



Lightning & Surge Protection for Solar PV Plants



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With the growing awareness of global warming and the need for effective energy conservation, we are increasingly looking to new sources of renewable and eco-friendly energy. One of the front-runners in this search for 'safe' power is the use of photovoltaic (PV) and/or solar thermal sources - in other words, Solar Power. Such systems by design are located outdoors, and as such are susceptible to the damaging effects of lightning strike. Surge currents and surge voltages constitute a severe threat for PV systems. To ensure safe and reliable operation, these systems must be protected with suitable direct lightning protection system, earthing and surge protection device.

Solar Photovoltaic (PV) plants are always wide spread and isolated extensions or roof top installations. The cost of the equipment is high and their damage is detrimental to power supply, especially if they are connected to the distribution network. Their working is controlled by sensitive electronic equipment that may be severely affected by transient over voltages. Therefore, they are high risk installations for lightning protection.

LIGHTNING & SURGE PROTECTION FOR SOLAR PV PLANT

For such a complex type of installation as a solar power plant, it is necessary to make an assessment of the damage risk due to lightning strikes according to IEC 62305-2 (EN 62305-2), the result to be taken into account on designing. In case of a solar power plant the aim is to protect both the building and the PV array against damage by fire (direct lightning strike) and the electrical & electronic systems (inverters, remote diagnostics system, generator) against the effects of lightning electromagnetic impulses (LEMP)

Most of the solar module manufacturers offer a warranty of 20 years or more on their products. The cost of such devices is then calculated on this very long period. However those installations are very regularly exposed to lightnings and overvoltages, which can considerably reduce the desired life expectancy. The use of adapted surge protections is then highly recommended.

Several aspects have to be considered to evaluate the risk of "Lightning and Overvoltages" :

- ▶ The more the solar panel field is expanded, the more the risk of "lightning" issue is important.
- ▶ The risk is multiple: direct effect (lightning impact directly on the modules) and indirect effect (overvoltages on modules, on the converter/inverter and other connections).
- ▶ When the Photovoltaic devices are located on industrial sites, the risk of operation overvoltages should be taken into account as well.
- ▶ The risks level is directly linked to the density of local lightning and the exposure of the lines.



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Lightning Protection International Pty Ltd is a fully owned Australian manufacturer and supplier of direct strike lightning, surge and transient protection equipment and earthing products to a wide range of industries throughout the world.

DIRECT STRIKE LIGHTNING PROTECTION

LPI STORMASTER Early Streamer Emission (ESE) Air Terminals have been tested in official independent laboratories in order to obtain their advance time, for establishing their protection radius and to certify that they are able to withstand lightning currents. Stormaster ESE air terminals are tested and certified as per NF C 17 102 (2011) standard. Also it is tested and certified from CPRI (Central Power Research Institute), Government of India.

Considering Level 1 (the most exigent), a single air terminal can protect a surface of approximately 20,000m². For achieving this protection, air terminals have to be installed 6 meters above the solar cells height, however they may cause a problem of shadows. In order to minimize shadow effect, it is recommended to install the ESE air terminals around the photovoltaic plant perimeter. In this way, the shadow effect on solar cells are avoided as much as possible.

For a better performance it is recommended to place the air terminal on the 11mtrs self-standing masts so that the ESE air terminals reach a sufficient height over the solar cells.

An Early streamer Emission (ESE) air terminal is characterized by its response to lightning approach, going ahead any other element within its protection are and thus driving current to earth through a safe path. The Stormaster Early Streamer Emission air terminal uses the naturally occurring electrical field to complete the timely release of an upward streamer. This process provides for a safe and efficient method of controlling dangerous lightning energy at a preferred point.

As a thunder storm gathers overhead, the ambient electrical field surrounding the Stormaster ESE begins to rise in voltage. Upon the approach of a downleader towards the protected area, there is a rapid increase in the electric field which initiates the triggering of an upward streamer from the Stormaster ESE terminal. The concept of earlier allows for a larger or enhanced area of protection to be provided by the Stormaster ESE in comparison to a conventional rod. With the release of the upward streamer from the finial tip earlier than other competing structural points, the Stormaster ESE terminal becomes a preferred point for the capture of the lightning discharge within the protected area. It is fully autonomous, maintenance-free and its performance can be verified at any moment.

