CAMPBELL® SCIENTIFIC
WHEN MEASUREMENTS MATTER

Solar Energy

Summer 2016

Solar-energy monitoring solutions for research, resource assessment, and performance validation

www.campbellsci.com

For over 40 years, Campbell Scientific has been a worldwide leader in designing and manufacturing rugged measurement and control dataloggers and monitoring systems in environmental, research, and industrial applications.

Campbell Scientific designs, manufactures, and sells rugged dataloggers, data-acquisition systems, and measurement and control products used worldwide in environmental, research, and industrial markets. The company was established in 1974, with its corporate headquarters in Logan, Utah, United States. The majority of Campbell Scientific products are manufactured at its U.S. facility, which employs over 300 people in engineering, production, marketing, and administration departments.

Campbell Scientific products are known for their flexibility, precision measurements, and dependability—even in harsh, remote environments. In addition to a family of powerful dataloggers, Campbell Scientific offers a variety of related product lines for the measurement field, including sensors and devices for the collection, storage, communication, and retrieval of data. Using these components, Campbell Scientific employees work with customers to configure unique data-acquisition and measurement and control systems that meet specific instrument and application needs.

Contents

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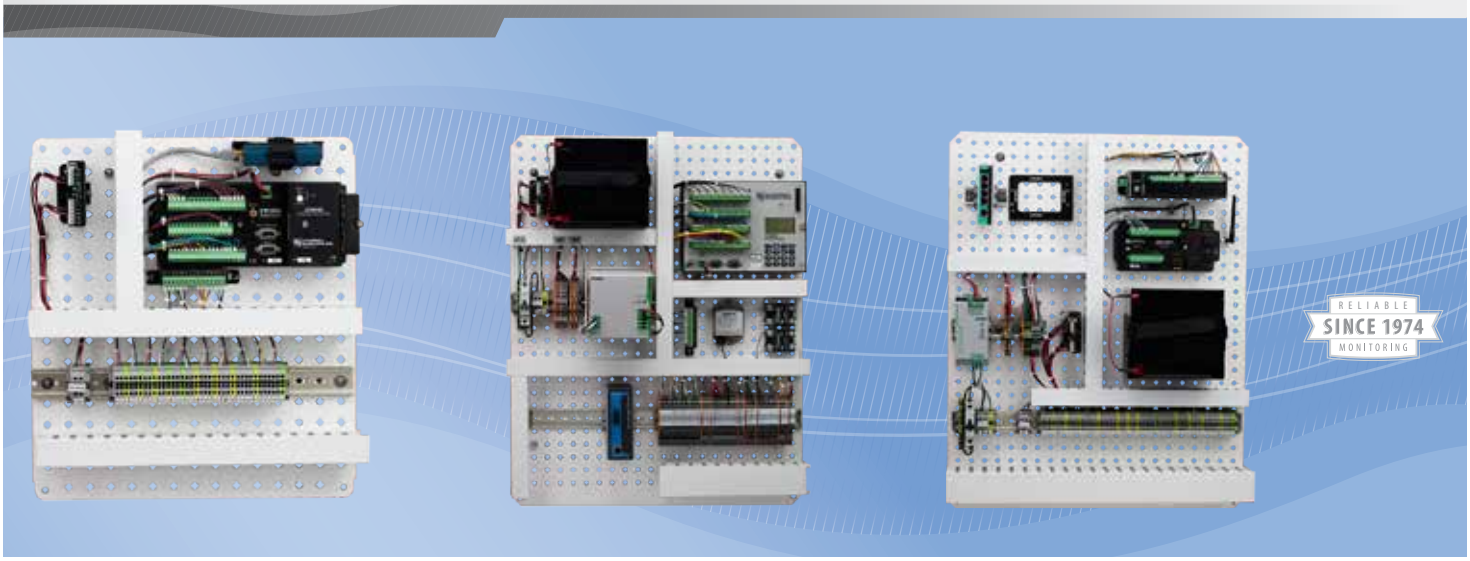
Systems Integrated



Campbell Scientific integrated measurement systems deliver the highest quality, highest data availability data sets, reliably in any weather condition in easy to install, easy to maintain packages. Systems are built using best-practice design and implementation methodology from industry and the knowledge gained from over 40 years of developing the world's most reliable, rugged, and trusted measurement and control dataloggers available.

Benefits and Features

Best-practice, experienced designs making met towers the easiest part of the project

- No programming
- No assembly
- No wiring
- No time wasted

Laboratory quality measurements in the field

- 24-bit (50 nV) resolution
- -55° to 85°C
- 50/60Hz noise rejection
- Input/excitation reversal
- Time synchronization
- Self-calibration
- Low power

Reliability

- Industry's longest datalogger warranty period available
- Any weather condition

Systems Integrated

- We build it
- We program it
- We document it
- We test it
- We support it for the life of the product

Data Security

- Multifactor authentication
- Data encryption
- Secured access

Extreme Flexibility

- Any measurement
- Any sensor configuration
- Any input power
- Any backup power size
- Any data collection method

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Solar Energy

Systems for Solar Resource Assessment, Power Performance, and Advanced Monitoring

Campbell Scientific offers automated data-acquisition systems specifically designed for solar monitoring applications. Preconfigured systems, designed to meet CAISO standards for solar telemetry, are available for photovoltaic and concentrated solar technology projects of all sizes. Our engineers work closely with the customer to design highly customized stations, advanced research and development stations, and custom application programming interfaces (API) for data collection.

MAJOR SYSTEMS

		Measurements		Datalogger	Power	Communications
		Typical	*Optional*			
SOLAR800 Complete MET Solution for Solar Resource Assessment		Global Horizontal Irradiance (GHI), Plane-of-Array Irradiance (POA), air temperature, wind speed, wind direction, precipitation, solar position	relative humidity, barometric pressure	CR800	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP
SOLAR1000 Operational Met Station for Solar Energy Producing Utilities		Global Horizontal Irradiance (GHI), Plane-of-Array Irradiance (POA), back-of-solar panel temperature, wind speed, wind direction, air temperature, relative humidity, barometric pressure, precipitation, solar position	DC current and voltage (string and/or module), visibility, electric field, cloud height, short circuit current, module soiling, surface moisture	CR1000, CR800 CR3000	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP, TCP/IP, fiber optic, radio, serial, field display, satellite, Wi-Fi
SOLAR1000-SCE Operational Met Station for Solar Energy Producing Utilities; meets CAISO, SCE compatible		Global Horizontal Irradiance (GHI), Plane-of-Array Irradiance (POA), diffuse radiation, back-of-solar panel temperature, wind speed, wind direction, air temperature, relative humidity, barometric pressure, precipitation, solar position	DC current and voltage (string and/or module), visibility, electric field, cloud height, short circuit current, module soiling, surface moisture	CR1000, CR3000	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP, TCP/IP, fiber optic, radio, serial, field display, satellite, Wi-Fi

		Measurements		Datalogger	Power	Communications
		Typical	*Optional*			
CSP100 Highest accuracy solar monitoring solution with 2-axis sun tracker		Direct Normal Irradiance (DNI), Diffuse Horizontal Irradiance (DIFF), Global Horizontal Irradiance (GHI), wind speed, wind direction, air temperature, relative humidity, barometric pressure, precipitation, solar position	visibility, cloud height, spectral irradiance	CR1000, CR3000	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP, TCP/IP, fiber optic, radio, serial, field display, satellite, Wi-Fi
RSR100 Rotating Shadow-band Radiometer		Global Horizontal Irradiance (GHI), Diffuse Horizontal Irradiance (DIFF), Plane-of-Array Irradiance (POA), Direct Normal Irradiance (DNI), back-of-module temperature (BOM), solar position/air mass, wind speed, wind direction, air temperature, relative humidity, barometric pressure, precipitation	string current and voltage	CR1000 CR800	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP, TCP/IP, fiber optic, radio, serial, field display, satellite, Wi-Fi
SMP100 Solar module performance solutions, including Soiling		module current, module voltage, back-of-panel temperature, short-circuit current, wind speed, irradiance, solar position	string current and voltage, spectral irradiance	CR1000 CR800	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP, TCP/IP, fiber optic, radio, serial, field display, satellite, Wi-Fi
SOLAR300 Small to Medium Commercial Solar Monitoring Solution		Global Horizontal Irradiance (GHI), Plane-of-Array Irradiance (POA), back-of-solar panel temperature, wind speed, wind direction	relative humidity, barometric pressure	CR300	AC, DC, or solar	Modbus, multidrop, cellular, TCP/IP, fiber optic, radio, satellite, Wi-Fi
UTILITY-MET100 Utility-Grade Weather Station for SCADA Operations		air temperature, relative humidity, wind speed, wind direction, precipitation, barometric pressure, solar radiation	back-of-solar panel temperature	CR1000	AC, DC, or solar	Modbus, multidrop, cellular, TCP/IP, fiber optic, radio, satellite, Wi-Fi

