OPEN DRIVE

OPEN DRIVE

STO System Handbook

Rev. 1.1

TDE MACNO

MAOPDX0050E0

LIST OF CONTENTS

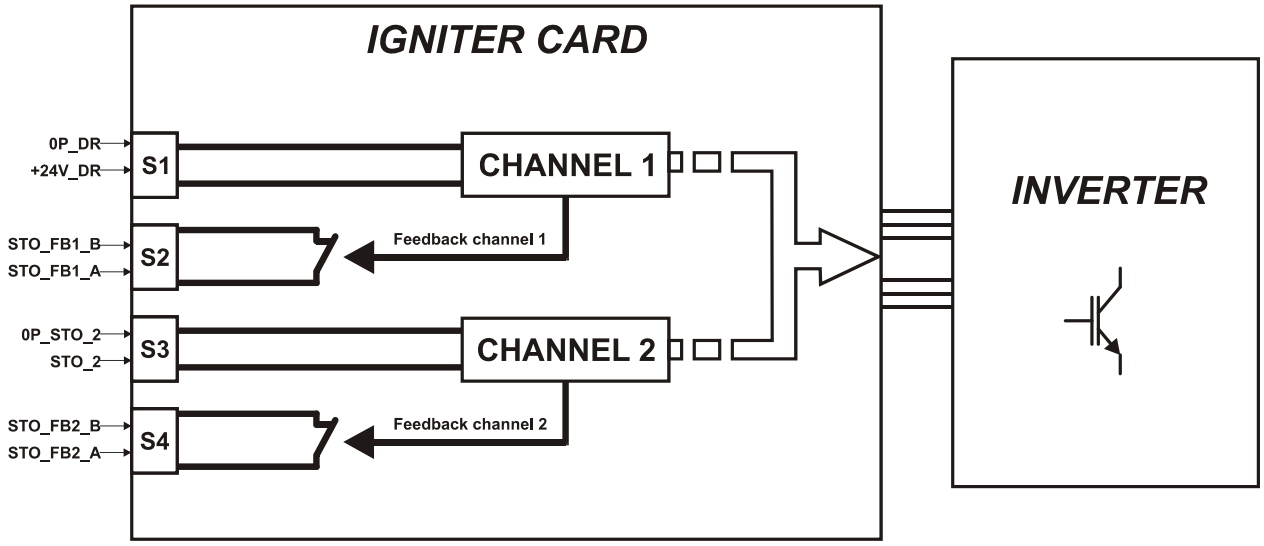
KEY TO SYMBOLS

Caution

Danger

1 General description

The OPEN DRIVE converter implements the Safe Torque Off (STO) system to prevent unexpected starting according to the EN 61800-5-2 standards. This system prevents the creation of a rotating magnetic field by disconnecting the control voltage from the power semiconductors. Thanks to these systems, it will be possible to conduct short operations such as cleaning and/or maintenance work on the non-electrical parts of the machine without disconnecting either the drive power supply or the connection between power and engine. The STO system, therefore, will be managed by components with limited power which means that the cost of the elements used in the switchboards will be reduced.
The STO system is implemented using two redundant channels, each of which has its own feedback signal accessible from the outside. The operating diagram is as follows:



The input to channel 1 is +24VDR (terminal board S1) and its feedback signal is STO_FB1 (terminal board S2). The input to channel 2 is STO_2 (terminal board S3) and its feedback is STO_FB2 (terminal board S4). Each of the feedbacks refers to a clean N.C. contact which can be read by an external logic managing the STO system at machine level.

2 Use limitations

The environmental constraints of the OPEN DRIVE converter are listed in a section of the installation manual and refer to its normal operation. The following paragraphs serve to clarify the use limitations of the converter with a view to making sure that its correct operation continues also when the STO system has been activated.

2.1 Climate class

Class 3K3 according to EN 60721-3-3

Environmental parameter	Limits	Unit of measurement
working temperature (1)	0÷40	°C
humidity	5÷85	%
atmospheric pressure	70÷106 (2)	kPa
maximum surrounding air movement	1	m/s
maximum temperature gradient	0.5	°C/min
maximum thermal irradiation	700	W/m^2
condensation	NO	
precipitation with wind	NO (3)	
water other than rain	NO	
ice formation	NO	

(1) The climate class 3K3 includes a 5÷40°C use limitation, but the converter can work also if the environmental temperature is 0°C. The maximum operating temperature of the converter reaches 45°C. In this case, declass the rated power to 88%.
(2) The atmospheric pressure limitations correspond to a 0÷3000m a.s.l. operating range. In actual fact, above 1000m it will be necessary to declass the rated power of the converter by 1% every 100m.
(3) The converter must be installed in a switchboard and not outside.

