PRODUCT MANUAL

Sensor

CS241DM G2

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

12/2025

RELIABLE MONITORING SINCE 1974

Campbell SCIENTIFIC®

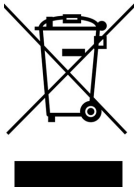
Please read first

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 Europe, Middle East, and Africa (EMEA) or Asia Pacific (APAC) 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 EMEA or APAC 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 EMEA or APAC market; in some cases alternatives are offered.

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



At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility, per The Waste Electrical and Electronic Equipment (WEEE) Regulations 2012/19/EU. Campbell Scientific can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories. For further support, please contact Campbell Scientific, or your local agent.

Table of contents

1. Introduction

The CS241DM G2 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 G2 has a digital RS-485 output that can be directly read by a MeteoPV, CR6, 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. The CS241DM G2 has the same programming and measurements as its predecessor, the CS241DM, but the pin-out is different. See Wiring (p. 9).

> **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.
- Prying the sensor head off will likely damage both the sensor and PV module.
- Do not use any force on the black plastic molded housing. Secure the molded housing to the PV module only by fastening cable ties around the cable adjacent to the housing.
- 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 G2 is shipped with a NIST-traceable calibration certificate. Please contact Campbell Scientific if you need an additional copy of the certificate for your records.

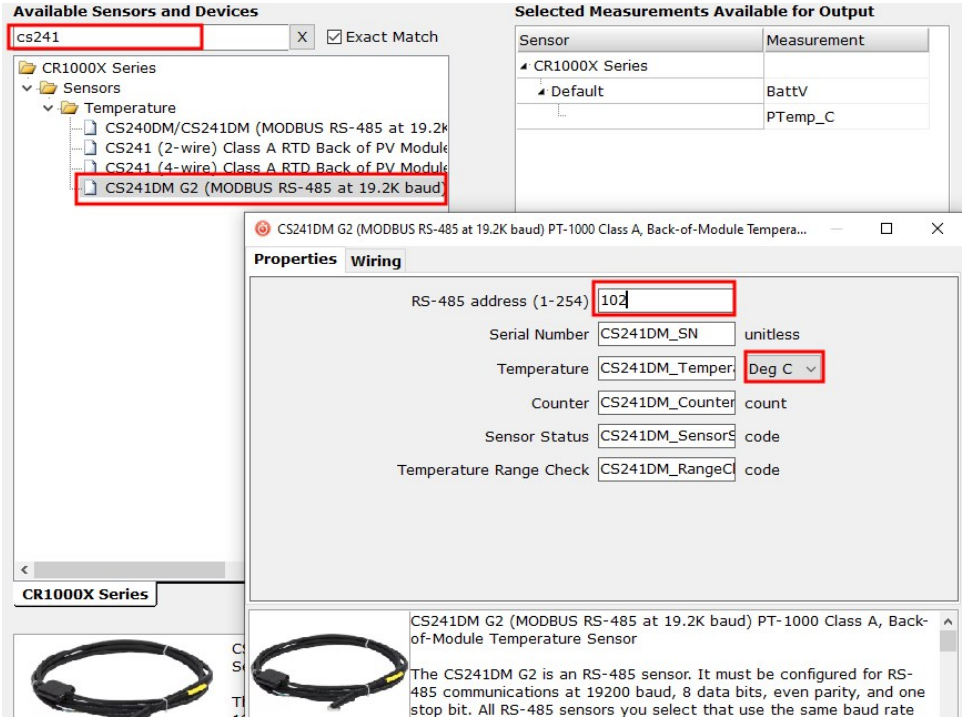
4. QuickStart

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. ***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. It is included in installations of ***LoggerNet***, ***RTDAQ***, or ***PC400***.

