DC/DC Converter

Application Information

IC Product Name	BD9F800MUX-Z
Topology	Buck (Step-Down) Switching Regulator
Type	Non-Isolation

No	VIN[V]	Output	Frequency[kHz]	Conditions
1	4.5 to 28	1V, 8A	300	
2	4.5 to 28	1.2V, 8A	300	
3	4.5 to 28	1.8V, 8A	300	
4	4.5 to 28	1.8V, 8A	600	
5	6 to 28	3.3V, 8A	300	
6	6 to 28	3.3V, 8A	600	
7	8 to 28	5V, 8A	300	
8	8 to 28	5V, 8A	600	
9	14 to 28	12V, 8A	300	L=5.6μH (Recommended)
10	16 to 28	12V, 8A	600	
11	14 to 28	12V, 8A	300	L＝4.7μH (Reference)

Typical Application Circuit

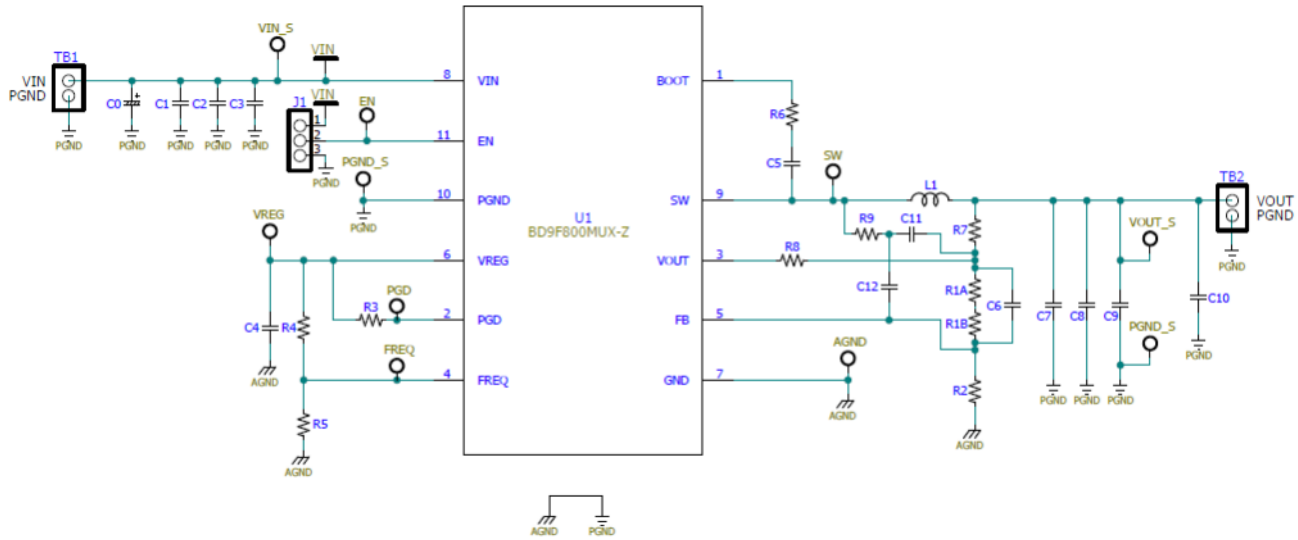


Figure 1. Schematic

EN pin setting (11-pin)

Table 1. EN pin setting and BD9F800MUX-Z operation

Terminal state	BD9F800MUX-Z operation
≥ 2.3V	Operation
≤ 0.7V	Power down

Operational Frequency Setting (4-pin)

Table 2. FREQ pin setting and BD9F800MUX-Z operational frequency

Terminal state	BD9F800MUX-Z operational frequency
≥ 2.2V	600kHz
≤ 0.8V	300kHz

However, please use within the following conditions for input/output voltage and operational frequency setting range.

$V_{OUT} \geqq V_{IN} \times 0.033 @ f_{SW}=300kHz$

$V_{OUT} \geqq V_{IN} \times 0.067 @ f_{SW}=600kHz$

Output LC Filter

In order to supply a continuous current to the load, the DC/DC converter requires an LC filter for smoothing the output voltage. The recommended inductance value is listed in Table 3.

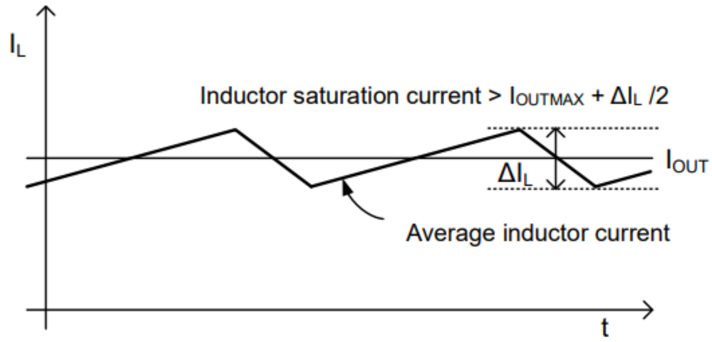


Figure 2. Waveform of current through inductor

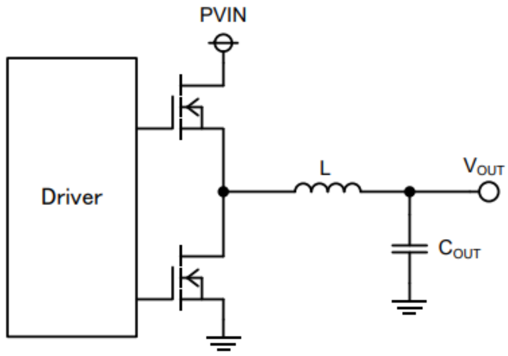


Figure 3. Output LC filter circuit

Here, when calculated with V_{IN} = 24V, V_{OUT} = 1.0V, L = 2.2µH, and switching frequency f_{SW} = 300 kHz, the inductor ripple current ⊿IL is the following equation.

$$\Delta I_L = \frac{V_{IN} - V_{OUT}}{L} \times \frac{V_{OUT}}{V_{IN}} \times \frac{1}{f_{SW}} = 1.452\ [\mathrm{A}] \quad (1)$$

The saturation current of the inductor must be larger than the sum of the maximum output current and 1/2 of the inductor ripple current ΔI_L.

Table 3. Recommended inductance value

Frequency	Output Voltage				
	1.0V	1.2V	3.3V	5.0V	12V
300kHz	2.2µH	2.2µH	3.3µH	4.7µH	5.6µH
600kHz	1.0µH	1.0µH	1.5µH	2.2µH	3.3µH

The output capacitor C_{OUT} affects the output ripple voltage characteristics. The output capacitor C_{OUT} must satisfy the required ripple voltage characteristics.

The output ripple voltage can be represented by the following equation.

$$\varDelta V_{RPL} = \varDelta I_L \times \left(R_{ESR} + \frac{1}{8 \times C_{OUT} \times f_{SW}}\right) [\mathrm{V}] \quad (2)$$

Where:
R_{ESR} is the Equivalent Series Resistance (ESR) of the output capacitor.

* The capacitor rating must allow a sufficient margin with respect to the output voltage.
The output ripple voltage is decreased with a smaller R_{ESR}.
Considering temperature and DC bias characteristics, please use ceramic capacitor of about 66µF to 100µF(300kHz), or 44µF to 100µF(600kHz).

* Be careful of total capacitance value, when additional capacitor C_{LOAD} is connected in addition to output capacitor C_{OUT}.
Use maximum additional capacitor C_{LOAD} (Max) which satisfies the following condition.

$$Maximum\ starting\ bottom\ ripple\ current\ I_{LSTART} < Current\ Limit\ Threshold\ 8.5[\mathrm{A}](Min) \quad (3)$$

Maximum starting inductor bottom ripple current I_{LSTART} can be expressed using the following equation.

$$I_{LSTART} = Maximum\ starting\ output\ current\ I_{OSS} + Charge\ current\ to\ output\ capacitor\ I_{CAP} - \frac{\Delta I_L}{2} \quad (4)$$

Charge current to output capacitor I_{CAP} can be expressed using the following equation.

$$I_{CAP} = \frac{(C_{OUT} + C_{LOAD}) \times V_{OUT}}{t_{SS}} \text{ [A]} \quad (5)$$

* C_{LOAD} has an effect on the stability of the DC/DC converter.
To ensure the stability of the DC/DC converter, make sure that a sufficient phase margin is provided.

Output Voltage Setting

The output voltage value can be set by the feedback resistance ratio. Please use resisters of about 1kΩ to 100kΩ.

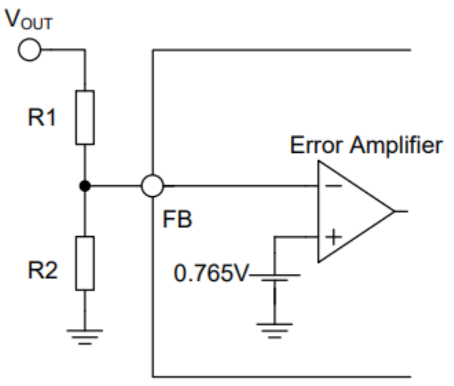


Figure 4. Feedback Resistor Circuit

$$V_{OUT} = \frac{R1 + R2}{R2} \times 0.765 \text{ [V]}$$

$$R2 = \frac{0.765}{V_{OUT} - 0.765} \times R1 \text{ [}\Omega\text{]}$$

$$0.765 \text{[V]} \le V_{OUT} \le 13.5 \text{[V]}$$

BD9F800MUX-Z operates under the condition which satisfies the following equation.

$$V_{IN} \times 0.033 \text{[V]} \le V_{OUT} \le V_{IN} \times 0.87 - 0.12 \times I_{OUT} \text{[V]} (300\text{kHz})$$

$$V_{IN} \times 0.067 \text{[V]} \le V_{OUT} \le V_{IN} \times 0.77 - 0.13 \times I_{OUT} \text{[V]} (600\text{kHz})$$

Input Capacitor

Use a ceramic capacitor. It is more effective by placing it near VIN and PGND terminals. In using capacitor, please consider temperature and DC bias characteristics. For normal setting, it is recommended to connect two 10μF and 0.1μF capacitors. Input ripple voltage can be reduced further by using larger values. Also, considering temperature and DC bias characteristics, do not use capacity less than 10μF(300kHz), 6μF(600kHz). In order to reduce the influence of high frequency noise, place 0.1μF ceramic capacitor close to VIN terminal and PGND terminal as much as possible.

VREG Capacitor

Connect a 2.2μF ceramic capacitor between VREG terminal and GND terminal. For the capacitance of VREG capacitor, take temperature characteristics, DC bias characteristics, etc. into consideration to set minimum value to no less than 1μF. Place VREG capacitor close to VREG terminal and GND terminal as much as possible.

Bootstrap Capacitor

Connect a 0.1μF ceramic capacitor between SW terminal and BOOT terminal. For the capacitance of bootstrap capacitor, take temperature characteristics, DC bias characteristics, etc. into consideration to set minimum value to no less than 0.047μF. Place bootstrap capacitor close to BOOT terminal and SW terminal as much as possible.

VOUT Pin Resistance

When setting the output voltage higher than 3.3V, connect a 10Ω resistor in series.

In this application note, R8 in Tables 10 to 14 of the Bill of Materials for output voltages of 5V and 12V is listed as 10Ω.

Bill of Materials and Application Data

1. V_{IN} = 4.5V to 28V, V_{OUT}=1.0V, I_{OUT}=8A, f_{SW}=300kHz

Table 4. Bill of Materials 1

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX-Z	ROHM	3.5 x 3.5
1	L1	Inductor	2.2µH	11A max, ±20%	CMLB104T2R2MS	Cyntec	L: 10.85 W: 10
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
0	C6	-	-	Open	-	-	-
1	C7	Ceramic Capacitor	47µF	6.3V, X5R, ±20%	GRM31CR60J476ME19	Murata	3216
1	C8	Ceramic Capacitor	22µF	6.3V, X5R, ±20%	GRM21BR60J226ME39	Murata	2012
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R1B	Resistor	6.8kΩ	50V, ±1%, 1/16W	MCR01MZPF6801	ROHM	1005
1	R2	Resistor	22kΩ	50V, ±1%, 1/16W	MCR01MZPF2202	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
0	R4	-	-	Open	-	-	-
1	R5	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
0	R9	-	-	Open	-	-	-

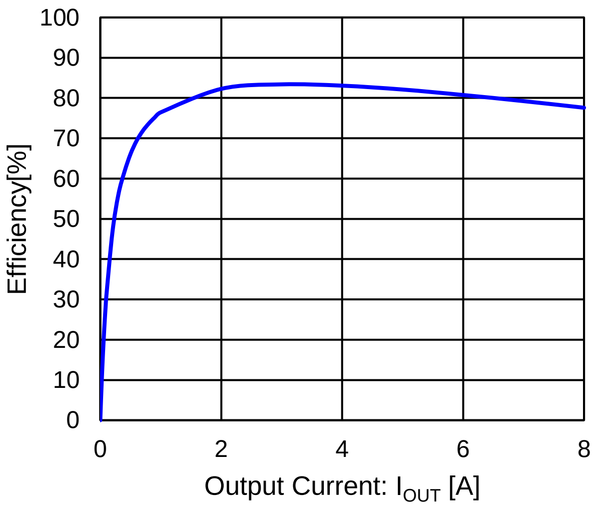


Figure 5. Efficiency vs Load Current

(BOM 1, V_{IN}=24V)

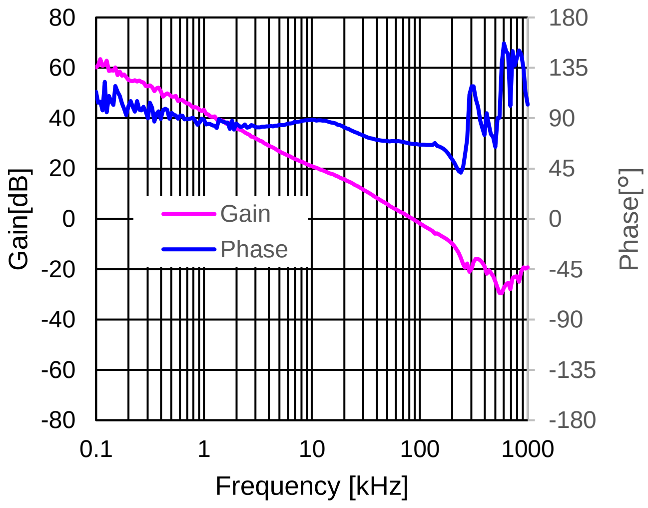


Figure 6. Frequency Response

(BOM 1, V_{IN}=24V, I_{OUT}=8A)

