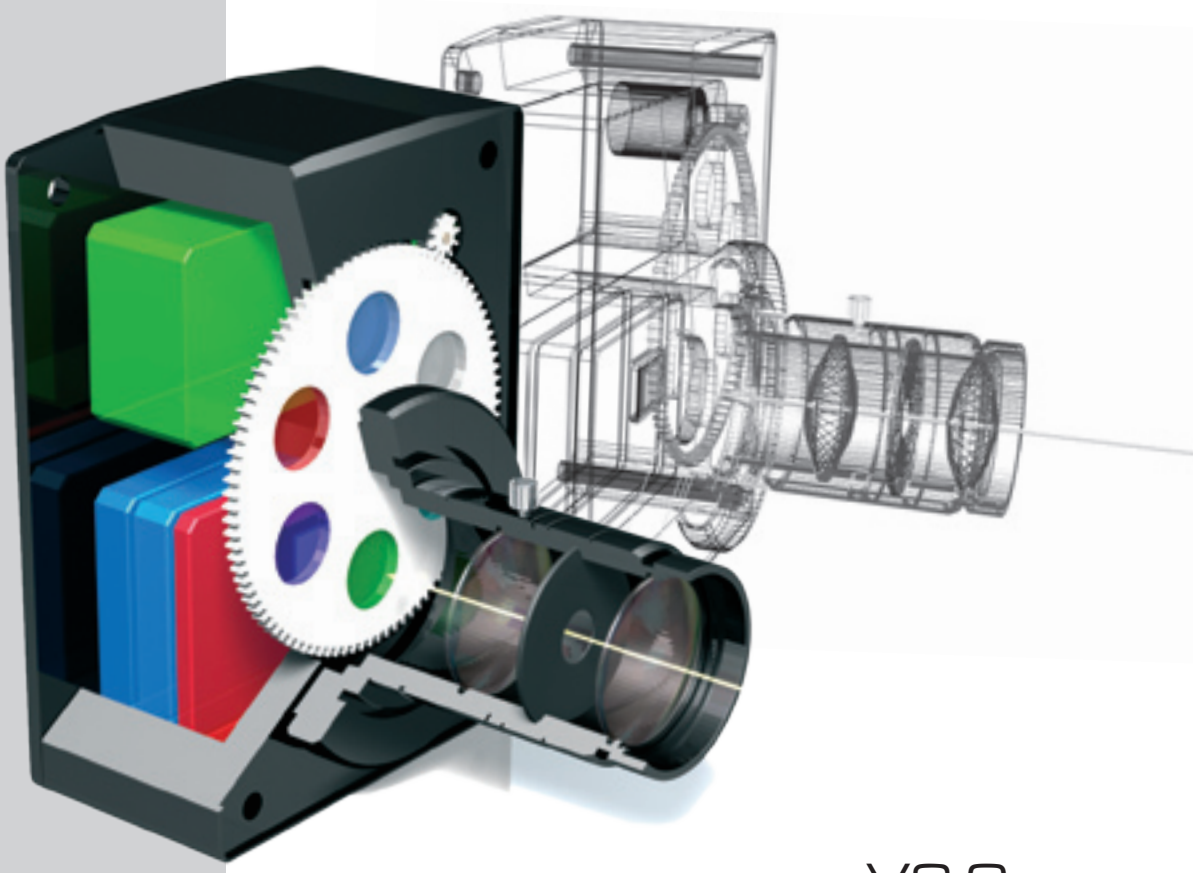
TechnoTeam
Bildverarbeitung GmbH



V2.0

VIDEO PHOTOMETER

IMAGING LIGHT AND
COLOUR MEASURING TECHNIQUE

LMK

Introduction

The spatially resolved analysis of light sources and illuminated scenes is getting more and more important. The complex evaluation of those scenes requires to know the luminance distribution within the whole field of view or at least in many selected parts of it. Solving the necessary measuring tasks by means of measuring devices working point by point either takes an enormous amount of time or is possible only within a coarse raster grid or is not possible at all. Thus, the development of spatially resolved radiation receivers, in particular CCD matrix cameras, has enabled the user to solve measuring problems such as measurements for glare evaluation according to the UGR method, the analysis of visibility conditions in the road traffic at night, immission evaluations of glare sources, the determination of contrasts in illumination situations (workplace) or directly on light sources (e.g. lamps/ luminaires, displays, night design, indicators).

- measuring of luminous and illuminated surfaces
- determination of luminous and background-lit symbols
- data for simulations in the development of lamps, luminaires and headlamps
- capturing of complex illumination and light distribution situations
- cataloguing and presentation

VIDEO PHOTOMETER

IMAGING LIGHT AND COLOUR MEASURING TECHNIQUE

Advantages

- complex evaluation of luminous and illuminated scenes by means of the photograph of an image-resolved luminance distribution
- simultaneous recording of a big number of connected measuring data
- easy data analysis (at a glance)

Result data

- luminance distributions in measuring images L(x,y)
- derived lighting-engineering parameters such as illuminance distribution E(x,y) and luminous intensity distribution I(x,y)
- luminance data in various formats
- statistical data for being used in calculation programs (e.g. EXCEL®, MatLAB®, LabVIEW®)

Technical data

Sensor:
CCD - imaging matrix system

Standard resolution
1380 x 1030 Pixel
Higher resolution
2448 x 2050 Pixel
4008 x 2672 Pixel
4008 x 4008 Pixel

Resolution (dynamic):
Single picture measurement: 1:1100 (~ 61 dB)
Multi picture measurement: 1:3600 (~ 71 dB)
High Dynamic measurement: 1:10000000 (~140 dB)
A/D conversion: 12/14 Bit

Measurement time:
from 1 to 15 sec. for different luminances, depending on adjusted exposure time

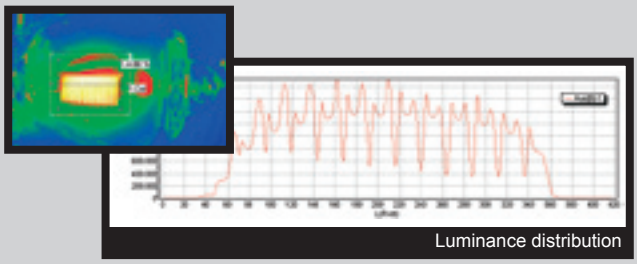
Measurement accuracy:
$\Delta L < 3$ % (for standard illuminant A)
$\Delta x,y < 0.0020$ (for standard illuminant A)

Spectral matching:
with full size filter matched to $V(\lambda)$-function for measuring luminances

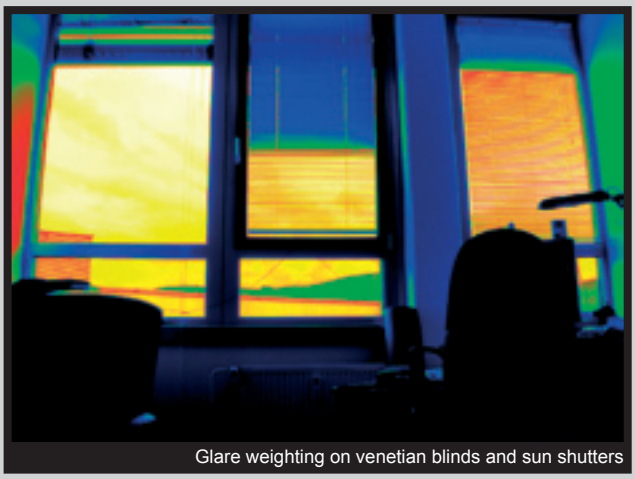
arranged with $X(\lambda)$-, $V(\lambda)$- and $Z(\lambda)$-filter for measuring colour values; additionally $C(\lambda)$-, $V'(\lambda)$-, BLH (blue light hazard) and IR-filter are available

