

Overcoming the technical challenges in implementing a driver-based method for detecting failed power LEDs

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Power LEDs are becoming the light source of choice in mission-critical applications such as traffic signals or airfield lighting. In these systems, it is important to alert the operator immediately when an LED fails. This article describes a highly integrated and low-cost method for implementing automatic failure detection.

LED biasing

In general, LEDs are current-driven: the luminous intensity of the LED is directly related to the forward current passing through the LED. The main task of an LED driver is therefore to keep a constant current passing through the LED.

When a current is applied to an LED, a voltage drop occurs across the diode. This voltage drop, called forward voltage, is determined by the typical current-vs-voltage characteristic of a diode. The threshold point of the forward voltage is dependent on the type and colour of the LED.

Power LEDs create considerable complexity, however, in relation to forward voltage. This is because the characteristics of power LEDs of the same type vary significantly due to variations in the production process.

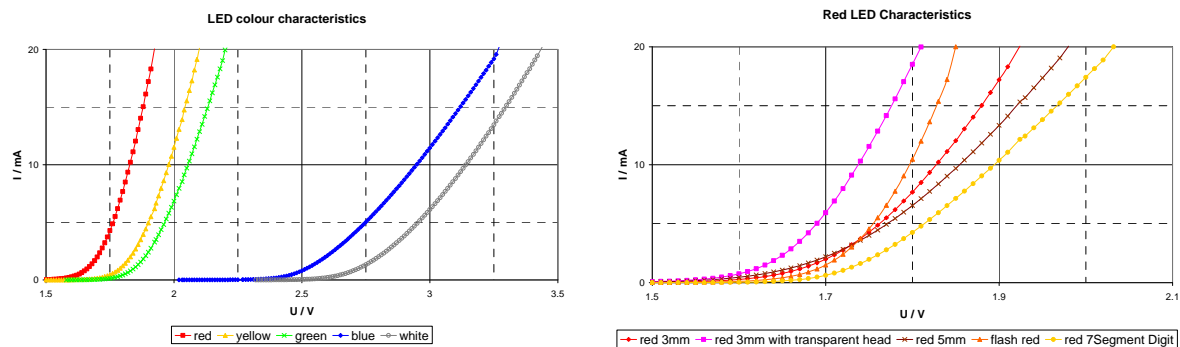


Fig. 1: I-V characteristics of LEDs of different colours. Source: austriamicrosystems laboratory

Figure 1 shows the I-V characteristics of LEDs of different types and colour (left-hand graph) and the variations of the I-V characteristics found in different types of red LEDs only (right-hand graph).

As can be seen, even LEDs of the same LED type and colour have different current-vs-voltage characteristics. As an example, for the HLMP-CB11-TW000 blue LED from Avago Technologies, the forward voltage is typically 3.2V at 20mA at an ambient temperature of 25°C; but this can vary in a range up to 3.85V at the same temperature (see Figure 2).

It is not surprising, then, that LED drivers are popular with solid-state lighting developers as a way of ensuring that an array of LEDs is fed the same current, to produce the same brightness.

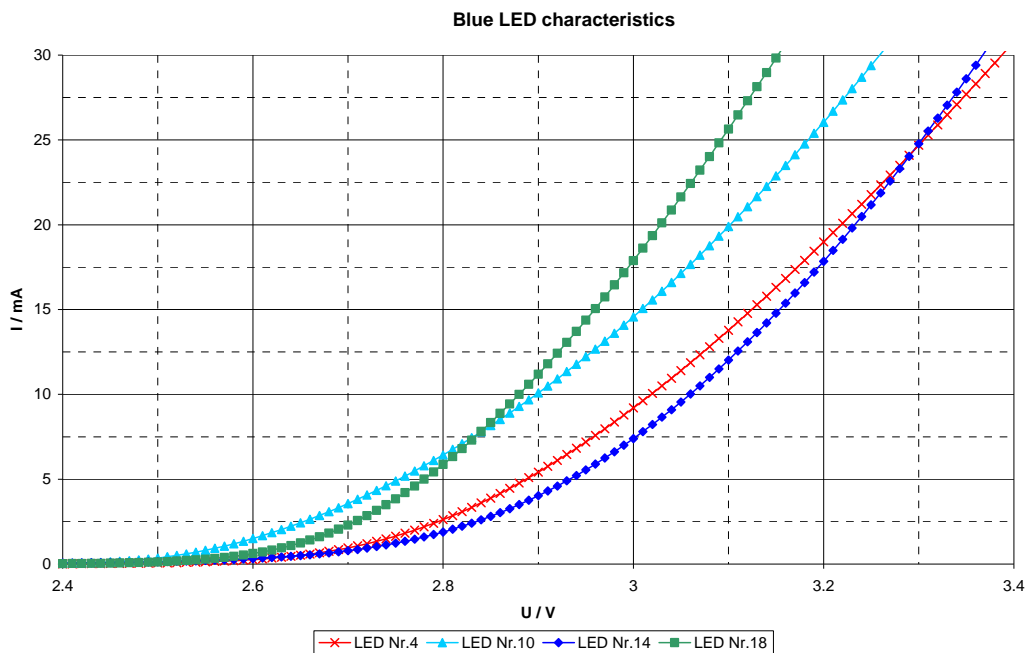


Fig. 2: I-V characteristics selection out of 20 samples of the HLMP-CB11-TW000 blue InGaN LED from Avago Technologies. Source: austriamicrosystems laboratory

LED failure mechanisms

There is also, however, a way to use the driver to implement a failure-detection function.

