White Paper
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NFC programming in lighting

NFC current configuration and constant lumen output (CLO) functions in LED power supplies

Abstract

In the LED market, more and more LED power supplies 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 in the most of the lifetime.

NFC programming and CLO, as of today, are typically implemented in high-end LED power supply products where a microcontroller is available. In high volume, the cost-sensitive middle- and low-end LED power supply markets and customers are looking for more cost-effective solutions.

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1 NFC technology and programming for lighting applications

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. This technology has been already widely used in various applications such as contactless payment.

NFC programming in LED luminaires is a relatively new concept, applied to set the operating characteristics of LED luminaires wirelessly and mains-voltage freely. It is faster and simpler than traditional LED programming ways and can enable more feature-rich and flexible LED-driver products.

Figure 1 shows the system setup of NFC programming for lighting applications. It consists of an NFC reader (the hardware) and an NFC tag integrated into a driver, which is responsible for data storage. The NFC reader is connected to a host PC that instructs it. An application software controls the NFC reader to program the NFC tag wirelessly via the 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.

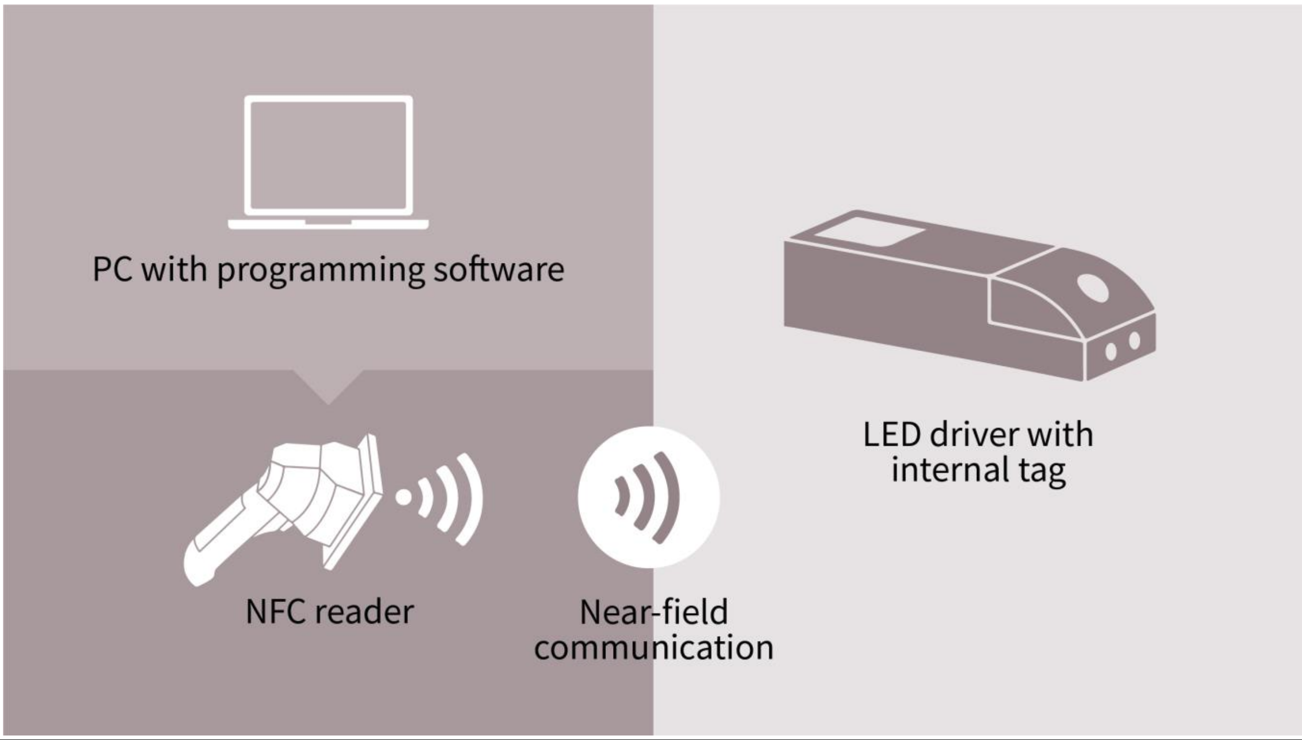

Figure 1 NFC programming of drivers – system overview

Compared with other wireless communication technologies, NFC has its unique characteristics which are attractive for an LED-driver use case:

- 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 authentication processes.
- 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.

