The Accelnet & Stepnet Plus Panels STO Manual

16-01338
Revision 05
September 16, 2021

Table of Contents

1.0 About This Manual

1.1 Title, Number, Revision

Table 1

Title	The *Accelnet & Stepnet Plus Panels STO Manual*
Document Number	16-01338
Current Revision	05

1.2 Revision History

Table 2

Revision	Date	ECO #	Comments
AA	12/09/2014	ECO-056695	Preliminary release to DESIGN lifecycle. Originated from 16-01168.
AB	12/30/2014	ECO-056909	Add hardware type designation and systematic capability specification
00	03/23/2015	ECO-057405	Release to PILOT lifecycle, add page numbers
01	02/21/2017	ECO-065615	Add BML Models
02	03/21/2017	ECO-066296	Update to reflect EN 61800-5-2:2007
03	10/22/2020	ECO-077762	Update to reflect IEC 61800-5-2:2016
04	12/8/2020	ECO-078133	Update to reflect latest edition of IEC 61800-5-1, 61800-5-2 and 61800-3
05	09/16/2021		Updated front panel images to reflect brake signals

1.3 Declaration of Conformity

The products covered by this manual comply with the EC Directives 2014/30/EU (EMC Directive), 2014/35/EU (Low Voltage Directive), 2006/42/EC (Machinery Directive) and 2011/65/EU (RoHS Directive). The complete EC Declaration of Conformity is available on the internet at www.copleycontrols.com.

Name and Address of the Manufacturer:

Analogic Corporation d/b/a Copley Controls
20 Dan Road
Canton, MA 02021
USA

Name and Address of the authorized representative:

BK Medical ApS
Mileparken 34, DK-2730
Herlev
Denmark

1.4 Original Instructions

This manual is considered to be “original instructions” as defined in EC Directive 2006/42/EC and the contents have been verified by Copley Controls.

2.0 Purpose and Scope of This Document

This document is intended to inform the reader about the Functional Safety features of the *Accelnet & Stepnet Plus Panel* drives and to provide information on the steps required to install it into systems so that a target level of Functional Safety performance can be achieved. The scope of this document is limited to those aspects of Functional Safety that relate to the installation, operation, and maintenance of the *Accelnet & Stepnet Plus Panel* drives.

2.1 Disclaimer

This manual contains information on the Safe Torque Off (STO) feature of the *Accelnet & Stepnet Plus Panel* drives and how it may be incorporated into an industrial motion control system. While every effort has been made to ensure the completeness and accuracy of this manual it must be emphasized that the responsibility for functional safety in the overall system into which the drive is installed rests ultimately with the manufacturer of the system into which the *Accelnet & Stepnet Plus Panel* drives are installed.

The equipment manufacturer must take into account all the aspects of the system in which the *Accelnet & Stepnet Plus Panel* drives are components.

Copley Controls does not accept any liability for direct or indirect injury or damage caused by the use of information in this document. The equipment manufacturer is always responsible for the safety of its product and its suitability under applicable laws. Copley Controls hereby disclaims all liabilities that may result from this document.

3.0 Risk Assessment & Responsibility of the Installer

The STO feature of the *Accelnet & Stepnet Plus Panel* drives is capable of the safety integrity level (SIL) and category/performance level (PL) stated in this manual and operates in accordance with the characteristics and limitations described herein. But it must be noted that the drive STO function is intended to be used only as one element of an overall safety chain and is not a complete safety function unto itself. Therefore the suitability for use of the *Accelnet & Stepnet Plus Panel* drives in a given application must be determined in part by one or more risk assessments of the overall safety of the end machine conducted in accordance with the applicable standards. Such risk assessments normally consist of a thorough review of overall machine operation to identify potential hazards. For each identified hazard, typical risk assessments take into account the severity of any potential injury resulting from the hazard, the frequency of exposure of persons to the hazard and the probability that persons are able to avoid the hazard if it were to occur. The machine designer is solely responsible for conducting any necessary risk assessments and for the ultimate determination as to the suitability of the *Accelnet & Stepnet Plus Panel* drives and the STO function for use in realizing a given overall safety function.

The installer should be experienced in motion control and functional safety.

4.0 Warnings

FAILURE TO CONSIDER THESE WARNINGS CAN RESULT IN EQUIPMENT DAMAGE, INJURY, OR DEATH

The user must take into consideration the necessary risk reductions, installation requirements, and other information contained in this manual in order to achieve the stated functional safety capabilities. Failure to do so could result in equipment damage, injury, or death.

4.1 Operate drives within the specifications provided in the relevant hardware manual or data sheet.

The information in this manual is specific to the functional safety features of the *Accelnet & Stepnet Plus Panel* drives. The user must use this manual along with the *Accelnet & Stepnet Plus Panel*s *User Guide* and the datasheets for the *Accelnet & Stepnet Plus Panel* models for proper and safe installation and overall commissioning of the drives.

4.2 Risk of electric shock

The *Accelnet & Stepnet Plus Panel* drives are made for operation from transformer-isolated, DC power supplies that provide galvanic isolation from AC mains and meet the requirements of overvoltage category II (OVC II). Hazardous voltages are connected to and exist within these drives under normal operating conditions. Persons responsible for installing and commissioning these drives must be experienced in all aspects of electrical equipment installations.

4.3 Disclaimer

There are no user serviceable parts in the *Accelnet & Stepnet Plus Panel* drives.

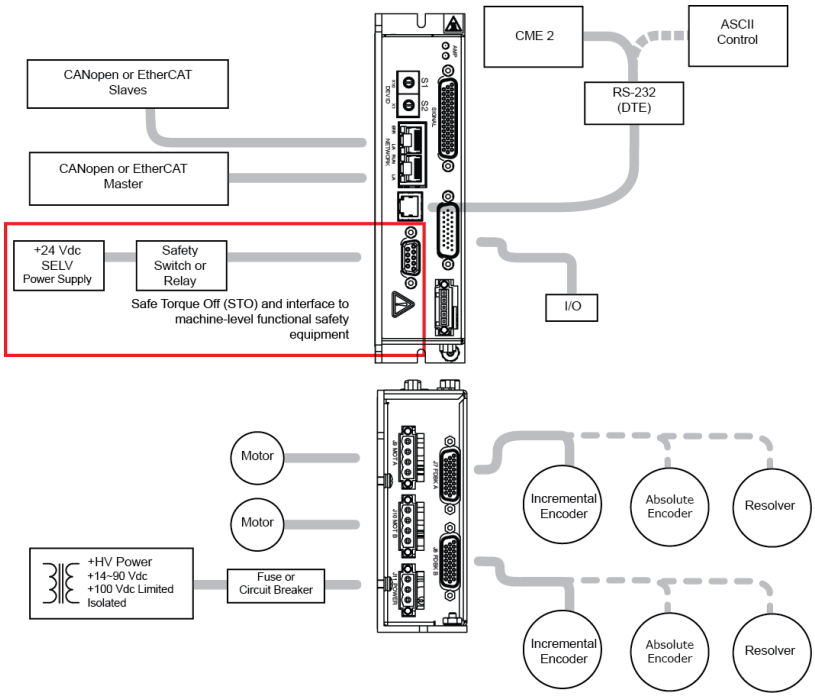
Removal of the cover or tampering with internal components will void the warranty.

4.4 Installation Overview

This graphic shows the elements of a complete *Accelnet & Stepnet Plus Panel* drive installation.

The STO feature and interface to the machine-level functional safety equipment are highlighted in red to emphasize the aspects of the installation that are addressed in this manual.

