

Automotive IPD Series

# 1ch High Side Switch with output abnormality detection

## BV1HJ180EFJ-C

### General Description

BV1HJ180EFJ-C is a 1ch high side switch for automotive application. It has a built-in overcurrent limit function, thermal shutdown protection function, open load detection function, low power output-OFF function and short-to-VCC detection function. It is equipped with diagnostic output function for abnormality detection. It also operates in deep drop of supply voltage, so it can deal with cold cranking.

### Key Specifications

■ Power Supply Operating Range	4 V to 28 V
■ ON-Resistance (Tj = 25 °C)	180 mΩ (Typ)
■ Overcurrent Limit	2.0 A (Min)
■ Standby Current (Tj = 25 °C)	0.5 μA (Max)
■ Active Clamp Tolerance (Tj = 25 °C)	55 mJ
■ UVLO Detection Voltage (in supply voltage decreasing):	2.8 V (Max)

### Features

- Cold Cranking Support  
Keeps active status of output up to 2.8 V (Max) when power supply voltage drops
- AEC-Q100 Qualified (Note 1)
- Built-in Overcurrent Protection Function (OCP)
- Built-in Dual TSD (Note 2)
- Built-in Open Load Detection Function
- Built-in Short-to-VCC Detection Function
- Built-in Under Voltage Lockout Function (UVLO)
- Built-in Diagnostic Output
- Monolithic power management IC with control unit (CMOS) and power MOSFET mounted on a single chip

(Note 1) Grade 1

(Note 2) Two type of built-in temperature protection:

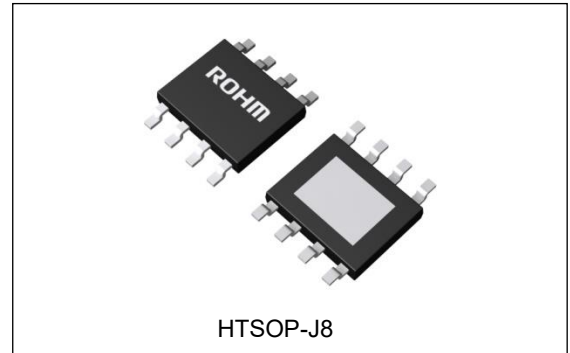
Junction temperature, and ΔTj protection that detects sudden temperature rise of the Power-MOS

### Package

HTSOP-J8

W (Typ) x D (Typ) x H (Max)

4.9 mm x 6.0 mm x 1.0 mm

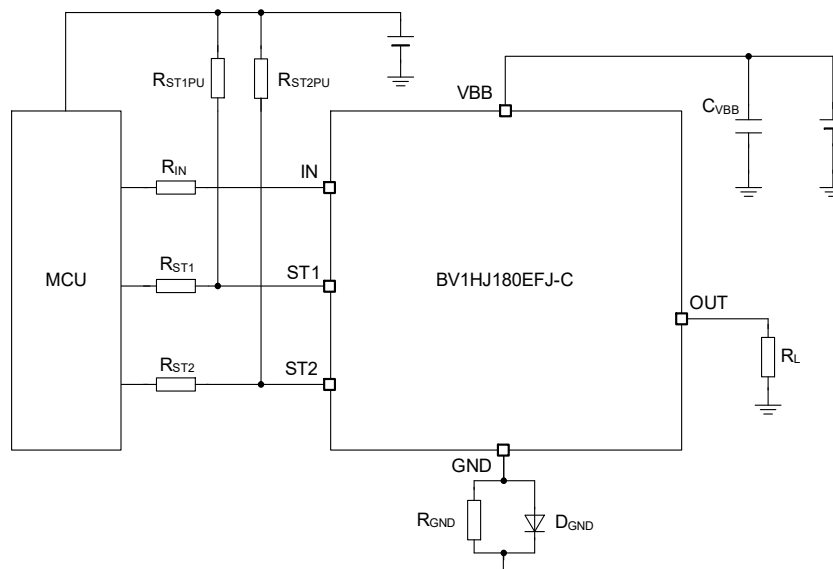


HTSOP-J8

### Application

- Resistance load, inductance load and capacitance load for automotive application

### Typical Application Circuit

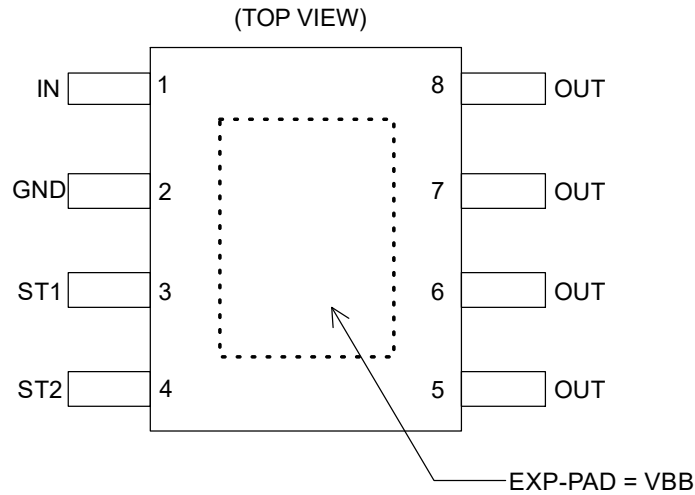


○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays

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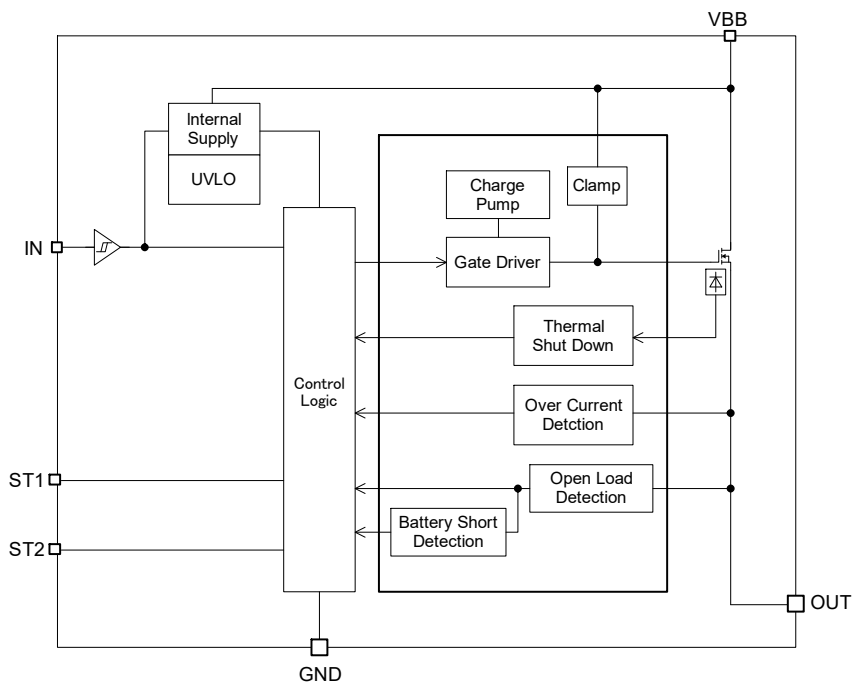
Pin Configuration



Pin Description

Pin No.	Pin Name	Function
1	IN	Input pin. Pull-down resistor is connected internally. Active High to turn on the switch.
2	GND	Ground pin
3	ST1	Self-diagnostic output pin 1
4	ST2	Self-diagnostic output pin 2
5	OUT	Switch output pin
6	OUT	Switch output pin
7	OUT	Switch output pin
8	OUT	Switch output pin
EXP-PAD	VBB	Power input pin, switch input pin

Block Diagram



Definition

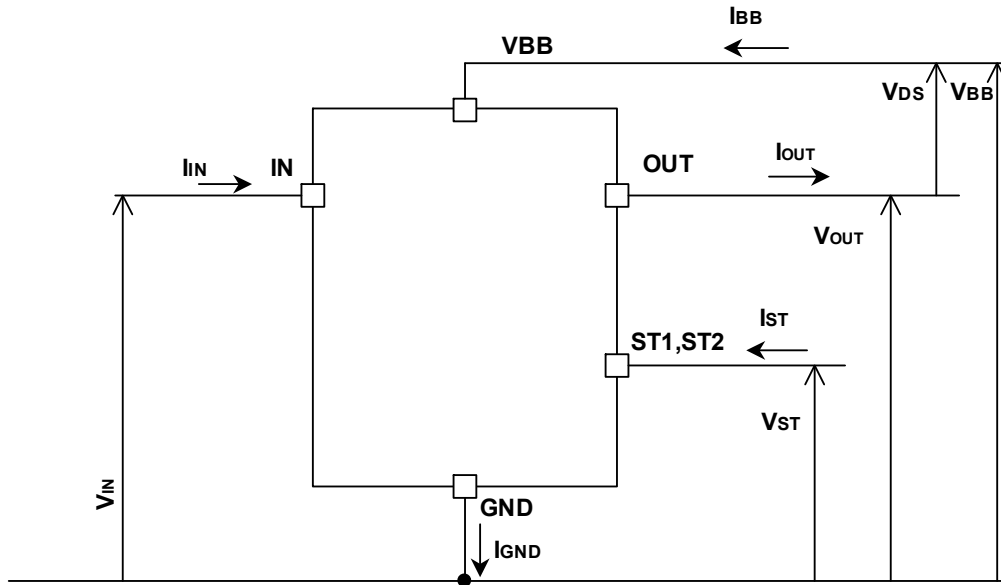


Figure 1. Voltage and Current Definition

**Absolute Maximum Ratings**

Parameter	Symbol	Rating	Unit
VBB - OUT Voltage	V <sub>DS</sub>	-0.3 to +45	V
Power Supply Voltage	V <sub>BB</sub>	-0.3 to +40	V
Input Voltage	V <sub>IN</sub>	-0.3 to +7.0	V
Diagnostic Output Voltage	V <sub>ST</sub>	- 0.3 to +7.0	V
Output Current	I <sub>OUT</sub>	Internal limit <i>(Note 1)</i>	A
Diagnostic Output Current	I <sub>ST</sub>	10	mA
Junction Temperature Width	T <sub>j</sub>	-40 to +150	°C
Storage Temperature Range	T <sub>stg</sub>	-55 to +150	°C
Maximum Junction Temperature	T <sub>jmax</sub>	+150	°C
Active Clamp Energy (Single Pulse) T <sub>J(START)</sub> = 25 °C, I <sub>OUT</sub> = 1 A <i>(Note 2)</i>	E <sub>AS(25 °C)</sub>	55	mJ
Active Clamp Energy (Single Pulse) T <sub>J(START)</sub> = 150 °C, I <sub>OUT</sub> = 1 A <i>(Note 2)</i>	E <sub>AS(150 °C)</sub>	25	mJ
Supply Voltage for Short Circuit Protection <i>(Note 3)</i>	V <sub>BBLIM</sub>	28	V

*(Note 1)* Internally limited by over current limit.

*(Note 2)* Not 100 % tested.

*(Note 3)* Maximum power supply voltage that can detect short circuit protection.

**Caution 1:** Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

**Caution 2:** Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design a PCB with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.

**Caution 3:** When IC turns off with an inductive load, reverse energy has to be dissipated in the BV1HJ180EFJ-C. This energy can be calculated by the following equation:

$$E_L = \frac{1}{2} L I_{OUT(START)}^2 \times \left( 1 - \frac{V_{BAT}}{V_{BAT} - V_{OUT(CL)}} \right)$$

Where:

L is the inductance of the inductive load.

I<sub>OUT(START)</sub> is the output current at the time of turning off.

V<sub>OUT(CL)</sub> is the output clamp voltage.

The IC integrates the active clamp function to internally absorb the reverse energy E<sub>L</sub> which is generated when the inductive load is turned off. When the active clamp operates, the thermal shutdown function does not work. Decide a load so that the reverse energy E<sub>L</sub> is active clamp tolerance E<sub>AS</sub> (refer to Figure .2) or under when inductive load is used.

