



High Output Light Sensors (HOPLS) Voltage & 4-20mA



SKL 2000 Series

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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.

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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 a 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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HOPL – High Output Light Sensors

1. INTRODUCTION

Skye Instruments' 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.

The HOPL High Output Light Sensors include a built in amplifier with a choice of outputs for compatibility with most dataloggers, data acquisition systems, controllers and PLC's. The outputs can be one of a range of voltages – please see your Calibration Certificate for the exact model and output range of your sensor.

This manual covers the five types of sensor in this range, three PAR or Photosynthetically Active Radiation sensors (PAR Quantum, PAR Special and PAR Energy), a total solar radiation Pyranometer plus Lux sensors for human or animal studies. Skye also manufacture HOPL sensors for UVA, UVB & UVI, these three sensors are covered in a separate manual.

As with Skye's standard output range of single channel light sensors, HOPLs are fully waterproof IP67 and suitable for temporary immersion (30 minutes) to a depth of 4m depth. They are ideal for monitoring light levels in all environments around the world.

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. TYPES OF SENSORS & OPERATION

2.1 LIGHT SENSORS FOR MEASURING FROM ANY LIGHT SOURCE

Sensor Type:	Voltage Output:	4-20mA Output:
PAR Special	SKL 2610	SKL 2615
PAR Quantum	SKL 2620	SKL 2625
PAR Energy	SKL 2640	SKL 2645
Lux	SKL 2633	SKL 2638

These sensors have cosine corrected heads, each containing a semi-conductor photodiode and optical filter system responding to light according to the response curves in Appendix 1.

These sensors are completely sealed and can be left in exposed conditions. They are rated IP67 – suitable for temporary immersion (30mins) to depths of 4m.

Each sensor has been calibrated against a reference lamp, whose own calibration has been carried out at the National Physical Laboratory (NPL). They are calibrated for use with any natural or artificial light source.

Linearity is excellent with a maximum of 1% deviation up to levels beyond 1500 W m⁻² (greater than normal solar irradiance).

N.B. The maximum output for some sensors will be limited by the amplifier gain and output voltage limits.

2.2 LIGHT SENSORS FOR TOTAL SOLAR RADIATION

Sensor Type:	Voltage Output:	4-20mA Output:
Silicon Cell Pyranometer	SKL 2650	SKL 2655

The Pyranometer cosine corrected head contains a special high grade silicon photocell, sensitive to light between 350 and 1100nm. The exact response curve is shown on Appendix 1.

These sensors are completely sealed and can be left in exposed conditions. They are rated IP67 – suitable for temporary immersion (30mins) to depths of 4m.

This sensor has been calibrated under open-sky conditions, against reference Pyranometers and hence referred 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.

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Because of the different spectral responses of the silicon photocell and the thermopile Pyranometers, to obtain accurate readings the sensor must be used in the same conditions as its calibration, i.e. under open sky only. The calibration of the SKL 2650/2655 silicon cell Pyranometer is not valid for measuring solar radiation inside glasshouses or polytunnels etc.

Different conditions of sun, cloud, etc., will slightly affect calibration, but absolute errors will always be within 5% and typically much better than 3%. Linearity is excellent, with a maximum of 1% deviation up to levels of 3000 W m^{-2} (greater than normal solar irradiance).

2.3 SENSOR POSITIONING

For accurate measurements, correct positioning of the sensor is essential. We recommend the use of a levelling unit (SKM 222), the sensor is secured using the M6 hole in the base and supplied bolt and washers. Great care should be given to the placing of the sensor, in order to achieve accurate and repeatable results. Avoid objects that will shade the sensor (unless it is permanently shaded, and is relevant to the study). We recommend taking readings facing the sun (so that extraneous objects such as sampling instruments and yourself do not cast a shade over the sensor).

The sensor is fully waterproof - rated to IP67 - and entirely suitable for long term monitoring in all weathers and all environments. We guarantee these sensors to a depth of 4m when submerged for 30 minutes.

