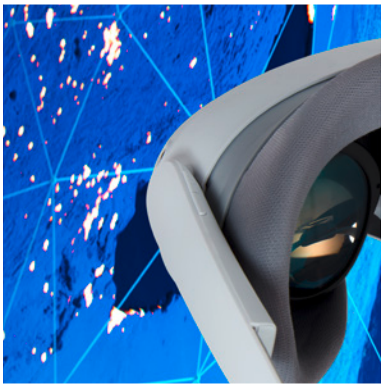
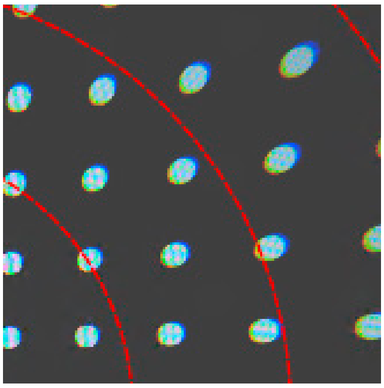
SYSTEMS & SOLUTIONS

AR/VR/MR Display Measurement
Portfolio & Solutions

For Near-Eye Displays

Instrument Systems
KONICA MINOLTA Group

01 \\ Introduction

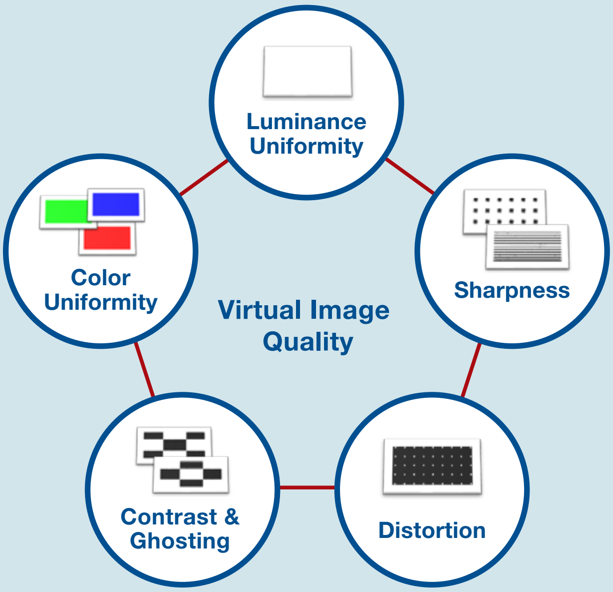
Near-eye displays (NEDs) are key components in augmented reality (AR) and virtual reality (VR) systems, enabling immersive visual experiences through compact optical designs positioned close to the user's eyes. Achieving high image quality, accurate color reproduction, and comfortable viewing requires precise optical measurement across the entire device pipeline.

Imaging and spot colorimeters quantify luminance and chromaticity across the display field to evaluate uniformity, contrast and color accuracy. **Imaging colorimeters** additionally reveal spatial characteristics such as sharpness, ghosting and distortion.

Goniometers capture angular-dependent changes in brightness and color, providing a detailed understanding of the display's viewing-angle performance. **Controlled background illumination** simulates real-world lighting conditions, enabling comprehensive testing of display performance under various environments.

Together, these measurement tools provide an integrated framework for validating, optimizing and qualifying AR/VR visual systems.

Display evaluation criteria

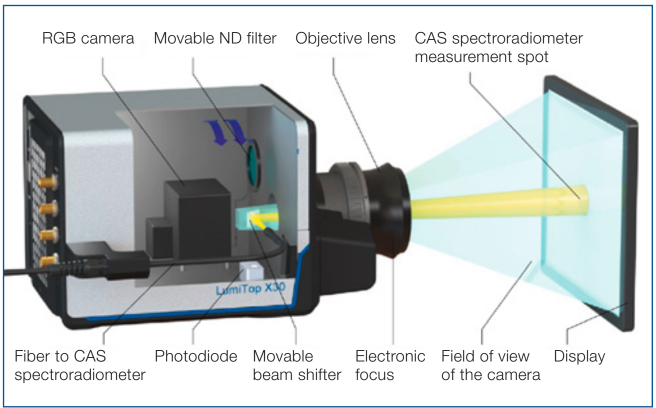


Within the Instrument Systems portfolio, various solutions are available to support these AR/VR measurement tasks. The following test systems are covered in this brochure:

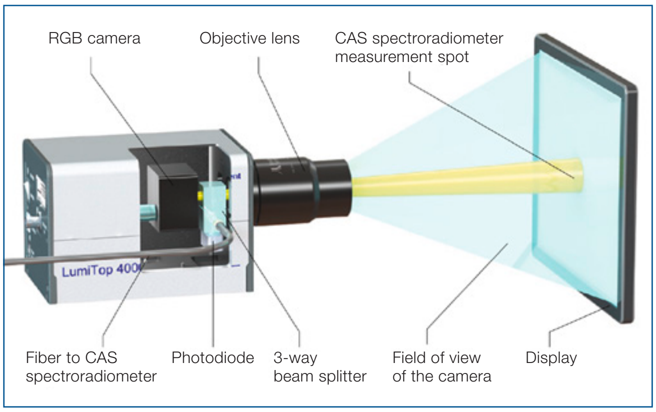
- **LumiTop Imaging Colorimeter**: Field-resolved luminance, chromaticity, MTF-related insights, and spatial defect detection
- **TOP 300 Optical Probe**: High-accuracy point measurements for calibration and verification tasks
- **DMS Goniometer**: Accuracy point measurements for calibration and verification tasks
- **CoboTop**: Flexible robotic positioning for repeatable, high-throughput test sequences
- **Illumination Sources**: Controlled background and scene lighting to simulate real-world conditions

02 \\ LumiTop Imaging Colorimeter

The LumiTop design combines a camera with a high-end array-spectroradiometer, which acts as a live reference to ensure true color measurement. Camera image and reference spectrum are taken within one image acquisition, and the spectral information is used to perform an instant fine correction of the measured color values.



Optical design concept of the LumiTop X30.



Optical design concept of the LumiTop 4000/5300.

Customized for lab and production demands

Within the LumiTop and LumiTop X series, various models offer diverse options for customization:

- High dynamic and low-noise CMOS RGB-cameras can be offered with sensors from 12 MP up to 31 MP for ultra-high resolution.
- Sensors with up to 81 dB dynamic range provide a huge measurement range for low and high luminance applications. Optionally, external filters can be used to extend the measurement range for extremely bright light sources.
- A variety of industry grade objective lenses serve customer-specific measurement needs for any device, be it a microdisplay, a flat panel display or a near-eye display in AR/VR devices.

For a perfect fit, different models of our high-class CAS spectroradiometer are available and complete the LumiTop system.

Especially LumiTop X20 and X30 provide maximum sensitivity for exceptional low luminance performance and offer the highest grade in flexibility. A switchable internal neutral density filter features enhanced dynamic range. They also provide a very precise, externally driven electronic focus, which offers a flexible focus setting with outstanding accuracy and repeatability.

LumiTop brings speed and absolute photometric accuracy to near-eye displays

Instrument Systems' AR/VR lenses for the LumiTop and LumiTop X imaging colorimeters are specifically designed for production testing of near-eye displays (NEDs) in virtual and augmented reality headsets and glasses. The optical design mimics the human eye, measuring color and luminance as perceived by the user, while also enabling the evaluation of contrast, sharpness, and distortion.

A large field of view, various pupil sizes and an adjustable focus distance cover a wide range of testing applications. The straight and periscopic lens options ensures optimum access to the NED even in confined assemblies.

LumiTop 4000/5300 with AR/VR lens

- Up to 120° x 105° FOV
- Adjustable focus
- Various pupil sizes
- Space for "two-eyes" measurement

LumiTop X with AR lens

- FOV: 42° x 32°
- Adjustable focus
- Various pupil sizes

In addition to the straight design, the periscope lens provides an optimal measurement position even within the tight spatial constraints of fully assembled head-mounted devices. Two LumiTop units can also be operated in parallel in a binocular setup.

User experience — true colors and luminance

- High-resolution camera to minimize Moiré effects
- Optimized lens design to capture the image as perceived by the human eye
- Fast photometer and trigger for precise synchronization and control of modulated light sources

LumiTop with AR/VR-optimized lenses enables highly reproducible, traceable, and absolute color and luminance measurements, ensuring optimal display quality for augmented and virtual reality devices. The spectrally corrected LumiTop AR/VR system brings high speed and absolute photometric accuracy to near-eye displays (NED).

LumiTop X30 AR with 30 MPx and a field of view of 42°x32°.