LIGHTNING STRIKE RECORDER (LSR1)

LPI have developed a LSR which is designed for easy mounting on a downconductor to effectively count the number of lightning strikes captured by the Stormaster ESE Terminal. When the lightning rod receive an impact of the lightning strike, discharge counter detects the energy dissipated by the down conductor, thereby incrementing the number. The LSR1 operates by sensing current by means of an inductive pick up loop. With the voltage impulse detected by the current transformer (CT) a trigger to the pulse counter then turns the counter to register the lightning event. The equipment does not require either external or internal power supply, as it is electromechanical and uses the power of the induced current dissipated through the down conductor.

Features

- 7 Digits
- Up to 9,999,999 counts
- IP 67 enclosure
- Testable using LSR-Tester

	PROTECTION RADIUS - Rp (m)											
h=height of Stormaster ESE terminal above the area to be protected (m)	2	4	5	6	10	15	20	45	60	80	100	
Protection Level I (Very High)												
Stormaster ESE 15	13	25	32	32	34	35	35	35	35	35	35	
Stormaster ESE 30	19	38	48	48	49	50	50	50	50	50	50	
Stormaster ESE 50	27	55	68	69	69	70	70	70	70	70	70	
Stormaster ESE 60	31	63	79	79	79	80	80	80	80	80	80	
Protection Level II (High)												
Stormaster ESE 15	15	30	37	38	40	42	44	44	44	44	44	
Stormaster ESE 30	22	44	55	55	57	58	59	59	59	59	59	
Stormaster ESE 50	30	61	76	76	77	79	79	79	79	79	79	
Stormaster ESE 60	35	69	86	87	88	89	89	89	89	89	89	
Protection Level III (Medium)												
Stormaster ESE 15	18	36	45	46	49	52	55	60	60	60	60	
Stormaster ESE 30	25	51	63	64	66	69	71	75	75	75	75	
Stormaster ESE 50	35	69	86	87	88	90	92	95	95	95	95	
Stormaster ESE 60	39	78	97	97	99	101	102	105	105	105	105	
Protection Level IV (Standard)												
Stormaster ESE 15	20	41	51	52	56	60	63	73	75	75	75	
Stormaster ESE 30	29	57	71	72	75	78	81	89	90	90	90	
Stormaster ESE 50	38	76	95	96	98	100	102	109	110	110	110	
Stormaster ESE 60	43	85	107	107	109	111	113	119	120	120	120	

Protection Performance

A protection radius (Rp) of a Stormaster ESE terminal is calculated using the following formula as defined in NF 17-102 (September 2011), namely:

$$Rp(h) = \sqrt{2rh - h^2 + \Delta(2r + \Delta)} \text{ for } h \geq 5 \text{ m}$$

and

$$Rp = h \times Rp_5 / 5 \text{ for } 2 \leq h < 5 \text{ m}$$

Where h = Stormaster height relative to the area being protected (m)

Rp₅ = value of Rp from Eqn. (1) when h = 5 m

r = 20 m for protection level I (Very High protection)

30 m for protection level II (High Protection)

45 m for protection level III (Medium protection)

60 m for protection level IV (Standard protection)

and Δ = Stormaster height advantage according to the Stormaster model installed:

Choice: Stormaster ESE 15: Δ = 15 m

Stormaster ESE 30: Δ = 30 m

Stormaster ESE 50: Δ = 50 m

Stormaster ESE 60: Δ = 60 m



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EARTHING SYSTEM

Earthing is essential for stabilizing the voltage of the equipment with respect to the ground during its normal operation. It is a common practice that the solar cells have a good earthing system. It is highly recommended to bond all the earthings, that is, that a general earthing network exists where all solar cells are connected. Besides, metallic masses (frames, fenders, supports and covers) should be also connected to the earthing according to UNE-EN 61173 in order to achieve the equipotentialization of all the elements thus avoiding differences of potential and dangerous sparks.



