Product Manual

Sensor

CS325DM

Silicon Irradiance Reference Sensor

Revision: 08/2021

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1. Introduction

The CS325DM, manufactured by Atonometrics as the RC18, is a silicon solar irradiation sensor commonly used as a reference cell in solar PV monitoring applications. The sensor element was designed to correspond to that of a photovoltaic (PV) module, including spectral selectivity and incident angle modifier. The data signals are Modbus RTU RS-485 or analog.

2. Precautions

- READ AND UNDERSTAND the Safety section at the back of this manual.
- Do not remove the screws on the top cover of the CS325DM, as this may compromise the weather-proof seal.
- To minimize the potential for water entry to the sealed housing, mount the CS325DM with the cable facing down or to the side.
- When opening the shipping package, do not damage or cut the cable jacket. If damage to the cable is suspected, consult with a Campbell Scientific support engineer.
- Although rugged, the CS325DM should be handled as a precision scientific instrument.

3. Initial inspection

- Upon receipt of the CS325DM, inspect the packaging and contents for damage. File damage claims with the shipping company.
- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the expected product and cable length were received.

4. Overview

The CS325DM is specifically designed for low-cost, high-accuracy solar irradiance measurements for outdoor monitoring of PV systems. It includes both user-configurable analog outputs and digital communication via Modbus (RS-485). The CS325DM includes a microprocessor that stores the calibration data, eliminating the need to reprogram data loggers or SCADA systems when installing a new unit.

The CS325DM measures irradiance using a crystalline silicon PV cell. The PV cell short-circuit current is measured with a precision shunt resistor and PV cell temperature is measured with a back-of-cell resistance temperature device (RTD).

The IP67-rated cast aluminum enclosure provides for solid mounting and protection from the elements. The M12 circular connector allows easy installation and cable replacement.

Features

- Rugged design with wide temperature operating range
- Analog and/or digital outputs available
- Spectral selectivity and incident angle modifier correspond to crystalline PV module
- Built-in cell temperature measurement and signal compensation

5. Specifications

Measurement range:	0 to 1500 W/m^2
Operating temperature:	–35 to 80 °C
Input power:	8 to 28 VDC
Photovoltaic cell:	Crystalline Si, 20 mm x 20 mm, ~135 mA @ 1 sun
Window:	Low-iron solar glass, or CdTe-matching filter
Cell temperature measurement:	–40 to +100 °C, Pt100 RTD
Calibration data:	Internally calibrated; no calibration data to manage
Enclosure material:	Powder-coated cast aluminum housing
Enclosure outdoor rating:	IP67
Cable type:	Shielded, weather-resistant, UV-rated, 24 AWG/0.2 mm^2

Cable connector:	M12 circular connector, IP67
Response time:	0.15 s
Electronics non-linearity:	±0.03% of range
Repeatability:	±0.02% of range
Temperature drift:	±0.4% at 1000 W/m^2 (–35 to 80 °C)
Resolution:	0.1 W/m^2
Factory calibration of electronics:	±0.1% of reading ±0.2% of range
Irradiance calibration:	±1.2%, calibrated to NREL-traceable reference standard
Overall measurement uncertainty:	±2.0% @ 1500 W/m^2, ±2.9% @ 100 W/m^2
Stability:	0.5% per year
Mounting:	Four mounting holes with diameter 5.50 mm (0.217 in)
Dimensions:	11.5 x 6.5 x 3.0 cm (4.5 x 2.6 x 1.2 in)
Weight:	0.3 kg (0.6 lb)
Digital output	
Communications protocols:	Modbus over RS-485, user-settable Modbus address
Baud rate:	Up to 57.6 kbps
Current consumption:	Typically 8 to 15 mA
Analog output	
Analog output options:	0 to 1.5 V; 0 to 10 V; 4 to 20 mA
Output signals:	Irradiance, cell temperature, short-circuit current
Output impedance:	2 kohm (0 to 1.5 V or 0 to 10 V mode)
Internal voltage drop:	Allow 3.5 V minimum (4 to 20 mA mode)

6. Wiring

The CS325DM outputs either a Modbus RTU RS-485 or an analog signal. Table 6-1 (p. 4) provides the Modbus RS-485 wiring and Table 6-2 (p. 4) provides analog wiring. The RS-485 output can be directly read by a MeteoPV, CR6, CR1000X, or Modbus RTU RS-485 network. Other Campbell Scientific data loggers can use an MD485 multidrop interface to read the RS-485 output. Refer to the MD485 manual for more information.

Table 6-1: RS-485 pin-out, wire color, function, and data logger connection

Wire color[1]	Pin-out	Function	Data logger[2] connection
Blue	8	RS-485 A-	**A-**, **C** (odd)
White/blue stripe	7	RS-485 B+	**B+**, **C** (even)
Brown	1	8 to 24 VDC	**12V**
White/brown stripe	2	Power and signal ground	**G**
Orange	3	G	**G**
Green	4	G	**G**
Clear	N/A	Shield	**G**

[1]The white/orange striped and white/green striped wires are not used.

[2]Assumes the sensor directly connects to the data logger.

Table 6-2: Analog pin-out, wire color, function, and data logger connection

Wire color[1]	Pin-out	Function	Data logger connection
White/orange stripe	5	Irradiance input	**U** configured for single-ended analog input[2], **SE** (single-ended, analog-voltage input)
White/green stripe	6	Temperature input	**U** configured for single-ended analog input[2], **SE** (single-ended, analog-voltage input)
Brown	1	8 to 24 VDC	**12V**
White/brown stripe	2	Power and signal ground	**G**
Orange	3	G	⏚ (analog ground)
Green	4	G	⏚ (analog ground)
Clear	N/A	Shield	⏚ (analog ground)

[1]The white/blue striped and blue wires are not used.

