Automobile Tail Lamp and Brake Lamp Controller

By Chau Tran

Light emitting diodes (LEDs), long used in consumer electronic products, are recently finding uses in automotive lighting, where they now provide signaling functions, daytime running lights, and interior lighting in production vehicles. As this lighting technology hits the road, manufacturers continue to investigate new ways to apply it, taking advantage of the styling possibilities afforded by LED headlights and taillights.

Red LEDs are now widespread for rear lighting. Cost remains an issue, but factors such as safety, environmental friendliness, and styling flexibility weigh heavily in favor of LEDs. One of the most popular applications is center brake lights. This design idea shows a way to use the same LED array for both taillights and brake lights.

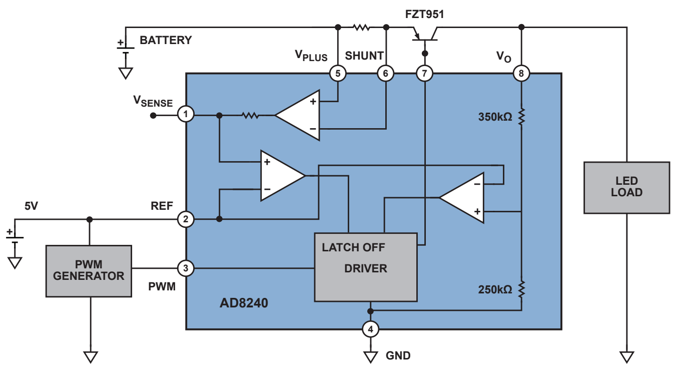

Figure 1. Running braking lamps controller.

The brightness of the LED is controlled by a simple switch, allowing dim lighting while running and bright lighting while braking. The block diagram, shown in Figure 1, includes an AD8240 LED Driver/Monitor, PNP pass transistor, and PWM generator. The AD8240 supplies a constant voltage to drive LED lamps. It also provides cost-effective LED lamp monitoring and short-circuit protection. The output is regulated at 12 V when the battery is between 12.5 V and 27 V.

Figure 2 shows the PWM generator, which consists of two 555 timers. The PWM signal controls the LED brightness. V_O is turned on when the PWM input is high and turned off when the input is low. The AD8240 is designed to work with a frequency up to 500 Hz and a typical duty cycle of 5% to 95%.

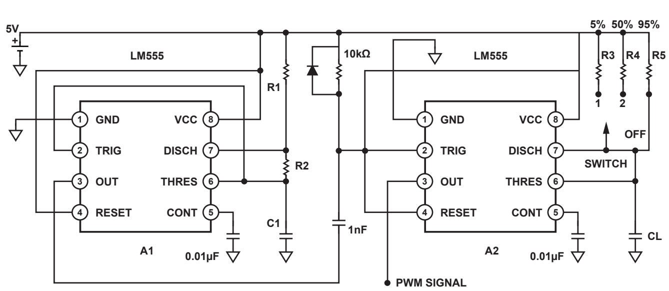

Figure 2. PWM signal generator.

With its low-power operation, the AD8240 provides a low-cost solution in a small package. An internal current-sense amplifier measures the voltage across an external current shunt, detecting an open LED when the measured current drops below a preset threshold. Output current limiting is provided by latching off the output voltage when the current reaches a level set by the value of the external current shunt. When the sense amplifier output exceeds 5 V, an internal comparator causes the driver to latch off the output voltage. The latch is reset during the next PWM cycle. An over-current condition can also be detected by measuring the sense amplifier output.

Costs are further reduced by eliminating the inductor required for a switching design; and a switching driver is not required because the LED lamps operate at much lower power than incandescent lamps.

The LEDs are turned on and off depending on the digital voltage on a CMOS-compatible PWM pin (AD8240 Pin 3). This voltage can be continuous for a simple on/off control, or PWM for dimming control. The PWM frequency should be less than 500 Hz, with a duty cycle from 5% to 100%. Typical values are 5% for running and 95% for braking. In Figure 2, the PWM frequency is determined by R1, R2, and C1 of timer A1. The pulse period is:

$$T = 0.693\ (R1 + 2 \times R2)\ C1$$

With R1 = 49.9 kΩ, R2 = 10 kΩ, and C1 = 0.1 µF, the period is 4.84 ms, or about 206 Hz.

Timer A2 converts the signal into a pulse-width-modulated signal with a duty cycle determined by R3, R4, R5, and C2. The pulse width is determined by:

$$Pulse\ width = 1.1 \times R \times C2$$

where R is equal to R5, the parallel resistance of R3 and R5, or the parallel resistance of R4 and R5, depending on the switch position. With R3 = 2.37 kΩ, R4 = 45.7 kΩ, R5 = 42.4 kΩ, and C2 = 0.1 µF, the duty cycle is 5% when the switch is in position 1, 50% when the switch is in position 2, and 95% when the switch is in the OFF position.

Note that the brightness of the LEDs increases as the duty cycle increases. When the brake is applied, the duty cycle is 95%, and the LED array is at maximum brightness. During normal operation, the duty cycle is at 5%, and the LED array is dimmed. Using a single LED array for both operations reduces cost.

If a short circuit or an overload condition occurs, the voltage at V_{SENSE} (Pin 1) falls to zero, and the output shuts down. This resets during the next PWM cycle. If the condition persists, the AD8240 attempts to drive the output to 12 V, shutting down and restarting after each PWM cycle.

This circuit presents a way to use a constant voltage, driving and monitoring the LEDs with only two wires (power and ground). In many cases, this can be reduced to one wire when the chassis or shared ground return is used. Currently, these lamps are controlled and driven by the body control ECU (electronic control unit). With this constant voltage architecture, the control and drive function for the LEDs can remain in the ECU with minimal design modifications.

Author

Chau Tran [chau.tran@analog.com] joined Analog Devices in 1984, where he works in the Instrumentation Amplifier Products (IAP) Group in Wilmington, MA. In 1990, he graduated with an MSEE degree from Tufts University. Chau holds more than ten patents and has authored more than ten technical articles.