Primary Buck DC/DC Converter

Single Buck DC/DC Converter For Automotive BD9P608MFF-C Evaluation Board

BD9P608MFF-TSB-001 (3.5V to 40V Input, 5.0V, 6.0A Output)

Introduction

This user’s guide will provide the necessary steps to operate the Evaluation Board of ROHM’s BD9P608MFF-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 440 kHz or 2.2 MHz buck DC/DC converter BD9P608MFF-C. BD9P608MFF-C is a current mode synchronous buck DC/DC converter with integrated POWER MOSFETs. The BD9P608MFF-C accepts a power supply input range of 3.5V to 40V and generates a maximum output current of 6A. BD9P608MFF-C generates an output voltage range of 0.8V to 8.5V using external resistors.

Application

Automotive Powered Supplies

Consumer Powered Supplies

Recommended Operating Conditions

Table 1. Recommended Operating Conditions

Parameter	Min	Typ	Max	Units	Conditions
Input Voltage	3.5	-	40	V	Initial startup is 4.0 V or more
Output Voltage (Note1)	0.8	-	8.5	V	
Output Current Range	-	-	6.0	A	
Switching Frequency fsw1	-	2.2	-	MHz	FREQ_SEL = 0 V
Switching Frequency fsw2	-	440	-	kHz	FREQ_SEL = 5 V
Maximum Efficiency	-	96.6	-	%	VIN = 12V, VO = 5.0V, fsw = 440kHz, Io = 1.74 A, Ta = 25 °C
Maximum Efficiency	-	93.9	-	%	VIN = 12V, VO = 5.0V, fsw = 2.2MHz, Io = 2.21 A, Ta = 25 °C

(Note1) Although the minimum output voltage is configurable up to 0.8 V, it may be limited by the SW min ON pulse width. For the same reason, although the maximum output voltage is configurable up to 8.5 V, it may be limited by the SW minimum OFF pulse width.

65UG070E Rev.002
Dec.2024

Evaluation Board

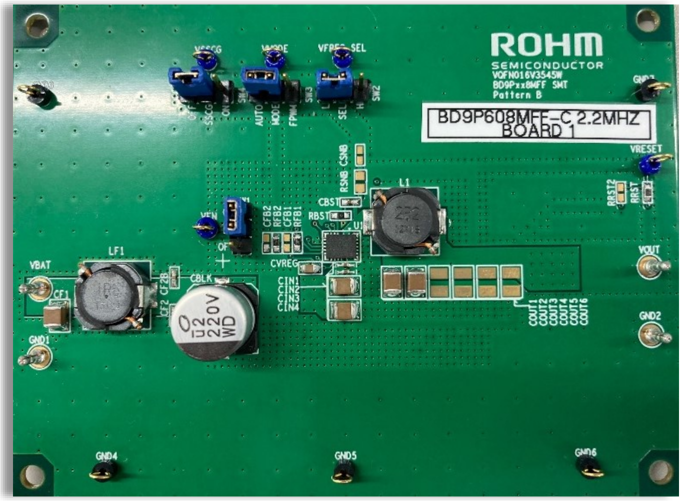

Figure 1. 2.2 MHz setting (FREQ_SEL = Low) (Top View)

