NCP5010 White LED Driver and DC/DC Boost Converter Evaluation Board

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EVALUATION BOARD MANUAL

Overview

The NCP5010 is a highly integrated 1 MHz inductive boost converter optimized for driving series configurations of LEDs in applications where space is a premium such as digital handsets and other portable electronics.

The intent of the demo boards is to illustrate typical operation of the device for laboratory characterization. There are 2 demo boards offered, the NCP5010EVB which configures the device driving a string of 2−5 White LEDs in series. In this configuration the NCP5010 is operated in a current regulation mode. The NCP5010BIASEVB showcases the device in a more traditional voltage feedback boost configuration for applications such as powering an OLED panel or LCD biasing. In addition to these demo boards, Application Note ANDXXXX/D deals with configuring the NCP5010 with a high side sense resistor to drive LEDs in serial or parallel eliminating the need for a low side sense trace in the LCD module assembly.

Demo Board NCP5010EVB (White LED Driver)

Figure 1 is the schematic of the White LED Driver configuration where the feedback voltage node is connected to cathode of the last LED in the string and a sense resistor which is used to set the LED current. The sense resistor R1 or R2 + R3 are selected by J6 jumper. The NCP5010 step−up DC/DC converter controls the loop in order to maintain 500 mV at the feedback pin. Equation 1 is used to determine the value of the sense resistor for a specific current:

$$R_{FB} = \frac{F_{BV}}{I_{OUT}} \qquad \text{(eq. 1)}$$

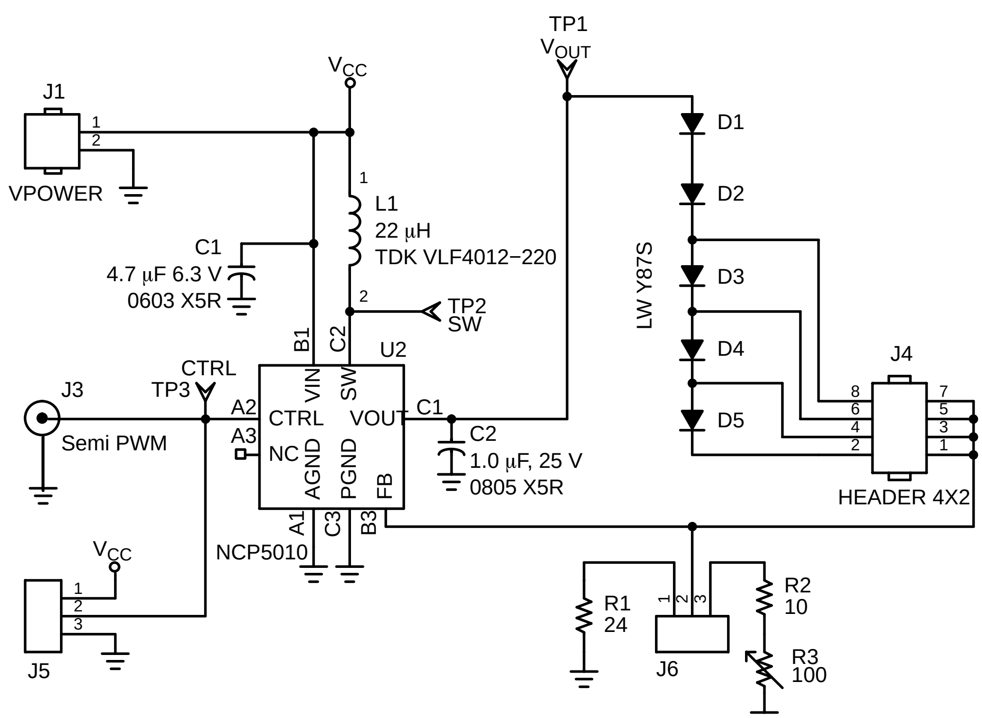

Figure 1. Schematic Diagram for Demo Board NCP5010EVB

INPUT POWER

Symbol	Switch Descriptions
J1−1	This is the positive connection for power supply. The leads to the input supply should be twisted and kept as short as possible.
J1−2	This is the return connection for the power supply
J7	Ground clip

SWITCHES SETUP

Symbol	Switch Descriptions
J3	CTRL / Enable This jumper should be used to demonstrate PWM dimming of the LED string. In that case jumper J5 MUST be left open for proper operation. When a digital signal with a high state logic level of 1.2 V or greater is applied this will enable the boost converter. By varying the duty cycle of this signal, the average LED current can be reduced thus dimming the LEDs. The frequency of this signal should be between 100 and 1000 Hertz.
J5	CTRL / Enable: To enable the boost converter connect a shorting jumper between J5−1 and J5−2
J4	LEDs Selection: This header allows the user to select the number of LEDs in the string to be driven by the boost converter. Connect the shorting jumper between J4−7−8 to drive 2 LEDs Connect the shorting jumper between J4−5−6 to drive 3 LEDs Connect the shorting jumper between J4−3−4 to drive 4 LEDs Connect the shorting jumper between J4−1−2 to drive 5 LEDs If no jumper is inserted in J4, then the driver will operate in the OVP (Over Voltage Protection) mode.
J6	Current Selection: This jumper allows to select two different output current: Shorting jumper between J6−1 and J6−2 give a fixed output current determining by R1. Shorting jumper between J6−2 and J6−3 R3 allow adjusting the output current via potentiometer R3.

