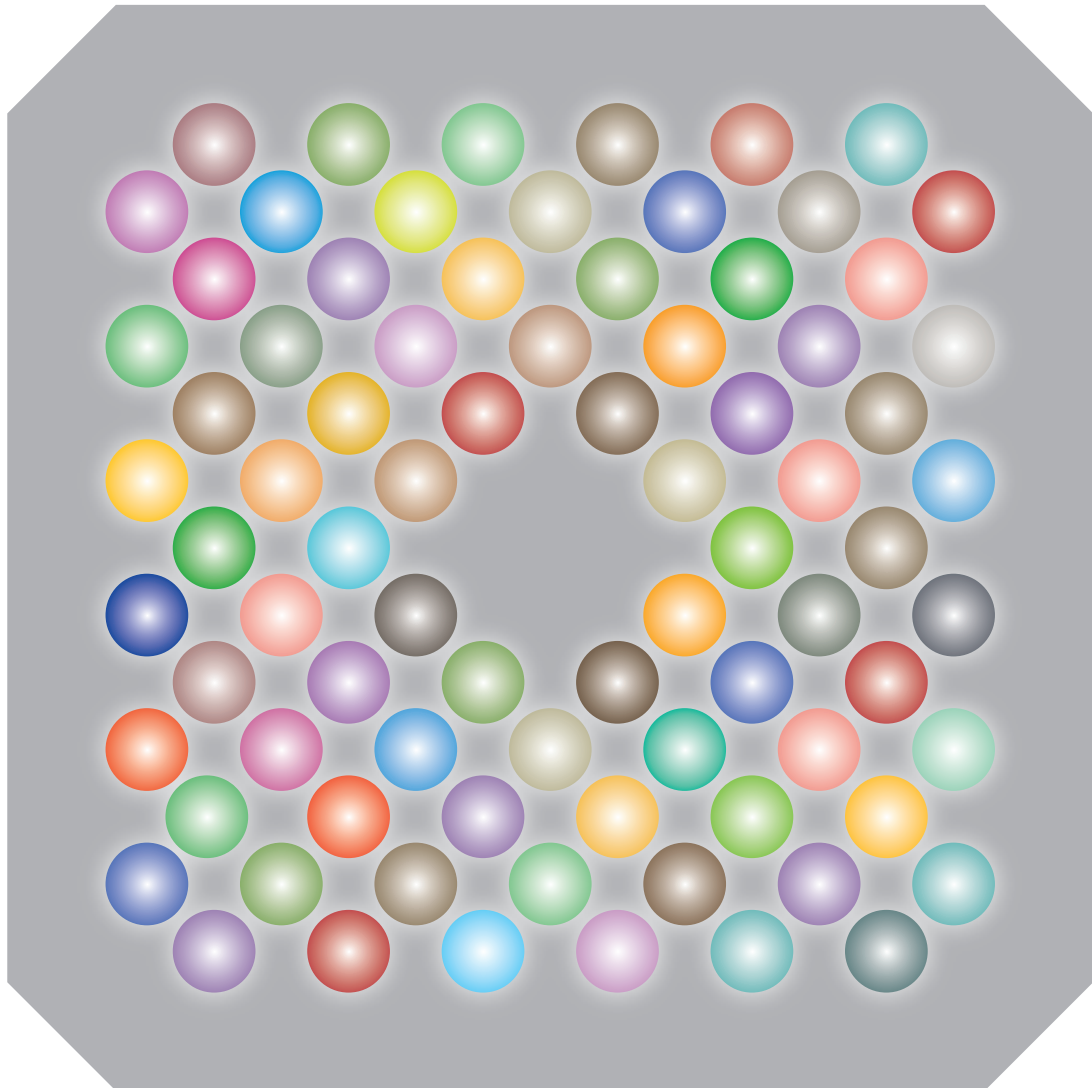


INNOVATIVE CAMERA CHARACTERIZATION BASED ON LED LIGHT SOURCE



iQ-LED



Image Engineering

iQ-LED TECHNOLOGY

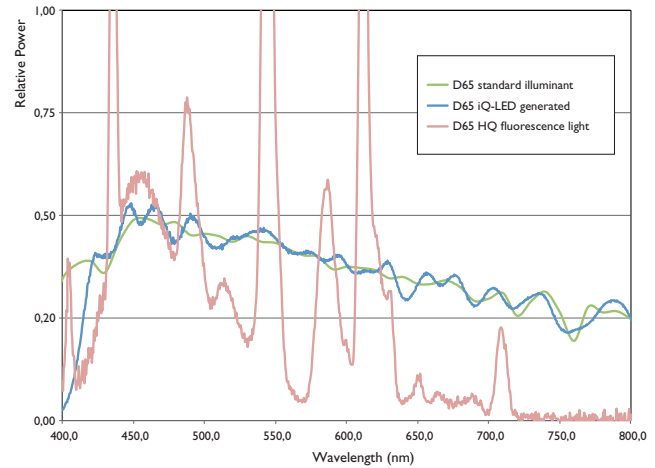
The most flexible LED-based light source is the heart of all adaptive IE lighting products

