rexroth
A Bosch Company

Control Cabinet

Air Conditioning, EMC, Design, IP Code, Electrics
ctrlX DRIVE, IndraDrive, Rexroth EFC/Fv, Sytronix

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Purpose of this Documentation

This documentation describes basic measures used in plant engineering to achieve electromagnetic compatibility (EMC). In addition, it contains practical tips regarding EMC for Sytronix applications.

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1 Air conditioning

1.1 Basic principles

1.1.1 Heat and control cabinets

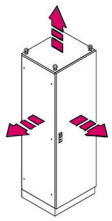
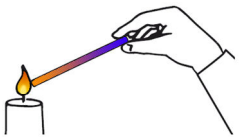
As electronic components become ever smaller and are more densely packed in control cabinets and electronic housings, systems are becoming increasingly sensitive to external influences, such as temperature, dust, humidity and oil.

In particular, increased temperatures significantly interfere with sensitive microelectronics.

Rule of thumb for semiconductors:

Increasing the operating temperature by 10 °C, in relation to the maximum allowed operating temperature, reduces the service life of semiconductors by half.

To ensure the longest possible service life of semiconductors, it is necessary to avoid too high temperatures in control cabinets.

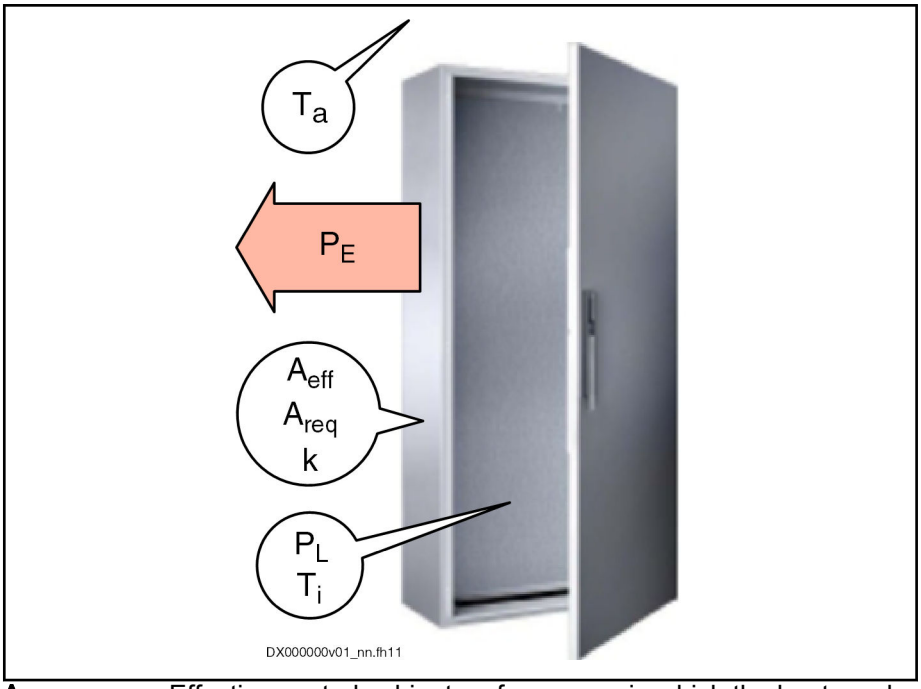
Heat transmission		
Convection	**Heat conduction**	**Radiation**
		
Energy flows with the matter. The transport medium (e.g. air) absorbs energy in the form of heat and dissipates energy as heat.	The matter transports heat without the matter itself moving. The energy is passed on from particle to particle.	Heat is transmitted from one body to another without a physical carrier in the form of radiant energy.

Tab. 1-1: Heat transmission

For the type of heat dissipation from a control cabinet it is decisive whether the control cabinet is open (permeable to air) or closed (impermeable to air).

Whereas the heat is dissipated by the air flow in the case of an open control cabinet, the heat can only be dissipated via the control cabinet walls in the case of a closed control cabinet.

1.1.2 Calculations



A_{eff}	Effective control cabinet surface area via which the heat can be radiated
A_{req}	Control cabinet surface area required to discharge heat loss from the control cabinet to the outside
k	Heat transfer coefficient
P_E	Radiated heat output
P_L	Heat loss
T_a	Ambient temperature
T_i	Inside temperature of control cabinet

Fig. 1-1: Physical values for calculating the air conditioning of control cabinets

Calculating the control cabinet surface area A_{req} required to discharge the heat loss P_L in the control cabinet:

$$A_{req} \geq \frac{P_L}{k \times (T_i - T_a)}$$

Fig. 1-2: Required control cabinet surface area A_{req}

The material of the control cabinet determines the heat transfer coefficient k:

Material	Heat transfer coefficient k [W/(m²×K)]
Sheet steel	5.5
Plastic	3.5
Double-walled aluminum housing	5.0
Double-walled aluminum-zinc housing	2.5

Tab. 1-2: Heat transfer coefficient k for different materials

Calculating the heat output P_E, radiated via the effective control cabinet surface area A_{eff}:

$$P_E = k \times A_{eff} \times (T_i - T_a)$$

Fig. 1-3: Radiated heat output P_E

The effective control cabinet surface area A_{eff} for discharging the heat loss differs in accordance with the installation type.

Installation type		Effective control cabinet surface area A_{eff} [m^2]
Single housing, free-standing on all sides		1.8 × H × (W + D) + 1.4 × W × D
Single housing for wall mounting		1.4 × W × (H + D) + 1.8 × D × H
First or last housing in a suite, free-standing		1.4 × D × (H + W) + 1.8 × W × H
First or last housing in a suite, for wall mounting		1.4 × H × (W + D) + 1.4 × W × D
Housing within a suite, free-standing		1.8 × W × H + 1.4 × W × D + D × H
Housing within a suite, for wall mounting		1.4 × W × (H + D) + D × H
Housing within a suite, for wall mounting, covered roof surfaces		1.4 × W × H + 0.7 × W × D + D × H

W Control cabinet width
H Control cabinet height
D Control cabinet depth

Tab. 1-3: Installation types (according to VDE 0660-500)

Control cabinet dimensions [mm]			Effective control cabinet surface area A_{eff} [m^2] (depending on the installation type)						
W	H	D							
300	400	210	0.46	0.41	0.42	0.29	0.39	0.34	0.3
500	700	250	1.12	0.98	1.05	0.74	0.98	0.84	0.75
1000	1000	300	2.76	2.36	2.64	1.82	2.52	2.12	1.91
800	2000	800	6.66	6.02	6.02	4.48	5.38	4.74	4.29

W Control cabinet width
H Control cabinet height
D Control cabinet depth

Tab. 1-4: Exemplary values for determining the effective control cabinet surface area A_{eff}

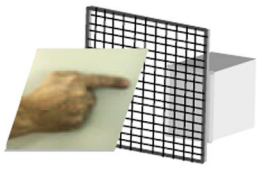
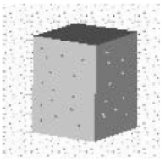
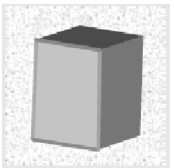
1.1.3 Degree of protection (IP code)

The **IP code** identifies the degree of protection of a housing. The degrees of protection differ in their quality of protection against the penetration of solid foreign objects and the ingress of water (in accordance with IEC 60529).

Example: IP23CH

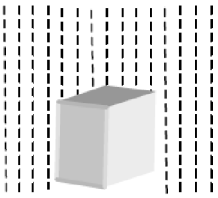
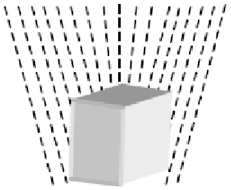
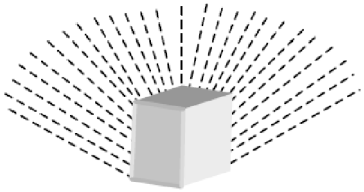
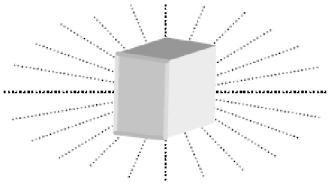
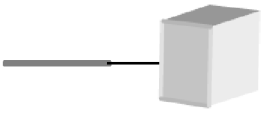
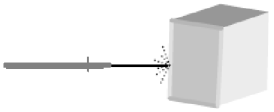
IP	International Protection (code letters)
2	Protection against access to hazardous parts and protection against penetration of solid foreign objects (first numeral)
3	Protection against ingress of water (second numeral)
C	Protection against access to hazardous parts (additional letter)
H	Supplementary information (supplementary letter)

Tab. 1-5: IP code

IP code First numeral IP x _ _ _	Protection against access to hazardous parts	Protection against penetration of solid foreign objects	Example
0	Non-protected	Non-protected	
1	Protected against access to hazardous parts with the back of a hand	Protection against foreign objects > 50 mm *	
2	Protected against access to hazardous parts with a finger	Protection against foreign objects > 12 mm *	
3	Protected against access to hazardous parts with a tool	Protection against foreign objects > 2.5 mm *	
4	Protected against access to hazardous parts with a wire	Protection against foreign objects > 1 mm *	
5	Protected against access to hazardous parts with a wire	Dust-protected Ingress of dust is not totally prevented. Dust shall not penetrate in a quantity to interfere with the function of the components or to impair safety.	
6	Protected against access to hazardous parts with a wire	Dust-tight	

* Diameter of the foreign object

Tab. 1-6: IP code, first numeral

IP code Second numeral IP _ x _ _	Protection against water	Example
0	Non-protected	
1	Dripping water	
2	Dripping water when housing tilted up to 15°	
3	Spraying water	
4	Splashing water	
5	Water jets	
6	Powerful water jets	

Tab. 1-7: IP code, second numeral

IP code Additional letter IP _ _ x _	Protected against access with …
A	Back of the hand
B	Finger
C	Tool
D	Wire

Tab. 1-8: IP code, additional letter

IP code Supplementary letter IP _ _ _ x	Description
H	High-voltage equipment
M	Tested for harmful effects due to the ingress of water when the movable parts of the equipment (e.g., the rotor of a rotating machine) are in operation
S	Tested for harmful effects due to the ingress of water when the movable parts of the equipment (e.g., the rotor of a rotating machine) are at standstill
W	Suitable for use under specified weather conditions and provided with additional protective measures or processes

Tab. 1-9: IP code, supplementary letter

1.2 Selecting the air conditioning

1.2.1 Criteria

When selecting the appropriate air conditioning for the control cabinet, take the following criteria into account:

Installation type

The bigger the effective control cabinet surface area A_{eff}, the better the heat can be dissipated from the inside of the control cabinet.

Ambient conditions

Which are the conditions at the site of installation of the control cabinet?

- Ambient temperature T_a
- Dust
- Humidity
- Oil
- Chemicals

Inside temperature of control cabinet

What is the maximum allowed inside temperature T_i of the control cabinet?

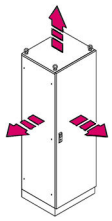
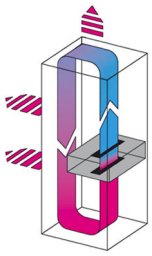
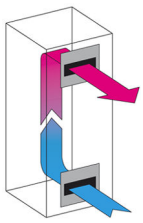
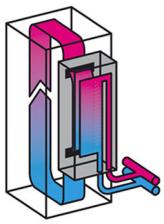
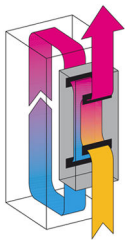
Heat loss

What is the heat loss P_L of the electric components in the control cabinet?

Degree of protection (IP code)

What are the requirements with regard to the degree of protection (IEC 60529)?

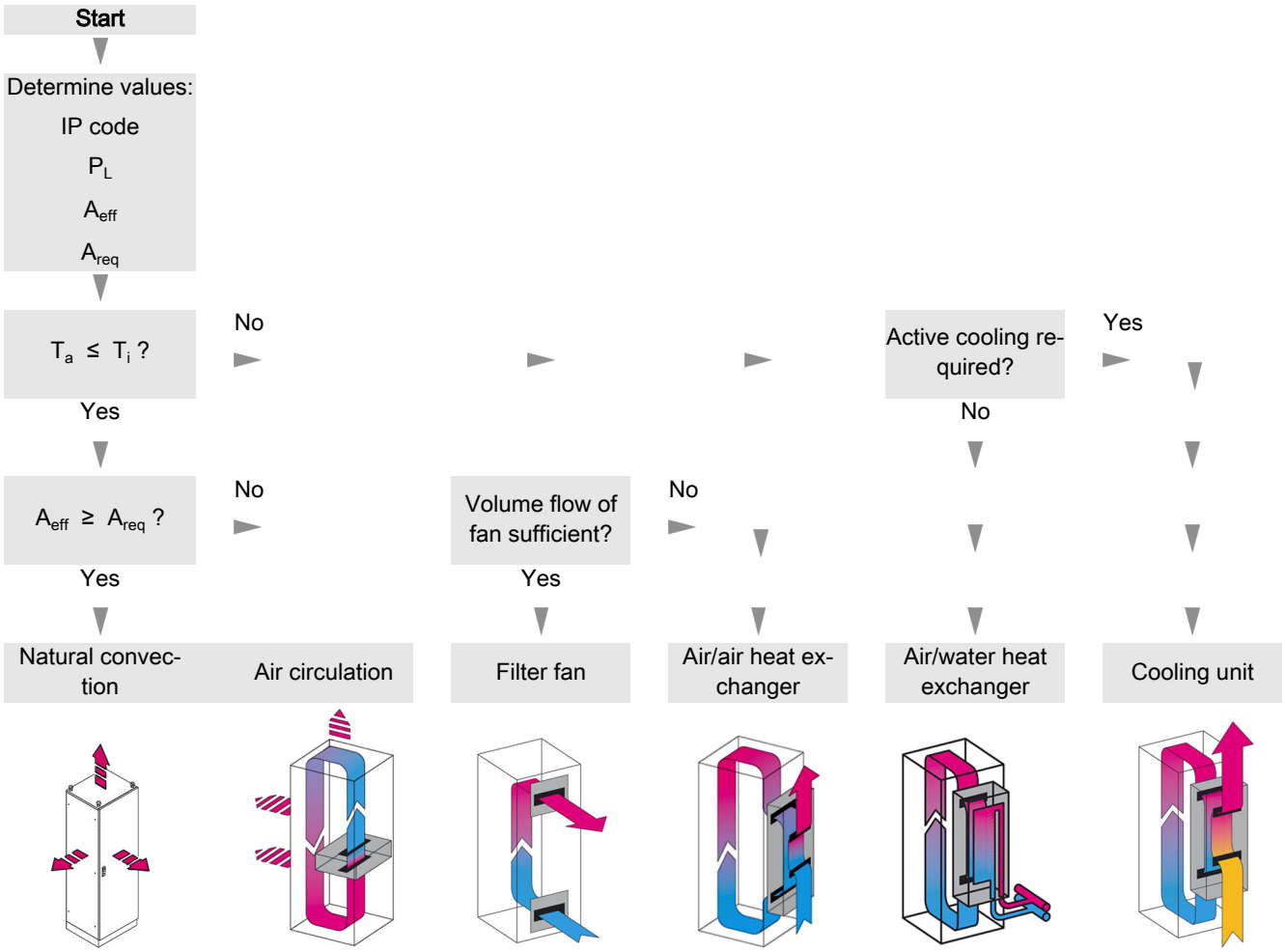
1.2.2 Types of air conditioning

Air conditioning			Condition
Passive	Natural convection		$T_a < T_i$
Active	Air circulation		
	Filter fan		
	Air/air heat exchanger		
	Air/water heat exchanger		$T_a > T_i$
	Cooling unit		

T_a Ambient temperature
T_i Inside temperature of control cabinet

Tab. 1-10: Types of air conditioning for control cabinets

Selecting the appropriate air conditioning



A_{eff}	Effective control cabinet surface area via which the heat can be radiated (depending on the installation type of the control cabinet)
A_{req}	Control cabinet surface area required to discharge heat loss from the control cabinet to the outside
P_E	Radiated heat output
P_L	Heat loss of the electric components in the control cabinet
T_a	Ambient temperature
T_i	Inside temperature of control cabinet

Tab. 1-11: Selecting the air conditioning

1.3 Passive air conditioning

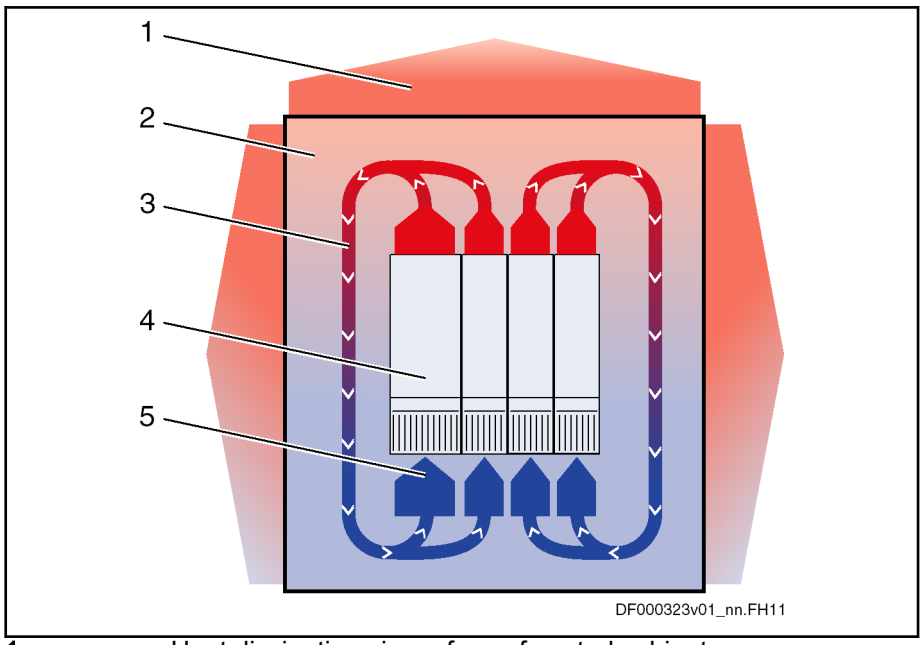
Passive air conditioning means: The natural convection over the surface of the control cabinet cools the control cabinet.

Passive air conditioning allows a high IP Code, because there aren't any ventilation holes or fans present.

Observe the following aspects:

- Avoid **additional temperature rise** of the control cabinet from the outside (e.g. solar radiation).
- Determine the **heat loss P_L** of the electric components in the control cabinet.
- Determine the **required control cabinet surface area A_{req}** required to discharge the heat loss.
- Calculate the **effective control cabinet surface area A_{eff}** depending on the control cabinet dimensions and the installation type.
- Calculate the **heat output P_E** radiated by the control cabinet housing.

In order that the allowed inside temperature of the control cabinet T_i not be exceeded, either the heat loss must be reduced or the control cabinet properties (housing material, effective control cabinet surface area) must be changed.



1 Heat dissipation via surface of control cabinet
2 Interior of control cabinet
3 Convection flow of air in control cabinet
4 Electric components in the control cabinet
5 Air intake of the components in the control cabinet

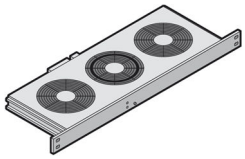
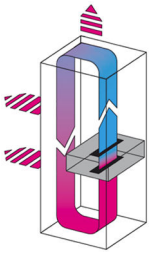
Fig. 1-4: Control cabinet with passive air conditioning (natural convection)

1.4 Active air conditioning

1.4.1 Air circulation

With air circulation, the air conditioning is like with natural convection, without ventilation holes in the control cabinet. Therefore, air circulation also allows a high IP code.

What distinguishes air circulation from natural convection is that a fan inside the control cabinet actively supports the heat compensation and the convection, and thereby avoids the generation of "pockets of heat" in the control cabinet.

Fan	Air circulation
	

Tab. 1-12: Air circulation

1.4.2 Filter fan

With filter fans, air from the environment flows to the interior of the control cabinet for cooling. In accordance with the required IP code, the ventilation holes must be sufficiently tight (e.g., by using appropriate filter mats and gaskets).

- The **ambient air** is sucked in by the ventilator at the bottom of the control cabinet and the air is filtered.
- The **filtered air** flows over the components dissipating heat in the control cabinet and thereby is heated up.
- By the overpressure generated by the ventilator, the **heated air** afterwards is pushed to the outside via the air outlet hole of the control cabinet.

  Besides, the **overpressure** in the control cabinet prevents dust and dirt from penetrating from the outside. This increases the service life and improves the functioning of the electric and electronic components in the control cabinet.
- When planning the control cabinet, make sure the **distance between air intake and air outlet** is as big as possible.

☞ **Regularly check the condition of the filters**. The higher the pollution degree and the dust concentration of the ambient air, the more often you must check the filters.

Replace or clean dirty filters.

