

LumiCam 1300/2400

2D imaging colorimeter with manual objective lenses



We bring quality to light.



Key features at a glance

- ▲ LumiCam variants Mono, Color, and Advanced
- ▲ High-resolution sensor up to five megapixels
- ▲ Wide luminance measuring range – up to 13 orders of magnitude
- ▲ Multiple exposures allow a dynamic range of five decades in a single image

01 \\ LumiCam – imaging colorimeter for advanced 2D light measurement

The key to a precise light measurement is foremost research, quality and consistency. With this in mind all products developed at Instrument Systems provide most advanced light analysis solutions in order to accomplish complex measurement requirements in aviation, automotive, general lighting or the display industry.

The 2D imaging colorimeter LumiCam features a precise determination of photometrical properties such as luminance and color distributions within seconds. Therefore, the camera has become an industry-leading light measurement system applied for quality assurance of dashboards, panel displays, widescreen cockpits

or instrument clusters in research, product development as well as production.

The unique combination of modern hardware with comprehensive software makes the LumiCam to a flexible measurement solution and allows data extraction possibilities especially tailored to the distinct needs of the individual user.

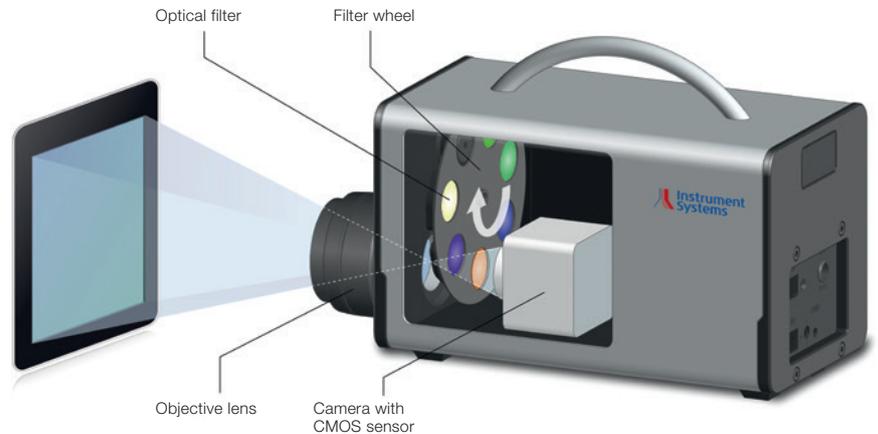


▲ LumiCam as 2D imaging colorimeter for quality assurance of dashboards in automotive industry.

02 \\ Functioning principle

The LumiCam is a high-resolution 2D luminance and color measurement device based on optical filters. Dependent on the LumiCam variant a sensor-adjusted filter is either permanently mounted between the lens and the sensor or a filter wheel allows for a successive pivoting of multiple individual filters into the detection path.

Each pixel of the camera sensor is assigned a calibrated luminance and color value to generate a 2D image of the photometric data. The data exchange between a LumiCam with its controlling PC is realized by a network cable while the filter wheel is controlled by USB.



Optical design of the LumiCam with color filter wheel.

03 \\ LumiCam variants and sensor resolution

Our LumiCam portfolio encompasses three different camera variants to technologically and economically address individual customer requirements to give access to diverse photometric data.



LumiCam Mono

The LumiCam Mono impresses with a compact design. It has a steady and sensor-calibrated Y' filter for an exact measurement of luminance, luminous intensity and luminous intensity distribution. The Y' filter represents the photopic luminosity function of the human eye $V(\lambda)$ with a precisely defined deviation of $f_1' < 3\%$.



LumiCam Color

The LumiCam Color is equipped with a positioning wheel holding the four color filters X1', X2', Y' and Z', jointly resembling the tristimulus functions of the eye receptors. Thus, the camera gives access to a detailed analysis of the color coordinates (x, y and u', v'), correlated color temperature, dominant wavelength as well as color purity.



LumiCam Advanced

The LumiCam Advanced features six color filters (X1', X2', Y', Z' plus two correction filters K', L') and a patented matrix optimization algorithm to achieve optimal measurement results also for narrow-band light sources, such as LEDs or OLEDs.

