Raycap

Protection against surges and overvoltages in Battery Energy Storage Systems

The purpose of this paper is to illustrate when and where the installation of surge protective devices (SPDs) is required in Battery Energy Storage Systems (BESS).

BESS systems contain AC/DC converters and battery banks implemented in concrete constructions or in metallic containers. These AC/DC converters have sensitive electronics, and the high-capacity batteries with low dielectric strength pose a risk of explosion in case of arcing. Therefore the need for optimized and reliable electrical protection against the influence of lightning and surge events becomes mandatory.

A risk assessment per IEC 62305-2 should first be performed to understand better if an external lightning protection system (LPS) is required.

The above standard considers the following four scenarios (Table 1), which are also applicable to a BESS, as shown in Figure 1.

S1	Direct strike to the lightning protection system (LPS) or the structure (e.g. battery containers)
S2	Strike near the structure
S3	Strike to the service lines connected to the structure
S4	Strike near the line entering the structure, which will induce voltage onto the line(s) and power/data

Table 1: Overvoltage causes

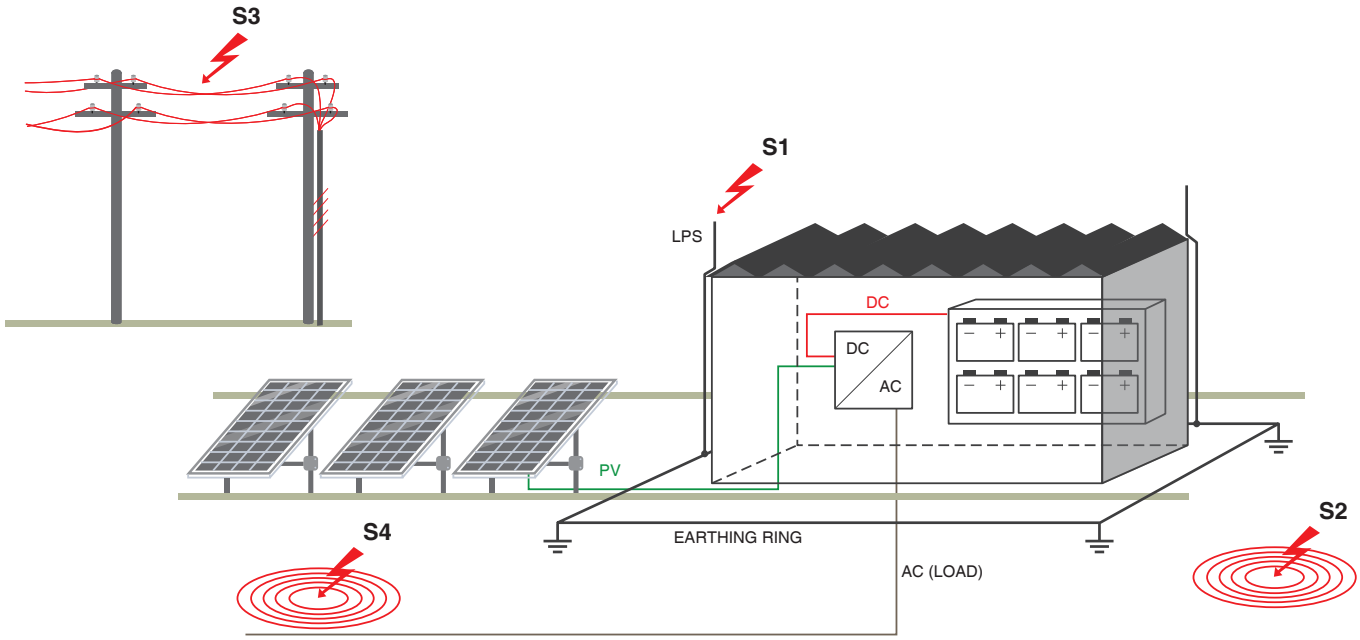


Figure 1: Cause of overvoltage at a BESS

The IEC 60364 series of standards are also applicable to fixed-wired installations such as permanently wired (non-mobile) BESS and need to be considered. Specifically, IEC 60364-4-44 addresses the protection of electrical installations and describes measures against voltage disturbances and electromagnetic disturbances, including transient overvoltages transferred via the supply lines. In addition, IEC 60364-5-53 addresses the selection and installation of SPDs for such applications.

