MSD Servo Drive

Specification Functional Safety

Servo drive

MSD Single-Axis Servo Drive

MSD Multi-Axis Servo Drive (**DISCONTINUED**)

Note:

- This document does not replace the
  Operation Manual MSD Single-Axis System
  (ID no.: CA65642-001) and
  Operation Manual MSD Multi-Axis System
  (ID no.: CA97554-001)
- Please always follow the information given in "For your safety", "Intended use" and "Responsibility" in the above-mentioned Operation Manuals.
- You will find information on mounting, installation and commissioning as well as the assured technical characteristics of the MSD Single-Axis System and MSD Multi-Axis System in the supplementary documents (Operation Manual, Device Help Manual, etc.).

MSD Servo Drive Specification Functional Safety

ID no.: CB38398-001, Rev. 2.3

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1 General

1.1 Supplements to the Operation Manual

As the function described in this specification (integrated safety control) is a variant that can be ordered as an option for the MSD Servo Drive system, it supplements the Operation Manual.

- MSD Single-Axis Servo Drive (ID no.: CA65642-001)
- MSD Multi-Axis Servo Drive (ID no.: CA97554-001)

Operating Manual		Specification FS		
Chapter		new	expanded	replaced
2	Safety			
3	Mechanical installation		3.1	
4	Installation	4.2, 4.3, 4.9	4.8, 4.6, 4.10	4.1, 4.4,
5	Commissioning		5	
6	Diagnostics		5.1	
Specification STO				
Chapter		**new**	**expanded**	**replaced**
7	Safe Torque Off (STO)	6 ff, 7 ff, A.1, A.2		6

Table 1.1 Additions and replacements to MSD Servo Drive Operation Manuals

1.2 Manufacturer's data

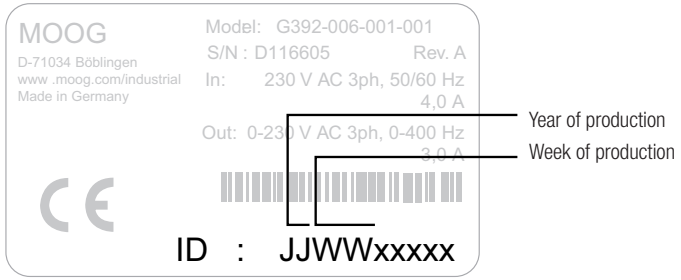
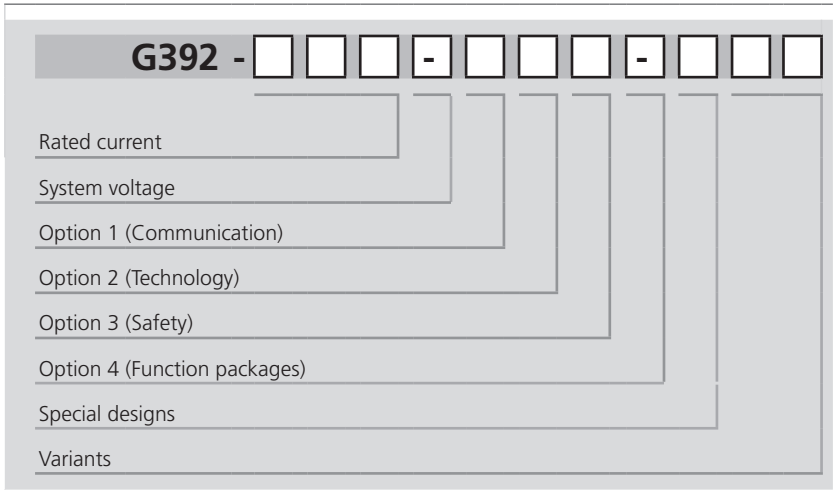


Figure 1.1 Rating plate MSD Servo Drive

On rating plates for the MSD Servo Drives you will find the serial number from which you can identify the date of manufacture based on the following key. For the location of the rating plates on the MSD Servo Drive refer to the Operation Manual MSD Servo Drive.

1.3 Type code



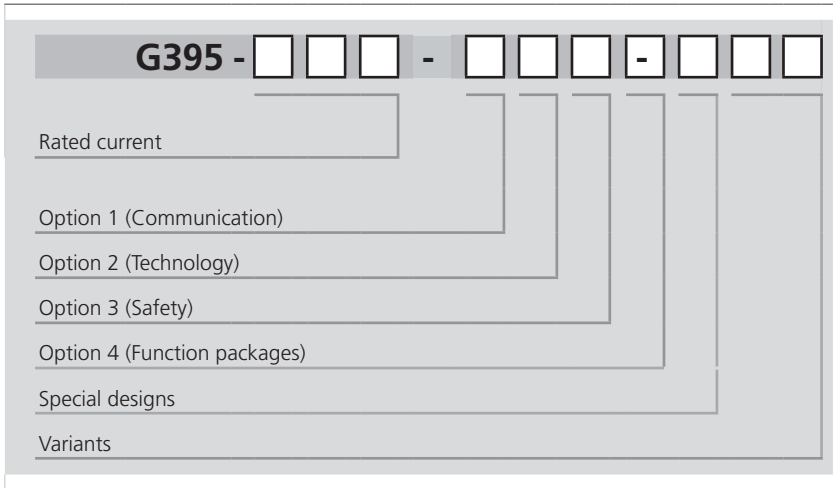
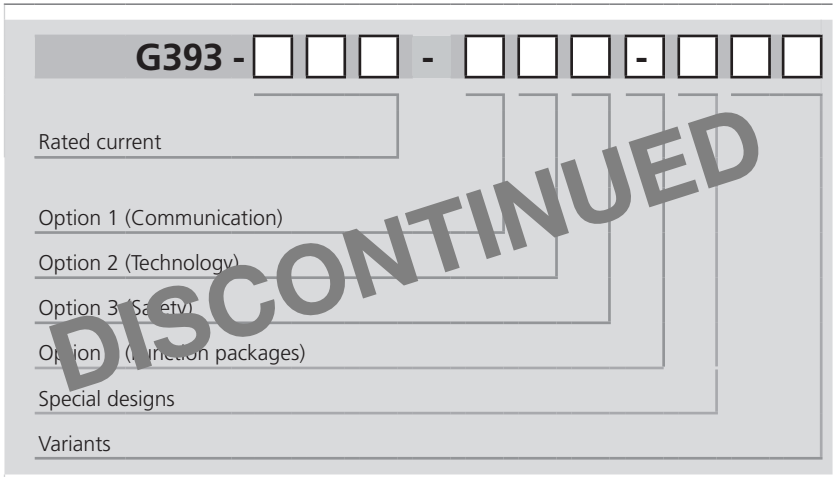


Table 1.2 MSD Single-Axis Servo Drive



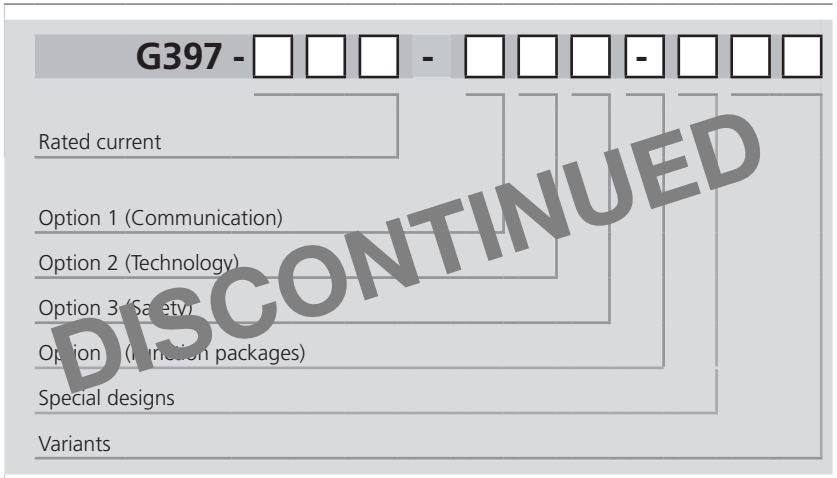


Table 1.3 MSD Multi-Axis Servo Drive (**DISCONTINUED**)

2 Safety

2.1 Intended use

MSD Servo Drives are components designed for installation in stationary electrical industrial and commercial systems or machines.

When installed in machines, the commissioning of the servo drive (i.e. start-up of intended operation) is prohibited, unless it has been ascertained that the machine fully complies with the Machinery Directive 2006/42/EC; compliance with IEC/EN 60204 is mandatory.

Commissioning (i.e. start-up of intended operation) is only permitted when strictly complying with the EMC Directive (2014/30/EU).

CE MSD Servo Drives comply with the Machinery Directive 2006/42/EC. They have been tested and certified in accordance with applicable standards, see declaration of conformity in the appendix.

The servo drives comply with the requirements of the harmonized product standard IEC/EN 61800-5-1.

If the servo drive is used for special applications, such as in areas subject to explosion hazard, the required standards and regulations (e.g. IEC/EN 50014, “General provisions” and IEC/EN 50018, “Flameproof housing”) must always be observed.

Repairs may only be carried out by authorised repair workshops. Unauthorised opening and incorrect intervention could lead to death, physical injury or material damage. The warranty provided by Moog would thereby be rendered void.

Note:

Deployment of the servo drives in non-stationary equipment is classed as non-standard ambient conditions, and is permissible only by special agreement.

Note:

Cabinet mounting with ingress protection IP54 is essential for the utilization of the certified safety functions.

2.2 Responsibility

Electronic devices are fundamentally not fail-safe. The company setting up and/or operating the machine or plant is itself responsible for ensuring that the drive is rendered safe if the device fails.

In the section on “Electrical equipment of machines” the standard IEC/EN 60204-1/ DIN VDE 0113 “Safety of machines” stipulates safety requirements for electrical controls. They are intended to protect personnel and machinery, and to maintain the function capability of the machine or plant concerned, and must be observed.

The function of an emergency off system does not necessarily have to cut the power supply to the drive. To avert or exclude hazards, it can be appropriate to place individual drives in a safe state using the safety functions that can be programmed in the safety control. The design of the safety functions is assessed by means of a risk analysis on the machine or system, including the electrical equipment, in accordance with EN ISO 14121, and is determined in accordance with EN ISO 13849-1, “Safety of machinery - Safety-related parts of control systems” by selecting the safety level/ category.

In addition, the user has the obligation to validate all machine safety functions on completion of the installation and programming work.

2.3 Maintenance

The servo drive series MSD Servo Drive is a maintenance-free product. Opening the housing is not allowed and will render the warranty void. If there is a fault or error, the servo drive must be sent to the manufacturer's Service department.

3 Installation

3.1 Overview of connections, size 1 to 4

The following shows the layout with the corresponding positions of the connectors and terminals. For improved clarity we have added an abbreviation to the designation for the connectors and terminals.