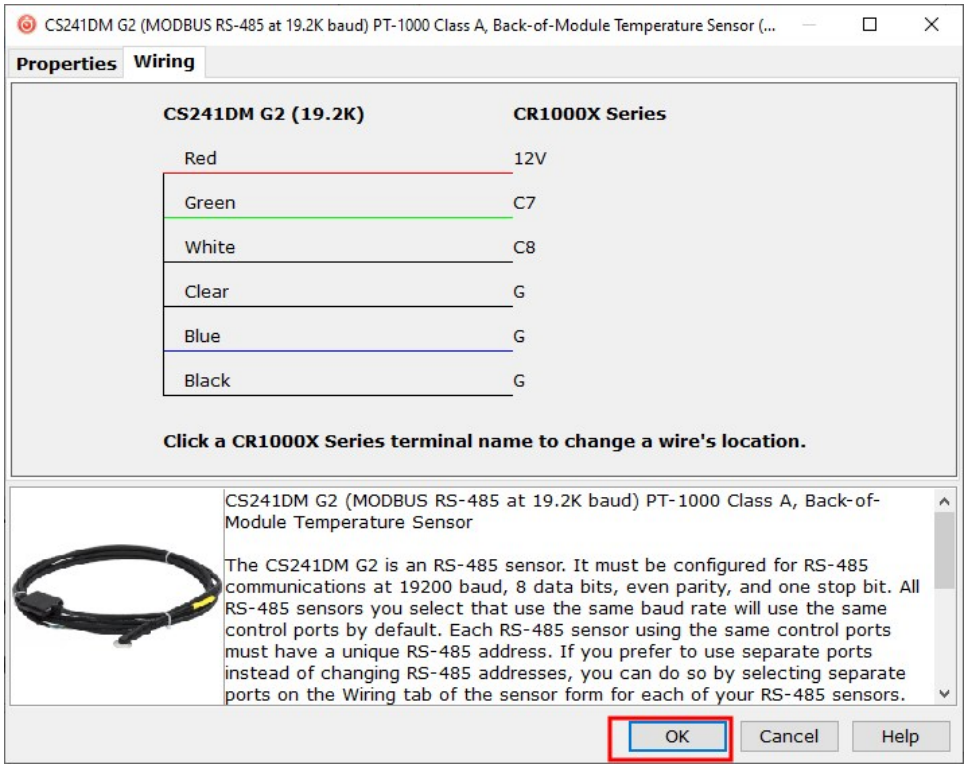
The following procedure also shows using ***Short Cut*** to program the CS241DM G2.

1. Open ***Short Cut*** and click **Create New Program**.
2. Double-click the data logger model.

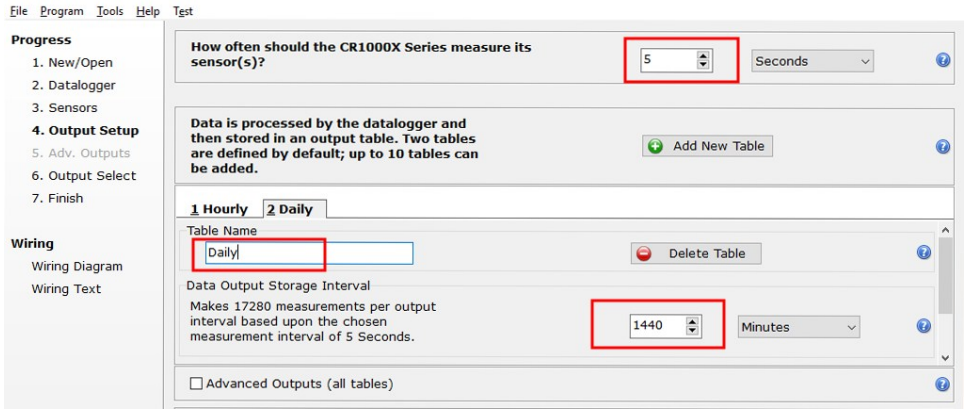
3. In the **Available Sensors and Devices** box, type CS241DM G2. You can also locate the sensor in the **Sensors** > **Temperature** folder. Double click **CS241DM G2**. Type the **RS-485 address**; default address is the last two digits of the serial number. The CS241DM G2 must have a unique RS-485 address. The surface temperature defaults to degree C. This can be changed by clicking the **Temperature** box and selecting one of the other options.



