

How to Flexibly Configure an LED Driver for Automotive Headlights



Issac Hsu

Electronic technology has advanced so that an electronic control unit (ECU) is required to control the functions of full LED automotive headlights. An ECU consists of mainly LED drivers for headlight functions such as high beams, low beams, daytime running lights, position lights, turn indicators and fog lights. In this article, I'll explain the advantage of having a flexibly configurable LED driver.

When LEDs were first introduced into the automotive headlight space, high-side switches connected to LED drivers drove the corresponding LEDs in each of the headlight functions. [Figure 1](#) shows a block diagram of a traditional automotive body control module (BCM) with LED drivers for corresponding headlight functions. The LED and input voltage relationship per headlight function determine the best DC/DC topology.

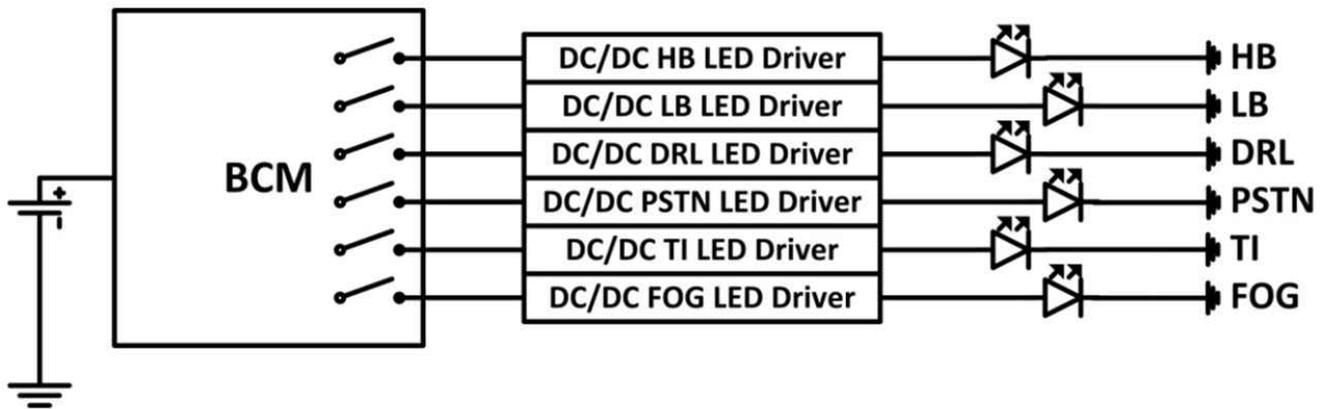


Figure 1. Traditional automotive BCM with DC/DC LED drivers for LED headlights

[Figure 2](#) shows basic schematics of common DC/DC LED driver topologies and their voltage relationships.

