The power of nature, the control of technology
From ABB's experience, OVR PV: surge protection in photovoltaic plants

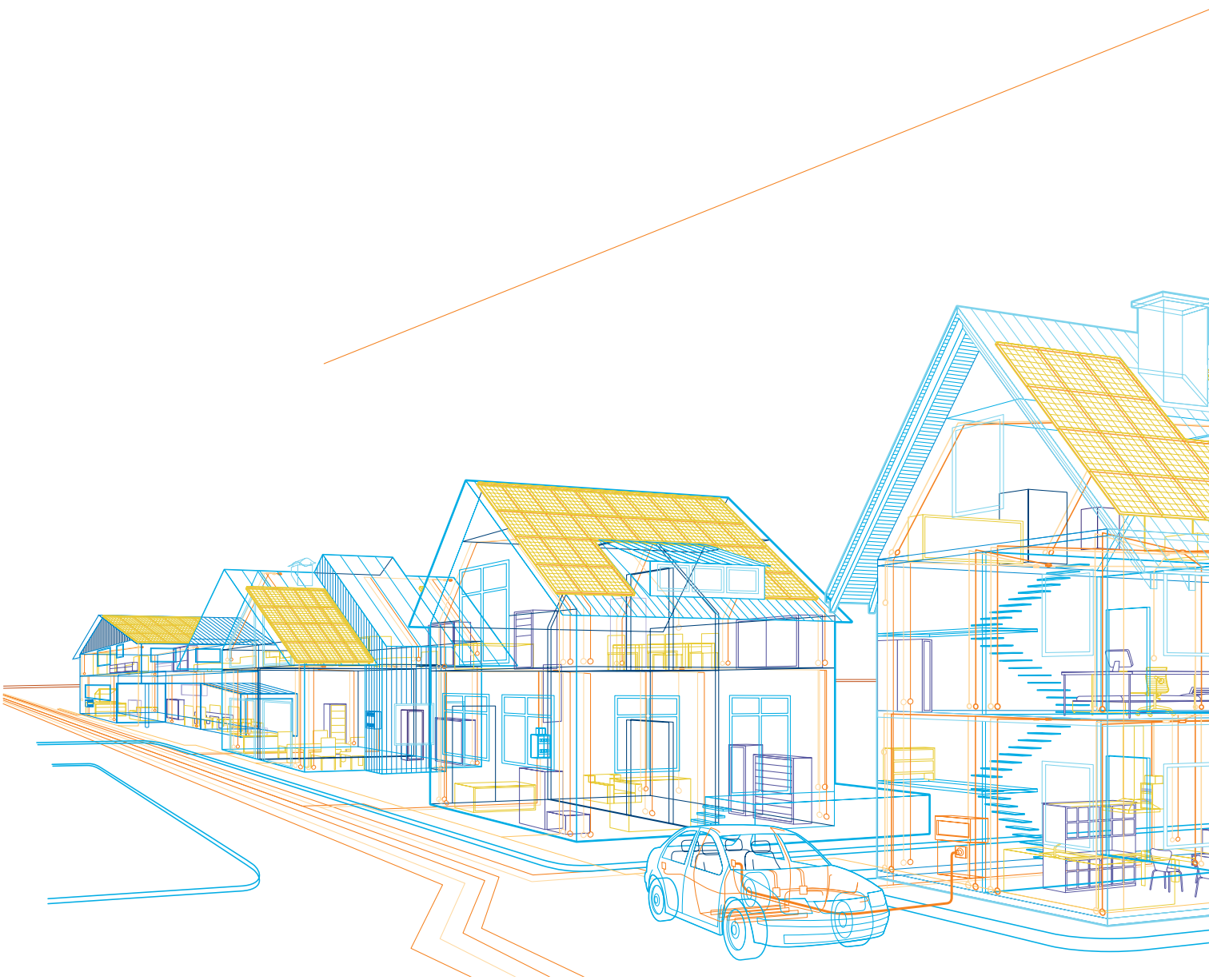
Power and productivity
for a better world™

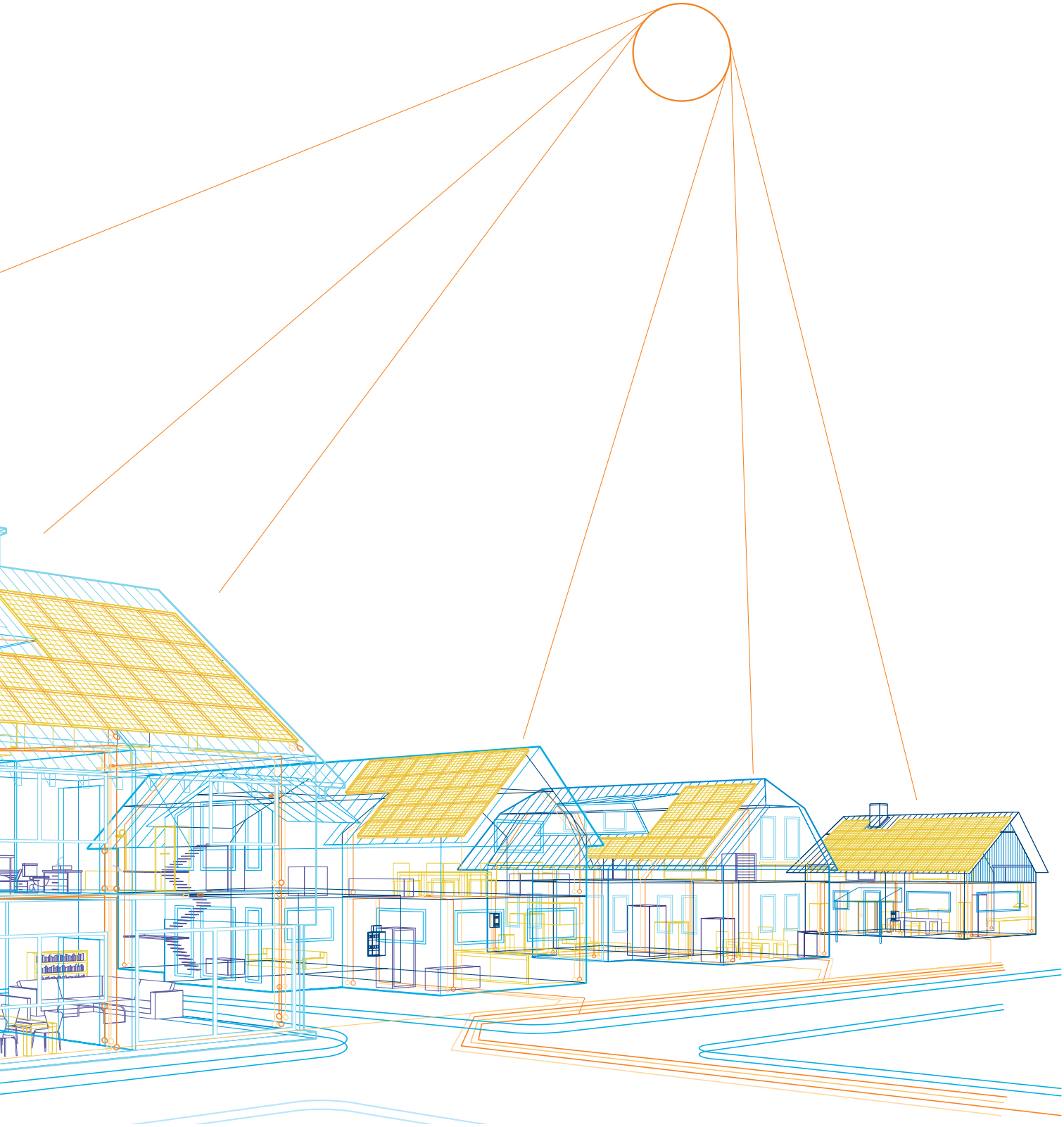
ABB

Made for the sun, threatened by atmospheric discharges
The importance of surge protective devices in PV plants