Sensor resolution

Each of the LumiCam variants is equipped with either a 1370 x 1020 pixels (LumiCam 1300) or a 2428 x 2028 pixels (LumiCam 2400) sensor. The LumiCam 2400 model provides a five megapixels image that represents the spatially resolved values for luminance and chromaticity. Optimized for Automotive applications, this model allows for precise imaging and light analysis of whole instrument clusters or for small details to be evaluated with high resolution.

LumiCam variants: Overview

Measurement task	LumiCam variant		
	Mono	Color	Advanced
Luminance	✓	✓	✓
Luminous intensity	✓	✓	✓
Luminous intensity distribution ¹⁾	✓	✓	✓
Color coordinates (x,y; u',v')		✓	✓
Correlated color temperature		✓	✓
Dominant wavelength		✓	✓
Color purity		✓	✓
Optimized LED color measurement			✓

¹⁾ With optional LVK analysis kit.

04 \ \ Powerful and fast analysis software

The LumiCam is supported with powerful diagnostic software for the investigation of photometric data. The large and continuously growing collection of graphical software analysis tools includes

- ▲ Spotmeter of variable sizes
- ▲ Line profiles and polylines generated by individually set anchor points
- ▲ Polygons for flexible bounding areas
- ▲ 3D objects

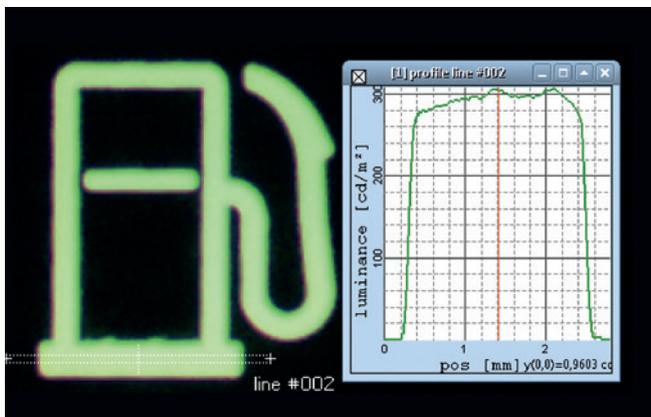
These features provide the user a straightforward and flexible way to define regions of interest within a captured image, where the 3D box permits a clear and detailed data visualization in false color scheme.

Based on the region of interest and the user defined analysis request the LumiCam software will promptly calculate relevant quantities such as

- ▲ Luminance distribution
- ▲ Color coordinates (x, y and u', v')
- ▲ Correlated color temperature
- ▲ Planck distance
- ▲ Dominant wavelength
- ▲ Purity
- ▲ Contrast

All extracted results can be displayed in a false color, logarithmic or 3D color scheme to support a clear and unambiguous visualization. The export and reporting functions of the LumiCam software offer the user documentation in ASCII or PDF format and thus allow a further processing of relevant data.

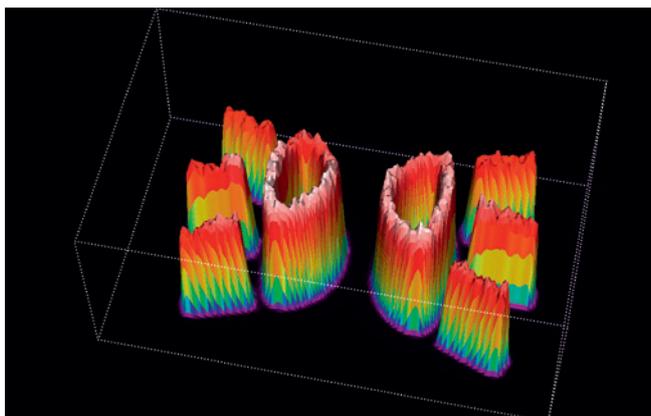
Our LumiCam software brings the opportunity to generate analysis recipes that can be saved as templates for streamlining and expediting recurring measurement tasks. The Windows supported Dynamic Link Library (DLL) of LumiCam allows for the implementation of customer-specific measuring functions. Within this context we offer LabVIEW virtual instruments packages to address the LumiCam DLL via LabVIEW and to grant way for user defined testing algorithms.



