SPICE Modeling Report

BD9060HFP-C
1ch Step-Down Switching Regulator

In this report, the characteristics that can be confirmed by the simulation using the SPICE model of the regulator IC BD9060HFP-C will be described.

Simulation Environment

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

SPICE MODEL

- Library File Name : BD9060.lib
- Subcircuit File Name : BD9060HFP_Tran (Transient Analysis SPICE MODEL)
  BD9060HFP_Average (AC Analysis SPICE MODEL)
- Revision : 2.00
- Terminal Information

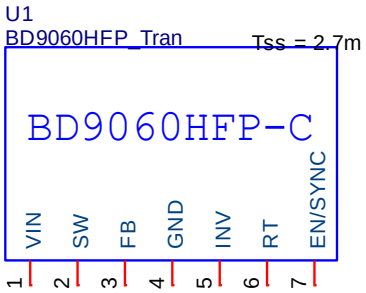

Figure 1. Symbol of BD9060HFP_Tran

Table 1. Pin Table

Pin No.	Pin Name
1	VIN
2	SW
3	FB
4	GND
5	INV
6	RT
7	EN/SYNC

(Note 1) Terminal information for BD9060HFP_Average is same like the above.

- Model Parameters

Table 2. Model Parameter Table

Parameter	Default Value	Description
BD9060HFP_Tran		
T_{SS}	2.7m	Please set any Soft Start Time. (100µ < T_{SS} < 5m)
BD9060HFP_Average		
F_{SW}	300k	Switching frequency is adjustable (50kHz to 500kHz). Please set the switching frequency.
VIN	13.2	Please set Input Voltage. This is used for calculation of dead time component depend on switching operation.
VO	5	Please set Output Voltage. This is used for calculation of dead time component depend on switching operation.

(Note 2) This model is not compatible with the influence of ambient temperature.
(Note 3) This model is not compatible with the external synchronization function.
(Note 4) Please use the simulation results only as a design guide and the data reported herein is not a guaranteed value.
Moreover, the characteristics which are not included in the report may change depending on the actual board design and ROHM strongly recommend to double check those characteristics with actual board where the chips will be mounted on.

Verifiable Characteristics

Electrical Characteristics (vs. Datasheet)

Table 3. Electrical Characteristics Comparison

(Unless otherwise specified, Ta=27°C, V_{IN}=13.2V, $V_{EN\ /\ SYNC}$=5V.)

Parameter	Modeled *(Note1)*	Design Value		Unit	Error	Condition
		Datasheet	SPICE			
Standby Circuit Current	✓	0	0	µA	0.0%	$V_{EN/SYNC}$=0V, Ta=-40°C to +105°C
Circuit Current	X	3.74	4.00	mA	-	I_O=0A, RT=51kΩ, V_{INV}=0.7V
[SW Block]						
POWER MOS FET ON Resistance	✓	0.3	0.3	Ω	0.0%	I_{SW}=50mA
Operating Output Current Of Overcurrent Protection	✓	4	4	A	0.0%	
Output Leak Current	✓	0	0	µA	0.0%	V_{IN}=35V, $V_{EN/SYNC}$=0V, Ta=-40°C to +105°C
[Error Amp Block]						
Reference Voltage 1	✓	0.800	0.800	V	0.0%	V_{FB}=V_{INV}
Reference Voltage 2	✓	0.800	0.800	V	0.0%	V_{FB}=V_{INV}, V_{IN}=5V to 35V
Reference Voltage Input Regulation	X	0.5	0.0	%	-	V_{IN}=5V to 35V
Input Bias Current	✓	-	0	µA	-	V_{INV}=0.6V
Maximum FB Voltage	✓	2.5	2.5	V	0.0%	V_{INV}=0V
Minimum FB Voltage	✓	0.51	0.51	V	0.0%	V_{INV}=2V
FB Sink Current	X	-1.23	-0.98	mA	-	V_{FB}=1V, V_{INV}=1V
FB Source Current	X	6.3	3.0	mA	-	V_{FB}=1V, V_{INV}=0.6V
Soft Start Time	✓	2.7	2.7	ms	0.0%	
[Oscillator Block]						
Oscillating Frequency	✓	300	291	kHz	3.0%	RT=51kΩ
Frequency Input Regulation	X	0.5	-	%	-	V_{IN}=5V to 35V
[Enable/Sync Input Block]						
Output ON Voltage	✓	-	1.5	V	-	$V_{EN/SYNC}$ Sweep Up
Output OFF Voltage	✓	-	1.5	V	-	$V_{EN/SYNC}$ Sweep Down
Sink Current	✓	19.2	19.0	µA	1.0%	

(Note 1) ✓: Model available (supported), X: Model not available" (not supported).

