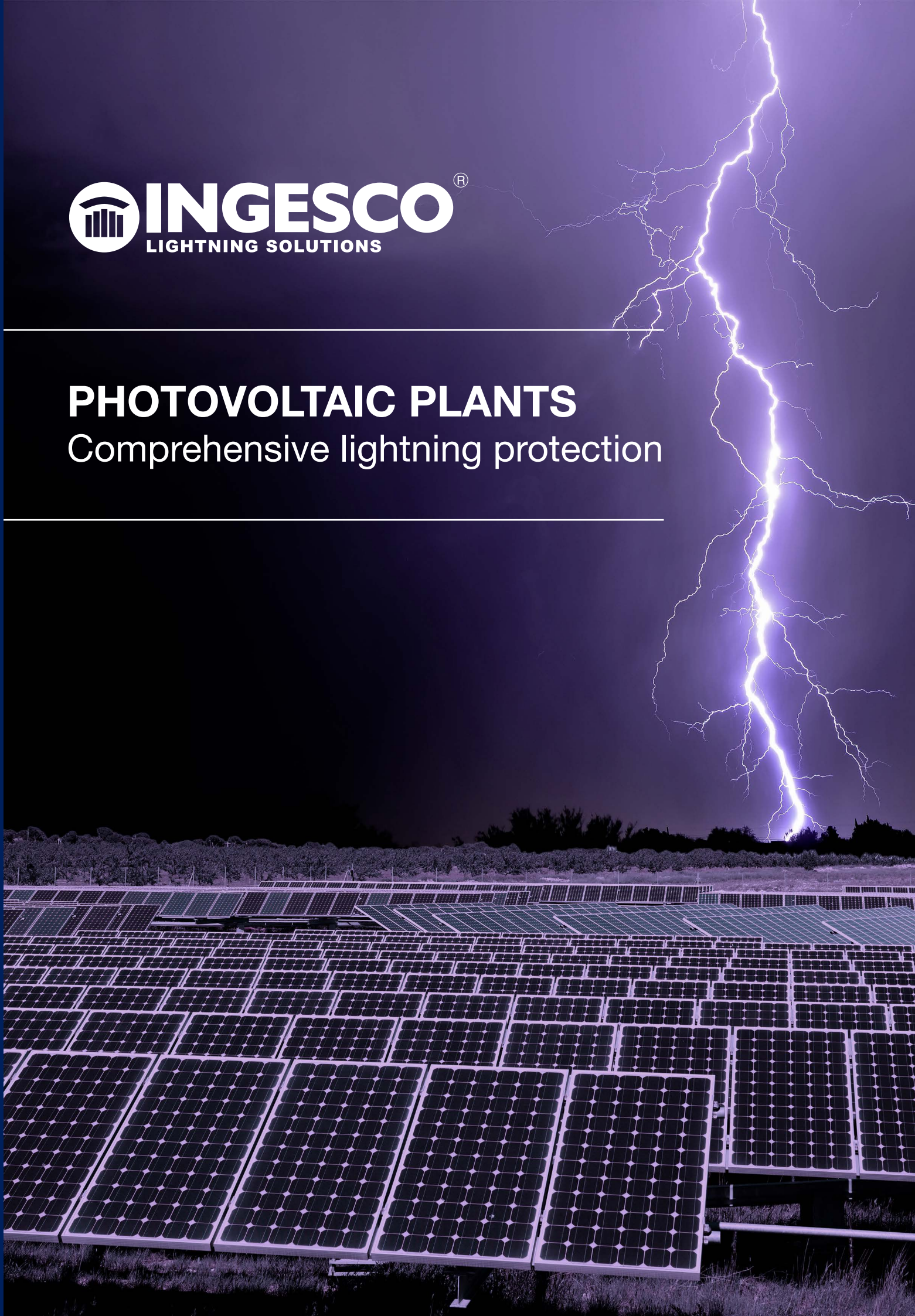
INGESCO®
LIGHTNING SOLUTIONS

PHOTOVOLTAIC PLANTS

Comprehensive lightning protection



1. Introduction

Photovoltaic (PV) plants are composed of many panels supported on large metal structures, located in open areas and normally highly exposed to the electrostatic perturbations caused by lightning. Such plants are expensive to install and set up, for which reason they should have long lifespans. Therefore, and for reasons of regulations and safety, every PV plant design project must include a comprehensive system to protect it against lightning and power surges.

