

D5040

I.S. SIL3 Loop-Powered Digital Output Driver

Models D5040S, D5040D



INSTRUCTION AND SAFETY MANUAL

SUMMARY OF CONTENT

1. Characteristics	2
2. Technical data	2
3. Ordering information	4
3.1 Ordering codes	4
3.2 Accessories	4
4. OVERALL DIMENSIONS	4
5. Terminal block connections.....	4
5.1 Hazardous Side / Field Side	4
5.2 Safe Side / System Side	4
6. Verification of intrinsically safe circuits	5
6.1 Intrinsically safe parameters table	5
7. Function diagram	6
8. Warning	7
9. Operation	7
10. Installation	8
11. Start-up.....	8
12. Functional Safety Manual and Application.....	9
12.1 Application of D5040S or D5040D for NE load	9

1. CHARACTERISTICS

General Description: The single or dual channel Loop Powered Digital Output Isolators, D5040S and D5040D, are suitable for driving solenoid valves, visual or audible alarms to alert a plant operator, or other process control devices in Hazardous Area from driving signals in Safe Area. They can also be used as controllable supplies to power measuring or process control equipment. Their use is allowed in applications requiring up to SIL 3 level (according to IEC 61508:2010 Ed. 2) in safety related systems for high risk industries. The Safety PLC or DCS driving signals control the field devices through D5040S and D5040D, which provide isolation. For each channel two basic output circuits are selectable, with different safety parameters, to interface the majority of devices on the market. The selection among the two output characteristics is obtained by connecting the field device to a different couple of terminal blocks.

Mounting on standard DIN-Rail 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

Loop Input:

loop powered control signal.

Loop Supply: 24 Vdc nom (18 to 30 Vdc) reverse polarity protected, 2 A time lag fuse internally protected.

Current consumption @ 24 V: 45 mA with 30 mA output for each channel of D5040D, typical in normal operation. 55 mA with 40 mA output (typical for D5040S).

Power dissipation: 0.75 W with 24 V supply, output energized at 35 mA nominal load for each channel of D5040D; 0.85 W with 24 V supply, output energized at 45 mA nominal load for D5040S.

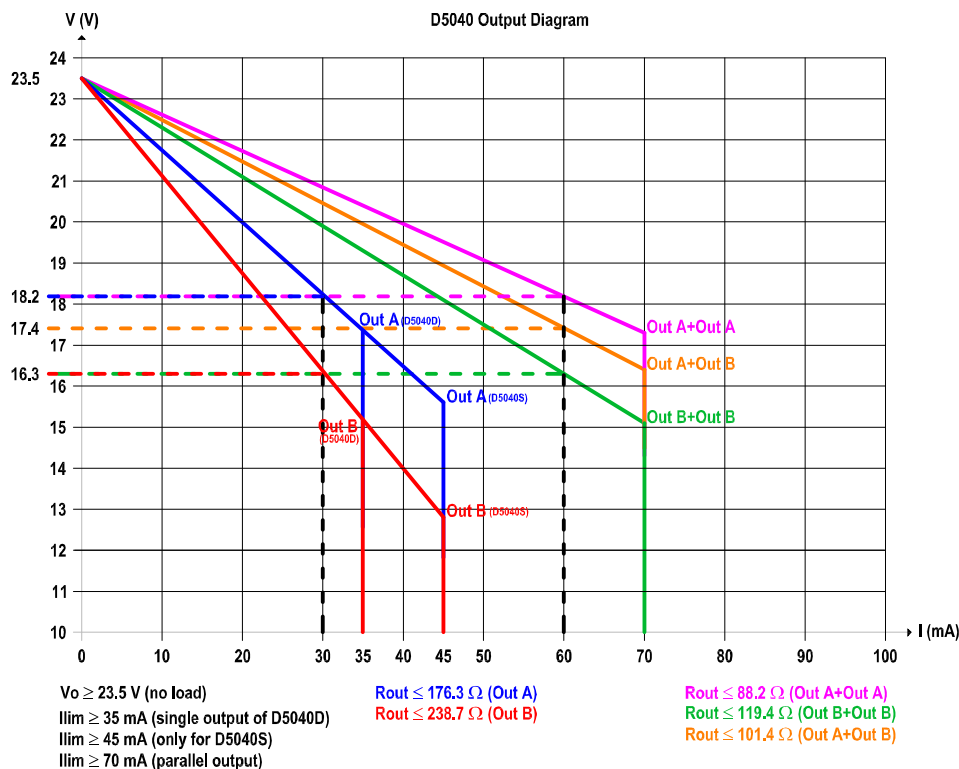
Isolation (Test Voltage):

I.S. Out/In 1.5 KV.