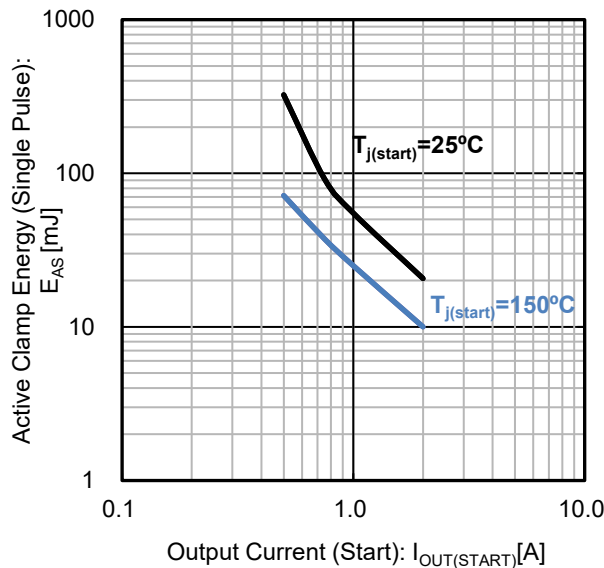


Figure 2. Active Clamp Energy (Single Pulse) vs Output Current (Start)

**Recommended Operating Conditions**

Parameter	Symbol	Min	Typ	Max	Unit
Power Supply Voltage Operating	V <sub>BB</sub>	4	14	28	V
Operating Temperature	T <sub>opr</sub>	-40	-	+150	°C
Input Frequency	f <sub>IN</sub>	-	-	1	kHz

**Thermal Resistance<sup>(Note 1)</sup>**

Parameter	Symbol	Typ	Unit	Condition
HTSOP-J8				
Between Junction and Surroundings Temperature Thermal Resistance	θ <sub>JA</sub>	169.8	°C/W	1s <sup>(Note 2)</sup>
		50.7	°C/W	2s <sup>(Note 3)</sup>
		37.8	°C/W	2s2p <sup>(Note 4)</sup>

(Note 1) The thermal impedance is based on JESD51-2A (Still-Air) standard. It is used the chip of BV1HJ180EFJ-C

(Note 2) JESD51-3 standard FR4 114.3 mm x 76.2 mm x 1.57 mm 1-layer (1s)  
(Top copper foil: ROHM recommended Footprint + wiring to measure, 2 oz. copper.)

(Note 3) JESD51-5 standard FR4 114.3 mm x 76.2 mm x 1.60 mm 2-layers (2s)  
(Top copper foil: ROHM recommended Footprint + wiring to measure/  
Copper foil area on the reverse side of PCB: 74.2 mm x 74.2 mm,  
copper (top & reverse side) 2 oz.)

(Note 4) JESD51-5/- 7 standard FR4 114.3 mm x 76.2 mm x 1.60 mm 4-layers (2s2p)  
(Top copper foil: ROHM recommended Footprint + wiring to measure/  
2 inner layers and copper foil area on the reverse side of PCB: 74.2 mm x 74.2 mm,  
copper (top & reverse side/inner layers) 2 oz./1 oz.)

■ PCB Layout 1 layer (1s)

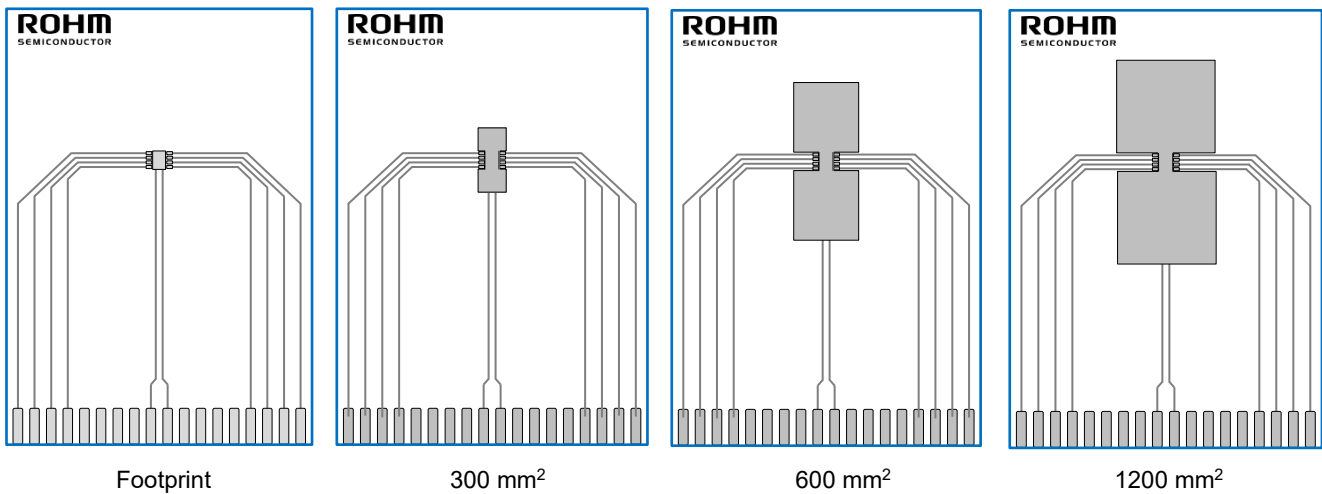


Figure 3. PCB Layout 1 Layer (1s)

Dimension	Value
Board Finish Thickness	1.57 mm ± 10 %
Board Dimension	76.2 mm x 114.3 mm
Board Material	FR4
Copper Thickness (Top Layer)	0.070 mm (Cu: 2 oz)
Copper Foil Area Dimension	Footprint/100 mm²/600 mm²/1200 mm²

Thermal Resistance – continued

- PCB Layout 2 layers (2s)

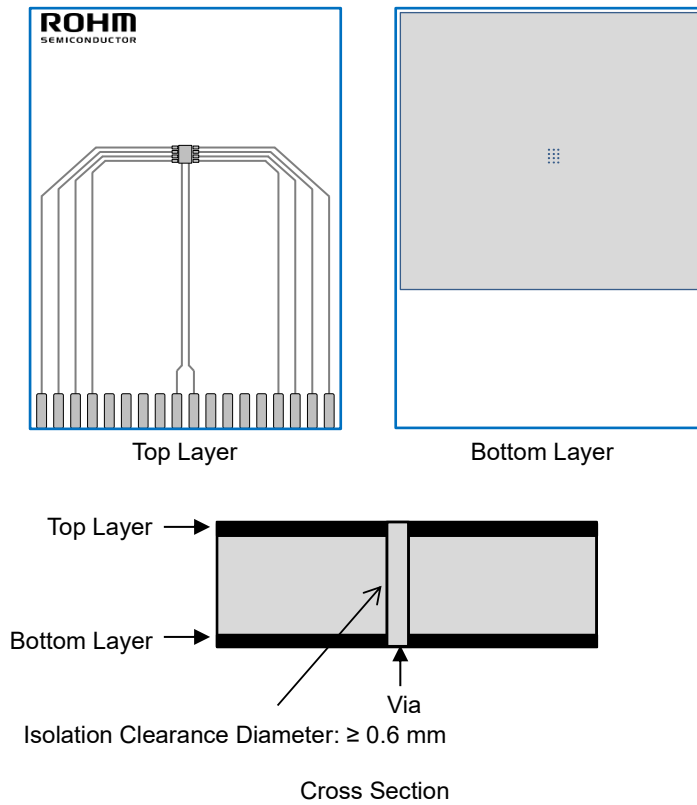
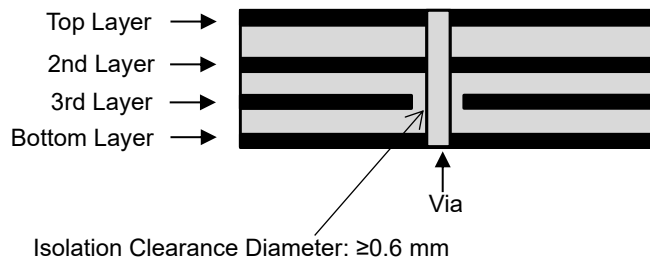
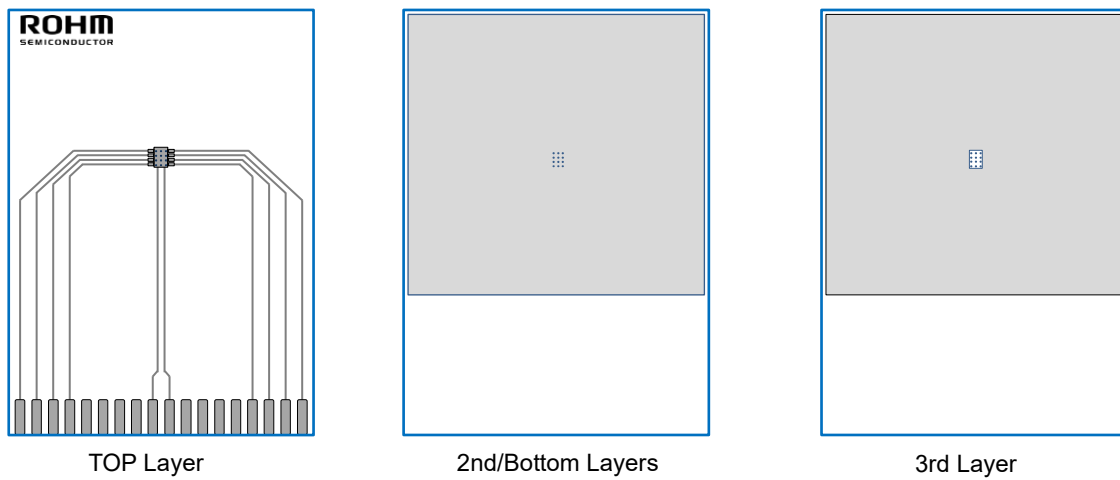


Figure 4. PCB Layout 2 Layers (2s)

Dimension	Value
Board Finish Thickness	1.60 mm $\pm$ 10 %
Board Dimension	76.2 mm x 114.3 mm
Board Material	FR4
Copper Thickness (Top/Bottom Layers)	0.070 mm (Cu +Plating)
Thermal Vias Separation/Diameter	1.2 mm/0.3 mm

Thermal Resistance – continued

- PCB Layout 4 layers (2s2p)



Cross Section

Figure 5. PCB Layout 4 Layers (2s2p)

Dimension	Value
Board Finish Thickness	1.60 mm $\pm$ 10 %
Board Dimension	76.2 mm x 114.3 mm
Board Material	FR4
Copper Thickness (Top/Bottom Layers)	0.070 mm (Cu +Plating)
Copper Thickness (Inner Layers)	0.035 mm
Thermal Via Separation/Diameter	1.2 mm/0.3 mm



**Thermal Resistance – continued**

- Transient Thermal Resistance (Single Pulse)

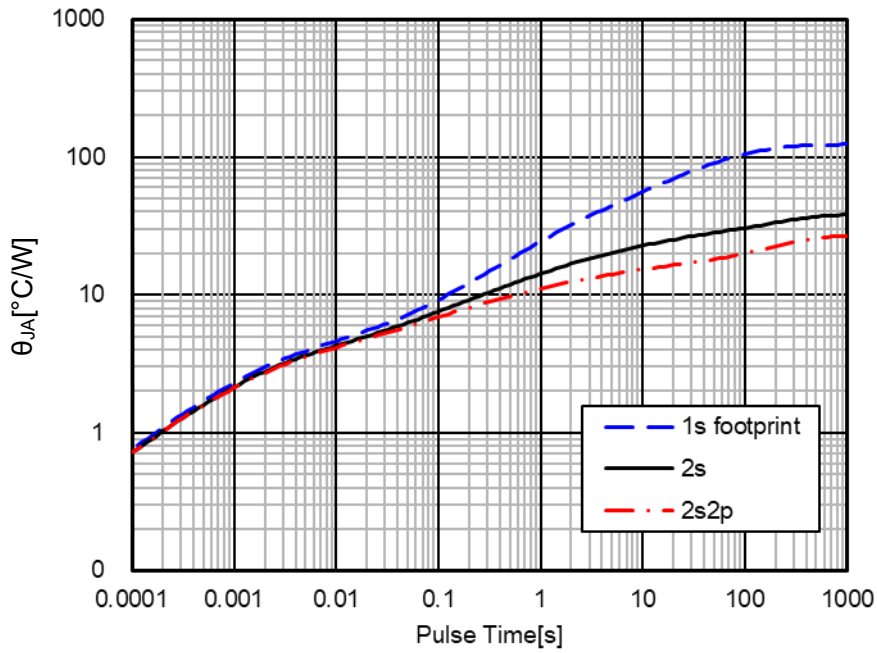


Figure 6. Transient Thermal Resistance

- Thermal Resistance ( $\theta_{JA}$  vs Copper foil area- 1s)

