Product Manual

SR20-D2
ISO Secondary Standard Pyranometer
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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, 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.
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1. SR20-D2 introduction

The SR20-D2, manufactured by Hukseflux Thermal Sensors, is an ISO 9060 digital secondary-standard pyranometer that measures solar short-wave radiation in a full hemisphere of the sky. It has a built-in case-temperature sensor and embedded heater for removing dew and light rain. It connects directly to Campbell Scientific data loggers and is designed for applications that require high measurement accuracy in demanding applications such as scientific meteorological observation networks and utility scale solar-energy-power production sites.

2. Installation

2.1 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 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.

2.2 Mounting procedure

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. The blue dots in the following figure indicate the mounting holes used for this pyranometer.
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. Secure the mounting bracket to the crossarm or vertical pole using the hardware included with the mounting bracket. The CM255 uses one U-bolt, nuts, flat washers, and lock washers to mount the bracket, as shown in the following figure.

5. For the CM255LS bracket, 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.

6. Verify mounting hardware is firmly tightened, and that the mounting bracket is at the desired angle. The CM255LS includes leveling bolts for additional adjustment of the pyranometer level.

3. SR20-D2 wiring

<table>
<thead>
<tr>
<th>Wire color</th>
<th>Pin out</th>
<th>Function</th>
<th>Data logger connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>5-2</td>
<td>RS-485A</td>
<td>A-, C (odd)</td>
</tr>
<tr>
<td>White</td>
<td>7-4</td>
<td>RS-485B</td>
<td>B+, C (even)</td>
</tr>
<tr>
<td>Red</td>
<td>2-1</td>
<td>Power in (12 V)</td>
<td>12V</td>
</tr>
<tr>
<td>Black</td>
<td>6-3</td>
<td>Power ground</td>
<td>G</td>
</tr>
<tr>
<td>Clear</td>
<td>9-5</td>
<td>Shield</td>
<td>$\equiv$ (analog ground)</td>
</tr>
</tbody>
</table>

1 Assumes the sensor directly connects to the data logger.
3. RS-485 default configuration

The default RS-485 settings are: 19200 baud rate, 8 data bits, even parity, one stop bit. This configuration is used for most Modbus networks.

4. SR20-D2 register map

Table 4-1 (p. 4) provides the register map for the most commonly used values. A comprehensive register map is available in the Hukseflux manual.

<table>
<thead>
<tr>
<th>Starting Register Number</th>
<th>Register Count</th>
<th>Data Format</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Signed 16 bit integer</td>
<td></td>
<td>Modbus address</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>Signed 32 bit integer</td>
<td>mW/m^2</td>
<td>Irradiance (temperature compensated signal)</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>Signed 32 bit integer</td>
<td>mW/m^2</td>
<td>Irradiance (temperature uncompensated signal)</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>Signed 16 bit integer</td>
<td>0.01 °C</td>
<td>Sensor body temperature</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>Signed 16 bit integer</td>
<td>x 0.1 Ω</td>
<td>Sensor electrical resistance</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>Signed 16 bit integer</td>
<td></td>
<td>Scaling factor irradiance</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>Signed 16 bit integer</td>
<td></td>
<td>Scaling factor temperature</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>Signed 32 bit integer</td>
<td>nV</td>
<td>Sensor voltage output</td>
</tr>
<tr>
<td>41</td>
<td>1</td>
<td>Signed 16 bit integer</td>
<td></td>
<td>Serial number</td>
</tr>
<tr>
<td>42</td>
<td>2</td>
<td>Float</td>
<td>µV/W/m^2</td>
<td>Sensor sensitivity</td>
</tr>
<tr>
<td>47</td>
<td>2</td>
<td>Signed 32 bit integer</td>
<td></td>
<td>Calibration date</td>
</tr>
<tr>
<td>99</td>
<td>1</td>
<td>Signed 16 bit integer</td>
<td>x 0.01 %</td>
<td>Humidity</td>
</tr>
</tbody>
</table>
5. RS-485 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.

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 sensor type (see SR20-D2 register map (p. 4)). `ModbusOption` is an optional parameter described in the CRBasic Editor Help. Refer to example program section for more information.