Out/Out 500 V.

In/In 500 V.

Output:



Short circuit current:

- $\geq$ 45 mA (50 mA typical) for single output configuration (D5040S);
- $\geq$ 35 mA (40 mA typical) for single output configurations (D5040D);
- $\geq$ 70 mA (80 mA typical) for parallel output configurations (D5040D).

Response time: $\leq$ 75 ms.

Frequency response: 50 Hz

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 °C, relative humidity 95 %, up to 55 °C.

Storage: temperature limits – 45 to + 80 °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: 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

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] IIIC; [Ex ia Da] IIIC

KCs: Ex nA [ia Ga] IIC T4 Gc

associated apparatus and non-sparking electrical equipment.

See next page for safety parameters.

Um = 250 Vrms, -40 °C $\leq$ Ta $\leq$ 70 °C.

Approvals:

BVS 14 ATEX E 159 X conforms to EN60079-0, EN60079-7, EN60079-11.

IECEX BVS 14.0111X conforms to IEC60079-0, IEC60079-7, 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.

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

KTL 16-KA4BO-443X for KCs approval (for D5040S).

KTL 16-KA4BO-444X for KCs approval (for D5040D).

TÜV Certificate No. TÜV IT 25 SIL 0633, SIL 3 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 or on customized Termination Board.

Weight: about 110 g.

Connection: by polarized plug-in disconnect screw terminal blocks to accomodate 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

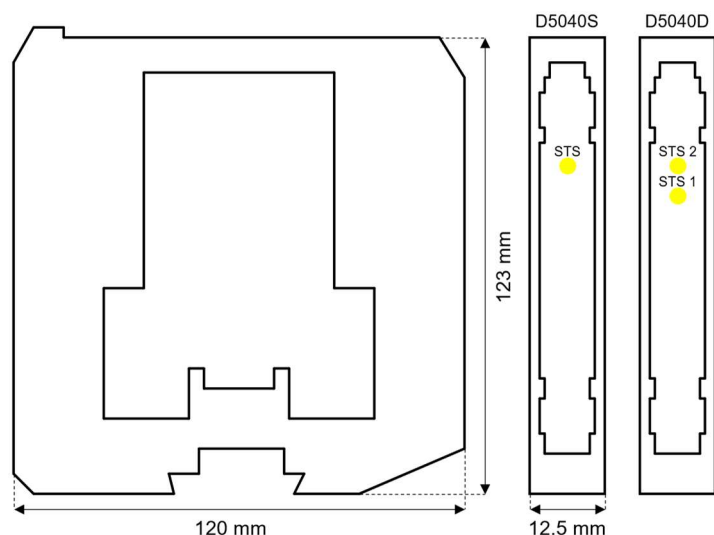
D5040S: 1 channel

D5040D: 2 channels

3.2 Accessories

DIN-Rail stopper MCHP196.

4. OVERALL DIMENSIONS



5. TERMINAL BLOCK CONNECTIONS

5.1 Hazardous Side / Field Side

- 7: + Output , Ch 1 for Solenoid Valve
- 8: - Output A, Ch 1 for Solenoid Valve
- 9: - Output B, Ch 1 for Solenoid Valve
- 10: + Output , Ch 2 for Solenoid Valve
- 11: - Output A, Ch 2 for Solenoid Valve
- 12: - Output B, Ch 2 for Solenoid Valve

5.2 Safe Side / System Side

- 1: + Input Ch 1
- 2: - Input Ch 1
- 3: + Input Ch 2
- 4: - Input Ch 2

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	≤	Ui or Vmax
Io or Isc	≤	Ii or Imax
Po or Pout	≤	Pi or Pmax
Co or Ca	≥	Ci + Ccable
Lo or La	≥	Li + Lcable
Lo/Ro	≥	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	≥	Uo or Voc
Ii or Imax	≥	Io or Isc
Pi or Pmax	≥	Po or Pout
Ci + Ccable	≤	Co or Ca
Li + Lcable	≤	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 ≤ 50 % of Co or Ca and Li device + L cable ≤ 50 % of Lo or La). The reduced capacitance of the external circuit (including cable) shall not be greater than 1 µF 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 µH per meter (0.20 µH per foot).

