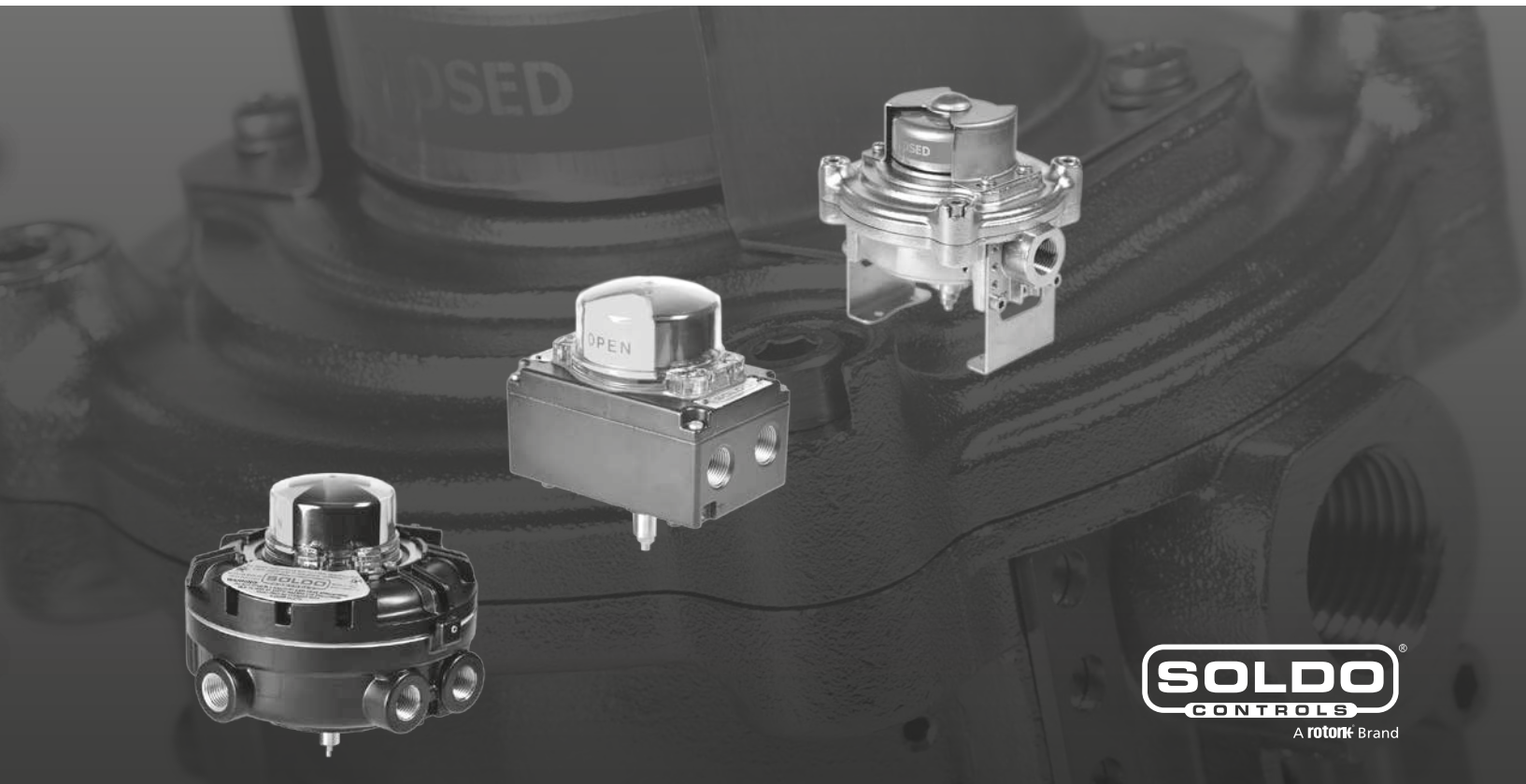


rotork®

Keeping the World Flowing
for Future Generations

Limit Switch Boxes

Safety Manual



SOLDO
CONTROLS
A rotork® Brand

Models: SS, SF, SB, HW, SX, SW, SY, SH, SI, CS, CA, XA, SK, SQ, SP. Microswitch Bolt Switch: BM, TB, BX, BJ

