INSTRUCTION & SAFETY MANUAL

SIL 2 - SIL 3 Digital Relay Output
Loop / Bus Powered
DIN-Rail Models D1044S, D1044D

Characteristics

General Description: The single and dual channel DIN Rail Digital Relay Output, D1044S and D1044D, are digital output modules enabling a Safe Area contact, logic level or drive signal, to control a device in Hazardous Area, providing 3 port isolation (input/output/supply).
Outputs are galvanically isolated and inputs are depolarized to ease wiring operations. Typical applications include switching of Hazardous Area circuits, changing of polarities and sounder tones, calibrating of strain gauge bridges, resetting of field devices, testing of fire detectors.
Each input channel can be isolated from supply (Bus Powered mode) or externally connected (by wiring) to supply (Loop Powered mode, where the safety PLC directly supplies the module and its input channel).
Each output channel provides a SPDT relay, with two contacts defined NO (Normally Open) and NC (Normally Close) when the output relay is de-energized.
Considering each channel NE (Normally Energized), the output relay is energized, so that NO contact is closed (useful for NE loads or Hazardous Area circuits) and NC contact is open (useful for ND loads or Hazardous Area circuits). The safe state is reached when the channel and the output relay are de-energized, so that NO contact is open (de-energizing loads or Hazardous Area circuits) and NC contact is closed (energizing loads or Hazardous Area circuits).

Function: 1 or 2 channels I.S. relay output, provides 3 port isolation (input/output/supply).
D1044S (Loop / Bus Powered mode) or **D1044D (Bus Powered mode with independent channels)**, as shown in function diagrams:
SIL 2 Safety Function for NE load (de-energized in safe state) is available at Terminal Blocks 9/10-11 and Terminal Blocks 13/14-15.
SIL 2 Safety Function for ND load (energized in safe state) is available at Terminal Blocks 12-11 and Terminal Blocks 16-15.
D1044D (Loop / Bus Powered mode with 1oo2 channel architecture), as shown in function diagram:
SIL 3 Safety Function for NE load (de-energized in safe state) is available at Terminal Blocks 13/14-11.
SIL 3 Safety Function for ND load (energized in safe state) is available at Terminal Blocks 16-15 (or 12-11 because externally connected in parallel).

Signalling LEDs: Power supply indication (green), output status (yellow).

EMC: Fully compliant with CE marking applicable requirements.

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.

Technical Data

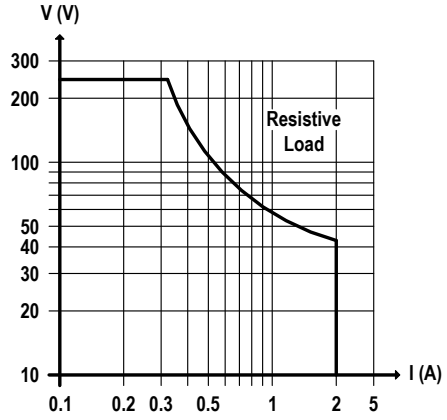
Supply: 24 Vdc nom (20 to 30 Vdc) reverse polarity protected, ripple within voltage limits ≤ 5 Vpp.
Current consumption @ 24 V: 55 mA for 2 channels D1044D, 35 mA for 1 channel D1044S with relays energized.
Power dissipation: 1.35 W for 2 channels D1044D, 0.85 W for 1 channel D1044S with 24 V supply voltage and relays energized.
Max. power consumption: at 30 V supply voltage and relays energized, 1.5 W for 2 channels D1044D, 0.9 W for 1 channel D1044S.

Isolation (Test Voltage): I.S. Out/In 1.5 KV; I.S. Out/Supply 1.5 KV; I.S. Out/I.S. Out 500 V; In/Supply 500 V; In/In 500 V.

Input: switch contact, logic level.
Trip voltage levels: OFF status ≤ 1.0 V, ON status ≥ 6.0 V (maximum 30 V).
Current consumption @ 24 V: 3 mA (≈ 10 KΩ input impedance).

Output I.S.: voltage free SPDT relay contact.
Contact material: AgNi90/10.
Contact rating: 60 Vdc, 2 A for use in Intrinsic Safety applications, 2 A 250 Vac 500 VA, 2 A 250 Vdc 80 W (resistive load) for non Intrinsic Safety applications.

DC Load breaking capacity:



Mechanical / Electrical life: 15 * 10^6 / 1 * 10^5 operation, typical.
Operate / Release time: 5 / 2 ms typical.
Bounce time NO / NC contact: 1 / 5 ms.
Response time In / Out: 20 ms.
Frequency response: 10 Hz maximum.

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 -20 to + 60 °C, relative humidity max 95 %.
Storage: temperature limits – 45 to + 80 °C.

Safety Description:
ATEX: II (1)G [Ex ia Ga] IIC, II (1)D [Ex ia Da] IIIC, I (M1) [Ex ia Ma] I, II 3G Ex ec nC IIC T4 Gc
IECEx: [Ex ia Ga] IIC, Ex ia [Ma] I, [Ex ia Da] IIIC, Ex ec nC IIC T4 Gc
INMETRO: [Ex ia Ga] IIC, Ex ia [Ma] I, [Ex ia Da] IIIC
FM: NI / I / 2 / ABCD / T4, NI / I / 2 / IIC / T4, AIS / I, II, III / 1 / ABCDEFG, AEx [ia] IIC
FM-C: NI / I / 2 / ABCD / T4, NI / I / 2 / IIC / T4, AIS / I, II, III / 1 / ABCDEFG, Ex [ia] IIC
EAC-EX: 2Ex nA nC [ia Ga] IIC T4 Gc X, [Ex ia Da] IIIC X, [Ex ia Ma] I X
UKR TR n. 898: 2ExnAnCiaIICT4 X, ExiaI X
associated electrical apparatus.
Uo/Voc = 0 V, Io/Isc = 0 mA, Po/Po = 0 mW at terminals 13/14-15-16, 9/10-11-12
(Uo, Io, Po equal to the connected Intrinsic Safety circuit).
Ui/Vmax = 60 V, Ii/Imax = 2 A, Ci = 0 nF, Li = 0 nH at term. 13/14-15-16, 9/10-11-12.
Um = 250 Vrms, -20 °C ≤ Ta ≤ 60 °C.
Approvals:
DMT 01 ATEX E 042 X conforms to EN60079-0, EN60079-11.
IECEx BVS 07.0027X conforms to IEC60079-0, IEC60079-11.
IMQ 09 ATEX 013 X conforms to EN60079-0, EN60079-7, EN60079-15.
IECEx IMQ 13.0011X conforms to IEC60079-0, IEC60079-7, IEC60079-15.
INMETRO DNV 13.0108 X conforms to ABNT NBR IEC60079-0, ABNT NBR IEC60079-11.
FM & FM-C No. 3024643, 3029921C, conforms to Class 3600, 3610, 3611, 3810, ANSI/ISA 12.12.02, ANSI/ISA 60079-0, ANSI/ISA 60079-11, C22.2 No.142, C22.2 No.157, C22.2 No.213, E60079-0, E60079-11, E60079-15,
EAЭC RU C-IT.HA67.B.00113/20 conforms to GOST 31610.0, GOST 31610.11, GOST 31610.15.
СЦ 16.0034 X conforms to ДСТУ 7113, ГОСТ 22782.5-78, ДСТУ IEC 60079-15.
TÜV Certificate No. C-IS-236198-04, SIL 2 / 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 No. TAA00002BM and KR No.MIL20769-EL001 Cert. for maritime applications.

