



DESIGN CONSIDERATIONS IN SELECTION OF CONVERTER CONFIGURATION FOR AUTOMOTIVE LED HEADLIGHT APPLICATIONS

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ABSTRACT

This application note discusses LED headlights for two-wheelers, passenger vehicles, commercial vehicles, and mild hybrid vehicles, and explores battery voltage and power requirements for the headlights used in these vehicles. Detailed analyses are provided to help select a converter topology. A survey of buck, boost, and buck-boost converter configurations showcases advantages and limitations when used in automotive headlight application. Converter configurations with and without an LED capacitor are highlighted, including design challenges, advantages, and limitations of both configurations.

Many diverse LED drivers and controllers offered by Allegro MicroSystems cater to the requirements of automotive headlight applications. These highly integrated ICs are offered in small packages with numerous features for headlight application as well as protection and diagnostics. Requirements and key specifications of the Allegro offerings are presented. Allegro devices for automotive headlight application are compared, with a focus on the specifications that are critical to the design and selection of converter configurations that use these devices.

The Allegro devices presented in this application note support the design of converters in different configurations and with various power and voltage levels.

INTRODUCTION

LEDs for automotive lighting application are becoming increasingly popular for their low power consumption and smaller form factor. These headlights are categorized based on luminous intensity levels, which are typically governed by regulating authorities. Luminous intensity levels partially determine the peak power requirement of a headlight.

LEDs in headlights are fed by either a constant-current LED driver or an LED controller, depending on the power level. In low-power applications, LED drivers are referred to a device with an integrated power stage. In high-power applications, an LED controller provides a gate driver with an external power stage.

LED drivers and controllers are designed into various converter configurations based on the voltage and power requirement of the headlights. Three converter configurations are widely used in the LED headlight application—buck, boost and buck-boost converter. Selecting from these converter topologies depends on the requirements of numerous input and output parameters such as the number of LEDs (i.e., output voltage), battery voltage (input voltage), and LED current (i.e., output power). Other specific parameters such as the LED driver/controller maximum specified voltages of various pins, board space, efficiency, and thermal requirements also determine the selection of the converter configuration.

HEADLIGHT CLASSIFICATION

Headlights are classified based on the minimum and maximum luminous intensity in low-beam operation, as presented in Table 1. The power requirement is calculated considering an average of 100 lumens per watt of LED efficiency. Two-wheeler headlights are generally Class B, whereas passenger vehicles are generally Class C or Class D, although, some high-end luxury vehicles use Class E headlights.

Table 1: Headlight Classification [1]

NOTE: This table presents a typical comparison based on data compiled from various regulations. Allegro does not guarantee the accuracy of this table and recommends referring to country-specific guidelines for details.

Headlight Class	LB Min. (Lumens)	LB Max. (Lumens)	LB Power (W)
Class A	150	900	~1.5 to 9
Class B	350	1000	~3.5 to 10
Class C	500	2000	~5 to 20
Class D	1000	2000	~10 to 20
Class E	>2000	–	> 20

[1] Considering typical ~100 lm/W LED efficiency, 100% optical efficiency

HEADLIGHT POWER/VOLTAGE CLASSIFICATION

Headlights can be classified in terms of the power and voltage requirements for different applications as follows.

Two-Wheeler (12 V Battery)

Class B headlights are generally required for two-wheelers, although some high-end two-wheelers require Class C or Class D headlights.

For low-power (Class B) headlights, the brightness (lumen) requirement is met using only a small quantity of LEDs—generally, three LEDs in high-beam operation. For a 12 V battery supply driving three LEDs, a buck converter can be used.

Because two-wheelers have a low current requirement, devices with integrated FETs are preferred for their ability to realize a smaller-size and lower-cost system.

A limited number of two-wheelers require Class D headlights. These applications use a buck-boost configuration.

Passenger Vehicle (PV) (12 V Battery)

Passenger vehicles implement a 12 V battery to drive the headlights. The lumen/power requirement for passenger vehicles generally is Class C or higher. Depending on the number of LEDs in the high-beam operation, buck-boost or the boost controllers are used by numerous manufacturers. Because the power level is higher than two-wheelers, a controller (gate driver plus control) with an external MOSFET is generally used.

Commercial Vehicle (24 V Battery)

A few applications of commercial vehicles use a two-battery arrangement, which increases the typical battery voltage to 24 V. The headlight category for such vehicles is Class C or higher, which demands a device with support for higher voltage. For a 24 V battery, the requirement of the load-dump voltage also increases from 40 V in a 12 V battery to 60 V, which also limits the operation of the converter to certain voltage/current levels.

In this category, both buck-boost and boost controller configurations can be implemented depending on the number of LEDs.

Mild Hybrid (48 V Battery)

In recent trends, mild hybrid passenger vehicles started using 48 V batteries. A 48 V battery has a 60 V load-dump voltage. In such applications, only an input-voltage-referred buck converter can be used to drive the headlight with a limited number of series-connected LEDs.

CONVERTER CONFIGURATION

This section describes the various configurations of converters used for LED headlight applications. The advantages and disadvantages of various topologies are discussed and compared.

