



INSTRUCTION MANUAL

SIL 3 Powered Isolating Driver
Hart, DIN-Rail and Termination Board,
Models D5020S, D5020D



Characteristics

General Description: The single and dual channel Isolating Driver, D5020S and D5020D module is a high integrity analog output interface suitable for applications requiring SIL 3 level (according to IEC 61508) in safety related systems for high risk industries.

It isolates and transfers a 4-20 mA signal from a controller located in Safe Area to a load up to 700 Ω in Hazardous Area. It has a high output capacity of 15 V at 20 mA combined with a low drop across its input terminals. The circuit allows bi-directional communication signals, for Hart positioner.

In the 4-20 mA input range, a field open or short circuit, reflects a high impedance to the control device circuit and actuates (de-energizes) the channel Fault output transistor and actuates (energizes) the cumulative Fault output available on Power Bus connector. Fault output signal for each channel is available when mounted on customized Termination Board. In addition the single channel D5020S provides open collector transistor output on terminal blocks.

Short circuit fault detection can be enabled (two different levels can be selected) or disabled via DIP-Switch programming.

Mounting on standard DIN-Rail, with or without Power Bus, or on customized Termination Boards, in Safe Area or in Zone 2.

Technical Data

Supply: 24 Vdc nom (18 to 30 Vdc) reverse polarity protected, ripple within voltage limits ≤ 5 Vpp, 2 A time lag fuse internally protected.

Current consumption @ 24 V: 70 mA for 2 channels D5020D, 35 mA for 1 channel D5020S with 20 mA output on 500 Ω load.

Power dissipation: 1.3 W for 2 channels D5020D, 0.65 W for 1 channel D5020S with 24 V supply voltage and 20 mA output on 500 Ω load.

Isolation (Test Voltage): I.S. Out/In 2.5 KV; I.S. Out/Supply 2.5 KV; I.S. Out/Fault 2.5 KV; I.S. Out/I.S. Out 500 V; In/Supply 500 V; In/In 500 V; Fault/In 500 V; Fault/Supply 500V; Fault/Fault 500 V.

Input: 4 to 20 mA with ≤ 2.5 V voltage drop, reverse polarity protected in normal operation, ≥ 5 K Ω impedance (≈ 2 mA sinking from 10 to 30 Vdc) when fault condition detected.

Output: 4 to 20 mA, on max. 700 Ω load.

Response time: 25 ms (0 to 100 % step change).

Output ripple: ≤ 20 mVrms on 250 Ω communication load on 0.5 to 2.5 KHz band.

Frequency response: 0.5 to 2.5 KHz bidirectional within 3 dB (Hart protocol).

Fault detection: field device and wiring open circuit or short circuit detection; short circuit detection can be disabled via dip-switch.

Short output detection: load resistance < 50 Ω or < 100 Ω dip-switch selectable (≈ 2 mA forcing to detect fault).

Open output detection: load resistance $> (21$ V / Loop current) - 300 Ω (for example, if Loop current = 20 mA: load resistance $> (21$ V / 20 mA) - 300 $\Omega = 750$ Ω).

Fault signalling: voltage free NE SPST optocoupled open-collector transistor (output de-energized in fault condition) available when mounted on Termination Board for model D5020D; for model D5020S in addition to Termination Board connection, also available on Safe Area side Terminal Block.

Open-collector rating: 100 mA at 35 Vdc (≤ 1.5 V voltage drop).

Leakage current: ≤ 50 μ A at 35 Vdc.

Response time: ≤ 30 ms.

Performance: Ref. Conditions 24 V supply, 250 Ω load, 23 ± 1 $^{\circ}$ C ambient temperature.

Calibration accuracy: $\leq \pm 0.1$ % of full scale.

Linearity error: $\leq \pm 0.1$ % of full scale.

Supply voltage influence: $\leq \pm 0.02$ % of full scale for a min to max supply change.

Load influence: $\leq \pm 0.1$ % of full scale for a 0 to 100 % load resistance change.

Temperature influence: $\leq \pm 0.01$ % of full scale on zero and span for a 1 $^{\circ}$ C change.

Compatibility:



CE mark compliant, conforms to 94/9/EC Atex Directive and to 2004/108/CE EMC Directive.

Environmental conditions:

Operating: temperature limits - 40 to + 70 $^{\circ}$ C, relative humidity 95 %, up to 55 $^{\circ}$ C.

Storage: temperature limits - 45 to + 80 $^{\circ}$ C.

