

Primary Buck DC/DC Converter

Single Buck DC/DC Converter

For Automotive

BD9P608MFF-C Evaluation Board

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

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.

Evaluation Board

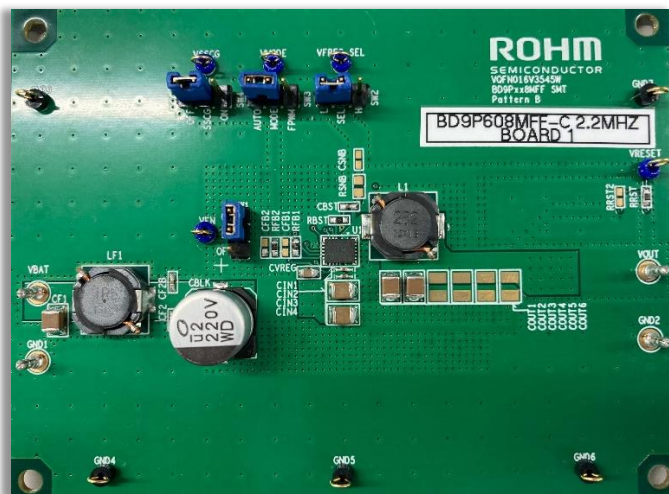


Figure 1. 2.2 MHz setting (FREQ_SEL = Low) (Top View)

