

CMP6, CMP10, CMP11, CMP21

Pyranometers



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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 or by telephoning (435) 227-9000 (USA). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **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, 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.

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Table of Contents

PDF viewers: These page numbers refer to the printed version of this document. Use the PDF reader bookmarks tab for links to specific sections.

1. Introduction.....	1
2. Precautions	1
3. Initial Inspection	1
3.1 Ships With.....	1
3.2 Calibration Certificate	2
4. QuickStart	2
5. Overview	4
6. Specifications	5
6.1 Pyranometers.....	5
6.2 CVF4 Ventilation Unit.....	6
7. Installation	7
7.1 Siting	7
7.2 Mounting to a Tripod or Tower.....	10
7.3 Wiring	11
7.4 Programming.....	13
7.4.1 Solar Radiation Measurements	13
7.4.1.1 Input Range	13
7.4.1.2 Multiplier.....	14
7.4.1.3 Offset.....	14
7.4.1.4 Output Format Considerations.....	15
7.4.2 CMP21 Internal Thermistor Measurement	15
8. Maintenance/Troubleshooting.....	15
8.1 Maintenance	15
8.1.1 Changing the Desiccant	16
8.1.2 Check Sensor Output	17
8.2 Recalibration	17
8.3 Troubleshooting	17

Appendices

A. Importing Short Cut Code Into CRBasic Editor... A-1	A-1
B. Example Programs	B-1
B.1 Example Program for Measuring a CMP6	B-1
B.2 Example Program for Measuring a CMP10 or CMP11	B-2

B.3 Example Program for Measuring a CMP21B-3

C. CVF4 Ventilation Unit C-1

C.1 General InformationC-1
 C.2 CVF4 Components.....C-1
 C.3 CVF4 InstallationC-3
 C.4 WiringC-7
 C.4.1 SchematicsC-8
 C.5 CVF4 Example ProgramC-9
 C.6 CVF4 Heater/Ventilator Maintenance.....C-11

Figures

6-1. Dimensions.....5
 7-1. Pyranometer installation.....8
 7-2. Pyranometer mounted horizontally for the Northern Hemisphere
 (left) and Southern Hemisphere (right).....8
 7-3. Two views of a pyranometer mounted at an angle for the Northern
 Hemisphere9
 7-4. Pyranometer mounted at an angle for the Southern Hemisphere9
 7-5. Exploded view of the pyranometer11
 7-6. Thermopile detector schematic11
 8-1. Reading is reduced if dome is not dry or clean16
 8-2. Changing the desiccant16
 C-1. CVF4 Components (top view, no cover).....C-2
 C-2. CVF4 Components (bottom view)C-2
 C-3. CVF4 Ventilation Unit and Ships With KitC-3
 C-4. Crossarm and Nu-Rail Crossover Fitting Mounted to Mast
 (exploded view)C-4
 C-5. CM220 Right-Angle Mounting Bracket attached to
 CM200-series crossarmC-4
 C-6. Mounting CVF4 feet to a mounting stand.....C-5
 C-7. Mounting the pyranometer to the CVF4C-5
 C-8. CVF4 Mounted to CVF4 Mounting Stand (pyranometer not
 shown)C-6
 C-9. 8-Pin SchematicC-8
 C-10. 4-Pin SchematicC-9
 C-11. CVF4 filter replacement.....C-12

Tables

5-1. Model Comparison.....4
 6-1. CMP-series Specifications6
 7-1. CMP6, CMP10, and CMP11 Wire Color, Function, and Data
 Logger Connection12
 7-2. CMP21 Wire Color, Function, and Data Logger Connection12
 7-3. Multipliers Required for Flux Density and Total Fluxes14
 B-1. CR1000X Wiring for CMP6 Example ProgramB-1
 B-2. CR1000X Wiring for CMP10/CMP11 Example ProgramB-2
 B-3. CR1000X Wiring for CMP21 Example ProgramB-3
 C-1. CVF4 8-Pin WiringC-7
 C-2. CVF4 4-Pin WiringC-7
 C-3. Wiring for Program Controlling CVF4 HeaterC-9

CRBasic Examples

B-1. CR1000X Example Program for Measuring a CMP6B-1
B-2. CR1000X Example Program for Measuring a CMP10 or CMP11 ..B-2
B-3. CR1000X Example Program for Measuring a CMP21B-3
C-1. CVF4 Example ProgramC-10

CMP6, CMP10, CMP11, and CMP21 Pyranometers

1. Introduction

CMP-series pyranometers are designed for continuous outdoor monitoring of solar radiation intensity. A flat spectral sensitivity from 285 to 2800 nm enables accurate measurements in natural sunlight, under plant canopies, and in green houses or buildings. When inverted, these pyranometers can measure reflected solar radiation. Applications include monitoring global horizontal irradiance (GHI) and plane-of-array irradiance (POA). Diffuse sky radiation can also be measured with the use of a shade mechanism.

NOTE

This manual provides information only for CRBasic data loggers. For Edlog data logger support, see a retired manual at www.campbellsci.com/old-manuals.

2. Precautions

- READ AND UNDERSTAND the *Safety* section at the front of this manual.
- These pyranometers are rugged, but they should be handled as precision scientific instruments.
- Care should be taken when opening the shipping package to not damage or cut the cable jacket. If damage to the cable is suspected, contact Campbell Scientific.
- Pyranometers purchased from Campbell Scientific have different wiring than pyranometers purchased directly from Kipp & Zonen.

3. Initial Inspection

Check the contents of the shipment. If there is a shortage (see Section 3.1, *Ships With (p. 1)*), contact Campbell Scientific. If any damage has occurred during transport, immediately file a claim with the carrier and contact Campbell Scientific to facilitate repair or replacement.

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 correct product and cable length are received.

3.1 Ships With

- (2) Bolts for mounting from original manufacturer
- (1) Instruction manual from original manufacturer
- (1) Sun shield from original manufacturer
- (2) Nylon washers from original manufacturer
- (1) Lens cloth from original manufacturer

3.2 Calibration Certificate

Each pyranometer is shipped with an instruction manual provided by Kipp & Zonen that contains information concerning its construction, spectral sensitivity, cosine response, and a simple sensor check out procedure. Included with the sensor and manual is a calibration certificate with the sensor sensitivity value and serial number.

NOTE

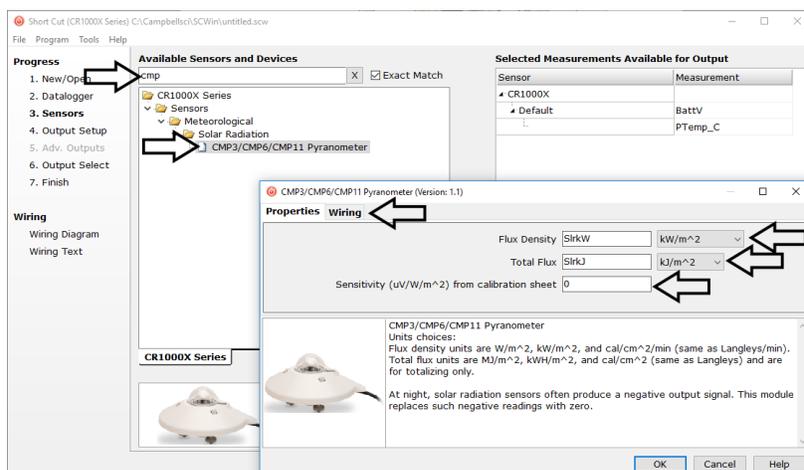
Cross check this serial number against the serial number on your pyranometer to ensure that the given sensitivity value corresponds to your sensor.

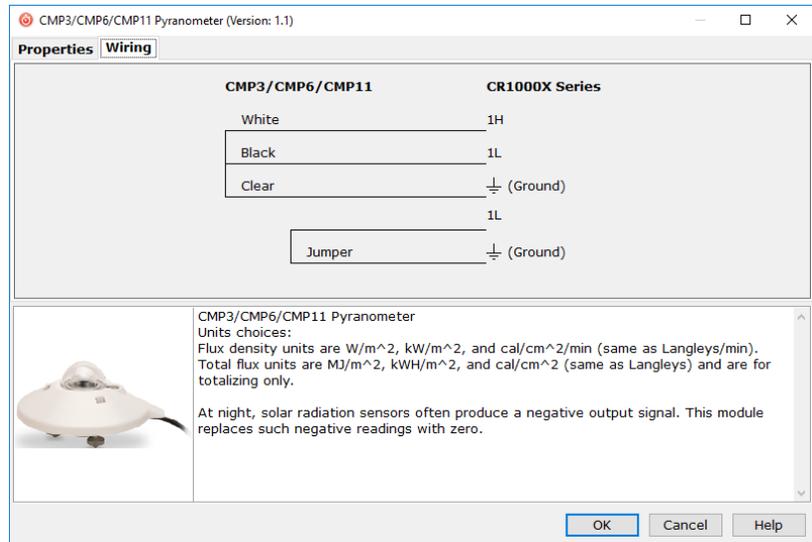
4. QuickStart

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

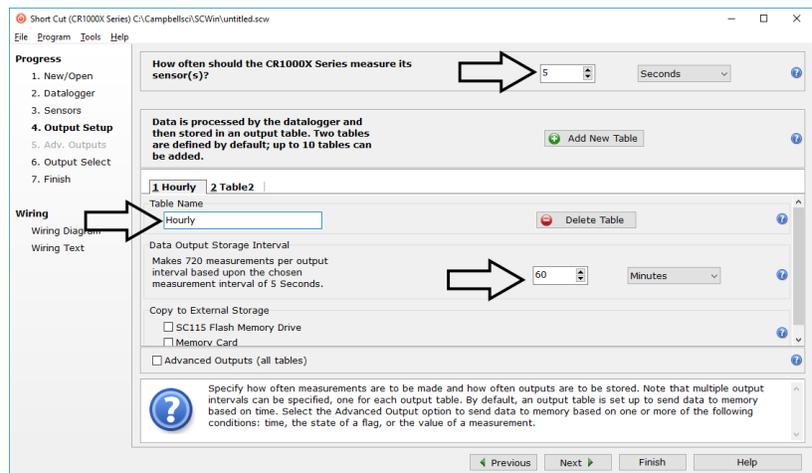
The following procedure also describes using *Short Cut* to program the pyranometer.