Characteristic on Board (vs. Measured Waveform)

1. Output Ripple Voltage / Switching Frequency

Simulation Setting
Type: Transient
Run Time: 5msec
(Maximum Step Size: 20nsec)

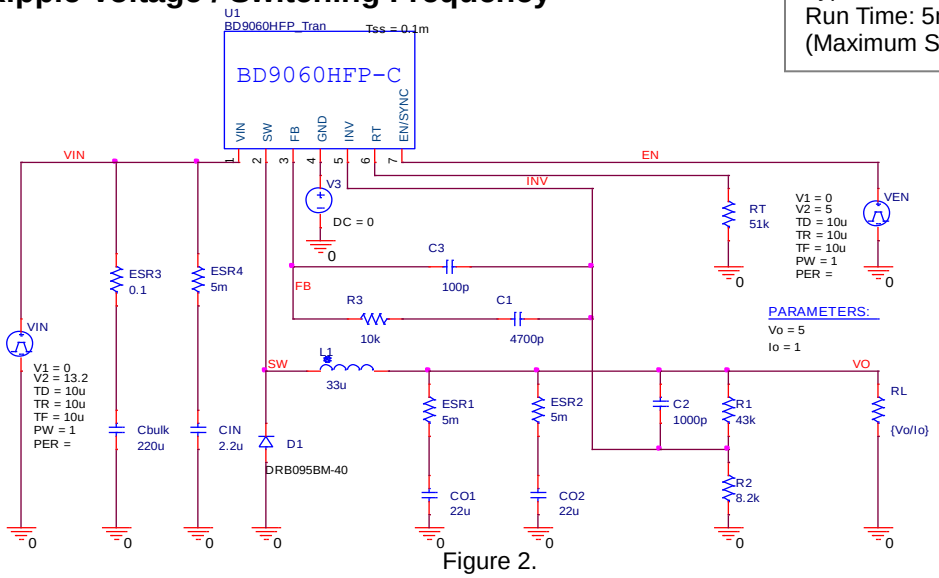

Figure 2.
Simulation Schematic 1

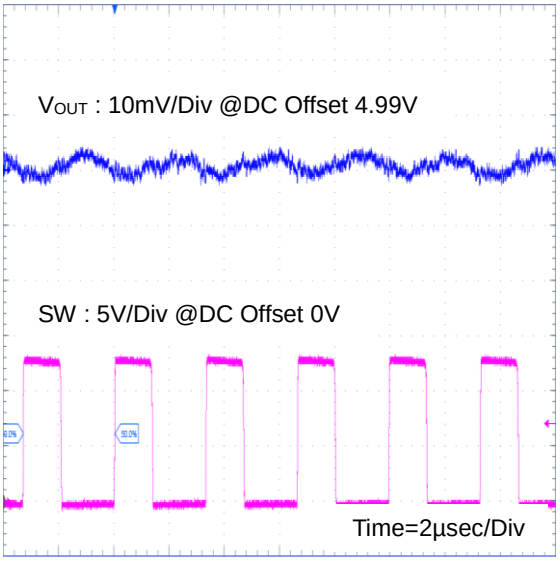

Figure 3.
Output Ripple Voltage / Switching Frequency
(Measured Waveform)

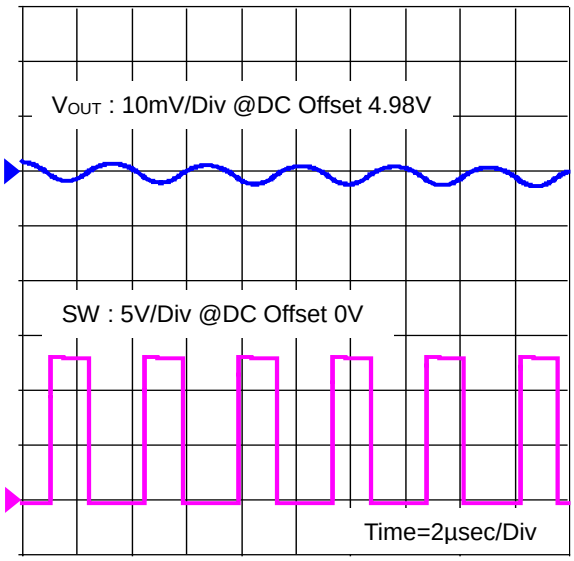

Figure 4.
Output Ripple Voltage / Switching Frequency
(SPICE Simulation)

Table 4. Characteristics Comparison

(Unless otherwise specified, Ta=27°C, V_{IN}=13.2V, $V_{EN\,/\,SYNC}$=5V.)