LMK

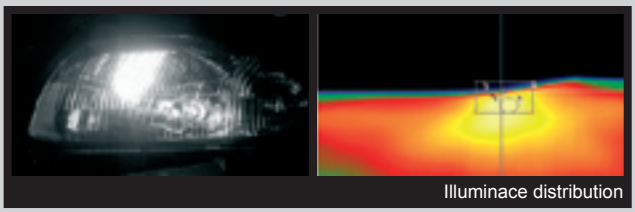
APPLICATIONS



Luminance distribution



Glare weighting on venetian blinds and sun shutters



Illuminace distribution

Measurement of colored LED's

Measuring luminance distributions

The measurement of luminance distributions L(x,y) allows the complex evaluation of numerous lighting-engineering devices. (lamps, luminaires, projectors and light control systems) as well as the evaluation of illumination scenes. The imaging luminance measuring technology provides the acquisition of both photometric parameters and geometrical data, thus allowing the user to determine further lighting-engineering quantities (luminous intensity, illuminance).
For describing lighting-engineering objects, not only simulation data but also various measuring data are necessary:

- description of luminous and illuminated surfaces of lamps and lighting fixtures by their luminance distributions L(x,y)
- glare assessment (e.g. according to the UGR standard)
- determination of contrasts and spatial contrast distributions
- determination of the illuminance distribution E(x,y) on illuminated surfaces (with diffusely reflecting Lambert characteristic) by means of the luminance distribution

Colorimetric measuring data

The imaging measurement and determination of colour and chromaticity values, for example of lamps and lighting fixtures, is gaining more and more importance. Using the **LMK color** camera adapted to the colour matching functions of the 2° standard CIE observer (CIE 1931) through a filter wheel, not only luminances can be determined but also tristimulus values. This permits the imaging measurement of chromaticity coordinates, which can be given in different colour spaces. So it is possible to solve tasks a lot faster compared with classical colour measuring techniques. The following tasks can be cited:

- description of the colour distribution on luminous and illuminated surfaces and symbols by means of the chromaticity coordinates x,y
- determination of the dominant wavelength λ_{dom} and the correlated colour temperature (CCT in Kelvin) of LEDs and lamps

Night Design

The cockpit and night design (automobile industry and its supply industry, avionics), offers manifold applications of the spatially-resolved luminance and colour measuring technology.

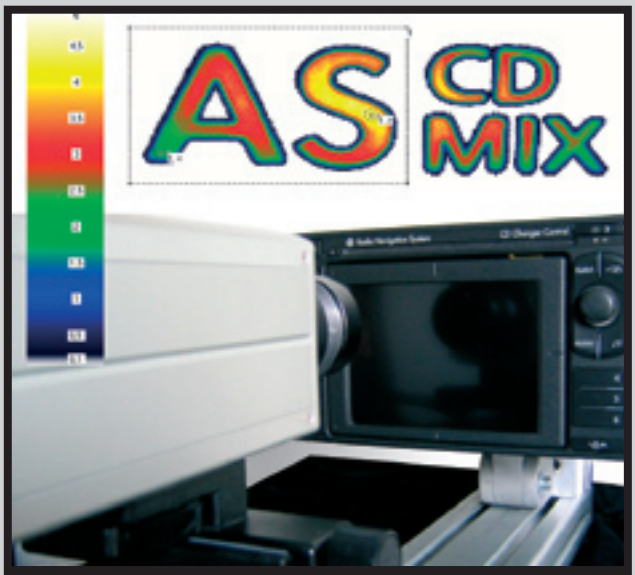
- brightness and uniformity of symbol illuminations
- colour rendering of the functional illumination
- contrast distribution on displays

For this purpose, the **TechnoTeam** company has designed special software solutions for recording and evaluating low luminances of smallest symbols, for example with the symbol object for measuring the mean luminance using adaptive algorithms to determine luminance thresholds, thus offering a number of adapted solutions.

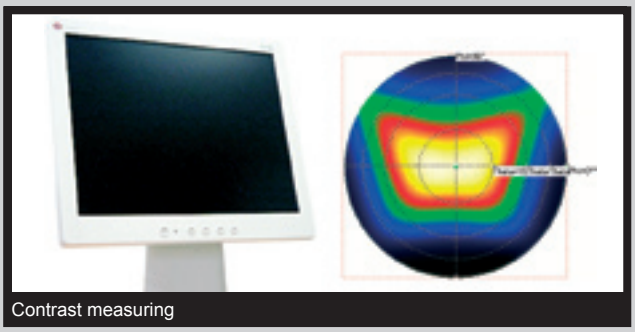
Display measuring

The imaging light and color measuring technology is exceptionally well suitable for analysing or also checking the rendering characteristics and quality features of monitors and displays.

- checking of the uniformity of background illumination according to existing standards
- control of the colour rendering characteristics on the basis of existing standards (e.g. EBU Tech. 3273)
- evaluation of the angle-dependent contrast distribution on displays (by means of a conoscopic lens)
- determination of defect pixels
- BlackMURA measurements according to German Automotive OEM Work Group Displays



Symbol measuring


Contrast measuring

Measuring lamps and lighting fixtures

Regarding the development of lamps and luminaires, the imaging measurement offers a number of advantages.

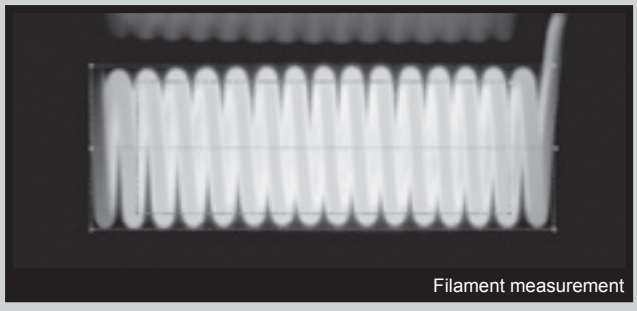
The **TechnoTeam** company has designed software solutions which allow the lighting-engineering evaluation of the measuring data with respect to characteristic values and guidelines to be simplified drastically.

- simple determination of the mean luminance of filaments and arcs (e.g. using the arc object according to ECE 99)
- imaging evaluation of local luminance maxima
- photographing of large lamps/luminaires by one shot
- documentation of time depending processes by means of a time-controlled series of shots

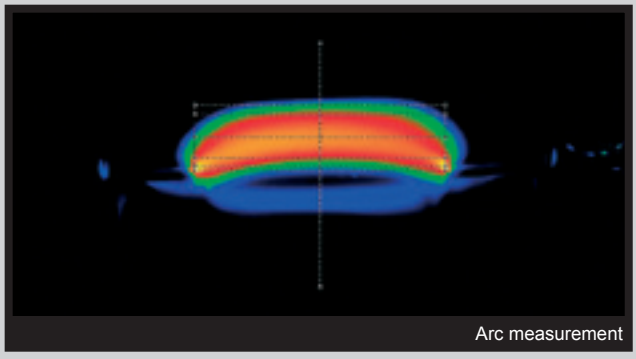
Measuring headlamps

Being the supplier of measuring equipment for a big number of manufacturers of lighting and illumination devices and maintaining close contacts to its scientific environment, the **TechnoTeam** company has gained experience in handling both lowest and highest luminances, and is thus in a position to offer solutions adapted to very special applications.

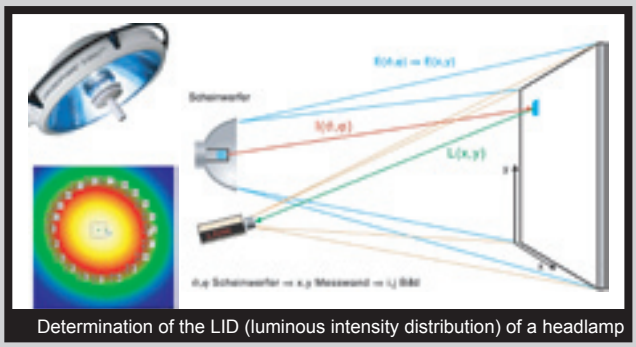
- determination of the illuminance distribution on plane surfaces
- calculation of the luminous intensity distribution of the headlamp
- measurement of the colour scale and colour deviations, e.g. on bright and dark edges in the projected image of a headlamp
- verification and observance of guidelines for car headlamps by means of prescribed measuring points (e.g. HV; AK31; B50L and many more)
- automatic alignment on measurement grids and positioning of measurement spots (ellbow-point detection)



Filament measurement



Arc measurement



Determination of the LID (luminous intensity distribution) of a headlamp

APPLICATIONS

Exterior lighting - Streets and tunnels

The **LMK** measuring system is very well suited to make measurements in an urban environment in public places and streets in order to make data for the lighting design in cities available. Thus, for example, the system allows colour differences on claddings or also the efficiency of lighting installations in public places to be evaluated in a simple way.

