

## SPICE Modeling Report

# BD9S000NXX-C

## 2.7 V to 5.5 V Input, 600 mA

# Single Synchronous Buck DC/DC Converter for Automotive

### General Description

This is a report of the BD9S000NXX-C SPICE Model.

The correlation between actual measurement and simulation result for BD9S000NXX-C were summarized.

### Simulation Environment

- Circuit Simulator : PSpice / Cadence Design System, Inc.
- Version Information : 17.2-2016
- OS Information : Windows 7 Pro 64-bit Edition

### File Information

- Library File Name : BD9S000NXX-C.lib
- Symbol File Name : BD9S000NXX-C.olb
- Subcircuit and Symbol

Table 1. Correspondence Table

Product Name	Subcircuit	Symbol
BD9S000NXX-C	BD9S000NXX-C_Tran (Rev:1.04) (Model for Transient Analysis)	BD9S000NXX-C_Tran
	BD9S000NXX -C_Average (Rev:1.04) (Model for AC Analysis)	BD9S000NXX-C_Average

### 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. Please 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.

## BD9S000NUX Spice Model

### ■ Terminal Information

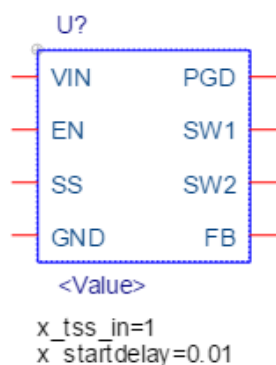


Figure 1. Symbol of BD9S000NUX\_Tran

(Note 1) Terminal information for BD9S000NUX\_Average is same like the above except for the parameters.

Table 2. Pin Table

Pin No.	Pin Name
1	SW1
2	SW2
3	SS
4	FB
5	PGD
6	EN
7	VIN
8	GND

### ■ Model Parameter

Table 3. Model Parameter Table

Parameter	Default Value	Description
BD9S000NUX_Tran		
x_tss_in	1	A coefficient for Soft Start duration. The actual soft start duration is reflected when x_tss_in is set to "1". The value shall be from 0.05 through 1.
x_startdelay	0.01	A coefficient for wait time from VEN being enabled. The actual wait time, t_wait, is reflected when x_startdelay is set to "1"
BD9S000NUX_Average		
Ind	1μ	Please set the inductor value connected to SW1,SW2 terminal.
v_vo	1	On Duty parameter for the Numerator.
v_vin	5	On Duty parameter for the Denominator. On Duty is given as {v_vo/v_vin}.

## Verifiable Characteristics

- Electrical Characteristics (vs. Datasheet).....3.4
- Characteristics on Board (vs. Measured Waveform)
  - BD9S000NUX\_Tran
    - ✓ Output Ripple Voltage / Switching Frequency.....5
    - ✓ Inductor Ripple Current.....6
    - ✓ Load Response.....7
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  - BD9S000NUX\_Average
    - ✓ Frequency Characteristic.....9

## Electrical Characteristics (vs. Datasheet)

Table 4. Electrical Characteristics Comparison

(Unless otherwise specified,  $V_{IN}=5V$ ,  $V_{EN}=5V$ ,  $T_a=25^{\circ}C$ )

