

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, 1.2V, 4A Output)

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 $50 \text{ [ns]} \leq \frac{V_{out}}{V_{IN} \times f_{sw}}$

Evaluation Board

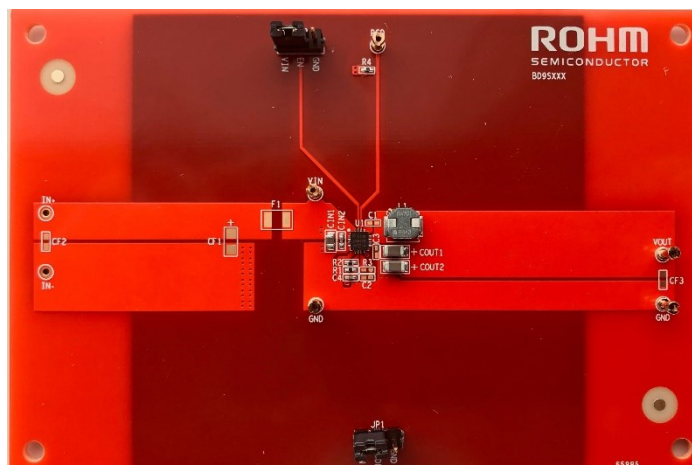


Figure 1. Evaluation Board Top View

Evaluation Board Schematic

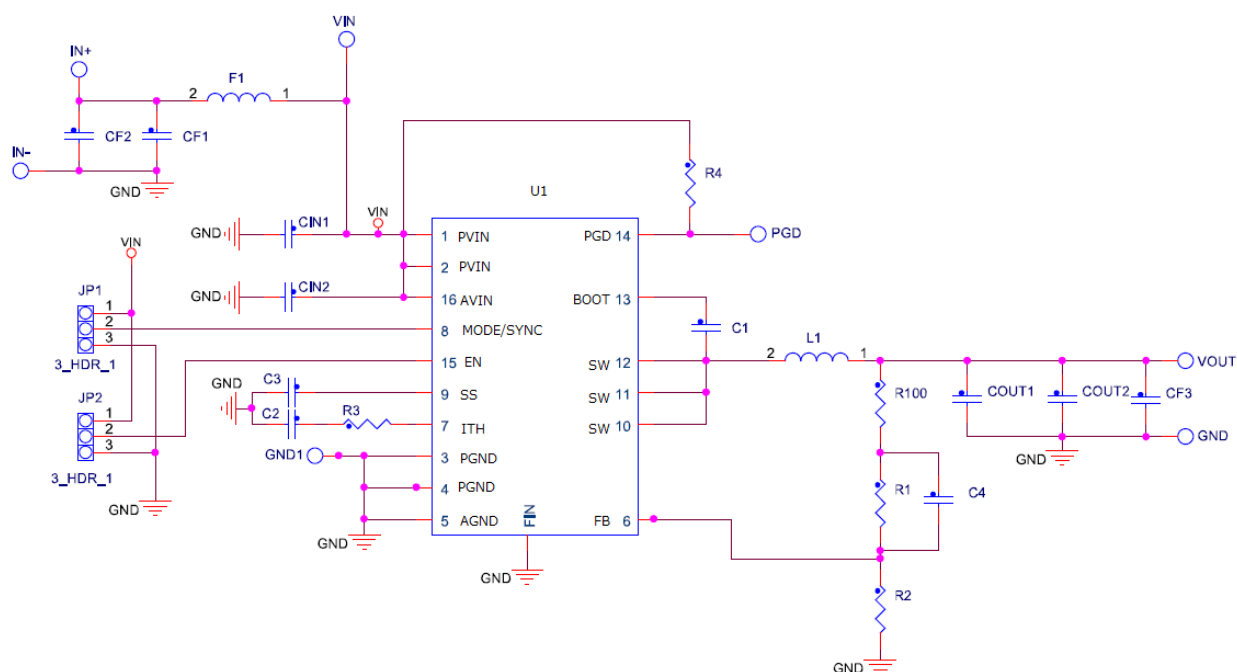


Figure 2. Circuit Diagram

(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

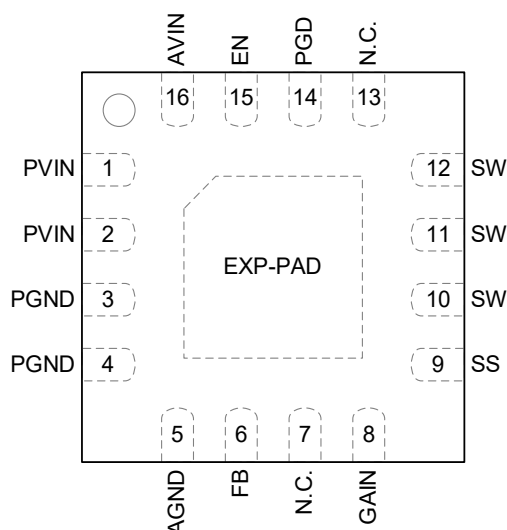


Figure 3. Pin Configuration

Pin Description

Table 2. Mode Terminal Description

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

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

Table 3. VIN and EN Terminal Description

VIN PIN	EN PIN	VOUT
VIN \geq 2.55 V(TYP)	EN \geq 1.0 V	Start up with Soft Start
VIN \geq 2.55 V(TYP)	EN \leq 0.4 V	Shutdown (Note)
VIN \leq 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 \geq 1.0 V	0.648 V(TYP) > FB \geq 0.48 V(TYP)	Enabled	No detection
	FB \leq 0.42 V and remains 1 ms(TYP)		SCP
	FB \geq 0.648 V(TYP)		OVP
EN \leq 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 μ H	SPM5030VT-R47M-D	Inductor	TDK
COUT1	3216	22 μ F, X7R, 6.3 V	GCM31CR70J226KE26	Ceramic Capacitor	Murata
COUT2	3216	22 μ F, X7R, 6.3 V	GCM31CR70J226KE26	Ceramic Capacitor	Murata
CIN1	2012	10 μ F, 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 k Ω , 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 μ H	SPM5030VT-R47M-D	Inductor	TDK
COUT1	3216	22 μ F, X7R, 6.3 V	GCM31CR70J226KE26	Ceramic Capacitor	Murata
COUT2	-	-	-	-	-
CIN1	2012	10 μ F, 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 k Ω , 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.

$$V_{OUT} = \frac{R1+R2}{R2} \times 0.6 \text{ [V]}$$

(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.

