NPMPC / NPAPC / UDMCB

Functional Safety Manual

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ACS MOTION CONTROL

NPMpc / NPApc / UDMcb

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www.acsmotioncontrol.com

support@acsmotioncontrol.com

sales@acsmotioncontrol.com

Revision History

Date	Revision	Description
October 2017	1.30	Updated CE Declaration of Conformity
Septembnber 2017	1.20	Added CE Declaration of Conformity Added product labels Removed P/N examples
August 28, 2017	1.10	Added Declarations Content Updated standards listing to EN/IEC 61800-5- 2 Ed. 2, PL e and SIL 3
August 2017	1.00	First release

Conventions Used in this Guide

Text Formats

Format	Description
Bold	Names of GUI objects or commands.
BOLD+ UPPERCASE	ACSPL+ variables and commandss
`Monospace + grey background`	Code example.
Italic	Names of other documents.
Blue	Web pages, and e-mail addresses.
[ ]	In GUIs indicates optional item(s)
|	In GUIs indicates either/or items

Flagged Text

	**Note** - includes additional information or programming tips.
	**Caution** - describes a condition that may result in damage to equipment.
	**Warning** - describes a condition that may result in serious bodily injury or death.
	**Model** - highlights a specification, procedure, condition, or statement that depends on the product model.
	**Advanced** - indicates a topic for advanced users.

Related Documents

Documents listed in the following table provide additional information related to this document.

The most updated version of the documents can be downloaded by authorized users from www.acsmotioncontrol.com/downloads.

Online versions for all ACS software manuals are available to authorized users at ACS Motion Control Knowledge Center.

Document	Description
NPMPC Installation and Carrier Board Design Guide	Provides installation information.
NPAPC Installation and Carrier Board Design Guide	Provides installation information.
UDMCB Installation and Carrier Board DesignGuide	Provides installation information.

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1. Introduction

1.1 Overview

Functional safety in the NPMPC/NPAPC and UDMCB is implemented by the STO (Safe Torque Off) function. The STO prevents:

- Unexpected motor movement
- Rotational field within the motor
- The motor from generating a torque on the shaft

This manual describes the use of the STO function in the NPMPC/NPAPC and UDMCB.

The STO is applicable only when using Acs STO module p/n SB-16530-200/LF which is not part of the NPMPC/NPAPC and UDMCB and should be ordered separately.

The STO is applicable only to drives that are certified for functional safety, see Certified products list.

This manual includes critical information, including expected behavior of the motion systems when using the STO, limitations, and the requirements for three-month testing by the user.

1.2 What is STO?

The Safe Torque Off (STO) functionality disables the drive's output MOSFET's according to IEC 61800-5-2, by disconnecting power from the gate drive optocouplers. This results in preventing the drive's output power devices from switching in the necessary way to generate AC power to the motor. When STO is enabled while the motor is in motion, the motor shaft and its mechanical elements coast until brought to a stop. When the STO is enabled, the drive cannot generate torque energy. The safety function "Safe torque off" (STO) can be used to realize an "Emergency Stop" according to EN 60204 Stop 0 while the power is still supplied to the frequency inverter.

STO can be used in applications where the motor is expected to reach a standstill within a sufficiently short time based on the load and the friction and when coasting down of the motor will not have any impact on safety.

Systems with a suspended load must have an additional mechanical safety block like a motor brake. The drive cannot hold the load when STO is engaged. When designing a machine, consider the timing and distance for a coasting to stop. Serious injury could result if the load is not properly held.

Connecting 5V to pin J1/130 and J1/132 of the drive (see Figure 5-1) from a source other than Acs STO module p/n SB-16530-200/LF can result in a failure of the safety function.

1.3 STO block diagram

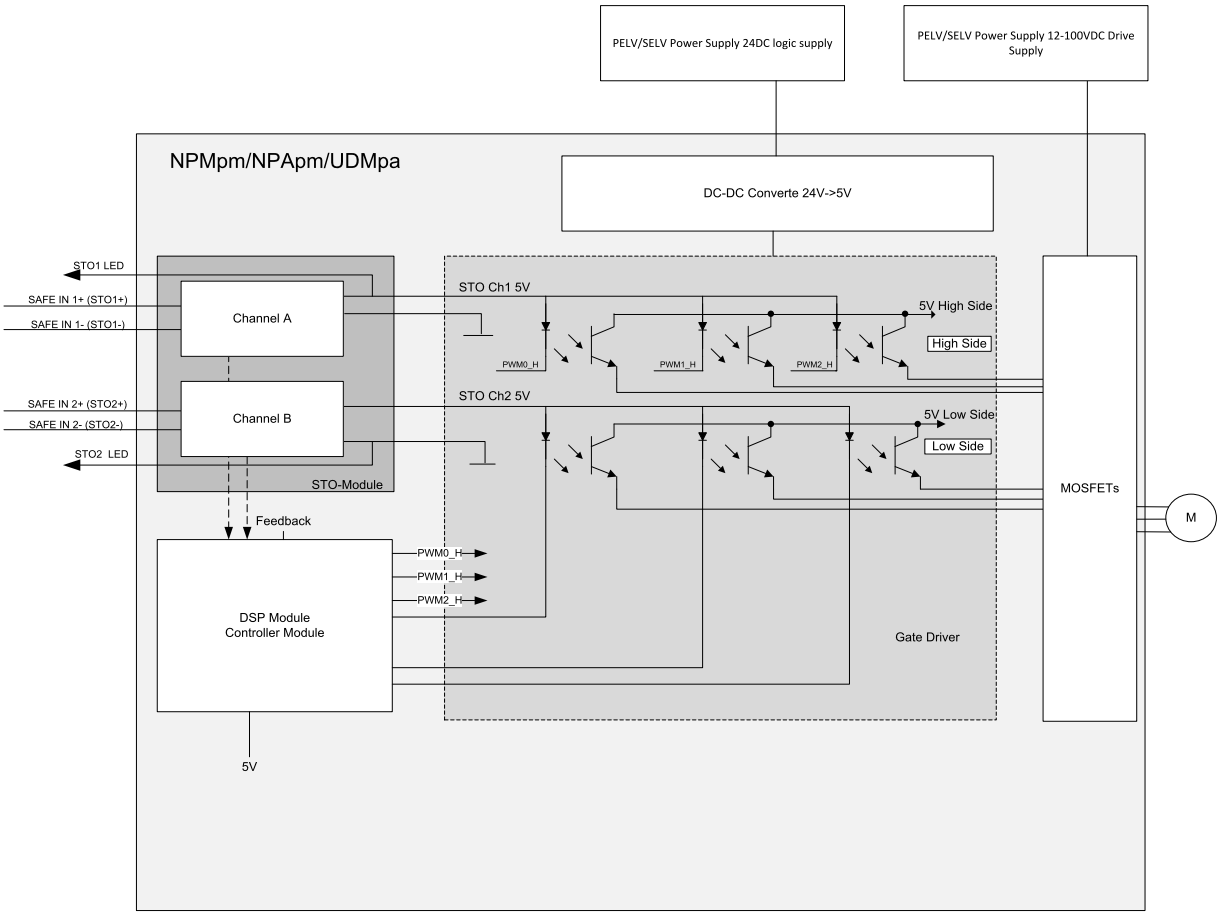

Figure 1-1. STO block diagram

1.4 Certification

The NPMPC/NPAPC and UDMCB Safe Torque Off option module is certified for use in safety applications up to and including SIL-3 according to:

