# *SP1110 Pyranometer Sensor*

## *User Guide*

*Issued 4.7.11*



CSL 140

# Guarantee

This equipment is guaranteed against defects in materials and workmanship. This guarantee applies for twelve months from date of delivery. We will repair or replace products which prove to be defective during the guarantee period provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific
- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order.  Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

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Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

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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.

Part numbers prefixed with a "#" symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

## 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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## *Figure*



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# *SP1110 Pyranometer Sensor*

*This is a compact high-output thermally stable solar radiation sensor. The cosine corrected head contains a special high grade silicon photocell sensitive to light between 350 and 1100nm. The head is completely sealed and can be left indefinitely in exposed conditions.*

*The sensor is calibrated under open-sky conditions against reference pyranometers, and is hence referenced to the World Radiometric Reference. The calibration thus refers to solar energy in the waveband 300nm to 3000nm, i.e. the acceptance band of thermopile pyranometers.*

*Because of the different spectral responses of the silicon photocell and the thermopiles, to obtain accurate readings the SP1110 must be used under natural lighting.*

*Different conditions of sun, cloud, etc. affect calibration slightly, but absolute errors are always within 5%, and typically much better than 3%.*

*Linearity is excellent, with a maximum of 1% deviation up to levels of 3000Wm$^{-2}$ (greater than normal solar irradiance).*

## 1. Specifications

- Sensitive to light between 350nm and 1100nm (see Figure 1)
- Output 1mV per 100Wm$^{-2}$ (nominal – see calibration sheet)
- Absolute accuracy ±5% (typically <±3%)
- Cosine corrected head (typical errors zero 0-70°, <10% 85-90°; see Figure 2)
- Blue-enhanced silicon photocell detector with low fatigue characteristics
- Constructed from Dupont ‘Delrin’, sensor head fully sealed to IP68
- Operating temperature -35°C to +75°C

