We bring quality to light.

Photometers

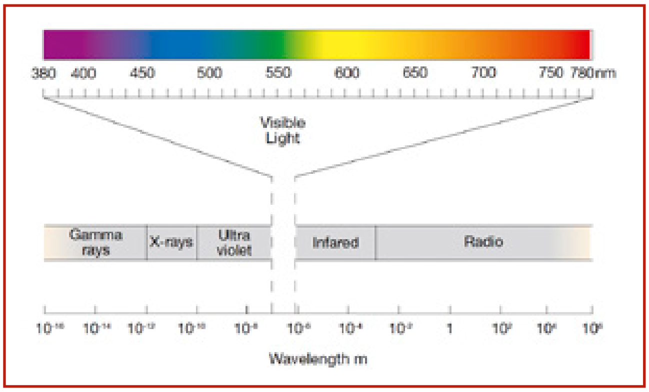
Instrument Systems

KONICA MINOLTA Group

Radiometry vs. Photometry
The CIE V (λ) Function

Visible light is only a small section of electro-magnetic radiation which produces a sensation of brightness and color in the human eye.

Electromagnetic radiation is a form of energy. The spectrum of such radiation provides information on its energy composition. The entire spectrum of electro-magnetic radiation ranges from X-ray radiation at the high-energy, short-wave end to radio waves at the low-energy, long-wave end. Radiometry is the measure-ment of optical radiation, which is electromagnetic radiation within the frequency range between $3x10^{11}$ and $3x10^{16}$ Hz. This range corresponds to wavelengths between 0.01 and 1000 micrometers (mm), and includes the regions commonly called the ultraviolet (UV), the visible (VIS), and the infrared (IR). Two of the many typically encountered units are watt/m^2 and photon/sec-steradian. Photometry is the measurement of light, which is defined as electromagnetic radiation detectable by the human eye. It is thus restricted to the wavelength range from about 380 to 780 nanometers (nm; 1000 nm = 1 mm). Photometry is just like radiometry except that everything is weighted by the spectral response of the eye.

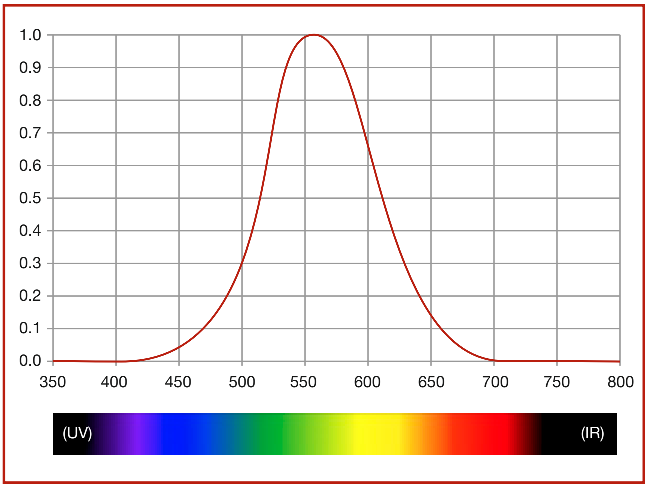


Electromagnetic radiation / VIS (visible radiation)

Visual photometry uses the eye as a comparison detector, while physical photometry uses either optical radiation detectors constructed to mimic the spectral response of the eye, or spectroradiometry coupled with appropriate calculations to do the eye response weight-ing. Typical photometric units include lumen, lux, and candela.

In order to have also a well defined photometer, an “artificial eye” has been constructed to simulate the light sensitivity of the human eye. The relative response of the normal human eye to monochromatic light at the different spectral frequencies was determined experimentally by the CIE and standardized in 1924. This is known as the photopic luminous efficiency function. The symbol of this function is V(λ) and it is usually expressed as a function of the wavelength of light (in air).

The following procedure was conducted to determine the photopic luminous efficiency function: First, light of constant intensity was emitted and its frequency was varied until the lightness perceived by the observer was found to be maximal. This occurred at a frequency of about 540 THz, corresponding to wavelengt λ_m = 555 nm.



V(λ) curve

The wavelength was then set to another λ and the power was readjusted until the lightness was judged to be the same as at λ_m. V(λ) could thus be computed as the ratio of the radiated power at λ_m and λ, respectively.

Of course, this experiment has been conducted by many observers and the resulting average was used to define the so called CIE standard eye which is an optical sensor with sensitivity corresponding to the function V(λ).

The photopic luminous efficiency function serves as a link between the subjective response of the human eye and normal physical measurement techniques. It thus provides the basis for a group of photometric units.

Photopic detector

Radiometric and luminous quantities

Quantity	Radiometric	Photometric
Power	Flux: watt (W)	Luminous flux: lumen (lm)
Power per unit area	Irradiance: W/m^2	Illuminance: lm/m^2 = lux (lx)
Power per unit solid angle	Intensity: W/sr	Luminous intensity: lm/sr = candela (cd)
Power per area per solid angle	Radiance: $W/m^2 \cdot sr$	Luminance: $lm/m^2 \cdot sr = cd/m^2$

Intensity

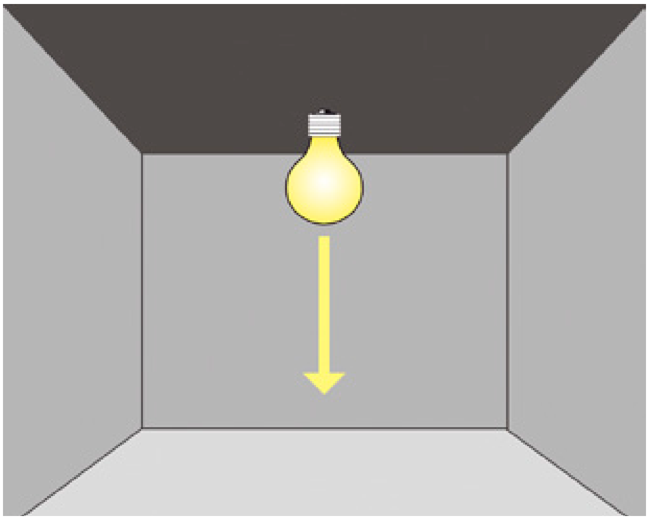
The candela is the basic unit in photometry. All other luminous quantities can principally be derived from it.

The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540x10^{12} Hertz and that has a radiant intensity in that direction of 1/683 Watt per Steradian.

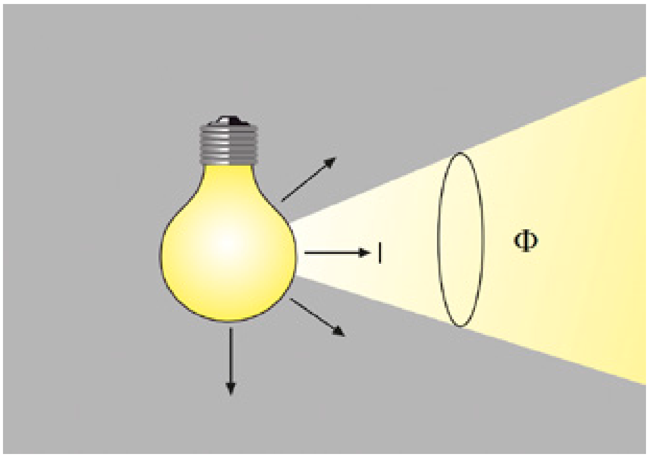
One Steradian (sr) is the solid angle that, having its vertex in the center of a sphere, segments an area on the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.

The candela is abbreviated as ***cd*** and its symbol is I_v. The above definition was adopted by the 16th CGPM (International Committee of Weights and Measures in Paris) in 1979.