Parameter	Modeled <i>(Note1)</i>	Design Value		Unit	Error	Condition
		Datasheet (Typ)	SPICE			
VIN						
Shutdown Circuit Current	Yes	0	0	μA	0.0%	V <sub>EN</sub> =0V
Circuit Current	Yes	350	350.0	μA	0.0%	I <sub>OUT</sub> =0mA Non-switching
UVLO Detection Voltage	Yes	2.45	2.450	V	0.0%	V <sub>IN</sub> Falling
UVLO Release Voltage	Yes	2.55	2.550	V	0.0%	V <sub>IN</sub> Rising
UVLO Hysteresis Voltage	Yes	100	100.0	mV	0.0%	
ENABLE						
EN Threshold Voltage High	Yes	0.75	0.750	V	0.0%	
EN Threshold Voltage Low	Yes	0.70	0.700	V	0.0%	
EN Input Current	Yes	5	5.0	μA	0.0%	
Reference Voltage						
FB Pin Voltage	Yes	0.8	0.80	V	0.0%	
FB Input Current	Yes	0	0.0	μA	0.0%	V <sub>FB</sub> =0.8V
Soft Start						
Soft Start Time	Yes	1.0	1.10	ms	+10.0%	The SS Pin OPEN
	Yes	1.2	1.21	ms	+0.8%	The SS Pin OPEN
SS Charge Current	Yes	-1.0	-1.00	μA	0.0%	
Switching Frequency						
Switching Frequency	Yes	2.2	2.21	MHz	+0.5%	
Power Good						
PGD Falling (Fault) Voltage	Yes	V <sub>FB</sub> *0.85	V <sub>FB</sub> *0.850	V	0.0%	V <sub>FB</sub> Falling
PGD Rising (Good) Voltage	Yes	V <sub>FB</sub> *0.90	V <sub>FB</sub> *0.900	V	0.0%	V <sub>FB</sub> Rising
PGD Rising (Fault) Voltage	Yes	V <sub>FB</sub> *1.15	V <sub>FB</sub> *1.150	V	0.0%	V <sub>FB</sub> Rising
PGD Falling (Good) Voltage	Yes	V <sub>FB</sub> *1.10	V <sub>FB</sub> *1.100	V	0.0%	V <sub>FB</sub> Falling
PGD Output Leakage Current	Yes	0	0.0	μA	0.0%	V <sub>PGD</sub> =5V
PGD FET ON Resistance	Yes	60	60.0	Ω	0.0%	
PGD Output Low Level Voltage	Yes	0.06	0.060	V	0.0%	I <sub>PGD</sub> =1mA

(Note 1) Yes : There is a good correlation between measurement result and simulation result.

No : No correlation between measurement result and simulation result.

(Unless otherwise specified,  $V_{IN}=5V$ ,  $V_{EN}=5V$ ,  $T_a=25^{\circ}C$ )

(Unless otherwise specified, VIN=5V, VEN=5V, Ia=250μA)						
Parameter	Modeled (Note1)	Design Value		Unit	Error	Condition
		Datasheet (Typ)	SPICE			
Switch MOSFET						
High Side FET ON Resistance	Yes	270	274.0	mΩ	+1.5%	VIN=5V
	Yes	330	334.0	mΩ	+1.2%	VIN=3.3V
Low Side FET ON Resistance	Yes	180	181.0	mΩ	+0.6%	VIN=5V
	Yes	210	211.0	mΩ	+0.5%	VIN=3.3V
High Side FET Leakage Current	Yes	0	0.0	μA	0.0%	VIN=5.5V, VSW=0V
Low Side FET Leakage Current	Yes	0	0.0	μA	0.0%	VIN=5.5V, VSW=5.5V
SW Current of Over Current Protection	Yes	1.2	1.20	A	0.0%	
SW Discharge Resistance	Yes	650	650.3	Ω	0.0%	
SCP, OVP						
Short Circuit Protection Detection Voltage	Yes	0.56	0.560	V	0.0%	
Output Over Voltage Protection Detection Voltage	Yes	0.92	0.920	V	0.0%	

(Note 1) Yes : There is a good correlation between measurement result and simulation result.

No : No correlation between measurement result and simulation result.

## Characteristic on Board (vs. Measured Waveform)

## 1. Output Ripple Voltage / Switching Frequency

## Simulation Setting

Type: Transient

Run Time: 20msec

(Maximum Step Size: 10nsec)