6.1 Intrinsically safe parameters table

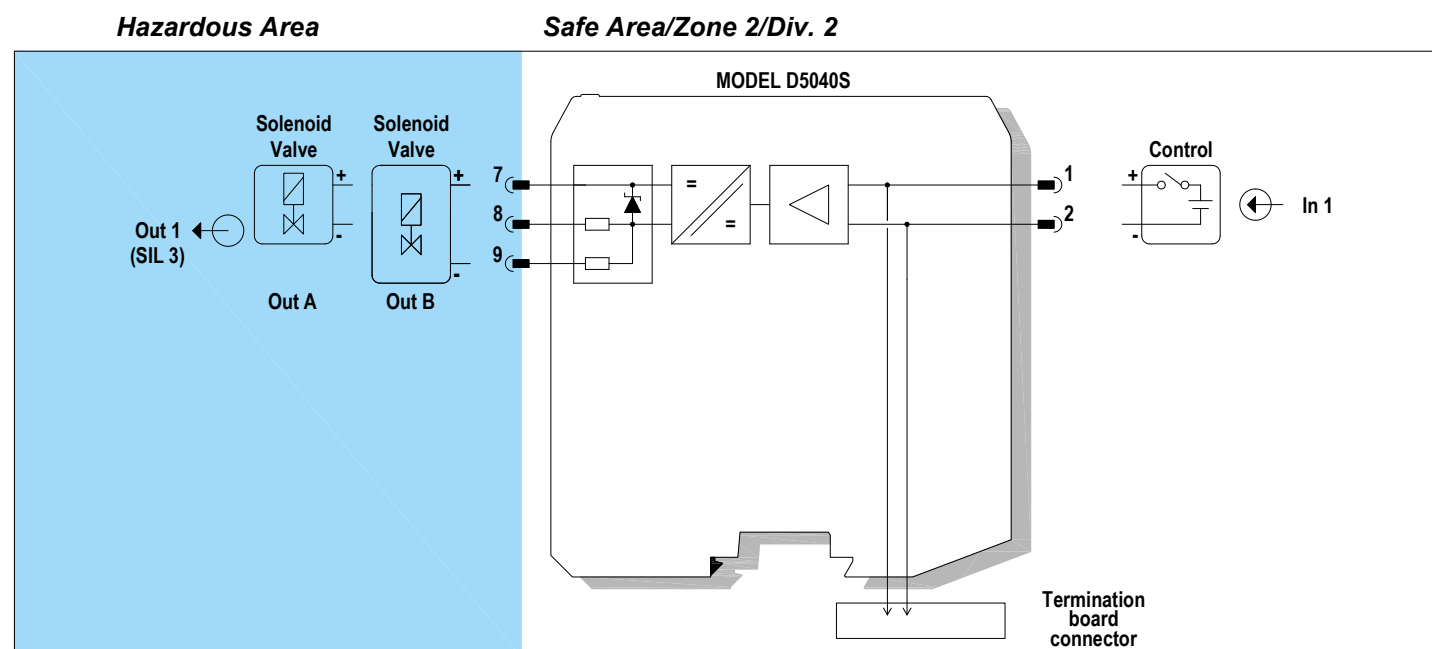
	Group	Co or Ca [µF]	Lo or La [mH]	Lo/Ro [µH/Ω]
Term. 10-11 (Out A), 7-8 (Out A): Uo(Voc)=25.2 V; Io(Isc)=146 mA; Po(Pout)=916 mW Characteristic: linear	IIC (A, B)	0.107	1.67	38.8
	IIB (C)	0.82	6.71	155.3
	IIA (D)	2.9	13.42	310.7
	I	4.8	22.01	509.8
	IIIC (E, F, G)	0.82	6.71	155.3
Term. 10-12 (Out B), 7-9 (Out B): Uo(Voc)=25.2 V; Io(Isc)=108 mA; Po(Pout)=676 mW Characteristic: linear	IIC (A, B)	0.107	3.07	52.6
	IIB (C)	0.82	12.3	210.4
	IIA (D)	2.9	24.61	420
	I	4.8	40.37	690.3
	IIIC (E, F, G)	0.82	12.3	210.4
Term. 7//10-8//11 (Out A + Out A) (D5040D): Uo(Voc)=25.2 V; Io(Isc)=292 mA; Po(Pout)=1831 mW Characteristic: linear	IIC (A, B)	0	0	0
	IIB (C)	0.82	1.67	77.6
	IIA (D)	2.9	3.35	155.3
	I	4.8	5.5	254.9
	IIIC (E, F, G)	0.82	1.67	77.6