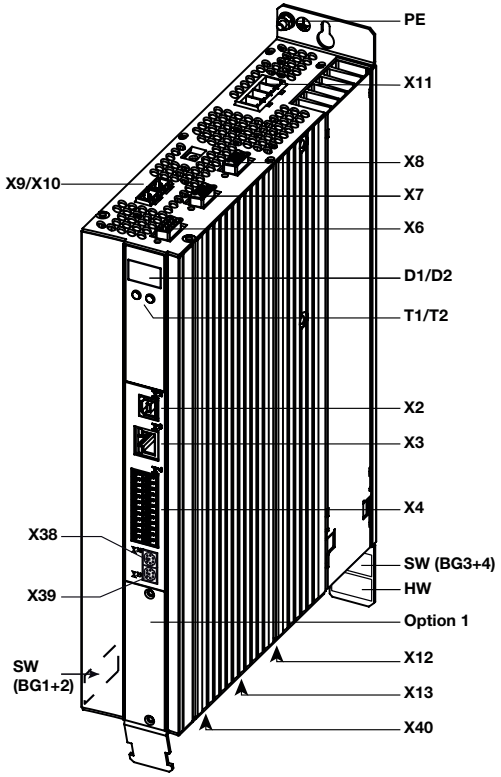
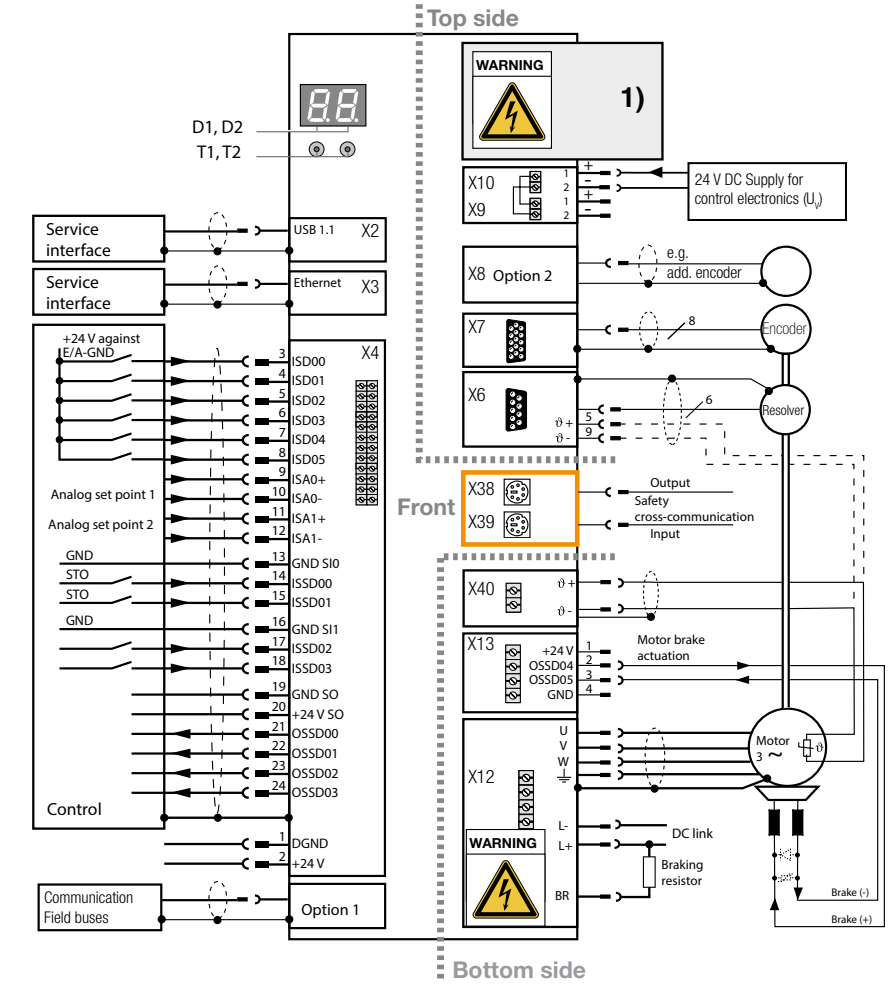


Figure 3.1 Layout size 1 to size 4 (here: size 1)



1) Supply for power electronics
(designation and connection system vary depending on size and device type, for details see Figure 3.3 to Figure 3.4 as well as the Operation Manual for the related device)

Figure 3.2 Overview of connections, size 1 to 4

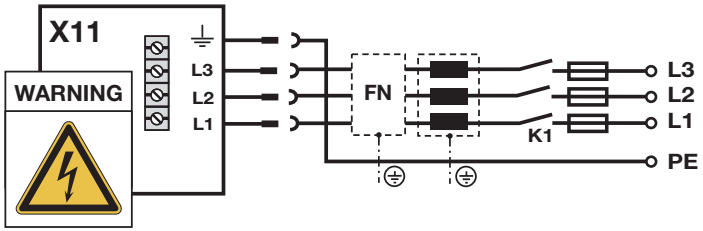


Figure 3.3 Power supply connection for MSD Servo Drive Single-Axis System, 3-phase (size 1 to 4)

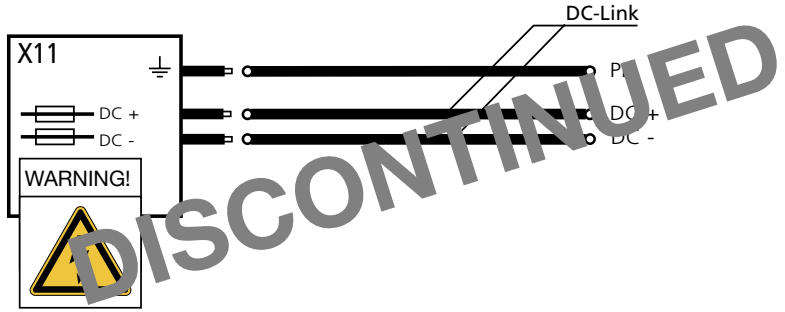


Figure 3.4 Power supply connection for MSD Servo Drive Multi-Axis System, DC-link (size1 to 4)

No.	Designation	Function	Details
D1, D2	7-segment display	Device state indication	see page 23
T1, T2	Button	Service functions	see page 23
X2	USB 1.1 interface	Service interface, Plug & Play connection to the PC	see Operation Manual
X3	Ethernet interface	Service interface, fast TCP/IP connection (RJ45)	see Operating Oanual
X4	Control terminals	6 digital inputs, 2 analog inputs, 4 safe digital inputs, 4 safe digital outputs	see page 15
Option 1	Communication	Factory-installed module for field buses, e.g. SERCOS, PROFIBUS-DP, EtherCAT or CANopen	see page 16

Table 3.1 Key to connection diagram size1 to 4

No.	Designation	Function	Details
X11	Connection for power supply	Depending on device type and size: single or three-phase AC mains supply	see figure 3.3
PE	Protective earth conductor connection	Connection schematic Bild 3.2	see Operating Manual
X9, X10	Connection for control supply U_V	24 V supply voltage for the control electronics in the servo drive	see Operating Manual
X8 Option 2	Technology	Additional encoder interface (see X7) or safety-related evaluation of an external axis	see page 16
X7	High-resolution encoder interface	Sin/Cos encoder, EnDat 2.1 encoder, HIPERFACE® encoder	section 3.9.3
X6	Resolver connection	Motor temperature monitoring can be undertaken via the resolver cable (X6/5 and 9)	section 3.9.2
X38, X39	Connection for safe cross-communication	Makes possible axis group comprising several MSD Servo Drive devices of model Safety	section 3.10
X40	Connection for motor temperature monitoring	PTC, based on DIN 44082 Linear temperature sensor KTY84-130 Automatic thermal cut-out Klixon	see Operating Manual
X13 (BG1-4)	Motor holding brake connection	Power output with cable break/overload detection up to the relay. Attention: Pay attention to freewheeling suppressor circuit	section 3.5
X12	Power connection	Motor, braking resistor and connection of the DC link	section 3.11
HW	Hardware rating plate	Contains serial number and electrical power data, for position see figure 3.1	see Operating Manual
SW	Software rating plate	Contains serial number, software version, MAC address, for position see figure 3.1	see Operating Manual

Table 3.1 Key to connection diagram size1 to 4

3.2 Overview of connections, size 5

The following shows the layout with the corresponding positions of the connectors and terminals. For improved clarity we have added an abbreviation to the designation for the connectors and terminals.

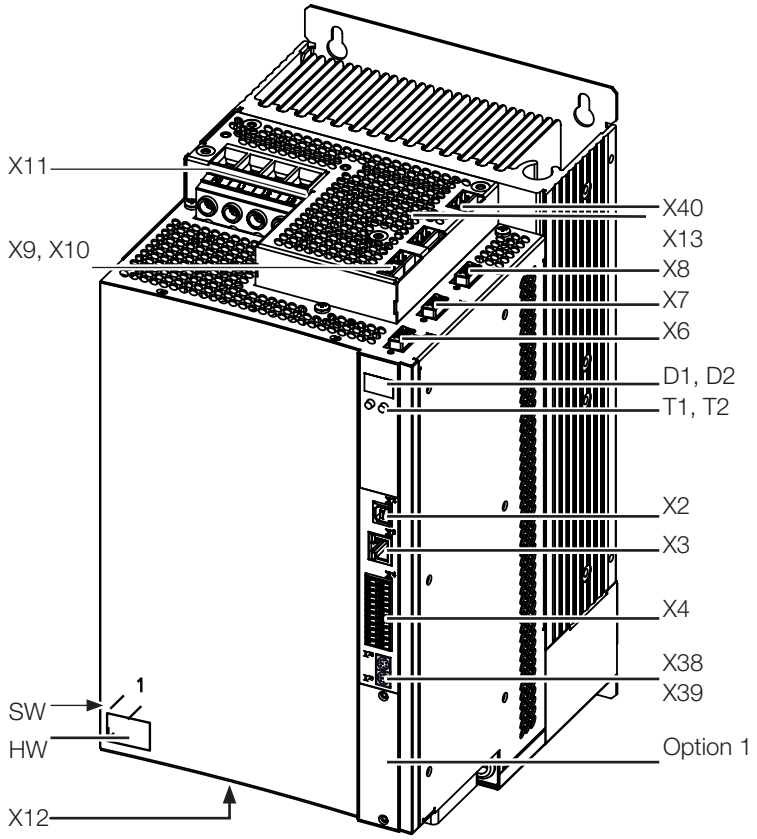
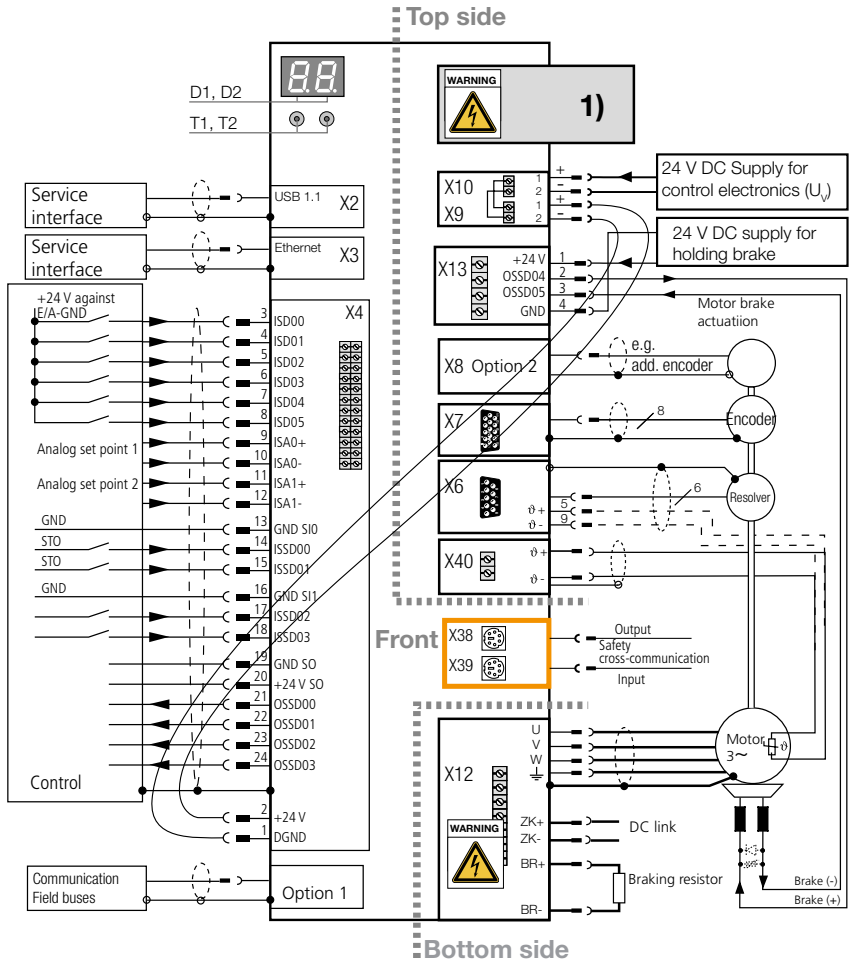