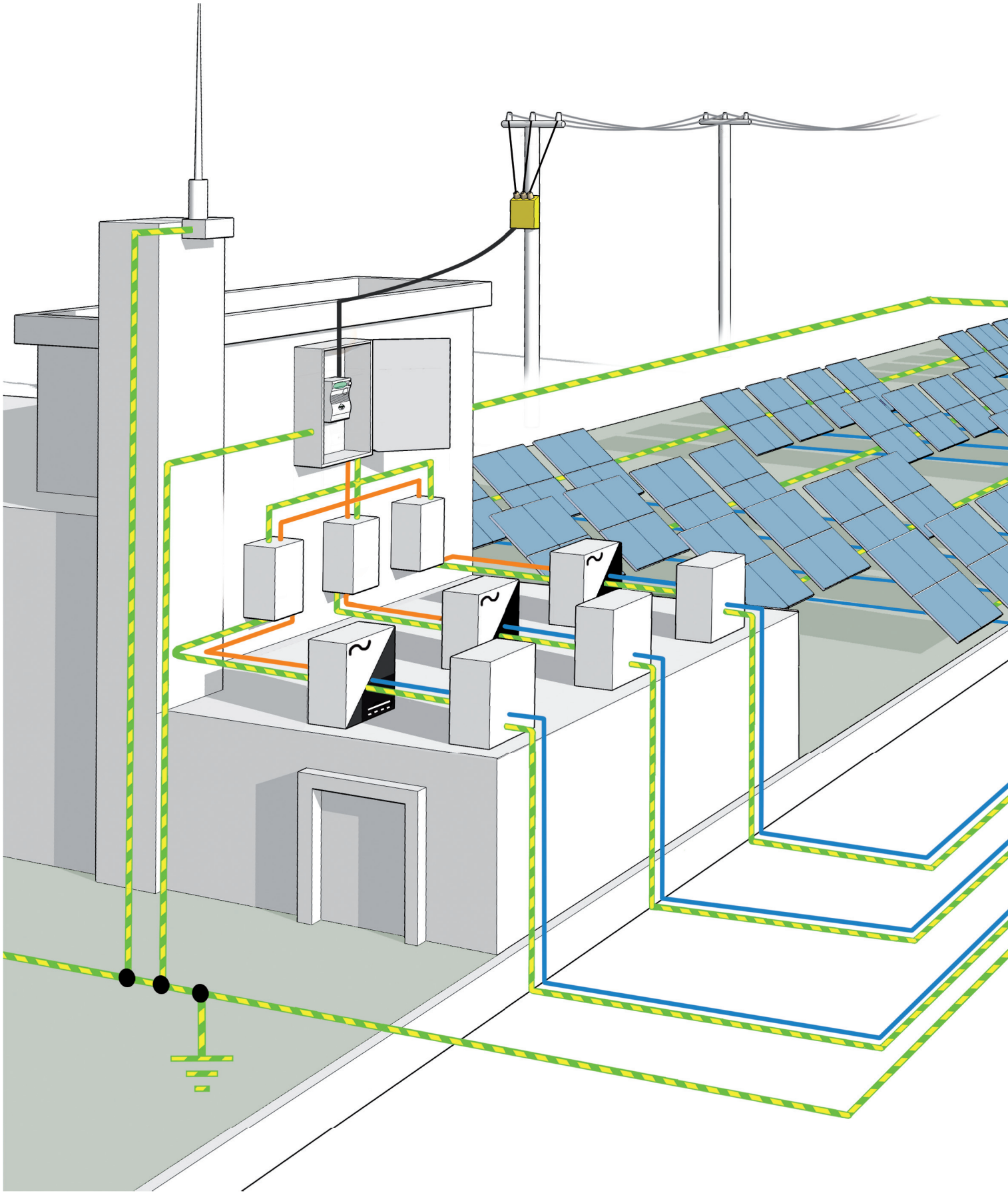
Installed outside, almost always in wide-open areas, photovoltaic plants are particularly subject to atmospheric phenomena and can sustain damage from surges caused by lightning strikes.

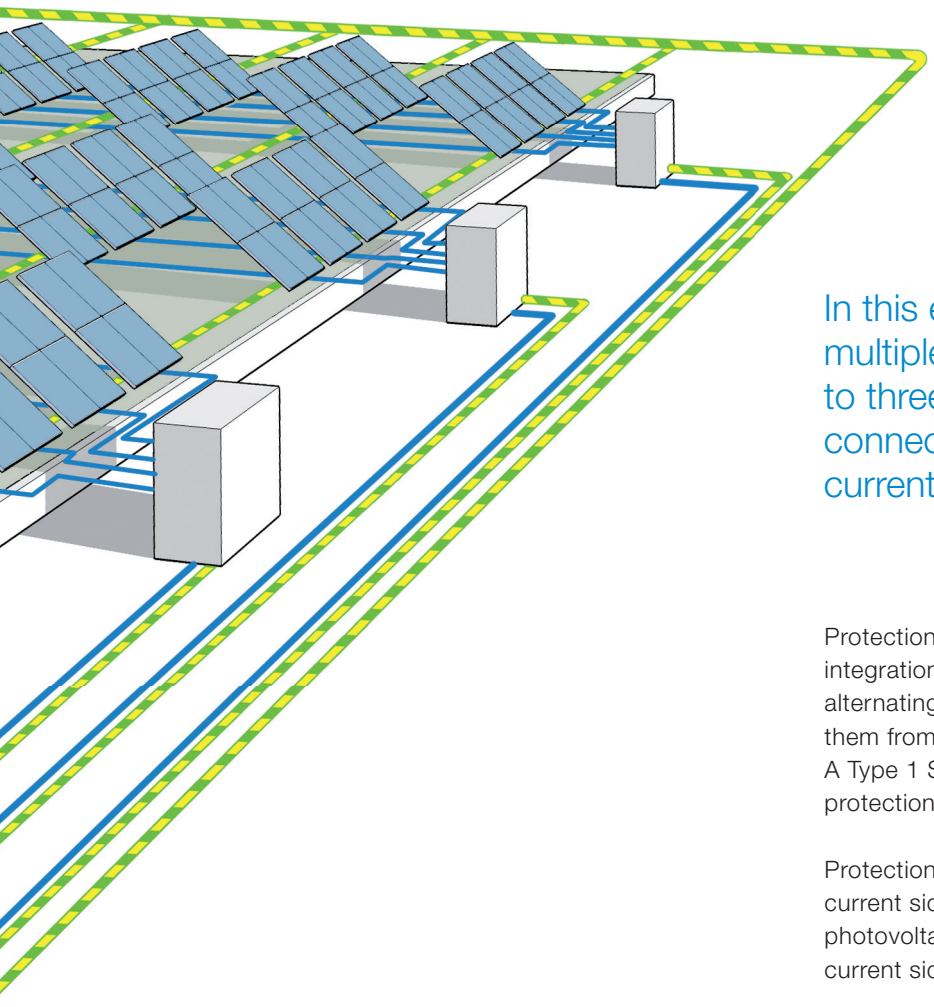
For this reason, and given the high value of the components and the high cost of any down time, it is always best practice to fit PV plants with suitable surge protection.