Contents

Section	Page
Introduction	2
1. Specification of the safety functions	3
2. Warnings	3
3. Configuration of the product	4
4. Limitation of use	7
5. Failure modes and estimated failure rates	7
6. Test and maintenance requirements	8
7. Troubleshooting	10
8. Hardware fault tolerance	11
9. Classification	11
10. Mean repair time	11
11. Common cause factors	11
12. Systematic capability	11

Introduction

Soldo® limit switch boxes are used as position indicators, by means of an electrical signal, if they mount microswitches or sensors, or by means of an analogue signal if they mount position transmitters. They can also have both signals when they mount both electrical devices.

Transmitters can be of the following types:

- Siemens SITRANS TH320/420
- PR electronics 5437D

These, combined with a potentiometer, become position transmitters.

The purpose of this Safety Manual, written in compliance with IEC 61508-2, Annex D, is to give all the necessary information to the system integrator for a correct use of the product in Safety Instrumented Systems for SIL classified applications.

1. Specification of the safety functions

The safety function is of 2 types:

Type A – Switches

The device is classified Type A according to IEC 61508-2.

The safety function is defined as follows:

1. **De-energize-to-trip operation:** when the actuator, on which the device is mounted, starts to drive the emergency valve to its safe position.
2. **De-energize-to-trip operation:** when the actuator, on which the device is mounted, reaches the “safe position”.

NOTES: the above-mentioned safety functions can be considered equivalent. In both cases, the safety function shall correspond to the situation in which the switches pass from “operating position” to “released position”, that is, the limit switch box, when used with safety function, shall work in “deenergize-to-trip” mode, and shall be configured in that way to perform the safety function.

The response time for the activation of the safety function is less than 10 ms.

The choice of the safety function to be implemented is the responsibility of the system integrator.

Type B – Position Transmitters (available for models SS, SF, SB, HW, SX, SW, SY, SH, SI)

The device is classified Type B according to IEC 61508-2.

The safety function is defined as follows:

1. Correct measuring of the position of the actuator on which the device is mounted (normally angular position), and generation of 4-20 mA output signal proportional to the position, within ± 2 % of tolerance.

The product has normally a single channel configuration (only one input is measured, only one current output is generated), with HFT=0.

A redundant (1oo2) configuration can be obtained in these ways:

- with one single micro switch box, internally completely redundant (2 potentiometers, 2 position transmitters, 2 separate outputs)
- with two micro switch boxes, each one internally in a single channel configuration

In both cases, the two analogue outputs shall be voted 1oo2 by the downstream controller.

The minimum response time is the following (in case no digital filter is applied):

- with position transmitters Siemens TH320/420 and PR electronics 5437D: ≤ 75 ms

NOTE: In the following paragraphs, a distinction between Type A and Type B is used, where necessary.

2. Warnings

The IEC 61508 standard describes a package of general requirements for every phase of the lifecycle of safety systems. The reliability analysis performed has shown that these products are suitable for use in such systems for safety class SIL 2 or SIL 3 according to switch options and barriers used.

For installation, maintenance, test and commissioning of these rotary switch boxes, the documents prescribed by the IEC 61508 standard should be used. Depending on the determined SIL class (2 or 3), they also prescribe the required measure of authority, skills and independence of the concerning personnel. All indications and prescriptions within the subjoined general installation and maintenance instructions are the basis for these above-mentioned documents. In order to warrant the reliability, the supplemental prescriptions mentioned below, should be observed as well:

- Suitably trained personnel shall carry out installation in accordance with applicable code of practice
- The user should not repair this equipment
- If the equipment is likely to come into contact with aggressive substances, it is the responsibility of the user to take suitable precautions that prevent it from being adversely affected, thus ensuring that the type of protection is not compromised

