UNDERSTANDING LED TECHNOLOGY

LED Guideline

BASICS

LED

Light emitting diodes in multi-coloured plastic casings

LUGA Shop COB LED Module

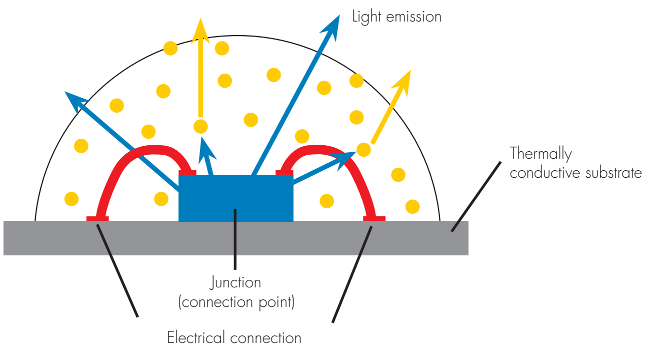
LEDs are becoming ever more important in the world of modern lighting systems. In Germany, LED-based systems already account for 20% of all new installations in the field of indoor lighting and more than 40% when it comes to outdoor lighting. The advantages of LEDs are numerous, yet patchy knowledge of the underlying technology often leads to indecisiveness and even incorrect decisions.

This brochure is designed to give you a guideline that is easy to understand and will inform you on what to look out for so that you can make the right decisions.

WHAT IS AN LED?

An LED – or Light Emitting Diode – is a semiconductor component that only lets current pass in one direction. If forward current is applied, the LED will emit light, dependent on the semiconductor material and doping (i.e. the inclusion of "foreign atoms").

Schematic of a white LED:



SMD OR COB?

SMD (Surface-Mounted Device)
The LED is soldered directly onto the PCB. In contrast to assembly with "wired components", SMD technology requires less space and improves the thermal connection.

LUGA Shop Module COB
2000 – 5500 lm

LEDLine Flex RGB and Monochrome

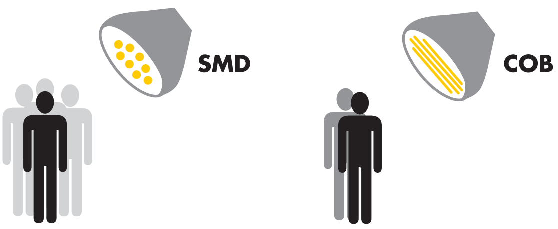
SMD LED module
(individual light points)

COB (Chip-on-Board)
The "naked" PCB without a casing is directly applied to the substrate, a process that enables much denser LED arrays in comparison to SMD technology. The great advantage of COB modules lies in the highly homogeneous light they emit. That means a consistent light beam is given off, without any visible individual light points. By then adding a ceramic substrate, the best conditions are created for optimal cooling, which in turn serves to increase efficiency and lengthen service life.

COB LED module
(high-density array,
homogeneous light emission)

LIGHT EMISSION

The homogeneous light emitted by COB LED modules is unaffected by individual light points or multi-shadows.



Clear contours thanks to homogeneous light provided by COB LED technology.

ADVANTAGES OF COB LUGA LED TECHNOLOGY ON A CERAMIC SUBSTRATE

Service Life, Failure Rate and Decrease in Luminous Flux:
Among other factors, the failure rate and decrease in luminous flux over the service life determine the quality of an LED module. The service life of LED Modules generally amounts to 50,000 hours.

Failure Rate:
In general, 0.2% of all LED modules will fail per 1,000 hours, which means that no more than 10% of all modules are permitted to fail after 50,000 hours. The failure rate is expressed by the C value.

Decrease in Luminous Flux or Degradation:
Due to chemical and physical changes, LED modules lose some of their luminance over their service life. This process (known as degradation) is denoted by **L**, and a common value for L is approx. 30%. Consequently, 70% of the initial luminous flux will be retained after 50,000 hours (L70). The **B** value is directly dependent on the **L** value and denotes how many modules (in per cent) are permitted to fall short of the L value. A common value is B50, which means that 50% of all modules can fall short of the L70 value after 50,000 hours.