Figure 3.5 Layout size 5 (here: wall mounting housing variant)



1) Supply for power electronics
(designation and connection system vary depending on size and device type, for details see Figure 3.8 to Figure 3.9 as well as the operating manual for the related device)

Figure 3.6 Connection diagram size 5

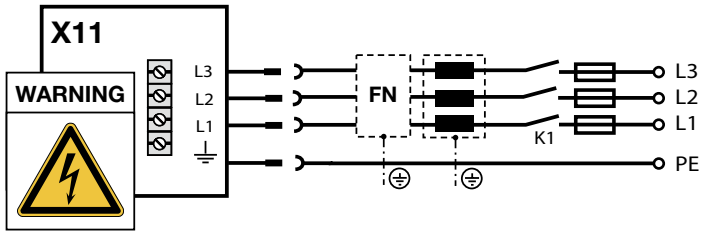


Figure 3.7 Power supply connection for ServoOne single-axis system, 3-phase (BG5)

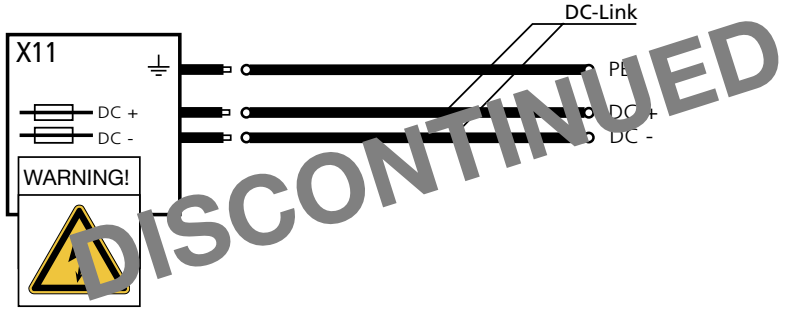


Figure 3.8 Power supply connection for ServoOne multi-axis system, DC-link (BG5)

No.	Designation	Function	Details
D1, D2	7-segment display	Device state indication	see page 23
T1, T2	Button	Service functions	see page 23
X2	USB 1.1 interface	Service interface, Plug & Play connection to the PC	see Operating Manual
X3	Ethernet interface	Service interface, fast TCP/IP connection (RJ45)	see Operating Manual
X4	Control terminals	6 digital inputs, 2 analog inputs, 4 safe digital inputs, 4 safe digital outputs	see page 15
Option 1	Communication	Factory-installed module for field buses, e.g. SERCOS, PROFIBUS-DP, EtherCAT or CANopen	section 3.7

Table 3.2 Key to connection diagram size 5

No.	Designation	Function	Details
X11	Connection for power supply	Depending on device type and size: single or three-phase AC mains supply or DC supply	see Operating Manual
PE	Connection for PE conductor	Connection schematic figure 3.6	see Operating Manual
X9, X10	Connection for control supply	24 V supply voltage for the control electronics in the servo drive	see Operating Manual
X8 (Option 2)	Technology	Additional encoder interface (see X7) or safety-related evaluation of an external axis	section 3.8
X7	High-resolution encoder	Sin/Cos encoder, EnDat 2.1 encoder, HIPERFACE® encoder	section 3.9.3
X6	Connection for resolver	Motor temperature monitoring can be undertaken via the resolver cable (X6/5 and 9)	section 3.9.2
X38, X39	Connection for safe cross-communication	Makes possible axis group comprising several MSD Servo Drive devices of model Safety	section 3.10
X40	Connection for motor temperature monitoring	PTC, based on DIN 44082 Linear temperature sensor KTY84-130 Automatic thermal cut-out Klixon	see Operating Manual
X13	Connection for motor brake	Power output with cable break/overload detection up to the relay. Attention: Pay attention to freewheeling suppressor circuit	See page 14
X12	Power connection	Motor, braking resistor and DC link	section 3.11
HW	Hardware rating plate	Contains serial number and electrical power data, for position see Bild 3.5	see Operating Manual
SW	Software rating plate	Contains serial number, software version, MAC address, for position see figure 3.5	see Operating Manual

Table 3.2 Key to connection diagram size 5

3.3 Power supply MSD Servo Drive

The control unit of the MSD Servo Drives must be supplied with +24 V +-20 % in accordance with SELV/PELV via the terminals X9 and X10.

3.4 Electrical isolation concept

The control electronics, with their logic (µP), the encoder terminals and the inputs and outputs, are electrically isolated from the power section (power supply/DC link). All control terminals are designed as safety extra-low voltage/protective extra-low voltage (SELV/PELV) circuits and must only be operated with such SELV/PELV voltages, as per the relevant specification. This provides reliable protection against electric shock on the control side.

A separate control supply, compliant with the requirements of a SELV/PELV, is therefore needed.

The overview opposite shows the potential references for the individual connections in detail.

This concept also delivers higher operational safety and reliability of the servo drive.

SELV = Safety Extra Low Voltage
PELV = Protective Extra Low Voltage

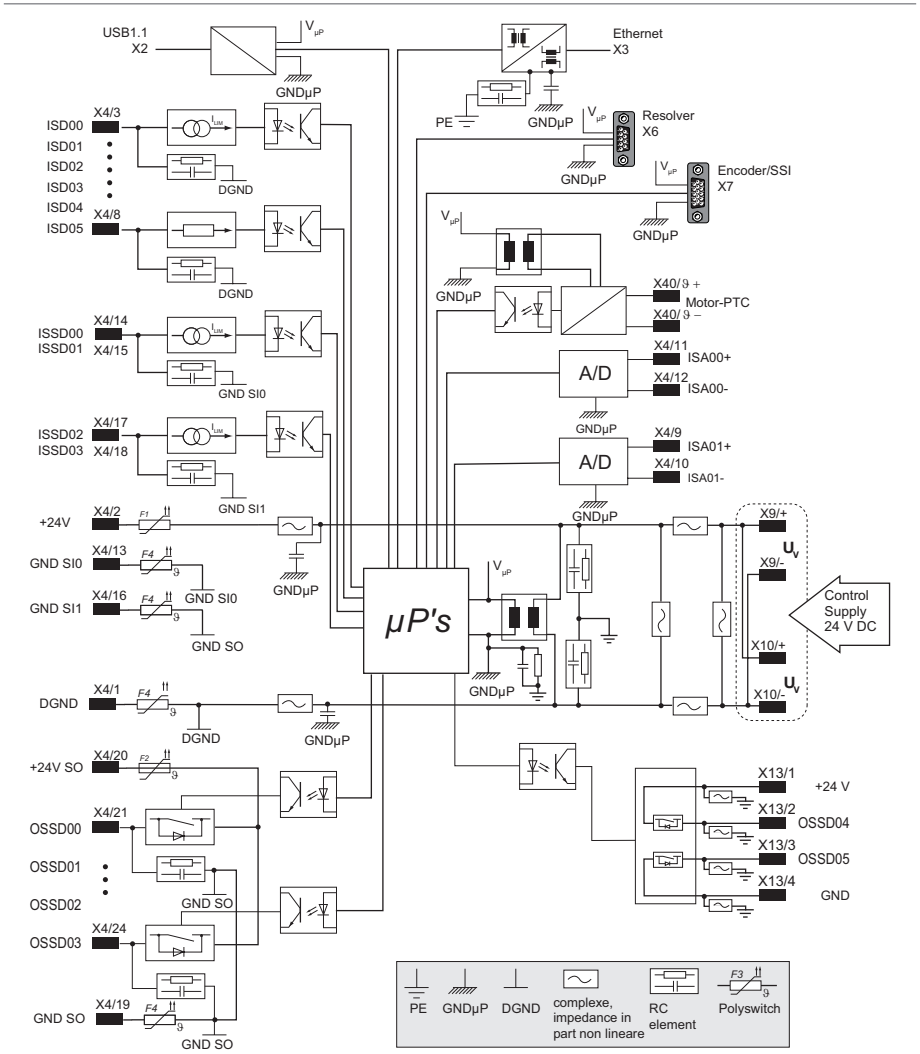


Figure 3.9 Electrical isolation concept for size 1 to 5

3.5 Motor holding brake connection

3.5.1 Brake driver power supply connection (+24 V DC)

The brake driver must be supplied via an external power source for all sizes.
The maximum current carrying capacity of the active output varies on the individual sizes, you will find information on this topic in chapter 7.

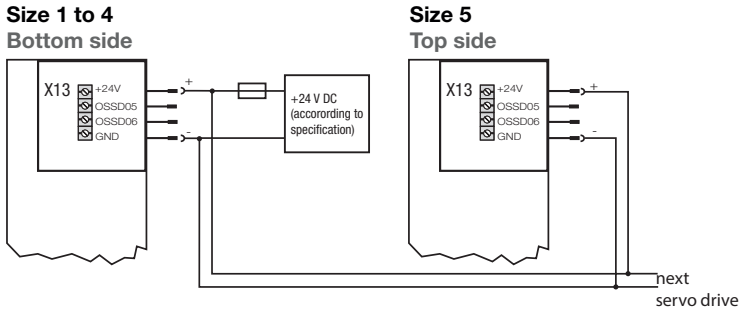


Figure 3.10 Brake driver supply connection, size 1 to 5

Brake driver supply		
Term. size 1-4	**Term. size 5**	**Specification**
X13/1 = + X13/4 = -	X13/1 = + X13/4 = -	UV = 24 V DC ±20 %, stabilised and filtered.

Table 3.3 Brake driver supply specification

Caution! Cable protection

Suitable measures must generally be applied to provide adequate cable protection.
The power supply for the safe brake driver output requires a voltage of +24 V DC in accordance with SELV/PELV.

3.5.2 Brake driver

On size 1 to size 5, the connector X13 is provided for connecting one or two motor holding brakes that act on a common axis.

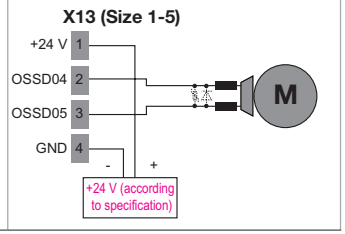
Des.	Terminal	Specification	Connection
+24 V OSSD04 OSSD05 GND	X13-1 X13-2 X13-3 X13-4	• Maximum current dependent on assembly! • For further details see chapter 7.3.	

Table 3.4 Specification of the terminal connection for one brake

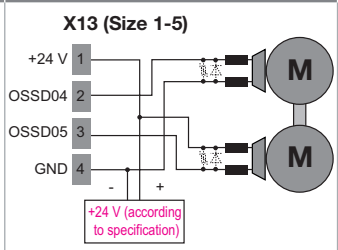
Des.	Terminal	Specification	Connection
+24 V OSSD04 OSSD05 GND	X13-1 X13-2 X13-3 X13-4	• Maximum current dependent on assembly! • For further details see chapter 7.3.	

Table 3.5 Specification of the terminal connection for two brakes

Note:

It is a prerequisite for this variant that both motor holding brakes act on a common axis.

