PRODUCT MANUAL

Sensor

SR05

ISO Spectrally Flat Class C (Second Class)
Pyranometer with Various Outputs

Revision: 04/2024

RELIABLE MONITORING SINCE 1974

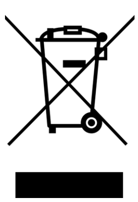
Please read first

About this manual

Please note that this manual was produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this. 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 from Campbell Scientific it will be suitable for use in your country*.

Reference to some radio transmitters, digital cell phones and aerials (antennas) 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.

Recycling information for countries subject to WEEE regulations 2012/19/EU



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, per The Waste Electrical and Electronic Equipment (WEEE) Regulations 2012/19/EU. Campbell Scientific 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 support, please contact Campbell Scientific, or your local agent.

Table of contents

1. Introduction

The SR05, manufactured by Hukseflux Thermal Sensors, is an ISO 9060:2018 spectrally flat Class C (second class) pyranometer designed for general solar radiation measurements in agricultural and meteorological networks and PV monitoring. Both analog output and Modbus over RS-485 are supported.

2. Precautions

- READ AND UNDERSTAND the Safety section at the back of this manual.
- Although the SR05 is rugged, it should be handled as a precision scientific instrument.

3. Initial inspection

- Upon receipt of the SR05, 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 correct product and cable length are received.

4. Specifications

ISO 9060:2018 classification:	Spectrally flat Class C (second class)
Digital output:	Modbus over 2-wire RS-485
Voltage output:	0 to 1 V
Analog output range:	0 to 1600 W/m^2
Default Modbus address:	1
Response time (95 %):	18 s

Calibration uncertainty:	< 1.8 % (k = 2)
Zero offset A:	< 15 W/m² (unventilated) response to 200 W/m² net thermal radiation
Zero offset B:	< ± 4 W/m² response to 5 K/h change in ambient temperature
Spectral range:	285 to 3000 nm
Operating temperature range:	–40 to 80 °C
Temperature response:	< ± 0.4 % (–30 to 50 °C)
Operating voltage range:	5 to 30 VDC
Power consumption:	<75 mW at 12 VDC
Weight:	0.35 kg (12.34 oz)

5. Siting

The solar radiation sensor is usually installed horizontally, but can also be installed at any angle, including an inverted position. Site the sensor to allow easy access for maintenance, but avoid locations with obstructions or reflections above the plane of the sensing element. It is important to mount the sensor such that a shadow or a reflection will not be cast on it at any time. If this is not possible, try to choose a site where any obstruction over the azimuth range between earliest sunrise and latest sunset has an elevation not exceeding 5°. Diffuse solar radiation is less influenced by obstructions near the horizon. The sensor should be mounted with the cable pointing towards the nearest magnetic pole. For example, in the northern hemisphere, point the cable toward the North Pole.

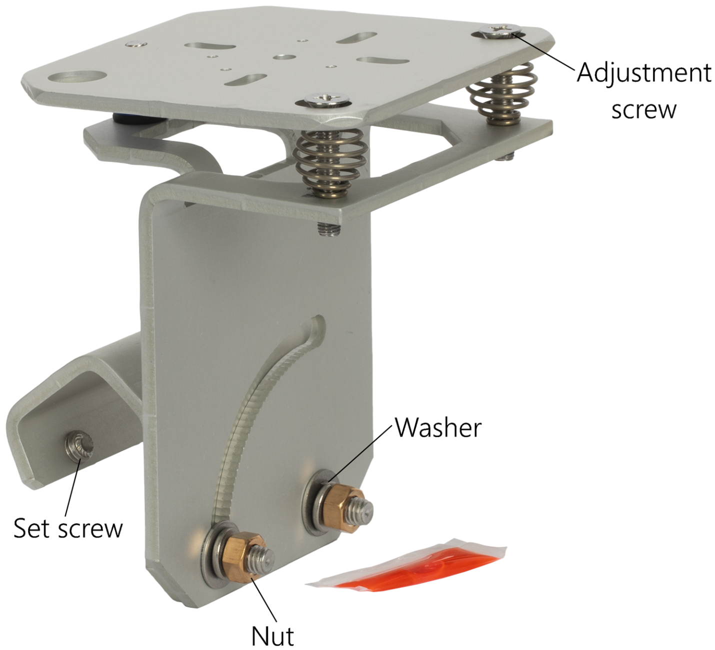
6. Mounting procedure

Required tools:

- Solar compass
- 8 mm (5/16-inch) open-end wrench or hex key wrench for U-bolt nuts
- CM256 mounting bracket

1. On a level surface, level the solar radiation sensor using the leveling feet on the sensor.
2. Secure the solar radiation sensor to the mounting bracket.

