

SPICE Modeling Report

34 V Breakdown Voltage Variable Overcurrent Detection 1ch Load Switch BV1HAL45EFJ

General Description

In this report, the characteristics that can be confirmed by the simulation using the SPICE model of the Load Switch series IC BV1HAL45EFJ 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 : BV1HAL45EFJ_PSpice.lib
- Symbol File Name : BV1HAL45EFJ.olb
- Subcircuit and Symbol

Table 1 Correspondence Table

Product Name	Subcircuit	Symbol
BV1HAL45EFJ	bv1hal45efj	BV1HAL45EFJ

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.

BV1HAL45EFJ Spice Model

■ Pin Information

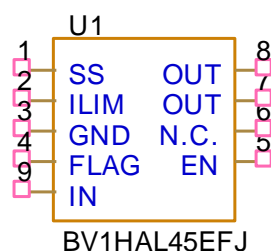


Figure 1. Symbol of BV1HAL45EFJ

Table 2 Subcircuit Pin Table

Pin No.	Pin Name	Function
1	SS	Variable soft-start time setting pin
2	ILIM	Variable overcurrent detection setting pin
3	GND	Ground pin
4	FLAG	Error flag output pin (Active low when TSD and OCD is detected.)
5	EN	Enable pin (Pull-down resistor is connected internally.) Active High to turn on the switch
6	N.C.	Not connected pin
7,8	OUT	Switch output pin
9	IN	Power input pin, switch input pin

Verifiable Characteristics

■	Electrical Characteristics (vs. Datasheet)	3
■	Characteristic in SPICE (vs. Measured Waveform).....	5
✓	1. Standby Current	5
✓	2. Operating Current	6
✓	3. Output ON Resistance	7
✓	4. Timing Chart (ONOFF).....	8
✓	5. Timing Chart (Latch-off due to Fixed Overcurrent Limit)	9
✓	6. Timing Chart (Latch-off due to Variable Overcurrent Detection).....	10
✓	7. Timing Chart (Duration of Overcurrent is less than t_{BLANK}).....	11
✓	8. Variable Overcurrent Detection	12
✓	9. Output ON Slew Rate ($V_{IN} = 24V$).....	13
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✓	11. Output ON Delay Time ($V_{IN} = 24V$).....	15
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Electrical Characteristics (vs. Datasheet)

Table 3 Electrical Characteristics Comparison

(Unless otherwise specified $8\text{ V} \leq V_{\text{BB}} \leq 32\text{ V}$, $T_a = 25\text{ }^{\circ}\text{C}$)

Unless otherwise specified: $V = V_{DD} = 0.2\text{ V}$, $I_D = 20\text{ }\mu\text{A}$

Parameter	Modeled (Note 1)	Design Value		Unit	Error	Condition
		Datasheet	SPICE			
[Power Supply]						
Standby Current	Yes	-	0	μA	-	$V_{\text{IN}} = 24\text{ V}$, $V_{\text{EN}} = 0\text{ V}$
Operating Current	Yes	2.00	2.00	mA	0.0%	$V_{\text{IN}} = 24\text{ V}$, $V_{\text{EN}} = 5\text{ V}$
UVLO Detection Voltage	Yes	-	4.5	V	-	
UVLO Hysteresis Voltage	Yes	0.9	0.9	V	0.0%	
[Input (V_{EN})]						
EN High Voltage	Yes	-	1.65	V	-	
EN Low Voltage	Yes	-	1.20	V	-	
EN Hysteresis Voltage	Yes	0.45	0.45	V	0.0%	
EN High Input Current	Yes	50	50	μA	0.0%	$V_{\text{EN}} = 5\text{ V}$
EN Low Input Current	Yes	-	0.0	μA	-	$V_{\text{EN}} = 0\text{ V}$
[Power MOS Output]						
Output ON Resistance	Yes	45	44.8	$\text{m}\Omega$	-0.4%	$V_{\text{EN}} = 5\text{ V}$
Output Leakage Current	Yes	-	0	μA	-	$V_{\text{EN}} = 0\text{ V}$, $V_{\text{OUT}} = 0\text{ V}$
Output ON Slew Rate	Yes	0.40	0.40	V/ms	0.0%	$V_{\text{IN}} = 24\text{ V}$, $R_{\text{SS}} = 100\text{ k}\Omega$, $R_{\text{L}} = 100\text{ }\Omega$, $V_{\text{OUT}}:20\text{ }\%\rightarrow 80\text{ }\%$
Output OFF Slew Rate	Yes	0.10	0.10	$\text{V}/\mu\text{s}$	0.0%	$V_{\text{IN}} = 24\text{ V}$, $R_{\text{SS}} = 100\text{ k}\Omega$, $R_{\text{L}} = 100\text{ }\Omega$, $V_{\text{OUT}}:80\text{ }\%\rightarrow 20\text{ }\%$
Output ON Delay Time	Yes	60	60	ms	0.0%	$V_{\text{IN}} = 24\text{ V}$, $R_{\text{SS}} = 100\text{ k}\Omega$, $R_{\text{L}} = 100\text{ }\Omega$, $V_{\text{EN}}:50\text{ }\%\rightarrow V_{\text{OUT}}:80\text{ }\%$
Output OFF Delay Time	Yes	360	360	μs	0.0%	$V_{\text{IN}} = 24\text{ V}$, $R_{\text{SS}} = 100\text{ k}\Omega$, $R_{\text{L}} = 100\text{ }\Omega$, $V_{\text{EN}}:50\text{ }\%\rightarrow V_{\text{OUT}}:20\text{ }\%$
Output Clamp Voltage	Yes	50	50	V	0.0%	$V_{\text{EN}} = 0\text{ V}$, $I_{\text{OUT}} = 10\text{ mA}$

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

(Unless otherwise specified $8\text{ V} \leq V_{\text{BB}} \leq 32\text{ V}$, $T_a = 25\text{ }^{\circ}\text{C}$)

Parameter	Modeled <i>(Note1)</i>	Design Value		Unit	Error	Condition
		Datasheet	SPICE			
[FLAG]						
FLAG Low Output Voltage	Yes	-	0.2	V	-	I _{FLAG} = 1 mA
FLAG Pin Leakage Current	Yes	-		μA	-	V _{FLAG} = 5 V
FLAG Output Delay Time	Yes	30	30	ms	0.0%	The time from overcurrent detection to V _{FLAG} = Low.
[Diagnostic Functions]						
Thermal Shutdown Detection	No	175	-	°C	-	
Thermal Shutdown Hysteresis	No	15	-	°C	-	
ΔTj Protection	No	105	-	°C	-	
ΔTj Protection Hysteresis	No	30	-	°C	-	
Fixed Overcurrent Limit	Yes	26	26	A	0.0%	
Variable Overcurrent Detection	Yes	5.8	5.8	A	0.0%	R _{LIM} = 100 kΩ

