SPICE Modeling Report

2.7V to 5.5V Input, 2.0A Integrated MOSFET Single Synchronous Buck DC/DC Converter

BD9B206NF-Z

General Description

In this report, the characteristics that can be confirmed by the simulation using the SPICE model of the regulator IC BD9B206NF-Z will be described.

Simulation Environment

- Circuit Simulator : PSpice / Cadence Design System, Inc.
- Version Information : 22.1-2022
- OS Information : Windows 10 64-bit Edition

File Information

- Library File Name : BD9B206NF-Z_PSpice.lib
- Symbol File Name : BD9B206NF-Z.olb
- Subcircuit and Symbol

Table 1 Correspondence Table

Product Name	Subcircuit	Symbol
BD9B206NF-Z	BD9B206NF-Z (Model for Transient Analysis)	BD9B206NF-Z
	BD9B206NF-Z_AVE*(Note1)* (Model for AC Analysis)	BD9B206NF-Z_AVE*(Note2)*

(Note 1) BD9B206NF-Z_AVE is the spice macro model for Frequency Characteristic (AC simulation). Refer to Page 13 to 14 for simulation detail.
(Note 2) Pin information for BD9B206NF-Z_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.

BD9B206NF-Z Spice Model

■ Pin Information

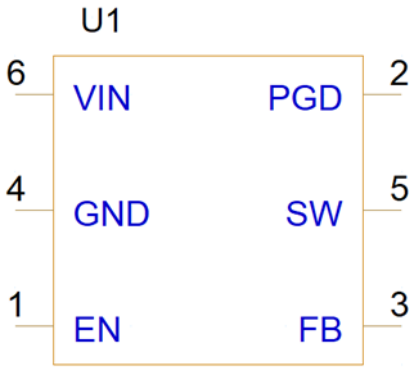

Figure 1 Symbol of BD9B206NF-Z

(Note) PIN configuration is different from the actual device.

Table 2 Subcircuit Pin Table

Pin No.	Pin Name	Pin No.	Pin Name
1.	EN	4.	GND
2.	PGD	5.	SW
3.	FB	6.	VIN

■ Model Parameter

Table 3 Model Parameter Table

Parameter	Default Value	Description
BD9B206NF-Z_AVE		
V_VIN	5	Set the VIN value.
V_VO	1.8	Set the VOUT value.

Verifiable Characteristics

Electrical Characteristics (vs. Datasheet)

Table 4 Electrical Characteristics Comparison

(Unless otherwise specified Tj = -40 to +125 °C, V_{IN} = 5 V, V_{EN} = 5 V, Typical values are at Tj = +25 °C)

Parameter	Modeled *(Note1)*	Design Value		Unit	Error	Condition
		Datasheet	SPICE			
Input Supply						
Shutdown Current	Yes	0	0	µA	0 %	V_{EN} = 0 V, Tj = 25 °C
Quiescent Current at No Load	Yes	4	4	µA	0 %	I_{OUT} = 0 A, Tj = 25 °C No switching
UVLO Detection Threshold Voltage	Yes	2.200	2.200	V	0 %	V_{IN} falling
UVLO Hysteresis Voltage	Yes	400	400	mV	0 %	
Enable						
EN Input Voltage High	Yes	> 1.0	> 1.0	V	-	V_{EN} rising
EN Input Voltage Low	Yes	< 0.4	< 0.4	V	-	V_{EN} falling
EN Input Current	Yes	0	0	µA	0 %	V_{EN} = 5 V, Tj = 25 °C
Reference Voltage, Error Amplifier, Soft Start						
FB Terminal Voltage	Yes	0.600	0.600	V	0 %	V_{IN} = 5 V, PWM mode
FB Input Bias Current	Yes	< 50	< 50	nA	-	V_{FB} = 0.6 V, Tj = 25 °C
Soft Start Time	Yes	1.25	1.25	ms	0 %	
On Time						
On time	Yes	248	248	ns	0 %	V_{IN} = 3.3V, V_{OUT} = 1.8 V, PWM mode, Tj = 25 °C
SW (MOSFET)						
High Side FET ON Resistance	Yes	25	25	mΩ	0 %	V_{IN} = 5 V, Tj = 25 °C
Low Side FET ON Resistance	Yes	25	25	mΩ	0 %	V_{IN} = 5 V, Tj = 25 °C
High Side FET Leakage Current	Yes	0	0	µA	0 %	No switching, Tj = 25 °C
Low Side FET Leakage Current	Yes	0	0	µA	0 %	No switching, Tj = 25 °C
High Side FET Current Limit	Yes	3.5	3.5	A	0 %	
Low Side FET Current Limit	Yes	2.7	2.7	A	0 %	
SW Discharge Resistance	Yes	5	5	Ω	0 %	V_{EN} = 0 V, V_{SW} = 0.3 V
Power Good						
PGD Rising (Good) Voltage	Yes	96	96	%	0 %	V_{FB} rising, $V_{PGDRG} = V_{FB} / V_{FBTH}$ x 100
PGD Falling (Fault) Voltage	Yes	92	92	%	0 %	V_{FB} falling, $V_{PGDFF} = V_{FB} / V_{FBTH}$ x 100
PGD Falling (Good) Voltage	Yes	105	105	%	0 %	V_{FB} falling, $V_{PGDFG} = V_{FB} / V_{FBTH}$ x 100
PGD Rising (Fault) Voltage	Yes	110	110	%	0 %	V_{FB} rising, $V_{PGDRF} = V_{FB} / V_{FBTH}$ x 100
PGD Output Leakage Current	Yes	0	0	µA	0 %	V_{PGD} = 5 V, Tj = 25 °C
PGD Output Low Level Voltage	Yes	0.125	0.125	V	0 %	I_{PGD} = 1 mA

(Note 1) Yes: Model available (supported), No: Model not available (not supported).