Safety Description:



ATEX: II 3(1) G Ex nA [ja Ga] IIC T4 Gc, II (1) D [Ex ia Da] IIC, I (M1) [Ex ia Ma] I

IECEX: Ex nA [ja Ga] IIC T4 Gc, [Ex ia Da] IIC, [Ex ia Ma] I, associated apparatus and non-sparking electrical equipment.

Uo/Voc = 25.9 V, Io/Isc = 93 mA, Po/Po = 595 mW at terminals 7-8, 9-10.

Um = 250 Vrms, -40 $^{\circ}$ C \leq Ta \leq 70 $^{\circ}$ C.

Approvals: BVS 10 ATEX E 113 X conforms to EN60079-0, EN60079-11, EN60079-15, EN60079-26, EN61241-11, EN50303,

IECEX BVS 10.0072 X conforms to IEC60079-0, IEC60079-11, IEC60079-15, IEC60079-26, IEC1241-11.

Russia according to GOST 12.2.007.0-75, R 51330.0-99, R 51330.10-99, R 51330.14-99 2ExnA[ia]IIC T4 X.

Ukraine according to GOST 12.2.007.0, 22782.0, 22782.3, 22782.5 2Exs[ia]IIC T4 X.

TUV Certificate No. C-IS-204194-01, SIL 2 / SIL 3 conforms to IEC61508.

Mounting: T35 DIN-Rail according to EN50022, with or without Power Bus or on customized Termination Board.

Weight: about 145 g D5020D, 120 g D5020S.

Connection: by polarized plug-in disconnect screw terminal blocks to accommodate terminations up to 2.5 mm².

Location: Safe Area/Non Hazardous Locations or Zone 2, Group IIC T4 installation.

Protection class: IP 20.

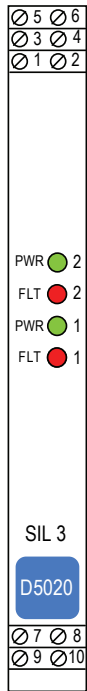
Dimensions: Width 12.5 mm, Depth 123 mm, Height 120 mm.

Ordering Information

Model:	D5020	
1 channel		S
2 channels		D

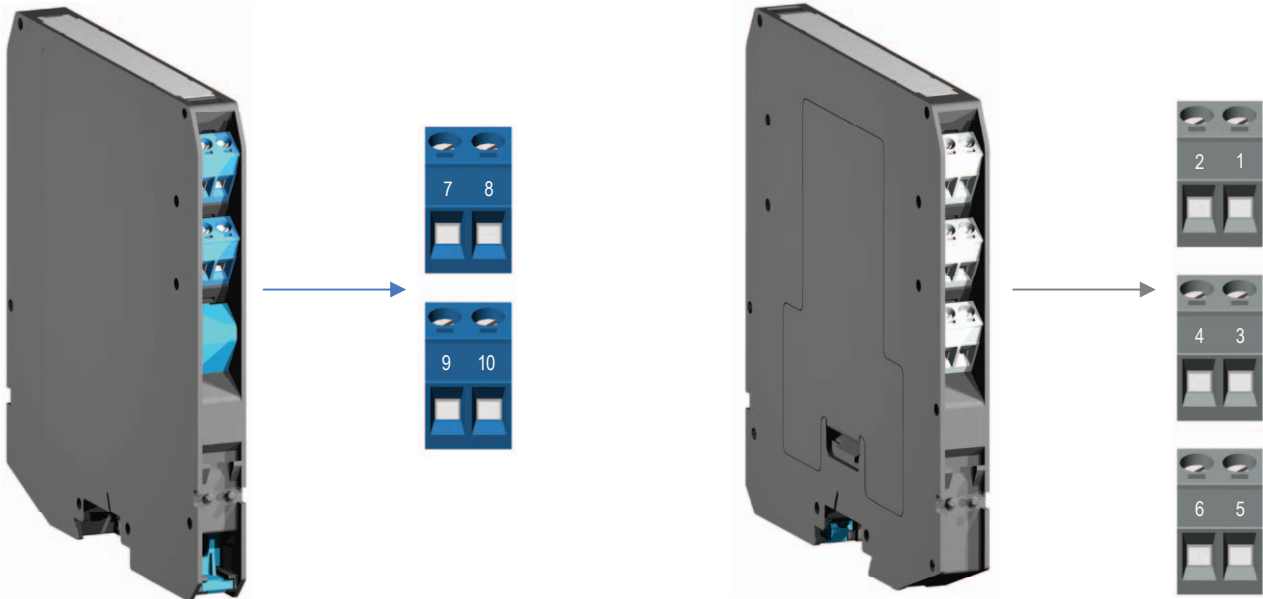
Power Bus and DIN-Rail accessories:
 Connector JDFT049 Cover and fix MCHP196
 Terminal block male MOR017 Terminal block female MOR022

