APPLICATION NOTE

System

SunSentry Surge Protection

Making Industry Best Practices Normative and Economical

04/2025

RELIABLE MONITORING SINCE 1974

Campbell SCIENTIFIC®

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1. Introduction

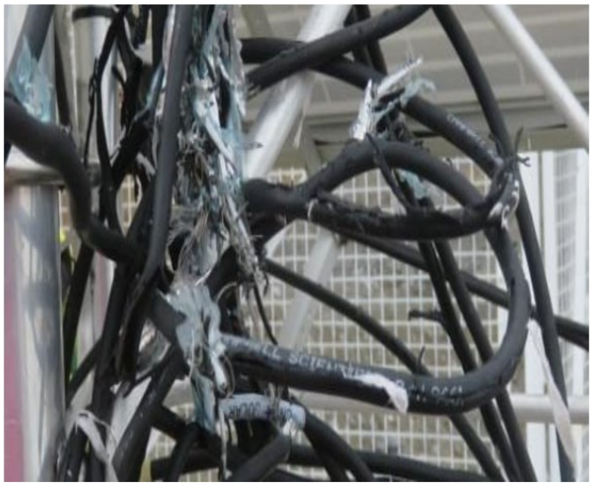
Protecting meteorological measurement equipment from surge events is an important consideration for a station meant to monitor a utility scale solar power plant. Designing a system that appropriately protects the high-value sensors while remaining flexible is a difficult engineering task. Utility scale solar energy projects are highly susceptible to damaging transient surge events, especially those sites in lightning prone areas. The following surge protection methods minimize the risk of damage to the SunSentry and its associated sensors during a surge event.

- Use devices with built-in surge protection
- Strategically install additional surge protection devices (SPD)
- Isolate devices from each other and from their mounting structures
- Ensure each device has a properly designed surge grounding path

2. Transient surges

Lightning from the sky to the ground can occur anytime and anywhere. Protecting electronics from a direct lightning strike is nearly impossible. Over 1 billion Joules of energy per bolt on average will overcome most protection devices. However, the probability of direct lightning strikes is very low. The more likely scenario is a lightning strike at close proximity to the weather station. This document discusses protecting the station from the more likely lightning events.

The following pictures show a cable and rain gauge from a general environmental monitoring meteorological station (not SunSentry). Each device was catastrophically affected by a nearby lightning strike. The massive electrical energy destroyed the cable as it sought a path to ground.



This rain gauge was a few meters from this common meteorological station. The lightning jumped from a nearby fence to the rain gauge, destroying the rain gauge. The rain gauge was not grounded, so the energy traveled to the met station through the cable causing damage to the met station. Had the rain gauge been properly grounded, the station likely would not have been destroyed. This example shows why connecting sensors to earth ground can be beneficial and overall, a cost savings effort.

The energy from a nearby lightning strike can also jump to a cable and act as an antenna to lightning, even if shielded and grounded. The energy seeks the shortest and lowest resistive path to ground. Unshielded cables carry the energy on the signal and power lines directly to the electronics if not intercepted by protective devices. Shielded cables with the shields terminated to earth ground provide a level of protection if the current is too large.

In the SunSentry, the main met station and many sensors have some surge protection.

3. System design

Utility-scale solar power projects include many sensors, topologies, configurations, and environmental factors. A typical system includes a main meteorological (met) station, sensors mounted on the PV array that transmit data back to the main met enclosure, and additional nearby sensors such as albedo sensors. Figure 3-1 (p. 3) shows a simple representation of a SunSentry installation. For more information on the SunSentry topology and preferred sensors, please read our SunSentry Network Improvements technical paper.

