



## CS241DM

Pt-1000 Class A, Precision Back-of-Module  
Temperature Sensor with  
Digital Modbus RS-485 Output



# 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

---

<b>1. Introduction</b>	<b>1</b>
<b>2. Precautions</b>	<b>1</b>
<b>3. Initial inspection</b>	<b>1</b>
<b>4. QuickStart</b>	<b>2</b>
<b>5. Overview</b>	<b>4</b>
<b>6. Specifications</b>	<b>6</b>
<b>7. Installation</b>	<b>8</b>
7.1 Wiring	8
7.2 Data logger programming	9
7.2.1 CRBasic programming	9
7.3 Placement on a photovoltaic (PV) module	10
7.4 Mounting/cable strain relief	11
7.4.1 Adhesive mounting strip	11
7.4.2 Cable strain relief	11
7.4.3 Extreme sealing tape	13
<b>8. Operation</b>	<b>14</b>
8.1 Electrical noisy environments	14
8.2 Long cable lengths	14
8.3 Modbus register map	15
8.4 Device Configuration Utility	16
<b>9. Maintenance and troubleshooting</b>	<b>18</b>
9.1 Maintenance	18
9.2 Troubleshooting	18
9.3 Recalibration	18
9.4 Removal	19
<b>Appendix A. Importing Short Cut code into CRBasic Editor</b>	<b>20</b>
<b>Appendix B. Sensor material properties</b>	<b>21</b>
B.1 3M F9473PC adhesive	21

# 1. Introduction

---

The CS241DM temperature sensor uses a precision 1000 ohm Class A platinum resistance thermometer (PRT) to measure temperature. It is designed for measuring the back-of-photovoltaic (PV) module temperature but also can be used to measure the surface temperature of other devices. The CS241DM has a digital RS-485 output that 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.

## NOTE:

This manual provides information only for CRBasic data loggers.

# 2. Precautions

---

- READ AND UNDERSTAND the [Safety](#) section at the back of this manual.
- Do not use epoxy to secure the sensor head to a PV module.
- Before mounting, the installers need to wash their hands, then clean the back of the PV module or other device.
- Prying the sensor head off will likely damage both the sensor and PV module.
- Proper strain relief of the cable is required after mounting the sensor to the measurement surface ([Mounting/cable strain relief](#) [p. 11]).
- Placement of the cable inside a rugged conduit is advisable for cable runs over 4.5 m (15 ft), especially in locations subject to digging, mowing, traffic, power tools, animals, or lightning strikes.

# 3. Initial inspection



---

- Upon receipt of the sensor, 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.

- The CS241DM is shipped with a NIST-traceable calibration certificate. Please contact Campbell Scientific if you need an additional copy of the certificate for your records.

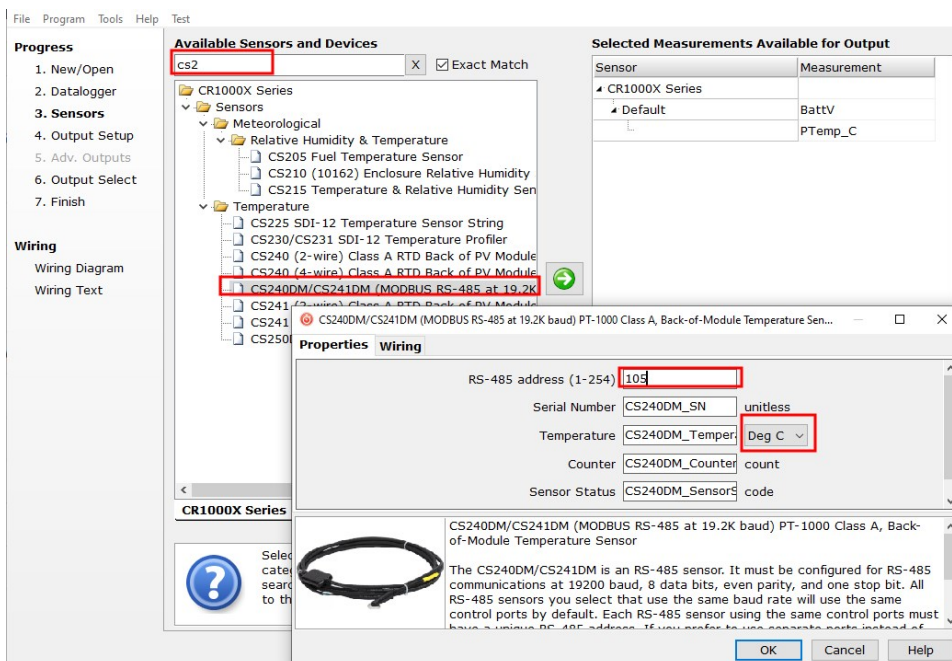
## 4. QuickStart

A video that describes data logger programming using *Short Cut* is available at:

