

# CS240 and CS240DM

PT-1000 Class A,  
Back-of-Module  
Temperature Sensors





## WARRANTY AND ASSISTANCE

This equipment is warranted by CAMPBELL SCIENTIFIC (CANADA) CORP. ("CSC") to be free from defects in materials and workmanship under normal use and service for **twelve (12) months** from date of shipment unless specified otherwise. \*\*\*\*\* **Batteries are not warranted.** \*\*\*\*\* CSC's obligation under this warranty is limited to repairing or replacing (at CSC's option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CSC. CSC will return such products by surface carrier prepaid. This warranty shall not apply to any CSC products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CSC is not liable for special, indirect, incidental, or consequential damages.

Products may not be returned without prior authorization. To obtain a Return Merchandise Authorization (RMA), contact CAMPBELL SCIENTIFIC (CANADA) CORP., at (780) 454-2505. An RMA number will be issued in order to facilitate Repair Personnel in identifying an instrument upon arrival. Please write this number clearly on the outside of the shipping container. Include description of symptoms and all pertinent details.

CAMPBELL SCIENTIFIC (CANADA) CORP. does not accept collect calls.

Non-warranty products returned for repair should be accompanied by a purchase order to cover repair costs.



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# Assistance

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For all returns, the client must fill out a "Statement of Product Cleanliness and Decontamination" form and comply with the requirements specified in it. The form is available from our web site at [www.campbellsci.ca/repair](http://www.campbellsci.ca/repair). A completed form must be either emailed to [repair@campbellsci.ca](mailto:repair@campbellsci.ca) or faxed to (780) 454-2655. Campbell Scientific (Canada) Corp. is unable to process any returns until we receive this form. If the form is not received within three days of product receipt or is incomplete, the product will be returned to the client at the client's expense. Campbell Scientific (Canada) Corp. reserves the right to refuse service on products that were exposed to contaminants that may cause health or safety concerns for our employees.

# Precautions

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

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at [www.campbellsci.ca](http://www.campbellsci.ca) or by telephoning (780) 454-2505 (Canada). 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 personnel (e.g. engineer). If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

## General

- Prior to performing site or installation work, obtain required approvals and permits.
- 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.

## Elevated Work and Weather

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

## Maintenance

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

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CLIENT 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.

# ***PLEASE READ FIRST***

## **About this manual**

Please note that this manual was originally produced by Campbell Scientific Inc. (CSI) primarily for the US market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

<b>Area:</b>	1 in <sup>2</sup> (square inch) = 645 mm <sup>2</sup>
<b>Length:</b>	1 in. (inch) = 25.4 mm
	1 ft (foot) = 304.8 mm
	1 yard = 0.914 m
	1 mile = 1.609 km
<b>Mass:</b>	1 oz. (ounce) = 28.35 g
	1 lb (pound weight) = 0.454 kg
<b>Pressure:</b>	1 psi (lb/in <sup>2</sup> ) = 68.95 mb
<b>Volume:</b>	1 US gallon = 3.785 litres

In addition, part ordering numbers may vary. For example, the CABLE5CBL is a CSI part number and known as a FIN5COND at Campbell Scientific Canada (CSC). CSC Technical Support will be pleased to assist with any questions.

## **About sensor wiring**

Please note that certain sensor configurations may require a user supplied jumper wire. It is recommended to review the sensor configuration requirements for your application and supply the jumper wire is necessary.



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# ***CS240 and CS240DM PT-1000 Class A, Back-of-Module Temperature Sensors***

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## **1. Introduction**

The CS240 and CS240DM temperature sensors use a precision 1000 ohm class A platinum resistance temperature detector to measure temperature from –40 to 105 °C. They are designed for measuring the back-of-photovoltaic (PV) module temperature but also can be used to measure the surface temperature of other devices. The CS240 can be measured with a 2-wire or 4-wire configuration and is compatible with most Campbell Scientific dataloggers. The CS240DM 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 dataloggers can use an MD485 multidrop interface to read the CS240DM output.

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### **NOTE**

This manual provides information only for CRBasic dataloggers. The CS240 is also compatible with most of our retired Edlog dataloggers. For Edlog datalogger support, contact Campbell Scientific.

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## **2. Precautions**

- READ AND UNDERSTAND the [Safety](#) section at the front of this manual.
- Do not use epoxy to secure the sensor to a PV module; use Kapton tape.
- Clean the PV module before adhering the sensor to it. The sensor must be adhered to a clean surface for its mounting strip adhesive to function properly.
- If using Kapton tape to secure the disk to the PV module, do not go over the sensor molding with the tape; only put tape over the metal disk portion of the sensor.
- Prying the sensor 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 (Section [7.2](#), *Mounting/Cable Strain Relief* (p. 7)).
- Placement of the cable inside a rugged conduit is advisable for long cable runs, especially in locations subject to digging, mowing, traffic, use of 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, cable length, wiring diagrams, and cable resistance (CS240 only) 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.