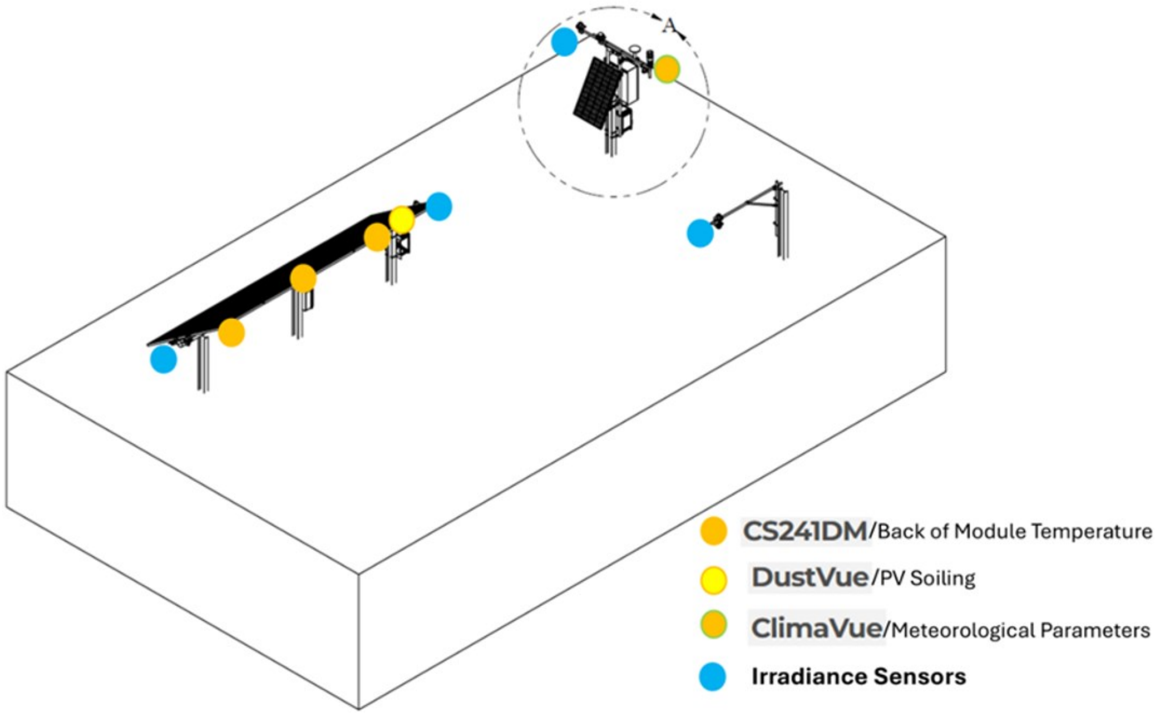


Figure 3-1. Illustration of common sensors deployed for utility scale solar energy monitoring

Figure 3-1 (p. 3) conceptually displays some of the sensors commonly deployed at a site. Sensors can have varying cable lengths from the main meteorological station enclosure. This can complicate surge protection efforts. While best practices dictate surge protection devices (SPD) be located as close to each device as possible, this may not be needed in all cases and is likely cost prohibitive. SunSentry stations have one primary enclosure and two to three secondary enclosures: main met, AC pull box, and junction boxes (1 or 2).

