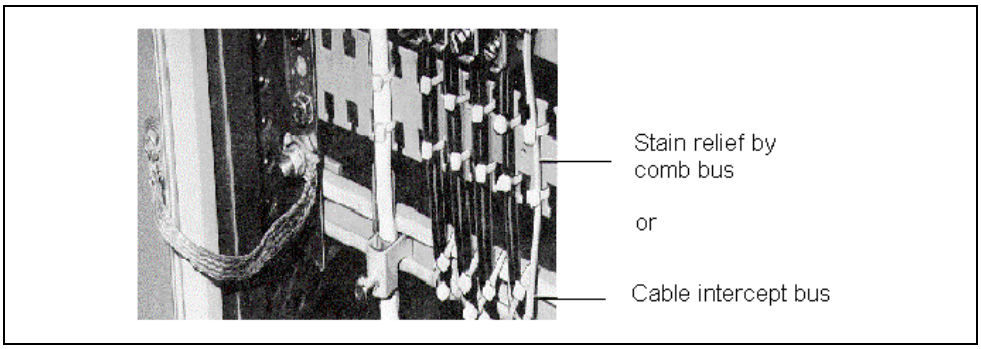


Fig. 6-1 Strain relief by comb bus and cable intercept bus

Connection of the shield
The shield should be placed directly after the entry of the line into the cabinet onto a shield bus and additionally routed up to the assembly. Screwing the plug to the component housing via the product-specific, ready-made lines ensures the shield contact.

Fastening of the shielding braid
For the fastening of the shielding braid to the cabinet housing, cable clamps of metal are preferably to be used. The clamps must enclose the shield extensively and ensure a good contact.

6.2.2 Basic rules for the shield connection of simple shielded lines

Double-sided shield connection

The line shield must be connected basically at both ends via extensive conduction to the housing Only so the shield is also effective against high-frequency interferences.

If external devices are connected to the controls for service or commissioning purposes (printer, programming devices, PCs, etc.), their line shields must also have a double-sided shield connection. It must be calculated with interference couplings with a single-sided shield connection.

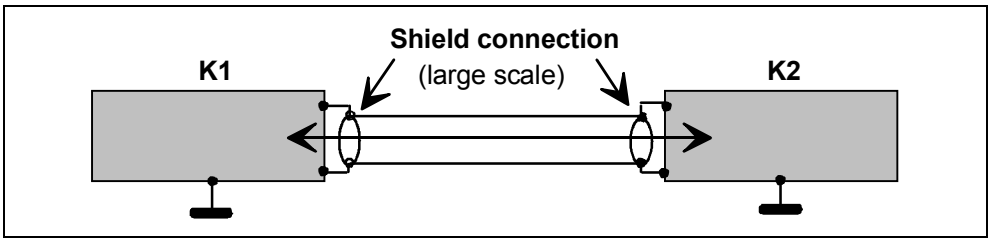


Fig. 6-2 Double-sided shield connection

Single-sided shield connection (special case)

The single-sided shield connection must be applied only for special cases (e.g. only analog systems without digital technology):

- Single-sided connected line shields effect exclusively electrostatically against low-frequency capacitive couplings and emissions.
- At interferences due to external earth potential differences , despite an existing equipotential bonding line between the components to be connected (e.g. between the actual value transmitter and the testing circuit assembly), it may be necessary in individual cases to connect the shield only on oneside with the housing earth. For the improvement of the shield effect, the open shield side can be connected in this case capacitively with the housing earth.

Shield connection with single-sided shield connection

- The shield must be linked at the side at which the electronic reference earth is connected to the device housing.
- If both devices are potential-free, attach the shield on the receiver side.
- If this housing connection exist on both devices, then a double-sided shield connection is necessary.