Front Panel and Features



- SIL 3 according to IEC 61508 for Tproof = 1 / 2 yrs (10 / 20 % of total SIF).
- SIL 2 according to IEC 61508 for Tproof = 10 / 20 yrs (10 / 20 % of total SIF).
- PFDavg (1 year) 9.26 E-05, SFF 95.02 %.
- 2 fully independent channels.
- Output to Zone 0 (Zone 20), installation in Zone 2.
- 4-20 mA Input, Output Signal.
- Hart compatible.
- Field open and short circuit detection and signaling for each channel and cumulative.
- High Accuracy.
- Three port isolation, Input/Output/Supply.
- EMC Compatibility to EN61000-6-2, EN61000-6-4, EN61326-1, EN61326-3-1 for safety system.
- In-field programmability by DIP Switch.
- ATEX, IECEx, Russian and Ukrainian Certifications.
- High Density, two channels per unit.
- Simplified installation using standard DIN-Rail and plug-in terminal blocks, with or without Power Bus, or customized Termination Boards.
- 250 Vrms (Um) max. voltage allowed to the instruments associated with the barrier.

Terminal block connections



HAZARDOUS AREA

- | | |
|-----------|---------------------------------|
| 7 | + Output Ch 1 for I/P Converter |
| 8 | - Output Ch 1 for I/P Converter |
| 9 | + Output Ch 2 for I/P Converter |
| 10 | - Output Ch 2 for I/P Converter |

SAFE AREA

- | | |
|----------|---|
| 1 | + Input Ch 1 |
| 2 | - Input Ch 1 |
| 3 | + Input Ch 2 (+ Fault output on D5020S) |
| 4 | - Input Ch 2 (- Fault output on D5020S) |
| 5 | + Power Supply 24 Vdc |
| 6 | - Power Supply 24 Vdc |

Parameters Table

In the system safety analysis, always check the Hazardous Area/Hazardous Locations devices to conform with the related system documentation, if the device is Intrinsically Safe check its suitability for the Hazardous Area/Hazardous Locations and group encountered and that its maximum allowable voltage, current, power (U_i/V_{max} , I_i/I_{max} , P_i/P_i) are not exceeded by the safety parameters (U_o/V_{oc} , I_o/I_{sc} , P_o/P_o) of the D5020 series Associated Apparatus connected to it. Also consider the maximum operating temperature of the field device, Check that added connecting cable and field device capacitance and inductance do not exceed the limits (C_o/C_a , L_o/L_a , L_o/R_o) given in the Associated Apparatus parameters for the effective group. See parameters indicated in the table below:

D5020 Terminals		D5020 Associated Apparatus Parameters		Must be	Hazardous Area/ Hazardous Locations Device Parameters
Ch1	7 - 8	$U_o / V_{oc} = 25.9 V$		\leq	U_i / V_{max}
Ch2	9 - 10				
Ch1	7 - 8	$I_o / I_{sc} = 93 mA$		\leq	I_i / I_{max}
Ch2	9 - 10				
Ch1	7 - 8	$P_o / P_o = 595 mW$		\leq	P_i / P_i
Ch2	9 - 10				
D5020 Terminals		D5020 Associated Apparatus Parameters Cenelec (US)		Must be	Hazardous Area/ Hazardous Locations Device + Cable Parameters
Ch1	7 - 8	$C_o / C_a = 100 nF$ $C_o / C_a = 770 nF$ $C_o / C_a = 2.63 \mu F$ $C_o / C_a = 4.02 \mu F$ $C_o / C_a = 770 nF$	IIC (A, B) IIB (C) IIA (D) I iaD (E, F, G)	\geq	C_i / C_i device + C cable
Ch2	9 - 10				
Ch1	7 - 8	$L_o / L_a = 4.1 mH$ $L_o / L_a = 16.7 mH$ $L_o / L_a = 33.5 mH$ $L_o / L_a = 54.9 mH$ $L_o / L_a = 16.7 mH$	IIC (A, B) IIB (C) IIA (D) I iaD (E, F, G)	\geq	L_i / L_i device + L cable
Ch2	9 - 10				
Ch1	7 - 8	$L_o / R_o = 59.7 \mu H/\Omega$ $L_o / R_o = 239.0 \mu H/\Omega$ $L_o / R_o = 478.1 \mu H/\Omega$ $L_o / R_o = 784.5 \mu H/\Omega$ $L_o / R_o = 239.0 \mu H/\Omega$	IIC (A, B) IIB (C) IIA (D) I iaD (E, F, G)	\geq	L_i / R_i device and L cable / R cable
Ch2	9 - 10				