Fig. 1



4.5 Definitions

There are certain terms used throughout this document that serve an important role in describing the operation and behavior of the Accelnet & Stepnet Plus Panels STO feature. These terms are discussed and defined as follows:

Activate – This term is used to refer to action taken that results in the safe state being entered. In the case of the STO feature, the STO function is activated (made active) by making the voltage at one or both STO inputs less than or equal to the maximum rated de-energize threshold voltage.

De-Activate – This term is used to refer to action taken that results in the safe state being exited. In the case of the STO feature, the STO function is de-activated (made inactive) by making the voltage at both STO inputs greater than or equal to the minimum rated energize threshold voltage.

Energize – This term refers to the application of voltage greater than or equal to the minimum rated energize threshold voltage to an individual STO input. Note that simultaneously energizing both STO inputs results in the STO function being de-activated.

De-Energize – This term refers to the application of voltage less than or equal to the maximum rated de-energize threshold voltage to an individual STO input. Note that de-energizing an STO input results in the STO function being activated.

4.6 Related Documentation

These documents have additional information on the *Accelnet & Stepnet Plus Panel*s models and are required for proper installation and commissioning of the drives.

All are available from the Downloads page of the Copley Controls web site:
www.copleycontrols.com

Accelnet Plus Panel:

Data Sheet

Accelnet Plus EtherCAT 1-Axis BEL
Accelnet Plus EtherCAT 2-Axis BE2
Accelnet Plus CANopen 1-Axis BPL
Accelnet Plus CANopen 2-Axis BP2
Accelnet Plus MACRO 1-Axis BML

Manual

Accelnet & Stepnet Plus Panels User Guide
Absolute & Serial Encoder Guide
Using CME2
CME2 Indexer User Guide
ASCII Programmers Guide
CMO Programmers Guide

Stepnet Plus Panel:

Data Sheet

Stepnet Plus EtherCAT 1-Axis TEL
Stepnet Plus EtherCAT 2-Axis TE2
Stepnet Plus CANopen 2-Axis TP2

Manual

Accelnet & Stepnet Plus Panels User Guide
Absolute & Serial Encoder Guide
Using CME2
CME2 Indexer User Guide
ASCII Programmers Guide
CMO Programmers Guide

4.7 Reference Standards

ISO 13849-1: 2015

Safety of machinery Safety-related parts of control systems

Part 1: General Principles for Design

ISO 13849-2: 2012

Safety of machinery

Safety-related parts of control systems — Part 2: Validation

IEC 61508-1: Ed. 2.0 2010

Functional safety of electrical/electronic/programmable electronic safety-related systems

Part 1: General requirements

IEC 61508-2: 2010, 2nd Ed.

Functional safety of electrical/electronic/programmable electronic safety-related systems

Part 2: Requirements for electrical/electronic/programmable electronic safety related systems

IEC 61800-5-1: 2007+AMD1:2016 CSV

Adjustable speed electrical power drive systems

Part 5-1: Safety requirements – Electrical, thermal and energy

IEC 61800-5-2:2016

Adjustable speed electrical power drive systems

Part 5-2: Safety requirements – Functional

4.8 Abbreviations and Acronyms

Table 3

Acronym	Description
Safety-Related	
a,b,c,d,e	Denotation of performance level (PL)
Cat	Category
CCF	Common Cause Failure
DC	Diagnostic Coverage
EMC	Electro Magnetic Compatibility
HFT	Hardware Fault Tolerance
MTTF	Mean Time to Failure
MTTFd	Mean Time to Dangerous Failure
PDS(SR)	Power Drive Systems (Safety Related)
PELV	Protected Extra Low Voltage (power supply)
PFD	Probability of Dangerous Failure upon Demand
PFH	Probability of Failure per Hour
PL	Performance Level
PWM	Pulse Width Modulation
S, S1, S2	Severity of Injury
SELV	Safety Extra Low Voltage (power supply)
SFF	Safety Failure Fraction
SIL	Safety Integrity Level
STO	Safe Torque Off
Vdc	Volts DC (Direct Current)
Copley Controls Related	
BEL	*Accelnet Plus Panel* EtherCAT 1-Axis
BPL	*Accelnet Plus Panel* CANopen 1-Axis
BML	*Accelnet Plus Panel* MACRO 1-Axis
BE2	*Accelnet Plus Panel* EtherCAT 2-Axis
BP2	*Accelnet Plus Panel* CANopen 2-Axis
TEL	*Stepnet Plus Panel* EtherCAT 1-Axis
TE2	*Stepnet Plus Panel* EtherCAT 2-Axis
TP2	*Stepnet Plus Panel* CANopen 2-Axis

5.0 Introduction to the Accelnet & Stepnet Plus Panels

5.1 Product Description

The *Accelnet & Stepnet Plus Panels* are 1-axis and 2-axis drives contained in a single mechanical package. These drives are intended to be operated from transformer-isolated, fused, DC power supplies and can drive motor currents up to 20 Adc per axis. The 2-axis drives have a single Safe Torque Off (STO) function that is common to both axes. When the STO function is activated, the ability to drive motor current is cut-off in both axes. In the case of rotary motors, the torque produced by the motor is zero when the current is cut-off. In the case of linear motors, the force produced by the motor is zero when the current is cut-off. The Safe Torque Off (STO) function has been developed in accordance with IEC 61508, ISO 13849-1 and IEC 61800-5-2:2016. All models in the *Accelnet & Stepnet Plus Panels* family are certified by TÜV SÜD as meeting the stated SIL Capability, Category and Performance Levels and other requirements of the given standards. The Safe Torque Off (STO) function is realized in “hardware only” such that no software, firmware, or programmable device is involved in the execution or reliability of the STO function.

5.2 Model Overview & Numbering

Table 4

Family	Axes	EtherCAT	CANopen	MACRO	Motor
Accelnet Plus	1	**BEL**	**BPL**	**BML**	Servo
	2	**BE2**	**BP2**	-	
Stepnet Plus	1	**TEL**	**-**	-	Stepper
	2	**TE2**	**TP2**	-	

This table shows the *Accelnet & Stepnet Plus Panel* models organized by family, number of axes, communications, and motor types. Models within a prefix (i.e. TE2) family vary by the supply voltage, output current, and options that are available.

All of these models have the same Safe Torque Off (STO) feature.

5.3 Accelnet Plus Panel Models

Network	Axes	Models	Ic	Ip	Vdc
EtherCAT	1-Axis	BEL-090-06	3	6	14~90
		BEL-090-14	7	14	
		BEL-090-30	15	30	
	2-Axis	BE2-090-06	3	6	
		BE2-090-14	7	14	
		BE2-090-20	10	20	
CANopen	1-Axis	BPL-090-06	3	6	
		BPL-090-14	7	14	
		BPL-090-30	15	30	
	2-Axis	BP2-090-06	3	6	
		BP2-090-14	7	14	
		BP2-090-20	10	20	
MACRO	1-Axis	BML-090-06	3	6	
		BML-090-14	7	14	
		BML-090-30	15	30	

Ic = Continuous Output Current, Adc (peak of sine), Ip = Peak Output Current, Adc (peak of sine), Vdc = HV power supply voltage (DC, line-isolated)

Table 5

The models listed above are available with the following options added to the part number:

-R: Resolver feedback (Example BEL-090-14-R). Resolver feedback not available on BML models.

