OCTOGON

MANUAL

ESMA

STRAIN GAUGE BRIDGE AMPLIFIER SIL3 / PL e

Safety Measuring Module SIL3 · Operating manual



Document	Version	Date	Applies to
Operating manual	V00x	10/2026	ESMA

This manual describes the Safety Measuring Module ESMA in the DIN rail enclosure: function, operational data, safety ratings, installation and connection, start-up and the evaluation concept of the safety controller (Safety PLC).

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1 General

– The Safety Measuring Module ESMA, described in this user manual, is carefully designed and manufactured using state-of-the-art technology. All components are subject to stringent quality and environmental criteria during production.

– This operating manual includes important information on handling the device. Basis for safe working is the observance of all given safety and work instructions. It is part of the product and must be kept in the immediate vicinity of the device and readily accessible to skilled personnel at any time.

– Observe the relevant local accident prevention regulations and general safety regulations for the device's range of use.

– The manual provides a full description of the Safety Measuring Module ESMA and skilled personnel must have carefully read and understood the operating instructions, prior to beginning any work.

– The manufacturer's liability is void in the case of any damage caused by using the product contrary to its intended use, non-compliance with these operating instructions, assignment of insufficiently qualified skilled personnel or unauthorised modifications to the device.

– If the serial number gets illegible (e. g. by mechanical damage), the retraceability of the device is not possible any more.

– The general terms and conditions contained in the sales documentation shall apply.

– The Safety Measuring Module is subject to technical modifications.

– Further information: www.octogon.org · office@octogon.org

2 Short description

– The Safety Measuring Module ESMA is a safety-related measuring amplifier, which meets the requirements for the functional safety according to the standards IEC 61508 / EN 62061 (SIL3) and the requirements of the standard EN ISO 13849-1, Performance Level „e“, Category 3. The Safety Measuring Module is suitable for load and force sensors with different bridge signals. For a safety-related application (SIL3), an additional Safety PLC with an implemented diagnostic software is necessary.

– The ESMA is the product type DIN rail enclosure with separate load/force cell. The complete safety-oriented system (SIL3) always consists of a sensor, a Safety Measuring Module and a connected safety diagnostic unit (Safety PLC).

2.1 Applications

Application fields of the Safety Measuring Module are all areas in which safety-related measuring systems are absolutely necessary. Examples: airport, crane systems, theatre.

3 Transport, packaging, storage

– Transport: Check the device for any damage that may have been caused during transportation. Obvious damage must be reported immediately.

– Packaging: Do not remove packaging until just before mounting. Keep the packaging as it will provide optimum protection during transport (e.g. change in installation site, sending for repair).

– Storage: Avoid exposure to the following factors:
  – Direct sunlight or proximity to hot objects
  – Mechanical vibration, mechanical shock (putting it down hard)
  – Soot, vapour, dust and corrosive gases
  – Moisture or wet environment

Store the device in its original packaging in a location that fulfils the conditions listed above.

4 Personnel qualification

WARNING Risk of injury if qualification is insufficient!

– For installation and starting of the devices the personnel has to be familiar with the relevant regulations and directives of the country and must have the required qualifications.

– Particularly the qualified personnel has to undergo a briefing or training about the use and handling of safety-related products according to the functional safety (SIL3, PL „e“ – Category 3).

– The activities described in these operating instructions may only be carried out by skilled personnel with appropriate qualifications. They have to be capable of carrying out the work as described responsibly and can independently recognize potential hazards. Depending on operational conditions, they need to have the corresponding knowledge.

5 Functional description

The block diagram below shows the structure of the safety measuring system. The safety-related measurement chain consists of a sensor (full bridge), a ESMA, a Safety PLC with a diagnostic software and connected actuators.