Parameter	Measured Result	SPICE Simulation Result	Unit	Error	Condition
Output Ripple Voltage	8.5	3.8	mV	55.3%	-
Switching Frequency	300	291	kHz	3.0%	R_{RT}=51kΩ

(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. Inductor Ripple Current

Simulation Setting
Type: Transient
Run Time: 5msec
(Maximum Step Size: 20nsec)

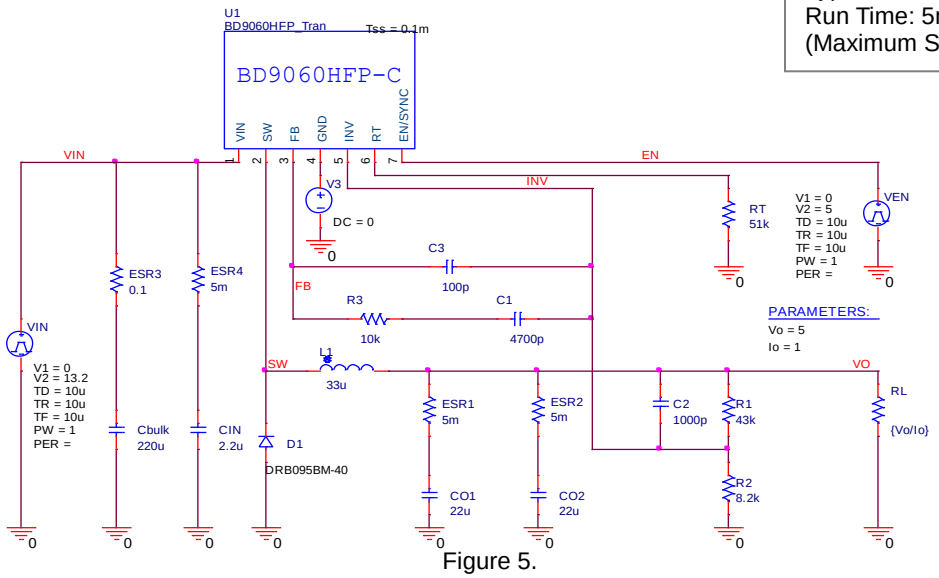

Figure 5.
Simulation Schematic 2

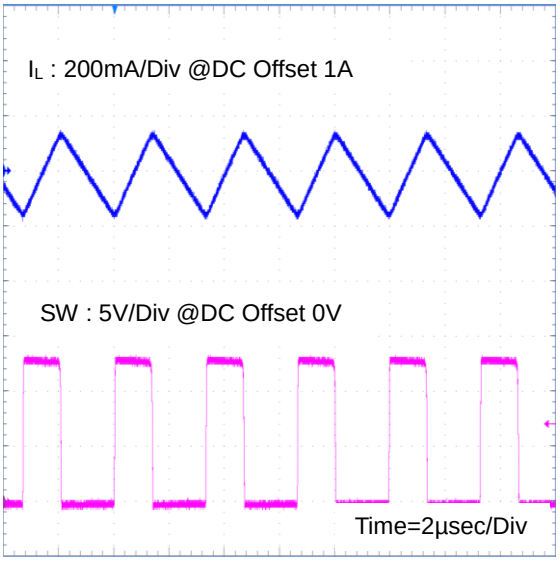

Figure 6.
Inductor Ripple Current
(Measured Waveform)

