



Manual



MOVITRAC[®] MC07B Functional Safety





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1 General Information

1.1 *How to use this documentation*

The documentation is an integral part of the product and contains important information on operation and service. The documentation is written for all employees who assemble, install, start up, and service this product.

The documentation must be accessible and legible. Make sure that persons responsible for the system and its operation, as well as persons who work independently on the unit, have read through the documentation carefully and understood it. If you are unclear about any of the information in this documentation, or if you require further information, contact SEW-EURODRIVE.

Make sure you always use the latest documentation and software version.

Our documentation is available in various languages for download from the SEW homepage (www.sew-eurodrive.com). Consult SEW-EURODRIVE if you are unclear about any of the information in this documentation, or if you require further information.

You can also order the printed documentation from SEW-EURODRIVE.

1.2 *Underlying standards*

The safety assessment of the unit is based on the following standards and safety classes:

Underlying standards	
Safety class/underlying standard	<ul style="list-style-type: none"> • Performance level (PL) according to EN ISO 13849-1:2008 • Category 3 according to EN 954-1:1996



1.3 Structure of the safety notes

1.3.1 Meaning of signal words

The following table shows the grading and meaning of the signal words for safety notes, notes on potential risks of damage to property, and other notes.

Signal word	Meaning	Consequences if disregarded
▲ DANGER	Imminent danger	Severe or fatal injuries
▲ WARNING	Possible dangerous situation	Severe or fatal injuries
▲ CAUTION	Possible dangerous situation	Minor injuries
NOTICE	Possible damage to property	Damage to the drive system or its environment
INFORMATION	Useful information or tip: implies the handling of the drive system.	

1.3.2 Structure of the section safety notes

Section safety notes do not apply to a specific action but to several actions pertaining to one subject. The symbols used either indicate a general hazard or a specific hazard.

This is the formal structure of a section safety note:



▲ SIGNAL WORD

Type and source of danger.

Possible consequence(s) if disregarded.

- Measure(s) to prevent the danger.

1.3.3 Structure of the embedded safety notes

Embedded safety notes are directly integrated in the instructions just before the description of the dangerous action.

This is the formal structure of an embedded safety note:

- **▲ SIGNAL WORD** Type and source of danger.
Possible consequence(s) if disregarded.
 - Measure(s) to prevent the danger.



1.4 Rights to claim under warranty

A requirement of fault-free operation and fulfillment of any rights to claim under limited warranty is that you adhere to the information in the MOVITRAC® documentation. Therefore, read the operating instructions before you start working with the unit.

Make sure that the documentation is available to persons responsible for the system and its operation as well as to persons who work independently on the unit. You must also ensure that the documentation is legible.

1.5 Exclusion of liability

Adherence to the operating instructions is essential to ensure safe operation of MOVITRAC® MC07B units and to achieve the specified product characteristics and performance features. SEW-EURODRIVE assumes no liability for injury to persons or damage to equipment or property resulting from non-adherence to these operating instructions. In such cases, any liability for defects is excluded.

1.6 Copyright notice

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Copyright law prohibits the unauthorized duplication, modification, distribution, and use of this document, in whole or in part.

1.7 Document content

This publication contains conditions and amendments related to MOVITRAC® MC07B units in safety-related applications.

The system comprises a drive inverter with AC motor and safety-tested external disconnecting device.

1.8 Other applicable publications

This document supplements the MOVITRAC® MC07B operating instructions and limits the application notes according to the following information. It may only be used together with the MOVITRAC® MC07B operating instructions.



2 Integrated Safety Technology

The safety technology of MOVITRAC® MC07B units described below has been developed and tested in accordance with the following safety requirements:

- Category 3 according to EN 954-1: 1996
- PL d according to EN ISO 13849-1: 2008

This was certified by TÜV Nord. Copies of the TÜV certificate can be obtained from SEW-EURODRIVE.

2.1 Safe condition

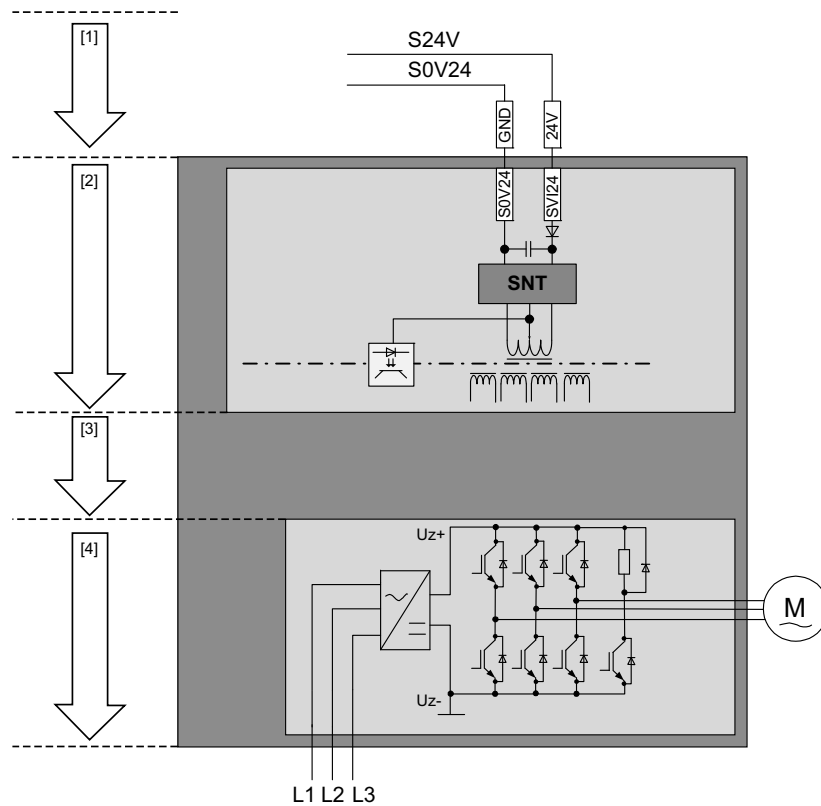
For safety-related operation of MOVITRAC® MC07B, safe torque off is defined as safe condition (see STO safety function). The safety concept is based on this definition.

2.2 Safety concept

- In the event of danger, any potential risk related to a machine must be eliminated as quickly as possible. Standstill with restart prevention is generally the safe condition for preventing dangerous movements.
- The MOVITRAC® MC07B inverter is characterized by the option to connect an external safety relay. This safety relay disconnects all active elements (disconnection of the safety-related 24 V power supply of the output stage control) that generate the pulse trains to the power output stage (IGBT) when a connected control device (E-STOP button with latching function) is activated.
- Disconnecting the safety-related 24 V supply voltage ensures that the supply voltages required for operating the inverter and consequently for generating a rotating field of pulse patterns (which allow the generation of a rotating field) are safely interrupted, preventing automatic restart.
- Instead of galvanic separation of the drive from the power supply by means of relays or switches, the disconnection of the 24 V supply described here safely prevents the control of the power semiconductors in the drive inverter. This process disconnects the rotating field generation for the respective motor. The individual motor cannot develop any torque in this state even though the line voltage is still present.



2.3 Schematic representation – "safety concept for MOVITRAC® B"



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- [1] Safety-related DC 24 V voltage supply
- [2] Electrical isolation
- [3] Voltage supply for control of power transistors
- [4] Pulse width modulated signals for the output stage



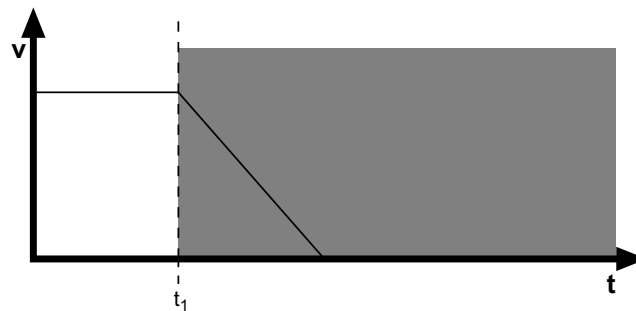
2.4 Safety functions

The following drive-related safety functions can be used:


- **STO** (safe torque off according to EN 61800-5-2) by disconnecting the STO input.
If the STO function is activated, the frequency inverter no longer supplies power to the motor for generating torque. This safety function corresponds to a non-controlled stop according to EN 60204-1, stop category 0.

The STO input must be disabled by a suitable external safety controller/safety relay.

