

SPICE Modeling Report

Automotive 2ch 45 mΩ High-Side Switch with Variable OCD and OCD Mask Function BV2HD045EFU-C

General Description

In this report, the characteristics that can be confirmed by the simulation using the SPICE model of the IPD series IC BV2HD045EFU-C will be described.

Simulation Environment

- Circuit Simulator : PSpice / Cadence Design System, Inc.
- Version Information : 17.4-2019
- OS Information : Windows 10 64-bit Edition

File Information

- Library File Name : BV2HD045EFU-C_PSpice.lib
- Symbol File Name : BV2HD045EFU-C.olb
- Subcircuit and Symbol

Table 1 Correspondence Table

Product Name	Subcircuit	Symbol
BV2HD045EFU-C	BV2HD045EFU-C	BV2HD045EFU-C

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.

BV2HD045EFU-C Spice Model

■ Pin Information

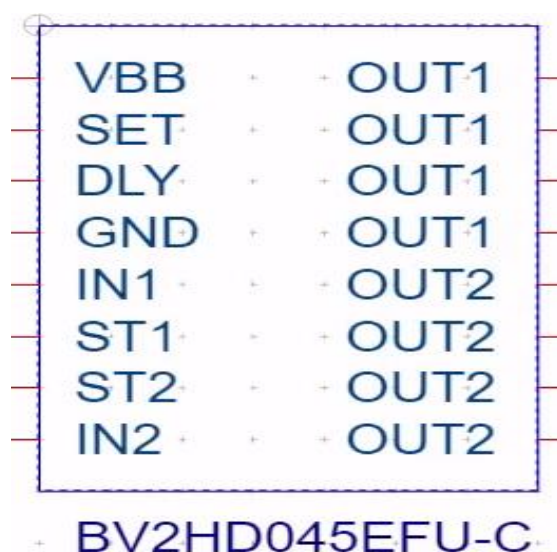


Figure 1. Symbol of BV2HD045EFU-C

Table 2 Subcircuit Pin Table

Pin No.	Pin Name	Function
1	VBB	Power supply pin
2	SET	Over current limit value setting pin
3	DLY	Over current mask time setting pin
4	GND	GND pin
5	IN1	Input pin1, with internal pull-down resistor
6	ST1	Diagnostic output pin1
7	ST2	Diagnostic output pin2
8	IN2	Input pin2, with internal pull-down resistor
9 to 12	OUT2	Output pin 2
13 to 16	OUT1	Output pin 1
EXP-PAD	VBB	Power supply pin

Verifiable Characteristics

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Electrical Characteristics (vs. Datasheet)

Table 3 Electrical Characteristics Comparison

(Unless otherwise specified $6\text{ V} \leq V_{\text{BB}} \leq 28\text{ V}$, $T_a = 25\text{ }^{\circ}\text{C}$)

Parameter	Modeled (Note1)	Design Value		Unit	Error	Condition
		Datasheet	SPICE			
[Power Supply]						
Standby Current	Yes	-	0	μA	-	V _{BB} = 14 V, V _{IN1} = 0 V, V _{IN2} = 0 V, V _{OUT1} = V _{OUT2} = 0 V
Operating Current	Yes	6	6.0	mA	0%	V _{BB} = 14 V, V _{IN1} = V _{IN2} = 5 V, V _{OUT1} = V _{OUT2} = open
UVLO Detection Voltage	Yes	-	3.1	V	-	
UVLO Hysteresis Voltage	Yes	0.3	0.3	V	0%	
[Input (V _{IN1} , V _{IN2})]						
High-Level Input Voltage	Yes	-	2.3	V	-	
Low-Level Input Voltage	Yes	-	2.0	V	-	
Input Voltage Hysteresis	Yes	0.3	0.3	V	0%	
High-Level Input Current	Yes	50	50	μA	0%	V _{IN1} = V _{IN2} = 5 V
Low-Level Input Current	Yes	-	0	μA	-	V _{IN1} = V _{IN2} = 0 V
[Output]						
Output On Resistance	Yes	45	45.0	mΩ	0%	V _{BB} = 8 V to 19 V
	Yes	-	55.2	mΩ	-	V _{BB} = 4.5 V
Output Leak Current	Yes	-	0	μA	-	V _{IN} = 0 V, V _{OUT} = 0 V
Output ON Slew Rate	Yes	0.3	0.30	V/μs	0%	V _{BB} = 14 V, R _L = 6.5 Ω
Output OFF Slew Rate	Yes	0.3	0.30	V/μs	0%	V _{BB} = 14 V, R _L = 6.5 Ω
Output ON Propagation Delay Time	Yes	70	70.0	μs	0%	V _{BB} = 14 V, R _L = 6.5 Ω
Output OFF Propagation Delay Time	Yes	50	49.8	μs	0.4%	V _{BB} = 14 V, R _L = 6.5 Ω
Output Clamp Voltage	Yes	48	48.0	V	0%	V _{IN1} = V _{IN2} = 0 V, I _{OUT1} = I _{OUT2} = 10 mA

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

(Unless otherwise specified $6\text{ V} \leq V_{\text{BB}} \leq 28\text{ V}$, $T_a = 25\text{ }^{\circ}\text{C}$)

Parameter	Modeled (Note1)	Design Value		Unit	Error	Condition
		Datasheet	SPICE			
[Diagnostic Output]						
Diagnostic Output Low Voltage	Yes	-	0.17	V	-	V _{IN1} = V _{IN2} = 5 V, I _{ST1} = I _{ST2} = 1 mA
Diagnostic Output Leak Current	Yes	-	0	μA	-	V _{IN1} = V _{IN2} = 0 V, V _{ST1} = V _{ST2} = 5 V
Diagnostic Output ON Propagation Delay Time	Yes	100	100.0	μs	0%	V _{BB} = 14 V, R _L = 6.5 Ω
Diagnostic Output OFF Propagation Delay Time	Yes	50	50.4	μs	0.8%	V _{BB} = 14 V, R _L = 6.5 Ω
[Diagnostic Function]						
Output ON Detection Voltage	No	3	-	V	-	V _{IN1} = V _{IN2} = 5 V
Fixed Over Current Limit	Yes	30	30.0	A	0%	V _{IN1} = V _{IN2} = 5 V
Variable Over Current Limit	Yes	4.1	4.10	A	0%	V _{IN1} = V _{IN2} = 5 V, R _{SET} = 47 kΩ
Open Load Detection Voltage	Yes	3.0	3.0	V	0%	V _{IN1} = V _{IN2} = 0 V
Open Load Detection Sink Current	Yes	-10	-10.0	μA	0%	V _{IN1} = V _{IN2} = 0 V, V _{OUT1} = V _{OUT2} = 5 V