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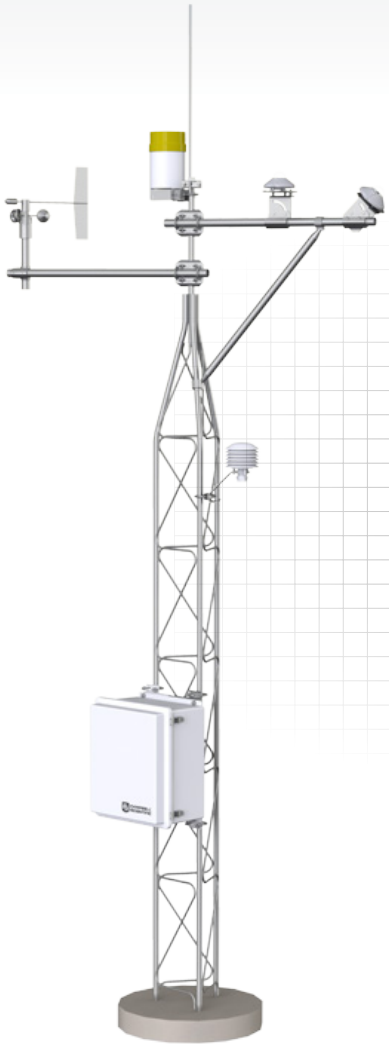
Solar1000

Solar Monitoring Station

Robust, Reliable, High Accuracy

Operational MET Station for Solar Energy Producing Utilities



Solar1000
Standard CAISO

Solar1000-SCE Meets
CAISO, SCE Compatible

Solar1000 Customized for PG&E

Overview

The Solar1000 is a configurable, turn-key solar measurement data acquisition station specifically designed to meet utility and industrial standards for solar monitoring applications, including power performance monitoring and operational assessment.

Built with fast to field features, delivered with complete system documentation including system drawings, wiring diagram, and installation guide, and supported by Campbell Scientific's experienced Application Engineers, the Solar1000 simplifies the high accuracy, high demand requirements of utility MET monitoring.

Configurable Any Spec or PPA

- *CAISO PIRP*
- *Southern California Edison*
- *Pacific Gas & Electric*
- *San Diego Gas & Electric*
- *Arizona Public Service*
- *MidAmerican Energy*
- *Duke Energy*
- *NextEra Energy*
- *Austin Energy*
- *Long Island Power Authority*

specs, questions, & quotes: **435.227.9030**
www.campbellsci.com/solar1000

Common Measurements Options

- Global Horizontal Irradiance (GHI)
- Plane of Array Irradiance (POA)
- Diffuse Horizontal Irradiance (DHI)
- Direct Normal Irradiance (DNI)
- Back of Module Temperature (BOM)
- Soiling
- Air Temperature
- Relative Humidity
- Wind Speed
- Wind Direction
- Precipitation
- Solar Position
- Barometric Pressure
- Visibility
- GPS Time and Position
- Snow Level
- Inclination/Position
- Sensor and Communication Fault Detection

Common Features and Options

- SCADA Protocols (Modbus, DNP3, and others)
- One Second Measurement, Data Delivery and Storage
- Wireless SCADA Connectivity
- Ethernet Connectivity
- Cellular Connectivity
- Fault Detection and Reporting
- AC and/or Autonomous DC Power Supply
- Operator's Manual and Installation Guide
- Technical Sales and Commissioning Support
- Engineering Services Available
- Contract Manufacturing Services Available

Any Configuration, Any Measurement, Any Data Transfer Media and Protocol

The Solar1000, based on the Campbell Scientific CR1000 Measurement and Control Datalogger, is completely customizable, allowing station configuration to meet your project's specifications, while retaining turn-key functionality. Nearly every aspect of the system is customizable, including sensors, communications, mounting, and power supply. Campbell Scientific dataloggers are the most versatile measurement platforms available. Any sensor can be measured and the data can be retrieved and sent over many different media, using any number of different protocols.

Turn-key measurement solutions such as the Solar1000 are built using industrial best practice system fabrication methods to our client's specification. System documentation, including schematics, wiring diagrams, and installation guides are offered.

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Solar1000-SCE

SCE Compatible Solar Monitoring Station

CAISO, SCE Compatible

Operational MET Station for Solar Energy Producing Utilities

Sensors / Equipment

- *Heated Wind*
- *Air Temperature*
- *Relative Humidity*
- *Total Global Plane of Array Irradiation (one per collector plane)*
- *Total Global Horizontal Irradiation*
- *Diffuse Radiation*
- *Solar Altitude Angle*
- *Solar Azimuth Angle*
- *Precipitation*
- *Back of Module Temperature*
- *Soiling (Optional)*

Overview

The Solar1000-SCE is a meteorological station that meets or exceeds CAISO PIRP standards and is compatible with SCE Exhibit T Meteorological Station Specifications. Although offered as a turn-key package, the Solar1000-SCE retains the powerful, module nature of the Campbell Scientific product line. Nearly every aspect of the station is customizable, including sensors, communications, mounting, and power supply.

Features

- Station designed to minimize field wiring errors and reduce deployment time
- Wiring diagram, system drawings, and support documentation included
- Technical sales and commissioning support from Campbell Scientific application engineers included
- Station factory fabricated and tested prior to shipment

Attributes

- Campbell Scientific CR1000 or CR3000 Measurement and Control Datalogger
- Battery-backed system sized to allow data collection during power outages and network failure
- Any communication technologies such as TCP/IP, RS-485, fiber, cellular, satellite, and radio supported
- Compliant with Modbus, PakBus, and DNP3 protocols
- One second data delivery, storage, and management operation

Typical Configuration

1. CR1000 Measurement and Control Datalogger
2. SCADA Connectivity via Modbus and DNP (wireless and remote options available)
3. Uninterruptible Power Supply (solar panels available)
4. Robust Instrumentation Tower and Mounting Hardware
5. Heated Wind Sensor
6. Air Temperature Sensor
7. Relative Humidity Sensor
8. Barometric Pressure Sensor
9. Total Global Plane of Array Irradiation Sensor (one per collector plane)
10. Total Global Horizontal Irradiation Sensor
11. Diffuse Radiation Sensor
12. Precipitation Sensor
13. Back of Module Temperature Sensor
14. Soiling (Optional)

See Also

Solar800

Solar Resource Assessment Station with turn-key functionality and data collection

CSP100

Power Plant Assessment Station with the best possible solar resource measurements.

