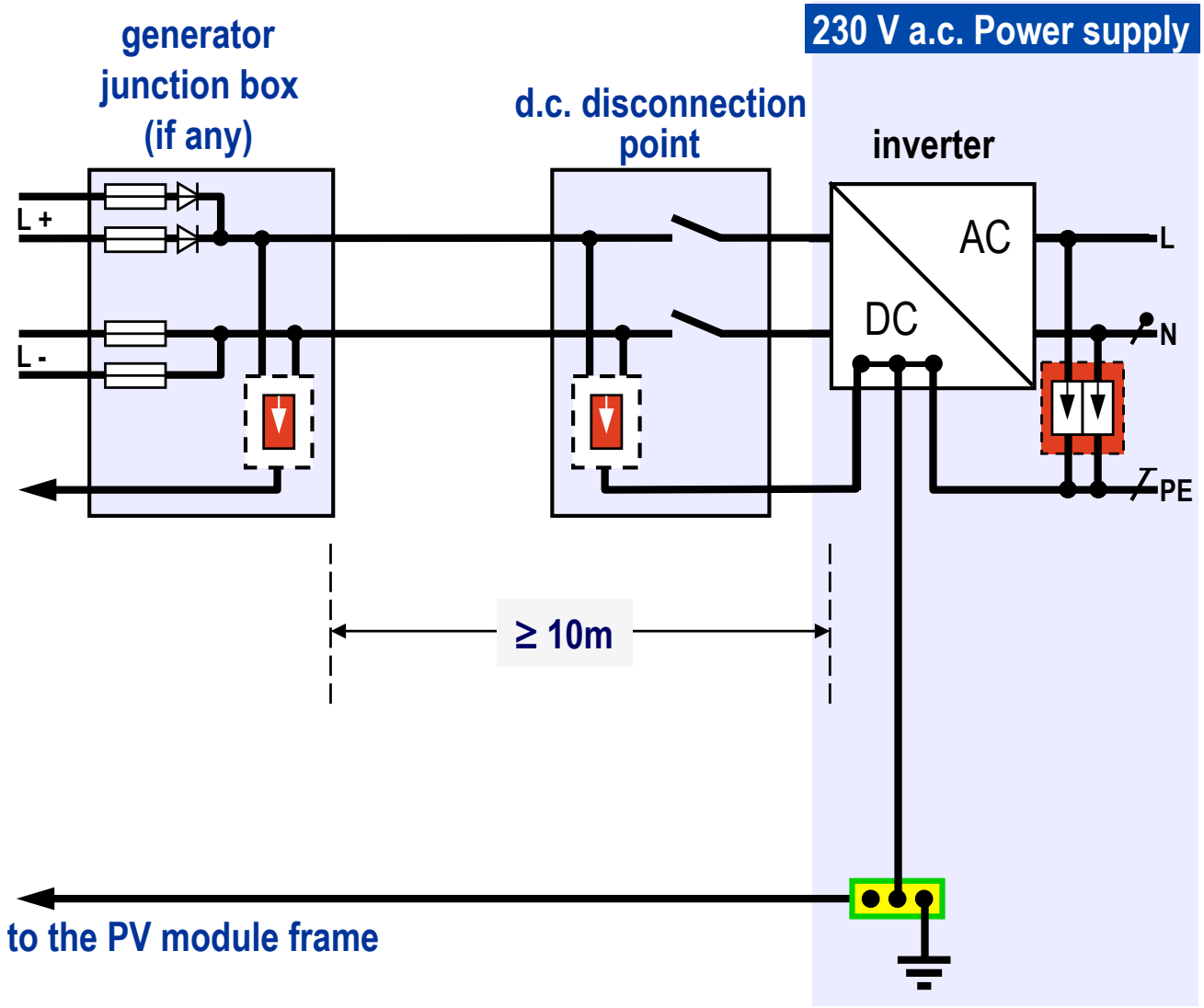
Specific requirements of Class II type SPDs installed on the DC-side of PV-generators

PV system protection against atmospheric and overvoltage surges

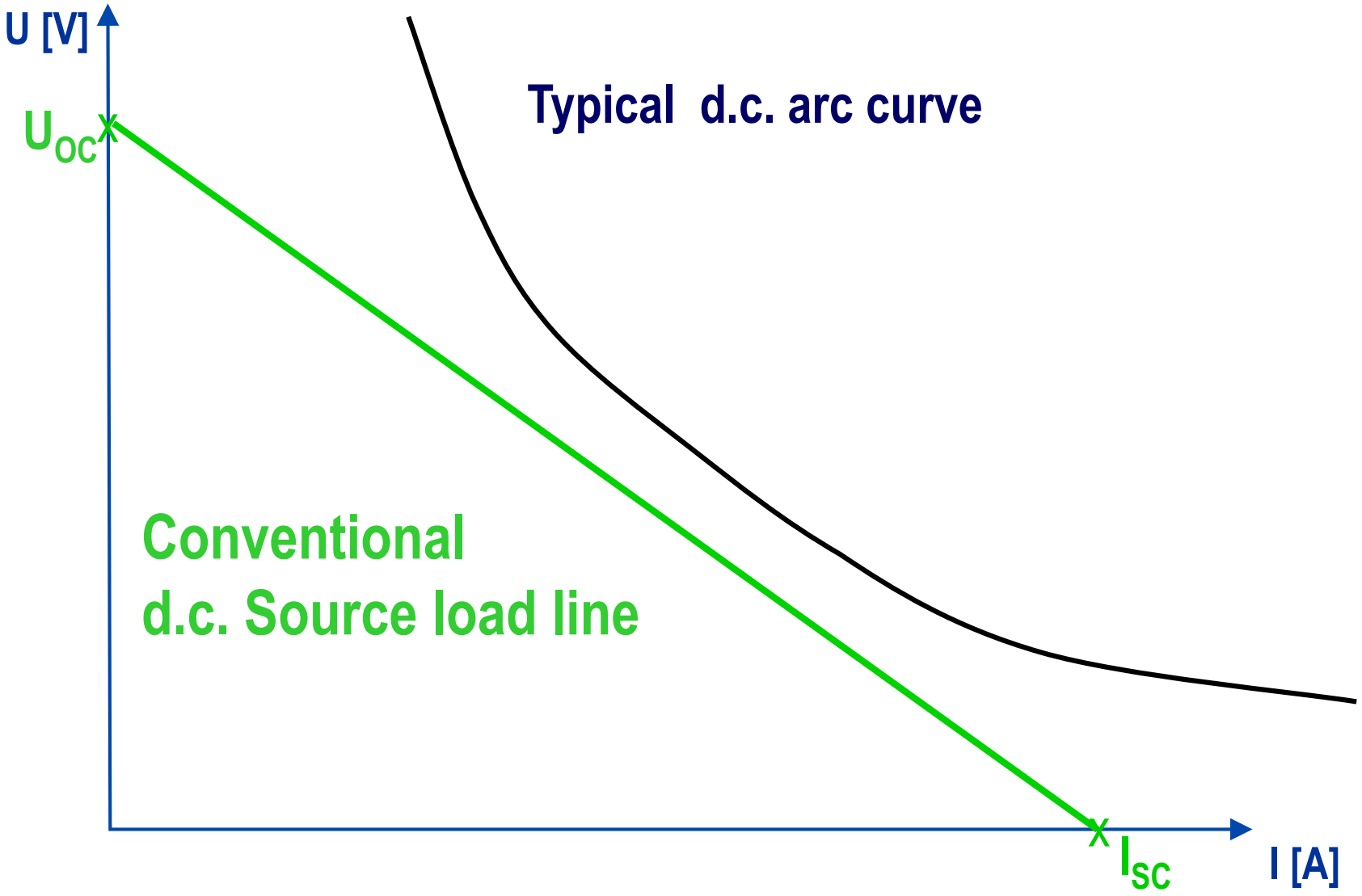


For application in PV-circuits:

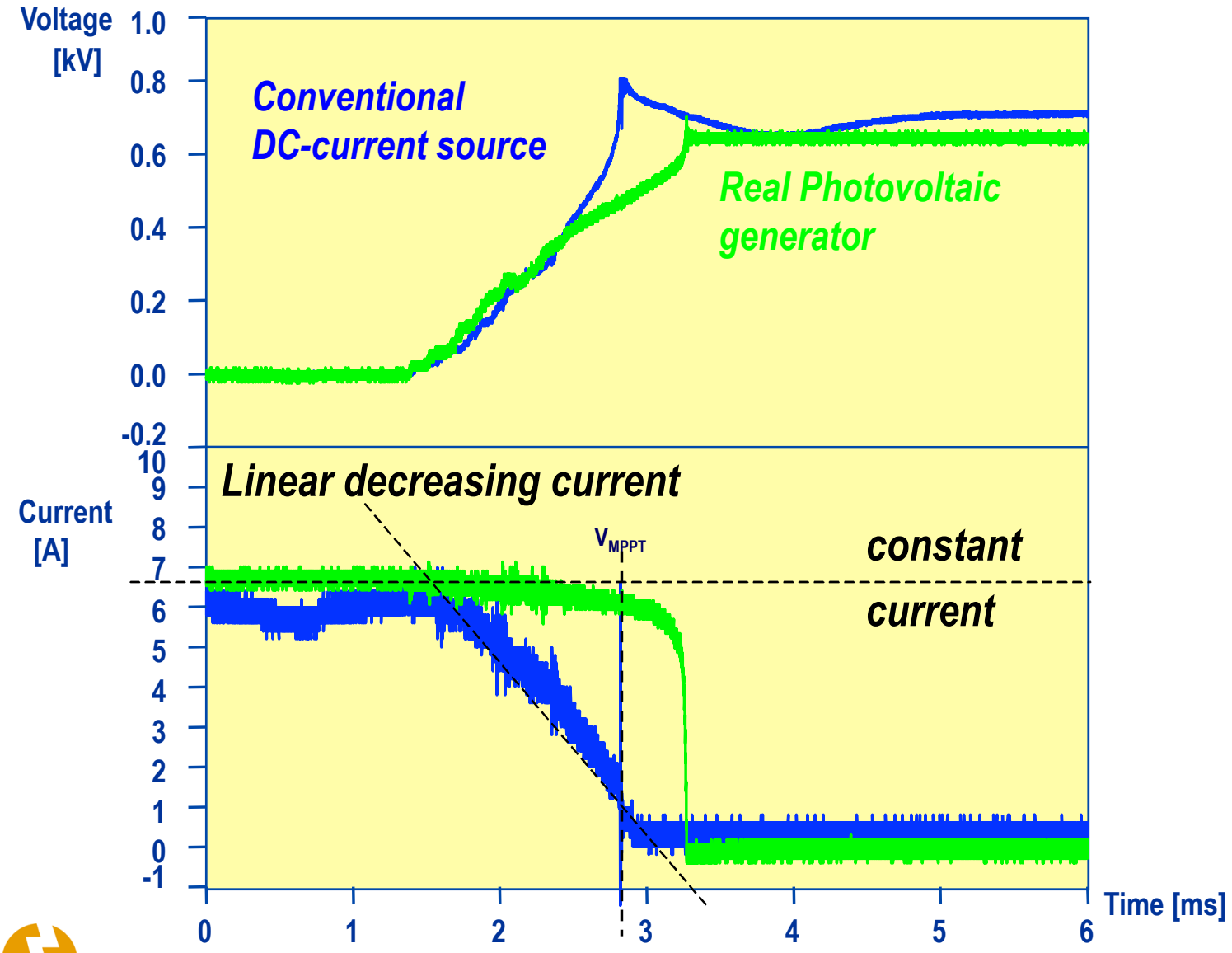
Why is the d.c arc such a problem in Surge Arrester and what can be done about it

?