For installations in which both the C_i and L_i of the Intrinsically Safe apparatus exceed 1 % of the C_o and L_o parameters of the Associated Apparatus (excluding the cable), then 50 % of C_o and L_o parameters are applicable and shall not be exceeded (50 % of the C_o and L_o become the limits which must include the cable such that C_i device + C cable \leq 50 % of C_o and L_i device + L cable \leq 50 % of L_o).

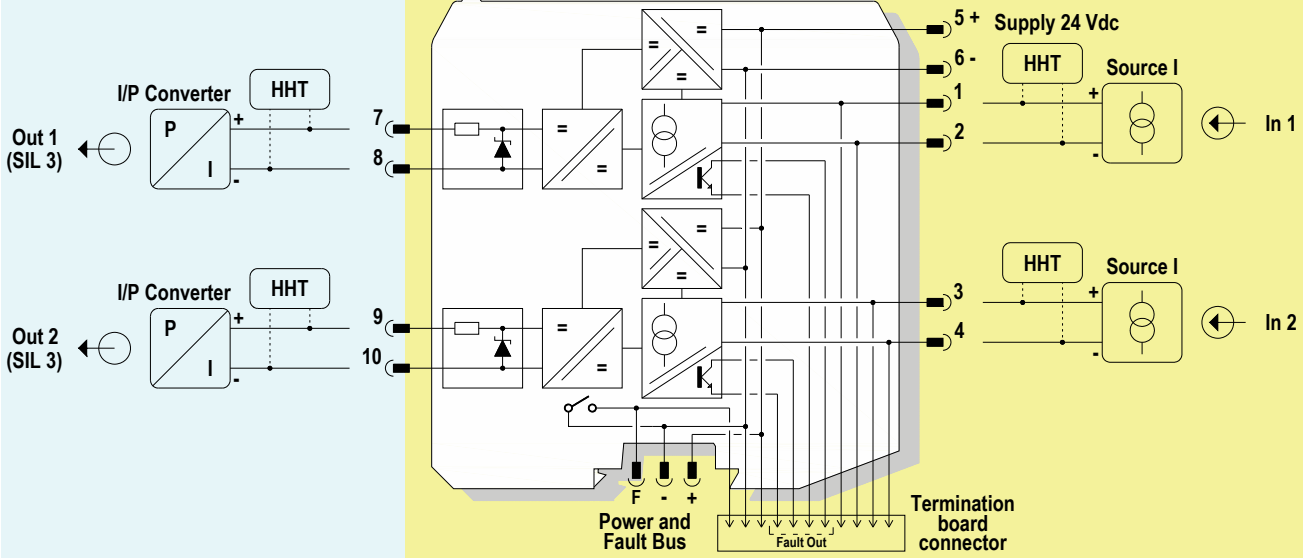
If the cable parameters are unknown, the following value may be used: Capacitance 180pF per meter (60pF per foot), Inductance 0.60 μ H per meter (0.20 μ H per foot).

