INSTRUCTION MANUAL

CMP6-L, CMP11-L, and CMP21-L Pyranometers

Revision: 9/13

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Tables

CMP6-L, CMP11-L, and CMP21-L 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. Uses 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.

CMP-series pyranometers are manufactured by Kipp & Zonen, and cabled by Campbell Scientific.

Before using these pyranometers, please study:

- Section 2, *Cautionary Statements*
- Section 3, *Initial Inspection*
- Section 4, *Quick Start*

More details are available in the remaining sections.

2. Cautionary Statements

- CMP-series 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, consult with a Campbell Scientific applications engineer.

3. Initial Inspection

Check the contents of the shipment. If there is a shortage (see Section 3.1, *Ships With*), 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 mfg
(1) Instruction Manual from original mfg
(1) Sun Shield from original mfg
(2) Nylon washers from original mfg

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. Quick Start

NOTE Appendix A, *CVF3 Heater/Ventilator*, provides the installation procedure for the CVF3 ventilation unit.

4.1 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 above the plane of the sensing element. It is important to mount the pyranometer such that a shadow 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 (e.g., in the Northern Hemisphere point the cable toward the North Pole); see FIGURE 4-1 through FIGURE 4-4.

4.2 Mounting

See Section 7.1, *Mounting to a Tripod Tower*, for more information.

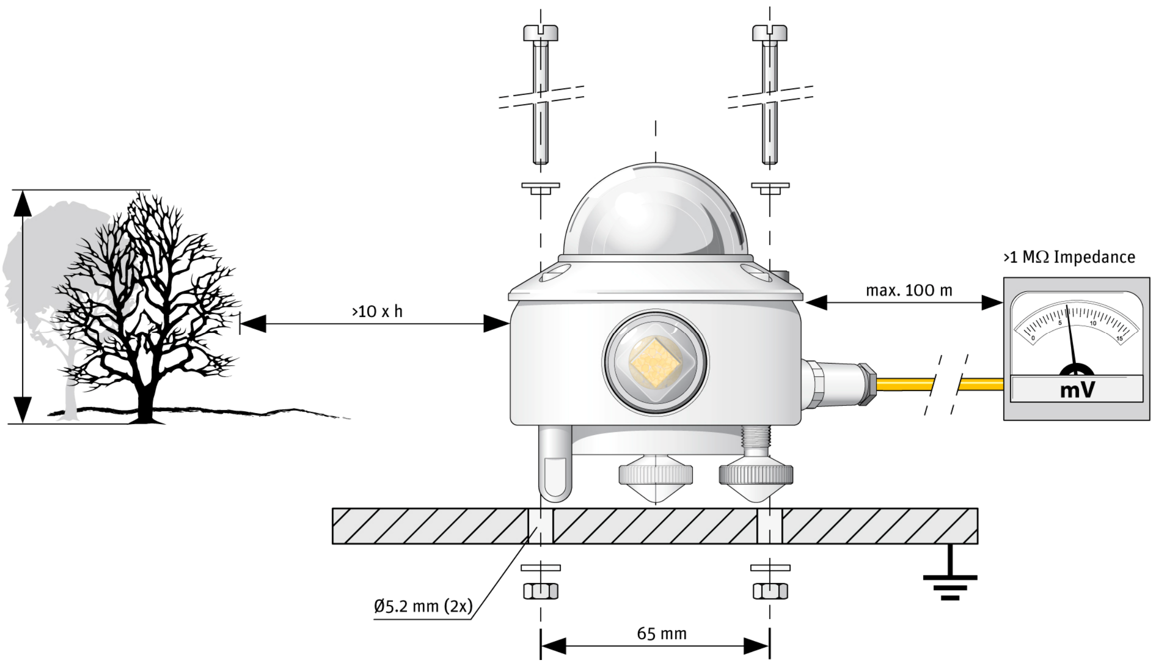


FIGURE 4-1. Pyranometer installation

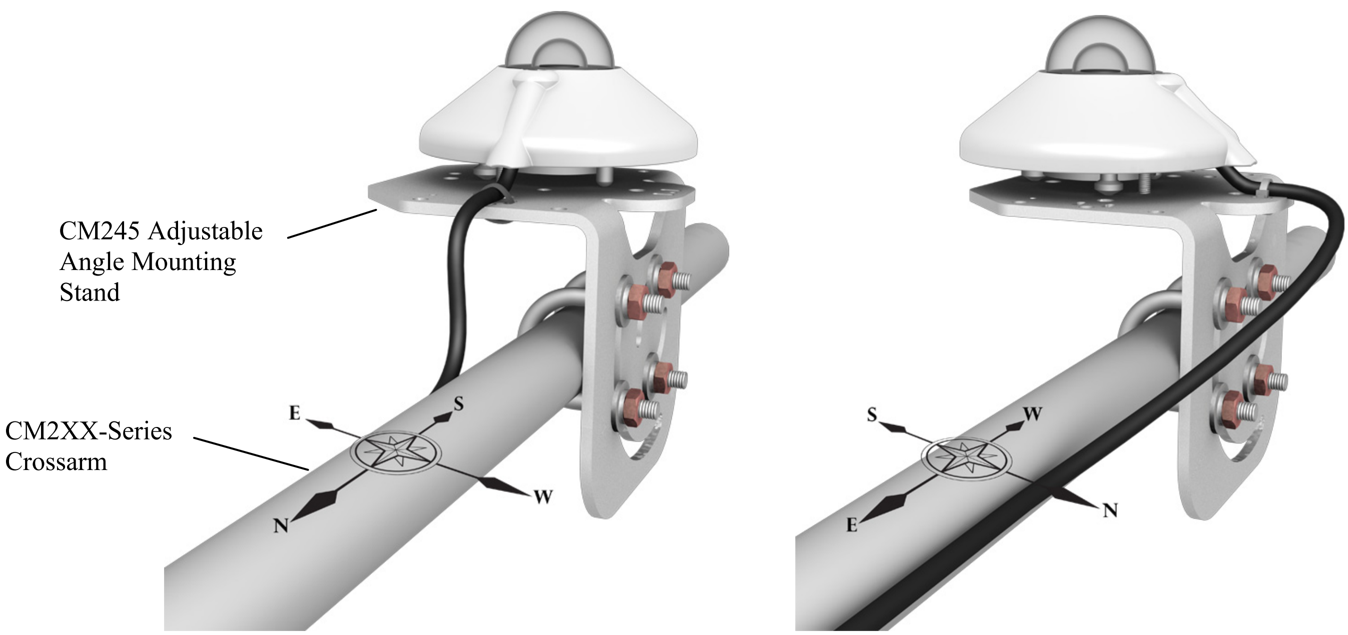


FIGURE 4-2. Pyranometer mounted horizontally for the Northern Hemisphere (left) and Southern Hemisphere (right)

FIGURE 4-3. Two views of a pyranometer mounted at an angle for the Northern Hemisphere