Take care to secure the sensor cable to avoid chafing, trapping etc. that may lead to permanent damage of sensor/sensor cable.

2.4 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 3. The cosine errors to an 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.

2.5 SENSOR MAINTENANCE

HOPL High Output 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. The sensor cable should be secured to avoid movement damage or chafing in the wind if used in an outdoor location.

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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. The calibration change, if any, since last calibration will also be shown on the certificate.

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3. OUTPUTS

Voltage output sensors require a power supply between 5 and 15 volts DC, however the power supply voltage must be increased for sensors with a maximum output >2V (see table below). Current consumption is approximately 1mA, meaning that they can be powered from a logic high output of some computer cards and PLC's (check the specifications of the equipment first).

4-20mA loop current versions require a power supply of 12-36 volts DC.

Sensor Output:

Up to 0-2 V

Up to 0-5 V

Up to 0-10 V

4-20 mA

Power Supply Required:

5-15 V DC

9-15 V DC

12-15 V DC

12-36 V DC

The output voltage or loop current is linear with increasing light levels and will rise to a maximum value.

The precise scaling factor is given on the sensor's calibration certificate. Typical sensor outputs are as follows:

Part Number	Description	Sensor Output	Working Range	Typical Value on a summer day
SKL 2610 / SKL 2615	PAR Special	0-2V / 4-20mA	0-3000 $\mu\text{mol m}^{-2} \text{s}^{-1}$	> 2000 $\mu\text{mol m}^{-2} \text{s}^{-1}$
SKL 2620 / SKL 2625	PAR Quantum	0-2V / 4-20mA	0-3000 $\mu\text{mol m}^{-2} \text{s}^{-1}$	> 2000 $\mu\text{mol m}^{-2} \text{s}^{-1}$
SKL 2633 / SKL 2638	Lux	0-2V / 4-20mA	0-150 klx	> 100 klx
SKL 2640 / SKL 2645	PAR Energy	0-2V / 4-20mA	0-600 W m^{-2}	> 500 W m^{-2}
SKL 2650 / SKL 2655	Pyranometer	0-2V / 4-20mA	0-1500 W m^{-2}	> 1100 W m^{-2}

Voltage output sensor will have a small zero/dark offset voltage of ± 0.2 mV. Even with a 2 V output sensor this represents an error of only 0.01% and can be reasonably ignored. With most systems it will be below the minimum resolution of measurement anyway and thus will not be resolved for measurement, it will appear as zero. If desired and possible, the offset can be measured and subtracted or added to all measurements, since it is a constant offset.

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4. CONNECTIONS

The sensor may be supplied wire ended for connection to the user's own equipment, or with a connector fitted for compatibility with Skye's own DataHog or MiniMet datalogger ranges, or SpectroSense2 meter range.

Part Number Suffix:	Description:
/I	Connector compatible with Skye DataHog2 and Apollo
/SS2	Connector compatible with Skye SpectroSense2 range
/X	Connector compatible with an "EXT" extension cable

4.1 VOLTAGE OUTPUT SENSORS

Great care should be taken not to apply power to the output lead. The output will drive loads with impedance from infinity to around 1k Ω . The output will not be damaged by momentary shorting to the common, but should never, even momentarily be shorted to the supply.

Wire Colour:	Function:	Pin Number (/I and /SS2):	Pin Number (/X):
Red	+ve power supply to sensor (5-15 VDC)	1	1
Green	Sensor -ve output	3	3
Yellow	Sensor +ve output	4	4
Blue	Power supply ground	5	5
White	Cable screen/sensor housing	5	6

4.2 4-20 mA SENSORS

Wire Colour:	Function:	Pin Number (/3 and /X):
Red	+ve in	1
Blue	-ve return	2
Green	Cable screen/sensor housing	3

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4.3 EXTENSION CABLES

The "EXT" range of extension cables can be used with sensors whose part number includes "/X".

EXT/1 These extension cables are compatible with voltage output sensors. At one end a 7 pin connector is fitted for connection to the sensor. At the other end a pin connector is fitted for connection to a Skye DataHog2, Apollo or SpectroSense2.

