PROCESS AUTOMATION

SAFETY MANUAL SIL

TEMPERATURE CONVERTER

KFD2-UT2-(Ex)*, HiD2082

SIL

IEC 61508/61511

ISO9001

SIL2

PEPPERL+FUCHS

PROTECTING YOUR PROCESS

1 **Introduction 4**

1.1 General Information 4

1.2 Intended Use 4

1.3 Manufacturer Information 5

1.4 Relevant Standards and Directives 6

2 **Planning 7**

2.1 System Structure 7

2.1.1 Low Demand Mode 7

2.1.2 High Demand Mode 7

2.1.3 Safe Failure Fraction 7

2.2 Assumptions 8

2.3 Safety Function and Safe State 9

2.4 Characteristic Safety Values 10

3 **Safety Recommendation 12**

3.1 Interfaces 12

3.2 Configuration 12

3.3 Useful Life Time 12

3.4 Installation and Commissioning 13

4 **Proof Test 14**

4.1 General 14

4.2 Proof Test Procedure for KFD2-UT2-(Ex)* 14

4.3 Proof Test Procedure for HiD2082 20

5 **Abbreviations 27**

1 Introduction

1.1 General Information

This manual contains information for application of the device in functional safety related loops.

The corresponding data sheets, the operating instructions, the system description, the Declaration of Conformity, the EC-Type-Examination Certificate, the Functional Safety Assessment and applicable Certificates (see data sheet) are integral parts of this document.

The documents mentioned are available from **www.pepperl-fuchs.com** or by contacting your local Pepperl+Fuchs representative.

Mounting, commissioning, operation, maintenance and dismounting of any devices may only be carried out by trained, qualified personnel. The instruction manual must be read and understood.

When it is not possible to correct faults, the devices must be taken out of service and action taken to protect against accidental use. Devices should only be repaired directly by the manufacturer. De-activating or bypassing safety functions or failure to follow the advice given in this manual (causing disturbances or impairment of safety functions) may cause damage to property, environment or persons for which Pepperl+Fuchs GmbH will not be liable.

The devices are developed, manufactured and tested according to the relevant safety standards. They must only be used for the applications described in the instructions and with specified environmental conditions, and only in connection with approved external devices.

1.2 Intended Use

KFD2-UT2-Ex* (Ex devices)

This isolated barrier is used for intrinsic safety applications. It is designed to connect RTDs, thermocouples, or potentiometers in the hazardous area, and provide a proportional 0/4 mA ... 20 mA (0/1 V ... 5 V) signal to the safe area.

The barrier offers 3-port isolation between input, output, and power supply.

A removable terminal block K-CJC-** is available for thermocouples when internal cold junction compensation is desired.

A fault is indicated by a red flashing LED per NAMUR NE44 and user-configured fault outputs.

The device is easily programmed with the PACTware™ configuration software.

A collective error messaging feature is available when used with the Power Rail system.

For additional information, refer to the manual and www.pepperl-fuchs.com.

KFD2-UT2-* (Non-Ex devices)

This signal conditioner is designed to connect RTDs, thermocouples, or potentiometers, and provide a proportional 0/4 mA ... 20 mA (0/1 V ... 5 V) signal.

The barrier offers 3-port isolation between input, output, and power supply.

A removable terminal block K-CJC-** is available for thermocouples when internal cold junction compensation is desired.

A fault is indicated by a red flashing LED per NAMUR NE44 and user-configured fault outputs.

The device is easily programmed with the PACTware™ configuration software.

A collective error messaging feature is available when used with the Power Rail system.

For additional information, refer to the manual and www.pepperl-fuchs.com.

HiD2082

This isolated barrier is used for intrinsic safety applications.

It is a universal temperature converter that accepts thermocouples (TC), millivolts, potentiometers, or resistance temperature detectors (RTD) from a hazardous area and converts them to an isolated, linearized analog output in the safe area.

The outputs can be selected as a current source, current sink, or voltage source with DIP switches on the side panel.

Line fault detection of the field circuit is indicated by a red LED and an output on the fault bus. The fault conditions are monitored via a Fault Indication Board.

The device is easily programmed by the use of a DIP switches on the side of the unit and with the PACTware™ configuration software.

This module mounts on a HiD Termination Board.

