COMPONENT

CAMPBELL SCIENTIFIC

WHEN MEASUREMENTS MATTER

CR-PVS1

PV Soiling-Loss Index RTU

Soiling-Loss Index Measurement Solution

Providing on-board data filtering and real-time soiling-loss index

Measurements

- *Soiling-Loss Index*
- *Short Circuit Current*
- *Back-of-Module Temperature*
- *Effective Irradiances*

Overview

Soiling, the loss of photovoltaic (PV) module power output due to accumulation of dirt and/or snow on the panel surface, has become one of the most important operational issues of solar energy power plant performance. The CR-PVS1 PV Soiling-Loss Index RTU provides solar energy professionals who are responsible for managing the performance of a PV power plant with the information needed to evaluate and manage the impact of soiling. Soiling loss indices are calculated using industry standard methodologies. Raw data is stored and available for additional post-processing.

Benefits and Features

- Real-time soiling loss index (SLI) measurement and control system
- On-board data filtering that assures quality data
- Daily average soiling loss index calculated
- Modbus, DNP3, Pakbus, data encyption, and Internet protocols supported
- No programming necessary
- Quick deploy guide that simplifies installation

Technical Description

The CR-PVS1 PV Soiling-Loss Index RTU can be the heart of an independent soiling measurement station or included as an add-on peripheral to any new or existing MET station. It supports many communication protocols including Modbus, DNP3, PakBus, PakBus encryption, and several internet protocols.

The CR-PVS1 is delivered field ready and requires no programming, simplying deployment/configuration. It calculates soiling-loss index from short-circuit current and back-of-module temperature measurements of a reference PV module, which is kept clean, and a test PV module, which is kept dirty. Two rugged, high-quality sensors are included with the CR-PVS1 for measuring back-of-PV module temperature. The reference and test PV modules can be user-supplied (up to 300 W PV modules supported) or ordered with the CR-PVS1 as an option (two 20 W modules included).

Measurements are made only when certain characteristics of global solar irradiance and temperature are met, avoiding differences in soiling due to environmental instability, cloud influence, zenith angle of the sun, module-current dependence on irradiance level, and to an extent, spectral effects. The CR-PVS1 calculates a quality factor to give the user some feedback on the number of qualified measurements.

From short-circuit current and back-of-module temperature, the effective irradiance of each module is calculated in accordance with IEC 60904 and a soiling loss index is calculated. A daily average soiling loss index is calculated, available for SCADA, and stored in on-board memory. For immediate feedback, a real-time soiling loss index and quality factor are available. Raw measured data are stored and available for the analysis or researcher looking to perform independent post-processing.

The procedure is straightforward and easily implemented with manual washing of the reference module, usually cleaned at the same time as the on-site pyranometer(s).

The graphs show the importance of filtering data based on stability of irradiance as well as back of module temperature in accordance with IEC 60904-2. Figures 1 and 2 show effective irradiance calculated from the short-circuit currents. Figures 3 and 4 show the filtered data based on stability conditions. In Figure 5, both modules were cleaned at record number 650. The soiling index after cleaning is 0.003 (±0.16) % on clear sky and 0.000 (±0.16) % on the variable sky conditions. This is an indication of the lowest level of soling loss that can be detected.

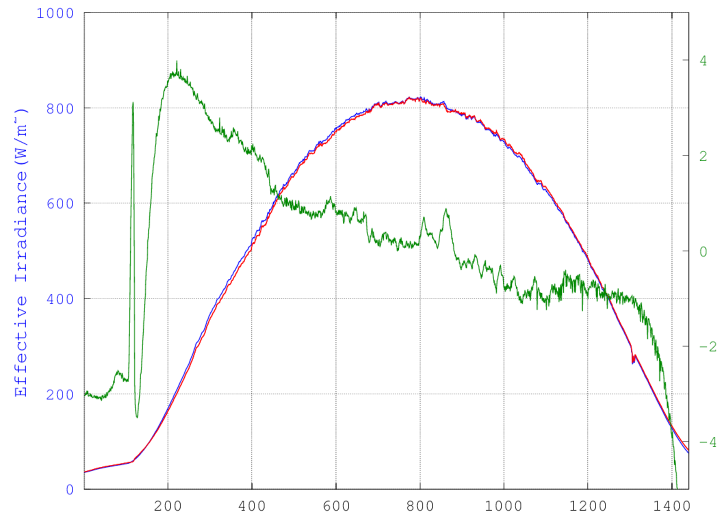

Figure 1: Effective Irradiance as calculated from short circuit current of the PV modules on a clear sky day. The green curve shows the soiling index. The SLI depends on the time of the day.