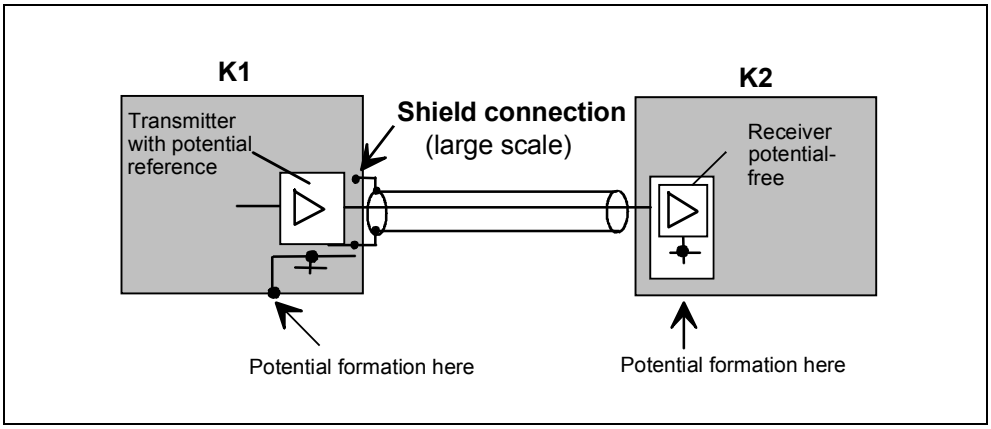


Fig. 6-3 One-sided connected shield with transmitter sided potential formation

6.2.3 Shielding measures with power lines

Shield connection – control side

All line shields must be inserted in relation to the control extensively and as close as possible to the respective terminal. For components which do not have any special shield connection, the contacting must be performed by means of pipe clamp or indentation bars on the blank assembly wall of the control cabinet. In any case, it must be ensured that the free line between the shield connection point and the terminal is as short as possible.

For the contacting of the shield of the shielded lines, shield connection plates are generally available with prepared clamp contacting and assembly points for brake clamps.

Shield connection – motor side

If the motor is equipped with a brake, then the shield of the brake feed line must be applied to both sides with the shield of the power line.

If there is no shield connection possibility on the motor side, a screw connection must be attached in the terminal connection box with the possibility of an extensive link shield – motor housing.

Basically shielded execution

A metal channel with an electrically extensively contacting cover can also be used for the motor and mains supply line. Ensure a double-sided extensive link of the shield/cable duct to the appropriate components (converter module, motor).

Warning

Unused cores of power lines (e.g. brake cores) and their shields must be installed on at least one side to an earthed housing potential in order to discharge the loads arising due to capacitive overcoupling.

Negligence can result in the presence of hazardous contact voltages on the unearthed shields and cores.

6.2.4 Further conduction of the line shield at the interruption point

Intermediate plug

If shielded lines must be interrupted, the shield must be continued via the respective plug housing. Only plugs suitable for this (HF-tight version with good, durable contacting of the shields) should be used.

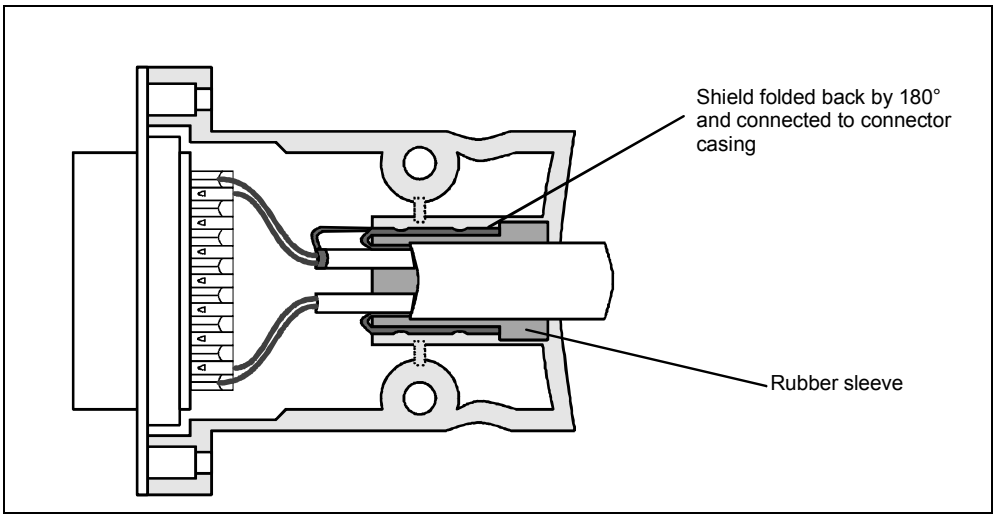


Fig. 6-4 Shield treatment in the plug housing

Terminals

Normally only suitable plugs and plug housings may be used with the interruption of the line shielding for the continuation of the shielding. If an interruption of the shielding and a twisting of the lines is absolutely necessary in exceptional cases, the line must be screwed extensively to a shield bus before and after the plug (terminal).

The following picture shows the principal structure of such an arrangement.