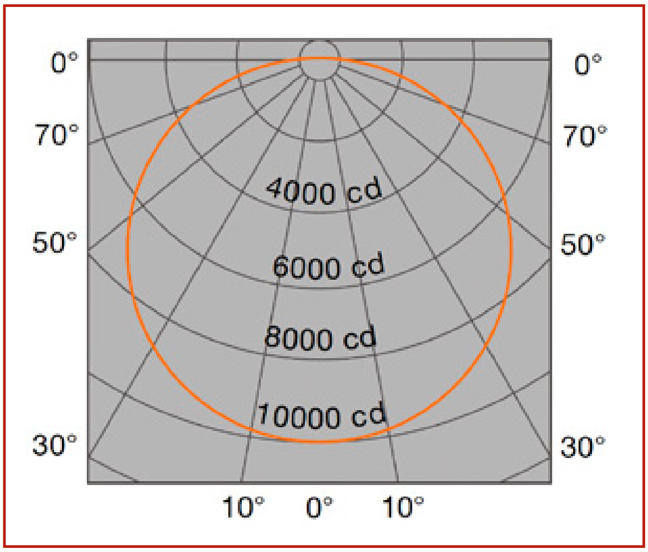
Goniophotometer used for luminous intensity measurement



Luminous intensity: Light emitted into specific direction



Luminous intensity Φ/ or lm/sr = cd



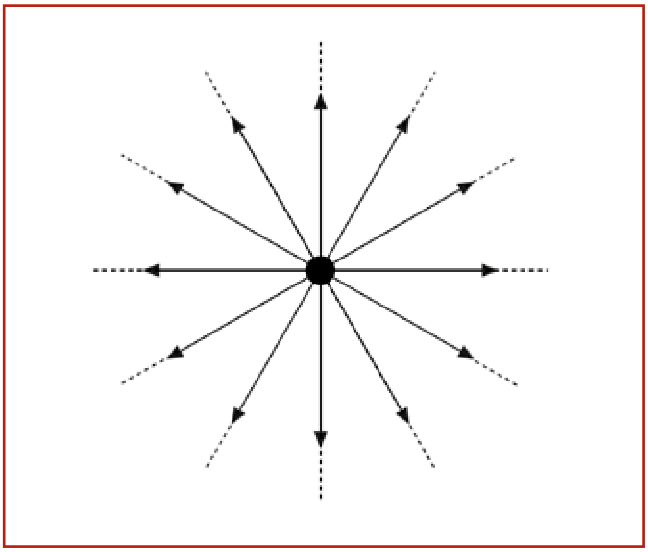
Polar diagram of luminous intensity curve

Method of luminous flux measurement

The light from a bulb is emitted into infinite space. It can be measured with a photopic detector rotating in a complete sphere around the lamp. Each discrete intensity point (lm/sr) is then integrated over 4π steradians. The higher the angular resolution of measurement the more accurate is the results. Missing values are added by interpolation.

The most common method however is an integrating sphere (see sketch) that integrates the luminous flux due to its highly reflective, "Lambertian" surface in comparison to a reference standard flux bulb. Its principle is based upon multiple reflections resulting from that specific coating.

Integrating sphere for luminous flux measurement

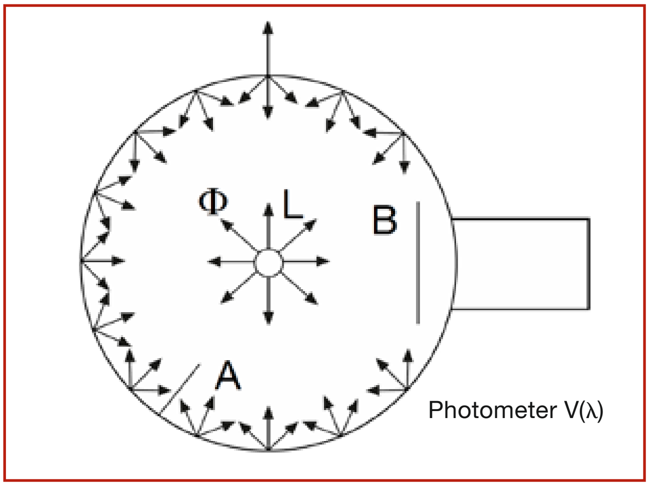


Flux distribution

Luminous Flux

The lumen is a derived unit for luminous flux. Its abbreviation is lm and its symbol is Φ_v. The lumen is derived from the candela and is the luminous flux emitted into unit solid angle (1 sr) by an isotropic point source having a luminous intensity of 1 candela. The lumen is the product of luminous intensity and solid angle, cd·sr. It is analogous to the unit of radiant flux (Watt), differing only in the eye response weighting. If a light source is isotropic, the relationship between lumen and candela is 1 cd = 4π lm. In other words, an isotropic source having a luminous intensity of 1 candela emits 4π lumens into space, which just happens to be 4π steradian. We can also state that 1 cd = 1 lm/sr, analogous to the equivalent radiometric definition.

If a source is not isotropic, the relationship between candela and lumen is empirical. A fundamental method used to determine the total flux (lumen) is to measure the luminous intensity (candela) in many directions using a goniophotometer, and then numerically integrate over the entire sphere. Thereafter, we can use this "calibrated" lamp as a reference in an integrating sphere for routine measurements of luminous flux.

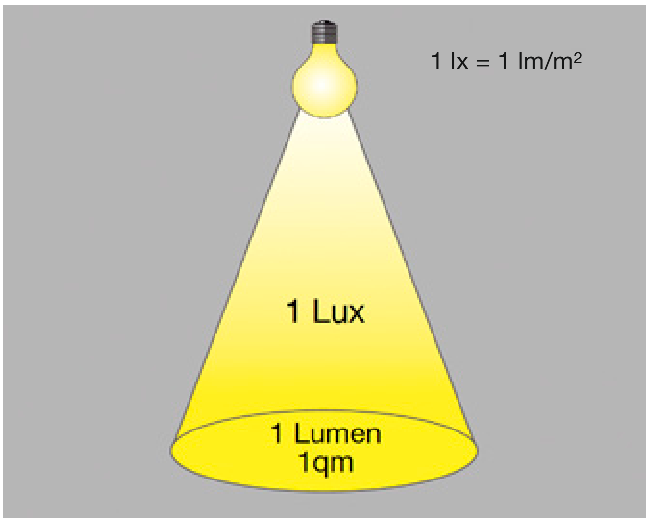


Principle of measurement

Φ = Luminous flux in lumen
L = Light source
B = Baffle
A = Lambertian highly reflective coating (80-98 %)

Illuminance

Illuminance is another quantity derived from intensity which denotes luminous flux density. It has a special name, lux, and is lumen per square meter, or lm/m². The symbol is E_v. Most light meters measure this quantity, as it is of great importance in illumination engineering. Some examples for typical illuminances range from 100,000 lx for direct sunlight, or 500 lx on a working desk in office to 20-50 lx for hospital corridors at night and 1 lx for emergency lighting.



Illuminance ***E***

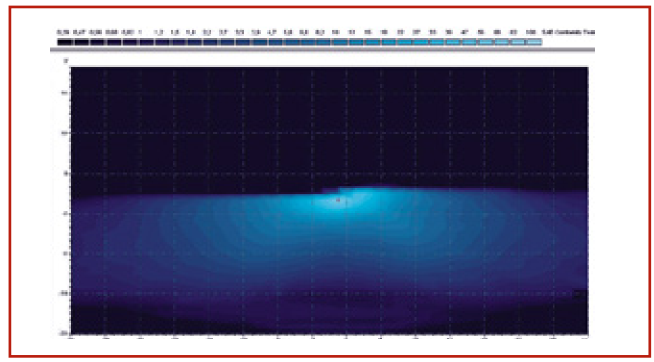
Luminance

Luminance is analogous to radiance, differentiating the lumen with respect to both area and direction, and is measured in cd/m². The symbol is L_v. It is most often used to characterize the “brightness” of flat emitting or reflecting surfaces.

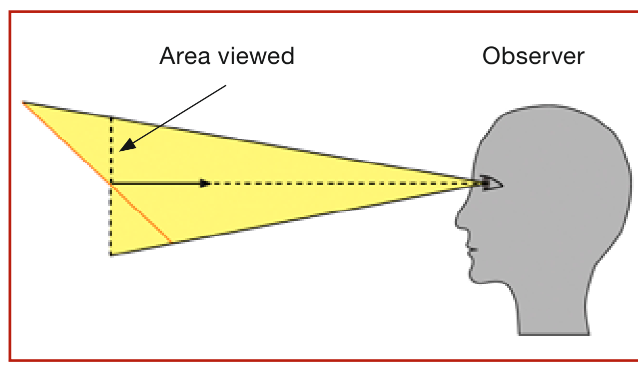
Luminance is the only photometric quantity that can be visually seen by human beings (except starlight). Lighting as well as illuminated surfaces (depending on their reflectance) have a certain luminance.