(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: 40 s

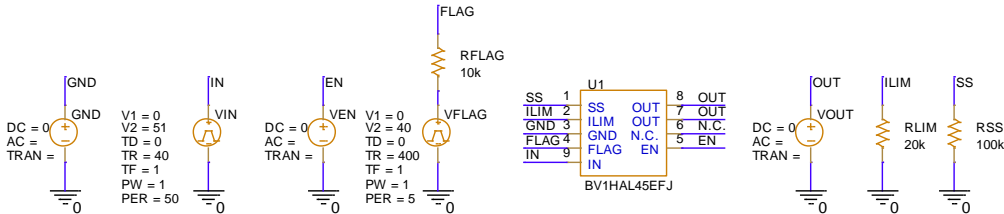


Figure 2.
Simulation Schematic 1

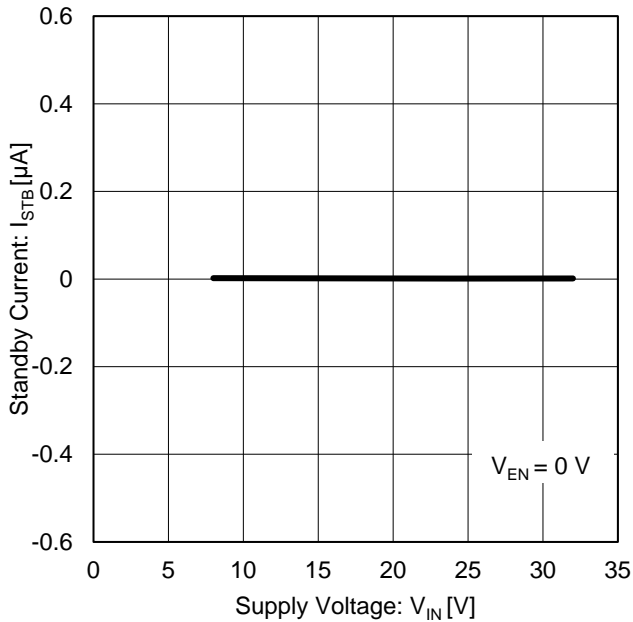


Figure 3.
Standby Current
(Measured Waveform)

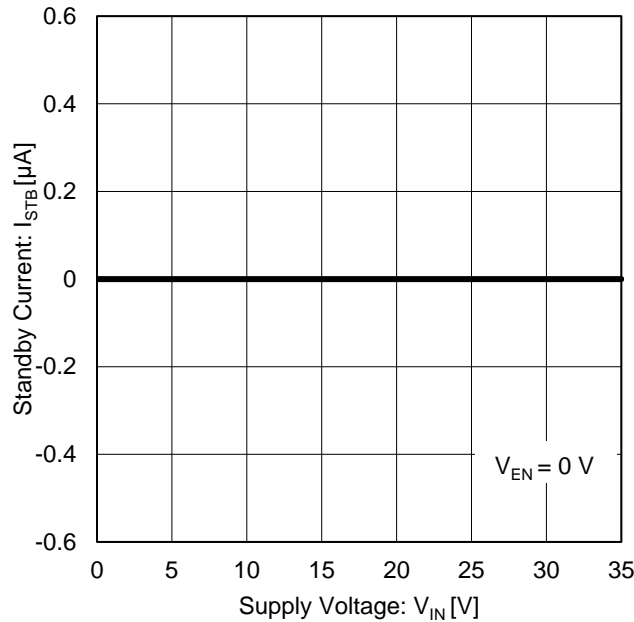


Figure 4.
Standby Current
(SPICE Simulation)

Table 4 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Standby Current	0	0	μA	0.0%	V _{IN} = 24 V, V _{EN} = 0 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: 40 s

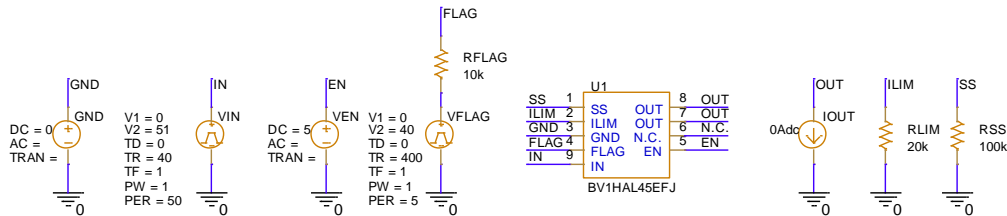


Figure 5.
Simulation Schematic 2

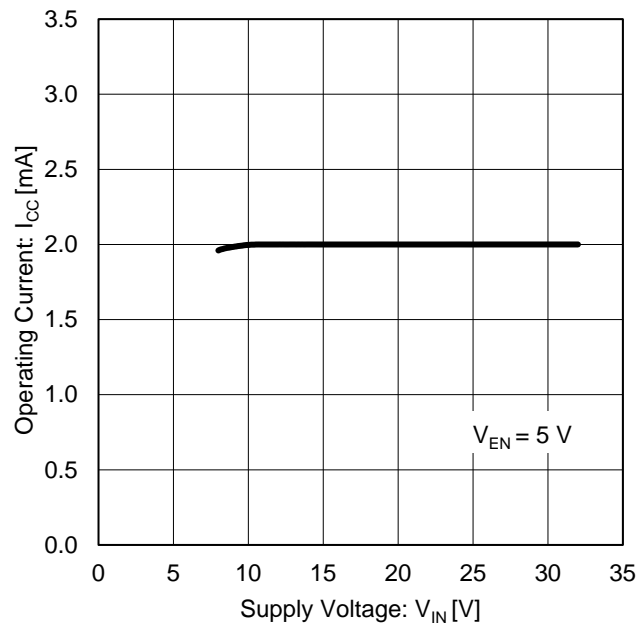


Figure 6.
Operating Current
(Measured Waveform)

