Functional Safety

Vibration Sensor VIM8*

Manual

SIL

IEC 61508/61511

ISO9001

CE SIL 2 PL d

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1 Introduction

1.1 Content of this Document

This document contains information for usage of the device in functional safety-related applications. You need this information to use your product throughout the applicable stages of the product life cycle. These can include the following:

- Product identification
- Delivery, transport, and storage
- Mounting and installation
- Commissioning and operation
- Maintenance and repair
- Troubleshooting
- Dismounting
- Disposal

Note

This document does not substitute the instruction manual.

Note

For full information on the product, refer to the instruction manual and further documentation on the Internet at www.pepperl-fuchs.com.

Note

For specific device information such as the year of construction, scan the QR code on the device. As an alternative, enter the serial number in the serial number search at www.pepperl-fuchs.com.

The documentation consists of the following parts:

- Present document
- Instruction manual
- Datasheet

Additionally, the following parts may belong to the documentation, if applicable:

- EU-type examination certificate
- EU declaration of conformity
- Attestation of conformity
- Certificates
- Control drawings
- FMEDA report
- Assessment report
- Additional documents

For more information about Pepperl+Fuchs products with functional safety, see www.pepperl-fuchs.com/sil.

1.2 Safety Information

Target Group, Personnel

Responsibility for planning, assembly, commissioning, operation, maintenance, and dismounting lies with the plant operator.

Only appropriately trained and qualified personnel may carry out mounting, installation, commissioning, operation, maintenance, and dismounting of the product. The personnel must have read and understood the instruction manual and the further documentation.

Intended Use

The device is only approved for appropriate and intended use. Ignoring these instructions will void any warranty and absolve the manufacturer from any liability.

The device is developed, manufactured and tested according to the relevant safety standards.

Use the device only

- for the application described
- with specified environmental conditions
- with devices that are suitable for this safety application

Improper Use

Protection of the personnel and the plant is not ensured if the device is not used according to its intended use.

1.3 Symbols Used

This document contains symbols for the identification of warning messages and of informative messages.

Warning Messages

You will find warning messages, whenever dangers may arise from your actions. It is mandatory that you observe these warning messages for your personal safety and in order to avoid property damage.

Depending on the risk level, the warning messages are displayed in descending order as follows:

Danger!

This symbol indicates an imminent danger.

Non-observance will result in personal injury or death.

Warning!

This symbol indicates a possible fault or danger.

Non-observance may cause personal injury or serious property damage.

Caution!

This symbol indicates a possible fault.

Non-observance could interrupt the device and any connected systems and plants, or result in their complete failure.

Informative Symbols

Note

This symbol brings important information to your attention.

Action

This symbol indicates a paragraph with instructions. You are prompted to perform an action or a sequence of actions.

2 Product Description

2.1 Function

The following vibration sensor versions are described in this manual:

Device version	Vibration variable	Bearing status parameter	Pre-alarm and main alarm	Window function
VIM8***-**B**-***-*******	Vibration acceleration	X	–	X
VIM8***-**C**-***-*******	Vibration speed	X	X	–
VIM8***-**G**-***-*******	Vibration acceleration	–	–	X
VIM8***-**V**-***-*******	Vibration speed	–	X	–

Table 2.1 Device versions

General

The vibration sensor is used to measure and monitor absolute bearing vibrations in machines in line with DIN ISO 10816. The effective vibration acceleration value is used as the measurement parameter.

The vibration sensor determines the vibration variable using rms (**r**oot **m**eas **s**quare) averaging. This form of quadratic averaging or pre-filtering enables precise trend statements about the condition of the application.

The device has 2 switching thresholds LIM1 and LIM2 and the corresponding delay times, which can be adjusted separately.

The device also has an analog current output. This current output supplies a direct current of 4 mA to 20 mA proportional to the vibration variable.

Some device versions have an analog current output for the output of the bearing status parameter, see table above. This output is not safety relevant.