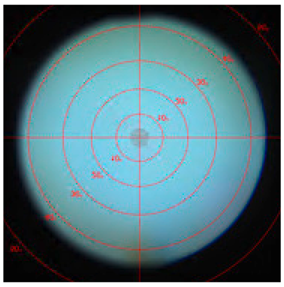
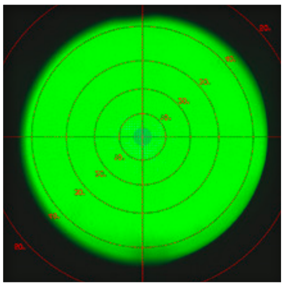
LumiTop 4000 AR/VR with 12 MPx resolution and a field of view of 120° x 85°.

LumiTop 5300 AR/VR with 24 MPx resolution and a field of view of 120° x 105°.

For easy integration and handling, the powerful LumiSuite software package has been developed. LumiSuite's user-friendly graphical user interface (GUI) intuitively guides the operator through the individual steps of a workflow for data evaluation. The workflow of the LumiSuite Smart Analysis is organized in an easy 3-step logical sequence. With its diverse Image analysis functions, LumiSuite SmartAnalysis is ideally suited for the comprehensive characterization of modules or NEDs. LumiSuite supports several analysis methods suitable for AR/VR applications, including a test pattern generator.

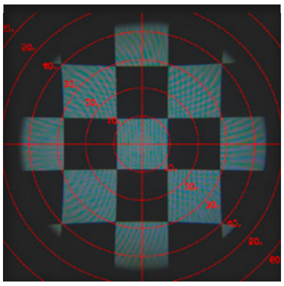
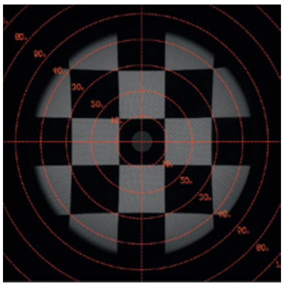
Variety of possible measurements using a LumiTop AR/VR system & LumiSuite software:

- Luminance and color uniformity
- Distortion
- Chromatic aberration
- Field of view
- Eye box scans
- Contrast ratio
- Michelson contrast
- Slanted edge analysis
- Virtual image distance

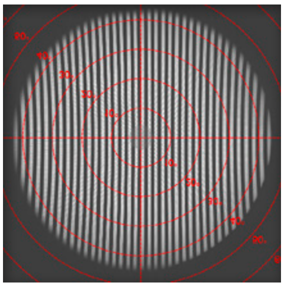
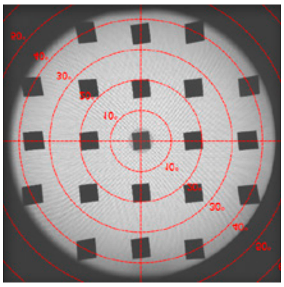
Luminance and color measurement of a NED for a VR headset

Luminance and color measurements are basic measurements to characterize and optimize NEDs, AR or VR devices. With one image measurement, the total field of view can be quantified within a second.

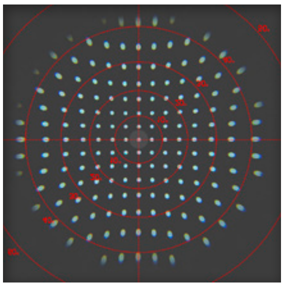
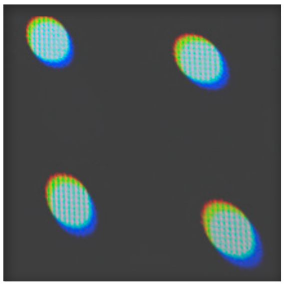
Contrast ratio measurement of a NED for a VR headset

Contrast ratio measurements are needed to guarantee a brilliant image. A high ratio between white and black is the desire of every display. With the LumiSuite AR/VR the contrast ratio of the image is measurable over the complete field of view.

Sharpness analysis based on the Michelson contrast or slanted edge analysis

Sharpness evaluation using the Michelson contrast or slanted edge method is also supported by the LumiSuite. The sharpness varies over the field of view and is a sensitive indicator of the quality of the optics used for the NED.

Distortion and chromatic aberration

Distortion and chromatic aberration describes the properties of the optics used in the NED display. LumiTop AR/VR together with LumiSuite allows a quick characterization of both properties.

