



# Manual



## EMC in Drive Technology EMC-Compliant Installation in Practice



## Table of contents

<b>1</b>	<b>Foreword</b> .....	<b>5</b>
<b>2</b>	<b>Grounding in a mesh structure</b> .....	<b>6</b>
<b>3</b>	<b>Leakage currents</b> .....	<b>7</b>
<b>4</b>	<b>Voltage supply</b> .....	<b>8</b>
4.1	Supply system selection .....	8
4.2	Extra-low voltage .....	9
4.3	24 V brake.....	9
<b>5</b>	<b>EMC-compliant installation in the control cabinet</b> .....	<b>11</b>
5.1	Sheet steel control cabinet.....	11
5.2	Mounting plate in the control cabinet .....	12
5.3	PE busbar .....	12
5.4	EMC zones in the control cabinet .....	13
<b>6</b>	<b>Cable routing in the control cabinet</b> .....	<b>15</b>
6.1	Supply system cable .....	15
6.2	DC link connection, voltage supply $V_z$ .....	15
6.3	Brake cable .....	16
6.4	Braking resistor cable .....	16
6.5	Cable of the temperature probe .....	17
6.6	Motor cable .....	17
6.7	Control cable .....	19
6.8	Encoder cable .....	19
6.9	Spare loops.....	21
<b>7</b>	<b>EMC components in the control cabinet</b> .....	<b>22</b>
7.1	Arrangement of the EMC components.....	22
7.2	Line choke.....	23
7.3	Line filter .....	24
7.4	Output choke (ferrite core choke) .....	25
7.5	Output filter (sine filter).....	29
<b>8</b>	<b>Cables</b> .....	<b>33</b>
8.1	Routing in the cable duct .....	33
8.2	Distance between conductors.....	33
8.3	Distance from the reference potential .....	33
8.4	Cable groups.....	34
8.5	Routing of cables outside the control cabinet .....	35
8.6	Faulty prefabrication of hybrid cables .....	37
<b>9</b>	<b>Shielding</b> .....	<b>38</b>
9.1	Shield types .....	39
9.2	Long, shielded cables .....	40
9.3	No shielded cables for group drives.....	40
9.4	Braided shield connection.....	40
9.5	Shielding of hybrid cables .....	44

<b>10</b>	<b>Equipotential bonding in the plant</b> .....	<b>45</b>
10.1	Equipotential bonding measures of a transport system .....	45
10.2	Interlinked equipotential bonding .....	46
10.3	Example: Drive with shaft-mounted gear unit .....	47
10.4	Example: Rotary table .....	48
10.5	Example: Electrified monorail system .....	49
10.6	Example: Hoist with integrated roller conveyor .....	50
10.7	ESD – electrostatic discharge .....	51
10.8	Low-resistance ground reference .....	54
10.9	Connection over a wide area .....	54
10.10	Ground strap .....	54
10.11	Contact .....	57
10.12	Cable duct connections .....	57
<b>11</b>	<b>Equipotential bonding for generation B control cabinet inverters</b> .....	<b>59</b>
11.1	MOVIDRIVE® MDX .....	59
11.2	Braking resistor .....	62
<b>12</b>	<b>Equipotential bonding of decentralized components</b> .....	<b>63</b>
12.1	Protective earth and equipotential bonding of decentralized inverters .....	63
12.2	Equipotential bonding of decentralized MOVI-C® devices .....	65
12.3	Equipotential bonding of decentralized generation B devices .....	71
<b>13</b>	<b>Equipotential bonding of AC motors</b> .....	<b>76</b>
13.1	Connection of options .....	76
13.2	Equipotential bonding / HF grounding at the connection box .....	76
13.3	DR motors, exterior LF grounding .....	77
13.4	"Improved grounding" option (HF grounding) for DR motors .....	78
<b>14</b>	<b>Functional safety</b> .....	<b>81</b>
<b>15</b>	<b>EMC interference</b> .....	<b>82</b>
15.1	Troubleshooting .....	82
15.2	Interference resolution .....	82
15.3	List of malfunctions .....	83
	<b>Index</b> .....	<b>85</b>

## 1 Foreword

Electromagnetic compatibility (EMC) denotes the capability to operate several electrical and electronic components together and next to each other within a certain environment without any interference.

This chapter helps you optimize the EMC of the system and eliminate existing EMC interference.

The notes in this chapter are not legal regulations, but only suggestions for improving the EMC of your system. For device-specific information and instructions, refer to the operating instructions of the device.

Observe the following guidelines, notes and information for electrical installation:

- General guidelines and instructions of the system manufacturer
- The general safety notes for the device
- Permissible conditions at the place of installation
- Information and instructions in the operating instructions and product manuals of the devices

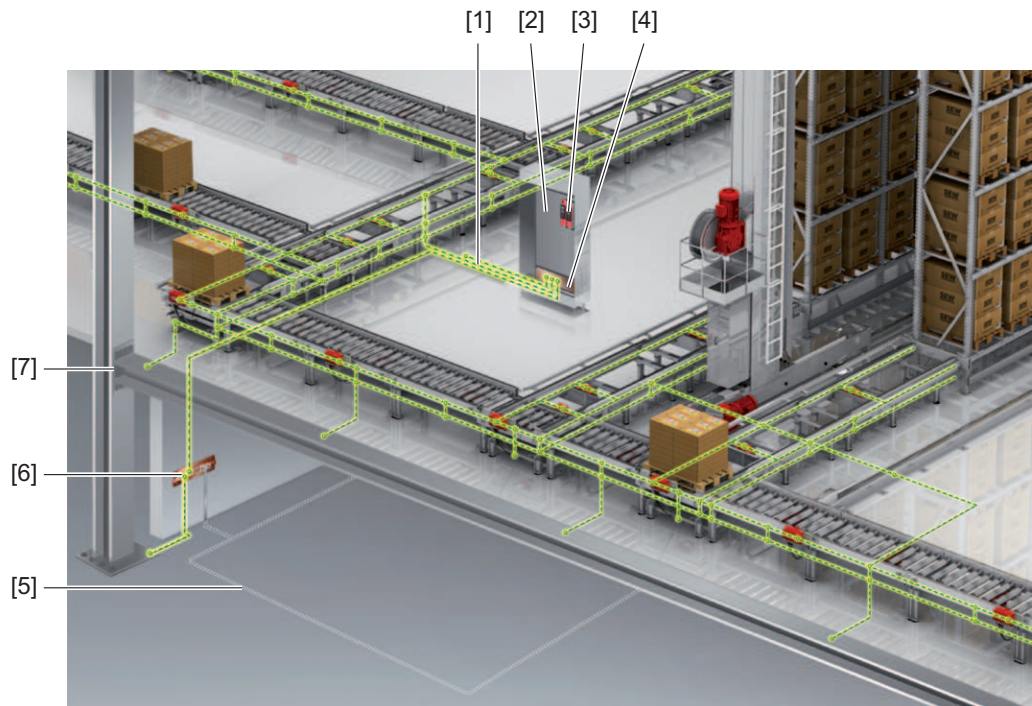
## 2 Grounding in a mesh structure

Grounding plays a particularly important role in the trouble-free operation of a system.

Therefore always observe the following information:

- All components of the system must always be grounded with low impedance in both the low-frequency range (LF) and the high-frequency range (HF). Therefore, the system must have a grounding network that ensures a consistent reference potential even for high frequencies.
- For high-frequency interference, the protective earth represents a high impedance. Ground cables only have a use in the HF range when they are **meshed**. This **parallel connection** reduces the line resistance. Keep loops as small as possible. With small loops, the enclosed area between the outgoing and return conductors is small.

The following figure shows an example of the components of a system that you must pay particular attention to with regard to grounding.



3771657867

- [1] "Sheet metal cable duct" (→ 33) (→ 46) (→ 57)
- [2] "Mounting plate in control cabinet" (→ 12)
- [3] Frequency inverter
- [4] "Equipotential bonding busbar (PE busbar)" (→ 12)
- [5] Foundation ground electrode
- [6] Equipotential bonding point
- [7] Steel construction

### 3 Leakage currents

In principle, a controlled drive system generates cable-bound, low-frequency and high-frequency interference. Appropriate EMC measures significantly reduce these types of interference and, in some cases, dissipate them as operational leakage currents to the ground potential.

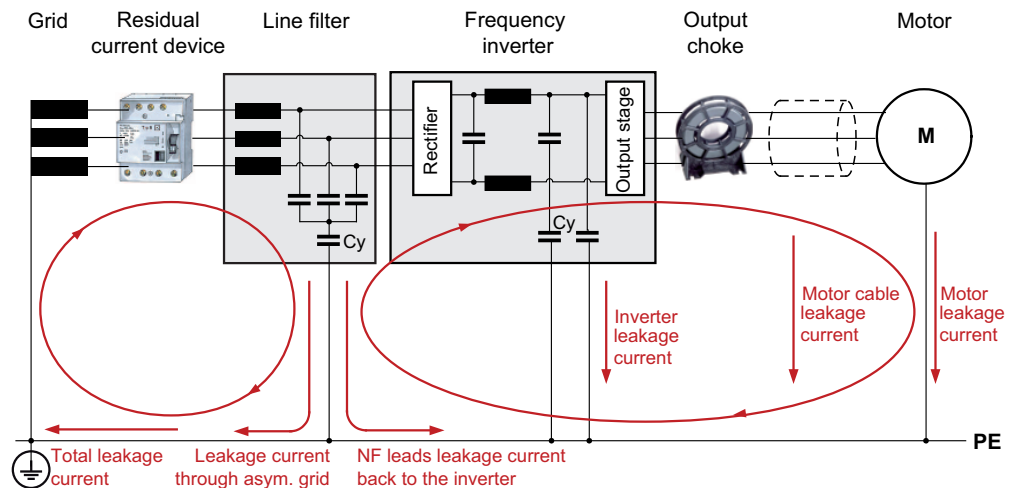
- The majority of the leakage currents should flow back to the frequency inverter.

This is why good, **low-impedance grounding** is particularly important. It prevents the leakage currents from taking another path and thus interfering with other devices.

- The inductance of a **line filter** counters the leakage current in the kHz range and feeds the majority of the leakage currents back to the frequency inverter via the Y capacitor.

The line filter thus keeps the leakage currents and interference voltages generated by the frequency inverter away from the grid and feeds them back to the frequency inverter (interference source).

The following figure shows the leakage currents of a controlled drive with suitable EMC measures.



3875098123

#### Conclusion

The majority of the leakage currents should flow back to the frequency inverter in order to not interfere with other devices.

#### INFORMATION



Further information on the topic of "leakage currents of frequency inverters" is available from SEW-EURODRIVE on request.

### 4 Voltage supply

The devices in a system must be connected to the supply source in star shape. Separate power supplies are required for sensitive devices and devices with high power.

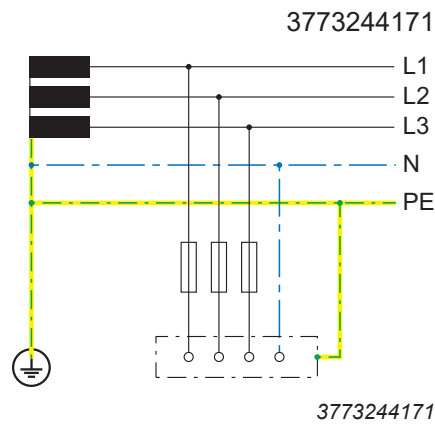
#### 4.1 Supply system selection

The insulated IT system has the worst EMC properties.

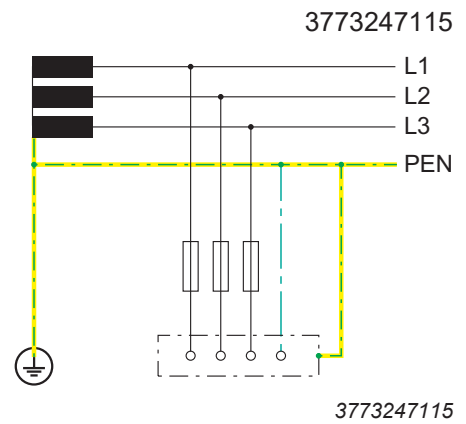
Different system types are permitted to supply the devices. The system types have a significant influence on the EMC behavior of a system.

The following figure shows the wiring diagrams of the system types.

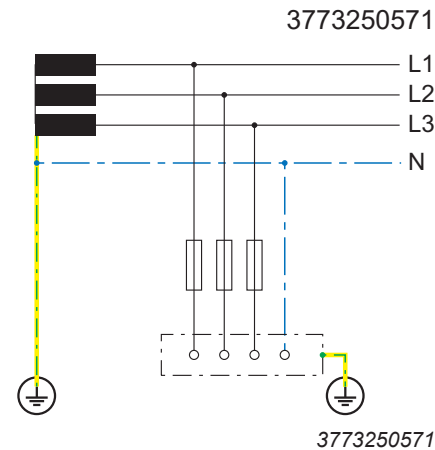
TN-S supply system



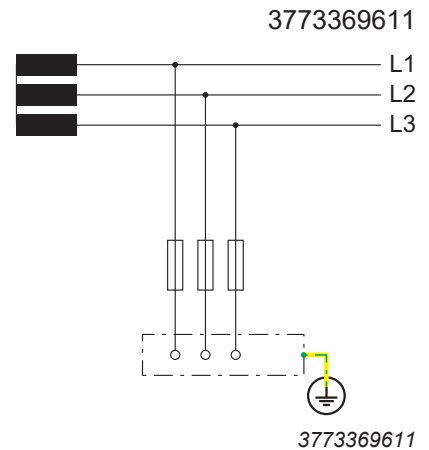
TN-C supply system



TT supply system



IT supply system



### 4.1.1 EMC properties of the system types

The following table shows the EMC properties of the system types.

System type	EMC property
TN-S supply system	Very good
TT supply system	Good
TN-C supply system	Poor
IT system	Poor

The TN-S supply system with 5 cores has the best EMC properties. The advantage of the TN-S system is the **separate routing of the N and PE conductors**. Both conductors are only connected at a central point in the building. The PE conductor is only used for dissipating interference currents. The leakage currents that occur in the PE conductor can flow separately from the N conductor and thus do not affect other devices on the network.

The insulated IT system has the worst EMC properties.

## 4.2 Extra-low voltage

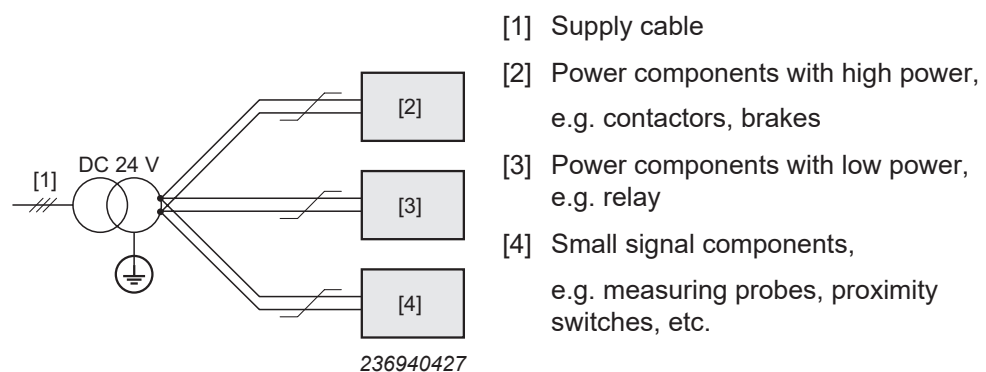
For extra-low voltages (e.g. 24 V), it is important that

- analog consumers (e.g. measuring probes, proximity switches, etc.)
- and consumers with high power ratings (e.g. contactors, brakes, etc.)

are distributed over different power supply units, or at least different strands. These strands must lead to the power supply unit in a star-shaped manner.

**The supply and return conductors must always be routed together.**

The following figure shows the supply concept for the extra-low voltage supply.



## 4.3 24 V brake

### 4.3.1 24 V brake control

For motors with a DC 24 V brake that are **not** controlled by a brake control (BMV or BSG), burned-out relay contacts and EMC interference of the 24 V supply can occur.

SEW-EURODRIVE therefore recommends always using a BMV (in the control cabinet) or BSG (in the terminal box) brake control for 24 V brakes.

# 4 Voltage supply

## 24 V brake

### 4.3.2 Brake with brake control (BMV or BSG)

The BMV and BSG brake controls are wear-free, electronic switches. Therefore, no EMC-interfering contact-breaking sparks occur when the brake is switched off. The brake control protects the brake against overvoltages.

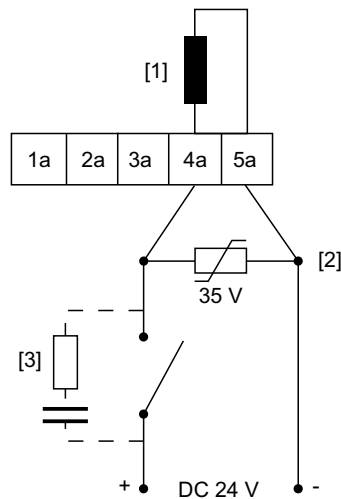
### 4.3.3 Brake without brake control

If the brake is **not** switched by a brake control (BMV or BSG), you must use a contactor or relay that is suitable for switching inductive loads of DC currents. For a 24 V brake, a **35 V varistor** parallel to the brake coil is required in this case as overvoltage protection and for EMC interference suppression of the 24 V supply, see figure below.

Use a 300 V varistor for brakes with a DC supply greater than 24 V.

If EMC interference still occurs, you can also connect an RC element in parallel to the contactor contact.

The following figure shows a 24 V brake with EMC interference suppression:



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[1] Brake coil

[2] Varistor (Example: SIOV S 10 K 35 => **35 V** from EPCOS)

[3] RC element (Example: RC BUG2/24-48V DC/DC from Murr)

### Conclusion

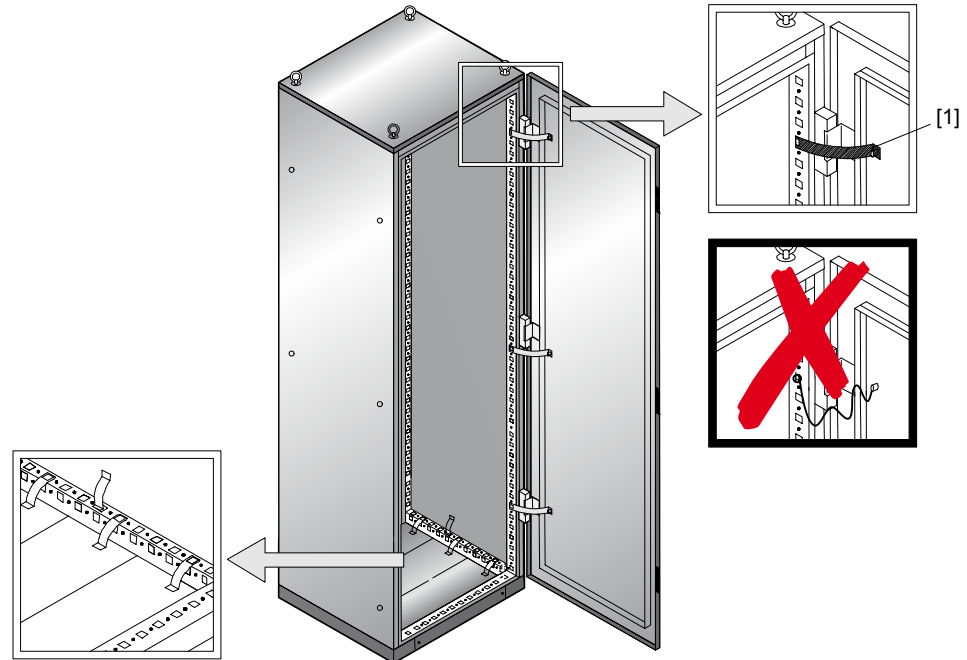
The BMV and BSG brake control units offer the following advantages compared to a contactor or relay:

- Significantly higher system availability
- Significantly better EMC compatibility
- Significantly longer service life

## 5 EMC-compliant installation in the control cabinet

### 5.1 Sheet steel control cabinet

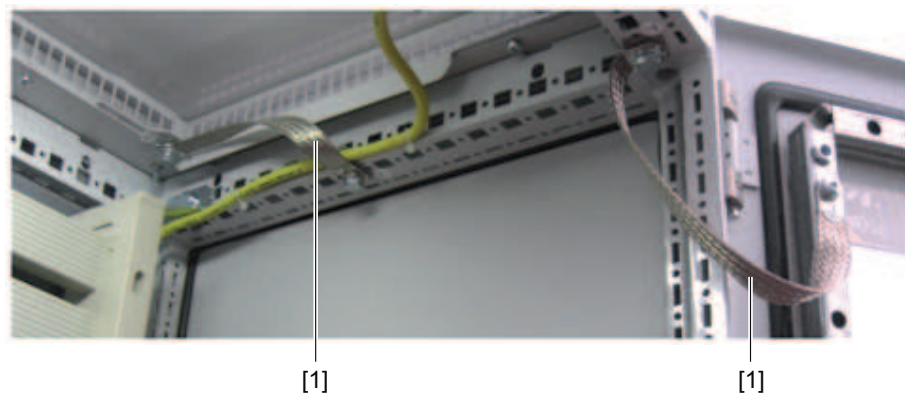
From an EMC perspective, a control cabinet made of sheet steel is a good solution because it particularly shields electromagnetic interference fields.



401657483

[1] HF litz wires

The following figure shows the HF equipotential bonding between the doors, sheet metal and the mounting plate:



3773699467

[1] HF equipotential bonding between doors, sheet metal and mounting plate

The control cabinet helps to reduce the radiation. Optimum equipotential bonding improves the shielding of the control cabinet. The integration of the doors and the cable bushings is important.

# 5 EMC-compliant installation in the control cabinet

Mounting plate in the control cabinet

## 5.2 Mounting plate in the control cabinet

The mounting plate in the control cabinet is used not only for fastening the components, but also for grounding built-in devices with metal housings over a wide area. Galvanized steel plates are best suited for this purpose.

The mounting plate must be in contact over a large area with the grounding system of the machine hall. This connection is established using a ground strap between the mounting plate and the PE busbar.

### 5.2.1 Mounting systems

Mounting systems are also used instead of mounting plates.

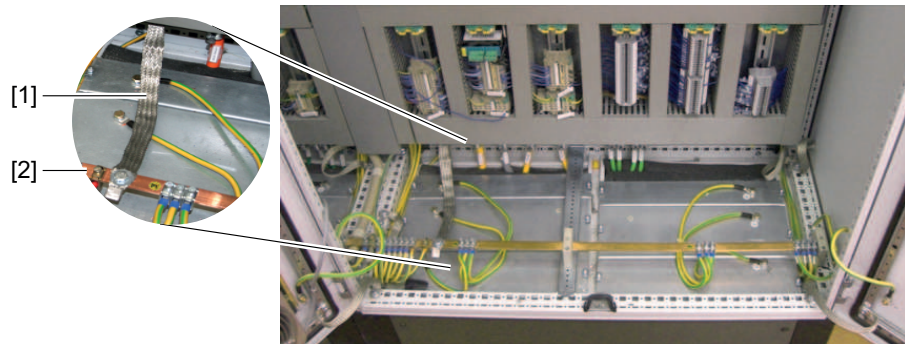
However, EMC-technical disadvantages arise due to the non-extensive connections to the inverter housings.

For mounting systems, all components such as frequency inverters, filters, and shielding must therefore be attached over a large area on a mounting plate integrated in the system.

## 5.3 PE busbar

The PE busbar is the central connection point for the PE conductors of each individual device in the control cabinet (star-shaped grounding). The PE connection does not replace the HF grounding or shielding. It is required for safety reasons for the ground connection.

The following figure shows the PE busbar and the HF equipotential bonding between the mounting plate and the PE busbar in the control cabinet.



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- [1] HF equipotential bonding between mounting plate and PE busbar
- [2] PE busbar

### 5.3.1 Conclusion

In terms of electrical safety, the PE busbar represents the star point.

In terms of EMC, it is advantageous if the mounting plate is used as a star point with respect to HF equipotential bonding.