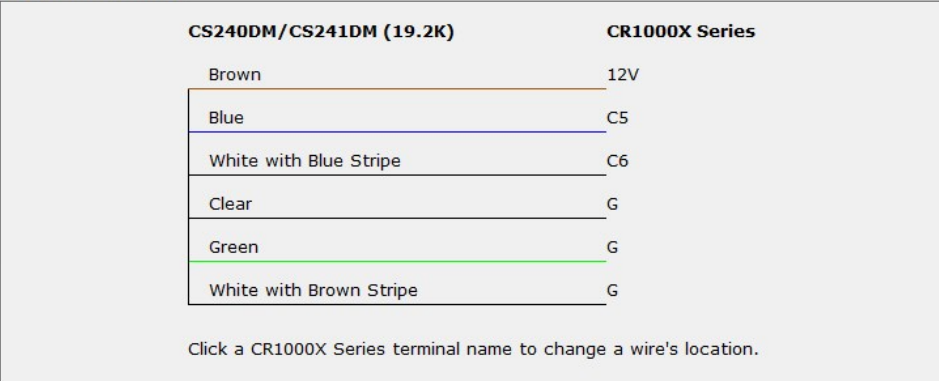
[www.campbellsci.com/videos/cr1000x-data-logger-getting-started-program-part-3](http://www.campbellsci.com/videos/cr1000x-data-logger-getting-started-program-part-3) . *Short Cut* is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. *Short Cut* is available as a download on [www.campbellsci.com](http://www.campbellsci.com) . It is included in installations of *LoggerNet*, *RTDAQ*, or *PC400*.

The following procedure also shows using *Short Cut* to program the CS241DM.

1. Open *Short Cut* and click **Create New Program**.
2. Double-click the data logger model.
3. In the **Available Sensors and Devices** box, type CS241DM. You can also locate the sensor in the **Sensors > Temperature** folder. Double click **CS204DM/CS241DM**. Type the **RS-485 address**; default address is the last two digits of the serial number. The CS241DM must have a unique RS-485 address. The surface temperature defaults to degree C. This can be changed by clicking the **Temperature** box and selecting one of the other options.




- Click on the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



CS240DM/CS241DM (19.2K)	CR1000X Series
Brown	12V
Blue	C5
White with Blue Stripe	C6
Clear	G
Green	G
White with Brown Stripe	G

Click a CR1000X Series terminal name to change a wire's location.

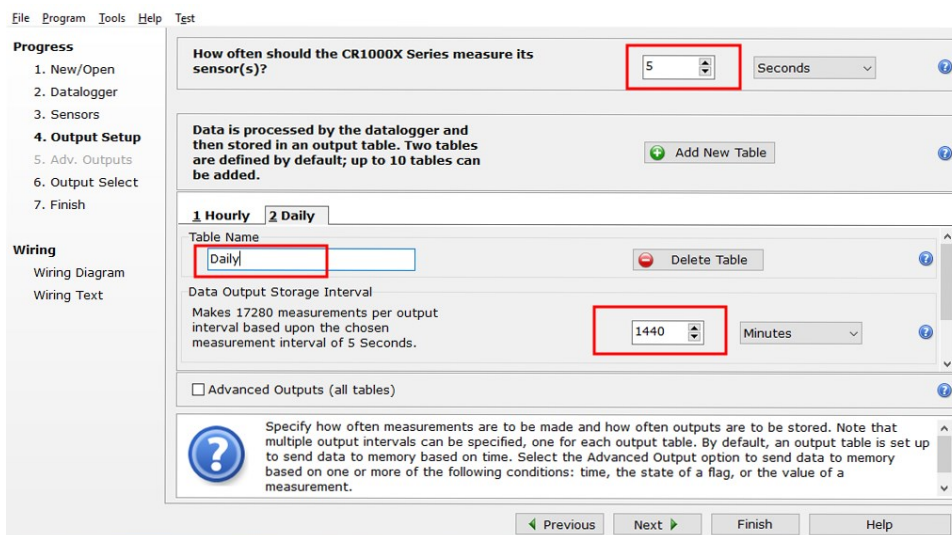


CS240DM/CS241DM (MODBUS RS-485 at 19.2K baud) PT-1000 Class A, Back-of-Module Temperature Sensor

The CS240DM/CS241DM is an RS-485 sensor. It must be configured for RS-485 communications at 19200 baud, 8 data bits, even parity, and one stop bit. All RS-485 sensors you select that use the same baud rate will use the same control ports by default. Each RS-485 sensor using the same control ports must have a unique RS-485 address. If you prefer to use separate ports instead of changing RS-485 addresses, you can do so by selecting separate ports on the

**OK** Cancel Help

- Repeat steps three and four for other sensors you want to measure. Click **Next**.
- In **Output Setup**, type the scan rate, a meaningful table name, and the **Data Output Storage Interval**.



File Program Tools Help Test

**Progress**

- New/Open
- Datalogger
- Sensors
- 4. Output Setup**
- Adv. Outputs
- Output Select
- Finish

**Wiring**

Wiring Diagram  
Wiring Text

How often should the CR1000X Series measure its sensor(s)? 5 Seconds

Data is processed by the datalogger and then stored in an output table. Two tables are defined by default; up to 10 tables can be added.

Add New Table

1 Hourly 2 Daily

Table Name Daily

Delete Table

Data Output Storage Interval  
Makes 17280 measurements per output interval based upon the chosen measurement interval of 5 Seconds.