- EN/IEC 61800-5-2 Ed. 2 (second environment)
- EN/ IEC 61800-5-1
- IEC 61508
- IEC 62061

Performance Level PLe and Category 3 according to:

- EN ISO 13849-1/-2

1.5 Operator responsibility

1.5.1 Safety considerations

- When applying Functional Safety, restrict access to qualified, authorized personnel who are trained and experienced.
- The operator must perform a periodic test of the STO function every three months in order to make sure the STO is working properly. See Verify operation for test details.

In the event of the failure of two output MOSFETs in the drive, when STO is activated (removing the power from the optocouplers), the drive can provide energy for up to 180° of rotation in a 2-pole motor before torque production in the motor ceases. However, the probability of such a failure is rare and therefore considered negligible.

Failure to maintain the specified environmental standards can result in a failure of the safety function.

The STO does not eliminate dangerous voltages at the drive output. Input power to the drive (drive supply) must be removed before performing any electrical work on the drive or machine.

2. Certified products list

CE

DECLARATION OF CONFORMITY

ACS Motion Control Ltd.

1 Hataasia St., Ramat Gabriel Industrial Park Migdal Ha'Emek 2307037
Israel, Tel: +972 4 654 6440 Fax: +972 4 654 6443

ACS Motion Control Ltd., declare on our sole responsibility that the following products:

UDMcb,UDMpa

1. Adhere to the following reference standards including Machinery Directive 2006/42/EC Annex IX and VIII. Applied harmonized standards:
   a. IEC 61800-5-2:2016
   b. IEC 61800-5-1:2016
   c. IEC 61800-3: 2017
   d. EN ISO 13849-1:2015
   e. EN ISO 13849-2:2012
   f. IEC 62061:2015
   g. IEC 60204-1:2016 (in extracts)

ACS Motion Control Ltd. Officer:

Signature: _____

Printed Name: Dror Marom, CEO

Date: 23.10.2017

CE DECLARATION OF CONFORMITY

ACS Motion Control Ltd. 1 Hataasia St., Migdal Ha'Emek 2307037
Israel, Tel: +972 4 654 6440, Fax: +972 4 654 6443

We, ACS Motion Control Ltd., declare on our sole responsibility that the following dual-axis Nano PWM drive product(s):

NPMpm,NPApm,NPMpc,NPApc

1. Adhere to the following reference standards including Machinery Directive 2006/42/EC Annex IX and VIII. Applied harmonized standards:
   a. IEC 61800-5-2:2016
   b. IEC 61800-5-1:2016
   c. IEC 61800-3: 2017
   d. EN ISO 13849-1:2015
   e. EN ISO 13849-2:2012
   f. IEC 62061:2015
   g. IEC 60204-1:2016 (in extracts)

ACS Motion Control Ltd. Officer:

Signature: 

Printed Name: Dror Marom, CEO

Date: 23.10.2017

in Migdal HaEmek

2.1 List of certified products

All the below products have been approved by The TÜV Rheinland for the Safe Torque Off option, for use in safety-related applications where the torque off state is considered to be the safe state.

The below products were certified:

- NPMpc-XXXXXXXXX-N-X, see NPMpc order part number for more details.
- NPApc-XX-N-X, see NPApc order part number for more details.
- UDMcb--XXXX-N0-XXXX, see UDMcb order part number for more details.

2.2 NPMpc order part number

The order part number (P/N) contains several characters (see example in Figure 2-1) that each specify a configuration characteristic ordered for the NPMPM module, as described in Table 2-1.

Figure 2-1. NPMpc Label

Table 2-1. NPMpc ordering options

Ordering Options	Field	Example User Selection	Available Ordering Option Values
Number of axes/drives	1	X	1,2
Current	2	X	A - 3.3/10A B - 6.6/20A C - 10/30A D - 13.3/40A
500kHz SIN-COS encoder interface	3	X	0,1,2,3,4
10MHz SIN-COS encoder interface	4	X	0,1,2,3,4
Absolute encoders type	5	X	N - None E - EnDAT 2.2 & 2.1 digital only S - Smart Abs P - Panasonic B - BiSS-A/B/C I - SSI A - Sanyo ABS
Number of Absolute encoders interface	6	X	0,1,2
Limit switch inputs	7	X	A - 5V, Source/PNP B - 5V, Sink/NPN C - 24V, Source/PNP D - 24V, Sink/NPN
Digital Inputs	8	X	A - 5V, two-terminal B - 24V, two-terminal

Ordering Options	Field	Example User Selection	Available Ordering Option Values
Digital Outputs	9	X	A - Source/PNP, 5V & 24V B - Sink/NPN, 5V & 24V
Special options	10	N	N - No
Total number of feedback channels	11	X	A - 2 (utilize 2 axes) B - 2 (utilize 1 axis)* C - 4 (utilize 4 axes) D - 4 (utilize 2 axes)*

*Available after Ver. 2.30 release.

2.3 NPApc order part number

The order part number (P/N) contains several characters (see example in Figure 2-2) that each specify a configuration characteristic ordered for the NPMPM module, as described in Table 2-2.

Figure 2-2. NPApc Label

Table 2-2. NPApc ordering options

Ordering Options	Field	Example User Selection	Available Ordering Option Values
Number of axes/drives	1	X	1,2
Current	2	X	A - 3.3/10A B - 6.6/20A C - 10/30A D - 13.3/40A
Special options	3	N	N - No
Type of motor	4	X	T - Three phase motor only S - Single phase motor only

*Available after Ver. 2.30 release.

2.4 UDMcb order part number

The order part number (P/N) contains several characters (see example in Figure 2-3) that each specify a configuration characteristic ordered for the NPMPM module, as described in Table 2-3.

