SPICE Modeling Report

4.0 V to 17 V Input, 3 A Integrated MOSFET Single Synchronous Buck DC/DC BD9D300MUV

General Description

In this report, the characteristics that can be confirmed by the simulation using the SPICE model of the regulator IC BD9D300MUV will be described.

Simulation Environment

- Circuit Simulator : PSpice / Cadence Design System, Inc.
- Version Information : 17.2-2016
- OS Information : Windows 10 64-bit Edition

File Information

- Library File Name : BD9D300MUV.lib
- Symbol File Name : BD9D300MUV.olb
- Subcircuit and Symbol

Table 1 Correspondence Table

Product Name	Subcircuit	Symbol
BD9D300MUV	BD9D300MUV (Model for Transient Analysis)	BD9D300MUV
		BD9D300MUV_CAD (Note2)
	BD9D300MUV_AVE (Note1) (Model for AC Analysis)	BD9D300MUV_AVE (Note3)
		BD9D300MUV_AVE_CAD (Note2) (Note3)

(Note 1) BD9D300MUV_AVE is the spice macro model for Frequency Characteristic (AC simulation). Refer to Page 10 to 11 for simulation detail.
(Note 2) Symbol with _CAD at the end of the name conform to IEC60617, and were designed so that signals flow from left to right.
(Note 3) Pin information for BD9D300MUV_AVE is same like Table 2.

Caution

- These model characteristics are specifically at Ta = 25 °C. Thus, the simulation result with temperature variances may significantly differ from the result with the one done at actual application board (actual measurement).
- The simulation result and characteristics described in this report may differ depending on the board design. It is recommended to perform the measurement on the actual board to verify the result.
- The values from the simulation results are not guaranteed. Use these results as a guide for your design.
- Actual measurement was done using a specific sample, thus the measured data is just as a reference.

BD9D300MUV Spice Model

■ Pin Information

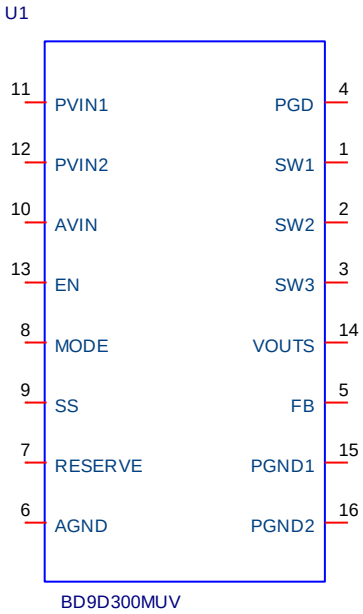

Figure 1 Symbol of BD9D300MUV

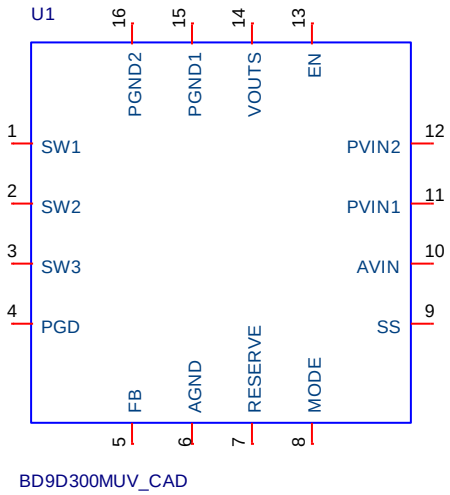

Figure 2 Symbol of BD9D300MUV_CAD

Table 2 Subcircuit Pin Table

Pin No.	Pin Name	Pin No.	Pin Name
1.	SW1	9.	SS
2.	SW2	10.	AVIN
3.	SW3	11.	PVIN1
4.	PGD	12.	PVIN2
5.	FB	13.	EN
6.	AGND	14.	VOUTS
7.	RESERVE	15.	PGND1
8.	MODE	16.	PGND2

■ Model Parameter

Table 3 Model Parameter Table

Parameter	Default Value	Description
BD9D300MUV_AVE		
v_vo	5	On Duty parameter for the Numerator.
v_vin	12	On Duty parameter for the Denominator. On Duty is given as { v_vo / v_vin }.

