ROHM Solution Simulator

Input voltage 5.5 V to 20 V
Maximum output current 150 mA
4ch LED Driver

BD18337EFV/BD18347EFV Simulation Guide

This material provides a guide for performing simulations on the BD18337EFV/BD18347EFV using the ROHM Solution Simulator. This material describes the BD18347EFV as an example, but the same information applies to the BD18337EFV if the number of LEDs connected in series in the circuit diagram is changed to 3 stages.

Contents

Information

・For more details on the product, see the following product information links.

▶ Product information links: BD18337EFV, BD18347EFV

・For a comparison between the actual equipment and the simulation results, see the following modeling reports.

▶ Modeling reports: BD18337EFV, BD18347EFV

Constant settings and simulation

Since the BD18337EFV/BD18347EFV has several external components, it is necessary to determine the constants so that target characteristics can be obtained. Table 1 shows the items required for design and simulation.

The design items are listed according to the procedure for determining the constants.

In the names of related parts column, the part names that can change the design item parameters are listed.

The simulator and analysis type use the ROHM Solution Simulator Time Domain (transient analysis) as standard, but other analysis methods that can be used in parallel are listed.

The column for the check locations and characteristics lists the locations where the waveform is displayed and the characteristics that can be checked as a result.

The right-hand side lists the pages that correspond to each item.

Although each item is simulated at the end, each part affects each characteristic. Therefore, simulations must be run again after all the constants of parts are determined to see if the design values are met.

Table 1. List of design and simulation items to be implemented

Design item	Names of related parts	Parallel analysis method	Location to be checked and the characteristics	**Page**
1. Output Current	R_{SETx} (x=1 to 4)	SystemVision®Cloud (NOTE 1)	I_{OUTx} (x=1 to 4) Output current	4
1-1. Energy Sharing control		Calculation formula	P_{TOTAL}, P_{IC}, P_{REXT} Power consumption	6
1-2. Cold Crank compliance test		-	I_{OUTx} (x=1 to 4) Output current	11
2. Output Capacitor	C_{OUTx} (x=1 to 4)	-	C_{OUTx}(x=1 to 4) Output capacitance	13
3. LED	Z_{Dx} (x=1 to 4)	Calculation formula	V_{fLED} LED Vf	13
4. Input Capacitor	C_{IN1}, C_{IN2}	-	CIN1, CIN2 Input capacitance	13

(NOTE 1) SystemVision® is a registered trademark of Mentor Graphics Corp.

Information The procedure in Table 1 shows the simulation method using ROHM Solution Simulator. If you are using another simulator, we offer a separate SPICE model, which you can obtain from the following links.

▶ SPICE model: BD18337EFV, BD18347EFV

Design parameter settings

When designing the circuits, determine the target parameters. An example is shown in Table 2. However, since different characteristics are considered important depending on the installed devices and functions, change these parameters as necessary.

Table 2. Example of the design parameters

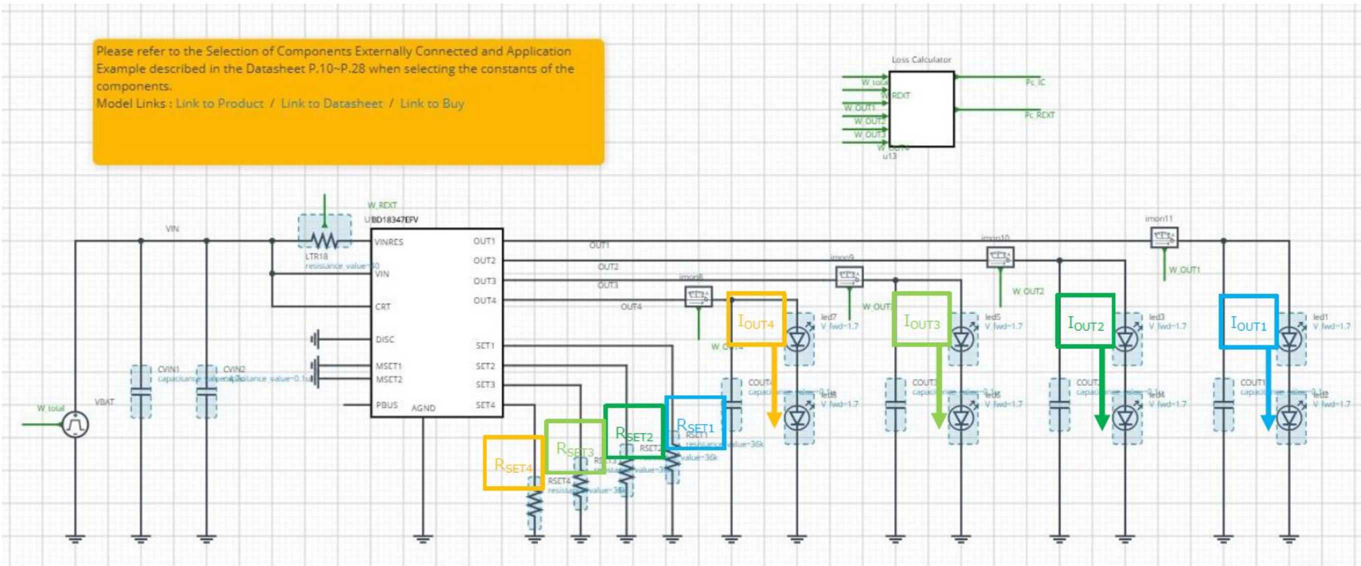
Item	Value
Input voltage	min 7.2 V, nominal 13.2 V, max 18 V
Output current	100 mA±5%

