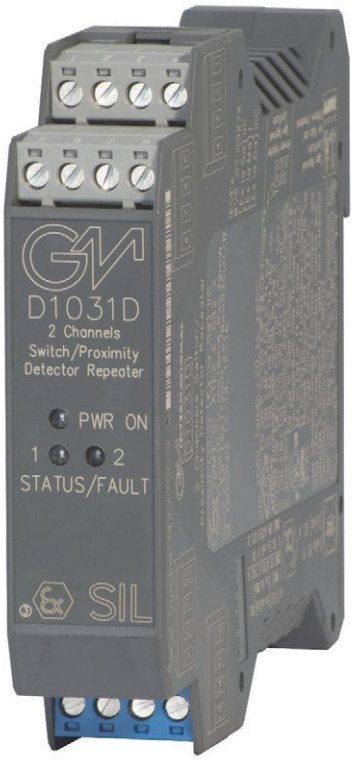


INSTRUCTION & SAFETY MANUAL

SIL 2 Switch/Proximity Detector Repeater Transistor Output DIN-Rail Models D1031D, D1031Q

Characteristics

General Description: The Switch/Proximity Detector Repeater type D1031 is a DIN Rail unit with two or four independent channels. The unit can be configured for contact or proximity detector, NO or NC and for NO or NC optocoupled open collector transistor output. Each channel enables a Safe Area load to be controlled by a switch, or a proximity detector, located in Hazardous Area.

D1031Q quad channel type has four independent input channels and actuates the corresponding output transistor. Two actuation modes can be independently DIP switch configured on each input channel: NO input/NC transistor or NO input/NO transistor. Contact or proximity sensor and its connection line short or open circuit fault detection is also DIP switch configurable: fault detection can be enabled (in case of fault it de-energizes the corresponding output transistor and turns the fault LED on) or disabled (in case of fault the corresponding output transistor repeats the input line open or closet status as configured).

D1031D dual channel type has two input channels and four output transistors; the unit has two DIP switch configurable operating modes:
Mode A) input channel actuates in parallel the two output transistors. Transistor actuation mode can be independently configured for each output in two modes:
NO input/NC transitor or NO input/NO transistor.
Mode B) input channel actuates output transistor A configurable in two modes as in mode A above. Output transistor B operates as a fault output (in case of input fault, transistor B actuates and the fault LED turns on while transistor A repeats the input line as configured). Actuation can be DIP switch configured in two modes:
No input fault/energized transistor (it de-energizes in case of fault) or No input fault/de-energized transistor (it energizes in case of fault).

Function: 2 or 4 channels I.S. switch repeater for contact or EN60947-5-6 proximity. Provides 3 port isolation (input/output/supply).
Signalling LEDs: Power supply indication (green), output status (yellow), line fault (red).
Field Configurability: NO/NC input for contact/proximitor, NO/NC transistor operation and fault detection enable/disable.
EMC: Fully compliant with CE marking applicable requirements.

Technical Data

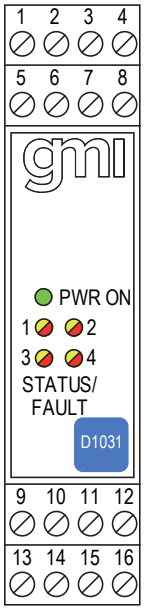
Supply: 12-24 Vdc nom (10 to 30 Vdc) reverse polarity protected, ripple within voltage limits ≤ 5 Vpp.
Current consumption @ 24 V: 50 mA for 4 channels D1031Q, 40 mA for 2 channels D1031D with input closed and transistors energized.
Current consumption @ 12 V: 100 mA for 4 channels D1031Q, 80 mA for 2 channels D1031D with input closed and transistors energized.
Power dissipation: 1.2 W for 4 channels D1031Q, 1.0 W for 2 channels D1031D with 24 V supply voltage, input closed and transistors energized.
Max. power consumption: at 30 V supply voltage, short circuit input and transistors energized, 1.4 W for 4 channels D1031Q, 1.0 W for 2 channels D1031D.
Isolation (Test Voltage): I.S. In/Out 1.5 KV; I.S. In/Supply 1.5 KV; Out/Supply 500 V; Out 1-3/Out 2-4 500 V.
Input switching current levels: ON ≥ 2.1 mA, OFF ≤ 1.2 mA, switch current ≈ 1.65 mA ± 0.2 mA hysteresis.
Fault current levels: open fault ≤ 0.2 mA, short fault ≥ 6.8 mA
(when enabled both faults de-energize channel transistor with quad channel unit D1031Q or actuate fault transistor with dual channel unit D1031D).
Input equivalent source: 8 V 1 KΩ typical (8 V no load, 8 mA short circuit).
Output: voltage free SPST optocoupled open-collector transistor.
Open-collector rating: 100 mA at 35 V (≤ 2.0 V voltage drop).
Leakage current: ≤ 50 µA at 35 V.
Response time: 500 µs.
Frequency response: 1 KHz 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 90 % non condensing, up to 35 °C.
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 IIC T4 Gc
IECEx: Ex ia Ga] IIC, [Ex ia Da] IIIC, [Ex ia Ma] I, Ex ec IIC T4 Gc
INMETRO: [Ex ia Ga] IIC, [Ex ia Da] IIIC, [Ex ia Ma] I
UL: NI / I / 2 / ABCD / T4, AIS / I, II, III / 1 / ABCDEFG, AEx nC [ia] IIC
C-UL: NI / I / 2 / ABCD / T4, AIS / I, II, III / 1 / ABCDEFG, Ex nC [ia] IIC
FM: NI / I / 2 / ABCD / T4, NI / I / 2 / IIC / T4, AIS / I, II, III / 1 / ABCDEFG, AEx [ia] IIC
FMC: NI / I / 2 / ABCD / T4, NI / I / 2 / IIC / T4, AIS / I, II, III / 1 / ABCDEFG, Ex [ia] IIC
EAC-EX: 2Ex nA [ia Ga] IIC T4 X, [Ex ia Da] IIIC X, [Ex ia Ma] I X.
UKR TR n. 898: 2ExnAiaIICT4 X, Exial X
Uo/Voc = 10.7 V, Io/Isc = 15 mA, Po/Po = 39 mW at terminals 13-14, 15-16.
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.
IECEx IMQ 13.0011X conforms to IEC60079-0, IEC60079-7.
INMETRO DNV 13.0108 X conforms to ABNT NBR IEC60079-0, ABNT NBR IEC60079-11.
UL & C-UL E222308 conforms to UL913, UL 60079-0, UL60079-11 for UL and
CSA-C22.2 No.157-92, CSA-E60079-0, CSA-E60079-11 for C-UL.
FM & FM-C No. 3024643, 3029921C, conforms to Class 3600, 3610, 3611, 3810 and
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 Declaration of Compliance No. C-IS-722238330, SIL 2 according to IEC 61508:2010 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 130 g D1031Q, 120 g D1031D.
Connection: by polarized plug-in disconnect screw terminal blocks to accomodate terminations up to 2.5 mm².
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: D1031		
2 channels	D	
4 channels	Q	
Power Bus enclosure		/B

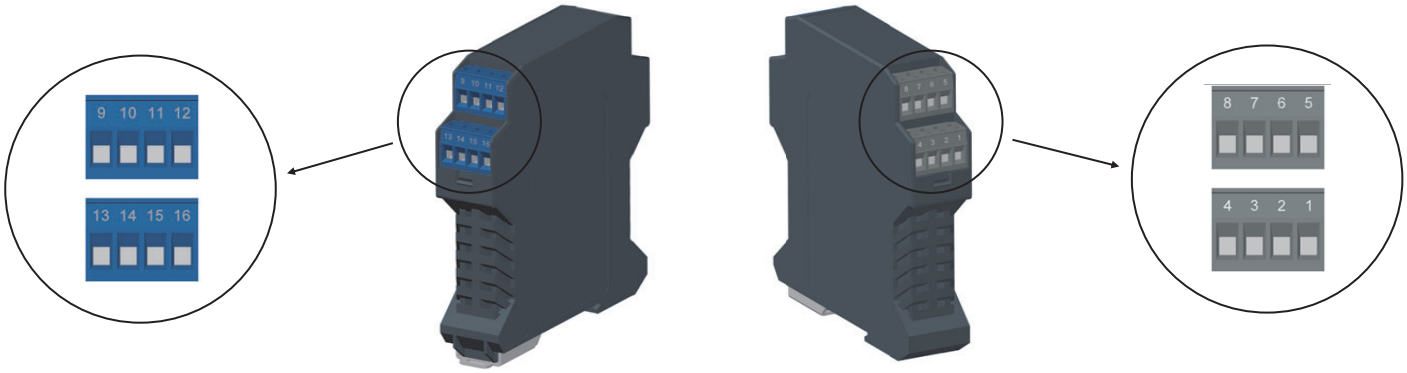
Power Bus and DIN-Rail accessories:
DIN rail anchor MCHP065 DIN rail stopper MORT016
Terminal block male MORT017 Terminal block female MORT022