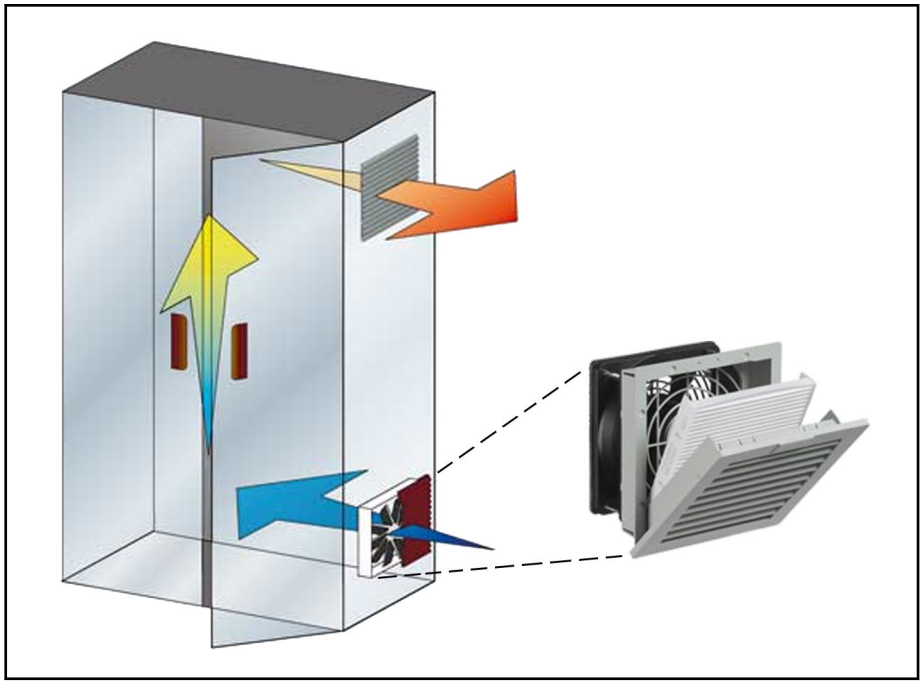


Fig. 1-5: Control cabinet with filter fan; fan with filter elements

Filter fans have to produce the flow rate required for cooling the control cabinet.

Additional filter elements required to comply with the IP code reduce the performance of the filter fan.

Required minimum flow rate V_{min} of the filter fan:

$$V_{min} = \frac{P_L}{T_i - T_a} \times f_{air}$$

f_{air} Air constant (depending on the installation altitude of the control cabinet; see table below)

Fig. 1-6: Required flow rate V_{min}

Installation altitude h [m]	Air constant f_{air} [m^3K/Wh]
0 … 100	3.1
100 … 250	3.2
250 … 500	3.3
500 … 750	3.4
750 … 1000	3.5

Tab. 1-13: Air constant f_{air} depending on installation altitude

If the performance of the filter fan (V_{min}) does not suffice to discharge the thermal losses from the control cabinet, you must use heat exchangers or cooling units, for example.

1.4.3 Air/air heat exchanger

With ambient temperatures **lower** than the desired inside temperature of the control cabinet, it makes sense to use an air/air heat exchanger. This applies, in particular, if the ambient air contains dust, oil or aggressive substances which must not penetrate the control cabinet.

Air/air heat exchangers consist of the following fundamental components:

- Heat exchanger package with channels alternately assigned to the internal air circuit of the control cabinet and the ambient air supply
- Fan for the air in the control cabinet
- Fan for the air outside of the control cabinet

Both air flows are hermetically separated. Via the heat exchanger package, the thermal losses are dissipated by the internal air to the ambient air. This allows the degree of protection IP54 to be achieved.

Air/air heat exchangers have a long service life due to their simple design.

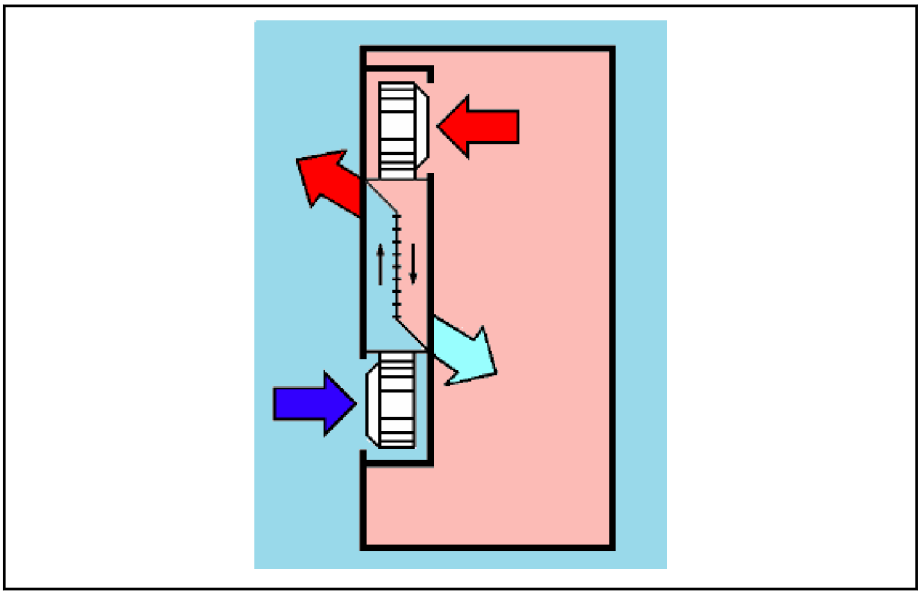


Fig. 1-7: Principle of an air/air heat exchanger

1.4.4 Air/water heat exchanger

With ambient temperatures **higher** than the desired inside temperature of the control cabinet, it makes sense to use an air/water heat exchanger. This applies, in particular, if the ambient air contains dust, oil or aggressive substances which must not penetrate the control cabinet.

Air/water heat exchangers consist of the following fundamental components:

- Heat exchanger package with channels alternately assigned to the internal air circuit of the control cabinet and the cooling water circuit
- Fan for the air in the control cabinet
- Cooling water circuit or connection to a recooling unit

The air flow in the control cabinet is hermetically separated from the cooling water circuit. In the heat exchanger package, the thermal losses are dissipated to the cooling water. This allows the degree of protection IP54 to be achieved.

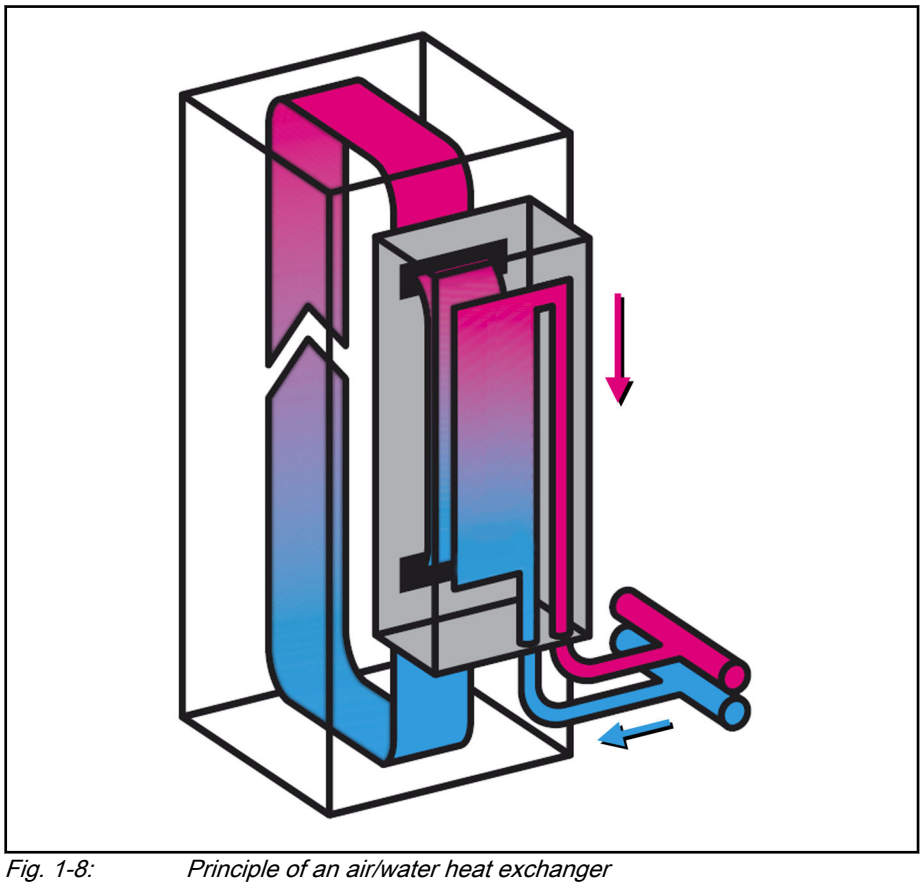


Fig. 1-8: Principle of an air/water heat exchanger

Avoiding moisture condensation

Moisture condensation occurs when the temperature of the device is lower than the ambient temperature.

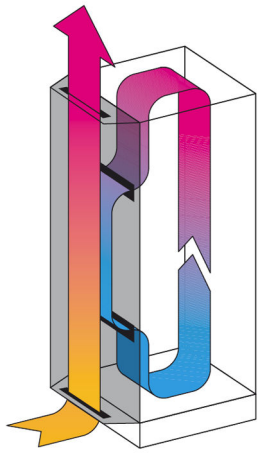
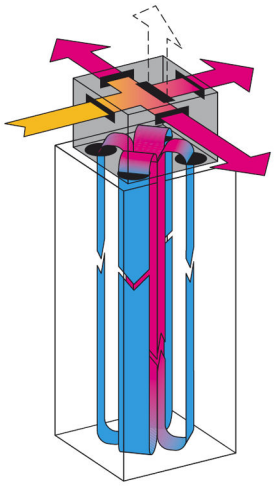
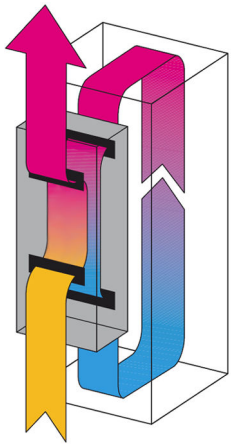
- Only use well-sealed control cabinets so that moisture condensation cannot arise as a result of warm and moist external air entering the cabinet.
- In the event that control cabinets are operated with the doors open (commissioning, servicing etc.), it is essential to ensure that after the

doors are closed the drive controllers cannot at any time be cooler than the air in the control cabinet. For this reason, sufficient circulation must be provided inside the control cabinet.

- Set the inside temperature of the control cabinet only as low as necessary.

1.4.5 Cooling units

Types of cooling units

Cooling units		
Integrated cooling technology	**Cooling unit for top mounting**	**Cooling unit for wall mounting**
		
The unit of control cabinet and cooling components cools in a particularly effective way. Mounting is not required. The investment costs for the complete unit are particularly low!	In the internal air circuit, the cooling air can be routed in a demand-oriented way. There are up to four cooling air outlet holes and channels that can be optionally used. In the outlet channel, the heated air escapes backwards, to the left, to the right and optionally upwards. Thus, control cabinets can be lined up in a row and placed close to a wall.	According to the required space, it is possible to integrate, partly integrate or attach the cooling unit. Big distances between the air intake and air outlet holes result in an effective cooling air flow in the control cabinet.

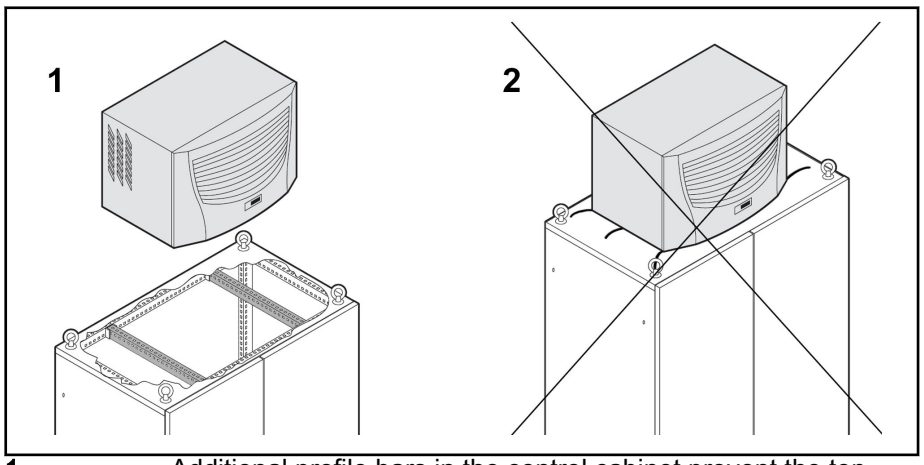
Tab. 1-14: Types of cooling units

Mounting

Mounting on and at control cabinets

Mount the cooling unit according to specification. The top plate of the control cabinet must not bend due to the weight of the cooling unit. If necessary, install additional profile bars in the control cabinet.

Do not obstruct any air intakes and air outlets in the internal circuit. Make sure the side walls and doors of the control cabinet do not bend.



1 Additional profile bars in the control cabinet prevent the top plate from bending.

2 The top plate is not allowed to bend.

Fig. 1-9: Mounting a cooling unit on a control cabinet

Arranging electric components in the control cabinet

Make sure electric components with self-ventilation in the form of fans or axial ventilators are correctly arranged in the control cabinet.

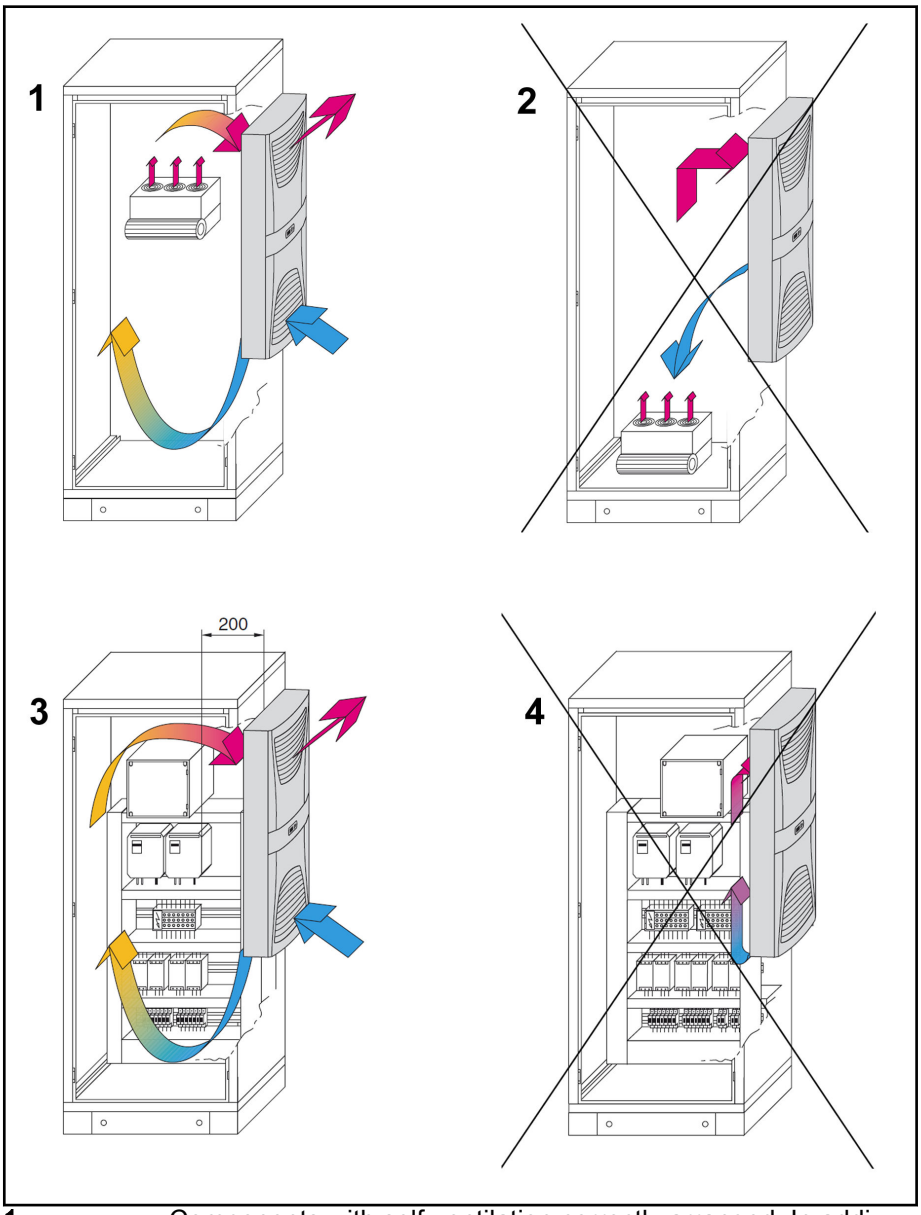
The air flow from these components must not be directed against the cooling air flow of the cooling unit. Otherwise, this can cause an air short circuit which prevents sufficient air conditioning, or the cooling unit stops its cooling mode.

☞ Never direct the cooling air flow to active components.

The air must be able to circulate well in the control cabinet. Do not obstruct any air inlets and air outlets of the cooling unit with components.

Make sure there is sufficient space between the components and the air inlets and air outlets of the cooling unit (> 200 mm; see also picture 3 in the figure below).

Wall-mounted cooling unit:



1 Components with self-ventilation correctly arranged. In addition, make sure there is sufficient distance between the components and the top of the control cabinet.

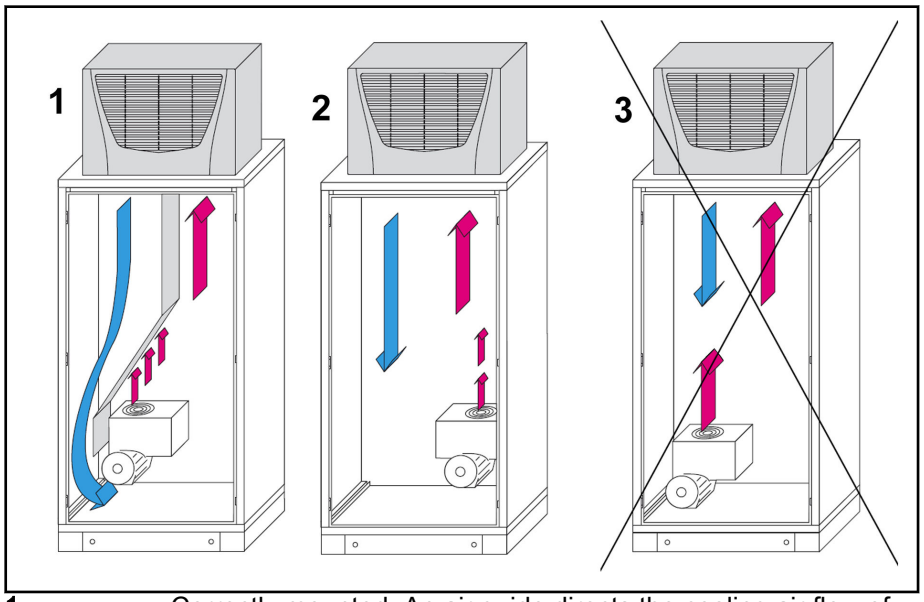
2 Components with self-ventilation incorrectly arranged. The air flow from the component is directed against the cooling air flow of the cooling unit.

3 Correctly arranged components in the control cabinet. The air can circulate well in the control cabinet. Make sure there is sufficient space between the components and the air inlets and air outlets of the cooling unit (> 200 mm).

4 Incorrectly arranged components in the control cabinet. Some components have been arranged too close to the air inlet and air outlet of the cooling unit. Thus, the air cannot circulate well in the control cabinet.

Fig. 1-10: Arranging electric components in the control cabinet with a wall-mounted cooling unit

Top-mounted cooling unit:



1	Correctly mounted. An air guide directs the cooling air flow of the cooling unit to the bottom of the control cabinet.
2	Correctly mounted. The air flow from the component is not directed against the cooling air flow of the cooling unit.
3	Incorrectly mounted. The air flow from the component is directed against the cooling air flow of the cooling unit.

Fig. 1-11: Top-mounted cooling unit

Operation

Avoiding moisture condensation

Moisture condensation occurs when the temperature of the device is lower than the ambient temperature.

- Set cooling units with temperature adjustment to the maximum surrounding temperature and not lower!
- Set cooling units with follow-up temperature in such a way that the interior temperature of the control cabinet is not lower than the temperature of the surrounding air. Set the temperature limitation to the maximum surrounding temperature!
- Only use well-sealed control cabinets so that moisture condensation cannot arise as a result of warm and moist external air entering the cabinet.
- In the event that control cabinets are operated with the doors open (commissioning, servicing etc.), it is essential to ensure that after the doors are closed the drive controllers cannot at any time be cooler than the air in the control cabinet. For this reason, sufficient circulation must be provided inside the control cabinet.

1.5 ctrlX DRIVE, IndraDrive and Rexroth Frequency Converter components

The components of the electric drive system ctrlX DRIVE, IndraDrive and Rexroth Frequency Converter have been designed for control cabinet mounting.

These components

- have the degree of protection IP20 (IP code in accordance with IEC 60529)

  (Exceptions are the IndraDrive Mi (KSM and KMS) servo drives with their degree of protection IP65 and ctrlX DRIVE cabinet-free (XMS and XMD) servo drives with their degree of protection IP65/IP67. These servo drive have been designed for operation outside of a control cabinet.)
- are used, inter alia, for variable-speed pump drives of the Sytronix series

The control cabinet must have a degree of protection of IP54 so that the components can be safely operated without malfunction during their entire service lives.

Select the appropriate type of air conditioning for the control cabinet so that the control cabinet complies with the required degree of protection of IP54 and can dissipate the occurring heat loss.

1.6 References

Title	Edition	Published by
Unterweisungsfolien für die Elektrofachkraft; IP-Schutz, Geräteschutz [Instruction foils for electrically qualified persons; IP protection, device protection]	2005	WEKA MEDIA GmbH & Co. KG
Klimatisierungslösungen [Air-conditioning solutions]	2002	Rittal GmbH & Co KG
Für Schaltschrank-Experten; Daten, Fakten, Informationen [For control cabinet experts; data, facts, information]	2008	
Rittal Praxis-Tipps; Schaltschrank-Klimatisierung und Maschinenkühlung [Practical tips by Rittal; control cabinet air conditioning and machine cooling]	2005	
Design and Construction of Control Cabinets (R911171506; internal documentation)	2008	Bosch Rexroth AG

Tab. 1-15: References

2 EMC

2.1 Control cabinet design

2.1.1 Reference ground

The back panel of the control cabinet has to be an unpainted metal mounting plate. The mounting plate is the reference ground (reference potential) for the devices installed in the control cabinet.

