

ROHM Switching Regulator Solutions

Evaluation Board: Step-down Switching Regulator With Built-in Power MOSFET



BD9G101G (5V | 0.5A Output)

No.0000000015

●Introduction

This application note will provide the steps necessary to operate and evaluate ROHM's step-down switching regulator using the BD9G101G evaluation boards. Board layout recommendations, operation procedures, application data and build of materials are provided.

●Description

This evaluation board has been developed for ROHM's step-down switching regulator customers evaluating BD9G101G. While accepting a wide power supply of 6-42V, a step down output of 1V-29V can be produced. The IC has an internal 800mohm Nch MOSFET (1A max) and a fixed operating frequency range of 1.5MHz. A Soft Start circuit prevents in-rush current during startup along with UVLO (low voltage error prevention circuit), OCP (over-current protection) and TSD (thermal shutdown detection) protection circuits. An EN pin allows for simple ON/OFF control of the IC to reduce standby current consumption.

●Applications

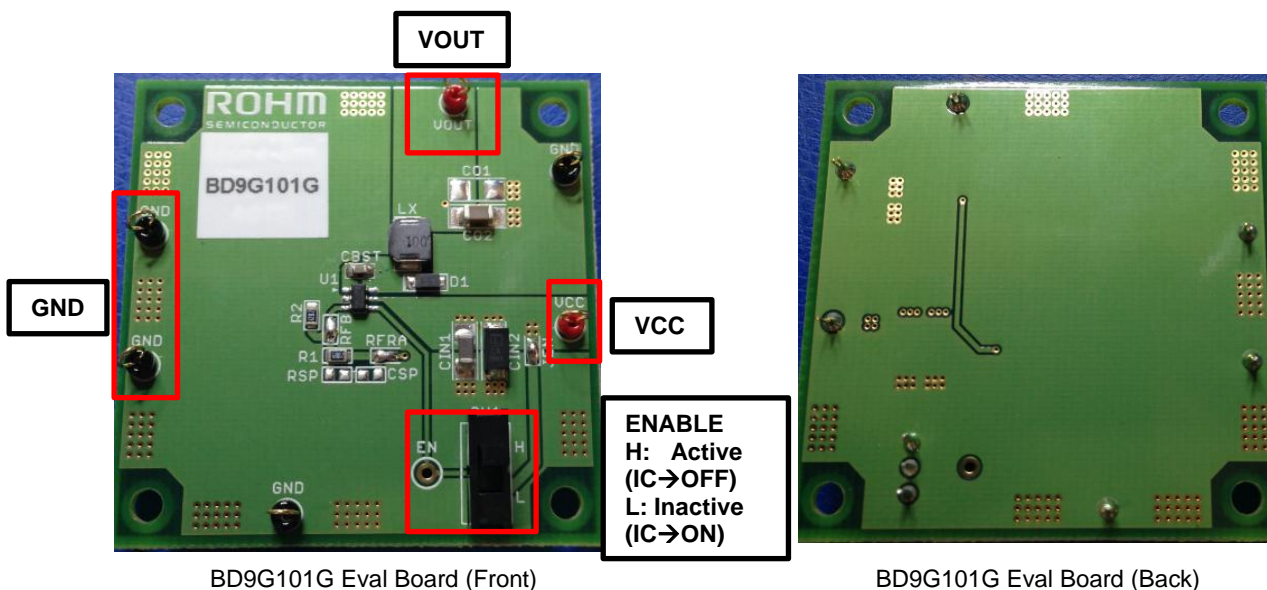
Industrial distributed power applications
Automotive and battery powered equipment

●Evaluation Board Operating Limits and Absolute Maximum Ratings

Parameter	Symbol	Limit			Unit	Conditions	
		MIN	TYP	MAX			
Supply Voltage							
	BD9G1010G	VCC	6	-	42	V	
Output Voltage / Current							
	BD9G101G	VOUT	-	5	-	V	*Set by R1 and R2
	BD9G101G	IOUT	-	0.5	-	A	

●Evaluation Board

Below is the evaluation board with the BD9G101G. Component selection and board layout guidelines are provided in the BD9G101G datasheet.

