A New LED Controller Technology to Expedite the Next Level of Smart Lighting

Lighting installations that use artificial lighting and often deemed more comfortable and energy efficient are generally referred to as "Smart Lighting". While no clear definition exists "Smart Lighting" has become a common catch phrase. Kurt Marquardt, Senior Director LED Lighting Systems and Product Marketing, Infineon Technologies has a more accurate definition. For him, the term "smart lighting" describes the capability of the lighting system to adapt automatically to the needs of the users and the room. He presents an alternative way to implement smart lighting systems, using the new XDPL8221 digital LED-driver IC [1].

Many lighting installations are conceived to make the use of artificial lighting more comfortable and energy efficient. Usually, systems with such features are referred to as "Smart Lighting". This buzzword is used to promote a variety of features: starting from simply connected luminaires - potentially with smartphone control - up to a fully connected lighting installation with sensors and devices controlled through a cloud application. However, a common denominator of all definitions is the demand for communication and information, but there is more that can be expected from "Smart Lighting".

Addressing smart-lighting features and customer requirements can add significant cost to lighting installations. Extra costs are caused by additional sensor components and the need for microcontrollers with numerous ADC channels. A microcontroller may also be required to control multiple operating parameters, including controlling LED-array brightness and dimming level. Sometimes the microcontroller's influence on the system/driver control may cause unwanted instabilities within the system. This is seen as variation of brightness, usually called flicker, and non-linearity of the brightness control, and luminaires that turn dark due to software bugs.

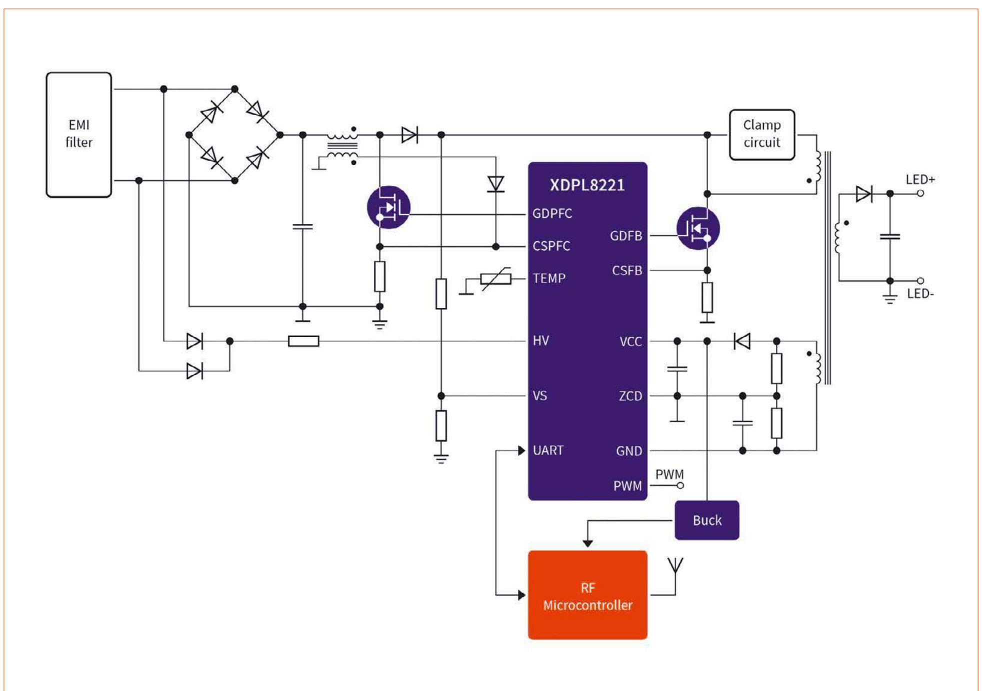

Figure 1: Schematic of the driver application and the inclusion of the UART for control and analysis

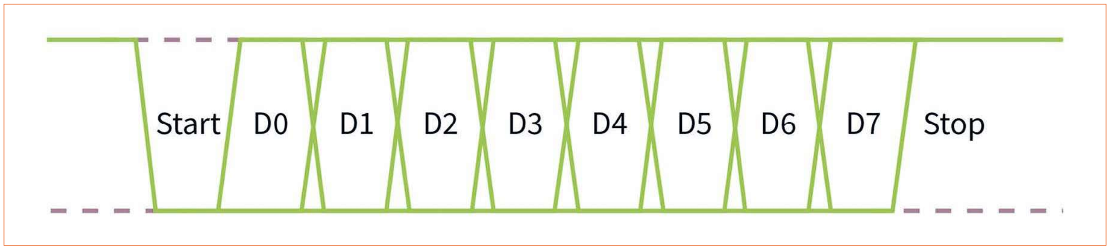

Figure 2:
Principle waveform of the UART and basic concept of a byte frame

A UART as Key Element for "Smart Lighting"

The distinctive 'universal asynchronous receiver transmitter' (UART) serial communication interface offers a new measure for control and analysis. The UART communication can control the power conversion in an AC/DC converter as a typical mixed-signal controller, with the added benefits of updates, communication, and storing the data of the converters health and operating conditions. System issues and failures like output over- or under-voltage can be instantly tracked through the UART monitoring functions. It permits to keep an eye on the device functioning or activated protections, bringing the considerable benefit of accurately determining the nature and location of any deficiency. This eases then the issue analysis process and permits to save costs and time by supporting a technician to identify the failing device, fix it instantly and efficiently thanks to the information read through the UART interface. In short, maintenance personnel can be purposefully sent to the right place with the needed replacement parts to fix the failing device. This saves significant cost as the maintenance personnel does not need to browse through the buildings to find failed devices and fetch the spare part from stock until repair can start.

Additionally, real-time measurement data are available via the UART. Operating data, like output voltage and output current, can be read at any moment. The constant availability of these values permits, for example, to determine the actual output power, and therefore gives insight into detailed information about the device's power consumption, and manage it. Moreover, regular monitoring of LED current/voltage provides insight into the device aging. This allows the user to analyze the healthiness of the device and therefore permits the planning of maintenance. With this predictive maintenance, only necessary activities produce cost and downtimes are minimized. Considering a large building equipped with LED luminaries, the existence of a UART in each of these luminaries makes it possible to access the real-time data in every LED array. Any device showing deviations from 'normal' could be precisely detected, and therefore easily replaced before final failure.

UART Commands and Basic Functionality

The UART's SET commands can influence many operating modes. For instance, the SET command configures the behavior of power conversion in multiple ways, i.e., determining the value for the maximum output defines the maximum brightness of the LED. Additionally, the SET command, which sets the dimming level, determines the final brightness. The numeric values of the parameters in the SET command eliminate uncertainty in recognition of an analog or PWM input signal. In PWM, for example, imprecise data results from the sampling of the input signal for measurement. During the input sampling and quantization, for the high and low times, the precision of the calculated duty cycle depends on the sampling frequency, the threshold for the input stage, or the slope of the input signal. Inaccuracies of both high- and low-time measurements add up to the uncertainties of the duty-cycle value. Higher sampling frequency would reduce the error at the price of higher energy consumption and additional noise. Whereas the UART provides exact numerical values without any inaccuracies.

Multi-Control Operation: One Hardware Design for Various Drivers

Another highlight is the multi-control operation, with the automatic selection of constant current (CC), constant voltage (CV), and limited power (LP). This facilitates its use for a wide variety of LED-driver products, based on the same hardware design. The mode is selected in accordance with the operating situations such as load and configuration. The LP mode is a special feature and allows utilizing the limits of the hardware to the full extent without jeopardizing safe operation. During LP mode, the device controls current and voltage in a way that the output power never exceeds the defined value. An additional advantage of this mode is the safe operation of cold LEDs, for example, in outdoor luminaires. In fact, the LED forward voltage and temperature are inversely proportional. This constitutes a problem in conventional constant current controls, which might run into overvoltage protection before any current flows through the LEDs. The result of this behavior might be that illumination will not start up from low temperatures. On the contrary, the new driver concept guarantees that it will at least drive current until the maximum output voltage is reached, which can be much higher than usual as the maximum power is also taken into account if some current reduction is doubted.