The driver/controller IC is generally limited by:

- Input voltage (V_{in})
- Output (LED) voltage (V_{out})
- Voltage on the LED sense resistor nodes (L_p/L_N)
- Voltage on the switching node (i.e., switch voltage)
- Minimum and maximum duty (D_{min} and D_{max})
- LED configuration (V_{in} -referred or GND-referred)
- Thermal limitation

Various converter configurations are described next.

Buck Converter

The advantage of an input-referred buck converter (as shown in Figure 1) is the use of a low-side switch that leads to simple gate driver design. The LEDs are connected on the input side as shown in Figure 1, and a buck converter controls the cathode voltage of the LEDs. The output voltage of the buck converter is always lower than the input voltage, which limits the number of LEDs at lower input voltage to small quantities.

For a 12 V battery application, the load dump voltage is typically approximately 40 V, which requires the driver/controller input voltage to be higher than 40 V. Considering the minimum input voltage of 12 V, a maximum of three LEDs can be driven because the voltage drop across these LEDs is typically ~10 V. The operation of the buck is limited by the maximum duty (D_{max}) of the converter.

However, in a 48 V application, a maximum of 10 LEDs can be driven with the typical output voltage of ~33 V. In this scenario, buck converter operation is also limited by the maximum duty at the lowest input voltage of 40 V, considering a voltage margin for the buck converter operation.

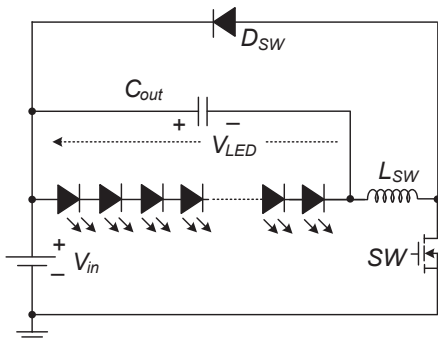


Figure 1: Buck converter configuration.

Boost Converter

A boost converter configuration, which provides an output voltage higher than the input voltage, is shown in Figure 2. In this configuration, the minimum number of LEDs is limited by the maximum output voltage.

Considering a 12 V battery application with load-dump voltage of approximately 40 V, the converter is intended to operate at this voltage. Because it is a boost converter, the minimum output voltage must be more than 40 V. Therefore, the boost converter requires at least 15 LEDs for low-beam operation, which corresponds to a typical output voltage of ~50 V. This also provides enough margin for the boost converter minimum duty operation (D_{min}). Moreover, the maxi-

imum number of LEDs in the boost converter is also limited by the voltage rating of the LP/LN pins and the switching node (SW pin) voltage, which is equal to the output voltage. This voltage is typically 60 V, which limits the maximum quantity of LEDs to 20.

Similarly, the minimum and maximum quantity of LEDs for a 24 V battery can be designed based on the rating of the LP/LN pins and SW pin.

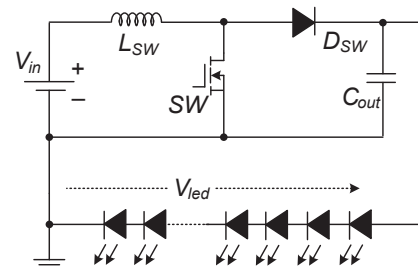


Figure 2: Boost converter configuration.

Buck-Boost/SEPIC Converter

The buck-boost converter is a very versatile configuration due to the ability to buck and boost the voltage. A buck-boost converter driven with a low-side switch is shown in Figure 3. This allows wide flexibility in the number of LEDs in a design. However, the voltage stress on the switch (i.e., voltage on the switching node) is the sum of the input voltage and the output voltage and is the deciding factor in an LED driver/controller implementation.

To drive five LEDs, the output voltage requirement of the converter is typically ~16.5 V. This leads to an overall voltage stress of ~66.5 V (on the SW and LP/LN pins) at 40 V input voltage (load dump) for a typical driver. If the voltage rating of the driver is higher, the number of LEDs can be increased in similar fold.

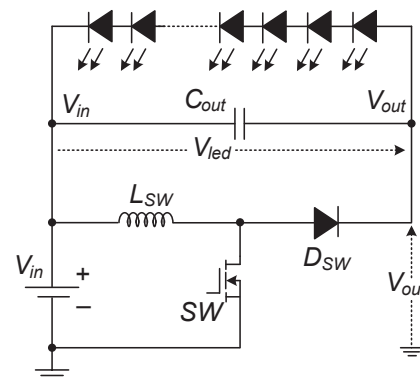


Figure 3: A buck-boost converter configuration.

COMPARISON OF VARIOUS CONVERTER CONFIGURATIONS

Criteria for topology selection, summarized in Table 2, include the output voltage (V_o), inductor (L), output capacitor (C_o), peak switch node voltage stress (V_{sw}), peak switch current stress (I_{sw}), rms switch current (I_{swr}), average switch current (I_{swa}), average free-wheeling diode current (I_{Da}) (“diode” for nonsynchronous and “switch” for synchronous configurations), and inductor current (I_L) for three configurations of buck, boost, and buck-boost converters.