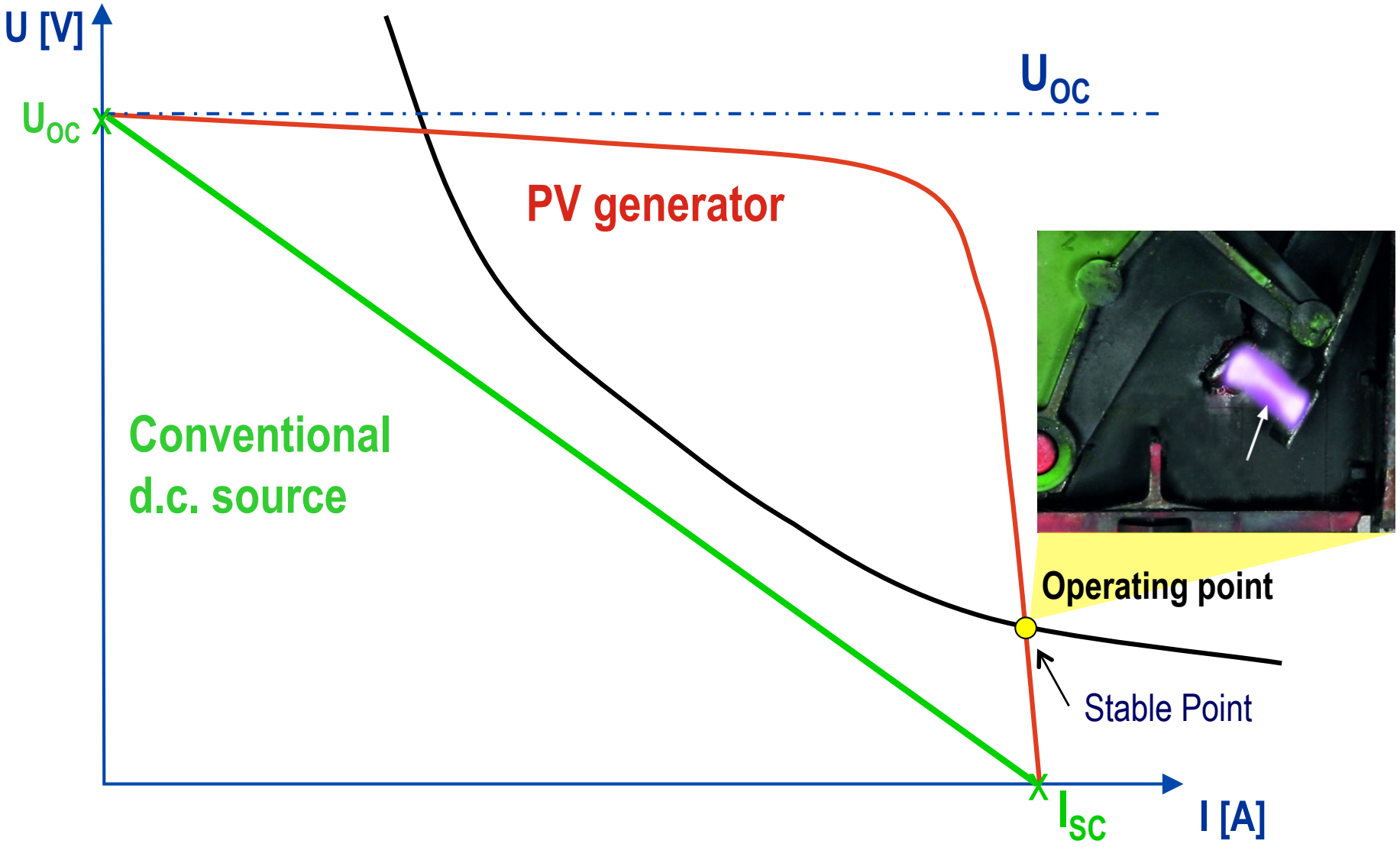
Comparison of the source characteristic of a conventional d.c. source with the characteristic of a PV generator



Comparison test of switching devices on a conventional DC-source and a real PV-generator-during switch-off

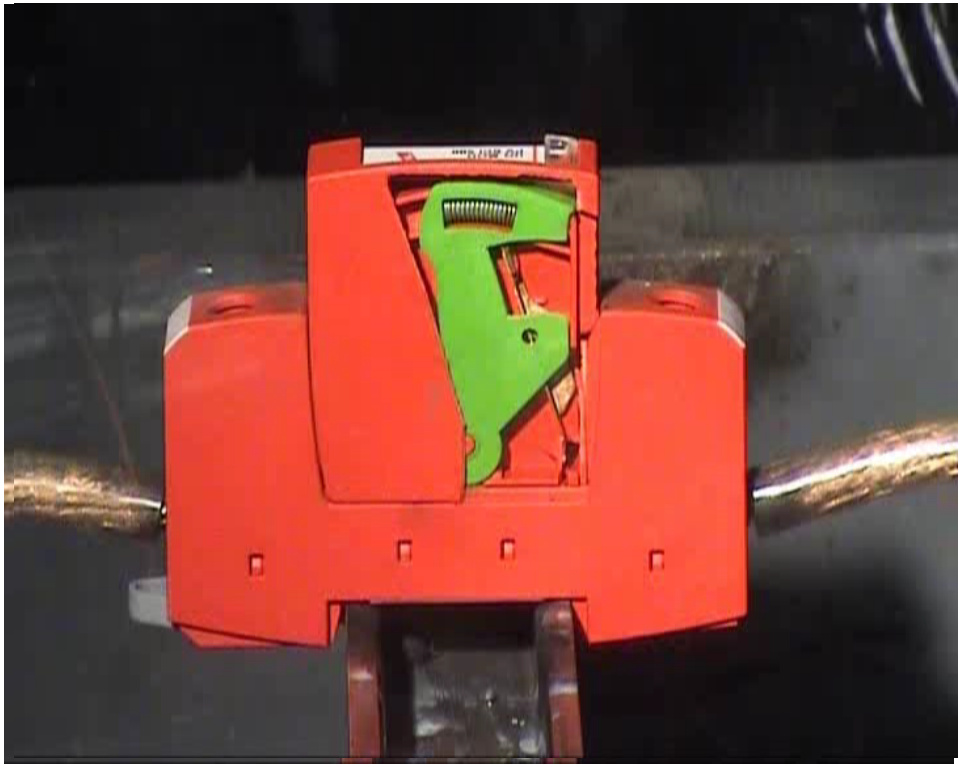


Comparison of the source characteristic of a conventional d.c. source with the characteristic of a PV generator



Surge Arrester DEHNguard®
Disconnection – 1000V / 50 A –

Conventional a.c/d.c. Surge Arrester



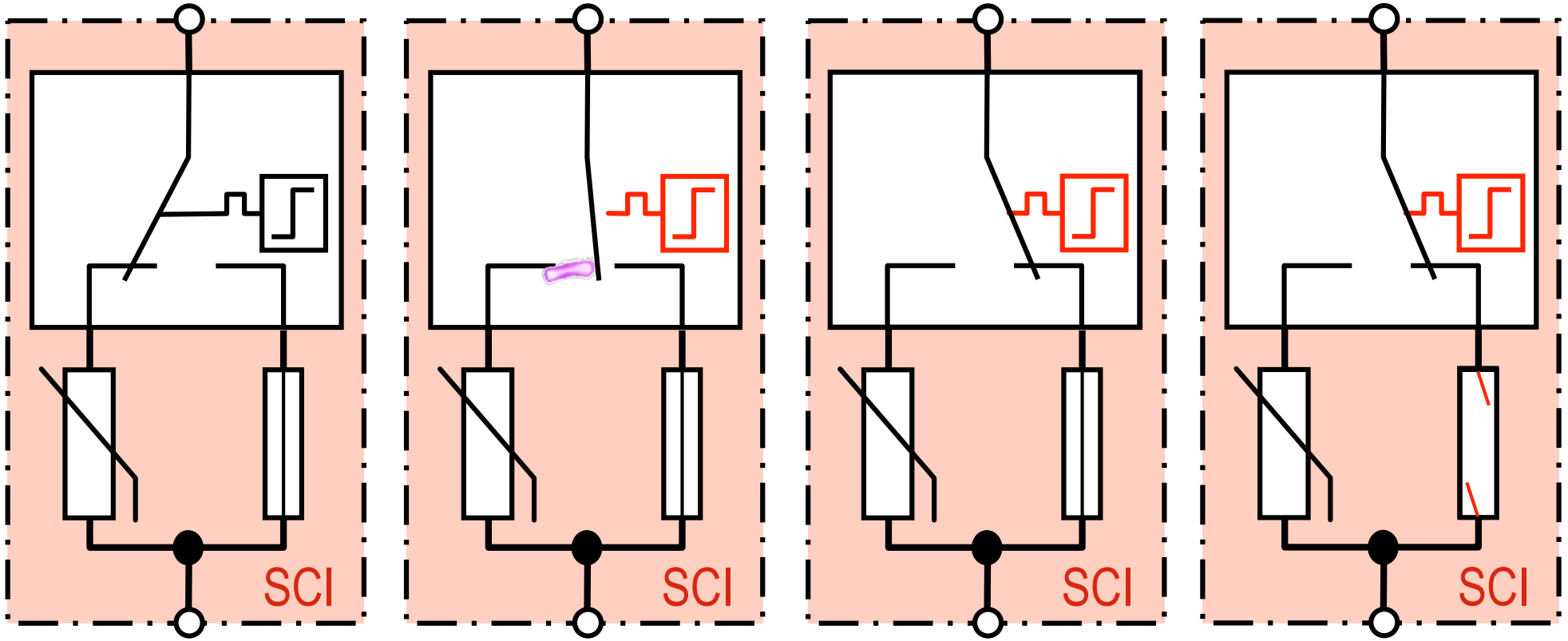
Video „Disconnection of conventional SPD“

The Solution

!

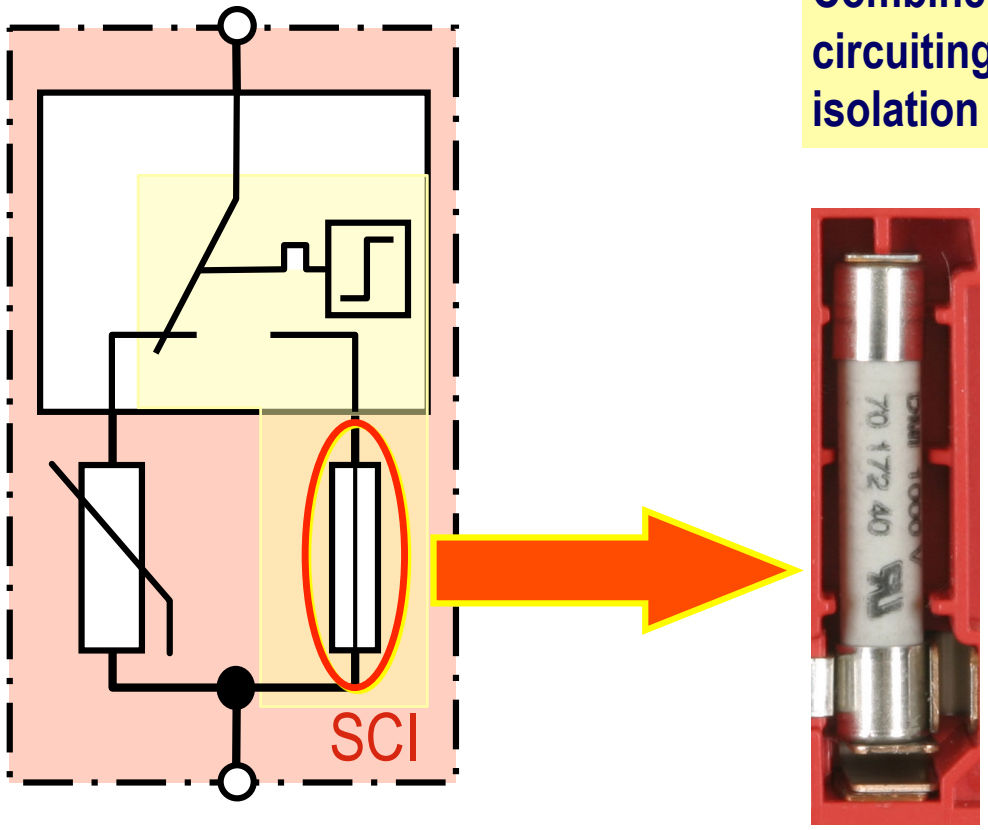
Surge Arrester DEHNguard® M YPV SCI
Switching stages or 3-step d.c. switching device

Original state	1. Response of the disconnection device	2. Arc extinction	3. Safe electrical isolation



Development of a surge protective device for PV systems with three-step d.c. switching device (SCI)

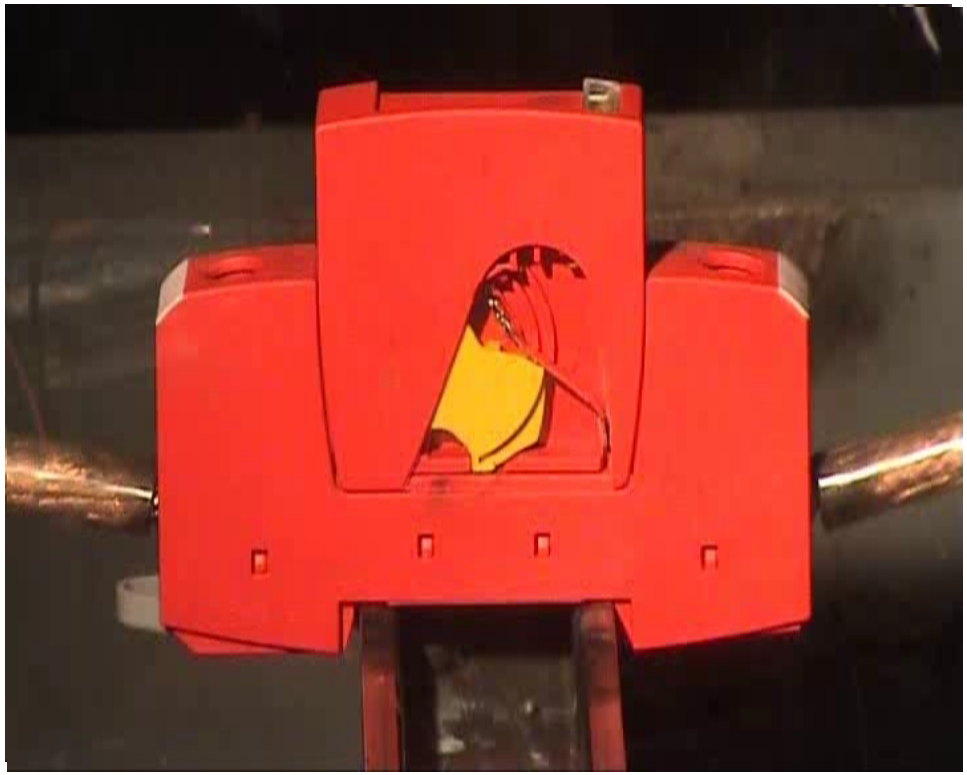
Combined disconnection and short-circuiting device with safe electrical isolation