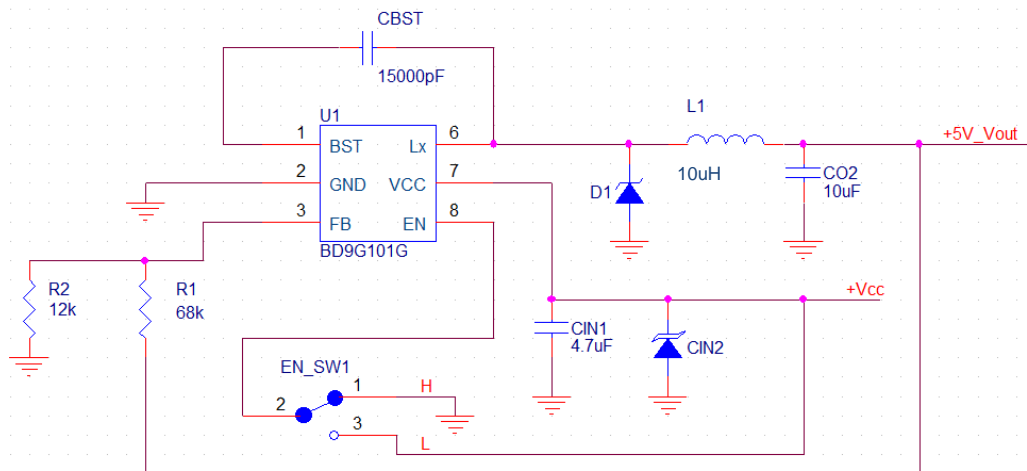


BD9G101G Eval Board (Front)

BD9G101G Eval Board (Back)

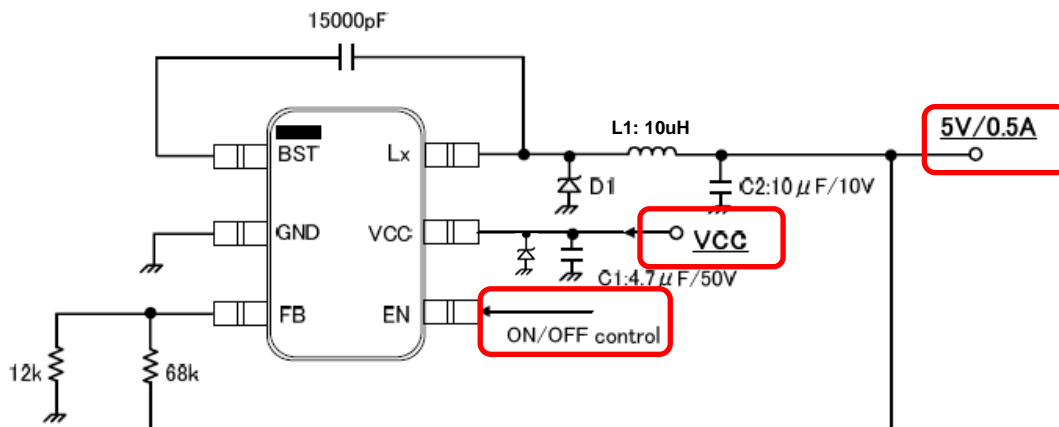
● Evaluation Board Schematic

Below is the evaluation board schematic for BD9G101G.