Aggressive substances – for example, Acidic liquids or gases that may attack the switch box housing
- The electrical ratings on nameplates or on adhesive labels on the enclosure must be respected, otherwise the product’s SIL grade will not be guaranteed
- PEPPERL & FUCHS SIL certified barriers must be used in conjunction of the correct P+F proximity switches as described in PEPPERL & FUCHS documentations for SIL applications
- Operational testing shall be performed according to the following indications:
 - Maximum applicable voltage: 24 Volt DC. Line monitoring system works only if Terminals 1-2 and 4-5 (normally closed) or 2-3 and 5-6 (normally open) are connected; don’t connect terminals that are normally open and normally closed
 - This safety manual must be used in conjunction with the safety manual for the position transmitter included in the device: Siemens TH320/420 (Paragraphs 4, 14 and 15), or PR Electronics 5437D (Paragraphs 7, 17 and 18)

3. Configuration of the product

Type A: Microswitch box configurations

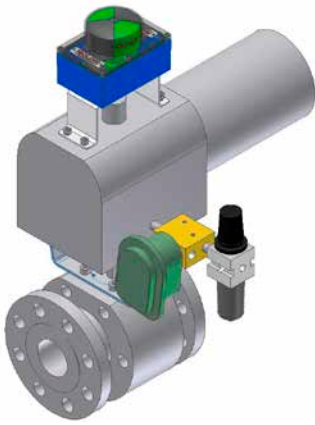


Fig. 1. Actuator mounted in open position

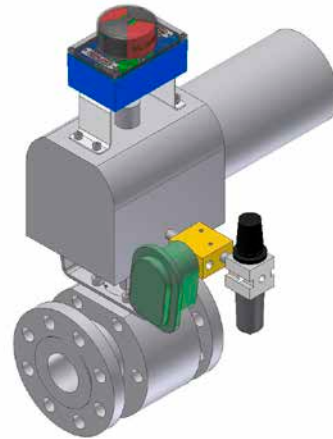


Fig. 2. Actuator mounted and moved in closed position

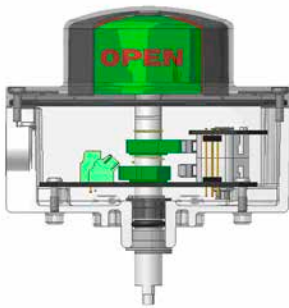


Fig. 3. Box & microswitches in open position

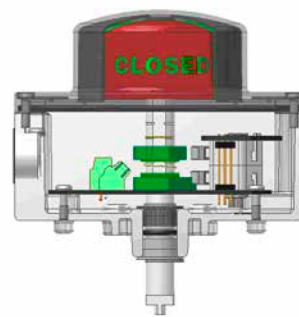


Fig. 4. Box & microswitches in closed position

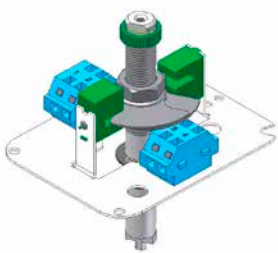


Fig. 5. Two slotted proximity sensors

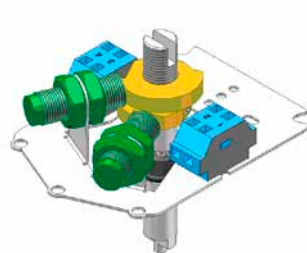


Fig. 6. Two cylindrical proximity sensors



Fig. 7. Two mechanical sensors



Fig. 8. Three magnetic sensors

3. Configuration of the product

Type A: Microswitch box configurations (continued)

