



Red/Far-Red Sensor



SKR 110

Skye Instruments Ltd.,
21 Ddole Enterprise Park,
Llandrindod Wells,
Powys LD1 6DF UK
Tel: +44 (0) 1597 824811
skyemail@skyeinstruments.com

www.skyeinstruments.com

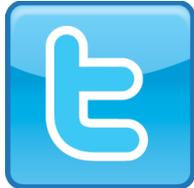
Iss. 1.2

Skye Instruments Ltd.

Skye Instruments is based in the UK and we are very proud to be celebrating being in business since 1983. Our products are designed and built in the UK. We have a very wide product base and our sensors & systems are used for plant & crop research; micro-climate, global climate change studies; environmental monitoring and controlled environment installations.

Products include light sensors & systems, weather monitoring sensors, automatic weather stations, plant research systems, soil and water research systems.

Feel free to contact us via our e-mail, or any of the methods below:



Have a Smartphone? Scan this QR code to access our website for more information about your product:



Please be aware that the information in this manual was correct at time of issue, and should be 100% relevant to the accompanying product. We take great pride in our ever-evolving range of products, which means that sometimes the product may change slightly due to re-design.

If you have any queries, please do not hesitate to contact our technical team by any of the methods above.

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Red/Far-Red Sensor

1. INTRODUCTION

Skye Instruments Limited family of specialist light sensors include sensors to measure different parts of the ultra violet, visible and infra-red spectrum for a wide range of applications.

All sensors use high quality photodiodes and spectral filters, and are individually calibrated to National Standards. Each is supplied with a traceable Calibration Certificate. Recalibration is recommended every two years.

The Red / Far-Red Light Sensors are fully waterproof and guaranteed submersible to 4m depth. They are ideal for monitoring light levels in all environments around the world.

This two-channel sensor consists of two filtered photodiodes, usually to measure red light centred and far-red light. Other wavelengths are supplied and calibrated to the user's specifications. The part number for sensors with other wavelengths is SKR 118/S, all other features describe in this manual are the same as the SKR 110/S.

These sensors are cosine corrected, which means that they accept incoming light according to Lambert's Cosine Law. Essentially this means that light is measured from the hemisphere directly above the sensor.

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2. OPERATION

The SKR 110 Red / Far-Red sensor is actually 2 sensors in one housing. It consists of 2 sets of photodiodes and filters, one set for the Red light channel and one set for the Far-red light channel. The standard Red channel has a 20 nm bandwidth and is associated with the P_R form of the Phytochrome molecule, and the Far-Red channel has a 20 nm bandwidth and is associated with the P_{FR} form of the Phytochrome molecule. The Phytochrome molecule is important in the regulation of plant growth and development. Other wavelengths and bandwidths are also available, please check your Calibration Certificate for the exact details for your sensor.

The SKR 110 sensor is fully waterproof and guaranteed submersible to 4m depth. The system is ideal for monitoring light levels in all environments around the world.

Each sensor has been calibrated against a reference lamp, whose own calibration has been carried out at the National Physical Laboratory (N.P.L.) in the UK. They are calibrated for use with any natural or artificial light source. Please see the sensor's Calibration Certificate and Response Curve in the Booklet provided.

2.1 Positioning of Sensor

For accurate positioning of the sensor Skye recommend the use of a levelling unit (SKM 221). Great care should be given to the placing of the sensor, in order to achieve accurate and repeatable results. Avoid objects, trees, etc., that will shade the sensor selectively, compared with the areas under study.

2.2 Cosine Correction

Since the sensor is intended to measure light falling on a horizontal plane (i.e. the ground), it is designed to collect light from the whole hemisphere of sky above it. This is why light sensors are cosine corrected.

Light rays perpendicular to the sensor are fully measured, while those at 90° are not accepted (they pass parallel to the surface of the plane or the ground and never intercept it). Rays at intermediate angles are treated according to the cosine of their angle to the perpendicular. Imagine the sun overhead, you feel its rays strongest when directly overhead, and much weaker when the sun is near the horizon. The sensor measures light from the different angles in a similar way, stronger when overhead than at low angles.

The cosine response of the sensor is shown in Appendix I. The cosine errors to angle of 70° are minimal and are less than 5% to an angle of 80° . The graph shows the actual response of the sensor as a percentage of the ideal response. At 90° , even the most insignificant acceptance of light represents an infinite error, and because of this, accurate plotting beyond 85% is not practical. Errors from such low angle light in nature are generally not material in most studies.

