CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

SMP100

Solar-Module Soiling Measurement System

In-Field Soiling Measurement for Operational and Site Assessment

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

Measurements

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

Overview

Soiling, the loss of photovoltaic (PV) module power output due to the accumulation of dirt and/or snow on the panel surface, is an important operational issue of solar energy power plant performance. The SMP100 Solar-Module Soiling Measurement System 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 is calculated using industry-standard methodologies. Raw data is stored and available for additional post-processing.

Benefits and Features

- Real-time soiling-loss measurement and control system
- On-board data filtering that assures quality data
- Daily average soiling loss calculated
- Modbus, DNP3, PakBus, data encryption, and internet protocols supported
- No programming necessary
- Quick-deploy guide that simplifies installation

Technical Description

The SMP100 Solar-Module Soiling Measurement System 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 SMP100 is delivered field ready and requires no programming, simplifying deployment/configuration. It calculates the soiling loss from short-circuit current and back-of-module methods on a clean reference PV module and a test PV module that is allowed to stay dirty. Two rugged, high-quality sensors are included with the SMP100 for measuring back-of-PV-module temperature. The reference and test PV modules can be user-supplied (full-sized production modules supported) or ordered with the SMP100 as an option (two 20-W modules included).

Measurements are included in the daily average only when a threshold of global solar irradiance is met, avoiding differences in soiling due to environmental instability, module-current dependence on irradiance level, and to an extent, spectral effects. The SMP100 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 measured in accordance with IEC 60904. A daily average soiling loss is calculated, which is made available for SCADA and stored in on-board memory. For immediate feedback, a real-time soiling loss and quality factor are available. Raw measured data are stored and available for analysis or for researchers 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 the stability of irradiance as well as the back-of-module temperature in accordance with IEC 60904-2.

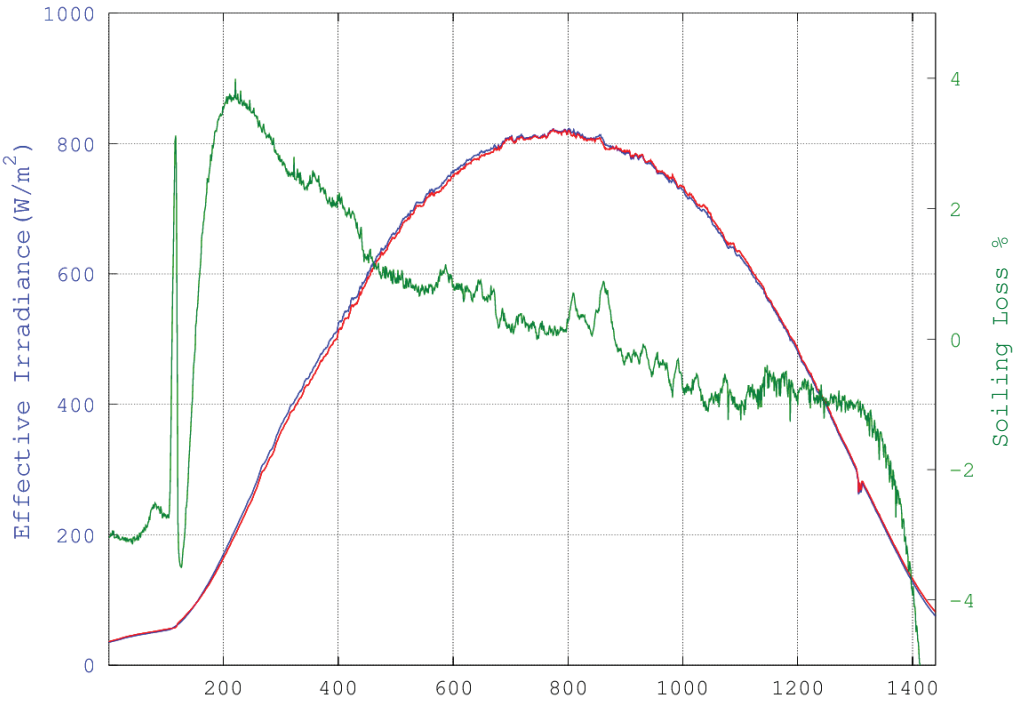

Figure 1: Effective irradiance as calculated from the short-circuit current of the PV modules on a clear-sky day. The green curve shows daily soiling loss.