- Checking the brightness and colour rendering of large luminous boards and information carriers with regard to their perceptibility (e.g. contrast measurements)
- Glare evaluation, determination of the visibility distance of local lighting installations
- Determination of the luminance distribution according to DIN EN 13201 for streets and tunnels
- Checking the recognizability of roadway markings in varying weather conditions

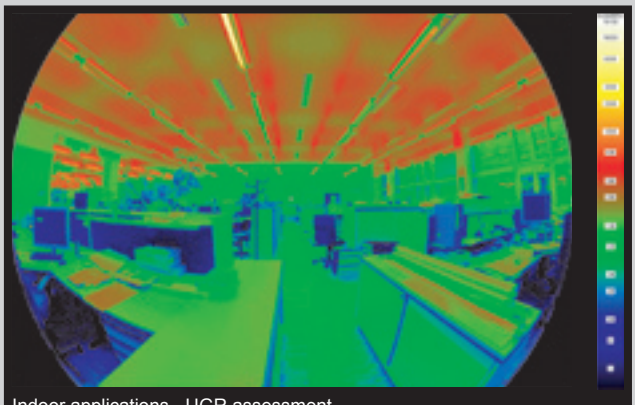
By means of the **LMK** camera, it is possible to make street lighting measurements also out of a car in motion.

Indoor lighting

The **LMK** measuring system allows spatially resolved measurements for verifying existing standard and design projects to be made in a simple and fast way with regard to full illumination, ergonomics and well-being.

- Evaluation of brightness distribution and colour of light in lighted rooms
- Determination of contrast and glare evaluation of window surfaces and video workstations located in the vicinity of windows (e.g. CRF measurement, UGR determination)
- Determination of the illuminance distribution with regard to ergonomic and economic aspects of workplaces; evaluation of circadian action potentials of artificial lighting with regard to the health and well-being of humans
- Checking existing standard for emergency and safety lighting

Outdoor applications



Indoor applications - UGR assessment

LMK models

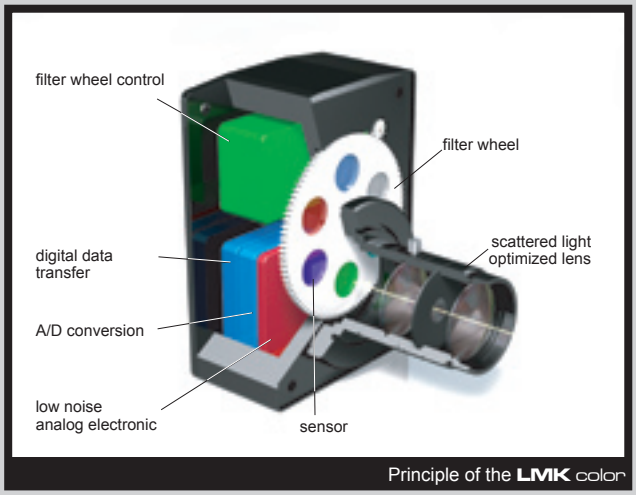
The centrepiece of the **LMK** family is a imaging luminance measuring device (ILMD). The systems are using selected CCD sensors made by Sony or Kodak.

For the cameras equipped with the Sony CCD the **Techno**Team company developed a complete new camera system himself with a lot of internal correction algorithms making the image capture and correction faster than ever before.
The cameras can be used with desktop PC as well as with notebooks.

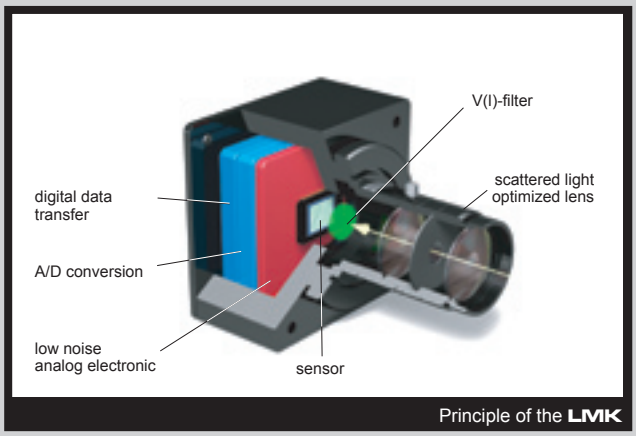
The luminance measuring camera **LMK** can be equipped with 1.3, 5, 11 or 16 mega pixel sensors representing solutions for fields of applications which require a high 2D measurement resolution.

Different software packages are available to fulfill the very different requirements of applications.

For mobile applications, however, the **LMK** mobile advanced is available. It is based on the high-quality digital cameras of the Canon EOS series, which have been up-graded to suit this application purpose. Thus, the users have at their disposal a luminance measuring system which is easy to operate and which can be applied for solving mobile measuring tasks.



Principle of the **LMK** color



Principle of the **LMK**

LMK 5

Sensor

CCD Sony [ICX 285 AL (2/3")]
effective Pixel [1380 (H) x 1030 (V)]
CCD Sony [ICX 655 AL (2/3")]
effective Pixel [2448 (H) x 2050 (V)]
[14 Bit digital, progressive scan]

Dynamic range

Single picture measurement (SinglePic)
[1:1100 (~61 dB)]
Multi picture measurement (MultiPic;10 pics)
[1:3600 (~71 dB)]
High Dynamic measurement
[1:10000000 (~140 dB)]

Data transmission

Gigabit Ethernet Interface(GigE®)

Metrological specifications

V(λ) [$f_1' < 3.5\%$[1]]

Measuring quantities

Luminance [L (cd/m²)]
Further measuring quantities can optionally be defined via scaling factors.

Measuring range

Setting the luminance measuring ranges by choosing the integration time from 100 µs...15 s
Accuracy rating depending on lens (aperture number = k), e.g.:
1ms ...appr. 1800 cd/m² & 3s ...appr. 0.6 cd/m² (k = min.)
1ms ... 60000 cd/m² & 3s ... appr. 20 cd/m² (k = max.)
Higher luminances can be achieved using optional neutral density filters.

Calibration uncertainty[2]

fix focused lenses ΔL [< 2%]
focusable lenses ΔL [< 2.5%]

Repeatability[3]

ΔL [< 0.1%]

Measuring accuracy

ΔL [< 3% (for standard illuminant A)]

Uniformity

ΔL [< 2%]

Fields of application

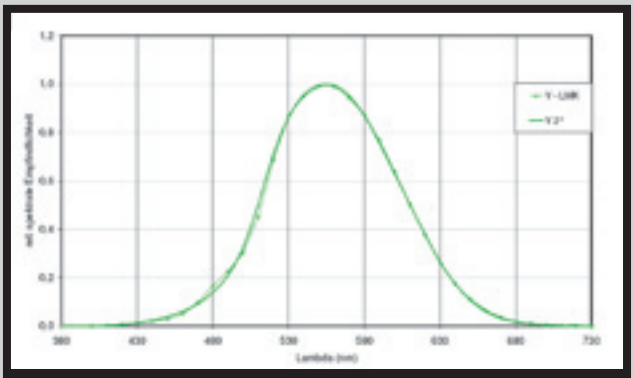
laboratory measurements, field measurements, industry automation

LMK MODELS

The **LMK** 5 is a high-tech digital CCD camera system equipped with a precise analogue electronic system for signal generation. Each camera is provided with a especially calculated and manufactured full filter in order to achieve a high-quality V(λ)-adaptation for determining the luminance.

The camera models equipped with a Sony CCDs (1.3 and 5 megapixel) are developed by **Techno**Team company. The models with Kodak CCD (11 and 16 mega pixel, see page 10) are using high quality CCD cameras from other camera manufactures.