3.6 Control connections

3.6.1 Specification of the control connections

Des.	Term.	Specification	Electrical isolation
		Analogue inputs	
ISA0+ ISA0- ISA1+ ISA1-	X4/9 X4/10 X4/11 X4/12	U_{IN} = ±10 V DC Resolution 12 bits; R_{IN} approx. 101 kΩ Terminal scan cycle in "IP mode" = 125 µs, otherwise = 1 ms Tolerance: U ±1 % of the measuring range end value	No
		Digital inputs	
ISD00 ISD01 ISD02 ISD03 ISD04 ISD05	X4/3 X4/4 X4/5 X4/6 X4/7 X4/8	Standard input Frequency range < 500 Hz Sampling cycle: 1 ms Switching level Low/High: ≤ 4.8 V / ≥ 18 V I_{max} at 24 V = 3 mA typ.	Yes
		Safe digital inputs	
ISSD00 ISSD01 ISSD02 ISSD03	X4/14 X4/15 X4/17 X4/18	Standard input Frequency range < 500 Hz Sampling cycle: 1 ms Switching level Low/High: ≤ 5 V / ≥ 15 V I_{max} at 24 V = 3 mA typ.	Yes
		Safe digital outputs	
OSSD00 OSSD01 OSSD02 OSSD03	X4/21 X4/22 X4/23 X4/24	Rated operating voltage: 24 V (19.2 - 28.8 V) Maximum total current: 400 mA Maximum current per output: 100 mA	**Yes**
		Auxiliary voltage	
+24 V	X4/2	Auxiliary voltage to feed the digital control inputs $U_H = U_V$-ΔU (ΔU typically approx. 1.2 V),no destruction in event of short circuit (+24 V -> GND), but device may briefly shut down. I_{max} = 80 mA (per pin) with self-resetting circuit breaker (polyswitch)	Yes

X4

OSSD03	24	12	ISA1-
OSSD02	23	11	ISA1+
OSSD01	22	10	ISA0-
OSSD00	21	9	ISA0+
+24 V SO	20	8	ISD05
GND SO	19	7	ISD04
ISSD03	18	6	ISD03
ISSD02	17	5	ISD02
GND SI1	16	4	ISD01
ISSD01	15	3	ISD00
ISSD00	14	2	+24V
GND SIO	13	1	DGND

Table 3.6 Specification of the control connections X4

Des.	Term.	Specification	Electrical isolation	
+24V SO	X4/20	Connection for ext. auxiliary voltage to feed the safe digital outputs OSSD00 to OSSD03	Yes	
Digital ground				
DGND	X4/1	Reference ground for +24 V, I_{max} = 80 mA (per pin) with self-resetting circuit breaker (polyswitch)	Yes	
	X4/13 X4/16 X4/19	GND SIO = Reference ground for ISSD00 and ISSD01 GND SI1 = Reference ground for ISSD02 and ISSD03 GND SO = Reference ground for OSSD00 to OSSD03	Yes	Insulated in relation to DGNG

Table 3.6 Specification of the control connections X4

Note: Prevent loop currents

- If excessively high currents flow via the earth terminals, high impedance isolation from the device earth is possible. In certain circumstances this can result in the malfunction of the drive. To prevent this situation arising, prevent loop currents in the wiring.

3.7 Option 1

Depending on the MSD Servo Drive variant, Option 1 is factory-configured with various options. Field bus options such as EtherCAT or SERCOS are available.

You will find all available options in the MSD Servo Drive Ordering Catalog. The user manuals for the respective options provide detailed information on commissioning.

3.8 Option 2

Option 2 can be factory-configured with various technology options. Additional or special encoders can be evaluated here for example. The safety-related evaluation of encoder signals for an external axis is also possible.

You will find all available options in the MSD Servo Drive Ordering Catalog. The user manuals for the respective options provide detailed information on commissioning. For further details see appendix.

3.9 Encoder connection

3.9.1 Safe encoder evaluation

Along with the drive and control-related evaluation of various encoder signals, with the MSD Servo Drive it is also possible to monitor the encoder signals in the context of functional safety. This internal diagnostic feature makes it possible to integrate the various safety monitoring functions (cf. chapter 6). On the additional usage of a monitoring sensor in a redundant configuration, it is possible to increase the Performance Level (PL) or Safety Integrity Level (SIL) for the application, provided both encoder systems act on a common axis.

The following list of encoders shows the possible combinations:

No.	Process encoder	Monitoring encoder	External axis monitoring	Maximum SIL
1	Sin/Cos			3
2	Sin/Cos		X [1]	3/2[5]
3	Sin/Cos	Sin/Cos [2]		3
4	Sin/Cos	TTL [2]		3
5	Sin/Cos	HTL / counting pulses		3
6	TTL	TTL [2]		2
7	TTL	HTL / counting pulses		2
8	SSI	Sin/Cos [4]		3
9	SSI	Sin/Cos	X [1]	3/2[5]
10	SSI	Sin/Cos [2]		3
11	SSI	TTL [2]		3
12	SSI	SSI [3]		3
13	SSI	HTL / counting pulses		3
14	Resolver			3
15	Resolver		X [1]	3/2[5]
16	Resolver	TTL		3
17	Resolver	TTL	X [1]	3/2[5]
18	Resolver	HTL / counting pulses		3

1) Option 2 required, safety technology option for external axis monitoring (Sin/Cos1)
2) Option 2 required, safety technology option for second safe axis monitoring (Sin/Cos)
3) Option 2 required, safety technology option for second safe axis monitoring (SSI)
4) Option 2 not required, both encoder signals in the same connector
5) Relates to the maximum SIL for the external axis monitoring.

Table 3.7 Combinations of different safety monitoring functions

Caution! Complete safety appraisal

The safety-related evaluation and monitoring of the individual encoder signals internally in the controller is not always sufficient. A complete safety appraisal must be undertaken for uncertified encoder systems.
In addition, the fault "Loosening of attachment during standstill or during motion" (safety standard IEC/EN 61800-5-2, Annex D, Table D.16) is to be taken into account by means of the exclusion of a shaft break on single-channel systems, independent of the certification.

Notes: Safety appraisal

A safety appraisal on uncertified encoder systems includes, among other issues, the following points:

- Fault appraisal and FMEA based on tables from Annex D of the safety standard IEC/EN 61800-5-2.
- Appraisal of the internal layout of the encoder based on the manufacturer's documentation. Important points of such an appraisal are:
  - Are sin and cos signals processed separately?
  - Can the encoder disc become detached from the shaft or can it slip?
    - Can the sensor suffer interference due to external light?
  - Is the power of the transmit LED controlled and is end-of-life monitoring undertaken?
  - Are Sin/Cos or TTL signals generated using signal processing and/or an interpolator?
  - Are the systems for the absolute position and the incremental track independent?
  - For encoders that contain complex ASICs or similar for signal processing or interpolation, the following fault assumption applies: "Incorrect output signal due to malfunction of the ASIC" that cannot be excluded and that cannot be diagnosed without the usage of a second, independent encoder.
  - For encoders that use a "complex" protocol that requires a processor or ASIC for the processing in the encoder, the fault model for communication buses applies.
- Encoder cable:
  Only approved encoder cables with a maximum length of 30 m (1181.1 in) are allowed to be used for the connection of safe encoders.
- Speed and signal frequencies
  The maximum values for speeds and signal frequencies stated in the tables are not allowed to be exceeded.
- Reaction time for shutdown
  If redundancy in the form of a monitoring encoder is used in an application, the resolution of the monitoring encoder defines reaction time for shutdown on specific failures.

Note:

On the usage of 2 encoders, the accuracy of the safe evaluation always relates to the encoder with the poorer resolution.

3.9.2 Requirements on a resolver

Feature	Value
Maximum signal frequency that can be evaluated	600 Hz
Maximum speed that can be acquired	36000 rpm
Speed calculation method	Maximum signal frequency / number of pole pairs (p) * 60
Maximum encoder cable length	30 m (1181.1 in)
Ratio	2:1
Maximum phase shift (incl. cable)	-30° to +30°
Excitation amplitude	8 V_{pp} (2.8 V_{rms})
Excitation frequency	8 kHz
Maximum excitation current	100 mA_{pp} (35 mA_{rms})
Permissible number of pole pairs	1 to 5

Table 3.8 Requirements on the usage of a resolver

Caution! Undetected failures during axis standstill

Undetected failures can occur during axis standstill. To be able to detect these failures, the resolver must rotate (to be implemented by the application) automatically by at least 360° (electrical) at an interval of maximum 24 h on a regularly recurring basis.

Note:

- Pay attention to tolerances
  The monitoring of the resolver signals has a specific tolerance. The usage of different cable types or longer encoder cables, also the usage other resolver types with different specifications may cause undesirable error messages because the monitoring tolerances are infringed as a result.
  For this reason only cable types and cable lengths approved by Moog are allowed to be used.
- Positive/friction-locked joints
  On the usage of a resolver, the rotor must be connected to the motor shaft with positive locking due to the fault exclusion measured above! The stator must also be mounted with positive or friction locking with corresponding oversizing!
  In addition, the "shaft break" fault is to be excluded by corresponding oversizing of the motor shaft!
- Fault exclusion
  Attention must be paid to the fault exclusion "Magnetic interference at the installation location" in the safety standard IEC/EN 61800-5-2, Annex D, Table D.16 on external systems!
- Achievable safety
  The system is able to achieve PLe as per EN ISO 13849-1 or SIL3 as per IEC/EN 61508 / IEC/EN 62061 for the evaluation of the resolver while taking into account all the points stated.
- Application area
  The safety-related evaluation of resolvers is not dependent on specific motor types. It is possible to use both synchronous and asynchronous motors.
  It is not absolutely necessary that the resolver is integrated into the control loop and/or the servo drive's commutation.
  In addition, a specific type or manufacturer of resolver is not stipulated. However, it is to be noted that the resolver used must match the electrical specifications of the safety system!
  The user is responsible for ensuring the resolver used is suitable for achieving the safety level required for the application and that all the related necessary measures are implemented.

3.9.3 Requirements on a high-resolution encoder system

	TTL	Sin/Cos
Maximum signal frequency that can be evaluated	400 kHz	400 kHz
Speed calculation method	Maximum input frequency / resolution (pulses per revolution)	
Signal level	Digital signals EIA422	Analog signals 1 V_{pp}

Table 3.9 Technical data encoder inputs

Caution! Fault at standstill

- On incremental encoders, faults can occur that are not detected at standstill. To be able to diagnose all faults, one rotation of the encoder by at least one period of the encoder is required within 24h.

Notes:

- Pay attention to tolerances
  The monitoring of the incremental encoder signals is undertaken by magnitude monitoring, among other means, and has a specific tolerance. The tolerance range is from 55 % to 130 % of the specified signal level.
- Achievable safety
  The achievable Safety Integrity Level depends on the selection of the encoder. The evaluation of the encoder signals is able, in conjunction with a suitable encoder, to achieve PLe as per EN ISO 13849-1 or SIL3 as per IEC/EN 61508 / IEC/EN 62061.

3.9.4 Pin assignment X7

The pin assignment on the MSD Servo Drive FS is different to that on the MSD Servo Drive Standard. This difference affects pin 4+5 (zero pulse) as well as pin 9+10 (temperature evaluation). See table below.