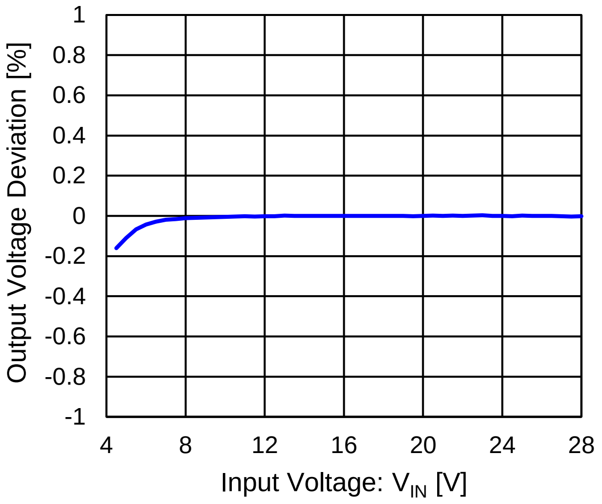


Figure 7. Line Regulation

(BOM 1, I_{OUT}=8A)

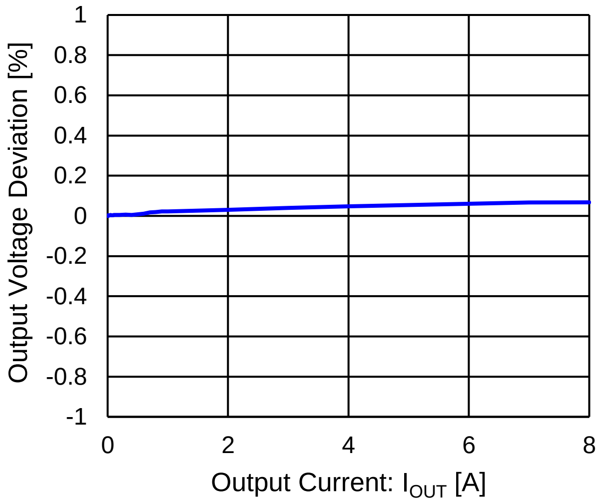


Figure 8. Load Regulation

(BOM 1, V_{IN}=24V)

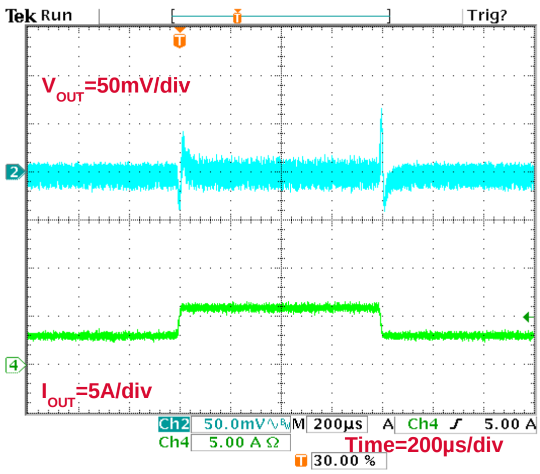


Figure 9. Load Transient Response

(BOM 1, V_{IN}=24V, I_{OUT}=3A⇔6A, SR=0.5A/µs)

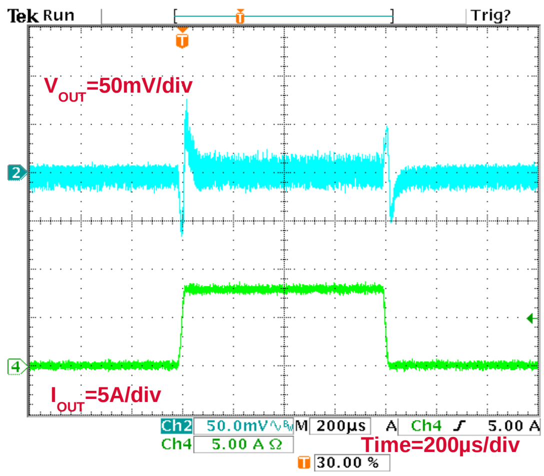


Figure 10. Load Transient Response

(BOM 1, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/µs)

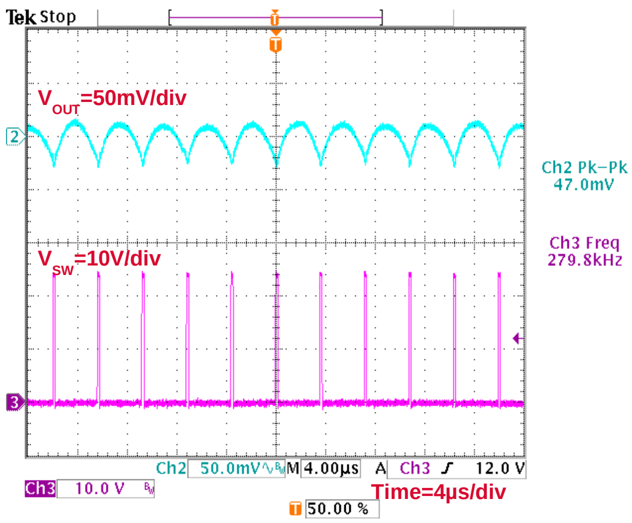


Figure 11. Output Ripple Voltage

(BOM 1, V_{IN}=24V, I_{OUT}=8A)

Bill of Materials and Application Data(continued)

2. V_{IN}=4.5 to 28V, V_{OUT}=1.2V, I_{OUT}=8A, f_{SW}=300kHz

Table 5. Bill of Materials 2

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX-Z	ROHM	3.5 x 3.5
1	L1	Inductor	2.2µH	11A max, ±20%	CMLB104T2R2MS	Cyntec	L: 10.85 W: 10
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
0	C6	-	-	Open	–	-	-
1	C7	Ceramic Capacitor	47µF	6.3V, X5R, ±20%	GRM31CR60J476ME19	Murata	3216
1	C8	Ceramic Capacitor	22µF	6.3V, X5R, ±20%	GRM21BR60J226ME39	Murata	2012
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R1B	Resistor	6.8kΩ	50V, ±1%, 1/16W	MCR01MZPF6801	ROHM	1005
1	R2	Resistor	12kΩ	50V, ±1%, 1/16W	MCR01MZPF1202	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
0	R4	-	-	Open	-	-	-
1	R5	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
0	R9	-	-	Open	-	-	-

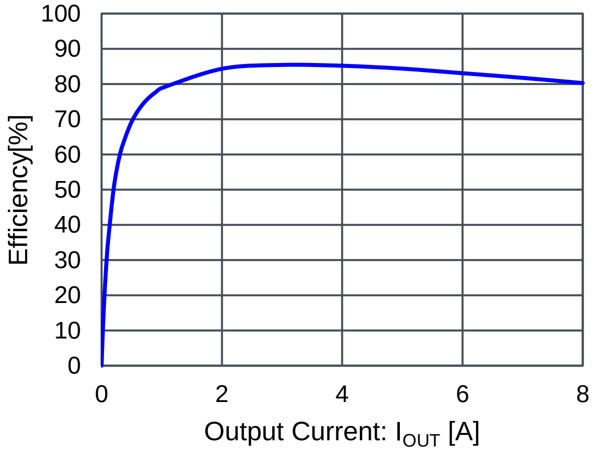


Figure 12. Efficiency vs Load Current
(BOM 2, V_{IN}=24V)

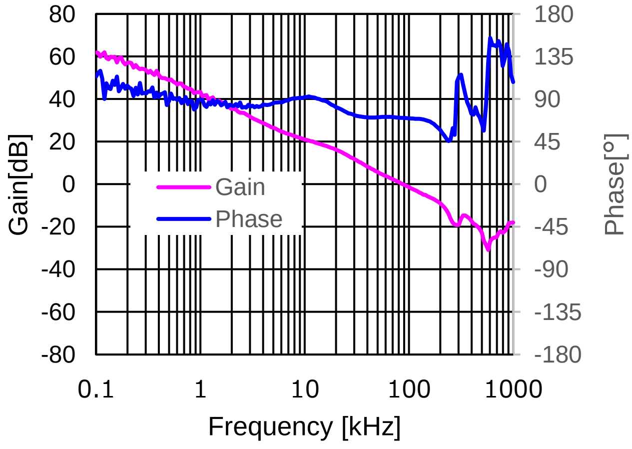


Figure 13. Frequency Response
(BOM 2, V_{IN}=24V, I_{OUT}=8A)

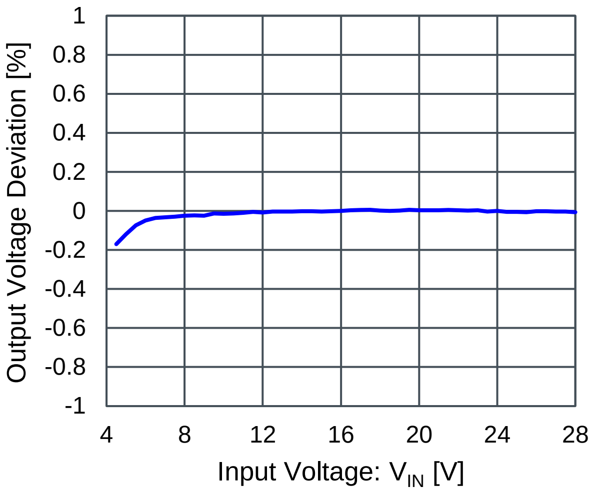


Figure 14. Line Regulation
(BOM 2, I_{OUT}=8A)

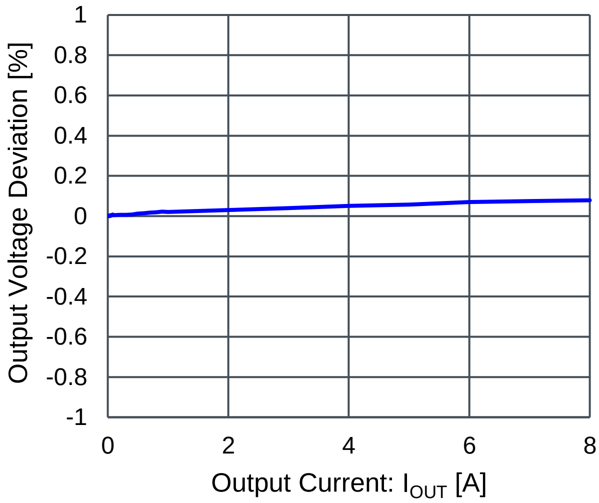


Figure 15. Load Regulation
(BOM 2, V_{IN}=24V)

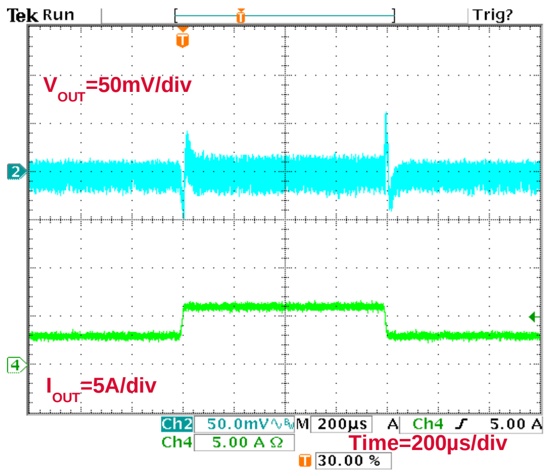


Figure 16. Load Transient Response
(BOM 2, V_{IN}=24V, I_{OUT}=3A⇔6A, SR=0.5A/µs)

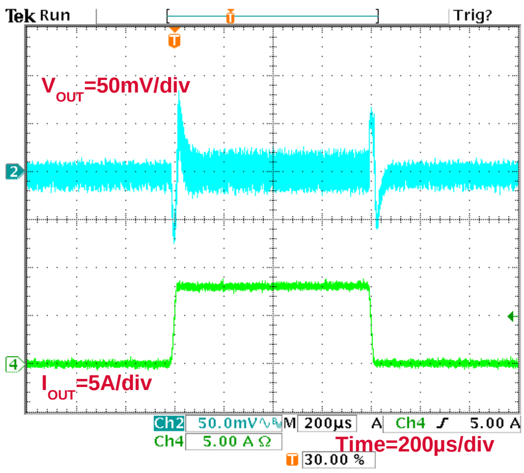


Figure 17. Load Transient Response
(BOM 2, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/µs)

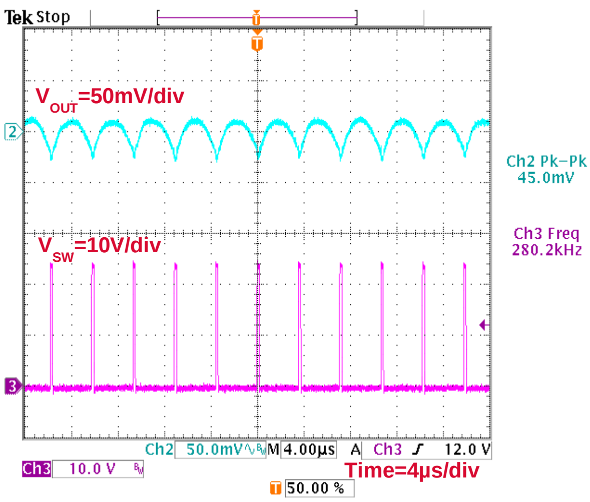


Figure 18. Output Ripple Voltage
(BOM 2, V_{IN}=24V, I_{OUT}=8A)

Bill of Materials and Application Data(continued)

