AN-1585 LM3402 and LM3404 High Power PSOP-8 Evaluation Board

1 Introduction

The LM3402/02HV and LM3404/04HV are buck-regulator derived, controlled current sources designed to drive a series string of high power, high brightness LEDs (HBLEDs) such as the Luxeon™ K2 Emitter at forward currents of up to 0.5A (LM3402/02HV) or 1.0A (LM3404/04HV). This evaluation board demonstrates the enhanced thermal performance of the PSOP-8 package option of any of those four ICs. The LM3404HV was chosen for the example circuit because the combination of high output current, high input voltage, and high duty cycle create the greatest demand for low junction-to-ambient thermal resistance (θ_{JA}). Note that the LM3404/04HV in SO-8 can also be used with this evaluation board, with reduced thermal performance.

LED drivers are often placed in small, closed spaces with no air flow and high ambient temperature due to the dissipation of the LEDs. When properly soldered the PSOP-8 package offers a θ_{JA} that is as little as one-half that of the standard SO-8 package, and as little as one-third that of the MSOP-8 package.

2 Circuit Performance with LM3404HV

This evaluation board uses the LM3404HV to provide a constant forward current of 1.0A ±10% to a string of ten series-connected HBLEDs with a forward voltage of approximately 3.7V each from an input of 48V ±5%. The LED ripple current, Δi_F, will not exceed 80 mA_{P-P}, and the switching frequency is 550 kHz ± 10%. The circuit can operate over an extended input voltage range of 40V to 60V, however output current may exceed the ±10% specification.

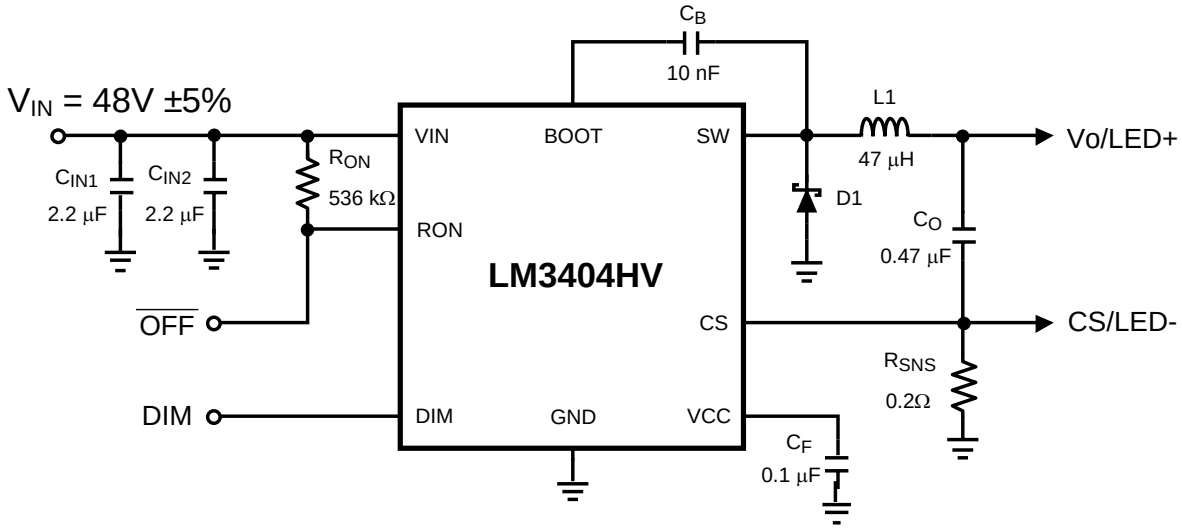


Figure 1. Standard Schematic

3 Thermal Performance

The PSOP-8 package is pin-for-pin compatible with the SO-8 package with the exception of the thermal pad, or exposed die attach paddle (DAP). The DAP is electrically connected to system ground. When the DAP is properly soldered to an area of copper on the top layer, bottom layer, internal planes, or combinations of various layers, the θ_{JA} of the LM3404/04HV can be significantly lower than that of the SO-8 package or MSOP-8 package in the case of the LM3402/02HV. The PSOP-8 evaluation board is two layers of 1oz copper each, and measures 1.25" by 1.95". The DAP is soldered to approximately one square inch of top and two square inches of bottom layer copper. Five thermal vias connect the DAP to the bottom layer of the PCB, and the recommended DAP/via layout is shown in Figure 2.

