# PI-EX-SD-21-25

## Ex-i solenoid driver for Group IIC gases, loop-powered, pluggable

## INTERFACE

Data Sheet
103211_00_en



## 1 Description

The solenoid driver **PI-EX-SD-21-25** links a signaling device installed in the safe area to a device located in the hazardous area. The block itself is installed outside the hazardous area or in Zone 2.

Solenoid valves, alarm modules, or other intrinsically safe devices can be connected, and simple electrical equipment such as LEDs can be operated.

The safety data allows loads to be operated in an IIC group gas.

The solenoid driver PI-EX-SD-21-25 does not require its own power supply; instead, it is simply looped into the circuit.

### 1.1 Properties

- Single-channel
- Loop-powered
- Output [Ex ia] IIC
- Installation in Zone 2
- Electrical 2-way isolation
- SIL 3 acc. to IEC 61508

**The device is associated equipment, which is suitable for use in Zone 2, provided that particular conditions have been observed.**

When installing and operating the device, the applicable safety directives (including national safety directives), accident prevention regulations, as well as general technical regulations, must be observed.

**Observe the safety regulations and installation notes on page 4.**

Make sure you always use the latest documentation.
It can be downloaded at www.download.phoenixcontact.com.

A conversion table is available on the Internet at
www.download.phoenixcontact.com/general/7000_en_00.pdf.

This data sheet is valid for all products listed on the following page:

## Table of Contents



## 2 Ordering Data

**Ex Solenoid Driver**

| Description | Type | Order No. | Pcs./Pck. |
|---|---|---|---|
| Ex-i solenoid driver for Group IIC gases, loop-powered, pluggable | PI-EX-SD-21-25 | 2865201 | 1 |

**Accessories**

| Description | Type | Order No. | Pcs./Pck. |
|---|---|---|---|
| Motherboard | See "INTERFACE" catalog | | |
| Ex basic terminal block for intrinsically safe signals with knife disconnection and test connections | PI-EX-TB | 2835901 | 10 |
| Intrinsically safe basic terminal block, with knife disconnection, test connections, and surge protection, for mounting on NS 35/7,5 | TT-PI-EX-TB | 2858386 | 10 |
| Basic terminal block for **non**-intrinsically safe signals, **with** surge protection | TT-PI-TB | 2858373 | 10 |
| Basic terminal block for **non**-intrinsically safe signals, **without** surge protection | PI-TB | 2835943 | 10 |
| Continuous plug-in bridge, 500 mm long, insulated, can be cut to length, for potential distribution, $I_{max}$ = 32 A, color of the insulating material: | | | |
| Red | FBST-500-PLC-RD | 2966786 | 20 |
| Blue | FBST-500-PLC-BU | 2966692 | 20 |
| Gray | FBST-500-PLC-GY | 2966838 | 20 |

For additional accessories, please refer to the "INTERFACE" catalog from Phoenix Contact.

## 3 Technical Data

| Input | |
|---|---|
| Input signal | 20 V DC - 30 V DC |

| Output | |
|---|---|
| Output characteristic curve (see Figure 1 on page 3) | $U_V$ = 21.9 V (guaranteed voltage)<br>$R_i$ = 654 Ω (internal resistance) |
| Output voltage, intrinsically safe | 5.5 V at 25 mA |
| Current limit | At 25 mA |

### Output characteristic curve

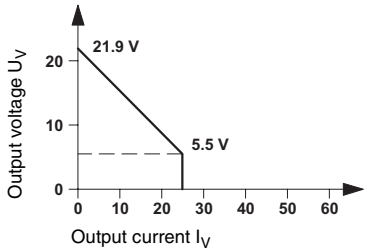


Figure 1 Output characteristic curve for PI-EX-SD-21-25

| General Data | |
|---|---|
| Supply voltage range | (No separate supply voltage necessary) |
| Maximum current consumption at 24 V DC | 130 mA |
| Maximum power dissipation at 24 V DC | 0.9 W |
| Electrical isolation (input/output) | 375 V (peak value according to EN 50020) |
| Housing material | PBT and polyamide PA non-reinforced |
| Inflammability class according to UL 94 | V0 |
| Degree of protection | IP20 |
| Color | Green |
| Dimensions | |
| Without basic terminal block (width x height)<br>With basic terminal block (width x height x length) | 12.4 mm x 108.6 mm<br>12.4 mm x 147 mm x 145 mm |