3. V_{IN}=4.5 to 28V, V_{OUT}=1.8V, I_{OUT}=8A, f_{SW}=300kHz

Table 6. BOM 3

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX-Z	ROHM	3.5 x 3.5
1	L1	Inductor	2.2µH	11A max, ±20%	CMLB104T2R2MS	Cyntec	L: 10.85 W: 10
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
0	C6	-	-	Open	-	-	-
1	C7	Ceramic Capacitor	47µF	6.3V, X5R, ±20%	GRM31CR60J476ME19	Murata	3216
1	C8	Ceramic Capacitor	22µF	6.3V, X5R, ±20%	GRM21BR60J226ME39	Murata	2012
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R1B	Resistor	27kΩ	50V, ±1%, 1/16W	MCR01MZPF2702	ROHM	1005
1	R2	Resistor	20kΩ	50V, ±1%, 1/16W	MCR01MZPF2002	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
0	R4	-	-	Open	-	-	-
1	R5	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
0	R9	-	-	Open	-	-	-

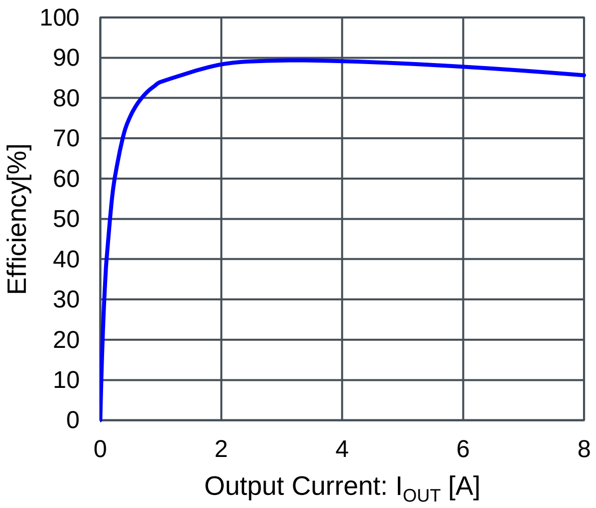


Figure 19. Efficiency vs Load Current

(BOM 3, V_{IN}=24V)

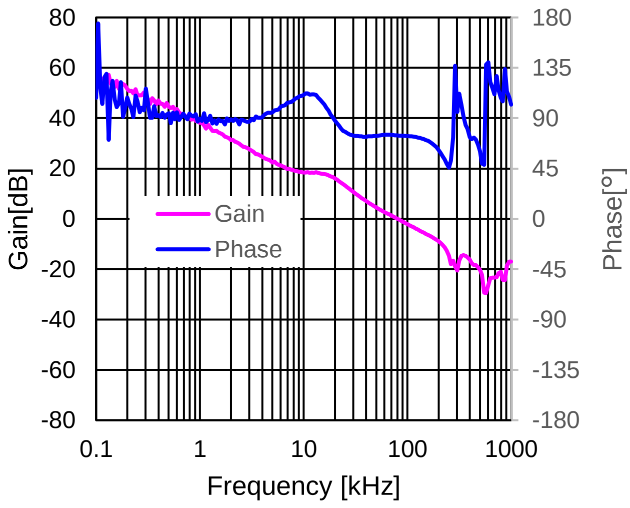
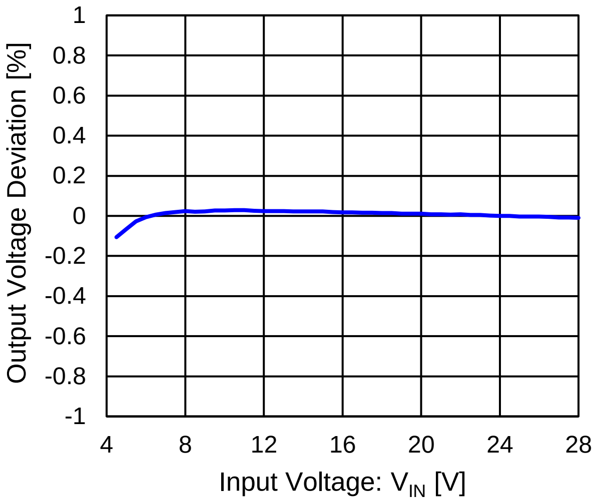


Figure 20. Frequency Response

(BOM 3, V_{IN}=24V, I_{OUT}=8A)



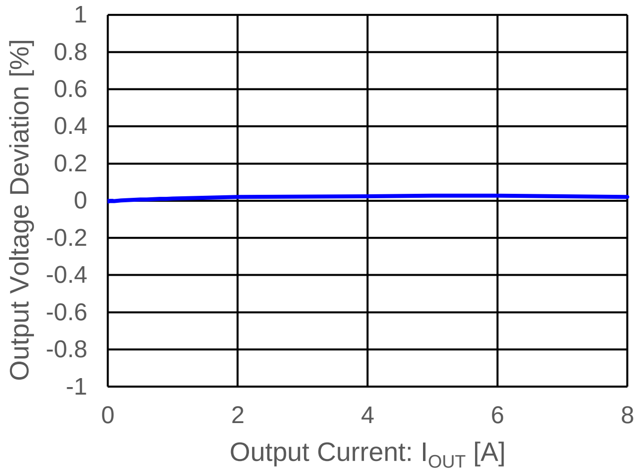


Figure 21. Line Regulation

(BOM 3, I_{OUT}=8A)

Figure 22. Load Regulation

(BOM 3, V_{IN}=24V)

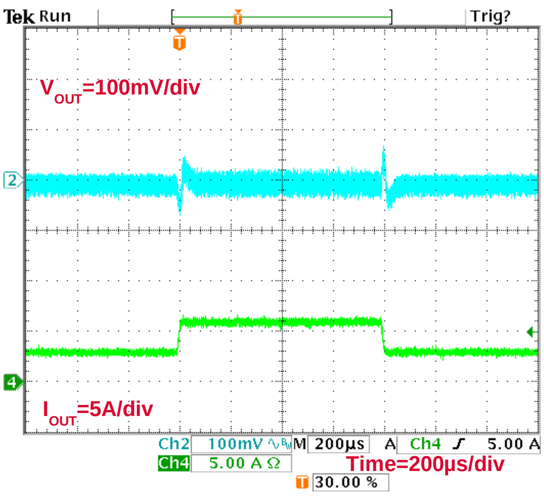


Figure 23. Load Transient Response

(BOM 3, V_{IN}=24V, I_{OUT}=3A⇔6A, SR=0.5A/µs)

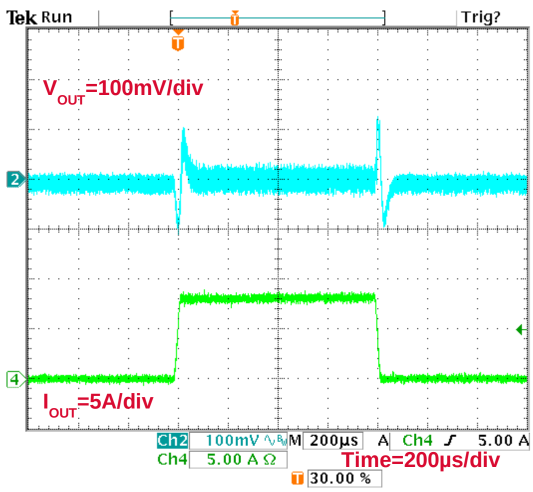


Figure 24. Load Transient Response

(BOM 3, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/µs)

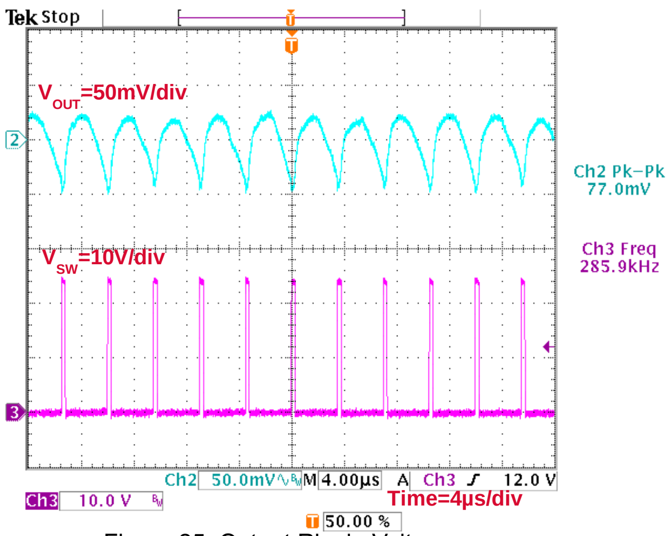


Figure 25. Output Ripple Voltage

(BOM 3, V_{IN}=24V, I_{OUT}=8A)

Bill of Materials and Application Data(continued)

4. V_{IN}=4.5 to 28V, V_{OUT}=1.8V, I_{OUT}=8A, f_{SW}=600kHz

Table 7. Bill of Materials 4

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX	ROHM	3.5 x 3.5
1	L1	Inductor	1.0µH	16.5A max, ±20%	784771010	WURTH Elektronik	L: 12 W: 12
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
1	C7	Ceramic Capacitor	47µF	6.3V, X5R, ±20%	GRM31CR60J476ME19	Murata	3216
1	C8	-	-	Open	-	-	-
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R1B	Resistor	27kΩ	50V, ±1%, 1/16W	MCR01MZPF2702	ROHM	1005
1	R2	Resistor	20kΩ	50V, ±1%, 1/16W	MCR01MZPF2002	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
1	R4	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
0	R5	-	-	Open	-	-	-
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
0	R9	-	-	Open	-	-	-

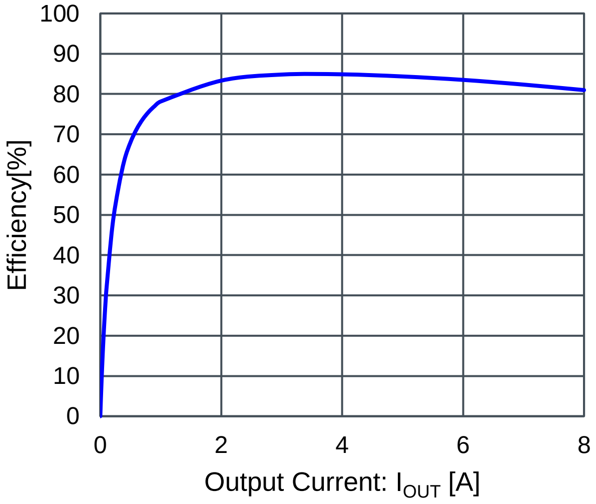


Figure 26. Efficiency vs Load Current

(BOM 4, V_{IN}=24V)

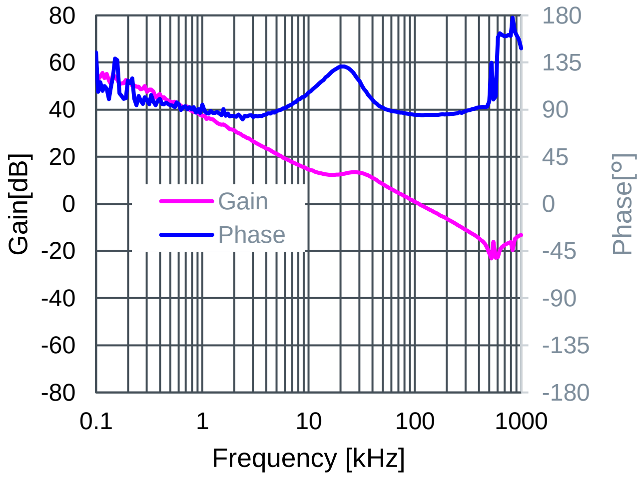


Figure 27. Frequency Response

(BOM 4, V_{IN}=24V, I_{OUT}=8A)

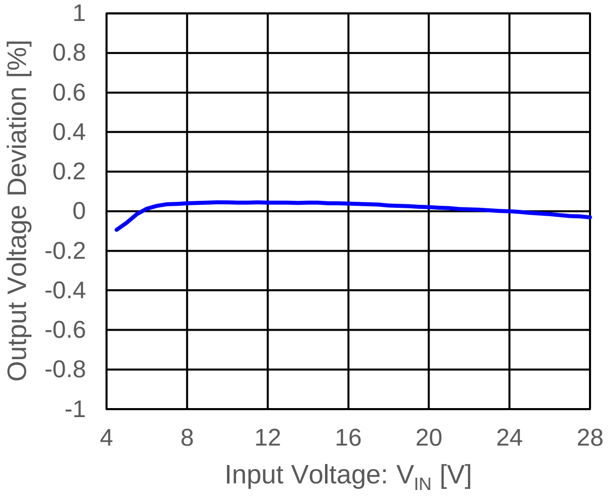


Figure28. Line Regulation

(BOM 4, I_{OUT}=8A)

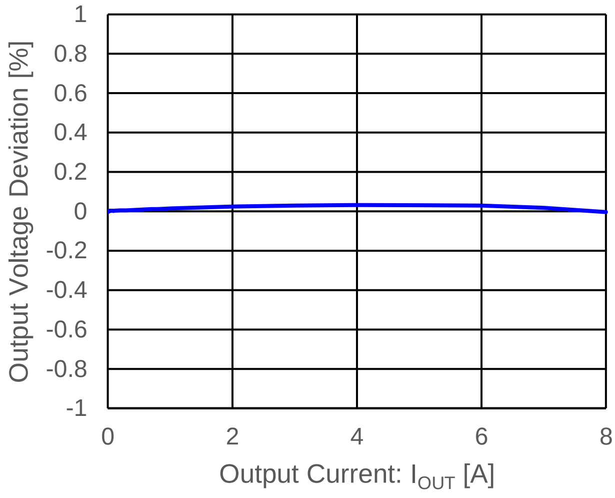


Figure 29. Load Regulation

(BOM 4, V_{IN}=24V)