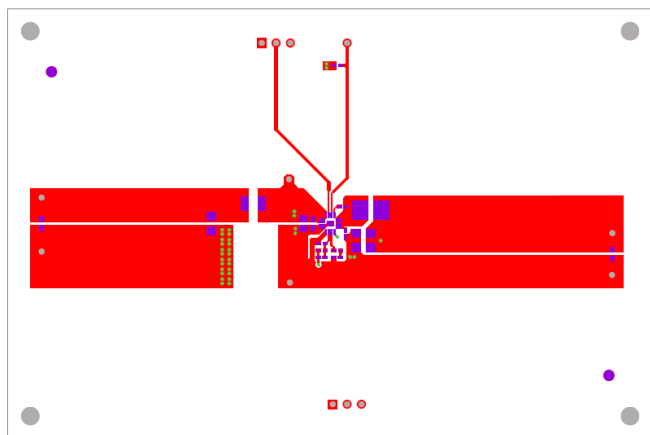


Figure 4. Top Layer Layout

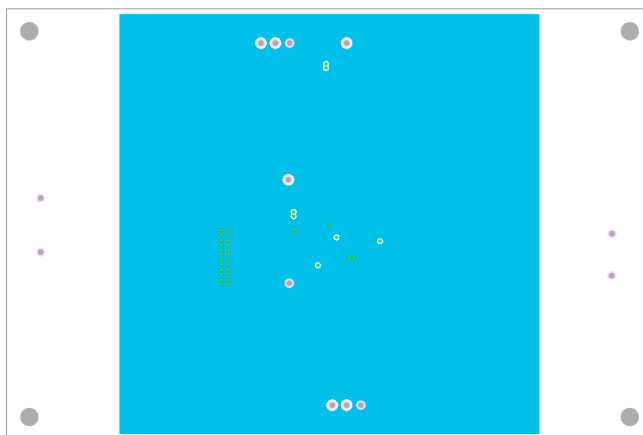


Figure 5. Middle1 Layer Layout

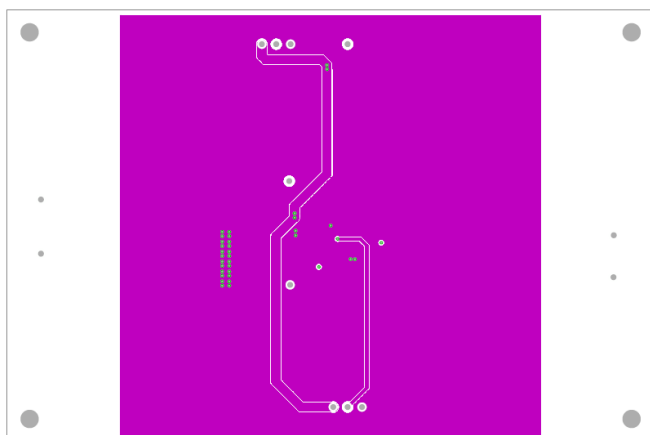


