

# SR05

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



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# 1. Introduction

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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

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- 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

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- 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

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|                                      |  |
|--------------------------------------|--|
| <b>ISO 9060:2018 classification:</b> | Spectrally flat Class C (second class) |
| <b>Digital output:</b>               | Modbus over 2-wire RS-485              |
| <b>Voltage output:</b>               | 0 to 1 V                               |
| <b>Analog output range:</b>          | 0 to 1600 W/m <sup>2</sup>             |
| <b>Default Modbus address:</b>       | 53                                     |
| <b>Response time (95 %):</b>         | 18 s                                   |

|                              |   |
|------------------------------|---|
| Calibration uncertainty:     | < 1.8 % (k = 2)   |
| Zero offset A:               | < 15 W/m <sup>2</sup> (unventilated) response to 200 W/m <sup>2</sup> net thermal radiation |
| Zero offset B:               | < ± 4 W/m <sup>2</sup> 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

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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 while ideally avoiding any 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.

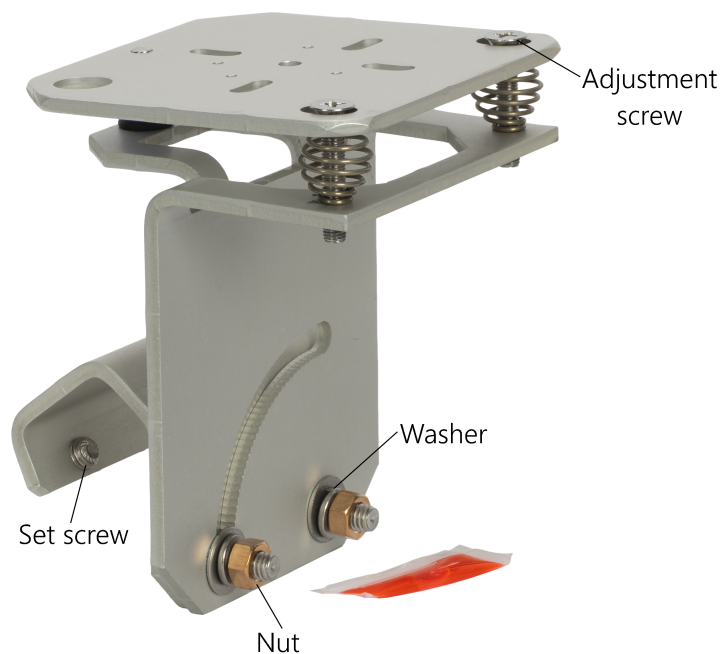
## 6. Mounting procedure

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Required tools:

- Diopter
- Solar compass
- 8 mm (5/16-inch) open-end 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. Alternatively, remove the sensor leveling feet to allow it to be mounted directly to the mounting bracket.
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 <sup>1</sup>  | Function        | Data logger connection <sup>2</sup> | 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                  |         |

<sup>1</sup> Blue wire is not used.

<sup>2</sup> Assumes the sensor directly connects to the data logger.

| Table 7-2: Analog wire color, function and data logger connection |                              |   |         |
|---|------------------------------|---|---------|
| Wire color <sup>1</sup>   | Function                     | Data logger connection  | Pin out |
| Blue  | Pyranometer signal high      | U configured for differential input <sup>2</sup> ,<br>DIFF H (differential high, analog-voltage input)                | 3       |
|   | Pyranometer signal reference | U configured for differential input <sup>2, 3</sup> ,<br>DIFF L (differential low, analog-voltage input) <sup>3</sup> |         |
| Red   | Power in (12 V)              | 12V   | 1       |
| Black   | Ground                       | ⊥ (analog ground)   | 4       |
| Clear   | Shield                       | ⊥ (analog ground)   |         |

<sup>1</sup> Green and white wires are not used.

<sup>2</sup> U terminals are automatically configured by the measurement instruction.

<sup>3</sup> Jumper to ⊥ with user-supplied wire.

# 8. Programming

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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](http://www.campbellsci.com/downloads/sr05-example-programs) .

## 8.1 Modbus 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).

A CR6 or CR1000X data logger programmed as a Modbus Master can retrieve the values stored in the Input Registers. To do this, the CRBasic program requires a `SerialOpen()` instruction followed by the `ModbusMaster()` instruction.

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 `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.

## 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/m <sup>2</sup>    | Irradiance (temperature compensated signal) <sup>1</sup> |
| 7                        | 1              | Signed 16-bit integer                                 | °C                  | Sensor body temperature <sup>1</sup>                     |
| 8                        | 1              | Signed 16-bit integer                                 | x 0.1 Ω             | Sensor electrical resistance                             |
| 9                        | 1              | Signed 16-bit integer                                 |                     | Scaling factor irradiance (default = 100) <sup>1</sup>   |
| 10                       | 1              | Signed 16-bit integer                                 |                     | Scaling factor temperature (default = 100) <sup>1</sup>  |
| 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/m <sup>2</sup> | Sensor sensitivity                                       |
| 47                       | 2              | 32-bit float or long/no reversal of byte order (ABCD) | YYYYMMDD            | Calibration date   |


<sup>1</sup> 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 `VolDiff()` CRBasic instruction or `VolSE()` 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](http://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 multiplying the maximum expected irradiance (in  $W/m^2$ ) by the calibration factor (in  $\mu V/W/m^2$ ). Divide the answer by 1000 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](http://www.campbellsci.com/downloads/sr05-example-programs) .

| Units          | Multiplier                              | Output processing |
|----------------|---|-------------------|
| $W/m^2$        | M                                       | Average           |
| $MJ/m^2$       | $M \times t \times 0.000001$            | Totalize          |
| $kJ/m^2$       | $M \times t \times 0.001$               | Totalize          |
| $cal/cm^2$     | $M \times t \times 0.0239 \times 0.001$ | Totalize          |
| $cal/cm^2/min$ | $M \times 1.434 \times 0.001$           | Average           |
| $W\ hr/m^2$    | $M \times t / 3600$                     | Totalize          |

$M = 1000/c$ , where  $c$  is the sensor output in  $\mu V / W / m^2$   
 $t =$  data logger program execution interval in seconds

# 9. Maintenance and troubleshooting

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The SR05 has no service items requiring 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 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

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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](http://www.campbellsci.com)<sup>↗</sup>. 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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# Safety

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**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](http://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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