Functional Safety – Application

Radar Sensor MWC25M-L2M-B*

Manual

ISO9001

CE PL c

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Contents

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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
- 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.

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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 radar sensor emits electromagnetic waves that are reflected by an object and received again by the radar sensor.

The device is used for object detection, distance measurement and speed measurement.

Diagnostic Functions in Conjunction with a Logic Unit

In safety applications, operate the device in conjunction with a logic unit. The device has a CAN interface for parameterizing and transferring the process data to the logic unit.

It is not possible to parameterize the diagnostic functions on the device.
Use the parameterization options of the logic unit via the CAN interface, see chapter 4.3.

Note

For more information, refer to the relevant datasheet and manual.

2.2 Interfaces

The device has the following interfaces:

- Safety-related interface: CAN interface
- Non-safety-related interface: none

Note

For corresponding connections see datasheet.

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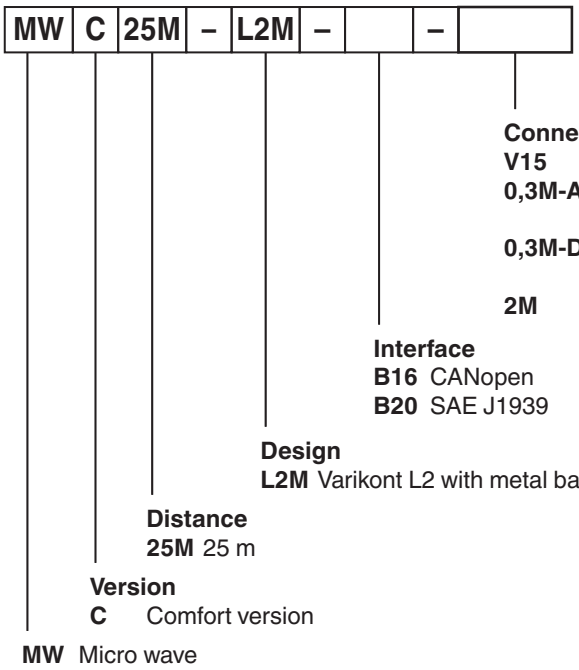
2.3 Marking

Pepperl+Fuchs Group Lilienthalstraße 200, 68307 Mannheim, Germany
Internet: www.pepperl-fuchs.com

Radar sensor, Varikont L2 design with CAN interface	Up to PL c and category 2, refer to application examples also



2.4 Standards and Directives for Functional Safe

Device specific standards and directives

Machinery regulation (EU) 2023/1230	EN/ISO 13849-1:2023: Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design

3 Planning

3.1 Assumptions

The following assumptions have been made during the FMEDA:

- Failure rate based on the Siemens standard SN 29500.
- Failure rates are constant, wear is not considered.
- The system calculation used the $MTTF_D$ value at +40 °C as a basis.
- The total failure budget was calculated on the assumption that 50 % of all faults are rated as safe resp. dangerous.
- The device will be used under average industrial ambient conditions comparable to the classification **stationary mounted** according to MIL-HDBK-217F.

  Alternatively, operating stress conditions typical of an industrial field environment similar to IEC/EN 60654-1 Class C with an average temperature over a long period of time of 40 ºC may be assumed. For a higher average temperature of 60 ºC, the failure rates must be multiplied by a factor of 2.5 based on experience. A similar factor must be used if frequent temperature fluctuations are expected.

Applications according to EN/ISO 13849-1

- In safety applications, operate the device in conjunction with a logic unit.
- The device was qualified for use in safety functions according to EN/ISO 13849-1. The device fulfills the requirements of PL c according to EN/ISO 13849-1. The logic unit must have at least a PL c.
- For a category 2 PL c application, the diagnostic coverage DC must at least be low (> 60 %).
- When using the diagnostics functions, a diagnostic coverage of 60 % according to EN/ISO 13849-1, annex E, table E.1 can be assumed for input elements, see chapter 3.2.
- The required diagnostics must be implemented at the system level and validated according to Machinery Regulation (EU) 2023/1230.

