Secondary Buck DC/DC Converter

Single Synchronous Buck DC/DC Converter For Automotive BD9S402MUF-C Evaluation Board

BD9S402MUF-TSB-001 (2.7V to 5.5V Input, 4A)

Introduction

This user's guide will provide the necessary steps to operate the Evaluation Board of ROHM's BD9S402MUF-C Buck DC/DC converter. This includes the external parts, operating procedures and application data.

Description

This Evaluation Board was developed for ROHM's single Synchronous buck DC/DC converter BD9S402MUF-C. It is a synchronous buck DC/DC converter with built-in low On Resistance power MOSFETs. BD9S402MUF-C accepts a power supply input range of 2.7 V to 5.5 V and generates a maximum output current of 4 A. Small inductor is applicable due to high switching frequency of 2.2 MHz. It has fast transient response performance due to current mode control, and the built-in QuiCur™ maximizes the response performance. It has a built-in phase compensation circuit. Applications can be created with a few external components.

Application

Automotive Equipment

Other Electronic Equipment

Recommended Operating Conditions

Table 1. Recommended Operating Conditions

Parameter	Min	Typ	Max	Units	Conditions
Input Voltage	2.7	-	5.5	V	
Output Voltage (Note1)	0.6	-	PVIN×0.75	V	
Output Current Range	-	-	4.0	A	
Switching Frequency	-	2.2	-	MHz	
Maximum Efficiency (Vo = 3.3 V)	-	93.5	-	%	VIN = 5.0 V, Io = 1.4 A, Ta = 25 °C
Maximum Efficiency (Vo = 1.0 V)		86.2		%	VIN = 3.3 V, Io = 0.9A, Ta = 25 °C

(Note 1) Although the minimum output voltage is configurable up to 0.6 V, it may be limited by the SW min ON pulse width.
SW Minimum ON Time that BD9S420MUF-C can output stably in the entire load range is 50 ns. Use the value to calculate the input and output conditions that satisfy the equation of 50 [ns] $\leqq \frac{Vout}{VIN \times fsw}$