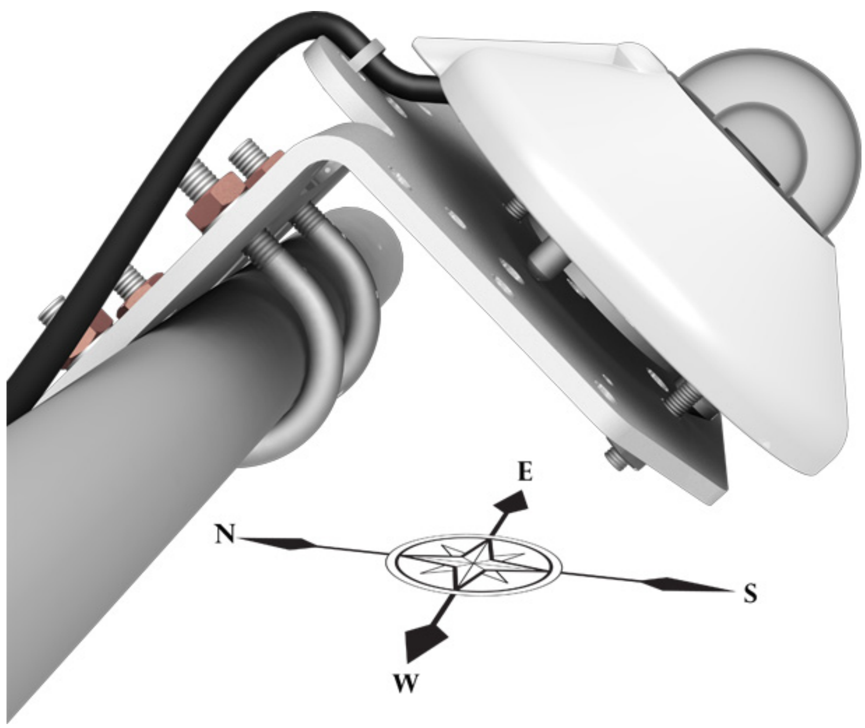


FIGURE 4-4. Pyranometer mounted at an angle for the Southern Hemisphere

4.3 Datalogger Programming / Wiring

The simplest method for programming the datalogger to measure a CMP6 or CMP11 is to use Campbell Scientific's SCWin Short Cut Program Generator (see FIGURE 4-5). Wire the pyranometer according to the wiring diagram generated by Short Cut.

NOTE The CMP21 is not included in Short Cut. Refer to Section 7, *Installation*, for wiring and programming information if not using Short Cut.

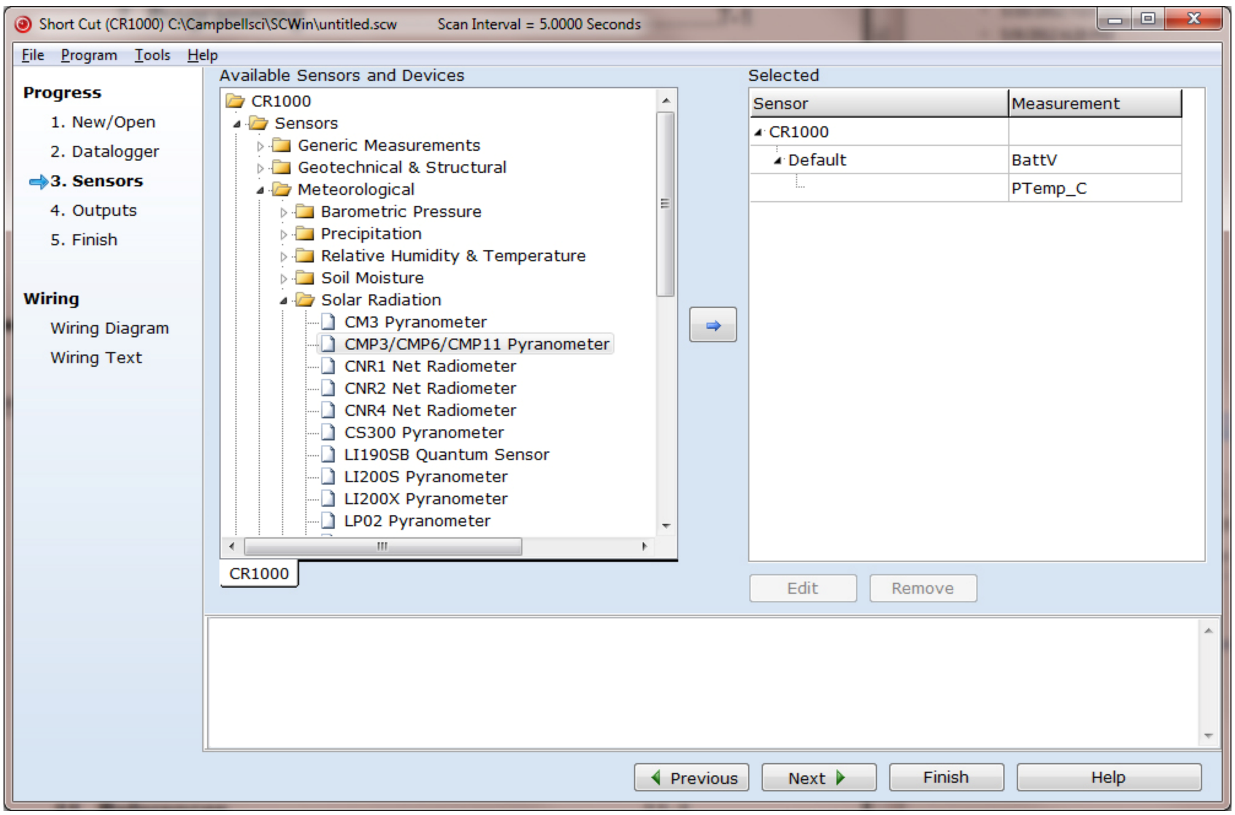


FIGURE 4-5. SCWin Short Cut Program Generator

5. Overview

5.1 Models

CMP-series models differ in accuracy and performance. See Section 6, *Specifications*. The CMP21 also includes an internal thermistor allowing individually optimized compensation of the measurements. The –L portion of the model number indicates that the pyranometer has a user-specified cable length. The pyranometers have several cable termination options. Their cables can terminate in:

- Pigtails that connect directly to a Campbell Scientific datalogger (cable termination option –PT).
- Connector that attaches to a prewired enclosure (cable termination option –PW).
- Connector that attaches to a CWS900 Wireless Sensor Interface (cable termination option –CWS). The CWS900 enables the pyranometer to be used in a wireless sensor network. Please note that this option is not available for the CMP21.

5.2 Construction

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.

6. Specifications

6.1 Pyranometers

TABLE 6-1. CMP-series Specifications

Specification	CMP6	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*	20 to 200 Ω	10 to 100 Ω	

* 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.