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 CMP, or locate the sensor in the **Sensors | Meteorological | Solar Radiation** folder. Double-click **CMP3/CMP6/CMP11 Pyranometer**. Default units are kW/m² for flux density units and kJ/m² for total flux. These can be changed by clicking the **Flux Density** and **Total Flux** boxes and selecting different values. A sensitivity value needs to be entered. This value is unique to each sensor and is listed on the calibration sheet that is included with the sensor. Click on the **Wiring** tab to see how the sensor is to be wired to the data logger.

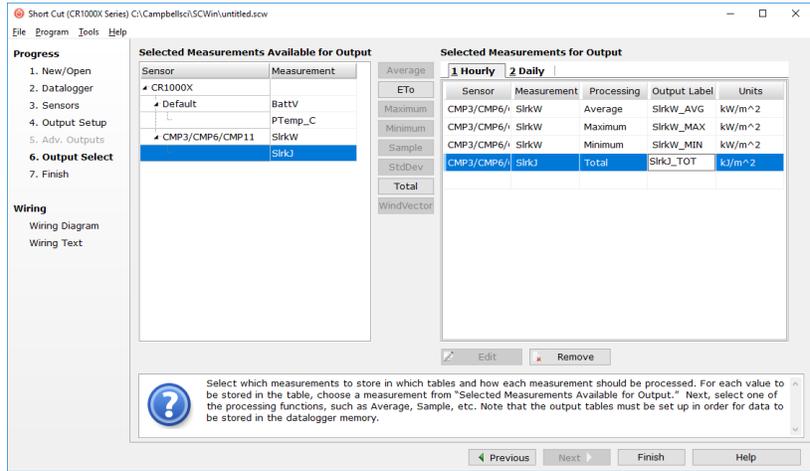




- Repeat step three for other sensors.
- In **Output Setup**, type the scan rate, meaningful table names, and the **Data Output Storage Interval**.



6. Select the measurement and its associated output options.



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

NOTE

Short Cut uses the execution interval to make total flux calculations (TABLE 7-3). This needs to be taken into account while editing the *Short Cut* program.

5. Overview

The model differences are provided in TABLE 5-1. Refer to Section 6, *Specifications* (p. 5), for accuracy and performance information for each model.

Characteristic	CMP6	CMP10	CMP11	CMP21
ISO Classification	First Class	Secondary Standard	Secondary Standard	Secondary Standard
Internal thermistor				✓
Dome dew prevention method ¹	Drying cartridge with desiccant (Section 8.1.1, <i>Changing the Desiccant</i> (p. 16))	Internal drying cartridge that lasts ≥10 years if housing is not opened. Reduces maintenance by eliminating need to replace desiccant.	Drying cartridge with desiccant (Section 8.1.1, <i>Changing the Desiccant</i> (p. 16))	Drying cartridge with desiccant (Section 8.1.1, <i>Changing the Desiccant</i> (p. 16))

¹ The CVF4 Heater Ventilator Unit is also available to keep the domes free from dew (Appendix C, *CVF4 Ventilation Unit* (p. C-1)).

The pyranometers consist of a thermopile sensor, housing, two glass domes, and cable. The thermopile is coated with a black absorbent coating. The paint absorbs the radiation and converts it to heat. The resultant temperature difference is converted to a voltage by the copper-constantan thermopile. The thermopile is encapsulated in the housing in such a way that it has a field of view of 180 degrees and the angular characteristics needed to fulfill the cosine response requirements.

The pyranometers are compatible with the optional CVF4 Heater/Ventilator Unit, which can keep their dome free from ice and dew (see Appendix C, *CVF4 Ventilation Unit (p. c-1)*). In some applications, the CVF4 may also reduce the deposition of dust on the dome, and therefore reduce the cleaning interval frequency.

6. Specifications

Features:

- Double glass dome
- Integrated bubble level is visible without removing sun shield
- Measures reflected solar radiation when inverted
- Desiccant-filled drying cartridge prevents dew from forming on the inner sides of the domes
- Provides measurements in direct sunlight, under plant canopies, when the sky is cloudy, and in artificial light
- Compatible with Campbell Scientific CRBasic data loggers: CR300 series, CR6 series, CR800 series, CR1000, CR1000X, CR3000, CR5000, and CR9000(X)

6.1 Pyranometers

Dimensions are shown in FIGURE 6-1 and the other specifications are provided in TABLE 6-1.

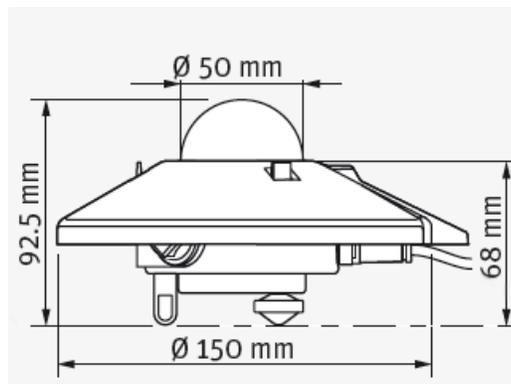


FIGURE 6-1. Dimensions

TABLE 6-1. CMP-series Specifications			
Specification	CMP6	CMP10/CMP11	CMP21
ISO Classification	First Class	Secondary Standard	
Maximum irradiance	2000 W•m ⁻²	4000 W•m ⁻²	
Spectral range (50% points)	285 to 2800 nm		
Response time (95 %)	<18 s	<5 s	
Expected daily uncertainty	<5%	<2%	
Zero offset due to thermal radiation (200 W•m ⁻²)	<15 W•m ⁻²	<7 W•m ⁻²	
Zero offset due to temperature change (5 K•hr ⁻¹)	<4 W • m ⁻²	<2 W•m ⁻²	
Non-stability (change/year)	<1 %	<0.5%	
Non-linearity (0 to 1000 W•m ⁻²)	<1%	<0.2%	
Directional error (up to 80° with 1000 W•m ⁻² beam)	<20 W•m ⁻²	<10 W•m ⁻²	
Tilt error (at 1000 W•m ⁻²)	<1%	<0.2%	
Level accuracy	0.1°		
Operating temperature	-40 to 80 °C		
Temperature dependence of sensitivity	<4% (-10 to 40 °C)	<1% (-10 to 40 °C)	<1% (-20 to 50 °C)
Sensitivity	5 to 20 μV / W•m ⁻²	7 to 14 μV / W•m ⁻²	
Typical signal output for atmospheric applications	0 to 20 mV	0 to 15 mV	
Weight	0.6 kg (1.3 lb) without cable; 0.9 kg (2 lb) with 10 m (33 ft) cable		
Impedance ¹	20 to 200 Ω	10 to 100 Ω	

¹ Impedance is defined as the total electrical impedance at the radiometer output connector fitted to the housing. It arises from the electrical resistance in the thermal junctions, wires, and passive electronics within the radiometer.

EU Declaration of Conformity:

View at: www.campbellsci.com/cmp6cbl and www.campbellsci.com/cmp10-l

6.2 CVF4 Ventilation Unit

- Compatible pyranometers:** CMP6, CMP10, CMP11, CMP21
- Power supply:** 12 VDC, 0.9 A (with 5.5 W heater)
- Operating temperature range:** -40 to 70 °C
- Ventilation power:** 5 W continuously

Heating power:	5.5 W
Heater induced offset:	<1 W•m ⁻² (with CMP10/CMP11 pyranometer)
Weight without cable:	1.6 kg (3.5 lb)
Height:	12.95 cm (5.1 in)
Length:	35.5 cm (14.0 in)
Width:	23.0 cm (9.1 in)
EU Declaration of Conformity:	View at: www.campbellsci.com/cvf4-1

7. Installation

If you are programming the data logger with *Short Cut*, skip Section 7.3, *Wiring* (p. 11), and Section 7.4, *Programming* (p. 13). *Short Cut* does this work for you. See Section 4, *QuickStart* (p. 2), for a tutorial.

7.1 Siting

The pyranometer is usually installed horizontally for global horizontal measurements. However, the pyranometer can be installed at any angle for POA measurements and in the inverted position for reflected measurements. In all cases it will measure the solar flux incident on the sensor surface.

Site the pyranometer to allow easy access for maintenance while ideally avoiding any obstructions or reflections above the plane of the sensing element. It is important to mount the pyranometer such that a shadow or reflection will not be cast on it at any time.

If this is not possible, try to choose a site where any obstruction over the azimuth range between earliest sunrise and latest sunset has an elevation not exceeding 5°. Diffuse solar radiation is less influenced by obstructions near the horizon. For instance, an obstruction with an elevation of 5° over the whole azimuth range of 360° decreases the downward diffuse solar radiation by only 0.8%.