Front Panel and Features



- SIL 2 according to IEC 61508:2010 (Route 2H) with Tproof = 7 / 10 years (≤10% / >10 % of total SIF).
- SC2: Systematic Capability SIL2.
- Input from Zone 0 (Zone 20), Division 1, installation in Zone 2, Division 2.
- NO/NC contact/proximity Detector Input.
- Four opto isolated voltage free Transistor Output Signals.
- Transistor Output for fault detection on dual channel version.
- Three port isolation, Input/Output/Supply.
- EMC Compatibility to EN61000-6-2, EN61000-6-4, EN61326-1.
- In-field programmability by DIP Switch.
- ATEX, IECEx, UL & C-UL, FM & FM-C, INMETRO, EAC-EX, UKR TR n. 898, TÜV Certifications.
- Type Approval Certificate DNV and KR for maritime applications.
- High Reliability, SMD components.
- High Density, four 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



D1031Q

HAZARDOUS AREA		SAFE AREA	
9	+ Input Ch 3 for Proximity or Input Ch 3 for Voltage free Contact	1	Output Ch 1
10	- Input Ch 3 for Proximity or Input Ch 3 for Voltage free Contact	2	Output Common Ch 1 and Ch 3
11	+ Input Ch 4 for Proximity or Input Ch 4 for Voltage free Contact	3	+ Power Supply 24 Vdc
12	- Input Ch 4 for Proximity or Input Ch 4 for Voltage free Contact	4	- Power Supply 24 Vdc
13	+ Input Ch 1 for Proximity or Input Ch 1 for Voltage free Contact	5	Output Ch 2
14	- Input Ch 1 for Proximity or Input Ch 1 for Voltage free Contact	6	Output Common Ch 2 and Ch 4
15	+ Input Ch 2 for Proximity Input Ch 2 for Voltage free Contact	7	Output Ch 3
16	- Input Ch 2 for Proximity Input Ch 2 for Voltage free Contact	8	Output Ch 4

D1031D

HAZARDOUS AREA		SAFE AREA	
13	+ Input Ch 1 for Proximity or Input Ch 1 for Voltage free Contact	1	Output Ch 1-A
14	- Input Ch 1 for Proximity or Input Ch 1 for Voltage free Contact	2	Output Common Ch 1-A and Ch 1-B
15	+ Input Ch 2 for Proximity or Input Ch 2 for Voltage free Contact	3	+ Power Supply 24 Vdc
16	- Input Ch 2 for Proximity or Input Ch 2 for Voltage free Contact	4	- Power Supply 24 Vdc
		5	Output Ch 2-A
		6	Output Common Ch 2-A and Ch 2-B
		7	Output Ch 1-B
		8	Output Ch 2-B

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 D1031 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:

D1031 Terminals		D1031 Associated Apparatus Parameters		Must be	Hazardous Area/ Hazardous Locations Device Parameters
Ch1	13 -14	Uo / Voc = 10.7 V		≤	Ui / Vmax
Ch2	15 -16				
Ch3	9 - 10				
Ch4	11 - 12				
Ch1	13 -14	Io / Isc = 15 mA		≤	Ii / Imax
Ch2	15 -16				
Ch3	9 - 10				
Ch4	11 - 12				
Ch1	13 -14	Po / Po = 39 mW		≤	Pi / Pi
Ch2	15 -16				
Ch3	9 - 10				
Ch4	11 - 12				

D1031 Terminals		D1031 Associated Apparatus Parameters		Must be	Hazardous Area/ Hazardous Locations Device + Cable Parameters
Ch1	13 -14	Co / Ca = 2.23 µF	IIC (A, B)	≥	Ci / Ci device + C cable
Ch2	15 -16	Co / Ca = 15.6 µF	IIB (C)		
Ch3	9 - 10	Co / Ca = 69 µF	IIA (D)		
Ch4	11 - 12	Co / Ca = 60 µF	I		
		Co / Ca = 15.6 µF	IIIC		
Ch1	13 -14	Lo / La = 172 mH	IIC (A, B)	≥	Li / Li device + L cable
Ch2	15 -16	Lo / La = 689 mH	IIB (C)		
Ch3	9 - 10	Lo / La = 1300 mH	IIA (D)		
Ch4	11 - 12	Lo / La = 2263 mH	I		
		Lo / La = 689 mH	IIIC		
Ch1	13 -14	Lo / Ro = 930 µH/Ω	IIC (A, B)	≥	Li / Ri device and L cable / R cable
Ch2	15 -16	Lo / Ro = 3720 µH/Ω	IIB (C)		
Ch3	9 - 10	Lo / Ro = 7440 µH/Ω	IIA (D)		
Ch4	11 - 12	Lo / Ro = 12200 µH/Ω	I		
		Lo / Ro = 3720 µH/Ω	IIIC		

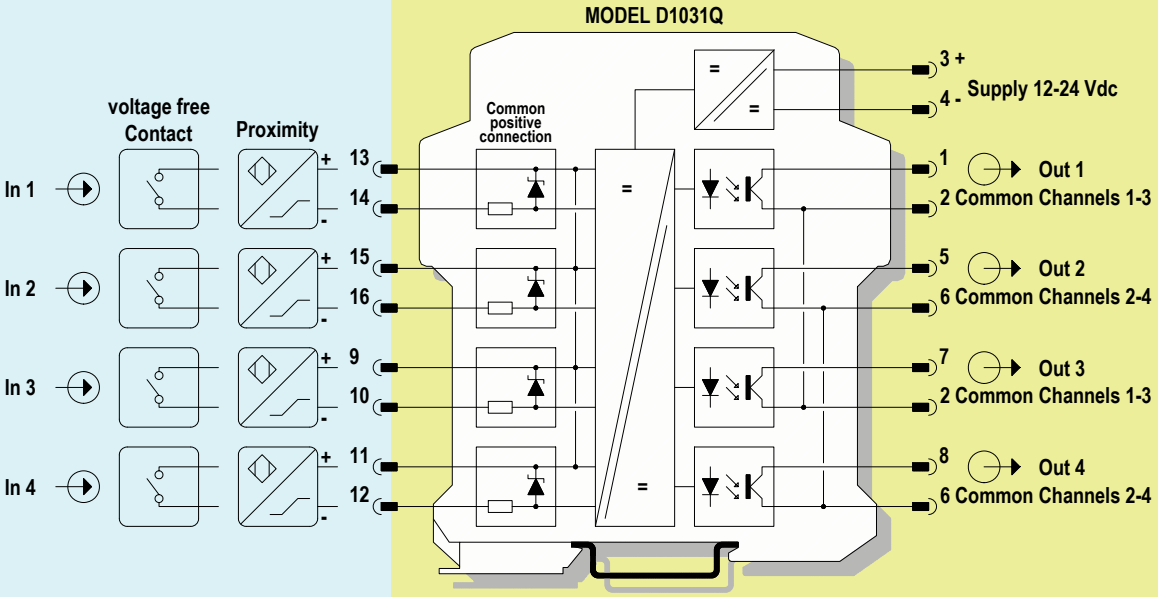
NOTE for USA and Canada:
IIC equal to Gas Groups A, B, C, D, E, F and G,
IIB equal to Gas Groups C, D, E, F and G,
IIA equal to Gas Groups D, E, F and G