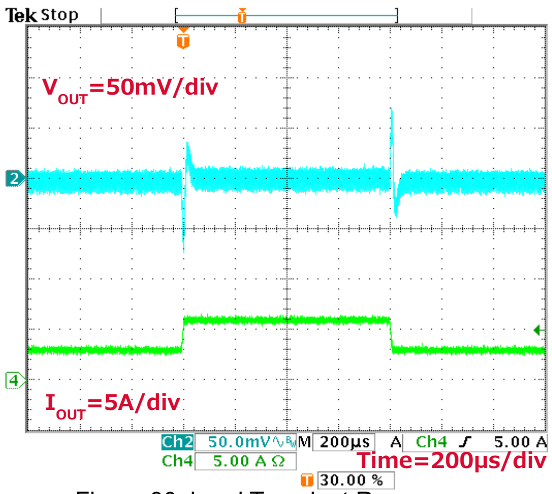


Figure 30. Load Transient Response

(BOM 4, V_{IN}=24V, I_{OUT}=3A⇔6A, SR=0.5A/µs)

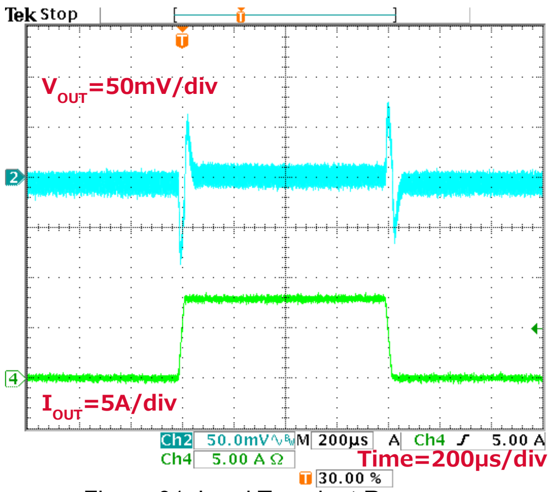


Figure 31. Load Transient Response

(BOM 4, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/µs)

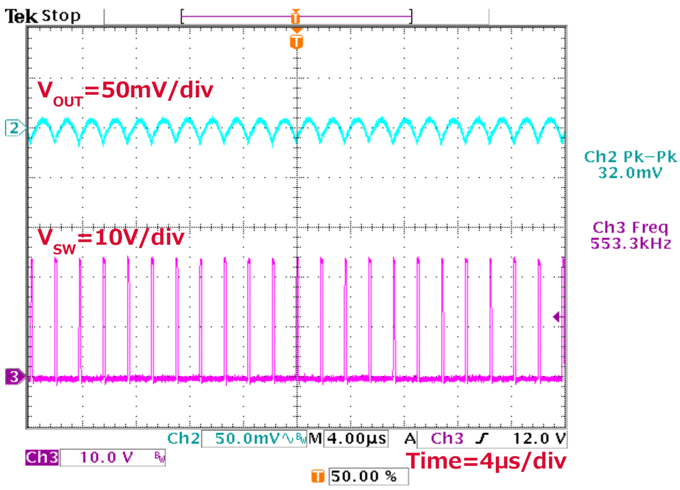


Figure 32. Output Ripple Voltage

(BOM 4, V_{IN}=24V, I_{OUT}=8A)

Bill of Materials and Application Data(continued)

5. V_{IN}=6 to 28V, V_{OUT}=3.3V, I_{OUT}=8A, f_{SW}=300kHz

Table 8. Bill of Materials 5

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX-Z	ROHM	3.5 x 3.5
1	L1	Inductor	3.3µH	10.8A max, ±30%	1274AS-H-3R3N=P3	Murata	L: 10 W: 10
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
0	C6	-	-	Open	-	-	-
1	C7	Ceramic Capacitor	47µF	6.3V, X5R, ±20%	GRM31CR60J476ME19	Murata	3216
1	C8	Ceramic Capacitor	22µF	6.3V, X5R, ±20%	GRM21BR60J226ME39	Murata	2012
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	5.1kΩ	50V, ±1%, 1/16W	MCR01MZPF5101	ROHM	1005
1	R1B	Resistor	68kΩ	50V, ±1%, 1/16W	MCR01MZPF6802	ROHM	1005
1	R2	Resistor	22kΩ	50V, ±1%, 1/16W	MCR01MZPF2202	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
0	R4	-	-	Open	-	-	-
1	R5	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
0	R9	-	-	Open	-	-	-

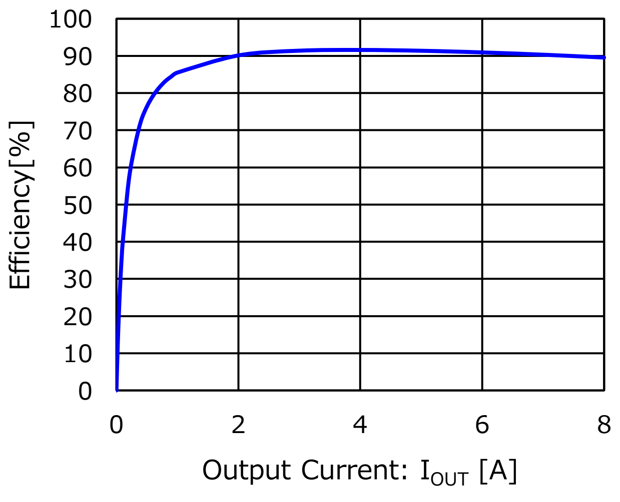


Figure 33. Efficiency vs Load Current

(BOM 5, V_{IN}=24V)

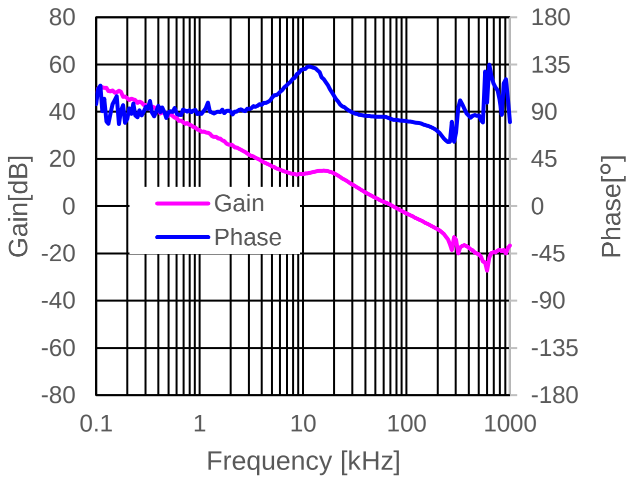


Figure 34. Frequency Response

(BOM 5, V_{IN}=24V, I_{OUT}=8A)

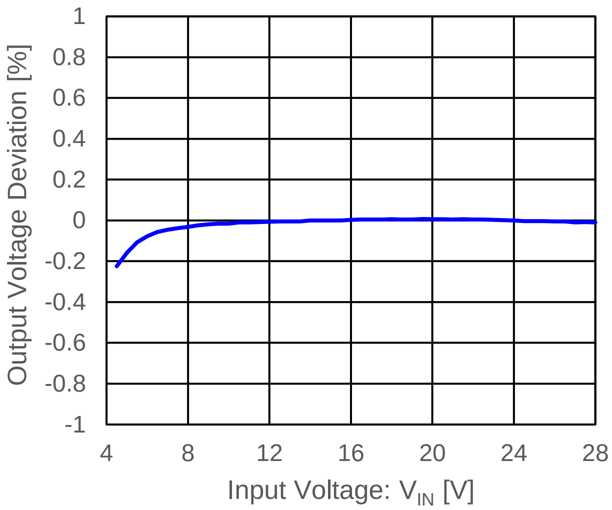


Figure 35. Line Regulation

(BOM 5, I_{OUT}=8A)

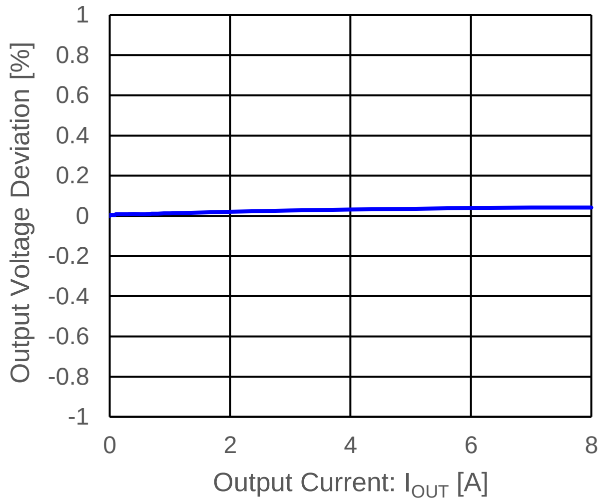


Figure 36. Load Regulation

(BOM 5, V_{IN}=24V)

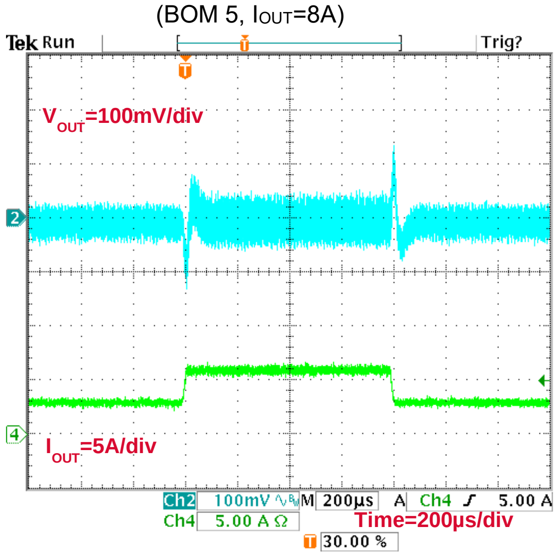


Figure 37. Load Transient Response

(BOM 5, V_{IN}=24V, I_{OUT}=3A⇔6A, SR=0.5A/μs)

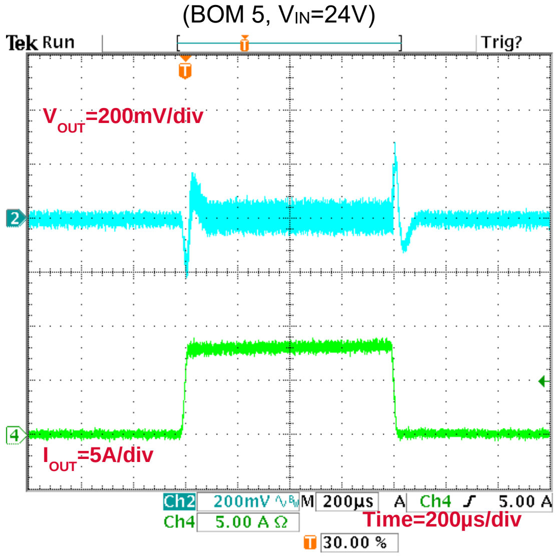


Figure 38. Load Transient Response

(BOM 5, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/μs)

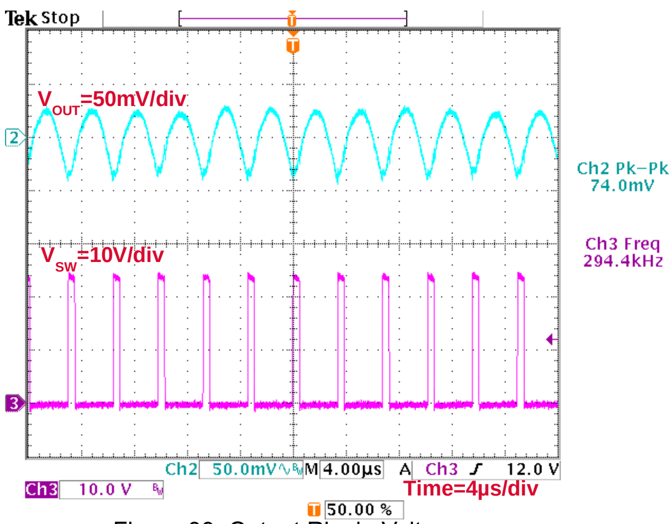


Figure 39. Output Ripple Voltage

(BOM 5, V_{IN}=24V, I_{OUT}=8A)

Bill of Materials and Application Data(continued)

6. V_{IN}=6 to 28V, V_{OUT}=3.3V, I_{OUT}=8A, f_{SW}=600kHz

Table 9. Bill of Materials 6

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX-Z	ROHM	3.5 x 3.5
1	L1	Inductor	1.5µH	15.3A max, ±30%	1274AS-H-1R5N=P3	Murata	L: 10 W: 10
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
0	C6	-	-	Open	-	-	-
1	C7	Ceramic Capacitor	47µF	6.3V, X5R, ±20%	GRM31CR60J476ME19	Murata	3216
0	C8	-	-	Open	-	-	-
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	5.1kΩ	50V, ±1%, 1/16W	MCR01MZPF5101	ROHM	1005
1	R1B	Resistor	68kΩ	50V, ±1%, 1/16W	MCR01MZPF6802	ROHM	1005
1	R2	Resistor	22kΩ	50V, ±1%, 1/16W	MCR01MZPF2202	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
1	R4	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
0	R5	-	-	Open	-	-	-
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
0	R9	-	-	Open	-	-	-

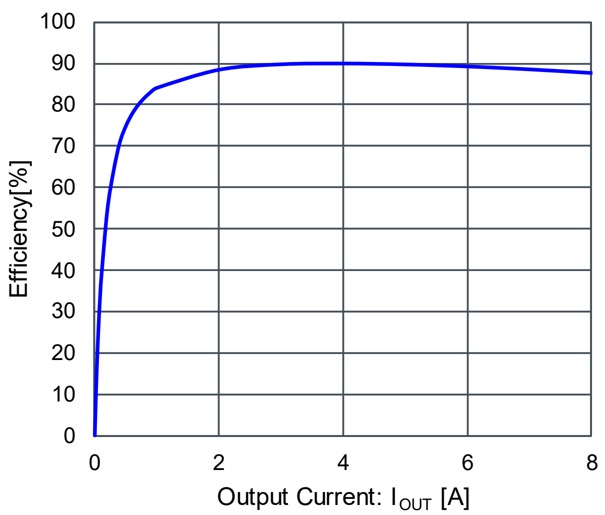


Figure 40. Efficiency vs Load Current
(BOM 6, V_{IN}=24V)