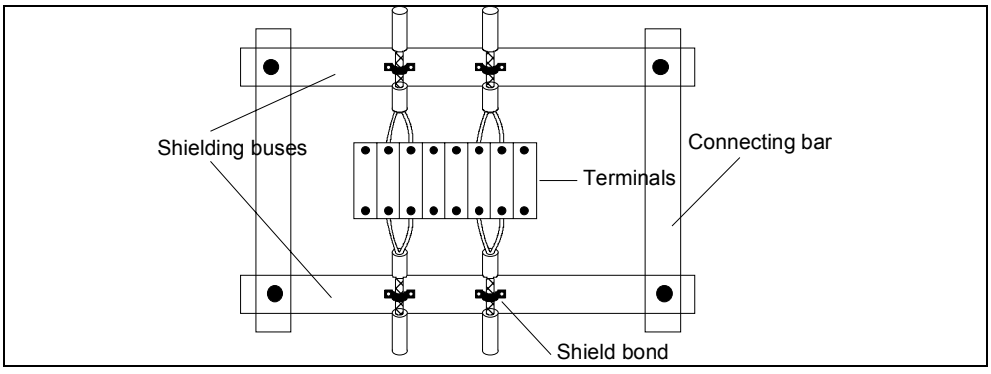


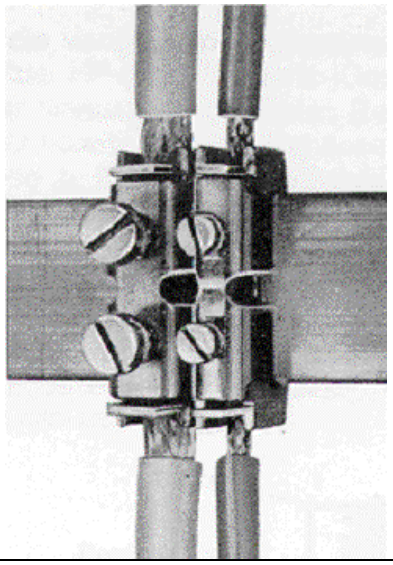
Fig. 6-5 Shield treatment with terminal strips

6.2.5 Example of shield connections

Optimal shield connection

The two following pictures show the shield connection directly to the equipotential bonding bus.

The figure shows the terminals of a copper bus. The maximum line diameter is 15 mm
Order No.: 8US1921-2AC00 (5 mm)
8US1921-2BC00 (10 mm)



The figure shows the rider terminals of a copper bus. The maximum line diameter is 10 mm.
Order No.: 8HS7104, 8HS7174, 8HS7164

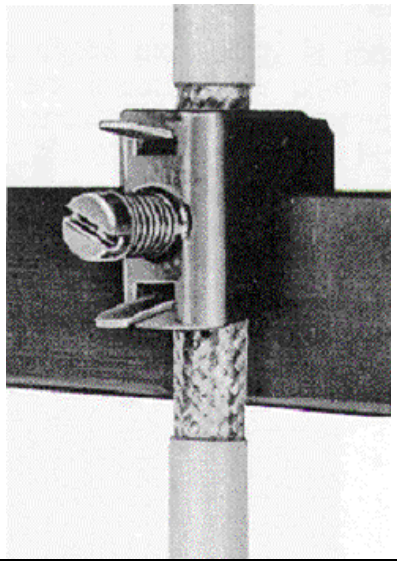


Fig. 6-6 Shield connection at the equipotential bonding bus

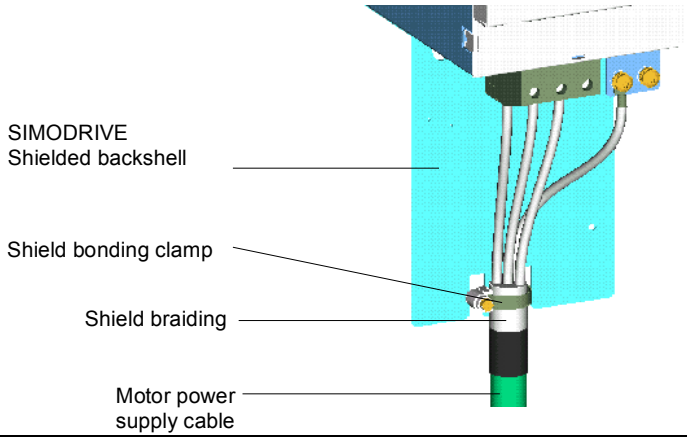


Fig. 6-7 Shield contacting by means of shield connection clamp at the shield connection plate

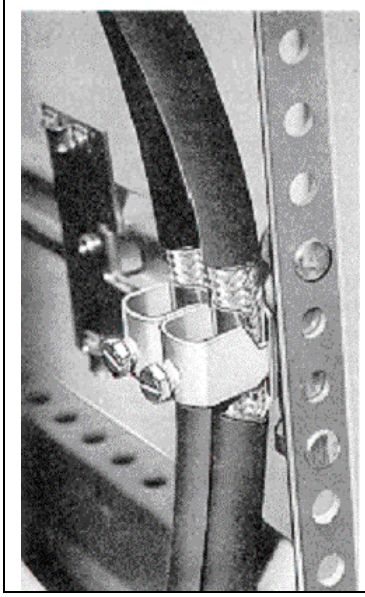
Caution

Danger of crushing with overtightening of the screws of the terminals (Order No. 8US1921-2AC00 and 8US1921-2BC00).