The following figure shows the STO function:



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v	Velocity
t	Time
t_1	Time at which STO is triggered
	Disconnection range



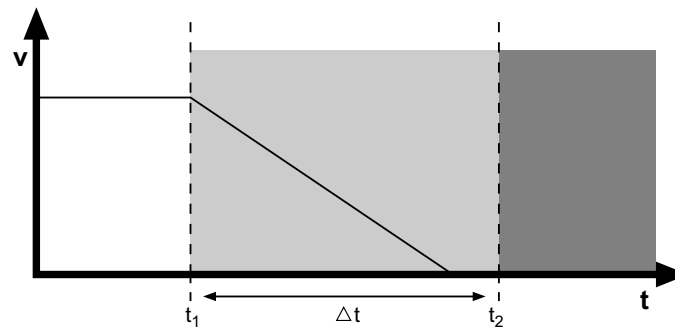
- **SS1(c)** (safe stop 1, function variant c according to EN 61800-5-2) by means of suitable external control (e.g. safety relay with delayed disconnection)

The following sequence is mandatory:



- Decelerate the drive using an appropriate brake ramp specified via setpoints.
- Disconnect the STO input (= triggering the STO function) after a specified safety-related time delay.

This safety function corresponds to a controlled stop according to EN 602041, stop category 1.

The following figure illustrates the SS1(c) function:



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v	Velocity
t	Time
t_1	Point of time when the brake ramp is initiated
t_2	Point of time when STO is triggered
Δt	Time between initiating the brake ramp and STO
	Safe time delay range
	Disconnection range



2.5 Restrictions

- Note that if the drive does not have a mechanical brake, or if the brake is defective, the drive may coast to a halt (depending on the friction and mass moment of inertia of the system). In case of regenerative loads, the drive can even accelerate. This must be taken into account in a risk assessment of the system/machine. Additional safety measures might have to be implemented (e.g. safety brake system).
MOVITRAC® MC07B cannot be used without an additional brake system for application-specific safety functions that require active deceleration (braking).
- When using the SS1(c) function as described in chapter "Safety functions", the brake ramp of the drive is not monitored with respect to safety. In case of a fault, the drive might not be decelerated after the delay time, or it might be accelerated in the worst case. In this case, the STO function (see chapter "Safety functions") is only activated after the set time delay has elapsed. The resulting danger must be taken into account in the risk assessment of the system/machine. Additional safety measures might have to be implemented.



⚠ WARNING

The safety concept is only suitable for performing mechanical work on the system/machine components.

When the STO signal is disconnected, the line voltage is still present at the DC link of MOVITRAC® MC07B.

Severe or fatal injuries from electric shock.

- Before working on the electric part of the drive system, disconnect it from the supply system using an appropriate external disconnecting device and secure it against unintentional reconnection to the power supply.



INFORMATION

In case of safety-related disconnection of the DC 24 V supply at X17 (STO activated), the brake is **always** applied. The brake control in MOVITRAC® MC07B is not safety-related.



3 Safety Conditions

The requirement for safe operation is that the safety functions of MOVITRAC® MC07B are properly integrated into an application-specific higher-level safety function. A system/machine-specific risk assessment must be carried out by the system/machine manufacturer and taken into account for operating the drive system with MOVITRAC® MC07B.

The system/machine manufacturer and the operator are responsible for compliance of the system/machine with applicable safety regulations.

The following requirements are mandatory when installing and operating MOVITRAC® MC07B units in safety-related applications.

The requirements are divided into:

- Approved devices
- Requirements on the installation
- Requirements on external safety controllers and safety relays
- Requirements on startup
- Requirements on operation



3.1 Approved devices

The following unit variants of MOVITRAC® MC07B are permitted for safety-related applications:

3.1.1 MOVITRAC® MC07B for a supply voltage of 3 × AC 380 – 500 V

Power kW	Size	Type
0.55	0S	MC07B0005-5A3-4-S0
0.75	0S	MC07B0008-5A3-4-S0
1.1	0S	MC07B0011-5A3-4-S0
1.5	0S	MC07B0015-5A3-4-S0
2.2	0L	MC07B0022-5A3-4-S0
3.0	0L	MC07B0030-5A3-4-S0
4.0	0L	MC07B0040-5A3-4-S0
5.5	2S	MC07B0055-5A3-4-00
7.5	2S	MC07B0075-5A3-4-00
11	2	MC07B0110-5A3-4-00
15	3	MC07B0150-503-4-00
22	3	MC07B0220-503-4-00
30	3	MC07B0300-503-4-00
37	4	MC07B0370-503-4-00
45	4	MC07B0450-503-4-00
55	5	MC07B0550-503-4-00
75	5	MC07B0750-503-4-00

3.1.2 MOVITRAC® MC07B for a supply voltage of AC 200 – 240 V

Power kW	Size	Type
0.55	0S	MC07B0005-2A3-4-S0
0.75	0S	MC07B0008-2A3-4-S0
1.1	0L	MC07B0011-2A3-4-S0
1.5	0L	MC07B0015-2A3-4-S0
2.2	0L	MC07B0022-2A3-4-S0
3.7	1	MC07B0037-2A3-4-00
5.5	2	MC07B0055-2A3-4-00
7.5	2	MC07B0075-2A3-4-00
11	3	MC07B0110-203-4-00
15	3	MC07B0150-203-4-00
22	4	MC07B0220-203-4-00
30	4	MC07B0300-203-4-00



3.2 Installation requirements

- For size 0 units of the type MC07B...-S0, an external 24 V supply must always be connected because the control electronics can only be powered in this way.
- The safety-related DC 24 V supply voltage must be routed according to EMC guidelines as follows:
 - Outside an electrical installation space, shielded cables must be routed permanently (fixed) and protected against external damage, or other equivalent measures have to be taken.
 - Individual conductors can be routed inside an electrical installation space.
 - Adhere to the regulations in force for the application.
- Power lines and safety-related control lines have to be installed in separate cables.
- Make sure that no parasitic voltages can be generated in the safety-related control lines.
- Wiring technology must comply with EN 60204-1.
- Use only grounded voltage sources with safe isolation (PELV) according to VDE0100 and EN 60204-1. In case of a single fault, the voltage between the outputs or between any output and grounded parts must not exceed DC 60 V.
- Observe the notes in the "MOVITRAC® MC07B" operating instructions for information on EMC-compliant cabling. It is essential that you connect the shield of the safety-related DC 24 V supply cable to the housing at both ends.
- The lines of the safety-related 24 V voltage supply (terminal X17) must be clamped under the signaling electronics shield clamp.
- When planning the installation, observe the technical data of MOVITRAC® MC07B.
- Observe the values specified for safety components when designing the safety circuits.
- The cable length of the safety-related DC 24 V supply may not exceed 100 m.
- The safety-related DC 24 V supply may not be used for feedback.



- All connections (such as lines or data communication using bus systems) must already have been taken into account in the performance level of one of the sub-systems involved, or it must be possible that faults in the connections can be excluded or neglected.

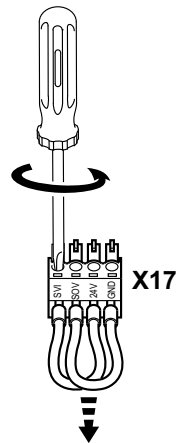
The fault assumption "short circuit between any two conductors" can be excluded according to EN ISO 13849-2: 2008 under the following conditions:

The conductors are

- permanently (fixed) installed and protected against external damage (for example using a cable duct or armored conduit)
- installed in different light plastic-sheathed cables in an electrical installation space provided that both the lines and the installation space meet the relevant requirements, see EN 60204-1
- protected individually by a ground connection

The fault assumption "short circuit between any conductor and an exposed conductive part or earth or a protective conductor" can be excluded under the following conditions:

- Short circuit between conductor and any exposed conductive part in an installation space.
- For applications with safety-related disconnection of the drive, remove the jumpers on X17:1 to X17:4 (→ following figure).

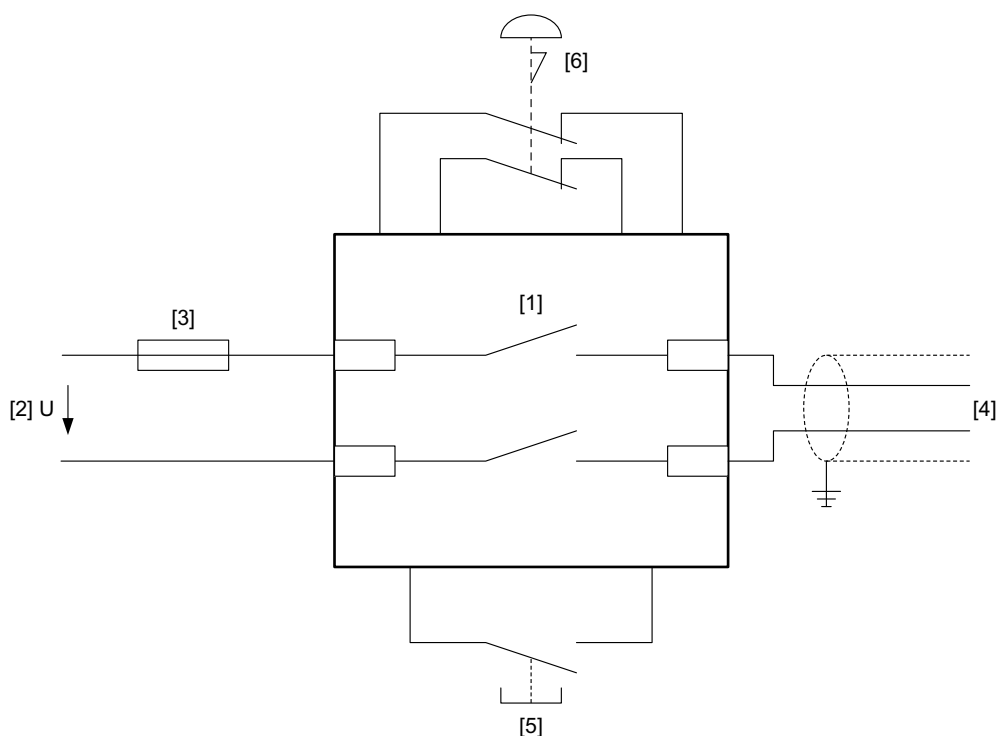


Removing jumpers

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3.3 Requirements on the external safety controller