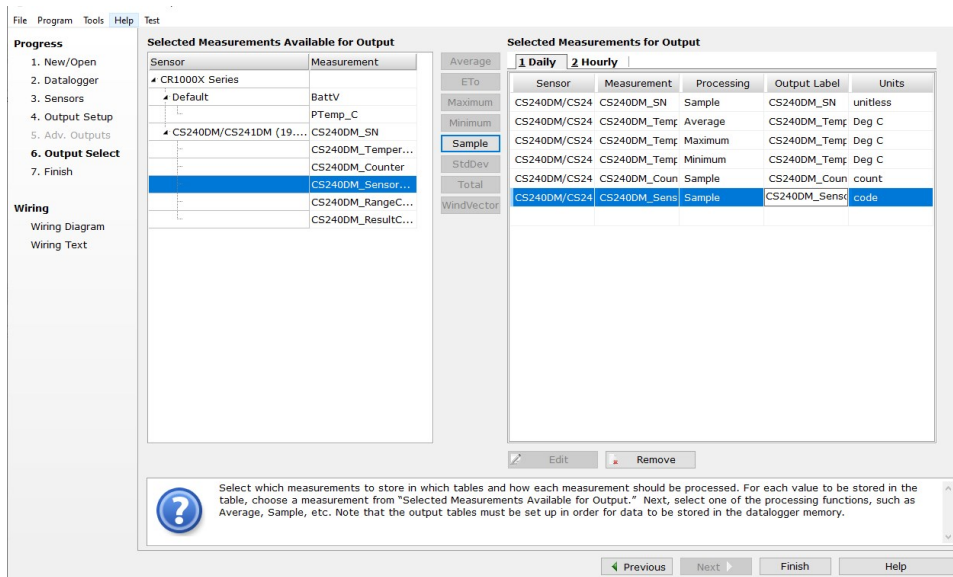
1440 Minutes

☐ Advanced Outputs (all tables)

Specify how often measurements are to be made and how often outputs are to be stored. Note that multiple output intervals can be specified, one for each output table. By default, an output table is set up to send data to memory based on time. Select the Advanced Output option to send data to memory based on one or more of the following conditions: time, the state of a flag, or the value of a measurement.

Previous Next Finish Help

7. Select the measurement and its associated output option.



8. Click **Finish** and save the program. Send the program just created to the data logger if the data logger is connected to the computer.
9. If the sensor is connected to the data logger, check the output of the sensor in the data logger support software data display in *LoggerNet*, *RTDAQ*, or *PC400* to make sure it is making reasonable measurements.

## 5. Overview

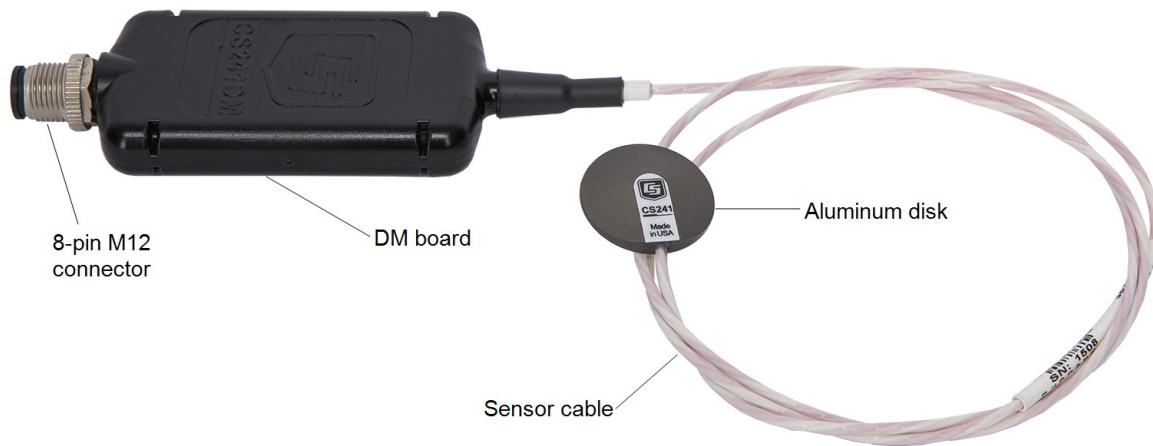
The CS241DM is a surface mountable platinum resistive thermometer (PRT) that measures back-of-module temperature for solar energy applications. It uses a precision PT-1000 Class A PRT to provide the highest level of accuracy. To withstand the harsh treatment that commonly occurs with meteorological station installation, the sensing element is safely housed inside a specially designed self-adhesive aluminum disk (Figure 5-1 [p. 5]).

The disk protects the PRT, particularly during installation, and promotes heat transfer from the surface. An adhesive tab on the disk fastens the sensor to the measurement surface.

The CS241DM includes a Campbell Scientific precision analog-to-digital, smart-sensor module for making the measurements. The module design is optimized for the Class A PRT that minimizes self-heating and wire resistance. Measurement electronics are surge protected with 1200 V isolation and environmentally protected with a rugged overmolding.



The CS241DM provides PV stakeholders with highly accurate back-of-module temperature, even at long cable lengths, in power performance modeling and simulation of solar energy applications. Back-of-module temperature is critical for any evaluation of effective irradiance and power conversion.



*Figure 5-1. CS241DM temperature sensor*

#### **Benefits and features:**


- Designed for optimal performance on bifacial PV module
- Easy installation
- NIST-traceable, serialized calibration certificate supplied with every sensor
- Meets or exceeds IEC 61724 Class A performance specifications
- Precision PT-1000 Class A sensing element
- Compliant with IEC 60751, DIN EN 60751 (according to IEC 751)
- Slim design to minimize sensor impact on bifaciality (<2% of full-size cell area)
- Thermal conductance greater than 600 W/(m<sup>2</sup> K)
- Maximum sensor-to-module bonding
- High temperature rating to 150 °C
- Internal four-wire measurement with 24-bit A/D and precision resistor maximize measurement accuracy
- Compatible with Campbell Scientific CRBasic data loggers: CR6, CR1000X-series, CR350, CR3000 (with MD485), CR1000 (with MD485), CR800 series (with MD485)
- Easily interfaces with the MeteoPV platform without programming
- Connects directly to a Modbus RTU RS-485 network