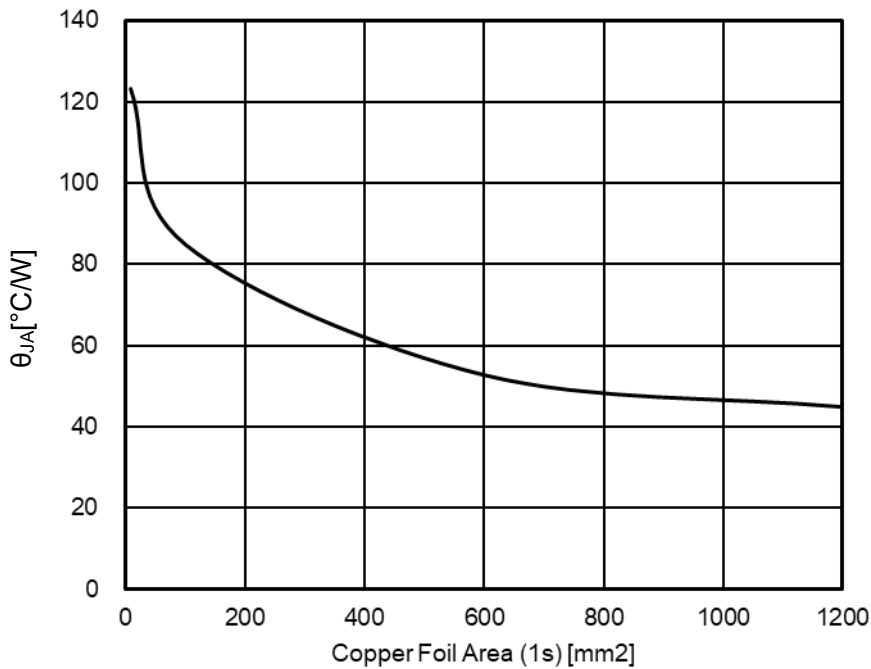


Figure 7. Thermal Resistance

Electrical Characteristics (unless otherwise specified  $V_{BB} = 4\text{ V to }28\text{ V}$ ,  $T_j = -40\text{ }^\circ\text{C to }150\text{ }^\circ\text{C}$ )

Parameter	Symbol	Limit			Unit	Condition
		Min	Typ	Max		
<b>Power Supply</b>						
Standby current 1	$I_{BBL1}$	-	-	0.5	$\mu\text{A}$	$V_{BB} = 14\text{ V}$ , $V_{IN} = 0\text{ V}$ , $V_{OUT} = 0\text{ V}$ , $T_j = 25\text{ }^\circ\text{C}$
Standby current 2	$I_{BBL2}$	-	-	20	$\mu\text{A}$	$V_{BB} = 14\text{ V}$ , $V_{IN} = 0\text{ V}$ , $V_{OUT} = 0\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$
Operating Current	$I_{BBH}$	-	3.0	4.5	$\text{mA}$	$V_{BB} = 14\text{ V}$ , $V_{IN} = 5\text{ V}$ , $V_{OUT} = \text{open}$
UVLO Detection Voltage	$V_{UVLO}$	-	-	2.8	$\text{V}$	
UVLO Hysteresis	$V_{UVHYS}$	-	-	0.45	$\text{V}$	
<b>Input</b>						
High Level Input Voltage	$V_{INH}$	2.1	-	-	$\text{V}$	
Low Level Input Voltage	$V_{INL}$	-	-	0.9	$\text{V}$	
Input Hysteresis	$V_{HYS}$	-	0.15	-	$\text{V}$	
High Level Input Current	$I_{INH}$	-	50	150	$\mu\text{A}$	$V_{IN} = 5\text{ V}$
Low Level Input Current	$I_{INL}$	-10	-	+10	$\mu\text{A}$	$V_{IN} = 0\text{ V}$
<b>Power MOS Output</b>						
Output ON Resistance 1	$R_{ON1}$	-	180	240	$\text{m}\Omega$	$V_{BB} = 8\text{ V to }28\text{ V}$ , $T_j = 25\text{ }^\circ\text{C}$ , $I_{OUT} = 1\text{ A}$
Output ON Resistance 2	$R_{ON2}$	-	-	400	$\text{m}\Omega$	$V_{BB} = 8\text{ V to }28\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ , $I_{OUT} = 1\text{ A}$
Output ON Resistance 3	$R_{ON3}$	-	-	300	$\text{m}\Omega$	$V_{BB} = 4\text{ V}$ , $T_j = 25\text{ }^\circ\text{C}$ , $I_{OUT} = 1\text{ A}$
Output ON Resistance 4	$R_{ON4}$	-	-	1800	$\text{m}\Omega$	$V_{BB} = 2.8\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ , $I_{OUT} = 200\text{ mA}$
Output Leak Current 1	$I_{OUTL1}$	-	-	0.5	$\mu\text{A}$	$V_{IN} = 0\text{ V}$ , $V_{OUT} = 0\text{ V}$ , $T_j = 25\text{ }^\circ\text{C}$
Output Leak Current 2	$I_{OUTL2}$	-	-	10	$\mu\text{A}$	$V_{IN} = 0\text{ V}$ , $V_{OUT} = 0\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$
Output Slew Rate when ON	$SR_{ON}$	-	0.3	1.0	$\text{V}/\mu\text{s}$	$V_{BB} = 14\text{ V}$ , $R_L = 15\text{ }\Omega$ $V_{OUT} = 20\% \rightarrow 80\%$ of $V_{BB}$
Output Slew Rate when OFF	$SR_{OFF}$	-	0.3	1.0	$\text{V}/\mu\text{s}$	$V_{BB} = 14\text{ V}$ , $R_L = 15\text{ }\Omega$ $V_{OUT} = 80\% \rightarrow 20\%$ of $V_{BB}$
Propagation Delay when ON	$t_{OUTON}$	-	60	120	$\mu\text{s}$	$V_{BB} = 14\text{ V}$ , $R_L = 15\text{ }\Omega$
Propagation Delay when OFF	$t_{OUTOFF}$	-	60	120	$\mu\text{s}$	$V_{BB} = 14\text{ V}$ , $R_L = 15\text{ }\Omega$
Output Clamp Voltage	$V_{DS}$	45	50	55	$\text{V}$	$V_{IN} = 0\text{ V}$ , $I_{OUT} = 10\text{ mA}$
<b>Diagnostics</b>						
Diagnostic Output L Voltage	$V_{STL}$	-	-	0.5	$\text{V}$	$I_{ST} = 1\text{ mA}$
Diagnostic Output Leak Current	$I_{STL}$	-	-	10	$\mu\text{A}$	$V_{ST} = 5\text{ V}$
Propagation Delay Time when Diagnostic Output is ON	$t_{STON}$	-	100	200	$\mu\text{s}$	$V_{BB} = 14\text{ V}$ , $R_L = 15\text{ }\Omega$
Propagation Delay Time when Diagnostic Output is OFF	$t_{STOFF}$	-	50	125	$\mu\text{s}$	$V_{BB} = 14\text{ V}$ , $R_L = 15\text{ }\Omega$
<b>Protection Circuit</b>						
Overcurrent Limit Value	$I_{LIM}$	2.0	3.2	4.4	$\text{A}$	$V_{DS} > 5\text{ V}$
Short-to-V <sub>BB</sub> Detection Voltage	$V_{SHV}$	$V_{BB}-1.8$	$V_{BB}-1.2$	$V_{BB}-0.5$	$\text{V}$	$V_{BB} = 6\text{ V to }28\text{ V}$ , $V_{IN} = 0\text{ V}$
Open Load Detection Voltage	$V_{OLD}$	2.0	3.0	4.0	$\text{V}$	$V_{BB} = 6\text{ V to }28\text{ V}$ , $V_{IN} = 0\text{ V}$
Open Load Detection Sink Current	$I_{OLD}$	-	8	24	$\mu\text{A}$	$V_{BB} = 6\text{ V to }28\text{ V}$ , $V_{IN} = 0\text{ V}$ , $V_{OUT} = 4\text{ V}$
Open Load Detection Time	$t_{OLD}$	-	200	350	$\mu\text{s}$	$V_{BB} = 6\text{ V to }28\text{ V}$ , $V_{IN} = 5\text{ V to }0\text{ V}$
Thermal Shutdown (Note 1)	$T_{TSD}$	150	175	200	$^\circ\text{C}$	
Thermal Shutdown Hysteresis (Note 1)	$T_{TSDHYS}$	8	15	24	$^\circ\text{C}$	
Operating Temperature Detection Value (Note 1)	$T_{DTJ}$	-	90	-	$^\circ\text{C}$	

(Note 1) Not 100 % tested.

**Typical Performance Curves**

(Unless otherwise specified  $V_{BB} = 14\text{ V}$ ,  $I_N = 5\text{ V}$ ,  $T_j = 25\text{ }^\circ\text{C}$ )

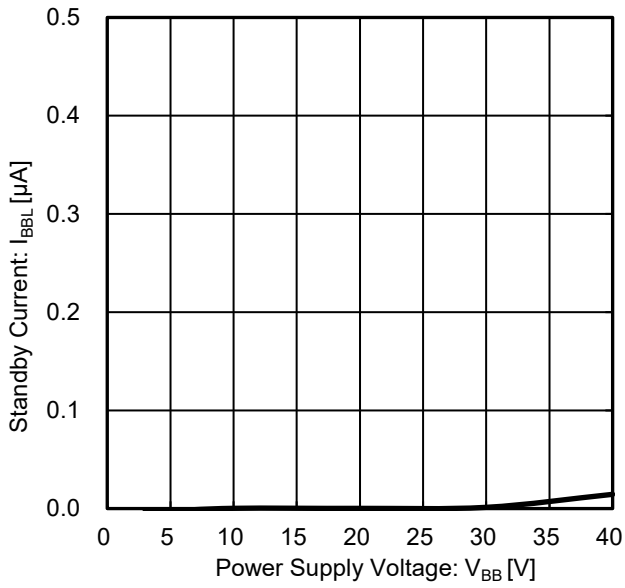


Figure 8. Standby Current vs Power Supply Voltage

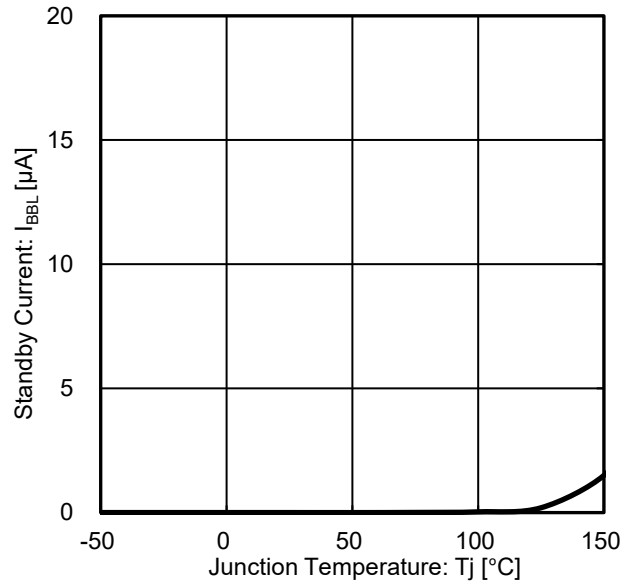


Figure 9. Standby Current vs Junction Temperature

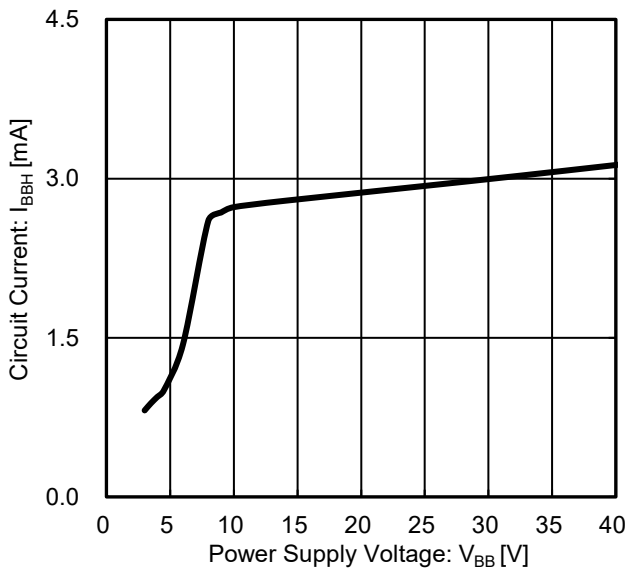


Figure 10. Circuit Current vs Power Supply Voltage

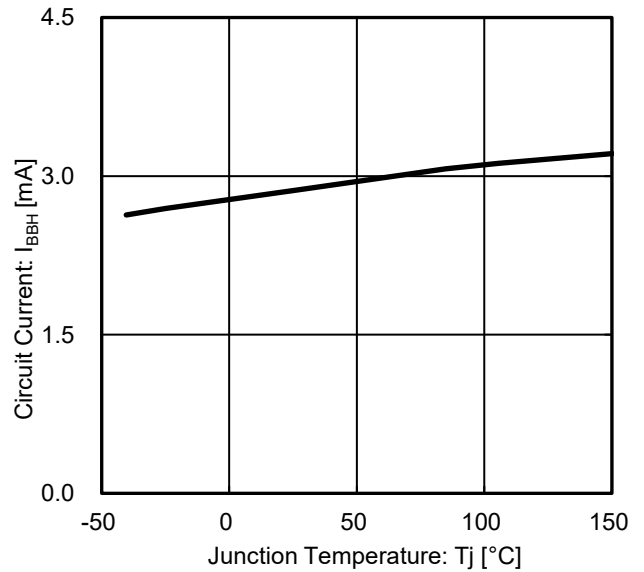


Figure 11. Circuit Current vs Junction Temperature

Typical Performance Curves - continued

(Unless otherwise specified  $V_{BB} = 14\text{ V}$ ,  $I_N = 5\text{ V}$ ,  $T_j = 25\text{ }^\circ\text{C}$ )

