INFRANOR

XtrapulsPac

XtrapulsPac
Safe Torque Off manual

Digital drive for sinusoidal synchronous AC motors

XtrapulsPac

WARNING

This manual describes a series of servo drives having output capability suitable for driving AC brushless sinusoidal servo motors.

Please see also:

- **XtrapulsPac Installation Guide** for the hardware installation of the drive (mounting, wiring, ...)
- **XtrapulsPac User Guide** for the operation of the drive (commissioning, configuration, ...)
- **XtrapulsPac Templates** for the templates of target applications.
- **Gem Drive Studio software Quick Start** manual for the drive parameterization.
- **EtherCAT® fieldbus interface** manual for the XtrapulsPac-et version.
- **GDPS** manual, for the use of the GDPS power supply unit.

Instructions for storage, use after storage, commissioning as well as all technical details require the MANDATORY reading of the manual before getting the drives operational.

Maintenance procedures should be attempted only by highly skilled technicians having good knowledge of electronics and servo systems with variable speed (EN 60204-1 standard) and using proper test equipment.

The conformity with the standards and the "CE" approval is only valid if the items are installed according to the recommendations of the drive manuals. Connections are the user's responsibility if recommendations and drawings requirements are not met.

Any contact with electrical parts, even after power down, may involve physical damage.
Wait for at least 5 minutes after power down before handling the drives (a residual voltage of several hundreds of volts may remain during a few minutes).

ESD INFORMATION (ElectroStatic Discharge)
INFRANOR drives are conceived to be best protected against electrostatic discharges. However, some components are particularly sensitive and may be damaged if the drives are not properly stored and handled.

STORAGE

- The drives must be stored in their original package.
- When taken out of their package, they must be stored positioned on one of their flat metal surfaces and on a dissipating or electrostatically neutral support.
- Avoid any contact between the drive connectors and material with electrostatic potential (plastic film, polyester, carpet…).

HANDLING

- If no protection equipment is available (dissipating shoes or bracelets), the drives must be handled via their metal housing.
- Never get in contact with the connectors

ELIMINATION
In order to comply with the 2002/96/EC directive of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), all INFRANOR devices have got a sticker symbolizing a crossed-out wheel dustbin as shown in Appendix IV of the 2002/96/EC Directive.
This symbol indicates that INFRANOR devices must be eliminated by selective disposal and not with standard waste.

INFRANOR does not assume any responsibility for any physical or material damage due to improper handling or wrong descriptions of the ordered items.
Any intervention on the items, which is not specified in the manual, will immediately cancel the warranty.

Infranor reserves the right to change any information contained in this manual without notice.

Issue: **1.2**

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Chapter 1 – General description

Safe Torque Off (**STO**) definition according to the EN 61800-5-2 standard:
"Power, that can cause the rotation of a motor (or displacement in the case of a linear motor), is not applied to the motor. The drive will not provide energy to the motor which can generate torque (or force in the case of a linear motor)".

Used alone, the STO function corresponds to an uncontrolled stopping in accordance with the stop category 0 of the EN 60204-1 standard.
The STO function may be used where power removal is required to prevent an unexpected start-up.
In circumstances where external influences (with vertical loads for example) are present, additional measures (e.g. mechanical brakes) may be necessary to prevent any hazard.
When using a mechanical brake, it will be mandatory to introduce a safe contact from an external device into the brake actuation line.
The STO function cannot be considered as a safe insulation device for the motor. It does not prevent from any voltage on the motor terminal block.

The integrated STO function fulfills the EN ISO 13849-1:2006 category 3 PLd requirements.
PLd corresponds to SIL2, according to "Table 4 - Relationship between PL and SIL" of 13849-1 standard.