1.3 Manufacturer Information

Pepperl+Fuchs GmbH

Lilienthalstrasse 200
68307 Mannheim/Germany

KFD2-UT2-(Ex)*, HiD2082

Up to SIL2

1.4 Relevant Standards and Directives

Device specific standards and directives

- Functional safety IEC 61508 part 1 – 7, edition 2000:
  Standard of functional safety of electrical/electronic/programmable electronic safety-related systems (product manufacturer)
- Electromagnetic compatibility:
  - EN 61326-1:2006
  - NE 21:2006

System specific standards and directives

- Functional safety IEC 61511 part 1 – 3, edition 2003:
  Standard of functional safety: safety instrumented systems for the process industry sector (user)

2 Planning

2.1 System Structure

2.1.1 Low Demand Mode

If there are two 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 **F**ailure on **D**emand) and T_{proof} (proof test interval that has a direct impact on the PFD_{avg})
- the SFF value (**S**afe **F**ailure **F**raction)
- the HFT architecture (**H**ardware **F**ault **T**olerance architecture)

2.1.2 High Demand Mode

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

The relevant safety parameters to be verified are:

- PFH (**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 architecture)

2.1.3 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 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 elements, subsystems and the complete system, but not of a single device.

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

2.2 Assumptions

The following assumptions have been made during the FMEDA analysis:

- Failure rates are constant, wear out mechanisms are not included.
- Propagation of failures is not relevant.
- Sufficient tests are performed prior to shipment to verify the absence of vendor and/or manufacturing defects that prevent proper operation of specified functionality to product specifications or cause operation different from the design analyzed.
- All modules are operated in the low demand mode of operation.
- External power supply failure rates are not included.
- Short circuit (SC) detection and Lead Breakage (LB) detection are activated.
- The "HOLD" function is disabled.
- Process related parameters are protected by password.
- Failures during parameterization are not considered.
- Only one input and one output are part of the considered safety function (only 2-channel version).
- The collective error output which signals if the field wiring is broken or shorted is not considered in the FMEDA and the calculations.
- The characteristics of the current output are set to NE43 (4 mA ... 20 mA).
- The device shall claim less than 10 % of the total failure budget for a SIL2 safety loop.
- For a SIL2 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}.
- The stress levels are average for an industrial environment and can be compared to the Ground Fixed Classification of MIL-HNBK-217F. Alternatively, the assumed environment is similar to:
  - IEC 60654-1 Class C (sheltered location) with temperature limits within the manufacturer's rating and an average temperature over a long period of time of 40 ºC. Humidity levels are assumed within manufacturer's rating. For a higher average temperature of 60 ºC, the failure rates should be multiplied with an experience based factor of 2.5. A similar multiplier should be used if frequent temperature fluctuation must be assumed.
- The safety-related device is considered to be of type **B** components with a Hardware Fault Tolerance of **0**.
- The IEC 61511-1 section 11.4.4 allows devices to be used in applications one SIL higher than given by table 3 of IEC 61508-2, if the device is proven in use. The assessment and proven-in-use demonstration lead to the result that the device may be used in applications up to SIL2. However, it is the responsibility of the end-user to decide on applying proven-in-use devices.
- Failure rate based on the Siemens SN29500 data base.
- It was assumed that the appearance of a safe error (e. g. output in safe state) would be repaired within 8 hours (e. g. remove sensor burnout).

2011-09

- During the absence of the device for repairing, measures have to be taken to ensure the safety function (for example: substitution by an equivalent device).
- For the calculation it was also assumed that the indication of a dangerous error (via fault bus) would be detected within 1 hour by the logic solver (SPS).
- The application program in the safety logic solver is configured to detect underrange and overrange failures. Therefore these failures have been classified as **dangerous detected** failures.

2.3 Safety Function and Safe State

SIL2 Safety Function

The safety function of the device is fulfilled, as long as the output repeats the **linearized** input signal with a tolerance of 2 %.

Safe State

The safe state is defined, as the output being < 4 mA or > 20 mA.

Reaction Time

The reaction time for:

- temperature inputs: < 1.5 s
- potentiometer inputs: < 3 s

For additional information, refer to the manual and www.pepperl-fuchs.com.

2.4 Characteristic Safety Values

The following tables contain no data for the SFF, since this performance value has to be calculated with consideration of the connected field device.

KFD2-UT2-(Ex)*

Parameters acc. to IEC 61508	Variables
Device type	B
Demand mode	Low Demand Mode
Safety function	Transfer of analog value
HFT	0
SIL	2 (proven-in-use acc. to EN 61511)
λ_s	0 FIT
λ_{dd} [1]	333 FIT
λ_{du} [2]	79.2 FIT
$\lambda_{no\ effect}$ [3]	295 FIT
$\lambda_{total\ (safety\ function)}$	706 FIT
$\lambda_{no\ part}$	33.4 FIT
SFF	88.78 %
MTBF [4]	154 years
PFD_{avg} for T_1 = 1 year	3.74×10^{-4}
T_{proof} max.	2 years

[1] "Fail high" and "Fail low" failures are considered as dangerous detected failures λ_{dd}.
[2] Annunciation failure rates that only influence the diagnostic function were marginal and added to the λ_{du}.
[3] "No effect" failures are not influencing the safety functions and are therefore added to the λ_s.
[4] acc. to SN29500. This value includes failures which are not part of the safety function (MTTR = 8 h).