Basic circuit diagram of a protection module, SCI with three-step d.c. switching device

Surge Arrester DEHNguard® M YPV SCI
Disconnection – 1200V / 50 A –

DEHNguard® M YPV with SCI



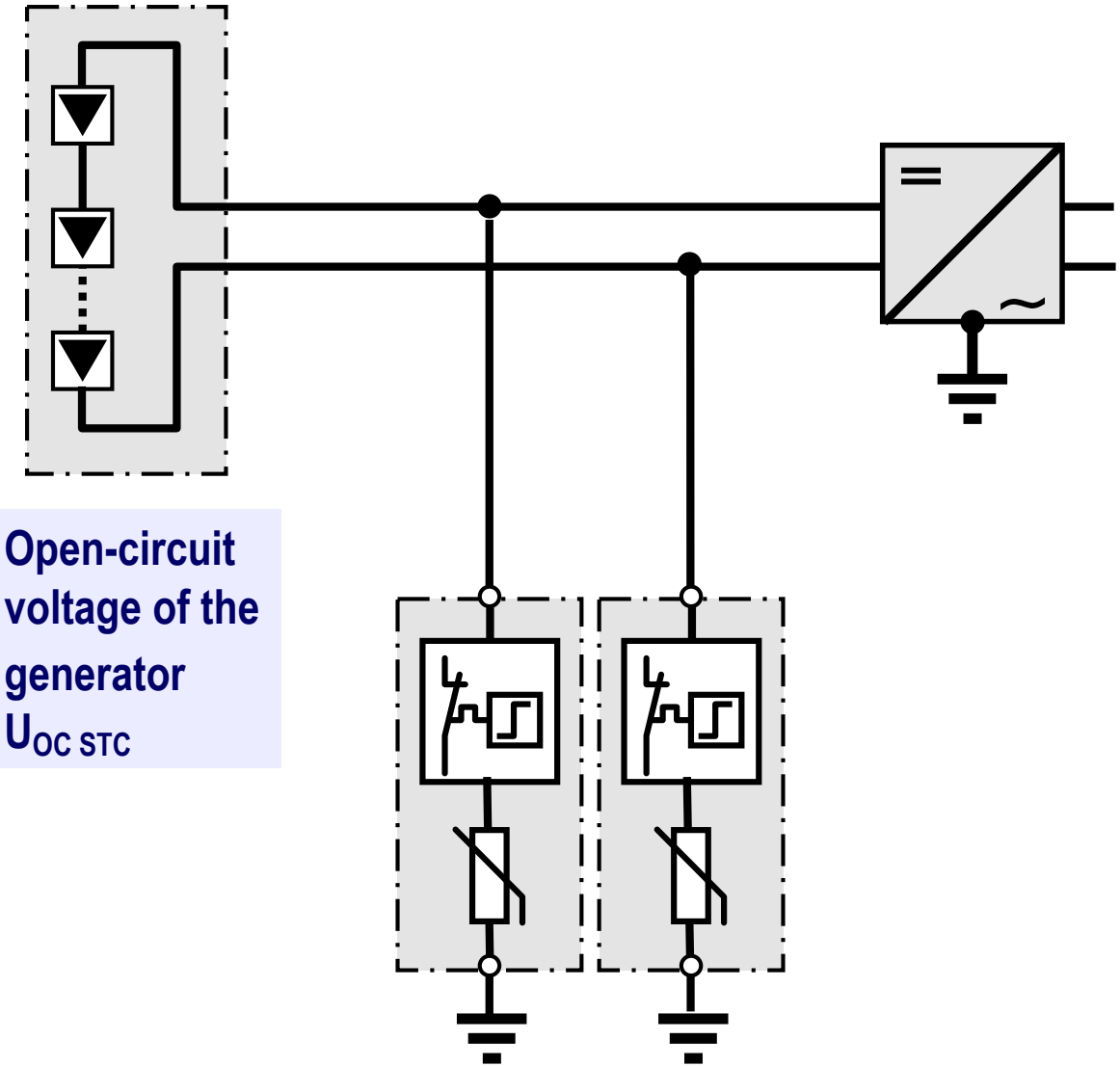
Video „Disconnection with SCI“

For application in PV-circuits:

Why conventional AC / DC SPDs solution cannot be used to solve PV d.c. problems

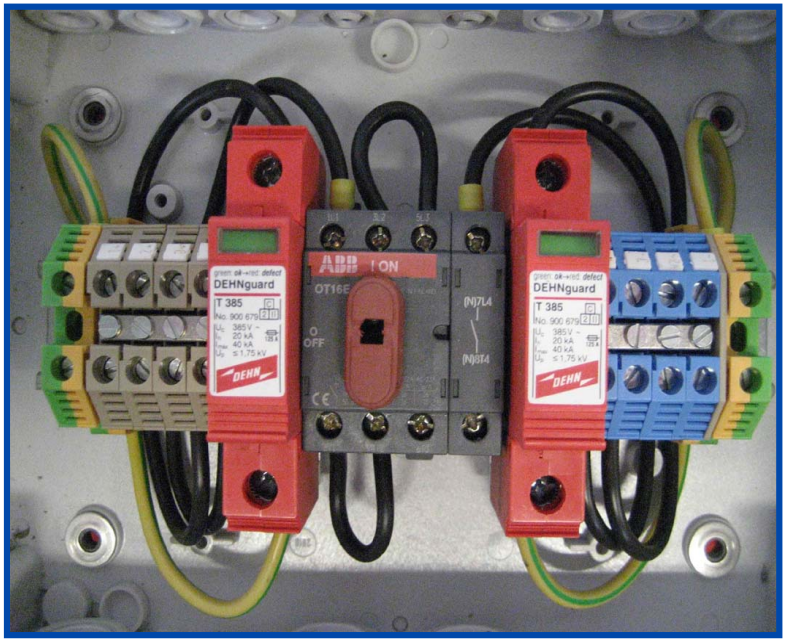
?

Selection of surge protective devices
Case 1: Type 2 SPD with $U_C \geq 0.5\ U_{OC\ STC}$ with thermal disconnection device



Open-circuit voltage of the generator $U_{OC\ STC}$

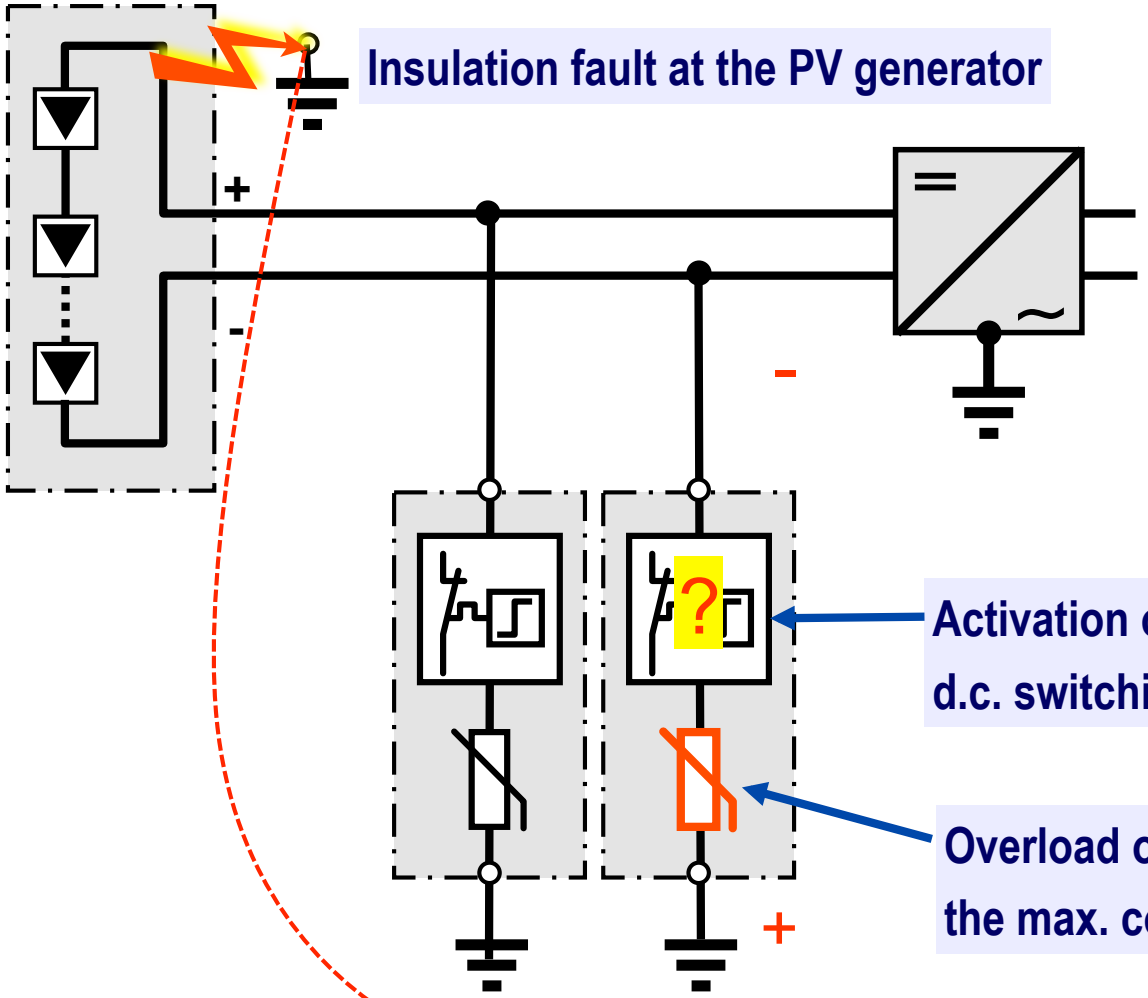
Practical example:



Performance of surge protective devices in case of overload

Case 1: Type 2 SPD with $U_C \geq 0.5\ U_{OC\ STC}$ with thermal disconnection device

Example: Insulation fault in the PV generator circuit



+/- $U_{OC\ STC}$ = 1000 V

U_c = 500 V

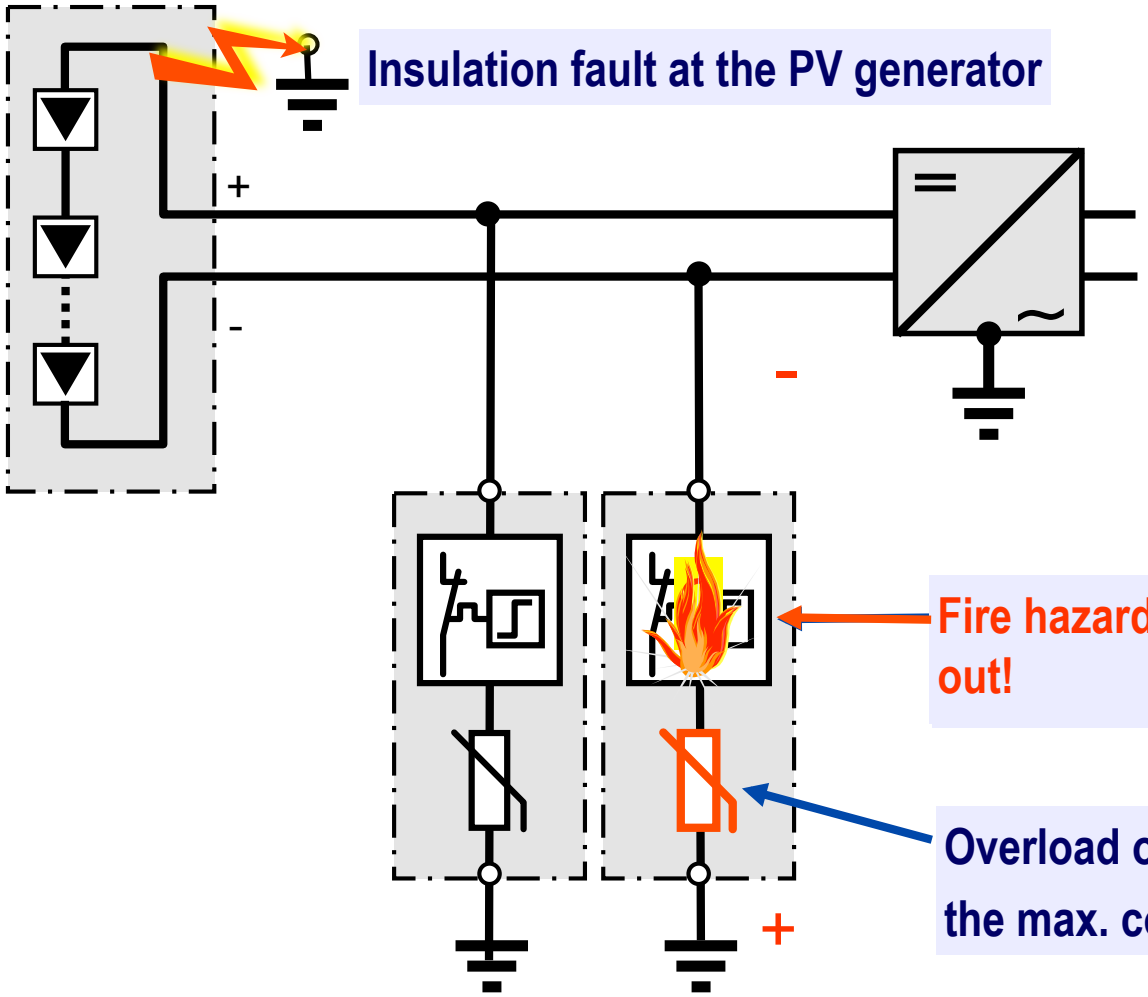
Activation of the disconnection device - limited d.c. switching capacity