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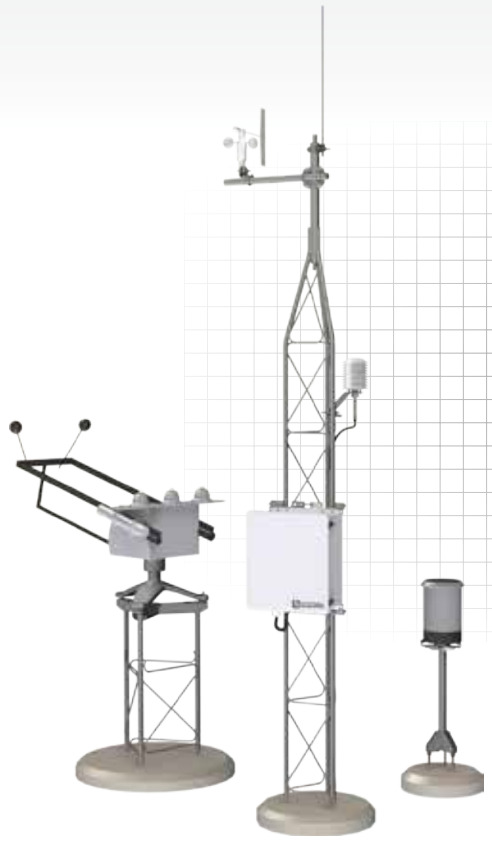
CSP100

Concentrated Solar Power Monitoring System with 2-Axis Sun Tracker



High Accuracy

Resource Assessment and Power Performance Monitoring for Concentrated Solar Power

Common Measurements

- *Direct Normal Irradiance (DNI)*
- *Diffuse Horizontal Irradiance (DIFF)*
- *Global Horizontal Irradiance (GHI)*
- *Wind Speed*
- *Wind Direction*
- *Air Temperature*
- *Relative Humidity*
- *Barometric Pressure*
- *Precipitation*
- *Solar Position*

Overview

The CSP100 is a turn-key automated data acquisition system specifically designed to meet CAISO meteorological station requirements of concentrated solar power generating facilities. It is recommended for assessing power plant performance, which requires the best possible solar resource measurements.

The CSP100 is field ready with features to minimize installation time and field wiring errors. Though offered as a turn-key package, nearly every aspect of the system is customizable, including sensors, communications, mounting, and power supply.

Benefits and Features

- Contains a Campbell Scientific CR1000 Measurement and Control Datalogger
- Provides the lowest uncertainty of the GH, DNI, and DIFF solar radiation measurements
- Fast to field with industry-proven, high-accuracy sensors
- Factory fabrication, programming, and testing minimizes field wiring errors and reduces deployment time
- Meets CAISO required meteorological data points
- Approved California ISO Remote Intelligent Gateway (RIG) for secure encrypted information transmission to CAISO
- Complies with Modbus, PakBus, and DNP3 protocols
- Supports nearly all communication technologies such as RS-485, fiber, TCP/IP, cellular, or satellite
- Reference design: "Solar Resource and Meteorological Project (SOLRMAP)", NREL
- Provides a modular, programmable, and customizable system
- Provides a battery back system that allows data collection during power outages and network failure
- Acts as single point data gateway for environmental, inverter, and meter data
- Supports TCP/IP functionality, including: HTTP Get, HTTP Post, FTP server and client, TelNet server, PING, Micro serial server, DHCP client, DNS client, email send and receive
- Supports Web Service API
- Supports individual module and string level power measurements
- Shipped with a quick-deploy installation guide and system schematics

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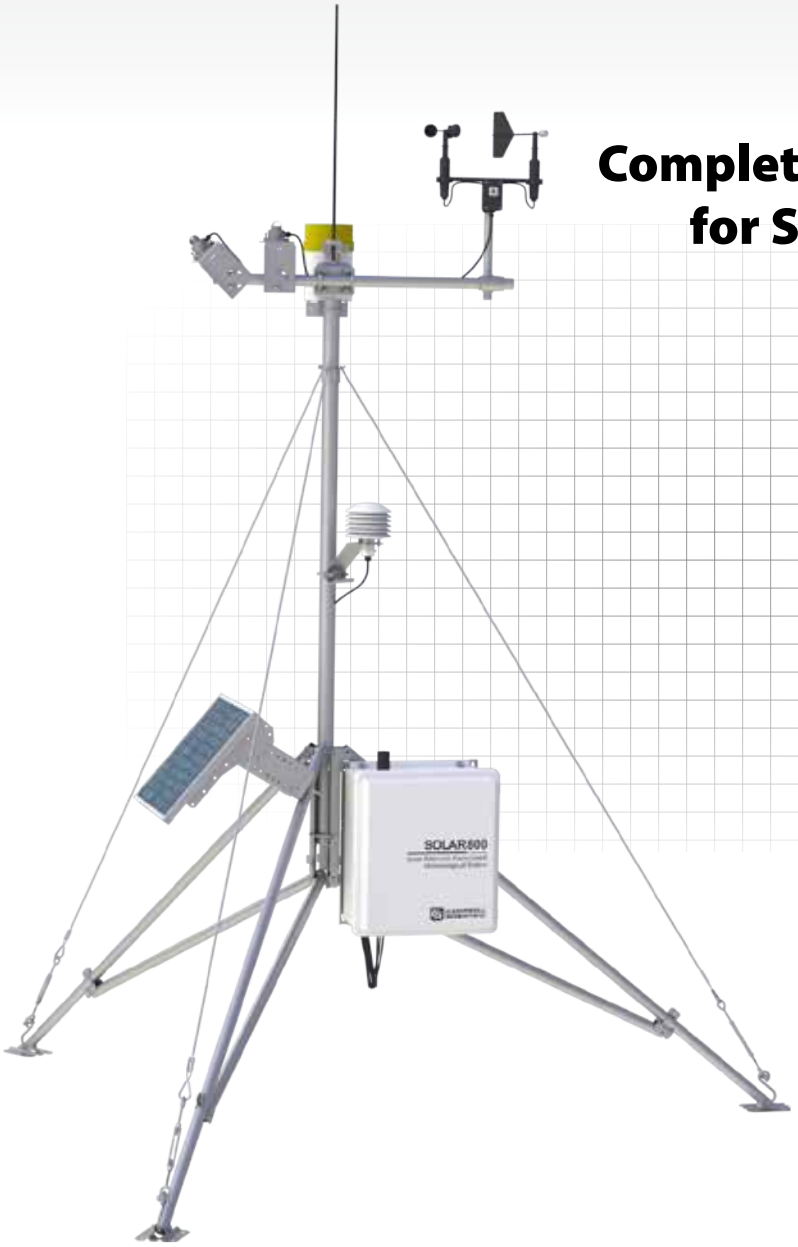
SOLAR800

Quick-Deploy Solar Resource Assessment Station



End-to-End

Complete Meteorological Solution for Solar Resource Assessment

Key Benefits

- *The right measurements*
- *Easy and quick to deploy*
- *No specialized training*
- *Data automatically delivered*

Overview

The SOLAR800 is a complete solar measurement data acquisition solution specifically designed for solar resource assessment. The SOLAR800 delivers the on-site observations essential for a thorough understanding of a project site's solar resource and variability.

The SOLAR800 is easy and quick to deploy, requiring no specialized training for proper installation and operation. Data is automatically sent to the client's server, cloud, SCADA, and/or FTP site.

Major System Components

Configuration Software

- Communication IP Addressing

MET Station

- Tripod
- Power Supply
- Cell modem and/or Ethernet interface

MET Measurements

- Solar Position
- Global Horizontal Irradiance
- Plane of Array Irradiance
- Air Temperature
- Wind Speed
- Precipitation
- Relative Humidity
- Wind Direction
- Barometric Pressure

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RSR100

Rotating Shadowband Radiometer

Solar Resource Measurement System

with Rotating Shadowband Radiometer

Measurements

- *Global Horizontal Irradiance (GHI)*
- *Diffuse Horizontal Irradiance (DIFF)*
- *Plane-of-Array Irradiance (POA)*
- *Direct Normal Irradiance (DNI)**
- *Back of Module Temperature (BOM)*
- *Solar Position/Air Mass*

**Computed*

- *Wind Speed*
- *Wind Direction*
- *Air Temperature*
- *Relative Humidity*
- *Barometric Pressure*
- *Precipitation*
- *GPS position and time*

Overview

The RSR100, Rotating Shadowband Radiometer, offers a lower-cost option for providing solar measurements GH, DIFF, and DNI. The RSR100 system uses the fast response time of a Li-Cor photocell diode (10 µs) coupled with the burst measurement (up to 2 kHz), control, and processing capability of a Campbell Scientific datalogger to measure GHI and DIFF solar irradiance and compute DNI.