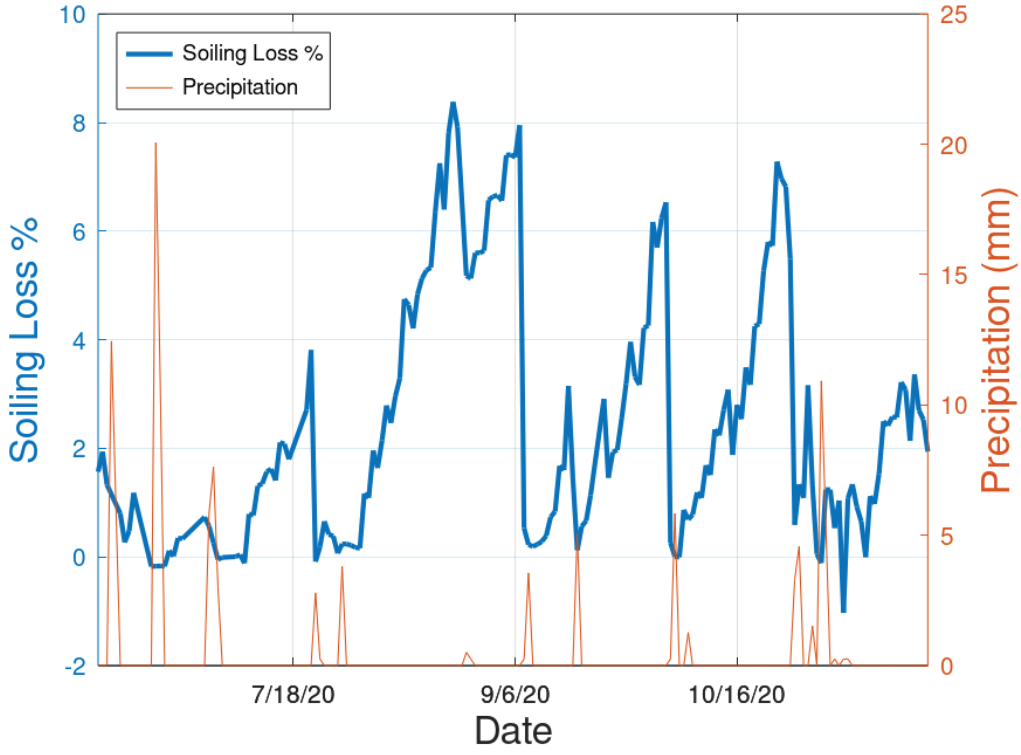

Figure 2: Daily average of daily soiling-loss rate over a period of eight months along with precipitation data.