Table 2: Comparison of Various Converter Configurations

Parameter	Buck	Boost	Buck-Boost
V_o	$V_o = DV_{in}$	$V_o = \frac{1}{(1-D)}V_{in}$	$V_o = \frac{D}{(1-D)}V_{in}$
L	$\frac{V_o(1-D)}{\Delta I_{Lsw}f_{sw}}$	$\frac{DV_{in}}{\Delta I_{Lsw}f_{sw}}$	$\frac{DV_{in}}{\Delta I_{Lsw}f_{sw}}$
C_o	$\frac{\Delta I_{Lsw}}{8f_{sw}\Delta V_o}$	$\frac{DI_o}{\Delta V_o f_{sw}}$	$\frac{DI_o}{\Delta V_o f_{sw}}$
V_{sw}	V_{in}	V_o	$V_{in} + V_o$
I_{sw}	I_o	I_{in}	$I_{sw} = I_{in} + I_o$
I_{swr}	$\sqrt{DI_o}$	$\sqrt{DI_{in}}$	$\sqrt{D(I_{in} + I_o)}$
I_{swa}	DI_o	DI_{in}	$D(I_{in} + I_o)$
I_{Da}	$(1-D)I_o$	$(1-D)I_{in}$	$(1-D)(I_{in} + I_o)$
I_L	I_o	I_{in}	$I_{sw} = I_{in} + I_o$

As presented in this section:

- Because the buck converter cannot drive a large number of LEDs, it is preferred for applications with few LEDs where current can be high. Buck configurations are also applicable to 48 V battery systems.
- Boost offers a better advantage in terms of the voltage at the switch node, which allows use of the driver for a large number of LEDs, but has limitations when driving fewer quantities of LEDs.
- Buck-boost overcomes the limitations of the boost converter. However, the voltage stress on the switching node is higher, which eventually limits the quantity of LEDs that can be included in large numbers.

Therefore, a combination of buck-boost (low-beam) and boost (high-beam) is used to attain operation with wide-ranging LED quantities. The quantity of LEDs is mapped by power requirements for the various converter configurations in Figure 4.

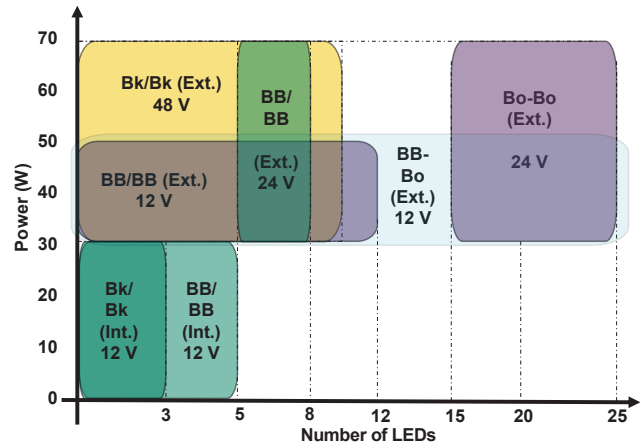


Figure 4: Converter mapping of power vs. quantity of LEDs.

EVALUATION OF CONFIGURATIONS WITH/WITHOUT OUTPUT CAPACITOR

This section presents a comparison of buck converter configurations with and without an output capacitor. Various aspects of the converter such as LED ripple current, cost, power loss/efficiency, size, EMI consideration, stability, and PWM accuracy are considered using the example of a 48 V buck configuration. Buck converter configurations are shown in Figure 5 and Figure 6, without and with output capacitor, respectively.

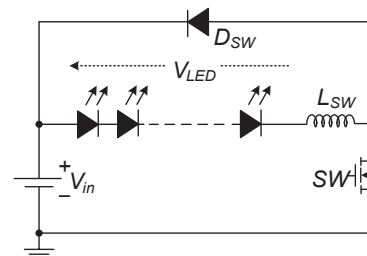


Figure 5: Buck converter configuration without LED capacitor.

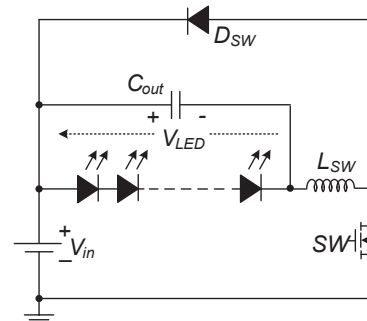


Figure 6: Buck converter configuration with LED capacitor.

System specifications for design evaluation are:

- Supply voltage (V_{in}) = 48 V (typical), 40 to 56 V
- Number of LEDs in high-beam operation = 6
- LED current = 2 A (regulated)
- LED dynamic resistance = $\sim 1.9 \Omega$
- Expected LED current ripple is <10% at 48 V
- Worst-case inductor ripple current is $\sim 50\%$ at 48 V

Evaluation parameters are discussed next.

LED CURRENT AND VOLTAGE RIPPLE

For a buck configuration without capacitor, the inductor is connected directly in series with LEDs. Therefore, inductor current and LED current are the same. Moreover, the ripple voltage across the LED is governed by the dynamic resistance of the series-connected LEDs. To achieve a lower LED ripple current, i.e., <10%, a 220 μH inductor is considered. Simulation results for the buck converter without a capacitor are shown in Figure 7. As can be observed, the inductor current, I_{L1} , and the LED current, I_{LED} , are the same, with a ripple of 150 mA ($\sim 7.5\%$). The LED ripple voltage of ~ 280 mV is observed considering the dynamic resistance on the order of $\sim 1.9 \Omega$ (series-connected LEDs).

