Technical Article

CHMSL: the Third Brake Light

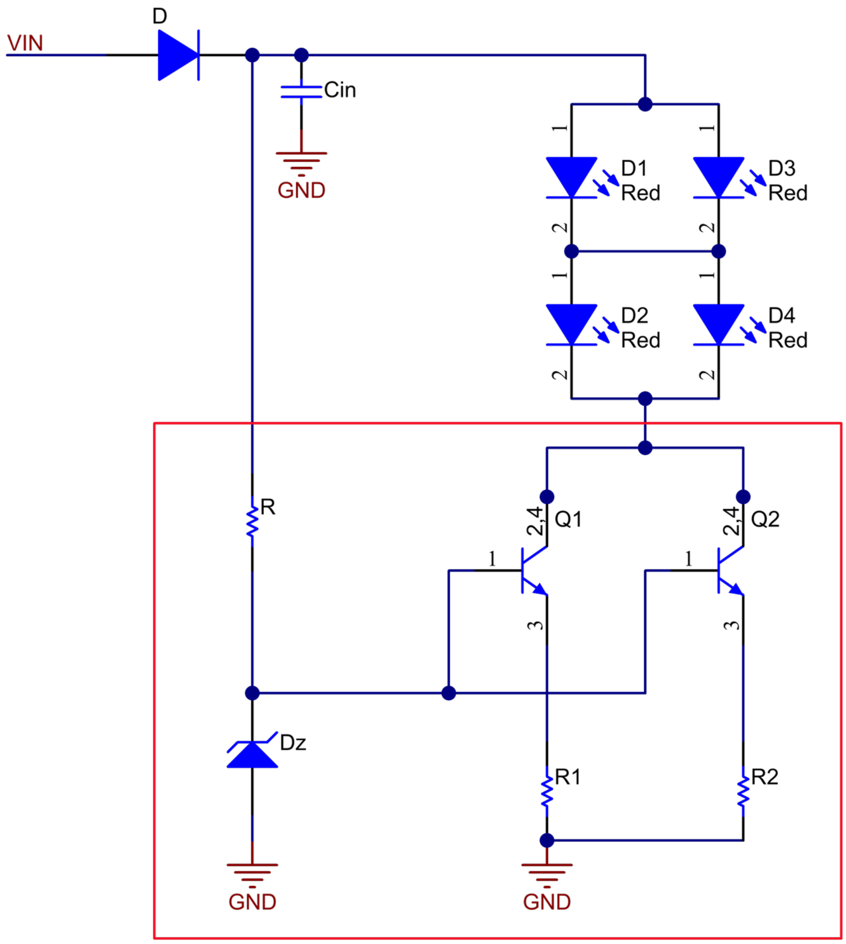
Michael Helmlinger

CHMSL stands for the center high-mounted stop lamp. In a vehicle, the CHMSL is mounted above the left and right brake lights (also called stop lamps). According to the National Highway Traffic Safety Administration, when brakes are applied, the CHMSL provides a conspicuous and unambiguous message to drivers of the following vehicles that they must slow down. Since the CHMSL is mounted in addition to the left and right brake lights, it is also known as the “third brake light.” Some vehicles, such as pickup trucks, feature a reverse light integrated in the CHMSL in addition to the brake light function.

A CHMSL Implementation Using Discrete Components

In modern vehicles, the illuminant inside the CHSMSL is mostly based on light-emitting diode (LED) strings. Transistor-based circuits drive the LED strings in the CHMSL. CHMSL LED driver circuits are typically linear circuits as opposed to switching circuits; that is, the LEDs are driven with circuits in which the transistor operates in its linear region.

Designers often realize the LED driver circuit in a CHMSL with discrete components, using separate resistors and low-side bipolar junction transistors (BJTs) or circuits. Figure 1 shows an example of a discrete LED driver circuit for a CHMSL. In this circuit, the CHMSL consists of two LED strings where each string is based on two red LEDs in series. The BJTs are on the lower side of the LEDs.



Thermal Considerations

You must consider thermal performance when designing linear LED driver circuits. The circuit design and component choices have to ensure the components are not getting hot to the point of damage. Based on the schematic in Figure 1, you can see as the supply voltage increases, so does the voltage across the BJT and the resistor, thereby increasing power dissipation in these components. More power dissipation implies higher temperatures. Thus, in linear LED driver applications, the input voltage range contributes to most of the thermal concerns.

To analyze thermal issues for the schematic in Figure 1, consider an example in which the total CHMSL LED current is 90mA, so each LED string is driven with 45mA of current. With a 16V supply voltage, Equation 1 calculates the maximum voltage drop on the BJT to 9V:

$$V_{BJT} = 16V - V_D - V_{LED} - V_R = 16V - 1V - 4V - 2V = 9V \quad (1)$$

Equation 2 calculates the maximum power dissipation of the BJTs to 0.81W:

$$P_{DMAX} = V_{BJT} * I = 9V * 90mA = 0.81W \quad (2)$$

Assuming the maximum operating ambient temperature is 85°C, and by using BJTs in the small-outline transistor (SOT)-223 package with a thermal resistance of 80°C/W, Equation 3 calculates the maximum BJT junction temperature as:

$$T_{JMAX} = 85°C + 80°C/W * 0.81W = 149.8°C \quad (3)$$

This calculation shows the junction temperature is very close to the typical maximum allowable junction temperature of 150°C.