Characteristic in SPICE (vs. Measured Waveform)

1. Output Ripple Voltage (V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 0.1 A)

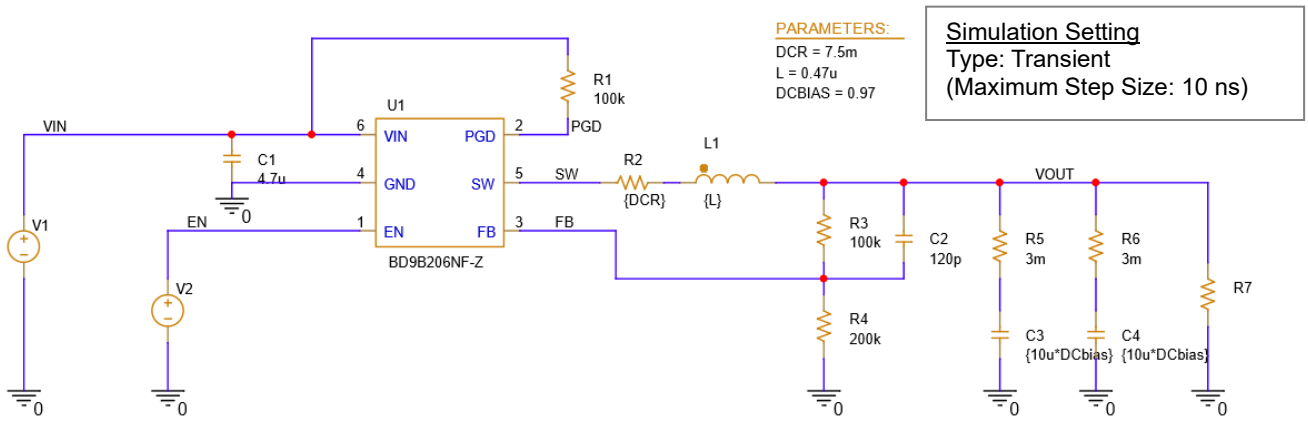

Figure 2.
Simulation Schematic 1

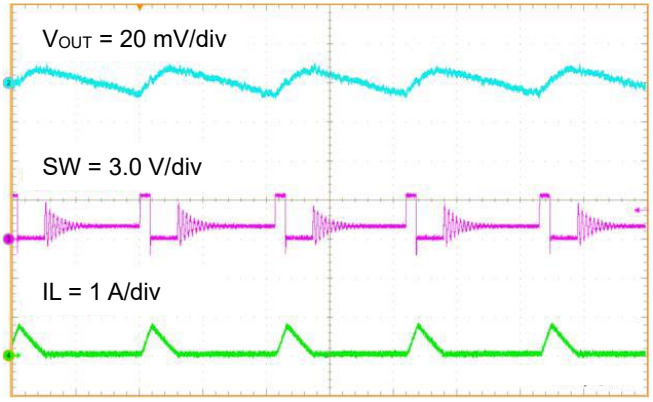

Figure 3.
Output Ripple Voltage
(V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 0.1 A)
(Measured Waveform)

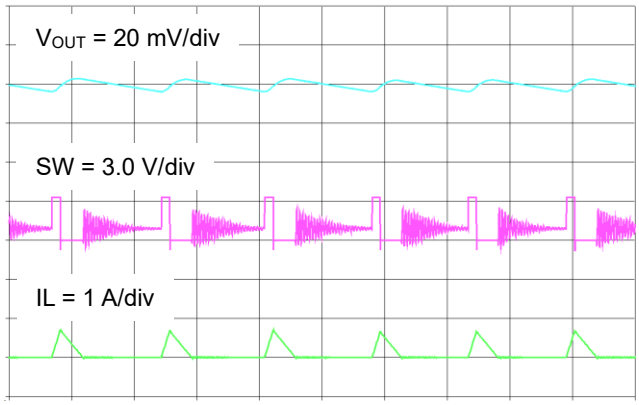

Figure 4.
Output Ripple Voltage
(V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 0.1 A)
(SPICE Simulation)

Table 5 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Output Ripple Voltage	13	8.8	mV	-30.8 %	V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 0.1 A

(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. Output Ripple Voltage (V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1 A)

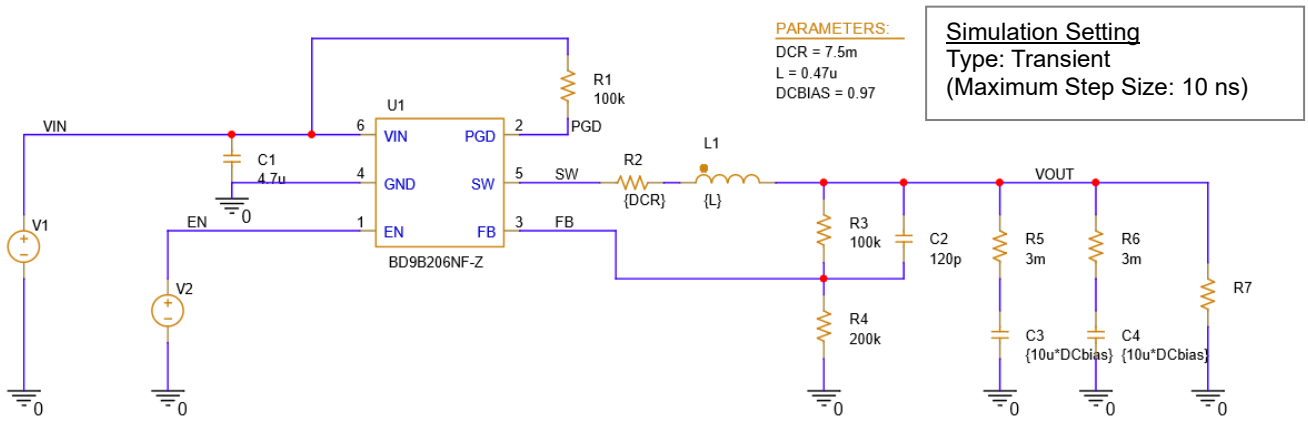

Figure 5.
Simulation Schematic 2

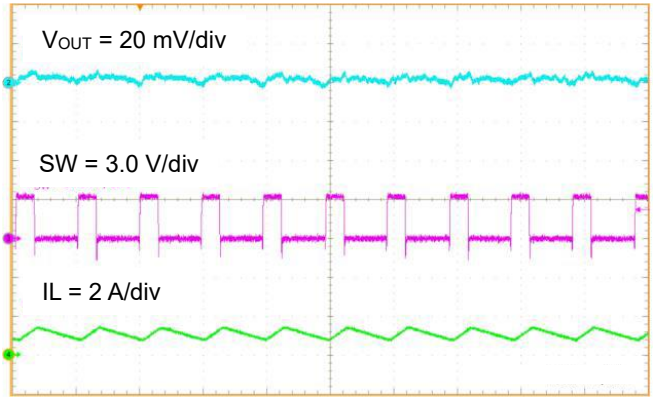

Figure 6.
Output Ripple Voltage
(V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1 A)
(Measured Waveform)