The simulation results of the buck converter with a capacitor across LEDs is shown in Figure 8. In this configuration, an inductor of 33 μH is considered, and a small ceramic capacitor of 2.2 μF is added across the LEDs. Because the inductor size is reduced more than six-fold, the inductor ripple current increases in similar fold to ~ 1 A (50%). However, the capacitor across the LEDs acts as a filter and bypasses the inductor current ripple such that current ripple in the LED is low. The LED ripple current observed is ~ 100 mA (5% of LED current). Moreover, the voltage ripple across the LED (LED capacitor) is observed to be approximately 150 mV, which is almost half the value observed in the configuration without the capacitor.

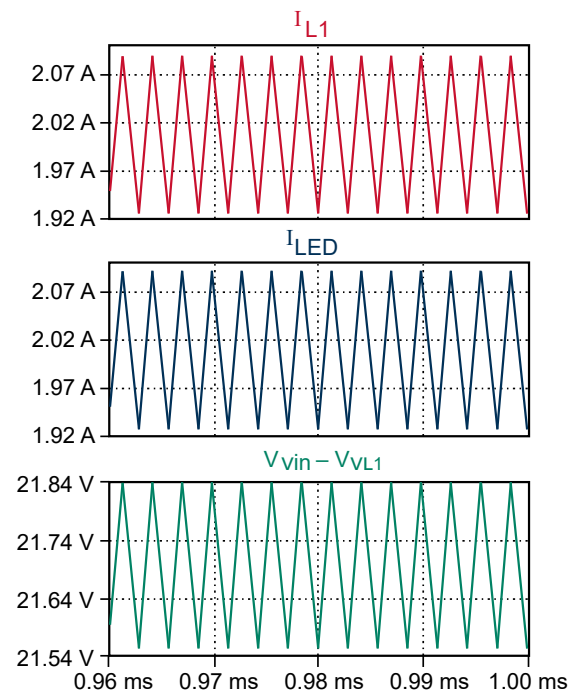


Figure 7: Simulation of buck converter without capacitor ($L = 220 \mu\text{H}$), with 48 V supply voltage.

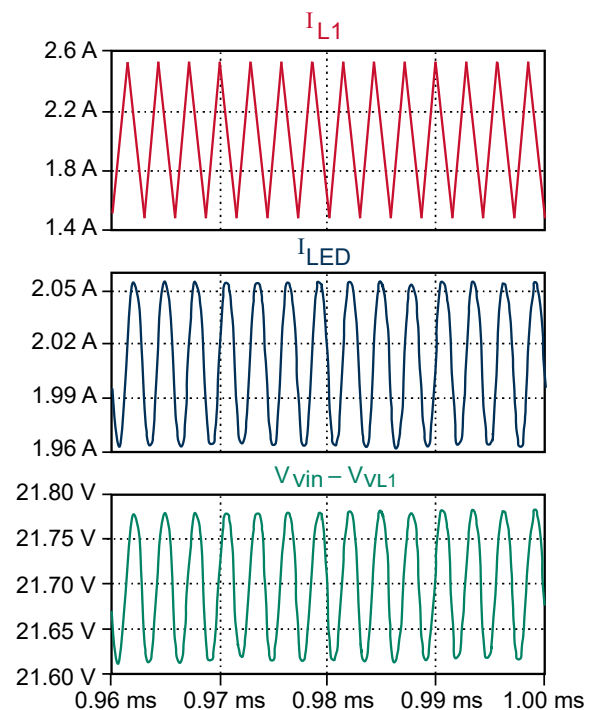


Figure 8: Simulation of buck converter with capacitor ($L = 33 \mu\text{H}$, $C = 2.2 \mu\text{F}$), with 48 V supply voltage.

Six configurations of buck converters (with and without a capacitor across the LEDs) are compared:

- 180 μH inductor, no capacitor
- 220 μH inductor, no capacitor
- 33 μH inductor, 1 μF LED capacitor
- 33 μH inductor, 2.2 μF LED capacitor
- 47 μH inductor, 1 μF LED capacitor
- 47 μH inductor, 2.2 μF LED capacitor

The variation of LED current ripple (%) with supply voltage for all six converters is shown in Figure 9. All have LED current ripple of less than 10% at the rated supply voltage of 48 V. Moreover, the LED ripple current of the 180 μH inductor, no capacitor configuration is very similar to the 33 μH inductor, 1 μF capacitor configuration. Increasing to a 47 μH inductor significantly reduces inductor ripple to less than 5% using a 1 μF capacitor and to less than 2% using a 2.2 μF capacitor.

