**Application Note APN0037**
**Use of D5091S in conjunction with**
**Smart F&G Solenoid Driver D5294S**

# Index of contents

## 1. Presentation

The D5294S is a SMART Relay output module for the switching of safety related circuits, up to SIL 3 level according IEC 61508 and IEC 61511.

D5294S has 2+2 SPST relay contacts connected in parallel to improve functional safety and then in series to avoid spurious trips, hence increasing availability.
As a summary, the D5294S module allows a direct relation between PLC input and Load status:
  - When the driving signal is low (0 Vdc), the relay is de-energized and load is de-energized.
  - When the driving signal is high (24 Vdc), the relay is energized, and the load is energized.

Certain applications require that this behavior is inverted, leading to an indirect relation between PLC input and Load status. To do so, it is necessary to interpose a D5091S Module between PLC input and D5294S Module.

See wiring connections for more details.
Section 3 shows how SIL levels are impacted by such a configuration.

## 2. Wiring connections
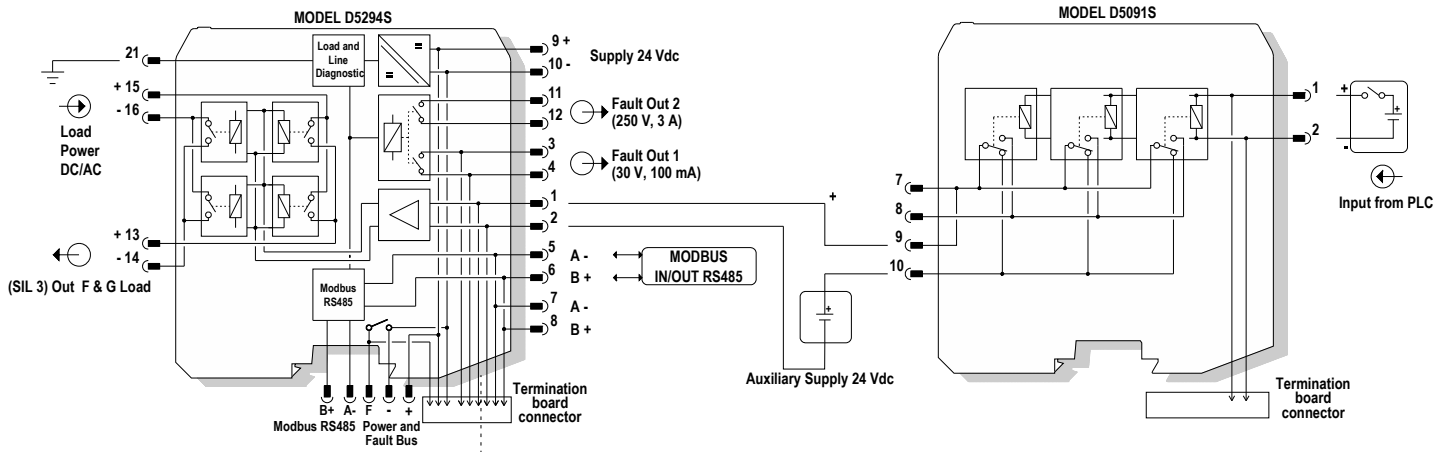


The figure shows the cabling of D5091S and D5294S.
Starting from the right, we have Input from PLC on pins 1,2 of D5091S. The output signal on pins 9,10 is used to energize or de-energize the D5294S.
The following table shows the behaviour of the Load connected on pins 13,14 of D5294S, based on the status of the Input from PLC of D5091S

| D5091S PLC Input (pins 1,2) | D5294S Power (pins 1,2) | D5294S Load (pins 13,14) |
|---|---|---|
| OFF | ON | ENERGIZED |
| ON | OFF | DE-ENERGIZED |

The D5091S is therefore able to invert the functionality of the D5294S.

## 3. SIL considerations

The safety function analysis of the system is the following:

1) **D5091S:**
- (NE) Normally Energized (at TB 1 & 2) with open output contact (at TB 9 & 10);
- De-energized in Safe State or Trip (at TB 1 & 2) with closed output contact (at TB 9 & 10);
- $\lambda du$ = 1.60 FIT ;
  $\lambda su$ = 400.40 FIT ;
  SFF = 99.60% ;
  PFDavg (1 year) = 7.01 E-06 ;
  MTBF (Safety Func.) = 284 years;
- 1oo3 internal parallel relay architecture (with HFT = 2) permits to reach **SIL 3 value up to 10 years**.

2) **D5294S** (specific analysis for ND load with ND relay condition):
- (ND) Normally De-energized (at TB 1 & 2, because D5091S output contact is open) with open output contacts and (ND) Normally De-energized load (at TB 13 & 14);
- Energized in Safe State or Trip (at TB 1 & 2, because D5091S output contact is closed) with closed output contacts and Energized load (at TB 13 & 14);
- $\lambda du$ = 8.72 FIT ;
  $\lambda su$ = 507.28 FIT ;
  SFF = 98.31% ;
  PFDavg (1 year) = 3.82 E-05 ;
  MTBF (Safety Func.) = 221 years;
- $\lambda$ not part (diagnostic circuit) = 740 FIT ;
  MTBF (Total including "not part" of diagnostic circuit) = 91 years;
- 1oo2 internal parallel + series relay architecture (with HFT = 1) allows the reaching
  **SIL 2 value up to 20 yrs**.

3) **Total System D5091S + D5294S**:
- (NE) Normally Energized (at TB 1 & 2 of D5091S) with D5294S open output contacts and (ND) Normally De-energized load (at TB 13 & 14 of D5294S);
- De-energized in Safe State or Trip (at TB 1 & 2 of D5091S) with D5294S closed output contacts and Energized load (at TB 13 & 14 of D5294S);
- $\lambda du$ tot = 10.32 FIT ;
  $\lambda su$ tot = 907.68 FIT ;
  SFF tot = 98.88% ;
  PFDavg tot (1 year) = 4.52 E-05 ;
  MTBF tot (Safety Func.) = 124 years;
- $\lambda$not part tot (diagnostic circuit) = 740 FIT ;
  MTBF (Total including "not part" of diagnostic circuit) = 69 years;
- D5091S + D5294S system reaches **SIL 2 value (limited by D5294S) up to 20 years**, supposing
  D5091S + D5294S system contributes 10% of entire SIF:
  - PFDavg tot (20 years) = 9.04 E-04 < 1 E-03 = 10% of 1 E-02 (SIL 2 limit of SIF).

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| APN0032-0 D1093S SIL 3 Relays in ND condition with diagnostic for both lines: voltage Supply and Load current | Page 4 of 4 |
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