

D5020

I.S. SIL2 HART® Isolating Driver

Models D5020S, D5020D



INSTRUCTION AND SAFETY MANUAL

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1. 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 2 level (according to IEC 61508:2010 Ed. 2) 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 / Non Hazardous Location or in Zone 2 / Class I, Division 2 or Class I, Zone 2.

Functional Safety Management Certification:

G.M. International is certified by TUV to conform to IEC61508:2010 part 1 clauses 5-6 for safety related systems up to and included SIL3.

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 $< 50 \Omega$ or $< 100 \Omega$ dip-switch selectable (≈ 2 mA forcing to detect fault).

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

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: $\leq 50 \mu\text{A}$ at 35 Vdc.

Response time: ≤ 30 ms.

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

Compatibility:

CE mark compliant, conforms to Directive: 2014/34/EU ATEX, 2014/30/EU EMC, 2014/35/EU LVD, 2011/65/EU RoHS.

Environmental conditions:

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

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

Max altitude: 2000 m a.s.l.

Safety Description:

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

IECEx / INMETRO: Ex ec [ia Ga] IIC T4 Gc, [Ex ia Da] IIIC, [Ex ia Ma] I

UL: NI / I / 2 / ABCD / T4, AIS / I, II, III / 1 / ABCDEFG, AEx nA [ia Ga] IIC T4 Gc

C-UL: NI / I / 2 / ABCD / T4, AIS / I, II, III / 1 / ABCDEFG, Ex nA [ia Ga] IIC T4 Gc

FM: NI-AIS / I / 2 / ABCD / T4, AIS / I,II,III / 1 / ABCDEFG, I / 2 / AEx nA [ia] / IIC / T4

FMC: NI-AIS / I / 2 / ABCD / T4, AIS / I,II,III / 1 / ABCDEFG, I / 2 / Ex nA [ia] / IIC / T4

EAC-EX: 2Ex ec [ia Ga] IIC T4 Gc X; [Ex ia Da] IIIC X; [Ex ia Ma] I X.

CCC: Ex ec [ia Ga] IIC T4 Gc; [Ex ia Ga] IIC; [Ex ia Da] IIIC

KCs: Ex nA [ia Ga] IIC T4 Gc

PESO: Ex ec [ia Ga] IIC T4 Gc

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 $^{\circ}\text{C} \leq T_a \leq 70$ $^{\circ}\text{C}$.

Approvals:

BVS 10 ATEX E 113 X conforms to EN60079-0, EN60079-7, EN60079-11.

IECEx BVS 10.0072 X conforms to IEC60079-0, IEC60079-7, IEC60079-11.

INMETRO DNV 13.0109 X conforms to ABNT NBR IEC60079-0, ABNT NBR IEC60079-7, ABNT NBR IEC60079-11.

UL & C-UL E222308 conforms to UL913, UL 60079-0, UL60079-11, UL60079-15, ANSI/ISA 12.12.01 for UL and CSA-C22.2 No.157-92, CSA-E60079-0, CSA-E60079-11, CSA-C22.2 No. 213 and CSA-E60079-15 for C-UL.

FM 3046304 and FMC 3046304C conforms to Class 3600, 3610, 3810, 3611,

ANSI/ISA-60079-0, ANSI/ISA-60079-11, ANSI/ISA-60079-15, C22.2 No.142, C22.2 No.157, C22.2 No.213, C22.2 No. 60079-0, C22.2 No. 60079-11, C22.2 No. 60079-15.

EA3C RU C-IT.AA87.B.01310/24 conforms to GOST 31610.0, GOST 31610.7, GOST 31610.11.

CCC n. 2020322316000978 conforms to GB/T 3836.1, GB/T 3836.3, GB/T 3834.4

TC21009 for TIIS approval.

KTL 21-KA4BO-0232X for KCs approval (for D5020S). KTL 21-KA4BO-0233X for KCs approval (for D5020D).

PESO P652307 conforms to IEC60079-0, IEC60079-7, IEC60079-11.

TÜV Certificate No. TUV IT 25 SIL 0633, 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.
DNV Type Approval Certificate No. TAA00001U0 and KR No.MIL20769-EL002 Certificates for maritime applications.

Mounting:

EN/IEC60715 TH 35 DIN-Rail with or without Power Bus or on customized Termination Board.