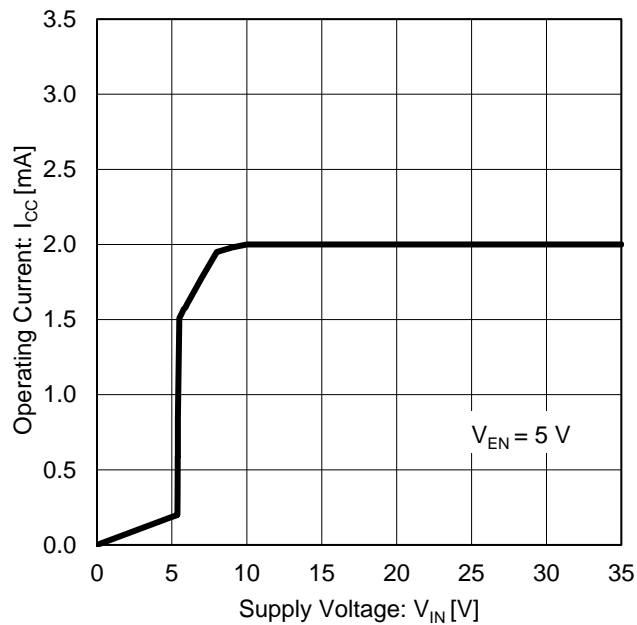


Figure 7.
Operating Current
(SPICE Simulation)

Table 5 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Operating Current	2	2	mA	0.0 %	$V_{IN} = 24$ V, $V_{EN} = 5$ 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.

3. Output ON Resistance

Simulation Setting
Type: Transient
Run Time: 10 ms

PARAMETERS:
IN = 14

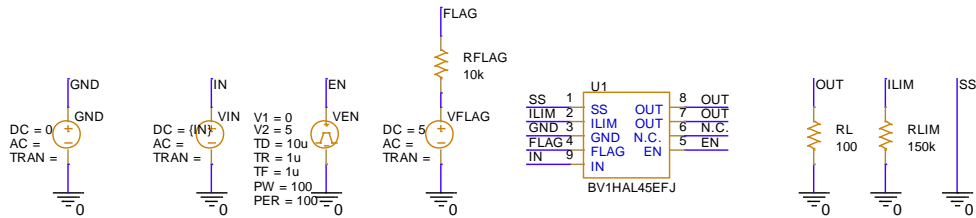


Figure 8.
Simulation Schematic 3

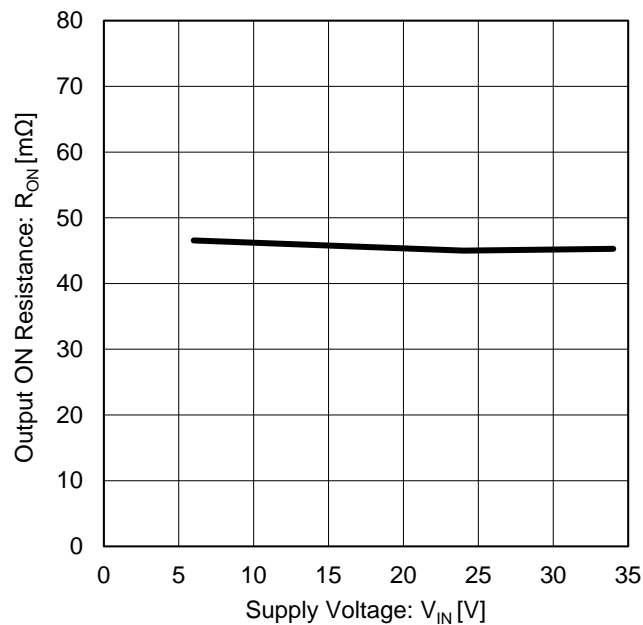


Figure 9.
Output ON Resistance
(Measured Waveform)

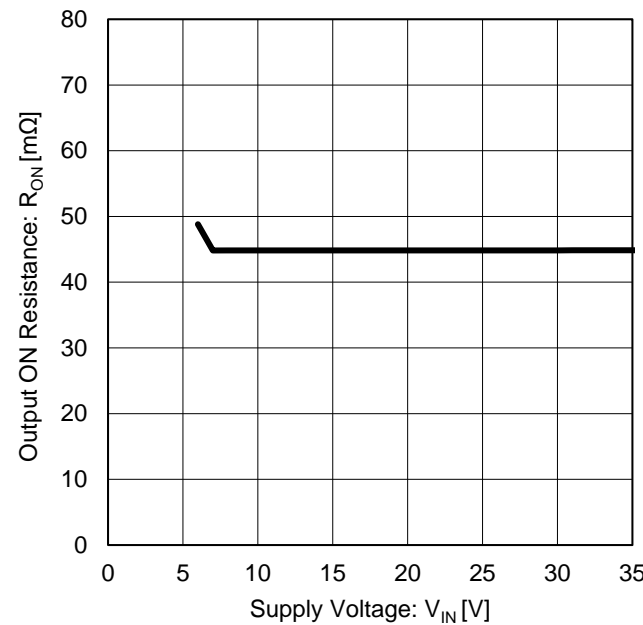


Figure 10.
Output ON Resistance
(SPICE Simulation)

Table 6 Characteristics Comparison

Parameter	Measured Result (Note1)(Note2)	SPICE Simulation Result	Unit	Error	Condition
Output ON Resistance	45	44.8	mΩ	-0.4 %	$V_{EN} = 5\text{ V}$

(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.

4. Timing Chart (ONOFF)

Simulation Setting

Type: Transient

Run Time: 150 ms

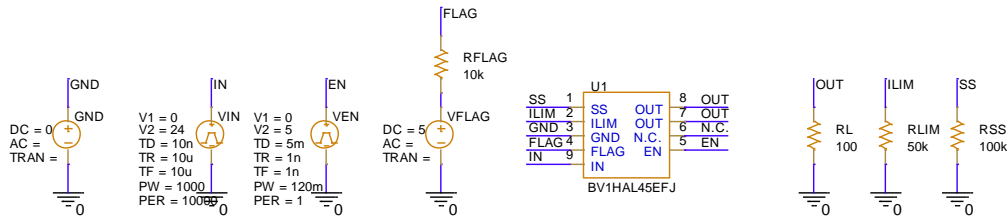


Figure 11.
Simulation Schematic 4

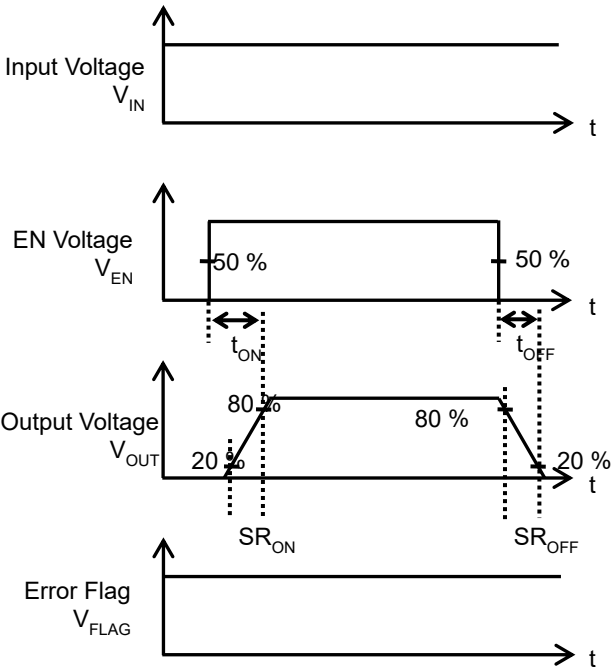


Figure 12.
Timing Chart (ONOFF)
(Measured Waveform)