Examples for luminance:

- Open window a little cloudy:
  5,000 - 50,000 cd/m²
- Opal incandescent bulb 100 W:
  60,000 cd/m²
- White sheet of paper, illuminated 500 lx:
  130 - 150 cd/m²



Isolux diagram of automotive headlamp



Luminance ***L***: cd/m²

Luminous quantities

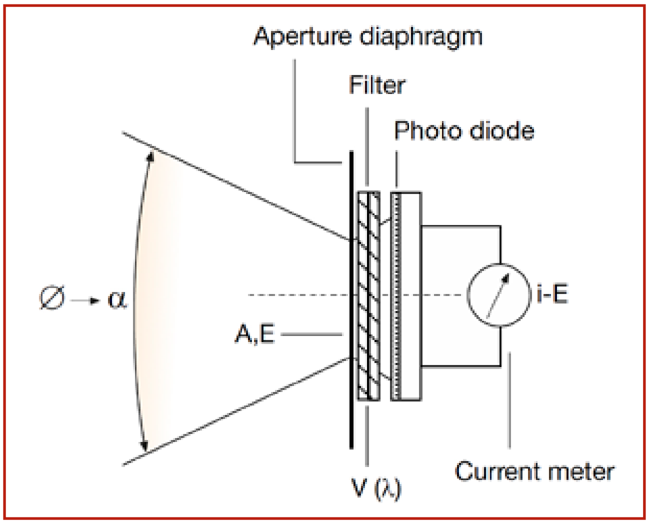
Type	Value	Symbol	Formula	Name	Unit
Radiation value	Luminous flux	Φ	Φ = I	Lumen	[lm]
Sender-side value	Luminous intensity	I	I = Φ/	Candela	[cd]
	Luminance	L	L = I/A	Candela per square meter	[cd/m²]
Recipient-side value	Illuminance	E	E = Φ/A	Lux	[lux]

Principle of Photometer

Our proprietary photopic filters consist of several elements designed to match the CIE photopic response curve to achieve an f'_1 to better than 1.5% at all wavelengths (f'_1 < 1.5% defines the highest accuracy class L according to DIN 5032 and CIE No. 69). The sensitivity in the IR and UV range is reduced to a minimum < 0.1%. The careful design of the detectors ensures best-of-class equipment and repeatable measurement results, even for monochromatic radiation sources.

Precision operation amplifiers convert the photocurrent in nA resulting from the light sensation into a proportional voltage. The voltage is converted by a precision AD converter into a signal that is proportional to the expected illuminance in lux.

Each Optronik Line photometer is carefully tested and calibrated in our own calibration laboratories with intensity calibration sources traceable to National standard (PTB); e.g., a WI41G calibration bulb operated under stable conditions (25°C ambient temperature), electrical values with a color temperature corresponding with CIE standard illuminant A (2856 K).



Photometer principle

Optronik Line detector

WI41G standard intensity calibration bulb

Digilux 9500

The Digilux 9500 is a precision luxmeter that enables convenient measurement of illuminance in a laboratory or on the production floor. Incorporating the latest amplifier and microprocessor technology, this instrument offers operating and display functions never seen in its class and an excellent price performance ratio.

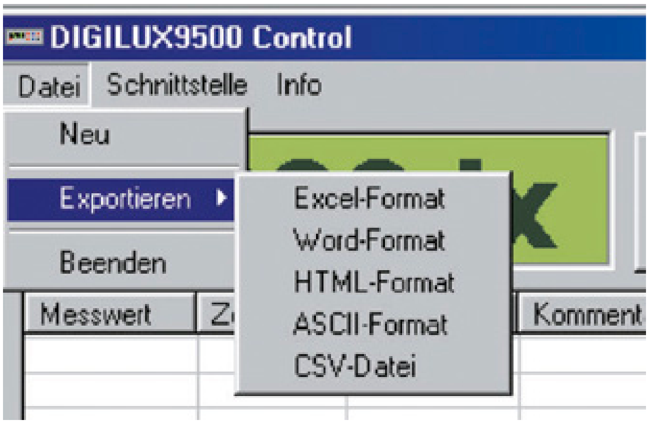
The precision photometer head, with V(λ) filter, is thermo-stabilized. It can be delivered in different versions, with an inhouse test report or optionally with PTB (Federal Institute for Physics and Technology) test report.

Standard: DIN 5032-7, class L/A, CIE 69, DIN-EN 13032-1

Applications

High precision photometer used to measure illuminance, luminous intensity, and luminous flux in laboratory or field applications as well for control purposes for lighting systems.

4½ digit display



Digilux control screenshot

Digilux 9500 with 30 mm detector

Characteristics

- 6 (optionally 7) measurement ranges
- Display range 0.1 mlx (last digit) to 200,000 lx
- 4½-digit, 7-segment LED display
- V.24-(RS 232-) interface
- Ranging auto/manual, or remote programmable
- Adjustable factor 0.001 – 99.99 for conversion into other luminous quantities, such as luminous intensity
- Approx. 5 readings/s, integration time 20 ms
- International wide range power supply for 90-260 V
- Power consumption 20 VA
- Nominal frequency: 40 - 400 Hz
- Different photometer heads FE10 available 10, 6, 12, 30, 10 x 10 mm diameter light sensitive surface
- Superb V(λ)-approximation according to DIN 5032-7, class L/A, CIE 69, cos-correction available
- Thermostatic stabilization 35°C (depending upon version selected)
- 2 m connection cable, power cable with Euro plug
- Calibration, traceable to PTB standard, with calibration certificate
- Individual test report for V(λ)-approximation class A, L acc. to DIN 5032 part 7, and according to DIN-EN 13032-1
- DigiluxControl software

Options

- Range extension for low level illuminance 0.01 mlx
- Range extension for high level illuminance 2 mlx
- Digilumen: display of both illuminance and flux; fixed lux, freely selectable lumens calibration for integrating sphere applications
- Built-in rechargeable battery, low battery indicator
- Analog output: proportional to measured value analog output in following versions: 0...20 mA, resistance max. 400 ½; 0...10 V, resistance min. 500 ½; 0...5 V, resistance min. 500 ½
- Memory for approx. 1000 measured values
- 4 programmable limit switches
- Automatic light control
- PTB calibration certificate
- Tube for stray light reduction and tripod
- Special extender cable 5 m for photometer head
- Special extender cable 10 m for photometer head
- Special extender cable 20 m for photometer head
- Stable transportation case

Application Digilumen with integrating sphere and SNT 10 DC power supply

Transportation case

DSP 10 Photometer / AMS Controller

The AMS Controller has been originally designed for fast goniophotometric measurement in conjunction with the well established family of Optronik Line goniometers.

Up to 8 DSP 10 preamplifiers can be connected, each disposing of an individual calibration available in lx, cd or cd/m².

The precision photometer head, with V(λ) filter, is thermo-stabilized. It can be delivered with an inhouse test report or optionally with PTB (Federal Institute for Physics and Technology) test and calibration report.

Standard: DIN 5032-7, class L/A, CIE 69, DIN-EN 13032-1.

Applications

High performance precision photometer used for measurements in laboratory environments. Goniometer control unit.

