ROHM Switching Regulator Solutions

Evaluation Board for ROHM's BD9B300MUV Synchronous Buck DC/DC Converter with Integrated FET

BD9B300MUV-E2EVK-101 (3.3V | 3A Output) USAP58-A-0001

- **Introduction**

This application note will explain the steps necessary to operate and evaluate ROHM's BD9B300MUV synchronous buck DC/DC converter using the BD9B300MUV-E2EVK-101 evaluation board. Component selection, board layout recommendations, operating procedures, and application data are included.

- **Description**

This evaluation board has been specifically developed to evaluate the BD9B300MUV synchronous buck DC/DC converter with integrated 35mΩ Pch high-side and Nch low-side power MOSFETs. Features include up to 3A output and variable switching frequency: 1MHz (FREQ pin connected to V_{IN}) or 2MHz (FREQ pin connected to ground). Multiple protection functions are also built in, including a fixed soft start circuit that prevents inrush current during startup, UVLO (Under Voltage Lock Out), TSD (Thermal Shutdown), OCP (Over Current Protection), and SCP (Short-Circuit Protection). An EN pin allows for simple ON/OFF control of the IC to reduce standby current consumption, while a MODE pin that enables users to select fixed frequency PWM mode or Deep-SLLM control that automatically switches between modes.

- **Applications**

Step-Down Power Supplies for DSPs, FPGAs, Microcontrollers, and more
Laptop PCs/Tablet PCs/Servers
LCD TVs
Storage Devices (HDDs/SSDs)
Printers, OA Equipment
Entertainment Devices
Distributed and Secondary Power Supplies

- **Evaluation Board Operating Limits and Absolute Maximum Ratings**

Parameter		Symbol	Limit			Unit	Conditions
			MIN	TYP	MAX		
Supply Voltage							
	BD9B300MUV	V_{CC}	2.7	-	5.5	V	
Output Voltage / Current							
	BD9B300MUV	V_{OUT}	-	3.3	-	V	
		I_{OUT}	-	-	3	A	

• Evaluation Board

Below is an image of the BD9B300MUV-E2EVK-101 evaluation board.

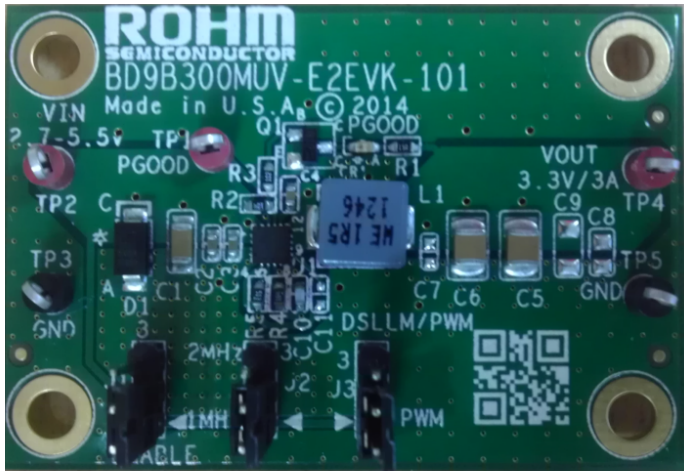
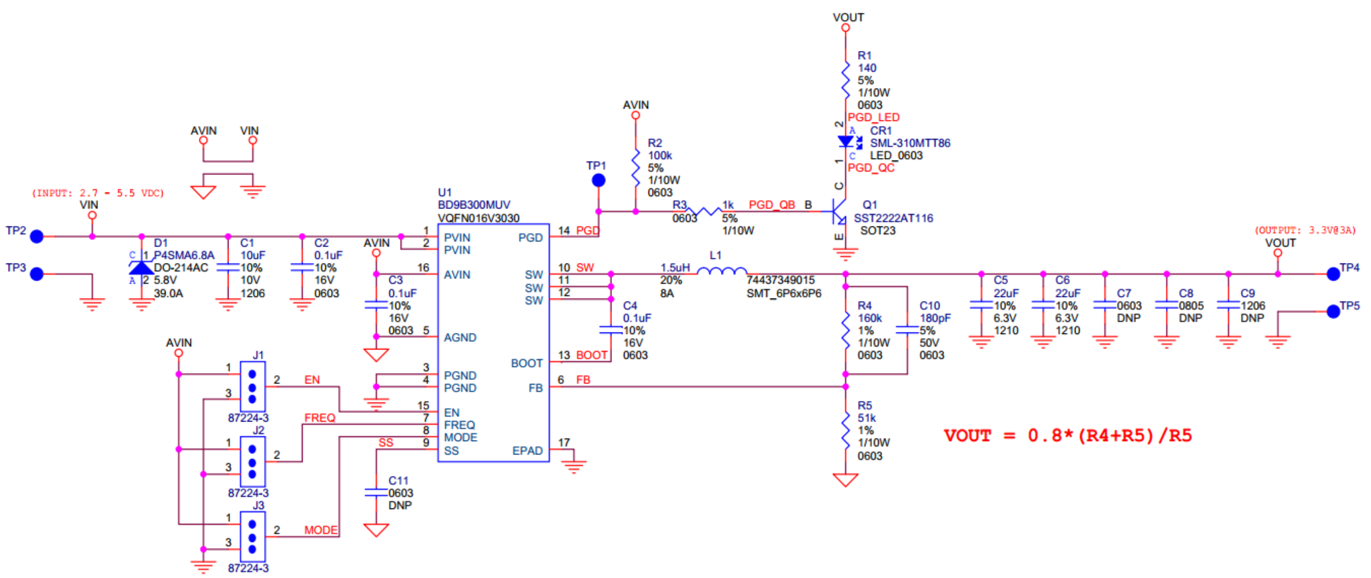