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Device with Pre-Alarm and Main Alarm

The device evaluates the vibration amplitude in two independent channels.
If the vibration variable is exceeded, this is signaled at the switching contacts.
The switching contacts can be used to generate a pre-alarm and a main alarm.

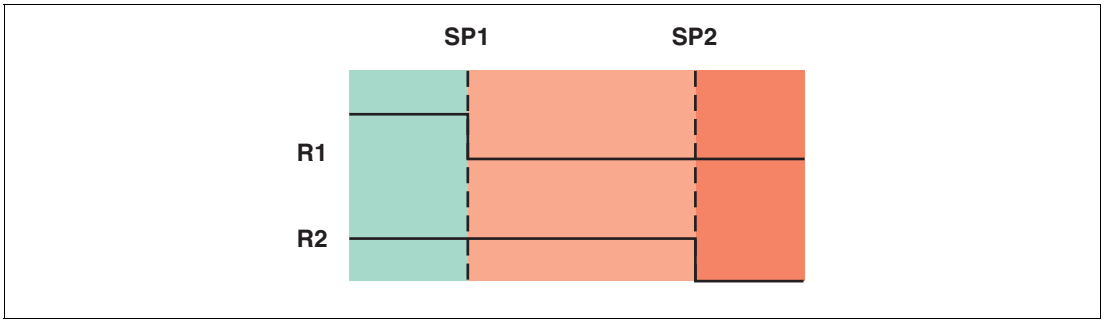

Figure 2.1 Vibration sensor with pre-alarm and main alarm

R1 Relay contact output R1
R2 Relay contact output R2
SP1 Switching threshold LIM1
SP2 Switching threshold LIM2
W Critical state = pre-alarm from SP1/main alarm from SP2 = relay open = like de-energized state

Device with Window Function

The lower switching threshold of the window area is adjusted on LIM1 and the upper switching threshold is adjusted on LIM2. If the acceleration value is below or above the adjustable window area, an alarm will be triggered.

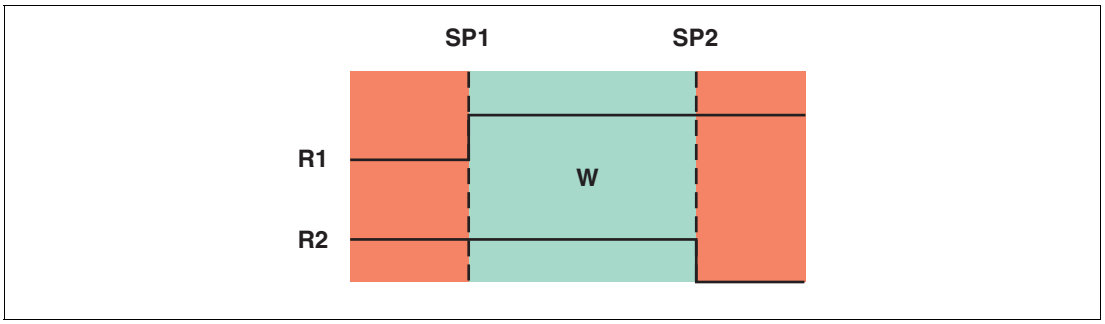

Figure 2.2 Vibration sensor with window function

R1 Relay contact output R1
R2 Relay contact output R2
SP1 Switching threshold LIM1
SP2 Switching threshold LIM2
W Window area
Critical state = out of window (SP1, SP2) = relay is open = like de-energized state

Note

See corresponding datasheets for further information.

2.2 Interfaces

The device has the following interfaces.

Device with Pre-Alarm and Main Alarm

- Safety relevant interfaces:
  - Pre-alarm relay (output 1)
  - Main alarm relay (output 2)
  - Analog current output for the output of the vibration variable (output 3)
- Non-safety relevant interfaces: analog current output for the output of the bearing status parameter (output 4, only for VIM8***-**C**-***-******* device version)

Device with Window Function

- Safety relevant interfaces:
  - Relay for lower switching threshold (output 1)
  - Relay for upper switching threshold (output 2)
  - Analog current output for the output of the vibration variable (output 3)
- Non-safety relevant interfaces: analog current output for the output of the bearing status parameter (output 4, only for VIM8***-**B**-***-******* device version)

Note

For corresponding connections see datasheet.