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- [1] Safety relay with approval
- [2] DC 24 V voltage supply
- [3] Fuses in accordance with the manufacturer's specifications of the safety relay
- [4] Safety-related DC 24 V voltage supply
- [5] Reset button for manual reset
- [6] Approved EMERGENCY STOP actuating device

A safety relay can be used as an alternative to a safety controller. The following requirements apply analogously.

- The safety controller and all other safety-related subsystems must be approved for at least that safety class which is required in the overall system for the respective, application-related safety function.

The following table shows an example of the required safety class of the safety controller:

Application	Safety controller requirements
Performance level d according to EN ISO 13849-1	Performance level d according to EN ISO 13849-1 SIL 2 according to EN 61508



- The wiring of the safety controller must be suitable for the required safety class, (see manufacturer documentation).
 - If the DC 24 V supply is safely disconnected at the positive pole only, no test pulses must be applied to this pole in disconnected condition.

If the DC 24 V supply is disconnected at both poles, the test pulses must not be applied at the same time at the plus and minus outputs. In this case, the test pulse must be applied with a time delay.
 - SEW-EURODRIVE recommends to switch off the 24 V supply at two poles.
- The values specified for the safety controller must be strictly adhered to when designing the circuit.
- The switching capacity of the safety relays or the relay outputs of the safety controller must correspond at least to the maximally permitted, limited output current of the 24 V voltage supply.

Observe the manufacturer's instructions concerning the permitted contact loads and fusing that may be required for the safety contacts. If the manufacturer provides no specific information, the contacts must be protected with 0.6 times the nominal value of the maximum contact rating specified by the manufacturer.
- To ensure protection against unintended restart in accordance with EN 1037, the safe control system must be designed and connected in such a way that resetting the control device alone does not lead to a restart. A restart may only be carried out after a manual reset of the safety circuit.

3.4 Requirements on startup

- To validate the implemented safety functions, they must be documented and checked after successful startup (validation).

Observe the limitations for safety functions in chapter "Limitations" for the validation of the safety functions. Non-safety-related parts and components that affect the result of the validation test (e.g. motor brake) must be deactivated, if necessary.
- For using MOVITRAC® MC07B in safety-relevant applications, it is essential that you perform and record startup checks for the disconnecting device and for proper wiring.

3.5 Requirements on operation

- Operation is only allowed within the limits specified in the data sheets. This principle applies to the external safety control as well as to MOVITRAC® MC07B and approved options.
- You must check the safety functions on a regular basis to ensure proper functioning. The test intervals should be specified in accordance with the risk assessment.



4 Connection Variants

4.1 General information

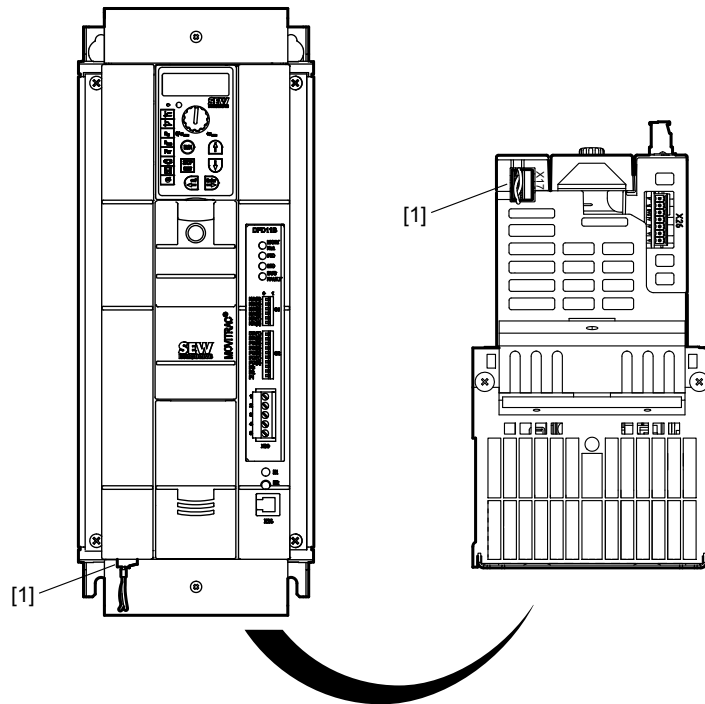
Generally, all the connection variants listed in this documentation are permitted for safety-relevant applications as long as the basic safety concept is met. This means you have to make sure that the DC 24 V safety inputs are operated by an external safety relay or a safety controller, thus preventing an automatic restart.

All safety conditions mentioned in chapter 2, 3 and 4 of this documentation must be met for the basic selection, installation, and application of the safety components, such as safety relay, EMERGENCY STOP switch, etc., and the approved connection variants.

The wiring diagrams are block diagrams whose only purpose is to show the safety function(s) with the relevant components. Circuit-related measures, which usually always have to be implemented additionally, are not shown in the diagrams to enhance clarity. Such measures are taken, for example, to ensure protection against contact, to handle overvoltage and undervoltage, to detect insulation faults, line-to-ground faults and short circuits, which can occur on externally installed lines, or to ensure the necessary immunity against electromagnetic interference.

4.1.1 X17 terminal on MOVITRAC® MC07B

The following figure shows the X17 terminal at the bottom of the control unit.



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* View of the underside of the unit

[1] X17: Signal terminal block for STO safety contacts



4.2 Requirements

4.2.1 Use of safety relays

The requirements of the manufacturers of safety relays (such as protecting the output contacts against welding) or other safety components must be strictly observed. For cable routing, the basic requirements apply as described in this publication.

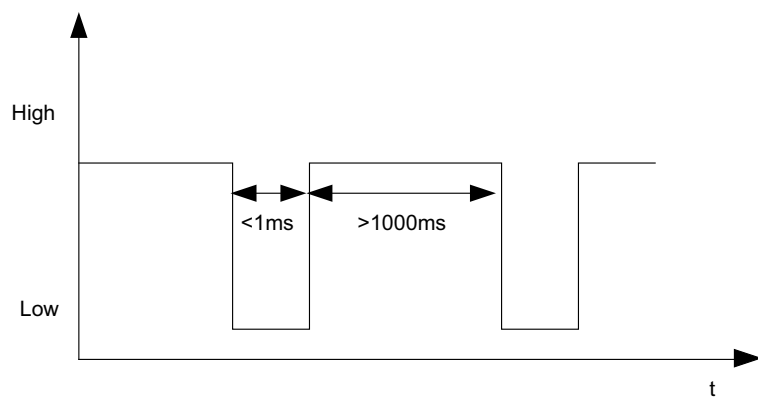
For connecting MOVITRAC® with the safety relays, observe the installation requirements in chapter "Installation requirements" (page 14).

Other instructions by the manufacturer on the use of safety relays for specific applications must also be observed.

4.2.2 Use of safety relays

Observe the ZVEI specifications for safety sensors if you use a safety PLC.

The starting and stopping pulses of the safe digital outputs (F-DO) used must be ≤ 1 ms. The ratio must not fall below 1:1000.



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INFORMATION

If the DC 24 V supply at X17 is switched off safely (STO activated), you must observe chapter "Requirements on the external safety controller (page 16)" with regard to the test pulses.



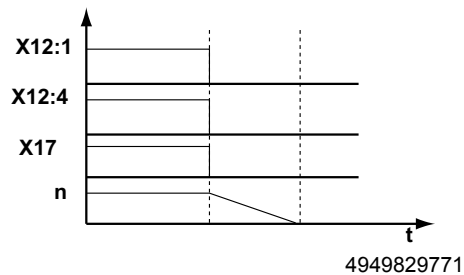
4.3 Disconnection of a single drive

4.3.1 STO according to PL d (EN ISO 13849-1)

The procedure is as follows:

- Recommendation: X12:1 and X12:4 are disconnected **at the same time**, e.g. in case of an emergency stop.
- The 24 V safety input X17 is disabled.
- The motor coasts to a halt, if no brake is installed.