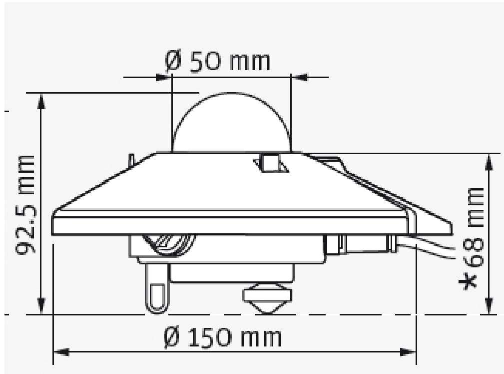


FIGURE 6-1. Dimensions of the CMP6, CMP11, and CMP21

6.2 CVF3 Ventilation Unit

Compatible Pyanometers: CMP6, CMP11, CMP21

Power supply: 12 Vdc, 1.3 A (with 10 W Heater)

Operating temperature range: –40° to 70°C

Ventilation power: 5 W continuously

Heating power: 5 W and 10 W

Heater induced offset: <1 W•m^{-2} (with CMP11 Pyranometer)

Weight without cable: 1.6 kg (3.5 lb)

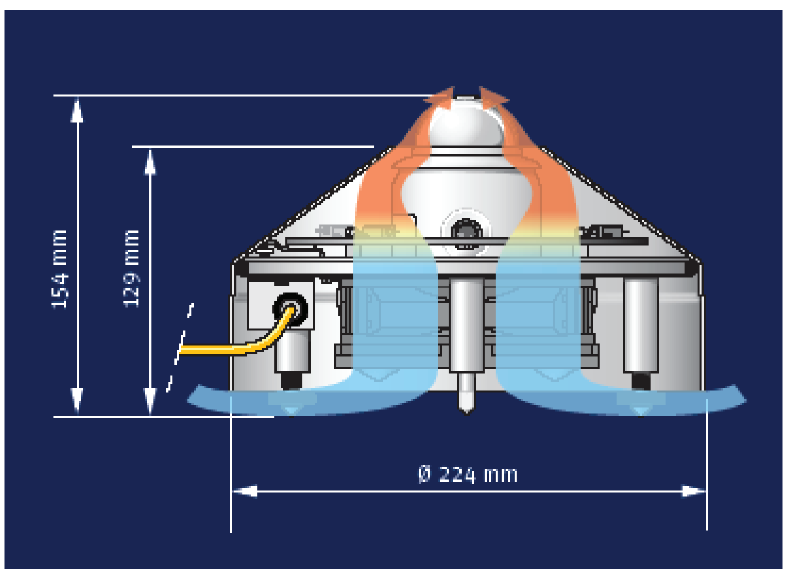


FIGURE 6-2. Dimensions of the CVF3

7. Installation

7.1 Mounting to a Tripod or Tower

Tools required for installation on a tripod or tower:

Small and medium Phillips screwdrivers
5/16”, 1/2” open end wrenches
5/32” Allen wrench
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 mount to a mast, crossarm, or pole (1.0 in. to 2.1 in. outer diameter) via the CM245 Mounting Stand.

NOTE If using a CFV3 Ventilation Unit, a different mounting stand, the 27084, is required. Refer to Appendix A, *CVF3 Heater/Ventilator*, for more information.

The CM245 includes slots that allow it to 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. Angle positions are included on the bracket label (see FIGURE 7-1 and FIGURE 7-2).

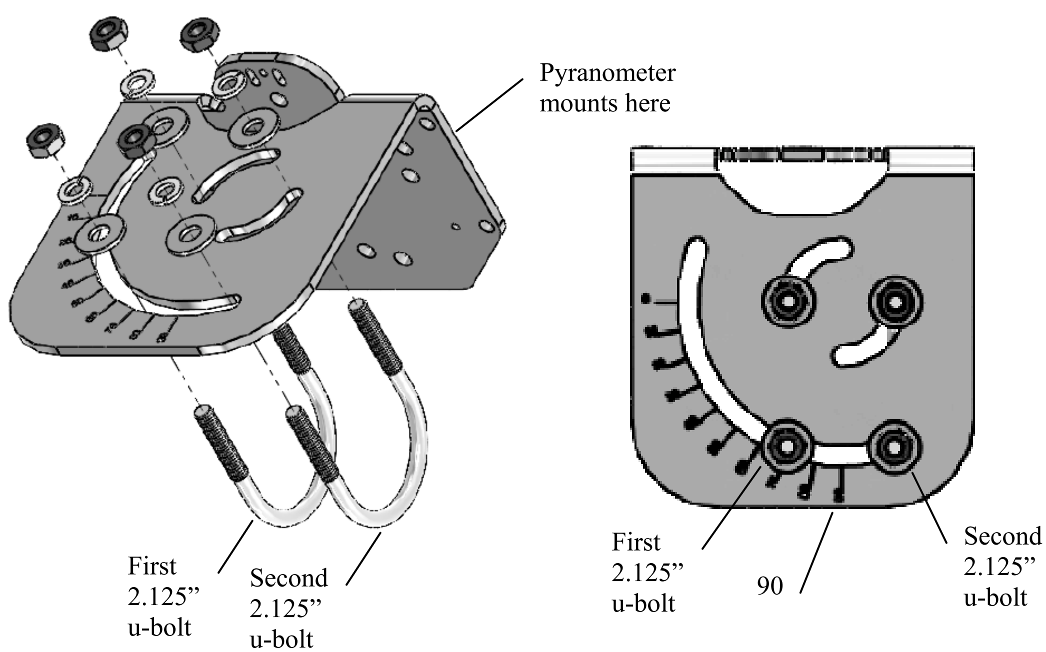
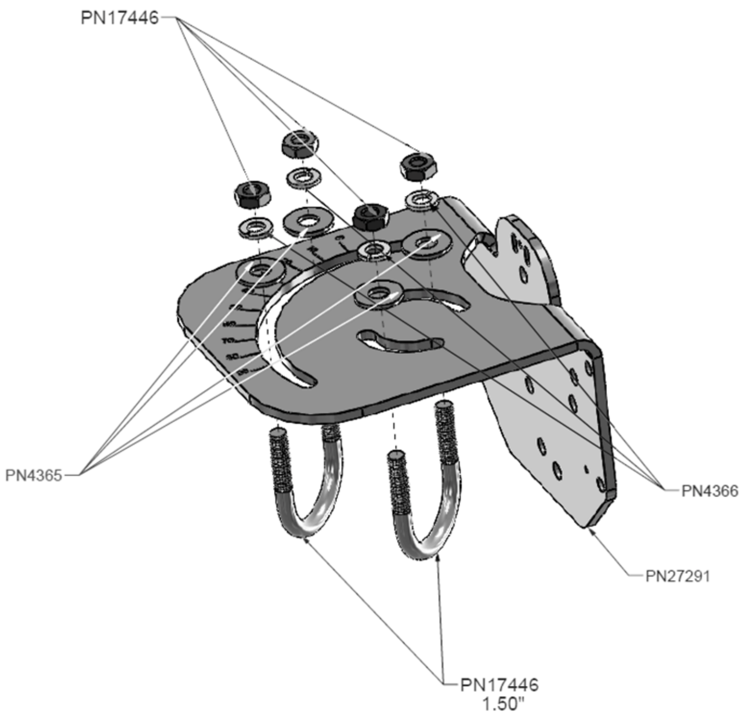


FIGURE 7-1. CM245 bracket with 2.125” u-bolts positioned to mount the pyranometer horizontally on a crossarm



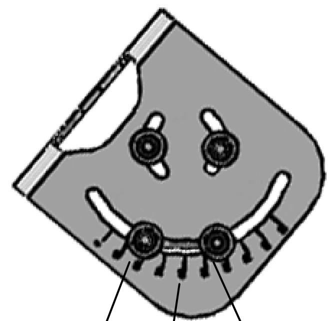


FIGURE 7-2. CM245 bracket with 1.5” u-bolts positioned to mount pyranometer at a 40° angle on a vertical pipe

Do the following to level the pyranometer horizontally (see FIGURE 7-3):

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. Tighten the mounting screws to 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.