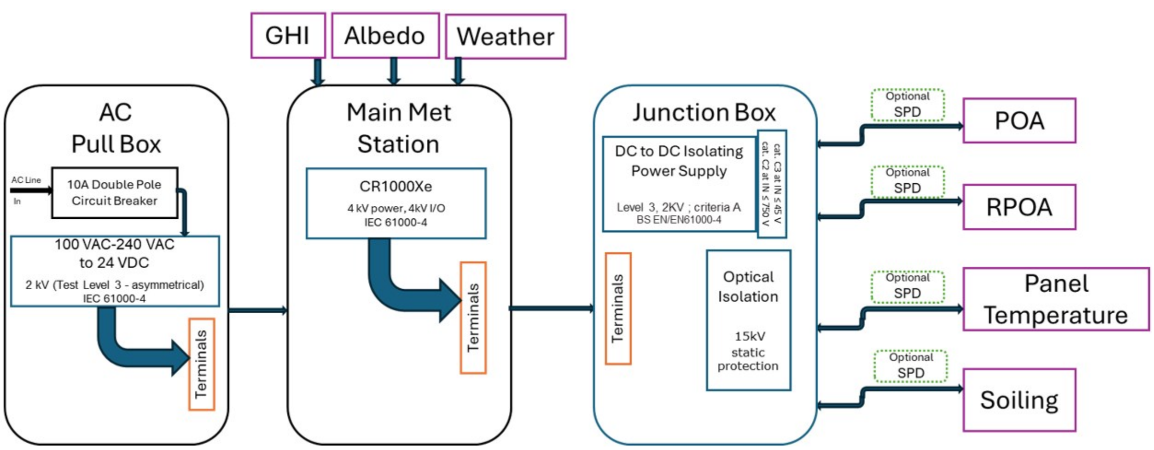


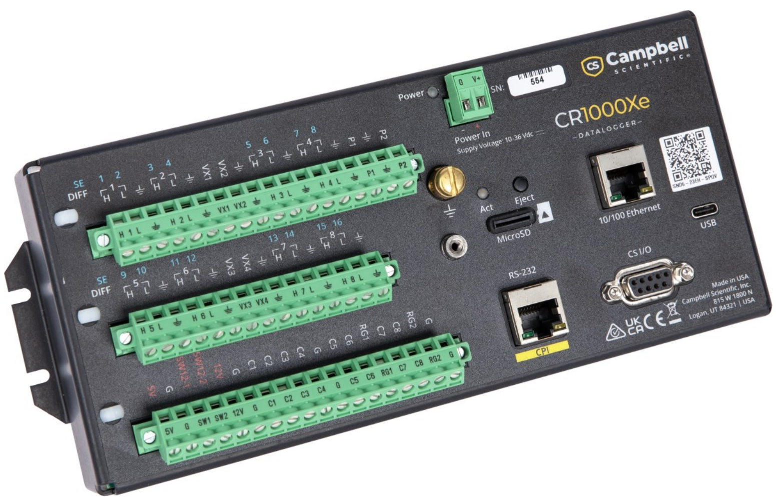
Figure 3-2. SunSentry block diagram displaying protection provided

Since data acquisition serves as the central point for collecting data from multiple sensors, starting with a reliable and robust data logger is essential to prevent station-wide failures and loss of communication with the SCADA system.

4. Data acquisition

Campbell Scientific has a long tradition of making extremely reliable data loggers. The CR1000Xe provides circuit protection on all data lines using fast acting, gas-discharge tubes. These discharge tubes pop before a surge can enter the data logger. Additional SPD could be installed in the main met enclosure for the most lightning-prone locations. Refer to the CR1000Xe manual for more information.

At the core of the SunSentry is the CR1000Xe data logger which has surge protection built in on all measurement, control, and power terminals.



The CR1000Xe meets the IEC 61000-4-5 standard for class 4 surge immunity. The CR1000Xe also meets or exceeds the IEC 61000-4-2, 61000-4-3, 61000-4-4, 61000-4-6 standards for ESD, Radiated RF, EFT, and Conducted RF.

I/O signal/control (unsymmetrical)	±1 kV line-to-line, ±2 kV line-to-ground
I/O signal/control (symmetrical)	±1 kV line-to-line, ±1 kV line-to-ground
I/O signal/control (directly connected to mains)	±2 kV line-to-line, ±4 kV line-to-ground

5. AC pull box

Stations are commonly deployed near large inverters. These inverters provide either AC or DC power to the SunSentry. The SunSentry AC pull box allows the AC termination to be separate from the main meteorological enclosure, providing greater safety and allowing for variation in local regulations regarding licensed electrician requirements.

Campbell Scientific uses high quality components for the AC pull box to help mitigate damage caused by inverter surges. Additional surge protection is available and is discussed later in this document.

6. SunSentry junction boxes

In general, surge protection effectiveness decreases as the distance from the main meteorological enclosure increases. Fortunately, the SunSentry uses junction boxes, allowing for a hybrid network topology with some sensors daisy-chained and others in a short star configuration. Each junction box uses an isolated DC-DC converter, as well as additional surge protection on the power lines, and optical isolation for the signals.

Since monitoring stations can be installed with a wide range of sensor types, models, and performance classifications, it is a challenge to find a common solution for all configurations. SunSentry junction boxes were designed to aid in safeguarding sensors in the field by following cost-effective best practices. While not all conditions and scenarios can be planned for, the junction boxes provide industry leading protection from the enclosure rather than adding specific protection to every individual sensor.

Communication lines are protected with optical isolation. This effectively protects RS-485 devices from ground loops, transient surges, remote lightning, and spikes; it also eliminates ground loop and noise problems. The optical isolation device includes 600 W surge protection and 15 kV static protection.

The 24 VDC power is also isolated and protected to category C2 and C3. This isolation assists in blocking the surges at the junction box from transmitting to the main met station through the DC power lines.

Nominal discharge current (8/20 µs) (line)	300 A
Nominal discharge current (8/20 µs) (total)	5 kA
Protection level (line/line) (cat. C2 at IN)	≤ 50 V
Protection level (line/protected ground) (cat. C2 at IN)	≤ 750 V
Protection level (line/line) (cat. C3 at IN)	≤ 45 V
Protection level (line/protected ground) (cat. C3 at IN)	≤ 650 V

6.1 Isolation

Communication lines from the SunSentry junction boxes to the main met enclosure are protected with optical isolation. Optical isolation converts electrical signals to optical pulses, reads the optical pulses, then converts the pulses back to electronic signals. This process creates a hard break in the path transient surges can traverse. Additionally, the isolating hub provides 15 kV static protection against surge currents. Other products, such as the CS241DM, have galvanic isolation, which is reliable and robust in power performance monitoring applications.