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

Characteristic in SPICE (vs. Measured Waveform)

1. Standby Current

Simulation Setting

Type: Transient

Run Time: 100 s

(Maximum Step Size: 10 ms)

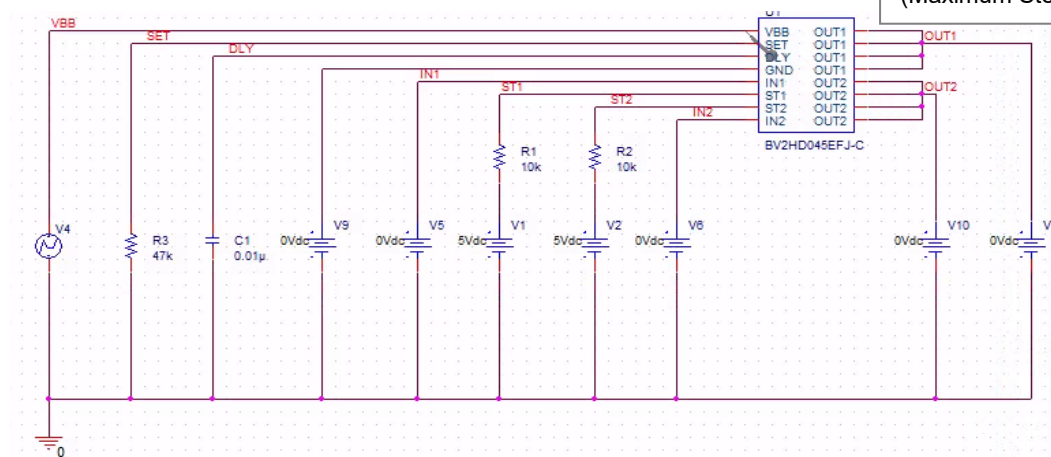
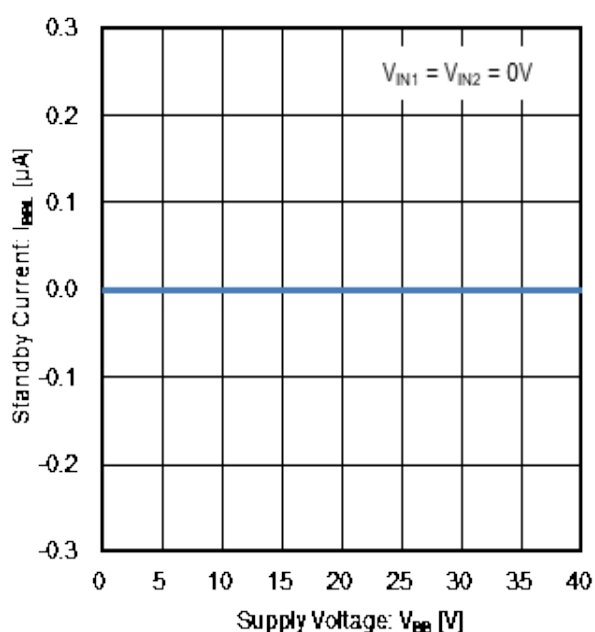
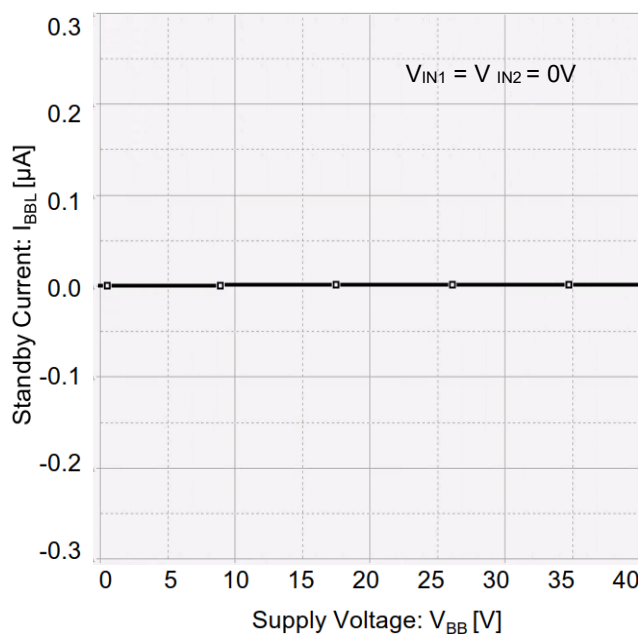
Figure 2.
Simulation Schematic 1Figure 3.
Standby Current
(Measured Waveform)Figure 4.
Standby Current
(SPICE Simulation)

Table 4 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Standby Current	0.0	0.00	μA	-	$V_{BB} = 14\text{ V}$, $V_{IN1} = 0\text{ V}$, $V_{IN2} = 0\text{ V}$, $V_{OUT1} = V_{OUT2} = 0\text{ V}$

(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. Operating Current

Simulation Setting
Type: Transient
Run Time: 100 s
(Maximum Step Size: 10 ms)