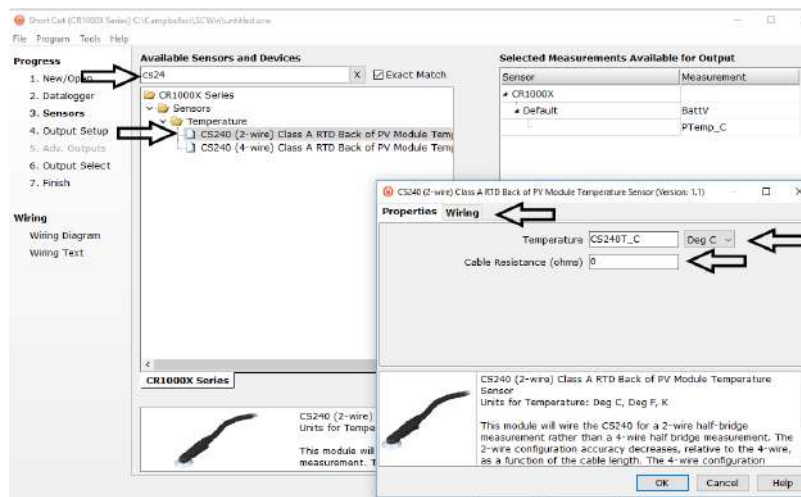
### 4. QuickStart

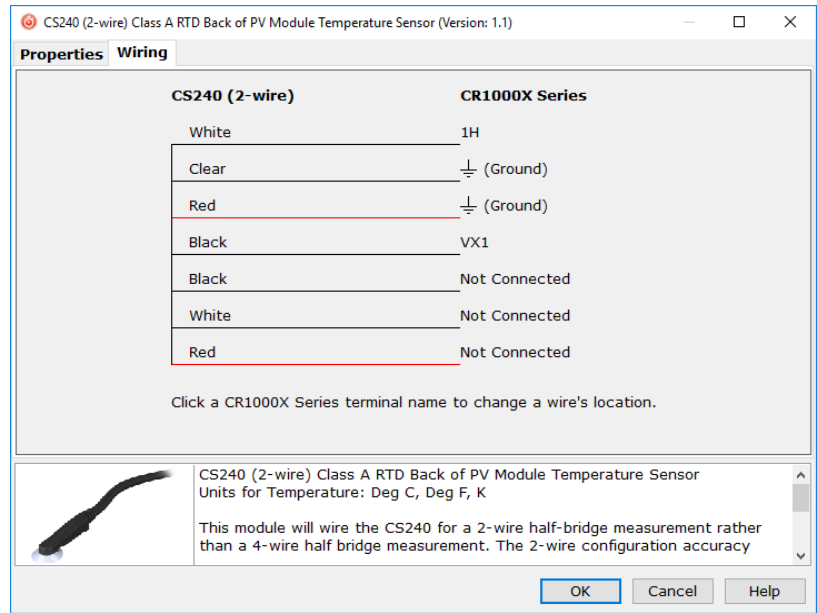
The information provided in this section is for the CS240.

A video that describes datalogger programming using *Short Cut* is available at: [www.campbellsci.com/videos/cr1000x-datalogger-getting-started-program-part-3](http://www.campbellsci.com/videos/cr1000x-datalogger-getting-started-program-part-3). *Short Cut* is an easy way to program your datalogger to measure the CS240 and assign datalogger wiring terminals. *Short Cut* is available as a download on [www.campbellsci.com](http://www.campbellsci.com). It is included in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ*.

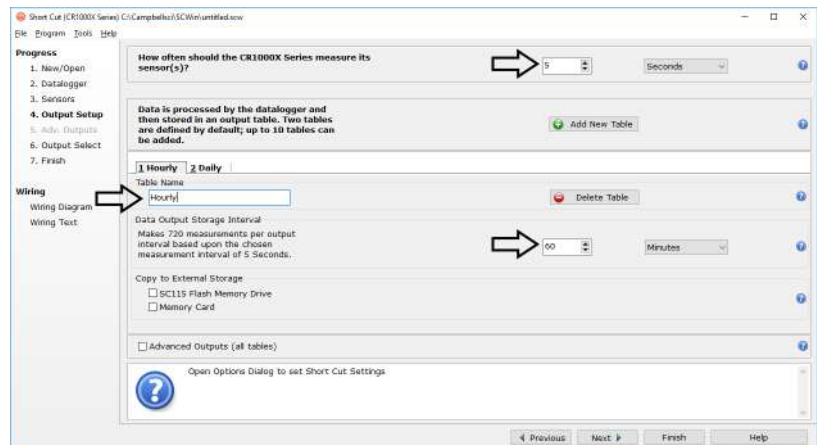
The following procedure also shows using *Short Cut* to program the CS240.

1. Open *Short Cut* and select to create a new program.
2. Double-click the datalogger model.
3. In the **Available Sensors and Devices** box, type CS240. You can also locate the sensor in the **Sensors | Temperature** folder. Double-click either **CS240 (2-Wire) RTD** or **CS240 (4-Wire) RTD**. If using the 2-wire configuration, type the **Cable Resistance**. This value is unique for each CS240, and is printed on the heat shrink label attached to the sensor cable. The surface temperature defaults to degree C. This can be changed by clicking the **Temperature** box and selecting one of the other options. After entering the **Properties**, click on the **Wiring** tab to see how the sensor is to be wired to the datalogger.

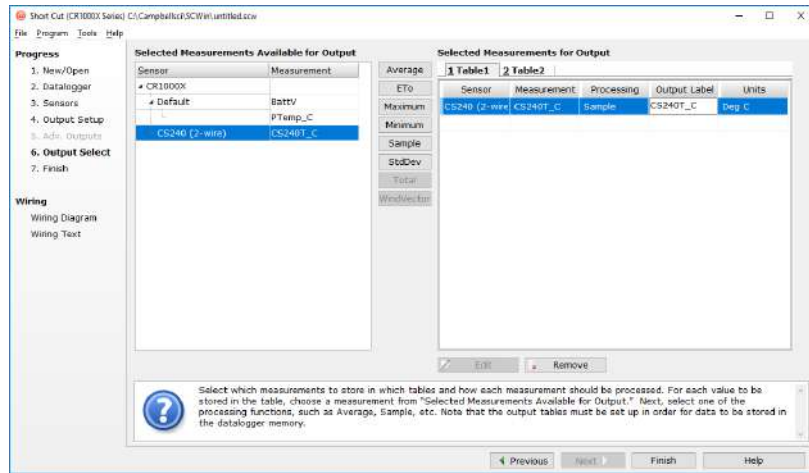




- Repeat step three for other sensors you want to measure.
- In **Output Setup**, type the scan rate, a meaningful table name, and the **Data Output Storage Interval**.