Evaluation Board

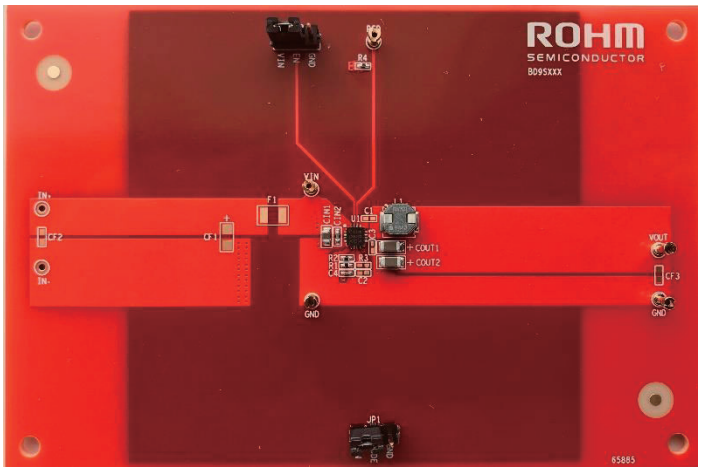

Figure 1. Evaluation Board Top View

Evaluation Board Schematic

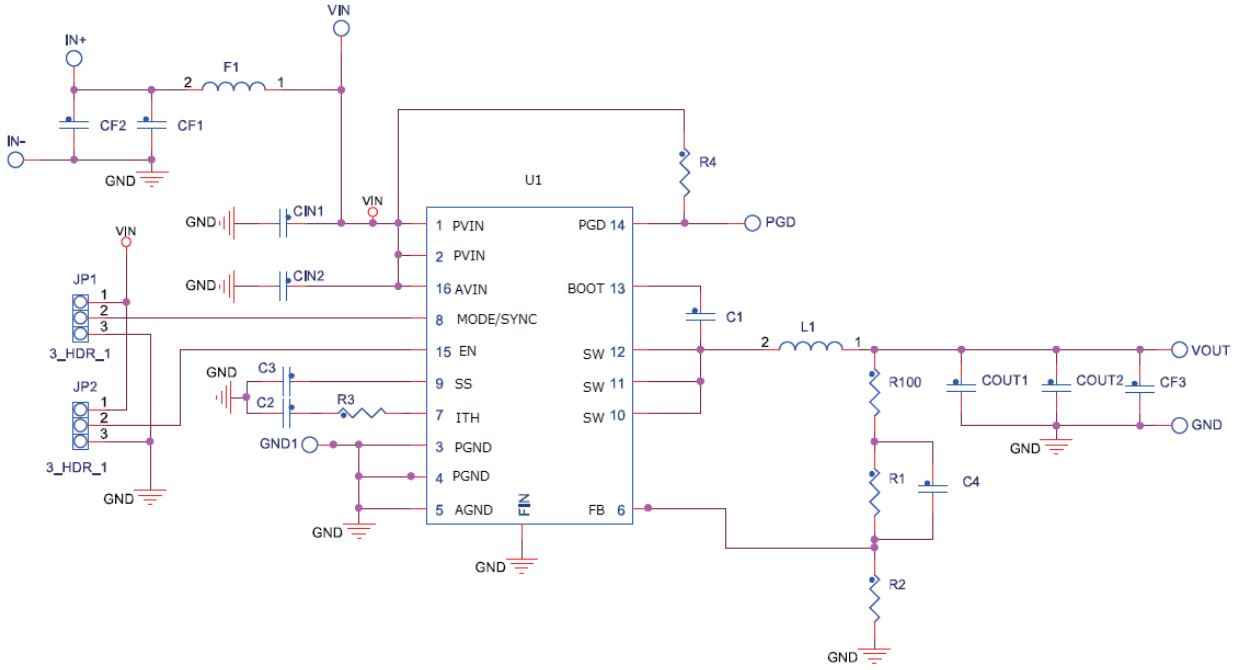

Figure 2. Circuit Diagram

(Note) This schematic pattern is common with BD9Sxxx series so some pin names of BD9S402MUF are different.

Operating Procedure

1. Turn off EN and connect the GND terminal of the power supply to the GND terminal of Evaluation Board.
2. Connect power supply to the VIN terminal of the Evaluation Board.
3. Connect the load to the Evaluation Board's VOUT and GND terminals. When using an electronic load, connect with the load turned off.
4. Connect a voltmeter to the Evaluation Board's VOUT and GND terminals.
5. Turn on the Power supply of VIN. Turn ON the switch of EN terminal.
6. Make sure that the voltmeter is set to measure voltage.
7. Turn on the electronic load.

(Caution) This Evaluation Board does not support hot plug. Do not perform hot plug test.

(Note) If EN = High (EN short to VIN) before Power ON, the turn ON and turn OFF is controlled by VIN only.

Pin Configuration

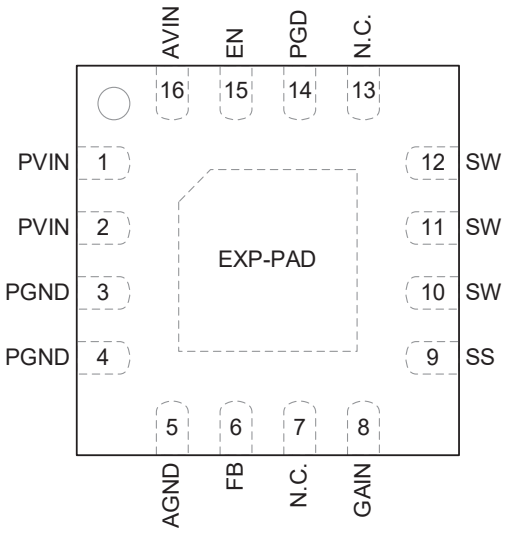

Figure 3. Pin Configuration

Pin Description

Table 2. Mode Terminal Description

Terminal	Setting	Operation Mode	Function	COUT
GAIN	HIGH	Fast load response mode	Error amplifier gain is set high to suppress output voltage changes during load transient	44 µF (TYP) or more
	LOW or OPEN	Low output capacitance mode	Stable operation even when COUT is 22 µF	22 µF

(Note) Do not switch the GAIN pin connection during operation.

Table 3. VIN and EN Terminal Description

VIN PIN	EN PIN	VOUT
VIN ≧ 2.55 V(TYP)	EN ≧ 1.0 V	Start up with Soft Start
VIN ≧ 2.55 V(TYP)	EN ≦ 0.4 V	Shutdown (Note)
VIN ≦ 2.45 V(TYP)	-	Shutdown (UVLO)

(Note) During shutdown, the SW pin is pulled down with resistance R_{DIS} (50 Ω, TYP) to discharge the output voltage.

Table 4. EN and FB Terminal Description

EN Pin	FB PIN	Protection	Protection item
EN ≧ 1.0 V	0.648 V(TYP) > FB ≧ 0.48 V(TYP)	Enabled	No detection
	FB ≦ 0.42 V and remains 1 ms(TYP)		SCP
	FB ≧ 0.648 V(TYP)		OVP
EN ≦ 0.4 V	-	Disabled	-

(Note) When the FB pin voltage has fallen to 0.42 V (TYP) or less and remained there for 1 ms (TYP), SCP stops the operation for 14 ms (TYP) and subsequently initiates a restart.

When the FB pin voltage becomes over or equal to 0.648 V (TYP), which is Output Over Voltage Protection Detection Voltage, the MOSFETs on the output stage are turned OFF to prevent the increase in the output voltage.

Parts list

Table 5. Parts list (The fast load response mode when GAIN = High (Note1))

No	Package	Parameters	Part Name (Series)	Type	Manufacturer
L1		0.47 µH	SPM5030VT-R47M-D	Inductor	TDK
COUT1	3216	22 µF, X7R, 6.3 V	GCM31CR70J226KE26	Ceramic Capacitor	Murata
COUT2	3216	22 µF, X7R, 6.3 V	GCM31CR70J226KE26	Ceramic Capacitor	Murata
CIN1	2012	10 µF, X7R, 10 V	GCM21BR71A106KE21	Ceramic Capacitor	Murata
CIN2	1005	4700 pF, X7R, 25 V	GCM155R71E472KA37	Ceramic Capacitor	Murata
R100	-	SHORT	-	-	-
R1 (Note2)	1005	Depends on VOUT	MCR01MZPF Series	Chip Resistor	ROHM
R2 (Note2)	1005	Depends on VOUT	MCR01MZPF Series	Chip Resistor	ROHM
R3 (Note4)	-	-	-	-	-
R4	1005	100 kΩ, 1 %, 1/16 W	MCR01MZPF Series	Chip Resistor	ROHM
C1 (Note3)	-	-	-	-	-
C2 (Note4)	-	-	-	-	-
C3	-	-	-	-	-
C4 (Note2)	1005	Depends on VOUT	GCM155R71E Series	Ceramic Capacitor	Murata
F1	-	-	-	-	-
CF1	-	-	-	-	-
CF2	-	-	-	-	-
CF3	-	-	-	-	-
JP1 (GAIN)	-	High	-	-	-

