4 – Channel Light Sensor

SKR 1850

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Skye Instruments Ltd.

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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:

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

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1 INTRODUCTION

The SKR 1850 is a four channel sensor, with the ability to simultaneously detect and measure four separate bands of light that are chosen at the time of ordering by the purchaser. The wavelengths can be between 400 and 1050nm with bandwidths of set widths. The exact wavebands will be shown on the Calibration Certificate of each sensor for each of the four channels in each sensor.

The sensor may be used as either a cosine-corrected head or a narrow angle sensor, by the use of a removable diffuser. To remove the diffuser, grasp the black ring and twist whilst pulling it firmly off the top of the sensor, it should slide gently off of the top of the unit.

Sensors that are supplied in pairs will have normally have one sensor fitted with a cosine-corrected diffuser and one without. The sensor fitted with the cosine-corrected diffuser is usually mounted with the diffuser facing upwards for measuring the incident light. These sensors will have the suffix D after the part number. The sensor supplied without the cosine-corrected diffuser is normally mounted with the light collecting apertures facing downwards, for the measurement of reflected light. These sensors have the suffix ND after the part number.

The sensor may be used with a data logger (e.g. Skye DataHog2) or other readout devices (e.g. Skye SpectroSense 2+, Apollo, etc.), or alternatively with a third party display meter or logger.

SKR 1850A is optically and externally physically identical to SKR 1850 but has a built in amplifier to give a higher output level of millivolts (typically ranging 0–1V) as opposed to the small current outputs of the standard SKR 1850 sensor.

Models with up to a 0 - 2 volt output require a power supply between 5 and 15 volts.

Models with up to a 0 – 5 volt output require a power supply between 9 and 15 volts.

Please ascertain which model you have before making connections to it. Refer to the serial number label or its unique Calibration Certificate.

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2 OPERATION

The sensor is machined mainly from black anodised aluminium alloy material.

The optics and electronics are fully sealed and weatherproof. It is suitable for use in any orientation. It should be borne in mind, if continuous outside exposure is envisaged, that since the cosine diffuser is removable, it is possible for moisture to collect below it after a while, which may support the growth of algae, etc., and upset the light collection. Thus a periodic check should be made. Equally the recessed wells exposed when the diffuser is removed may fill with water. As long as this is optically clear then it will have little effect on the calibration, but again prolonged exposure may permit algal growth which must be removed. The sensor may be cleaned with moist soft tissues. Avoid the use of solvents.

The response of the sensor to light coming from different angles is clearly different depending on whether or not the diffuser is in place. Without the diffuser the response to light is from a 25° cone directly above the sensor. When the cosine diffuser is in place (be sure to twist it gently on to the rubber 'holding' ring), the collection of light depends on the cosine of the angle the ray of light makes to the axis down the length of the sensor.

Please see Appendix 1 for the narrow angle response and area of measurement for these sensors.

The sensor may be mounted to any flat surface using the M6 threaded hole in its base. It may be hand-held in many applications.

From serial number 41802 the sensor is also fitted with a cable gland at exit point of cables. This is a crucial part of the ingress protection, and should never be undone in case of cable damage and/or affecting ingress protection.

2.1 Sensor Maintenance

Light and Radiation Sensors require very little maintenance apart from cleaning. It is important keeping the light collecting surface clean and dust free.

For the white diffusing disc on cosine corrected Incident or Irradiance sensors, simply wipe clean with a soft cloth dampened with de-ionised water. Take care not to scratch this surface as this may affect the sensor calibration.

For the clear glass disc on the narrow angle Reflected light or Radiance sensors, simply wipe clean with a soft cloth dampened with de-ionised water. Take care not to scratch this surface as this may affect the sensor calibration.

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For narrow angle Reflected light or Radiance sensors which have 2 or 4 deep columns, the glass at the bottom of the columns can be cleaned using a cotton ear bud dampened with de-ionised water. Take care not to scratch this surface as this may affect the sensor calibration. When installed permanently outdoors, especially in forestry areas, this should be done at regular periods to ensure it is kept clear of insects and their nests.