Evaluation Board Schematic

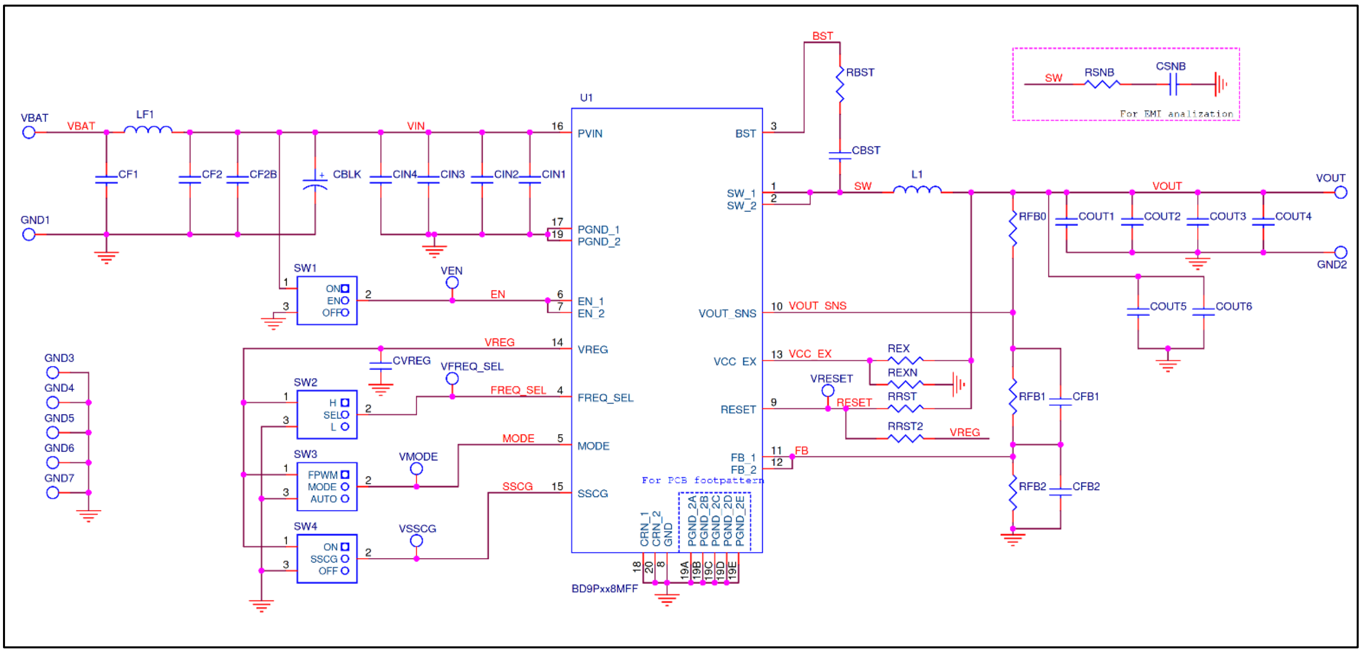

Figure 2. BD9P608MFF-C Circuit Diagram

Operating Procedure

1. Turn off EN and connect the GND terminal of the power supply to the GND terminal of Evaluation Board.
2. Connect VCC pin of power supply to the VBAT pin 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 VBAT. 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 VBAT only.

Operation Mode Settings

Below is a table of BD9P608MFF-C operation modes selectable using FREQ_SEL, MODE and SSCG terminals.

Table 2. Mode Settings

Terminal	Setting	Operation Mode	Function
FREQ_SEL (Note1)	HIGH	Switching frequency selection	Switching frequency is set to 440 kHz (Typ.)
	LOW		Switching frequency is set to 2.2 MHz (Typ.)
MODE	HIGH	FPWM	Forced PWM mode
	LOW or OPEN	AUTO	Automatically switched between PWM and LLM mode.
	Apply a clock to this pin	SYNC	Activate synchronization mode
SSCG	ON (HIGH)	Select Spread Spectrum function	Enable Spread Spectrum
	OFF (LOW)		Disable Spread Spectrum

(Note1) Do not change the setting of the FREQ_SEL terminal during IC operation.

(Note2) If setting is High, the terminal is shorted to VREG, and if setting is Low, the terminal is shorted to GND.

Pin Configuration

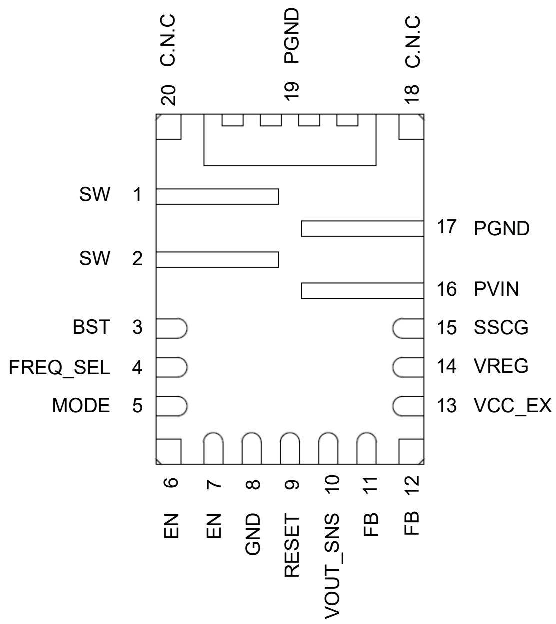

Figure 3. Pin Configuration (Top View)

Parts List (BD9P608MFF-C)

Table 3. Parts list (5.0 V, 6.0 A, 2.2 MHz (FREQ_SEL = Low))

	Part No.	Value	PKG(inch)	PKG(mm)	Manufacturer	Part Name(Series)
π type filter	CF1	4.7µF	1210	3225	Murata	GCM32ER71H475K
	LF1	1.5µH	-	W7.0 x H5.4 x L7.5	TDK	SPM7045VC-1R5M-D
	CF2	0.1µF	0402	1005	Murata	GCM155R71H104K
	CF2B	0.1µF	0402	1005	Murata	GCM155R71H104K
	CBLK	220µF	0404h04	1010h10	Nichicon	UWD1V221MCL1GS
Basic	CIN4	4.7µF	1210	3225	Murata	GCM32ER71H475K
	CIN3	4.7µF	1210	3225	Murata	GCM32ER71H475K
	CIN2	0.1µF	0402	1005	Murata	GCM155R71H104K
	CIN1	0.022µF	0402	1005	Murata	GCM155R71H223K
	CVREG	1µF	0805	2012	Murata	GCM21BR71C105K
	CBST	0.1µF	0402	1005	Murata	GCM155R71H104K
	RBST	0Ω	0402	1005	ROHM	MCR01 Series
	RRST	10kΩ	0402	1005	ROHM	MCR01 Series
	RRST2(Note3)	Open	-	-	-	-
Application	L1(Note1)	2.2µH	-	W7.0 x H5.4 x L7.5	TDK	SPM7045VC-2R2M-D
	COUT1(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT2(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT3(Note1)	Open	-	-	-	-
	COUT4(Note1)	Open	-	-	-	-
	COUT5(Note1)	Open	-	-	-	-
	COUT6(Note1)	Open	-	-	-	-
	RFB0	0Ω	0402	1005	ROHM	MCR01 Series
	RFB1	68kΩ	0402	1005	ROHM	MCR01 Series
	RFB2	13kΩ	0402	1005	ROHM	MCR01 Series
	CFB1	Open	-	-	-	-
	CFB2	Open	-	-	-	-
	RSNB	Open	-	-	-	-
	CSNB	Open	-	-	-	-
	REX(Note2)	0Ω	0402	1005	ROHM	MCR01 Series
	REXN(Note2)	Open	-	-	-	-