Table 2.1

HiD2082

Parameters acc. to IEC 61508	Variables
Device type	B
Demand mode	Low Demand Mode
Safety function	Transfer of analog value
HFT	0
SIL	2 (proven-in-use acc. to EN 61511)
λ_s	75 FIT
λ_{dd} [1]	328.6 FIT
λ_{du} [2]	98.1 FIT
$\lambda_{no\ effect}$ [3]	312 FIT
$\lambda_{total\ (safety\ function)}$	814 FIT
$\lambda_{no\ part}$	43 FIT
SFF	87.93 %
MTBF [4]	133 years
PFD_{avg} for T_1 = 1 year	4.30×10^{-4}
T_{proof} max.	2 years

[1] "Fail high" and "Fail low" failures are considered as dangerous detected failures λ_{dd}.
[2] Annunciation failure rates that only influence the diagnostic function were marginal and added to the λ_{du}.
[3] "No effect" failures are not influencing the safety functions and are therefore added to the λ_s.
[4] acc. to SN29500. This value includes failures which are not part of the safety function (MTTR = 8 h).

Table 2.2

The characteristic safety values like PFD/PFH, SFF, HFT and T_{proof} are taken from the SIL report/FMEDA report. Please note, PFD and T_{proof} are related to each other.

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

3 Safety Recommendation

3.1 Interfaces

The device has the following interfaces. For corresponding terminals see data sheet.

- Safety relevant interfaces:
  - input I, input II (only 2-channel version)
  - output I, output II (only 2-channel version)
- Non-safety relevant interfaces: programming socket, collective error output

3.2 Configuration

The configuration of the device is performed by means of PACTware™ and has to be verified after each programming procedure. The verification procedure has to be adopted to the individual application and shall cover all parameterized functions.

3.3 Useful Life Time

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

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

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

Our experience has shown that the useful life time of a Pepperl+Fuchs product can be higher

- if there are no components with reduced life time in the safety path (like electrolytic capacitors, relays, flash memory, opto coupler) which can produce dangerous undetected failures and
- if the ambient temperature is significantly below 60 °C.

Please note that the useful life time refers to the (constant) failure rate of the device. The effective life time can be higher.

3.4 Installation and Commissioning

Installation has to consider all aspects regarding the SIL level of the loop. During installation or replacement of the device the loop has to shut down. Devices have to be replaced by the same type of devices.

4 Proof Test

4.1 General

According to IEC 61508-2 a recurring proof test shall be undertaken to reveal potentially dangerous failures that are otherwise not detected by diagnostic tests.

The functionality of the subsystem must be verified at periodic intervals depending on the applied PFD_{avg} in accordance with the data stated in the "Characteristic Safety Values" chapter (see chapter 2.4).

The functionality of the subsystem must be verified at periodic intervals depending on the applied PFD_{avg} in accordance with the data provided in the safety certificate available on our webpage www.pepperl-fuchs.com.

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

With the following instructions a proof test can be performed which will reveal almost all of the possible dangerous faults (diagnostic coverage > 90 %).

4.2 Proof Test Procedure for KFD2-UT2-(Ex)*

General

The proof test shall be performed with the same configuration which is used in the application. The sensors shall be substituted by sensor simulator/calibrators.

Prove the safety function at input values which are configured to set the output to 4 mA, 12 mA, 20 mA.

Measurement set up:

- Sensor simulation/voltage source/resistor
- Current meter/digital multimeter (DMM)

Thermocouple Input (TC)

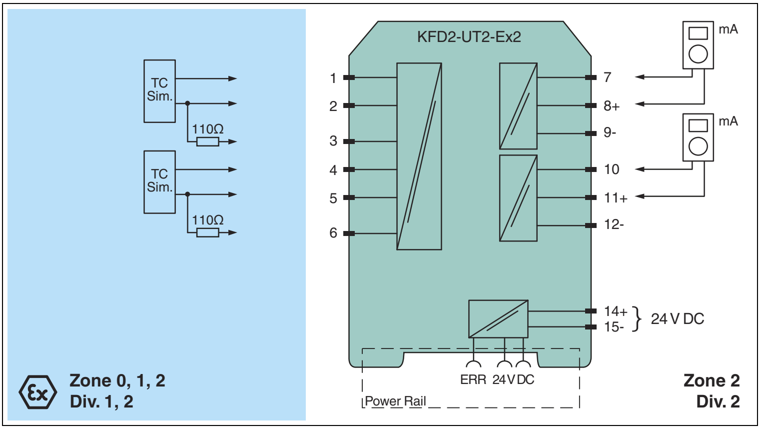

Figure 4.1 Example proof test set-up for KFD2-UT2-(Ex)* (TC)
Usage in Zone 0, 1, 2/Div. 1, 2 only for KFD2-UT2-Ex1 and KFD2-UT2-Ex2
1-channel versions KFD2-UT2-1 and KFD2-UT2-Ex1 have only one channel.