Figure 2-3. UDMcb Label

Table 2-3. UDMcb ordering options

Ordering Options	Field	Example User Selection	Available Ordering Option Values
Number of axes/drives	1	X	1,2
Current	2	X	A - 3.3/10A B - 6.6/20A C - 10/30A D - 13.3/40A
Maximum voltage	3	X	A - 60V B - 100V
500kHz Sin-Cos encoder interface	4	X	0,1,2
Absolute encoders type*	5	N	N - None
Number of Absolute encoders interface*	6	0	0
Limit switch inputs	7	X	A - 5V, Source/PNP B - 5V, Sink/NPN C - 24V, Source/PNP D - 24V, Sink/NPN
Digital Inputs	8	X	A - 5V, two-terminal B - 24V, two-terminal
Digital Outputs	9	X	A - Source/PNP, 5V & 24V B - Sink/NPN, 5V & 24V

Ordering Options	Field	Example User Selection	Available Ordering Option Values
Special options	10	X	N - No A - Third Sin-Cos encoder, replacing two analog inputs

*Absolute encoders are currently not supported

3. Reliability data (PFD and PFH)

Safety-related systems can be classified as operating in either a Low Demand mode or in a High Demand/Continuous mode.

PFD and PFH calculations are based on the equations from Part 6 of IEC 61508.

Table 3-1 shows the functional safety data of the NPMPC/NPAPC and UDMCB when using Acs STO module (SB-16530-200/LF).

Table 3-1. Functional safety data

	STO
PFD	2,27E-6
PFH	1,24E-11
PL	e
SIL	3
Category	3
$MTTF_D$	390521y

4. STO specification

In order to use STO safe function in NPMPC/NPAPC and UDMCB drives an additional STO module (SB-16530-200/LF) has to be connected to the drive STO inputs. No other devices or modules can be connected between the STO module (SB-16530-200/LF) output and the NPMPC/NPAPC and UDMCB but the PCB traces.

Table 4-1 describes the STO input specification when the STO module (SB-16530-200/LF) is used.

Table 4-1. STO input specification

Name	Description	Value	Note
STO power supply	24V supply (nominal)	24Vdc	
	Power supply type	SELV/PELV	Accordign to EN 60204-1
Input current	@18Vdc	30mA	
	@33Vdc	20mA	
Input ON voltage (min-max)	Input ON voltage (min-max)	18-33Vdc	
Input OFF voltage (Max)	Input OFF voltage (Max)	<5V	
Input OFF current (max) @5V	Input OFF current (max) @5V	0.15mA	
Maximum reaction time (ms)	Time from STO activation until the power is removed from optocouplers	350mS	
Maximum duration of OSSD pulse	Duration of pulse that will active the STO function	<1mS, with period of >200ms	
Connector	Type and p/n	Connector: JST 5 PIN 2mm male SM05B-PASS-1	
		Mating: JST 5 PIN 2mm female PAP-05V-S	

Name	Description	Value	Note
		Pin type: SPHD-001T-P0.5	
	Wire gauge	22-24AG	
PCB clearance and creepage for traces between STO module and drive	Over voltage category 2 and pollution degree 2	>0.2mm	

4.1 Environmental specification

Table 4-2. Environmental specification

Category	Specification	Note
Operational temperature	0-40°C	
Storage temperature	0-70°C	
Humidity	10-90%	
Altitude	Up to 2000m	
Pollution degree	2	
Over voltage category	2	
EMC	IEC 61800-3 IEC 61800-5-2 Ed. 2 (second environment)	

Failure to maintain the specified ambient temperature can result in a failure of the safety function.

5. STO installation requirements

5.1 Carrier board

In order to use the STO safety function, user has to design a carrier board which include the below connectors (J1, J2 and J3) and can accommodate the NPMpc/NPApc and UDMcb and the STO module. The user is responsible that the design of the carrier board as well as other user system, has to be comply with the following standards:

- EN/IEC 61800-5-2 ED. (second environment)
- EN/ IEC 61800-5-1
- IEC 61508
- IEC 62061

Performance Level PLe and Category 3 according to

- EN ISO 13849-1/-2

The user is responsible that the design of this carrier board as well as other customer hardware e.g. housing etc. will be approved by integration tests. These integration tests have to show that the requirements of the below listed standards for electrical safety; EMC and environmental conditions are met.

Category	Specification	Note
Operational temperature	0-40°C	
Storage temperature	0-70 °C	
Humidity	10-90%	
Altitude	Up to 2000 m	
Pollution degree	2	
Over voltage category	2	
EMC	IEC 61800-3. IEC 61800-5-2	
Electrical safety	IEC 61800-5-1	

For more details about how to design the carrier board as well as the mechanical requirements, refer to the **Mechanical considerations** section in the **Carrier Board Design** chapter in the Installation and Carrier Board Design Guide for the product in question.

- The assembled board is mounted in an enclosure giving protection against conductive contamination and the printed side(s) are coated with an ageing resistant varnish or protective layer covering all conductor paths.

- The carrier board internal traces between the STO module and the NPMPC/NPAPC and UDMCB shall be checked by FMEA.

5.2 STO connectors

The STO circuit has three connectors:

- J1, Molex 200 pin connector, main drive connector. Connecting the drive to the carrier board.
- J2 , Samtec 20 pin connector, STO module board to board connector, connecting the STO module to the carrier board
- J3, JST 5 PIN 2mm male p/n SM05B-PASS-1, STO user connector, the two safe 24V inputs should be connected to this connector.