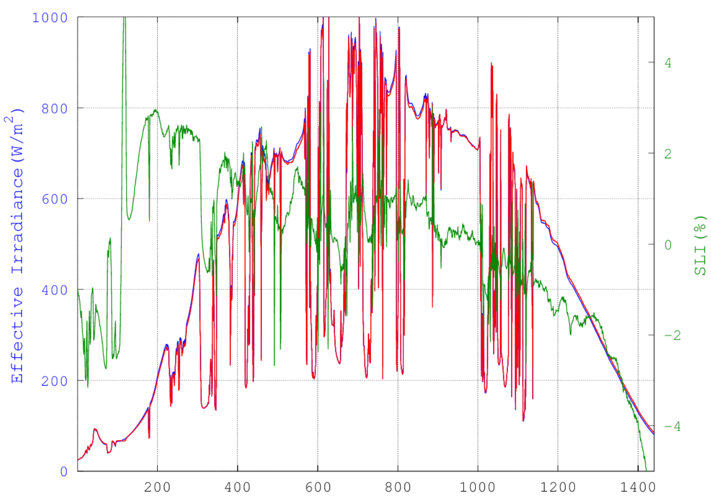

Figure 2: Effective Irradiance and SLI on a cloudy day.

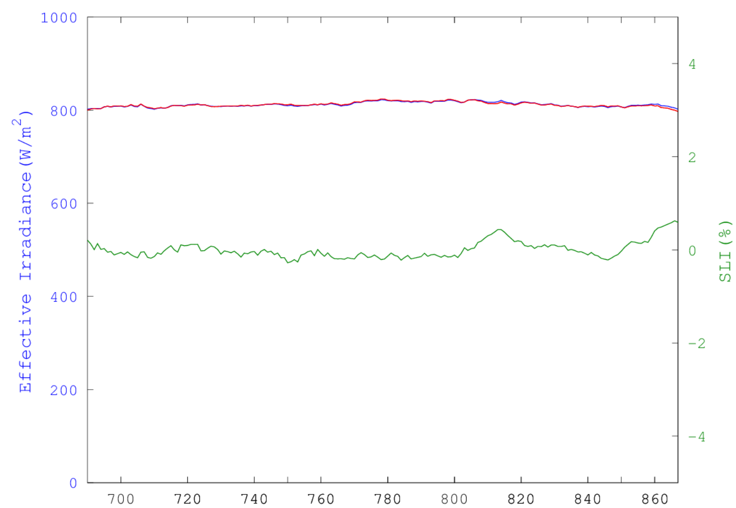

Figure 3: Effective irradiance and SLI during ±1 hour of solar noon and Geffref > 800 W/m². The time of the day dependence is absent during this time.

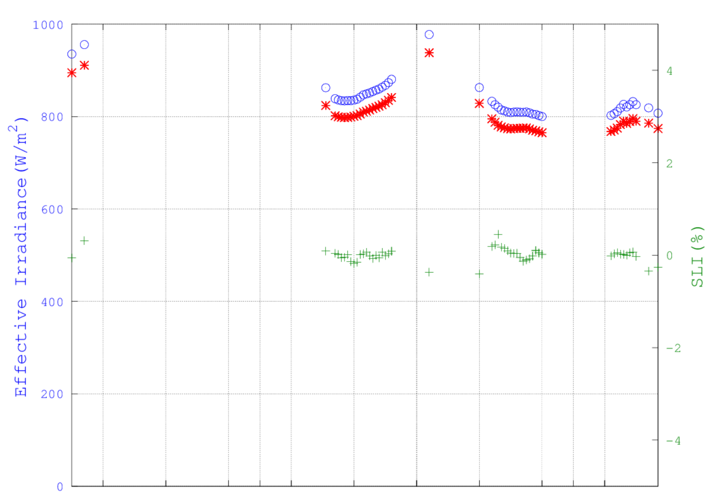

Figure 4: Geff and SLI taken during a cloudy day with Geffref > 800 w/m² during ±1 hour of solar noon.