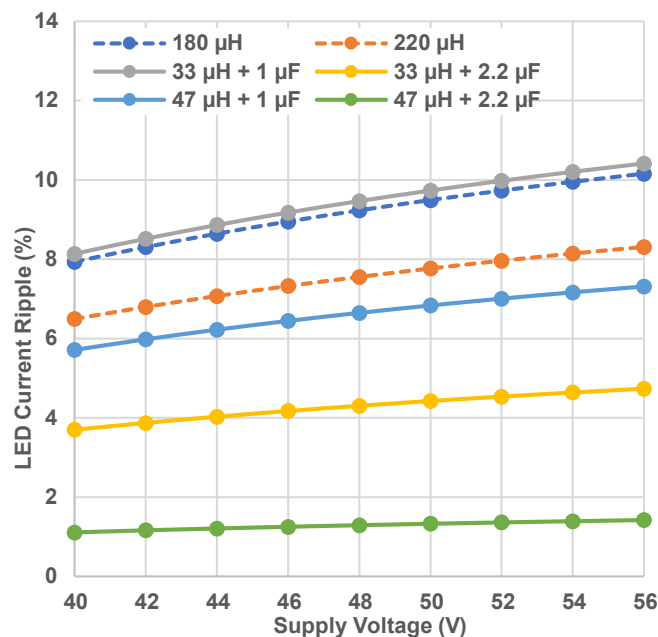


Figure 9: LED current ripple vs. supply voltage for different inductor and capacitor combinations.

The variation of the LED ripple voltage with supply voltage for six combinations of the buck converter is shown in Figure 10.

As can be observed, the LED voltage ripple for the buck converter with the 180 μH inductor, no capacitor, is very similar to the buck converter with a 33 μH inductor, 1 μF capacitor. Moreover, compared to other configurations, the voltage ripple reduces significantly (less than ~ 170 mV) with a 2.2 μF capacitor (with 33 μH or 47 μH inductor).

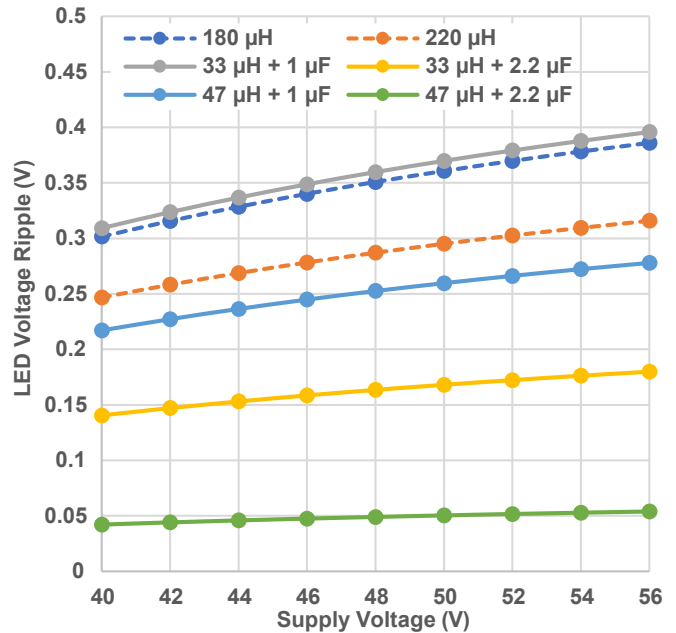


Figure 10: LED voltage ripple vs. supply voltage for different inductor and capacitor combinations.

Power Loss and Thermal Impact

At similar current ratings, higher-value inductors have higher DC resistance (DCR). For example, the DCR of a 220 μH inductor (2.3 A-rated current) is typically approximately 885 m Ω ; however, for a similar current rating, 33 μH inductors are typically available with a DCR value of 100 m Ω .

The eight-fold difference in DCR significantly impacts power losses in the inductor. The power loss for a 2 A-rated current for 33 μH is approximately 400 mW; whereas, for a 220 μH inductor, this increases to 3.54 W. Such high power loss impacts the overall efficiency of the converter system and increases the overall temperature of the PCB. Power losses in various inductors of similar current rating are compared in Figure 11.

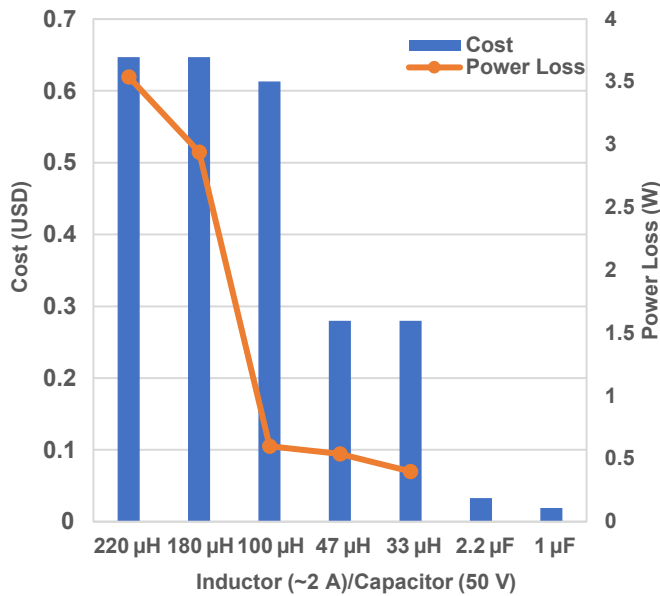


Figure 11: Cost and power loss of various inductors and capacitors.