Table 6. Parts list (The low output capacitance mode when GAIN = Low (Note1))

No	Package	Parameters	Part Name (Series)	Type	Manufacturer
L1		0.47 µH	SPM5030VT-R47M-D	Inductor	TDK
COUT1	3216	22 µF, X7R, 6.3 V	GCM31CR70J226KE26	Ceramic Capacitor	Murata
COUT2	-	-	-	-	-
CIN1	2012	10 µF, X7R, 10 V	GCM21BR71A106KE21	Ceramic Capacitor	Murata
CIN2	1005	4700 pF, X7R, 25 V	GCM155R71E472KA37	Ceramic Capacitor	Murata
R100	-	SHORT	-	-	-
R1 (Note2)	1005	Depends on VOUT	MCR01MZPF Series	Chip Resistor	ROHM
R2 (Note2)	1005	Depends on VOUT	MCR01MZPF Series	Chip Resistor	ROHM
R3 (Note4)	-	-	-	-	-
R4	1005	100 kΩ, 1 %, 1/16 W	MCR01MZPF Series	Chip Resistor	ROHM
C1 (Note3)	-	-	-	-	-
C2 (Note4)	-	-	-	-	-
C3	-	-	-	-	-
C4 (Note2)	1005	Depends on VOUT	GCM155R71E Series	Ceramic Capacitor	Murata
F1	-	-	-	-	-
CF1	-	-	-	-	-
CF2	-	-	-	-	-
CF3	-	-	-	-	-
JP1 (GAIN)	-	Low	-	-	-

(Note1) For more information on each mode, please refer to table 2.

(Note2) Please refer to table 7 for R1, R2, and C4 values.

VOUT= $\frac{R1+R2}{R2} \times 0.6$ [V]

(Note3) C1 is a capacitor for BOOT pin (Common PCB pattern with BD9Sxxx series). BD9S402MUF doesn't have BOOT pin so C1 should be open.

(Note4) C2, R3 are PCB patterns for the output of the gm error amplifier, ITH pin (Common PCB pattern BD9Sxxx series). BD9S402MUF doesn't have ITH pin so C2 and R3 should be open.

(Note5) C3, F1, CF1, CF2, CF3 patterns are only optional. They can be utilized for adjusting the characteristics constants.

Table 7. Configuration Resistors and Capacitor

Output Voltage VOUT	R1	R2	C4
0.8 V	13 kΩ	39 kΩ	47 pF
0.9 V	15 kΩ	30 kΩ	47 pF
1.0 V	22 kΩ	33 kΩ	47 pF
1.2 V	47 kΩ	47 kΩ	47 pF
1.5 V	15 kΩ	10 kΩ	47 pF
1.8 V	30 kΩ	15 kΩ	33 pF
3.3 V	68 kΩ	15 kΩ	33 pF

(Note) If the recommended parts on tables 5 and 6 are not available anymore due to end of production, different parts will be used on the test board because the end of production parts are deprecated.

Board Layout

Evaluation Board PCB information

Number of Layers	Material	Board Size	Copper Thickness
4	FR4	114.3mm x 76.2mm x 1.6mm	2oz(70μm) / 1oz (35μm) / 1oz (35μm) / 2oz(70μm)

The layout of BD9Sxxx series board is shown below.

