

# **A NEW DIGITAL ILLUMINANCE-METER WITH A SPECIAL LUMINANCE – TUBEADAPTER FOR UNIVERSAL APPLICATIONS IN LIGHTING ENGINEERING**

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## **SUMMARY**

A new digital illuminance-meter “MINILUX” with a special luminance-tubeadapter is developed by the University of Applied Sciences Berlin in cooperation with the Technical University of Zhejiang China for universal applications in lighting engineering.

## **ZUSAMMENFASSUNG**

Ein neues Digital-Luxmeter “MINILUX” mit einem speziellen Leuchtdichte-Vorsatztubus wurde von der University of Applied Sciences Berlin in Kooperation mit der Technical University of Zhejiang China für universelle Anwendungen in der Lichttechnik entwickelt.

## **SOMMAIRE**

Un nouveau luxmètre digital „MINILUX“ avec un tube pour mesure de luminance pour les applications universelles de l'éclairage a été évolué par la University of Applied Sciences Berlin en coopération avec la Technical University of Zhejiang China pour les applications universelles à la technique de l'éclairage.

## 1. Introduction

Compared with the total turnover of electrical engineering, the extent of lighting technics is constantly rising. Therefore, the exact measurement of light technical quantities such as illuminance, luminance, luminous intensity and luminous flux gains more and more importance. The following article presents a new, reasonable, universally usable and portable digital illuminance-meter for accurate illuminance and luminance measurements.

The measuring of luminous flux, luminous intensity and luminance is based on the measuring of illuminance by means of the photometric fundamental law. That is, why this quantity has got a special significance. A state-of-the-art illuminance-meter should have the following conditions.

## 2. Technical requirements on a state-of-the-art illuminance-meter

- Fine approximation to the spectral luminous efficiency curve  $V(\lambda)$  of the human eye
- Photometer-head with cosine-correction
- Linear relation between illuminance and photocurrent
- Low temperature influence, ageing and fatigue of the lightsensor
- Correct light-measurement of AC-powered discharged lamps (linear mean of wavy light in accordance with the Talbot-Plateau law )
- Wide measure range, so that the following measurements are possible with just one instrument:
  - measuring of daylight up to 200000 lx
  - measuring of indoor lighting up to 2000 lx
  - measuring of low illuminances, e.g. street lighting up to 20 lx
  - Emergency-lighting up to 2 lx
- Simple operation, that means no application of weakening filters and correction-factors
- Correct reading of the measuring results by a digital display

## 3. Functions of the digital luxmeter

Based on the mentioned conditions, the digital illuminance-meter „Minilux“ was developed at the University of Applied Sciences, Berlin in cooperation with the Technical University of Zhejiang, China. Concrete, it is a newly developed, portable illuminance-meter for universal applications concerning the whole lighting technic (Fig. 1).



Fig. 1. The MINILUX- device with photosensor (silicon-cell with  $V(\lambda)$ - and cosine-correction in accordance to DIN 5032, class B)

Fig. 2 shows the block diagram of „Minilux“. Two amplifiers with an extremely low bias-current are used for protection against overload, when for example high pressure sodium-xenon lamps with pulsed current supply and a high luminous flux crest-factor are measured (Fig. 3). The first amplifier OPA 1 serves the range, the second OPA 2 works as a mean-forming active low-pass-filter.

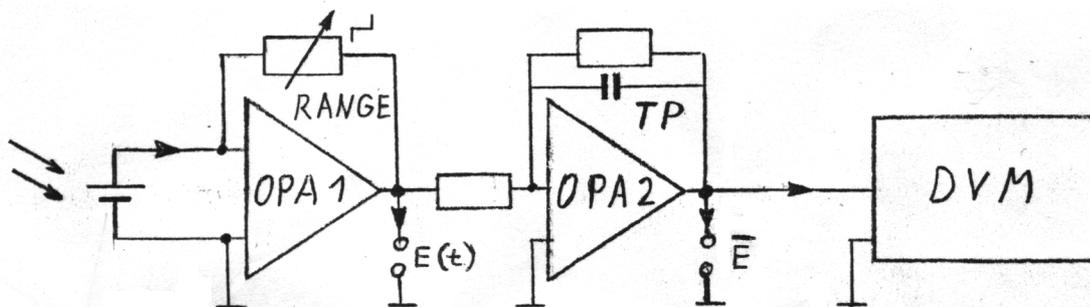


Fig. 2. Block circuit of the Minilux illuminance-photometer. Measurement capacity: 0.001 lx.....199.9 klx (6 ranges), luminance capacity: 0.1 cd/m<sup>2</sup>.....19.99 Mcd/m<sup>2</sup> (6 ranges)