Detailed procedures

1. Output Current

External component to be designed: $R_{SETx(x=1\ to\ 4)}$

Monitoring point: $I_{OUTx(x=1\ to\ 4)}$



Calculate the output current

● The output current can be calculated with the following equation.

$$I_{OUTx} = \frac{1800}{R_{SETx}} \quad [A]$$

For example, to set the output current to 50 mA, set R_{SETx} to 36 kΩ.

$$I_{OUTx} = \frac{1800}{36k} = 50 \quad [mA]$$

Detailed procedures

1. Output current (continued)

Set the simulation time

● In this material, transient analysis (Time Domain) is used as the simulation type and the results are converted to the VIN axis. Therefore, the VIN is set to sweep up over 15 ms so that the result is not affected by the time axis.

Perform the simulation

● Click ▶ to perform the simulation and wait until the simulation is completed.

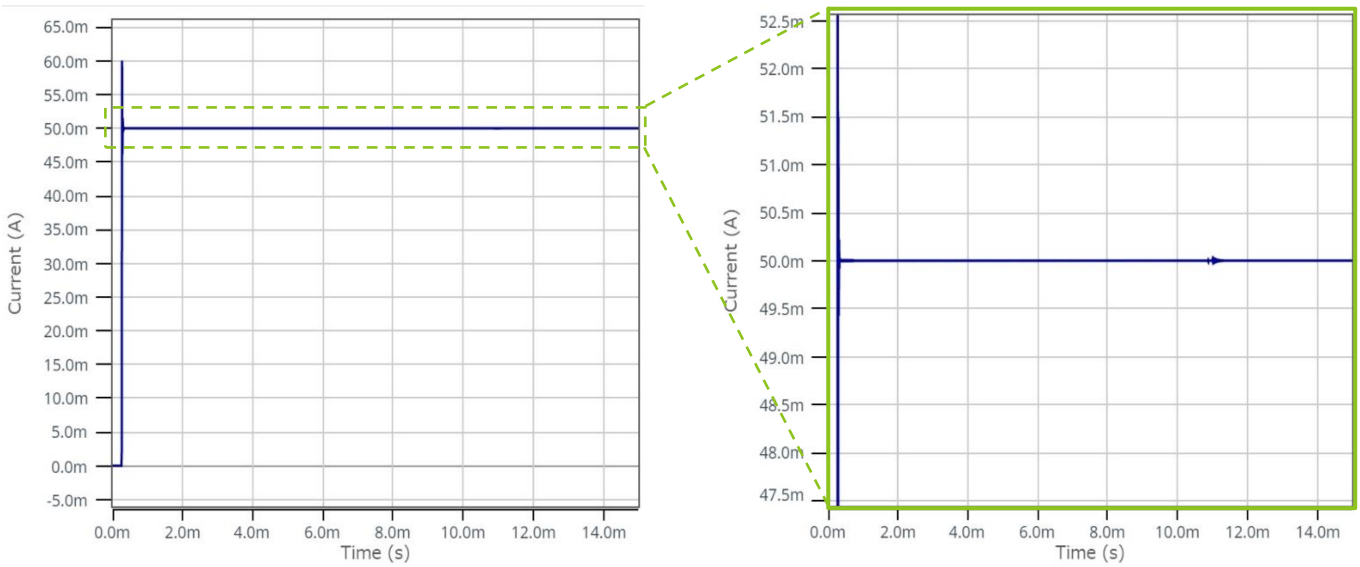
Information	The simulation takes approximately 30 seconds. The time varies with the server usage rate. For Advanced Options, "Balanced" is recommended.

Display the waveform and read the current value with the cursor

1. Drag and drop "Waveform Probe" onto the LED1 in the circuit diagram and select i(p) from the list that appears to display the waveform.

2. Enlarge the waveform in the y-axis direction and confirm that the current value is stable.

3. Right-click on Waveform Viewer and select "Add Cursor". Move the cursor that appears to the right side to display the current value, and confirm that it is within the range of the design parameters.



Detailed procedures

1-1. Energy Sharing control

Next, we explain Energy Sharing control using the same circuit.

What is Energy Sharing control?

- Energy Sharing control is a control method that reduces the amount of heat generated by the IC by inserting a resistor R_{EXT} between the power supply VIN and the power supply terminal of the IC.