Overload of the arrester due to exceeding the max. continuous operating voltage U_c of SPD

Performance of surge protective devices in case of overload

Case 1: Type 2 SPD with $U_C \geq 0.5\ U_{OC\ STC}$ with thermal disconnection device

Example: Insulation fault in the PV generator circuit



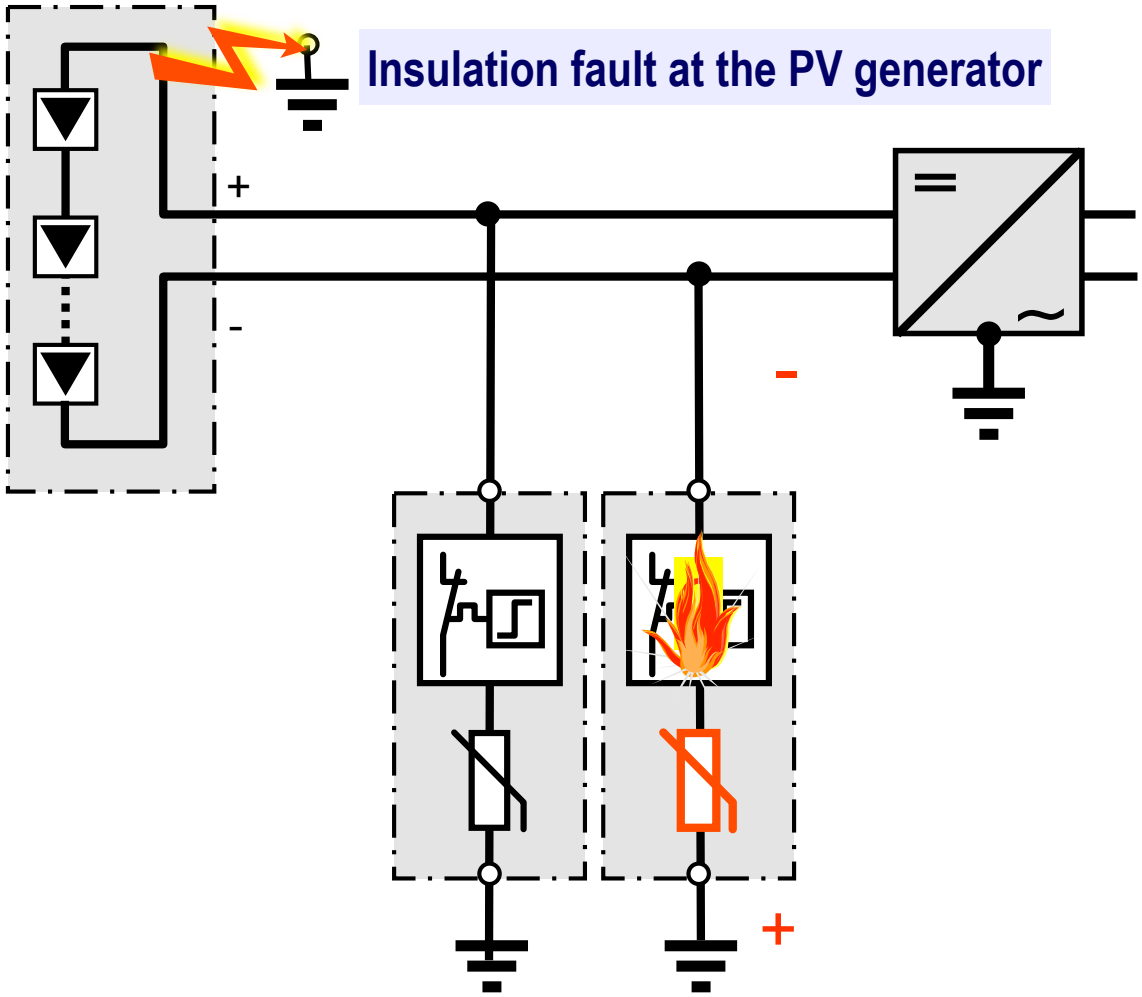
Fire hazard cannot be ruled out!

Overload of the arrester due to exceeding the max. continuous operating voltage U_c of SPD

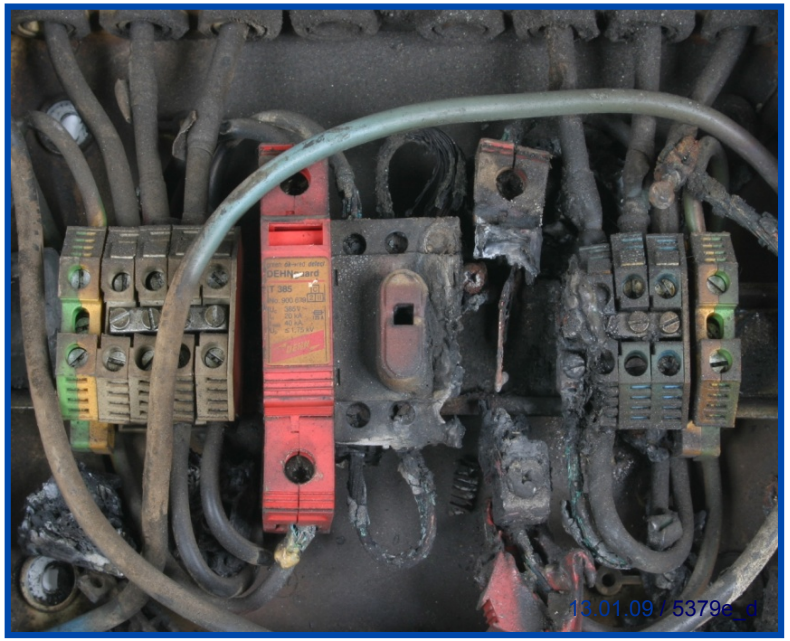
Performance of surge protective devices in case of overload

Case 1: Type 2 SPD with $U_C \geq 0.5\ U_{OC\ STC}$ with thermal disconnection device

Example: Insulation fault in the PV generator circuit

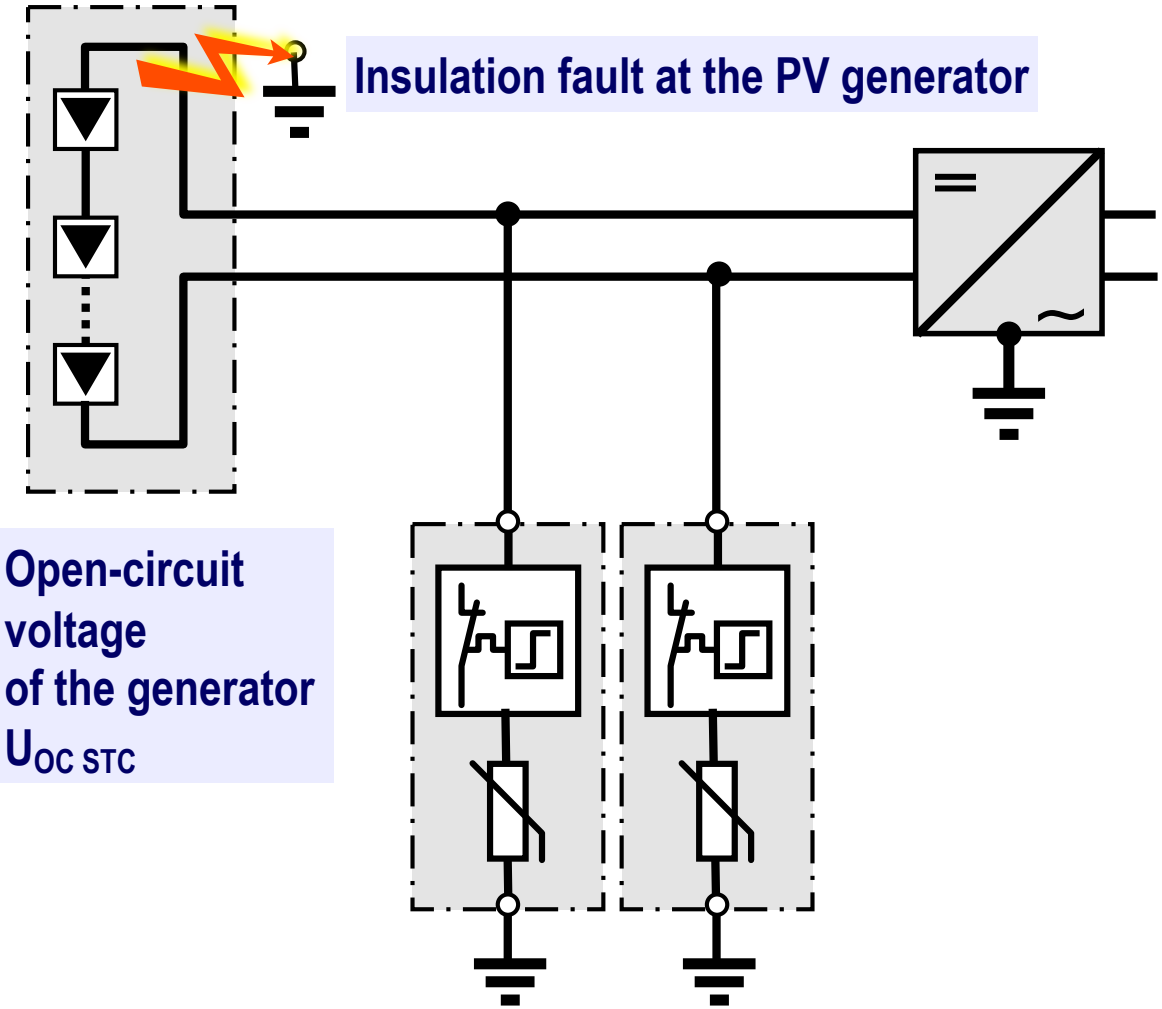


Example of damage:



Selection of surge protective devices
Case 1: Type 2 SPD with $U_C \geq 0.5\ U_{OC\ STC}$ with thermal disconnection device

Result:



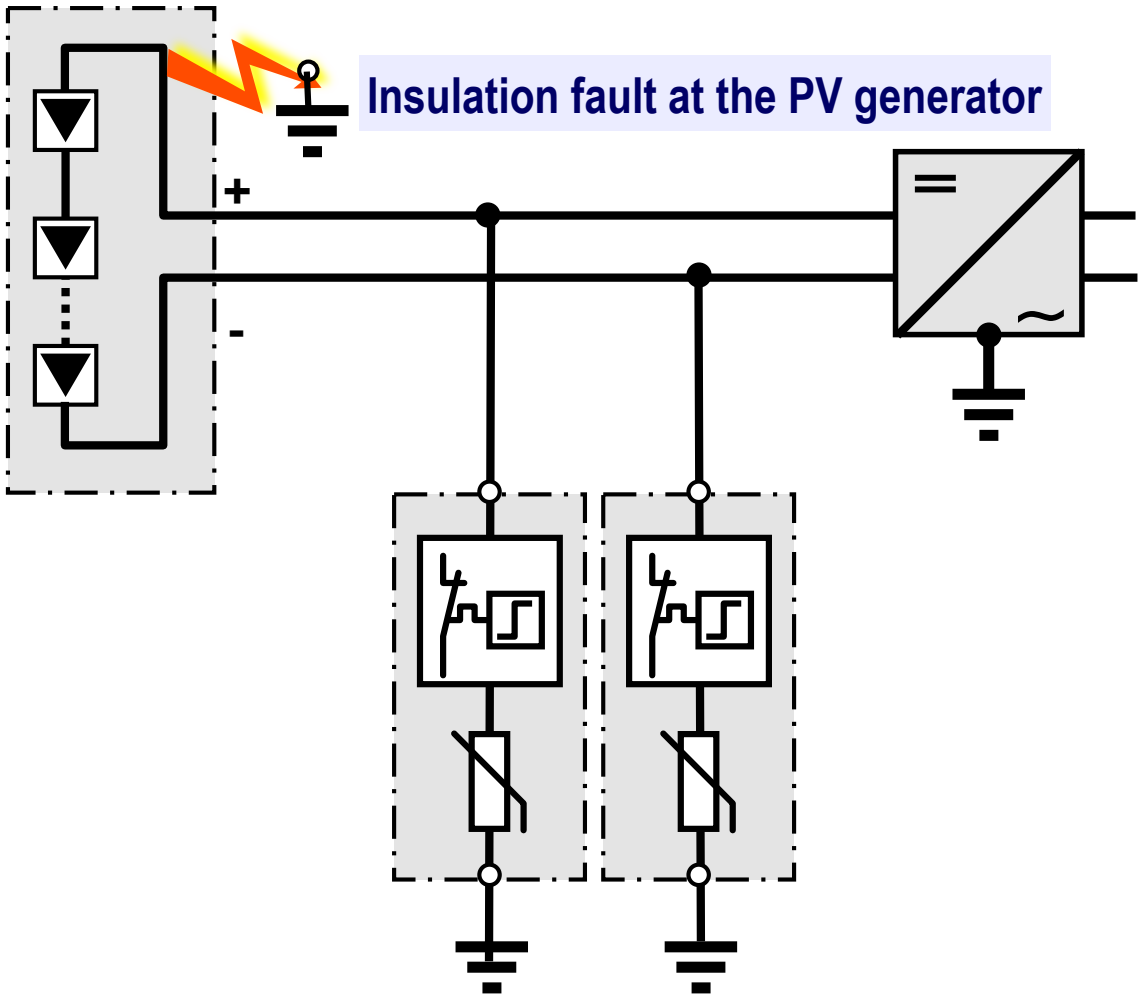
Advantages:

- Simple design
- Cost-effective
- "Standard protective devices"

Disadvantages:

- Overload of the arresters in case of insulation faults
- Fire hazard due to lack of d.c. switching capability of the disconnection device

Protection levels and Insulation coordination!