EXT/3 These extension cables are compatible with voltage output sensors. At one end a 7 pin connector is fitted for connection to the sensor. At the other 100mm wire tails are left for connection to the users own datalogger, meter or PLC.

Wire Colour:	Function:	Pin Number: (7 pin)	Pin Number: (5 pin)
Black	+ve power supply to sensor (5-15 VDC)	1	1
Red	-	2	2
Yellow	Sensor -ve output	3	3
Green	Sensor +ve output	4	4
Blue	Power supply ground	5	5
White	Cable screen/sensor housing	6	5

EXT/6 These extension cables are compatible with 4-20 mA sensors. At one end a 3 pin connector is fitted for connection to the sensor. At the other 100mm wire tails are left for connection to the users own datalogger, meter or PLC.

Wire Colour:	Function:	Pin Number:
Red	+ve in	1
Blue	-ve return	2
Green	Cable screen/sensor housing	3

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5. SPECIFICATIONS

	SKL 2610 SKL 2615	SKL 2620 SKL 2625	SKL 2640 SKL 2645	SKL 2650 SKL 2655	SKL 2633 SKL 2638
Working Range (1)	0-3000 $\mu\text{mol m}^{-2} \text{s}^{-1}$		0-600 W m^{-2}	0-1500 W m^{-2}	0-150 klx
Sensor Passband	PAR 400 - 700 nm			350 - 1100 nm	CIE photopic Curve V(λ)
Housing	Delrin & anodised aluminium				Anodised aluminium
Dimensions	65mm (h) x 34mm (d)				67mm (h) x 34mm (d)
Weight	200g (with 3m cable)				
Cable	Voltage output: 7-1-4C military specification 4-20mA: 7-2-2C military specification				
Detector	Silicon photodiode				
Sensor Output	Voltage output (customer choice of 0-1V up to 0-10V) or 4-20mA loop current				
Linearity error over working range	<0.2%				
Absolute calibration error (2)	Typically 3%, but <5%				
Cosine error (3)	3%				
Azimuth error (4)	<1%				
Temperature Co-efficient	$\pm 0.1\%/^{\circ}\text{C}$				
Long term stability (5)	$\pm 2\%$				
Response Time (6)	<10ms				
Operating Range	-20°C to +70° C 0-100% RH				
Mounting	M6 x 7mm tapped hole in base. Sensor supplied with M6 x 16mm screw + 4 x 1.5mm washers to suit panel thicknesses of 3-10mm				
Power Supply Requirements	Voltage output sensors – max output +2V DC 4-20mA loop current sensors require 12-36V DC				

NOTES ON SPECIFICATIONS

(1) All Skye sensors will work at levels of irradiance well above that found in terrestrial sunlight conditions, room or growth chamber lighting. These are default working ranges, check individual calibration certificate.

(2) Main source of this error is uncertainty of calibration of Reference Lamp. Skye calibration standards are directly traceable to NPL standard references.

(3) Cosine error to 80° is typically 5% max. Figures shown are for normal use sources, e.g. sun plus sky, diffuse sun, growth chambers, etc.

(4) Measured at 45° elevation over 360°.

(5) 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.

(6) Times are generally less than the figure quoted, which is in milliseconds. They may be slightly increased if long leads are fitted, or those of a higher capacity cable.

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APPENDIX 1 – NON-STANDARD PART NUMBERS