Besides technical advantages, all stakeholders across the LED-lighting value chain can benefit from using an NFC interface:

- The LED-driver vendor can set the product current level automatically in the manufacturing line, thus saving labor cost, and even adjust it just before shipment to any warehouse worldwide. It provides supply chain flexibility, and can save substantial logistics costs. The output tolerance level of an LED driver can also be significantly improved after in-production calibration. More important that the product gives more freedom and flexibility to their customers.
- The manufacturer of luminaires can easily program the LED driver to match the LED module, thus changing the vendor of the LED modules can be easily done. 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). Logistics complexity related to the national standard can be reduced by doing shipment destination based NFC configuration.
- An installation service company can offer additional services to the end customers, such as individual room lighting configuration.

2 NFC programming system concepts for lighting applications

As exposed in the previous chapter, NFC programming of the LED drivers is a futureproof concept. It can bring numerous advantages to all stakeholders throughout the entire value chain. The main question at the moment is how to implement it effectively and efficiently.

2.1 The traditional concept: microcontroller + NFC interface

The existing implementation concept of NFC programming features a microcontroller and an NFC dynamic tag as showed in Figure 2. 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

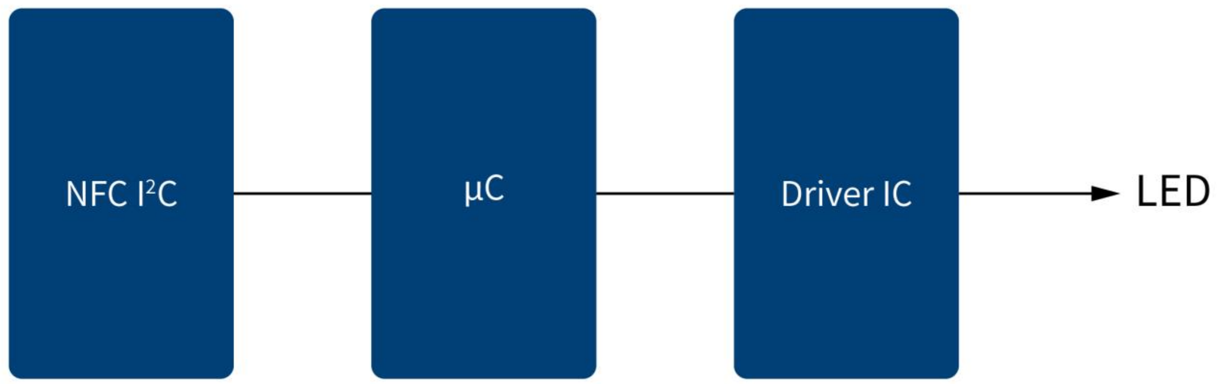

Figure 2 The traditional NFC-microcontroller concept

2.2 The new concept from Infineon: the NFC-PWM series

Infineon's new NFC-PWM approach is to use a featured NFC IC with PWM output to control the analog driver IC directly. Showed in Figure 3. Our solution can enable both NFC programming and CLO functions in analog systems without the need for microcontrollers. The solution is compatible with existing analog LED-driver designs and the NFC programming specification from the Module-Driver Interface Special Interest Group (MD-SIG).