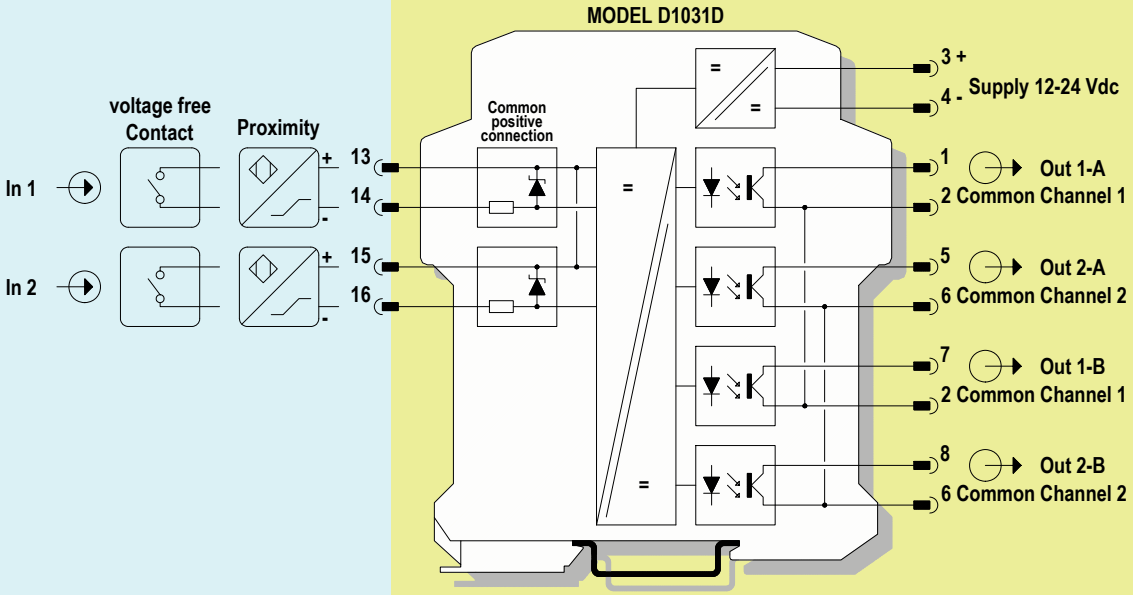
For installations in which both the Ci and Li of the Intrinsically Safe apparatus exceed 1% of the Co and Lo parameters of the Associated Apparatus (excluding the cable), then 50% of Co and Lo parameters are applicable and shall not be exceeded (50% of the Co and Lo become the limits which must include 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

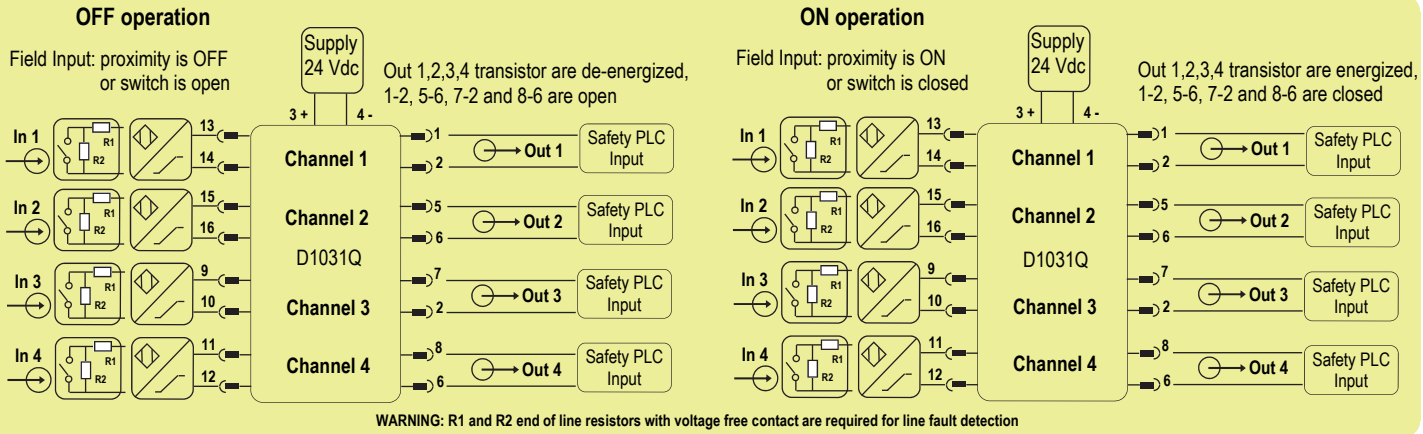
HAZARDOUS AREA ZONE 0 (ZONE 20) GROUP IIC,
HAZARDOUS LOCATIONS CLASS I, DIVISION 1, GROUPS A, B, C, D,
CLASS II, DIVISION 1, GROUPS E, F, G, CLASS III, DIVISION 1,
CLASS I, ZONE 0, GROUP IIC

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





Application for D1031Q



WARNING: R1 and R2 end of line resistors with voltage free contact are required for line fault detection

Description: For this application, enable input line fault (open or short) detection and direct input to output transfer function, by set the internal dip-switches in the following mode (see page 11 for more information):

Dip-switch position	1	2	3	4	5	6	7	8
ON/OFF state	ON	ON	ON	ON	ON	ON	ON	ON

The module is powered by connecting 24 Vdc power supply to Pins 3 (+ positive) - 4 (- negative). The green LED is lit in presence of supply power.
Input signals from field are applied to Pins 13-14 (In 1 - Ch.1), Pins 15-16 (In 2 - Ch.2), Pins 9-10 (In 3 - Ch.3) and Pins 11-12 (In 4 - Ch.4).
The following table describes for each channel the state (open or closed) of its output contacts when its input signal is in OFF or ON state, and it gives information about turn-on or turn-off of the related channel status LED and channel fault LED:

Input signal state Pins 13-14 (In 1-Ch.1) or 15-16 (In 2-Ch.2) or Pins 9-10 (In 3-Ch.3) or Pins 11-12 (In 4-Ch.4)	Output transistor state Pins 1-2 (Out 1 - Ch.1) or 5-6 (Out 2 - Ch.2) Pins 7-2 (Out 3 - Ch.3) or 8-6 (Out 4 - Ch.4)	Channel status yellow LED state	Channel fault red LED state
Proximity sensor is OFF or switch is open	Open (De-energize transistor)	OFF	OFF
Proximity sensor is ON or switch is closed	Closed (Energized transistor)	ON	OFF
Independently from proximity sensor or switch state, the input line is break	Open (De-energized transistor as safe state condition)	OFF	ON
Independently from proximity sensor or switch state, the input line is in short circuit	Open (De-energized transistor as safe state condition)	OFF	ON

Safety Function and Failure behavior:

D1031Q is considered to be operating in Low Demand mode, as a Type B module, having Hardware Fault Tolerance (HFT) = 0.
The failure behavior is described from the following definitions, valid for each channel:

- □ Fail-Safe State: it is defined as the channel output transistor being de-energized (its output is open).
- □ 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 channel output transistor remains energized (its output keeps closed).
- □ Fail Dangerous Detected: a dangerous failure which has been detected from module internal diagnostics so that channel output transistor is forced to be de-energized (as Fail-Safe state, with its output is open).
- □ Fail "No Effect": failure mode of a component that plays a part in implementing the safety function but is neither a safe failure nor a dangerous failure. When calculating the SFF, this failure mode is not taken into account;
- □ Fail "Not Part": failure mode of a component which is not part of the safety function but which is part of the circuit diagram and is listed for completeness. When calculating the SFF, this failure mode is not taken into account.

As the module has been evaluated in accordance with Route 2H (proven-in-use) of the IEC 61508:2010, Diagnostic Coverage DC ≥ 60% is required for Type B elements.
Being HFT = 0, in Low Demand mode the maximum achievable functional safety level is SIL 2.
The 4 channels of D1031Q module can not be used to increase the hardware fault tolerance, needed for a higher SIL of a certain Safety Function, as they are not completely independent one from another. Failure rate data: taken from Siemens Standard SN29500.

Failure rate table:

Failure category	Failure rates (FIT)
λ_{dd} = Total Dangerous Detected failures	73.09
λ_{du} = Total Dangerous Undetected failures	29.61
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	58.71
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	**161.41**
MTBF (safety function, one channel) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)	**707 years**
$\lambda_{no\ effect}$ = "No Effect" failures	115.00
$\lambda_{not\ part}$ = "Not Part" failures	121.00
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	**397.41**
MTBF (device) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)	**287 years**

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

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	DC	SFF
0.00 FIT	58.71 FIT	73.09 FIT	29.61 FIT	71.17%	81.66%

where DC means the diagnostic coverage for the input sensor by module internal diagnostic circuits. This type "B" system, operating in Low Demand mode with HFT = 0, has got DC = 71.17 % ≥ 60 % as required by Route 2H evaluation (proven-in-use) of the IEC 61508:2010.

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

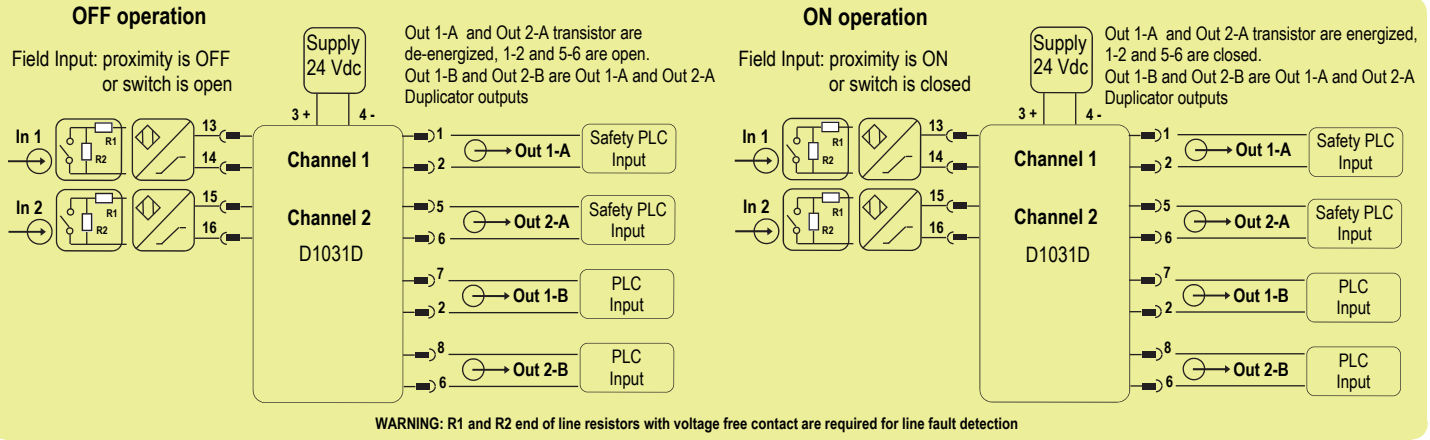
T[Proof] = 1 year	T[Proof] = 7 years
PFDavg = 1.31 E-04 Valid for **SIL 2**	PFDavg = 9.17 E-04 Valid for **SIL 2**

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 = 1.31 E-03 Valid for **SIL 2**

SC 2: Systematic capability SIL 2.

Application for D1031D



WARNING: R1 and R2 end of line resistors with voltage free contact are required for line fault detection

Description: For this application, enable input line fault (open or short) detection and direct input to output transfer function, by set the internal dip-switches in the following mode (see page 13 for more information):

Dip-switch position	1	2	3	4	5	6	7	8
ON/OFF state	ON	ON	ON	ON	OFF	-	OFF	-

The module is powered by connecting 24 Vdc power supply to Pins 3 (+ positive) - 4 (- negative). The green LED is lit in presence of supply power.
Input signal from field is applied to Pins 13-14 (In 1 - Ch.1) and Pins 15-16 (In 2 - Ch.2).
Only Out 1-A (Pins 1-2) and Out 2-A (Pins 5-6) are functional safety related, while Out 1-B (Pins 7-2) and Out 2-B (Pins 8-6) (as Duplicator of Out 1-A and Out 2-A outputs) are only for service purpose, not functional safety related.
The following table describes for each channel the state (open or closed) of its output when its input signal is in OFF or ON state, and it gives information about turn-on or turn-off of its channel status LED and channel fault LED:

Input signal state Pins 13-14 (In 1 - Ch.1) or 15-16 (In 2 - Ch.2)	Output transistor state Out 1-A (Pins 1-2) or Out 2-A (Pins 5-6) (Functional safety related output)	1-A or 2-A Ch. status yellow LED state	1-A or 2-A Ch. fault red LED state
Proximity sensor is OFF or switch is open	Open (De-energized transistor)	OFF	OFF
Proximity sensor is ON or switch is closed	Closed (Energized transistor)	ON	OFF
The input line is broken	Open (De-energized transistor as safe state condition)	OFF	ON
The input line is in short circuit	Open (De-energized transistor as safe state condition)	OFF	ON

Safety Function and Failure behavior:

D1031D is considered to be operating in Low Demand mode, as a Type B module, having Hardware Fault Tolerance (HFT) = 0.
The failure behavior is described from the following definitions, valid for each channel:

- □ Fail-Safe State: it is defined as the channel output transistor being de-energized (its output is open).
- □ 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 channel output transistor remains energized (its output keeps closed).
- □ Fail Dangerous Detected: a dangerous failure which has been detected from module internal diagnostics so that channel output transistor is forced to be de-energized (as Fail-Safe state, with its output is open).
- □ Fail "No Effect": failure mode of a component that plays a part in implementing the safety function but is neither a safe failure nor a dangerous failure. When calculating the SFF, this failure mode is not taken into account;
- □ Fail "Not Part": failure mode of a component which is not part of the safety function but which is part of the circuit diagram and is listed for completeness. When calculating the SFF, this failure mode is not taken into account.

As the module has been evaluated in accordance with Route 2H (proven-in-use) of the IEC 61508:2010, Diagnostic Coverage DC ≥ 60% is required for Type B elements.
Being HFT = 0, in Low Demand mode the maximum achievable functional safety level is SIL 2.
Only Out 1-A and Out 2-A are functional safety related, while Out 1-B (Pins 7-2) and Out 2-B (Pins 8-6) (as Duplicator of Out 1-A and Out 2-A outputs) are only for service purpose, not functional safety related. The 2 channels of D1031D module can not be used to increase the hardware fault tolerance, needed for a higher SIL of a certain Safety Function, as they are not completely independent one from another. Failure rate data: taken from Siemens Standard SN29500.

Failure rate table:

Failure category	Failure rates (FIT)
λ_{dd} = Total Dangerous Detected failures	73.09
λ_{du} = Total Dangerous Undetected failures	29.61
λ_{sd} = Total Safe Detected failures	0.00
λ_{su} = Total Safe Undetected failures	58.71
$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$	**161.41**
MTBF (safety function, one channel, Out A) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)	**707 years**
$\lambda_{no\ effect}$ = "No Effect" failures	115.00
$\lambda_{not\ part}$ = "Not Part" failures	107.80
$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$	**384.21**
MTBF (device) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)	**297 years**

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

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	DC	SFF
0.00 FIT	58.71 FIT	73.09 FIT	29.61 FIT	71.17%	81.66%

where DC means the diagnostic coverage for the input sensor by module internal diagnostic circuits. This type "B" system, operating in Low Demand mode with HFT = 0, has got DC = 71.17 % ≥ 60 % as required by Route 2H evaluation (proven-in-use) of the IEC 61508:2010.

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

T[Proof] = 1 year	T[Proof] = 7 years
PFDavg = 1.31 E-04 Valid for **SIL 2**	PFDavg = 9.17 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 = 1.31 E-03 Valid for **SIL 2**

SC 2: Systematic capability SIL 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.
Note for switch input: to detect a broken wire, or a short circuit condition, in the input connections it is necessary to mount, close to the switches, the end of line resistors: R1=1 KΩ typical (470 Ω to 2 KΩ range) resistor in series and R2=10 kΩ typical (5 KΩ to 15 KΩ range) resistor in parallel to the contacts.