▲ Analysis tool: line profile



▲ Analysis tool: Polygon



▲ Analysis tool: 3D box

05 \\ Advanced software packages

Black Mura audit

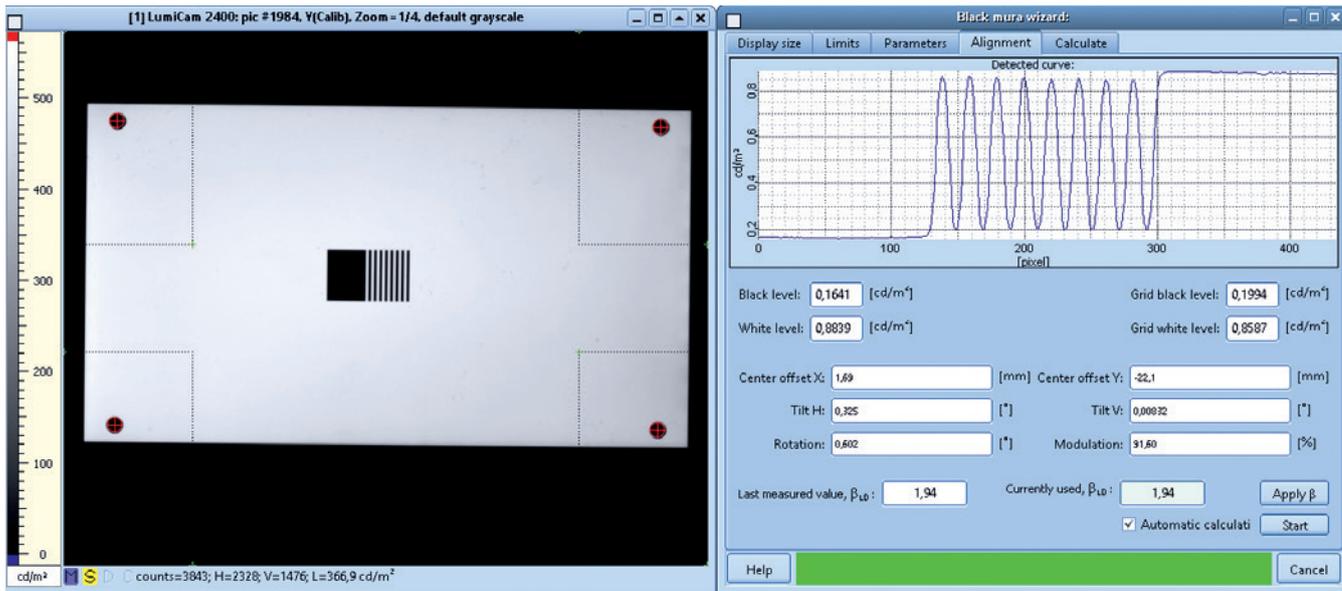
The Japanese expression ‘Mura’ addresses unwanted local luminance and/or color variations within a liquid crystal (LC) display where Black Mura stands for Mura effects at black screen condition. The quantification of Black Mura effects in LC displays is of particular importance as the human eye at dark conditions has highest contrast sensitivity (Weber-Fechner law). In combination with the fact that LCs are embedded in a black mask within a black display frame, the task to determine the luminance uniformity under black

screen condition is essential to the automotive industry for example.

The LumiCam Black Mura tool offers a user-friendly, clear and dependable audit of uniformity defects as requested by the “Uniformity Measurement Standard for Displays” released by the German Automotive OEM Work Group Displays. The scope of the Black Mura tool is the evaluation of mean luminance, luminance uniformity, and relative luminance gradient for small to medium sized LC displays with respect to the latest OEM specifications.

Standardized data evaluation

Instrument Systems continually advances its analysis software solutions to provide an evaluation of measured display data according to latest international standards as well as specifications. While this is of great interest to the general display market it is predominantly important to the automotive industry in order to meet specified OEM display criteria.



▲ Black Mura alignment pattern. A green bar confirms a successful orientation of the device under test with regards to the camera.

