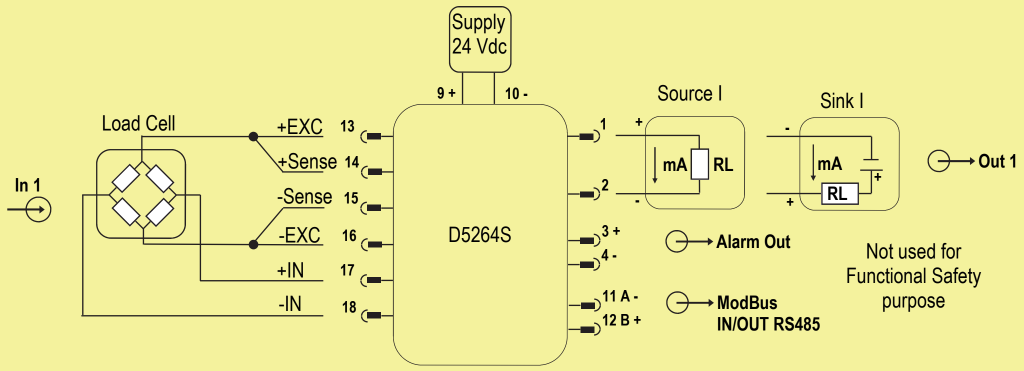
SAFETY MANUAL

SIL 2 Load Cell/Strain Gauge Bridge Isolating Converter DIN-Rail, Power Bus and Termination Board Model D5264S

Approval: TÜV Certificate No. C-IS-722160171, SIL 2 conforms to IEC61508:2010 Ed.2 .
SIL 3 Functional Safety TÜV Certificate conforms to IEC61508:2010 Ed.2, for Management of Functional Safety.

Reference must be made to the relevant sections within the instruction manual ISM0228 and ISM0154 (for SWC5090 Configuration Software instruction manual), which contain basic guides for the installation and configuration of the equipment.

Application for D5264S - with 4-20 mA current source (or sink) output.



Description:

By means of SWC5090 Configuration Software, as user interface on PC to comunicate with the module, select: Input/Output window with Type "4-20 mA Sink" or "4-20 mA Source".
The module is powered by connecting 24 Vdc power supply to Pins 9 (+ positive) - 10 (- negative). The green LED is lit in presence of supply power.
Connect load cell or strain gauge bridge voltage supply at terminal "13" positive and terminal "16" negative.
Connect load cell or strain gauge bridge voltage sensing supply at terminal "14" positive and terminal "15" negative.
If load cell or strain gauge bridge has no internal voltage sensing capability always connect terminal "14" to terminal "13" and terminal "15" to terminal "16"; for better performance connect the wire at the end of the line near the load cells.
Connect load cell or strain gauge bridge output signal at terminal "17" positive and terminal "18" negative.
Connect current source mode positive output at terminal "1" and negative output at "2" or current sink mode positive output at terminal "2" and negative output at terminal "1" (output can be used only one type at a time, not contemporary). Alarm output and ModBus communication are only used for service purpose (not for Functional Safety purpose).

Safety Function and Failure behavior:

D5264S is considered to be operating in Low Demand mode, as a Type B module, having Hardware Fault Tolerance (HFT) = 0.
The failure behavior of D5264S module with 4-20 mA current source (or sink) output is described by the following definitions:

- □ fail-Safe State: it is defined as the output going to 0 mA due to module shutdown;
- □ fail Safe: failure mode that causes the module / (sub)system to go to the defined Fail-Safe state without a demand from the process;
- □ fail Dangerous: failure mode that does not respond to a demand from the process or deviates the output current by more than 5 % (± 0.8 mA) of full span;
- □ fail High: failure mode that causes the output signal to go above the maximum output current (> 20 mA). Assuming that the application program in the Safety logic solver is configured to detect High failures, they have been classified as Dangerous Detected (DD) failures.
- □ fail Low: failure mode that causes the output signal to go below the minimum output current (< 4 mA). Assuming that the application program in the Safety logic solver is configured to detect Low failures, they have been classified as Dangerous Detected (DD) failures.
- □ fail Dangerous Detected: it's a dangerous failure which has been detected from module internal diagnostic so that output signal is forced below the minimum output current < 4mA (as Fail Low) or above the maximum output current > 20mA (as Fail High).
- □ fail "No effect": failure mode of a component that plays a part in implementing the safety function but is neither a safe failure nor a dangerous failure; When calculating the SFF this failure mode is not taken into account.
- □ fail "Not part": failure mode of a component which is not part of the safety function but part of the circuit diagram and is listed for completeness; When calculating the SFF this failure mode is not taken into account.

As the module has been evaluated in accordance with Route 2H (proven-in-use) of the IEC 61508:2010, Diagnostic Coverage DC ≥ 60% is required for Type B elements.
Being HFT = 0, in Low Demand mode the maximum achievable functional safety level is SIL 2.
Failure rate data: taken from Siemens Standard SN29500.

