Product Manual

MS-80M
Secondary Standard Pyranometer
with RS-485 Modbus Communication
Limited warranty

The MS-80M is warranted for five (5) years subject to this limited warranty:

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CAMPBELL SCIENTIFIC, INC.
RMA#____
815 West 1800 North
Logan, Utah 84321-1784

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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 or by telephoning (435) 227-9000 (USA). 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 hard hat 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.
# Table of contents

1. MS-80M introduction .................................................................................................................. 1
2. MS-80M specifications .............................................................................................................. 1
3. Installation .................................................................................................................................. 2
   3.1 Siting ..................................................................................................................................... 2
   3.2 Mounting procedure ............................................................................................................. 2
4. MS-80M wiring .......................................................................................................................... 4
5. RS-485 default configuration ..................................................................................................... 5
6. MS-80M register map ................................................................................................................ 5
7. RS-485 programming ................................................................................................................. 6
8. MS-80M example program ....................................................................................................... 7
9. Maintenance and troubleshooting ............................................................................................ 8
1. MS-80M introduction

The MS-80M, manufactured by EKO Instruments, is an innovative, next-generation secondary standard pyranometer inspired by the combination of latest technologies and state-of-the-art thermopile sensor with an unprecedented, low zero-offset behavior; fast sensor response; Modbus RTU 485 output; and a five-year warranty and recalibration interval.

The MS-80M features a compact design with internal desiccation, single dome, isolated thermopile detector, quartz diffusor, immunity to offsets, ultra-low temperature dependency, and exceptional non-linearity characteristics. EKO instruments is the only ISO 17025 accredited pyranometer manufacturer in the world, enabling highest-quality calibration, compliant to international standards (ISO/IEC 17025/9847).

2. MS-80M specifications

ISO 9060:classification: Secondary standard
Output: Modbus RS-485
Default Modbus address: 53
Response time 95%: 1 s
Zero offset A: < 1 W/m² (response to 200 W/m² net thermal radiation)
Zero offset B: ±1 W/m² (5 K/hr)
Non-stability: ±0.5% change in 5 years
Non-linearity: ±0.2% (1000 W/m²)
Directional response: ±10 W/m² (1000 W/m²)
Spectral selectivity: ±3% (0.35 to 1.5 µm)
Spectral range: 285 to 3000 nm
Operating temperature range: −40 to 80 °C
Temperature response: < 0.4% (−10 to 40 °C), < 0.5% (−20 to 50 °C)
Tilt response: ±0.2% (1000 W/m²)
Irradiance range: 0 to 4000 W/m²
3. Installation

3.1 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.

3.2 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.

4. MS-80M wiring

<table>
<thead>
<tr>
<th>Wire color</th>
<th>Pin-out</th>
<th>Function</th>
<th>Data logger connection&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>2</td>
<td>RS-485A</td>
<td>A–, C (odd)</td>
</tr>
<tr>
<td>White</td>
<td>1</td>
<td>RS-485B</td>
<td>B+, C (even)</td>
</tr>
<tr>
<td>Red</td>
<td>4</td>
<td>Power in (12 V)</td>
<td>12V</td>
</tr>
<tr>
<td>Black</td>
<td>5</td>
<td>Power ground</td>
<td>G</td>
</tr>
<tr>
<td>Yellow</td>
<td>3</td>
<td>RS-485 ground</td>
<td>G</td>
</tr>
<tr>
<td>Clear</td>
<td>6</td>
<td>Shield</td>
<td>☉ (analog ground)</td>
</tr>
</tbody>
</table>

<sup>1</sup> Assumes the sensor directly connects to the data logger.
5. 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.