Verifiable Characteristics

Electrical Characteristics (vs. Datasheet)

Table 4 Electrical Characteristics Comparison

(Unless otherwise specified Ta = 25 °C, V_{PVIN} = V_{AVIN} = 12 V, V_{EN} = 5 V, V_{MODE} = GND)

Parameter	Modeled *(Note1)*	Design Value		Unit	Error	Condition
		Datasheet	SPICE			
Power Supply (AVIN)						
Shutdown Current	Yes	3	3	µA	0%	V_{EN} = 0 V
Operating Quiescent Current	Yes	20	20	µA	0%	I_{OUT} = 0 A, No switching
UVLO Detection Threshold Voltage	Yes	3.6	3.6	V	0%	V_{IN} falling
UVLO Hysteresis Voltage	Yes	200	200	mV	0%	
Enable						
EN Input High Level Voltage	Yes	-	0.55	V	-	
EN Input Low Level Voltage	Yes	-	0.45	V	-	
EN Input Current	Yes	-	0	µA	-	
Reference Voltage, Error Amplifier, Soft Start						
FB threshold Voltage	Yes	0.8	0.8	V	0%	
FB Input Current	Yes	1	1	nA	0%	V_{FB} = 0.8 V
Soft Start Charge Current	Yes	2.5	2.5	µA	0%	
Internal Soft Start Time	Yes	1	1	ms	0%	
Control						
MODE Input High Level Voltage	Yes	-	0.65	V	-	
MODE Input Low Level Voltage	Yes	-	0.55	V	-	
On Time	Yes	333	333	ns	0%	V_{OUT} = 5.0 V
Power Good						
Power Good Rising Threshold Voltage	Yes	95	95	%	0%	V_{FB} rising, V_{PGDR} = V_{FB} / V_{FBTH} x 100
Power Good Falling Threshold Voltage	Yes	90	90	%	0%	V_{FB} falling, V_{PGDF} = V_{FB} / V_{FBTH} x 100
PGD Output Leakage Current	Yes	0	0	nA	0%	V_{PGD} = 5 V
PGD MOSFET ON Resistance	Yes	100	100	Ω	0%	
PGD Low Level Voltage	Yes	0.2	0.2	V	0%	I_{PGD} = 2 mA
SW (MOSFET)						
High-Side FET ON Resistance	Yes	110	110	mΩ	0%	
Low-Side FET ON Resistance	Yes	50	50	mΩ	0%	
High-Side Output Leakage Current	Yes	0	0	µA	0%	No switching
Low-Side Output Leakage Current	Yes	0	0	µA	0%	No switching

(Continued)

Parameter	Modeled *(Note1)*	Design Value		Unit	Error	Condition
		Datasheet	SPICE			
Protection						
Output OVP Detection Voltage	Yes	120	120	%	0%	V_{FB} rising, $V_{OVPH} = V_{FB} / V_{FBTH}$ x 100
Output OVP Release Voltage	Yes	115	115	%	0%	V_{FB} falling, $V_{OVPL} = VFB / V_{FBTH}$ x 100
Low-Side FET Over Current Detection Current *(Note 2)*	Yes	3.8	3.8	A	0%	

(Note 1) Yes: Model available (supported), No: Model not available (not supported).
(Note 2) No tested on outgoing inspection.

Characteristic in SPICE (vs. Measured Waveform)
1. Steady State (Vin = 12 V, Vout = 5 V)

Simulation Setting
Type: Transient
Run Time: 3 ms
(Maximum Step Size: 10 ns)