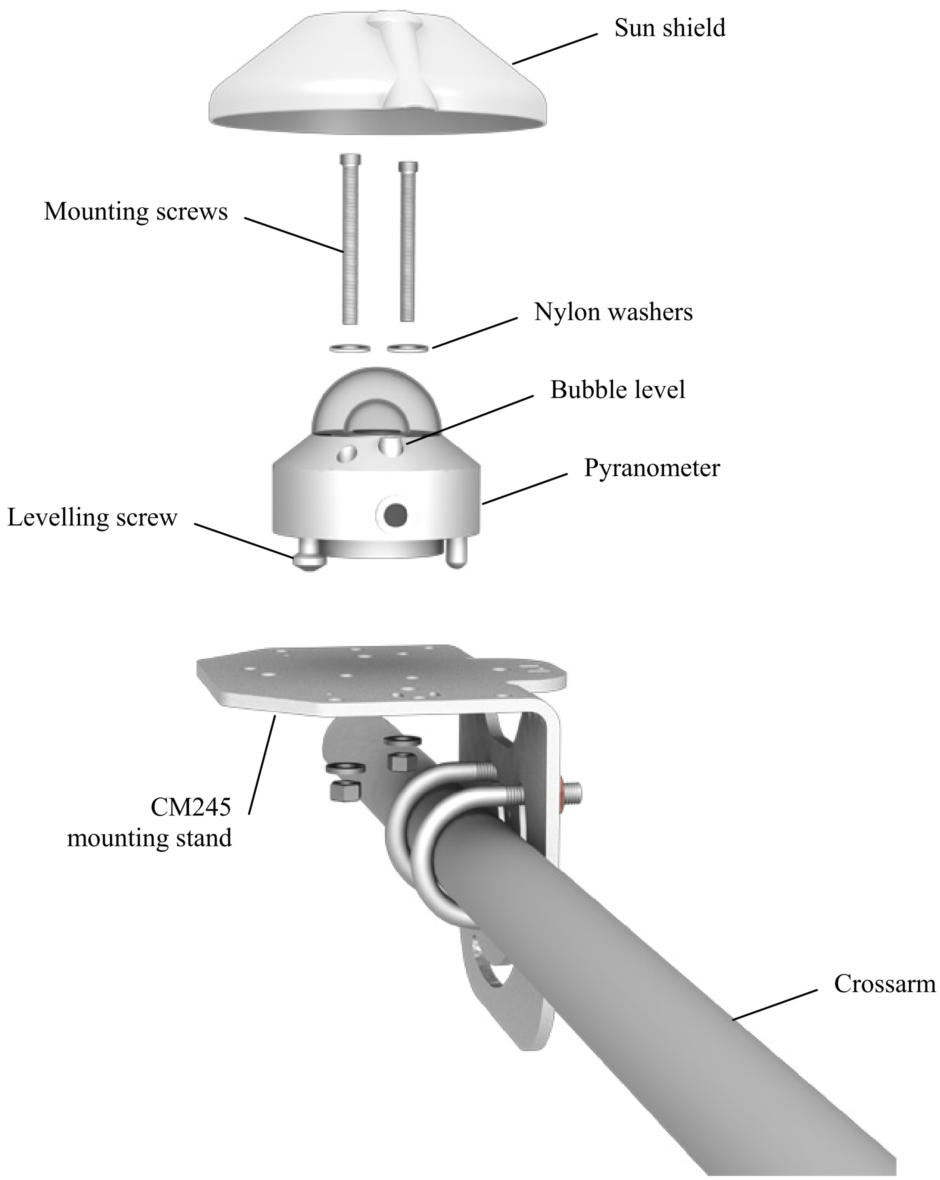


FIGURE 7-3. Exploded view of the pyranometer mounting

7.2 Wiring

NOTE Short Cut users should wire the sensor according to the wiring diagram generated by Short Cut.

The cable of the CMP6 and CMP11 has two conductors and a shield. The cable of the CMP21 has five conductors and a shield. The additional conductors on the CMP21's cable are for connecting its internal thermistor. A schematic for the CMP6, CMP11, and the thermopile of the CMP21 is provided in Section 7.2.1, *CMP6, CMP11, and CMP21 Thermopile Schematic*. Wiring for the CMP6 and CMP11 is described in Section 7.2.2, *CMP6 and CMP11 Wiring*, wiring for the CMP21 is described in Section 7.2.3, *CMP21 Wiring*.

7.2.1 CMP6, CMP11, and CMP21 Thermopile Schematic

A schematic diagram of a CMP6, CMP11, or CMP21 thermopile is shown in FIGURE 7-4.

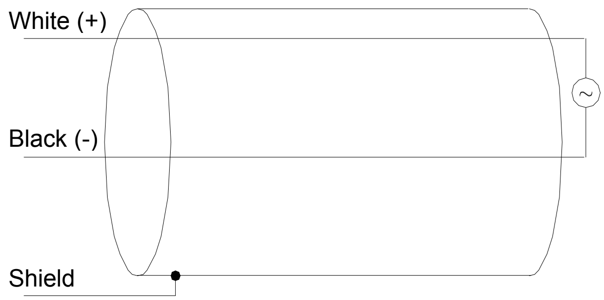


FIGURE 7-4. CMP6, CMP11, and CMP21 thermopile detector schematic

7.2.2 CMP6 and CMP11 Wiring

NOTE A CMP6 or CMP11 purchased from Campbell Scientific has different wiring than a pyranometer purchased directly from Kipp & Zonen.

The pyranometer is measured using either differential analog channels or single-ended analog channels.

A differential voltage measurement is recommended because it has better noise rejection than a single-ended measurement.

Connections to Campbell Scientific dataloggers for a differential measurement are given in TABLE 7-1. A user-supplied jumper wire should be connected between the low side of the differential input and ground (AG or ⏚) to keep the signal in common mode range.

Connections to Campbell Scientific dataloggers for a single-ended measurement are given in TABLE 7-2.

TABLE 7-1. CMP6 and CMP11 Differential Connections to Campbell Scientific Dataloggers

Color	Description	CR9000(X), CR5000, CR3000, CR1000, CR800	CR510, CR500, CR10(X)	21X, CR7, CR23X
White	Signal (+)	DIFF Analog High	DIFF Analog High	DIFF Analog High
Black	Signal (–)	*DIFF Analog Low	*DIFF Analog Low	*DIFF Analog Low
Shield	Shield	⏚	G	⏚

* Jumper to AG or ⏚ with user supplied 26 AWG or larger wire.

TABLE 7-2. CMP6 and CMP11 Single-Ended Connections to Campbell Scientific Dataloggers				
Color	**Description**	**CR9000(X), CR5000, CR3000, CR1000, CR800**	**CR510, CR500, CR10(X)**	**21X, CR7, CR23X**
White	Signal (+)	SE Analog	SE Analog	SE Analog
Black	Signal (–)	⏚	AG	⏚
Clear	Shield	⏚	G	⏚

7.2.3 CMP21 Wiring

NOTE A CMP21 purchased from Campbell Scientific has different wiring than a CMP21 purchased directly from Kipp & Zonen.

The CMP21's pyranometer can be measured using either differential analog channels or single-ended analog channels. A differential voltage measurement is recommended because it has better noise rejection than a single-ended measurement. If a differential channel is not available, a single-ended measurement can be used.

A single-ended channel and a voltage excitation channel are used to measure the CMP21's internal thermistor.