X7 Pin	Sin/Cos and TTL	Sin/Cos absolute value encoder SSI/EnDat	Absolute value encoder EnDat (digital)	Absolute value encoder HIPER-FACE®
1	A-	A-	-	REFCOS
2	A+	A+	-	+COS
3	+5 V DC ±5 %, IOUT maximum = 250 mA (150 mA for hardware versions 0..1), monitoring via sensor cable			7 to 12 V (typ. 11 V) maximum 100 mA
4	R+	Data +	Data +	Data +
5	R-	Data -	Data -	Data -
6	B-	B-	-	REFSIN
7	-	-	-	U_S - Switch
8	GND	GND	GND	GND
9	ϑ- (PTC, KTY, Klixon) internally connected to X6/9			
10	ϑ+ (PTC, KTY, Klixon) internally connected to X6/5			
11	B+	B+	-	+SIN
12	Sense +	Sense +	Sense +	U_S - Switch
13	Sense -	Sense -	Sense -	-
14	-	CLK+	CLK+	-
15	-	CLK -	CLK -	-

The sum of the currents tapped at X7/3 and X6/4 must not exceed the specified value!

After connecting pin 7 to pin 12, there is a voltage of 11.8 V on X7, pin 3!

Table 3.10 Pin assignment, connector X7 MSD Servo Drive FS

3.9.5 Requirements on an HTL encoder or on counting pulses

On the usage of an HTL encoder or on the usage of counting pulses (e.g. with proximity switches) the signals are provided to the MSD Servo Drive for evaluation via the safe digital inputs (see also chapter 6).

Due to the low resolution of counting pulses (HTL, proximity switches, among others) they are only allowed to be used as additional redundancy for high-resolution encoders and resolvers.

Attention is to be paid to the following specifications:

Feature	Value
Maximum input frequency that can be evaluated	200 kHz
Speed calculation method	Maximum input frequency / resolution (pulses per revolution)
Input level	+24 V DC as per IEC/EN 61131-2, type 1

Table 3.11 Requirements on the usage of a resolver

Caution! Evaluation of speed and direction of rotation

Counting pulses can only be evaluated if the mechanical layout includes two proximity switches that supply signals with an offset of 90°. Otherwise, it is not possible to evaluate the speed and direction of rotation!

Notes:

- Safety appraisal
  The usage of HTL encoders or proximity switches requires a safety appraisal of the installation, wiring and power supply!
- Achievable safety
  The additional usage of counting pulses for a process encoder creates, in certain circumstances, the necessary redundancy for achieving PLe as per EN ISO 13849-1 or SIL3 as per IEC/EN 61508 / IEC/EN 62061. HTL encoders are treated like counting pulses!

3.10 Safe axis cross-communication (SCC)

Safe axis cross-communication (SCC = Safe Cross Communication) is used to create an axis group comprising up to six axes (MSD Servo Drive Safety). Within such an axis group, all relevant data for the implementation of the safety and monitoring functions are available to all devices within defined cycle times.

Feature	CB72529-001
Temperature range	-10 ... +80 °C (+14 ... +176 °F)
Cable diameter approx.	6 mm (0.24 in)
Maximum cable length per segment between servo drives	40 cm (15.76 in)
Maximum total cable length (incl. connectors)	2.8 m (9.19 ft)
Maximum number of cable segments	5
Outer sheath material	PVC

Table 3.12 Technical data, ready made SCC cable

Note:
The automatic configuration of the addressing on the SCC bus only takes place after power-on.

Figure 3.11 SCC cable

3.11 Braking resistor (BR)

In regenerative operation, e.g. when braking the drive, the motor feeds energy back to the servo drive. Consequently, the voltage in the DC link increases. If the voltage exceeds a threshold, the internal brake chopper transistor is switched on (only available up to and including size 4) and the regenerated power is converted into heat by means of a braking resistor.

4 Commissioning

The MSD Servo Drive devices with integrated safety control no longer incorporate, unlike the standard model of the MSD Servo Drive devices, the two inputs ENPO and ISDSH for enabling the power stage or for switching the safety function STO.

To be able to switch the power stage, a program must be written and transferred with the aid of the user software Safety PLC Functions (you will find more information on this aspect in the Programming Manual).

As supplied, the MSD Servo Drive with integrated safety control already contains a program using which the power stage can be switched by activating the safe digital inputs ISSD00 and ISSD01.

In this way the drive-related section can be commissioned as per the requirements in the Operation Manual for the MSD Servo Drive independent of the usage of the user software Safety PLC Functions.

Caution!

If the default program mentioned above is overwritten by transferring a program from Safety PLC Functions, it will not be possible to restore the program using the "Reset to factory settings" function!

To make it possible to switch the power stage again, a program with the safety module STO must be transferred (you will find more information on this aspect in the Programming Manual).

5 Diagnostics

5.1 Status indication on the device

Along with the device states indicated automatically (cf. Operation Manual MSD Servo Drive), the MSD Servo Drive with integrated safety control has state information on the safety section.

Open the menu with a long press (approx. 1s) on button T1.

Actuate T1 several times or hold it pressed to display the indication "FS".

If you now actuate the button T2, the state of the safety part is indicated after the sequence of letters "S", "A", "F" and "E"; the state may contain the following information:

Display (D1+D2)	Mode	Meaning
	STARTUP	Synchronisation between processor systems and check on the configuration/ firmware data
	SENDCONFIG	Distribution of the configuration/firmware data and range check
	STARTUP BUS	Initialisation of the bus system
	RUN	Normal operation of the system. All outputs are switched as a function of the current logic.
	STOP	Stop mode for transferring the parameter and program data

Table 5.1 Status and error indication

Display (D1+D2)	Mode	Meaning
	ALARM	Alarm state. Can be reset via digital input or acknowledgement mechanism in DriveAdministrator.
	FAILURE	Error state. Can only be reset using 24 V reset on the MSD Servo Drive.

Table 5.1 Status and error indication

In the event of an alarm or an error, a 4-digit code is displayed in sequence after the indication of "A" or "F". Refer to the error list in the Programming Manual for a description of the related code.

Note:

If there is a 5-digit code (to be read on the master), the first digit refers to the slave in the axis group.

A slave only outputs 4-digit codes.

5.1.1 Status messages from the safe part in the error-free state

In the error-free state the 7-segment display indicates the state of the safe part on the left, and the state of the non-safe part on the right. The following table describes the states of the safe part.

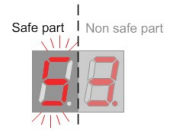
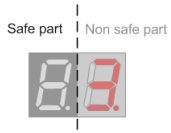
Display	Explanation	Comment
	A flashing "S" indicates that the related axis is in STO	Indicated on all axes (master and slave).
	. A flashing "C" indicates that the program in the master axis and the configuration are not validated and there is no request for STO.	Only indicated on the master axis.
	If nothing is indicated, there is no request for STO for the related axis.	Indicated on all axes (master and slave).
	A flashing "." indicates that the device with the Safety PLC Function user interface is online.	Only indicated on the master axis.

Table 5.2 Status messages, safe part

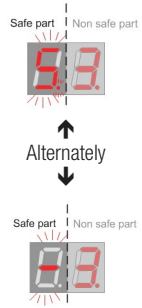
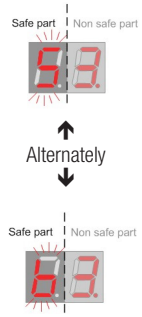
Display	Explanation	Comment
	Alternate indication of an "S." and a "-" indicates that the safe part is in the "STOP" state (the program and/or the configuration data can be loaded onto the device).	Only indicated on the master axis.
	A rotating "-" with flashing "." indicates that a program or a configuration is being loaded into the master axis.	Only indicated on the master axis.
	Alternate indication of an "S" and a "b" indicates that the related axis is in the "Bus run" (booting cross-communication) state.	Indicated on all axes (master and slave).
	All other states feature a continuous "S" indication.	

Table 5.2 Status messages, safe part

5.2 Status and error indication in MDA 5

After the occurrence of an alarm or an error, a pop-up window appears immediately with information in the "Cause" field that there may be an alarm or error from the safe part.

In addition, in the "Additional information" field there is a short description and the code.

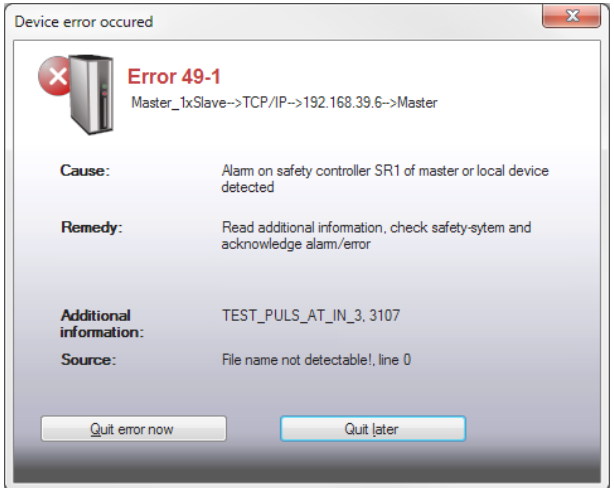


Figure 5.9 Status and error indication MDA 5

6 Functional safety

6.1 Hazard analysis and risk assessment

The user of the integrated safety functions of the MSD Servo Drive must follow the currently applicable version of the Machinery Directive 2006/42/EC.

The manufacturer or the manufacturer's representative has the obligation to undertake a hazard analysis (as per Machinery Directive 2006/42/EC) prior to placing a machine on the market. The manufacturer must undertake an analysis of the hazards that emanate from the machine and implement appropriate measures to reduce/eliminate the hazards. With the hazard analysis the prerequisites are met to be able to define the necessary safety functions.

The safety functions on the MSD Servo Drive with integrated safety control are approved by the accredited certification body "TÜV-Rheinland" (see appendix).

The approval is applicable to the servo drive types identified as per the order code (chapter 1.3).

Caution!

The operator of the safety-related system must be trained such that his/her level of knowledge is appropriate for the complexity and the safety integrity level of the safety-related system. The training includes the study of the main features of the production process and knowledge of the relationship between the safety-related system and the EUC (Equipment Under Control).

6.2 Definition of terminology

Safety functions

A safety function is a function that is implemented by an E/E/PE (electrical/ electronic/ programmable electronic) safety-related system, a safety-related system based on other technology, or external devices for risk reduction with the goal, taking into account a specific undesirable event, of achieving or maintaining a safe state for the EUC.

STO: Safe Torque Off

- The supply of power to the motor is safely disconnected by electrically isolating the drive. The axis then coasts down.
- Attention: STO is the fall-back solution for all safety functions!

SS1: Safe Stop 1

- The drive is braked by the action of the drive control and during this process the change in velocity or the time is monitored. Once standstill has been reached or the time has elapsed, the STO function is activated.

SS2: Safe Stop 2

- The drive reduces the motion to standstill and during this process the change in velocity is monitored. Once standstill has been reached, the SOS function is activated.

SOS: Safe Operating Stop

- An operating stop is the state in which the motor is maintained at standstill, during this process the drive is in the state speed or position control.

SLS: Safely-Limited Speed

- The drive is monitored for compliance with a defined velocity limit (vmax).

SLI: Safely-Limited Increment

- The travel of the drive is monitored for a limiting value as a function of the motion task. This safety function makes possible a jog mode.

SDI: Safe Direction

- Monitoring of the stipulated direction of rotation or movement of the axis.

SCA: Safe Cam

- If the motor speed or the motor position is in a defined range, a safe signal is output.

SEL: Safe Emergency Limit

- Monitoring of the permissible velocity referred to the relative distance from the maximum limit for the movement range or positioning range.
- This safety function can replace the usual safety limit switch.

SLP: Safely-Limited Position

- Monitoring that the drive does not pass a defined position as a limiting dimension.

SBT: Safe Brake Test

- Safety function for checking holding brakes subject to wear.

