Safety Manual

VEGASWING 66

Transistor (NPN/PNP)

With SIL qualification

Document ID: 45308

Contents

45308-EN-230925

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1 Document language

DE	Das vorliegende *Safety Manual* für Funktionale Sicherheit ist verfügbar in den Sprachen Deutsch, Englisch, Französisch und Russisch.
EN	The current *Safety Manual* for Functional Safety is available in German, English, French and Russian language.
FR	Le présent *Safety Manual* de sécurité fonctionnelle est disponible dans les langues suivantes: allemand, anglais, français et russe.
RU	Данное руководство по функциональной безопасности *Safety Manual* имеется на немецком, английском, французском и русском языках.

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2 Scope

2.1 Instrument version

This safety manual applies to point level sensors

VEGASWING 66 - Transistor (NPN/PNP) with SIL qualification

Electronics module:

- SG60HT-I

Valid versions:

- from HW Ver 1.0.0
- from SW Ver 1.1.0

SIL The version "Plastic housing" is excluded!

2.2 Application area

The transmitter can be used for level detection of liquids in a safety-related system according to IEC 61508 in the modes *low demand mode* or *high demand mode*.

Due to the systematic capability SC3 this is possible up to:

- SIL2 in single-channel architecture
- SIL3 in multiple channel architecture

The following interface can be used to output the measured value:

- Transistor (NPN/PNP)

SIL Both transistor outputs must be evaluated!

Shielded cable must be used for connection!

2.3 SIL conformity

The SIL confirmity was judged and certified independently by *TÜV Rheinland* according to IEC 61508:2010 (Ed.2) (verification documents see " *Supplement*").

SIL The certificate is valid for the entire service life of all instruments that were sold before the certificate expired!

3 Planning

3.1 Safety function

Safety function

To monitor a limit level, the sensor detects via the conditions " *Vibrating element uncovered*" or " *Vibrating element covered*" a limiting value defined by the mounting location.

The detected status is signalled on the output with " *Transistor non-conductive*" or " *Transistor conductive*".

3.2 Safe state

Safe state

The safe state of the output signal is independent of the mode adjusted on the sensor.

SIL For the safety function, both transistor outputs must be used!

Examples:

- When controlling an output load, it is connected to terminals 2 and 3
- With connected SPLC, the outputs NPN and PNP are evaluated by two separate channels

Mode	Overflow protection Mode max.	Dry run protection Mode min.
Vibrating element	covered	uncovered
Transistors	non-conductive (currentless)	non-conductive (currentless)

Fault signals in case of malfunction

Transistor outputs:

- Non-conductive

3.3 Prerequisites for operation

Instructions and restrictions

- The measuring system should be used appropriately taking pressure, temperature, density and chemical properties of the medium into account. The application-specific limits must be observed.
- The specifications according to the operating instructions manual, particularly the current load on the output circuits, must be kept within the specified limits
- When used as dry run protection, buildup on the vibrating system should be avoided (probably shorter proof test intervals will be necessary)
- The instructions in chapter " *Safety-related characteristics*", paragraph " *Supplementary information*" must be noted
- All parts of the measuring chain must correspond to the planned " *Safety Integrity Level (SIL)*"

4 Safety-related characteristics

4.1 Characteristics acc. to IEC 61508

Parameter	Value
Safety Integrity Level	SIL2 in single-channel architecture SIL3 in multiple channel architecture [1]
Hardware fault tolerance	HFT = 0
Instrument type	Type B
Mode	Low demand mode, High demand mode
SFF	> 90 %
MTTR	8 h
MTBF = MTTF + MTTR [2]	1.17 x 10^6 h (134 years)
Diagnostic test interval [3]	< 120 s
Fault reaction time [4]	< 2 s

