LM3492 Evaluation Board Reference Design

National Semiconductor
Application Note 2056
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Introduction

The LM3492 integrates a boost converter and a two-channel current regulator to implement a high efficient and cost effective LED driver for driving two individually dimmable LED strings with a maximum power of 15W and an output voltage of up to 65V. The boost converter employs a proprietary Projected-On-Time control method to give a fast transient response with no compensation required, and a nearly constant switching frequency programmable from 200 kHz to 1 MHz. The application circuit is stable with ceramic capacitors and produces no audible noise on dimming. The programmable peak current limit and soft-start features reduce current surges at startup, and an integrated 190 mΩ, 3.9A N-Channel MOSFET switch minimizes the solution size. The fast slew rate current regulator allows high frequency and narrow pulse width dimming signals to achieve a very high contrast ratio of 1000:1 at a dimming frequency of more than 3 kHz. The LED current is programmable from 50 mA to 200 mA by a single resistor.

To maximize the efficiency, Dynamic Headroom Control (DHC) automatically adjusts the output voltage to a minimum. DHC also facilitates a single BOM for different number of LED in a string, which is required for backlight panels of different size, thereby reducing overall development time and cost. The LM3492 comes with a versatile COMM pin which serves as a bi-directional I/O pin interfacing with an external MCU for the following functions: power-good, over-temperature, IOUT over- and under-voltage indications, switching frequency tuning, and channel 1 disabling. Other supervisory functions of the LM3492 include precise enable, VCC under-voltage lockout, current regulator Over-Power protection, and thermal shutdown protection. The LM3492 is available in the thermally enhanced eTSSOP-20 package.

This application note details the design of a LM3492 evaluation board which drives 2 LED strings, each of which consists of 10 LEDs running at 150 mA and the forward voltage of each LED is typically 3.8V. The input voltage is from 9V to 16V. The evaluation board schematic, PCB layout, Bill of Materials, and circuit design descriptions are shown. Typical performance and operating waveforms are also provided for reference.

Evaluation Board Schematic and PCB Layout

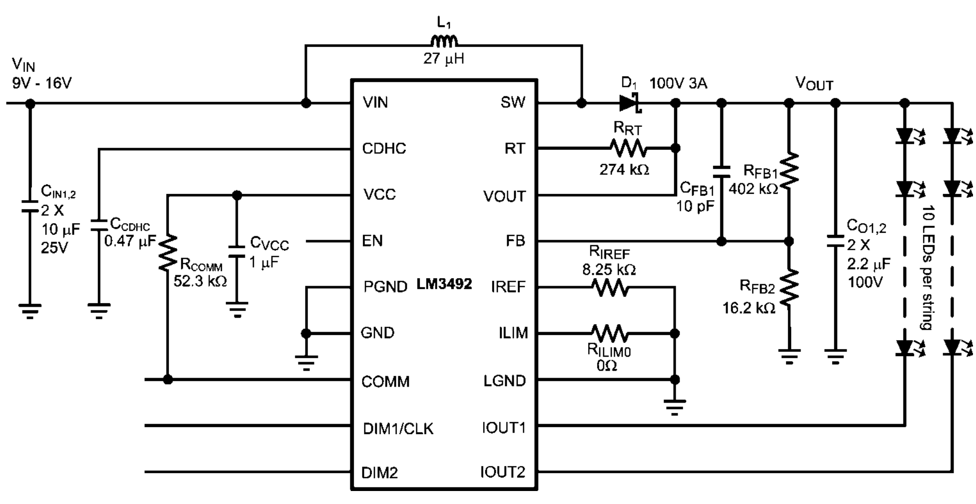

FIGURE 1. LM3492 Evaluation Board Schematic

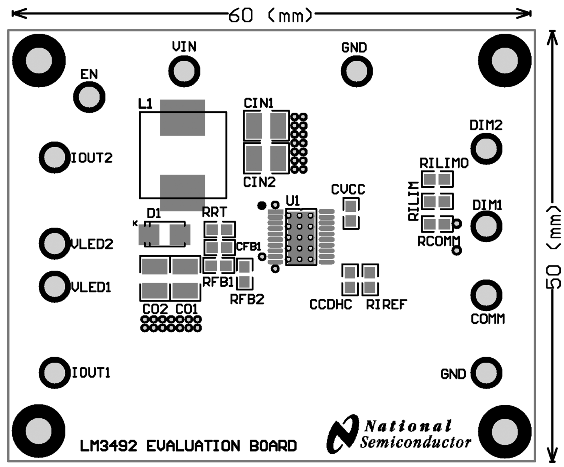

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FIGURE 2. LM3492 Evaluation Board Top Overlay