STO – Safe Torque Off (EN 61800-5-2)

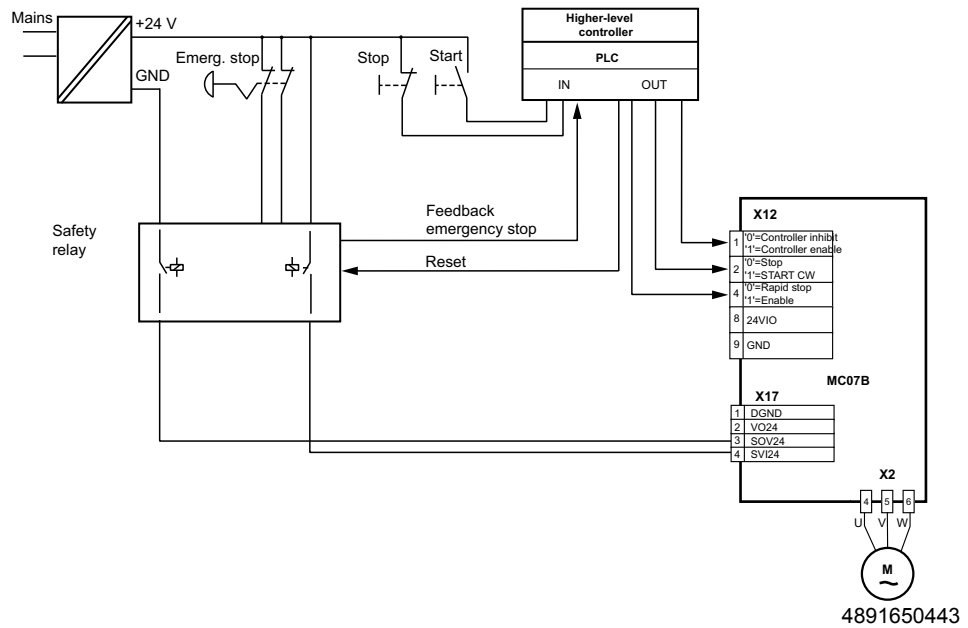


INFORMATION

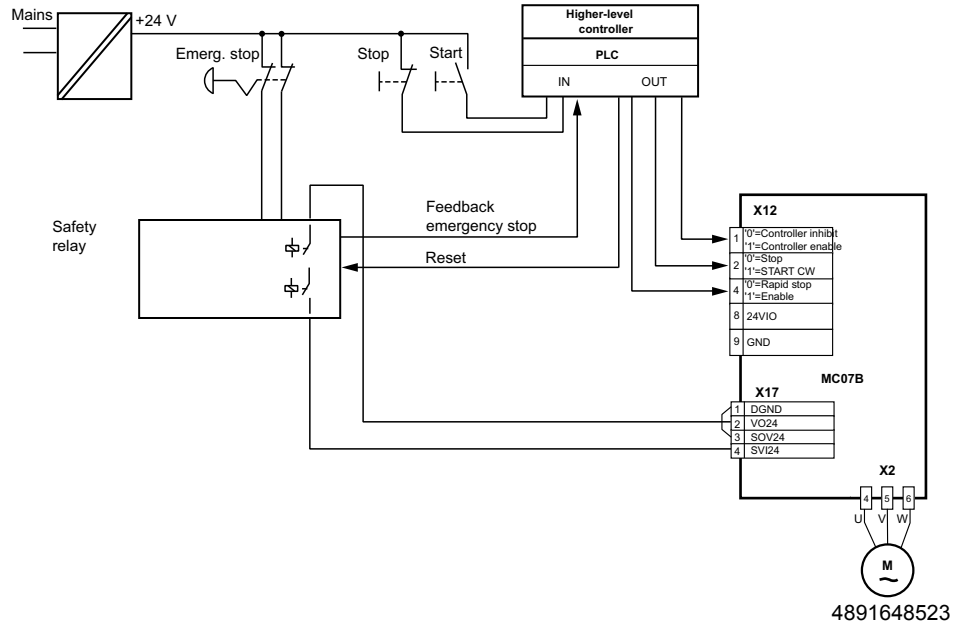
- The illustrated STO disconnections can be used up to PL d according to EN ISO 13849-1 taking account of chapter "Requirements" (page 19).
- MOVITRAC® MC07B size 0 requires an external DC 24 V voltage supply.



Binary control with safety relay (dual-channel)



Binary control with safety relay (single-channel)



INFORMATION

With single-channel disconnection, certain fault assumptions have to be made and handled through fault exclusion. Observe the "Requirements" (page 19) chapter.

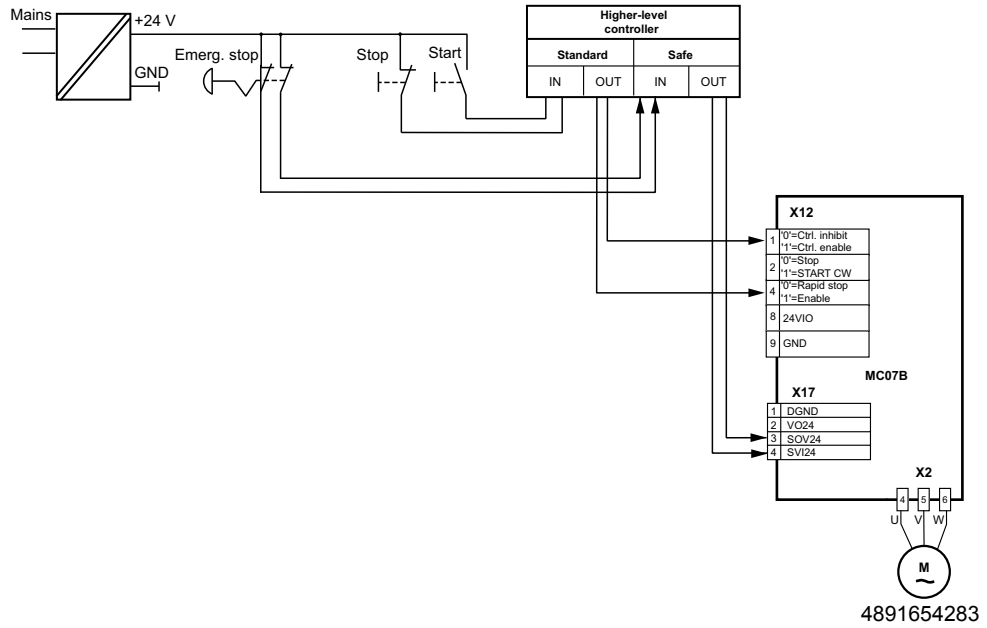
SEW-EURODRIVE recommends to switch off the 24 V supply of the STO input X17 at two poles.



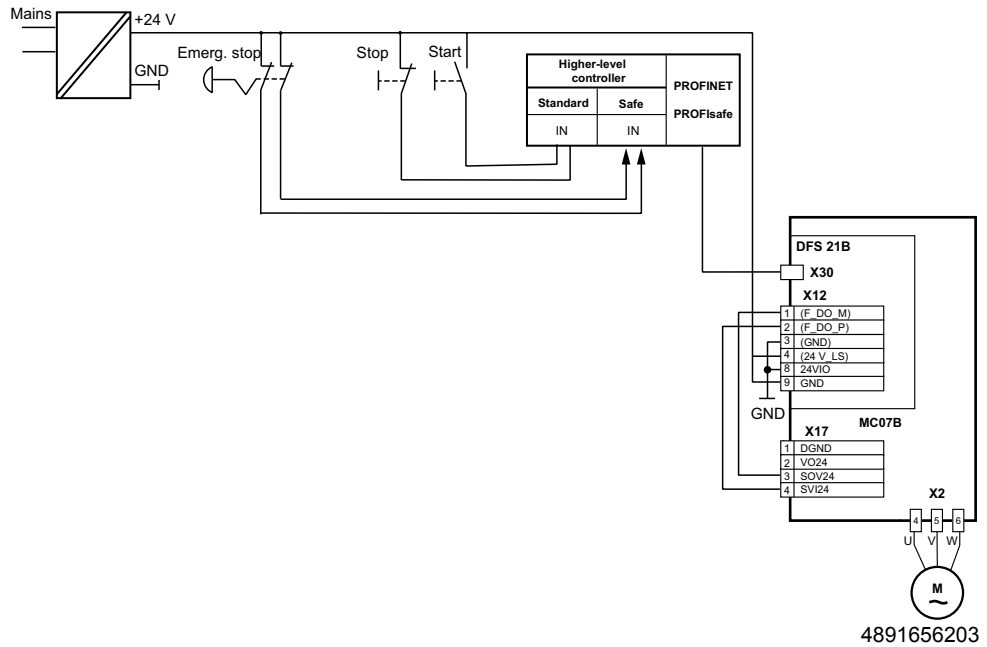
Connection Variants

Disconnection of a single drive

Binary control with safety PLC



Fieldbus control with safety PLC



INFORMATION

- Controller inhibit/enable and rapid stop/enable are set via fieldbus.
- Note the respective fieldbus manuals, e.g.
 - "DFS11B PROFIBUS DP-V1 Fieldbus Interface with PROFIsafe" manual
 - "DFS21B PROFINET IO Fieldbus Interface with PROFIsafe" manual