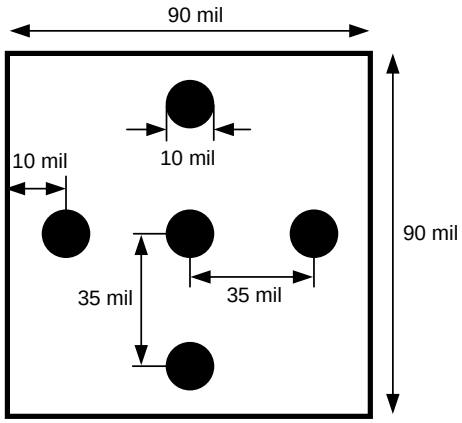


Figure 2. Thermal Pad and Via Layout

Calibrated testing was performed on the PSOP-8 evaluation board to compare the performance of the PSOP-8 with the DAP soldered and the standard SO-8 package. The example circuit dissipation is approximately 1.1W. (see the LM3404/04HV datasheet for detailed thermal calculations.) For dissipation ranging from 0.5W to 1.5W the θ_{JA} of the PSOP-8 package is 50°C/W ±10%. The θ_{JA} of the SO-8 package is 100°C/W ±10%.

4 Connecting to LED Array

The LM3404/04HV Evaluation Board includes a female 6-pin SIP, **J1**, connector as well as two standard 94mil turret connectors for the cathode and anode connections of the LED array. Figure 3 shows the pinout of **J1**. Solid 18 or 20 gauge wire with about 1 cm of insulation stripped away makes a convenient, solderless connection to **J1**.

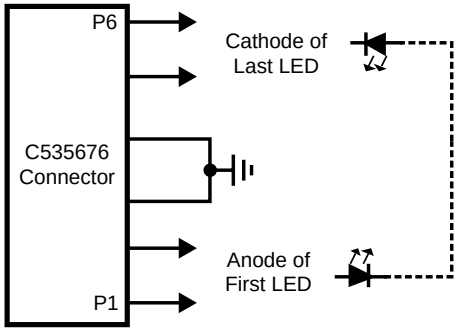


Figure 3. LED Connector

5 Setting the LED Current

The default forward current I_F delivered to the LED array is 1.0A, typical of many 3W LEDs. To adjust this value the current setting resistor R_{SNS} can be changed according to the following equation:

$$R_{SNS} = \frac{0.2 \times L}{I_F \times L + V_O \times t_{SNS} - \frac{V_{IN} - V_O}{2} \times t_{ON}} \quad (1)$$

$$t_{SNS} = 220 \text{ ns} \quad (2)$$

This resistor should be rated to handle the power dissipation of the LED current. For this example, the closest 5% tolerance resistor to set an LED current of 1.0A is 0.2 Ω. In steady state this resistor will dissipate (1.0 x 0.2) = 200 mW, indicating that a resistor with a 1/4W power rating is appropriate.

6 PWM Dimming

The **DIM** terminal on the PCB provides an input for a pulse width modulation signal for dimming of the LED array. In order to fully enable and disable the LM3404/04HV the PWM signal should have a maximum logic low level of 0.8V and a minimum logic high level of 2.2V. The maximum PWM dimming frequency, minimum PWM duty cycle and maximum duty cycle are illustrated in Figure 4. PWM frequency should be at least one order of magnitude below the LM3404/04HV switching frequency. The interval t_D represents the delay from a logic high at the DIM pin to the onset of the output current. The quantities t_{SU} and t_{SD} represent the time needed for the output current to slew up to steady state and slew down to zero, respectively. Typical response time is shown in Typical Performance Characteristics.