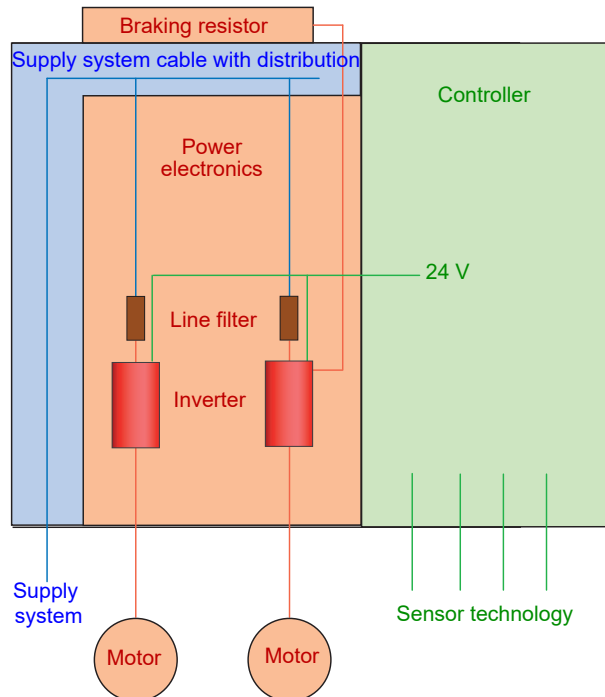
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## 5.4 EMC zones in the control cabinet

Install the interference sources and interference sinks in a control cabinet spatially separated from each other.

The **power electronics** must not interfere with the **supply system cable and controller**. Therefore, classify the control cabinet into EMC zones.

The following figure shows an example of the EMC zones in the control cabinet.



### 5.4.1 Supply system cable

Protect the supply system cable zone from high-frequency interference of the power electronics.

In the supply system cable zone, there are options such as:

- Fuses
- Switch
- Contactors

### 5.4.2 Power electronics

In the power electronics zone, for example, the following components are sources of interference:

- Frequency inverters with motor power
- Braking resistor with braking resistor cable
- DC link connection
- Brake
- Valves
- Coils
- Contactors
- Switched-mode power supplies

**5.4.3 Controller**

In the controller zone, for example, the following components are sources of interference:

- Evaluation electronics
- Bus communication
- Encoders
- Sensors

## 6 Cable routing in the control cabinet

### 6.1 Supply system cable

Do not route the supply system cable and control electronics in parallel with unshielded power electronics.

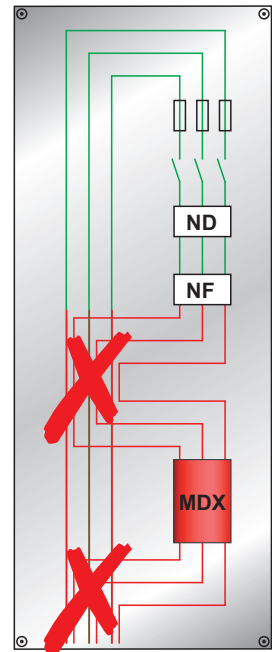
The supply system cable (before the line filter) must not run parallel to the interference-affected cable (after the line filter).

Otherwise, the already filtered cable will be subjected to interference again.

If you cannot meet this requirement, shielded cables must be used.

If a prefabricated cable is designed too long, do not wind it up in the control cabinet base.

Route long cables in larger spare loops in a cable duct outside the control cabinet. If necessary, plan an additional cable duct in advance.



### 6.2 DC link connection, voltage supply $V_z$

The two conductors of the DC link connection for the voltage supply  $V_z$  of a safe brake rectifier are unfiltered.

The following frequencies are available:

- 300 Hz of the input rectifiers
- PWM frequency of the IGBT transistors

Therefore, observe the following notes when installing the  $+V_z$  and  $-V_z$  cores:

- Keep all conductors as short as possible.
- Twist the conductors together.
- Route the conductors separately from unshielded, sensitive cables.

### 6.3 Brake cable

#### 6.3.1 Protect the brake cable from HF interference peaks of the motor cable

Observe the following information when connecting the brake cable:

- Always route the brake cable between the brake control and the brake separately from other power cables with clocked voltages (minimum distance: 20 cm).
- If you cannot meet this requirement, shielded brake cables are required.

If the motor cable with clocked voltages is insufficiently shielded, HF interference peaks can be transmitted to the brake cable.

#### 6.3.2 Damage to the brake control and the brake

These HF interference peaks in the brake cable can cause an impermissibly high load on the brake control.

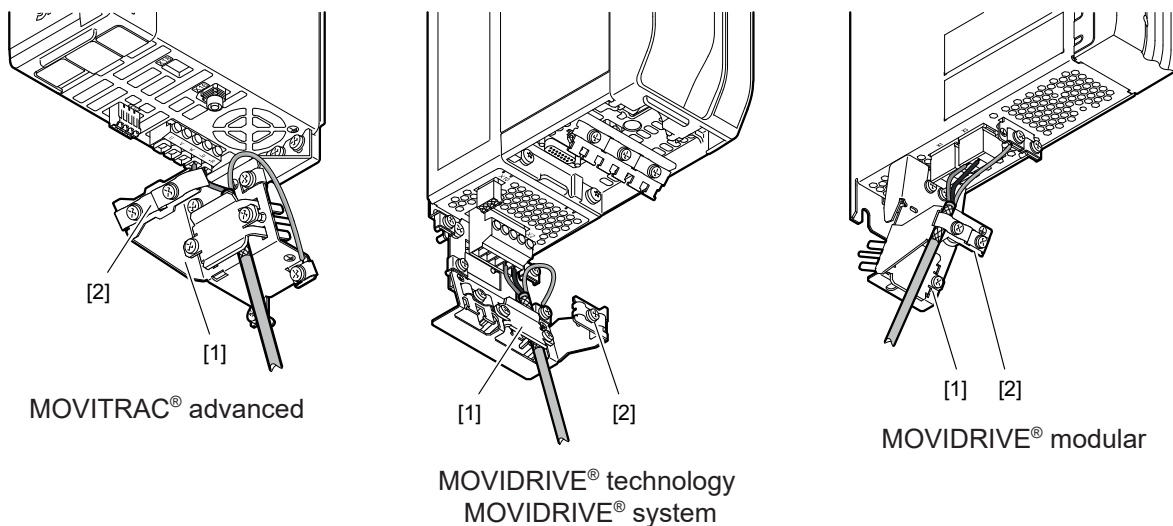
In the long term, these HF interference peaks can damage the brake control and, as a consequence, the brake coil.

### 6.4 Braking resistor cable

Observe the following information when connecting the braking resistor cable:

- Use 2 closely twisted cores or 1 shielded power cable to connect braking resistors.
- With the shielded cable, apply the braided shield over the entire circumference over a large area.
- For the shield connection, use the designated shield plates at the basic unit.

The following figures show an example of the connection of a shielded braking resistor cable.



- [1] Rear shield connection  
[2] Front shield connection

Depending on the cable cross-section, you can establish the electrical contact to the cable shielding beneath either the large or the small shielding plate.

## 6.5 Cable of the temperature probe

The cable of the temperature probe transmits the temperature readings measured at the motor to the controller.

If the cable for the temperature probe is unshielded or if the shielding is grounded only on one side, voltage peaks can be transferred from the 0 V reference potential of the 24 V voltage supply to the electronics of the control unit.

These voltage peaks can trigger encoder errors or communication errors.

The shields of the temperature probe cable and the encoder cable carry leakage currents. Therefore, do not treat these cables like a bus cable or a binary input and output cable.

Observe the following information when connecting the temperature probe cable:

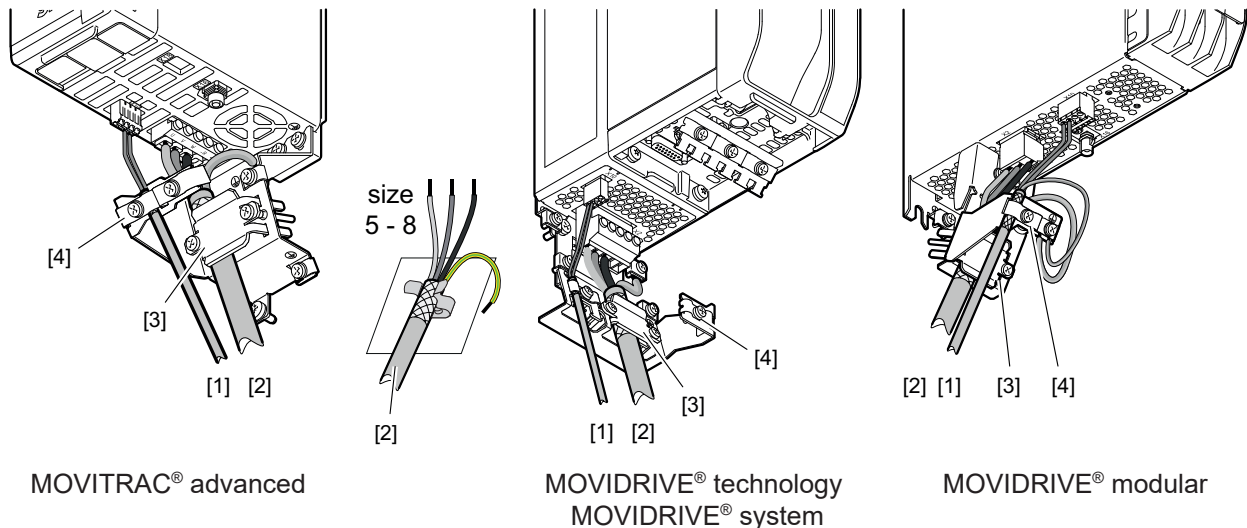
- Use only shielded cables.
- Ground the shielding of the temperature probe cable on both sides.

## 6.6 Motor cable

Observe the following information when connecting the motor cable:

- Connect the shield of the motor cable over a large area to the shield plate of the inverter.
- Route the three conductors of the unshielded, unfiltered motor cable twisted and separated from unshielded, sensitive cables.

The following figures show examples of how to connect the motor and the brake.



- [1] Temperature probe cable
- [2] Motor cable
- [3] Rear shield connection
- [4] Front shield connection

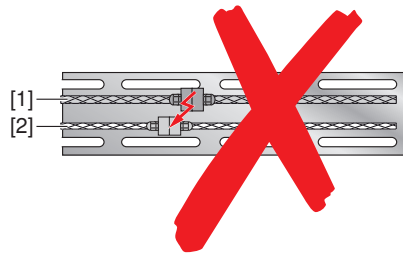
Depending on the cable cross section, you can contact the shielding of the cable under the large or small shield plate.

### 6.6.1 Motor cable causes interference in encoder cable through the shield

If you connect the shield of the motor cable directly to the shield of the encoder cable, interference pulses can be transmitted from the motor cable to the encoder cable. These interference pulses can trigger encoder faults.

Therefore always observe the following information:

- Use separate shield plates, shield strips, shield terminals to connect the motor cable and encoder cable.
- Even if two separate shield plates are grounded together again, a separate shield connection nevertheless offers higher protection in the event of high-frequency interference currents.
- Do not place EMC cable glands of the motor cable and the encoder cable directly next to each other.
- Make sure that the plug connectors of the motor cable and the encoder cable do not touch each other.



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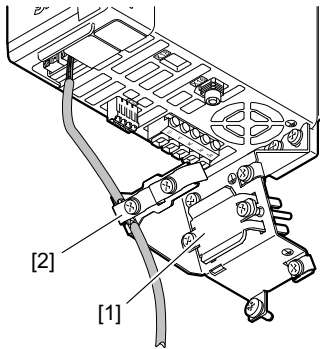
- [1] Motor cable  
[2] Encoder cable

## 6.7 Control cable

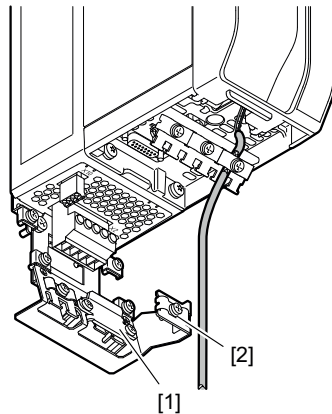
Observe the following information when connecting the control cable:

- You can use unshielded single conductors to connect the digital inputs **in the control cabinet**.
- Use shielded cables to connect the digital inputs **outside the control cabinet**. Shielded cables increase the EMC.
- Connect the control cable shielding to the shield plate provided for this purpose.

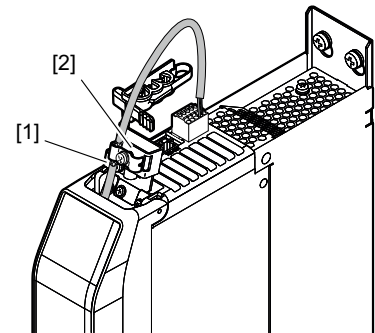
The following figures show examples of the connection of the control cable shielding.



MOVITRAC® advanced



MOVIDRIVE® technology  
MOVIDRIVE® system



MOVIDRIVE® modular

- [1] Rear shield connection  
[2] Front shield connection

## 6.8 Encoder cable

SEW-EURODRIVE recommends using prefabricated encoder cables.

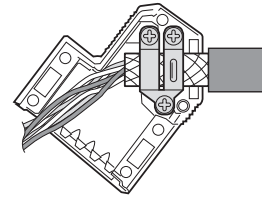
Ground the shield of the encoder cable over a large area on both sides.



### 6.8.1 Encoder cable shield

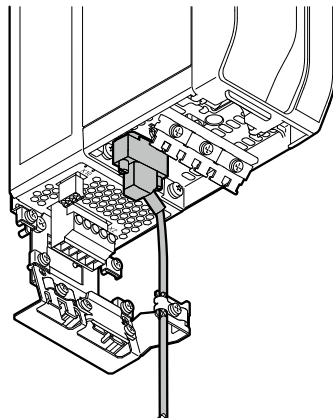
The shield contact of the encoder cable is made in the connector.

This contact is usually sufficient.



You can also attach the shield of the encoder cable

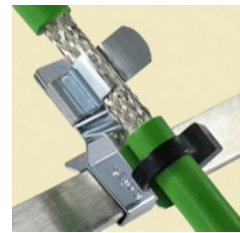
- To the shield plate of the inverter
- Or to a shield terminal/shield strip on the mounting plate



Shield connection on the MOVIDRIVE® technology inverter



EMC shield terminal with hat rail



Shield terminal for busbar

SEW-EURODRIVE recommends the additional shield connection for the following systems:

- Systems with long encoder cables
- Systems with poor HF equipotential bonding
- Systems with deactivated EMC filter capacitors
  - Contact screw removed or IT version
  - For IT system

### 6.8.2 Prefabricated encoder cable

If you **do not** use a prefabricated encoder cable from SEW-EURODRIVE and have a problem with encoder faults, first replace your encoder cable with an original encoder cable from SEW-EURODRIVE. Practical experience has shown that this measure eliminates encoder faults with a probability of 70%.

You can replace the encoder cable yourself. Therefore, replacing the encoder cable is usually cheaper than lengthy troubleshooting.

The longer the motor cable and the encoder cable, the greater the risk of encoder interference.

For lengths of over 100 m, use only the prefabricated motor and encoder cables from SEW-EURODRIVE for the following reasons:

- SEW-EURODRIVE motor and encoder cables are made from a high-quality low capacitance cable.
- Many years of practical experience are incorporated into the production of SEW-EURODRIVE cables. These experiences are reflected in the EMC compatibility and also in the durability of the contacts.
- SEW-EURODRIVE checks each individual cable after production.

This means that errors in encoder cables that occur frequently in practice no longer occur with encoder cables from SEW-EURODRIVE.

### 6.8.3 Properties of an encoder cable

Only use cables with the following properties as encoder cables:

- Low capacitance (operating capacity between the cores  $C_{\text{core/core}} \leq 70 \text{ pF/m}$ )
- With braided shield
- Twisted in pairs

**Example:** Encoder cables from the company HELUKABEL®

HELUKABEL® type	Use
Li9YCY	SEW-EURODRIVE uses this cable (70 pF/m) as a low-capacitive encoder cable as standard.
Li2YCY	This cable is also suitable as an encoder cable. $C_{\text{core/core}} = 70 \text{ pF/m}$

## 6.9 Spare loops

If a prefabricated cable is dimensioned too long:

- Do not shorten the cable.
- Do not wind up the cable.

Route long cables in larger spare loops in a cable duct outside the control cabinet. If necessary, plan an additional cable duct in advance.



Negative example

## 7 EMC components in the control cabinet

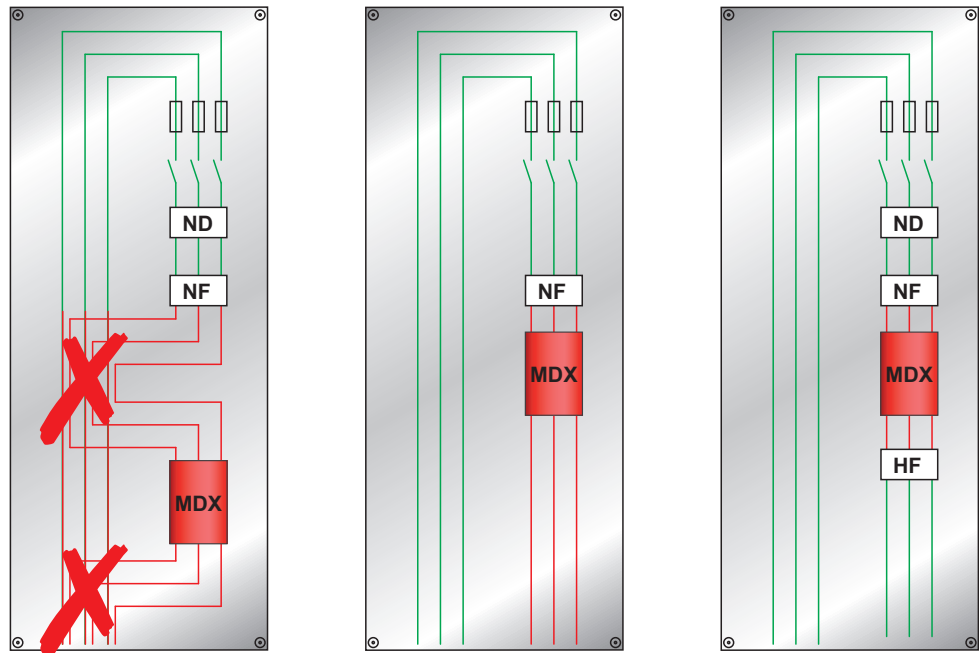
### 7.1 Arrangement of the EMC components

To improve EMC, you can install EMC components.

**EMC components, such as line filters and output filters, require a metallic contact on a common mounting plate with the inverter.**

They must be installed as close as possible to the inverter so that the cables between the EMC component and the device are short (max. 50 cm).

Observe the following sequence of components in the control cabinet according to the following figures:



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ND Line choke

LF Line filter

MDX Inverters

HF Output filter

Green cable = Interference-filtered cable

Red cable = Interference-affected cable

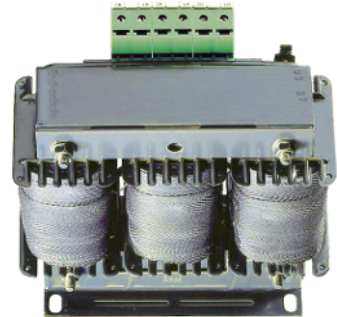
To avoid unintended coupling, route filtered and unfiltered cables separately from each other. Otherwise, the already filtered cable will be subjected to interference again.

If these requirements cannot be met, it makes sense to use shielded cables. To eliminate inductive coupling, you should not use single conductors for connection.

If you install EMC components on the base plate of the control cabinet due to their high weight (which is not ideal in terms of EMC), you must connect the base plate to the mounting plate using a ground strap.

## 7.2 Line choke

A line choke dampens voltage and current peaks. As a result, the line harmonics are also dampened.



### 7.2.1 Line harmonics

During operation, an inverter always generates line harmonics. An optimization of the inverter can limit or reduce these harmonics already when they are generated.

Inverters with high line current distortion are connected upstream to line chokes. These smooth the input current almost sinusoidal. This reduces the amplitude of the line harmonics.

### 7.2.2 SEW-EURODRIVE inverters

For modern frequency inverters with a slim DC link (e.g. inverters from SEW-EURODRIVE), the harmonics are already reduced to such an extent that no additional line choke is usually required.

### 7.2.3 Voltage spikes

Switching contactors with higher power causes overvoltage pulses in the supply system.

A line choke protects the inverter from these voltage peaks. In critical grid conditions where overvoltage pulses are to be expected, SEW-EURODRIVE recommends a line choke to protect the inverter.

### 7.2.4 Inrush current spikes

When several frequency inverters are switched on at the same time, the total inrush current adds up.

In the case of small line contactors, an excessive inrush current can lead to sticking or welding of the contacts.

If several frequency inverters are connected simultaneously during operation, you can switch a line choke in front of the frequency inverter. This limits the total inrush current. Match the line choke to the back-up fuse.

### 7.3 Line filter

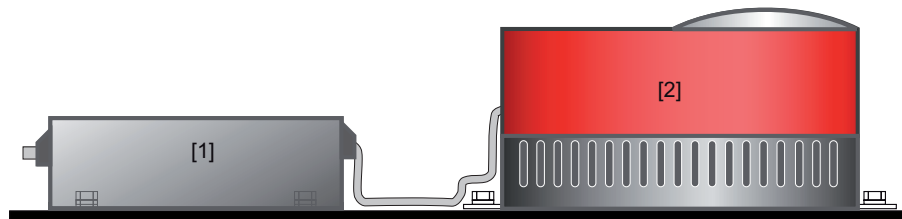
A line filter reduces interference emission via the supply system cable, which is generated by the inverter due to its principle.

In addition, a line filter dampens the interference from the grid affecting the inverter.



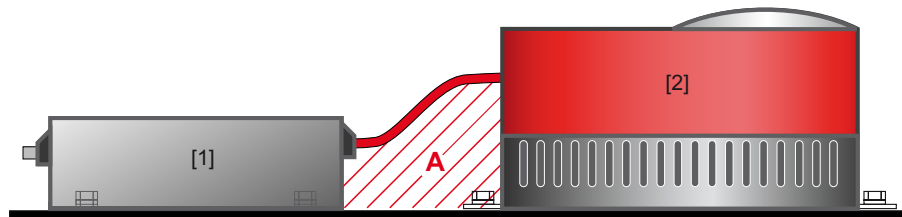
Observe the following information:

- The selection of the line filter depends on the inverter current and the line voltage of the frequency inverter.
- Select the line filter according to the project planning specifications of the corresponding frequency inverter.
- Install one line filter each just before each frequency inverter.
- Do not install a switching component between the line filter and the frequency inverter (e.g. contactor).
- Route the cable between the filter [1] and the frequency inverter [2] as close to the mounting plate as possible.



Flat metallic contact on the common mounting plate

- If you install the cable at a large distance from the mounting plate, this increases the radiation area and consequently the interference emissions.



A Radiation surface between cable and mounting plate

- Therefore, route the cables as close as possible to the reference potential (mounting plate).

**Suspended cables act as active and passive antennas.**

#### 7.3.1 Use

The use of line filters is recommended under the following requirements:

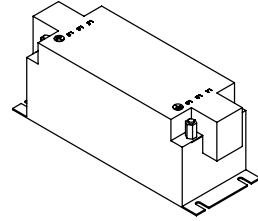
- Reduction of interference emission via the supply system cable
- Compliance with EMC limit values
- Reduction of potential equalizing currents
- Reduction of leakage currents with long motor cable lengths

## 7.4 Output choke (ferrite core choke)

As a cost-effective measure, the output choke reduces the interference potential on the motor cable of the inverter.

With suitable dimensioning, the emission limit values for radio interference suppression are adhered to.

The output choke has the advantage that no additional voltage drop occurs at the inverter output.



### 7.4.1 Output choke design

Select the output choke as follows:

- Selection using the assignment lists for the corresponding EMC limit value classes in the technical data.
- Selection based on the S1 motor current,  
e.g. group drive: One output choke for each motor cable.