Calculate the power distribution that results from Energy Sharing

To protect the IC, the power consumed by the IC P_{IC} must not exceed the power dissipation P_d.

$$P_{IC} < P_d$$

P_{IC} and P_d can be expressed by the following equations.

$$\text{Power dissipation} \quad P_d = \frac{T_{Jmax} - T_A}{\theta_{JA}} = \frac{150 - 25}{36} = 3.47 \qquad [W]$$

$$\text{Power consumed by IC} \quad P_{IC} = W_{TOTAL} - P_{C\_REXT} - P_{LED\_TOTAL} \qquad [W]$$

The power of the entire circuit can be calculated by the following formula.

$$W_{TOTAL} = VIN \times I_{TOTAL} \qquad [W]$$

Also, using the resistor R_{LTR18} connected between the VIN and VINRES pins and the current I_{LTR18}, the power consumed by the resistor can be calculated by the following equation.

$$P_{C\_REXT} = {I_{LTR18}}^2 \times R_{LTR18}$$

In addition, calculate the power consumed by the LED using the following conditions:

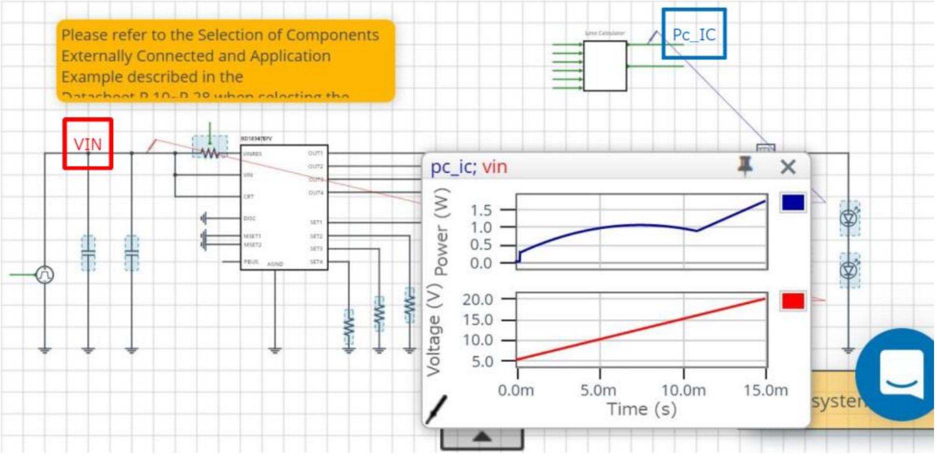
$\mathrm{I_{LED_n}}$: Current that flows in each LED = 50mA
$\mathrm{V_{OUT_n}}$: Each output voltage = 4V

$$\text{Power consumed by LED} \quad \mathrm{P}_{LED\_TOTAL} = \sum_{n=1}^{4} I_{LED_n} \times V_{OUT_n} = 50\mathrm{m} \times 4 \times 4 = 0.8\ [\mathrm{W}]$$

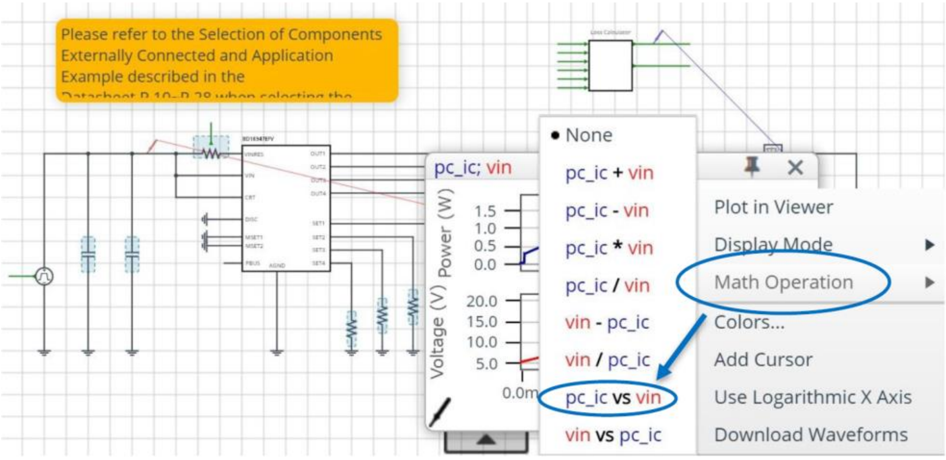
Display the waveform and confirm that the power is distributed.