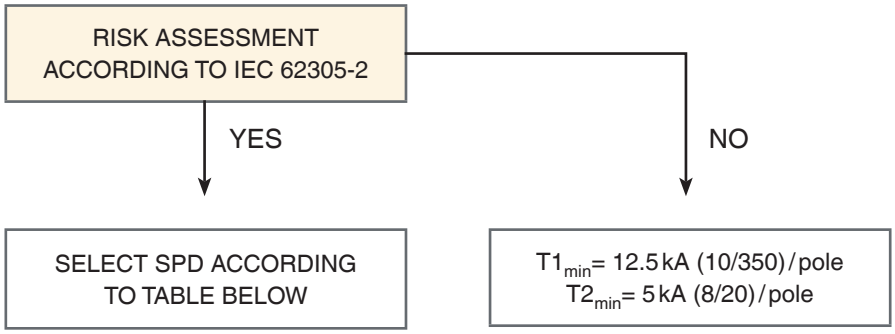
Beyond these standards, any national standards and applicable installation rules must also be followed.

Required surge ratings of AC SPDs

When an LPS is installed (which is typically the case with a BESS), the AC SPDs shall be selected using Table 2.

In the rare event that no LPS is required, the AC SPDs shall be rated as Class II/Type 2 (T2) devices.

Attention: According to IEC 60364-5-53, when the lines entering the BESS building/container are overhead, SPDs rated as Class I/Type 1 (or better T1/T2) with an I_{imp} = 5 kA per conductor shall be selected. This general rule may differ in national harmonized standards (such as in Germany VDE 0100 543).



LPL	Flash to Structure		Flash to Structure		Direct and Indirect Flashes to the Service		
	S1 (10/350)		S1 (8/20)	S2 (8/20)	S3 (10/350)		S4 (8/20)
	1 phase	3 phase	Inductive coupling	Induced current	1 phase	3 phase	Inductive coupling
I	50 kA	25 kA	10 kA	0.2 kA	20 kA	10 kA	5 kA
II	35 kA	17.5 kA	7.5 kA	0.15 kA	15 kA	7.5 kA	3.75 kA
III / IV	25 kA	12.5 kA	5 kA	0.1 kA	10 kA	5 kA	2.5 kA

Table 2: AC SPD ratings

All values are per conductor

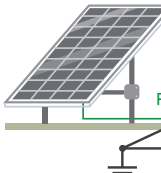
Required surge ratings of DC SPDs

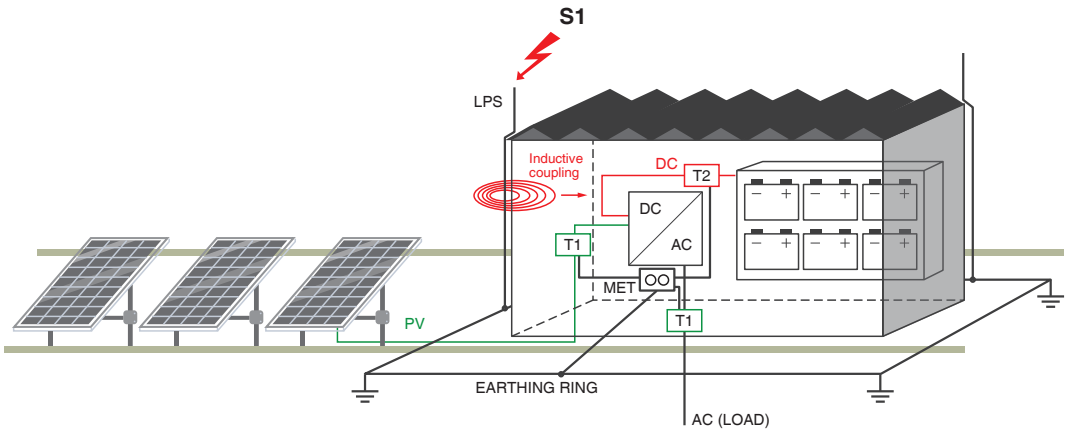
While rules for the selection and installation of DC SPDs for PV applications is well described in IEC 61643-32, the selection of DC SPDs for BESS applications is relatively new, and a dedicated standard is currently not available.

