CS241DM

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

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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 and 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. 10)).
- 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.

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.

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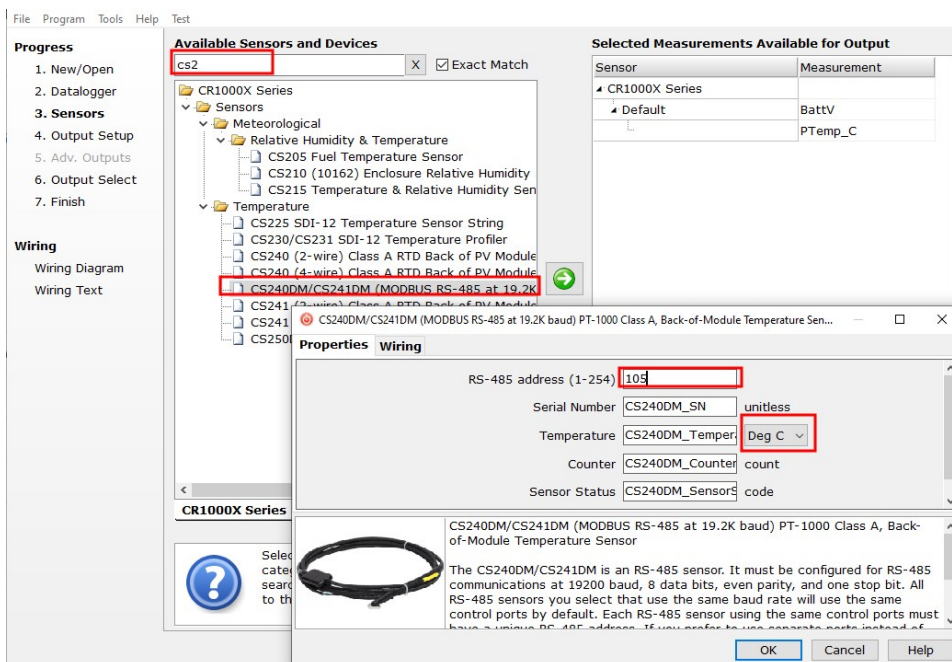
4. Click on the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.

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.
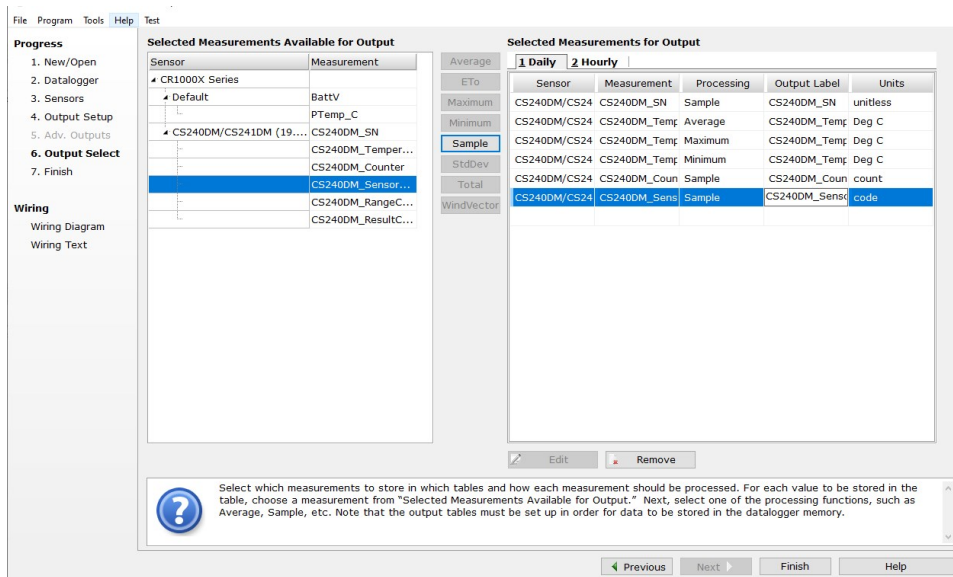
8. Click **Finish** and save the program. Send the program just created to the data logger if the data logger is connected to the computer.