● Evaluation Board I/O

Below is the reference application circuit that shows the inputs (Vcc and EN) and the output (Vout @ 5V/0.5A)



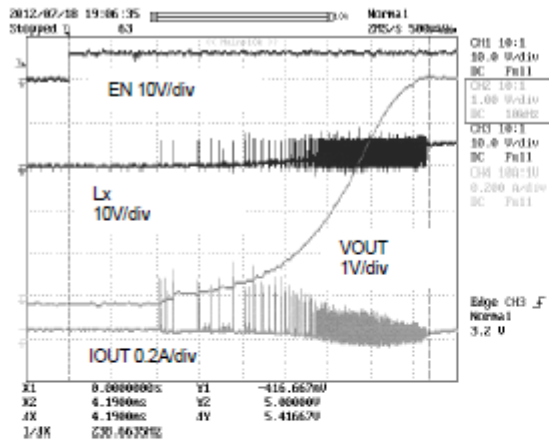
● Evaluation Board Operation Procedures

Below is the procedure to operate the evaluation board

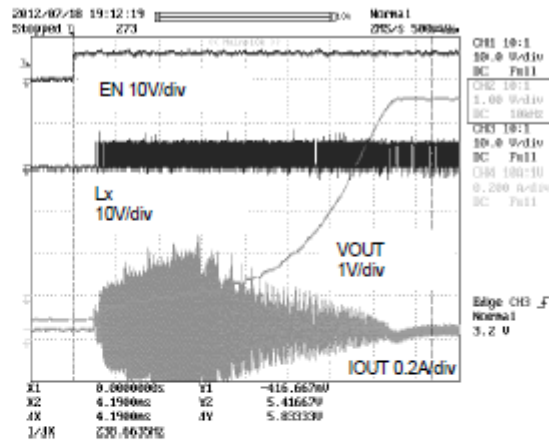
1. Connect GND to a GND pin on the evaluation board
2. Connect Vcc to the VCC_pin. This will provide Vcc to the Vcc pin of the IC
 - i. Note: EN pin is pulled HIGH as default. EN needs to be set to LOW for IC operation.
3. Output voltage can be measured from the VOUT_pin on the evaluation board. Output current can be measured with a proper load at VOUT.

●Reference Graphs Application Data for BD9G101G

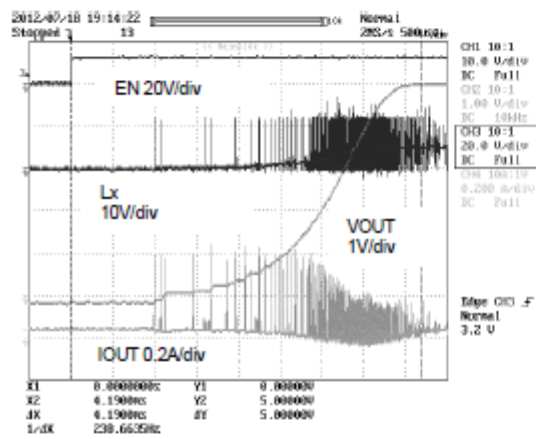
Below graphs show efficiency, frequency response and load characteristics of the BD9G101G eval board.



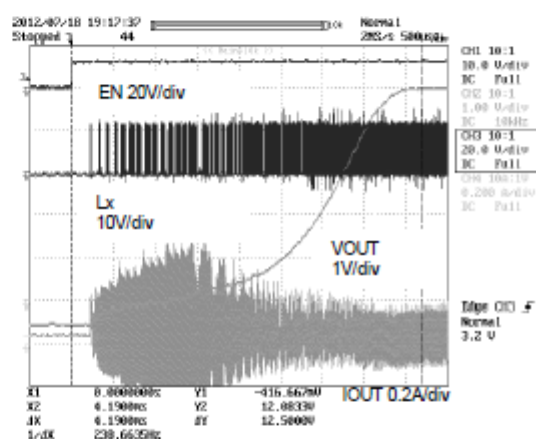
Start-up Characteristics
VIN=8V, IOUT=0mA, VOUT=5V



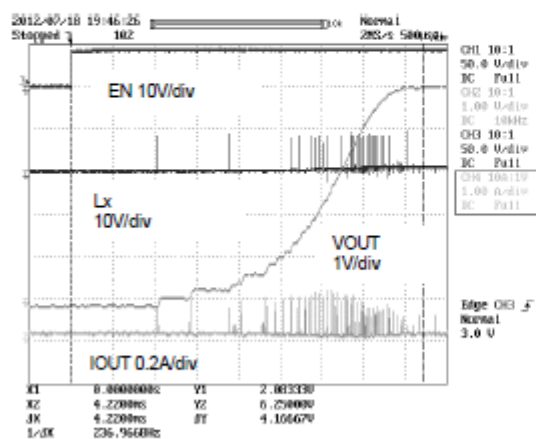
Start-up Characteristics
VIN=8V, IOUT=500mA, VOUT=5V



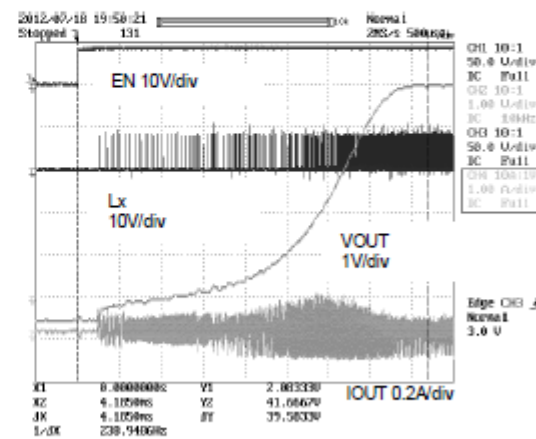
Start-up Characteristics
VIN=12V, IOUT=0mA, VOUT=5V



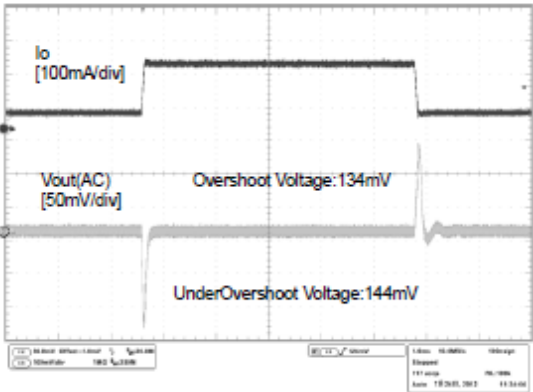
Start-up Characteristics
VIN=12V, IOUT=500mA, VOUT=5V



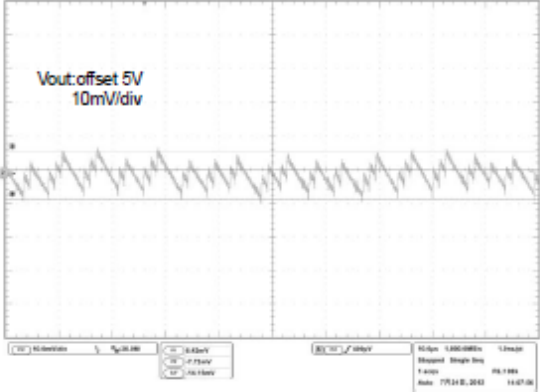
Start-up Characteristics
VIN=42V, IOUT=0mA, VOUT=5V



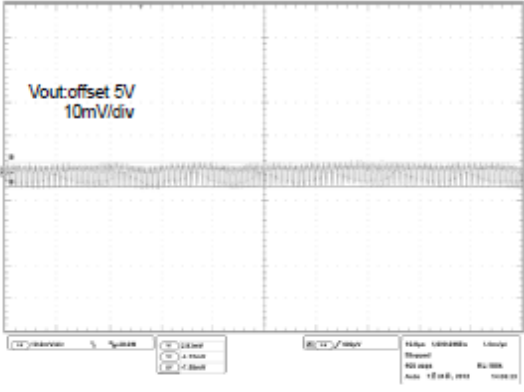
Start-up Characteristics
VIN=42V, IOUT=500mA, VOUT=5V