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3.2 Safety Function and Safe State

Safe State

The safe state is achieved when the system enters a predefined state in the event of a fault to prevent undesirable or dangerous situations. The predefined state means that the power supply to the actuators is interrupted.

Example

In a system, drive elements are used to perform certain movements. If an object is detected or a distance or speed value is reached, the power supply to the drive elements is interrupted. The drive elements come to a standstill. This corresponds to the safe state.

Safety Function

Depending on the requirements, the STO/SS1 safety function can be implemented, for example.

- immediate shutdown: STO
- Time-delayed shutdown: SS1

The STO/SS1 safety function is a standardized safety function according to IEC/EN 61800-5-2.

Diagnostic Functions in Conjunction with a Logic Unit

In safety applications, operate the device in conjunction with a logic unit.

It is not possible to parameterize the diagnostic functions on the device.
Use the parameterization options of the logic unit via the CAN interface, see chapter 4.3.

- **Cyclical evaluation of process data:**
  The process data telegram is sent at regular intervals. The measuring cycles are counted in the process data. If this counter does not change within a certain time span or if counter values are skipped, this constitutes a fault.
- **Emergency messages and fault registers:**
  An emergency message is sent when a fault is detected in the device, e. g., a temperature or supply voltage outside the defined range.
- **Acyclic polling of process data parameters:**
  The logic unit queries the process data. If the device does not respond within a certain time span or does not respond with the expected data, this constitutes a fault.
- **Heartbeat function (CANopen interface only):**
  The device is able to send heartbeat telegrams cyclically. If the heartbeat telegram is missing for a certain period of time, this constitutes a fault.

Note

To achieve a diagnostic coverage of 60 %, enable at least the following diagnostic functions.

- Cyclical evaluation of process data
- Emergency messages and fault registers

These 2 diagnostic functions are preset at the factory.

Reaction Times

Safety reaction time is the maximum time required from the removal of the reference object to the response of the outputs in normal operation without a fault. The safety reaction time is included in the fault reaction time.

Fault reaction time is the time from the occurrence of a fault to the response of the system's outputs. This time depends on the application.

Cross Fault

A cross fault is a short circuit between the data lines (CAN_H <> CAN_L) or between a data line and the power supply (CAN_H <> supply or CAN_L <> supply). Depending on the type of cross fault, the fault is detected and indicated either immediately or during the next switching operation.

Such a cross fault interferes with CAN communication. The cross fault is detected by the control due to a cycle counter that is no longer changing.

In the event of a communication fault, the bus signal is changed. This change is detected by other bus devices and the device switches to the safe state (off state).

3.3 Characteristic Safety Values

Parameters	Characteristic values	
Assessment type and documentation	Full assessment	
Safety function	Safe distance measurement	Safe speed measurement
PL	c	c
Category	2	2
DC_{avg}	60 % (low)	60 % (low)
$MTTF_D$	310 years [1]	310 years [1]
PFH_D (control)	5.30×10^{-7} 1/h	5.30×10^{-7} 1/h
Time delay before availability	≤ 400 ms	≤ 400 ms
Safety reaction time	≤ 220 ms	≤ 220 ms
Function test interval	maximum 1 year	maximum 1 year
Useful lifetime T_M	maximum 20 years	maximum 20 years

Table 3.1

[1] reduced to 100 years

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3.4 Useful Lifetime

Although a constant failure rate is assumed by the probabilistic estimation this only applies provided that the useful lifetime of components is not exceeded. Beyond this useful lifetime, the result of the probabilistic estimation is meaningless as the probability of failure significantly increases with time. This useful lifetime is highly dependent on the component itself and its operating conditions – temperature in particular. For example, electrolytic capacitors can be very sensitive to the operating temperature.

This assumption of a constant failure rate is based on the bathtub curve, which shows the typical behavior for electronic components.

Therefore it is obvious that failure calculation is only valid for components that have this constant domain and that the validity of the calculation is limited to the useful lifetime of each component.

It is assumed that early failures are detected to a huge percentage during the installation and therefore the assumption of a constant failure rate during the useful lifetime is valid.