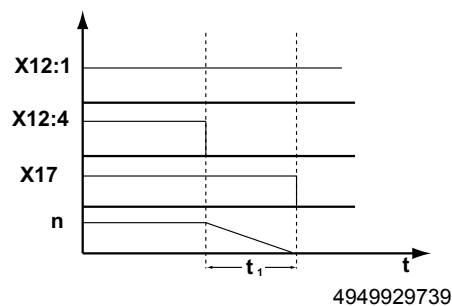


4.3.2 SS1(c) according to PL d (EN ISO 13849-1)

The procedure is as follows:

- X12:1 must not be disconnected.
- X12:4 is disconnected, e.g. in case of an emergency stop.
- During the safety time interval t_1 , the motor decelerates to a complete stop along the ramp.
- After t_1 has elapsed, the safety input X17 is disconnected. The safety time interval t_1 must be sufficient for the motor to reach a complete stop.

SS1(c) – Safe Stop 1 (EN 61800-5-2)



INFORMATION

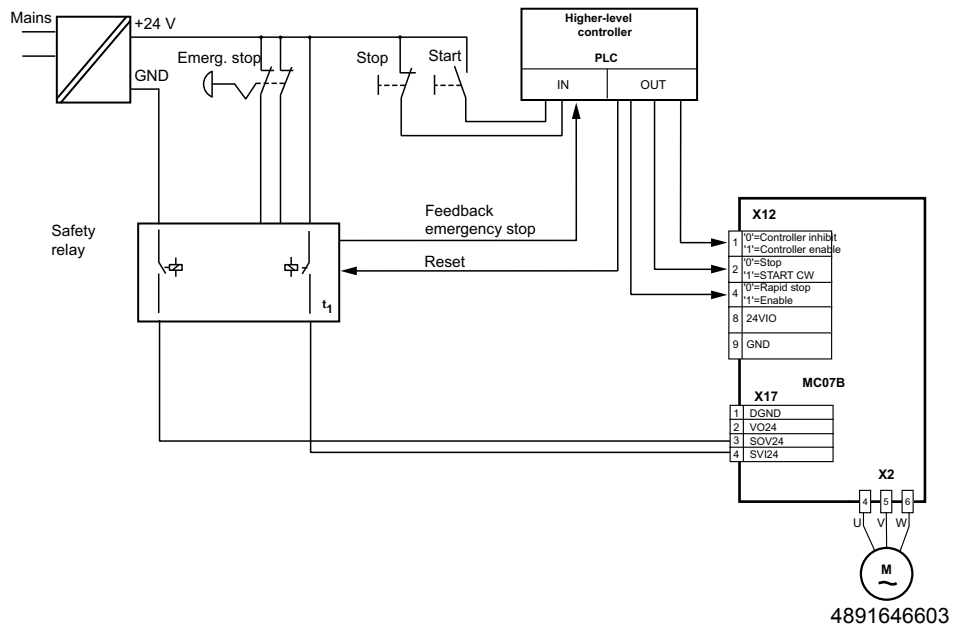
- The illustrated SS1(c) disconnections can be used up to PL d according to EN ISO 13849-1 taking account of chapter "Requirements" (page 19).
- MOVITRAC® MC07B size 0 requires an external DC 24 V voltage supply.



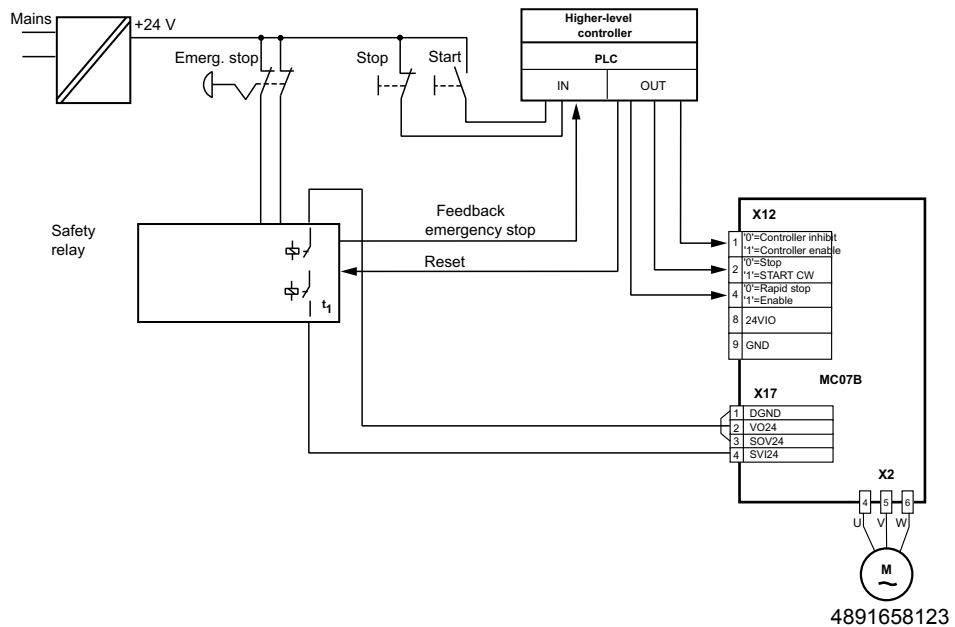
Connection Variants

Disconnection of a single drive

Binary control with safety relay (dual-channel)



Binary control with safety relay (single-channel)



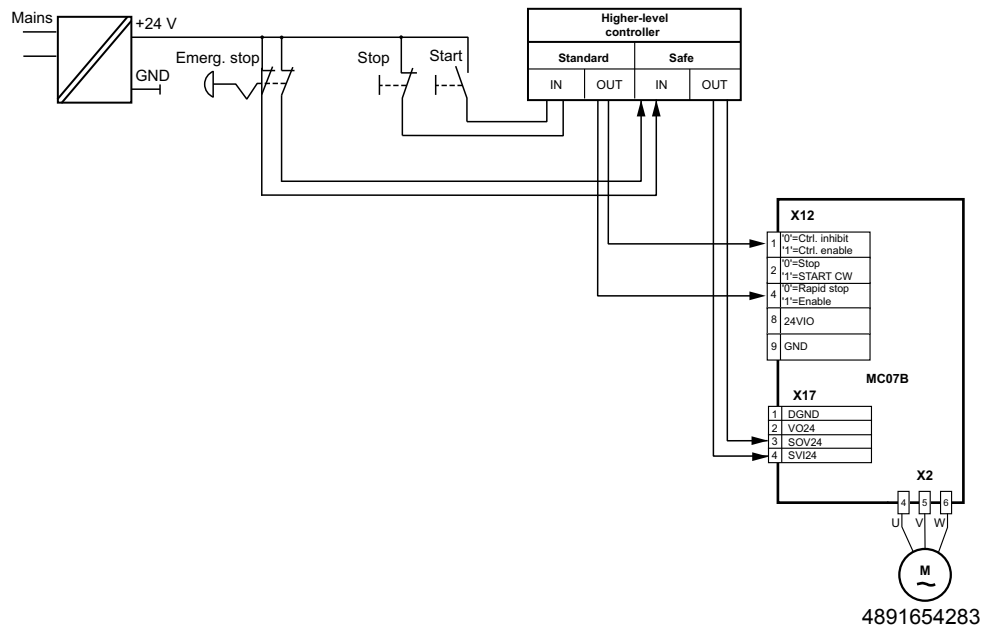
INFORMATION

With single-channel disconnection, certain fault assumptions have to be made and handled by fault exclusion. Observe the "Requirements" (page 19) chapter.