6. SR20-D2 example program

<table>
<thead>
<tr>
<th>Wire color</th>
<th>Function</th>
<th>Data logger connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>RS-485A</td>
<td>C5</td>
</tr>
<tr>
<td>White</td>
<td>RS-485B</td>
<td>C6</td>
</tr>
<tr>
<td>Red</td>
<td>Power in (12 V)</td>
<td>12V</td>
</tr>
</tbody>
</table>
Table 6-1: Wiring for example program

<table>
<thead>
<tr>
<th>Wire color</th>
<th>Function</th>
<th>Data logger connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>Power ground</td>
<td>G</td>
</tr>
<tr>
<td>Clear</td>
<td>Shield</td>
<td>(analog ground)</td>
</tr>
</tbody>
</table>

CRBasic Example 1: CR1000X program for measuring the SR20-D2

'CR1000X Series Datalogger
'Hukseflux SR20-D2 Pyranometer
'SR20 is an ISO 9060 Secondary Standard digital pyranometer
'D2 uses Modbus RS-485 protocol
'PN 34088 SR20-D2CBL-L (CSI's SR20D2 Cable)
Dim SR20D2(15) As Long
Public SR20D2_IRR_TC 'Temperature compensated x 0.01 W/m^2
Public SR20D2_IRR 'Uncompensated x 0.01 W/m^2
Public SR20D2_BodyTemp As Float
Public SR20D2.SerialNumber As Float
Public SR20D2_CalDate As Long
Public SR20D2_Humidity As Float
Public SR20D2_ScaleFactor_IRR As Long
Public SR20D2_ScaleFactor_BodyTemp As Long
Public SR20D2_ElecResistance As Long
Public SR20D2_VoltageOut As Float
Public ModbusResult_IRR_TC
Public ModbusResult_IRR
Public ModbusResult_BodyTemp
Public ModbusResult_SN
Public ModbusResult_CalDate
Public ModbusResult_Humidity
Public ModbusResult_SFIRR
Public ModbusResult_SRTemp
Public ModbusResult_ElecRes
Public ModbusResult_VoltOut
Units SR20D2_IRR = W/m^2
Units SR20D2_IRR_TC = W/m^2
Units SR20D2_BodyTemp = DegC
Units SR20D2_Humidity = %
Units SR20D2_ElecResistance = Ohm
Units SR20D2_VoltageOut = uV
DataTable (OneMin,1,-1)
  DataInterval (0,1,Min,10)
  Average (1,SR20D2_IRR,IEEE4,False)
  Average (1,SR20D2_IRR_TC,IEEE4,False)
  Maximum (1,SR20D2_IRR_TC,IEEE4,False,False)
  Minimum (1,SR20D2_IRR_TC,IEEE4,False,False)
CRBasic Example 1: CR1000X program for measuring the SR20-D2

```plaintext
StdDev (1,SR20D2_IRR_TC,IEEE4,False)
Average (1,SR20D2_BodyTemp,IEEE4,False)
EndTable

DataTable (SR20D2_MetaData,1,-1)
  Sample (1,SR20D2_ElecResistance,IEEE4)
  Sample (1,SR20D2_VoltageOut,IEEE4)
  Sample (1,SR20D2_Humidity,IEEE4)
EndTable

DataTable (SR20D2_SensorID,1,100)
  Sample (1,SR20D2_SerialNumber,FP2)
  Sample (1,SR20D2_CalDate,Long)
  Sample (1,SR20D2_ScaleFactor_IRR,FP2)
  Sample (1,SR20D2_ScaleFactor_BodyTemp,FP2)
EndTable

BeginProg
  SerialOpen (ComC5,19200,2,0,50,4)
  ModbusMaster (ModbusResult_SN,ComC5,19200,53,4,SR20D2(1),41,1,1,100,3)
    'Serial Number
    SR20D2_SerialNumber = SR20D2(1)
  ModbusMaster (ModbusResult_CalDate,ComC5,19200,53,4,SR20D2(2),47,1,1,100,2)
    'Cal Date
    SR20D2_CalDate = SR20D2(2)
  ModbusMaster (ModbusResult_SFIRR,ComC5,19200,53,4,SR20D2(3),9,1,1,100,3)
    'Scaling Factor IRR
    SR20D2_ScaleFactor_IRR = SR20D2(3)
  ModbusMaster (ModbusResult_SRTemp,ComC5,19200,53,4,SR20D2(4),10,1,1,100,3)
    'Scaling Factor Temp
    SR20D2_ScaleFactor_BodyTemp = SR20D2(4)
  ModbusMaster (ModbusResult_ElecRes,ComC5,19200,53,4,SR20D2(10),_ 8,1,1,100,1)
    'Electrical Resistance
    SR20D2_ElecResistance = SR20D2(10)/10
  ModbusMaster (ModbusResult_VoltOut,ComC5,19200,53,4,SR20D2(11),_ 11,2,1,100,2)
    'Voltage output
    SR20D2_VoltageOut = SR20D2(11)
  ModbusMaster (ModbusResult_Humidity,ComC5,19200,53,4,SR20D2(13),99,1,1,100,3)
    'Humidity
    SR20D2_Humidity = SR20D2(13)/100
  Scan (1,Sec,0,0)
    ModbusMaster (ModbusResult_IRR_TC,ComC5,19200,53,4,SR20D2(5),3,2,1,100,2)
      'Irradiance temperature compensated
      SR20D2_IRR_TC = SR20D2(5)/SR20D2_ScaleFactor_IRR
    ModbusMaster (ModbusResult_IRR,ComC5,19200,53,4,SR20D2(7),5,2,1,100,2)
      'Irradiance uncompensated
      SR20D2_IRR = SR20D2(7)/SR20D2_ScaleFactor_IRR
    ModbusMaster (ModbusResult_BodyTemp,ComC5,19200,53,4,SR20D2(9),7,1,1,100,1)
EndProg
```