The installation of a radial earthing arrangement is recommended for each lightning protection earth, the radial earthing configuration provides an effective means for the safe dissipation of the lightning energy into the ground mass.

All individual lightning earths should be bonded together in a ring earth arrangement to minimise ground loops and potential differences under transient conditions. Compliance to NF C17-102 (2011) requires an earth DC resistance reading of less than 10 ohms for the lightning earths.

If installing either a radial earthing system or grid type earthing system it is recommended that all earthing conductors be installed at a depth of between 500mm and 750mm (recommended) with a maximum depth of 1000mm. In order to further assist in improving the earth resistance of the system, it is recommended that the excavated soil of poor quality (rocky/sandy) shall be replaced with the soil of a good quality (garden loam) prior to backfilling the trench.

Key components of a lightning earth include: Earth Rods

Copper bonded (threaded or unthreaded),
Solid Copper or Stainless Steel.

LPI Resistance Lowering Compound (LPI RESLO)

The requirement for a low resistance is extremely important with the installation of any earthing system. LPI's RESLO provides the ability to



dramatically reduce soil resistivity even in soils with average electrical conductivity. LPI RESLO is supplied in 10 Kgs packaged bags to suit the site application.

RESLO comprises specifically selected compounds, which possess excellent electrical conductivity. When RESLO is mixed with water and poured around the earthing system and surrounding soil, the powder and water react to form a hardened mass within an earthing system. RESLO will not wash away under seasonal conditions and therefore provides a permanent presence in working to improve and maintain the integrity of an earthing system. Given that RESLO does not wash away, the requirement to re-treat the soil as is the case with other enhancing compounds is eliminated.



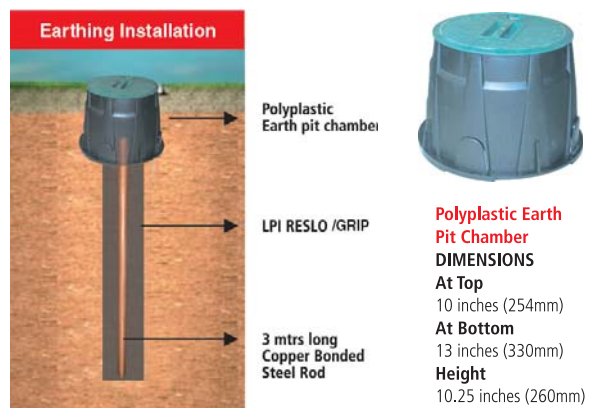
LPI Ground Resistance Improvement Powder (LPI GRIP)

The requirement for a low resistance is extremely important with the installation of any earthing system. LPI's GRIP provides the ability to substantially reduce soil resistivity in soils of the poorest electrical conductivity such as rocky ground or sandy soils. LPI GRIP is supplied in two kit sizes - A 10 Kgs kit comprises two 5 Kg containers; one 5 Kg kit contains a copper compound whilst the other 5 Kg kit holds a mix of compounds which assist in the mixing process (Hardener).



When GRIP is mixed with water and poured around the earthing system and surrounding soil, the powder and water react to form a gelatinous hygroscopic mass which forms an integral part of an earthing system, this effectively increases the surface area of the earthing system in contact with the surrounding soil.

GRIP will not wash away under seasonal conditions and therefore provides a permanent presence in working to improve and maintain the integrity of an earthing system. Given that GRIP does not wash away, the requirement to re-treat the soil is eliminated.



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Ltd. belongs since its establishment in 1994 to major producers of surge protection devices in Europe. The company obtained ISO 9001 certificate in 1997. The production of surge protection devices is a specific area with great demands on professional knowledge of the company's management as well as the production and research staff. Introduction of new technologies and using the latest testing equipment enable engineers to extend their technical knowledge.

Hakel's products are exported world wide. The surge protection product range offered by Hakel company enables customers to apply the products easily in every industry, offices or households. Hakel's products are used in the whole industrial world, offices and institutes of any kind so they can safely protect all kinds of communication, data and coaxial systems against surge. Following the continual electronic development helps Hakel to achieve higher standards and better technical parameters. That is one of the reasons why Hakel stands among the world market leaders. Products are tested according to standard EN 61 643-11 and IEC 61643-1.

