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)

• 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Limit</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MIN</td>
<td>TYP</td>
<td>MAX</td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>BD9B300MUV</td>
<td>V_{CC}</td>
<td>2.7</td>
<td>-</td>
</tr>
<tr>
<td>Output Voltage / Current</td>
<td>BD9B300MUV</td>
<td>V_{OUT}</td>
<td>-</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I_{OUT}</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
• **Evaluation Board**
  Below is an image of the BD9B300MUV-E2EVK-101 evaluation board.

![Evaluation Board Image](image-url)

**Fig 1:** Evaluation Board for the BD9B300MUV

• **Board Schematic**

![Board Schematic Image](image-url)

**Note:**

\[
V_{OUT} = 0.8 \times \left( \frac{R4 + R5}{R5} \right)
\]

**Fig 2:** BD9B300MUV-E2EVK-101 Evaluation Board Schematic

<table>
<thead>
<tr>
<th>Reference Designator</th>
<th>Position</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1</td>
<td>2 - 1</td>
<td>Enable UI</td>
</tr>
<tr>
<td></td>
<td>2 - 3</td>
<td>Disable UI</td>
</tr>
<tr>
<td>J2</td>
<td>2 - 1</td>
<td>Set switching frequency of UI is 1.0MHz</td>
</tr>
<tr>
<td></td>
<td>2 - 3</td>
<td>Set switching frequency of UI is 2.0MHz</td>
</tr>
<tr>
<td>J3</td>
<td>2 - 1</td>
<td>Set operation mode of UI is fixed frequency PWM mode</td>
</tr>
<tr>
<td></td>
<td>2 - 3</td>
<td>Set operation mode of UI is automatically switched between the Deep-SLIM control and fixed frequency PWM mode</td>
</tr>
</tbody>
</table>
• Board I/O
Below is a reference application circuit that shows the inputs $V_{IN}$, EN, FREQ, and MODE and output $V_{OUT}$.

![Application Note](image-url)

**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\textsubscript{IN}=5.5V, V\textsubscript{OUT}=3.3V, I\textsubscript{OUT}=3A, FREQ=L, MODE=L

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

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

Fig 7: Load Response Characteristics
(V\textsubscript{IN}=5V, V\textsubscript{OUT}=3.3V, I\textsubscript{OUT}=0 \rightarrow 3A, FREQ=L, MODE=L)

Fig 8: Load Response Characteristics
(V\textsubscript{IN}=5V, V\textsubscript{OUT}=3.3V, I\textsubscript{OUT}=3A \rightarrow 0, FREQ=L, MODE=L)

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

Fig 10: Output Voltage Ripple Response Characteristics
(V\textsubscript{IN}=5V, V\textsubscript{OUT}=3.3V, I\textsubscript{OUT}=3A, FREQ=L, MODE=L)
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 ($V_{IN}=5V$, $V_{OUT}=3.3V$, $I_{OUT}=0 \rightarrow 3A$, FREQ=H, MODE=L)

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

Fig 29: Load Response Characteristics ($V_{IN}=5V$, $V_{OUT}=3.3V$, $I_{OUT}=3A \rightarrow 0$, 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.

![Current Loops of Buck Regulator System](image)

**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.

![Thermal Derating Characteristics](image)

**Fig 33: Thermal Derating Characteristics**

(1) 4-layer board (surface heat dissipation copper foil 5505 mm$^2$)
   - Copper foil laminated on each layer
   - $\theta_{JA}$ = 47.0°C/W
(2) 4-layer board (surface heat dissipation copper foil 6.28 mm$^2$)
   - Copper foil laminated on each layer
   - $\theta_{JA}$ = 70.62°C/W
(3) 1-layer board (surface heat dissipation copper foil 6.28 mm$^2$)
   - $\theta_{JA}$ = 201.6°C/W
(4) IC only
   - $\theta_{JA}$ = 462.9°C/W
**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 \(\Delta L\)=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:

\[
I_{PEAK} = I_{OUT MAX} + \frac{\Delta I_L}{2}
\]
• Evaluation Board BOM  
Below is a table showing the bill of materials. Part numbers and supplier references are also provided.

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

No copying or reproduction of this document, in part or in whole, is permitted without the consent of ROHM Co., Ltd.

The content specified herein is subject to change for improvement without notice.

The content specified herein is for the purpose of introducing ROHM's products (herein after "Products"). If you wish to use any such Product, please be sure to refer to the specifications which can be obtained from ROHM upon request.

Examples of application circuits, circuit constants and any other information contained herein illustrate the standard usage and operations of the Products. The peripheral conditions must be taken into account when designing circuits for mass production.

Great care was taken in ensuring the accuracy of the information specified in this document. However, should you incur any damage arising from any inaccuracy or misprint of such information, ROHM shall bear no responsibility for such damage.

The technical information specified herein is intended only to show the typical functions of and examples of application circuits for the Products. ROHM does not grant you, explicitly or implicitly, any license to use or exercise intellectual property or other rights held by ROHM and other parties. ROHM shall bear no responsibility whatsoever for any dispute arising from the use of such technical information.

The Products specified in this document are intended to be used with general-use electronic equipment or devices (such as audio visual equipment, office-automation equipment, communication devices, electronic appliances and amusement devices).

The Products specified in this document are not designed to be radiation tolerant.

While ROHM always makes efforts to enhance the quality and reliability of its Products, a Product may fail or malfunction for a variety of reasons.

Please be sure to implement in your equipment using the Products safety measures to guard against the possibility of physical injury, fire or any other damage caused in the event of the failure of any Product, such as derating, redundancy, fire control and fail-safe designs. ROHM shall bear no responsibility whatsoever for your use of any Product outside of the prescribed scope or not in accordance with the instruction manual.

The Products are not designed or manufactured to be used with any equipment, device or system which requires an extremely high level of reliability the failure or malfunction of which may result in a direct threat to human life or create a risk of human injury (such as a medical instrument, transportation equipment, aerospace machinery, nuclear-reactor controller, fuel-controller or other safety device). ROHM shall bear no responsibility in any way for use of any of the Products for the above special purposes. If a Product is intended to be used for any such special purpose, please contact a ROHM sales representative before purchasing.

If you intend to export or ship overseas any Product or technology specified herein that maybe controlled under the Foreign Exchange and the Foreign Trade Law, you will be required to obtain a license or permit under the Law.

Thank you for your accessing to ROHM product information.
More detail product information and catalogs are available, please contact us.

ROHM Customer Support System

http://www.rohm.com/contact/