Functional Safety

Switch Amplifier HiC284*

Manual

SIL

IEC 61508/61511

ISO9001

CE SIL 2

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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.

The documentation consists of the following parts:

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.

- 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

This isolated barrier is used for intrinsic safety applications.

The device transfers digital signals (NAMUR sensors/mechanical contacts) from the explosion-hazardous area to the non-explosion-hazardous area.

The proximity sensor or switch controls two passive transistors for the safe area load. Both transistor outputs are isolated from each other and isolated from the power supply. The output changes state when the input signal changes state.

Via switches the mode of operation can be reversed and the line fault detection can be switched off.

This device mounts on a HiC termination board.

2.2 Interfaces

The device has the following interfaces.

- Safety relevant interfaces:
  HiC2841: input I, output I, output II (optional)
  HiC2842: input I, input II, output I, output II
- Non-safety relevant interfaces: fault indication output

Note

For corresponding connections see datasheet.

2.3 Marking

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Internet: www.pepperl-fuchs.com

HiC2841, HiC2842	Up to SIL 2

2.4 Standards and Directives for Functional Safety

Device specific standards and directives

Functional safety	IEC/EN 61508, part 1 – 7, edition 2010: Functional safety of electrical/electronic/programmable electronic safety-related systems (manufacturer)

System-specific standards and directives

Functional safety	IEC 61511-1:2016+COR1:2016+A1:2017 EN 61511-1:2017+A1:2017 Functional safety – Safety instrumented systems for the process industry sector (user)

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3 Planning

3.1 System Structure

3.1.1 Low Demand Mode of Operation

If there are two control loops, one for the standard operation and another one for the functional safety, then usually the demand rate for the safety loop is assumed to be less than once per year.

The relevant safety parameters to be verified are:

- the PFD_{avg} value (average **P**robability of dangerous **F**ailure on **D**emand) and the T_1 value (proof test interval that has a direct impact on the PFD_{avg} value)
- the SFF value (**S**afe **F**ailure **F**raction)
- the HFT architecture (**H**ardware **F**ault **T**olerance)

3.1.2 High Demand or Continuous Mode of Operation

If there is only one safety loop, which combines the standard operation and safety-related operation, then usually the demand rate for this safety loop is assumed to be higher than once per year.

The relevant safety parameters to be verified are:

- the PFH value (**P**robability of dangerous **F**ailure per **H**our)
- Fault reaction time of the safety system
- the SFF value (**S**afe **F**ailure **F**raction)
- the HFT architecture (**H**ardware **F**ault **T**olerance)

3.1.3 Safe Failure Fraction

The safe failure fraction describes the ratio of all safe failures and dangerous detected failures to the total failure rate.

$SFF = (\lambda_s + \lambda_{dd}) / (\lambda_s + \lambda_{dd} + \lambda_{du})$

A safe failure fraction as defined in IEC/EN 61508 is only relevant for elements or (sub)systems in a complete safety loop. The device under consideration is always part of a safety loop but is not regarded as a complete element or subsystem.

For calculating the SIL of a safety loop it is necessary to evaluate the safe failure fraction of the elements and subsystems, but not of a single device.

Nevertheless the SFF of the device is given in this document for reference.

3.2 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 safety-related device is considered to be of type **A** device with a hardware fault tolerance of **0**.
- 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 °C may be assumed. For a higher average temperature of 60 °C, 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.
- Since the outputs of the device use common components, these outputs must not be used in the same safety function.

SIL 2 Application

- To build a SIL safety loop for the defined SIL, it is assumed as an example that this device uses 10 % of the available budget for PFD_{avg}/PFH.
- For a SIL 2 application operating in low demand mode the total PFD_{avg} value of the SIF (**S**afety **I**nstrumented **F**unction) should be smaller than 10^{-2}, hence the maximum allowable PFD_{avg} value would then be 10^{-3}.
- For a SIL 2 application operating in high demand mode the total PFH value of the SIF should be smaller than 10^{-6} per hour, hence the maximum allowable PFH value would then be 10^{-7} per hour.
- Since the safety loop has a hardware fault tolerance of **0** and it is a type **A** device, the SFF must be > 60 % according to table 2 of IEC/EN 61508-2 for a SIL 2 (sub) system.

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3.3 Safety Function and Safe State

Safe State

The safe state is the de-energized state of the outputs land II.