The RSR100 is built around Irradiance, Inc.'s RSR2™ Rotating Shadowband Radiometer. The RSR2 is a second-generation instrument incorporating improvements in accuracy and mechanical reliability from collaborative research conducted at NREL, Sandia, and the University of Oregon Solar Monitoring Lab. Irradiance has manufactured over 500 RSR2 units operating across six continents.

Benefits and Features

- Contains a Campbell Scientific CR1000 Measurement and Control Datalogger
- Fast to field with industry-proven design
- Factory fabrication, programming, and testing minimizes field wiring errors and reduces deployment time
- Complies with Modbus, PakBus, and DNP3 protocols
- Provides a battery back system that allows data collection during power outages and network failure

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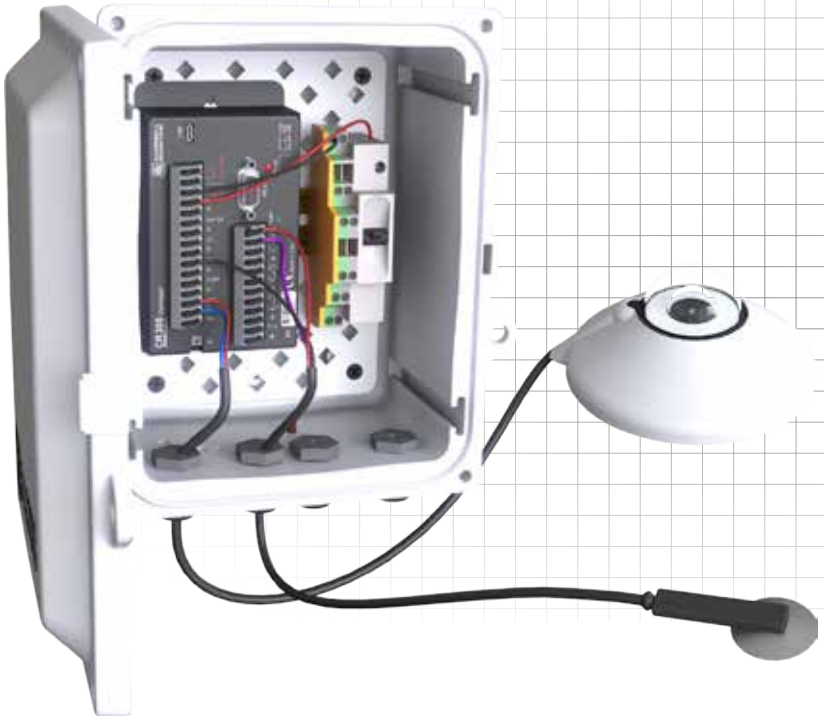
SOLAR300
Solar Monitoring Station

Commercial and Industrial Solar Monitoring Station

Simple, Flexible, Field-Ready



Measurements

Standard:
- *Plane-of-Array Irradiance*
- *Back-of-Module Temperature*

Extended:
- *Air Temperature*
- *Wind Speed*
- *Precipitation*
- *Global Horizontal Irradiance*

Overview

The SOLAR300 is a simple solar monitoring solution for commercial and industrial installations. This turnkey station is delivered field-ready, designed for quick and easy installation and commissioning. Critical parameters solar irradiance and back of module temperature(s) are measured and reported along with data quality and station performance and operational status indication and feedback. Additional measurements; air temperature, wind speed, precipitation, and/or global horizontal irradiance are optional. The SOLAR300's data are obtained via Modbus RS-485 or TCP/IP, cellular modem, or using Campbell Scientific's LoggerNet Software package.

Benefits and Features

- High reliability and longevity with a Campbell Scientific CR300 Measurement and Control Datalogger
- Easy, turn-key installation
- Standard, off-the-shelf, station configurations
- Customizable options to pin-point station specifications
- Complete station factory test prior to shipment maximizes field-readiness
- Battery-backed system for continuous data collection
- RS-485, TCP/IP, cellular, Wi-Fi, and other wireless communication options

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CRSI2
Soiling Index Datalogger

Soiling Index Measurement Solution

Featuring advanced datalogger technology

Overview

Soiling, the loss of 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 CRSI2 Soiling Index Datalogger, 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 and soiling rate are calculated using industry standard methodologies. Raw data is stored and available for additional post-processing.

Benefits and Features

- Purpose built Campbell Scientific datalogger
- Complete system easily integrates into any SCADA network or existing MET station
- Supports Modbus, DNP3, PakBus, data encryption, and Internet protocols
- No programming required
- Web interface for data viewing and simple configuration
- Soiling loss indices and soiling rate calculated using industry standard methodologies.
- Measurements of reference and test modules: short-circuit current, back of module temperature, and open-circuit voltage

Technical Description

The CRSI2 Soiling Index Datalogger is designed to be at the heart of an independent soiling measurement station or as an add-on peripheral to any new or existing MET station. It supports many communication protocols such as Modbus, DNP3, PakBus, PakBus encryption and several internet protocols. Deployment/configuration is simple and easy through a built-in web configuration page. The CRSI2 is delivered field ready and requires no programming. It will work with any user-supplied solar module up to 300 W or can be ordered with mini 20 W modules. Two highly accurate and rugged back-of-temperature sensors are included.

The CRSI2 measures short-circuit current (Isc), open-circuit voltage (Voc), and back of module temperature of two solar modules every 30 s by default (configurable) ±60 min. of local solar noon. The CRSI2 evaluates (1) if the module power output is appropriate for calculating soiling index and (2) the stability of the atmospheric conditions. If the criteria are met, then effective irradiance is calculated, flagged and used for determining the soiling index. If all necessary and appropriate criteria are met, the soiling index is updated once daily.

Taking advantage of the extremely flexible Campbell Scientific datalogger platform, the CRSI2 offers additional soiling management solutions. Because many of our users want immediate feedback, the CRSI2 also provides a real-time index based on the typically very stable short-circuit current ratio. Additionally, raw measured data are stored and available for analyst and researchers who are looking to perform independent post-processing.