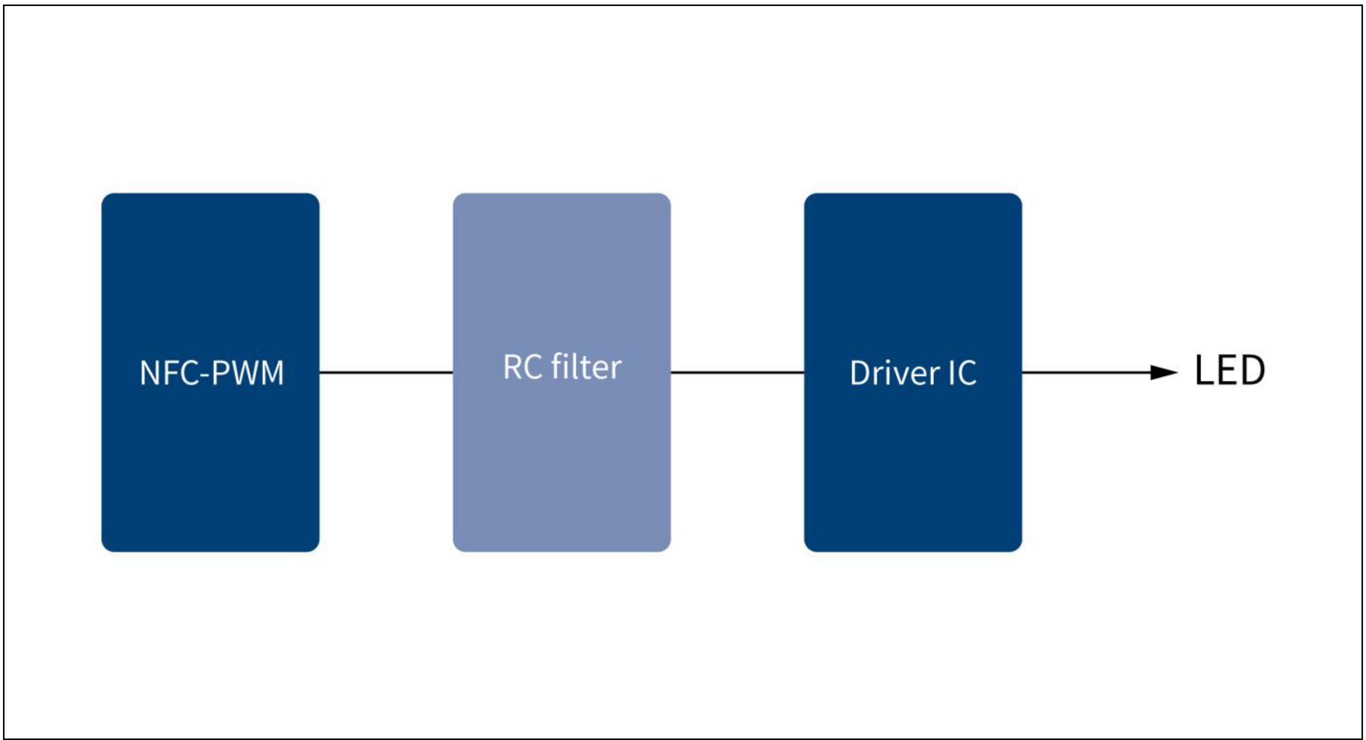

Figure 3 **Infineon's NFC-PWM concept**

2.2.1 Working principle of the NFC-PWM series

Figure 4 shows a typical application diagram using the products of Infineon's NFC-PWM series. It consists of four parts: the antenna, the NFC IC (e.g., NLM0011), the RC filter, and the LED-driver IC. The working principle is as follows:

1. The customer configures the PWM parameters via a wireless NFC interface.
2. While powered on, the chip generates a PWM output.
3. The PWM signal is converted (via the RC filter) to DC voltage to control the output current.
4. Adjusting the duty cycle of the PWM signal regulates the DC control voltage.

