ZED STO Safety User Manual

ORIGINAL DOCUMENT

Manual Revision 5.0

Revision History

Manual Rev.	Date	Notes
Rev. 5.0	8 July 2026	Removed Safety Notice on front page, since the product is now certified.
Rev. 4.0	22 May 2026	Fixing document formatting
Rev. 3.0	15 Mar. 2026	Adding a note regarding “Protection against corruption” in the context of cybersecurity
Rev. 2.0	11 Mar. 2026	Update only ZED

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CANopen Vendor-ID

Vendor-ID **0x00000513** has been registered to STXI Motion Ltd.

EtherCAT Vendor-ID

Vendor-ID **0x00000D2B** has been registered to STXI Motion Ltd.

Definitions

Abbreviation/Term	Definition
FMEA	Failure mode and effects analysis
HFT	Hardware failure tolerance
OSSD	Output signal switching device
PELV	Protected extra low voltage
PL	Performance level, according to DIN EN ISO 13849
Pulse block/ Optocoupler lock	Switching off the pulse patterns required for commutation via a supply cut-off of the optocouplers
SFF	Safe failure fraction
SIL	Safety Integrity level, according to DIN EN 61508
SMM	Safety Motion Module (safe drive module)
STO	Safe Torque Off
STO Asserted	The STO safety function is active and power is not supplied to the motor
STO Disasserted	The STO safety function is not active and the motor can be powered by the servo drive
ZED	Customer’s servo product

Contents

1 Introduction

1.1 About this Manual

Functional safety in the CO and EC versions of the ZED servo drive is implemented by means of the **Safe Torque Off (STO**) function. STO ensures that the drive will not provide power to the motor, thereby preventing the motor from generating a torque on the shaft.

Note The term STO function **asserted** means that power to the motor is inhibited.

This manual describes the characteristics and use of the STO function in the ZED servo drive.

This manual includes critical operational information, including expected behavior of motion systems when using the STO function, limitations in its use, and requirements for periodic testing by the user.

1.2 Reference to User Manual

There is a separate technical under manual for the ZED, in which all aspects of handling, installation, wiring, and operation are covered.

- *ZED Servo Drive User Manual*

2 STO Safety Function Overview

2.1 STO Safety Function Definition

The STO safety function is defined in standard EN/IEC 61800-5-2 as follows:

> **This function prevents force-producing power from being provided to the motor.**

The safety function corresponds to an uncontrolled stop in accordance with stop category 0 of EN/IEC 60204-1.

2.2 Behavior When STO is Asserted

When the STO safety function is asserted, power from the servo drive to the motor will be cut off. If the motor shaft is moving at the time then the motor will coast, with its speed rate of decrease dependent on the motor and load friction and inertia.

The following figure illustrates this behavior:

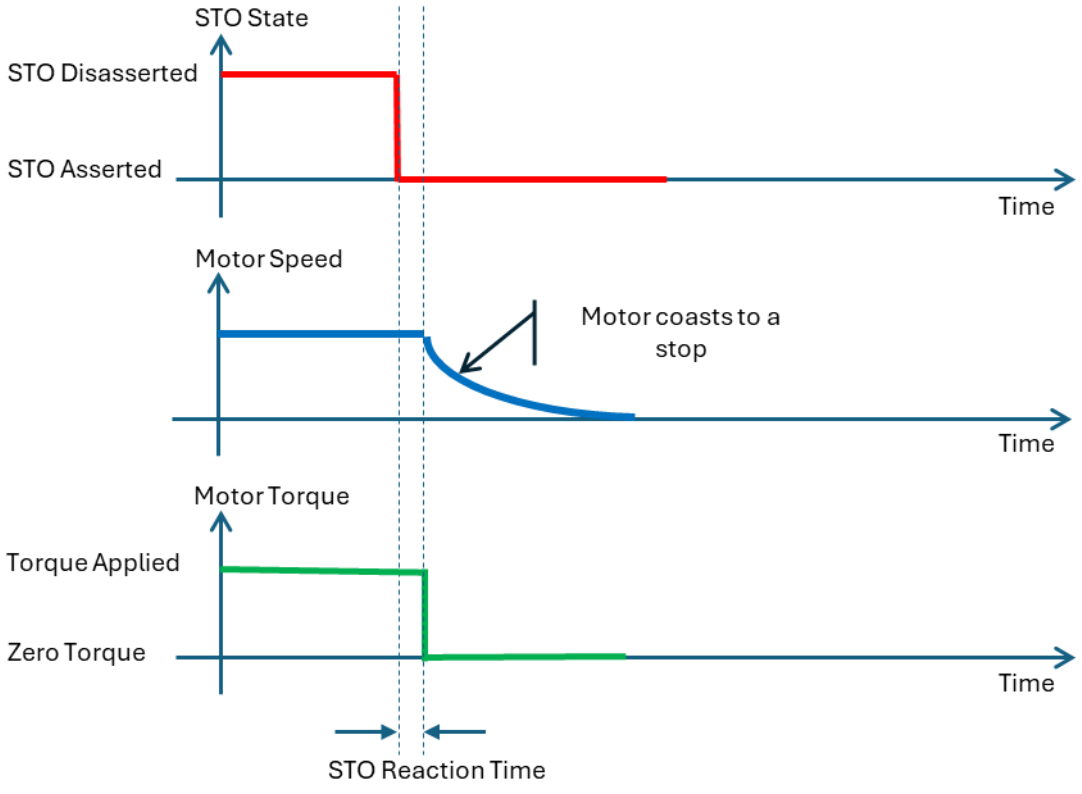

Figure 2-1. Behavior when STO is Asserted

2.3 Safe State of the Safety Function

The safe state is the de-energized state. STO is asserted. Power from the servo drive to the motor will be cut off.

2.4 STO Certification and Reliability Data

The STO function in the ZED is implemented in a dual channel architecture with diverse redundancy.

The implementation in the ZED is currently undergoing certification by TuV SUD Rail GmbH.

The following table shows the functional safety data for the STO safety function drive.

Characteristic	Product Values	Remark
PL	e	Component failure rates are based on SN29500
CAT	3	
DC [%]	Greater than 90% (Medium)	
Mission Time Lifetime	20 years	
MTTFd [years]	570 years (High)	
PFH [h^{-1}]	Less than 5 FIT (5x10-9)	
SFF [%]	Greater than 90% (HFT=1)	
SIL	3	

3 ZED with STO Functional Safety

3.1 ZED Products Approved for STO Functional Safety

The STO Functional Safety Certification applies to the “Communication” field only, and only products with “EC” are certified for STO functional safety.

Table 3-1. ZED models certified for STO Functional Safety

		SD02	-	065	1D	AB	EC	-	000
	ZED SD02 Single-Axis Servo Drive								
	Rating – Cont. Current, Peak Current								
SD02	45 Arms, 135 Arms peak, nom. 48 VDC								
	Power								
1D	Bus 20-60 VDC, Logic 24 VDC optional								
	Feedback								
AB	Incremental AB quadrature, index, Halls, 12 bit RS422 Absolute single turn 21-bit Absolute multiturn 24-bit								
	Communication								
CO	CANopen								
EC	EtherCAT								
	Options								
000	Standard, RJ45 fieldbus connectors								
M80	M8 fieldbus connectors								

4 STO Technical Specifications

4.1 Electrical Specification

Feature	Details	Specification
STO supply voltage	Nominal voltage	24 VDC
	Voltage levels in accordance with Type 3	11–30 VDC: STO function not engaged (motion allowed) 0–5 VDC: STO function engaged (motion inhibited) 5–11 VDC: functionality is neither defined nor guaranteed
Current drain	At 24 VDC	8 mA
Maximum reaction time	Time within which the motion is inhibited	21 milliseconds
Maximum duration of PLC/OSSD test pulse	Test pulse is ignored by the drive	TBD*
Maximum frequency of PLC/OSSD test pulses	Absolute maximum frequency of test pulses that will be successfully filtered by the drive	TBD*
* Values will be specified after test by STXi Motion		

4.2 Environmental Specifications

For environmental specifications, refer to:

- *ZED 65 Servo Drive User Manual.*

4.3 Standards Compliance

The STO safety function complies with the following standards.

Standard	Title	Version
EN IEC 61508, parts 1-4	Functional safety of electrical/electronic/programmable electronic safety-related systems	Edition 2, 2010
EN IEC 61800-5-2	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional	2016
EN ISO 13849-1	Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design	2023
EN ISO 13849-2	Safety of machinery — Safety-related parts of control systems — Part 2: Validation	2012

For additional standards compliance, please refer to:

- *ZED Servo Motor Drive User Manual*

5 Installation

5.1 Avoiding Uncontrolled Access

ZED installation must be done such that personnel access is limited. For example: installed in a locked cabinet, or other inaccessible location.

Note Access to the product must be restricted to trained personnel only.

5.2 ZED C1 – STO Pinout

C1 Connectors

Interface	Item	Manufacturer	Manufacturer PN
1 	Mating connector: Micro-Fit 3.0 Receptacle Housing, Single Row, 5 Circuits Micro-Fit 3.0 Crimp Terminal, Female	Molex	 436450500 430300001

C1 Pinout

Pin #	Signal Description
1	STO_1
2	NC
3	STO_2
4	NC
5	STO_GND

5.3 Using a Power Supply

A typical STO system configuration, with a power supply as the source of the STO voltage, is shown in the figure and includes the following components:

- ZED with two STO inputs
- The power supply must be of type ES1 per EN 62368-1 (previously called SELV/PELV), with a nominal output voltage of 24VDC
- Safety-certified Emergency stop or other switch to cut the power to the STO