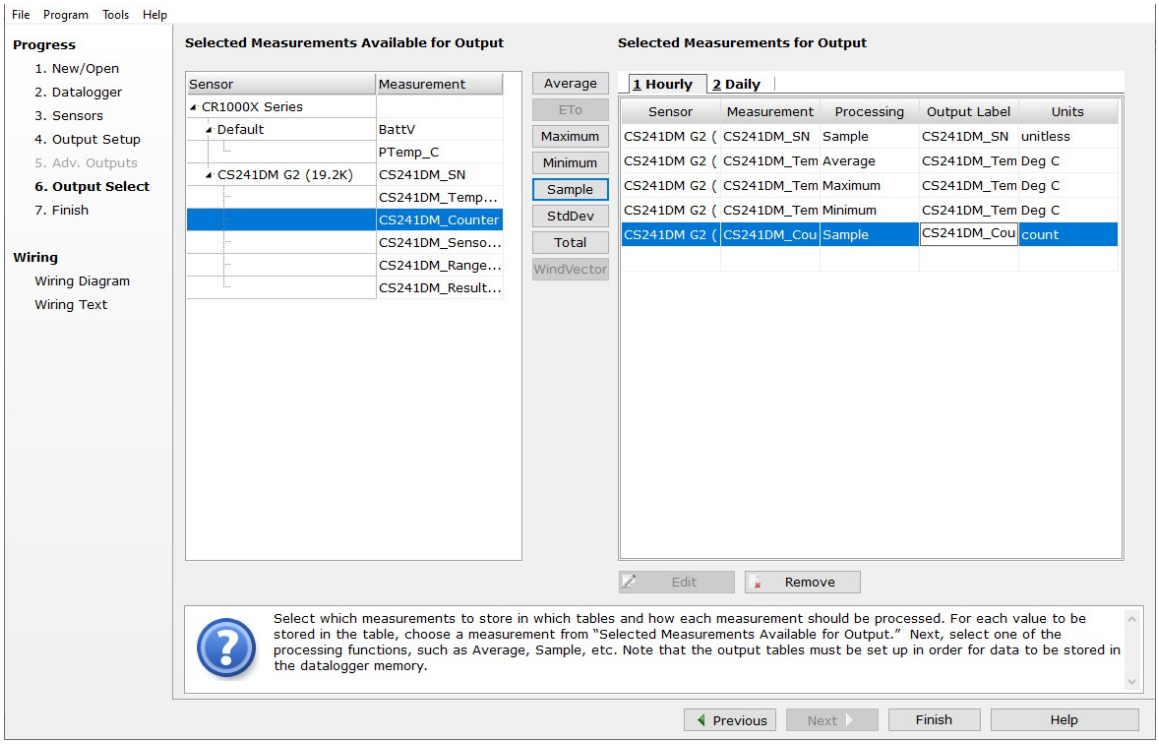
4. Click on the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



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



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 G2 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. 6]).

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 G2 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 molded housing.

The CS241DM G2 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.