| Ambient Conditions | |
|---|---|
| Ambient temperature (operation) | -20°C - +55°C (perpendicular mounting of DIN rail)<br>-20°C - +60°C (horizontal mounting of DIN rail) |
| Average temperature according to IEC 61508 | 40°C |
| Ambient temperature (storage/transport) | -40°C - +80°C |
| Permissible humidity (operation) | 10% - 95% (relative humidity, no condensation) |

| Indicators | |
|---|---|
| Status indicator | Yellow LED (switching state)<br>Red LED (line fault) |

| EU Conformity | |
|---|---|
| Complies with EMC directive 89/336/EEC | Yes |
| Ex directive (ATEX) | Yes |

| Safety Data According to ATEX for Intrinsically Safe Circuits | | | |
|---|---|---|---|
| Maximum output voltage $U_o$ | 25.1 V | | |
| Maximum output current $I_o$ | 39 mA | | |
| Maximum output power $P_o$ | 245 mW | | |
| Gas group | IIA | IIB | IIC |
| Max. external inductance $L_o$<br>Max. external capacitance $C_{o'}$ | 20 mH<br>0.66 µF | 5 mH<br>0.43 µF | 0.5 mH<br>0.093 µF |
| True r.m.s. value of maximum AC voltage $U_m$<br>Maximum DC voltage $U_m$ | 250 V AC<br>125 V DC | | |

| Certificates | |
|---|---|
| ATEX | Ⓔx II (1) GD [EEx ia] IIC/IIB/IIA, TÜV 06 ATEX 553193<br>Ⓔx II 3 G Ex nA II T4 X |
| UL/CUL | UL applied for |

# 4 Safety Regulations and Installation Notes

## 4.1 Installation and Operation

Follow the installation instructions.

Installation, operation, and maintenance may only be carried out by qualified specialist personnel.

When installing and operating the device, the applicable safety directives (including national safety directives), accident prevention regulations, as well as general technical regulations, must be observed.

Access to the circuits within the device is prohibited.

Do not repair the device yourself, but replace it with an equivalent device. Repairs may only be carried out by the manufacturer.

The device is suitable for IP20 degree of protection if:

– It is installed outside the potentially explosive area.
– The area around the device is clean and dry.

Install the device in a suitable housing with a suitable degree of protection in accordance with IEC 60529 in order to protect it from mechanical and electrical damage.

## 4.2 Safety Regulations for Installation in the Potentially Explosive Area

### Regulations for Intrinsically Safe Circuits

**WARNING: Risk of explosion**
When taking **measurements** on the intrinsically safe side, it is imperative that you observe the relevant regulations regarding the connection of intrinsically safe equipment.

**Only use equipment approved for intrinsically safe circuits.**

**WARNING: Risk of explosion**
If the **device has been used in non-intrinsically safe circuits,** it must **not** be used again in intrinsically safe circuits.

Clearly label the module as being non-intrinsically safe.

The safety data may be derived from the operating instructions and the certificates (EC type examination certificate; additional certificates if necessary).

### Installation in Zone 2

**WARNING: Risk of explosion**
The device is associated equipment of the "intrinsic safety" protection type, and is suitable for installation in Zone 2 if the Ex symbol is printed on the block.

Observe the specified conditions for use in potentially explosive areas.

**WARNING: Risk of explosion**
Install the device in a suitable **housing with a minimum of IP54 degree of protection**.
Within this context, observe the requirements of IEC 60079-14/EN 60079-14, e.g., steel housing with a wall thickness of 3 mm.

**WARNING: Risk of explosion**
Disconnect the block **before** you:

– Snap it on or remove it.
– Connect or dismantle cables for non-intrinsically safe circuits.

**WARNING: Risk of explosion**
Only use Category 3G PI-EX modules (ATEX 94/9/EC).

### Installation in Areas With a Danger of Dust Explosions

**WARNING: Risk of explosion**
The device is **not** designed for use in areas where there is a danger of dust explosions.