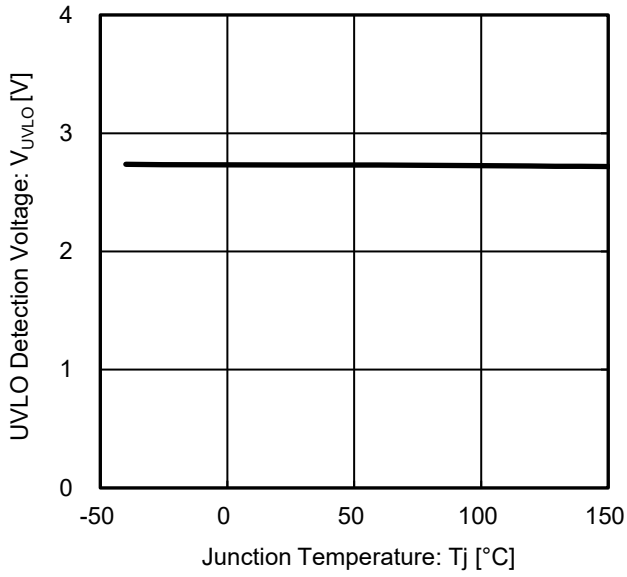


Figure 12. UVLO Detection Voltage vs Junction Temperature

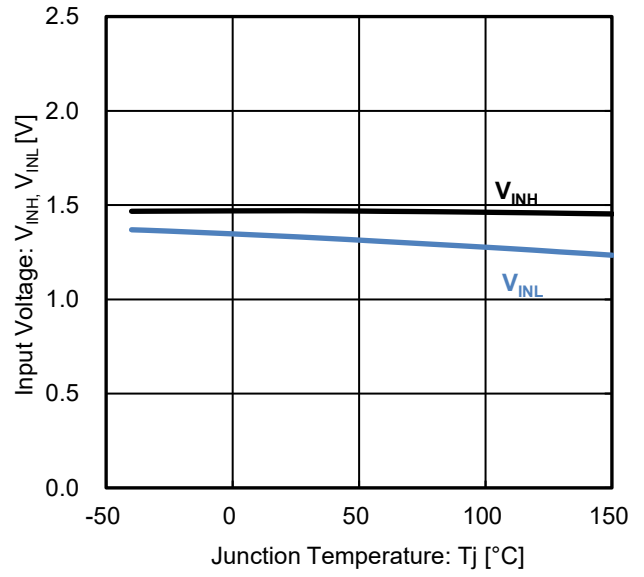


Figure 13. Input Voltage vs Junction Temperature

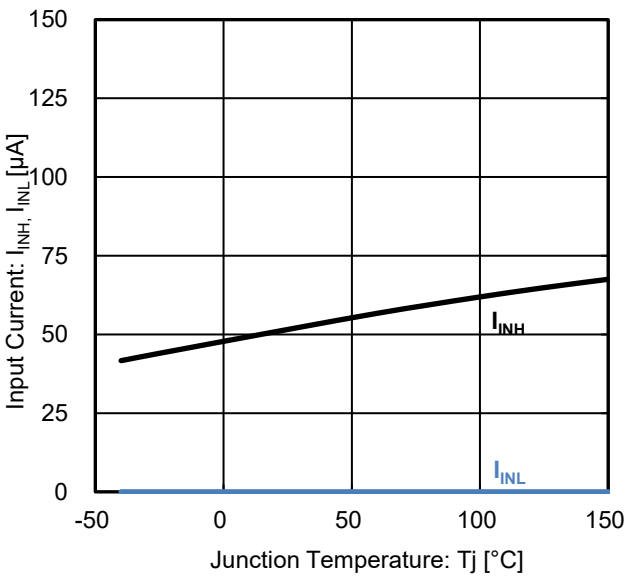


Figure 14. Input Current vs Junction Temperature

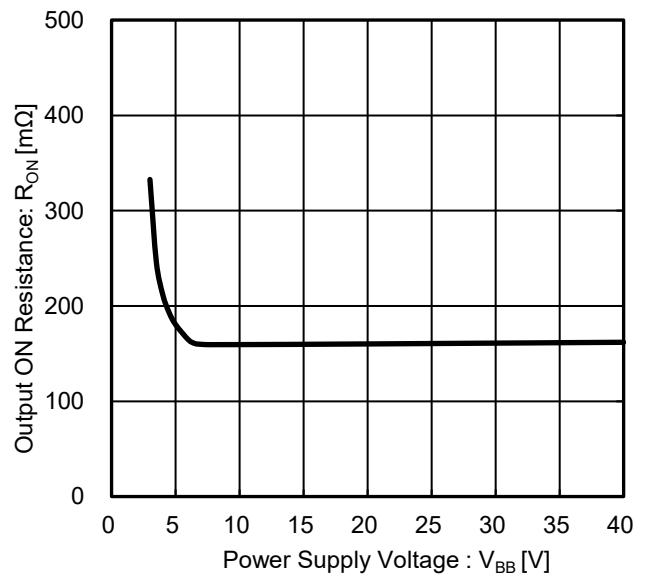


Figure 15. Output ON Resistance vs Supply Voltage

Typical Performance Curves - continued

(Unless otherwise specified  $V_{BB} = 14\text{ V}$ ,  $I_N = 5\text{ mA}$ ,  $T_j = 25\text{ }^\circ\text{C}$ )

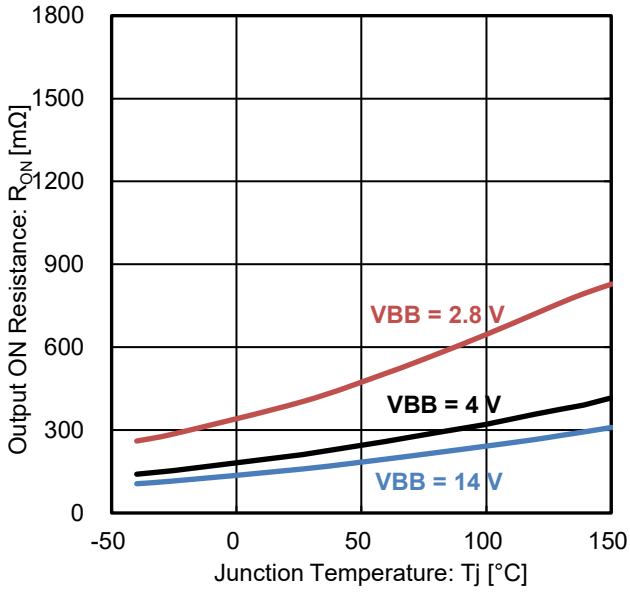


Figure 16. Output ON Resistance vs Junction Temperature

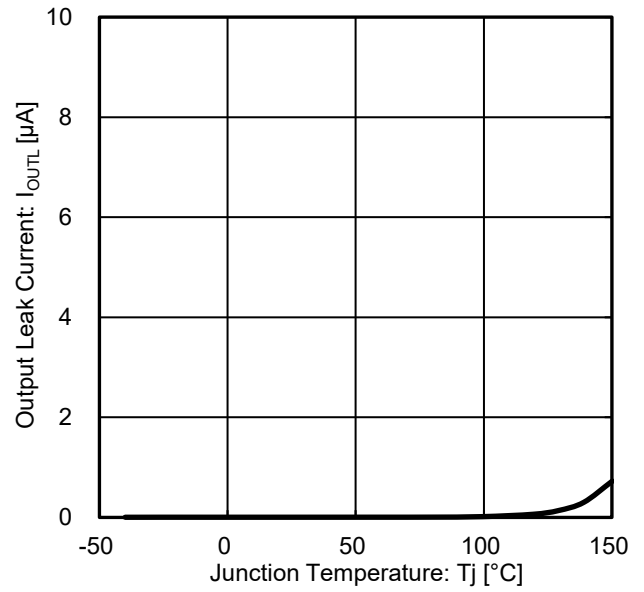


Figure 17. Output leak Current vs Junction Temperature

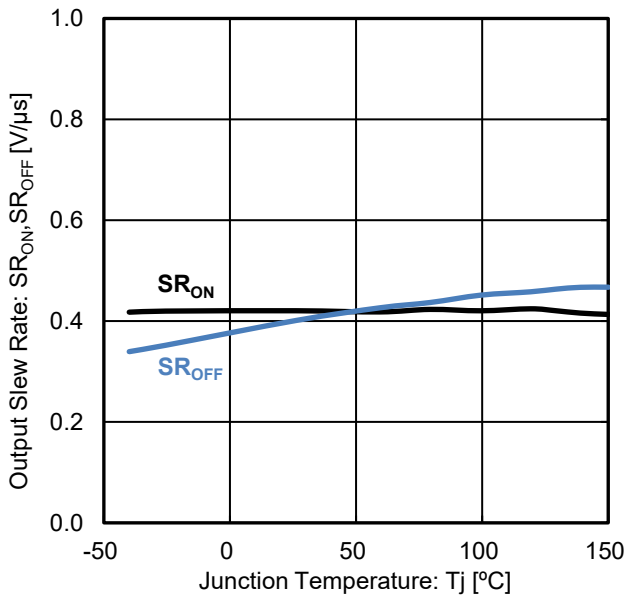


Figure 18. Output Slew Rate vs Junction Temperature

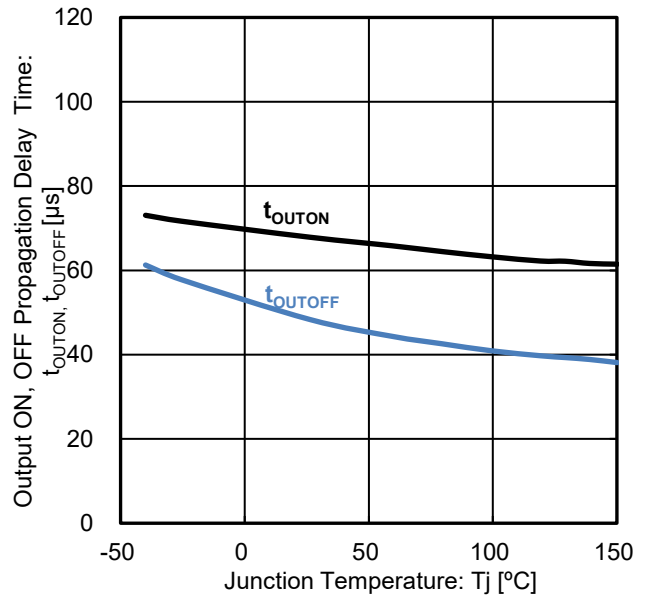


Figure 19. Output ON, OFF Propagation Delay Time vs Junction Temperature

Typical Performance Curves - continued

(Unless otherwise specified  $V_{BB} = 14\text{ V}$ ,  $I_N = 5\text{ V}$ ,  $T_j = 25\text{ }^\circ\text{C}$ )