Red/Far-Red Sensor

2.3 Sensor Maintenance

Light Sensors require very little maintenance apart from keeping the top light collecting surface (small white diffusing disc) clean and dust free. This can be done using a soft cloth dampened with de-ionised water. Take care not to scratch this surface as this may affect the sensor calibration.

Skye Instruments light sensors and meters are recommended to be calibrated every 2 years. Please return to Skye where the sensor will be calibrated against the reference lamp and a new calibration certificate issued.

Red/Far-Red Sensor

3. WIRING

The sensor does not require a power supply as photodiodes generate a current when exposed to light. External voltages must not be applied to the sensor, the silicon photodiode and precision resistive elements may be damaged by reverse voltage or excess current.

The two large area photodiodes in the sensor are connected back to back between the red, green and blue wires in the sensor cable. When the sensor is exposed to light the blue (Red channel) and red (Far-Red channel) wires will become negative with respect to the green (common or ground) wire.

Connection details for the μA output is shown in Appendix 2. The use of a precision resistor to produce a mV output is also shown.

Output currents from the photodiodes are very low, typically $0.1 \mu\text{A}$ in low light conditions. For accurate measurements, it is advised to use sensitive equipment that will ensure the diode current in short circuit mode, e.g. the Skye DataHog logger, SpectroSense2 meter or Display Meter.

Typical outputs on a sunny day are about $150 \mu\text{mol m}^{-2} \text{s}^{-1}$ for each channel, equivalent to around $5 \mu\text{A}$ output signal (or 5mV if connected via a $1\text{k}\Omega$ precision resistor).

Skye also offer the SKP 120 2-channel amplifier, which is housed in a weatherproof enclosure, for connection to customer's own dataloggers if they cannot measure the direct output from the SKR 110 sensor. Please ask for details.

/S

Sensors which have the suffix "/S" indicates that the cable includes an uncommitted screen. The sensor part number may include another suffix as shown below. This suffix was in use after March 2008 until the middle of 2011.

NO SUFFIX PRE MARCH 2008

Sensors manufactured prior to March 2008 will have no suffix and will be fitted with a 2 core (red and blue) screened cable, where a green "tail" is fitted to the cable screen.

NO SUFFIX MID 2011 ONWARDS

These sensors will be fitted with a 3 core (red, blue & green) screened cable, where a grey "tail" is fitted to the cable screen.

Red/Far-Red Sensor

/LT

These sensors have been fitted with cable suitable for low temperatures. Whilst the special cable is rated for use at low temperatures, it is still advisable to avoid undue stress, movement, etc., of the cable when at low temperatures. A special modified levelling unit (SKM 221S) is available to give extra support to the cable and minimise unnecessary movement.

/BNC

The SKR 110/BNC sensors are fitted with 2 BNC connectors, one for each channel. The connectors are marked and wired as shown below:

BNC Label	Connection	Wire Colour	Function
Channel 1	Centre pin	Blue	Negative current output from Channel 1 (Red Light)
	Outer	Green	Common or ground
Channel 2	Centre pin	Red	Negative current output from Channel 2 (Far-Red Light)
	Outer	Green	Common or ground

/I

These sensors have been fitted with a 5 pin plug for a Skye DataHog logger connection and wired for a 2-channel current input socket of the logger, as shown below:

DataHog connector	Wire Colour	Function
Pin 1	not connected	-
Pin 2	not connected	-
Pin 3	Red	Negative current output from Channel 2 (Far-Red Light)
Pin 4	Blue	Negative current output from Channel 1 (Red Light)
Pin 5	Green & cable screen	Common or ground

Red/Far-Red Sensor

/SS2

These sensors have been fitted with a 5 pin plug for a Skye SpectroSense2 meter connection and wired for a 2-channel current input socket of the meter, as shown below:

SpectroSense2 connector	Wire Colour	Function
Pin 1	not connected	-
Pin 2	not connected	-
Pin 3	Red	Negative current output from Channel 2 (Far-Red Light)
Pin 4	Blue	Negative current output from Channel 1 (Red Light)
Pin 5	Green & cable screen	Common or ground

/X

These sensors have been fitted with a 7pin plug for a light sensor extension cable (EXT/1 or EXT/3) connection.