One approach to this difficulty is to follow relevant recommendations found in IEC 62305-4. Because an AC/DC converter is always installed, and SPDs are installed at entering lines (AC/PV), parameters S3 and S4 can be eliminated. Scenarios S1 and S2, however, do need to be considered relative to the building structure, the grounding system, the physical distance between the AC/DC converter and the battery, and the associated cable routing. The withstand voltage of the AC converter and battery must also be considered. The selected SPDs need to have a voltage protection level that will adequately protect this, usually $U_p < U_w$ is used. Generally, the withstand level of the common mode voltages of +DC to ground and -DC to ground need to be carefully evaluated to ensure that no electrical arc to chassis can occur.

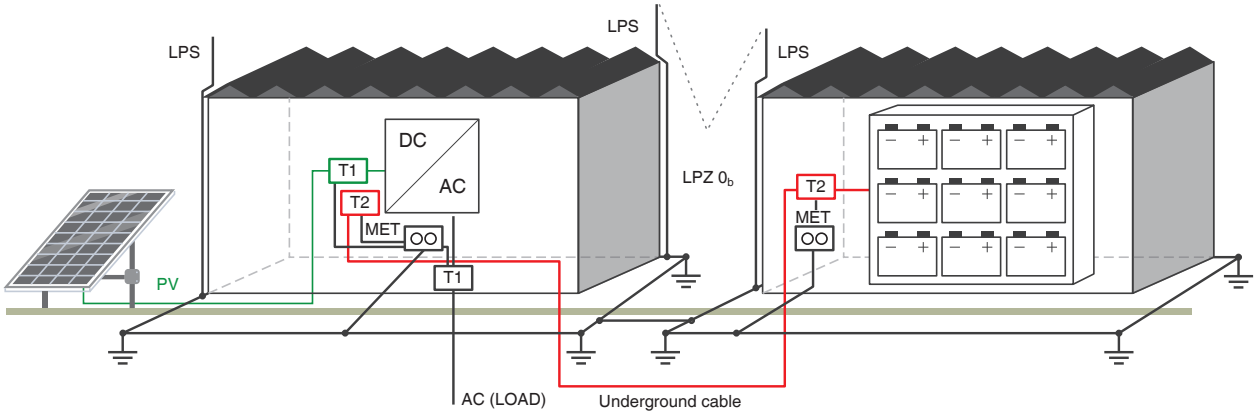
The withstand voltage of live parts (e.g., battery poles) to ground is a function of environmental conditions (humidity, salty air etc.), which need to be limited to safe levels using appropriately selected DC SPDs.

The following figures illustrate the selection and installation of DC SPDs under each of the possible lightning scenarios.