For all sensors, ensure the cable is not bent or curled up near the point where it exits the base of the sensor. The cable should not be tightly coiled at any point. These tips will help to increase the cable's lifetime.

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.

3 OUTPUTS

3.1 SKR 1850, SKR 1850D, SKR 1850ND Current Output Sensor

The output from each channel is in the form of a current that is directly proportional to the amount of light falling on the sensor within the waveband of the filter for that channel. The output is linear over many decades of light level, extending well beyond natural ranges. In complete darkness the current will always be zero.

The calibration certificate will show the calibration values relevant to the model ordered. If you have purchased an SKR 1850, calibration values for use with and without a diffuser if provided. For the model SKR 1850D, only calibration values for the sensor with a diffuser is provided, and likewise for the SKR 1850ND, only calibration values for the sensor without a diffuser is provided.

When the cosine diffusing head is in place the Calibration Certificate shows the output current for a stated amount of light falling on the surface of the sensor. Since the output is linear with no offset, the zero and this stage define the output response of the sensor.

Since February 2014, radiance sensors have been supplied with an absolute calibration figure and this is shown on the calibration certificate.

Radiance Sensors supplied prior to February 2014

Previous to 2014 when the sensor was used without the diffuser, a relative factor was given to relate one channel to another. Absolute calibration as done with the diffuser was not possible without the cosine correcting diffuser.

The currents coming from the channels being measured without the diffuser disc should be multiplied by the factors shown on the calibration certificate so that the sensor response can be quoted in relevant units.

Note though that this 'corrected' current is directly proportional to the level of light detected by the channel in its waveband. This factor has only corrected the relative sensitivity of the channels to light in terms of current produced for light intercepted.

If the outputs of the sensors channels are to be related in an attempt to gain knowledge of spectral distribution then the bandwidth of each channel should be taken into account.

The bandwidth shown on the calibration certificate is the range (around the centre wavelength) over which the sensitivity of the channel is greater than 50% of its peak. This is a common way of defining optical bands, and since the sensitivity of the SKR 1850 channels falls off very sharply beyond these 50% points this band definition includes most of the light detected. It is a consistent way of relating the widths of the channels.

Thus the currents (without the diffuser disc) or the number of µmol m^{-2} s^{-1} (with diffuser disc), detected by any channel, if divided by its bandwidth will then give a figure of, or proportional to, the light intensity per nanometre. Remember however that this will be an approximation, and that it is the mean value of the light level at each wavelength, depending on the bandwidth of the sensor.

If a voltage output is needed to drive a logger or similar, then a resistor may be employed as a current to voltage converter. Appendix 2 shows how this may be accomplished.

The maximum value of resistor that should be used in this connection is 5 to 10 kohms. In general however the minimum value that can be used to give the desired mV output should be used. This will minimise the pickup of electrical interference. The output will be as follows :-

mV per light unit = µA per light unit * resistor (kohm)

When the sensor is used without the diffuser then the currents, or mV output from each channel should be divided be the relative factors shown on the calibration certificate (N.B. only for sensors supplied prior to February 2014). In this way the true ratios of the reflected or direct light levels detected by each channel will be determined. If a meter or output amplifier is employed then the reading or current conversion ratio of this must be taken into account.

It will be noticed that the ratio of channel sensitivities with and without the diffuser are slightly different. This arises as a result of different transmission of the diffuser at different wavelengths.

Any Skye Display Meter, SpectroSense2 meter, DataHog logger or external current amplifier that is built for the sensor or supplied with it will have the cosine diffuser calibration built in to it and will readout directly or have an output in direct engineering units, i.e.. the display will read in Mmol m^{-2} s^{-1} or the output is scaled at (usually) 10mV / Mmol m^{-2} s^{-1} or units appropriate to the sensor. If this meter or external current amplifier is used where the sensor is without the cosine correcting diffuser, then its gain as well as the factors which relate the currents of the channels will need to be taken into account.