An LED lighting system can fail in one of two ways. On the one hand, the failure of the LED itself; on the other, mechanical failure of support systems or the power cable to the LED.

In the case of 'failure' of the LED itself, there is today no electronic method of detection. This is because LEDs do not burn out as an incandescent light source does; they simply get dimmer over time. Indeed, there is no distinctive effect that characterises the end of an LED's life. There is no standard or definition of lifetime or usable time either.

In mission-critical applications, the extent of the LEDs' dimming, and an appropriate LED-replacement schedule, can be determined by reference to the LED manufacturer's data combined with periodic optical tests on the system in operation.

Electronic circuitry can, however, detect failures in a lighting system caused by 'in-field effects'. Such effects can include mechanical defects in support modules, electrical contact problems caused by failed multi-point connectors, board soldering failures, maintenance mistakes, and faults such as accidental damage to a power cable.

Methods of error detection

In-field effects could short an LED or lead to power cable damage. The normal method of detecting an open or short circuit is to monitor the voltage of the Output Current pins of the driver. This could be achieved using two comparators at each Driver Output pin: one for detecting an open-LED failure, and another for detecting a short-LED failure.

But in addition, a module which creates an interface to communicate with the system's control software is needed. Put together, such a circuit requires a large number of components, which leads to high bill-of-materials and assembly costs (see Figure 3a).

The component count could be somewhat reduced by cutting the number of comparators to two, and adding a multiplexer to connect the driver outputs to the comparators for the defect-testing process.

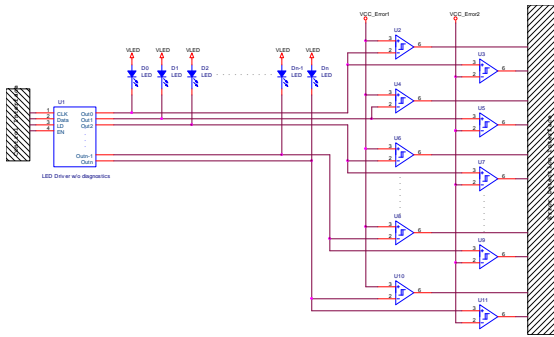


Fig. 3a: achieving error detection by use of comparators, and an LED driver with no built-in diagnostic capability

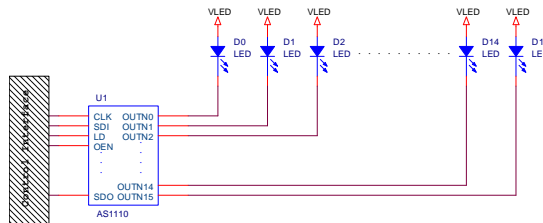


Fig. 3b: achieving error detection by using an LED driver (AS1110) with built-in diagnostic capability

The solution to this problem is to use an LED driver with integrated diagnostic functionality, such as the AS1109/10/12/13 devices from austriamicrosystems (see Figure 3b). The open-LED and shorted-LED detection functions in such a device are accomplished by comparing each voltage on the Output Current Driver pins and two threshold voltages, which are generated internally in the device. The first threshold voltage used for detection of a broken LED circuit (the open-LED condition) is fixed and cannot be changed. The second threshold voltage used for detecting short-LED failures is directly dependent on the driver's power supply voltage. (The voltage at the driver's Output pin has to be calculated carefully, taking into account the wide variations in the forward voltage of LEDs.)

Open-LED and shorted-LED detection is based on the comparison of the voltage at the Output Driver pins and two different threshold voltages, V_{THL} and V_{THH} , which are generated internally. The threshold voltage V_{THL} is used for detection of an open-LED condition. For reliable failure detection, the voltage at the output current driver, the cathode of the LED, has to be higher than V_{THLmax} .

A shorted LED is detected by comparison of the voltage at the output current driver with the internally generated reference voltage V_{THH} , which is directly dependent on

the driver's power supply voltage. In order to ensure the detection of a shorted LED, the voltage at the operating LED's cathode terminal has to be lower than V_{THHmin} , otherwise a properly functioning LED could be mistaken for a shorted LED.

In both cases the design parameter susceptible to change by the application's designer is the LED supply voltage.

This method of detecting LED failures due to in-field effects succeeds, then, in reducing component count and system cost by using diagnostic functionality integrated in the LED driver. The designer must, however, take account of the LED's forward voltage spread in setting the LED's supply voltage.