

Understanding LED Driver Technology

LED Driver Guideline

BASICS

LED DRIVERS



LED Drivers – Various Models

Within the lighting industry, the increasingly important topic of LEDs is inextricably linked with the development of suitable control gear for operating LED modules. Further to our LED Guideline, "Understanding LED Technology", this brochure is intended as an "Understanding Driver Technology" supplement. Like LED modules, LED drivers are available with a broad array of technical and quality-relevant properties and features. With this guidelines, we wish to provide easily understandable information on drivers, their uses and what to look out for when choosing one.

■ WHAT IS A DRIVER AND WHAT IS IT USED FOR?

Operating an LED module always requires control gear (a ballast), which in the field of LEDs is called a driver.

Current can only flow in one direction through an LED (diode). A rise in internal temperature during operation can lead to a rise in current and with that power uptake within the LED, which in turn leads to a further increase in temperature. Failing to limit this vicious circle can lead to the destruction of an LED. Preventing this from happening is one of the tasks performed by a driver.

LED modules can be operated with one of two different supply sources (drivers) depending on gearshift assembly:

- a constant current source
- a constant voltage source

■ DRIVERS FOR CONSTANT CURRENT OR CONSTANT VOLTAGE OPERATION

If an LED module is operated using a constant voltage source but without current limitation, the current will increase up to the thermal destruction of the LED. To avoid this effect, LED modules for operation with constant voltage are fitted with integrated current control.

When operating an LED using a constant current source, the current operating the LED is kept at a constant level, with current control being integrated in the driver. Constant current sources can feature either transistors or integrated circuits. The use of a constant current source is more efficient.



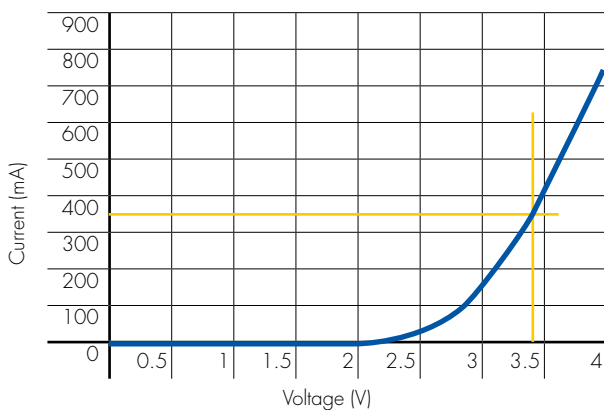
COB LED modules for shop lighting applications



Compact LED drivers for shop lighting

Characteristic curve of a white high-performance LED

Nominal current 350 mA, Voltage 3.4 V



Operating point = intersection of the yellow auxiliary lines

Tolerance values for output currents constitute a qualitative criterion and a value of $\pm 5\%$ is typical for high-quality devices, while a value of $\pm 10\%$ is characteristic of low-cost devices.

■ AC OR DC

The primary or mains connection side of universal drivers should be suitable for use with both AC (alternating current) and DC (direct current). This makes it possible to supply these devices both with 230 V AC mains power during normal operation and with 220 V DC battery power during emergency operation. The driver's secondary side always provides direct voltage, since LEDs are semi-conductors that only let current pass in one direction.

■ SELV OR NOT SELV

Standing for "Safety Extra Low Voltage", SELV describes low voltages with safe isolation, e.g. with an isolation transformer. SELV ensures an enhanced degree of protection against electrical shock, as laid down in the requirements of the basic safety standard IEC 61140 "Protection against electric shock – Common aspects for installation and equipment", which, as a European standard, also has the status of a German standard (EN 61140). This standard is applicable with regard to affording protection against electric shock to humans and livestock. The standard intends to lay down principles and requirements that together

will apply to electrical appliances, systems and control gear or that are required for their coordination. The standard applies to equipment, systems and control gear without voltage limitation. The requirements of the standard are applicable only if they have been integrated into other standards or if in such standards reference is made to these requirements. The standard is not designed to act as an independent standard. SELV devices feature special insulation to parts conducting mains voltage, which constitutes safe isolation. The permissible magnitude of SELV voltages that carry a risk of accidental contact is specified in the respective applications. Should these maximum voltages be exceeded, protection against direct contact is required. As a rule of thumb it can be said that SELV devices are more technically sophisticated than non-SELV devices. But they also provide optimum protection.

■ POWER FACTOR AND EFFICIENCY

In the field of electrical engineering, the power factor φ expresses the ratio of real power P to apparent power S (see formula):
 $\lambda = P / S$

Real power P is a physical value that constitutes the amount of transferred power. Apparent power S is a product of effective voltage and effective current, and thus more of an "artificial" concept that serves to specify the loads acting on means of transfer (e.g. conductors). As a result, the power factor λ is always a positive value of ≤ 1 . It thus defines the degree to which power is converted into usable energy in a device.