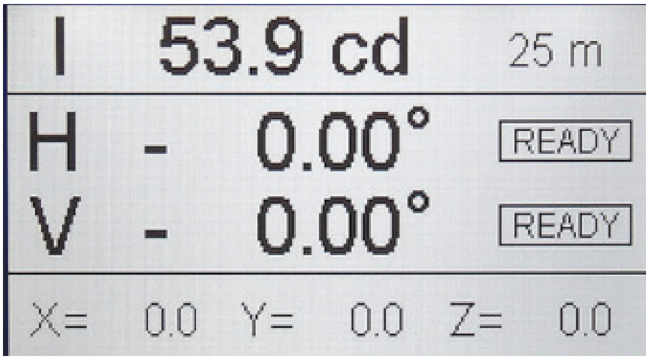
Control Panel

Characteristics

- 8 measurement ranges
- Display range 0.1 mlx to 50.000 lx
- Display: 4 decimal digits (selectable)
- Graphical LCD display: full textual display of value and measurement unit (lx, cd, cd/m²) and other information (e.g., in conjunction with goniometer)
- V.24-(RS 232-) interface and CAN bus
- Adaptive auto-ranging
- Sampling rate (single points): 5 ms
- Sampling rate (scan mode): < 200 ms (up to 5000 measurements/s in scan mode with goniometer)
- Display refresh time: < 0.8 s
- Rated voltage: 90 - 250 V
- Power consumption: < 50 VA
- Rated frequency: 45 Hz to 65 Hz
- Operating temperature: 10 to 50°C
- Different photometer heads FE10 available 10 x 10, 30 mm diameter light sensitive surface (see separate list)
- Superb V(λ) approximation according to DIN 5032-7, class L/A, CIE 69
- Thermostatic stabilization 35° or dark current compensation
- Calibration, traceable to PTB standard, with calibration certificate
- Individual test report for V(λ) approximation class L acc. to DIN 5032 part 7 and acc. to DIN EN-13032-1
- 19” housing, three height units, prepared for integration into control racks
- Control of the manual measuring system independently from PC via front panel keys or directly via PC-program LightCon
- Normally, the measurement of test objects is supported by the LightCon software with PC operation, but most of the functions can be controlled manually by the AMS unit (if manual mode is activated)
- Indication of error messages

Options

- Additional measurement distances (e.g. 3.162, 5, 10, 15, 25 m)
- Tube for stray light reduction
- Tripod
- Separate 19” bench top housing
- Flash measurement
- LightCon software for light measurement, data processing, evaluation, and graphical representation in different formats



Graphic LC display

Features DSP 10 (in combination with AMS Goniometer)

The DSP 10 is used as a photometric front-end in conjunction with the well established AMS goniophotometer system. It utilizes an unique combination of traditional analog amplifier technology and state-of-the-art digital signal processing to measure illuminance with a V(λ)-matched silicon photo cell. The measured value passes a digital, auto-adaptive filter to remove all modulation and interference from the signal, depending on the type of light source under test. By monitoring the signal, the filter characteristics are continuously optimized. This is all performed by an ultra-fast digital signal processor, assuring excellent stability and reproducibility.

DSP 10 with detector

Measurement principle

- A precision V(λ)-(photopic) matched photometer head produces a photo-current that is proportional to the illuminance on the light sensitive surface.
- This photocurrent is fed to the DSP 10, where it is converted into a proportional voltage by a gain-controlled amplifier with a wide dynamic range.
- After digitizing this voltage by a high-speed A-to-D converter, the signal is processed by a digital, auto-adaptive filter to remove all modulation and interference.
- The signal and its frequency composition are monitored continuously to determine the applicable filter strategy and filter characteristics.
- The resulting, filtered signal represents the average value of the illuminance.
- Using an integrated, high-speed, digital field bus interface (optoCAN), the DSP 10 transmits the processed data to the AMS Controller and the PC.

Measurement modes

- Single-point measurement: In this mode, the current illuminance value is transmitted on request. The goniometer is motionless during measurement.
- Scan measurement: Measurements are acquired and transmitted “on the fly” while the light source is being moved by the goniometer in horizontal or vertical direction. Because the signal is monitored by the DSP 10 continuously, the system is capable of controlling the speed of movement in a way that ensures shortest possible scanning times while maintaining the full accuracy of measurement.

Special features

- Integrated display: graphic LCD with 120 x 32 pixel resolution, variable backlight illumination
- A backlit graphic LCD at the front panel displays the current measurement value as well as status information. Six buttons are used for manual operation, calibration, set-up, and testing
- Free selection of measured quantity
- The measured value can be displayed in lx, cd, lm, cd/m^2, or cd/lx to handle all common photometer heads
- Integrated calibration unit
- An integrated, microprocessor controlled current source can be connected internally to the amplifier's input, allowing easy and error-free calibration and testing of the analog circuitry
- Integrated power supply
- The integrated switch-mode power supply generates all necessary operating voltages and also supplies the thermostabilization of the photometer head

Signal monitoring

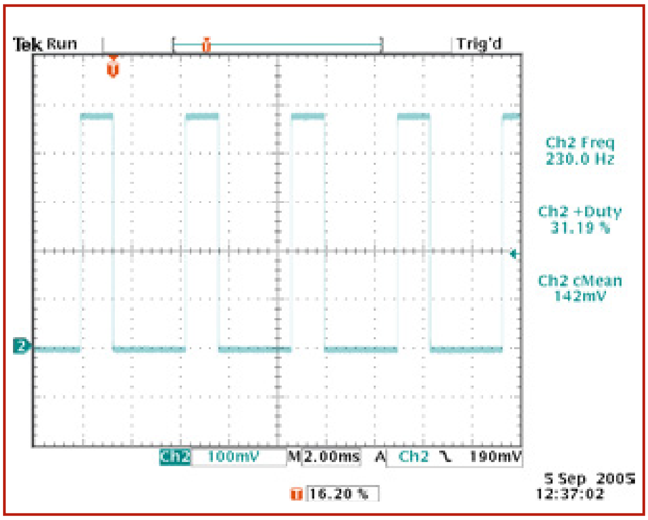
- Continuous overrange/underrange check with adaptive switch-over timing and automatic range control
- Fast-Fourier transformation based analysis of frequency composition
- Automatic detection of measured light source (incandescent/PWM-LED/neon/xenon) with suitable filter strategy selected accordingly

Filtering

- FIR (finite impulse response) filter on sampled data
- Filter coefficients are automatically set according to the measured fundamental frequency
- Optimized coefficient sets for different light sources
- Integrated calibration source

Back side of DSP 10 with CAN-Bus and RS232 interfaces

Pulse width modulated LED lamp



Typical pulse width modulation of automotive rear signal lamp

LM 20 Luminance Meter

Application

The LM 20 Luminance Meter is a precision measurement instrument designed for laboratory application to measure the luminance of automotive license plates in a most convenient and time saving way.

It is installed in a fixed position 3.126 m from the test object, either on an automatic positioning unit or tripod, to target the reference field of 25 mm most accurately. It therefore conforms to the specifications of ECE R4 and corresponding SAE regulations. A patented LED targeting device that creates an image of the reference field on the sample plane is used for targeting the 25 mm measurement spot.

The unit is equipped with a DSP 10 preamplifier connected to the AMS control and display unit, indicating, and evaluation device and transmitting the measured data to the PC.

The LM 20 provides an automatic integrated solution for the completion of a photometry lab for measuring vehicle lamps.

