



TechnoTeam
Bildverarbeitung GmbH



Display test and
measurement software
for photometer/colorimeter

LMK
display

LMK display

Display characterization is a broad field that encompasses many different metrology concepts. These concepts use a variety of light measurement devices such as Imaging Luminance and Color Measurement Devices (ILMD/ICMD) for measurement tasks based on luminance, contrast, and color. Even more so, ILMDs are particularly effective for all measurement tasks requiring simultaneous inspection of all display pixels and where high-resolution images are needed. Examples include defect and uniformity analysis, as well as resolution measurements that require accurate absolute luminance data and high image quality at the same time. The high-resolution **LMK 6-12** and **6-30** combined with the **LMK display** package fulfill these measurement tasks in three main aspects:

- Correlation to human perception
- Fast measurements
- Reproducible measurements

These are ensured by maintaining and continuously improving the high quality of our absolutely calibrated high transmission filter-based **LMK** luminance cameras, our certified calibration and QM processes, and by constantly developing innovative methods and metrology concepts. Our stray light correction (SLC) for high-contrast measurements, our image trigger for simple and accurate temporal alignment, or our phase compensation DeMOIRÉ are only a few examples. Each system is configured and calibrated with selected manual or autofocus standard lenses. The range of display metrology tasks covered is further extended by our own lens developments, such as conoscopic, macroscopic, microscopic, and NED lenses. In addition, we offer customer-specific lens developments.

Various software packages such as the **LMK LabSoft** are optimized for laboratory measurement tasks and come with over 400 SDK functions to support customer R&D. Other software packages such as the **LightChecker** offer an ideal solution for fast and precise easy to parametrize in-line inspection tasks. TechnoTeam software covers free updates over the complete product's lifetime, including newly developed display metrology concepts.

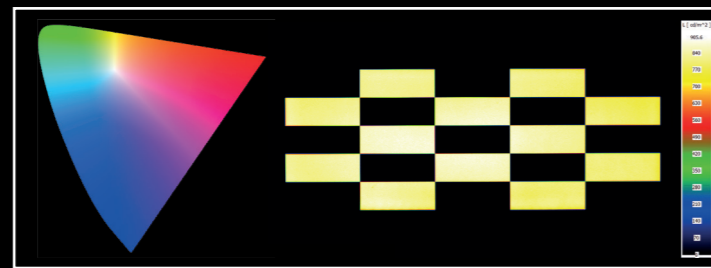
Further, TechnoTeam actively contributes to national and international standardization in photometry (CIE, DIN), display metrology (DFF, DKE, IEC, ICDM) as well as national and international conferences and scientific journals, with more than 20 contributions on display metrology in the past three years.

LMK

display

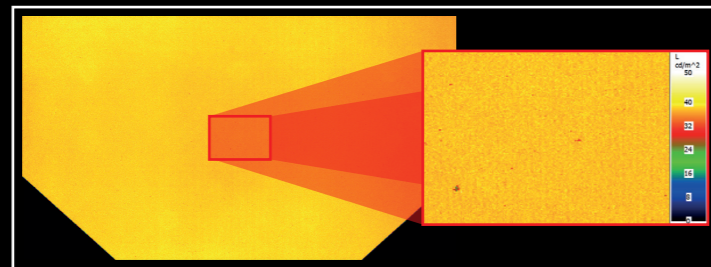
LMK Basic

Allows evaluations of display quality such as luminance, uniformity, contrast, halo, color, etc. The optional SLC correction ensures a higher precision for high dynamic range images as required for checkerboard contrast or halo.



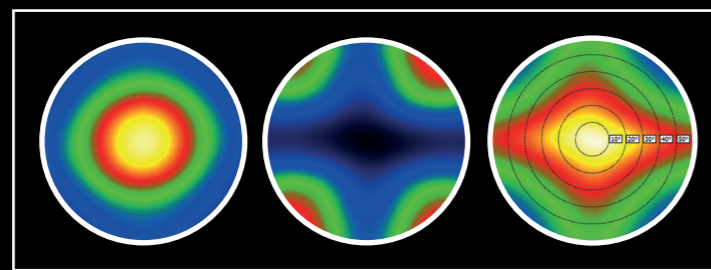
LMK DeMURA

Enables precise single capture measurements for the fast acquisition of pixel-level luminance data required to correct single-pixel emitters or to identify and localize defects. The software is based on an advanced pixel registration concept (APR) and highly precise DeMOIRÉ technique by phase compensation.



LMK CCM (Conoscopic contrast measurement)

Allows the user to easily determine fast evaluations of angular resolved luminance, color and contrast variations. It features conversion to H/V angular coordinates and definition of measurement regions and points in the ϑ, ϕ and ϑ_H, ϑ_V angular coordinate system with presets for automotive displays.