-H: Factory-installed heatsink (Example: BEL-090-14-H)

-R-H: Resolver option with factory-installed heatsink (Example: BEL-090-14-R-H)

5.4 Stepnet Plus Panel Models

Network	Axes	Models	Ic	Ip	Vdc
EtherCAT	1-Axis	TEL-090-06	3	6	14~90
		TEL-090-14	7	14	
	2-Axis	TE2-090-07	5	7	
		TE2-090-10	5	10	
CANopen	2-Axis	TP2-090-07	5	7	
		TP2-090-10	5	10	

Ic = Continuous Current, Adc (peak of sine), Ip = Peak Current, Adc (peak of sine), Vdc = HV power supply voltage (DC, line-isolated)

Table 6

The models listed above are available with the following option added to the part number:

-H: Factory-installed heatsink (Example: TEL-090-14-H)

6.0 Specifications Overview

6.1 Control Modes

Cyclic Synchronous Position-Velocity-Torque (CSP, CSV, CST in EtherCAT drives only)

Cyclic Synchronous Torque Mode with Commutation Angle (CSTCA in EtherCAT drives only)

Profile Position-Velocity-Torque, Interpolated Position, Homing (CANopen & EtherCAT drives)

Camming, Gearing

Indexer (Internal program execution)

6.2 Command Sources

BPL, BP2, TP2 models: CANopen

BEL, BE2, TEL, TE2 models: CANopen application protocol over EtherCAT (CoE)

BML models: MACRO

ASCII and discrete I/O

Stepper position commands

±10V position/velocity/torque

PWM velocity/torque command

Master encoder (Gearing/Camming)

6.3 Power Sources

DC voltage:	+14~90 Vdc
Aux DC voltage	+14~90 Vdc

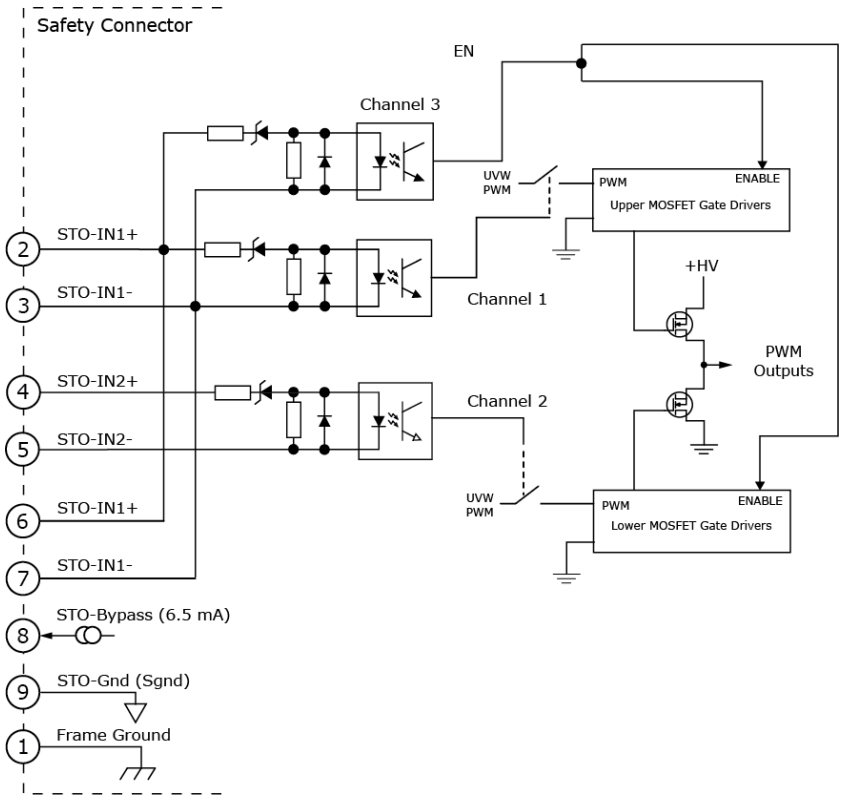
The Aux power is optional and powers the control core and communications in the drive when +HV power has been removed so that the drive can continue to communicate and report status via the communication link.

Complete specification and wiring details are provided in the Accelnet & Stepnet Plus Panels User Guide (16-01339)

7.0 STO Architecture and Function

The STO function in *Accelnet & Stepnet Plus Panel*s is suitable for use in safety loops up to SIL 3 and/or Cat. 3 PL d performance. Because Cat. 3 PL d performance requires that the safety function continues to operate even in the event of two failures, the STO circuit concept uses a quasi three-channel architecture. This architecture is shown in the system block diagram for a BE2 2-axis servo drive below.

Fig. 2



In the Safe State, the drive will not produce torque or force in the motor. The STO function achieves and maintains a safe state by disabling the ability of the attached motor(s) to produce torque/force. This halts any drive induced acceleration already in process and prevents initiation of motion. The expectation is that an inability of the motor to produce torque/force translates into a reduction of risk of hazardous motion for the larger system.

The STO circuit concept involves disabling the ability of the motor drive output stages to produce current. The output stage consists of one subset of high side output MOSFETs that switch motor terminals to the positive rail of the DC bus (+HV), and a second subset of low side output devices that switch motor terminals to negative rail of the DC bus (HVCOM). The basic STO circuit architecture is derived from the fact that current flow in the motor, and therefore torque/force production, requires both subsets to function. STO Channel 1 disables the drive (both axes) by removing power from the high side MOSFET gate drives and STO Channel 2 disables the drive (both axes) by removing power from the low side MOSFET gate drives.

STO Channel 3 disables the drive (both axes) by disabling both the high and low side MOSFET gate drivers. Any of the three channels by itself is therefore sufficient to prevent the initiation of motion or halt drive induced acceleration when the STO function is activated.

Each STO channel receives an input in the form of a voltage (typically +24 Vdc to energize and 0V or open to deenergize) applied to STO_IN1 (+,-) and STO_IN2 (+,-). Note in figure 2 that STO_IN1 (+,-) drives two parallel connected opto-coupler stages (Channel 1 and Channel 3). STO_IN2 (+.-) drives the opto-coupler stage for Channel 2 only. Both STO inputs must be simultaneously energized in order for torque/force to be produced. To achieve the rated SIL and PL capability, both STO inputs must be held simultaneously de-energized by the larger system when the STO function is activated. In a typical machine application, each STO input is driven by a +24 Vdc supply voltage switched through a safety relay. Note that the STO inputs are designed to withstand input voltages to +60 Vdc to provide a measure of overvoltage protection. By definition, the output of an SELV rated power supply is a maximum of +60 Vdc in a fault condition. Therefore a constraint on the larger system is that the power supply used to energize the STO inputs must be an SELV type.

7.1 STO Channel Operation

STO Function Active = No force/torque production is possible in motor

STO Function Inactive = Force/torque production in motor is under control of the drive

Table 7

STO IN1	STO IN2	STO Function State
0	0	STO function is active , both inputs de-energized
1	0	STO function is active, one input de-energized
0	1	
1	1	STO function is inactive, both inputs energized

The table above shows the operation of the STO channels.

0 = Voltage applied to the STO input is less than or equal to the rated maximum de-energize level.

1 = Voltage applied to the STO input is greater than or equal to the rated minimum energize level.

A motion control system design for Cat. 3 PL d, and/or SIL 3 rating must use 2 channels for the STO function.