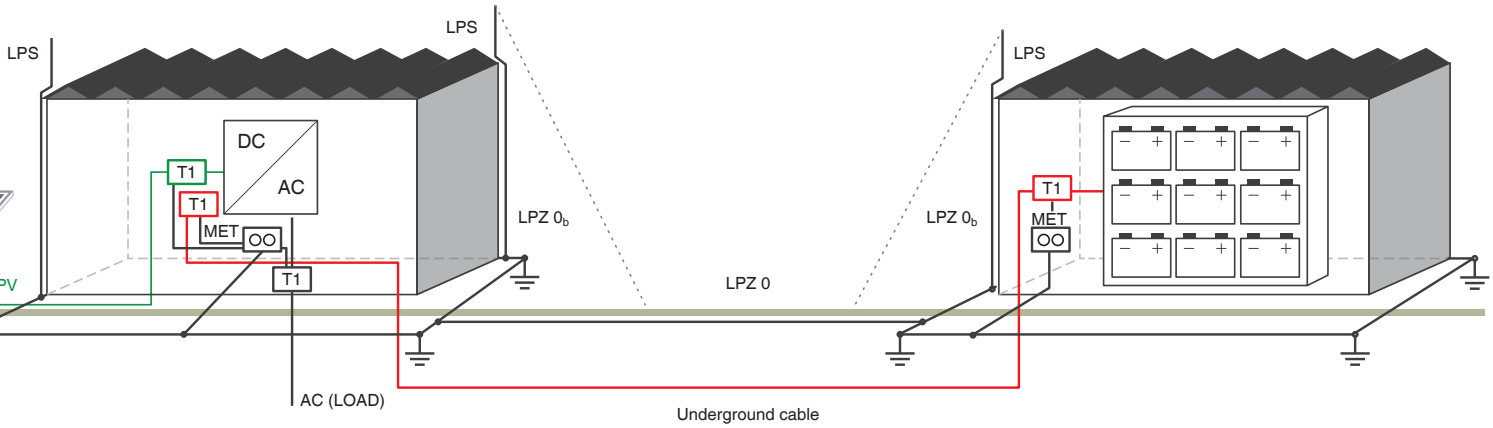




Scenario 1: BESS with common concrete structure for AC/DC converter and battery. Separation distance between the LPS and the BESS equipment is maintained. One T2 DC SPD needs to be installed to protect against the influence of the S1 event (inductive coupling). In the case of metal construction with lightning current sharing via the housing (walls), the inductive coupling is reduced, and the DC SPD may be eliminated.



Scenario 2: BESS with separate concrete structures for AC/DC converter and the battery located nearby. The separation distance between the LPS and the BESS equipment is maintained. Common grounding, DC cable routed underground in a protected area (LPZ 0b). T2 DC SPDs required; T1/T2 recommended. If the DC cable length is <10m, only one DC SPD (either at the inverter or the battery) is required. The same approach counts for metal constructions.



Scenario 3: BESS with separate concrete structures for AC/DC converter and battery. The separation distance between the LPS and the BESS equipment is maintained. Common or separated grounding, DC cable is routed above ground or underground in a cable trench in the LPZ 0 area. T1 DC SPDs are required; T1/2 is recommended. The same approach counts for metal constructions.

DC SPD Specification

Standards IEC 61643-11 and IEC 61643-31 cover the requirements for selecting SPDs for use in AC and PV applications. However, there are currently no specific EN/IEC standards that address SPD selection and testing for use in BESS-related applications. However, the standard IEC 61643-41, which covers SPDs connected to low-voltage DC power systems, is presently in draft form and circulating among national committees.

Not having suitable national or international standards to cover the selection and installation of DC SPDs on BESS systems can lead to incorrect SPD choices.

IEC 61643-31 clearly states that the standard applies only to SPDs installed on the DC side of photovoltaic (PV) systems. Furthermore, it does not cover SPDs used inside the systems, e.g., batteries or capacitor banks. This is because there are significant differences in the end-of-life behavior of DC SPDs when connected to a PV constant current source compared to a DC battery source.

Raycap DC SPDs are tested according to IEC 61643-31 and have been further optimized and field-tested for use in BESS DC applications. Strikesorb 35, ProBloc B and SafeTec T2-1000 products are all relevant for use and complementary to this application.

The Strikesorb 35 Series employs patented technology to ensure effective and safe operation on BESS systems up to 1500 VDC and is certified to UL 1449 5th edition under the new supplement SB category covering Direct Current (DC) SPDs.

Many surge protective devices will require a dedicated backup fuse. This will lead to higher costs, more significant space requirements, and increased voltage protection levels. However, Strikesorb 35 technology can, in many cases, be installed without an additional backup fuse. For example, Strikesorb 35 can be installed without a dedicated backup fuse even when the prospective fault current to which it is connected is as high as 100 kA, which is typically the case with BESS. This is a major benefit of Strikesorb 35 in these applications.

The functional tests performed on DC SPDs under UL 1449 5th edition supplement SB are more demanding than those used to test PV SPDs. The fact that only a limited number of DC SPDs suitable for operation on system voltages greater than 500 VDC are listed on UL's database indicates that fulfilling the onerous testing of the SB supplement is providing a challenge to many SPD manufacturers.

ProBloc B 1000 DC and **SafeTec T2-1000** are DIN rail mountable SPDs suitable for DC applications. These products are dedicated for use in smaller-sized BESS and rely on additional backup fuses.

Recommended Raycap SPDs for use in BESS

Strikesorb 35
Class I/T1 SPD
12.5 kA (10/350 µs)

ProBloc B 1000 DC
Class I/T1 SPD
6.25/12.5 kA (10/350 µs)

SafeTec T2-1000 DC
Class II/T2 SPD
20/65 kA (8/20 µs)

In conclusion, Raycap has the technology, products, and expertise to help engineers determine which solution best fits the protection needs of their BESS implementation.

For more information please contact Raycap at info@raycap.com, or visit our website at www.raycap.com.

Contact Raycap if you need technical assistance about how to protect against surge or overvoltage damage, or if you have questions about your applications.

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