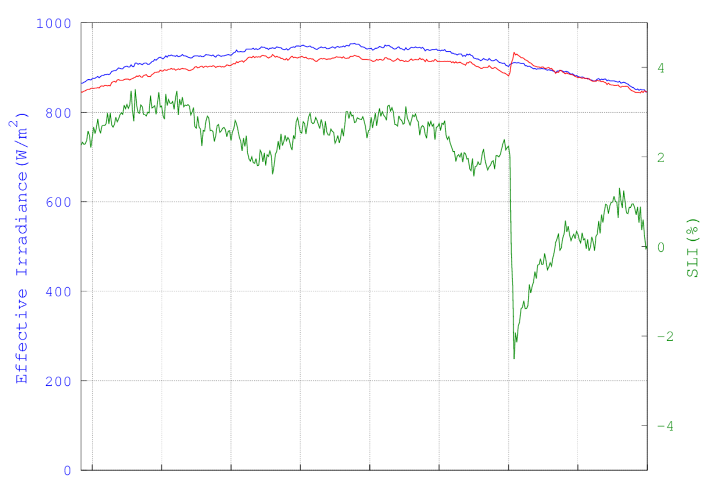

Figure 5: Change in SLI after a cleaning event. Both modules were cleaned at a time corresponding to the record number 650.

Application Overview

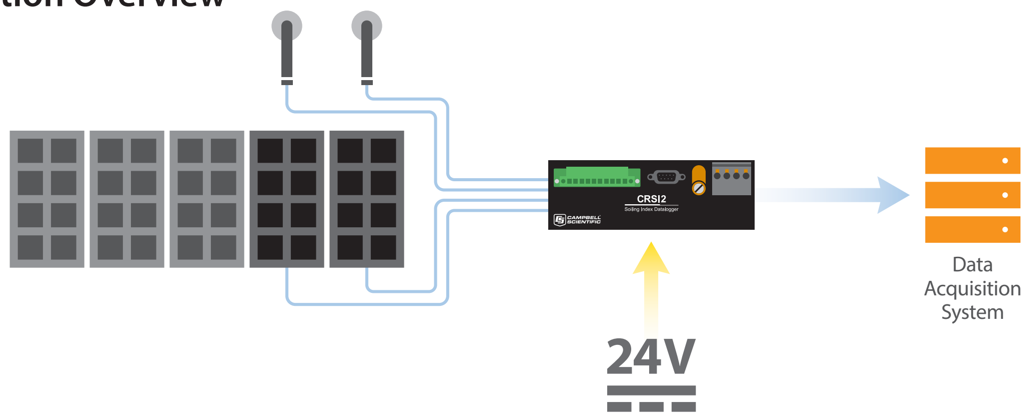

Figure 6 (a)

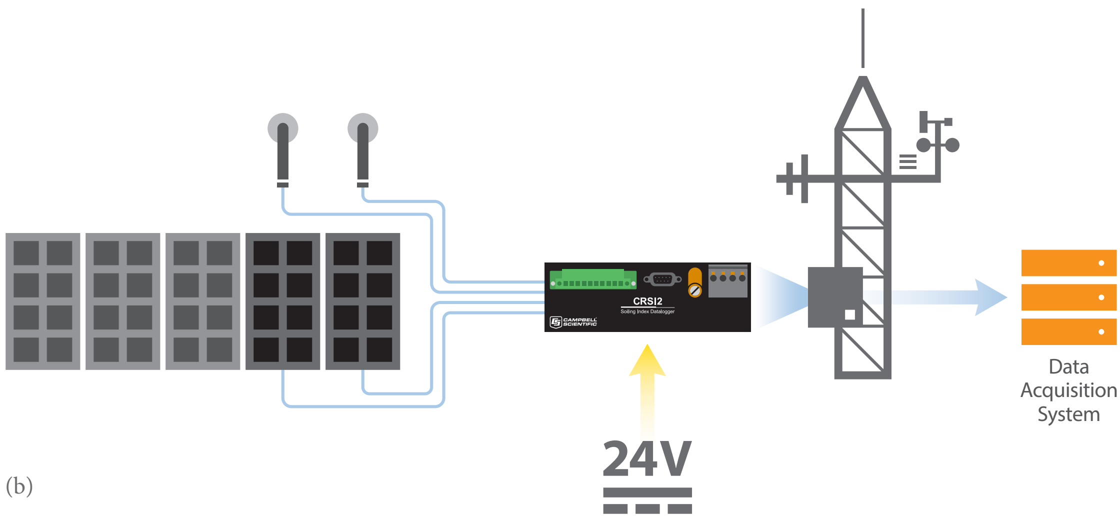

Figure 6 (b)