TYPICAL OPERATING CHARACTERISTICS

Condition: Efficiency = 100 x (Number of LED stacked x V_{LED} x I_{LED})/P_{IN}

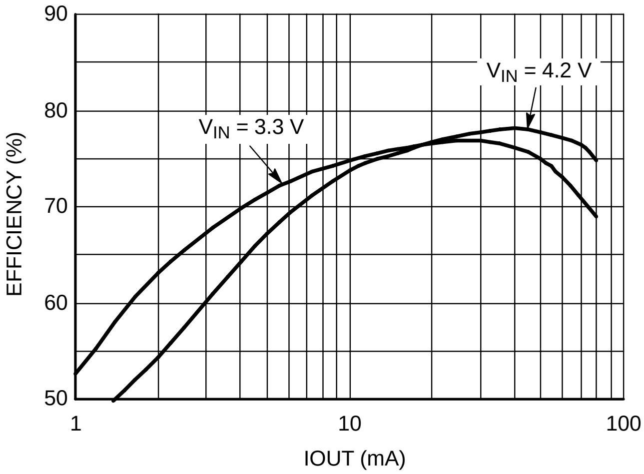

Figure 2. Efficiency vs. Current @ 2 LEDS (7.0 V)

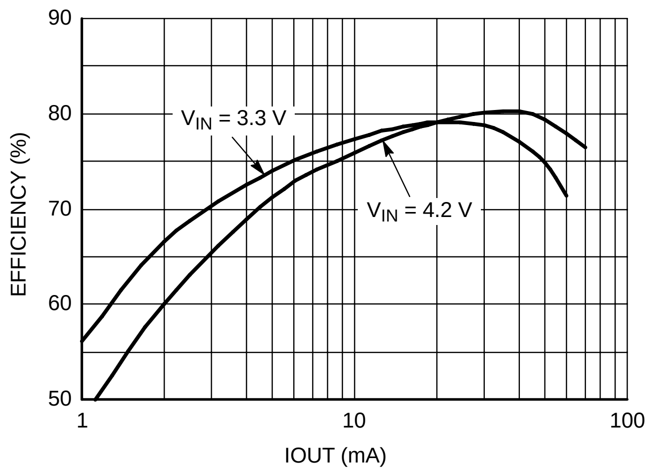

Figure 3. Efficiency vs. Current @ 3 LEDS (10.5 V)

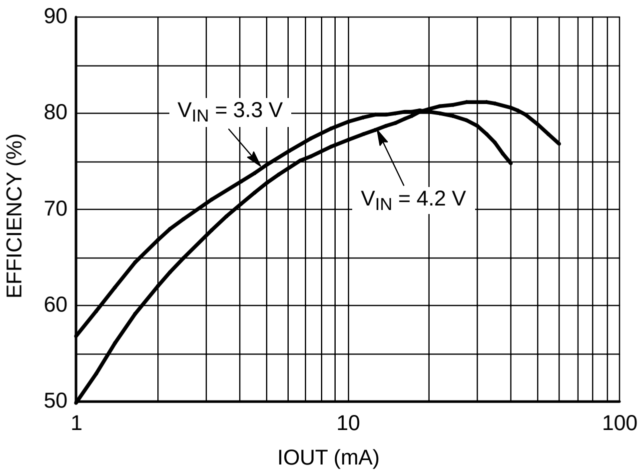

Figure 4. Efficiency vs. Current @ 4 LEDS (14 V)

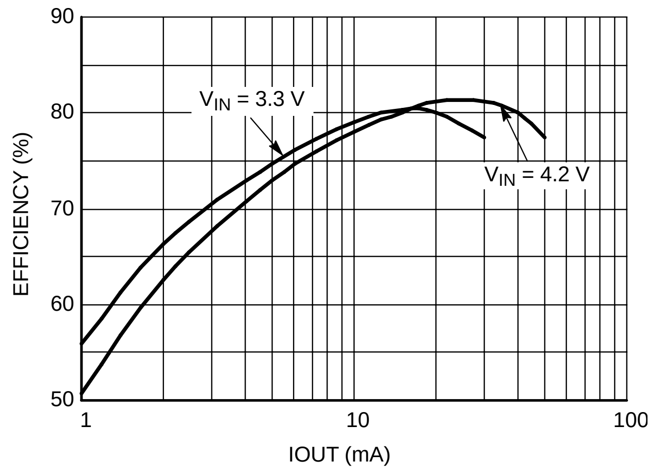

Figure 5. Efficiency vs. Current @ 5 LEDS (17.5 V)

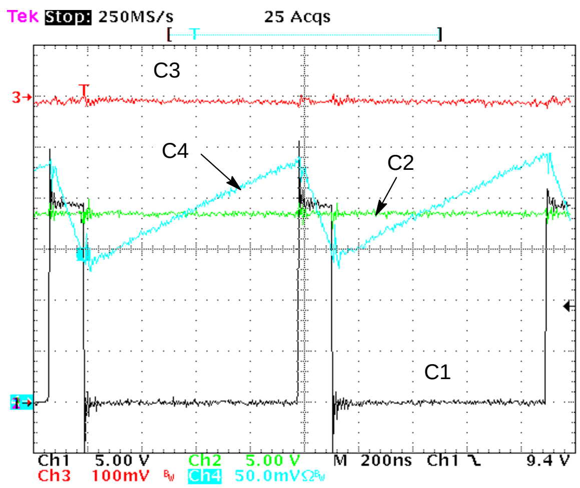

Figure 6. Ch1 SW, 5 V/div DC, Ch2 Vout, 5 V/div DC, Ch3 Vfb 100 mV/div DC, Ch4 Inductor Current 50 mA/div DC, T = 200 ns/div

PCB LAYOUT

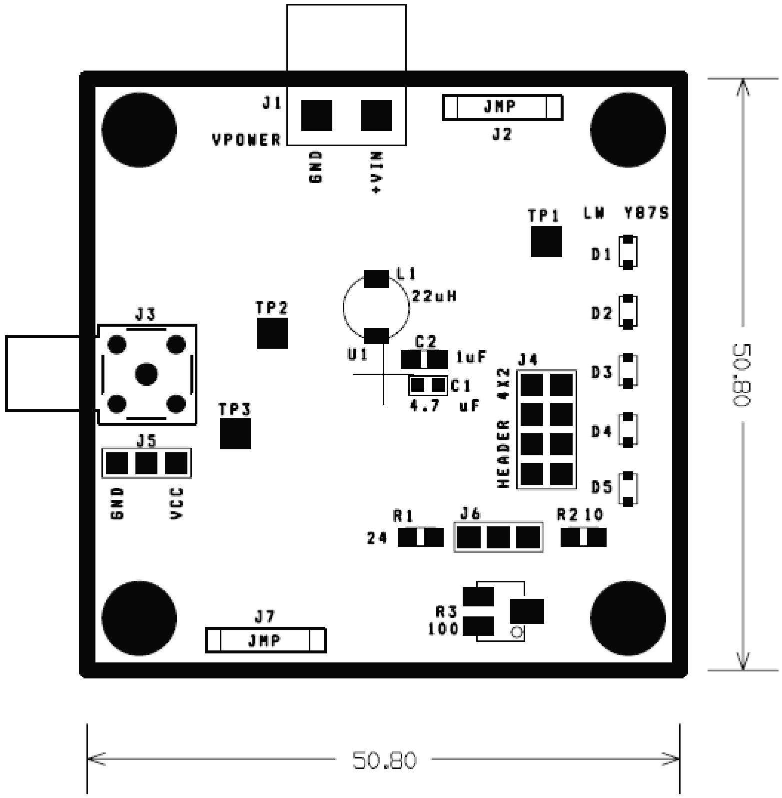

Figure 7. Assembly Layer

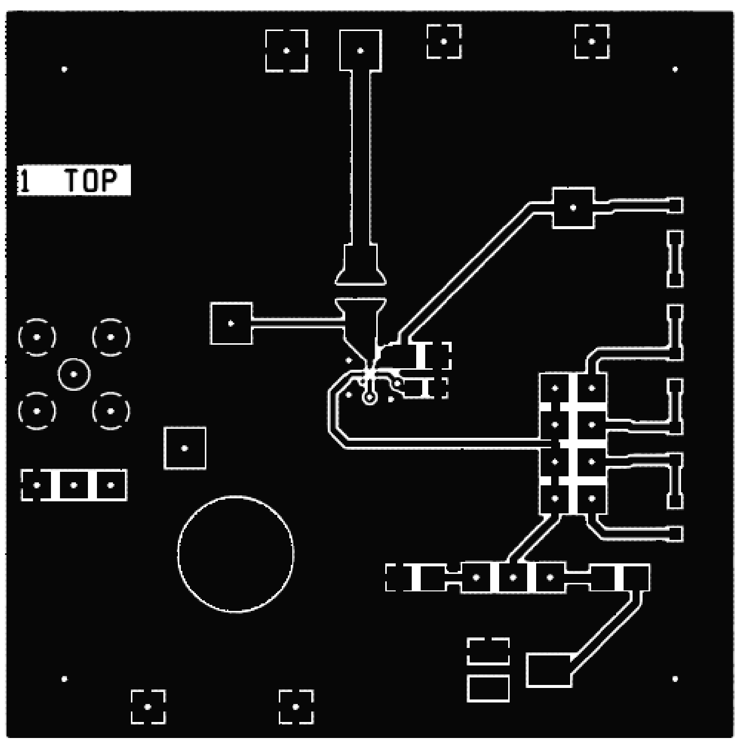

Figure 8. Top Layer Routing

DEMONSTRATION BOARD BILL OF MATERIALS

Qty.	Ref Des.	Description	Size	Manufacturer	Part Number
1	U1	500 mW Boost LED Driver	8−Pin 1.7x1.7 mm Flip−Chip	ON Semiconductor	NCP5010FCT1G
1	C1	Capacitor, Ceramic, 4.7 μF 6.3 V	0603	TDK	C1608X5R0J475MT
1	C2	Capacitor, Ceramic, 1 μF, 25 V, X5R	0805	TDK	C2012X5R1E105MT
5	D1,D2,D3, D4,D5	White LED, SMT	1.2 x 2.2 mm	OSRAM	LW Y87S
1	J1	Mal SL5.08/2/90B plus Fem BLZ 5.08/2		Weidmuller	SL5.08/2/90B + BLZ 5.08/2
1	J4	Header 2x4 pin, 100 mil spacing	0.200 x 4	Kontek Comatel	4731955180470
1	J3	SMA or SMB connector (Option)		Radiall	R 114 665
2	J5,J6	Header 3 pin, 100 mil spacing	0.100 x 3		4711955140470
2	J2,J7	GND Connection		Std	Std
1	L1	Inductor, SMT, 22 μH, 520 mA, 710 mΩ	3.8 x 4.0 mm	TDK	VLF4012AT−220MR51
1	R1	Resistor, chip, 24 Ω, 5%	0805	Std	Std
1	R2	Resistor, chip, 10 Ω, 5%	0805	Std	Std
1	R3	Adjustable Resistor, 100 Ω		BOURNS	3224W −1− 101
1	TP1,TP2, TP3	Test point		Std	Std
1	PCB	PCB 2.0 in x 2.0 in x 1.0 mm, 4 Layer		Any	TLS−P−001−C−0304−HG

Demo Board NCP5010BIASEVB (DC/DC Boost Converter)

Figure 12 is the schematic of the NCP5010 configured to provide a constant voltage. Here the network divider R2/R4 is used to sampling the output voltage and provide feedback voltage to the FB input.

The Equation 2 is used to determine the value of V_{OUT}.

$$V_{OUT} = V_{FB} \times \left(\frac{R2 + R4}{R2}\right) \qquad \text{(eq. 2)}$$

For example, should one need a V_{OUT} of 15 V. If we fix one of them like R2 = 10 kΩ, the value of R4 is given by:

$$R4 = R2\left(\frac{V_{OUT} - V_{FB}}{V_{FB}}\right) \qquad \text{(eq. 3)}$$

$$R4 = 10^3 \times \left(\frac{15 - 0.5}{0.5}\right) = 287\ k\Omega \qquad \text{(eq. 4)}$$

Then choose a standard value that is close to the above−calculated value.

R2 should be 2.2 to 22 kΩ and R4 lower than 1 MΩ.

The NCP5010 has built in short circuit protection so when the converter is started by a high logic signal on the CTRL pin a small current source (10 mA nominal) charges the output capacitor (C2) up to 66 % of V_{IN} at which point the DC/DC boost converter enters the switching mode. Care must be observed to ensure that the load does not sink more than 2 mA during this phase until the output reaches 0.66 V_{IN} (nom) to allow proper startup of the converter.

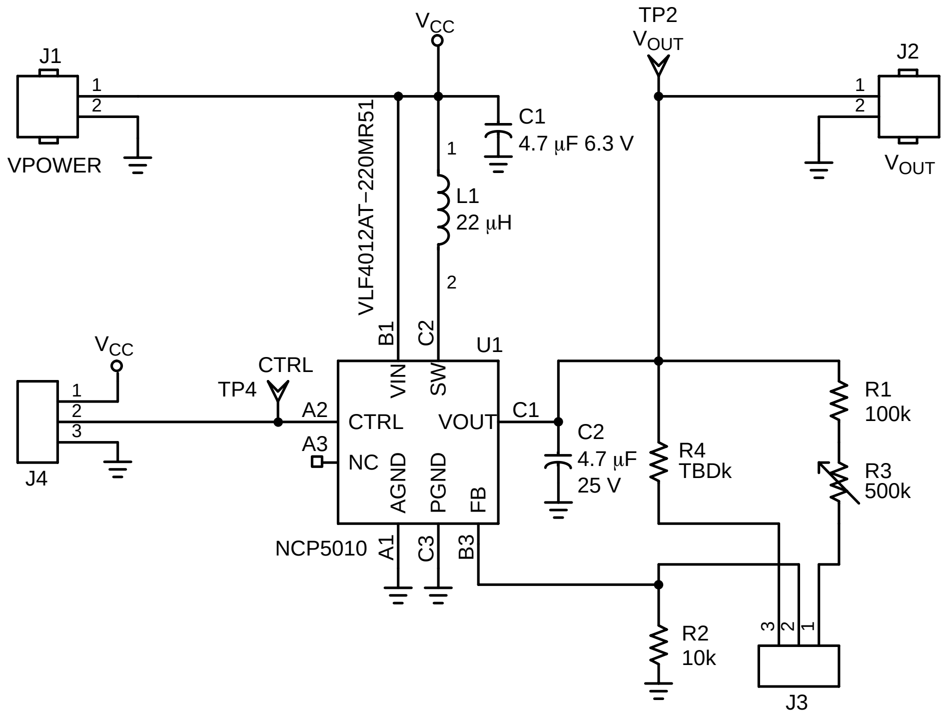

Figure 9. Schematic Diagram for Demo Board NCP5010BIASEVB

INPUT and OUTPUT POWER

Symbol	Switch Descriptions
J1−1	This is the positive connection for power supply. The leads to the input supply should be twisted and kept as short as possible.
J1−2	This is the return connection for the power supply
J6	Ground clip
J2−1	Ground of the load connection
J2−2	This is the output positive connection for the DC/DC boost converter

SWITCHES SETUP

Symbol	Switch Descriptions
J4	CTRL / Enable: To enable the boost converter connect a shorting jumper between J4−1 and J4−2
J3	Voltage Selection: This jumper allows to select two different output voltage: Shorting jumper between J6−2 and J6−3 give a fixed output voltage setup by R2/R4. Shorting jumper between J6−1 and J6−2 R3 allow adjusting the output voltage.

TYPICAL OPERATING CHARACTERISTICS

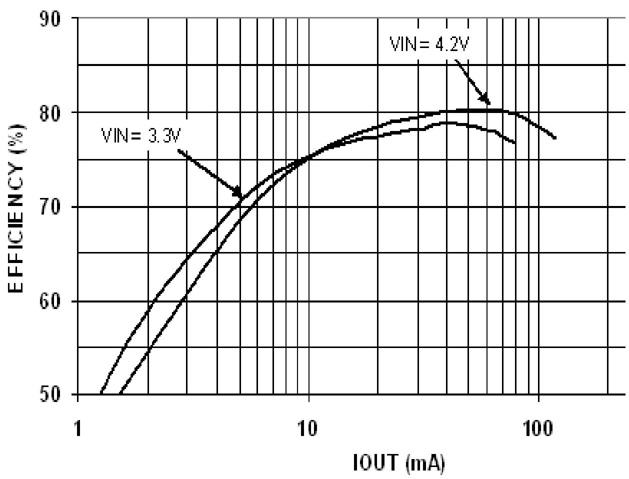

Figure 10. Efficiency vs. I_{OUT}
V_{OUT} = 6.0 V, L = 10 μH, VLF 4012−100

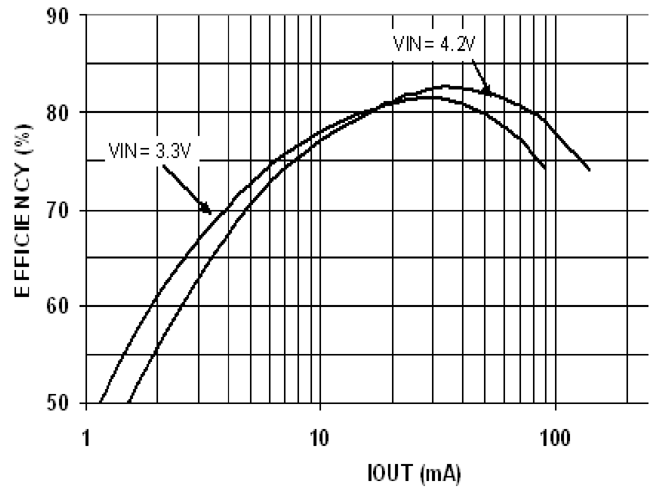

Figure 11. Efficiency vs. I_{OUT}
V_{OUT} = 6.0 V, L = 22 μH, VLF 4012−220

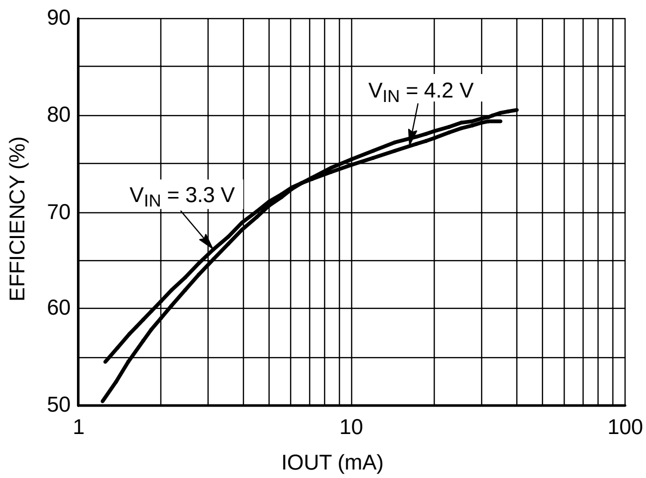

Figure 12. Efficiency vs. I_{OUT}
V_{OUT} = 12 V, L = 10 μH, VLF 4012−100

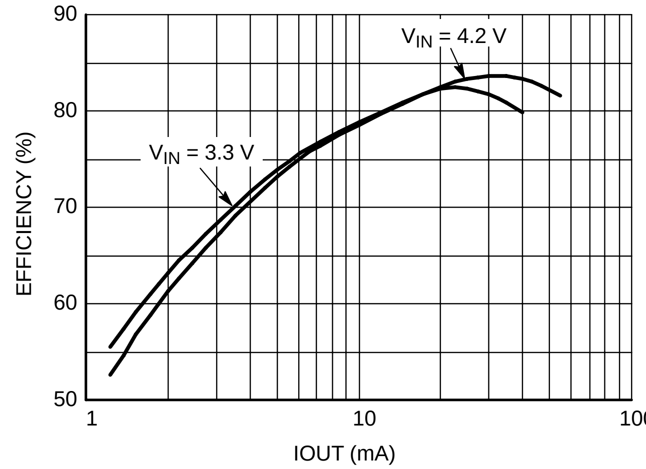

Figure 13. Efficiency vs. I_{OUT}
V_{OUT} = 12 V, L = 22 μH, VLF 4012−220

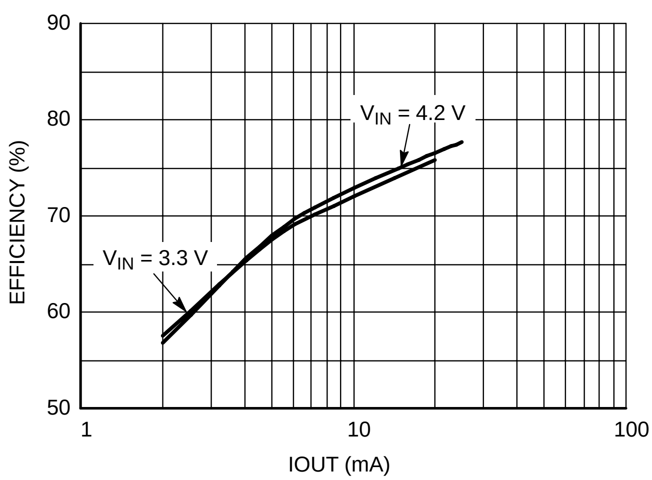

Figure 14. Efficiency vs. I_{OUT}
V_{OUT} = 18 V, L = 10 μH, VLF 4012−100

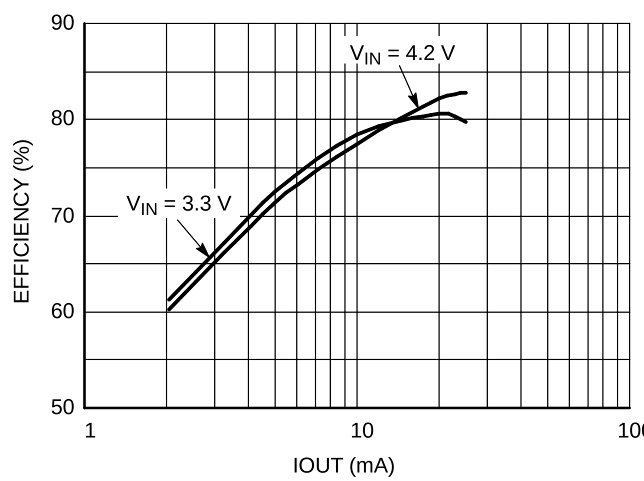

Figure 15. Efficiency vs. I_{OUT}
V_{OUT} = 18 V, L = 22 μH, VLF 4012−220

TYPICAL OPERATING CHARACTERISTICS

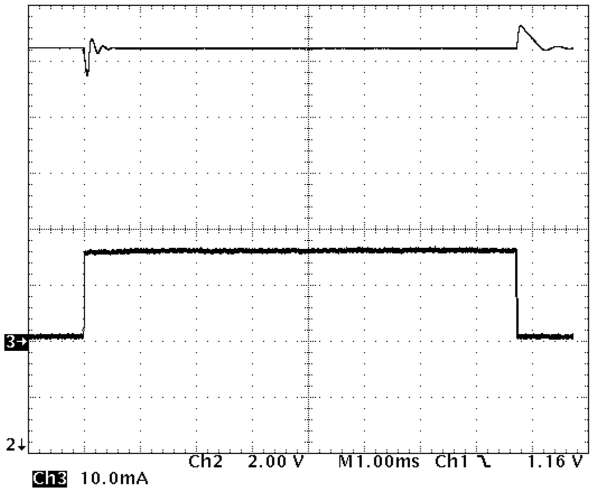

Figure 16. Load Transient Response, I_{OUT} 0 to 20 mA 2 V_{OUT}, 2V/div DC, 3 IOUT, 10mA/div DC, T = 1 ms/div

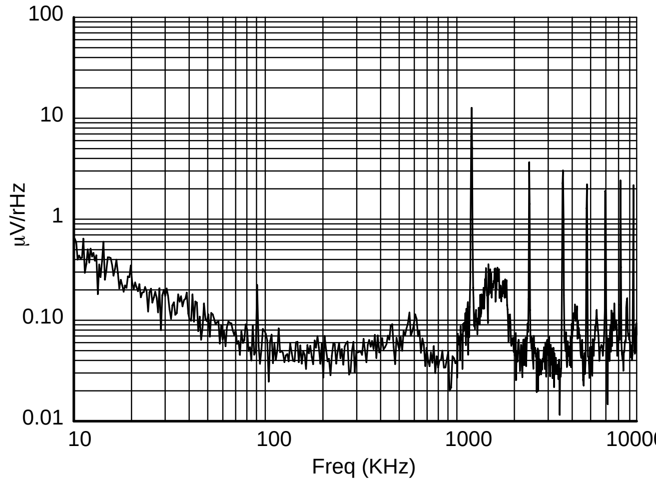

Figure 17. Output Switching Noise V_{IN} = 3.7 V, V_{OUT} = 15 V / 35 mA L = 22 μH VLF 4012−220

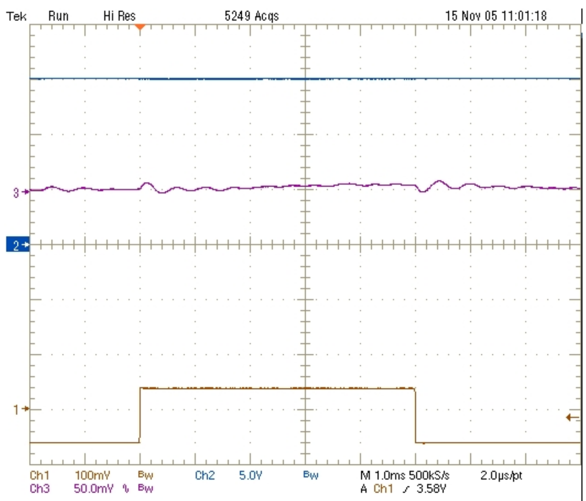

Figure 18. Line Transient Rejection, 1 V_{IN} 3.5 to 3.7 V, 2 V_{OUT}, 5V/div DC, 3 VOUT, 50mV/div AC, T = 1 ms/div