Weight: about 145 g D5020D, 130 g D5020S.

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

Location: installation in Safe Area/Non Hazardous Locations or Zone 2, Group IIC T4 or Class I, Division 2, Group A,B,C,D, T4 or Class I, Zone 2, Group IIC, T4.

Protection class: IP 20.

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

3. ORDERING INFORMATION

3.1 Ordering codes

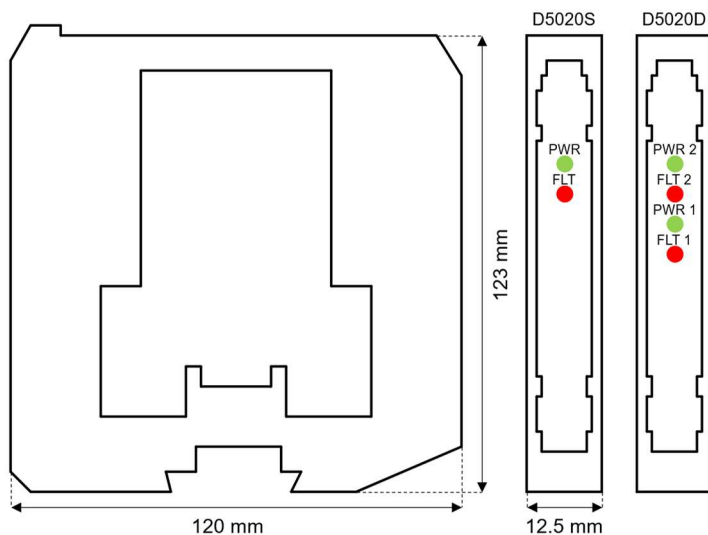
D5020S: 1 channel

D5020D: 2 channels

3.2 Accessories

Bus Connector JDFT049, Bus Mounting Kit OPT5096.

4. OVERALL DIMENSIONS



5. TERMINAL BLOCK CONNECTIONS

5.1 Hazardous Side

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

5.2 Safe Side

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

6. VERIFICATION OF INTRINSICALLY SAFE CIRCUITS

In the system safety analysis, always check that field device maximum allowable voltage, current and power are not exceeded by the safety parameters of the associated apparatus connected to it. Check also that added connecting cable and field device capacitance and inductance do not exceed the limits given in the associated apparatus parameters for the effective gas group (Co, Lo, Lo/Ro).

Associated apparatus		Field device
Uo or Voc	$\leq$	Ui or Vmax
Io or Isc	$\leq$	Ii or Imax
Po or Pout	$\leq$	Pi or Pmax
Co or Ca	$\geq$	Ci + Ccable
Lo or La	$\geq$	Li + Lcable
Lo/Ro	$\geq$	Li/Ri and Lcable/Rcable

When used with separate powered intrinsically safe devices, check also that maximum allowable voltage, current and power of the associated apparatus are not exceeded by the safety parameters of the field device.

Associated apparatus		Field device
Ui or Vmax	$\geq$	Uo or Voc
Ii or Imax	$\geq$	Io or Isc
Pi or Pmax	$\geq$	Po or Pout
Ci + Ccable	$\leq$	Co or Ca
Li + Lcable	$\leq$	Lo or La

For installations in which both the Ci and Li of the Intrinsically Safe apparatus exceed 1% of the Co or Ca and Lo or La parameters of the Associated Apparatus (excluding the cable), then 50% of Co or Ca and Lo or La parameters are applicable and shall not be exceeded (50% of the Co or Ca and Lo or La become the limits which must include the cable such that Ci device + C cable $\leq$ 50 % of Co or Ca and Li device + L cable $\leq$ 50 % of Lo or La). The reduced capacitance of the external circuit (including cable) shall not be greater than 1 μ F for Groups I, IIA (or D), IIB (or C) and 600 nF for Group IIC (or A, B). If the cable parameters are unknown, the following value may be used: Capacitance 200 pF per meter (60 pF per foot), Inductance 1 μ H per meter (0.20 μ H per foot).