06 \\ Flexible hardware options



LumiCam measurement equipment encompasses a variety of lenses with matching neutral density filters as well as external apertures.

Optical accessories: Density filters, lenses & external apertures

External optical equipment for the LumiCam includes calibrated neutral density filters such as OD2 or OD4. In combination with internal or external apertures they account for a dynamic measurement range of up to 13 orders of magnitude.

Magnetic mounts ensure an easy and reproducible installation of the provided external apertures and density filters while the set of lenses with focal lengths from 28 mm to 100 mm covers a wide range of viewing directions.



◀ Have a closer look: Magnetic mounts ensure an easy and reproducible installation of external apertures and filters.

Lenses: Overview

	28 mm lens	50 mm lens	100 mm lens
Focal length	28 mm	50 mm	100 mm
Minimum focusing distance (DUT to lens)	18 cm	37 cm	11 cm
Minimum measurement distance (DUT to housing)	25 cm	50 cm	30 cm
LumiCam 2400			
Image size at min. measurement distance (h x v)	61 mm x 51 mm	73 mm x 61 mm	14 mm x 12 mm
Image size (one pixel) at min. measurement distance (h x v)	25 μm x 25 μm	30 μm x 30 μm	6 μm x 6 μm
Image size at 1 m distance (h x v)	282 mm x 236 mm	154 mm x 129 mm	76 mm x 63 mm
Image size (one pixel) at 1 m distance (h x v)	116 μm x 116 μm	63 μm x 63 μm	31 μm x 31 μm
LumiCam 1300			
Image size at min. measurement distance (h x v)	64 mm x 48 mm	77 mm x 57 mm	14 mm x 10 mm
Image size (one pixel) at min. measurement distance (h x v)	47 μm x 47 μm	56 μm x 56 μm	10 μm x 10 μm
Image size at 1 m distance (h x v)	300 mm x 220 mm	160 mm x 120 mm	80 mm x 60 mm
Image size (one pixel) at 1 m distance (h x v)	217 μm x 217 μm	119 μm x 119 μm	58 μm x 58 μm

▲ Overview of available LumiCam lenses and their optical properties.

Manual positioning system DTS 400

The manual positioning system DTS 400 permits an exact positioning of the device under test with respect to the LumiCam for all three spatial dimensions. This can be of special interest when it comes to the observation of instrument clusters, where an accurate re-positioning of the camera is required.



The DTS 400 permits a precise positioning of the LumiCam at far distance from the device under test.

07 \\ Innovative measurement solutions

LVK analysis kit

Instrument Systems provides a turnkey analysis kit called LVK (German abbreviation for luminous intensity distribution curves) to accurately determine

- ▲ Luminous intensity distribution curves
- ▲ Spatial homogeneity of color coordinates
- ▲ Correlated color temperature

It is designed for small to mid-sized light sources such as single LEDs, LED modules, retrofit lamps and small luminaires.



The LVK analysis kit comprises a LumiCam, a light permeable screen and a light source.

The LVK measurement setup¹⁾ is comprised of an optical bench, a light-permeable screen, a holder for the LumiCam and a mount for the luminaire. The LumiCam detects the luminance distribution arising on the screen up to an angle of 65° from

which spatial radiation patterns or angle-dependent differences in the color coordinates are calculated.

The typical measuring time is less than one minute independent of how many luminous intensity

distribution curves are calculated from the obtained data. The short measurement time allotted by the LVK analysis kit makes it an ideal solution to quickly and successfully accomplish tasks in – for example – goods control or quality assurance.

