Design Considerations
TIDA-00503 Automotive LED Backlight 2P/4P-3S and 4P-2S SEPIC Design

Design

The TIDA-00503 is a reference design using the LP8861-Q1 LED driver in a SEPIC configuration used to drive 2, 3, or 4 parallel strings of 3 or 2 LEDs in series. The LED driver operates at a switching frequency of 2.2MHz for a smaller overall footprint and all components are limited to <3mm in height.

A standard LP8861-Q1 SEPIC EVM was modified and used along with a LED load board to generate the test report. The original design used a coupled inductor that did not meet the desired 3mm maximum height requirement and was replaced by two smaller single inductors. The switching frequency and maximum output voltage resistor settings were updated and the aluminum electrolytic input and output capacitors were replaced with lower profile ceramic capacitors.

Inductor Selection:

The TIDA-00503 reference design has a maximum height limitation of 3mm. For this reason, two single inductors were used vs a coupled inductor to provide the best tradeoffs to meet the height restriction.

"Power Stage Designer™ Tools" can be used for the SEPIC inductance calculation:
http://www.ti.com/tool/powerstage-designer.

Setting the switching frequency:

The LP8861-Q1 can operate at any switching frequency between 250kHz and 2.2MHz. The TIDA-00503 uses a higher switching frequency to enable the use of smaller passive components with the tradeoff of slightly lower system efficiency. Solving the equation below with fsw = 2.2MHz and choosing the closest standard value, R_{FSET} = 24kOhm.

fsw = 67600/(RFSET + 6.4)

Where:
fsw – switching frequency, kHz
R_{FSET} – frequency setting resistor, kΩ

Choosing the maximum output voltage:

Maximum output voltage should be chosen based on the maximum voltage required for the LED strings. It is recommended that the maximum voltage is about 30% higher than the maximum LED string voltage. The LEDs used in our design have a maximum voltage of 3.4V. For 3 series LED/string configuration we designed our maximum output voltage to be (3*3.4V)*1.3 = 13.26V. And from the equation below, we can solve for R1 = 249kohm.

$$V_{MAX\ BOOST} = \left(\frac{V_{BG}}{R2} + 0.0387 \right) \times R1 + V_{BG}$$

Where:

$V_{BG} = 1.2V$

R2 recommended value is 130 kΩ

Resistors values are in kΩ

Higher output currents:

The maximum LED current per string in a 4-channel application is 100mA/ch. In applications requiring fewer channels and higher currents, the LP8861-Q1's outputs can be tied together to drive higher current. In our application, for 2 parallel strings with 200mA/string, we tied OUT1 to OUT2 and OUT3 to OUT4.

Layout Guidelines

Here are some main points from the LP8861-Q1 IC datasheet to help the PCB layout work:

- Current loops need to be minimized:
    - For low frequency the minimal current loop can be achieved by placing the boost components as close to the SW and PGND pins as possible. Input and output capacitor grounds need to be close to each other to minimize current loop size
    - Minimal current loops for high frequencies can be achieved by making sure that the ground plane is intact under the current traces. High frequency return currents try to find route with minimum impedance, which is the route with minimum loop area, not necessarily the shortest path. Minimum loop area is formed when return current flows just under the "positive" current route in the ground plane, if the ground plane is intact under the route
- GND plane needs to be intact under the high current boost traces to provide shortest possible return path and smallest possible current loops for high frequencies
- Current loops when the boost switch is conducting and not conducting needs to be on the same direction in optimal case
- Inductor placement should be so that the current flows in the same direction as in the current loops. Rotating the inductor 180° changes current direction
- Use separate power and noise free grounds. Power ground is used for boost converter return current and noise free ground for more sensitive signals, like LDO bypass capacitor grounding as well as grounding the GND pin of LP8861-Q1 itself.
- Boost output feedback voltage to LEDs need to be taken out "after" the output capacitors, not straight from the diode cathode.
- LDO 1 µF bypass capacitor as close to the LDO pin as possible
- Input and output capacitors need strong grounding (wide traces, many vias to GND plane)
- If two output capacitors are used they need symmetrical layout to get both capacitors working ideally
- Output ceramic capacitors have DC-bias effect. If the output capacitance is too low, it can cause boost to become instable on some loads and this increases EMI. DC bias characteristics need to

be obtained from the component manufacturer; it is not taken into account on component tolerance. X5R/X7R capacitors are recommended.

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