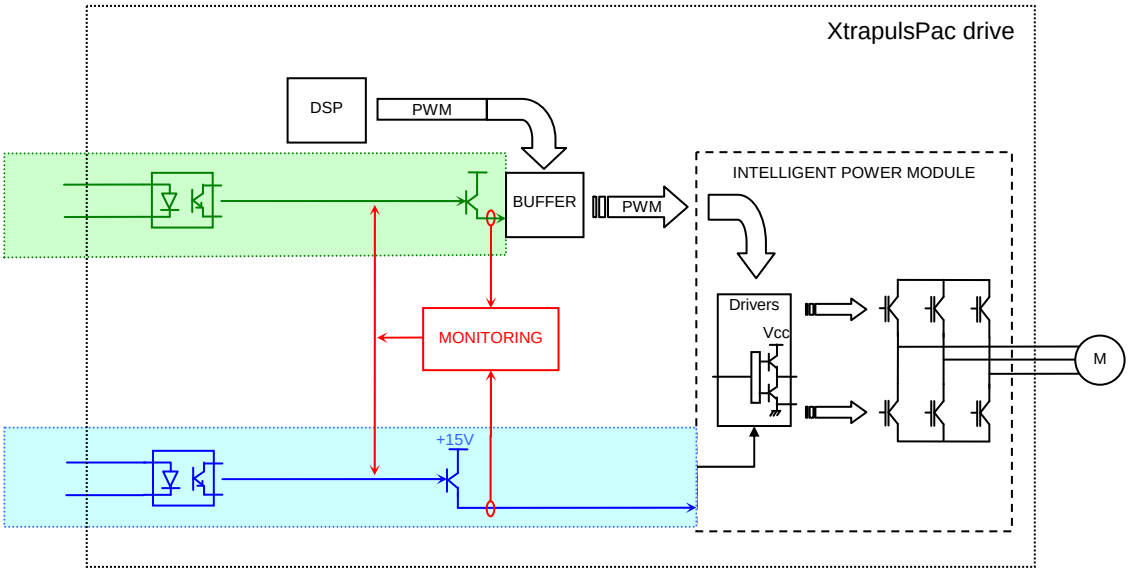
Chapter 2 – Specifications

2.1 – FUNCTIONAL DIAGRAM

The "Safe Torque Off" function allows to keep the motor shaft free by avoiding the IGBT module commutation.
This is achieved by means of two techniques:

- IGBT command supply removal,

- PWM removal.



The different parts of the functional diagram are described below:

- The green part is the first channel of the safety function. PWM signals are disabled by inhibiting the buffer commutation.

- The blue part is the second channel of the safety function. IGBT gate signals are disabled by the power supply shut down.

- The red part is the monitoring function which detects faults by comparing both channel outputs. If a fault is detected, this function locks both channels in safe state.

- The black part is the functional part of the drive which is not used to achieve the safety function.

2.2 – COMMAND SYSTEM CONCEPTION

2.2.1 – SAFETY INSTRUCTIONS

The integration of the STO function must be the result of a risk analysis of the complete machine. All control components must comply with the requirements of this risk analysis.
Installing and commissioning of safety functions must be performed by a skilled staff only.

Short-circuit avoidance:
Install the drive in a control cabinet with a minimum IP54 protection.
Avoid control signals proximity. Any short-circuit between two control signals must be detected:

- The short circuit will either be detected by the circuit-breaking system (e.g. fuse); in this case, the voltage reference is grounded, and shielded pair cables must be used (shield is connected to the ground), or a ribbon cable with all unused wires connected to the ground to prevent proximity with hot potential signals,

- or a short-circuit detection device must be integrated.

Take care that, as the STO function performs the motor power removal without shutting down the power supply, electrical risks are remaining when the STO function is active or inactive.

In applications with vertical axes, additional measures (mechanical brake) may be necessary.

Refer to the EN13849-2 standard for any complementary information.