Figure 6. Middle2 Layer Layout

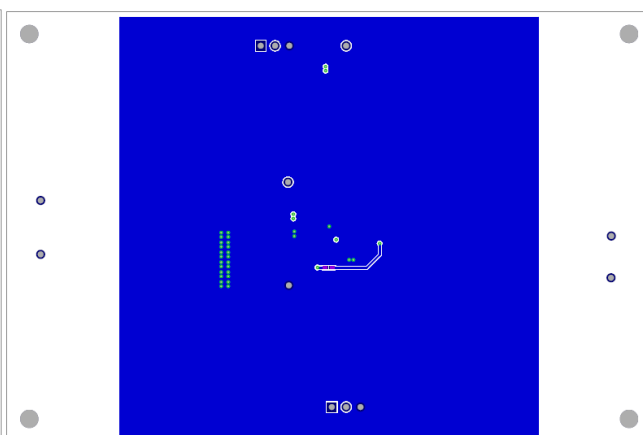


Figure 7. Bottom Layer Layout

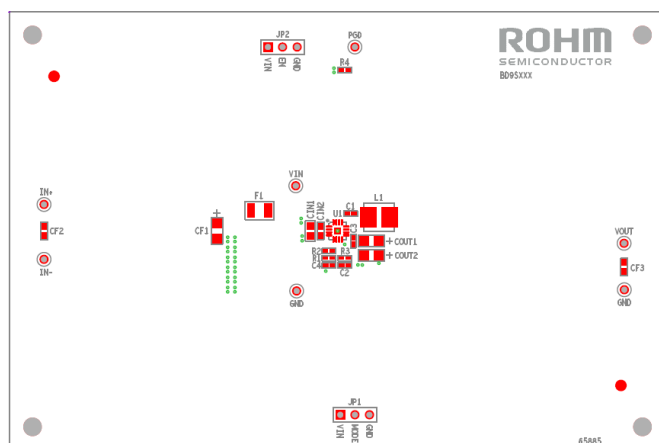


Figure 8. Top Parts Placement