2.3 Marking

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VIM8***-**B**-***-*******, VIM8***-**C**-***-******* VIM8***-**G**-***-*******, VIM8***-**V**-***-*******	Up to SIL 2 and PL d

The *-marked letters of the type code are placeholders for versions of the device.

2.4 Standards and Directives for Functional Safe

Device-specific standards and directives

Functional safety	IEC/EN 61508, part 1 – 2, edition 2010: Functional safety of electrical/electronic/programmable electronic safety-related systems (manufacturer)

Machinery Directive 2006/42/EC	EN/ISO 13849, part 1, edition 2015: Safety-related parts of control systems (manufacturer)

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3 Planning

3.1 Assumptions

The following assumptions have been made during the FMEDA:

- The vibration sensor was developed as **High Demand System**.
- The device corresponds to a 1oo1 architecture with a diagnostic coverage of > 90 %. The diagnostics are permanent and automatic during operation and the start-up phase of monitoring.
- The device fulfils a Safe Failure Fraction of 60 % to 90 %. The monitoring is thus a sensor system in accordance with SIL2.
- The fault mode is the equivalent to alarm operating mode for the switching contacts.

Configuration Mode Use Case

- A vibration sensor in configuration mode is not considered to be in a safe state.

  The operator can set the sensor in configuration mode as described in the operating manual. The safety functions as specified will not operate until configuration has been saved and the sensor is in the normal operating mode.

Fault Exclusion

- According to ISO 13849-2 (table D.7), the multi-pole plug connection was chosen to exclude a short circuit between any two adjacent pins.

3.2 Safety Function and Safe State

Safe State

In the event of a fault that cannot be corrected (e. g. hardware defect, or vibration in resonance with the sensor), the sensor will switch to the safe state. This state can only be exited by power cycling.

The safe state can be recognized when all 3 of the following occur at the same time

- All status LEDs are switched (red, yellow, green).
- All switching contacts are opened (low level).
- Current output is set to 0 mA.

Safety Function

Device with Pre-Alarm and Main Alarm

The system includes 3 safety functions:

1. If the measured vibration variable exceeds the threshold value set for the pre-alarm for longer than the set delay period, the pre-alarm relay will open.
2. If the measured vibration variable exceeds the threshold value set for the main alarm for longer than the set delay period, the main alarm relay will open.
3. The analog current output depicts the vibration variable measured in the interval between 4 mA and 20 mA. The vibration variable is the vibration speed.

Device with Window Function

The system includes 3 safety functions:

1. If the measured vibration variable falls below the lower limit value of the switching threshold LIM1 of the window area for longer than the set delay period, the relay will open.
2. If the measured vibration variable exceeds the upper limit value of the switching threshold LIM2 of the window area for longer than the set delay period, the relay will open.
3. The analog current output depicts the vibration variable measured in the interval between 4 mA and 20 mA. The vibration variable is the vibration acceleration.

Note

The next control device must trigger the shutdown should the current output deliver more than 20 mA.

Note

See corresponding datasheets for further information.

3.3 Characteristic Safety Values

Parameters	Characteristic values
Assessment type and documentation	Full assessment
Device type	B
Mode of operation	Low demand mode or high demand mode
SIL	2
PL	d
DC/DC_{avg}	95 %
Category	2
λ_{sd}	600 FIT
λ_{dd}	350 FIT
$\lambda_{no\ part}$	80
$\lambda_{total\ (safety\ function)}$	1030 FIT
λ_{du}	15 FIT
λ_{dd}	350 FIT
SFF	94 %
PFD	$\geq 10^{-3}$ to $< 10^{-2}$
PFH	$< 2 \times 10^{-7}$ 1/h [1]
MTTF	112.43 years
$MTTF_d$	329.85 years (high)
CCF	95 (fulfilled)
Reacktion time	200 ms

Table 3.1

[1] With an average expected requirement rate of fewer than 25 times per year

3.4 Useful Lifetime

The measuring system has a useful lifetime of 10 years.