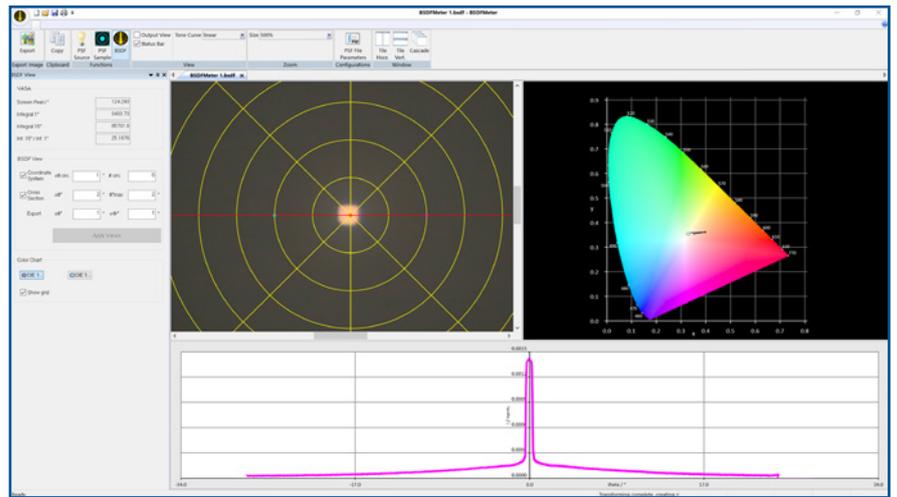
¹⁾ In the LVK setup the LumiCam is equipped with a special 14 mm objective lens.

BSDF analysis kit

Instrument Systems offers an advanced and straightforward BSDF (bidirectional scattering distribution function) analysis kit for a precise directional analysis of scattered light.

The BSDF setup is comprised of an isotropic point light source with stabilized power supply and an optical bench holding the sample as well as the LumiCam. The component lineup can be chosen to measure either the bidirectional reflection distribution function (BRDF) or to determine the bidirectional transmission distribution function (BTDF) of the device under test.

The planar test sample is illuminated by the point light source having isotropic emission which results in an illuminance that varies across the sample surface. To each element of the sample surface one specific



direction of light incidence and one specific direction of scattered light can be addressed while the luminance and chromaticity of the scattered light is recorded by the LumiCam. The provided BSDF software takes the details of the setup into calculation and automatically unveils the scattering distribution function.

The Instrument Systems BSDF analysis kit permits a time-effective identification and separation of (non-)specular components and thus an evaluation of appearance characteristics like haze or distinctness of an image.



▶ BSDF measurement setup in reflective operation mode.

08 \\ Accredited quality

As a leading manufacturer of light measurement equipment Instrument Systems strives to ensure that you can put greatest possible trust in our instruments. Thanks to the accreditation of our test laboratories according to DIN EN ISO/IEC 17025, our customers enjoy reliable and

traceable measurement results and guaranteed comparability between different measurement instruments. This enables our customers to demonstrate the quality of measurements to any third party and ensures excellent accountability. Besides the DIN EN 13032-1 test

procedure for photometric quantities, we follow DIN EN ISO 11664 for the measurement of colorimetric quantities. All standards used are directly traceable to reference standards of the national laboratories PTB (Germany) or NIST (USA).

09 \\ Service and support

At Instrument Systems we set a benchmark with our products and our services. We secure the long-term value of your investment and guarantee optimum productivity over the entire period of use with industry leading support.

Our service offerings include the following:

- ▲ Engineering services
- ▲ Technical advice, also post-sales
- ▲ Certified re-calibration
- ▲ Instrument repair and hardware upgrade
- ▲ Software updates