The EN/ISO 13849-1 standard defines a useful lifetime T_M for devices used within industrial environments. For the useful lifetime of the device described here refer to chapter 3.3. Observe that the useful lifetime can be reduced if the device is exposed to the following conditions:

- highly stressful environmental conditions such as constantly high temperatures
- temperature cycles with high temperature differences
- permanent repeated mechanical stress (vibration)

According to DIN EN 61508-2 standard note N3, appropriate measures taken by the manufacturer and plant operator can extend the useful lifetime.

Our experience has shown that the useful lifetime of a Pepperl+Fuchs product can be higher if the ambient conditions support a long useful lifetime, for example if the ambient temperature is significantly below the maximum ambient temperature.

Please note that the useful lifetime refers to the (constant) failure rate of the device. The effective lifetime can deviate from this.

The estimated useful lifetime is greater than the warranty period prescribed by law or the manufacturer's guarantee period. However, this does not result in an extension of the warranty or guarantee services. Failure to reach the estimated useful lifetime is not a material defect.

4 Mounting and Installation

Mounting and Installing the Device

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.
5. Check the safety function to ensure the expected output behavior.

4.1 Mounting

The device has a dead band in which the function is unsafe.

Danger!

Danger to life from loss of safety function

If an object is unintentionally located in the dead band of the device and cannot be detected by the device, the safety function is no longer guaranteed.

- Take suitable measures to prevent that objects are inside the dead band of the device.
- Mount the device according to the application.
- Setup the device according to the application. Keep the required operating distances.
- Check the assured distances.

Mounting the Device

1. Mount the device. Observe the mounting conditions, see figure below.
2. To precisely align the device (1), loosen the sensor bracket screws (2).
3. Align the device (1) according to the application.
4. Tighten the screws (2) with the recommended tightening torque.
5. Mount the sensor (1) on a suitable mounting surface (4).
6. Tighten the screws (3) to the recommended tightening torque.

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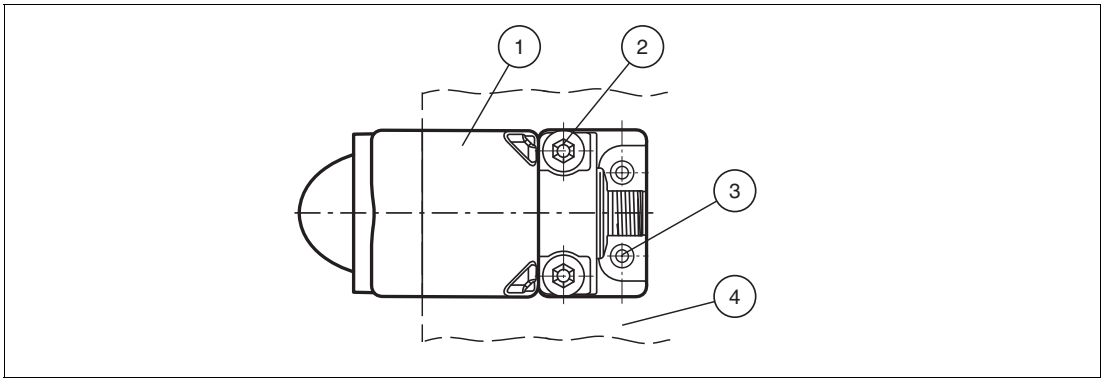

Figure 4.1

1 Sensor
2 M6 screw, recommended tightening torque 4 Nm
3 M5 screw, recommended tightening torque 2.7 Nm
4 Mounting surface

Using a Reference Object

1. To make use of the full detection range of the device, use a reference object.
The reference object is available as an accessory.
2. If it is not possible to use a reference object, observe the following instructions:
   - Use an object with a large radar cross-section. We recommend a radar cross-section of approx. 70 m^2.
   - Use an object with good reflectivity for radar waves. We recommend objects made of metal or a liquid medium.
   - Ensure that the object is correctly aligned with the device.
   - Ensure that the object is detected reliably and there is no interfering object in the relevant environment. Observe the response curves of the device, see datasheet.