- Connect the mounting plate to the metal housing of the control cabinet at multiple points. Integrate the control cabinet in the ground connection of the installation.
- Directly screw all electrical components to the mounting plate.
- Directly fix all cables and lines to the mounting plate.
- Directly connect cable and line shields to the mounting plate with metal clips or metal clamps.

2.1.2 Ground connections

Establish equipotential bonding between metal structures (back panel of control cabinet, electrical equipment, machine housing, pipes, cable ducts, …):

- On the local level (installation in a defined space, machine, control cabinet, …)
- On the installation level

Continuously interconnect all metal structures of an installation.

- Directly screw all ground connections of electrical components to the mounting plate of the control cabinet.
- Do not use yellow-green equipment grounding conductors (PE) for ground connection. Due to its length, the yellow-green equipment grounding conductor (PE) is not a high-quality ground connection for discharging high-frequency voltages.

Properties of good ground connections:

- **Short**
- **Cover a large surface area**
- **Large conductor cross section**

These are good ground connections:

- **Grounding bar**
- **Grounding strip**

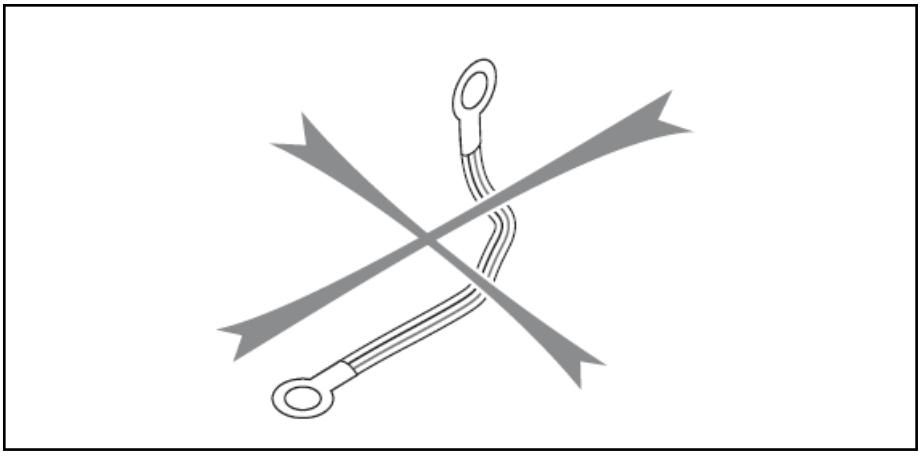


Fig. 2-1: Bad ground connection (cable)

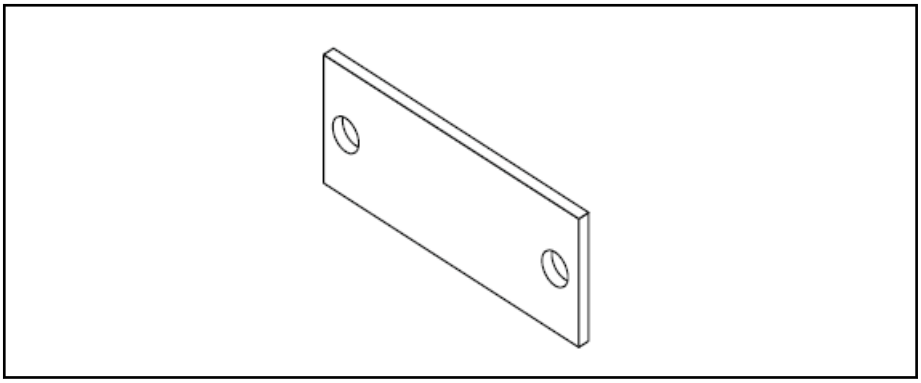
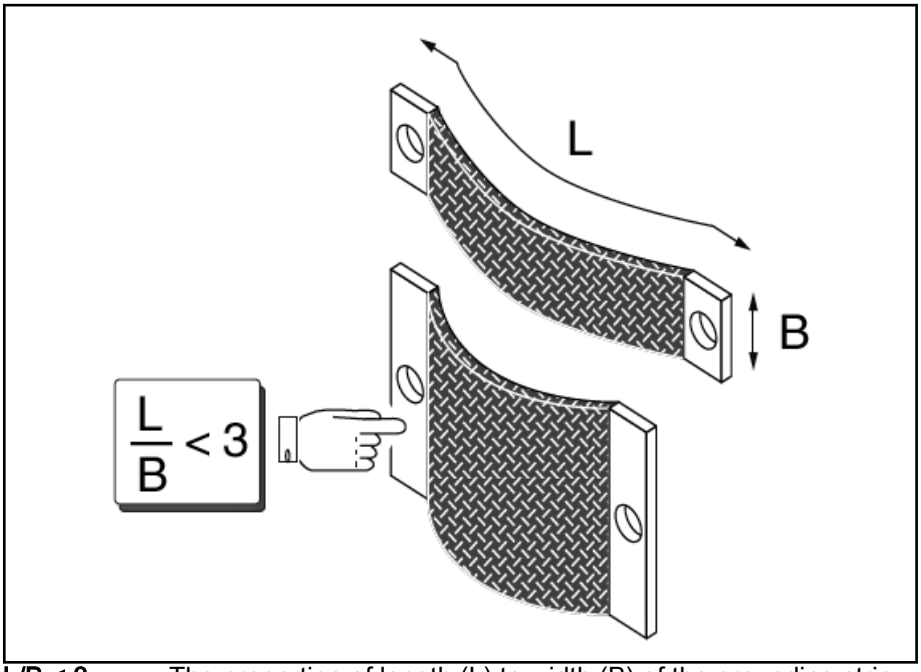


Fig. 2-2: Good ground connection (grounding bar)



L/B < 3 The proportion of length (L) to width (B) of the grounding strip has to be smaller than 3

Fig. 2-3: Optimum ground connection (grounding strip)

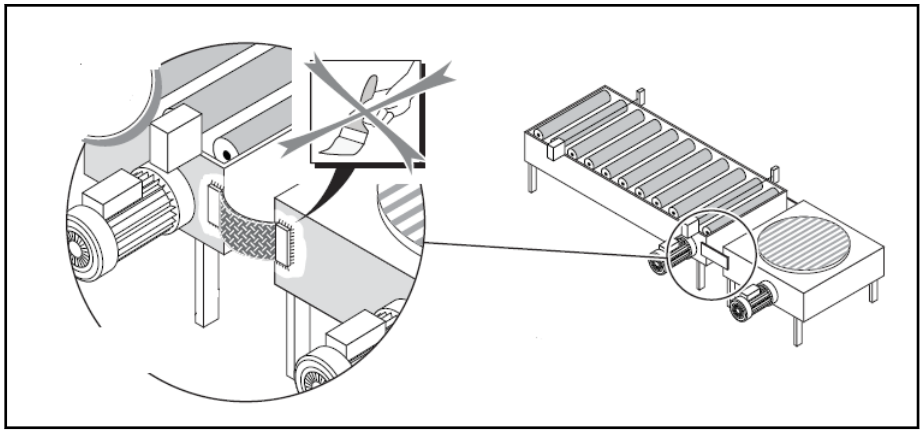


Fig. 2-4: Good ground connection between parts of the installation

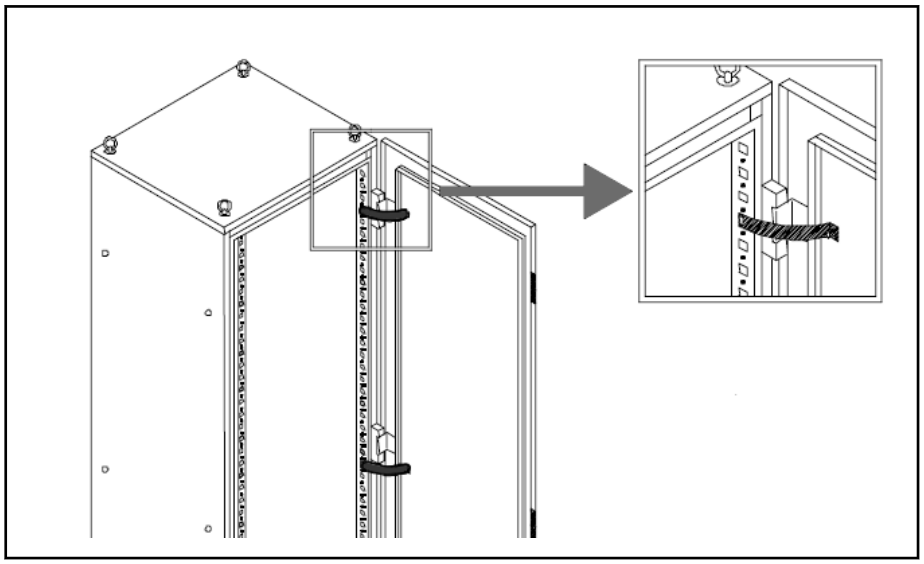


Fig. 2-5: Good ground connection between control cabinet housing and control cabinet door

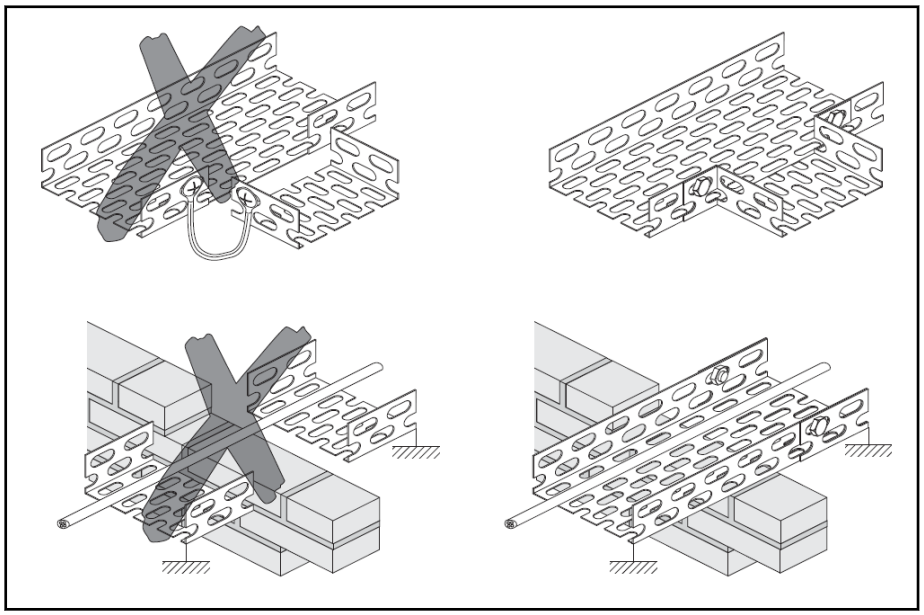
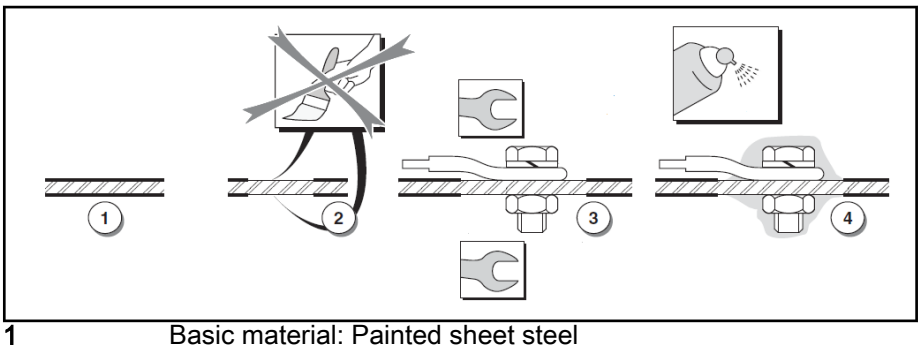


Fig. 2-6: Bad ground connection (left) and good ground connection (right) with metal cable ducts

2.1.3 Establishing the ground connection

Remove substances like paint, oil, grease or insulation material adhering to the contact points. All contact points of the ground connection have to be of bare metal.

Establish a metal-metal contact with a high contact pressure between all conductive parts.



1 Basic material: Painted sheet steel
2 Remove paint ⇒ establish bare metal contact points
3 Establish a firm mechanical contact, e.g. by a screw connection with washers
4 Paint the contacts or apply grease for protection against corrosion so that the contacts are protected

Fig. 2-7: Establishing a good ground connection

2.1.4 Cable entry

Filter interference-susceptible cables and lines before the cable entry point. Select housing feedthroughs (PG glands) with particular care, since these connections are important for good EMC shielding.

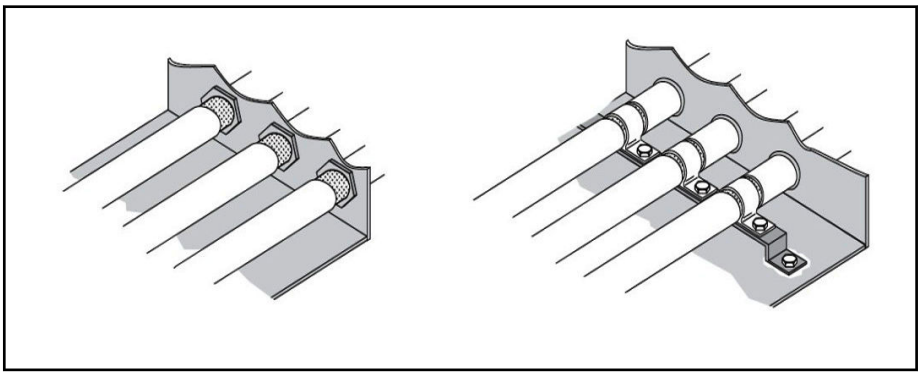


Fig. 2-8: Correct cable entry to the control cabinet with cable glands (left) and with clips (right)

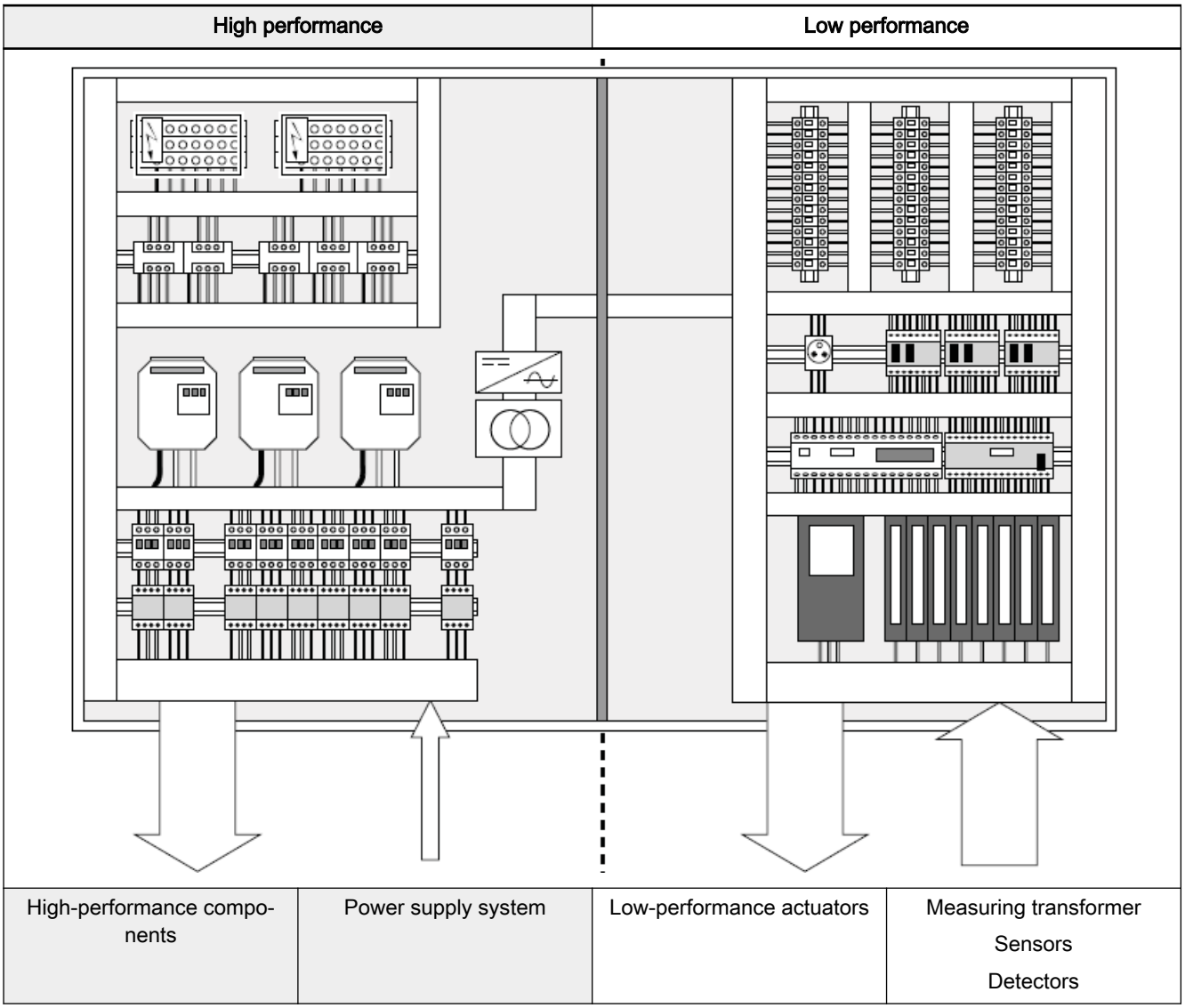
2.1.5 Installing electrical components in the control cabinet

Separate control cabinets

Install sensitive and interference-emitting electrical components, lines and cables in separate control cabinets.

Small control cabinet

Divide the control cabinet using separating sheets grounded at multiple points.

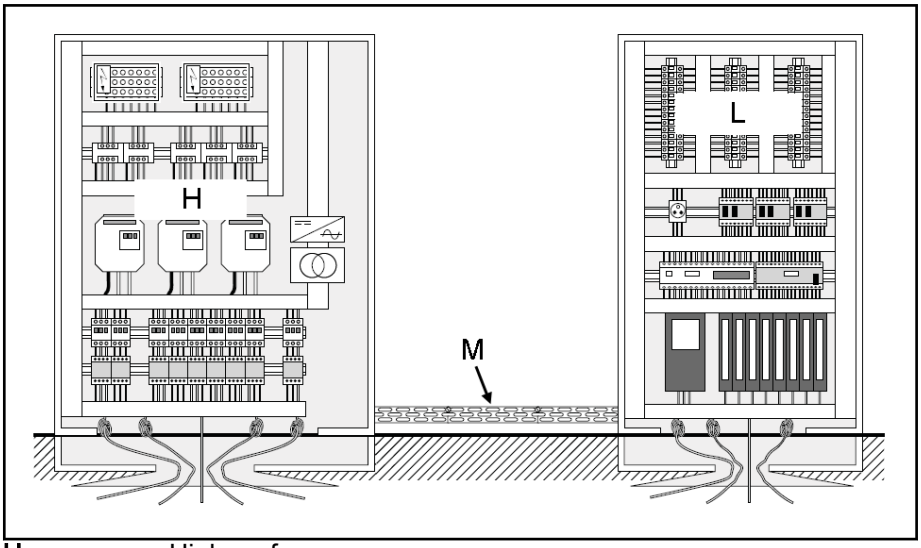


Tab. 2-1: Example of a small control cabinet

Large control cabinet

Control cabinets used to supply interference-emitting and sensitive equipment have to be functionally and spatially separated.

Do not mix cables and lines. Wind up surplus lines.



H High performance
L Low performance
M Metal cable duct

Fig. 2-9: Good example of a large control cabinet

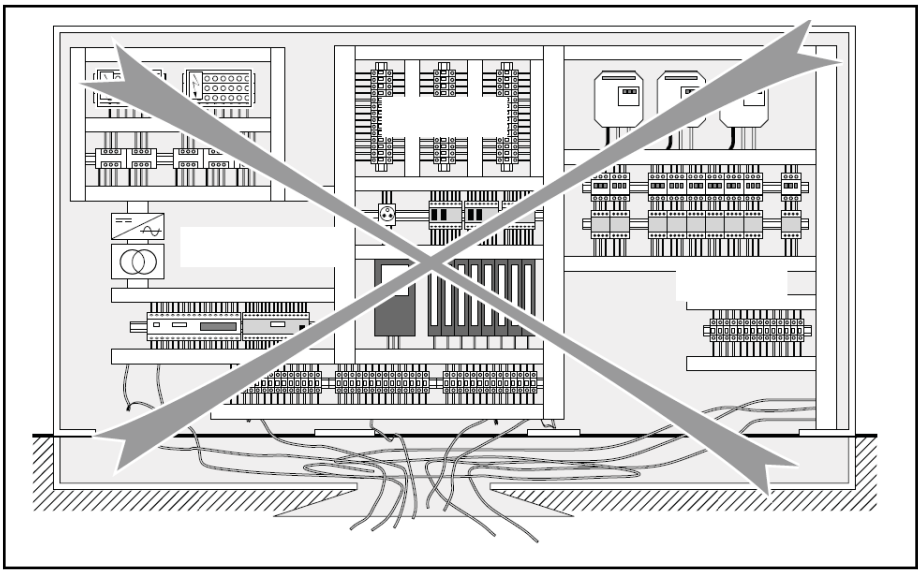


Fig. 2-10: Bad example of a large control cabinet

Line groups and line types

The wiring plays a significant role in the EMC of an installation. Lines are classified into different line groups.