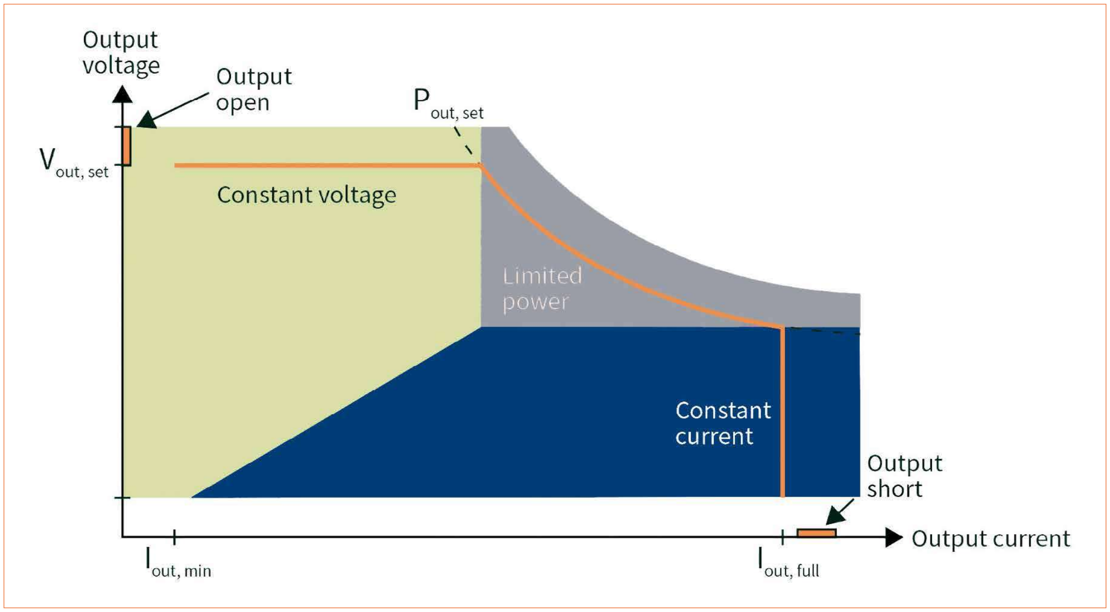

Figure 3:
Safe operation area and protection functionality

The market demand for ever-expanding LED-driver lifetime requires thorough design, testing, including ´highly accelerated lifetime testing´ (HALT), and ´highly accelerated stress testing´ (HAST), and that the controller recognizes potentially dangerous situations and reacts appropriately.

Protection Features

A comprehensive set of protection features makes the new driver robust against failures and unsafe conditions. Two of the protections are output under- and overvoltage protections that commonly occur when the output is shorted or disconnected from the LED array.

As desired for up-to-date LED drivers, it offers multiple parameters to configure the reaction; this includes the override of the default reaction, such as auto-restart or latch mode. Furthermore, an adjustable blanking time permits monitored signal perturbations due to the possibility of masking the switching noise and disallowing false triggering of the protection schemes.

Similarly, the input over- and under-voltage protection allows for a flexible system while maintaining stability from adverse events on the AC line. This allows, for example, the adaptation of the LED driver behavior to a weak power grid. In fact, frequent voltage fluctuation in these grids usually triggers the under-voltage protection for classic devices. The IC offers, in contrast, a more significant margin by configuring the threshold values and prevents most light-off situations due to grid fluctuations.