Fig 1: Evaluation Board for the BD9B300MUV

• Board Schematic



BD9B300MUV EVM Jumper Positions

Reference Designator	Position	Description
J1	2 - 1	Enable U1
	2 - 3	Disable U1
J2	2 - 1	Set switching frequency of U1 is 1.0MHz
	2 - 3	Set switching frequency of U1 is 2.0MHz
J3	2 - 1	Set operation mode of U1 is fixed frequency PWM mode
	2 - 3	Set operation mode of U1 is automatically switched between the Deep-SLLM control and fixed frequency PWM mode

Note:

1. 0.8V =< VOUT =< 0.8*VIN

Fig 2: BD9B300MUV-E2EVK-101 Evaluation Board Schematic

- **Board I/O**

Below is a reference application circuit that shows the inputs V_{IN}, EN, FREQ, and MODE and output V_{OUT}.

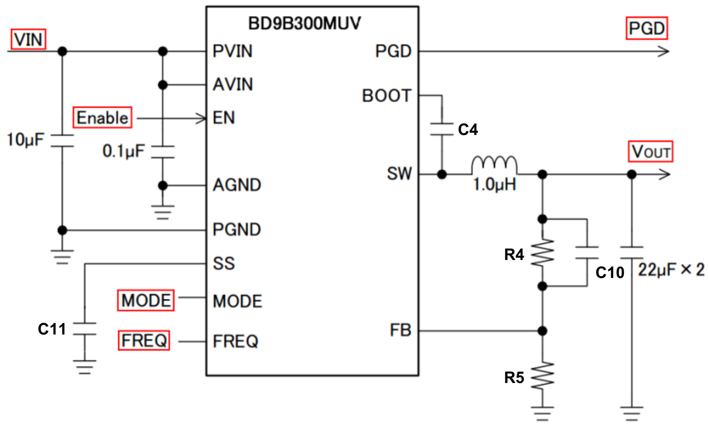


Fig 3: BD9B300MUV-E2EVK-101 Evaluation Board I/O

- **Operating Procedures**

1. Connect the power supply's GND terminal to GND test point TP3 on the evaluation board.
2. Connect the power supply's V_{CC} terminal to V_{IN} test point TP2 on the evaluation board. This will provide V_{IN} to the IC U1. Please note that V_{CC} should be in the range from 2.7V to 5.5V.
3. Set the operating mode by changing the position of shunt jumper J3 (If Pin2 is connected to Pin1, the MODE pin of IC U1 will be pulled high and IC U1 will operate in Fixed frequency PWM mode, otherwise the MODE pin of IC U1 will be pulled low and IC U1 will operate by automatically switching between Deep-SLLM control and fixed frequency PWM modes).
4. Set the switching frequency by changing the position of shunt jumper J2 (If Pin2 is connected to Pin1, the FREQ pin of IC U1 will be pulled high and IC U1 will switch frequency to 1.0MHz, otherwise the FREQ pin of IC U1 will be pulled low and the frequency will be switched to 2.0MHz).
5. Check that shunt jumper J1 is in the ON position (Connect Pin 2 to Pin 1, the EN pin of IC U1 is pulled high as a default).
6. Connect the electronic load to TP4 and TP5. Do not turn the load ON.
7. Turn on the power supply. The output voltage V_{OUT} (+3.3V) can be measured at the test point TP4. Now turn the load ON. The load can be increased up to 3A MAX.

- **Reference Application Data for BD9B300MUV-E2EVK-101**
  The following are graphs of the hot plugging test, quiescent current, efficiency, load response, and output voltage ripple response of the BD9B300MUV-E2EVK-101 evaluation board.

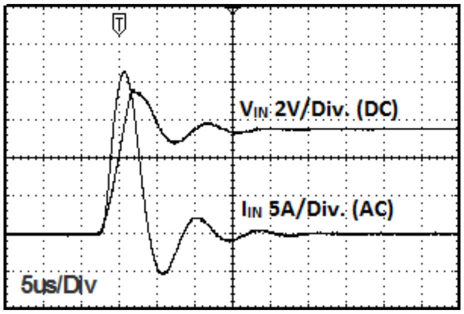


Fig 4: Hot Plug-in Test with Zener Diode P4SMA6.8A, V_{IN}=5.5V, V_{OUT}=3.3V, I_{OUT}=3A, FREQ=L, MODE=L

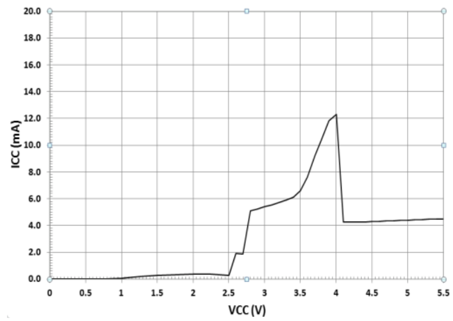


Fig 5: Circuit Current vs. Power Supply Voltage (Temp=25°C, FREQ=L, MODE=L)