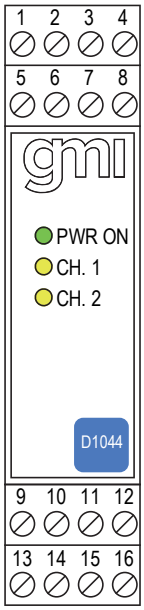
Mounting: EN/IEC60715 TH 35 DIN-Rail.
Weight: about 140 g D1044D, 120 g D1044S.
Connection: by polarized plug-in disconnect screw terminal blocks to accomodate terminations up to 2.5 mm^2.
Location: Safe Area/Non Hazardous Locations or Zone 2, Group IIC T4, Class I, Division 2, Groups A, B, C, D Temperature Code T4 and Class I, Zone 2, Group IIC, IIB, IIA T4 installation.
Protection class: IP 20. ***Dimensions:*** Width 22.5 mm, Depth 99 mm, Height 114.5 mm.

Ordering information

Model:	D1044	
1 channel	S	
2 channels	D	
Power Bus enclosure		/B

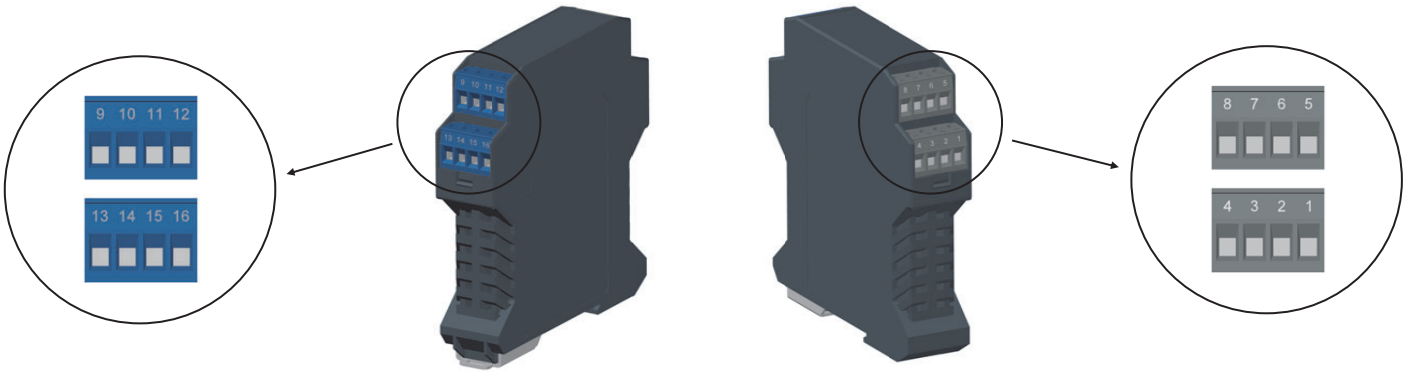
Power Bus and DIN-Rail accessories:
DIN rail anchor MCHP065
DIN rail stopper MORT016
Terminal block male MORT017
Terminal block female MORT022

Front Panel and Features



- SIL 2 according to IEC 61508:2010 Ed. 2D1044S or D1044D Bus Powered mode for each channel for Tproof = 6 / 10 yrs (≤10% / >10 % of total SIF).
- SIL 2 according to IEC 61508:2010 Ed. 2 D1044S Loop Powered mode for Tproof = 7 / 10 yrs (≤10% / >10 % of total SIF).
- SIL 3 according to IEC 61508:2010 Ed. 2 D1044S or D1044D Loop / Bus Powered mode with 1oo2 channel architecture for Tproof = 10 yrs (≤10% of total SIF).
- PFDavg (1 year) 1.63 E-04, SFF 77.24 % with 1oo1 channel architecture.
- PFDavg (1 year) 8.16 E-06, SFF 99.16 % with 1oo2 channel architecture.
- SIL 3 Systematic capability.
- Output to Zone 0 (Zone 20), Division 1, installation in Zone 2, Division 2.
- Voltage, contact, logic level input.
- Two SPDT Relay Output Signals.
- Three port isolation, Input/Output/Supply.
- EMC Compatibility to EN61000-6-2, EN61000-6-4, EN61326-1.
- ATEX, IECEx, FM & FM-C, INMETRO, EAC-EX, UKR n. 898, TÜV Certifications.
- TÜV Functional Safety Certification.
- Type Approval Certificate DNV and KR for maritime applications.
- High Reliability, SMD components.
- High Density, two channels per unit.
- Simplified installation using standard DIN Rail and plug-in terminal blocks.
- 250 Vrms (Um) max. voltage allowed to the instruments associated with the barrier.

Terminal block connections



HAZARDOUS AREA		SAFE AREA	
9	Output Ch 2 NO (Normally Opened)	1	Not used
10	Output Ch 2 NO (Normally Opened)	2	Not used
11	Output Ch 2 COM (Common)	3	+ Power Supply 24 Vdc
12	Output Ch 2 NC (Normally Closed)	4	- Power Supply 24 Vdc
13	Output Ch 1 NO (Normally Opened)	5	Input Ch 1 for Control
14	Output Ch 1 NO (Normally Opened)	6	Input Ch 1 for Control
15	Output Ch 1 COM (Common)	7	Input Ch 2 for Control
16	Output Ch 1 NC (Normally Closed)	8	Input Ch 2 for Control

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 gas group encountered and that its maximum allowable voltage, current, power (Ui/Vmax, Ii/Imax, Pi/Pi) are not exceeded by the safety parameters (Uo/Voc, Io/Isc, Po/Po) of the D1044 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 (Co/Ca, Lo/La, Lo/Ro) given in the Associated Apparatus parameters for the effective gas group. See parameters on enclosure side and the ones indicated in the table below:

D1044 Terminals		D1044 Associated Apparatus Parameters	Must be	Hazardous Area/ Hazardous Locations Device Parameters
Ch1	13/14 - 15 - 16	Uo / Voc = 0 V (Uo equal to the connected I.S. circuit)	≤	Ui / Vmax
Ch2	9/10 - 11 - 12			
Ch1	13/14 - 15 - 16	Io / Isc = 0 mA (Io equal to the connected I.S. circuit)	≤	Ii/ Imax
Ch2	9/10 - 11 - 12			
Ch1	13/14 - 15 - 16	Po / Po = 0 mW (Po equal to the connected I.S. circuit)	≤	Pi / Pi
Ch2	9/10 - 11 - 12			

When connected to other intrinsically safe devices or associated apparatus, check that maximum allowable voltage, current (Ui/Vmax, Ii/Imax) of the D1044 Associated Apparatus are not exceeded by the safety parameters (Uo/Voc, Io/Isc) of the Intrinsically Safe device, indicated in the table below:

D1044 Terminals		D1044 Associated Apparatus Parameters	Must be	Hazardous Area/ Hazardous Locations Device Parameters
Ch1	13/14 - 15 - 16	Ui / Vmax = 60V	≥	Uo / Voc
Ch2	9/10 - 11 - 12			
Ch1	13/14 - 15 - 16	Ii / Imax = 2 A	≥	Io / Isc
Ch2	9/10 - 11 - 12			
Ch1	13/14 - 15 - 16	Ci = 0 nF, Li= 0 nH		
Ch2	9/10 - 11 - 12			