Evaluation Board Schematic

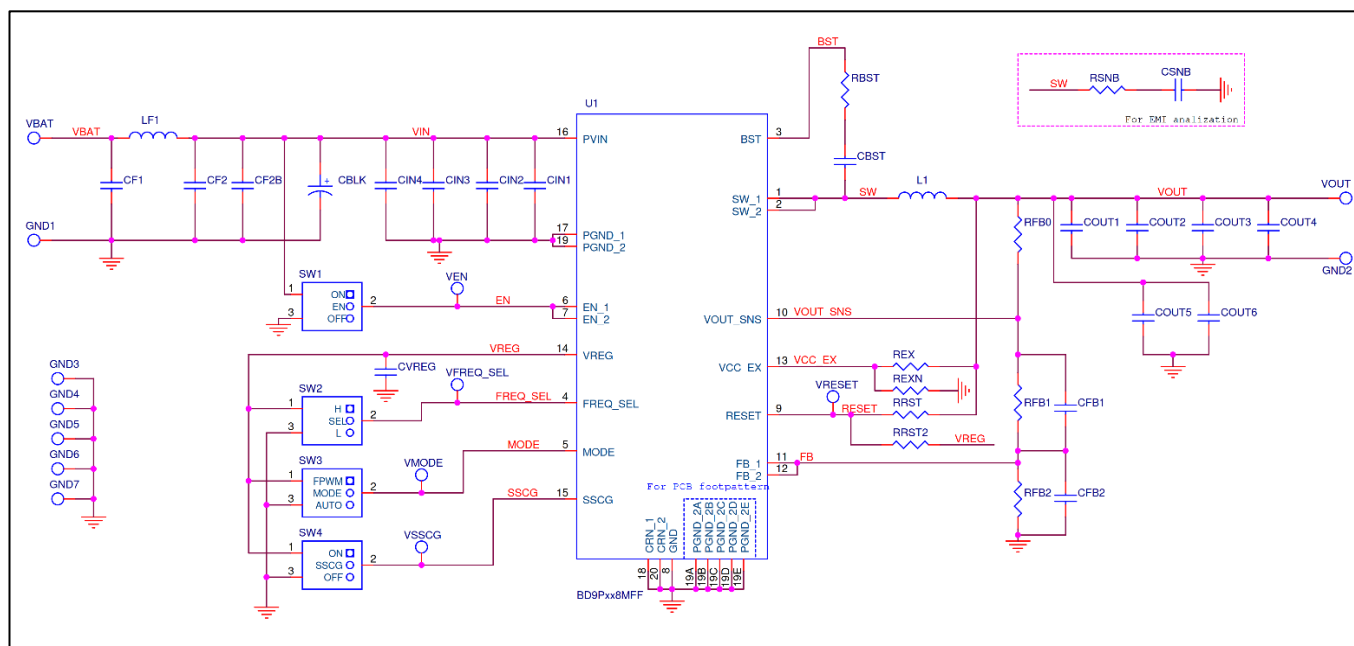


Figure 2. BD9P608MFF-C Circuit Diagram

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

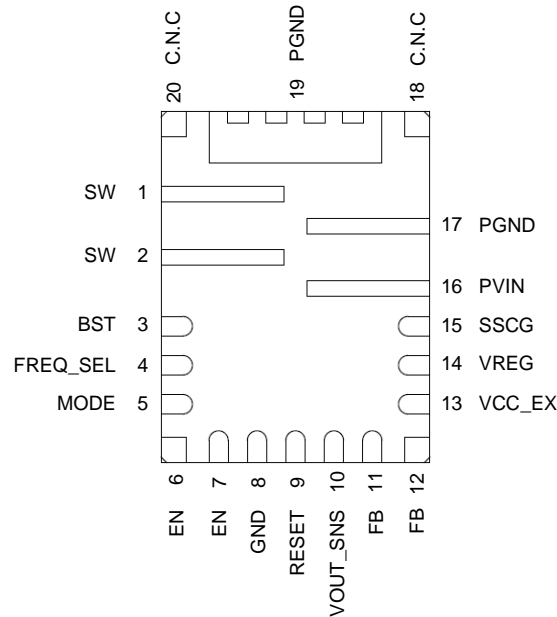


Figure 3. Pin Configuration (Top View)

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	-	W9.7 x H3.8 x L10.0	TDK	CLF10040T-1R5N-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	L ₁ ^(Note1)	2.2μH	-	W9.7 x H3.8 x L10.0	TDK	CLF10040T-2R2N-D
	COUT ₁ ^(Note1)	22μF	1210	3225	Murata	GCM32ER71A226K
	COUT ₂ ^(Note1)	22μF	1210	3225	Murata	GCM32ER71A226K
	COUT ₃ ^(Note1)	Open	-	-	-	-
	COUT ₄ ^(Note1)	Open	-	-	-	-
	COUT ₅ ^(Note1)	Open	-	-	-	-
	COUT ₆ ^(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	-	W9.7 x H3.8 x L10.0	TDK	CLF10040T-1R5N-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	-	W12.1 x H5.5 x L12.5	TDK	CLF12555T-6R8N-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	-	W9.7 x H3.8 x L10.0	TDK	CLF10040T-1R5N-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	-	W9.7 x H3.8 x L10.0	TDK	CLF10040T-2R2N-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	-	W9.7 x H3.8 x L10.0	TDK	CLF10040T-1R5N-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	-	W12.1 x H5.5 x L12.5	TDK	CLF12555T-6R8N-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	COUT ≥ 44 μF	COUT_WORST ≥ 30 μF
< 5 V	L	2.2 MHz	2.2 μH	$COUT \geq \frac{220}{VOUT} [\mu F] (*)$	$COUT_WORST \geq \frac{150}{VOUT} [\mu F] (*)$
≥ 5 V	H	440 kHz	6.8 μH	COUT ≥ 88 μF	COUT_WORST ≥ 60 μF
< 5 V	H	440 kHz	6.8 μH	$COUT \geq \frac{440}{VOUT} [\mu F] (*)$	$COUT_WORST \geq \frac{300}{VOUT} [\mu F] (*)$

* VOUT is the output voltage [V]

(Note 1-1) When selecting the output capacitor, ensure that the capacitance, COUT_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
$4.6\text{ V} \leq V_{OUT} \leq 5.65\text{ V}$	0 Ω	Open	Connected to VOUT
$V_{OUT} < 4.6\text{ V}$ or $V_{OUT} > 5.65\text{ V}$	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.

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.