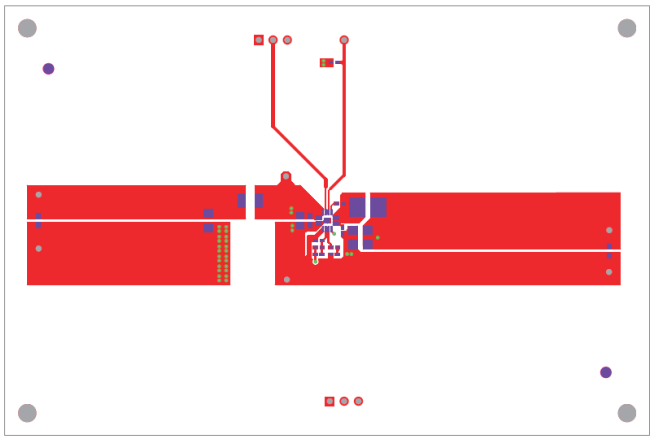

Figure 4. Top Layer Layout

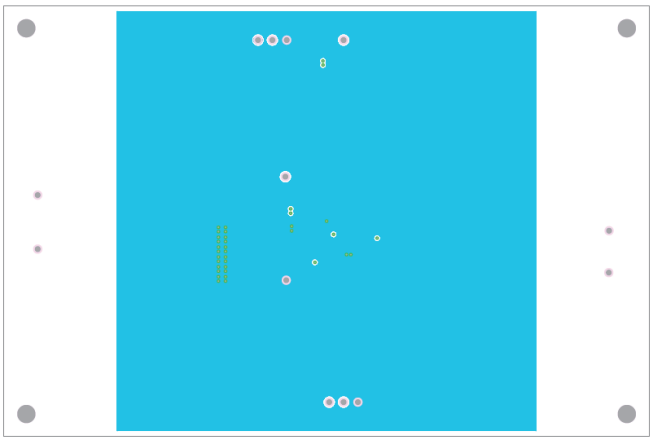

Figure 5. Middle1 Layer Layout

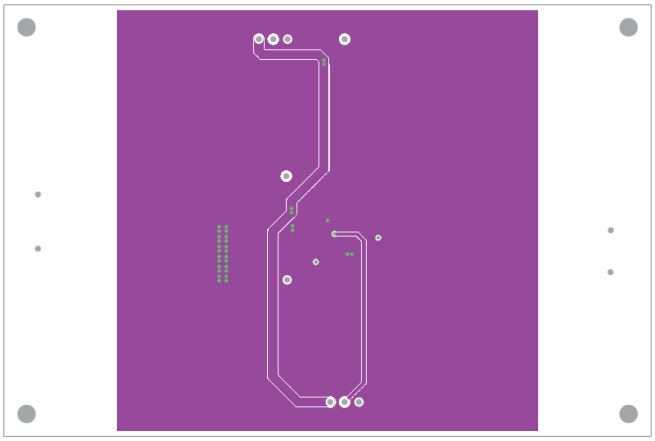

Figure 6. Middle2 Layer Layout

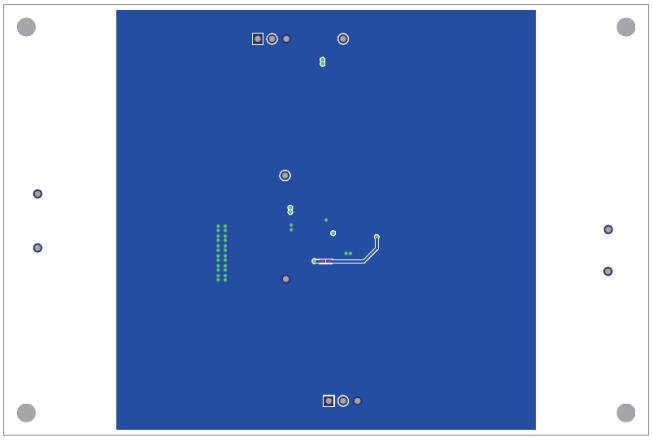

Figure 7. Bottom Layer Layout

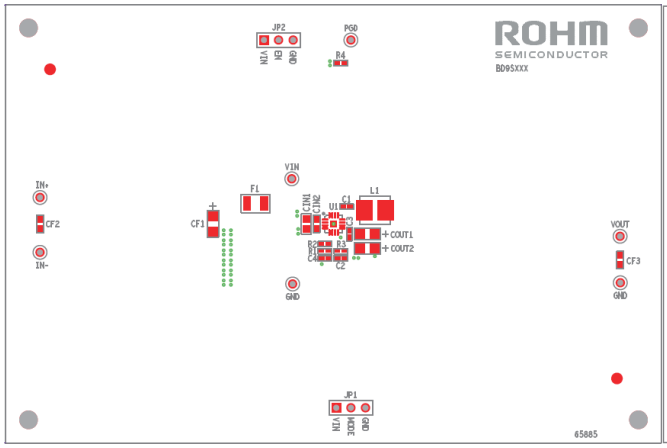

Figure 8. Top Parts Placement

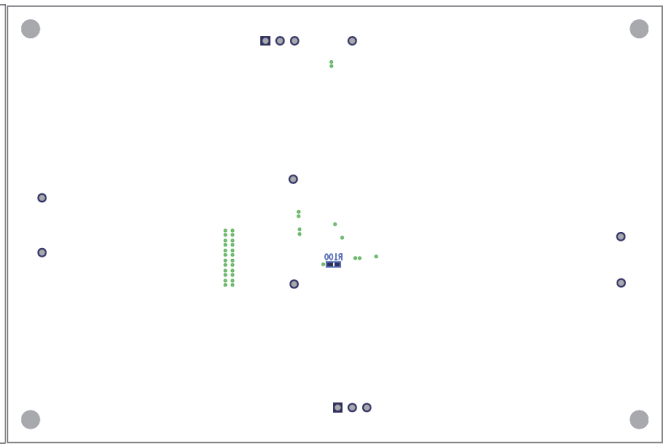

Figure 9. Bottom Parts Placement

Reference application data (BD9S402MUF-C)

(VIN = VEN = 5.0V, VOUT = 1.0V/3.3V, Ta = 25°C)