Table 4. Parts list (5.0 V, 6.0 A, 440 kHz (FREQ_SEL = High))

	Part No	Value	PKG(inch)	PKG(mm)	Manufacturer	Part Name(Series)
π type filter	CF1	4.7µF	1210	3225	Murata	GCM32ER71H475K
	LF1	1.5µH	-	W7.0 x H5.4 x L7.5	TDK	SPM7054VC-1R5M-D
	CF2	0.1µF	0402	1005	Murata	GCM155R71H104K
	CF2B	0.1µF	0402	1005	Murata	GCM155R71H104K
	CBLK	220µF	0404h04	1010h10	Nichicon	UWD1V221MCL1GS
Basic	CIN4	4.7µF	1210	3225	Murata	GCM32ER71H475K
	CIN3	4.7µF	1210	3225	Murata	GCM32ER71H475K
	CIN2	0.1µF	0402	1005	Murata	GCM155R71H104K
	CIN1	0.022µF	0402	1005	Murata	GCM155R71H223K
	CVREG	1µF	0805	2012	Murata	GCM21BR71C105K
	CBST	0.1µF	0402	1005	Murata	GCM155R71H104K
	RBST	0Ω	0402	1005	ROHM	MCR01 Series
	RRST	10kΩ	0402	1005	ROHM	MCR01 Series
	RRST2(Note3)	Open	-	-	-	-
Application	L1(Note1)	6.8µH	-	W10.5x H6.5 x L10.5	TDK	SPM10065VC-6R8M-D
	COUT1(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT2(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT3(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT4(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT5(Note1)	Open	-	-	-	-
	COUT6(Note1)	Open	-	-	-	-
	RFB0	0Ω	0402	1005	ROHM	MCR01 Series
	RFB1	68kΩ	0402	1005	ROHM	MCR01 Series
	RFB2	13kΩ	0402	1005	ROHM	MCR01 Series
	CFB1	Open	-	-	-	-
	CFB2	Open	-	-	-	-
	RSNB	Open	-	-	-	-
	CSNB	Open	-	-	-	-
	REX(Note2)	0Ω	0402	1005	ROHM	MCR01 Series
	REXN(Note2)	Open	-	-	-	-

Table 5. Parts list (3.3 V, 6.0 A, 2.2 MHz (FREQ_SEL = Low))

	Part No	Value	PKG(inch)	PKG(mm)	Manufacturer	Part Name(Series)
π type filter	CF1	4.7µF	1210	3225	Murata	GCM32ER71H475K
	LF1	1.5µH	-	W7.0 x H5.4 x L7.5	TDK	SPM7054VC-1R5M-D
	CF2	0.1µF	0402	1005	Murata	GCM155R71H104K
	CF2B	0.1µF	0402	1005	Murata	GCM155R71H104K
	CBLK	220µF	0404h04	1010h10	Nichicon	UWD1V221MCL1GS
Basic	CIN4	4.7µF	1210	3225	Murata	GCM32ER71H475K
	CIN3	4.7µF	1210	3225	Murata	GCM32ER71H475K
	CIN2	0.1µF	0402	1005	Murata	GCM155R71H104K
	CIN1	0.022µF	0402	1005	Murata	GCM155R71H223K
	CVREG	1µF	0805	2012	Murata	GCM21BR71C105K
	CBST	0.1µF	0402	1005	Murata	GCM155R71H104K
	RBST	0Ω	0402	1005	ROHM	MCR01 Series
	RRST	10kΩ	0402	1005	ROHM	MCR01 Series
	RRST2(Note3)	Open	-	-	-	-
Application	L1(Note1)	2.2µH	-	W7.0 x H5.4 x L7.5	TDK	SPM7054VC-2R2M-D
	COUT1(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT2(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT3(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT4(Note1)	Open	-	-	-	-
	COUT5(Note1)	Open	-	-	-	-
	COUT6(Note1)	Open	-	-	-	-
	RFB0	0Ω	0402	1005	ROHM	MCR01 Series
	RFB1	75kΩ	0402	1005	ROHM	MCR01 Series
	RFB2	24kΩ	0402	1005	ROHM	MCR01 Series
	CFB1	Open	-	-	-	-
	CFB2	Open	-	-	-	-
	RSNB	Open	-	-	-	-
	CSNB	Open	-	-	-	-
	REX(Note2)	Open	-	-	-	-
	REXN(Note2)	0Ω	0402	1005	ROHM	MCR01 Series