Surge protection in photovoltaic plants
Production plant





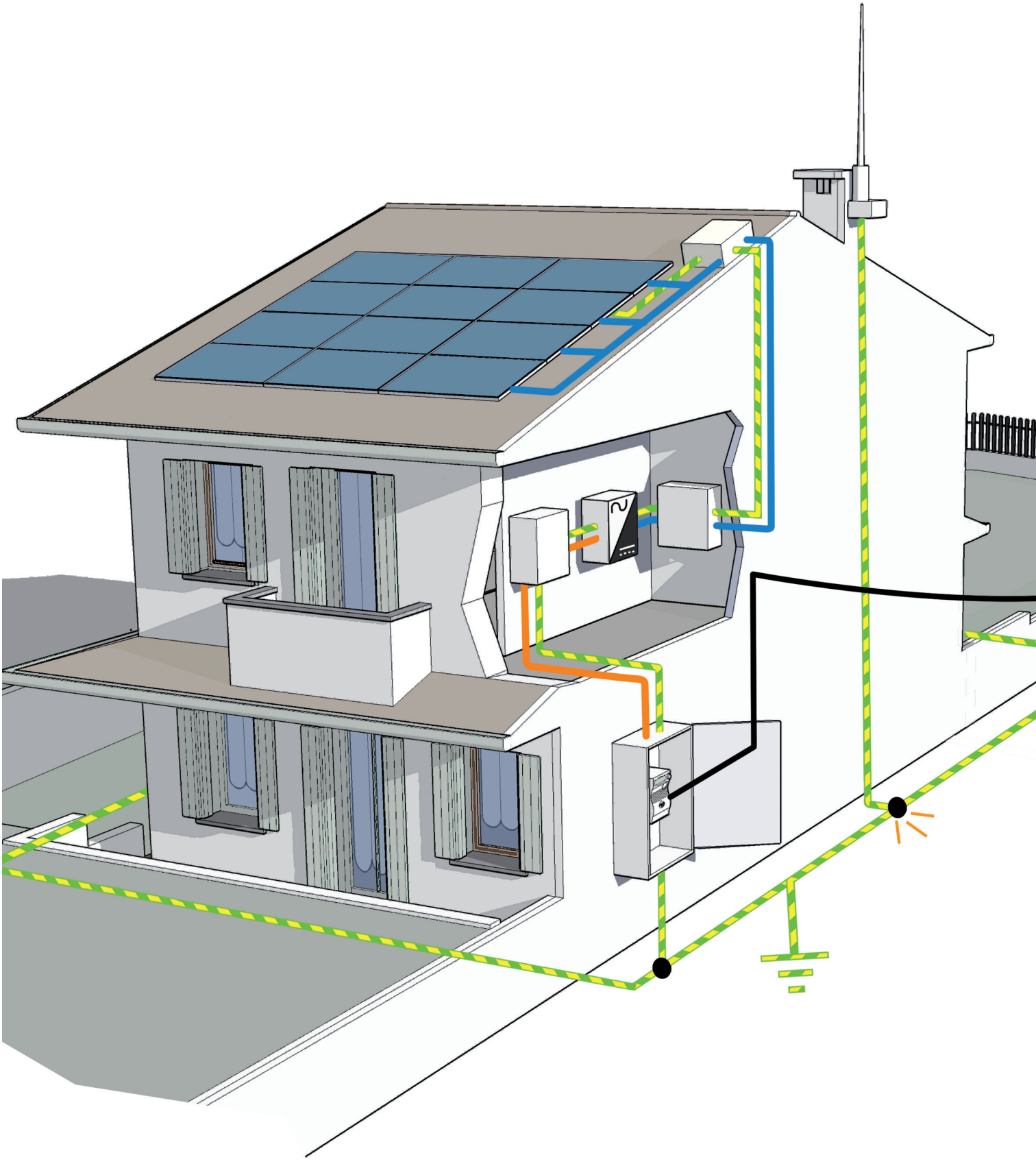
In this example, the plant is composed of multiple strings in parallel and connected to three inverters. The inverters are in turn connected in parallel on the alternating current side.

Protection against direct lightning strikes is ensured by integration with a lightning conductor, connected on the alternating current side. It covers all the panels, protecting them from damage from direct lightning strikes.
A Type 1 SPD is installed in the main switchboard (D) for protection from direct lightning strikes.

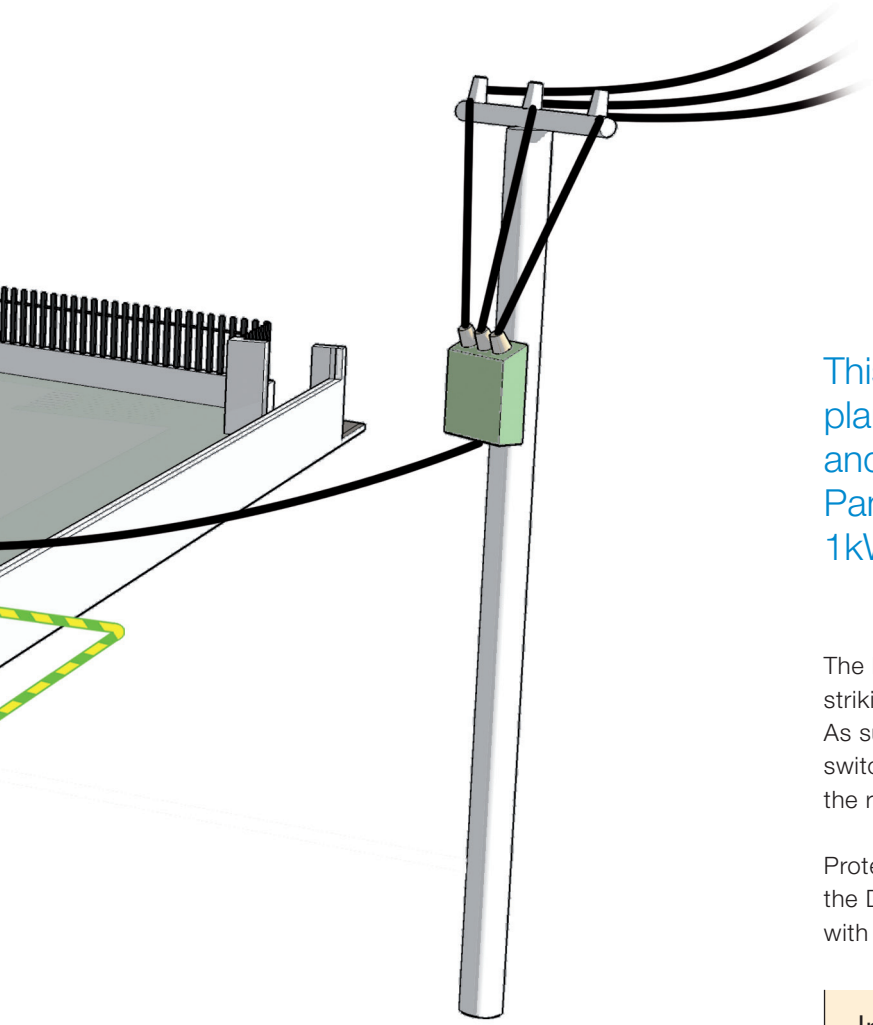
Protection against indirect lightning strikes, on the direct current side, is ensured by using OVR PV SPDs for photovoltaic plants. OVR T2 SPDs are used on the alternating current side.