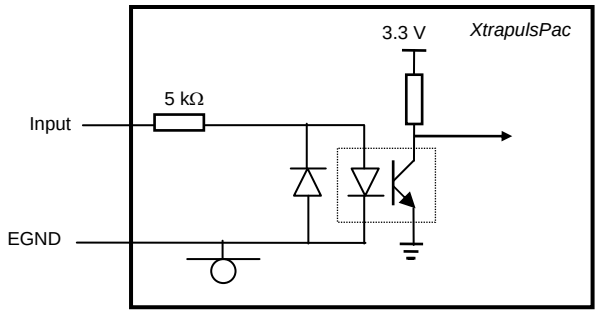
2.2.2 – STO CONNECTION

2.2.2.1 - INPUTS-OUTPUTS CONNECTOR: X2

SUB D 26 PIN FEMALE HD CONNECTOR

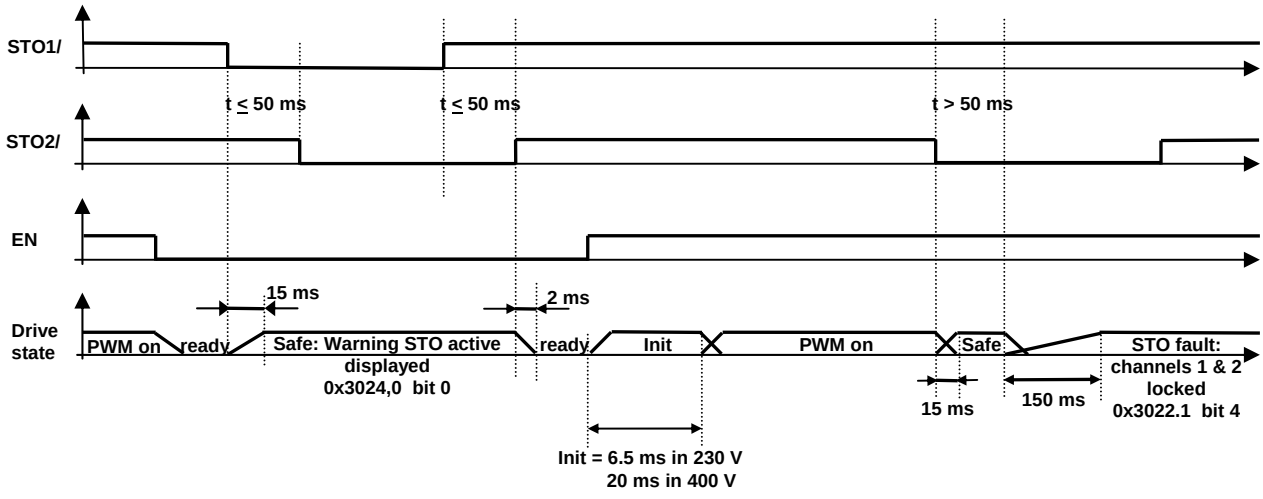
PIN	FUNCTION	I/O	DESCRIPTION
19	STO2/	I	All logic inputs are optocoupled EGND = optocoupled inputs reference Vin voltage = 18 V < Vin < 30 V Input impedance Zin = 5 kOhms Tin input filter = 20 µs
20	EGND		
21	STO1/	I	

2.2.2.2 - SPECIFICATION OF THE LOGIC INPUTS



2.2.3 – TIMINGS

The STO function has an activation / release response time of 15ms / 2ms max.
However, an additional delay of 6,5 ms in 230 V and 20 ms in 400 V after STO inputs are high is necessary before the enable/inhibit signal activation, as mentioned on the following chronogram:



A functional incoherence state between channels 1 and 2 is allowed during 50 ms. The response time of the monitoring part is 200 ms.
If the monitoring part detects incoherences between channel 1 and 2, it locks both channels in the safe state. The STO fault cannot be reset. This state can only be exited by shutting down the 24V power supply. At this moment, the user must find and solve the problem that caused this fault state.

The STO function feedback is available in objects:
- 0x3024,0.bit0 : STO active warning,
- 0x3022,1.bit4 : STO channel 1 & 2 errors).

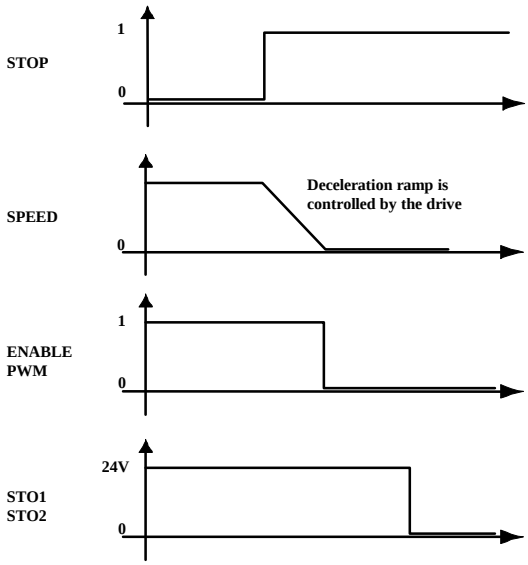
All these state feedbacks are provided for informative purpose and cannot be used as safe information.