Connection to **intrinsically safe circuits in areas with a danger of dust explosions** (Zones 20, 21, or 22) is **only** permitted if the equipment connected to this circuit is approved for these zones (e.g., Category 1D, 2D, or 3D).

## 4.3 Use in Safety-Related Applications (SIL 3)

When using the PI-EX-SD-21-25 in safety-related applications, observe the instructions in Section 9, as the requirements differ for safety-related functions.

# 5 Structure

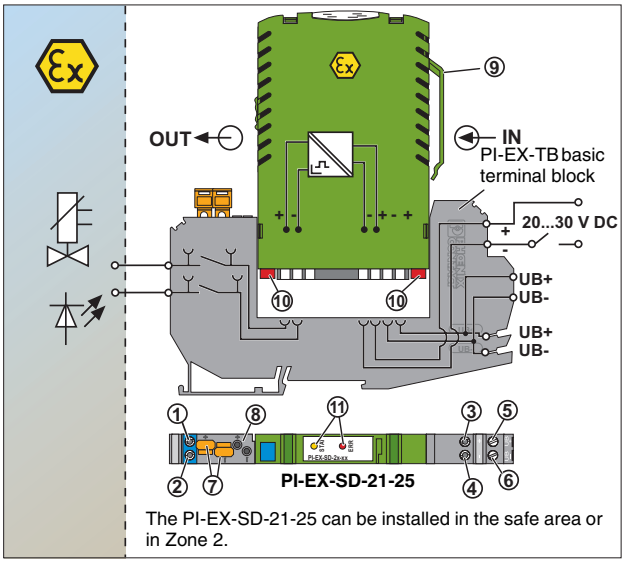


Figure 2 Structure

① Output "+"
② Output "–"
③ Input signal "+"
④ Input signal "–"
① – ④ Terminal screw with integrated test socket
⑤ ⑥ Not used
⑦ Isolating connectors
⑧ Test sockets
⑨ Locking clips
⑩ Keying pin
⑪ Status indicators

**Dimensions**

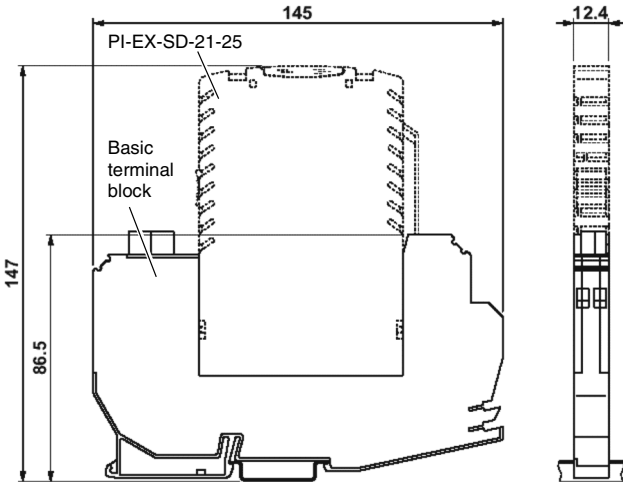


Figure 3 Dimensions (in mm)

# 6 Installation

**Electrostatic discharge**

The device contains components that can be damaged or destroyed by electrostatic discharge. When handling the device, observe the necessary safety precautions against electrostatic discharge (ESD) according to EN 61340-5-1 and EN 61340-5-2.

**WARNING: Risk of explosion**
When being used as equipment in **Zone 2**, the electronic module must **not be disconnected** from the base element while it is still **live**.

Connecting and disconnecting cables for non-intrinsically safe circuits **is only permitted if they are not live**.

## 6.1 Base Elements

The device is designed for installation in the control cabinet and must be plugged into a base element (basic terminal block, electronics base, or motherboard). Incorrect connection of the electronic module is prevented by a keyway in the base element and bars in the housing. A locking clip ⑨ is provided in order to prevent accidental removal. To remove the electronic module, gently press the locking clip towards the housing; it can then be removed.

**WARNING: Risk of explosion**
If the **device has been used in non-intrinsically safe circuits,** it must **not** be used again in intrinsically safe circuits.