This document presents a selection of measures to be taken to properly protect PV systems in accordance with current regulations.

1.1. National and international standards:

IEC 62305-2: Lightning protection Part 2: Risk management

IEC 62305-3: Lightning protection Part 3: Physical damage to structures and life hazard

IEC 62305-4: Lightning protection Part 4: Electrical and electronic systems within structures

UNE 21186:2011: Lightning protection: Lightning conductors protection systems with early streamer emission systems

NF C 17-102:2011: Lightning protection: Lightning protection systems with early streamer emission systems

IEC 61643-11: Low-voltage surge protective devices

IEC 62793-2020: Thunderstorm warning systems. Protection against lightning

BS EN IEC 62793:2018: Protection against lightning. Thunderstorm warning systems

Made in EUROPE

2. External lightning protection

An external lightning protection system consists of an air termination system, a down conductor system and a grounding system.

The external protection system needs to protect the PV panels, the supports, buildings and all items, equipment or persons located outdoors and susceptible to direct lightning strikes.

The numbers and models of lightning rods to correctly protect a PV system are determined from a calculation of the level of protection using the risk assessment calculations published in **NF C 17-102 2011** Annex A / IEC 62305-2.

External protection may be by an INGESCO lightning rod with ESE or simple spikes.

2.1. Air termination systems See website

INGESCO lightning rod with ESE See website

One or more INGESCO lightning rods with ESE will be installed, depending on the area to be protected, located on existing structures (sheds, lighting towers, etc.) or on their own poles around the perimeter of the plant. In both cases, the lightning rods must be at least 2 metres higher than the highest point on the solar panels and must not cast any shade on the panels.

Lightning rod with ESE mod.	PDC 3.1	PDC 3.3	PDC 4.3	PDC 5.3	PDC 6.3	PDC 6.4
Reference	101000	101001	101003	101005	101008	101009
Δt	15 µs	25 µs	34 µs	43 µs	54 µs	60 µs
NIVEL I	35 m	45 m	54 m	63 m	74 m	80 m
NIVEL II	43 m	54 m	63 m	72 m	83 m	89 m
NIVEL III	54 m	65 m	74 m	84 m	95 m	102 m
NIVEL IV	63 m	75 m	85 m	95 m	106 m	113 m

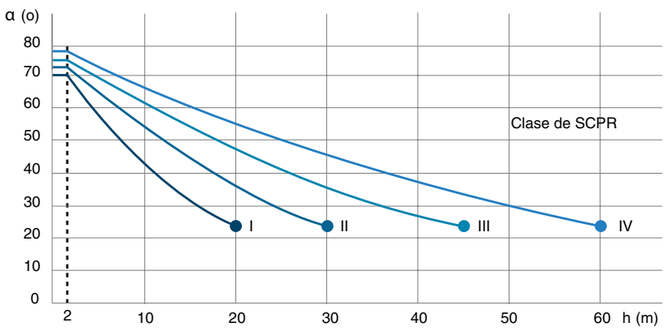
Protection radii calculated using standards UNE 21.186:2011, NFC 17.102:2011 and NP 4426:2013. (These protection radii were calculated using a height between the tip of the lightning rod and the horizontal plane of 20 m).

Lightning rod See website

It is also possible to design protection systems using simple lightning rods. However, as more spikes are needed, these may shade the panels.

For protection using simple air terminations, the resulting radius of protection must be determined on the basis of the level of protection applied and the height of the spike.