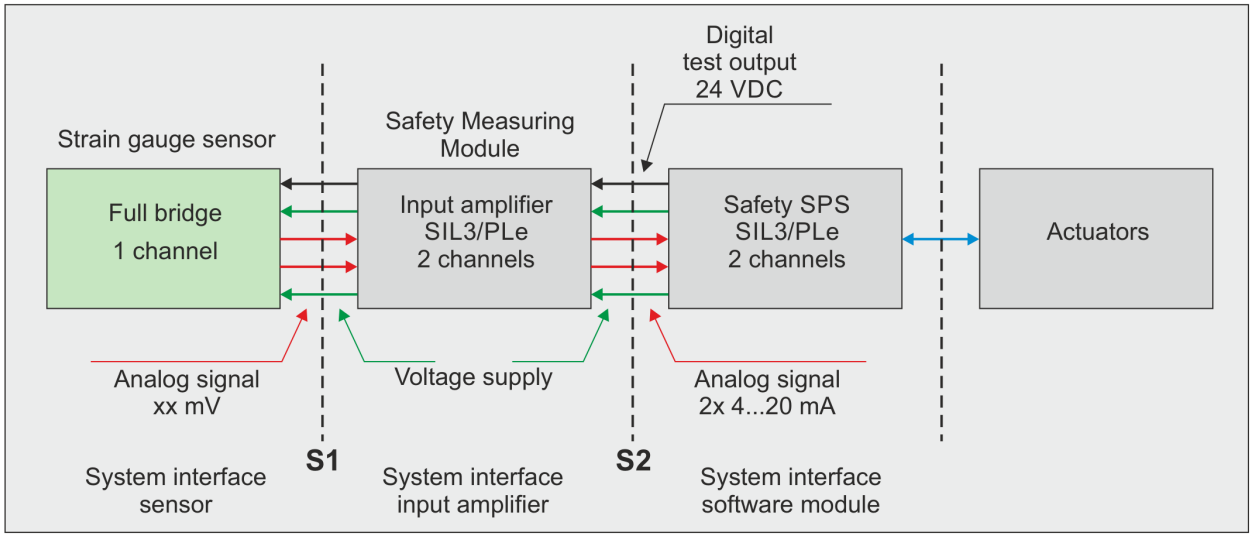


Figure 1: Block diagram of the measurement chain

The safety concept of the Safety Measuring Module is based on a two-channel measurement system which converts the physical variable (force, pressure) to be measured in 2 proportional standard current values. The deviation of current of the two channels may not be more than 5% (ΔI = 0,8 mA) maximally when the measurement is proper.

For monitoring of overloads and faulty signals the diagnostic software of a Safety PLC or safety input and output unit is being used.

Each of the both measuring amplifiers has a preceding module for the supply of needed voltages and a cutoff on over- and undervoltage (36 V or 18 V). The amplifiers are supplied with U = 24 VDC ±10% using a PELV/SELV power unit.

For the detection of faulty signals from the connected sensor (sensor break, sensor short circuit, sensor drift) and in both measuring amplifiers a Safety PLC has to generate a diagnostic pulse of U = 24 V ±20%. When all signals come right, the diagnostic pulse increases the current output value of channel B by ΔIout = 1 mA. If the current value changes by more than ±5% of this value, the faulty signals can be identified by the diagnostic module of the Safety PLC.

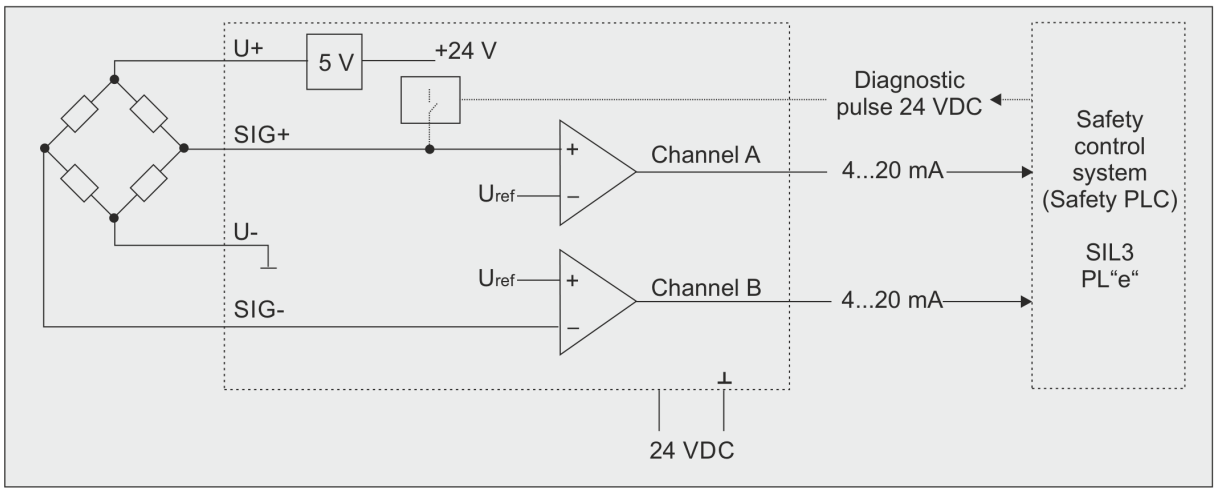


Figure 2: Safety measure arrangement: ESMA with sensor bridge circuit and Safety PLC according to SIL3 / PL „e“, Category 3

6 General operational data

WARNING · DANGER The operator has to ensure that the system is supplied by a PELV/SELV power unit and that the supply voltage is limited to 60 VDC on error.

6.1 Rating

Description	Output current Ia, channel A, channel B	Comment
Current range	4 ... 20 mA	Corresponds to value range of the signal
Measuring range-1: 0 ... 100%	0 ... 8 mA	Zero point at 8 mA abs (measuring range abs.: 8 ... 16 mA)
Measuring range-2: –50 ... +50%	±4 mA	Zero point at 12 mA abs (measuring range abs.: 8 ... 16 mA)
Extension of operating range	±2 mA	Reserve of calibration for application program
Operating range	0 ... 12 mA	Relevant for safety evaluation unit (PLC); measuring range ± reserve of calibration (8 mA ±2 mA); operating range min = 6 ... 14 mA abs; operating range max = 10 ... 18 mA abs
Malfunction at minimum	<8 mA: –5%	Error analysis
Malfunction at maximum	>16 mA: +5%	Error analysis
Diagnostic pulse/detuning	1 mA	Detuning of output current of channel B
Maximal tolerance per channel	±5%	Measuring accuracy of the current value per channel: ±0,4 mA referring to the measuring range 8 mA + zero point
Tolerance of the channel symmetry	5%	Measuring accuracy of the current symmetry (channel A – channel B); maximal deviation of current: 0,8 mA abs