Display Uniformity

Display Quality

LMK 6

Member of
DFF
German Flat Panel
Display Forum

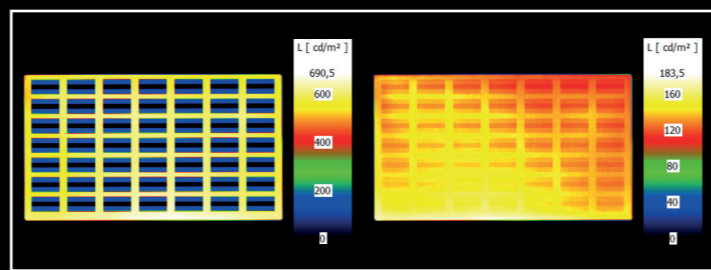


Display Defects

Pixel Level Evaluation

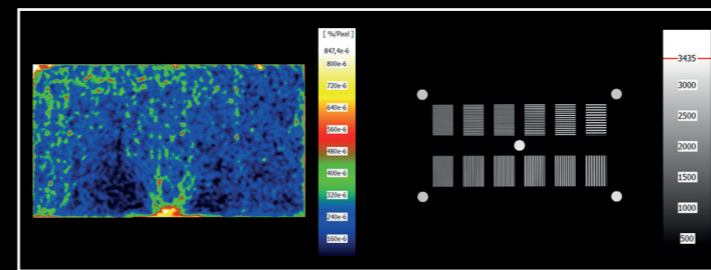
LMK Sticking image

Analyzes display sensitivity to static content through rapid luminance measurement series. The software package includes evaluations according to the three-level and two-level methods with both local and temporal corrections for highly accurate image sticking results. Exact timing is ensured by **LMK 6** image trigger technology.



LMK BlackMURA

Analyzes the bright and black-level uniformity of displays, taking into account the full area luminance distribution and its gradients based on human perception. Short-distance evaluations for large displays are possible using by applying correction models. The software allows adjustments to the viewing conditions with presets for automotive displays according to the DFF.

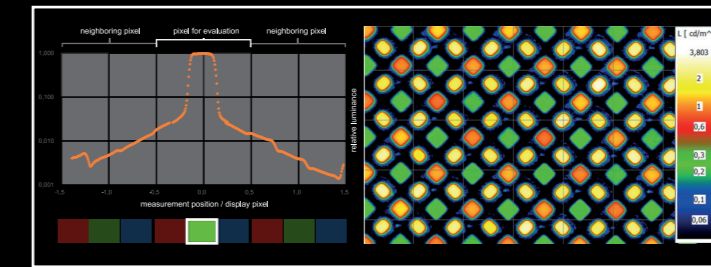


LMK Lenses



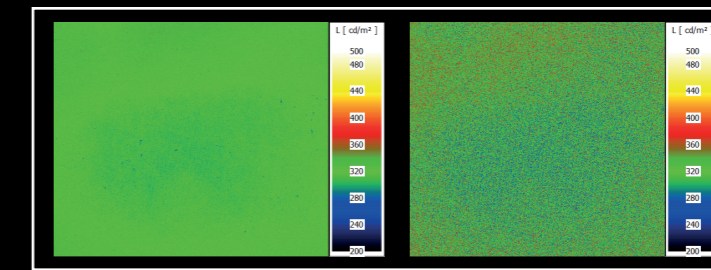
LMK Resolution

Evaluates the luminance distribution of individual subpixels and determines the perceived display resolution. The method is based on measurements with high-resolution macroscopic and microscopic lenses. The optional SLC correction ensures high precision and contrast.



LMK Sparkle

Determines high-frequency luminance variations such as display sparkle caused by anti-glare layers or OLED graininess in a simple and reproducible way – within flexible setups. The software allows adjustments to viewing conditions with presets for automotive displays for an optimal correlation of measured values to human perception.



LMK for automotive display metrology

Over the past 30 years, TechnoTeam gained extensive knowledge in photometry and colorimetry for automotive exterior and interior, including measuring displays of all shapes and sizes. Examples include passenger displays, central information displays, cluster elements or pillar-to-pillar displays, curved and s-shaped displays based on LCD and OLED technology, as well as head-up displays, camera-monitor-systems, and many more. Customers trust and choose the **LMK** to ensure the optical quality of automotive displays because of the expected high quality of metrology and support. Another reason is that many of our developments improve automotive display metrology in terms of reproducibility and speed.

One example is the **LMK Position** system. It is a combination of a 6-axis robot with an **LMK** and was developed to improve the reproducibility and effectivity of automotive BlackMURA measurements. It allows image stitching of large pillar-to-pillar displays and easy, fast and reproducible alignment of the **LMK** at the driver and passenger vantage points, even for complex 3D curved and freeform displays. Another example is the short-distance BlackMURA concept. It allows production measurements of large displays at reasonable measurement distances.