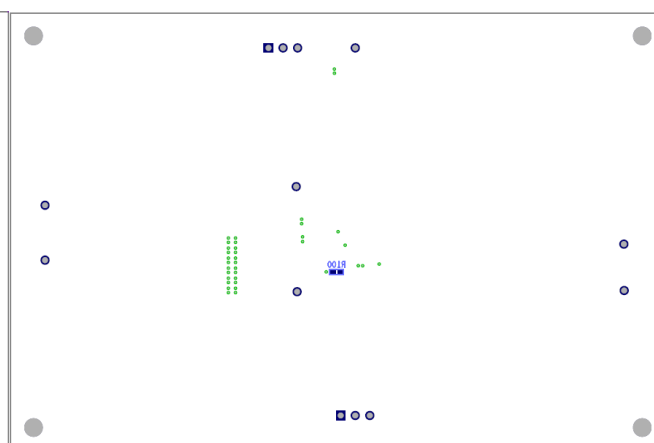
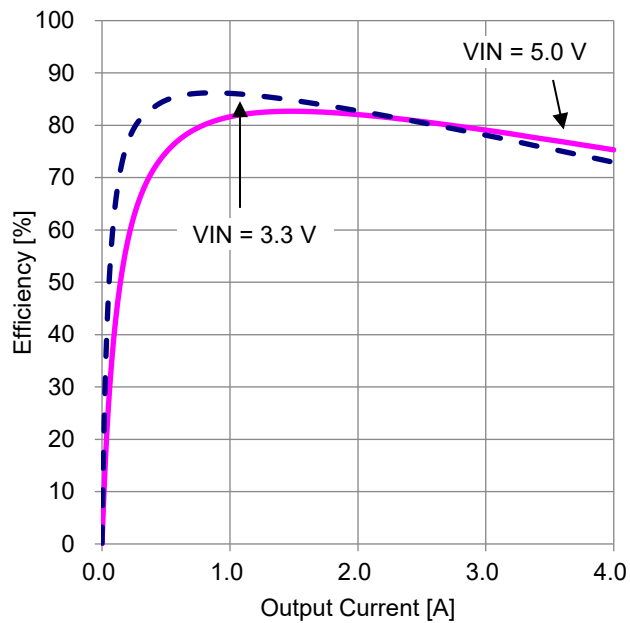
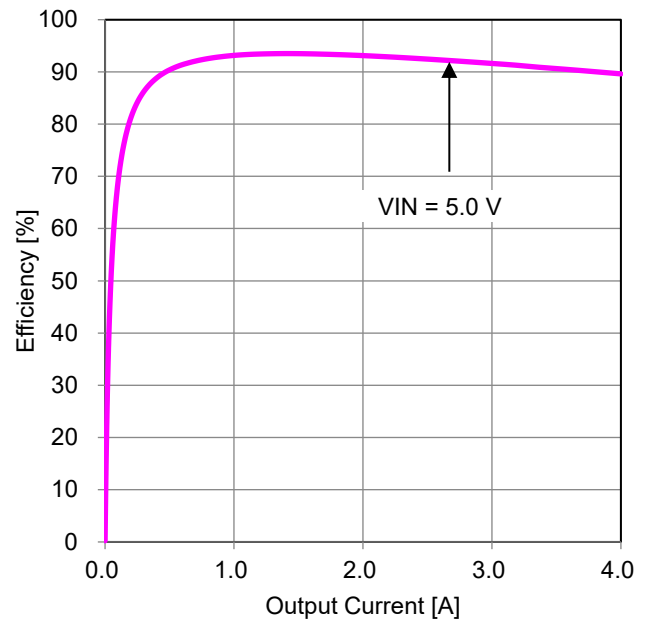
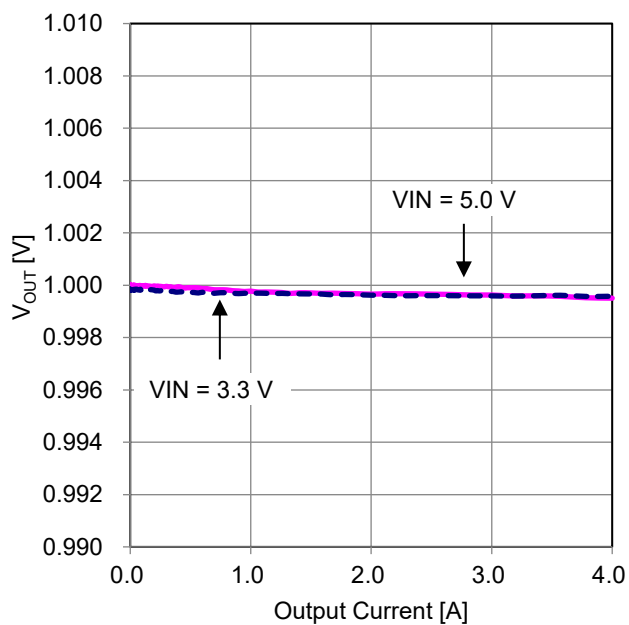
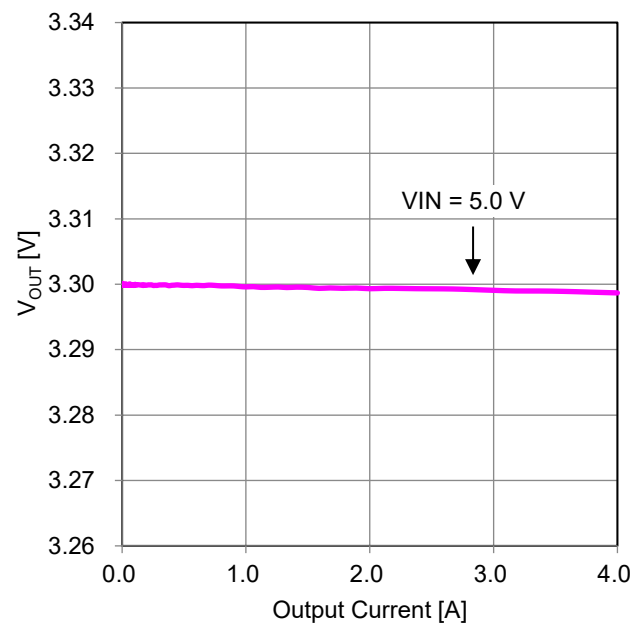