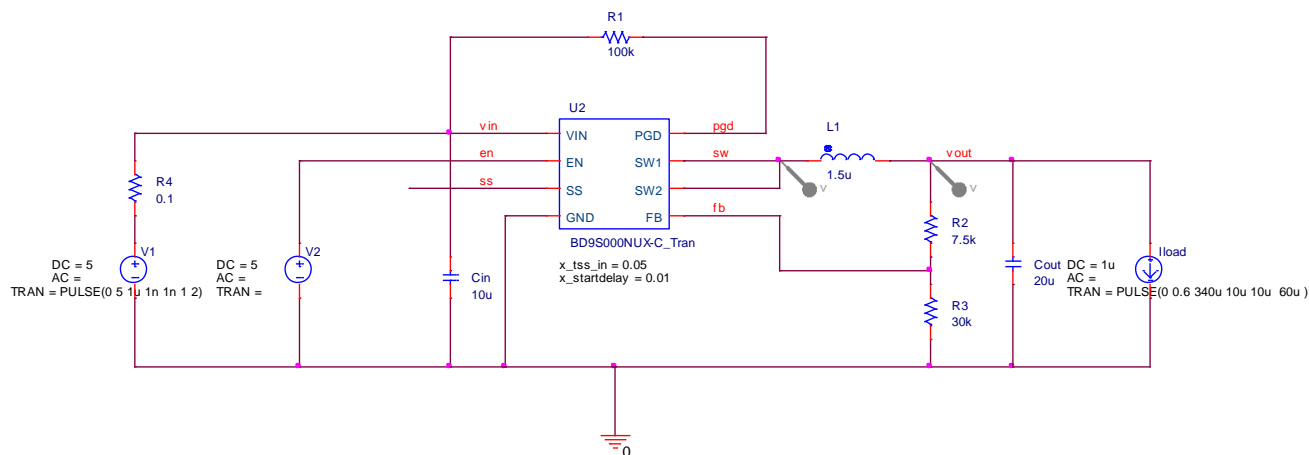
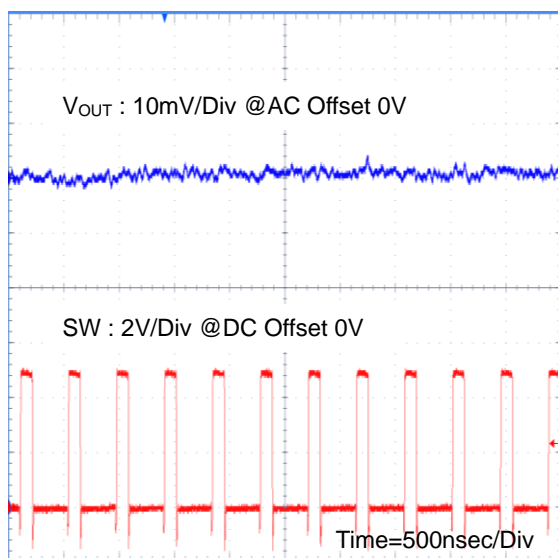
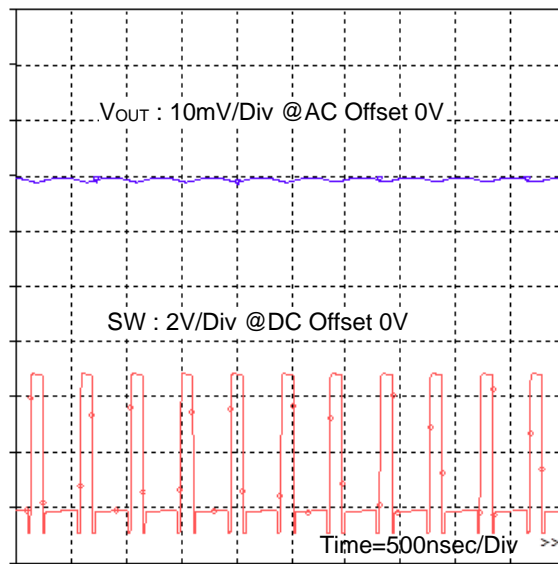
Figure 2.  
Simulation Schematic 1Figure 3.  
Output Ripple Voltage / Switching Frequency  
(Measured Waveform)Figure 4.  
Output Ripple Voltage / Switching Frequency  
(SPICE Simulation)

Table 5. Characteristics Comparison

(Unless otherwise specified, VIN=5V, EN=5V)

Parameter	Measured Result (Note 1)	SPICE Simulation Result	Unit	Error	Condition
Output Ripple Voltage	5.7	0.86	mV	+84.9%	-
Switching Frequency	2.2	2.21	MHz	+0.5%	-

(Note 1) These characteristics depend on some dynamic characteristics of external components, input signal speed, PCB pattern and mounting condition of each on-board parts.