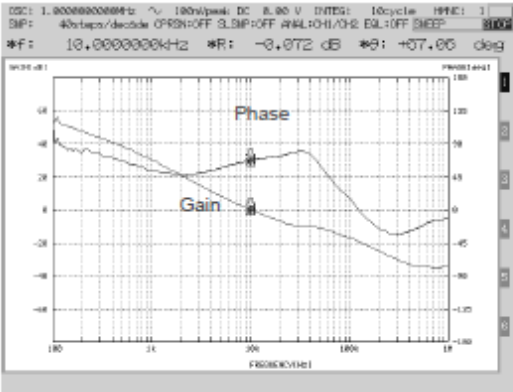
Load Response
 $I_o=50\text{mA} \leftrightarrow 200\text{mA}$



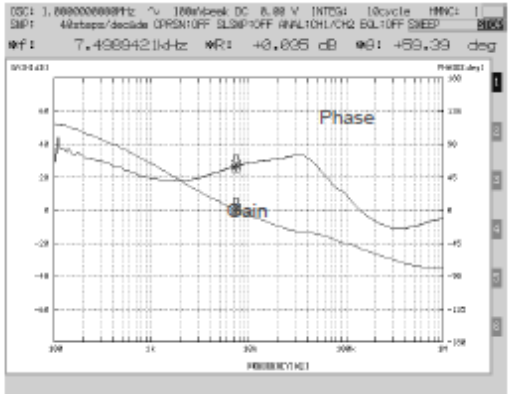
Lx Switching/ Vout Ripple
 $I_o = 20\text{mA}$



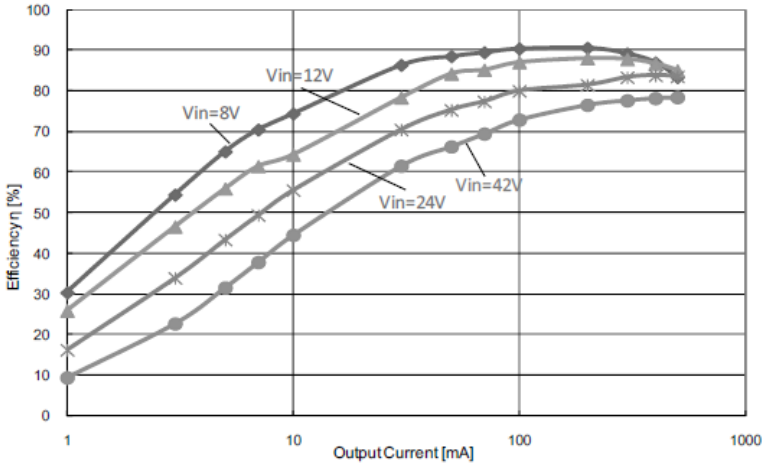
Lx Switching/ Vout Ripple
 $I_o=200\text{mA}$



Frequency Response
 $I_o=100\text{mA}, V_{OUT}=5\text{V}$



Frequency Response
 $I_o=500\text{mA}, V_{OUT}=5\text{V}$



Efficiency - Output Current $V_{OUT}=5\text{V}$

● Application Components Selection Method

(1) Inductors

Something of the shield type that fulfills the current rating (Current value I_{peak} below), with low DCR is recommended. Value of Inductance influences Inductor Ripple Current and becomes the cause of Output Ripple. In the same way as the formula below, this Ripple Current can be made small for as big as the L value of Coil or as high as the Switching Frequency.

$$I_{\text{peak}} = I_{\text{out}} + \Delta I_L / 2 \quad [\text{A}] \quad (4)$$

$$\Delta I_L = \frac{V_{\text{in}} - V_{\text{out}}}{L} \times \frac{V_{\text{out}}}{V_{\text{in}}} \times \frac{1}{f} \quad [\text{A}] \quad (5)$$

(ΔI_L : Output Ripple Current, f: Switching Frequency)

For design value of Inductor Ripple Current, please carry out design tentatively with about 20%~50% of Maximum Input Current.

In the BD9G101G, it is recommended the below series of 2.2 μH ~10 μH inductance value.