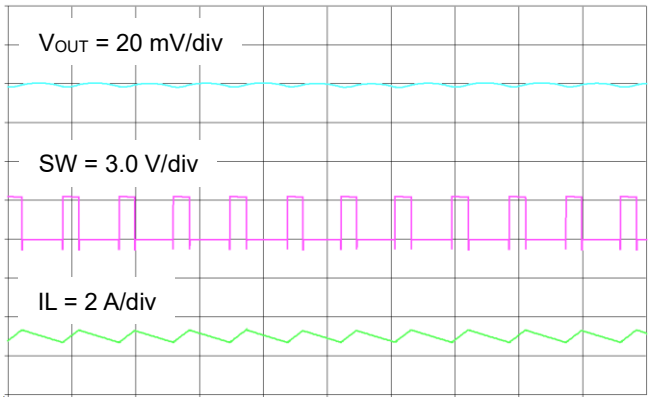

Figure 7.
Output Ripple Voltage
(V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1 A)
(SPICE Simulation)

Table 6 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Output Ripple Voltage	4.2	2.2	mV	-47.6 %	V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1 A

(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. Output Ripple Voltage (V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 0.1 A)

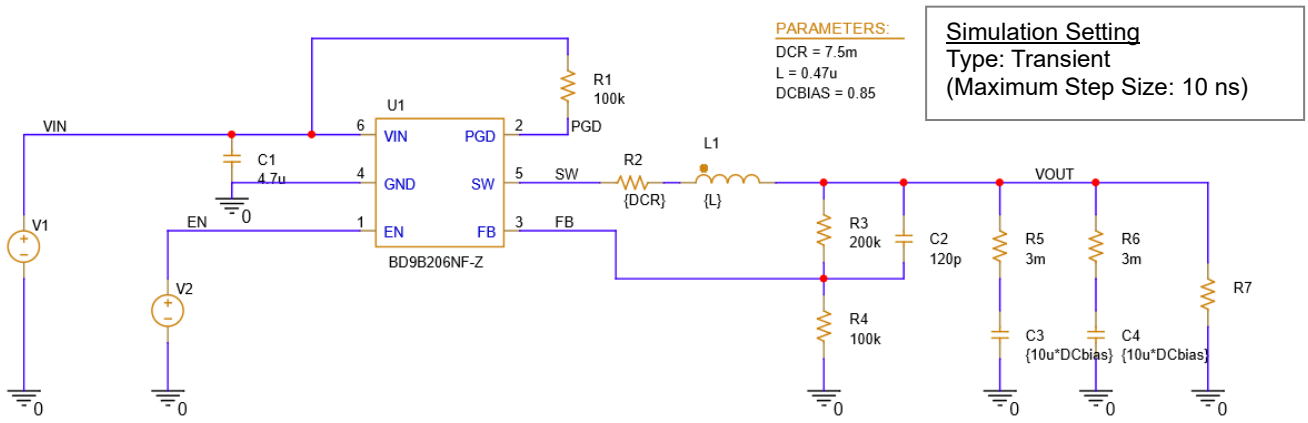

Figure 8.
Simulation Schematic 3

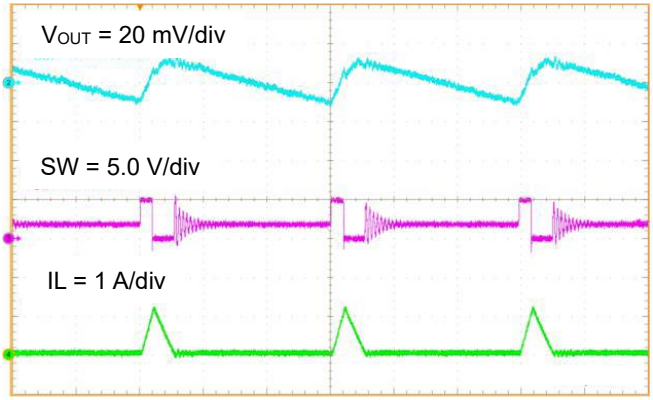

Figure 9.
Output Ripple Voltage
(V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 0.1 A)
(Measured Waveform)

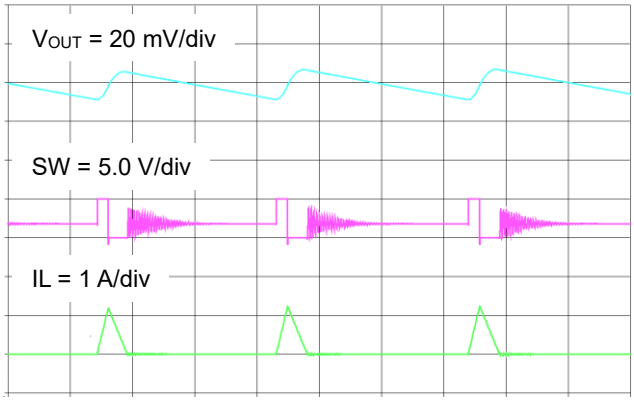

Figure 10.
Output Ripple Voltage
(V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 0.1 A)
(SPICE Simulation)

Table 7 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Output Ripple Voltage	21	15.2	mV	-28.6 %	V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 0.1 A

(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. Output Ripple Voltage (V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1 A)