These may be installed on the PV panels or on free-standing poles on the site.



Angles of protection for different classes of LPS, IEC 62305-3

2.2. Conductor system See website

The lightning rod must be connected by two down conductors with materials and cross-sections standardised by per **IEC 62561-2**—to their respective grounding systems.

If free-standing poles are used for installation of ESE lightning rods, then in accordance with point 5.3.2 of **NF C 17-102 2011**, only one down conductor will be needed for each lightning rod. The down conductor may be installed inside the pole through to the grounding system.

It is advisable to fit the system with a lightning strike counter (**CDR-11** or **CDR Universal**).

2.3. Grounding systems See website

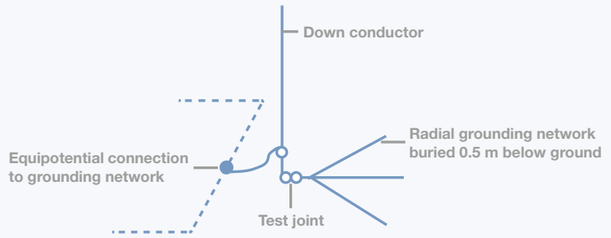
The main purpose of grounding systems is to limit the voltage with respect to ground that metal masses may have at any given moment and to prevent dangerous potential differences, enabling fault or atmospheric discharge currents to discharge to ground.

Standards **IEC 62305-3, NF C 17-102:2011 and UNE 21186:2011** state that grounding systems must have an ohmic value below 10Ω when measured at low frequency and isolated from any conductive element.

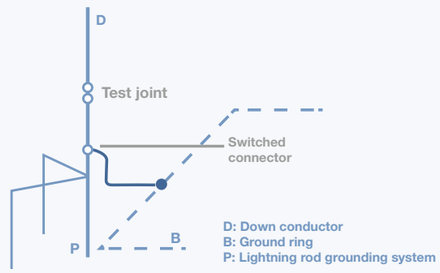
It is highly recommended to shield the DC cables running from the PV modules to the inverters, to reduce induction in the DC system. If cables are shielded, the shielding must be capable of conducting partial lightning currents. The shielding must be connected at both ends to equipotential bonding bars.

In addition, it is also recommended to have ground level equipotential bonding between the lightning rod grounding systems and the PV panel grounding systems.

Types of grounding systems



Grounding system 1: horizontal conductors, 50 cm deep, 7 to 8 m in length



Grounding system 2: The ground rods are connected by a conductor with the same cross-section as the down conductor.

Grounding system 3: Ground grid: If a grid-type grounding system is installed, the IEC 62305-4 standard recommends 20x20 m as the correct size.