The sensor should be mounted with the cable pointing towards the nearest magnetic pole. For example, in the Northern Hemisphere, point the cable toward the North Pole (FIGURE 7-1 through FIGURE 7-4).

NOTE

Appendix C, *CVF4 Ventilation Unit* (p. C-1), provides the mounting information for the CVF4 ventilation unit.

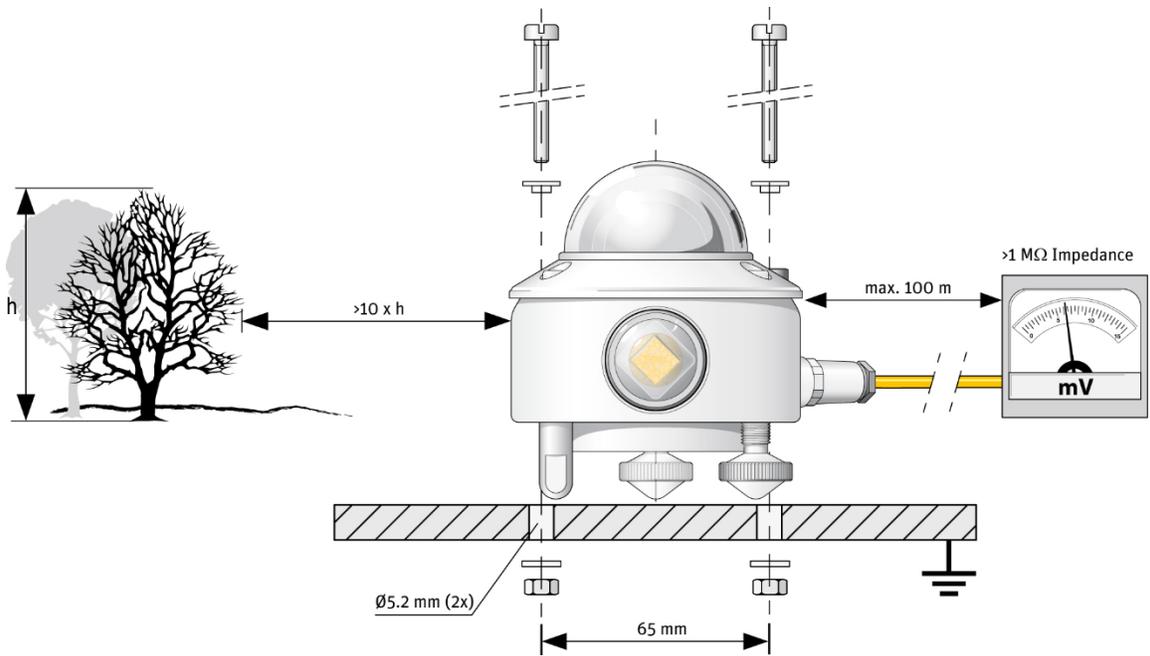


FIGURE 7-1. Pyranometer installation

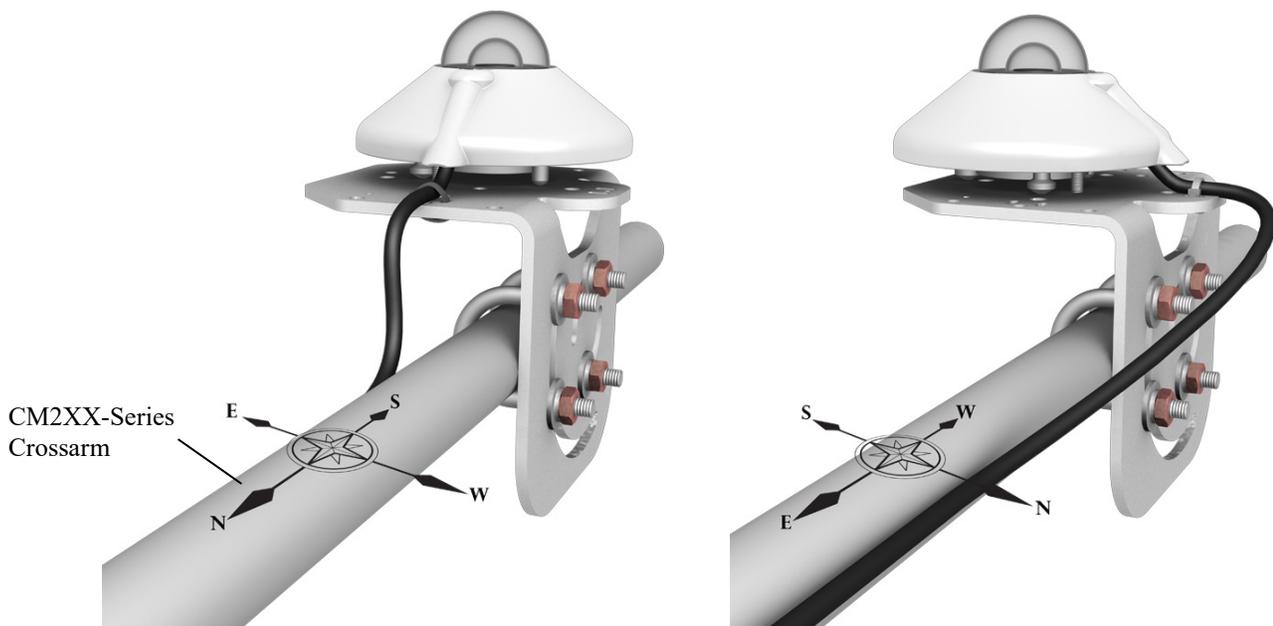


FIGURE 7-2. Pyranometer mounted horizontally for the Northern Hemisphere (left) and Southern Hemisphere (right)



FIGURE 7-3. Two views of a pyranometer mounted at an angle for the Northern Hemisphere



FIGURE 7-4. Pyranometer mounted at an angle for the Southern Hemisphere

7.2 Mounting to a Tripod or Tower

Tools required for installation on a tripod or tower:

4 mm (5/32-inch) Allen wrench
8 mm (5/16-inch) open-end wrench for U-bolt nuts
Tape measure
UV-resistant wire ties
Side-cut pliers
Compass
Step ladder

The pyranometers include a bubble level and two leveling screws, which allow them to be leveled horizontally without using a leveling base. They typically mount to a crossarm via the CM255 or CM255LS Mounting Stand.

NOTE

The CM255 and CM255LS are not compatible with a pyranometer housed in a CVF4 Ventilation Unit. The CVF4 mounts to a tripod or tower by using the CVF4 Mounting Stand and either the CM220 Right-Angle Mount or the 1-inch-by-1-inch Nu-Rail Crossover Fitting. Refer to Appendix C, *CVF4 Ventilation Unit (p. c-1)*, for more information.

The CM255 and CM255LS can be adjusted to any angle from horizontal to vertical. If mounting the pyranometer at an angle, ensure that the crossarm is leveled horizontally before placing the bracket at its proper angle. Refer to the [015ARM, CM225, CM255, CM255LS, CM260, and CM265 Solar Radiation Sensor Mounts](#) manual for more information.

Do the following to level the pyranometer horizontally (FIGURE 7-5):

1. Attach the mounting stand to the crossarm.
2. Loosely mount the pyranometer on the mounting stand. Do not fully tighten the two mounting screws.
3. Turn the leveling screws as required to bring the bubble of the level within the ring.
4. Use the Allen wrench to tighten the mounting screws and secure the assembly in its final position. Check that the pyranometer is still correctly leveled and adjust as necessary.
5. Attach the white plastic sun screen to the pyranometer.
6. Route the sensor cable along the underside of the crossarm to the tower/tripod mast, and to the instrument enclosure.
7. Secure the sensor cable to the crossarm and mast by using cable ties.

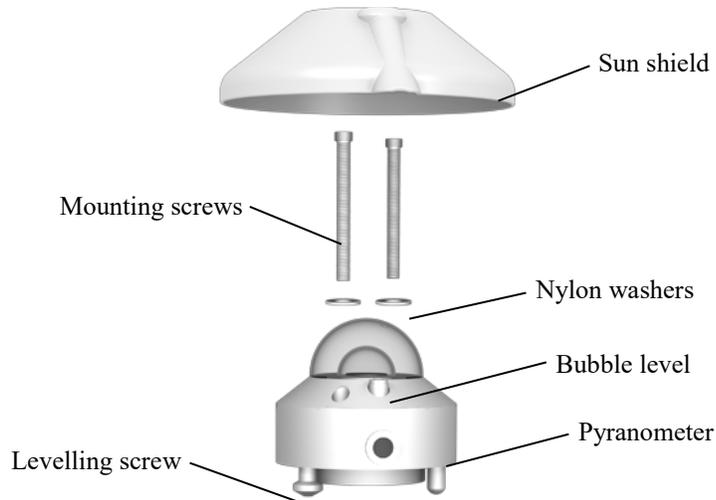


FIGURE 7-5. Exploded view of the pyranometer

7.3 Wiring

NOTE

Pyranometers purchased from Campbell Scientific have different wiring than pyranometers purchased directly from Kipp & Zonen.

FIGURE 7-6 provides a schematic of the thermopile contained in these pyranometers.