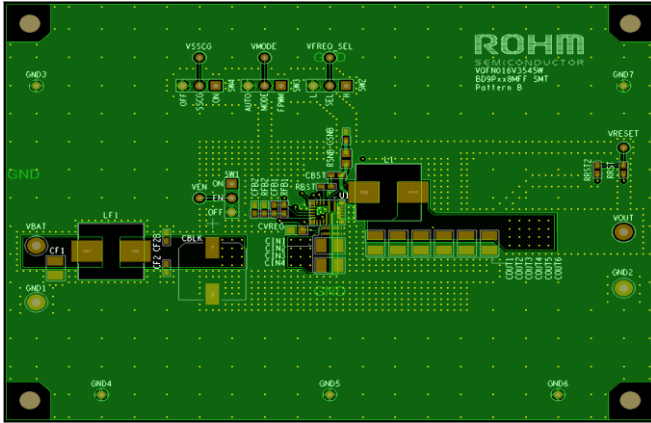


Figure 4. Top Layer Layout

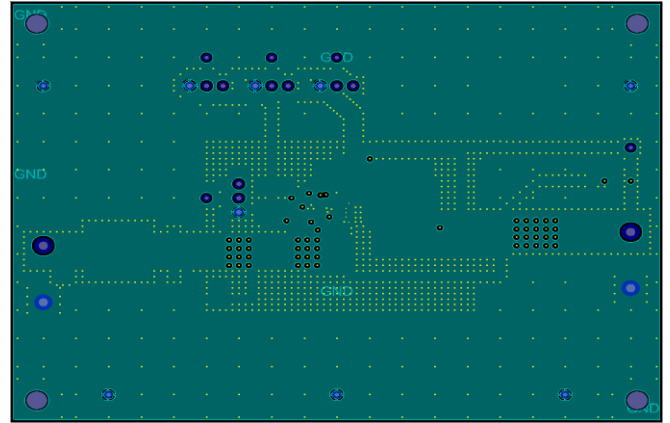


Figure 5. Middle1 Layer Layout

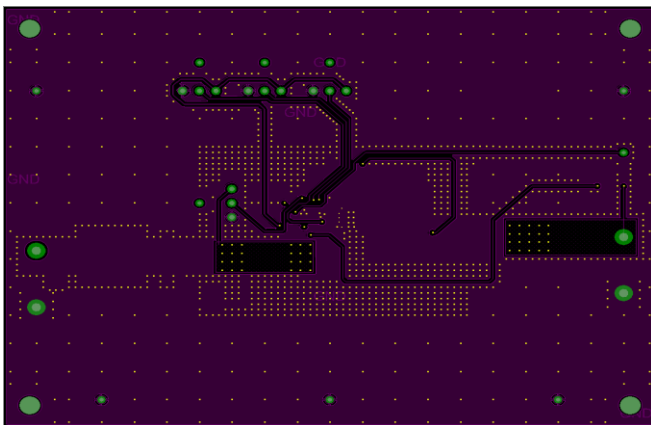


Figure 6. Middle2 Layer Layout

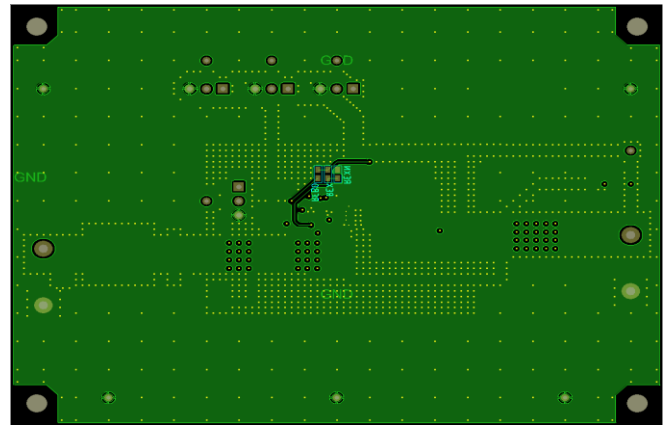


Figure 7. Bottom Layer Layout

Reference application data

($T_a=25^\circ\text{C}$, $V_{IN}=12\text{V}$, $V_{OUT}=5\text{V}$, $FREQ=2.2\text{MHz}$)

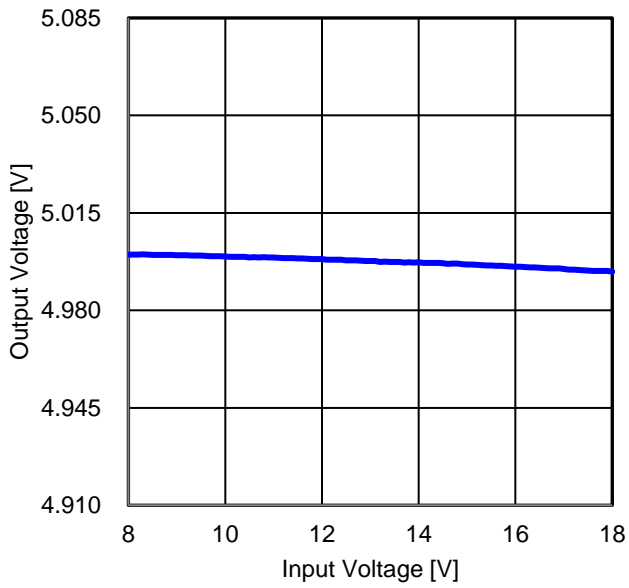


Figure 8. Line Regulation (I_{OUT} = 3 A)