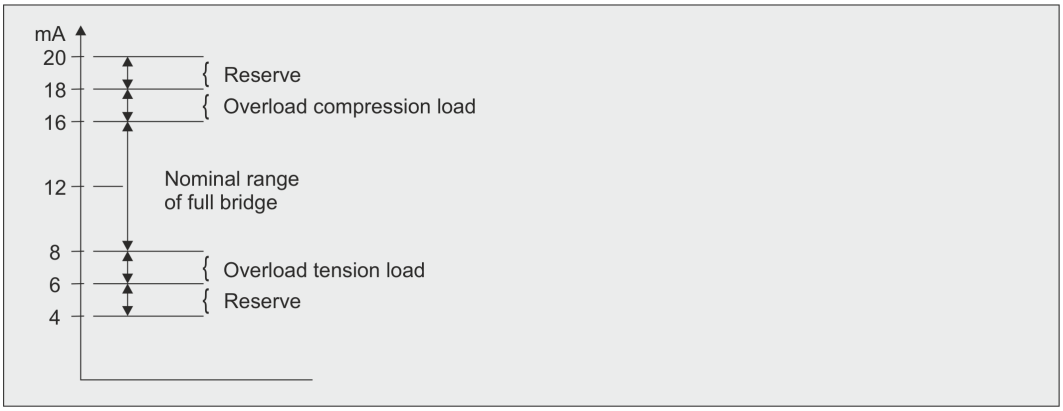


Figure 3: Overview of operation modes

6.2 Safe state

In the following cases the PLC has to switch to a safe state:

1. The current output values of channel A and/or channel B are below the zero point of 7,2 mA (8 mA – 0,8 mA (–5%)).
2. The current output values of channel A and/or channel B are above the maximal measuring range of 16,8 mA (16 mA + 0,8 mA (5%)).
3. The difference of current (symmetry of current) between channel A and channel B is more than 0,8 mA (5%).
4. The response of detuning by the diagnostic pulse UPI = 24 VDC is outside of the range 0,95 mA ... 1,05 mA (±5%).

6.3 Safety ratings

Safety ratings ESMA (without PLC)
HFT = 1; 1oo2 architecture structure (HFT (Hardware Failure Tolerance) = 1 means, that if there are appearing two failures simultaneously, the safe state of the system is lost)
SIL3 – Product safety SIL3 is only available when a Safety PLC with a diagnostic software is analysing the signals
PL „e“ / Category 3 – Product safety PL „e“ / Category 3 is only available when a Safety PLC with a diagnostic software is analysing the signals
DCavg = 97,00% (Average of diagnostic coverage must be ≥97%)
PFH = 2,00 E-9 h^{-1} (Possibility of a dangerous failure per hour)
MTTFd = 100 years (Mean time to dangerous failure)
The frequency of the diagnostic pulse has to be specified in that way, that the complete system is switching to a safe state within the process safety time (dependent on application) when a dangerous failure appears.
The reaction time of the ESMA: t = 3 ms

7 Requirements for the mechanical load transmission of the load/force cell

Make sure that the load/force cell meets the relevant mechanical requirements according to EN ISO 13849 so that the mechanical load transmission generates a proper signal for the electronics.

Take care that the application of force during first start-up and normal operation uses always the direction of action of the load/force sensor, so that the effective force effect can be measured.

Once a year an in situ inspection of the product takes place where the mechanical load transmission is checked too. Corrosion or similar harmful influences on the load transmission are not to be expected between maintenance intervals.

For the measurement of the force effect all usual load/force sensors with one strain gauge full bridge and a sensitivity of 0,1 ... 4 mV/V can be used.

8 Technical data

8.1 General technical data

Physical quantity	Ratings
Maximal allowed supply voltage according to PELV/SELV and DIN EN 60204-1	UBmax = 60 VDC
Nominal supply voltage	UN = 24 VDC
Nominal supply voltage range	21,6 ... 26,4 VDC
Tolerance of nominal supply voltage	±10%
Maximal deviation of output current	±0,8 mA (±5%)
Diagnostic pulse	UPI = 24 VDC
Range of diagnostic pulse	19,2 ... 28,8 VDC
Tolerance of diagnostic pulse	±20%
Increase of current output on diagnostic pulse	Channel B: ΔIOUT = 1 mA
Valid range of increase of current output on diagnostic pulse	0,95 ... 1,05 mA (±5%)
Frequency of diagnostic pulse	>(3/TPST) – PST: Process Safety Time
Maximal current consumption	100 mA
Environmental operation temperature	T = –25 ... +60 °C
Storage temperature	T = –25 ... +85 °C
Relative humidity without condensation	rH = 0 ... 96%
Air pressure	p = 86 ... 106 kPa
Vibration fatigue limit (wave)	Sine wave: f = 5 ... 500 Hz, UAMP = 0,15 mm, amax = 20 m/s^2
Impact strength (shock) maximal acceleration, half-sine	amax = 150 m/s^2
Difference of velocity	Δv = 1,1 m/s
Time of nominal pulse	T = 11 ms
Maximal altitude for application	H = 2000 m

8.2 Technical data DIN rail enclosure

Physical quantity	Ratings
Protection class	IP20
Dimensions	L = 117,2 mm, B = 22,5 mm, H = 113,6 mm
Electrical connection	Plug-in terminal strip (6 × 4-pole)
Weight	240 g

9 Installation and connection

9.1 Installation and set-up

Supplied items: DIN rail enclosure (ESMA) with 1 × Safety Measuring Module

This enclosure has to be built in in a switch cabinet with a protection class of at least IP54.