Create your own light by adjusting the 22 channels in the visible range to suit your needs. You can automatically simulate standard light sources, reconstruct the daylight distribution from dawn until dusk, create patches of a high-saturated color chart, or reconstruct the spectral distribution of a measured light source. By using the individual channels, you can even measure the spectral sensitivities of a camera.

The iQ-LED provides you with the closest match to standard D light sources in a broad range from 400 up to 820 nm. Aside from many other predefined light sources, you will also be able to generate your own custom spectra in combination with the spectral radiometer EX2. The intensity variation is realized with a pulse width modulation (PWM) of 32 kHz, in order to enable working with short exposure times. Linear tuning of the intensity for each channel using 1000 steps provides an accurate way to manipulate every part of the spectrum. The internal temperature stabilization enables a constant spectrum for a period of a fraction of a second, to well over a few hours. A software-based, quick and easy self-calibration avoids any kind of effects caused by burn-in or long-term degradation of the LEDs on predefined spectra, ensuring a long lifetime. Due to its extremely short response time, light settings can be changed with frequencies of up to 40 Hz. The technical characteristics of the iQ-LED are particularly designed for the higher requirements in the area of camera testing and camera calibration. On request, we supply the iQ-LED system as a stand-alone version. We combine it with a NIST traceable calibrated spectrometer and the control software, which allows you to create your own light source adapted to your needs.

The standard module consists of 22 different channels and 80 LEDs arranged on a 10 x 10 cm board. This board can be combined with other boards to form larger and more intense light sources.

The iQ-LED extension module was developed to extend the spectral range to the infrared region. It also consists of 80 LEDs on a 10 x 10 cm board, but it has 11 channels mostly in the IR region. It is typically used in combination with two standard



Comparison of D65 spectra:
HQ Fluorescence and iQ-LED

iQ-LED modules so as to level the intensities of all channels. In order to offer you an opportunity to integrate the iQ-LED in your individual test procedures, we optionally provide a C++ Application Programming Interface (API) for the entire iQ-LED product line.

iQ-LED Basic Features:

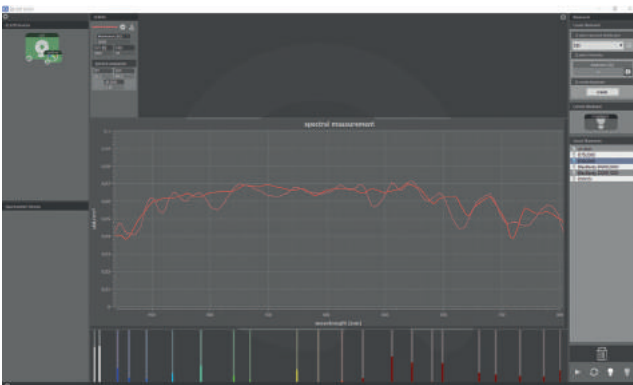
- free selectable spectral distribution
- fast calibration
- constant spectral distribution for every intensity level
- predefined standard illuminants (A, B, C, D50, D75)
- black body curve by selected CCT (correlated color temperature)
- auto generation of external measured or imported spectra
- creation of individual test sequences
- real time display of spectral measurement
- real time calculation of CCT, CRI, illumination level
- C++ API available

A grant for the flexible simulation of light types.



iQ-LED SOFTWARE

Desktop control software and EX2 for iQ-LED devices are included



iQ-LED Software Basic Features:

- suitable for any iQ-LED device
- user friendly interface
- handles of multiple devices
- saving and loading illuminants
- controlling every single spectral channel
- composing and running illumination sequences
- spectrometer aided control loop for high-precision illuminants
- device calibration ensuring constant quality at the highest level

Calculated quantities

Photometry:

- Illuminance [lux]
- Luminance [cd/m²]
- Correlated Color Temperature (CCT) [K]
- Color rendering index (CRI)

Colorimetry:

- color difference Delta E (CIE 2000) between actual and reference illuminant

Accuracy:

- accordance between actual and reference spectrum (FIT)
- Spectral Camera Calibration Index (SCI)

iQ-LED API

Application Programming Interface

The iQ-LED API provides a comprehensive and intuitive programming interface for the iQ-LED light source and the EX2 spectrometer.