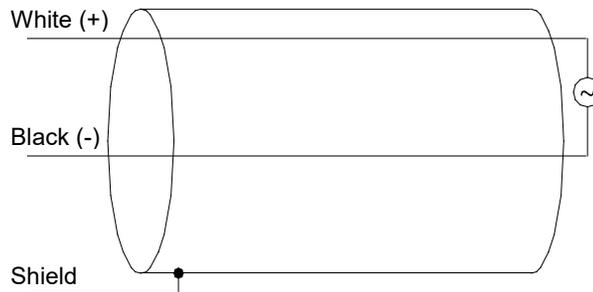


FIGURE 7-6. Thermopile detector schematic

Connections to Campbell Scientific data loggers are given in TABLE 7-1 (CMP6, CMP10, and CMP11) and TABLE 7-2 (CMP21). Solar radiation can be measured by using either differential or single-ended analog terminals. The differential measurement has better noise rejection and is therefore recommended. For differential measurements, a user-supplied jumper wire needs to be connected between the low side of the differential input and ground to keep the signal in common mode range. Single-ended and voltage excitation terminals are used to measure the CMP21 internal thermistor.

TABLE 7-1. CMP6, CMP10, and CMP11 Wire Color, Function, and Data Logger Connection			
Wire Color	Wire Function	Differential Data Logger Connection Terminal	Single-Ended Data Logger Connection Terminal
White	Signal High	U configured for differential input ¹ , DIFF H (differential high, analog-voltage input)	U configured for single-ended analog input ¹ , SE (single-ended, analog-voltage input)
Black	Signal Reference	U configured for differential input ^{1,2} , DIFF L (differential low, analog-voltage input) ²	⏏ (analog ground)
Clear	Shield	⏏ (analog ground)	⏏ (analog ground)
¹ U terminals are automatically configured by the measurement instruction. ² Jumper to ⏏ with a user-supplied wire.			

TABLE 7-2. CMP21 Wire Color, Function, and Data Logger Connection			
Wire Color	Wire Function	Differential Data Logger Connection Terminal	Single-Ended Data Logger Connection Terminal
White	Pyranometer Signal High	U configured for differential input ¹ , DIFF H (differential high, analog-voltage input)	U configured for single-ended analog input ¹ , SE (single-ended, analog-voltage input)
Blue	Pyranometer Signal Reference	U configured for differential input ^{1,2} , DIFF L (differential low, analog-voltage input) ²	⏏ (analog ground)
Yellow	Thermistor Voltage Excitation	U configured for voltage excitation ¹ , EX, VX (voltage excitation)	U configured for voltage excitation ¹ , EX, VX (voltage excitation)
Black	Thermistor Signal	U configured for single-ended analog input ¹ , SE (single-ended, analog-voltage input)	U configured for single-ended analog input ¹ , SE (single-ended, analog-voltage input)
Brown	Thermistor Reference	⏏ (analog ground)	⏏ (analog ground)
Clear	Shield	⏏ (analog ground)	⏏ (analog ground)
¹ U terminals are automatically configured by the measurement instruction. ² Jumper to ⏏ with a user-supplied wire.			

7.4 Programming

Short Cut is the best source for up-to-date data logger programming code.

If 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 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 data loggers are provided in the following sections. Complete program examples for select data loggers can be found in Appendix B, *Example Programs* (p. B-1).

7.4.1 Solar Radiation Measurements

Solar radiation can be reported as an average flux density ($\text{W}\cdot\text{m}^{-2}$) or daily total flux density ($\text{MJ}\cdot\text{m}^{-2}$). The appropriate multipliers are listed in TABLE 7-3. Programming examples are given for both average and daily total solar radiation.

The pyranometers output a low level voltage ranging from 0 to a maximum of up to 20 mV, in natural light, depending on the calibration factor and radiation level.

This voltage output is measured by using either the **VoltDiff()** CRBasic instruction or **VoltSE()** CRBasic instruction.

CAUTION

Nearby AC power lines, electric pumps, or motors can be a source of electrical noise. If the sensor or data logger is located in an electrically noisy environment, the measurement should be made with the 60 or 50 Hz rejection integration option as shown in the example programs.

7.4.1.1 Input Range

The output voltage is usually between 5 and 20 mV per $1000 \text{ W}\cdot\text{m}^{-2}$. When estimating the maximum likely value of sensor output a maximum value of solar radiation of $1100 \text{ W}\cdot\text{m}^{-2}$ can be used for field measurements on a horizontal surface. Plane-of-array irradiances can exceed $1500 \text{ W}\cdot\text{m}^{-2}$.

Select the input range as follows:

1. Estimate the maximum expected input voltage by multiplying the maximum expected irradiance (in $W \cdot m^{-2}$) by the calibration factor (in $\mu V / W \cdot m^{-2}$). Divide the answer by 1000 to give the maximum in millivolt units.
2. Select the smallest input range that is greater than the maximum expected input voltage. The exact range will depend on the sensitivity of your individual sensor and the maximum expected reading. With some data loggers, an autorange option can be used if measurement time is not critical.

7.4.1.2 Multiplier

The multiplier converts the millivolt reading to engineering units. The sensitivity value supplied by the manufacturer gives the output of the sensor as μV (micro-volts) / $W \cdot m^{-2}$. As the data logger voltage measurement instructions give a default output in mV, the following equation should be used to calculate the multiplier to give the readings in $W \cdot m^{-2}$:

$$M = 1000/c$$

Where,

M = multiplier

c = sensor output in $\mu V / W \cdot m^{-2}$

Other units can be used by adjusting the multiplier as shown in TABLE 7-3.

TABLE 7-3. Multipliers Required for Flux Density and Total Fluxes		
Units	Multiplier	Output Processing
$W \cdot m^{-2}$	M	Average
$MJ \cdot m^{-2}$	$M \cdot t \cdot 0.000001$	Totalize
$kJ \cdot m^{-2}$	$M \cdot t \cdot 0.001$	Totalize
$cal \cdot cm^{-2}$	$M \cdot t \cdot 0.0239 \cdot 0.001$	Totalize
$cal \cdot cm^{-2} \cdot min^{-1}$	$M \cdot 1.434 \cdot 0.001$	Average
$W \cdot hr \cdot m^{-2}$	$M \cdot t / 3600$	Totalize
M = calibration factor with units of $W \cdot m^{-2} / mV$ t = data logger program execution interval in seconds		

7.4.1.3 Offset

The offset will normally be fixed at zero as the sensor should output no significant signal in dark conditions. In practice, because of the nature of thermopile detector sensors, there will be some offset in dark conditions; sometimes this offset can give negative light readings. This offset varies with factors, such as rate of change of sensor temperature, so it cannot be removed with a fixed offset. Some users remove small negative readings by including code after the measurement instructions that sets negative readings to zero.

7.4.1.4 Output Format Considerations

Over-ranging may be an issue if the measurement values are totalized. Over-ranging can be prevented by storing the data in the IEEE4 format.

7.4.2 CMP21 Internal Thermistor Measurement

The thermistor is measured by using the **BrHalf()** CRBasic instruction. The value provided by the half bridge instruction needs to be converted to resistance and then converted to temperature.

The following equation is used to convert to resistance:

$$\text{Res.} = 1000 \left(\frac{V_x}{1 - V_x} \right)$$

Where,

V_x = the value provided by the half bridge instruction

The conversion to resistance is entered as a mathematical expression.

The following Steinhart-Hart equation converts resistance to temperature in degree Celsius:

$$\text{Temperature} = 1/[A + B \cdot \ln(\text{resistance}) + C \cdot (\ln(\text{resistance}))^3] - 273.15$$

Where A, B, and C are coefficients for the Steinhart-Hart equation.

The coefficients for the Steinhart-Hart equation are specific to the thermistor contained in your CMP21. A calibration certificate that lists these coefficients is shipped with each CMP21 pyranometer.

8. Maintenance/Troubleshooting

8.1 Maintenance

Every week, physically inspect the pyranometer to ensure that:

- Dome is free of dirt, condensation, and ice. Remove accumulated dust, condensation, or ice from the dome and pyranometer body by using a soft cloth dampened with water or alcohol (FIGURE 8-1).
- The drying cartridge in the CMP6, CMP11, and CMP21 have orange and opaque desiccant granules (Section 8.1.1, *Changing the Desiccant (p. 16)*).
- Mounting is secure.
- Pyranometer is level or is at the correct angle.
- Cables are in good condition.



FIGURE 8-1. Reading is reduced if dome is not dry or clean

8.1.1 Changing the Desiccant

The CMP10 has an internal drying cartridge that will last for at least ten years if the housing is not opened. This significantly minimizes maintenance.

The drying cartridge of the CMP6, CMP11, and CMP21 uses desiccant that needs to be periodically replaced. The silica gel desiccant granules in the drying cartridge should be orange and opaque. Replace the desiccant granules when they become translucent (normally after several months). Refill packs of desiccant are shipped with the pyranometer and can be purchased from Campbell Scientific. The drying cartridge uses the content of one refill pack. FIGURE 8-2 shows the replacement process.

When changing the desiccant, ensure that:

- Surfaces touching the rubber O-ring are clean. Dirt, in combination with water, can cause corrosion, harming it.
- Rubber O-ring is coated with silicon grease or petroleum jelly. The grease coating improves the O-ring seal.
- Drying cartridge is tightly threaded into the pyranometer body.

