

AN1153

AL8860Q - LED Driver Remote Mounting and LED open/short to GND protection solution

Jia Li, Application Engineer, Diodes Incorporated

1. Introduction

The AL8860Q is a hysteresis mode DC-DC buck LED driver, designed for driving single or multiple series connected LEDs in automotive lamps. In some circumstances the LED string should become in fault status such as open-circuit, short-circuit, LED string anode shorted to GND, which may result in damage to the system and battery. For safety and reliability, the total solution in automotive LED lighting application must take these fault conditions in consideration. This application note describes the performance of AL8860Q when LED string is in fault status.

2. AL8860Q Operation

Figure 1 shows the reference design of AL8860Q. In normal operation, when a voltage is applied at +Vin, the AL8860Q internal NDMOS switch is turned on. Current starts to flow through sense resistors R1, R2, inductor L1, and the LED string. The current ramps up linearly, the ramp rate being determined by the input voltage +Vin and the inductor L1. This rising current produces a voltage ramp across R1 and R2. The internal circuit of the AL8860Q senses the voltage across R1 and R2 and applies a proportional voltage to the input of the internal comparator. When this voltage reaches an internally set upper threshold, the NDMOS switch is turned off. The inductor current continues to flow through R1, R2, L1, the LED string and the Schottky diode D1, and back to the supply rail, but it decays, with the rate of decay determined by the forward voltage drop of the LED string and the Schottky diode. This decaying current produces a falling voltage at R1 and R2, which is sensed by the AL8860Q. A voltage proportional to the sense voltage across R1 and R2 is applied at the input of the internal comparator. When this voltage falls to the internally set lower threshold, the NDMOS switch is turned on again. This switch-on-and-off cycle continues to provide the average LED current set by the sense resistor R1 and R2. Please refer to the datasheets for the threshold limits, AL8860Q internal circuits, electrical characteristics and parameters.

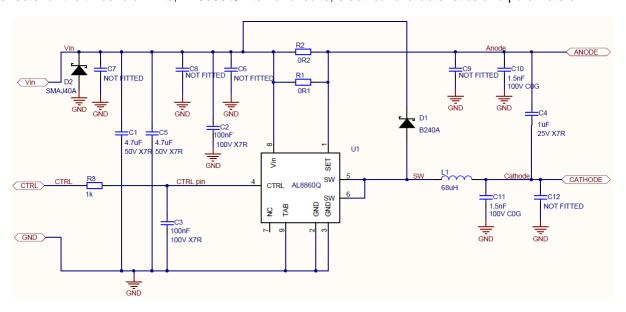


Figure 1: Schematic diagram



3. Open Circuit of LED string

The AL8860Q has by default open LED protection. Figure 2 shows the operation when LED string open circuit happens and then LED string is reconnected. If the LED string is open circuit, the AL8860Q will stop oscillating and the SW pin will fall to GND. No excessive voltages will be seen by the AL8860Q and no damages will be caused to the system. Once the LED string is reconnected, the AL8860Q will resume normal operation.

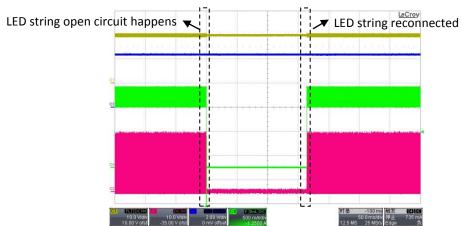


Figure 2. LED open protection (Vin=20V, 3LEDs) (Y-Vin, B-CTRL, G-I₁, R-SW)

4. Short Circuit of LED string

If the LED string should become shorted together (the anode of the top LED becomes shorted to the cathode of the bottom LED), the AL8860Q will continue to switch and the current through the AL8860Q's internal switch will still be at the regulated current - so no excessive heat will be generated within the AL8860Q. However, the duty cycle at which it operates will change dramatically and the switching frequency will most likely decrease.

Figure 3 shows the operation when LED string short circuit happens. The on-time of the internal power MOSFET switch is significantly reduced because almost all of the input voltage is now developed across the inductor. The off-time is significantly increased because the reverse voltage across the inductor is now just the schottky diode voltage causing a much slower decay in inductor current.

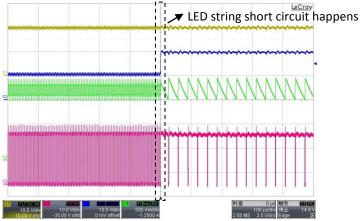


Figure 3. LED short protection (Vin=20V, 3LEDs) (Y-Vin, B-LED K, G-I_L, R-SW)



5. LED anode shorted to GND consideration

LED drivers and power supplies can be remote mounted from the LED modules. The remote mounting distance is based on the voltage drop generated across the supply leads. The voltage drop will vary based on the operating current and the gauge wire used. Typically a maximum voltage drop of 1V across the output leads is acceptable. Table 1 shows the lead length based on the current and wire gauge that will generate a 1V drop.

	Length of Wire (in feet) for 1V Drop				
	Operating Current (Amps)				
Wire Gauge	0.350	0.700	1.050	1.400	5.0
18	447	224	149	112	31
16	711	356	237	178	50
14	1132	566	377	283	79

Table 1. Remote Mounting Distance Chart

When LED string is on a separate board away from the AL8860Q driver board, there may be chances that the anode terminal of the AL8860Q driver board is shorted to GND by misconnection. To avoid damage from this event, a fuse resistor can be added at the input. See Figure 4, if LED anode is shorted to GND, the input power supply will be connected to GND via fuse (F1) and sense resistor (R1, R2), and the current flowing through F1 is Vin/(R1//R2), which is high enough to blow out the fuse to cut off the current path.

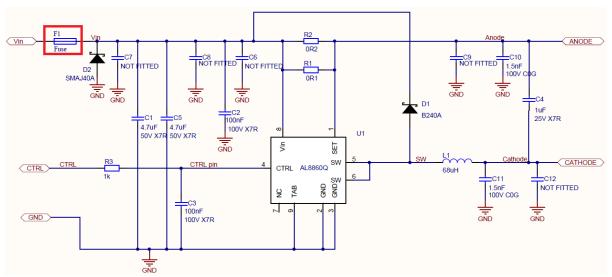


Figure 4. Solution for LED anode shorted to GND

6. Summary

It has been demonstrated how the AL8860Q reacts when fault status occurs. The AL8860Q is capable of providing robust protections against LED open, LED short and LED anode short to GND, ensuring safety and reliability in automotive applications.



IMPORTANT NOTICE

DIODES INCORPORATED MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

Diodes Incorporated and its subsidiaries reserve the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. Diodes Incorporated does not assume any liability arising out of the application or use of this document or any product described herein; neither does Diodes Incorporated convey any license under its patent or trademark rights, nor the rights of others. Any Customer or user of this document or products described herein in such applications shall assume all risks of such use and will agree to hold Diodes Incorporated and all the companies whose products are represented on Diodes Incorporated website, harmless against all damages.

Diodes Incorporated does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel

Should Customers purchase or use Diodes Incorporated products for any unintended or unauthorized application, Customers shall indemnify and hold Diodes Incorporated and its representatives harmless against all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized application.

Products described herein may be covered by one or more United States, international or foreign patents pending. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks.

This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes Incorporated.

LIFE SUPPORT

Diodes Incorporated products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

- A. Life support devices or systems are devices or systems which:
 - 1. are intended to implant into the body, or
 - 2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.
- B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

Copyright © 2020, Diodes Incorporated

www.diodes.com