## 2. Inductor Ripple Current

Simulation Setting  
 Type: Transient  
 Run Time: 20msec  
 (Maximum Step Size: 10nsec)

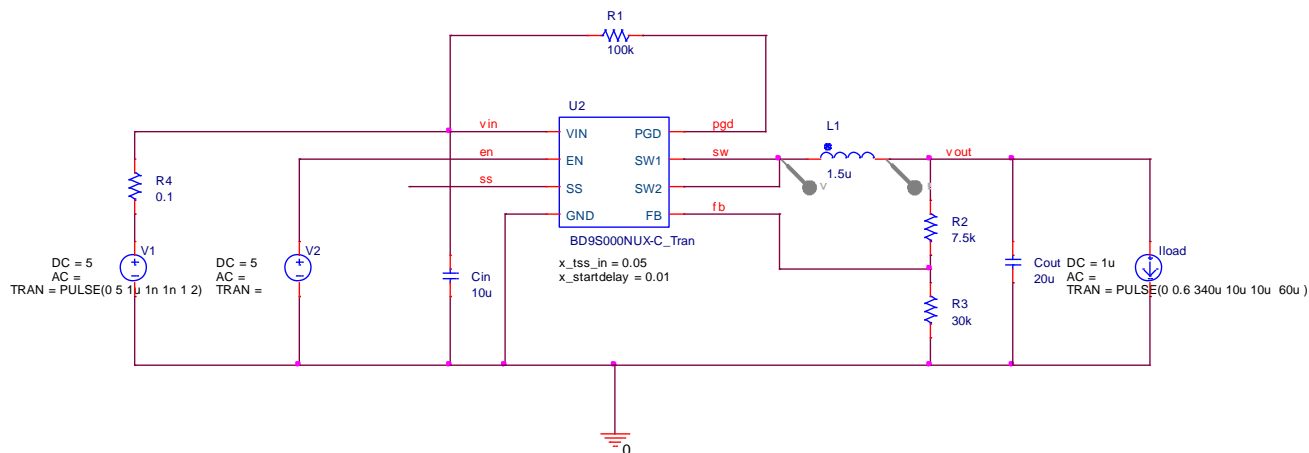


Figure 5.  
Simulation Schematic 2

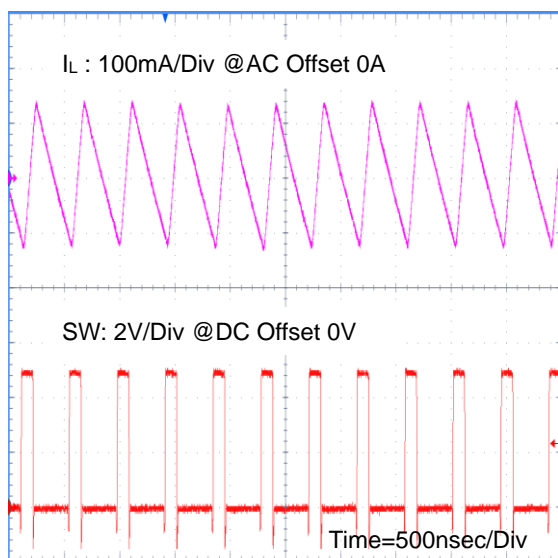


Figure 6.  
Inductor Ripple Current  
(Measured Waveform)

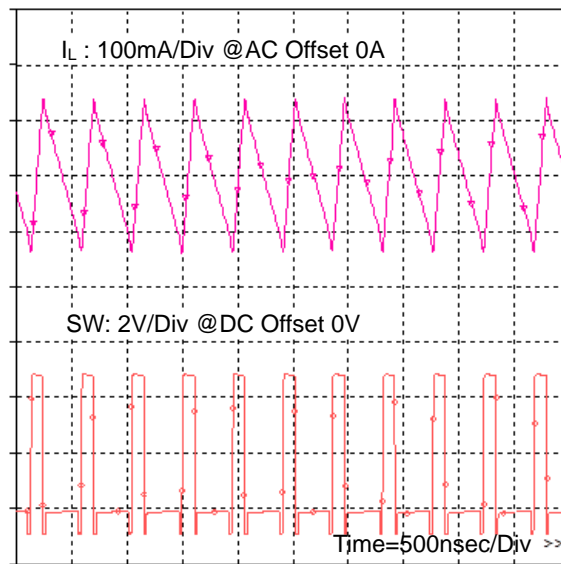


Figure 7.  
Inductor Ripple Current  
(SPICE Simulation)

