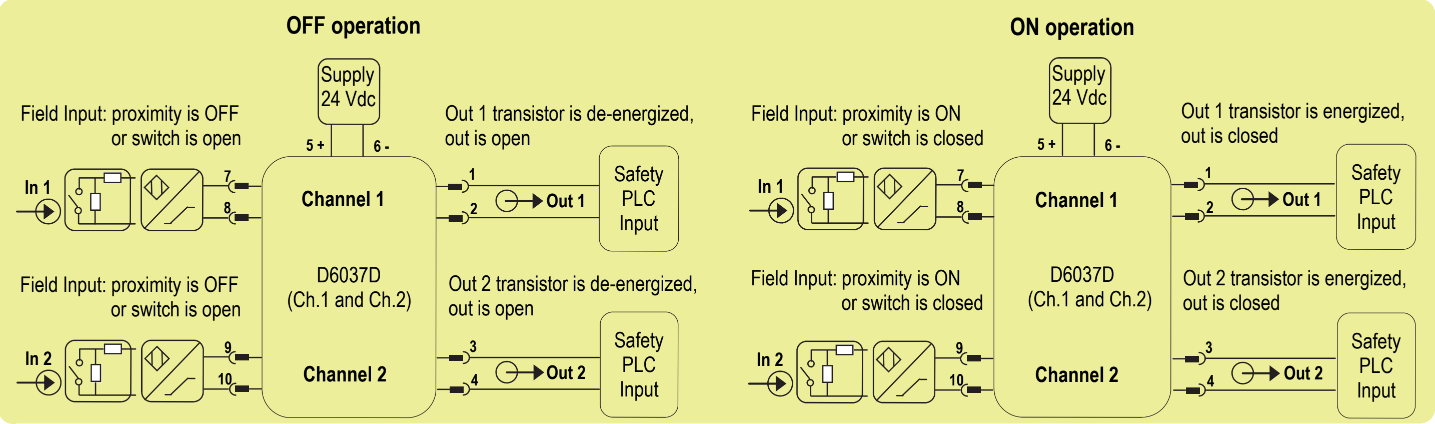
# SAFETY MANUAL

## SIL 2 Switch/Proximity Detector Repeater Transistor Out, DIN-Rail and Termination Board, Models D6037S, D6037D

Reference must be made to the relevant sections within the instruction manual ISM0409, which contain basic guides for the installation of the equipment.

gmi technology for safety

## Application for D6037D



**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 9 for more information):

| Dip-switch position | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| ON/OFF state | ON | OFF | ON | OFF |

The module is powered by connecting 24 Vdc power supply to Pins 5 (+ positive) - 6 (- negative). The green LED is lit in presence of supply power.
Input signals from field are applied to Pins 7-8 (In 1 - Ch.1) and Pins 9-10 (In 2 - Ch.2).
Transistor outputs Pins 1-2 (for Channel 1) and Pins 3-4 (for Channel 2) are both normally open (or transistor de-energized as safe state condition) for OFF operation, while they are both closed (or transistor energized) for ON operation.
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 the related channel status LED and channel fault LED:

| Input signal state<br>Pins 7-8 (In 1 - Ch.1) or 9-10 (In 2 - Ch.2) | Transistor output state<br>Pins 1-2 (Out 1 - Ch.1) or 3-4 (Out 2 - Ch.2) | 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:**

D6037D is considered to be operating in Low Demand mode, as a Type A module, having Hardware Fault Tolerance (HFT) = 0.
The failure behavior is described from the following definitions :

□ Fail-Safe State: it is defined as the transistor output being 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 transistor output remains closed;
□ 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 that is 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 D6037D module must 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 each other, containing common components.
Failure rate date: taken from Siemens Standard SN29500.