Function Diagram

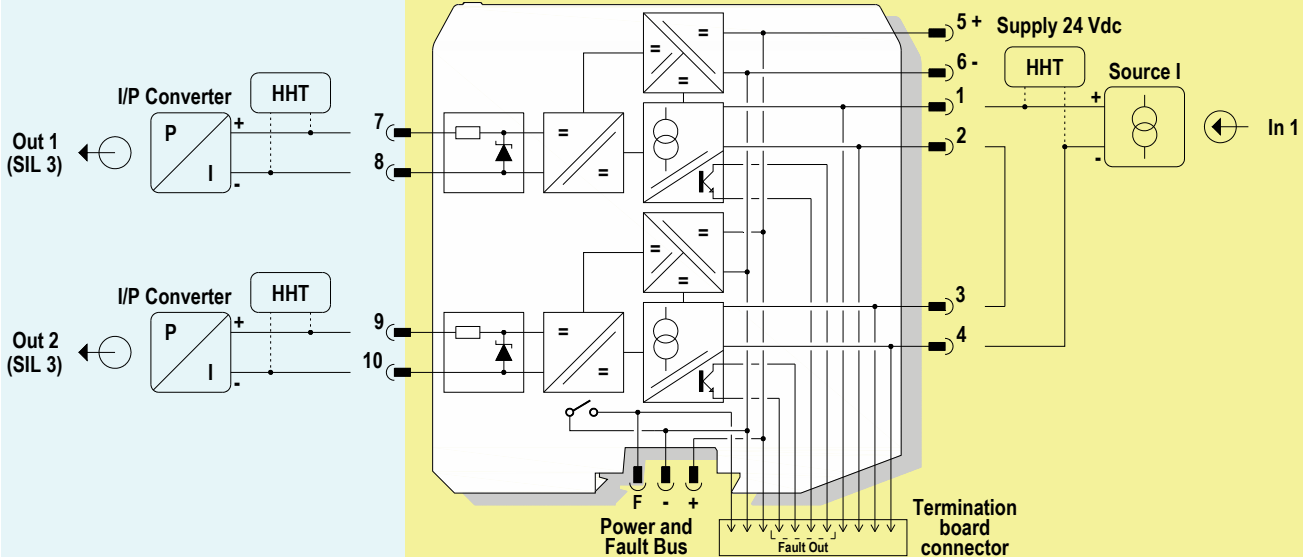
HAZARDOUS AREA ZONE 0 (ZONE 20) GROUP IIC

SAFE AREA, ZONE 2 GROUP IIC T4

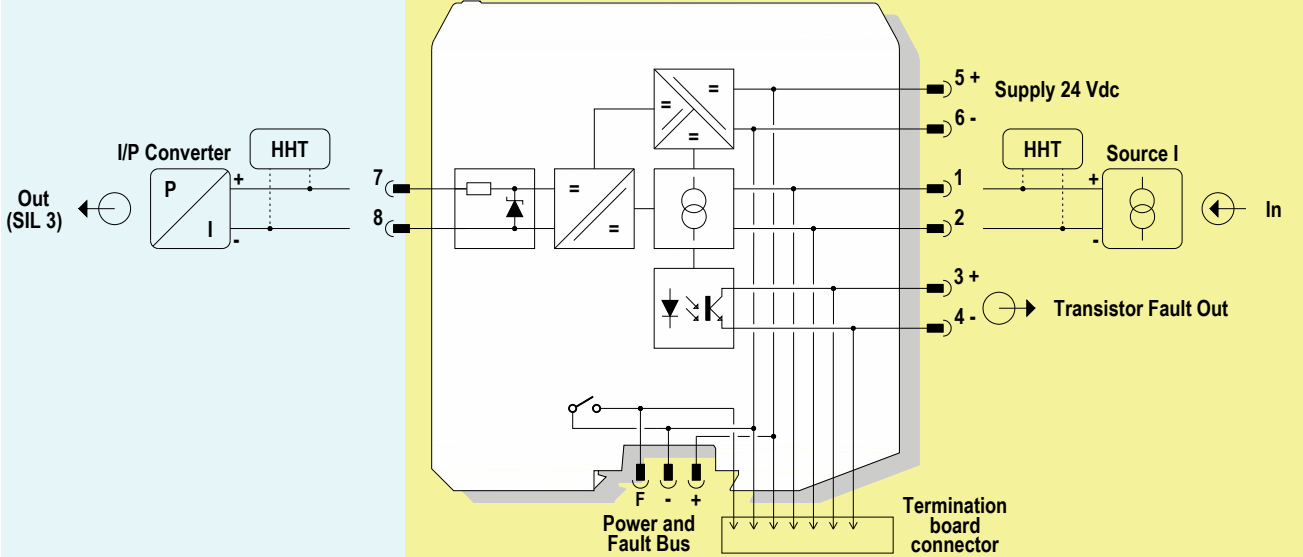
MODEL D5020D



MODEL D5020D Duplicator



MODEL D5020S



Warning

D5020 series are isolated Intrinsically Safe Associated Apparatus installed into standard EN50022 T35 DIN-Rail located in Safe Area or Zone 2, Group IIC, Temperature T4, Hazardous Area (according to EN/IEC60079-15) within the specified operating temperature limits Tamb -40 to +70 °C, and connected to equipment with a maximum limit for AC power supply Um of 250 Vrms.