Standard: DIN 5032-7, class L/A, CIE 69

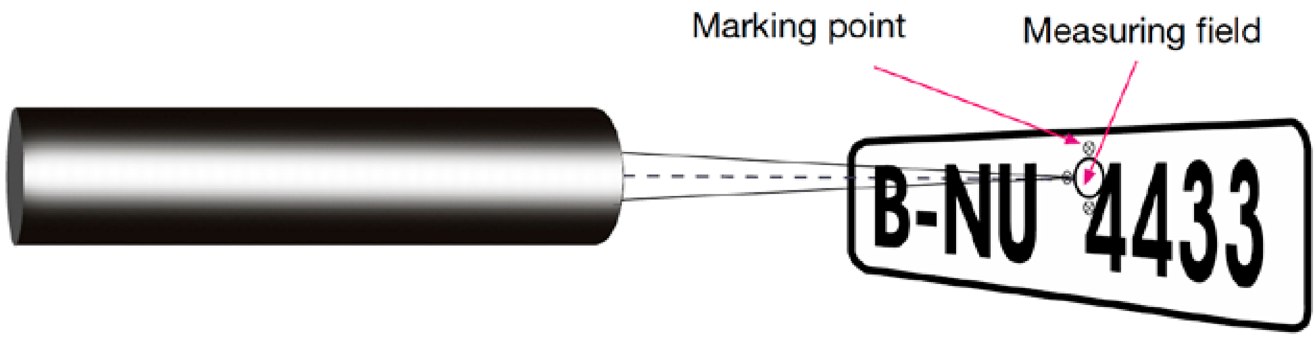
LM 20 in automated application with automatic photometer positioning unit

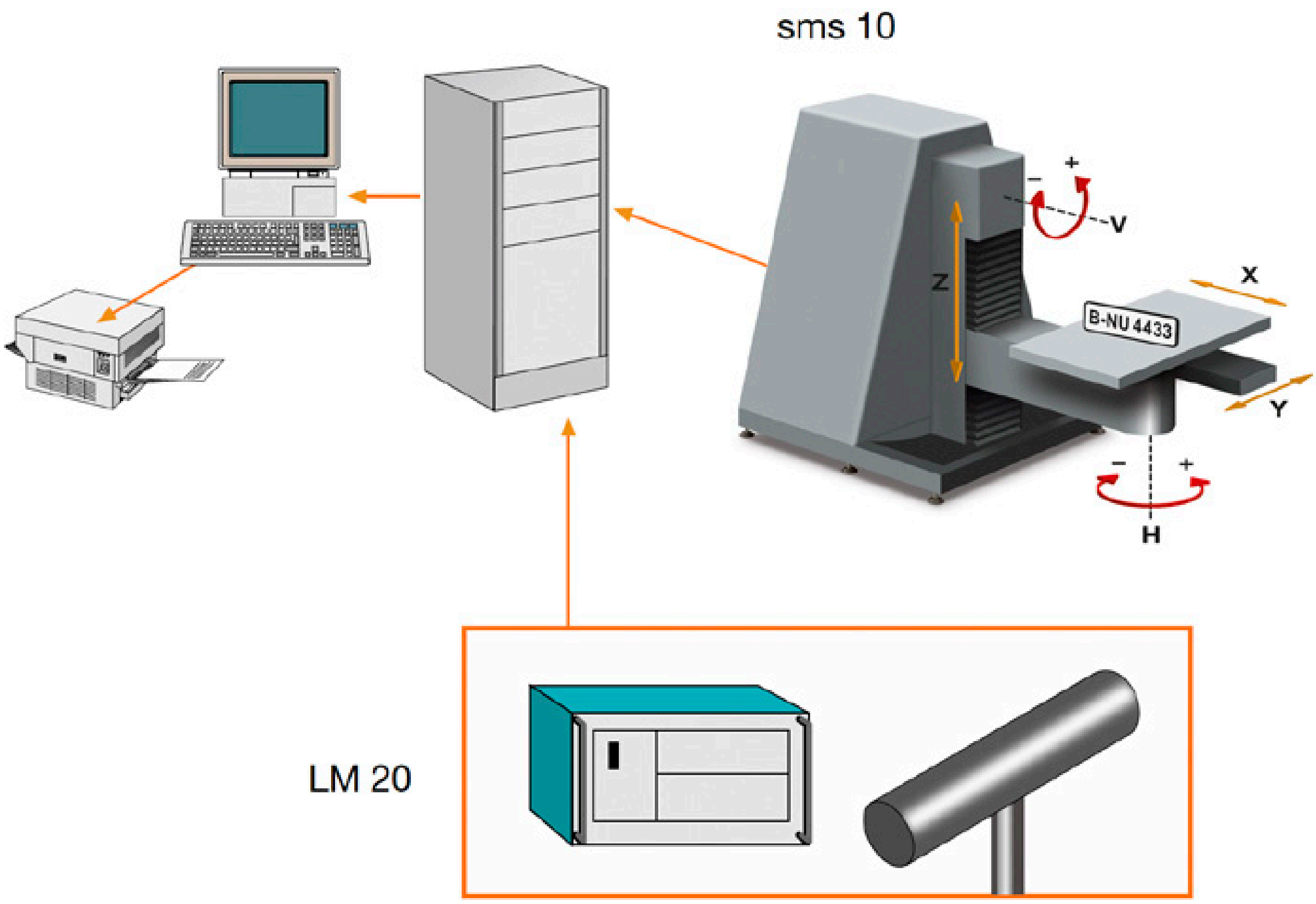
LM 20/CM 10 V(λ) 3.162 m in photometric lab

Characteristics

- Fixed angular observation field 0.45° (targeting of 25 mm reference field)
- Display range 0.02 cd/m² (last digit) to 1,000,000 cd/m²
- Measuring distance: 3.162 m
- Photometer head with Si-photoelement, superior V(λ)-approximation (typ. f_1' < 1.5 - 2.0 %)
- Luminance meter classification: classA/L, DIN5032-7
- Linearity < 0.2 % or better
- 4-digit display at AMS photometer display unit and the PC screen
- Connection via CAN bus and RS232C serial interface to AMS measuring system
- Auto Ranging
- Individual test report for V(λ)-approximation
- Calibration traceable to PTB standard with Optronik calibration certificate
- Power supply: 24 V DC
- Power rating: 0.5 A max.
- Dimensions : (L x Ø) 680 x 110 mm
- Weight: 3.3 kg (only LM 20 tube unit).

Example of application





Options

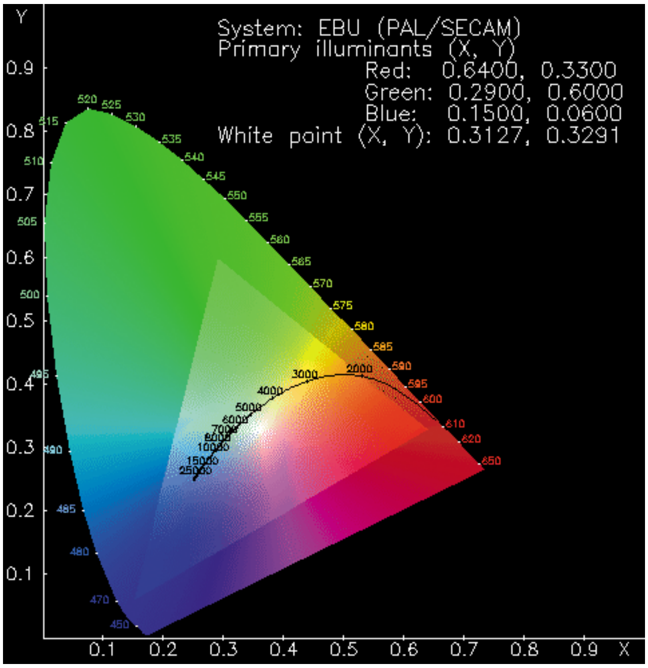
- License plate holder with fixtures for lamps and license plate dummies
- License plate dummies: ECE, SAE, Chinese and other sizes with reflectance standard
- Automatic photometer positioning unit
- Tripod
- TÜV or PTB certificate available.

Colorimetry

Colorimetry is based on the fact that observers can match colors with additive mixtures of three reference stimuli in amounts known as tristimulus values. Using reference stimuli at specified wavelengths, CIE has defined a standard set of tristimulus values to match each different wavelength of the spectrum. These data constitute the CIE 1931 standard colorimetric observer. The reference-color stimuli are radiations of wavelength 700 nm for the red stimulus (R), 546.1 nm for the green stimulus (G) and 435.8 nm for the blue stimulus (B).

The tristimulus values were chosen to match the typical white color. There is a great imbalance in the three amounts (the amount of green being the greatest and the amount of blue being much smaller). As white is a color that is not biased towards red, green, or blue, new relative units of R and B were chosen so that the amounts are equal to the amount of green.

Series of measurements have been carried out with the standard colorimetric observer to find the different tristimulus values for different colors. To make use of the huge resulting data file, CIE has worked up a specific “map” of colors. As three stimuli are assigned to each color, a three-dimensional coordinate system would have been needed to plot the actual coordinates. To simplify this representation (at the expense of losing the lightness information), coordinate transformation and some other calculations have been done, resulting in a two-dimensional chart called chromaticity diagram. In spite of this, the suitability of the diagram for all colorimetric measurements without the need of the related mathematical apparatus gives the chromaticity diagram an outstanding importance.