Table 6. Parts list (3.3 V, 6.0 A, 440 kHz (FREQ_SEL = High))

	Part No	Value	PKG(inch)	PKG(mm)	Manufacturer	Part Name(Series)
π type filter	CF1	4.7µF	1210	3225	Murata	GCM32ER71H475K
	LF1	1.5µH	-	W7.0 x H5.4 x L7.5	TDK	SPM7054VC-1R5M-D
	CF2	0.1µF	0402	1005	Murata	GCM155R71H104K
	CF2B	0.1µF	0402	1005	Murata	GCM155R71H104K
	CBLK	220µF	0404h04	1010h10	Nichicon	UWD1V221MCL1GS
Basic	CIN4	4.7µF	1210	3225	Murata	GCM32ER71H475K
	CIN3	4.7µF	1210	3225	Murata	GCM32ER71H475K
	CIN2	0.1µF	0402	1005	Murata	GCM155R71H104K
	CIN1	0.022µF	0402	1005	Murata	GCM155R71H223K
	CVREG	1µF	0805	2012	Murata	GCM21BR71C105K
	CBST	0.1µF	0402	1005	Murata	GCM155R71H104K
	RBST	0Ω	0402	1005	ROHM	MCR01 Series
	RRST	10kΩ	0402	1005	ROHM	MCR01 Series
	RRST2(Note3)	Open	-	-	-	-
Application	L1(Note1)	6.8µH	-	W10.5x H6.5 x L10.5	TDK	SPM10065VC-6R8M-D
	COUT1(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT2(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT3(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT4(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT5(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	COUT6(Note1)	22µF	1210	3225	Murata	GCM32ER71A226K
	RFB0	0Ω	0402	1005	ROHM	MCR01 Series
	RFB1	75kΩ	0402	1005	ROHM	MCR01 Series
	RFB2	24kΩ	0402	1005	ROHM	MCR01 Series
	CFB1	Open	-	-	-	-
	CFB2	Open	-	-	-	-
	RSNB	Open	-	-	-	-
	CSNB	Open	-	-	-	-
	REX(Note2)	Open	-	-	-	-
	REXN(Note2)	0Ω	0402	1005	ROHM	MCR01 Series

(Note 1)

VOUT	FREQ_SEL	SW Frequency	Recommended L Value	Recommended COUT Value	Minimum COUT Value (Note1-1,2)
≥ 5 V	L	2.2 MHz	2.2 µH	$C_{OUT} \geq 44$ µF	$C_{OUT\_WORST} \geq 30$ µF
< 5 V	L	2.2 MHz	2.2 µH	$C_{OUT} \geq \frac{220}{VOUT}$ [µF] (*)	$C_{OUT\_WORST} \geq \frac{150}{VOUT}$ [µF] (*)
≥ 5 V	H	440 kHz	6.8 µH	$C_{OUT} \geq 88$ µF	$C_{OUT\_WORST} \geq 60$ µF
< 5 V	H	440 kHz	6.8 µH	$C_{OUT} \geq \frac{440}{VOUT}$ [µF] (*)	$C_{OUT\_WORST} \geq \frac{300}{VOUT}$ [µF] (*)

* VOUT is the output voltage [V]

(Note 1-1) When selecting the output capacitor, ensure that the capacitance, C_{OUT_WORST}, of the above equation is maintained at the characteristics of DC Bias, AC Voltage, temperature, and tolerance.

(Note 1-2) If the capacitance falls below this value, oscillation may happen. When using electrolytic capacitor and conductive polymer hybrid aluminum electrolytic capacitor, please place it in addition to the ceramic capacitors with the capacity described above. The changes in the frequency characteristic are greatly affected by the type and the condition (temperature, etc.) of parts that are used, the wire routing and the layout of the PCB. Please confirm stability and responsiveness in actual application.

(Note 2) VCC_EX is power supply input for internal circuit. VREG voltage is supplied from VCC_EX when voltage between 4.6 V (V_{TEXH}, Max) and 5.65 V (V_{EXOVPL}, Min) is connected to this pin. Connecting this pin to VOUT improves efficiency. In case of not use this function, connect this pin to GND.

Output Voltage	REX setting	REXN setting	VCC_EX State
4.6 V ≤ VOUT ≤ 5.65 V	0 Ω	Open	Connected to VOUT
VOUT < 4.6 V or VOUT > 5.65 V	Open	0 Ω	Connected to GND

(Note 3) RESET terminal should be pulled-up to VREG via RRST2 when the output setting is over 6.5 V because RESET pin's absolute maximum rating is 7.0 V. If RESET is not pulled-up to VOUT, it can be pulled-up to VREG via RRST2 by default.

(Note 4) If the recommended parts on tables 3 to 7 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	FR-4 High Tg	100mm x 75mm x 1.6mm	2oz(70μm) / 1oz (35μm) / 1oz (35μm) / 2oz(70μm)

The layout of BD9P608MFF-C is shown below.