Connection	Cable	Length
Strain gauge sensor – ESMA	single shielded, made up in factory	up to 50 m
ESMA – PLC	single shielded	up to 100 m
Location	ESMA in switch cabinet (IP54), PLC in switch cabinet	–

The load/force sensor comes with a factory-installed single shielded cable with a length of maximal 50 m. The single shielded cable between ESMA and PLC may have a maximal length of 100 m. The signal cables can be laid locally by the user.

WARNING Electromagnetic parasitic inductions may impair the function and safety of the system. Therefore it is necessary to use at least single shielded cables for the connecting cables between strain gauge sensor <> ESMA and ESMA <> PLC or supply unit.

9.2 Pin assignment

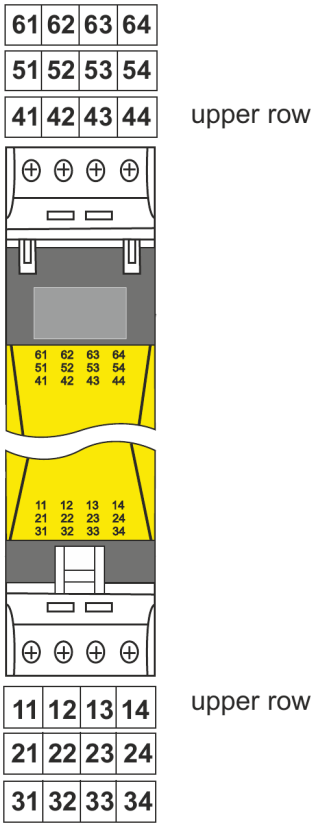


Figure 4: Position of terminals at DIN rail enclosure (top: upper surface, bottom: lower surface)

4-pole plug-in terminal strip (strain gauge sensor)

Terminal	Function	Description
21	UBr = 5 V ±5%	Bridge supply +
22	S+ = 2,5 V ±5%	Sensor output +
23	S– = 2,5 V ±5%	Sensor output –
24	GND	Bridge supply – GND

4-pole plug-in terminal strip (power supply and current output – channel B)

Terminal	Function	Description
41	UB = 24 V ±10%	Supply voltage
42	GND	Supply voltage – GND
43	+IB_out = 0 ... 20 mA	Current output – channel B
44	GND	Current output channel B – GND

4-pole plug-in terminal strip (diagnostic pulse and current output – channel A)

Terminal	Function	Description
51	+IA_out = 0 ... 20 mA	Current output – channel A
52	GND	Current output channel A – GND
53	UPulse = 24 V ±20%	Diagnostic pulse PLC
54	GND	Diagnostic pulse PLC – GND

4-pole plug-in terminal strip (shield strain gauge)

Terminal	Function	Description
31	Earth	Supply line
32	Shield	for strain gauge cable
33	Shield	for strain gauge cable
34	Shield	for strain gauge cable

4-pole plug-in terminal strip (shield for power supply, outputs, diagnostic pulse)

Terminal	Function	Description
61	Earth	Supply line
62	Shield	for supply cable
63	Shield	for output cable
64	Shield	for diagnostic pulse cable

4-pole plug-in terminal strip (calibration / I²C bus) – for factory configuration only

Terminal	Function	Description
11	SDA U = 5 V ±5%	Serial data, I²C bus
12	SCL U = 5 V ±5%	Clock pulse, I²C bus
13	HCV U = 24 VDC ±10%	Activation protection commands of digital potentiometer
14	GND	I²C bus – GND

WARNING · DANGER The pin assignment of the 4-pole plug-in terminal strip (terminals 11 to 14) is only for information. The assignment of the other terminal strips is for the connection of the supplied cable (strain gauge sensor <> ESMA) and the cables provided by the user (ESMA <> PLC/power supply), during the user's system installation. Furthermore, the user is not allowed to apply unauthorized other signals to the pins or connection lines.

10 Start-up, maintenance and repair

10.1 Start-up

For the operator/user, start-up is limited to laying cables on location and connecting these cables to the devices. The calibration of the product type is done by the manufacturer only, either at factory or at site.

The devices are handed over sealed to the operator/user by the manufacturer. After the calibration of the system, the valid running period and the serial number are recorded by the manufacturer.

WARNING · DANGER The operator/user is not allowed to interfere with the product types. The operator/user is not allowed to carry out repairs or conduct changes.

10.2 Maintenance

Maintenance has to be carried out once a year by skilled personnel from octogon. Maintenance work, duration and date are recorded by the company.

10.3 Repair

WARNING · DANGER Only skilled personnel from octogon is allowed to conduct repair and maintenance measures on the product types.

11 Disposal

Dispose devices, instrument components and packaging materials in accordance with the respective waste treatment and disposal regulations of the region or country to which the sensor is supplied.

12 Safety specifications

The ESMA meets the specified safety requirements, which is certified by TÜV Rheinland. The examination of the Safety Measuring Module (electronics) was done according to the standards below.