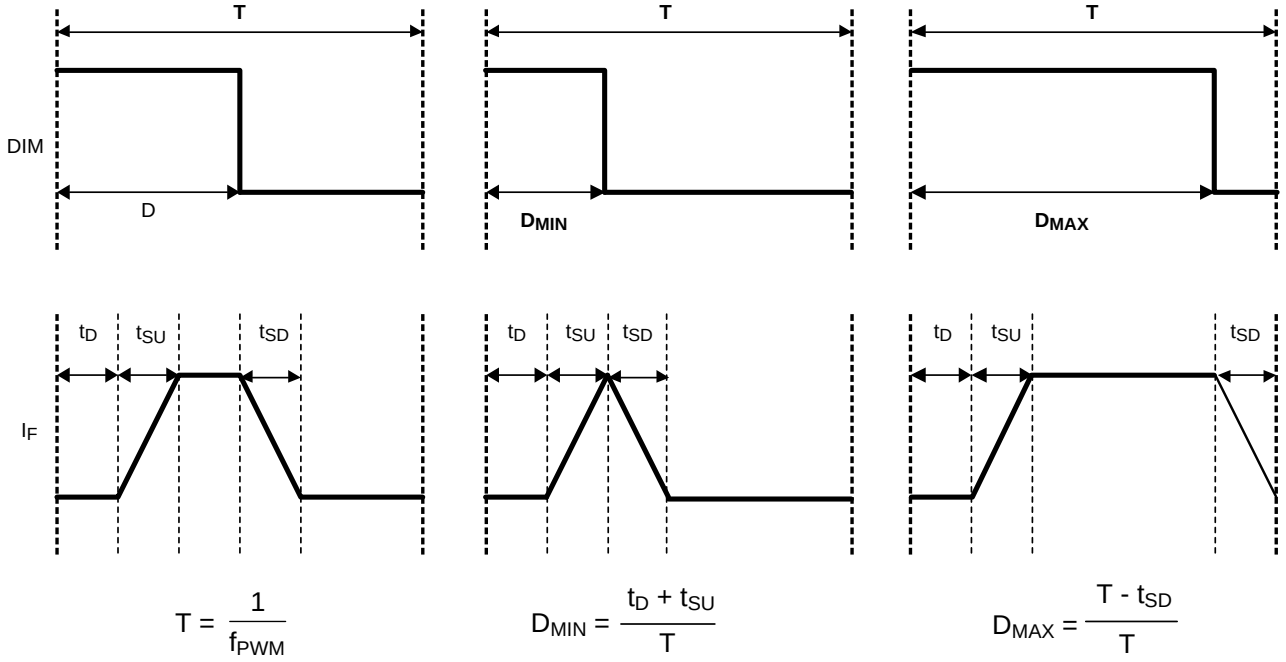


Figure 4. PWM Dimming Limits

The logic of **DIM** is direct, hence the LM3404HV will deliver regulated output current when the voltage at **DIM** is high, and the current output is disabled when the voltage at **DIM** is low. Connecting a constant logic low will disable the output, and the LM3404/04HV is enabled if the DIM pin is open-circuited. The **DIM** function disables only the power MOSFET, leaving all other circuit blocks functioning to minimize the converter response time.

7 Low Power Shutdown

The LM3404HV can be placed into a low power shutdown (I_Q typically 90 µA) by grounding the **OFF*** terminal. During normal operation this terminal should be left open-circuit.

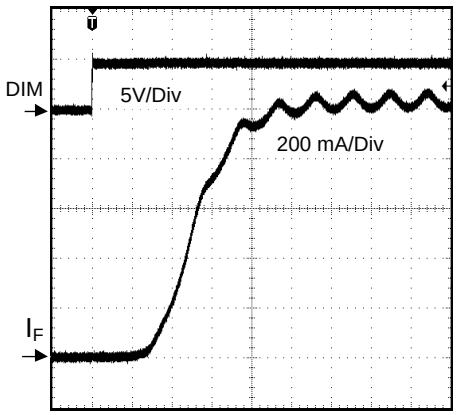
8 Bill of Materials

Table 1. Bill of Materials

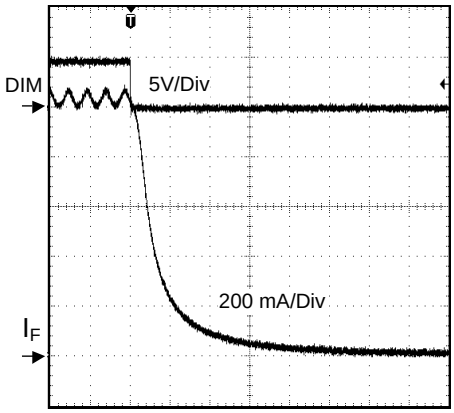
ID	Part Number	Type	Size	Parameters	Qty	Vendor
U1	LM3404HV	LED Driver	PSOP-8	75V, 1.0A	1	NSC
L1	SLF10145T- 470M1R4	Inductor	10.1 x 10.1 x 4.5mm	47µH, 1.4A, 0.1Ω	1	TDK
D1	CMSH2-60M	Schottky Diode	SMA	60V, 2A	1	Central Semi
Cf	VJ0603Y104KXXAT	Capacitor	0603	100nF 10%	1	Vishay
Cb	VJ0603Y103KXXAT	Capacitor	0603	10nF 10%	1	Vishay
Cin1, Cin2	C4532X7R2A225M	Capacitor	1812	2.2µF, 100V	2	TDK
Co	C3216X7R2A474M	Capacitor	1206	0.47µF, 100V	1	TDK
Rsns	ERJ8BQFR20V	Resistor	1206	0.2Ω 1%	1	Panasonic
Ron	CRCW06035363F	Resistor	0603	536kΩ 1%	1	Vishay
DIM1, OFF*	160-1512	Terminal	0.062”		2	Cambion
GND, VIN, Vo/LED+, CS/LED-	160-1026	Terminal	0.094”		5	Cambion
J1	535676-5	Connector	Custom	6 Pins	1	Tyco/AMP