Some sensors installed in the solar array are protected from each other and the main met station by optical isolation in the junction box. A four port RS-485 hub provides port-to-port isolation and isolates the junction box from the main met station. The SunSentry design connects the back of module to separate terminals for temperature sensors, plane of array (POA) sensors, rear plane of array (RPOA) sensors, and soiling sensors.

An isolating DC/DC converter in the junction box isolates power to the array sensors from the main met power. This device also boosts the voltage at the junction box if it falls below 24 V and isolates the grounds to prevent ground loops.

7. Surge protection devices (SPD)

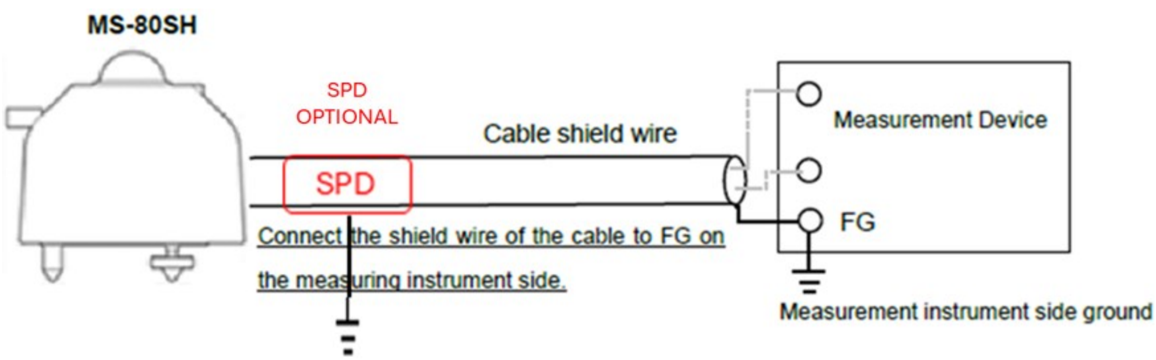
A growing problem in solar energy performance monitoring is sensors failing from surge events. Several components of SunSentry have internal surge protection. The four port RS-485 hub also contains surge suppression. Additional surge protection or isolation provisions can further increase the reliability of a monitoring station and provide peace of mind to site owners by ensuring optimal data availability. SPD are meant to be inexpensive, sacrificial components that protect devices from transient surges. These components are much less expensive to replace than the device(s) they protect.

8. Surge grounding path

Equipment manufacturers address grounding differently. Refer to the equipment manufacturer's manual for grounding recommendations.

The best practice for grounding during surge events, such as lightning, is to provide a short path to earth ground as close to the source of energy as possible and isolate the sensor from the conductive mount. The best practice for signal noise immunity is to terminate the cable shield wire at only one end of the cable to avoid ground loops, typically at the measurement device end of the cable. The following are two examples of how the manufacturer addresses the grounding of the pyranometer.

Example 1:



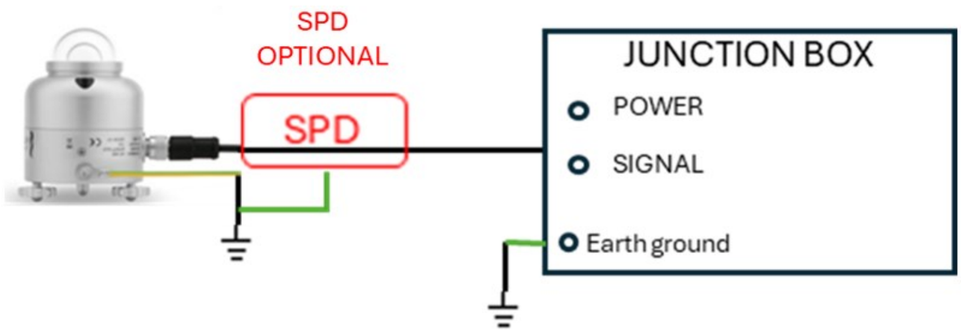
EKO MS-80SH connects the cable shield to the housing of the pyranometer and recommends isolating pyranometer housing from the mounting surface and connecting the shield to earth ground at the measurement device location. This pyranometer has internal surge protection and relies on the cable shield to pass the energy to the earth ground. This approach relies on the cable shield to carry any lightning surge current to the measurement device ground.

Mounting on a ground isolating surface is important because the current will go through the housing and can raise the ground potential of the electronics to an unsafe level if the pyranometer housing is mounted to a grounded, conductive surface.

Recommendation:

- Mount the pyranometer on an isolation plate.
- Option: Place an SPD close to the pyranometer. Connect the SPD ground to earth ground.
- Connect the cable shield to earth ground at the measurement device.

