An LED (Light Emitting Diode) generates light because semiconductor photons of certain wavelengths are emitted when current flows through differently doped layers. LED light has a very narrow spectrum and has hardly any infrared content; however, there are various technologies with which colors can be mixed or transformed into other colors in the LED. As a matter of principle, an LED can be operated in one direction only – it blocks in the reverse direction. LEDs are not designed for negative voltages in the reverse direction, not even short-term. Depending on the LED power, considerable heat is generated by the electron transition. The housing must therefore be designed in such a way that the heat does not damage the semiconductor by internal overheating, but is adequately dissipated instead.

**Multi-talented LED**

As an electronic component the LED requires a certain degree of attention and requires some caution on the part of the power supply and monitoring. Due to its diode characteristics, an LED behaves in a similar way to a thermistor with an exponentially increasing curve: If the voltage increases, the current also increases disproportionately. At the same time the internal temperature increases, which reduces the internal resistance and leads to an even higher current consumption. Therefore a reliable current controller and the operation of an LED on a constant current source are essential. The light yield corresponds to the current consumed – from a weak glow to a short bright flash, everything is possible with just one LED.

The short-term overload capability of the barrier layer is often exploited: in continuous operation, as much current can be sent through the LED as the heat dissipating capacity of the housing will allow; this corresponds to a duty cycle of 100 %. On the other hand, for example, if a duty cycle of only 10 % is selected and the barrier layer is suitable, a 10 x higher current could be permissible, with a correspondingly higher light yield. In the remaining 90 % of the pulse time, the heat then has time to dissipate from the housing. This intentionally limited short-term overload is consciously selected in lighting applications in order to best exploit LED lights with a high light yield.

LED lights are also preferably used because the LED is relatively wear-free in operation and can be expected to have a service life of several tens of thousands of operating hours. At the same time, however, it is subject to aging effects, which lead to a gradual reduction in brightness and a change in the color temperature. Depending on the application or legal regulations this can be a problem, so that it may be necessary to increase the current using a control loop with a brightness sensor or with empirical values that compensates for the aging effect.

**Dimming of LEDs in current-controlled and voltage-controlled operating mode**

At the electrical user level, two different LED versions are commonly available on the market: If the pure LED is operated, it must be connected in accordance with the manufacturer’s specifications to a constant current source in the so-called
current-controlled operating mode. The rated current typically lies between 2 and 20 mA, for signal LEDs over 50 mA, for small lights up to 350 to 700 mA per LED. The forward voltage drop across the LED lies within the range of 2 to 4 V, depending on the barrier layer material.

Such LEDs can only be connected in series — even with minimal material scattering, a parallel connection will lead to uneven current consumption and thus to damage to the LED under certain circumstances.

If an LED is to be dimmed, there are in principle two possibilities: one way is to reduce the current, but this entails a change in the color temperature, which is not always desirable. The other method is the fast switching of the rated current by means of a PWM controller.

Voltage-controlled operation on a constant voltage source is more convenient for many users. If the LED or lamp manufacturer has already integrated the current control, the connection of a sometimes coarsely regulated voltage (e.g. 12 or 230 V) is sufficient. Such LED lights must then be connected in parallel. However, the integrated current control produces heat, thus lowering the efficiency of the light. The simplest example of this is a series resistor, which is dimensioned in such a way that it simply ‘burns’ the voltage difference between the supply voltage and the LED forward voltage. Dimming by reducing the voltage leads to poorly reproducible results; PWM control is preferable here.

Users in the industrial environment have different demands on an LED controller: in buildings (e.g. home automation) a large number of LED lights are often installed. Attention here is focused on low installation costs, low wiring expenditure, error-tolerant installation techniques and the lowest possible channel prices of the decentralized ballasts. In the mechanical engineering environment the attention is focused more strongly on the reliable and high-quality operation of an individual source of light because it operates, for example, as a functionally relevant flash lamp for a camera, as an obstruction warning lamp on a wind turbine or on shipping lanes, or as a true-color light for inspection systems. Since high-quality lights are used here, the user expects comprehensive diagnostic information and real-time feedback from the power circuit for their operation and commissioning.

**EL2595 EtherCAT Terminal controls supply of current to LEDs**

For quite some time now, Beckhoff has offered I/O modules for the voltage-controlled operation of LEDs, such as the EL2502 PWM output terminal (2 x 24 V/0.5 A), the KL2512 Bus Terminal (2 x 24 V/1.5 A) or the EL2262 (2x 24 V/0.5 A), with which the PWM signal is calculated in TwinCAT PLC software. The EL/KL2535 as well as the EL7332 and EL7342 terminals, which regulate the output current, require an inductance in the load such as the DC software. The EL/KL2512 Bus Terminal (2 x 24 V/0.5 A), the KL2595 as well as the EL2502 PWM output terminal, the EL2262 and the EL/KL2535 can be used for non-integrated special tasks in the bus system and to adopt the logic behind it into the central PLC code. As a limited resource, the engineering know-how on the user side can thus be shifted to the in-house implementation of the function, in this case the obstacle light control, instead of the engineering of the interface specification. The result is direct real-time access to performance data and simple parameterization with complete user access down to the lowest level: instead of elaborate commissioning tests, the lighting function can be designed in advance on the PC. The final integration step can then be color and brightness sensors in the EtherCAT system, which retroact on the EL2595 LED controller in real-time via PLC control loops.

The new Beckhoff EL2595 LED terminal specifically covers these requirements. As a highly efficient, constant current source on an (approximately) resistive load, it is designed to supply an LED strand made up of series-connected LEDs with a continuous current of up to 700 mA. It automatically generates the required forward voltage for LEDs ranging from 2 to 48 V from the supply voltage of 24 V. The LED can be dimmed by specifying the setpoint value for the current. For monitoring and commissioning, the input current/voltage and output current/voltage can be read along with the process data and monitored, for example, using the TwinCAT Scope 2 software supplement. The terminal itself goes into the warning or error state in the case of exceeding defined operating windows; i.e. it resets itself automatically or, optionally, requires an express reset.

For the standard operation of a light the output from the PLC can be set like a normal output. The EL2595 is suitable for fast, repetitive and precise lighting procedures. It represents the high performance XFC (eXtreme Fast Control) I/O extension and is timestamp-capable with Distributed Clocks; i.e. the start time (resolution of 1 ns) and pulse length (from 1 μs) can be set from TwinCAT. The EL2595 then automatically outputs the pulse at a defined time with the specified constant current intensity. A higher output current than 700 mA is often useful; the EL2595 can also supply that briefly.

**Obstacle light control is designed in advance on the PC**

Until now, black boxes have been implemented in many applications on sometimes functionally limited interfaces for special tasks. This additional hardware level does not result in a lean integration of all functions. The EL2595 is a further EtherCAT module from Beckhoff that enables the user to take over the function of non-integrated special components in the bus system and to adopt the logic behind it into the central PLC code. As a limited resource, the engineering know-how on the user side can thus be shifted to the in-house implementation of the function, in this case the obstacle light control, instead of the engineering of the interface specification. The result is direct real-time access to performance data and simple parameterization with complete user access down to the lowest level: instead of elaborate commissioning tests, the lighting function can be designed in advance on the PC. The final integration step can then be color and brightness sensors in the EtherCAT system, which retroact on the EL2595 LED controller in real-time via PLC control loops.

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