1. Drag and drop "Waveform Probe" to Pc_IC.

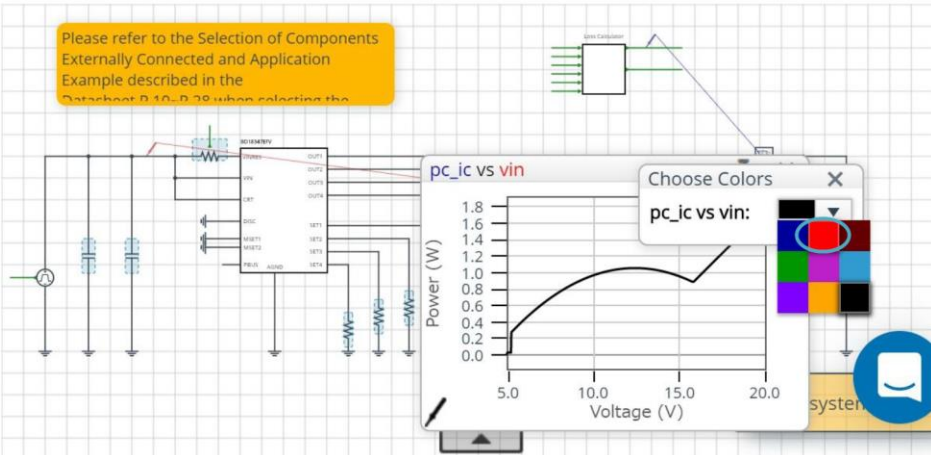
2. Drag and drop the probe at the bottom left of the window that appears to VIN to add a waveform.



3. Right-click on the waveform and select "pc_ic vs vin" from "Math Operation" that appears to create a waveform with VIN as the x-axis.



4. Color the Pc_IC waveform to improve visibility. Right-click on the waveform and make the color red.

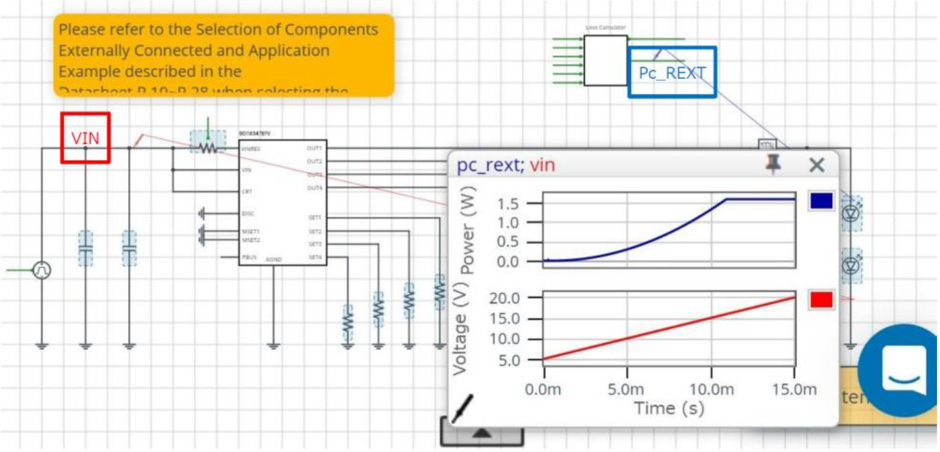


5. Right-click on the waveform and select "Plot in Viewer" to display the waveform in Waveform Viewer.

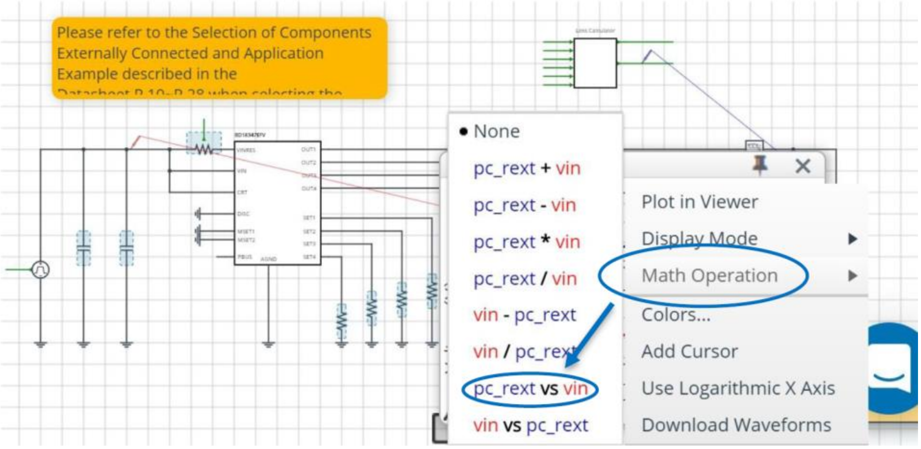
6. Next, display Pc_REXT.