In accordance with the IEC 62384 performance standard, the power factor for LED drivers will be displayed on the type label as follows: $\lambda = 0.95$

The efficiency of a device is defined using its power efficiency value η . The power efficiency factor of a device is defined as the output power P_{out} divided by the input power P_{in} . The respective measuring procedure for LED drivers will be defined in the IEC 62442-3 standard, which is currently under preparation. High-quality devices feature a power efficiency factor upwards of 85% ($\eta \geq 0.85$).

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LED Roadway module



■ THERMAL BEHAVIOUR

To ensure that electronic components function safely, it is important to observe their maximum thermal loads. Normally, the manufacturer will specify a precise point on the driver for temperature measuring purposes. To avoid shortening the service life of a device, the specified highest temperature must not be exceeded at this so-called t_c point. This measuring point is defined by testing the driver during normal operation at the maximum permissible ambient temperature t_a . As both the design-related ambient temperature and the driver's level of self-heating, which is dependent on the power supply, can greatly vary, the casing temperature should be measured at the t_c point under realistic installation conditions. The difference between the t_c and the t_a value is a measure for the level of self-heating and thus the driver's power loss. The lower this difference in value is, the higher the quality of the driver. Good air circulation can improve thermal behaviour and positively influence the driver's service life.

■ SPIKE RESISTANCE

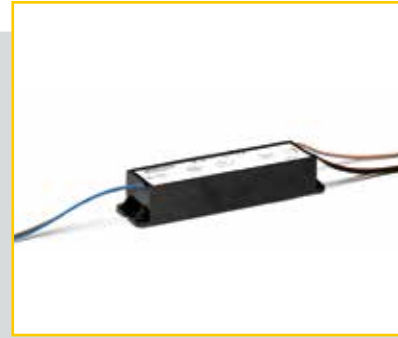
In practice, mains power supply networks are susceptible to transients and do not correspond to the clean sinus wave pattern they should theoretically display. Such irregularities in mains power can, for instance, be caused by switching large inductive or capacitive loads. Voltage spikes, in particular, pose a particular challenge for control gear.

To ensure drivers can withstand such voltage spikes, they must be designed in accordance with IEC 61547 "Equipment for general lighting purposes – EMC immunity requirements". The standard lays down requirements for the electromagnetic immunity of lighting systems. The provisions of this standard are based on the requirements for residential, commercial and industrial environments, as set out in IEC 61000-6-1, but adapted to suit real-life conditions for operating lighting technology.

In line with EN 61547, drivers are tested with a test voltage of 1 kV for inputs ≤ 25 W and 2 kV for inputs > 25 W between power and earth. However, manufacturers of high-quality devices normally conduct such tests with higher voltages. The requirements for outdoor applications are much more stringent, demanding test voltages of 2–8 kV between phase and neutral conductor, depending on the respective manufacturer's classification.



LED constant current driver, IP20/IP66



LED constant current driver, IP67

■ RIPPLE

Ripple refers to alternating voltage superimposed on direct voltage. The corresponding ripple current leads to a rise in temperature inside LED modules and decrease the light quality. Two factors are decisive in this respect: the magnitude of the current and its frequency.

The ripple value is a clear performance marker. High-quality drivers will come with a value of approx. 10%, while lower-performance drivers will have values of $\geq 30\%$.

■ NO-LOAD, OVERLOAD AND SHORT-CIRCUIT PROTECTION

The above-mentioned operational states can impair driver functions or even lead to driver destruction. It is therefore important to ensure that such devices are fitted with sufficient short-circuit and overload protection, and are suitable for no-load operation.

Before they exceed the upper temperature limit, high-quality devices limit current consumption and, by reducing the power supply, thus reduce the internal temperature. Should the devices continue to be overloaded, a safety cut-out will activate and switch the devices off. From a technical point of view, this is achieved using an NTC (negative temperature coefficient) resistor or an electronic circuit. When overloaded, low-performance devices simply switch off and remain switched off or even break down completely.

A difference is made between short-term and permanent short circuits. Devices for both types are available on the market. In this regard, it is important to note that ensuring permanent short-circuit resistance is more technically sophisticated, but also provides the highest level of protection. No-load operation can also lead to the destruction of devices without protection. For this reason, devices must also be resistant to no-load operation.