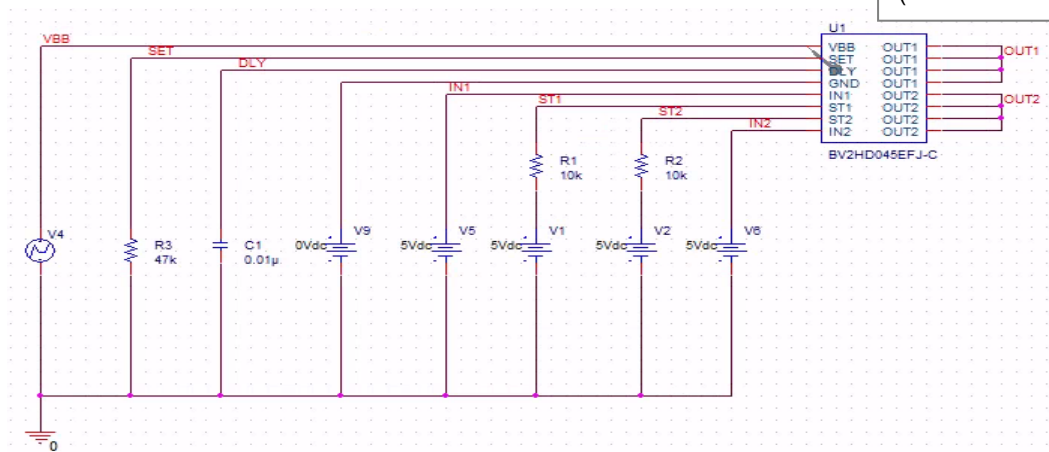


Figure 5.
Simulation Schematic 2

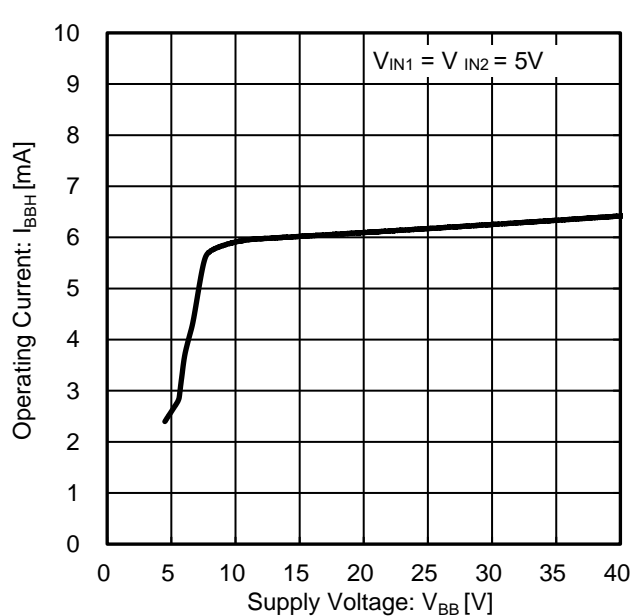


Figure 6.
Operating Current
(Measured Waveform)

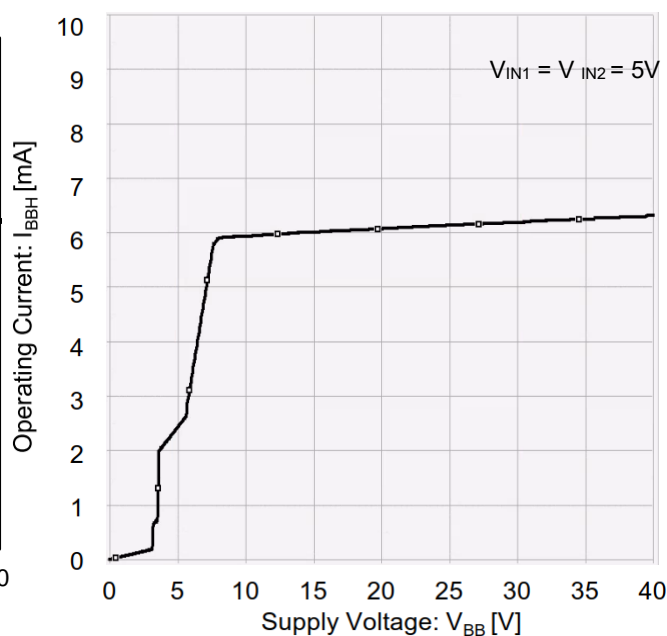


Figure 7.
Operating Current
(SPICE Simulation)

Table 5 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Operating Current	6.0	6.0	mA	0.0 %	V _{BB} = 14 V, V _{IN1} = V _{IN2} = 5 V, V _{OUT1} = V _{OUT2} = open

(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 ON Resistance

Simulation Setting

Type: Transient

Run Time: 0.5 ms

(Maximum Step Size: 1 us)