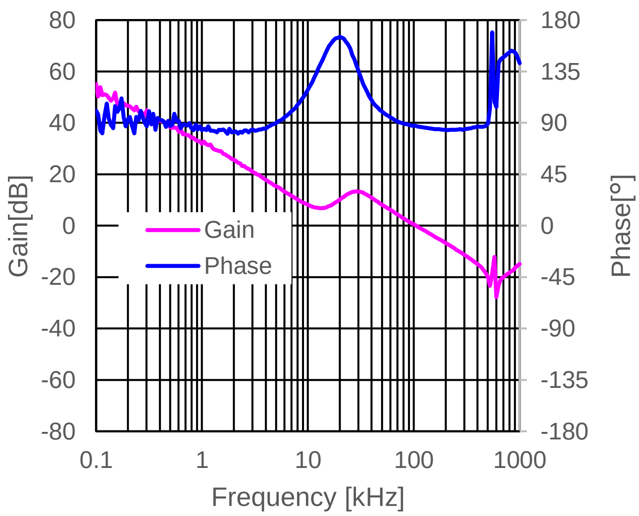


Figure 41. Frequency Response
(BOM 6, V_{IN}=24V, I_{OUT}=8A)

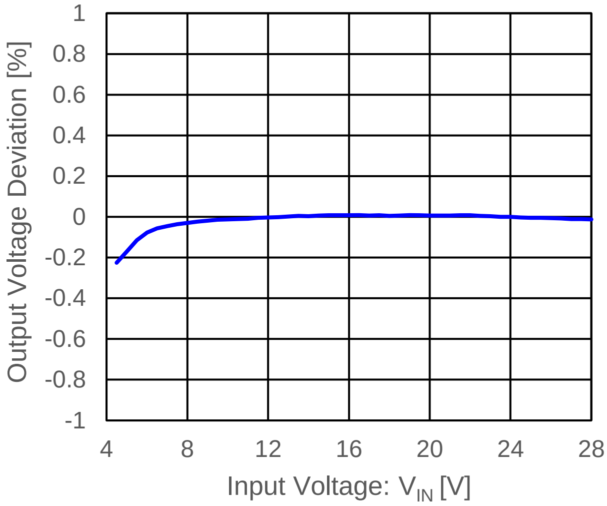


Figure 42. Line Regulation

(BOM 6, I_{OUT}=8A)

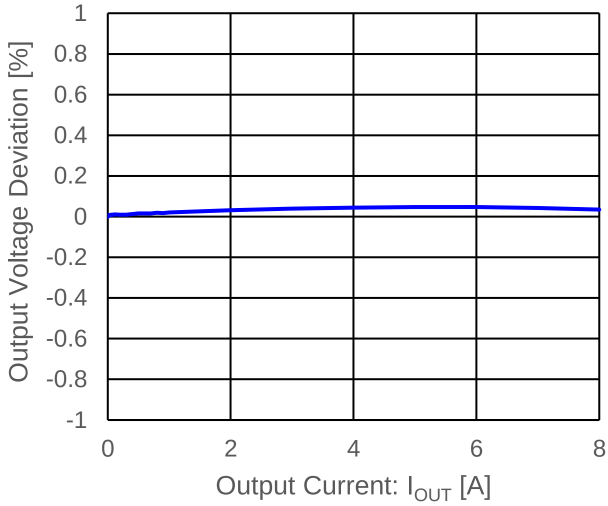


Figure 43. Load Regulation

(BOM 6, V_{IN}=24V)

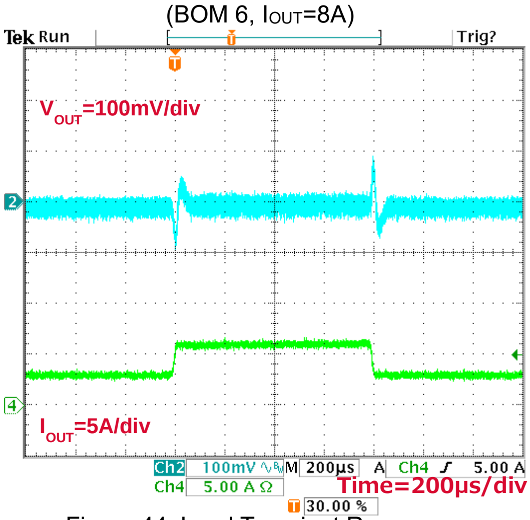


Figure 44. Load Transient Response

(BOM 6, V_{IN}=24V, I_{OUT}=0A⇔8A, SR=0.5A/µs)

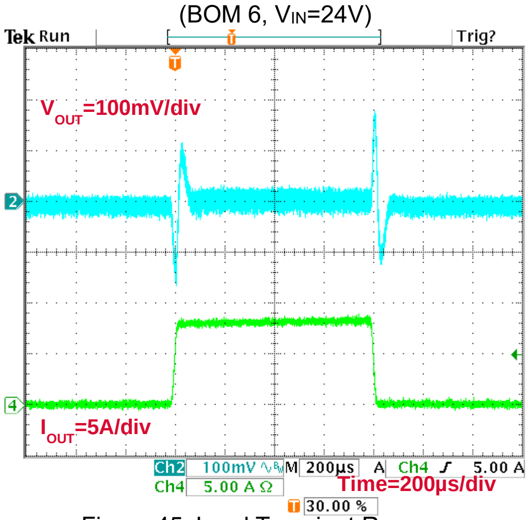


Figure 45. Load Transient Response

(BOM 6, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/µs)

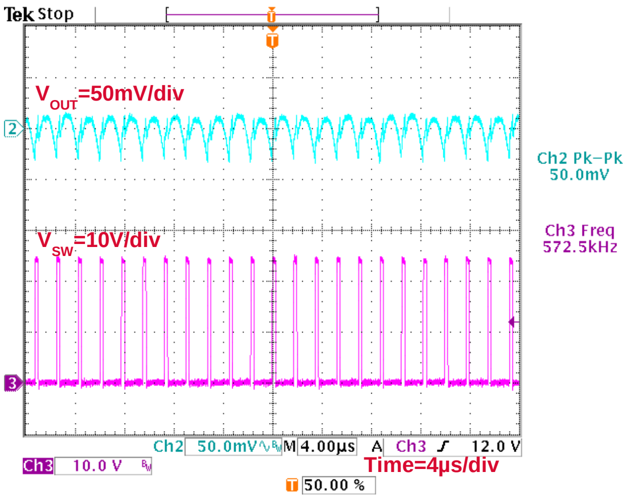


Figure 46. Output Ripple Voltage

(BOM 6, V_{IN}=24V, I_{OUT}=8A)

Bill of Materials and Application Data(continued)

7. V_{IN}=8 to 28V, V_{OUT}=5V, I_{OUT}=8A, f_{SW}=300kHz

Table 10. Bill of Materials 7

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX-Z	ROHM	3.5 x 3.5
1	L1	Inductor	4.7µH	9.5A max, ±30%	1274AS-H-4R7N=P3	Murata	L: 10 W: 10
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
0	C6	-	-	Open	-	-	-
1	C7	Ceramic Capacitor	47µF	6.3V, X5R, ±20%	GRM31CR60J476ME19	Murata	3216
1	C8	Ceramic Capacitor	22µF	6.3V, X5R, ±20%	GRM21BR60J226ME39	Murata	2012
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	8.2kΩ	50V, ±1%, 1/16W	MCR01MZPF8201	ROHM	1005
1	R1B	Resistor	47kΩ	50V, ±1%, 1/16W	MCR01MZPF4702	ROHM	1005
1	R2	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
0	R4	-	-	Open	-	-	-
1	R5	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	10Ω	50V, ±5%, 1/16W	MCR01MZPJ100	ROHM	1005
0	R9	-	-	Open	-	-	-

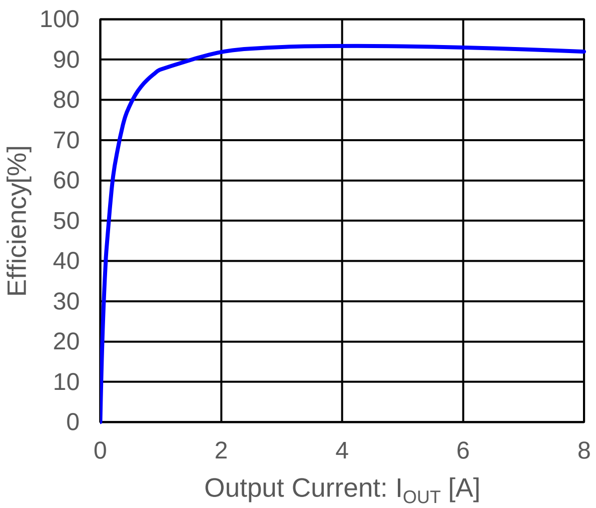


Figure 47. Efficiency vs Load Current

(BOM 7, V_{IN}=24V)

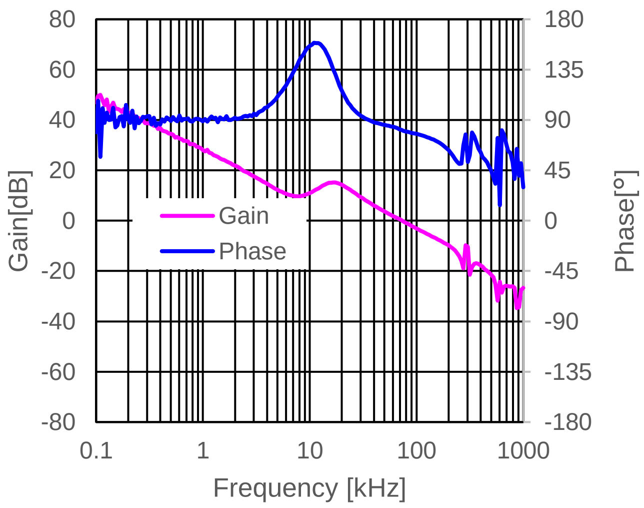


Figure 48. Frequency Response

(BOM 7, V_{IN}=24V, I_{OUT}=8A)

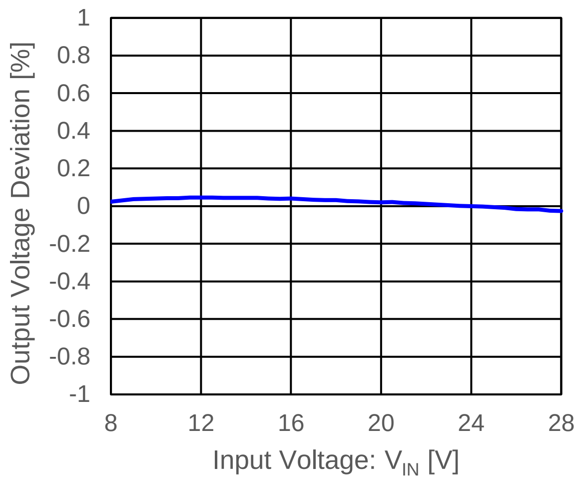


Figure 49. Line Regulation

(BOM 7, I_{OUT}=8A)

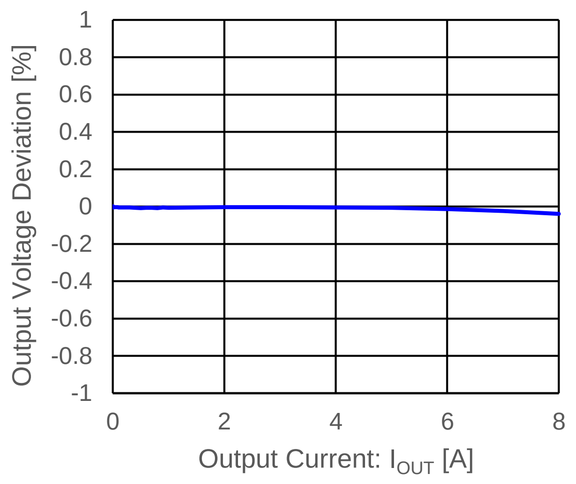


Figure 50. Load Regulation

(BOM 7, V_{IN}=24V)

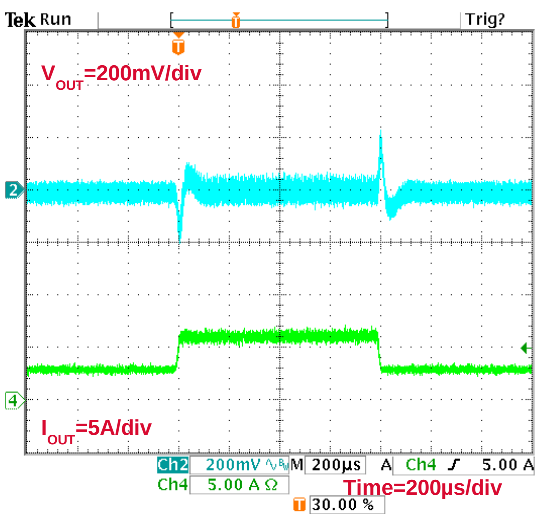


Figure 51. Load Transient Response

(BOM 7, V_{IN}=24V, I_{OUT}=3A⇔6A, SR=0.5A/μs)

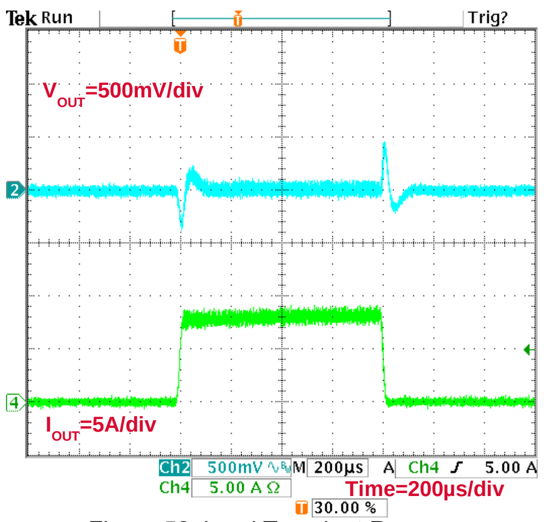


Figure 52. Load Transient Response

(BOM 7, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/μs)