Safety Function

HiC2841

- For output I:
  - Switch S1 in position II (normal operation)
    In this case the safety function is defined as **output I is de-energized**, if the **input I is in de-energized state**.
  - Switch S1 in position I (inverse operation)
    In this case the safety function is defined as **output I is de-energized**, if the **input I is in conducting state**.
- For output II:
  - Switch S3 in position I (output II follows output I)
    Output II follows output I. The safety function is the same as for output I.
  - Switch S3 in position II (output II assigned to line fault detection)
    Output II is not part of the safety function.

HiC2842

- For channel I:
  - Switch S1 in position II (normal operation)
    In this case the safety function is defined as **output I is de-energized**, if the **input I is in de-energized state**.
  - Switch S1 in position I (inverse operation)
    In this case the safety function is defined as **output I is de-energized**, if the **input I is in conducting state**.
- For channel II:
  - Switch S3 in position II (normal operation)
    In this case the safety function is defined as **output II is de-energized**, if the **input II is in conducting state**.
  - Switch S3 in position I (inverse operation)
    In this case the safety function is defined as **output II is de-energized**, if the **input II is in conducting state**

LB/SC Diagnosis

The input loops of all versions are supervised, if the line fault detection is active (mandatory, see datasheet). The related safety function is defined as the outputs are in fault state (safe state), if there is a line fault detected.

Note

The fault indication output is not safety relevant.

Reaction Time

1. The reaction time for input to output safety functions is < 0.2 ms. (load conditions: 24 V, 10 kΩ)
2. The fault detection and fault reaction time is < 100 ms. A fault diagnosis at the input leads to output safe state.
3. The fault indication output is not safety relevant. (< 100 ms)

Note

See corresponding datasheets for further information.

3.4 Characteristic Safety Values

Parameters	Characteristic values
Assessment type	Full assessment
Device type	A
Mode of operation	Low Demand Mode or High Demand Mode
HFT	0
SIL	2
SC	3
MTBF [1]	353 years
Safety function	All modes of operation [2]
λ_s	140 FIT
λ_{dd}	0 FIT
λ_{du}	28.9 FIT
$\lambda_{no\ part}$	51 FIT
$\lambda_{total\ (safety\ function)}$	169 FIT
SFF [3]	82.9 %
PFH	2.89×10^{-8} 1/h
PFD_{avg} for T_1 = 1 year	1.26×10^{-4}
PFD_{avg} for T_1 = 2 years	2.53×10^{-4}
PFD_{avg} for T_1 = 5 years	6.32×10^{-4}
PTC	100 %

Table 3.1

1 acc. to SN29500. This value includes failures which are not part of the safety function/MTTR = 8 h.

2 The device can be used in two modes of operation, inverse operation and normal operation.

3 "No effect failures" are not influencing the safety function and are therefore not included in SFF and in the failure rates of the safety function.

The characteristic safety values like PFD, PFH, SFF, HFT and T_1 are taken from the FMEDA report. Observe that PFD and T_1 are related to each other.

The function of the devices has to be checked within the proof test interval (T_1).

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3.5 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. The 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.

However, according to IEC/EN 61508-2, a useful lifetime, based on general experience, should be assumed. Experience has shown that the useful lifetime often lies within a range period of about 8 to 12 years.

As noted in DIN EN 61508-2:2011 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 life time, 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 life time 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 Configuration

Configuring the Device

The device is configured via DIP switches. The DIP switches for setting the safety functions are on the side of the device.

1. De-energize the device before configuring the device.
2. Remove the device.
3. Configure the device for the required safety function via the DIP switches, see chapter 3.3.
4. Secure the DIP switches to prevent unintentional adjustments.
5. Mount the device.
6. Connect the device again.

Note

See corresponding datasheets for further information.

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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 within 8 hours. Take measures to maintain the safety function while the device is being repaired.

5.1 Proof Test

This section describes a possible proof test procedure. The user is not obliged to use this proposal. The user may consider different concepts with an individual determination of the respective effectiveness, e. g. concepts according to NA106:2018.

According to IEC/EN 61508-2 a recurring proof test shall be undertaken to reveal potential dangerous failures that are not detected otherwise.

Check the function of the subsystem at periodic intervals depending on the applied PFD_{avg} in accordance with the characteristic safety values. See chapter 3.4.