CIE Tristimulus Diagram

Luminous Color

Value	Symbol	Unit
Color temperature	T_{cp}	[K]
Color rendering index Color rendering group	R_a	[1]
Trichromatic values	X, Y, Z	[1]

CM 10 Tristimulus Colorimeter

Application

Tristimulus colorimeter for color measurement on primary light sources; e.g., lamps, luminaries, light signals, flares, monitors, displays, glasses, and filters.

Colorimeter of highest precision for absolute measurements with the tristimulus method according to DIN 5033 section 6 and CIE Publ. No. 15.2 (1966), respectively.

CM 10 Colorimeter

Characteristics

Microprocessor-controlled tristimulus colorimeter with 4 spectrally matched silicon detectors equipped with graphic LC display with backlight illumination

- Precision colorimeter heads with superior approximation to the CIE color matching functions $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, and $\bar{z}(\lambda)$
- 6 measuring ranges in decades, higher sensitivity for lower illuminance 200 mlx
- Highest displayed value: 600,000 lx
- Resolution (last digit) 0.0001 lx in Y-channel (most sensitive range)
- 4-digit displays: Display modes: X-Y-Z (CIE-LAB), x-y-Y (CIE-LAB), u v Y (CIE-UCS 1960), u' v' Y (CIE-UCS 1976), color temperature T_{cp}
- Measurement of luminous flux in lm (with integrating sphere) (factor specification for freely selectable lumen calibration).
- Measurement of intensity in cd
- Representation of color coordinates in CIE color diagram on LC display
- Automatic range switching
- Automatic average value calculation
- Highest accuracy class L (in Y-channel) according to DIN 5032 (f_{1y} < 1.5 %)
- Light sensitive surface 14 mm diameter, built-in thermostatic stabilization 35°C
- 19-inch 3 height units housing for rack mounting
- Calibration, traceable to PTB standard, with calibration certificate
- Individual test report on spectral sensitivity
- Rated voltage: 230 V ±10%
- Power usage: < 50 VA
- Rated frequency: 50 Hz
- Operating temperature: 10…50°C
- Storage temperature: 0…70°C
- Dimensions : 450 x 325 x 135 mm
- Detector connecting cable 3 m (longer if desired)
- Weight: Display device approx. 8 kg; detector approx. 0.9 kg
- V.24 (RS232) interface

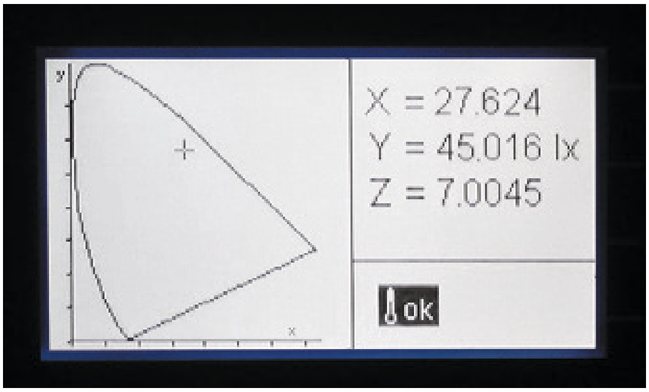
Options

- Separate 19“ benchtop housing
- TÜV or PTB certificate available optionally
- Cable extensions
- Tube for stray light reduction
- Tripod
- FMS software for PC control, test report generation, data storage and processing, graphical representation (isocolor diagrams, CIE tri-chromatic diagram, etc.)

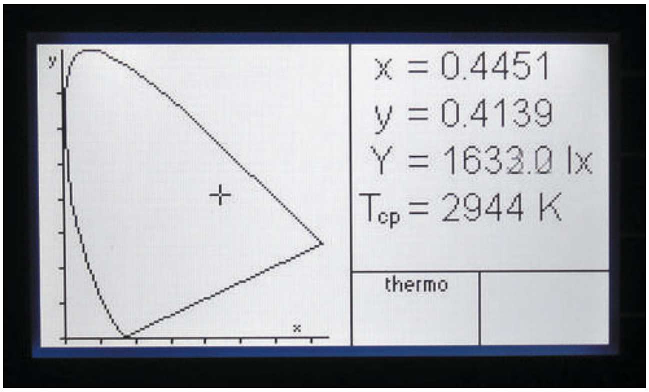
Feature

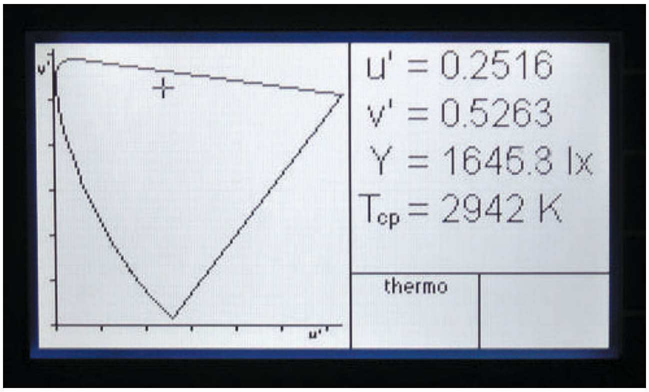
New CM 10: Small light sensitive surface of just 14 mm available with remaining sensitivity for measuring directional light sources with uneven light distribution; this offers the unique advantage of ensuring that detector is fully illuminated, thus guaranteeing correct measurement results.

New design of colorimeter head with 14 mm aperture and improved sensitivity for low illuminance levels



Graphic LC display with CIE color diagram





Typical display modes of CM 10

RMS 1200 Retroreflectometer

Application

Retroreflection measurement in mcd/lx. Absolute measurement method simulating nighttime conditions with a light source that is accurately regulated to standard illuminant A (2856 K). Applicable standards and regulations:

- CIE Publication No. 54.2-2001
- DIN 67520
- EN 471 High-visibility clothing
- ECE Regulations R 3, R 27, R 69, R 70, R 104 (at 10 m or 30.5 m measuring distance)
- SAE regulations J 594, J 774, J 943, J 2041 and similar regulations at 30.5 m distance
- DIN 5032-7, class A

Retroreflectometer measures automotive and traffic (pavement markers) retroreflectors

The RMS 1200 offers a hardware and software solution for absolute retroreflection measurement. The LightCon software provides graphical interface with menu driven controls for data acquisition, display, and analysis. The light source is temperature regulated to standard illuminant A, making it ready for use without long burn-in procedures. The unit can be positioned at distances of 10 m (ECE) or 100 ft (SAE). Both ECE/SAE tests can also be performed at 100 ft if desired. The motor driven detector can be controlled via PC or from front panel keypad and the remote control panel in the main control rack.

RMS 1200 offers a complete hardware and software solution for absolute retroreflection measurement, including the LightCon software, which provides a graphical interface with menu driven controls for data acquisition, display, and analysis.

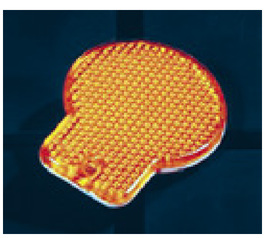
In combination with the AMS goniophotometers, the RMS 1200 provides accurate measurement of the photometric properties of a variety of retroreflectors.