Good shield connection

If the line shield cannot be contacted directly with the equipotential bonding bus, a good shield connection can likewise be achieved by contacting the line shields with a cable intercept bus.

Line shield contacting by means of bracket.



Clamp and metallic counter-tub on a cable intercept bus.
Order No.: 5VC5540... and 5VC7641...

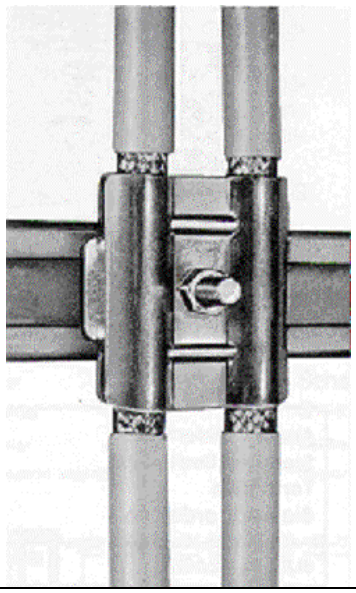
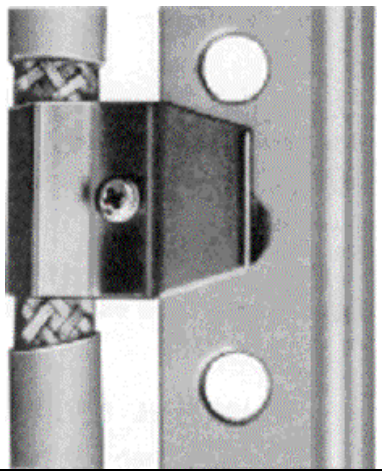


Fig. 6-8 Shield connection by means of clamps

Metallic hose clamps or cable ties on metallic blank comb/indentation bars.



Contacting by means of cable clamp.
Order No.: J48028

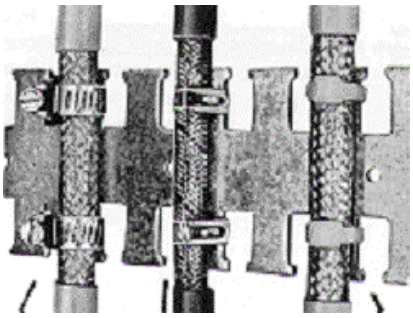


Fig. 6-9 Shield connection by means of hose and cable clamp

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Notes

7 Filtration

The filtration is a supplementary EMC measure for shielding and is used to decouple the grid-bound interference sizes. Because of this, the filters are inserted into the grid-bound transmission path between the interference source and interference sink. Filters reduce the grid-bound radio interferences and increase the noise immunity of electrical facilities without the disadvantageous influence of the transmission of the information signals.

7.1 Interference suppression of inductors

Inductive interference sources

Relays, contactors, valves, motor brakes, principally all solenoids (inductors), generate inductive voltages when shutting down and must be therefore radioshielded by wiring.

Induction voltages of 800 volts arise in 24 V coils and in 230 V coils several 1000 V can be adjacent to the switch when the coil is switched off.

Interference suppression by wiring

When using, for example, RC wirings the very high interference voltages of switched coils can be prevented. The wiring considerably reduces the interference voltage and thus also their decoupling in lines which are routed parallel to the coil line.

Notes

- On assemblies are only suitable for the wiring of the line inductivity. They do not replace the direct coil wiring.
- The coil wiring must be performed directly on the coil.

