

CMP3 ***Pyranometer Sensor***

User Guide

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PLEASE READ FIRST

About this manual

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

Some useful conversion factors:

Area:	1 in ² (square inch) = 645 mm ²
Length:	1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km
Mass:	1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
Pressure:	1 psi (lb/in ²) = 68.95 mb
Volume:	1 UK pint = 568.3 ml 1 UK gallon = 4.546 litres 1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Recycling information



At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.



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Contents

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

1. General Description	1
2. Specifications	1
3. Installation	2
4. Wiring	3
5. Example Programs	4
5.1. Input Range	5
5.2. Multiplier	5
5.3. Offset	6
5.4. Example Programs	6
5.4.1 CR1000 Example Program	6
5.4.2 CR10X Example Program	7
5.5. Output Format Considerations	8
6. Maintenance	9
7. Troubleshooting	9
Appendix A. Principle of Operation	A-1

Figure

4-1. CMP3 Schematic	3
---------------------------	---

Tables

4-1. Differential Connections to Campbell Scientific Dataloggers	4
4-2. Single-Ended Connections to Campbell Scientific Dataloggers	4
5-1. Multipliers Required for Flux Density and Total Fluxes	5
5-2. Wiring for Example Programs	6

CMP3 Pyranometer Sensor

1. General Description

This manual provides information for interfacing Kipp & Zonen's CMP3 Pyranometer to various models of Campbell Scientific dataloggers.

The CMP3 is shipped with an instruction manual provided by Kipp & Zonen that contains information concerning the CMP3's 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 calibration constant and serial number. Cross check this serial number against the serial number on your CMP3 to ensure that the given calibration constant corresponds to your sensor.

The CMP3 pyranometer is designed for continuous outdoor use. Due to its flat spectral sensitivity from 300 to 3000 nm, it can be used in natural sunlight, under plant canopies, in green houses or buildings, and inverted to measure reflected solar radiation. Two CMP3s can be used in combination to measure albedo. The CMP3 can also be used to measure most types of artificial light (Xenon lamps, Halogen lamps, etc.).

The CMP3 pyranometer consists of a thermopile sensor, housing, dome, 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 fulfil the cosine response requirements.

2. Specifications

The CMP3 is an ISO Second Class pyranometer. While the worst case accuracy for daily sums given by Kipp & Zonen is $\pm 10\%$, the typical accuracy is $\pm 5\%$.

ISO SPECIFICATIONS:

Response Time 95%:	18 seconds
Zero offset due to 200 W/m ² thermal radiation:	< 15 Wm ⁻²
Zero offset due to temperature change of 5°K / hr:	< ± 4 Wm ⁻²
Non stability (% change/year):	< $\pm 1\%$
Non linearity (at 1000 W/m ²):	< $\pm 2.5\%$
Directional error (at 80° with 1000 W/m ² beam):	< ± 20 Wm ⁻²

Temperature Dependence of sensitivity: $\pm 5\%$ (-10° to $+40^{\circ}\text{C}$)

Tilt response ($\pm 80^{\circ}$) (at 1000 W/m^2): $< \pm 2\%$

OTHER SPECIFICATIONS

Expected accuracy for daily sums: $\pm 10\%$

Spectral range (50% points, nm): 310 to 2800 nm

Sensitivity: 5 to $20\ \mu\text{V W}^{-1}\text{ m}^2$

Expected signal output in atmospheric application: 0 to 15 mV

Impedance: 30 to 100 (Ω)

Operating Temperature: -40° to $+80^{\circ}\text{C}$

Max. irradiance: 2000 Wm^{-2}

Detector: Copper-constantan multi junction thermopile

Standard cable length: 10 m (34 feet)

Level accuracy: 1 degree

DIMENSIONS / SHIPPING DIMENSIONS

CMP3: $79 \times 67\text{ mm}$ (without cable)

WEIGHT/SHIPPING WEIGHT

CMP3: 300 g (without cable)

3. Installation

The CMP3 is usually installed horizontally, but can also be installed at any angle including an inverted position. In all cases it will measure the flux that is incident on the surface that is parallel to the sensor surface.

Site the CMP3 to allow easy access for maintenance while ideally avoiding any obstructions above the plane of the sensing element. It is important to mount the CMP3 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.

The CMP3 is normally mounted on Campbell Scientific weather stations using 016E or 018E mounting arms. These arms should be fitted with the mounting plate towards the south side of the structure (north side in the southern hemisphere) to minimise shading of the sensor. The sensor is attached to the plate using the two bolts provided, using the following levelling procedure.

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

Level the instrument as follows:

1. Loosely mount the pyranometer and fixture on the mounting arm, with the levelling screws lightly touching the mounting plate. Do not fully tighten the two mounting screws.
2. Turn the levelling screws as required to bring the bubble of the spirit level within the ring. (For easy levelling first use the screw nearest the spirit level.)
3. Tighten the mounting screws to secure the assembly in its final position. Check that the pyranometer is still correctly levelled and adjust as necessary. Install the white plastic radiation shield as a last step.