Projector

- Projector with color temperature acc. to standard illuminant A
- Measuring distance 100 ft (30.5 m) or 100 ft and 10 m
- Projector aperture: 50 mm diameter (SAE); 29 mm diameter (200 mm)
- Measuring field in 10 m: Ø 175 mm or 250 mm
- Measuring field in 100 ft: > Ø 250 mm (up to approx. 700 mm for measuring complete warning triangles according to ECE R27)
- Uniformity of illuminance < 5%
- Pre-adjusted lamp socket assembly for repeatable positioning of lamp
- Color temperature regulation to standard illuminant A (color temperature is measured and automatically adjusted; projector ready for operation after a few seconds) color temperature adjustable 2500 - 3200 K
- Housing with adjusting screws to direct the illuminant axis to the reference point of the measuring object
- Built-in power supply for 230 V, 50 - 60 Hz
- Halogen bulb, 250 W
- Illuminance on sample plane 10...65 lx (depending on measurement distance selected)
- Dimension (W x H x D): 600 x 2450 x 600 mm
- Weight approx. 75 kg

Photometer Head

- Photometer head with Si-photo element, superior approximation to the V(λ) function
- Photopic receiver: 29 mm (ECE); 1 x 1/2 inch (25 x 12.6 mm) (SAE) (automatic diaphragm recognition)
- V (λ) approximation (f_1 < 2.0 %) according to DIN 5032 section 7 CIE 54.7 and CIE Publ. No. 53 (1982)
- Individual measuring report of the photometer head
- Optical lens system for stray light reduction
- Angular resolution of detector movement: 0.001°
- Automatic tilting mechanism for detector for accurate targeting
- Auto-calibration function: Periodically, the detector will be locked against light incidence to auto-calibrate the unit, removing all influences resulting from dark currents (no check of illuminance on sample plane required as for conventional retroreflectometers)
- Precision operational amplifier with additional voltage/current converter
- Projector and photometer head are built into one housing and adjusted within the observation plane



Reflex reflector

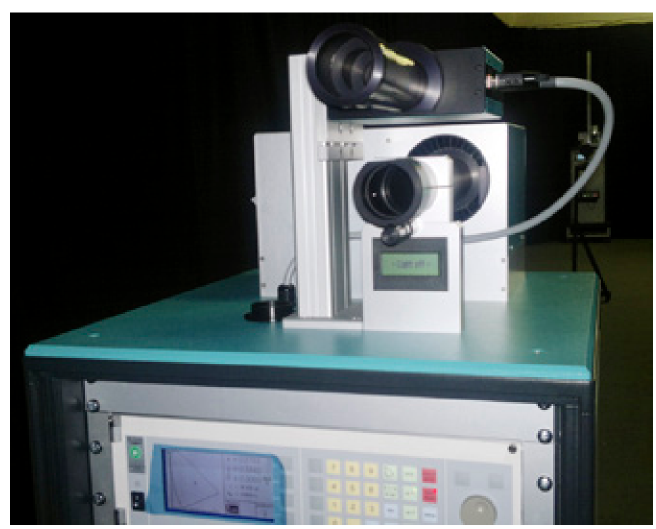
RMS Versions

Measurement distance	Minimal observation angle	Maximal observation angle
10 m	0.2°	4.5°
10 m	0.333°	4.5°
10 m	0.333°	2.0°
15 m	0.2°	2.0°
15 m	0.1°	2.0°
30.5 m (100 ft)	0.2°	1.5°
30.5 m (100 ft)	0.2°	2.0°
30.5 m (100 ft)	0.1°	2.0°

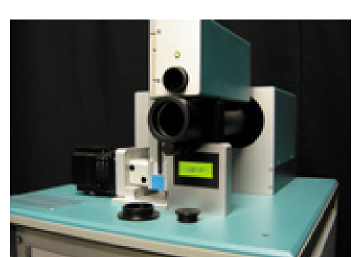
Other versions on request

Electronic displayand control unit

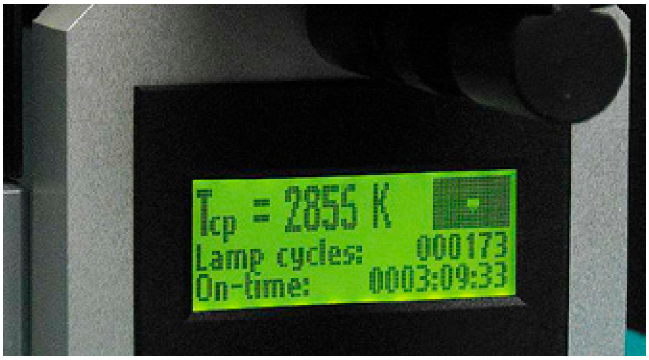
- 2 display and control units, one in the instrument, another in the main control rack of the goniometer (option)
- Five-digit display of measuring values
- Display range 0.1 mcd/lx (last digit) to 199 900 mcd/lx (maximum)
- For samples with a size of 10 x 10 cm, the corresponding range of the coefficient of retroreflection is R' = 0.01 - 19990 cd/lx/m^2
- Range selection automatically
- Resolution 0.025 % of maximum in the selected range
- Absolute measuring error < ± 1.5 % ± 1 digit against PTB standard
- Graphic LC display, background illuminated with information on lamp cycles, total burning time, projector temperature, illuminance on sample plane in lux, auto-calibration function if in progress, mode of operation (ECE/SAE) angular position with 0.001° resolution
- Repeatability error < ± 0.2 % ± 1 digit
- Linearity error < ± 0.15 % ± 1 digit
- Digital display for observation angles with resolution of 0.001°
- Selection of observation angles manually or automatically via RS232 bus interface
- Switch for projector lamp for zero-setting
- Built-in power supply for 230 V, 50 - 60 Hz
- Calibration of RMS traceable to PTB standard, with calibration certificate.



RMS 1200 Color for measuring color of reflex reflectors

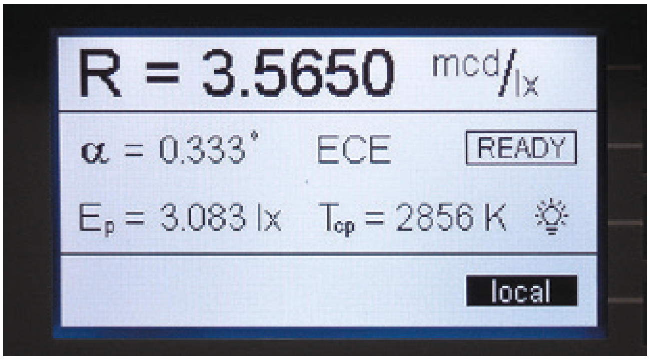


Color temperature regulated projector



Projector display indicating:

- Color temperature
- Lamp cycles
- Burning time of bulb



Graphic LC display indicating:

- Retroreflectance value in mcd/lx
- Mode of operation (local or remote operation, ECE, SAE, autocalibrationin progress)
- Color temperature in K
- Illuminance on sample surface
- Observation angle

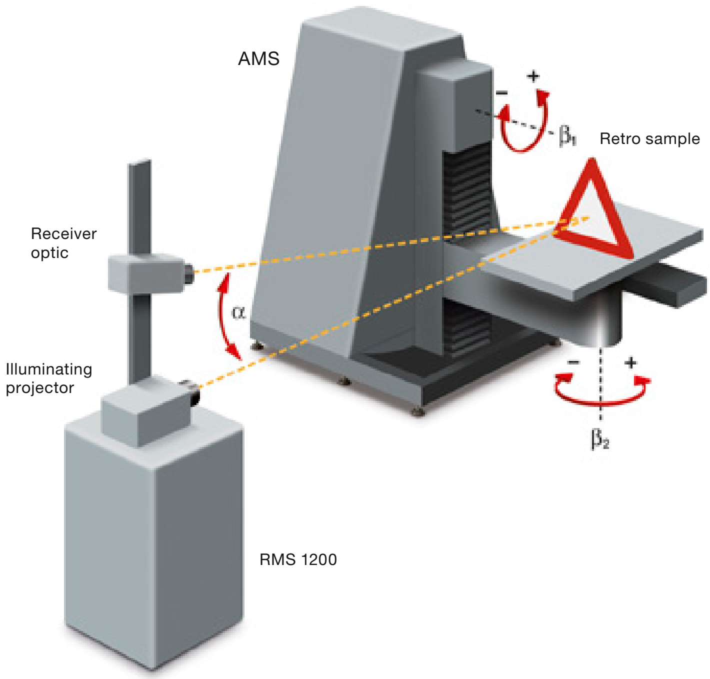
Feature

- Time and cost saving operation due to color temperature regulation (ready for use after a few seconds – no burn-in time required as for conventional retroreflectometers)
- Auto-calibration function; no additional luxmeter required to check the illuminance on the sample plane.
- Moveable detector enables the system to record complete retro slices and grids to get information about the complete light distribution, not just at a few points
- All functions can be controlled at the instrument itself, from the main control rack (remote display), and by PC command