6. Select the measurement and its associated output option.



7. Click **Finish** and save the program. Send the program just created to the datalogger if the datalogger is connected to the computer.
8. If the sensor is connected to the datalogger, check the output of the sensor in *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* to make sure it is making reasonable measurements.

## 5. Overview

The CS240 and CS240DM are surface mountable platinum resistive thermometers (PRT) that measure back-of-module temperature for solar energy applications. They use a precision PT-1000 class A PRT to provide the highest level of accuracy. To withstand the harsh treatment commonly seen in meteorological station installation, the sensing element is safely housed inside a specially designed self-adhesive aluminum disk (FIGURE 5-1).

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. If the temperature may exceed 70 °C, Kapton tape is also required to secure the sensor.

The CS240DM 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 lead-wire resistance. Measurement electronics are surge protected with 1200 V isolation and environmentally protected with a rugged overmolding with an IP65 rating.

The CS240 and CS240DM provide PV stakeholders with highly accurate back-of-module temperature, even at long cable lengths, for use 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.

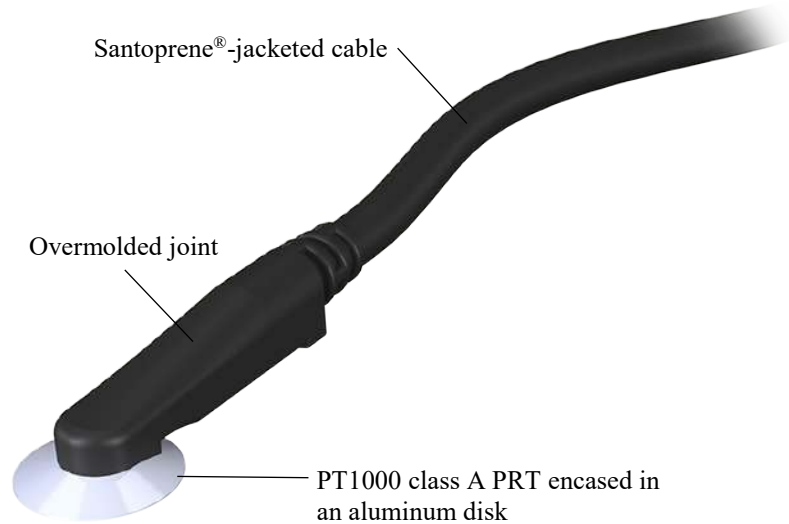


FIGURE 5-1. CS240/CS240DM Temperature Sensor

## 6. Specifications

### Features:

- Precision PT1000 class A sensing element
- Any cable length available—user-selectable and standard lengths offered
- Rugged design holds up in harsh conditions and conduit installations
- Self-adhesive backing for easy mounting lasts decades
- CS240 has 2-wire or 4-wire configurations to satisfy accuracy even at long cable lengths
- CS240 compatible with Campbell Scientific CRBasic dataloggers: CR300 series, CR6 series, CR800 series, CR1000, CR1000X series, CR3000, and CR5000
- CS240DM compatible with Campbell Scientific CRBasic dataloggers: CR6 series, CR1000X series, CR300 series (with MD485), CR800 series (with MD485), CR1000 (with MD485), CR3000 (with MD485)
- CS240DM easily interfaces with the MeteoPV Platform without coding
- CS240DM can connect directly with Modbus RTU RS-485 Networks
- Calibration services with certification available

<b>Sensor:</b>	Precision 1000 ohm class A platinum sensing element
<b>Accuracy:</b>	$\pm (0.15 + 0.002t) ^\circ\text{C}$
<b>Temperature Range:</b>	$-40$ to $135 ^\circ\text{C}$
<b>Temperature Coefficient:</b>	TCR = 3850 ppm/K
<b>Long-term Stability:</b>	Max $R_o$ drift = 0.04% after 1000 h at $400 ^\circ\text{C}$

<b>CS240 Measuring Current:</b>	0.1 to 0.3 mA
<b>Disk Diameter:</b>	2.54 cm (1.0 in)
<b>Overall Sensor Length:</b>	6.35 cm (2.5 in)
<b>Overmolded Joint Dimensions</b>	
<b>Width:</b>	1.12 cm (0.44 in)
<b>Height:</b>	1.47 cm (0.58 in)
<b>Length:</b>	5.72 cm (2.25 in)
<b>Cable Diameter:</b>	0.622 cm (0.245 in)
<b>Disk Material:</b>	Anodized aluminum
<b>Weight:</b>	90.7 g (0.2 lb) with 3.2 m (10.5 ft) cable
<b>CS240DM Analog-to-Digital Module:</b>	24-bit Adc
<b>A/D Measurement</b>	
<b>Uncertainty:</b>	±0.015 °C
<b>Power Consumption:</b>	15 mA
<b>Surge Protection:</b>	1200 V isolation
<b>Environmental Protection:</b>	Rugged overmolding with IP65 rating
<b>Approvals:</b>	UL AWM 2586 1000V 105 °C; CSA AWM 600V 105 °C FT1
	Conforms with Electromagnetic Compatibility Directive (EMC)
	Conforms with the Restriction of Hazardous Substances Directive (RoHS2)
<b>Compliance:</b>	View EU Declaration of Conformity at <a href="http://www.campbellsci.com/cs240">www.campbellsci.com/cs240</a> or <a href="http://www.campbellsci.com/cs240dm">www.campbellsci.com/cs240dm</a>
	Compliant with IEC 60751, DIN EN 60751, Industrial Design (IEC Class 4) (according to IEC 751)
<b>CS240 Cable</b>	
<b>Jacket Material:</b>	Black semi-gloss PVC, UL VW-1 sunlight resistant for outdoor use
<b>Wire Size and Type:</b>	24 AWG (7/32) tinned copper
<b>Nominal Wire Diameter:</b>	0.61 mm (0.024 in)
<b>Insulation Type:</b>	PVC
<b>UL:</b>	AWM 10012 1000V 105 °C
<b>Filler:</b>	Fibrillated polypropylene as required for uniform round construction.
<b>Drain:</b>	24 AWG (7/32) tinned copper (cabled, touching foil)
<b>Shield:</b>	Aluminum/mylar (100% coverage, 25% minimum overlap, foil facing in)