Example 2:



Hukseflux SR300 connects the cable shield to the housing of the pyranometer and recommends isolating pyranometer housing from the mounting surface to protect against surge transmitted through the mounting hardware. Connect the pyranometer ground lug to earth ground with at least 14 awg wire. Connect the cable shield to earth ground at the pyranometer with the ground lug and at the measurement device.

Recommendation:

- Mount the pyranometer on an isolation plate.
- Option: Place an SPD within 3 meters of the pyranometer. Connect the SPD ground to earth ground. Ensure the SPD and pyranometer earth grounds are at equipotential.
- Connect the pyranometer ground lug to earth ground within 3 meters of the pyranometer.

9. Lightning rods

The following image was taken from the Hukseflux manual to provide information for protecting the SR300 pyranometers from a lightning strike. Placing lightning rods away from the solar panels and met station will help avoid a direct hit.

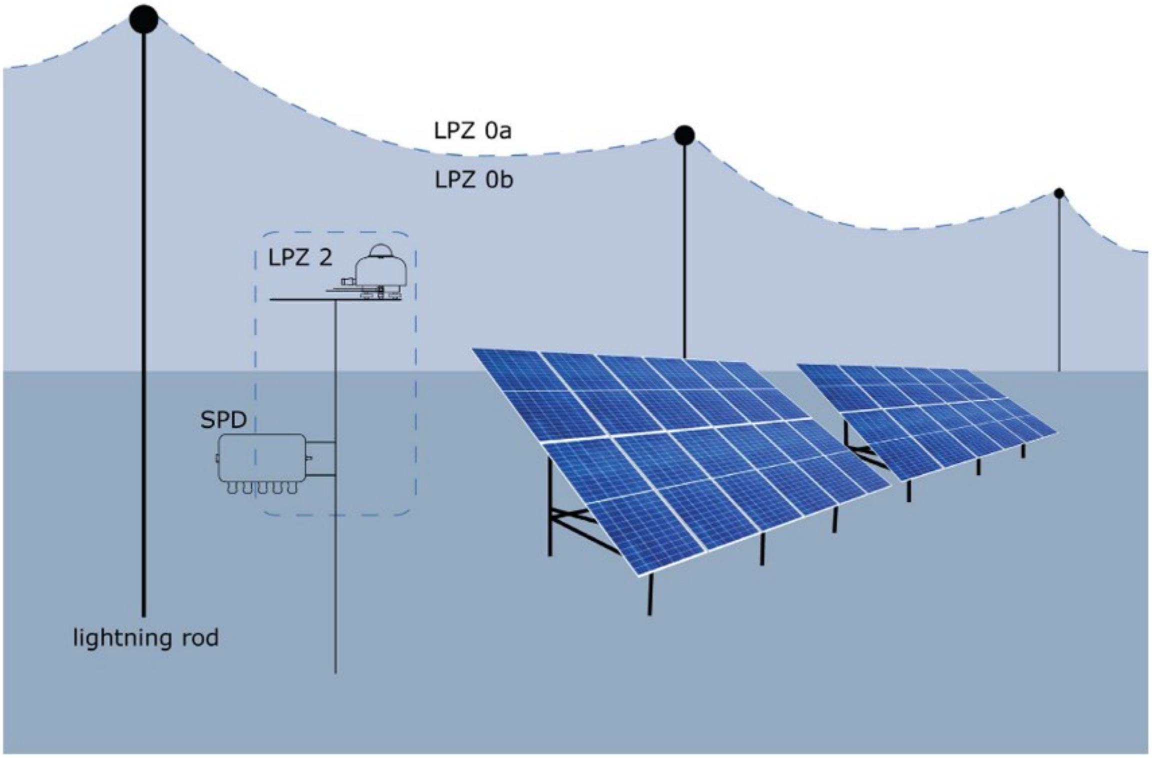


Figure 9-1. Hukseflux industrial pyranometers should be installed in LPZ2. Hukseflux SPD01 is a type 2 SPD which is used on the zone boundary from LPZ0b to LPZ2.

10. IEC 61000-4-5 class 4 surge immunity testing

Campbell Scientific, Inc. is an ISO 9001:2015-certified company that designs and manufactures products using rigorous quality control processes and thorough testing. Campbell Scientific invests in tools, such as radio frequency and surge test chambers and environmental chambers, to ensure products and systems perform as advertised.

Figure 10-1. Campbell Scientific RF and surge test chamber

For lightning prone regions, additional surge protections are available and can be determined in consultation with a Campbell Scientific sales engineer.

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