3.2 SKR 1850A, SKR 1850D/A, SKR 1850ND/A Amplified Voltage Output Sensor

This model, as mentioned previously is optically and externally physically identical to the SKR 1850 but instead of giving low level current outputs has an integral amplifier (4 channels) to give outputs in millivolts.

The gain of this amplifier and hence the output in millivolts per unit of light will vary from unit to unit (It may be specified by the user at the time of ordering). The scaling (millivolts/light units) is given on the calibration certificate for each channel of the sensor.

Models with up to a 0 - 2 volt output require a power supply between 5 and 15 volts.

Models with up to a 0 – 5 volt output require a power supply between 9 and 15 volts.

The current required is less than 3mA. The power should be applied to the amplifiers at least 500mSec (0.5 secs) before readings are taken. Most data loggers allow a greater time than this.

The output impedance of the amplifier is fairly low, but they should only be used to feed high impedance (5K or more) inputs. Almost all loggers, digital meters, chart recorders have suitably high input impedances.

Please note that with the internal amplifier only the voltage output (mV) may be used. The low level current output is not available.

The outputs of the amplifiers should not be shorted together or to ground. They should never be shorted to the positive supply input. This may destroy the sensor.

The output of the amplifier will be nominally zero in the dark (when the sensor receives no light) but a small zero offset will almost certainly be present. This offset will vary from channel to channel, but will be a constant offset that for the very highest precision should be added (if negative) or subtracted (if positive) from all readings. The magnitude of the offset will depend to a degree on the gain of the amplifier (higher gain, higher offset) but will generally be below 1mV. In many cases it will be low enough to be reasonably ignored, if chosen to do so.

Unlike the SKR 1850, the calibration certificate shows either the Absolute calibration for each channel of the sensor with the cosine diffuser fitted or the factors that readings obtained (mV) without the diffuser should be multiplied by to relate them in terms of light level. Each sensor will have scaled for use either with or without the cosine diffuser, this is specified at the time ordering.

Note also that if spectral densities are to be considered, i.e. light levels per nm., then the output of each channel will need to be divided by its bandwidth (see calibration certificate). See the discussion of this for the SKR 1850 type sensor in the previous section.

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4. CONNECTIONS

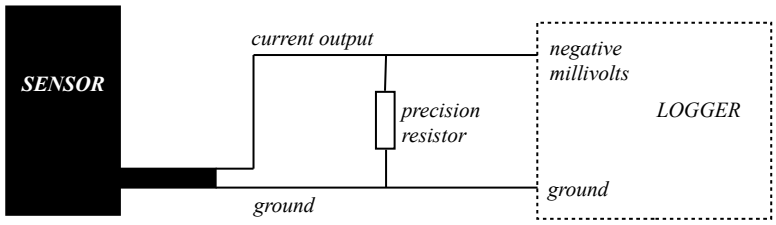
The sensors may be supplied wire ended for connection to the user's own instruments, or may be fitted with a waterproof connector suitable for Skye's DataHog logger or SpectroSense 2 meter.

4.1 SKR 1850, SKR 1850D, SKR 1850ND, SKR 1850/SS2, SKR 1850/I - Current Output Sensor

Wire Colour	*Function*	*Skye Connector*
Red	**Channel 1 negative current output**	**Pin 1**
Yellow	**Channel 2 negative current output**	**Pin 2**
Green	**Channel 3 negative current output**	**Pin 3**
Blue	**Channel 4 negative current output**	**Pin 4**
White	**Ground**	**Pin 5**
Grey	**Cable Screen**	**Pin 5**

N.B. Older style sensors did not have an uncommitted screen and the grey wire was the ground and the screen connection

The current output from this sensor is often very small, e.g. 1 microamp or less. If the datalogger or recorder does not have a current input, then a precision resistor may be placed across each of the 4 sensor outputs to give a millivolt signal as below:



The millivolt signal will be proportional to the current output and resistor value as shown:

mV per unit of light = microamp per unit of light * resistor (kohms)

The resistor value should be as low as possible to get the mV output required for the anticipated light levels, and should not exceed 10 kohm (10,000 ohm). The millivolt output derived should not be greater than 60 mV otherwise a degree of non-linearity may occur.