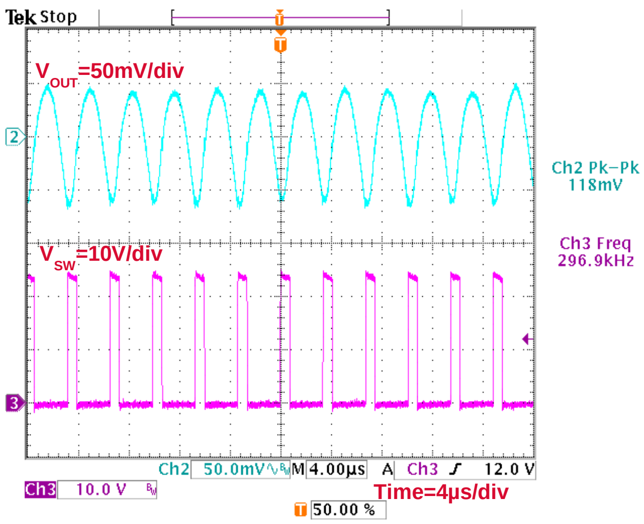


Figure 53. Output Ripple Voltage

(BOM 7, V_{IN}=24V, I_{OUT}=8A)

Bill of Materials and Application Data(continued)

8. V_{IN}=8 to 28V, V_{OUT}=5V, I_{OUT}=8A, f_{SW}=600kHz

Table 11. Bill of Materials 8

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX-Z	ROHM	3.5 x 3.5
1	L1	Inductor	2.2µH	11A max, ±20%	CMLB104T2R2MS	Cyntec	L: 10.85 W: 10
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
0	C6	-	-	Open	-	-	-
1	C7	Ceramic Capacitor	47µF	6.3V, X5R, ±20%	GRM31CR60J476ME19	Murata	3216
0	C8	-	-	Open	-	-	-
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	8.2kΩ	50V, ±1%, 1/16W	MCR01MZPF8201	ROHM	1005
1	R1B	Resistor	47kΩ	50V, ±1%, 1/16W	MCR01MZPF4702	ROHM	1005
1	R2	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
1	R4	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
0	R5	-	-	Open	-	-	-
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	10Ω	50V, ±5%, 1/16W	MCR01MZPJ100	ROHM	1005
0	R9	-	-	Open	-	-	-

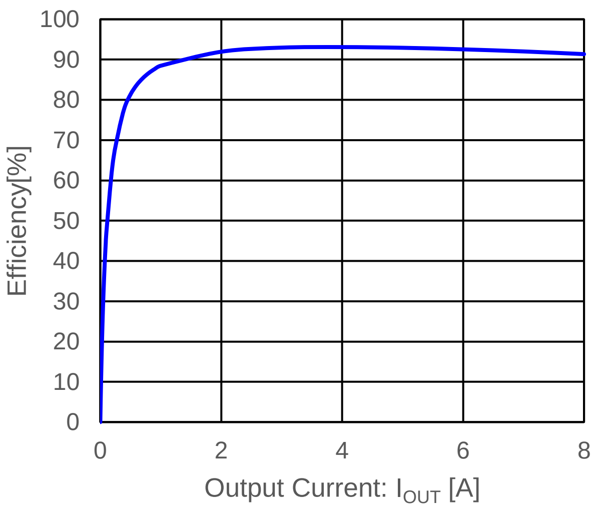


Figure 54. Efficiency vs Load Current
(BOM 8, V_{IN}=24V)

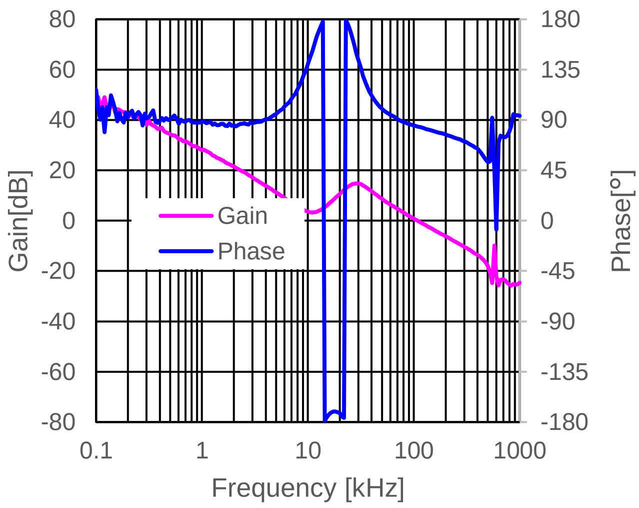


Figure 55. Frequency Response
(BOM 8, V_{IN}=24V, I_{OUT}=8A)

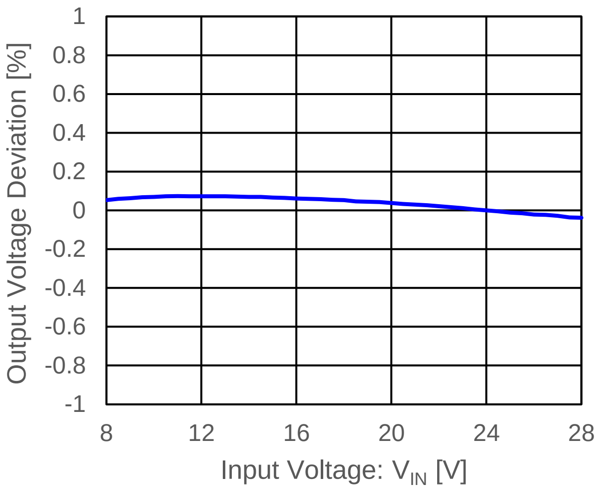


Figure 56. Line Regulation

(BOM 8, I_{OUT}=8A)

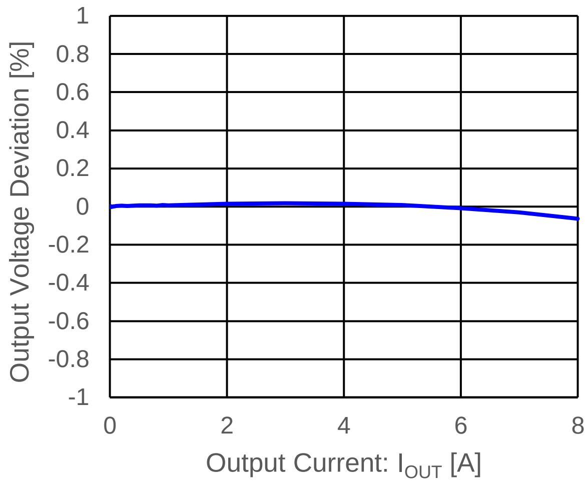


Figure 57. Load Regulation

(BOM 8, V_{IN}=24V)

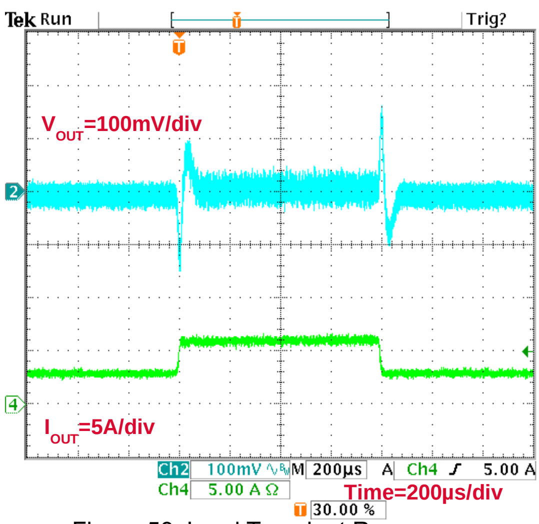


Figure 58. Load Transient Response

(BOM 8, V_{IN}=24V, I_{OUT}=3A⇔6A, SR=0.5A/µs)

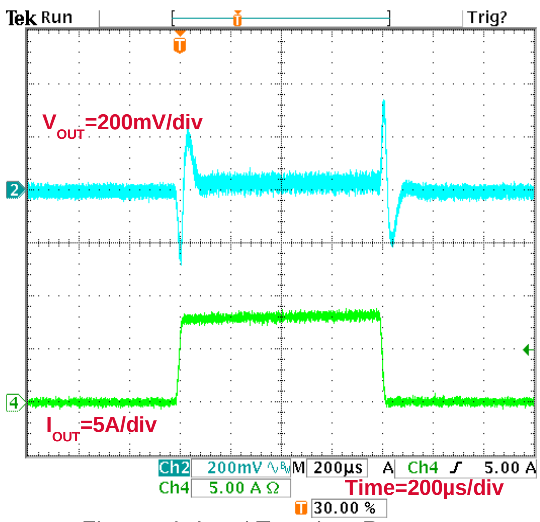


Figure 59. Load Transient Response

(BOM 8, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/µs)

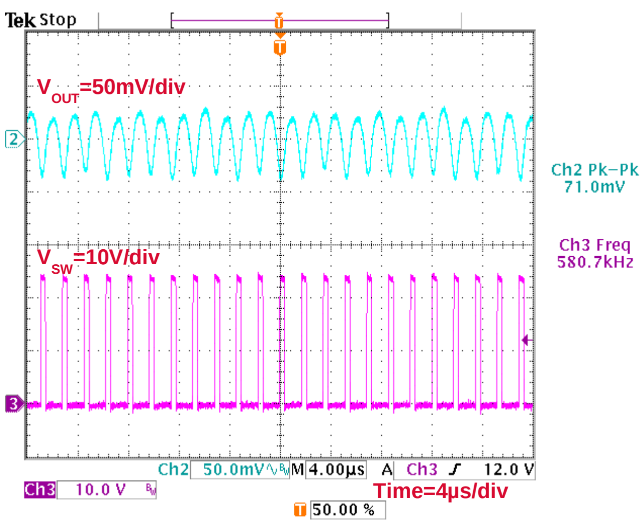


Figure 60. Output Ripple Voltage

(BOM 8, V_{IN}=24V, I_{OUT}=8A)

Bill of Materials and Application Data(continued)

9. V_{IN}=14 to 28V, V_{OUT}=12V, I_{OUT}=8A, f_{SW}=300kHz, L=5.6µH(Recommended)

Table 12. Bill of Materials 9

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX-Z	ROHM	3.5 x 3.5
1	L1	Inductor	5.6µH	11.5A max, ±20%	74439369056	WURTH Elektronik	L: 11.6 W: 10.5
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
0	C6	-	-	Open	-	-	-
1	C7	Ceramic Capacitor	47µF	16V, X6S, ±10%	GRM32EC81C476KE15	Murata	3216
1	C8	Ceramic Capacitor	22µF	25V, X5R, ±20%	GRM21BR61E226ME44L	Murata	2012
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R1B	Resistor	91kΩ	50V, ±1%, 1/16W	MCR01MZPF9102	ROHM	1005
1	R2	Resistor	6.2kΩ	50V, ±1%, 1/16W	MCR01MZPF6201	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
0	R4	-	-	Open	-	-	-
1	R5	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	10Ω	50V, ±5%, 1/16W	MCR01MZPJ100	ROHM	1005
0	R9	-	-	Open	-	-	-

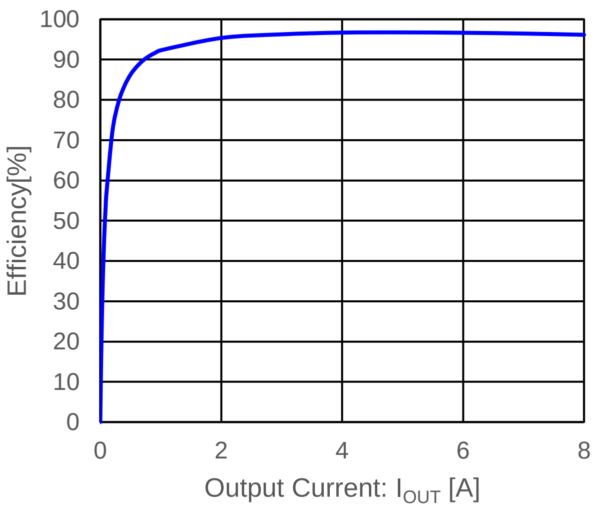


Figure 61. Efficiency vs Load Current

(BOM 9, V_{IN}=24V)

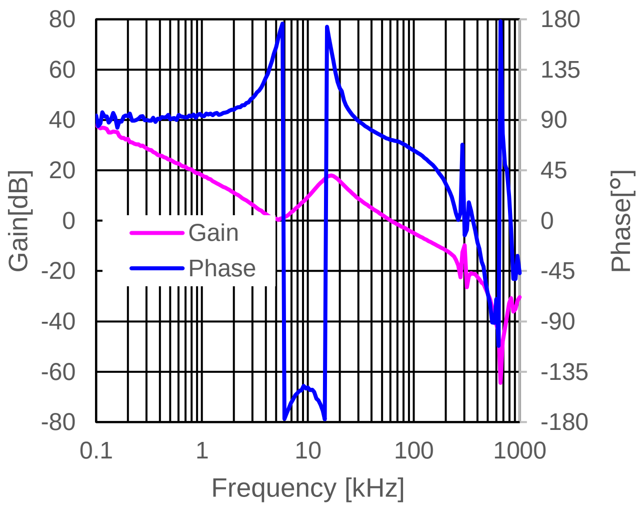


Figure 62. Frequency Response

(BOM 9, V_{IN}=24V, I_{OUT}=8A)

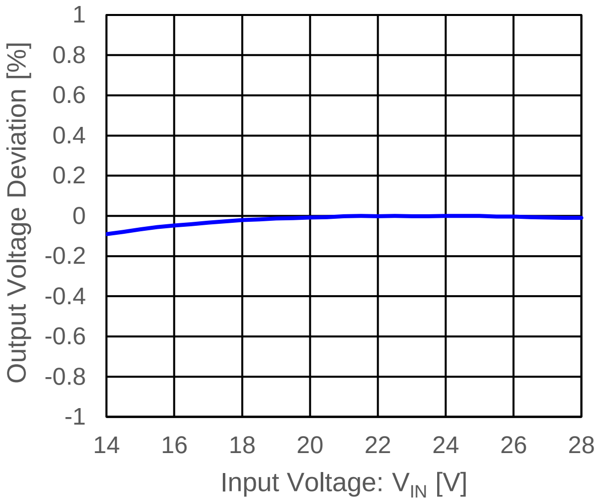


Figure 63. Line Regulation

(BOM 9, I_{OUT}=8A)