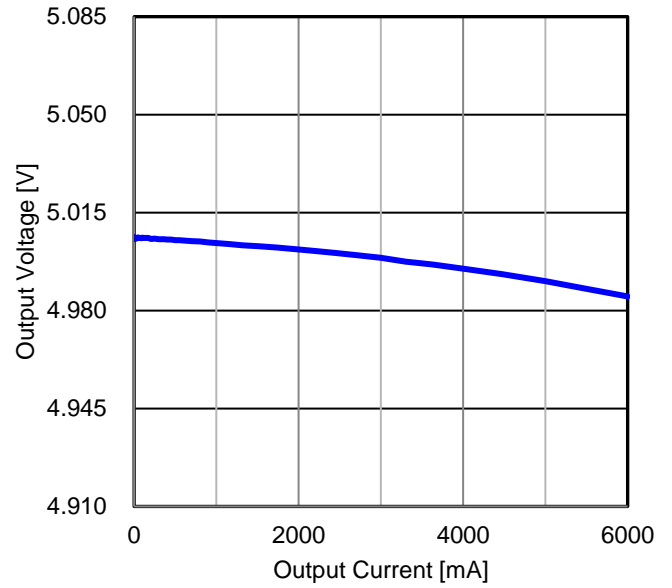


Figure 9. Load Regulation

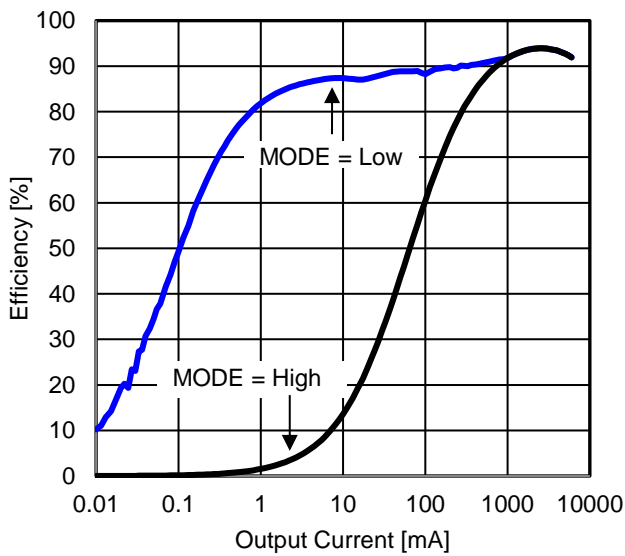


Figure 10. Efficiency vs Output Current

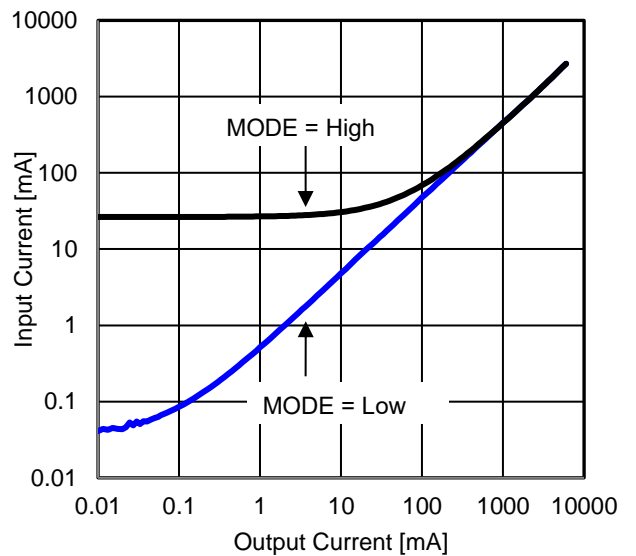


Figure 11. Input Current vs Output Current

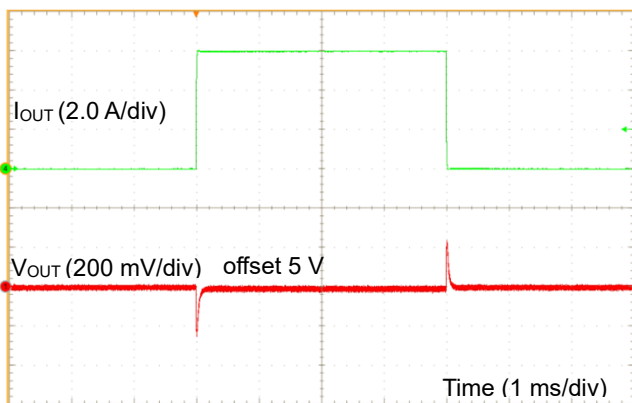


Figure 12. Load Response 1
($V_{IN} = 12\text{V}$, $V_{MODE} = 5\text{V}$, $I_{OUT} = 0\text{A to } 6\text{A}$)