**CS240DM Cable****Features:**

High flex construction with jacket for pulling through conduit

**Jacket Material:**

Black semi-gloss PVC, UL VW-1 sunlight resistant for outdoor use; weld spatter and oil resistant

**Nominal Wire Diameter:**

0.61 mm (0.024 in)

**Agency Approvals:**

UL AWM Style 2463 and NEC/CEC CMX outdoor

## 7. Installation

If you are programming your datalogger with *Short Cut*, skip Section 7.3, *Wiring* (p. 9), and Section 7.4, *Datalogger Programming* (p. 12). *Short Cut* does this work for you. See Section 4, *QuickStart* (p. 2), for a *Short Cut* tutorial.

### 7.1 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.

### 7.2 Mounting/Cable Strain Relief

**CAUTION**

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

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#### 7.2.1 Adhesive Mounting Strip

The CS240 and CS240DM include an adhesive mounting strip adhered to the flat surface of the aluminum disk. To mount the sensor, remove the paper from the mounting strip and adhere it to the back of the PV module or other device. The mounting strip must be adhered to a clean surface for its adhesive to function properly.

**CAUTION**

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

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#### 7.2.2 Kapton Tape

Use Kapton tape for cable strain relief; a yellow label on the cable indicates where the cable must be secured (FIGURE 7-1). If the temperature might exceed 70 °C, Kapton tape is also required to better secure the sensor to the measurement surface (FIGURE 7-2).

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

1. For strain relief, place the first strip of tape across the cable just below the yellow heat shrink (FIGURE 7-1) and rub the tape surface to remove bubbles.



2. Place the other strips of tape on the first strip of tape and rub the tape surface to remove bubbles. These strips of tape should be perpendicular to the first strip of tape—forming an “H” (FIGURE 7-2).
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 (Section 7.1, *Placement on a Photovoltaic (PV) Module* (p. 7)).
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.

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**CAUTION**

Do not go over the sensor molding with the tape; only put tape over the metal disk portion of the sensor.

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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 (FIGURE 7-2).



FIGURE 7-1. Strain Relief Label on the Cable

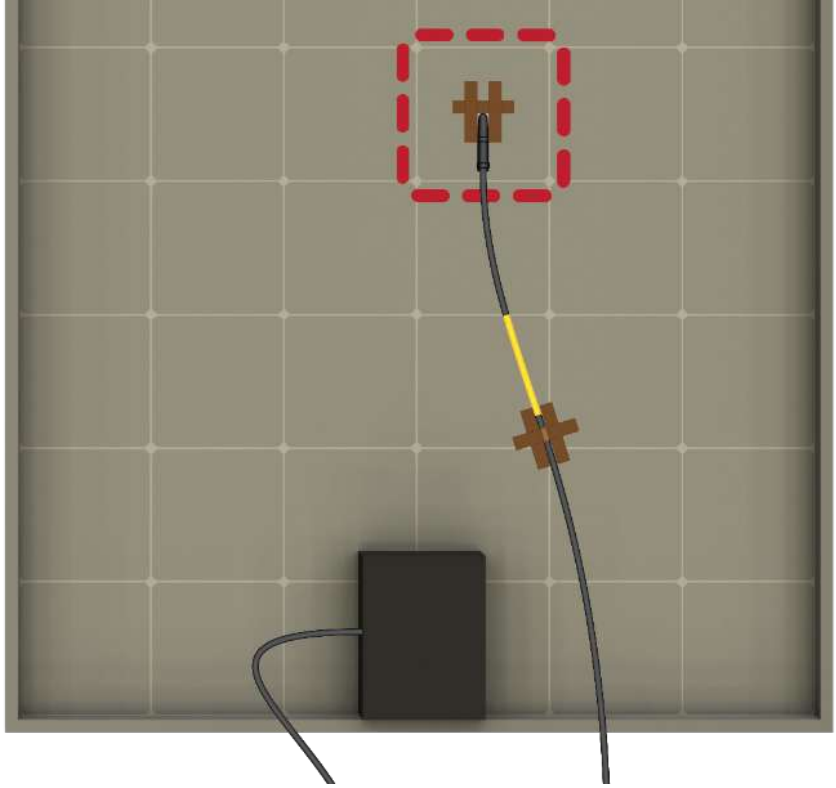


FIGURE 7-2. Proper Kapton Tape Usage

### 7.2.3 Strain Relief of CS240DM Analog-to-Digital Module

The CS240DM has an analog-to-digital, smart-sensor module incorporated that needs to be secured to the side of PV module. Use two cable tie tabs and cable ties to do this.

## 7.3 Wiring

### 7.3.1 Circuit Diagrams

FIGURE 7-3 provides the circuit diagrams for the CS240 2-wire configuration. FIGURE 7-4 provides the circuit diagram for the CS240DM or the CS240 4-wire configuration.