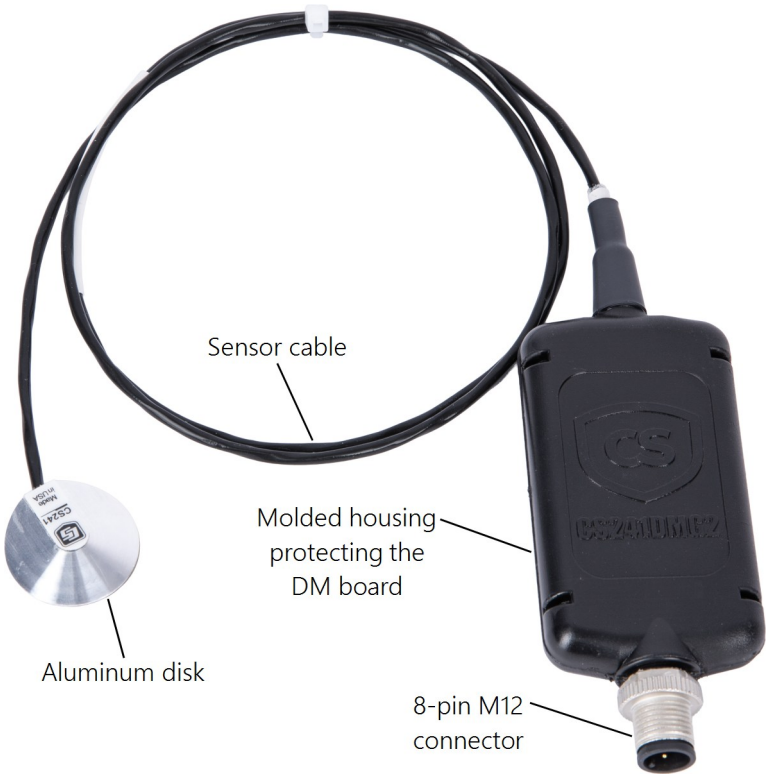


Figure 5-1. CS241DM G2 temperature sensor

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^2 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:	± (0.15 + 0.002t) °C
Operating temperature range:	–50 to +150 °C
Temperature coefficient:	TCR = 3850 ppm/K
Long-term stability:	Maximum R_0 drift = 0.04% after 1000 hours at 400 °C
Temperature uncertainty:	±(0.3 to 0.4 °C) for the –40 to 100 °C measurement range when using the CR1000X-series 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:	±0.015 °C
Supply voltage:	5 to 30 VDC
Power consumption:	15 mA
RS-485 signal isolation:	1200 V isolation
Surge protection:	Class 4 IEC 61400-4
Environmental protection:	Rugged molded housing

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)
Approvals:	Conforms with the Restriction of Hazardous Substances Directive (RoHS2)
Compliance:	View compliance documents at: www.campbellsci.com/cs241dm-g2 Meets or exceeds IEC 61724 Class A performance specifications
Industrial standards:	Compliant with IEC 60751, DIN EN 60751, Industrial Design (IEC Class 4) (according to IEC 751)
IP rating:	IP68 rating (self certified): 1 m (3 ft) submersion for 90 minutes
EMC compliance:	Conforms with Electromagnetic Compatibility Directive (EMC)
RoHS2:	Conforms with Restriction of Hazardous Substances Directive (RoHS2)
POE compliance:	POE compliant (802.3af) to 100 meters when installed per recommendations in TIA TSB-184
CAT5e:	Cable will meet CAT5e channel requirements to 100 meter length
Sensor cable (sensor head-to-molded housing)	
Cable diameter:	0.216 cm (0.085 in)
Cable length:	0.9 m (3 ft)
Jacket material:	Black semi-gloss perfluoroalkoxy (PFA), insulated
Jacket rating:	–75 to 250 °C
Minimum bend radius:	6 mm (0.25 in) at least 6 mm (0.25 in) away from sensor disk
Connector:	Circular plastic M12 , female 5-pin connector

7. Installation

If you are programming your data logger with ***Short Cut***, skip and Data logger programming (p. 10). ***Short Cut*** does this work for you. See QuickStart (p. 2) for a ***Short Cut*** tutorial. This section discusses the following:

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. 7). Sensor wiring is also available in the ***Device Configuration Utility*** and the ***MeteoPV User Interface***.

Table 7-1: Wire color, station connection, and function

> NOTE:
> This pin-assignment is different than the CS240DM.

Wire color	Pin-out	Station (data logger) terminal	Function
Green	5	**A–** (**C** odd)	RS-485 A/A [–]
White	2	**B+** (**C** even)	RS-485 B/B [+]
Red	1	**12V**	5 to 30 VDC
Black	4	**G**	Ground (power)
Blue	3	**G**	Signal ground

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. 15) and Long cable lengths (p. 15) prior to programming your data logger.

7.2.1 CRBasic programming

> NOTE:
> Contact Campbell Scientific if using a data logger that requires an MD485 interface.

A downloadable CRBasic program example is available at www.campbellsci.com/downloads/cs241dm-g2-program-example.

A data logger programmed as a Modbus client can retrieve the values stored in the CS241DM G2 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 G2 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 G2 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.

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.