3. Using a diopter in combination with a solar compass, install and orient the crossarm on the tripod or the mast. If installing the mounting bracket on a vertical pole, ensure the pole is truly vertical.
4. Use the two set screws to secure the bracket to the crossarm or pole as shown in the following figure. For pyranometers mounted horizontally, ensure the mounting bracket is horizontal in two dimensions. For pyranometers mounted at an angle, set the mounting bracket angle to the desired angle prior to tightening the mounting hardware.



5. Verify mounting hardware is firmly tightened, and that the mounting bracket is at the desired angle.

7. Wiring

Table 7-1 (p. 4) provides RS-485 wiring and Table 7-2 (p. 4) provides analog wiring.

Table 7-1: RS-485 wire color, function, and data logger connection

Wire color[1]	Function	Data logger connection[2]	MeteoPV connection	Pin out
Green	RS485 A-	**C** (odd)	**A-**	5
White	RS485 B+	**C** (even)	**B+**	2
Red	Power in (12 V)	**12V**	**12V**	1
Black	Power ground	**G**	**G**	4
Clear	Shield	**G**	**G**	

[1] Blue wire is not used.

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

Table 7-2: Analog wire color, function and data logger connection

Wire color[1]	Function	Data logger connection	Pin out
Blue	Pyranometer signal high	**U** configured for differential input[2], **DIFF H** (differential high, analog-voltage input)	3
	Pyranometer signal reference	**U** configured for differential input[2, 3], **DIFF L** (differential low, analog-voltage input)[3]	
Red	Power in (12 V)	**12V**	1
Black	Ground	⏚ (analog ground)	4
Clear	Shield	⏚ (analog ground)	

[1] Green and white wires are not used.

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

[3] Jumper to ⏚ with user-supplied wire.

8. Programming

Programming basics for CRBasic data loggers are provided in the following sections. Downloadable Modbus and analog voltage programs are available from www.campbellsci.com/downloads/sr05-example-programs.

8.1 Modbus CRBasic programming

The RS-485 output can be directly read by a MeteoPV, CR6-series, 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). Refer to www.campbellsci.com/videos/meteopv for information about using the MeteoPV.

A CR6 or CR1000X data logger programmed as a Modbus client can retrieve the values stored in the input registers. To do this, the CRBasic program requires a `SerialOpen()` instruction followed by the `ModbusClient()` instruction.

> **NOTE:**
> `ModbusClient()` was formerly `ModbusMaster()`. Campbell Scientific, in conjunction with the Modbus Organization, is now using "client-server" to describe Modbus communications. The Modbus client(s) initiates communications and makes requests of server device(s). Server devices process requests and return an appropriate response (or error message). See https://modbus.org for more information. Existing programs that use the old Modbus terminology will still compile in the data logger.

The `SerialOpen` instruction has the following syntax:

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

The `Format` 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 `ModbusClient()` instruction has the following syntax:

```
ModbusClient (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. 6]SR05 register map [p. 1]). `ModbusOption` is an optional parameter described in the *CRBasic Editor* Help.

8.2 Register map

Table 8-1 (p. 6) provides the register map for the most commonly used values. A comprehensive register map is available in the Hukseflux manual.

Table 8-1: RS-485 register map

Starting register number	Register count	Data format	Scaled units	Description
1	1	Signed 16-bit integer		Modbus address (default = 1)
3	2	32-bit float or long/no reversal of byte order (ABCD)	W/m²	Irradiance (temperature compensated signal)[1]
7	1	Signed 16-bit integer	°C	Sensor body temperature[1]
8	1	Signed 16-bit integer	x 0.1 Ω	Sensor electrical resistance
9	1	Signed 16-bit integer		Scaling factor irradiance (default = 100)[1]
10	1	Signed 16-bit integer		Scaling factor temperature (default = 100)[1]
11	2	Signed 32-bit integer	nV	Sensor voltage output
41	1	Unsigned 16-bit integer		Serial number
42	2	32-bit float or long/no reversal of byte order (ABCD)	µV/W/m²	Sensor sensitivity
47	2	32-bit float or long/no reversal of byte order (ABCD)	YYYYMMDD	Calibration date

[1] To calculate irradiance and sensor body temperature, divide by the scale factor.

8.3 Analog programming

The pyranometer outputs a low level voltage that is measured using either the `VoltDiff()` CRBasic instruction or `VoltSE()` CRBasic instruction.

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 as shown in the analog voltage program available at: www.campbellsci.com/downloads/sr05-example-programs.

If measurement time is not critical, the autorange option can be used in the `VoltDiff()` or `VoltSE()` instruction; the autorange adds a few milliseconds to the measurement time. Otherwise, select the input range as follows:

1. Estimate the maximum expected input voltage by dividing the maximum expected irradiance (in W/m^2) by 1.6 (in W/m^2/mV) to give the maximum in millivolt units.
2. 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. Table 8-2 (p. 7) provides the calculations required for the various units. The offset will normally be fixed at zero (see the downloadable analog voltage program available at: www.campbellsci.com/downloads/sr05-example-programs).

Table 8-2: Multipliers required for flux density and total fluxes

Units	Multiplier	Output processing
W/m^2	1.6	Average
MJ/m^2	1.6 × t × 0.000001	Totalize
kJ/m^2	1.6 × t × 0.001	Totalize
cal/cm^2	1.6 × t × 0.0239 × 0.001	Totalize
cal/cm^2/min	1.6 × 1.434 × 0.001	Average
W hr/m^2	1.6 × t / 3600	Totalize

t = data logger program execution interval in seconds

9. Maintenance and troubleshooting

The SR05 has no service items that require scheduled replacement. There is no accessible desiccant cartridge to maintain. Use pure alcohol or distilled water and a lint-free cloth to clean the dome, removing smears and deposits. Local conditions and application dictate a cleaning interval. Sophisticated research applications require daily cleaning. For typical PV applications, clean once per week, bi-monthly, or monthly. The SR05 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 two years. Contact Campbell Scientific for more information.

Unexpected results typically occur because of improper wiring or programming, electromagnetic radiation, or damaged cables. Ensure that the data logger program includes the correct parameters for the measurement instructions. Check for the presence of strong sources of electromagnetic radiation. Check the cable for damage and ensure that it is properly connected to the data logger.

Limited warranty

Covered equipment is warranted/guaranteed against defects in materials and workmanship under normal use and service for the period listed on your sales invoice or the product order information web page. The covered period begins on the date of shipment unless otherwise specified. For a repair to be covered under warranty, the following criteria must be met:

1. There must be a defect in materials or workmanship that affects form, fit, or function of the device.

2. The defect cannot be the result of misuse.

3. The defect must have occurred within a specified period of time; and

4. The determination must be made by a qualified technician at a Campbell Scientific Service Center/ repair facility.

The following is not covered:

1. Equipment which has been modified or altered in any way without the written permission of Campbell Scientific.

2. Batteries; and

3. Any equipment which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country. For directions on how to return equipment, see Assistance.

Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

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MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Campbell Scientific hereby disclaims, to the fullest extent allowed by applicable law, any and all warranties and conditions with respect to the products, whether express, implied, or statutory, other than those expressly provided herein.

Campbell Scientific will, as a default, return warranted equipment by surface carrier prepaid. However, the method of return shipment is at Campbell Scientific's sole discretion. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This warranty and the Company’s obligation thereunder is in lieu of all other warranties, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

In the event of any conflict or inconsistency between the provisions of this Warranty and the provisions of Campbell Scientific's Terms, the provisions of Campbell Scientific's Terms shall prevail. Furthermore, Campbell Scientific's Terms are hereby incorporated by reference into this Warranty. To view Terms and conditions that apply to Campbell Scientific, Logan, UT, USA, see Terms and Conditions. To view terms and conditions that apply to Campbell Scientific offices outside of the United States, contact the regional office that serves your country.

Assistance

Products may not be returned without prior authorization. Please inform us before returning equipment and obtain a **return material authorization (RMA) number** whether the repair is under warranty/guarantee or not. See Limited warranty for information on covered equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country.

When returning equipment, a RMA number must be clearly marked on the outside of the package. Please state the faults as clearly as possible. 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, when equipment is returned to Campbell Scientific, Logan, UT, USA, it is mandatory that a "Declaration of Hazardous Material and Decontamination" form be received before the return can be processed. If the form is not received within 5 working days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. For details on decontamination standards specific to your country, please reach out to your regional Campbell Scientific office.

> **NOTE:**
> All goods that cross trade boundaries may be subject to some form of fee (customs clearance, duties or import tax). Also, some regional offices require a purchase order upfront if a product is out of the warranty period. Please contact your regional Campbell Scientific office for details.

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, 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, 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.

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.

Use and disposal of batteries

- Where batteries need to be transported to the installation site, ensure they are packed to prevent the battery terminals shorting which could cause a fire or explosion. Especially in the case of lithium batteries, ensure they are packed and transported in a way that complies with local shipping regulations and the safety requirements of the carriers involved.
- When installing the batteries follow the installation instructions very carefully. This is to avoid risk of damage to the equipment caused by installing the wrong type of battery or reverse connections.
- When disposing of used batteries, it is still important to avoid the risk of shorting. Do not dispose of the batteries in a fire as there is risk of explosion and leakage of harmful chemicals into the environment. Batteries should be disposed of at registered recycling facilities.

Avoiding unnecessary exposure to radio transmitter radiation

- Where the equipment includes a radio transmitter, precautions should be taken to avoid unnecessary exposure to radiation from the antenna. The degree of caution required varies with the power of the transmitter, but as a rule it is best to avoid getting closer to the antenna than 20 cm (8 inches) when the antenna is active. In particular keep your head away from the antenna. For higher power radios (in excess of 1 W ERP) turn the radio off when servicing the system, unless the antenna is installed away from the station, e.g. it is mounted above the system on an arm or pole.

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.

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