Connections to Campbell Scientific dataloggers for a differential measurement are given in TABLE 7-3. A user-supplied jumper wire should be connected between the low side of the differential input and ground (AG or ⏚) to keep the signal in common mode range. Connections to Campbell Scientific dataloggers for a single-ended measurement are given in TABLE 7-4.

TABLE 7-3. CMP21 Differential Connections to Campbell Scientific Dataloggers				
Wire Color	**Wire Label/ Description**	**CR9000(X), CR5000, CR3000, CR1000, CR800**	**CR510, CR500, CR10(X)**	**21X, CR7, CR23X**
White	Pyranometer Sig	DIFF Analog High	DIFF Analog High	DIFF Analog High
Blue	Pyranometer Ref	*DIFF Analog Low	*DIFF Analog Low	*DIFF Analog Low
Yellow	Thermistor Volt Excite	VX or EX	E	EX
Black	Thermistor Sig	Single-ended analog	Single-ended analog	Single-ended analog
Brown	Thermistor Ref	⏚	AG	⏚
Clear	Shield	⏚	G	⏚

* Jumper to AG or ⏚ with user-supplied wire.

TABLE 7-4. CMP21 Single-Ended Connections to Campbell Scientific Dataloggers				
Wire Color	**Wire Label/ Description**	**CR9000(X), CR5000, CR3000, CR1000, CR800**	**CR510, CR500, CR10(X)**	**21X, CR7, CR23X**
White	Pyranometer Sig	Single-ended analog	Single-ended analog	Single-ended analog
Blue	Pyranometer Ref	⏚	AG	⏚
Yellow	Thermistor Volt Excite	VX or EX	E	EX
Black	Thermistor Sig	Single-ended analog	Single-ended analog	Single-ended analog
Brown	Thermistor Ref	⏚	AG	⏚
Clear	Shield	⏚	G	⏚

7.3 Programming

NOTE This section is for users who write their own datalogger programs. You do not need to read this section if using our Short Cut Program Generator, or connecting the pyranometer to a prewired enclosure or CWS900 Wireless Sensor Interface. Our prewired enclosures include a datalogger program. Refer to the Wireless Sensor Manual for programming information if using a CMP6 or CMP11 with a CWS900.

7.3.1 Solar Radiation Measurements

Solar radiation can be reported as an average flux density ($W\bullet m^{-2}$) or daily total flux density ($MJ\bullet m^{-2}$). The appropriate multipliers are listed in TABLE 7-5. 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 using either a differential voltage instruction (**VoltDiff()** in CRBasic or Instruction 2 (P2) in Edlog) or a single-ended voltage instruction (**VoltSE()** in CRBasic or Instruction 1 (P1) in Edlog).

CAUTION Nearby AC power lines, electric pumps, or motors can be a source of electrical noise. If the sensor or datalogger 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.

7.3.1.1 Input Range

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

Select the input range as follows:

1. Estimate the maximum expected input voltage by multiplying the maximum expected irradiance (in W•m$^{-2)}$ by the calibration factor (in µV / W•m^{-2}). Divide the answer by 1000 to give the maximum in millivolt units.

2. Select the smallest input range which is greater than the maximum expected input voltage. Normally the 50 mV range for the CR3000, CR5000, CR9000(X), CR7, and CR23X and the 25 mV or 250 mV range for the CR800, CR850, CR1000, CR510, and CR10(X) will be suitable. The exact range will depend on the sensitivity of your individual sensor and the maximum expected reading. With some dataloggers an autorange option can be used if measurement time is not critical.

The parameter code for the input range also specifies the measurement integration time. The slow or 60 Hz rejection integration gives a more noise-free reading. The 250 µs (CRBasic) or a fast (Edlog) integration takes less power and allows for faster throughput.

7.3.1.2 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•m^{-2}. As the datalogger 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•m^{-2}:

$$m = 1000/c$$

Where,
m = multiplier
c = sensor output in µV / W•m^{-2}

Other units can be used by adjusting the multiplier as shown in TABLE 7-5.

TABLE 7-5. Multipliers Required for Flux Density and Total Fluxes

Units	Multiplier	Output Processing
W•m^{-2}	M	Average
MJ•m^{-2}	M * t * 0.000001	Totalize
kJ•m^{-2}	M * t * 0.001	Totalize
cal•cm^{-2}	M * t * 0.0239 * 0.001	Totalize
cal • cm^{-2} • min^{-1}	M * 1.434 * 0.001	Average
W • hr • m^{-2}	t / 3600	Totalize

M = calibration factor with units of W•m^{-2} / mV
t = datalogger program execution interval in seconds

7.3.1.3 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 several factors (e.g., rate of change of sensor temperature), so it cannot be removed with a fixed offset. Some users may wish to remove small negative readings by including code after the measurement instructions that sets negative readings to zero.

7.3.1.4 Output Format Considerations

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

When using Edlog, the largest number the datalogger can store in final storage is 6999 in low resolution mode (FP2) and 99999 in high resolution mode (if available). The following example shows how over-ranging can be a problem for Edlog dataloggers.

Example

Assume that daily total flux is desired, and that the Edlog datalogger scan rate is 1 second. With a multiplier that converts the readings to units of kJ•m^{-2} and an average irradiance of 0.5 kW•m^{-2}, the maximum low resolution output limit will be exceeded in less than four hours.

Solution 1 – Change the multiplier in the instruction to (m * 0.001). This will totalize MJ•m^{-2} instead of kJ•m^{-2}.

Solution 2 – Record the average flux density and later multiply the result by the number of seconds in the output interval to arrive at total flux.

Solution 3 – Record the total flux using the high resolution format. The draw back to high resolution is that it requires four bytes of memory per data point, consuming twice as much memory as low resolution. Instruction 78 is used to switch to high resolution in the Edlog dataloggers.

7.3.2 CMP21 Internal Thermistor Measurement

The thermistor is measured using a half bridge measurement instruction (BrHalf instruction in CRBasic or Instruction 5 (P5) in Edlog). 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,
Vx = the value provided by the half bridge instruction

In CRBasic, the conversion to resistance is entered as a mathematical expression. In Edlog, Instruction P59 (Bridge Transform) does the conversion.

The Steinhart-Hart equation is used to convert resistance to temperature. The Steinhart-Hart equation for converting resistance to degree Celsius is as follows:

Temperature = 1/[A + B*LN(resistance) + C*(LN(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.

In CRBasic, the Steinhart-Hart equation is entered as a mathematical expression. Edlog dataloggers can use Instruction P200 (requires a newer datalogger operating system).

7.3.3 Example Programs

7.3.3.1 CR1000 Example Program for Measuring a CMP6

Although this example is for the CR1000, other CRBasic dataloggers are programmed similarly. The following program measures the CMP6 every second and converts the millivolt output to W•m^{-2}. A sensor calibration of 14.33 µV / W•m^{-2} is used for the example program. Every 10 minutes, the program outputs the average and standard deviation of the flux (W•m^{-2}) measurements.

Wiring for this example is given in TABLE 7-6.

