

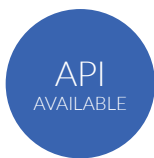
# CAL Product Line

## iQ-LED light sources for camera calibration and characterization

The CAL product line uses our multispectral iQ-LED technology for flexible camera calibration and characterization. A full calibration can be performed in as little as a few seconds due to the short response time of the iQ-LEDs.

### Main Features

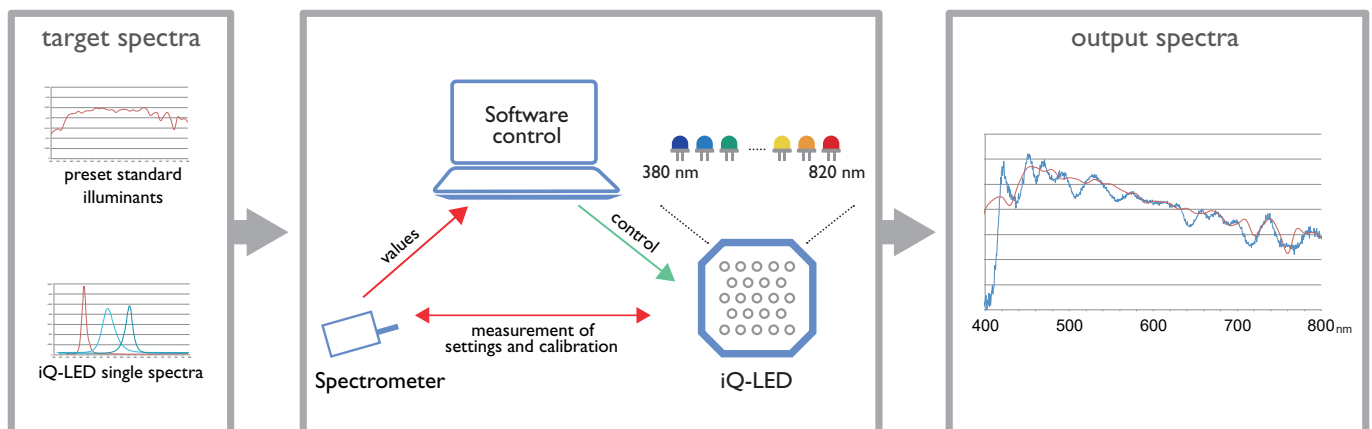
- \* Includes all of the features from iQ-LED
- \* Measurement of the spectral sensitivity
- \* Calibration of gain/sensitivity for exposure
- \* Calibrate luminance and color shading
- \* Check white balance under various light sources
- \* Optimized for production line integration
- \* Detection of defect pixels



### Only one light source

Each of our CAL devices has iQ-LED control software and a spectrometer to ensure you have proper illumination over the lifetime of the device. Using iQ-LED, the CAL devices can recreate various spectra including everything from standard light sources to different color patches.

Example of the CAL1

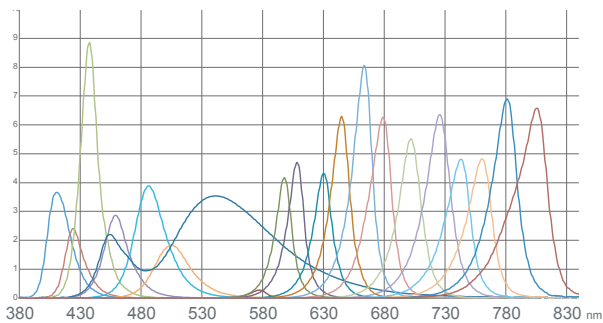


iQ-LED workflow

## Advanced features of the CAL line

Each CAL product is uniquely designed using a non-reflecting special diffuser filter to ensure even light distribution on the measuring plane. So, as long as the image processing and transfer of the camera are fast enough, a full camera calibration can be completed in a matter of seconds. This capability is what makes the CAL products ideal for calibrating cameras on production lines.

The devices are controlled with the iQ-LED control software. We also offer an iQ-LED C++ API for easy integration into your designs. A built-in spectrometer is also included with each device.