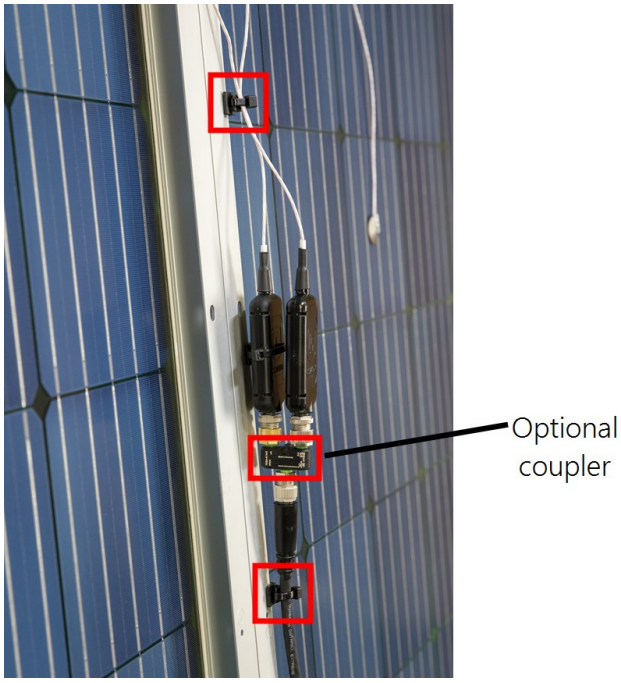
7.4.2 Cable strain relief

> 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 G2 comes with three cable ties and three edge clips.

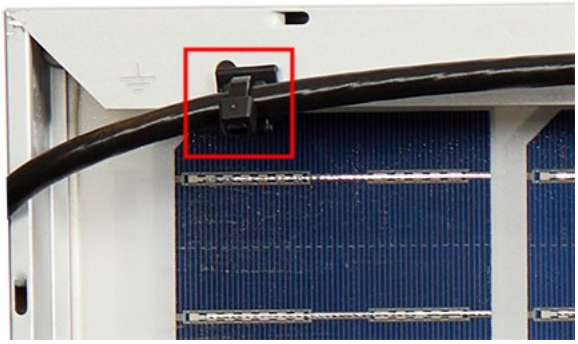
1. Fasten the edge clips at the top of the PV module in the following locations:
    a. Above the sensor.

b. On both sides of the molded housing.



> **NOTE:**
> A user-supplied coupler allows two CS241DM G2 sensors to connect to the same cable. Each CS241DM G2 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 G2 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. 11]).
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).

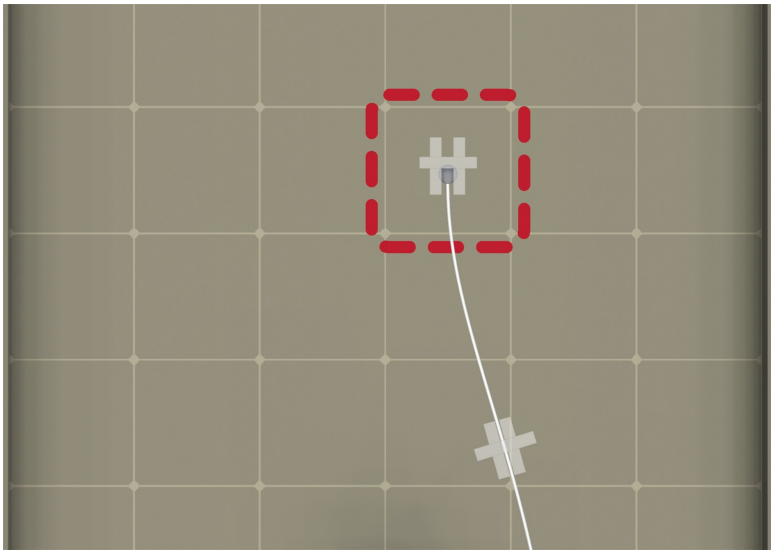


Figure 7-1. Proper tape usage

8. Operation

This section discusses the following:

8.1 Electrical noisy environments

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. 16) 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[1]	Specifies the sensor serial number assigned by the factory
30003	Temperature	Float[1]	The stored value is in degrees Celsius.
30005	Counter	Float[1]	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[1]	0 = good 1 = open/short
30009	Temperature range check	Float[1]	0 = good/in range 1 = out of range

[1]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[1]	Modbus device address (1 to 247)
40002	Baud rate	Unsigned short[1]	1 = 9600 bps 2 = 19200 bps 3 = 38400 bps 4 =57600 bps 5 = 115200 bps
40003	Parity	Unsigned short[1]	0 = no parity 1 = odd 2 = even
40004	Stop bit	Unsigned short[1]	1 = 1 stop bit 2 = 2 stop bits
40005	Termination resistor	Unsigned short[1]	0 = off/disable 1 = on/enable

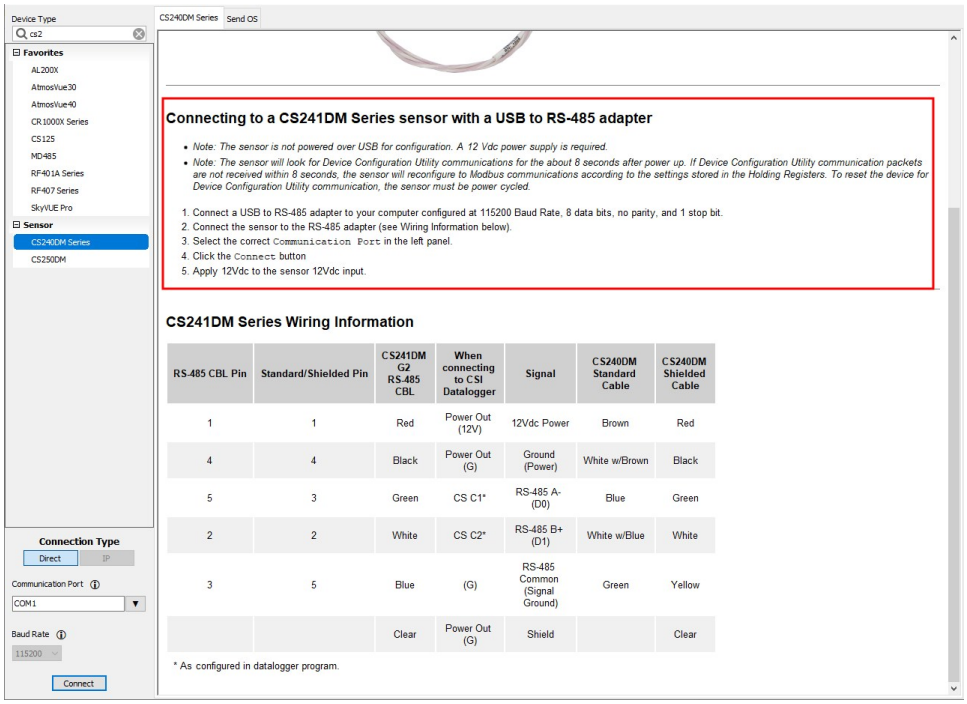
[1]Unsigned short data is a 16-bit positive integer.