7.2 STO Function Specifications

Table 8

Specification	Requirement
Operation	When STO is active, motor current that can cause rotation (or motion in the case of a linear motor) is not applied by either Axis A or Axis B. The PWM outputs of both axes are disabled and cannot source or sink current. This STO function is defined in IEC-61800-5-2, clause 4.2.2.2
Standards Conformance	IEC-61508-1, IEC-61508-2, IEC-61800-5-2, ISO 13489-1
Safety Integrity Level	SIL 3
Category & Performance Level	Category 3, Performance Level PL d
Implementation	Hardware only – Type A components
Systematic Capability	SC 3
Certifications	TÜV SÜD Functional Safety Mark (Pending)
Signals (Functional Safety Related)	STO-IN1(+), STO-IN1(-), STO-IN2(+), STO-IN2(-), Frame ground (shield)
Signals (for muting)	STO-Bypass, STO-Gnd
STO DC Power	+24 Vdc, typical, maximum withstand voltage +60 Vdc
STO DC Power Source	SELV power supply required
STO Input Energize Voltage	Vin-HI ≥ +15.0 Vdc between STO-IN(+) and STO-IN(-)
STO Input De-energize Voltage	Vin-LO ≤ +6.0 Vdc or open between STO-IN(+) and STO-IN(-)
Input current (typical)	STO-IN1: 11.2 mA, STO-IN2: 11.2 mA Current flow is into STO-IN1(+) and STO-IN2(+) and out of STO-IN1(-) and STO-IN2(-). STO inputs must be connected in parallel.
Response Time	From Vin ≤ 6.0 Vdc or open to PWM outputs disabled (off): 2 ms
Type	Opto-isolators, +24 VDC compatible
Maximum cable length	30 m (98.4 ft)

7.3 Environmental Specifications

Table 9

Specification	Requirement
Operating Temperature	0 °C to 45 °C per IEC 60068-2-1:2007 and IEC 60068-2:2007
Operating Humidity	0 to 95 %RH, non-condensing per IEC 60068-2-78:2001
Storage Temperature	-40 °C to 85 °C per IEC 60068-2-1:2007 and IEC 60068-2-2:2007
Altitude	≤ 2000 m per IEC 60068-2-13:1983
Contaminants	Pollution Degree 2 per IEC 60664-1:2007
Mechanical Shock	10*g*, 10 ms, 1/2 Sine Pulse per IEC 60068-2-27:2008
Vibration	2*g*, peak, 10~500 Hz (Sine) per IEC 60068-2-6:2007

7.4 Safety Related Parameters

Servo, 1-Axis: BEL, BPL

Table 10

IEC 61508: 2010				ISO 13849-1: 2015			
SIL	3	HFT	2	PL	d	Category	3
PFH	3.3×10^{-9}	SFF	<60%	CCF	80	$MTTF_D$	100 yrs
PFD	2.9×10^{-4}	PTI	20 yrs	DC	69%		

Servo, 2-Axis: BE2, BP2

Table 11

IEC 61508: 2010				ISO 13849-1: 2015			
SIL	3	HFT	2	PL	d	Category	3
PFH	3.3×10^{-9}	SFF	<60%	CCF	80	$MTTF_D$	100 yrs
PFD	2.9×10^{-4}	PTI	20 yrs	DC	73%		

Stepper, 1-Axis: TEL

Table 12

IEC 61508: 2010				ISO 13849-1: 2015			
SIL	3	HFT	2	PL	d	Category	3
PFH	3.3×10^{-9}	SFF	<60%	CCF	80	$MTTF_D$	100 yrs
PFD	2.9×10^{-4}	PTI	20 yrs	DC	71%		

Stepper, 2-Axis: TE2, TP2

Table 13

IEC 61508: 2010				ISO 13849-1: 2015			
SIL	3	HFT	2	PL	d	Category	3
PFH	3.3×10^{-9}	SFF	<60%	CCF	80	$MTTF_D$	100 yrs
PFD	2.9×10^{-4}	PTI	20 yrs	DC	73%		

7.5 Regulatory Specifications

Table 14

Specification	Requirement
Approvals	UL recognized component to UL 61800-5-1 TÜV SÜD Functional Safety to IEC 61508 and ISO 13849-1
Functional Safety	IEC 61508-1:2010, IEC 61508-2:2010, ISO 13849-1:2015, ISO 13849-2:2012, IEC 61800-5-2:2016
Electrical Safety	Directive 2014/35/EU – Low Voltage, IEC/UL/CSA 61800-5-1:2007+AMD1:2016 CSV
EMC	Emissions: IEC 61800-3:2017, Category C3 Immunity: IEC 61800-3:2017, Category C3 Functional Safety Immunity: IEC 61800-5-2:2016
Markings	• UL recognized component (Canada and US) • CE • TÜV SÜD Functional Safety • HV warning symbol per IEC 60417-5036 (2002-10)
Hazardous Substances	Lead free and RoHS compliant

7.6 Limitations and Necessary Risk Reductions

7.6.1 Electrical Isolation

The STO function does not provide electrical isolation between the drive and the motor.
Hazardous voltages may be present on the motor output terminals J3 and J4 even with the STO function activated.

7.6.2 DC Brush Motors

Failure of a MOSFET in the outputs of the drive that renders the MOSFET a virtual short-circuit might result in continuous torque/force production in a DC motor. Unlike brushless motors that limit rotation to one half of an electrical cycle, a DC motor can rotate uncontrollably under a failed MOSFET scenario. As result, the STO function cannot be used with DC brush motors.

7.6.3 180 Degree Electrical Movement

In the event of MOSFET failures in the PWM outputs, unexpected motor movement of up to 180 electrical degrees can occur. It is the responsibility of the designer of the larger system to assess and address any hazards that this unexpected movement could create.

7.6.4 Loads and Other Torque/Force Producing Sources

The STO function produces an uncontrolled stop of category 0 as described in IEC 60204-1.
Any motor that is moving when the STO function is activated will coast to a stop unless there are other forces operating on the same load. The STO function only removes torque/force produced by current flow from the drive to the associated motor(s). Torque/force created by gravity-influenced loads or other torque/force producing components mechanically connected to the motor shaft cannot and will not be affected by the drive STO function. It is the responsibility of the designer of the larger system to assess and address any hazards arising from torque/force producing sources.

7.6.5 STO Input Signal Level

The STO inputs (STO-IN1, STO-IN2) can withstand input voltages to +60 Vdc in case of an overvoltage fault condition. Therefore a constraint on the larger system is that the power supply used to drive the STO inputs must be an SELV type with a +24 Vdc output.

7.6.6 Control Modes and STO

The drive can control the position, velocity, and torque of motors while operating from a number of control sources. But it can only do this when the STO function is inactive. And, while the digital control core and firmware of the drive can observe the state of the STO function, it cannot interact with, or exercise any control over the STO function.

The STO function operates completely independently of the control core of the drive and is implemented entirely in hardware. It does not depend on the control core for its operation and the control core of the drive has no control over the STO function.

7.6.7 +HV and AuxHV DC Power Supply

The power supply used to provide the +HV and AuxHV drive power must have protections to limit the output voltage to 100Vdc or less even in a single fault condition. Furthermore the power supply output must have galvanic isolation from AC mains that meets the requirements for reinforced or double insulation..

7.6.8 STO DC Power Supply

DC power for STO circuits should be +24 Vdc and must be supplied by power supplies with an SELV rating. This ensures that the maximum voltage output will be limited to +60 Vdc.

7.6.9 Wiring to the STO Inputs

Electrical connections to the STO inputs must meet the requirements for fault exclusions for short circuits between conductors and short circuits between conductors and other conductive parts or earth or the protective bonding conductor. Fault exclusion requirements are given in ISO 13849-2 and IEC 61800-5-2:2016.

Toward this end, the STO cable connector is a crimp and poke type in order to meet the relevant fault exclusions. The contacts and connector provide spacing that is greater than the minimum creepage and clearance of 1.24 mm. that is required for fault exclusion when considering the FMEDA (Failure Modes, Effects, and Diagnostic Analysis) of the system..