Take care of the automatic restart: when the STO function is disabled, the restart of the machine should only be possible by an explicit demand to prevent unexpected automatic restart. Take care of this point when a DNC is used.

Used alone, the STO function corresponds to an uncontrolled stop in accordance with stop category 0 of the EN 60204-1 standard. So, this function is suited to machines with low inertia or high resistive torque.

When using high inertia or low resistive torque machines, the user should initiate a controlled stop. To achieve a controlled stop in accordance with stop category 1 of the EN 60204-1 standard, the control system of the machine must generate the following sequences:

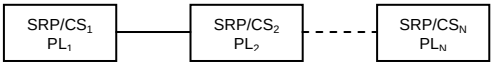
- Deceleration of the load by means of the drive control,
- Disabling of the PWM when the load is at standstill or almost,.
- Finally, activation of the STO function.



2.2.4 – PERFORMANCE LEVEL

The **Safe Torque Off** function fulfills **category 3 /PLd** (1) requirements of the EN ISO 13849-1:2006 standard. **PLd** corresponds to **SIL2** according to "Table 4 - Relationship between PL and SIL" of the EN ISO 13849-1:2006 standard.

To achieve overall PL by combining safety related parts in series, refer to section 6.3 of the 13849-1 standard:



PL_{Low}	N_{Low}	⇨	PL
a	>3	⇨	None, not allowed
	≤3	⇨	a
b	>2	⇨	a
	≤2	⇨	b
c	>2	⇨	b
	≤2	⇨	c
d	>3	⇨	c
	≤3	⇨	d
e	>3	⇨	d
	≤3	⇨	e

NOTE: The values calculated for this look-up table are based on reliability values at the mid-point for each PL.

Additional specifications:

- MTTFd = 300 years
- Average diagnostic coverage: medium.

2.2.5 – PERIODIC INSPECTION ROUTINES

The well-working of the function needs to be checked at least once a year and during the validation of the machine safety functions.
The goal of this procedure is to verify that all subsystems of the safety function are operational. The command system must integrate a checking mode reserved to an operator aware of potential risks due to a wrong operation of the safety system. It is highly recommended to get the operator signing a register in order to sensitize him.

STEP	INPUT		STATE	
N°	STO1/	STO2/	MOTOR	DESCRIPTION
1	1	1	Powered	No fault is displayed.
2	0	0	Free	STO active warning is displayed.
3	1	1	Powered	No fault is displayed.
4	0	1	Free	STO fault is displayed.
5	1	1	Free	STO fault is displayed and must be **unresettable**.
6	X	X	X	Shut down of 24 V power supply to reset STO fault

At each step, the operator must verify whether the motor is providing torque or not.
If the drive behavior is different from the one described in the table above, the drive must be replaced.

2.2.6 – RESIDUAL RISK

In case of short-circuit between two power transistors, there is a residual risk of motor shaft rotation that can reach: $\frac{360°}{2p}$ (2p: number of motor poles).