It is under the responsibility of the plant operator to define the type of proof test and the interval time period.

Check the settings after the configuration by suitable tests.

5.2 Proof Test Procedure

Equipment required:

- Digital multimeter with an accuracy of 0.1 %

  Use for the proof test of the intrinsic safety side of the device a special digital multimeter for intrinsically safe circuits.

  If intrinsically safe circuits are operated with non-intrinsically safe circuits, they must no longer be used as intrinsically safe circuits.
- Power supply set to nominal voltage of 24 V DC
- Simulate the sensor state by a potentiometer of 4.7 kΩ (threshold for normal operation), by a resistor of 220 Ω (short circuit detection) and by a resistor of 150 kΩ (lead breakage detection).

Proof Test Procedure

1. Put out of service the entire safety loop. Protect the application by means of other measures.
2. Prepare a test set-up, see figures below.
3. Simulate the sensor state by connecting a potentiometer, a resistor for short circuit detection or by a resistor for lead breakage detection.
   Test each input channel individually.
4. Connect a potentiometer of 4.7 kΩ (threshold for normal operation) to the input.

   ↳ The threshold must be between 1.4 mA and 1.9 mA, the hysteresis must be between 170 µA and 250 µA.
   - If the input current is above the threshold the output must be activated for normal mode of operation. The yellow LED lights up.
   - If the input current is below the threshold the output must be activated for inverted mode of operation. The yellow LED lights up.
5. Connect a resistor R_{SC} (220 Ω) or a resistor R_{LB} (150 kΩ) to the input.

   ↳ The device must detect an external fault. This state is indicated by red LED and the output of the corresponding channel must be de-activated.
6. Test both outputs with a specific current, e. g. 10 mA. To avoid electric shock, use a test voltage of 24 V DC. Check that the outputs contacts are not conducting.

   ↳ The outputs must be de-activated. The outputs must **definitely not conducting**, if the yellow LED is off.
7. Set back the device to the original settings for the current application after the test.
8. Check the correct behavior of the safety loop. Is the configuration correct?
9. Secure the DIP switches to prevent unintentional adjustments.

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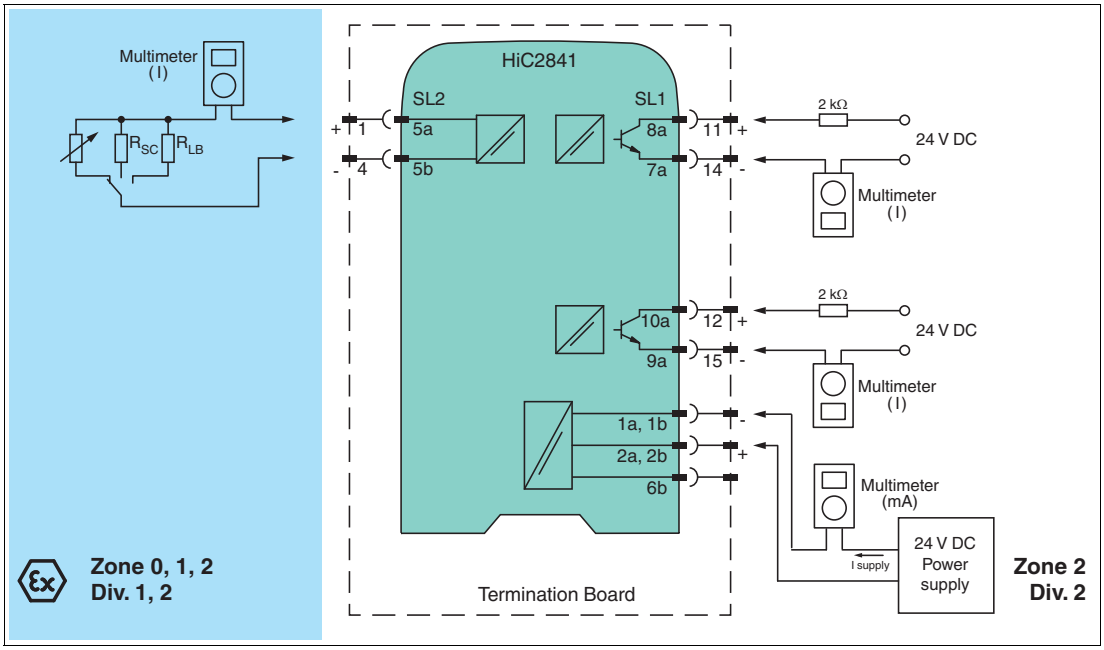