Additional set up: 110 Ω fixed resistor

1. Connect TC simulator to the input terminals 1+ and 2- (channel I) and 4+ and 5- (channel II).
2. Connect current meter/digital multimeter (DMM) to the current output terminals 7 and 8 (channel I) and 10 and 11 (channel II).
3. Set compensation/reference temperature in the simulator to 26 °C.
4. Connect a 110 Ω fixed resistor (0.1 % accuracy) to terminals 2 and 3 (channel I) and 5 and 6 (channel II) (instead of the special sensor for internal compensation).
5. Set the TC simulator sequentially to the temperature values representing 4 mA, 12 mA, 20 mA and measure the output current.
6. Proof test is passed if the measured output values are within 2 % of the output span. This means:
   - 3.7 mA ... 4.3 mA
   - 11.7 mA ... 12.3 mA
   - 19.7 mA ... 20.3 mA
7. Remove the 110 Ω resistor from terminals 2 and 3 (channel I) and 5 and 6 (channel II), to check if the lead breakage of the CJC is monitored. The red LED must be blinking. The output behaviour in the event of a failure depends on the device configuration.

This test is also applicable if external compensation (setting of a fixed compensation temperature in the module) is used in the application. Adapt CJC value in the simulator during step 3 accordingly.

Additionally the loop diagnosis shall be tested to prove that the fault signalling via the current output is working correctly. The output current in the event of a failure depends on the device configuration. Please record this configuration and the resulting expected fault signalling current in the test report. Example: if downscale is configured, 2.0 mA ±1 % must be measured in the event of a failure. The red LED must be blinking.

Thermocouple:

- Disconnect simulator (lead breakage).
- Disconnect fixed resistor (lead breakage of CJC).
- Apply short circuit between terminal 2 and 3 for channel I and between terminals 5 and 6 for channel II (short circuit of CJC).

RTD Input

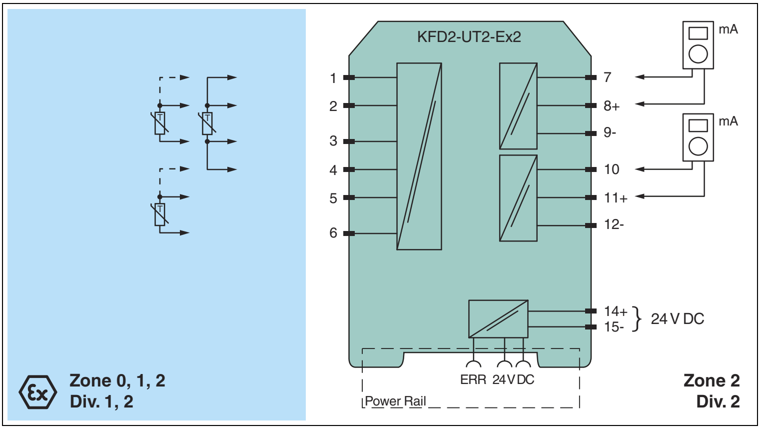

Figure 4.2 Example proof test set-up for KFD2-UT2-(Ex)* (TC)
Usage in Zone 0, 1, 2/Div. 1, 2 only for KFD2-UT2-Ex1 and KFD2-UT2-Ex2
1-channel versions KFD2-UT2-1 and KFD2-UT2-Ex1 have only one channel.

1. Connect RTD simulator to terminals, depending on the application:
   - for 4-wire: terminals 1, 2, 3, 4
   - for 3-wire: terminals 1, 2, 3 (channel I) and 4, 5, 6 (channel II)
   - for 2-wire: terminals 2, 3 (channel I) and 5, 6 (channel II)
2. Connect current meter/digital multimeter (DMM) to the current output terminals 7 and 8 (channel I) and 10 and 11 (channel II).
3. Set the RTD simulator sequentially to the temperature values representing 4 mA, 12 mA, 20 mA and measure the output current.
4. Proof test is passed if the measured output values are within 2 % of the output full scale. This means:
   - 3.7 mA ... 4.3 mA
   - 11.7 mA ... 12.3 mA
   - 19.7 mA ... 20.3 mA

Additionally the loop diagnosis shall be tested to prove that the fault signalling via the current output is working correctly. The output current in the event of a failure depends on the device configuration. Please record this configuration and the resulting expected fault signalling current in the test report. Example: if downscale is configured, 2.0 mA ±1 % must be measured in the event of a failure. The red LED must be blinking.