Not to be connected to control equipment that uses or generates more than 250 Vrms or Vdc with respect to earth ground.

D5020 series must be installed, operated and maintained only by qualified personnel, in accordance to the relevant national/international installation standards (e.g. IEC/EN60079-14 Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines)), following the established installation rules, particular care shall be given to segregation and clear identification of I.S. conductors from non I.S. ones.

De-energize power source (turn off power supply voltage) before plug or unplug the terminal blocks when installed in Hazardous Area or unless area is known to be nonhazardous.

Warning: substitution of components may impair Intrinsic Safety and suitability for Zone 2.

Explosion Hazard: to prevent ignition of flammable or combustible atmospheres, disconnect power before servicing or unless area is known to be nonhazardous.

Failure to properly installation or use of the equipment may risk to damage the unit or severe personal injury.

The unit cannot be repaired by the end user and must be returned to the manufacturer or his authorized representative.

Any unauthorized modification must be avoided.

Operation

D5020 isolates and transfers a 4-20 mA signal from a controller located in Safe Area to a load up to 700 Ω in Hazardous Area. It has a high output capacity of 15 V at 20 mA combined with a low drop across its input terminals. The circuit allows bi-directional communication signals, for Hart positioner.

In the 4-20 mA input range, a field open or short circuit, reflects a high impedance to the control device circuit and actuates (de-energizes) the channel Fault output transistor and actuates (energizes) the cumulative Fault output available on Power Bus connector. Fault output signal for each channel is available when mounted on customized Termination Board. In addition the single channel D5020S provides open collector transistor output on terminal blocks. Short circuit fault detection can be enabled (two different levels can be selected) or disabled via DIP-Switch programming.

Presence of supply power, as well as integrity or fault condition of device and connecting line are displayed by signaling LEDs (green for power and red for fault condition).

Installation

D5020 series are Isolated Driver hart compatible housed in a plastic enclosure suitable for installation on T35 DIN-Rail according to EN50022, with or without Power Bus or on customized Termination Board.

D5020 unit can be mounted with any orientation over the entire ambient temperature range.

Electrical connection of conductors up to 2.5 mm² are accommodated by polarized plug-in removable screw terminal blocks which can be plugged in/out into a powered unit without suffering or causing any damage (**for Zone 2 installations check the area to be nonhazardous before servicing**).

The wiring cables have to be proportionate in base to the current and the length of the cable.

On the section "Function Diagram" and enclosure side a block diagram identifies all connections.

Identify the number of channels of the specific card (e.g. D5020S is a single channel model and D5020D is a dual channel model), the function and location of each connection terminal using the wiring diagram on the corresponding section, as an example:

Connect 24 Vdc power supply positive at terminal "5" and negative at terminal "6".

For Model D5020S connect positive input of channel 1 at terminal "1" and negative input at terminal "2".

For Model D5020D in addition to channel 1 connections above, connect positive input of channel 2 at terminal "3" and negative input at terminal "4".

For Model D5020S connect positive output of fault signaling at terminal "3" and negative output at terminal "4".

For Model D5020S connect positive output of channel for I/P Converter at terminal "7" and negative output at terminal "8".

For Model D5020D in addition to channel 1 connections above, connect terminal "9" for positive and "10" for negative on channel 2.

Intrinsically Safe conductors must be identified and segregated from non I.S. and wired in accordance to the relevant national/international installation standards (e.g. EN/IEC60079-14 Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines)), make sure that conductors are well isolated from each other and do not produce any unintentional connection.

Connect SPST fault output transistors checking the load rating to be within the maximum rating (100 mA at 35 Vdc (≤ 1.5 V voltage drop)).

The enclosure provides, according to EN60529, an IP20 minimum degree of mechanical protection (or similar to NEMA Standard 250 type 1) for indoor installation, outdoor installation requires an additional enclosure with higher degree of protection (i.e. IP54 to IP65 or NEMA type 12-13) consistent with the effective operating environment of the specific installation.

Units must be protected against dirt, dust, extreme mechanical (e.g. vibration, impact and shock) and thermal stress, and casual contacts.

If enclosure needs to be cleaned use only a cloth lightly moistened by a mixture of detergent in water.

Electrostatic Hazard: to avoid electrostatic hazard, the enclosure of D5020 must be cleaned only with a damp or antistatic cloth.

Any penetration of cleaning liquid must be avoided to prevent damage to the unit. Any unauthorized card modification must be avoided.