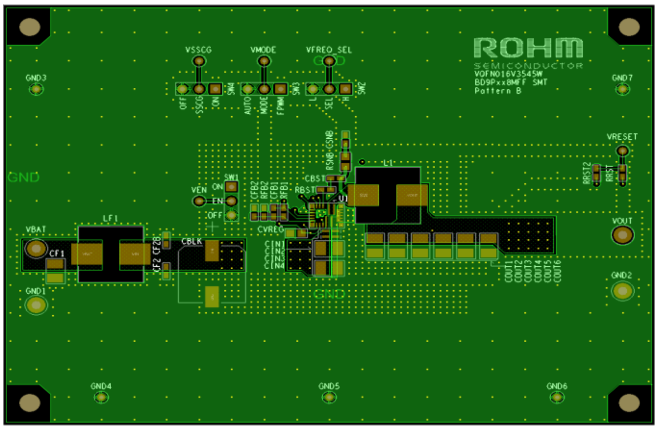

Figure 4. Top Layer Layout

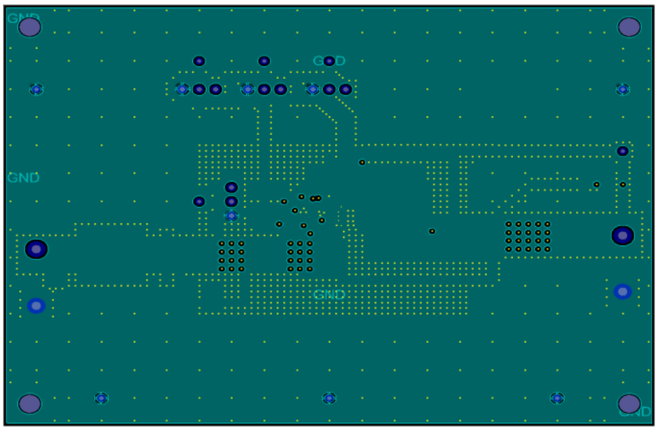

Figure 5. Middle1 Layer Layout

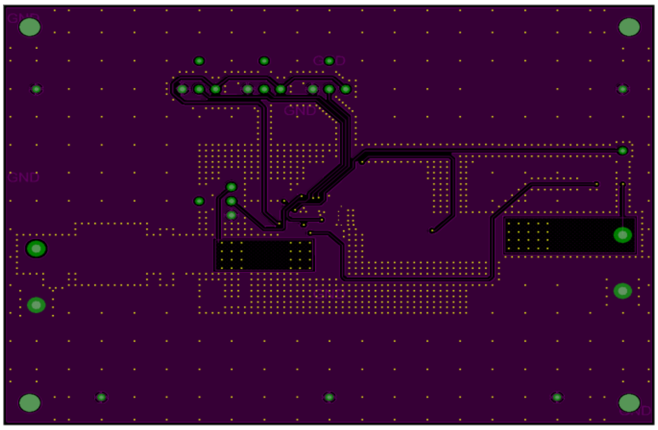

Figure 6. Middle2 Layer Layout

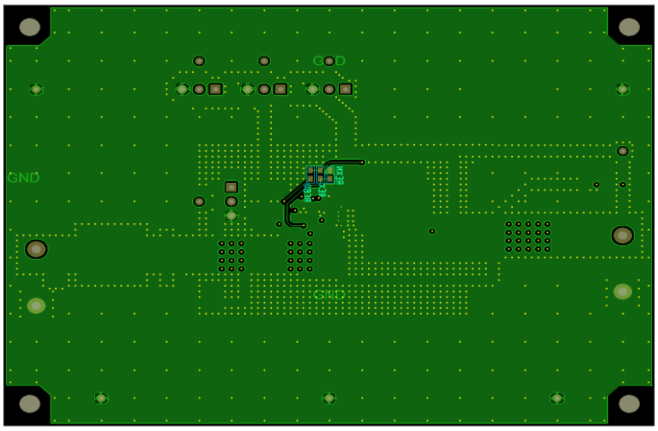

Figure 7. Bottom Layer Layout

Reference application data

(Ta=25°C, VIN=12V, VOUT=5V, FREQ=2.2MHz)

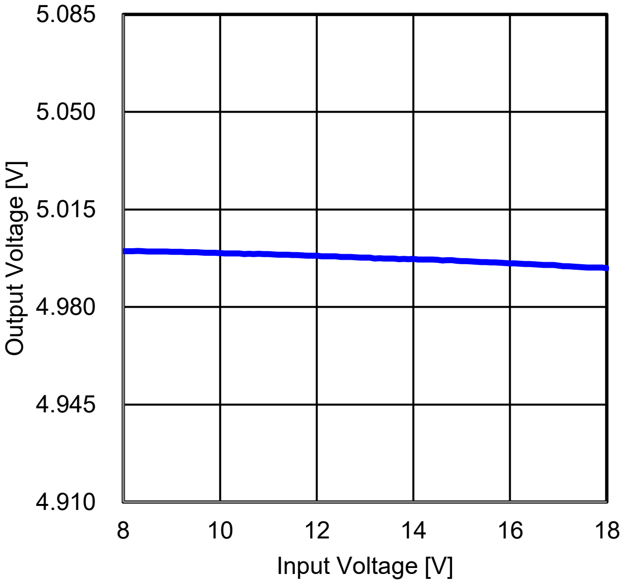

Figure 8. Line Regulation (IOUT = 3 A)