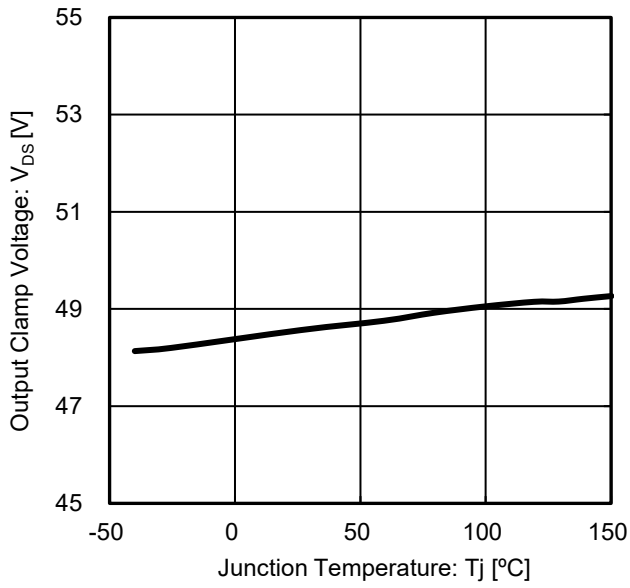


Figure 20. Output Clamp Voltage vs Junction Temperature

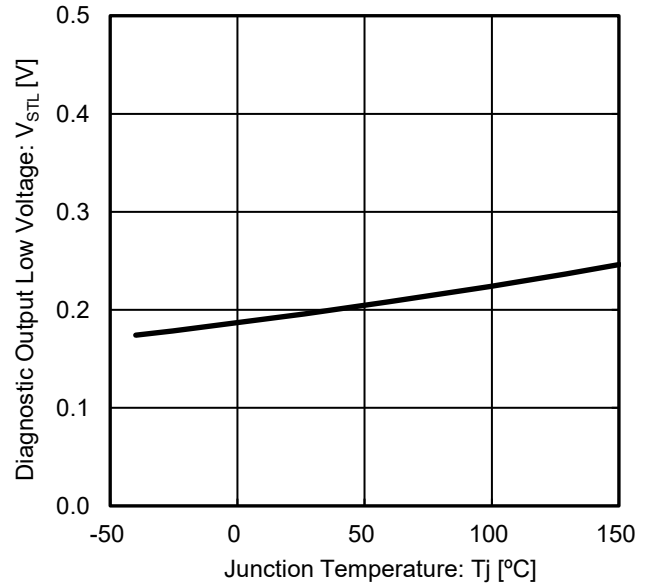


Figure 21. Diagnostic Output Low Voltage vs Junction Temperature

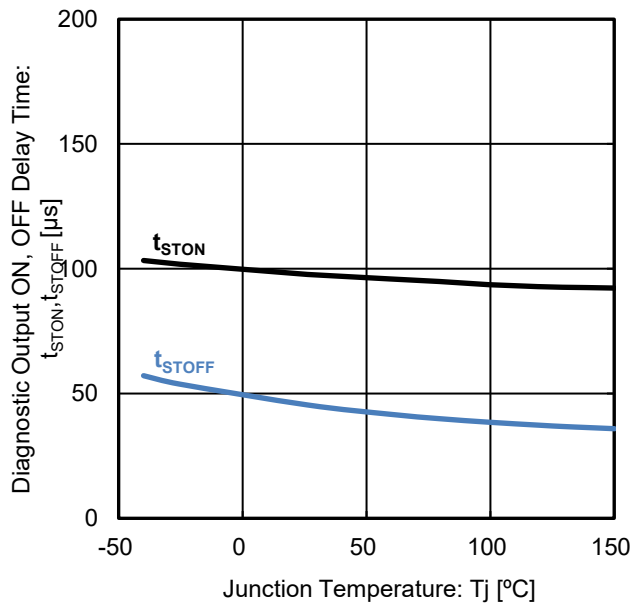


Figure 22. Diagnostic Output ON, OFF Propagation Delay Time vs Junction Temperature

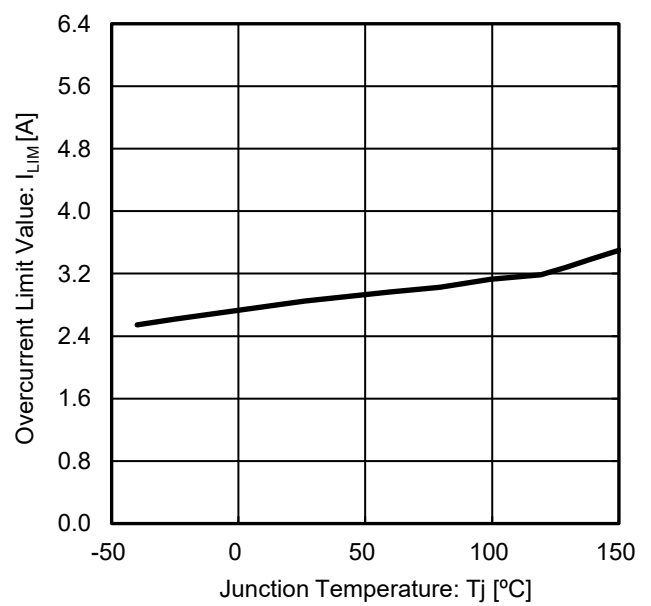


Figure 23. Overcurrent Limit Value vs Junction Temperature

Typical Performance Curves - continued

(Unless otherwise specified  $V_{BB} = 14\text{ V}$ ,  $I_N = 5\text{ V}$ ,  $T_j = 25\text{ }^\circ\text{C}$ )

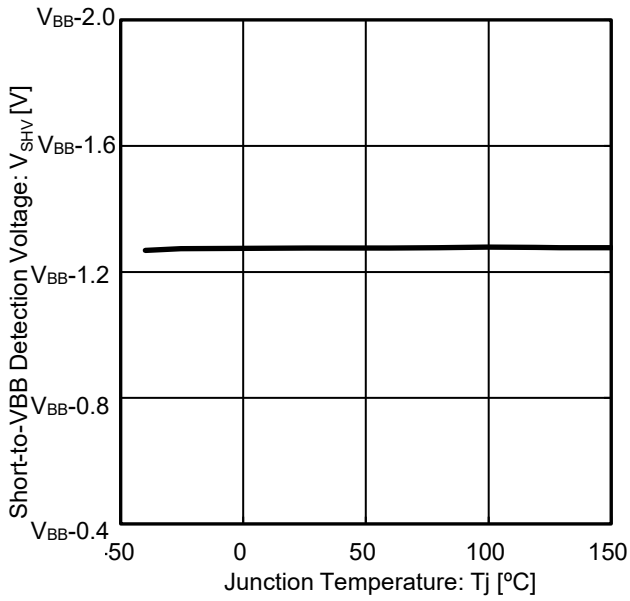


Figure 24. Short-to-VBB Detection Voltage vs Junction Temperature

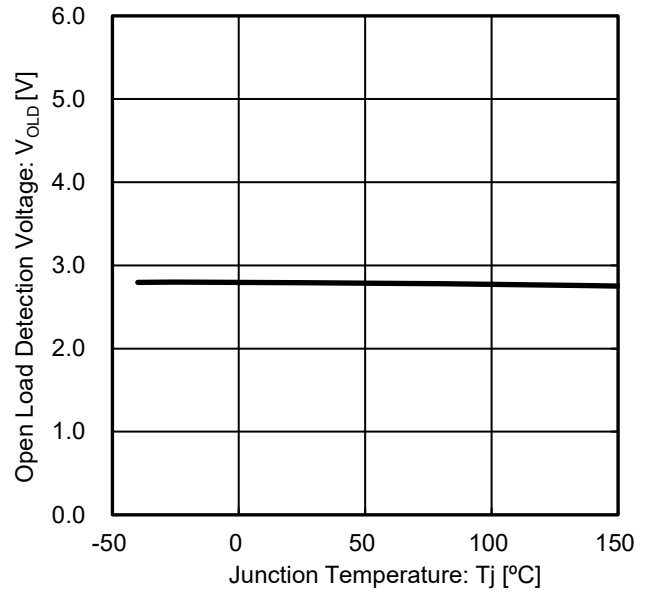


Figure 25. Open Load Detection Voltage vs Output Current

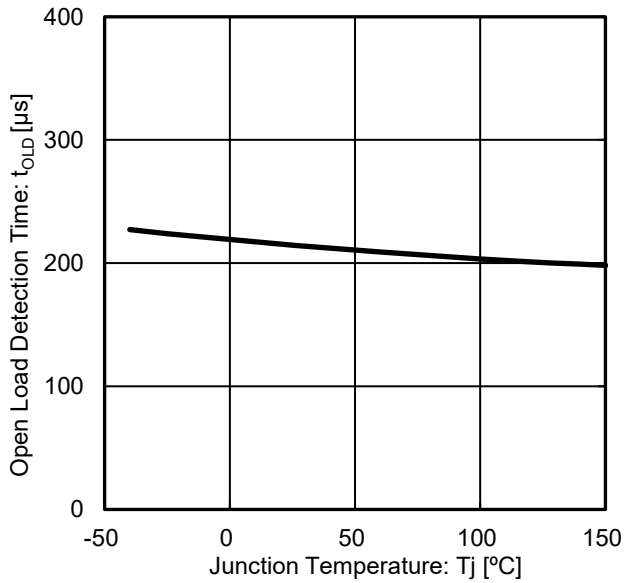


Figure 26. Open Load Detection Time vs Junction Temperature

Measurement Circuit

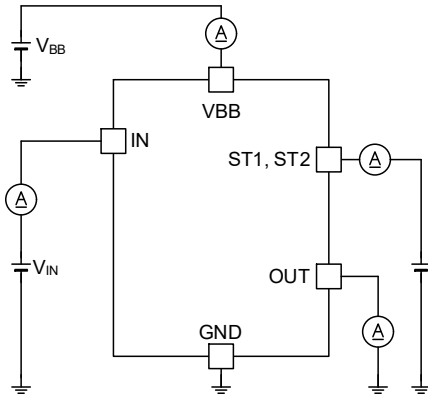


Figure 27. Standby Current 1/2  
 Low Level Input Current  
 Output Leak Current 1/2  
 Diagnostic Output Leak Current

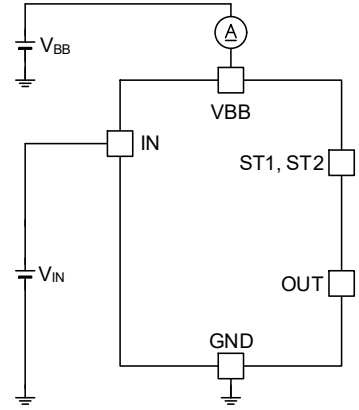


Figure 28. Operating Current

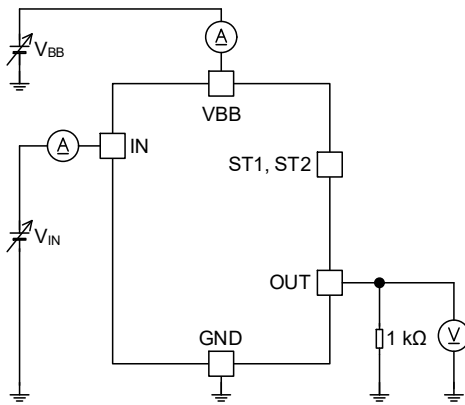


Figure 29. UVLO Detection Voltage  
 UVLO Hysteresis  
 High Level Input Voltage  
 Low Level Input Voltage  
 Input Voltage Hysteresis  
 High Level Input Current  
 Thermal Shutdown  
 Thermal Shutdown Hysteresis

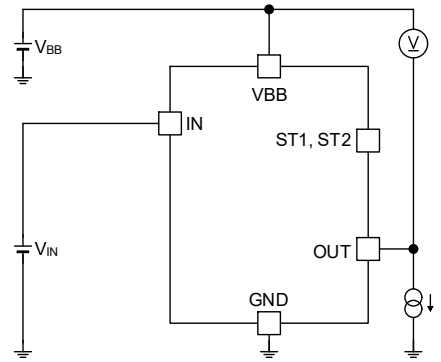


Figure 30. Output ON Resistance 1/2/3/4  
 Output Clamp Voltage



Measurement Circuit - continued

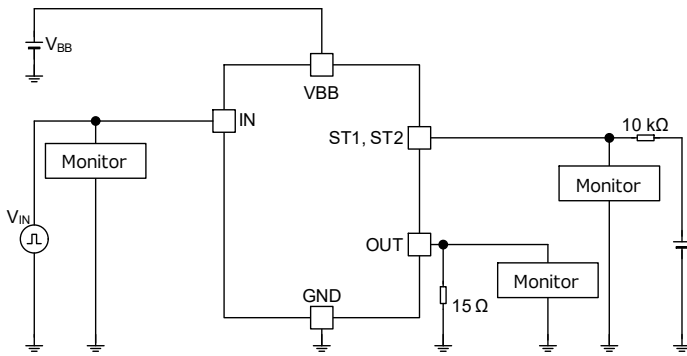


Figure 31. Output ON Slew Rate  
Output OFF Slew Rate  
Output ON Propagation Delay Time  
Output OFF Propagation Delay Time  
Diagnostic Output ON Propagation Delay Time  
Diagnostic Output OFF Propagation Delay Time