# 6. Specifications

---

Sensor:	Precision 1000 ohm Class A platinum sensing element
Class A sensor accuracy:	$\pm (0.15 + 0.002t) \text{ }^{\circ}\text{C}$
Operating temperature range:	$-40$ to $150 \text{ }^{\circ}\text{C}$
Temperature coefficient:	TCR = 3850 ppm/K
Long-term stability:	Maximum $R_0$ drift = 0.04% after 1000 hours at $400 \text{ }^{\circ}\text{C}$
Temperature uncertainty:	$\pm(0.3$ to $0.4 \text{ }^{\circ}\text{C})$ for the $-40$ to $100 \text{ }^{\circ}\text{C}$ measurement range when using the CR1000X data logger
Disk diameter:	2.54 cm (1.0 in)
Height:	0.419 cm (0.165 in)
Disk material:	Anodized aluminum
Shipping weight:	90.7 g (0.2 lb)
Analog-to-digital module (DM):	24-bit ADC
A/D measurement uncertainty:	$\pm 0.015 \text{ }^{\circ}\text{C}$
Supply voltage:	5 to 30 VDC
Power consumption:	15 mA
Surge protection:	1200 V isolation
Environmental protection:	Rugged overmolding
IP rating:	IP68 rating (self certified); 1 m submersion for 90 min
Communications:	
Protocol:	Modbus RTU (over RS-485)
Format:	8 data bits, 1 stop bit, even parity as default (user configurable)
Baud rate:	19200 bps as default (user-configurable)
Modbus ID:	Last two digits of serial number as default (user-configurable)

<b>Approvals:</b>	Conforms with the Restriction of Hazardous Substances Directive (RoHS2)
<b>Compliance:</b>	View compliance documents at: <a href="http://www.campbellsci.com/cs241dm">www.campbellsci.com/cs241dm</a> 
	Meets or exceeds IEC 61724 Class A performance specifications
<b>Industrial standards:</b>	Compliant with IEC 60751, DIN EN 60751, Industrial Design (IEC Class 4) (according to IEC 751)
<b>IP rating:</b>	IP68 rating (self certified): 1 m (3 ft) submersion for 90 minutes
<b>EMC compliance:</b>	Conforms with Electromagnetic Compatibility Directive (EMC)
<b>RoHS2:</b>	Conforms with Restriction of Hazardous Substances Directive (RoHS2)
<b>POE compliance:</b>	POE compliant (802.3af) to 100 meters when installed per recommendations in TIA TSB-184
<b>CAT5e:</b>	Cable will meet CAT5e channel requirements to 100 meter length
<b>Sensor cable (sensor head-to-DM board)</b>	
<b>Cable diameter:</b>	0.216 cm (0.085 in)
<b>Cable length:</b>	0.9 m (3 ft)
<b>Jacket material:</b>	White semi-gloss perfluoroalkoxy (PFA), insulated
<b>Jacket rating:</b>	–75 to 250 °C
<b>Minimum bend radius:</b>	6 mm (0.25 in) at least 6 mm (0.25 in) away from sensor disk
<b>Connector:</b>	Circular plastic M12 , female 5-pin connector
<b>DM cable (DM board to pigtail)</b>	
<b>Temperature rating:</b>	–40 to 105 °C
<b>Overall cable diameter:</b>	7.37 mm nominal ± 0.13 mm (0.29 inch nominal ± 0.005 in)
<b>Conductor material:</b>	22 AWG 19/0.0058 stranded tinned copper
<b>Cable type:</b>	4 twisted pairs twisted together and wrapped with clear polyester tape to form a cable core

Connector:	Circular, plastic, M12 male, 5-pin, A-coded connector
Jacket material:	Thermoplastic elastomer, 1.07 mm (0.042 in) nominal wall thickness (pressure)
Insulation material:	High-density polyethylene 0.254 mm (0.01 in) nominal wall thickness
Dielectric strength:	2000 V RMS
Approvals:	UL AWM 2463 (80C 600V) NEC (UL) TYPE PLTC NEC (UL) TYPE CMX OUTDOOR – CM CEC C(UL) TYPE CMX OUTDOOR – CM PENNSYLVANIA D.E.P. – MSHA

## 7. Installation

---

If you are programming your data logger with *Short Cut*, skip and [Data logger programming](#) (p. 9). *Short Cut* does this work for you. See [QuickStart](#) (p. 2) for a *Short Cut* tutorial. This section discusses the following:

<a href="#">7.1 Wiring</a> .....	8
<a href="#">7.2 Data logger programming</a> .....	9
<a href="#">7.3 Placement on a photovoltaic (PV) module</a> .....	10
<a href="#">7.4 Mounting/cable strain relief</a> .....	11

### 7.1 Wiring

The DM module is embedded in a short cable that attaches to the sensor head and has a 5-pin, M12 female circular connector. A cable with a 5-pin M12 male circular connector is used to attach the sensor to the station or data logger ([Table 7-1](#) [p. 9]). Using connectors between the sensor head and the station or data logger cable allows in-field sensor head replacement without disconnecting the cable from the data logger.

The following table provides sensor wiring and cable pin-out. Detailed information about the cables are provided in the [Specifications](#) (p. 6). Sensor wiring is also available in the *Device Configuration Utility* and the *MeteoPV User Interface*.