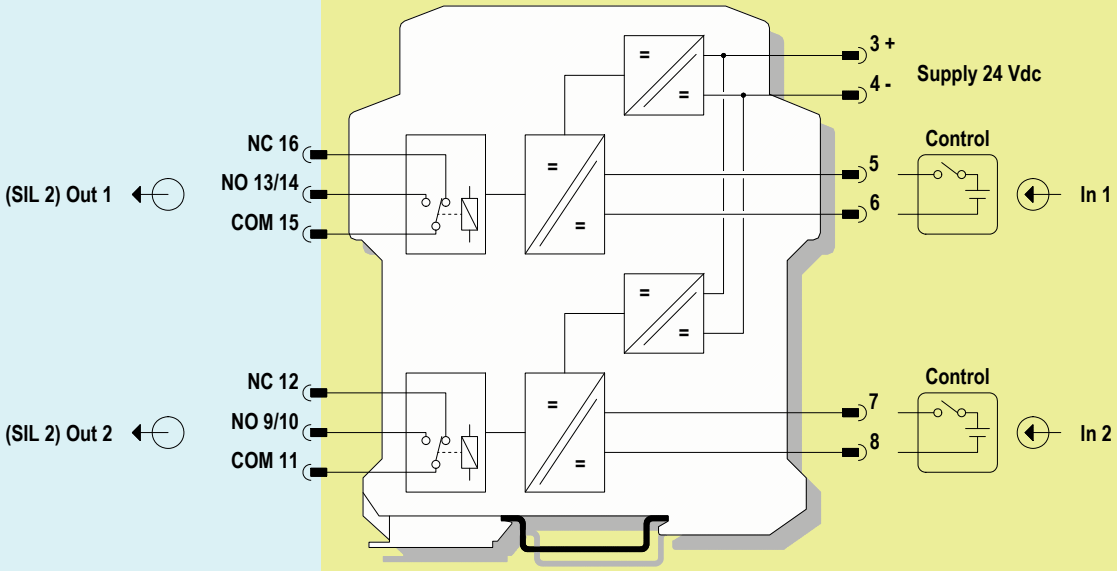
For installations in which both the Ci and Li of the Intrinsically Safe apparatus exceed 1% of the Co and Lo parameters of the Associated Apparatus (excluding the cable), then 50% of Co and Lo parameters are applicable and shall not be exceeded (50% of the Co and Lo become the limits which must include the cable such that Ci device + C cable ≤ 50 % of Co and Li device + L cable ≤ 50 % of Lo). The reduced capacitance of the external circuit (including cable) shall not be greater than 1 µF for Groups I, IIA, IIB and 600 nF for Group IIC. 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).
The Intrinsic Safety Entity Concept allows the interconnection of Intrinsically Safe devices approved with entity parameters not specifically examined in combination as a system when the above conditions are respected.
For Division 1 and Zone 0 installations, the configuration of Intrinsically Safe Equipment must be FM approved under Entity Concept (or third party approved);
for Division 2 installations, the configuration of Intrinsically Safe Equipment must be FM approved under non-incendive field wiring or Entity Concept (or third party approved).

Function Diagram

HAZARDOUS AREA ZONE 0 (ZONE 20) GROUP IIC,
HAZARDOUS LOCATIONS CLASS I, DIVISION 1, GROUPS A, B, C, D,
CLASS II, DIVISION 1, GROUPS E, F, G, CLASS III, DIVISION 1,
CLASS I, ZONE 0, GROUP IIC

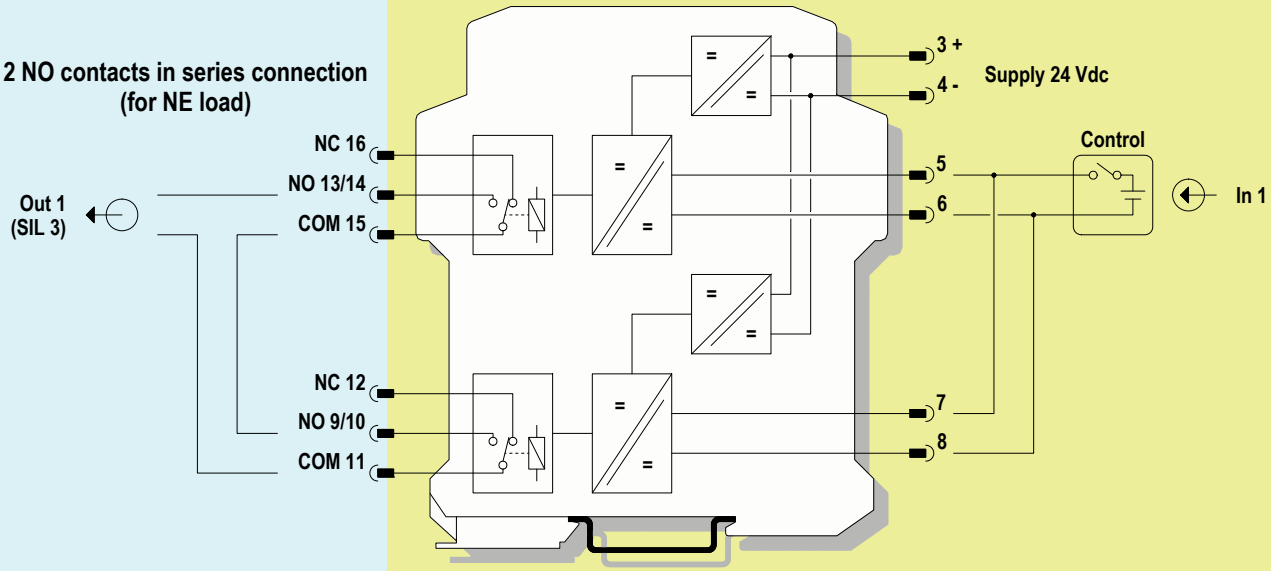
SAFE AREA, ZONE 2 GROUP IIC T4,
NON HAZARDOUS LOCATIONS, CLASS I, DIVISION 2,
GROUPS A, B, C, D T-Code T4, CLASS I, ZONE 2, GROUP IIC T4

MODEL D1044D Bus powered (independent channels)



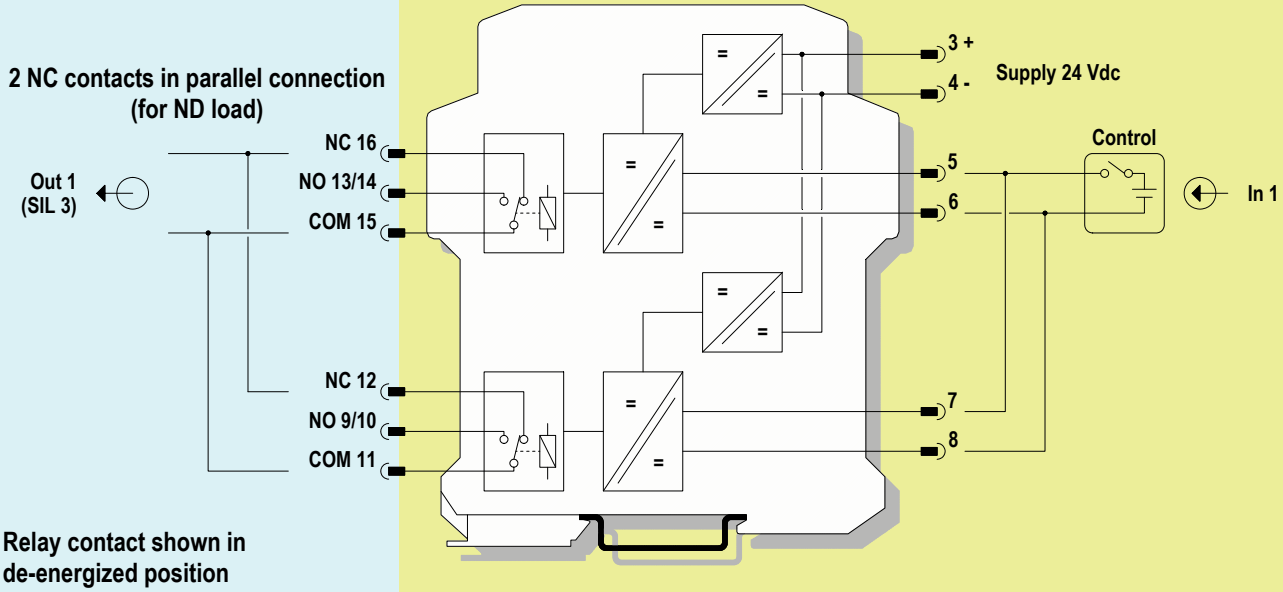
MODEL D1044D Bus powered (1oo2 channel architecture)