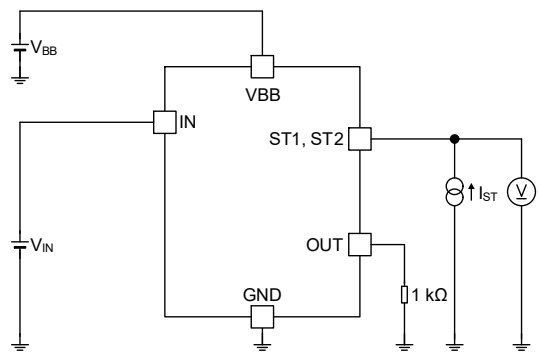


Figure 32. Diagnostic Output Low Voltage

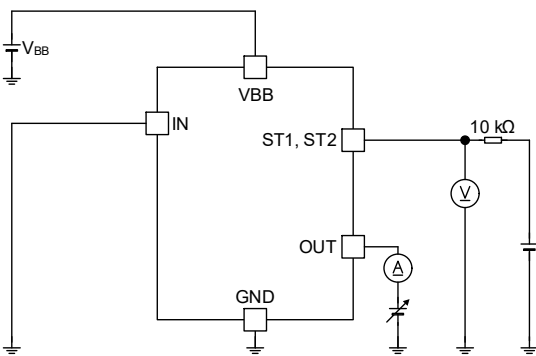


Figure 33. Overcurrent Limit  
Short to VBB Detection Voltage  
Open Load Detection Voltage  
Open Load Detection Sink Current

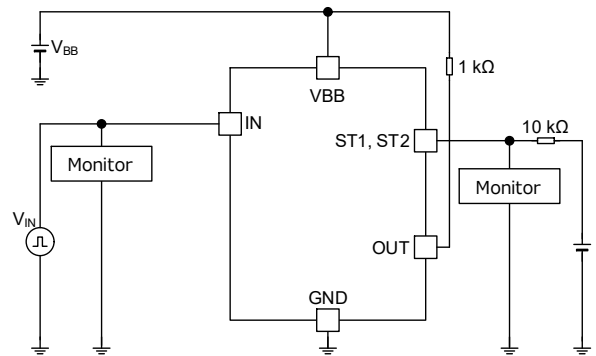


Figure 34. Diagnostic Output Low Voltage

Timing Chart

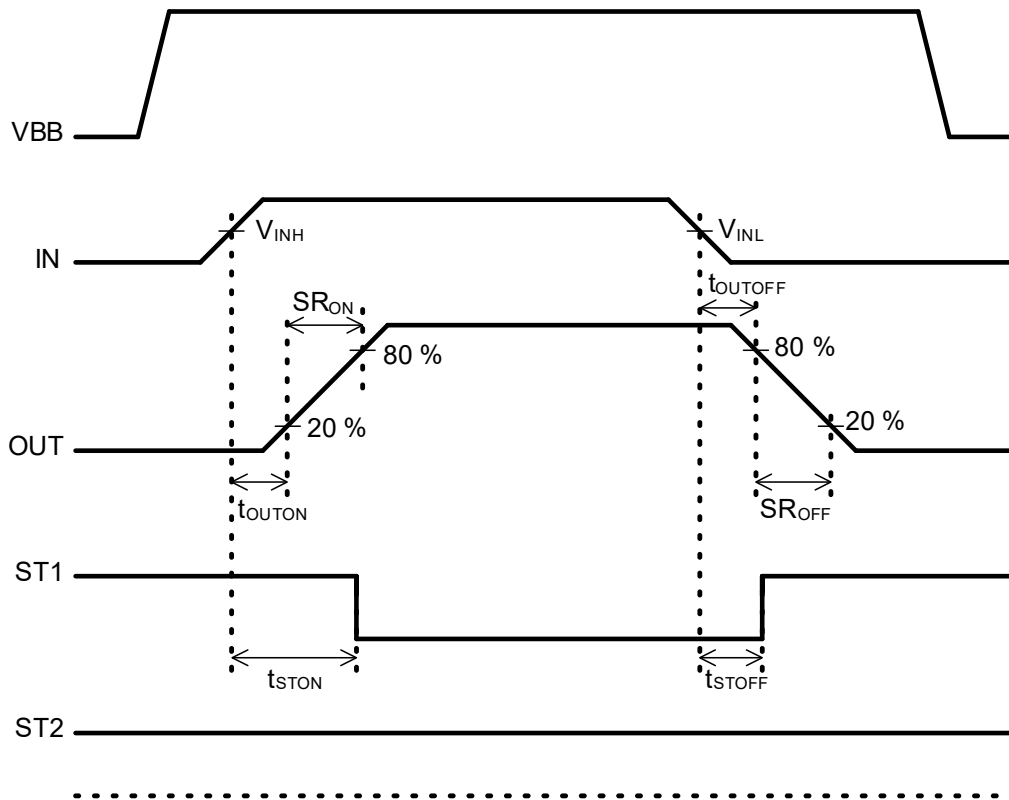


Figure 35. ON/OFF Operation Timing Chart

## Function Description

## 1. Protection Function

Table 1. Detection and Release Conditions of Each Protection Function and Diagnostic Output

Mode		Conditions	IN	ST1	ST2
Normal Condition	Standby	-	Low	High	High
	Operating	-	High	Low	High
Open Load Detect (OLD)		Detect $V_{OUT} \geq 3.0 \text{ V (Typ)}$	Low	Low	High
		Release $V_{OUT} \leq 2.4 \text{ V (Typ)}$	Low	High	High
Short-to-VBB Detection		Detect $V_{OUT} \geq V_{BB} - 1.2 \text{ V (Typ)}$	Low	Low	Low
		Release $V_{OUT} \leq V_{BB} - 1.6 \text{ V (Typ)}$	Low	Low	High
Thermal Shutdown (TSD)		Detect $T_j \geq 175 \text{ }^\circ\text{C (Typ)}$	High	High	High
		Release $T_j \leq 160 \text{ }^\circ\text{C (Typ)}$	High	Low	High
$\Delta T_j$ Protection <i>(Note 1)</i>		Detect $\Delta T_j \geq 90 \text{ }^\circ\text{C (Typ)}$	High	High	High
		Release $\Delta T_j \leq 30 \text{ }^\circ\text{C (Typ)}$	High	Low	High
Over Current Protection (OCP)		Detect $I_{OUT} \geq 3.2 \text{ A (Typ)}$	High	High	High
		Release $I_{OUT} \leq 3.2 \text{ A (Typ)}$	High	Low	High

*(Note 1)* Protect function by detecting Power-MOS sharp increase of temperature difference with control circuit.

This IC has a built-in abnormal detection function as mentioned above and outputs the abnormal condition with ST1 and ST2 pins.

It will automatically recover when the abnormality is resolved.

ST1 outputs the diagnostic result that detects the output voltage.

ST1 change from High to Low when OUT rise more than  $V_{BB} - 1.2 \text{ V (typ)}$  during normal operation.

And change from Low to High when detect each protection or OUT is less than  $V_{BB} - 1.6 \text{ V (Typ)}$ .

ST2 is output to identify the difference between Open Load Detection and Short-to-VBB Detection during IN = Low.

Function Description - continued

2. Overcurrent Protection

This IC has a built-in overcurrent protection function. When overcurrent flows in the output, the output current is limited to 3.2 A (Typ) and self-diagnostic output (ST1) becomes High. Figure 36 shows the timing chart during output short to GND fault.

3. Thermal Shutdown and  $\Delta T_j$  Protection

3.1 Thermal Shutdown Protection

This IC has a built-in thermal shutdown protection function. When the IC chip temperature exceeds 175 °C (Typ), the output is turned OFF and self-diagnostic output (ST1) becomes High. When the temperature goes below 160 °C (Typ), output will self-reset and operation becomes normal.

3.2  $\Delta T_j$  Protection

This IC has a built-in  $\Delta T_j$  protection function. When the difference ( $T_{DTJ}$ ) between the temperature ( $T_{POWER-MOS}$ ) of Power-MOS part in the IC and the temperature ( $T_{AMB}$ ) of the control part is 90 °C (Typ) or more, the output is turned off.

The delta Tj protector has a built-in hysteresis that returns to normal when the temperature difference reaches 30 °C (Typ) or less ( $T_{DTJREL}$ ).

Figure 36 shows the timing chart during output short to GND fault.

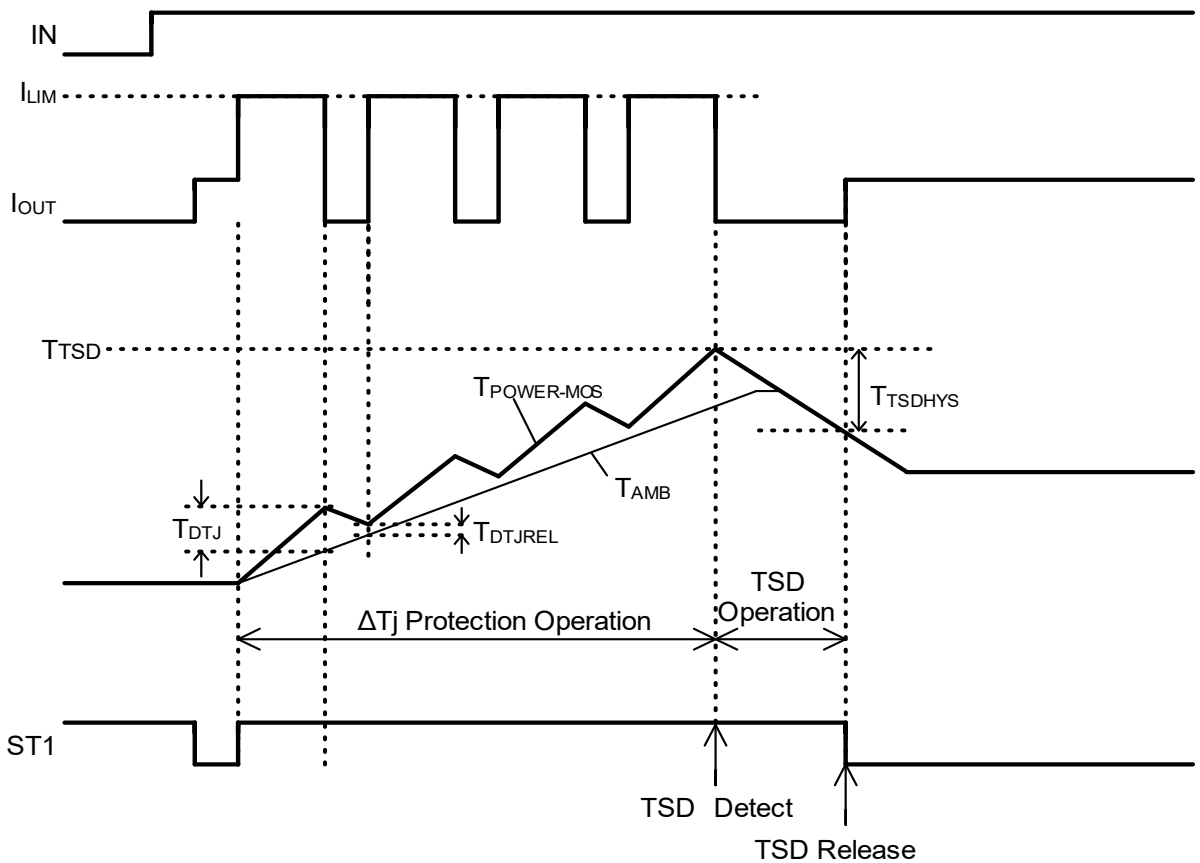


Figure 36. Timing Chart during output short to GND fault

## Function Description - continued

## 4. Open Load Detection

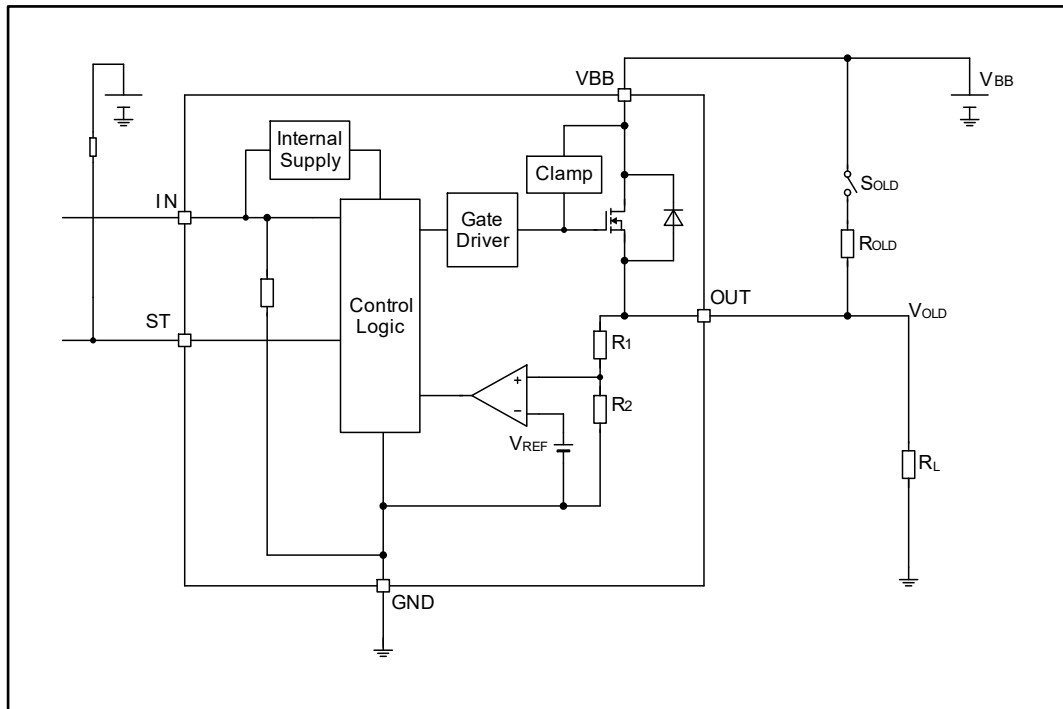


Figure 37. Open Load Detection Block Diagram

By inserting an external resistor  $R_{OLD}$  between the power supply  $V_{BB}$  and the output  $OUT$ , this IC detects a disconnection of the load when the input  $IN$  is low and self-diagnostic output ( $ST1$ ) becomes Low.