Table 7-1: Wire color, station connection, and function			
Wire color	Pin-out	Station (data logger) terminal	Function
Blue	3	A– (C odd)	RS-485 A/A [–]
White/blue stripe	2	B+ (C even)	RS-485 B/B [+]
Brown	1	12V	5 to 30 VDC
White/brown stripe	4	G	Ground (power)
Green	5	G	Modbus common

## 7.2 Data logger programming

*Short Cut* is the best source for up-to-date data logger programming code. If your data acquisition requirements are simple, you can probably create and maintain a data logger program exclusively with *Short Cut*. If your data acquisition needs are more complex, the files that *Short Cut* creates are a great source for programming code to start a new program or add to an existing custom program.

### NOTE:

*Short Cut* cannot edit programs after they are imported and edited in *CRBasic Editor*.


A *Short Cut* tutorial is available in [QuickStart](#) (p. 2). If you wish to import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in [Importing Short Cut code into CRBasic Editor](#) (p. 20). Programming basics for CRBasic data loggers are provided in the following section.

If applicable, please read [Electrical noisy environments](#) (p. 14) and [Long cable lengths](#) (p. 14) prior to programming your data logger.

### 7.2.1 CRBasic programming


### NOTE:

Programming basics for the CR6 and CR1000X data loggers are provided in this section. Contact Campbell Scientific if using a data logger that requires an MD485 interface.

Downloadable CRBasic program example is available at [www.campbellsci.com/downloads/cs241dm-program-example](http://www.campbellsci.com/downloads/cs241dm-program-example) .

A CR6 or CR1000X data logger programmed as a Modbus client can retrieve the values stored in the CS241DM input registers ([Modbus register map](#) [p. 15]). To do this, the CRBasic program uses 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 CS241DM Modbus address. Each Modbus address must be unique on a Modbus network. The default value for the Modbus address is the last two digits of the sensor serial number, with exceptions for serial numbers ending in 00 and 01. These exceptions default to Modbus addresses of 110 and 111, respectively. To collect all of the CS241DM values, the **Start** parameter needs to be 1 and the **Length** parameter needs to be 5. **ModbusOption** is an optional parameter described in the CRBasic Editor Help.

## 7.3 Placement on a photovoltaic (PV) module

The PV module may or may not have distinctive photocells. If the PV module does not have distinctive photocells, center the sensor on the back of the PV module. If the module has several distinctive photocells, center the sensor on the back of the photocell that is the middle of the PV module.

## 7.4 Mounting/cable strain relief

### CAUTION:

Before mounting, the installers need to wash their hands, then clean the back of the PV module or other device.

### 7.4.1 Adhesive mounting strip

A pressure-activated adhesive mounting strip is adhered to the flat surface of the aluminum disk. To mount the sensor, remove the paper from the mounting strip and place the disk on the back of the PV module or other device. Press the disk firmly for 2 to 3 seconds to initiate long-term bonding of the sensor to the surface. The mounting strip must be adhered to a clean surface for its adhesive to function properly.

### CAUTION:

Do not use epoxy to secure the sensor head to a PV module.

### 7.4.2 Cable strain relief

### NOTE:

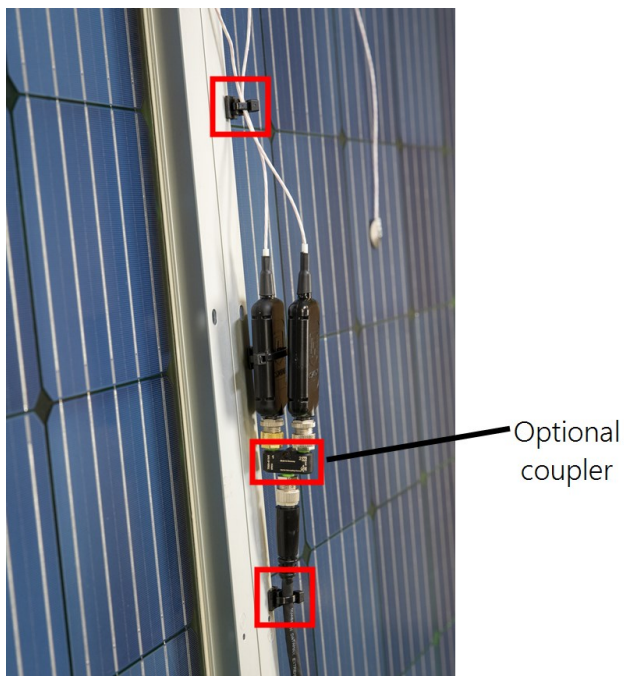
Placement of the cable inside a rugged conduit is advisable for cable runs over 4.5 m (15 ft), especially in locations subject to digging, mowing, traffic, power tools, animals, or lightning strikes.

The cable must be properly strain relieved after mounting the sensor to the measurement surface. To accomplish this, the CS241DM comes with three cable ties and three edge clips.

1. Fasten the edge clips at the top of the PV module in the following locations:
  - a. Above the sensor



- b. On both sides of the DM board

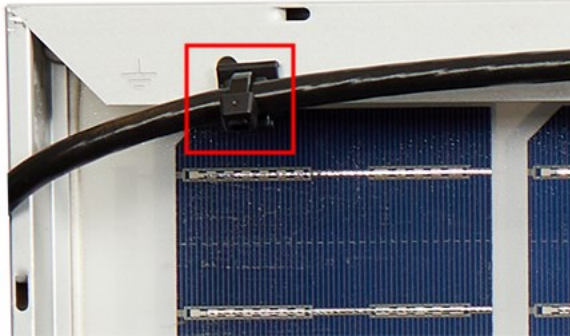




**NOTE:**

A user-supplied coupler allows two CS241DM sensors to connect to the same cable. Each CS241DM must have a unique Modbus address.