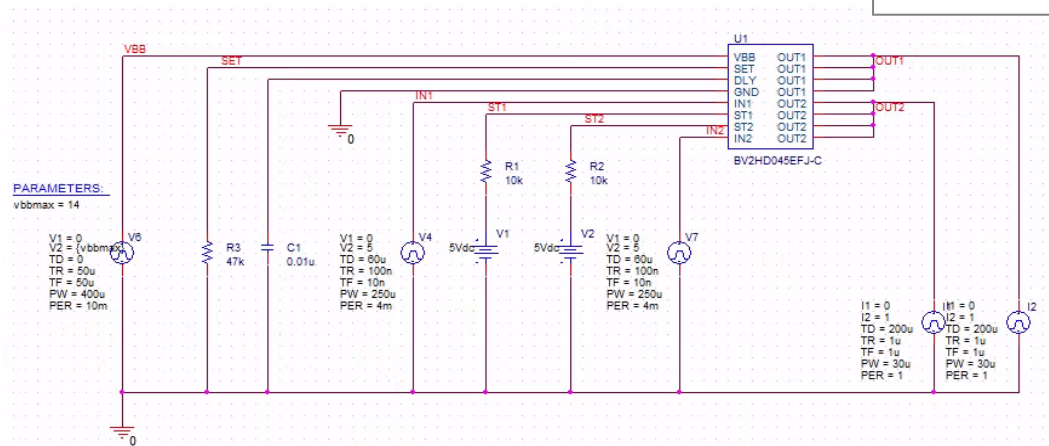
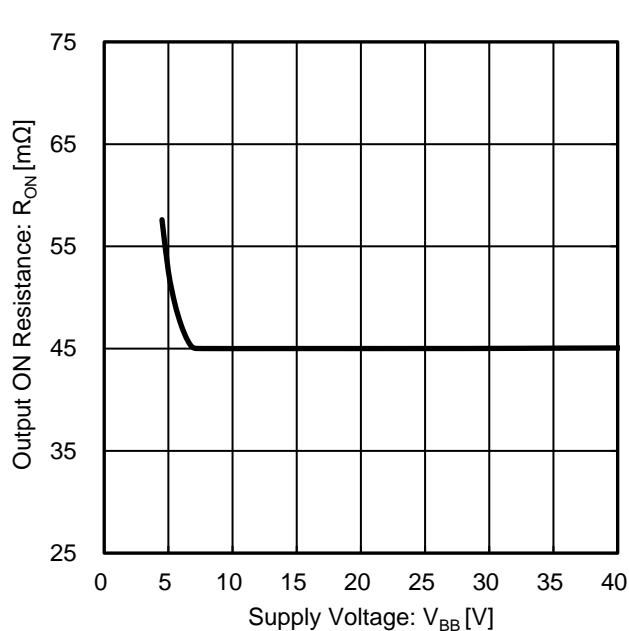
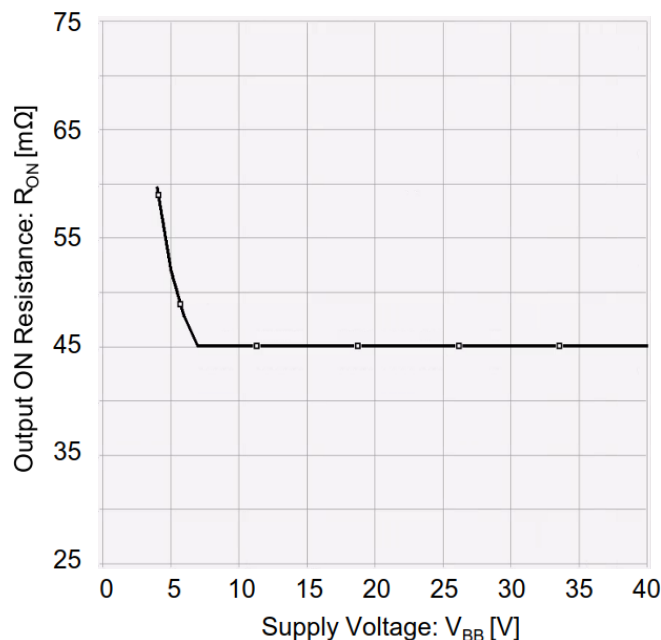
Figure 8.
Simulation Schematic 3Figure 9.
Output ON Resistance
(Measured Waveform)Figure 10.
Output ON Resistance
(SPICE Simulation)

Table 6 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Output On Resistance (V _{BB} = 8 to 19V)	45	45.0	mΩ	0.0 %	V _{BB} = 8 V to 19 V V _{BB} = 4.5V
Output On Resistance (V _{BB} = 4.5V)	55.9	55.2	mΩ	0.2 %	

(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. Timing Chart (Propagation Delay Time)

Simulation Setting
 Type: Transient
 Run Time: 0.5 ms
 (Maximum Step Size: 1 us)

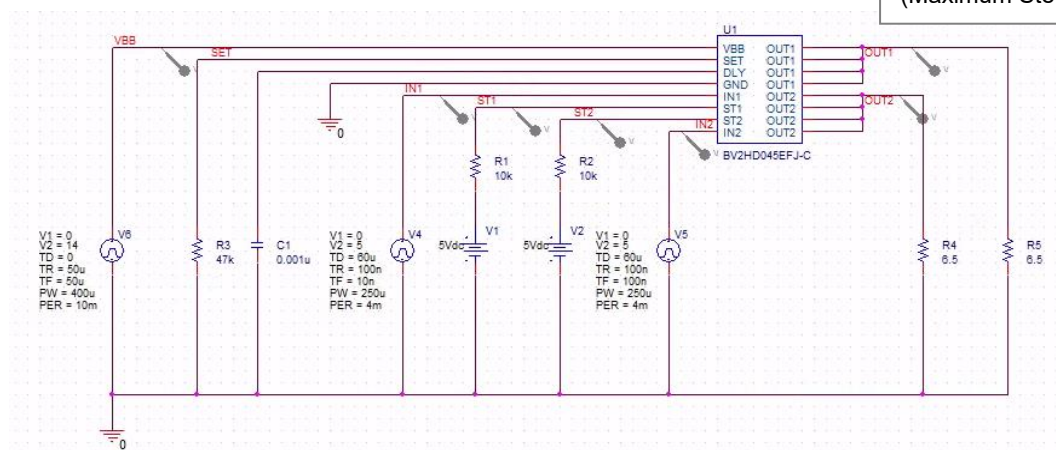


Figure 11.
Simulation Schematic 4

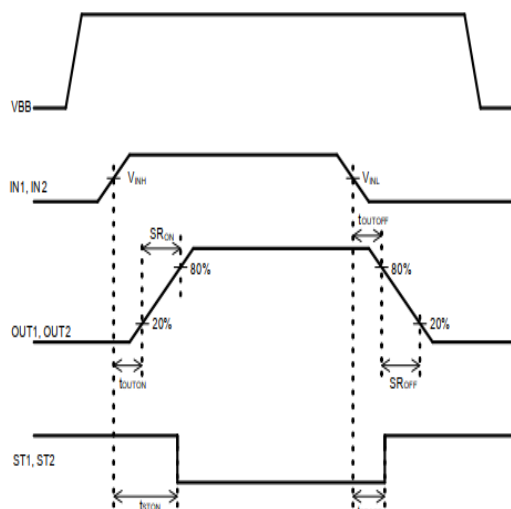


Figure 12.
Timing Chart (Propagation Delay Time)
(Target Waveform)