When the  $OUT$  voltage is higher than the Short-to- $V_{BB}$  Detection Voltage  $V_{BB}-1.2\text{ V}$  (Typ), the auto-diagnostic output ( $ST2$ ) becomes Low, so that the open-load and short-to- $V_{BB}$  can be distinguished.

An undetected period is provided to prevent false detection immediately after the output is turned off. Therefore, it is possible to judge the abnormality after the Open Load Detection Time  $350\ \mu\text{s}$  (Max) after switching the input  $IN$  to Low. Similarly, immediately after the power supply ( $V_{BB}$ ) is turned on, the open-load and short-to- $V_{BB}$  are not detected for  $350\ \mu\text{s}$  (Max).

Also, note that if  $R_L$  is large enough, the open-load may be detected without lowering the output  $OUT$  even if the input  $IN$  is low.

The external resistance  $R_{OLD}$  value for detecting the open-load can be calculated from the maximum value of the Open Load Detection Voltage  $V_{OLD}$  and the minimum value of the power supply voltage  $V_{BB}$  used by the following equation.

$$R_{OLD} < \frac{V_{BB(\text{Min})} \times (R_{1(\text{Min})} + R_{2(\text{Min})})}{V_{OLD(\text{Max})}} - (R_{1(\text{Min})} + R_{2(\text{Min})}) \quad [\text{k}\Omega]$$

$$R_{OLD} < V_{BB(\text{Min})} \times 75 - 300 \quad [\text{k}\Omega]$$

To distinguish between the open-load state and the short-to- $V_{BB}$  state, set  $R_{OLD}$  value to be greater than  $R_{OLD}$  value of the following equation and less than  $R_{OLD}$  value of the above equation, which is obtained from the maximum value of the Short-to- $V_{BB}$  Detection Voltage  $V_{SHV}$ .

$$R_{OLD} > \frac{V_{BB(\text{Min})} \times (R_{1(\text{Min})} + R_{2(\text{Min})})}{V_{SHV(\text{Max})}} - (R_{1(\text{Min})} + R_{2(\text{Min})}) \quad [\text{k}\Omega]$$

$$R_{OLD} > \frac{V_{BB(\text{Min})}}{V_{SHV(\text{Max})}} \times 300 - 300 \quad [\text{k}\Omega]$$

Function Description - continued

5. Other Detection

5.1 GND open protection

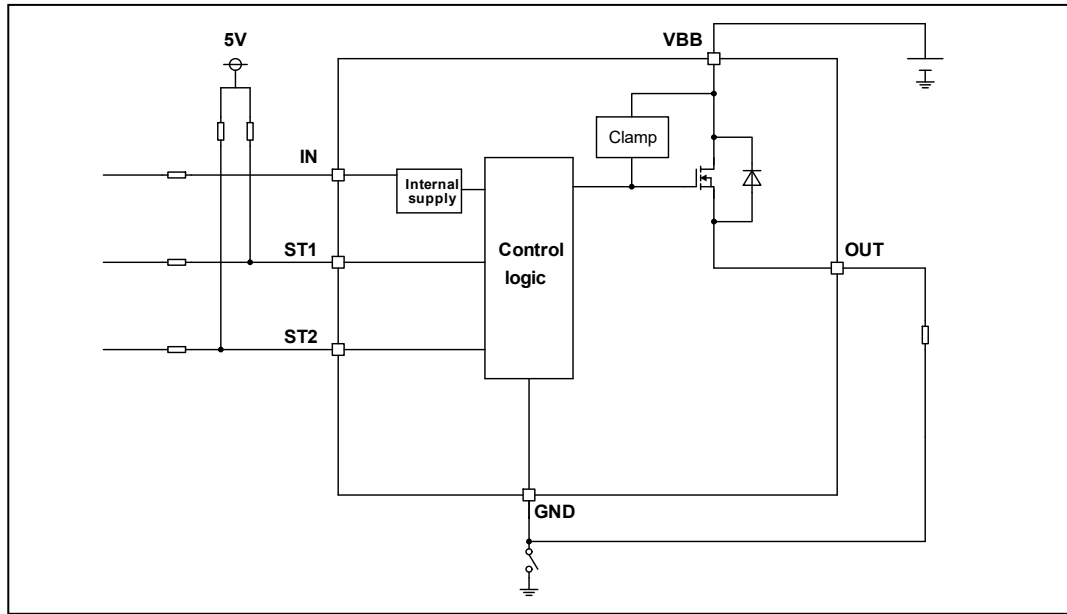


Figure 38. GND Open Detection Block Diagram

When GND of the IC is open, the output is switched OFF regardless of the input voltage. However, self-diagnostic output is not flagged. When an inductive load is connected, the active clamp operates when the GND pin is open

5.2 MCU I/O Protection

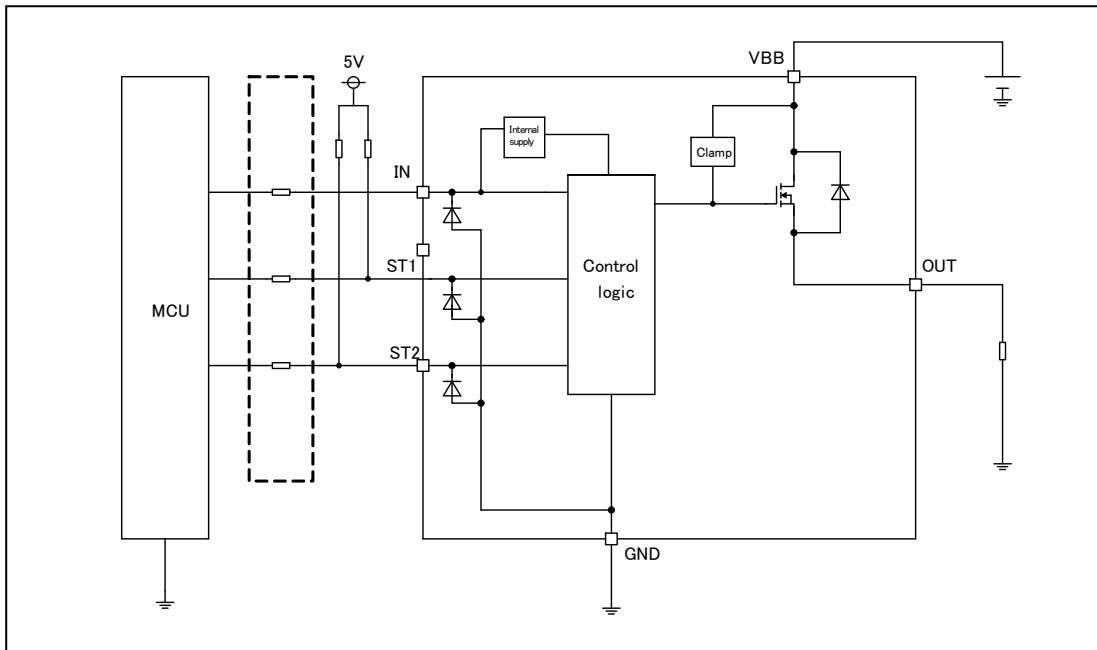


Figure 39. MCU I/O Protection

As a countermeasure to prevent damage from the surge voltage, limiting resistance is inserted in between input terminal and MCU. Recommended input resistance range values are 4.7 kΩ to 10 kΩ.

Application Circuit Diagram

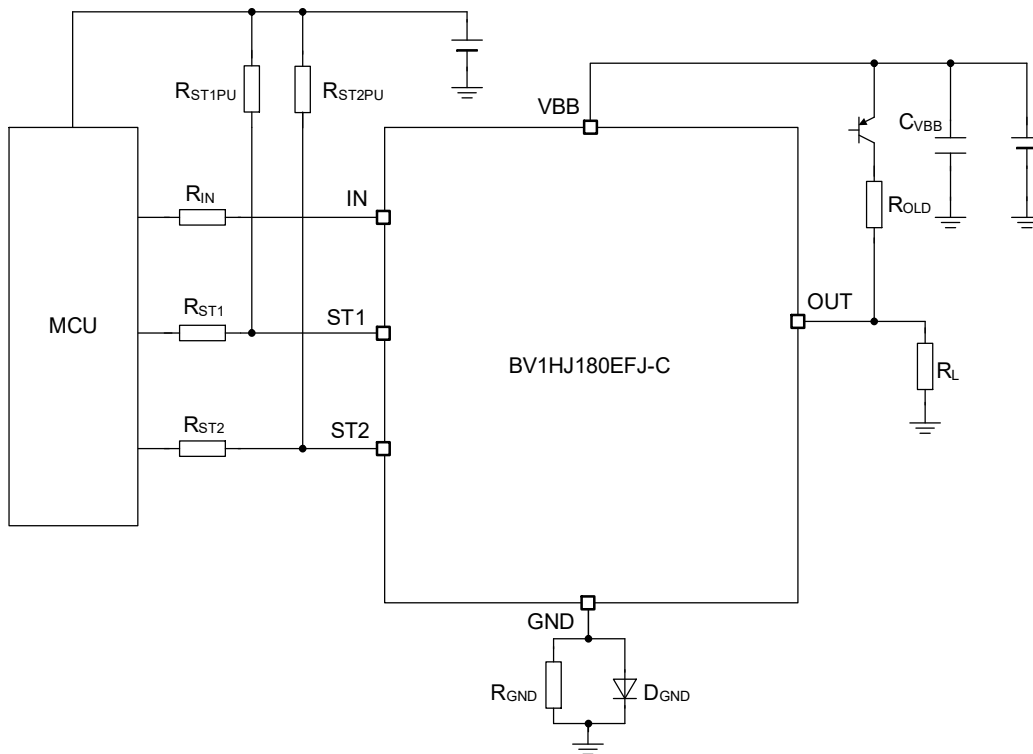
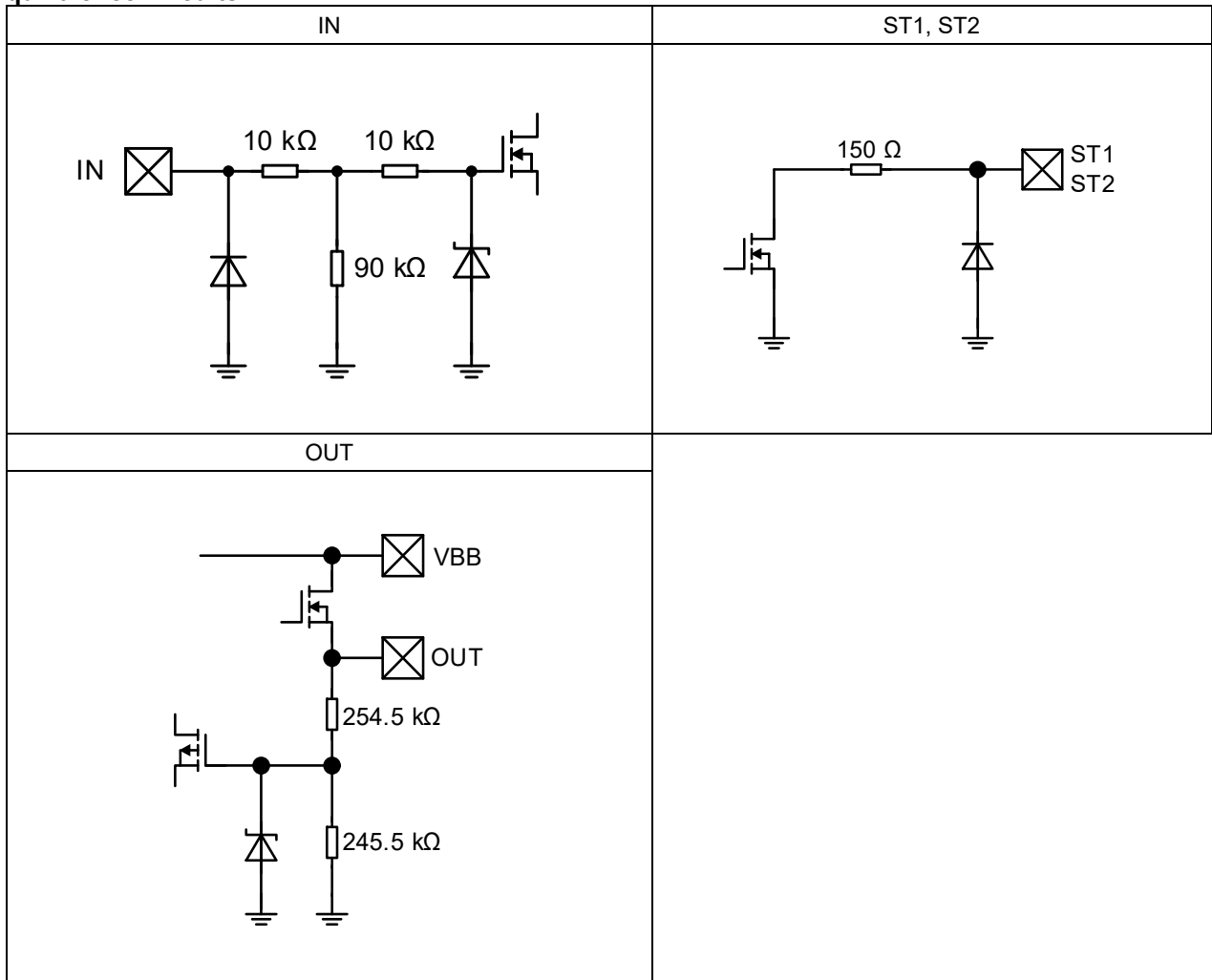


