

Using Dual High-current Op Amps to Drive Automotive LED Lights



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Automotive applications require that output Light Emitting Diode (LED) be driven by a constant current source with short-circuit protection for the LED driver. This current solution is a more discrete approach to the problem, with amplifier and comparators to drive field-effect transistors (FETs) or integrated protection FETs. This enables the circuit to have protection, but at a higher cost and increased board space.

The high-current capability of TI's [ALM2402](#), a dual high-voltage, high-current operational amplifier (op amp) enables it to drive loads up to 400mA; applications include lighting automotive tail lights or direction indicators. The [ALM2402](#) has short-to-battery and short-to-ground protection and also features a flag output that enables the control system to shut down the device in case of adverse conditions. In this post, I will explain how to use the [ALM2402](#) in LED automotive applications such as daytime running lights, brake lights and direction indicators.

First, consider the following two items:

- You have to regulate V_{LED} at the output.
- Current has to be regulated at the output.

[Figure 1](#) shows an implementation of the regulated high-side drive for an LED taillight application. The diode in the series is required to protect against reverse battery conditions in the harsh working environment.

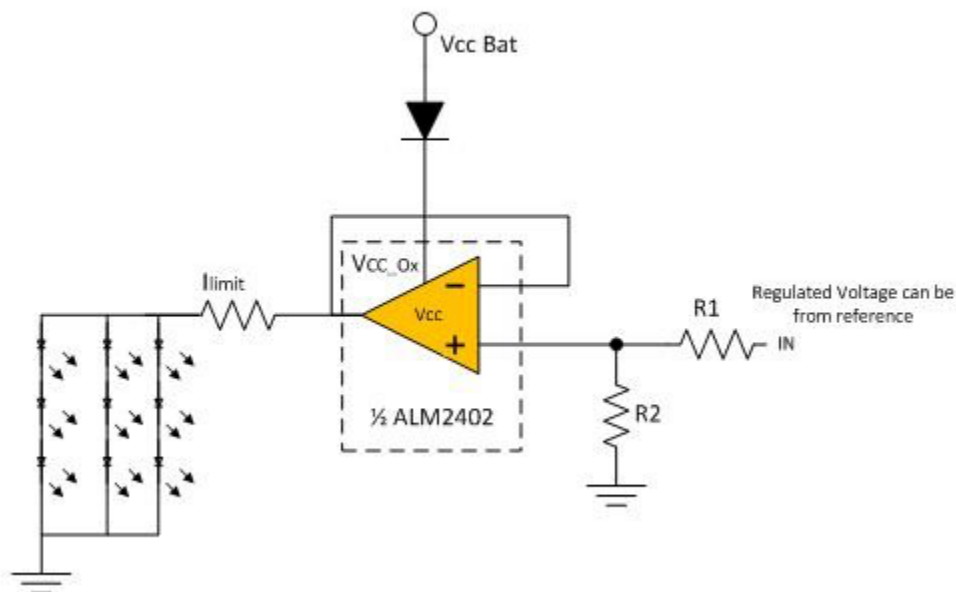


Figure 1. LED Drive Using the [ALM2402-Q1](#)

Let us consider a design scenario where $V_{ccBat} = 12V$ and $V_{led} = 2.6V$. Let's assume not. of LED in series = 3, there are 3 parallel strings of these LEDs. Max current through each LED = 30mA. These conditions require you to design for a maximum current of 90mA, since three LED strings are in parallel. The total voltage across

LEDs = 7.8V. You can regulate the V_{out} of the ALM2402 to ensure constant current across LEDs by adjusting $R1$ and $R2$. In this case, suppose you have $I_N = 12V$ (from a battery or a regulated switched-mode power supply [SMPS]). Assuming that $R1 = 100K\Omega$, $R2$ is calculable using [Equation 1](#):

$$V_{out} = 12 * R2 / (R1 + R2) \quad (1)$$

To ensure the proper operation of LEDs with regulated current, you can regulate the output of ALM2402 to 9V. The choice of 9V ensures regulated voltage across LEDs with V_{bat} fluctuations.

Considering that:

$$V_{out} = 9, R2 = 300K\Omega. \quad (2)$$

Note there is an I limit current-limiting resistor in series with LED's. This resistor basically sets the total current through the LEDs. The equation to calculate the series resistance is shown below:

$$R_{I \text{ limit}} = (V_{led} * \text{No. of LED in series} - 9V) / (90mA) = 13.3\Omega \quad (3)$$

Pulling I_N , which is non inverting input for ALM2402, down can disable the output as shown in [Figure 2](#). This allows the circuit to work as a turn/direction indicator application in automotive as well. You can use a timer IC like the [NE555](#) to control the flash rate.

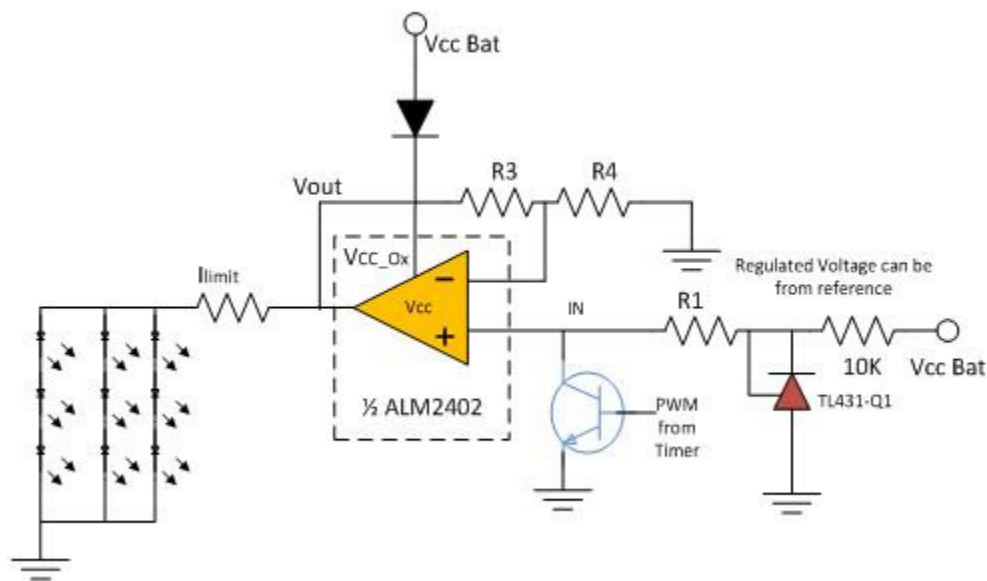


Figure 2. Examples with Reference Voltage at in

You can also use a precise reference like the [TL431-Q1](#) for output voltage control. The output voltage is based on this reference voltage resulting in precise output control. In this example The [TL431-Q1](#) provides a reference of 2.5V. In the case of [Figure 2](#), v_{out} can be designed using below equation.

$$V_{out} = 2.5 * (R3/R4 + 1) \quad (4)$$

If we choose $R3 = 200K\Omega$, $R4$ is calculated to be close to $77K\Omega$. You can adjust the I limit resistor to compensate for the long wires from the control board to the LED boards to ensure precise LED currents.

[ALM2402-Q1](#) is a dual amplifier in single package allowing it to be a cost and performance optimized solution to driving LED's in automotive applications. Driving LEDs in linear mode is simple but does have challenges around designing the layout for proper thermal dissipation. For more efficient power conversion, it is advised to use switch mode power supplies. For more information about driving your LEDs, see resources on our [website](#).

Additional Resources

- Download the [ALM2402 datasheet](#).

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