Line groups

Line group	Interference generator	Sensitive	Example
1 (very sensitive)	-	++	Lines for analog small signals, measuring lines
2 (sensitive)	o	+	Lines for digital small signals (bus lines)
3 (interference generator)	+	o	Contactors, mains supply lines
4 (strong interference generator)	++	-	Welding installations, frequency converters

++ Applicable
+ Mainly applicable
o Partly applicable
- Less applicable

Tab. 2-2: Line groups

The following line types are recommended for the above-defined line groups ("Line groups" table):

Assigning line types to line groups:

Line group	Single wire	Twisted two-wire line	Shielded twisted two-wire line	Shield (Braid)	Shield (Braid + foil)
1 (very sensitive)	-	o	+	++	++
2 (sensitive)	o	+	+	++ *)	++ *)
3 (interference generator)	o	+	+	++ *)	++ *)
4 (strong interference generator)	--	-	o	+	++

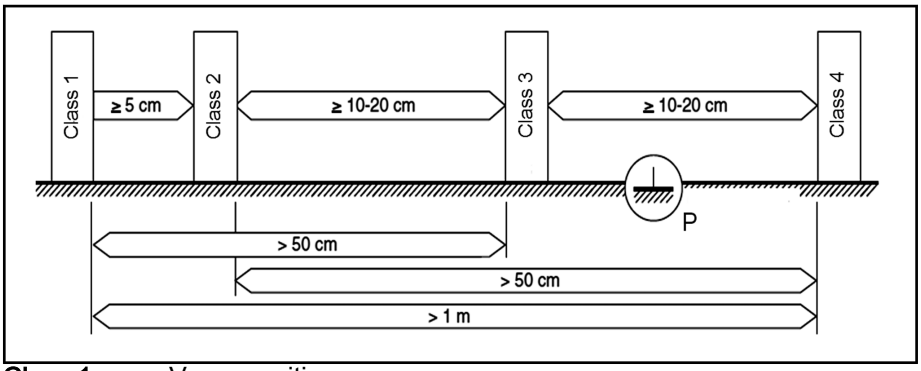
++ Applicable
+ Mainly applicable
o Partly applicable
- Less applicable
-- Not applicable
***)** Expensive, usually not required

Tab. 2-3: Assigning line types to line groups

Running the lines

Observe the following rules for lines with sensitive signals (Classes 1 and 2) and interference-emitting signals (Classes 3 and 4):

- **Never run them in the same cable, cable bundle or channel**
- **Limit lines run in parallel to a minimum**
- **Maintain the maximum possible safety clearance**



Class 1 Very sensitive
Class 2 Less sensitive
Class 3 Less interference-emitting
Class 4 Strongly interference-emitting
P Reference ground

Fig. 2-11: Safety clearance between lines of different classes

The longer the line, the bigger the safety clearance:

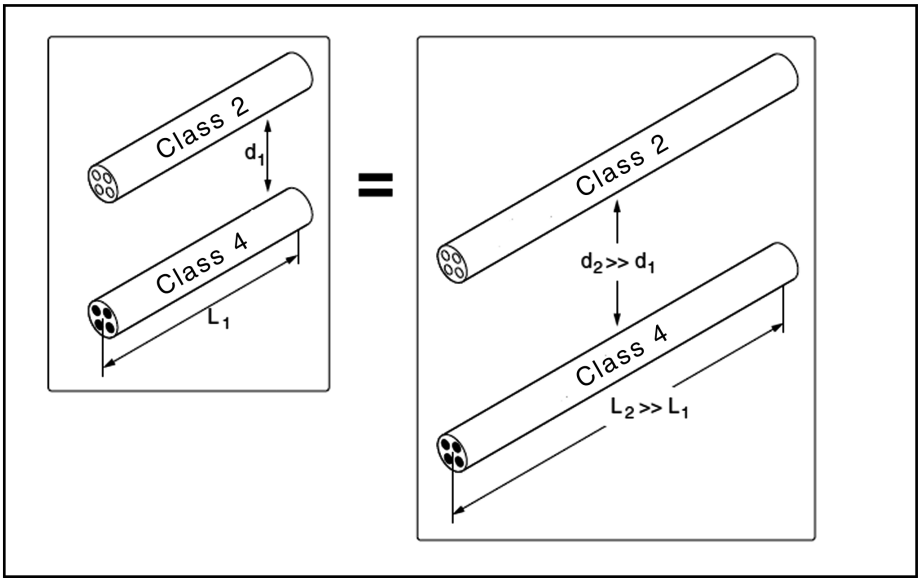


Fig. 2-12: Safety clearance between lines depending on the line length

Keep the area within the individual ground connections as small as possible:

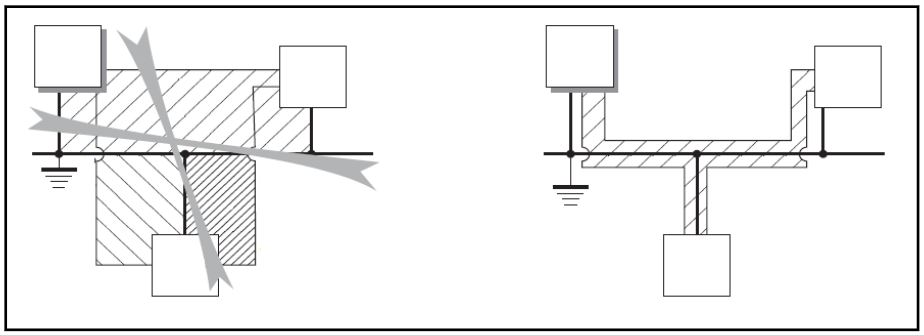
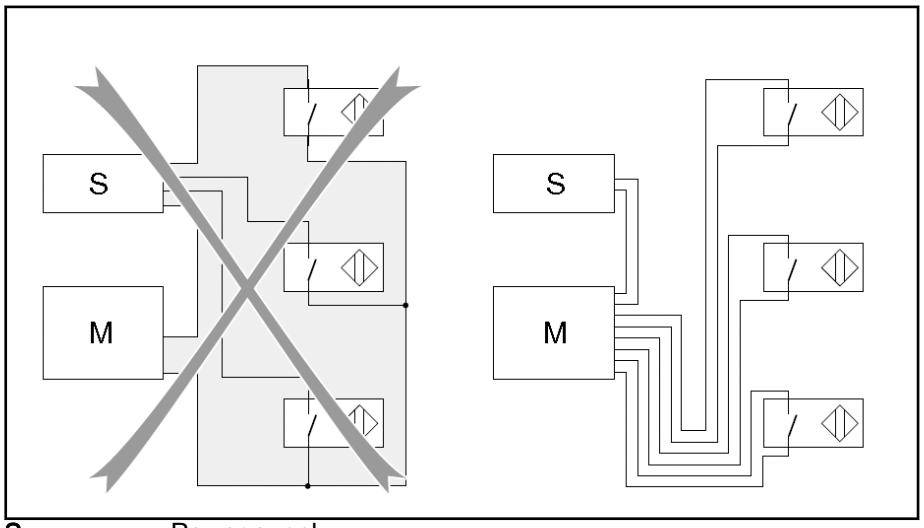


Fig. 2-13: Ground connections with bad EMC compliance (left) and good EMC compliance (right)

Run the supply and return lines as near as possible side by side. Run long lines in twisted form to minimize interference:



S Power supply
M Machine

Fig. 2-14: Supply and return lines run with bad EMC compliance (left) and good EMC compliance (right)

Continuously connect loose or unused lines of a cable to ground (chassis, cable duct, control cabinet, …) at both ends:

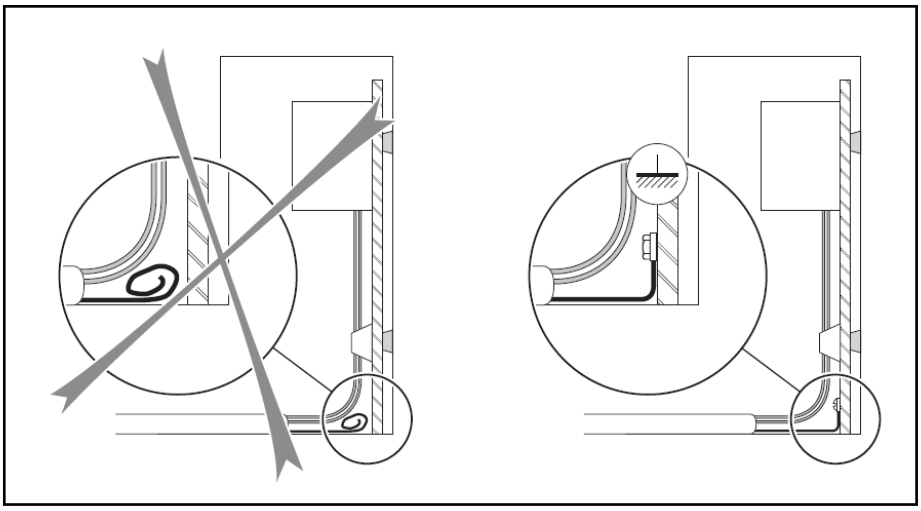


Fig. 2-15: Bad ground connection (left) and good ground connection (right) of loose or unused lines

Run lines with signals of different classes at right angles to each other:

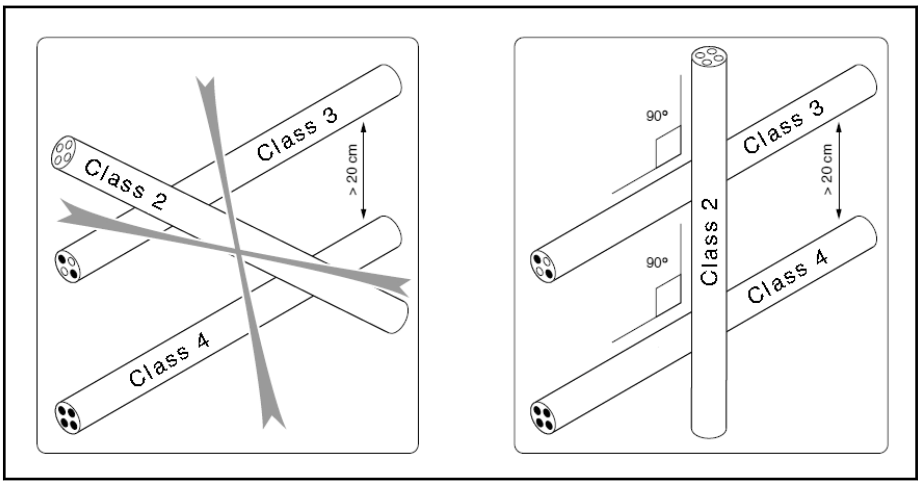
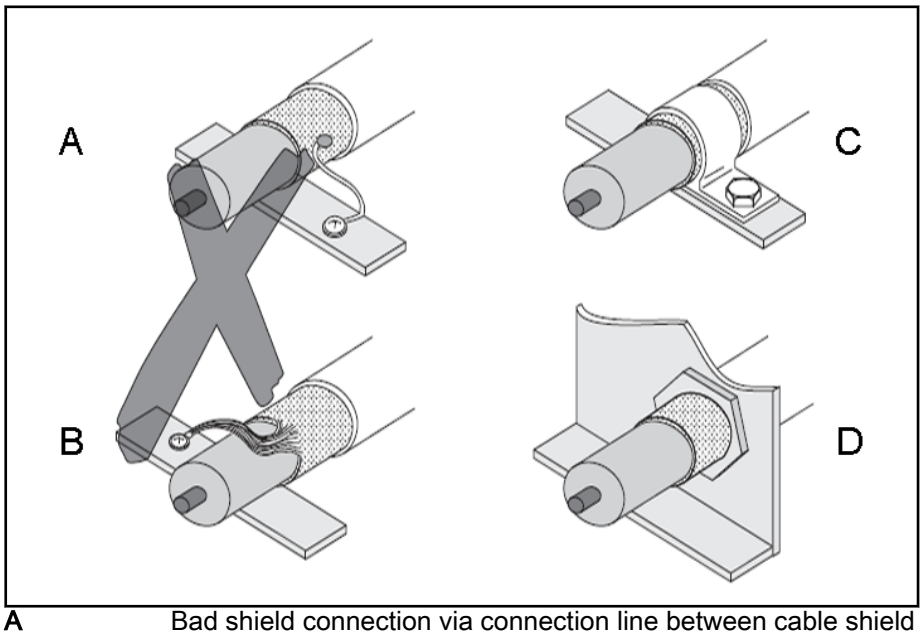


Fig. 2-16: Lines badly run (left) and lines well run (right)

2.1.6 Shielding

A good shield connection to the ground potential is important for the shielding effect.

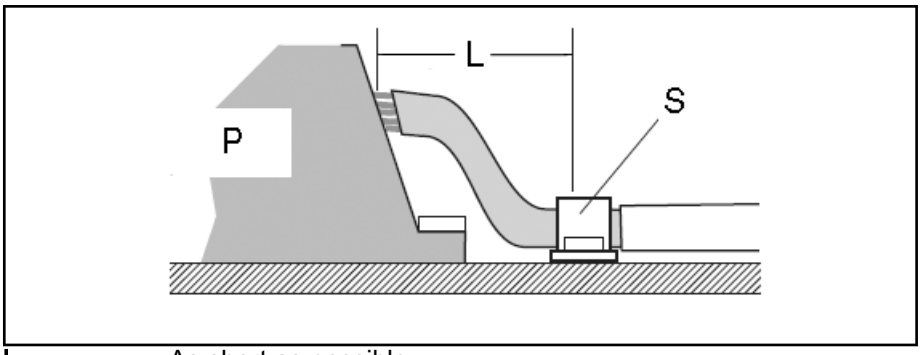
- Interference injection on lines can be considerably reduced by shielding them.
- Braided shields provide much better shielding than foil shields.
- Run unshielded lines in closed cable ducts made of metal.
- Using a metal clip or an EMC-compliant cable gland, connect the shields of shielded lines to the ground potential over a large surface area.



A Bad shield connection via connection line between cable shield and ground potential
B Bad shield connection by connecting single fibers of the braided shield to the ground potential
C Good shield connection with metal clip
D Good shield connection with EMC-compliant cable gland

Fig. 2-17: Bad and good shield connections

With plastic housings, connect the shield as near as possible to the housing. Continue the shield up to the terminal connector in or at the housing:



L As short as possible
P Housing made of plastic
S Electrical contact of shield applied via metal clip

Fig. 2-18: Shield connection for plastic housing

2.1.7 EMC filters

Function

Filtering lines is important for EMC. Filtering always takes effect in both directions:

- It increases the noise immunity
- It reduces the noise emission

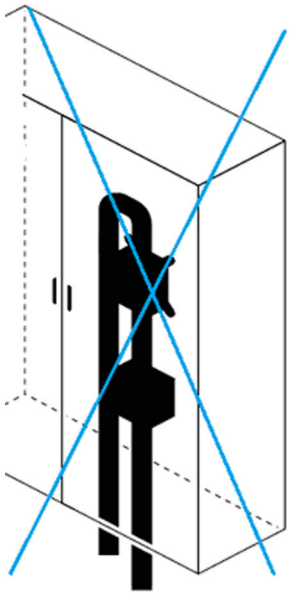
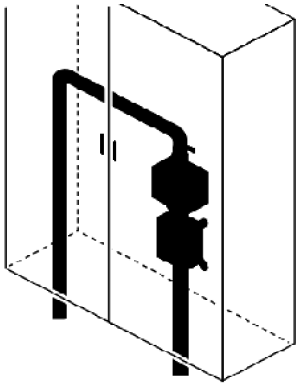
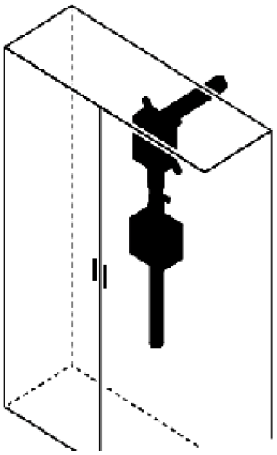
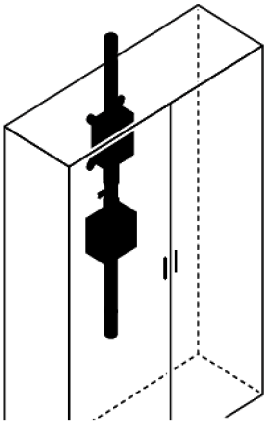
The correct function of the filter depends on the following factors:

- Point of installation
- Grounding
- Line routing

Point of installation

Good points of installation for an EMC filter:

- Directly at the feedthrough of the filtered line into the metal housing
- Directly at the device for which interference is to be suppressed

			
Bad	Good (lines have sufficient clearance)	Very good (directly at the feedthrough into the control cabinet)	Very good (directly at the device for which interference is to be suppressed)

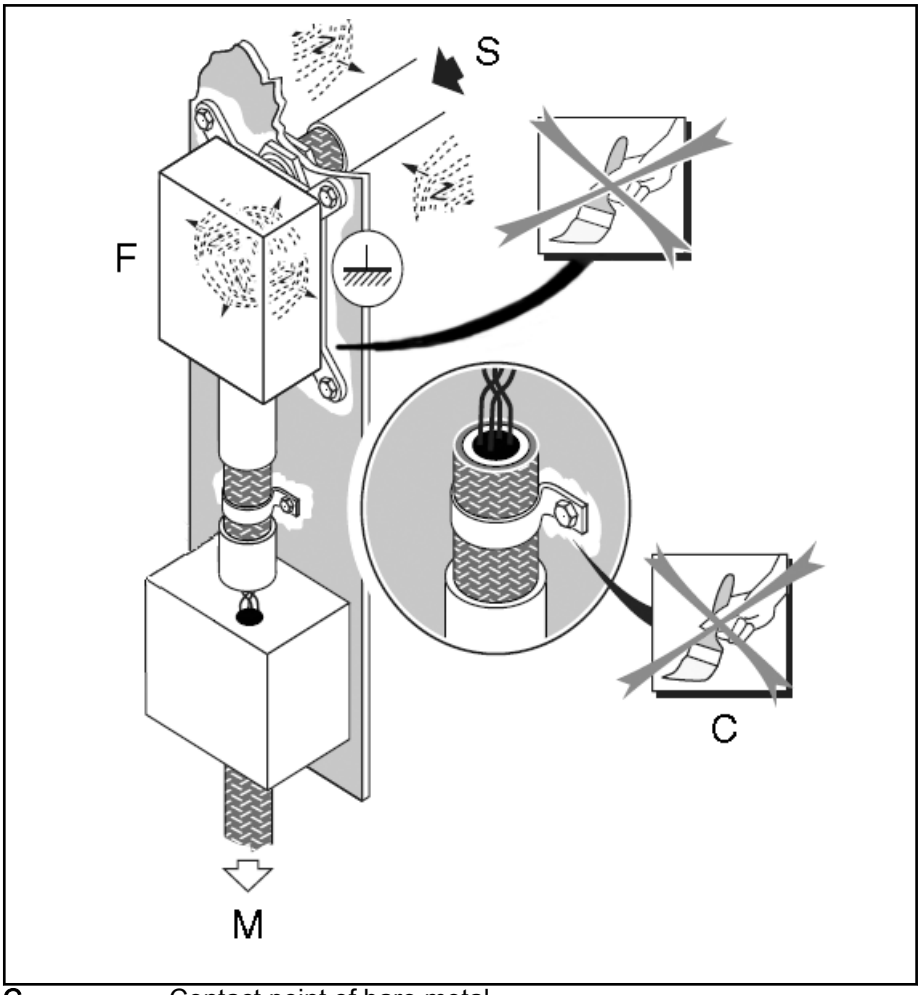
Tab. 2-4: Points of installation for EMC filters

Grounding

Ground EMC filters over a large surface area.

- All contact points have to be of bare metal. Remove substances like paint, oil, grease or insulation material adhering to the metal.
- Connect filters with mounting screws and in conductive form to the mounting plate of the control cabinet.

☞ Install the equipment grounding conductor (PE) of the EMC filter with a sufficient cross section. The cross section of the equipment grounding conductor has to match at least the cross section of an outer conductor.



C Contact point of bare metal
F Filter
M Output to the machine
S Power supply

Fig. 2-19: EMC-compliant grounding of the filter

Line routing of the EMC filter

Run input lines and output lines of the EMC filter separately.

Run filtered and unfiltered lines with the greatest possible clearance between them. If it is impossible to run the lines separately: Shield unfiltered lines.