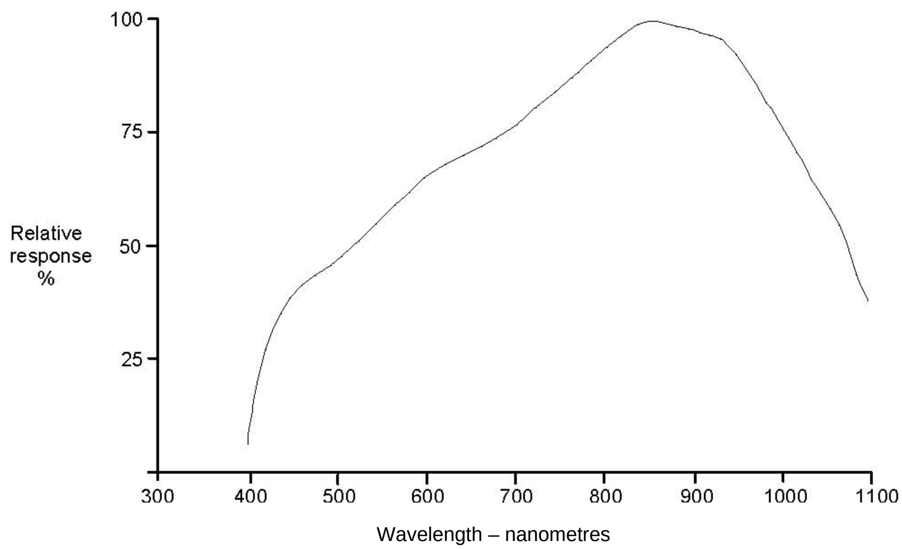



*Figure 1 Typical Spectral Response of SP1110*

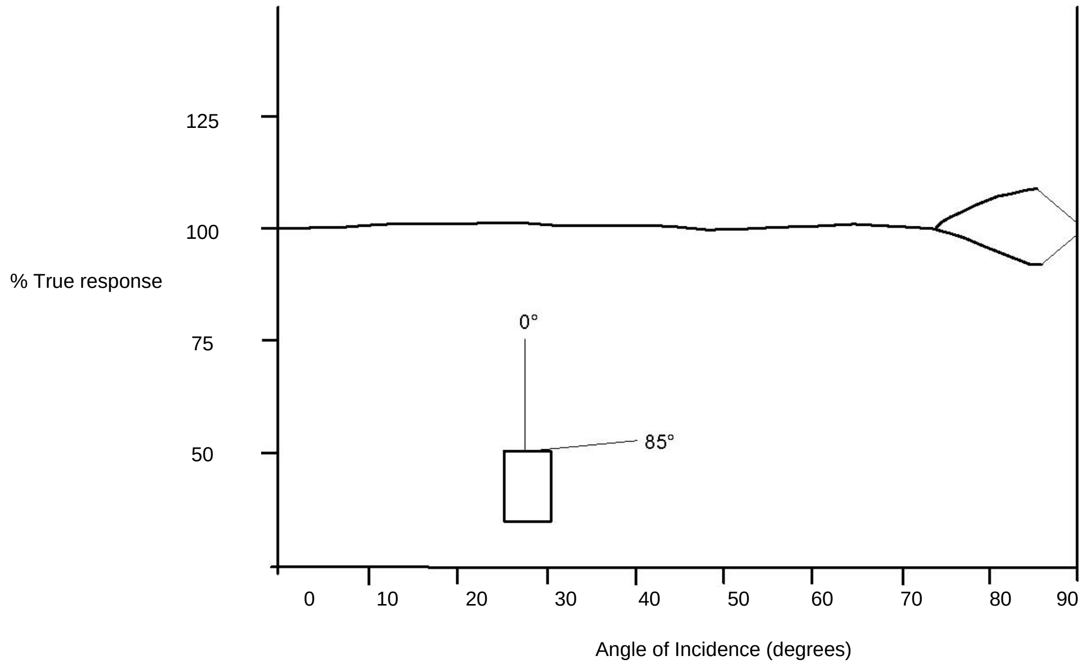



*Figure 2  Typical Cosine Response Error for SP1110*

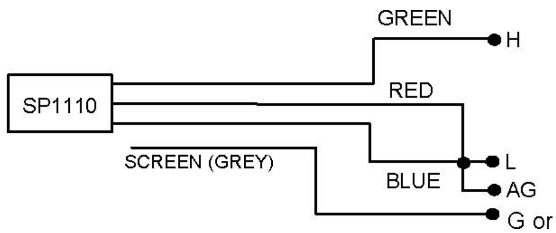
# 2. Installation

For accurate positioning of the sensor we recommend the use of a levelling fixture (SKE211). To achieve accurate and repeatable results great care should be taken in siting the sensor. Avoid objects such as trees that may shade the sensor selectively compared with the areas under study.

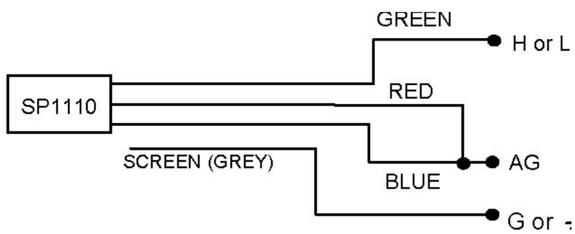
The SP1110 can give a voltage output or a current output (see Figure 3). Voltage output is normally used with Campbell Scientific dataloggers. To obtain voltage output, the red and blue wires must be connected to the same point; differential and single-ended connections to the datalogger are shown in Figure 3.

**NOTE** If the SP1110 is supplied with a connector the red and blue wires are joined inside the connector.

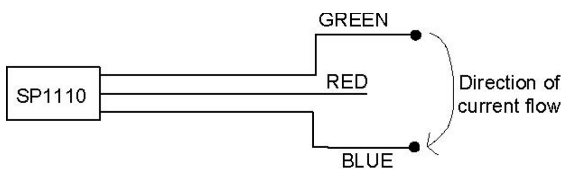
**CAUTION** External voltages must not be applied to the sensor, as the silicon photocell and precision resistive elements may be damaged by reverse voltage or excess current.




*(a) Differential Measurement*




*(b) Single-Ended Measurement*




*(c) Current Output*

*Figure 3 SP1110 Wiring*

**NOTE**

1. AG refers to Analogue Ground and G refers to Power Ground on the CR10/CR10X which are the same as ground (⏚) for the 21X and CR7.

2. For the differential measurement, the low side of the differential channel is connected to analogue ground in order to keep the output signal inside the common mode range of the datalogger.

3. Current output is not normally used with Campbell Scientific dataloggers.

# 3. Programming

The SP1110 outputs a low level voltage ranging from 0 to a maximum of about 10mV depending on sensor calibration and radiation level. A differential voltage measurement (VoltDiff/Instruction 2) is recommended because it has better noise rejection than a single-ended measurement. If a differential channel is not available, a single-ended measurement (VoltSE/Instruction 1) 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.

## 3.1 Input range

The output voltage of the SP1110 is usually between 5 and 15 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 µV/$Wm^{-2}$). 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, CR3000, CR5000, CR9000 and CR7, and the 25 mV or 250 mV range for the CR510, CR10X, CR800 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.

## 3.2 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 (V x $10^{-6}$) 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 3-1.

**Table 3-1. 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 |
| cal $cm^{-2}$ $min^{-1}$ | m*1.434*0.001 | Average |
| m = calibration factor in $Wm^{-2}$/mV<br>t = datalogger program execution interval in seconds | | |

## 3.3 Output Format Considerations

The largest number the datalogger can store in Final Storage is 6999 in low resolution and 99999 in high resolution. If the measurement value is totalized, there is some danger of overranging 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 $.5kWm^{-2}$, the maximum low resolution output limit will be exceeded in less than four hours.

*Solution 1* – Change the multiplier in the instruction to (t*0.0001). This will totalise $MJm^{-2}$ 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.

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.

**NOTE** At night, imperfections in the sensor can cause apparently negative radiation values. Since these values have no meaning, they can be detected and set to zero, if required, by adding the appropriate instructions to the datalogger program.

# 4. Maintenance

The only regular maintenance required is to clean the sensor surface with a blast of clean, dry air or a soft brush every 1-3 months depending on the environment.

Recalibration is recommended every two years, and the sensor should be returned to Campbell Scientific for this.

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