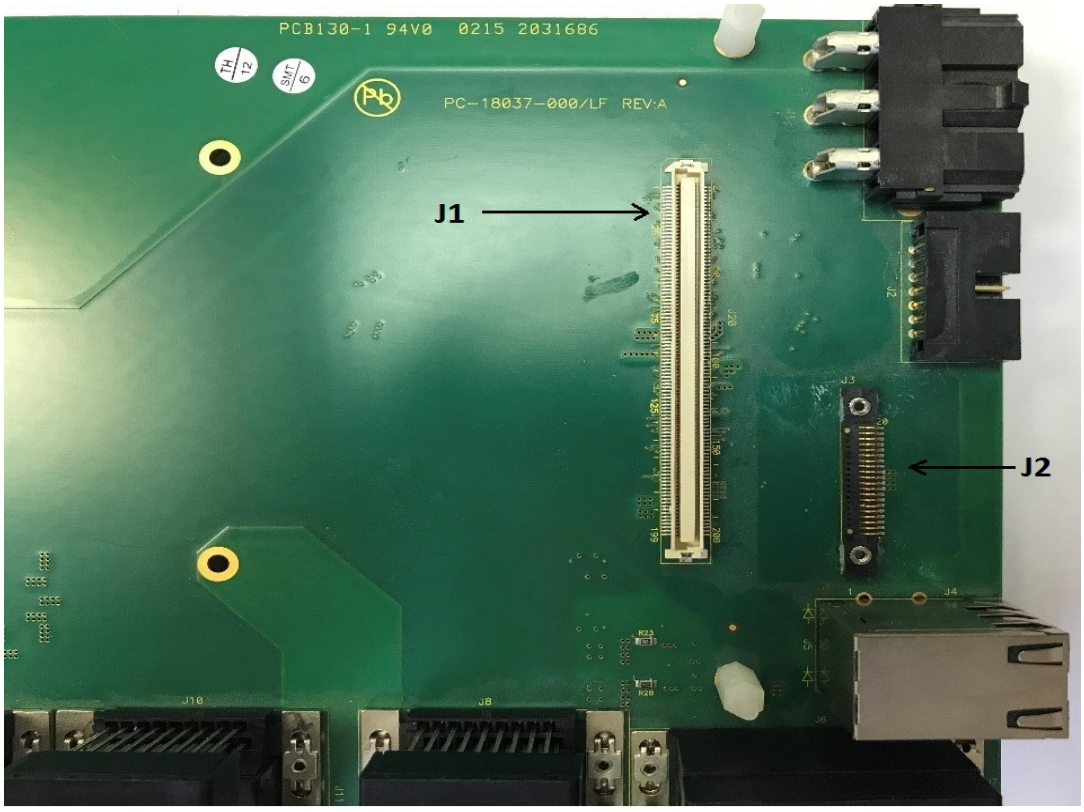

Figure 5-1. STO J1 and J2 connectors

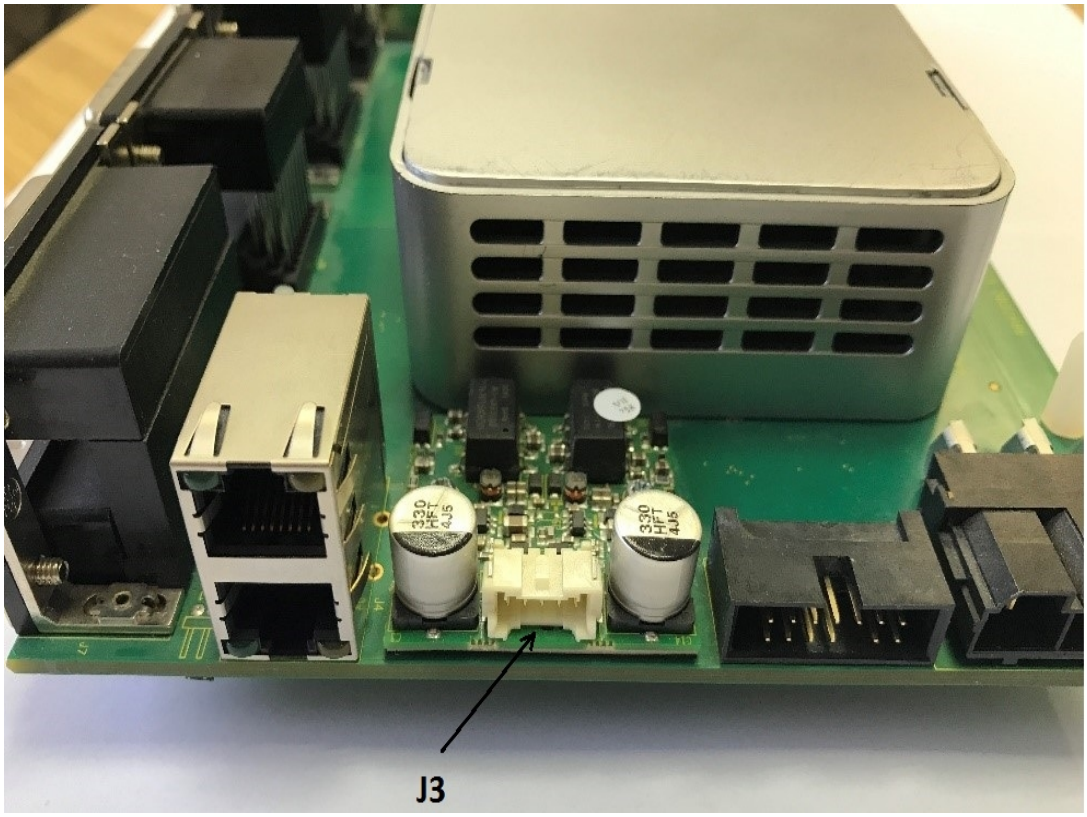

Figure 5-2. STO J3 connector

- In the case that another connector for the external interface is used, it should have a pollution degree 3 and an over voltage category 3.
- In the case of internal connecotr it should have a pollution degree 2 and an over voltage category 2.
- Internal or external connectors or other gaps should keep on creepage and clearances according to IEC 61800-5-1:2007, 4.3.

5.3 STO connector pinout

Table 5-1, Table 5-2, and Table 5-3 describe the pinoiuts for STO connectors J1, J2, and J3, respectively.

Table 5-1. J1 main drive connector description

	Name	Description
1	AIN2+	Analog input 2 non-inverted signal
2	AIN3+	Analog input 3 non-inverted signal
3	AIN2-	Analog input 2 inverted signal

	Name	Description
4	AIN3-	Analog input 3 inverted signal
5	AOUT2+	Analog output 2 non-inverted signal
6	AOUT3+	Analog output 3 non-inverted signal
7	AOUT2-	Analog output 2 inverted signal
8	AOUT3-	Analog output 3 inverted signal
9	CMD1_0+	Current command 0 for axis 1 non-inverted input
10	CMD1_1+	Current command 1 for axis 1 non-inverted input
11	CMD1_0-	Current command 0 for axis 1 inverted input
12	CMD1_1-	Current command 1 for axis 1 inverted input
13	SIN2+	Axis 2 (or secondary axis 0) Encoder SIN non-inverted input
14	SIN3+	Axis 3 (or secondary axis 1) Encoder SIN non-inverted input
15	SIN2-	Axis 2 (or secondary axis 0) Encoder SIN inverted input
16	SIN3-	Axis 3 (or secondary axis 1) Encoder SIN inverted input
17	COS2+	Axis 2 (or secondary axis 0) Encoder COS non-inverted input
18	COS3+	Axis 3 (or secondary axis 1) Encoder COS non-inverted input
19	COS2-	Axis 2 (or secondary axis 0) Encoder COS inverted input
20	COS3-	Axis 3 (or secondary axis 1) Encoder COS inverted input
21	SC_I_2+	Axis 2 analog Encoder INDEX non-inverted input
22	SC_I_3+	Axis 3 analog Encoder INDEX non-inverted input
23	SC_I_2-	Axis 2 analog Encoder INDEX inverted input
24	SC_I_3-	Axis 3 analog Encoder INDEX inverted input
25	1_DSW1	DIP switch 1 for axis 1
26	FLT1	Axis 1 drive fault output
27	1_DSW2	DIP switch 2 for axis 1