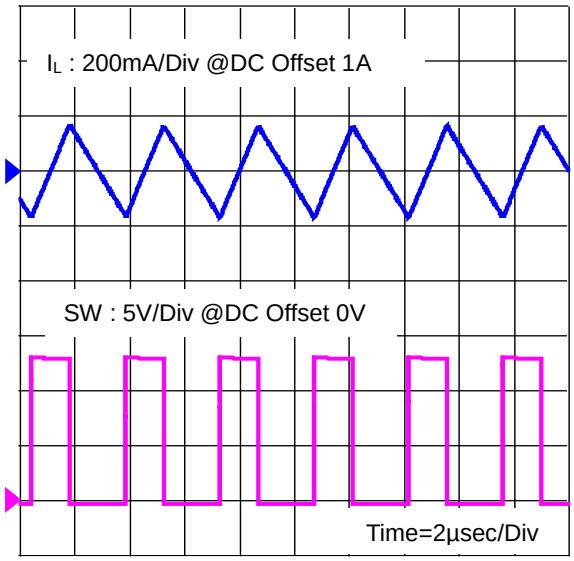

Figure 7.
Inductor Ripple Current
(SPICE Simulation)

Table 5. Characteristics Comparison

(Unless otherwise specified, Ta=27°C, V_{IN}=13.2V, $V_{EN\,/\,SYNC}$=5V.)

Parameter	Measured Result	SPICE Simulation Result	Unit	Error	Condition
Inductor Ripple Current	323	339	mA	5.0%	-

(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

Simulation Setting
Type: Transient
Run Time: 11msec
(Maximum Step Size: 20nsec)

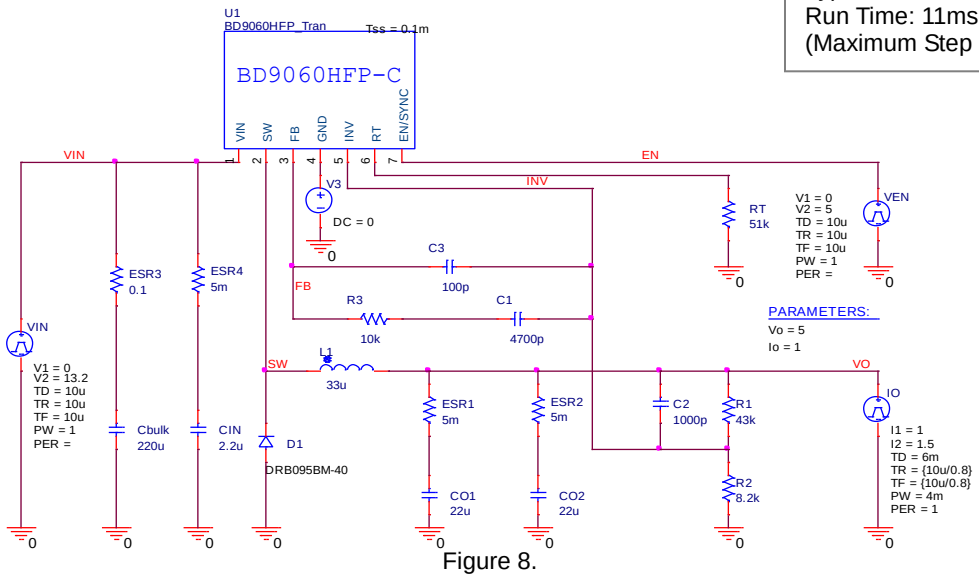

Figure 8.
Simulation Schematic 3

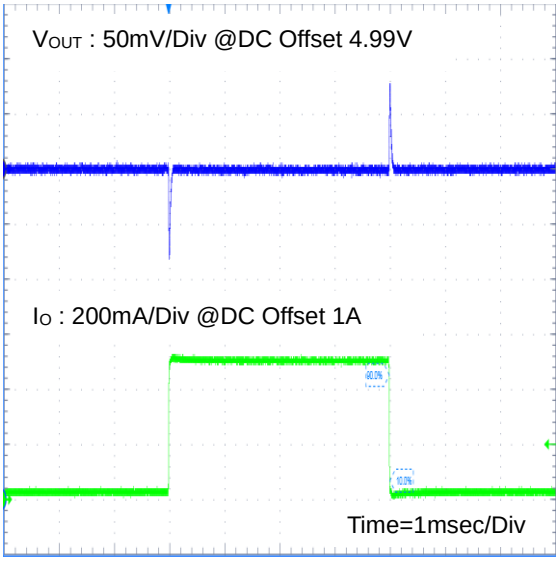

Figure 9.
Load Response
(Measured Waveform)

