AN-1590 LM3405 Demo Board

1 Introduction

The LM3405 demo board is configured to drive a series string of high power, high brightness LEDs at a forward current of 1A using the LM3405 constant current buck regulator. The board can accept a full input operating range of 3V to 15V. The converter output voltage adjusts as needed to maintain a constant current through the LED array. The LM3405 is a step-down regulator with an output voltage range extending from a $V_{O(MIN)}$ of 205mV (the reference voltage) to a $V_{O(MAX)}$ determined by the maximum duty cycle (typically 94%). It can drive up to 3 LEDs in series at 1A forward current, with the single LED forward voltage of approximately 3.7V (Typical of white, blue, and green LEDs using InGaN technology).

As shown in the demo board schematic circuit in Figure 1, the board is configured with the boost voltage derived from V_{IN} through a shunt zener (D3). This will ensure that the gate drive voltage V_{BOOST} - V_{SW} falls in the recommended range of 2.5V to 5.5V when V_{IN} varies from 5V to 15V. In cases of low input voltages (3V to 5V) being used, the boost diode (D2) can be directly connected to V_{IN} (R3 short, C4 and D3 not installed) to obtain sufficient gate drive voltage for best performance.

Table 1 lists the bill of materials of this demo board. The measured performance characteristics and layout of this board are also included below. Additional Circuit Configuration Schematics section illustrates other possible circuit configurations of this board to accommodate various input and output requirements as discussed in the LM3405 datasheet.

2 Connecting to LED Array

The LM3405 Demo Board includes a female 6-position SIP connector **P1** as well as two standard 72mil turret connectors for the cathode and anode connections of the LED array. Solid 18 or 20 gauge wire with about 1cm of insulation stripped away makes a convenient, solderless connection to **P1**.

3 Setting the LED Current

The default forward current I_F delivered to the LED array is 1.0A. To adjust this value the current setting resistor R1 can be changed according to the following equation:

$$I_F = V_{FB} / R1 \quad (1)$$

The feedback voltage V_{FB} is regulated at 0.205V typically. The resistor R1 should be rated to handle the power dissipation of the LED current. R1 should be less than approximately 1Ω, to ensure that the LED current is kept above 200mA. If average LED currents of less than 200mA are desired, the EN/DIM pin should be used for PWM dimming.

4 PWM Dimming

The default connection of the PWM terminal is tied to V_{IN} through a 100kΩ resistor (R2) to enable the chip, which allows the set current to flow through the LEDs continuously. This PWM terminal can also be connected separately to a periodic pulse signal at different frequencies and/or duty cycle for PWM dimming. A typical LED current waveform in PWM dimming mode is shown in Figure 2. Figure 3 shows the average LED current versus duty cycle of PWM dimming signal for various frequencies. Due to an approximately 100µs delay between the dimming signal and LED current, the dimming ratio reduces dramatically if the applied PWM dimming frequency is greater than 5kHz.