7.6.10 Periodic Test Requirements

In order to meet the diagnostic coverage requirements for Cat. 3, PL d, the STO function must be checked at least once per year. See section 9 for specific details.

8.0 Installation Using STO for Accelnet & Stepnet Plus Panels

8.1 STO Overview

This diagram gives detail on the physical cabling, shielding, and grounding of the wiring between the STO inputs of the drive and the machine level safety circuits.

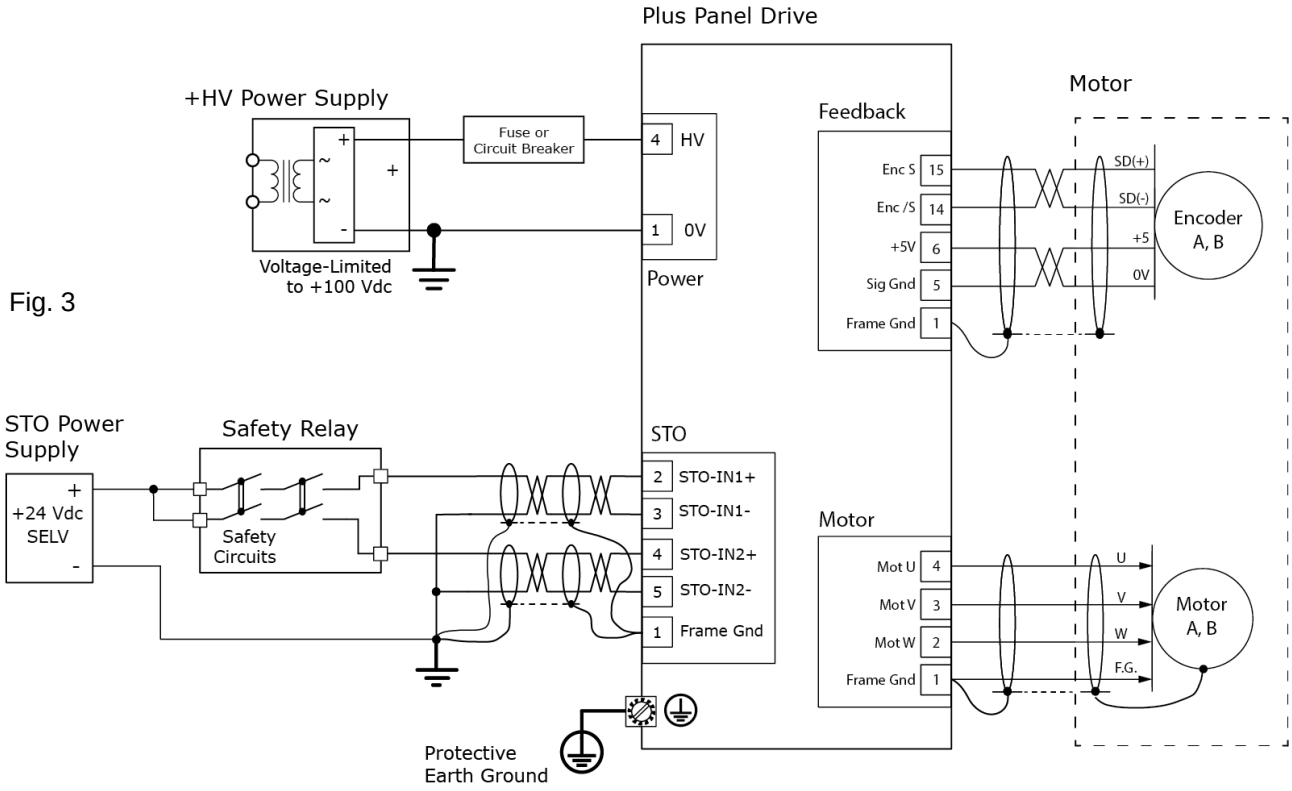


Fig. 3

8.1.1 STO Power Requirements

The +24 Vdc power supply for the STO inputs must be SELV rated.

The +HV DC power supply for the drive power must be transformer-isolated from AC mains and voltage-limited to +100 Vdc.

8.1.2 STO Wiring Requirements

Electrical connections to the STO inputs must meet the requirements for fault exclusions for short circuits between conductors and short circuits between conductors and other conductive parts or earth or the protective bonding conductor. These requirements are given in ISO 13849-2 and IEC 61800-5-2:2016.

When driven from a single +24 Vdc power supply, the STO inputs must be connected in parallel as shown above. Driving the STO inputs in series would require a higher voltage than the nominal +24 Vdc, and if one of the STO inputs or its wiring were to fail as a short-circuit, it would apply the full DC power to a single input.

8.1.3 STO (Safety) Cable Connector

The STO connector on the *Accelnet & Stepnet Plus Panel*s is a DB-09F type receptacle with selective-gold plating on the sockets. Threaded bosses accept #4-40 locking screws from the cable connector.

The STO cable plug is an AMPLIMITE HDP-20 that uses crimp and poke contacts with selective-gold plating. This plug, the contacts, and the STO connector in the drive provide spacings that are greater than the minimum creepage and clearance distance of 1.24 mm. that is required for fault exclusion when considering the FMEDA (Failure Modes, Effects, and Diagnostic Analysis) of the system.

STO Locations

Fig. 4

2-Axis:
BE2, BP2
TE2, TP2

1-Axis:
BEL, BPL, BML
TEL

8.2 Example Wiring Diagram (SIL 3 and Cat. 3 PL d STO Implementation)

8.2.1 Emergency Stop: Stopping Category 1

Figure 5 below shows a wiring example for implementing a SIL 3, Cat. 3 PL d emergency stop function using a *Accelnet & Stepnet Plus Panel*s drive. The example shows a safety relay with two sets of output contacts – one set (K1, K2) reacts immediately to changes on the safety relay inputs and the other (K3, K4) reacts after a user-programmable delay. A double pole, single throw E-stop switch is used to drive two independent inputs to the safety relay. A momentary switch is wired to the safety relay reset input and is used to reset the relay at start-up and after an E-stop event. The enable input on the drive is wired to one of the immediate response contacts. The drive is programmed such that when this input is de-energized, the drive decelerates the motor speed in a controlled fashion. After the user-programmed delay time, contacts K3 and K4 open and de-energize the STO inputs to the drive. The drive STO function responds accordingly and the safe state is entered within the specified drive STO response time. This type of implementation brings the motor speed to near zero before the STO function is activated. It is important to note that the safe state is not entered immediately upon actuation of the E-stop button. The safe state is entered only after the STO inputs have become de-energized and the specified STO response time has elapsed.

