Technical Article

Shining a Light on Op Amps: Considerations in LED Lighting

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As a college student, I would often drive back to my dorm room very late at night. On my route, I would always have to drive on a long stretch of road with lots of overhanging trees on either side. It was beautiful by day but terrifying at night, as it seemed like other students would randomly pop out to walk right in front of my car.

Thankfully, my LED headlights were able to illuminate my fellow night owls. And behind the scenes, helping ensure that my headlights worked, was an often tiny but important device – the operational amplifier (op amp). In this blog post, I'll cover the key parameters to consider when choosing an op amp for an external lighting application.

Before we drill down on the op amp, let's summarize how LED lighting works. The current of the LED is the main consideration for lighting systems, as it controls the brightness and intensity of the light. The LED actually pulses a modulated light at above 200Hz – which the human eye averages out.

Because the LED current controls the brightness and intensity of the light, the op amp is often used as a current sense to help control the current going into the LEDs. High-current peaks in the pulse-width modulation (PWM) signal can overshoot the LED's specified current level and negatively impact its life span. Figure 1 below shows the overall system block diagram of a LED headlight and where the op amp is used in the application.

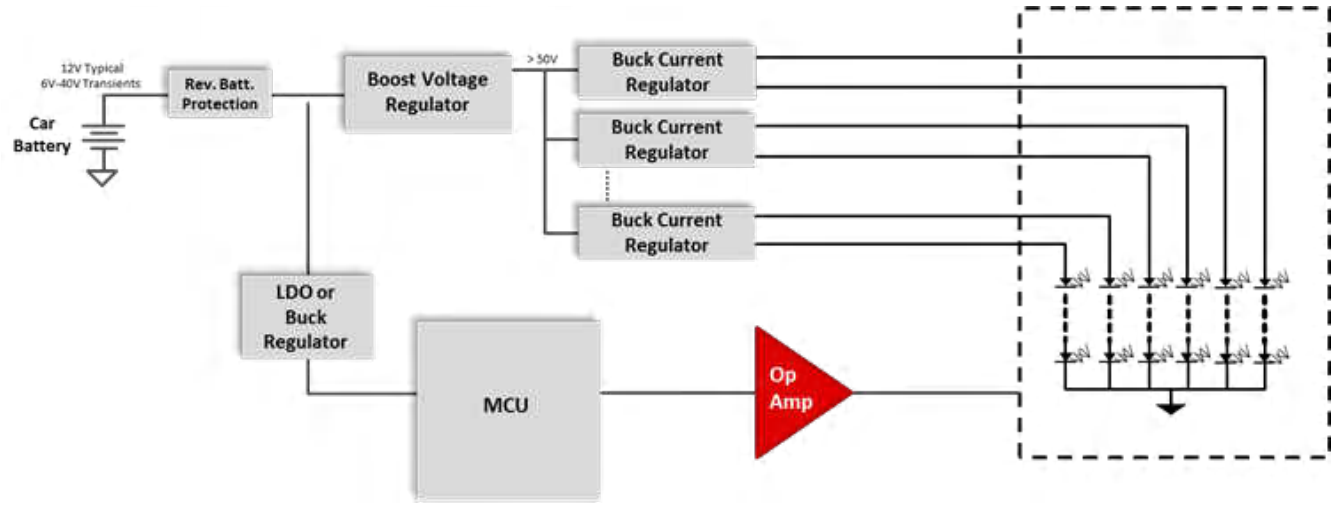

Figure 1. High-level System Block Diagram of LED Headlamp Lighting

To pick a suitable op amp as a current sense, it should have:

- Low offset voltage (Vos) to enable better accuracy for the current output to the LED
- Low drift over temperature to help the system achieve constant brightness over various temperature ranges.
- High output-current capability (in some cases) to drive the LED if the op amp directly connects to it (rather than to a buffer or transistor).
- Rail-to-rail capabilities to maximize the signal input and output, and avoid clipping.

As cost is always a strong factor in these systems, TI offers a wide range of op amps suitable for external lighting applications, such as the TLC2272A-Q1 or TLV2372-Q1. For higher-resolution needs, the OPA365-Q1 is another option due to its wide bandwidth, very low offset and rail-to-rail output (RRO) features.

As the sun starts setting earlier, don’t forget about these op amps when you turn on your headlights and drive home into the night. See TI’s wide automotive op amp portfolio here, and visit TI’s body electronics and lighting overview page here for more information on system-level needs

Additional Resources

- For more information about the power considerations in LED lighting, see the following blog posts below:
  - “Improving road safety by the headlight: LED matrix manager” about the TPS92661-Q1
  - “Lighting the road ahead: LEDs in automotive front lighting” about the TPS92515HV-Q1
  - For other op amp alternatives in headlight, see “Using dual high-current op amps to drive automotive LED lights” about the ALM2902-Q1
  - View TIDM-AUTO-DC-LED-LIGHTING to see how op amps (OPA4322-Q1 and LM2902-Q1) are used in headlight applications

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