Example Plot

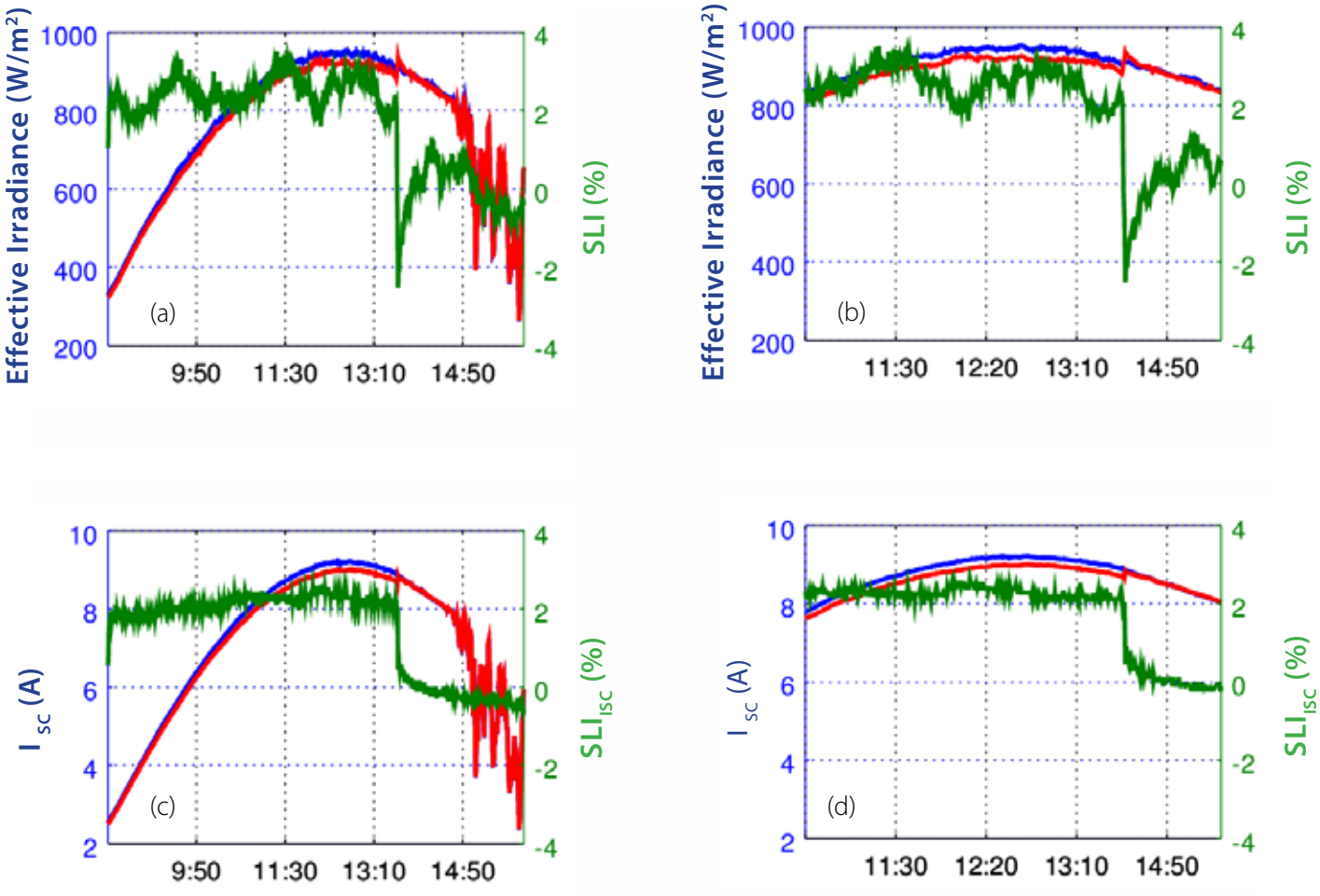

Figure 1: Example data file shows a cleaning event at ~ 1:30 p.m. The tables on the right show stable subsets of data ±1 hr of local solar noon. This data is used for long-term soiling index analysis. (a) and (b): Curve in blue is effective irradiance from the reference panel and the curve in red is the effective irradiance from the test panel. The green curve is the soiling index calculated from the ratio of these two. Higher value of SLI before 1:30 p.m. indicates loss due to soiling. (c) and (d): Curve in blue is short circuit current from the reference panel and the curve in red is the same quantity from the test panel. The green curve is the soiling index calculated from the ratio of these two. Higher value of SLI before 1:30 p.m. indicates loss due to soiling.

Application Overview

Figure 2(a)

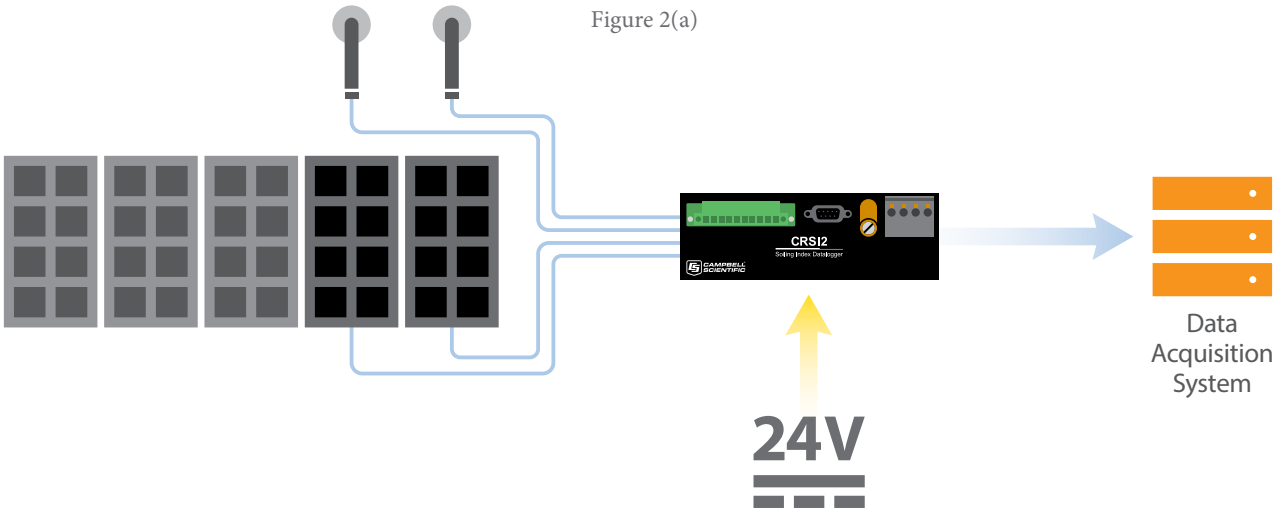

Figure 2(b)

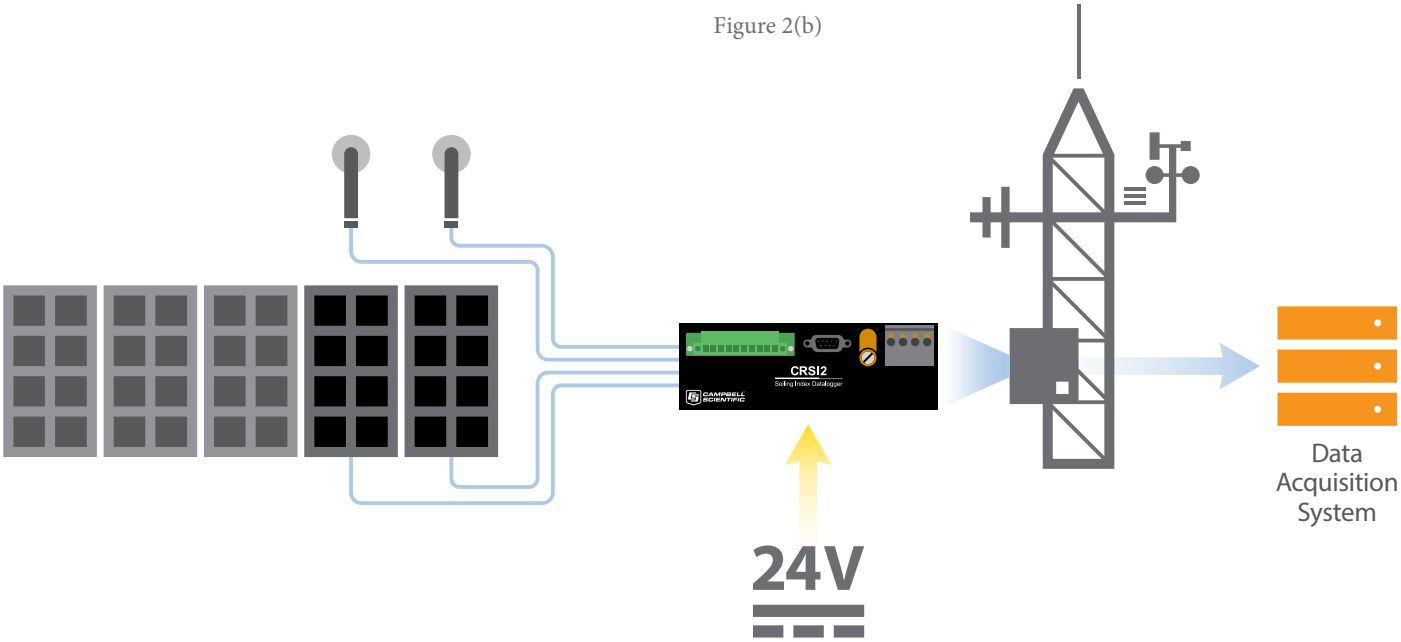

Figure 2: The CRSI2 can act as the system's central measurement and control unit (a) or as a peripheral unit that is added to any new or existing solar meteorological monitoring system (b). Data transfer from the CRSI2 is simple. The CRSI2 supports many communication options, including; Internet protocols, 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.