	Name	Description
28	ENA1	Axis 1 drive enable input
29	1_DSW3	DIP switch 3 for axis 1
30	AXIS1_DIS_LED	Axis 1 disable LED (red)
31	1_DSW4	DIP switch 4 for axis 1
32	AXIS1_ENA_LED	Axis 1 enable LED (green)
33	2_CHA+	Digital encoder 2 - A,B,I: channel A non-inverted, Clk/Dir: Clk+, Absolute encoder: Data+
34	3_CHA+	Digital encoder 3 - A,B,I: channel A non-inverted, Clk/Dir: Clk+, Absolute encoder: Data+
35	2_CHA-	Digital encoder 2 - A,B,I: channel A inverted, Clk/Dir: Clk-, Absolute encoder: Data-
36	3_CHA-	Digital encoder 3 - A,B,I: channel A inverted, Clk/Dir: Clk-, Absolute encoder: Data-
37	2_CHB+	Digital encoder 2 - A,B,I: channel B non-inverted, Clk/Dir: Clk+, Absolute encoder: Data+
38	3_CHB+	Digital encoder 3 - A,B,I: channel B non-inverted, Clk/Dir: Clk+, Absolute encoder: Data+
39	2_CHB-	Digital encoder 2 - A,B,I: channel B inverted, Clk/Dir: Clk-, Absolute encoder: Data-
40	3_CHB-	Digital encoder 3 - A,B,I: channel B inverted, Clk/Dir: Clk-, Absolute encoder: Data-
41	2_CHI+	Digital encoder 2 - A,B,I: channel Index non-inverted
42	3_CHI+	Digital encoder 3 - A,B,I: channel Index non-inverted
43	2_CHI-	Digital encoder 2 - A,B,I: channel Index inverted
44	3_CHI-	Digital encoder 2 - A,B,I: channel Index inverted
45	PEG1+	PEG output 1 non-inverted
46	DR_IN1_0	Dynamic range input for axis 1
47	PEG1-	PEG output 1 inverted

	Name	Description
48	DRV_1_ON	Drive 1 on/off output status
49	1_HA	Motor 1 Hall A
50	1_HC	Motor 1 Hall C
51	1_HB	Motor 1 Hall B
52	1_OVER_T	Motor 1 over temperature input
53	7-SEG_1_A	7 segment 1 , A segment output
54	7-SEG_1_E	7 segment 1 , E segment output
55	7-SEG_1_B	7 segment 1 , B segment output
56	7-SEG_1_F	7 segment 1 , F segment output
57	7-SEG_1_C	7 segment 1 , C segment output
58	7-SEG_1_G	7 segment 1 , G segment output
59	7-SEG_1_D	7 segment 1 , D segment output
60	7-SEG_1_DO	7 segment 1 , DO segment output
61	AIN0+	Analog input 0 non-inverted
62	AIN1+	Analog input 1 non-inverted
63	AIN0-	Analog input 0 inverted
64	AIN1-	Analog input 1 inverted
65	AOUT0+	Analog output 0 non-inverted
66	AOUT1+	Analog output 1 non-inverted
67	AOUT0-	Analog output 0 inverted
68	AOUT1-	Analog output 1 inverted
69	CMD0_0+	Current command 0 for axis 0 non-inverted input
70	CMD0_1+	Current command 1 for axis 0 non-inverted input
71	CMD0_0-	Current command 0 for axis 0 inverted input

	Name	Description
72	CMD0_1-	Current command 1 for axis 0 inverted input
73	SIN0+	Axis 0 Encoder SIN non-inverted input
74	SIN1+	Axis 1 Encoder SIN non-inverted input
75	SIN0-	Axis 0 Encoder SIN inverted input
76	SIN1-	Axis 1 Encoder SIN inverted input
77	COS0+	Axis 0 Encoder COS non-inverted input
78	COS1+	Axis 1 Encoder COS non-inverted input
79	COS0-	Axis 0 Encoder COS inverted input
80	COS1-	Axis 1 Encoder COS inverted input
81	SC_I_0+	Axis 0 analog Encoder INDEX non-inverted input
82	SC_I_1+	Axis 1 analog Encoder INDEX non-inverted input
83	SC_I_0-	Axis 0 analog Encoder INDEX inverted input
84	SC_I_1-	Axis 1 analog Encoder INDEX inverted input
85	5F	5.1V analog encoder supply output
86	5F	5.1V analog encoder supply output
87	AGND	Analog ground for SIN-COS and CMD signals
88	FGND	Analog ground for AIN and AOUT signals
89	AGND	Analog ground for SIN-COS and CMD signals
90	AGND	Analog ground for SIN-COS and CMD signals
91	0_DSW1	DIP switch 1 for axis 0
92	FLT0	Drive fault output
93	0_DSW2	DIP switch 2 for axis 0
94	DRV_0_ON	Drive 0 on/off output status
95	0_DSW3	DIP switch 3 for axis 0

	Name	Description
96	DR_IN0_0	Dynamic range input for axis 0
97	0_DSW4	DIP switch 4 for axis 0
98	ENA0	Axis 0 drive enable input
99	5U	5.1V digital encoder supply output
100	5U	5.1V digital encoder supply output
101	DGND	Digital ground
102	DGND	Digital ground
103	0_CHA+	Axis 0 Digital encoder, channel A non-inverted input, Absolute encoder Data+. Squared Sin non-inverted output
104	1_CHA+	Axis 1 Digital encoder, channel A non-inverted input, Absolute encoder Data+. Squared Sin non-inverted output
105	0_CHA-	Axis 0 Digital encoder, channel A inverted input, Absolute encoder Data-. Squared Sin inverted output
106	1_CHA-	Axis 1 Digital encoder, channel A inverted input, Absolute encoder Data-. Squared Sin inverted output
107	0_CHB+	Axis 0 Digital encoder, channel B non-inverted input, Absolute encoder CLK+. Squared COS non-inverted output.
108	1_CHB+	Axis 1 Digital encoder, channel B non-inverted input, Absolute encoder CLK+. Squared COS non-inverted output.
109	0_CHB-	Axis 0 Digital encoder, channel B inverted input, Absolute encoder CLK-. Squared COS inverted output.
110	1_CHB-	Axis 1 Digital encoder, channel B inverted input,