RTD:

- Disconnect sequentially every single connection wire (2-, 4, depending on the configuration). Verify that the output indicates a lead breakage.
- Short circuit terminals 2 and 3 without disconnecting the wires or RTD simulator. Verify that the output indicates a short circuit. For channel II apply the short circuit between terminals 5 and 6.

Voltage Input (mV)

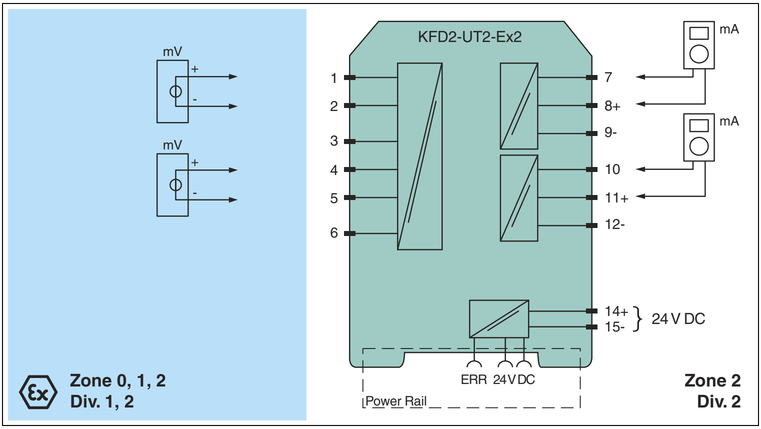

Figure 4.3 Example proof test set-up for KFD2-UT2-(Ex)* (TC)
Usage in Zone 0, 1, 2/Div. 1, 2 only for KFD2-UT2-Ex1 and KFD2-UT2-Ex2
1-channel versions KFD2-UT2-1 and KFD2-UT2-Ex1 have only one channel.

1. Connect mV source to terminals 1 and 2 (channel I) and 4 and 5 (channel II).
2. Connect current meter/digital multimeter (DMM) to the current output terminals 7 and 8 (channel I) and 10 and 11 (channel II).
3. Set the mV source sequentially to the voltage values representing 4 mA, 12 mA, 20 mA and measure the output current.
4. Proof test is passed if the measured output values are within 2 % of the output full scale. This means:
   - 3.7 mA ... 4.3 mA
   - 11.7 mA ... 12.3 mA
   - 19.7 mA ... 20.3 mA

Additionally the loop diagnosis shall be tested to prove that the fault signalling via the current output is working correctly. The output current in the event of a failure depends on the device configuration. Please record this configuration and the resulting expected fault signalling current in the test report. Example: if downscale is configured, 2.0 mA ±1 % must be measured in the event of a failure. The red LED must be blinking.

Voltage Input:

- Disconnect voltage source. Verify that the output indicates a lead breakage.

Potentiometer Input

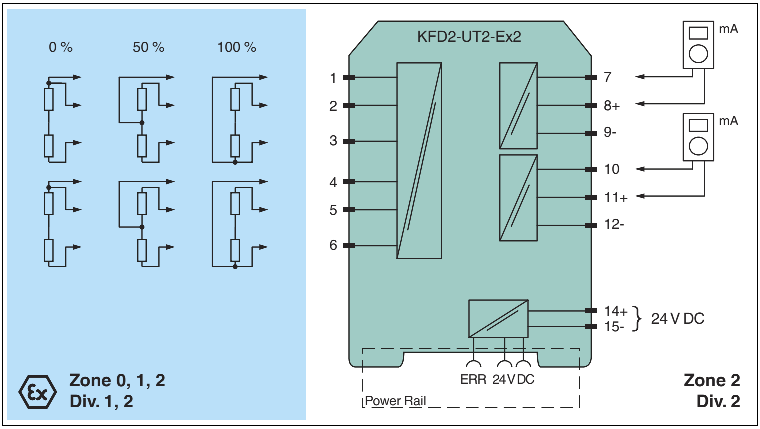

Figure 4.4 Example proof test set-up for KFD2-UT2-(Ex)* (TC)
Usage in Zone 0, 1, 2/Div. 1, 2 only for KFD2-UT2-Ex1 and KFD2-UT2-Ex2
1-channel versions KFD2-UT2-1 and KFD2-UT2-Ex1 have only one channel.

The resistor values which are used to simulate the potentiometer shall be chosen so that they represent the full scale value of the potentiometer when connected in series. The individual resistors shall both be of the same resistance value and have an accuracy of 1 %.