Figure 40. Application Circuit Diagram

Symbol	Value	Purpose
R <sub>IN</sub>	4.7 kΩ	Limit resistance for negative surge
R <sub>ST1</sub> , R <sub>ST2</sub>	4.7 kΩ	Limit resistance for negative surge
R <sub>ST1PU</sub> , R <sub>ST2PU</sub>	10 kΩ	Pull up ST1/ST2 pin to MCU power supply, these pins are open drain output
C <sub>VBB</sub>	1 μF	For battery line voltage spike filter
R <sub>GND</sub>	1 kΩ	For current limit for reverse battery connection
D <sub>GND</sub>	-	BV1HJ180EFJ-C protection for reverse battery connection
R <sub>OLD</sub>	51 kΩ	For open load detection

I/O Equivalence Circuits



Resistance values shown in the diagrams above are typical values



## Operational Notes

### 1. Reverse Connection of Power Supply

Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

### 2. Power Supply Lines

Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

### 3. Ground Voltage

Except for pins the output and the input of which were designed to go below ground, ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

### 4. Ground Wiring Pattern

When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

### 5. Recommended Operating Conditions

The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

### 6. Inrush Current

When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

### 7. Testing on Application Boards

When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

### 8. Inter-pin Short and Mounting Errors

Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other specially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

### 9. Unused Input Pins

Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So, unless otherwise specified, unused input pins should be connected to the power supply or ground line.

### 10. Ceramic Capacitor

When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

### 11. Thermal Shutdown Circuit (TSD)

This IC has a built-in thermal shutdown function that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If by any chance the rating is exceeded for a continued period, the junction temperature ( $T_j$ ) will rise which will activate the TSD function that will turn OFF power output pins. When the  $T_j$  falls below the TSD threshold, the circuits are automatically restored to normal operation. Note that the TSD function operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD function be used in a set design or for any purpose other than protecting the IC from heat damage.

**Operational Notes – continued****12. Over Current Protection Function (OCP)**

This IC incorporates an integrated overcurrent protection function that is activated when the load is shorted. This protection function is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection function.

**13. Active Clamp Operation**

The IC integrates the active clamp function to internally absorb the reverse energy  $E_L$  which is generated when the inductive load is turned off. When the active clamp operates, the thermal shutdown function does not work. Decide a load so that the reverse energy  $E_L$  is active clamp tolerance  $E_{As}$  (refer to Figure 2. Active Clamp Energy (Single Pulse) vs Output Current (Start)) or under when inductive load is used.

**14. OPEN Power Supply Pin**

When power supply pin (VBB) becomes open at ON (IN = High), the output is switched to OFF regardless of input voltage. If an inductive load is connected, the active clamp operates when VBB is OPEN and becomes the same potential as that on the ground. At this time, the output voltage drops down to -50 V (Typ).

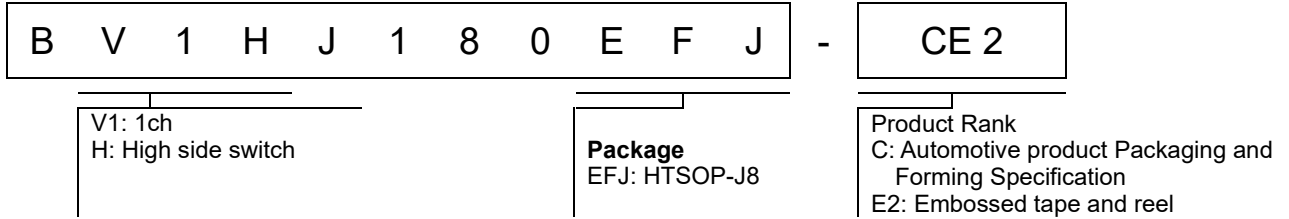
**15. OPEN GND Pin**

When GND pin becomes open at ON (IN = High), the output is switched to OFF regardless of the input voltage. If an inductive load is connected, the active clamp operates when GND pin is open.

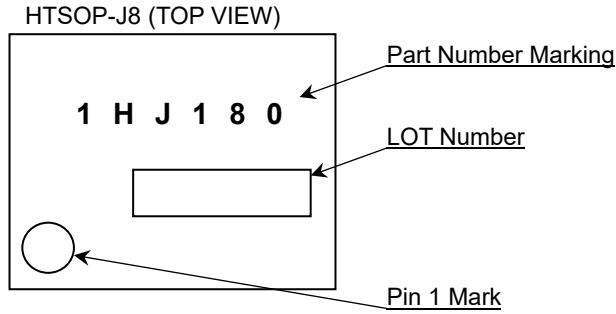
**16. OUT Pin Voltage**

Ensure that keep OUT pin voltage less than (VBB + 0.3 V) at any time, even during transient condition. Otherwise malfunction or other problems can occur.

Ordering Information



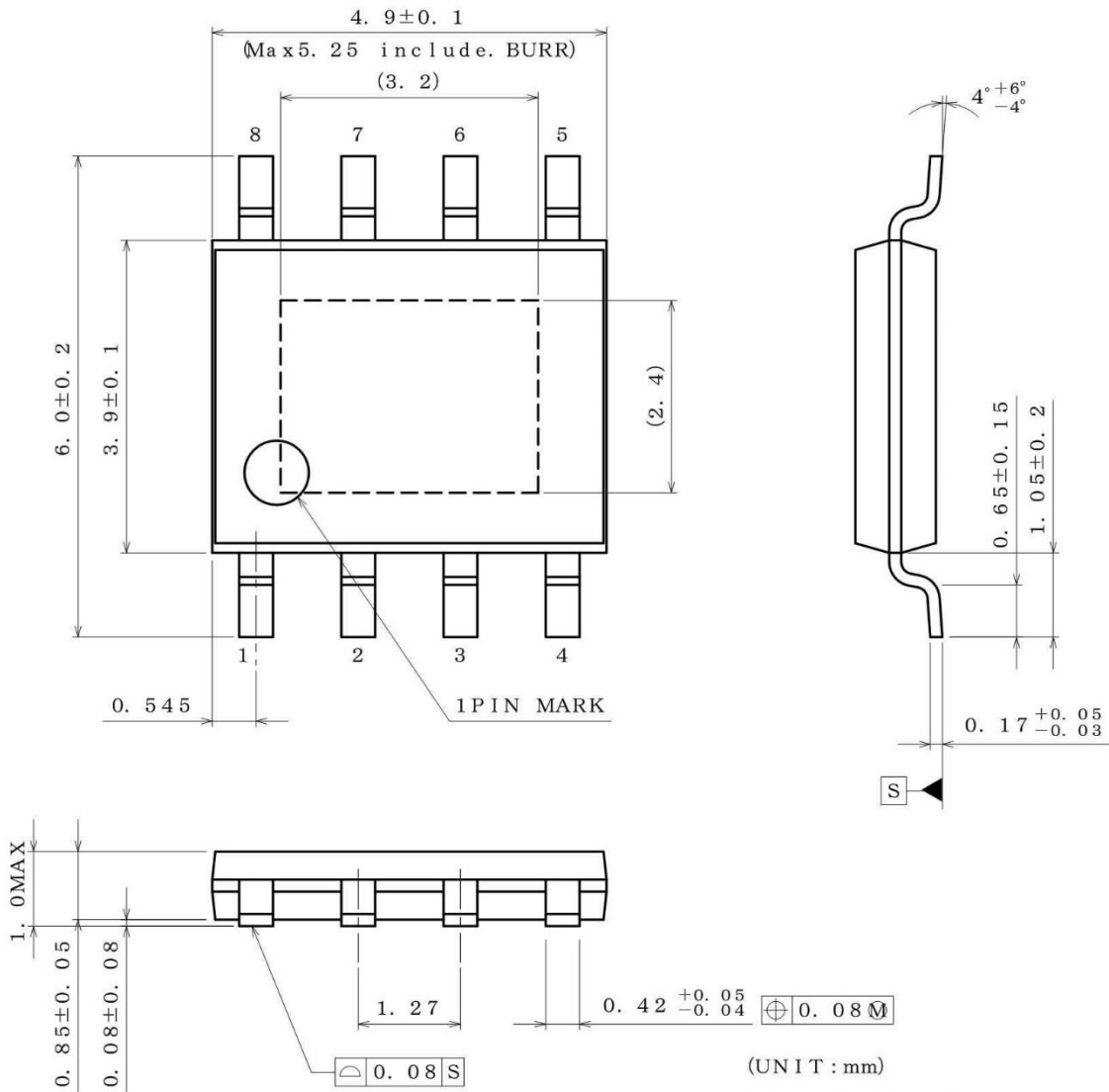
Marking Diagram



Physical Dimension and Packing Information

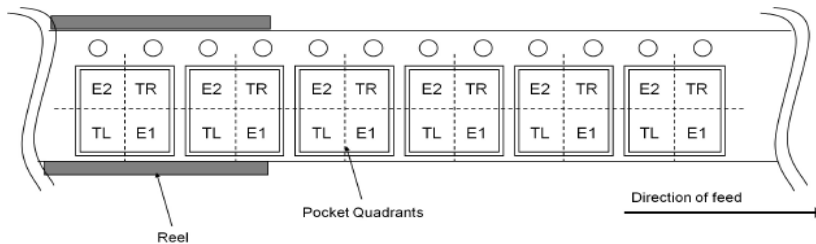
Package Name

HTSOP-J8



< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 The direction is the pin 1 of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand



## Revision History

Date	Revision	Changes
14.Jul.2021	001	New Release
08.Oct.2021	002	P.10 Electrical Characteristics Limit of Open Load Detection Time is changed. Limit of Thermal Shutdown Hysteresis is changed. P.21 Function Description Value of Open Load Detection Time is changed.

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JAPAN	USA	EU	CHINA
CLASS III	CLASS III	CLASS II b	CLASS III
CLASS IV		CLASS III	

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  - [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - [h] Use of the Products in places subject to dew condensation
4. The Products are not subject to radiation-proof design.
5. Please verify and confirm characteristics of the final or mounted products in using the Products.
6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.
8. Confirm that operation temperature is within the specified range described in the product specification.
9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

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2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

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  - [b] the temperature or humidity exceeds those recommended by ROHM
  - [c] the Products are exposed to direct sunshine or condensation
  - [d] the Products are exposed to high Electrostatic
2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
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4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

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