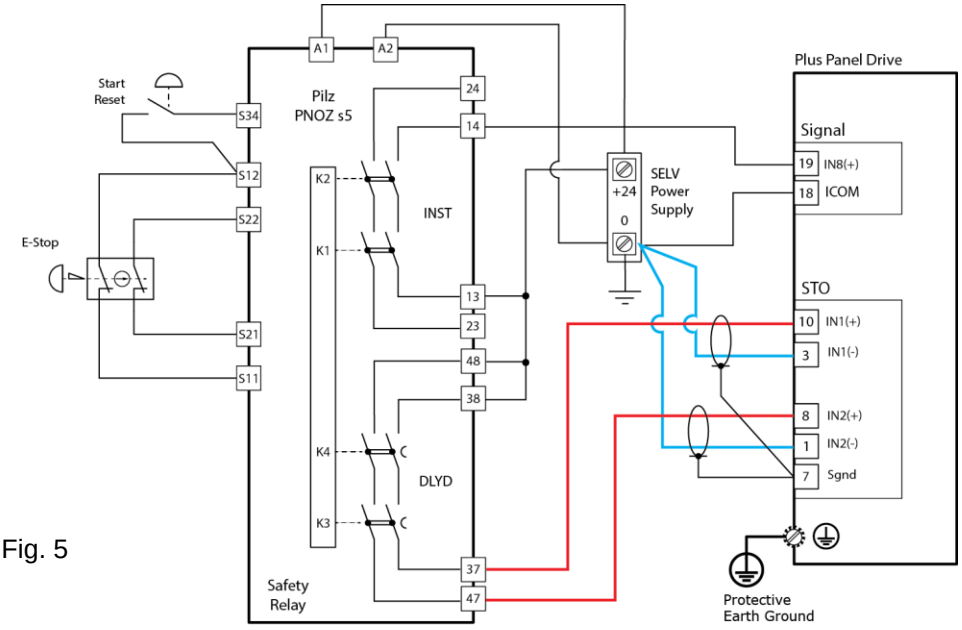


Fig. 5

8.2.2 Accelnet & Stepnet Plus Panels Configuration

[IN8] is an opto-isolated input configured for an Enable function. The [ICOM] signal for [IN8] connects to ground. When +24 VDC is applied to [IN8] it will enable the *Accelnet & Stepnet Plus Panel*s if no other inputs are configured as Enables and no Enable inputs are inactive.

If more than one input is configured as Enable, then all must be active in order to enable the drive.

The PNOZ relay uses both contacts of the delayed relay for two-channel control of the STO function, which is necessary for SIL 3, Cat. 3 PL d.

8.2.3 Example STO Timing

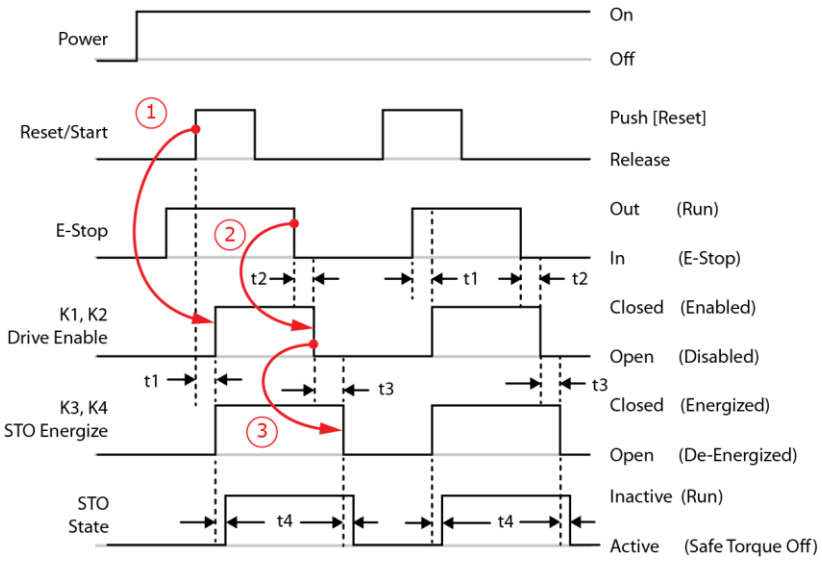


Fig. 6

Power	+24 VDC supplied to the safety relay
Reset/Start	Momentary push-button that causes the K1~K2 relay contacts to close, supplying power to the STO inputs of the drive, and de-activating the STO function. This allows the drive to produce torque/force in the motor when it is enabled.
E-Stop	The latching push-button switch inputs to the safety relay. The HI level of this indicates that the button has been released, opening the NC (Normally Closed) contacts.
K1, K2	The instantaneous contacts in the relay. A HI level indicates that the contacts are closed, supplying power to an Enable input of the drive to place it in an enabled state.
K3, K4	Relay contacts that will open after a pre-set time delay. This allows time for the drive to remain in an enabled state while is performs a controlled deceleration that brings the motor to a standstill before the STO function is activated, preventing any torque/force production in the motor.
t1	Switch-on delay. If the E-Stop button is out, this is the delay after the Reset/Start button is pressed in and the K1~K4 relay contacts close, deactivating the STO function and enabling the drive (1).
t2	Delay-on de-energization. When the E-Stop button is pressed in (E-Stop), this is the delay to the opening of the K1~K2 contacts which disables the drive, initiating a controlled deceleration of the motor (2).
t3	Waiting period. This is the time-delay that allows for the controlled deceleration of the motor. When the E-Stop button is pressed in, this is the time delay to the K3~K4 contact opening which will activate the STO (3).
t4	STO response time. This is the time between the de-energizing of the drive STO inputs (K3~K4 contacts open) and the entry into the safe-state.

8.3 Start-Up Checklist

Proper operation of a safety function must be validated at various points in the product lifetime of the end-use machine.

Validation tests, in accordance with the checklist given in table 15, must be conducted by an authorized person experienced in the functional safety of machines. Validation tests must be conducted:

- At initial installation and start-up of the safety function.
- After any changes related to the safety function (wiring, components, settings, etc.)
- After any maintenance work related to the safety function.
- At the required periodic test intervals.

8.3.1 Preliminary checks

Before powering the drive, and commencing with the functional safety tests, check:

- That the installation requirements given in the *Accelnet & Stepnet Plus Panels User Guide* and this manual have been adhered to. Specifically ensure that proper grounding, shielding, overcurrent, and overvoltage protection measures are in place in regards to electrical safety and electromagnetic compatibility.
- That the wiring between the machine level safety circuits and the drive STO inputs meets the requirements set forth in this manual and those in IEC 61800-5-2:2016 and ISO 13849-1 for wiring-associated fault exclusions.
- That the motor(s) and associated loads are free to move.
- That any other safety measures or warnings needed to ensure safe execution of validation tests are in place.

8.3.2 Start-Up Checklist

Chk	Requirement	Comments	Initials
☐	Ensure that the drive can be run and stopped freely during the commissioning.		
☐	Stop the drive (if running), and safely remove +HV power from the drive.		
☐	Check the STO-IN1 and STO-IN2 circuits and connections against a wiring diagram.		
☐	Apply +HV mains power to the drive. Energize both the STO-IN1 and STO-IN2 circuits.		
☐	Test the operation of the STO-IN1 function when the motor is stopped. Give a stop command for the drive (if running) and wait for the motor to come to a standstill. While keeping STO-IN2 energized, de-energize the STO-IN1 circuit and give a start command for the drive. Ensure that the motor remains at a standstill. Then, energize the STO-IN1 circuit.		
☐	Test the operation of the STO-IN2 function when the motor is stopped. Give a stop command for the drive (if running) and wait for the motor to come to a standstill. While keeping STO-IN1 energized, de-energize the STO-IN2 circuit and give a start command for the drive. Ensure that the motor remains at a standstill. Then, energize the STO-IN2 circuit.		
☐	Restart the drive and check that the motor runs normally		
☐	Test the operation of the STO-IN1 function when the motor is running: Start the drive and ensure that the motor is running. While keeping STO-IN2 energized, de-energize the STO-IN1 circuit. Ensure that the motor stops. Reset any latching fault that may have occurred (these depend on the drive's control mode settings). Try to start the drive. Ensure that the motor stays at a standstill. Energize the STO-IN1 circuit		
☐	Test the operation of the STO-IN2 function when the motor is running: Start the drive and ensure that the motor is running. While keeping STO-IN1 energized, de-energize the STO-IN2 circuit. Ensure that the motor stops. Reset any latching fault that may have occurred (these depend on the drive's control mode settings). Try to start the drive. Ensure that the motor stays at a standstill. Then, energize the STO-IN2 circuit		
☐	Restart the drive and ensure that the drive and motor operate normally.		