	Group	Co or Ca [uF]	Lo or La [mH]	Lo/Ro [uH/Ω]
Term. 7//10-9//12 (Out B + Out B) (D5040D): Uo(Voc)=25.2 V; Io(Isc)=216 mA; Po(Pout)=1352 mW Characteristic: linear	IIC (A, B)	0	0	0
	IIB (C)	0.82	3.07	105.2
	IIA (D)	2.9	6.15	210.4
	I	4.8	10.09	345.1
	IIIC (E, F, G)	0.82	3.07	105.2
Term. 7//10-8//12 (Out A + Out B), 7//10-9//11 (Out A + Out B) (D5040D): Uo(Voc)=25.2 V; Io(Isc)=254 mA; Po(Pout)=1592 mW Characteristic: linear	IIC (A, B)	0	0	0
	IIB (C)	0.82	2.22	89.3
	IIA (D)	2.9	4.44	178.7
	I	4.8	7.28	293.2
	IIIC (E, F, G)	0.82	2.22	89.3

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.

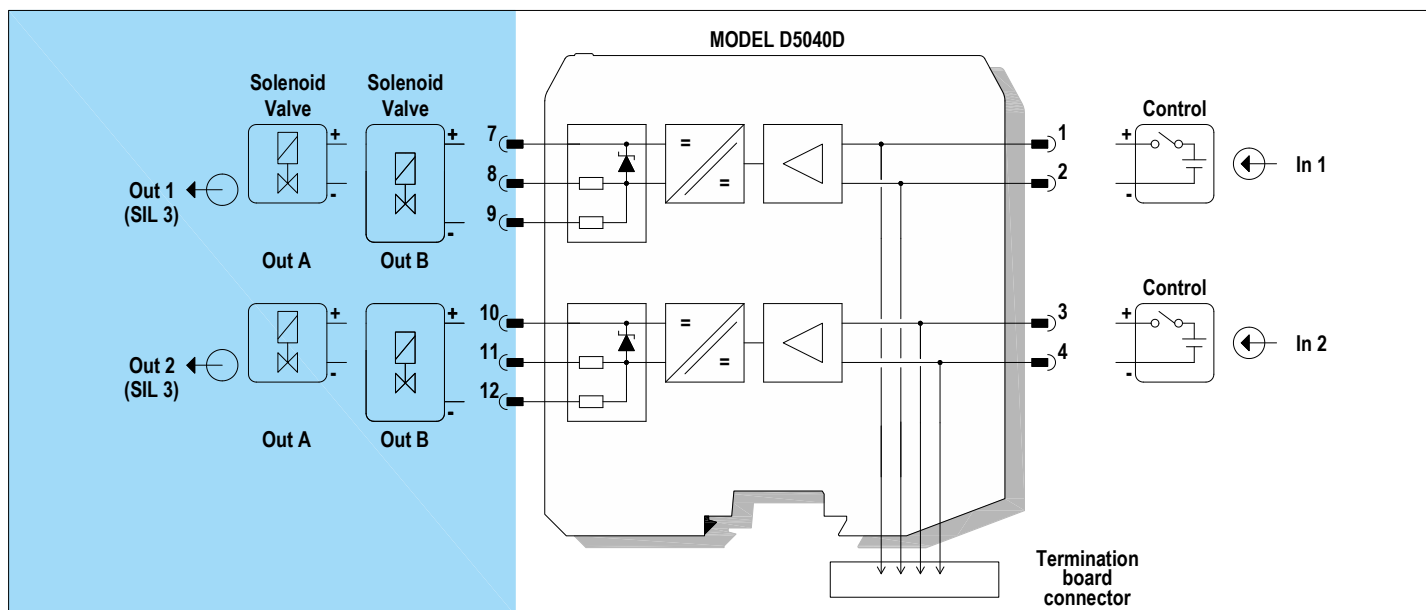
IS parameters listed above comply with all applicable certifications for this product. For details regarding IS parameters of a specific certification, please refer to the certificate itself, that can be found on www.gminternational.com website.