Functional safety

Standard	Requirement
IEC 61508:2010	SIL3
EN 62061:2005+AC:2010+A1:2013	SIL3
ISO 13849-1:2008+AC:2009	PL „e“, Cat. 3

Standards for EMC

Standard	Requirement
DIN EN 61326-1:2013	CE conformity
DIN EN 61326-2-1:2013	CE conformity
DIN EN 61326-3-1:2008	SIL3

Standards for environment

Standard	Requirement
DIN EN 60068-2-1:2008	Test procedure cold, Ae
DIN EN 60068-2-2:2008	Test procedure dry heat, Ae
DIN EN 60068-2-30:2005	Test procedure humid heat, Db
DIN EN 60068-2-6:2008	Test procedure vibration (sinusoidal), Fc
DIN EN 60068-2-31:2009	Test procedure shocks for instruments, Ec
DIN EN 60529	Test procedure enclosure protection

13 Evaluation concept PLC

13.1 General

The following two diagrams are showing the scoring logic for the evaluation unit of the PLC. The first diagram represents the basic flow of the software concept on the basis of a final state machine and the second diagram represents the program flow chart of the diagnostic unit.

WARNING · DANGER A safety related application according to SIL3 with the Safety Measuring Module ESMA requires an additional Safety PLC or a safety related input/output unit, which meets the requirements according to IEC 61508 (SIL 3) and PL „e“, Category 3. Only then the complete safety related system will cover the standards IEC 61508 / EN 62061 / ISO EN 13849. Particularly for program creation the standard IEC 61508-3 is mandatory.

13.2 Final state machine

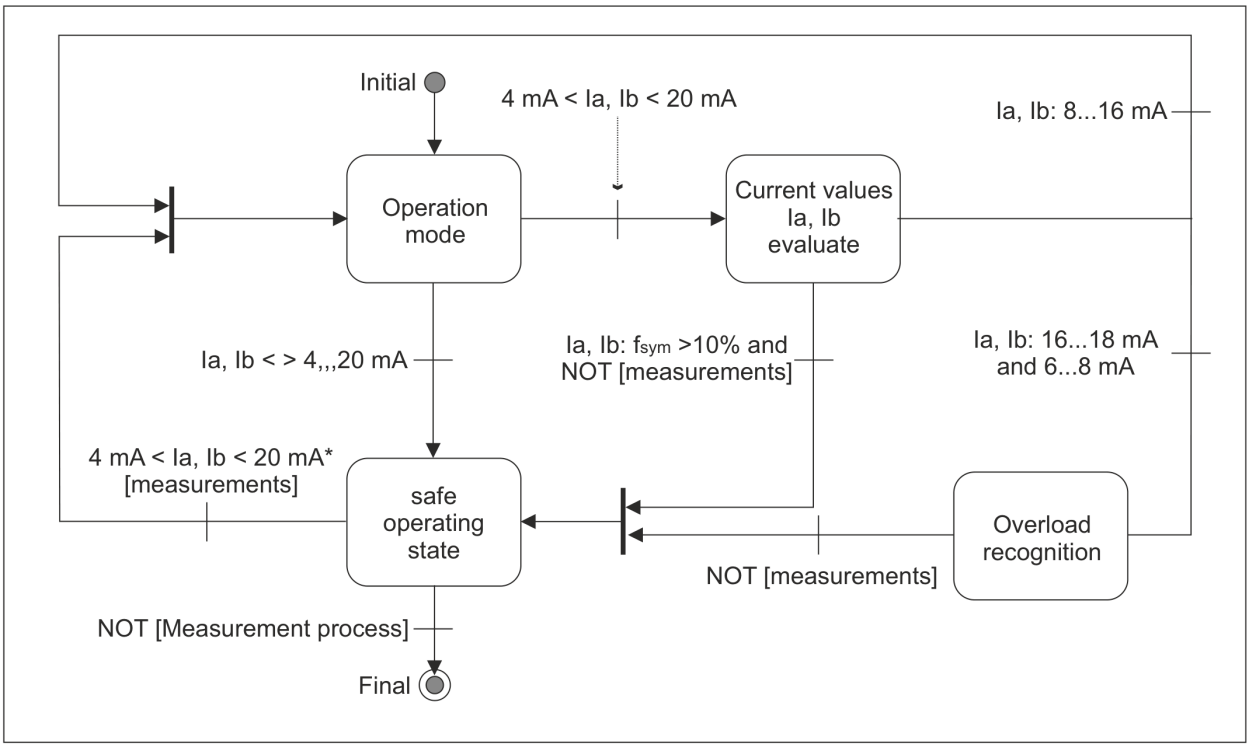


Figure 5: Final state machine diagnostic module

13.3 Flow charts

The flow charts in the following figures show the basic processing of the evaluation unit of a PLC for the current output values of the Safety Measuring Module ESMA. In the main program the current output values are analyzed with the polling method and processed further with plausibility check and an information request about their inspected values. On incorrect current output values the system switches to a safe state.