Specifications

All CRSI2 dataloggers 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

24-BIT ADC MEASUREMENT ACCURACY: ~ 2 µV

VOLTAGE MEASUREMENTS

INPUT RESISTANCE: 5 GΩ (f_{N1} = 50/60), 300 MΩ (f_{N1} = 4000)

DC COMMON MODE REJECTION:
>120 dB with input reversal (≥90 dB without input reversal)

NORMAL MODE REJECTION: >71 dB @ 50 Hz, >74 dB @ 60 Hz

RANGE AND RESOLUTION:

Notch Frequency (f_{N1}) (Hz)	Range[1] (mV)	Typical Resolution[2] (Differential w/Input Reversal)		Typical Resolution[2] (Differential w/o Input Reversal)	
		Effective Resolution		Effective Resolution	
		RMS µV	bits	RMS µV	bits
4000	-100 to +2500	23	16.8	33	16.3
	-34 to +34	3.0	14.5	4.2	14.0
400	-100 to +2500	3.8	19.4	5.4	18.9
	-34 to +34	0.58	16.8	0.82	16.3
50/60	-100 to +2500	1.6	20.6	2.3	20.1
	-34 to +34	0.23	18.2	0.33	17.7

ACCURACY:

0° to 40°C	-40° to 70°C
±(0.04% of reading + offset)	±(0.1% of reading + offset)

OFFSETS:

Range (mV)	Differential with Input Reversal (µV)	Differential without Input Reversal (µV)	Single-Ended (µV)
-100 to +2500	±20	±40	±60
-34 to +34	±3	±7	±10

MEASUREMENT SPEED:
*(multiplexed measurement time (ms) * reps + 0.8 ms)*

f_{N1} (Hz)	Multiplexed Measurement Time (ms)	
	w/Input Reversal	SE or w/o Input Reversal
4000	2.9	1.4
400	14.6	7.3
50/60	103	51.5

DEFAULT SETTLING TIME: 500 µs

COMMUNICATIONS

INTERNET PROTOCOLS: PPP, ICMP/Ping, Auto-IP(APIPA), IPv6, UDP, TCP, TLS, DHCP Client, SLAAC, DNS Client, Telnet

ADDITIONAL PROTOCOLS SUPPORTED: PakBus, SDI-12, Modbus RTU, Modbus ASCII, Modbus TCP/IP, DNP3. Custom user-definable over serial

DATA FILE FORMATS: CSV, XML, JSON, binary, encrypted

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

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

SERIAL (C1, C2): 0 to 5 V output, 3.3 V input, 1200 to 115.2k bps

SDI-12 (C1, C2): Two independent SDI-12 V1.3 compliant terminals configurable as sensor or recorder

SYSTEM

CLOCK ACCURACY: ±1 min. per month

CLOCK RESOLUTION: 1 ms

PROGRAM EXECUTION: 100 ms to one day

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: 1.5 mA

ACTIVE 1 HZ SCAN WITH ANALOG MEASUREMENTS: 5 mA

USB POWER (USB): For programming and limited functionality.

COMPLIANCE

CE: All terminals tested to Class 4 levels (IEC 61000-4-5: 2013) for surge and (IEC 61000-4-2:2008) for ESD

SHOCK AND VIBRATION: ASTM D4169-09

PROTECTION: IP30

WARRANTY

Three years against defects in materials and workmanship.

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WHEN MEASUREMENTS MATTER

Solar Energy Sensors & Components

Pyranometers, pyrheliometers, radiometers, reference cells, spectroradiometers & sun trackers

Campbell Scientific offers pyranometers, pyrheliometers, radiometers, reference cells, spectroradiometers, and sun trackers, all designed to measure various aspects of the energy imparted by the sun on the Earth's surface.

ISO SECONDARY STANDARD

	Features	Spectral Range	Sensitivity	Operating Temperature
SR20[a] | ISO-Secondary Standard Pyranometer 	• Low calibration uncertainty • Reduced "zero offset A" • Low temperature dependence • Characterized temperature dependence • Characterized directional response • Built in dome heater • Built in temperature sensor	285 to 3000 nm	15 µV/W/m²	-40° to +80°C
SR25[a] | ISO-Secondary Standard Pyranometer 	• Sapphire outer dome • Negligible zero offsets • Internal heater to suppress dew and frost deposition • Highly suitable for diffuse measurements • Best measurement accuracy	285 to 3000 nm	15 µV/W/m²	-40° to +80°C
CMP10 | ISO-Secondary Standard Pyranometer 	• Based on CMP11 technology • Internal drying cartridge • 5-year warranty	285 to 3000 nm	15 µV/W/m²	-40° to +80°C
CMP11 | ISO-Secondary Standard Pyranometer 	• Temperature compensated detector • Fast response time • Low tilt error • Excellent linearity	285 to 2800 nm	7 to 14 µV/W/m²	-40° to +80°C
CMP21 | ISO-Secondary Standard Pyranometer 	• Verified cosine response • Verified temperature dependence • Low dome IR offset error • Excellent linearity • Fast response time	285 to 2800 nm	7 to 14 µV/W/m²	-40° to +80°C
CMP22 | ISO-Secondary Standard Pyranometer 	• Most accurate pyranometer currently available • Negligible thermal gradient zero-offset • Lowest zero-offset due to FIR radiation • Low directional error • Wide spectral range	285 to 2800 nm	7 to 1 4 µV/W/m²	-40° to +80°C (<1%)
SMP10[a] | ISO-Secondary Standard Pyranometer 	• No change of desiccant for 10 years • RS-485 Modbus communications • Identical sensitivity and connections on every sensor	285 to 2800 nm	2-wire RS-485 Modbus	-20° to +50°C (<1%) -40° to 70°C (<2%) (Range of specified temperature dependence of sensitivity)
SMP11[a] | ISO-Secondary Standard Pyranometer 	• RS-485 Modbus communications, 0 to 1 V or 4 to 20 mA • Identical sensitivity and connections on every sensor	285 to 2800 nm	2-wire RS-485 Modbus	-20° to +50°C (<1%) -40° to 70°C (<2%)
MS-802[a] | ISO-Secondary Standard Pyranometer 	• Fast response time (95% < 5 s) • Temperature compensated in a wide temperature range • High quality optical glass for proper cosine response • ISO 17025 Accreditation	285 to 3000 nm	7 µV/W/m²	-40° to +80°C

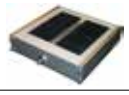
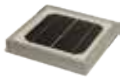
VENTILATION UNIT

	Features	Sensitivity	Operating Temperature
VU01[a] | Ventilation Unit 	• 5 W and 10 W heaters on board, individually controllable • Small footprint, compact design • Fully specified, complies with ISO/TR 9901	Heater: 5 and 10 W at 12 Vdc Vent: 7.8 W at 12 Vdc	-40° to 70°C
CVF4-L | Ventilation Unit 	• Improved flow over the top of the dome • Integrated 5.5 W heater • New heater position and cover material reduce power requirement • Replaces CVF3 ventilation unit	Heater: 5.5 W at 12 Vdc Vent: 7.8 W at 12 Vdc	-40º to +70°C
MS-802F [a] | ISO- Secondary Standard with Ventilation 	• Ventilation and sensor combination • Prevents/minimizes the effect of dew, rain, snow, ice, and dust	120 V, 220 V, 240 V, 15 W	-40° to 50°C

