LITIX™ Power

Multitopology controllers with PWM dimming through power line

About this document

This document explains how to manage pulse width modulation (PWM) through power line to dim light sources. The content is also useful for the design of welcome functions when fading is enabled through power line modulation.

Scope and purpose

The purpose of this application note is to inform the audience about possible implementations of dimmed light sources using the multitopology controllers of LITIX™ Power family. The devices covered by this application note are: TLD5095EL, TLD5097EL, TLD5098EL, TLD5097EP, TLD5098EP and TLD5099EP.

Intended audience

This application note is intended for designer engineers who want to have a clear view on how to manage the PWM dimming through power line.

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1   Introduction

Light sources play an important role in automotive environment. Early in automotive history, bulbs were used as light source only at front of the car merely to illuminate the road in front for the driver at night. After, OEMs added bulbs also at rear and for turn indicators to improve the road safety. Later, other light functions have been added, for example taillights and daytime running lights, mainly to increase the safety.

Later in 1980's OEMs started to use the same lamp for different functions, modulating the power delivered to the bulb with a PWM signal; daytime running light (DRL) dimmed down to position light (PL) is one of these cases. The main purpose of this challenge is to save a number of bulbs without reducing the overall safety.

The event of LEDs as light source in automotive forced the OEM to use DC/DC as driver for these kinds of lamps. To speed up the adoption of LED in the cars, DC/DC drivers provided by Infineon offer the compatibility with modulated power supply to enable two functions on the same light source as used in the past with bulbs.

2 System overview

In a car, light functions are usually managed by an electronic module that includes a microcontroller. This module is placed outside the lamp and it is frequently called body control module (BCM). BCM uses various types of communication systems to enable and diagnose the status of a lamp, including dimming scenario and animated features like welcome functions and wiping indicators.

In some applications, the LED driver module (LDM) has a microcontroller inside and in this case the communication between the BCM and the LDM is established through a communication bus. Dimming settings and faults are managed by the microcontroller into the LDM. An example of this architecture is depicted in Figure 1.
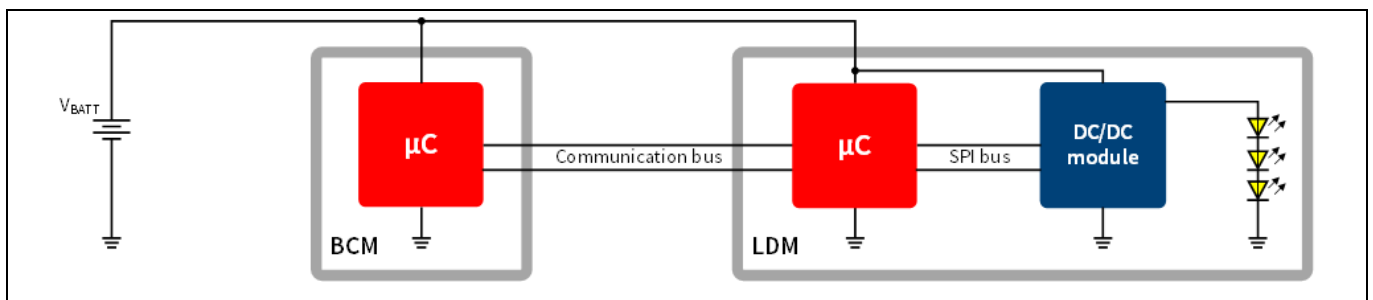
Figure 1 Simplified architecture of LED lamp with microcontroller controlled by BCM through CAN interface