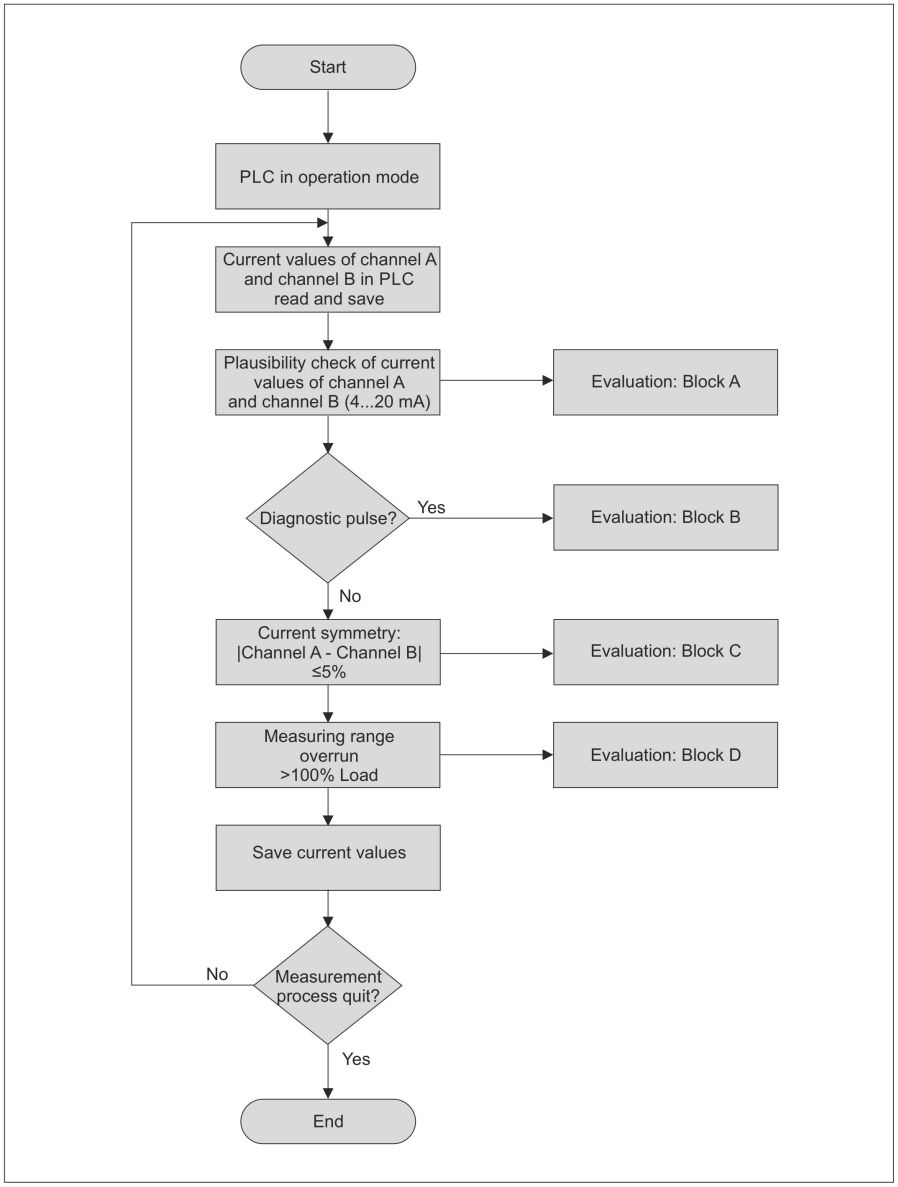


Figure 6: Flow chart (overview)

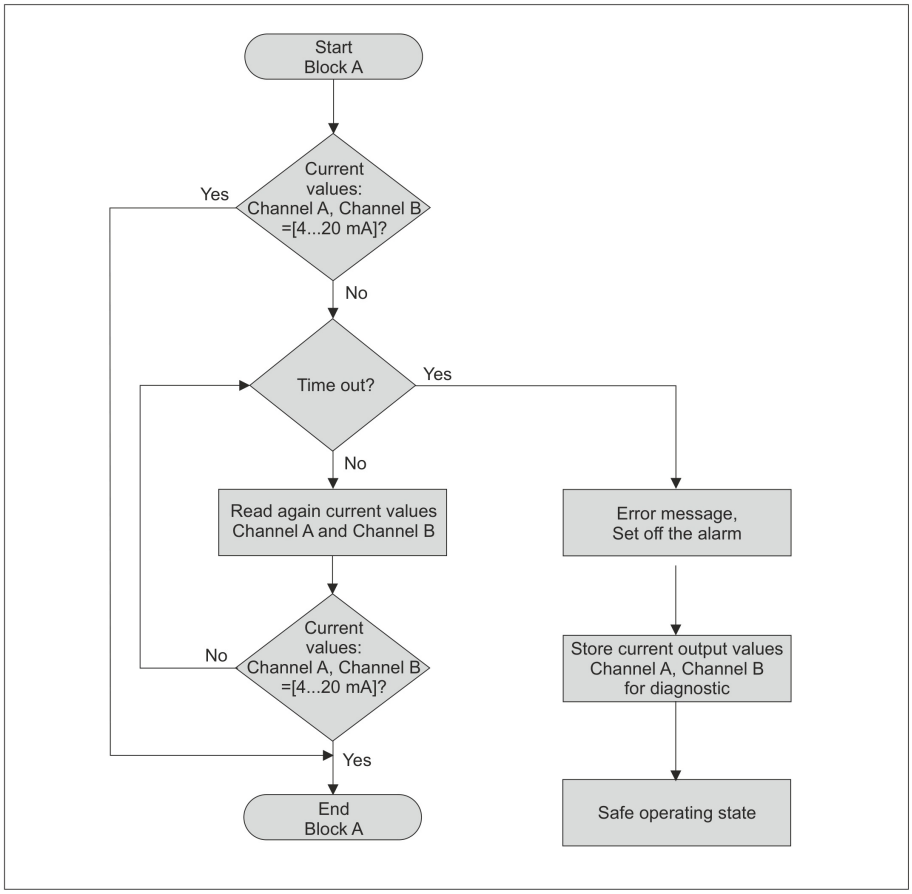


Figure 7: Flow chart (block A)

WARNING The time-out period should be one third of the Process Safety Time at maximum!