PART NUMBER SUFFIXES

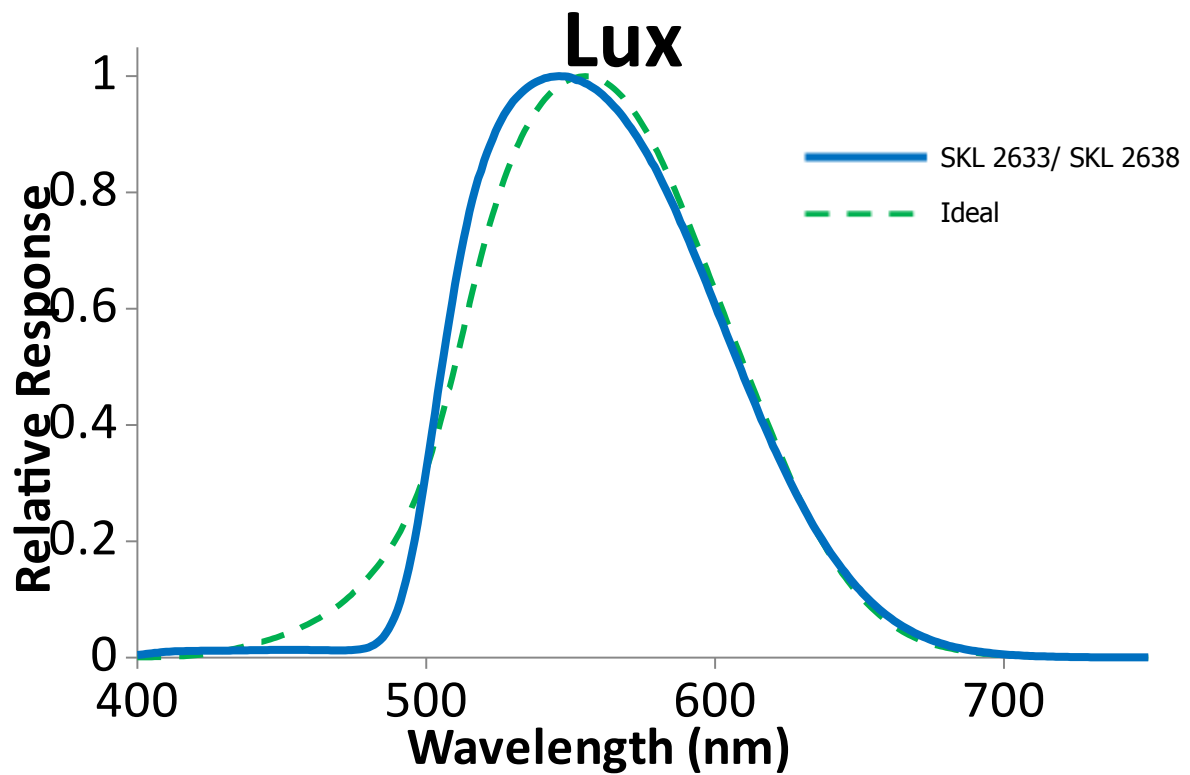
<u>/LT</u>	These sensors have been fitted with cable suitable for lower temperatures. Whilst the special cable is rated for use at low temperatures, it is still advisable to avoid undue stress, movement, etc. of the cable when at low temperatures. Wire colours and connections may vary and are shown on a separate wiring sheet.
<u>/WEISS</u>	These sensors have been fitted with a special cable for Weiss manufactured cabinets and chambers.
<u>SKL2625/WEISS</u>	This product has a 5m cable terminating in a 3-pin inline socket Binder part number 99-0406-800-03 and is supplied with a mating connector, a 3-pin plug binder part number 99-0405-800-03 connected with a 0.3m extension cable.
<u>-20V</u>	These sensors have an output range of 0-5V and require a power supply of 14-20 V DC.
<u>-24V</u>	These sensors have an output range of 0-10V and require a power supply of 23-26 V DC.