It is necessary to protect both the direct current and alternating current circuits from surges: lightning is not interested in what type of current is flowing in the cables!

Surge protection in photovoltaic plants
Domestic plant



Domestic plant - On-site exchange
- DC side: zones A, B
- AC side: zones C, D



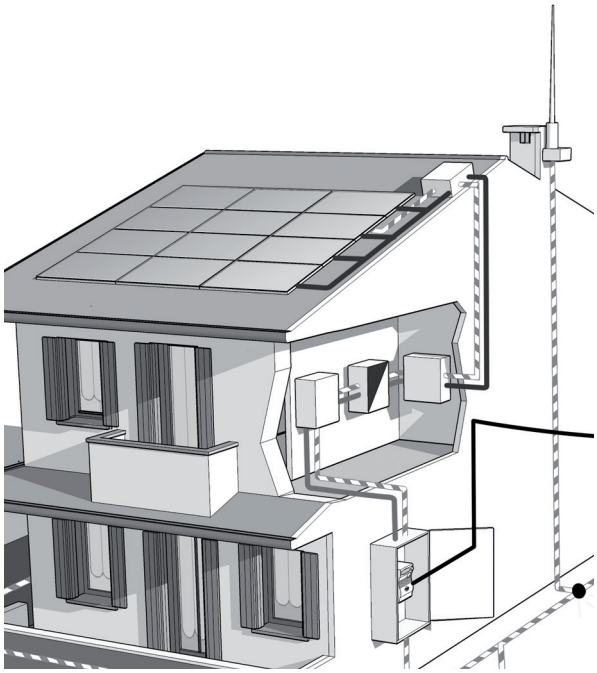
This example shows a small domestic plant in a suburban area with one string and a single inverter.
Panels with a combined output power of 1kW are installed on the roof.

The house is subject both to the risk of lightning striking the building and the aerial BT line.
As such, a Type-1 SPD has been installed in the main switchboard (D) on the AC side and a lightning conductor on the roof.

Protection against direct lightning strikes is ensured both on the DC side by using an OVR PV SPD and on the AC side with an OVR T2 SPD.

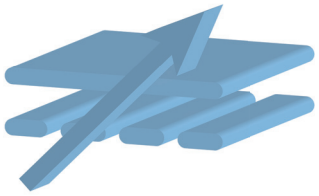
In this case, too, it is necessary to protect both the direct current and alternating current circuits from surges: lightning is not interested in what type of current is flowing in the cables!

Surge protection is effective only when it is complete
Protect the four zones.



Zone A
– Field or parallel switchboard
– Protection of panels and strings from surges of atmospheric origin
– Required if distance between A and B is greater than 10 m

Zone B
– Direct current side inverter
– Protection of the inverter from surges of atmospheric origin
– Always required



In the table and the figures, the direct current parts are indicated in blue, while the alternating current parts are indicated in orange

Side	Zone	Description	Protection function	When to protect	Presence of external LPS or aerial supply	
Direct current 	A	Field or parallel switchboard	Protection of panels and strings from surges of atmospheric origin	Required if distance between A and B is greater than 10 m		
	B	Direct current side inverter	Protection of the inverter from surges of atmospheric origin	Always required		
Alternating current	C	Alternating current side inverter	Protection of the inverter from surges of atmospheric and grid origin	Required if distance between C and D is greater than 10 m		
	D	Delivery point, alternating current-side plant origin	Protection of the electrical installation from surges of atmospheric and grid origin and from direct lightning strikes	Always required	No	
					Yes	

Zone C
– Alternating current side inverter
– Protection of the inverter from surges of atmospheric and grid origin
– Required if distance between C and D is greater than 10 m

Zone D – No lightning conductor
– Delivery point, alternating current side plant origin
– Protection of the electrical installation from surges of atmospheric and grid origin
– Always required

Zone D – No lightning conductor
– Delivery point, alternating current side plant origin
– Protection of the electrical installation from direct lightning strikes and from surges of atmospheric and grid origin
– Always required

	SPD				Back-up protection			
	Version	Remote contact	Type	Code	When to install it	Rating	Fuse or MCB disconnector	
							Type	Code
	670 V	-	OVR PV 40 600 P	2CTB803953R5300	Required only if the short-circuit current at the installation point of the SPD is greater than 100 A DC.	10 A gPV	E 92/32 PV S802PV-S10 or S804PV-S10	
		1 NO/NC	OVR PV 40 600 P TS	2CTB803953R5400				
	1000 V	-	OVR PV 40 1000 P	2CTB803953R6400				
		1 NO/NC	OVR PV T1 6.25 1000 P TS	2CTB803953R6500				
	670 V	-	OVR PV 40 600 P	2CTB803953R5300				
		1 NO/NC	OVR PV 40 600 P TS	2CTB803953R5400				
		1 NO/NC	OVR PV T1 6.25 600 P TS	2CTB803953R5700				
	1000 V	-	OVR PV 40 1000 P	2CTB803953R6400				
		1 NO/NC	OVR PV 40 1000 P TS	2CTB803953R6500				
		1 NO/NC	OVR PV T1 6.25 1000 P TS	2CTB803953R6700				
	3P+N	If required, see “TS” versions in the System pro *M* compact® catalogue	OVR T2 3N 40 275s P	2CTB803953R0800	Always required	50A gG (M277543)	E 93hN/32	
	3P		OVR T2 3L 40 275s P	2CTB803853R2200			E 93/32	
	1P+N		OVR T2 1N 40 275s P	2CTB803952R0800			E 91hN/32	
	3P+N	If required, see “TS” versions in the System pro *M* compact® catalogue	OVR T2 3N 40 275s P	2CTB803953R0800			E 93hN/32	
	3P		OVR T2 3L 40 275s P	2CTB803853R2200			E 93/32	
	1P+N		OVR T2 1N 40 275s P	2CTB803952R0800			E 91hN/32	
	3P+N		OVR T1 3N 25 255	2CTB815101R1600		125 A gG (M258343)	E 933N/125	
	3P		OVR T1 3L 25 255	2CTB815101R1300			E 933/125	
	1P+N		OVR T1 1N 25 255	2CTB815101R1500			E 931N/125	

Surge protection in photovoltaic plants prEN 50539-11 standard

Many indications regarding protection from surges due to direct lightning strikes have been taken from prEN 50539-11 on requirements and tests for SPDs installed on the d.c. side of photovoltaic installations.