For lower cost solution, microcontroller could be also not present inside the LDM. In this case, the BCM controls the dimming of LEDs through the power line merely modulating it with a pulse width modulation (PWM). Faults on LDM are detected from BCM by sensing a dedicated feedback signal from the LDM module. This solution is shown in the Figure 2.
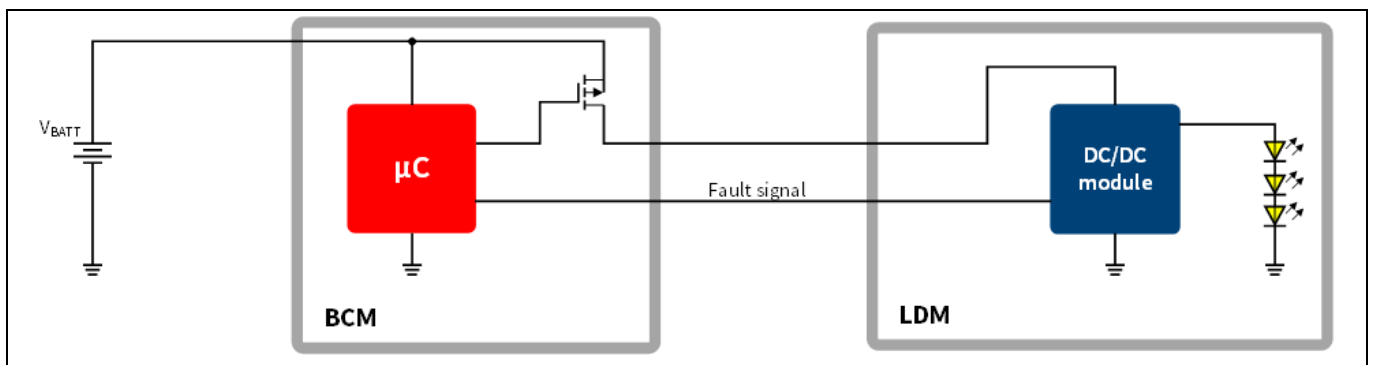
Figure 2 Simplified architecture of LED lamp controlled directly through BCM

In this architecture, the battery voltage modulated by the BCM is applied at the input voltage of the DC/DC module and internally it is also connected to EN/PWMI pin of the controller. In this way, when the voltage on EN/PWMI pin falls below its threshold, the DC/DC stops the switching activity.

Both presented LDM solutions need a PI filter at the input to fulfil EMC requirements (CISPR 25 standard), and a reverse protection device (diode or MOS) to protect the module from reverse polarity of supply line (ZVEI LV 124 standard).

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3   LDM without microcontroller hardware implementations

The main goal of the LDM is to drive the LEDs with a current as requested by the BCM. In particular the dimming/animation are much easier to implement when a microcontroller inside the LDM controls them. Otherwise some attention has to be paid when the power line of LED is modulated by the BCM.

The two architectures presented in Chapter 2 have some differences:

- In the first solution, the microcontroller inside the LDM enables all the animations and dimming functions; they are addressed by the BCM sending proper commands on the communication bus. Once received, they are exchanged between the microcontroller and the DC/DC module.

- In the second solution, the input V_{IN_LDM} comes from BCM; it is the battery voltage modulated by a high side switch.

An example of hardware implementation for the second architecture is shown in Figure 3. $V_{IN\text{-}LDM}$ is shaped by the reverse protection device and PI filter before supplying the DC/DC controller. EN/PWMI pin (EN/PWMI/PWMA pin on TLD5099EP) and the input voltage of the DC/DC controller are connected together.