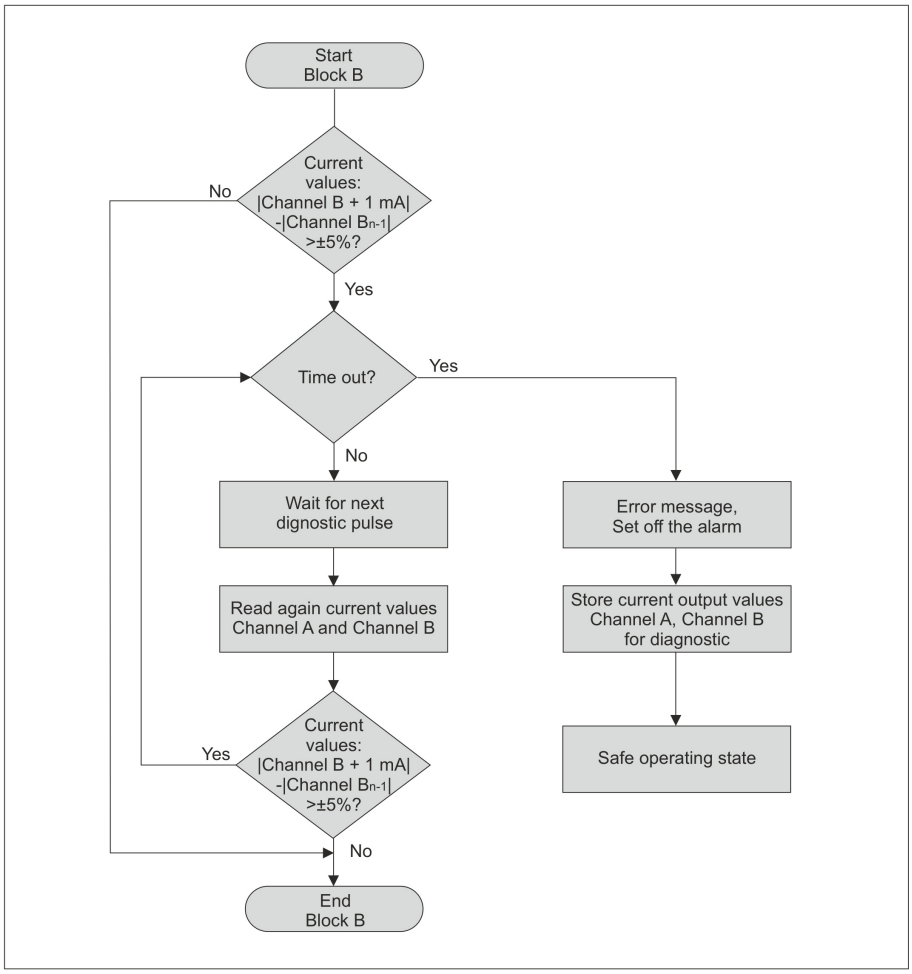


Figure 8: Flow chart (block B)

WARNING The time-out period should be one third of the Process Safety Time at maximum!

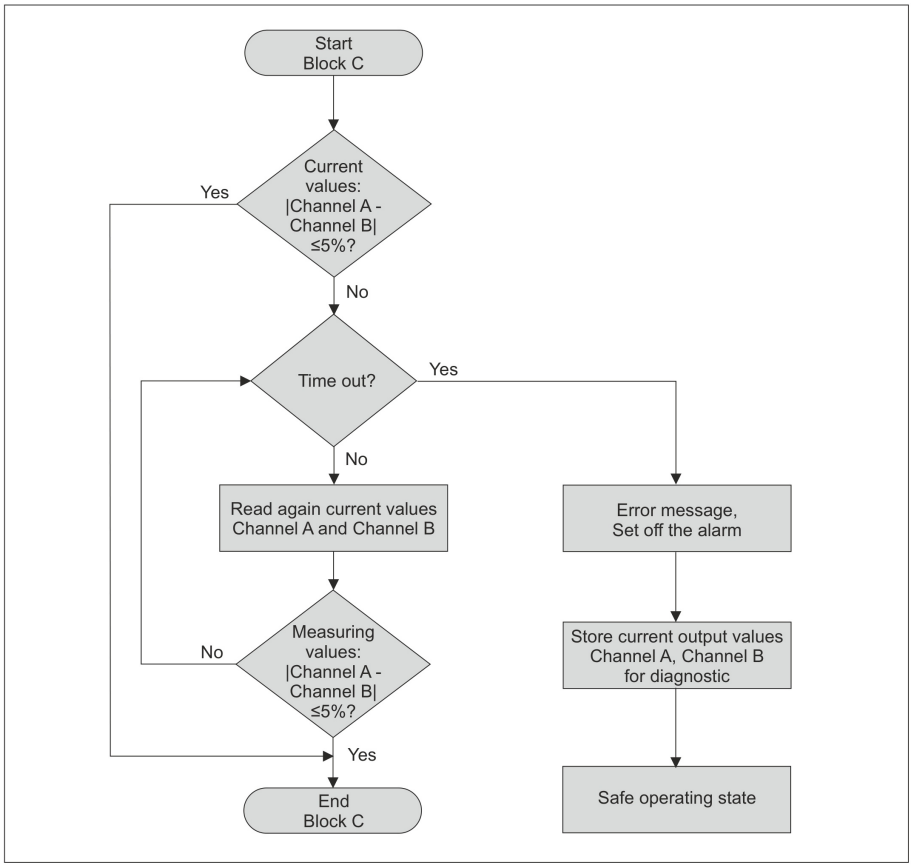


Figure 9: Flow chart (block C)

WARNING The time-out period should be one third of the Process Safety Time at maximum!