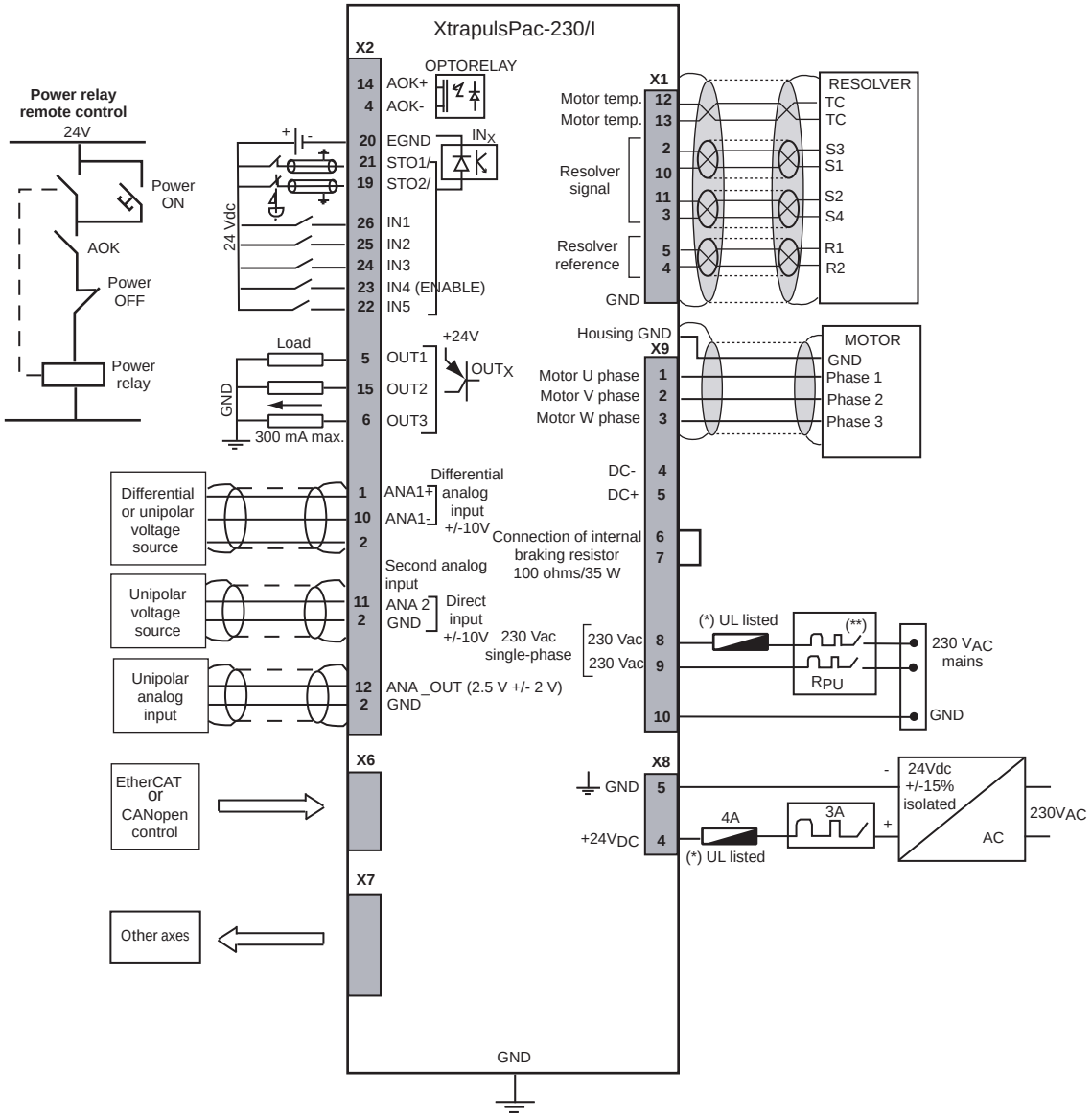
Take care of electrical risks, as the STO function performs the motor power removal without shutting down the power supply and there is no galvanic insulation.

Chapter 3 – Connection example

The following diagram examples are given to make the integration of the safety function easier. The integration of the STO function must be the result of a risk analysis of the complete machine.

3.1 – Example 1: Stop category 0 according to EN 60204-1 complying with EN13849-1 cat. 3

Low inertia axis application / high resistive torque



(*) See fuses table for the UL conformity.