Combining the values for C and B gives you **F**, which takes account of the effects of ageing and the total failure of an LED module.

Vossloh-Schwabe's LUGA COB LED modules principally set themselves apart due to their excellent values. At L90/F10, a total of 90% of the initial luminous flux is retained and only 10% of the modules will have failed or fallen short of the L90 value after 50,000 hours.

Thanks to the extremely stable operating behaviour (L90/F10) of VS LUGA modules, savings can already be made while planning a lighting system since the failure rate and ageing factor are almost negligible. The decrease in luminous flux of modules more affected by degradation is usually compensated for by increasing the number of modules during the planning stage. However, this also raises overall energy requirements.

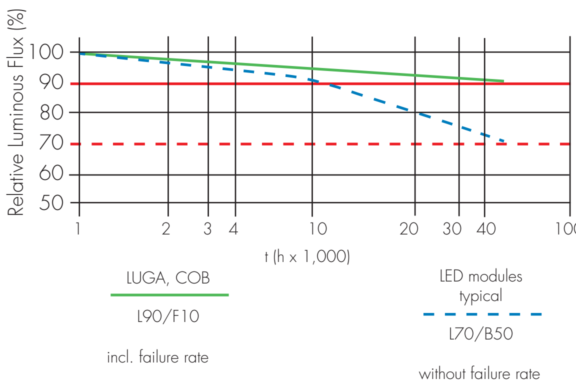
BASICS

LED

Diffuser for LUGA Line Modules

LUGA Line COB LED Module

Degradation after 50,000 h

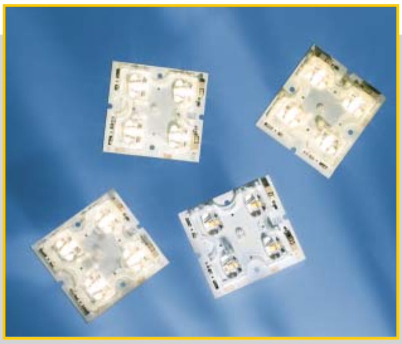


Luminous Flux

Expressed in lumens (lm), luminous flux is dependent on the current flowing through the control gear (driver). Commonly available drivers operate at typical currents of 350 / 500 / 700 / 1050 mA. The higher the driver current is, the higher the luminous flux. But luminous flux is also dependent on the light colour. The "cooler" the light is (high colour temperature) the higher the luminous flux. VS LUGA modules attain a luminous flux of up to 10,000 lm.

EFFICIENCY

The term efficiency refers to the ratio of luminous flux L in lumens (lm) to the applied electrical output P in Watt (W). It should be noted that output refers to the system output (light source plus control gear) and luminous flux refers to "warm lumens" (luminous flux plus operating temperature). In this regard, an optimised system solution is built on matching components. The parameters of the individual components can then be used to arrive at the best possible choice. The parameters of the LED drivers are, first and foremost, the efficiency and power factors. The efficiency factor should be > 0.85 and the power factor, for devices with a power supply of > 25 W, at 0.90. By now, VS LUGA COB modules attain a light output of up to 147.



LED Modules for Industrial Lighting

Comparison:
Colour rendering value ~80/>85

Comparison between LED Modules and Fluorescent Lamps (adequate luminous flux values)

Fluorescent Lamps T8* light colour 830 = 3000 K			**LED Module LUGA Line 3000 K**				
Output	Luminous Flux	**Efficiency**	Driver	No. of Modules	Output	Luminous Flux	**Efficiency**
W	lm	**lm/W**	mA		W	lm	**lm/W**
18	1350	**75**	350	2	10.1	1414	**140**
36	3350	**93**	500	3	22.8	2967	**130**
58	5200	**90**	700	4	44.9	5344	**119**

* Lamp data without control gear

Comparison between System Output of LED Modules and Fluorescent Lamps, each with control gear (adequate luminous flux values)

System Output Lamp plus Ballast*			**System Output LED Module plus Driver****				
Output	Luminous Flux	**Efficiency**	Driver	No. of Modules	Output	Luminous Flux	**Efficiency**
W	lm	**lm/W**	mA		W	lm	**lm/W**
19.5	1350	**69.2**	350	2	11.4	1414	**124**
34.5	3350	**97.1**	500	3	25.7	2967	**115**
55	5200	**104**	700	4	50.6	5344	**106**