LMK 5



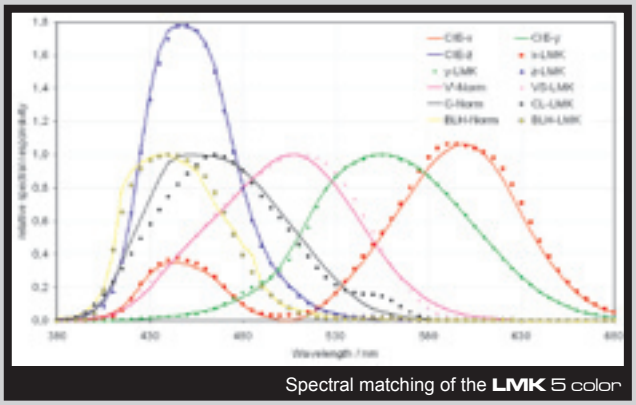
Spectral matching of the **LMK** 5

1 Measurements according to DIN 5032 Part 6/CIE Pub. 69 | 2 Calibration according to DIN 5032 Part 6 using a luminance standard led back from the Physical-Technical Federal Institute | 3 Measurement performed on a stabilized white LED light source L=100cd/m². Mean value over 100 Pixel; repeatability as variability of the mean value.

LMK MODELS

The **LMK** 5 color is equipped with a filter wheel for colour measurement, adapted to the CIE colour matching functions of the 2° standard observer (CIE 1931). Thus, luminances and colour coordinates can be measured in a spatially resolved way.
The filter wheel permits a total of 6 filters to be incorporated, with 4 filters being necessary for colour measurement. In addition, the measuring system can also be equipped with filters for the scotopic luminance V´(λ), the circadian function of action C(λ), an IR-filter (measurements in the NIR range 780-1000 nm), a BLH (blue light hazard), or a clear glass filter.

LMK 5 color



Spectral matching of the **LMK** 5 color

1 Measurements according to DIN 5032 Part 6/CIE Pub. 69 | 2 Dominant wavelength, saturation, correlated color temperature | 3 Calibration according to DIN 5032 Part 6 using a luminance standard led back from the Physical-Technical Federal Institute | 4 Measurement performed on a stabilized white LED light source L=100cd/m². Mean value over 100 Pixel; repeatability as variability of the mean value. | 5 Measured value based on 30 test colors with different spectral distributions based on ROSCO color filters

LMK 5 color

Sensor

CCD Sony [ICX 285 AL (2/3")]
effective Pixel [1380 (H) x 1030 (V)]
CCD Sony [ICX 655 AL (2/3")]
effective Pixel [2448 (H) x 2050 (V)]
[14 Bit digital, progressive scan]

Dynamic range

Color High Dynamic measurement
[1:10000000 (~140 dB)]

Data transmission

Gigabit Ethernet Interface(GigE®)

Metrological specifications

V(λ) [f_1 < 3.5%[1]]; X(λ) [f^*_1 < 4%]
Z(λ) [f^*_1 < 6%]; V´(λ) [f^*_1 < 6%]

Measuring quantities

Luminance: L (cd/m²), chromaticity coordinates: x,y, Supported colour spaces: RGB, XYZ, sRGB, EBU-RGB, User, Lxy, Luv, Lu'v', L*u*v*, C*h*s*uv, L*a*b*, C*h*ab, HIS, HSV, HSL, WST[2]
Further measuring quantities can optionally be defined via scaling factors.

Measuring range

Setting the luminance measuring ranges by choosing the integration time from 100 µs...15 s
Accuracy rating depending on lens (aperture number = k), e.g.:
1ms ...appr.7500 cd/m² & 3 s ...appr. 2.5 cd/m² (k = min.)
1ms ... 60000 cd/m² & 3 s ...appr. 20 cd/m² (k = max.)
Higher luminances can be achieved using optional neutral density filters.

Calibration uncertainty[3]

fix focused lenses ΔL [< 2%]
focusable lenses ΔL [< 2.5%]

Repeatability[4]

ΔL [< 0.1%]
Δx,y [< 0,0001]

Measuring accuracy

ΔL [< 3% (for standard illuminant A)]
Δx,y [< 0.0020 (for standard illuminant A)]
Δx,y [< 0.0100 (set of test colours)[5]]

Uniformity

ΔL [< 2%]

Fields of application

laboratory measurements, field measurements, industry automation

LMK 50/ LMK 50 color

Sensor

CCD Kodak [KAI-11002/16000M, square pixel]
active Pixel [4008 (H) x 2672/4008 (V)]
[12 Bit digital, progressive scan (1-3 fps)]

Dynamic range

Single picture measurement (SinglePic)
[1:1100 (~61 dB)]
Multi picture measurement (MultiPic;10 pics)
[1:3600 (~71 dB)]
High Dynamic measurement
[1:10000000 (~140 dB)]

Data transmission

Gigabit Ethernet Interface [GigE®]

Metrological specifications

$V(\lambda)$ f'_1 < 3.5 %[1]

Measuring quantities

Luminance [L (cd/m²)]
Further measuring quantities can optionally be defined via scaling factors.

Measuring range

Setting the luminance measuring ranges by choosing the integration time from
1 ms ... 15 s
Accuracy rating depending on lens (aperture number = k), e.g.:
[1 ms ...appr. 6000 cd/m² & 3 s ...appr. 2 cd/m²]
Higher luminances can be achieved using optional neutral density filters.

Calibration uncertainty[2]

focusable lenses: ΔL [< 2.5%]

Repeatability[3]

ΔL [< 0.1 %]

Measuring accuracy

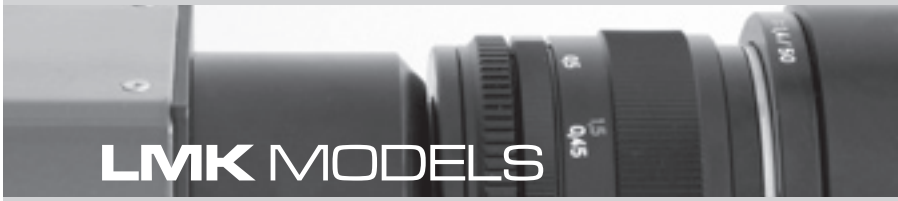
ΔL [< 3% (for standard illuminant A)]

Uniformity

ΔL [< 2%]

Fields of application

laboratory measurements
industry automation

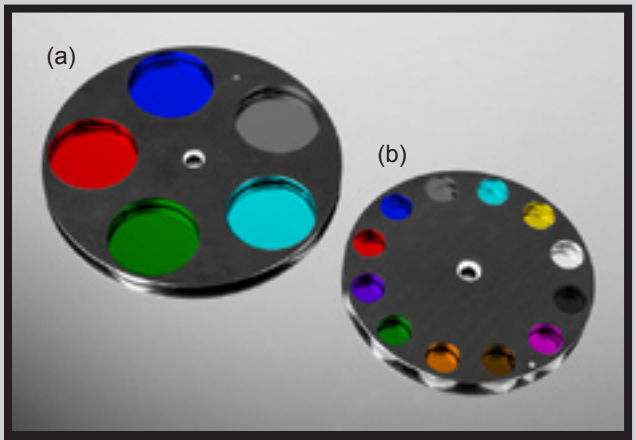


LMK MODELS

large camera housing with filter wheel of the LMK 50 color

For the large camera housing two different filter wheels are available:

(a) a filter wheel with 5 positions for Kodak CCDs (11 and 16 mega pixel) and
(b) a filter wheel with 12 positions for Sony CCDs (1.3 and 5 mega pixel).



filter wheel of the LMK 50 color

1 Measurements according to DIN 5032 Part 6/CIE Pub. 69 | 2 Calibration according to DIN 5032 Part 6 using a luminance standard led back from the Physical-Technical Federal Institute | 3 Measurement performed on a stabilized white LED light source L=100cd/m². Mean value over 100 Pixel; repeatability as variability of the mean value.

LMK MODELS

The application of high-quality digital cameras in the **LMK**-system allows an easy and fast capture of luminance images without depending on your measuring computer. For evaluating the images, the complete functionality of the **LMK** LabSoft software can also be utilized.