4.2 Connection

Caution!

Danger to life from loss of safety function

If the supply voltage exceeds 36 V DC in a fault condition, the safety function is no longer guaranteed.

Take appropriate measures to prevent that the supply voltage exceeds 36 V DC.
Use a suitable power supply.

Connecting the Device

1. Connect the device to the power supply.
2. Connect the device to the logic unit.
3. If you are using the device in a category 2, PL c safety loop, connect the device to the logic unit via the CAN interface.
4. Use a shielded 5-wire connection cable.
5. Observe the pin assignment, since the standard pin assignment (A-coded M12 plug) differs from the CAN interface assignment.

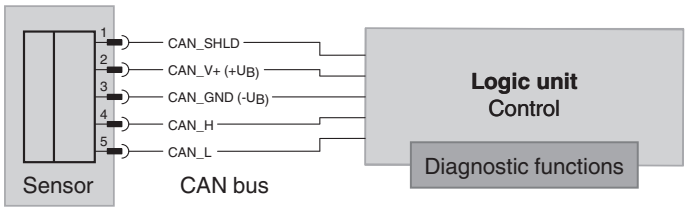

Figure 4.2 Example of a safety path via CAN interface in conjunction with a logic unit

Note

For more information, refer to the relevant datasheet and manual.

4.3 Parameterization

It is not possible to parameterize the diagnostic functions on the device.
Use the parameterization options of the logic unit via the CAN interface.

The device can be parameterized using appropriate parameterization software, e. g., FDT framework program PACTware with DTM **D**evice **T**ype **M**anager. The DTM described below offers you a variety of options for easy parameterization of the device and analysis of the device behavior.

Note

For more information, refer to the relevant datasheet and manual.

4.3.1 Parameterization of Diagnostic Functions via DTM

Note

In the following screenshots of the DTM, the device represents all versions of the MWC25M-L2M-B* series.

Parameterizing the Device

In the **Configuration** menu, parameterize the device using the respective submenus.