Clearly label the module as being non-intrinsically safe.

| | |
|---|---|
| Connection cross section (solid and stranded): | 0.2 $mm^2$ - 2.5 $mm^2$ |
| Tightening torque: | 0.5 Nm - 0.6 Nm |

### 6.2 Automatic Keying of the Electronic Modules

The base element is not keyed upon delivery. The user-friendly keying is located in the electronic module and consists of four plastic parts, which are joined together. The first time the electronic module is removed, the bottom part of the keying pins (⑩ in Figure 2 on page 5) remains in the base element. In this way, it is automatically keyed to the relevant electronic module.

If an electronic module is accidentally inserted in the wrong place, any plastic parts remaining in the base element can be removed using a screwdriver.

| Automatic keying | Electronic module | | Base element | |
|---|---|---|---|---|
| | View from below (locking clip to the right) | | View from above (isolating connector to the left) | |
| | Input | Output | Input | Output |
| PI-EX-SD-21-25 | △ | ▽ | ▽ | △ |

## 7 Comparison of Safety Data

Compare the safety data before connecting a device in the Ex-i area to the PI-EX-SD-21-25. Please also observe the internal capacitance and inductance of the base elements.

Safety data of the

| | |
|---|---|
| Field devices: | $U_i$, $I_i$, $P_i$, $L_i$, $C_i$ |
| Solenoid driver: | $U_o$, $I_o$, $P_o$, $L_o$, $C_o$ |
| Base elements: | $L_{iB}$, $C_{iB}$, |

For the values for $U_o$, $I_o$, $P_o$, $L_o$ , and $C_o$, please refer to "Safety Data According to ATEX for Intrinsically Safe Circuits" on page 3.

**Capacitances and Inductances of Base Elements**

| | PI-EX-TB PI-EX-TB/T | TT-PI-EX-TB TT-PI-EX-TB/T | Motherboards Electronics bases |
|---|---|---|---|
| $L_{iB}$ | 1 µH | 1 µH | 0 µH |
| $C_{iB}$ | 1 nF | 3 nF | 0 nF |

**Ex i Prerequisites:**

$U_i \geq U_o$
$I_i \geq I_o$
$P_i \geq P_o$
$L_i + L_c + L_{iB} \leq L_o$ ($L_c$ and $C_c$ are dependent on the
$C_i + C_c + C_{iB} \leq C_o$ cables/lines used.)

## 8 Calculation of a Valve Circuit

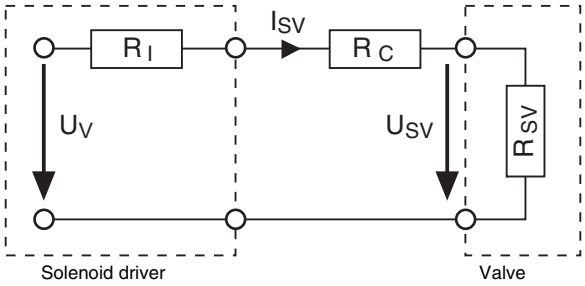


Figure 4 Equivalent circuit

In order to connect a solenoid valve to the device, it is necessary to compare the safety data and calculate the measurements.

- $R_i$: Internal resistance of solenoid driver
- $U_V$: Guaranteed voltage of the solenoid driver without load
- $I_V$: Maximum current that can be supplied by the solenoid driver
- $R_C$: Maximum permissible conductor resistance when connecting the solenoid driver and valve
- $R_{SV}$: Effective coil resistance of the solenoid valve (the copper resistance of the coil depends on the temperature)
- $I_{SV}$: The current required by the solenoid coil so that the valve can close tightly
- $U_{SV}$: The voltage which is applied across the coil with $I_{SV}$

$R_{SV}$ and $U_{SV}$ are dependent on the ambient temperature due to the copper resistance.

The values of $R_{SV}$ and $I_{SV}$ must be found out from the valve manufacturer. The values for $R_i$ and $U_V$ can be found in the technical data under "Output" on page 2.

On the basis of this, the permissible conductor resistance can be calculated according to the formula below:

$$R_C = \frac{U_V}{I_{SV}} - R_i - R_{SV}$$

Recommendation:

For $R_C$, the actual conductor resistance +25 Ω is to be calculated.