Failure rates

λ_S	λ_{DD}	λ_{DU}	λ_H	λ_L	λ_{AD}
211 FIT	167 FIT	31 FIT	0 FIT	0 FIT	11 FIT

PFD_{AVG}	0.026 x 10^{-2}	(T1 = 1 year)
PFD_{AVG}	0.038 x 10^{-2}	(T1 = 2 years)
PFD_{AVG}	0.075 x 10^{-2}	(T1 = 5 years)
PFH_D	0.031 x 10^{-6} 1/h	

Proof Test Coverag (PTC)

Test type [5]	Remaining failure rate of dangerous undetected failures	PTC
Test 1	11 FIT	64 %
Test 2	2 FIT	95 %

4.2 Characteristics acc. to ISO 13849-1

Derived from the safety-related characteristics, the following figures result according to ISO 13849-1 machine safety): [6]

Parameter	Value
MTTFd	544 years
DC	85 %

[1] Homogeneous redundancy possible.
[2] Including errors outside the safety function.
[3] Time during which all internal diagnoses are carried out at least once.
[4] Time between the occurrence of the event and the output of a fault signal.
[5] See section "Proof test".
[6] ISO 13849-1 was not part of the certification of the instrument.

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Parameter	Value
PFH_D	3.12 x 10^{-8} 1/h

4.3 Supplementary information

Determination of the failure rates

The failure rates of the instruments were determined by an FMEDA according to IEC 61508. The calculations are based on failure rates of the components according to **SN 29500**:

All figures refer to an average ambient temperature of 40 °C (104 °F) during the operating time. For higher temperatures, the values should be corrected:

- Continuous application temperature > 50 °C (122 °F) by factor 1.3
- Continuous application temperature > 60 °C (140 °F) by factor 2.5

Similar factors apply if frequent temperature fluctations are expected.

Assumptions of the FMEDA

- The failure rates are constant. Take note of the useful service life of the components according to IEC 61508-2.
- Multiple failures are not taken into account
- Wear on mechanical parts is not taken into account
- Failure rates of external power supplies are not taken into account
- The environmental conditions correspond to an average industrial environment

Calculation of PFD_{AVG}

The values for PFD_{AVG} specified above were calculated as follows for a 1oo1 architecture:

$$PFD_{AVG} = \frac{PTC \times \lambda_{DU} \times T1}{2} + \lambda_{DD} \times MTTR + \frac{(1 - PTC) \times \lambda_{DU} \times LT}{2}$$

Parameters used:

- T1 = Proof Test Interval
- PTC = 90 %
- LT = 10 years
- MTTR = 8 h

Boundary conditions relating to the configuration of the processing unit

A connected control and processing unit must have the following properties:

- The failure signals of the measuring system are judged according to the idle current principle
- " *fail low*" and " *fail high*" signals are interpreted as a failure, whereupon the safe state must be taken on

If this is not the case, the respective percentages of the failure rates must be assigned to the dangerous failures and the values stated in chapter *Safety-related characteristics*“ redetermined!

Multiple channel architecture

Due to the systematic capability SC3, this instrument can also be used in multiple channel systems up to SIL3, also with a homogeneously redundant configuration.

The safety-related characteristics must be calculated especially for the selected structure of the measuring chain using the stated failure

rates. In doing this, a suitable Common Cause Factor (CCF) must be considered (see IEC 61508-6, appendix D).

5 Setup

5.1 General information

Mounting and installation

Take note of the mounting and installation instructions in the operating instructions manual.

Setup must be carried out under process conditions.

5.2 Adjustment instructions

Adjustment elements

The adjustment elements must be set according to the specified safety function:

- Slide switch for changeover of the mode (min./max.)
- Slide switch for changeover of the sensitivity

The function of the adjustment elements is described in the operating instructions manual.

Please note!

SIL During adjustment process, the safety function must be considered as unreliable!

If necessary, you must take other measures to maintain the safety function.

SIL With regard to the switch on/swich off delay it must be ensured that the sum of all switching delays from the transmitter to the actuator is adapted to the process safety time!