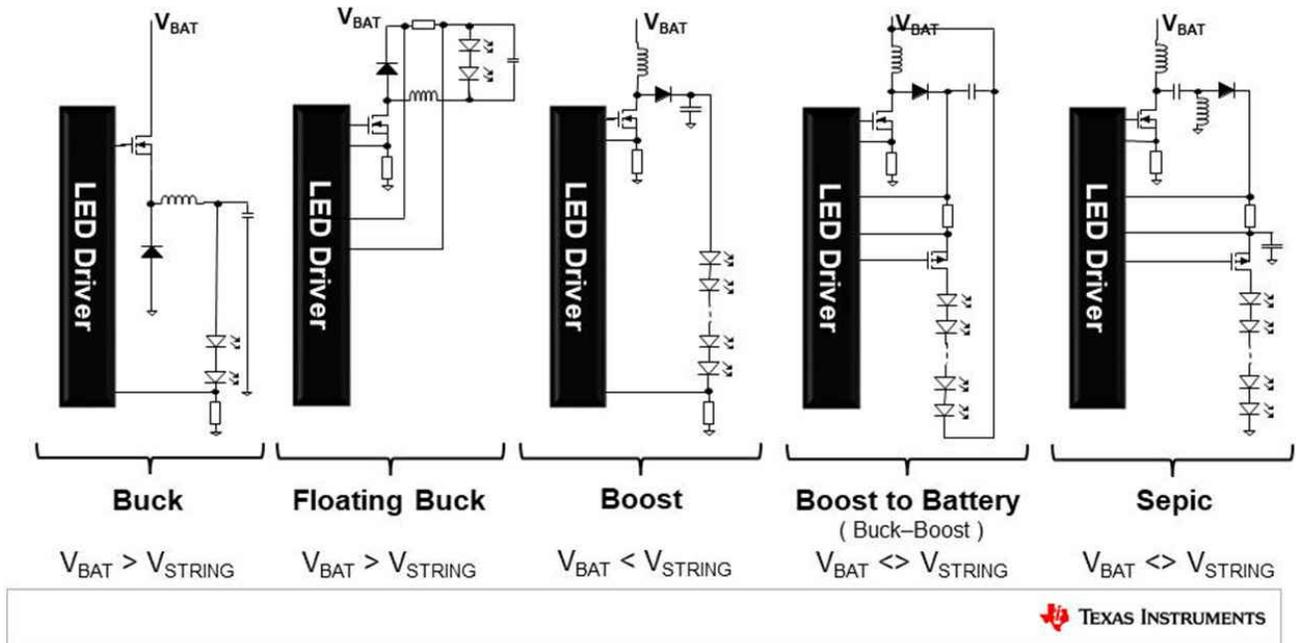


Figure 2. Basic schematics of common DC/DC LED driver topologies

Except buck LED drivers, which require a high-side metal-oxide semiconductor field-effect transistor (MOSFET), all other topologies can be implemented with a low-side MOSFET controller. Hence, a low-side MOSFET controller is one of the necessary elements to build a flexibly configurable LED driver.

As electronic technology advances and car manufacturers feel more comfortable adding electronic controls to their vehicles, a modern full LED automotive headlight will employ an ECU with a modernized BCM, including microcontrollers (MCUs). The ECU should be able to communicate through the MCU upon receiving commands from the BCM and all headlight functions are controlled accordingly. [Figure 3](#) shows a modern architecture for a full LED automotive headlight.

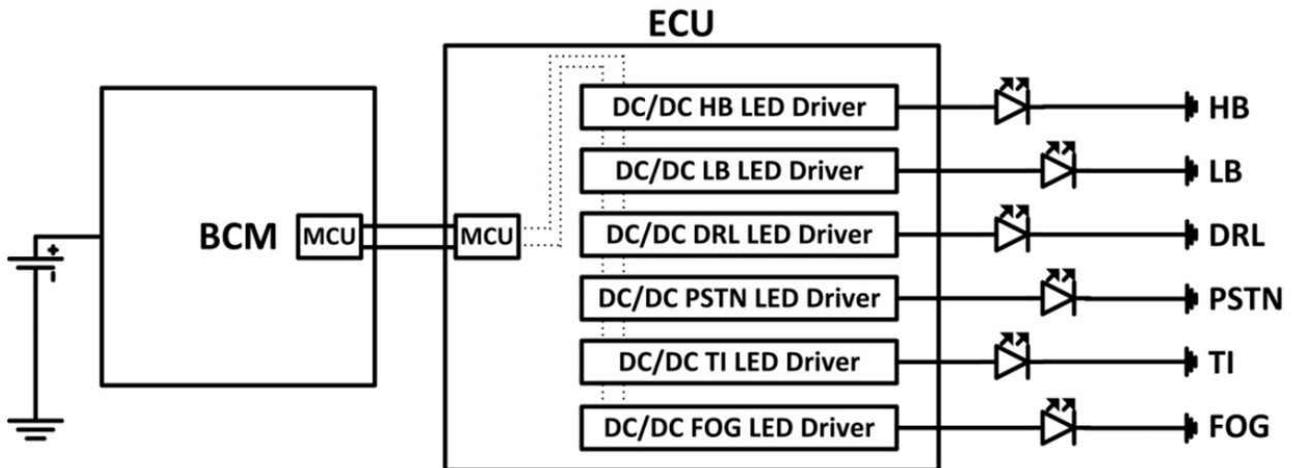


Figure 3. Modern architecture for full LED automotive headlight

The MCU in the ECU receives information from the BCM to determine which headlight function to turn on or off. More advanced models might require the ECU to change individual headlight brightness based on BCM commands. It would be best to have an effective digital protocol control, such as SPI, within the ECU such that the MCU can communicate with individual DC/DC LED drivers through the digital interface.

The TPS92682-Q1 is a dual-channel low-side N-type MOSFET controller with Serial Peripheral Interface (SPI) for parametric setup through digital controls. With a low-side N-type MOSFET controller, different DC/DC LED driver topologies can be built, such as boost, boost-to-battery, single-ended primary inductor converter and floating buck. SPI enables the MCU to provide parametric setup information through digital protocols. More importantly, the dual-channel device has two fully independent controllers that can be programmed flexibly according to the ECU's commands. As illustrated in [Figure 4](#), it's possible to build a six-channel ECU with three TPS92682-Q1 devices.