**Failure rate table:**

| Failure category | Failure rates (FIT) |
|---|---|
| $\lambda_{dd}$ = Total Dangerous Detected failures | 0.00 |
| $\lambda_{du}$ = Total Dangerous Undetected failures | 27.48 |
| $\lambda_{sd}$ = Total Safe Detected failures | 0.00 |
| $\lambda_{su}$ = Total Safe Undetected failures | 98.30 |
| **$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$** | **125.78** |
| **MTBF (safety function, channel 1) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)** | **907 years** |
| $\lambda_{no\ effect}$ = "No Effect" failures | 142.42 |
| $\lambda_{not\ part}$ = "Not Part" failures | 148.40 |
| **$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$** | **416.60** |
| **MTBF (device, channel 1) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)** | **274 years** |

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

| $\lambda_{sd}$ | $\lambda_{su}$ | $\lambda_{dd}$ | $\lambda_{du}$ | SFF |
|---|---|---|---|---|
| 0.00 FIT | 98.30 FIT | 0.00 FIT | 27.48 FIT | 78.15% |

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

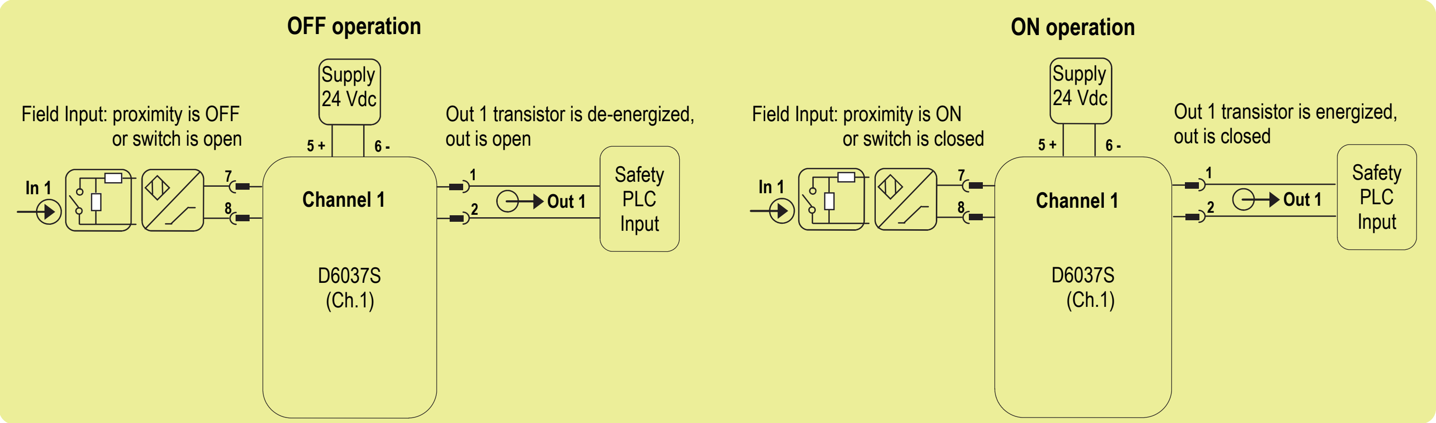
| T[Proof] = 1 year | T[Proof] = 8 years |
|---|---|
| PFDavg = 1.21 E-04 Valid for **SIL 2** | PFDavg = 9.65 E-04 Valid for **SIL 2** |

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

| T[Proof] = 20 years |
|---|
| PFDavg = 2.41E-03 Valid for **SIL 2** |

**Systematic capability SIL 3.**

## Application for D6037S


OFF operation
Field Input: proximity is OFF or switch is open
Supply 24 Vdc
5 +
6 -
Out 1 transistor is de-energized, out is open
In 1
7
8
Channel 1
D6037S (Ch.1)
1
2
Out 1
Safety PLC Input
ON operation
Field Input: proximity is ON or switch is closed
Supply 24 Vdc
5 +
6 -
Out 1 transistor is energized, out is closed
In 1
7
8
Channel 1
D6037S (Ch.1)
1
2
Out 1
Safety PLC Input