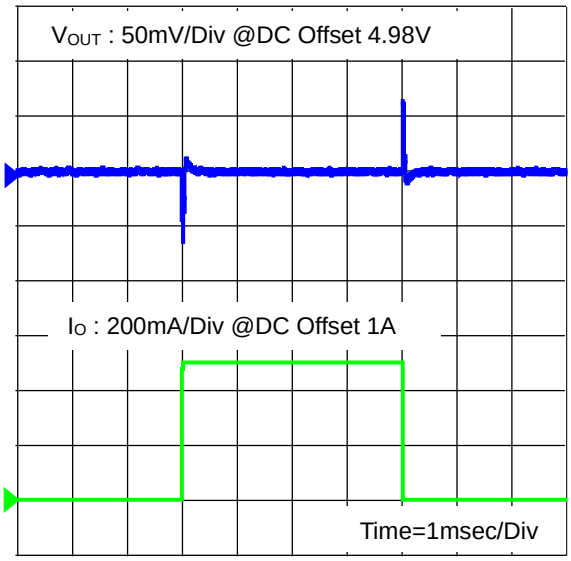

Figure 10.
Load Response
(SPICE Simulation)

Table 6. Characteristics Comparison

(Unless otherwise specified, Ta=27°C, V_{IN}=13.2V, $V_{EN\,/\,SYNC}$=5V.)

Parameter	Measured Result	SPICE Simulation Result	Unit	Error	Condition
Overshoot	78	67	mV	14.1%	I_{OUT}:1.0A to 1.5A (Tr=10µsec)
Undershoot	81	68	mV	16.0%	I_{OUT}:1.5A to 1.0A (Tf=10µsec)

(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.
(Note 3) Tr/Tf is defined as 10% to 90% of the waveform.

4. Line Response

Simulation Setting
Type: Transient
Run Time: 11msec
(Maximum Step Size: 20nsec)

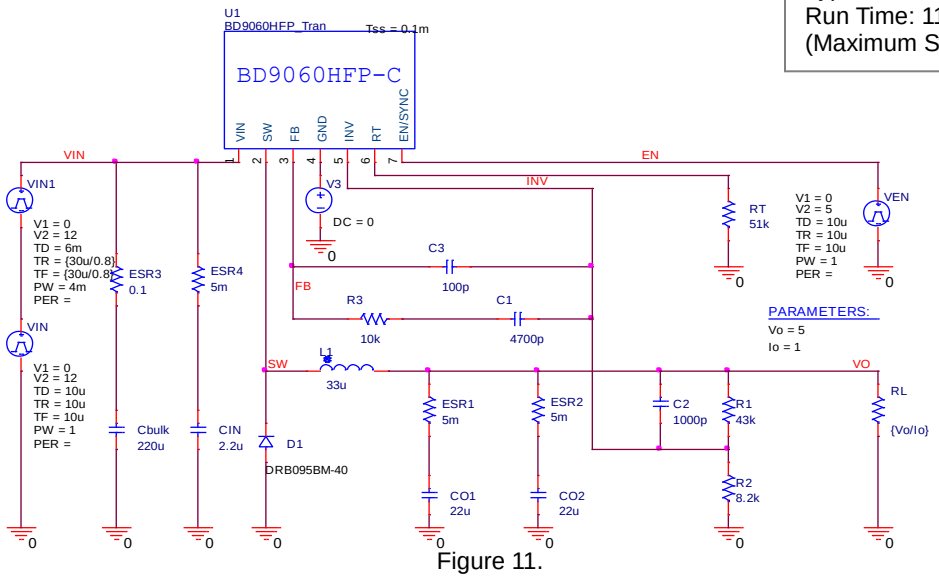

Figure 11.
Simulation Schematic 4

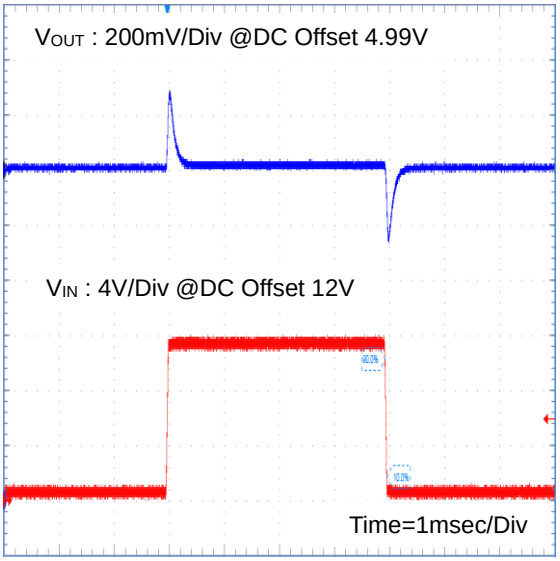

Figure 12.
Line Response
(Measured Waveform)