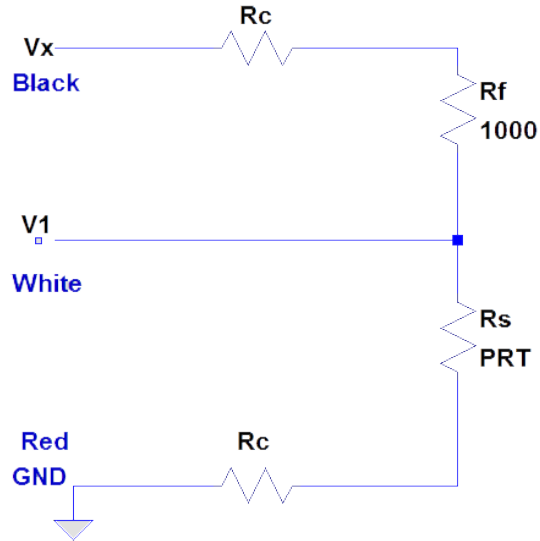


FIGURE 7-3. 2-Wire Circuit Diagram

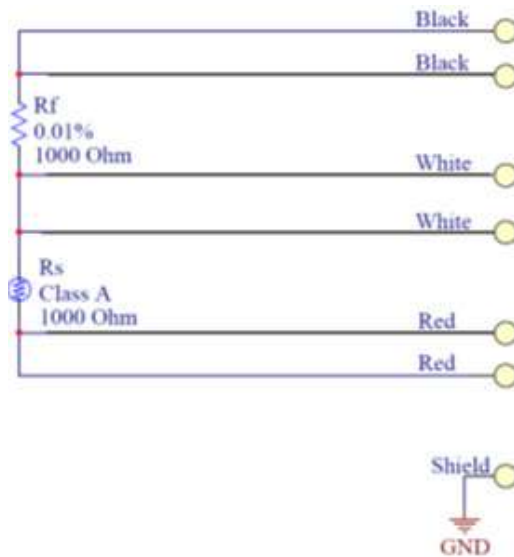


FIGURE 7-4. 4-Wire Circuit Diagram

### 7.3.2 CS240-to-Datalogger Wiring

The dataloggers can measure the CS240 by using a 2-wire or 4-wire configuration (TABLE 7-1 and TABLE 7-2). The 2-wire configuration accuracy decreases, relative to the 4-wire, as a function of the cable length. The 4-wire configuration eliminates resistance due to cable length and is the most accurate way to measure this sensor. The CS240 is shipped ready for the 2-wire configuration. The wires used only for the 4-wire configuration are taped to the side of the cable.

<b>TABLE 7-1. Wire Color, Function, and Datalogger Connection for the CS240 2-Wire Configuration</b>		
<b>Wire Color</b>	<b>Wire Function</b>	<b>Datalogger Connection Terminal</b>
Black	Voltage excitation input	U configured for voltage excitation <sup>1</sup> , <b>EX</b> , <b>VX</b> (voltage excitation)
White	Analog voltage output	U configured for single-ended analog input <sup>1</sup> , <b>SE</b> (single-ended, analog input)
Red	Reference	$\perp$ (analog ground)
<sup>1</sup> U terminals are automatically configured by the measurement instruction.		

<b>TABLE 7-2. Wire Color and Datalogger Connection for the CS240 4-Wire Configuration</b>		
<b>Wire Color</b>	<b>Wire Function</b>	<b>Datalogger Connection Terminal</b>
White	Analog voltage output	U configured for differential high analog input <sup>1</sup> , <b>DIFF H</b> (differential high, analog-voltage input)
White	Reference	U configured for differential low analog input <sup>1</sup> , <b>DIFF L</b> (differential low, analog-voltage input)
Red	Voltage excitation input	U configured for voltage excitation <sup>1</sup> , <b>EX</b> , <b>VX</b> (voltage excitation)
Red	Analog voltage output	U configured for differential high analog input <sup>1</sup> , <b>DIFF H</b> (differential high, analog-voltage input)
Black	Reference	U configured for differential low analog input <sup>1</sup> , <b>DIFF L</b> (differential low, analog-voltage input)
Black	Ground	$\perp$ (analog ground)
Clear/ Shield	Shield	$\perp$ (analog ground)
<sup>1</sup> U terminals are automatically configured by the measurement instruction.		

### 7.3.3 CS240DM Wiring

Connections to Campbell Scientific dataloggers are given in TABLE 7-3. The wiring for the CS240DM is also available in *Device Configuration Utility*.

TABLE 7-3. Wire Color, Function, and Datalogger Connection for the CS240DM		
Wire Color	Wire Function	Datalogger Connection Terminal
White/ Brown Striped	12 V Power	12V
Brown	Ground (Power)	G
Blue	RS-485 A- (D0)	C (control terminal)
White/ Blue Striped	RS-485 B+ (D1)	C (control terminal)
White/ Green Striped	RS-485 Common (Signal Ground)	⏏ (analog ground)

## 7.4 Datalogger Programming

### 7.4.1 CS240 Programming

*Short Cut* is the best source for up-to-date datalogger programming code.

If your data acquisition requirements are simple, you can probably create and maintain a datalogger 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 Section 4, *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 Appendix A, *Importing Short Cut Code Into CRBasic Editor* (p. A-1).

Programming basics for *CRBasic* dataloggers are provided in the following sections. Complete program examples for select *CRBasic* dataloggers can be found in Appendix B, *Example Programs* (p. B-1).

If applicable, please read Section 8.1, *Electrical Noisy Environments* (p. 14), and Section 8.2, *Long Cable Lengths* (p. 14), prior to programming your datalogger.

#### 7.4.1.1 Resistance Measurement

*CRBasic* instructions used to measure resistance are the **BrHalf4W** (4-wire configuration) or **BrHalf** (2-wire configuration). The **BrHalf4W()** instruction reduces cable errors, and the **BrHalf()** instruction uses the fewest input terminals.

A typical **BrHalf4W()** instruction is:

```
BrHa1f4W(CS240X,1,mV200,mV200,U1,U5,1,350,True,True,0,60,1,0)
```

A typical **BrHalf()** instruction is:

```
BrHalf(CS240X,1,mV200,U7,U3,1,350,True,0,60,1,0)
```

A multiplier of 1.0 and offset of 0.0 should be used in the instructions.

#### 7.4.1.2 Converting Resistance Measurement to Temperature

The **PRTCalc()** instruction converts the ratio  $R_s/R_o$  to temperature, where  $R_s$  is the measured resistance of the RTD, and  $R_o$  is the resistance of the RTD at 0 degrees Celsius ( $1000\ \Omega$ ).