4. Wiring

A schematic diagram of the CMP3 is shown in Figure 4-1.

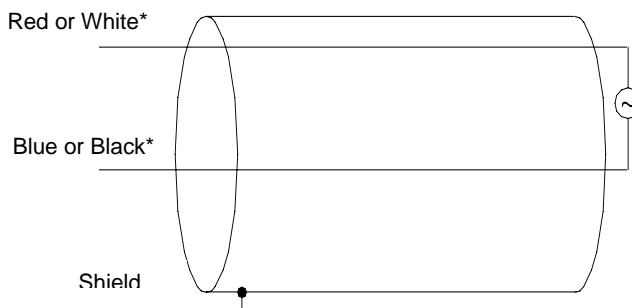


Figure 4-1. CMP3 Schematic

When Short Cut for Windows software is used to create the datalogger program, the sensor should be wired to the channels shown in the wiring diagram created by Short Cut.

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.

Connections to Campbell Scientific dataloggers for a Differential measurement are given in Table 4-1. A user supplied jumper wire should be connected between the low side of the differential input and ground (AG or \equiv) to keep the signal in common mode range.

*Depending on cable fitted

Connections to Campbell Scientific dataloggers for a Single-Ended measurement are given in Table 4-2.

Table 4-1. Differential Connections to Campbell Scientific Dataloggers				
Colour	Description	CR9000(X) CR5000 CR3000 CR1000 CR800	CR510 CR500 CR10(X)	21X CR7 CR23X
Red or White*	Signal (+)	DIFF Analogue High	DIFF Analogue High	DIFF Analogue High
Blue or Black*	Signal (-)	**DIFF Analogue Low	**DIFF Analogue Low	**DIFF Analogue Low
Shield	Shield	$\underline{\underline{\text{---}}}$	G	$\underline{\underline{\text{---}}}$

*Depending on cable fitted

** Jumper to AG or $\underline{\underline{\text{---}}}$ with user supplied wire.

Table 4-2. Single-Ended Connections to Campbell Scientific Dataloggers				
Colour	Description	CR9000(X) CR5000 CR3000 CR1000 CR800	CR510 CR500 CR10(X)	21X CR7 CR23X
Red or White*	Signal (+)	Single-Ended Analogue	Single-Ended Analogue	Single-Ended Analogue
Blue or Black*	Signal (-)	$\underline{\underline{\text{---}}}$	AG	$\underline{\underline{\text{---}}}$
Shield	Shield	$\underline{\underline{\text{---}}}$	G	$\underline{\underline{\text{---}}}$

*Depending on cable fitted

5. Example Programs

This section is for users who write their own datalogger programs. A datalogger program to measure this sensor can be created using Campbell Scientific's Short Cut Program Builder software. You do not need to read this section to use Short Cut.

Solar radiation can be reported as an average flux density (W m^{-2}) or daily total flux density (MJ m^{-2}). The appropriate multipliers are listed in Table 5-1. Programming examples are given for both average and daily total solar radiation.

The CMP3 outputs a low level voltage ranging from 0 to a maximum of up to 25 mV, in natural light, depending on the calibration factor and radiation level.

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. The acceptability of a single-ended measurement can be determined by simply comparing the results of single-ended and differential measurements made under the same conditions.

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.

5.1 Input Range

The output voltage of the CMP3 is usually between 5 and 20 mV per 1000 Wm^{-2} . When estimating the maximum likely value of sensor output a maximum value of solar radiation of 1100 Wm^{-2} can be used for field measurements on a horizontal surface.

Select the input range as follows:

1. Estimate the maximum expected input voltage by multiplying the maximum expected irradiance (in Wm^{-2}) by the calibration factor (in $\mu\text{V}/\text{Wm}^{-2}$). 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 CR23X, CR5000, CR9000 and CR7, and the 25 mV or 250 mV range for the CR510, CR10X and CR1000 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 speed of measurement is not critical.

The parameter code for the input range also specifies the measurement integration time. The slow or 50 Hz rejection integration gives a more noise-free reading. A fast integration takes less power and allows for faster throughput.

5.2 Multiplier

The multiplier converts the millivolt reading to engineering units. The calibration supplied by the manufacturer normally states the output of the sensor (c) as a number of microvolts ($\text{V} \times 10^{-6}$) per Wm^{-2} . As the datalogger voltage measurement instructions give a default output in mV, the following equation should be used to calculate the multiplier (m) to give the readings in Wm^{-2} :

$$m = 1000/c$$

Other units can be used by adjusting the multiplier as shown in Table 5-1.