Where negative resistance occurs, it is no longer possible to guarantee that the connection will function.

Function prerequisites: $I_V \geq I_{SV}$ and $R_C > 0\ \Omega$.

You can obtain a list of suitable valves from the Download Center at www.download.phoenixcontact.com.

# 9 Safety-Related Applications (SIL 3)

## 9.1 Installation

Use one of the following base elements:

– PI-EX-TB... basic terminal block
– TT-PI-EX-TB... basic terminal block or
– PI-EX-MB... motherboard

## 9.2 Response Times

Following a state change at the input, the output enters the safe state in ≤ 40 ms.

## 9.3 Operating Mode of the Safety Function

Operating mode according to IEC 61508: "Low demand mode"

## 9.4 Failure Behavior and Required Response

1. The safe state is entered in the event of an input voltage failure.
2. The safe state is reached by removing the device from the base element.

## 9.5 Safety Integrity Requirements

### Error Rates

– Type A device (according to IEC 61508-2)
– Safety Integrity Level (SIL) 3

| $\lambda_{SAFE}$ | $\lambda_{DANGEROUS}$ | SFF[1] | $DC_S$[2] | $DC_D$[2] |
|---|---|---|---|---|
| 284 FIT[3] | 0 FIT | 100% | 0% | 0% |

[1] SFF = Safe Failure Fraction

[2] DC = Diagnostic coverage (safe or dangerous)

[3] FIT = Failure in Time (1 FIT = 1 failure/$10^9$ h)

### $PFD_{AVG}$ Values

| T[PROOF] = | 1 year | 5 years | 10 years |
|---|---|---|---|
| $PFD_{AVG}$[1] = | 0 | 0 | 0 |

[1] PFD = Probability of Failure on Demand

Since the $PFD_{AVG}$ value is 0, it is not necessary to perform regular Proof Tests; however, this is still recommended (see Section 9.6).

### Failure Limit

The operating mode is based on low demand mode. The percentage of the device at PFH/PFD for the overall safety loop is less than 10%.

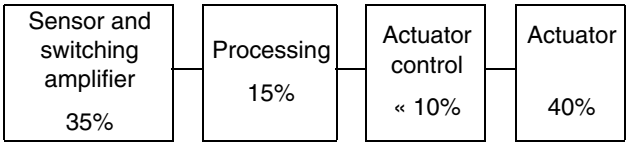


Figure 5 Safety loop

### Conditions

– The failure rates of the components used remain constant throughout the period of use.
– Propagation of errors by the device in the system is not taken into consideration.
– The repair time (= replacement) should take eight hours.
– The failure rates of the external signaling device are not taken into consideration.
– The average temperature at which the device is to be used is +40°C. This is based on standard industrial conditions.

## 9.6 Proof Test

Even where the $PFD_{AVG}$ value is 0, it is still recommended that you check the function of the valve burner in conjunction with the entire safety loop.

1. Take appropriate steps to prevent incorrect use. Prevent other areas of the system from being affected by the Proof Test (e.g., set the control system to test mode).
2. When a voltage of between 20 V and 30 V is applied at the input, check whether a voltage of > 0 can be measured at the output terminal blocks. The field device must switch at the same time.
3. Restore the safety circuit to full functionality.
4. Return to normal operation.

# 10 Appendix

Exida Assessment Summary (3 pages)


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# Failure Modes, Effects and Diagnostic Analysis

Project:
Solenoid Driver with Motherboard

Customer:

Phoenix Contact GmbH & Co. KG
Blomberg
Germany

Contract No.: Phoenix Contact 06/06-05
Report No.: Phoenix Contact 06/06-05 R004
Version V2, Revision R0, January 2008
Philipp Neumeier

## Management summary

This report summarizes the results of the hardware assessment carried out on the solenoid drivers type PI-EX-SD-**-** with a corresponding motherboard and on the solenoid drivers with top hat rail design, MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP.

Table 1 gives an overview of the different devices. Within each type the different devices have the same circuit diagram.

