Semiconductors for automotive lighting solutions

Original equipment manufacturers are implementing modern automotive lighting use cases. This article introduces semiconductor technologies from Texas Instruments (TI) impacting headlight, rear light, and other lighting systems.

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(Source: Texas Instruments)

Automotive lighting applications include dynamic and static headlights (low beam, high beam, turn indicators, etc.), rear lights, as well as interior light systems. Adaptive headlight systems (see Figure 1) adjusting the beam shape are available on cars in Europe, but yet for- bidden in the USA. The systems use high-powered LEDs (light-emitting diodes) as a light source. The LEDs require high-powered drivers to regulate current and to achieve the required brightness. Switching LED drivers must be implemented as dual-stage power-processing topologies.

Headlight ECU reference design

The headlight ECU implements a two-stage boost controller of multiple buck LED drivers that support four channels to an LED matrix manager. The system overview is shown in Figure 2. The TPS92682-Q1 boost controller is set in voltage regulation mode capable of 130-W output power. The boost output drives two TPS92520-Q1 dual-channel synchronous buck LED drivers. This makes a total of four buck channels with a 120-W total output. The synchronous buck channels manage pixel- controlled loads using the TPS92662 LED matrix manager devices. The LED matrix-manager ICs (integrated circuits) are responsible for adjusting the headlight beam shape (see Figure 1). They control the intensity of each pixel to generate different beam patterns and to illuminate the entire field of view while avoiding glare from oncoming traffic.

The MSP432E401Y micro-controller enables the headlight ECU with two CAN interfaces. The micro- controller communicates with the in-vehicle CAN networks. It controls the TPS92682-Q1 and the two TPS92520-Q1 devices via SPI (serial peripheral interface). It also communicates with the lighting matrix module using UART (universal asynchronous receiver transmitter) communications via the TCAN1042 CAN transceiver.

Adaptive headlights adjust the beam shape and illuminate the entire field of view while avoiding glare from oncoming traffic. (Source: Texas Instruments)

The system can operate at voltages from 9 V_{DC} to 24 V_{DC} with a derate down to 6 V_{DC}. It also operates during cold crank and load dump conditions when the battery volt- age varies. A two-stage ECU is needed due to the dynamic nature of a matrix load. Here, the LED current regulation is done by a low-output capacitor topology such as a buck at the second stage. The wide input voltage variability of an automotive battery system requires to boost the first stage to ensure a consistent input voltage for the buck second stage.

Further headlight options

Headlights based on TI's DLP technology enable beam shape adjustment as well as symbol projection. Symbols can be made visible to the drivers as well as to other road participants. For example, the lane marking uses headlights to draw the planned driving path on the road. This can help drivers to navigate within hazardous driving conditions. This marking helps also the others to see where the vehicle will be traveling. Company's DLP5531-Q1 chipset for headlight such applications is already used on the road.

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