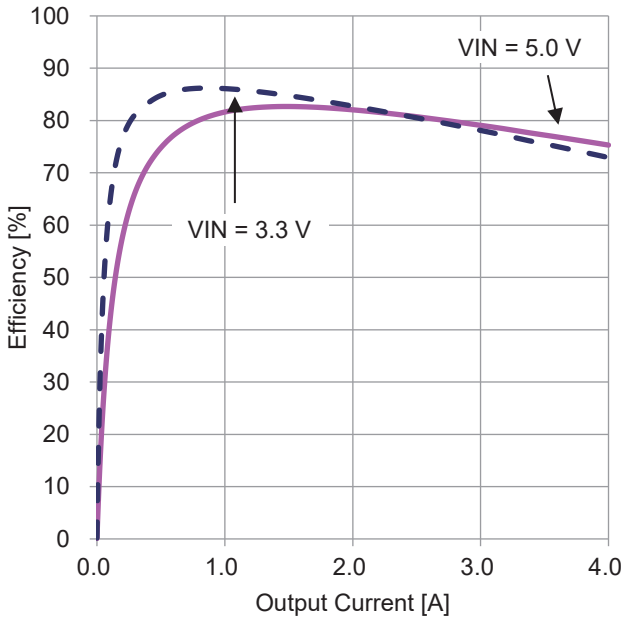

Figure 10. Efficiency vs Output Current
(VOUT = 1.0 V)

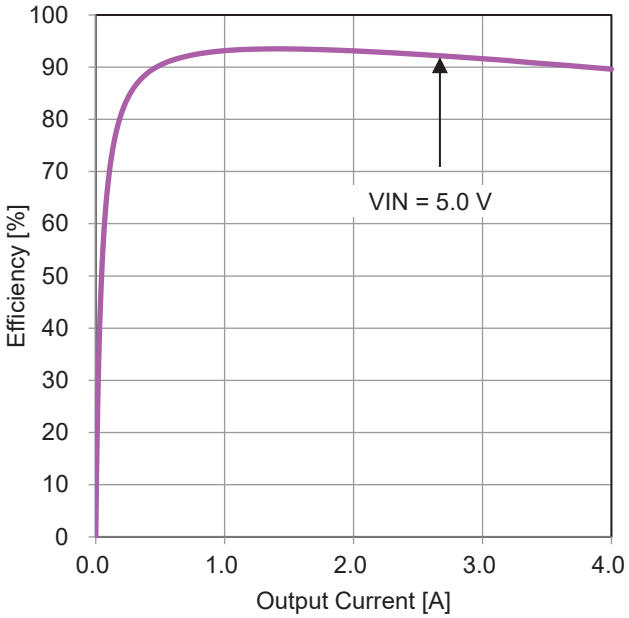

Figure 11. Efficiency vs Output Current
(VOUT = 3.3 V)

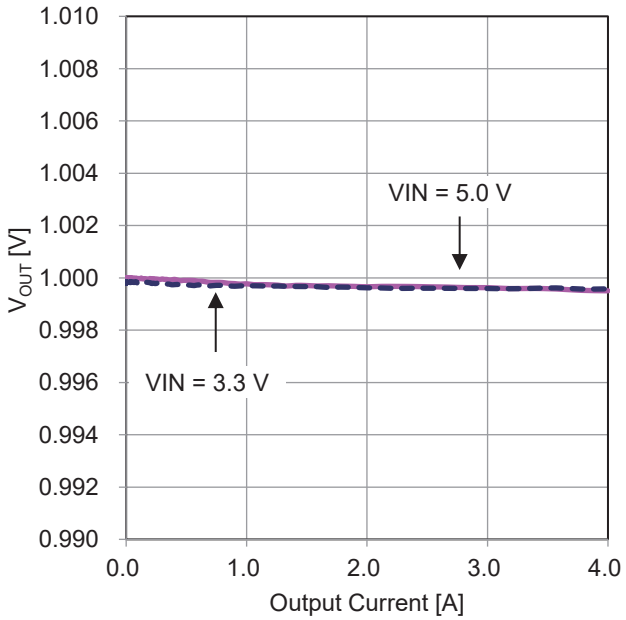

Figure 12. Output Voltage vs Output Current
(VOUT = 1.0 V)

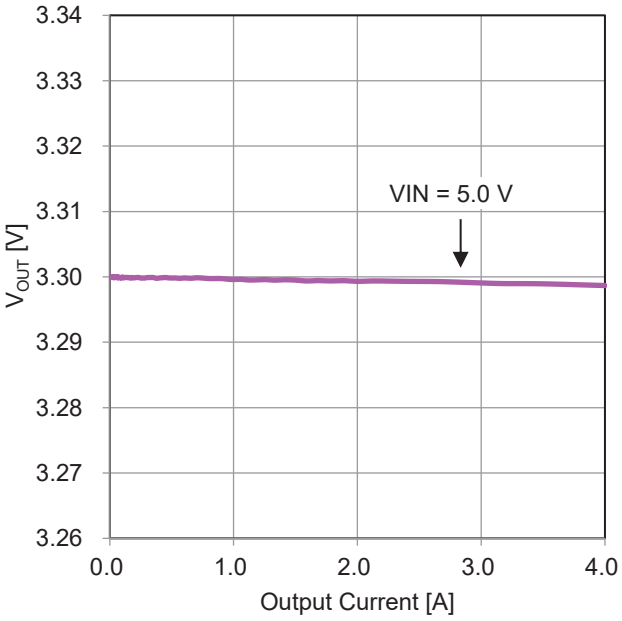

Figure 13. Output Voltage vs Output Current
(VOUT = 3.3 V)

Reference application data (BD9S402MUF-C) - continued

(VIN = VEN = 5.0V, VOUT = 1.0V/3.3V, Ta = 25°C)

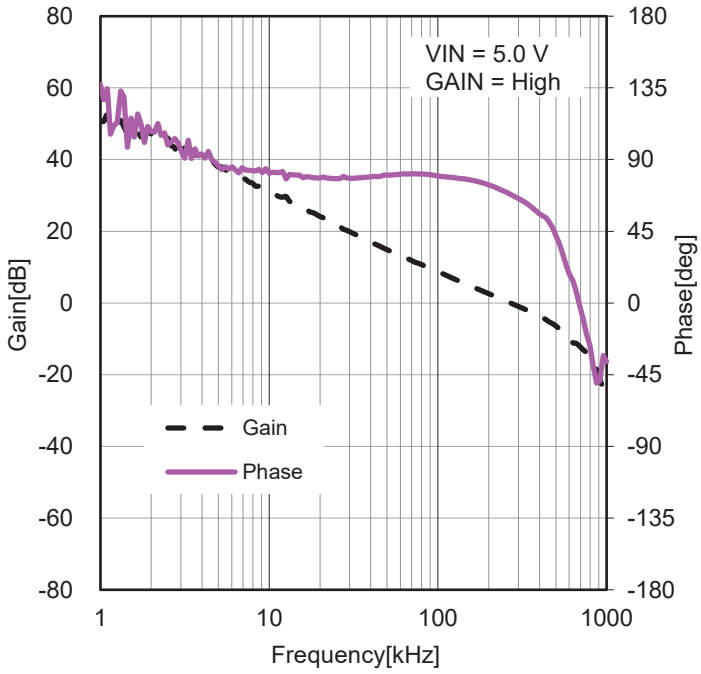

Figure 14. Frequency Characteristics
(VOUT = 1.0 V, GAIN = High, IOUT = 2 A)

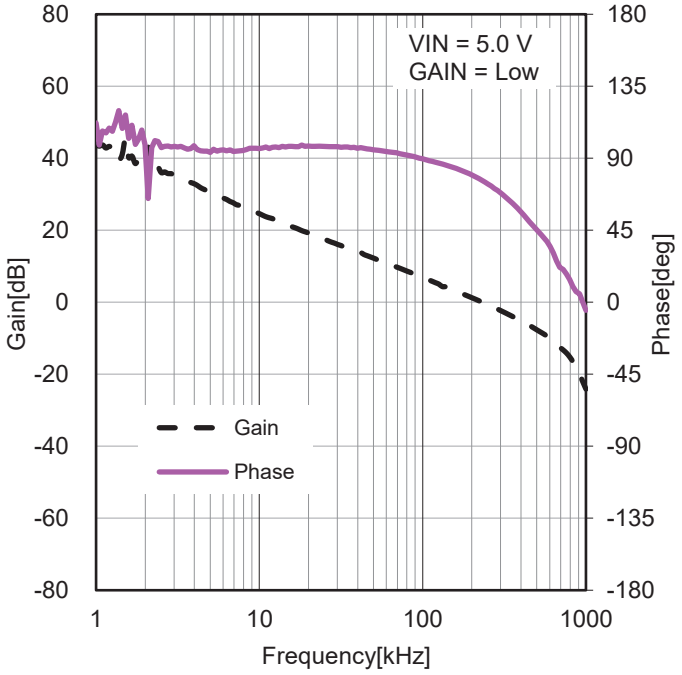

Figure 15. Frequency Characteristics
(VOUT = 1.0 V, GAIN = Low, IOUT = 2 A)

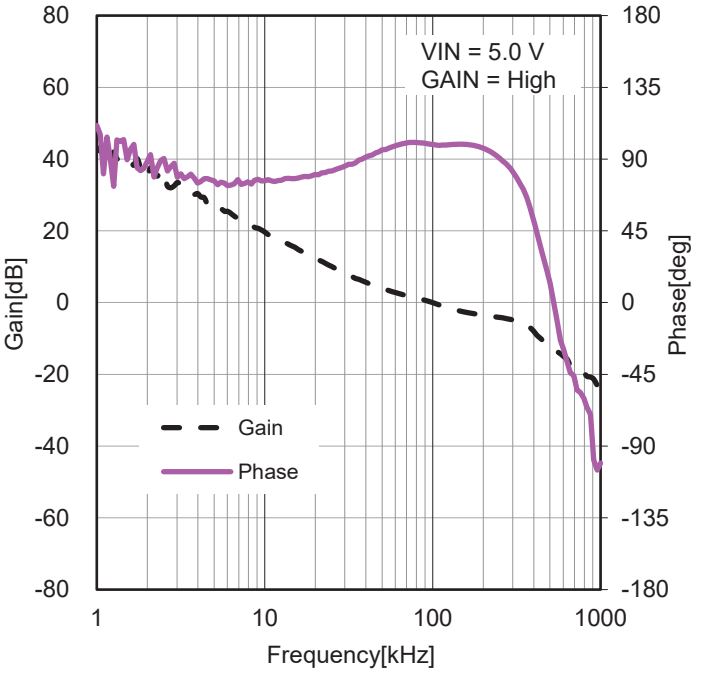

Figure 16. Frequency Characteristics
(VOUT = 3.3 V, GAIN = High, IOUT = 2 A)