7. Drag and drop "Waveform Probe" to Pc_REXT in the same way as Pc_IC.

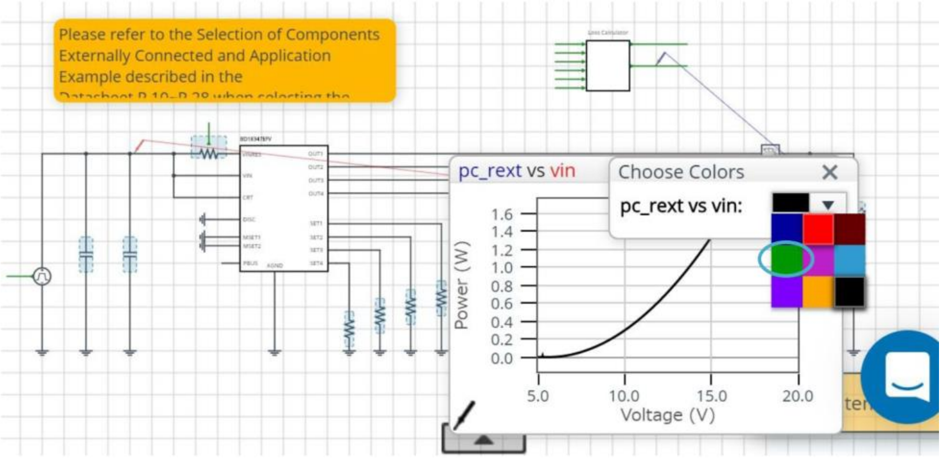
8. Drag and drop the probe at the bottom left of the window that appears to VIN to add a waveform.



9. Right-click on the waveform and select "pc_rext vs vin" from "Math Operation" that appears to create a waveform with VIN as the x-axis.



10. Color the Pc_REXT waveform to improve visibility. Right-click on the waveform and make the color green.

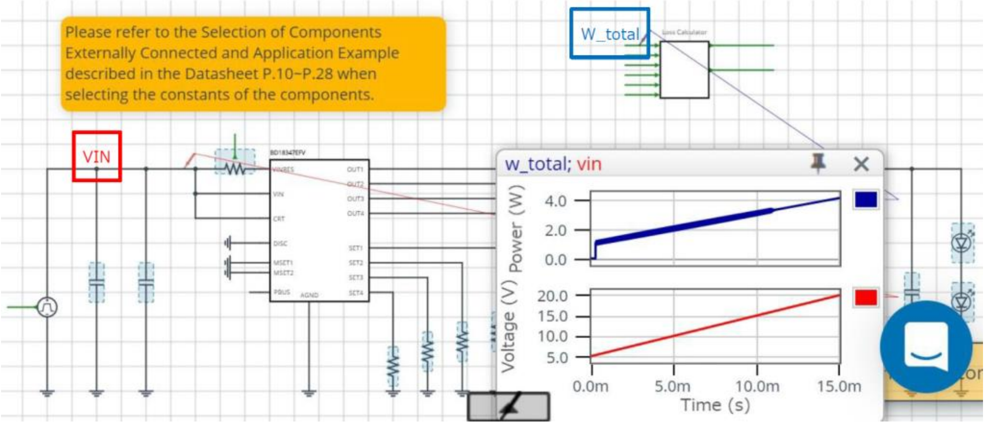


11. Right-click on the waveform and select "Plot in Viewer" to display the waveform in Waveform Viewer.

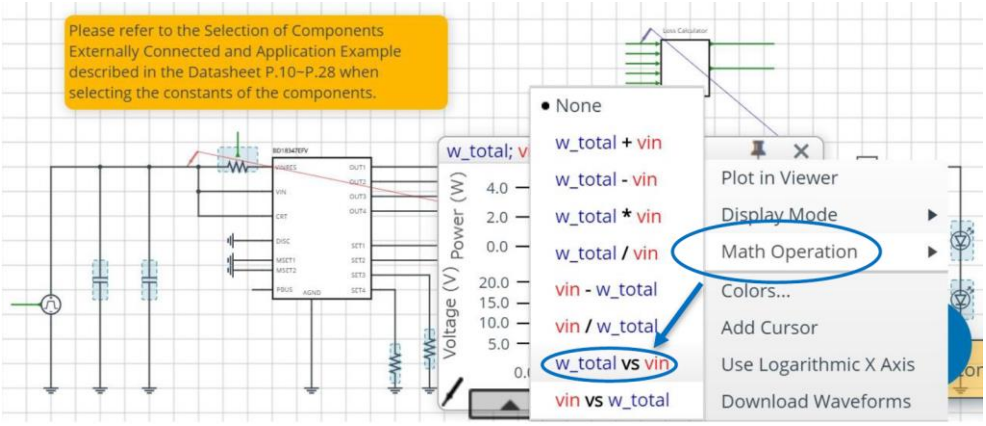
12. Finally, display W_total.