6.1 Intrinsically safe parameters table

	Group	Co or Ca [μ F]	Lo or La [mH]	Lo/Ro [μ H/ Ω]
Term. 7-8, 9-10: Uo(Voc)=25.9 V; Io(Isc)=93 mA; Po(Pout)=595 mW Characteristic: linear	IIC (A, B)	0.1	4.1	59.7
	IIB (C)	0.77	16.7	239
	IIA (D)	2.63	33.5	478.1
	I	4.02	54.9	784.5
	IIIC (E, F, G)	0.77	16.7	239

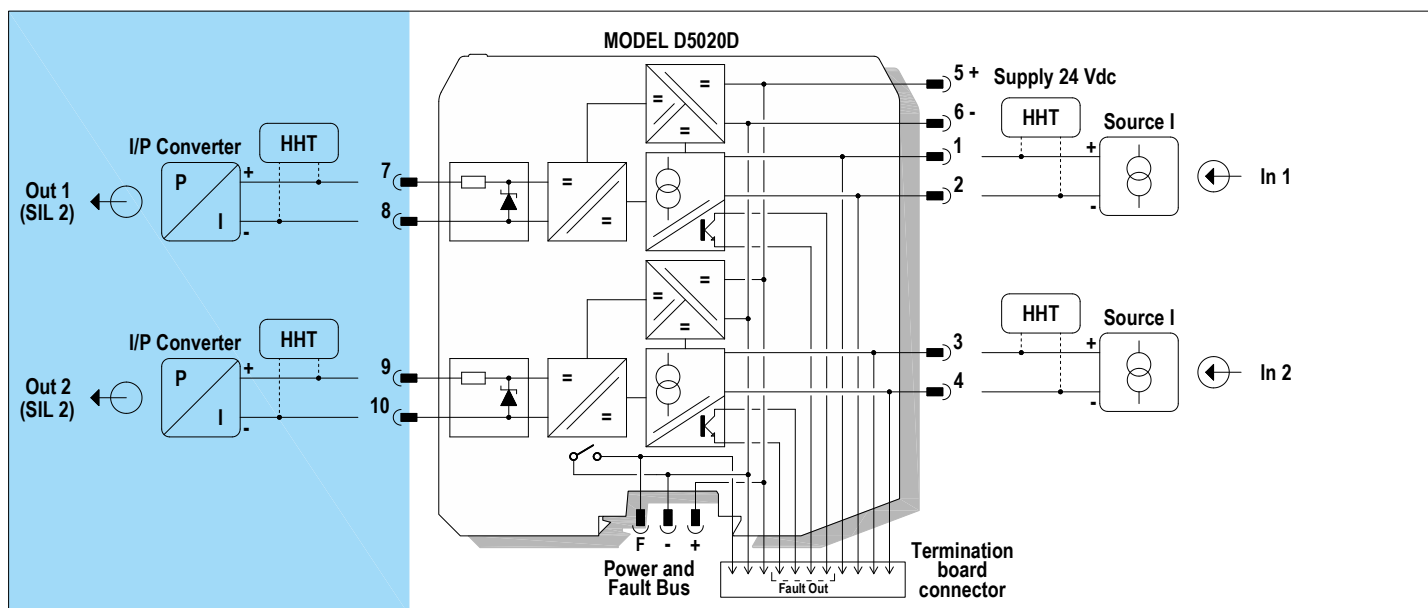
Isolation in accordance with EN/IEC 60079-11 clause 6.3.13 is provided between non-intrinsically safe circuits and intrinsically safe circuits. Isolation in accordance with EN/IEC 60079-11 clause 6.3.13 is provided between separated intrinsically safe circuits.

IS parameters listed above comply with all applicable certifications for this product. For details regarding IS parameters of a specific certification, please refer to the certificate itself, that can be found on www.gminternational.com website.