LIGHTNING & SURGE PROTECTION FOR PHOTOVOLTAIC (PV) SYSTEMS

The guaranteed service life of 20 years or more is offered for their system by most of the solar module manufacturers. The cost of the modules are justified by calculating this long period of operation. However PV installations are very much exposed to the lightnings and surges/transients. Not only house owners install a PV system on their rooftop but also private companies make more and more investments in shared systems, which are erected on large-surface roofs, on traffic structures or unused open areas.

Because of the big space requirements of the photovoltaic generator, PV systems are especially threatened by lightning discharges during thunderstorms. Causes for surges in PV systems are inductive or capacitive voltages deriving from lightning discharges as well as lightning surges and switching operations in the upstream power supply system. Lightning surges in the PV system can damage PV modules and inverters. This can have serious consequences for the operation of the system. It may leads to high repair costs and system failure can result in considerable profit cuts for the operator of the plant.

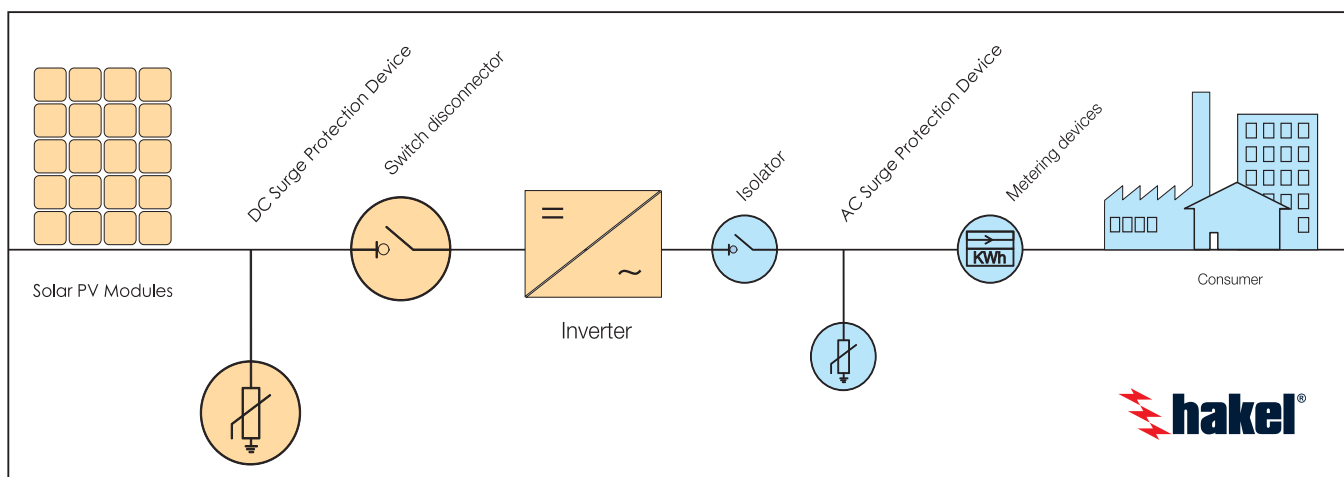
Since the surge protection device shunts the transient/surges to the earth, a low impedance good conductivity earthing, at the same potential is critical for the surge arresters to function

properly. Equipotential bonding has to be done for the protection scheme to work efficiently.

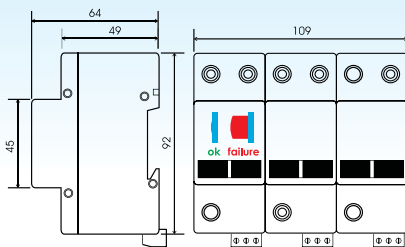
HAKEL, a Czech Republic company offers a complete range of surge protection solutions specifically for the photovoltaic market. HAKEL surge protection devices are high performance solutions complaint with the international standards in order to ensure the efficiency and reliability of the photovoltaic system.