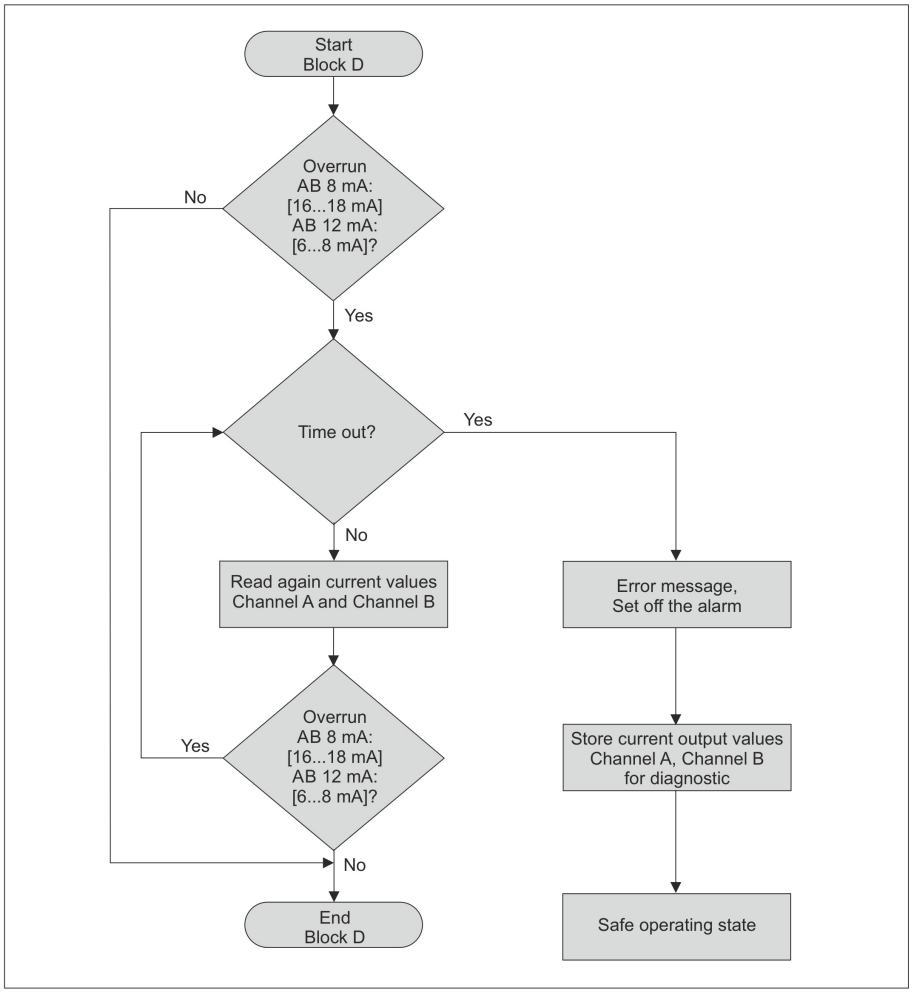


Figure 10: Flow chart (block D)

WARNING The time-out period should be one third of the Process Safety Time at maximum!

14 Checklist for start-up

WARNING · DANGER The proper integration of the ESMA in a complete system has to be validated. For this purpose, all safety-relevant advice and warnings of this user manual have to be observed and the following check list has to be processed. This will guarantee the functional safety of the ESMA.

Check no.	Requirements	Rating OK / not OK
1	The ESMA is supplied with a PELV/SELV power unit	
2	The operating voltage is within the specified range	
3	Ensure that the downstream PLC with diagnostic unit fulfils the safety-related requirements according to SIL3 (Cat. 3) and PL „e“	
4	Ensure that the complete system being composed of sensor, measuring amplifier and PLC fulfils the safety-related requirements according to SIL3 (Cat. 3) and PL „e“	
5	Ensure that the complete system changes into a safe state when the current output values of both channels A/B are below Fail Min (8 mA – 0,8 mA (5%))	
6	Ensure that the complete system changes into a safe state when the current output values of both channels A/B are above Fail Max (16 mA + 0,8 mA (5%))	
7	Ensure that an increase of current of ΔI = 1 mA is generated (5%) when the diagnostic pulse of UPI = 24 VDC is started	
8	Ensure that the complete system changes into a safe state when the current pulse is different to the expected value (out of the range 1,05 ... 0,95 mA)	
9	Ensure that the complete system changes into a safe state when the difference of current (symmetry of current) between channel A and channel B is more than 0,8 mA (5%)	
10	Ensure that the frequency of the diagnostic pulse together with the time of evaluation is within the Process Safety Time (PST) and that the detection of the error and the change of the application into a safe state is guaranteed within the PST	

Check no.	Requirements	Rating OK / not OK
11	Ensure that only suitable sensors with measuring bridges according to the ESMA requirements are used	
12	Ensure that mechanical components, which transmit the load onto the measuring amplifier, meet the requirements according to the standard EN ISO 13849 / Category 3	

15 Contact

For questions about the products or faulty function in the application (a detailed description of the fault is necessary) use the following address:

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