TABLE 7-6. CR1000 Wiring for CMP6 Example Program

Wire Color	**Description**	**CR1000**	**Jumper***
White	Solar Signal (+)	1H	
Black	Solar Signal (–)	1L	⏌
Clear	Shield	⏚	⏌

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

```
'CR1000 Series Datalogger

Public PTemp
Public Batt_Volt
Public CMP6_Irr

Units CMP6_Irr = W/m2

DataTable (TenMin,1,-1)
  DataInterval (0,1,Min,4)
  Minimum (1,Batt_Volt,FP2,0,False)
  Sample (1,PTemp,FP2)
  Average (1,CMP6_Irr,FP2,False)
  StdDev (1,CMP6_Irr,FP2,False)
EndTable

BeginProg
  Scan (1,Sec,0,0)

    'Measure the Battery Voltage and Panel Temperature
    PanelTemp (PTemp,250)
    Battery (Batt_Volt)

    'Measure the CMP6
    VoltDiff (CMP6_Irr,1,mV25C,1,True ,10000,_60Hz,1000/14.33,0)

    CallTable TenMin

  NextScan
EndProg
```

7.3.3.2 CR1000 Example Program for Measuring a CMP11

Although this example is for the CR1000, other CRBasic dataloggers are programmed similarly. The following program measures the CMP11 every second and converts the millivolt output to W•m^{-2}. A sensor calibration of 8.55 µV / W•m^{-2} is used for the example program. Every 10 minutes, the program outputs the average and standard deviation of the flux (W•m^{-2}) measurements.

Wiring for this example is given in TABLE 7-7.

TABLE 7-7. CR1000 Wiring for CMP11 Example Program

Wire Color	Description	CR1000	Jumper*
White	Solar Signal (+)	2H	
Black	Solar Signal (–)	2L	⏋
Clear	Shield	⏚	

* Jumper 2L to ⏚ with user-supplied 26 AWG or larger wire.

```
'CR1000 Series Datalogger

Public PTemp
Public Batt_Volt
Public CMP11_Irr

Units CMP11_Irr = W/m2

DataTable (TenMin,1,-1)
  DataInterval (0,1,Min,4)
  Minimum (1,Batt_Volt,FP2,0,False)
  Sample (1,PTemp,FP2)
  Average (1,CMP11_Irr,FP2,False)
  StdDev (1,CMP11_Irr,FP2,False)
EndTable

BeginProg
  Scan (1,Sec,0,0)

    'Measure the Battery Voltage and Panel Temperature
    PanelTemp (PTemp,250)
    Battery (Batt_Volt)

    'Measure the CMP11
    VoltDiff (CMP11_Irr,1,mV25C,2,True ,10000,_60Hz,1000/8.55,0)

    CallTable TenMin

  NextScan
EndProg
```

7.3.3.3 CR1000 Example Program for Measuring a CMP21

Although this example is for the CR1000, other CRBasic dataloggers are programmed similarly. The following program measures the CMP21 every second. It converts the pyranometer's millivolt output to W•m^{-2}. A pyranometer calibration of 8.65 µV / W•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•m^{-2}) measurements and temperature measurements.

Wiring for this example is given in TABLE 7-8.

TABLE 7-8. CR1000 Wiring for CMP21 Example Program

Wire Color	Description	CR1000	Jumper*
White	Solar Signal (+)	3H	
Blue	Solar Signal (–)	3L	
		⏚	
Yellow	Voltage Excitation	VX1	
Black	Temp Signal	15 SE	
Brown	Signal Reference	⏚	
Clear	Shield	⏚	

* Jumper 3L to ⏚ with user-supplied 26 AWG or larger wire.

```
'CR1000 Series Datalogger

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 (0,1,Min,8)
  Minimum (1,Batt_Volt,FP2,0,False)
  Sample (1,PTemp,FP2)
  Average (1,CMP21_Irr,FP2,False)
  StdDev (1,CMP21_Irr,FP2,False)
  Average (1,CMP21_T_C,FP2,False)
  StdDev (1,CMP21_T_C,FP2,False)
  Average (1,CMP21_T_K,FP2,False)
  StdDev (1,CMP21_T_K,FP2,False)
EndTable

BeginProg
  Scan (1,Sec,0,0)

    'Measure the Battery Voltage and Panel Temperature
    PanelTemp (PTemp,250)
    Battery (Batt_Volt)

    'Measure the CMP21 pyranometer
    VoltDiff (CMP21_Irr,1,mV25C,3,True,10000,_60Hz,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
```

7.3.3.4 CR10X Example Program for Measuring a CMP6

The following program uses a CR10X to measure a CMP6 every 10 seconds and convert the mV output to W•m^{-2} and MJ•m^{-2}. A sensor calibration of 14.33 µV / W•m^{-2} is used for this example program. The program outputs an hourly average flux (W•m^{-2}), and a daily total flux density (MJ•m^{-2}).

Wiring for the example is given in TABLE 7-9.

TABLE 7-9. CR10X Wiring for CMP6 Example Program

Wire Color	Description	CR10X	Jumper*
White	Solar Signal (+)	1H	
Black	Solar Signal (–)	1L	⏋
Clear	Shield	AG	⏌

* Jumper 1L to AG terminal on CR10X with user-supplied 26 AWG or larger wire.

```
;{CR10X}
*Table 1 Program
  01:  10.0000        Execution Interval (seconds)

; CMP6 measurement in W/m2

1:  Volt (Diff) (P2)
  1:   1              Reps
  2:   23             25 mV 60 Hz Rejection Range    ;use the 50 mV range for the CR7, 21X and CR23X
  3:   1              DIFF Channel                   ;use the 250 mV range for the CR10X if
  4:   3              Loc [ Solar_Wm2 ]              ;calibration factor is > 25 µV/Wm-2
  5:   69.7837        Multiplier                     ;1000/14.33
  6:   0              Offset

; Set negative values to zero

2:  If (X<=>F) (P89)
  1:   3              X Loc [ Solar_Wm2 ]
  2:   4              <
  3:   0              F
  4:   30             Then Do

3:  Z=F x 10^n (P30)
  1:   0              F
  2:   0              n, Exponent of 10
  3:   3              Z Loc [ Solar_Wm2 ]

4:  End (P95)

; Calculate units in MJ, where MJ = m * t * 0.000001.
; m = Solar_Wm2 from above, and t = 10 (scan interval).

5:  Z=X*F (P37)
  1:   3              X Loc [ Solar_Wm2 ]
  2:   .00001         F
  3:   4              Z Loc [ Solar_MJ  ]

6:  If time is (P92)
  1:   0              Minutes (Seconds --) into a
  2:   60             Interval (same units as above)
  3:   10             Set Output Flag High (Flag 0)
```

```
7:  Set Active Storage Area (P80)
   1:   1              Final Storage Area 1
   2:   101            Array ID

8:  Real Time (P77)
   1:   1220           Year,Day,Hour/Minute (midnight = 2400)

9:  Average (P71)
   1:   1              Reps
   2:   3              Loc [ Solar_Wm2 ]

10:  If time is (P92)
   1:   0              Minutes (Seconds --) into a
   2:   1440           Interval (same units as above)
   3:   10             Set Output Flag High (Flag 0)

11:  Set Active Storage Area (P80)
   1:   1              Final Storage Area 1
   2:   102            Array ID

12:  Real Time (P77)
   1:   1220           Year,Day,Hour/Minute (midnight = 2400)

13:  Resolution (P78)
   1:   1              High Resolution

14:  Totalize (P72)
   1:   1              Reps
   2:   4              Loc [ Solar_MJ  ]

15:  Resolution (P78)
   1:   0              Low Resolution
```

8. Maintenance

At regular intervals, physically inspect the pyranometer to ensure that:

- Dome is free of dirt, condensation, and ice (see Section 8.1, *Cleaning Domes*).
- Desiccant granules are orange and opaque (see Section 8.2, *Changing the Desiccant*).
- Mounting is secure.
- Pyranometer is level (if mounted horizontally).
- Cables are in good condition.