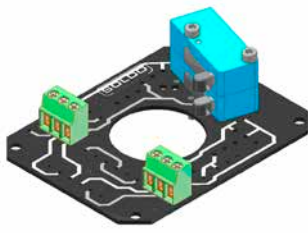


Fig. 9. Two microswitches configuration

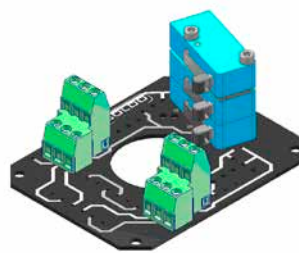


Fig. 10. Three microswitches configuration

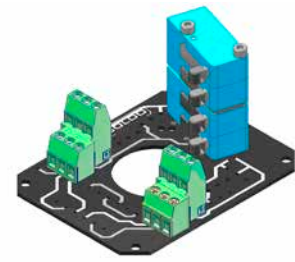


Fig. 11. Four microswitches configuration

Type A: Easy switch configuration

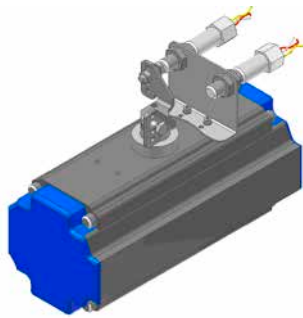


Fig. 12. Bolt switches in closed position

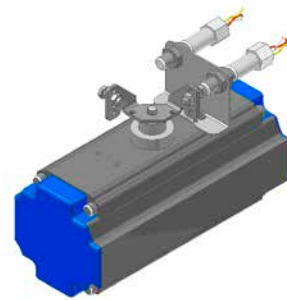


Fig. 13. Bolt switches in open position

Type B: Position transmitter configurations

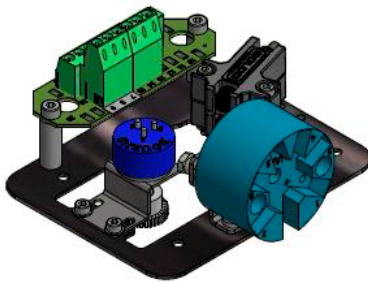


Fig. 14. 4-20 mA position transmitter and microswitches configuration

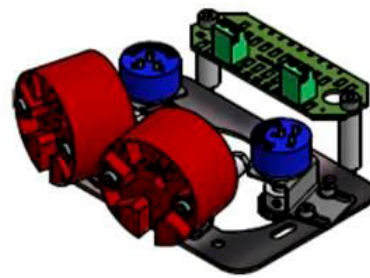


Fig. 15. 4-20 mA redundant position transmitter configuration

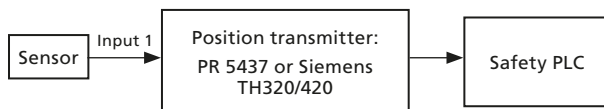


Fig. 16. Single transmitter 1oo1 operation

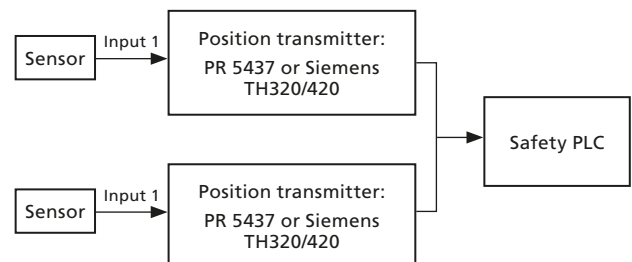


Fig. 17. Two transmitters 1oo2 operation

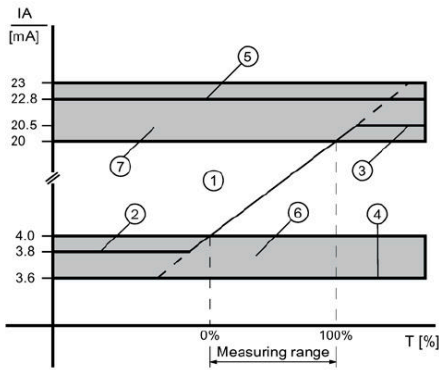
3. Configuration of the product

Default parameters

Siemens TH320/420 and PR 5437D

- Safety error: 3.5 mA or 23 mA (defined as a failure signal). The devices enter this mode if the system detects a safety related error in Safety Operation mode. The possible errors are listed in the error list of the device.

Function/Parameter	Setting
Output range 0%	4.0 mA (20 mA overturned potentiometer)
Output range 100%	20.0 mA (4 mA overturned potentiometer)
Limit Check Configuration	Enabled
Output Limit – Error value	Must be ≤ 3.6 mA or ≥ 21.0 mA (if enabled on output)
Output Lower Limit	3.8 mA
Output Upper Limit	20.5 mA
Sensor Error Action	“Broken and Shorted”
Broken Sensor - Error Value	23.0 mA
Shorted Sensor - Error Value	3.5 mA
Sensor Drift - Error Value	Must be ≤ 3.6 mA or ≥ 21.0 mA (if enabled)
Input Limits - Error Value	23.0 mA
Analogue Output Calibration Gain	Must be 1.0 (calibration of output current is not allowed)
Analogue Output Calibration Offset	Must be 0.0 (calibration of output current is not allowed)
Loop Current Mode	“Enabled” (HART® 7 only)
HART® Polling Address	0 (HART 5 only)
Damping (Response time)	0 sec



- ① Linear control range
- ② Lower limit of the control range (default value = 3.80 mA)
- ③ Upper limit of the control range (default value = 20.5 mA)
- ④ Lower fault current value (default value = 3.6 mA)
- ⑤ Upper fault current value (default value = 22.8 mA)
- ⑥ Recommended setting range for lower fault current range and lower control range limit
- ⑦ Recommended setting range for upper fault current range and upper control range limit

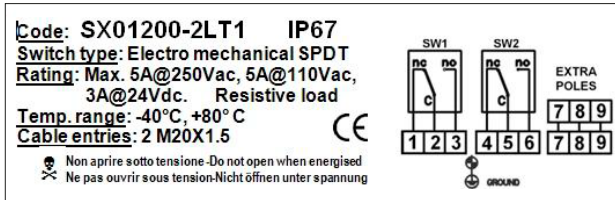
4. Limitation of use

Type A

Environment

Standard versions are suitable for ambient temperature from -20 to +80 °C. Microswitch boxes and bolt switches for low and high temperature are available on request.

Environmental limits are indicated on the product nameplate as indicated on the sample below.



NOTE:

For the specific case of Pepperl+Fuchs proximity switch model SJ3,5-SN, the lower temperature of the switch working limit has been improved by Rotork Instruments Italy and assessed by the Certification Body from -40 °C (P+F declared value) down to -50 °C by performing the following tests:

- 1,000,000 cycling test at -50 °C checking the functionality during the test
- Two weeks stall test at -50 °C checking the functionality at the end of the test

Pepperl+Fuchs proximity switch model SJ3,5-S1N is qualified for safety functions in a temperature range from -25 to +100 °C and model NJ4-12GK-SN is qualified for safety functions in a temperature range from -40 to +100 °C.

For Werner Turck proximity switches the ambient temperature range is -25 to +70 °C for all models with exceptions that can reach -55 °C and +100 °C.

Lifetime

The lifetime is estimated to be of 20 years.

Type B

Environment

The ambient operating temperature range of Siemens TH320/420 and PR 5437D is -40 to +80 °C.

Environmental limits are indicated on the product nameplate.

Lifetime

The useful lifetime of the Siemens TH320/420 and PR Electronics 5437D is 15 years.

After this the user must replace the products.

5. Failure modes and estimated failure rates

Please refer to the values of λ and SFF included in the latest valid version of SIL certificates available on www.rotork.com/en/ documents, and choose Product – Soldo Switch Box.

NOTES FOR SOLDOTM BOLT – TYPE A:

- No internal diagnostics is included in the device. Diagnostic is only possible via external means as described in par. 6.
- The random failure rates are estimated in the following way:
 - FMEDA of the product
 - Performing of cycling test at low and high temperature
 - Evaluation of field feedback

Rotork Instruments Italy has an effective system to manage field feedbacks, including failure and root cause analysis.

NOTES FOR SOLDOTM MICROSWITCH BOXES – TYPE B:

- The random failure rates are estimated with a FMEDA of the product

6. Test and maintenance requirements

6.1 Proof test

Type A

The proof test should be performed at least once a year, during the testing of the actuator-valve assembly on which the device is mounted.

The "Proof Test" of the device corresponds to the "Full Stroke Test" of the actuator-valve assembly. Considering the functioning of the microswitch, the "Proof Test Coverage" can be considered 100%.