Blende	4	4	11
ISO	100	1600	100
t_i= 0.001 s	20 kcd/m²	1200 cd/m²	140 kcd/m²
t_i= 3.0 s	6 cd/m²	0.36 cd/m²	50 cd/m²

Light sensitivity (measure range end value)

Halogen metal discharge lamps	2-9%
High pressure sodium discharge lamp	7-13%
Fluorescent lamp	8-10%
LED white	5-12%

IIntegral spectral mismatch in % for several lamp types / spectra

Ti\Av	4	5.6	8	11
0.25 ms	7.6	8.0	8.2	8.8
2.5 ms	6.0	6.3	6.5	7.2
25 ms	5.8	6.2	6.4	7.0
0.25 s	5.8	6.2	6.4	7.0
2.5 s	5.8	6.2	6.4	7.0

Measuring uncertainty ΔL in % (for standard illuminant A)

LMK mobile advanced

LMK mobile advanced

Sensor

CMOS Canon APS-C
5184(H) x 3456(V)
effective pixel (resolution of the luminance image) 2592(H) x 1728(V)
14 Bit RAW - data with Bayer structure, uncompressed

Dynamic range

Single picture measurement (SinglePic)
[1:4000 (~60 dB)]
High Dynamic measurement
[1:32000 (1/1250 sec. < ti < 8 sec.)]

Data transmission

USB 2.0 and/or SD/SDHC memory card

Metrological specification

Spectral matching [numerical weighting of the RGB tristimulus values (multiplying matrices)]

Focal length / Visual field angle

Focal length 17mm: 65°(H) x 45°(V)
Focal length 50mm: 28°(H) x 19°(V)

Selection of measuring range

Selecting aperture, exposure time and ISO speed.

Calibration uncertainty

ΔL [2.5%]

Uniformity

ΔL [< 2%]

Fields of application

laboratory measurements
field measurements

LMK LabSoft

Additionally to all camera systems of the **LMK** family, the **LMK** LabSoft is supplied.
The measuring software offers a big number of possible applications when using the luminance measuring systems, as well as for data evaluation and processing.

Ease of operation is guaranteed to the user through the integration of task-specific capture functions.

SinglePic-capture - permits a luminance image to be taken very quickly.

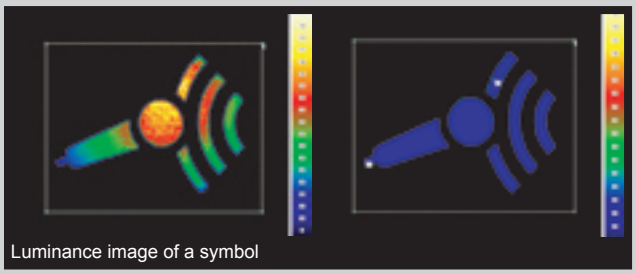
MultiPic-capture - permits the repeated capture of several single images so as to eliminate statistical measuring errors through averaging.

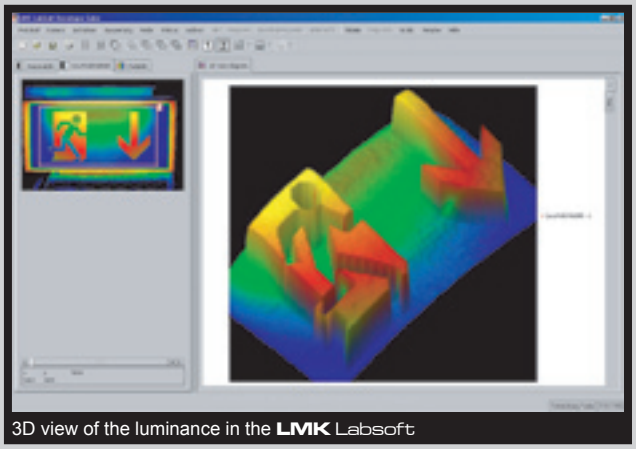
HighDyn-algorithm - permits the capture of a luminance image composed of single images at various integration times so as to realize a higher dynamic range.

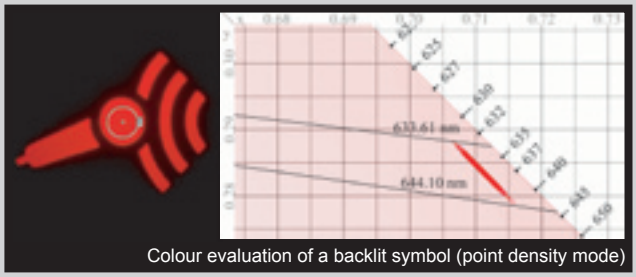
For the visualization of the measuring results, the user can choose, among other things, from a freely scalable pseudocolouring as well as several logarithmic representations. Pre-made and freely scalable point, line, circular and rectangular cursors permit the measuring data to be accessed in a quick and flexible way. The defining of measuring regions by means of geometrical basic shapes facilitates evaluation. In addition, they provide many auxiliary means for the statistical evaluation of the data (tables, sectional diagrams, histograms, and photometric evaluation algorithms).
Furthermore, the software offers a function for an automatical detection of regions by means of luminances. This is both useful and advantageous for detecting complex geometrical structures.

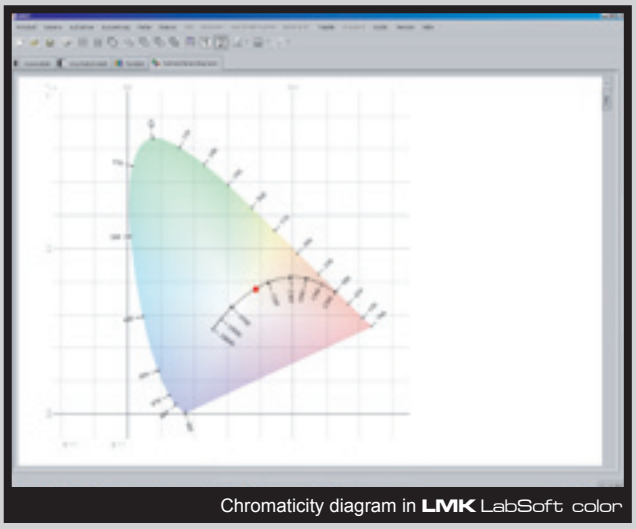
The report function for an export of measurement data and evaluation results to MS Word® and MS Excel® is a simple and comfortable possibility for the communication and the sharing of measurement data with others. Furthermore, they offer the advantage of a standard or individual printing template to create a printing report.

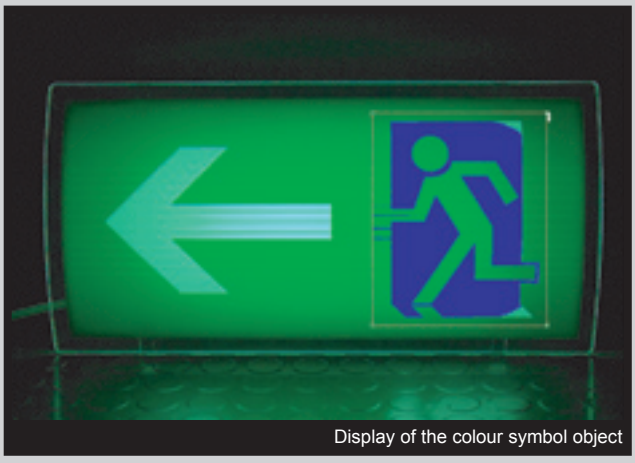
The **LMK** LabSoft software provides a big variety of data formats for the export and import of image and measuring data, for example for MatLAB®, LabVIEW® and SPEOS®. The data exchange with Microsoft Office® products and other software programs is enabled by the functions of the Windows® clipboard.


Luminance image of a symbol


3D view of the luminance in the **LMK** Labsoft


Colour evaluation of a backlit symbol (point density mode)


Chromaticity diagram in **LMK** LabSoft color


Display of the colour symbol object

Enhanced software package for colour capture

With the **LMK** LabSoft color the complete functionality of the luminance measuring software **LMK** LabSoft is available for the assessment of chromaticity values out of three channel colour images. The measured X,Y,Z colour values can be converted into different colour spaces (e.g. RGB, XYZ, sRGB, EBU-RGB, Lxy, Luv, L*a*b*, HIS, HSV). In case of measuring LEDs or lamps a colour space showing the dominant wavelength, the colour saturation and the correlated colour temperature is available. It is possible to calculate colour distances and colour differences in several colour spaces. Among to the standard graphical forms of showing measured values in graphs and diagrams (in three channels) the chromaticity coordinates can be represented in a colour space diagram (e.g. horse shoe view), which shows the colour gradient and statistical accumulation points.