A typical **PRTCalc()** instruction is:

```
PRTCalc(CS240T_C,1,CS240Rs/1000,1,1,0)
```

If the **BrHalf** instruction (2-wire configuration) was used to measure resistance, the following expression also must precede the **PRTCalc** instruction:

$$CS240Rs = CS240X \cdot (1000 + R_c) / (1 - CS240X) - R_c$$

Where CS240X is the variable containing the **BrHalf** measurement and  $R_c$  is the cable resistance provided on the cable label.

## 7.4.2 CS240DM Programming

### NOTE

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

A CR6 or CR1000X datalogger programmed as a Modbus Master can retrieve the values stored in the CS240DM Input Registers (TABLE 7-4). To do this, the CRBasic program requires a **SerialOpen()** instruction followed by the **ModbusMaster()** instruction.

TABLE 7-4. CS240DM Stored Values		
Value	Description	
Serial Number	Specifies the sensor serial number assigned by the factory	
Temperature	The CS240DM measures temperature by using a 4-wire configuration. The stored value is in degrees Celsius.	
Counter	The counter provides an indicator that the sensor is actively taking measurements. This value will increment once per measurement, rolling over at 10,000.	
Sensor Status	<b>Value</b>	<b>State</b>
	0	Good
	1	Open/Short
Temperature Range Check	<b>Value</b>	<b>State</b>
	0	Good/In Range
	1	Out of Range

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 CS240DM 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 CS240DM 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*.

For more information, refer to Appendix B.3, *CS240DM Program (p. B-7)*.

## 8. Operation

### 8.1 Electrical Noisy Environments

AC power lines, pumps, power inverters, and motors can be the source of electrical noise. If the CS240 sensor or datalogger is located in an electrically noisy environment, the CS240 sensor should be measured with the 60 or 50 Hz rejection option.

### 8.2 Long Cable Lengths

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

#### 8.2.1 CS240 Cable Resistance/Long Cable Lengths

Cable resistance can cause significant error. The 4-wire configuration is the best configuration for long cable lengths.

The heat shrink label on the CS240 cable provides the cable resistance (ohms). When using the 2-wire configuration, subtract this cable resistance from the measured resistance value. The value included on the label is calculated with the following equation:

Cable resistance = 0.0274 ohms • cable length (in feet)

Additional settling time may be required for cable lengths longer than 300 feet, where settling time is the delay before the measurement is made. The 60 and 50 Hz integration options include a 3 ms settling time; longer settling times can be typed into the **Settling Time** parameter in the **BrHalf4W()** or **BrHalf()** instruction.

## 8.2.2 CS240DM Long Cable Lengths

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 datalogger 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 CS240DM and *Device Configuration Utility*

*Device Configuration Utility* (*DevConfig*) is bundled in Campbell Scientific's datalogger support software and can also be acquired, at no cost, from [www.campbellsci.com/downloads](http://www.campbellsci.com/downloads). *DevConfig* can be used to change the CS240DM settings, view stored values, and update the CS240DM operating system (OS). It also provides CS240DM wiring information.

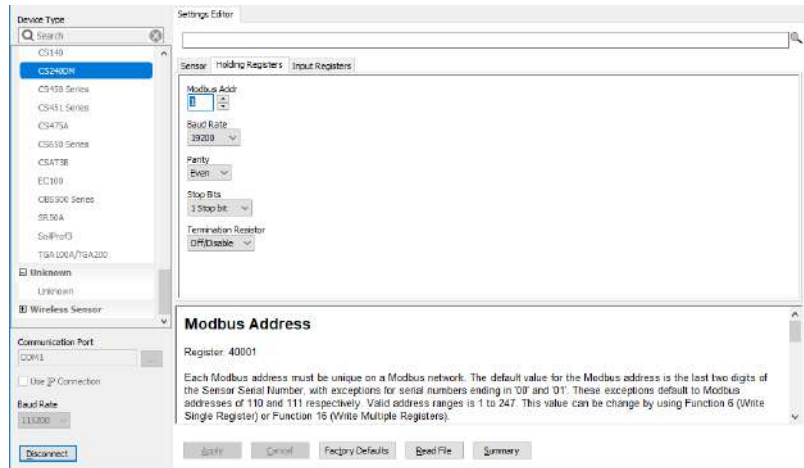
To use *DevConfig*, the CS240DM must be connected to a computer and 12 Vdc power source. A USB-to-RS-485 adapter is required to connect the CS240DM to the computer. The following is the procedure for connecting to *DevConfig*:

1. Open *DevConfig*.
2. Under **Device Type**, click **CS240DM**.
3. Follow steps listed under **Connecting to a CM240DM with a USB to RS-485 adaptor**.





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



The values stored are shown in the **Input Registers** tab.

## 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 front of this manual for more information.

### 9.1 Troubleshooting

Symptom: Temperature is NAN, -INF, -9999, -273

Verify wiring of sensor to the datalogger; cross-reference datalogger program or the measurement system wiring diagram.

Symptom: Incorrect Temperature

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

Symptom: Unstable Temperature

Make sure the clear shield or white/green striped wire is connected to datalogger ground, and the datalogger is properly grounded. For the CS240, try using the 60 or 50 Hz integration options and/or increasing the settling time.

### 9.2 Maintenance

The CS240 and CS240DM sensors require minimal maintenance. Periodically check cabling for proper connections, signs of damage, and possible moisture intrusion.

# Appendix A. Importing Short Cut Code Into CRBasic Editor

---

This tutorial shows:

- Importing a *Short Cut* program into a program editor for additional refinement
- Importing a wiring diagram from *Short Cut* into the comments of a custom program

*Short Cut* creates files, which can be imported into *CRBasic Editor*. Assuming defaults were used when *Short Cut* was installed, these files reside in the C:\campbellsci\SCWin folder:

- .DEF (wiring and memory usage information)
- .CR300 (CR300-series datalogger code)
- .CR6 (CR6-series datalogger code)
- .CR8 (CR800-series datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR1X (CR1000X-series datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)

Import *Short Cut* code and wiring diagram into *CRBasic Editor*:

1. Create the *Short Cut* program following the procedure in Section 4, *QuickStart* (p. 2). Finish the program. On the **Advanced** tab, click the **CRBasic Editor** button. The program opens in CRBasic with the name **noname.CR\_**. Provide a name and save the program.