Figure 9. Bottom Parts Placement

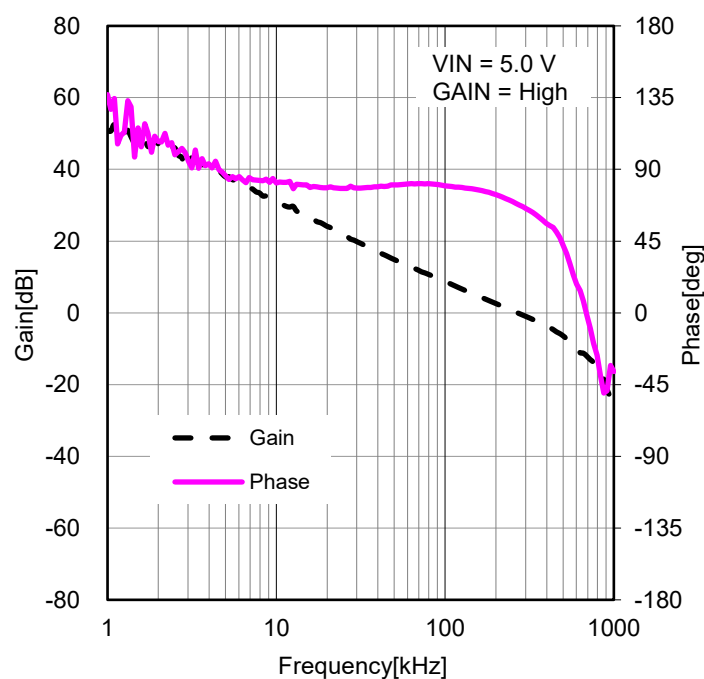
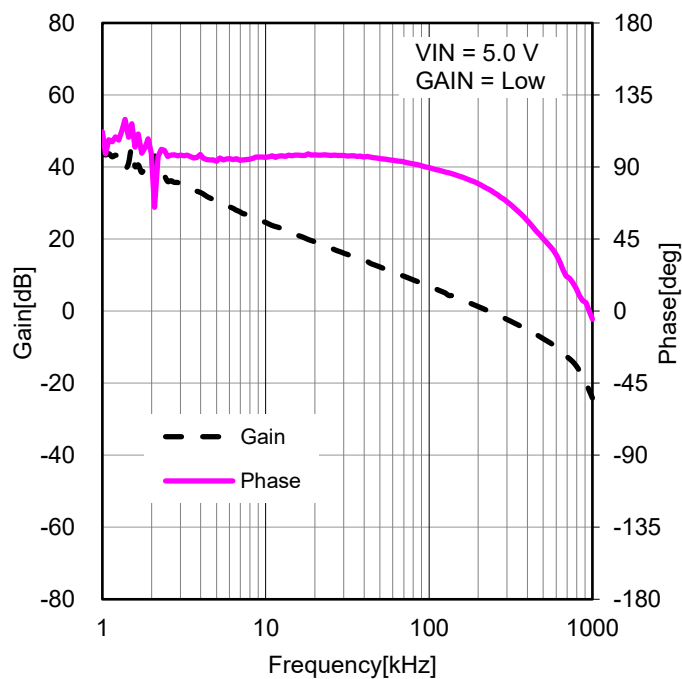