7. FUNCTION DIAGRAM



Hazardous Area

Safe Area/Zone 2/Div. 2



8. WARNING

D5040 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.

D5040 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

The single and double channel Loop Powered Digital Output Isolators, D5040S and D5040D, are suitable for driving solenoid valves, visual or audible alarms to alert a plant operator, or other process control devices in Hazardous Area from driving signal in Safe Area. The presence of the input signal is also indicated by a yellow LED (one for each channel). They can also be used as a controllable supply to power measuring or process control equipment.

Their use is allowed in applications requiring up to SIL 3 level (according to IEC 61508) in safety related systems for high risk industries. The Safety PLC or DCS driving signals power The field device through the D5040S and D5040D, which provides isolation.

Two basic output circuits for each channel are selectable, with different safety parameters, to interface the majority of devices on the market. The selection among the two output characteristics is obtained by connecting the field device to a different couple of terminal blocks.

10. INSTALLATION

D5040 series are digital output driver housed in a plastic enclosure suitable for installation on EN/IEC60715 TH 35 DIN-Rail, or on customized Termination Board. D5040 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.

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

Identify the function and location of each on the connection terminal using the wiring diagram on the corresponding section, as an example:

- Connect positive input at terminal "1" and negative input at "2" (or "3" and "4" for channel 2).
- Connect positive output A for solenoid valve to terminal "7" and negative at "8" or output B to terminal "7" and negative to "9" (or "10" and "11" or "10" and "12" for 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.

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 D5040 series must be cleaned only with a damp or antistatic cloth.

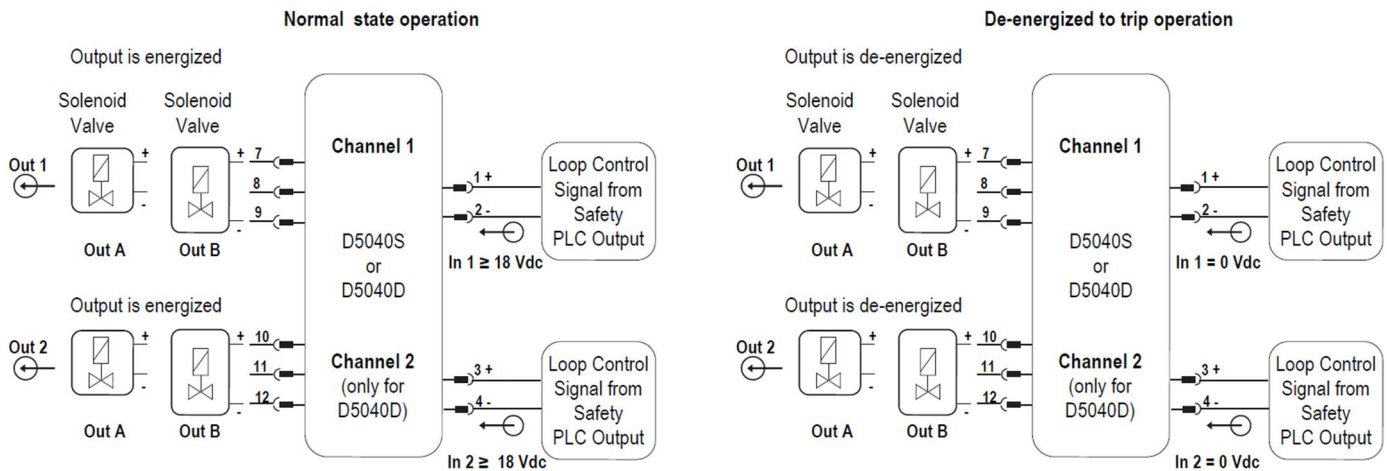
Any penetration of cleaning liquid must be avoided to prevent damage to the unit. Any unauthorized modification must be avoided. All circuits connected to D5040 series must comply with the overvoltage category II (or better) according to EN/IEC60664-1.