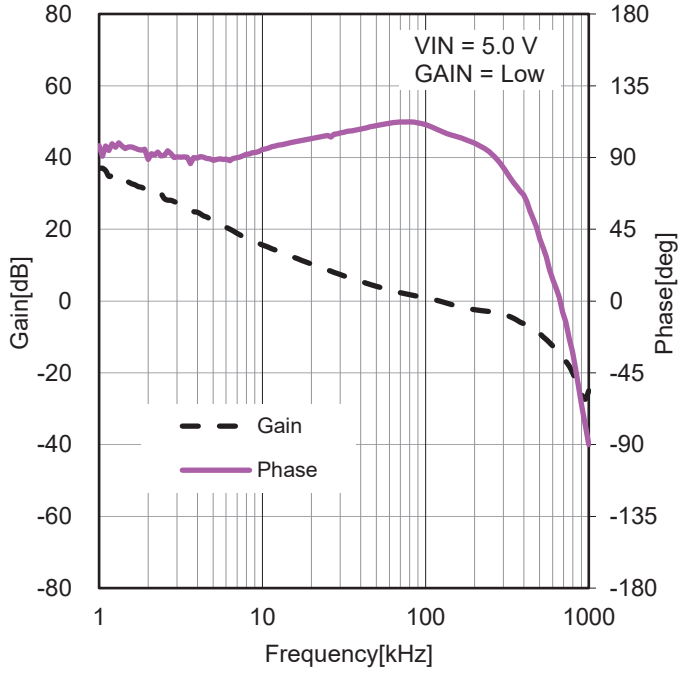

Figure 17. Frequency Characteristics
(VOUT = 3.3 V, GAIN = Low, IOUT = 2 A)

Reference application data (BD9S402MUF-C) - continued

(VIN = VEN = 5.0V, VOUT = 1.0V/3.3V, Ta = 25°C)

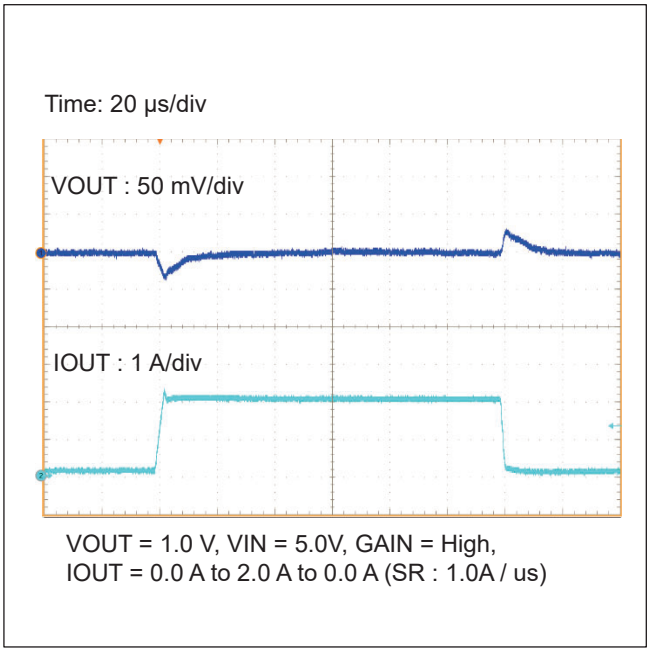

Figure 18. Load Transient Response
(VOUT = 1.0 V, GAIN = High)

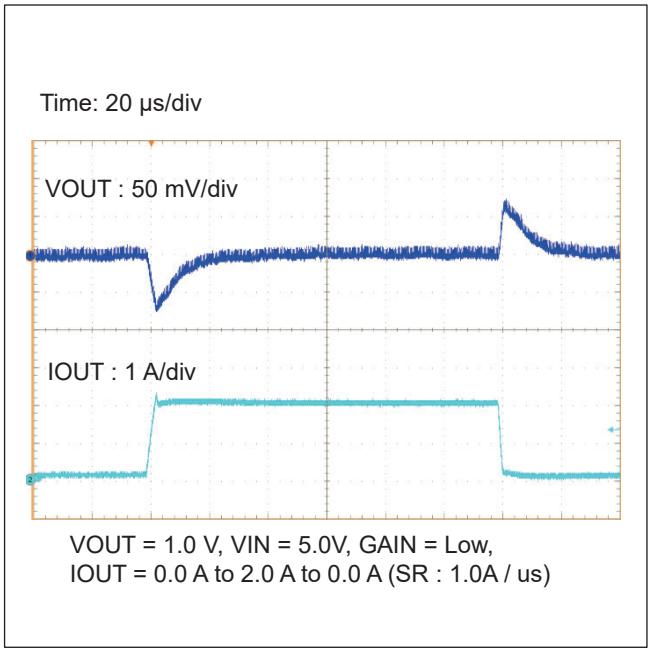

Figure 19. Load Transient Response
(VOUT = 1.0 V, GAIN = Low)