2 NO contacts in series connection (for NE load)



MODEL D1044D Bus powered (1oo2 channel architecture)

2 NC contacts in parallel connection (for ND load)



Relay contact shown in de-energized position

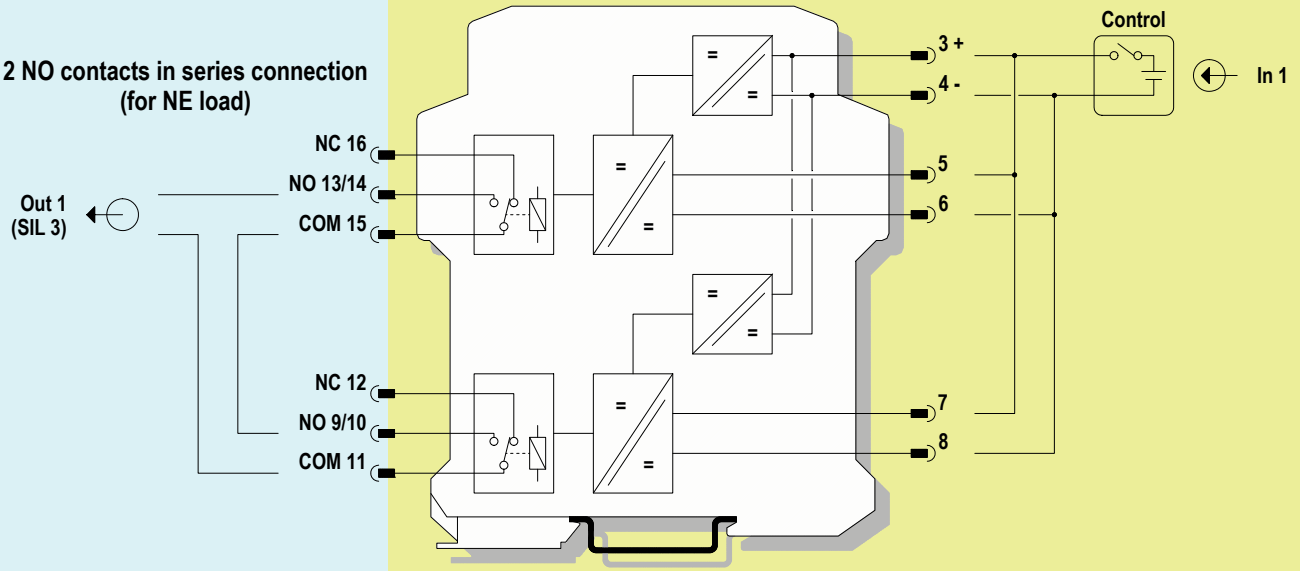
Function Diagram

HAZARDOUS AREA ZONE 0 (ZONE 20) GROUP IIC,
HAZARDOUS LOCATIONS CLASS I, DIVISION 1, GROUPS A, B, C, D,
CLASS II, DIVISION 1, GROUPS E, F, G, CLASS III, DIVISION 1,
CLASS I, ZONE 0, GROUP IIC

SAFE AREA, ZONE 2 GROUP IIC T4,
NON HAZARDOUS LOCATIONS, CLASS I, DIVISION 2,
GROUPS A, B, C, D T-Code T4, CLASS I, ZONE 2, GROUP IIC T4

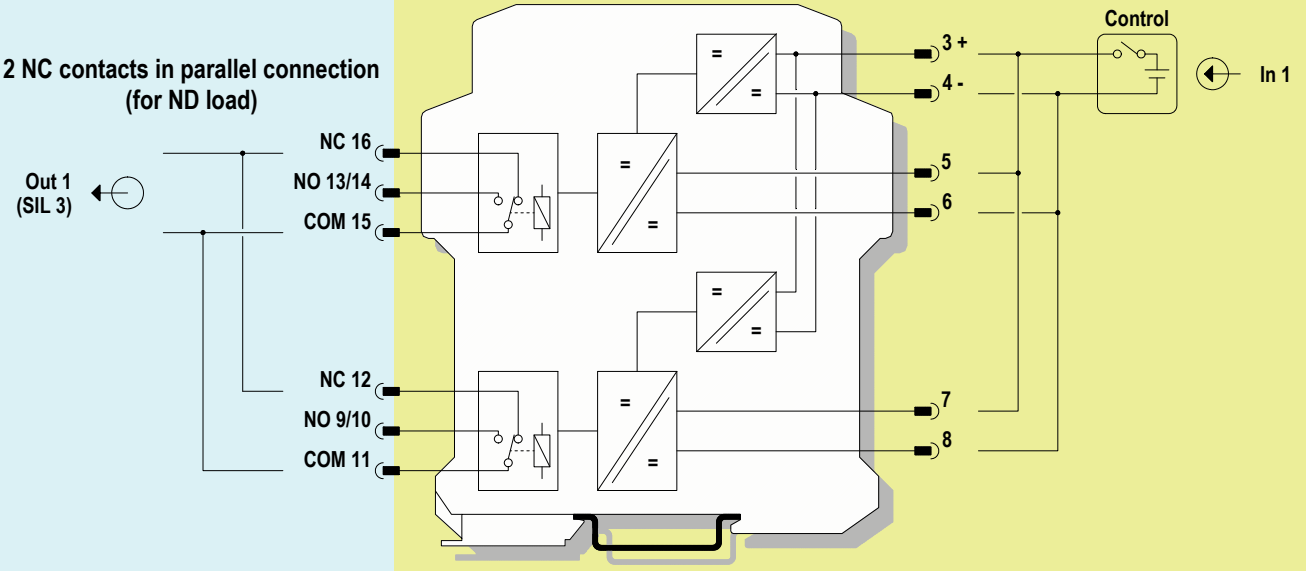
MODEL D1044D Loop powered (1oo2 channel architecture)

2 NO contacts in series connection (for NE load)



MODEL D1044D Loop powered (1oo2 channel architecture)

2 NC contacts in parallel connection (for ND load)



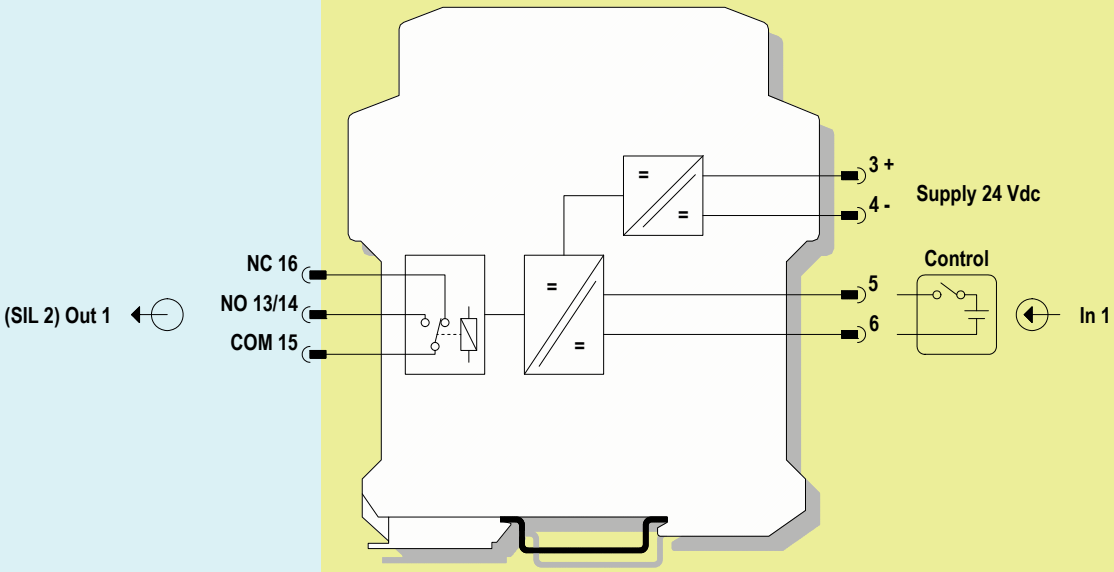
Relay contact shown in de-energized position

