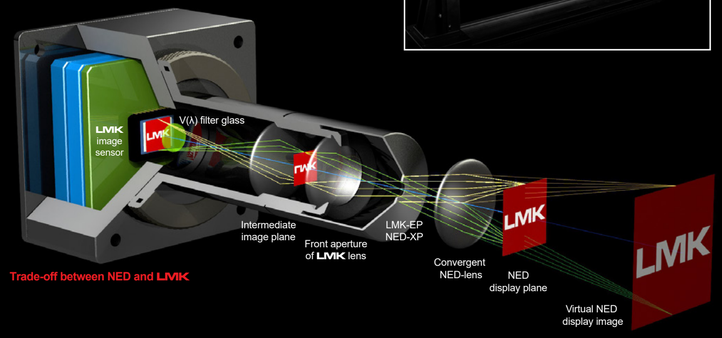
Characterization of Near-Eye Display design (NED)

Imaging Luminance and Color Measuring Devices (ILMD / ICMD) in combination with adapted measuring lenses provide effective one-shot solutions to evaluate modern Near-Eye Displays (NED). NED-suppliers ask for **LMK**-solutions adapted to their specific instrument structure. Here, the wide range of fields of view (FOV) and of NED-resolutions needs to be considered.On the basis of our experience in creating **LMK**'s we offer a set of formulas to determine the basic parameters of lenses for different NED-concepts.



Trade-off between NED and **LMK**

Paraxial LMK Relationship

The principal set point for a lens design must be a classical optical instrument like microscope and binocular. The human eye oversees the complete imaged field only in a position when the iris is placed in the Exit pupil (XP) of the NED. Consequently, with NED-design, its XP has to be reachable by the iris.

An Eye Box-concept suggests a certain axial and lateral space to place the iris. The reason is the diameter of the NED-XP, which could be much larger than with classical optical instruments. Very often, this position is quite close to the last optical NED-surface. If the **LMK** aims to capture the complete NED-field of view, the **LMK** Entrance pupil (EP) has to be located inside the NED-XP. Therefore, a universal **LMK**-lens design must have the aperture stop (resp. the EP) in front of all optical surfaces.

Conoscopic lens arrangement

Conoscopic lens means that ray bundles form a real intermediate image plane, and the final image on the image sensor is reversed in reference to a classical **LMK**-lens. The chosen conoscopic lens arrangement is convergent and offers a variable focal length to realize different FOV up to 120°(circular image).

Special front-stop lenses

- This lens works with a real intermediate image plane. The resulting focal length of these special front-stop lenses range from 8mm up to 16mm.
- It suggests a captured field of view of ±30° down to ±15°.
- This field of view is smaller than the nominal field of most NED designs. An ideal device under test for this would be a monocular notifying that it realizes a field angle of maximal ±30°.

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Display metrology and characterisation
equipment for **LMK** photometer and colorimeter

LMK
display

LMK Display

The characterisation of different display types - small mobile phone displays up to large TV displays or also head-up displays - is an important topic in various R&D applications and the quality management for production accompanying processes.
For example automotive displays and their very strict performance, quality and safety requirements or the measurement of virtual displays (VR/AR, ocular systems) are becoming more and more important.

Imaging Luminance and Color measuring devices (ILMD/ICMD) can be used to analyse a various range of performance and quality benchmarks for the different display types.

The image measuring technology can be used to evaluate uniformity parameters like black-level gradients in a few seconds measurement time.
Using special lenses (e.g. hyper-centric lens (Conoscope) or Macroscopic lenses) the user can perform angular luminance and color characterisation for small parts of the display or for single pixel / subpixel structures.

Additionally parameters like the Gamma-curve can be measured with one shot within seconds. In addition, the evaluation of sticking images is possible with the same measuring device.

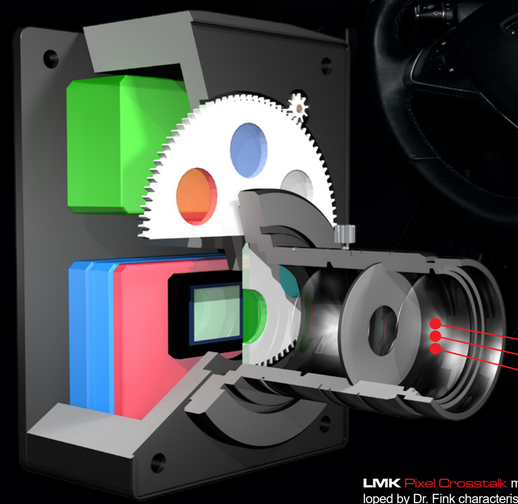
The **LMK** Luminance/Color system can be equipped with three different lens types for display analysis