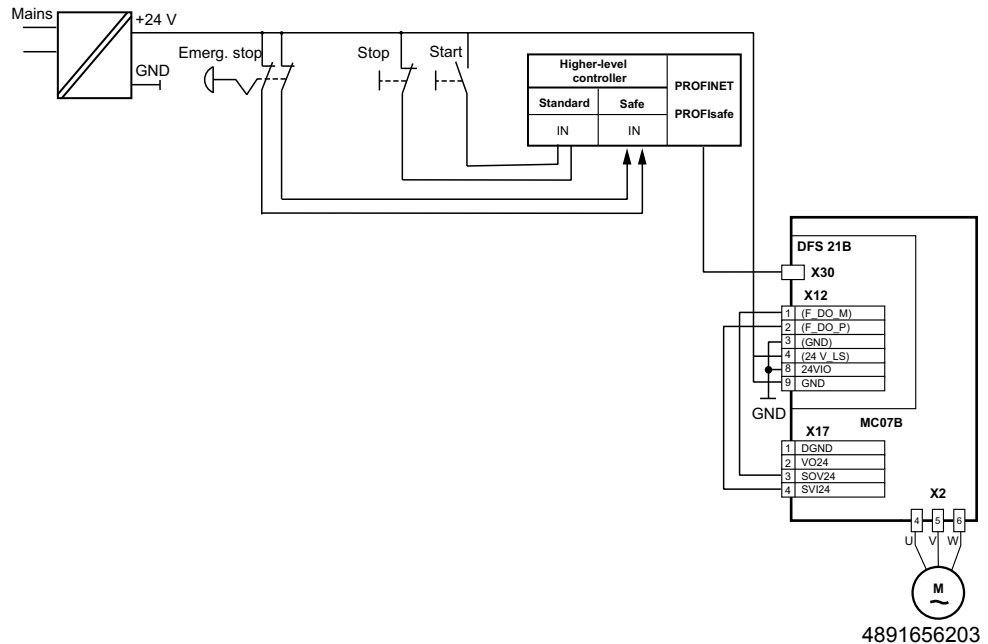
SEW-EURODRIVE recommends to switch off the 24 V supply of the STO input X17 at two poles.



Binary control with safety PLC



Fieldbus control with safety PLC



INFORMATION

- Controller inhibit/enable and rapid stop/enable are set via fieldbus.
- Note the respective fieldbus manuals, e.g.
 - "DFS11B PROFIBUS DP-V1 Fieldbus Interface with PROFIsafe" manual
 - "DFS21B PROFINET IO Fieldbus Interface with PROFIsafe" manual



4.4 Disconnection of group drives

This chapter describes how several MOVITRAC® MC07B units are controlled safely.



INFORMATION

SEW-EURODRIVE does not recommend group disconnection via safety PLC.

4.4.1 Requirements

For group drives, the 24 V safety inputs of several MOVITRAC® MC07B inverters can be made available by a single safety relay. The maximum number of axis modules results from the maximum permitted contact load of the safety relay or safety controller.

Other requirements of the manufacturers of safety relays (such as protecting the output contacts against welding) or other safety components must be strictly observed. For cable routing, observe the basic requirements in chapter "Installation requirements" (page 14).

For connecting MOVITRAC® inverters with safety relays, observe the installation requirements in chapter "Installation requirements" (page 14).

Other instructions by the manufacturer on the use of safety relays for specific applications must also be observed.

Determining the maximum number of MOVITRAC® units for group disconnection

The number (n units) of MOVITRAC® MC07B units that can be controlled with group disconnection is limited by the following points:

1. Switching capacity of the safety relay.

A fuse must be connected in front of the safety contacts according to the specifications of the emergency stop relay manufacturer to prevent contact welding.

The project planner is responsible for ensuring that the specifications for the switching capacity to EN 60947-4-1, 02/1 and EN 60947-5-1, 11/97 as well as on contact fuse protection given in the operating instructions of the safety relay manufacturer are strictly observed.
2. Maximum permitted voltage drop in the 24 V power supply cable.

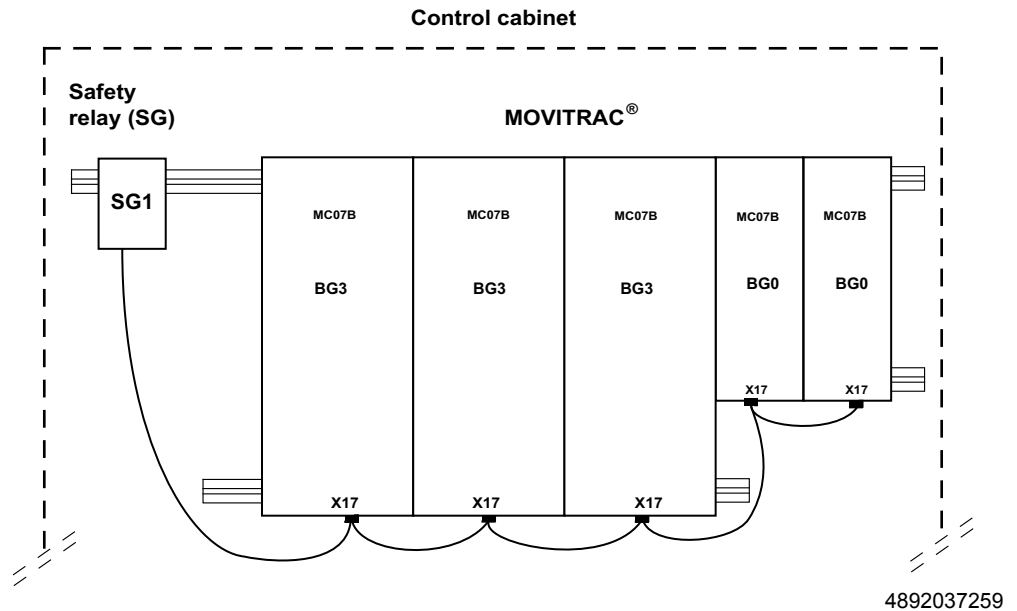
Values concerning cable lengths and permitted voltage drops must be observed during project planning for axis systems.
3. Maximum cable cross section of $1 \times 1.5 \text{ mm}^2$ or $2 \times 0.75 \text{ mm}^2$.
4. Power consumption of STO input X17: Input voltage, see chapter "Technical Data" (page 30).
5. When using self-testing semiconductor outputs, the increased capacitances of STO input X17 caused by group disconnection (parallel connection) might result in diagnostics errors.

kVA	n
	f
i	
P	H_z

4.4.2 Implementing group disconnection with a safety relay

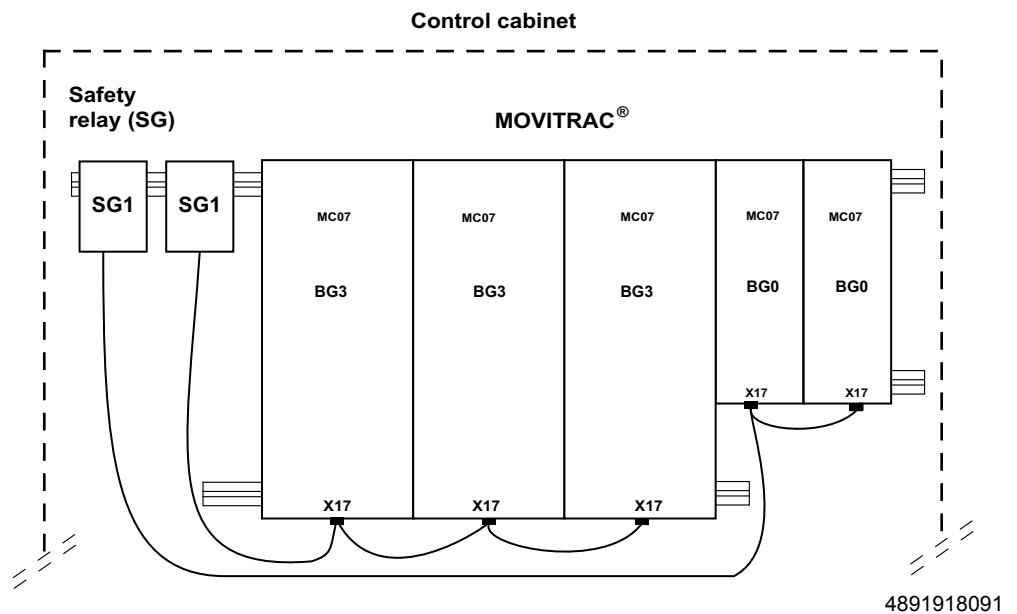
Group disconnection with one safety relay

The safety inputs of all MOVITRAC® MC07B can be controlled with one safety relay.



Group disconnection with two safety relays

The safety inputs of the assigned MOVITRAC® MC07B inverters can be controlled with several safety relays. In the following example, MOVITRAC® MC07B size 3 inverters and MOVITRAC® MC07B size 0 inverters each form one group, and each group is controlled by a safety relay.



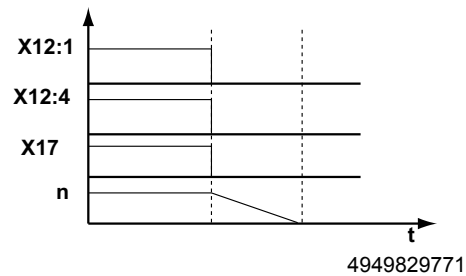


4.4.3 STO according to PL d (EN ISO 13849-1)

The procedure is as follows:

- Recommendation: X12:1 and X12:4 are disconnected **at the same time**, e.g. in case of an emergency stop.
- The 24 V safety input X17 is disconnected.
- The motor coasts to a halt, if no brake is installed.