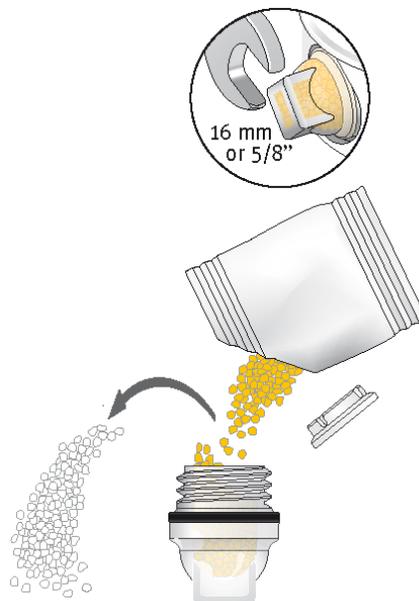


FIGURE 8-2. Changing the desiccant

8.1.2 Check Sensor Output

Check the data returned from the sensor as it will show the first indication of a fault. However, several expected phenomena can cause strange measurements. In particular, on clear, windless nights the outer dome temperature of horizontally placed pyranometers can fall as low as the dew point temperature of the air, due to infrared radiation exchange with the cold sky. (The effective sky temperature can be 30 °C lower than the ground temperature, which results in an infrared emission of $-150 \text{ W}\cdot\text{m}^{-2}$). If this happens, dew, glazed frost or hoar frost can form on the top of the outer dome and can stay there for several hours in the morning. An ice cap on the dome is a strong diffuser and can increase the pyranometer signal by up to 50% in the first hours after sunrise.

8.2 Recalibration

The calibration of the pyranometer may drift with time and exposure to radiation. Campbell Scientific recommends recalibrating every two years. The sensor should be returned to Campbell Scientific for recalibration. Refer to the [Assistance](#) page for information on returning the pyranometer to Campbell Scientific for recalibration.

8.3 Troubleshooting

Symptom: NAN, -9999, or radiation values around 0

1. Check that the sensor is wired to the differential terminal specified by the measurement instruction.
2. Verify that the range code is correct for the data logger type.
3. Measure the impedance across the white and black sensor wires. This should be around 100 ohms plus the cable resistance (typically $0.1 \text{ ohm}\cdot\text{m}^{-1}$). If the resistance is low, there may be a short circuit (check the wiring). Resistances somewhat lower than expected could be due to water ingress into the sensor or enclosure connectors. If the resistance is infinite, there is a broken connection (check the wiring).
4. Disconnect the sensor cable and check the voltage output from the sensor. With the sensor located 8 inches below a 60 W incandescent light bulb the voltage should be approximately 2.5 mV. No voltage indicates a problem with the sensor.

Symptom: sensor signal is unrealistically high or low

1. Check that the right calibration factor has been properly entered into the data logger program. Please note that each sensor has its own individual calibration factor.
2. Check the condition of the sensor cable.

Symptom: sensor signal shows unexpected variations

1. Check for the presence of strong sources of electromagnetic radiation, such as radar or radio interference.
2. Check the condition and the connection of the sensor shield wire.
3. Check the condition of the sensor cable.

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 following the procedure in Section 4, *QuickStart* (p. 2). 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. Example Programs

NOTE For an example program for using the CVF4 ventilator, see Appendix C, *CVF4 Ventilation Unit (p. c-1)*.

B.1 Example Program for Measuring a CMP6

Although this example is for the CR1000X, other CRBasic data loggers are programmed similarly. The following program measures the CMP6 every second and converts the millivolt output to $W \cdot m^{-2}$. A sensor calibration of $14.33 \mu V / W \cdot m^{-2}$ is used for the example program. Every 10 minutes, the program outputs the average and standard deviation of the flux ($W \cdot m^{-2}$) measurements.

Wiring for this example is given in TABLE B-1.

Wire Color	Description	CR1000X	Jumper ¹
White	Solar Signal (+)	1H	
Black	Solar Signal (-)	1L	
Clear	Shield	⊥	

¹ Jumper 1L to ⊥ with user-supplied 26 AWG or larger wire.

CRBasic Example B-1. CR1000X Example Program for Measuring a CMP6

```
'CR1000X Series Data Logger

Public PTemp
Public Batt_Volt
Public CMP6_Irr

Units CMP6_Irr = W/m2

DataTable (TenMin,1,-1)
  DataInterval (0,10,Min,10)
  Minimum (1,Batt_Volt,FP2,0,False)
  Sample (1,PTemp,FP2)
  Average (1,CMP6_Irr,IIEEE4,False)
  StdDev (1,CMP6_Irr,IIEEE4,False)
EndTable

BeginProg
  Scan (1,Sec,0,0)

  'Measure the Battery Voltage and Panel Temperature
  PanelTemp (PTemp,60)
  Battery (Batt_Volt)

  'Measure the CMP6. Multiplier (M) = 1000/c where c = 14.33.
  VoltDiff (CMP6_Irr,1,mV200C,1,True ,10000,60,1000/14.33,0)

  CallTable TenMin

NextScan
EndProg
```

B.2 Example Program for Measuring a CMP10 or CMP11

Although this example is for the CR1000X, other CRBasic data loggers are programmed similarly. The following program measures the CMP11 every second and converts the millivolt output to $W \cdot m^{-2}$. A sensor calibration of $8.55 \mu V / W \cdot m^{-2}$ is used for the example program. Every 10 minutes, the program outputs the average and standard deviation of the flux ($W \cdot m^{-2}$) measurements.

Wiring for this example is given in TABLE B-2.

Wire Color	Description	CR1000X	Jumper ¹
White	Solar Signal (+)	2H	
Black	Solar Signal (-)	2L	
Clear	Shield	\perp	

¹ Jumper 2L to \perp with user-supplied 26 AWG or larger wire.

CRBasic Example B-2. CR1000X Example Program for Measuring a CMP10 or CMP11

```
'CR1000X Series Data Logger

Public PTemp
Public Batt_Volt
Public CMP11_Irr

Units CMP11_Irr = W/m2

DataTable (TenMin,1,-1)
  DataInterval (0,10,Min,10)
  Minimum (1,Batt_Volt,FP2,0,False)
  Sample (1,PTemp,FP2)
  Average (1,CMP11_Irr,IEEE4,False)
  StdDev (1,CMP11_Irr,IEEE4,False)
EndTable

BeginProg
  Scan (1,Sec,0,0)

  'Measure the Battery Voltage and Panel Temperature
  PanelTemp (PTemp,60)
  Battery (Batt_Volt)

  'Measure the CMP11. Multiplier (M) = 1000/c where c = 14.33.
  VoltDiff (CMP11_Irr,1,mV200C,2,True ,10000,60,1000/8.55,0)

  CallTable TenMin

NextScan
EndProg
```

B.3 Example Program for Measuring a CMP21

Although this example is for the CR1000X, other CRBasic data loggers are programmed similarly. The following program measures the CMP21 every second. It converts the pyranometer millivolt output to $W \cdot m^{-2}$. A pyranometer calibration of $8.65 \mu V / W \cdot m^{-2}$ is used for the example program. The resistance of the internal thermistor is converted to degree Celsius and then to Kelvin. Every 10 minutes, the program outputs the average and standard deviation of the flux ($W \cdot m^{-2}$) measurements and temperature measurements.

Wiring for this example is given in TABLE B-3.

Wire Color	Description	CR1000X	Jumper ¹
White	Solar Signal (+)	3H	
Blue	Solar Signal (-)	3L	
		⊥	
Yellow	Voltage Excitation	VX1	
Black	Temp Signal	15 SE	
Brown	Signal Reference	⊥	
Clear	Shield	⊥	

¹ Jumper 3L to ⊥ with user-supplied 26 AWG or larger wire.

CRBasic Example B-3. CR1000X Example Program for Measuring a CMP21

```
'CR1000X Series Data Logger

Public PTemp
Public Batt_Volt
Public CMP21_Irr
Public CMP21_T_C
Public CMP21_T_K
Dim Rs,Vs_Vx

Units CMP21_Irr = W/m2
Units CMP21_T_C = Degrees C
Units CMP21_T_K = Degrees K

DataTable (TenMin,1,-1)
  DataInterval (0,10,Min,10)
  Minimum (1,Batt_Volt,FP2,0,False)
  Sample (1,PTemp,FP2)
  Average (1,CMP21_Irr,IEEE4,False)
  StdDev (1,CMP21_Irr,IEEE4,False)
  Average (1,CMP21_T_C,IEEE4,False)
  StdDev (1,CMP21_T_C,IEEE4,False)
  Average (1,CMP21_T_K,IEEE4,False)
  StdDev (1,CMP21_T_K,IEEE4,False)
EndTable

BeginProg
  Scan (1,Sec,0,0)
```

```
'Measure the Battery Voltage and Panel Temperature
PanelTemp (PTemp,60)
Battery (Batt_Volt)

'Measure the CMP21 pyranometer. Multiplier (M) = 1000/c where c = 8.65.
VoltDiff (CMP21_Irr,1,mV200C,3,True,10000,60,1000/8.65,0)

'CMP21 Thermistor Measurement
BrHalf (Vs_Vx,1,mV5000,15,Vx1,1,2500,True ,0,250,1.0,0)
Rs = 1000*(Vs_Vx/(1-Vs_Vx))
CMP21_T_C = 1/(1.0295e-3+2.391e-4*LN(Rs)+1.568e-7*(LN(Rs))^3)-273.15

'Convert CMP21 temp to Kelvin.
CMP21_T_K = CMP21_T_C+273.15

CallTable TenMin

NextScan
EndProg
```

Appendix C. CVF4 Ventilation Unit

C.1 General Information

Ventilation of radiometers improves the reliability and accuracy of the measurement by reducing dust, raindrops and dew on the dome. With thermopile-based instruments ventilation stabilizes the temperature of the radiometer and suppresses thermal offsets. The integrated heater can be used to disperse precipitation and melt frost, or even melt snow and ice in cold climates.

CVF4 is a low power, low maintenance ventilation unit. The only part that needs maintenance is the removable air inlet filter, which should be checked at regular intervals and cleaned or replaced when necessary.