SIL The instrument must be protected against inadvertent or unauthorized adjustment!

6 Diagnostics and servicing

6.1 Behaviour in case of failure

Internal diagnosis

The instrument is permanently monitored by an internal diagnostic system. If a malfunction is detected, the respective output signals change to the safe status (see section " *Safe status*").

This condition is maintained for at least 1 second. If an error is no longer detected, the safety function is performed correctly again.

The diagnosis interval is specified in chapter " *Safety-related characteristics*".

SIL If failures are detected, the entire measuring system must be shut down and the process held in a safe state by other measures.

The manufacturer must be informed of the occurrence of a dangerous undetected failure (incl. fault description).

6.2 Repair

Electronics exchange

The procedure is described in the operating instructions manual. Note the instructions for setup.

7 Proof test

7.1 General information

Objective

To identify possible dangerous, undetected failures, the safety function must be checked by a proof test at adequate intervals. It is the user's responsibility to choose the type of testing. The time intervals are determined by the selected PFD_{AVG} (see chapter " *Safety-related characteristics*").

For documentation of these tests, the test protocol in the appendix can be used.

If one of the tests proves negative, the entire measuring system must be switched out of service and the process held in a safe state by means of other measures.

In a multiple channel architecture this applies separately to each channel.

Preparation

- Determine safety function (mode, switching points)
- If necessary, remove the instruments from the safety chain and maintain the safety function by other means

Unsafe device status

Warning:
During the function test, the safety function must be treated as unreliable. Take into account that the function test influences downstream connected devices.

If necessary, you must take other measures to maintain the safety function.

After the function test, the status specified for the safety function must be restored.

7.2 Test 1: Without filling or dismounting the sensor

Conditions

- Instrument in installed condition
- Output signal corresponds to the level (covered or uncovered vibrating element)
- **The two transistor outputs NPN and PNP must be tested separately!**

Procedure

1. Carry out a restart (switch the instrument off and then on again)
2. Push the min./max. switch

Expected result

to 1: Output signal corresponds to the level

to 2: Output signal changes status

Proof Test Coverage

See *Safety-related characteristics*

7.3 Test 2: With filling or dismounting of the sensor

Conditions

- **Alternative 1:** the instrument remains mounted; the condition "*Vibrating element uncovered*"/" *Vibrating element covered*" can be changed by filling or emptying to the switching point.
- **Alternative 2:** the instrument is dismounted; the condition "*Vibrating element uncovered*"/" *Vibrating element covered*" can be changed by dipping the instrument into the original medium
- Output signal corresponds to the level (covered or uncovered vibrating element)
- **The two transistor outputs NPN and PNP must be tested separately!**

Procedure

1. Push the min./max. switch
2. Filling or emptying up to the switching point or immersion into the original medium

Expected result

to 1: Output signal changes status

to 2: Output signal corresponds to the modified level

Proof Test Coverage

See *Safety-related characteristics*

8 Appendix A: Test report

Identification	
Company/Tester	
Plant/Instrument TAG	
Meas. loop TAG	
Instrument type/Order code	
Instrument serial number	
Date, setup	
Date, last function test	

Test reason		Test scope	
(…)	Setup	(…)	without filling or dismounting the sensor
(…)	Proof test	(…)	with filling or dismounting the sensor

Mode		Sensitivity	
(…)	Overflow protection	(…)	≥ 0.7 g/cm³ (0.025 lbs/in³)
(…)	Dry run protection	(…)	≥ 0.5 g/cm³ (0.018 lbs/in³)

Test result

Test step	Level	Expected measured value	Real value	Test result

Confirmation	
Date:	Signature:

9 Appendix B: Term definitions

Abbreviations

SIL	Safety Integrity Level (SIL1, SIL2, SIL3, SIL4)
SC	Systematic Capability (SC1, SC2, SC3, SC4)
HFT	Hardware Fault Tolerance
SFF	Safe Failure Fraction
PFD_{AVG}	Average Probability of dangerous Failure on Demand
PFH_D	Average frequency of a dangerous failure per hour (Ed.2)
FMEDA	Failure Mode, Effects and Diagnostics Analysis
FIT	Failure In Time (1 FIT = 1 failure/10^9 h)
λ_{SD}	Rate for safe detected failure
λ_{SU}	Rate for safe undetected failure
λ_S	$\lambda_S = \lambda_{SD} + \lambda_{SU}$
λ_{DD}	Rate for dangerous detected failure
λ_{DU}	Rate for dangerous undetected failure
λ_H	Rate for failure, who causes a high output current (> 21 mA)
λ_L	Rate for failure, who causes a low output current (≤ 3.6 mA)
λ_{AD}	Rate for diagnostic failure (detected)
λ_{AU}	Rate for diagnostic failure (undetected)
DC	Diagnostic Coverage
PTC	Proof Test Coverage (Diagnostic coverage for manual proof tests)
T1	Proof Test Interval
LT	Useful Life Time
MTBF	Mean Time Between Failure = MTTF + MTTR
MTTF	Mean Time To Failure
MTTR	IEC 61508, Ed1: Mean Time To Repair IEC 61508, Ed2: Mean Time To Restoration
$MTTF_d$	Mean Time To dangerous Failure (ISO 13849-1)

10 Supplement C: SIL conformity

SIL Manufacturer declaration, NE130: Form B.1

Manufacturer	
VEGA Grieshaber KG Am Hohenstein 113, D-77761 Schiltach, Germany	

General			
Device designation and permissible types	**VEGASWING 66** with SIL qualification		Item-No: SG66.*****S/I/L***
Safety-related output signal	S: Relay (2 x SPDT)	I: Transistor (NPN/PNP)	L: Two-wire (8/16 mA)
Fault current	n/a	n/a	≥ 21 mA; ≤ 3,6 mA
Process variable / function	Covered or uncovered vibrating element		
	Relay contact open or closed	Transistor non-conductive or conductive	output current 8 mA or 16 mA
Safety function(s)	Monitoring a limit level for overflow protection (MAX) or dry run protection (MIN)		
Device type acc. to IEC 61508-2	☐ Type A	☒ Type B	
Operating mode	☒ Low Demand Mode	☒ High Demand or Continuous Mode	
Valid Hardware-Version	≥ 1.0.0		
Valid Software-Version	≥ 1.1.0		
Safety manual	Document ID: 45307	Document ID: 45308	Document ID: 45309
Type of evaluation (check only one box)	☒ Complete HW/SW evaluation parallel to development incl. FMEDA and change request acc. to IEC 61508-2, 3		
	☐ Evaluation of "Prior use" performance for HW/SW incl. FMEDA and change request acc. to IEC 61508-2, 3		
	☐ Evaluation of HW/SW field data to verify „prior use" acc. to IEC 61511		
	☐ Evaluation by FMEDA acc. to IEC61508-2 for devices without software		
Evaluation through (incl. certificate no.)	TÜV Rheinland Industry Service GmbH, Nr./No. 968/EZ 567.04/18		
Test documents	Development documents	Test reports	Data sheets

Safety Integrity			
Systematic Capability (SC)		☐ SC2 for SIL2	☒ SC3 for SIL3
Hardware Safety Integrity	Single-channel use (HFT=0)	☒ SIL2 capable	☐ SIL3 capable
	Multi-channel use (HFT≥1)	☐ SIL2 capable	☒ SIL3 capable

FMEDA	**Version**		
	VEGASWING 66 R (S)	**VEGASWING 66 T (I)**	**VEGASWING 66 Z (L)**
Safety function(s)	MIN / MAX	MIN / MAX	MIN / MAX
λ_{DU} (FIT = Failure In Time / 10^9 h)	36 FIT	31 FIT	29 FIT
λ_{DD}	198 FIT	179 FIT	402 FIT
λ_{SU}	329 FIT	211 FIT	0 FIT
λ_{SD}	0 FIT	0 FIT	0 FIT
SFF (Safe Failure Fraction)	> 90 %	> 90 %	> 90 %
PTC (Proof Test Coverage)	Test 1: 68% / Test 2: 96%	Test 1: 64% / Test 2: 95%	Test 1: 61% / Test 2: 95%
FMEDA data source	SN 29500		

Declaration	
☒	Our internal company quality management system ensures information on safety-related systematic faults which become evident in the future.