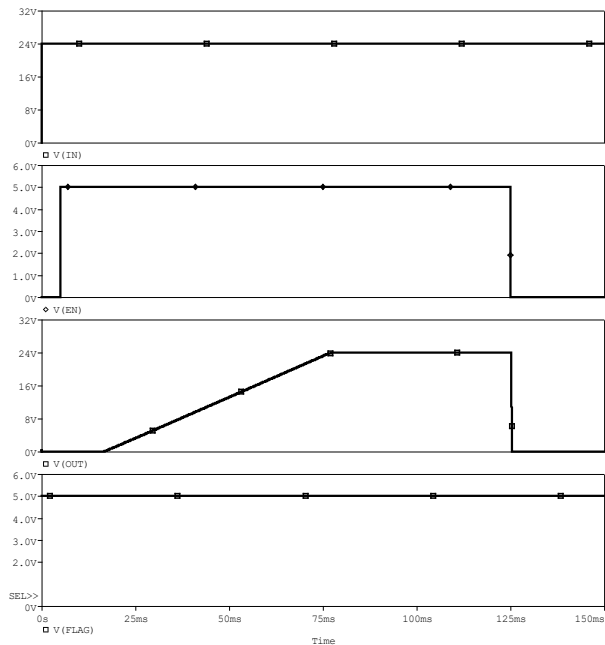


Figure 13.
Timing Chart (ONOFF)
(SPICE Simulation)

5. Timing Chart (Latch-off due to Fixed Overcurrent Limit)

Simulation Setting

Type: Transient

Run Time: 60 ms

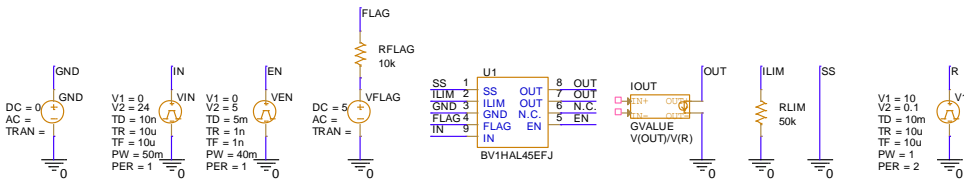


Figure 14.
Simulation Schematic 5

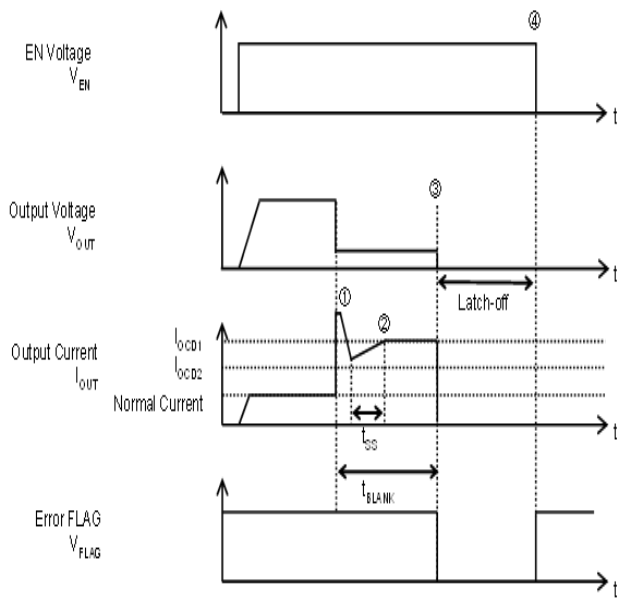


Figure 15.
Timing Chart (Latch-off due to Fixed Overcurrent Limit)

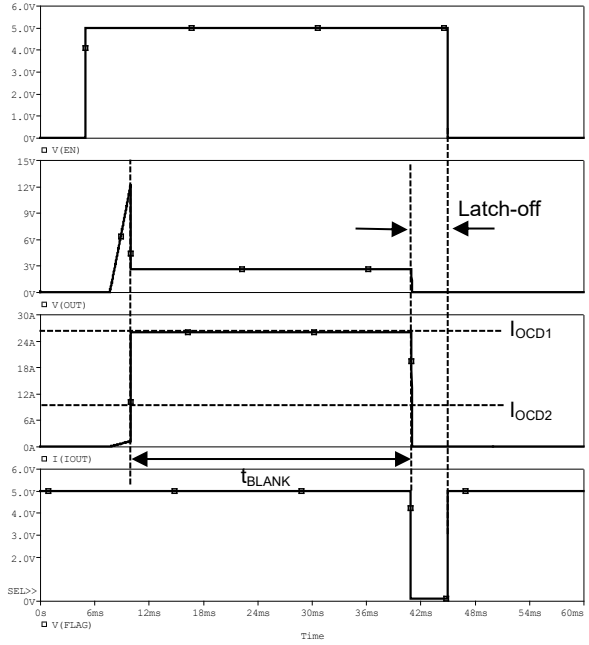


Figure 16.
Timing Chart (Latch-off due to Fixed Overcurrent Limit)