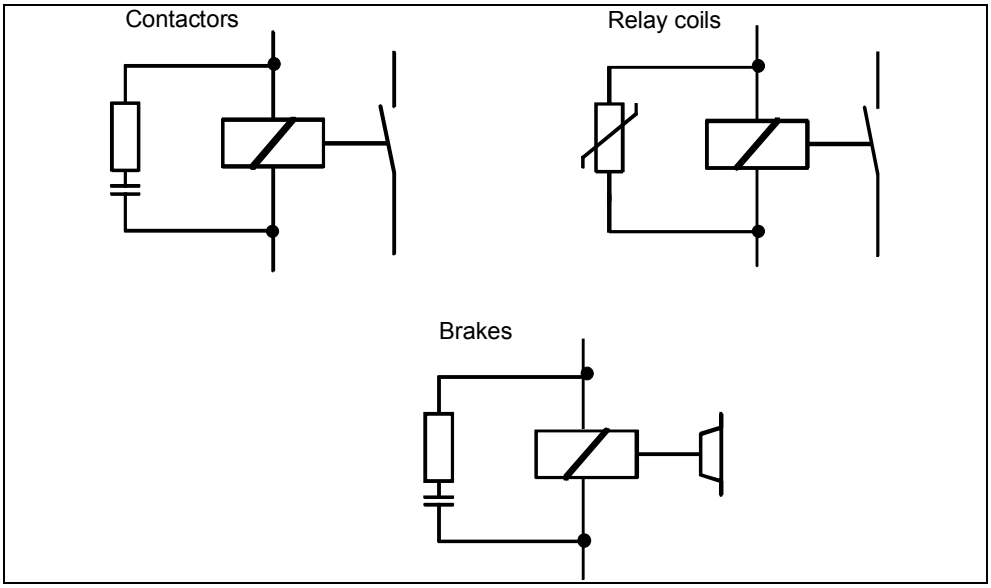

Fig. 7-1 Wiring measures for interference suppression

7.2 Filter

To adhere to the radio interference thresholds according to specialist basic standard EN 50081-2 or product standard EN 61800-3, filter modules must be used for the drive control. These filter modules are used only for the purpose of filtering the interference sizes generated by the converter. Therefore, they cannot be used for the interference suppression of other consumers of a system.

Apart from the reduction of the radio interference voltage in the required frequency range 150 kHz to 30 Mhz, these filter modules additionally reduce for the controlled mains feed the grid-bound interference sizes in the frequency range below 150 kHz (reduction of mains feedback).

Filter assembly in the control cabinet

- With system-specific filters, the assembly occurs according to the type of construction and corresponding to the assembly regulations in the manufacturer's documentation.
- Assembly on metal plate with extensive, good conductive contacting.
- Painted control cabinet walls, hat rails or similar assembly aids with a small contact surface and low potential link are not suitable for the assembly of the converter and filter.

Wiring

- Supply lines and shunts to the filter are to be routed with spatial separation.
- Power and signal lines must basically be conducted separately. For this, the power lines from the converter must be conducted functionally downwards and the transmitter lines upwards, to achieve as large a spatial distance as possible (see also Chapter 6 for this).
- To comply with the radio interference thresholds, it is necessary to create all motors and main lines with shielding. Optionally, an earthed metal channel with an electrically extensive contacted cover may be used. The extensive link of the shielding to the appropriate components (motor, converter) must always be ensured.

Functional earthing

The extensive conducting assembly of the filter in the cabinet provides the functional earthing. If only a more or less insulated installation is possible, then the functional earthing must be provided via an equipotential bonding conductor.

Protection earthing

Basically, the regulations for protection earthing also apply. However, additional measures are necessary for converters due to the high deflection currents.

Caution

According to EN 50178, only currents ≤ AC 3.5 mA or ≤ DC 10 mA may flow to a conductor. As the interference currents of current converter-filters normally exceed these values, the following measures must be performed:

1. Laying of a second conductor via separated clamps parallel to the current conductor, whereby this equipotential bonding conductor must likewise meet the requirements for conductors according to IEC 364-6-543.
2. Use of a conductor with a cross-section ≥ 10mm^2 Cu.

Warning

Unused cores of power lines (e.g. brake cores) and their line shields must be installed on at least one side to the earthing potential in order to discharge the loads arising through capacitive overcoupling. Hazardous contact voltages on the unearthed shields and cores may arise if this warning is disregarded.

■

Notes

8 Troubleshooting and Fault Elimination

8.1 Troubleshooting

Exact observation and recording of the errors which have occurred facilitates troubleshooting. The more precise the error description, the more accurate the resultant troubleshooting. Ensure that no misinterpretation is possible or has occurred when passing on the error description.

Localisation of the interference source

- Is the malfunction continuous or intermittent?
- Is there any relationship between the occurrence of errors, the error rate and the operation modes of the malfunctioning system with the operation of other devices?
- Is it possible to identify the interference source via step-by-step shutdown of the devices within the system?
- Check the supply voltages!

Localisation of the interference sink

- Does no malfunction clearly exist due to hardware or software errors?
- Are there devices or system components which are, however, affected but those malfunctions are not directly detectable, e.g. transmitters which can influence the complete system?
- Use the diagnostic possibilities which are available in the systems (LEDs, error displays, error counters….) for the identification of the affected appliance.
- The intentional shutdown/separation/replacement of parts of the system assists when locating the affected part. Shutdown e.g. by:
  - Modification of the mode of operation.
  - Deactivation of functions.

8.2 Fault clearance

For the elimination of malfunctions due to insufficient EMC, the basic procedure is as follows:

- Eliminating or reducing the interference sizes generated by the interference source by means of coil wiring, filter, shield plates, etc.
- Increasing the noise immunity of the influenced appliance by means of filters, shielded housing etc.

- Elimination of coupling paths to prevent interference sizes on reaching the interference sink from the interference source (e. g. increase distance between power and signal lines, inserting shielded lines, conduct lines to mass proximity).
- Check the adherence of the measures requested in this EMC Guideline and the product-specific documentation.