SR20-D2 ISO Secondary Standard Pyranometer
CRBasic Example 1: CR1000X program for measuring the SR20-D2

'Body Temp
SR20D2_BodyTemp = SR20D2(9)/SR20D2_ScaleFactor_BodyTemp
CallTable OneMin
NextScan
SlowSequence
Scan (6,Hr,0,0)
  ModbusMaster (ModbusResult_ElecRes,ComC5,19200,53,4,SR20D2(10),8,1,1,100,1)
'Electrical Resistance
SR20D2_ElecResistance = SR20D2(10)/10
ModbusMaster (ModbusResult_VoltOut,ComC5,19200,53,4,SR20D2(11),_,11,2,1,100,2)
'Voltage output
SR20D2_VoltageOut = SR20D2(11)
ModbusMaster (ModbusResult_Humidity,ComC5,19200,53,4,SR20D2(13),_,99,1,1,100,3)
'Humidity
SR20D2_Humidity = SR20D2(13)/100
CallTable SR20D2_MetaData
NextScan
SlowSequence
Scan (1,Sec,0,1)
If SR20D2_SerialNumber = 0 Then
  ModbusMaster (ModbusResult_SN,ComC5,19200,53,4,SR20D2(1),41,1,1,100,3)
'Serial Number
SR20D2_SerialNumber = SR20D2(1)
ModbusMaster (ModbusResult_CalDate,ComC5,19200,53,4,SR20D2(2),_,47,1,1,100,2)
'Cal Date
SR20D2_CalDate = SR20D2(2)
ModbusMaster (ModbusResult_SFIRR,ComC5,19200,53,4,SR20D2(3),9,1,1,100,3)
'Scaling Factor IRR
SR20D2_ScaleFactor_IRR = SR20D2(3)
ModbusMaster (ModbusResult_SRTemp,ComC5,19200,53,4,SR20D2(4),10,1,1,100,3)
'Scaling Factor Temp
SR20D2_ScaleFactor_BodyTemp = SR20D2(4)
ModbusMaster (ModbusResult_ElecRes,ComC5,19200,53,4,SR20D2(10),_,8,1,1,100,1)
'Electrical Resistance
SR20D2_ElecResistance = SR20D2(10)/10
ModbusMaster (ModbusResult_VoltOut,ComC5,19200,53,4,SR20D2(11),_,11,2,1,100,2)
'Voltage output
SR20D2_VoltageOut = SR20D2(11)
ModbusMaster (ModbusResult_Humidity,ComC5,19200,53,4,SR20D2(13),_,99,1,1,100,3)
'Humidity
SR20D2_Humidity = SR20D2(13)/100
7. Maintenance and troubleshooting

The pyranometer 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, ensuring no smears or deposits are left on the dome. 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 pyranometer 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 and use the 50 or 60 Hz integration option in the data logger program if electromagnetic radiation can be a problem. Check the cable for damage and ensure that it is properly connected to the data logger.
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