7 pin in line socket	Wire Colour	Function
Pin 1	not connected	-
Pin 2	not connected	-
Pin 3	Red	Negative current output from Channel 2 (Far-Red Light)
Pin 4	Blue	Negative current output from Channel 1 (Red Light)
Pin 5	Green	Common or ground
Pin 6	Cable screen	Cable screen
Pin 7	not connected	-

Red/Far-Red Sensor

EXT/1

An EXT/1 light sensor extension cable can be used on an SKR 110/X sensor. It has a 7 pin plug at one end (to connect to an SKR 110/X) and a 5 pin plug at the other end (to plug into a Skye DataHog logger or a Skye SpectroSense2 meter).

5 pin plug	Wire Colour	Function
Pin 1	Black	-
Pin 2	Red	-
Pin 3	Yellow	Negative current output from Channel 2 (Far-Red Light)
Pin 4	Green	Negative current output from Channel 1 (Red Light)
Pin 5	Blue, White, Screen	Common or ground

EXT/3

An EXT/3 light sensor extension cable can be used on an SKR 110/X sensor. It has a 7 pin plug at one end (to connect to an SKR 110/X) and the other end is wire ended.

Wire Colour	Function
Black	-
Red	-
Yellow	Negative current output from Channel 2 (Far-Red Light)
Green	Negative current output from Channel 1 (Red Light)
Blue	Common or ground
White	Cable screen

DATAHOG / SPECTROSENSE2 WATERPROOF BINDER 5 PIN PLUG

OUTSIDE PIN VIEW

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4. SPECIFICATIONS

Sensitivity (per channel) (1)	3 μA / 100 $\mu\text{mol m}^{-2} \text{s}^{-1}$
Working range (2)	<500 $\mu\text{mol m}^{-2} \text{s}^{-1}$
Linearity error - to above level	<0.2%
Absolute calibration error (3)	typically <3%, 5% maximum
Response time (7) - voltage output	10ns
Cosine error (4)	3%
Azimuth error (5)	<1%
Temperature Co-efficient	$\pm 0.1\%/^{\circ}\text{C}$
Long term stability (6)	$\pm 2\%$
Housing	Material - Dupont "Delrin" Sealed to IP68, submersible to 4m Cosine Corrected head
Dimensions	34 mm diameter 69 mm height
Cable	3 core screened (7 - 2 - 3C) Def. Std. 6H2 Pt4
Sensor Waveband *	Channel 1 - Red Light (20 nm) Channel 2 - Far-Red Light (20 nm)
Detector	Silicon photocell
Filters	Interference Bandpass
Operating Range	-35 to +75 $^{\circ}\text{C}$ 0-100% RH

* Please check Calibration Certificate Booklet for exact details of your sensor

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- (1) Current output varies from sensor to sensor. Each individual unit will have a slightly different output. A calibration certificate is supplied with each sensor.
- (2) All Skye sensors will work at levels of irradiance well above that found in terrestrial sunlight conditions, room or growth chamber lighting.
- (3) Main source of this error is uncertainty of calibration of Reference Lamp. Skye calibration standards are directly traceable to National Standards from the UK's National Physical laboratory.
- (4) Cosine error to 80° is typically 5% maximum. Figures shown are for normal use sources, e.g., sun plus sky, diffuse sun, growth chambers, etc.
- (5) Measured at 45° elevation over 360° .
- (6) Maximum change in one year. Calibration check recommended at least every two years. Experience has shown that changes are typically much less than figures quoted.
- (7) Times are generally less than the figure quoted, which is in nanoseconds. They may be slightly increased if long leads are fitted, or those of a higher capacity cable.

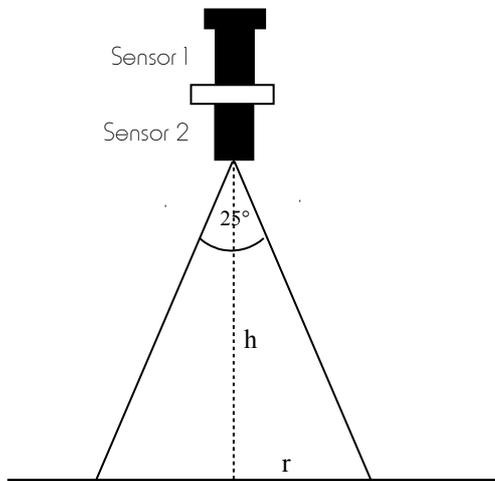
Red/Far-Red Sensor

APPENDIX 1 – NARROW ANGLE LIGHT ACCEPTANCE AREA

The SKR 110 2- channel light sensors are fitted with a removable cosine correcting light acceptance head. When taking incident or down-welling light measurements, the head is left in place so that the sensor is fully cosine corrected (accepts light in accordance with Lambert's Cosine Law).