In the low duty cycle scenario, when the input voltage falls to 0 V the voltage $V_{IN\text{-}DC/DC}$ discharges slowly and EN/PWMI pin detects delayed the falling edge of the PWM signal. When power supply has high duty cycle, $V_{IN\text{-}DC/DC}$ does not reach 0 V. In this scenario, EN/PWMI pin does not stop the DC/DC activity at the right time. As a result, the output current generated by the LDM does not fit the request of BCM sent by PWM through the power line.
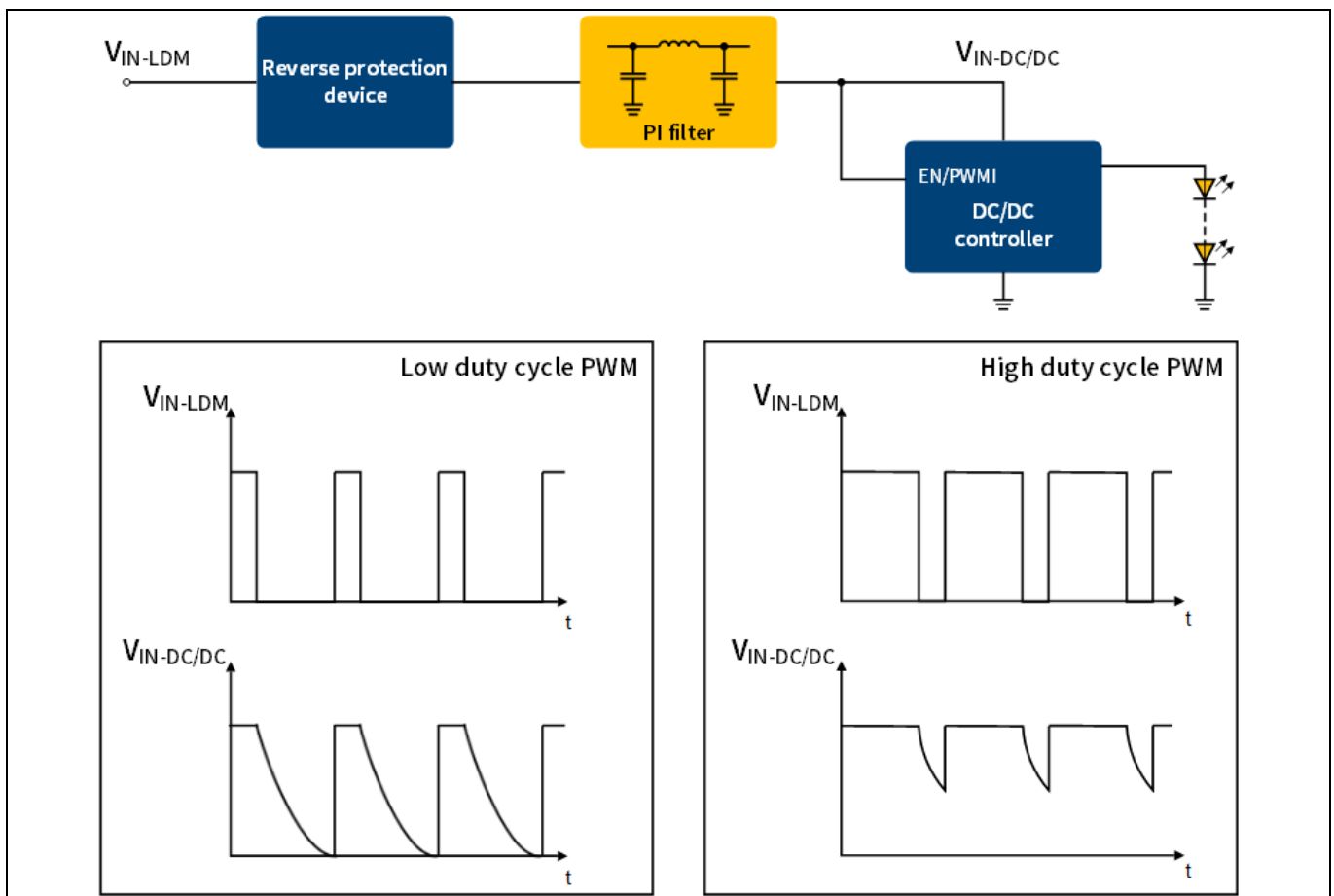

Figure 3   Shape of input voltage after PI filter plus rectifier

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A solution to increase the timing performces is depicted in Figure 4. The proposed circuit has EN/PWMI pin connected to V_{IN-LDM}. This connection grants the EN/PWMI pin to detect also fast pulses and then PWM with high duty cycle are processed without degradation of performances. Moreover, $V_{IN-DC/DC}$ shows almost no ripple, because the capacitors of PI filter are not discharged. Two scenarios of PWM duty cycle are sketched where the small ripple on $V_{IN-DC/DC}$ is highlighted.