System Cost

The cost of the inductor is a significant portion of the overall system cost. For a buck converter without a capacitor, the cost of a 220 μH, 2.3 A inductor or a 180 μH, 2.6 A inductor is approximately \$0.647 (when purchased in quantities of 5,000). However, for a buck converter with capacitor, use of a 33 μH, 2.3 A inductor or a 47 μH, 2 A inductor significantly reduces cost to \$0.28 (when purchased in quantities of 5,000). Ceramic capacitors are significantly less expensive, with a typical cost of approximately \$0.033 for a 2.2 μF, 50 V ceramic capacitor to approximately \$0.019 for a 1 μF, 50 V ceramic capacitor. This brings the overall cost of the inductor (47 μH) and capacitor (2.2 μF) to \$0.313—approximately half the cost of a 180 μH/220 μH inductor. Details of various inductors used for evaluation are provided in Table 3. The costs of various 2 A inductors and 50 V ceramic capacitors are compared in Figure 11.

Table 3: Comparison of Various Inductors

Value (μH)	Current (A)	DCR (mΩ)	Company	Cost (USD)
220 μH	2.3	885	Pulse Electronics	0.647
180 μH	2.6	735		0.647
100 μH	2.1	150	Bourns	0.613
47 μH	2	135	Eaton	0.28
33 μH	2.3	100		0.28

Size (Area and Volume)

The size of the inductor increases with inductance. Therefore, a larger inductor requires larger PCB area, resulting in a larger-volume solution, which is problematic for space-constrained applications. Areas and volumes of inductors listed in Table 3 are compared in Figure 12. As shown in the figure, the area and volume requirements of the 220 μH, 180 μH, and 100 μH inductors (the higher inductive values) are very high compared to the 47 μH and 33 μH inductors (the lower inductive values). The PCB space requirement for the larger inductors is almost 2.7 times that of the smaller inductors. This size difference becomes a crucial criterion in the selection of a converter configuration.

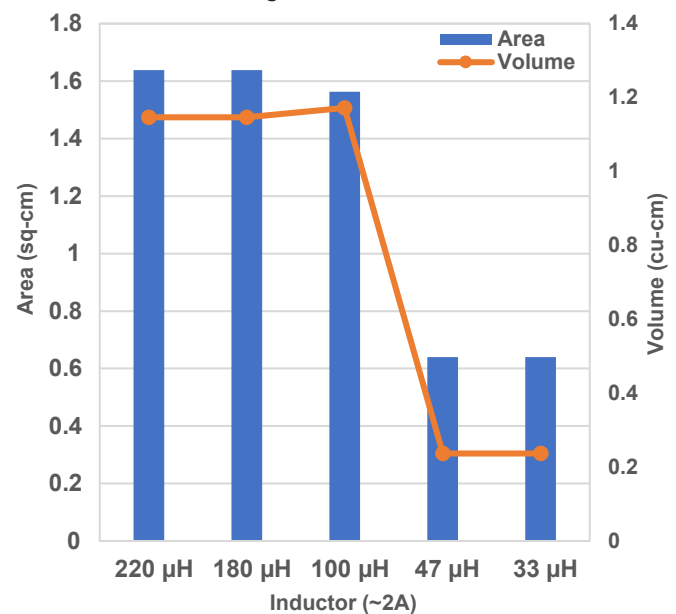


Figure 12: Area and volume requirements of various inductors.

Electromagnetic Interference (EMI)

In headlight applications, the converter portion of the headlight LED design is generally placed on a separate PCB and connected via long cables. These cables act as an antenna, which increases the overall radiated emission of the board. These emissions are directly proportional to the di/dt and dv/dt on the cables, which can be related to the voltage and current ripple on the LEDs. As discussed earlier, use of a capacitor connected across the LEDs significantly reduces the current and voltage ripple in the converter. Therefore, EMI-related issues are comparatively less in capacitor-based converters. Moreover, some smaller capacitors can also be connected to filter-out noise at a specified frequency of interest.

Stability

The buck converter without an output capacitor provides a direct load-to-inductor connection. Therefore, current control in the inductor (or load) can be performed simply using a hysteresis (bang-bang) controller, which gives an advantage of easy implementation. Moreover, because the LED capacitor is not present, the buck converter is realized as a single-pole system where the crossover frequency and bandwidth are high, thus making the converter inherently stable.

For a buck converter with an output LED capacitor, the overall system response is of the second order (pole and zero). The current control implementation generally employs a peak current control mode with added slope compensation for handling subharmonic issues at higher duty. To realize a stable system over the required load/voltage specifications, the compensation loop must be tuned properly. This tuning for system stability can be achieved with long- and widely-used loop-compensation techniques.

PWM Accuracy

PWM dimming is a commonly used feature in automotive LED applications. In a buck converter without an LED capacitor, the inductor current and the load current are the same. Also, because an LED capacitor is not present, the peak current requirement for capacitor charging is eliminated. As a result, inductor (load) current quickly rises to the peak value, at which point the device enters current-limiting operation.