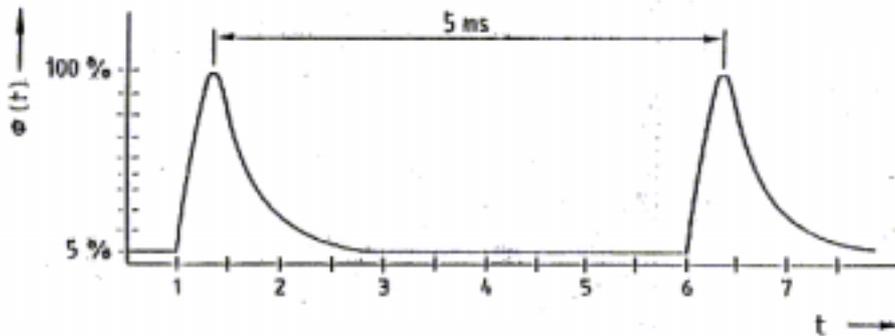


Fig. 3. Time dependence of the luminous flux of a sodium-xenon HID-lamp supplied by pulsed high-frequency current

Accurate photometry of high-pressure discharge lamps with pulsed current supply calls for a special photocurrent amplifier, which, in accordance with the Talbot-Plateau-law, reliably estimate the linear mean value of luminous flux.

Ordinary luxmeters are generally not designed to measure high pulsating light sources. Therefore, to avoid errors, the staff of photometric laboratories should heed this recommendation before measuring such light sources. Critical evaluation and investigation of the suitability of the photometer for measurements of pulsating light is required.

The new measuring instrument avoids these disadvantages and thereby closes a gap in the market.

#### 4. Important technical data

- Silicon photosensor with  $V(\lambda)$ - and  $\cos$ -correction (Fig. 4, Fig.5)
- Diameter of the sensitive light area  $D = 11\text{mm}$
- 6 lux-ranges
- Total measure range: 1 mlx to 199900 lx
- Resolution: 1 mlx
- Class B in accordance with DIN 5032, section 6
- Crestfactor: about 15
- dual-slope-digitalvoltmeter with auto-zero
- 7-segment LC-display
- Automatic low-battery-indicator, if  $U_{\text{bat}} < 7\text{V}$
- Supply-current : only about 2 mA
- 9-V-lithium-blockbattery with 1,2 Ah (working time of the Minilux with this high-performance battery approximately 600 hours !)
- Analog output 1: to measure the waveform of illuminance  $E(t)$  with an oscilloscope
- Analog output 2: 0 ... 199.9 mV DC for recorder, plotter, PC etc
- 4-seconds-delay timer with indication-hold-function inclusive of

display- light and display-functioning test (e.g. suitable for shadingfree measurements )

- Dimensions: 157 mm x 84 mm x 30 mm
- Weight: 300g
- Price:  $\approx$  400 USD

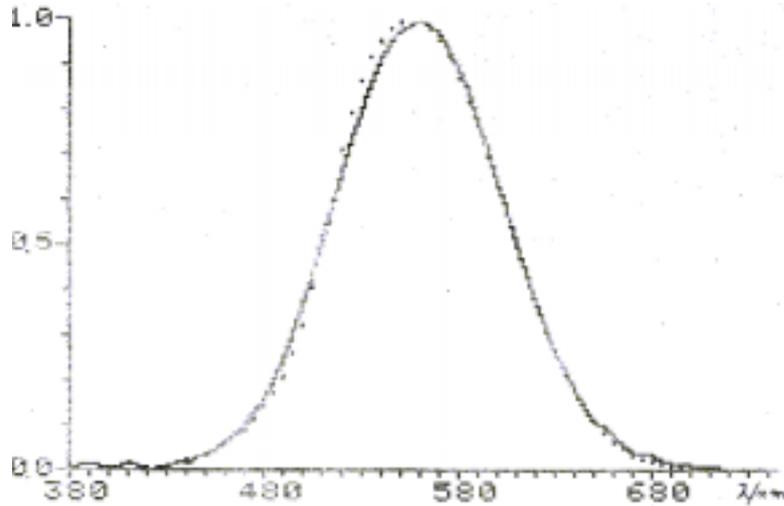


Fig. 4.  $V(\lambda)$ - approximation of the silicon-photosensor in accordance to DIN 5032, class B