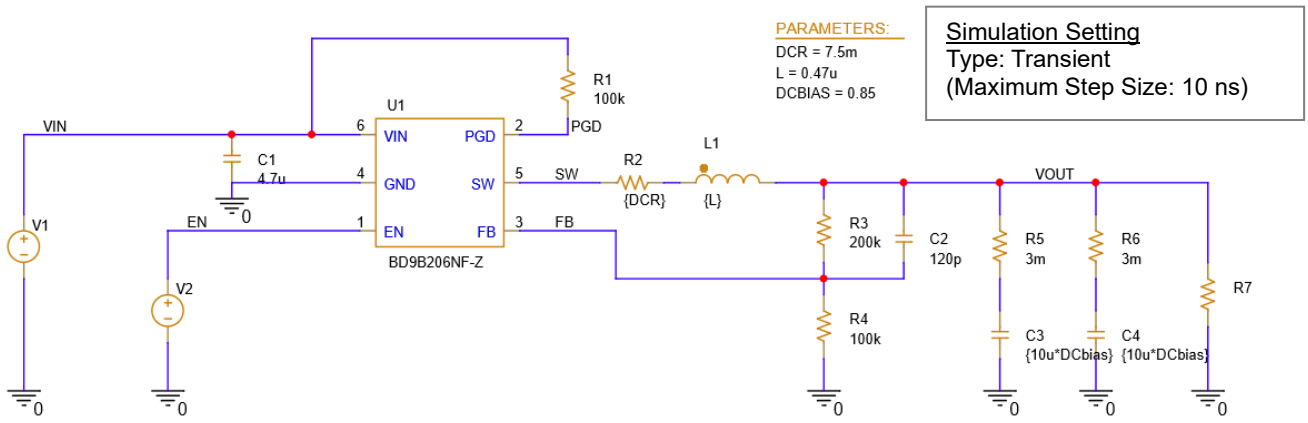

Figure 11.
Simulation Schematic 4

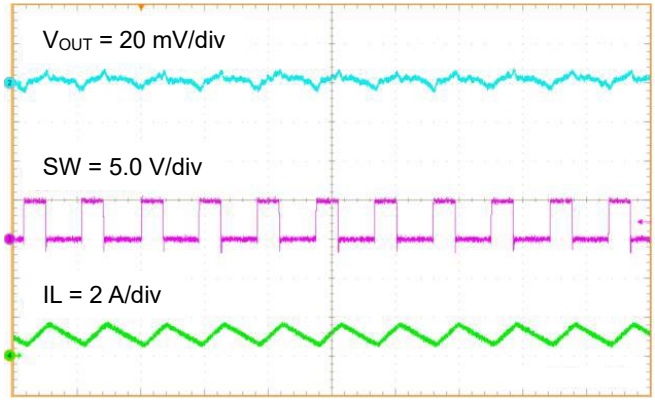

Figure 12.
Output Ripple Voltage
(V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1 A)
(Measured Waveform)

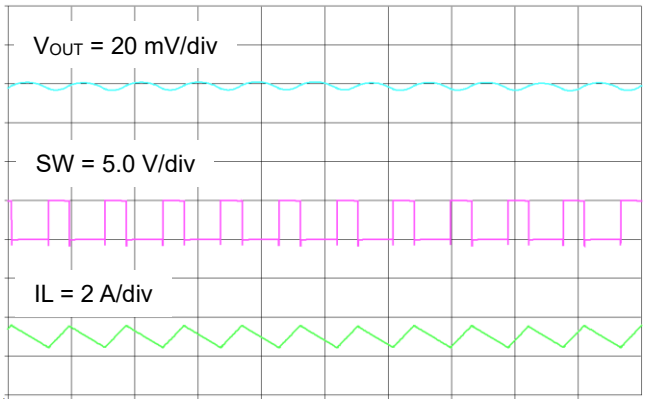

Figure 13.
Output Ripple Voltage
(V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1 A)
(SPICE Simulation)

Table 8 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Overshoot	6.2	4.1	mV	-33.9 %	V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1 A

(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. Load Transient Response (V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 0.05 A to 1.0 A)

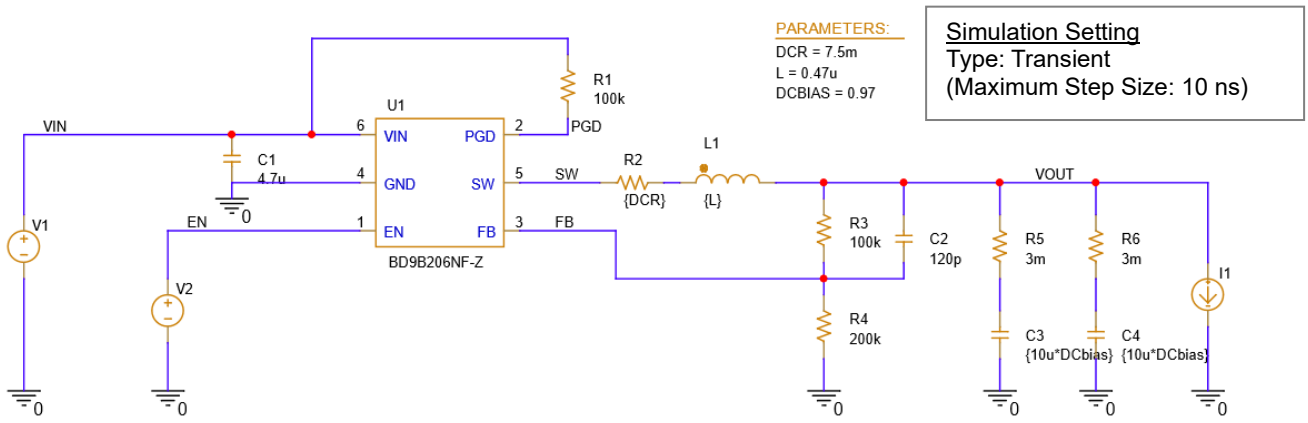

Figure 14.
Simulation Schematic 5

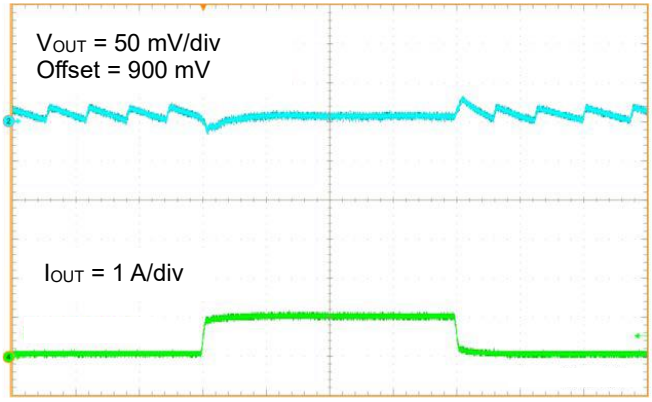

Figure 15.
Load Transient Response
(V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 0.05 A to 1.0 A)
(Measured Waveform)