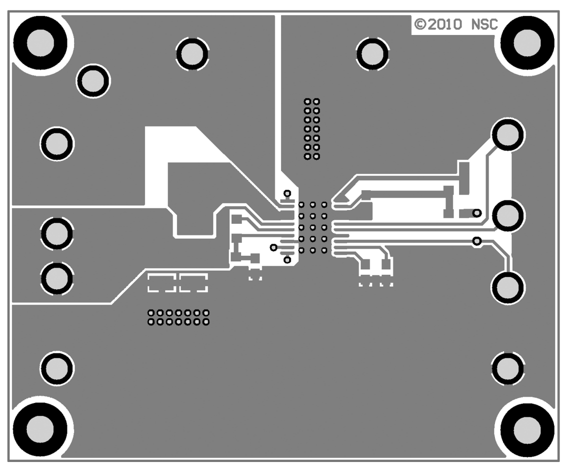

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FIGURE 3. LM3492 Evaluation Board Top View

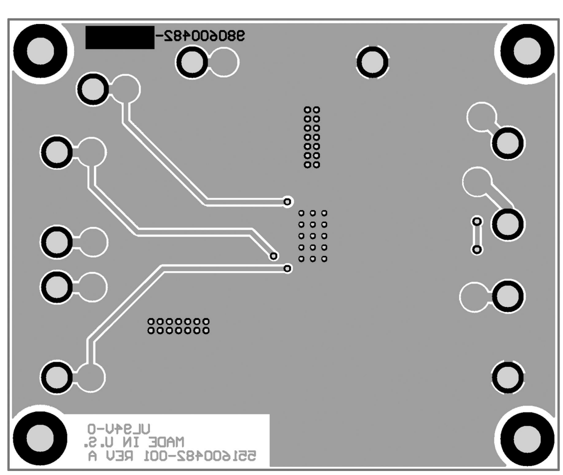

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FIGURE 4. LM3492 Evaluation Board Bottom View

Evaluation Board Quick Setup Procedures

Step	Description	Notes
1	Connect a power supply to VIN and PGND terminals	V_{IN} range: 9V to 16V
2	Connect 2 LED strings: from VLED1 to IOUT1 terminals, and VLED2 to IOUT2 terminals	Each LED string consists of 10 LEDs with a forward voltage of 3.8V per LED at 150 mA
3	The EN terminal should be left open for normal operation. Ground this terminal to shutdown	
4	Connect DIM1 and DIM2 terminals to a voltage > 2V, apply V_{IN} = 12V	Nominal LED current is 150 mA per channel
5	Ground the EN terminal to check the shutdown function	

Evaluation Board Performance Characteristic

Description	Symbol	Condition	Min	Typ	Max	Unit
Input Voltage	V_{IN}		9	12	16	V
Rail Voltage	V_{OUT}			39		V
LED Current	I_{LED}			150		mA
LED Current Regulationt	ΔI_{LED}	ALL V_{IN} conditions	-3		+3	%
Efficiency		V_{IN} = 9V		85.7		%
		V_{IN} = 12V		88.2		%
		V_{IN} = 16V		89.1		%

Design Procedure

The following procedures detail the design of the LM3492 evaluation board driving 2 LED strings consists of 10 LEDs per string. The forward voltage of each LED is 3.8V, and the LED current is 150 mA. The input voltage is ranged from 9V to 16V. The switching frequency f_{SW} is designed to be 500 kHz.

Design Parameters:

V_{IN} = 9V to 16V, typical 12V

I_{LED} = 150 mA

Step 1: Calculate the output voltage feedback circuit

The nominal voltage of the LED string with 10 LEDs is 38V, and the minimum voltage of the IOUTn pin (n = 1, 2) is 0.75V for an I_{LED} of 150 mA. Hence, $V_{OUT(NOM)}$ is 38.75V. Since the dynamic range of V_{FB} under DHC is from 1.05V to 2V, the nominal voltage on the FB pin $V_{FB(NOM)}$ is designed to be around 1.5V. Hence, $V_{OUT(MAX)}$ is designed to be 65V. Since

$$V_{OUT(MAX)} = 2.5V\,(1 + R_{FB1} / R_{FB2}) \quad (1)$$

By designing R_{FB2} to be 16.2 kΩ, R_{FB1} is calculated to be 405 kΩ, and a standard resistor value of 402 kΩ is selected. C_{FB1} is selected to be 10 pF as recommended.

Step 2: Determine the inductance

The main parameter affected by the inductor is the peak to peak inductor current ripple (I_{LR}). To maintain a continuous conduction mode (CCM) operation, the average inductor current I_{L1} should be larger than half of I_{LR}.

For a boost converter, I_{L1} equals to the input current I_{IN}. The minimum I_{IN} occurs when V_{IN} is maximum, which is 16V in this example, and only 1 LED string is turned on (the 2 LED strings are individually dimmable). Hence,

$$I_{IN(MIN)} = (V_{OUT(NOM)} \times I_{LED}) / V_{IN(MAX)} \quad (2)$$

Also

$$t_{on} = (1 - V_{IN}/V_{OUT}) / f_{SW} \quad (3)$$

To ensure a CCM operation,

$$L_1 = (V_{IN(MAX)} \times t_{on}) / 2I_{IN(MIN)} \quad (4)$$

It can be calculated that $I_{IN(MIN)}$, t_{on}, and L_1 are 0.363A, 1.17 µs, and 25.8 µH. On the other hand, I_{IN} is maximum when V_{IN} is minimum, which is 9V in this example, and 2 LED strings are turned on. Hence $I_{IN(MAX)}$ is 1.29A. From (3), t_{on} is 1.54 µs when V_{IN} is 9V. Then I_{LR} is

$$I_{LR} = (V_{IN} \times t_{on}) / L_1 \quad (5)$$

From (5), I_{LR} is 0.53A. The steady state peak inductor current $I_{L1(PEAK)}$ is

$$I_{L1(PEAK)} = I_{L1} + I_{LR} / 2 \quad (6)$$

As a result, $I_{L1(PEAK)}$ is 1.56A. A standard value of 27 µH is selected for L_1, and the saturation current of L_1 should be larger than 1.56A.

Step 3: Determine the diode

The selection of the boost diode D_1 depends on two factors. The first factor is the reverse voltage, which equals to V_{OUT} in a boost converter. The second factor is the peak diode current at the steady state, which equals to the peak inductor current as shown in (6). In this example, a 100V 3A schottky diode is selected.

Step 4: Determine the value of other components

C_{IN} and C_{OUT}: The function of the input capacitor C_{IN} and the output capacitor C_{OUT} is to reduce the input and output voltage ripples. Experimentation is usually necessary to determine their value. The rated DC voltage of capacitors used should be higher than the maximum DC voltage applied.

Owing to the concern of product lifetime, ceramic capacitors are recommended. But ceramic capacitors with high rated DC voltage and high capacitance are rare in general. Multiple capacitors connecting in parallel can be used for C_{IN} and C_{OUT}. In this example, two 10 µF 25V ceramic capacitor are used for C_{IN}, and two 2.2 µF 100V ceramic capacitor are used for C_{OUT}.

C_{VCC}: The capacitor on the VCC pin provides noise filtering and stabilizes the LDO regulator. It also prevents false triggering of the VCC UVLO. C_{VCC} is recommended to be a 1 µF good quality and low ESR ceramic capacitor.

C_{CDHC}: The capacitor at the CDHC pin mainly determines the soft-start time t_{SS}, i.e. the time for the output voltage to reach its maximum. t_{SS} is determined from the following equation:

$$t_{SS} = \frac{C_{CDHC} \times 2.25V}{120\ \mu A} \quad (7)$$

In this example, C_{CDHC} is recommended to be a 0.47 µF good quality and low ESR ceramic capacitor.

R_{RT} and R_{IREF}: The resistors R_{RT} and R_{IREF} set the switching frequency f_{SW} of the boost converter and the LED current I_{LED} respectively. From the LM3492 datasheet, R_{RT} is selected to be 274 kΩ if f_{SW} is 500 kHz (Figure 1 of the datasheet), and R_{IREF} is selected to be 8.25 kΩ if I_{LED} is 150 mA (Figure 4 of the datasheet).

R_{COMM}: Since the COMM pin is open drain, a resistor R_{COMM} of 52.3 kΩ is used to connect the VCC and COMM pins to implement a pull-up function.

PC Board Layout

The layout of the printed circuit board is critical to optimize the performance of the LM3492 application circuit. In general, external components should be placed as close to the LM3492 and each other as possible in order to make copper traces short and direct. In particular, components of the boost converter C_{IN}, L_1, D_1, C_{OUT}, and the LM3492 should be closed. Also, the output feedback capacitor C_{FB1} should be closed to the output capacitor C_{OUT}. The ground plane connecting the GND, PGND, and LGND pins and the exposed pad of the LM3492 and the ground connection of the C_{IN} and C_{OUT} should be placed on the same copper layer.

Good heat dissipation helps optimize the performance of the LM3492. The ground plane should be used to connect the exposed pad of the LM3492, which is internally connected to the LM3492 die substrate. The area of the ground plane should be extended as much as possible on the same copper layer around the LM3492. Using numerous vias beneath the exposed pad to dissipate heat of the LM3492 to another copper layer is also a good practice.

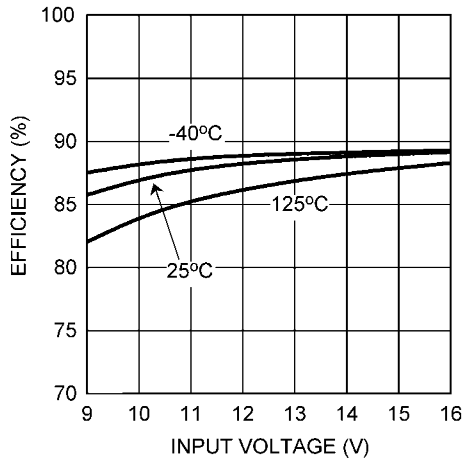
Bill of Materials

Item	Part Number	Mfg name	Part Description	Qty	Ref Designator(s)	Size
1	GRM31CR61E106KA12L	muRata	Cap 10 µF 25V X5R	2	C_{IN1}, C_{IN2}	1206
2	GRM188R71C474KA88D	muRata	0603/X7R/0.47 µF/16V	1	C_{CDHC}	0603
3	GRM1885C2A100RA01D	muRata	0603/COG/10 pF/100V	1	C_{FB1}	0603
4	GRM188R71C105KA12D	muRata	0603/X7R/1 µF/16V	1	C_{VCC}	0603
5	GRM32ER72A225KA35L	muRata	Cap 2.2uF 100V X7R	2	C_{O1}, C_{O2}	1210
6	CRCW060352K3FKEA	Vishay	Resistor Chip 52.3 kΩ 1%	1	R_{COMM}	0603
7	CRCW0603274KFKEA	Vishay	Resistor Chip 274 kΩ 1%	1	R_{RT}	0603
8	CRCW0603402KFKEA	Vishay	Resistor Chip 402 kΩ 1%	1	R_{FB1}	0603
9	CRCW060316K2FKEA	Vishay	Resistor Chip 16.2 kΩ 1%	1	R_{FB2}	0603
10	CRCW06038K25FKEA	Vishay	Resistor Chip 8.25 kΩ 1%	1	R_{IREF}	0603
11	CRCW06030000Z0EA	Vishay	Resistor Chip 0Ω 1%	1	R_{ILIM0}	0603
12	CDRH10D68/ANP-270MC	Sumida	Inductor 27 µH 1.9A	1	L_1	10×10×6.8
13	SK310A-TP	Micro Commercial	Schottky 100V 3A	1	D_1	SMA
14	1502-2k-ND	KEYSTONE	Terminal DBL Turret 0.109”L Brass	11	VIN, GND, PGND, VLED1, VLED2, IOUT1, IOUT2, DIM1, DIM2, COMM, EN	
15	LM3492EVAL	NSC	LM3492 demo board	1	PCB	
16	LM3492MH	NSC	IC LM3492	1	U1	eTSSOP-20

Typical Performance and Waveforms

All curves and waveforms taken at V_{IN} = 12V with the evaluation board and T_A = 25°C unless otherwise specified.

Efficiency vs Input Voltage (I_{LED} = 150 mA)



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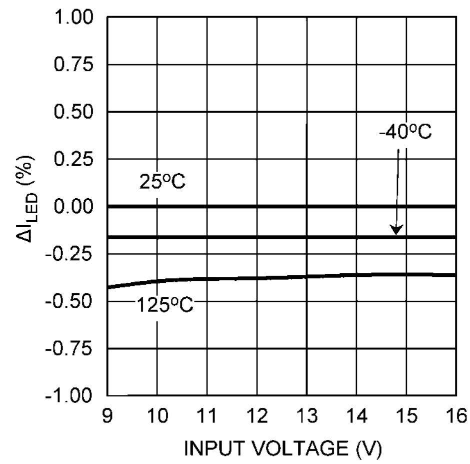
I_{LED} Regulation vs Input Voltage (I_{LED} = 150 mA)



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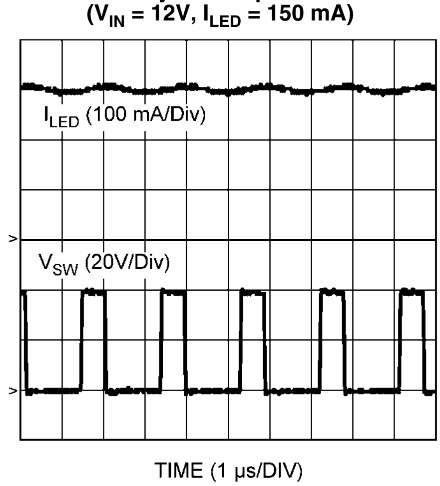
Steady State Operation (V_{IN} = 12V, I_{LED} = 150 mA)



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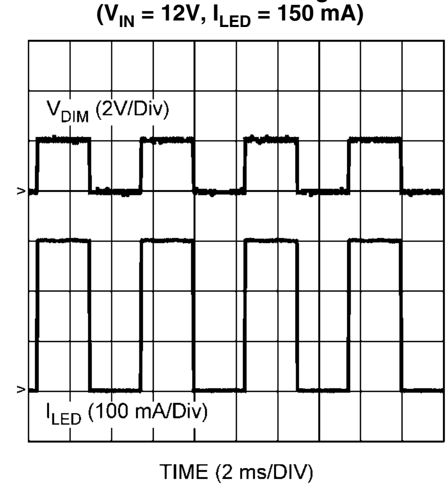
LED 50% Dimming (V_{IN} = 12V, I_{LED} = 150 mA)



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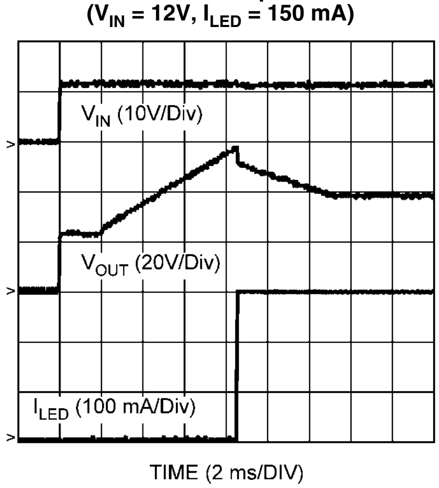
Power Up (V_{IN} = 12V, I_{LED} = 150 mA)



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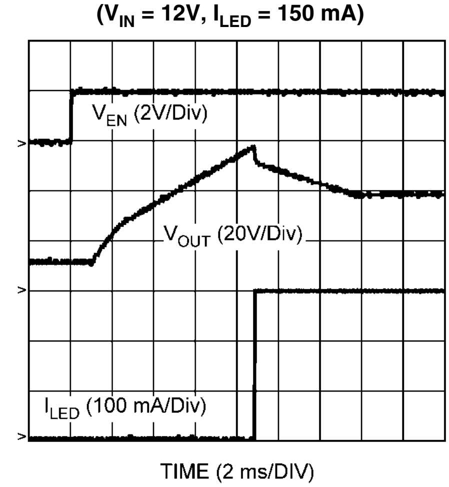
Enable Transient (V_{IN} = 12V, I_{LED} = 150 mA)



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Notes

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