7. FUNCTION DIAGRAM

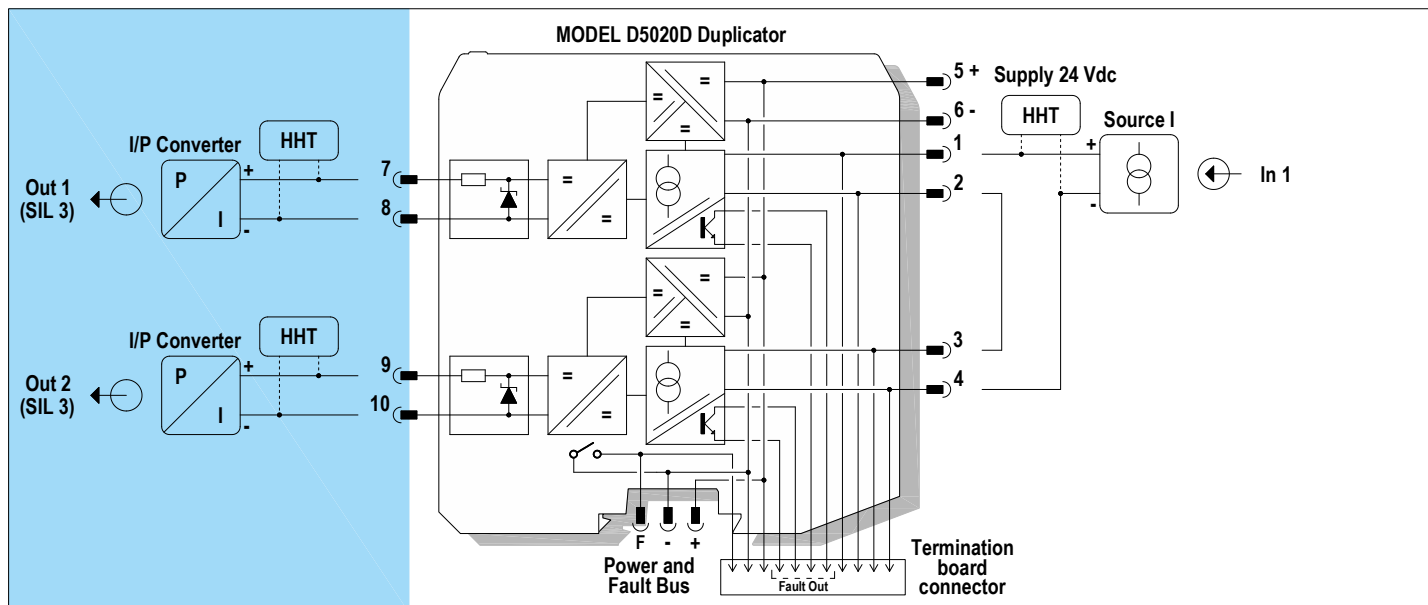
Hazardous Area

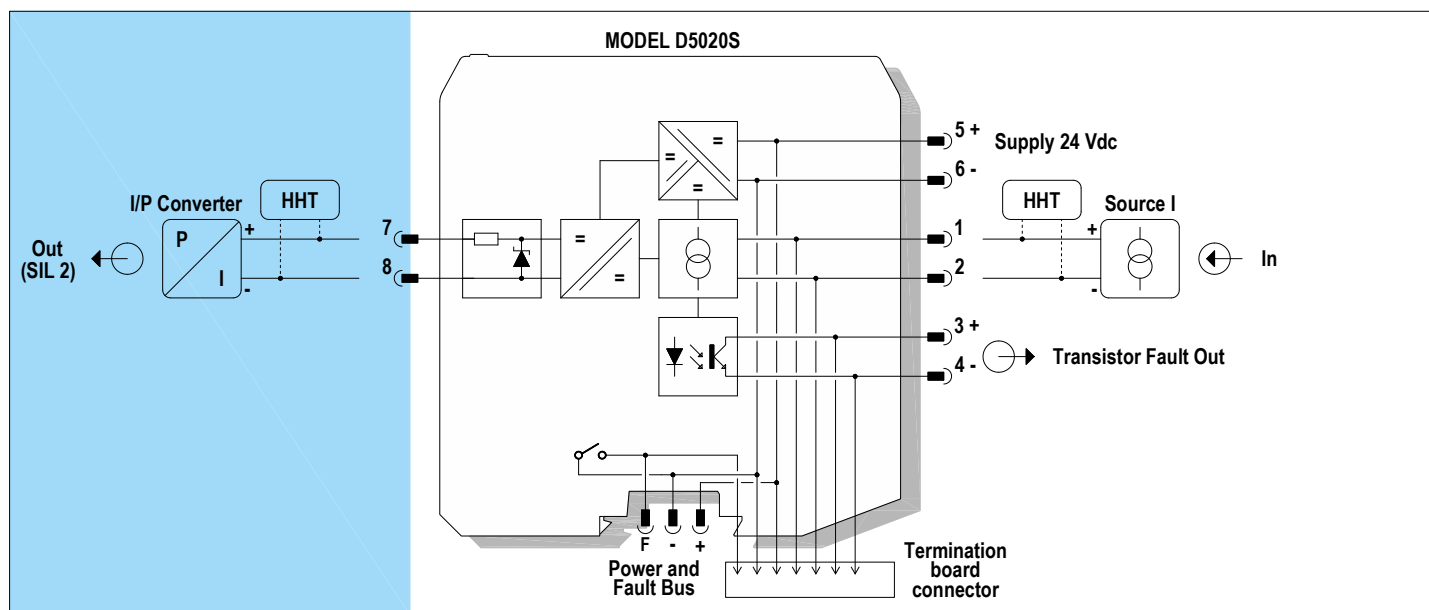
Safe Area/Zone 2/Div. 2



Hazardous Area

Safe Area/Zone 2/Div. 2





8. WARNING

D5020 series are isolated Intrinsically Safe Associated Apparatus installed into standard EN/IEC60715 TH 35 DIN-Rail located in Safe Area or Zone 2, Group IIC, Temperature T4, Hazardous Area within the specified operating temperature limits $T_{amb} -40$ to $+70$ °C, and connected to equipment with a maximum limit for AC power supply U_m 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.

9. 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).

10. INSTALLATION

D5020 series are Isolated Driver hart compatible housed in a plastic enclosure suitable for installation on EN/IEC60715 TH 35 DIN-Rail, with or without Power Bus or on customized Termination Board.

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

Electrical connection 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)**. Connect only one individual conductor per each clamping point, use conductors up to 2.5 mm² (13 AWG) and a torque value of 0.5-0.6 Nm. The wiring cables have to be proportionate in base to the current and the length of the cable.

In case of installation in zone 2, the connecting cables of non-intrinsically safe circuits must be safely routed in a cable duct or similar. The distance between the pluggable connection terminal and the cable duct should not exceed 500 mm cable length.