* Data refer to operation with an electronic ballast

** Example for constant current drivers up to 2 x 40 W

COLOUR TEMPERATURE

Colour temperature in Kelvin, e.g.:

- 3000 K for warm white
- 4000 K for neutral white
- 5000 K for cool white

These colour temperature categories are defined in the "Photometric Code" and apply to LEDs and fluorescent lamps in equal measure.
Example: 830 stands for 8 = colour rendering index (CRI) > 80, 30 = 3000 K. If "cooler" light colours are acceptable for a given application, the efficiency of a lighting system can be improved still further.

COLOUR RENDERING

14 defined test colours are used to calculate the colour rendering index (CRI). However, only the first eight test colours are used for the purpose of calculating the general colour rendering index, R_a.

CRI Test Colour Samples

R1	Light greyish red	R9	Strong red
R2	Dark greyish yellow	R10	Strong yellow
R3	Strong yellow green	R11	Strong green
R4	Moderate yellowish green	R12	Strong blue
R5	Light bluish green	R13	Light yellowish pink
R6	Light blue	R14	Moderate olive green
R7	Light violet		
R8	Light reddish purple		

Colour **R**endering **I**ndex, **CRI > 80**
This value represents an average value, which means that given the same CRI, individual colour deviations (Ri) can still occur. Depending on the visual task involved (colour recognition in textiles, office or control room work), the requirements placed on colour rendering are very different. If the CRI is not expected to satisfy any particular requirements, this can go to benefit system efficiency, since lower CRI values go hand in hand with a higher light output.

COLOUR TOLERANCE

MacAdam ellipses are used to determine colour differences and constitute the areas in the colour diagram in which the comparative colours surrounding a reference colour are perceived to be an equal colour distance apart (MacAdam; American physicist). Colour tolerances are practically imperceptible up to a value of 3 MacAdams. At higher values, colour differences become visible. The CIE chromaticity diagram on page 6 clearly shows that the MacAdam ellipses in the green and yellow zones are considerably larger than in the blue or violet zones; this means that the human eye is less capable of recognising colour differences affecting green LEDs than differences between blue LEDs.

BASICS

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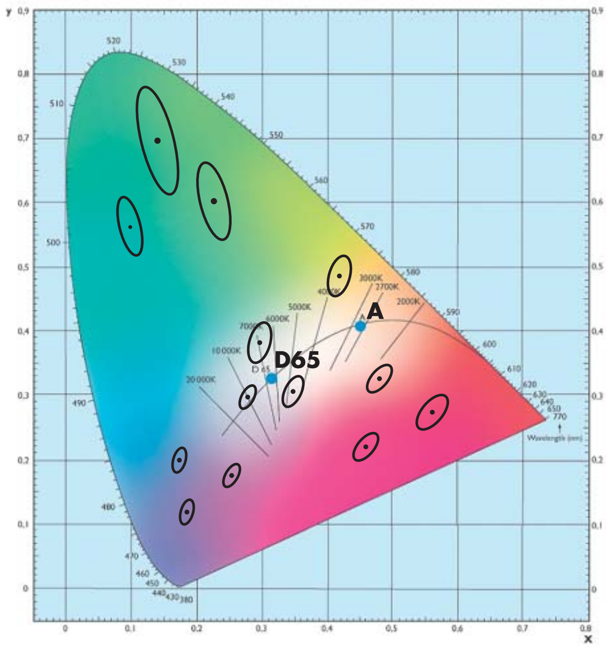
VS LUGA Shop

MClass High Bay LED module



MacAdam ellipses (10 x magnification for easy recognition)
A: incandescent lamp at 2856 K
D65: daylight phase with a colour temperature of 6500 K

BINNING

Due to minute tolerance differences that occur during the manufacturing process, LEDs can be affected by deviations in luminous flux and colour temperature. To keep these deviations to a minimum, LEDs are separated into different tolerance categories (so-called bins). As a result, the quality of an LED is directly linked to the defined tolerance limits.