Table 15

8.4 STO Status Indications

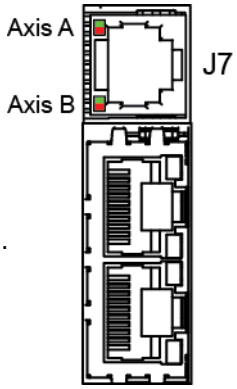
Although they are not and must not be considered part of the safety function, indications of the STO status are available from the Accelnet & Stepnet Plus Panels drive for convenience purposes. Specifically the Axis A & B LEDs, two user-accessible data objects bits, and the CME Control Panel provide some information on STO status. The LEDs, data objects, and CME are not part of the drive safety function.

8.4.1 Axis A & B LEDs

The example shown is for a 2-axis drive. On 1-axis drives the AMP LED is located apart from the RS-232 connector. Colors do not alternate, and can be solid ON or blinking. When multiple conditions occur, only the top-most condition will be displayed. When that condition is cleared the next one below will shown.

Red/Blinking	=	Latching fault. Operation will not resume until drive is Reset
Red/Solid	=	Transient fault condition. Drive will resume operation when the condition causing the fault is removed.
Green/Double-Blinking	***=***	***STO circuit active, drive outputs are Safe-Torque-Off***
Green/Slow-Blinking	=	Drive OK but NOT-enabled. Will run when enabled.
Green/Fast-Blinking	=	Positive or Negative limit switch active. Drive will only move in direction not inhibited by limit switch.
Green/Solid	=	Drive OK and enabled. Will run in response to reference inputs or communication commands.

Fig. 7



8.4.2 STO Circuit Status Data Objects

The *Accelnet & Stepnet Plus Panel*s have a variety of data objects that can be read by the end user via CANopen, EtherCAT, or serial communications. The status of the STO circuit is available in ASCII parameter 0x139 and DS-402 parameter 0x219D. Bits 0 & 1 show the status of the STO-IN1 and STO-IN2 inputs. Bit 8 has no function in the *Accelnet & Stepnet Plus Panels.*

Table 16

Bit	Safety Circuit Status
0	Set (1) when STO-IN1 is active and preventing the drive from producing torque
1	Set (1) when STO-IN2 is active and preventing the drive from producing torque

8.4.3 CME Control Panel

CME is the PC based software tool used for configuring, commissioning, and troubleshooting Copley Control digital servo drives. A graphic LED labeled “Safety” on the CME Control Panel screen gives the status of the STO function:

Green = STO inactive. Torque production in the motor is under user control.

Red = STO active. Drive outputs are Safe-Torque-Off and cannot produce torque in the motorw1

In the screen capture below the Safety (STO) LED is red, indicating that the STO function is active.

The message in the box to the right “Active: STO-1, STO-2 off” refers to the STO channels, both of which are de-energized, activating the STO function.

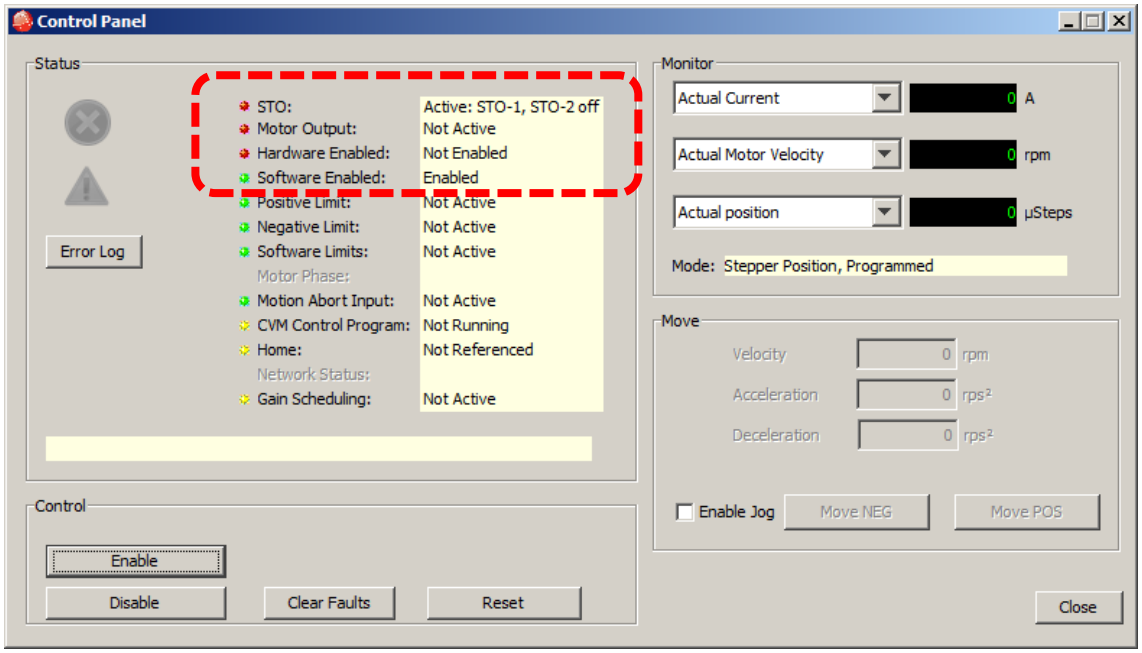


Fig. 8

8.5 Troubleshooting

The status of the STO function in the *Accelnet & Stepnet Plus Panel*s servo drives can be viewed via LED indicators on the drive, via data objects accessible over CANopen or EtherCAT connections, and using the configuration software CME. Other Copley software products such as CMO (Copley Motion Objects), CML (Copley Motion Libraries), CPL (Copley Programming Language) and ASCII communications can read the status of the STO function.

The LED indicators and data parameters are not part of the drive safety function. They are informational only, and cannot be relied upon for any safety related functions of the user.

8.5.1 How to tell if the STO function is active

- The voltage to one or both of the STO channels in the drive is < 6 Vdc, or open.
- The Axis A and Axis B LEDs (on 2-axis drives) or AMP LED on 1-axis drives double-flashes green, then pause. This pattern repeats when the STO function is active.
- Bit 0 OR bit 1 of ASCII parameter 0x139 (DS-402 0x219D) is set (1).
- The Safety LED on the CME Control Panel is red when the STO function is active.
- Bit 2 of the DS-402 Status Word 0x6041 (Axis A) or 0x6841 (Axis B) is zero, indicating a hardware-disabled state. This bit is controlled by any input that is programmed for the Enable function, and by the STO function. When bit is zero, then it is necessary to check 0x219D (ASCII 0x139) to see if bit 0 or bit 1 is set (1). If this condition is true, then the STO function is active.

8.5.2 How to tell if the STO function is inactive

- The voltage applied to both STO inputs of the drive is ≥ 15 Vdc (wired in parallel).
- The Axis A and Axis B LEDs (on 2-axis drives) or AMP LED on 1-axis drives are solid green or slow-blinking green.
- Bit 0 AND bit 1 of ASCII parameter 0x139 (DS-402 0x219D) are zero.
- The Safety LED on the CME Control Panel is green when the STO function is inactive.
- Bit 2 of the CANopen Status Word 0x6041 (Axis A) or 0x6841 (Axis B) is set(1), indicating a hardware-enabled state. The drive cannot be hardware-enabled until all inputs programmed as Enable inputs are true AND the bits 0 AND bit t in the STO function status parameter (0x219D) are zero.