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 protection (or similar to NEMA Standard 250 type 1). The equipment shall only be used in an area of at least pollution degree 2, as defined in IEC 60664-1. When installed in EU Zone 2, the unit shall be installed in an enclosure that provides a minimum ingress protection of IP54 in accordance with IEC 60079-0. When installed in a Class I, Zone 2 Hazardous Location, the unit shall be mounted in a supplemental AEx or Ex enclosure that provides a degree of protection not less than IP54 in accordance with UL/CSA 60079-0. When installed in a Class I, Division 2 Hazardous Location, the unit shall be mounted in a supplemental enclosure that provides a degree of protection not less than IP54. The enclosure must have a door or cover accessible only by the use of a tool. The end user is responsible to ensure that the operating temperature of the module is not exceeded in the end use application.

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 series 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 modification must be avoided. D5020 series must be connected to SELV or PELV supplies. All circuits connected to D5020 series must comply with the overvoltage category II (or better) according to EN/IEC60664-1.

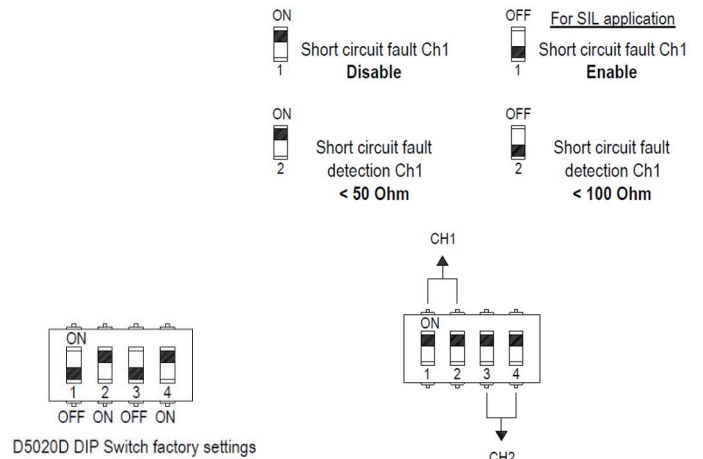
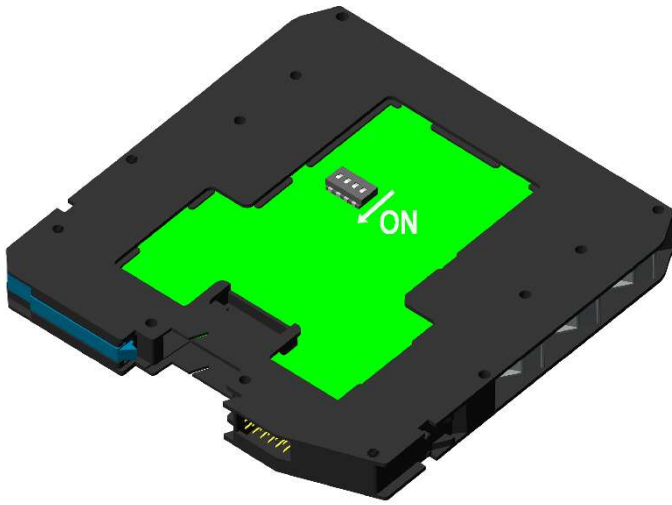
11. START-UP