Recommended Inductor	TOKO DE4518C Series
	TAIYO YUDEN NR4018 Series

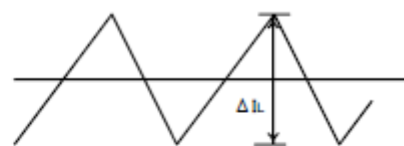


Figure 43. Inductor Current

(2) Input Capacitor

In order for capacitor to be used in input to reduce input ripple, mount low ceramic capacitor of ESR near the V_{CC} pin.

In the BD9G101G, it is recommended the 4.7 μF or more capacitor value. In case of using the electrolytic capacitor, mount 1 μF ceramic capacitor in parallel in order to prevent oscillation

(3) Output Capacitor

In order for capacitor to be used in output to reduce output ripple, Low ceramic capacitor of ESR is recommended.

Also, for capacitor rating, on top of putting into consideration DC Bias characteristics, please use something whose maximum rating has sufficient margin with respect to the Output Voltage.

Output ripple voltage is looked for using the following formula.

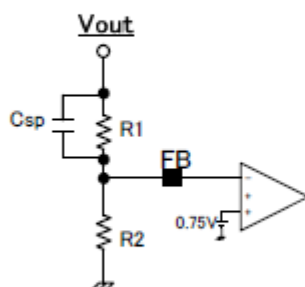
$$V_{\text{pp}} = \Delta I_L \times \frac{1}{2\pi \times f \times C_o} + \Delta I_L \times R_{\text{ESR}} \quad [\text{V}] \quad (6)$$

Please design in a way that it is held within Capacity Ripple Voltage.

In the BD9G101G, it is recommended a ceramic capacitor over 10 μF .

(4) Output voltage setting

The internal reference voltage of ERROR AMP is 0.75V. Output voltage is determined like (7) types.



$$V_o = \frac{(R1+R2)}{R2} \times 0.75[\text{V}] \quad \dots (7)$$

Figure 6. Output voltage setting

However, in order to avoid the BSTUVLO operation at the time of a reduced power and light load, please set up R1+R2 is satisfied the following formulas.

$$R1 + R2 \leq V_{\text{out}} \times 10^3 \quad \dots (8)$$

The example of output resistances setting :
 output voltage 5V R1=3.9k Ω R2=0.68k Ω
 output voltage 12V R1=7.5k Ω R2=0.51k Ω

(5) Feed-forward capacitor C_{sp}

Please mount feed-forward capacitor in parallel to output resistance $R1$.

In order that a feed-forward capacitor may adjust the loop characteristic by adding the pair of a pole and zero to the loop characteristic. A phase margin is improved and transient response speed improves.

The feed-forward capacitor C_{sp} should use the value near the following formulas.

$$C_{sp} = \frac{4.7k}{R1} \times 0.15 \quad [\mu F] \quad \dots (9)$$

The example of a C_{sp} setting :
 output voltage 5V $R1=3.9k\Omega$ $R2=0.68k\Omega$ $C_{sp} = 0.1\mu F$ or $0.22\mu F$
 output voltage 12V $R1=7.5k\Omega$ $R2=0.51k\Omega$ $C_{sp} = 0.1\mu F$

By above mentioned measure, there is not BSTUVLO operation in light load and $V_{in}-V_{out}<3V$.

(6) Bootstrap Capacitor

Please connect from 15000pF (Laminate Ceramic Capacitor) between BST Pin and Lx Pins.

(7) Diode

Select suitable shottky diode for break down voltage and input current.

- Note: Feed-forward capacitor C_{sp} is not populated on the BD9G101G evaluation board. The capacitor is recommended for designs requiring improved phase margin and transient response.

● Evaluation Board Layout Guidelines

Below are the guidelines that have been followed and recommended for BD9G101G designs.