- 50mm focusable lens (whole screen analysis like uniformity measurement)
- Conoscopic lens (angular dependent luminance and color measurements)
- Macroscopic lens (single-/subpixel structure analysis e.g. for Pixel-Crosstalk analysis or the evaluation of anti-glare and anti-reflection coatings)

The **LMK** display software package is available for the current **LMK** 5 systems and the future **LMK** 6 generation based on CMOS sensor.

LMK 5 [CCD based]
1386 (H) × 1035 (V) (1MP)
2448 (H) x 2050 (V) (5MP)

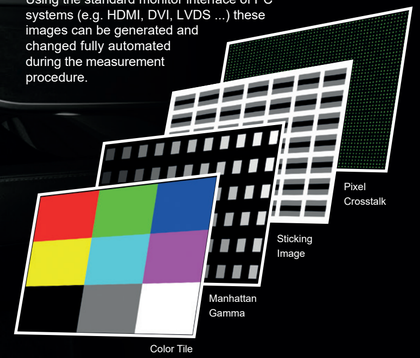
LMK 6 [CMOS based]
1936 (H) × 1216 (V) (2MP)
2448 (H) x 2048 (V) (5MP)
4100 (H) x 3000 (V) (12MP)



Automotive displays

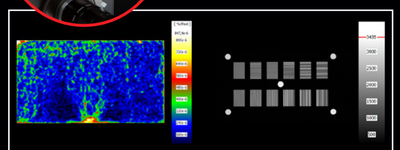
Test Image Generator

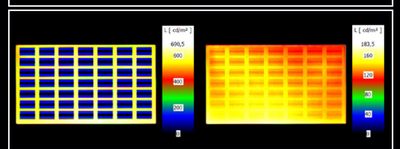
Using the standard monitor interface of PC systems (e.g. HDMI, DVI, LVDS ...) these images can be generated and changed fully automated during the measurement procedure.



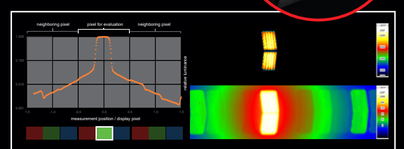
LMK BlackMURA supplies the analysis of display screen quality according to the black-level uniformity. Thus the package is providing an extension to the functions of the **LMK** LabSoft for realising a gradient filter detection of particular non-uniformity on the display screen.

LMK Sticking Image supplies the analysis of display screen quality according to the three-level burn-in method developed by Dr. Lauer.

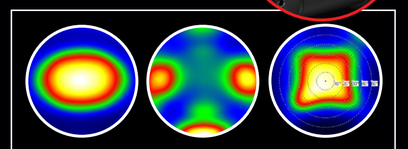




LMK Pixel Crosstalk method developed by Dr. Fink characterises the loss of image clarity caused by anti-glare coatings. The method uses high-resolution imaging with a Macroscopic lens, giving a distribution and evaluation of scattered light.



LMK CCM (Conoscopic contrast measurement)
The software package allows the user to perform angular contrast determination of displays in an easy way. It provides the capability of conversion to H/V angular coordinates as well as the definition of measurement regions and points in the ϑ,ϕ and ϑ_H, ϑ_V angular coordinate system.



Member of DFF
German Flat Panel Display Forum

Target applications

- Various topics in the application of display evaluation (human machine interface (HMI) displays, Head-Up display (HUD), AR/VR displays) such as luminance level, color settings, luminance/color uniformity and angular dependence of luminance/color
- Material evaluation (e.g. Brightness enhancement foils, Combiner windows for HUD)
- Evaluation of display screen surfaces (anti reflection / anti glare coatings)

Research & Development (R&D)

- BlackMURA analysis according to DFF Standard „Uniformity Measurement Standard for Displays V1.3"
- Sticking Image determination according to the "three-level burn-in Method" of Dr. Lauer (Visteon) and the "two-level burn-in specification" using a checkerboard burn-in pattern only.
- Pixel Crosstalk analysis according to the method of Dr. Fink (Porsche)
- Angular contrast measurements with the Conoscopic lens

Production control

- Luminance and Color evaluation
- BlackMURA
- Sticking Image (available soon)