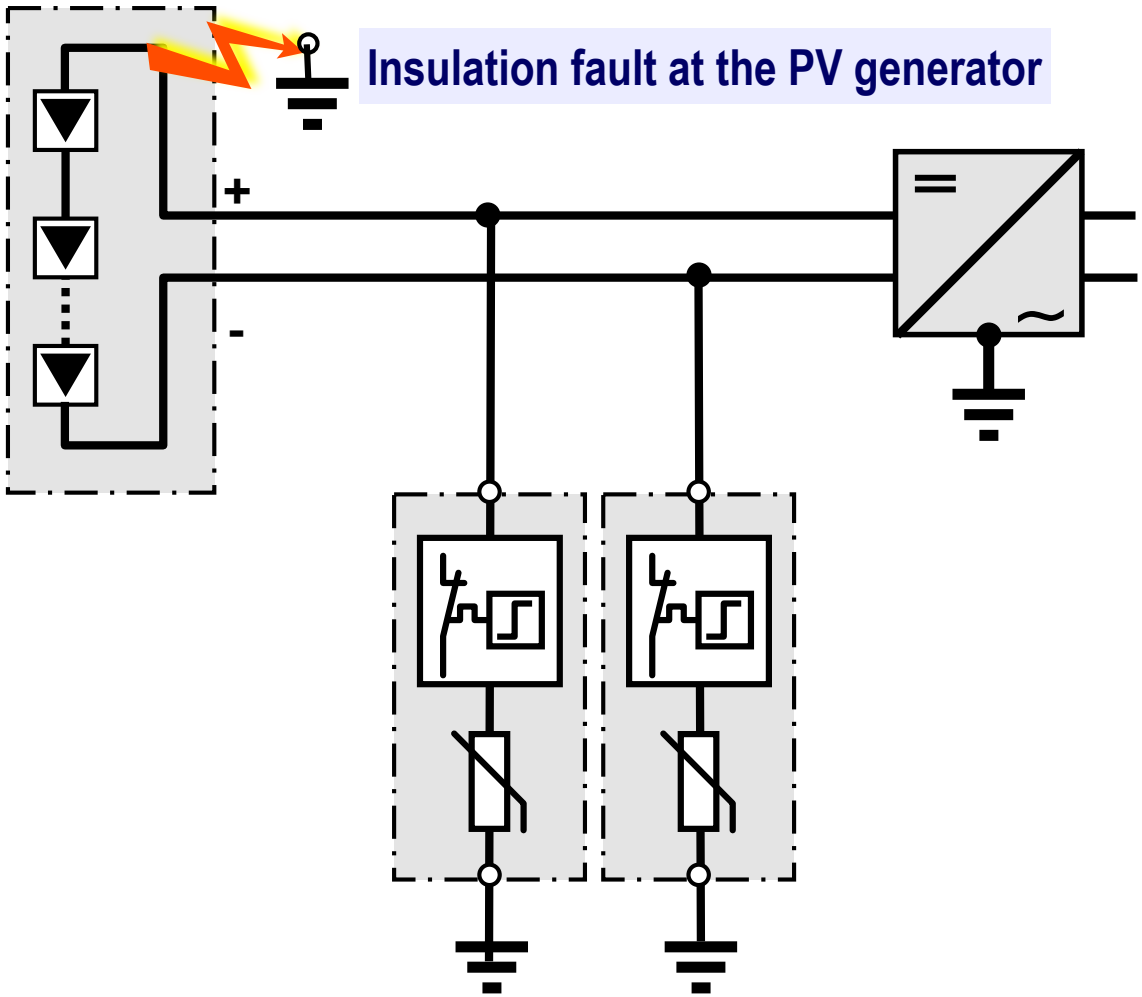
+/- $U_{OC\ STC}$ = 1 000 V

U_c = 500 V

U_p is roughly 5 times U_C of SPD

U_p 5 x 2 x 500 = 5 000

Protection levels and Insulation coordination!



+/- $U_{OC\ STC}$ = 1 000 V

U_c = 1 000 V

U_p is roughly 5 times U_C of SPD

U_p 5 x 2 x 1 000 = 10 000

PV Impulse voltage versus maximum system voltage

Maximum System Voltage V	Impulse Voltage	
	Application Class A	Application Class B
100	1 500	800
150	2 500	1 500
300	4 000	2 500
600	6 000	4 000
1 000	8 000	6 000

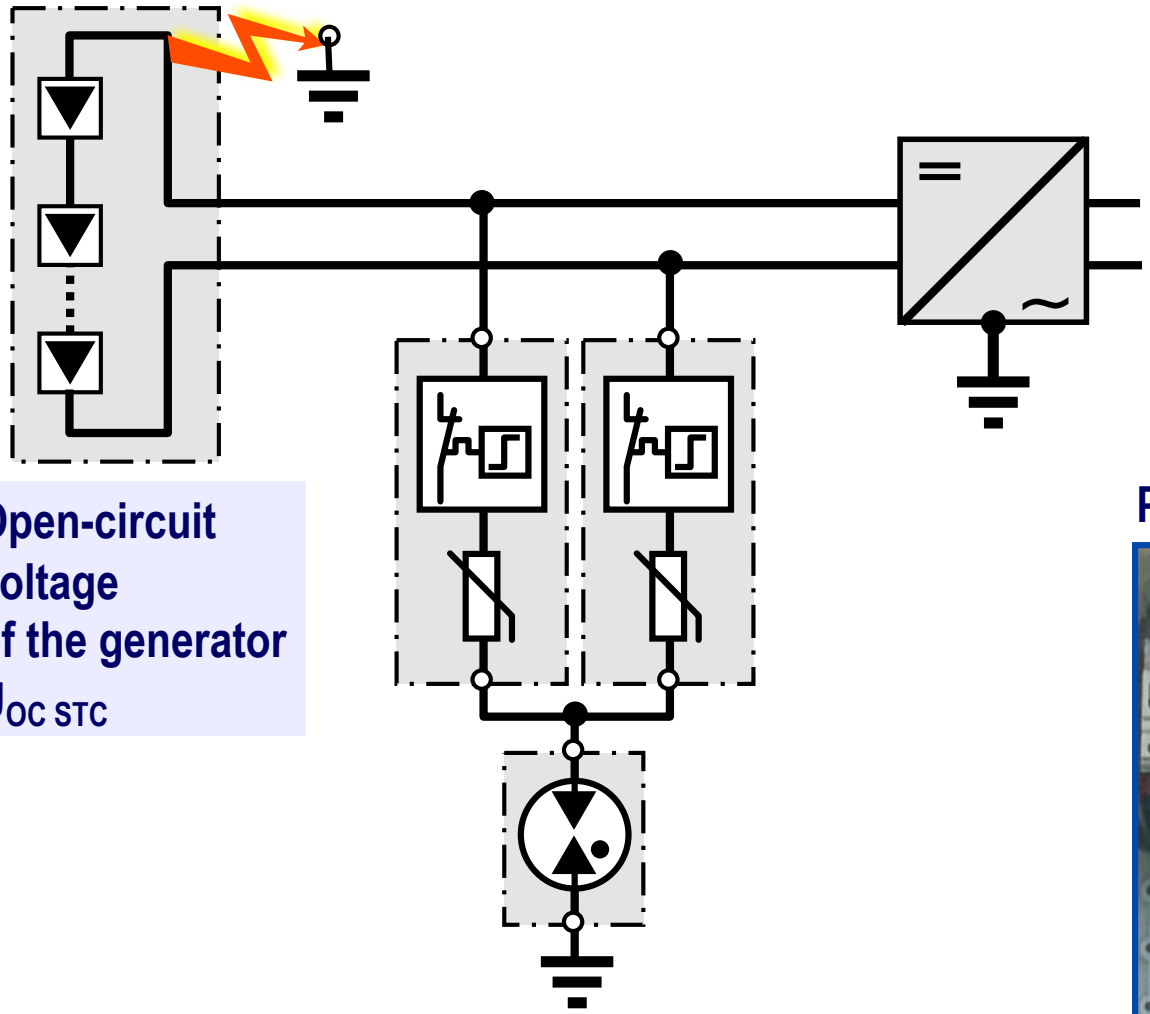
Ref: IEC 61730-1 Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction

IEC 61730-2 Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing Table 8

DEHNguard® DG M YPV SCI 1000 – Class II type SPD specifically tested & certified for PV Systems

	DG M YPV SCI 1000
SPD according to EN 6143-11	Type 2
SPD according to IEC 6143-1	Class II
Max. PV voltage [U_{CPV}]	≤ 1000 V
Total discharge current (8/20 µs)	40 kA
Nominal discharge current (8/20 µs) [(DC+/DC-)→ PE] (I_n)	12.5 kA
Maximum discharge current (8/20 µs) [(DC+/DC-)→ PE] (I_{max})	25 kA
Voltage protection level (U_P)	≤ 4 kV
Voltage protection level at 5 kA (U_P)	≤ 3.5 kV
Response time (t_A)	≤ 25 ns
Operating temperature range (T_u)	- 40 ^{0}C..+ 80^{0}C
Breaking capacity of integrated fuse	30 kA / 1000 V d.c.
Approvals, Certifications	UL

Selection of surge protective devices
Case 2: Y-connected Type 2 SPD with spark gap

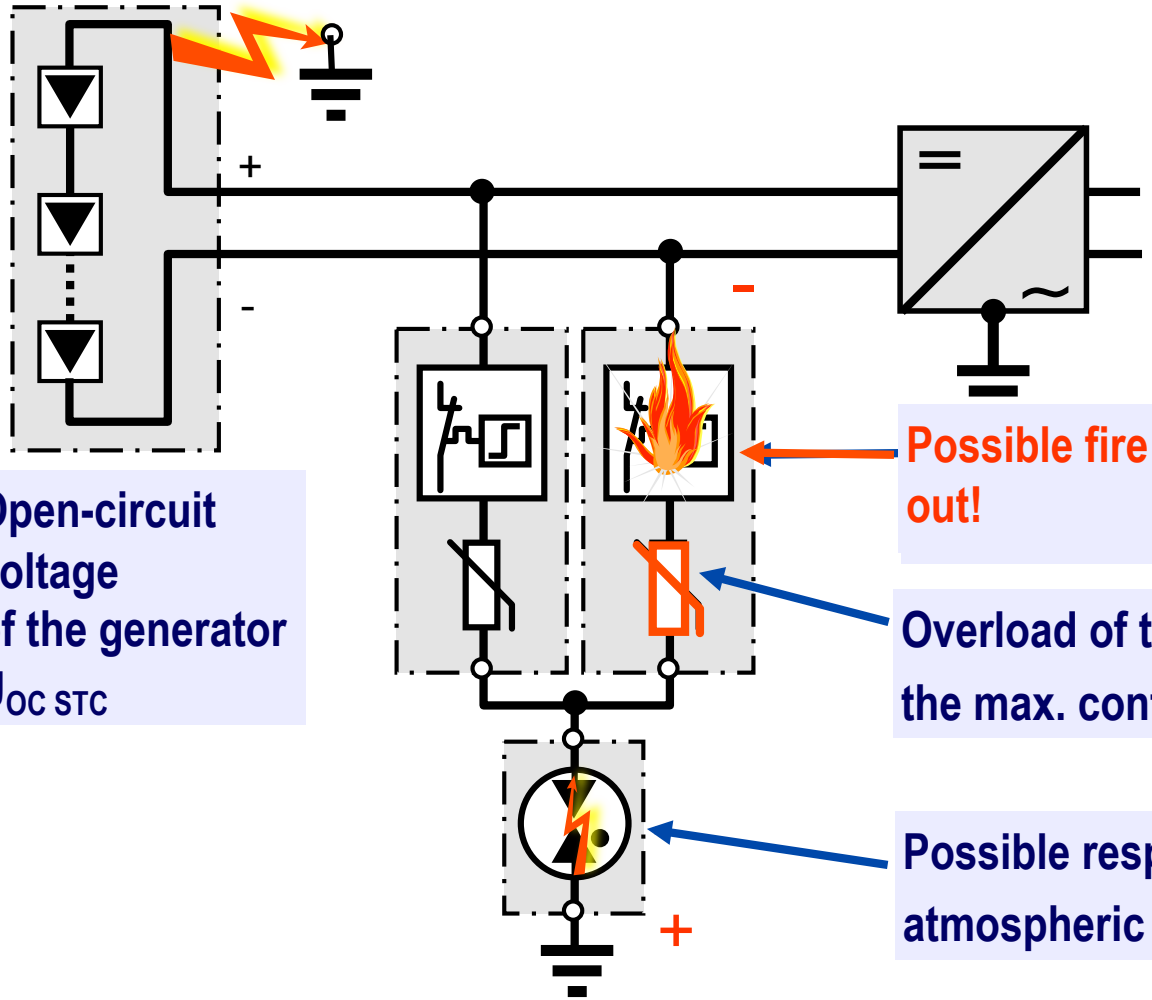


Open-circuit voltage of the generator $U_{OC\ STC}$

Practical example:

Performance of surge protective devices in case of overload
Case 2: Y-connected Type 2 SPD with spark gap

Example: Insulation fault in the PV generator circuit



Open-circuit voltage of the generator $U_{OC\ STC}$

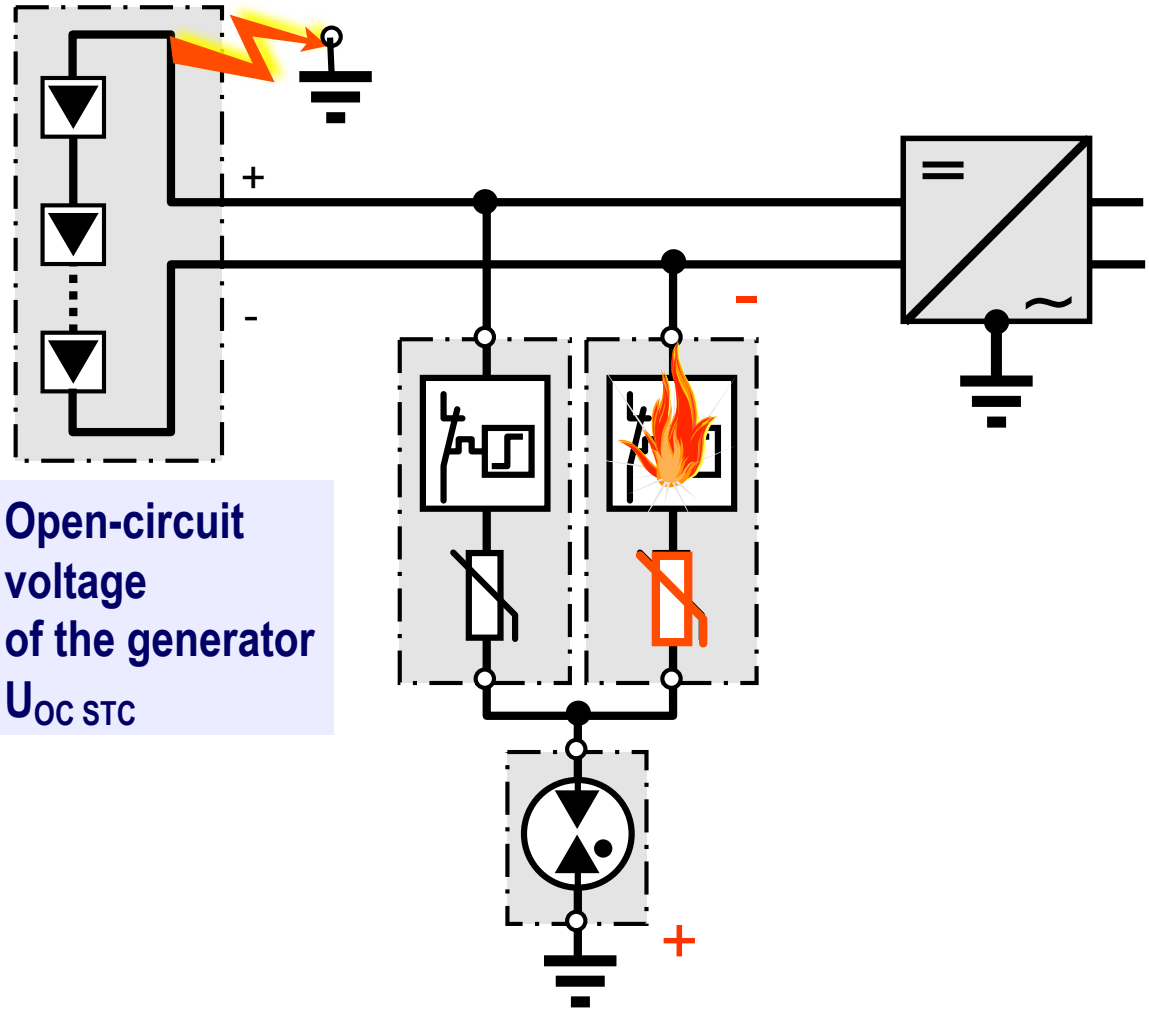
Possible fire hazard cannot be completely ruled out!

Overload of the arrester due to exceeding the max. continuous operating voltage U_c

Possible response of the spark gap due to atmospheric discharge or a high PV voltage

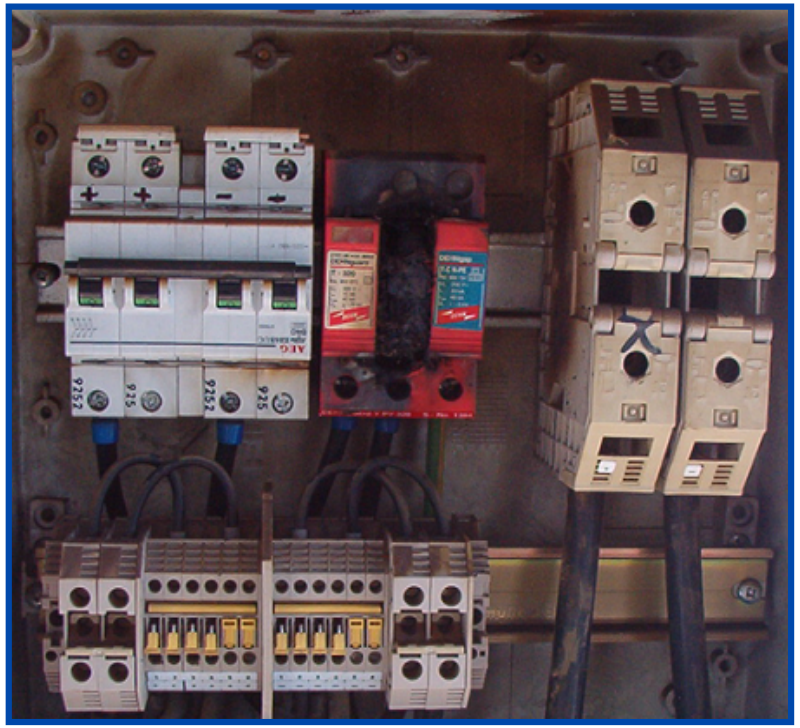
Performance of surge protective devices in case of overload
Case 2: Y-connected Type 2 SPD with spark gap

Example: Insulation fault in the PV generator circuit



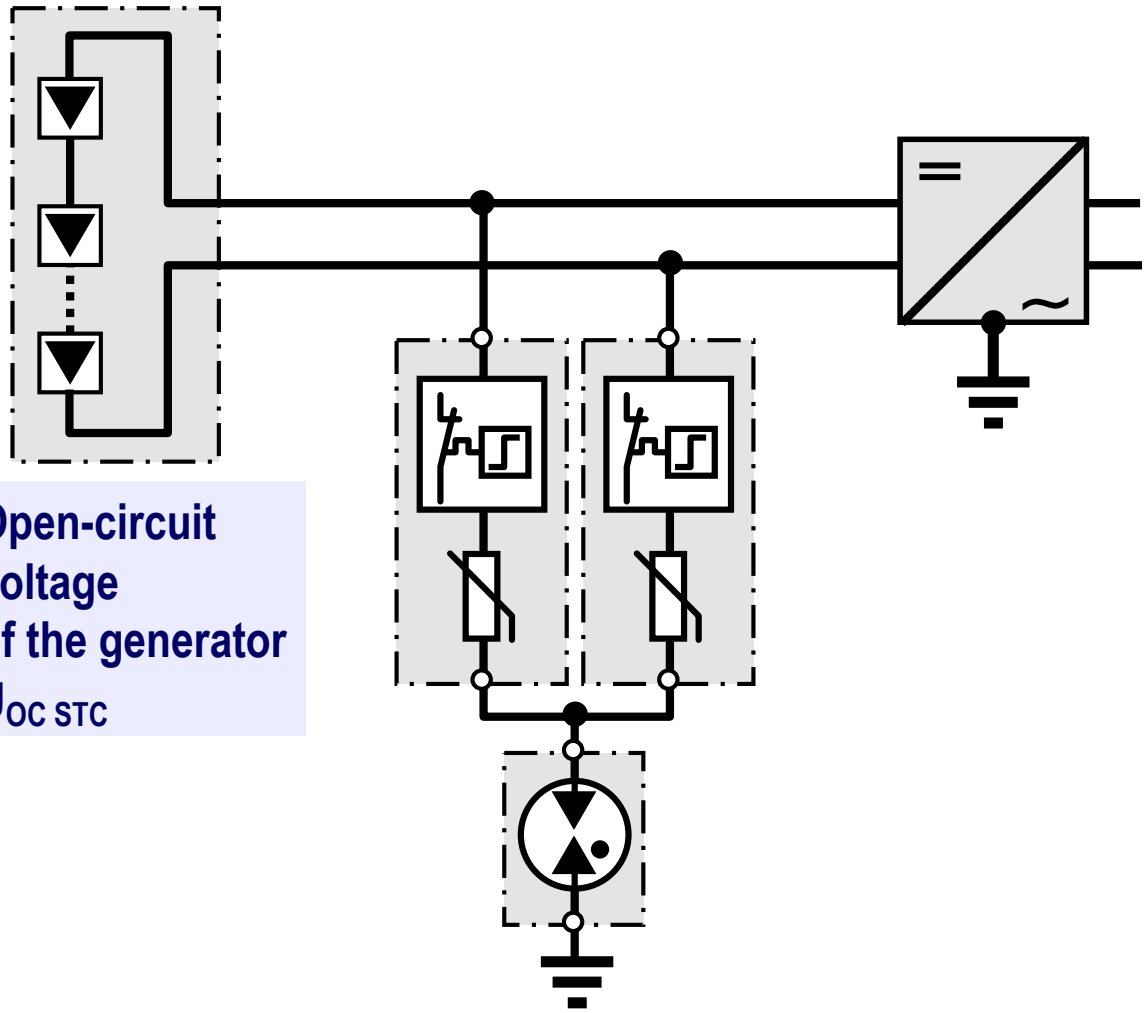
Open-circuit voltage of the generator $U_{OC\ STC}$

Example of damage:



Performance of surge protective devices in case of overload
Case 2: Y-connected Type 2 SPD with spark gap

Result:



Open-circuit voltage of the generator $U_{OC\ STC}$

Advantages:

- No leakage currents
- "Standard protective devices"

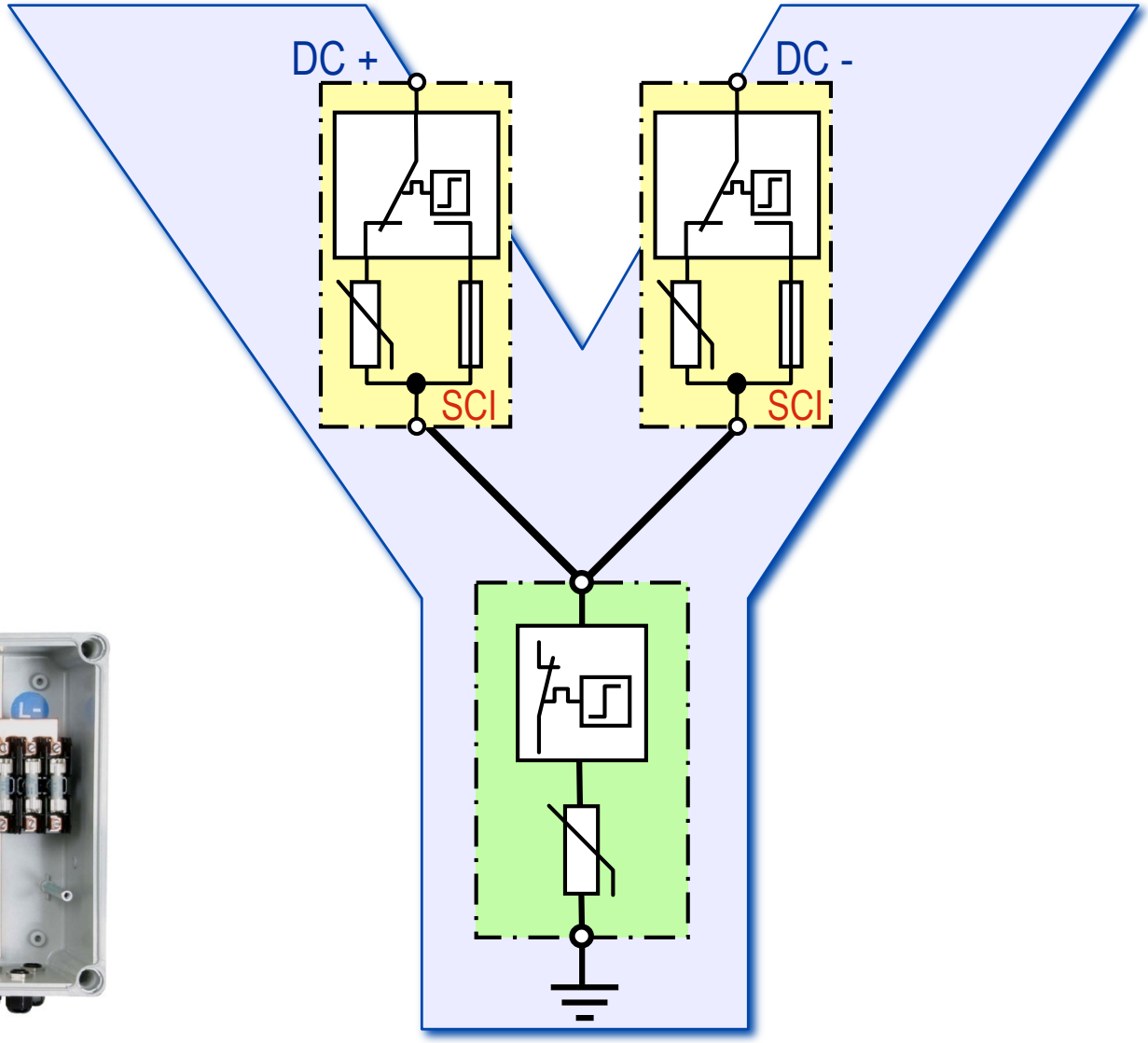
Disadvantages:

- Overload of the arresters in case of overvoltage surges or insulation faults and triggered spark gap
- Fire hazard due to the lack of d.c. switching capacity of the disconnection device

The Solution

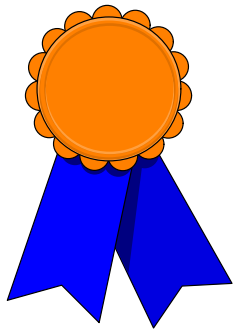
!