Emergency stop

Corresponding to the national and European foreword to IEC/EN 60204-1, electrical equipment is also allowed to be used for emergency stop devices if the equipment is compliant with, e.g., the standards DIN EN 954-1 and/or IEC/EN 61508. The "STO" function can therefore be used for emergency stop functions.

Note:
The term "emergency stop device" has been replaced with the new term "emergency operation". The term "emergency switching off" has been replaced with "emergency stop", see paragraph 9.2.5.4.2 of IEC/EN 60204-1.

EN ISO 13849-1:2008

Safety of machinery. Safety-related parts of control systems.

EN ISO 13849 evolved from DIN EN 954-1, supplemented with the aspect of quality management and reliability.

EN 62061:2005

Safety sector standard for the area of machinery, evolved from IEC/EN 61508.

EN 61508:1998-2010

International generic safety standard that describes the state-of-the-art in all aspects.

EN 61800-5-1:2007

Adjustable speed electrical power drive systems. part 5-1: Safety requirements - Electrical, thermal and energy.

EUC (equipment-under-control)

EUC - System
System that reacts to the process's and/or user's input signals and generates output signals that permit the EUC to operate in the required manner.

EUC - Equipment
Equipment, machine, apparatus or plant used for manufacturing, production and processing, transporting, medical or other activities.

EUC - Risk
Risk that results from the EUC or its interaction with the EUC system.

PFH (Probability of dangerous Failure per Hour)

Is the value for the probability of a dangerous failure per hour.

Validation

Confirmation that the special requirements for a specific purpose are met by checking and the provision of objective evidence.

Validation is the activity that demonstrates the safety-related system considered corresponds to every aspect of the specified safety requirements for the safety-related system, before or after installation.

Positive opening of a contact element

Symbol for positive opening in accordance with IEC/EN 60947-5-1 Annex K 

On the positive opening of a contact element, the separation of the contact is achieved as the direct result of a specific movement of the actuating element by means of non-elastic elements (no springs).

Safety circuit

A safety circuit has a dual-channel layout and has been accepted by accredited certification bodies as per the standards. There are many manufacturers who offer a wide variety of safety circuits for a broad range of applications.

6.3 Function description

The safety control in the MSD Servo Drive is certified in accordance with the requirements of EN ISO 13849-1 "PLe / Cat 4" and IEC/EN 61508 / IEC/EN 62061 "SIL CL 3".

The safety function "STO" describes a protective measure as an interlocking or control function. Category 4 signifies that the safety function is retained on the occurrence of up to two failures. The STO function is the fall-back solution for all other safety functions, as it ensures the drive does not produce any torque. The other safety functions can be used up to maximum SIL3 / PLe (Cat 3) depending on the sensors used.

The safety-related parts must be designed such that:

- A single failure in any of these parts does not result in the loss of the safety function, and
- The single failure is detected on or before the next demand upon the safety function. If this detection is not possible, an accumulation of failures must not result in the loss of the safety function.

Compared to the conventional solution, the integrated safety functions offer the following advantages:

- External motor contactors are not required
- Less wiring effort
- Space-saving
- Better EMC behaviour due to the continuous screening of the motor cable
- Shorter reaction times

As supplied, the safety function "STO" is enabled by the two safe digital inputs ISSD00 and ISSD01. It is possible to change this configuration using the programming software Safety PLC Functions.

Caution!

Certain failures are detected by the internal diagnostics in the active state or on the transition from the active state to the inactive state of the safety function. To reduce the residual risk due to undetected failures, it is necessary to request the safety functions once with 24 h, if they are not tested automatically by a pulse pattern. Otherwise, the safety function may fail due to the accumulation of two or more undetected failures! The SIL achieved by the application's forced state change must be determined by the user.

Caution!

The safety function STO is accepted in accordance with SIL3, PLe (Cat 4), an accumulation of more than two failures can result in the failure of the safety function if the control signals are not tested automatically. Shutdown by the user or the machine control system at least once every 24 h must be ensured.

6.4 Validation

Always define a validation plan. The tests and analyses you have used to demonstrate the compliance of the solution (e.g. suggested circuit) with the requirements from your application are defined in the plan.

In all cases check whether

- All safety-related output signals are generated in the correct, logical manner from the input signals.
- The behaviour in the event of a failure corresponds to the circuit categories defined.
- The control and the equipment are adequately dimensioned for all operation modes and ambient conditions.

Prepare a validation report on completion of the analyses and tests. This report should contain as a minimum:

- All items to be tested
- The personnel responsible for the testing
- Test equipment (including details on the calibration) and simulation instruments
- The tests undertaken
- The problems found and their solution
- The results

Keep the documented results in traceable form.

Safety instructions

While undertaking the validation follow the safety instructions as per section 6.5.

6.5 Safety instructions

HAZARD DUE TO ELECTRICAL VOLTAGE!

- If the servo drive is in the state "STO", the motor and mains cable, braking resistor and DC link supply cable will carry dangerous voltages in relation to the PE conductor.
- Without additional measures it is not possible to implement "shutdown of the power supply in an emergency" using the function "STO". There is no electrical isolation between motor and servo drive! As such there is a risk due to electric shock and other risks of an electrical origin.

HAZARD DUE TO ROTATING PARTS!

- If the action of external force is to be expected with the safety function "STO", e.g. due to a suspended load, this movement must be safely prevented by additional measures, e.g. by means of two brakes, locking device or clamping device with brake.
- In the event of a short circuit in two offset branches of the power section, a brief axis movement dependent on the number of poles on the motor may be triggered.

Example

Synchronous motor: On a 6-pole synchronous motor, the movement can be maximum 30°. On a directly driven ball screw, e.g. 20 mm (0.79 in) per revolution, this movement corresponds to a single maximum linear movement of 1.67 mm (0.06 in).

Example

Asynchronous motor: The short circuits in two offset branches of the power section have almost no effect, as the excitation field collapses with the inhibition of the inverter and has decayed completely after approx. 1 s.

7 Safe inputs/outputs

7.1 Specification of the safe inputs, MSD Servo Drive

The MSD Servo Drive has four safe digital inputs. They are used to connect single or dual-channel signals with and without pulses or cross-circuit testing. Used individually, they satisfy the requirements of SIL2 / PLd, a group of two inputs satisfies the requirements of SIL3 / PLe.

Each of the four inputs is suitable for the connection of OSSD (output signal switching device) signals as are used, e.g., on various safe outputs for internal self-tests or shutdown tests.

The MSD Servo Drive detects a "high" level on the related input if the voltage connected is greater than 15 V and a low level if the voltage is lower than 5 V (as per IEC/EN 61131-2).

A device-internal diagnostics function checks the correct function of the inputs. The maximum transition time (the period in which the input voltage on an input is between the defined switching thresholds) is allowed to be 16 ms. If one channel reads a different input signal to the other channel for longer than 16 ms, an error message is generated and all outputs switched inactive at the same time.

Note: Outputs
If delays are not configured, all outputs and output functions (OSSD0x, STO and outputs on the expansion module) are shut down (delays can be configured as a de-escalation strategy for OSSD04, OSSD05 and STO).

Note:
Short circuits, earth faults and cross-circuits can result in the failure of the safety function and must be prevented as per EN ISO 13849.

The safe digital inputs are also able to check the test pulses generated on the safe digital outputs by the MSD Servo Drive (cf. section 7.2 "Specification of the safe outputs, MSD Servo Drive"). Faults can be detected in the external wiring using these test pulses on the inputs, as only the related pulse pattern configured is accepted.

Each input can therefore be configured separately for the following signal sources:

- Input is allocated pulse 1
- Input is allocated pulse 2
- Input is allocated pulse 3
- Input is allocated pulse 4
- Input is allocated DC 24 V continuous voltage

In addition, for the inputs ISSD02 and ISSD03 it is possible to use two pulse generators (e.g. proximity switches or similar) or an HTL encoders as counting pulses for the encoder evaluation.

7.2 Specification of the safe outputs, MSD Servo Drive

Along with the safe inputs, the MSD Servo Drive has four safe digital outputs. These outputs satisfy the requirements of SIL2 / PLd, a group of two outputs satisfies the requirements of SIL3 / PLe (see section 7.4.2 "Example output circuits")

The outputs can be used as safety-related outputs, in this case internal cyclic shutdown tests on the output driver switch the outputs to a potential of 0 V DC (OSSD) for a maximum test duration of 500 µs. If the outputs are not used as safety-related outputs, this internal test does not take place, and no test pulses are output on the signals. If safe outputs are to be used as standard outputs on the servo drive, this aspect must be programmed correspondingly in Safety PLC Function (see Programming Manual).

In conjunction with the digital inputs, the outputs can also be used as signature outputs (test pulse) for the detection of faults in the external wiring (see section 7.1 "Specification of the safe inputs, MSD Servo Drive"). In this case they behave like switching 24 V DC outputs.

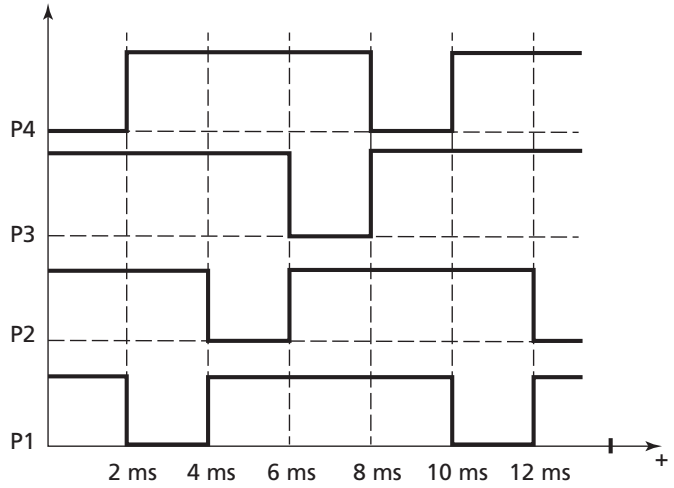


Figure 7.1 Signatures

You will find more detailed information on the usage and programming of the signature outputs in the Programming Manual.

The diagram describes the characteristics of the signatures over time:

Attention!

If the system is operated in an axis group with several MSD Servo Drive, short circuits between the safe digital outputs for the various axes must be excluded.

Notes:

Only monitoring function

The signature outputs are only intended for monitoring the digital inputs and cannot be used for any other function in the application.

Furthermore, the various signatures are only intended for mechanical switching elements. Other switching elements can result in signal distortion and therefore the generation of errors.

Pay attention to maximum output current

The high-side driving outputs are implemented for a current of 100 mA per output. If a higher current is required, the driver for the brake output (high-side and low-side) or external relays can be used (digital outputs as per IEC/EN 61131-2).

Relay drop-out voltage

If relays are connected to the outputs, their drop-out voltage must not be less than 5 V.

Supply

The power supply for the safe outputs requires a voltage of +24 V DC in accordance with SELV/PELV.

Output groups

The grouping of two outputs that are to satisfy the requirements of SIL3 / PLe is either OSSD00 and OSSD02 or OSSD01 and OSSD03.

7.3 Specification of the safe brake driver output

Along with the four safe digital outputs, the MSD Servo Drive has a further safe digital output with high driver power - the brake driver output. This output is of dual-channel design with a high-side and a low-side driver such that, along with holding brakes, e.g. contactors, guard locks, etc. can also be connected directly using two channels. If two brakes or two actuators are connected, they must act on the same safety function or on a common axis in the application. To use the brake driver outputs, they must first be programmed correspondingly in Safety PLC Function as per the Programming Manual.

Caution!

Minimum drop-out voltage
The drop-out voltage of the brake(s) or actuator(s) used must not be lower than 8 V.