The flow that the CVF4 creates is unique. At the top of the pyranometer dome the flow is high and it swirls to improve the air distribution over the dome. The position of the heaters and the cover material ensure only half the heating power is needed to melt frost and snow compared to older ventilation units.

CVF4 is designed to be used with Kipp & Zonen:

- CMP / SMP pyranometers
- CGR 4 pyrgeometer
- CUV 5 total UV radiometer

CVF4 can be mounted on the 2AP and SOLYS 2 sun trackers.

CVF4 replaces the successful and widely used CVF3 ventilation unit.

The CVF4 is meant to run continuously. The heater can either be powered on continuously for cold regions or be switched on by a Campbell Scientific data logger to remove dew in the morning and be switched off afterwards. In that case, the heater could operate for a period of time before and after sunrise. This saves power in situations where power is limited, such as PV operated systems.

NOTE

The CVF4 is manufactured by Kipp & Zonen and cabled by Campbell Scientific. The wiring of a CVF4 purchased from Campbell Scientific is different than the wiring of a CVF4 purchased directly from Kipp & Zonen.

C.2 CVF4 Components

FIGURE C-1 and FIGURE C-2 show the components of the CVF4. It is shipped with a cover, power cable, eight washers, four screws, Allen wrench, and five spare filters (FIGURE C-3).

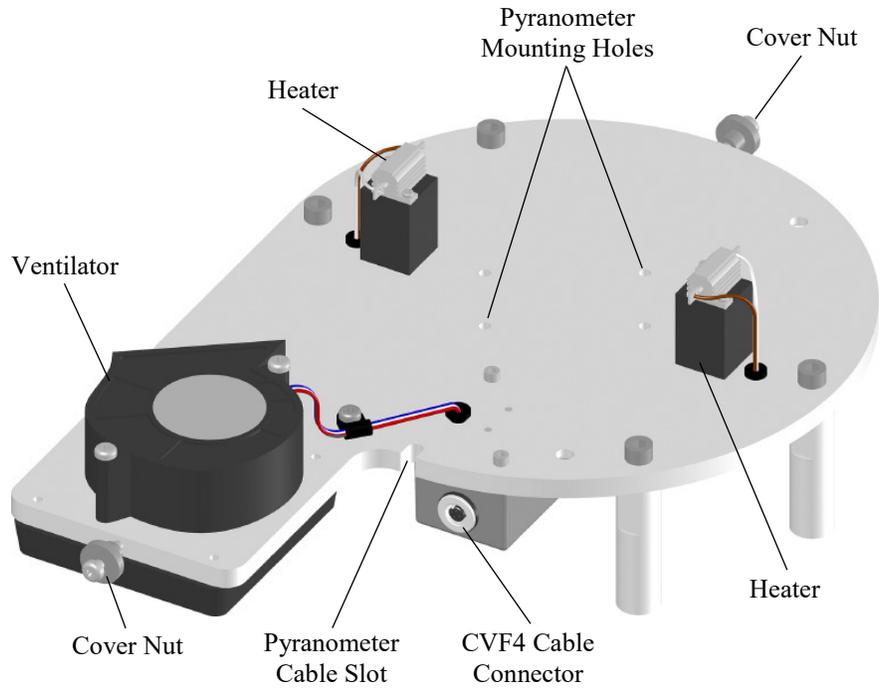


FIGURE C-1. CVF4 Components (top view, no cover)

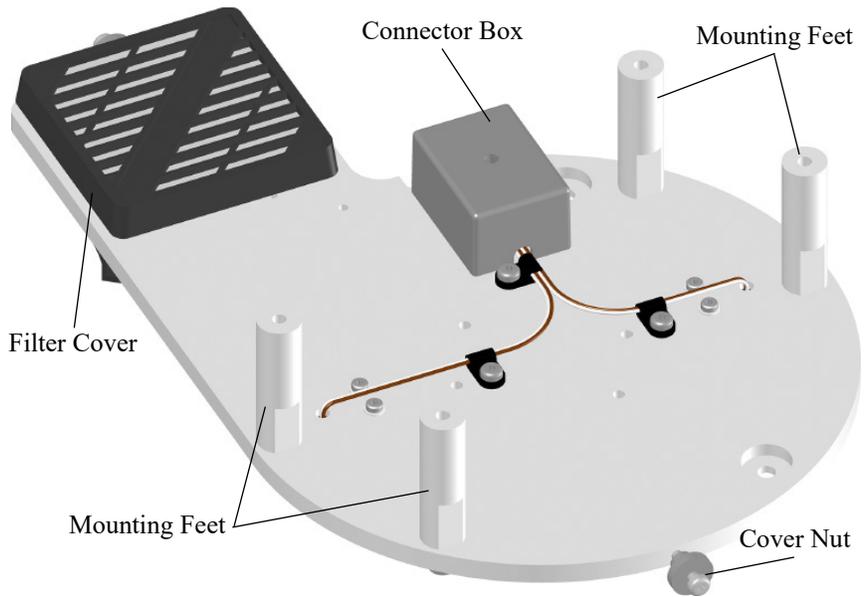


FIGURE C-2. CVF4 Components (bottom view)



FIGURE C-3. CVF4 Ventilation Unit and Ships With Kit

C.3 CVF4 Installation

Siting information provided in Section 7.1, *Siting* (p. 7), is pertinent when using the CVF4 heater/ventilation.

1. CVF4 heater/ventilator unit includes the heater/ventilator unit, white cover, cable, and mounting hardware. The CVF4 is mounted to a crossarm by using the CVF4 Mounting Stand and either the CM220 Right-Angle Mounting Bracket or the 1-inch-by-1-inch Nu-Rail Crossover Fitting.

NOTE

Refer to the Kipp & Zonen Instruction Manual if mounting the CVF4 to a SOLYS 2 Solar Tracker or to a CM 121C Shadow Ring.

Tools required for mounting to a tripod or tower are:

- Allen wrench supplied with the CVF4
- 8 mm (5/16-inch) open-end wrench for U-bolt nuts
- Tape measure
- UV-resistant wire ties
- Side-cut pliers
- Step ladder

To install, do the following:

1. Mount the crossarm to the tripod or tower (FIGURE C-4).

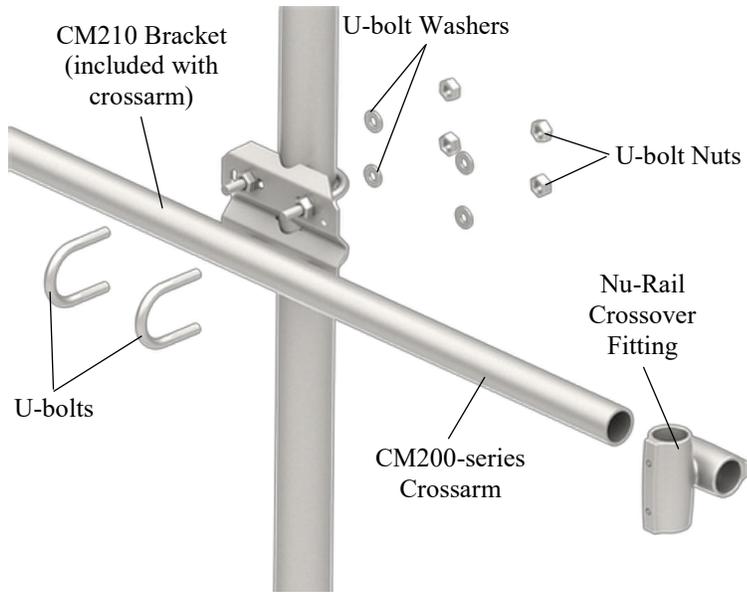


FIGURE C-4. Crossarm and Nu-Rail Crossover Fitting Mounted to Mast (exploded view)

2. Attach the CM220 Right-Angle Mounting Bracket (FIGURE C-5) or a 1-inch-by-1-inch Nu-Rail Crossover Fitting (FIGURE C-4) to the crossarm.

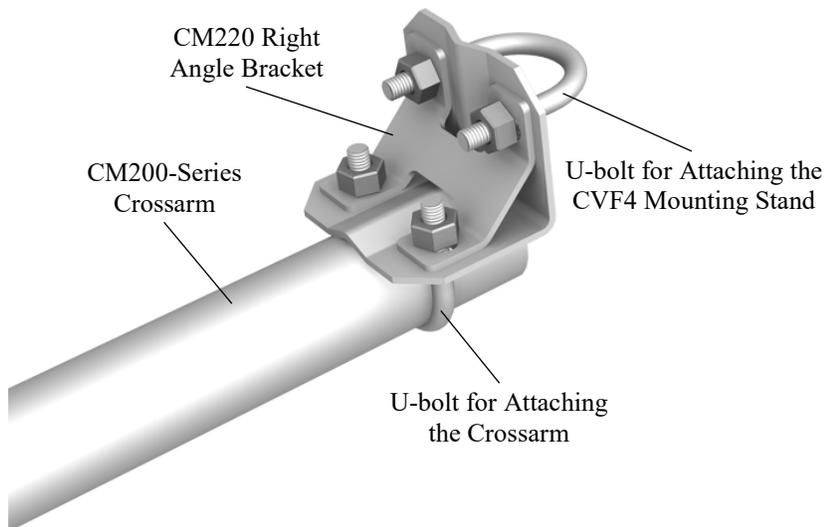


FIGURE C-5. CM220 Right-Angle Mounting Bracket attached to CM200-series crossarm

3. Place the CVF4 (without the white plastic cover) on the CVF4 Mounting Stand with the fan hanging over the edge of the plate and with the mounting feet lined up with the mounting holes.
4. Fasten the CVF4 feet to the mounting stand by using the supplied washers and screws (FIGURE C-6).