---

## NOTE

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

---

2. The program can now be edited, saved, and sent to the datalogger.
3. Import wiring information to the program by opening the associated .DEF file. By default, it is saved in the c:\campbellsci\SCWin folder. Copy and paste the section beginning with heading “–Wiring for CRXXX–” into the CRBasic program, usually at the head of the file. After pasting, edit the information such that an apostrophe (') begins each line. This character instructs the datalogger compiler to ignore the line when compiling. You can highlight several lines of CRBasic code then right-click and select **Comment Block**. (This feature is demonstrated at about 5:10 in the [CRBasic | Features](#) video.)



# Appendix B. Example Programs

---

## B.1 CS240 Two-Wire Configuration Programs

CRBasic Example B-1. CR300 2-Wire Configuration for Measuring the CS240

```
'CR300 Series

'Declare Variables and Units
Dim CS240X
Dim CS240Rs
Public CS240T_C

Units CS240T_C=Deg C

'Define Data Tables
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min,10)
  Sample(1,CS240T_C,FP2)
EndTable

'Main Program
BeginProg
  'Main Scan
  Scan(5,Sec,1,0)
    'CS240 (2-wire) Class A RTD Back of PV Module Temperature Sensor measurement 'CS240T_C'
    BrHalf(CS240X,1,mV2500,1,Vx1,1,350,True,0,60,1,0)

    'Convert ratio to ohms and remove cable resistance
    CS240Rs=CS240X*(1000+0.274)/(1-CS240X)-0.274

    'Calculate temperature from resistance
    PRTCalc(CS240T_C,1,CS240Rs/1000,1,1,0)

    'Call Data Tables and Store Data
    CallTable Hourly
  NextScan
EndProg
```

CRBasic Example B-2. CR6 2-Wire Configuration for Measuring the CS240
<pre> 'CR6 Series  'Declare Variables and Units Dim CS240X Dim CS240Rs Public CS240T_C  Units CS240T_C=Deg C  'Define Data Tables DataTable(Hourly,True,-1)     DataInterval(0,60,Min,10)     Sample(1,CS240T_C,FP2) EndTable  'Main Program BeginProg     'Main Scan     Scan(5,Sec,1,0)         'CS240 (2-wire) Class A RTD Back of PV Module Temperature Sensor measurement 'CS240T_C'         BrHalf(CS240X,1,mV200,U2,U1,1,350,True,0,60,1,0)          'Convert ratio to ohms and remove cable resistance         CS240Rs=CS240X*(1000+0.274)/(1-CS240X)-0.274          'Calculate temperature from resistance         PRTCalc(CS240T_C,1,CS240Rs/1000,1,1,0)          'Call Data Tables and Store Data         CallTable Hourly     NextScan EndProg </pre>

**CRBasic Example B-3. CR1000X 2-Wire Configuration for Measuring the CS240**

```

'CR1000X Series

'Declare Variables and Units
Dim CS240X
Dim CS240Rs
Public CS240T_C

Units CS240T_C=Deg C

'Define Data Tables
DataTable(Hourly,True,-1)
    DataInterval(0,60,Min,10)
    Sample(1,CS240T_C,FP2)
EndTable

'Main Program
BeginProg
'Main Scan
Scan(5,Sec,1,0)
    'CS240 (2-wire) Class A RTD Back of PV Module Temperature Sensor measurement 'CS240T_C'
    BrHalf(CS240X,1,mV200,1,Vx1,1,350,True,0,60,1,0)

    'Convert ratio to ohms and remove cable resistance
    CS240Rs=CS240X*(1000+0.274)/(1-CS240X)-0.274

    'Calculate temperature from resistance
    PRTCalc(CS240T_C,1,CS240Rs/1000,1,1,0)

    'Call Data Tables and Store Data
    CallTable Hourly
NextScan
EndProg

```

## B.2 CS240 Four-Wire Configuration Programs

**CRBasic Example B-4. CR300 4-Wire Configuration for Measuring the CS240**

```

'CR300 Series

'Declare Variables and Units
Dim CS240X
Dim CS240Rs
Public CS240T_C

Units CS240T_C=Deg C

'Define Data Tables
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min,10)
  Sample(1,CS240T_C,FP2)
EndTable

'Main Program
BeginProg
  'Main Scan
  Scan(5,Sec,1,0)
    'CS240 (4-wire) Class A RTD Back of PV Module Temperature Sensor measurement 'CS240T_C'
    BrHalf4W(CS240X,1,mV2500,mV2500,1,Vx1,1,350,True,True,0,60,1,0)

    'Convert ratio to ohms
    CS240Rs=CS240X*1000

    'Calculate temperature from resistance
    PRTCalc(CS240T_C,1,CS240Rs/1000,1,1,0)

    'Call Data Tables and Store Data
    CallTable Hourly
  NextScan
EndProg

```

**CRBasic Example B-5. CR6 4-Wire Configuration for Measuring the CS240**

```

'CR6 Series

'Declare Variables and Units
Dim CS240X
Dim CS240Rs
Public CS240T_C

Units CS240T_C=Deg C

'Define Data Tables
DataTable(Hourly,True,-1)
    DataInterval(0,60,Min,10)
    Sample(1,CS240T_C,FP2)
EndTable

'Main Program
BeginProg
'Main Scan
Scan(5,Sec,1,0)
    'CS240 (4-wire) Class A RTD Back of PV Module Temperature Sensor measurement 'CS240T_C'
    BrHalf4W(CS240X,1,mV200,mV200,U3,U1,1,350,True,True,0,60,1,0)

    'Convert ratio to ohms
    CS240Rs=CS240X*1000

    'Calculate temperature from resistance
    PRTCalc(CS240T_C,1,CS240Rs/1000,1,1,0)

    'Call Data Tables and Store Data
    CallTable Hourly
NextScan
EndProg