	Name	Description
		Absolute encoder CLK-. Squared COS inverted output.
111	0_CHI+	Axis 0 Digital encoder, channel INDEX non-inverted input
112	1_CHI+	Axis 1 Digital encoder, channel INDEX non-inverted input
113	0_CHI-	Axis 0 Digital encoder, channel INDEX inverted input
114	1_CHI-	Axis 1 Digital encoder, channel INDEX inverted input
115	TCK	Servo processor JTAG TCK signal
116	VCC3	3.3V auxiliary voltage
117	EMU0	Servo processor JTAG EMU0 signal
118	TMS	Servo processor JTAG TMS signal
119	EMU1	Servo processor JTAG EMU1 signal
120	TDI	Servo processor JTAG TDI signal
121	TRST	Servo processor JTAG TRST signal
122	TDO	Servo processor JTAG TDO signal
123	MPU_LED_ ENA	Communication LED green
124	0_HA	Motor 0 Hall A
125	MPU_LED_ DIS	Communication LED red
126	0_HB	Motor 0 Hall B
127	AXIS_0_DIS_ LED	Axis 0 disable LED (red)
128	0_HC	Motor 0 Hall C
129	AXIS_0_ ENA_LED	Axis 0 enable LED (green)
130	**5V_STO_1**	**5V supply from STO card, input 1**
131	**STO1**	**STO1 input status (from STO card)**

	Name	Description
132	5V_STO_2	5V supply from STO card, input 2
133	STO2	STO2 input status (from STO card)
134	7-SEG_0_E	7 segment 0 , E segment output
135	7-SEG_0_A	7 segment 0 , A segment output
136	7-SEG_0_F	7 segment 0 , F segment output
137	7-SEG_0_B	7 segment 0 , B segment output
138	7-SEG_0_G	7 segment 0 , G segment output
139	7-SEG_0_C	7 segment 0 , C segment output
140	7-SEG_0_DO	7 segment 0 , DO segment output
141	7-SEG_0_D	7 segment 0 , D segment output
142	RJ45_IN_ D2P	Run LED for RJ45 input port anode (yellow LED)
143	SA_MODE	Setup mode input
144	RJ45_IN_ D2N	Run LED for RJ45 input port cathode (yellow LED)
145	RJ45_OUT_ D2P	Control supply LED for RJ45 output port anode (yellow LED)
146	RJ45_IN_ D1N	Link LED for RJ45 input port cathode (yellow LED) Note: the anode of this LED must be connected to 3.3V
147	RJ45_OUT_ D2N	Control supply LED for RJ45 output port cathode (yellow LED)
148	PEG0+	PEG0 output non-inverted
149	RJ45_OUT_ D1N	Link LED for RJ45 output port cathode (yellow LED) Note: the anode of this LED must be connected to 3.3V
150	PEG0-	PEG0 output inverted
151	BRK0	Control for dynamic brake relay of axis 0
152	0_OVER_T	Motor 0 over temperature input

	Name	Description
153	BRK1	Control for dynamic brake relay of axis 1
154	NC	Not connected
155	NC	Not connected
156	NC	Not connected
157	NC	Not connected
158	NC	Not connected
159	NC	Not connected
160	NC	Not connected
161	MARK0+	Mark input 0 non-inverted
162	MARK2+	Mark input 2 non-inverted
163	MARK0-	Mark input 0 inverted
164	MARK2-	Mark input 2 inverted
165	MARK1+	Mark input 1 non-inverted
166	MARK3+	Mark input 3 non-inverted
167	MARK1-	Mark input 1 inverted
168	MARK3-	Mark input 3 inverted
169	OUT1	General purpose digital output or mechanical brake
170	OUT0	General purpose digital output or mechanical brake
171	0_RL	Axis 0 right limit input
172	V_SUP_IO	Supply for general purpose digital output
173	0_LL	Axis 0 left limit input
174	V_RTN_IO	Supply return for general purpose digital output
175	1_RL	Axis 1 right limit input
176	V_SUP_SFTY	Supply for safety input

	Name	Description
177	1_LL	Axis 1 left limit input
178	V_RTN_SFTY	Supply return for safety input
179	24V	24V control supply
180	24V	24V control supply
181	24V_RTN	24V control supply return
182	24V_RTN	24V control supply return
183	NC	Not connected
184	NC	Not connected
185	NC	Not connected
186	NC	Not connected
187	NC	Not connected
188	NC	Not connected
189	RJ45_IN_1	EtherCAT input RJ45 pin 1
190	RJ45_IN_3	EtherCAT input RJ45 pin 3
191	RJ45_IN_2	EtherCAT input RJ45 pin 2
192	RJ45_IN_6	EtherCAT input RJ45 pin 6
193	RJ45_IN_4	EtherCAT input RJ45 pin 4
194	RJ45_IN_7	EtherCAT input RJ45 pin 7
195	RJ45_OUT_1	EtherCAT output RJ45 pin 1
196	RJ45_OUT_3	EtherCAT output RJ45 pin 3
197	RJ45_OUT_2	EtherCAT output RJ45 pin 2
198	RJ45_OUT_6	EtherCAT output RJ45 pin 6
199	RJ45_OUT_4	EtherCAT output RJ45 pin 4
200	RJ45_OUT_7	EtherCAT output RJ45 pin 7

Table 5-2. J2 STO board to board connector description

	Name	Description
1	24V_STO1_RTN	Safety torque input 1 inverted (24V return)
2	24V_STO1	Safety torque input 1 non-inverted (24V)
3	NC	Not connected
4	STO1	STO1 status – output control signal
5	STO1	STO1 status – output control signal
6	NC	Not connected
7	5V_STO1	Safety torque output 1 non-inverted (5V)
8	5V_STO1	Safety torque output 1 non-inverted (5V)
9	DGND	Safety torque output 1 inverted (Digital ground)
10	DGND	Safety torque output 1 inverted (Digital ground)
11	DGND	Safety torque output 2 inverted (Digital ground)
12	DGND	Safety torque output 2 inverted (Digital ground)
13	5V_STO2	Safety torque output 2 non-inverted (5V)
14	5V_STO2	Safety torque output 2 non-inverted (5V)
15	NC	Not connected
16	STO2	STO2 status – output control signal
17	STO2	STO2 status – output control signal
18	NC	Not connected
19	24V_STO2	Safety torque input 2 non-inverted (24V)
20	24V_STO2_RTN	Safety torque input 2 inverted (24V return)

Table 5-3. J3 STO connector description

	Name	Descritpion
1	STO1	STO input 1, 24V return input
2	STO1	STO input 1, +24V input

	Name	Descritpion
3	NC	not connected
4	STO2	STO input 2, +24V input
5	STO2	STO input 2, 24V return input

5.4 Wiring and cables

For J3 connector:

It is recommended to use 22-24 AWG copper wire with an insulation rating of 600V or higher.