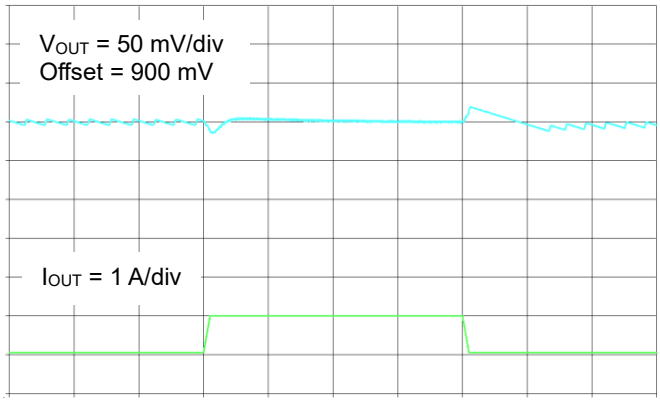

Figure 16.
Load Transient Response
(V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 0.05 A to 1.0 A)
(SPICE Simulation)

Table 9 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Overshoot	23	18.1	mV	-25.0 %	V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1.0 A to 0.05 A : -1 A/us
Undershoot	22	17.3	mV	-22.7 %	V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 0.05 A to 1.0 A : 1 A/us

(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. Load Transient Response (V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1.0 A to 2.0 A)

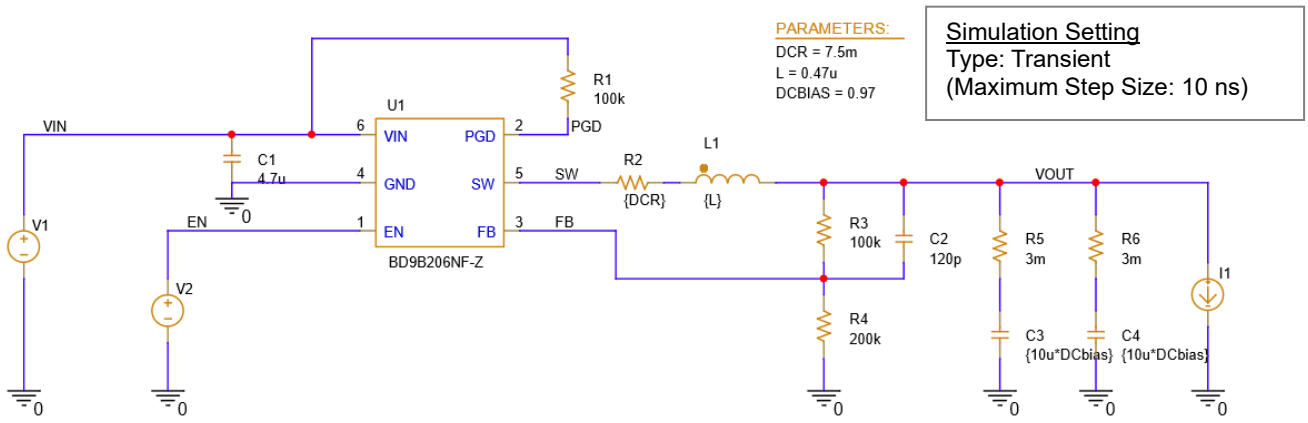

Figure 17.
Simulation Schematic 6

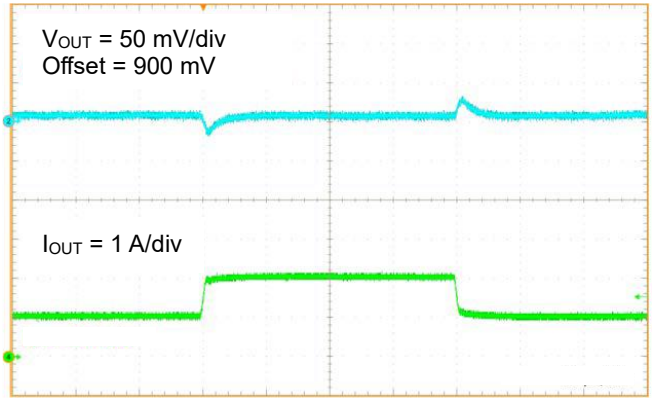

Figure 18.
Load Transient Response
(V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1.0 A to 2.0 A)
(Measured Waveform)

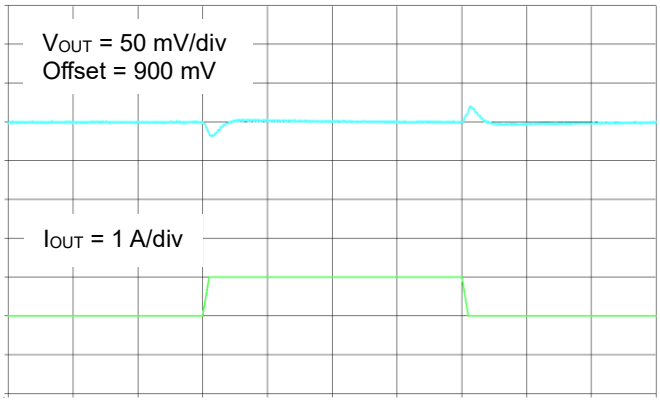

Figure 19.
Load Transient Response
(V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1.0 A to 2.0 A)
(SPICE Simulation)

Table 10 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Overshoot	22	18.9	mV	-13.6 %	V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 2.0 A to 1.0 A : -1 A/us
Undershoot	21	18.1	mV	-14.3 %	V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1.0 A to 2.0 A : 1 A/us

(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.