Maximum holding current
Brakes or actuators connected must not have a holding current of less than 15 mA, as a reverse leakage current flows in the switched off state on the dual-channel connection of a load.

Exclusion of short circuits
If the system is operated in an axis group with several MSD Servo Drive, short-circuits between the brake driver outputs for the various axes must be excluded.

Capacitive loads
In general the brake driver outputs are designed for an ohmic-inductive load (inductance minimum = 100 µH). With a purely ohmic load the output current is reduced to 50 % of the rated current.
Capacitive loads, e.g. electronic contactors, are not allowed.

Status not to master
The status of the brake outputs is not transferred to the master.

Note:
The output current on the brake driver output is dependent on the size.

Size MSD Servo Drive	Connection	Output current $I_{BR\ max.}$
size 1	X13	2 x 1.4 A
size 2	X13	2 x 2.1 A
size 3	X13	2 x 2.45 A
size 4	X13	2 x 2.45 A
size 5	X13	2 x 2.45 A

Table 7.1 Output currents, brake driver on X13

7.4 Circuit examples

In the following circuit examples it is a prerequisite that the switching elements used have safety-related approval or are designed as per the required PL in accordance with EN ISO 13849-1 or SIL in accordance with IEC/EN 61508 / IEC/EN 62061.

In addition the following points must be noted:

- The safety regulations and EMC guidelines must be met.
- In relation to the fault exclusions assumed, reference is made to the table in Annex D of the standard EN ISO 13849-2.

The examples shown in the following and their characteristic architecture define the allocation to a category in accordance with EN ISO 13849-1. The resulting maximum possible performance levels in accordance with EN ISO 13849 continue to be dependent on the following factors related to the external components:

- Structure (single or redundant)
- Detection of common cause failures (CCF)
- Diagnostic coverage on demand (DCavg)
- Time to the dangerous failure of a channel (MTTFd)

7.4.1 Example input circuits

Caution!

On the usage of the safe digital outputs, a short circuit between two outputs for different axes must be excluded.

On the usage of 2 inputs for a function, a discrepancy time of 3 s is to be taken into account.

Example 1: Single-channel sensor without cross-circuit test

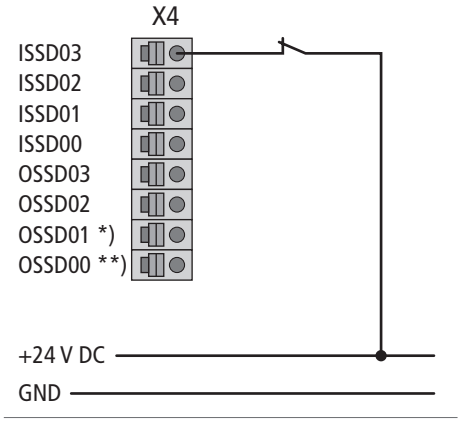


Figure 7.2 Input circuit example 1

The single-channel sensor is connected to an input on the MSD Servo Drive without pulsing. This configuration is **not** to be recommended for safety applications, as the failure of the switching element would deactivate the safety function, a short circuit between the wires to and from the switching element would bypass the switching element and it is not possible to detect a cross-circuit.

PLb can be achieved as a maximum.

Example 2: Dual-channel sensor without cross-circuit test

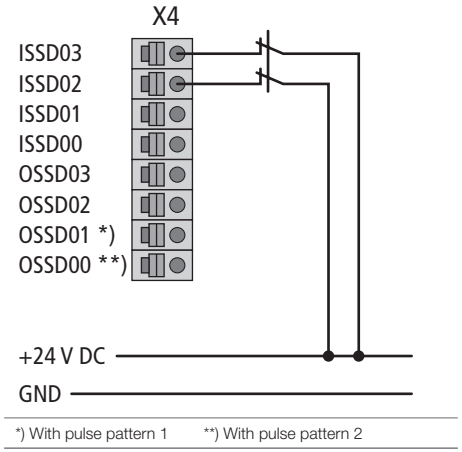


Figure 7.3 Input circuit example 2

The usage of dual-channel homogeneous sensors without a test pulse includes a redundant shutdown path, however, a short circuit between the wires to and from the switching element will bypass the switching element. Furthermore, it is not possible to detect a cross-circuit. Safe operation can only be achieved by separate cable routing and exclusion of a short circuit on the terminals. This type of connection is **not** to be recommended for safety applications outside the cabinet.

Taking into account the short circuit and cross-circuit fault exclusion (as per EN ISO 13849-1), PLe can be achieved.

Example 3: Single-channel sensor with cross-circuit testing

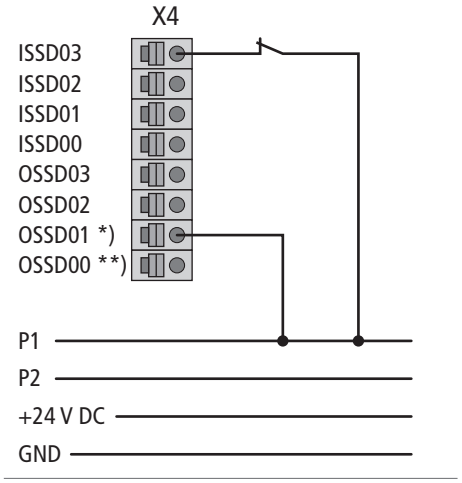
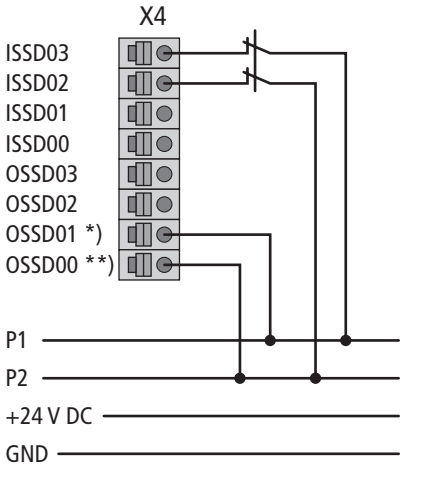


Figure 7.4 Input circuit example 3

On the usage of a single-channel sensor with pulsing, short circuits to 24 V DC and 0 V DC as well as break in the cable are detected. However, cable short circuits between the two connections for the sensor and a short circuit between the input and pulse output are not detected. The failure of the switching element is also not detected, which would result in a loss of the safety function.

Taking into account the short circuit and cross-circuit fault exclusion (as per EN ISO 13849-2 Table D.8), PLd can be achieved, if a suitable switching element with positively opening contacts is used and the sensor is triggered at regular intervals and the safety function therefore demanded.

Example 4: Dual-channel sensor with cross-circuit testing



*) With pulse pattern 1 **) With pulse pattern 2

Figure 7.5 Input circuit example 4

By using two independent pulse signals on the homogeneous sensor, all cross-circuits and short circuits can be detected. Normally closed contacts are recommended for safety applications, as only these can be continuously tested using the test pulses.

On the usage of suitable switching elements with positively opening contacts, PLe as per EN ISO 13849-1 is achieved.

7.4.2 Example output circuits

Example 1: Static, single-channel output

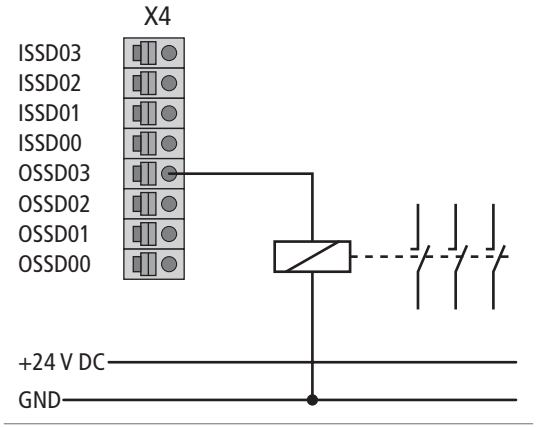
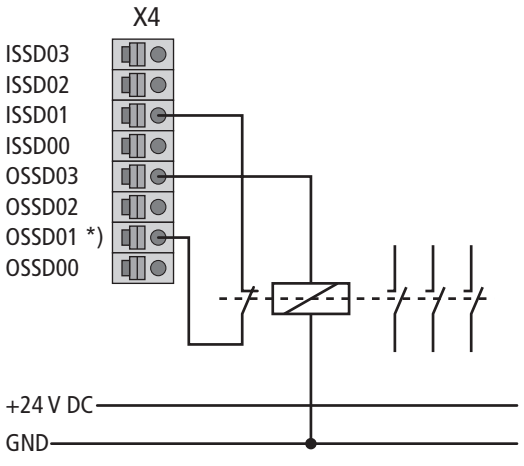


Figure 7.6 Output circuit example 1

On single-channel switching outputs without external or internal testing, the MSD Servo Drive will not detect if a contact connected sticks together. Shutdown is also not possible. This circuit variant is **not** suitable for safety applications!

Example 2: Dynamic, single-channel output (OSSD) with plausibility check



*) With pulse pattern (alternatively also +24 V)

Figure 7.7 Output circuit example 2

Due to internal diagnostic measures and plausibility checks on the switching element, faults that occur are detected, unlike example 1 (Figure 7.2).

However, it is not possible to deactivate the switched function without positive opening after one or more external contacts stick together. Due to these measures it is possible to achieve PLd as per EN ISO 13849-1.

Example 3: Static, dual-channel output in one group

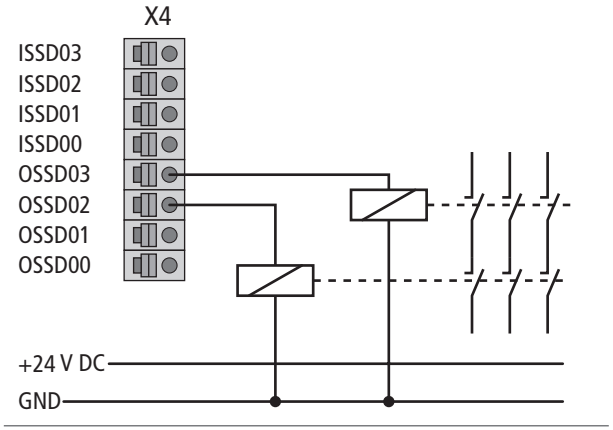


Figure 7.8 Output circuit example 3

As in example 1 (Figure 7.2), without diagnostics the detection of a fault and therefore shutdown in the event of a fault is **not** possible in this case.

By means of suitable external measures as well as fault detection by the process, PLd (as per EN ISO 13849-1) can be achieved, if positively opening contacts are used.

Example 4: Static, dual-channel output, different group

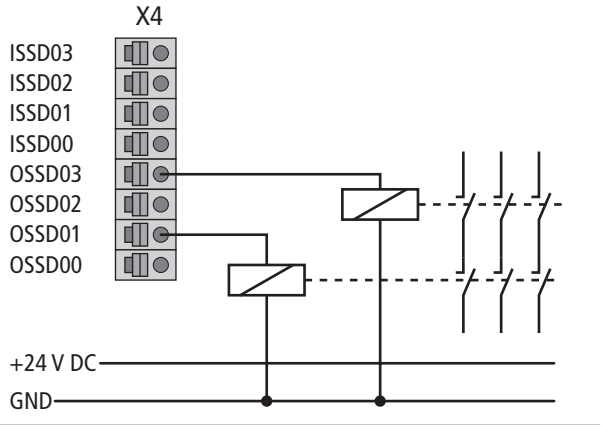


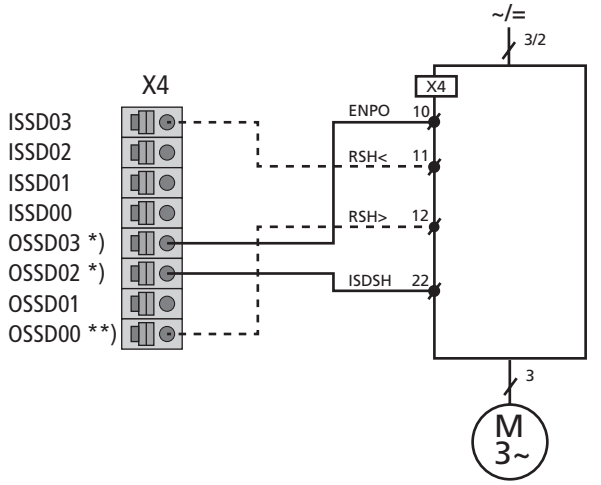
Figure 7.9 Output circuit example 4

If the fault exclusion "Short circuit on an output to +24 V" or "Cross-circuit" is possible in this example, by means of suitable external diagnostic measures as well as fault detection by the process and the usage of positively opening contacts, it is possible to achieve PLe as per EN ISO 13849-1.