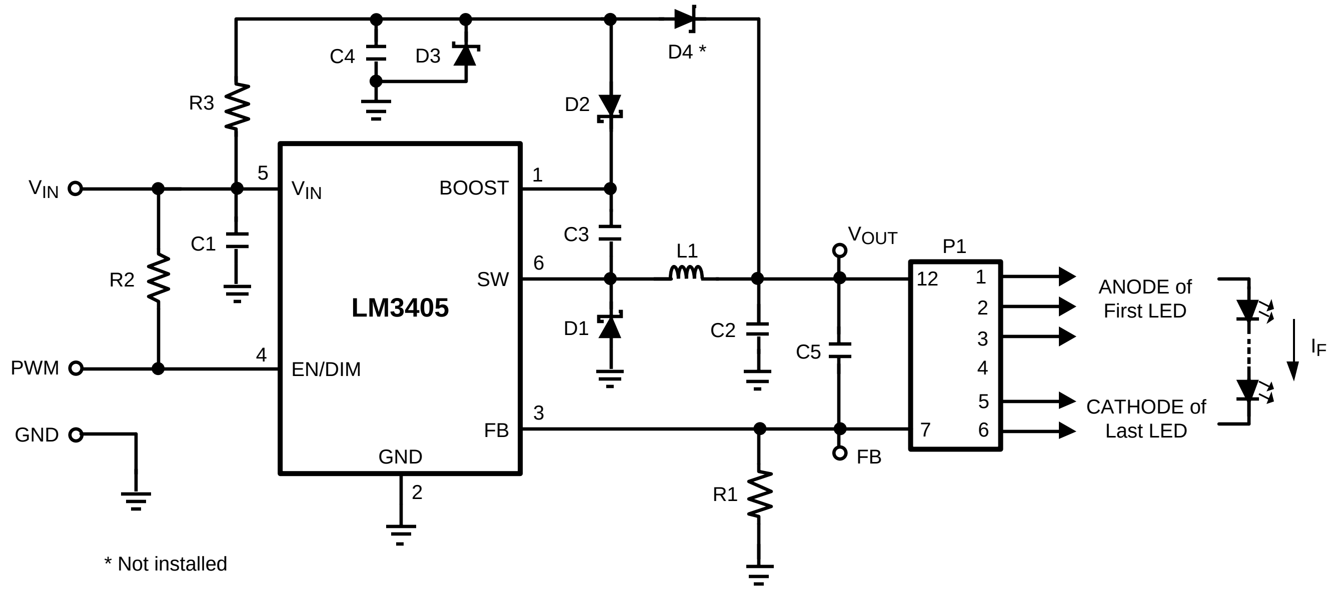

Figure 1. LM3405 Demo Board Schematic

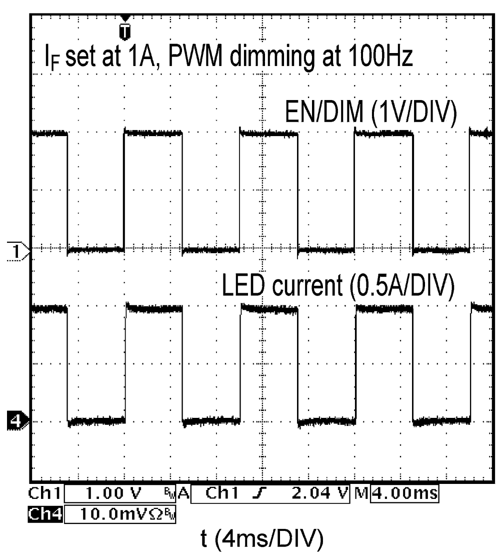

Figure 2. PWM Dimming of LEDs

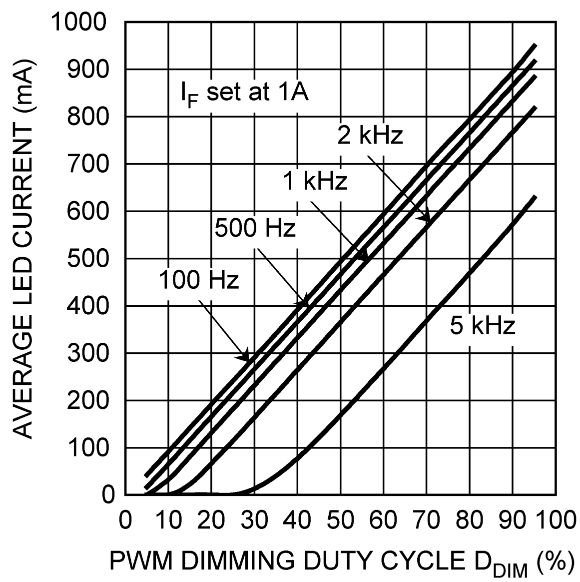

Figure 3. Average LED Current versus Duty Cycle of PWM Dimming Signal at PWM Terminal