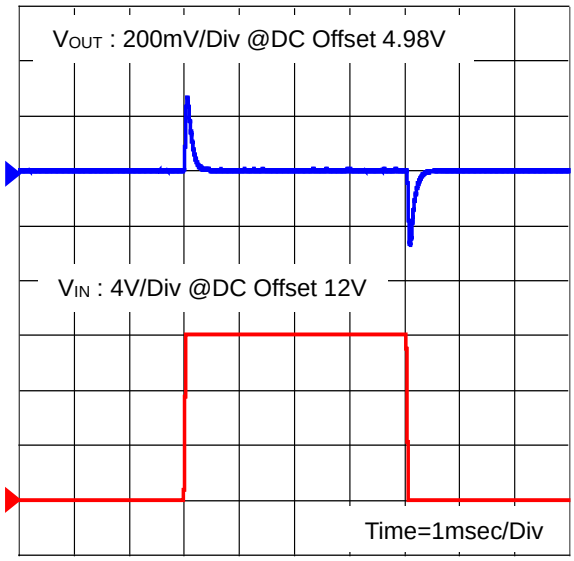

Figure 13.
Line Response
(SPICE Simulation)

Table 7. Characteristics Comparison

(Unless otherwise specified, Ta=27°C, V_{IN}=13.2V, $V_{EN\,/\,SYNC}$=5V.)

Parameter	Measured Result	SPICE Simulation Result	Unit	Error	Condition
Overshoot	275	266	mV	3.3%	V_{IN}:12V to 24V (Tr=30µsec)
Undershoot	274	271	mV	1.1%	V_{IN}:24V to 12V (Tf=30µsec)

(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.
(Note 3) Tr/Tf is defined as 10% to 90% of the waveform.

5. Switching Frequency Setting Resistance

Simulation Setting
Type: Transient, Parametric Sweep
Run Time: 5msec
(Maximum Step Size: 20nsec)