NOTE:

The same applies for a circuit on OSSD00 and OSSD02.

Example 5: Dynamic, dual-channel output (OSSD) in one group with plausibility check



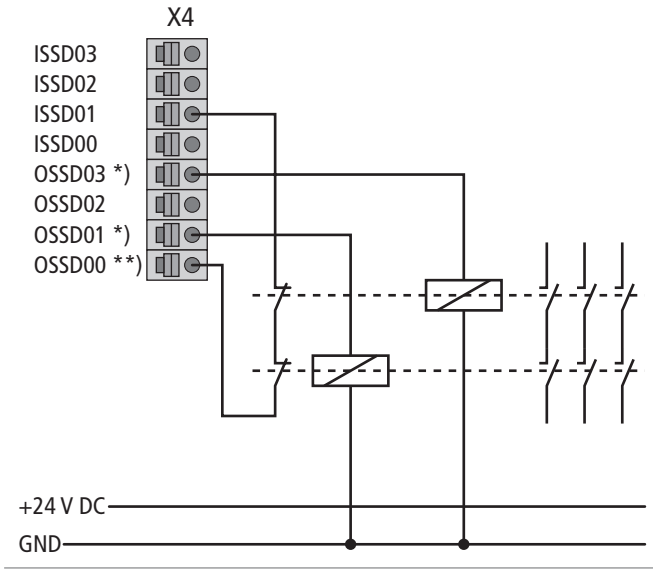
*) With pulse pattern **) With pulse pattern (alternatively also +24 V possible)

Figure 7.10 Output circuit example 5

This circuit is an example of switching the STO on the device series c-line, MSD Servo Drive and MSD Servo Drive Compact using the outputs on the MSD Servo Drive Safety model.

With this circuit all faults to be expected are detected by the diagnostic process. As the internal architecture of the outputs on the MSD Servo Drive Safety is, however, based on category 2, as a maximum it is possible to achieve PLd as per EN ISO 13849-1.

Example 6: Dynamic, dual-channel output (OSSD), different group with plausibility check



*) With pulse pattern **) With pulse pattern (alternatively also +24 V possible)

Figure 7.11 Output circuit example 6

Due to the separation of the two outputs in different groups, category 4 is achieved. As a consequence, if the elements connected also meet the requirements of the safety category, PLe as per EN ISO 13849-1 is achieved with this circuit.

7.4.3 Brake driver circuit examples

Caution!

The usage of the brake outputs for two actuators or brakes is **not** allowed for safety purposes! Functionally, the high-side driven output can be used as a non-safe digital output.

On the non-safe usage of the brake drivers, they must be programmed as per the "Programming Manual".

Example 1: Dual-channel connection of one brake

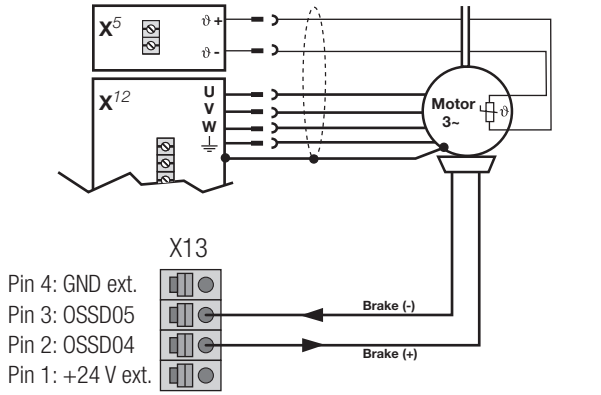


Figure 7.12 Brake driver circuit example 1

Due to the internal architecture and the dual-channel connection of a suitable brake, PLe as per EN ISO 13849-1 is achieved.

Example 2: Dual-channel connection of one actuator (contactor, guard lock, etc.)

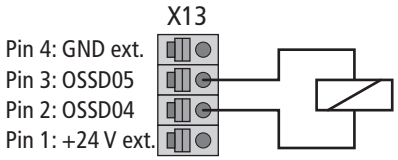


Figure 7.13 Brake driver circuit example 2

Due to the internal architecture and the dual-channel connection of a suitable brake, PLe as per EN ISO 13849-1 is achieved.

Example 3: Dual-channel connection of two brakes that act on a common axis

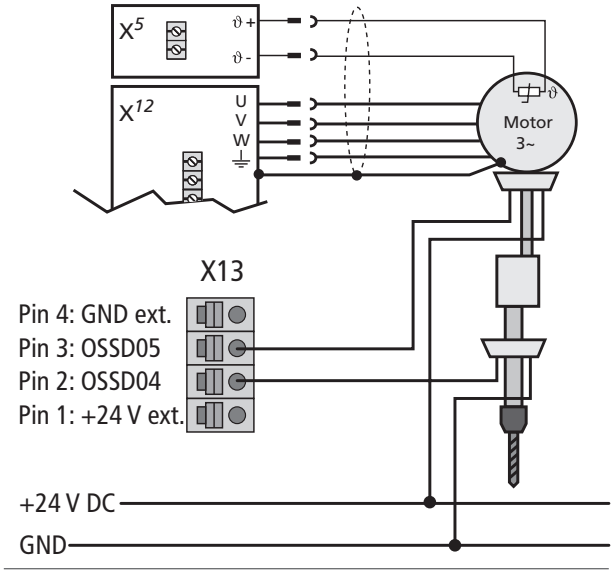


Figure 7.14 Brake driver circuit example 3

In this example the brake driver provides two channels that are used as separate channels with internal diagnostics. The redundant or dual-channel element of the overall system is provided by the usage of two brakes on one axis. Depending on whether the brakes have safety approval as per the intended Performance Level, with this configuration PLe as per EN ISO 13849-1 can be achieved.

Example 4: Dual-channel connection of two actuators (contactors, guard locks, etc.) that act on a safety function

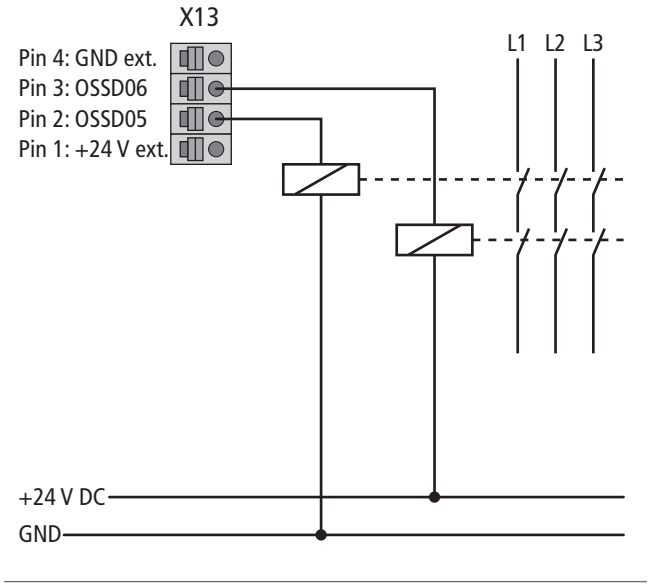


Figure 7.15 Brake driver circuit example 4

In this circuit example, two mains contactors connected in series are each switched by a driver output to be able to switch the mains supply for a servo drive. The descriptions from example 3 also apply here.

7.5 Reaction times

Two different reaction times are available in the MSD Servo Drive with integrated safety control. The standard cycle during which the Safety PLC Function program is executed, and a fast cycle (fast channel) for the rapid execution of individual important safety functions.

Function		Standard cycle		Fast channel [1]	
		1 axis	2-6 axes	1 axis (FCi)	2-6 axes (FCe)
I/O - reactions	Input M > STO M	20	28	6 (14)	6 (14)
	Input M > STO S		52		6 (14)
	Input S > STO M		44		6 (14)
	Input M > STO S		68		6 (14)
	Input M > Output M	20	28	6 (14)	6 (14)
	Input M > Output S		52		6 (14)
	Input S > Output S		44		6 (14)
	Input S > Output M		68		6 (14)
Reaction time encoder error/speed error	"Reaction time speed safety function shutdown output M"	24	40	4	4
	"Reaction time speed safety function shutdown output S"		64		4
	"Reaction time speed safety function shutdown output STO M"	24	40	4	4
	"Reaction time speed safety function shutdown output STO S"		64		4

[1] (with signature pulse on the input)

Table 7.2 Reaction time error in ms

Note:

The fast channel can only be used for safe shutdown, not for the activation of a safety function.

A Appendix

A.1 Safety-related approvals

Safety-related parameters in accordance with EN ISO 13849:

PL: .....e

Category: 4

MTTFd:.....416

DC_{avg} = ...92 %

Safety-related parameters in accordance with IEC/EN 62061 / IEC/EN 61508:

SIL:.....3

PFD_{AV} (T_1 = 20a) = 1.16 x 10^{-4}

PFH:.....1.34 x 10^{-9} 1/h

A.2 Declaration of conformity

As per Machine Directive 2006/42/EC:

EU DECLARATION OF CONFORMITY

IN ACCORDANCE WITH EN ISO/IEC 17050-1 | PAGE 1 OF 1

DOCUMENT NO. MRQ66944-001-REV. A (TRANSLATION OF ORIGINAL)

The Manufacturer Moog GmbH	Hanns-Klemm-Str. 28 – 71034 Boeblingen - Germany +49 703 1 622 0 +49 703 1 622 100 info.germany@moog.com http://www.moog.de

DECLARES UNDER SOLE RESPONSIBILITY that the following products has been manufactured in conformity with the requirements of the Directive 2006/42/EC (Machinery-Directive) of the European Parliament and of the Council on machinery and the Directive 2014/30/EU (EMC-Directive) of the European Parliament and of the Council on the harmonization of the laws of the Member States relating to the making available on the market of electromagnetic compatibility.

MODULAR MULTI-AXIS SERVO DRIVE SYSTEM WITH INTEGRATED SAFETY CONTROL	
Product types	G392-00xAxx1xxx (1 AC 230 V, 4 A, BG 1) G392-0xx-xx1xxx (3 AC 400 V, 4-32 A, BG 1-4) G396-0xx-xx1xxx (3 AC 400 V, 16-32 A, BG3-4)
Following harmonized standards have been applied	EN ISO 13849-1:2015 EN 61800-5-1:2007 + A1:2017 + A11:2021, 4, 3 EN 61800-5-2:2017 IEC 61508-1-7:2010
Quality Manager	Richard Konse

March 01, 2023	Moog GmbH Boeblingen	Thomas Czeppel	
Date	Site	Managing Director	Signature

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Figure A.1 Declaration of conformity (preliminary not including size 5)

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