The API enables you to write your own software using all of the advantages of the device while staying as flexible as possible by focusing only on your requirements.

Of course, its integration into already existing software systems is also possible.

The API consists of classes which represent physical devices as well as convenient data container classes. Its interface only depends on standard ISO C++ and its Standard Library STL. All required hardware drivers are supplied.

Extensive API documentation is accompanied by useful and practical code examples leading you through the most commonly used cases.

Application Programming Interface available



LE7

Uniform, multispectral, iQ-LED powered chart illumination par excellence

A software controlled integrating sphere with an internal mini spectrometer for spectral control and homogeneous illumination of transparent test charts in size D280. Depending on the device power, intensities can be set between 25 and 6000 lx.

Features:

- iQ-LED Basic Features
- high homogeneity >97%
- available with different max illumination values
- integrated mini spectrometer to verify your spectral distribution in real time



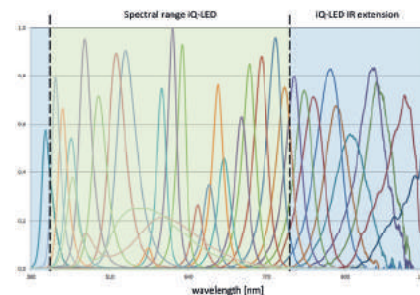
LE7-IR

Tunable light spectrum extended to IR

LE7-IR is the extended version of the LE7. The 480 LEDs of the light source create different spectra not only in the visible but also in the near infrared spectrum up to 1050 nm.

Features:

- iQ-LED Basic Features
- LE7 Features
- extended spectral range from 380 up to 1050 nm



CAL

Camera characterization and calibration light sources

Today more than ever camera technology is subject to constant change. In order to keep pace with the market's quality requirements, the need for a reliable test system grows. For the characterization and calibration of cameras in the laboratory, or in the production line, the specialists of Image Engineering have developed the CAL product line. These compact calibration light sources are equipped with multispectral iQ-LED technology and offer the highest degree of flexibility in your choice of lighting type. You only need one device for all light sources such as A, D50, D65, or any other standard light source or self-generated spectra. For spectral sensitivity measurements, the CAL product line allows for the individual activation of each of the 20 narrow band color channels.

The special design, connected with a non-reflecting special diffuser filter, ensures an even light distribution on the measuring plane. As a result of the iQ-LED's very short response time, a

full calibration can be performed in a few seconds if the image processing and transfer in the camera is fast enough.

The easy-to-use iQ-LED control software controls the CAL devices or, if upgraded with the iQ-LED C++ API, they can be integrated into your individual test procedures.

The different CAL devices feature the main functions of the iQ-LED.

Possible applications are:

- calibration of the exposure control
- detection of defect pixels
- determining the luminance and color shading
- checking of the auto white balance under various light sources (i.e. A, C, D50 D55, D65, D75)
- measurement of the spectral sensitivity

CALI

The one light source solution in the field of camera characterization and calibration

Its compact design consists of one iQ-LED element in a 0.3 m integrating sphere that illuminates a 70 mm opening.

Features:

- iQ-LED Basic Features
- high homogeneity >98%
- integrated mini spectrometer

CAL3

Camera calibration light source based on iQ-LED for wide-angle lenses

Its design consists of one spectral programmable iQ-LED element in a 0.3 m integrating sphere that illuminates a 38 mm concave curved luminous surface.

Features:

- iQ-LED Basic Features
- high homogeneity >95%
- concave curved luminous surface for wide-angle lenses
- integrated mini spectrometer

iQ-ALIGN

Precise adjustment for extreme wide-angle cameras in front of calibration light sources CALI and CAL3

For a comfortable and precise adjustment of cameras in the security and automotive area, we recommend iQ-Align. It can be used with the calibration light sources CALI and CAL3. The camera align system is based on a linear guidance in combination with an iQ-Mobilemount.

CAL2

The small light source for the flexible integration into a production line

The CAL2 can substitute for multiple devices on a production line. It solves 90% of all calibration issues and it saves time and money. The 60 x 60 mm large opening allows you to calibrate multiple cellphone camera modules at the same time, while also making calibration faster and more accurate than with any other device.