HISTORICAL PART NUMBERS

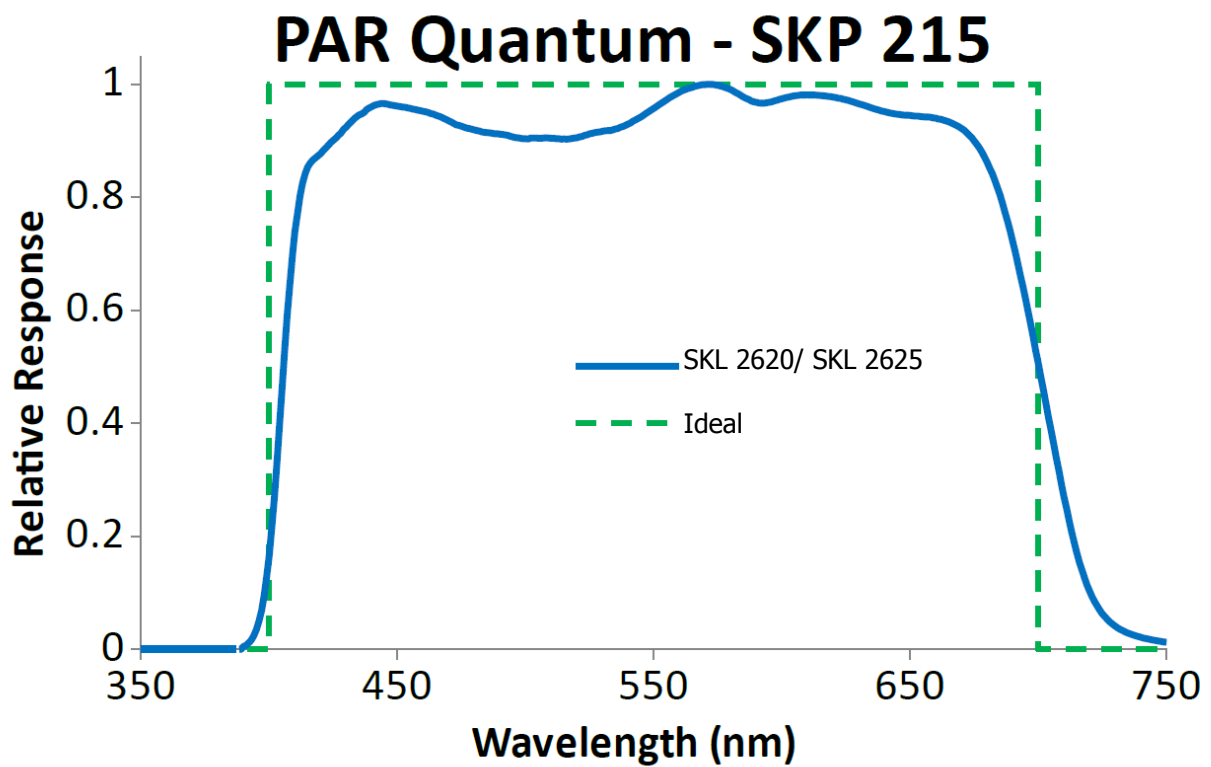
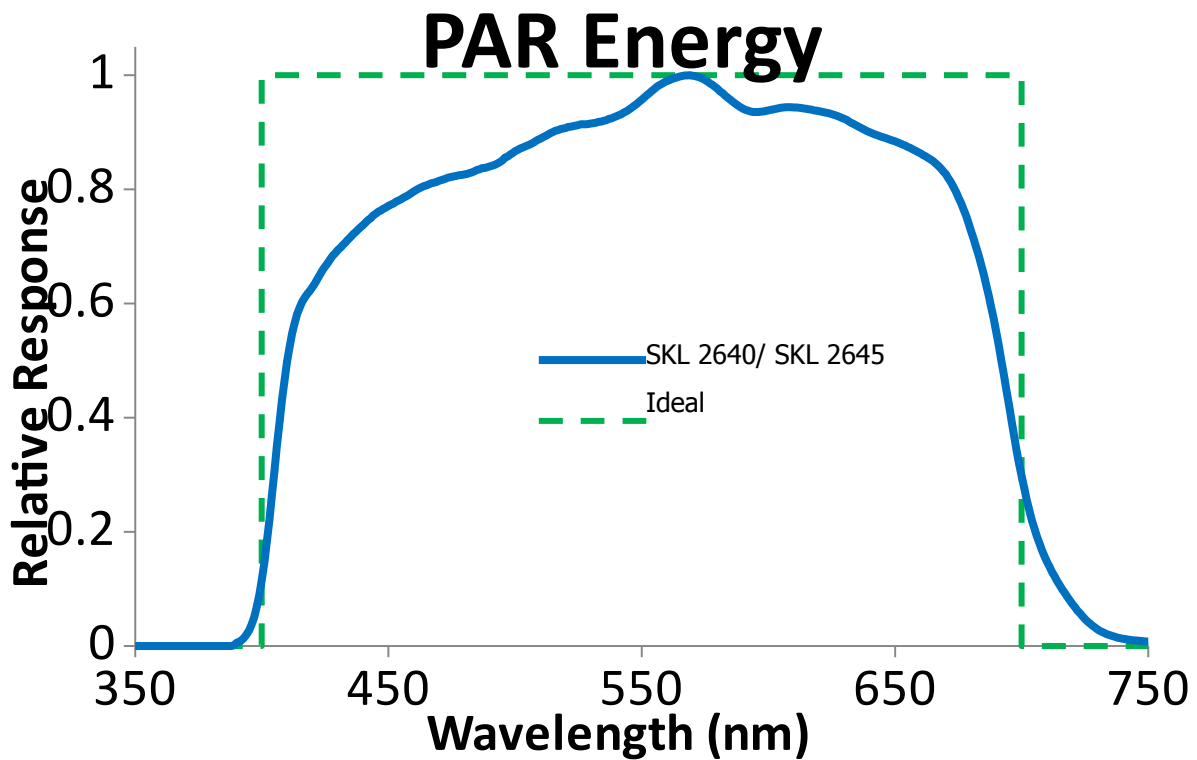
<u>SKL 2630 / 2335</u>	Lux response in a delrin housing.
<u>SKL 2630L / 2635L</u>	Lux response but fitted with a Large Area Photodiode for increased sensitivity at low light levels in a delrin housing.
<u>SKL 2632L</u>	Lux response with a Large Area Photodiode in an aluminium housing.
<u>/LS</u>	These sensors have been fitted with a Large Area Photodiode plus a non cosine correcting diffuser for maximum sensitivity at low light levels. All other sensor specifications and wire connections remain the same. The sensitivity of the individual sensor is shown on the Calibration Certificate.