```



**CRBasic Example B-6. CR1000X 4-Wire Configuration for Measuring the CS240**

```
'CR1000X Series

'Declare Variables and Units
Dim CS240X
Dim CS240Rs
Public CS240T_C

Units CS240T_C=Deg C

'Define Data Tables
DataTable(Hourly,True,-1)
    DataInterval(0,60,Min,10)
    Sample(1,CS240T_C,FP2)
EndTable

'Main Program
BeginProg
    'Main Scan
    Scan(5,Sec,1,0)
        'CS240 (4-wire) Class A RTD Back of PV Module Temperature Sensor measurement 'CS240T_C'
        BrHalf4W(CS240X,1,mV200,mV200,1,Vx1,1,350,True,True,0,60,1,0)

        'Convert ratio to ohms
        CS240Rs=CS240X*1000

        'Calculate temperature from resistance
        PRTCalc(CS240T_C,1,CS240Rs/1000,1,1,0)

        'Call Data Tables and Store Data
        CallTable Hourly
    NextScan
EndProg
```

## B.3 CS240DM Program

### CRBasic Example B-7. CS240DM RS-485 Modbus Program

*'CR6 Series Datalogger*

```

Public PTemp
Public batt_volt

Public ResultCode(4)
Public CS240DM(20)
Public AveTemp(4)
Public SD_Temp
Public AvgTemp

Alias ResultCode(1) = CS240DM_1_ResultCode
Alias ResultCode(2) = CS240DM_2_ResultCode
Alias ResultCode(3) = CS240DM_3_ResultCode
Alias ResultCode(4) = CS240DM_4_ResultCode

Alias CS240DM(1) = CS240DM_1_SN
Alias CS240DM(2) = CS240DM_1_Temperature
Alias CS240DM(3) = CS240DM_1_Counter
Alias CS240DM(4) = CS240DM_1_SensorStatus
Alias CS240DM(5) = CS240DM_1_RangeCheck
Alias CS240DM(6) = CS240DM_2_SN
Alias CS240DM(7) = CS240DM_2_Temperature
Alias CS240DM(8) = CS240DM_2_Counter
Alias CS240DM(9) = CS240DM_2_SensorStatus
Alias CS240DM(10) = CS240DM_2_RangeCheck
Alias CS240DM(11) = CS240DM_3_SN
Alias CS240DM(12) = CS240DM_3_Temperature
Alias CS240DM(13) = CS240DM_3_Counter
Alias CS240DM(14) = CS240DM_3_SensorStatus
Alias CS240DM(15) = CS240DM_3_RangeCheck
Alias CS240DM(16) = CS240DM_4_SN
Alias CS240DM(17) = CS240DM_4_Temperature
Alias CS240DM(18) = CS240DM_4_Counter
Alias CS240DM(19) = CS240DM_4_SensorStatus
Alias CS240DM(20) = CS240DM_4_RangeCheck

DataTable (Hourly,1,-1)
  DataInterval (0,60,min,10)
  Sample (20,CS240DM(),IEEE4)
  Sample (1,AvgTemp,IEEE4)
  Sample (1,SD_Temp,IEEE4)
EndTable

BeginProg

  SerialOpen (ComC1,19200,2,0,50,4)

  Scan (1,Sec,0,0)
    PanelTemp (PTemp,15000)
    Battery (batt_volt)
    ModbusMaster (ResultCode(1),ComC1,19200,111,4,CS240DM(1),1,5,3,100,2)
    ModbusMaster (ResultCode(2),ComC1,19200,2,4,CS240DM(6),1,5,3,100,2)
    ModbusMaster (ResultCode(3),ComC1,19200,3,4,CS240DM(11),1,5,3,100,2)
    ModbusMaster (ResultCode(4),ComC1,19200,4,4,CS240DM(16),1,5,3,100,2)

    AveTemp(1) = CS240DM(2)
    AveTemp(2) = CS240DM(7)
    AveTemp(3) = CS240DM(12)
    AveTemp(4) = CS240DM(17)

    AvgTemp = (AveTemp(1) + AveTemp(2) + AveTemp(3) + AveTemp(4))/4

```

```
StdDevSpa (SD_Temp,4,AveTemp())  
CallTable Hourly  
NextScan  
EndProg
```

# ***Appendix C. Sensor Material Properties***

---

The sensor consists of 6061 aluminum (clear anodized), RTD, 3M9485PC adhesive, and Santoprene® jacketed cable.

## **C.1 3M 9485PC Adhesive**

**Humidity Resistance:** High humidity has a minimal effect on adhesive performance. Bond strengths are generally higher after exposure for 7 days at 90 °F (32 °C) and 90% relative humidity.

**U.V. Resistance:** When properly applied, nameplates and decorative trim parts are not adversely affected by outdoor exposure.

**Water Resistance:** Immersion in water has no appreciable effect on the bond strength. After 100 hours in room temperature water, the bond actually shows an increase in strength.

**Temperature Cycling Resistance:** Bond strength generally increases after cycling four times through:

- 4 hours at 158 °F (70 °C)
- 4 hours at –20 °F (–29 °C)
- 16 hours at room temperature

**Chemical Resistance:** When properly applied, adhesive will hold securely after exposure to numerous chemicals including gasoline, oil, Freon™ TF, sodium chloride solution, mild acids, and alkalis.

**Heat Resistance:** Adhesive is usable for short periods (minutes, hours) at temperatures up to 350 °F (177 °C) and for intermittent longer periods (days, weeks) up to 250 °F (121 °C).

**Low Temperature Service:** –40 °F (–40 °C). Parts should be tested for low temperature shock service.





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for your local US or international representative.