

ROHM Solution Simulator

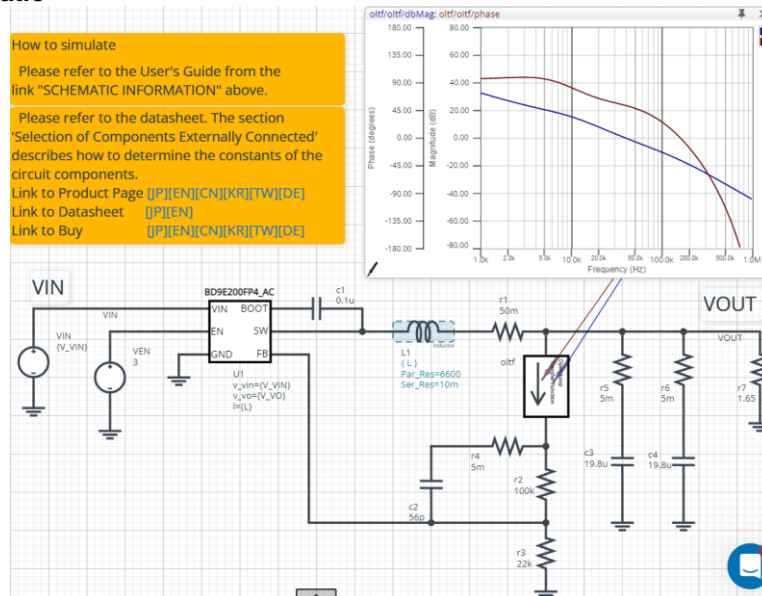
4.5V~26V Input, 2.0A Integrated MOSFET Single Synchronous Buck DC/DC Converter BD9E200FP4-Z / Frequency Response

This circuit simulates the frequency response of BD9E200FP4-Z. You can observe the loop gain and measure phase margin. You can customize the simulation conditions by changing the parameters of components highlighted in blue. You can simulate the circuit in the published application note: Measurement Method for Phase Margin with FRA. [\[JP\]](#) [\[EN\]](#) [\[CN\]](#)

General Cautions

- Caution 1:** The values from the simulation results are not guaranteed. Use these results as a guide for your design.
- Caution 2:** These model characteristics are specifically at $T_a = 25\text{ }^\circ\text{C}$. Thus, the simulation result with temperature variances may significantly differ from the result with the one done at actual application board (actual measurement).
- Caution 3:** Please refer to the datasheet for details of the technical information.
- Caution 4:** The characteristics 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.

1 Simulation Schematic



2 How to simulate

The simulation settings, such as frequency range or convergence options, are configurable from the 'Simulation Settings' shown in Figure 1, and Table 1 shows the default setup of the simulation.

In case of simulation convergence issue, you can change advanced options to solve.

The parameters V_VIN , V_VO and L are defined in the 'Manual Options'.

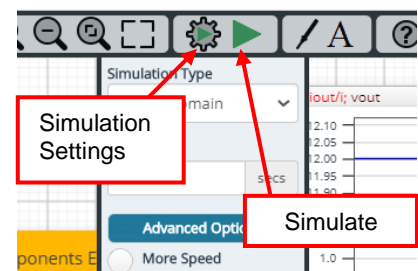


Table 1. Simulation settings default setup

| Parameters | Default | Note |
|------------------|--------------------------------------|---|
| Simulation Type | Frequency-Domain | (Do not change Simulation Type) |
| Start Frequency | 1 Hz | Simulate the frequency response for the frequency range from 1 Hz to 1 MHz. |
| End Frequency | 1Meg Hz | |
| Advanced options | Balanced Convergence Assist | |
| Manual Options | “.param V_VIN=12 V_VO=3.3 and L=10u” | See “Simulation Condition” for details |

3 Simulation Conditions

3.1 How to define V_{IN} , V_{OUT} and L

These parameters are used to setup the simulation conditions and BD9E200FP4_AC model parameters, therefore these are defined in the Manual Options as the common variables.

Table 2 shows the default value of V_{IN} , V_{OUT} and L. Those values are defined and can be set in the 'Manual Options' text box from Simulation Settings as shown in Figure 2.

The output voltage of V_{IN} , output inductance of L1, and the load resistance of r7 are automatically set according to those parameters. Note that feedback resistors are not automatically set by V_{VO} . Set r2 and r3 manually.

Table 2. Simulation Conditions

| Parameters | Variable Name | Default Value | Units | Descriptions |
|------------|---------------|---------------|-------|-----------------|
| V_{IN} | V_VIN | 12 | V | Input Voltage |
| V_{OUT} | V_VO | 3.3 | V | Output Voltage |
| L | L | 10u | H | Output Inductor |

(Note 1) Set it to the guaranteed operating range of the DC/DC Converter.