Recommendations of Surge Protection Device (SPD):

1. **AC SPD:** The output side of the PV inverter where the AC power supply is fed to the load. Depending upon the power supply system, Single or Three phase AC SPD is recommended.
2. **DC SPD:** The power supply which is fed into the inverter is of DC which flows from PV modules and are exposed to the lightning & induced surges. Suitable DC SPD ratings (200, 400, 600, 800, 1000V DC, etc) is recommended.
3. **DATALINE SPD:** Some of the PV installations are connected to the central monitoring system through the datalines (transmitters, receivers, modems, etc) which may get effected by the lightning & induced surges. Suitable DATALINE SPD is recommended.



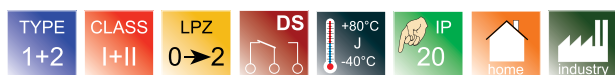
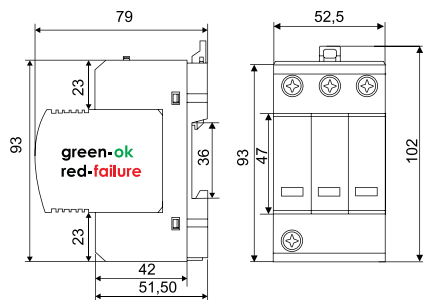
Lightning & Surge Protection for Solar PV Plants



LIGHTNING & SURGE ARRESTERS - VARISTOR

SPC PV is surge arrester type 1+2 according to EN 61643-11. It is designed for protection of positive and negative busbars of Photovoltaic systems against the surge effects. These arresters are recommended for use in the Lightning Protection Zones Concept at the boundaries of LPZ 0-1 (according to IEC 1312-1 and EN 62305). Particular varistor sectors connected between terminals L+, L- and PE are equipped with internal disconnectors which are activated when varistors fail (overheat). Failure indication of these disconnectors is partly mechanical (by red signaling target) and partly remote monitoring (by potential free switching contacts).

		SPC PV 600 DS	SPC PV 800 DS	SPC PV 1000 DS
Max. continuous operating voltage	U_{CPV}	650 V DC	880 V DC	1000 V DC
Open circuit voltage of PV generator	U_{OCSTC}	$U_{OCSTC} < U_{CPV} / 1.2 = 540V$	$U_{OCSTC} < U_{CPV} / 1.2 = 740V$	$U_{OCSTC} < U_{CPV} / 1.2 = 830V$
Short circuit with stand	I_{SCWPV}	25 A	25 A	25 A
Lightning impulse current (10/350)	I_{imp}	12.5 kA	12.5 kA	12.5 kA
- charge	Q	6 As	6 As	6 As
- specific energy	W/R	36 kJ/ohm	36 kJ/ohm	36 kJ/ohm
Application		L+L-, L+/PE, L-/PE	L+L-, L+/PE, L-/PE	L+L-, L+/PE, L-/PE
Nominal discharge current (8/20)	I_n	25 kA	25 kA	25 kA
Voltage protection level at I_n	U_p	<2.4 kV	<3.1 kV	<3.5 kV
Response time	t_A	<25 ns	<25 ns	<25 ns
Weight	m	900 g	900 g	900 g
		SPC PV 600 - 10 168	SPC PV 800 - 10 169	SPC PV 1000 - 10 170
		SPC PV 600 DS - 10 068	SPC PV 800 DS - 10 069	SPC PV 1000 DS - 10 070



LIGHTNING & SURGE ARRESTERS - VARISTOR

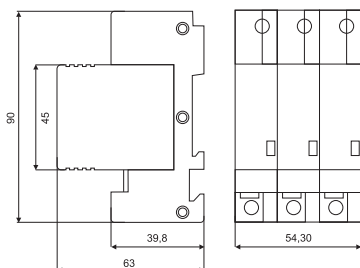
PIVM PV is lightning and surge arrester type 1+2 according to EN 61643-11, EN 60530-11 and UTE C 61-740-51. Complete device consists of a base part and pluggable modules. These arresters are recommended for use in the Lightning Protection Zones Concept at the boundaries of LPZ 0-2 (according to IEC 1312-1 and EN 62305) for equipotential bonding of positive and negative busbars of photovoltaic systems and elimination of transient overvoltage that originate during atmospheric discharges of switching processes. Failure indication of these disconnectors is partly visual (Green-Ok/Red-Fault) and partly remote monitoring by potential free switching contacts (only PIVM PV* DS type)