Configuration Menu

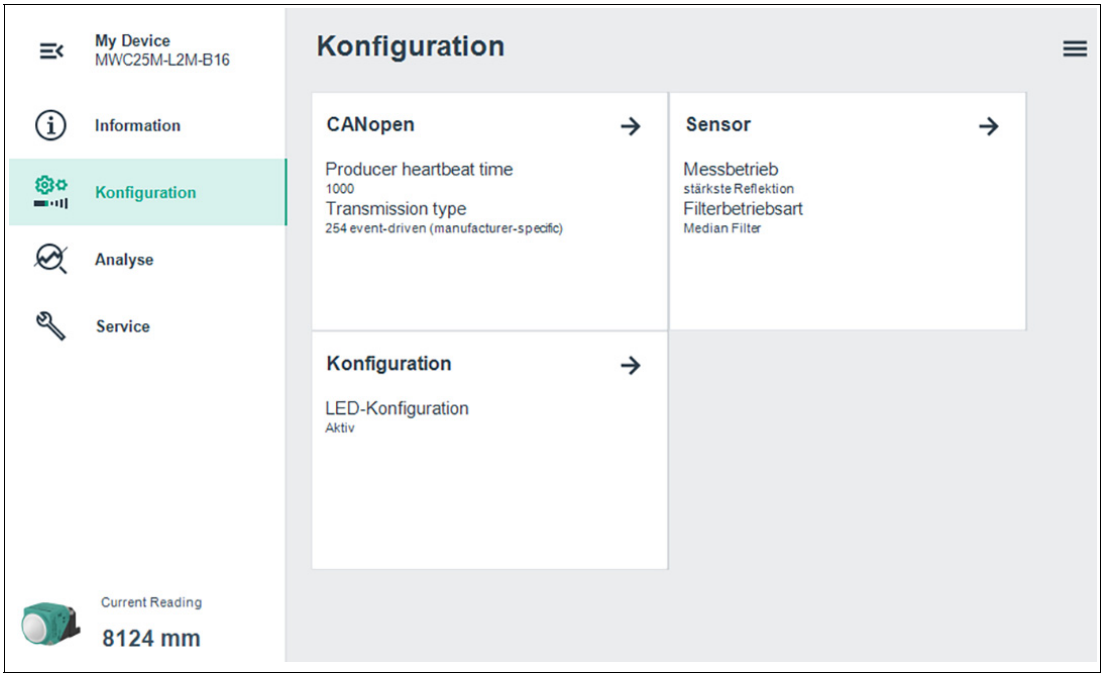

Figure 4.3

Setting up the Safety Function

1. In the **CANopen** submenu, enable the producer heartbeat time and the PDO mapping of the device.
2. Enable at least one of the following safety functions:

Note

To ensure the safety function, it is sufficient to enable one PDO value, e. g. PDO mapping 1: distance. Additional values are optional.

For object detection by speed, additionally enable PDO mapping 2.

- PDO mapping 1: distance
- PDO mapping 2: speed
- PDO mapping 3: signal quality

3. Check the values at system level.

↳ In case of fault, the safe state (off state) is assumed depending on the application.

CANopen Submenu

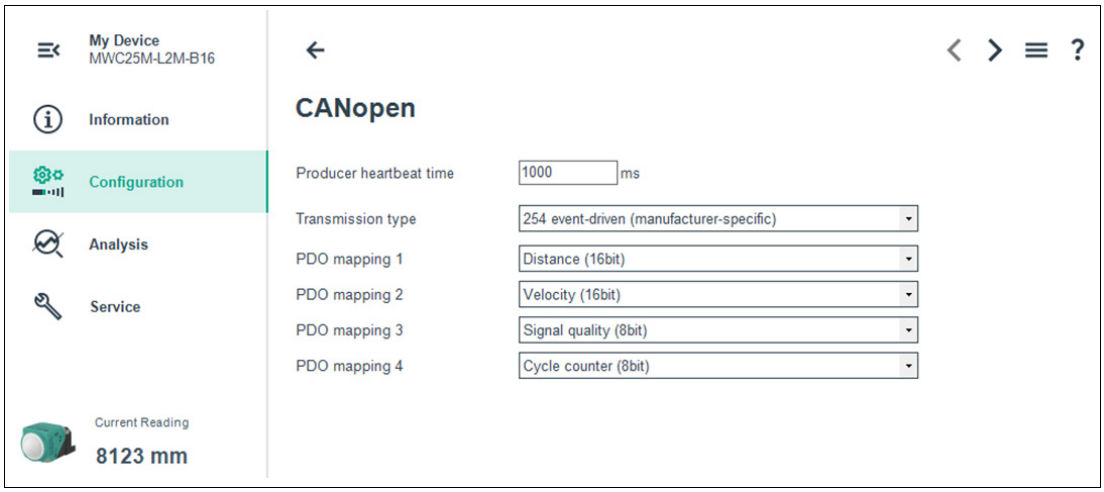

Figure 4.4

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 instruction 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 within 24 hours. Take measures to maintain the safety function while the device is being replaced.

5.1 Functional Test

This functional test is only required for applications according to EN/ISO 13849-1, category 2.

Functional Test Procedure

1. A one-time check of the correct function within the application is sufficient.
2. In category 2 safety loops, check the safety function once a day or when the device is switched on.
3. Because this device has low failure rates, you can extend the functional test interval to up to 1 year.
4. Select the functional test interval depending on the load on the device in the application, e. g., in accordance with environmental stress or mechanical stress.
5. Select the functional test interval taking into account the operating procedures, e. g., always on Mondays, the first of the month, etc.

5.2 Proof Test

Proof Test Procedure

1. Check the device for damage to the housing. If moisture penetrates the device or internal components of the device are damaged, this can have unpredictable effects.
2. Check whether the device is working properly. If the device does not work or works incorrectly, replace the device.
3. If the device is used in a safety loop for distance measurement, check the measured distance value of the device using a reference object.
4. If the device is used in a safety loop for speed measurement, check the measured speed value of the device using a reference object.
5. Check the correct function of the status indication during the regular inspection.
6. Check the correct behavior of the safety loop. Is the parameterization correct?