Figure 6: The CR-PVS1 can act as the system's central measurement and control unit (a) or as a peripheral unit that is added to any new or existing solar meteorological monitoring system (b). Data transfer from the CR-PVS1 is simple. The CR-PVS1 supports many communication options, including; Internet protocols, Modbus, DNP3, SDI-12, PakBus, and PakBus encryption. (See Communications on the Specifications page for a complete list.) Data files (many file formats are available) are sent directly to the cloud via email or FTP, for example.

Short Circuit Current Methodology

Numerous studies and documents have been published over several decades outlining and testing various methods in order to calculate losses due to soiling, along with their advantages and disadvantages. These studies show that the short circuit current of a solar module is directly proportional to the light intensity, and can be used as a reliable method to measure changes in light intensity from reaching the solar cells.

While other methods have been studied, such as I-V curve tracers or maximum power point trackers, these systems can provide minimal accuracy gains only under certain conditions that may not be practical in a field setting. The disadvantage to these systems is their cost and scalability, as they are typically a much more expensive and complicated endeavor.

The CR-PVS1 uses the short circuit measurement method, in order to provide end users with a simple, lower cost solution that is more easily scalable and deployable in larger numbers on utility scale solar projects using proven methods.

Specifications

All CR-PVS1 RTUs are tested and guaranteed to meet electrical specifications in a standard -40° to +70°C non-condensing environment. Datalogger recalibration is recommended every three years. System configuration and critical specifications should be confirmed with Campbell Scientific before purchase.

SOILING LOSS INDEX: can detect ~1%

SOLAR MODULES: up to 300 W crystalline or thin-film

MAXIMUM VOLTAGE: 50 V

MAXIMUM CURRENT: 20 A

MEASUREMENT ACCURACY: ≈2 µV

BACK-OF-MODULE TEMPERATURE MEASUREMENTS

MEASUREMENT RANGE: -40° to +135°C

TEMPERATURE UNCERTAINTY:

Temperature	*Tolerance*
-40° to +70°C	±0.2°C
71° to 105°C	±0.5°C
106° to 135°C	±1°C

STEINHART-HART LINEARIZATION EQUATION ERROR: 0.0024°C maximum (at -40°C)

SHORT-CIRCUIT CURRENT MEASUREMENTS

CURRENT SHUNT:

Maximum Operating Temperature	*Shunt Accuracy*
+80°C	±0.25%

COMMUNICATIONS

MODBUS RTU:

Format	*Supported Functions*	*Modbus Address*	*Data Type*
RS-232, 19200 bps, 8 data bits, no parity, 1 stop bit	03	11	32-bit float, CDAB

USB: USB micro-B device only, 2.0 full-speed 12 Mbps, for computer connection

RS-232: female RS-232, 9-pin interface

SYSTEM

CLOCK ACCURACY: ±1 minute per month

CLOCK RESOLUTION: 1 ms

PROGRAM EXECUTION: 30 s

POWER REQUIREMENTS

CHARGER INPUT (CHG): 16 to 32 Vdc, current limited at 0.9 A. Power converter or solar panel input.

EXTERNAL BATTERIES (BAT): 12 Vdc, lead-acid 7 Ah battery, typical

INTERNAL LITHIUM BATTERY: 3 V coin cell CR2016 (Energizer) for battery-backed clock. 6 year life with no external power source.

TYPICAL POWER REQUIREMENTS

Sleep	*Active 1 Hz Scan with Analog Measurements*
1.5 mA	5 mA

USB POWER (USB): For programming and limited functionality

COMPLIANCE

View the EU declaration of conformity at: www.campbellsci.com/cr-pvs1

SHOCK AND VIBRATION: ASTM D4169-09

PROTECTION: IP30

PHYSICAL

WIDTH: 20.3 cm (8 in); 21.6 cm (8.5 in) with mounts

HEIGHT: 6.3 cm (2.5 in)

DEPTH: 14 cm (5.5 in)

WARRANTY

One year against defects in materials and workmanship.