13. Drag and drop "Waveform Probe" to W_total in the same way as Pc_IC.

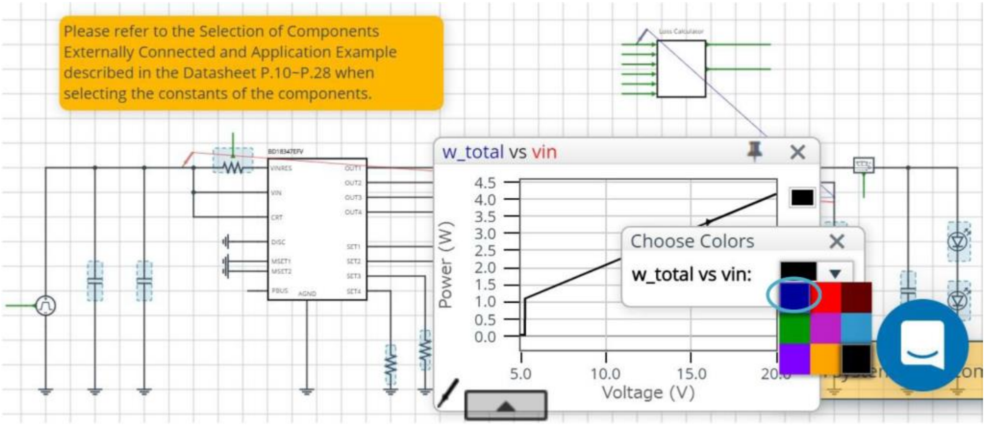
14. Drag and drop the probe at the bottom left of the window that appears to VIN to add a waveform.



15. Right-click on the waveform and select "w_total vs vin" from "Math Operation" that appears to create a waveform with VIN as the x-axis.



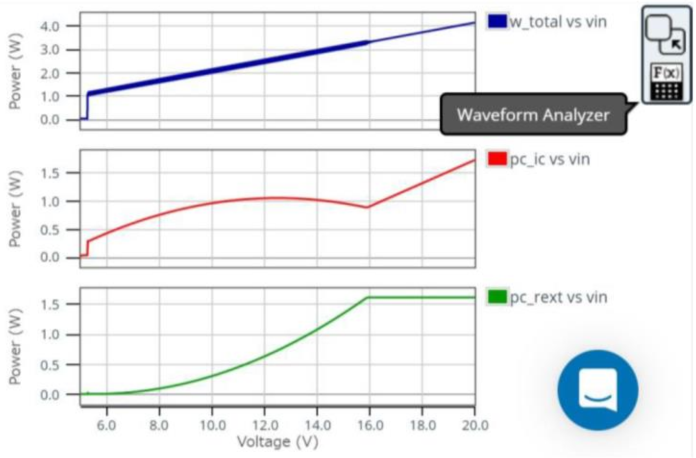
16. Color the W_total waveform to improve visibility. Right-click on the waveform and make the color blue.



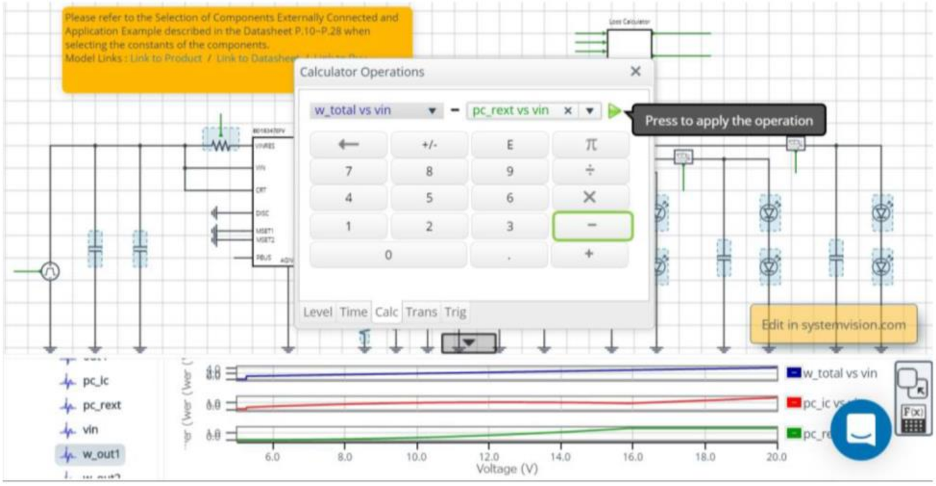
17. Right-click on the waveform and select "Plot in Viewer" to display the waveform in Waveform Viewer.