Function Diagram

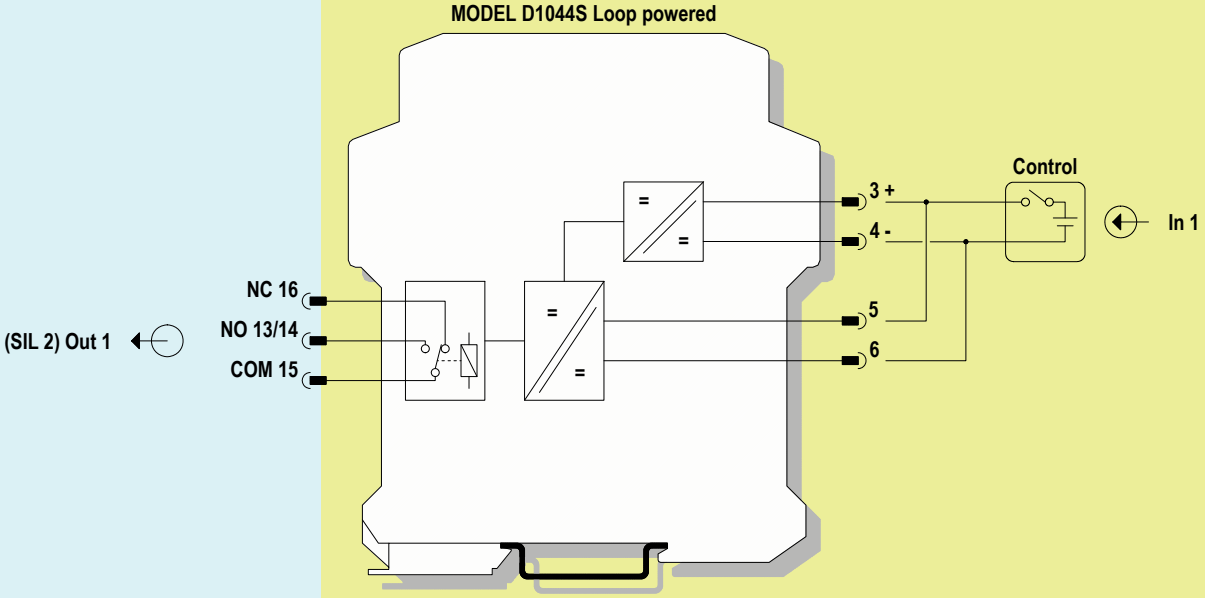
HAZARDOUS AREA ZONE 0 (ZONE 20) GROUP IIC,
HAZARDOUS LOCATIONS CLASS I, DIVISION 1, GROUPS A, B, C, D,
CLASS II, DIVISION 1, GROUPS E, F, G, CLASS III, DIVISION 1,
CLASS I, ZONE 0, GROUP IIC

SAFE AREA, ZONE 2 GROUP IIC T4,
NON HAZARDOUS LOCATIONS, CLASS I, DIVISION 2,
GROUPS A, B, C, D T-Code T4, CLASS I, ZONE 2, GROUP IIC T4

MODEL D1044S Bus powered



MODEL D1044S Loop powered

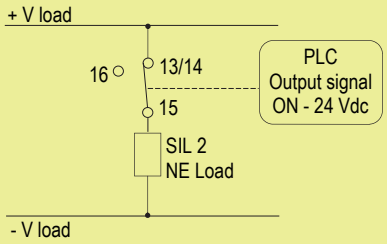


Relay contact shown in de-energized position

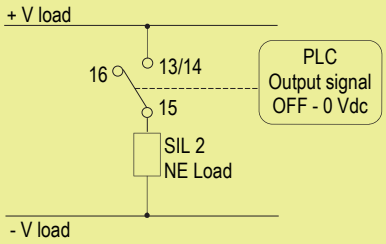
1) Application D1044S with Bus Powered Mode

SIL 2 Normally Energized Relay Condition for NE Load

Normal state operation

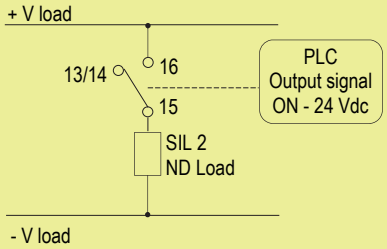


De-energized to trip operation

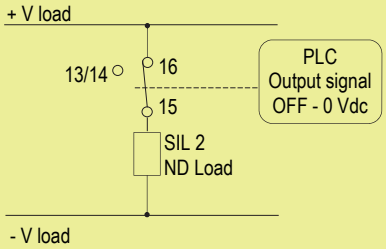


SIL 2 Normally Energized Relay Condition for ND Load

Normal state operation



De-energized to trip operation



Description:

The module is powered by a 24 Vdc power supply at pins 3 (positive pole) and 4 (negative pole). Input Signal from PLC/DCS is normally High (24 Vdc) and is applied to pins 5-6 in order to Normally Energize (NE) or Normally De-energize (ND) load.
For NE load, the Input Signal from PLC/DCS is Low (0 Vdc) during "de-energized to trip" operation, in order to de-energize the load.
For ND load, the Input Signal from PLC/DCS is Low (0 Vdc) during "de-energized to trip" operation, in order to energize the load.
The following table describes the status (open or closed) of each output contact when the input signal is High or Low for both NE and ND loads:

Operation	Input Signal Pins 5-6	Pins 13/14 - 15	Pins 15 – 16	NE Load (SIL2) Pins 15 - -Vload	ND Load (SIL2) Pins 15 - -Vload
Normal	High (24 Vdc)	Closed	Open	Energized	De-Energized
Trip	Low (0 Vdc)	Open	Closed	De-Energized	Energized

Safety Function and Failure behavior:

D1044S is considered to be operating in Low Demand mode, as a Type A module, having Hardware Fault Tolerance (HFT) = 0.
The failure behaviour of D1044S is described by the following definitions:

- fail-Safe State: it is defined as the relay being de-energized (so that the NO-COM contact is open and the NC-COM contact is closed);
- 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 (i.e. being unable to go to the defined fail-safe state), so that the relay remains energized (that is, the NO-COM contact remains closed and the NC-COM contact remains open);
- 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 that 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.

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	37.24
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	126.39
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	**163.63**
MTBF (safety function, single channel) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)	**697 years**
$\lambda_{no\ effect}$ = "No effect" failures	106.17
$\lambda_{not\ part}$ = "Not Part" failures	2.00
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	**271.80**
MTBF (device, single channel) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)	**420 years**

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

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF
0.00 FIT	126.39 FIT	0.00 FIT	37.24 FIT	77.24%

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] = 6 years
PFDavg = 1.63 E-04 - Valid for **SIL 2**	PFDavg = 9.80 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:

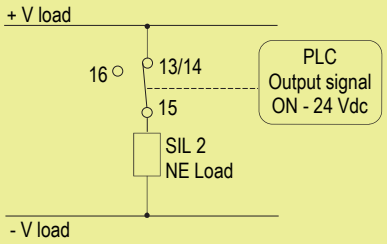
T[Proof] = 10 years
PFDavg = 1.63 E-03 - Valid for **SIL 2**

Systematic capability SIL 3.