- c. At a top corner of the PV module



2. Use the cable ties to secure the cable to the edge clips.

### 7.4.3 Extreme sealing tape

The CS241DM was designed to minimize surface area and mass. This design minimizes the effects of installation on bifacial modules and also increases the adhesion properties of the sensor to the module surface. When back-of-module temperatures may exceed 150 °C, use extreme sealing tape for additional adhesion and cabling relief.

To ensure the sensor disk and cable are adequately fastened to the measurement surface, use three strips of tape in two places each:

1. For strain relief, place the first strip of tape across the cable 20 to 40 cm (8 to 16 in) from the sensor head and rub the tape surface to remove bubbles.
2. Place the other strips of tape perpendicular and on top of the first strip of tape and rub the tape surface to remove bubbles (see [Figure 7-1](#) [p. 14]).
3. To secure the sensor to the module surface, remove the paper from the bottom of the disk and adhere the disk to the PV module ([Placement on a photovoltaic \(PV\) module](#) [p. 10]).
4. Place a strip of tape across the sensor head, perpendicular to the cable and rub the tape surface to remove bubbles. Rub as close as possible to the sensor disk.
5. Place the two other strips of tape on the ends of the sensor disk, perpendicular to the first piece of tape and parallel to the cable then rub the tape surface into the module surface. These strips of tape should form an H (see the following Figure).

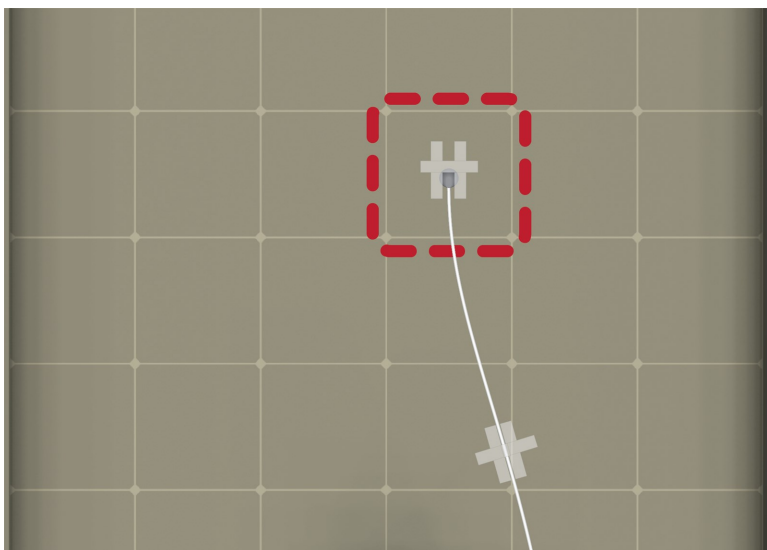


Figure 7-1. Proper tape usage

## 8. Operation

---

This section discusses the following:

8.1 Electrical noisy environments .....	14
8.2 Long cable lengths .....	14
8.3 Modbus register map .....	15
8.4 Device Configuration Utility .....	16

### 8.1 Electrical noisy environments

AC power lines, pumps, power inverters, and motors can be the source of electrical noise.

### 8.2 Long cable lengths

Placement of the cable inside a rugged conduit is advisable for cable runs over 4.5 m (15 ft), especially in locations subject to digging, mowing, traffic, power tools, animals, or lightning strikes.

Digital data transfer eliminates offset errors due to cable lengths. However, digital communications can break down when cables are too long, resulting in either no response from the sensor or corrupted readings. Maximum cable lengths depend on the number of sensors

connected, the type of cable used, and the environment of the application. Follow these guidelines when using long cables:

- Use low capacitance, low resistance, screened cable (as fitted by Campbell Scientific) to reach distances of several hundred meters.
- Ensure that the power ground cable has low resistance and is connected to the same ground reference as the data logger control terminals.
- Be aware that daisy-chaining sensors reduces the maximum cable length roughly in proportion to the number of sensors connected in parallel.

## 8.3 Modbus register map

[Table 8-1](#) (p. 15) provides the input register map (function code 4) and [Table 8-2](#) (p. 16) provides the holding register map (functions 3, 6, and 16).

Table 8-1: Input register map			
Input register	Value	Modbus data type	Description
30001	Serial number	Float <sup>1</sup>	Specifies the sensor serial number assigned by the factory
30003	Temperature	Float <sup>1</sup>	The stored value is in degrees Celsius.
30005	Counter	Float <sup>1</sup>	The counter indicates that the sensor is actively taking measurements. It increments by one with each measurement and resets to 1 after reaching 10000.
30007	Sensor status	Float <sup>1</sup>	0 = good 1 = open/short
30009	Temperature range check	Float <sup>1</sup>	0 = good/in range 1 = out of range
<sup>1</sup> Modbus float is a 32-bit integer.			