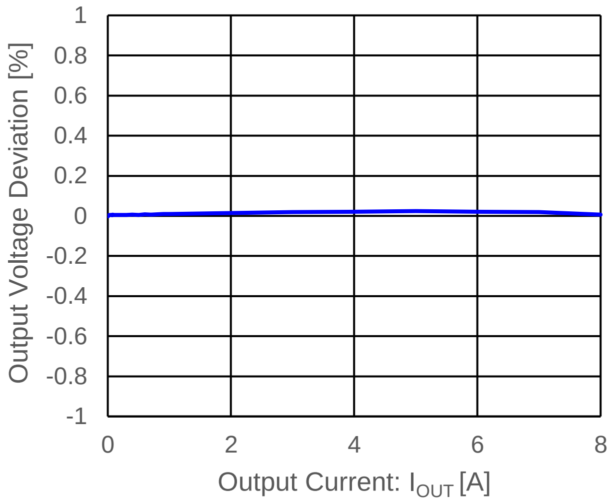


Figure 64. Load Regulation

(BOM 9, V_{IN}=24V)

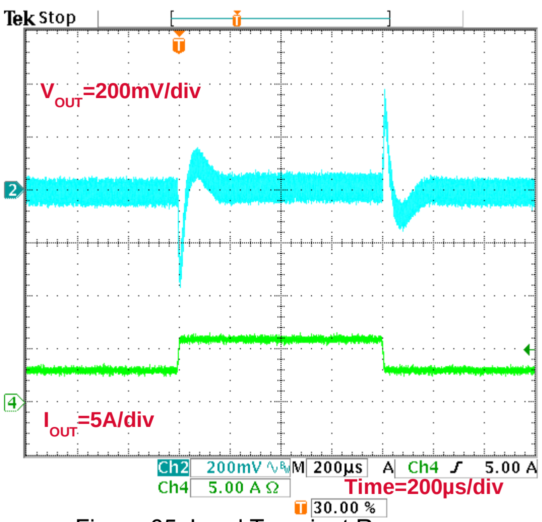


Figure 65. Load Transient Response

(BOM 9, V_{IN}=24V, I_{OUT}=3A⇔6A, SR=0.5A/µs)

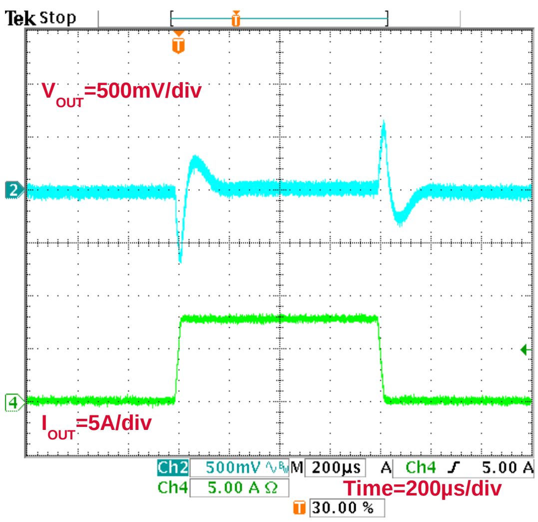


Figure 66. Load Transient Response

(BOM 9, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/µs)

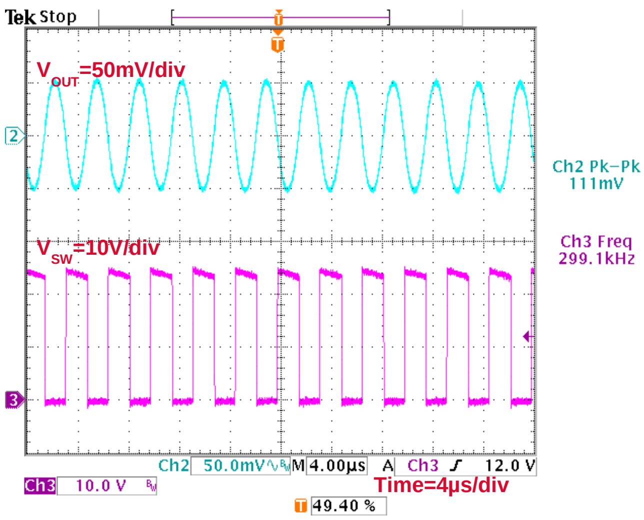


Figure 67. Output Ripple Voltage

(BOM 9, V_{IN}=24V, I_{OUT}=8A)

Bill of Materials and Application Data(continued)

10. V_{IN}=16 to 28V, V_{OUT}=12V, I_{OUT}=8A, f_{SW}=600kHz

Table 13. Bill of Materials 10

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX-Z	ROHM	3.5 x 3.5
1	L1	Inductor	3.3µH	10.8A max, ±30%	1274AS-H-3R3N=P3	Murata	L: 10 W: 10
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
0	C6	-	-	Open	-	-	-
1	C7	Ceramic Capacitor	47µF	16V, X6S, ±10%	GRM32EC81C476KE15	Murata	3216
0	C8	-	-	Open	-	-	-
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R1B	Resistor	91kΩ	50V, ±1%, 1/16W	MCR01MZPF9102	ROHM	1005
1	R2	Resistor	6.2kΩ	50V, ±1%, 1/16W	MCR01MZPF6201	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
1	R4	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
0	R5	-	-	Open	-	-	-
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	10Ω	50V, ±5%, 1/16W	MCR01MZPJ100	ROHM	1005
0	R9	-	-	Open	-	-	-

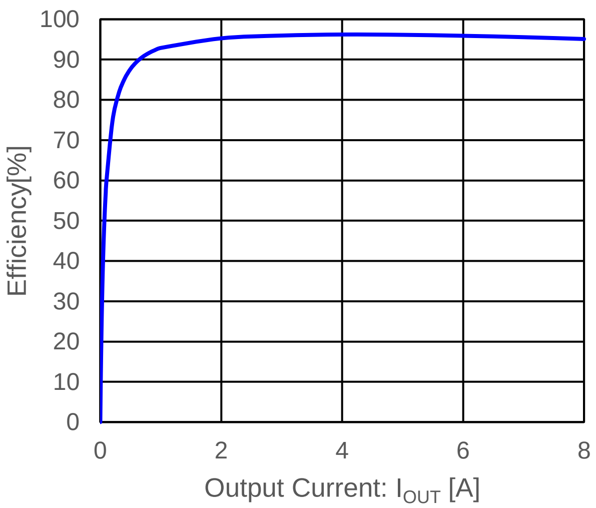


Figure 68. Efficiency vs Load Current

(BOM 10, V_{IN}=24V)

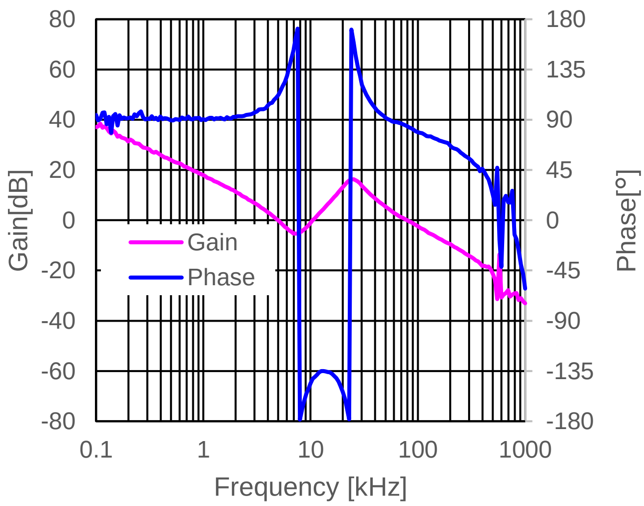


Figure 69. Frequency Response

(BOM 10, V_{IN}=24V, I_{OUT}=8A)

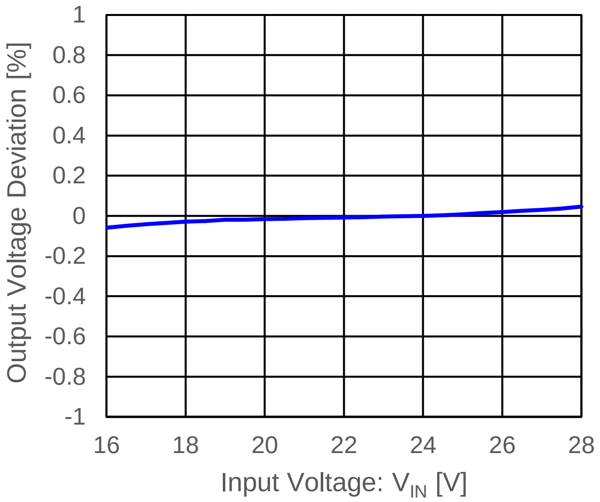


Figure 70. Line Regulation

(BOM 10, I_{OUT}=8A)

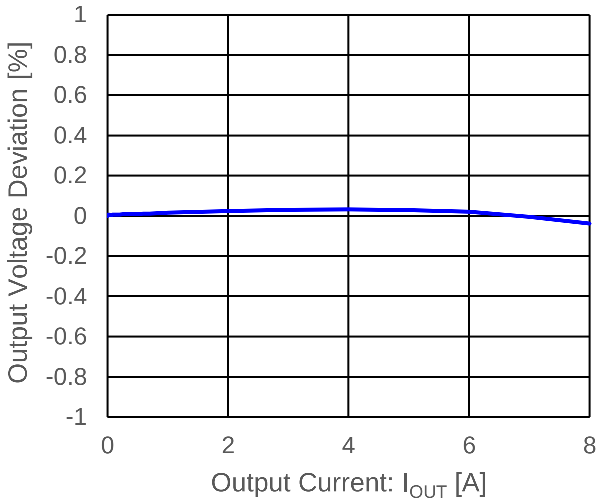


Figure 71. Load Regulation

(BOM 10, V_{IN}=24V)

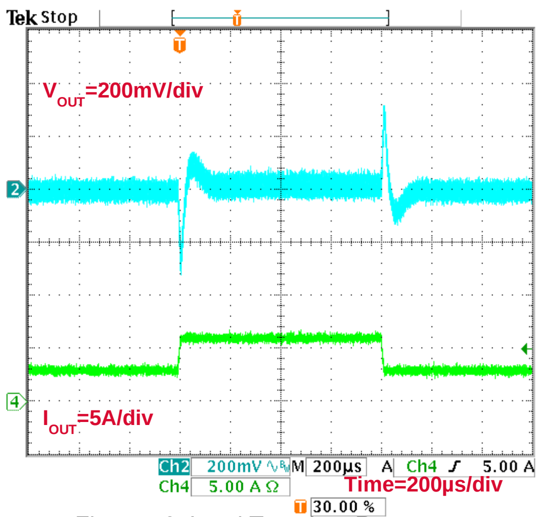


Figure 72. Load Transient Response

(BOM 10, V_{IN}=24V, I_{OUT}=3A⇔6A, SR=0.5A/µs)

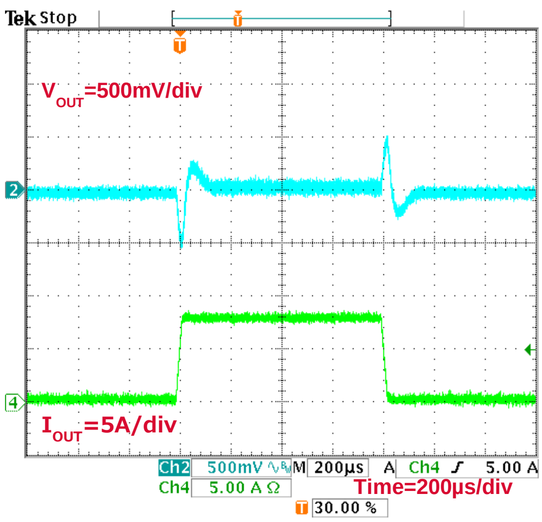


Figure 73. Load Transient Response

(BOM 10, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/µs)

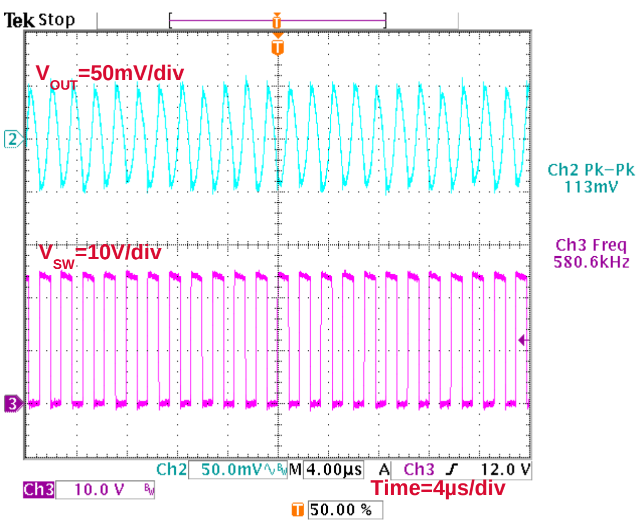


Figure 74. Output Ripple Voltage

(BOM 10, V_{IN}=24V, I_{OUT}=8A)

Bill of Materials and Application Data(continued)

11. V_{IN}=14 to 28V, V_{OUT}=12V, I_{OUT}=8A, f_{SW}=300kHz, L=4.7µH(Reference：
For use when 5.6µH of 8Ax 1.3 tolerance cannot be procured)