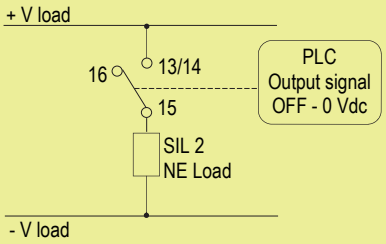
2) Application D1044S - with Loop Powered Mode

SIL 2 Normally Energized Relay Condition for NE Load

Normal state operation

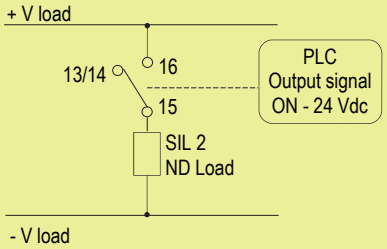


De-energized to trip operation

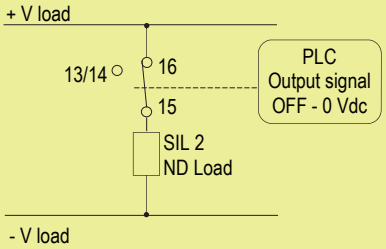


SIL 2 Normally Energized Relay Condition for ND Load

Normal state operation



De-energized to trip operation



Description:
Input Signal from PLC/DCS is normally High (24 Vdc) and is applied to pins 3-4 and 5-6 in order to Normally Energize (NE) or Normally De-energize (ND) load.
For NE load, the Input Signal from PLC/DCS is Low (0 Vdc) during "de-energized to trip" operation, in order to de-energize the load.
For ND load, the Input Signal from PLC/DCS is Low (0 Vdc) during "de-energized to trip" operation, in order to energize the load.
The following table describes the status (open or closed) of each output contact when the input signal is High or Low for both NE and ND loads.

Operation	Input Signal Pins 3-4 and 5-6	Pins 13/14 - 15	Pins 15 – 16	NE Load (SIL2) Pins 15 - -Vload	ND Load (SIL2) Pins 15 - -Vload
Normal	High (24 Vdc)	Closed	Open	Energized	De-Energized
Trip	Low (0 Vdc)	Open	Closed	De-Energized	Energized

Safety Function and Failure behavior:
D1044S is considered to be operating in Low Demand mode, as a Type A module, having Hardware Fault Tolerance (HFT) = 0.
The failure behaviour of D1044S is described by the following definitions:

- fail-Safe State: it is defined as the relay being de-energized (so that the NO-COM contact is open and the NC-COM contact is closed);
- 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 (i.e. being unable to go to the defined fail-safe state), so that the relay remains energized (that is, the NO-COM contact remains closed and the NC-COM contact remains open);
- 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 that 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.

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	32.00
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	131.72
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	**163.72**
MTBF (safety function, single channel) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)	**697 years**
$\lambda_{no\ effect}$ = "No effect" failures	106.08
$\lambda_{not\ part}$ = "Not Part" failures	2.00
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	**271.80**
MTBF (device, single channel) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)	**420 years**

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

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF
0.00 FIT	131.72 FIT	0.00 FIT	32.00 FIT	80.45%

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] = 7 years
PFDavg = 1.40 E-04 - Valid for **SIL 2**	PFDavg = 9.83 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:

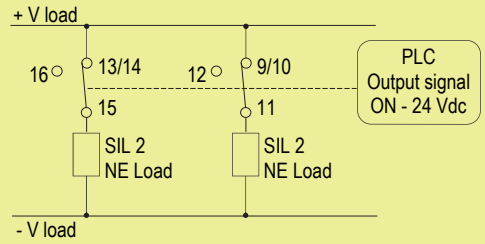
T[Proof] = 10 years
PFDavg = 1.40 E-03 - Valid for **SIL 2**

Systematic capability SIL 3.

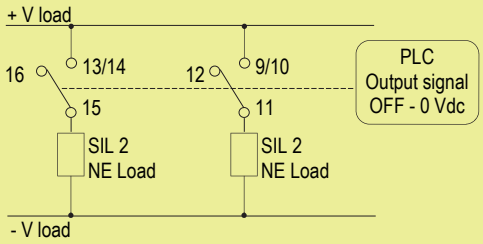
3) Application D1044D with Bus Powered Mode and independent channels

SIL 2 Normally Energized Relay Condition for NE Load

Normal state operation

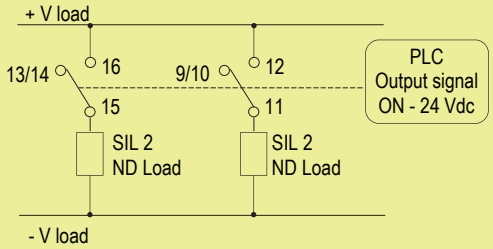


De-energized to trip operation

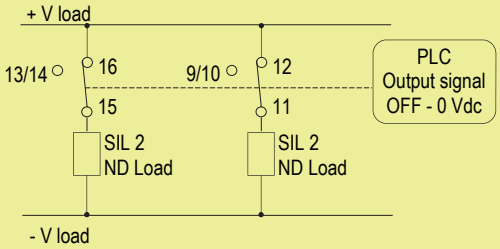


SIL 2 Normally Energized Relay Condition for ND Load

Normal state operation



De-energized to trip operation



Description:
The module is powered by a 24 Vdc power supply at pins 3 (positive pole) and 4 (negative pole). The Input Signals from PLC/DCS are normally High (24 Vdc) and are applied to pins 5-6 (for Ch. 1) and 7-8 (for Ch. 2) in order to Normally Energize (NE) or Normally De-energize (ND) loads.
For NE loads, the Input Signals from PLC/DCS are Low (0 Vdc) during "de-energized to trip" operation, in order to de-energize the loads.
For ND loads, the Input Signals from PLC/DCS are Low (0 Vdc) during "de-energized to trip" operation, in order to energize the loads.
The following table describes the status (open or closed) of each output contact when the input signal is High or Low for both NE and ND loads.

Operation	Input Signal Pins 5-6 (Ch. 1) or 7-8 (Ch. 2)	Pins 13/14 – 15 (Ch. 1) or 9/10 – 11 (Ch. 2)	Pins 15 – 16 (Ch. 1) or 11 – 12 (Ch. 2)	NE Load (SIL2) Pins 15 - -Vload (Ch. 1) or 11 - -Vload (Ch. 2)	ND Load (SIL2) Pins 15 - -Vload (Ch. 1) or 11 - -Vload (Ch. 2)
Normal	High (24 Vdc)	Closed	Open	Energized	De-Energized
Trip	Low (0 Vdc)	Open	Closed	De-Energized	Energized

Safety Function and Failure behavior:
D1044D is considered to be operating in Low Demand mode, as a Type A module, having Hardware Fault Tolerance (HFT) = 0.
The failure behaviour of D1044D is described by the following definitions:

- □ fail-Safe State: it is defined as the relay being de-energized (so that the NO-COM contact is open and the NC-COM contact is closed);
- □ 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 (i.e. being unable to go to the defined fail-safe state), so that the relay remains energized (that is, the NO-COM contact remains closed and the NC-COM contact remains open);
- □ 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 that 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.