In order to improve the circuit's thermal performance, using two transistors in parallel splits the power dissipation, enabling the maximum temperature to stay below 150°C even in worst-case conditions, as shown by the calculation in Equation 4:

$$T_{JMAX} = 85°C + 80°C/W * 0.405W = 117.4°C \quad (4)$$

When using a different BJT package type with a higher thermal resistance, you need more BJTs to split the power dissipation. The number and size of transistors in parallel is mainly based on the LED current and the maximum power dissipation allowed in the transistors.

A CHMSL Implementation Using Integrated LED Driver ICs

Another way to drive the LEDs is to use a specific linear LED driver integrated circuit (IC) such as TI's TPS92610-Q1, as shown in Figure 1. In such driver ICs, the transistor and transistor driver circuit are all integrated in the IC. The transistor is still operating in its linear region. Because all of the components are integrated inside the IC, you only need the IC and one sense resistor for this solution.

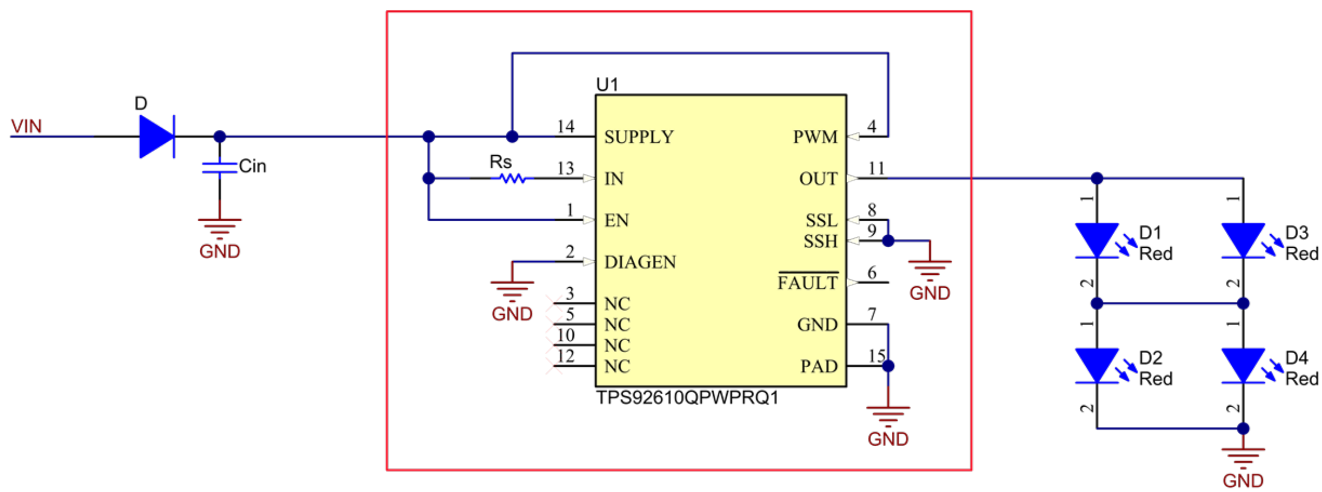


Figure 1. TPS92610-Q1 integrated LED driver circuit

Thermal Considerations Again

Let's look at thermals in this design; specifically, the junction temperature of the IC. With a 16V supply voltage, Equation 5 calculates the maximum voltage drop on the IC as 11V:

$$V_{IC} = 16V - V_D - V_{LED} = 16V - 1V - 4V = 11V \quad (5)$$

Assuming the same 90mA of current, a maximum voltage drop of 11V on the IC and a thermal resistance of 52°C/W, Equation 6 calculates the maximum junction temperature:

$$T_{JMAX} = 85°C + 52°C/W * 0.99W = 136.5°C \quad (6)$$

136.5°C is well below the maximum specified IC junction temperature of 150°C. Thus, you need only one driver IC to operate the example CHMSL LED strings.

Advantages of an Integrated Solution

One obvious advantage of an integrated solution over a discrete solution is the reduced number of components. Reducing the number of components on the board obviously leads to lower space requirements.

Another key advantage is the current regulation accuracy over the full temperature range. The driver IC can maintain constant current in the IC as the forward voltage of the LEDs change with temperature. This is in contrast to the discrete circuit shown in Figure 1, which cannot regulate current in the LED as the temperature changes.

The third advantage of a linear LED driver IC-based solution is its diagnostic features, which enable the detection of LED circuit faults such as LED opens and shorts, and notify the driver of faults.

Finally, the implementation shown in Figure 1 could be cheaper than the implementation in Figure 1 when considering the number of components and the cost of each component.

More Information

The Automotive Linear LED Driver Reference Design for Center High-Mounted Stop Lamp (CHMSL) is an integrated solution for driving LED strings for a CHMSL, which includes brake and reverse lights. Each light is capable of independent control by applying power to its supply line. The design uses three TPS92610-Q1 automotive-qualified linear LED drivers, which result in a low bill-of-materials count and feature-rich solutions.

For other interesting automotive body electronics and lighting solutions, check out TI's Body Electronics and Lighting overview page.