Finally, most of our measurement concepts are the result of joint research projects with our Automotive OEM, Tier 1 and Tier 2 industry partners. Successful development projects include:

- The uniformity measurement BlackMURA (OEM Working Group, DFF)
- The uniformity measurement Sparkle (Volkswagen and Elektrobit Automotive)
- The display resolution measurement Pixel Cross Talk (Porsche)
- The defect analysis Sticking Image 2 Level (Mercedes)
- The defect analysis Sticking Image 3 level (Johnson Controls and Visteon, DFF)
- The angular contrast evaluation region in the CCM (OEM Working Group)

LMK

display

LMK 6 & LMK 6 color

Sensor

[12 Bit digital, CMOS]

LMK 6-5 luminance/color

Sony IMX250 [2464 x 2046]

LMK 6-12 luminance/color

Sony IMX253 [4104 x 3008]

LMK 6-30 luminance/color

Sony IMX342 [6480 x 4860]

Dynamic range

Color High Dynamic measurement
[1:10.000.000 (-140 dB)]

Data transmission

Gigabit Ethernet Interface (GigE[®])

Metrological specifications

$V(\lambda)$ [$f_{i,E} < 4\%$]; $X(\lambda)$ [$f_{i,E} < 4\%$]

$Z(\lambda)$ [$f_{i,E} < 6\%$]; $V^*(\lambda)$ [$f_{i,E} < 6\%$]

Measuring quantities

Luminance: L (cd/m^2)

Chromaticity coordinates: (x,y)

Supported color spaces:

RGB, XYZ, sRGB, EBU-RGB, User, L_{xy} , L_{uv} ,
 $L^*u^*v^*$, $L^*a^*b^*$, C^*h^*ab , HIS,
HSV, HSL, WST²

Further measuring quantities can optionally be
defined via scaling factors.

Measuring range¹

Integration time from 100 μs to 15 s

1 ms $\approx 10000 \text{ cd}/\text{m}^2$

3 s $\approx 3.3 \text{ cd}/\text{m}^2$

The detection limit¹ ($f_{s,0}$) in all measurement
ranges is about 0.04 % relative to the highest
measurement value in the range.

Higher luminances can be achieved using
optional neutral density filters.

Calibration uncertainty²

fix focused lenses ΔL [$< 2\%$]

focusable lenses ΔL [$< 2.5\%$]

Repeatability³

ΔL [$< 0.1\%$]

$\Delta x,y$ [< 0.0001]

Measuring accuracy

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

$\Delta x,y$ [< 0.0020 (for CIE standard illuminant A)]

$\Delta x,y$ [< 0.0100 (set of test colors⁴)]

Uniformity⁵

f_{21} [$< 2\%$]

Fields of application

laboratory measurements, field
measurements, industry automation

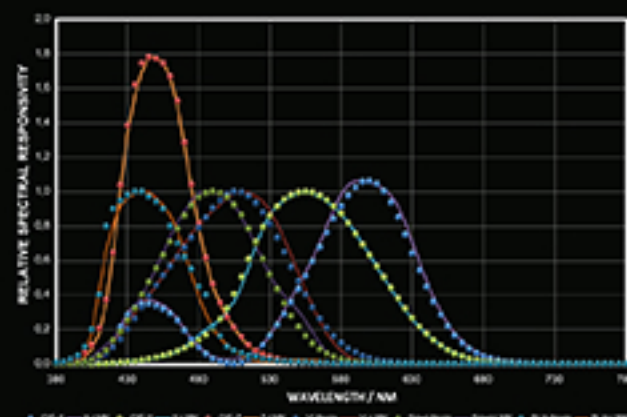
The **LMK 6** features small dimensions, low weight at high sensor resolution, an optimized stray light, and high filter transmissions. In addition, it offers full sensor control for customized image sizes. This allows task-specific data transfer rates for high speeds while reducing data size. A special readout mode allows an image content based trigger for precise timing in dynamic scenarios.



LMK 6 luminance/color

The **LMK 6 color** equipped with an internal filter wheel offers a total number of six full glass filters. Four of them are used for color measurements according to the CIE-XYZ 2° standard observer. This allows to measure both luminance and color data. The remaining free slots on the filter wheel can be equipped with special filters:

- Scotopic filter $V(\lambda)$
- Melanopic filter $s_{\text{mel}}(\lambda)$ (ipRGC, acc. to CIE S 026:2018)
- Infrared filter (NIR range of 780 – 1100 nm)
- Blue light hazard filter (acc. to IEC 62471)
- BK7 glass filter to work with the spectral responsivity of the sensor directly



Spectral matching of the **LMK 6 color**

¹ Measurements according to DIN 5032 Part 6 / ISO/IEC 15478:2014 (JIS S 023E:2013) | ² Dominant wavelength, saturation, correlated color temperature | ³ The luminance values represent the measuring range and values at the corresponding integration times. | ⁴ Definition and measurement according to CIE244:2001. | ⁵ Measurements according to CIE244:2001 using luminance standards traceable to the PTB (Physikalisch-Technische Bundesanstalt, the National Metrology Institute of Germany). | ⁶ Measurement performed on a stabilized white LED light source $L = 100 \text{ cd}/\text{m}^2$. Standard deviation of the mean value over 100 pixels. | ⁷ Maximum difference of the measured value to the reference measurements using 12 LED-based luminance/color standards.

Presented by:

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