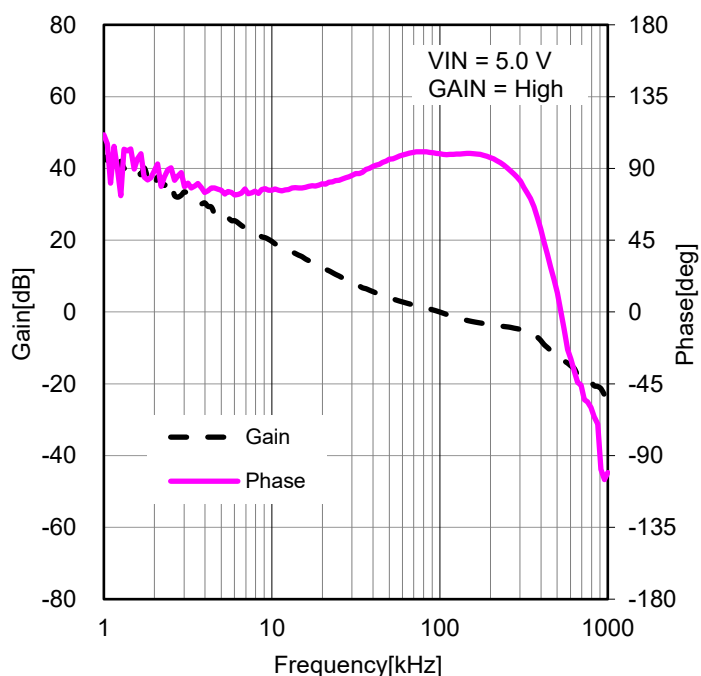
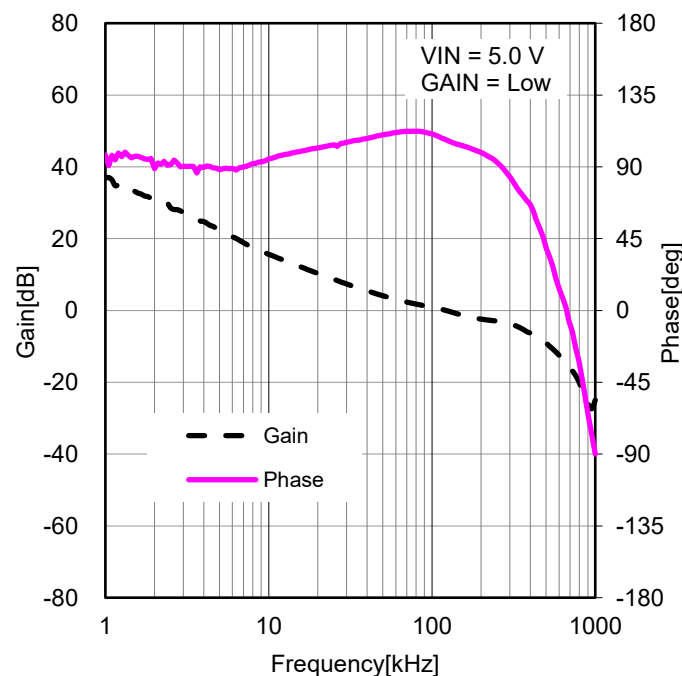
Reference application data (BD9S402MUF-C)