6. Timing Chart (Latch-off due to Variable Overcurrent Detection)

Simulation Setting

Type: Transient

Run Time: 60 ms

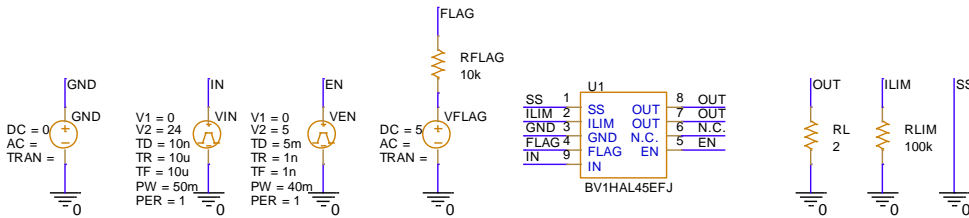


Figure 17.
Simulation Schematic 6

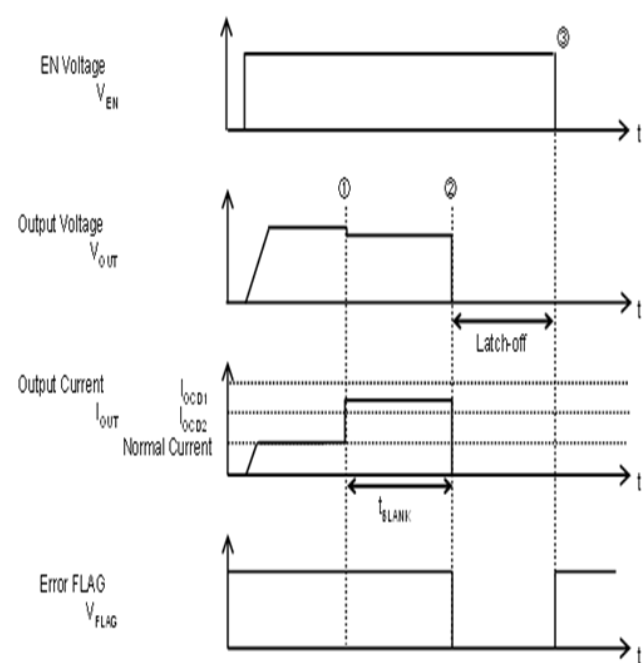


Figure 18.
Timing Chart (Latch-off due to Variable Overcurrent Detection)

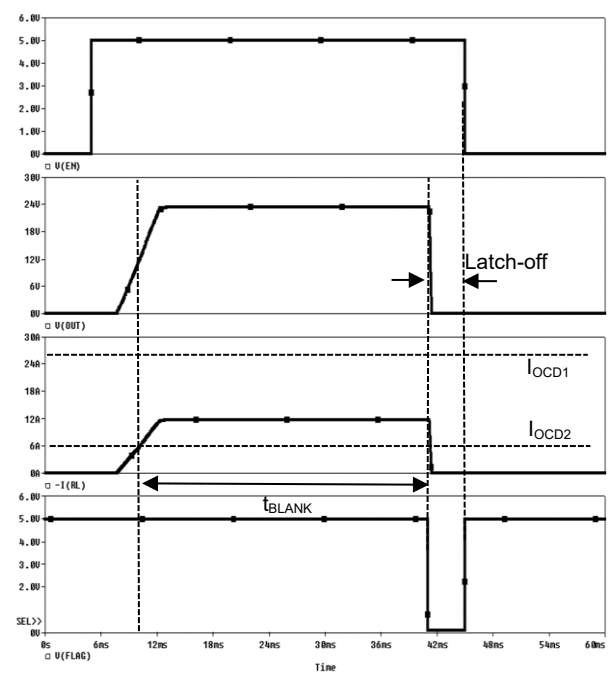


Figure 19.
Timing Chart (Latch-off due to Variable Overcurrent Detection)

7. Timing Chart (Duration of Overcurrent is less than t_{BLANK})

Simulation Setting

Type: Transient

Run Time: 60 ms

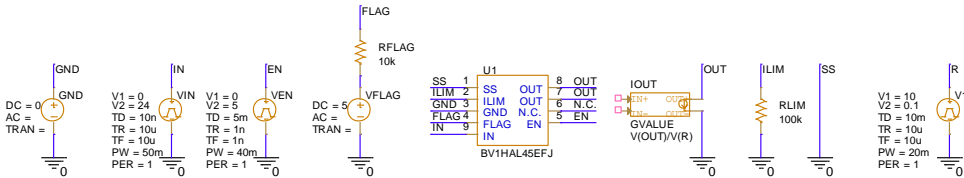


Figure 20.
Simulation Schematic 7

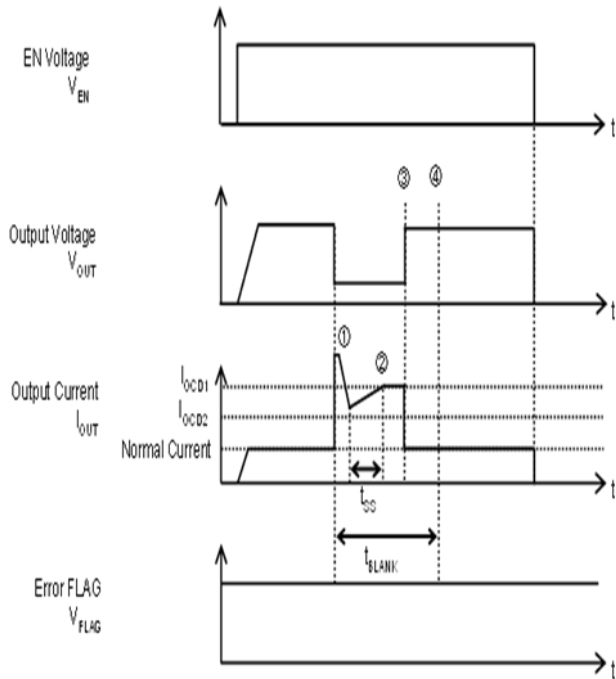


Figure 21.
Timing Chart (Duration of Overcurrent is less than t_{BLANK})

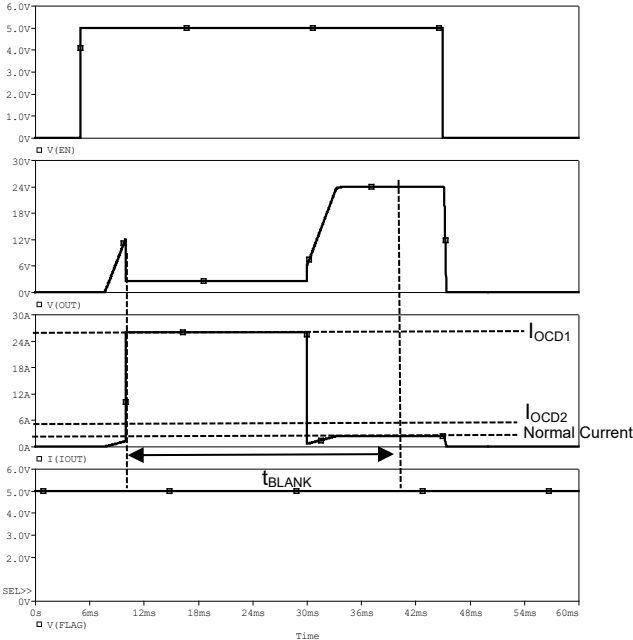


Figure 22.
Timing Chart (Duration of Overcurrent is less than t_{BLANK})

8. Variable Overcurrent Detection

Simulation Setting
Type: Transient
Run Time: 50 ms

PARAMETERS:
RLIM = 50k

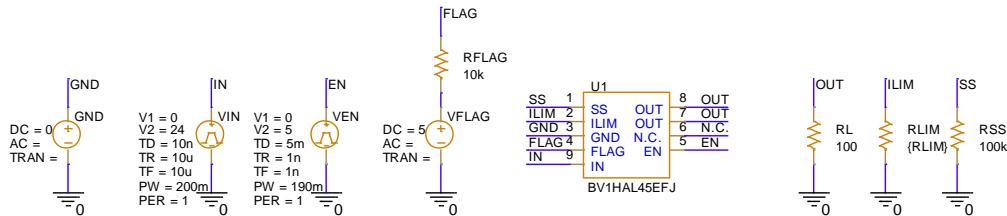


Figure 23.
Simulation Schematic 8

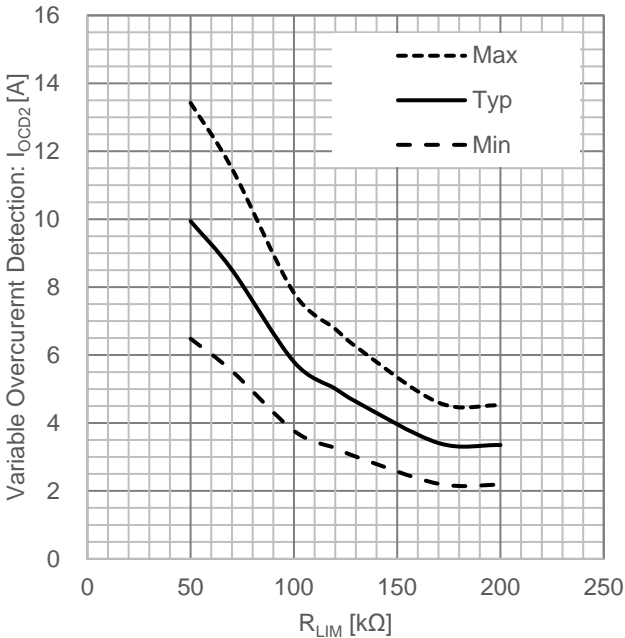


Figure 24.
Variable Overcurrent Detection
(Measured Waveform)

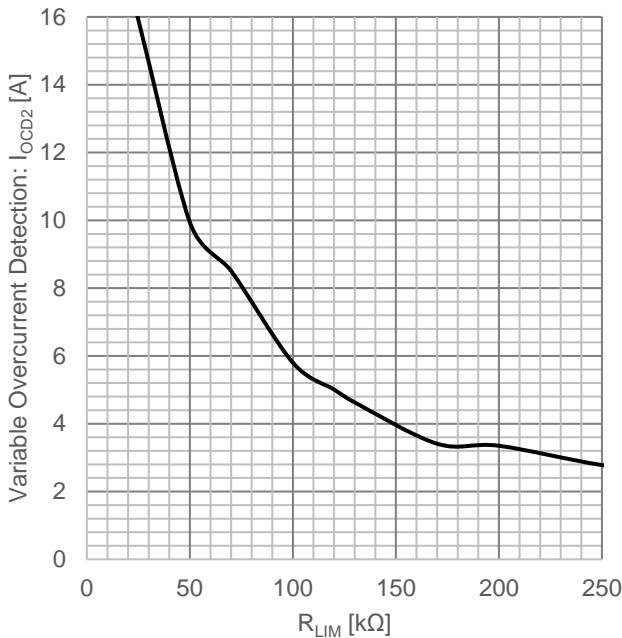


Figure 25.
Variable Overcurrent Detection
(SPICE Simulation)

9. Output ON Slew Rate (VIN = 24V)

Simulation Setting

Type: Transient

Run Time: 400 ms

PARAMETERS:

RSS = 50k

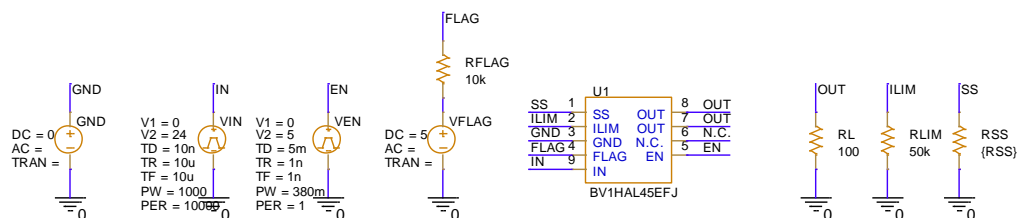


Figure 26.
Simulation Schematic 9

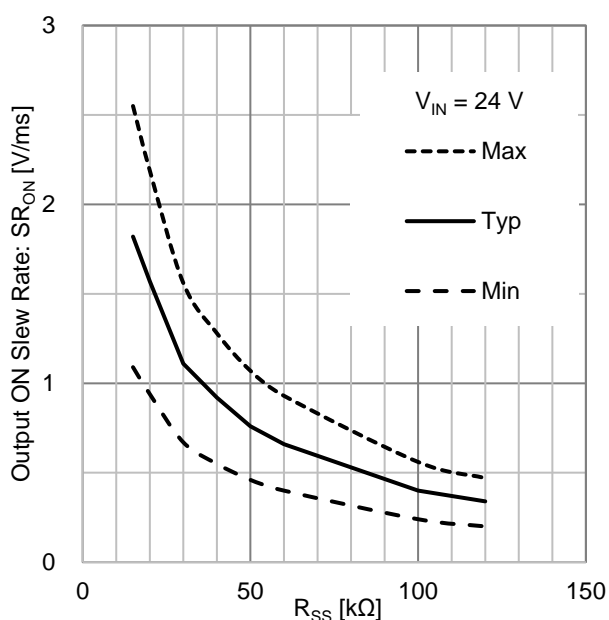


Figure 27.
Output ON Slew Rate (VIN = 24V)
(Measured Waveform)