		PIVM PV 600 DS	PIVM PV 800 DS	PIVM PV 1000 DS
Max. continuous operating voltage	U_{CPV}	600 V DC	800 V DC	1050 V DC
Open circuit voltage of PV generator	U_{OCSTC}	$U_{OCSTC} < U_{CPV} / 1.2 = 500V$	$U_{OCSTC} < U_{CPV} / 1.2 = 730V$	$U_{OCSTC} < U_{CPV} / 1.2 = 875V$
Short circuit with stand	I_{SCWPV}	100 A	100 A	100 A
Lightning impulse current (10/350)	I_{imp}	7 kA	6.5 kA	6.5 kA
- charge	Q	3.5 As	3.25 As	3.25 As
- specific energy	W/R	12 kJ/ohm	10 kJ/ohm	10 kJ/ohm
Maximal discharge current (8/20)	I_{max}	40 kA	40 kA	40 kA
Nominal discharge current (8/20)	I_n	20 kA	15 kA	15 kA
Voltage protection level at I_n (L/PE)	U_p	<1.3 kV	<1.65 kV	<1.9 kV
Response time	t_A	<25 ns	<25 ns	<25 ns
Application		L+L-, L+/PE, L-/PE	L+L-, L+/PE, L-/PE	L+L-, L+/PE, L-/PE
Weight	m	300 g	390 g	400 g
		PIVM PV 600 - 16 070	PIVM PV 800 - 16 073	PIVM PV 1000 - 16 076
		PIVM PV 600 DS - 16 071	PIVM PV 800 DS - 16 074	PIVM PV 1000 DS - 16 077

Lightning & Surge Protection for Solar PV Plants

SURGE ARRESTERS - VARISTOR

SPUM PV is surge arrester type 2 according to EN 61643-11. Complete device consists of a base part and pluggable modules. These arresters are recommended for use in the Lightning Protection Zones Concept at the boundaries of LPZ 1-2 (according to IEC 1312-1 and EN 62305) for equipotential bonding of positive and negative busbars of photovoltaic systems and elimination of transient overvoltage that originate during atmospheric discharges or switching processes. Failure indication of these disconnectors is partly visual (Green-Ok/Red-Fault) and partly remote monitoring by potential free switching contacts (only SPUM PV* DS type).