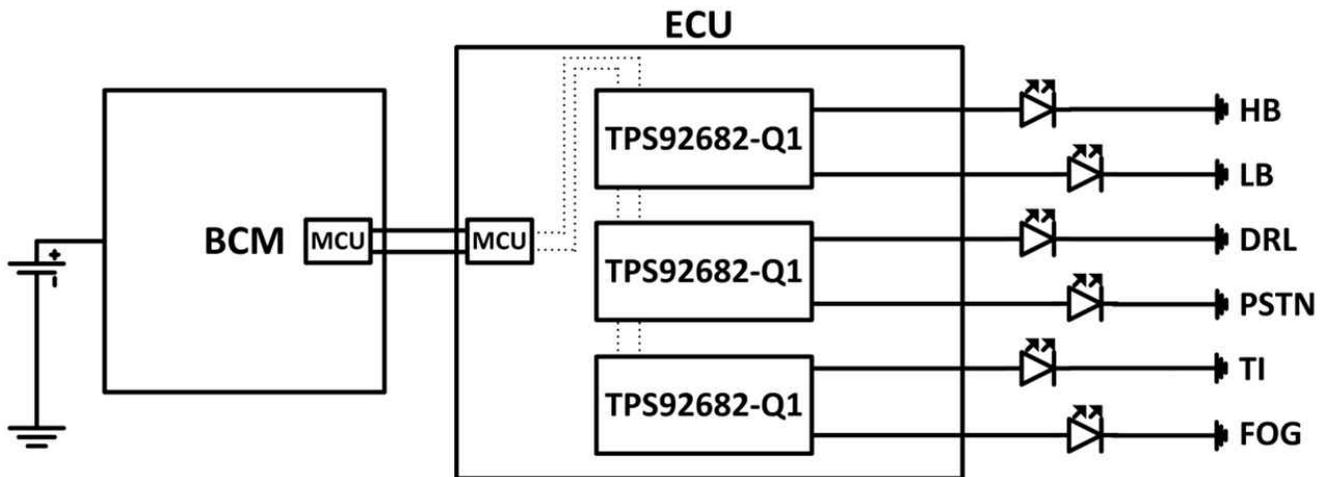


Figure 4. Six-channel ECU example block diagram with the TPS92682-Q1

The TPS92682-Q1 has the ability to configure channels to be current output or voltage output. Simple ECUs normally provide current sources to LEDs for different headlight functions. More advanced headlights, such as matrix LED headlights, require that the LED drivers be in a boost-to-buck configuration for pixel brightness control compatibility with LED matrix managers. Figure 5 shows a typical ECU block diagram for an advanced headlight.