The protection must be:
- specific
- complete
- safe
- permanent

The protection must be …	Principles of surge protection	ABB's response
Specific	The installation of an SPD protecting the panels and the sensitive electronic equipment (inverter) must be evaluated	OVR PV is the ABB range specifically designed to protect equipment in photovoltaic plants
Complete	SPDs must, in general, provide both residual current (+/-) and common (+/PE, -/PE) protection	OVR PV is a multi-pole (+/-/PE) module ideal for providing both common and residual current protection
Safe	The installation of suitable fuse protection upstream of the SPDs is recommended	OVR PV is auto-protected up to a short-circuit current of 100 A and, for higher values, must be protected with suitable fuses
Permanent	Since photovoltaic installations are most of the time installed in remote places, it is recommended to install an SPD with integrated remote signalling contact.	The TS versions of OVR PV incorporate an end-of-life remote signalling contact. The dimensions of the versions with and without contacts are the same.

End-of-life, safety begins
Why so many precautions?

Varistors and spark gaps are non-linear components: at rated voltages they behave like an open circuit, while in the presence of an overvoltage they close the circuit.
In the example below we will try to explain intuitively how a varistor SPD works with a concept borrowed from plumbing: the safety relief valve.

A safety relief valve

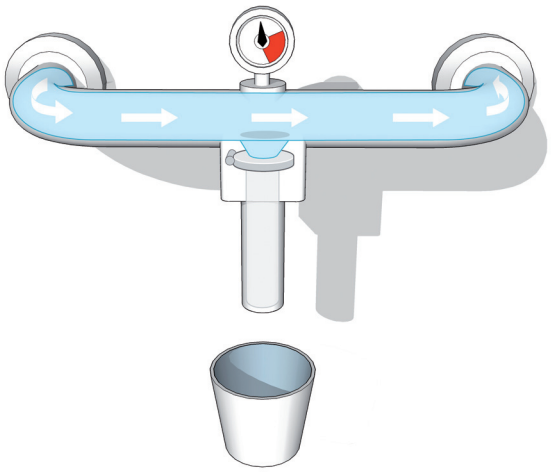
– The varistor behaves like a safety valve. When the pressure in the pipe (the voltage) is normal, the valve is closed

– When the pressure undergoes a sudden increase, this could cause the pipes (the electrical wires) or the equipment connected to them to break

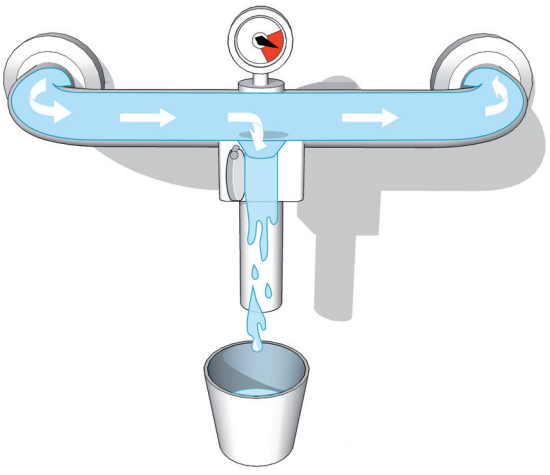
– The safety relief valve uses the pressure in the pipe to open the safety bleed outlet, letting a little of the liquid (the discharge current) flow out

– When the pressure has returned to normal, the valve re-closes by itself

Normal water pressure



Sudden increase in pressure



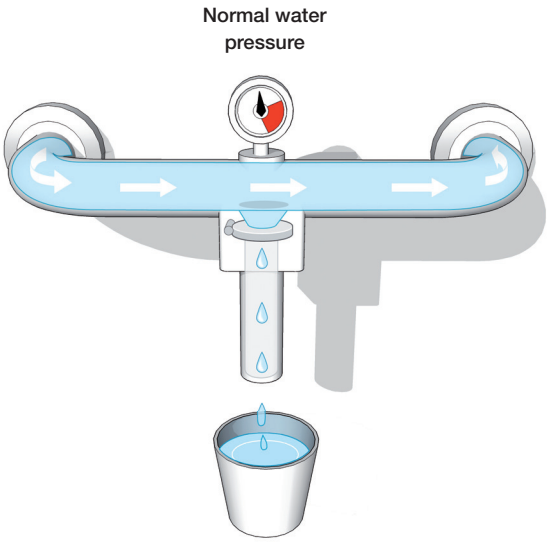
End-of-life, safety begins
What is it?

After many sudden changes, even with normal pressure … The safety valve starts to leak!

Back to electrotechnical…

– The varistor is no longer able to isolate the network
– Even under normal voltages it conducts a current, to earth or between two phases
– This current is ever as small as the lower the short-circuit current of the system is at the installation point: for PV it can be just a few amps
– In any case the varistor does not have zero resistance
– According to Joule's law:
  Loss in Watts = Resistance x Current ^{2}
  therefore …

$$R_{(large)} \times I^2_{(small)} \times T_{(minutes)} = \textbf{heat!}$$

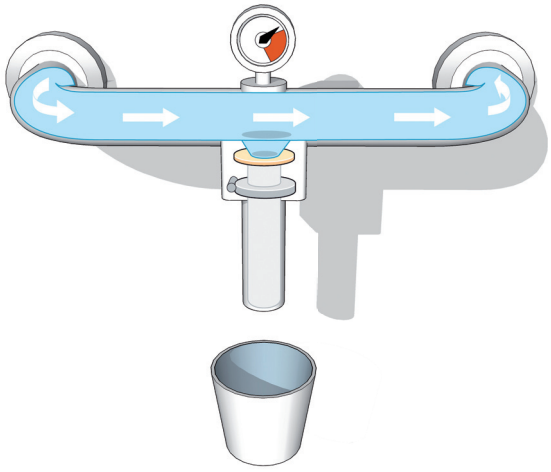


The passage of this current through the varistor is problematic, provoking dangerous overheating!

The heat generated by a varistor in end-of-life conditions can be sufficient to cause dangerous overheating of the SPD case and even cause the component to catch fire. To keep the system safe, each varistor is accompanied by a thermal disconnector and, if necessary, back-up protection is installed upstream.

The back-up fuse

– The SPD manufacturer must ensure adequate protection and prevent overheating of the varistor at the end of its life. If necessary, additional back-up protection must be provided: in general, fuses are used for PV
– If fitted, the fuse must be quite fast-acting in order to disconnect the varistor from the network at the end of its life before the heat generated has negative consequences
– Since the short-circuit currents are small in PV installations, the fuses must be able to cut in after a few seconds at low currents, so in general they will have a small rating compared to alternating current systems



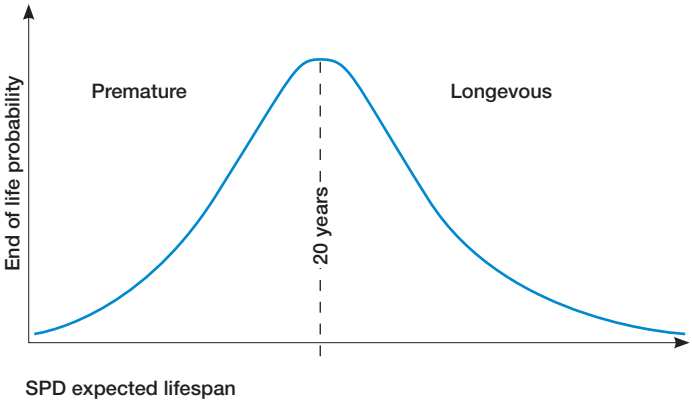
This is why ABB has developed the specific OVR PV range, which does not require any back-up protection up to 100 A short-circuit current (auto-protected)
while for values above 100 A it must be protected by a 10 A gPV fuse or 10A S800PV-S..