7. Load Transient Response (V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 0.05 A to 1.0 A)

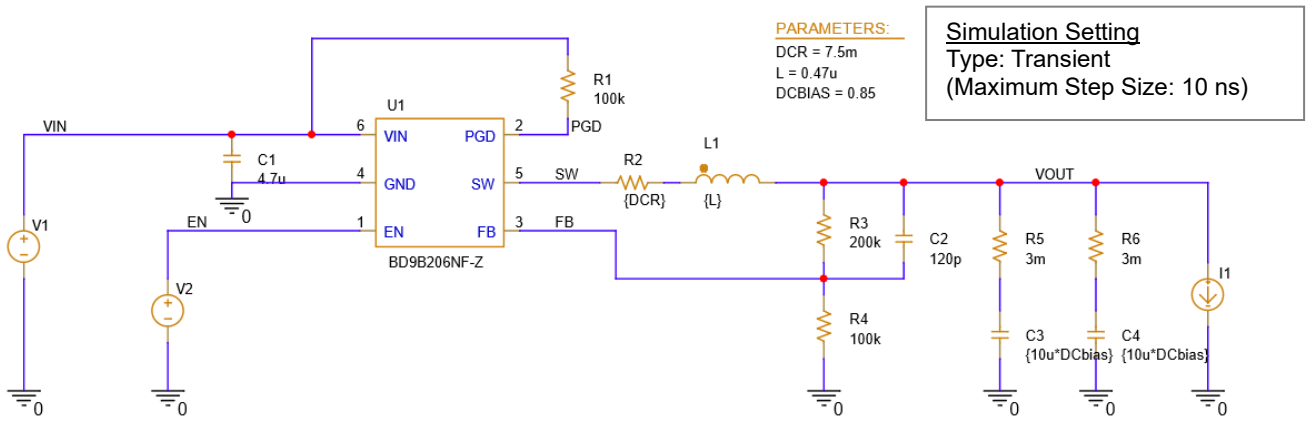

Figure 20.
Simulation Schematic 7

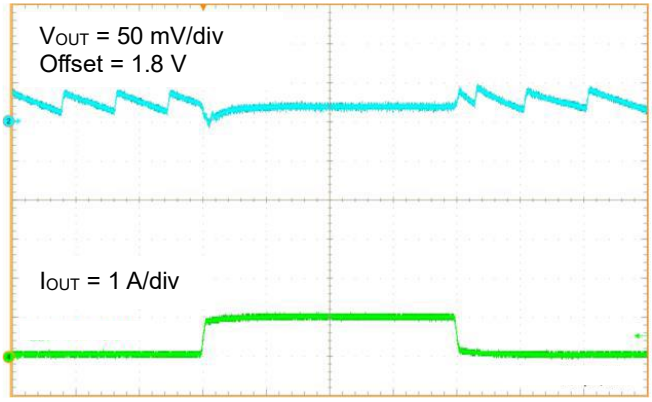

Figure 21.
Load Transient Response
(V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 0.05 A to 1.0 A)
(Measured Waveform)

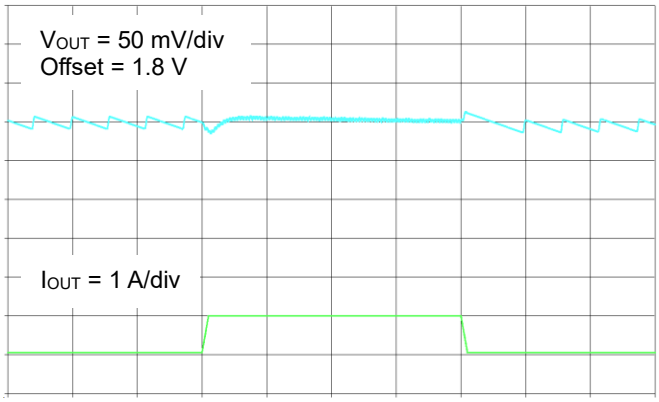

Figure 22.
Load Transient Response
(V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 0.05 A to 1.0 A)
(SPICE Simulation)

Table 11 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Overshoot	20	16.1	mV	-20.0 %	V_{IN} = 5.0 V, V_{OUT} = 1.8 V I_{OUT} = 1.0 A to 0.05 A : -1 A/us
Undershoot	19	15.2	mV	-21.1 %	V_{IN} = 5.0 V, V_{OUT} = 1.8 V I_{OUT} = 0.05 A to 1.0 A : 1 A/us

(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.

8. Load Transient Response (V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1.0 A to 2.0 A)

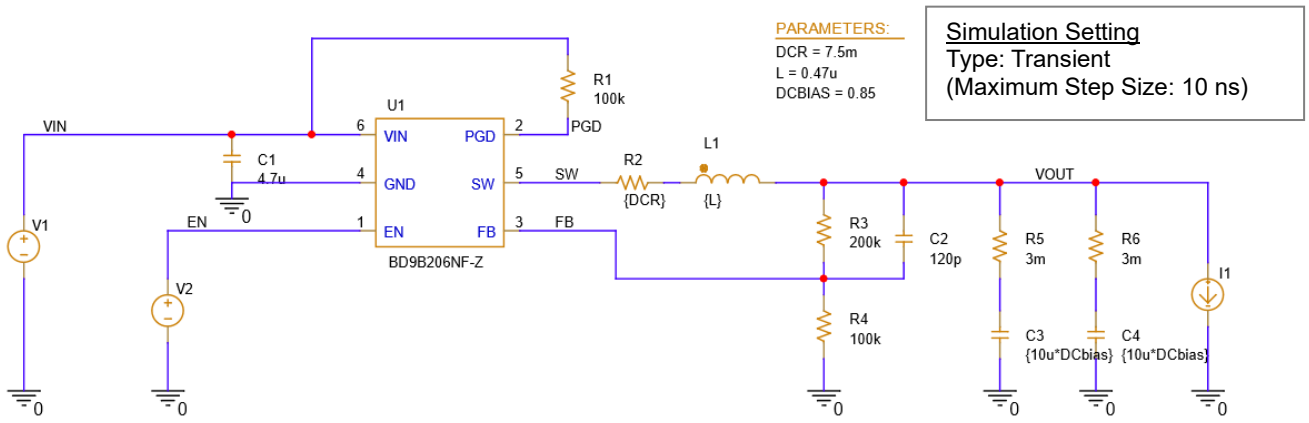

Figure 23.
Simulation Schematic 8

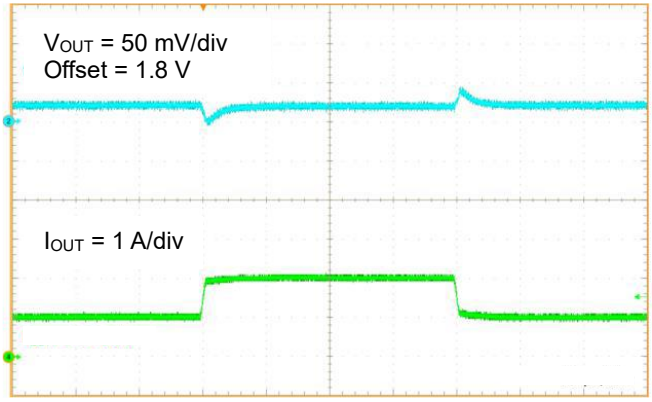

Figure 24.
Load Transient Response
(V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1.0 A to 2.0 A)
(Measured Waveform)