BACK OF MODULE TEMPERATURE

	Sensor	Measurement Description	Sensitivity	Operating Temperature
110PV-L | Surface-Mount Thermistor Rugged, Accurate 	Thermistor with specially designed protective aluminum disk	Back of Module Temperature	+1°C	-40º to +135°C
CS220-L | Surface-Mount Type E Thermocouple 	Type E Thermocouple meets ASTM E230-ANSI MC 96.1	Back of Module Temperature	+1°C	up to 260 °C
CS223-L | Surface-Mount Class A RTD 	100 Ω DIN Class A RTD	Back of Module Temperature	±0.06 Ω or ±0.15 °C	-73º to +260 °C

REFERENCE CELL

	Sensor	Measurement Description	Spectral Range	Sensitivity	Operating Temperature
Si-01TC-T-K[a] | Reference Cell 	General purpose mono-crystalline solar cell	Reference Cell	varies	1 mV/W/m^2	-20º to +70°C
ESTI[a] | Reference Cell 	User-supplies cell or chooses between mono or poly reference cell	Reference Cell	varies	varies	varies
PVMeasurements[a] | Module Type Outdoor Reference Cell 	Multiple configurations, including module packages available	Reference Cell	varies	varies	varies

SPECTRORADIOMETERS & ROTATING SHADOWBAND RADIOMETERS

	Sensor	Measurement Description	Spectral Range	Sensitivity	Operating Temperature
MS-700[a] | Spectroradiometer Permanent Outdoor Usage 	Spectroradiometer for permanent outdoor usage	Spectral flux density over visible wavelengths	350 to 1050 nm	10 nm (spectral resolution FWHM)	-20° to 50°C
WISER System (MS-711/ MS-712)[a] | Spectroradiometer 	Full spectrum spectroradiometer	Higher resolution spectral flux density over visible and NIR wavelengths	300 to 1700 nm	5 nm (MS-710), 7 nm (MS-712) spectral resolution	-10° to 40°C
RSR2[a] | Rotating Shadow-band Radiometer 	Silicon-cell photo-diode with rotating shadowband	Global, diffuse, and direct irradiance	400 to 1100 nm	0.2 kW m^{-2} mV^{-1}	-40° to 65°C

SUN TRACKER

		Sensor	Measurement Description	Sensitivity	Operating Temperature
SOLYS 2[a] | Sun Tracker		Fully automatic sun tracker	BSRN level performance. Can be interfaced for status information over IP	< 0.1° passive tracking <0.02° active tracking (with optional sun sensor)	-20º to +50°C
STR-22G[a] | Sun Tracker		Compact fully automatic sun tracker	BSRN level perfor-mance. Can be inter-faced for status information over serial	± 0.01° (with sun sensor)	-40º to +50°C

SOLAR TRACKER MOUNTING STANDS

		Used With	Material	Heights	Allowable Wind Gusts
Sun Tracker Mounting Stands		SOLYS 2 and EKO STR-22G	Hardened aluminum, corrosion-resistant	178 cm, 132 cm, or 86 cm	178 cm: 51 m/s 132 cm: 59 m/s 86 cm: 66 m/s

ISO FIRST CLASS PYRHELIOMETER

		Features	Spectral Range	Sensitivity	Operating Temperature
DR01[a] | ISO First Class Pyrheliometer		• ISO First Class • Heated window • Option temperature sensor • Optional temperature dependence characterization	(0 to 2000) W/m^2	10 x 10^{-6} V/(W/m^2)	-40° to 80°C
CHP1 | First Class Pyrheliometer		• ISO First Class • Built on legacy CH 1 • Built-in temperature sensors • Excellent temperature dependence of sensitivity	(200 to 4000) nm	7 to 14 µV/W/m^2	-40º to +80°C
MS-56[a] | ISO First Class Pyrheliometer		• ISO First Class • Ultra-fast response detector • Excellent temperature stability • Outdoors calibration • Window heater	200 to 4000 nm	6 to 10 µV/W/m^2	-40° to 80°C
NIP[a] | WMO First Class Pyrheliometer		• Same geometric dimensions as AHF Cavity Radiometer • Optional calibration can be performed against AHF • Meets ISO Secondary Standard	(0 to 1400) W/m^2	8 µV/W/m^2	-40° to 40°C

ISO FIRST-CLASS STANDARD

		Features	Spectral Range	Sensitivity	Operating Temperature
SR12[a] | ISO-First-Class Pyranometer		• Meets ISO 9060 "solar energy test applications" • Built in dome heater • Low calibration uncertainty (first class)	285 to 3000 nm	15 µV/W/m^2	-40° to +80°C
CMP6 | ISO-First-Class Pyranometer		• Fully compliant with ISO 9060:1990 • Fast response time • Long term stability characteristics	285 to 2800 nm	5 to 20 µV/W/m^2	-40° to +80°C

ISO SECOND-CLASS STANDARD

		Features	Spectral Range	Sensitivity	Operating Temperature
LP02 | ISO-Second Class Pyranometer		• ISO 9060 Second Class • Designed for continuous indoor and outdoor use	305 to 2800 nm	15 µV/W/m^2	-40° to +80°C
CMP3 | ISO-Second-Class Pyranometer		• ISO 9060 Second Class • Designed for continuous indoor and outdoor use	300 to 2800 nm	5 to 20 µV/W/m^2	-40° to +80°C

SILICON PYRANOMETERS

		Features	Spectral Range	Sensitivity	Operating Temperature
LI200X | Silicon Pyranometer		• Long record of performance at NREL • Cosine corrected miniature head • Calibrated against Eppley PSP	400 to 1100 nm	0.2 kW m^{-2} mV^{-1}	-40° to +65°C
CS300 | Silicon Pyranometer		• Patented dome-shape does not trap water or debris • Excellent cosine response (silicon-cell pyranometer) • Four year warranty	360 to 1120 nm	5 mV/Wm^{-2}	-40° to +70°C

WIND SPEED & WIND DIRECTION

		Sensor	Accuracy	Output Range	Operating Temperature
034B-L | Wind Set Good all purpose wind set		3-cup anemometer and wind vane	Wind Speed ±0.1 m s^{-1} or ±1.1% Wind Direction ±4°	Wind Speed 0 to 50 m s^{-1} Wind Direction 0° to 360°	-30° to +70°C
03002-L | Wind Sentry Set Good all purpose wind set		3-cup anemometer and wind vane	Wind Speed ±0.5 m s^{-1} Wind Direction ±5°	Wind Speed 0 to 50 m s^{-1} Wind Direction 0° to 360°	-50° to 50°C
05103-L | Helicoid Wind Monitor Designed to prevent ice buildup Rugged, Reliable Wind Measurements		heliocoid anemometer and wind vane	Wind Speed ±0.3 m s^{-1} Wind Direction ±3°	Wind Speed 0 to 75 m s^{-1} Wind Direction 0° to 360°	-50° to 50°C
WS200-UMB[a] | Heated Ultrasonic for SCE Applications		2-D sonic anemometer	Wind Speed 0.1 m s^{-1} Wind Direction < 3°	Wind Speed 0 to 90 m s^{-1} Wind Direction 0° to 359.9°	-50° to 60°C
CSAT3 | 3D Sonic Anemometer Best instrument for flux and other high-level turbulence research projects		3-D sonic anemometer	Resolution ux, uy: 1 mm s^{-1} rms uz: 0.5 mm s^{-1} rms c: 15 mm s^{-1} (0.025°C) rms Wind Direction 0.06°	Full Scale Wind ±65.535 m s^{-1}	-50° to 70°C

BAROMETRIC PRESSURE SENSORS

		Signal Type/Output	Measurement Description	Output Range	Operating Temperature
CS100 (Setra 278) | Standard Barometer Reliable and accurate		analog voltage	barometric pressure	600 to 1100 mb[b]	-40° to 60°C
092-L | Includes Weather-proof Enclosure Reliable and accurate		analog voltage	barometric pressure	600 to 1100 mb	-40° to 55°C