18. Verify the correctness of the waveform using the calculation function of Waveform Viewer.

19. Click Waveform Analyzer at the upper right of Waveform Viewer to display the calculation function.

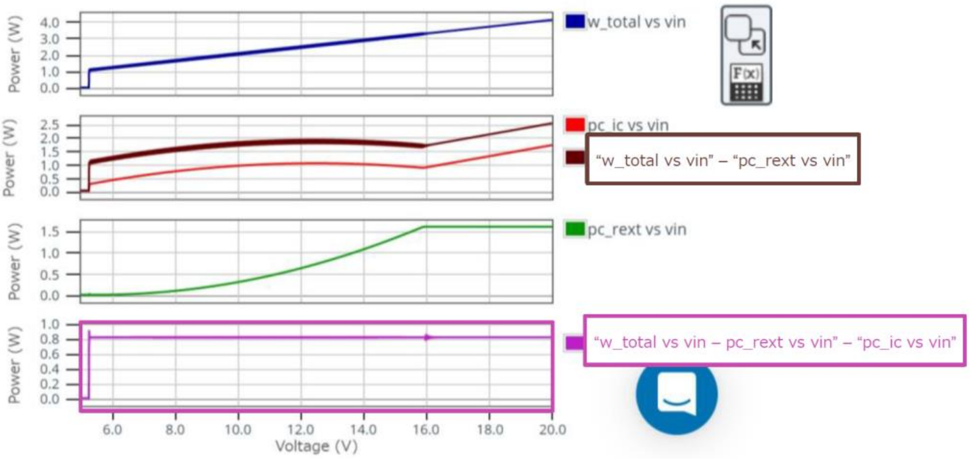


20. Select the "Calc" tab, create the formula ["w_total vs ic" – "pc_rext vs ic"], then click ▶.



21. Then, create the formula ["w_total vs ic – pc_rext vs ic" – "pc_ic vs ic"] in the same way, and click ▶.

22. It can be confirmed that the waveform appearing in 21. is P_{LED_TOTAL} $= 0.8$[W] (page 6), and the correctness can be verified.



Procedures

1-2. Cold Crank compliance test

What is Cold Crank?

● The Cold Crank test is defined by SAE in the US and JIS in Japan as the current value that can maintain a voltage of 7.2 V 30 seconds after the start of discharge at a temperature of -18ºC. The larger this value, the higher the performance. To comply with Cold Crank, the circuit must be able to maintain the set current even if the input drops to 7.2 V.

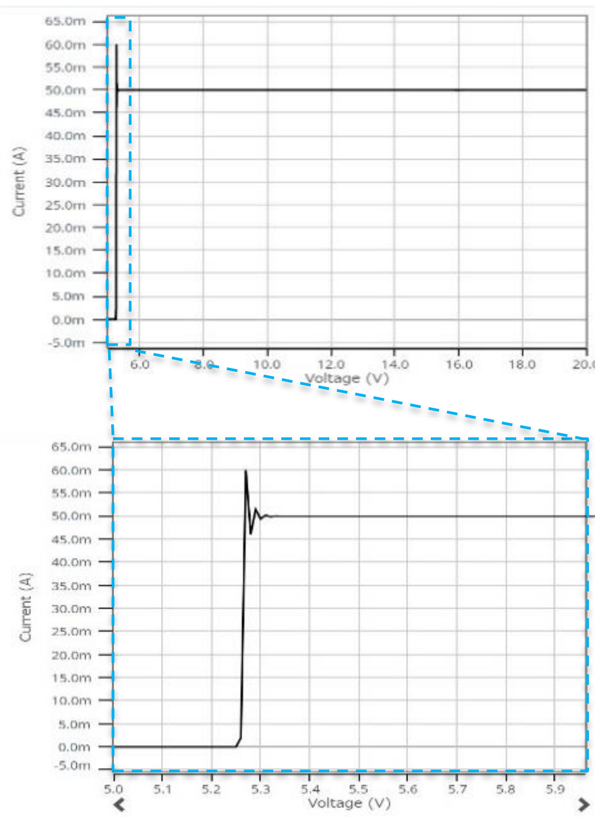
Display the waveform and check the operation at low voltage

1. Drag and drop "Waveform Probe" to LED1 on the circuit diagram and select i(p) to display the waveform.

2. Drag and drop the probe at the bottom left of the waveform that appears to VIN to add a waveform.

3. Right-click on the waveform and select "i(p) vs vin" from "Math Operation" that appears to create a waveform with VIN as the x-axis.

4. Reading the value of VIN where the current stabilizes shows that it is 5.4 V. Therefore, it can be seen that the circuit complies with Cold Crank.