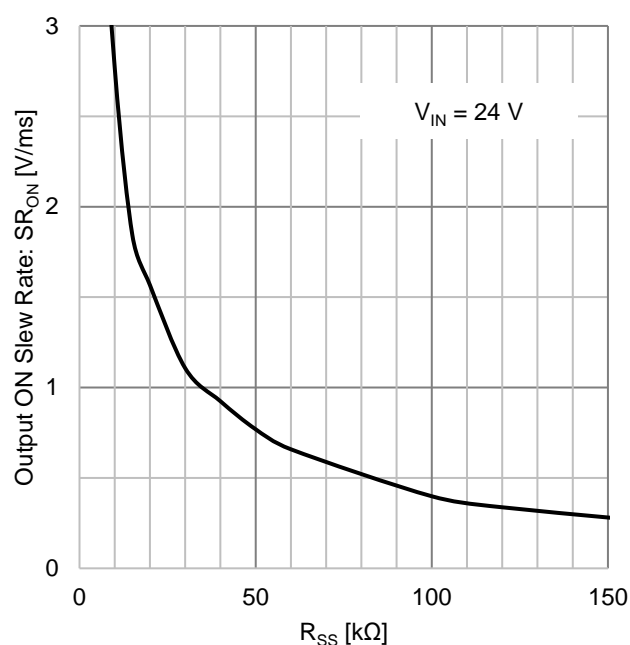


Figure 28.
Output ON Slew Rate (VIN = 24V)
(SPICE Simulation)

10. Output ON Slew Rate (VIN = 12V)

Simulation Setting
Type: Transient
Run Time: 400 ms

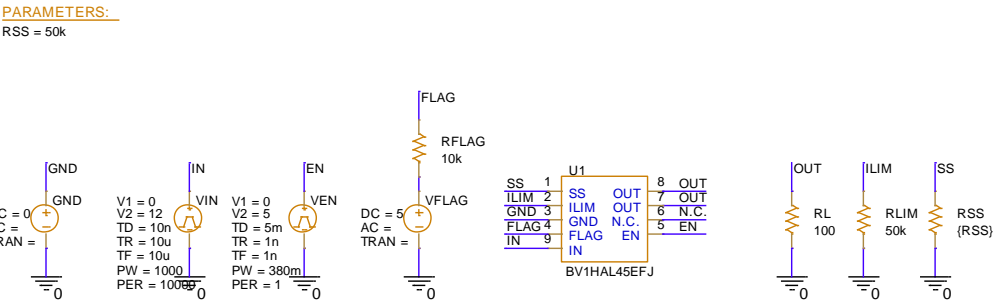


Figure 29.
Simulation Schematic 10

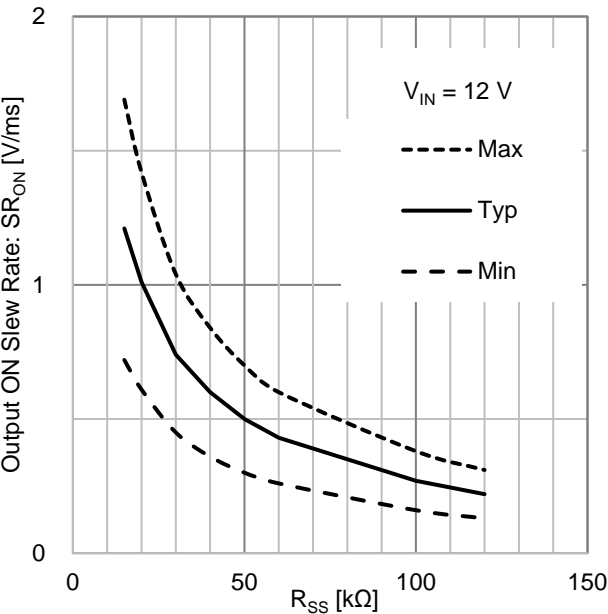


Figure 30.
Output ON Slew Rate (VIN = 12V)
(Measured Waveform)

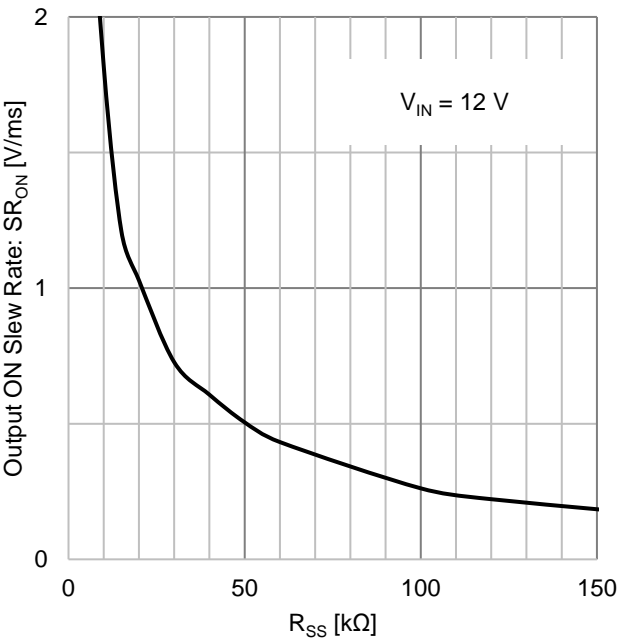


Figure 31.
Output ON Slew Rate (VIN = 12V)
(SPICE Simulation)