Table 6. Characteristics Comparison

(Unless otherwise specified, VIN=5V, EN=5V)

Parameter	Measured Result (Note 1)	SPICE Simulation Result	Unit	Error	Condition
Inductor Ripple Current	273	279.0	mA	+2.2%	-

(Note 1) 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

Simulation Setting  
 Type: Transient  
 Run Time: 20msec  
 (Maximum Step Size: 10nsec)

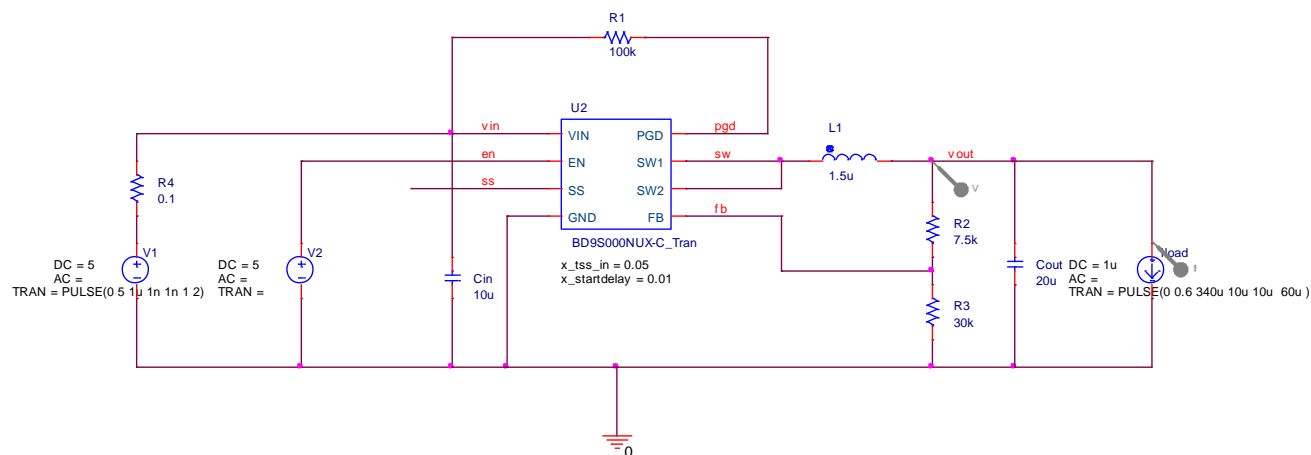


Figure 8.  
Simulation Schematic 3

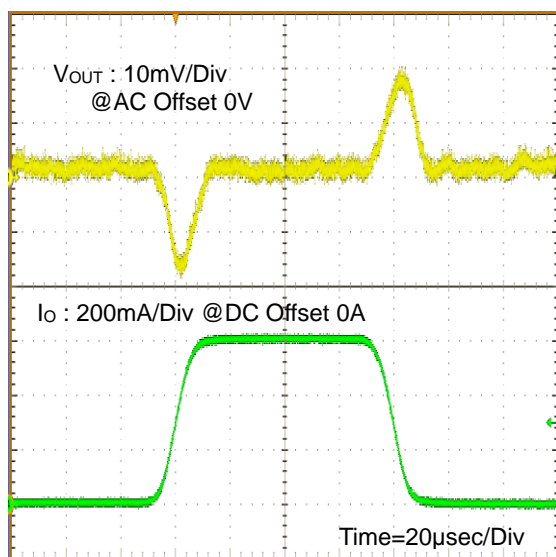


Figure 9.  
Load Response  
(Measured Waveform)