9 Typical Performance Characteristics

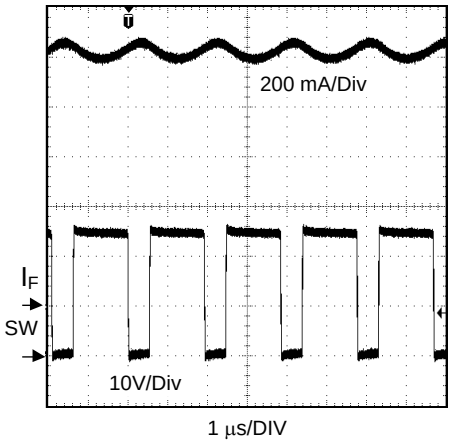
DIM Pin Enable



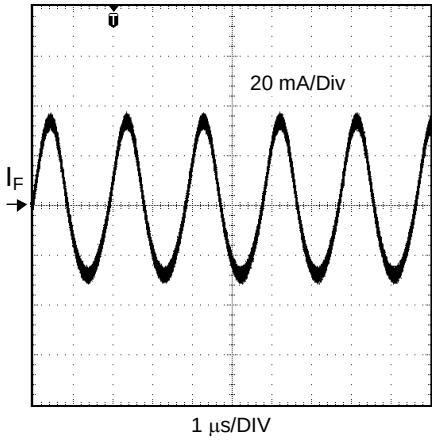
DIM Pin Disable



Switching Waveforms



Output Ripple Current



10 Layout