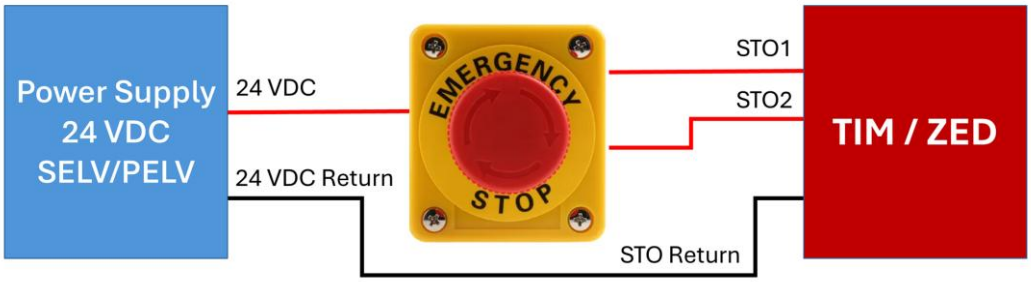

Figure 5-1. Power Supply for STO

Notes:

- The 24VDC power supply unit must comply with PELV/SELV, as per EN 60204-1 (*Safety of Machinery - Electrical Equipment of Machines - Part 1: General Requirements*). The output voltage shall not exceed 60VDC under normal or failure conditions.
- A single E-stop button, with two outputs, connects the Power Supply to both STO inputs.

5.4 Using a PLC

A PLC can be used to source the 24VDC to the STO inputs, as shown in the figure below. In that case, the PLC should be a Safe PLC.

5.5 STO Cable Requirements

The STO cable must be no more than 30 meters in length.

The cable does not need to be shielded.

Double insulated cables must be used, in order to avoid a short circuit between the two STO signals. If the Safety PLC provides OSSD outputs, then this is not necessary

The wire gauge for the cable wire must be for

- ZED : between 20 AWG and 24 AWG

per the specifications of the connector and mating connector.

The STO cable must be spatially separated from any sources of environmental stress, be it mechanical, electrical, thermal or chemical.

5.6 Caution about Using STO

Warning The STO safety function must not be used in conditions where external influences will create a hazard when the function is engaged, as for example, the dropping of a suspended or unbalanced load.

In these cases, additional measures (such as mechanical brakes) are required to prevent any hazard.

The STO function is specifically prohibited for use in elevator applications.

5.7 Protection Against Corruption – Cybersecurity

5.7.1 Background

The functional safety standards are related to the EU Machinery Regulation, which has replaced the EU Machinery Directive. The Machinery Regulation has requirements with respect to cybersecurity, namely that the safety and reliability of control systems shall be protected from corruption.

5.7.2 Analysis

These TIM integrated motors are not connected to internet, nor to an external internet-connected network. The devices connect to EtherCAT or CAN bus – direct connection to the machine controller only. Therefore, they are inherently protected against corruption, as long as the machine controller is protected.

The STO Safety Function has no variables. The behaviour is fixed. Other product behaviour is determined by variables that are set by the machine controller.

5.7.3 Statement Regarding Protection Against Corruption

The responsibility for protection against corruption lies with the machine control system and the operator. A risk assessment shall be done on system level to determine the potential threads and their mitigations (e.g. physical access must be restricted).

The machine controller, and not the servo drives, needs to be protected against corruption – IF the controller is connected to the internet or to an external network

6 Using STO

6.1 Determining the STO State

The state of the STO safety function – that is, whether STO is asserted or not – can be queried over the communication channel.

There is no direct command to query the STO status. However, the STO status can be deduced from the existing warnings and faults.

When STO is asserted, there should be either an STO fault or STO warning, as described in the section Behavior When STO is Asserted. You can analyze the response to serial command **status** or **FaultList** to deduce whether STO is asserted or not.

Similarly, in EtherCAT there is a bit-wise object that holds all faults and warnings.

The Enable/Disable state of the ZED, and the indication of a fault, are shown in the GUI, in the Faults and Warnings screen.

6.2 Asserting the STO Safety Function

The STO is asserted when the STO input voltage drops to 5VDC or below.

Therefore, in order to assert the STO, simply disconnect the STO input voltage.
Or, if using a PLC, set the PLC output to the logic low state.

Once the STO is asserted, power from the servo drive to the motor will be cut off. If the motor shaft is moving at the time, then the motor will coast.

Refer to the section Behavior When STO is Asserted.

6.3 Drive State when STO is Asserted

If the STO is asserted when the drive is **disabled**, the drive will generate a warning. If the STO is disasserted, the warning disappears.

If the STO is asserted when the drive is **enabled**, or when the drive is disabled and trying to enable the drive, the drive will generate a fault. This fault is persistent, and requires the **ClearFaults** command to clear it.

Note that the drive becomes disabled when there is a fault. If the user clears the STO fault while the STO is still asserted, the STO warning will be generated.

6.4 Resuming Normal Operation

Since the drive enters the fault state when STO is asserted while the drive is enabled, an automatic restart by disasserting the STO is not possible.

To resume normal operation after STO is asserted, the following steps must be performed:

- Disassert the STO by returning the STO input voltage to the nominal level
- Clear faults
- Enable the drive

Only after these actions have been performed, motion can resume.

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