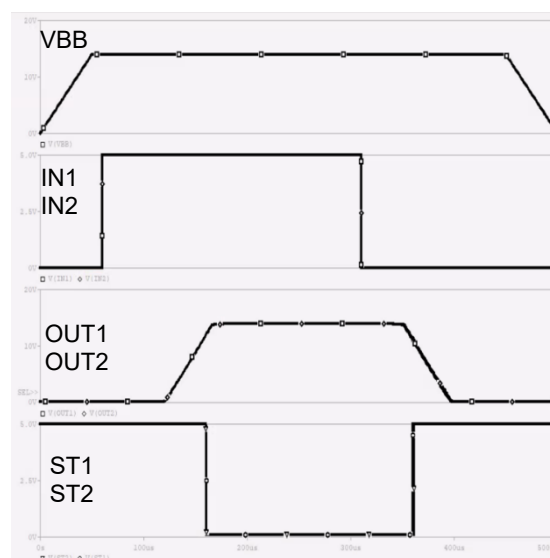


Figure 13.
Timing Chart (Propagation Delay Time)
(SPICE Simulation)

5. Over Current Limiting Operation in one side channel

Simulation Setting
Type: Transient
Run Time: 12 ms
(Maximum Step Size: 1 us)

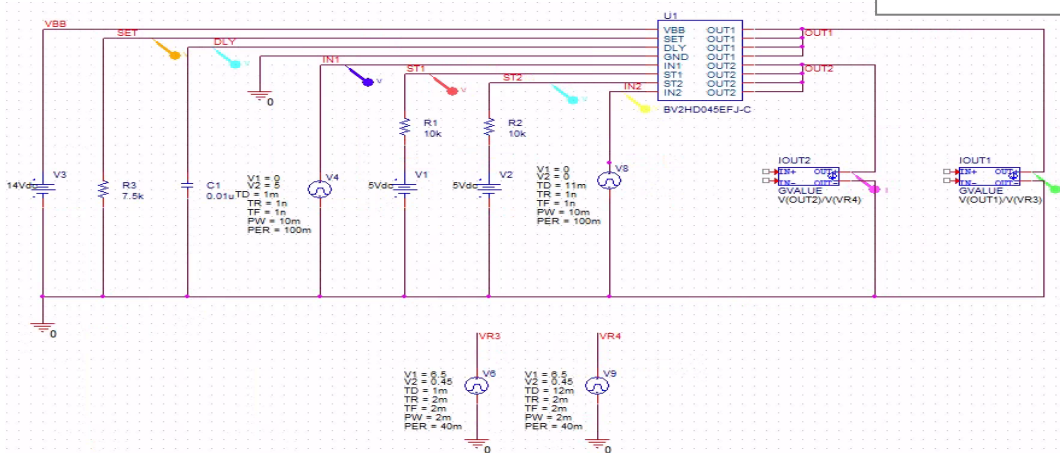


Figure 14.
Simulation Schematic 5

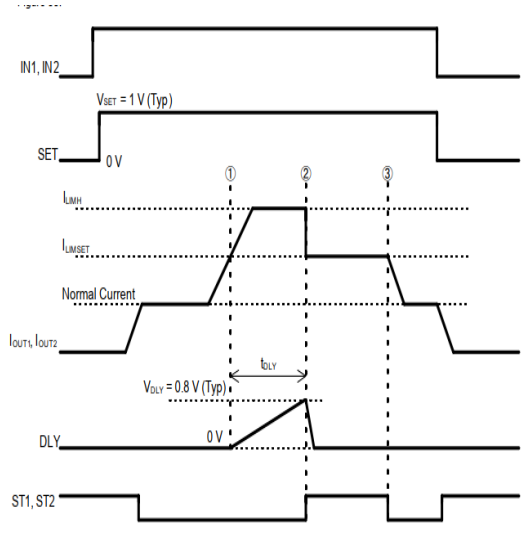


Figure 15.
Over Current Limiting Operation in one side channel
(Target Waveform)

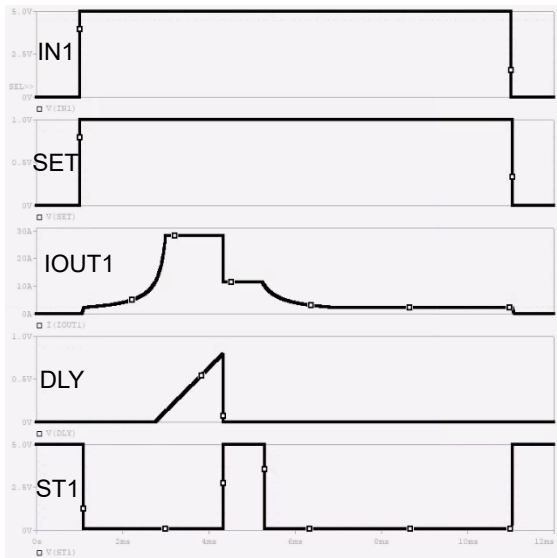


Figure 16.
Over Current Limiting Operation in one side channel
(SPICE Simulation)

6. Over Current Detection in Both Outputs

Simulation Setting
Type: Transient
Run Time: 10 ms
(Maximum Step Size: 1 us)

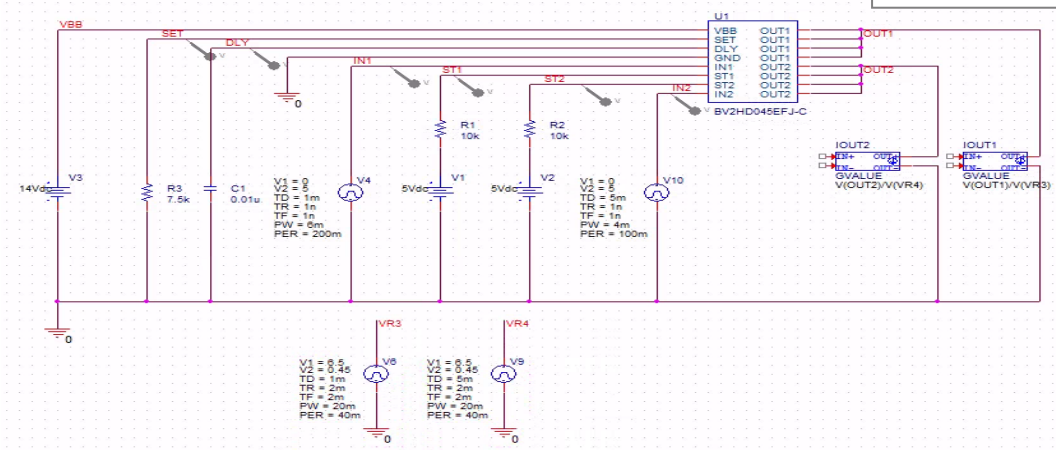


Figure 17.
Simulation Schematic 6

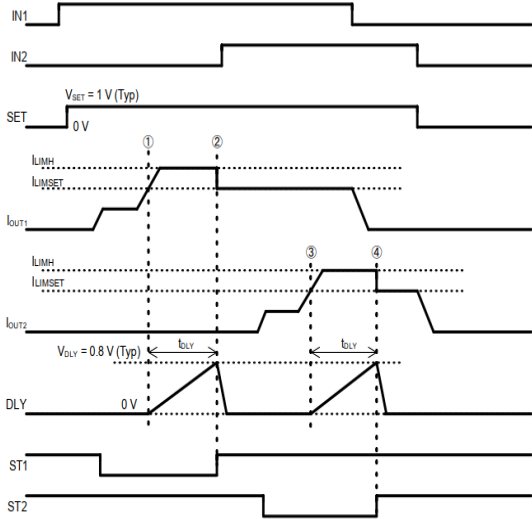


Figure 18.
Over Current Detection in Both Outputs
(Target Waveform)

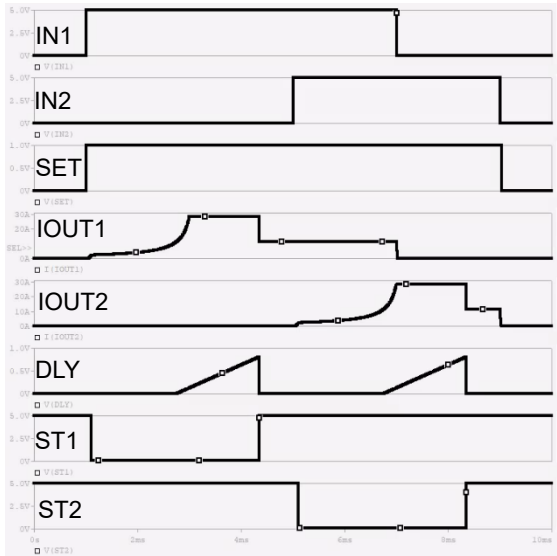


Figure 19.
Over Current Detection in Both Outputs
(SPICE Simulation)

7. Over Current Detection by Other Channel while C_{DLY} is charging.

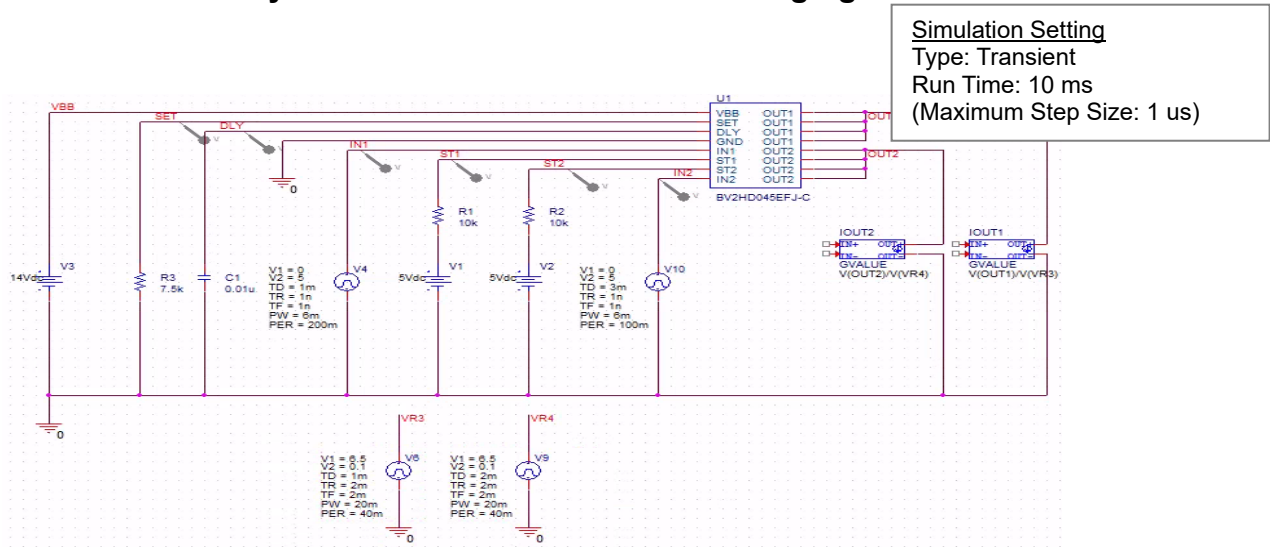


Figure 20.
Simulation Schematic 7

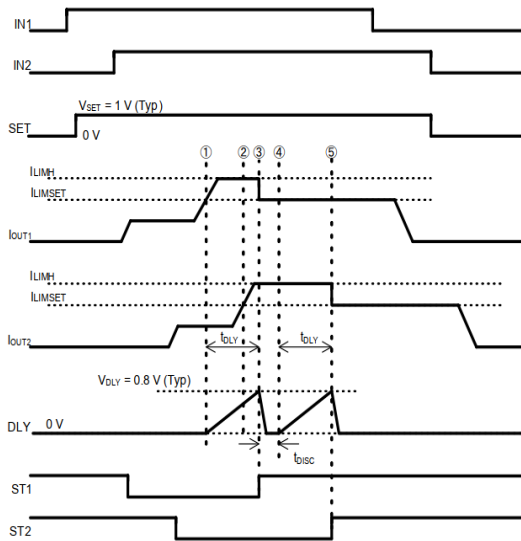


Figure 21.
Over Current Detection by Other Channel while
CDLY is charging.
(Target Waveform)