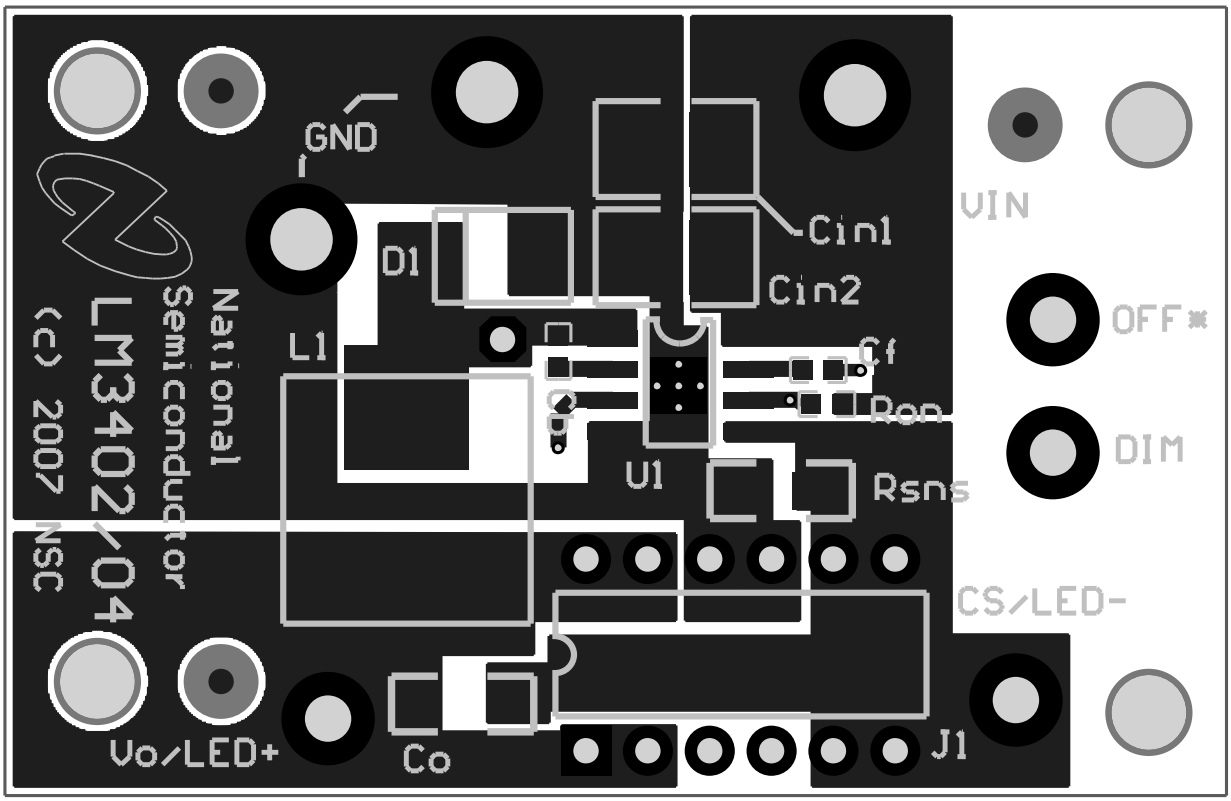


Figure 5. Top Layer and Top Overlay

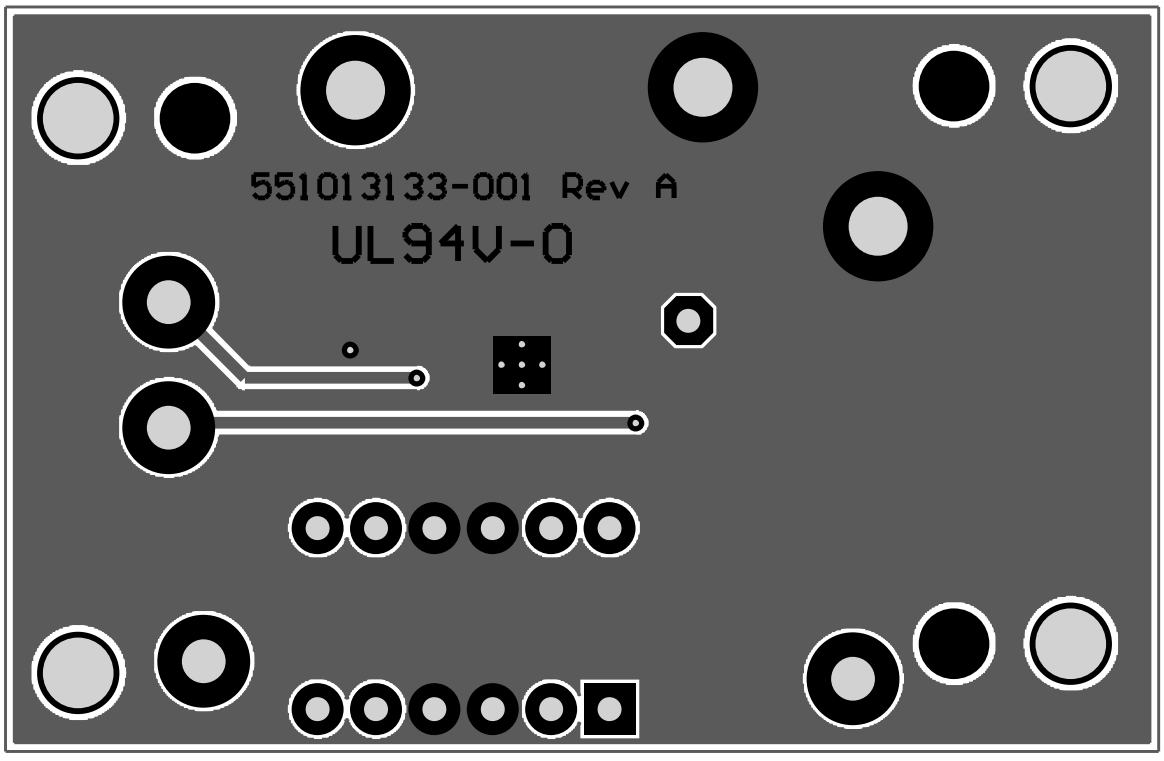


Figure 6. Bottom Layer and Bottom Overlay

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