20 individual spectral channels



iQ-LED software main screen

At a Glance	iQ-LED V2 in CAL product line
Principle	High power SMD-LED based spectral broadband light module for spectral programmable camera calibration and characterization devices
Light sources	41 SMD high power LEDs / separated in 20 color channels / spectral range: 380 – 820 nm / intensity controlled via 4000 steps per channel and 32 kHz PWM (switchable to 1000 steps with 128 kHz)
Spectral measurement	Closed loop functionality with calibrated mini spectrometer via control software Spectral Range: 350 – 870 nm / Resolution: 2048 pixel / FWHM: 2.4 nm
Control system	Software-based control system via USB (included with all CAL devices), C++ API available* Storage of up to 44 different illuminants, one sequence, and default light source / controllable via microswitch controller (without connected PC)
Included reference illuminants	D50, D55, D65, D75, A, B, C, E Planckian spectral curve by selected temperature (1900 - 18000 K) The iQ-LED technology is optimized for the best spectral match and allows CRI values up to 99, depending on illuminant and intensity
Output data	Real-time measurement of the spectral trend, CCT, CRI, illumination, and radiant power, with closed loop link with micro-spectrometer
Production line integration	Operation hour counter Self-diagnosis Self-calibration with calibrated spectrometer
Software requirements	PC with Windows 7 operating system (or higher) and USB port
Additional functions	<ul style="list-style-type: none"> <li>• Auto-generation of standard illuminants or externally measured spectra</li> <li>• Save and load function of self-defined spectral arrangements or intensities</li> <li>• Storage of illuminants/sequences on device</li> <li>• Creation of test sequences</li> <li>• Real-time display of spectral measurement</li> <li>• Real-time calculation of CCT, CRI, curve fit and illumination level</li> </ul>

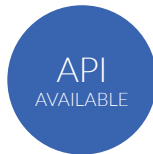
# CAL1

## Our original uniform light source for camera calibration

The CAL1 is a 0.3 m integrating sphere that uses iQ-LED technology to illuminate a 70 mm opening for camera characterization and calibration. A non-reflective diffuser filter with improved Lambertian characteristics on the sphere opening ensures illumination uniformity.

### Main Features

- \* Includes all of the features from iQ-LED
- \* Uniformity of > 98%
- \* Camera calibration in less than one second
- \* Improved non-reflective diffuser filter



### How to use the CAL1

The CAL1 can be used as a stand-alone testing device for single camera testing in a lab. It can also be integrated into a production line for more efficient calibration and characterization of multiple cameras.



A modified CAL1 for size D35 transparent test charts

At a Glance	CAL1
Principle	Integrating sphere with uniform illumination for camera calibration and characterization.
Output window	70 mm diameter, circular output window
Light source	1 x iQ-LED V2: 41 SMD high power LEDs
Uniformity	> 98% (70 mm diameter)
Maximum / Minimum illumination level	25 lx up to 8000 lx (for standard D illuminants) / depending on illuminant and required curve fit / CRI

# CAL2

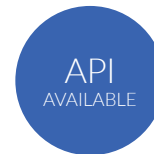
## The highly adaptable camera calibration light source

This ultra-compact light source is based on iQ-LED technology and can adapt to many different areas of measurement. Its edge box design makes it particularly suited for calibrating cameras on a production line. A non-reflective diffuser filter with improved Lambertian characteristics on the box opening ensures illumination uniformity.



### Main Features

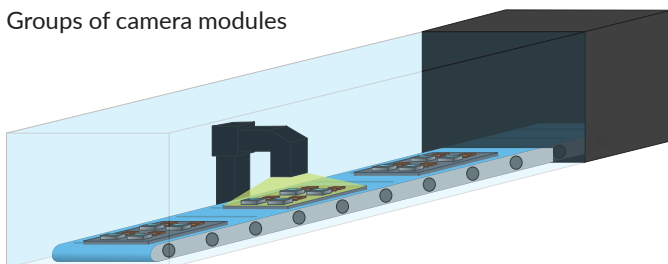
- \* Includes all of the features from iQ-LED
- \* Uniformity of > 96%
- \* Camera calibration within seconds
- \* Improved non-reflective diffuser filters
- \* Optimized for production line integration
- \* Small compact design



### Production line integration

The CAL2, and the accompanying LED software, can substitute for multiple calibration and testing devices on a production line, making mass camera calibration and characterization far more efficient. We provide a separate spectrometer for the CAL2 when it is integrated into a production line.