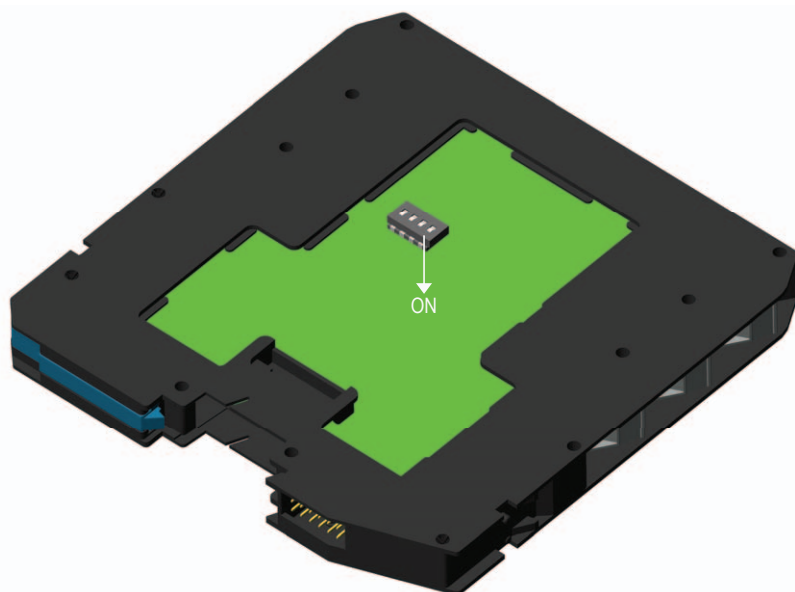
According to EN61010, D5020 series must be connected to SELV or SELV-E supplies.

Start-up

Before powering the unit check that all wires are properly connected, particularly supply conductors and their polarity, input and output wires, also check that Intrinsically Safe conductors and cable trays are segregated (no direct contacts with other non I.S. conductors) and identified either by color coding, preferably blue, or by marking. Check conductors for exposed wires that could touch each other causing dangerous unwanted shorts. Turn on power, the "power on" green led must be lit, output signal should be corresponding to the input from the controller. If possible change the input value and check the corresponding Hazardous Area output.

Configuration

A short circuit fault detection configuration DIP Switch is located on component side of pcb. This switch allows the short circuit fault detection enable and trip level.

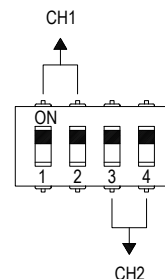


ON position
Short circuit fault Ch1
Disable

OFF position
Short circuit fault Ch1
Enable

ON position
Short circuit fault
detection Ch1
< 50 Ohm

OFF position
Short circuit fault
detection Ch1
< 100 Ohm



ON position
Short circuit fault Ch2
Disable

OFF position
Short circuit fault Ch2
Enable

ON position
Short circuit fault
detection Ch2
< 50 Ohm

OFF position
Short circuit fault
detection Ch2
< 100 Ohm

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 fault, which have been noted during the FMEDA, can be detected during proof test. **The Proof test** consists of the following steps:

Steps	Action
1	Bypass the safety-related PLC or take other appropriate action to avoid a false trip.
2	<p>Set the following configuration for SW dip-switches:</p> <ul style="list-style-type: none"> • SW-1 (for Ch1) or SW-3 (for Ch2) = ON (to disable the field short circuit fault detection); • SW-2 or SW-4 = ON or OFF (not used because load diagnostic is disabled). <p>For each channel, the series connection of 700 Ω load resistor with an ammeter must be connected to output terminals of channel. Then, connect a current calibrator to input terminals of channel. Supply the D5020 at 24 Vdc and apply (by calibrator) the following input dc current values:</p> <ul style="list-style-type: none"> • 20 mA (high current limit) and verify that the output current is ≈ 20 mA (within the specified accuracy); • 4 mA (low current limit) and verify that the output current is ≈ 4 mA (within the specified accuracy); • 8 mA, 12 mA and 16 mA or other values included in the range 4 ÷ 20 mA and verify that the output current has the equivalent current value (within the specified accuracy). <p>The same test must be executed with lower load resistance values, reaching 50 Ω (low resistance limit).</p>
3	<p>Set the following configuration for SW dip-switches: SW-1 (for Ch1) or SW-3 (for Ch2) = OFF (to enable the field short circuit fault detection).</p> <p>For each channel, connect the series connection of a current calibrator with an ammeter to input terminals of channel and supply the D5020 at 24 Vdc. Firstly, don't connect anything to the output terminals and verify that red fault LED is lit because of field open circuit.</p> <p>Then, connect the series connection of a decade resistor box (set to 250 Ω) with an ammeter to output terminals of channel. Applying (by calibrator) an input dc current in the range 4 ÷ 20 mA, consider the following configuration:</p> <ul style="list-style-type: none"> • SW-2 or SW-4 = OFF (to detect short circuit fault for load resistance < 100 Ω): reduce (by decade resistor box) the load resistance and verify that diagnostic circuit detects short circuit fault when load resistance is < 100 Ω; • SW-2 or SW-4 = ON (to detect short circuit fault for load resistance < 50 Ω): reduce (by decade resistor box) the load resistance and verify that diagnostic circuit detects short circuit fault when load resistance is < 50 Ω; <p>During short circuit fault, the red fault LED is lit, the input ammeter measures ≈ 2 mA because the D5020 module reflects a high impedance to the input calibrator (which reaches the overload state) and therefore the output ammeter shows a low current ≤ 2 mA. This situation is held until normal configuration (without short circuit fault) is restored.</p>
4	Restore the loop to full operation.
5	Remove the bypass from the safety-related PLC or restore normal operation.

This test will detect almost 100 % of possible Dangerous Undetected failures in the powered isolating driver.

D5020S and D5020D Powered Isolating Driver

• Safety function

For each channel, the field open or short circuit fault detection should be enabled (in case of fault, the output load is de-energized (low output current is imposed) until normal condition is restored and low sinking current is imposed to Safety PLC output because high impedance is reflected to the control device circuit).

The failure behaviour is described from the following definitions:

- fail-Safe State: is defined as the output going to fail low;
- fail Safe: failure mode that causes the module 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 (i.e. being unable to go to the defined fail-safe state) 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 maximum output current (> 20 mA). This mode is considered a Dangerous Undetected failure;
- fail Low: failure mode that causes the output signal to go below minimum output current (< 4 mA). This mode is considered a Safe Undetected failure;
- fail "No Effect": failure mode of a component that is part of the safety function but that has no effect on the safety function or deviates the output current by not more than 5 % (0.8 mA) of full span. For the calculation of the SFF it is considered a safe undetected failure;
- 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. It is also not considered for the total failure rate (safety function) evaluation;

- The 2 channels of D5020D module could be used to increase the hardware fault tolerance, needed for a higher SIL of a certain Safety Function, as they are completely independent each other, not containing common components. In fact, the analysis results got for D5020S (single channel) are also valid for each channel of D5020D (double channel).

• Failure rates table:

Failure category	Failure rates (FIT) - Active Input
λ_{dd} = Total Dangerous Detected failures	0.00
λ_{du} = Total Dangerous Undetected failures = $\lambda_{du\ int.} + \lambda_{high}$	21.14
↳ $\lambda_{du\ int.}$ = Dangerous Undetected failures	16.26
↳ λ_{high} = High failures	4.88
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures = $\lambda_{no\ effect} + \lambda_{low}$	403.73
↳ $\lambda_{no\ effect}$ = "No Effect" failures	263.62
↳ λ_{low} = Low failures	140.11
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	424.87
$\lambda_{not\ part}$ = "Not Part" failures	65.70
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{not\ part}$	490.57
MTBF (single channel) = $(1 / \lambda_{tot\ device}) + MTTR$ (8 hours)	233 years
$MTTF_S$ (Total Safe) = $1 / (\lambda_{sd} + \lambda_{su})$	283 years
$MTTF_D$ (Dangerous) = $1 / \lambda_{du}$	5400 years

• Failure rates table according to IEC 61508:

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF
0.0 FIT	403.73 FIT	0.00 FIT	21.14 FIT	95.02%

• PFDavg vs T[Proof] table, with determination of SIL supposing module contributes 10% of entire safety function:

T[Proof] = 1 year	T[Proof] = 10 years
PFDavg = 9.26 E-05 Valid for SIL 3	PFDavg = 9.26 E-04 Valid for SIL 2

• PFDavg vs T[Proof] table, with determination of SIL supposing module contributes 20% of entire safety function:

T[Proof] = 2 years	T[Proof] = 20 years
PFDavg = 1.85 E-04 Valid for SIL 3	PFDavg = 1.85 E-03 Valid for SIL 2