Type B

The proof test should be performed at least once a year, during the testing of the actuator-valve assembly on which the device is mounted.

The procedure is the following:

Step	Action
1	Bypass the safety PLC or take other appropriate action to avoid a false trip/measurement.
2	Disconnect the input signal(s) from the input terminals and connect instead a simulator suited for simulating the actual input setup for each active input channel.
3	Apply input value(s) to each active channel, corresponding to 0% and 100% output range.
4	Observe whether the output acts as expected.
5	Restore the input terminals to normal operation, that is, re-connect the input signal(s).
6	Measure the process value at the connected input(s) and observe that the output current corresponds to the applied input value(s).
7	Remove the bypass from the safety PLC or otherwise restore normal operation.

6.2 Line monitoring

In order to properly detect the fault in the field wiring, additional resistance is required at the switch in the field. The addition of a 1 k Ω resistor in series and 10 k Ω resistor in parallel to the switch allows a small amount of current ($i_1 < i$) to flow when switch changes status from NC to NO, allowing the IS barrier to detect an open or short of the field.

Line monitoring introduction

Soldo™ line monitoring system provides four 10 k Ω resistors to allow the customer to choose if connecting normally open logic or normally closed logic.

Line monitoring system works only if the customer connects terminals 1-2 and 4-5 (normally closed) or 2-3 and 5-6 (normally open).

Line monitoring is available with:

- Electro-mechanical SPDT, max 4 provided
- Electro-mechanical DPDT, max 2 provided
- Electro-magnetic N1 and N3, max 4 provided
- Reed type SPDT, max 4 provided
- Reed type DPDT, max 2 provided

Line monitoring performances

- Maximum applicable voltage: 24 VDC
- Switch 1 and 2 in NC position: circuit resistance 11 k Ω
- Switch 1 and 2 in NO position: circuit resistance 11 k Ω

6. Test and maintenance requirements

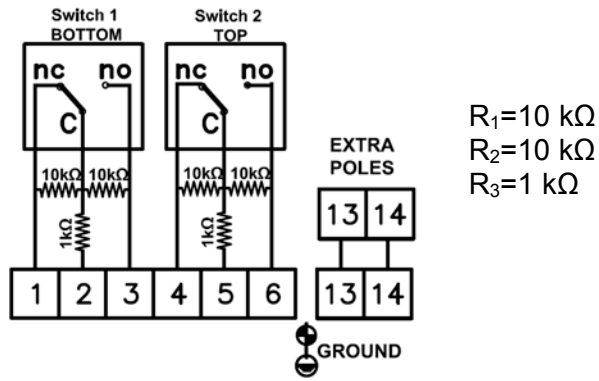


Fig. 18. 1° wiring diagram: 2 switches SPDT

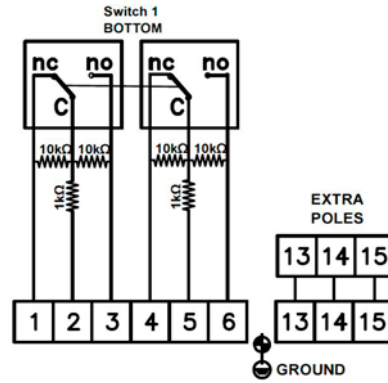


Fig. 19. 2° wiring diagram: one switch DPDT

Detected faults

Fault	Effect in NC	Effect in NO
Open circuit R_1	Not relevant*	Open circuit
Open circuit R_2	Open circuit	Not relevant*
Open circuit R_3	Open circuit	Open circuit
Change of R_1 value	Not relevant*	$R \neq 11 \text{ k}\Omega$
Change of R_2 value	$R \neq 11 \text{ k}\Omega$	Not relevant*
Change of R_3 value	$R \neq 1 \text{ k}\Omega$	$R \neq 1 \text{ k}\Omega$

* fault is not relevant to the safety function of Paragraph 1

Excluded faults

According to EN/ISO 13849-2 standard, the short circuit condition can be excluded because the resistor is of the film type.