Application Overview

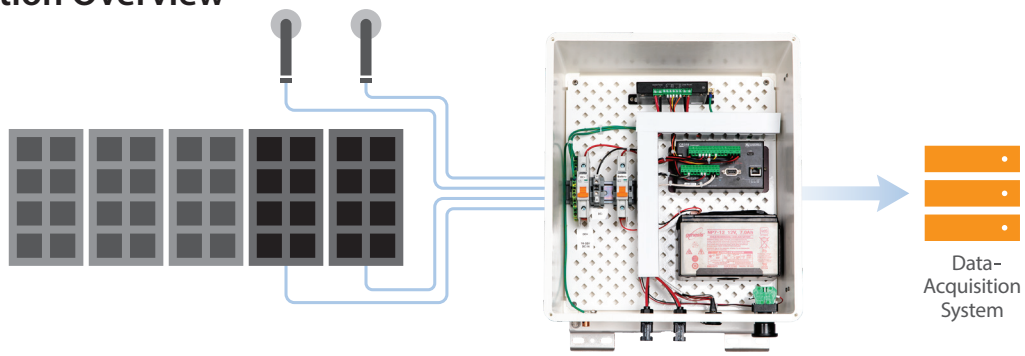

Figure 3

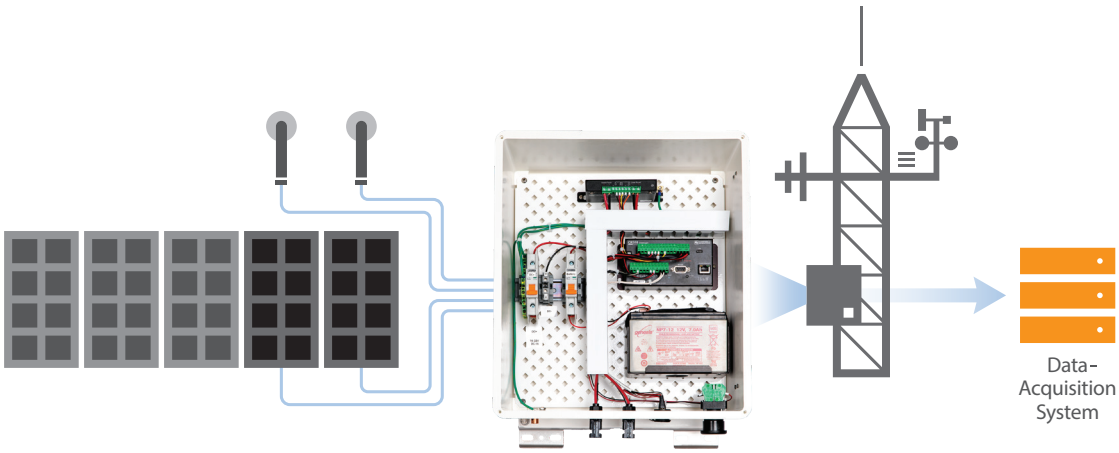

Figure 4

Figures 3 and 4: The SMP100 can act as the system's central measurement and control unit (Fig. 3) or as a peripheral unit that is added to any new or existing solar meteorological monitoring system (Fig. 4). Data transferral from the SMP100 is simple. The SMP100 supports many communication options. Data files can also be sent directly to the cloud via email or FTP.

Short-Circuit Current Methodology

Numerous studies and documents have been published over several decades outlining and testing various methods 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 gain only under certain conditions that may not be practical in a field setting. The disadvantage of these systems is their cost and scalability, as they are typically a much more expensive and complicated endeavor.

The SMP100 uses the short-circuit measurement method to provide end users with a simple, lower-cost solution that is more readily scalable and deployable in larger numbers on utility-scale solar projects using proven methods.

Specifications

All SMP100 Solar-Module Soiling Measurement Systems are tested and guaranteed to meet electrical specifications in a standard -40° to +70°C non-condensing environment. Data logger recalibration is recommended every three years. System configuration and critical specifications should be confirmed with Campbell Scientific before purchase.

SOILING LOSS: can detect ~1%

Configuration	Max Voltage	Max Current	Shunt Value and Accuracy
Chrystaline PV Panels	100 V	15 A	0.02 ohms ± -0.1%
Thin-Film Panels	300 V	5 A	0.02 ohms ± -0.1%

BACK-OF-MODULE TEMPERATURE MEASUREMENTS

OPERATING TEMPERATURE RANGE: -40° to +150°C

CLASS A PRT ACCURACY: ±(0.15 + 0.002t)°C

TEMPERATURE COEFFICIENT: TCR = 3850 ppm/K

ELEMENT TYPE: Precision 1000 ohm Class A platinum sensing element (PT-1000)

LONG-TERM STABILITY: Maximum R_0 drift 0.04% (after 1000 h at 400°C)

COMMUNICATIONS

MODBUS TCP:

Format	Supported Functions	Modbus Address	Data Type
TCP IP	03	11	32-bit float, CDAB

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

MAINTENANCE BUTTON

PRESS < 3 s: Records cleaning of reference panel. Recommend doing twice per week, depending on user requirements.

PRESS > 3 s: Records cleaning of both panels to initiate an offset correction procedure. Recommend doing once a year.

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. Six-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

WARRANTY

One year against defects in materials and workmanship

April 29, 2022