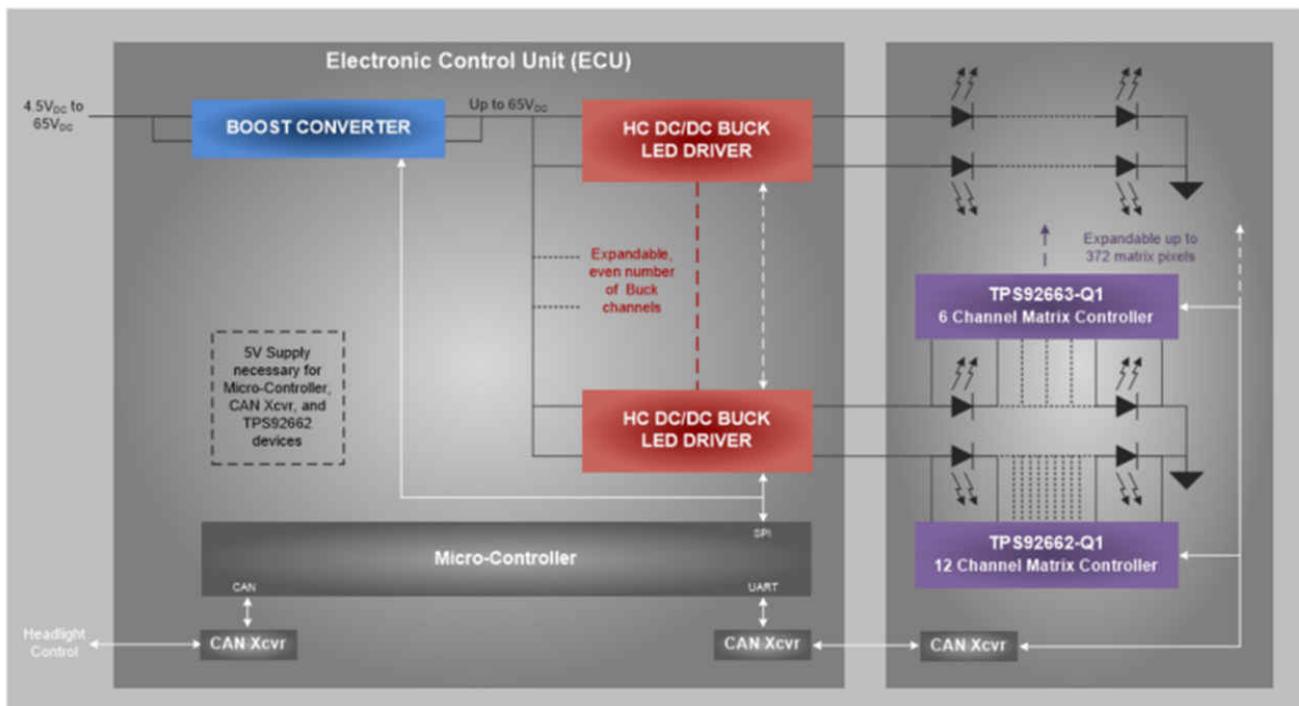


Figure 5. Typical ECU block diagram for an advanced headlight

The two channels of the TPS92682-Q1 can be programmed to run as a two-phase voltage-output regulator. This enables high output power – up to 120 W. However, there are simple headlight LED drivers that require a boost-to-floating-buck architecture. By configuring one channel as a boost voltage output with another channel configured as a floating buck current output, it's possible to configure a simple boost-to-floating-buck LED driver with a single TPS92682-Q1 device. Figure 6 shows a concept schematic of a boost-to-floating buck using the TPS92682-Q1.

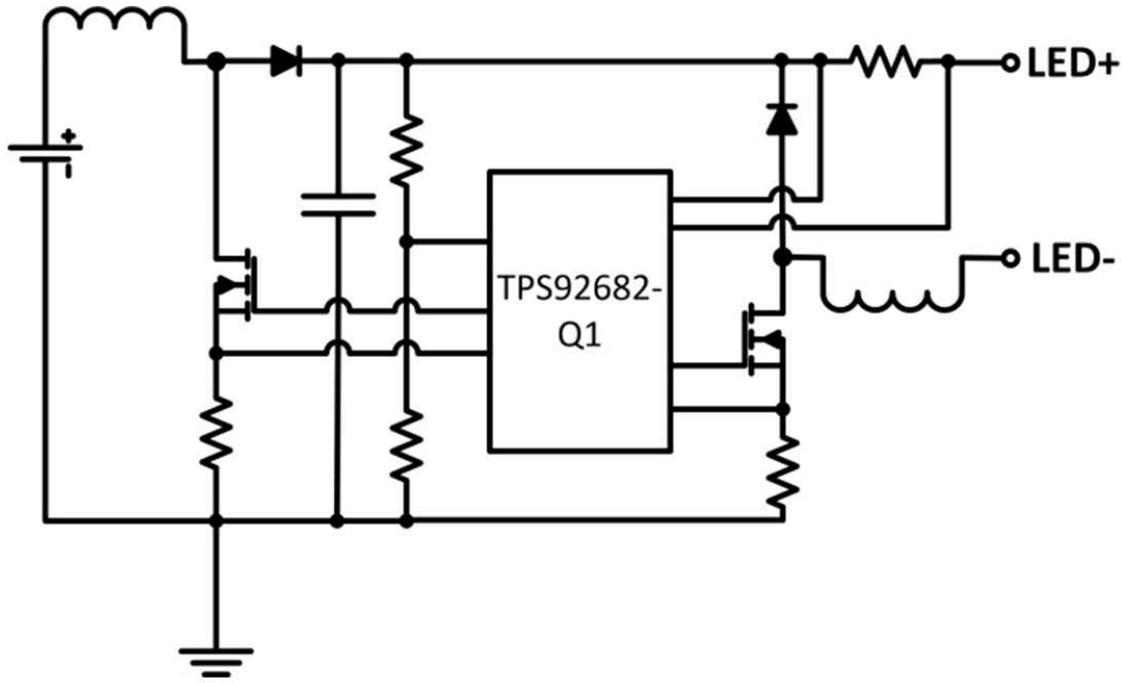


Figure 6. Concept schematic of a boost-to-floating buck using the TPS92682-Q1

As automotive headlights move from bulbs, xenon and high-intensity lamps to LEDs, the TPS92682-Q1 helps implement a flexibly configurable automotive headlight ECU that can communicate with a modern BCM.

Additional resource

- Learn how to select the right topology for LED matrix managers in [“An ECU Architecture for Adaptive Headlights.”](#)

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated