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Smart lighting control: First NFC configuration IC with integrated CLO

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Shedding new light on NFC programming for LEDs

Using a PWM output to control analog LED-driver ICs directly

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In the LED market, more and more LED power suppliers to offer two novel functions: near-field communication (NFC) programming and constant lumen output (CLO). The NFC programming function is designed to replace the labor-intensive "plug-in resistor" current setting method to improve the flexibility across the value chain. Products with the CLO function can compensate for the luminous flux drop (aging effect) of the LED module by adjusting the LED current during the lifetime. Besides gaining customer satisfaction with improved lighting quality, this function is also beneficial for the environment since it reduces the total energy consumption by avoiding overcurrent for most of the lifetime.

However is there a cost-effective solution in NFC for lighting applications that can target the cost-sensitive middle- and low-end LED power supply markets? In this article, we expose a new concept from Infineon that offers full flexibility via NFC function to its customers' convenience.

The promise of NFC technology for lighting

NFC programming in LED luminaires is a relatively new concept. The term, NFC, refers to a set of communication protocols that enable devices to communicate wirelessly if they are in a near distance from each other. In the lighting world, it is used to set the operating characteristics of the LED luminaires wirelessly and mains-voltage freely. The transmitted parameters are pre-defined and configurable for a desired setting of the luminaire. It is faster and simpler than traditional LED programming ways and can enable more feature-rich and flexible LED driver products.

The system consists of an NFC reader (the hardware) and an NFC tag integrated into a driver. This NFC tag is responsible for data storage. The NFC reader is connected to a host PC. This PC instructs, and an application software controls the NFC reader to program the NFC tag wirelessly via NFC commands. The transmitted parameters are pre-defined and configurable in the application software based on the manufacturer's specifications for a desired setting of the luminaire.

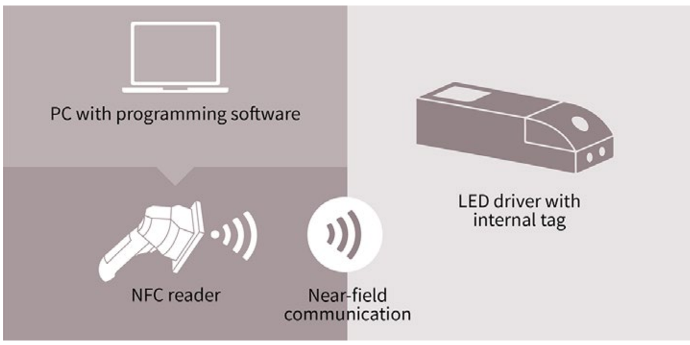

Figure 1 NFC programming of drivers – system overview

What makes NFC attractive for an LED-driver use case compared to other wireless communication technologies? Its unique characteristics, such as:

- The nature of the short-distance communication ensures that only objects at a defined physical position are contacted and programmed. This feature is highly beneficial in the manufacturing environment, and can significantly reduce the complexity of the identification, and the authentication process.
- In a system that consists of an NFC reader and an NFC tag, the tag can operate passively (without an external power supply). The power is harvested from the RF field sent by the NFC reader. Thus, an object equipped with an NFC tag can be programmed in the assembly line without the need to connect to a power supply. It is a huge advantage that can improve operational efficiency.
- Operating in the globally available 13.56 MHz unlicensed radio frequency ISM band, and following well-defined standards allows for large-scale global rollouts.
- Its low data rate (106 to 424 kbit/s) and low frequency (13.56 MHz) reduce the complexity of the hardware design. A low-cost printed PCB antenna is sufficient for the application. Compared to other wireless communication technologies such as BLE, its hardware cost is relatively low.

Apart from technical advantages, there may be other benefits for all stakeholders across the LED-lighting value chain. For instance, a LED-driver vendor can set the product current level automatically in the manufacturing line to save labor cost, and even adjust it just before shipment to any warehouse worldwide. It provides supply chain flexibility and can save substantial logistic costs. The output tolerance level of an LED driver can also be significantly improved after taking in-production calibration. More important, your product gives more freedom and flexibility to your customers. Manufacturers can easily program the LED driver to match with the LED module. This makes it easier to change the vendor of the LED modules. Also, the light output can be more precisely controlled since the stepwise adjustment using plug-in resistor is replaced by a continuous adjustment using NFC programming. Logistic complexity – triggered by varying national standards - can also be reduced by doing shipment-destination-based NFC configuration.

At last but not at least, additional services are made possible at the installation stage. It is easy to set up any tailor-made lighting configuration that perfectly matches the user's specific needs. Now let's have a look at how NFC function is traditionally implemented in lighting systems.

The NFC-microcontroller concept

The existing implementation concept consists of a microcontroller and an NFC dynamic tag. Although this solution has its potential, it is expensive for the following reasons:

- The microcontroller itself and the additionally required passive components increase the overall component count
- A multi-layer PCB is needed (if the LED driver is using a single-layer or two-layer PCB, a separated daughter card is needed).
- In addition, to enable the microcontroller to operate, the user has to write firmware. It can be challenging for some manufacturers who lack the experience and knowledge in software writing or microcontroller firmware.

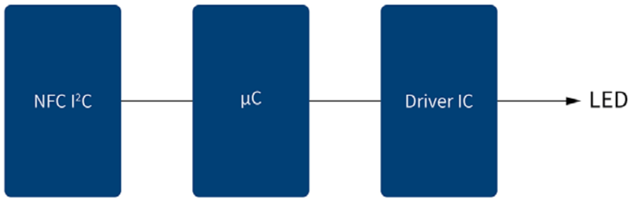

Figure 2 The NFC-microcontroller concept

So, is there a more compact solution that reduces component count, thus costs and still effective? This is where Infineon comes into place with its new NFC-PWM concept.