Table 8-1 Fault clearance

Misconduct	Possible cause	Fault elimination
Sporadic failure	Non-wired coils of contactors, valves, horns, …	Wire the coils
	Adjacent sparking machines (welding equipment)	Route the lines of the control in another way (increase the distance to the interference source)
	Transmitter, round control system	Additional shielding
	Lines with incorrect shield connection, incorrect core twisting or incorrect parameters	Use original lines, check the core occupancy
	Interruption in the line shield (e.g. with intermediate switching of a line distributor)	Connection of the line shields, shielding of the interruption point
	Incorrectly routed equipotential bonding line	Reroute equipotential bonding line (see Chapter 4)
	Contamination of the control	Clean control and assemblies, provide for clean supply air
Remaining offset	Such as sporadic failure	Such as sporadic failure
	Actual value line	Route equipotential bonding line between transmitter housing and control housing or improve equipotential bonding
Irregular processing surface	Poor equipotential bonding connection between position transmitter and control	• Provide for extensive, blank, corrosion-resistant earth connection between control and position transmitter • Equipotential bonding line: Increase cross-section, create direct connection
	Large compensating current on setpoint line shields (analog setpoint)	Interrupt shield connection on the control side
	Foreign drive control: Setpoint input of the drive control does not suit the Siemens EMC concept	Change the input wiring of the drive control (according to the wiring of the Siemens drive controls)
Flickering screen characters or screen	Adjacent magnetic field-producing device (e.g. transformer, electric motor) or line with current flowing through it	• Increase the distance between the screen and the interference source • In extreme cases, shield the screen or interference source with MUMETALL®
Extensive off-colours of the screen display	Magnetic field of an adjacent permanent solenoid	• Eliminate the interference source • Shield the interference source with MUMETALL® Note: Picture disturbance disappears without demagnetization measures only some days after the elimination of the cause
Transmitter error	Transmitter line shield is interrupted	Insert original lines (product-specific)
	Lines with poor shield features	
	Transmitter line shield put on via separate wire/line	Insert shields on both sides
	Electrostatic charging/discharging of belts or rotor	Use belts with antistatic coating, earth rotor via earthing brush.
Telephones, fax machines, copying machines are whistling	Short-circuit capacity of the mains is too small	• Increase the short-circuit capacity of the mains • Supply the affected devices from another mains • Insert original filter module
Fuse case with small power supply units		

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9 Electrostatically Sensitive Assemblies (ESA)

9.1 What does ESD mean?

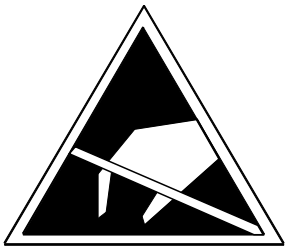
Definition: ESD

For technical reasons, electrical and electronic devices are highly sensitive to overvoltages and also sensitive to discharges of static electricity.

For these **E**lectrostatically **S**ensitive **C**omponents/Devices, the abbreviated identification **ESC** has become established. In addition, you will find the internationally common designation **ESD** for **E**lectrostatically **S**ensitive **D**evice.

Electrostatically sensitive devices are identified with the following symbol:

Identification



Caution

- Electrostatically sensitive devices can already be destroyed by voltages which are far below human perception limits. As long as you have not discharged when touching an assembly, you possess a dangerous voltage for components.
- The damage which occurs on an assembly due to overvoltage cannot be detected immediately but becomes apparent only after longer time of operation.

9.2 Electrostatic charging of objects and people

Charging

Objects and people connected non-conductively to the electrical potential of their environment can become electrostatically charged.

Examples of such charging are:

- Plastic cover or insulating slides up to 5,000 V
- Books and notebooks with plastic wrapping up to 8,000 V
- Persons when
  - Walking on plastic floors up to 12,000 V
  - Seating on upholstered chair up to 15,000 V
  - Walking on synthetic fitted carpet up to 15,000 V

Discharge current/energy

If, for example, a voltage of 10,000 volts is discharged due to touching a component, then a discharge current of 15 A can flow for a short time. The electrical energy that a component must thus take up is around 10^{-3} Ws. This energy is sufficient to destroy semiconductors, e.g. integrated circuits, rectifiers and signal diodes, or at least damage them.

Caution

Protect your assemblies and prolong their service life by observing the protective measures in a responsible manner and applying them uncompromisingly.

9.3 Packing and dispatch of electrostatically sensitive assemblies

Package assemblies without housing and components in conductive ESD original packaging whenever possible. You can also use plastic boxes metallized on the outside, or uncoated cartons. Store electrostatically sensitive assemblies in high-impedance conductive packing.

9.4 Basic protective measures against static electricity discharges

Avoid charging

The best protection against the consequences of electrostatic discharging is to prevent static electricity from developing in the environment of the exposed items.