5 Bill of Materials

Table 1. Bill of Materials

Part ID	Part Value	Part Number	Manufacturer
U1	1A constant current buck regulator, SOT-6	LM3405	Texas Instruments
L1	6.8µH, 1.5A, 35mΩ, 6.0 x 6.0 x 2.8mm	SLF6028T-6R8M1R5-PF	TDK
C1	10µF, 25V, X5R, 1206	GRM31CR61E106KA12L	Murata
C2	1µF, 25V, X7R, 1206	C1206C105K3RACTU	Kemet
C3	0.01µF, 16V, X7R, 0805	0805YC103KAT2A	AVX
C4	0.1µF, 16V, X7R, 0805	GRM219R71C104KA01D	Murata
C5	1µF, 25V, X5R, 0805	GRM216R61E105KA12D	Murata
D1	Schottky, 30V, 1A, SMA	MBRA130LT3G	ON Semiconductor
D2	Schottky, 30V, 200mA, SOD-323	BAT54WS-TP	Micro Commercial Co.
D3	5.1V, 0.35W, SOT23	BZX84C5V1	Fairchild Semiconductor
D4	Not installed		
R1	0.5W, 0.2Ω, 1%, 2010	WSL2010R2000FEA	Vishay
R2	100kΩ, 1/8W, 1%, 0805	CRCW0805100KFKEA	Vishay
R3	1.0kΩ, 1%, 1/8W, 0805	CRCW08051K00FKEA	Vishay
P1	6-position connector	5535676-5	Tyco/AMP

6 Typical Performance Characteristics

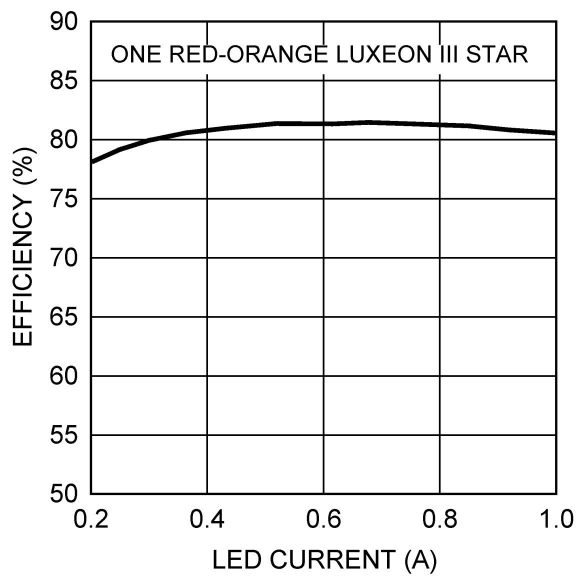

Figure 4. Efficiency vs. LED Current (V_{IN} = 5V, V_{BOOST} Derived from V_{IN})

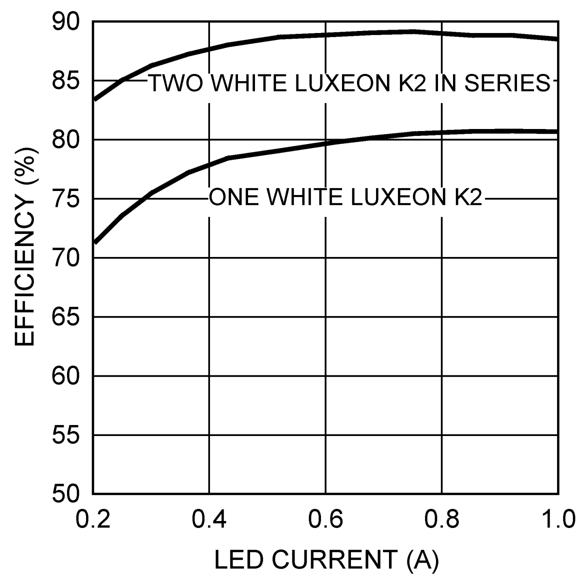

Figure 5. Efficiency vs. LED Current (V_{IN} = 12V)

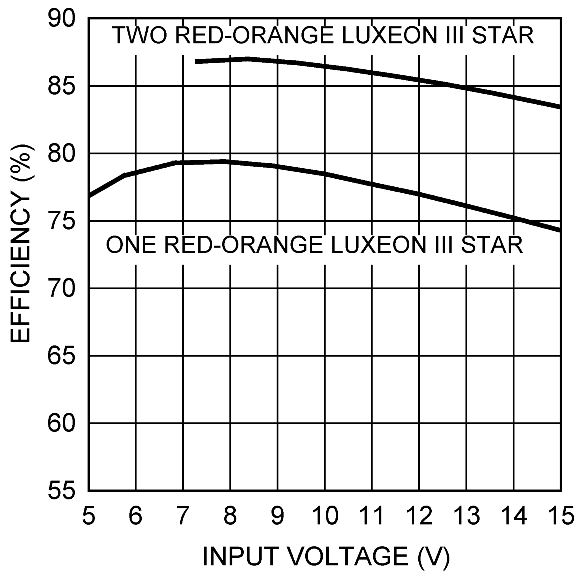

Figure 6. Efficiency vs. Input Voltage (I_F = 1A)

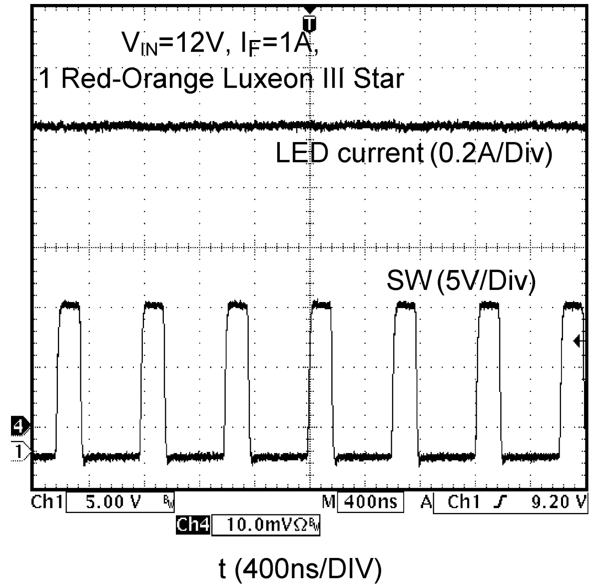

Figure 7. Switching Waveforms

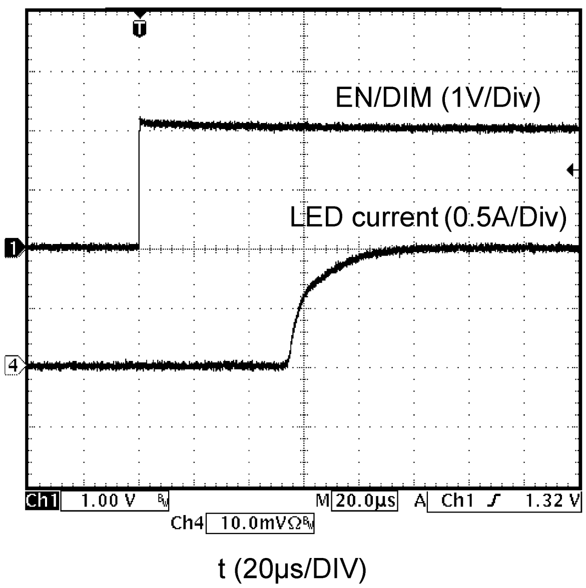

Figure 8. Startup during PWM Dimming (V_{IN} = 12V, I_F = 1A)

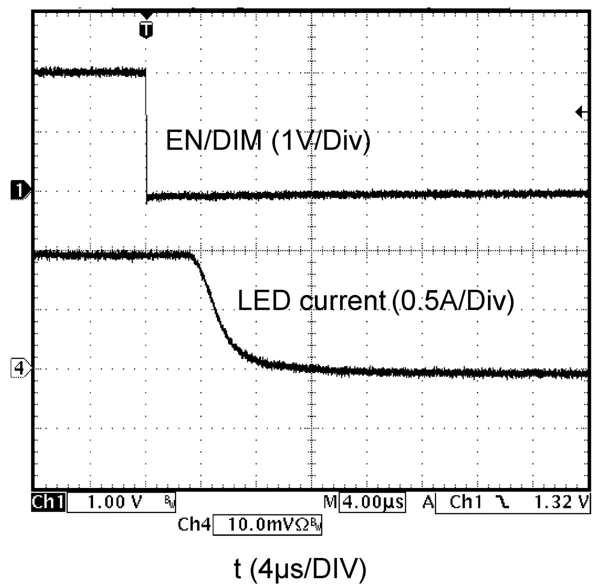

Figure 9. Shutdown during PWM Dimming (V_{IN} = 12V, I_F = 1A)

7 Layout

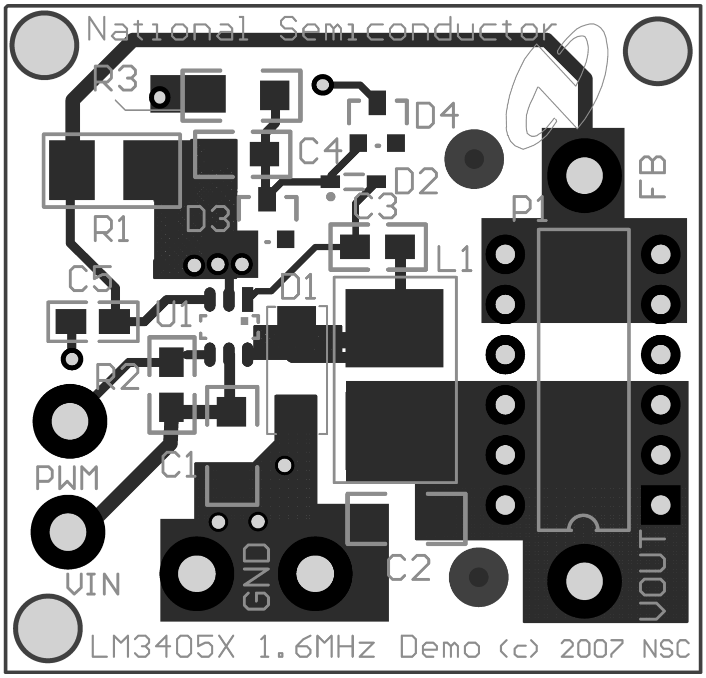

Figure 10. Top Layer and Top Overlay

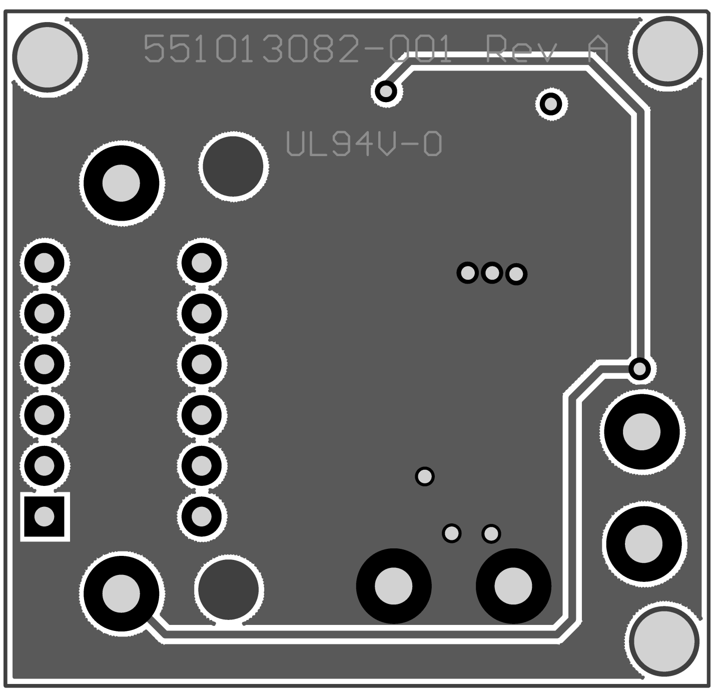

Figure 11. Bottom Layer and Bottom Overlay

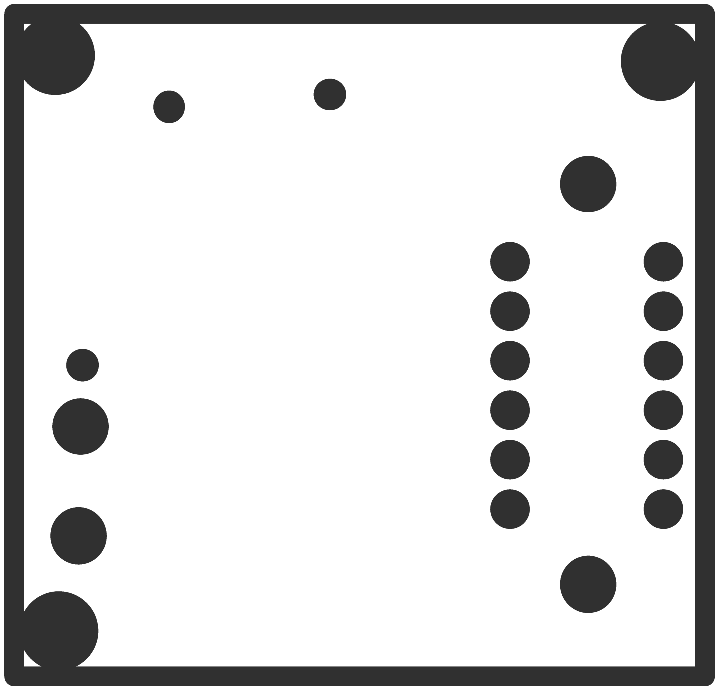

Figure 12. Internal Plane 1 (GND)

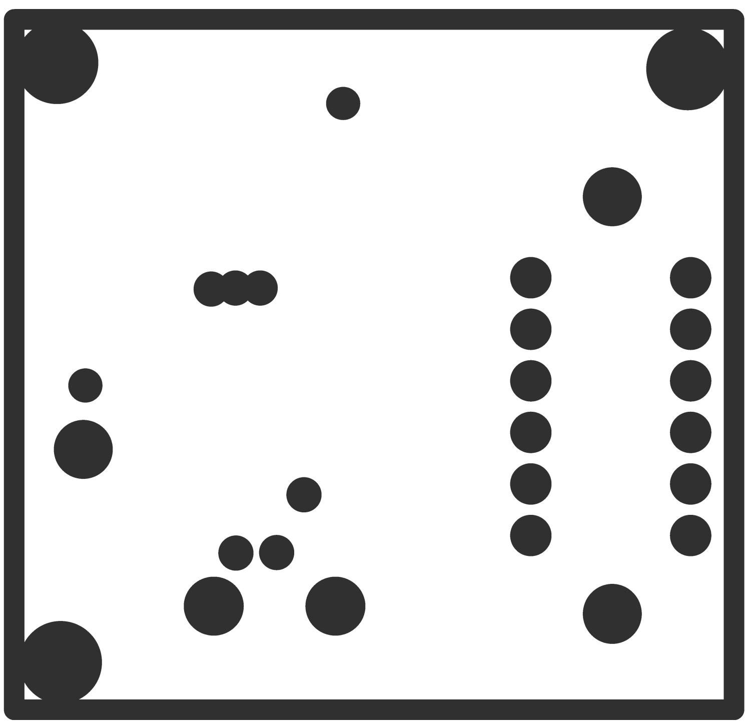

Figure 13. Internal Plane 2 (V_{IN})