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4.2 SKR 1850/X, SKR 1850D/X, SKR 1850ND/X - Current Output Sensor with Extension Cable EXT/2

Function	*Skye Connector (5 pin connector of EXT/2)*
Channel 1 negative current output	Pin 1
Channel 2 negative current output	Pin 2
Channel 3 negative current output	Pin 3
Channel 4 negative current output	Pin 4
Ground	Pin 5
Cable Screen	Pin 5

4.3 SKR 1850/X, SKR 1850D/X, SKR 1850ND/X - Current Output Sensor with Extension Cable EXT/3

Wire Colour	*Function*
Black	Channel 1 negative current output
Red	Channel 2 negative current output
Yellow	Channel 3 negative current output
Green	Channel 4 negative current output
Blue	Ground
White	Cable Screen / Sensor Body

4.4 SKR 1850A/X, SKR 1850D/A, SKR 1850ND/A - Amplified Voltage Output Sensor with Extension cable EXT/4

Wire Colour	*Function*
Brown	Cable screen / sensor body
Red	Power supply ground
Orange	Sensor signal ground
Yellow	Power supply positive
Green	Channel 1 positive voltage output
Blue	Channel 2 positive voltage output
Violet	Channel 3 positive voltage output
White	Channel 4 positive voltage output

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4.5 SKR 1850/LT, SKR 1850D/LT, SKR 1850ND/LT - Current Output Sensor

From serial number 40739 onwards these sensors are fitted with a grey cable that has the following temperature specifications;

Moving;	-20°C to +80°C
Fixed;	-40°C to +80°C

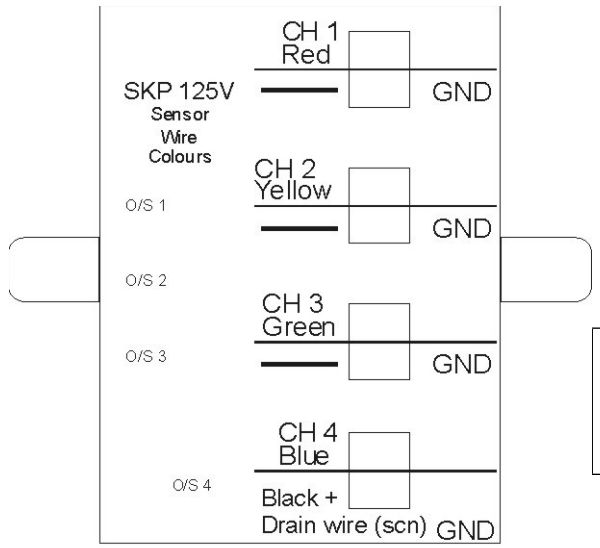
Wire Colour	*Function*
Brown	Channel 1 negative current output
Yellow	Channel 2 negative current output
Grey	Channel 3 negative current output
White	Channel 4 negative current output
Green	Ground
Pink	Cable Screen

4.6 SKR 1850A, SKR 1850D/A, SKR 1850ND/A Voltage Output Sensor with Internal Amplifier

Wire Colour	*Function*	*Skye Connector*
Grey	Cable screen / sensor body	Pin 1
Blue + black	Power supply ground	Pin 2
Violet + green	Sensor signal ground	Pin 3
Red	Power supply positive	Pin 4
Brown	Channel 1 positive voltage output	Pin 5
White	Channel 2 positive voltage output	Pin 6
Orange	Channel 3 positive voltage output	Pin 7
Yellow	Channel 4 positive voltage output	Pin 8

4.7 SKR 1850, SKR 1850D, SKR 1850ND Current Output Sensor with 0-1V External Amplifier

SKP 125V 4 Channel Voltage Amplifier



Cable Gland + cable to sensor (see wiring details below)(sensor wires are connected to terminal blocks inside the box)

Please note: If you need to separate the Sensor from the Amplifier, please undo the 4 external retaining screws to access sensor terminals as per diagram.

