Product Manual

Sensor

CS325DM

Silicon Irradiance Reference Sensor

Revision: 08/2021

CSL I.D - 1347

RELIABLE SINCE 1974 MONITORING

CAMPBELL SCIENTIFIC

Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific
- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense.

Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

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About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area: 1 in^2 (square inch) = 645 mm^2

Length: 1 in. (inch) = 25.4 mm
1 ft (foot) = 304.8 mm
1 yard = 0.914 m
1 mile = 1.609 km

Mass: 1 oz. (ounce) = 28.35 g
1 lb (pound weight) = 0.454 kg

Pressure: 1 psi (lb/in^2) = 68.95 mb

Volume: 1 UK pint = 568.3 ml
1 UK gallon = 4.546 litres
1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a "#" symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.

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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.eu or by telephoning +44(0) 1509 828 888 (UK). 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

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- 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, or 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.

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.

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.

Table of contents

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 analogue.

2. Precautions

- READ AND UNDERSTAND the Safety section at the front 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 analogue 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 aluminium 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
- Analogue 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 aluminium 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
Analogue output	
Analogue 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 analogue signal. Table 6-1 (p. 4) provides the Modbus RS-485 wiring and Table 6-2 (p. 4) provides analogue 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 colour, function, and data logger connection

Wire colour[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: Analogue pin-out, wire colour, function, and data logger connection

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

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

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/m^2	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 Analogue programming

Two `VoltSE()` CRBasic instructions are required to measure the analogue 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 levelling 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.

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