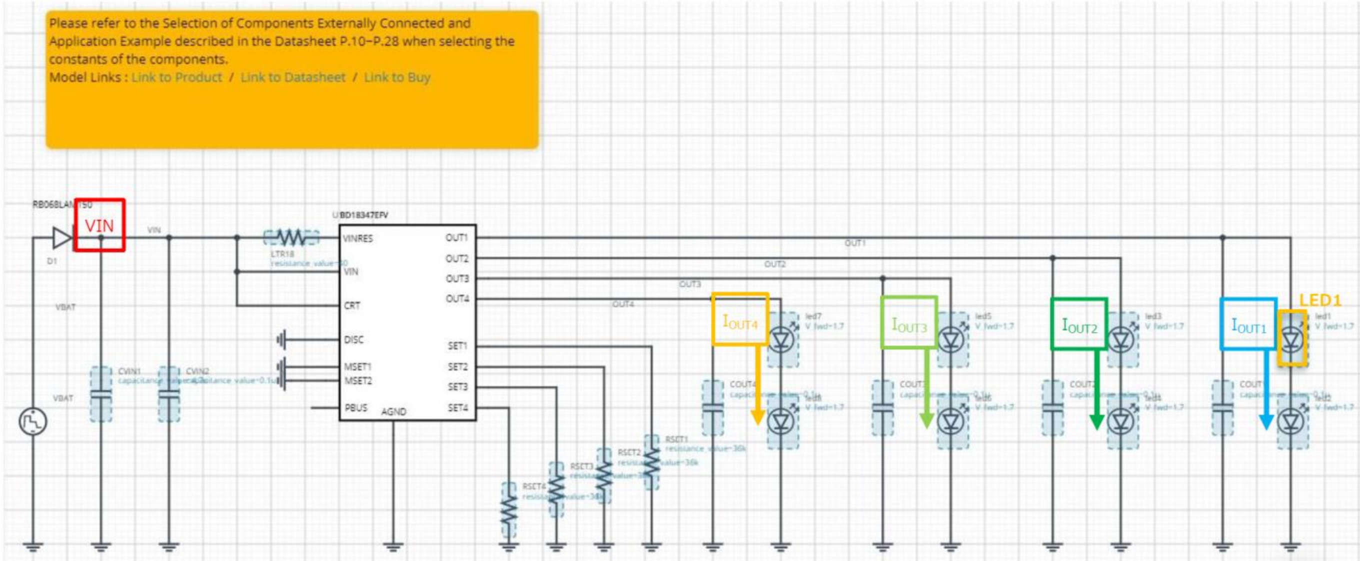


Next, we will verify whether the circuit can handle a transient drop of VIN to 7.2 V.

Circuit diagram

External component to be designed: -

Monitoring point: $I_{OUTx(x=1\ to\ 4)}$



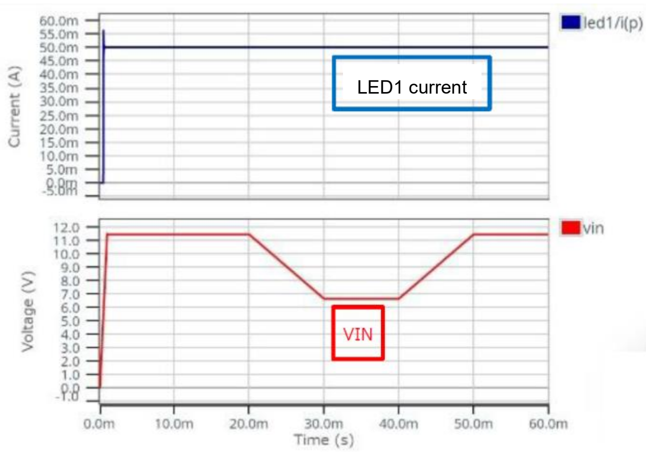
Perform the simulation

● Click ▶ to perform the simulation and wait until the simulation is completed.

Information	The simulation takes approximately 30 seconds. The time varies with the server usage rate. For Advanced Options, "Balanced" is recommended.

Display the waveform and check the current value

1. Drag and drop "Waveform Probe" to LED1 on the circuit diagram and select i(p).
2. Drag and drop the probe at the bottom left of the waveform that appears to VIN.
3. The current flowing through LED1 is maintained even if VIN drops to 7.2 V. Therefore, it can be seen that the circuit complies with Cold Crank even if VIN changes transiently.



Detailed procedures

2. Output Capacitor

Selection of the output capacitor

- Use a 0.1 μF MLCC (Multi-Layer Ceramic Capacitor) for the output capacitor. However, an MLCC has a DC bias characteristic, and the actual capacitance decreases as the voltage increases. When using an MLCC, assume the maximum value of VOUT and design so that the actual capacitance does not fall below 0.047 μF.

Detailed procedures

3. LED

Calculate the upper limit potential difference across the LED

- The BD18337EFV/BD18347EFV introduced in this material is a linear type LED driver. Therefore, the output voltage cannot be higher than the input voltage. Therefore, the following expression must be satisfied.

$$\mathrm{VIN} \geq V_{f_{LED}} \times N + V_{DR} + R_{ON} \times (I_{OUT1} + I_{OUT2} + I_{OUT3} + I_{OUT4})$$

As an example, in the case of VIN = 20 V, N = 2 (for BD18337, substitute 3), V_{DR} = 15.8 V, R_{ON} = 1, I_{OUTx} = 50 mA.

$$20 \geq V_{f_{LED}} \times 2 + 15.8 + 1 \times 200m$$

$$V_{f_{LED}} \leq \frac{20 - 16}{2} = 2.0 \quad [\mathrm{V}]$$

Detailed procedures

4. Input Capacitor

Selection of the input capacitor

- For all applications, connect a bulk capacitor: nominal capacitance 4.7 μF and a bypass capacitor: nominal capacitance 0.1 μF. An MLCC is used for the capacitor, but an MLCC has a DC bias characteristic, and the actual capacitance decreases as the voltage increases. When using an MLCC, assume the maximum value of VIN and select the input capacitor so that the actual capacitance does not fall below the nominal capacitance of 2.2 μF.

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