3. Internal lightning protection

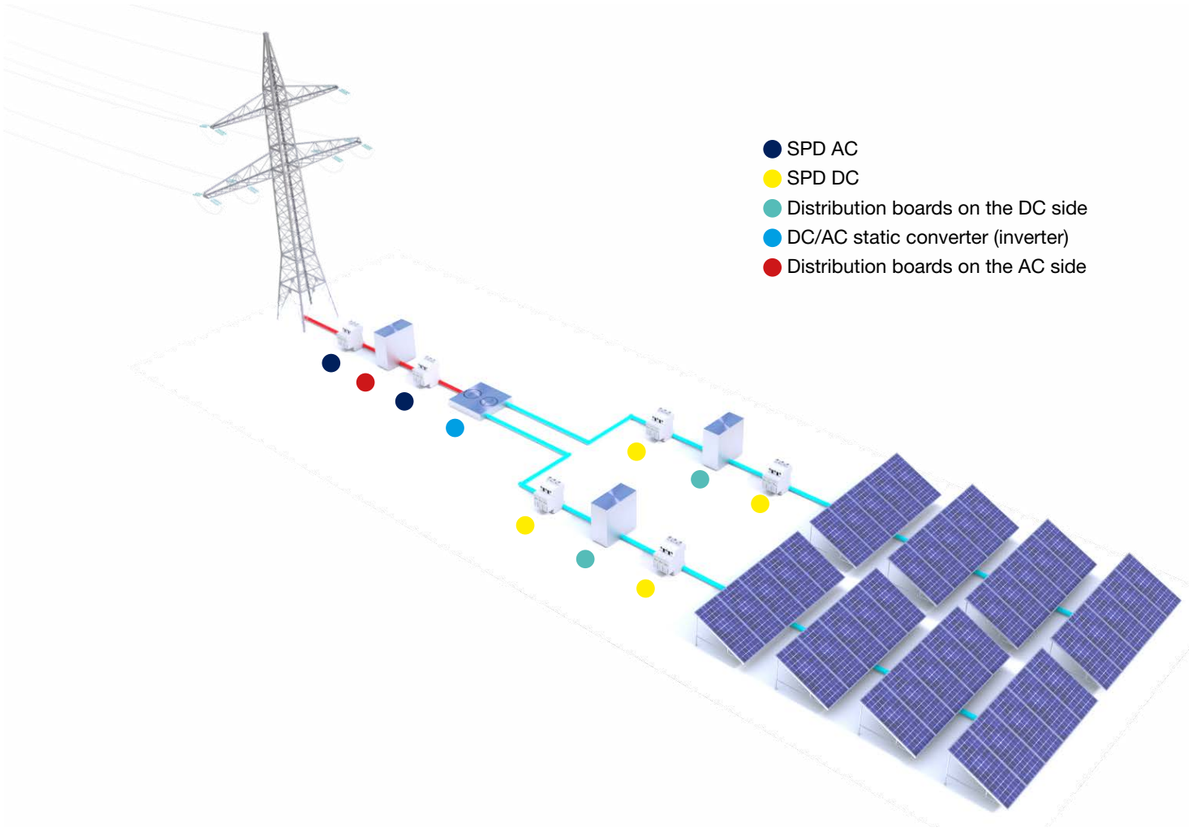
3.1. Transient overvoltages See website

The transient overvoltages (surges) that appear in PV plant installations are produced by different phenomena and may be:

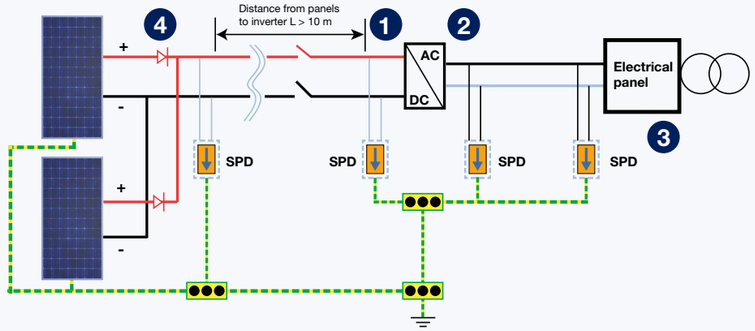
- Due to direct lightning strikes on the external protection system
- Due to direct strikes and their induced currents distributed over the power grid
- Transmitted from the power grid, originating from atmospheric causes or from switching in the lines
- Caused by variations in the electrical field as a result of lightning

The heart of a PV system is its inverter, and that is why it should be the focus of protection against lightning and voltage surges. To properly protect the inverter, surge protection devices (SPDs) should be fitted on both the DC and AC sides. These devices must comply with EN 61643-11 Part 11: (Surge protective devices connected to low-voltage power systems - Requirements and test methods), and must be installed according to technical specification CLC/TS 50539-12:2010: (Low-voltage surge protective devices - Surge protective devices for specific application including d.c. Part 12 Selection and application principles - SPDs connected to photovoltaic installations).

In addition, PV panels and their metal supports must be connected to the grounding system.



Whenever there is an installation in which the distance between the modules and the inverter **exceeds 10 m**, the installation of SPDs must be repeated.