THERMAL MANAGEMENT

Thermal management is decisive for both the light output and the service life of an LED module.
Targeted use of heat sinks make a fundamental contribution to thermal management. Detailed information on this topic can be found on our website at: www.vossloh-schwabe.com under Products -> Notes on LED Technology -> Thermal Management Guide.

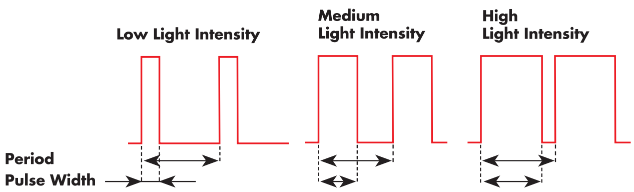
Light control system LiCS

LED modules with drivers

LIGHTING CONTROL

It is fundamentally possible to dim LEDs, to which end pulse width modulation (PWM) technology has become an industry standard. Both interfaces for conversion into PWM signals as well as integrated devices are available to enable common 1–10 V, DALI and DMX light control signals.

Pulse Width Modulation (PWM)



STANDARDS AND DIRECTIVES

Safety:

- LED modules for general lighting
  DIN EN 62031 (VDE 0715-5)
  The standard defines safety requirements as well as compliance criteria and test procedures for LED modules, with or without integrated control gear.
- LED Control Gear
  IEC 61347-1 and IEC 61347-2-13
  The standard defines safety requirements for control gear used with LED modules.
- Uniform Terminology for LED Technology
  IEC 62504 (CDV stage)
  This standard specifies uniform terminology and definitions that are designed to enable a consistent evaluation of LED technology on the basis of commonly shared knowledge.

Function:
IEC/PAS 62717 (LED modules) and IEC 62384 (LED control gear).
The specialist technical committees of the CIE have drawn up the following specifications regarding light technology:

- Standards for LED intensity measurements TC2-46 CIE/ISO
- Measurements of optical properties of LED clusters and arrays TC2-50
- Measuring LED radiation and luminance TC2-58
- Optical measurement of high-power LEDs TC2-63
- Quick test method for LEDs TC2-64

Photo-biological safety of lamps and lamp systems:
IEC 62471, DIN EN 62471 (VDE 0837-471)
This international standard, which in Europe forms part of the safety low-voltage directive, describes the methods used to measure and evaluate light sources, which include LEDs, LED modules and LED luminaires.

ZHAGA

In view of the continuing rapid progress being made in the field of LED technology, ZHAGA – an international consortium of the lighting industry – intends to ensure the interoperability of products made by various manufacturers. To this end, interfaces are defined for numerous application-specific light engines (combination of LED modules and control gear). ZHAGA specifications cover physical dimensions as well as photometric, electrical and thermal parameters of LED light engines (LLEs).

LED SYSTEMS MADE BY VOSSLOH-SCHWABE – THE ADVANTAGES AT A GLANCE

- Cutting-edge COB technology (homogeneous light, improved thermal behaviour)
- Long service life (50,000 hours)
- Excellent light output
- Minimal decrease in luminous flux and extremely low failure rate (L90/F10)
- High CRI
- Narrow colour tolerance
- Drivers with minimal losses and thermal cut-out
- Holders and optical attachments, e.g. lenses, especially designed for use with LED modules

LED systems can be further optimised by integrating light control systems (LiCS) for indoor or outdoor use.

Our high quality standards are documented by our voluntary 5-year product warranty.

Whenever an electric light goes on around the world, Vossloh-Schwabe is likely to have made a key contribution to ensuring that everything works at the flick of a switch.

Headquartered in Germany, Vossloh-Schwabe has been a member of the global Panasonic group since 2002 and counts as a technology leader within the lighting sector. Top-quality, high-performance products form the basis of the company's success.

Whether cost-effective standard components or tailor-made product developments are needed, Vossloh-Schwabe can satisfy even the most diverse market and customer requirements. Vossloh-Schwabe's extensive product portfolio covers all lighting components: LED systems with matching control gear units, OLEDs and state-of-the-art control systems (LiCS) as well as electronic and magnetic ballasts and lampholders.

A member of the Panasonic group **Panasonic**

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