03 \\ TOP 300 AR/VR Optical Probe

Key features at a glance

- Robust, compact and lightweight design for manufacturing applications
- Integrated viewfinder camera with 5 MP
- Optics mimic the human eye with a FOV of ±1.2°
- Configurable entrance pupil and focus distance
- Binocular setup possible
- Fiber guide with integrated mode-mixing adapter

Live Demo:
AR/VR Testing with TOP 300 Optical Probe and CAS 140D Spectrometer

Scan to watch the TOP 300 AR/VR setup in action

The TOP 300 AR/VR optical probe from Instrument Systems is designed for high-accuracy luminance and color measurement, enabling precise determination of luminance and spectral radiance. It provides detailed color analysis of light sources, optical lenses, optical modules, and fully assembled AR/VR devices. This advanced instrument guarantees exceptional accuracy in characterizing near-eye displays and other optical components used in AR/VR applications. In combination with a high performance spectroradiometer CAS and the powerful software tool SpecWinPro it is easy to setup a very accurate and precise system for NED measurements.

TOP 300 features a viewfinder camera and pairs best with a high-end CAS spectroradiometer.

04 \\ DMS AR/VR Goniometer

The DMS series is a worldwide reference for comprehensive electro-optical analysis of displays, materials and optical components across the entire engineering and production process.

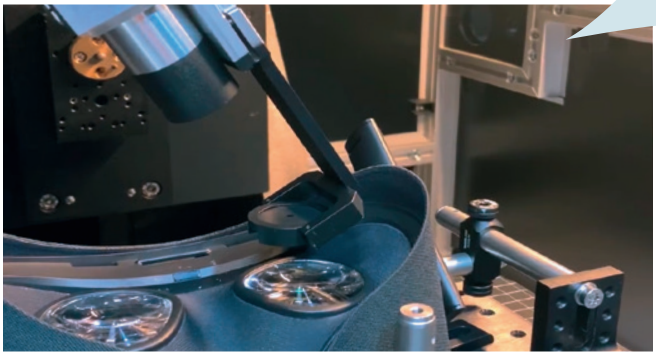
When combined with AR/VR-specific optics that mimic the human eye, DMS systems measure the virtual image produced by near-eye displays (NEDs) with laboratory-grade accuracy.

The DMS systems provide:

- Measurement of luminance, contrast and chromaticity across various display drive states and viewing directions
- Determination of flicker and response time
- Qualification of environmental influences such as ambient illumination and temperature variations

DMS AR/VR measurement

- Luminance
- Color
- MTF
- Eye box mapping at varying eye relief distances
- Gaze or FOV scan



Optical model replicating the human eye geometry (entrance pupil, lens, eye center) for accurate full-field-of-view characterization.

Learn more about the DMS Goniometer Series.

DMS 803 Goniometer

- Maximum versatility for small to medium sized samples
- 6 motorized axes for automated measurements
- Multiple accessories to test DUT under ambient illumination and different temperature

05 \\ Cobot-Based Solution for AR/VR Testing

Instrument Systems offers advanced sensors and solutions tailored for near-eye display (NED) and headset measurements in AR/VR applications. Key products include the **TOP 300 AR/VR Optical Probe** and **LumiTop AR/VR Imaging Light Measurement Device**, both designed for precise luminance and spectral radiance analysis to ensure superior performance.

For advanced tasks like eye-box scans or eye-gaze measurements, these sensors can be paired with additional mechanical equipment. High-precision goniometer solutions, such as the **DMS 803**, further expand measurement capabilities across a wide range of AR/VR applications.

When flexibility is essential, cobot-based goniometer systems offer an innovative alternative. With enhanced degrees of freedom and a larger working area, these solutions provide versatility for complex testing scenarios.

A standout in this category is the CoboTop, a cobot-based system developed in collaboration with Konica Minolta's CoboSense technology. Integrated with the TOP 300, the CoboTop automates inspection workflows, repetitive tasks and testing procedures, delivering exceptional precision and efficiency.

By combining the accuracy of the TOP 300 with CoboSense's automated capabilities, manufacturers can achieve unparalleled quality control, reduce costs, and streamline production processes. This innovative approach empowers the AR/VR industry with scalable, automated solutions designed to meet the demands of a rapidly evolving market.

CoboTop integrates the TOP 300, CoboSense and CAS 140D for precise, automated AR/VR testing.

Scan to watch CoboTop in action

06 \\ Illumination Sources for XR Devices

Environmental illumination has a decisive impact on see-through near-eye displays used in AR glasses. Depending on its color and brightness, ambient light can obscure virtual content for the user. Conversely, AR optics such as waveguide combiners can alter the perceived color and luminance of the environment, while scattering effects may introduce artefacts that reduce visual comfort.