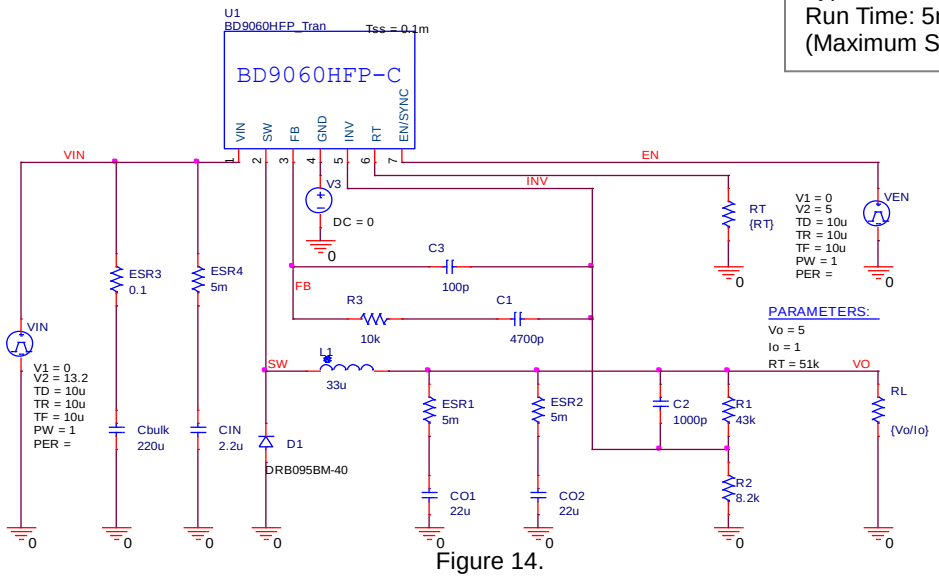

Figure 14.
Simulation Schematic 5

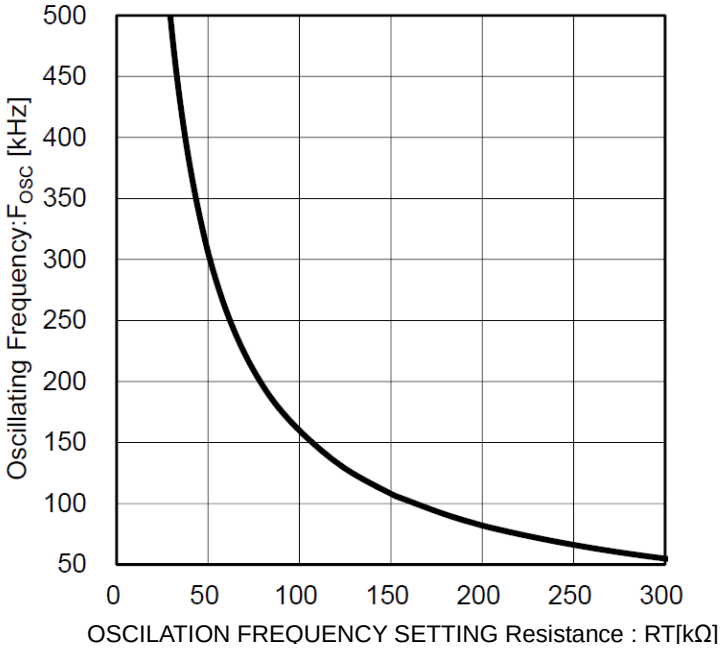

Figure 15.
Switching Frequency Setting Resistance
(Measured Waveform)

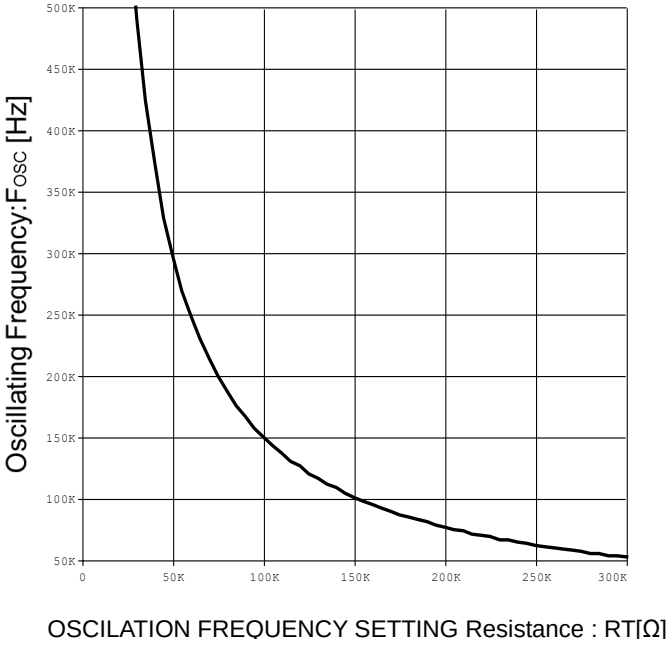

Figure 16.
Switching Frequency Setting Resistance
(SPICE Simulation)

Table 8. Characteristics Comparison

(Unless otherwise specified, Ta=27°C, V_{IN}=13.2V, $V_{EN\,/\,SYNC}$=5V.)

Parameter	Measured Result	SPICE Simulation Result	Unit	Error	Condition
Switching Frequency	300	291	kHz	3.0%	R_{RT}=51kΩ

(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

Simulation Setting
Type: AC
Frequency Range: 100Hz to 1MHz
(Points/Decade: 20)