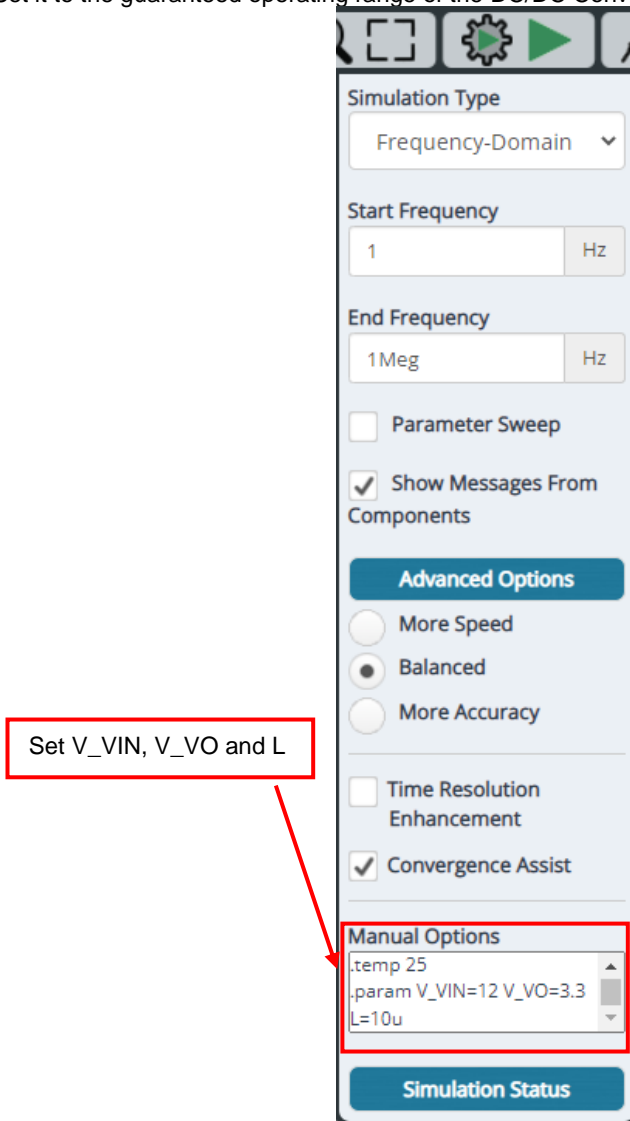


Figure 2. Definition of V_{IN} , V_{OUT} and L

3.2 Resistive Load r7

The resistive load is r7 and its resistance is determined from V_{OUT} and I_{OUT} . The resistance value is defined using the equation below. I_{OUT} in this setup is set at 2A.

Table 3. Resistive load

| Instance Name | Default Value | Unit |
|---------------|------------------|----------|
| r7 | { $V_{VO} / 2$ } | Ω |

4 BD9E200FP4_AC model

The simulation model in this circuit is designed for frequency response, and the functions not related to frequency response are not implemented.

Table 4. BD9E200FP4_AC model pins used for frequency response

| Pin Name | Description |
|----------|------------------------------|
| VIN | Power supply input. |
| EN | Enable input. |
| BOOT | Pin for bootstrap. |
| SW | Switching node. |
| FB | Output voltage feedback pin. |
| GND | Ground. |

4.1 BD9E200FP4_AC Model Parameters

BD9E200FP4_AC model has its parameters shown in Table 5. All the parameters are pre-defined and fixed in the simulation. V_VIN is substituted to V_VIN, V_VO is substituted to V_VO, and L is substituted to L as shown in Table 5.

Table 5. Parameter List

| Parameters | Default Values | Description |
|------------|----------------|-------------------|
| V_VIN | V_VIN | VIN voltage |
| V_VO | V_VO | VOU voltage |
| L | L | Output inductance |

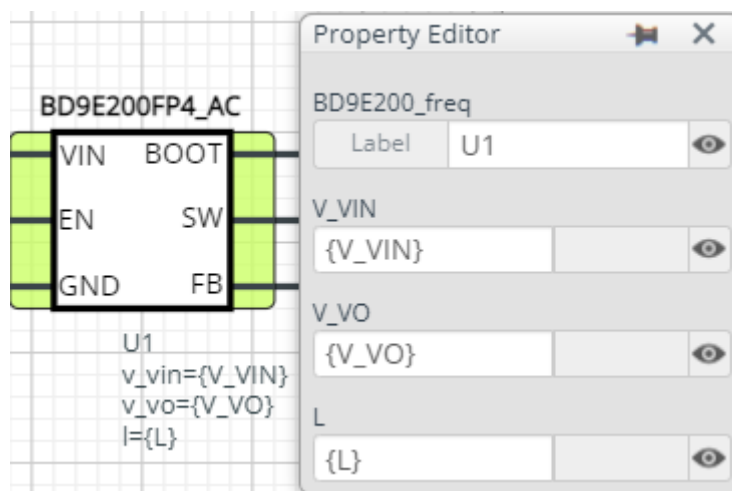


Figure 3. Property Editor of BD9E200FP4_AC model

5 Peripheral Components

To set parameters of components, open 'property' by double click or right click on a component. You can input a value to a property text box if available. Please refer to the hands-on manual for more details.