Options

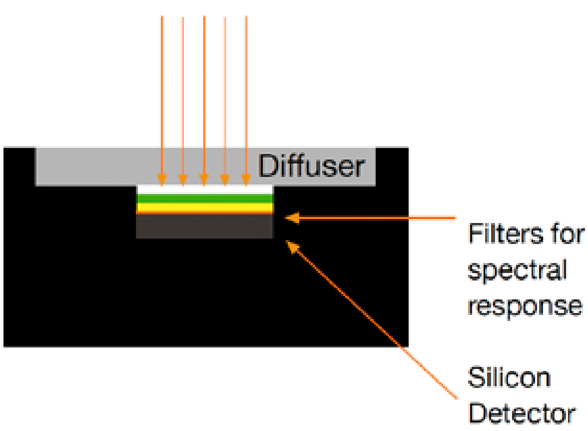
- Docking stations for repeatable positioning if used at both 100 ft and 10 m
- Different goniometer types for sample rotation
- RMS10 color ECE to measure both retroreflection and color of retroreflectors according to ECE regulations
- Observation angle down to 0.1°
- LightCon Retro software module for automaticand PC controlled operation with goniometer
- EN 471 software
- EPS 10 epsilon rotation unit for traffic reflex reflectors
- Single axis goniometer for measurement EN 471
- TÜV conformity certificate.

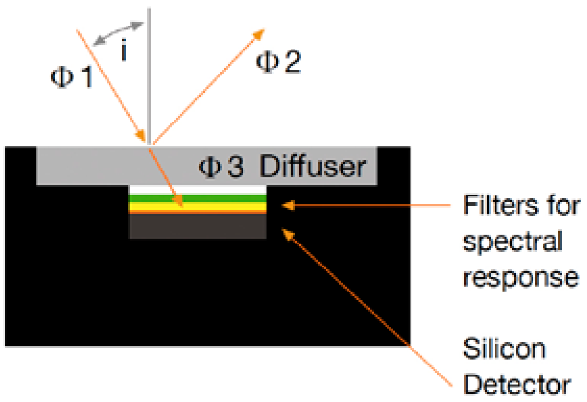
Measurement method



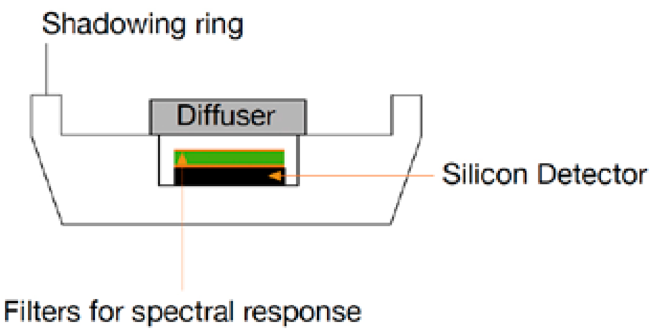
The quality of our photometer heads represents the highest level of technology according to DIN 5032-7, CIE Publication No.69, DIN-EN 13032-1

Construction scheme detectors





Detector without cosine correction



Detector with cosine correction

Light-sensitive detectors

- Si-photoelements of excellent quality and longtime stability
- Classified and selected for specific applications
- Illuminance and photocurrent absolutely proportional

Relative spectral responsiveness

- Approximated to the spectral luminous efficiency V(λ) of the human eye (according to CIE, DIN)
- Excellent V(λ) approximation by full filtering, error f_1' (CIE) resp. f_1' (DIN) < 1.5 %.
- Superior V(λ) approximation by full filtering, error f_1' (CIE) resp. f_1' (DIN) < 2.5 %
- UV and IR response < 0.1 %

Influence of non-uniform illumination

- Due to full filtering excellent repeatability even for non-uniform illumination of the detector surface error f_9

Directional response

- Photometer heads for perpendicular light incidence
- Cosine correction for measurement of illuminance by light incidence from different directions, error f_2 (CIE, DIN) < 1.5 %

Temperature independence

- Without thermostatic stabilization $\alpha_0 < 0.1$ %/K
- With thermostatic stabilization $\alpha_0 < 0.01$ %/K

Sensitivity

- Measurement down to 0.01 mlx in conjunction with high precise photocurrent amplifiers

Light sensitive surface

- Light sensitive surfaces 6, 10, 12, 30 mm Ø, 10 x 10 mm, and user specified diameters

Special detectors

- Photometer heads in rain-proof housing and with heating device for outdoor installation
- Special detectors for integrating sphere applications (ITS, KMS 500)

Technical data and calibration

- Individual test report for relative spectral responsiveness
- Individual test report for directional response
- Specified errors acc. to DIN 5032 Section 7, EN-DIN 13032-1 and CIE Publ. No. 69 (1987)
- Inhouse certificate for calibration against luminous intensity standard lamp with calibration certificate from PTB (Physikalisch- Technische Bundesanstalt, Germany), uncertainty of calibration standard ± 0.6 %, NIST traceable calibration on request

Photopic detectors overview

Customized detectors available on request

Version	Light sensitive surface	V(λ) response	Cos. correction	Thermostatic stabilization	Classification DIN 5032	Display unit	Maximal display resolutions	Highest value	Accessories	Weight dimensions
FE10-6A	6 mm	< 2.5 %	Yes	No	A	Digilux	0.1 mlx	2 mlx	Connecting cable with Lemosa plug, individual detector report	21,5 Ø x 28,5 mm 35 g
FE10-6AEX	6 mm	< 2.5 %	Yes	Housing for outdoor installation with heating system for temps down to -20°… +35°	A	Digilux	0.1 mlx	2 mlx	Connecting cable with Lemosa plug, individual detector report	21,5 Ø x 28,5 mm 35 g (without housing)
FE10-10A	10 mm	< 2.5 %	Yes	Yes	A	Digilux	0.1 mlx 0.01 mlx (option)	200 klx	Connecting cable with Lemosa plug, individual detector report	50 Ø x 50 mm 150 g
FE10-12A	12 mm	< 2.5 %	Yes	Yes	A	Digilux	0.1 mlx 0.01 mlx (option)	200 klx	Connecting cable with Lemosa plug, individual detector report	50 Ø x 50 mm 150 g
FE10-10A	10 mm	< 1.5 %	Yes	Yes	L	Digilux	0.1 mlx 0.01 mlx (option)	200 klx	Connecting cable with Lemosa plug, individual detector report	50 Ø x 50 mm 150 g
FE10-12A	12 mm	< 1.5 %	Yes	Yes	L	Digilux	0.1 mlx 0.01 mlx (option)	200 klx	Connecting cable with Lemosa plug, individual detector report	50 Ø x 50 mm 150 g
FE10-30A	30 mm	< 2.5 %	No	Yes	A	Digilux AMS DSP 10	0.1 mlx 0.01 mlx (option)	200 klx	Connecting cable with Lemosa plug, individual detector report	50 Ø x 50 mm 150 g
FE10-30L	30 mm	< 1.5 %	No	Yes	L	Digilux AMS DSP 10	0.1 mlx 0.01 mlx (option)	200 klx	Connecting cable with Lemosa plug, individual detector report	50 Ø x 50 mm 150 g
FE10-10A	10 x 10 mm	< 2.5 %	No	Yes	A	AMS DSP 10	0.1 mlx 0.01 mlx (option)	200 klx	Connecting cable with Lemosa plug, individual detector report	50 Ø x 50 mm 150 g
FE10-10L	10 x 10 mm	< 1.5 %	No	Yes	L	AMS DSP 10	0.1 mlx 0.01 mlx (option)	200 klx	Connecting cable with Lemosa plug, individual detector report	50 Ø x 50 mm 150 g
CE10-14	14 mm	< 1.5 %	No	Yes	L (Y channel)	CM 10	0.1 mlx	600 klx	Connecting cable with Lemosa plug, individual detector report	-

Options: 4-pin plug | 4-pin connector | Cable extensions: 5, 10, 15, 20, 25 m | PTB certificate

Instrument Systems

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