Caution during contact with plastics

Plastics in particular should therefore be kept away from sensitive assemblies, since most plastics can easily be statically charged.

Ensure good earthing

When using electrostatically sensitive assemblies, ensure high-impedance (200 kW to 1 GW) earthing of humans, workplace and packaging.

Refrain from direct touching

Touch electrostatically sensitive assemblies only when it is unavoidable (e.g. to perform work on it). Touch assemblies in such a way that you do not touch component pins or the conducting path. In this way, the energy of the discharges cannot reach the sensitive components and damage them.

Avoid hard discharges

If an electrostatic discharge cannot be avoided, the possibility of a smooth discharge should be always created, e.g. via a high-impedance resistance with R > 200 kW.

Use only earthed equipment

Measure or solder electrostatically sensitive assemblies only when

- The equipment is earthed (e.g. via a protective conductor).
- With potential-free indicators, the measuring head is discharged before measuring (e.g. by briefly touching earthed metal parts).

Particular caution with ESD assemblies

Please consider the following measures for assemblies with electrostatically sensitive components which are not protected against touching by a housing and therefore are identified appropriately (identification: See the beginning of this chapter):

- Touch electrostatically sensitive assemblies only
  - When you are earthed via an ESD wristband,
  - When you are wearing ESD shoes or an ESD earthing strip, as long as you are walking on an ESD floor,
  - When you are not wearing man-made fibres or an ESD coat.

- Discharge your body before working on the assembly. To do so, touch earthed metallic objects.
- Protect assemblies before touching them with chargeable and highly insulating materials such as plastic foils, insulating desk plates or clothing made from synthetic fibres.
- Place only electrostatic endangered assemblies on conductive bases.
  - Table with ESD support plate,
  - Conductive ESD foam material or ESD packaging,
  - A normal uncoated cardboard box should be used at least temporarily.
- Do not place electrostatically sensitive assemblies in the direct vicinity of devices with large electromagnetic fields as data display units, monitors or television sets (minimum distance to the screen 10 cm).

ESD protective measures

In the following picture, the ESD protective measures are again illustrated.

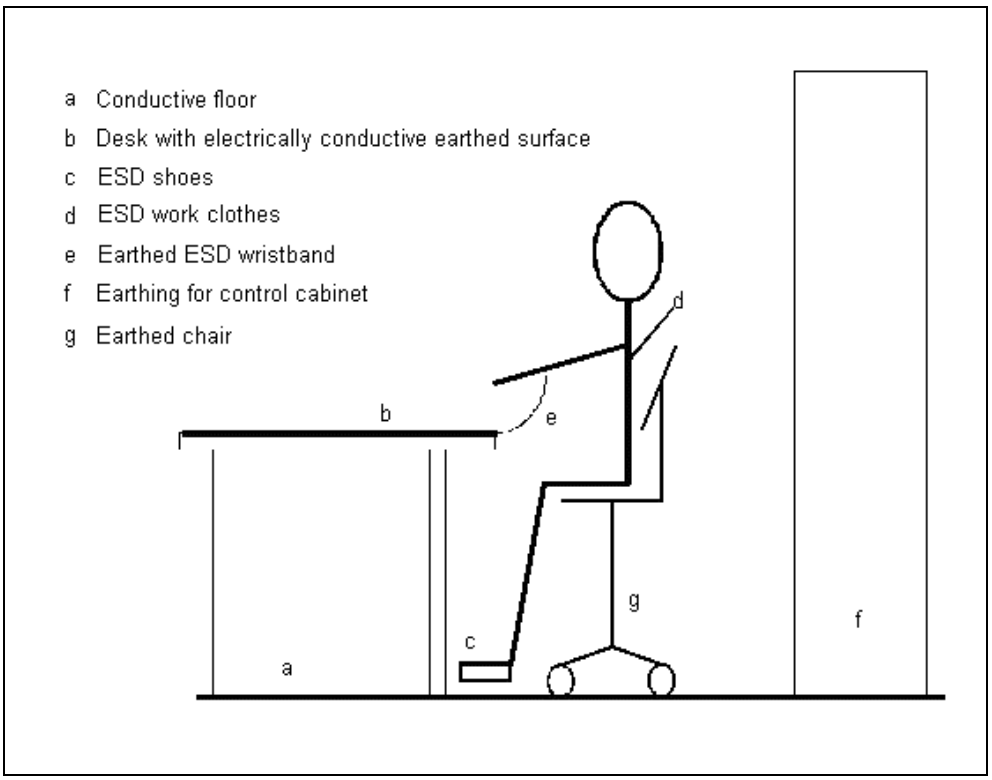


Fig. 9-1 ESD protective measures

■

10 EMC Law and CE Mark

10.1 Notes on the EMC rule

Validity of the EMC law

Compliance with the EMC law concerning the electromagnetic compatibility of devices as an implementation of Guideline 89/336/EEC of the Council, dated May 3rd, 1989, is compulsory for devices which can cause electromagnetic failures or whose operation can be impaired by such failures.