The new concept: the NFC-PWM series

This solution enables both NFC programming and CLO functions in analog systems using a featured NFC IC with PWM output to control the analog driver IC directly. Thus, the need for a microcontroller is eliminated.

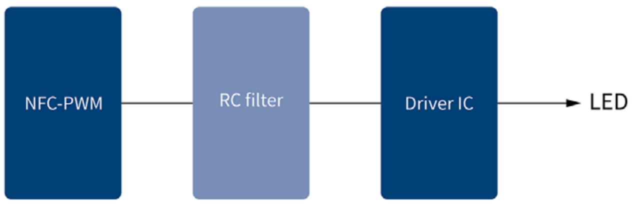

Figure 3 Infineon's NFC-PWM concept

The system in a general setup consists of four parts: the antenna, the NFC IC, the RC filter, and the LED-driver IC.

How does this work? The working principle is simple. The configuration of the PWM parameters happens via a wireless NFC interface. While being powered, the chip generates a PWM output.
Then the PWM signal is converted (via the RC filter) to DC voltage to control the output current.
And finally, by adjusting the duty cycle of the PWM signal, it regulates the DC control voltage.

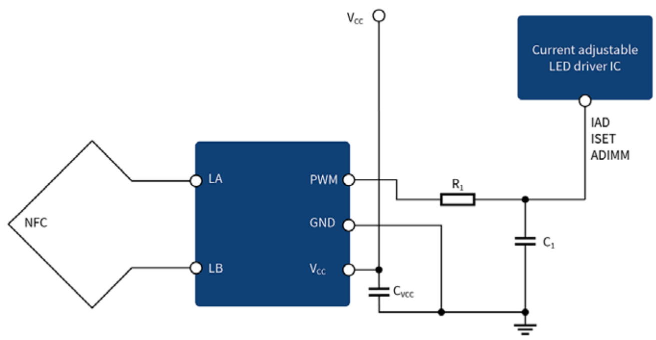

Figure 4 Application diagram

Being compatible with existing analog LED-driver designs and the NFC programming specification from the Module-Driver Interface Special Interest Group (MD-SIG), makes this new NFC-PWM concept a perfect fit for cost-sensitive segments.

The NFC-PWM method relies on dual-mode NFC configuration ICs (NLM0010 and NLM0011*) with PWM output primarily designed for LED applications. In addition to the NFC programming advanced features like CLO, operating-time counting, and on/off counting are also integrated into the chips - without the need for any additional microcontroller or firmware development efforts.

The PWM parameters

The pulse width modulation (PWM) signal consists of three main components that define its behavior: an amplitude, a duty cycle, and a frequency. The duty cycle describes the amount of time the signal is in a high (on) state as a percentage of the total time it takes to complete one cycle. The frequency determines how fast the PWM completes a cycle. A simple RC filter can convert the PWM signal to a DC voltage. The level of the DC voltage is therefore adjustable by modifying the PWM amplitude or the PWM duty cycle and can be calculated as follows:

$$V_{target} = DC \times (V_{oh} - V_{ol}) + V_{ol}$$

Where DC is the duty cycle of the PWM, V_{oh} is the high voltage of the PWM output, and V_{ol} is the low voltage of PWM output.

Since the stability of the PWM signal has a direct influence on the tolerance level of the finished LED power supply, it is important to evaluate the tolerance requirement and the NFC IC capability at an early design stage. The critical NFC IC parameters are the duty cycle and the absolute PWM amplitude (Voh - Vol).

The products in the NFC-PWM series generate a PWM signal with a fixed amplitude at 2.8 V. Thanks to the integrated voltage regulator (LDO), the level and the stability of the external supply voltage does not influence the PWM amplitude. The duty cycle can be configured between 0% - 100% with an accuracy level better than 0.1 percent. The PWM resolution depends on the selected PWM frequency: 15 bit @ 1 kHz or 10 bit @ 30 kHz. Therefore, with Infineon's new NFC-PWM series, customers can achieve the required tolerance level without any significant design efforts. An extreme low tolerance level can be achieved by adding an in-production calibration step into the production test.

CLO implementation

The CLO is a quasi-control system (self-regulating system) that fights the natural degradation of the LEDs' light output trying to maintain the luminous flux constant by regulating the LED current.
The NLM0011 IC has an integrated 8-point CLO table to store the degradation curve of the LED module. Manufacturers can program this curve according to their needs. As soon as the CLO table is programmed, the duty cycle of the PWM signal is then automatically adjusted to compensate for the LED degradation. The actual duty cycle as a function of the actual runtime OTC is calculated by linear interpolation between two adjacent reference points. The IC is continuously counting the operation time (OTC function) and is continuously interpolating the duty-cycle correction factor, which is then multiplied with the nominal duty-cycle value to get actual duty-cycle value.
Being compatible with existing analog LED-driver designs and the NFC programming specification from the Module-Driver Interface Special Interest Group (MD-SIG) makes this new NFC-PWM concept a perfect fit for cost-sensitive segments.
An industry leader in power management, Infineon delivers solutions for next-generation LED lighting systems. For more information, please visit www.infineon.com/nfc-pwm.
* coming soon