Situation		Types of surge protection devices (SPD) IEC61643-32:2017		
		Location 3	Location 2	Locations 1 and 4
	Without external LPS	SPD class I (IEC61643-11) or SPD class II (IEC61643-11)	SPD classs II (IEC61643-11)	SPD class II (IEC61643-31)
	With external LPS with separation distance	SPD class I (IEC61643-11)	SPD class II (IEC61643-11)	SPD class II (IEC61643-31)
	With external LPS without separation distance	SPD class I (IEC61643-11)	SPD class I (IEC61643-11)	SPD class I (IEC61643-31)

Surge protectors recommended according to type of external protection
CLS/TS 50539-12 (SPD for specific application including DC – SPD connected to PV installations).

DC-side protectors

SLS-PV1500 V/Y

Ref: 370299

	L-N
U_{CPV}	1500 V DC
I_n	15 kA
I_{max}	40 kA
U_p	6,4 kV
t_a	25 ns

AC-side protectors

SLS-B+C100/3+1

Ref: 370214

	L-N	NPE
U_n	230 V AC	-
U_c	260 V AC	255 V AC
I_{imp}	25 kA	100 kA
I_n	30 kV	100 kA
I_{max}	60 ns	100 kA
U_p	<1,50kV	
t_A	100ns	

SLS-C20/3+1

Ref: 370220

	L-N	NPE
U_n	230 V AC	-
U_c	275 V AC	255 V AC
I_{imp}	-	12 kA
I_n	20 kV	20 kA
I_{max}	40 ns	40 kA
U_p	<1,35kV	<1,50kV
t_A	25ns	100ns

4. Preventive protection

The lightning protection methods specified by the regulations have the goal of limiting damage, but do not cover other potentially dangerous situations resulting from thunderstorms and lightning, situations that can be dynamically prevented or reduced using timely measures based on early warnings provided by a detection system.

The European standard for storm detection **BS EN IEC 62793:2018** and the international standard **IEC 62793: 2020** (Protection against lightning - Thunderstorm warning systems) have been published in order to implement lightning hazard preventive measures.

4.1. Previstorm See website

With the approach or formation of a thundercloud, the electrostatic field at ground level undergoes a significant change. In normal conditions, the electrostatic field has an average value of 120 V/m.

In the presence of a thundercloud, the electrostatic field changes and can reach several tens of kV/m. It takes around 20 minutes for such thunderclouds to form.

The PREVISTORM® system detects lightning pre-emptively, even before the first electrical discharges occur.

It consists of:

- **An outdoor “field mill” sensor (FMS)**
- **A data acquisition module (DAM)**
- **An uninterruptible power supply**

The **field mill** dynamically measures changes in the electrostatic field.

The **data acquisition module** provides:

- System configuration and control,
- Display of the field value,
- Triggering of relays associated with the alarms,
- Display of configuration parameters.

PREVISTORM® is a valuable system that provides real-time information on the development of storms and lightning, 24 hours a day.

It provides highly reliable information before the first lightning strike, so as to pro-actively:

Activate safety protocols. Ensure the protection of persons.

Ensure the protection of persons.

Ensure continuity of service and prevent production outages.

Increase the level of protection.

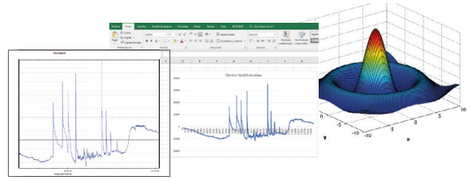
Prevent the unnecessary ageing of protective systems.

Ensure the operation of the most sensitive equipment, reducing maintenance costs.

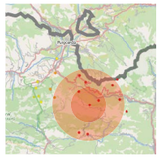
Fig. 23 – System PREVISTORM THUNDERSTORM WARNING SYSTEM

Indications and Alerts

Information



Integration with other systems



Previstorm.net

Programmable logic controllers