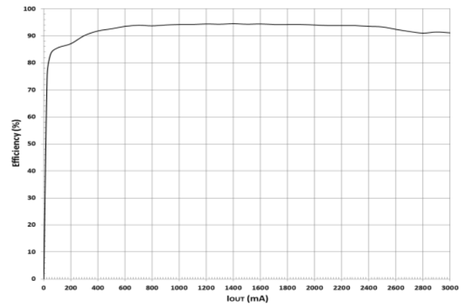


Fig 6: Electric Power Conversion Rate (V_{OUT}=3.3V, FREQ=L, MODE=L)

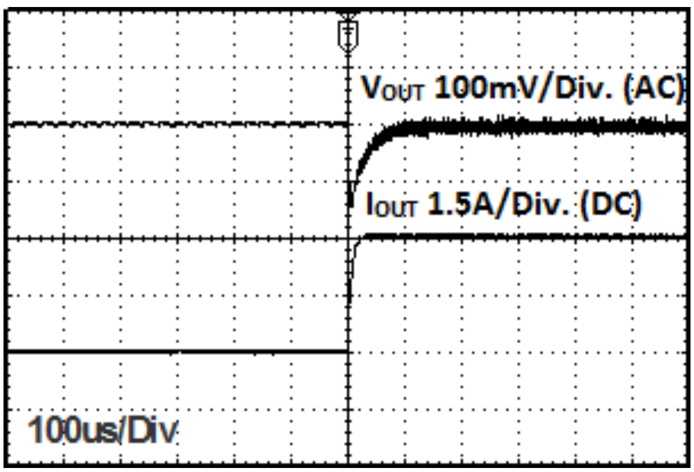


Fig 7: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0 → 3A, FREQ=L, MODE=L)

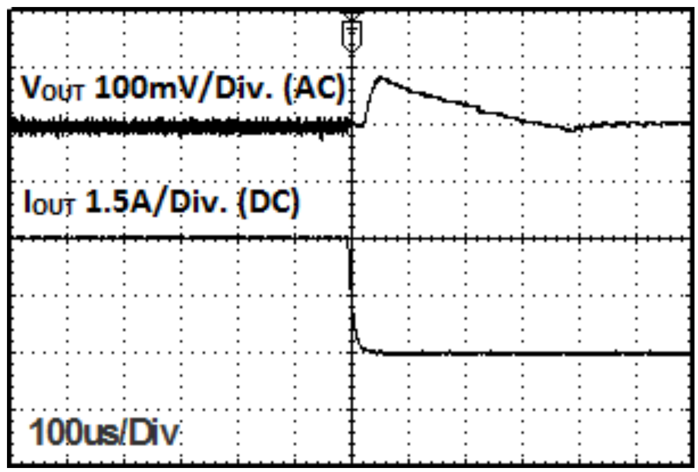


Fig 8: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=3A → 0, FREQ=L, MODE=L)

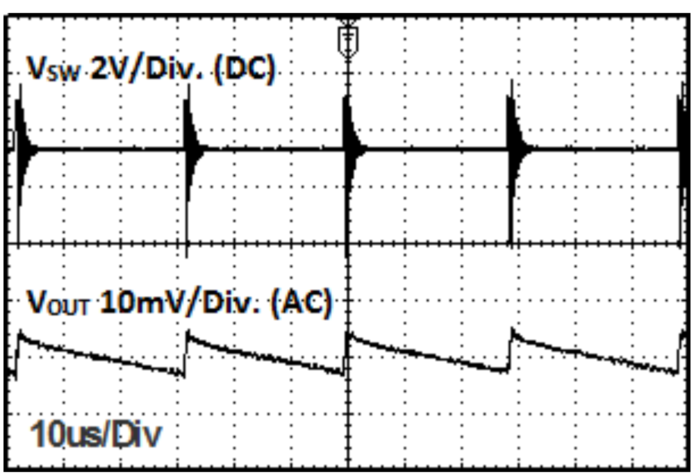


Fig 9: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0, FREQ=L, MODE=L)

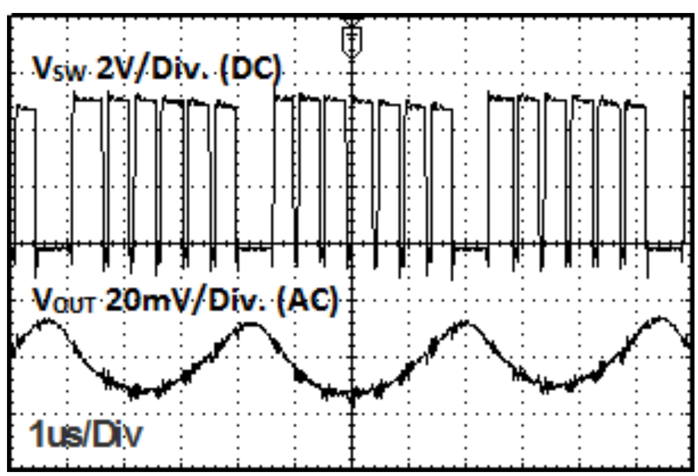


Fig 10: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=3A, FREQ=L, MODE=L)

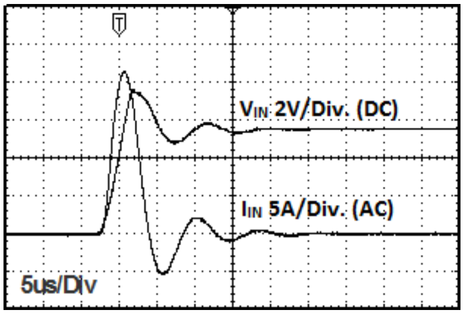


Fig 11: Hot Plug-in Test with Zener Diode P4SMA6.8A, V_{IN}=5.5V, V_{OUT}=3.3V, I_{OUT}=3A, FREQ=L, MODE=H