11. START-UP

Before powering the unit, check that all wires are properly connected and verify their polarity, 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. The status yellow LED must be in accordance with the condition of the corresponding input line.

12. FUNCTIONAL SAFETY MANUAL AND APPLICATION

12.1 Application of D5040S or D5040D for NE load



Description:

The D5040S (single channel) and D5040D (double channel) modules are single or double channel digital output drivers, loop powered for NE load (Normally Energized) loads. The Safety PLC or DCS driving/control signals power the field devices through the single or double channel digital output driver D5040S or D5040D (1 or 2 intrinsic safety channels, Loop Powered), which provides the electrical isolation between Input and Output. The presence of the input loop signal is also indicated by a yellow LED on the front panel (one for each channel).

In order to interface the majority of field devices available on the market, two basic output circuits with different safety parameters (outputs A and B) are provided for each channel. The selection among the two output characteristics is obtained by connecting the field devices to a different couple of terminal blocks.

Loop Control signals from Safety PLC Outputs are applied to Pins 1 - 2 (In. 1 - Ch. 1) and Pins 3 - 4 (In 2 - Ch.2, only for D5040D).

The Output NE loads are connected to Pins 7 - 8 or 7 - 9 (for Channel 1) and Pins 10 - 11 or 10 - 12 (for Channel 2, only for D5040D).

The following table describes the state (de-energized or energized) of each output when its control signal is in the High or Low state:

Operation	Input Signal State Pins 1 - 2 (In. 1 - Ch.1) or 3 - 4 (In 2 - Ch. 2, only D5040D)	Input Signal State Pins 1 - 2 (In. 1 - Ch.1) or 3 - 4 (In 2 - Ch. 2, only D5040D)
Normal	High (18 to 30 Vdc)	Energized
Trip	Low (0 Vdc)	De-energized (as safe state condition)

Safety Function and Failure behavior:

D5040 is considered to be operating in Low Demand mode, as a Type A module, having Hardware Fault Tolerance (HFT) = 0.

The failure behaviour of D540S/D for NE loads is described by the following definitions:

- fail-Safe State: it is defined as the output being 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: it is defined as a failure mode that does not respond to a demand from the process (i.e. being unable to go to the defined fail-safe state), so that output remains energized;
- 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 the D5040D 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 one from each other, not containing common components.

In fact, the analysis results got for D5040S (single channel) are also valid for each channel of D5040D (double channel). Since the loop powered modules are directly supplied by the digital output of a Safety PLC, if the safety PLC imposes a shutdown state of these modules, there is no additional power supply which can keep the D5040S and D5040D outputs energized in case of an internal fault. Therefore, all internal faults have either “no effect” on the safety function or lead to the safe state, according to the Safety Function definitions.

Failure rate data: taken from Siemens Standard SN29500.

Failure rate table:

Failure category	Failure rates (FIT)
λ_{dd} = Total Dangerous Detected failures	0.00
λ_{du} = Total Dangerous Undetected failures	0.00
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	104.46
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	104.46
MTBF (safety function, single channel) = $(1 / \lambda_{tot\ safe}) + MTTR$ (8 hours)	1092 years
$\lambda_{no\ effect}$ = “No Effect” failures	102.54
$\lambda_{not\ part}$ = “Not Part” failures	10.20
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	217.20
MTBF (device, single channel) = $(1 / \lambda_{tot\ device}) + MTTR$ (8 hours)	525 years
PFDavg (TI = 1 year) = $\frac{1}{2} \lambda_{du} * 8760\ h$	0.00E+00

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

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF
0.00 FIT	104.46 FIT	0.00 FIT	0.00 FIT	100%

Therefore, the D5040S and D5040D modules have SIL 3 level for lifetime of 20 years.

Systematic capability SIL 3.

Since no dangerous undetected failures have been noted during the FMEDA analysis, there is no need to perform a proof test to reveal dangerous faults which cannot be otherwise detected.