Failure rate table:

Failure category	Failure rates (FIT)
λ_{dd} = Total Dangerous Detected failures	188.85
λ_{du} = Total Dangerous Undetected failures	47.98
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	100.11
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	**336.94**
MTBF (safety function, single channel) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)	**339 years**
$\lambda_{no\ effect}$ = "No effect" failures	254.16
$\lambda_{not\ part}$ = "Not Part" failures	65.70
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	**656.80**
MTBF (device) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)	**174 years**

Failure rates table according to IEC 61508:2010 Ed.2:

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	DC	SFF
0.00 FIT	100.11 FIT	188.85 FIT	47.98 FIT	79.74%	85.76%

where DC means the diagnostic coverage for the input sensor by module internal diagnostic circuits and by Safety logic solver. This type "B" system, operating in Low Demand mode with HFT = 0, has got DC = 79.74 % ≥ 60 % as required by Route 2H evaluation (proven-in-use) of the IEC 61508:2010.

PFDavg vs T[Proof] table (assuming Proof Test coverage of 99%), with determination of SIL supposing module contributes ≤10% of total SIF dangerous failures:

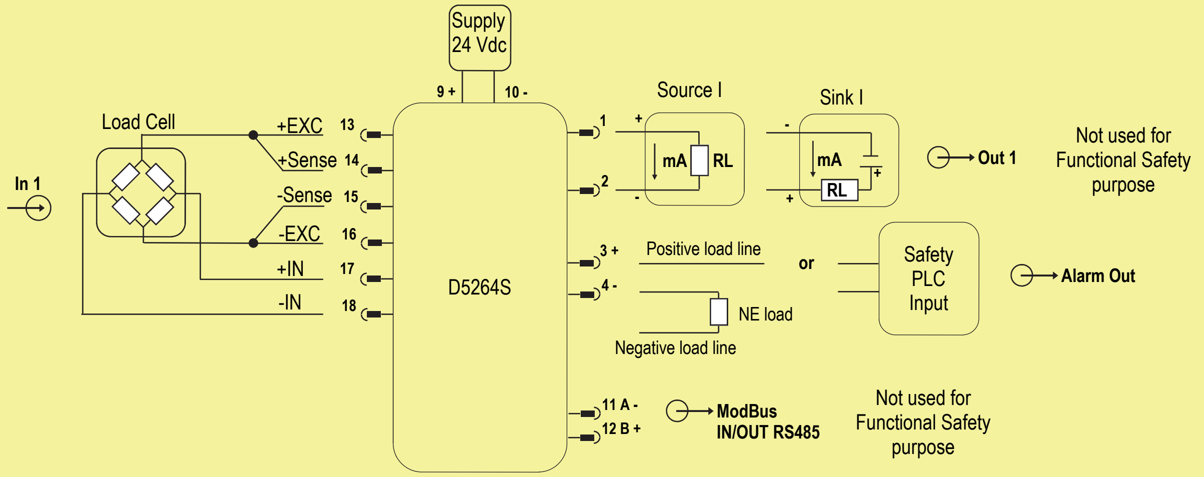
T[Proof] = 1 year	T[Proof] = 4 years
PFDavg = 2.12 E-04 Valid for **SIL 2**	PFDavg = 8.48 E-04 Valid for **SIL 2**

PFDavg vs T[Proof] table (assuming Proof Test coverage of 99%), with determination of SIL supposing module contributes >10% of total SIF dangerous failures:

T[Proof] = 20 years
PFDavg = 4.24 E-03 - Valid for **SIL 2**

SC 3: Systematic capability SIL 3.

Application for D5264S - with alarm output.



Description:

By means of SWC5090 Configuration Software, as user interface on a PC to comunicate with the module, select Alarm window with: Type “Low” or “High” or “Window”; “Contact position in case of alarm = Open”; imposing Low Set and Low Hysteresys values if Type “Low” or “Window” have been chosen, OR imposing High Set and High Hysteresys values if Type “High” or “Window” have been chosen.
The module is powered by connecting 24 Vdc power supply to Pins 9 (+ positive) - 10 (- negative). The green LED is lit in presence of supply power.
Connect load cell or strain gauge bridge voltage supply at terminal “13” positive and terminal “16” negative.
Connect load cell or strain gauge bridge voltage sensing supply at terminal “14” positive and terminal “15” negative.
If load cell or strain gauge bridge has no internal voltage sensing capability always connect terminal "14" to terminal "13" and terminal "15" to terminal "16"; for better performance connect the wire at the end of the line near the load cells.
Connect load cell or strain gauge bridge output signal at terminal “17” positive and terminal “18” negative.
Alarm Output is applied to Pins 3-4, with possible connection to Normally Energized (NE) load or to Safety PLC input. Source or Sink output current ModBus communication are only used for service purpose (not for Functional Safety purpose).