STO – Safe Torque Off (EN 61800-5-2)

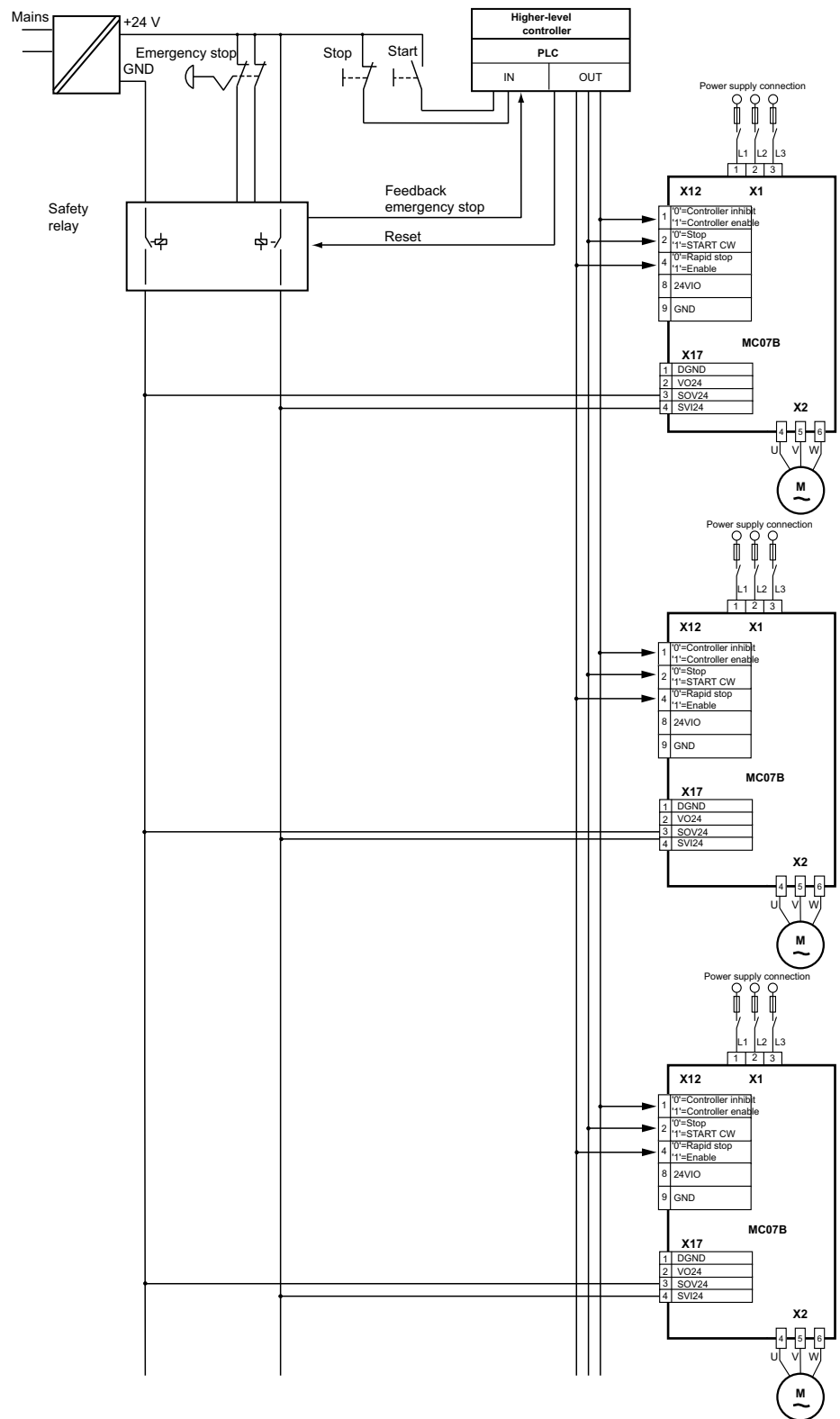


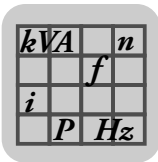
INFORMATION

The displayed STO disconnections can be used up to PL d according to EN ISO 13849-1.



Example: Group disconnection with three MOVITRAC® MC07B





5 Technical Data

The table below shows the technical data of MOVITRAC® MC07B related to integrated safety technology. The technical data and approvals in the respective MOVITRAC® MC07B operating instructions must also be observed.

5.1 Safety characteristics

Safety characteristics	
Tested safety class / underlying standards	<ul style="list-style-type: none"> Category 3 according to EN 954-1 Performance Level d according to EN ISO 13849-1
Probability of dangerous failure per hour (PFH value)	0 (fault exclusion)
Service life	20 years, after which the component must be replaced with a new one.
Safe condition	Safe torque off (STO)
Safety function	STO, SS1 ¹⁾ according to EN 61800-5-2

1) With suitable external control

5.2 Electronics data X17: Signal terminal block for STO safety contact

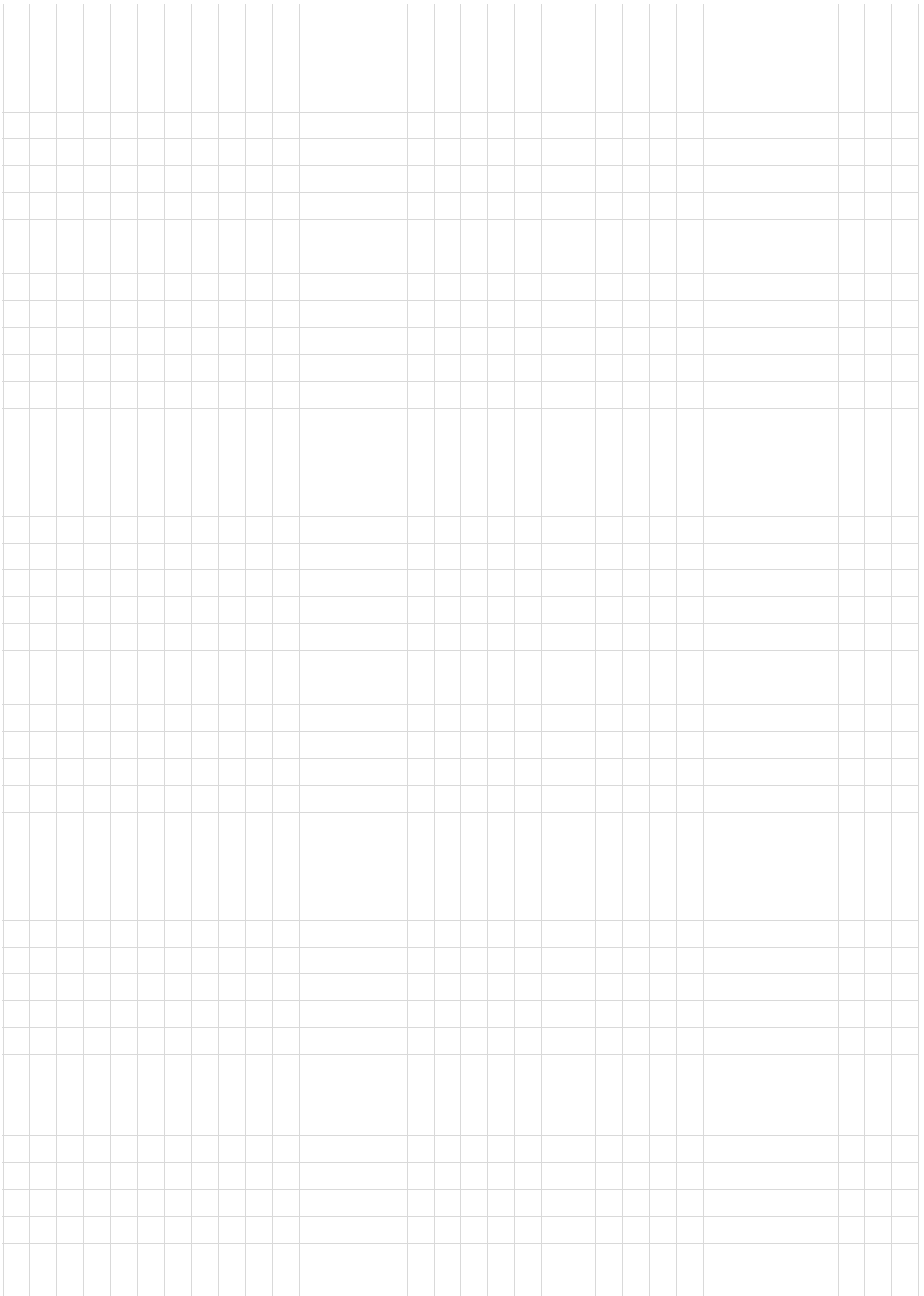
MOVITRAC® MC07B	General electronics data
Safety contact X17:1 X17:2 X17:3 X17:4	DGND: Reference potential for X17:2 VO24: : $V_{OUT} = DC\ 24\ V$, only to supply X17:4 of the same unit; cannot be used to supply other units. SOV24: Reference potential for DC +24 V "STO" input (safety contact) SVI24: DC+24 V "STO" input (safety contact)
Permitted cable cross section	One core per terminal: 0.08...1.5 mm ² (AWG28...16) Two cores per terminal: 0.25 ... 1.0 mm ² (AWG23...17)
Power consumption X17:4	Size 0: 3 W Size 1: 5 W Size 2: 6 W Size 3: 7.5 W Size 4: 8 W Size 5: 10 W
Input capacitance X17:4	Size 0: 27 µF Sizes 1 to 5: 270 µF