End-of-life, safety begins ....But when does it occur?

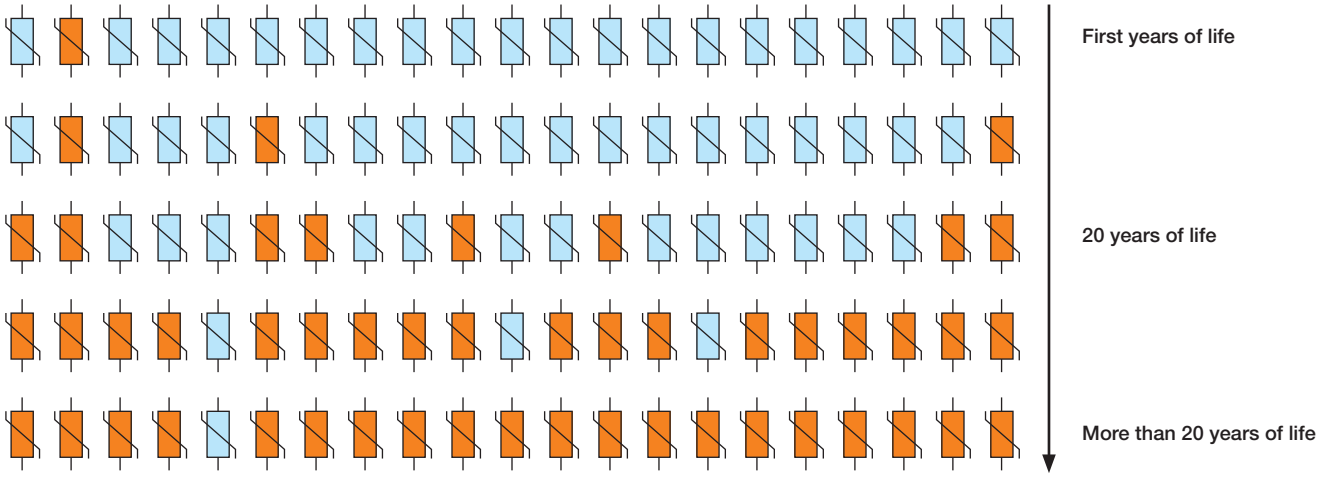
On average, a 20 kA Type 2 SPD has a lifespan of twenty years, but some may last thirty, and others only five!
The data refer to the frequency of lightning strikes according to IEC 62305 standards, to SPD lifespan tests according to IEC 61643-11 and to basic statistics.

A statistical question

– The lifespan of an SPD depends on its resilience connected to its rated discharge current I_n, but also to the number of times lightning strikes near the system each year
– On average, a 20 kA SPD in Europe will reach the end of its life after twenty years
– Given the long functional life of a PV plant and the large number of SPDs installed, statistics tell us that an SPD reaching the end of its life is far from an improbable occurrence; some SPDs (premature) could reach the end of their lives in the first few years of the system's operation ...



What happens to each SPD installed in the PV plant over the years?



SPDs replacement cartridges allow surge protection to be renewed when one of the SPDs reaches the end of its life cycle.

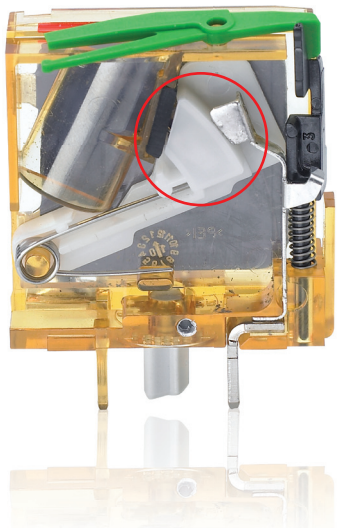
OVR PV thermal disconnector
Safety through and through

OVR PV photovoltaic SPDs contain varistors which are subject to slight wear at each electrical discharge.

After approximately twenty years of use the electrical resistance diminishes appreciably and the SPDs allow current to flow which becomes dangerous, overheating the product to the point where it is damaged. This is called the end of life of the SPD, which must be disconnected from the network supply to prevent the risk of fire.
Given the difficulty in extinguishing an electric arc in direct current, ABB has developed and patented a thermal disconnector able to disconnect the end-of-life SPD in complete safety. The operation of the thermal disconnector on the OVR PV is explained in these three figures:

Operating principle of the SPD when it has not reached the end of its life

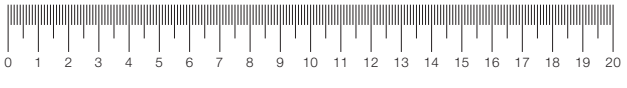
At end-of-life, the opening of the thermal disconnector and ignition of an electric arc in direct current



Extinguishing of the electric arc when the patented device cuts in

How much measures an electric arc: difference between alternating and direct current, indicative values for a 10 A current

	Minimum distance between electrodes to extinguish the arc
Alternating current 400V	
Direct current 600V	
Direct current 1000V	



An electric arc can spark between two electrodes because of the voltage present at their edges.
The extinguishing of the arc is more complex in direct current than in alternating current because the current never passes through zero.

- Extinguishing may take place at lesser distances, for example by quickly separating two electrodes.
- The thermal disconnector contained in OVR PV photovoltaic SPDs is able to extinguish the electric arc thanks to the fast opening of the contact and the isolation of the parts by insertion of an obstacle in the path of the arc.

Expert's corner:
What criteria are used to choose the SPDs for PV plants?

Are there international standards?
Since 2010, only the French UTE C 61740-51 was the reference to certify safety in SPDs for PV applications. In 2012, a European regulation shall come out with the EN 50539-11. In agreement with the UTE C, it does introduce the idea of testing the behaviour of the SPD in end of life for the safety of the equipment.

If the SPD is rated for alternating current performance, is it ok to use?
Since in theory, but only in theory an SPD can support a peak voltage of $\sqrt{2}$ x V AC, we might be tempted to use a product designed and certified for AC systems in a PV application
for example adapting a 440 V AC SPD for a 600 V DC installation.

This calculation does not take into account the SPD's end of life, a particularly critical case since the SPD must extinguish a DC arc, which is much more difficult compared to an AC arc.
ABB's OVR PV SPDs are specifically designed for direct current and their performance is specified on the product documentation as well as being clearly printed on the product.

On the following page you will find further information about DC electric arcs and the patented ABB solution to make PV plants safer than ever.