With the new colour symbol object - chromaticity coordinates can be matched to their luminance levels. So it is easier to detect regions for a colorimetrical evaluation (e.g. backlit symbols) with respect to a luminance threshold.

The user can exert an influence on the calibration data and change the algebra of matrices. So it is possible to adjust the **LMK** system for an own colour space or for balancing the **LMK** system with own reference quantities. In this way the spectral matching can be adapted to specific measurement tasks (e.g. LED measurements).

Throughout the measurement in several channels X, Y, Z and V´(λ) and optional C(λ) or BLH (Blue Light Hazard) and the subsequent image processing different radiation measurements for different perception models can be made (e.g. mesopic brightness perception).

Versions of the LMK LabSoft

LMK LabSoft

With the new measurement and evaluation software **LMK** LabSoft **Techno**Team provides the consistently ongoing development of the well proven **LMK** 2000 software. As a result of an intensive exchange of experience with our customers we could enhance our evaluation functionalities. Also the usability is optimised and partly completely overdone. Thus the functionalities for the documentation and the reporting of the measurement results are now totally compatible with MS Office®.
Furthermore the new embedded TCL script language allows the recording and linking of often used functionalities. Thus the automation of complete working procedures is possible.

LMK LabSoft simple

The **LMK** simple package offers a measurement system which includes the known camera hardware in combination with only essential software components at a lower price. Therefore, all video photometer systems can be equipped with the **LMK** LabSoft simple software. This software is reduced to several selected basic functionalities.

LMK LabSoft extended

With this version of the **LMK** LabSoft software the possibilities for an interaction and automation of the image processing procedures is rapidly increased. By using an ActiveX® Interface the **LMK** LabSoft and their essential functionalities can be controlled by several other software applications. The assessement of the image and measurement data can be done directly via the host application. Therefore, the integration of the software into an existing workflow is no problem.
Furthermore, a new interface provides the possibility to use over 200 algorithms especially developed by **Techno**Team from the field of industrial machine vision and image processing in the **LMK** LabSoft software. Thus it is possible to solve complex issues in uncommon and specific fields of action with one specific software solution in one click. Such software solutions will be provided by **Techno**Team on request.

Software functionality	LMK LabSoft simple	LMK LabSoft
Image capture		
Live image (grey scale value)	x	x
Exposure adjustment	x	x
Image capture (SinglePic, MultiPic, HighDyn, Color HighDyn)	x	x
Capturing modulated light	x	x
Live luminance image SinglePic, HighDyn, Color HighDyn		x
Capturing measurement series *(manual, time controlled, mechanical controlled)*		x
Representation of images *(Pseudo-colours, ISO colours, scaling)*	x	x
Working with images *(load, save, delete, copy, print)*	x	x
Displaying measuring values by means of cursors (standard, rectangle, circle, line, circular ring, cross, zoom)	x	x
Measurement regions *(load, save, copy, paste, group, print)*	x	x
Measuring value indication using inspectors		
Standard statistics *(standard evaluation, histogram, sectional view, time statistics, luminance object, integral object, symbol object, arc object, filament object)*	x	x
Report function *(create, load, save, print)*	x	x
Evaluation images and image processing		
Additional evaluation images	1	N
Physical parameters and units	x	x
Assigning list of regions		x
Assigning image tab windows		x
Image arithmetics		x
Coordinate transformation		x
Projective rectification - orthophotographs	x	x
ISO lines in luminance images	x	x
Colour images and colour metrics		
Colour space and measuring values	x	x
Calculation of colour differences	x	x
Decomposition of colour images into colour extract images		x
Composition of colour extract images into colour images		x
Test colour images		x
Measurement protocols *(create, load, save, comments)*	x	x
Automation via TCL-Macro and ActiveX®		
Recording of TCL - Macros		x
Running of TCL - Macros	x	x
ActiveX® programming interface	●	●
Running of IPED – automated image processing macros		●
Extras		
Motor control		●
Black Mura - display measurement		●
Luminous intensity distribution measurement		●

x available ● optional available

User-related solutions

A number of specific features of the **LMK** LabSoft software have been developed to satisfy customer wishes. So for specific measuring tasks, a number of various additional modules for the **LMK** LabSoft software are available.

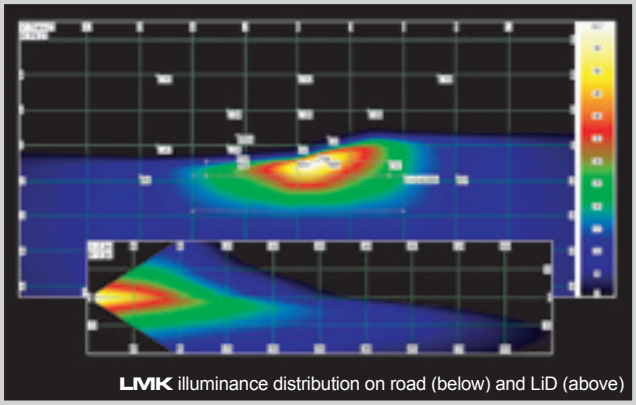
On the basis of its technical know-how, the **TechnoTeam** company will provide customer-specific solutions in the future.

- **LMK** LabSoft **Headlamps** means an extended version (or additional module) which permits the corresponding illuminance image and also the LiD (luminous intensity distribution curve) to be calculated from the original luminance image captured by means of the **LMK** camera. Here, the illuminance can be determined either on a plane (e.g. on a projection wall located at a distance of 10 m) or on a hemisphere (e.g. 25 m radius for ECE). Furthermore, the conversion into the illuminances prevailing on the road is provided as an additional option particularly for the automobile sector.

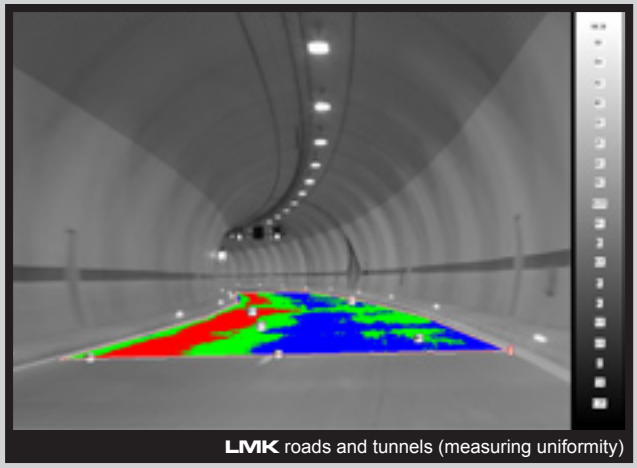
  Headlamps emit light over very large angles, sometimes even over the entire half-space. In most cases, only much smaller angles can be captured in one image. So, several partial images captured at different angular ranges can be put together to form one complete image.

- **LMK** LabSoft **Roads and tunnels**, is an additional package supplied by means of which street lightings can be measured in a fast and easy way. The user is able to acquire all parameters necessary for the DIN EN 13201 standard by one single capture. The measured luminance values will then be processed by the software for further use.

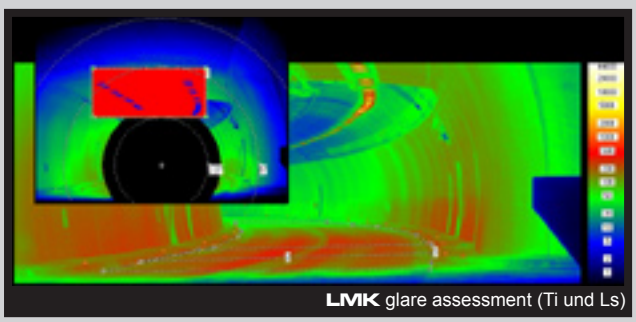
- **LMK** LabSoft **Glare evaluation** contains a data package which allows the fast and easy assessment of some essential glare parameters. Using the software, the user is able to determine important quantities such as the vertical illuminance, the solid angle of the glare source, and the veiling luminance according to common standards.
  These glare quantities are the basis for parameters such as UGR; DGI; TI, etc.