■ SERVICE LIFE AND FAILURE RATE

When used in combination with LED modules, a driver's service life and failure rate are further decisive criteria. In real-life applications, care should be taken to ensure components perfectly match to prevent damaging the system due to the presence of an "inferior" component. High-quality drivers provide a service life of $\geq 50,000$ hours with a failure rate of 0.2% per 1,000 hours. Low-performance devices come with a service life of 30,000 hours and failure rates of 0.5% per 1,000 hours.

■ EMC

EMC (electromagnetic compatibility) not only covers outgoing interference, but also immunity against such interference and the creation of mains current and mains voltage irregularities. To ensure the most diverse electrical and electronic devices can work alongside each other without causing problems, it is important that limit values for radio disturbance are not exceeded and that minimum requirements for immunity to interference are satisfied. Observing specified limit values forms the basis for this. Proof is furnished by applying the European standard EN 55015: "Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment", which is based on the IEC/CISPR standard of the same name.

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Fixing kit LUGA Line Fix

■ DEGREE OF PROTECTION AND MARK OF CONFORMITY

Together with the mark of conformity issued by testing institutes, the pertinent approbations are a "MUST" for all kinds of control gear. In this regard, a difference is made between safety tests (EN 61347), performance tests (EN 62384), energy consumption tests (EN 62442-3), EMC tests (EN 55015, EN 61547, EN 61000-3-2) and tests regarding the assessment of electromagnetic fields (EN 62493). For drivers, the ENEC mark serves to document that relevant safety and performance requirements have been met. The degree of protection of control gear is expressed by an IP number. IP20 devices are suitable for integration in indoor luminaires without special requirements. IP65 devices are, for instance, used for outdoor lighting applications.

■ PROTECTION CLASS I AND PROTECTION CLASS II



All electrically conductive casing parts must be protected by connection to electrical earth for Protection Class I (see symbol) devices. Devices designed for independent operation must feature a mechanical cable grip for the power supply cable.



Devices of Protection Class II (see symbol) feature double or reinforced insulation between the mains power circuit and the output side or the metal casing. If a cable with a protective earth conductor is used, this must not be connected to the casing

■ BUILT-IN AND INDEPENDENT OPERATION

Drivers for LEDs can be suitable for two different kinds of operation:

1. Built-in
Permanent integration in a luminaire or a casing that performs a task that is similar to a luminaire.
2. Independent Operation
As for instance when installed in a false ceiling.



Stricter EMC test methods apply for devices destined for independent operation since cable lengths can vary in such cases. With regard to devices designed for independent use, care must be taken to ensure that they feature the symbol shown on the left.



Linear LED constant current driver



LED Light Panel SMD

■ DIMMABLE DRIVERS

Dimming LED lighting using light control systems and dimmable drivers provides several advantages:

- Energy and cost savings due to reduced power consumption
- Less environmental impact due to lower CO₂ emissions
- More convenient thanks to flexible light scenes to suit any occasion

From technical point of view, there are various ways to address a driver, in which regard a basic difference is made between digital and analogue control options. When it comes to ways of effecting digital control, DALI (Digital Addressable Lighting Interface) is becoming ever more established. DMX is a further digital control protocol and often used for RGB and effect lighting. Analogue control is effected with the help of a 1–10 V control voltage interface. Directly addressing the 230 V mains voltage side enables phase-cutting control.

■ TUNEABLE WHITE

In a manner similar to the way that light intensity can be varied by dimming, Tuneable White enables infinite adjustment of the light temperature. From "warm white" to "cool" daylight, light-colour moods ranging between, e.g., 1,700 K and 6,500 K are possible.

This function provides the advantage of customising lighting moods even further. Different times of the day or seasons can be recreated and dynamically reproduced. State-of-the-art drivers and light control devices make it possible to precisely adjust light temperatures to suit the given circumstances, not only in retail and office environments, but also in medical facilities and in private applications. The positive effect of adjustable light, as enabled by suitable control gear, is always at the forefront.

■ STANDARDS AND DIRECTIVES

Within the EU, the general rule applies that electrical control gear is allowed to retail on the market only if the basic requirements of the applicable European directives (adopted as national laws) have been met. Control gear used for lighting applications is subject to the EC low-voltage directive, the EMC directive and the ErP directive (and possibly further directives as well). As a result, safety, EMC, EMF, eco-design, etc. requirements must be satisfied by products and documentation must be ensured.

With regard to technology, legal regulations refer to the "state of the art", which itself is mainly defined via pertinent standards. These standards are also listed in the EU's Official Journal.