2.1 Resistance to chemically active substances

Class 3C1R according to EN 60721-3-3

Environmental parameter	Maximum value	Unit of measurement
sea salts	NO	-
sulphur dioxide	0,01	mg/m^3
	0,0037	cm^3/m^3
hydrogen sulphide	0,0015	mg/m^3
	0,001	cm^3/m^3
chlorine	0,001	mg/m^3
	0,00034	cm^3/m^3
hydrochloric acid	0,001	mg/m^3
	0,00066	cm^3/m^3
hydrofluoric acid	0,001	mg/m^3
	0,0012	cm^3/m^3
ammonia	0,03	mg/m^3
	0,042	cm^3/m^3
ozone	0,004	mg/m^3
	0,002	cm^3/m^3
nitrogen oxide	0,01	mg/m^3
	0,005	cm^3/m^3

2.2 Resistance to vibrations

As regards vibrations, the OPEN DRIVE has the following use limitations:

10Hz ≤ frequency ≤ 57Hz	0.075	mm (width)
57Hz ≤ frequency ≤ 150Hz	1	g

In the event of vibrations exceeding the limits indicated above, suitable reduction measures will have to be adopted.

2.3 Protection and pollution degree

Protection degree	IP20
Pollution degree	2 (1)

(1) Non-conductive pollution and – occasionally and temporarily – conductive pollution generated by condensation.

2.4 Storage

2.4.1 Environmental storage conditions

temperature	-10÷60	°C
humidity	5÷95	%
condensation	NO	

2.4.2 Recovery procedure after storage

The converter cannot be used immediately after a storage period. To avoid converter failures, use the following recovery procedure.
PHASE 1:

Non-powered converter		
temperature	15÷35	°C
humidity	5÷75	%
condensation	NO	
Atmospheric pressure	86÷106	kPa
Recovery time (1)	1	h

(1) After this recovery time, there must be no trace of condensation inside or outside the operation (well—aired environment).

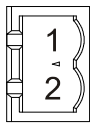
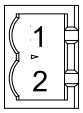
PHASE 2:
For long storage periods (one or more months) regenerate the electrolytic condensers of the power bus. Feed the converter from the terminal boards L1, L2 and L3 for 30min-1 hour without letting it run.

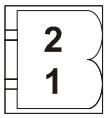
Once the regeneration process has been completed, the converter can work normally.

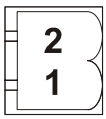
3 Adjustment and igniter feeding

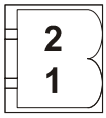
3.1 Terminal board description

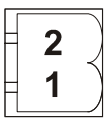
The following tables list the terminal boards used to feed the OPEN DRIVE cards and to perform the diagnostic work on the STO system.

Adjustment card feeding			
X3	**Pin**	**Name**	**Description**
03A÷60A  70A÷460A 	1 2	+24V 0P	+24V (22V÷26V) min. 600mA (OPD3-7-12-15A), min. 800mA (OPD22A), min. 1A (OPD32-40-48-60A) The terminal boards X3-1 and X3-2 power the adjustment card, the sensor in the motor and the cooling fans of the radiator.

CHANNEL 1 for STO system (ignitor card feeding)			
S1	**Pin**	**Name**	**Description**
	1 2	+24V_DR 0P_DR	+24V (22V÷26V) min. 200mA Powering voltage for the first of the two STO safety system channels. This channel powers the IGBT power drivers. When the drive is working normally, the +24V_DR driver must be provided. On the other hand, to enable the STO system, it is necessary to disconnect +24V_DR.

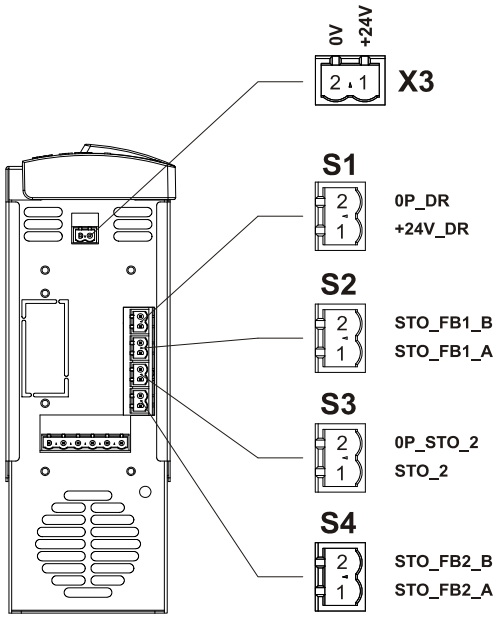
Monitor of CHANNEL 1 for the STO system (STO_FB1)			
S2	**Pin**	**Name**	**Description**
	1 2	STO_FB1_A STO_FB1_B	Clean N.C. contact max. 60Vdc max. 0.5A Monitor of the first STO system channel which indicates whether the IGBT drivers are powered or not. When the terminal board S1 is powered, the contact is open.

CHANNEL 2 for STO system			
S3	**Pin**	**Name**	**Description**
	1 2	STO_2 0P_STO_2	+24V (22V÷26V) min. 40mA Power voltage for the second of the two STO safety system channels. This channel powers the relay which disconnects the IGBT driver controls. When the drive is working normally the STO_2 must be powered. On the contrary, to enable to STO system, it is necessary to disconnect STO_2.