4 Mounting, Installation and Commissioning

Mounting and Installing the Device with Pre-Alarm and Main Alarm

1. Observe the safety instructions in the instruction manual.
2. Observe the information in the manual.
3. Observe the requirements for the safety loop.
4. Connect the device only to devices that are suitable for this safety application.
   - Depending on the sensor version, connect the pre-alarm (output 1) to pins 5 and 6 or to cables GR and RS.
   - Depending on the sensor version, connect the pre-alarm (output 2) to pins 7 and 8 or to cables BU and RD.
   - Depending on the sensor version, connect the vibration variable output (output 3) to pin 3 or to cable GN.
   - Connect the supply to pin 1 or to cable WH. The sensor must be powered by a SELV power supply in safe operation.
5. Check the safety function to ensure the expected output behavior.
   Select the limit values so that the safety function is triggered before any damage can be done to the system.

Mounting and Installing the Device with Window Function

1. Observe the safety instructions in the instruction manual.
2. Observe the information in the manual.
3. Observe the requirements for the safety loop.
4. Connect the device only to devices that are suitable for this safety application.
   - Depending on the sensor version, connect the lower switching threshold (output 1) to pins 5 and 6 or to cables GR and RS.
   - Depending on the sensor version, connect the upper switching threshold (output 2) to pins 7 and 8 or to cables BU and RD.
   - Depending on the sensor version, connect the vibration variable output (output 3) to pin 3 or to cable GN.
   - Connect the supply to pin 1 or to cable WH. The sensor must be powered by a SELV power supply in safe operation.
5. Check the safety function to ensure the expected output behavior.
   Select the limit values so that the safety function is triggered before any damage can be done to the system.

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4.1 Parameterization

Parameterizing the Device

The device is parameterized via HEX switches **LIM1**, **LIM2** and **TIME**. The HEX switches are on the front of the device.

1. The safety function is disabled during the parameterization. Take measures to maintain the safety function while the device is being parameterized.
2. Open the cover.
3. Briefly press the **Save Config** button.

   ↳ The current parameterization is indicated by the LEDs on the HEX switches.
4. Parameterize the limit values and delay times by using the respective HEX switch.

Note

For concrete details regarding the adjustable limit values and delay times, please refer to the manual.

↳ As soon as a switch position is changed, all LEDs start flashing.

5. Press and hold the **Save Config** button for 3 seconds to save the parameterization.

   ↳ The acceptance of the parameterization is indicated by steady lighting up of the LEDs in the selected HEX switch position. After about 5 minutes the LEDs turn off automatically.
6. Close the cover.

The measured signal is only validated again after leaving the parameterization mode and meets the requirements for the safety function.

Note

For more information see the manual.

5 Operation

Danger!

Danger to life from missing safety function

If the safety loop is put out of service, the safety function is no longer guaranteed.

- Do not deactivate the device.
- Do not bypass the safety function.
- Do not repair, modify, or manipulate the device.

Operating the device

1. Observe the safety instructions in the instruction manual.
2. Observe the information in the manual.
3. Use the device only with devices that are suitable for this safety application.
4. Correct any occurring safe failures. Take measures to maintain the safety function while the device is being repaired.

   The device has 2 limit values LIM1 and LIM2 and the corresponding delay times. The delay times can be adjusted separately.

   If the defined limit value is exceeded and after the set delay time has expired, the corresponding volt-free switching contact is opened.

   A subsequent fall below the limit value is also signaled at volt-free switching contacts 1 and 2, i. e. the respective switching contact automatically closes.

   - This is used for a device with pre-alarm and main alarm to generate a pre-alarm and a main alarm.
   - This is used for a device with window function to generate a signal for the lower and upper switching threshold.

   The device also has an analog current output. This supplies direct current of 4 mA to 20 mA proportional to the vibration variable.