**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 10 for more information):

| **Dip-switch position** | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **ON/OFF state** | ON | OFF | Not used | Not used |

The module is powered by connecting 24 Vdc power supply to Pins 5 (+ positive) - 6 (- negative). The green LED is lit in presence of supply power.
Input signal from field is applied to Pins 7-8 (In 1 - Ch.1).
Transistor output Pins 1-2 (for Channel 1) is normally open (or transistor de-energized as safe state condition) for OFF operation, while it is closed (or transistor energized) for ON operation.
The following table describes for Channel 1 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 1 signal state**<br>**Pins 7-8 (In 1 - Ch.1)** | **Transistor Out 1 state**<br>**Pins 1-2 (Out 1 - Ch.1)** | **Channel 1 status yellow LED state** | **Channel 1 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:**

D6037S is considered to be operating in Low Demand mode, as a Type A module, having Hardware Fault Tolerance (HFT) = 0.
The failure behavior is described from the following definitions :

- □ Fail-Safe State: it is defined as the transistor output being 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 transistor output remains closed;
- □ 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 that is part of the circuit diagram and is listed for completeness. When calculating the SFF, this failure mode is not taken into account.

Failure rate date: taken from Siemens Standard SN29500.

**Failure rate table:**

| **Failure category** | **Failure rates (FIT)** |
|---|---|
| $\lambda_{dd}$ = Total Dangerous Detected failures | 0.00 |
| $\lambda_{du}$ = Total Dangerous Undetected failures | 27.48 |
| $\lambda_{sd}$ = Total Safe Detected failures | 0.00 |
| $\lambda_{su}$ = Total Safe Undetected failures | 92.76 |
| **$\lambda_{tot\ safe}$ = Total Failure Rate (Safety Function) = $\lambda_{dd} + \lambda_{du} + \lambda_{sd} + \lambda_{su}$** | **120.24** |
| **MTBF (safety function, one channel) = (1 / $\lambda_{tot\ safe}$) + MTTR (8 hours)** | **949 years** |
| $\lambda_{no\ effect}$ = "No Effect" failures | 132.06 |
| $\lambda_{not\ part}$ = "Not Part" failures | 17.50 |
| **$\lambda_{tot\ device}$ = Total Failure Rate (Device) = $\lambda_{tot\ safe} + \lambda_{no\ effect} + \lambda_{not\ part}$** | **269.80** |
| **MTBF (device, one channel) = (1 / $\lambda_{tot\ device}$) + MTTR (8 hours)** | **423 years** |

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

| $\lambda_{sd}$ | $\lambda_{su}$ | $\lambda_{dd}$ | $\lambda_{du}$ | **SFF** |
|---|---|---|---|---|
| 0.00 FIT | 92.76 FIT | 0.00 FIT | 27.48 FIT | 77.15% |

**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] = 8 years** |
|---|---|
| PFDavg = 1.21 E-04 Valid for **SIL 2** | PFDavg = 9.65 E-04 Valid for **SIL 2** |

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

| **T[Proof] = 20 years** |
|---|
| PFDavg = 2.41 E-03 Valid for **SIL 2** |

**Systematic capability SIL 3.**

## 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-related PLC or take any other appropriate action in order to avoid a false trip. |
| 2 | Vary the state conditions of the input sensors/contacts coming from field and verify that the transistor outputs change from de-energized to energized and vice versa; then, check that the de-energized state condition corresponds to the required Safety-related function. |
| 3 | If input line fault detection is enabled for each channel by means of a dip-switches specific set up, disconnect the input wiring coming from the field sensor/contact and check that the correspondent transistor output is de-energized. Then, put in short circuit condition the input connections and verify that the same output remains de-energized. In both cases, the related red alarm LEDs on the front panel will be turned on. |
| 4 | Restore the loop to full operation. |
| 5 | 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 repeater.