Use of the SCI system in connection with the fault-resistant Y circuit



Surge Arrester DEHNguard® M YPV SCI „Evolution of Safety“

Multipole modular
Type 2 surge arrester with
3-step d.c. switching device for PV systems with
U_{PVmax} up to 1200V
(classification in accordance with IEC 61643-11)

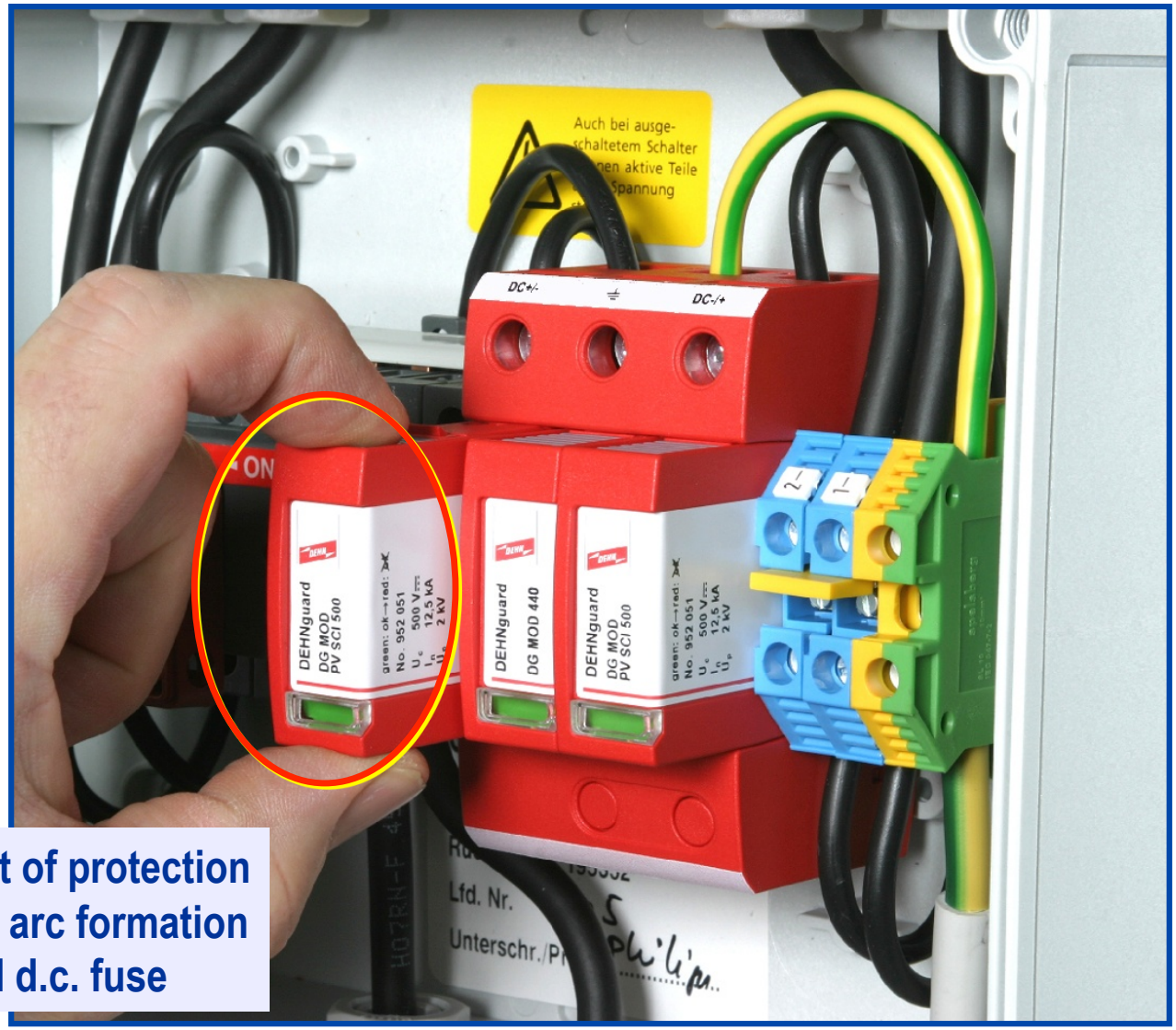


24th PV symposium 2009 in Bad Staffelstein / Germany
Innovation forum 3rd place

Type	DG M YPV SCI 1200 (FM)
Part No.	952 517 (952 512)

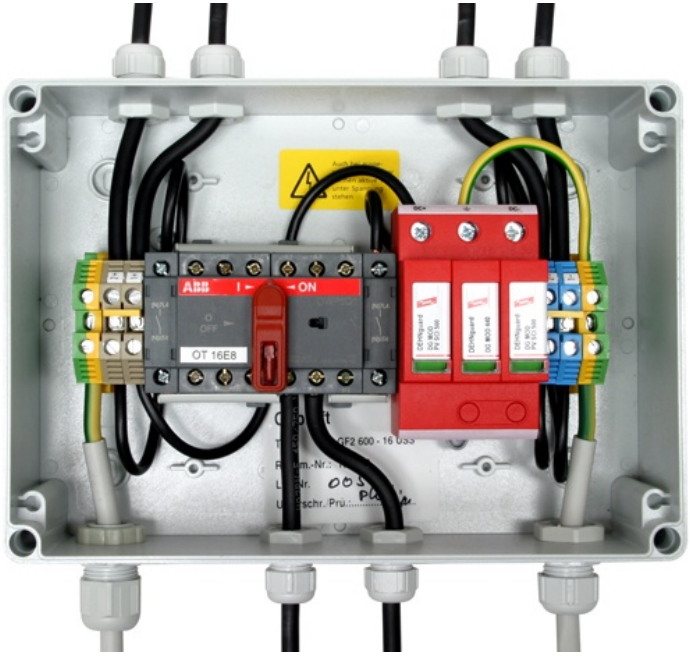
Surge Arrester DEHNguard® M YPV SCI

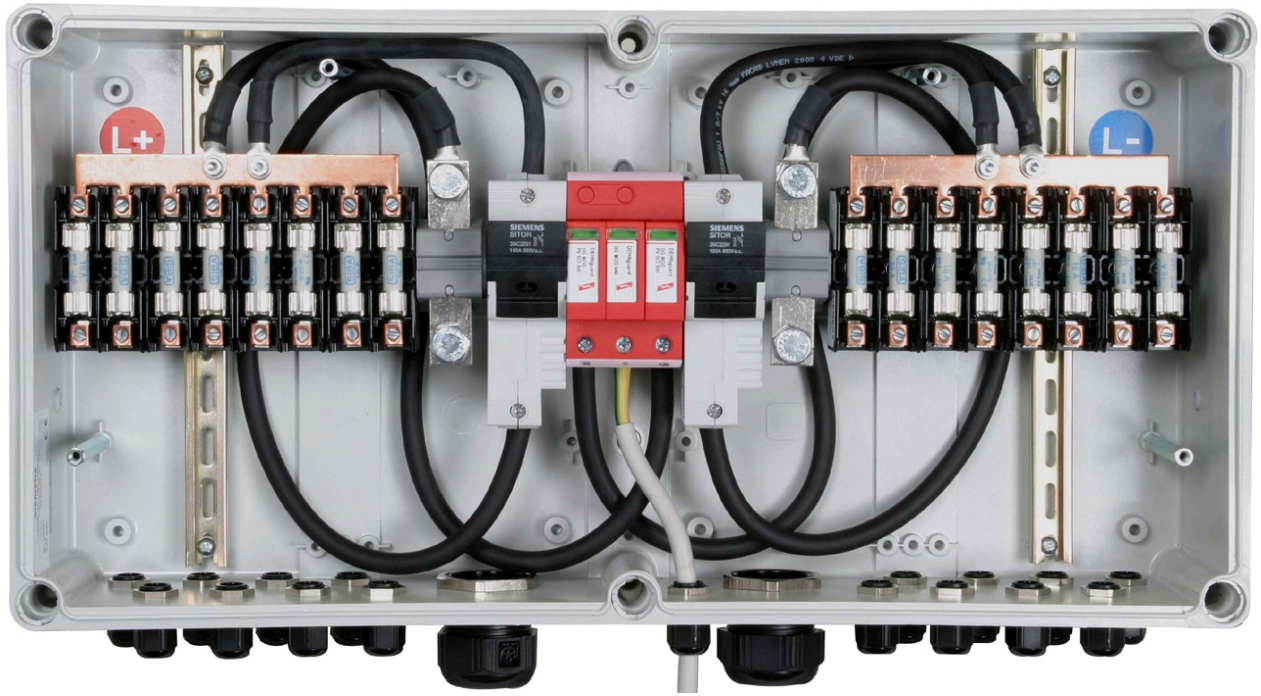
Replacement of protection modules without arc formation



Safe replacement of protection modules without arc formation due to integrated d.c. fuse

Surge Arrester DEHNguard® M YPV SCI
Example of use





Summary - surge protective device reuirements for use in PV systems

- Must protect connected equipment against surges and ensure energy coordination between equipment,

- Must be tested and certified suitable for use in PV d.c. systems,
- Must NOT present a fire risk when overload protection disconnection mechanism is activated,

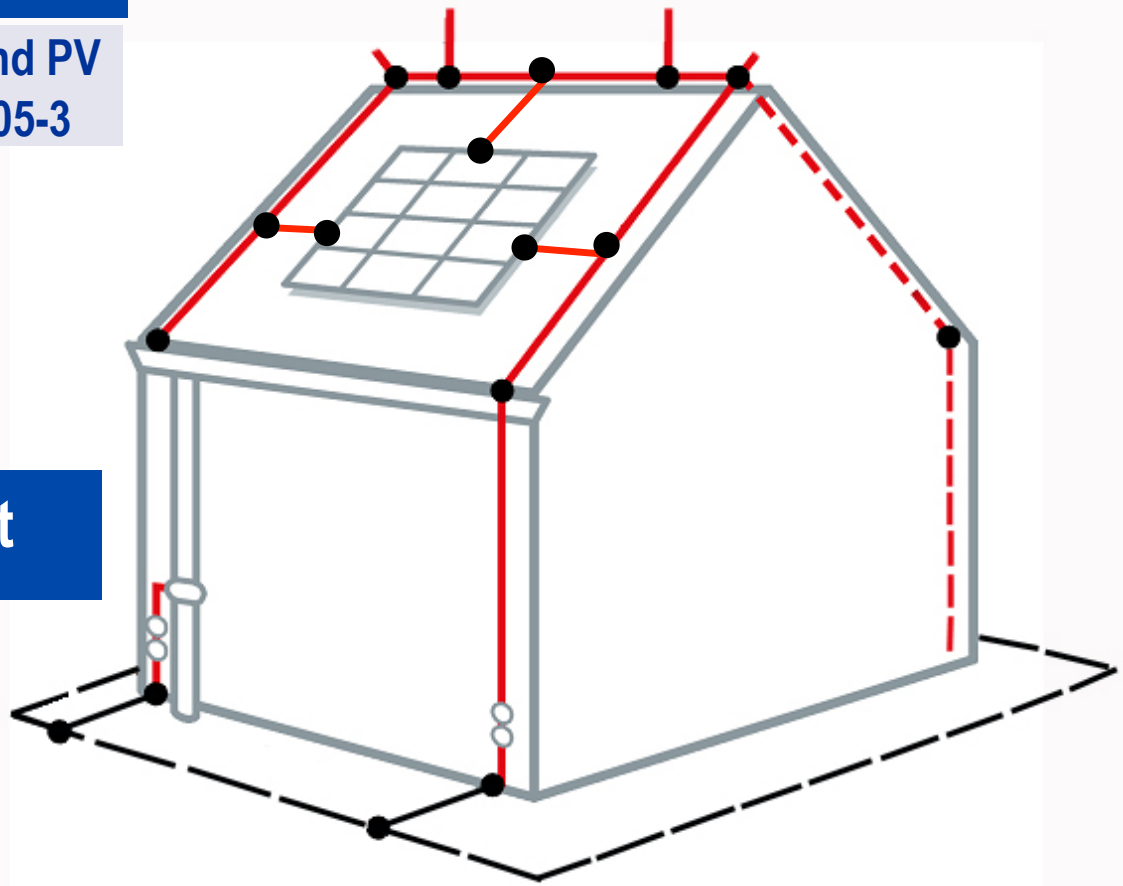
- May not present a danger to the installer during maintenance or repair work.