8 Additional Circuit Configuration Schematics

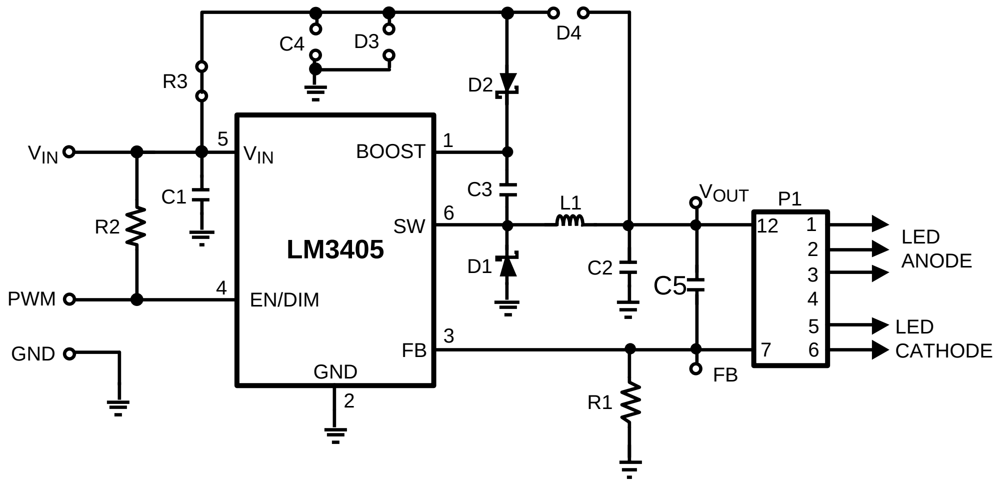

Figure 14. V_{BOOST} Derived from V_{IN}

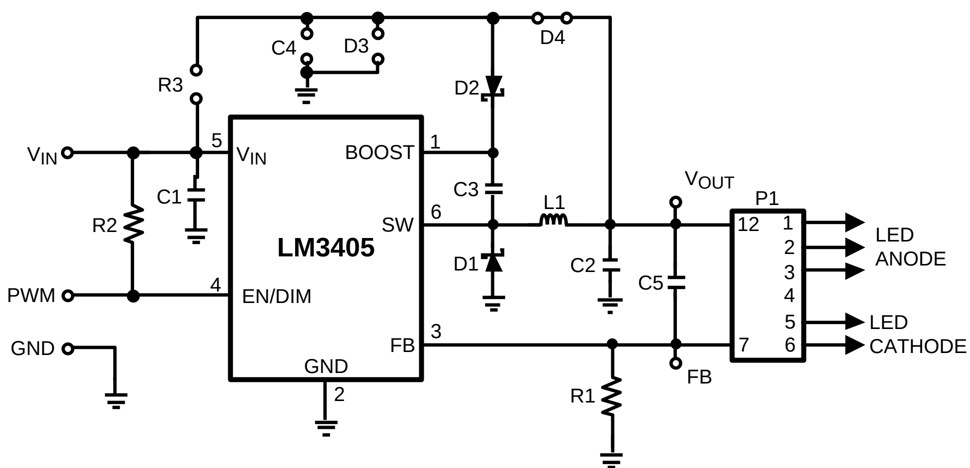

Figure 15. V_{BOOST} Derived from V_{OUT}

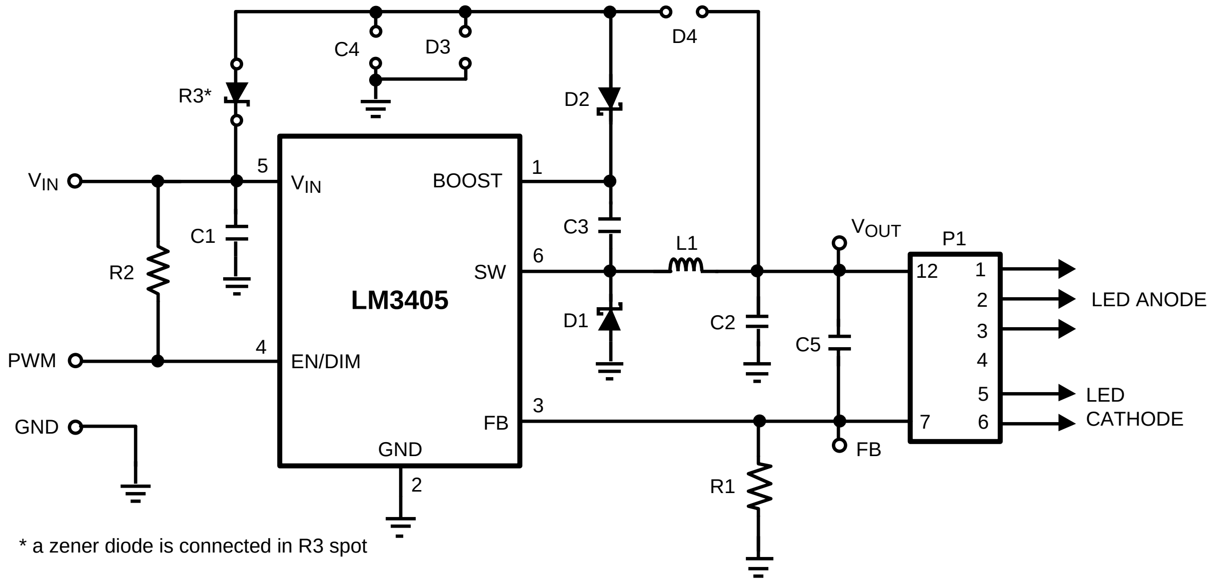