Reference application data - continued

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

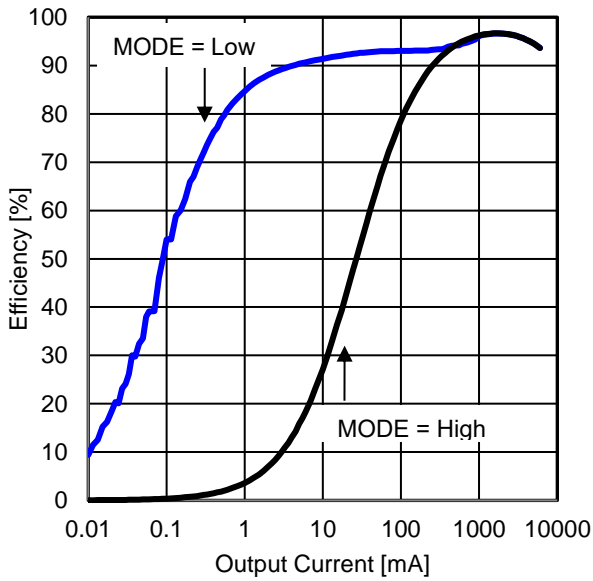


Figure 13. Efficiency vs Output Current

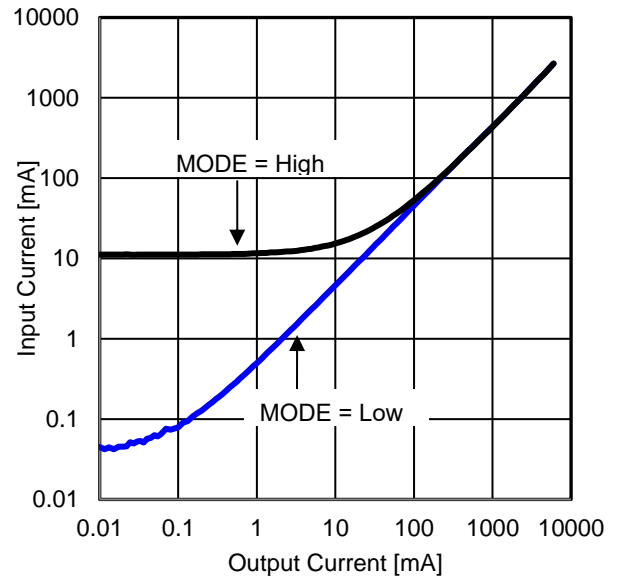


Figure 14. Input Current vs Output Current

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

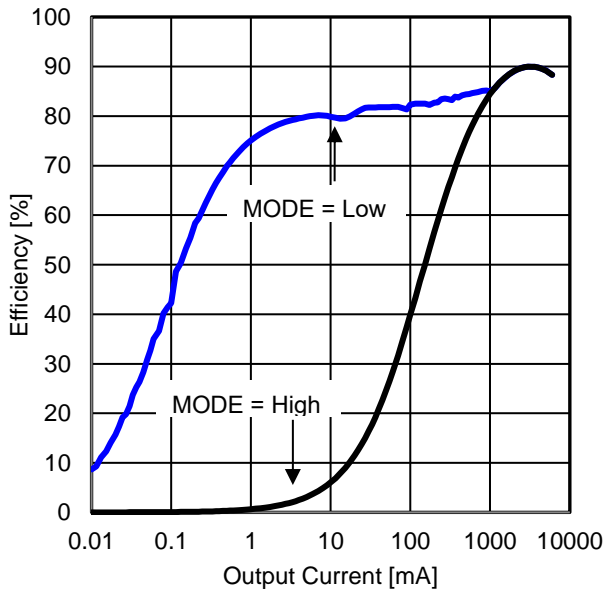


Figure 15. Efficiency vs Output Current

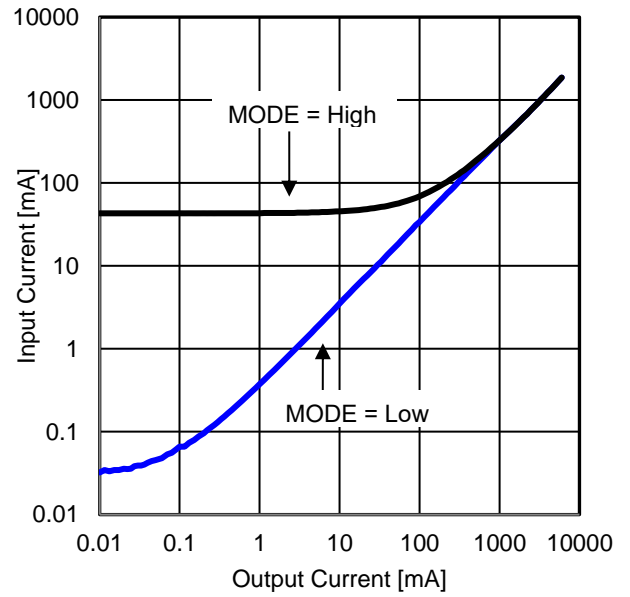


Figure 16. Input Current vs Output Current

Reference application data - continued

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