### 7.4.2 Larger output choke with longer motor cable

Long motor cables can cause the output choke to become saturated due to increased leakage currents. From a motor cable length of 150 m, use the next larger choke.

### 7.4.3 Output choke (ferrite ring core choke)

SEW-EURODRIVE offers output chokes in open mounting positions HD001, HD002, HD003 for various core cross sections.

Usually 3 – 5 turns around a toroidal core are sufficient.



Output chokes are usually used with unshielded motor cables.

### Shielded motor cable with several plug connectors

From an EMC perspective, plug connectors within a shielded motor cable are **not an optimal solution**.

However, the automotive industry often requires motor cables with plug connectors to reduce the downtime in the event of a system failure.

If a shielded motor cable has several plug connectors, the shielding effect may deteriorate.

In such special cases, an output choke can be used in combination with a motor cable shield. However, this is usually not necessary.

The leakage currents dissipated via the motor cable shield place an additional load on the output choke. This then leads to an increased temperature.

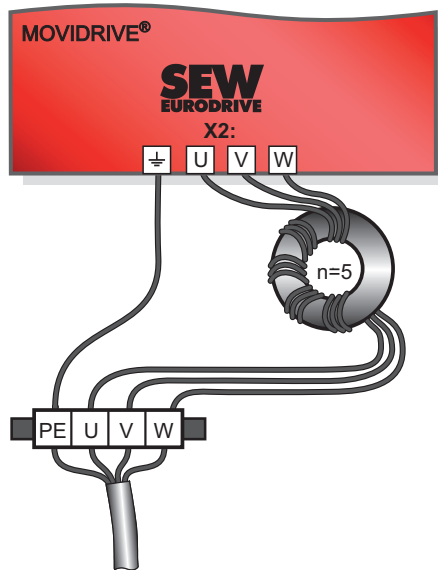
#### 7.4.4 High operating temperature

The output choke can achieve high operating temperatures (above 100 °C) at the toroidal core due to its function.

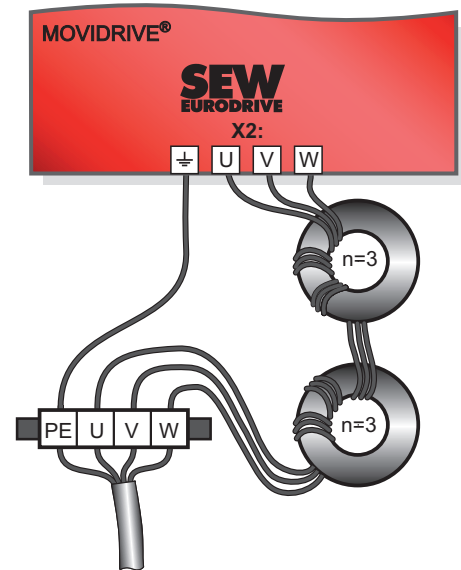
In open designs, a plastic grid protects the core insulation of the motor cables. If lower temperatures are desired in the system, the temperature can be reduced by using a second output choke.

When installing a second output choke, you must reduce the number of cable windings on the ferrite core:

1 output choke with 5 windings



2 output choke with 3 windings



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#### 7.4.5 Installation



Always wind the motor cable conductors together on the output choke as follows:

1. Take the three conductors into one hand.
2. Secure the beginning of the three conductors with a cable tie.
3. Wind the three conductors together through the toroidal core five times.

Now all three conductors are routed in parallel around the toroidal core.

Observe the following information:

- Wind all three conductors in the same direction.
- Do not mix up the beginning and the end of the conductor. Otherwise this will cancel the effect of the choke.
- If you wind each conductor around the toroidal core individually, there is a risk that the winding direction or the beginning and end of the conductor are mixed up.

In addition, an increased stray field can occur at the non-wound areas of the toroidal core between the phases, which can interfere with sensitive cables.

The following figure shows how to connect the output choke:

**Incorrectly wound output choke**

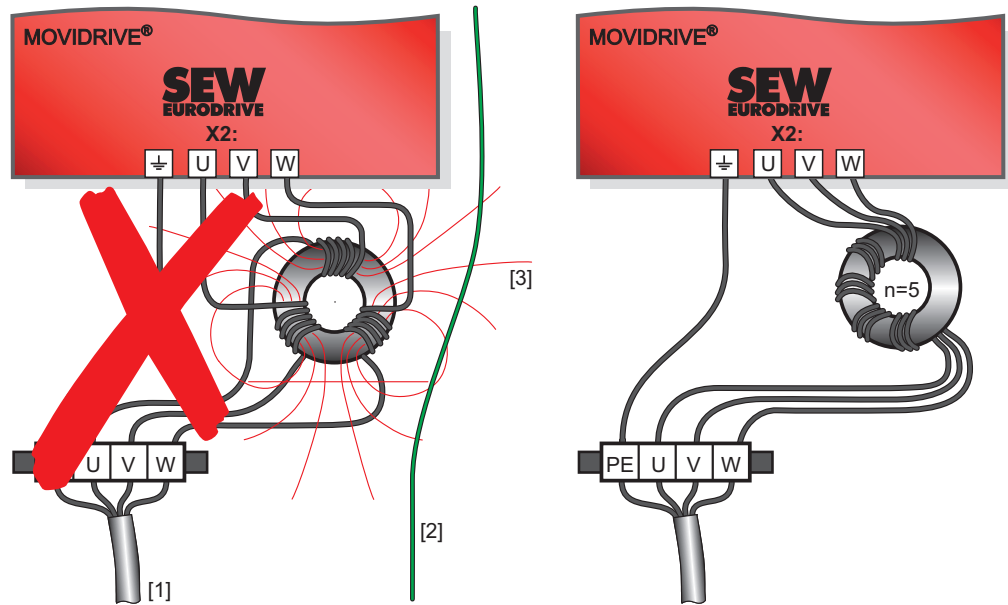
(Conductors wound individually)

**Correctly wound output choke**

(Conductors wound together)

# 7 EMC components in the control cabinet

Output choke (ferrite core choke)



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- [1] Motor line
- [2] Sensitive signal line
- [3] Stray field

## 7.4.6 Use

An output choke suppresses interference at the inverter output.  
An individual output choke is quickly overloaded by a group drive.

## 7.5 Output filter (sine filter)

The output voltage of an inverter is formed from square-wave pulses.

An output filter converts this square-wave output voltage to an almost sinusoidal voltage, see the following figure.



237376395

### 7.5.1 Group drive

The square-wave output voltage of the inverter generates leakage current spikes in the parasitic capacitances of the motor cable and motor windings.

In group drives, these leakage current spikes add up and can reach values that are not permitted for the inverter.

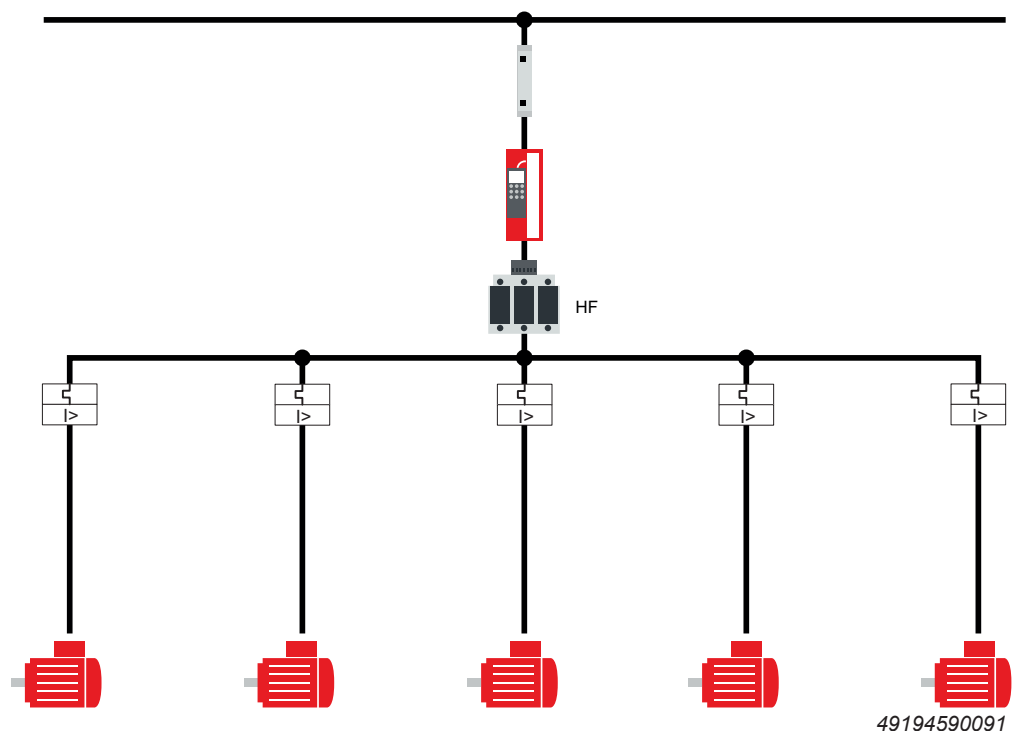
The leakage current spikes depend on:

- The number of motors connected in parallel
- The type and length of the cable at the inverter output
- The size of the motors

When using an output filter, these leakage current spikes are significantly reduced due to its sinusoidal output voltage.

The output filter loads the inverter with a filter current component, which is independent of external factors such as number of motors, cable type, and cable length.

The following figure shows an example of the installation topology of a group drive with an HF output filter:



### 7.5.2 Motors that are not designed for inverter operation

The square-wave output voltage of the inverter can cause overvoltages in the motor.

In motors that are not designed for inverter operation, these overvoltages can destroy the winding insulation of the motor.

Using an output filter solves this problem reliably.

- Thanks to the sinusoidal voltage after the output filter, the overvoltage is significantly reduced. This takes load off the insulation system of the motors.
- To avoid overvoltages caused by resonance against ground potential (e.g. in case of long cables), the output filter should also filter against the ground potential. Filtering against the ground potential is realized by feeding the signal back to the DC link ( $V_z$  connection).

**7.5.3 Noise filtering**

The square-wave pulses of the inverter output cause audible noise in the motor. This noise in the range of the inverter pulse frequency can be very unpleasant. The output filter dampens this noise in the motor considerably. However, the filter itself creates noise in the range of the inverter switching frequency.

**7.5.4 Radio interference suppression**

The use of an output filter enables operation without shielded motor cable also in applications that stipulate limit values.

**7.5.5 Output filter without DC link connection**

An output filter **without** DC link connection converts a pulsed inverter voltage to a sinusoidal voltage when connected phase-to-phase.

However, when connected phase-to-ground, it has a considerably reduced filter effect.

**7.5.6 Output filter with DC link connection**

An output filter **with** DC link connection converts a pulsed inverter voltage to a sinusoidal voltage when connected phase-to-phase and phase-to-ground.

When connecting the output filter to the DC link, you must increase the clock frequency. With a clock frequency of 12 kHz, the inverter only delivers about 70% of its nominal power.

**7.5.7 Dimensioning**

Match the HF output filter to the nominal motor current.

For a group drive, match the HF output filter to the sum of the nominal motor currents:

- At least to the nominal motor current (minimum)
- At most to twice the nominal motor current (maximum)

**7.5.8 Lower motor voltage due to voltage drop at the output filter**

According to the technical data, a voltage drop occurs at the output filter. This voltage drop reduces the voltage available to the motor.

Calculate the maximum voltage drop at the HF filter as follows:

$$\text{Maximum voltage drop at HF filter} = \frac{200 \times \text{inverter output frequency}}{\text{Line voltage}}$$

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**7.5.9 Motor cable**

Only use an unshielded cable as the motor cable at the output of an output filter.

If shielded motor cables are used, resonance vibrations can occur between the shield capacitance and the capacitance of the output filter. These resonance vibrations can damage the output filter.

**7.5.10 Use**

The use of output filters is recommended in the following applications:

- Group drive (several motors on one inverter)
- Use as a noise filter
- Radio interference suppression operation with unshielded motor cables
- As protection against overvoltage peaks

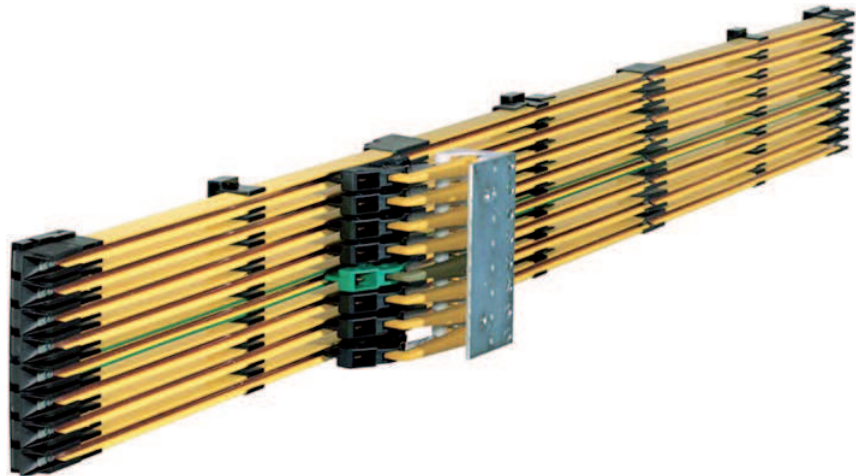
**7.5.11 Price**

The purchase price, size and energy losses of an output filter and an inverter are similarly high. Many project planners therefore try to avoid using an output filter, although the output filter is an almost optimal solution from the EMC perspective.

**7.5.12 Conductor rail as motor cable**

If you are using insulated conductor rails after a frequency inverter as a motor supply (e.g. from the companies Wampfler or Vahle), SEW-EURODRIVE recommends using an output filter. A shielded cable is not possible in this case.

- The output filter protects the system against EMC interference.
- In addition, the output filter protects the output stage of the inverter in the event of problems with the current collectors. The output filter acts like a buffer.



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Only use conductor rails with double current collectors (two brushes in series).  
For the PE conductor, use two current collectors with two separate holders.

## 8 Cables

### 8.1 Routing in the cable duct

Observe the following information:

- Always route the supply and return cables together.
- Avoid spare loops in all connection cables.
- Unused conductors must be grounded at both ends.
- Preferably route cables that are subject to interference in the corners of a metallic cable duct or corner profile. This reduces the radiation of the cable.



235879819

- K Cable duct
- E Corner profile
- S Shielding effect

The shielding effect is improved significantly by using enclosed cable ducts.

### 8.2 Distance between conductors

The greater the distance between the cables, the smaller the parasitic capacitance, and thus the interference current.

The parasitic capacity (interference capacity) increases

- with decreasing cable distance
- with increasing length of cables routed in parallel

The interference current increases with increasing voltage on the interfering cable.

### 8.3 Distance from the reference potential

Route the cables as close as possible to the reference potential, such as the mounting plate, metal cable duct, or grounded machine support.

**Suspended cables act as active and passive antennas.**

## 8.4 Cable groups

The interference source (e.g. motor cable) is usually coupled with the susceptible equipment (e.g. sensitive conductor, device) via the connected circuits. This is why cable routing and the type of cable play an important role in EMC.

For systematic cable routing, the cables are classified into groups according to the signals they transmit. This classification makes it possible to define general, practical rules for cable routing.

In practice, a classification into four cable groups has proven useful. The cable groups can be characterized as follows:

Cable group	Examples
<b>Group 1</b> Very sensitive	Encoder cable Analog sensors Measuring line Capacitive proximity switches Bus cable
<b>Group 2</b> Sensitive	Cables for low-level signals Low-level signal supply (10 V, 24 V)
<b>Group 3</b> Interference sources	Control cables for inductive loads (brakes, contactors, relays) Interference-suppressed power cables Power supply cables (unswitched)
<b>Group 4</b> Strong interference sources	Power circuits Switched power cables (inductive loads, e.g. contactors) Pulsed power cables (inverter)

This group classification is the basis for the following rules of thumb for cable selection:

Cable group	In the control cabinet	Outside the control cabinet
<b>Group 1</b>	Shielded, low-capacitance cable Without interruptions up to the unit, if possible Routed at some distance to groups 3 and 4	
<b>Group 2</b>	Unshielded cable Separate from groups 3 and 4	Cable Routed at some distance to groups 3 and 4
<b>Group 3</b> <b>Group 4</b>	Shielded or filtered cable	

Parallel, safe routing of cables from different groups is only possible with additional measures, such as shielding, filtering, or spacing.

## 8.5 Routing of cables outside the control cabinet

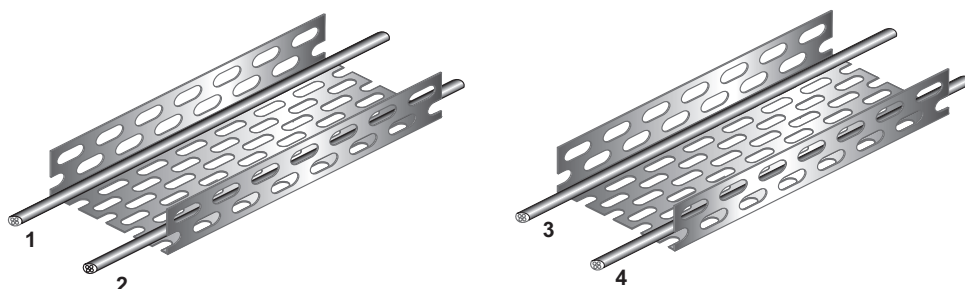
**Outside the control cabinet**, cables are often routed in parallel over long distances with little space in between. In case of non-EMC-compliant cable routing, this leads to increased coupling between the transmitted signals.

Outside the control cabinet, a distance of 20 cm between cables of group 1 or 2 and cables of group 3 or 4 is usually sufficient.

### 8.5.1 Routing of cables from different groups

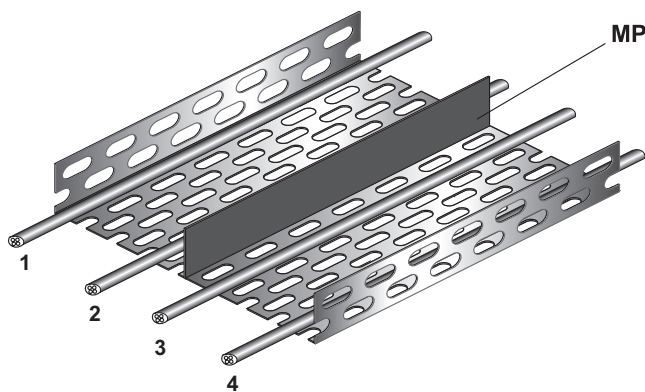
Observe the following information when routing cables from different groups:

- Route cables of groups 1 and 2 as far from cables of groups 3 and 4 as possible.



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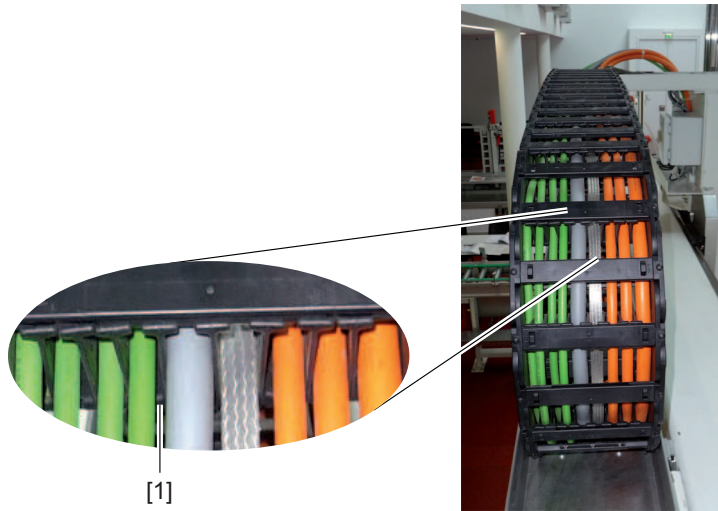
- Or separate them by means of a metallic partition.



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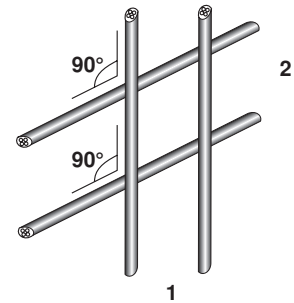
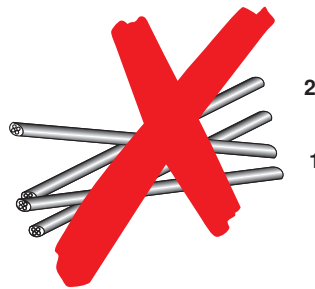
MP = Metallic partition

- The motor cables behind an output filter can be routed in the same cable duct as cables of other groups.  
Only use cable carriers with dividers [1].



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- Cross cables of groups 1 and 2 with cables of groups 3 and 4 at a right angle, if possible.



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## 8.6 Faulty prefabrication of hybrid cables

Prefabricated hybrid cables are often shortened on the motor side by customers or assembled by the customers themselves.

The following error frequently occurs:

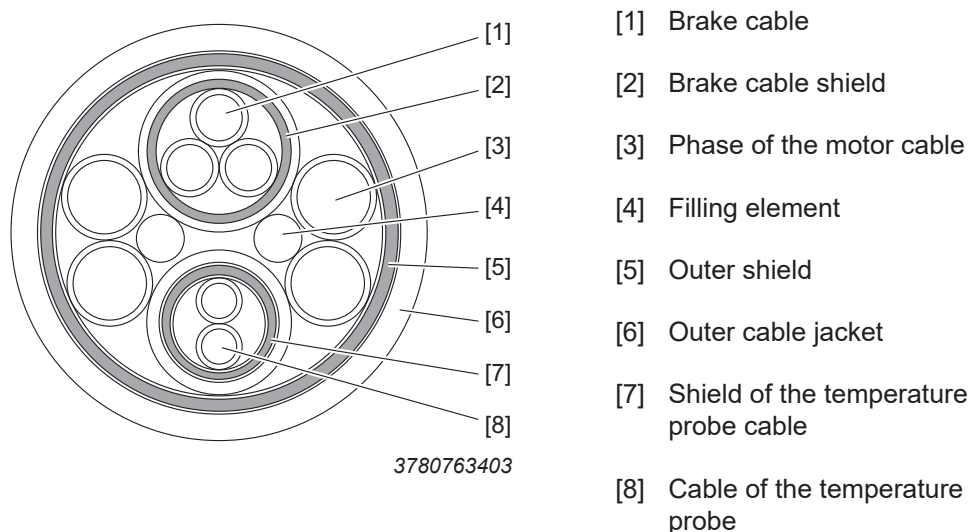
- The outer shield is connected correctly.
- The inner shield is connected correctly on the inverter side.
- **Error:** The inner shield is **not** connected correctly on the motor side.

### 8.6.1 Example of motor/brake cable

If the shield of the brake cable is connected only on one end, the shielding effect is not sufficient.

In case of a pulsed motor cable with insufficient shielding, HF interference peaks are induced in the brake cable. These HF interference peaks in the brake cable put an impermissibly high load on the brake control, causing it to age more quickly.

The following figure shows the cross section of a hybrid cable (SEW-EURODRIVE, type D) with cores for connecting the motor [3], the brake [1], and the temperature probe [8]:



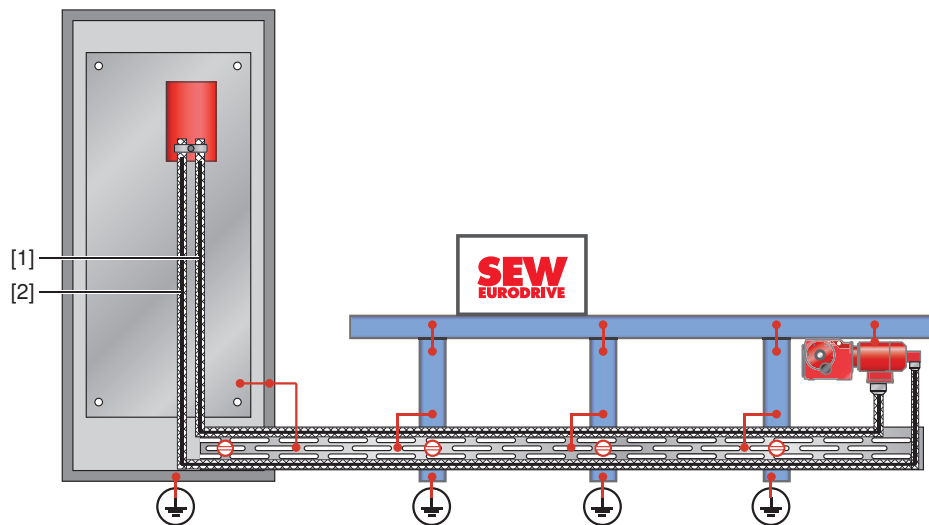
- In the long run, connecting the inner shield of the brake cable in the hybrid cable on only one side can damage the brake control and, as a resulting fault, the brake coil.
- If the shield of a temperature probe cable is not grounded on both sides, encoder faults can be triggered.