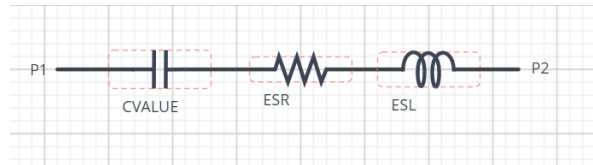
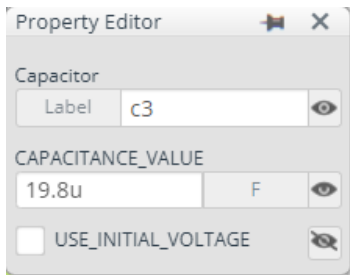
5.1 Bill of Material

Table 6 shows the list of components used in the simulation schematic. Each of the capacitor and inductor has the parameters of equivalent circuit shown below. The default value of equivalent components are set to zero except for the parallel resistance of L and series resistance of capacitors. You can modify the values of each component.

Table 6. List of components used in the simulation circuit

| Type | Instance Name | Default Value | Units |
|-----------|---------------|---------------|---------------|
| Resistor | r1 | 50m | Ω |
| | r2 | 100k | Ω |
| | r3 | 22k | Ω |
| | r4 | 5m | Ω |
| | r5 | 5m | Ω |
| | r6 | 5m | Ω |
| | r7 | 1.65 | Ω |
| Capacitor | c1 | 0.1 | μF |
| | c2 | 56 | pF |
| | c3 | 19.8 | μF |
| | c4 | 19.8 | μF |
| Inductor | L1 | 10 | μH |

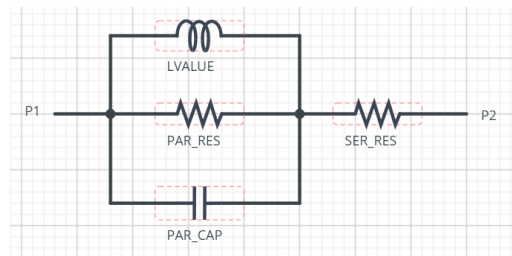
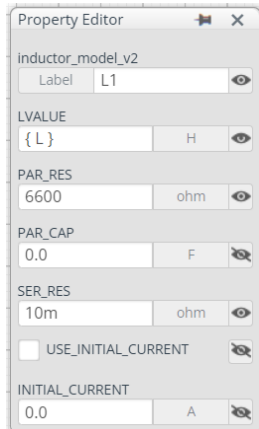
5.2 Capacitor Equivalent Circuits



(a) Property editor (b) Equivalent circuit
Figure 4. Capacitor property editor and equivalent circuit

The default value of ESR is 0 m Ω .

5.3 Inductor Equivalent Circuits



(a) Property editor (b) Equivalent circuit
Figure 5. Inductor property editor and equivalent circuit

The default value of PAR_RES is 6.6 k Ω and SER_RES is 10 m Ω .

(Note 2) These parameters can take any positive value or zero in simulation but it does not guarantee the operation of the IC in any condition. Refer to the datasheet to determine adequate value of parameters.

6 Open Loop Transfer Function (OLTF) Monitor

OLTF1 is the insert model to measure AC open loop transfer function and is inserted to acquire the gain and phase output. To monitor the gain and phase from OLTF1, select probe items 'dbMag' for gain and 'phase' for phase plot, respectively from 'property' of OLTF1.

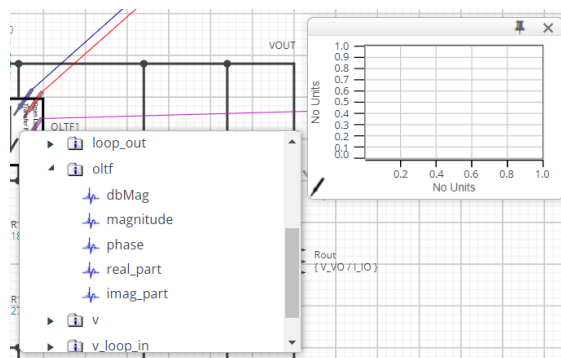


Figure 6. Probe Items of OLTF1

7 Link to the product information and tools

7.1 DC/DC Converter

BD9E200FP4-Z : Integrated MOSFET Single Synchronous Buck DC/DC Converter. [\[JP\]](#) [\[EN\]](#) [\[CN\]](#) [\[KR\]](#) [\[TW\]](#) [\[DE\]](#)

7.2 General Purpose Chip Resistors

MCR01MZPF : Thick Film Chip Resistors. [\[JP\]](#) [\[EN\]](#) [\[CN\]](#) [\[KR\]](#) [\[TW\]](#) [\[DE\]](#)

Technical Articles and Tools can be found in the Design Resources on the product web page.

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