Certificate

Nr./No.: 968/EZ 567.06/23

Prüfgegenstand **Product tested**	Sensoren zur Grenzstanderfassung Sensors for level detection	**Zertifikats-inhaber** **Certificate holder**	VEGA Grieshaber KG Am Hohenstein 113 77761 Schiltach Germany
Typbezeichnung **Type designation**	VEGASWING 66 S (Relay), VEGASWING 66 I (Transistor), VEGASWING 66 L (8/16mA)		
Prüfgrundlagen **Codes and standards**	IEC 61508 Parts 1-7:2010		
Bestimmungsgemäße Verwendung **Intended application**	Sensoren zur Grenzstanderfassung in Flüssigkeiten. Die Sensoren der VEGASWING 66 Serie erfüllen die Anforderungen der genannten Prüfgrundlagen und können in einem sicherheitsbezogenen System in einer HFT=0 Konfiguration bis SIL 2 gemäß IEC 61508 und redundant (HFT=1) bis SIL 3 (Systematische Eignung SC 3) verwendet werden. Die Produkte können im Anwendungsbereich der IEC 61511-1:2016 + AMD1:2017, EN 12952-11:2007 und der EN 12953-9:2007 eingesetzt werden. Weiterhin wurden die Anforderungen der IEC 61010-1:2017 + COR1:2019 und IEC 61326-3-2:2017 nachgewiesen. Sensors for level detection of liquids. The sensors of the VEGASWING 66 Series comply with the requirements of the stated standards and can be used in a safety-related system in a HFT=0 configuration up to SIL 2 acc. IEC 61508 and redundantly (HFT=1) up to SIL 3 (Systematic Capability SC 3). The product can be used in the application area of IEC 61511-1:2016 + AMD1:2017, EN 12952-11:2007 and EN 12953-9:2007. Furthermore the requirements of IEC 61010-1:2017 + COR1:2019 and IEC 61326-3-2:2017 were verified.		
Besondere Bedingungen **Specific requirements**	Die zugehörigen Betriebsanleitungen und das Safety Manual sind zu beachten. The operating instructions and the safety manual shall be considered.		

Gültig bis / Valid until 2028-08-29

Der Ausstellung dieses Zertifikates liegt eine Evaluierung entsprechend dem Zertifizierungsprogramm CERT FSP1 V3.0:2020 in der aktuellen Version zugrunde, deren Ergebnisse im Bericht Nr. 968/EZ 567.06/23 vom 29.08.2023 dokumentiert sind. Dieses Zertifikat ist nur gültig für Erzeugnisse, die mit dem Prüfgegenstand übereinstimmen. Ausgestellt von der durch die DAkkS nach DIN EN ISO/IEC 17065 akkreditierte Zertifizierungsstelle. Die Akkreditierung gilt nur für den in der Urkundenanlage D-ZE-11052-02-01 aufgeführten Akkreditierungsumfang.
The issue of this certificate is based upon an evaluation in accordance with the Certification Program CERT FSP1 V3.0:2020 in its actual version, whose results are documented in Report No. 968/EZ 567.06/23 dated 2023-08-29. This certificate is valid only for products, which are identical with the product tested. Issued by the certification body accredited by DAkkS according to DIN EN ISO/IEC 17065. The accreditation is only valid for the scope listed in the annex to the accreditation certificate D-ZE-11052-02-01.

Köln, 2023-08-29

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