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	37.24
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	131.99
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	**169.23**
MTBF (safety function, single channel) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)	**674 years**
$\lambda_{no\ effect}$ = "No effect" failures	115.57
$\lambda_{not\ part}$ = "Not Part" failures	188.60
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	**473.40**
MTBF (device, single channel) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)	**241 years**

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

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF
0.00 FIT	131.99 FIT	0.00 FIT	37.24 FIT	77.99%

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] = 6 years
PFDavg = 1.63 E-04 - Valid for **SIL 2**	PFDavg = 9.80 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] = 10 years
PFDavg = 1.63 E-03 - Valid for **SIL 2**

Systematic capability SIL 3.

4) Application D1044D with Bus Powered Mode and 1oo2 channel architecture

SIL 3 Normally Energized Relay Condition for NE Load

SIL 3 Normally Energized Relay Condition for ND Load

Description:

The module is powered by a 24 Vdc power supply at pins 3 (positive pole) and 4 (negative pole). The Input Signal from PLC/DCS is normally High (24 Vdc) and is applied to pins 5-6 and 7-8 in order to Normally Energize (NE) or Normally De-energize (ND) load.
For NE load, the Input Signal from PLC/DCS is Low (0 Vdc) during "de-energized to trip" operation, in order to de-energize the load.
For ND load, the Input Signal from PLC/DCS is Low (0 Vdc) during "de-energized to trip" operation, in order to energize the load.
The following tables describe the status (open or closed) of each output contact when the input signal is High or Low for both NE and ND loads.

Operation	Input Signal Pins 5-6 and 7-8	Pins 13/14 – 15 and 9/10 – 11	Pins 15 – 16 and 11 – 12	NE Load (SIL3) Pins 11 - -Vload	ND Load (SIL3) Pins 11/15 - -Vload
Normal	High (24 Vdc)	Closed	Open	Energized	De-Energized
Trip	Low (0 Vdc)	Open	Closed	De-Energized	Energized

Safety Function and Failure behavior:

D1044D is considered to be operating in Low Demand mode, as a Type A module, having Hardware Fault Tolerance (HFT) = 0.
The failure behaviour of D1044D is described by the following definitions:

- fail-Safe State: it is defined as the relay being de-energized (so that the NO-COM contact is open and the NC-COM contact is closed);
- 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 (i.e. being unable to go to the defined fail-safe state), so that the relay remains energized (that is, the NO-COM contact remains closed and the NC-COM contact remains open);
- 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 that 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.

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	1.86
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	218.80
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	**220.66**
MTBF (safety function, single channel) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)	**517 years**
$\lambda_{no\ effect}$ = "No effect" failures	248.74
$\lambda_{not\ part}$ = "Not Part" failures	4.00
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	**473.40**
MTBF (device, single channel) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)	**241 years**

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

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF
0.00 FIT	218.80 FIT	0.00 FIT	1.86 FIT	99.16%

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] = 10 years
PFDavg = 8.16 E-06 - Valid for **SIL 3**	PFDavg = 8.16 E-05 - Valid for **SIL 3**

Systematic capability SIL 3.

5) Application D1044D with Loop Powered Mode and 1oo2 channel architecture

SIL 3 Normally Energized Relay Condition for NE Load

SIL 3 Normally Energized Relay Condition for ND Load

Description:

The Input Signal from PLC/DCS is normally High (24 Vdc) and is applied to pins 3-4, 5-6 and 7-8 in order to Normally Energize (NE) or Normally De-energize (ND) load.
For NE load, the Input Signal from PLC/DCS is Low (0 Vdc) during "de-energized to trip" operation, in order to de-energize the load.
For ND load, the Input Signal from PLC/DCS is Low (0 Vdc) during "de-energized to trip" operation, in order to energize the load.
The following tables describe the status (open or closed) of each output contact when the input signal is High or Low for both NE and ND loads.

Operation	Input Signal Pins 3-4, 5-6 and 7-8	Pins 13/14 – 15 and 9/10 – 11	Pins 15 – 16 and 11 – 12	NE Load (SIL3) Pins 11 - -Vload	ND Load (SIL3) Pins 11/15 - -Vload
Normal	High (24 Vdc)	Closed	Open	Energized	De-Energized
Trip	Low (0 Vdc)	Open	Closed	De-Energized	Energized

Safety Function and Failure behavior:

D1044D is considered to be operating in Low Demand mode, as a Type A module, having Hardware Fault Tolerance (HFT) = 0.
The failure behaviour of D1044D is described by the following definitions:

- □ fail-Safe State: it is defined as the relay being de-energized (so that the NO-COM contact is open and the NC-COM contact is closed);
- □ 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 (i.e. being unable to go to the defined fail-safe state), so that the relay remains energized (that is, the NO-COM contact remains closed and the NC-COM contact remains open);
- □ 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 that 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.

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	1.60
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	229.46
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	**231.06**
MTBF (safety function, single channel) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)	**494 years**
$\lambda_{no\ effect}$ = "No effect" failures	238.34
$\lambda_{not\ part}$ = "Not Part" failures	4.00
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	**473.40**
MTBF (device, single channel) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)	**241 years**

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

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF
0.00 FIT	229.46 FIT	0.00 FIT	1.60 FIT	99.31%

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] = 10 years
PFDavg = 7.02 E-06 - Valid for **SIL 3**	PFDavg = 7.02 E-05 - Valid for **SIL 3**

Systematic capability SIL 3.

Testing procedure at T-proof

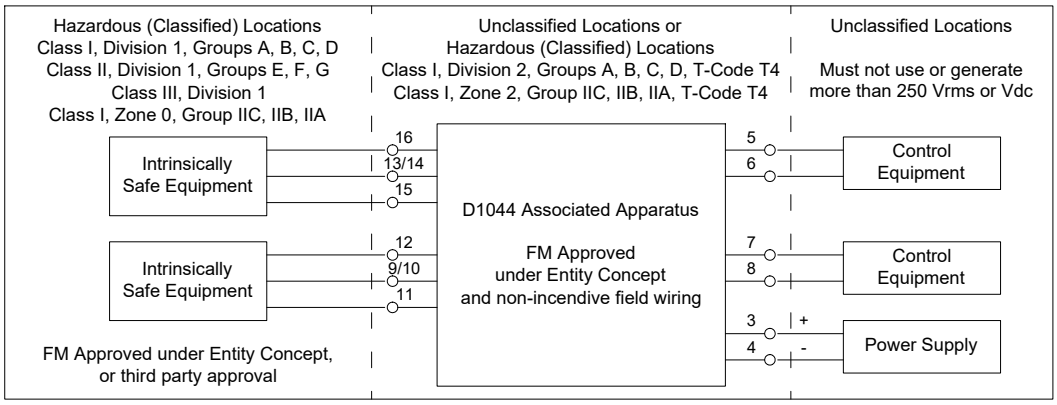
The proof test must be performed to reveal dangerous faults which cannot be otherwise detected. This means that it is necessary to specify how dangerous undetected faults, which have been noted during the FMEDA analysis, can be revealed during the proof test.
The **Proof test** consists of the following steps.