The device can also be used for camera calibration and testing purposes when space is limited. In this case, the spectrometer, utilized for calibrating the device, is separated from the light source. This means one single spectrometer can be operated for several calibration stations equipped with the CAL2. Should there be any special requirements regarding implementation into your test setup and workflow, the whole system can be customized to fit your needs. The special internal design, for which we have a patent pending, allows you to achieve a similar uniformity (>96%) and intensity (up to 3000 lx) that we have in the CALI with its integrating sphere.



Features:

- iQ-LED Basic Features
- high homogeneity >96%
- mini spectrometer for calibration
- ideal for production line integration

iQ-FLATLIGHT

The spectrally tunable source to illuminate large areas

The iQ-Flatlight is designed to illuminate larger areas, such as our size A1066 test charts, or even small rooms with the comfort of a spectrally tunable light source. The iQ-Flatlights are normally sold as a pair, where each of the two units has an approximate luminous area of 0.7 x 0.7 m² and consist of 10 or 20 iQ-LED modules. The construction allows the lights to be fixed on ceilings or walls in different ways. In combination with a camera test stand, they come on rollable stands that can be adjusted in front of the test charts in a flexible way to achieve uniform illumination. The illumination of large charts and areas has never been more flexible.



Features:

- iQ-LED Basic Features
- illuminates large areas
- mini spectrometer included

iQ-CHART BOX

Compact LED illumination unit for reflective charts

The iQ-Chart Box makes it possible to illuminate reflective test charts quickly and homogeneously. It is the compact solution for providing optimal conditions for the image quality testing of cameras and cell phones. The light source consists of 8 iQ-LED modules. Chart changing is carried out quickly and easily by means of a movable carriage.



Features:

- iQ-LED Basic Features
- compact
- high uniformity
- low light conditions with ND filters down to 1,5 lx



iQ-LED LIGHT HEAD

A technological breakthrough in test scene illumination

The iQ-LED lightHEAD provides the possibility to illuminate the real scene of the lighthSTUDIO for visual analysis with every standard illumination or any other kind of light. Several iQ-LED modules are combined into a single light head to reach an adequate illumination level. Just as our other iQ-LED-based products, the lightHEAD works with an internal spectrometer, to enable realtime measurements of the spectrum in your scene. The lightSTUDIO is available with different features, please have a look on our website (www.image-engineering.com).



EX2

Measure daylight or light sources with one of the smallest calibrated spectral radiometers

The EX2 is based on the same mini spectrometer that is used in our adaptive lighting products. With its compact design and connection through just one USB cable to your laptop, you can measure the spectral distribution of any kind of light source when and wherever needed. The EX2 comes fully NIST traceable calibrated and with an easy-to-use software. After measuring a light source, you can import the spectral distribution to all of your iQ-LED products control software and reproduce it in just a few seconds.

Main Features:

- usable everywhere
- easy and quick handling
- measure spectral distribution

EX2	
Principle	mini spectrometer for directive measurement via optical fiber opening (~25° FOV) or cosine corrector add on (~180° FOV)
Spectral range VIS version	350 – 870 nm
Spectral range VIS-IR version	380 – 1100 nm
Resolution VIS version	Sensor: 2024 pixel/ FWHM: 2.4 nm
Resolution VIS-IR version	Sensor: 2024 pixel / FWHM: 2.35 nm
Integration time	1.05 ms – 10 minutes
Control system	software based control
System requirements	Windows 7 operating system (or higher)
Calibration	NIST traceable calibrated It is recommended to recalibrate the EX2 once a year, regardless of the operating hours