TEMPERATURE & RELATIVE HUMIDITY

		Signal Type/Output	Measurement Description	Output Range	Operating Temperature
CS215-L | Reliable and easy to maintain		SDI-12	temperature relative humidity	Temperature -40° to 70°C Relative Humidity 0 to 100%	-40° to 70°C
083E-L | Accurate and reliable sensor		analog voltage	temperature relative humidity	Temperature -50° to 50°C Relative Humidity 0 to 100%	-50° to 50°C
HC2S3-L | Accurate and rugged		analog voltage	temperature relative humidity	Temperature -40° to 60°C Relative Humidity 0 to 100%	-40° to 100°C
43347-L | Highly accurate RTD for atmospheric stability monitoring ±0.1°C accuracy with NIST calibration		analog voltage	temperature	±50°C	±50°C
43502-L | Aspirated Shield, provides more accurate measurement		NA	Delta T: <0.05°C RMS with like shields	5 to 11 m s^{-1}	-50° to 60°C

OTHER

		Signal Type/Output	Measurement Description	Measurement Range	Operating Temperature
CS120A | Visibility Sensor High Performance Visibility Measurements		RS-232, RS-485	Meteorological Observable Range (MOR)	12 m to 32 km	-25° to 60°C
SR50A-L | Sonic Ranging Sensor used to measure snow depth		SDI-12, RS-232, RS-485	snow depth	0.5 to 10 m (1.6 to 32.8 ft)	-45° to +50°C
LWS-L | Surface Wetness Sensor Dielectric sensor to determine presence of water and ice		analog voltage	dry, frosted, wet	250 mV to 1500 mV, millivolt reading relates to moisture state	-20° to 60°C
CS135 | LIDAR Ceilometer Sensitive, Long Range Cloud Measurement		RS-232, RS-485	cloud height and vertical visibility	5 m to 10 km: up to four cloud layers reported	-40° to 60°C
CS616-L | Soil Water Content Reflectometer		±0.7 V square wave with frequency dependent on water content	soil volumetric water content	0% to saturation	0° to 70°C
WS600-UMB[a] | All-in-One Weather Sensor Meets CAISO		SDI-12, Modbus	air temperature, RH, PPT, BP, WD, WS	Temperature: -50° to 60°C RH: 0 to 100% Precipitation: 0.3 to 5 mm Barometric pressure: 300 to 1200 mb Wind direction: 0° to 359.9° Wind speed: 0 to 90 m s^{-1}	-50° to 60°C
CC5MPX | Digital Camera High resolution, Low power		PakBus, FTP, email, Web page	image or video	Field of View: 27° to 80°	-40° to 60°C

NOTES:

[a] *Item is special ordered and cabled by Campbell Scientific.*

[b] *The CS100 is available in special ranges of 500 to 1100 and 800 to 1110 mb; contact Campbell Scientific for more information.*

CAMPBELL SCIENTIFIC®
WHEN MEASUREMENTS MATTER

Solar Resource Assessments

Ground data from Campbell Scientific dataloggers reduces solar project finance costs

The utility-scale solar industry specifies Campbell Scientific equipment to measure irradiance and other environmental conditions both before and during solar power generation.

These solar-monitoring stations, when accompanied by a data-quality program, generate low uncertainty datasets used to model energy production. In this way, Campbell Scientific and system integrators like GroundWork Renewables make renewable energy projects possible by reducing capital financing costs and increasing the bankability of the projects.

GroundWork designs, builds, installs, and maintains stations to meet project requirements, including plant type, size, ISO (CAISO), or PPA (e.g., SCE, PGE), and offers a rigorous data-quality program (GroundWatch) that uses Campbell Scientific's Loggernet. The integrators turn to Campbell Scientific for dataloggers, enclosures, sensors, communication, remote power, and mounting equipment.

For irradiance and ancillary weather data measurements, the stations are based on a Campbell datalogger installed on a temporary meteorological tower with remote power and cellular or satellite communication. The stations can measure any and all irradiance components, wind speed and direction, relative humidity, temperature, barometric pressure, and precipitation.

With stations deployed across the country, there are all-weather options with pyranometer ventilators and heaters and heated ancillary sensors. To further assist power modelers, soiling study stations can be integrated into the Campbell logger to analyze soiling trends, effects of weather events and module cleaning requirements.

Independent engineers and developers take the ground data to tune the satellite estimates, generating an adjusted historical time series for the site. The resource assessment that most closely represents solar irradiance at the project site is used to model the plant's energy output.

CAMPBELL SCIENTIFIC®
WHEN MEASUREMENTS MATTER

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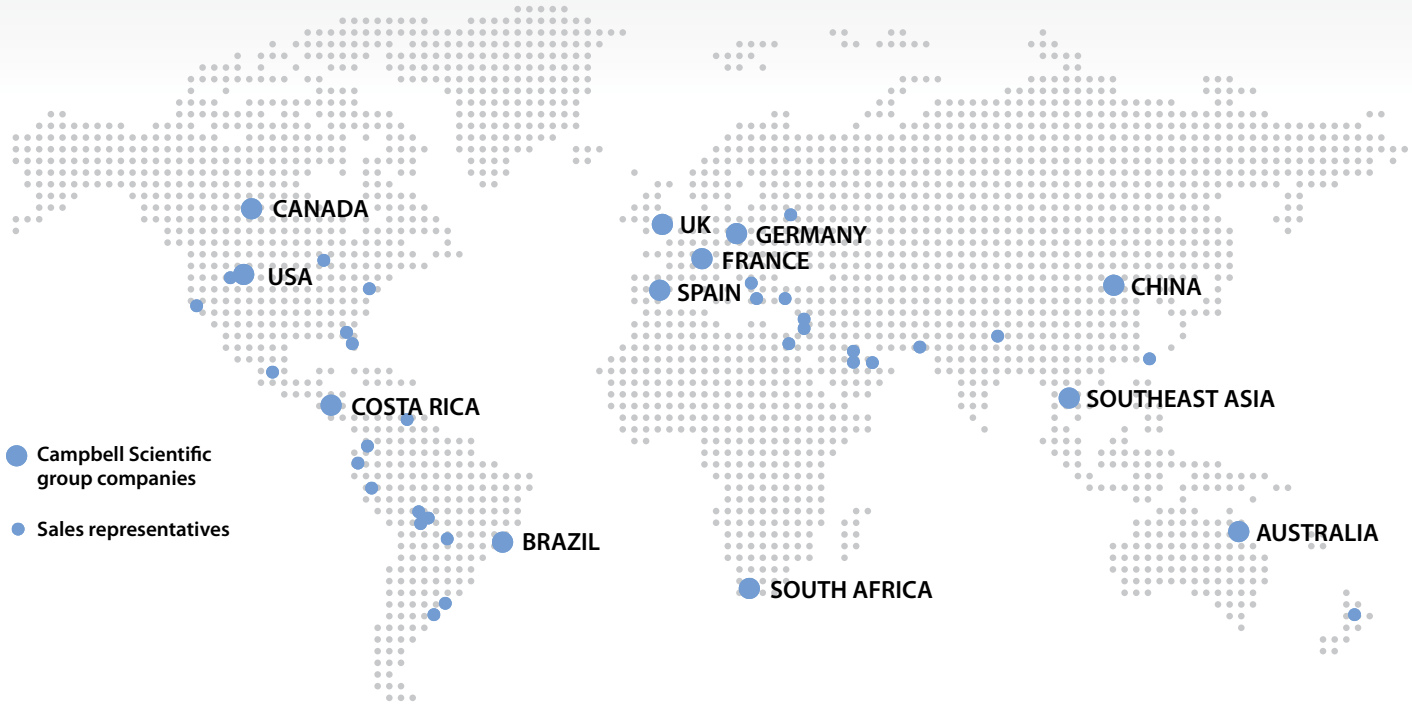
A worldwide network of companies to help meet your needs



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