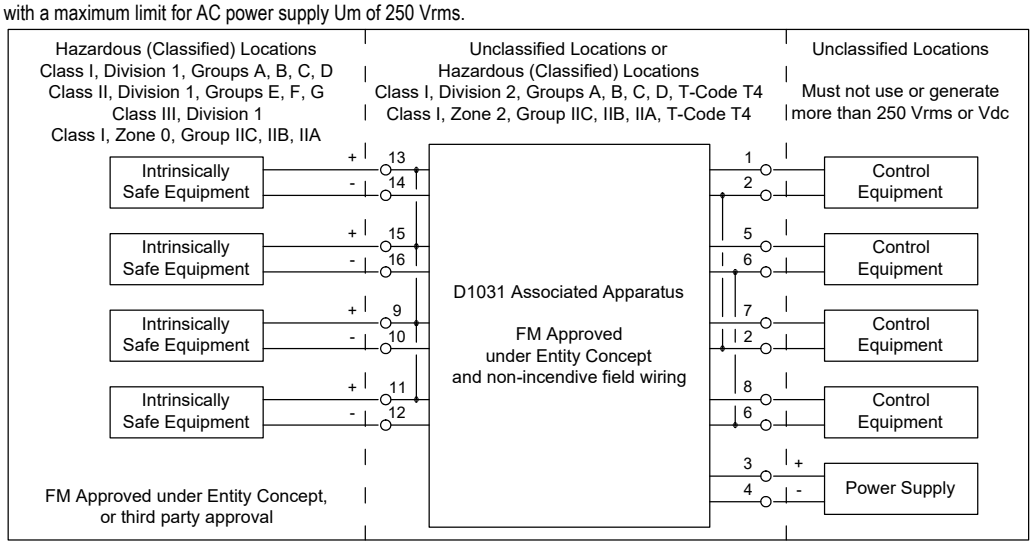
The Proof test consists of the following steps:

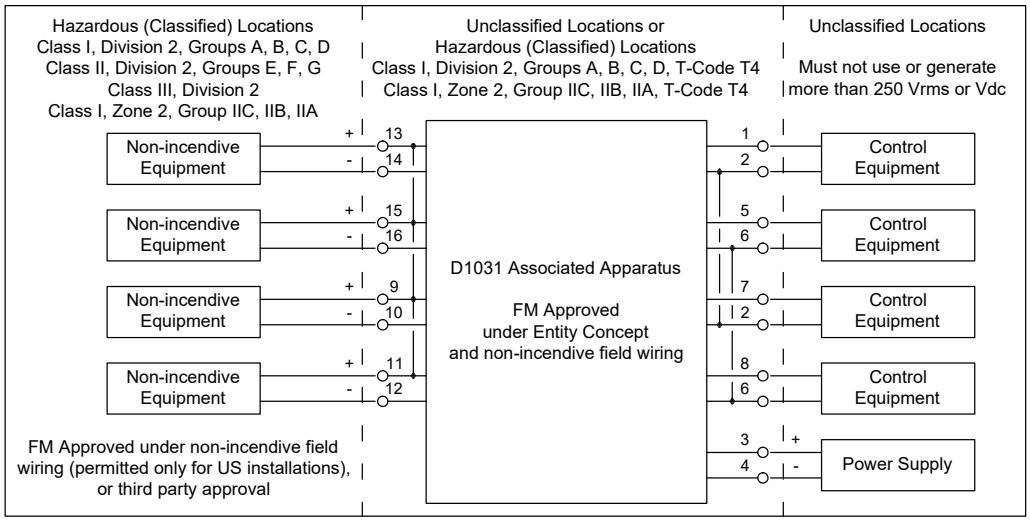
Steps	Action
1	Bypass the Safety PLC or take any other appropriate action to avoid a false trip.
2	Vary the state conditions of the input sensor / contact coming from field and verify that the transistor channel output changes its state from energized to de-energized and vice-versa; also check that the de-energized state condition corresponds to the required Safe State of the Safety Function.
3	Disconnect the input wiring coming from the field sensor / contact and check that the transistor channel output remains de-energized.
4	Short the input connection and verify that the transistor channel output remains de-energized. In both 3rd and 4th steps, the corresponding alarm LED on the front panel must be turned red .
5	Restore the loop to full operation.
6	Remove the bypass from the safety-related PLC or restore normal operation.

This test will reveal approximately 99 % of possible Dangerous Undetected failures in the switch/proximity repeater.

Warning

D1031 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 D1031 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.
D1031 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.
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

D1031 accepts as an input from Hazardous Area/Hazardous Locations a proximity sensor or voltage free electrical contact and repeats their status to Safe Area/Non Hazardous Locations by optoisolated open collector transistor. Presence of supply power and status of output (energized or de-energized), as well as integrity or fault condition of sensor and connecting line are displayed by signaling LEDs (green for power, yellow for status and red for fault condition). D1031Q (quad channel type) has four independent input channels and actuates the corresponding output transistor; two actuation modes can be independently DIP switch configured for each input channel:
Normally open input / Normally close transistor or Normally close input / Normally close transistor.
Contact or proximity sensor and its connection line short or open circuit fault detection is also DIP switch configurable. Fault detection can be enabled (in case of fault de-energizes the corresponding output channel transistor (open) and turns ON the fault LED) or be disabled (in case of fault the corresponding output channel transistor repeats the input line open or close status as configured). D1031D (dual channel type) has two input channel and four output transistors; the unit has two DIP switch configurable operating modes:

A) Input channel actuates in parallel output transistors (providing a DPST type of output). Transistors actuation can be independently configured for each output in two modes:
   Normally open input / Normally close transistor or Normally close input / Normally close transistor
B) Input channel actuates output transistor (A) configurable in two modes as above. Output transistor B operates as fault output (in case of input fault, transistor B actuates and the fault LED turns on while transistor A repeats the input line as configured). Actuation can be configured in two modes:
   No input fault / Close transistor (it de-energizes in case of fault) or No input fault / Open transistor (it energizes in case of fault).

Note: use of voltage free electrical contacts with fault detection enabled requires, near the switch at the end of the line, a 1 KΩ series connected resistor and a 10 KΩ parallel connected resistor in order to allow the fault detection circuit to distinguish between a condition of contact close/open and a line open/short circuit fault.

Installation

D1031 series are switch/proximity detector repeaters housed in a plastic enclosure suitable for installation on EN/IEC60715 TH 35 DIN-Rail.
D1031 unit can be mounted with any orientation over the entire ambient temperature range.
Electrical connection of conductors up to 2.5 mm² are accommodated by polarized plug-in removable screw terminal blocks which can be plugged in/out into a powered unit without suffering or causing any damage **(for Zone 2 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 and configuration DIP switches.
Identify the number of channels of the specific card (e.g. D1031D is a dual channel model and D1031Q is a quad channel model), the function and location of each connection terminal using the wiring diagram on the corresponding section, as an example:
Connect 12-24 Vdc power supply positive at terminal "3" and negative at terminal "4".
For Model D1031Q connect common output of channel 1-3 at terminal "2" and transistor output at terminal "1" for channel 1 and "7" for channel 3.
For Model D1031Q connect common output of channel 2-4 at terminal "6" and transistor output at terminal "5" for channel 2 and "8" for channel 4.
For Model D1031D connect proximity sensor or voltage free contact at terminal "13" positive and "14" negative for channel 1, connect at terminal "15" and "16" respectively for channel 2.
For Model D1031Q in addition to channel 1-2 connections above, connect terminal "9" positive and "10" negative for channel 3 and "11" positive and "12" negative for channel 4.