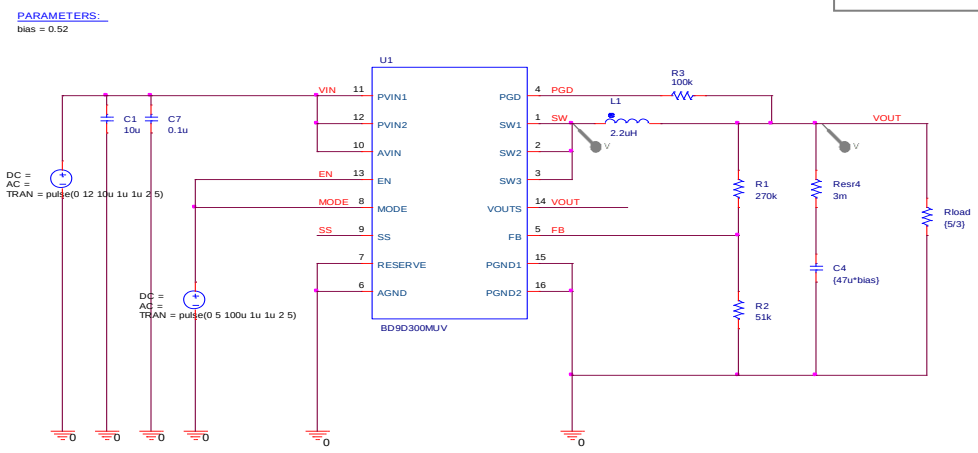

Figure 3.
Simulation Schematic 1

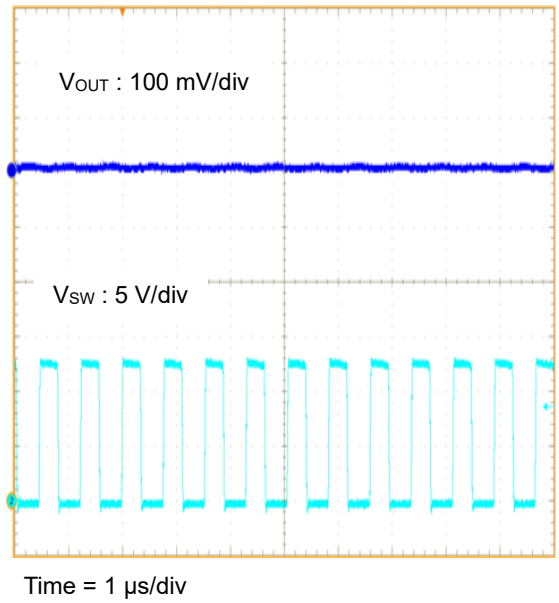

Figure 4.
Steady State (Vin = 12 V, Vout = 5 V)
(Measured Waveform)

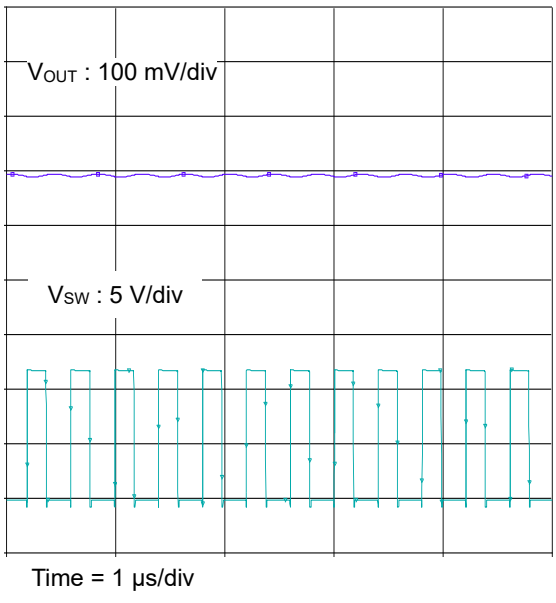

Figure 5.
Steady State (Vin = 12 V, Vout = 5 V)
(SPICE Simulation)

Table 5 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Switching Frequency	1.25	1.24	MHz	-0.8 %	V_{IN} = 12 V, V_{OUT} = 5 V, I_{OUT} = 3 A MODE = High

(Note 1) The above data is based on a specific sample and it is not a guaranteed value.
(Note 2) These characteristics depend on some dynamic characteristics of external components, input signal speed, PCB pattern and mounting condition of each on-board parts.

2. Steady State (Vin = 12 V, Vout = 3.3 V)

Simulation Setting
Type: Transient
Run Time: 3 ms
(Maximum Step Size: 10 ns)