Connect the shield of the hybrid cable and of the temperature probe cable **on both sides**.

## 9 Shielding

Observe the following notes for shielding:

- Every cable can emit or receive a magnetic field. This means that every cable can act both as a transmitting and a receiving antenna.
- A single unshielded or unfiltered cable can nullify all the other measures taken.
- Single-sided shielding of a cable is only effective against capacitive coupling of parallel cables, not against magnetic fields.
- To protect against electromagnetic emissions, you must always **connect the shield on both sides**. The shield should be made of copper.

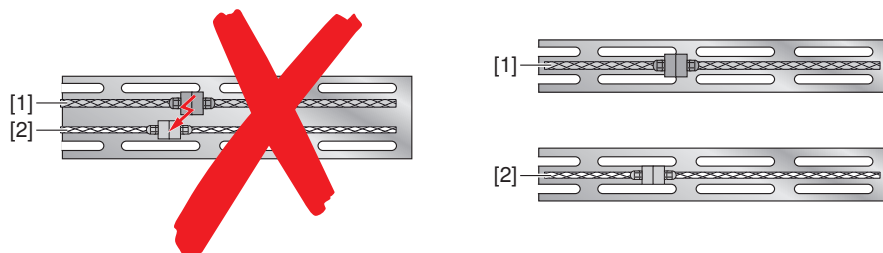


- [1] Motor cable (grounded on both sides)
- [2] Encoder cable (grounded on both sides)

### Exception:

- Routing the cable in a **metal duct** dampens radiation as well, but not as effectively as a copper shield.
- **Metal pipes** are good shields. Special attention must be paid to the connection of the shield at both pipe ends.
- **Shielded cables** from different groups that are grounded on both sides can be routed in the same cable duct.

However, **cables that have been extended with plug connectors** must be routed in separate cable ducts. Otherwise, interference can be transmitted via the plug connectors.



- [1] Motor cable
- [2] Encoder cable

**Practical experience:**

- Often, non-EMC-compliant plug connectors are used for extended shielded encoder or motor cables.
- The plug connectors of extended cables are often not assembled in line with EMC requirements.

Therefore, only use prefabricated cables from SEW-EURODRIVE for extended encoder and motor cables.

## 9.1 Shield types

In practice, different shield types are used for electric conductors. The following table shows the characteristics of the different shield types:

Shield type	Characteristic
<b>Foil shield</b>	Foil shields are often used for signal cables. Their advantage is the high degree of shield coverage of 100%. As the conductive layer is very thin, the effectiveness of foil shields is limited, especially in case of: <ul style="list-style-type: none"> <li>• Strong electromagnetic interference fields</li> <li>• Higher interference currents due to small cross sections</li> </ul> <p>Make sure that the shield foil is not damaged by bending.</p>
<b>Braided shield</b>	Braided shields are usually used for power cables. The higher shield cross section of braided shields offers better protection from high interference currents and strong magnetic fields. Optical shield coverage is an important characteristic of this type of shield. For EMC purposes, it must be at least 85%. Cables with iron armoring are not suitable for EMC purposes.
<b>Multi-shields</b>	Multi-shielded cables offer better screening attenuation compared with singleshield cables. The combination of foil and braided shields offers the advantages of both types. As the manufacturing of such cables is very complex, they are usually only used for transmitting sensitive signals.
<b>Piping</b>	A special type of shielding is routing cables in metallic pipes. Metal pipes offer a large shield cross section and a shield coverage of 100%. This is why metal pipes are well-suited for shielding purposes. Special attention must be paid to the connection of the shield at both pipe ends and to the coupling between cables that are routed together in the pipe.
<b>Ferrite coating</b>	For power cables, there are sheath materials available with integrated ferrite particles for dampening interference currents. These cables are not very significant in practice due to their length-dependent damping and effectiveness. Especially with respect to longer cable lengths and the complex manufacturing technique, these cables are not very common.

## 9.2 Long, shielded cables

Observe the following notes for long shielded cables:

- The shielding effect decreases with increasing cable length. You can improve the shielding of longer cables by grounding the shield at regular intervals with several cable clamps.
- Each cable has a parasitic capacitance that drains off earth-leakage currents to ground. Shielding significantly increases this parasitic capacitance.
- In long shielded motor cables, the high leakage currents can cause considerable interference. Use output filters or ferrite cores instead of the shielded cable in such cases.

If the shield of an already installed shielded cable is not wanted, there is no need to replace this cable.

Alternatively, you can disconnect and insulate the shield on both sides. Make sure that the insulation is sound, e.g. with heat shrink tubing. In case of poor insulation, sparks can be created at the shield ends against ground or other conductive objects.

Disconnecting the shield can be necessary for the following reasons.

- Subsequent installation of an output filter
- Increased leakage current
- Capacitance of long cable is too high
- Group drives

## 9.3 No shielded cables for group drives

Group drives have increased leakage currents as the capacitance of the motor cables and motors increases with parallel connection. The leakage currents put an additional load on the output stage of the frequency inverter.

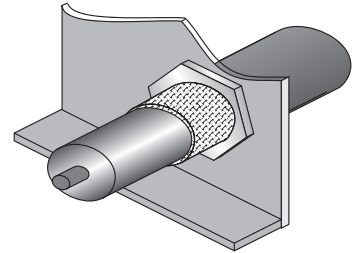
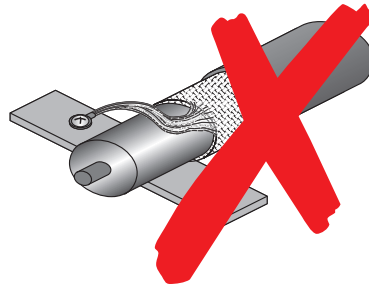
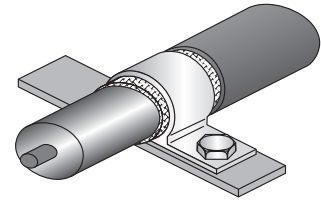
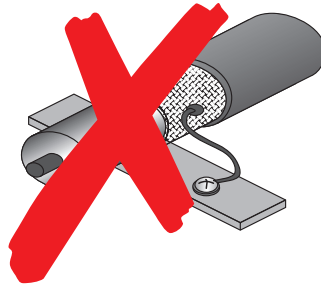
These leakage currents strongly increase when shielded motor cables are used. They can also trip the motor protection switch that is usually used in group drives. This is why you should preferably use unshielded cables for group drives. If the system must meet EMC limit values, install an output filter instead.

## 9.4 Braided shield connection

Connect the braided shield over its entire circumference using grounding clamps or EMC cable glands.

Do **not** connect the shield via a twisted braid (so-called pigtail) or a wire extension. This can reduce the shielding effect by up to 90%.

The following figure shows the different options for connecting the shield:



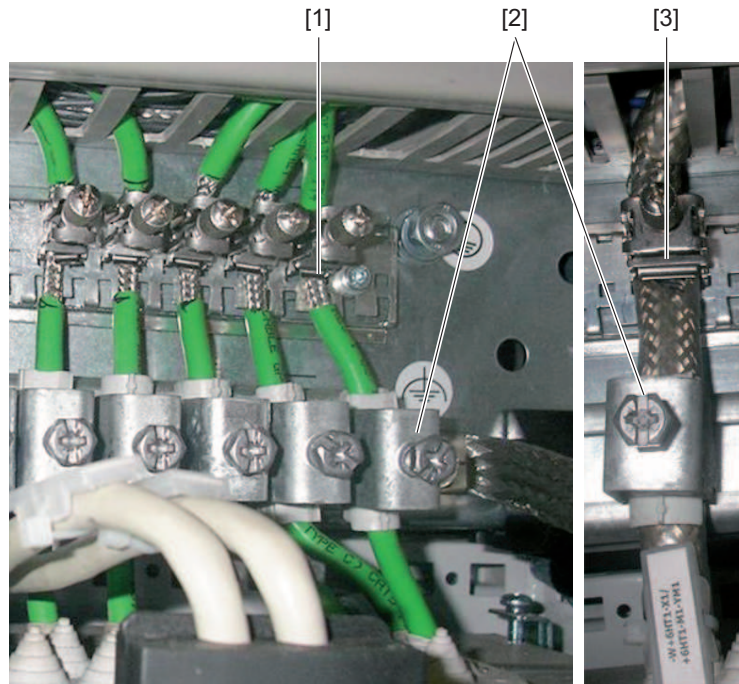
235857803

**Incorrect shield connection**  
via wire extension  
or twisted braiding

**Correct shield connection**  
over entire circumference to housing  
or grounded surface

## 9.4.1 Practice

The following figures show braided shield connections in practice:



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- [1] Shield of encoder cable connected to shield plate of control components
- [2] Mechanical cable relief
- [3] Shield of motor cable connected to shield plate of power components

Observe the following information:

- Connect the braided shields of the encoder and bus cables to the shield plate of the control components [1].
- Connect the braided shield of the motor cable to the separate shield plate for power components [3].
- Fix the cables in position with mechanical cable reliefs [2].
- If the shield plate is not directly connected to the uncoated mounting plate, you have to establish an HF connection to the PE busbar in the control cabinet.
- The braided shield can also be connected directly at the frequency inverter.

9.4.2 EMC screw fittings

Use an EMC screw fitting for the cable bushing in a housing.



3881041803

Example

Manufacturer	Sales	Thread	Type
Company Jacob	Company Sonepar	Mxx	50.6xx M / EMC
		M20	50,620 M / EMC

Alternatively, you can also use EMC screw fittings from Hummel:

- HSK-M-EMV: Type comparable with 50.6xx M / EMC from the company Jacob
- HSK-MZ-EMV: With integrated strain relief and bending protection
- HSK-M-EMV-D: For leading through the braided shield

#### 9.5 Shielding of hybrid cables

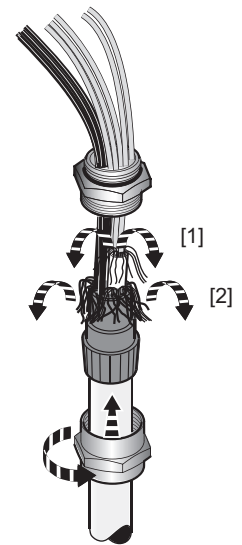
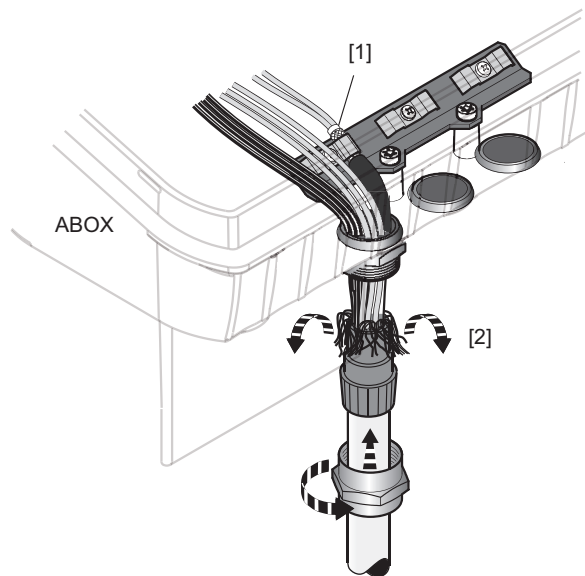
Always connect the shield of a hybrid cable on both sides.

##### 9.5.1 Example with MOVIFIT®

Place the inner shield on the shield plate.

Connect the outer shield over the EMC screw fitting.

Connect the inner shield with the outer shield together over the EMC screw fitting.



[1] Inner shield

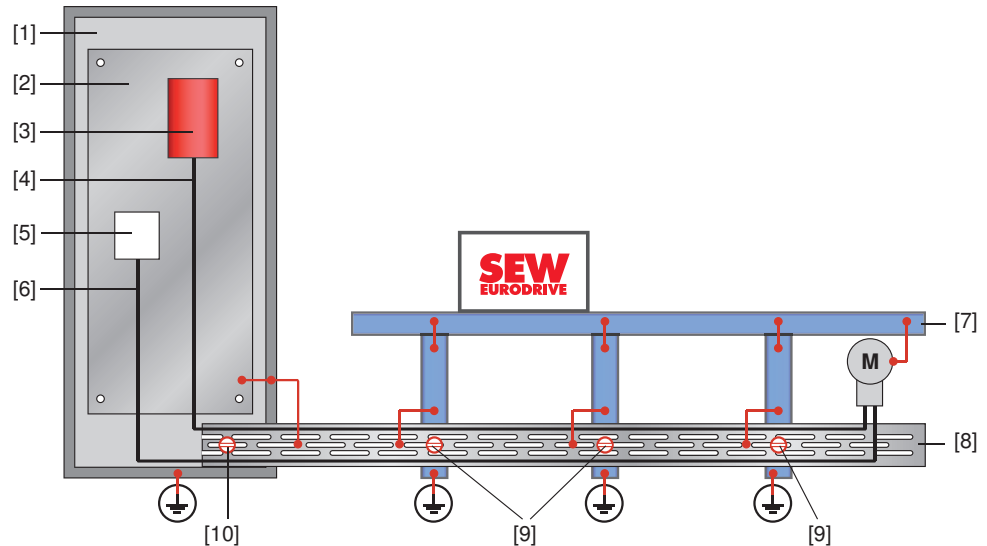
[2] Outer shield

If there is no shield clamp for another braided shield of a hybrid cable, you must connect all braided shields to the EMC screw fitting together.

## 10 Equipotential bonding in the plant

### 10.1 Equipotential bonding measures of a transport system

The following figure shows the equipotential bonding measures of a transport system with one drive:



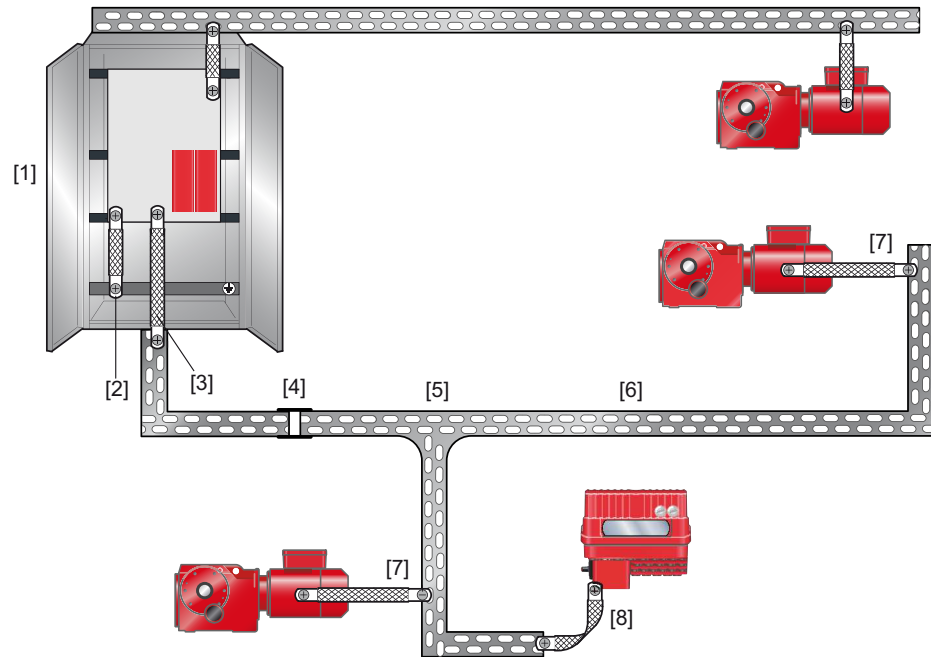
- [1] Control cabinet
- [2] Mounting plate
- [3] Inverters
- [4] Motor cable
- [5] PLC
- [6] Signal cable
- [7] Metallic construction
- [8] Sheet metal cable duct
- [9] Sheet metal cable duct screwed to the metal machine construction over a large area
- [10] Sheet metal cable duct screwed to the rear panel of the control cabinet over a large area

## 10.2 Interlinked equipotential bonding

If you interlink several machines, equipotential bonding is required between the control cabinet, conveyor elements, cable ducts, and operating resources.

- In terms of electrical safety, the PE busbar represents the star point.
- In terms of EMC, it is advantageous if the mounting plate is used as a star point with respect to HF equipotential bonding.

The following figure shows an example of interlinked equipotential bonding between multiple components:



- [1] Control cabinet with PE busbar
- [2] Connection between mounting plate and PE busbar
- [3] HF-capable connection of cable duct to PE busbar
- [4] Large contact area between cable ducts
- [5] Branches with extensive angles
- [6] Sheet metal cable duct
- [7] HF-capable equipotential bonding of the gearmotor to the cable duct
- [8] HF-capable equipotential bonding of the MOVIFIT® unit to the cable duct

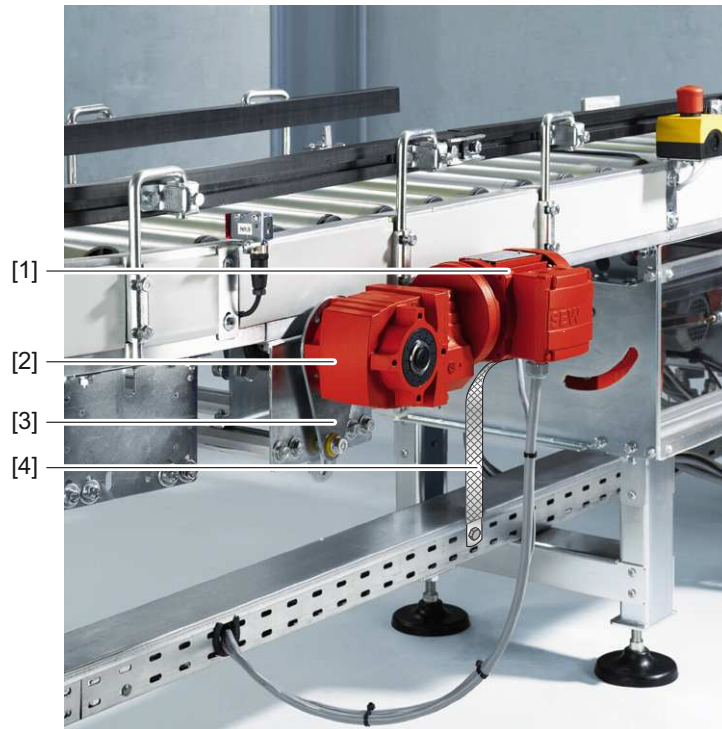
Observe the following information when establishing equipotential bonding:

- Install the control cabinet with PE busbar according to the figure above.
- Connect the cable duct to the control cabinet over a large area.
- Connect the cable duct to the mounting plate in the control cabinet [3] using a ground strap.
- Connect the PE busbar with the mounting plate [2] over a large area.
- Connect the parts of the sheet metal cable duct with each other [4] over a large area.
- Connect cable ducts that branch off using large-area brackets [5].
- Connect the PE connection of the MOVIFIT® device to the cable duct [8] using a ground strap.
- Connect the gearmotor with the cable duct [7] in the same way.

### 10.3 Example: Drive with shaft-mounted gear unit

#### 10.3.1 Equipotential bonding for protecting the brake rectifier

A drive with shaft-mounted gear unit is mechanically connected to the plant only via the shaft and a torque arm.



5374678539

- [1] Motor
- [2] Shaft-mounted gear units
- [3] Torque arm with rubber bushing
- [4] Ground strap

The bearings of the gear unit offer no sufficient equipotential bonding for the drive. The torque arm is often equipped with an elastic rubber bushing that electrically isolates the drive from the system. This means the drive has no HF-capable equipotential bonding.

Due to this insufficient equipotential bonding, some of the leakage currents from the motor flow back to the inverter in the control cabinet via the brake cable. This means that the leakage currents flow through the brake control, damaging the electronic components of the brake rectifier. This can lead to accelerated aging and to an early failure of the brake rectifier.

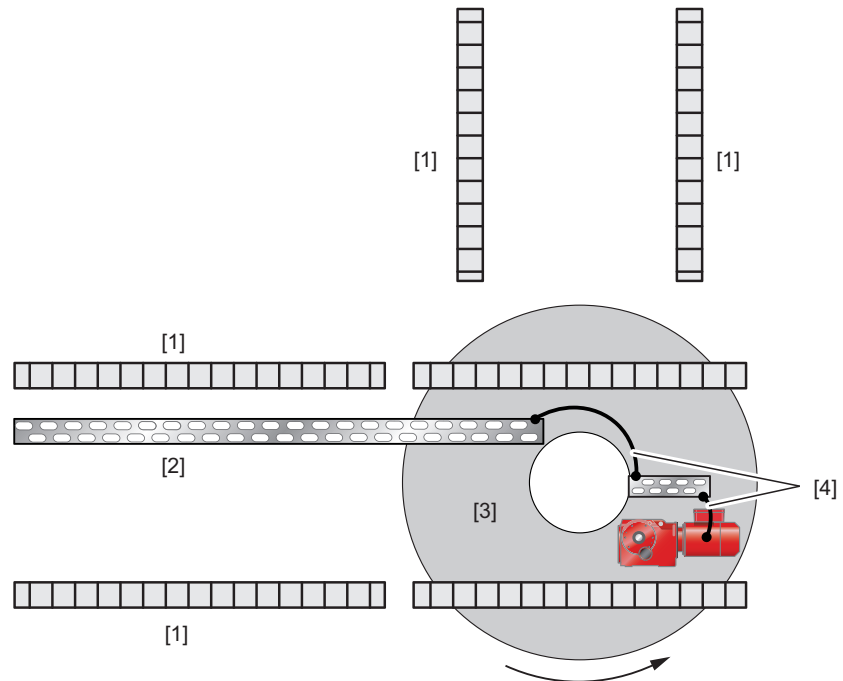
In hoists and rotary tables, the equipotential bonding of the mobile drive may also be unsuitable for HF. The insufficient equipotential bonding of mobile drives of hoists and rotary tables can also result in an early failure of the brake control.

#### 10.3.2 Conclusion

Therefore, in shaft-mounted gear units, hoists, and rotary tables, always install a ground strap between the motor and the system. The leakage currents will then flow to ground via the ground strap.