(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)

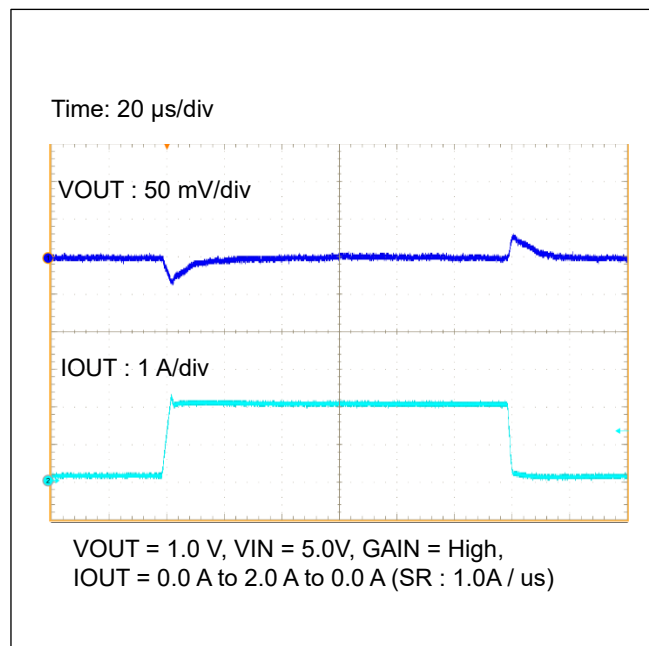
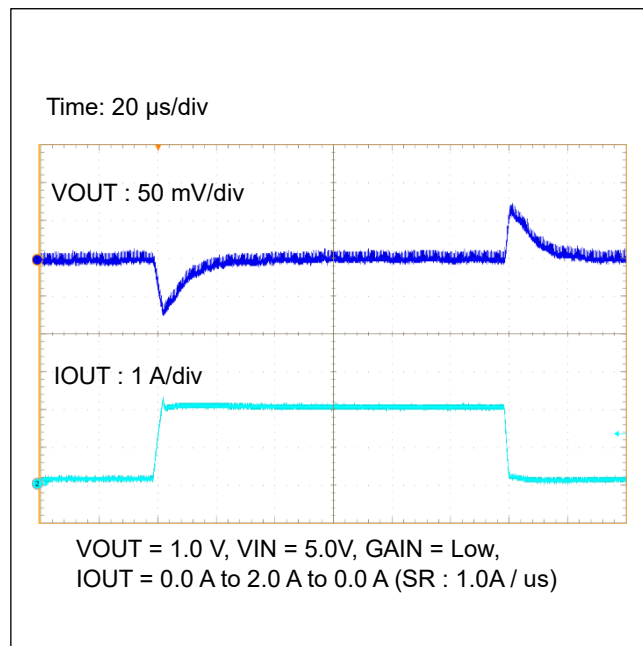
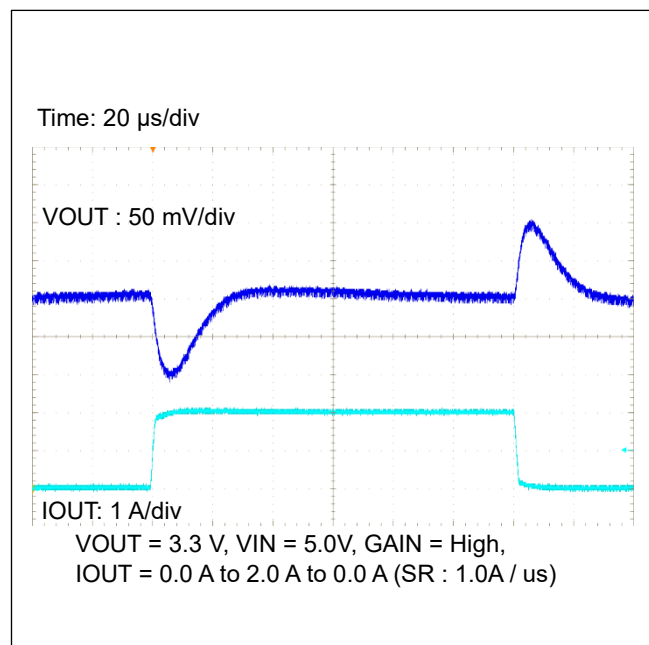
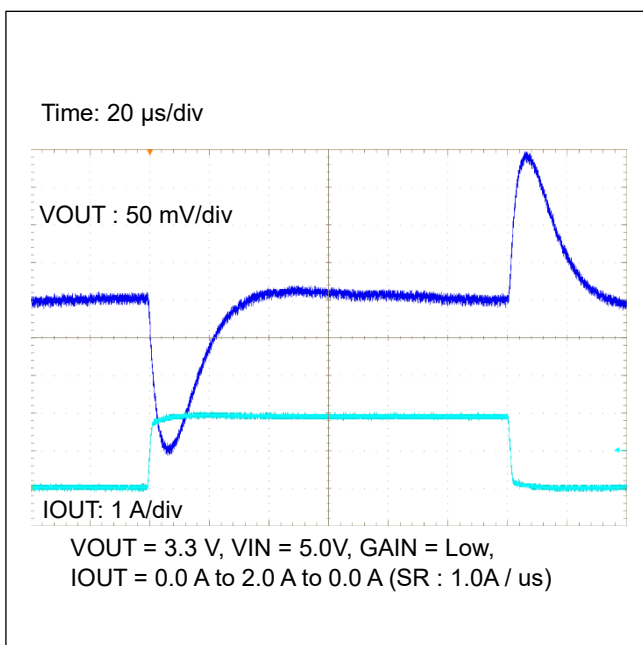
Reference application data (BD9S402MUF-C) - continued

(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	001	Initial release
6. Jan. 2025	002	Add the VOUT setting value of Test Board to sub title

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