LMK illuminance distribution on road (below) and LiD (above)



LMK roads and tunnels (measuring uniformity)



LMK glare assessment (Ti und Ls)

Lenses

Various focusable **standard lenses** with a fixed aperture for different focal lengths f´= 8mm, 16mm, 25mm and 50mm are on offer. They are set and optimized by us for the concrete application. For an integration time of 3sec., the sensitivity of these lenses is up to 1cd/m² measurement range end value. Furthermore, all those lenses can be ordered with a fix focus for fixed measurement dis- tances.
For small object fields a telecentric **macroscopic lens (Macro)** is available. Furthermore, this lens can be adapted to the measuring field via various distance rings.

Special imaging systems

The hemi spherical lens allows the capture of an object field at a field angle of ±92°. This lens can be used for capturing complex illumination situations, for example in the case of the evaluation of interiors.

For determining the radiation characteristics of small fields, for example for determining the angle-dependent contrast of displays, a conoscopic lens is offered which can be used to record the luminance within an angular range of ± 60°.

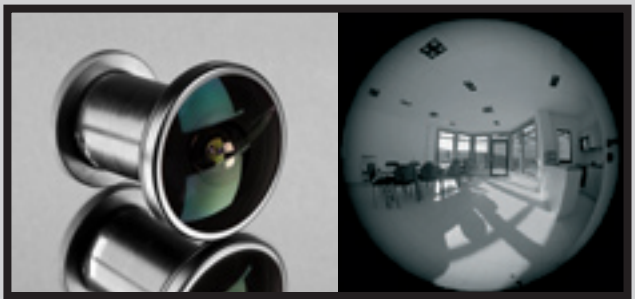
Neutral density filters

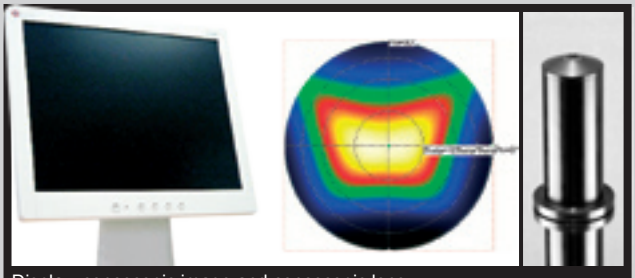
ND-filters with different transmissions ranging from 0.5 … 0.00001 enhance the measurement range of the CCD camera to be increased for the measurement of very high luminances.

aperture (f=mm)	min. measuring distance[1] (mm)	least field of view (circa)	least field of view (mm x mm)	field of view with a distance of 500 mm	field of view with a distance of 1000 mm
8	500	60°(H) x 56°(V)	520 x 390	520 x 390	1125 x 845
16	185	30°(H) x 22°(V)	85 x 64	270 x 203	540 x 407
25	220	20°(H) x 15°(V)	58 x 44	160 x 120	360 x 275
50	280	10°(H) x 7°(V)	32 x 23	75 x 56	160 x 120

telecentric macro lens with distance ring	measuring distance[1] (mm)	field of view (mm x mm)	depth of focus (mm)
0 mm	160	14 x 10	± 0.3
+ 10mm	160	10 x 8	± 0.2
+ 20mm	160	7 x 6	± 0.15
+ 30mm	164	6,5 x 5	± 0.15

Further lens solutions with other viewing types can be realized on request.

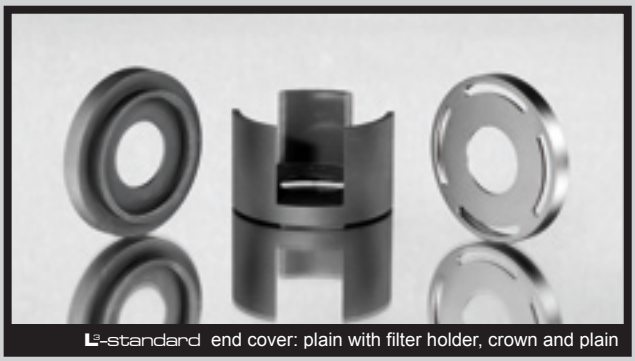

Fisheye lens and half space image


Display, conoscopic image and conoscopic lens

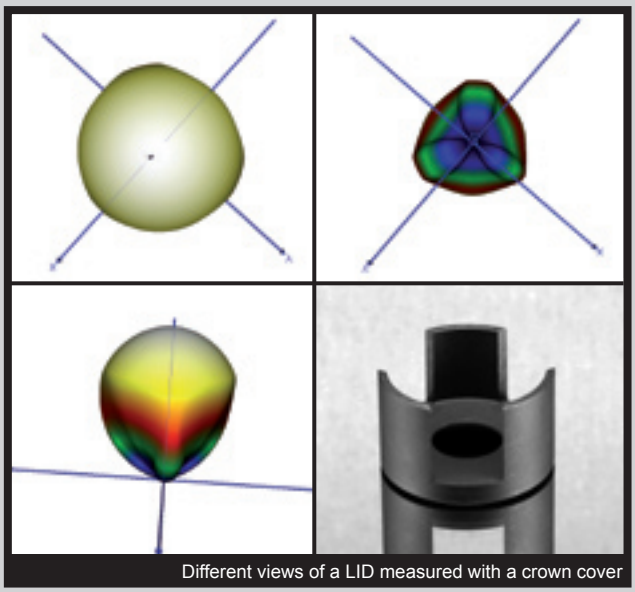
1 measuring distance = lens - leasing edge of camera

ACCESSOIRES

L³-standard with optional accessories



L³-standard end cover: plain with filter holder, crown and plain



Different views of a LID measured with a crown cover

L³-standard

With the L³-standard the **Techno**Team Company offers stable coloured standards for Luminance, Luminous flux and Luminous intensity based on LEDs.
The stability of the photometric quantities is achieved through a temperature control containing a Peltier device, and an intensity control containing a spectrally matched photodiode. In the closed housing, which has an exchangeable end cover, a pre-aged and selected HighPower-LED is used for each L³-standard operated at about 2/3 of its rated current.

- high stability of the luminance (< 1%/100h)
- high stability of the dominant wavelength/ colour (<1nm/100h)
- stable function independent of the room temperature (15°C bis 30°C)
- homogeneous luminance over the outlet opening (<2% inhomogenity)
- standard equipment in (red, green, blue, yellow, orange, white)
- USB interface for reading the current operation status (seirial number, working hours, temperature, …)

In addition to the standard colours, also other colours can be supplied on customer's request. For this, the customer shall select, in cooperation with the **Techno**Team company, the type of LED.
For each L³-standard **Techno**Team provides a certification for the factory calibration. For the traceability of the photometric data of the LED luminance standards it is possible to calibrate the devices at a national metrology institute (e.g. PTB (D) or METAS (CH)).

Evaluation computer

For operating the **LMK** LabSoft software, the minimum hardware requirements are:

- Intel dual core processor
- Current state-of-the-art devices and interfaces like hard disc, USB, …
- Alt least one Gigabit Ethernet adapter (GigE®-interface) (For PCs a second one is recommended to allow a separate interface apart from the standard network interface.)

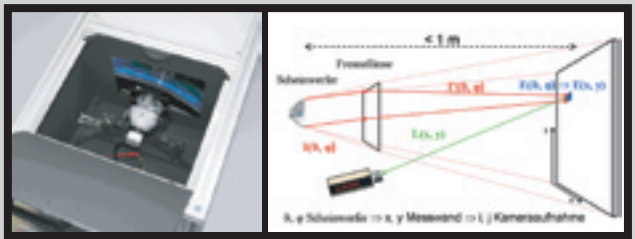
TechnoTeam recommends sufficient testing of the PCs to be used. If necessary, the customer may obtain from **Techno**Team advice on the currently available makes.