	LE7 WITH 2 iQ-LED	LE7 WITH 4 iQ-LED	LE7 WITH 6 iQ-LED	LE7-IR
Principle	integrating sphere			
Light source	2 x iQ-LED 160 LEDs, 22 channels (20 color, 2 white) 32 kHz PWM	4 x iQ-LED 320 LEDs, 22 channels (20 color, 2 white) 32 kHz PWM	6 x iQ-LED 480 LEDs, 22 channels (20 color, 2 white) 32 kHz PWM	4 x iQ-LED 2 x iQ-LED IR extension 480 LEDs, 33 channels (31 color, 2 white) 32 kHz PWM
Spectral range	400 – 820 nm			380 – 1050 nm
Predefined standard illuminants	D50, D55, D65, D75, A, B, C Planckian spectral curve by selected temperature (1900 - 18,000 K)			
Uniformity of illumination	active chart area (>97%) resp. full chart area (>96%)			
Illumination stability	+/- 2% ^{**}			+/- 2% (380 – 820 nm) +/- 4% (820 – 1050 nm)
Maximum / Minimum illumination values	Standard D illuminants: 1400 lx	Standard D illuminants: 2800 lx	Standard D illuminants: 4200 lx	Standard D illuminants: 2800 lx
	max: up to 2000 lx min: down to 25 lx	max: up to 4000 lx min: down to 25 lx	max: up to 6000 lx min: down to 25 lx	max: up to 4000 lx min: down to 25 lx
	max. and min. depending on illuminant and required curve fit/CRI			
	for low intensity use the system can be combined with a neutral density filter			
Intensity use	depending on illuminant, for low intensity use the system can be combined with a neutral density filter			
Spectral measurement	integrated NIST traceable calibrated mini spectrometer			
Spectral range /spectrometer	350 – 870 nm / resolution: 2048 pixel			350 – 1050 nm resolution: 2048 pixel
Features	easily adjustable spectral distribution of the emitting light via 22 (LE7-IR 33) software controlled LED channels, standard illuminants or reproduction of external measured spectra, self defined arrangements including single channels for color calibration, creation of test sequences, application programming interface (API) available on request			

^{**} measured for selected standard illuminants after changing an illuminant at optimal temperature
See complete datasheet for detailed information.

	CAL1	CAL2	CAL3
Principle	integrating sphere	our patented edge box with adaptable design	integrating sphere
Light source	1 x iQ-LED: 80 LEDs, 22 channels (20 color, 2 white) / 32 kHz PWM		
Spectral range	400 – 820 nm		
Uniformity of luminance in active area	70 mm circle* output >98%	60 x 60 mm output window >96%	>95%* for FOV <160° at min. 10 mm depth inside diffuser for 160°- 180° FOV and at min. 20 mm depth inside diffuser
Predefined standard illuminants	D50, D55, D65, D75, A, B, C, Planckian spectral curve by selected temperature (1900 up to 18,000 K) depending on illuminant		
Illumination stability	+/- 2% ^{**}		
Standard D illuminants	2000 lx		1700 lx
Maximum / Minimum illumination values	max. up to 3000 lx min. down to 25 lx	max. up to 3000 lx min. down to 25 lx	max. up to 2500 lx min. down to 25 lx
	depending on illuminant and required curve fit / CRI		

* measurement performed in the center of diffuser, standard illuminant D65
^{**} measured for selected standard illuminants after changing an illuminant at optimal ambient temperature

	iQ-FLATLIGHT	iQ-CHART BOX	iQ-LED LIGHTHEAD
Principle	diffuse light panel	chart holder with illumination device (includes mini spectrometer), software controlled	diffuse light head
Light sources	10 or 20 Image Engineering iQ-LED units: 80 LEDs/unit / 22 channels (20 color, 2 white) / 32 khz PWM / 1 or 2 FI I fluorescent tubes OSRAM L 18W/940	8 x Image Engineering iQ-LED units: overall 640 LEDs 2 white and 20 color channels, 32 khz PWM, spectral range: 400 – 820 nm , 4 x 18W fluorescent tubes D50	iQ-LED (10 PCS.): 800 LEDs, 22 channels (20color, 2 white) / 32 kHz PWM / 400 -820 nm / approx. lifetime 10,000 h
Spectral range	400 – 820 nm	400 – 820 nm	400 – 820 nm
Predefined standard illuminants	D50, D55, D65, D75, A, B, C, Planckian spectral curve by selected, temperature (1900 up to 18,000 K), CRI up to 99) depending on illuminant and intensity		
Illumination stability	+/- 2% ^{**}	+/- 2% ^{**}	+/- 2% ^{**}
Maximum / Minimum illumination values	10 units two flatlights, illumination on chart: predefined illuminants: up to 400 lx without defined spectra: up to 1000 lx	max. up to 500 lx standard D illuminants: 400 lx* min. down to 25 lx with ND filters down to 1,5 lux* (depending on illuminant and required curve fit / CRI)*	max. up to 600 lx / min. down to 25 lx, depending on illuminant
	20 units two flatlights, illumination on chart: predefined illuminants: up to 800 lx without defined spectra: up to 2000 lx		
	condition: two iQ-LED flatlights placed beside a IEA1066 size test chart in ~80 cm distance and ~45° viewing angle		

* measured at center of A460 sized test chart

^{**} measured for selected standard illuminants after changing an illuminant at optimal temperature