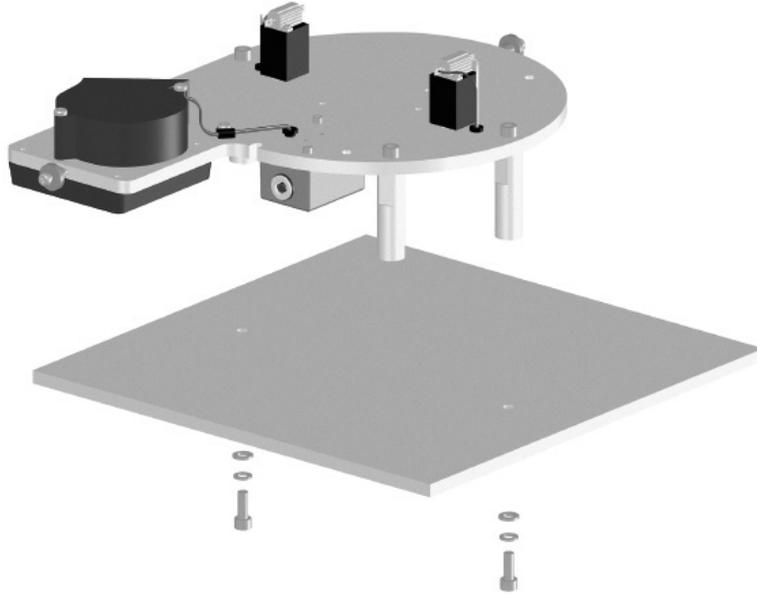


FIGURE C-6. Mounting CVF4 feet to a mounting stand

5. Loosely mount the pyranometer on the CVF4 by using the mounting screws and washers. Do not fully tighten the pyranometer two mounting screws (FIGURE C-7).

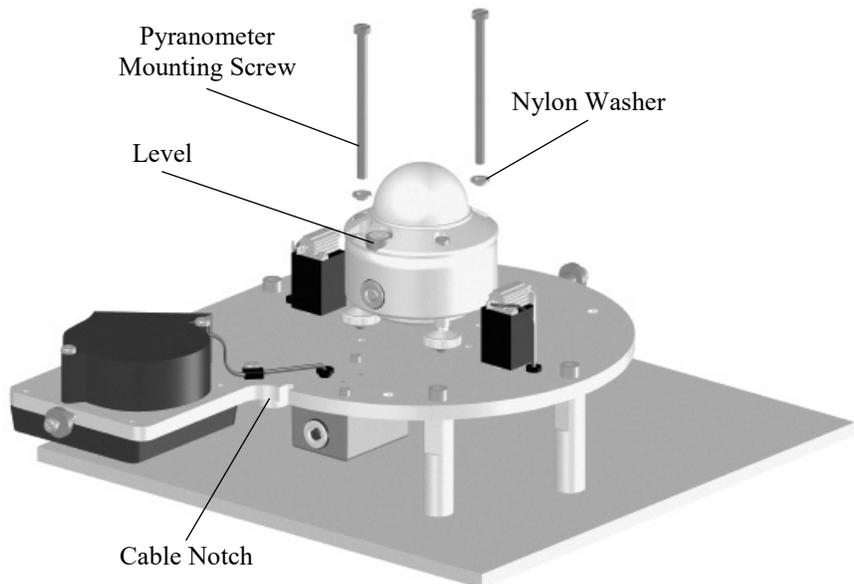


FIGURE C-7. Mounting the pyranometer to the CVF4

6. Turn the pyranometer leveling screws as required to bring the bubble of the level within the ring.
7. Tighten the pyranometer mounting screws to secure the assembly in its final position. Check that the pyranometer is still correctly leveled and adjust as necessary.
8. Route the pyranometer cable through the cable notch.
9. Fit the white cover onto the CVF4 and secure it with the cover nuts (see FIGURE C-8).

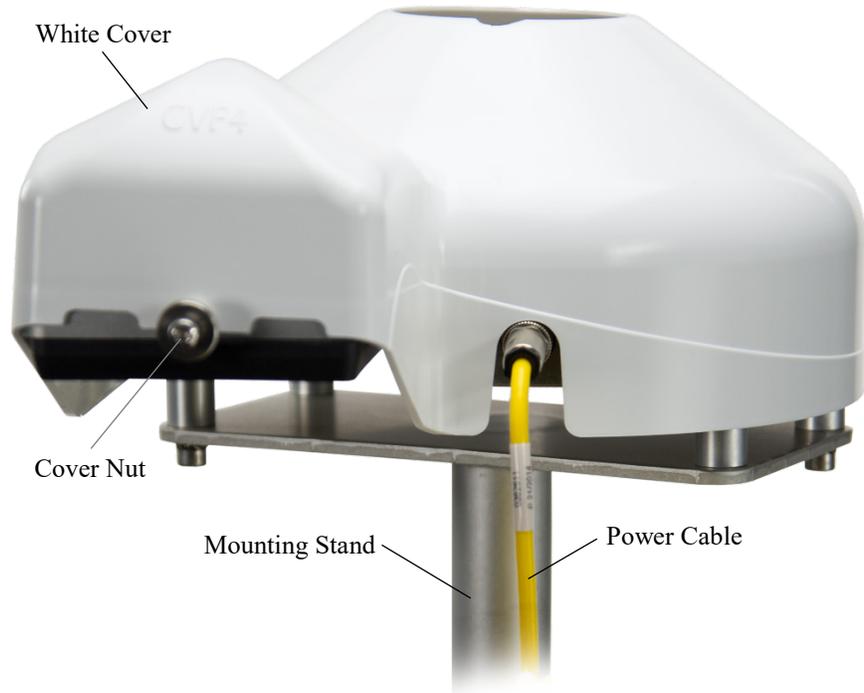


FIGURE C-8. CVF4 Mounted to CVF4 Mounting Stand (pyranometer not shown)

10. Attach the power cable to the CVF4 connector.
11. Route the cables along the underside of the crossarm to the tower/tripod mast, and to the instrument enclosure.
12. Secure the cables to the crossarm and mast by using cable ties.

C.4 Wiring

Wiring of the CVF4 is shown in TABLE C-1 and TABLE C-2. Refer to Section 7.3, *Wiring (p. 11)*, for information about wiring the pyranometer.

Wire Color	Description	Power Supply Connection	Data Logger Connection
Brown	Ventilator Power	+12V	--
Blue	Heater Power	+12V	--
Black	Power Ground	G	--
White	Tachometer Signal	--	U configured for pulse input ¹ , P (pulse input), C (control port) or P_SW (pulse, switch closure input)
Clear	Shield	--	⏏ (analog ground)
¹ U and C terminals are automatically configured by the measurement instruction.			

Wire Color	Description	Power Supply Connection	Data Logger Connection
Red	Ventilator Power	+12V	--
White	Heater Power	+12V	--
Black	Power Ground	G	--
Green	Tachometer Signal	--	U configured for pulse input ¹ , P (pulse input), C (control port) or P_SW (pulse, switch closure input)
Clear	Shield	--	⏏ (analog ground)
¹ U and C terminals are automatically configured by the measurement instruction.			