Figure 5.1 Proof test set-up for HiC2841

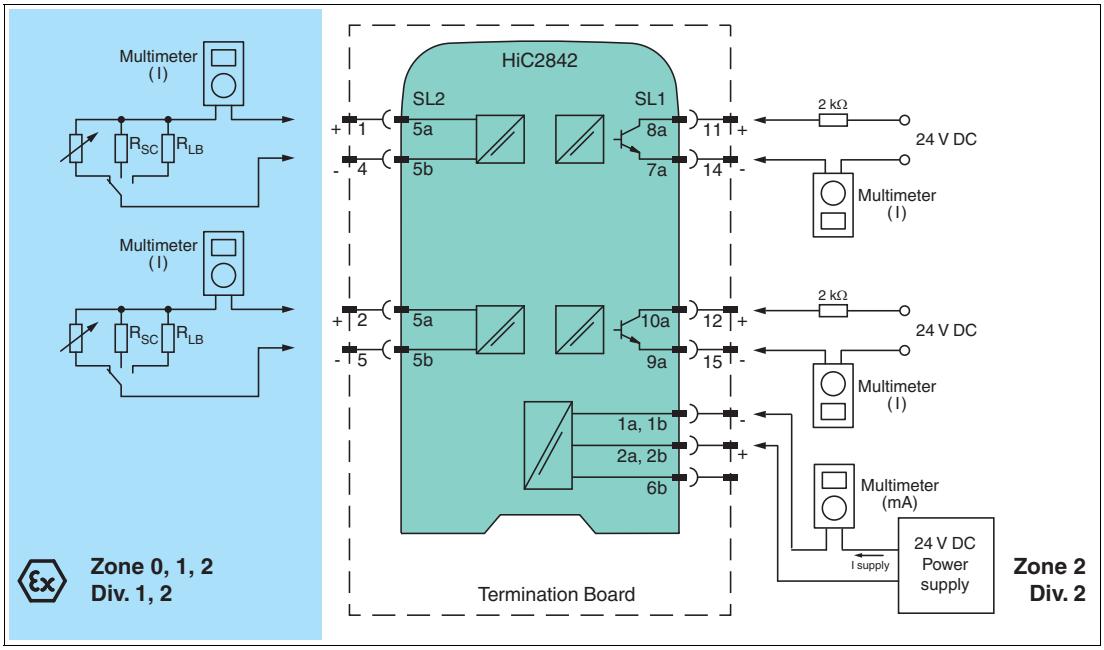

Figure 5.2 Proof test set-up for HiC2842

Tip

The easiest way to test HiC devices is by using a stand-alone HiCTB**-SCT-***-**-** termination board. In this test, it is not necessary to disconnect the wiring of the existing application. Faults in a subsequent wiring can be avoided.

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, Repairing or Replacing the Device

In case of maintenance, repair 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, repaired or replaced, the safety function does not work.
   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. A defective device must only be repaired by the manufacturer.
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

ESD	**E**mergency **S**hut**d**own
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
MTTR	**M**ean **T**ime **T**o **R**estoration
PCS	**P**rocess **C**ontrol **S**ystem
PFD_{avg}	Average **P**robability of dangerous **F**ailure on **D**emand
PFH	Average frequency of dangerous failure per hour
PLC	**P**rogrammable **L**ogic **C**ontroller
PTC	**P**roof **T**est **C**overage
SC	**S**ystematic **C**apability
SFF	**S**afe **F**ailure **F**raction
SIF	**S**afety **I**nstrumented **F**unction
SIL	**S**afety **I**ntegrity **L**evel
SIS	**S**afety **I**nstrumented **S**ystem
T_1	Proof Test Interval
FLT	Fault
LB	**L**ead **B**reakage
LFD	**L**ine **F**ault **D**etection
SC	**S**hort **C**ircuit
$T_{service}$	Time from start of operation to putting the device out of service

Your automation, our passion.

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
- HART Interface Solutions
- Surge Protection
- Wireless Solutions
- Level Measurement

Industrial Sensors

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

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