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.

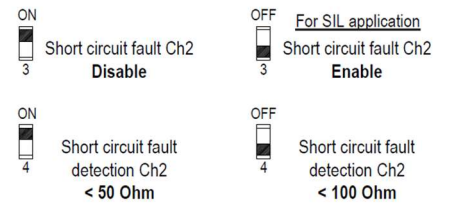
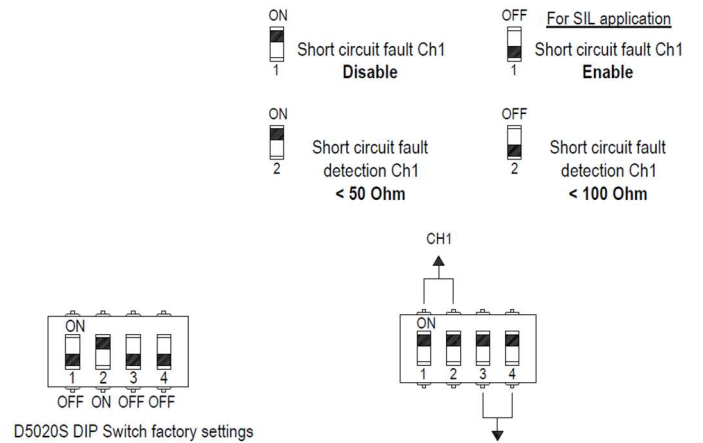
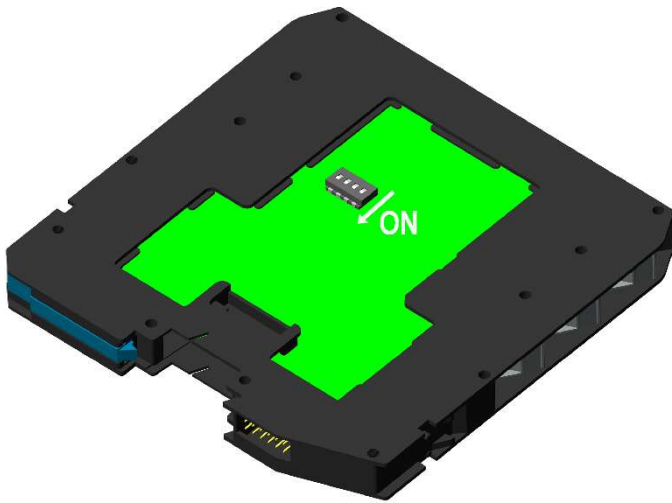
12. CONFIGURATION

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.