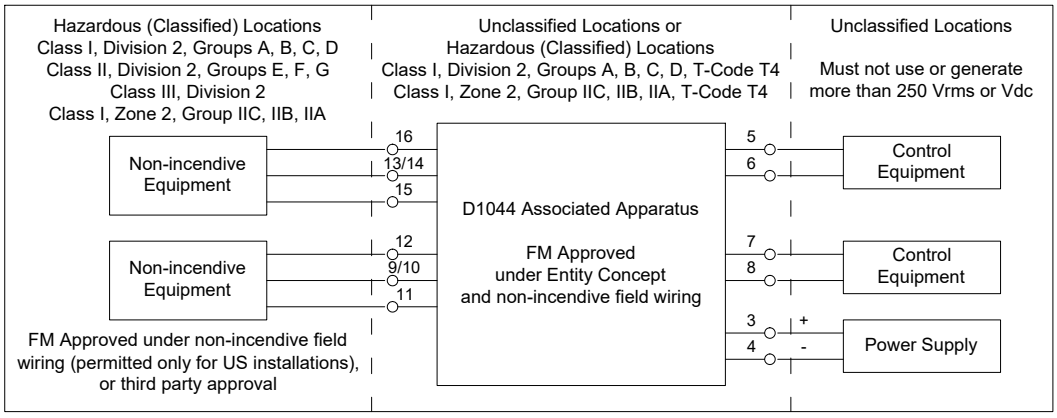
Steps	Action
1	Bypass the Safety-related PLC or take any other appropriate action to avoid a false trip.
2	For the single channel, verify the input to output channel functionality: a) For the NO contact, the output load is normally energized (NE) when the input channel is ON, while the de-activation (Fail-Safe State) of the input channel de-energizes the load; b) For the NC contact, the output load is normally de-energized (ND) when the input channel is ON, while the de-activation (Fail-Safe State) of the input channel energizes the load. The channel functionality must be verified in the 20 to 30 Vdc supply voltage range of the module. Connect a DC power supply to the input terminals, in order to enable or disable the input channel. In order to check the ohmic continuity of the NO and NC contacts, connect an ohmmeter in series with the NO-COM output contact and another one in series with the NC-COM output contact. Perform the following procedure: 1. Do not enable (DC power supply voltage ≤ 1V) the input channel (terminals "5" - "6" or "7" - "8") of the unit under test and verify that the ohmic continuity is absent at the NO-COM output contact (terminals "13/14" - "15" or "9/10" - "11"), while it is present at the NC-COM output contact (terminals "16" - "15" or "12" - "11"); 2. Enable (DC power supply voltage ≥ 6V) the input channel (terminals "5" - "6" or "7" - "8") of the unit under test and verify that the ohmic continuity is present at the NO-COM output contact (terminals "13/14" - "15" or "9/10" - "11"), while it is absent at the NC-COM output contact (terminals "16" - "15" or "12" - "11").
3	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 digital relay module.

Warning

D1044 series are isolated Intrinsically Safe Associated Apparatus installed into standard EN/IEC60715 TH 35 DIN-Rail located in Safe Area/Non Hazardous Locations or Zone 2, Group IIC, Temperature Classification T4, Class I, Division 2, Groups A, B, C, D, Temperature Code T4 and Class I, Zone 2, Group IIC, IIB, IIA Temperature Code T4 Hazardous Area/ Hazardous Locations (according to FM Class No. 3611, CSA-C22.2 No. 213-M1987, CSA-E60079-15) within the specified operating temperature limits Tamb -20 to +60 °C, and connected to equipment with a maximum limit for AC power supply Um of 250 Vrms.





Non-incendive field wiring is not recognized by the Canadian Electrical Code, installation is permitted in the US only.
For installation of the unit in a Class I, Division 2 or Class I, Zone 2 location, the wiring between the control equipment and the D1044 associated apparatus shall be accomplished via conduit connections or another acceptable Division 2, Zone 2 wiring method according to the NEC and the CEC.
Not to be connected to control equipment that uses or generates more than 250 Vrms or Vdc with respect to earth ground.
D1044 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), BS 5345 Pt4, VDE 165, ANSI/ISA RP12.06.01 Installation of Intrinsically Safe System for Hazardous (Classified) Locations, National Electrical Code NEC ANSI/NFPA 70 Section 504 and 505, Canadian Electrical Code CEC) 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/Hazardous Locations or unless area is known to be nonhazardous.
Warning: substitution of components may impair Intrinsic Safety and suitability for Division 2, Zone 2.
Warning: de-energize main power source (turn off power supply voltage) and disconnect plug-in terminal blocks before opening the enclosure to avoid electrical shock when connected to live hazardous potential.
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

D1044 series are digital output modules enabling a Safe Area contact, logic level or drive signal, to control a device in Hazardous Area, providing 3 port isolation (input/output/supply). Outputs are galvanically isolated and inputs are depolarized to ease wiring operations. Typical applications include switching of Hazardous Area circuits, changing of polarities and sounder tones, calibrating of strain gauge bridges, resetting of field devices, testing of fire detectors.
Each input channel can be isolated from supply (Bus Powered mode) or externally connected (by wiring) to supply (Loop Powered mode, where the safety PLC directly supplies the module and its input channel).
Each output channel provides a SPDT relay, with two contacts defined NO (Normally Open) and NC (Normally Close) when the output relay is de-energized.
Considering each channel NE (Normally Energized), the output relay is energized, so that NO contact is closed (useful for NE loads or Hazardous Area circuits) and NC contact is open (useful for ND loads or Hazardous Area circuits). The safe state is reached when the channel and the output relay are de-energized, so that NO contact is open (de-energizing loads or Hazardous Area circuits) and NC contact is closed (energizing loads or Hazardous Area circuits).
Presence of supply power and status of output (energized or de-energized) are displayed by signaling LEDs (green for power, yellow for status).

Installation

D1044 series are digital relay output housed in a plastic enclosure suitable for installation on EN/IEC60715 TH 35 DIN-Rail.
D1044 unit can be mounted with any orientation over the entire ambient temperature range, see section “Installation in Cabinet” and "Installation of Electronic Equipments in Cabinet" Instruction Manual D1000 series for detailed instructions.
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 or Division 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. D1044S is a single channel model and D1044D is a dual channel model), the function and location of each connection terminal using the wiring diagram on the corresponding section, as an example (considering a Bus Powered mode application):
Connect 24 Vdc power supply positive at terminal “3” and negative at terminal “4”.
For model D1044S connect input signal at terminal “5” and “6” regardless the polarity.
For model D1044D in addition to channel 1 connections above, connect terminal “7” and “8” regardless the polarity.
For model D1044S connect common relay contact output of channel 1 at terminal “15”, normally closed contact at “16” and normally opened contact at “13” or “14”.
For model D1044D connect common relay contact output of channel 2 at terminal “11”, normally closed contact at “12” and normally opened contact at “9” or “10”.

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), BS 5345 Pt4, VDE 165, ANSI/ISA RP12.06.01 Installation of Intrinsically Safe System for Hazardous (Classified) Locations, National Electrical Code NEC ANSI/NFPA 70 Section 504 and 505, Canadian Electrical Code CEC), make sure that conductors are well isolated from each other and do not produce any unintentional connection.
Connect SPDT relay contacts checking the load rating to be within the contact maximum rating (2 A, 60 V for use in Intrinsic Safety applications or 2 A, 250 V, 500 VA 80 W resistive load for non Intrinsic Safety applications).
The enclosure provides, according to EN/IEC 60529, an IP20 minimum degree of protection. The equipment shall only be used in an area of at least pollution degree 2, as defined in EN/IEC 60664-1. For hazardous location, the unit shall be installed in an enclosure that provides a minimum ingress protection of IP54 in accordance with EN/IEC 60079-0, that must have a door or cover accessible only by the use of a tool. 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 D1044 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, D1044 series must be connected to SELV or SELV-E supplies.
Relay output contact must be connected to loads non exceeding category I, pollution degree I overvoltage limits.
Warning: de-energize main power source (turn off power supply voltage) and disconnect plug-in terminal blocks before opening the enclosure to avoid electrical shock when connected to live hazardous potential.

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, status led on each channel must be in accordance with condition of the corresponding input line.
If possible close and open input lines one at time checking the corresponding status leds condition as well as output to be correct.