Table 14. Bill of Materials 11

Count	Parts No.	Type	Value	Description	Manufacturer Part Number	Manufacturer	Configuration (mm)
1	U1	IC	-	Single Synchronous BUCK Converter	BD9F800MUX-Z	ROHM	3.5 x 3.5
1	L1	Inductor	4.7µH	9.5A max, ±30%	1274AS-H-4R7N=P3	Murata	L: 10 W: 10
0	C0	-	-	Open	-	-	-
1	C1	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C2	Ceramic Capacitor	10µF	50V, X7S, ±20%	GRM32EC72A106ME05	Murata	3225
1	C3	Ceramic Capacitor	0.1µF	50V, X5R, ±10%	GRM155R61H104KE14	Murata	1005
1	C4	Ceramic Capacitor	2.2µF	10V, X5R, ±10%	GRM188R61E225KA12	Murata	1608
1	C5	Ceramic Capacitor	0.1µF	25V, X7R, ±10%	GRM155R71E104KE14	Murata	1005
0	C6	-	-	Open	-	-	-
1	C7	Ceramic Capacitor	47µF	16V, X6S, ±10%	GRM32EC81C476KE15	Murata	3216
1	C8	Ceramic Capacitor	22µF	25V, X5R, ±20%	GRM21BR61E226ME44L	Murata	2012
0	C9	-	-	Open	-	-	-
0	C10	-	-	Open	-	-	-
0	C11	-	-	Open	-	-	-
0	C12	-	-	Open	-	-	-
1	R1A	Resistor	0 Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R1B	Resistor	91kΩ	50V, ±1%, 1/16W	MCR01MZPF9102	ROHM	1005
1	R2	Resistor	6.2kΩ	50V, ±1%, 1/16W	MCR01MZPF6201	ROHM	1005
1	R3	Resistor	100kΩ	50V, ±1%, 1/16W	MCR01MZPF1003	ROHM	1005
0	R4	-	-	Open	-	-	-
1	R5	Resistor	10kΩ	50V, ±1%, 1/16W	MCR01MZPF1002	ROHM	1005
1	R6	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R7	Resistor	0Ω	Jumper	MCR01MZPJ000	ROHM	1005
1	R8	Resistor	10Ω	50V, ±5%, 1/16W	MCR01MZPJ100	ROHM	1005
0	R9	-	-	Open	-	-	-

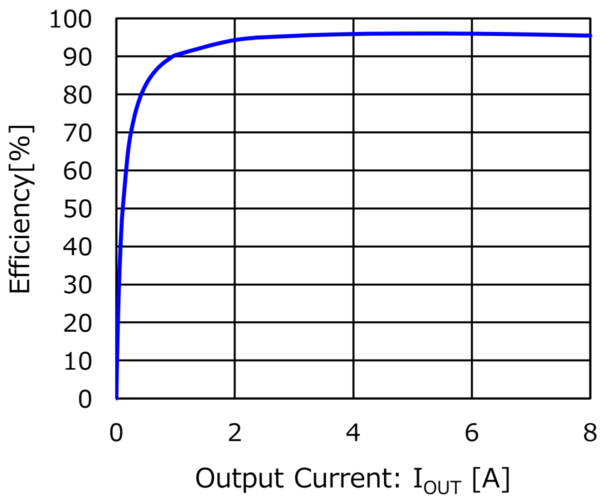


Figure 75. Efficiency vs Load Current
(BOM 11, V_{IN}=24V)

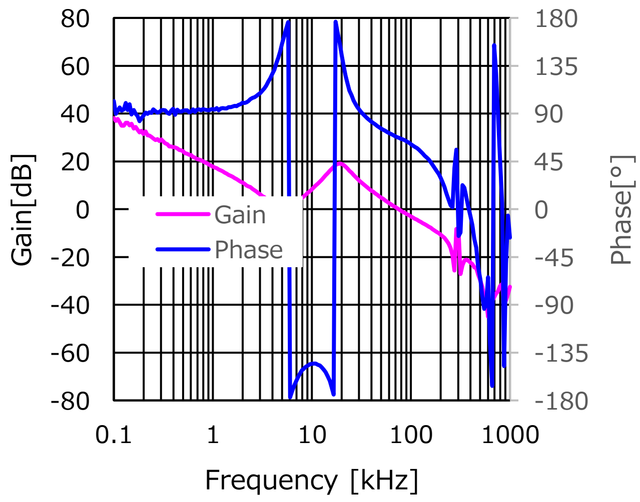


Figure 76. Frequency Response
(BOM 11, V_{IN}=24V, I_{OUT}=8A)

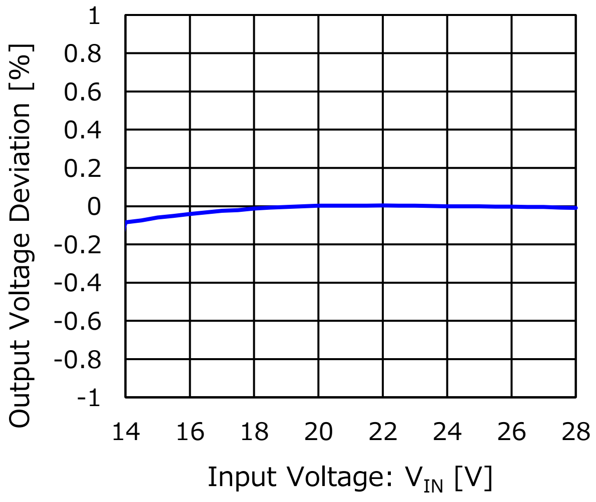


Figure 77. Line Regulation

(BOM 11, I_{OUT}=8A)

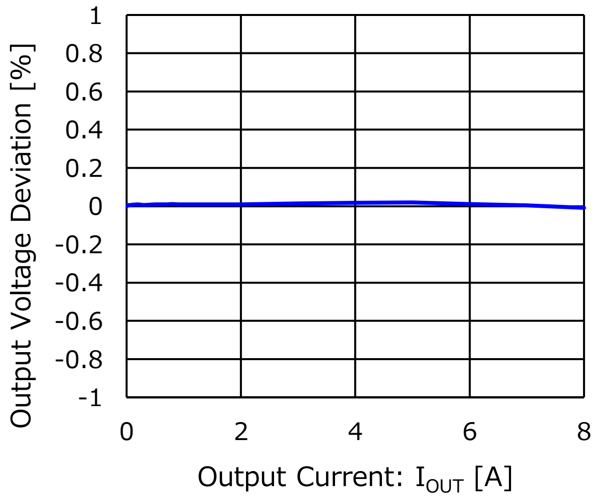


Figure 78. Load Regulation

(BOM 11, V_{IN}=24V)

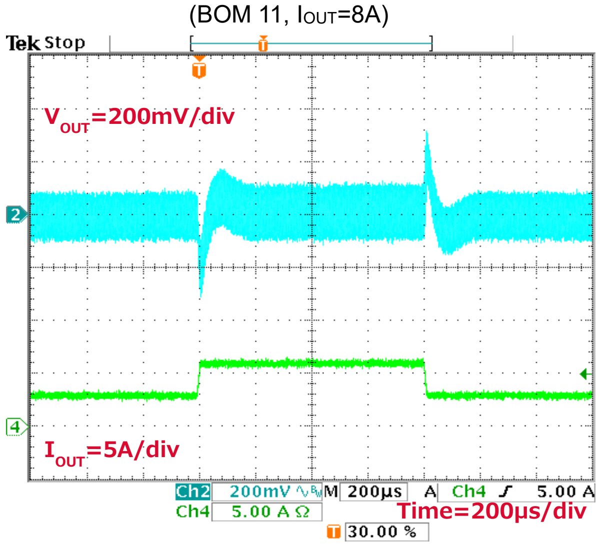


Figure 79. Load Transient Response

(BOM 11, V_{IN}=24V, I_{OUT}=3A⇔6A, SR=0.5A/µs)

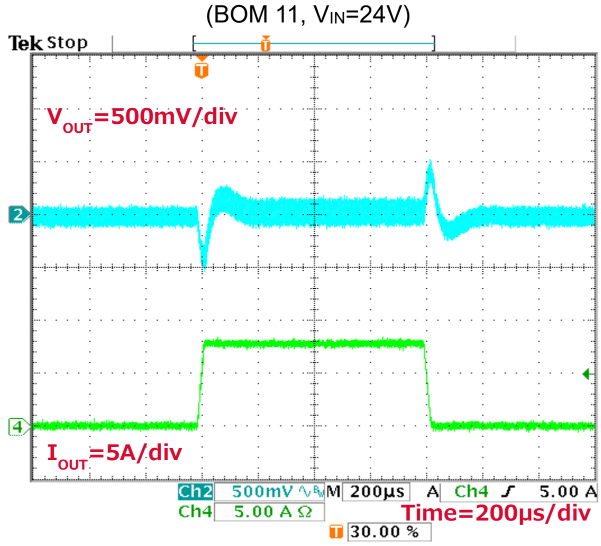


Figure 80. Load Transient Response

(BOM 11, V_{IN}=24V, I_{OUT}=0.1A⇔8A, SR=0.5A/µs)

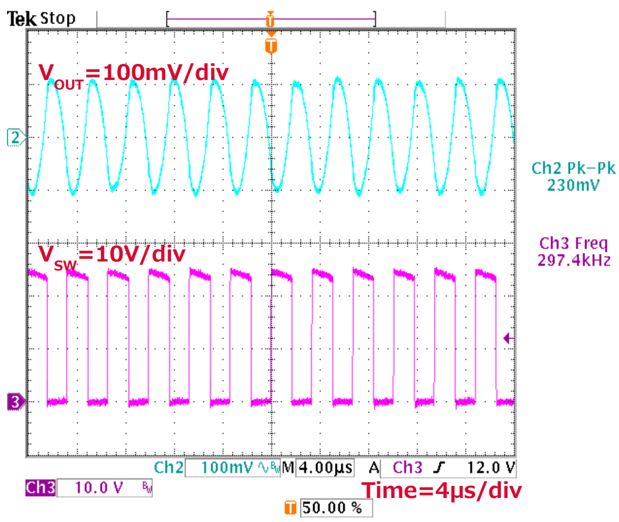


Figure 81. Output Ripple Voltage

(BOM 11, V_{IN}=24V, I_{OUT}=8A)

Parts listed in the Bill of Materials

The parts listed in the bill of materials list are available during the time of creating this application note. In case some parts are no longer available in the future, select the equivalent products.

Relationship between C_{LOAD} and I_{OSS} for stable start-up

The maximum capacitor value C_{LOAD} that can be connected to V_{OUT} in addition to C_{OUT} can be calculated using the external components L1, C7, C8, C9, and C10 as described in the bill of materials, and operating conditions, f_{SW}, V_{IN}, V_{OUT}, and the constants t_{SS}, which can be computed from the equations (1), (3), (4) and (5) on pages 3 and 4 and express as the equation:

$$C_{LOAD} < \frac{\left(8.5 - I_{OSS} + \frac{1}{2} \times \frac{V_{IN} - V_{OUT}}{L1} \times \frac{V_{OUT}}{V_{IN}} \times \frac{1}{f_{SW}}\right) \times t_{ss}}{V_{OUT}} - C_{OUT}$$

where C_{OUT} = C7 + C8 + C9 + C10 is the capacitance component of the LC filter configured for the output.

Figure 82 shows the relationship between C_{LOAD} and I_{OSS} plotted with the same t_{SS}=0.5ms (Minimum value in datasheet) and f_{SW}=Typical value +10% as used in the calculation tool "Calculation-Sheet For The Circuit Theoretical Formula - BD9F800MUX-Z" with constants for each bill of materials. For stable start-up, design the value of C_{LOAD} below each curve. Figure 82 shows the start-up conditions, which means that during normal operation after start-up, the upper operating conditions of each curve may be used as long as it is within the specifications of the BD9F800MUX-Z.

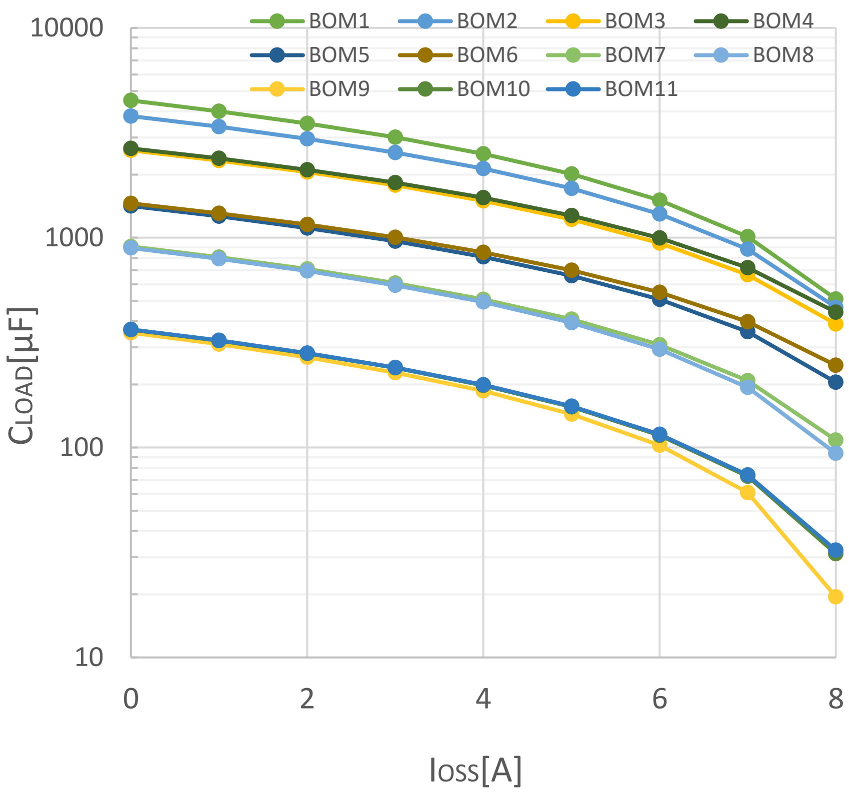


Figure 82. Relationship between C_{LOAD} and I_{OSS} for stable startup at each bill of materials

Revision History

Date	Revision Number	Description
5. Sep. 2022	001	Initial release
13. May. 2024	002	Typo error correction Change to 0ΩJumper from Opem onR1A in Table12 in Page22, Table13 in Page24 and Table14 in Page26.

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