**Table 1: Device overview**

| Motherboard type: | Top hat rail type: | Output values: |
|---|---|---|
| PI-EX-SD-21-25 | MACX MCR-EX-SL-SD-21-25-LP / MACX MCR-EX-SL-SD-21-25-LP-SP | 21 V / 25 mA |
| PI-EX-SD-21-40 | MACX MCR-EX-SL-SD-21-40-LP / MACX MCR-EX-SL-SD-21-40-LP-SP | 21 V / 40 mA |
| PI-EX-SD-21-45 | MACX MCR-EX-SL-SD-21-45-LP / MACX MCR-EX-SL-SD-21-45-LP-SP | 21 V / 45 mA |
| PI-EX-SD-24-48 | MACX MCR-EX-SL-SD-24-48-LP / MACX MCR-EX-SL-SD-24-48-LP-SP | 24 V / 48 mA |
| PI-EX-SD-21-60 | MACX MCR-EX-SL-SD-21-60-LP / MACX MCR-EX-SL-SD-21-60-LP-SP | 21 V / 60 mA |

The hardware assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMEDA). A FMEDA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMEDA, failure rates are determined and consequently the Safe Failure Fraction (SFF) is calculated for the device. For full assessment purposes all requirements of IEC 61508 must be considered.

The failure rates used in this analysis are the basic failure rates from the Siemens standard SN 29500.

According to table 2 of IEC 61508-1 the average PFD for systems operating in low demand mode has to be $\geq 10^{-4}$ to $< 10^{-3}$ for SIL 3 safety functions. However, as the modules under consideration are only one part of an entire safety function they should not claim more than 10% of this range, i.e. they should be better than or equal to 1,00E-04.

The solenoid drivers type PI-EX-SD-**-** with a corresponding motherboard and the solenoid drivers with top hat rail design, MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP are considered to be Type A[1] components with a hardware fault tolerance of 0.

For Type A components the SFF has to be 90% to < 99% according to table 2 of IEC 61508-2 for SIL 3 (sub-) systems with a hardware fault tolerance of 0.

The solenoid drivers PI-EX-SD-**-** and MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP are operated in passive mode, and can therefore be regarded as loop powered modules. Because loop powered modules are directly driven from the digital output of a safety PLC there is no additional power supply which can keep the output energized in case of an internal fault. Thus all internal faults have either no effect on the safety function or lead to a safe state.

[1] Type A component: "Non-complex" component (all failure modes are well defined); for details see 7.4.3.1.2 of IEC 61508-2.

## Results for solenoid drivers PI-EX-SD-**-** with Motherboard:

The following table shows how the above stated requirements are fulfilled.

**Table 2: Summary for PI-EX-SD-**-** with Motherboard – IEC 61508 failure rates [2]**

| $\lambda_{SAFE}$ | $\lambda_{DANGEROUS}$ | SFF | $PFD_{AVG}$ |
|---|---|---|---|
| 284 FIT | 0 FIT [3] | 100% | 0,00E+00 |

## Results for top hat rail type solenoid drivers MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP:

The following table shows how the above stated requirements are fulfilled.

**Table 3: Summary for MACX MCR-EX-SL-SD-**-**-LP / MACX MCR-EX-SL-SD-**-**-LP-SP – IEC 61508 failure rates [2]**

| $\lambda_{SAFE}$ | $\lambda_{DANGEROUS}$ | SFF | $PFD_{AVG}$ |
|---|---|---|---|
| 282FIT | 0 FIT [3] | 100% | 0,00E+00 |

The above results show that the solenoid drivers PI-EX-SD-**-** with Motherboard and MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP - both when loop powered - can be used for all safety applications.

The calculations are based on the assumption that the devices are mounted in an environment that is IP 54 compliant (e.g. housing, control cabinet or control room).

The failure rates are valid for the useful life of the solenoid drivers PI-EX-SD-**-** and MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP (see Appendix 1).

[2] It is assumed that practical fault insertion tests can demonstrate the correctness of the failure effects assumed during the FMEDAs.

[3] In order to deal with the excluded faults in the quantitative analysis it might be reasonable to consider a dangerous failure rate of 0.1 FIT, leading to a SFF of 99,97% and a $PFD_{AVG}$ of 4,38E-06 for a proof time of 10 years.

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