1. Connect two precision resistors in series.
2. Connect both open ends of the series resistors to the device (DUT) (channel I: terminal 2 and 3, channel II: 5 and 6).
3. Connect the wiper input (channel I: terminal 1, channel II: terminal 4) to the junction of the two simulation resistors.
4. Connect current meter/digital multimeter (DMM) to the current output terminals 7 and 8 (channel I) and 10 and 11 (channel II).
5. Set the simulation resistor to 0 %, 50 % and 100 % of the potentiometer value (see above).
6. Proof test is passed if the measured output values are within 2 % of the output full scale. This means:
   - 3.7 mA ... 4.3 mA, for 0 % of potentiometer value
   - 11.7 mA ... 12.3 mA, for 50 % of potentiometer value
   - 19.7 mA ... 20.3 mA, for 100 % of potentiometer value

Additionally the loop diagnosis shall be tested to prove that the fault signalling via the current output is working correctly. The output current in the event of a failure depends on the device configuration. Please record this configuration and the resulting expected fault signalling current in the test report. Example: if downscale is configured, 2.0 mA ±1 % must be measured in the event of a failure. The red LED must be blinking.

Test Variation for Voltage Output/Current Sink Applications

Voltage Output

Instead of an current meter, a voltmeter has to be connected to the outputs. The input values shall be chosen that they represent 1 V, 2.5 V and 5 V. The proof test is passed if the output values are within 2 % of the output span. This means:

- 0.9 V ... 1.1 V
- 2.4 V ... 2.6 V
- 4.9 V ... 5.1 V

Current Sink Output Mode

The pass/fail criteria given for the current source output mode are also applicable for the current sink output mode. Additionally to the above described test set up, a voltage source has to be connected to the output (simulating the original application).

Proof Test Coverage

The Proof Test Coverage$_{device}$ is assumed to be min. 90 %.

With λ_{du} = 66 FIT (device), the proof test can reveal only 60 FIT.

4.3 Proof Test Procedure for HiD2082

General

The proof test shall be performed with the same configuration which is used in the application. The sensors shall be substituted by sensor simulator/calibrators.

Prove the safety function at input values which are configured to set the output to 4 mA, 12 mA, 20 mA.

Measurement set up:

- Sensor simulation/voltage source/resistor
- Current meter/digital multimeter (DMM)
- Termination Board

Thermocouple Input (TC)

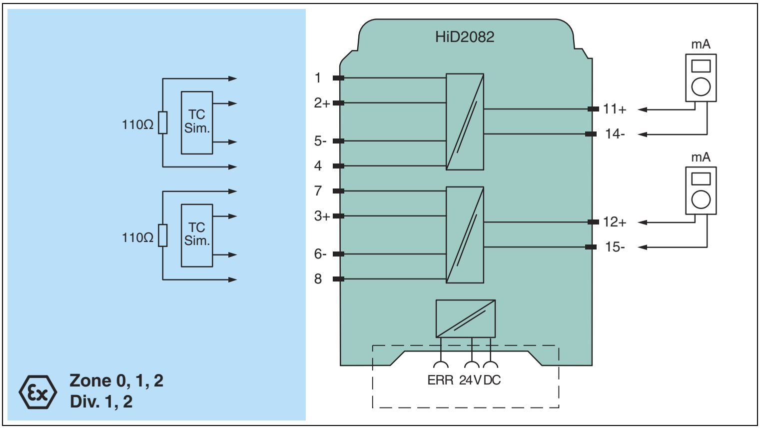

Figure 4.5 Proof test set-up for HiD2082 (TC)

Additional set up: 110 Ω fixed resistor

1. Connect TC simulator to the input terminals 2+ and 5- (channel I) and 3+ and 6- (channel II).
2. Connect current meter/digital multimeter (DMM) to the current output terminals 11 and 14 (channel I) and 12 and 15 (channel II).
3. Set compensation/reference temperature in the simulator to 25 °C.
4. Connect a 110 Ω fixed resistor (0.1 % accuracy) to terminals 1 and 4 (instead of the special sensor for internal compensation).
5. Set the TC simulator sequentially to the temperature values representing 4 mA, 12 mA, 20 mA and measure the output current.
6. Proof test is passed if the measured output values are within 2 % of the output span. This means:
   - 3.7 mA ... 4.3 mA
   - 11.7 mA ... 12.3 mA
   - 19.7 mA ... 20.3 mA
7. Remove the 110 Ω resistor from terminals 1 and 4, to check if the lead breakage of the CJC is monitored. The red LED must be blinking. The output behaviour in the event of a failure depends on the device configuration.

This test is also applicable if external compensation (setting of a fixed compensation temperature in the module) is used in the application. Adapt CJC value in the simulator during step 3 accordingly.

Additionally the loop diagnosis shall be tested to prove that the fault signalling via the current output is working correctly. The output current in the event of a failure depends on the device configuration. Please record this configuration and the resulting expected fault signalling current in the test report. Example: if downscale is configured, 2.0 mA ±1 % must be measured in the event of a failure. The red LED must be blinking.

Thermocouple:

- Disconnect simulator (lead breakage).
- Disconnect fixed resistor (lead breakage of CJC).
- Apply short circuit between terminal 1 and 4 (short circuit of CJC).