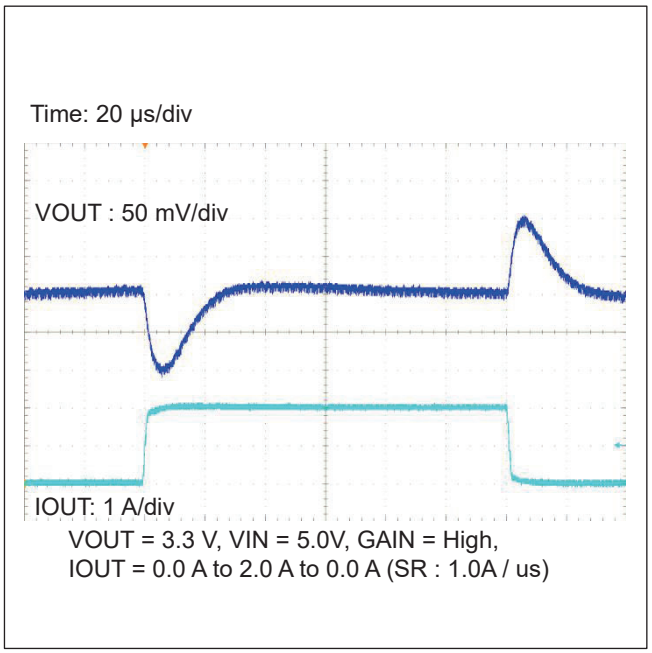

Figure 20. Load Transient Response
(VOUT = 3.3 V, GAIN = High)

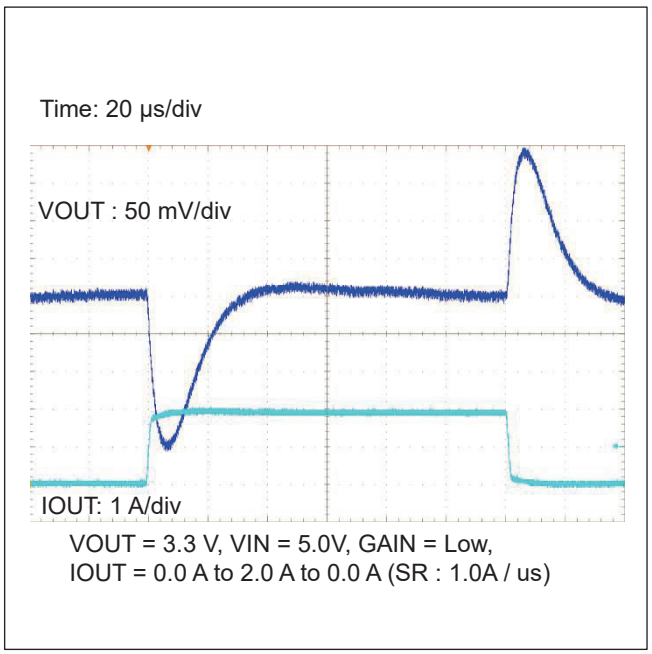

Figure 21 . Load Transient Response
(VOUT = 3.3 V, GAIN = Low)

Other series application data please refer to datasheet.

Revision History

Date	Revision Number	Description
May 2022	Rev.001	Initial release

Notes

1) The information contained herein is subject to change without notice.

2) Before you use our Products, please contact our sales representative and verify the latest specifications :

3) Although ROHM is continuously working to improve product reliability and quality, semiconductors can break down and malfunction due to various factors.
Therefore, in order to prevent personal injury or fire arising from failure, please take safety measures such as complying with the derating characteristics, implementing redundant and fire prevention designs, and utilizing backups and fail-safe procedures. ROHM shall have no responsibility for any damages arising out of the use of our Poducts beyond the rating specified by ROHM.

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

5) 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 or any other parties. ROHM shall have no responsibility whatsoever for any dispute arising out of the use of such technical information.

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

7) For use of our Products in applications requiring a high degree of reliability (as exemplified below), please contact and consult with a ROHM representative : transportation equipment (i.e. cars, ships, trains), primary communication equipment, traffic lights, fire/crime prevention, safety equipment, medical systems, servers, solar cells, and power transmission systems.

8) Do not use our Products in applications requiring extremely high reliability, such as aerospace equipment, nuclear power control systems, and submarine repeaters.

9) ROHM shall have no responsibility for any damages or injury arising from non-compliance with the recommended usage conditions and specifications contained herein.

10) ROHM has used reasonable care to ensure the accuracy of the information contained in this document. However, ROHM does not warrants that such information is error-free, and ROHM shall have no responsibility for any damages arising from any inaccuracy or misprint of such information.

11) Please use the Products in accordance with any applicable environmental laws and regulations, such as the RoHS Directive. For more details, including RoHS compatibility, please contact a ROHM sales office. ROHM shall have no responsibility for any damages or losses resulting non-compliance with any applicable laws or regulations.

12) When providing our Products and technologies contained in this document to other countries, you must abide by the procedures and provisions stipulated in all applicable export laws and regulations, including without limitation the US Export Administration Regulations and the Foreign Exchange and Foreign Trade Act.

13) This document, in part or in whole, may not be reprinted or reproduced without prior consent of ROHM.

ROHM SEMICONDUCTOR

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

ROHM Customer Support System

https://www.rohm.com/contact/