Instrument Systems provides illumination sources designed to ensure clear, high-quality images for XR devices under these varying lighting conditions. They support reliable testing according to IEC-63145 and IDMS standards and can be adapted to specific product requirements and environments. These light sources are essential for evaluating AR glasses and see-through displays, enabling optical assessments that accurately capture environmental perception and the influence of ambient light on virtual image quality.

With proven expertise in the manufacturing and characterization of light sources, Instrument Systems delivers luminance and spectral outputs traceable to primary standards for maximum accuracy. The systems are available with different luminance levels, emitting aperture diameters and spectral characteristics such as white or sun-like spectra. This flexibility makes them ideal for both compact and full-scale test setups in R&D and production environments.

Illumination source with a 75 mm emitting aperture and a sun-like spectrum.

XR test setup with illumination source and LumiTop AR/VR imaging colorimeter system.

09 \\ Technical Specifications

LumiTop 4000/5300 AR/VR

Model	LumiTop 4000 AR/VR (preliminary)	LumiTop 5300 AR/VR (preliminary)
Measurement quantities		
2D	Luminance, color	
Spot	Spectrum, luminance, color, flicker	
General specifications		
Operating system	Windows 10 (64 bit), Windows 11 (64 bit)	
Dimensions (l x w x h) [1]	With periscope lens: 452 mm x 190 mm x 180 mm WIth straight lens: 527 mm x 190 mm x 180 mm	
Weight [2]	5.4 kg	
Power supply	24 V	
Operating temperature range	15 – 35 °C	

Camera specifications		
Effective resolution (h x v)	4096 x 3000 pixels (12 megapixels, CMOS)	5312 x 4600 pixels (24 megapixels, CMOS)
AD converter	12 bit	
Interface camera	Gigabit Ethernet, M12 12-Pin Female	
Measurement range 2D [3] [4]	L = 0.012 cd/m^2 – 170,000 cd/m^2	
Angular Resolution	> 30 px/deg (average over FOV)	> 40 px/deg (average over FOV)
Lens specifications		
Field of View (FOV) (H x V)	120° x 85°	120° x 105°
Adjustable focus distance	0.5 m – 1.5 m (other on request)	
Entrance pupil [15]	1.0 – 3.6 mm	
Measurement time [8]		
Measurement time hybrid mode	0.7 s	
Measurement time camera only	0.7 s	
Accuracy and precision	**Luminance**	**Color**
Accuracy of camera (rel. to CAS) [5]	±0.4 %	±0.002
Instrumental precision camera [6]	±0.03 %	±0.0001
Camera uniformity (RNU) [7]	±0.35 %	±0.0013

CAS specifications	CAS 140D	
Interface CAS	USB, Gigabit Ethernet	
Measurement range CAS [3] [9]	L = 0.003 cd/m^2 – 4 x 10^7 cd/m^2	
Accuracy and precision	**Luminance**	**Color**
Accuracy of CAS	±3.0 % [10]	±0.0015 [11]
Instrumental precision CAS [6]	±0.1 %	±0.0001
Polarization sensitivity [12]	±2.0 %	±0.002

Flicker specifications	
Flicker range	5 cd/m^2 – ca. 600 cd/m^2
Flicker accuracy [13]	±1 dB
Flicker instrumental precision [13] [14]	±0.02 dB

1) Inclusive lens and fiber exit.
2) Without CAS, with mode mixer.
3) Contact us for extended measurement range options.
4) Lower measurement limit based on a signal to noise ratio of 10:1 for maximum exposure time of 10 seconds. Upper measurement limit based on a Y channel signal level < 80 % for a white (non-modulated) LED light source using a minimum exposure time of 28 µs.
5) Typical value for maximum deviation over the FOV relative to the CAS spot; calculated for an image with 21 pixels cropped at each edge binning (34 averages).
6) 2σ of repeated measurements of one instrument (L ≈ 100 cd/m^2, autoexposure).
7) RNU (response non-uniformity) is defined as 99.7 % percentile of the deviation of the mean image value; calculated for an image with 21 pixels cropped at each edge binning (34 averages) immediately after calibration with reference used for flat-field correction.
8) Time between beginning of two subsequent measurements using the SDK; determined with a camera exposure time of 20 ms and CAS exposure time of 200 ms for a white LED (L ≈ 500 cd/m^2). Depends mainly on PC processing capability.
9) Lower measurement limit based on a signal to noise ratio of 10:1 for maximum exposure times 65 s for CAS 140D. Upper measurement limit based on a signal level < 80 % for a white (non-modulated) LED light source using a CAS internal optical density filter OD4 and minimum exposure time of 4 ms (CAS 140D). Values valid for CAS 140D with 250 µm slit width.
10) Immediately after calibration relative to calibration standard.
11) Immediately after calibration.
12) Maximum deviation from average of repeated CAS measurements with a linear polarized light source and varying polarization angle.
13) L ≈ 150 cd/m^2, 30 Hz, 10 % sine wave.
14) 2σ of repeated measurements of one instrument.
15) The entrance pupil is exchangeable. Standard sizes are: 1.0 mm, 1.5 mm, 2.0 mm, 2.5 mm, 3.0 mm and 3.6 mm.