10 \\ Technical specifications

LumiCam 2400

LumiCam 2400	Mono	Color	Advanced
Quantities			
Photometric quantities	Luminance (cd/m ²), luminous intensity (cd), contrast		
Colorimetric quantities	-	Color coordinates (x,y), color coordinates (u',v'), tristimulus values (X, Y, Z), dominant wavelength (nm), color saturation, correlated color temperature CCT (K)	
Camera data			
Sensor	Sony IMX264LLR CMOS Sensor		
Sensor size	2/3", 11.1 mm diagonal		
Effective number of pixels (h x v)	2428 x 2028 (5 MP)		
Pixel size	3.45 μm x 3.45 μm		
AD converter	12 bit		
Exposure time	40 μs to 30 s		
Aperture reproducibility ¹⁾	0.5 %		
Luminance measurement			
Measurement range ²⁾	1 mcd/m ² ... 2 Mcd/m ²		
Extended measurement range ^{3), 4)}	up to 2 x 10 ¹⁰ cd/m ²		
Measurement time incl. data saving time (at 10 cd/m ²) ⁵⁾	2.1 s		
Measurement time incl. data saving time (at 100 cd/m ²) ⁵⁾	2.1 s		
Accuracy for std. illuminant A ⁶⁾	±3 %	±3 %	±3 %
Accuracy for LED color light ⁷⁾	-	-	±2 %
Repeatability ⁸⁾	±0.1 %		
Uniformity ⁹⁾	±0.5 %		
Filter match ¹⁰⁾	f ₁ ' < 3 %		
Smear	No smear (due to CMOS technique)		
Color measurement			
Measurement time incl. data saving time (at 10 cd/m ²) ⁵⁾	-	14 s	22 s
Measurement time incl. data saving time (at 100 cd/m ²) ⁵⁾	-	11 s	18 s
Accuracy (x, y) for std. illuminant A ¹¹⁾	-	±0.003	±0.003 ¹³⁾
Accuracy (x, y) for color light ^{11), 12)}	-	±0.010	±0.010 ¹³⁾
Accuracy (x, y) for LED color light ⁷⁾	-	-	±0.005
Repeatability (x, y) ⁹⁾	-	±0.0001	±0.0001
Uniformity (x, y) ⁹⁾	-	±0.001	±0.001
Accuracy (dominant wavelength) ⁷⁾	-	-	±1 nm
Repeatability (dominant wavelength) ¹⁴⁾	-	±0.05 nm	±0.05 nm

Filter match	$f_1' (Y) < 3 \%$	$f_1' (Xb) < 6 \%$ $f_1' (Xr) < 6 \%$ $f_1' (Y) < 3 \%$ $f_1' (Z) < 4 \%$	$f_1' (Xb) < 6 \%$ $f_1' (Xr) < 6 \%$ $f_1' (Y) < 3 \%$ $f_1' (Z) < 4 \%$
General			
Interface	Gigabit Ethernet	Gigabit Ethernet, USB 1.0/2.0	
Operating system	Windows 7 (32/64 bit), Windows 10 (64 bit)		
Dimensions incl. objective lens	182 mm x 100 mm x 81 mm	285 mm x 120 mm x 175 mm	
Weight	1 kg	3 kg	
Power supply	12 V external		
Operating conditions	10 to 40 °C ¹⁵⁾ , max. 75 % relative humidity (non-condensing)		

Instrument Systems continuously endeavours to develop and improve its products. Any technical changes, errors or misprints do not form ground for compensation. The company's terms of delivery and payment apply in all other respects. If not otherwise stated explicitly, all specifications refer to the Nikon 50 mm lens with a 16 mm aperture.

- ¹⁾ For external apertures (diameter 4 mm, 8 mm, 16 mm, 32 mm) with effective f-numbers 14 (4 mm) – 1.4 (32 mm).
- ²⁾ The lower limit corresponds to the maximal exposure time and smallest f-number at SNR 10:1 and vice versa.
- ³⁾ Valid for OD4 filter.
- ⁴⁾ Specification of LumiCam 2400 Advanced in the extended measurement range identical to the LumiCam 2400 Color (e.g. regarding accuracy of color coordinates).
- ⁵⁾ Value calculated from 100 repetitions taking data saving time into account.
- ⁶⁾ Calculated from 100 repetitions. Refers to the deviation of the mean from the reference value.
- ⁷⁾ Verified using a test set of color LEDs (peak wavelength between 449 nm and 640 nm) and white LEDs (3000 K to 5000 K); maximum deviation from measurement with reference spectrometer.
- ⁸⁾ Calculated from 50 repetitions. Refers to the double standard deviation of the measured values.
- ⁹⁾ Refers to the maximum deviation from the mean value calculated from flat-field verification image.
- ¹⁰⁾ Deviation of the filter transmission from the $V(\lambda)$ curve integrated over the entire visible spectrum.
- ¹¹⁾ Narrowband and LED based light sources (white and monochrome) should be measured using advanced mode. For other broadband light sources (e.g. illuminant A) color mode is recommended.
- ¹²⁾ Maximum deviation from the reference source (Illuminant A with set of color glass filters).
- ¹³⁾ Using 4-filter color mode.
- ¹⁴⁾ Derived from 20 repetitions for R, G, and B - LEDs with optimized signal level. Refers to the double standard deviation.
- ¹⁵⁾ 20 to 25 °C for specified measurement accuracy.