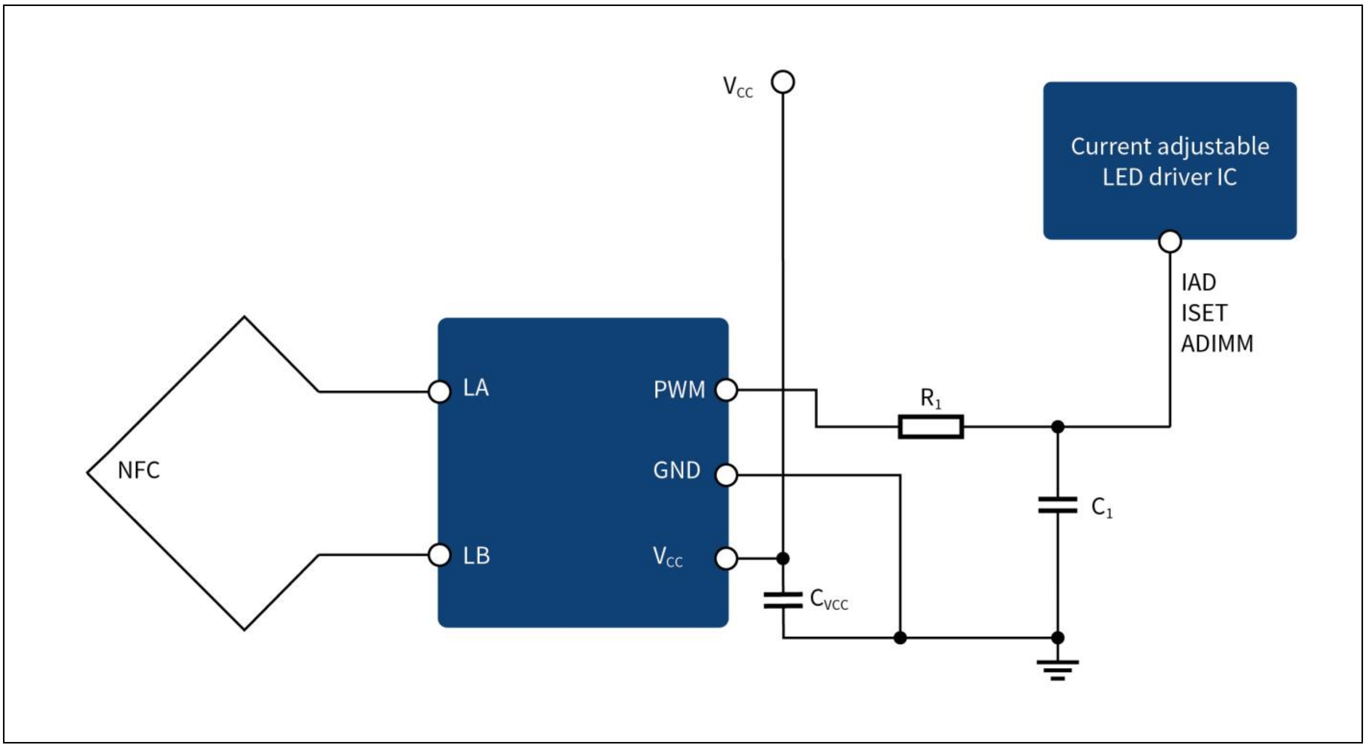

Figure 4 Application diagram

2.2.2 Features of the NFC-PWM series

The products in the NFC-PWM series, the NLM0011 and NLM0010, are dual-mode NFC configuration ICs with PWM output, primarily designed for LED applications. In addition to the NFC programming advanced features like CLO, operating-time counting (OTC), and on/off counting are integrated. Customers can easily enable these without the need for any additional microcontroller. No firmware development efforts are required, and the device can be easily adapted in existing designs.

2.2.2.1 Operation modes

The NLM0011 has two operating modes: configuration and lighting mode.

1. In configuration mode, when the LED driver is not powered (no V_{cc} applied to NFC IC), the energy that is harvested from the RF field (sent from NFC IC) supplies the power to the NFC reader. The parameters stored in NVM can be contactless configured via the NFC interface.

2. In lighting mode, as soon as the LED driver is under power (V_{cc} applied to NFC IC), a PWM output is generated according to the stored parameters. In this active mode, the NFC interface is disabled.

2.2.3 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

$$V_{target} = DC \times (V_{oh} - V_{ol}) + V_{ol} \qquad \text{Equation 1}$$

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 (V_{oh} - V_{ol}).

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.

2.2.4 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 integrated operation-time counter of the NLM0011 automatically records the accumulated operation time. The NVM value of the operation time is incremented/updated every 4 hours. The maximum countable operating time is 262114 hours, and the time counter value is frozen once this limit is reached. In the case of switch-off, the undervoltage-lockout function detects the event, and stores the value of the last count cycle (hours and minutes) in the NVM. As a result, ± 30 s timing counting accuracy is achieved in each on/off cycle.

The NLM0011 also has an integrated 8-point CLO table to store the degradation curve of the LED module. LED luminaire manufacturers program this curve according to the LED selection. 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 NLM0011 is continuously counting the operation time 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.

Note: The NLM0010 is a light version without CLO function.

3 Summary

In this paper, we presented a new NFC-PWM concept that enables fast and cost-effective NFC programming for LED lighting without the need for an additional microcontroller. A new NFC-PWM series (NLM0011, NLM0010) was developed and qualified by Infineon to enable its customers to implement this new concept. In addition to the NFC programming, novel features such as the integrated CLO function, operation-time counting, and on/off counting are also integrated into the NLM0011 for the LED lighting manufacturers' greater convenience.

References

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[2] NFC Programming of LED Driver Parameters Is Standardized by MD-SIG (March 14, 2018), LED Professional, https://www.led-professional.com/resources-1/standardization/nfc-programming-of-led-driver-parameters-is-standardized-by-md-sig

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