2.1.8 EMC troubleshooting for frequency converters

Malfunction	Effect
Frequency converter interferes with analog or digital measuring devices	Analog measuring devices: Instable operation, measuring errors Digital measuring devices: Data loss
Cause	**Remedy**
Increased leakage current due to converter clock frequency on grounding system	• Connect components with low impedance to central ground point • Shield motor power cables • Use mains filters and/or converter output filters with low leakage current • Reduce motor cable length (if possible)
Unshielded motor line	Use shielded motor line
Shield not connected over a large surface area	Connect shield over a large surface area
Shield of motor line interrupted (e.g., by terminal strips, switches, …)	• Spatial separation • Use motor choke / motor filter
Additional, unshielded line run within the motor line (e.g., temperature monitoring)	Run additional lines separately and shield them
Too long unshielded wire ends of the motor line	Shorten unshielded wire ends to a maximum of 40 mm

Tab. 2-5: Information on EMC troubleshooting, part 1

Malfunction	Effect
Frequency converter exceeds noise emission level on the mains side	Reception interference of telecommunication devices
Cause	**Remedy**
Terminal strips for the motor line placed directly next to supply terminals	Spatially separate terminal strips for the motor line from supply terminals and other control terminals by a distance of at least 100 mm
Painted mounting plate	Optimize ground connection: • Completely remove paint • Use zinc-coated mounting plate
RF short circuit	• Check line routing • Make sure EMC zones are separated
Mains filter overloaded or defective because nominal current or leakage current is too high	Choose correct mains filter with regard to rated electrical values (nominal current, max. leakage capacitance, min./max. Y-capacitance) (see corresponding Project Planning Manuals of the drive components used)

Tab. 2-6: Information on EMC troubleshooting, part 2

2.1.9 Examples of EMC-compliant design of a control cabinet

ctrlX DRIVE with XLI mains connection module, XVR supply unit and XMS inverter

The exemplary figure below illustrates components and connections within a control cabinet.

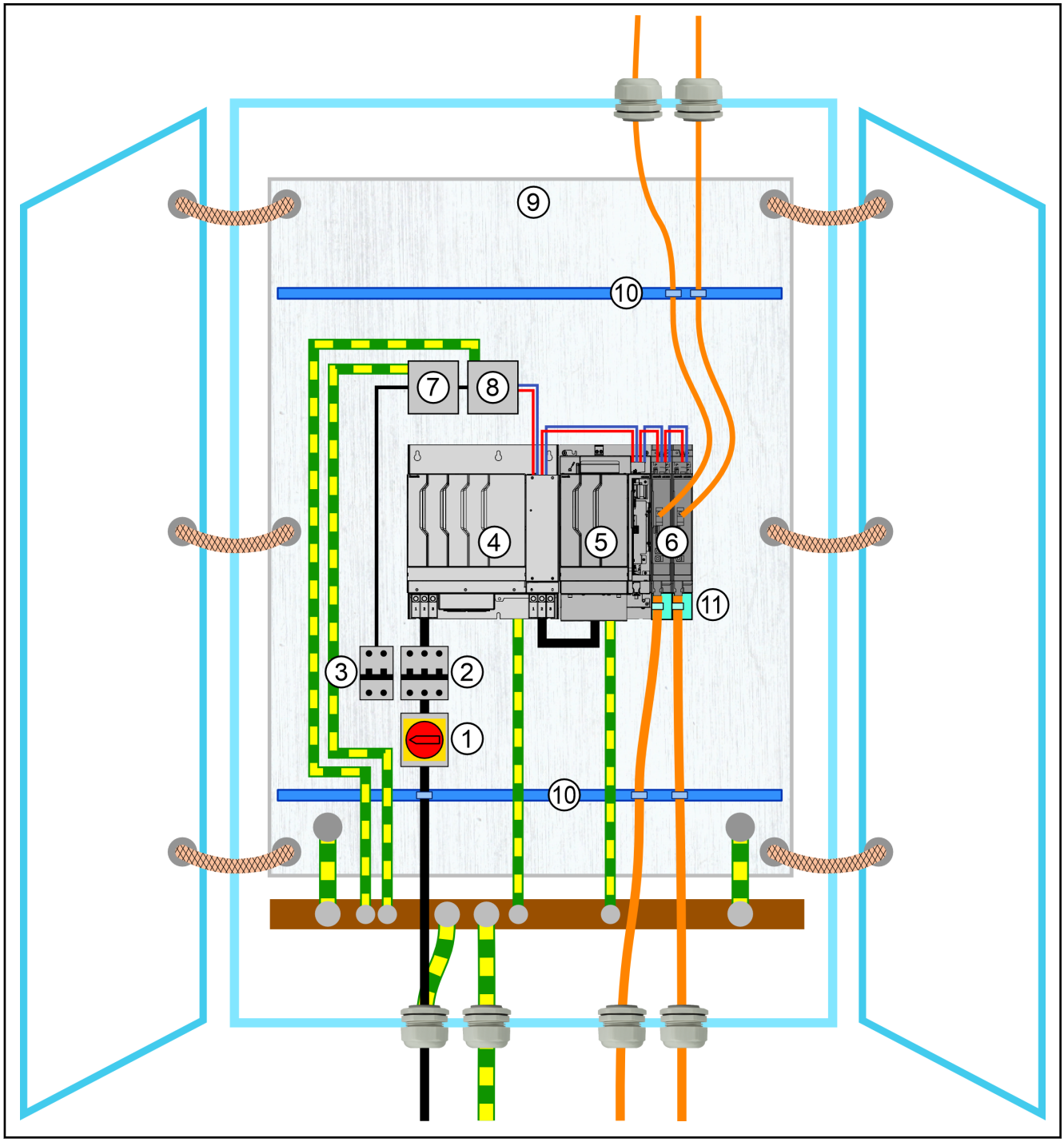
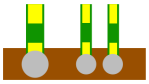


Fig. 2-20: Components and connections within a control cabinet

Components			Connections	
1	Main switch			Equipment grounding conductor
2	Circuit breakers/fuses			Lines of mains voltage supply
3	Switch of control voltage supply			Motor cable
4	XLI mains connection module			Encoder line
5	XVR supply unit			Lines of control voltage supply
6	XMS inverter			Grounding strip
7	Mains filter for control voltage supply			Connection bar of equipment grounding conductor; PE busbar
8	Control voltage supply			
9	Unpainted, zinc-coated mounting plate			
10	Strain relief of the cables with top-hat rail/C-rail/ screw mounting or bracket clips for C-rail			
11	Motor power cable shield connection (e.g., with XAS2 accessories)			

Tab. 2-7: Components, connections

IndraDrive M with HMV supply unit and HMS inverter

The exemplary figure below illustrates components and connections within a control cabinet.

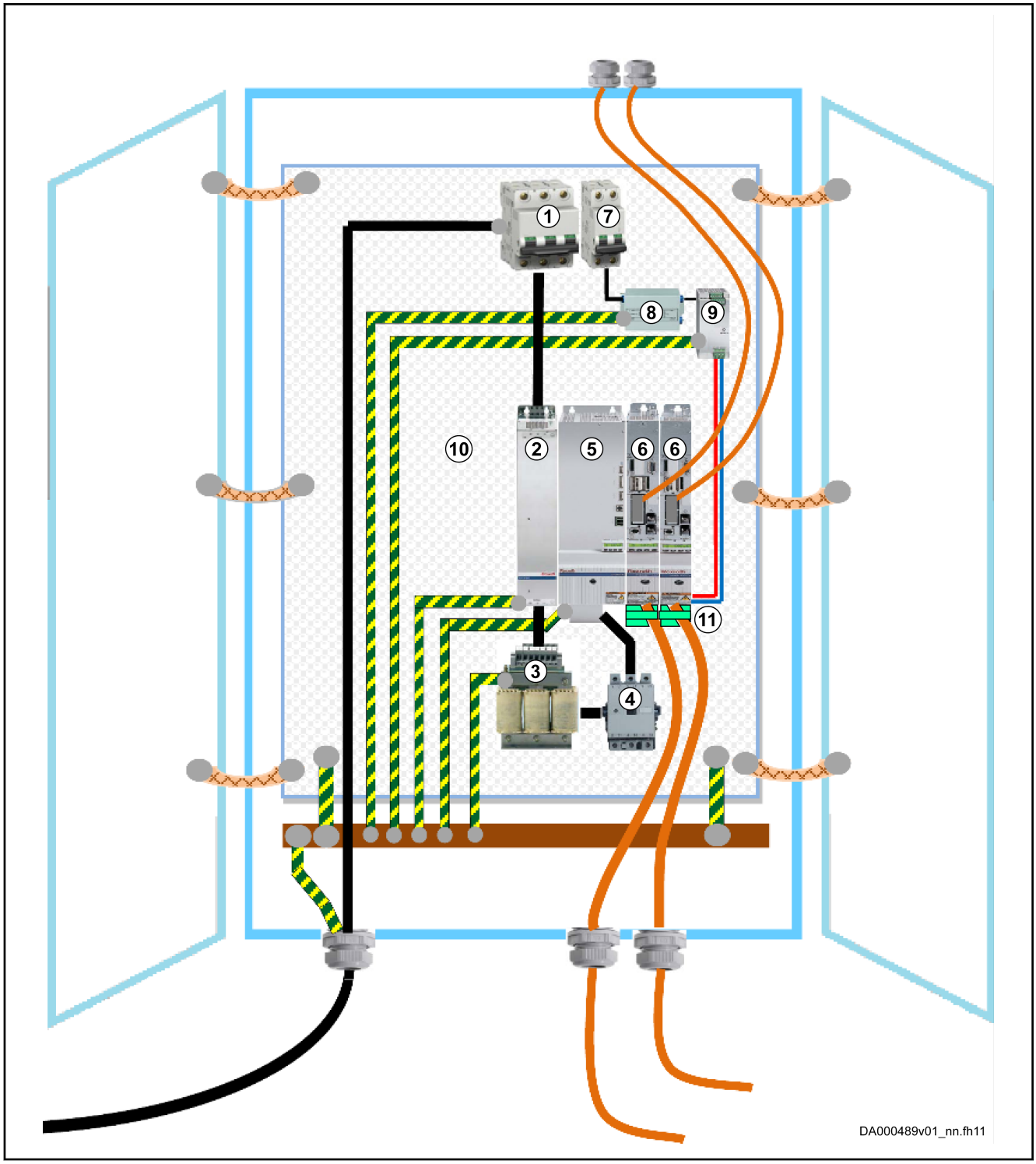


Fig. 2-21: Components and connections within a control cabinet

Components			Connections	
1	Main switch			Equipment grounding conductor
2	Mains filter for supply units and drive controllers			Lines of mains voltage supply
3	Mains choke			Motor cable
4	Mains contactor			Encoder line
5	Supply unit			Lines of control voltage supply
6	Inverter			Grounding strip
7	Switch of control voltage supply			Connection bar of equipment grounding conductor; PE busbar
8	Mains filter for control voltage supply			
9	Control voltage supply			
10	Unpainted, zinc-coated mounting plate			
11	Motor power cable shield connection (e.g., with HAS2 accessories)			

Tab. 2-8: Components, connections

Rexroth Frequency Converter Fv or EFC

The exemplary figure below illustrates components and connections within a control cabinet.

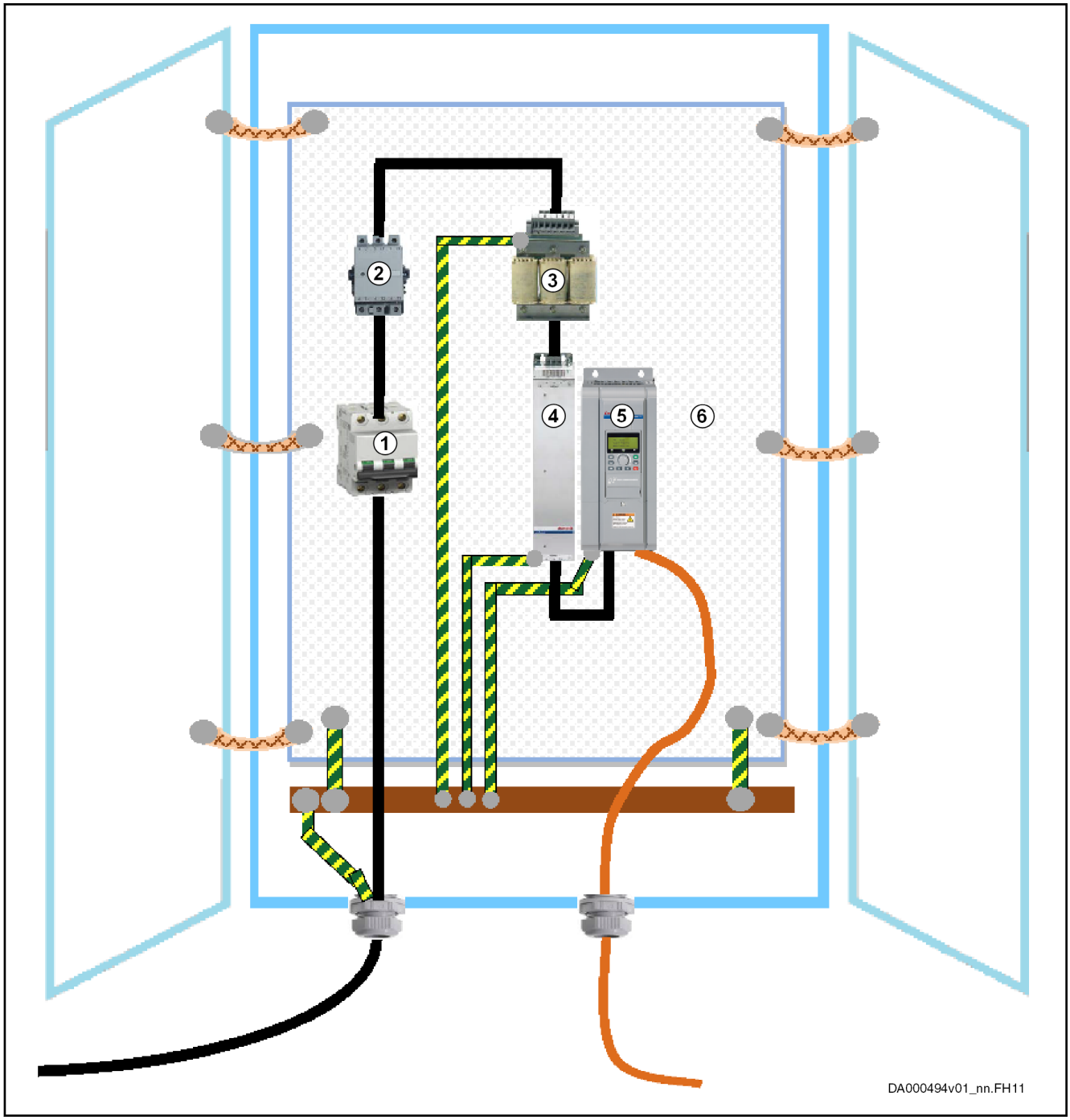
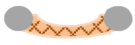
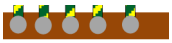


Fig. 2-22: Components and connections within a control cabinet

Components			Connections	
1	Main switch			Equipment grounding conductor
2	Mains contactor			Lines of mains voltage supply
3	Mains choke			Motor cable
4	Mains filter			Grounding strip
5	Frequency converter			Connection bar of equipment grounding conductor; PE busbar
6	Unpainted, zinc-coated mounting plate			

Tab. 2-9: Components, connections

Example with equipment grounding connections at mounting plate

As an alternative to the connection bar of the equipment grounding conductor, you can also connect the equipment grounding conductors of the components to the mounting plate of the control cabinet.

The exemplary figure below illustrates components and connections within a control cabinet.

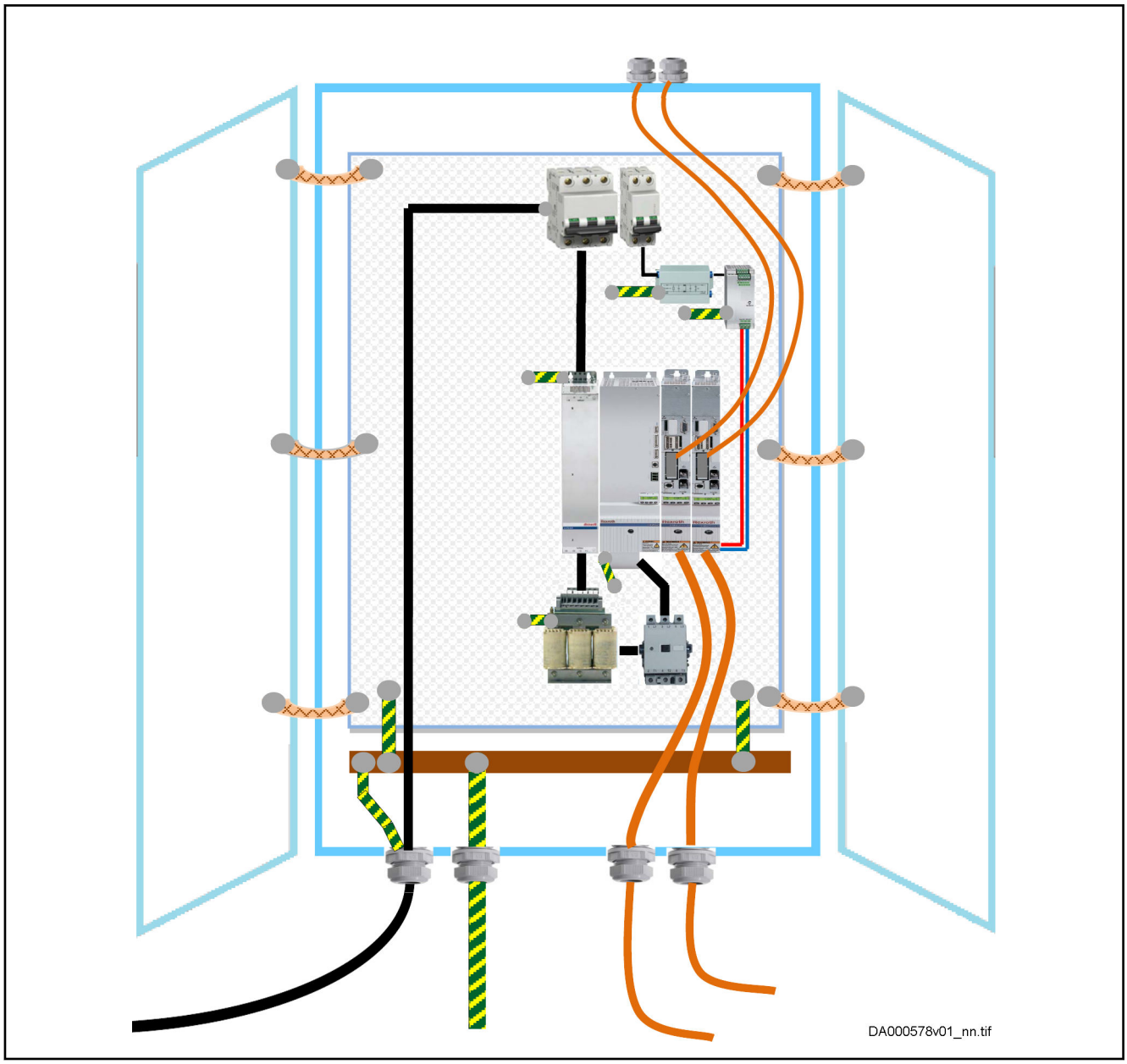


Fig. 2-23: Components and connections within a control cabinet

Components			Connections	
1	Main switch			Equipment grounding conductor
2	Mains filter for supply units and drive controllers			Lines of mains voltage supply
3	Mains choke			Motor cable
4	Mains contactor			Encoder line
5	Supply unit			Lines of control voltage supply
6	Inverter			Grounding strip
7	Switch of control voltage supply			Connection bar of equipment grounding conductor; PE busbar
8	Mains filter for control voltage supply			
9	Control voltage supply			
10	Unpainted, zinc-coated mounting plate			

Tab. 2-10: Components, connections

2.2 Sytronix

2.2.1 Variable-speed pump drives

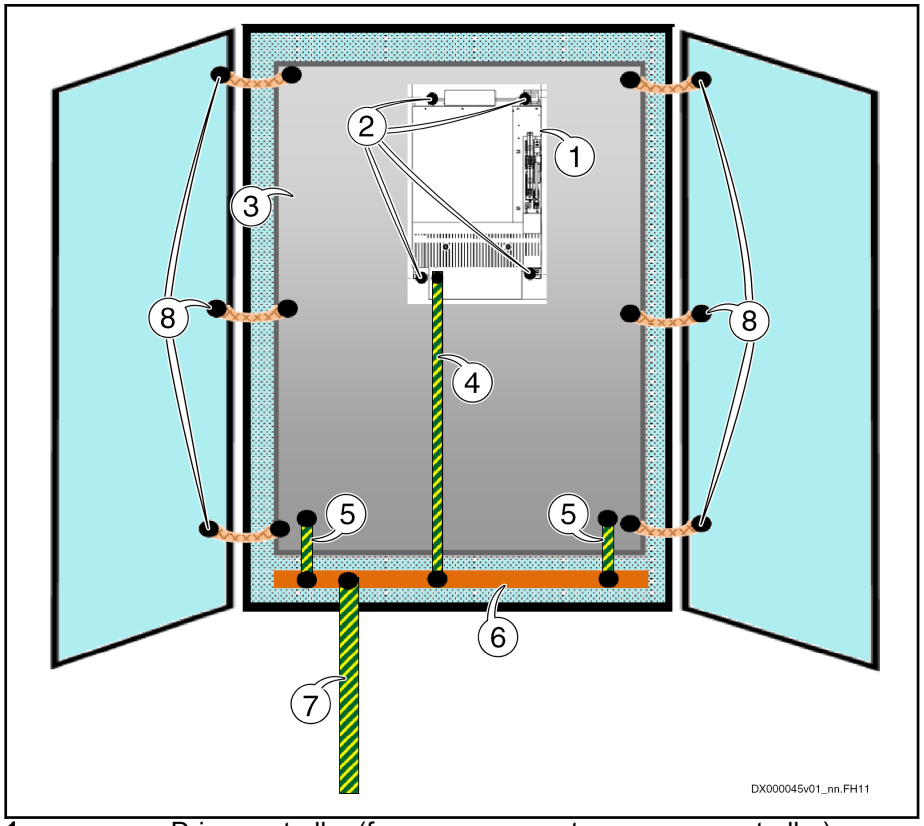
Sytronix are variable-speed pump drives and consist of the following components:

- Drive controller (frequency converter or servo controller)
- Motor (electric standard or servo motor)
- Hydraulic pump

2.2.2 EMC measures for the control cabinet

- **Back panel of control cabinet: unpainted, zinc-coated mounting plate**
- **Mount ground bar as the central grounding point in the control cabinet**
- **Connect ground bar to mounting plate in low-impedance form**

  With multiple mounting plates: Connect each single mounting plate in low-impedance form to ground bar
- **Mount drive controller directly to the mounting plate**



1	Drive controller (frequency converter or servo controller)
2	Mounting screws of drive controller; drive controller has direct contact to mounting plate
3	Unpainted, zinc-coated mounting plate
4	Equipment grounding connection of drive controller to ground bar
5	Low-impedance connection of mounting plate to ground bar
6	Ground bar as the central grounding point in the control cabinet
7	External protective grounding conductor, connection to installation grounding system
8	EMC-compliant connection of control cabinet doors to control cabinet housing

Fig. 2-24: EMC-compliant grounding system in the control cabinet

The equipment grounding connection of the drive controller (4) can also be established at the mounting plate:

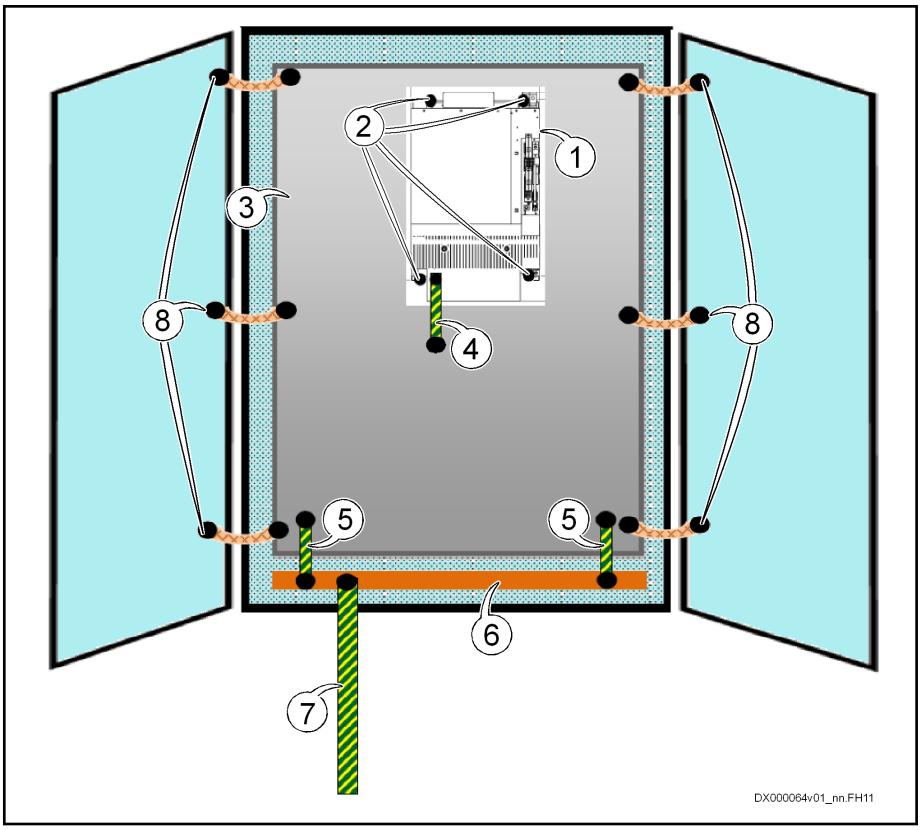
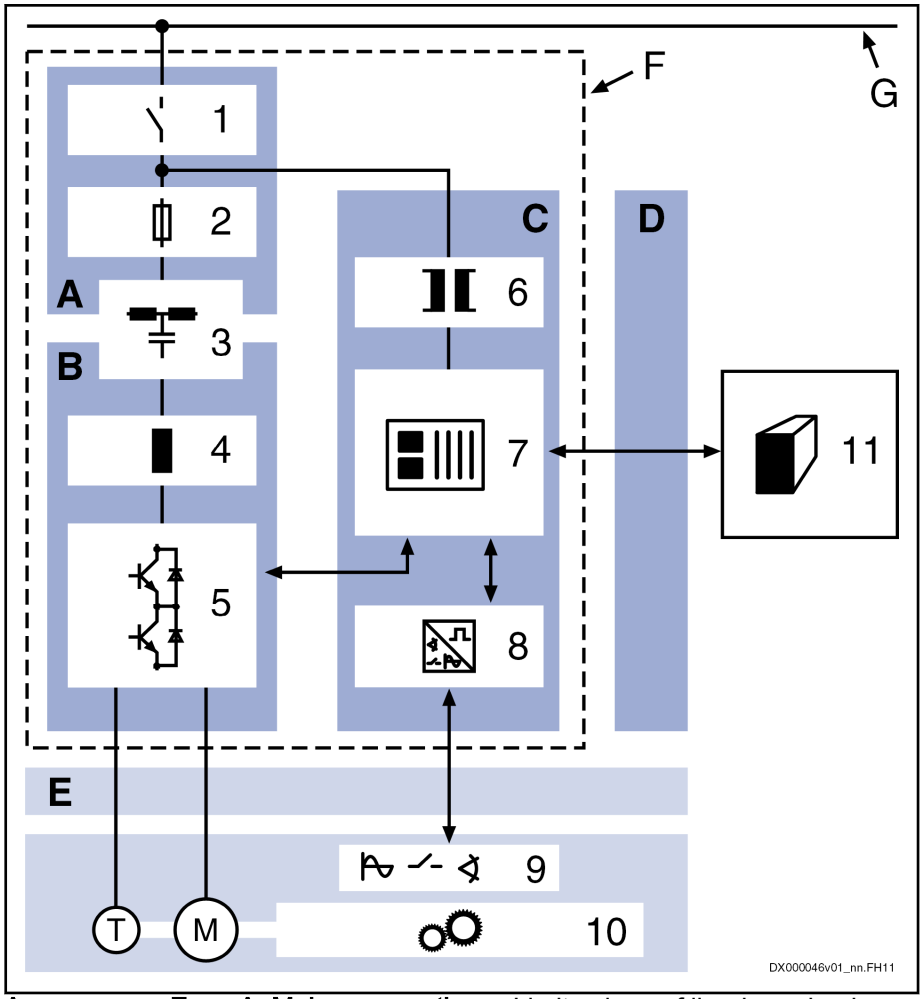


Fig. 2-25: EMC-compliant grounding system in the control cabinet

2.2.3 EMC zones of electric drive systems



A	**Zone A: Mains connection** → Limit values of line-based noise emission and noise immunity must be complied with
B	**Zone B: Power electrics and electronics** → Potential sources of interference
C	**Zone C: Control and sensors** → Potential noise receivers
D	**Zone D: Peripherals and interfaces** → Limit values of noise immunity must be complied with
E	**Zone E: Motor and supply lines** → Potential sources of interference
F	Control cabinet
G	Mains
M	Motor
T	Encoder
1	Main switch
2	Contactor, fuse
3	Mains filter
4	Mains choke
5	Power converter
6	Transformer, power supply unit
7	Control
8	Sensor evaluation
9	Sensors
10	Drive mechanics

11 External master computer

Fig. 2-26: EMC zones of an electric drive system

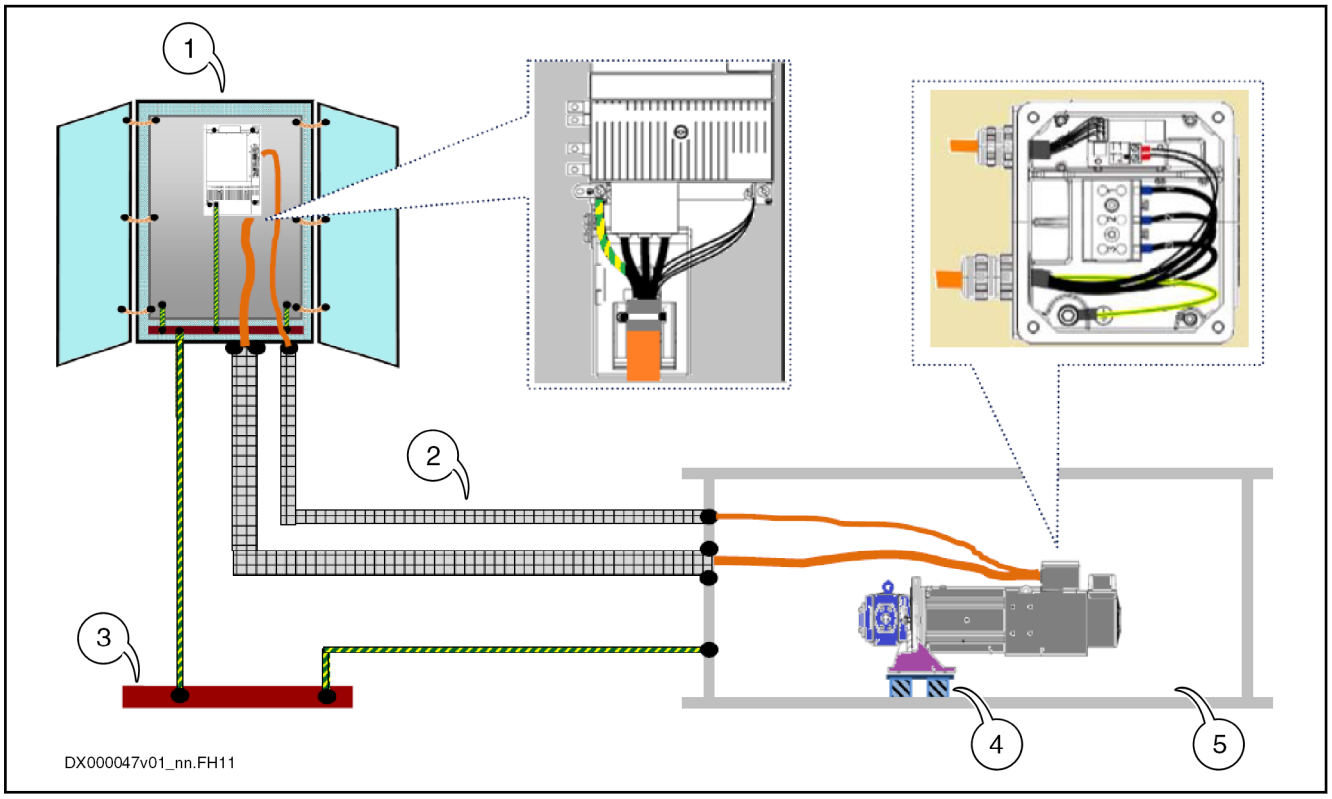
An important EMC measure within and outside of the control cabinet is to divide it into EMC zones.

1. Classify devices in accordance with their properties as sources of interference and noise receivers
2. Divide installations into zones of equal noise emission and noise immunity
3. Separate the zones (as far as possible and useful)
   - Spatial separation, e.g. with metal housings and grounded separating sheets
   - Electrical separation at the transitions between the zones, e.g. by
     – Completely separated line routing
     – Shielded lines
     – Filter
     – Galvanic signal isolation

2.2.4 EMC measures for motor-pump unit

Overview

- Connect all metal parts of the installation to the grounding system with low impedance
- Connect the shield of the motor power cable to the housing of the drive controller over a large surface area
- Connect the shield of the encoder cable to the housing of the drive controller over a large surface area

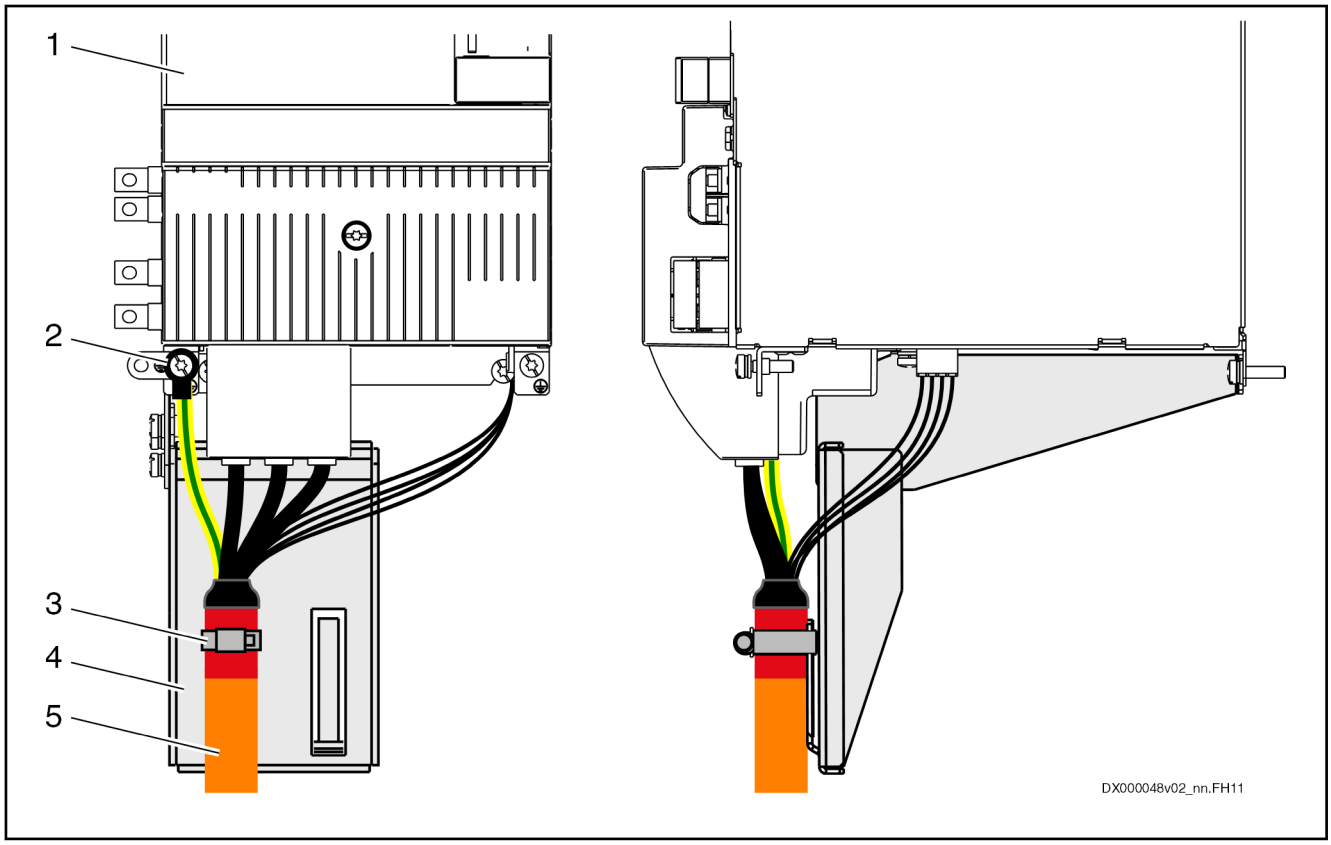


1	Control cabinet with drive controller (see chapter 2.2.2 "EMC measures for the control cabinet" on page 46)
2	Cable ducts made of metal (optional)
3	Central grounding point of the installation
4	Vibration buffer (optional)
5	Machine with motor-pump unit

Fig. 2-27: Drive system

EMC-compliant connection of the motor cable at the drive controller

Example: HMS01.1N-W0210 with HAS02.1-003 accessories



1	Drive controller (HMS01.1N-W0210)
2	Connection point of equipment grounding conductor (PE)
3	Metal clip for shield connection (HAS02.1-003 accessories)
4	Plate for shield connection (HAS02.1-003 accessories)
5	Motor power cable