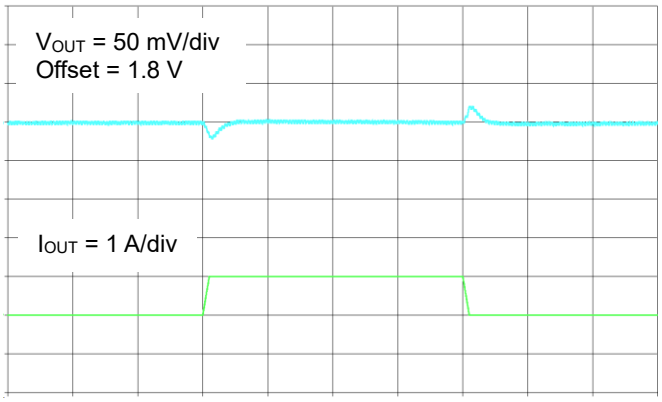

Figure 25.
Load Transient Response
(V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1.0 A to 2.0 A)
(SPICE Simulation)

Table 12 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Overshoot	22	20.9	mV	-4.5 %	V_{IN} = 5.0 V, V_{OUT} = 1.8 V I_{OUT} = 2.0 A to 1.0 A : -1 A/us
Undershoot	21	19.8	mV	-4.8 %	V_{IN} = 5.0 V, V_{OUT} = 1.8 V I_{OUT} = 1.0 A to 2.0 A : 1 A/us

(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.

9. Frequency Characteristics (V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1.0 A)

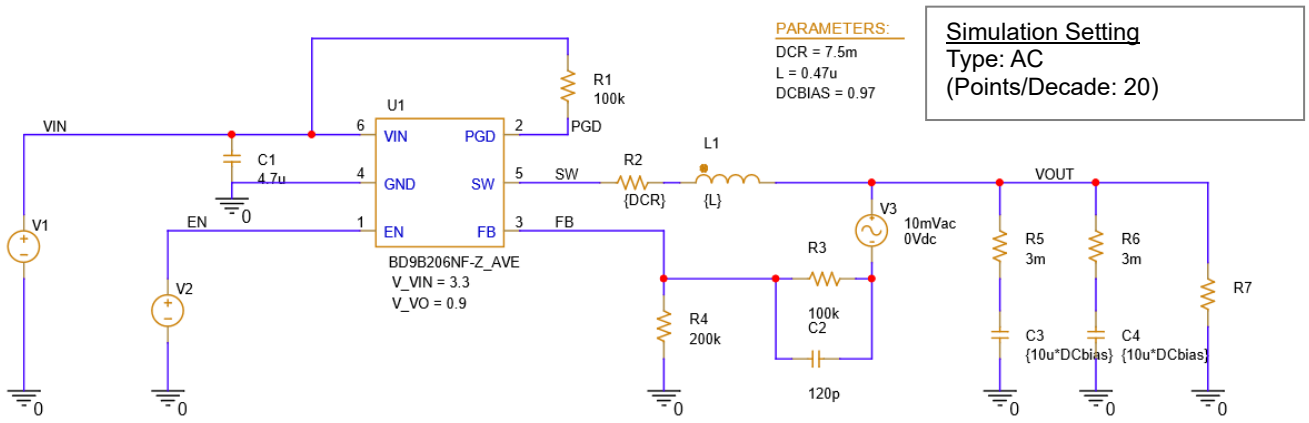

Figure 26.
Simulation Schematic 9

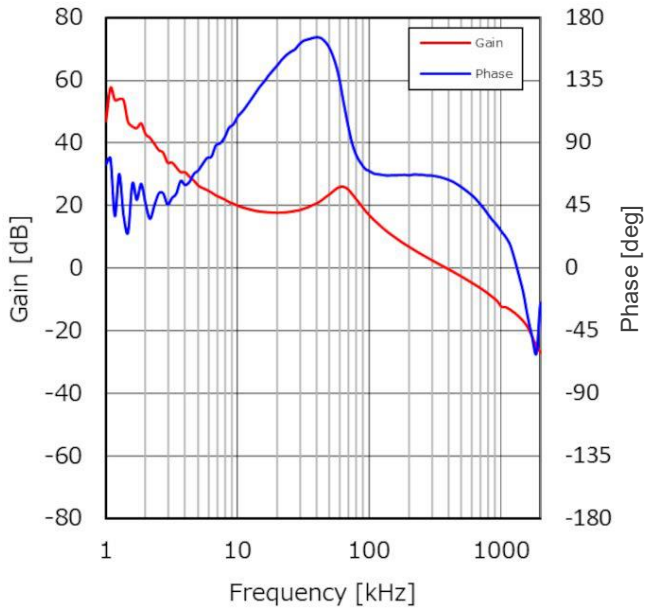

Figure 27.
Frequency Characteristics
(V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1.0 A)
(Measured Waveform)