Is it enough for the SPD to be fitted with an integrated thermal disconnector?
The thermal disconnector is a component required by law in all varistor SPDs; it is necessary in any case to be sure that the disconnector has been designed and tested to interrupt a DC short circuit.
The disconnector is the component which ensures SPDs at the end of their lives do not cause fires. ABB knows this very well and therefore has designed a specific one for the OVR PV range.

How can I be sure that the back-up protection is correct?
The IEC guide states that SPD back-up must be co-ordinated. The co-ordination is ensured by special tests carried out by the manufacturer and must be consistent with the maximum short-circuit current of the system, almost always very low.
The tests performed by ABB on the OVR PV range ensure that back-up protection is not required up to 100 A.
Above this value, a 10 A gPV fuse or 10A S800PV-S. must be installed to ensure end-of-life protection.

What guarantees does ABB give on the safety of its SPDs for PV plants?
Until recently, the only regulation applicable to SPDs was EN 61643-11, but it still does not deal with DC, much less end-of-life in PV plants.

Today, the guide UTE C 61-740-51 and the future prEN 50539-11 are the only products standards for PV SPDs in the world to supply clear and unambiguous indications on the tests to be performed to ensure that an SPD is safe for PV applications. UTE conformity is today an additional guarantee of the quality and safety of OVR PV.

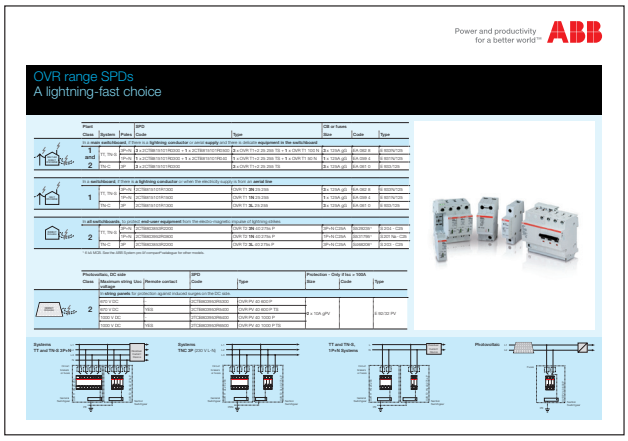
A quick technical guide to identify the ideal protection

OVR Facile 2
Quick product selection software for protection against surges

Among the new features of the software, the possibility to choose surge protection for photovoltaic applications and the possibility to print a personalised solution in just a few clicks. The software requires the installation of Microsoft Access or Access Runtime.

Software: 2CSC432010E0902
Downloadable from the following address:
http://inside.abb.com/abblibrary/downloadcenter/

The new deskmat for the OVR range



Protecting the electric system from surges is important for personal safety, as well as to safeguard precious electronic equipment. The new deskmat from the OVR range is a complete tool to be kept on the desktop or on the work bench, helping to quickly find the correct solution to protect against surges in industrial, civil and photovoltaic plants.

Deskmat in pdf: 2CSC432005E0902

S802PV-M25 and OTM switch disconnectors.
Two reliable types, one absolute safety.

From ABB's experience in the PV sector, two types of switch disconnectors which are safe, reliable and designed to meet all requirements. The S802PV-M25 has a maximum voltage of 650 V DC and is a switch disconnector to be used downstream of photovoltaic strings; it can be fed from both sides and with interchangeable terminals. It ensures the safety of the system during maintenance in only 3 modules.
The OTM series of switch disconnectors is particularly indicated for isolating the PV field and the inverter on the DC side and immediately after the inverter on the AC side and is thus the ideal supplement for maintenance of PV plants in complete safety, covering voltages up to 750 V DC.
The OTM series can be accessorised with ancilliary contacts and knobs for the return rotating manoeuvre, and can be integrated with the System pro *M* compact® line of products and compatible with the OT series accessories.

The OVR range
Global protection of the PV plant

The ABB range of SPDs offers global protection for photovoltaic plants.

Aside from direct current side protection against indirect lightning strikes with OVR PV, ABB offers a complete range of protective devices
for photovoltaic plants:

OVR T1

The Type-1 SPD is installed
in the main (AC side) switchboard at the system input and is able to direct the voltage of a direct lightning strike to earth. It is used as a first level of protection to ensure safety in the case of a direct lightning strike.

OVR T2

Type-2 alternating current SPDs protect the inverter, the equipment installed in the main switchboard and other delicate equipment on the AC side. All OVR T2 devices are fitted with end-of-life indicators and have simplified maintenance, thanks to the possibility to replace only the cartridge instead of the whole device.

OVR TC

The OVR TC data line SPDs protect the monitoring lines of the PV plants from surges. They are installed in series with the network and have removable cartridges, making maintenance simple, without having to cut the power to the telecommunications line.

For more information:
OVR guide: 1TXH000083C0202
OVR TC brochure : 2CTC432006B0901
The new edition of the OVR guide will soon be published, enhanced with the results of years of collaboration between ABB and users of OVR SPDs.

Designed for PV
Designed to always be effective
The advantages of OVR PV

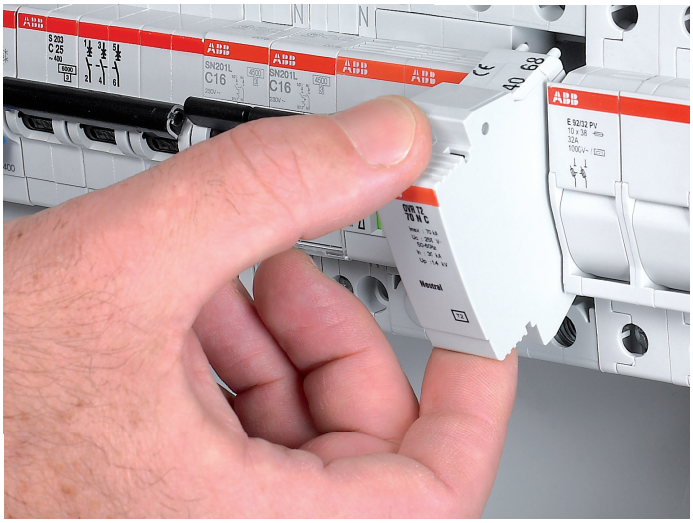
ABB's OVR PV SPDs are 100% safe and compatible with all types of PV plants.

The OVR PV SPDs are fitted with a patented thermal disconnector which ensures a safe end-of-life for the SPD in points of the plant with short circuit current up to 100 A in DC.
Where the short circuit current is less than 100 A DC, OVR PV can be installed without any back-up protection, while if it is above this value then it must be protected with a 10 A gPV fuse or 10A S800PV-S.

Experience
– The OVR PV range has been designed by ABB specifically for PV applications

Practicality
– All OVR PV models are multi-pole and have terminals for the two poles and PE
– The wiring system is fast and foolproof, since bars or other accessories are not required

A spark gap normally behaves like an open circuit, and conducts only when discharging. The nature of the spark gap therefore prevents permanent flow of current to earth.