11. Output ON Delay Time (VIN = 24V)

Simulation Setting
Type: Transient
Run Time: 400 ms

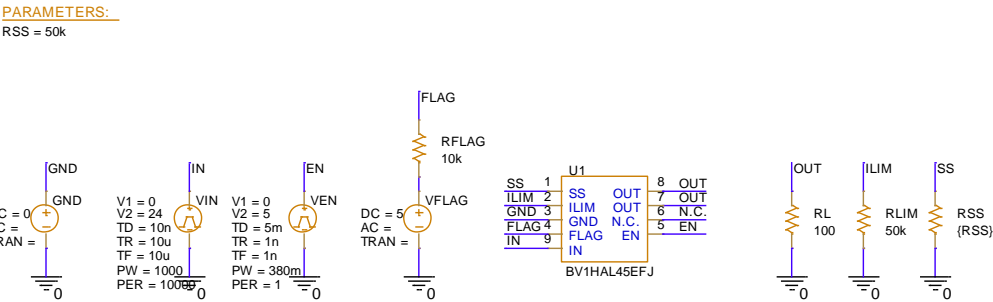


Figure 32.
Simulation Schematic 11

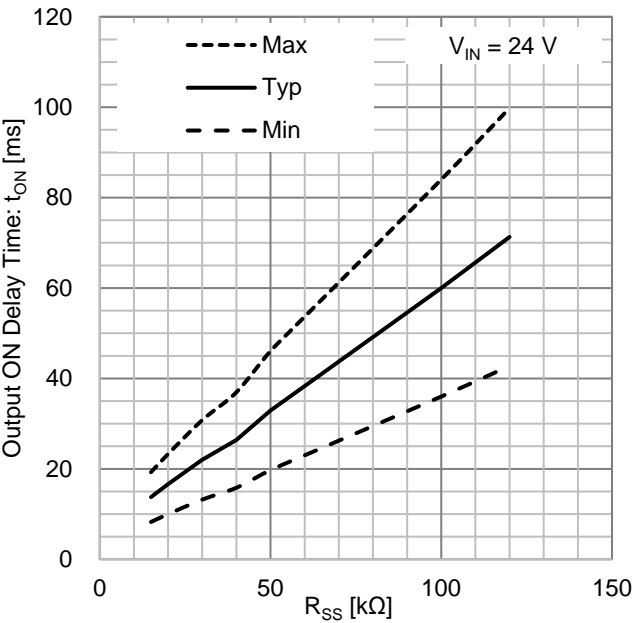


Figure 33.
Output ON Delay Time (VIN = 24V)
(Measured Waveform)

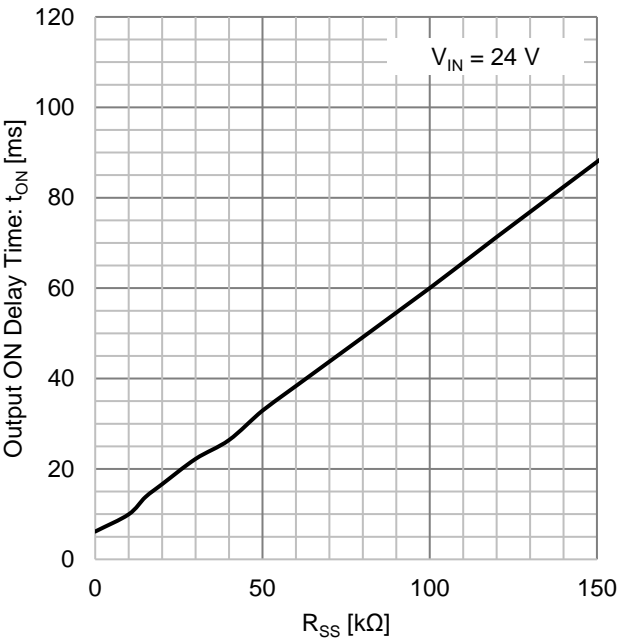


Figure 34.
Output ON Delay Time (VIN = 24V)
(SPICE Simulation)

12. Output ON Delay Time (VIN = 12V)

Simulation Setting
Type: Transient
Run Time: 400 ms

PARAMETERS:
RSS = 50k

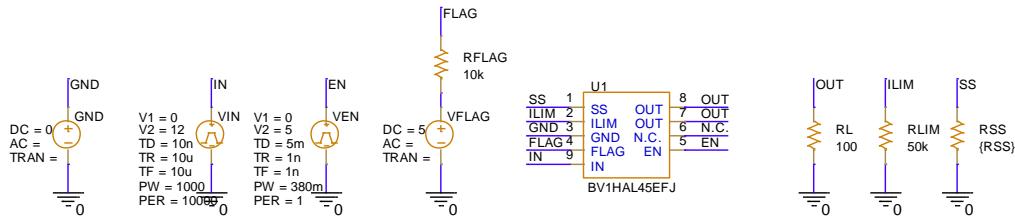


Figure 35.
Simulation Schematic 12

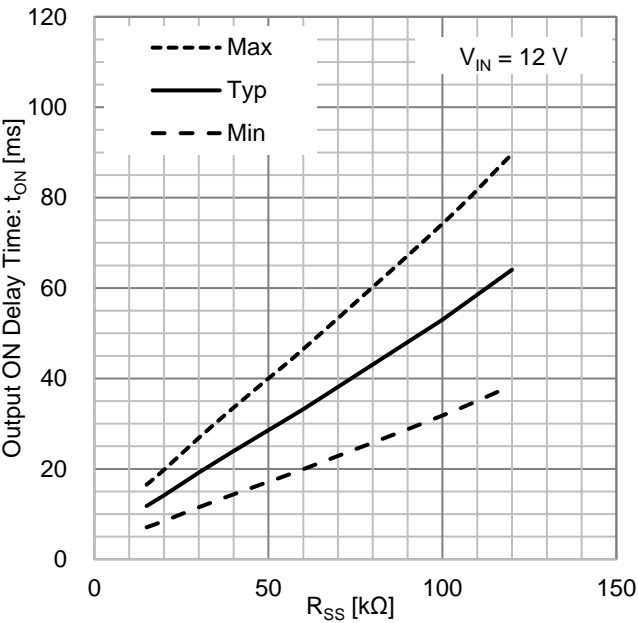


Figure 36.
Output ON Delay Time (VIN = 12V)
(Measured Waveform)

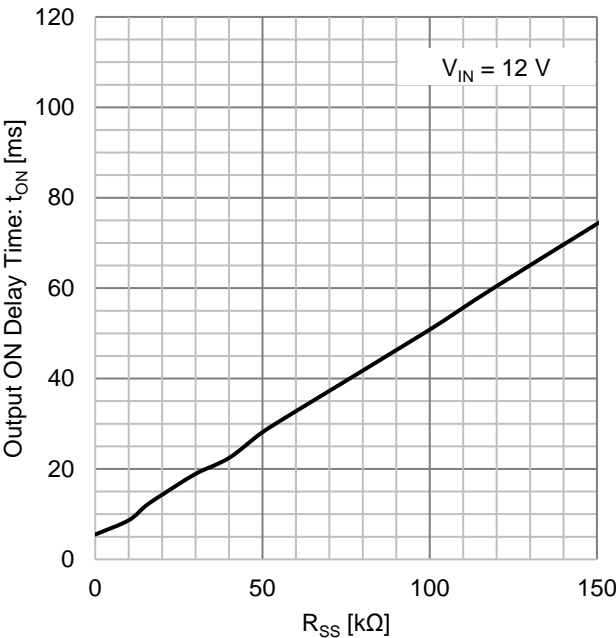


Figure 37.
Output ON Delay Time (VIN = 12V)
(SPICE Simulation)

Revision History

Date	Revision	Changes
Dec.2023	001	New Release

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