RTD Input

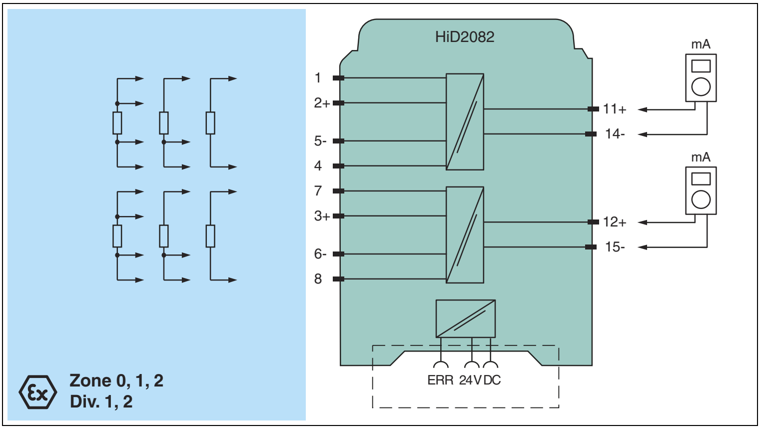

Figure 4.6 Proof test set-up for HiD2082 (RTD)

1. Connect RTD simulator to terminals, depending on the application:
   - for 4-wire: terminals 1, 2, 5, 4 (channel I) and 7, 3, 6, 8 (channel II)
   - for 3-wire: terminals 1, 5, 4 (channel I) and 7, 6, 8 (channel II)
   - for 2-wire: terminals 1, 4 (channel I) and 7, 8 (channel II)
2. Connect current meter/digital multimeter (DMM) to the current output terminals 11 and 14 (channel I) and 12 and 15 (channel II).
3. Set the RTD simulator sequentially to the temperature values representing 4 mA, 12 mA, 20 mA and measure the output current.
4. Proof test is passed if the measured output values are within 2 % of the output full scale. This means:
   - 3.7 mA ... 4.3 mA
   - 11.7 mA ... 12.3 mA
   - 19.7 mA ... 20.3 mA

Additionally the loop diagnosis shall be tested to prove that the fault signalling via the current output is working correctly. The output current in the event of a failure depends on the device configuration. Please record this configuration and the resulting expected fault signalling current in the test report. Example: if downscale is configured, 2.0 mA ±1 % must be measured in the event of a failure. The red LED must be blinking.

RTD:

- Disconnect sequentially every single connection wire (2-, 4, depending on the configuration). Verify that the output indicates a lead breakage.
- Short circuit terminals 1 and 4 without disconnecting the wires or RTD simulator. Verify that the output indicates a short circuit. For channel II apply the short circuit between terminals 7 and 8.

Voltage Input (mV)

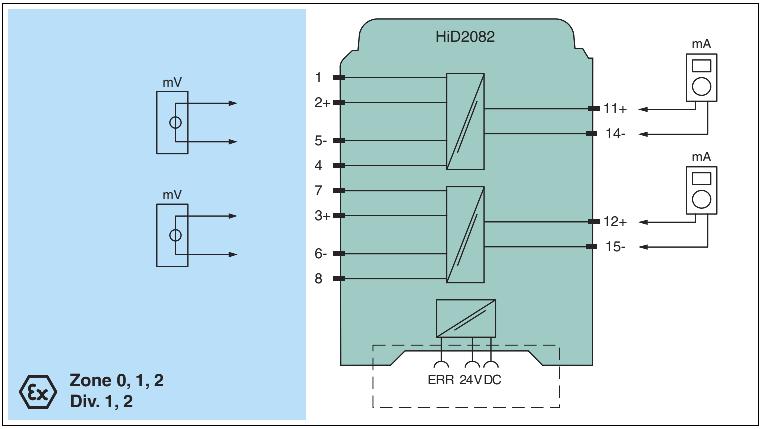

Figure 4.7 Proof test set-up for HiD2082 (mV)

1. Connect mV source to terminals 2 and 5 (channel I) and 3 and 6 (channel II).
2. Connect current meter/digital multimeter (DMM) to the current output terminals 11 and 14 (channel I) and 12 and 15 (channel II).
3. Set the mV source sequentially to the voltage values representing 4 mA, 12 mA, 20 mA and measure the output current.
4. Proof test is passed if the measured output values are within 2 % of the output full scale. This means:
    - 3.7 mA ... 4.3 mA
    - 11.7 mA ... 12.3 mA
    - 19.7 mA ... 20.3 mA

Additionally the loop diagnosis shall be tested to prove that the fault signalling via the current output is working correctly. The output current in the event of a failure depends on the device configuration. Please record this configuration and the resulting expected fault signalling current in the test report. Example: if downscale is configured, 2.0 mA ±1 % must be measured in the event of a failure. The red LED must be blinking.