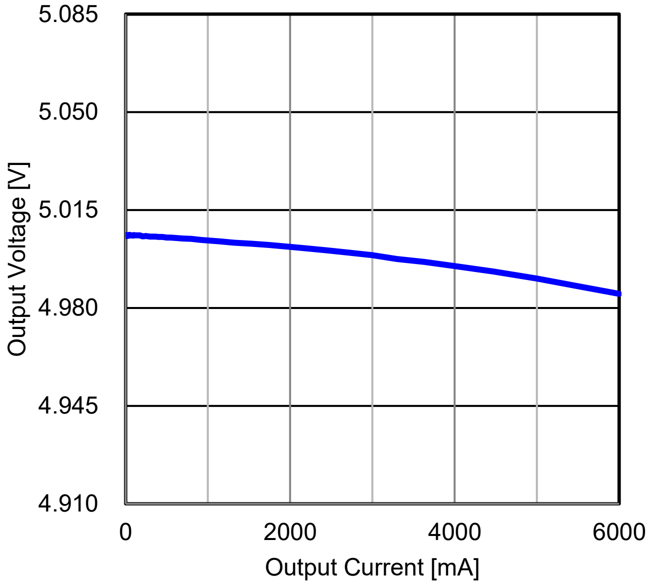

Figure 9. Load Regulation

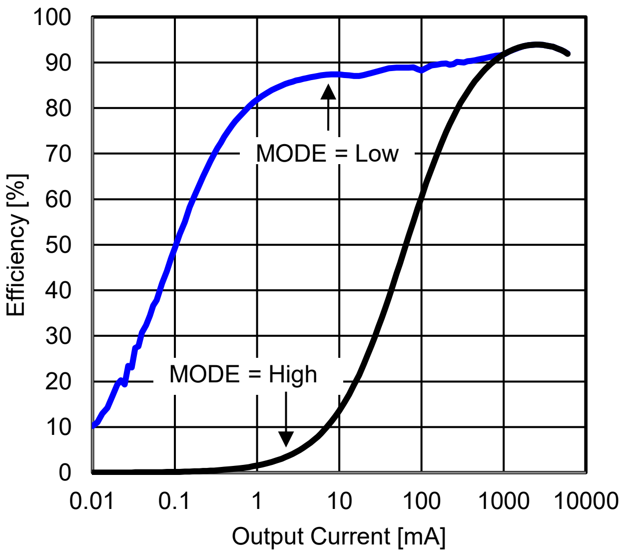

Figure 10. Efficiency vs Output Current

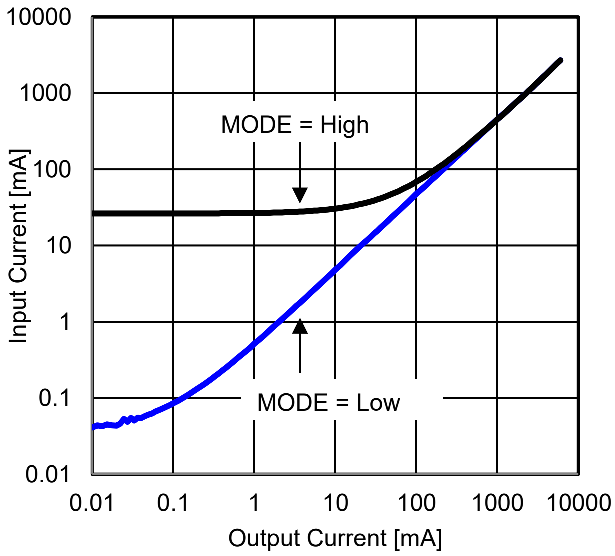

Figure 11. Input Current vs Output Current

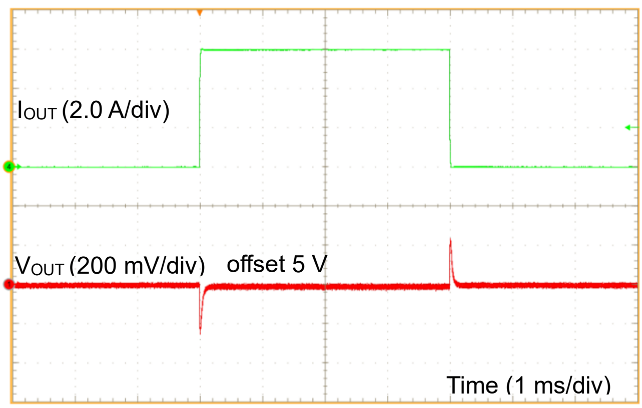

Figure 12. Load Response 1

(VIN = 12 V, VMODE = 5 V, IOUT = 0 A to 6 A)

Reference application data - continued

(Ta=25°C, VIN=12V, VOUT=5.0V, FREQ=440kHz)