6. MS-80M register map

Table 6-1 (p. 5) provides the register map for the most commonly used values. A comprehensive register map is available in the EKO 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>14</td>
<td>1</td>
<td>16 bit integer</td>
<td>W/m²</td>
<td>Irradiance minimum output</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>16 bit integer</td>
<td>W/m²</td>
<td>Irradiance maximum output</td>
</tr>
<tr>
<td>17</td>
<td>2</td>
<td>Float</td>
<td>µV/W/m²</td>
<td>Pyranometer sensitivity</td>
</tr>
<tr>
<td>19</td>
<td>1</td>
<td>16 bit integer</td>
<td></td>
<td>Temperature units 1 = °C, 2 = K, 3 = °F</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td>Float</td>
<td>mV</td>
<td>Sensor voltage output with three decimals</td>
</tr>
<tr>
<td>22</td>
<td>2</td>
<td>Float</td>
<td>W/m²</td>
<td>Irradiance</td>
</tr>
<tr>
<td>24</td>
<td>2</td>
<td>Float</td>
<td>°C</td>
<td>Internal temperature</td>
</tr>
<tr>
<td>26</td>
<td>1</td>
<td>16 bit integer</td>
<td></td>
<td>Password (required for setting the temperature and linearity corrections)</td>
</tr>
<tr>
<td>27</td>
<td>2</td>
<td>Float</td>
<td></td>
<td>Temperature response correction factor¹ a</td>
</tr>
<tr>
<td>29</td>
<td>2</td>
<td>Float</td>
<td></td>
<td>Temperature response correction factor¹ b</td>
</tr>
<tr>
<td>Starting register number</td>
<td>Register count</td>
<td>Data format</td>
<td>Units</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------</td>
<td>-------------</td>
<td>-------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>31</td>
<td>2</td>
<td>Float</td>
<td></td>
<td>Temperature response correction factor(^1) c</td>
</tr>
<tr>
<td>33</td>
<td>2</td>
<td>Float</td>
<td></td>
<td>Temperature response correction factor(^1) d</td>
</tr>
</tbody>
</table>

\(^1\) If temperature correction is required, the following formula is used:

\[ ETC(E,T) = \frac{E}{TC1(T)}; \]
\[ TC1(T) = a + b + cT + dT^2 + eT^3 \]

Where,

- ETC(E,T): Measurement voltage with temperature correction (mV)
- E: Measurement voltage (mV)
- TC1(T): Correction coefficient
- T: Internal temperature (°C)
- a, b, c, d: Correction coefficients

### 7. 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 MS-80M register map (p. 5)). ModbusOption is an optional parameter described in the CRBasic Editor Help. Refer to example program section for more information.

8. MS-80M example program

Table 8-1 (p. 7) provides wiring for the example program. Although, this program is for the CR1000X, other CRBasic dataloggers are programmed similarly.

Table 8-1: Wiring for example program

<table>
<thead>
<tr>
<th>Wire Color</th>
<th>Function</th>
<th>CR1000X</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>
<tr>
<td>Black</td>
<td>Power ground</td>
<td>G</td>
</tr>
<tr>
<td>Yellow</td>
<td>RS-485 G</td>
<td>(analog ground)</td>
</tr>
<tr>
<td>Clear</td>
<td>Shield</td>
<td>(analog ground)</td>
</tr>
</tbody>
</table>

CRBasic Example 1: CR1000X program that measures the MS-80M

' Variables associated with Pyranometer 1 (MS-80M)
Dim ModbusMS80_1(2) As Float
Public ModbusResult_1
Public MS80M_Irradiance As Float
Units MS80M_Irradiance=W/m²
Public MS80M_InternalTemp As Float
Units MS80M_InternalTemp = DegC
DataTable (OneMin,True,-1)
  Datinterval (0,1,Min,10)
  Average (1,MS80M_Irradiance,IEEE4,False)
  StdDev (1,MS80M_Irradiance,IEEE4,False)
  Maximum (1,MS80M_Irradiance,IEEE4,False,False)
  Minimum (1,MS80M_Irradiance,IEEE4,False,False)
  Average (1,MS80M_InternalTemp,IEEE4,False)
  StdDev (1,MS80M_InternalTemp,IEEE4,False)
  Maximum (1,MS80M_InternalTemp,IEEE4,False,False)
  Minimum (1,MS80M_InternalTemp,IEEE4,False,False)
EndTable
BeginProg
**CRBasic Example 1: CR1000X program that measures the MS-80M**

```
SerialOpen (ComC5,19200,2,0,50,4)
Scan(1, Sec, 0, 0)
'MS-80M
   ModbusMaster (ModbusResult_1,ComC5,19200,65,3,ModbusMS80_1,22,2,1,100,0)
   MS80M_Irradiance = ModbusMS80_1(1)
   MS80M_InternalTemp = ModbusMS80_1(2)
CallTable OneMin
NextScan
EndProg
```

## 9. 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. Check the cable for damage and ensure that it is properly connected to the data logger.
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