Voltage Input:

- Disconnect voltage source. Verify that the output indicates a lead breakage.

PEPPERL+FUCHS

Potentiometer Input

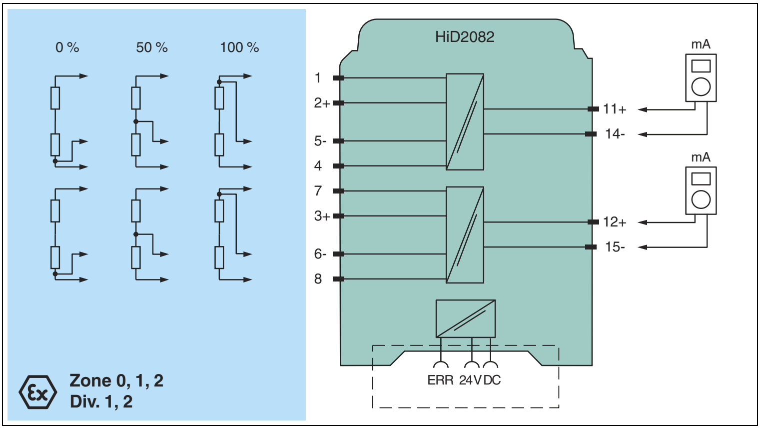

Figure 4.8 Proof test set-up for HiD2082 (Potentiometer)

The resistor values which are used to simulate the potentiometer shall be chosen so that they represent the full scale value of the potentiometer when connected in series. The individual resistors shall both be of the same resistance value and have an accuracy of 1 %.

1. Connect two precision resistors in series.
2. Connect both open ends of the series resistors to the device (DUT) (channel I: terminal 1 and 4, channel II: 7 and 8).
3. Connect the wiper input (channel I: terminal 5, channel II: terminal 6) to the junction of the two simulation resistors.
4. Connect current meter/digital multimeter (DMM) to the current output terminals 11 and 14 (channel I) and 12 and 15 (channel II).
5. Set the simulation resistor to 0 %, 50 % and 100 % of the potentiometer value (see above).
6. Proof test is passed if the measured output values are within 2 % of the output full scale. This means:
   - 3.7 mA ... 4.3 mA, for 0 % of potentiometer value
   - 11.7 mA ... 12.3 mA, for 50 % of potentiometer value
   - 19.7 mA ... 20.3 mA, for 100 % of potentiometer value

Additionally the loop diagnosis shall be tested to prove that the fault signalling via the current output is working correctly. The output current in the event of a failure depends on the device configuration. Please record this configuration and the resulting expected fault signalling current in the test report. Example: if downscale is configured, 2.0 mA ±1 % must be measured in the event of a failure. The red LED must be blinking.

Test Variation for Voltage Output/Current Sink Applications

Voltage Output

Instead of an current meter, a voltmeter has to be connected to the outputs. The input values shall be chosen that they represent 1 V, 2.5 V and 5 V. The proof test is passed if the output values are within 2 % of the output span. This means:

- 0.9 V ... 1.1 V
- 2.4 V ... 2.6 V
- 4.9 V ... 5.1 V

Current Sink Output Mode

The pass/fail criteria given for the current source output mode are also applicable for the current sink output mode. Additionally to the above described test set up, a voltage source has to be connected to the output (simulating the original application).

Proof Test Coverage

The Proof Test Coverage$_{device}$ is assumed to be min. 90 %.

With λ_{du} = 66 FIT (device), the proof test can reveal only 60 FIT.

Tip

Normally the easiest way to test H-System modules is by using a stand-alone HiDTB08-UNI-SC-SC Termination Board. The tester then has no need to disconnect wires in the existing application, so subsequent miswiring of the module is prevented.

5 Abbreviations

FMEDA	**F**ailure **M**ode, **E**ffects and **D**iagnostics **A**nalysis
HFT	**H**ardware **F**ault **T**olerance
PFD$_{avg}$	Average **P**robability of **F**ailure on **D**emand
PFH	**P**robability of dangerous **F**ailure per **H**our
PTC	**P**roof **T**est **C**overage
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$_{proof}$	Proof Test Interval
DUT	**D**evice **u**nder **T**est
DMM	**D**igital **M**ulti**m**eter

PROCESS AUTOMATION – PROTECTING YOUR PROCESS

Worldwide Headquarters
Pepperl+Fuchs GmbH
68307 Mannheim · Germany
Tel. +49 621 776-0
E-mail: info@de.pepperl-fuchs.com

For the Pepperl+Fuchs representative
closest to you check www.pepperl-fuchs.com/pfcontact

PEPPERL+FUCHS
PROTECTING YOUR PROCESS

www.pepperl-fuchs.com

TDOCT-2078AENG
09/2011