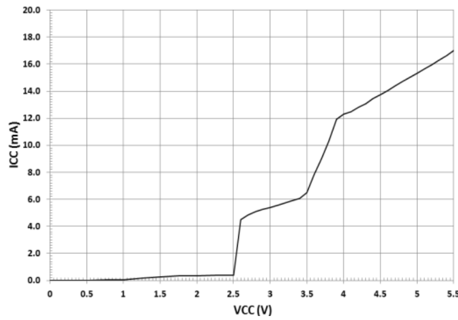


Fig 12: Circuit Current vs. Power Supply Voltage (Temp=25^{o}C, FREQ=L, MODE=H)

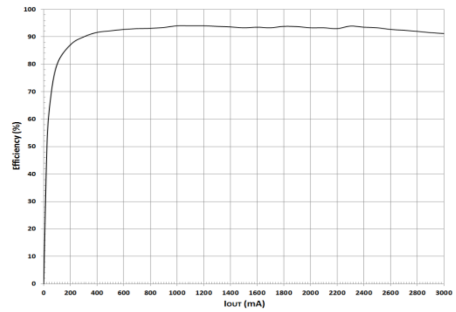


Fig 13: Electric Power Conversion Rate (V_{OUT}=3.3V, FREQ=L, MODE=H)

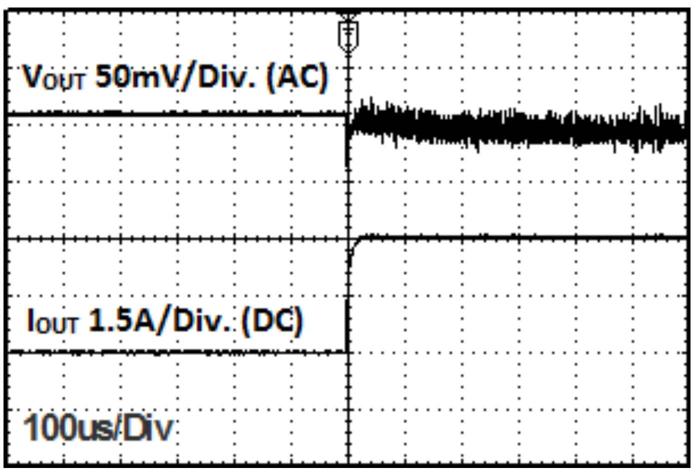


Fig 14: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0 → 3A, FREQ=L, MODE=H)

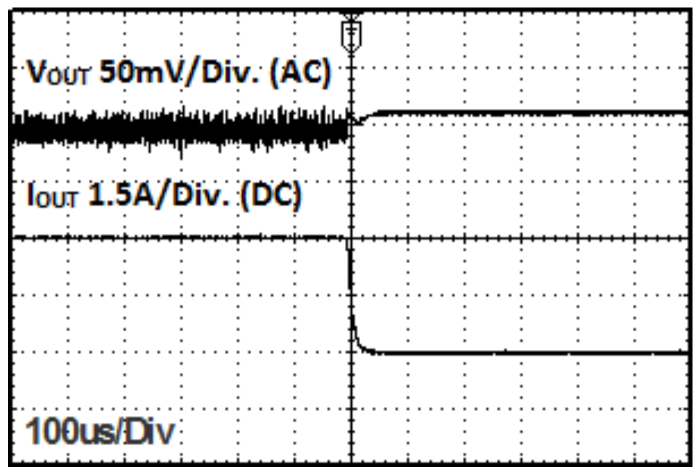


Fig 15: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=3A → 0, FREQ=L, MODE=H)

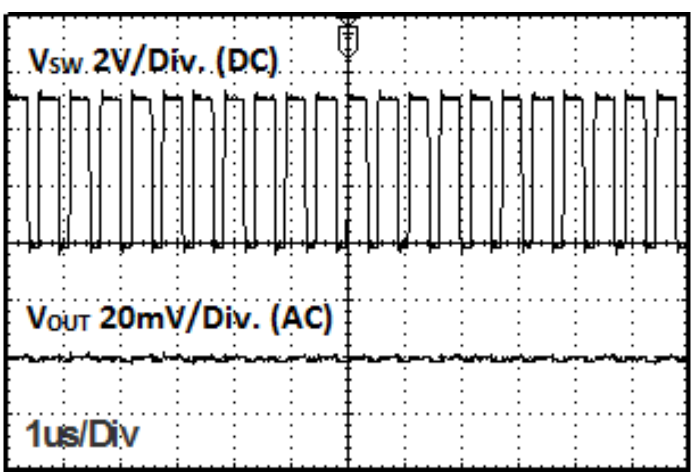


Fig 16: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0, FREQ=L, MODE=H)

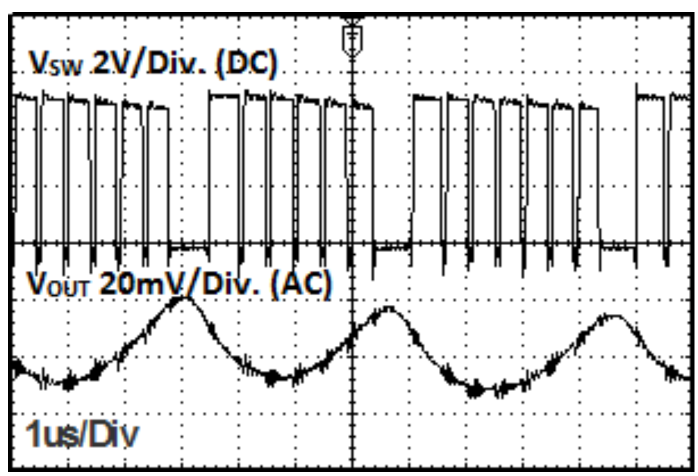


Fig 17: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=3A, FREQ=L, MODE=H)