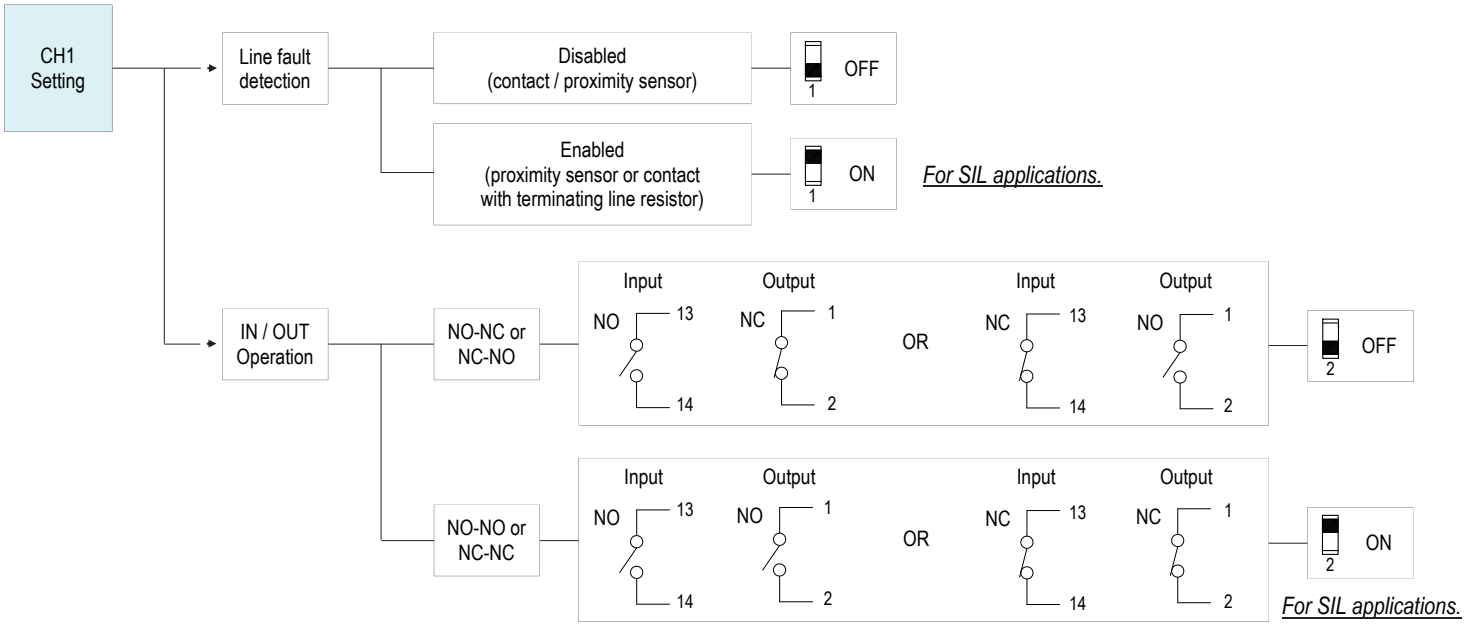
Intrinsically Safe conductors must be identified and segregated from non I.S. and wired in accordance to the relevant national/international installation standards (e.g. EN/IEC60079-14 Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than 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 SPST output transistors checking the load rating to be within the maximum rating (100 mA, 35 V resistive load).
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 D1031 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, D1031 series must be connected to SELV or SELV-E supplies.

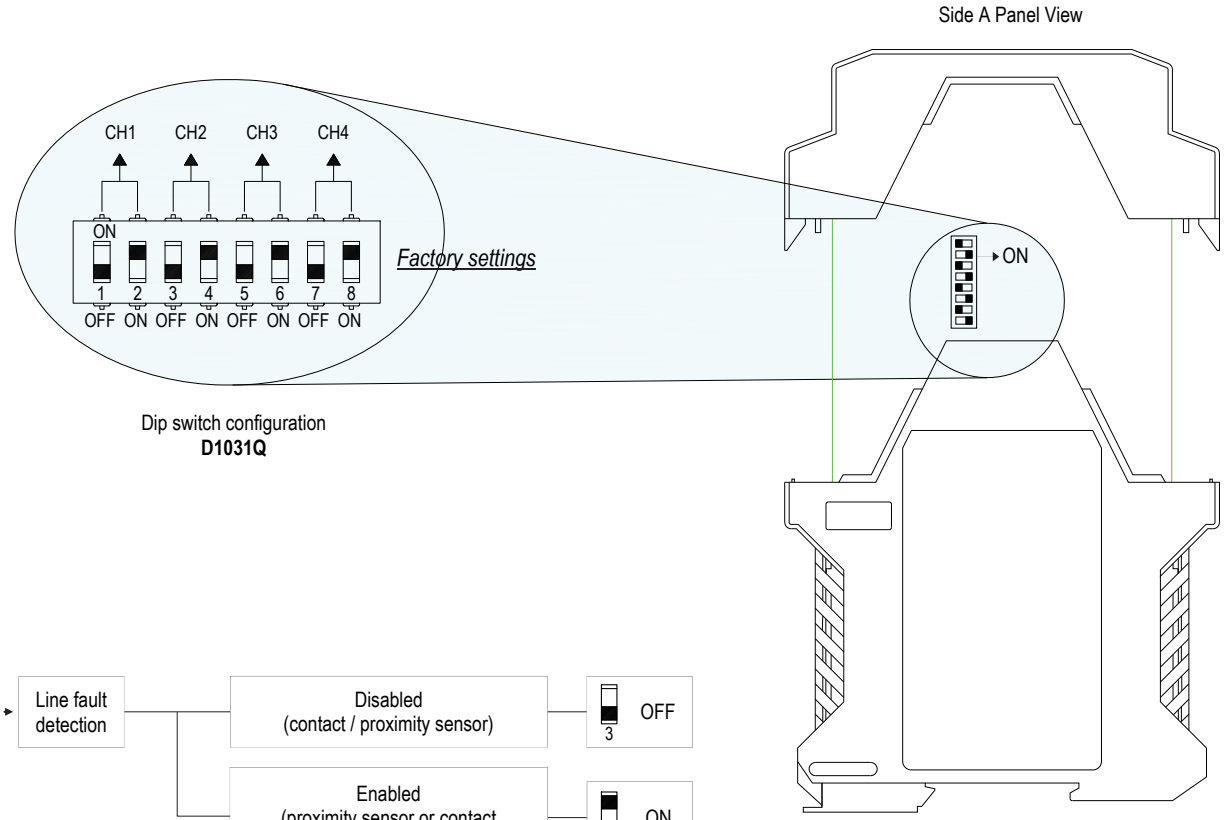
Start-up

Before powering the unit check that all wires are properly connected, particularly supply conductors and their polarity, input and output wires, also check that Intrinsically Safe conductors and cable trays are segregated (no direct contacts with other non I.S. conductors) and identified either by color coding, preferably blue, or by marking. Check conductors for exposed wires that could touch each other causing dangerous unwanted shorts. Turn on power, the "power on" green led must be lit, status and fault 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 and fault leds condition as well as output to be correct.