8.1 Cleaning Domes

Clean the outer dome at regular intervals (e.g., every week or so). Remove any accumulated dust, condensation, or ice from the dome and pyranometer body using a soft cloth dampened with water or alcohol (see FIGURE 8-1).

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

8.2 Changing the Desiccant

A desiccant-filled drying cartridge prevents dew from forming on the inner sides of the domes; Campbell Scientific part number 27052 is the replacement desiccant for this cartridge. The optional CVF3 Heater/Ventilator Unit is also available to keep the pyranometer dome free from ice and dew (see Appendix A, *CVF3 Heater/Ventilator*). In some applications, the CVF3 may also reduce the deposition of dust on the pyranometer dome, and therefore reduce the cleaning interval frequency.

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:

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

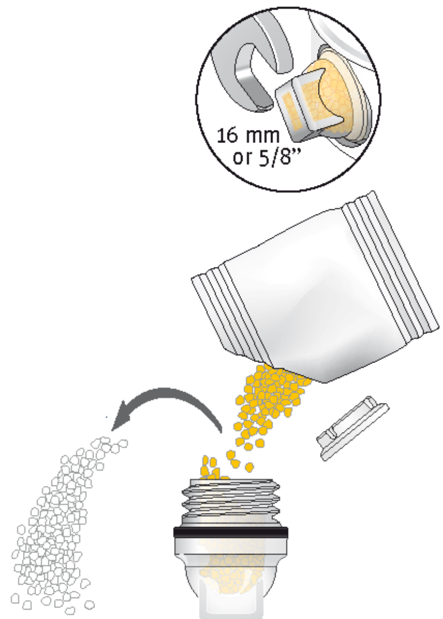


FIGURE 8-2. Changing the desiccant

8.3 Check Sensor Output

It is also important to check the data returned from the sensor as it will show the first indication of a fault. When doing this you should be aware of several expected phenomena that 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 infra-red emission of –150 W•m^{-2}). If this happens, dew, glazed frost or hoar frost can be precipitated 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.

8.4 Recalibration

The calibration of the pyranometer may drift with time and exposure to radiation. Recalibration every two years is recommended. The sensor should be returned to Campbell Scientific for recalibration. A Returned Materials Authorization (RMA) is required (refer to the Assistance page for more information).

9. Troubleshooting

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

1. Check that the sensor is wired to the differential channel specified by the measurement instruction.

2. Verify that the range code is correct for the datalogger type.

3. Measure the impedance across the red and blue sensor wires. This should be around 100 ohms plus the cable resistance (typically 0.1 ohm•m^{-1}). If the resistance is very 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" 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 datalogger 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 (radar, radio, etc.).

2. Check the condition and the connection of the sensor shield wire.

3. Check the condition of the sensor cable.

Appendix A. CVF3 Heater/Ventilator

A.1 General Information

The CVF3 consists of a ventilation unit and heaters. The ventilation unit uses a fan and inlet filter to draw clean air over the pyranometer's domes. The fan runs continuously to reduce dust and dirt settling, to dissipate rain drops, and to stabilize the dome temperature.

The CVF3 has both a 5 W and a 10 W heater. The 5 W heater raises the temperature of the dome slightly above ambient temperature to prevent the formation of dew and frost. The 10 W heater is used for more extreme climates to melt snow and ice.

The 10 W heater's current drain is approximately 850 mA at 12 Vdc, and the 5 W heater's current drain is approximately 420 mA at 12 Vdc. The ventilator draws an additional 5 W of power at 12 Vdc. These power requirements are large compared to most Campbell Scientific products. Because of this, the CVF3 should be connected to the 21326 Power Net 5 A Power Supply and the 7321 Crydom Relay.

The Crydom relay allows the heater power to be controlled by the datalogger program and thus reducing power consumption. For example, the datalogger program can turn on the heater only when the light level falls below 20 W/m^2 or, if a measurement of air humidity is available, when the dew point of the air falls to within 1ºC of the sensor body temperature.

A.2 Siting

Siting information provided in Section 4.1, *Siting*, is pertinent when using the CVF3 heater/ventilation. Additionally, the area directly under the CVF3's 120-mm diameter hole needs to be free from snow, leaves, or other obstructions that could inhibit the air flow (see FIGURE A-1).

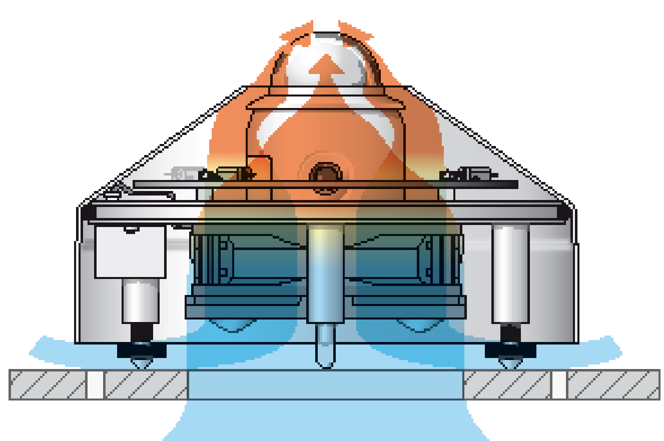


FIGURE A-1. Transparent view of CVF3 shows air flow

A.3 CVF3 Installation

The CVF3 heater/ventilator unit includes the heater/ventilator unit, white cover, cable, and mounting hardware.

Tools required for mounting to a tripod or tower are:

- Small and medium Phillips screwdrivers
- 5/16”, 1/2” open end wrenches
- 5/32” Allen wrench
- Tape measure
- UV-resistant wire ties
- Side-cut pliers
- Compass
- Step ladder

To install, do the following:

1. Remove leveling screws from the pyranometer.
2. Fit the pyranometer in the upper plate of the CVF3 (see FIGURE A-2).
3. Use the counter sink screws, nylon rings, and nuts to secure the upper plate of the CVF3 with the lower portion of the unit (see FIGURE A-2).