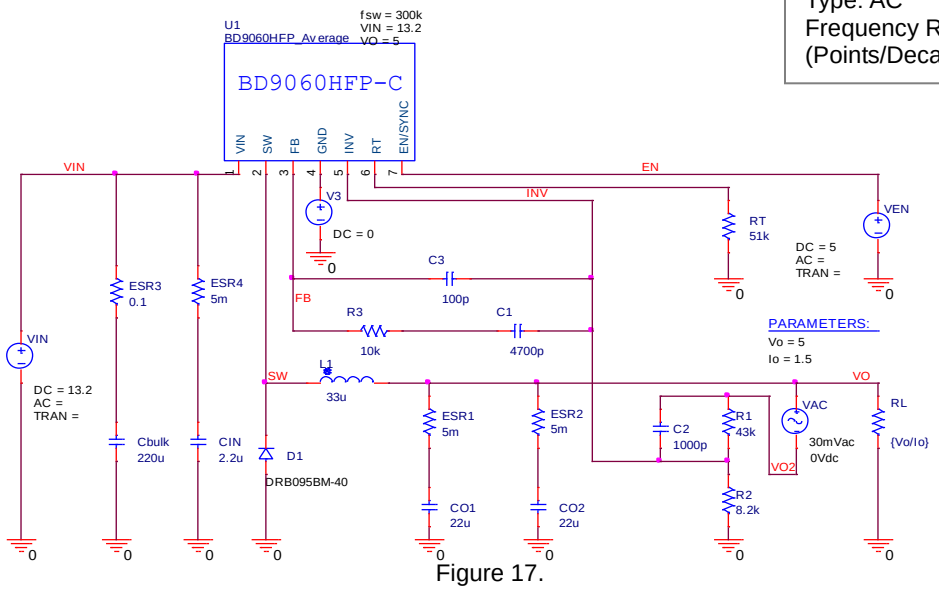

Figure 17.
Simulation Schematic 6

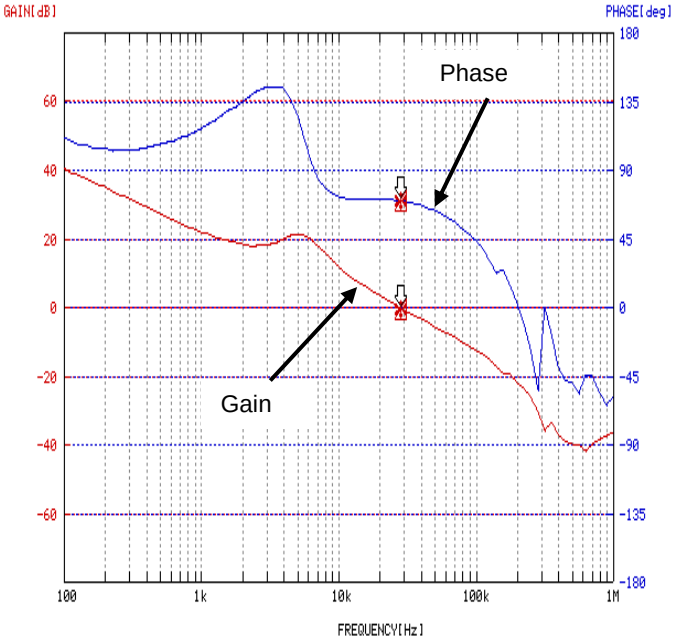

Figure 18.
Frequency Characteristic
(Measured Waveform)

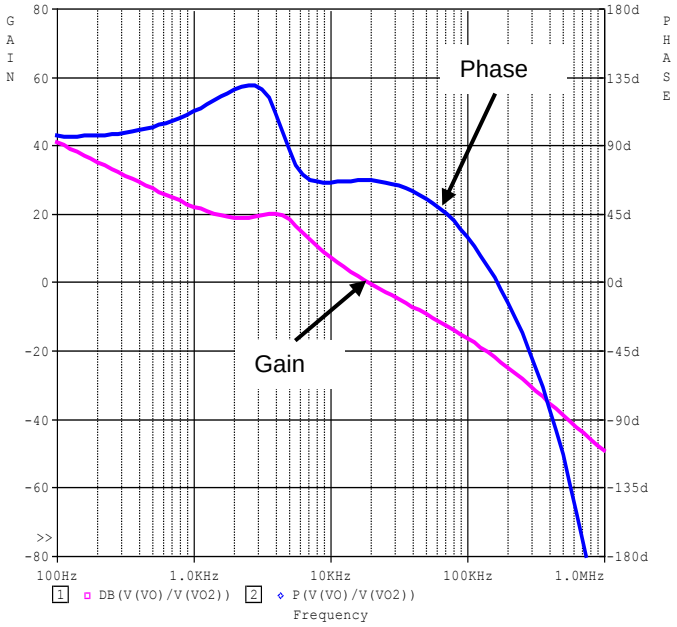

Figure 19.
Frequency Characteristic
(SPICE Simulation)

Table 9. Characteristics Comparison

(Unless otherwise specified, Ta=27°C, V_{IN}=13.2V, $V_{EN\,/\,SYNC}$=5V.)

Parameter	Measured Result	SPICE Simulation Result	Unit	Error	Condition
Phase Margin	69.8	66.8	degree	4.3%	At Gain = 0dB
Gain Margin	-23.0	-22.5	dB	2.2%	At Gain = 0degree
Crossover Frequency	28.2	18.9	kHz	33.0%	At Gain = 0dB

(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
Aug.2017	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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