Charging and discharging have finite slopes that are dependent on input voltage (V_{in}), output voltage (V_o), and inductor value (L). The charging slope is different than the discharging slope, as shown in Figure 13. As a result, PWM accuracy (applied duty vs. actual duty) varies slightly and external compensation must be made.

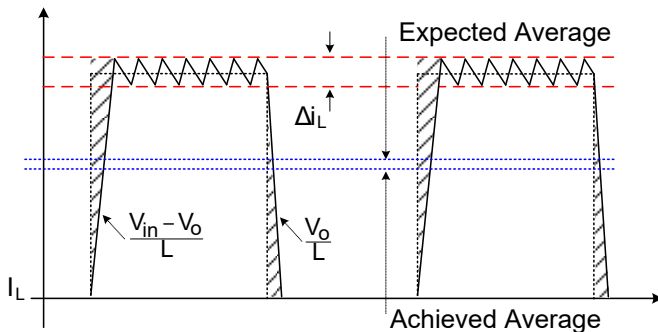


Figure 13: PWM accuracy in current-controlled converters.

The need to compensate for variation in PWM accuracy is prominent in the case of a buck converter with an output

LED capacitor, where the output capacitor demands extra current. Moreover, to limit the peak current, many devices use a soft-start feature, which further reduces the current charging slope. This worsens the overall PWM accuracy, and compensation must be made by the driver/controller. Buck converters designed with and without an LED capacitor are compared in Table 4.

Table 4: Comparison of Buck Converter Configurations With and Without LED Capacitor

Parameters	Without Capacitor (High Inductance)	With Capacitor (Low Inductance)
Inductor Current Ripple	Low	High
LED Current Ripple	Medium	Low
LED Voltage Ripple	Medium	Low (High Cap.)
Power Loss	High	Low
Thermals	Higher Heating	Lower Heating
System Cost	High	Low
Size (Area /Volume)	Very High	Low
EMI Issues	High	Low
Converter Stability	Minimal Tuning	Need Tuning
PWM Accuracy	Better	Nominal

ALLEGRO PORTFOLIO FOR AUTOMOTIVE HEADLIGHT APPLICATION

Allegro offers a wide range of devices that cater to different automotive headlight applications. Different Allegro devices for a variety of applications are compared in Figure 14 based on power vs. supply voltage. Details of the device offerings are presented next.

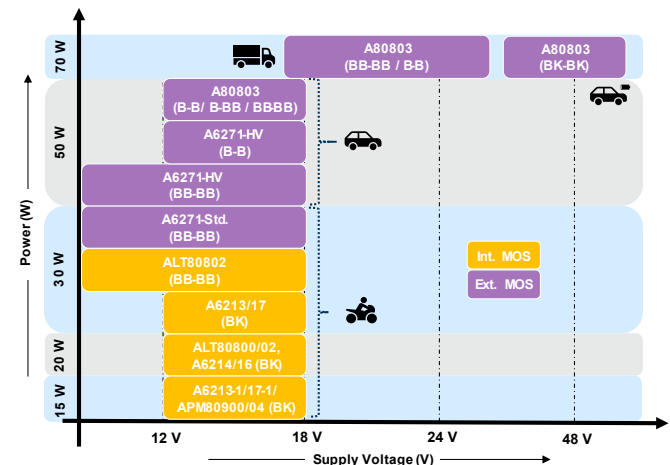


Figure 14: Power and voltage map showcasing various Allegro devices for headlight application.

Two-Wheeler Application

Two-wheelers require a small quantity of LEDs powered by a 12 V battery. The preferred device for this application typically has an integrated MOSFET. This minimizes size and cost. Allegro devices for this application include:

- $I_{LED} < 1.5 \text{ A}$: [A6213-1](#), [A6217-1](#), [APM80904](#)
- $I_{LED} < 2 \text{ A}$: [A6214](#), [A6216](#), [ALT80802](#), [ALT80800](#) (Synch. Buck)
- $I_{LED} < 3 \text{ A}$: [A6213](#), [A6217](#), [A6271-1](#) (Gate Driver)

Four-Wheeler (Passenger Vehicle) Application

Passenger vehicles require a greater number of LEDs powered by a 12 V battery. The preferred device for this application is therefore typically a controller IC (i.e., gate driver plus control). Allegro devices for this application include:

- [A6217-1](#) (Standard Configuration)
- [A6271-1](#) (High-Voltage Configuration)
- [A80803](#) (Multi-Topology Configuration)

Truck Application

The battery voltage requirement for trucks is 24 V. This application also requires a greater quantity of LEDs (>10) for headlights. Therefore, controller ICs such as the [A80803](#) are suited for this application.

Mild-Hybrid Application

This application requires power from a 48 V battery and support for a 60 V load dump. Thus, this application requires an input-voltage-referred buck controller. The Allegro [A80803](#) device is recommended for driving this configuration.

Key headlight specifications and recommended Allegro devices are summarized in Table 5. Key specifications of various Allegro devices are compared in Table 6.