## 10.4 Example: Rotary table

The following figure shows the equipotential bonding of a rotary table:



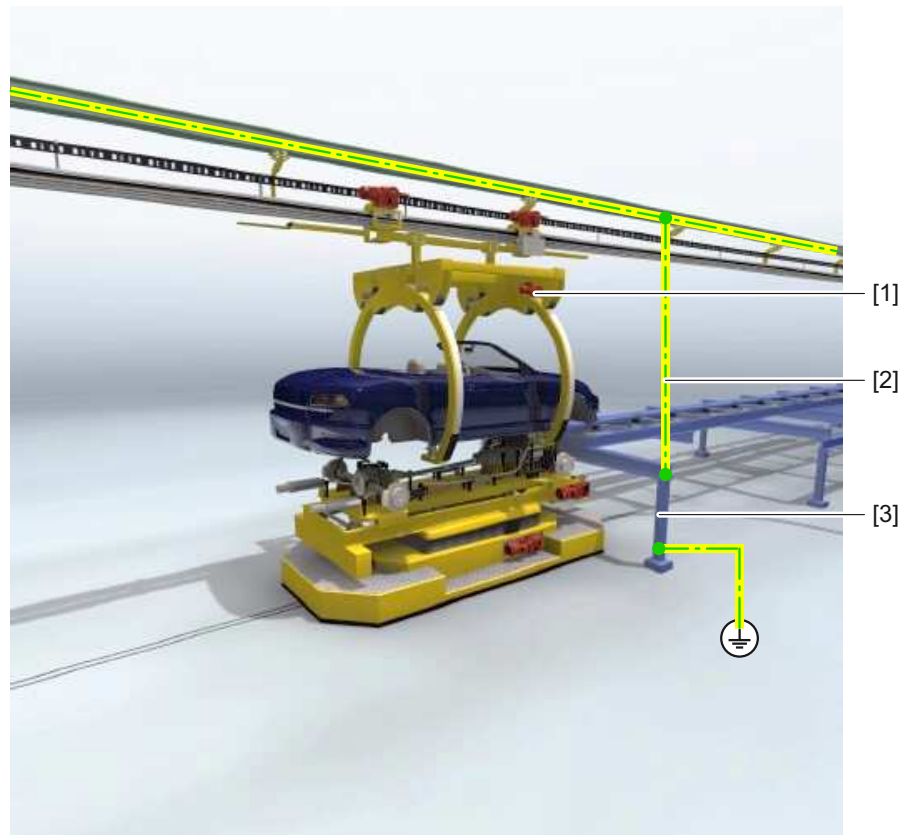
3854592267

- [1] Chain of the chain conveyor
- [2] Sheet metal cable duct
- [3] Rotary table
- [4] Equipotential bonding between stationary and mobile cable ducts and motor

Establish equipotential bonding between the stationary cable ducts, mobile cable ducts, and the motor as shown in the figure above [3].

## 10.5 Example: Electrified monorail system

The following figure shows the equipotential bonding at the docking station of an electrified monorail system:



3855975947

- [1] Frequency inverter of the turning device with line filter
- [2] Equipotential bonding of PE busbar to docking station
- [3] Docking station

- Mobile drive on the electrified monorail system

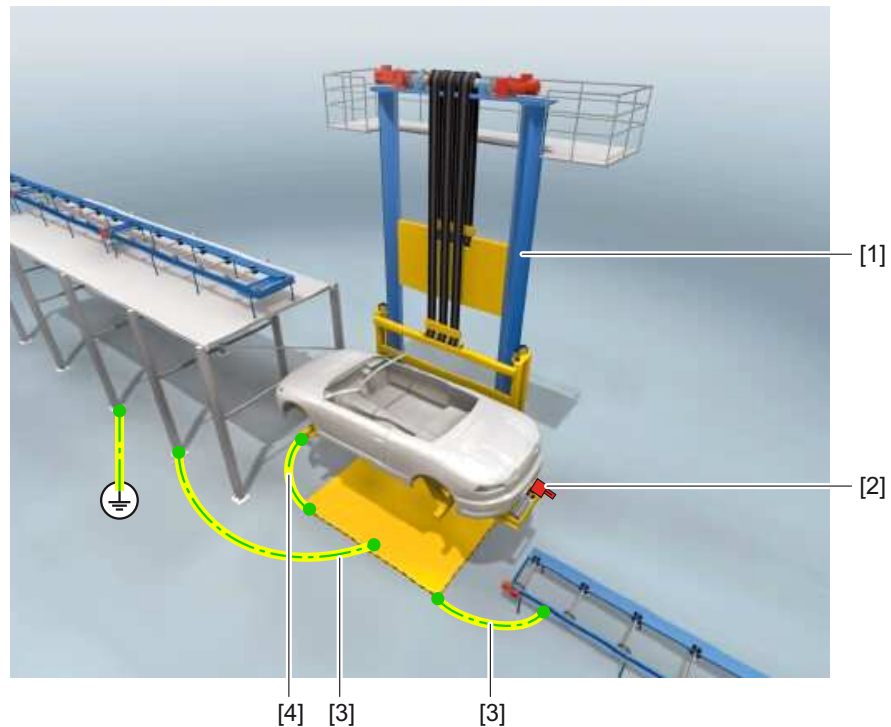
If a controlled drive travels on an electrified monorail system, the mobile drive must be equipped with a line filter. The line filter is already integrated in smaller sizes. The line filter feeds the largest part of the leakage currents back to the frequency inverter. This reduces the risk of leakage currents dissipating via other components and interfering with the equipment or communications.

- Equipotential bonding of the electrified monorail system at the docking station

If an electrified monorail system is supplied with power via a conductor rail system, you must install an equipotential bonding cable between the PE busbar of the conductor rail system and the stopping point of the docking station. This ensures that no potential difference can occur between the electrified monorail system and the docking station. This prevents electrical hazards to persons.

### 10.6 Example: Hoist with integrated roller conveyor

The following figure shows the equipotential bonding of a hoist with integrated roller conveyor:



3857042187

- [1] Hoist
- [2] Mobile drive
- [3] Equipotential bonding
- [4] Equipotential bonding (traveling cable) of the fork

If a controlled drive [2] travels on a hoist, the mobile drive must be equipped with a line filter. The line filter is already integrated in smaller sizes. The line filter feeds the largest part of the leakage currents back to the frequency inverter. This reduces the risk of leakage currents dissipating via other components and interfering with the equipment or communications.

If the frequency inverter and the bus module of a roller conveyor drive are both installed on the fork of the hoist, correct equipotential bonding of the fork is especially important.

For example, the following cables are suitable as traveling cables [4]:

- Round, tinned copper strip, e.g. RTCB from the company ERICO.  
This is the best solution with respect to EMC.
- Separate PE cable with larger cable cross section, e.g. 16 mm<sup>2</sup>.

## 10.7 ESD – electrostatic discharge

Electrostatic discharge (ESD) is a disruptive discharge or spark caused by charge separation between two different electrically insulating materials. ESD causes a very short, high electrical current impulse that strongly interferes with the components in the system.

### 10.7.1 Cause

The cause for the high potential difference is usually continuous charging due to the triboelectric effect, for example:

- Walking on a rug with insulating shoes
- Handling plastic parts
- Pulling off plastic or paper webs from reels
- When using plastic rollers, e.g. in roller conveyors or hoists

### 10.7.2 Effects

- Interference with electronic equipment, especially in case of bus communication
- Damage to semiconductors, creeping defects
- Encoder malfunctions

### 10.7.3 Remedy

You can protect the system from ESD by installing components for dissipating the charge at all points where insulating materials rub against each other.

The following measures are suitable for dissipating charges within the system:

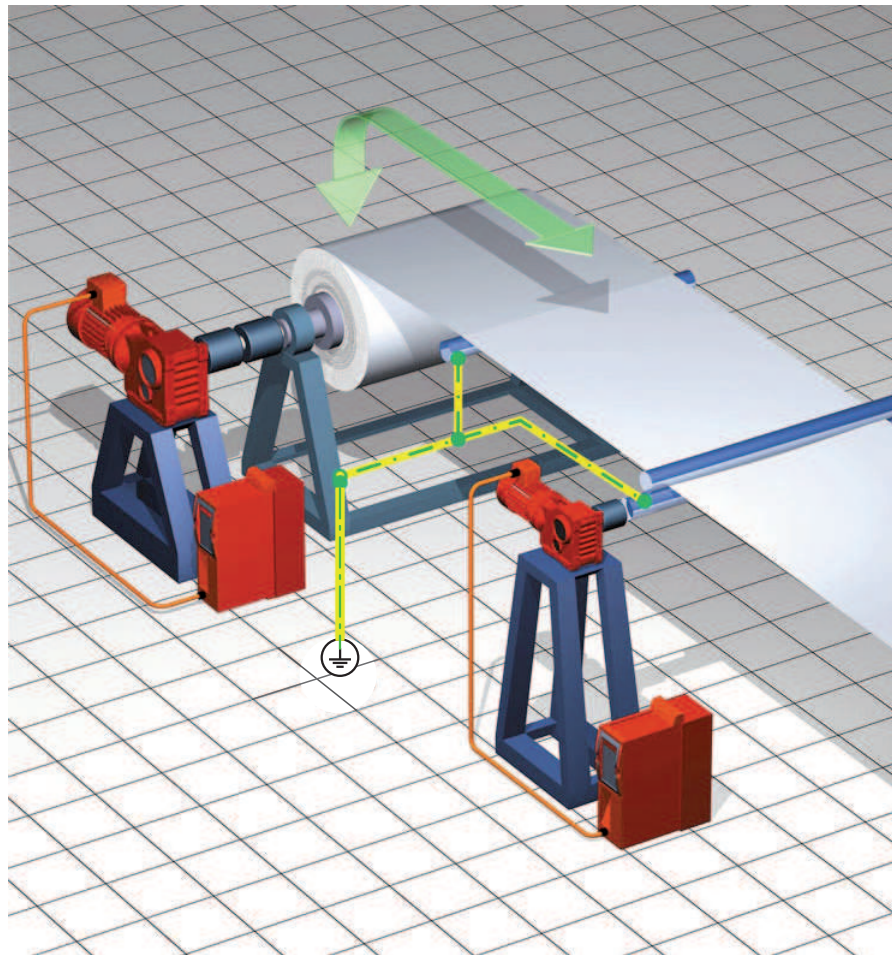
- Conductive combs
- Brushes, metal filaments
- Sliders, metal rollers, metal drums, etc.

These protective measures are especially important for the following applications:

- Conveyor belts
- Pulling off plastic or paper webs from reels.

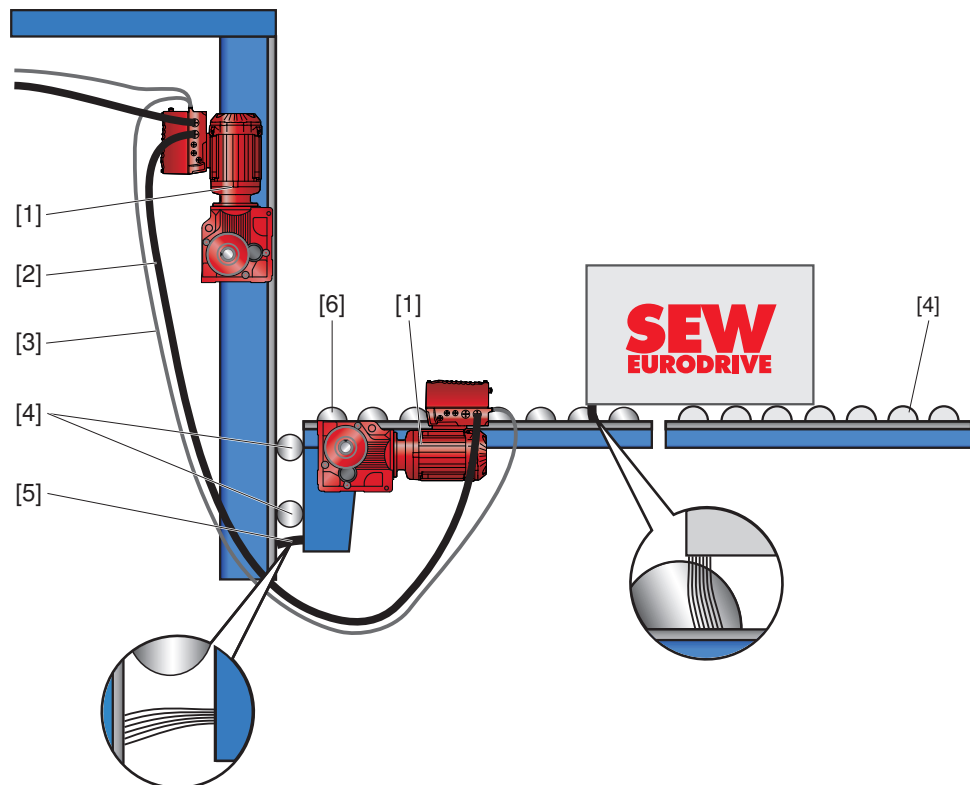
In large moving objects (e.g. winders), the charges can become so high that ESD protection is necessary for reasons of operator protection alone.

The following figure shows the ESD protection of a winder:



3859323147

The following figure shows the ESD protection of a hoist and roller conveyor with metal and plastic rollers:



18014398810888587

- [1] Drive unit with inverter
- [2] Hybrid cable (power, bus communication)
- [3] EMC-compliant equipotential bonding cable
- [4] Plastic rollers (made of PVC)
- [5] Metal comb
- [6] Metal rollers

The charges of the mobile part are dissipated continuously via the metal comb to the frame of the hoist. This prevents electrostatic charging of the transported goods. Consequently, this protects the electronics of the field distributor and inverter.

#### 10.7.4 Conclusion

IN ESD-sensitive systems, ESD protection measures are required in addition to HF-compliant equipotential bonding.

The following measures are required:

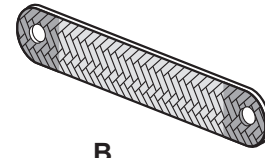
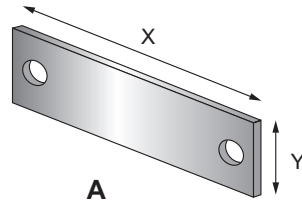
- EMC-compliant **equipotential bonding** against interference emissions
- **ESD protection** as device protection

In case of large, moving objects, ESD protection is necessary also for operator safety reasons.

### 10.8 Low-resistance ground reference

For optimized equipotential bonding in the HF range, a low-resistance ground reference is obligatory.

The following connection elements ensure low-impedance ground reference:



235057163

- A Connection over a large area with a size ratio of  $X:Y < 3:1$ ,  
e.g. for connecting sheet metal ducts
- B Ground strap

### 10.9 Connection over a wide area

To connect individual machine parts or sheet metal ducts, you can use a wide metal plate [A].

Connect it to the reference potential at both ends over a large area.

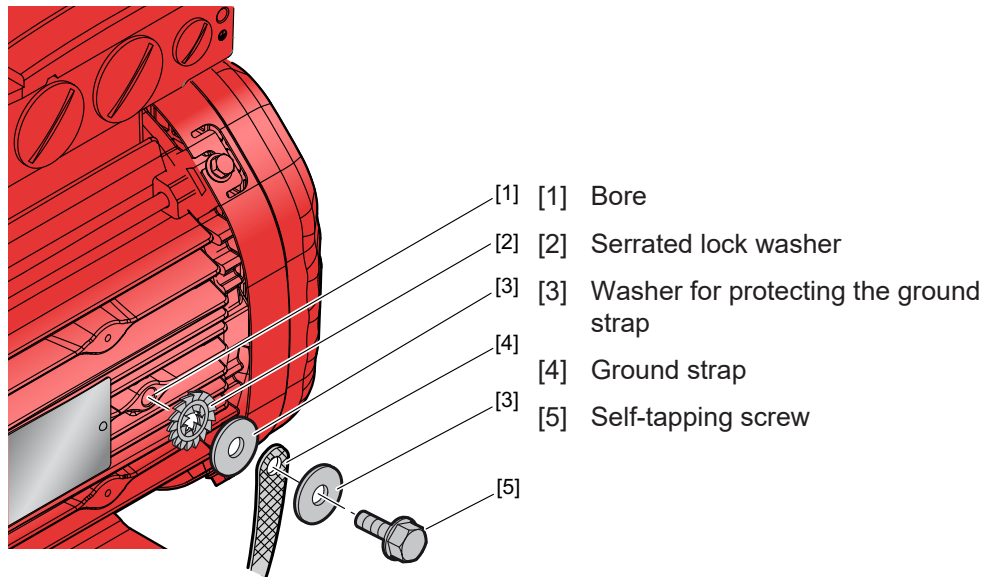
### 10.10 Ground strap

If the use of large-area connections is not possible, you can use flexible ground straps [B] instead.

According to **EN 60204-1**, chapter 13.2.2 from 2006, ground straps can be used as PE conductors if the connection points are marked with the ground symbol.

Protect the ground strap using 2 washers to prevent it from being damaged when the screw is tightened or when it is subjected to vibrations. Note the structure of the screw connection below.

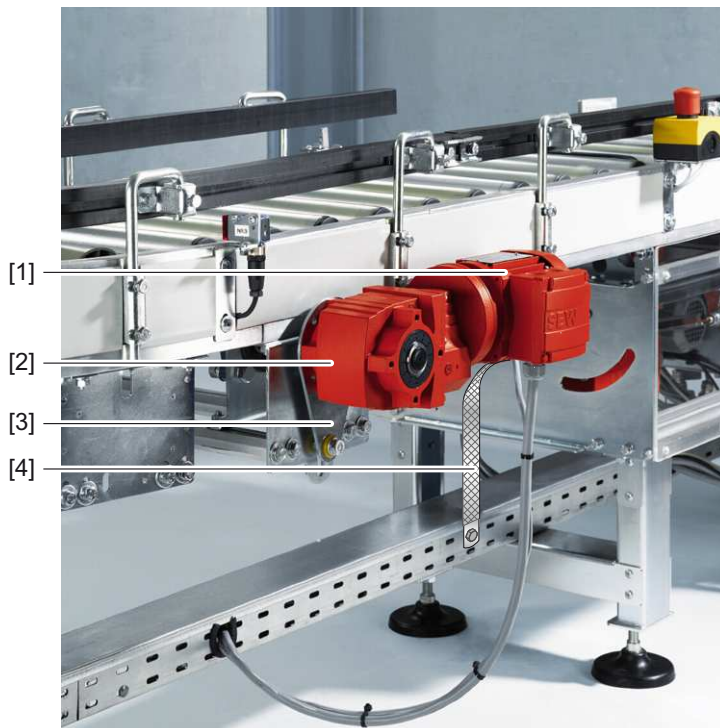
The following figure shows an example of how the ground strap can be attached to a DR.100M motor:



### INFORMATION



High-frequency interference frequencies can cause encoder faults or damage the brake rectifier. Connecting an additional ground strap can divert these interference frequencies to ground.

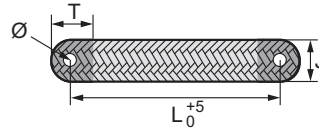


- [1] Motor
- [2] Shaft-mounted gear units
- [3] Torque arm with rubber bushing
- [4] Ground strap

SEW-EURODRIVE recommends the following ground straps from ERICO for establishing equipotential bonding for SEW-EURODRIVE drives:

- For the standard equipotential bonding connection of SEW-EURODRIVE components such as motors and decentralized controllers, use a ground strap with a hole diameter of 6.5 mm.
- For the "Improved grounding" option for DR motors, use a ground strap with a hole diameter of 8.5 mm.

The following figure shows the ERICO ground strap:



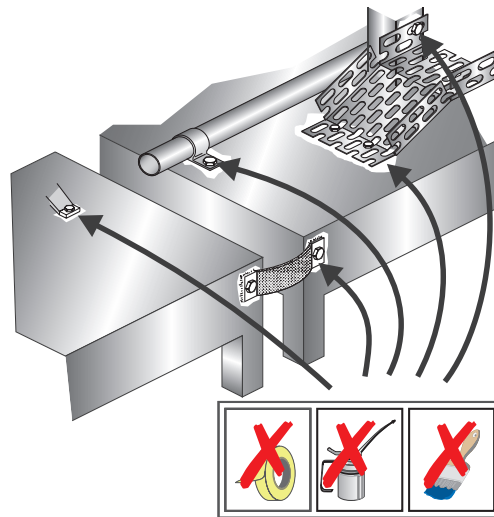
The following table shows the technical data of the ground straps:

	<b>SEW-EURODRIVE standard connection for equipotential bonding</b>	<b>"Improved grounding" option (→ 78)</b>
Item number (ERICO)	556610	556660
Type	MBJ 10-300-6	MBJ 16-300-8
[L] Length	300 mm	300 mm
[J] Width	12 mm	15 mm
[Ø] Hole diameter	6.5 mm	8.5 mm
[T] Minimum contact length	22 mm	25 mm
Current carrying capacity	Max. 75 A	Max. 120 A
Cable cross section	10 millimeters <sup>2</sup>	16 millimeters <sup>2</sup>

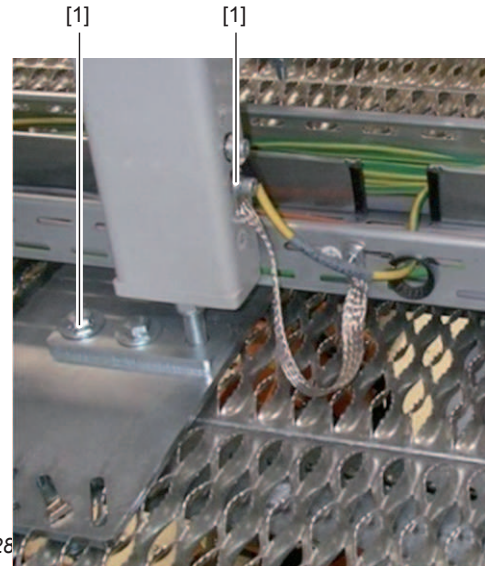
## 10.11 Contact

The contacts of the grounding connections have a significant influence on the quality of the grounding connection.

The following figures show examples of suitable contact options:



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3879515275

[1] Connection options

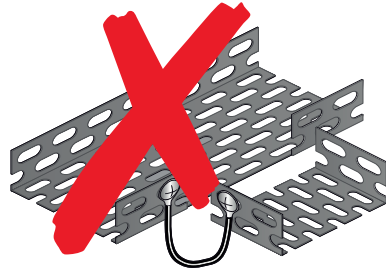
## 10.12 Cable duct connections

Observe the following notes for the installation of cable ducts:

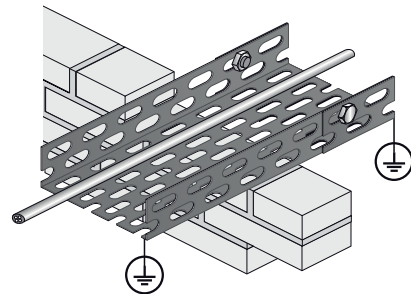
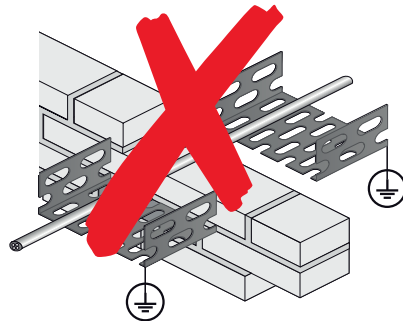
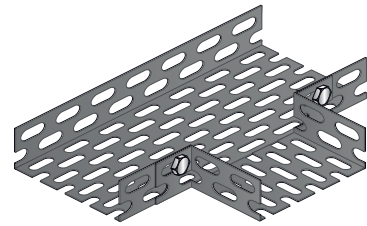
- Ensure connection over a large area by using metal brackets for the cable ducts.
- A continuous ground reference surface (sheet metal duct) must exist between two plant components.
- Route all cables along the ground reference surface.
- Make sure that the contact points pose no tripping hazard.

The following figures show examples of suitable contact options:

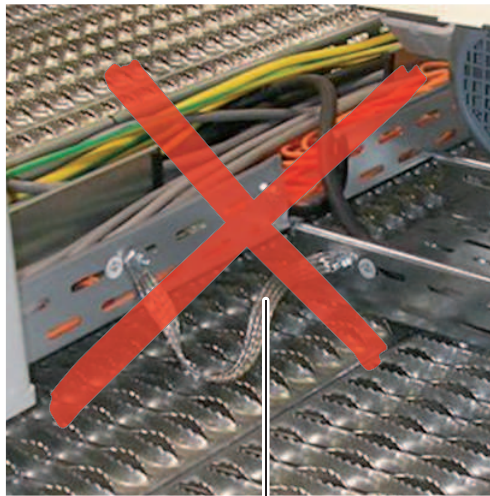
Non-recommended connections



Recommended connections



The following figures show negative examples of contact options:



[1]

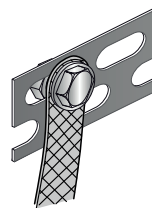


[1]

[1] Connection poses a tripping hazard

Do **not** establish connections [1] as shown in the pictures above, as they do not offer contact over a large area and pose a tripping hazard.

Always attach the ground strap at the end of the slotted hole.