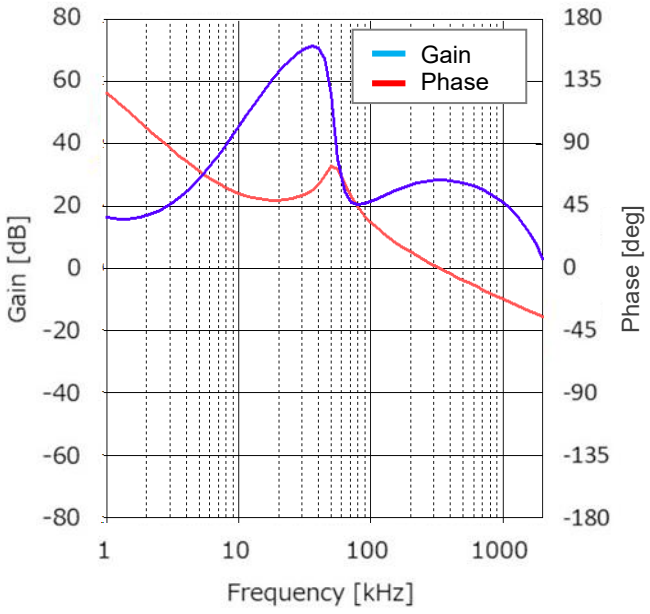

Figure 28.
Frequency Characteristics
(V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1.0 A)
(SPICE Simulation)

Table 13 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Phase Margin	58.2	56.1	degree	-3.3 %	V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1.0 A
Crossover Frequency	386	334	kHz	-13.4 %	V_{IN} = 3.3 V, V_{OUT} = 0.9 V, I_{OUT} = 1.0 A

(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.

10. Frequency Characteristics (V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1.0 A)

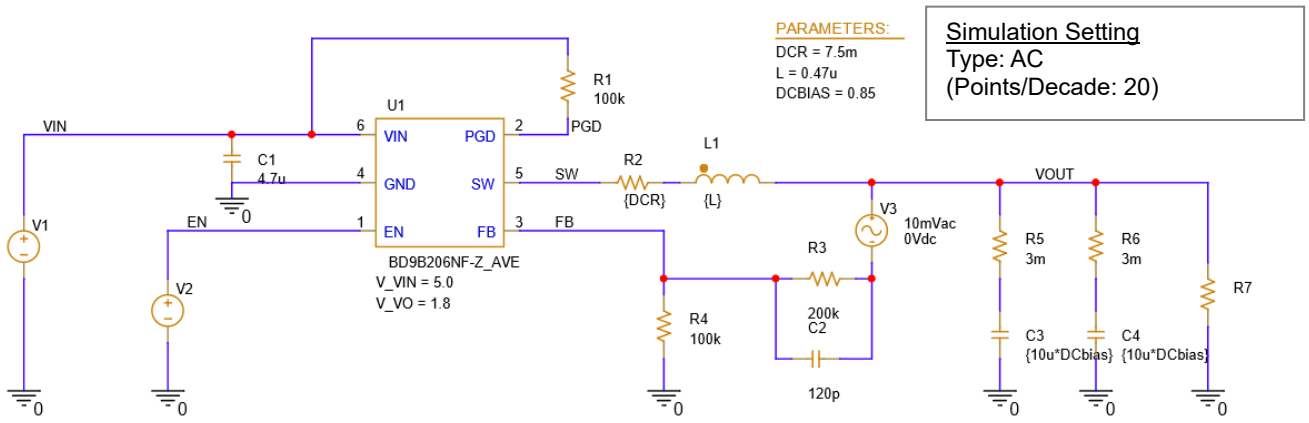

Figure 29.
Simulation Schematic 10

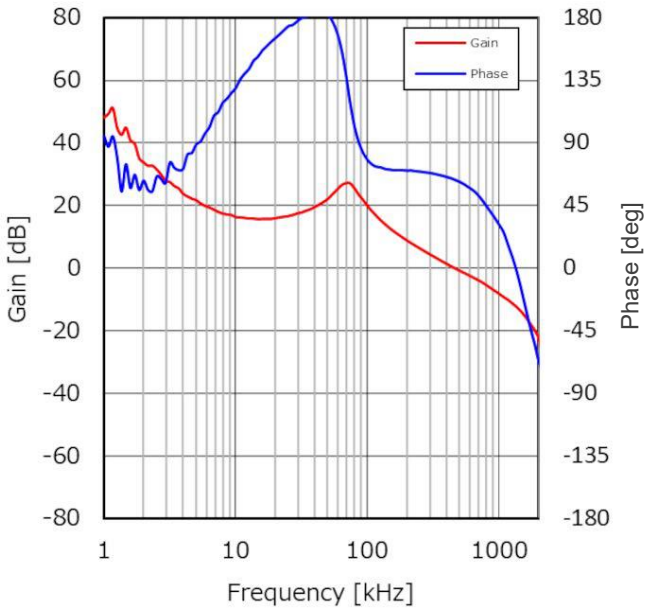

Figure 30.
Frequency Characteristics
(V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1.0 A)
(Measured Waveform)

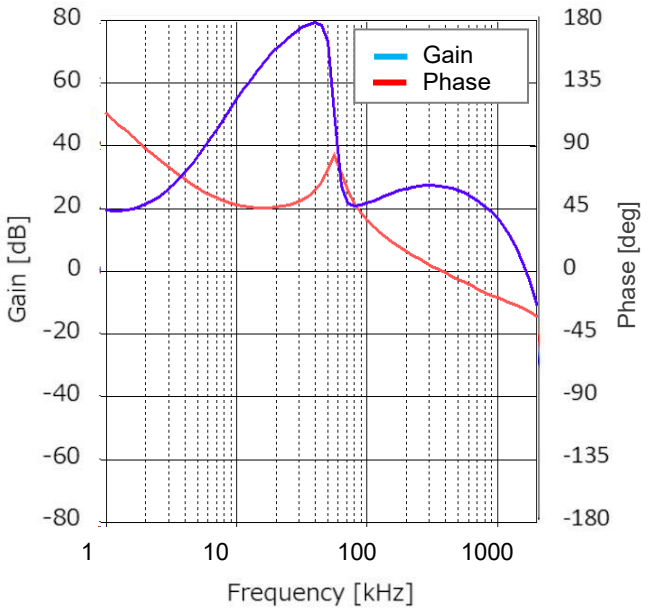

Figure 31.
Frequency Characteristics
(V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1.0 A)
(SPICE Simulation)

Table 14 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Phase Margin	56.4	50.2	degree	-11.0 %	V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1.0 A
Crossover Frequency	440	379	kHz	-13.7 %	V_{IN} = 5.0 V, V_{OUT} = 1.8 V, I_{OUT} = 1.0 A

(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
Jan.2024	001	New Release

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