Table 8-2: Holding register map			
Holding register	Value	Modbus data type	Description
40001	Modbus address	Unsigned short <sup>1</sup>	Modbus device address (1 to 247)
40002	Baud rate	Unsigned short <sup>1</sup>	1 = 9600 bps 2 = 19200 bps 3 = 38400 bps 4 = 57600 bps 5 = 115200 bps
40003	Parity	Unsigned short <sup>1</sup>	0 = no parity 1 = odd 2 = even
40004	Stop bit	Unsigned short <sup>1</sup>	1 = 1 stop bit 2 = 2 stop bits
40005	Termination resistor	Unsigned short <sup>1</sup>	0 = off/disable 1 = on/enable
<sup>1</sup> Unsigned short data is a 16-bit positive integer.			

## 8.4 Device Configuration Utility

*Device Configuration Utility* is bundled in Campbell Scientific data logger support software and can also be acquired, at no cost, from [www.campbellsci.com/downloads](http://www.campbellsci.com/downloads). *Device Configuration Utility* can be used to change the CS241DM settings, view stored values, and update the CS241DM operating system (OS). It also provides wiring information.

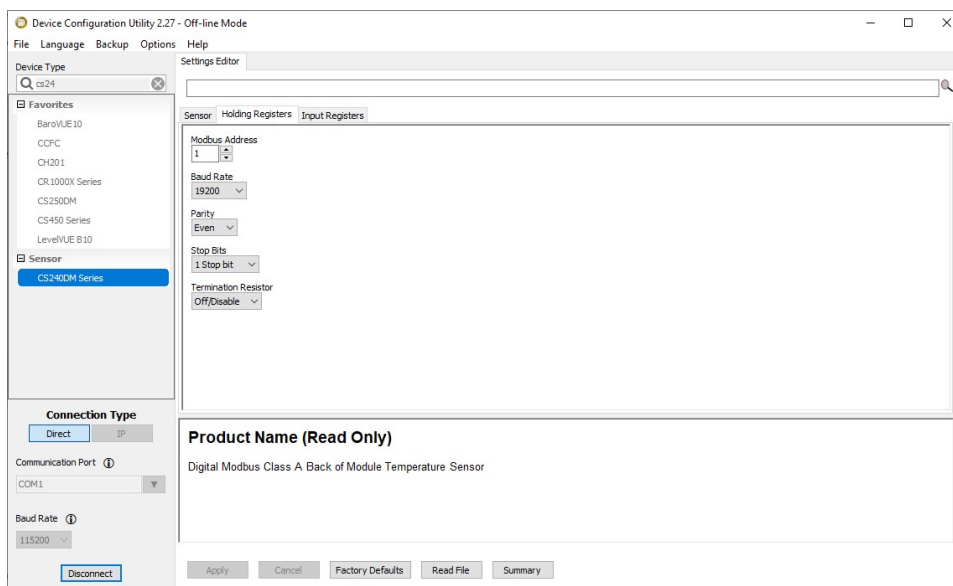
To use *Device Configuration Utility*, the CS241DM must be connected to a computer and 12 VDC power source. A USB-to-RS-485 adapter is required to connect the CS241DM to the computer. The following is the procedure for connecting to *Device Configuration Utility*:

1. Open the *Device Configuration Utility*.
2. Under **Device Type**, click **CS240DM Series**.

- Follow steps listed under **Connecting to a CM240DM Series sensor with a USB to RS-485 adapter**.



- Click the **Holding Registers** tab to change the settings. Except for the **Modbus Address**, the default settings are typical for most Modbus systems and therefore, the settings rarely need to be changed.



- Click the **Input Registers** tab to view the values.

# 9. Maintenance and troubleshooting

---

## NOTE:

For all factory repairs, customers must get an RMA number. Customers must also properly fill out a “Declaration of Hazardous Material and Decontamination” form and comply with the requirements specified in it. Refer to the [Assistance](#) page at the back of this manual for more information.

## 9.1 Maintenance

The CS241DM sensor requires minimal maintenance. Periodically check cabling for proper connections, signs of damage, and possible moisture intrusion.

## 9.2 Troubleshooting

**Symptom:** Incorrect Temperature

Check the cable for signs of damage and possible moisture intrusion.

**Symptom:** Unstable Temperature

Make sure the clear shield wire is connected to data logger ground, and the data logger is properly grounded.

## 9.3 Recalibration

The CS241DM is shipped with a NIST-traceable calibration certificate. Please contact Campbell Scientific if you need an additional copy of the certificate for your records.

Campbell Scientific does not have any recommended schedule for recalibration due to the sensing principle used. Customers can use their own industry-specific recommendations in this matter. Please note that due to the low cost of the sensor and nature of install, it might be more economical to replace the CS241DM sensor head (keeping the existing cable in place) instead of a recalibration.

## 9.4 Removal

**CAUTION:**

Campbell Scientific does not recommend removing the CS241DM because of potential damage to both the PV module and sensor, as well as the inability to reliably adhere the sensor to the surface again.

If removal is necessary, sliding a robust, but small gauge string or wire, such as fishing line, between the sensor and mounting surface has proven to be effective. Note that considerable force is needed, and hand protection is necessary.



# Appendix A. Importing *Short Cut* code into *CRBasic Editor*

---


*Short Cut* creates a .DEF file that contains wiring information and a program file that can be imported into *CRBasic Editor*. By default, these files reside in the C:\campbellsci\SCWin folder.

Import *Short Cut* program file and wiring information into *CRBasic Editor*.

1. Create the *Short Cut* program, then save it. Click the **Advanced** tab then the **CRBasic Editor** button. Your program file will open in CRBasic with a generic name. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

**NOTE:**

Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the program.