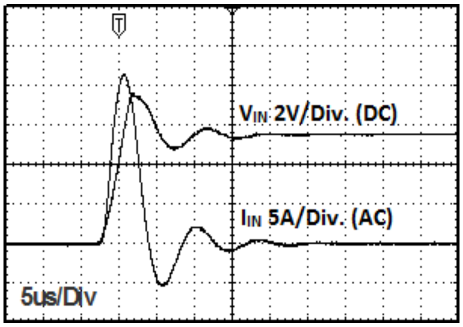


Fig 18: Hot Plug-in Test with Zener Diode P4SMA6.8A, V_{IN}=5.5V, V_{OUT}=3.3V, I_{OUT}=3A, FREQ=H, MODE=L

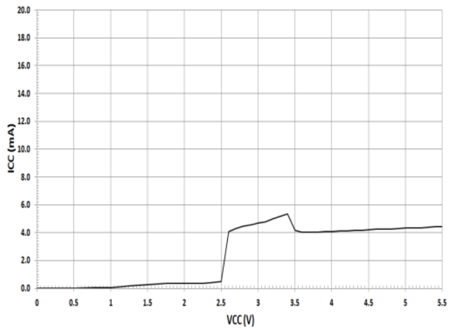


Fig 19: Circuit Current vs. Power Supply Voltage (Temp=25°C, FREQ=H, MODE=L)

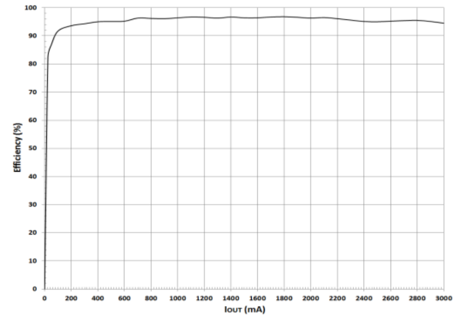


Fig 20: Electric Power Conversion Rate (V_{OUT}=3.3V, FREQ=H, MODE=L)

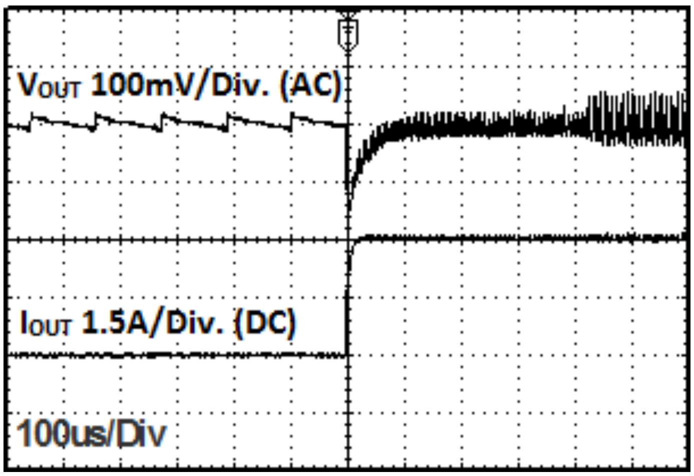


Fig 21: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0 → 3A, FREQ=H, MODE=L)

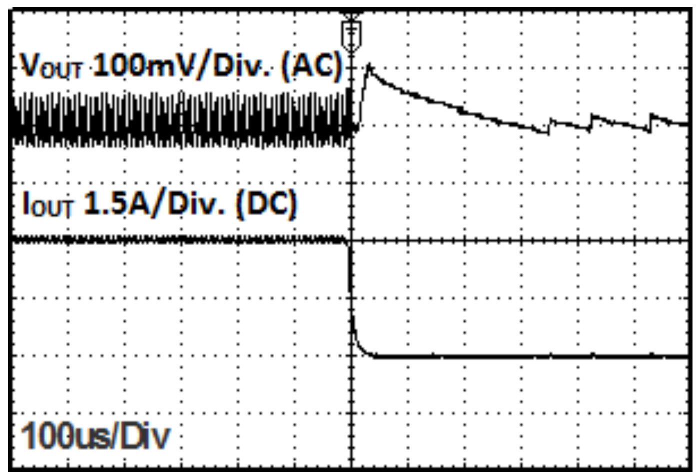


Fig 22: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=3A → 0, FREQ=H, MODE=L)

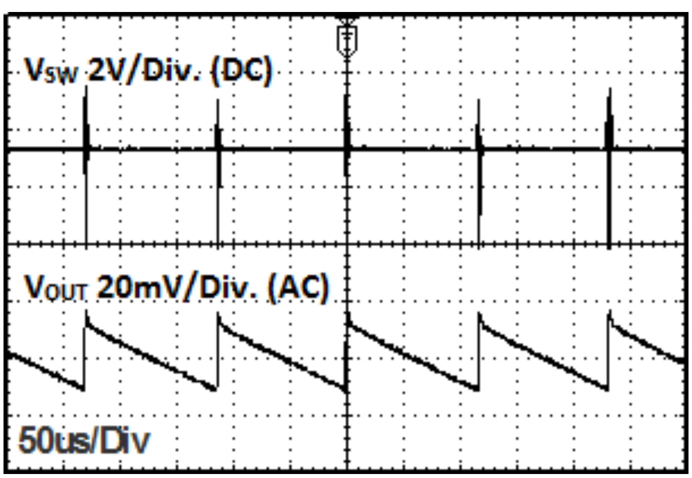


Fig 23: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0, FREQ=H, MODE=L)