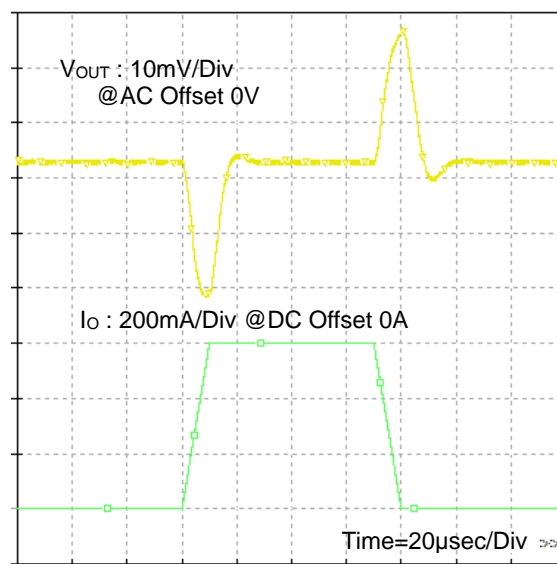


Figure 10.  
Load Response  
(SPICE Simulation)

Table 7. Characteristics Comparison

(Unless otherwise specified, VIN=5V, EN=5V)

Parameter	Measured Result (Note 1)	SPICE Simulation Result	Unit	Error	Condition (Note 2)
Overshoot	20.9	24.8	mV	+18.7%	I <sub>OUT</sub> : 0A to 0.6A (Tr=10μsec)
Undershoot	18.6	24.0	mV	+29.0%	I <sub>OUT</sub> : 0.6A to 0A (Tf=10μsec)

(Note 1) These characteristics depend on some dynamic characteristics of external components, input signal speed, PCB pattern and mounting condition of each on-board parts.

(Note 2) Tr/Tf is defined as 10% to 90% of the waveform.

## 4. Line Response

Simulation Setting  
 Type: Transient  
 Run Time: 20msec  
 (Maximum Step Size: 10nsec)

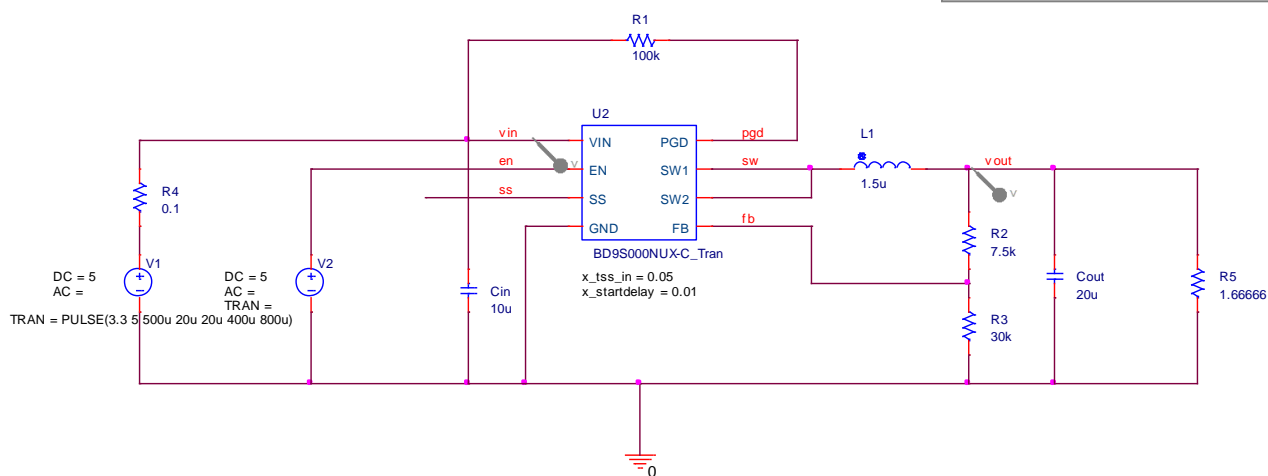


Figure 11.  
Simulation Schematic 4

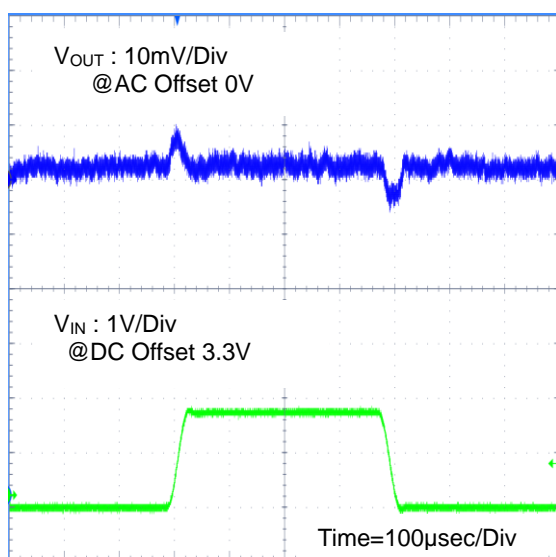


Figure 12.  
Line Response  
(Measured Waveform)

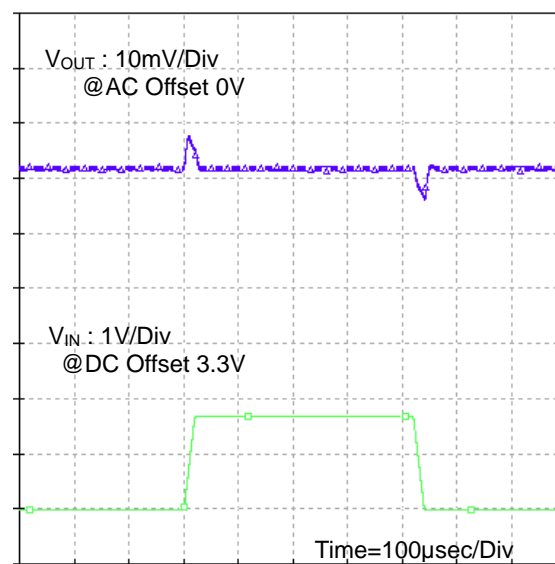


Figure 13.  
Line Response  
(SPICE Simulation)

Table 8. Characteristics Comparison

(Unless otherwise specified, VIN=5V, EN=5V)

Parameter	Measured Result (Note 1)	SPICE Simulation Result	Unit	Error	Condition (Note 2)
Overshoot	10.4	5.61	mV	-46.1%	VIN: 3.3V to 5.0V (Tr=20µsec)
Undershoot	5.7	6.00	mV	+5.3%	VIN: 5.0V to 3.3V (Tf=20µsec)

(Note 1) These characteristics depend on some dynamic characteristics of external components, input signal speed, PCB pattern and mounting condition of each on-board parts.

(Note 2) Tr/Tf is defined as 10% to 90% of the waveform.



## 5. Frequency Characteristic

### Simulation Setting

Type: AC

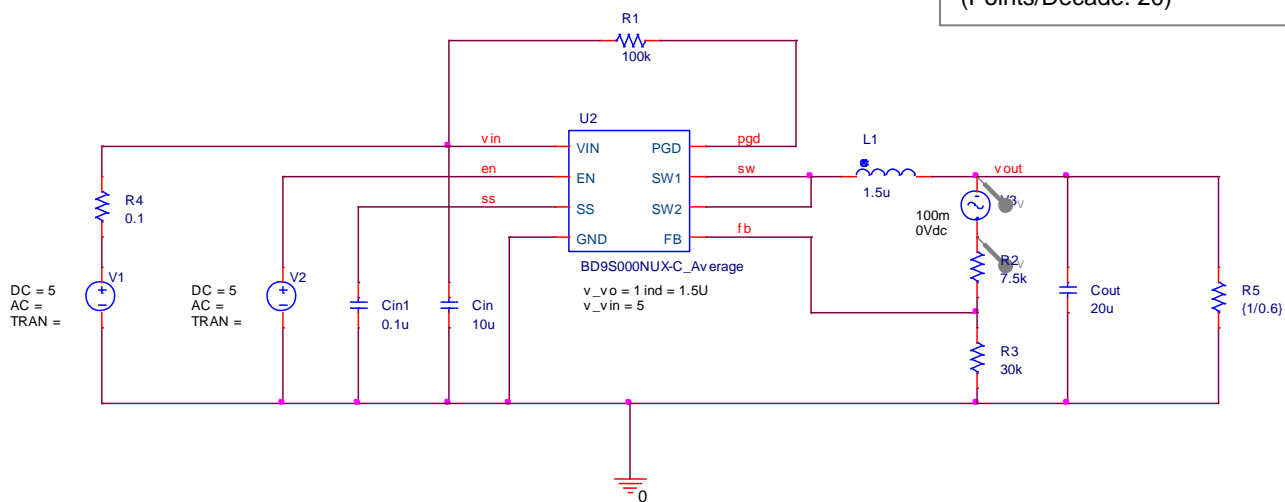
Frequency Range: 1kHz to 1MHz  
(Points/Decade: 20)