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6 Application Examples

This chapter shows how to integrate the device into a safety path.

1-channel Design with Diagnostics (Categorie 2 according to EN/ISO 13849-1)

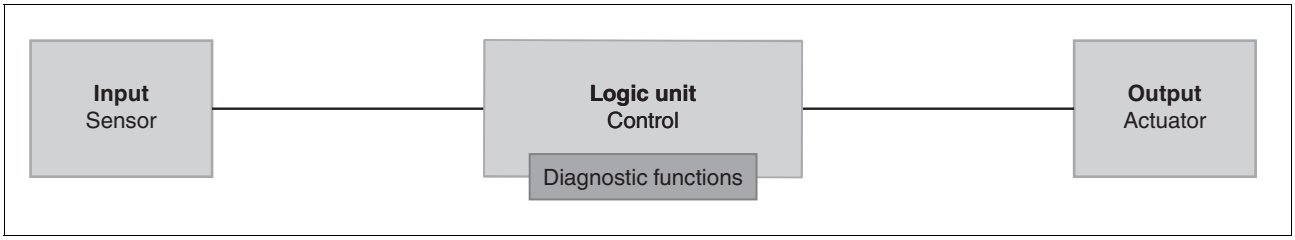

Figure 6.1 Example of a safety path with diagnostics up to PL c and category 2

You can use the device under the following conditions up to category 2, PL c:

- Operate the device in safety applications in conjunction with a logic unit, see chapter 4.3.
- Connect the device to the power supply.
- Connect the device to the logic units via the CAN interface, see chapter 4.2.
- Enable the safety path with diagnostics according to the required performance level, see chapter 4.3.1.
- If a safe shutdown is required, this must be implemented according to the required performance level, see chapter 3.1
- Protect unconnected output cables from short circuits.

Application Example 1 – Diagnosis via Table Value

Assumption: The detection of an object is classified as a **fault**.

- If an object is detected and the distance matches the table value, the device is switched off. This corresponds to the safe state (off state).
- If an object is detected and the distance **does not** match the table value, the system is in normal operation, e. g. when the object is outside the hazardous area.

Application Example 2 – Diagnosis via Table Value

Assumption: The detection of an object is classified as **normal operation**.

- If an object is detected and the distance matches the table value, the system is in normal operation.
- If an object is detected and the distance **does not** match the table value, the device is switched off. This corresponds to the safe state (off state).

Note

In the logic unit, expected distance values for various use cases are entered in tables. These table values serve as limit values for distance measurement.

A table value can also represent an area, e. g. a hazardous area: 800 mm to 1200 mm.

Application Example 3 – Speed Monitoring

For speed monitoring, additionally enable PDO mapping 2, see chapter 4.3.1.

- If an object is detected and the speed is greater than 0 m/s, the device is switched off. This corresponds to the safe state (off state).

Note

For more information, refer to the relevant datasheet and manual.

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7 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 EN/ISO 13849-1, 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.

8 List of Abbreviations

DC	**D**iagnostic **C**overage of dangerous faults
FIT	**F**ailure **I**n **T**ime in 10^{-9} 1/h
FMEDA	**F**ailure **M**ode, **E**ffects, and **D**iagnostics **A**nalysis
λ_s	Probability of safe failure
λ_{dd}	Probability of dangerous detected failure
λ_{du}	Probability of dangerous undetected failure
$\lambda_{no\ effect}$	Probability of failures of components in the safety loop that have no effect on the safety function.
$\lambda_{not\ part}$	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
HFT	**H**ardware **F**ault **T**olerance
MTBF	**M**ean **T**ime **B**etween **F**ailures
$MTTF_D$	**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
PL	**P**erformance **L**evel
PLC	**P**rogrammable **L**ogic **C**ontroller
SFF	**S**afe **F**ailure **F**raction
T_1	Proof Test Interval
T_M	Useful lifetime according to EN/ISO 13849-1 (mission time)

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