8.4 *Device Configuration Utility*

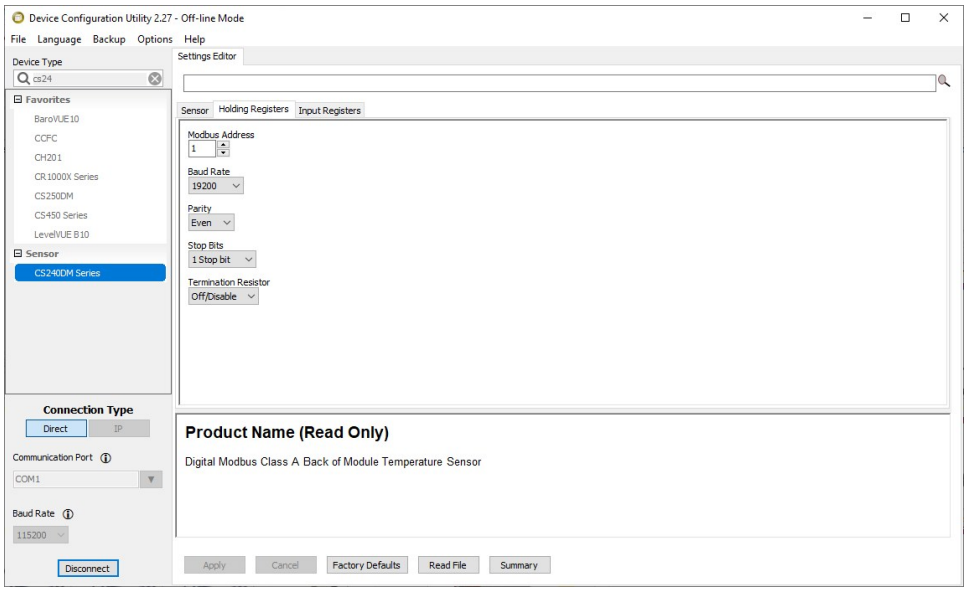
Device Configuration Utility is bundled in Campbell Scientific data logger support software and can also be acquired, at no cost, from www.campbellsci.com/downloads. ***Device Configuration Utility*** can be used to change the CS241DM G2 settings, view stored values, and update the operating system (OS). It also provides wiring information.

To use ***Device Configuration Utility***, the CS241DM G2 must be connected to a computer and 12 VDC power source. A USB-to-RS-485 adapter is required to connect the CS241DM G2 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**.
3. Follow steps listed under **Connecting to a CM241DM Series sensor with a USB to RS-485 adapter**.



4. 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.



5. 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 G2 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 G2 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 G2 sensor head (keeping the existing cable in place) instead of a recalibration.

9.4 Removal

> **CAUTION:**
> Campbell Scientific does not recommend removing the CS241DM G2 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. Example program

The following example CR6 program measures the CS241DM G2. This program can be used for the older CS241DM, but the wiring included in the program will be wrong. Refer to the CS241DM manual for more information.

CRBasic Example 1: CR6 program measuring the CS241DM G2

```
'CR6 Series data logger
'This program retrieves the serial number, temperature, counter,
'sensor status, and range check from the input register
'of four CS241DM G2 sensors. It then averages the temperature
'measurements and calculates the temperature standard deviation.

'Wiring for CS241DM G2
'Wire color  DL terminal
'Red         12V
'Black       G
'Blue        G
'White       C2*
'Green       C1*
'Clear       No Connection

' * = As Set In Data Logger Program

'Because the sensors are connected to the same terminals,
'each CS241DM G2 must have a unique Modbus address.

'Declare constants

'The Modbus addresses are entered as constants and must be changed to match
'your sensors Modbus addresses. 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.

Const mb_addr_1 = 111
Const mb_addr_2 = 2
Const mb_addr_3 = 3
Const mb_addr_4 = 4

'Declare public variables and aliases

Public PTemp
Public batt_volt
```