## 11 Equipotential bonding for generation B control cabinet inverters

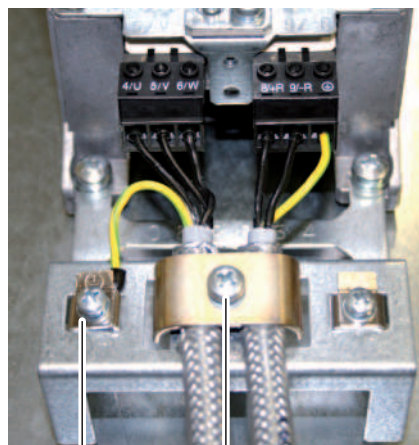
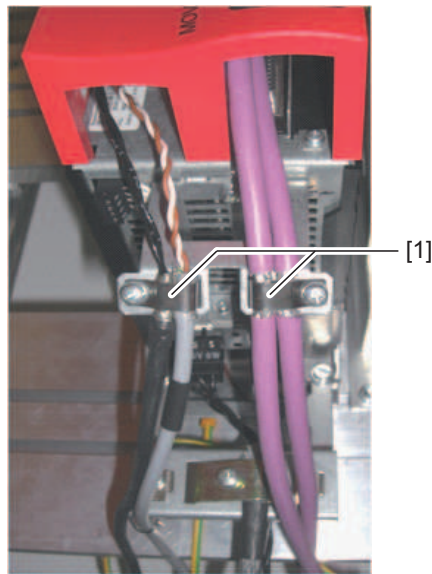
The following chapters exemplify equipotential bonding of the components in the SEW-EURODRIVE control cabinet.

### 11.1 MOVIDRIVE® MDX

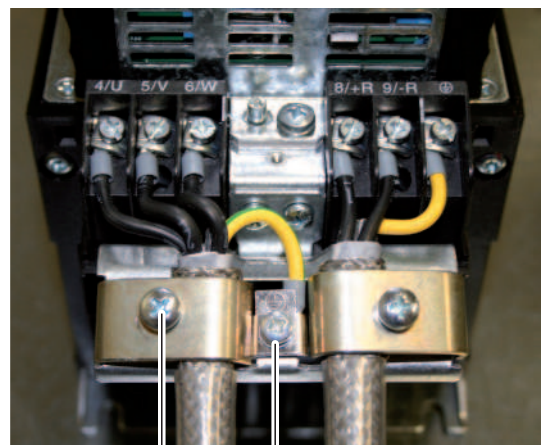
#### 11.1.1 Connection of braided shields for MOVIDRIVE® sizes 1 and 2

The following figures show the connection of braided shields to the MOVIDRIVE® MDX frequency inverter, size 1 and 2:

Control head



[3] [2]  
**Power section size 1**



[2] [3]  
**Power section size 2**

46072262155

- [1] Connection of braided shield signal cables (24 V cable, encoder cable, bus cable)
- [2] Connection of braided shield power cable (power section shield terminal)
- [3] PE connection

### 11.1.2 Connection of braided shields for MOVIDRIVE® sizes 3 to 6

The following figure shows the connection of the braided shields of MOVIDRIVE® MDX of sizes 3 – 6.

- Connect the braided shield of the motor cable to the input shield plate of the control cabinet.
- Or connect the motor cable shield to the mounting plate over a large area using a shield terminal according to the following images:



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### 11.1.3 Increased encoder availability due to grounding screw of MOVIDRIVE® B

By using the grounding screw at the MOVIDRIVE® B control unit, the reference potential of the 24 V supply can be separated from the PE conductor.



5481981067

- Ground screw screwed in → direct connection to 0 V of the 24 V supply  
DGND (X10, X12, X13, X16, X17) is connected to PE  
This means the MOVIDRIVE® B inverter has increased protection against encoder errors.
- Without screw → High insulation resistance  
Removing the M4 grounding screw creates electrical isolation.  
Ground connection is now via four capacitors and a high resistance to ground.

#### **Example: Insulation monitor in 24 V supply**

For additional operating reliability, the 24 V supply is partly monitored by an insulation monitor (e.g. in the chemical industry). This monitoring offers additional protection from malfunctions of the system in case of faulty insulation in the 24 V control circuit.

If electrical isolation is not possible in a unit, you must provide a separate 24 V supply.

## 11.2 Braking resistor

### 11.2.1 Braking resistor cables

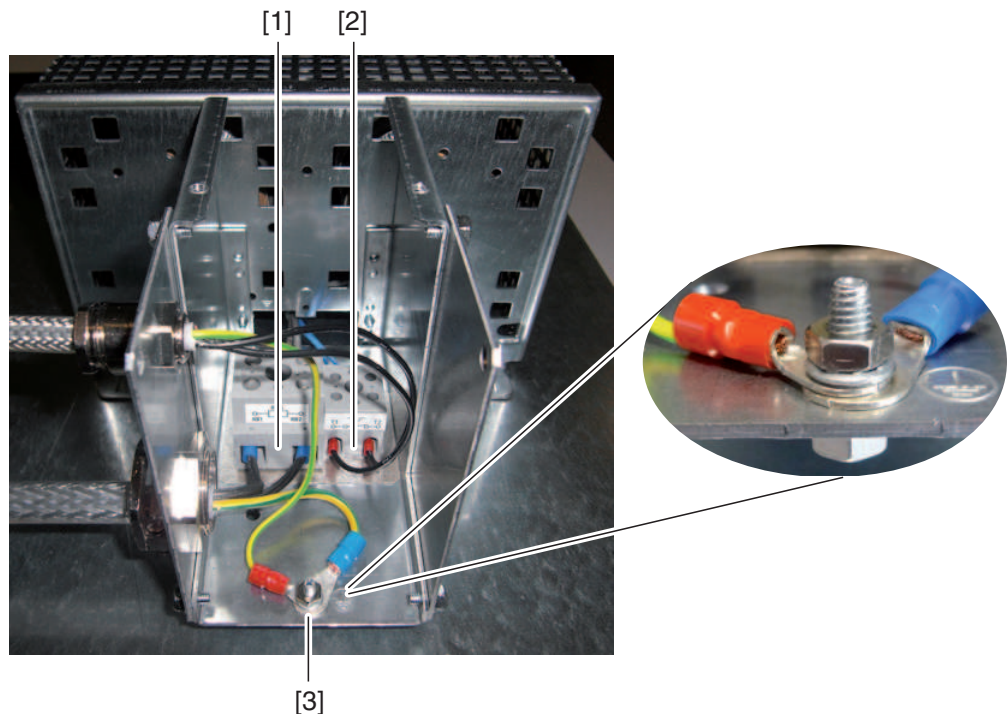
For connecting braking resistors to the inverter, use two closely twisted cores or a shielded power cable.

The nominal voltage of the braking resistor cable must be at least  $U_0 / U = 300 \text{ V} / 500 \text{ V}$  according to DIN VDE 0298.

### 11.2.2 Installation of steel-grid braking resistor

Install the braking resistor over a large, non-painted area, if possible. This is not possible, you can also mount the braking resistor to the control cabinet panel using tooth lock washers.

The following figure shows the connection of a steel-grid braking resistor with temperature sensor or temperature switch:



3852709899

- [1] Braking resistor connection
- [2] Connection of TH temperature switch
- [3] PE connection

## 12 Equipotential bonding of decentralized components

In decentralized applications, bus communication is distributed in the field. This is why HF-capable equipotential bonding is particularly important.

In addition to the PE connection, you must install low-impedance, HF-compatible equipotential bonding (e.g. a ground strap).

The following chapters exemplify equipotential bonding of the decentralized components from SEW-EURODRIVE.

### 12.1 Protective earth and equipotential bonding of decentralized inverters

#### 12.1.1 Requirements for protective earth and equipotential bonding

Observe the following information during electrical installation of decentralized inverters:

- During operation, frequency inverters cause a leakage current  $> 3.5$  mA.  
In accordance with standard EN 61800-5-1, you must install protective earth (PE) conductors on the frequency inverter. Observe the following information:
  - Install **1 PE conductor** with a minimum cross section of  $10 \text{ mm}^2$ .
  - or
  - Install a **second PE conductor** via separate terminals.
- Stable EMC-proof communication requires a low-impedance connection between the device and **equipotential bonding** (generally the cable duct).
  - For cable lengths  $< 2 \text{ m}$  (from the inverter to the equipotential bonding connection point), use a fine-stranded PE conductor to connect equipotential bonding.
  - For cable lengths  $> 2 \text{ m}$  (from the inverter to the equipotential bonding connection point), use a ground strap to connect equipotential bonding.

### 12.1.2 Combination of protective earth and equipotential bonding

If you meet both conditions (protective earth and equipotential bonding) by using a conductor, the protective earth can assume the function of equipotential bonding.

The following requirements must be fulfilled for this:

- Connection to an HF-compatible equipotential bonding is possible within 2 m.
- The conductor must meet the requirements of standard EN 61800-5-1 on the protective earth (PE connection).

### Protective earth

If you **do not** use a copper cable as PE protective earth, you must install a protective earth with a higher cross section by allowing the same amount of current to flow.

#### Quotations from standard EN 61800-5-1

- Chapter 5.3.5.4 A protective earth that is not part of a cable must not be smaller than
- 2.5 mm<sup>2</sup> Cu if protection against mechanical damage is provided.
  - 4 mm<sup>2</sup> Cu if **no** protection against mechanical damage is provided.

Chapter 8.2.2 A sheet metal cable duct must **not** be used as a PE conductor.

### 12.1.3 Example: Cable duct with integrated PE system

You can combine the second PE conductor and the ground strap in one cable if, within 2 m,

- there is an HF-compatible connection to the equipotential bonding (for example, a sheet metal cable duct)
- and a PE connection (for example, PE connection in the cable duct).



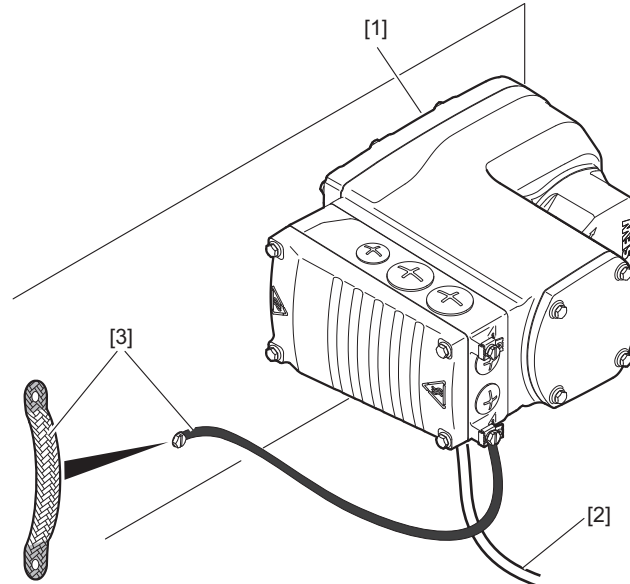
Use a fine-stranded copper cable with a cross section of min. 4 mm<sup>2</sup> for connecting the PE conductor/equipotential bonding.

A sheet metal cable duct is ideally suited as equipotential bonding, but do not use it as a PE conductor.

## 12.2 Equipotential bonding of decentralized MOVI-C® devices

### 12.2.1 Example equipotential bonding of MOVIGEAR® classic

The following figure shows equipotential bonding using the example of MOVIGEAR® classic:

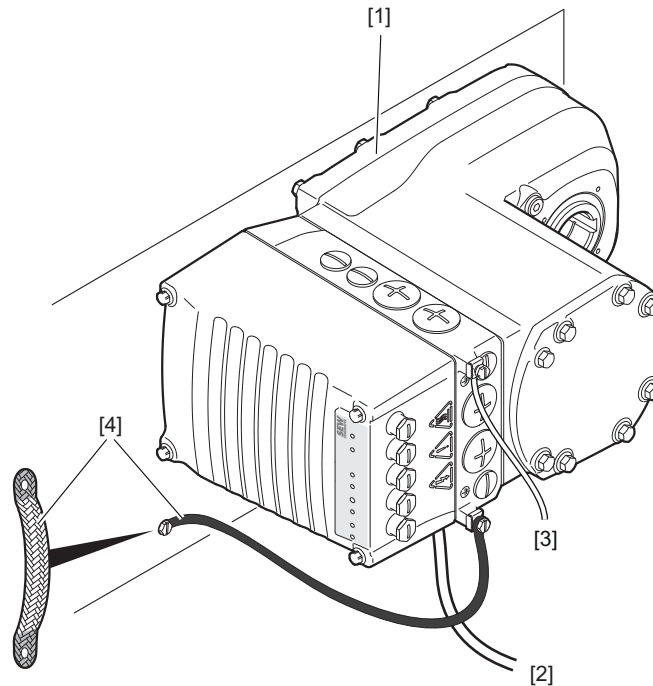


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- [1] The mechanical installation of a drive unit with hollow shaft does **not** create a conductive connection of drive unit and mounting plate.
- [2] Motor cable
- [3] Ground strap

### 12.2.2 Example equipotential bonding of MOVIGEAR® performance

The following figure shows equipotential bonding using the example of MOVIGEAR® performance:

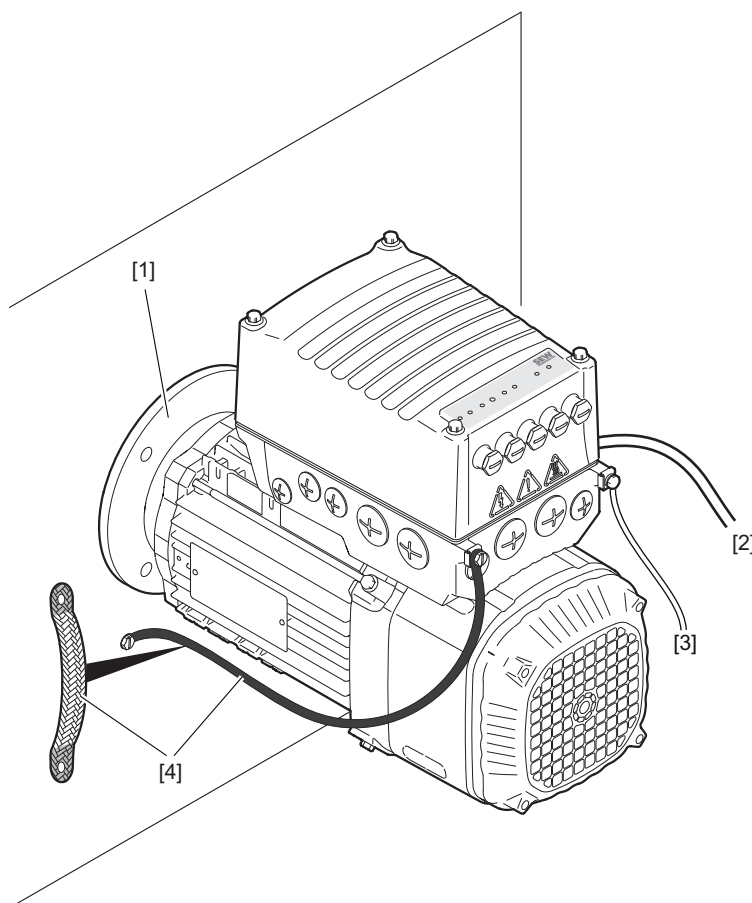


25167264651

- [1] The mechanical installation of a drive unit **with** hollow shaft does **not** create a conductive connection of drive unit and mounting plate. In this case, a low-impedance, Hf-capable equipotential bonding [4] is required. If you install a drive unit **without** a hollow shaft, this results in a large, conductive connection between the drive unit and the mounting plate. In this case, the entire contact surface must be electrically conductive (e.g. unpainted).
- [2] PE conductor in the supply system cable
- [3] 2nd PE conductor via separate terminals
- [4] EMC-compliant equipotential bonding, e.g. via a ground strap  
The contact surfaces must be electrically conductive (e.g. unpainted). For improved low-impedance grounding at high frequencies, SEW-EURODRIVE recommends using corrosion-resistant connecting elements. The HF grounding option can be combined with LF grounding at the terminal box.

### 12.2.3 Example equipotential bonding of MOVIMOT® advanced

The following figure shows equipotential bonding using the example of MOVIMOT® advanced without a gear unit:

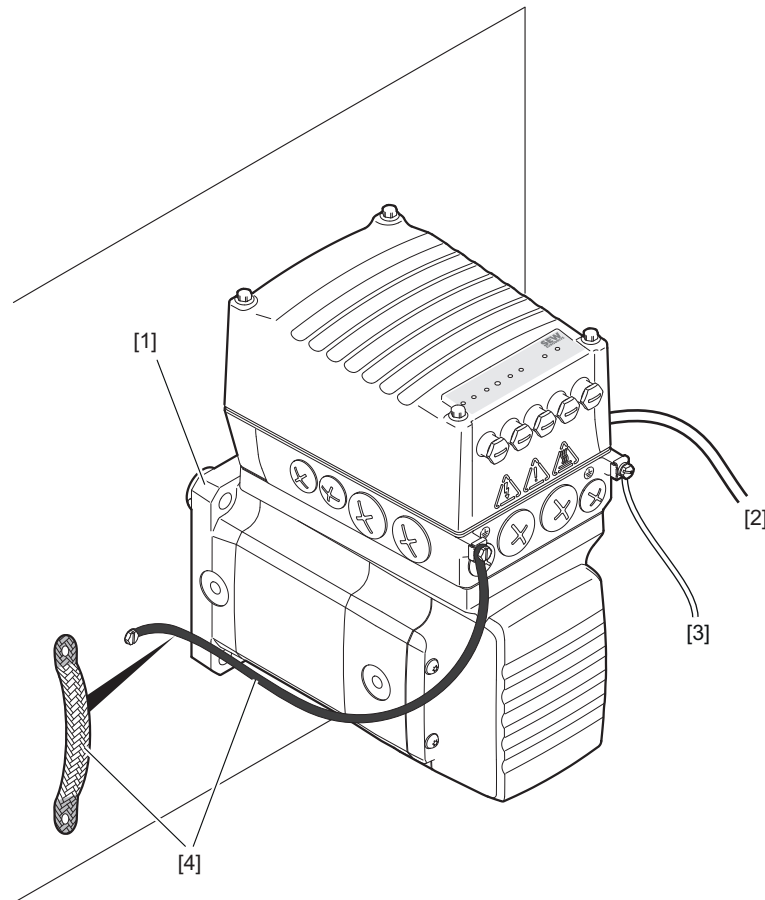


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- [1] The mechanical installation of a drive unit **with** hollow shaft does **not** create a conductive connection of drive unit and mounting plate. In this case, a low-impedance, Hf-capable equipotential bonding [4] is required. If you install a drive unit **without** a hollow shaft, this results in a large, conductive connection between the drive unit and the mounting plate. In this case, the entire contact surface must be electrically conductive (e.g. unpainted).
- [2] PE conductor in the supply system cable
- [3] 2nd PE conductor via separate terminals
- [4] EMC-compliant equipotential bonding, e.g. via a ground strap  
The contact surfaces must be electrically conductive (e.g. unpainted). For improved low-impedance grounding at high frequencies, SEW-EURODRIVE recommends using corrosion-resistant connecting elements. The HF grounding option can be combined with LF grounding at the terminal box.

### 12.2.4 Example equipotential bonding of MOVIMOT® performance

The following figure shows equipotential bonding using the example of MOVIMOT® performance without a gear unit:

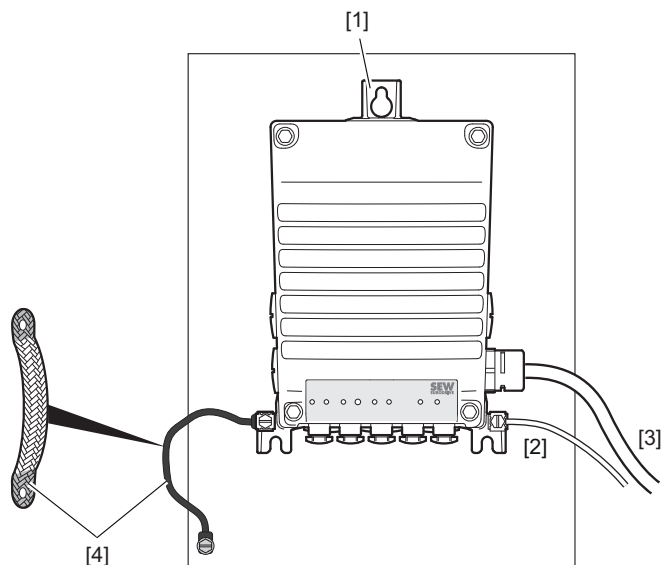


9007228366860811

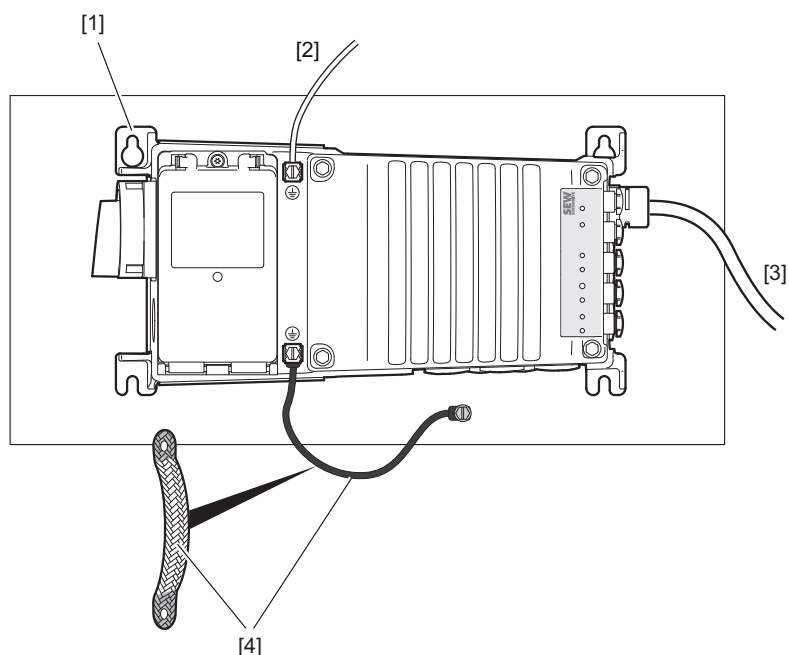
- [1] The mechanical installation of a drive unit **with** hollow shaft does **not** create a conductive connection of drive unit and mounting plate (e.g. in case of designs with gear unit). In this case, a low-impedance, Hf-capable equipotential bonding [4] is required. If you install a drive unit **without** a hollow shaft, this results in a large, conductive connection between the drive unit and the mounting plate. In this case, the entire contact surface must be conductive (e.g. unpainted).
- [2] PE conductor in the supply system cable
- [3] 2nd PE conductor via separate terminals
- [4] EMC-compliant equipotential bonding, e.g. via a ground strap  
The contact surfaces must be conductive (free of paint). For improved low-impedance grounding at high frequencies, SEW-EURODRIVE recommends using corrosion-resistant connecting elements. The HF grounding option can be combined with LF grounding at the terminal box.

### 12.2.5 Example equipotential bonding of MOVIMOT® flexible

The following figures show a flat connection between the mounting plate and the connection box of the device using the example of MOVIMOT® flexible:



46060469515

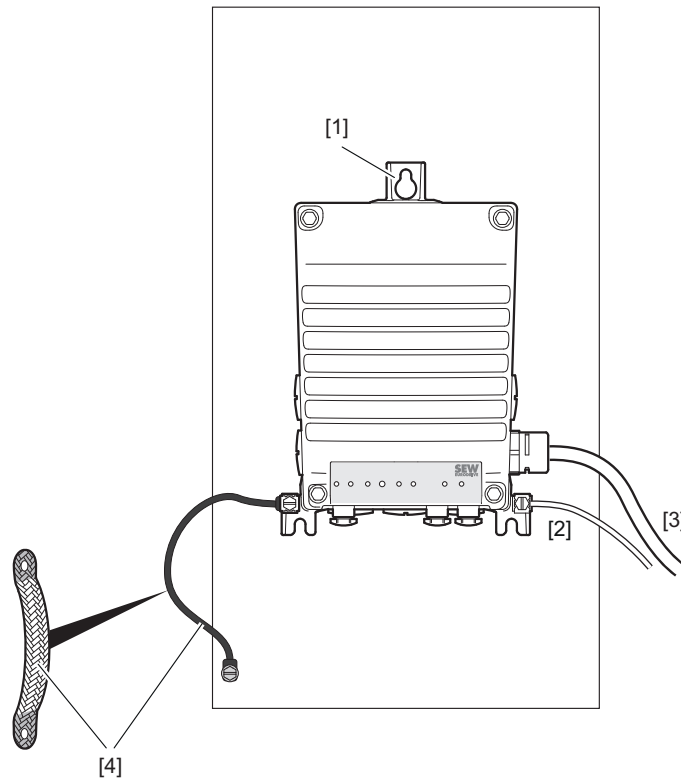


25826063115

- [1] Conductive connection over a wide surface between the decentralized frequency inverter and the mounting plate, in case the entire contact surface is electrically conductive (e.g. unpainted).
- [2] 2nd PE conductor via separate terminals
- [3] PE conductor in the supply system cable
- [4] EMC-compliant equipotential bonding, e.g. via a ground strap  
The contact surfaces must be electrically conductive (e.g. unpainted).

### 12.2.6 Example equipotential bonding of MOVI-C® FIELD CONTROLLER

The following figure shows equipotential bonding using the example of MOVI-C® FIELD CONTROLLER:



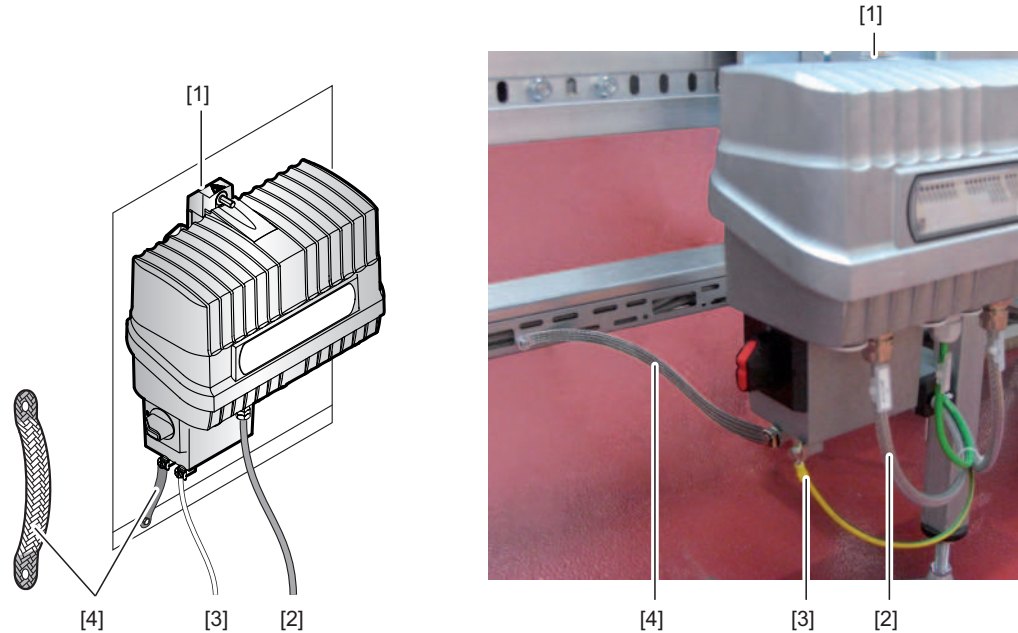
28713959179

- [1] Conductive connection over a wide surface between the device and the mounting plate, in case the entire contact surface is conductive (e.g. unpainted).
- [2] 2nd PE conductor via separate terminals (optional)
- [3] PE conductor in the supply system cable
- [4] EMC-compliant equipotential bonding, e.g. via a ground strap  
The contact surfaces must be electrically conductive (unpainted).

## 12.3 Equipotential bonding of decentralized generation B devices

### 12.3.1 MOVIFIT®

The following figure shows the PE conductors and the EMC-compliant equipotential bonding of MOVIFIT® devices:



- [1] Conductive connection over a large area between MOVIFIT® unit and the mounting rail
- [2] PE conductor in the supply system cable
- [3] 2nd PE conductor via separate terminals  
(double safety for leakage currents > 3.5 mA according to EN 61800-5-1)
- [4] EMC-compliant equipotential bonding via ground strap

From the perspective of electrical safety, **metallic cable ducts must not be used as a PE conductors.**

However, **from an EMC perspective**, a low-resistance connection between the control cabinet, the metal cable duct, and the motor for equipotential bonding offers **advantages** because the metal cable duct is always installed in parallel with the cables and can easily be checked for interruptions.

Observe the following notes when establishing equipotential bonding for MOVIFIT® devices:

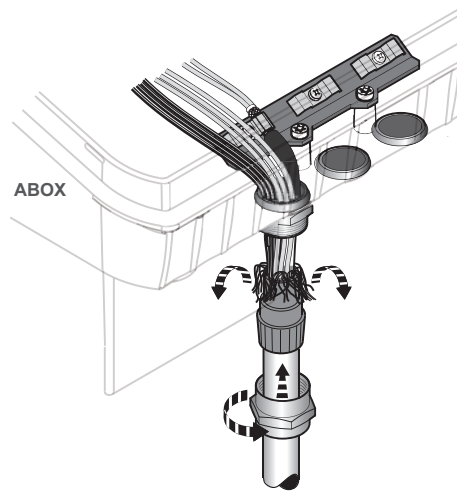
- Establish a large-area connection between the MOVIFIT® device and the grounding point of the system.
- To do so, install a ground strap between the MOVIFIT® device and the grounding point of the system.

# 12 Equipotential bonding of decentralized components

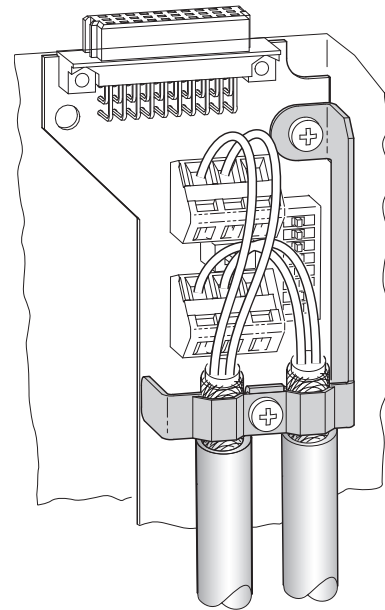
## Equipotential bonding of decentralized generation B devices

The following figures show the braided shield connection of hybrid and PROFIBUS cables at MOVIFIT® devices:

Hybrid cable connection



PROFIBUS connection

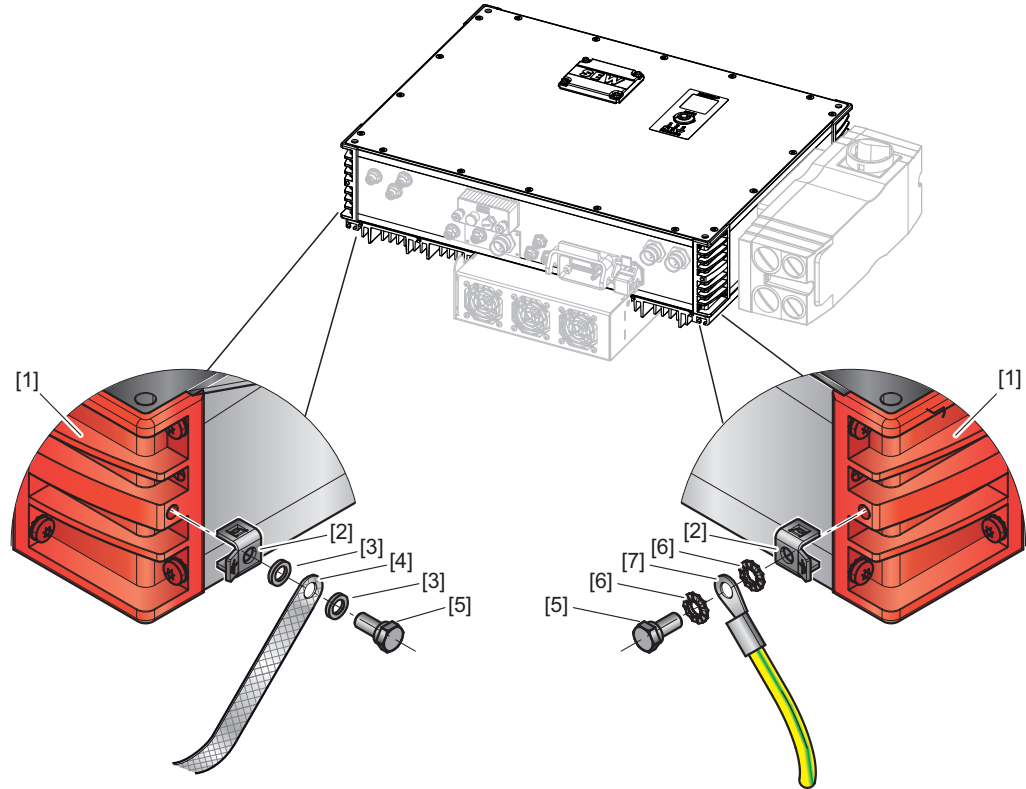


Use only EMC cable glands for connecting the hybrid cable to the MOVIFIT® device.

12.3.2 MOVIPRO® grounding kit

The scope of delivery of MOVIPRO® includes two grounding kits.

The following figure shows the positions of the connection points and the sequence in which to install the individual parts:



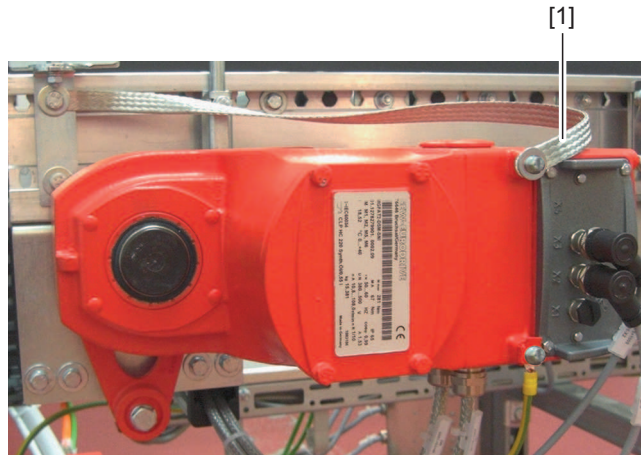
5462396939

- [1] Housing corner
- [2] Terminal clip
- [3] Washer for M5
- [4] Ground strap

- [5] M5 screw, self-tapping
- [6] Tooth lock washer
- [7] Ring cable lug for PE copper conductor

### 12.3.3 MOVIGEAR®

The following figure shows the equipotential bonding of MOVIGEAR® drive units:



9007203137960843

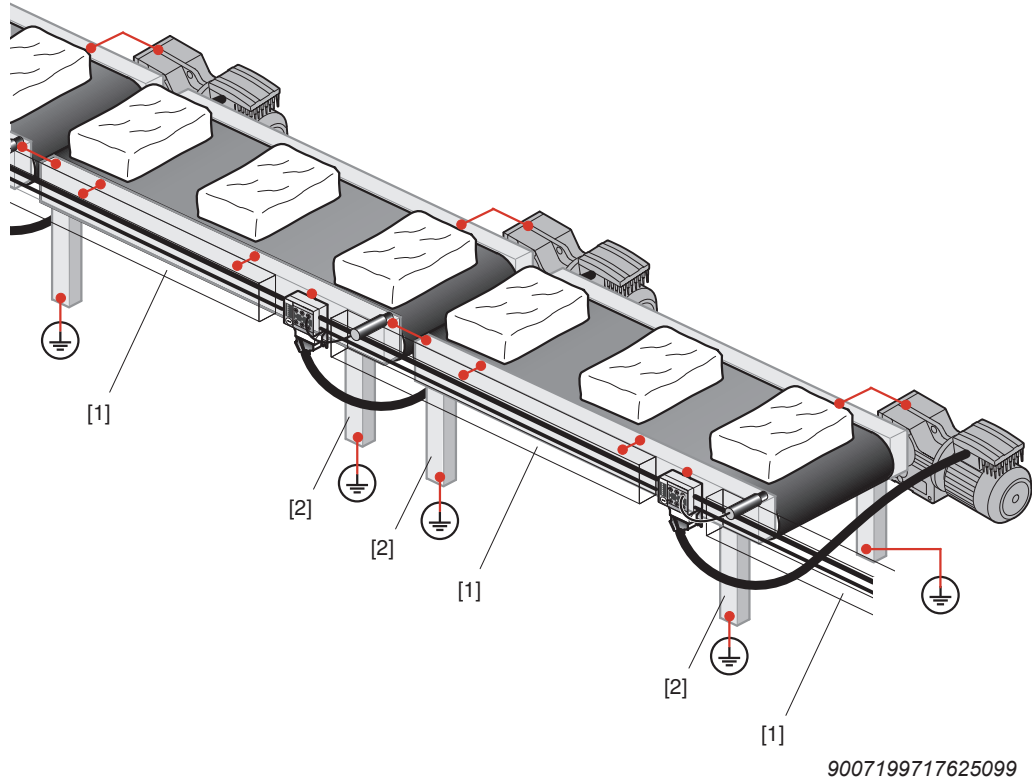
[1] Equipotential bonding of MOVIGEAR® drive unit

Observe the following notes when establishing equipotential bonding for MOVIGEAR® drive units:

- Establish a large-area connection between the MOVIGEAR® drive unit and the grounding point of the system.
- To do so, install a ground strap between the MOVIGEAR® drive unit and the grounding point of the system.

12.3.4 MOVIMOT® MM..D transport system with field distributor

The following figure shows the equipotential bonding measures of a transport system with several MOVIMOT® MM..D drives. Signal transmission and supply is via field distributors:



- [1] Cable duct
- [2] Metallic construction

The cables for fieldbus systems as well as for rotary and position encoders carry sensitive signals and, by design, run parallel to power cables such as the motor cables from frequency inverters.

To ensure the necessary protection from HF interference, these systems are equipped with high-quality HF shields. In such systems, equipotential bonding via cable ducts and the metal structure of the machine is especially important. Otherwise, equipotential bonding mainly occurs via the shields of the signal cables, which can cause interference.

## 13 Equipotential bonding of AC motors

### 13.1 Connection of options

#### 13.1.1 Temperature sensor connection

Route the cable of the TF temperature sensor separately from other power cables.

- Keep a minimum distance of 200 mm.
- Routing these cables together is only permissible if either the cable of the temperature probe or the power cable is shielded.

#### 13.1.2 Brake connection

Route the brake cable separately from other power cables.

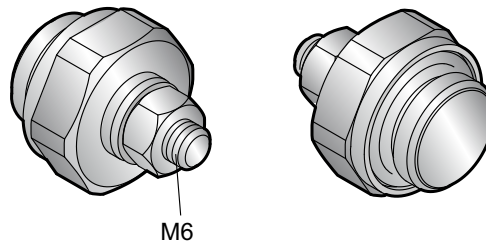
- Keep a minimum distance of 200 mm.
- The cables can only be routed together if either the brake cable or the power cable is shielded.

Use varistors for connections in the DC circuit of disk brakes. The varistors prevent harmful overvoltages.

Brake control systems from SEW-EURODRIVE are equipped with varistors as standard.

### 13.2 Equipotential bonding / HF grounding at the connection box

The following cable gland with an M6 stud bolt provides an additional option for HF-compatible equipotential bonding on a connection box:



9007203139701899

	Tightening torque		Part number
	Cable gland	M6 nut for stud bolt	
<b>M16 cable gland with M6 stud bolt</b>	4.0 Nm	3.0 Nm	08189234
<b>M25 cable gland with M6 stud bolt</b>	7.0 Nm	3.0 Nm	08192685

You can install this cable gland in a connection box as long as a cable entry of size M16 or M25 is still free.

Screw the cable gland into the free cable bushing and install the grounding cable (with a ring cable lug) or the ground strap on the M6 stud bolt.

### 13.3 DR motors, exterior LF grounding

In addition to the interior PE connection, a LF (low frequency) grounding cable can be attached to the outside of the terminal box. LF grounding is not installed as standard.

LF grounding can be ordered as completely pre-installed at the factory. For DR.71 – 132 motors, this requires a brake or gray-cast terminal box.

DR.160 – 225 motors, this option can be combined with all terminal box types.

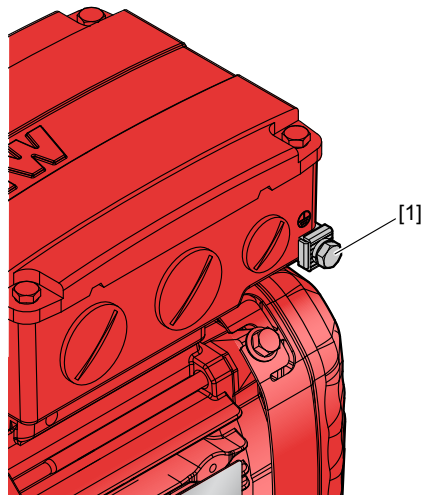
The option can be combined with HF grounding.

#### INFORMATION



All parts of the LF grounding kit are made from stainless steel.

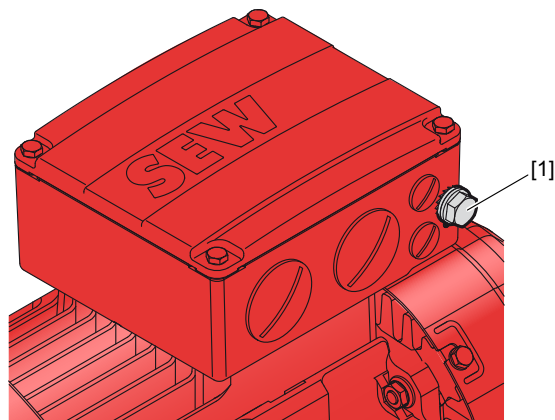
#### 13.3.1 Size DR.71 – DR.132



9007204717158539

[1] LF grounding at the terminal box

#### 13.3.2 Sizes DR.160 – DR.225



9007204718646539

[1] LF grounding at the terminal box

### 13.4 "Improved grounding" option (HF grounding) for DR motors

For improved, low-impedance grounding at high frequencies, the following connections are recommended. SEW-EURODRIVE recommends to use corrosion-resistant connection elements.

HF grounding is not installed as standard.

The HF grounding option can be combined with LF grounding at the terminal box.

If you require LF grounding in addition to HF grounding, you can connect the conductor to the same point.

The HF grounding option can be ordered as follows:

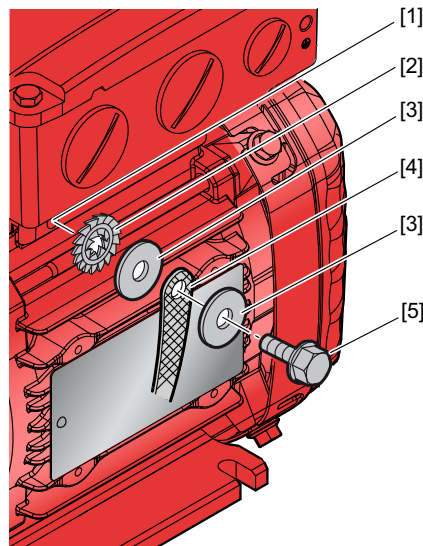
- Completely pre-installed at the factory, or as
- "Grounding terminal" kit for customer installation; part numbers listed in the following table.

Motor size	Part number of "grounding terminal" kit
DR.71S / M	13633953
DR.80S / M	
DR.90M / L	
DR.100M	13633945
DR.100L – DR.132 with aluminum terminal box	
DR.160 – DR.225 with aluminum terminal box	

All parts of the kit are made from stainless steel.

#### 13.4.1 Size DR.71S / M and DR.80S / M

The following figure shows how the grounding kit is installed:

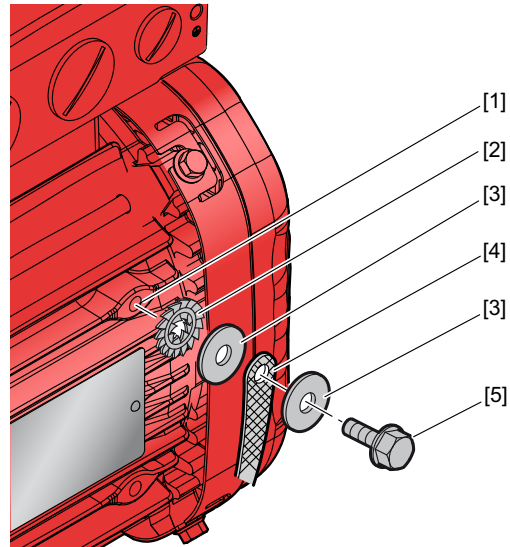


9007204719329675

- [1] Use of the pre-cast bore on the stator housing
- [2] Serrated lock washer
- [3] Washer 7093
- [4] Ground strap (not included in the scope of delivery)
- [5] Self-tapping screw DIN 7500 M6 × 16, tightening torque 10 Nm

### 13.4.2 Size DR.90M / L

The following figure shows how the grounding kit is installed:

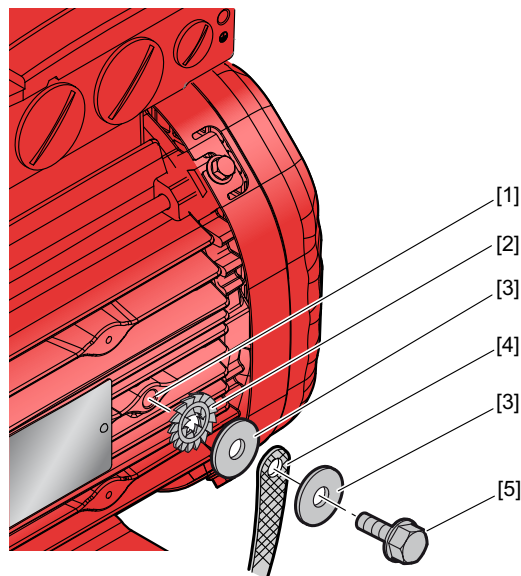


9007204722451083

- [1] Use of the pre-cast bore on the stator housing
- [2] Serrated lock washer
- [3] Washer 7093
- [4] Ground strap (not included in the scope of delivery)
- [5] Self-tapping screw DIN 7500 M6 × 16, tightening torque 10 Nm

### 13.4.3 Size DR.100M

The following figure shows how the grounding kit is installed:

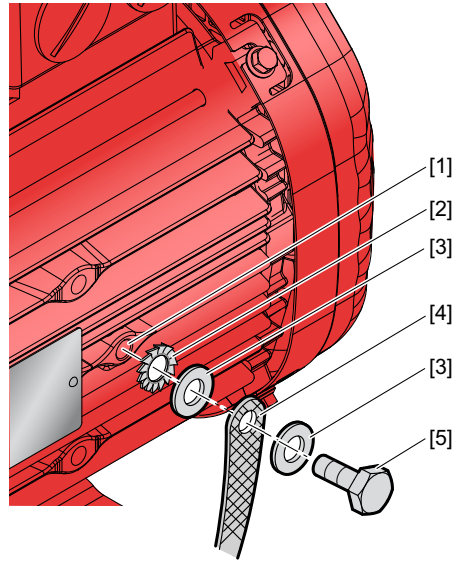


9007204735364875

- [1] Use of the pre-cast bore on the stator housing
- [2] Serrated lock washer
- [3] Washer 7093
- [4] Ground strap (not included in the scope of delivery)
- [5] Self-tapping screw DIN 7500 M6 × 16, tightening torque 10 Nm

## 13.4.4 Size DR.100L – DR.132

The following figure shows how the grounding kit is installed:

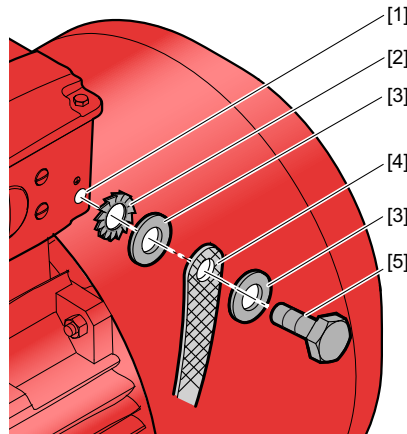


9007204735369227

- [1] Use of tapped hole for lifting eyes
- [2] Serrated lock washer DIN 6798
- [3] Washer 7089/7090
- [4] Ground strap (not included in the scope of delivery)
- [5] Hex head screw ISO 4017 M8 × 18, tightening torque 10 Nm

## 13.4.5 Sizes DR.160 – DR.315

The following figure shows how the grounding kit is installed:



9007204735374603

- [1] Use of the tapped hole on the terminal box
- [2] Serrated lock washer DIN 6798
- [3] Washer 7089/7090
- [4] Ground strap (not included in the scope of delivery)
- [5]
  - Hex head screw ISO 4017 M8 x 18 (with aluminum terminal boxes of size DR.160 – 225), tightening torque 10 Nm
  - Hex head screw ISO 4017 M10 x 25 (with gray cast iron terminal boxes size DR.160 – 225), tightening torque 10 Nm
  - Hex head screw ISO 4017 M12 x 30 (terminal boxes of size DR.250 – 315), tightening torque 15.5 Nm

## 14 Functional safety

Devices with integrated functional safety typically have diagnostic mechanisms for monitoring safety-relevant signals and voltages.