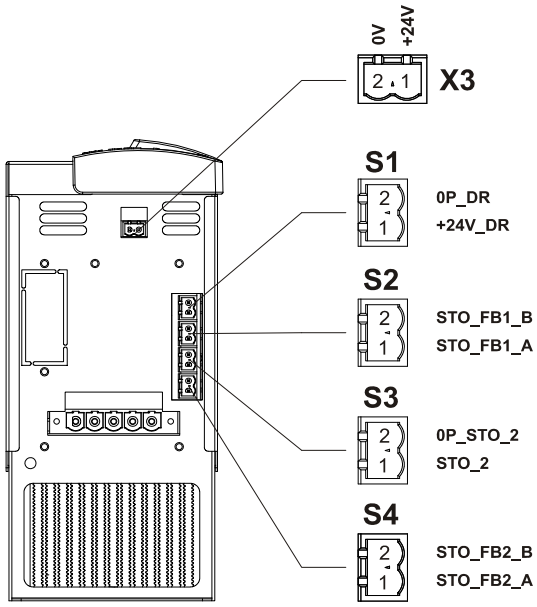
Monitor of CHANNEL 2 for the STO system (STO_FB2)			
S4	**Pin**	**Name**	**Description**
	1 2	STO_FB2_A STO_FB2_B	Clean N.C. contact max. 60Vdc max. 0.5A Monitor of the second STO system channel which indicates whether the relay which disconnect the IGBT drivers are powered or not. When the terminal board S3 is powered, the contact is open.

3.2 Terminal board positions

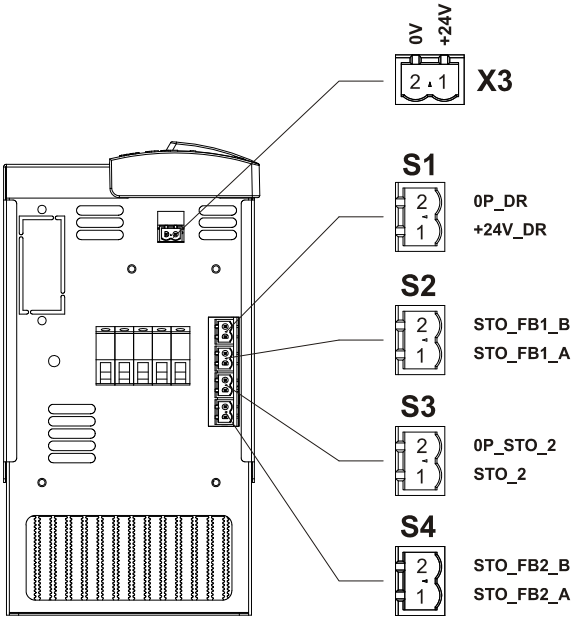
The X3, S1, S2, S3 and S4 terminal boards are placed on the same side as the converter as shown in the figures below