For the measurement of reflected or up-welling light, the cosine head is removed converting the sensor into a narrow angle acceptance instrument. The sensor has a smaller, defined field of view and can accurately measure from a defined ground area.

Without the cosine head, the 2-channel sensors have a 25° cone field of view (12.5° off perpendicular). The area of ground in view to the sensor is then defined by the height above the ground, as shown below:



Sensor 1 is fitted with the cosine correcting head and is measuring incident light.

Sensor 2 is narrow angle and is measuring reflected light.

Both incident and reflected light is measured simultaneously by 2 identical sensors, to eliminate fluctuations in solar radiation

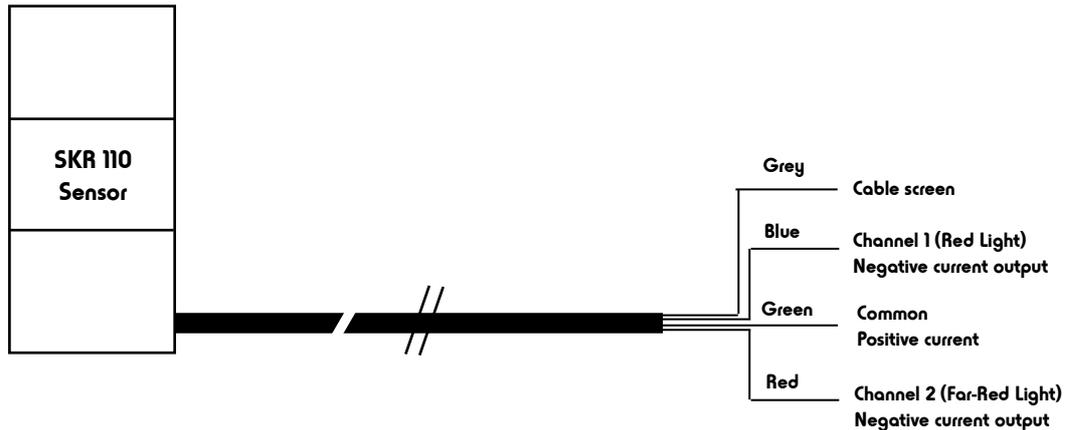
EXAMPLES OF MEASUREMENT AREA

HEIGHT OF SENSOR (h)	RADIUS OF CIRCLE (r)	AREA OF MEASUREMENT
0.50m	0.11m	0.04m ²
0.75m	0.17m	0.09m ²
1.00m	0.22m	0.15m ²
1.25m	0.28m	0.24m ²
1.50m	0.33m	0.35m ²
1.75m	0.39m	0.47m ²
1.80m	0.40m	0.50m ²
2.00m	0.44m	0.62m ²

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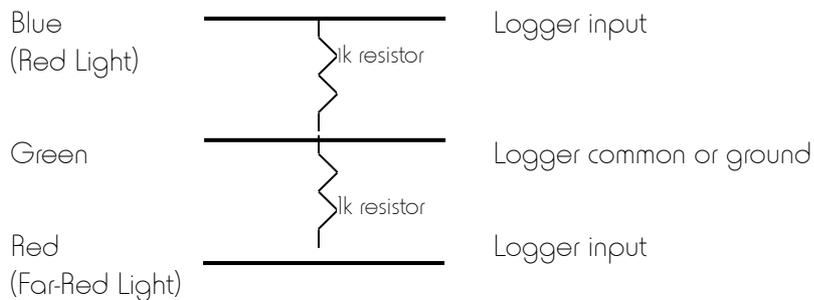
APPENDIX 2 - WIRE CONNECTIONS

CURRENT OUTPUT



VOLTAGE OUTPUT

A mV output can be obtained from the SKR 110 sensor by connecting a resistor across each channel of the logger or meter input, as shown:



If a precision resistor of 1k (0.1% ppm/°C)* is used, then the output in mV of the sensor will be identical to the current output in μA . For example, if the calibration certificate says the 660nm channel output is $30.25 \mu\text{mol m}^{-2} \text{s}^{-1}$ per μA , then when connected with a $1\text{k}\Omega$ resistor, $30.25 \mu\text{mol m}^{-2} \text{s}^{-1}$ will give an output of 1 mV.