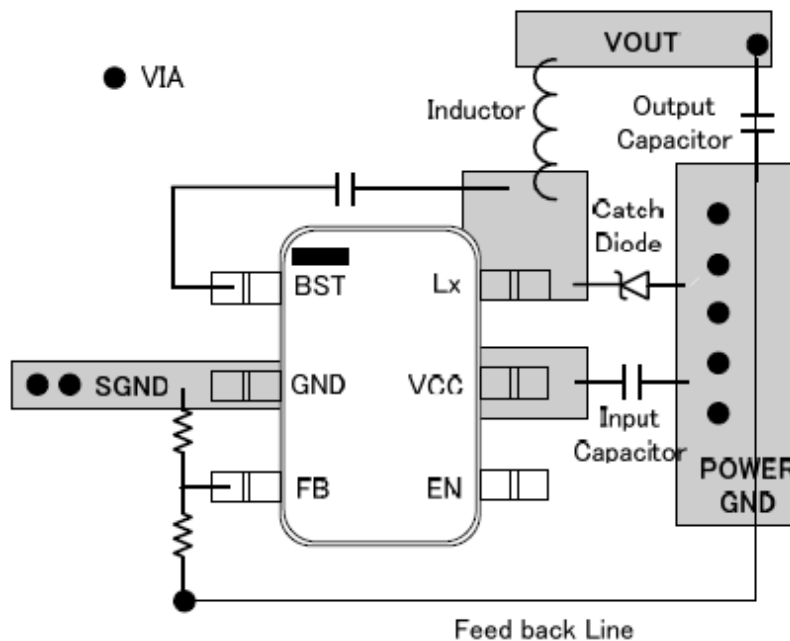


Figure 45. Reference PCB layout

Layout is a critical portion of good power supply design. There are several signals paths that conduct fast changing currents or voltages that can interact with stray inductance or parasitic capacitance to generate noise or degrade the power supplies performance. To help eliminate these problems, the VCC pin should be bypassed to ground with a low ESR ceramic bypass capacitor with B dielectric. Care should be taken to minimize the loop area formed by the bypass capacitor connections, the VCC pin, and the anode of the catch diode. See Figure.45 for a PCB layout example.

In the BD9G101G, since the LX connection is the switching node, the catch diode and output inductor should be located close to the LX pins, and the area of the PCB conductor minimized to prevent excessive capacitive coupling. And GND area should not be connected directly power GND, connected avoiding the high current switch paths. The additional external components can be placed approximately as shown.

● Evaluation Board BOM

Below is a table with the build of materials. Part numbers and supplier references are provided.

Item	Qty	Ref	Description	Manufacturer	Part Number	Digikey P/N
1	1	CIN1	CAP CER 4.7UF 50V Y5V 1206	Murata	GRM31CF51H475ZA01L	490-1828-1-ND
2	1	CIN2	DIODE TVS 30V 400W UNI 5% SMA	Littlefuse	SMAJ30A	SMAJ30ALFTR-ND
3	1	CO2	CAP CER 10UF 10V 10% X5R 1206	Murata	GRM31CR61A106KA01L	490-1820-2-ND
4	1	CBST	CAP CER 0.015UF 50V 10% X7R 0603	Murata	GRM188R71H153KA01D	490-1514-1-ND
5	1	D1	DIODE SCHOTTKY 60V 2A PMDU	ROHM	RB060M-60TR	RB060M-60CT-ND
6	1	SW1	SWITCH SLIDE SPDT 30V.2A PC MNT	E-Switch	EG1218	EG1903-ND
7	1	R1	RES 68.0K OHM 1/8W 1% 0805 SMD	Yageo	RC0805FR-0768KL	311-68.0KCRCT-ND
8	1	R2	RES 12.0K OHM 1/8W 1% 0805 SMD	Yageo	RC0805FR-0712KL	311-12.0KCRCT-ND
9	1	LX	INDUCT 10uH SOD-106	TOKO	DEM4518C 1235AS-H-100M	-
10	1	U1	5V, 0.5A Step-down SW Reg w/ FET	ROHM	BD9G101G	-

Notes

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