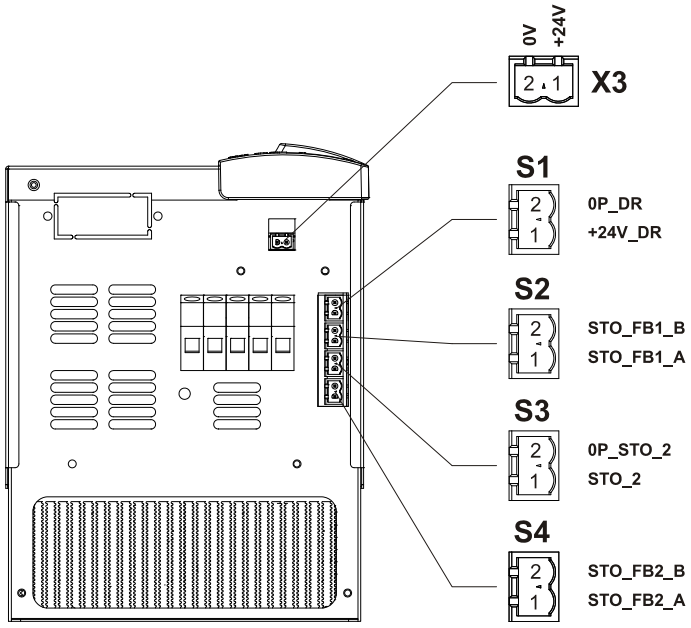
OPD SIZE. S



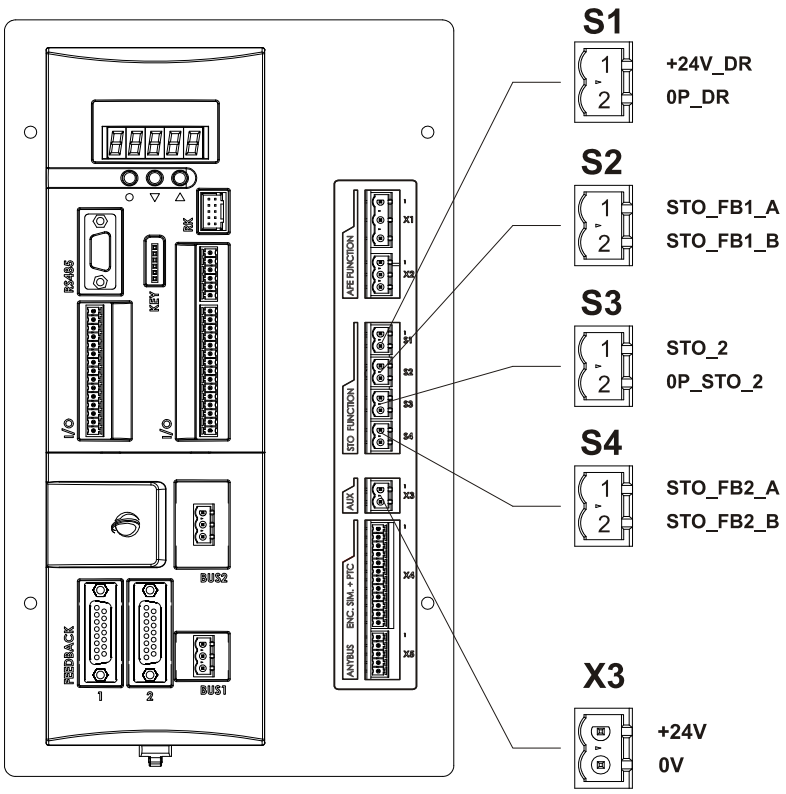
OPD SIZE. M



OPD SIZE. L



OPD SIZE. X


S1
1
2
+24V_DR
0P_DR
S2
1
2
STO_FB1_A
STO_FB1_B
S3
1
2
STO_2
0P_STO_2
S4
1
2
STO_FB2_A
STO_FB2_B
X3
+24V
0V
R3485
KEY
I/O
I/O
BUS2
BUS1
FEEDBACK
1
2
APE FUNCTION
STO FUNCTION
AUX
ANYBUS
ENC. SIM. + PTC
X1
X2
X3
X4
X5

CASE 1

4 External connections

The following paragraphs provide indications about the OPEN DRIVE connection only as regards the feeding of the adjustment card and STO safety system. For the remaining connections, please refer to the OPD installation handbook.
As indicated in par. 3.1, the terminal board X3 can be powered by the adjustment card (+24V). On the other hand, the terminal boards S1 and S3, power respectively the pilot drivers of the power IGBT and the relay which carries the controls of the adjustment card to the drivers.
The signals +24V_DR (referring to 0P_DR) and STO_2 (referring to 0P_STO_2) each relate to one channel of the STO safety system. For this reason it is particularly important to pay great attention when cabling these signals from the OPEN DRIVE to the safety module used on the switchboard.

a) For the X3 connection use a screened two-way cable whose strap must be connected to the 0P signal. Normally a screened cable is not required for adjustment powering. A screened cable is chosen to make sure that, in the event of failure of the powering cables, the safety system is disconnected. The reason is that:
   - the terminal board X3 is close to the terminal boards S1 and S3;
   - the powering cables for X3 and those for S1 and S3 will reach the converter inside the same conduit.

b) For the S1 connection use a screened two-way cable whose strap must be connected to the 0P_DR (S1-2) signal. A screened cable with the strap connected to 0P_DR serves to avoid disconnecting the safety system in the event of failure of the cables outside the converter. An example of this is the loss of insulation and subsequent accidental contact between one of the cables connected to 24V on the switchboard and +24V_DR.

c) For the S3 connection use a screened two-way cable whose strap must be connected to the 0P_STO_2 signal (S3-2). A screened cable with the strap connected to the 0P_STO_2 serves to avoid disconnecting the safety system in the event of failure of the cables outside the converter. An example of this is the loss of insulation and subsequent accidental contact between one of the cables connected to 24V on the switchboard and the STO_2 signal.

d) For the S2 and S4 connection, the type of cable to be used depends on how the diagnostic test on the safety chain is conducted. Some safety modules do not specify the type of cable to connect the signals used by the diagnostic system. The reason for this is that they are able to determine themselves whether there is a failure in these connections. If the diagnostic test on the safety channels is conducted directly by the manufacturer of the switchboard, it is necessary to determine whether this test is able to detect a failure in the connection cables. In the diagnostic test, failure of the monitor signal cables causes the test itself to fail. It is not possible to determine where the failure is: on the safety chain or on the monitor. The use of screened two-way cable for each of the two terminal boards S2 and S4, therefore, makes it at least possible to rule out a failure of the monitor signal connections

5 Description of STO operation on OPEN DRIVE

5.1 Enabling the STO system

If the converter is working normally, that is to say the STO system is disabled, it is necessary to power the +24V of the adjustment (X3), as well as +24VDR (S1) and STO_2 (S3). In this situation the clean monitor contacts (STO_FB1 on S2 and STO_FB2 on S4) will both have to be open.
To enable the safety system follow this procedure:

a) stop the motor
b) disconnect operation (1) (2)
c) disconnect +24V_DR (3)
d) disconnect STO_2 (3)

(1) it is possible to carry out operations a) and b) only by disconnecting operation if the converter settings include "stop at minimum speed" (C28=1). In this case the converter brings the motor to the minimum speed (set to zero through the parameter P50) then disconnects operation.
(2) in the presence of external influences (for example falling suspended loads), it might be necessary to take extra precautions (for example mechanical brakes) to prevent any risk.
(3) the sequence followed for items c) and d) is not relevant: for example the signals STO_2 and +24V_DR can also be temporarily disconnected.