CRBasic Example 1: CR6 program measuring the CS241DM G2

```
Public ResultCode(4)
Public CS241DM(20)
Public AveTemp(4)
Public SD_Temp
Public AvgTemp

Alias ResultCode(1) = CS241DM_1_ResultCode
Alias ResultCode(2) = CS241DM_2_ResultCode
Alias ResultCode(3) = CS241DM_3_ResultCode
Alias ResultCode(4) = CS241DM_4_ResultCode
Alias CS241DM(1) = CS241DM_1_SN
Alias CS241DM(2) = CS241DM_1_Temperature
Alias CS241DM(3) = CS241DM_1_Counter
Alias CS241DM(4) = CS241DM_1_SensorStatus
Alias CS241DM(5) = CS241DM_1_RangeCheck
Alias CS241DM(6) = CS241DM_2_SN
Alias CS241DM(7) = CS241DM_2_Temperature
Alias CS241DM(8) = CS241DM_2_Counter
Alias CS241DM(9) = CS241DM_2_SensorStatus
Alias CS241DM(10) = CS241DM_2_RangeCheck
Alias CS241DM(11) = CS241DM_3_SN
Alias CS241DM(12) = CS241DM_3_Temperature
Alias CS241DM(13) = CS241DM_3_Counter
Alias CS241DM(14) = CS241DM_3_SensorStatusk
Alias CS241DM(15) = CS241DM_3_RangeCheck
Alias CS241DM(16) = CS241DM_4_SN
Alias CS241DM(17) = CS241DM_4_Temperature
Alias CS241DM(18) = CS241DM_4_Counter
Alias CS241DM(19) = CS241DM_4_SensorStatus
Alias CS241DM(20) = CS241DM_4_RangeCheck

'Declare tables
DataTable (Hourly,1,-1)
DataInterval (0,60,min,10)
  Sample (20,CS241DM(),IEEE4)
  Sample (1,AvgTemp,IEEE4)
  Sample (1,SD_Temp,IEEE4)
EndTable

DataTable(Daily,True,-1)
  DataInterval (0,1440,Min,10)
  Minimum (1,batt_volt,FP2,False,False)
  Sample (1,PTemp,FP2)
EndTable

BeginProg
```

CRBasic Example 1: CR6 program measuring the CS241DM G2

```
  'This SerialOpen instruction configures the Com port as
  'RS485 half-duplex, transparent (CommsMode 4).
  'To do this, the CS241DM G2 must be connected to ComC1 or ComC3 in the CR6,
  'or connected to ComC5 or ComC7 in the CR1000Xe.

  SerialOpen (ComC1,19200,2,0,50,4)
  Scan (1,Sec,0,0)
    PanelTemp (PTemp,15000)
    Battery (batt_volt)

    'Retrieve input register information for the four sensors
    ModbusClient (ResultCode(1),ComC1,19200,mb_addr_1,4,CS241DM(1),1,5,3,100,2)
    ModbusClient (ResultCode(2),ComC1,19200,mb_addr_2,4,CS241DM(6),1,5,3,100,2)
    ModbusClient (ResultCode(3),ComC1,19200,mb_addr_3,4,CS241DM(11),1,5,3,100,2)
    ModbusClient (ResultCode(4),ComC1,19200,mb_addr_4,4,CS241DM(16),1,5,3,100,2)

    'Average the temperature measurements
    AveTemp(1) = CS241DM(2)
    AveTemp(2) = CS241DM(7)
    AveTemp(3) = CS241DM(12)
    AveTemp(4) = CS241DM(17)
    AvgTemp = (AveTemp(1) + AveTemp(2) + AveTemp(3) + AveTemp(4))/4

    'Calculate the standard deviation
    StdDevSpa (SD_Temp,4,AveTemp())

    'Call tables
    CallTable Hourly
    CallTable Daily
  NextScan
EndProg
```

Appendix C. Sensor material properties

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

C.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 to determine which Campbell Scientific office serves your country. For directions on how to return equipment, see Assistance.

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

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

Campbell Scientific will, as a default, return warranted equipment by surface carrier prepaid. However, the method of return shipment is at Campbell Scientific's sole discretion. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This warranty and the Company's obligation thereunder is in lieu of all other

warranties, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

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

Assistance

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

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

When returning equipment, a RMA number must be clearly marked on the outside of the package. Please state the faults as clearly as possible. Quotations for repairs can be given on request.

It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment. In support of this policy, when equipment is returned to Campbell Scientific, Logan, UT, USA, it is mandatory that a "Declaration of Hazardous Material and Decontamination" form be received before the return can be processed. If the form is not received within 5 working days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. For details on decontamination standards specific to your country, please reach out to your regional Campbell Scientific office.

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

Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.com You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a hardhat and eye protection, and take other appropriate safety precautions while working on or around tripods and towers.
- Do not climb tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- You can be killed or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in contact with overhead or underground utility lines.
- Maintain a distance of at least one-and-one-half times structure height, 6 meters (20 feet), or the distance required by applicable law, whichever is greater, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.

- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

Use and disposal of batteries

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

Avoiding unnecessary exposure to radio transmitter radiation

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

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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