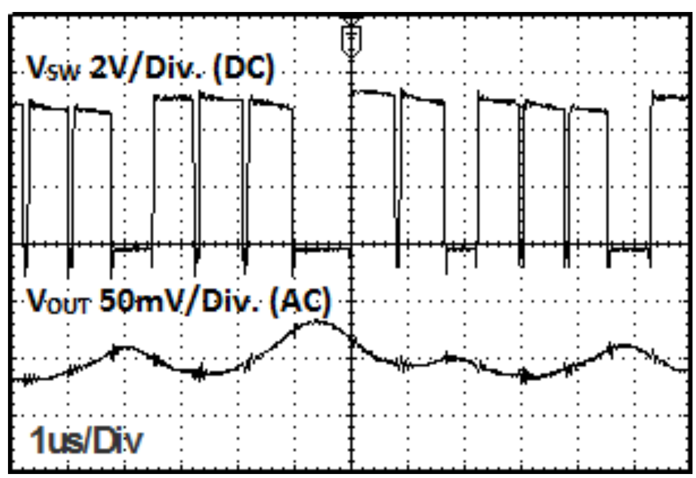


Fig 24: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=3A, FREQ=H, MODE=L)

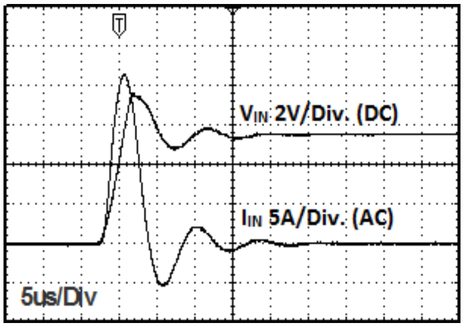


Fig 25: Hot Plug-in Test with Zener Diode P4SMA6.8A, V_{IN}=5.5V, V_{OUT}=3.3V, I_{OUT}=3A, FREQ=H, MODE=H

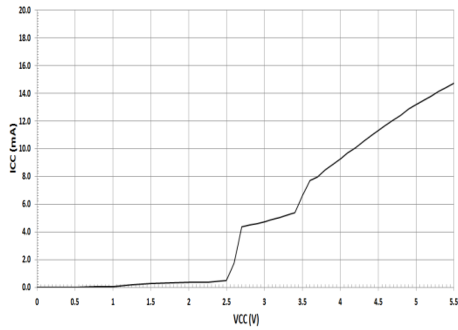


Fig 26: Circuit Current vs. Power Supply Voltage (Temp=25°C, FREQ=H, MODE=H)

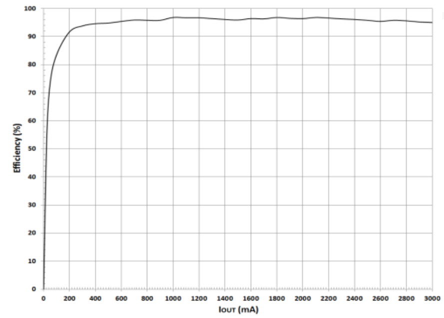


Fig 27: Electric Power Conversion Rate (V_{OUT}=3.3V, FREQ=H, MODE=H)

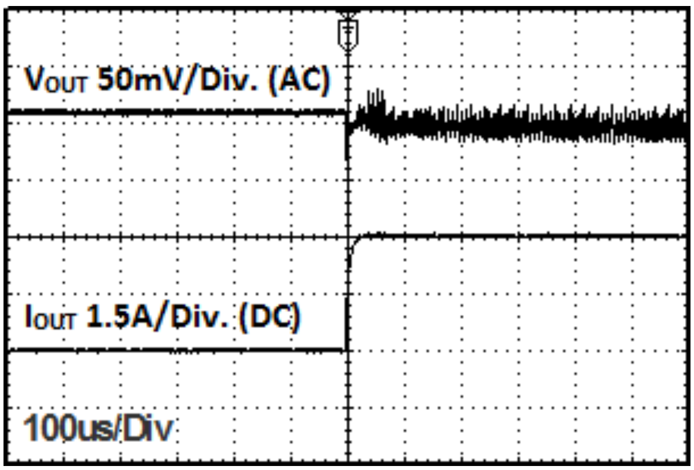


Fig 28: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0 → 3A, FREQ=H, MODE=H)

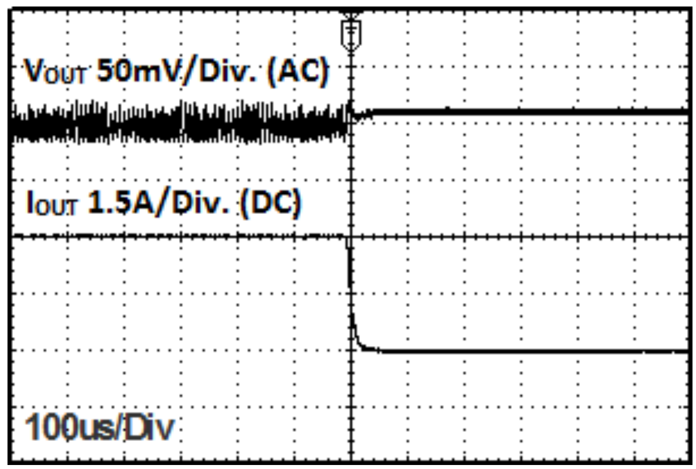


Fig 29: Load Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=3A → 0, FREQ=H, MODE=H)