CAUTION: enabling the STO system while the machine is running causes total loss of motor control. Enable the STO system only after its operation has been stopped following the procedure described above.

DANGER: the terminal boards +, -, U, V, W, F remain live. No maintenance work must be conducted and electrical component must not be touched.

CAUTION: after power has been disconnected, both channels take time to return to a safe condition. The times are indicated below.

CHANNEL 1	Maximum time after +24V_DR has been disconnected	1s
CHANNEL 2	Maximum time after STO_2 has been disconnected	20ms

DANGER: on brushless motors with permanent magnets, in the event of simultaneous failure of the two power switches, motor movement is possible up to 180° electrical equal to [180/n° polar motor couples] mechanical degrees.

In this situation the feedback contacts (STO_FB1 and STO_FB2) will both have to be closed.
Any discrepancy in only one of the monitor contacts compared to the converter status indicate a failure. In this case the safety system might not work correctly and needs to be immediately repaired.
Apart from the feedback contacts available outside, inside the OPEN DRIVE there is a feedback signal (only for channel 1) used by the adjustment card to manage this situation.
When the connection "enable safety stop only as signal" is disabled (C73=0 which is the default configuration), the converter indicates this status with the alarm presence A13 con d49=1. In this situation the logic output o17 "igniter card not powered" switches to high, the logic output o0 to low (the drive ready is disconnected) and the power insertion control is disconnected.
With the C73=1 connection, the converter still brings to a high level the logic output o17 "igniter card not powered", the power insertion control is disconnected but no specific alarm is generated and the logic output o0 "Drive ready" remains on high, that is to say the drive ready remains active (if no other alarms are present).

5.2 Disabling the STO system

To disable the STO system it is sufficient to power again +24V_DR (S1) and STO_2 (S3). Also in this case the sequence followed is not relevant.

CAUTION: From the moment the machine is powered, it takes time to disable the safety systems on both channels. The times are indicated below.

CHANNEL 1	Maximum time after the enabling of +24V_DR	100ms
CHANNEL 2	Maximum time after the enabling of STO_2	20ms

In this situation the feedback contacts (STO_FB1 ed STO_FB2) will both need to be open.
Any discrepancy in only one of the monitor contacts with respect to the converter status means that there is a failure. In this case the safety system might not be working properly and it needs to be repaired immediately.
In the case of the adjustment card, to return to the normal operation conditions it is necessary to do the following.

C73=0
Wait at least 100ms after introducing +24V_DR, then enable the alarm reset. In this condition the o17 logic output "igniter card not powered" reaches a low level. The o0 logic output "Drive ready" is on high which means that the converter is ready to work.

C73=1
The converter behaves in the same way as with C73=0 except that it is not necessary to enable the alarm reset.

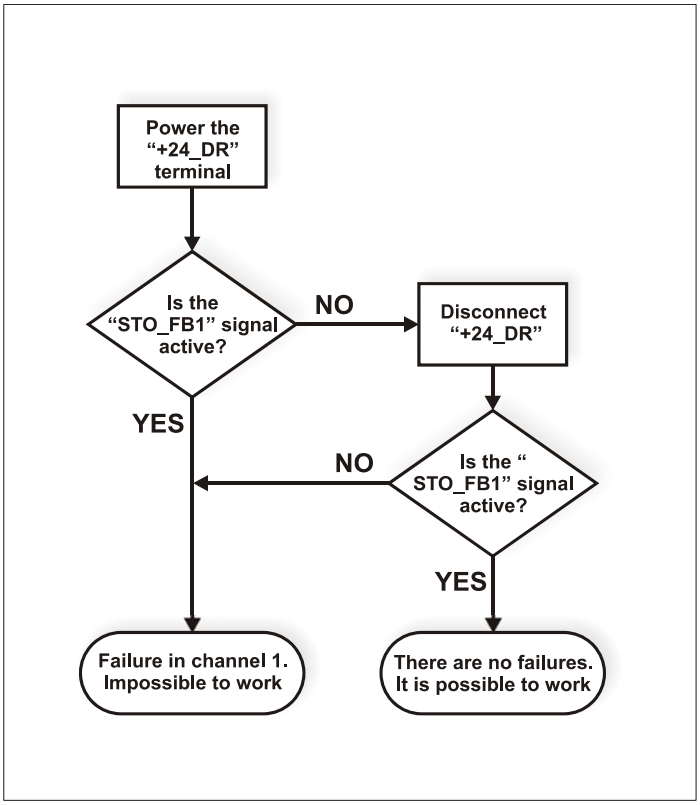
6 Diagnostic system

When the safety system is enabled, the feedback signals indicate whether it has been correctly performed. Make sure that:

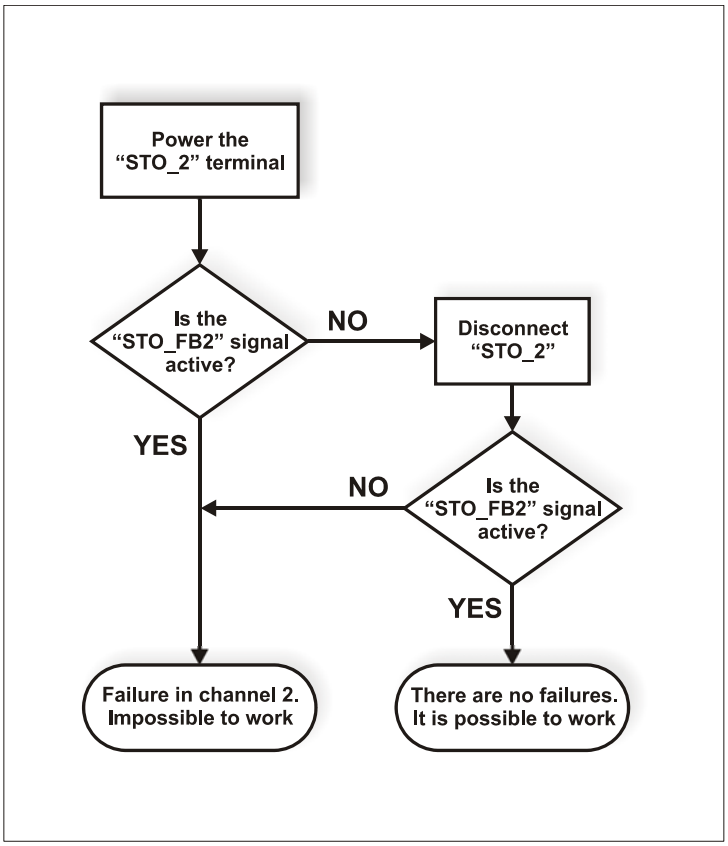
a) the feedback signals are monitored every time the machine on which the operation is to be assembled is started. The machine must be started only if the feedback contacts STO_FB1 ed STO_FB2 are both closed (both feedback signals “active”);
b) the reset control which releases the machine from the “emergency stop” condition is enabled only if the feedback contacts are both closed during the emergency stop.

See paragraph 7 for some examples of connections which meet these requirements.

By observing the consistency between the feedback signals and the presence or not of the incoming voltage powering the two STO channels, it is possible to conduct control sequences to detect some failures. The sequence for channel 1 is as follows:



The sequence to be followed for channel two is as follows:

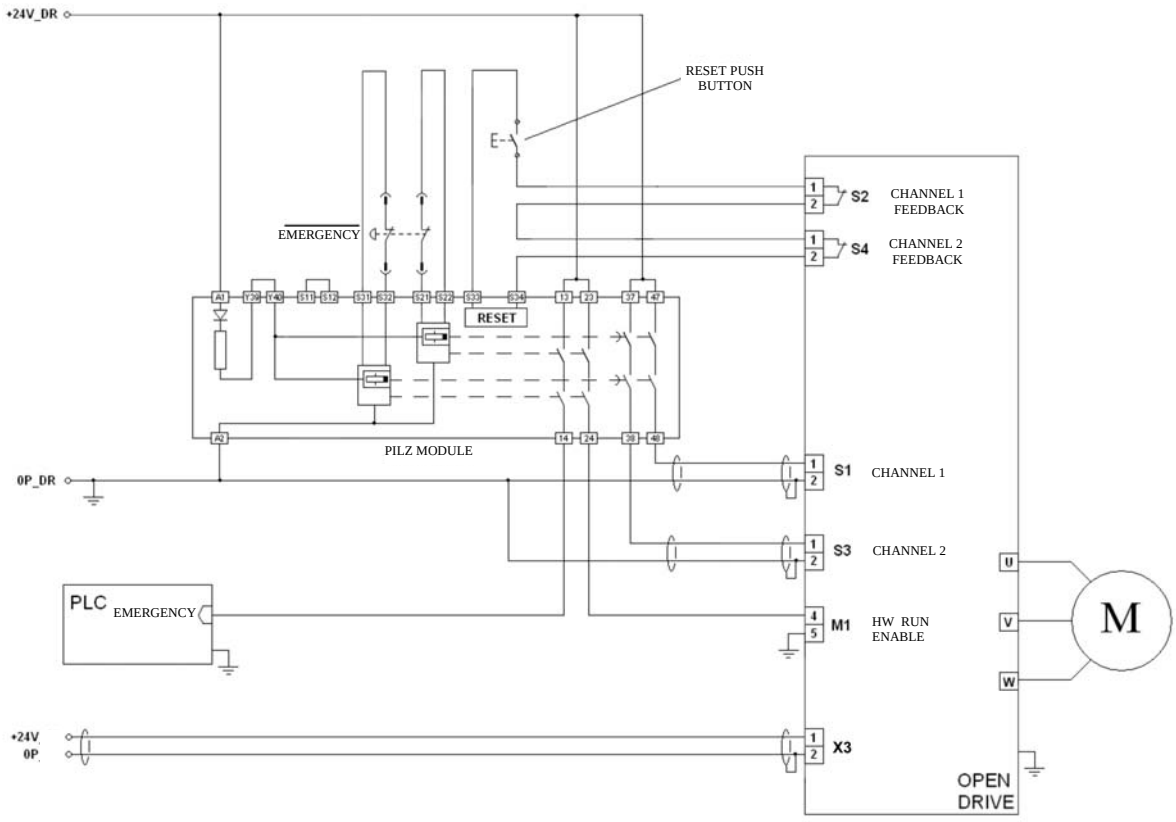


If the diagnostic test detects a failure, the converter must be immediately repaired, otherwise there could be a malfunction in the safety system during the subsequent intervention request.
It is recommended to conduct these tests on a regular basis after stopping the machine. In any case it is compulsory to meet at least conditions a) and b) described above.

7 Application examples

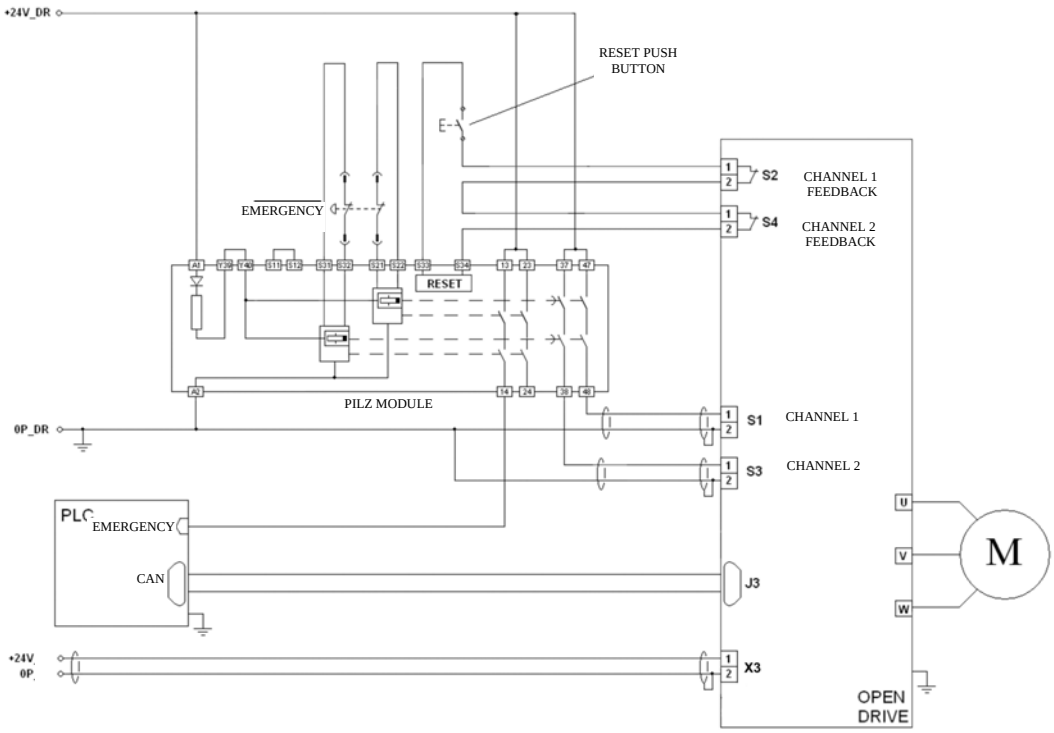
The following are some application examples of the STO system. In the various examples the OPD connector is linked to a safety module; regardless of the type of connection used, the safety module must be set in order to have a controlled manual start and not an automatic start. Moreover the feedback contacts must be connected in series to the reset button.
In this way the machine is started, and therefore operated, with the safety module on and it will be mandatory to press the reset button to enable its starting. This is necessary in order to conduct, when the machine is started, a test on the feedback signals.

Example 1 illustrates the use of a Pilz PNOZ XV2 safety module which includes two relays each of which has two immediate contacts and two timed contacts that are triggered after an adjustable delay. One of the activated systems in the converter is “stop with minimum speed” (the connection C28=1 needs to be set). If the emergency button is pressed, the start consent control is immediately disconnected from the converter causing its controlled stop. The PLC is informed that the emergency button has been pressed through the connection to its digital input. After a given delay, also the timed contacts of the Pilz module are opened which enable the two channels of the STO system, only when the motor has already been stopped. The delay time must be longer than the controlled stop time.
The feedback contacts of the STO systems are connected in series to the reset button which makes it possible to leave the emergency stop condition. Therefore, resetting is enabled only if the feedback contacts are closed at the same time as the STO system is enabled. If this does not happen, it means that there a failure has occurred in the converter and the feedback contact will remain open. This makes it possible to check the feedbacks of the STO system every time the machine is reset.