Safety Function and Failure behavior:

D5264S is considered to be operating in Low Demand mode, as a Type B module, having Hardware Fault Tolerance (HFT) = 0.
The failure behavior of D5264S module with alarm output (which is normally open in case of alarm) is described by the following definitions:

- □ fail-Safe State: is defined as the alarm output being de-energized, with open contact (the user can program the trip point value, according to the input measured value, at which the alarm output must be de-energized);
- □ fail Safe: failure mode that causes the module / (sub)system to go to the defined Fail-Safe state without a demand from the process;
- □ fail Dangerous: failure mode that leads to a measurement error more than 5% of the correct value and therefore has the potential not to respond to a demand from the process, so that the alarm output remains energized with closed contact;
- □ fail Dangerous Detected: it's a dangerous failure which has been detected from module internal diagnostic so that alarm output is forced to be de-energized (that is to Fail-Safe state), with open contact.
- □ fail “No effect”: failure mode of a component that plays a part in implementing the safety function but is neither a safe failure nor a dangerous failure; When calculating the SFF this failure mode is not taken into account.
- □ fail “Not part”: failure mode of a component which is not part of the safety function but part of the circuit diagram and is listed for completeness; When calculating the SFF this failure mode is not taken into account.

As the module has been evaluated in accordance with Route 2H (proven-in-use) of the IEC 61508:2010, Diagnostic Coverage DC ≥ 60% is required for Type B elements.
Being HFT = 0, in Low Demand mode the maximum achievable functional safety level is SIL 2.
Failure rate data: taken from Siemens Standard SN29500.

Failure rate table:

Failure category	Failure rates (FIT)
λ_{dd} = Total Dangerous Detected failures	124.15
λ_{du} = Total Dangerous Undetected failures	50.39
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	138.60
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	**313.14**
MTBF (safety function, alarm channel) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)	**365 years**
$\lambda_{no\ effect}$ = “No effect” failures	225.06
$\lambda_{not\ part}$ = “Not Part” failures	118.60
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	**656.80**
MTBF (device) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)	**174 years**

Failure rates table according to IEC 61508:2010 Ed.2:

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	DC	SFF
0.00 FIT	138.60 FIT	124.15 FIT	50.39 FIT	71.13%	83.91%

where DC means the diagnostic coverage for the input sensor by module internal diagnostic circuits. This type “B” system, operating in Low Demand mode with HFT = 0, has got DC = 71.13 % ≥ 60 % as required by Route 2H evaluation (proven-in-use) of the IEC 61508:2010.

PFDavg vs T[Proof] table (assuming Proof Test coverage of 99%), with determination of SIL supposing module contributes ≤10% of total SIF dangerous failures:

T[Proof] = 1 year	T[Proof] = 4 years
PFDavg = 2.22 E-04 Valid for **SIL 2**	PFDavg = 8.88 E-04 Valid for **SIL 2**

PFDavg vs T[Proof] table (assuming Proof Test coverage of 99%), with determination of SIL supposing module contributes >10% of total SIF dangerous failures:

T[Proof] = 20 years
PFDavg = 4.44 E-03 - Valid for **SIL 2**

SC 3: Systematic capability SIL 3.

Testing procedure at T-proof

The proof test shall be performed to reveal dangerous faults which are undetected by diagnostic.
This means that it is necessary to specify how dangerous undetected faults, which have been noted during the FMEDA, can be revealed during the proof test.
The test on **D5264S with 4-20 mA current source (or sink) output** consists of the following steps:

Proof test 1 (to reveal approximately 50 % of possible Dangerous Undetected failures in the converter)	
Steps	**Action**
1	Bypass the Safety PLC or take any other appropriate action to avoid a false trip.
2	Set the input load cell to the High (see Safety Function definition) voltage signal and verify that the related analog output current reaches the corresponding value. This test is for voltage compliance problems, such as a low power supply voltage or an increased wiring resistance, and for other possible failures .
3	Set the input load cell to the Low (see Safety Function definition) voltage signal and verify that the related analog output current reaches the corresponding value. This tests is for possible quiescent current related failures.
4	Restore the loop to full operation.
5	Remove the bypass from the Safety PLC or restore normal operation.

Proof test 2 (to reveal approximately 99 % of possible Dangerous Undetected failures in the converter)	
Steps	**Action**
1	Bypass the Safety PLC or take other appropriate action to avoid a false trip.
2	Perform steps 2 and 3 of **Proof Test 1**.
3	Perform a two-point calibration (i.e. down and full scale) of the connected load cell and verify that, forcing some values of the input range, the output current related values are within the specified accuracy (5 % (± 0.8 mA) of full span) as defined in the Safety Function. This requires that the input load cell has already been tested without the converter and it does not contain any dangerous undetected failures.
4	Restore the loop to full operation.
5	Remove the bypass from the Safety PLC or restore normal operation.

The test on **D5264S with Alarm output** consists of the following steps:

Proof test (to reveal approximately 99 % of possible Dangerous Undetected failures in the converter)	
Steps	**Action**
1	Bypass the Safety PLC or take any other appropriate action to avoid a false trip.
2	According to Alarm Function setting, force the input load cell to a voltage signal bigger than high limit for alarm tripping and verify that the alarm photo MOS is open because alarm output changes from normally energize state to de-energize to trip state .
3	According to Alarm Function setting, force the input load cell to a voltage signal smaller than low limit for alarm tripping and verify that the alarm photo MOS is open because alarm output changes from normally energize state to de-energize to trip state .
4	Restore the loop to full operation.
5	Remove the bypass from the Safety PLC or restore normal operation.