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 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.
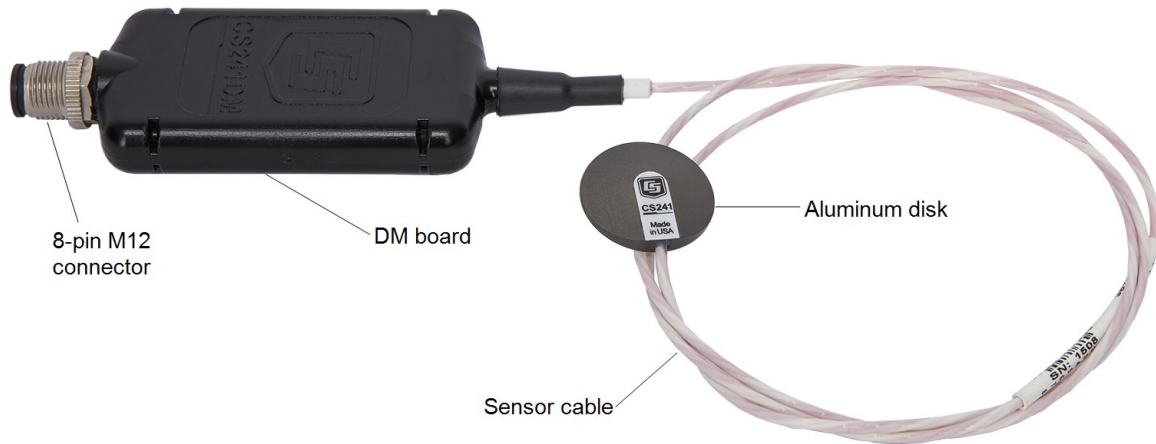
FIGURE 5-1. CS241DM temperature sensor

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^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, CR3000 (with MD485), CR800 series (with MD485), CR300 series (with MD485), CR1000 (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:	$\pm (0.15 + 0.002t)$ °C
Operating temperature range:	–40 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:	$\pm$(0.3 to 0.4 °C) for the –40 to 100 °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 °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)

Approvals:	Conforms with the Restriction of Hazardous Substances Directive (RoHS2)
Compliance:	View compliance documents at: www.campbellsci.com/cs241dm ↗
	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-DM board)

Cable diameter:	0.216 cm (0.085 in)
Cable length:	0.9 m (3 ft)
Jacket material:	White 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

Standard DM cable (DM board to pigtail)

Temperature rating:	–40 to 105 °C
Overall cable diameter:	7.37 mm nominal ± 0.13 mm (0.29 inch nominal ± 0.005 in)
Conductor material:	22 AWG 19/0.0058 stranded tinned copper
Cable type:	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:

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 standard cable or a 3-twisted-pair shielded 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				
Standard cable[1] wire color	Pin-out	3-twisted pair cable[1] wire color	Station (data logger) terminal	Function
Blue	3	Green	**A–** (**C** odd)	RS-485 A/A [–]
White/blue stripe	2	White	**B+** (**C** even)	RS-485 B/B [+]
Brown	4	Red	**12V**	5 to 30 VDC
White/brown stripe	1	Black	**G**	Ground (power)
Green	5	Yellow	**G**	Modbus common
--	N/A	Clear	**G**	Shield
[1]Cable has an 8-pin M12 connector.				

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. 19). Programming basics for CRBasic data loggers are provided in the following section. Downloadable program example is available at www.campbellsci.com/downloads/cs241dm-program-example ⬀.

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

7.2.1 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.

A CR6 or CR1000X data logger programmed as a Modbus Master can retrieve the values stored in the CS241DM Input Registers (Modbus register map (p. 14)). 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 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 and 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

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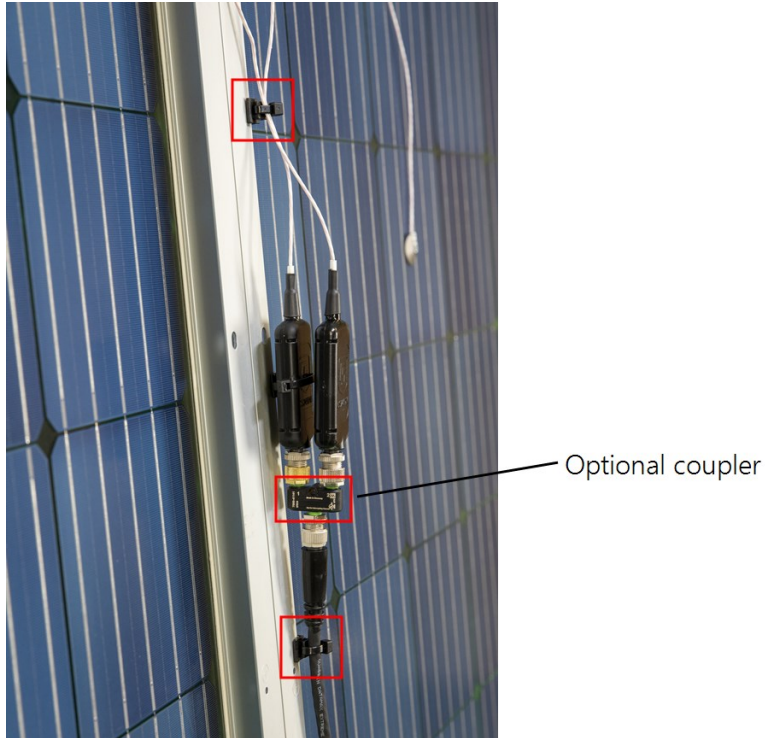
> **NOTE:**
> A user-supplied coupler allows two CS241DM sensors to connect to the same cable. Each CS241DM must have a unique Modbus address.

c. At a top corner of the PV module
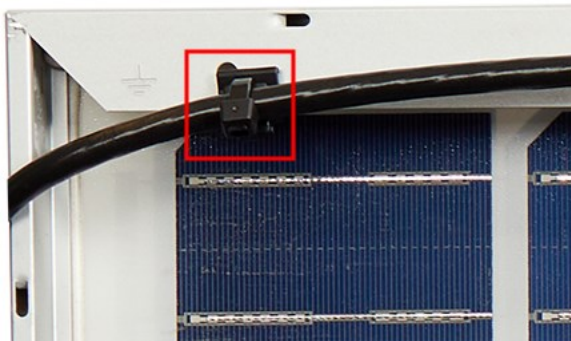
2. Use the cable ties to secure the cable to the edge clips.

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. These strips of tape should form an H (FIGURE 7-1 (p. 13)).

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. See the following figure.
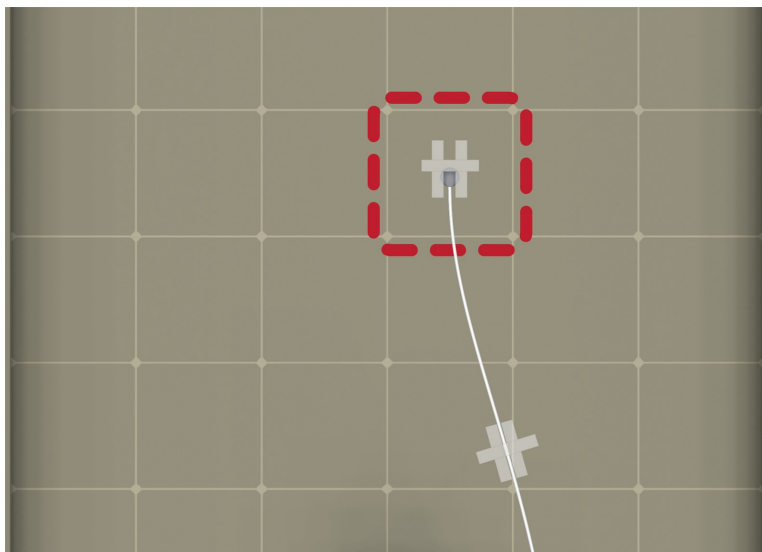
FIGURE 7-1. Proper tape usage

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. 15) provides the input register map (function code 4) and Table 8-2 (p. 15) 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 provides an indicator that the sensor is actively taking measurements. This value will increment once per measurement, resetting to 0.
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 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**.
3. Follow steps listed under **Connecting to a CM240DM 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.
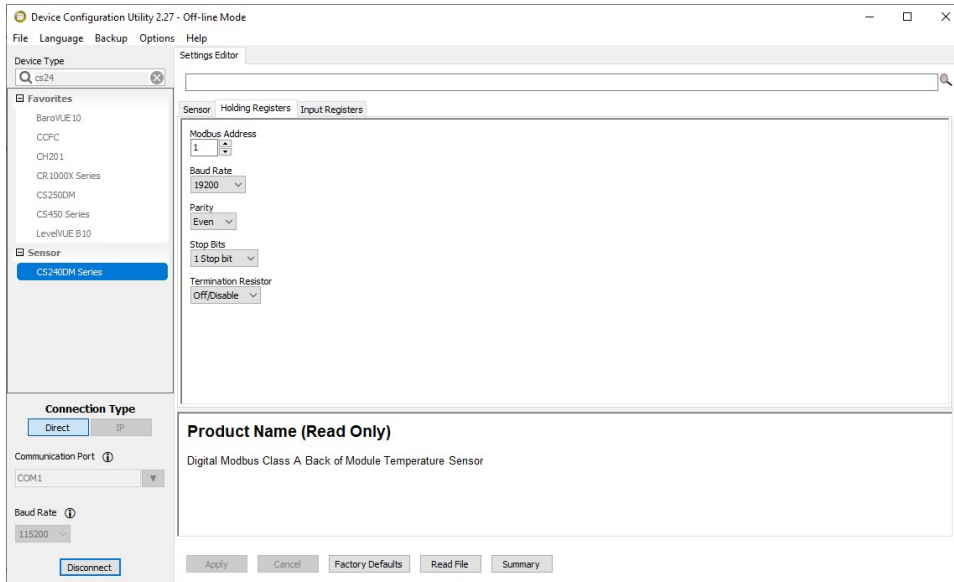
5. Click the **Input Registers** tab to view the values.

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 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.

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 the *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. After saving the *Short Cut* program, click the **Advanced** tab then the **CRBasic Editor** button. A program file with a generic name will open in CRBasic. 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 it created.

2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder, and copy the wiring information, which is at the beginning of the .DEF file.

3. Go into the CRBasic program and paste the wiring information into it.

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

Products manufactured by Campbell Scientific are warranted by Campbell Scientific to be free from defects in materials and workmanship under normal use and service for twelve months from the date of shipment unless otherwise specified on the corresponding product webpage. See Product Details on the Ordering Information pages at www.campbellsci.com. Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

Refer to www.campbellsci.com/terms#warranty for more information.

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Products may not be returned without prior authorization.

Products shipped to Campbell Scientific require a Returned Materials Authorization (RMA) or Repair Reference number and must be clean and uncontaminated by harmful substances, such as hazardous materials, chemicals, insects, and pests. Please complete the required forms prior to shipping equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page for the Global Sales and Support Network or visit www.campbellsci.com/contact ⬈ to determine which Campbell Scientific office serves your country.

To obtain a Returned Materials Authorization or Repair Reference number, contact your CAMPBELL SCIENTIFIC regional office. Please write the issued number clearly on the outside of the shipping container and ship as directed.

For all returns, the customer must provide a "Statement of Product Cleanliness and Decontamination" or "Declaration of Hazardous Material and Decontamination" form and comply with the requirements specified in it. The form is available from your CAMPBELL SCIENTIFIC regional office. Campbell Scientific is unable to process any returns until we receive this statement. If the statement is not received within three days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. Campbell Scientific reserves the right to refuse service on products that were exposed to contaminants that may cause health or safety concerns for our employees.

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.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

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

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

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

Internal Battery
- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.
- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

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

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