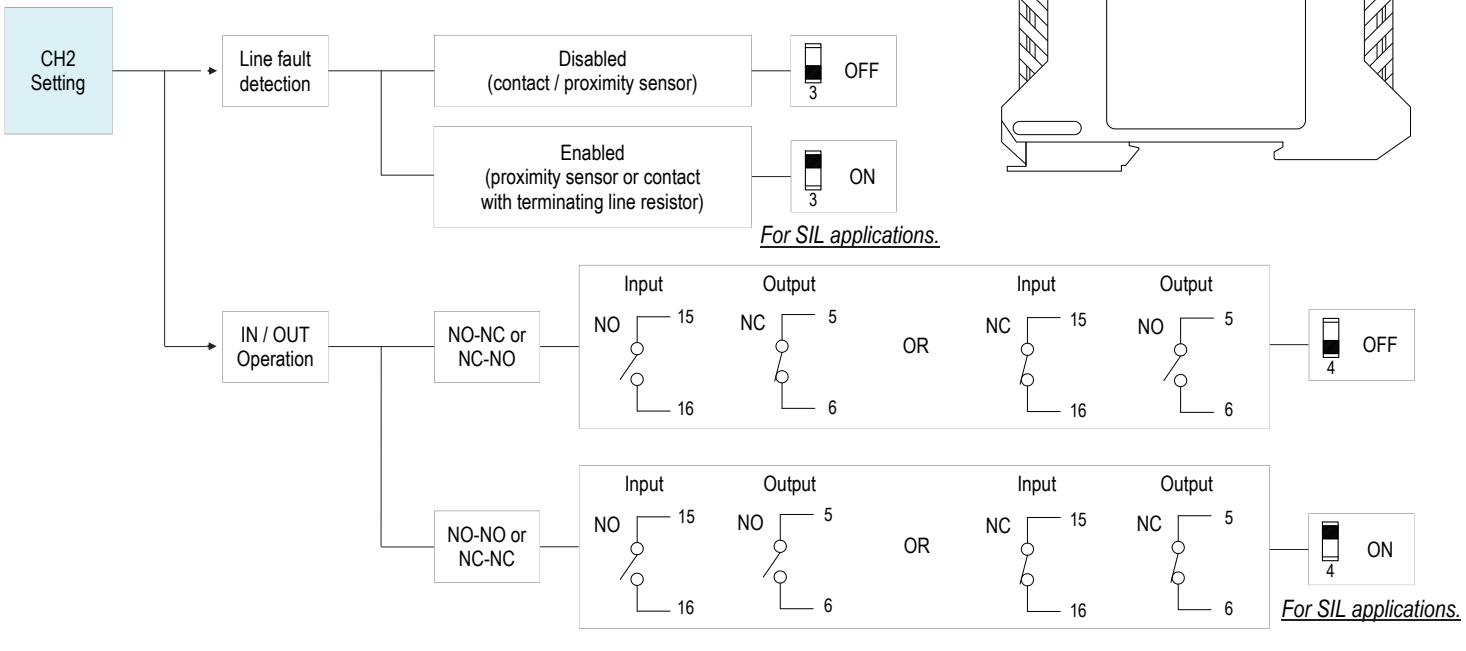
Configuration

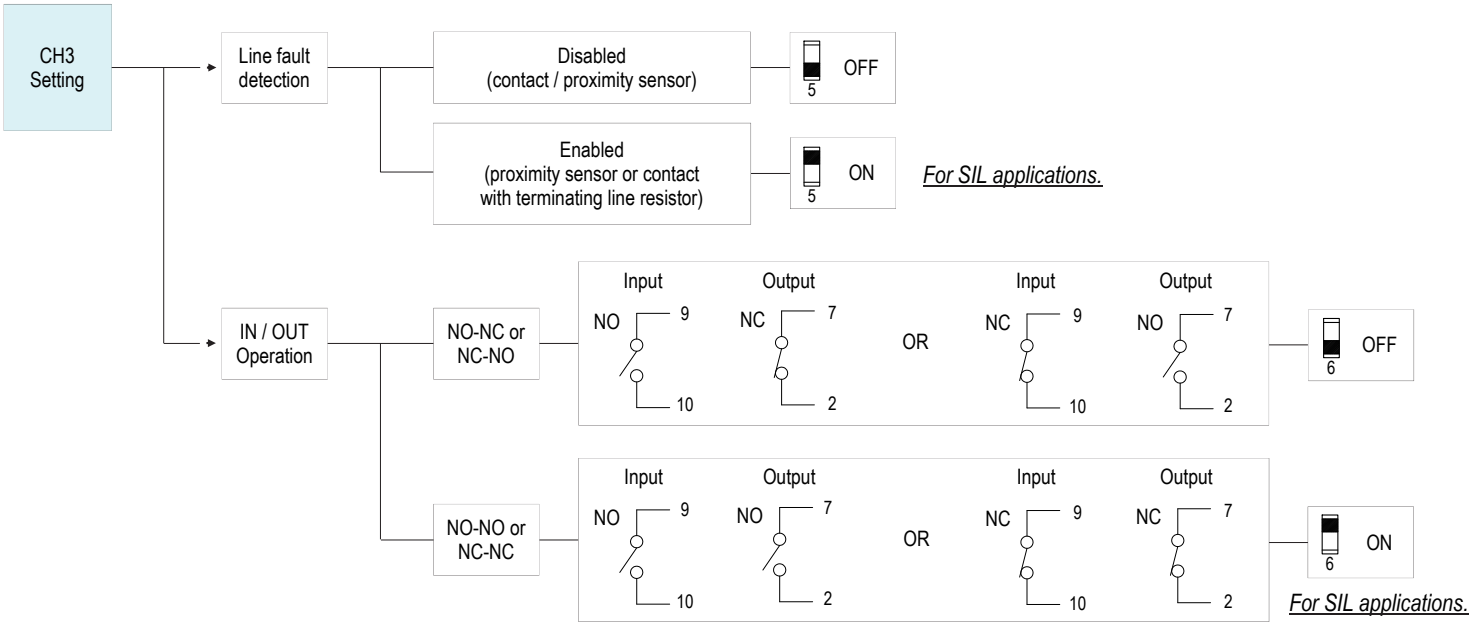
A configuration DIP switch is located on component side of pcb. This switch allows the configuration of input/output relationship, fault detection functions and operating mode.