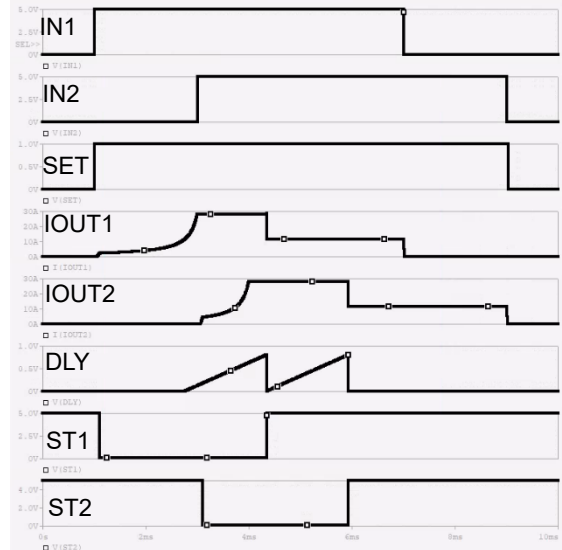


Figure 22.
Over Current Detection by Other Channel while
CDLY is charging.
(SPICE Simulation)

8. Variable Over Current Limit

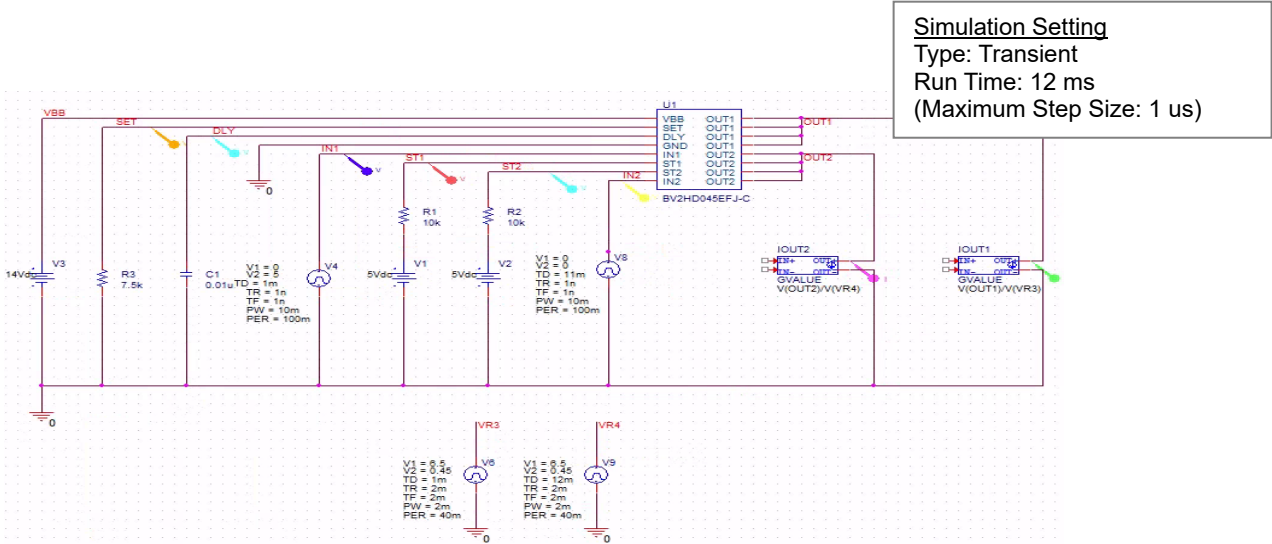


Figure 23.
Simulation Schematic 8

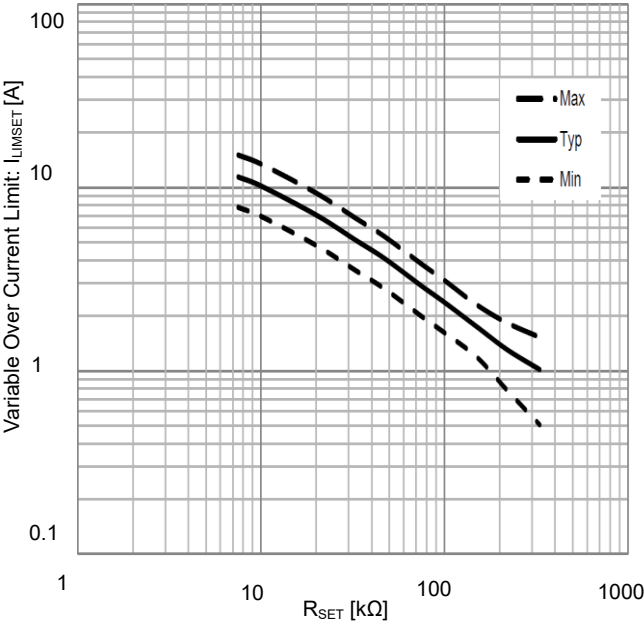


Figure 24.
Variable Over Current Limit
(Measured Waveform)

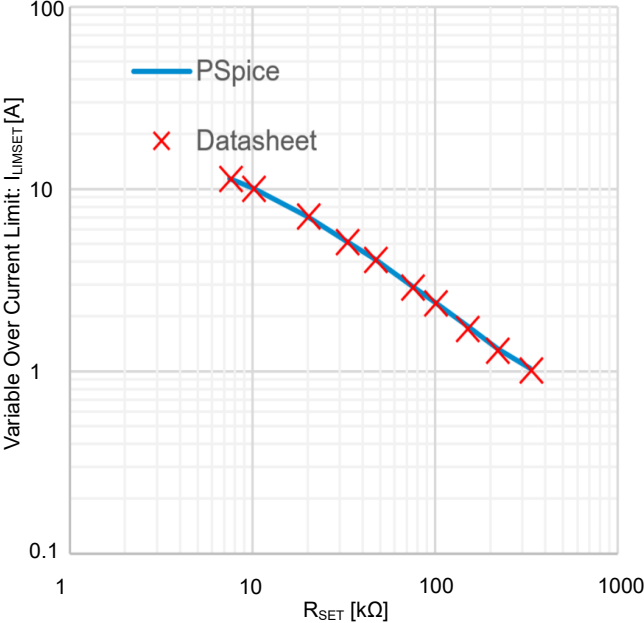


Figure 25.
Variable Over Current Limit
(SPICE Simulation)

