Instrument Systems
KONICA MINOLTA Group

Precise light measurement enables decentralized component production

Design color worlds in the automotive interior

To enhance the feeling of well-being of the drivers and passengers in a vehicle, interior displays and control elements should be color-coordinated so that all critical information is quickly and easily recognizable. The quality of optical parameters must be tested at the manufacturing stage, enabling decentralized component production.

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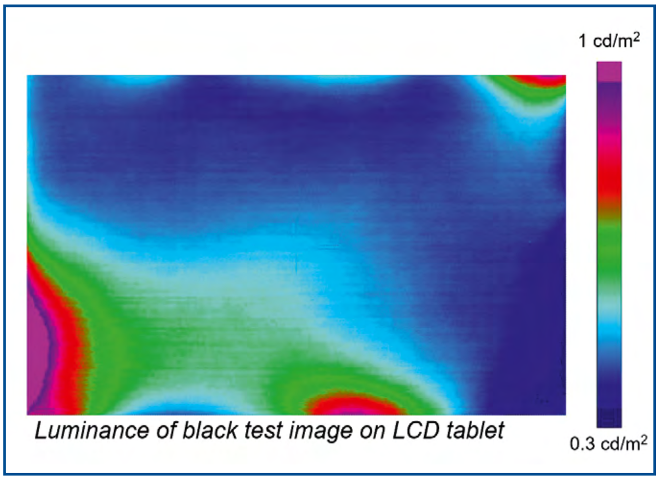

Figure 1: Black mura – irregularities in the brightness of an LCD are easily recognizable with a false color representation of luminance. For such measurements are 2D measurement methods are required.

TECHNICAL
ARTICLE

Presently, displays are becoming increasingly widespread as the main interactive elements for communication between the vehicle and its occupants. Besides typical infotainment functions, they assume more and more special tasks such as those of the side mirror. In addition, LED light strips and other illuminated elements in the passenger compartment make a positive contribution to comfort. The expectations of the vehicle occupants with regard to the image and color quality of displays are strongly influenced by mobile devices and are thus extremely high. Accordingly, the technical implementation of a color-coordinated interior concept by auto manufacturers is extremely complex and challenging.

\\ TECHNICAL CHALLENGES IN COLOR AND LUMINANCE MEASUREMENT

The combination of different optical elements can lead to irritation in the vehicle interior if their colors are not carefully coordinated. Even colors that only slightly, yet recognizably, differ from one another, may be distracting to passengers. The more vibrant visual components are present, the greater the risk of a diverging, unharmonious element.

Generally, the various components are manufactured by different suppliers. For objective and absolute testing of the optical parameters such as color and brightness, specific light measurement technology is therefore required at each production facility in order to guarantee highly comparable and metrologically traceable measurement results, and no reference measurement with a golden sample is required. For 2D displays an imaging, spatially resolved analysis and the evaluation of further aspects such as homogeneity is additionally necessary. This increases the complexity of the required test procedures and in turn the demands made on the measuring equipment.

\\ QUALITY REQUIREMENTS PLACED ON THE MANUFACTURER

Within the framework of the German Flat Panel Display Forum (DFF) in the German Automotive OEM Working Group, German automobile manufacturers Audi, BMW, Porsche and Volkswagen are drafting strict quality standards for the optical and imaging properties of LC displays in the automotive sector. The document Display Specification for Automotive Application V5.1 defines the pass/fail criteria for the optical parameters applicable to externally supplied displays and the limits of acceptance. Standardized measuring procedures and evaluation methods in different development phases are also defined together with metrology specialists.

A comprehensive examination is also necessary for end-of-line (EOL) testing. Among other aspects, this includes brightness with different grayscale values (gamma), uniformity of white and black images (Figure 1), and the detection of defective regions of the display (dot defects). The evaluation and analysis of the above-mentioned properties is not trivial and requires standardization of the test methods in order to make the results from different supply chains comparable.

\\ DECENTRALIZED COMPARABILITY

Because the specifications of the OEM Working Group contain absolute values for luminance and the color coordinates, the light meters used must be aligned to calibration standards so that their measurement results are traceable to a national institute such as the PTB (German National Metrology Institute). This test process guarantees that deviations in the readings can only occur due to the measurement uncertainty of the measuring instrument used. The higher the quality, the smaller the error budget and the better the conformity of repeated or decentralized measurements. Under these conditions a realistic comparison between the incoming and outgoing inspection of suppliers and OEMs is possible, and the efficiency of the overall supply chain can be improved.

\\ FAST AND PRECISE 2D MEASUREMENTS

2D light measurement technology is a prerequisite for the comprehensive testing of displays. Filter-based imaging photometers and colorimeters permit spatial resolution of the measurement and can analyze, if needed, at subpixel level. A precise color evaluation takes place by spectral measurements that characterize the intensity of the light relative to wavelength, and provide detailed information on which colors the display shows (Figure 2).