8.5.3 Why can’t the STO function be deactivated?

- The voltage between STO-IN1(+) and STO-IN1(-) is < 15 Vdc OR the voltage between STO-IN2(+) and STO-IN2(-) is < 15 Vdc. Both of these voltages must be ≥ 15 Vdc to deactivate the STO function

8.5.4 Why can’t the STO function be activated?

- The voltage between STO-IN1(+) and STO-IN1(-) is > 6 Vdc AND the voltage between STO-IN2(+) and STO-IN2(-) is > 6 Vdc. One or both of these voltages must be < 6.0 Vdc or the to activate the STO function

8.5.5 The drive is hardware-enabled but the motors don’t move.

- The STO function may be active. Check the Axis A/B LEDs to see if they are double-flashing red. If so, then the STO function is active. If not, check the LED blink patterns for indications of other faults or conditions that may inhibit motion.

9.0 Maintenance

9.1 Ease of Accessibility and Replacement of Internal Parts

There are no user-replaceable parts in the *Accelnet & Stepnet Plus Panel*s.

The warranty will be void if the user removes the cover or attempts any repairs.

For safety and to assure compliance with documented system data, only Copley Controls shall perform repairs to the *Accelnet & Stepnet Plus Panel*s.

9.2 Periodic STO Testing Interval

In order to meet the diagnostic coverage requirements corresponding to Cat. 3 PL d, the STO function must be tested at least once per year. The required test methodology is provided in checklist form in Table 17.

9.3 Periodic Testing Checklist

Table 17

Chk	Requirement	Comments	Initials
☐	Ensure that the drive can be run and stopped freely during the commissioning.		
☐	Stop the drive (if running), and safely remove +HV DC power from the drive.		
☐	Check the STO-IN1 and STO-IN2 circuits and connections against a wiring diagram.		
☐	Apply +HV DC power to the drive. Energize both the STO-IN1 and STO-IN2 circuits.		
☐	Test the operation of the STO-IN1 function when the motor is stopped. Give a stop command for the drive (if running) and wait for the motor to come to a standstill. While keeping STO-IN2 energized, de-energize the STO-IN1 circuit and give a start command for the drive. Ensure that the motor remains at a standstill. Energize the STO-IN1 circuit.		
☐	Test the operation of the STO-IN2 function when the motor is stopped. Give a stop command for the drive (if running) and wait for the motor to come to a standstill. While keeping STO-IN1 energized, de-energize the STO-IN2 circuit and give a start command for the drive. Ensure that the motor remains at a standstill. Energize the STO-IN2 circuit.		
☐	Restart the drive and check that the motor runs normally		
☐	Test the operation of the STO-IN1 function when the motor is running: Start the drive and ensure that the motor is running. While keeping STO-IN2 energized, de-energize the STO-IN1 circuit. Ensure that the motor stops. Reset any latching fault that may have occurred (these depend on the drive's control mode settings). Try to start the drive. Ensure that the motor stays at a standstill. Energize the STO-IN1 circuit		
☐	Test the operation of the STO-IN2 function when the motor is running: Start the drive and ensure that the motor is running. While keeping STO-IN1 energized, de-energize the STO-IN2 circuit. Ensure that the motor stops. Reset any latching fault that may have occurred (these depend on the drive's control mode settings). Try to start the drive. Ensure that the motor stays at a standstill. Energize the STO-IN2 circuit		
☐	Restart the drive and ensure that the drive and motor operate normally.		

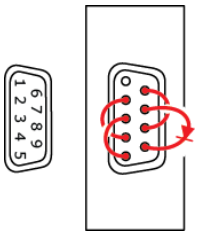
10.0 Muting & Suspension of Safety Functions

10.1 STO Muting

Muting (bypassing) means de-activating the STO function. A convenient method for muting the STO function is shown here for those installations that are not using the STO function.

An internal power source in the drive is brought out to the Safety connector. Connecting the STO inputs between this bypass power source and its ground supplies power to the STO opto-couplers, energizing them, and allowing the PWM outputs to be controlled by the drive. Figure 10 below shows the muting connector circuit, and fig. 9 shows the jumper locations.

Fig. 9

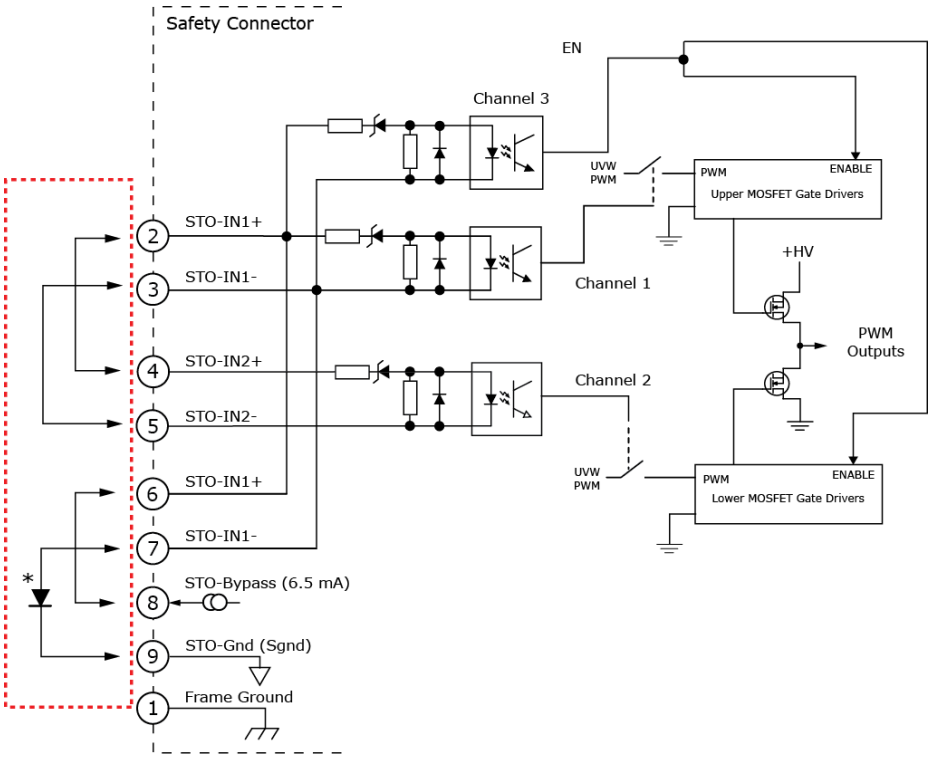


Jumper Wiring, no diode:
2-4, 3-5, 6-8, 7-9

Jumper Wiring, with diode:
2-4, 3-5, 6-8, 7-anode, 9-cathode

10.2 Muting Jumpers (STO Connector)

Fig. 10



* STO bypass connections on the Plus Panel drives and Xenus Plus XEL/XPL models are different. If both drives are installed in the same cabinet, the diode should be wired as shown to prevent damage that could occur if the STO bypass connectors are installed on the wrong drive. The diode is not required for STO bypass on the Plus Panel drives and can be replaced by a wire between pins 7 and 9 as shown above.

11.0 Decommissioning

Before decommissioning any safety system from active service:

- Evaluate the impact of decommissioning on adjacent operating units and facilities or other field services.
- Conduct a proper review and obtain required authorization.
- Ensure that the safety functions remain appropriate during decommissioning activities.
- Implement appropriate change management procedures for all decommissioning activities.

Accelnet & Stepnet Plus Panels STO Manual

P/N: 16-01338
Revision 05
Copley Controls
20 Dan Road
Canton, MA 02021 USA