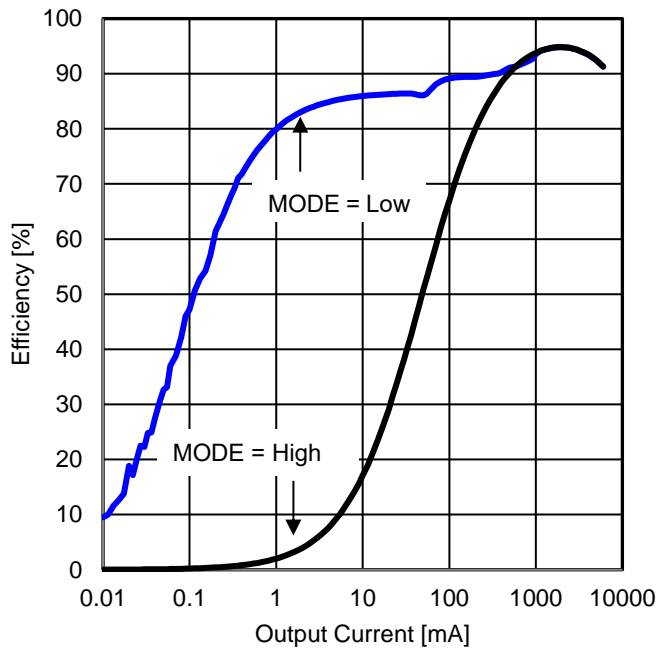


Figure 17. Efficiency vs Output Current

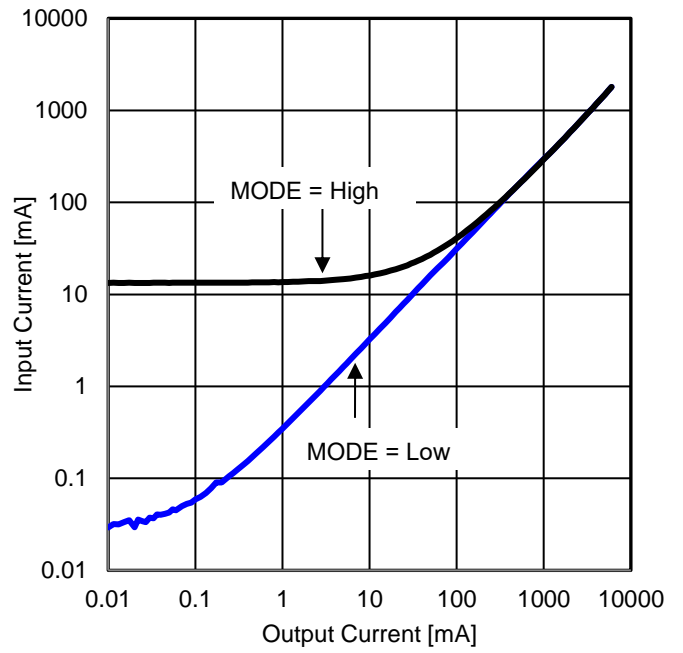


Figure 18. Input Current vs Output Current

Other series application data please refer to datasheet

Revision History

Date	Revision Number	Description
17. Nov. 2022	001	New release

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 Products 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.
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- 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.
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