Fig. 2-28: EMC-compliant connection of the motor cable at the drive controller

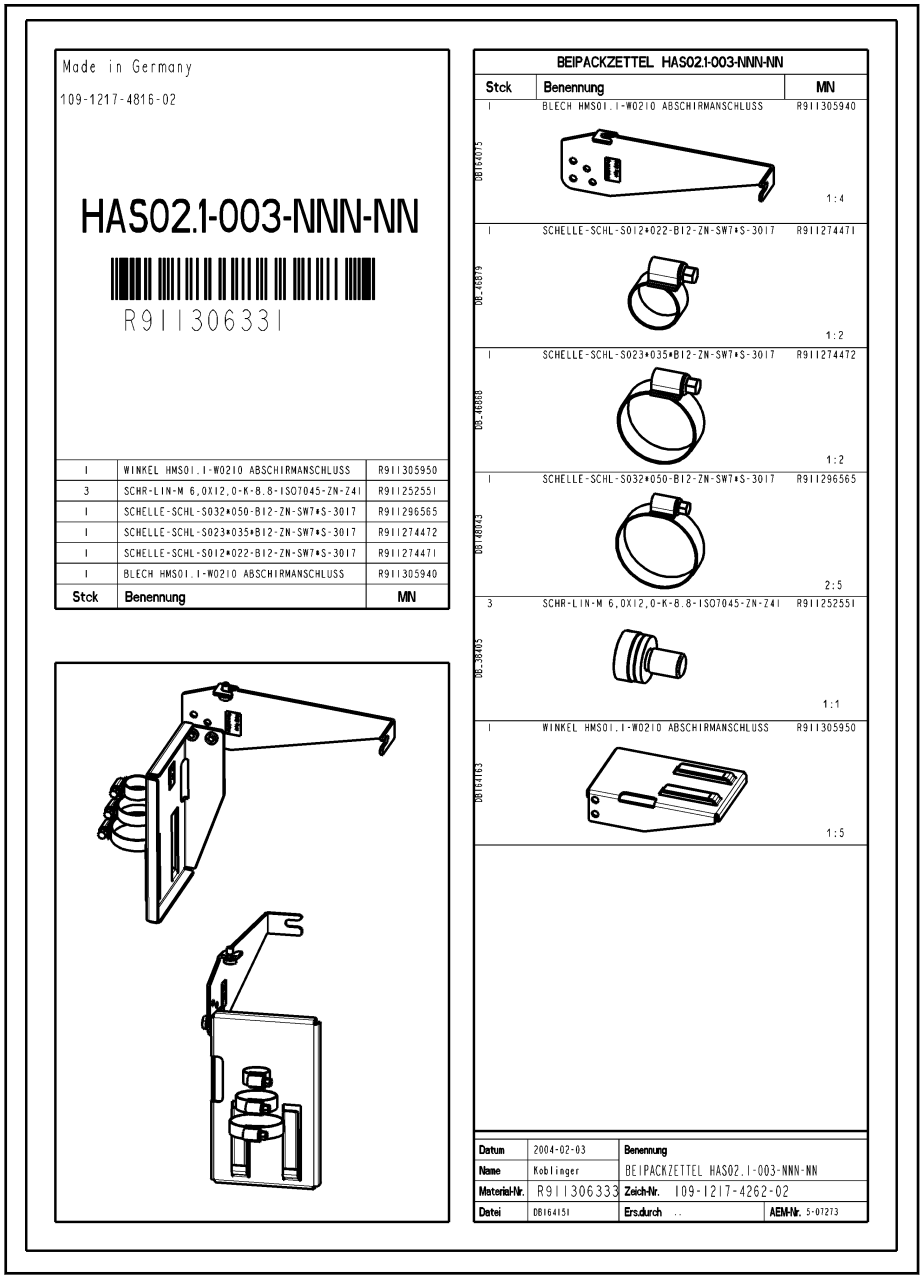


Fig. 2-29: Product insert HAS02.1-003

Example: HCS02.1E-W0028 with HAS02.1-002 accessories

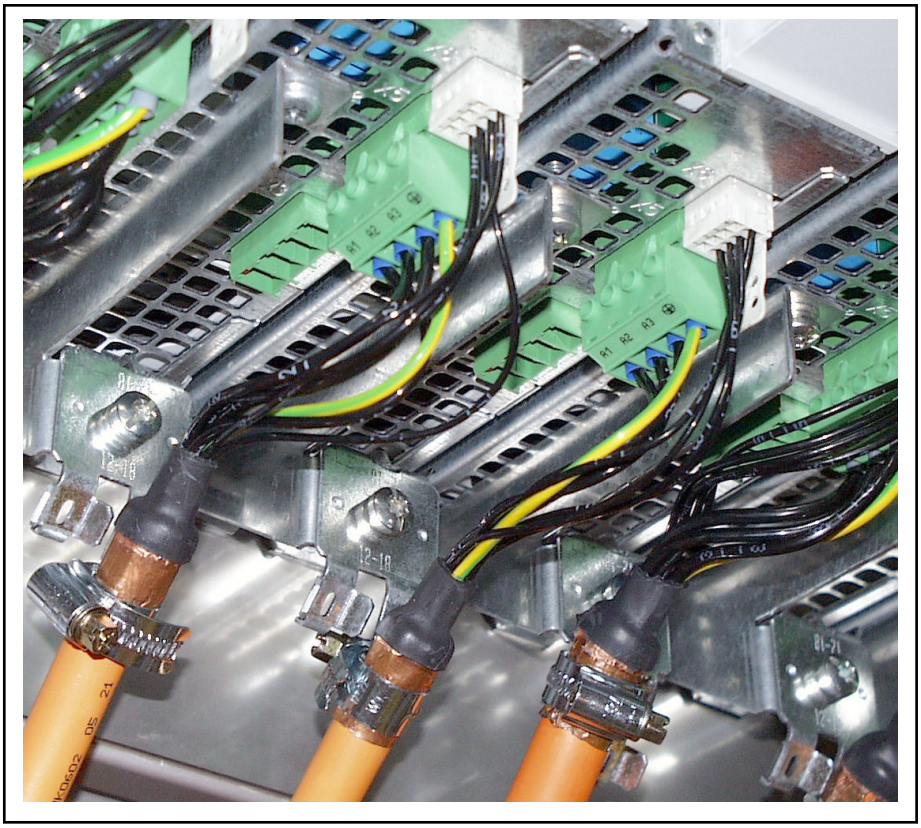


Fig. 2-30: HCS02.1E-W0054 with HAS02.1-002 accessories

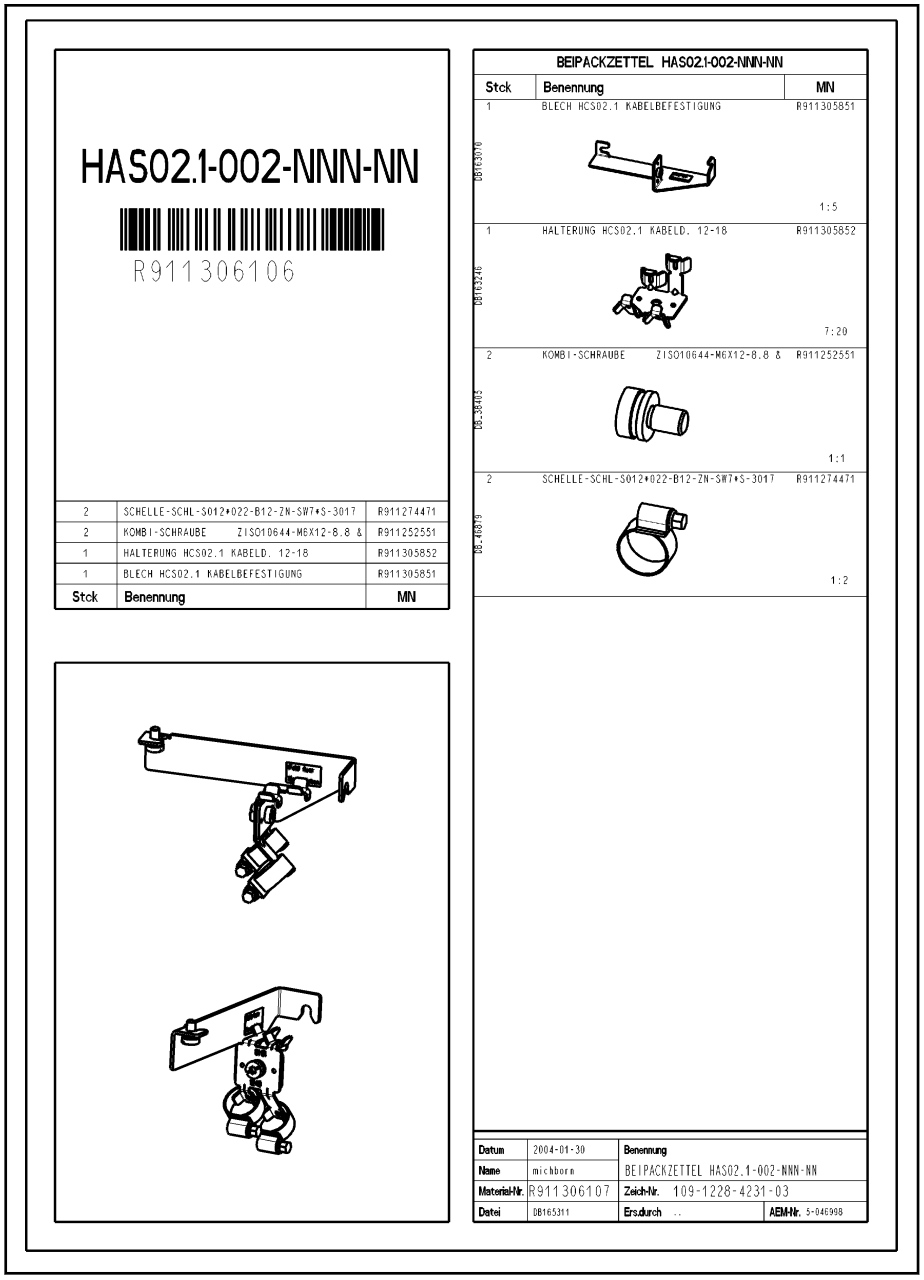
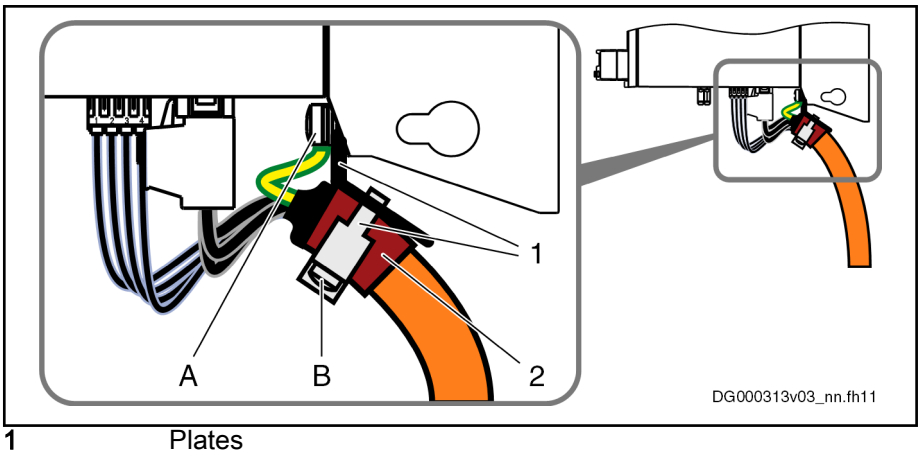


Fig. 2-31: Product insert HAS02.1-002

Example: HCS01.1E-W0028 with HAS09 accessories



1 Plates
2 Shield of motor cable
A Screw (M5×12 or M5×16); tightening torque: 5 Nm
B Screw (M5×30); tightening torque: 1 Nm

Fig. 2-32: Motor cable shield connection

HAS09.1-001-NNN-NN

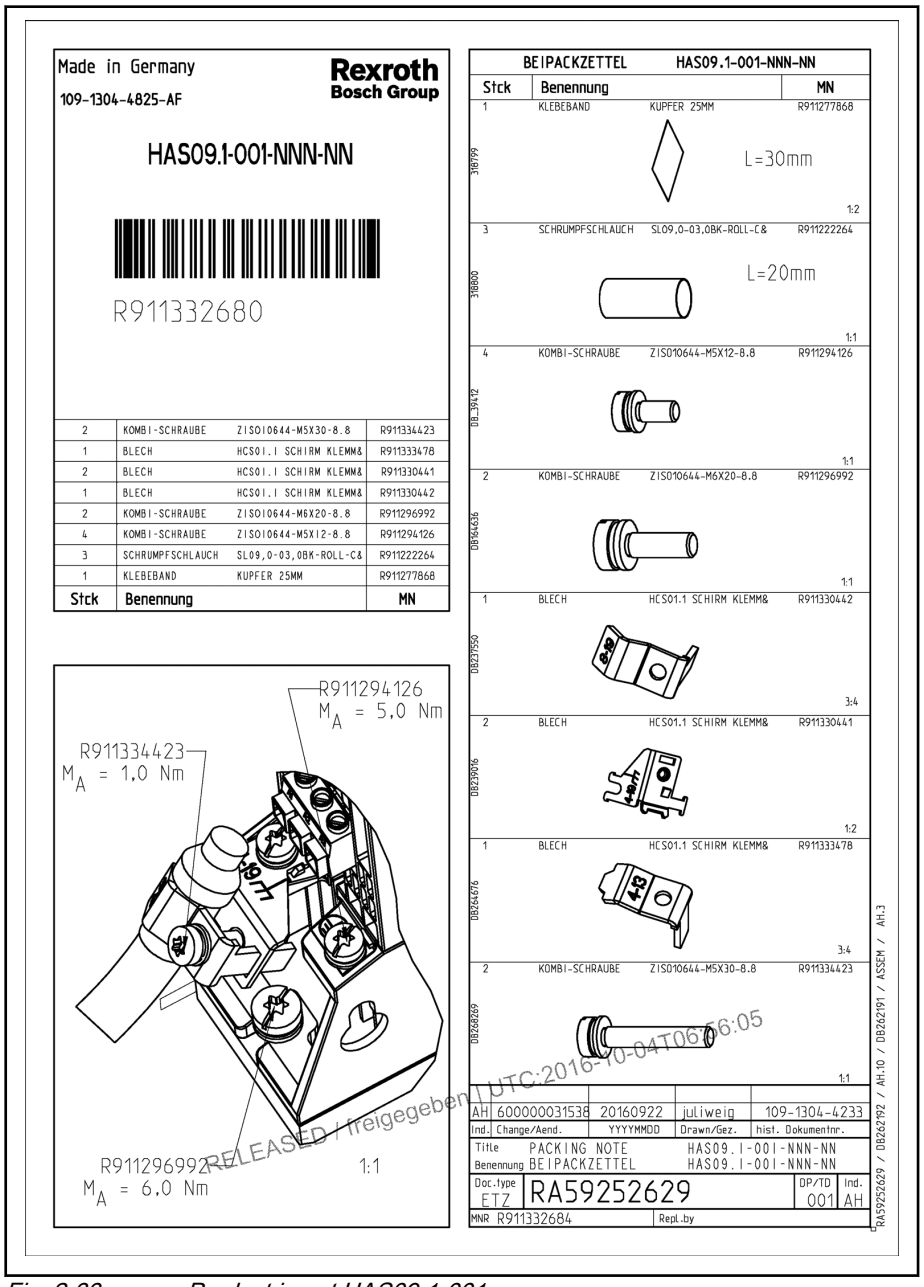


Fig. 2-33: Product insert HAS09.1-001

Example: Frequency Converter Fv with accessories FVAM01.1-GROUNDING-EXTENSION-...

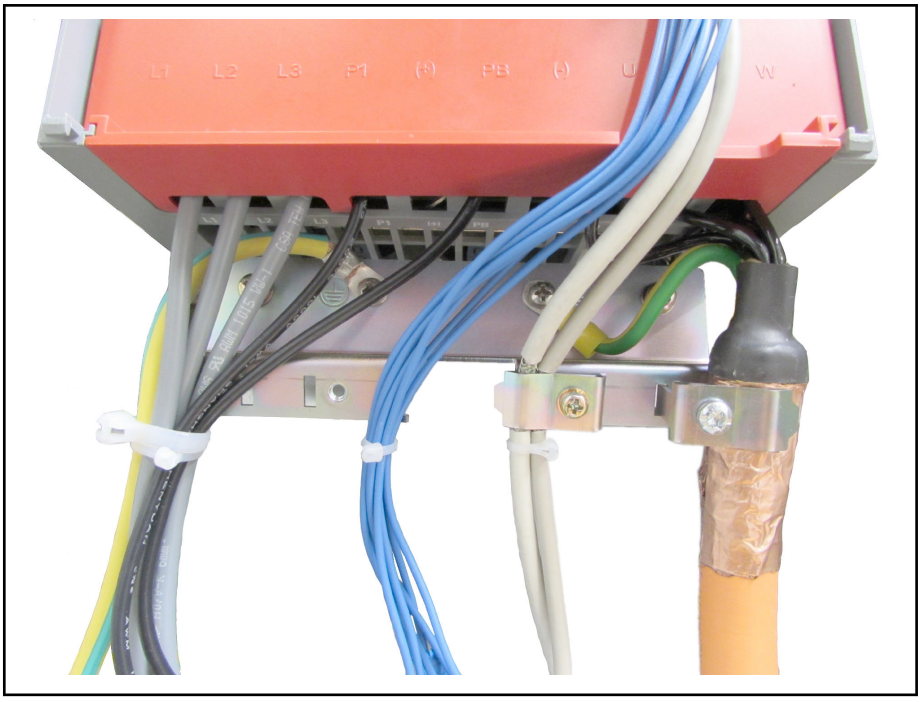


Fig. 2-34: Shield connection

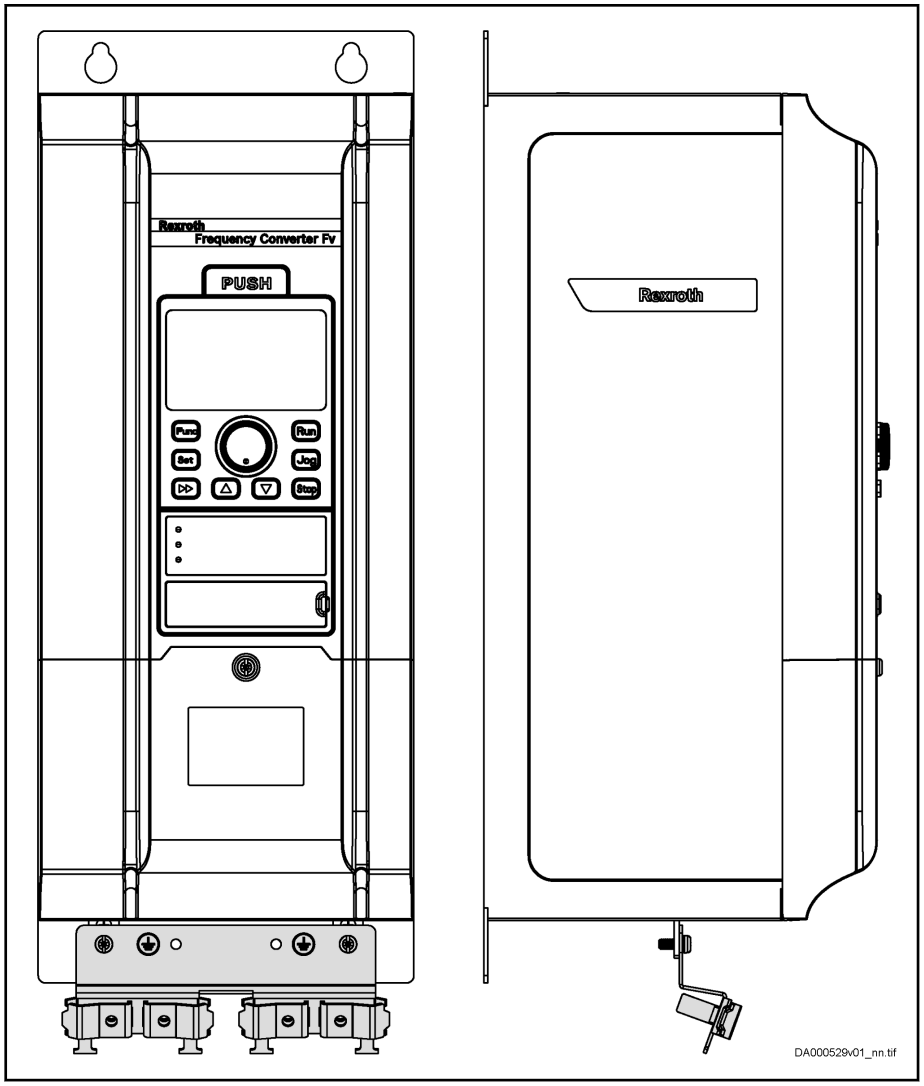


Fig. 2-35: Accessories FVAM01.1-GROUNDING-EXTENSION-...

Example: Frequency Converter EFC 5610 with accessories FEAM03.1-00x-NN-NNN

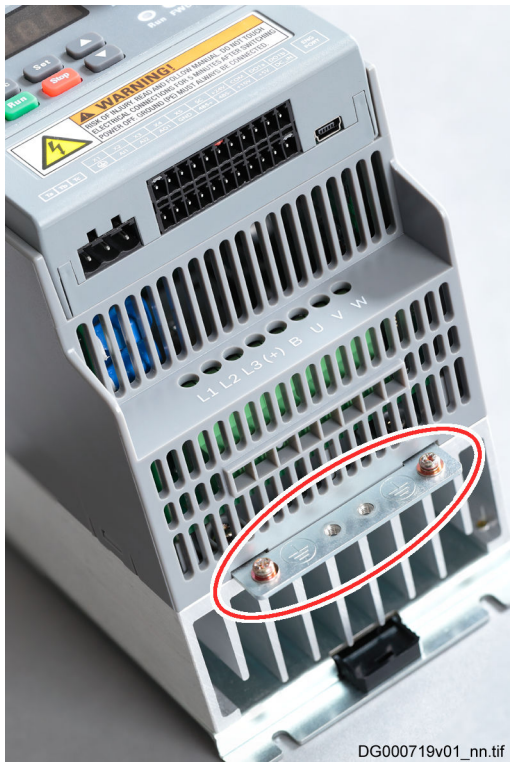


Fig. 2-36: Frequency Converter EFC 5610; connection point for accessories FEAM03.1

The shielding layer of the shielded cables has to be reliably connected to the shielding terminals of the frequency converter. Accessories (one connector and two screws) for the shielded cable connection are available for easier connection.

Illustration of dimensions and connection

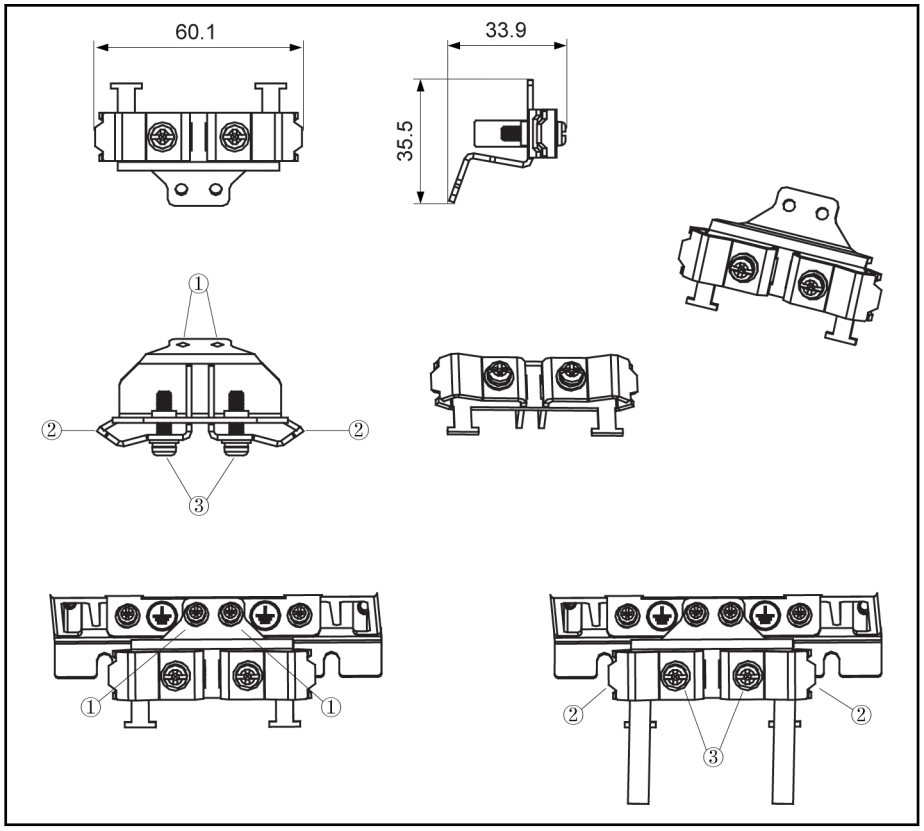


Fig. 2-37: Shielded cable connection with accessories for 0K40...4K00

How to proceed for connecting

Step 1: Place component ① of the connector on the two screw holes inside of the symbols ⏚ and tighten the screws.

Step 2: Insert the shielded cables through the component ② of the connector so that the shielding layer has reliable contact with the metal.

Step 3: Tighten the two screws of the accessories (component ③).