Figure 14.  
Simulation Schematic 5

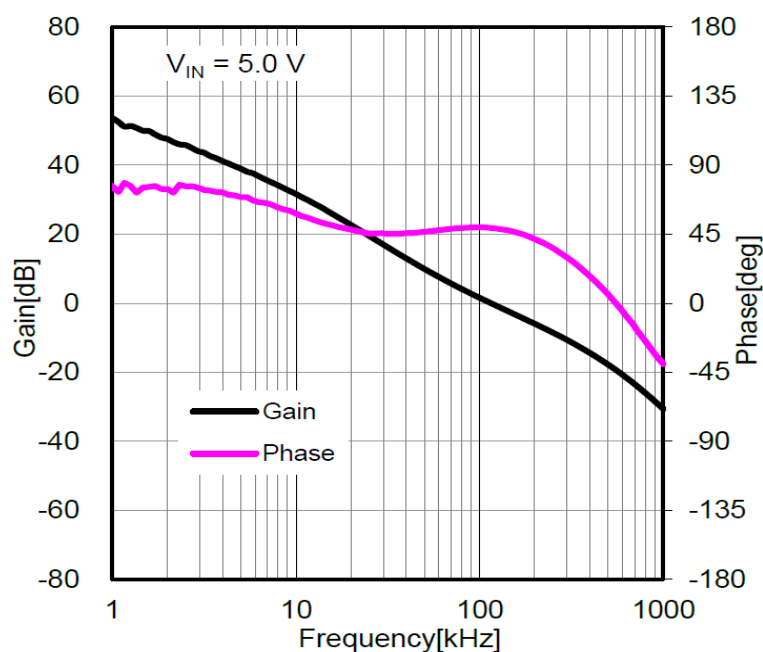


Figure 15.  
Frequency Characteristic  
(Measured Waveform)

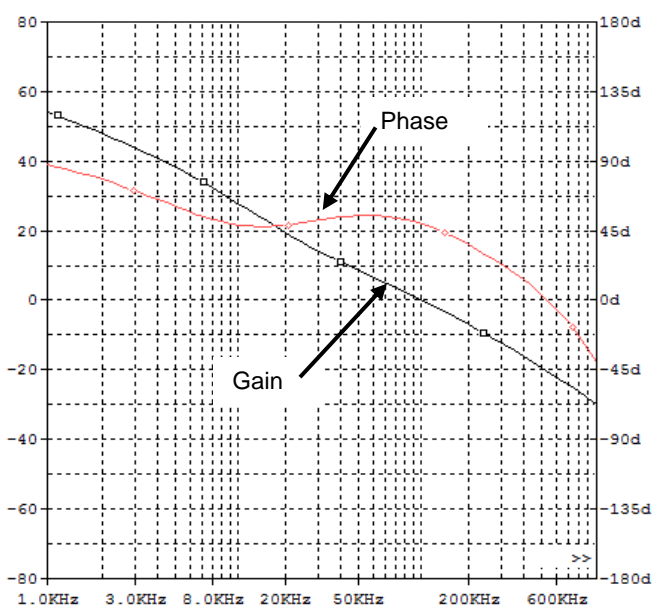


Figure 16.  
Frequency Characteristic  
(SPICE Simulation)

Table 9. Characteristics Comparison

(Unless otherwise specified, VIN=5V, EN=5V)

Parameter	Measured Result (Note 1)	SPICE Simulation Result	Unit	Error	Condition
Phase Margin	49	49.5	degree	+1.0%	At Gain = 0dB
Gain Margin	19	20.1	dB	+5.8%	At Gain = 0degree
Crossover Frequency	103	109.4	kHz	+6.2%	At Gain = 0dB

(Note 1) These characteristics depend on some dynamic characteristics of external components, input signal speed, PCB pattern and mounting condition of each on-board parts.

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**Revision History**

Date	Revision	Changes
NOV.2019	001	New Release

## Notes

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