No extra protection is needed for EN/PWMI pin against reverse polarity because this pin has maximum absolute rating from -40 V up to 45 V. The resistor R_{EN} is a pull-down device to discharge the capacitance of EN/PWMI pin; 1 to 10 kΩ is a good value for this application.
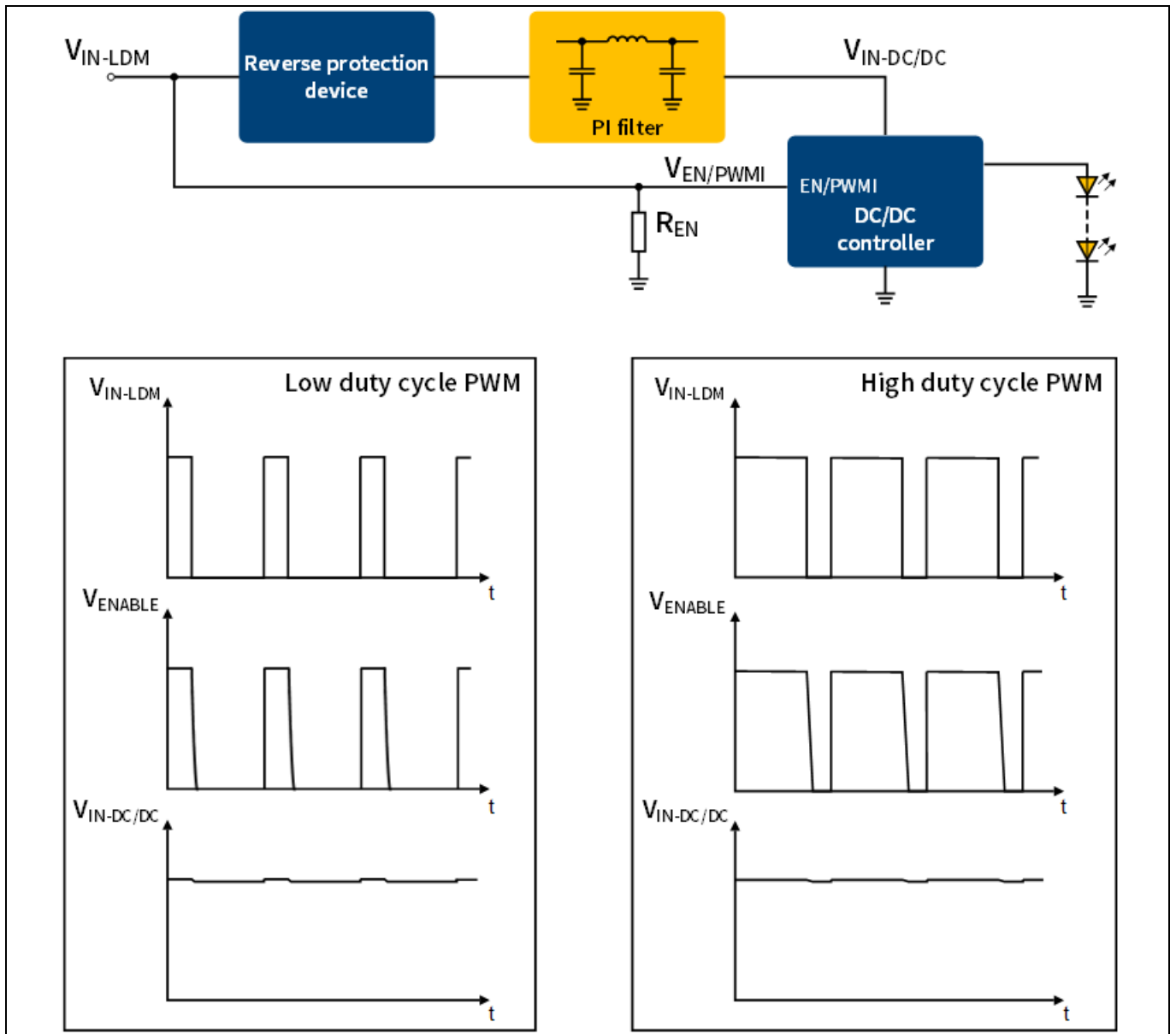
Figure 4   **Simplified schematic on connection of ENABLE pin**