In order to detect faults early on, these diagnostic mechanisms are more comprehensive and more sensitive than in devices without functional safety. This is used for the safety sub-functions (e.g. STO, SLS) of the devices and thus ensure the safety of the machine.

Reactions to safety-relevant signals and voltages due to EMC, e.g. as a result of insufficient installation, these devices can trigger the integrated diagnostics that lead to the machine being switched off. As a result, the availability of the machine may be restricted. The safety of the machine is maintained.

### INFORMATION



For devices with integrated functional safety in particular, ensure careful installation in compliance with the product documentation and the information in this EMC manual.

## 15 EMC interference

### 15.1 Troubleshooting

Careful observation and documentation of the errors that occurred will help you to determine the cause of the fault. The more detailed the error description, the more quickly and easily the fault can be eliminated. Make sure that the error description cannot be misinterpreted.

#### Identification of interference source

- Do the malfunctions occur permanently or only from time to time?
- Is there a connection between the occurrence of the malfunction, the error rate, and the operating modes of the malfunctioning system when other devices are operated?
- Identify the interference source by successively switching off units in the system.
- Check the supply voltages.

#### Identification of the interference sink

- Can you clearly rule out a malfunction due to hardware or software errors?
- Are there devices or system components that are malfunctioning, but the malfunction cannot clearly be determined? For example, an encoder that can affect the entire system?
- Use the diagnostics options of the system (LEDs, error display, error counter, etc.) to identify the affected device.
- Selective shutdown, disconnection, or replacement of system components helps you to locate the affected device. Disconnection, for example, by
  - Changing the operating mode
  - Deactivating functions

### 15.2 Interference resolution

To eliminate malfunctions that result from poor EMC, you can do the following:

- Eliminate or reduce the noise emitted by the interference source by means of coils, filters, or shield plates.
- Increase the interference immunity of the affected unit by using filters and/or shielded housings.
- Eliminate coupling sections to prevent the noise getting from the interference source to the susceptible equipment, e.g. by
  - Keeping sufficient distance between power and signal cables
  - Using shielded cables
  - Routing cables near ground
- Check compliance with the requirements described in this document and in the relevant product documentation.

### 15.3 List of malfunctions

The following list of malfunctions helps you to identify EMC-related malfunctions.

Malfunction	Cause	Solution
Sporadic malfunction	No interference suppression circuits (spark quenching) for coils of contactors, valves, or horns installed.	Install interference suppression elements (spark quenchers) for the coils. Use the interference suppression circuits recommended by the manufacturer.
	Machines that generate electric arcs (e.g. welding machines)	Check/correct the routing of the control cables of the interference-emitting machine. Increase the distance to the interference-emitting machine.
	Radio transmitter, ripple control system	Install additional shielding.
	Cables with poor shield connections, incorrect conductor twisting, or incorrect characteristic values	Use original part cables. Check the conductor assignment.
	Interruptions in the cable shield, e.g. cable branching	Connect the cable shields of the incoming and outgoing cables with each other by connecting them either to a common large metal surface or an EMC shield cable gland or a shield plate.
	Incorrectly installed equipotential bonding cable	Re-install the equipotential bonding cable, see previous chapters.
	Dirt in the controller	Clean the dirty controller and assemblies. Ensure clean air supply.
	No/insufficient equipotential bonding of the actual value conductor of an encoder	Install an equipotential bonding cable between the encoder housing and the controller housing. Improve the equipotential bonding connection.

Malfunction	Cause	Solution
	Shield of encoder cable interrupted	Replace the encoder cable with an original part encoder cable (product-specific).
	Encoder cable with poor shielding properties	
	Encoder cable shield connected via separate wire/conductor	Connect the shield of the encoder cable to an EMC shield terminal or shielded cable gland on both sides.
	Encoder cable with incorrect characteristic values used	Use the encoder cable type recommended by the manufacturer or replace the encoder cable with an original part encoder cable (product-specific).
	Encoder track cores not twisted in pairs	Only use twisted pair cables as encoder cables. Connect them in pairs according to the wiring diagram.
	Shield of temperature probe cable not grounded on both sides	Only use shielded cables as temperature probe cables. Connect the shield of the temperature probe cable on both sides.
Sporadic malfunction of stations in bus systems e.g. PROFIBUS	Incorrect terminating resistor e.g. PROFIBUS: 220 Ω CAN bus (SBus): 120 Ω	Measure with the ohmmeter whether the two terminating resistors are active in the bus segment. <b>Example:</b> PROFIBUS terminating resistor 220 Ω  The two terminating resistors must be active at the start and end of the bus segment. Both terminating resistors are connected in parallel through the bus conductors.  Resistance measurement between "Data+" and "Data -" (or "A" and "B") must produce about half the value of a terminating resistor (with PROFIBUS: about 95 – 110 Ω).
	Terminating resistor in the wrong place	During the resistance measurement, check whether the terminating resistor is in the right place by switching it off and on.

## Index

### A

AC motor, equipotential bonding .....	76
Arrangement of the EMC components .....	22

### B

Braided shield, connection .....	40
Brake switching .....	9
Brake, installation notes .....	76
Braking resistor	
Cables .....	62
PE connection .....	62

### C

Cable	
Distance .....	33
In the cable duct .....	33
Routing .....	33
Cable groups, classification .....	34
Encoder cable .....	21
Line groups, routing .....	35
Outside the control cabinet .....	35
Shielding .....	38
Cable bushing .....	43
Cable duct	
Connections .....	45
Position of the cables .....	33
Connections .....	57
Cable gland .....	43
Choke	
Ferrite core choke .....	25
Line choke .....	23
Output choke .....	25
Conductor rail .....	32
Contacting the equipotential bonding .....	57
Control cabinet .....	11
PE busbar .....	12
EMC components, arrangement .....	22
Mounting plate .....	12
Mounting systems .....	12

### D

Decentralized components, equipotential bonding .....	63
Description EMC .....	5

DR motor, equipotential bonding .....	77
DR motor, improved grounding .....	78

### E

Electrified monorail system, equipotential bonding .....	49
Electrostatic discharge .....	51
EMC components	
Arrangement in the control cabinet .....	22
Line filter .....	24
Sine filter .....	29
EMC interference, list of malfunctions .....	83
EMC screw fitting .....	43
EMC, description .....	5
EMV components	
Ferrite core choke .....	25
Line choke .....	23
Output choke .....	25
Output filter .....	29
Encoder cable .....	21
Equipotential bonding	
AC motor .....	76
Braking resistor .....	62
Motor .....	76
System .....	45
Contacting .....	57
Decentralized components .....	63
DR motors .....	77
DR motors, improved grounding .....	78
Drive system with field distributors .....	75
Electrified monorail system .....	49
Hoist with roller conveyor .....	50, 53
Interlinking .....	46
MOVIFIT® .....	71
MOVIGEAR® .....	74
MOVIPRO® .....	73
On the connection box (option) .....	76
Rotary table .....	48
System .....	6
Transport system .....	45
Winders .....	52
ESD .....	51
ESD protection .....	52
Extra-low voltage, supply .....	9

**F**

Ferrite core choke ..... 25

Field distributor, equipotential bonding..... 75

Filter

    Line filter ..... 24

    Output filter..... 29

    Sine filter ..... 29

Frequency inverter

    Interference emission ..... 24

**G**

Ground reference, low-impedance ..... 54

Ground strap ..... 54

Grounding

    System ..... 6

Group drive

    Leakage current spikes ..... 30

    Shielding of the cable ..... 40

**H**

Hoist with roller conveyor

    Equipotential bonding ..... 50

    ESD protection ..... 53

Hybrid cable

    Cross section..... 37

    Faulty prefabrication..... 37

    Shielding, connection ..... 44

**I**

Inrush current ..... 23

Interference emission inverter ..... 24

IT system ..... 8

**L**

Leakage currents..... 7

Line choke ..... 23

Line filter ..... 24

List of malfunctions..... 83

**M**

Meshed EMC concept ..... 6

Metal connection ..... 54

Metal screw fitting..... 43

Motor

    Equipotential bonding ..... 76

Mounting plate..... 12

Mounting systems ..... 12

MOVIDRIVE®

    Shielding connection..... 59, 60

MOVIFIT®

    Equipotential bonding ..... 71

    PE connection..... 71

    Shielding connection hybrid cable ..... 72

    Shielding connection PROFIBUS cable..... 72

MOVIGEAR®

    Equipotential bonding ..... 74

MOVIPRO®

    Equipotential bonding ..... 73

    Grounding set ..... 73

**N**

Noise filtering ..... 31

**O**

Output choke ..... 25

Output filter ..... 29

**P**

PE busbar ..... 12

Pigtail ..... 40

**R**

Radio interference suppression ..... 25, 31

Rotary table, equipotential bonding ..... 48

**S**

Shielding

    Braided shield, connection..... 40

    Cable for group drive ..... 40

    Connection..... 40

    EMC screw fitting..... 43

    MOVIDRIVE® sizes 1-2 shield connection ..... 59

    MOVIDRIVE® sizes 3-6 shield connection ..... 60

    Of hybrid cables, connection ..... 44

    Of long cables..... 40

    Shield types ..... 39

Sine filter ..... 29

System type ..... 8

**T**

TF temperature probe, installation notes ..... 76

TF, installation notes..... 76

TN-C supply system ..... 8

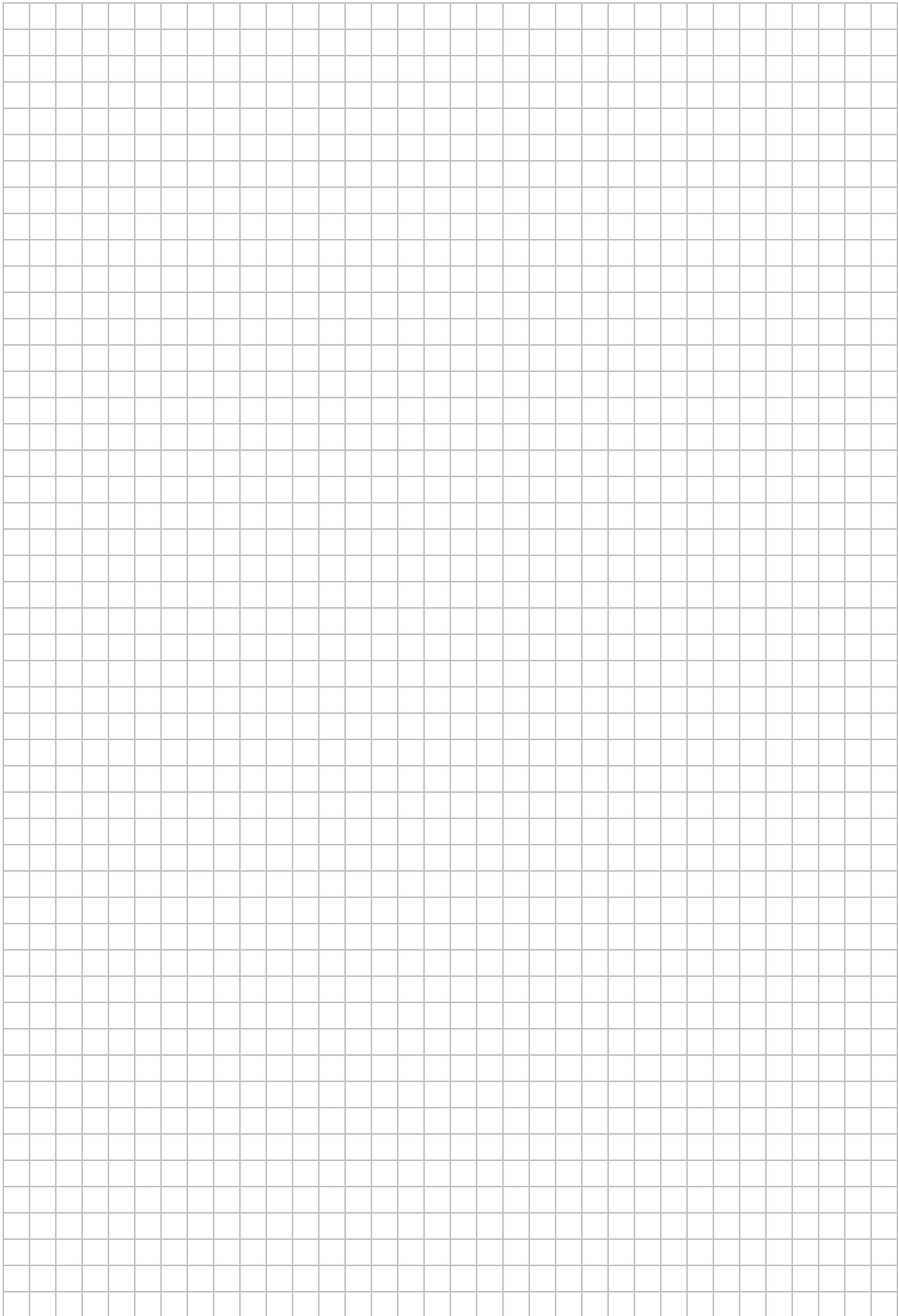
TN-S supply system .....	8
Troubleshooting.....	82
TT supply system .....	8

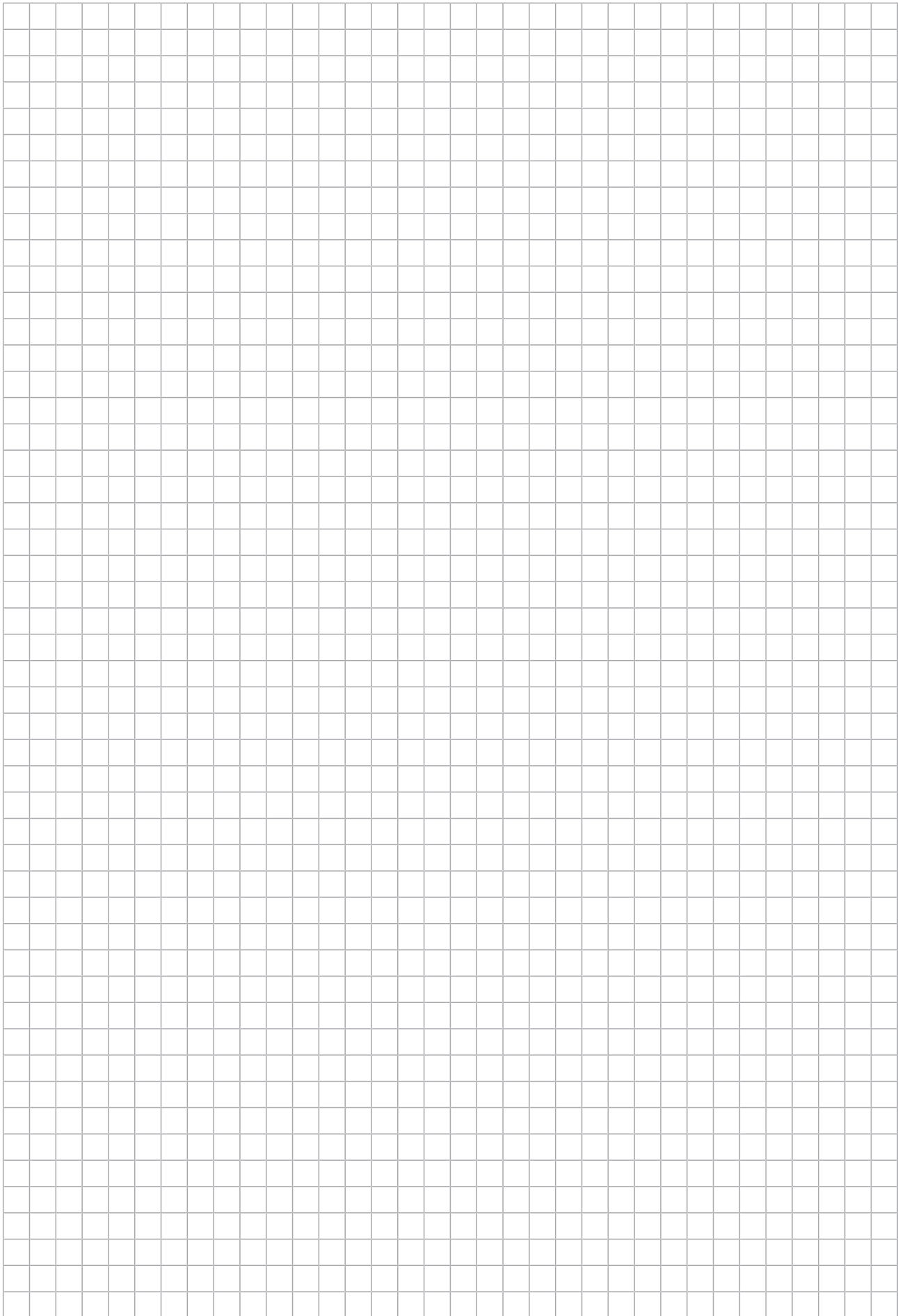
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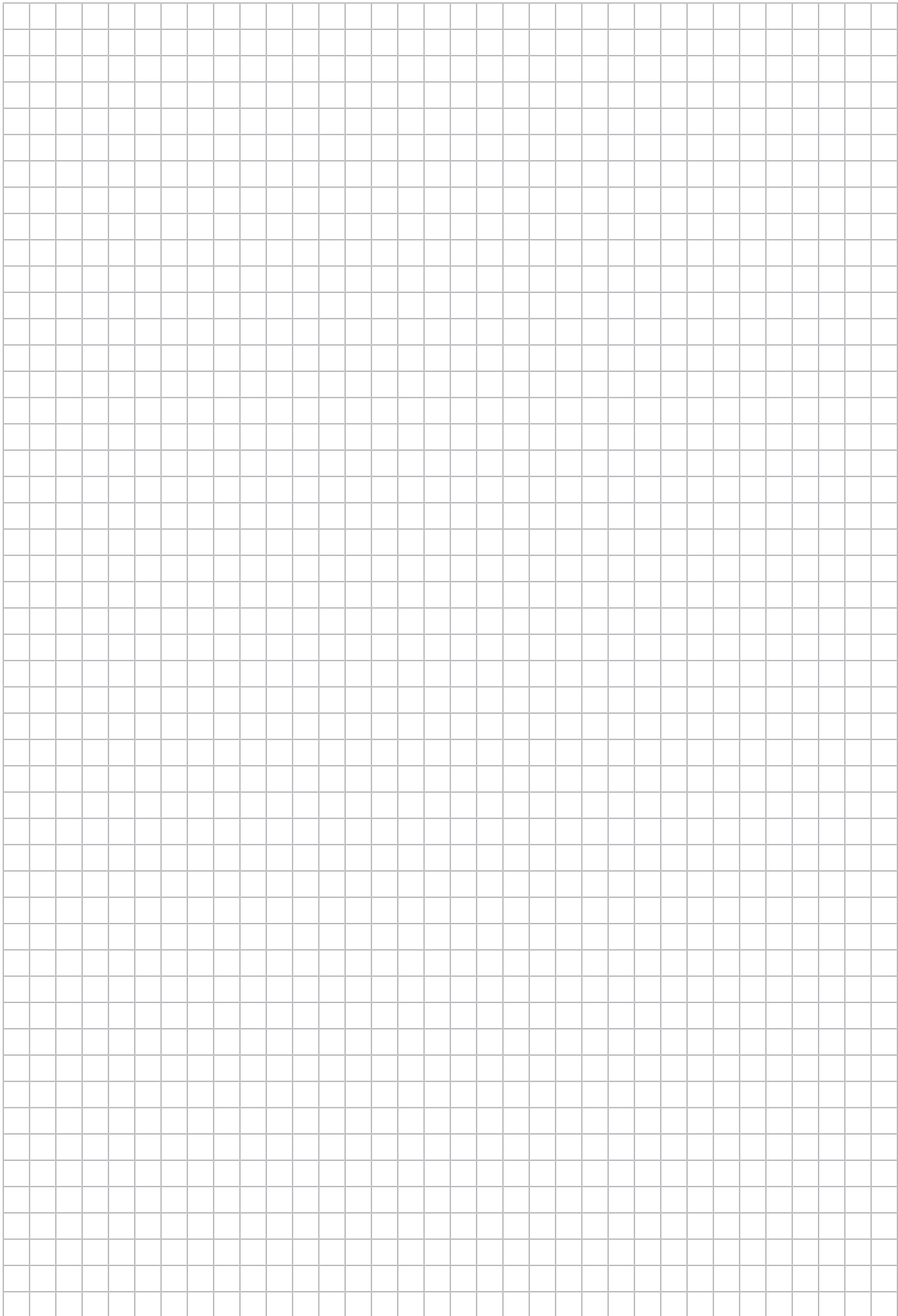
Voltage supply .....	8
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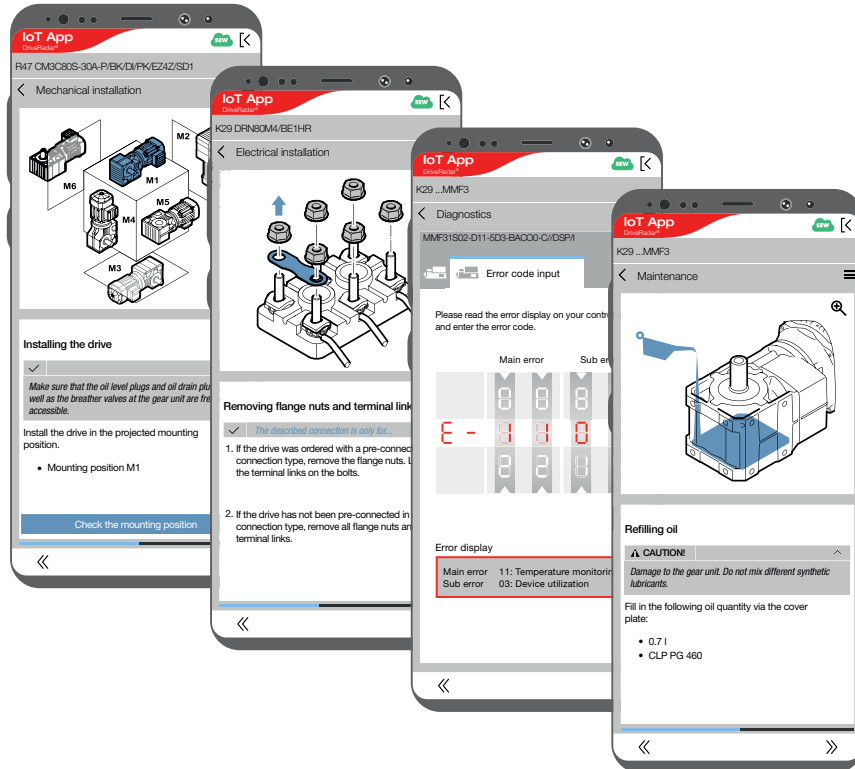
**W**

Winder, equipotential bonding .....	52
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## THE GREEN SIDE OF DRIVE

Documentation and technical information on your smartphone –  
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Driving the world

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**EURODRIVE**

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