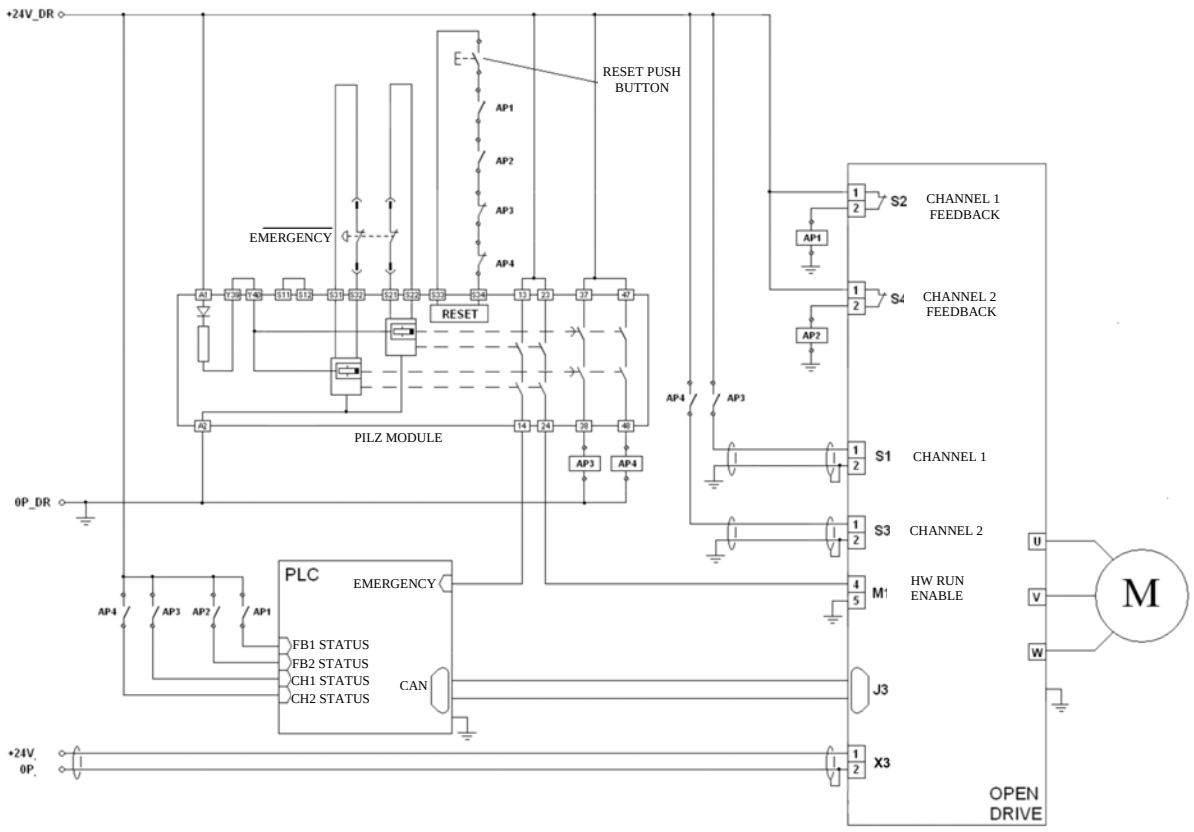
Example 1

Example 2 is a diagram where the operation is started by a field bus and therefore it is the PLC itself which, having read the "emergency" signal, controls the converter to activate the motor stop procedure. As is example 1, also in this case, the STO system is activated by the timed contacts of the Pilz module.



Example 2

Example 3 shows an application where the PLC is able to read both the status of the incoming STO signals and the feedback signals. This means that it is possible to conduct a regular check on the PLC which compares the incoming status with the feedback status. If the PLC notices a discrepancy, it means there is a failure which will be reported.



Example 3

8 Technical data

EN 61800-5-2	
SIL	2
PFH	$8{,}4 \cdot 10^{-8}\ h^{-1}$
Hardware Fault Tolerance	1
Lifetime	10 years

UNI EN ISO 13849-1	
PL	D
Class	3
$MTTF_d$	39.6 years

CERTIFICATE
of Conformity

TÜVRheinland®

Registration No.: AK 60026361 0001

Report No.: 28102343 003

Holder:
TDE MACNO S.p.A.
via dell'Oreficeria, 41
36100 Vicenza VI
Italia

Product:
Machinery Accessory
Adjustable speed electrical power drive system

Identification:
OPD 03A OPD 07A OPD 12A OPD 15A OPD 22A
OPD 32A OPD 40A OPD 48A OPD 60A OPD 05A-310Vdc
OPD 20A-310Vdc OPD 35A-310Vdc OPD 50A-310Vdc

Only the "safe torque off" (STO) safety function has been evaluated and found to comply with:
* PL=d, according to EN 13849-1:2008
* SIL 2, according to EN 61800-5-2:2007

Tested acc. to:
EN ISO 13849-1:2008
EN 61800-5-2:2007

The certificate of conformity refers to the above mentioned product. This is to certify that the specimen is in conformity with the assessment requirement mentioned above. This certificate does not imply assessment of the production of the product and does not permit the use of a TÜV Rheinland mark of conformity.

Certification Body

TÜV Rheinland Product Safety GmbH Zertifizierungsstelle

Cologne, 05.08.2009

Dipl.-Ing. M. Leone

TÜV Rheinland Product Safety GmbH - Am Grauen Stein - D-51105 Köln