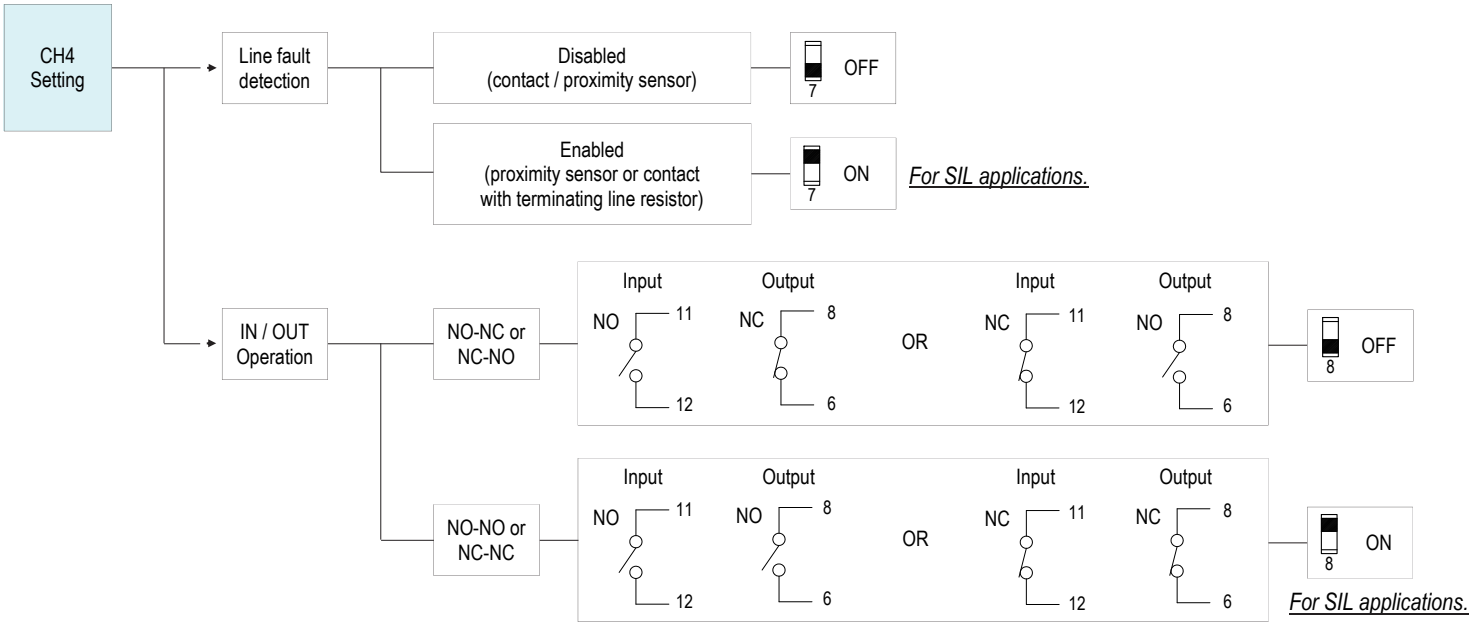




Dip switch configuration
D1031Q



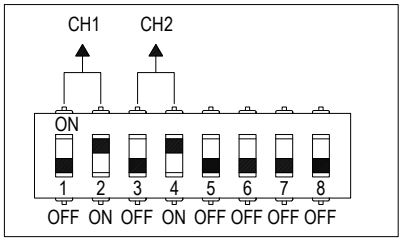




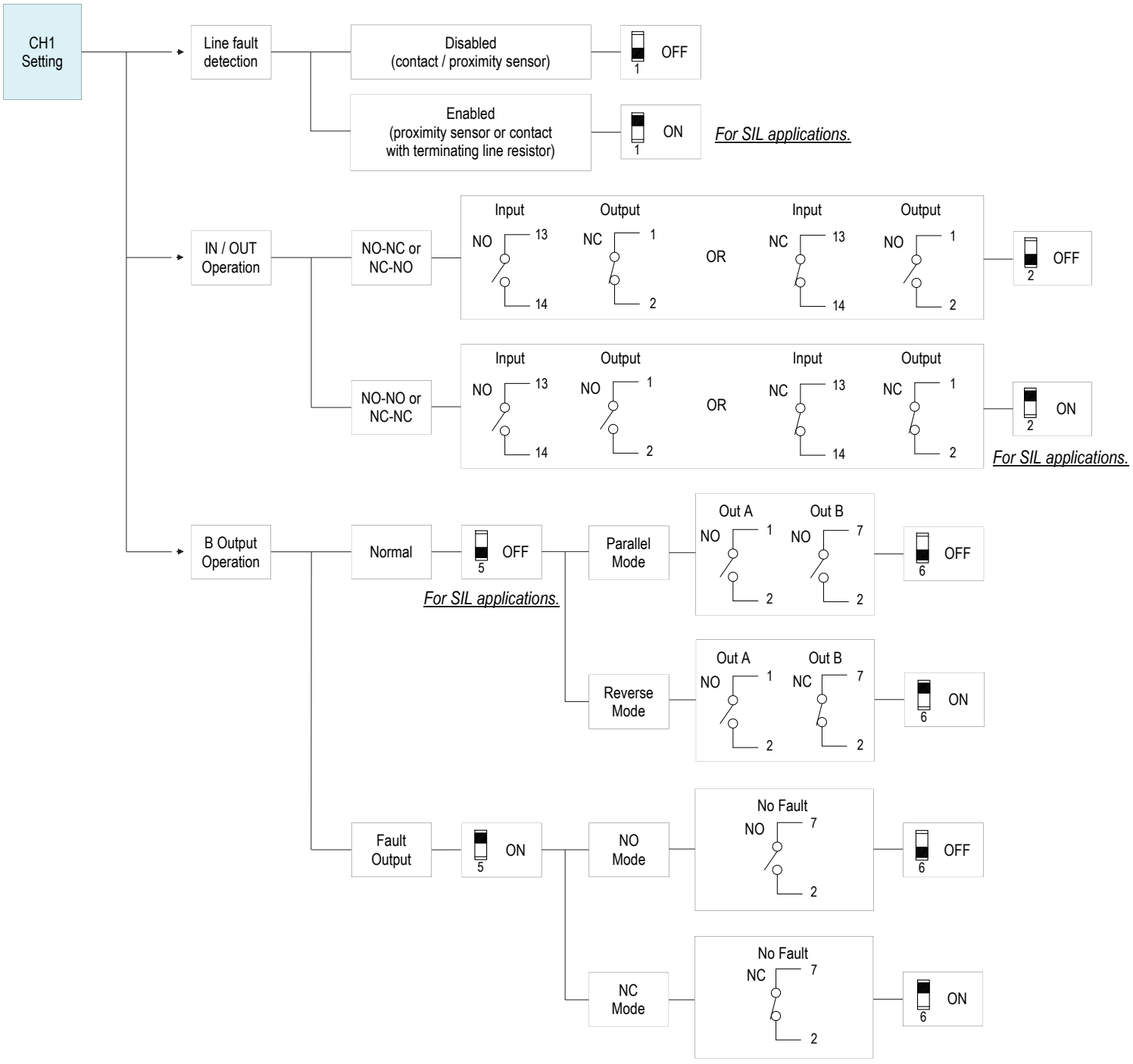
D1031Q Configuration Summary Table

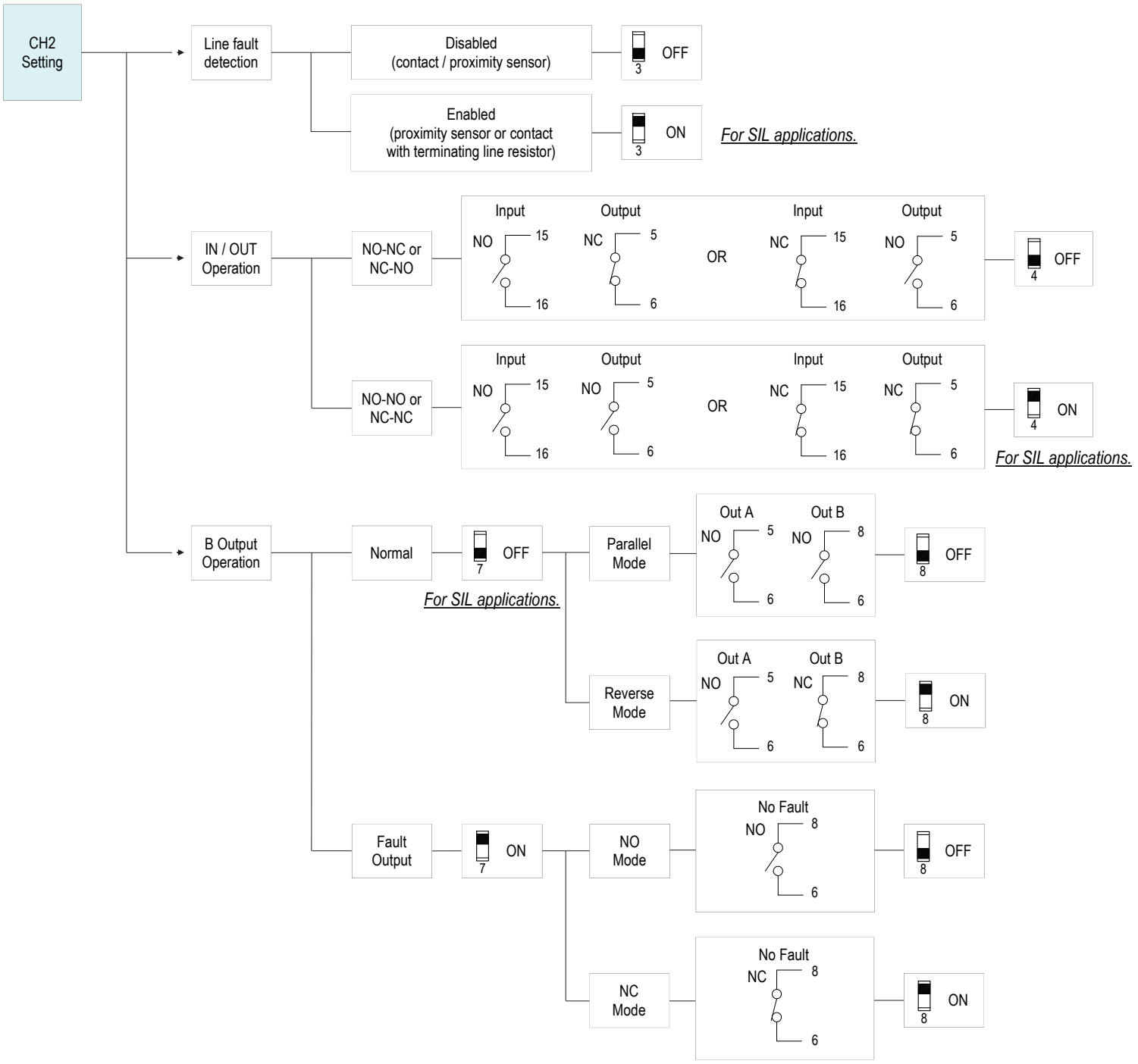
Channel	1	2	3	4
IN/OUT Operation	SW2	SW4	SW6	SW8
NO-NC or NC-NO	OFF	OFF	OFF	OFF
NO-NO or NC-NC *(For SIL applications.)*	ON	ON	ON	ON

Channel	1	2	3	4
Line fault detection	SW1	SW3	SW5	SW7
Disabled (contact/proximity sensor)	OFF	OFF	OFF	OFF
Enabled *(For SIL applications.)* (proximity sensor or contact with terminating line resistor)	ON	ON	ON	ON



Dip switch configuration
D1031D





D1031D Configuration Summary Table

Channel	1	2
IN/OUT Operation	SW2	SW4
NO-NC or NC-NO	OFF	OFF
NO-NO or NC-NC *(For SIL applications.)*	ON	ON

Channel	1	2
Line fault detection	SW1	SW3
Disabled	OFF	OFF
Enabled *(For SIL applications.)*	ON	ON

Channel	1	2	Mode	1	2
B Output Operation	SW5	SW7		SW6	SW8
Normal *(For SIL applications.)*	OFF	OFF	Direct	OFF	OFF
			Reverse	ON	ON
Fault Output	ON	ON	NO	OFF	OFF
			NC	ON	ON