6.3 Partial stroke

In the case of Partial Stroke Test, the 0° position microswitch is tested at 100%, while the 90° position microswitch is not tested.

6.4 Periodical maintenance

No specific periodic maintenance is required.

7. Troubleshooting

Type A

Problem	Possible causes	Solutions
Switches do not work	Incorrect wiring	Correct the wiring
Switches do not work	Switches damaged	Substitute
Visual position indicator does not properly indicate valve position	Fixing screw not properly fixed	Fix it
Open circuit	Electrical failure	PCB substitution
Random change of resistance value	Electrical failure	PCB substitution

Please note that, with the use of Pepper+Fuchs fail-safe interface (when the proximity switch allows it), the values of λ_{dr} , PFD_{AVG} and SFF are improved, and globally adequate for SIL 3 application.

Type B

On detection of a fault, the output goes out-of-range (Safe State), according to the following table.

Micro switch box series	Output behaviour on detection of a fault
Soldo™ micro switch boxes with position transmitters Siemens TH320/420 / PR electronics 5437D	Output ≤ 3.6 mA or Output ≥ 22.8 mA

A suitable configuration tool is able to show the diagnostic message describing the detected error:

- If the fault is caused by a sensor error or sensor wiring, the LED on transmitter will flash red and the correct output current will automatically be re-established when the fault has been corrected
- If the fault is in the device itself (detected by internal diagnostic measures), the LED on the transmitter will light constantly RED

There are 2 ways of bringing the device out of Safe State:

1. Power-cycle the device
2. Reset the device by using a configuration tool that supports a reset of the device. If the error is persistent, the device will enter the Safe State again

8. Hardware fault tolerance

Type A

The normal HFT of the device is 0, unless the case of microswitch boxes (for example, using Nova V3 DPDT switch) or bolt switches in which two microswitches are used "in parallel" to obtain redundancy. The connection to obtain this redundancy is up to the final user.

Route 2_H for architectural constraints is applied.

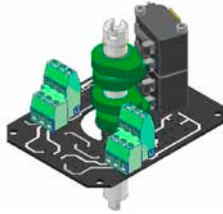


Fig. 20. shows an example of realization of a redundant configuration

Type B

The product has normally a single channel configuration, HFT=0. A 1oo2 configuration can be obtained as follows:

- with one single micro switch box, internally completely redundant (2 potentiometers, 2 position transmitters, 2 separate outputs)
- with two micro switch boxes, each one internally in single channel configuration In both cases, the two analogue outputs shall be voted 1oo2 by the downstream controller

9. Classification

Type A

The product is classified Type A according to IEC 61508.

Type B

The product is classified Type B according to IEC 61508.

10. Mean repair time

In case of failure, the complete limit switch box must be substituted. So the mean repair time (MRT) is four hours (conservative value).

The MRT is estimated considering availability of skilled personnel for maintenance, spare parts and adequate tools and materials on site (that is, it encompasses the actual time to repair and the time before the component is put back into operation).

11. Common cause factors

The Common cause factors, relevant when the product is used in redundant configuration, are:

$$\beta = \beta_D = 0.05$$

NOTES:

The above value is the value for 1oo2 architecture. The values for other architectures shall be calculated according to IEC 61508 Part 6, Table D.5.

The above value is calculated in the hypothesis of redundancy without diversity.

12. Systematic capability

The systematic capability of the device is 3.

This systematic capability is guaranteed only if the user:

1. Uses the device according to the instructions for use
2. Uses the device in the appropriate environment

rotork®



www.rotork.com

A full listing of our worldwide sales and service network is available on our website.

Rotork plc
Brassmill Lane, Bath, UK
tel +44 (0)1225 733200
email mail@rotork.com

PUB109-157-00 / IOM00069_ENG rev. 0-6
Issue 03/23

As part of a process of on-going product development, Rotork reserves the right to amend and change specifications without prior notice. Published data may be subject to change. For the very latest version release, visit our website at www.rotork.com

The name Rotork is a registered trademark. Rotork recognises all registered trademarks. Published and produced in the UK by Rotork. POLTG0323