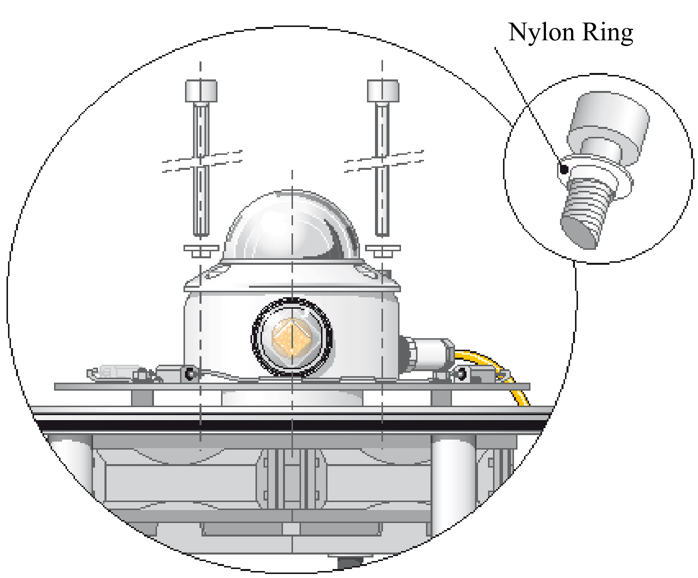


FIGURE A-2. Pyranometer mounted to the CVF3

4. Loosely mount the pyranometer on the 27084 mounting stand. Do not fully tighten the two mounting screws.

5. Turn the CVF3's leveling screws bringing the bubble of the pyranometer's level within the ring (see FIGURE A-3).

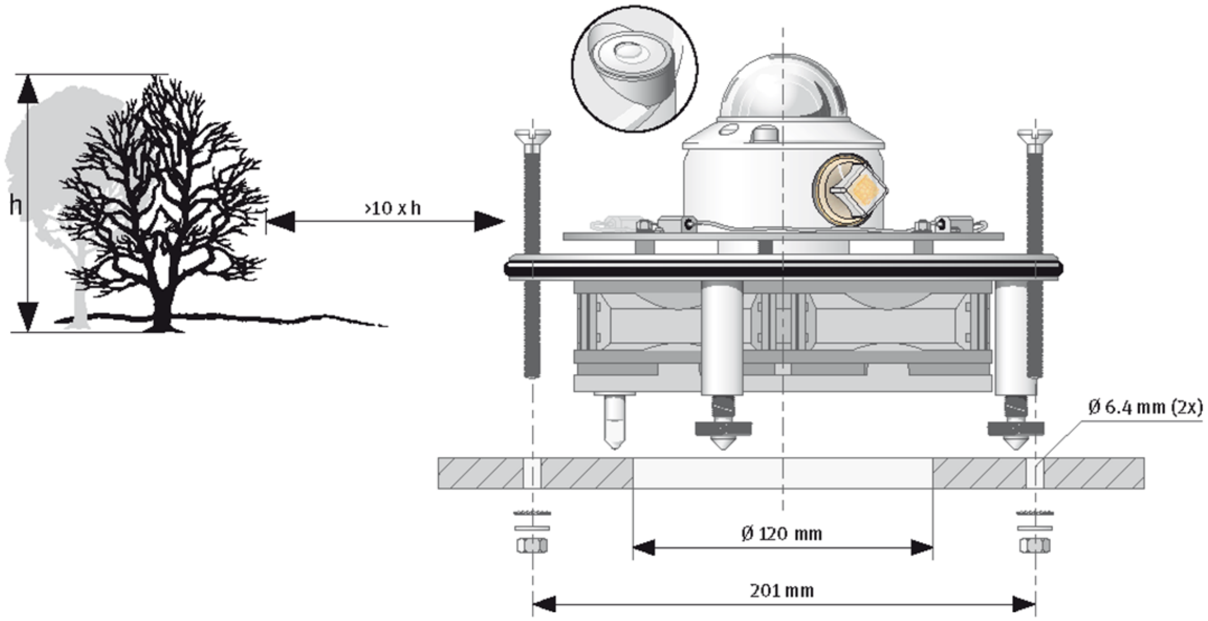


FIGURE A-3. CVF3 installed onsite

6. Tighten the mounting screws to secure the assembly in its final position. Check that the pyranometer is still correctly leveled and adjust as necessary.

7. Use the cover's screws to fasten the white cover to the pyranometer (see FIGURE A-4).

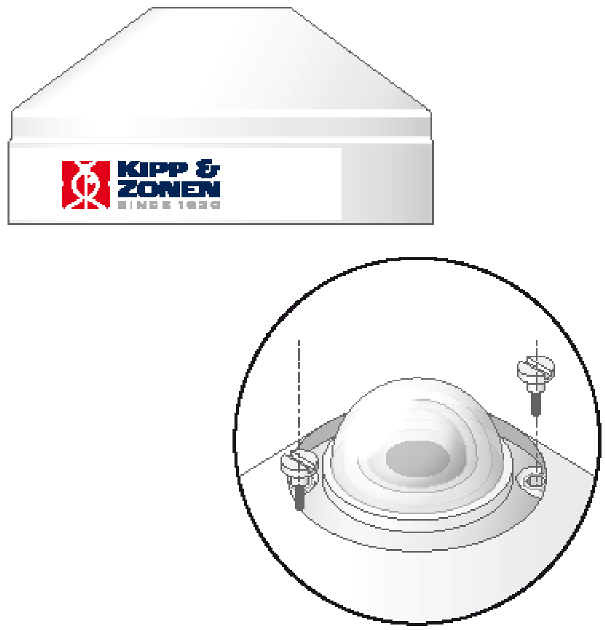


FIGURE A-4. Fastening cover on CVF3

8. Attach the power cable to the CVF3 connector.

A.4 Wiring

Wiring of the CVF3 is shown in TABLE A-1. Refer to Section 7.2, *Wiring*, for information about wiring the pyranometer.

TABLE A-1. CVF3 Wiring

Wire Color	Description	Connection
Red	Ventilator Power	+12V on 21326 Power Supply
Brown	Ventilator Power	+12V on 21326 Power Supply
Blue	Ventilator Ground	G on 21326 Power Supply
Black	Ventilator Ground	G on 21326 Power Supply
Gray	Ventilator Ground	G on 21326 Power Supply
Green	5 W Heater Power	+12V on 21326 Power Supply
White	5 W Heater Power	+12V on 21326 Power Supply
Clear	Shield	⏚ on 21326 Power Supply
Yellow	5 V Tacho Output	Control port on datalogger

A.5 CVF3 Heater/Ventilator Maintenance

1. Refer to Section 8, *Maintenance*, for the pyranometer's maintenance.

2. Inspect the area directly under the 120 mm diameter hole in the mounting plate to ensure that it is free from leaves, snow, or other obstructions that can inhibit air flow.

3. Unclip the CVF3's filter cover and check the filters (see FIGURE A-5).

4. Replace filters as needed.

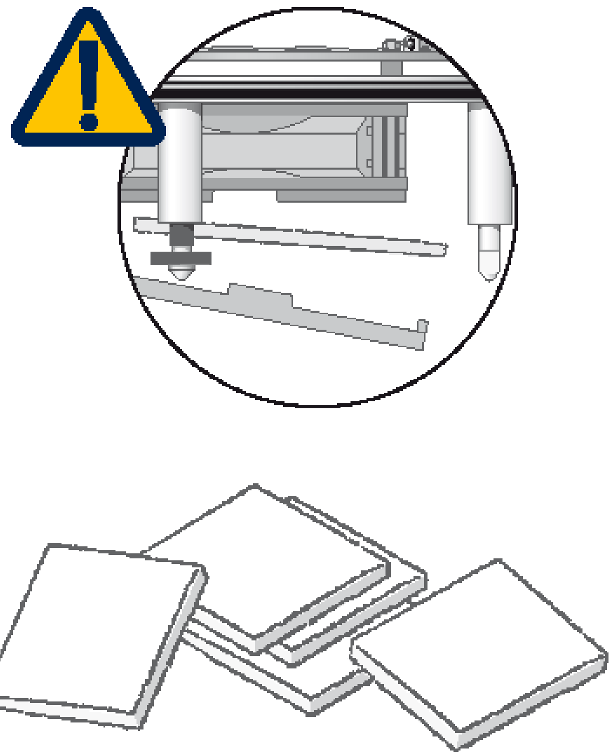


FIGURE A-5. CVF3 filter replacement

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