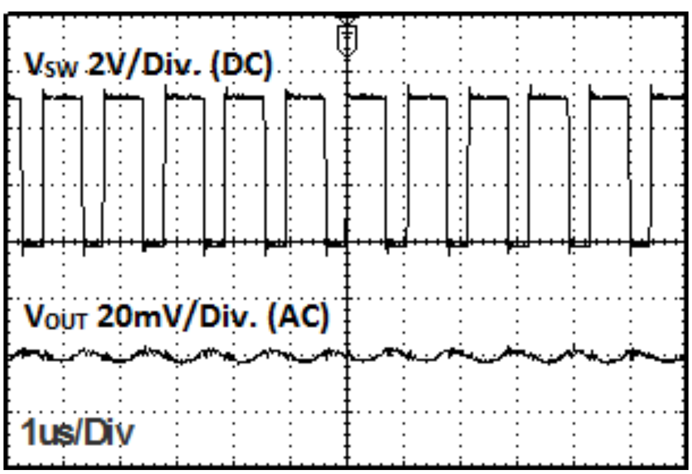


Fig 30: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0, FREQ=H, MODE=H)

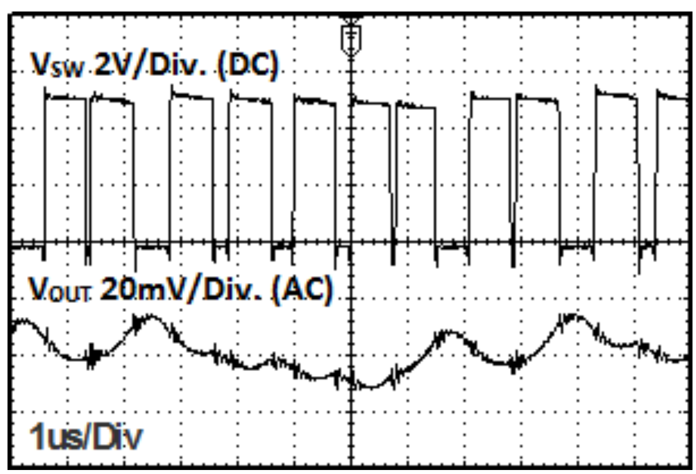


Fig 31: Output Voltage Ripple Response Characteristics (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=3A, FREQ=H, MODE=H)

- **Evaluation Board Layout Guidelines**
In the step-down DC/DC converter, a large pulse current flows through two loops. The first loop is the one into which current flows when the High-Side FET is turned ON. The flow starts from the input capacitor C_{IN}, runs through the FET, inductor L, and output capacitor C_{OUT}, then back to the GND of C_{IN} via the GND of C_{OUT}. In the second loop current flows when the Low-Side FET is turned ON. Flow starts from the Low-Side FET, runs through the inductor L and output capacitor C_{OUT}, then back to the GND of the Low-Side FET via the GND of C_{OUT}. We recommend routing these two loops as thick and as short as possible to minimize noise and improve efficiency. The input and output capacitors should be connected directly to the GND plane. Please note that the PCB layout has a large influence on the DC/DC converter in terms of heat generation, noise, and efficiency.

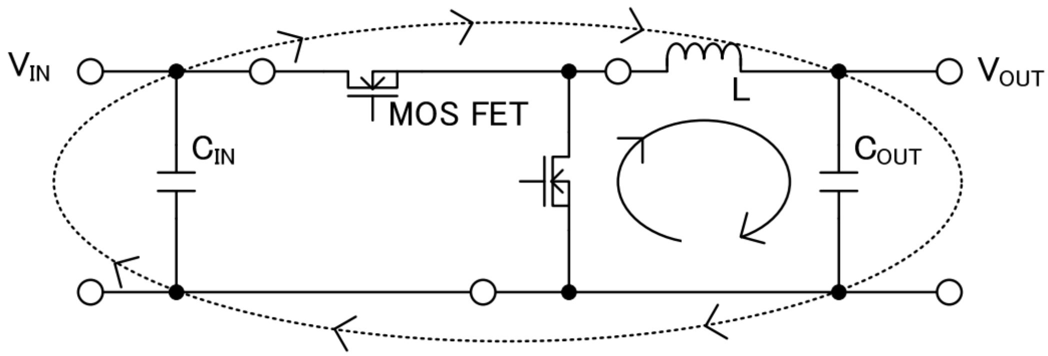


Fig 32: Current Loops of Buck Regulator System

Accordingly, when designing the PCB layout please consider the following points:

- Connect an input capacitor as close as possible to the IC PVIN terminal on the same plane as the IC.
- If there is any unused area on the PCB, provide a copper foil plane for the GND node to assist heat dissipation from the IC and the surrounding components.
- Switching nodes such as SW are susceptible to noise due to AC coupling with other nodes. Therefore, route the coil pattern as thick and as short as possible.
- Ensure that lines connected to FB are far from the SW nodes.
- Place the output capacitor away from the input capacitor in order to avoid the effects of harmonic noise from the input.

Power Dissipation
When designing the PCB layout and peripheral circuitry sufficient consideration must be given to ensure that the power dissipation is within the allowable dissipation curve.