The STO cable must be shielded and isolated from any sources of environmental Stress.

The measures of EN13849-2 D.7 for the connector wiring is required.

5.5 Mating connector

The STO (J3) mating connector is JST 5 PIN 2mm female PAP-05V-S. The pin type for this connector is: SPHD-001T-P0.5

5.6 PCB wiring and traces

- The PCB traces between J1 (main drive connector) and J2 (STO module board to board connector) should have a minimum clearance the creepage of 0.2mm. The traces should be not less than 20mil width in 1Oz copper thickness.
- The material of the PCB shall have a CTI>175

5.7 Power supplies

The external power supply that feeds the STO input is to be low voltage 24Vdc±10% power supply that complies with EN60950 (SELV) or EN50178 (PELV).

The STO circuit has to be safely within the voltage range between 24VDC+20% and 60VDC. Appling voltages outside this range will result in a failure of the safety function and might damage the drive.

Take appropriate measures to avoid a failure due to voltage reverse protection, short circuit or turnover of component (wrong placement).

5.8 Typical system configuration

A typical system configuration includes:

- Acs drive (NPMpc/NPApc or UDMcb)
- Acs STO module (SB-16530-200/LF)
- Carrier board (designed by the user)
- Emergency stop or other switch
- SELV/PELV power supply (24Vdc)

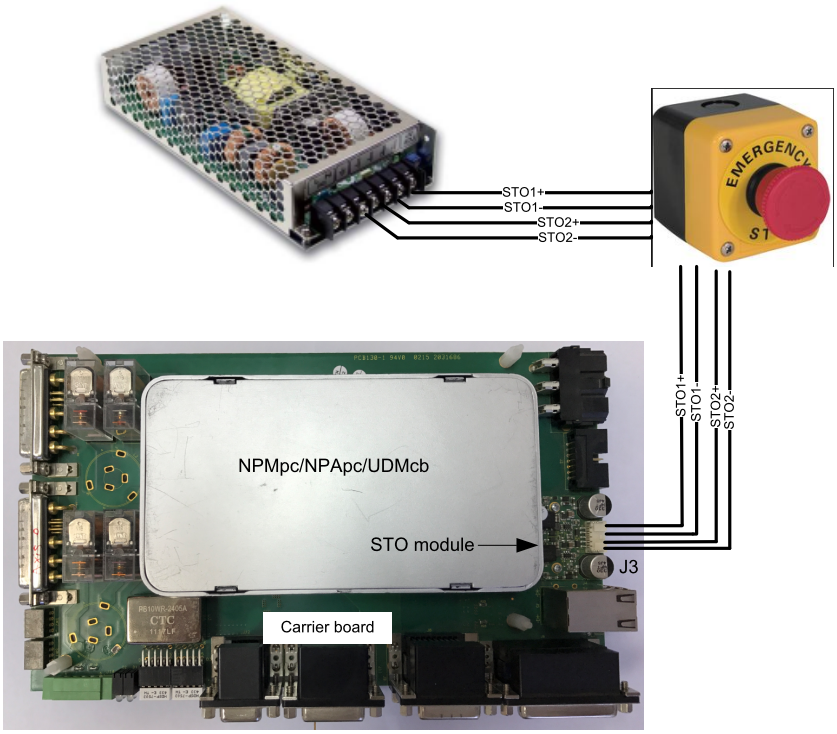

Figure 5-3. Typical system configuration

6. STO diagnostic and functionality

6.1 STO diagnostic

When STO is activated, i.e. power is removed from one of the STO safe channels input (24Vdc), it disables the drive's output MOSFET's by removing the power from the gate drive optocouplers. The STO1 and STO2 LEDs are OFF. The controller generates a message (in the ACS SPiiPlus MMI Application Studio software interface) similar to the one shown in Figure 6-1.

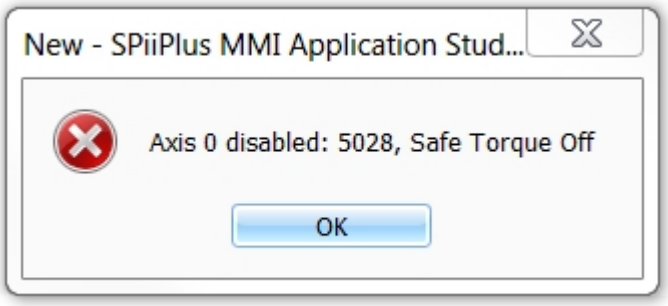

Figure 6-1. Sample warning message

6.2 Recovery from a STO event

After activation of STO (that is power is removed from optocouplers), the system can be restarted by resetting the STO inputs (both channels receive power of 24Vdc) and the drive is activated using an additional **ENABLE_$** command. The **ENABLE_$** command is not safety related but must be integrated in a way so that a stuck-at fault cannot rerun the drive automatically. In some applications, an automatic rerun is required, this case requires an additional Signal or Command initiated by the Control system.

7. Verify operation

7.1 Maintenance and diagnosis

The user is responsible to perform periodic tests to ensure that the STO circuits are functioning.

The two options to perform a periodic tests are Automatic test or Manual test.

The periodic test is to be done every three months.

7.1.1 Automatic test

When the STO is connected with a Safety PLC controller. The Safety-PLC controller is responsible for testing in sufficient cycle time. In this case, it is required to check a feedback signal concerning the motion state of the motor.

The PLC has to test each input separately in the following sequence:

1. PLC controller activates both channels of STO, i.e. disconnects the 24V of both STO inputs on J3.
2. User has to verify that both LEDs, STO1 and STO2 are off.
3. Motion controller sends command to the motor to start motion.
4. PLC controller reads the motor feedback and verifies no motion.
5. PLC controller applies 24V between pin 1 and 2 of J3 (STO channel 1 deactivated).
6. User has to verify that STO1 LED is on and STO2 LED is off.
7. Motion controller sends command to the drive to start motion.
8. PLC controller reads the motor feedback and verifies no motion.
9. PLC disconnects the 24V from pin 1 and 3 of J3.
10. PLC connects 24V between pins 4 and 5 of J3 (STO channel 2 deactivated).
11. User has to verify that STO2 LED is on and STO1 LED is off.
12. Motion control sends command to the drive to start motion.
13. PLC controller reads the motor feedback and verify no motion.
14. PLC reconnects both STO channels (deactivate the both STO channels).