Marking

Devices which

- can be operated independently or
- are commonly available,

require the CE mark in conjunction with an EU declaration of conformity.

The CE mark is attached to the goods itself, to the packaging or in the accompanying documents.

Devices which are supplied exclusively as vendor parts or spare parts for the further processing by competent companies do not require any CE mark or EU declaration of conformity in respect of the EMC law. In addition, CE mark is not required for equipment which is assembled only on site (e.g. control cabinets).

Factory conformity

The radio interference and the noise immunity in equipment is dependent on factors such as, e.g. factory assembly, device combination, cable laying, cable length, etc., as well as product-specific factors. Checking the permissible EMC thresholds with consideration of all these factors and their variations would result in almost endless checking. Thus the EMC is ascertained on typical factory configurations during factory assembly and confirmed by the appropriate declaration of conformity.

! Important

If the difference between the factory configuration of the machine and the factory configuration in accordance with the CE declaration of conformity is so large that more unfavourable EMC thresholds are to be expected when using the machine, the EMC measurements must be repeated on site, if necessary. In this case, please contact your local Siemens office.

10.2 Notes for machine manufacturers

Definition

Controls and drives are not machines in the sense of the EU machines guideline 98/37/EU. Electronic controls only become machines when integrated into the units to be controlled. Thus, no declaration of conformity exists for these controls in respect of the EU machines guideline.

EU Machines Guideline 98/37/EU

The EU machines guideline governs the requirements for a machine. The entirety of the combined parts or devices is to be regarded as a machine (see also DIN EN 292-1, paragraph 3.1).

The Siemens controls are part of the electrical equipment of a machine and must therefore be integrated by the machine manufacturer into the EU declaration of conformity procedure.

10.3 CE mark/EU declaration of conformity

CE mark

Products which bear the CE mark comply with the requirements of EU Guideline 89/336/EEC “Electromagnetic compatibility” and the relevant harmonized European Standards (EN). The CE mark is the external feature for the conformity of the product with the requirements of the respective guideline.

EU Declaration of Conformity

An EU Declaration of Conformity is thus a necessary prerequisite for a CE mark. With assembled products or in factories, the declaration of conformity performs the same function as the external visibly attached CE mark.

The EU Declaration of Conformity for the EMC can be found/obtained from:

- on the F80 intranet:
  http://intra1.ad.siemens.de/qm/Themen/konform_emv.pdf
- in the internet:
  http://www4.ad.siemens.de/WW/llisapi.dll?func=cslib.csinfo&objid=15257461&objAction=csopen&siteid=csius&lang=de
- at the relevant branch office of the A&D MC group of Siemens AG.

Area of application

The products indicated in the declaration of conformity are designed according to EMC for use in the industrial sector.

These products may be also used in combination with an individual licence for emitted interference in residential areas (residential, commercial and industrial areas, small enterprises). This individual licence may be obtained from an authority or testing organization. In Germany, the Federal Office for Post and Telecommunications and its branch offices acts as the grantor of this individual licence.

Siemens products meet the following requirements:

Area of application	**Requirements**	
	Emitted interference	Noise immunity
Industrial	DIN EN 61000-64 or DIN EN 61800-3	DIN EN 61000-6-2 or DIN EN 61800-3
Residential area	Individual licence is required	

Observe the guidelines

The products comply with the EMC requirements if you

1. adhere to the guidelines described in the respective product documentation for installation and operation.
2. also consider the rules
   - for the installation of the devices,
   - for work performed on control cabinets and
   - the notes on individual components.
3. give fundamental consideration to the relevant EMC Guidelines for these products.

■

Notes

11 Health Protection

General

The trade association for precision mechanics and electrical engineering prescribes thresholds for electromagnetic load factor in the workplace. In addition, the Federal Immissions Control Law must be considered in the Federal Republic of Germany.

Requirements for the workplace

Adherence to the anti-interference thresholds in respect of EMC does not also ensure adherence to the requirements for workplaces.

Machine construction, control cabinet structure, shop environment, feed conditions and other installations have a substantial impact on adherence to the thresholds required by the trade association for the respective workplace.

At a fundamental level, the operator must clarify whether wearers of pacemakers or metallic implants may be employed at the planned workplace without endangering their health.

■

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Suggestions

Corrections

For Publication/Manual:

EMC Installation Guideline

Manufacturer Documentation

From

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Company/Dept.

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Suggestions and/or corrections

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