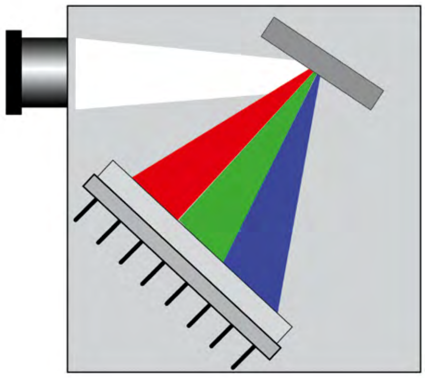

Figure 2: Spectral measurements are preferred for color measurement, as they can be used to determine the intensity of the individual colors of which the light is composed.

However, neither implementation with a spectrometer nor with a filter-based colorimeter can fulfil all the requirements of the OEM Working Group. Spectrometers determine the color coordinates with outstanding accuracy and are significantly better, e.g. than filter-based imaging colorimeters. But the results are determined for a limited spot and therefore unsuitable for a 2D surface analysis. An imaging (filter wheel) colorimeter can measure luminance and color coordinate in 2D, but is significantly slower than the spectrometer because the different-colored filters of the camera measure in sequence.

A system that optimally satisfies all requirements in terms of speed and accuracy is a combination of imaging photometer and colorimeter with a spectrometer. The spectrometer delivers precise data for a spot that can be used as a reference for the imaging colorimeter. The result is measurement data with spectroradiometric precision for the entire 2D image. The combined system exhibits a fast cycle time and can capture the entire image in less than a second. It therefore satisfies the typical requirement in the automotive sector of generating several dozen images, including their evaluation, in only a few seconds.

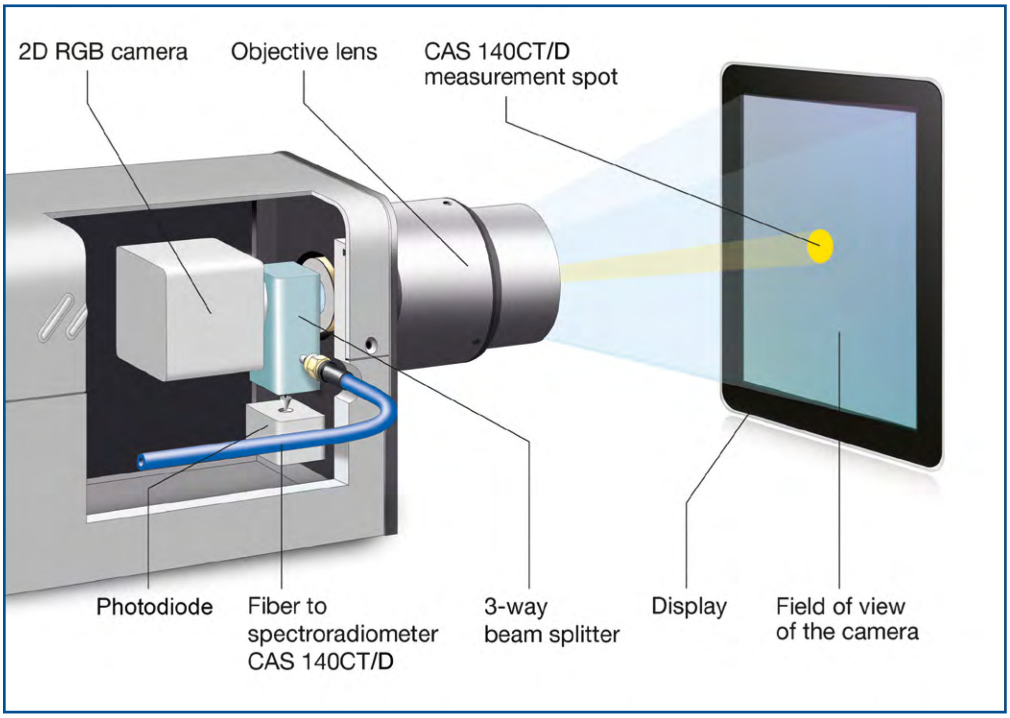

Figure 3: The LumiTop principle of the 3-in-1 solution (color camera, spectrometer and photometer) permits EOL testing with high precision, fast measurements and robust operation.

In addition to simple measurements (including maximum brightness for white, red, blue and green display) the measuring system must also be capable of complex analyses, e.g. of luminance homogeneity and gray settings under diverse operating conditions. These include the ambient temperature (temperature range -40 °C to +85 °C) or the ambient light (day- or nightlight) or long-term tests (strived-for service life up to 15 years).

\\ IMPLEMENTATION IN THE PRODUCTION LINE

Measuring instruments developed for EOL tests must satisfy exacting requirements: high measurement accuracy in addition to short measurement times and a robust 24/7 performance. Instrument Systems developed the LumiTop principle (Figure 3) for this specific purpose. The latter combines an RGB camera and a fast photodiode with a high-end spectroradiometer. Independently of operating voltage or backlight, LCDs can show recognizable optical modulations in luminance that may irritate a user. This flicker effect can be analyzed and determined according to the JEITA standard (Japan Electronics and Information Technology Industries Association) by means of a photodiode. In the production line the 3-in-1 LumiTop solution offers a fast and simple measurement solution for these and other measurement scenarios.