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5.1 Proof Test and Self-Diagnostics

The sensor has a set of self-diagnostic measures. These are divided into 2 categories:

Start-up Diagnostics

These tests are only run in the sensor's initial start-up phase. Among other things, hardware-critical pathways are tested here that cannot be switched off once the device is in operation.

One of these critical tests is the diagnostics of the switching outputs:

- On a device with pre-alarm and main alarm for the pre-alarm and the main alarm
- On a device with window function for the lower and upper switching thresholds

In order to ensure the functionality of the switching outputs over the product's useful lifetime, the system operator must make sure to cycle the power on the vibration sensor once a year.

Cyclical Monitoring

The cyclical monitoring is fully automated and ensures that all tests are performed and evaluated within 12 hours for a diagnostic coverage of > 90 %.

6 Maintenance and Repair

Danger!

Danger to life from missing safety function

Changes to the device or a defect of the device can lead to device malfunction.
The function of the device and the safety function is no longer guaranteed.

Do not repair, modify, or manipulate the device.

Maintaining or Replacing the Device

In case of maintenance or replacement of the device, proceed as follows:

1. Implement appropriate maintenance procedures for regular maintenance of the safety loop.
2. While the device is maintained or replaced, the safety function does not work.
   Exception: The safety function is still guaranteed if the device is operated in redundancy.
   Take appropriate measures to protect personnel and equipment while the safety function is not available.
   Secure the application against accidental restart.
3. Do not repair a defective device.
4. If there is a defect, always replace the device with an original device.

Reporting Device Failure

If you use the device in a safety loop according to IEC/EN 61508, it is required to inform the device manufacturer about possible systematic failures.

Report all failures in the safety function that are due to functional limitations or a loss of device function – especially in the case of possible dangerous failures.

In these cases, contact your local sales partner or the Pepperl+Fuchs technical sales support (service line).

It is not necessary to report failures in the safety function that are due to external influences or damage.

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7 List of Abbreviations

CAT	Category according to EN ISO 13849-1:2008
CCF	**C**ommon **C**ause **F**ailure
DC/DC$_{avg}$	**D**iagnostic **C**overage/**Av**era**g**e **D**iagnostic **C**overage
FIT	**F**ailure **I**n **T**ime, 1 FIT = 1 failure / 10 h
FMEDA	**F**ailure **M**ode, **E**ffects, and **D**iagnostics **A**nalysis
λ_{sd}	Probability of safe detected failure
λ_{su}	Probability of safe undetected failure
$\lambda_{not\ part}$	Probability of failure of components that are not in the safety loop
$\lambda_{total\ (safety\ function)}$	Probability of failure of components that are in the safety loop
λ_{dd}	Probability of dangerous detected failure
λ_{du}	Probability of dangerous undetected failure
HFT	**H**ardware **F**ault **T**olerance
MTBF	**M**ean **T**ime **B**etween **F**ailures
MTTF	**M**ean **T**ime **T**o **F**ailure
MTTF$_D$	**M**ean **T**ime **T**o dangerous **F**ailure
MTTR	**M**ean **T**ime **T**o **R**estoration
PFD$_{avg}$	Average **P**robability of dangerous **F**ailure on **D**emand
PFH	Average frequency of dangerous failure per hour
SFF	**S**afe **F**ailure **F**raction
SIL	**S**afety **I**ntegrity **L**evel

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Explosion Protection

- Intrinsic Safety Barriers
- Signal Conditioners
- FieldConnex® Fieldbus
- Remote I/O Systems
- Electrical Ex Equipment
- Purge and Pressurization
- Industrial HMI
- Mobile Computing and Communications
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- Surge Protection
- Wireless Solutions
- Level Measurement

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- Proximity Sensors
- Photoelectric Sensors
- Industrial Vision
- Ultrasonic Sensors
- Rotary Encoders
- Positioning Systems
- Inclination and Acceleration Sensors
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- AS-Interface
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- Displays and Signal Processing
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