LMK

AUTOMATION

Compact measuring box

The **KMP** is a mobile solution for the indirect measurement of light without a specially adapted laboratory room. The **KMP** has 2 chambers. A reflective wall and an aperture are fixed in the measuring chamber. In the object chamber (archetype chamber) there is a fixed mounting for head-lights as well as the fixed positioned measuring camera.
The LiD (luminous intensity distribution) of the headlight will be imaged on the reflective wall placed in the focal plane of the imaging system of the **KMP** .
Between the two chambers an optical system is located. This optical system (lens) cuts the measuring distance to a shorter distance (e.g. outer dimension L x W x D: 95cm x 50cm x 43cm). According to the path of rays on the imaging side of the optical system the light source to be measured is virtually placed at an infinite distance. Therefore, the system works in compliance with the photometrical border distance.
The luminance image is measured with an **LMK**. Thus with the illuminance the luminous intensity distribution can be calculated.



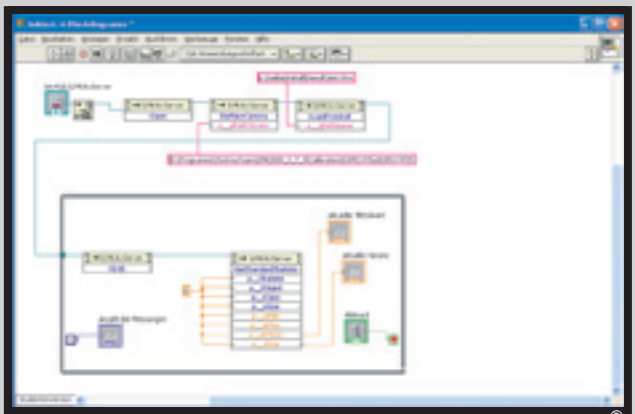
KMP (compact measuring box)

Symbolchecker

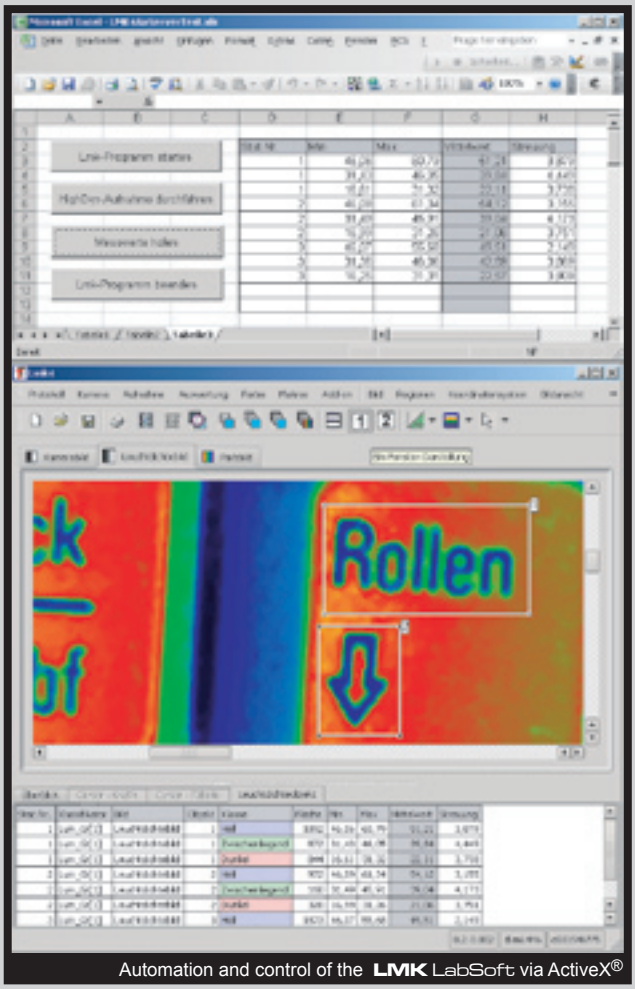
The **Symbolchecker** is a semi-automatic stand-alone system for quality management in the production of backlit symbols (e.g. switches and dashboard instruments).

- **Average of luminance** as an average value for the automatically detected complete backlit symbol
- **Uniformity:** is calculated with the minimum, average value and maximum of the luminance within the symbol, determined with a measuring spot of 3 x 3 pixel size.
- **Position:** as the average of the segment centroids, calculated out of the contour of the segment. The determination of the contour is sub pixel exact.
- **Structure width:** means a geometrical measurement of symbol segments with parallel outer lines. With the calculated distances over an iterative calculated average value (eliminating the values with the largest difference from the current average value) the structure width of the symbol is determined.
- **Symbol quality:** means the percentage matching of the symbol with the pattern recognized.

Symbolchecker



Automation and control of the **LMK** LabSoft via ActiveX®



Automation and control of the **LMK** LabSoft via ActiveX®

Programming interface **LMK** LabSoft extended

The **LMK** LabSoft extended has an ActiveX®-interface available and can be controlled by a host application with ActiveX® capability (e.g. MS Excel®, LabView®). In this way it is possible to use the functionality of the **LMK** LabSoft as a server for other applications.

All capturing modes will be provided: capturing Live camera images; SinglePic-, MultiPic- and HighDyn-algorithm for the capturing and calculation of luminance images; ColorHighDyn-algorithm for calculation of colour values by using a **Techno**Team colour filter camera.

By using the interface all statistical operators (e.g. luminance, integral and symbol object) are available. So directly after the image capturing the currently measured data can be imported into the host application (e.g. Excel® spread sheet analysis). In addition it is possible to open and save already prepared protocol files with parameterised statistic objects via ActiveX®.

Furthermore it is possible to run self-made TCL script macros, which are prepared and saved with the **LMK** LabSoft beforehand, via ActiveX® from the host application.

On customer request it is possible to extend the interface to all functions of the functionality provided in the interactive use of the **LMK** LabSoft.

References (abstract)

Adam Opel AG I Audi AG I BMW AG I Daimler AG I Dr. -Ing. h.c. F. Porsche AG I Ford AG I SEAT, S.A. I ŠKODA AUTO a.s.I VW AG II ALPINE ELECTRONICS GmbH I Automotive Lighting GmbH I Behr-Hella Thermocontrol GmbH I Blaupunkt GmbH I Bosch-Gruppe Motometer GmbH I Continental Automotive AG I Delphi Packard Deutschland GmbH I DST Dräxlmaier Systemtechnik GmbH I Goodrich Lighting Systems GmbH I Hella KG Hueck & Co. I Leopold Kostal GmbH I Marquardt GmbH I TRW Automotive Electronics & Components & Co. KG I Valeo Auto-Electric Hungary LLC I VISTEON Deutschland GmbH I Ansorg GmbH I AE Austria Email I Lehner WerkMetall Jürgen Lehner GmbH I D. Swarovski & Co. Lichtlabor I Diemer & Fastenrath OHG I GE Hungary ZRt. I OSHINO Lamps GmbH I OSRAM GmbH I OSRAM Opto Semiconductors GmbH & Co. OHG I Philips GmbH I Philips Lighting B.V. I RZB-Leuchten I TRILUX-LENZE GmbH+Co. KG I Siteco Beleuchtungstechnik GmbH I Zumtobel GmbH I BOE-LA Siebdrucktechnik GmbH I Bosch Siemens Hausgeräte GmbH I Braun GmbH I Cherry GmbH I Comtronic GmbH I Fresnel Optics GmbH I Hella Aerospace GmbH I Optrex Europe GmbH I Siemens AG I BGIA Berufsgenossen-schaftliches Institut für Arbeitssicherheit I HVBG Hauptverband der gewerblichen Berufsgenossen-schaften e.V. I Fraunhofer Institut Solare Energie-systeme I VBG Verwaltungsberufsgenossenschaft I Autobahnamt Thüringen I BASt Bundesanstalt für Straßenwesen I LANUV Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen I Magistrat der Stadt Wien I METAS Bundesamt für Metrologie (CH) I BTU Cottbus I Carl-v.-Ossietzky Universität Oldenburg I EFI Trontheim I ETH Zürich Institut für Hygiene und Arbeitsphysiologie I FH Aachen Solar Institut Jülich I FH Biberach I FH Göttingen I FH Jena I Technische Universität Berlin I Technische Universität Dresden I Technische Universität, Ilmenau I Universität der Bundeswehr Hamburg I Universität Dortmund I Universität Paderborn I Universität Teheran

V2.0

LMK

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