PCB LAYOUT

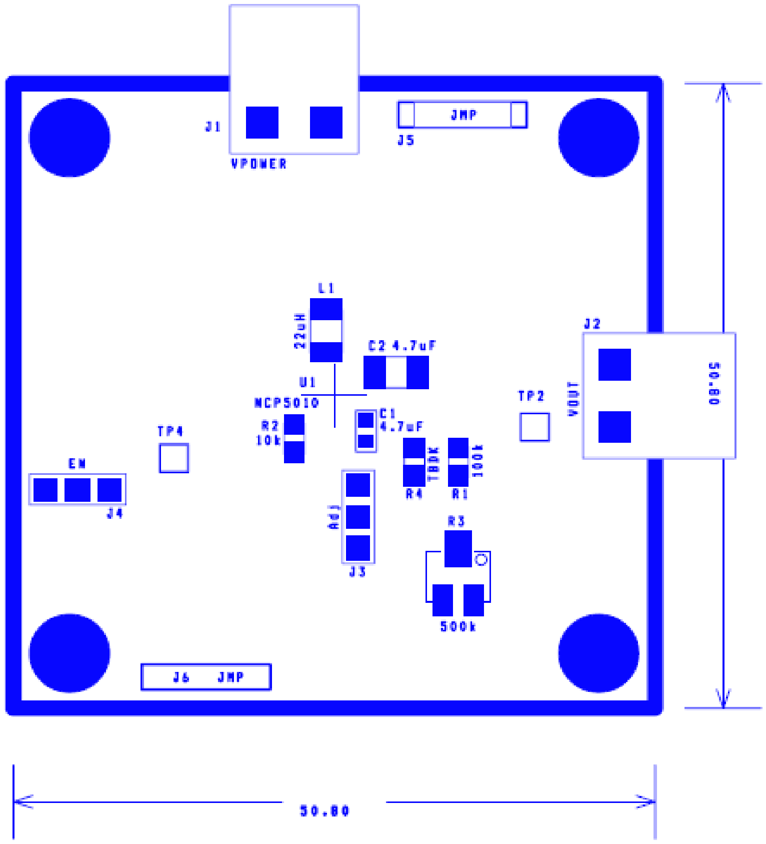

Figure 19. Assembly Layer

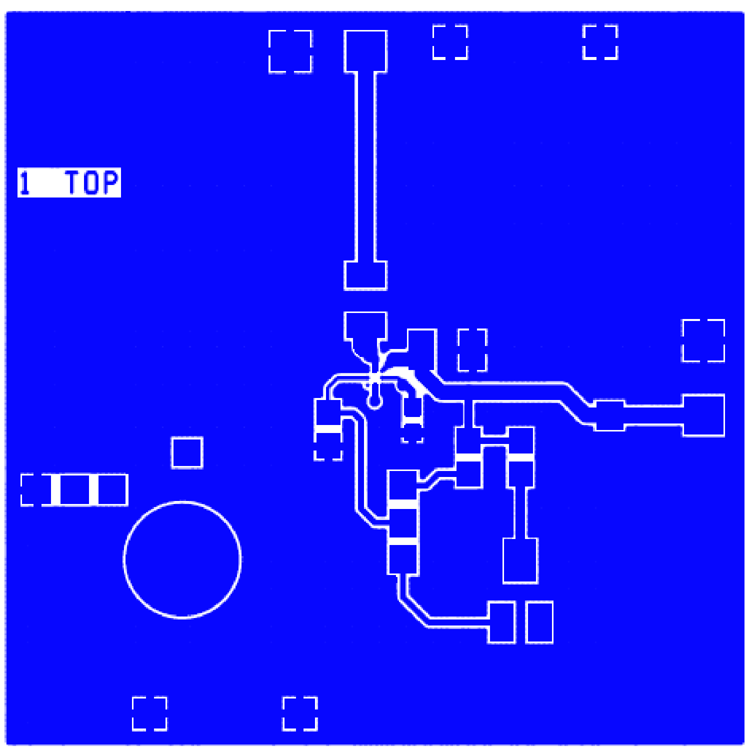

Figure 20. Top Layer Routing

DEMONSTRATION BOARD BILL OF MATERIALS

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1	C1	Capacitor, Ceramic, 4.7 μF 6.3 V	0603	TDK	C1608X5R0J475MT
1	C2	Capacitor, Ceramic, 4.7 μF, 25 V, X5R, 20 % or 4.7 μF, 16 V, X5R, 20%	0805	MURATA or TDK	GRM21BR61E475KA or C2012X5R1C475MT
2	J1, J2	Mal SL5.08/2/90B plus Fem BLZ 5.08/2		Weidmuller	SL5.08/2/90B + BLZ 5.08/2
2	J3, J4	Header 3 pin, 100 mil spacing	0.100 x 3		4711955140470
2	J5, J6	GND Connection		Std	Std
1	L1	Inductor, SMT, 22 μH, 520 mA, 710 mΩ	3.8 x 4.0 mm	TDK	VLF4012AT−220MR51
1	R1	Resistor, Chip, 100 kΩ, 5 %	0805	Std	Std
1	R2	Resistor, Chip, 10 kΩ, 5 %	0805	Std	Std
1	R3	Adjustable Resistor, 500 kΩ		BOURNS	3224W −1− 504
1	R4	Resistor, Chip, TBD kΩ	0805	Std	−
1	TP1, TP4	Test point		Std	Std
1	PCB	PCB 2.0 in x 2.0 in x 1.0 mm, 4 Layer		Any	TLS−P−002−B−0304−HG

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