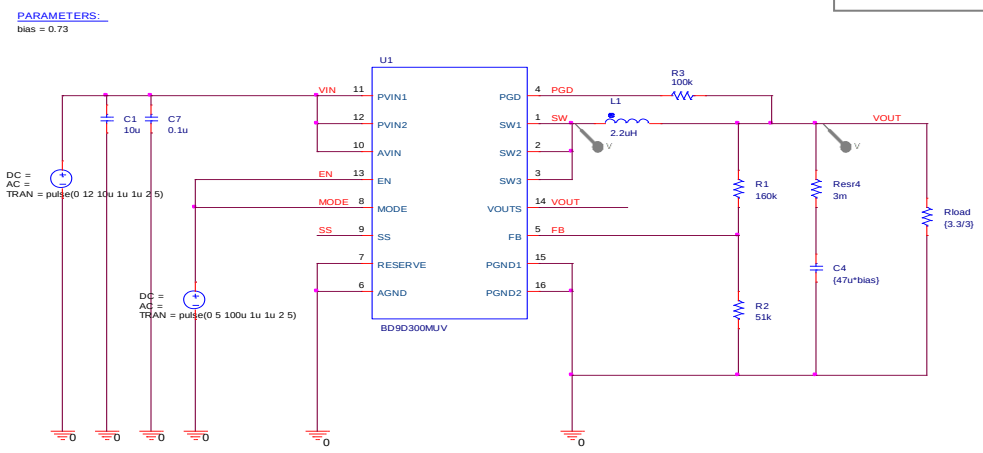

Figure 6.
Simulation Schematic 2

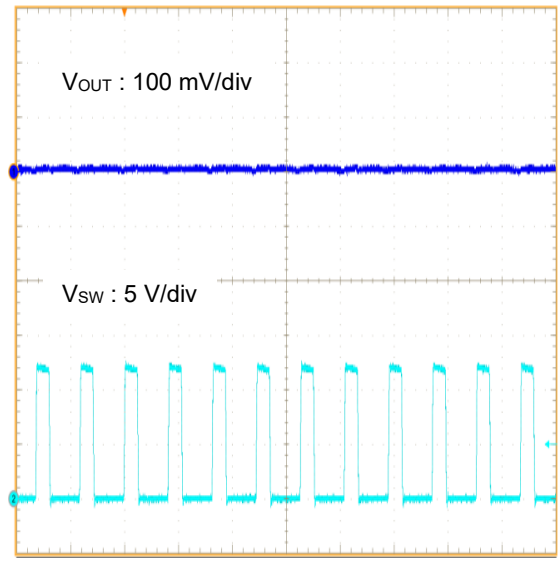

Figure 7.
Steady State (Vin = 12 V, Vout = 3.3 V)
(Measured Waveform)

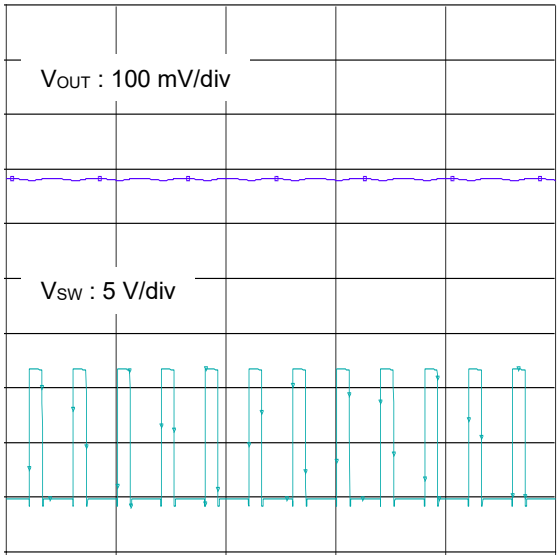

Figure 8.
Steady State (Vin = 12 V, Vout = 3.3 V)
(SPICE Simulation)

Table 6 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Switching Frequency	1.25	1.25	MHz	0.0 %	V_{IN} = 12 V, V_{OUT} = 3.3 V, I_{OUT} = 3 A MODE = High

(Note 1) The above data is based on a specific sample and it is not a guaranteed value.
(Note 2) These characteristics depend on some dynamic characteristics of external components, input signal speed, PCB pattern and mounting condition of each on-board parts.

3. Load Response (Vin = 12 V, Vout = 5 V)

Simulation Setting
Type: Transient
Run Time:12 ms
(Maximum Step Size: 10 ns)