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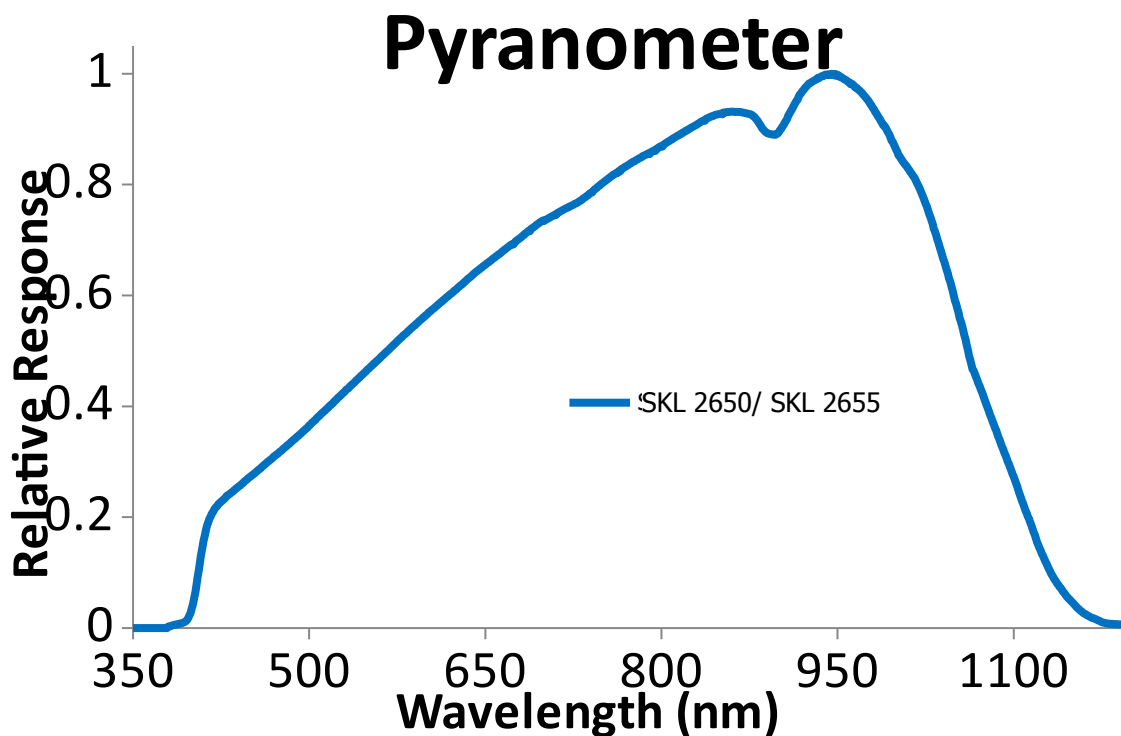
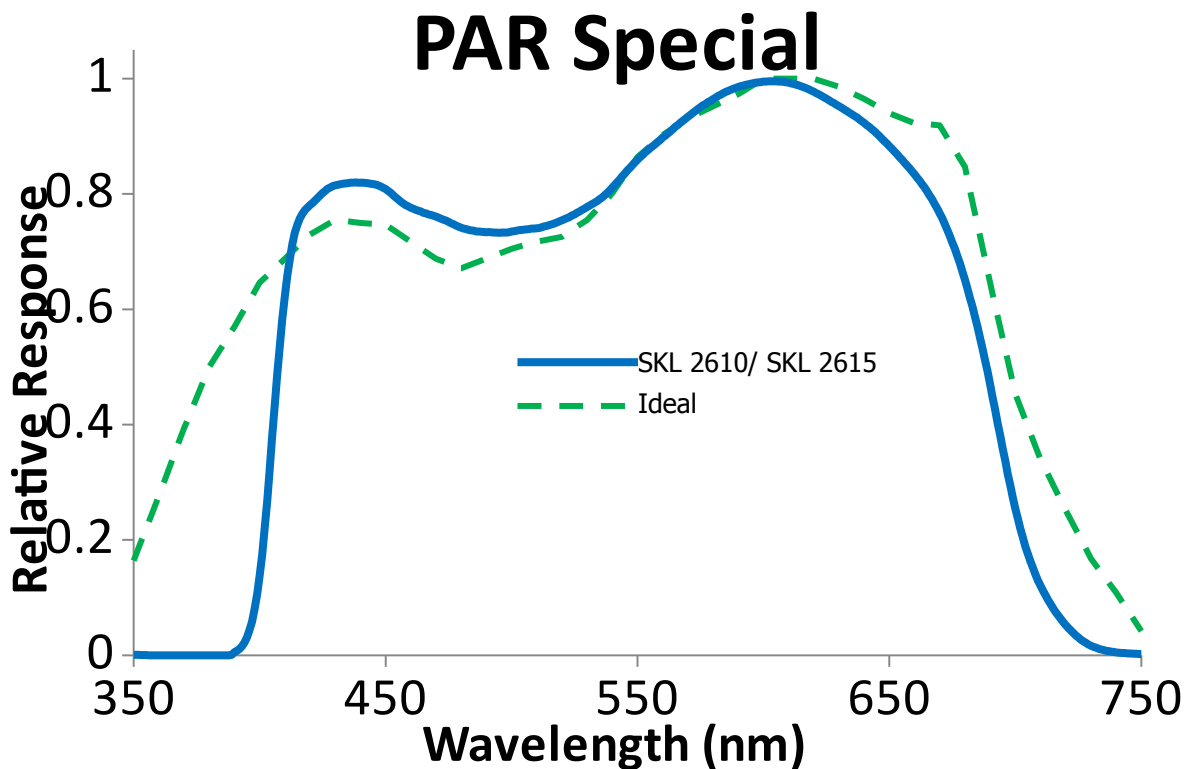
APPENDIX 2 - RESPONSE CURVES



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APPENDIX 3 – COSINE RESPONSE

Typical Cosine Response Error Window