Insulation

– The spark gap to earth on the OVR PV 40 600 P stops current flowing to the PE
– The number of SPDs which can be installed is unlimited, even
when insulation checks are present

Maximum protection

– The OVR PV has an extremely low level of protection: 1.4-2.8 kV for the 600 V version and 3.8 kV for the 1000 V version

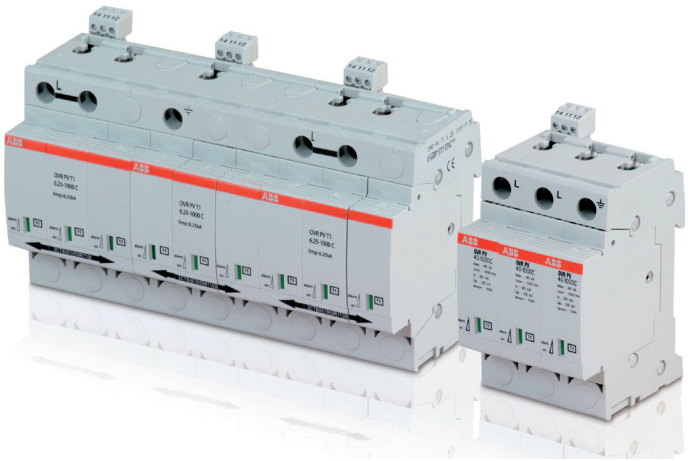
Removable cartridges

– The SPD can always be reused
– If a single cartridge reaches the end of its life, it is not necessary to replace the entire product
– Replacements can be made without cutting the power to the panel

Integrated contact

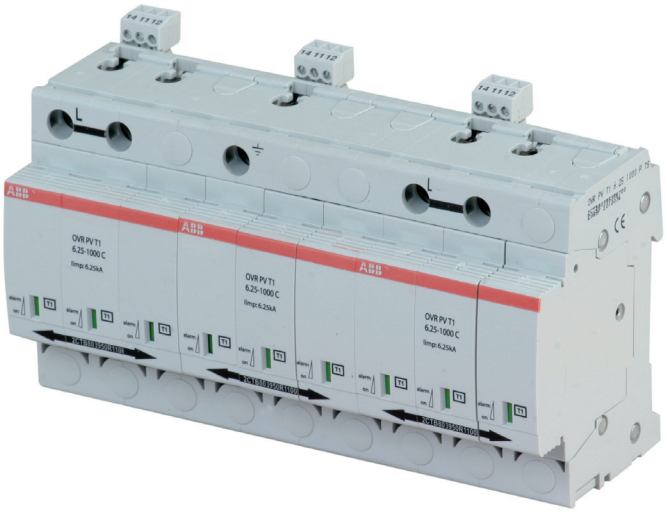
– Available on all versions
– Does not take up extra modules
– Signals the SPD end of life to the remote supervision systems

TS contact



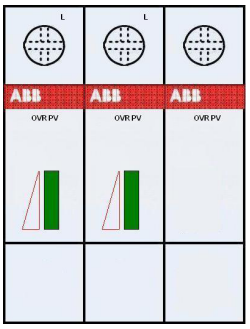
OVR PV SPDs for photovoltaic plants
Main features

Features
– SPDs designed by ABB specifically for the protection of photovoltaic plants
– Auto-protected from end-of-life short circuits up to 100 A DC thanks to the integrated thermal protection with direct current breaking capacity
– Removable cartridges
– Versions with and without end-of-life signalling contact
– “Y” configuration for a safer protection
– OVR PV T1 and T2 version

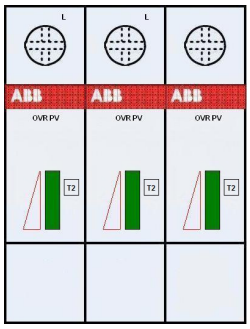


Main technical specifications		OVR PV T1	OVR PV 40
Reference standards		IEC 61643-11 / UTE C 61740-51 prEN 50539-11	
Configuration		Y	Y
SPDs Type / Test Class		T1 / I	T2 / II
Max. cont. Operating voltage Ucpv	V	670 / 1000	670 / 1000
Nominal discharge current In (8/20 µs)	kA	6.25	20
Impulse current Iimp (10/350 µs)	kA	6.25	-
Maximum discharge current Imax (8/20 µs)	kA	-	40
Voltage protection level Up	kV	1.9 / 2.5	2.8 / 3.8
Short circuit DC current withstand Iscwpv	A	100	100
Back-up protection: - if Iscwpv ≤100A - if Iscwpv >100A		- not required - 10A gPV fuse	- not required - 10A gPV fuse or MCB
Response time	ns	<25	<25
Specific integrated PV thermal disconnector		Yes	Yes
Pluggable		Yes	Yes
Auxiliary contact		TS	TS
Weight	g	1100	360

Backup protection
only required if Iscwpv > 100 A DC

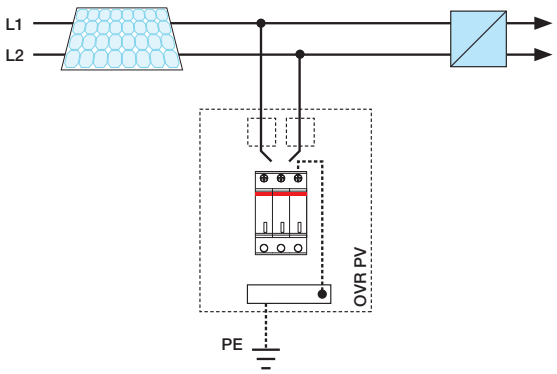


OVR PV 40 600 P



OVR PV 40 1000 P

Installation diagram



Ordering codes

Impulse current Imp (10/350) kA	Maxi discharge current Imax (8/20) kA	Nominal discharge current In (8/20) kA	Voltage protection level Up kV	Max. Cont. Operating Voltage Ucpv V	Short circuit DC current withstand Iscwpv A	Order details Type code	Order code	Bbn 3660308 EAN	Price 1 piece	Price group	Weight 1 piece kg	Pack unit ppc.
Type 1 PV, 9 poles												
6.25	-	6.25	1.9	670	100	OVR PV T1 6.25-600 P TS	2CTB803953R5700	518361	NEW		1.10	1
6.25	-	6.25	2.5	1000	100	OVR PV T1 6.25-1000 P TS	2CTB803953R6700	518378			1.10	1
Type 2 PV, 3 poles												
-	40	20	1.4	670	100	OVR PV 40-600 P	2CTB803953R5300	516527			0.38	1
-	40	20	1.4	670	100	OVR PV 40-600 P TS	2CTB803953R5400	516527			0.39	1
-	40	20	3.8	1000	100	OVR PV 40-1000 P	2CTB803953R6400	516534			0.38	1
-	40	20	3.8	1000	100	OVR PV 40-1000 P TS	2CTB803953R6500	516541			0.39	1
Replacement cartridges for Surge Protective Devices												
6.25	-	-	-	600	-	OVR PV T1 6.25-600 C	2CTB803950R1000	518978			0.24	1
6.25	-	-	-	1000	-	OVR PV T1 6.25-1000 C	2CTB803950R1000	518989			0.24	1
-	40	-	-	600	-	OVR PV 40-600 C	2CTB803950R0000	516558			0.12	1
-	40	-	-	1000	-	OVR PV 40-1000 C	2CTB803950R0100	516565			0.12	1
-	-	-	-	-	-	OVR PV MC	2CTB803950R0300	516756			0.12	1

Contacts

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