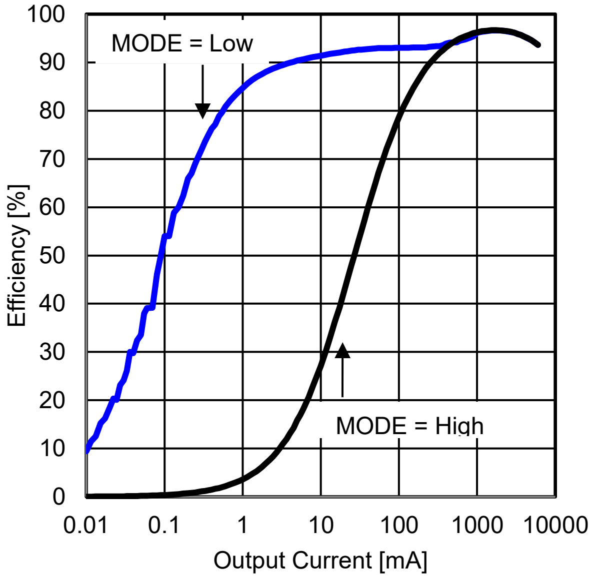

Figure 13. Efficiency vs Output Current

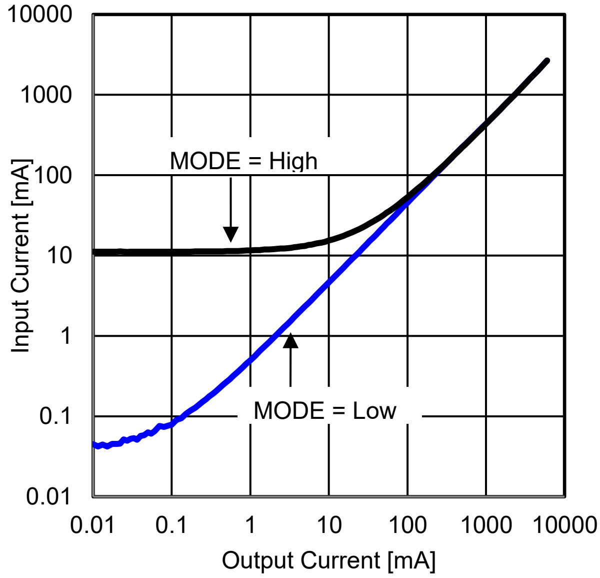

Figure 14. Input Current vs Output Current

(Ta=25°C, VIN=12V, VOUT=3.3V, FREQ=2.2MHz)

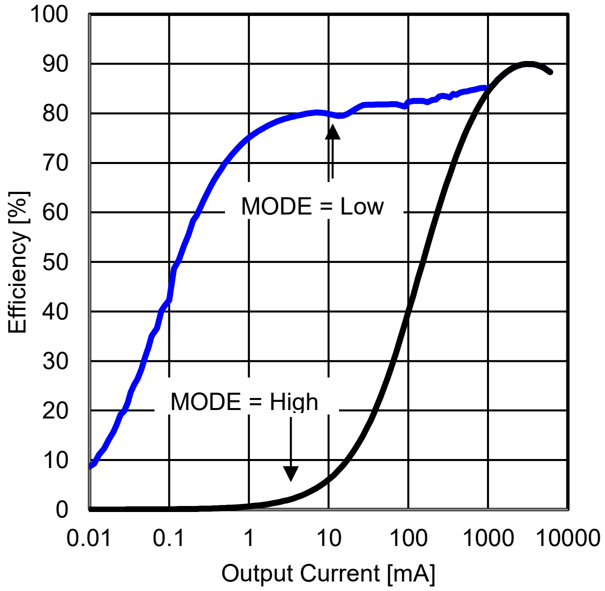

Figure 15. Efficiency vs Output Current

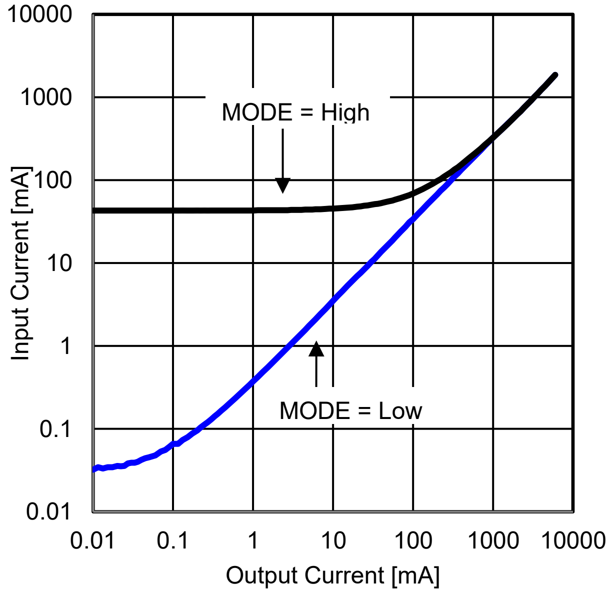

Figure 16. Input Current vs Output Current

Reference application data - continued

(Ta=25°C, VIN=12V, VOUT=3.3V, FREQ=440kHz)