In Figure 5 an example of the implementation using TLD5098EP is shown, while Figure 6 shows the waveforms from oscilloscope of V_{IN-LDM}, $V_{IN-DC/DC}$ and output current when at input a 200 Hz rectangular waveform with 99% duty cycle is applied. Measurements confirm that high duty cycle PWM signal applied at the input is well managed by the system.
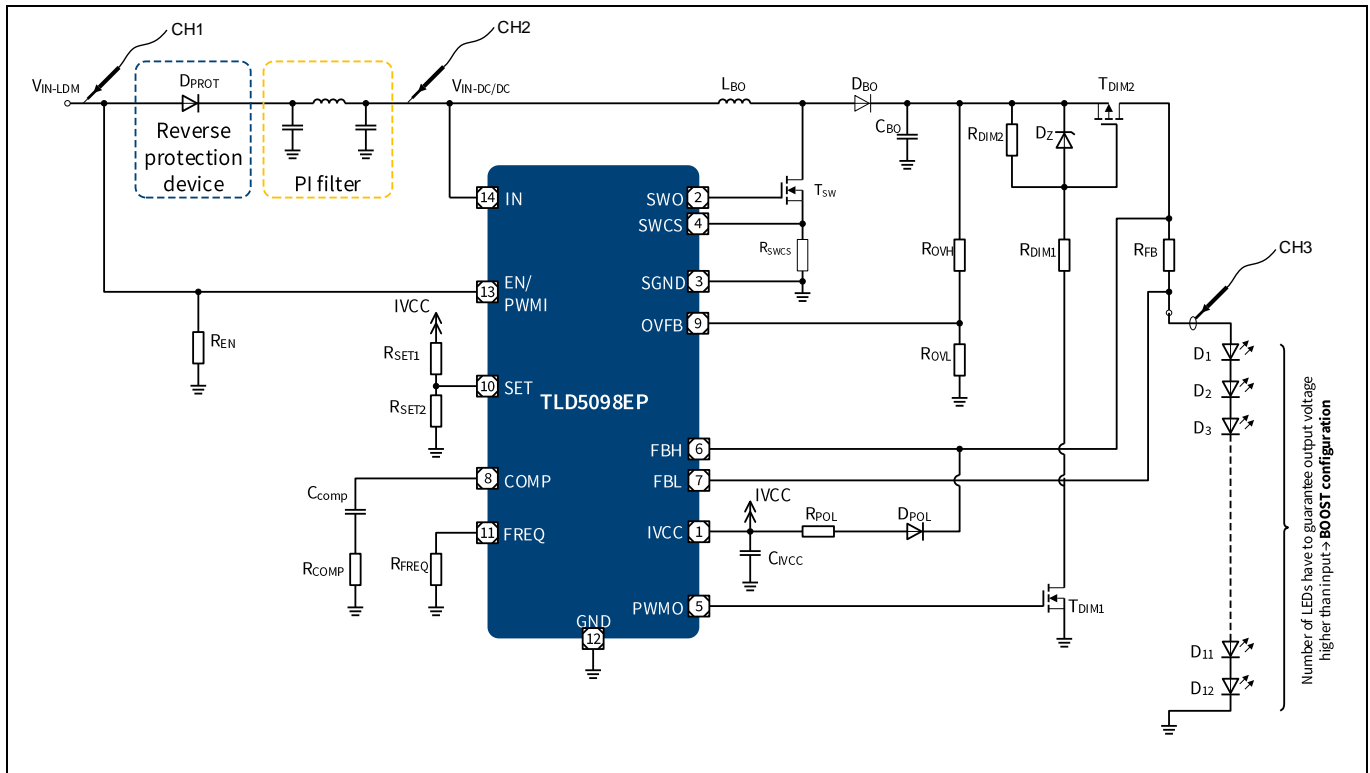
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Figure 5   Implementation of modulation through power line with TLD5098EP

Figure 6   Measurement on real case with TLD5098 with 200 Hz rectangular waveform with 99% duty cycle

4 Conclusions

In this application note a solution to manage PWM through power line is proposed.

Two architectures have been analysed; the suggested solution is to connect the ENABLE pin with the power input of LDM.

Reverse polarity protection for the EN/PWMI pin is not needed for either of the multitopology controllers of LITIX™ Power family, because they are internally protected. However, a pull-down resistor is needed to grant the good timing on current waveform at output.

This solution has also been validated by experimental results.

Revision history

Document version	Date of release	Description of changes
Rev.1.00	2019-11-29	First release

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