[2]**U** terminals are automatically configured by the measurement instruction.

7. Programming

Programming basics for CRBasic data loggers are provided in the following sections. Downloadable example programs are available at www.campbellsci.com/downloads/cs325dm-example-programs.

7.1 Modbus programming

The RS-485 output can be directly read by a MeteoPV, CR6-series, CR1000X-series, or Modbus RTU RS-485 network. Other Campbell Scientific data loggers can use an MD485 multidrop interface to read the RS-485 output. Refer to the MD485 manual for information about using the MD485. Refer to www.campbellsci.com/videos/meteopv for information about using the MeteoPV.

A CR6 or CR1000X data logger programmed as a Modbus Master can retrieve the values stored in the Input Registers (Register map (p. 5)). To do this, the CRBasic program requires `SerialOpen()` followed by `ModbusMaster()`. The `SerialOpen` instruction has the following syntax:

```
SerialOpen (ComPort, Baud, Format, TXDelay, BufferSize, Mode)
```

The `Format` parameter is typically set to logic 1 low; even parity, one stop bit, 8 data bits. The `Mode` parameter should configure the ComPort as RS-485 half-duplex, transparent.

The `ModbusMaster()` instruction has the following syntax:

```
ModbusMaster (Result, ComPort, Baud, Addr, Function, Variable, Start, Length,
Tries, TimeOut, [ModbusOption])
```

The `Addr` parameter must match the sensor Modbus address. To collect all of the values, the `Start` parameter needs to be 1 and the `Length` parameter needs to correspond with the register count (see Register map (p. 5)). `ModbusOption` is an optional parameter described in the ***CRBasic Editor*** Help.

7.1.1 Register map

Table 7-1 (p. 6) provides the register map for the most commonly used values. Calculated irradiance uses the following equation:

$$Irradiance = \frac{I_{sc}}{I_{sc,0} \cdot \left(1 + \alpha \cdot (T - 25\ ^\circ\mathrm{C})\right)} \cdot 1000\ \mathrm{W/m^2}$$

Table 7-1: RS-485 register map				
Starting register number	Register count	Data format	Units	Description
2	2	Single-precision 32 bit floating point	W/m²	Calculated irradiance
4	2	Single-precision 32 bit floating point	A	Measured short-circuit current (I_{SC}) of the PV cell, without temperature correction
6	2	Single-precision 32 bit floating point	°C	Measured temperature (T) of the PV cell
105	4	Char x 2	n/a	Serial number of the unit, up to eight characters, two characters per register
121	5	Signed 16 bit integer	n/a	Part number of the unit, up to 10 characters, two characters per register

7.2 Analog programming

Two `VoltSE()` CRBasic instructions are required to measure the analog output: one instruction for the irradiance measurement and the other instruction for the temperature measurement.

> **CAUTION:**
> Nearby AC power lines, electric pumps, or motors can be a source of electrical noise. If the sensor or data logger is located in an electrically noisy environment, the measurement should be made with the 60 or 50 Hz rejection integration option.

If measurement time is not critical, the autorange option can be used in the `VoltSE()` instruction; the autorange adds a few milliseconds to the measurement time. Select the smallest input range that is greater than the maximum expected input voltage.

If electromagnetic radiation can be a problem, use an f_{N1} of 50 or 60 Hz. Select 60 Hz Noise Rejection for North America and areas using 60 Hz AC voltage. Select 50 Hz Noise Rejection for most of the Eastern Hemisphere and areas that operate at 50 Hz. The multiplier converts the millivolt reading to engineering units.

8. Siting

A CS325DM used for monitoring PV installations must be installed with the same alignment and inclination as the PV generator. The mounting location should be free of shading. To facilitate maintenance and cleaning, mount the CS325DM in an easily accessible location such as near windows or skylights.

9. Mounting

Use the CM261-LP to mount to a single axis tracker or the CM256-LP to mount the sensor at a fixed angle.

1. Place the sensor on the top plate.
2. Use the mounting screws shipped with the sensor to secure the sensor to the top plate.
3. Using a diopter in combination with a solar compass, install and orient the crossarm on the tripod or the mast.
4. Place the V-bracket or U-bolt on the crossarm and tighten the bolts or U-bolt nuts.
5. Use the bubble level and leveling bolts to level the sensor.
6. If using the CM256-LP, tilt to the correct azimuth and tighten bolts.
7. Verify mounting hardware is firmly tightened, and that the mounting bracket is horizontal or at the desired angle.
8. Route the sensor cable to the enclosure.
9. Secure the cable to the crossarm and tripod or tower mast.

10. Maintenance and troubleshooting

The CS325DM should be recalibrated following industry standard best practices such as ASTM G167, ISO 9846, ASTM E824 or ASTM G207 by an accredited lab. The recommended recalibration interval is 2 years.

The most common reason for communication failure for the CS325DM is because the sensor is not configured properly. Ensure that the sensor has a unique Modbus address and proper RS-485 settings.

Limited warranty

Products manufactured by Campbell Scientific are warranted by Campbell Scientific to be free from defects in materials and workmanship under normal use and service for twelve months from the date of shipment unless otherwise specified on the corresponding product webpage. See Product Details on the Ordering Information pages at www.campbellsci.com. Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

Refer to www.campbellsci.com/terms#warranty for more information.

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Products may not be returned without prior authorization.

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Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.** FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.com. You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, 6 meters (20 feet), or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.
- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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