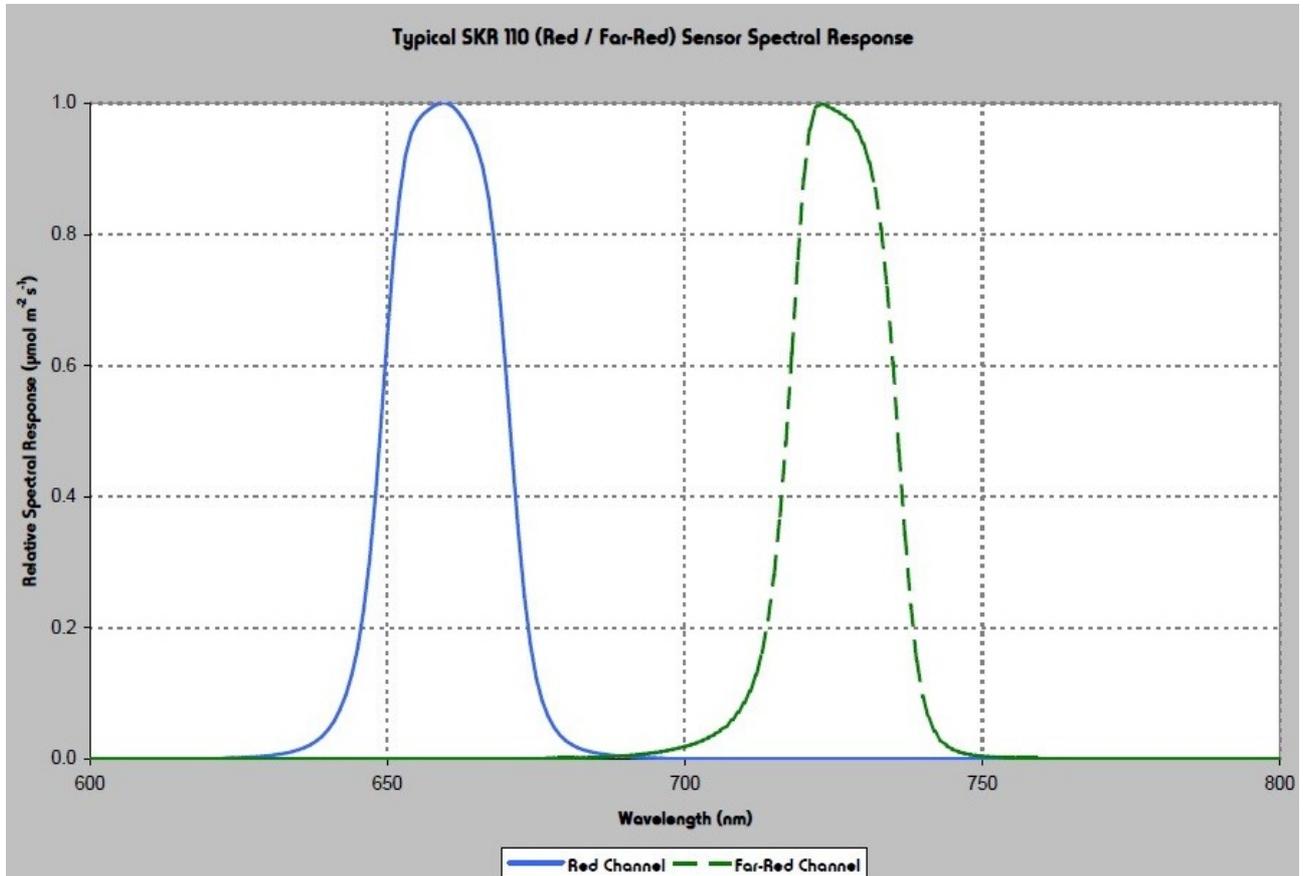
Other values of resistance may be calculated as follows:-

$$\begin{array}{l} \text{Sensitivity} \\ (\mu\text{mol m}^{-2} \text{s}^{-1} \text{ per mV}) \end{array} = \begin{array}{l} \text{Sensitivity} \\ (\mu\text{mol m}^{-2} \text{s}^{-1} \text{ per } \mu\text{A}) \end{array} / \begin{array}{l} \text{Resistance} \\ (\text{k}\Omega) \end{array}$$

Resistor values above $1\text{k}\Omega$ should be used with caution, as they may give rise to pickup noise. $10\text{k}\Omega$ is the maximum that should be used.

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APPENDIX 3 – SENSOR RESPONSE CURVES



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APPENDIX 4 – COSINE CORRECTION

Typical Cosine Response Error Window