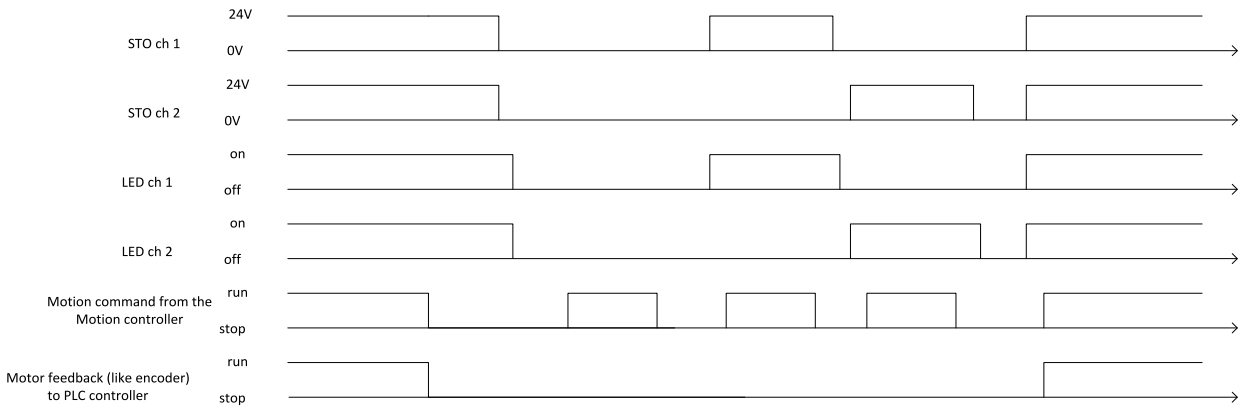

Figure 7-1. J3 signals and its LEDs

STO ch 1: STO input channel 1

STO ch 2: STO input channel 2

LED ch 1: Signal LED of channel 1 status see Figure 7-2 (STO1)

LED ch 2: Signal LED of channel 2 status see Figure 7-2 (STO2)

Motion command form the motion controller: the motion controller send command to the drive to start motion.

Motor feedback (like encoder) to safety PLC: motor feedback (like encoder or others) from motor to the PLC controller.

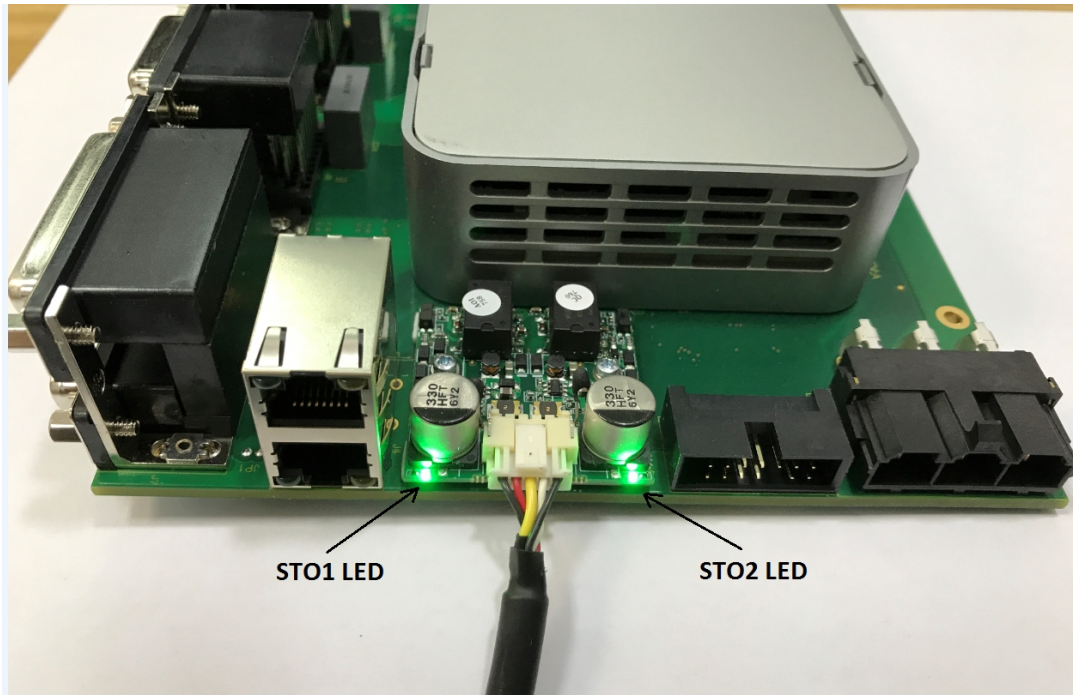

Figure 7-2. STO J3 connector and its LEDs

7.1.2 Manual test

The user tests the STO safe inputs by activating the STO function channel wise cyclically and checks that the LED's are off (STO1 and STO2, as in the picture above) depending by the activated channel.

The user is to test each input separately in the following sequence:

1. Activate both channels of STO, i.e. to disconnect the 24V of both STO inputs on J3.
2. Make sure both LEDs, STO1 and STO2 are off.
3. Deactivate STO channel 1 only (apply 24V between pin 1 and 2 of J3).
4. Make sure STO1 LED is on and STO2 LED is off.
5. Disconnect the 24V from pin 1 and 3 of J3.
6. Connect 24V between pins 4 and 5 of J3.
7. Make sure STO2 LED is on and STO1 LED is off.
8. Reconnect both STO channels (deactivate the both STO channels).
9. Make sure both LEDs, STO1 and STO2, are on.

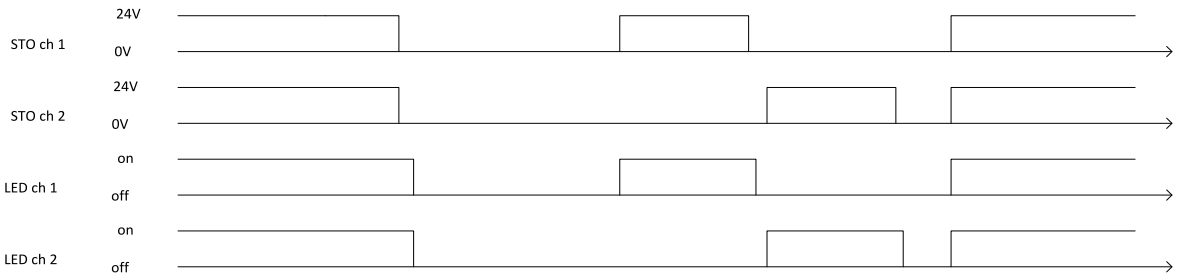

Figure 7-3. J3 signals and its LEDs

Smarter Motion

1 Hataasia St
Ramat Gabriel Industrial Park
Migdal Ha'Emek 2307037 Israel
Tel: (+972) (4) 654 6440 Fax: (+972) (4) 654 6443

ACS MOTION CONTROL