Cable Gland + cable to logger (see wiring details below)

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Sensor Cable Connections (8 core low temperature cable)

Wire Colour	*Function*
Red	Channel 1
Yellow	Channel 2
Green	Channel 3
Blue	Channel 4
Black	Common output Ground
Green	Silicon only "Drain" wire
Purple	N/C
Orange	N/C
Brown	N/C

Cable connections from Amplifier to Datalogger

Wire Colour	*Function*
Green silicon sleeving covering "Drain" bare wire	Cable screen / sensor body
Red	Power supply positive
Black	Power supply ground
Brown	Channel 1 positive voltage output
Yellow	Channel 2 positive voltage output
Green	Channel 3 positive voltage output
Blue	Channel 4 positive voltage output
Violet	Sensor signal ground

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5. SPECIFICATIONS

Range: Four channels each between 400-1050nm.

Construction: Black anodised aluminium housing
Cosine corrector head - acrylic & PVC
Unit completely waterproof with cosine corrector head removed, sealed with wide transparency glass flats "O" rings. Waterproof rating IP68, submergeable up to 4m. Submerging with the cosine corrector head in place is not advised as water under the head will cause calibration errors. Cable gland IP68 – Do not undo.

Filters: Metal interference and/or glass depending on wavelengths & bandwidths chosen, to military specification.

Detectors: GaP, GaAsP, or silicon depending on wavelengths and bandwidths chosen.

Cable: SKR 1850 - Screened. 7-1-4C military specification. 3m. standard length.
SKR 1850A - Screened. 7-1-9C military specification. 3m. standard length.

Temperature Range: -25 to +75 °C (Standard Cable when Fixed)

Humidity Range: 0-100%

Dimensions: Height: 8.2cm without cosine-corrector
8.5cm with cosine corrector
Width: 4.4cm without cosine-corrector
5.4cm at the top of the sensor with the cosine-corrector.

Weight: 400 grams.

Output: SKR 1850/S - current output which varies with filters used.
SKR 1850A - voltage output scaled according to filters used. 0-1V as standard, other ranges available.

Power Supply: SKR 1850 – not required
SKR 1850A only. 5-15 VDC @ 2 mA. For up to 2v outputs.
9 – 15VDC for units with full scale outputs in the range 2 to 5 volts

Linearity: Better than 0.2% of scaled range.

Cosine Error: Typically 3% to 80 degrees (cosine diffuser fitted)

Response Time: SKR 1850 - typically less than 100 nanoseconds.
SKR 1850A - 200 milliseconds

Absolute Calibration: Typically better than 5%. N.B. This error is to some extent dependant on bandwidth - wide bandwidths will be less subject to error than very low bandwidth channels.

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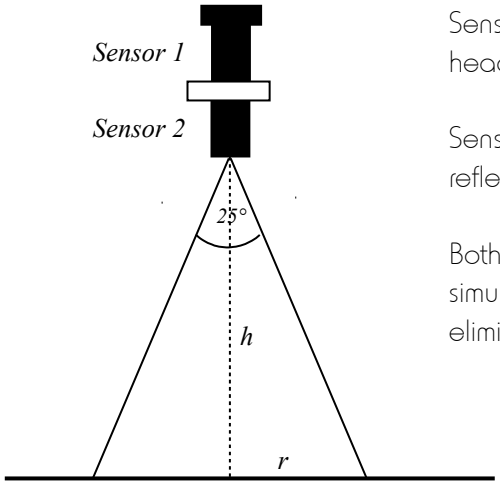
APPENDIX 1 – NARROW ANGLE LIGHT ACCEPTANCE AREA

The SKR 1850 and 1850A 4 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 4 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