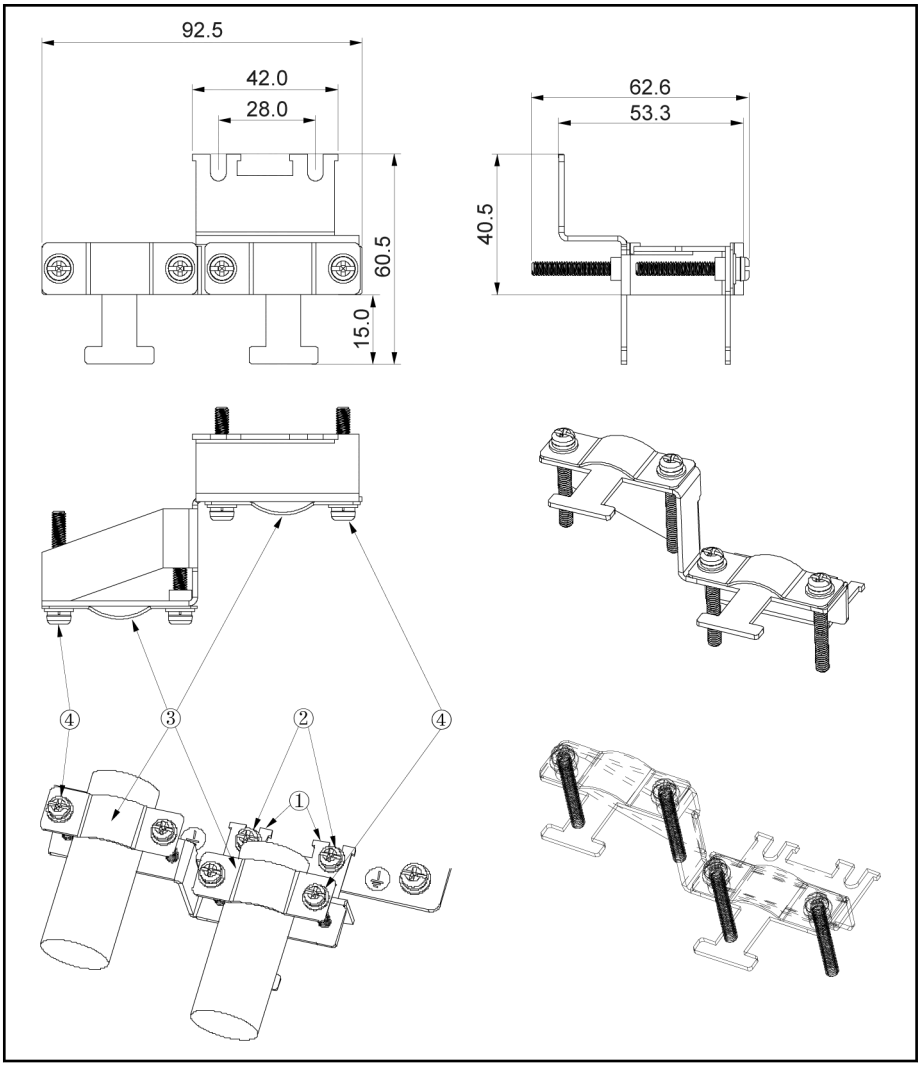


Fig. 2-38: Shielded cable connection with accessories for 5K50...18K5

How to proceed for connecting

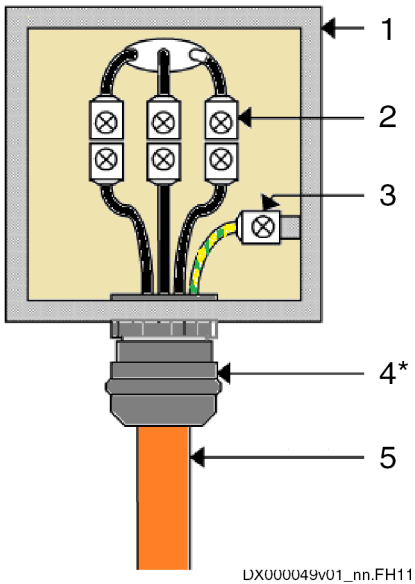
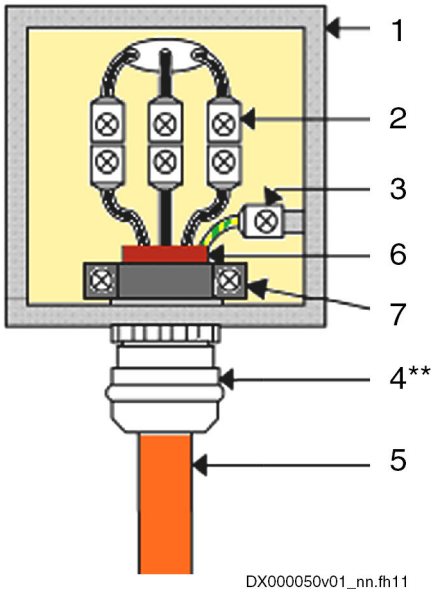
Step 1: Place component ① of the connector on the two screw holes inside of the symbols ⏚ and tighten the screws. (Component ②: M4 x 12).

Step 2: Insert the shielded cables through the component ③ of the connector so that the shielding layer has reliable contact with the metal.

Step 3: Tighten the four screws of the accessories (component ④: M4 x 45).

EMC-compliant connection at the motor terminal box

Options

Shield connection via cable gland	Shield connection via metal clip	
		1. Motor terminal box 2. Motor terminals 3. Ground terminal (PE) 4. Cable gland * EMC-compliant ** not EMC-compliant 5. Motor power cable 6. Cable shield 7. Metal clip

Tab. 2-11: Optimum EMC-compliant connection at the motor terminal box

2.3 Documentations

Document	Edition	Title
DIN EN 61800-3	09/2012	Adjustable speed electrical power drive systems – Part 3: EMC requirements including specific test methods
DIN IEC 60034-25 (draft)	06/2006	Rotating electrical machines – Part 25: Guide for the design and the operating behavior of cage induction motors specifically sized for the converter mode

Tab. 2-12: Documentations

2.4 References

Title	Edition	Published by
EMV leicht erreicht [EMC easily achieved]	2001	ZVEI (Zentralverband Elektrotechnik und Elektroindustrie e. V.)
EMV-gerechter Schaltschrankaufbau - Leitfaden [EMC-compliant control cabinet design - Guide]	2001, version 1	DEMVT (Deutsche Gesellschaft für EMV-Technologie e. V.)
Schaltschrankbau Praxistipps [Practical tips for control cabinet design]	2005	Rittal GmbH & Co KG
EMV-Leitfaden für elektrische Antriebstechnik [EMC guide for electric drive technology]	2005-06	ZVEI (Zentralverband Elektrotechnik und Elektroindustrie e. V.)

Tab. 2-13: References

3 Mains connection

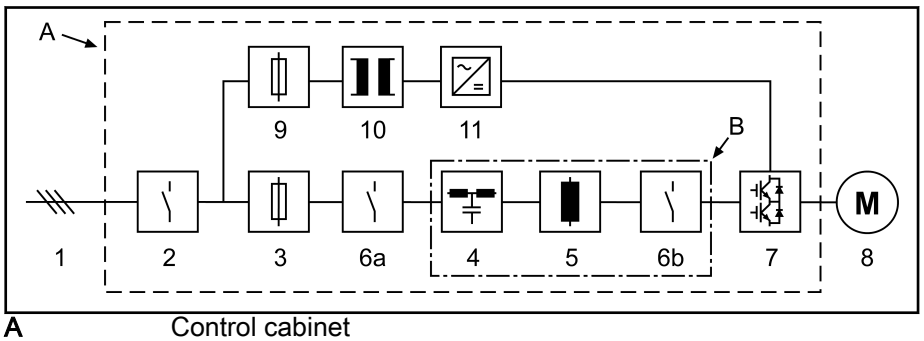
3.1 ctrlX DRIVE components

3.1.1 Drive controllers

ctrlX DRIVE		
Converter: • XCS • XCD	Inverter: • XMS • XMD • XMQ	Supply units: • XVE • XVR + XLI XLI: mains connection module; contains mains filter, mains choke, mains contactor

Tab. 3-1: Drive controllers of the ctrlX DRIVE product range

3.1.2 Order of the components



A Control cabinet
B XLI mains connection module; required for regenerative supply units XVR
1...11 See table below
Fig. 3-1: Order of the components for mains connection

No.	Component	Description	Further information [1)]
1	Mains voltage supply	Mains voltage of the drive system (e.g., 3 AC 400 V). If necessary, this mains voltage is beforehand transformed by a transformer to the value allowed for the drive system. The allowed mains voltage results from the technical data of the drive components. TN mains (e.g.: TN-S): Run equipment grounding conductor (PE) and neutral conductor separately.	• R911386579: – Chapter "Mains connection"
2	Main switch	Switches on or off the mains voltage supply of the entire drive system. Before maintenance work at the drive system, the mains voltage supply is interrupted with the main switch.	-

No.	Component	Description	Further information [1)]
3	Fuses	Fuses or circuit breakers protect against too high currents.	• R911386579: – Chapter "Sizing the line cross sections and fuses"
4	Mains filter	Mains filters reduce radio interference and mains pollution.	• R911386579: – Chapter "Selecting the mains filter"
5	Mains choke	Mains chokes reduce harmonics in the mains current.	• R911386579: – Chapter "Determining the mains choke"
6	Mains contactor	Electrically activated switch that switches on and off the voltage for the successive drive controller in a controlled way. 6a: External mains contactor (if XLI mains connection module is not used) 6b: Mains contactor integrated in XLI mains connection module	• R911386579: – Chapter "Sizing the mains contactor" – Chapter "Control circuit for the mains connection"
7	Drive controller	Converter (XC*) or inverter (XM*). Inverters additionally require a supply unit. Regenerative supply units require an XLI mains connection module	• R911386579: – XCS, XCD, XMS, XMD, XMQ
8	Motor	Electric motor of the machine or installation.	See documentation of the motor.
9	Fuses	Fuses or circuit breakers protect against too high currents.	• R911386579: – Chapter "Sizing the line cross sections and fuses"
10	Transformer	The transformer reduces the mains voltage to a value that is allowed for the successive power supply unit.	• R911386579: – Chapter "Project planning of control voltage"
11	Power supply unit	The power supply unit provides the control voltage for operating the drive controller.	

1) For further information, please see the documentations with the corresponding material numbers (R911…).

Tab. 3-2: Components

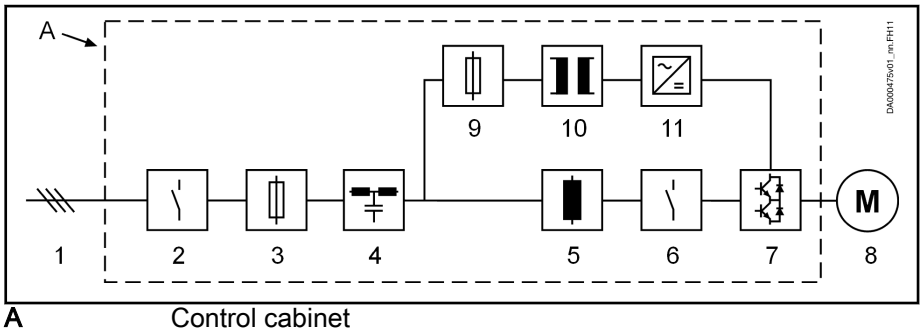
3.2 IndraDrive C and IndraDrive M components

3.2.1 Drive controllers

IndraDrive C	IndraDrive M	
Converter:	Inverter:	Supply units:
• HCS02	• HMS01	• HMV01
• HCS03	• HMS02	• HMV02
• HCS04	• HMD01	

Tab. 3-3: Drive controllers of the IndraDrive C and IndraDrive M product ranges

3.2.2 Order of the components



A Control cabinet
1…11 See table below

Fig. 3-2: Order of the components for mains connection

No.	Component	Description	Further information [1)]
1	Mains voltage supply	Mains voltage of the drive system (e.g., 3 AC 400 V). If necessary, this mains voltage is beforehand transformed by a transformer to the value allowed for the drive system. The allowed mains voltage results from the technical data of the drive components. TN mains (e.g.: TN-S): Run equipment grounding conductor (PE) and neutral conductor separately.	• R911309636: – Chapter "Project planning of mains connection" • R911327334 (HCS04): – Chapter "Mains voltage"
2	Main switch	Switches on or off the mains voltage supply of the entire drive system. Before maintenance work at the drive system, the mains voltage supply is interrupted with the main switch.	-
3	Fuses	Fuses or circuit breakers protect against too high currents.	• R911309636: – Chapter "Sizing the line cross sections and fuses" – Chapter "Mains contactor and fusing" • R911327334 (HCS04): – Chapter "Fuses and cable cross sections"

No.	Component	Description	Further information [1)]
4	Mains filter	Mains filters reduce radio interference and mains pollution.	• R911309636: – Chapter "Determining the mains filter" • R911327334 (HCS04): – Chapter "Radio interference filter HNF01.1B"
5	Mains choke	Mains chokes reduce harmonics in the mains current.	• R911309636: – Chapter "Determining the mains choke" • R911327334 (HCS04): – Chapter "HNL01.1E mains choke"
6	Mains contactor	Electrically activated switch that switches on and off the voltage for the successive drive controller in a controlled way.	• R911309636: – Chapter "Mains contactor and fusing" – Chapter "Mains contactor, Bb contact" • R911327334 (HCS04): – Chapter "Connecting and wiring" – Chapter "Switching rate"
7	Drive controller	Converter or inverter. Inverters additionally require a supply unit. Supply units have an integrated mains contactor (exception: HMV01.1R-W0120) so that the separate mains contactor pictured above is not required.	• R911318790: – HCS02, HCS03, HMS01, HMS02, HMD01, HMV01, HMV02 • R911327334 (HCS04): – HCS04
8	Motor	Electric motor of the machine or installation.	See documentation of the motor.
9	Fuses	Fuses or circuit breakers protect against too high currents.	• R911309636: – Chapter "Sizing the line cross sections and fuses" – Chapter "Mains contactor and fusing" • R911327334 (HCS04): – Chapter "Fuses and cable cross sections"
10	Transformer	The transformer reduces the mains voltage to a value that is allowed for the successive power supply unit.	• R911309636: – Chapter "Project planning of control voltage (24V supply)" • R911327334 (HCS04): – Chapter "HLT01.1A braking unit"
11	Power supply unit	The power supply unit provides the control voltage for operating the drive controller.	

1) For further information, please see the documentations with the corresponding material numbers (R911…).

Tab. 3-4: Components

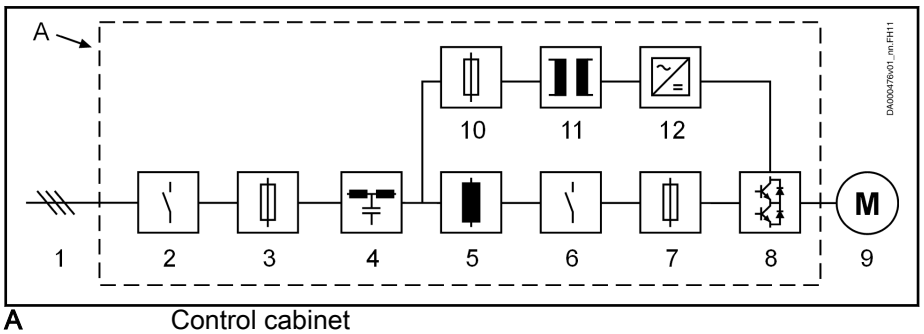
3.3 IndraDrive Cs components

3.3.1 Drive controllers

IndraDrive Cs
Converter: • HCS01

Tab. 3-5: Drive controllers of the IndraDrive Cs product ranges

3.3.2 Order of the components



A Control cabinet
1…12 See table below
Fig. 3-3: Order of the components for mains connection

No.	Component	Description	Further information [1)]
1	Mains voltage supply	Mains voltage of the drive system (e.g., 3 AC 400 V). If necessary, this mains voltage is beforehand transformed by a transformer to the value allowed for the drive system. The allowed mains voltage results from the technical data of the drive components. TN mains (e.g.: TN-S): Run equipment grounding conductor (PE) and neutral conductor separately.	• R911322210: – Chapter "Mains connection"
2	Main switch	Switches on or off the mains voltage supply of the entire drive system. Before maintenance work at the drive system, the mains voltage supply is interrupted with the main switch.	-
3	Fuses	Fuses or circuit breakers protect against too high currents.	• R911322210: – Chapter "Sizing the line cross sections and fuses" – Chapter "Mains contactor and fusing" – Chapter "Residual-current-operated circuit breakers (RCD, RCCB) as additional fusing" – Chapter "Mains voltage"

No.	Component	Description	Further information [1)]
4	Mains filter	Mains filters reduce radio interference and mains pollution.	• R911322210: – Chapter "Sizing the mains filter" – Chapter "Selecting the mains filter" – Chapter "Combining transformer, mains filter and mains choke" – Chapter "NFD / NFE mains filters"
5	Mains choke	Mains chokes reduce harmonics in the mains current.	• R911322210: – Chapter "Determining the mains choke" – Chapter "Combining transformer, mains filter and mains choke" – Chapter "Mains chokes"
6	Mains contactor	Electrically activated switch that switches on and off the voltage for the successive drive controller in a controlled way.	• R911322210: – Chapter "Sizing the mains contactor" – Chapter "Bb relay contact"
7	Fuses	Fuses or circuit breakers protect against too high currents.	• R911322210: – Chapter "Type of mains connection" – Chapter "Sizing the line cross sections and fuses"
8	Drive controller	Converter	• R911322210: – HCS01
9	Motor	Electric motor of the machine or installation.	See documentation of the motor.
10	Fuses	Fuses or circuit breakers protect against too high currents.	• R911322210: – Chapter "Sizing the line cross sections and fuses"
11	Transformer	The transformer reduces the mains voltage to a value that is allowed for the successive power supply unit.	• R911322210: – Chapter "Sizing the control voltage supply"
12	Power supply unit	The power supply unit provides the control voltage for operating the drive controller.	

1) For further information, please see the documentations with the corresponding material numbers (R911…).

Tab. 3-6: Components

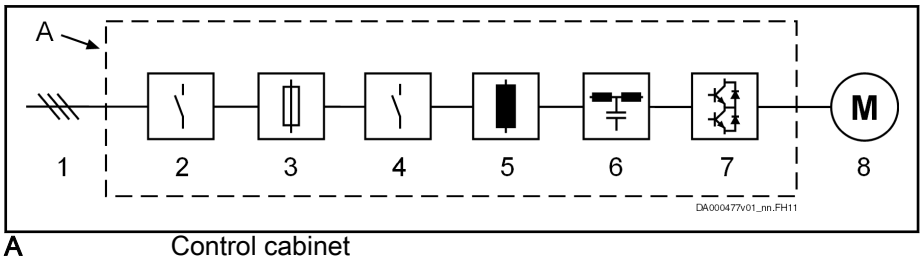
3.4 Rexroth Frequency Converter EFC components

3.4.1 Drive controllers

Rexroth Frequency Converter EFC
Frequency converter: • EFC

Tab. 3-7: Drive controllers of the Rexroth Frequency Converter EFC product ranges

3.4.2 Order of the components



A Control cabinet
1…8 See table below

Fig. 3-4: Order of the components for mains connection

No.	Component	Description	Further information [1)]
1	Mains voltage supply	Mains voltage of the drive system (e.g., 3 AC 400 V). If necessary, this mains voltage is beforehand transformed by a transformer to the value allowed for the drive system. The allowed mains voltage results from the technical data of the drive components. TN mains (e.g.: TN-S): Run equipment grounding conductor (PE) and neutral conductor separately.	• R912005854: – Chapter "Technical data" – Chapter "Wiring the frequency converter"
2	Main switch	Switches on or off the mains voltage supply of the entire drive system. Before maintenance work at the drive system, the mains voltage supply is interrupted with the main switch.	-
3	Fuses	Fuses or circuit breakers protect against too high currents.	• R912005854: – Chapter "Cable specifications"
4	Mains contactor	Electrically activated switch that switches on and off the voltage for the successive drive controller in a controlled way.	• R912005854: – Chapter "Cable specifications"
5	Mains choke	Mains chokes reduce harmonics in the mains current.	• R912005854: – Chapter "EMC measures for design and installation"
6	Mains filter	Mains filters reduce radio interference and mains pollution.	• R912005854: – Chapter "EMC measures for design and installation"

No.	Component	Description	Further information [1)]
7	Drive controller	Frequency converter	• R912005854: – EFC
8	Motor	Electric motor of the machine or installation.	See documentation of the motor.

1) For further information, please see the documentations with the corresponding material numbers (R912…).

Tab. 3-8: Components

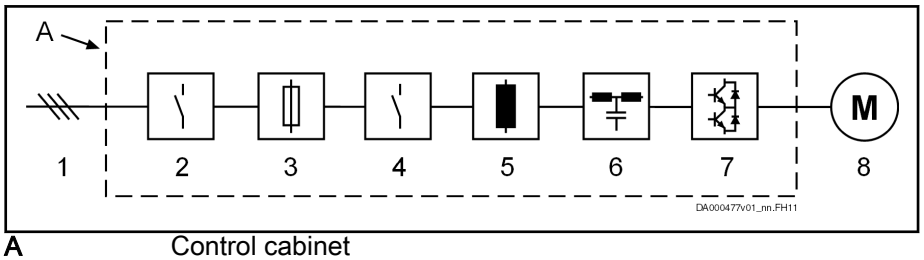
3.5 Rexroth Frequency Converter Fv components

3.5.1 Drive controllers

Rexroth Frequency Converter Fv
Frequency converter: • FVCA01

Tab. 3-9: Drive controllers of the Rexroth Frequency Converter Fv product ranges

3.5.2 Order of the components



A Control cabinet
1…8 See table below

Fig. 3-5: Order of the components for mains connection

No.	Component	Description	Further information [1)]
1	Mains voltage supply	Mains voltage of the drive system (e.g., 3 AC 400 V). If necessary, this mains voltage is beforehand transformed by a transformer to the value allowed for the drive system. The allowed mains voltage results from the technical data of the drive components. TN mains (e.g.: TN-S): Run equipment grounding conductor (PE) and neutral conductor separately.	• R912002625: – Chapter "Technical data" – Chapter "Connecting the power section"
2	Main switch	Switches on or off the mains voltage supply of the entire drive system. Before maintenance work at the drive system, the mains voltage supply is interrupted with the main switch.	-
3	Fuses	Fuses or circuit breakers protect against too high currents.	• R912002625: – Chapter "Sizing cables and fuses" – Chapter "Main circuit wiring diagram"
4	Mains contactor	Electrically activated switch that switches on and off the voltage for the successive drive controller in a controlled way.	• R912002625: – Chapter "Main circuit wiring diagram"
5	Mains choke	Mains chokes reduce harmonics in the mains current.	• R912002625: – Chapter "EMC measures for design and installation"

No.	Component	Description	Further information [1)]
6	Mains filter	Mains filters reduce radio interference and mains pollution.	• R912002625: – Chapter "EMC filters" – Chapter "EMC measures for design and installation"
7	Drive controller	Frequency converter	• R912002625: – FVCA01
8	Motor	Electric motor of the machine or installation.	See documentation of the motor.

1) For further information, please see the documentations with the corresponding material numbers (R912…).

Tab. 3-10: Components

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Notes

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DOK-DRIVE*-CABINET****-PR03-EN-P