LumiCam 1300

LumiCam 1300	Mono	Color	Advanced
Quantities			
Photometric quantities	Luminance (cd/m ²), luminous intensity (cd), contrast		
	Luminous intensity distribution ¹⁾ (cd), illuminance ¹⁾ (lux)		
Colorimetric quantities	-	Color coordinates (x, y), color coordinates (u', v'), tristimulus values (X, Y, Z), dominant wavelength (nm), color saturation, correlated color temperature CCT (K)	
Camera data			
Effective pixels (h x v)	1370 x 1020		
Pixel size	6.45 µm x 6.45 µm		
AD converter	12 bit		
Size CCD sensor	2/3", 11 mm diagonal		
Luminance measurement			
Dynamic range (single exposure) ²⁾	4,600:1		
Dynamic range (multiple exposure mode) ²⁾	6,000,000:1		
Measurement range ³⁾	0.1 mcd/m ² ... 100,000 cd/m ²		
Extended measurement range ^{4), 5)}	up to 10 ⁹ cd/m ²		
Measurement time (at 10 cd/m ²) ⁶⁾	1 s		
Measurement time (at 100 cd/m ²) ⁶⁾	0.8 s		
Accuracy for std. illuminant A ⁷⁾	±4 %	±4 %	±4 %
Accuracy for LED color light ⁸⁾	-	-	±2 %
Repeatability ⁹⁾	±0.1 %		
Linearity	±0.5 %		
Uniformity ¹⁰⁾	±1 %		
Filter match ¹¹⁾	f _i ' < 1.6 %		
Color measurement			
Measurement time (at 10 cd/m ²) ⁶⁾	-	13 s	16 s
Measurement time (at 100 cd/m ²) ⁶⁾	-	6 s	8 s
Accuracy (x, y) for std. illuminant A ⁵⁾	-	±0.003	±0.003
Accuracy (x, y) for color light ^{5), 12)}	-	±0.010	±0.003
Accuracy (x, y) for LED color light ^{5), 8)}	-	-	±0.005
Repeatability (x, y) ⁹⁾	-	±0.0001	±0.0001
Uniformity (x, y) ¹⁰⁾	-	±0.001	±0.001
Repeatability (dominant wavelength) ^{9), 13)}	-	±0.05 nm	±0.05 nm
Filter match	-	f _i ' < 6 % (for X), f _i ' < 4 % (for Z)	n. a.

General		
Interface	Gigabit Ethernet	Gigabit Ethernet, USB 1.0/2.0
Operating system	Windows 7 (32/64 bit), Windows 10 (64 bit)	
Dimensions incl. objective lens	182 mm x 98 mm x 78 mm	278 mm x 122 mm x 175 mm
Weight	1 kg	3 kg
Power supply	12 V external	
Environmental conditions	10 - 35 °C ¹⁴⁾ , max. 70 % relative humidity (non condensing)	
LVK analysis kit		
Angular range	-65° to 65°	
Angular accuracy	±1°	
Overall size (L x W x H)	2,000 mm x 708 mm x 678 mm	
Measurement area screen (W x H)	610 mm x 480 mm	
14 mm lens		
Focal length	14 mm	
Minimum focusing distance (DUT to lens)	11 cm	
Minimum measurement distance (DUT to housing)	25 cm	
Image size at min. measurement distance (h x v)	116 mm x 86 mm	
Image size (one pixel) at min. measurement distance (h x v)	85 µm x 85 µm	
Image size at 1 m distance (h x v)	570 mm x 425 mm	
Image size (one pixel) at 1 m distance (h x v)	416 µm x 416 µm	

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All specifications above are related to the 50 mm lens with aperture 2.8 unless otherwise specified.