green-OK
red-failure

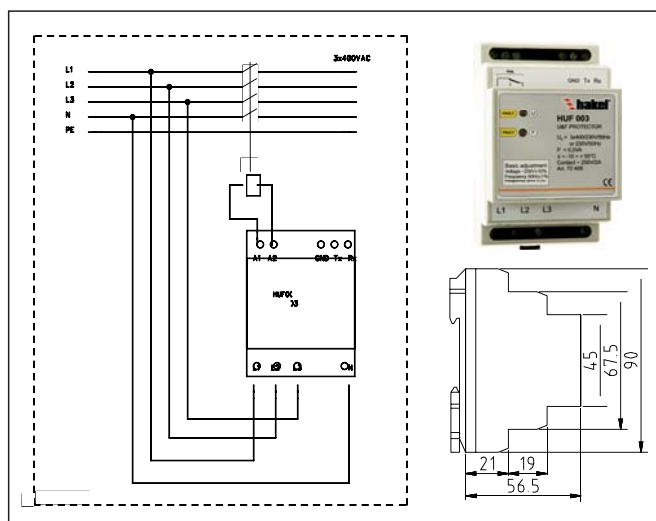


		SPUM PV 200 DS	SPUM PV 400 DS	SPUM PV 600 DS
Max. continuous operating voltage	U_c	200 V DC	400 V DC	600 V DC
Max. discharge current (8/20)	I_{max}	40 kA	40 kA	40 kA
Nominal discharge current (8/20)	I_n	15 kA	20 kA	15 kA
Application		L+L-, L+/PE, L-/PE	L+L-, L+/PE, L-/PE	L+L-, L+/PE, L-/PE
Voltage protection level at I_n	U_p	<0.95 kV	<1.7 kV	<2.5 kV
Response time	t_A	<25 ns	<25 ns	<25 ns
Max. back-up fuse		125 AgL/gG	125 AgL/gG	125 AgL/gG
Weight	m	300 g	300 g	300 g
		SPUM PV 200 - 24 181	SPUM PV 400 - 24 182	SPUM PV 600 - 24 183
		SPUM PV 200 DS - 24 081	SPUM PV 400 DS - 24 082	SPUM PV 600 DS - 24 083

		SPUM PV 800 DS	SPUM PV 1000 DS
Max. continuous operating voltage	U_c	800 V DC	1000 V DC
Max. discharge current (8/20)	I_{max}	40 kA	40 kA
Nominal discharge current (8/20)	I_n	20 kA	15 kA
Application		L+L-, L+/PE, L-/PE	L+L-, L+/PE, L-/PE
Voltage protection level at I_n	U_p	<2.8 kV	<3.5 kV
Response time	t_A	<25 ns	<25 ns
Max. back-up fuse		125 AgL/gG	125 AgL/gG
Weight	m	300 g	300 g
		SPUM PV 800 - 24 184	SPUM PV 1000 - 24 185
		SPUM PV 800 DS - 24 084	SPUM PV 1000 DS - 24 085

HUF 003 - VOLTAGE & FREQUENCY PROTECTOR

This Voltage & Frequency Protector is recommended for use in AC parts of photovoltaic systems or other types of AC electrical installations. HUF is equipped with switching contact intended for external contactor control. This contact will operate once the HUF gets connected to monitored system after initialization of its internal electronics. Subsequently, HUF device continuously monitors two basic magnitudes (voltage and frequency) of connected AC power system. In case of their deviation from the preset values the switch contact will open and consequently the external contactor will disconnect the equipment from the monitored AC power system immediately. HUF 003 is suitable for use in three-phase or in single phase applications since reconfiguration of measuring mode is made automatically by inbuilt microprocessor. The basic working limits of overvoltage/undervoltage/frequency and basic response time are set by producer.



Lightning & Surge Protection for Solar PV Plants

Our Expertise

Drawing on the combined strengths & overall experience of 38 years in the field of lightning protection, surge protection and grounding/earthing system, APS (Allied Power Solutions) has become the one of the first Indian company to be certified as "UL (USA) certified LPS (Lightning Protection System) Installer". LPS includes external lightning protection, internal lightning & surge protection and earthing/grounding solutions.

APS has been closely associated with various leading international companies to provide the world class solutions towards safety. Our valued principals are "Lightning Protection International Pty Ltd", Australia well known in the market as "LPI" - pioneer in the field of external lightning protection system & electrical grounding solutions and "HAKEL LTD", Czech Republic pioneer in Surge Protection Devices.

Furthermore, we have been a technical leader of providing the solution starting from designing of lightning protection for the solar farm to implement the same in any given area across the country. With the well spread dealer network across the country, we are able to offer all the

support and guidance required by our valued customers in no mean of time. Our catalog caters to solar installers, electrical contractors and other professionals working in the renewable energy field and "electrifying" solar industry. We are looking forward to working with you as we all strive to create a sustainable future. One of our goals is to provide a "one-stop solution" for all of your electrical safety product needs, including unsurpassed service.

Useful Application Information

We made the catalog more useful by incorporating our experience in the kinds of situations in which the products might be best applied. While basic, we believe it will help the people whom are new to the business or new to a particular arena.

Distributed by:

DISCLAIMER

- LPI & HAKEL maintains a policy of on-going product development, specifications are subject to change without notice.
- Application detail, illustrations and schematic drawings are representative only and should be used as guides.
- It should be noted that 100% protection level for direct strike lightning, lightning detection and surge and transient protection equipment is not possible and cannot be provided due to the lightning discharge process being a natural atmospheric event.



ALLIED POWER SOLUTIONS

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