Figure 16. V_{BOOST} Derived from V_{IN} through a Series Zener Diode

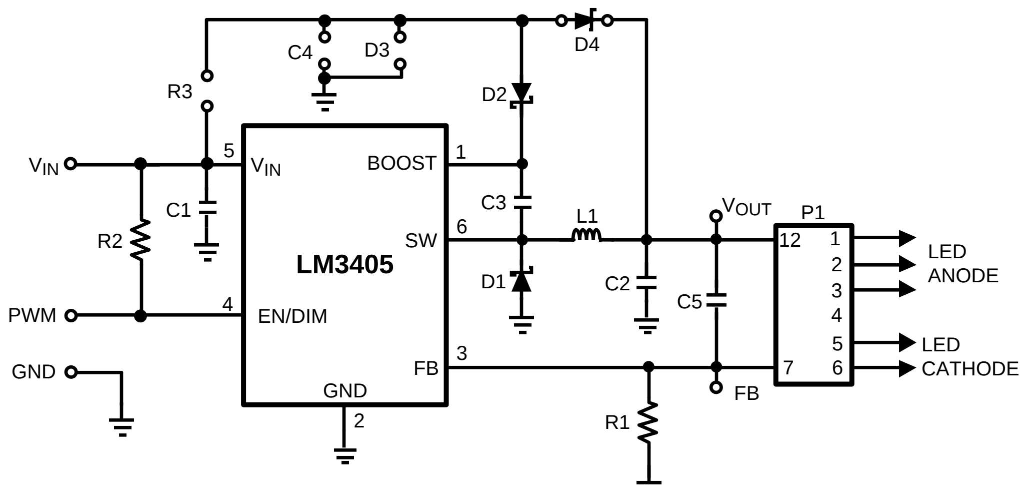

Figure 17. V_{BOOST} Derived from V_{OUT} through a Series Zener Diode

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