External Lightning Protection for PV-Systems

PV system on a building with external LPS

a) Separation distance *S* is kept

The separation distance *S* between the LPS and PV module frame calculated according to IEC 62305-3

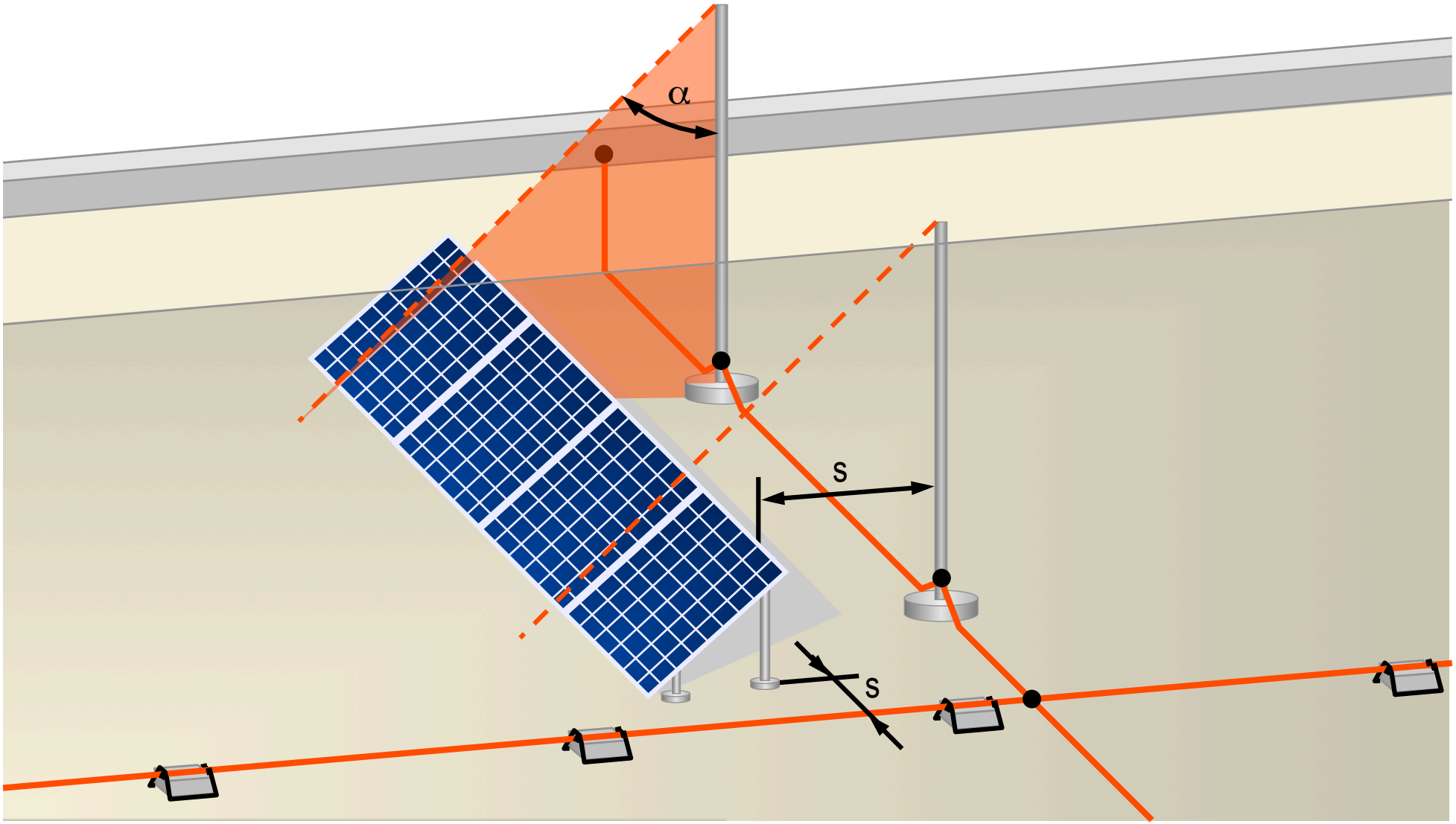


b) Separation distance *S* is not kept

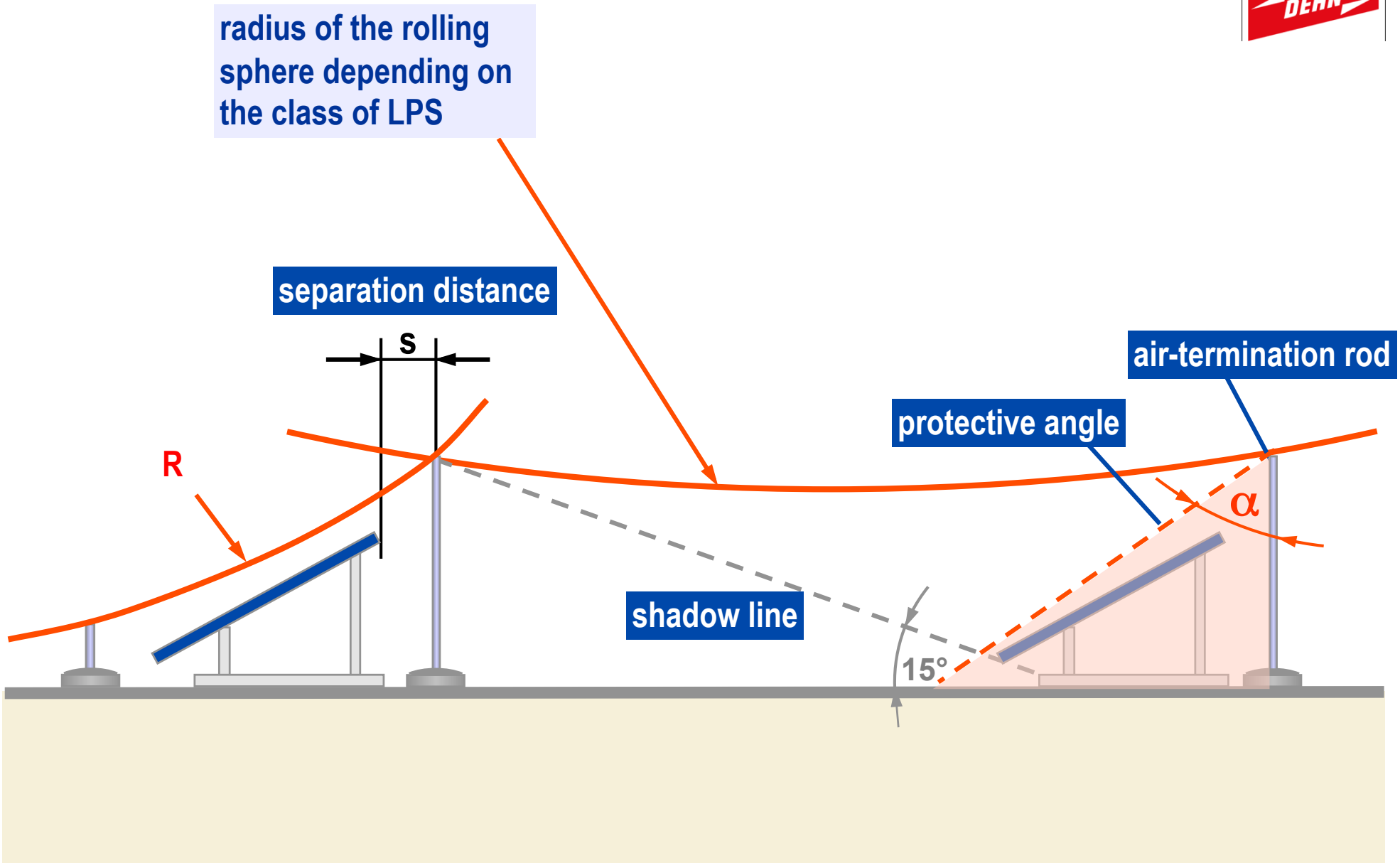
Direct conductive connection between external LPS and PV module frame.

Not recommended!

Separation distance *S* for PV modules

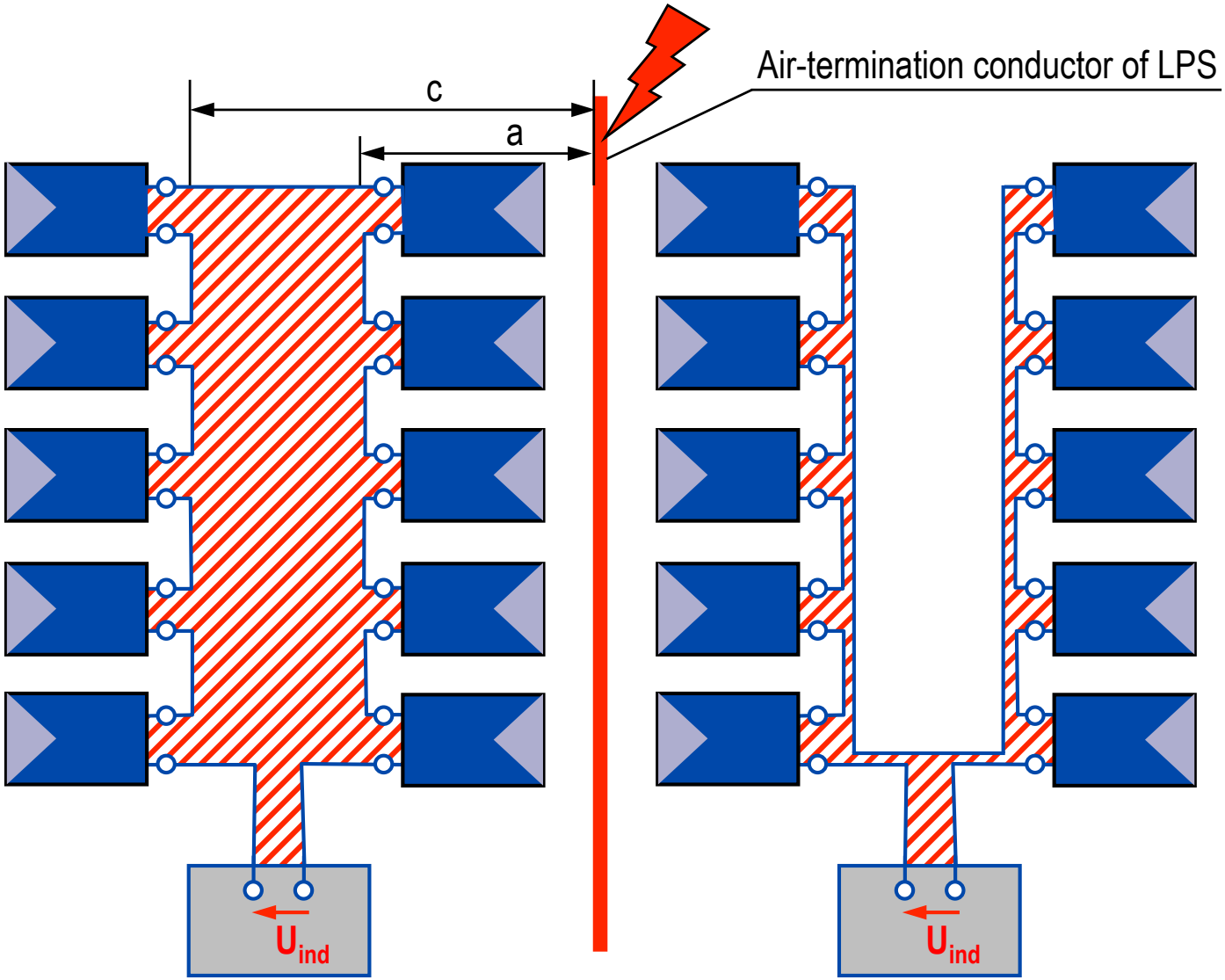


Designing air-termination system for PV-systems



Air-termination system on a flat roof

Reduction of induced voltage in PV-systems due to cable routing



Inappropriate cable routing:
Large loop for inductive coupling

Appropriate cable routing:
Minimized loop for inductive coupling

Ref: IEC62305-3

Recommended choice of SPD depending on location and LPS system employed in accordance with IEC 60364-5-534 and IEC 60364-4-443

Minimum Discharge current rating of SPDs are;

Class I type SPD I_{imp} : 12.5 kA (10/350µS)

Class II type SPD I_n: 5 kA (8/20µS)

Lightning Protection	SPDs on AC-output of Inverter	SPDs on DC-Inputs of Inverter
No External LPS	SPD Class II tested[1] recommended	SPD Class II tested[1] recommended
External LPS: Separation distance "S" kept	SPD Class I tested[1]	SPD Class II tested[1]
External LPS: Separation distance "S" NOT kept	SPD Class I tested[1]	SPD Class I tested[1]

[1] Tested and Certified by approved certification body

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