LumiTop X30 AR

LumiTop X30 AR (preliminary)		
Measurement quantities		
2D	Luminance, color	
Spot	Spectrum, luminance, color, flicker	
General specifications		
Dimensions (l x w x h)	730 mm x 288 mm x 215 mm	
Weight	17 kg	
Operating system	Windows 10 (64 bit), Windows 11 (64 bit)	
Power supply	24 V	
Operating temperature range	15 – 35 °C	

Camera specifications		
Effective resolution (h x v)	6464 x 4852 (31 megapixels, RGB, CMOS)	
Pixel size	3.45 µm x 3.45 µm	
AD converter	12 bit	
Size sensor	27.9 mm diagonal (APS-C)	
Interface camera	CoaXPress	
Angular resolution	150 px/°	
Lens specifications		
Lens shape	Straight	
Field of view (FOV) (h x v)	42° x 32°	
Focus distance VID	0.25 m to infinity (fixed)	
Entrance pupil	1 – 5 mm (fixed)	
Lens barrel diameter (between entrance pupil and fold mirror)	< 46 mm	
Virtual aperture position	12.5 mm from first surface	
Accuracy and precision	**Luminance**	**Color**
Accuracy of camera (rel. to CAS) [1]	±0.4 %	±0.0015
Instrumental precision camera [2]	±0.03 %	±0.00015
Camera uniformity [3]	±0.35 %	±0.0013

CAS specifications	CAS 140D	
Interface CAS	USB, Gigabit Ethernet	
Accuracy and precision	**Luminance**	**Color**
Accuracy of CAS	±3.0 % [4]	±0.0015 [5]
Instrumental precision CAS [2]	±0.1 %	±0.0001
Polarization sensitivity [6]	±2.0 %	±0.002

[1] Typical value for maximum deviation over the FOV relative to the CAS spot.
[2] 2σ of repeated measurements of one instrument (L ≈ 100 cd/m², autoexposure).
[3] RNU (response non-uniformity) is defined as 99.7 % percentile of the deviation of the mean image value.
[4] Immediately after calibration relative to calibration standard.
[5] Immediately after calibration.
[6] Maximum deviation from average of repeated CAS measurements with a linear polarized light source and varying polarization angle.

TOP 300 AR/VR Optical Probe

TOP 300 Optical Probe	
Optical properties	
Entrance pupil diameter (Others upon request)	2.5 mm / 3.0 mm / 3.6 mm / 4.5 mm (One entrance pupil can be configured)
Focus distance (Others upon request)	1000 mm / 1333 mm / 1500 mm (One focus distance can be configured)
Optical probe Field of View	±1.2°
View finder Field of View	±3.5°
Fiber length	Approx. 3 m
Bending radius fiber	200 mm
View finder resolution (H x W)	2592 px x 1944 px
Nominal resolution	5 MP
Type view finder	Mono
Environmental properties	
Operation temperature	+15 °C to +35 °C
Mechanical properties	
Dimensions (D x H x W)	255 mm x 80 mm x 40 mm
Weight	Optical probe without fiber: 690 g Optical probe with fiber: 1350 g
Mounting	4 x M3 thread (depth 9 mm) (60 mm x 20 mm pattern) 2 x dia. 3 H7 (depth 6 mm)
Electrical properties	
Power consumption	Via USB (1.4 W)
Connector type	USB 3.0 A
Protection class	Class III
Cable length	Approx. 1.1 m
Interface	
Interface protocol	USB vision

For detailed specifications of the DMS Goniometer Series, please scan the QR code on page 7.

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