Table 5: Key Headlight Specifications and Recommended Allegro Devices

S.No.	HB LED (Nos.)	LB LED (Nos.)	V _{bat} /Load Dump (V)	LED Current (A)	LED Power (W)	Vehicle Type	Headlight Class	Topology (HB)	Topology (LB)	Slew Control	Allegro IC
1	3	2	12 to 18 V, 40 V	< 1.5 A	~15 W	2-wheeler	A-B	Buck	Buck	Inherent (No o/p Cap.)	A6213-1/17-1
2	3	2	12 to 18 V, 40 V	< 1.5 A	~15 W	2-wheeler	A-B	Buck	Buck	External (with o/p Cap.)	A6213-1/17-1
3	3	2	12 to 18 V, 40 V	< 1.5 A	~15 W	2-wheeler	A-B	Buck	Buck	External	APM80900/04
4	3	2	12 to 18 V, 40 V	< 2 A	~20 W	2-wheeler	B-D	Buck	Buck	External	ALT80800/02 , A6214/16
5	3	2	12 to 18 V, 40 V	< 3 A	~30 W	2-wheeler	B-D	Buck	Buck	Inherent (No o/p Cap.)	A6213/17
6	3	2	12 to 18 V, 40 V	< 3 A	~30 W	2-wheeler	B-D	Buck	Buck	External (with o/p Cap.)	A6213/17
7	3-5	2-3	8 to 18 V, 40 V	< 2 A	~30 W	2-wheeler	B-D	Buck-Boost	Buck-Boost	External	ALT80802
8	≤ 5	≤ 5	8 to 18 V, 40 V	< 2 A	~30 W	2-wheeler	B-D	Buck-Boost	Buck-Boost	External	A6271-1 (Std.)
9	≤ 12	≤ 12	8 to 18 V, 40 V	< 1.2 A	~50 W	4-wheeler	≥ C	Buck-Boost	Buck-Boost	External	A6271-1 (HV)
10	≤ 20	≥ 15	12 to 18 V, 40 V	< 0.8 A	~50 W	4-wheeler	≥ C	Boost	Boost	External	A6271-1 (HV)
11	≤ 20	≥ 15	12 to 18 V, 40 V	< 0.8 A	~50 W	4-wheeler	≥ C	Boost	Boost	Integrated	A80803
12	≤ 20	1-11	12 to 18 V, 40 V	< 0.8 A	~50 W	4-wheeler	≥ C	Boost	Buck-Boost	Integrated	A80803
13	1 to 11	≤ 11	12 to 18 V, 40 V	< 1.5 A	~50 W	4-wheeler	≥ C	Buck-Boost	Buck-Boost	Integrated	A80803
14	8	5	16 to 36 V, 60 V	< 2.8 A	~70 W	Trucks	≥ C	Buck-Boost	Buck-Boost	Integrated	A80803
15	≥ 20-25	≥ 15	16 to 36 V, 60 V	< 0.8 A	~70 W	Trucks	≥ C	Boost	Boost	Integrated	A80803
16	10	< 10	40 to 56 V, 60 V	< 2 A	~70 W	4-wheeler (MH)	≥ C	Buck	Buck	Integrated	A80803

Table 6: Key Specification Comparison of Various Allegro ICs

Parameter	A6213	A6213-1	A6214/16	A6217	A6217-1	ALT80800	ALT80802	APM80904	A6271-1	A80803
Topology	N.Sy. Buck	N.Sy. Buck	N.Sy. Buck	N.Sy. Buck	N.Sy. Buck	Sy. Buck	NS Buck/BB	Sy. Buck	Multi	Multi
Int. MOS/Gate Driver	Int. MOS	Int. MOS	Int. MOS	Int. MOS	Int. MOS	Int. MOS	Int. MOS	Int. MOS.	Gate Drv.	Gate Drv.
Int. Inductor	No	No	No	No	No	No	No	Yes	No	No
I _{out}	3 A	1.5 A	2 A	3 A	1.5 A	2 A	2 A	1.5 A	–	–
V _{in}	6 to 48 V	6 to 48 V	4.5 to 55 V	6 to 48 V	6 to 48 V	4.5 to 55 V	3.8 to 50 V	4.5 to 36 V	4.2 to 50 V	5 to 37 V
SW	50 V	50 V	60 V	50 V	50 V	60 V	55 V	40 V	–	80 V
CS Node	–	–	60 V	7 V	7 V	60 V	55 V	40 V	58 V	80 V
LED Cap.	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Slew Control	No	No	No	No	No	No	No	No	No	Yes

CONCLUSION

To help designers find the appropriate device for specific automotive headlight applications, the automotive headlight application has been overviewed. Requirements of headlights for two-wheelers, passenger vehicles, commercial vehicles, and mild hybrid vehicles have been presented. Limitations and applicability of various topologies—such as the buck, boost and the buck-boost converter—have been reviewed. Comparisons of converter configurations with and without an output LED capacitor have been considered based on inductor and LED current ripple, LED voltage ripple, system cost, power loss (efficiency), thermals, solution size, EMI, stability, and PWM accuracy.

Several Allegro offering have also been presented for a wide range of products in LED drivers and controllers. The Allegro devices support numerous converter design configurations and are offered with integrated protection and diagnostics. With a high level of integration and a wide range of product selection, the Allegro devices give the user optimal design flexibility.

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Revision History

Number	Date	Description	Responsibility
-	March 9, 2023	Initial release	V. Bist, S. Wekhande

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