C.4.1 Schematics

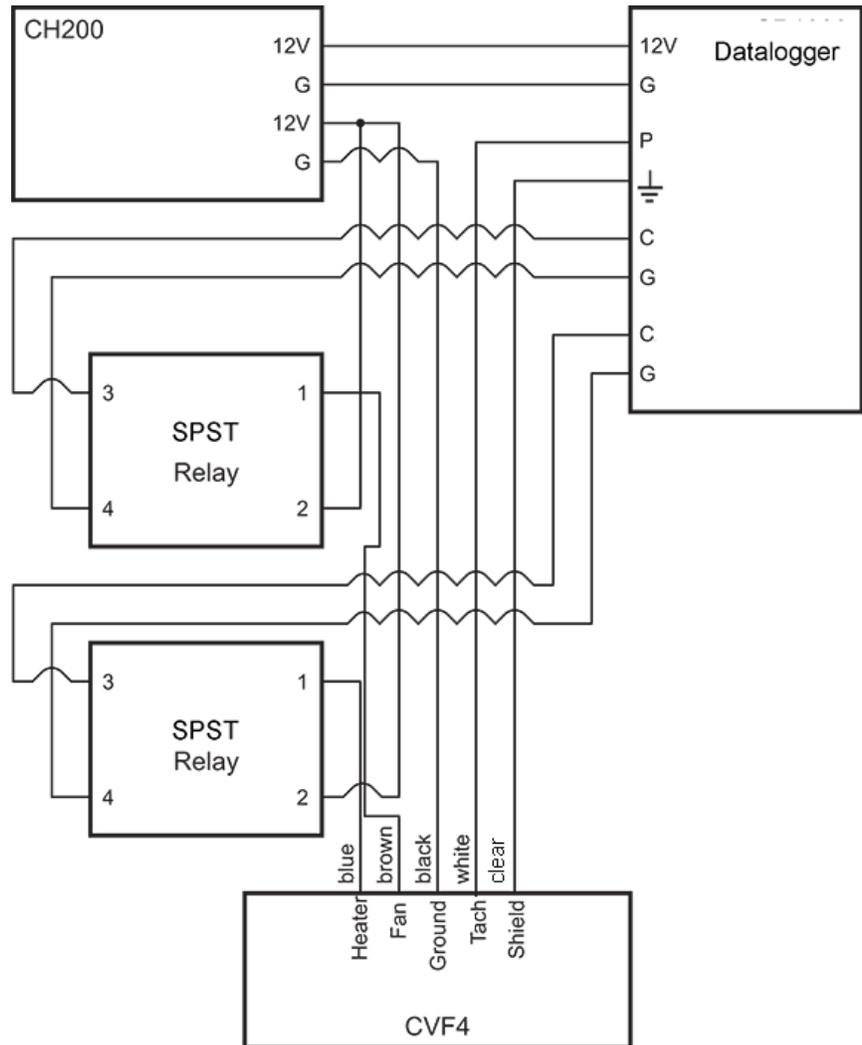


FIGURE C-9. 8-Pin Schematic

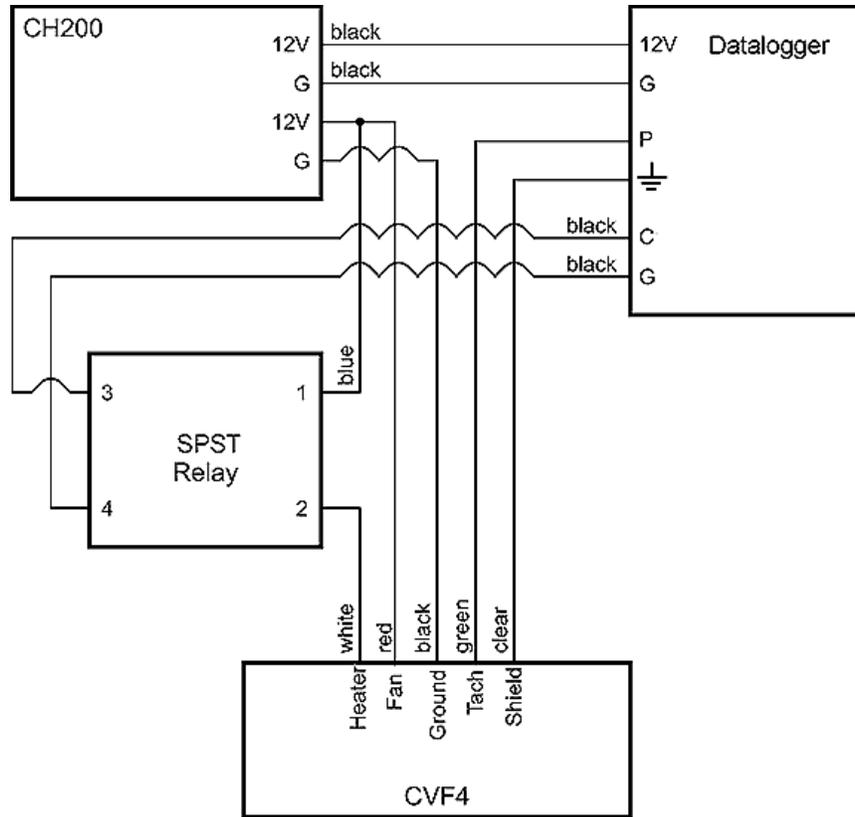


FIGURE C-10. 4-Pin Schematic

C.5 CVF4 Example Program

In the example program, the CVF4 heater is controlled based on the solar position. The 109 temperature sensor provides the temperature measurement used in the solar position instruction. The CVF4 fan is continuously on. Power to the CVF4 heater is switched using one SPST Single-Channel Solid-State Relay (FIGURE C-10). In the beginning of the program, the sensitivity of the CMP11 is entered as a constant. Wiring for the example is shown in Table C-3.

TABLE C-3. Wiring for Program Controlling CVF4 Heater

Function	CMP11 Wire Color	109 Wire Color	CVF4 Wire Color	Relay	Power Supply Terminal	CR1000X Terminal
CMP11 Signal High	White					1H
CMP11 Signal Reference	Black					1L
Clear	Shield					⊥
109 Signal		Black				VX1
109 Excitation		Red				SE3
109 Signal Ground		Purple				⊥

TABLE C-3. Wiring for Program Controlling CVF4 Heater

Function	CMP11 Wire Color	109 Wire Color	CVF4 Wire Color	Relay	Power Supply Terminal	CR1000X Terminal
109 Shield		Shield				⊥
CVF4 Ventilator Power			Red		12V	
CVF4 Heater Power			White	2		
CVF4 Power Ground			Black		G	
CVF4 Tachometer Signal			Green			P1
CVF4 Shield			Clear			⊥
Relay Control				3		C1
Relay Ground				4		G
Relay Power				1	12V	
Data Logger Power					12V	12V
Data Logger Power Ground					G	G

CRBasic Example C-1. CVF4 Example Program

```

'CR1000X Series Data Logger
'Example program for CVF4

'Declare Public Variables
Public PTemp, batt_volt
Public GH_Irradiance_CMP11
Public CVF4_Tach
Public SolarPos(5)
Public Airtemp
Public TimeArray(9)

'Declare Constants
Const CMP11_Sensitivity = 12.5
Const Latitude = 41.767561
Const Longitude = -111.85592
Const Altitude = 1358

'Define Aliases
Alias SolarPos(1) = SolarAzimuth
Alias SolarPos(2) = SunElevation
Alias SolarPos(3) = HourAngle
Alias SolarPos(4) = Declination
Alias SolarPos(5) = AirMass

'Define Data Tables
DataTable (Ten_Min,1,-1)
  DataInterval (0,10,Min,10)
  Minimum (1,batt_volt,FP2,0,False)
  Sample (1,PTemp,FP2)
  Average (1,GH_Irradiance_CMP11,IIEEE4,False)
  StdDev (1,GH_Irradiance_CMP11,IIEEE4,False)
  Average (1,CVF4_Tach,IIEEE4,False)
EndTable

```

```

'Main Program
BeginProg
Scan (1,Sec,0,0)
PanelTemp (PTemp,60) 'Measure wire panel temperature
Battery (batt_volt) 'Measure battery voltage

'Retrieve the current time for use in the Solar Position Calculation
'-----
RealTime (TimeArray())
'-----

'Measure Air Temperature
'-----
Therm109 (Airtemp,1,3,Vx1,0,60,1.0,0)
'-----

'Calculate the Solar Position
'-----
SolarPosition (SolarPos(),TimeArray,0,Latitude,Longitude,Altitude,-1,Airtemp)
'-----

'Measure GH Irradiance with CMP11 Pyranometer
'-----
VoltDiff (GH_Irradiance_CMP11,1,mV200,1,True,0,60,1000/CMP11_Sensitivity,0)
'-----

'Measure CVF4 Tachometer Output
'-----
PulseCount (CVF4_Tach,1,P1,3,1,1.0,0)
CVF4_Tach = CVF4_Tach*(60/2) 'convert to RPM, CVF4 outputs two pulses per revolution
'-----

'Control the CVF4 Heater
'-----
If SunElevation > -10 AND SunElevation < 10 Then
    PortSet (C1,1)
Else
    PortSet (C1,0)
EndIf
'-----

CallTable Ten_Min
NextScan
EndProg

```

C.6 CVF4 Heater/Ventilator Maintenance

1. Refer to Section 8.1, *Maintenance (p. 15)*, for the pyranometer maintenance.
2. Inspect the area directly under the fan to ensure that it is free from leaves, snow, or other obstructions that can inhibit air flow.
3. Regularly inspect the fan inlet by unclipping the cover. For optimal air flow, make sure the diagonal line on the filter cover is in line with the diagonal line on the ventilator (FIGURE C-11). The filter cover clicks back on the ventilator.
4. Clean or replace filters typically every 6 months.

NOTE

The filters may need to be cleaned or replaced more frequently depending on the site and air pollution.

5. If desired, clean the plastic cover by using water and a brush or cloth.

NOTE Discoloration of the plastic cover does not affect the operation of the CVF4. The cover only needs to be cleaned for aesthetic reasons.

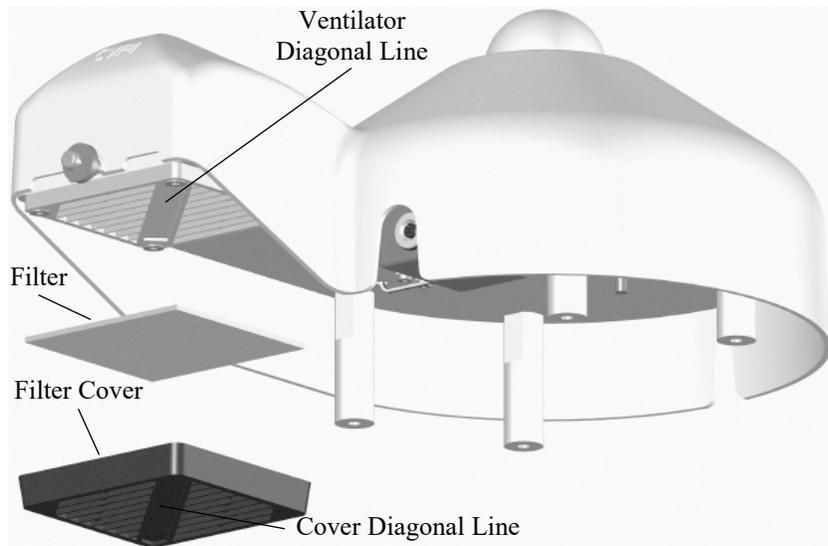


FIGURE C-11. CVF4 filter replacement



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