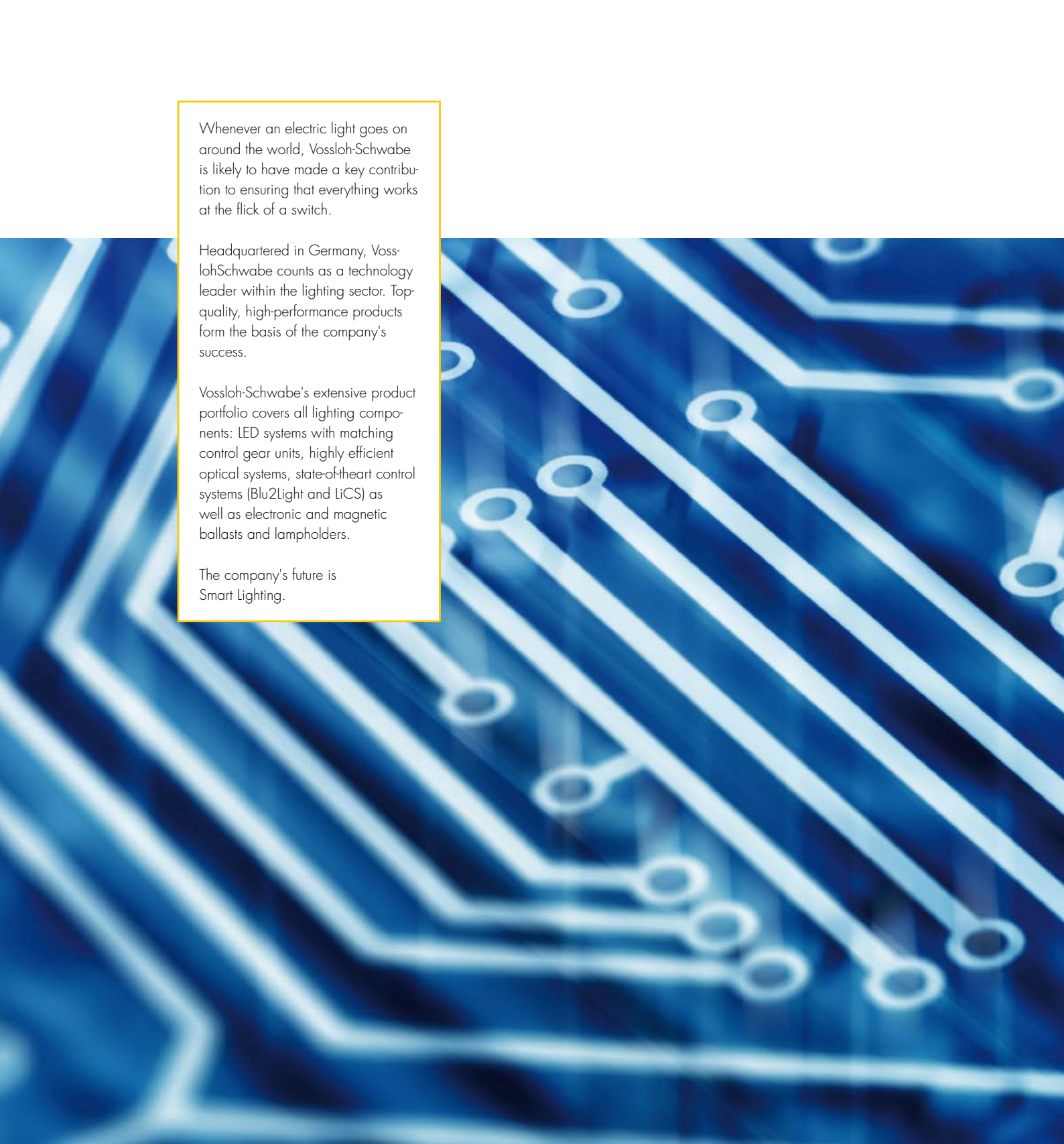
For LED drivers, these are mainly:

- IEC/EN 55015
- IEC/EN 61000-3-2
- IEC/EN 61347
- IEC/EN 61347-2-13
- IEC/EN 61547
- IEC/EN 62442-3
- IEC/EN 62493

■ VOSSLOH-SCHWABE DRIVERS: THE BENEFITS AT A GLANCE

- Optimised electronic design
- Long service life
- Minimal power loss
- Overload protection
- Short-circuit-proof
- No-load protection
- Low ripple

Our high quality standards are documented by our voluntary 5-year 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, VosslohSchwabe counts as a technology leader within the lighting sector. Top-quality, high-performance products form the basis of the company's success.

Vossloh-Schwabe's extensive product portfolio covers all lighting components: LED systems with matching control gear units, highly efficient optical systems, state-of-the-art control systems (Blu2Light and LiCS) as well as electronic and magnetic ballasts and lampholders.

The company's future is Smart Lighting.

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