Another important feature is over-temperature protection as the long-term reliability of the LED array and the LED driver is often dependent on their operating temperature and exposure to over-temperature events. An internal or external temperature sensor can be employed to sense, and trigger this protection function. The internal sensor protects the IC and any external components that have sufficient thermal couplings with the device. The external sensor can be placed strategically to protect external components such as transformer, MOSFETs or the LED array.

The internal temperature protection initiates a shutdown in case the temperature exceeds a critical level. The external temperature protection reacts if a critical 'negative temperature coefficient' (NTC) resistance passes a threshold. This feature provides additional functionality like adaptive temperature protection. It reduces the output current until the temperature is below the respective threshold to protect the load or the driver against over-temperature. Its functioning principle is quite simple: as long as the resistance of the NTC is below its temperature threshold, the driver reduces the current by a programmable step size. Once the resistance of the NTC is higher than the temperature threshold, the device increases the output current stepwise again. In short, the controller ensures operation below a critical temperature extending the operating life of the driver. If a reduction down to a minimum current level does not stop the over temperature situation, it will then trigger over-temperature protection and shuts the LED current off. For all over-temperature protection cases, the controller will only restart after the temperature drops below a configurable threshold. Over temperature-protections are essential to ensure the safety of users by preventing severe accidents and by saving components from failures. In fact, high temperatures are generally associated with faster device aging and deteriorating performance. Additionally, the GET command of the UART, temperatures can be read out. This enables the user to implement regular monitoring of the driver

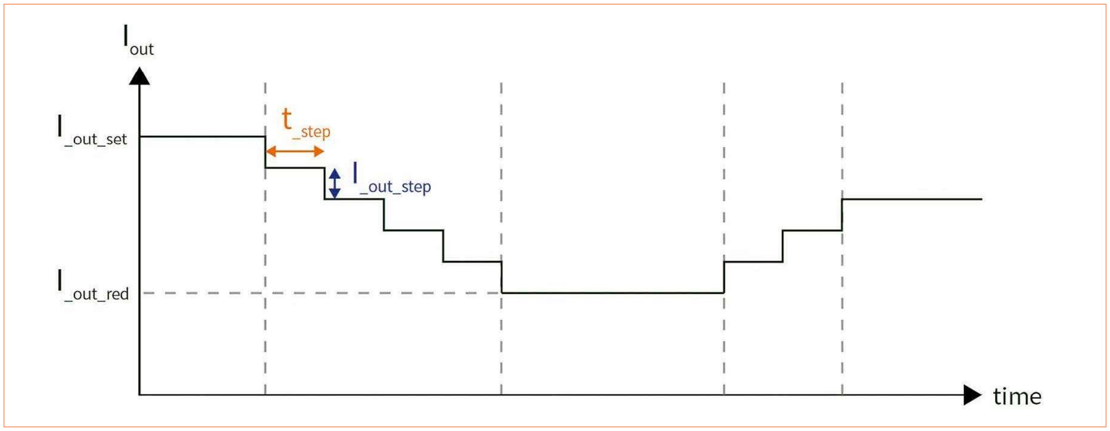

Figure 4: Adaptive operating principle of the external temperature protection opportunity

temperature. Some ways of using these data are the recording of temperatures, forecasting the lifetime of the driver, and supporting predictive maintenance.

The extensive set of configurable protection mechanisms ensures safe, reliable, and robust LED drivers for a wide set of use cases.

Conclusion

Unique features like the UART interface, multi-control-operation mode, or the incorporation of robust and comprehensive protections make this solution an excellent LED-driver IC and a perfect match for sophisticated applications. It is also worth mentioning that the driver was designed for primary side regulation (PSR). PSR permits to save external components and reduce noise. Programmable parameters similar to multimode operation enable using the same hardware for several applications thanks to a simple software configuration and then saves many different variants, making it possible to save costs thanks to a smaller bill of materials (BoM). ■

References:

[1] XDPL8221, www.infineon.com/xdpl8221