Groups of camera modules



An example of the CAL2 calibrating multiple camera modules at the same time

At a Glance	CAL2
Principle	Highly adaptable edge box for camera calibration and characterization on a production line
Output window	60 mm x 60 mm output window
Light source	1 x iQ-LED V2: 41 SMD high power LEDs
Uniformity	> 96% (60 x 60 mm output window)
Maximum / Minimum illumination level	25 lx up to 8000 lx (for standard D illuminants) / depending on illuminant and required curve fit / CRI

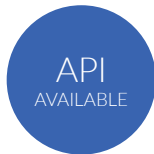
# CAL3

## Camera calibration light source for wide-angle lenses

The CAL3 is a 0.3 m integrating sphere that uses iQ-LED technology to illuminate a 38 mm concave curved opening. The curved opening as opposed to flat (CAL1) is more suited for wide-angle cameras. A bowl shaped non-reflective diffuser filter on the sphere opening ensures illumination uniformity.

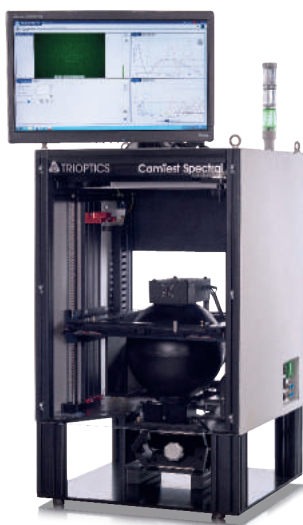
### Main Features

- \* Includes all of the features from iQ-LED
- \* Small compact design
- \* Uniformity of > 95%\*
- \* For cameras with a 180-degree field of view
- \* Production line integration



### Production line integration

As a result of the short response time of iQ-LED, a full calibration can be performed in less than a second making it ideal for integration into a production line.



Production line integration for camera control testing within the CamTest Spectral module from Trioptics GmbH

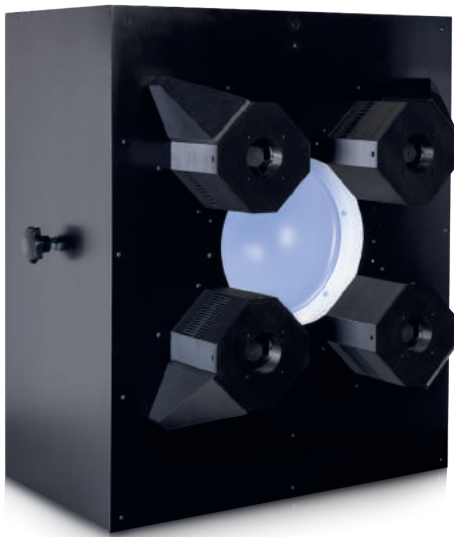
At a Glance	CAL3
Principle	Integrating sphere with uniform illumination for camera calibration and characterization of high field of view cameras.
Output window	38 mm diameter circular output window with bowl shaped diffuser
Light source	1 x iQ-LED V2: 41 SMD high power LEDs
Uniformity	> 95%* for FOV < 160° at min. 10 mm depth inside diffuser for 160°-180° FOV at min. 20 mm depth inside diffuser
Maximum / Minimum illumination level	25 lx up to 7000 lx (for standard D illuminants) / depending on illuminant and required curve fit / CRI

\*Measurement performed in the center of diffuser, standard illuminant D65

# CAL3-XL

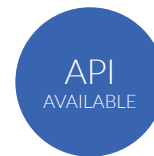
## A calibration light source for wide-angle cameras

The CAL3-XL is an iQ-LED integrating sphere with a circular 196 mm opening and a bowl-shaped diffuser for uniformity of illumination. It is ideal for camera calibration and testing of large cameras with wide-angles.



### Main Features

- \* Includes all of the features from iQ-LED
- \* Test large cameras with a wide-angle
- \* Uniformity of > 90%\*
- \* 500 mm diameter of integrating sphere
- \* For cameras with a 180-degree field of view



## CAL3-XL design

Due to its size, the CAL3-XL uses four iQ-LED elements as opposed to only one that is used by the normal CAL3. Four elements are necessary to ensure illumination uniformity with the much wider opening.

At a Glance	CAL3-XL
Principle	Integrating sphere with uniform illumination for camera calibration and characterization of cameras with wide-angles of view.
Output window	196 mm diameter circular output window with bowl shaped diffuser
Light source	4x iQ-LED V2: 164 SMD high power LEDs
Uniformity	> 90%* at a depth of approx. 65 - 85 mm inside diffuser
Maximum / Minimum illumination level	10 lx up to 4500 lx / (for standard D illuminants)

\*Measurement performed in the center of diffuser, standard illuminant D65