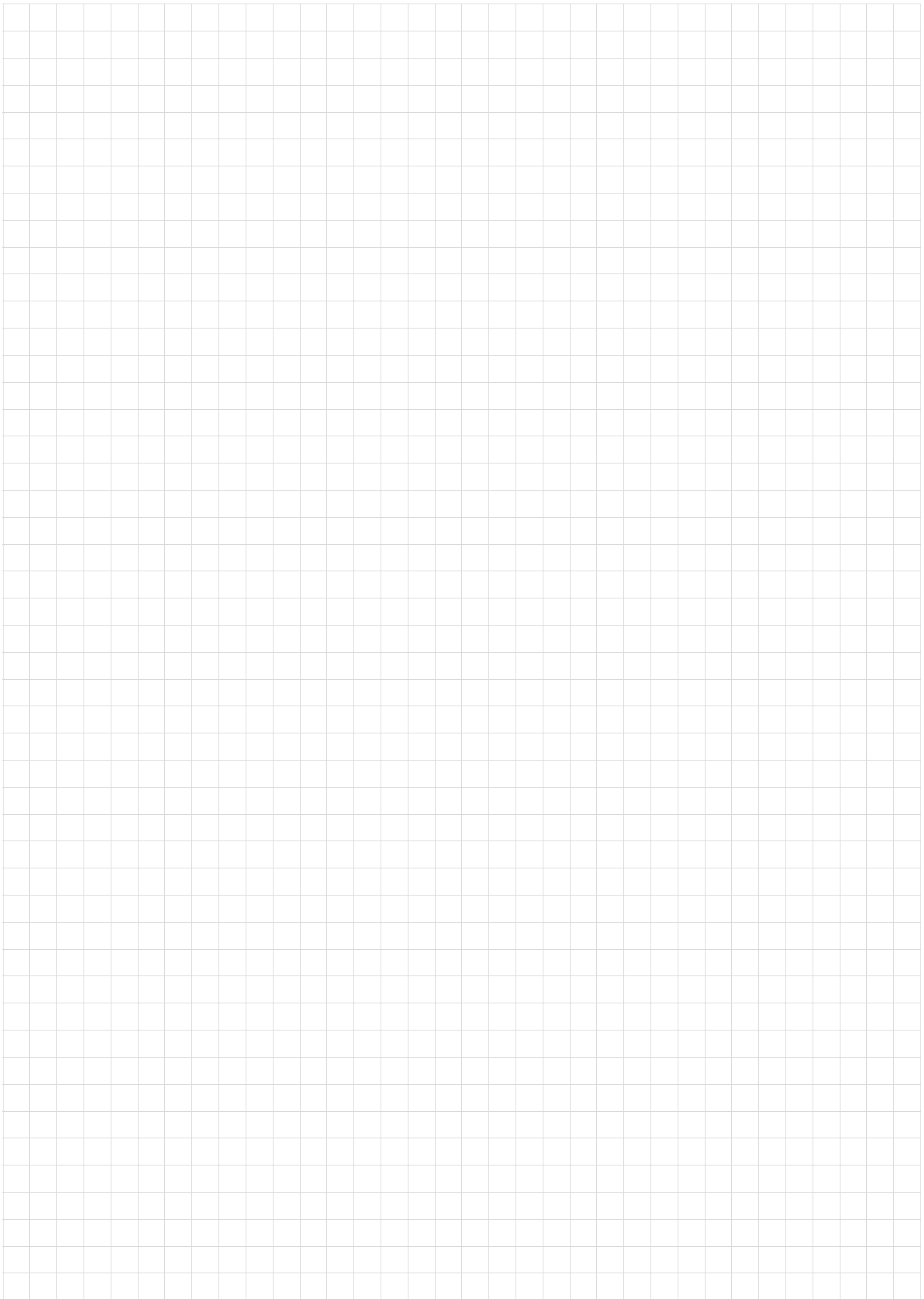
Technical data of the STO input	Min.	Typical	Max.
Input voltage range	DC 19.2 V	DC 24 V	DC 30 V
Time to inhibit the output stage			BG0 = 20 ms BG1 – 5 = 100 ms
Time for restart		200 ms	

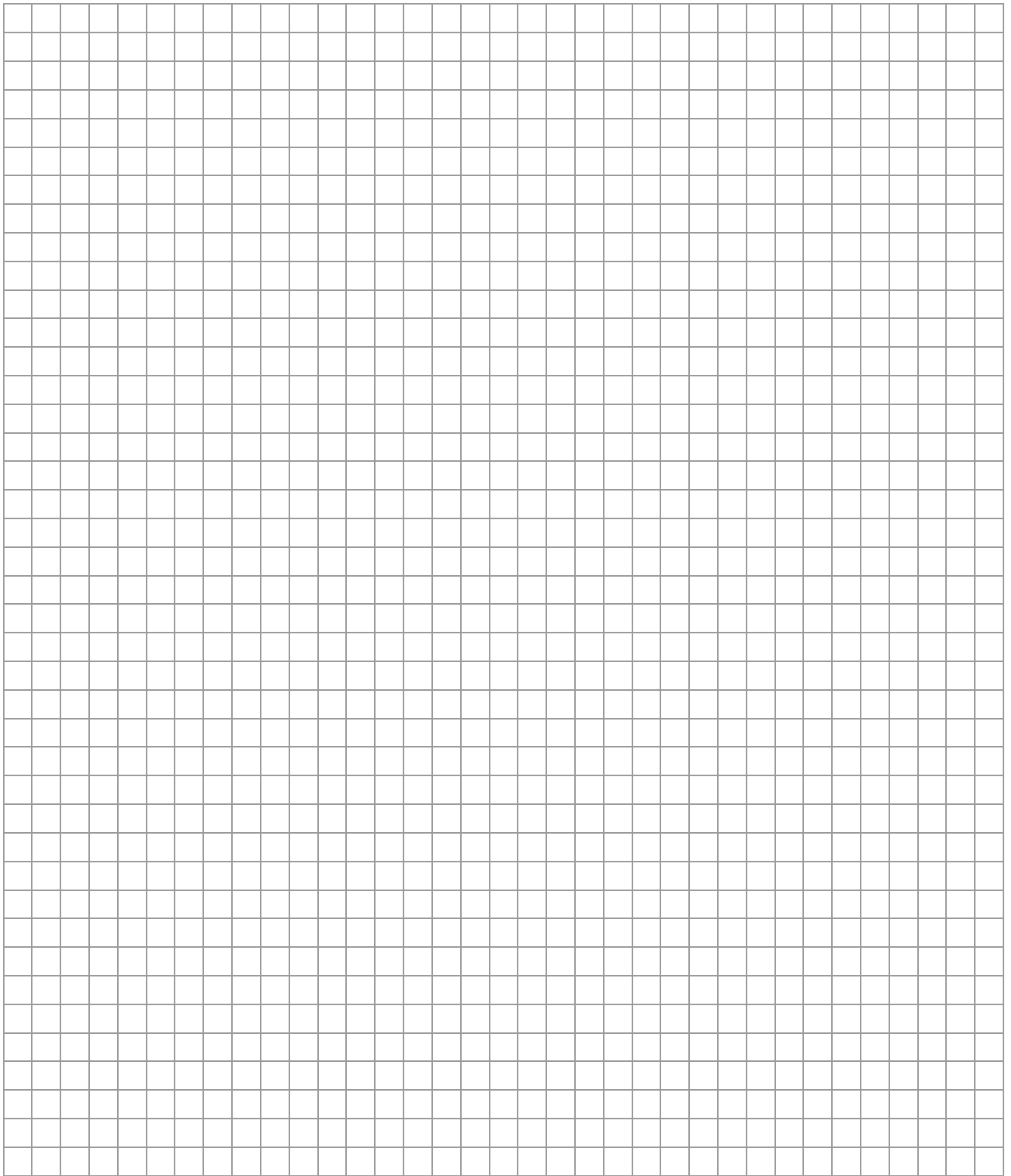


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