12.1 D5050D

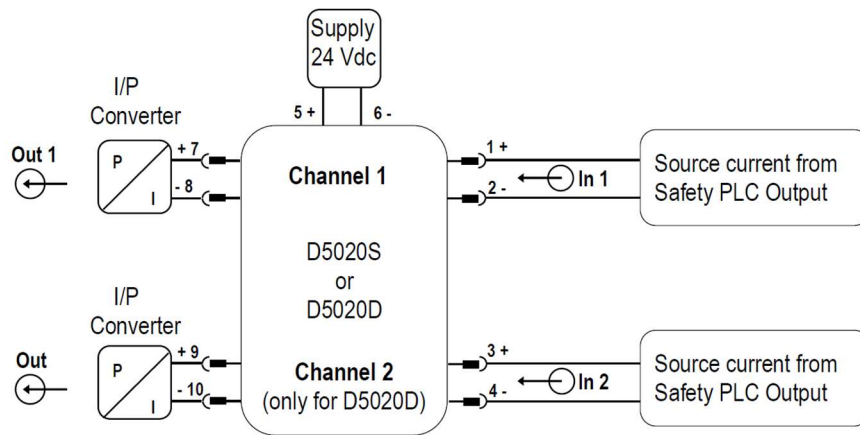


12.2 D5020S



13. FUNCTIONAL SAFETY MANUAL AND APPLICATION

13.1 Application for D5020S or D5020D



Description:

For this application, enable Short Circuit fault for ch. 1 or ch. 2, by set the internal dip-switches in the following mode (see. Section 12 for more information):

Dip-switch position (D5020S)	1	2	3	4
Short Circuit fault	OFF	-	-	-

Dip-switch position (D5020D)	1	2	3	4
Short Circuit fault ch.1	OFF	-	-	-
Short Circuit fault ch.2	-	-	OFF	-

The module is powered by connecting 24 Vdc power supply to Pins 5 (+ positive) - 6 (- negative). The green LED is lit in presence of supply power.

Current Input signals from Safety PLC Outputs are applied to Pins 1-2 (In 1 - Ch.1) and Pins 3-4 (In 2 - Ch.2).

Source output currents for I/P converters are applied to Pins 7-8 (for Channel 1) and Pins 9-10 (for Channel 2).

Safety Function and Failure behavior:

For each channel, 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). D5020 is considered to be operating in Low Demand mode, as a Type A module, having Hardware Fault Tolerance (HFT) = 0.

The failure behaviour is described from the following definitions :

- fail-Safe State: is defined as the output going Low, considering that the safety logic solver can convert the Low fail (dangerous detected) to the fail-safe state;
- 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 the 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 the minimum output current (< 4 mA). Assuming that the application program in the safety logic solver is configured to detect Low failure and does not automatically trip on this failure, this failure has been classified as a dangerous detected (DD) failure.
- fail "No Effect": failure mode of a component that plays a part in implementing the safety function but that 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

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).

This analysis is also valid for D5020D as Duplicator.

Failure rate data: taken from Siemens Standard SN29500.

Failure rate table:

Failure category	Failure rates (FIT)
λ_{dd} = Total Dangerous Detected failures	136.38
λ_{du} = Total Dangerous Undetected failures	21.00
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	0.00
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	157.38
MTBF (safety function, single channel) = $(1 / \lambda_{tot\ safe}) + MTTR$ (8 hours)	725 years
$\lambda_{no\ effect}$ = "No Effect" failures	255.92
$\lambda_{not\ part}$ = "Not Part" failures	65.70
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	479.00
MTBF (device, single channel) = $(1 / \lambda_{tot\ device}) + MTTR$ (8 hours)	238 years

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

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF	DCS	DCD
0.00 FIT	0.00 FIT	136.38 FIT	21.00 FIT	86.65%	0%	86.65%

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

T[Proof] = 1 year	T[Proof] = 10 years
PFDavg = 9.33 E-05 Valid for SIL 2	PFDavg = 9.33 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 = 1.87 E-03 Valid for SIL 2

Systematic capability SIL 3.

13.2 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 revealed 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.

Steps	Action
2	Set the following configuration for SW dip-switches: - 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). 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: 20 mA (high current limit) and verify that the output current is $\approx$ 20 mA (within the specified accuracy); 4 mA (low current limit) and verify that the output current is $\approx$ 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). The same test must be executed with lower load resistance values, reaching 50 Ω (low resistance limit).
3	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). 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. 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: - 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; During short circuit fault, the red fault LED is lit, the input ammeter measures $\approx$ 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 $\leq$ 2 mA. This situation is held until normal configuration (without short circuit fault) is restored.
4	Restore the loop to full operation.
5	Remove the bypass from the safety-related PLC or restore normal operation.

This test reveals almost 99 % of all possible Dangerous Undetected failures in the powered isolating driver.