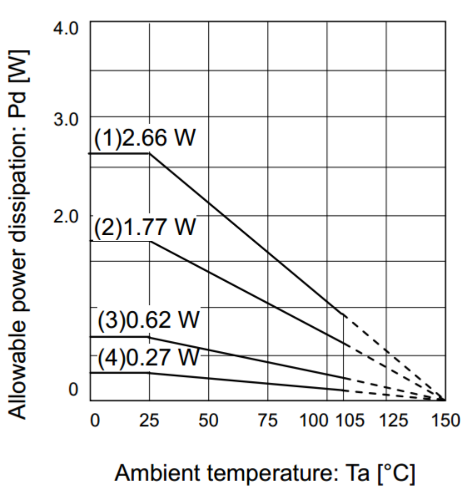


Fig 33: Thermal Derating Characteristics

(1) 4-layer board (surface heat dissipation copper foil 5505 mm^2)
(Copper foil laminated on each layer)
θJA= 47.0°C/W
(2) 4-layer board (surface heat dissipation copper foil 6.28 mm^2)
(Copper foil laminated on each layer)
θJA= 70.62°C/W
(3) 1-layer board (surface heat dissipation copper foil 6.28 mm^2)
θJA= 201.6°C/W
(4) IC only
θJA= 462.9°C/W

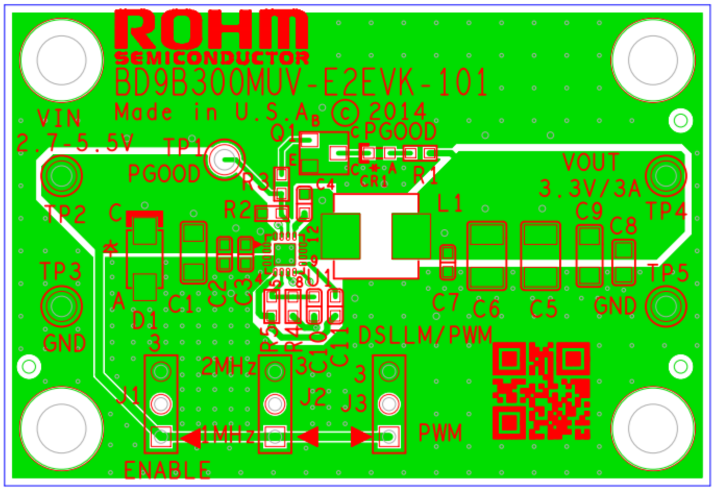


Fig 34: BD9B300MUV-E2EVK-101 Board PCB layout

- **Application Circuit Component Selection**

  Inductor (L)

  The inductance significantly depends on the output ripple current. As shown by the following equation, the ripple current decreases as the inductor and/or switching frequency increases.

$$\Delta I_L = \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{L \times V_{IN} \times f}$$

Where f=Switching Frequency, L=Inductance, and ΔL=Inductor Ripple Current.

As a minimum requirement, the DC current rating of the inductor should be equal to the maximum load current plus half of the inductor ripple current as shown by:

$$I_{LPEAK} = I_{OUTMAX} + \frac{\Delta I_L}{2}$$

- **Evaluation Board BOM**
  Below is a table showing the bill of materials. Part numbers and supplier references are also provided.

No.	Qty.	Ref	Description	Manufacturer	Part Number
1	1	CR1	LED 570NM GREEN WTR CLR 0603 SMD	Rohm	SML-310MTT86
2	1	C1	CAP CER 10UF 10V 10% X5R 1206	Murata	GRM319R61A106KE19D
3	3	C2,C3,C4	CAP CER 0.1UF 16V 10% X7R 0603	Murata	GRM188R71C104KA01D
4	2	C5,C6	CAP CER 22UF 6.3V 10% X5R 1210	Murata	GRM32DR60J226KA01L
5	1	C10	CAP CER 180PF 50V 5% NP0 0603	Murata	GRM1885C1H181JA01D
6	1	D1	DIODE TVS 400W 6.8V UNI 5% SMD	Littelfuse Inc	P4SMA6.8A
7	3	J1,J2,J3	CONN HEADER VERT .100 3POS 15AU	TE Connectivity	87224-3
8	1	L1	INDUCTOR WW 1.5UH 8A SMD	Wurth	74437349015
9	1	Q1	TRANSISTOR NPN 40V 0.6A SOT-23	Rohm	SST2222AT116
10	1	R1	RES 140 OHM 1/10W 1% 0603 SMD	Rohm	MCR03ERTF1400
11	1	R2	RES 100K OHM 1/10W 5% 0603 SMD	Rohm	MCR03ERTJ104
12	1	R3	RES 1K OHM 1/10W 5% 0603 SMD	Rohm	MCR03ERTJ102
13	1	R4	RES 160K OHM 1/10W 1% 0603 SMD	Rohm	MCR03ERTF1603
14	1	R5	RES 51K OHM 1/10W 1% 0603 SMD	Rohm	MCR03ERTF5102
15	3	TP1,TP2,TP4	TEST POINT PC MULTI PURPOSE RED	Keystone Electronics	5010
16	2	TP3,TP5	TEST POINT PC MULTI PURPOSE BLK	Keystone Electronics	5011
17	1	U1			
18	3		Shunt jumper for header J1, J2, J3 (item #7), CONN SHUNT 2POS GOLD W/HANDLE	TE Connectivity	881545-1

Notes

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ROHM SEMICONDUCTOR

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