(**) Curve D circuit-breaker
I1s = 10 x In
In = 10 A

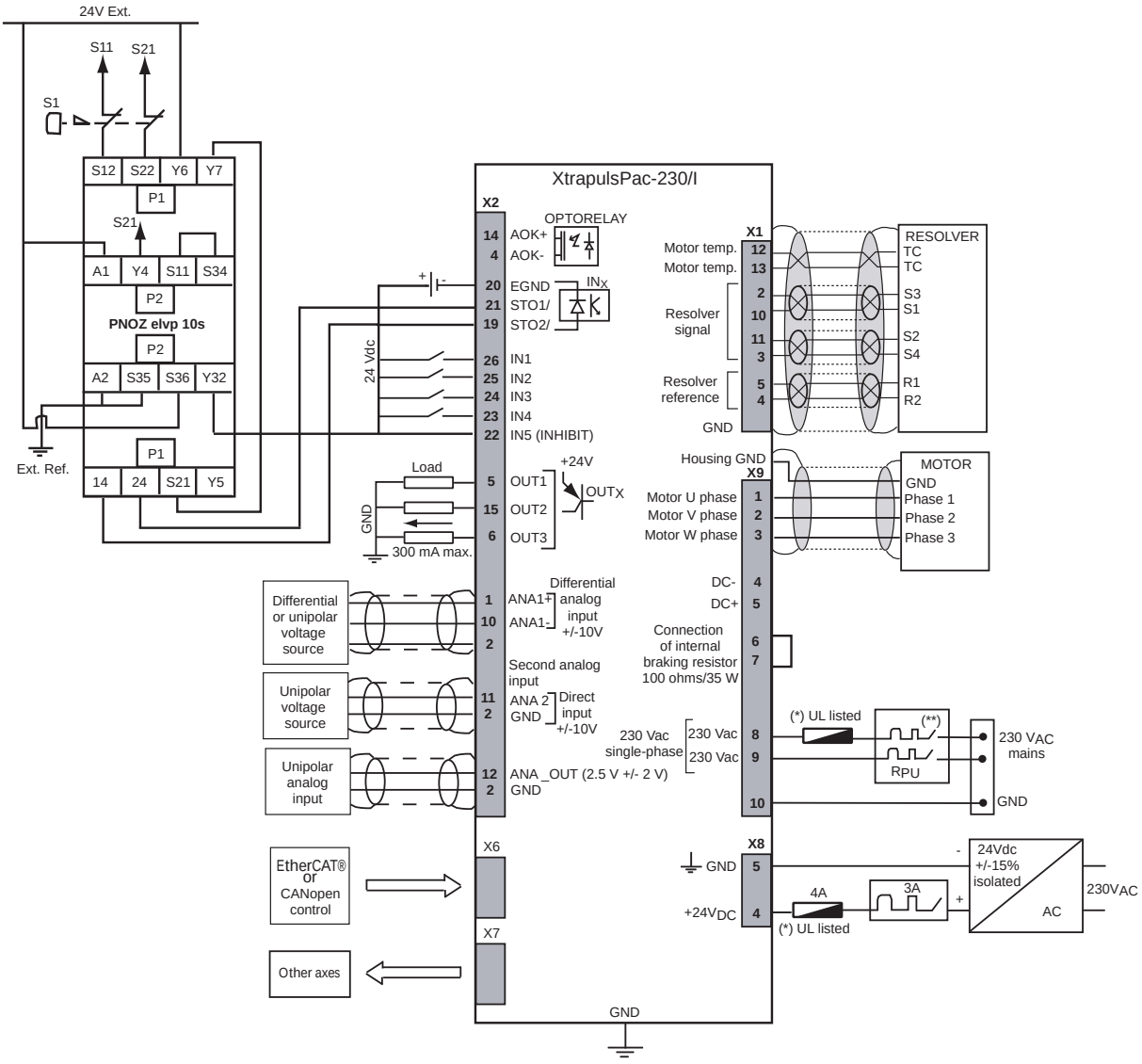
Use only copper conductors for the wiring terminations.
The torque values of the wiring terminations must comply with the certified bloc terminal.

Please note that the motor control must be disabled before activating the STO function.
In the example above, the "Enable" function is allocated to digital input IN4 to disable the PWM control.

3.2 – Example 2: Stop category 1 according to EN 60204-1 complying with EN13849-1 cat. 3

High inertia axis application / low resistive torque

In the following example, a safe Stop 1 is performed. The delay between the deceleration ramp and the STO activation is safe. The deceleration ramp is not safe according to EN13849-1 because it uses a common drive function.



In the connection diagram example above, the PILZ safety relay orders the servodrive to decelerate by the INHIBIT signal (allocated to digital input IN5). After a safety delay of 0.5 s, it activates the STO function of the drive.
Note that the behavior of the servo drive on the INHIBIT signal activation has to be setup in the appropriate mode (e.g. speed ramp deceleration) prior to any stop procedure.
In this example diagram, the user does not need to use shielded cables because the PILZ safety relay detects short-circuits.
The output used to generate the INHIBIT signal does not need to be a safety one.