2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder. Copy the wiring information found at the beginning of the .DEF file.
3. Go into the CRBasic program and paste the wiring information at the beginning of the program.
4. In the CRBasic program, highlight the wiring information, right-click, and select **Comment Block**. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The **Comment Block** feature is demonstrated at about 5:10 in the [CRBasic | Features](#) video .

# Appendix B. Sensor material properties

---

The sensor consists of 6061 aluminum (hard anodized), RTD, 3M F9473PC adhesive, and PFA-jacketed cable.

## B.1 3M F9473PC adhesive

**UV resistance:** Excellent UV resistance through outdoor weathering tests.

**Temperature resistance:** Relatively unaffected by long-term exposure to elevated temperatures. Adhesive can tolerate periodic short-term exposures to temperatures up to 260 °C. The adhesive softens as temperature increases and gets firmer as temperature decreases. As the adhesive becomes firmer, the bond strength generally increases. However, at very low temperatures (< -40 °C), the bond strength decreases.

**Solvent resistance:** No apparent degradation when exposed to splash testing of many common solvents and fluids including gasoline, JP-4 fuel, mineral spirits, motor oil, ammonia cleaner, acetone and methyl ethyl ketone. Three-splash testing cycles were 20 seconds submersion and 20 seconds air dry.

**Storage and shelf life:** Humidity controlled storage: 16 to 27 °C (60 to 80 °F) and 40 to 60% relative humidity. If stored properly, product retains its performance and properties for 24 months from date of manufacture. If the products have been exposed to severe weather conditions, we suggest to precondition the products at the above storage conditions for at least 24 hours before using them.

# 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](http://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.

CAMPBELL SCIENTIFIC EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF 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](http://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](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, 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.



# Global Sales and Support Network

A worldwide network to help meet your needs



## Campbell Scientific Regional Offices

### Australia

**Location:** Garbutt, QLD Australia  
**Phone:** 61.7.4401.7700  
**Email:** [info@campbellsci.com.au](mailto:info@campbellsci.com.au)  
**Website:** [www.campbellsci.com.au](http://www.campbellsci.com.au)

### Brazil

**Location:** São Paulo, SP Brazil  
**Phone:** 11.3732.3399  
**Email:** [vendas@campbellsci.com.br](mailto:vendas@campbellsci.com.br)  
**Website:** [www.campbellsci.com.br](http://www.campbellsci.com.br)

### Canada

**Location:** Edmonton, AB Canada  
**Phone:** 780.454.2505  
**Email:** [dataloggers@campbellsci.ca](mailto:dataloggers@campbellsci.ca)  
**Website:** [www.campbellsci.ca](http://www.campbellsci.ca)

### China

**Location:** Beijing, P. R. China  
**Phone:** 86.10.6561.0080  
**Email:** [info@campbellsci.com.cn](mailto:info@campbellsci.com.cn)  
**Website:** [www.campbellsci.com.cn](http://www.campbellsci.com.cn)

### Costa Rica

**Location:** San Pedro, Costa Rica  
**Phone:** 506.2280.1564  
**Email:** [info@campbellsci.cc](mailto:info@campbellsci.cc)  
**Website:** [www.campbellsci.cc](http://www.campbellsci.cc)

### France

**Location:** Montrouge, France  
**Phone:** 0033.0.1.56.45.15.20  
**Email:** [info@campbellsci.fr](mailto:info@campbellsci.fr)  
**Website:** [www.campbellsci.fr](http://www.campbellsci.fr)

### Germany

**Location:** Bremen, Germany  
**Phone:** 49.0.421.460974.0  
**Email:** [info@campbellsci.de](mailto:info@campbellsci.de)  
**Website:** [www.campbellsci.de](http://www.campbellsci.de)

### India

**Location:** New Delhi, DL India  
**Phone:** 91.11.46500481.482  
**Email:** [info@campbellsci.in](mailto:info@campbellsci.in)  
**Website:** [www.campbellsci.in](http://www.campbellsci.in)

### Japan

**Location:** Kawagishi, Toda City, Japan  
**Phone:** 048.400.5001  
**Email:** [jp-info@campbellsci.com](mailto:jp-info@campbellsci.com)  
**Website:** [www.campbellsci.co.jp](http://www.campbellsci.co.jp)

### South Africa

**Location:** Stellenbosch, South Africa  
**Phone:** 27.21.8809960  
**Email:** [sales@campbellsci.co.za](mailto:sales@campbellsci.co.za)  
**Website:** [www.campbellsci.co.za](http://www.campbellsci.co.za)

### Spain

**Location:** Barcelona, Spain  
**Phone:** 34.93.2323938  
**Email:** [info@campbellsci.es](mailto:info@campbellsci.es)  
**Website:** [www.campbellsci.es](http://www.campbellsci.es)

### Thailand

**Location:** Bangkok, Thailand  
**Phone:** 66.2.719.3399  
**Email:** [info@campbellsci.asia](mailto:info@campbellsci.asia)  
**Website:** [www.campbellsci.asia](http://www.campbellsci.asia)

### UK

**Location:** Shephed, Loughborough, UK  
**Phone:** 44.0.1509.601141  
**Email:** [sales@campbellsci.co.uk](mailto:sales@campbellsci.co.uk)  
**Website:** [www.campbellsci.co.uk](http://www.campbellsci.co.uk)

### USA

**Location:** Logan, UT USA  
**Phone:** 435.227.9120  
**Email:** [info@campbellsci.com](mailto:info@campbellsci.com)  
**Website:** [www.campbellsci.com](http://www.campbellsci.com)