\\ INTEGRATION OF FURTHER CONTROL ELEMENTS

For automated implementation in the production line, further control elements must normally be integrated into an EOL test station. These control the display indicator, retrieve the necessary images and enable adaptation of the display adjustment. For example, vertical alignment of the display with an accuracy of better than 0.5° in all directions is required for testing to the black mura standard. Ideally, each of the components of the test station has a software development kit (SDK) with

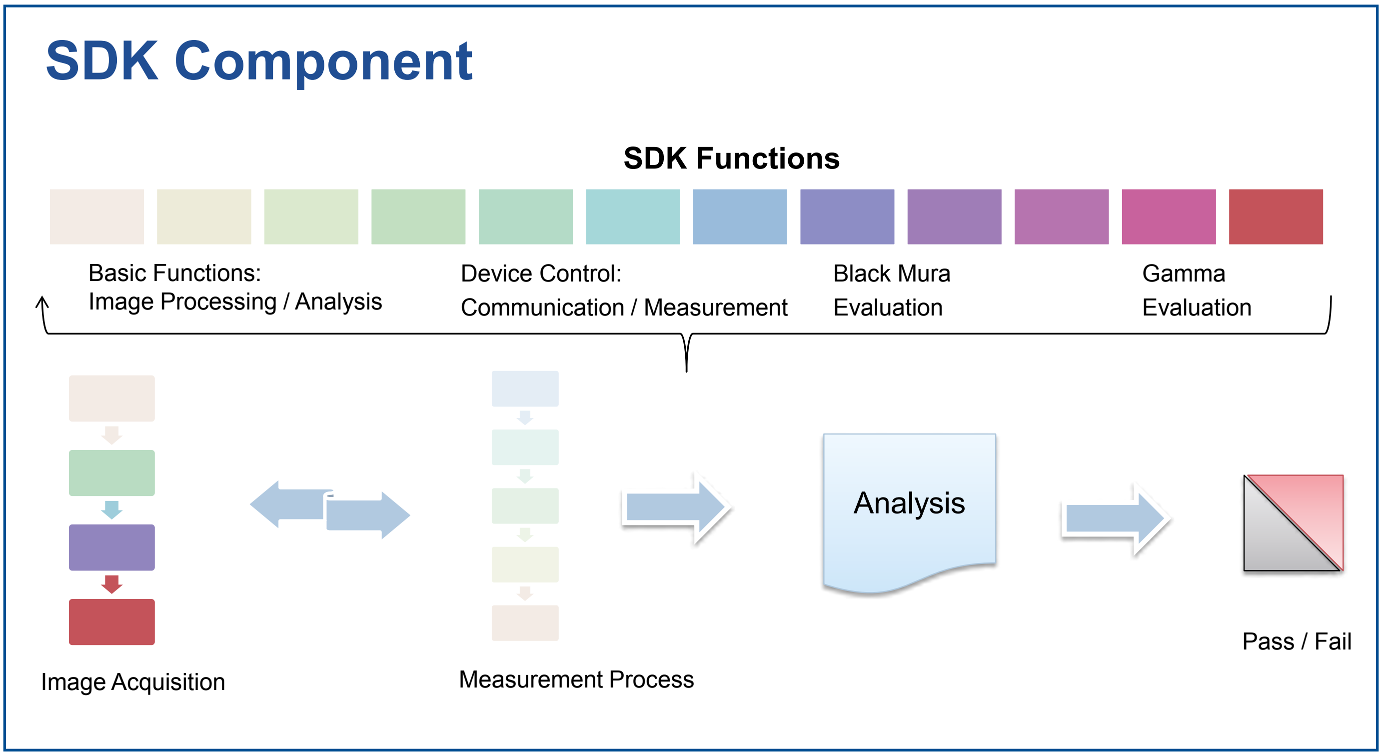

Figure 4: A camera SDK is essential for the integration of further EOL components.

a driver for all critical functions of the system. This facilitates integration into the handler system and ensure a smooth test procedure.

A standardized evaluation of the OEM specifications with the aid of preconfigured analysis tools is advantageous for performing fast evaluation to pass/fail criteria and optimizing throughput (Figure 4). All software modules should conform to OEM specifications in order to guarantee that results from different sources and measurements deliver the same quality.

The increasing number of displays in vehicle interiors and developments in the consumer electronics sector heighten the necessity for absolute and standardized measurements. For the meaningful comparison of EOL testing of suppliers and users, the light meters used must be traceably tested. The highest efficiency in production lines is ensured by combined systems that are accurate, fast and robust. For this purpose, Instrument Systems developed the LumiTop principle.

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