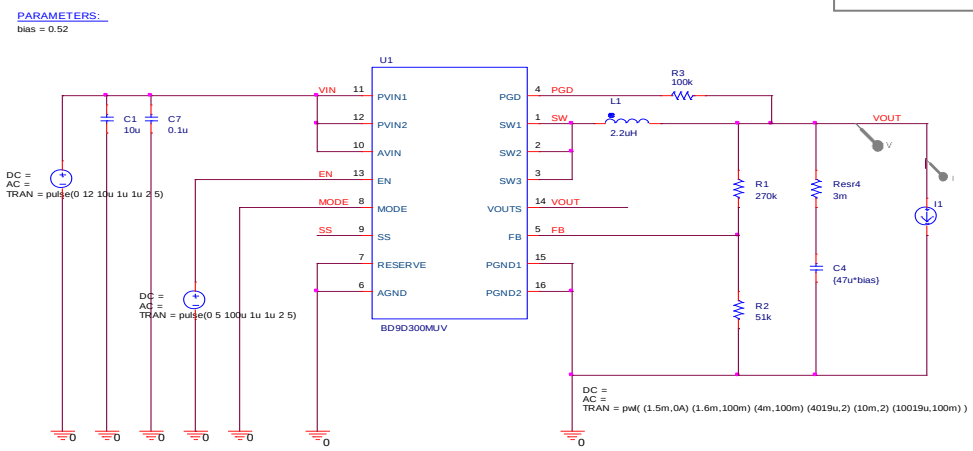

Figure 9.
Simulation Schematic 3

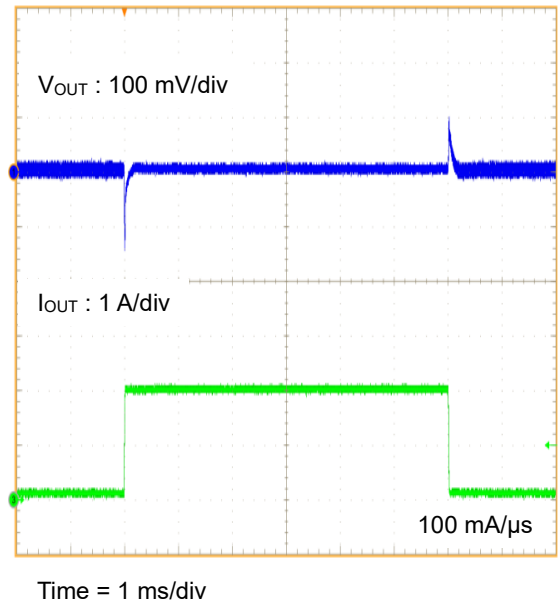

Figure 10.
Load Response (Vin = 12 V, Vout = 5 V)
(Measured Waveform)

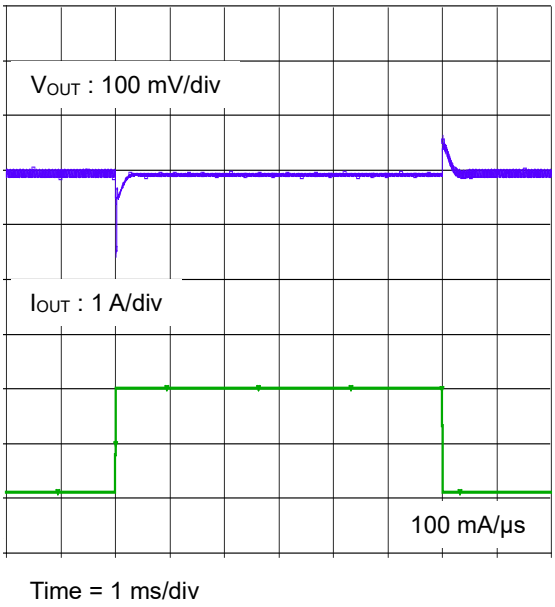

Figure 11.
Load Response (Vin = 12 V, Vout = 5 V)
(SPICE Simulation)

Table 7 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Undershoot	152.4	147.9	mV	-3.0 %	V_{IN} = 12 V, V_{OUT} = 5 V, I_{OUT} = 0.1 A to 2 A, MODE = Low
Overshoot	85.6	76.7	mV	-10.4 %	

(Note 1) The above data is based on a specific sample and it is not a guaranteed value.
(Note 2) These characteristics depend on some dynamic characteristics of external components, input signal speed, PCB pattern and mounting condition of each on-board parts.

4. Load Response (Vin = 12 V, Vout = 3.3 V)

Simulation Setting
Type: Transient
Run Time:12 ms
(Maximum Step Size: 10 ns)

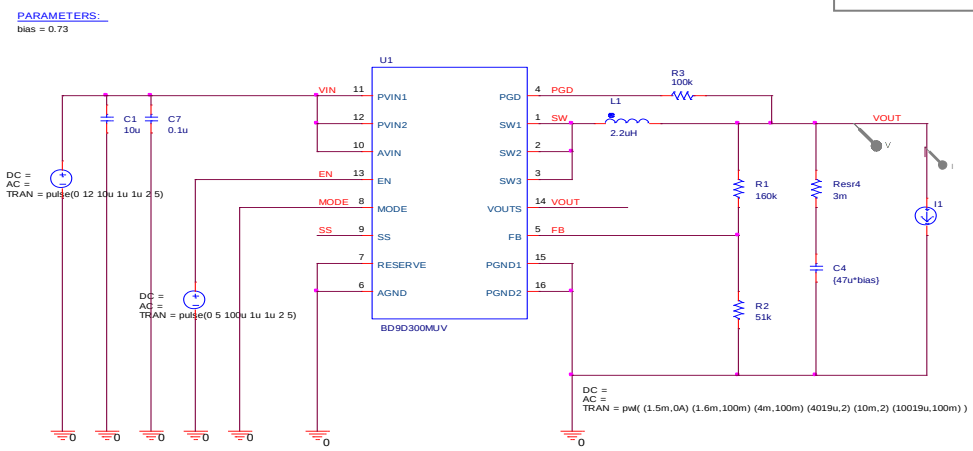

Figure 12.
Simulation Schematic 4

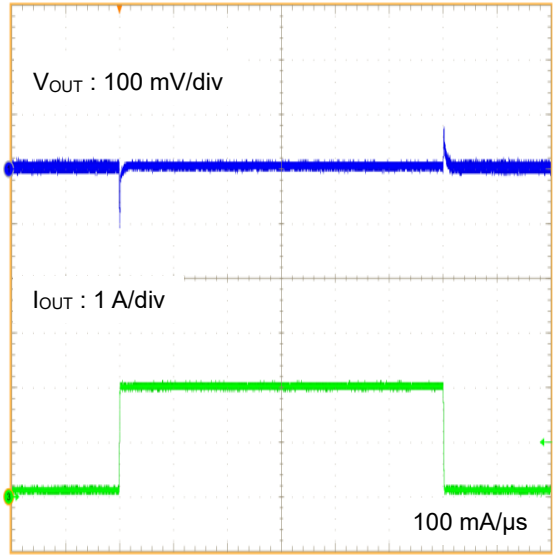

Figure 13.
Load Response (Vin = 12 V, Vout = 3.3 V)
(Measured Waveform)

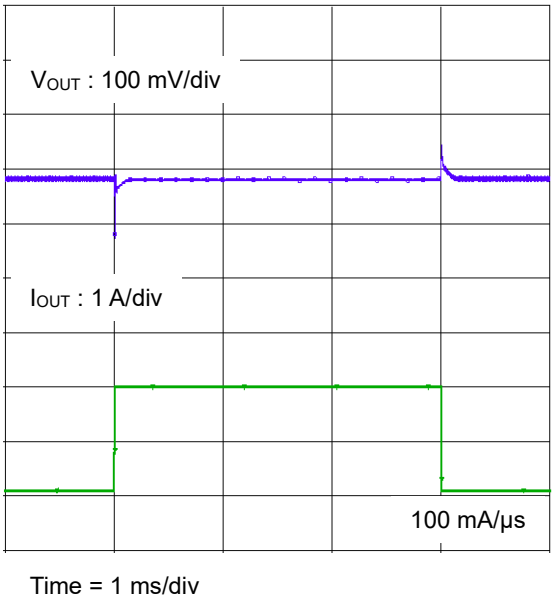

Figure 14.
Load Response (Vin = 12 V, Vout = 3.3 V)
(SPICE Simulation)

Table 8 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Undershoot	112.4	111.1	mV	-1.2 %	V_{IN} = 12 V, V_{OUT} = 3.3 V, I_{OUT} = 0.1 A to 2 A, MODE = Low
Overshoot	73.6	61.4	mV	-16.6 %	

(Note 1) The above data is based on a specific sample and it is not a guaranteed value.
(Note 2) These characteristics depend on some dynamic characteristics of external components, input signal speed, PCB pattern and mounting condition of each on-board parts.

5. Frequency Characteristic (Vin = 12 V, Vout = 5 V)

Simulation Setting
Type: AC
Frequency Range:
1 kHz to 1 MHz
(Points/Decade: 20)

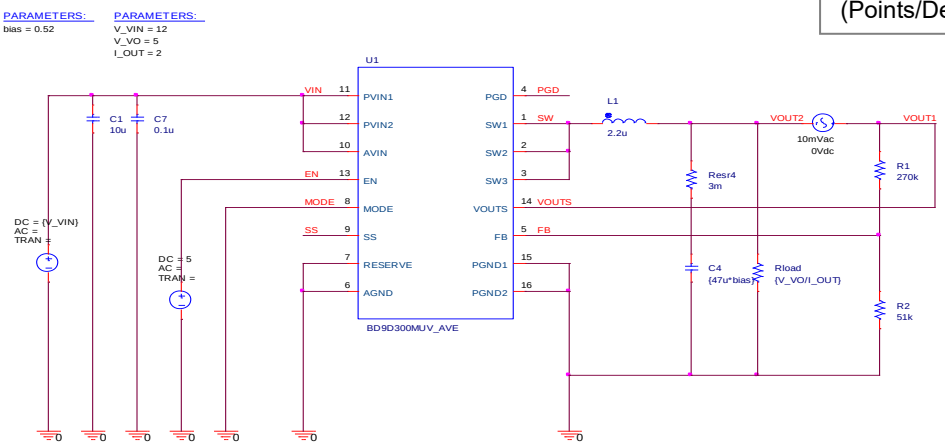

Figure 15.
Simulation Schematic 5

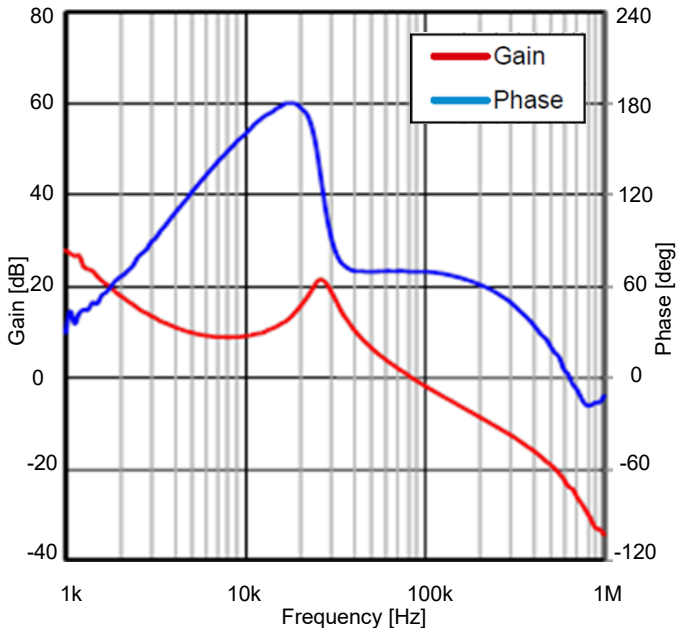

Figure 16.
Frequency Characteristic (Vin = 12 V, Vout = 5 V)
(Measured Waveform)

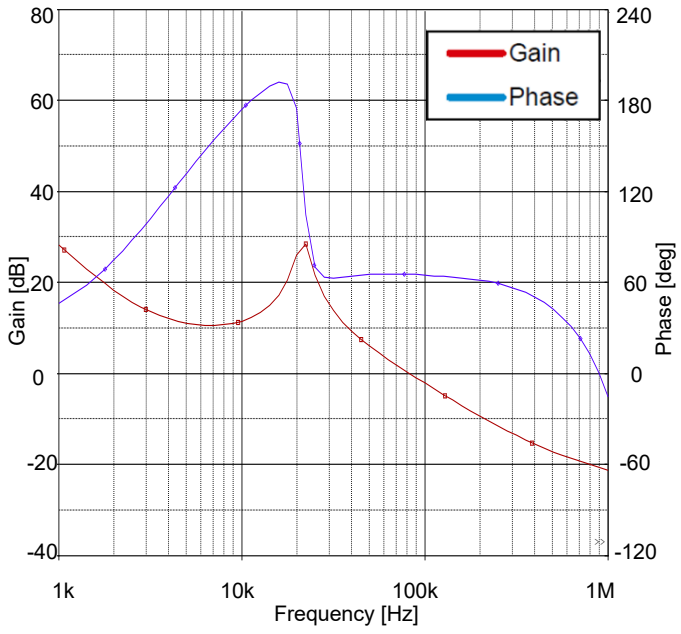

Figure 17.
Frequency Characteristic (Vin = 12 V, Vout = 5 V)
(SPICE Simulation)

Table 9 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Phase Margin	72	65.5	degree	-9.0 %	V_{IN} = 12 V, V_{OUT} = 5 V, I_{OUT} = 2 A, MODE = Low
Crossover Frequency	83	83.1	kHz	0.1 %	

(Note 1) The above data is based on a specific sample and it is not a guaranteed value.
(Note 2) These characteristics depend on some dynamic characteristics of external components, input signal speed, PCB pattern and mounting condition of each on-board parts.

6. Frequency Characteristic (Vin = 12 V, Vout = 3.3 V)

Simulation Setting
Type: AC
Frequency Range:
1 kHz to 1 MHz
(Points/Decade: 20)

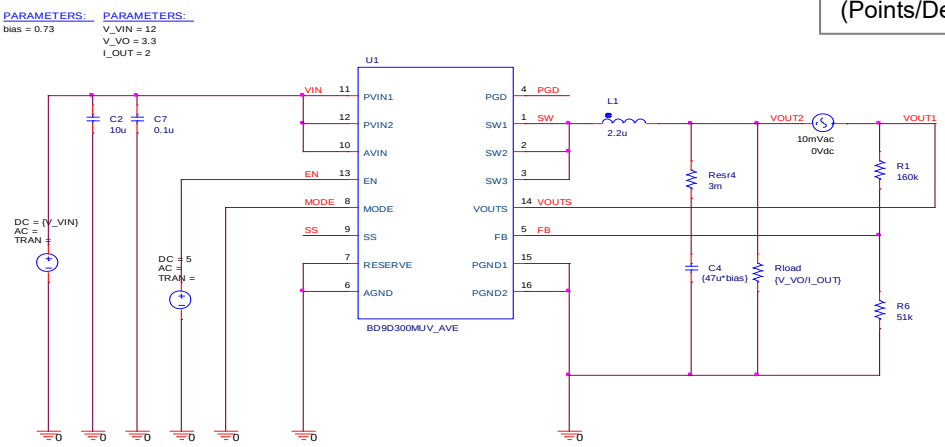

Figure 18.
Simulation Schematic 6

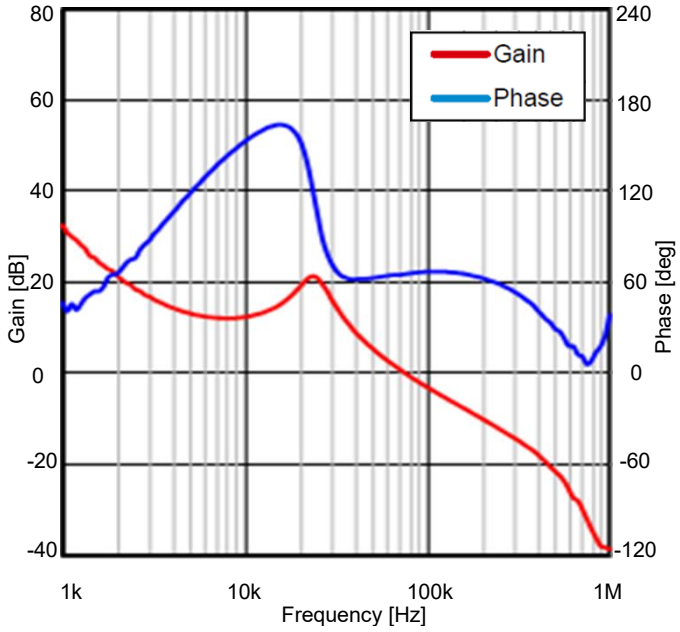

Figure 19.
Frequency Characteristic (Vin = 12 V, Vout = 3.3 V)
(Measured Waveform)

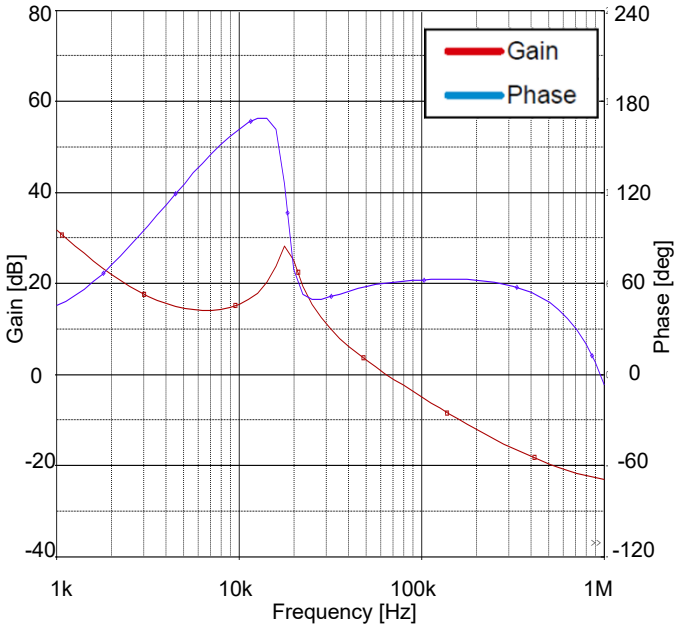

Figure 20.
Frequency Characteristic (Vin = 12 V, Vout = 3.3 V)
(SPICE Simulation)

Table 10 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Phase Margin	66	60.7	degree	-8.0 %	V_{IN} = 12 V, V_{OUT} = 3.3 V, I_{OUT} = 2 A, MODE = Low
Crossover Frequency	73	64.9	kHz	-11.1 %	

(Note 1) The above data is based on a specific sample and it is not a guaranteed value.
(Note 2) These characteristics depend on some dynamic characteristics of external components, input signal speed, PCB pattern and mounting condition of each on-board parts.

Revision History

Date	Revision	Changes
May.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.
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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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