9. Variable Over Current Mask Time

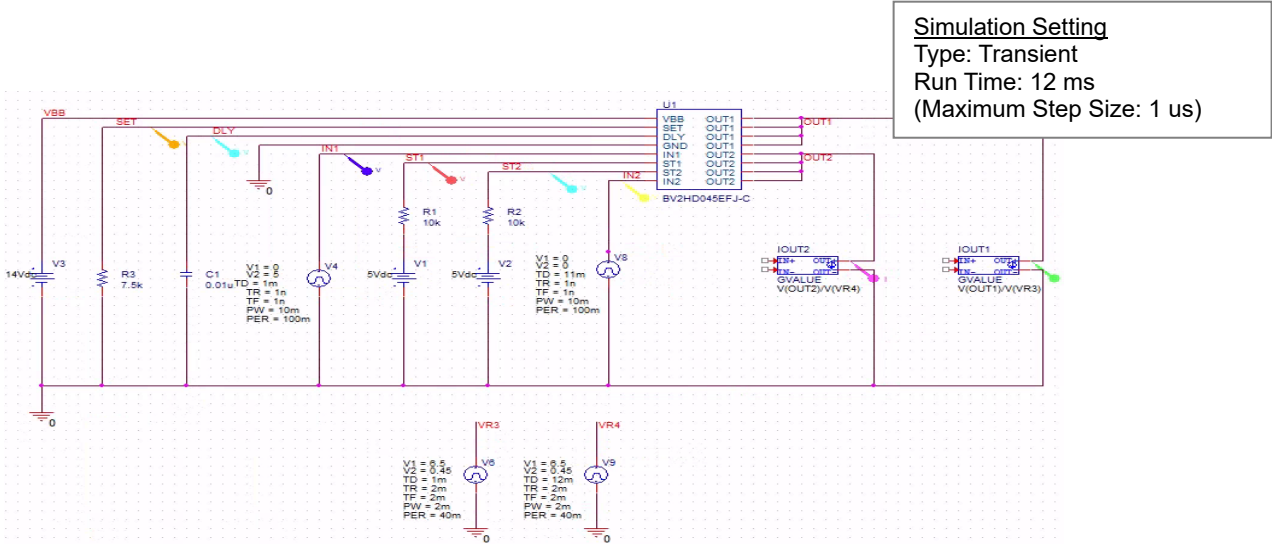


Figure 26.
Simulation Schematic 9

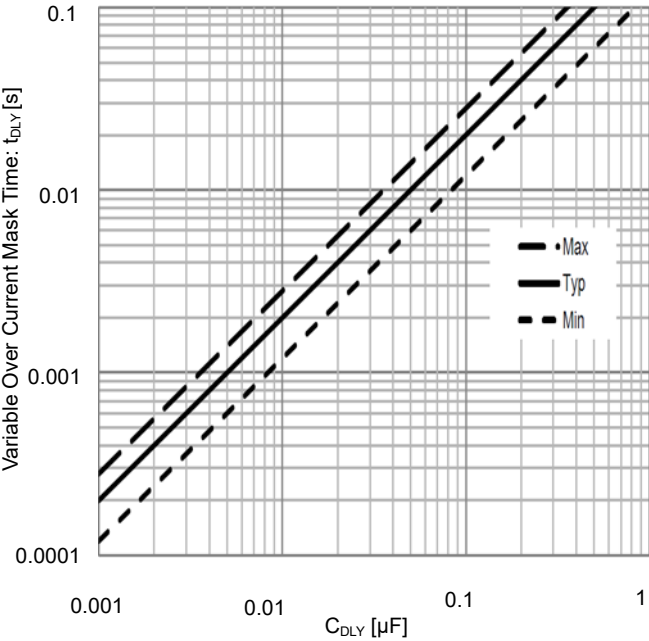


Figure 27.
Variable Over Current Mask Time
(Measured Waveform)

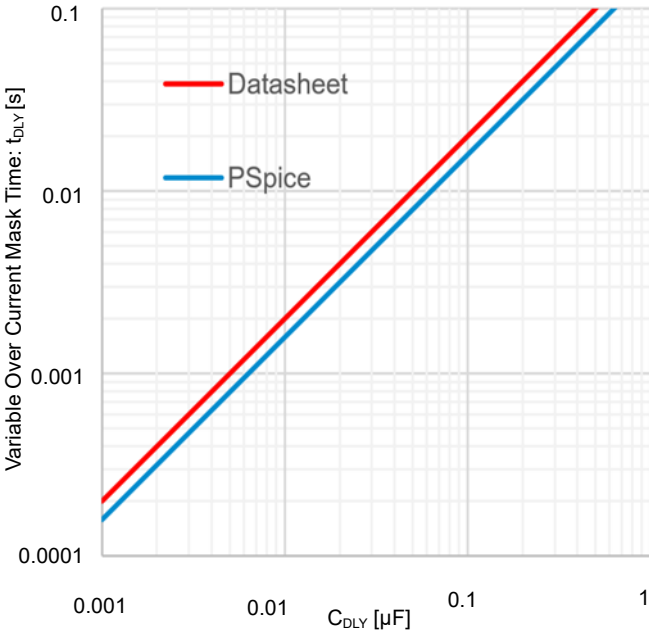


Figure 28.
Variable Over Current Mask Time
(SPICE Simulation)

Revision History

Date	Revision	Changes
May.2023	001	New Release

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