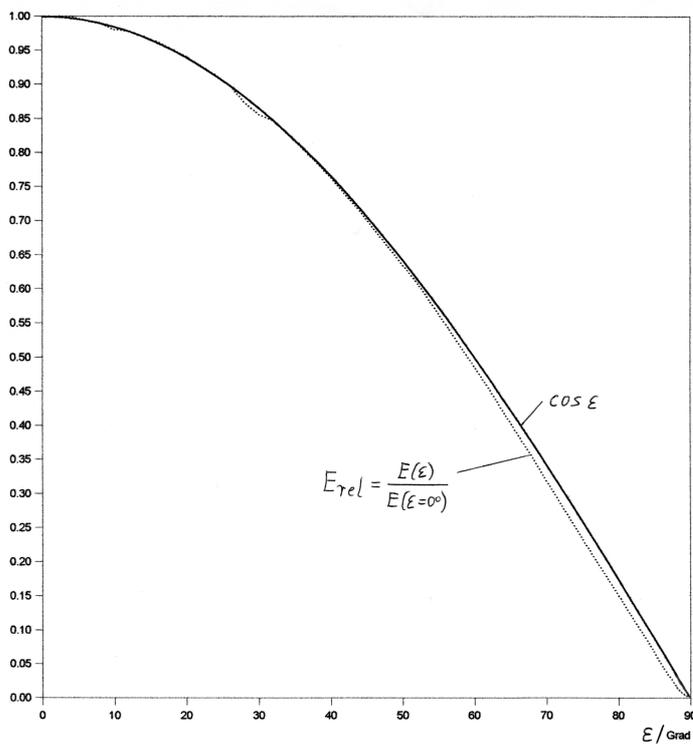


Fig. 5. Cosine-correction of the silicon-photosensor

The instrument measures lux-values from: 1 mlx (resolution) to 199900 lx.  
(Note: 1 fc = 10.764 lx // 1 lx = 0.0929 fc)

Range	Typical application
0.000 .....1.999 lx	Emergency measurements
00.00 ..... 19.99 lx	Street lighting measurements
000.0..... 199.9 lx	Interior lighting measurements
0.000.....1.999 klx	Interior lighting measurements
00.00..... 19.99 klx	Daylight measurements
000.0... .....199.9 klx	Daylight measurements

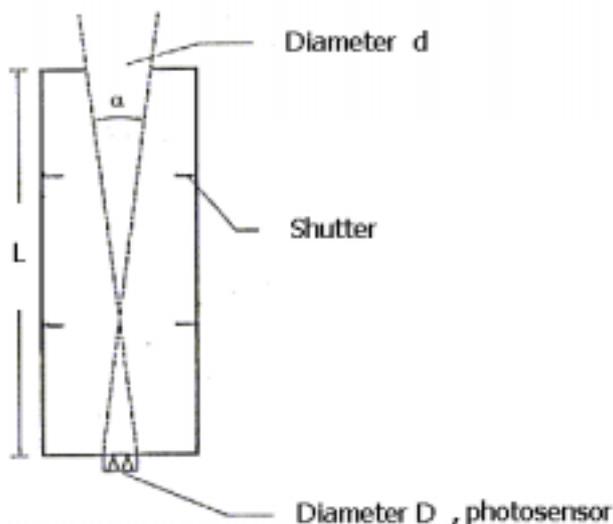


Fig. 6. Luminance-tubeadapter for the Minilux-photometer

The special luminance-tubeadapter (Fig. 6) has a measuring angle of  $\alpha = 13^\circ$ . The tube-geometry is so calculated, that the relation between luminance and illuminance is very simple:

$$L = 100 \cdot E \quad E \text{ in lx, } L \text{ in cd/ m}^2$$

The procedure of luminance-measurement is as follows:

Put the luminance-tubeadapter on the photocell and hold the tube in the direction, in which you want to measure the luminance of a surface. Read the lux-value from the

minilux-display and multiply this lux-value with the constant factor 100. The result is the actual average luminance.

Luminance-capability: 0.1 cd/m<sup>2</sup>....19.99 cd/m<sup>2</sup> (6 ranges)

Procedure for reflection-measurements of a diffuse surface: First measure the illuminance on the surface. Then measure the luminance of the surface at the same area. Calculate the reflection-value with the following formula:

$$\rho = (\pi \cdot L) / E \quad E \text{ in lx, } L \text{ in cd/ m}^2$$

## 5. Fields of applications

The instrument is suitable for

- the measuring of illuminance, luminance and reflection
- the measuring of luminous intensity by means of the photometrical law:  
 $I [\text{cd}] = E [\text{lx}] \cdot (R [\text{m}])^2$
- luminous flux measurements in accordance  
with  $\Phi [\text{lm}] = E [\text{lx}] \cdot A [\text{m}^2]$

Further applications are possible, e.g. for:

- luminous flux measurements in conjunction with the Ulbricht sphere
- control of the turning on and off of street luminaires
- brightness control for roadway tunnels
- Measurements of building materials used in lighting technology (e.g. for measurement of reflection, transmission, absorption, extinction etc.)
- Measurements for solar facilities
- Light measurements for applications in physics, optoelectronics, meteorology, botany, biology and medicine

## 6. Result

The new lux-meter provides a metrological basis for innovative, energy-efficient and consequently environmentally benign lighting systems. It supports systems based on the use of natural daylight in conjunction with supplementary artificial illuminance which is controlled in accordance with user demand, and which is equipped with dimmable high-frequency electronic ballast devices, which enables power savings of up to 70 %. The presented digital luxmeter contributes to the achievement of this aim.

## References

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