- ¹⁾ With optional light distribution curve test setup (LC-LVK).
- ²⁾ SNR 25:1, spotmeter radius 10 pixels.
- ³⁾ 0.1 mcd/m² at 30 s exposure time and aperture 1.4 and SNR 10:1; 100,000 cd/m² at 1 ms exposure time and aperture 16 (both without ND filters).
- ⁴⁾ With optionally available OD4 filter.
- ⁵⁾ Specification of LumiCam 1300 Advanced in the extended measurement range identical with LumiCam 1300 Color (e. g. regarding accuracy of color coordinates).
- ⁶⁾ Values for aperture 1.4 and auto-ranging mode; first measurement may take longer; with LumiCam 1300 Advanced a higher accuracy can be achieved in comparison to LumiCam 1300 Color, but then measurement time takes longer.
- ⁷⁾ For open aperture; traceable to PTB standard according to ISO 17025; extended measuring uncertainty applied to a twofold standard deviation.
- ⁸⁾ Verified using a test set of color LEDs (peak wavelength between 449 nm and 640 nm) and white LEDs (3000 K to 5000 K); measured max/min tolerance with respect to reference spectrometer.
- ⁹⁾ 2σ at 10 cd/m², auto ranging mode and within a series of measurements.
- ¹⁰⁾ Average of 10 x 10 pixels.
- ¹¹⁾ Y-filter (V_λ)-filter.
- ¹²⁾ Verified using a test set of color glass filters and white halogen lamp.
- ¹³⁾ For narrowband radiation (e. g. LED).
- ¹⁴⁾ 20 to 25 °C for specified measurement accuracy.

11 \ Ordering information

Order number	Description
LumiCam variant	
LC2400-100	LumiCam 2400 Mono Imaging photometer with 2428 x 2028 pixels; incl. Gigabit Ethernet interface, software and control computer
LC2400-200	LumiCam 2400 Color Imaging photometer and colorimeter with 2428 x 2028 pixels; incl. Gigabit Ethernet interface, software and control computer
LC2400-300	LumiCam 2400 Advanced Imaging photometer and colorimeter with 2428 x 2028 pixels; incl. Gigabit Ethernet interface, software and control computer
LC1300-102	LumiCam 1300 Mono Imaging photometer with 1370 x 1020 pixels; incl. Gigabit Ethernet interface, software and control computer
LC1300-202	LumiCam 1300 Color Imaging photometer and colorimeter with 1370 x 1020 pixels; incl. Gigabit Ethernet interface, software and control computer
LC1300-302	LumiCam 1300 Advanced Imaging photometer and colorimeter with 1370 x 1020 pixels; incl. Gigabit Ethernet interface, software and control computer
Lenses and accessories	
LC-311	14 mm objective lens (only for light distribution curve test setup LVK)
LC-312	28 mm objective lens
LC-314	50 mm objective lens
LC-316-1	100 mm objective lens
LC-314-10	Set of external irises for 50 mm lens LC-314 (4 apertures)
LC-316-10	Set of external irises for 100 mm lens LC-316-1 (4 apertures)
LC-362	Neutral density filter, optical density 2 (for LC-312, LC-314, LC-316-1)
LC-364	Neutral density filter, optical density 4 (for LC-312, LC-314, LC-316-1)
LC-367	adapter ring (for LC-316-1 in use with LC-362, LC-364)
DTS400	Manual XYZ positioning system
Software	
SW-501-BM	Black Mura Plug-in for LumiCam
Others	
LC-112	Laptop instead of desktop PC (for LumiCam)
LC-LVK-100	Optical bench and screen for measurement of intensity distribution curves with LumiCam
LC-LVK-110	Carrier for LumiCam for setup for measurement of intensity distribution curves
LC-LVK-120	Carrier for LED test sockets for light distribution curve test setup
LC-BSDF-100	BSDF analysis kit for LumiCam for the measurement of the "bidirectional reflectance/transmittance distribution function"
LC-BSDF-110	Optical bench for transmissive or reflective measurements with the BSDF analysis kit for the LumiCam
LC-BSDF-115	DUT holder for the BSDF setup in reflective configuration



KONICA MINOLTA Group

Instrument Systems GmbH

Kastenbauerstr. 2

81677 Munich, Germany

ph: +49 (0)89 45 49 43-58

fax: +49 (0)89 45 49 43-11

info@instrumentsystems.com

www.instrumentsystems.com

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