Table 5-1. Multipliers Required for Flux Density and Total Fluxes		
Units	Multipliers	Output Processing
Wm^{-2}	m	Average
MJm^{-2}	$m*t*0.000001$	Total
kJm^{-2}	$m*t*0.001$	Total
cal cm^{-2}	$m*t*0.0239*0.001$	Total
$\text{cal cm}^{-2} \text{ min}^{-1}$	$m*1.434*0.001$	Average
m = calibration factor in Wm^{-2}/mV t = datalogger program execution interval in seconds		

5.3 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.

5.4 Example Programs

The following programs measure the CMP3 every 10 seconds and convert the mV output to Wm^{-2} and MJm^{-2} . A sensor calibration of $15.02 \mu V$ per Wm^{-2} is used for the example programs. Both programs output an hourly average flux (Wm^{-2}), and a daily total flux density (MJm^{-2}).

Wiring for the examples is given in Table 5-2.

Colour	Description	CR1000	CR10X
Red or White*	Signal (+)	DIFF Analogue High	DIFF Analogue High
Blue or Black*	Signal (-)	**DIFF Analogue Low	**DIFF Analogue Low
Shield	Shield	\perp	G

*Depending on cable fitted
 ** Jumper to AG or \perp with user supplied wire.

5.4.1 CR1000 Example Program

```
'CR1000

'Declare Variables and Units
Public Solar_Wm2
Public Solar MJ

Units Solar_Wm2=W/m2
Units Solar MJ=MJ/m2

'Hourly Data Table
DataTable(Table1,True,-1)
  DataInterval(0,60,Min,10)
  Average(1,Solar_Wm2,FP2,False)
EndTable

'Daily Data Table
DataTable(Table2,True,-1)
  DataInterval(0,1440,Min,10)
  Totalize(1,Solar_MJ,IEEE4,False)
EndTable

'Main Program
BeginProg
  Scan(10,Sec,1,0)
```

```

'CMP3 Pyranometer measurement in Wm-2:

'The Multiplier (m) for this example is based upon a sensor calibration (c) of
'15.02 μV/Wm-2, and will be different for each sensor.
'Multiplier (m) = 1000/c = 66.577896.

VoltDiff(Solar_Wm2,1,mV25,1,True,0,_50Hz,66.577896,0) 'use the 50 mV range for the
CR3000, CR5000 and CR9000

'Set negative readings to zero:
If Solar_Wm2<0 Then Solar_Wm2=0

'Calculate units in MJ, where MJ = m * t * 0.000001. m = Solar_Wm2 from above, and
't = 10 (scan interval)

Solar_MJ=Solar_Wm2*0.00001

'Call Data Tables and Store Data
CallTable(Table1)
CallTable(Table2)
NextScan
EndProg

```

5.4.2 CR10X Example Program

```

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

; CMP3 measurement in Wm-2

1: Volt (Diff) (P2)
1: 1 Reps
2: 33 25 mV 50 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: 66.5778 Multiplier
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

5.5 Output Format Considerations

When using the Campbell Scientific floating point data format to store data, 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). If the measurement value is totalized, there is some danger of over-ranging the output limits, as shown in the following example:

Example

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

Solution 1 – Change the multiplier in the instruction to $(\text{m} \times 0.0001)$. This will totalize MJm^{-2} instead of kJm^{-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 drawback 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.

Dataloggers that are programmed in CRBasic can be programmed to store data in IEEE4 format which can represent a wider range of numbers so this is not a consideration for them.

6. Maintenance

Inspect and clean the outer dome at regular intervals, e.g. every week or so. Clean any accumulated dust, etc. off the dome and pyranometer body using a soft cloth dampened with water or alcohol. Check that there is no condensation within the dome.

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 infra-red 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 Wm^{-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.

The calibration of the CMP3 may drift with time and exposure to radiation. Recalibration every two years is recommended. The sensor should be returned to Campbell Scientific, the manufacturer, or a calibration lab with facilities to calibrate radiation sensors.

7. Troubleshooting

Symptom: -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 sensor wires. This should be around 100 ohms plus the cable resistance (typically 0.1 ohm/m). 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 between pins 1 and 3 on 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. Principle of Operation

The thermal detector in the CMP3 responds to the total power absorbed, and theoretically it is non-selective as to the spectral distribution of the radiation. This implies that the naked thermal detector is also sensitive to long wave infra-red radiation (thermal radiation $\lambda > 3000\text{nm}$) from the environment.

The radiant energy is absorbed by a black painted disk. The heat generated flows through a thermal resistance to the heat sink (the pyranometer body). The temperature difference across the thermal resistance of the disk is converted into a voltage.

The rise of temperature is easily affected by wind, rain and thermal radiation losses to the environment ('cold' sky). Therefore the detector is shielded by a glass dome. The dome allows equal transmitting of the direct solar component for every position of the sun on the celestial sphere. The transmission characteristics of the glass limit the spectral range of the pyranometer.

NOTE

As with any thermopile sensor, rapid changes in temperature can cause small transient offsets to appear on the sensor output. This can result in small negative readings during the night.

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