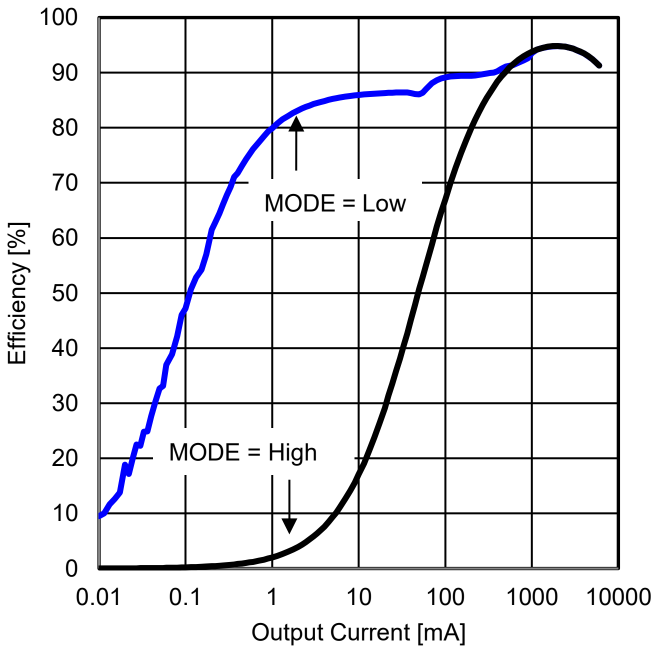

Figure 17. Efficiency vs Output Current

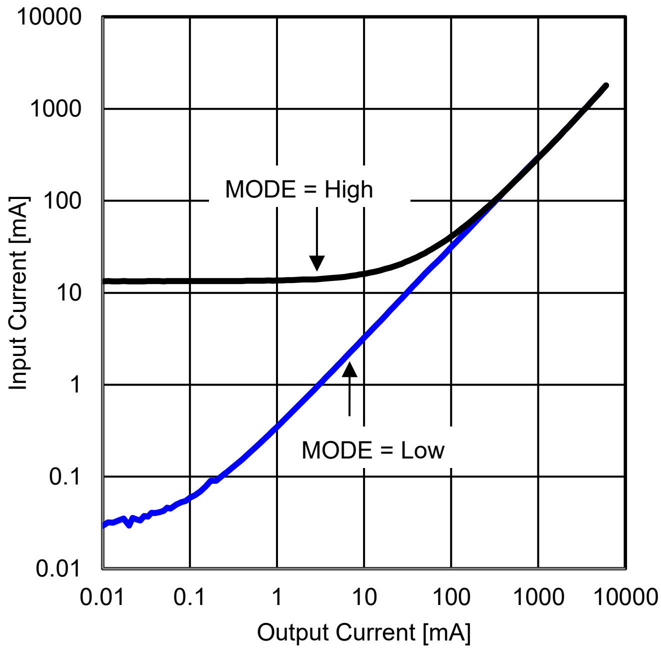

Figure 18. Input Current vs Output Current

Other series application data please refer to datasheet

Revision History

Date	Revision Number	Description
17.Nov. 2022	001	New release
27.Dec.2024	002	Add the VOUT setting value of Test Board to subtitle Some Part Name in Parts List

Notice

1) The information contained in this document is intended to introduce ROHM Group (hereafter referred to asROHM) products. When using ROHM products, please verify the latest specifications or datasheets before use.

2) ROHM products are designed and manufactured for use in general electronic equipment and applications (such as Audio Visual equipment, Office Automation equipment, telecommunication equipment, home appliances, amusement devices, etc.) or specified in the datasheets. Therefore, please contact the ROHM sales representative before using ROHM products in equipment or devices requiring extremely high reliability and whose failure or malfunction may cause danger or injury to human life or body or other serious damage (such as medical equipment, transportation, traffic, aircraft, spacecraft, nuclear power controllers, fuel control, automotive equipment including car accessories, etc. hereafter referred to as Specific Applications). Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses, or losses incurred by you or third parties arising from the use of ROHM Products for Specific Applications.

3) Electronic components, including semiconductors, can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against physical injury, and damage to any property, which a failure or malfunction of products may cause.

4) The information contained in this document, including application circuit examples and their constants, is intended to explain the standard operation and usage of ROHM products, and is not intended to guarantee, either explicitly or implicitly, the operation of the product in the actual equipment it will be used. As a result, you are solely responsible for it, and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses, or losses incurred by you or third parties arising from the use of such information.

5) When exporting ROHM products or technologies described in this document to other countries, you must abide by the procedures and provisions stipulated in all applicable export laws and regulations, such as the Foreign Exchange and Foreign Trade Act and the US Export Administration Regulations, and follow the necessary procedures in accordance with these provisions.

6) The technical information and data described in this document, including typical application circuits, are examples only and are not intended to guarantee to be free from infringement of third parties intellectual property or other rights. ROHM does not grant any license, express or implied, to implement, use, or exploit any intellectual property or other rights owned or controlled by ROHM or any third parties with respect to the information contained herein.

7) No part of this document may be reprinted or reproduced in any form by any means without the prior written consent of ROHM.

8) All information contained in this document is current as of the date of publication and subject to change without notice. Before purchasing or using ROHM products, please confirm the latest information with the ROHM sales representative.

9) ROHM does not warrant that the information contained herein is error-free. ROHM shall not be in any way responsible or liable for any damages, expenses, or losses incurred by you or third parties resulting from errors contained in this document.

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/contactus