

## USB HIGH-SIDE POWER SWITCH

NO.EA-168-180516

### OUTLINE

The R5523N is a high-side MOSFET switch IC for Universal Serial Bus (USB) applications. Low ON Resistance (Typ.130mΩ) and low supply current (Typ.20μA at active mode) are realized in this IC. An over-current limit circuit, a thermal shutdown circuit, and an under voltage lockout (UVLO) circuit are built-in as protection circuits. Further, a delay circuit for flag signal after detecting over-current, is embedded to prevent miss-operation of error flag because of inrush current. The R5523N Series is ideal for applications of protection for USB power supply. Since the package is small SOT-23-5, high density mounting on board is possible.

### FEATURES

- Built-in P-channel MOSFET Switch
- Supply Current .....Typ. 20μA (at Active Mode)
- Switch ON Resistance .....Typ. 130mΩ
- Output Current.....Min. 500mA
- Flag Delay Time .....Typ. 10ms.
- Package.....SOT-23-5
- Over- Current Limit / Short Circuit Protection
- Built-in Under Voltage Lockout (UVLO) Function
- Built-in Thermal Shutdown Protection
- Built-in Soft-start Function

### APPLICATIONS

- USB Peripherals
- Notebook PCs

### SELECTION GUIDE

The logic of the enable pin for the ICs can be selected at the user's request.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5523N001*-TR-FE	SOT-23-5	3,000 pcs	Yes	Yes

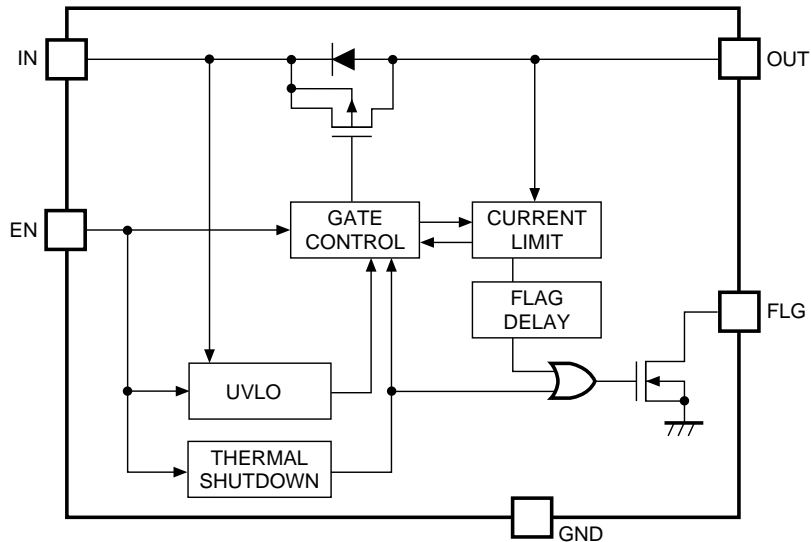
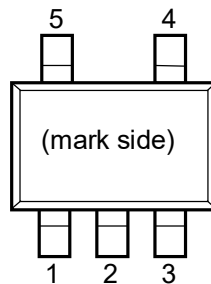
\* : Designation of the logic of the enable pin.  
 (A) "L" active  
 (B) "H" active

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**R5523N**

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**BLOCK DIAGRAM****R5523N Block Diagram****PIN DESCRIPTION****R5523N (SOT-23-5) Pin Configuration**

Pin No	Symbol	Pin Description
1	EN	Enable Pin
2	GND	Ground Pin
3	FLG	FLG pin (Open Drain Output)
4	VIN	Power Supply Pin
5	VOUT	Output Pin

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**ABSOLUTE MAXIMUM RATINGS**

Symbol	Item	Rating	Unit
$V_{IN}$	Input Voltage	6.5	V
$V_{EN}$	Enable Pin Input Voltage	-0.3 to $V_{IN}+0.3$	V
$V_{FLG}$	Flag Voltage	-0.3 to 6.5	V
$I_{FLG}$	Flag Current	14	mA
$V_{OUT}$	Output Voltage	-0.3 to $V_{IN}+0.3$	V
$I_{OUT}$	Output Current	Internal Limited	
$P_D$	Power Dissipation <sup>(1)</sup> (SOT-23-5, JEDEC STD.51-7)	660	mW
$T_j$	Junction Temperature Range	-40 to 125	°C
$T_{stg}$	Storage Temperature	-55 to 125	°C

**ABSOLUTE MAXIMUM RATINGS**

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

**RECOMMENDED OPERATING CONDITIONS**

Symbol	Parameter	Rating	Unit
$V_{IN}$	Operating Input Voltage	2.2 to 5.5	V
$T_a$	Operating Temperature Range	-40 to 85	°C

**RECOMMENDED OPERATING CONDITIONS**

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

<sup>(2)</sup> Refer to *POWER DISSIPATION* for detailed information.

## R5523N

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## ELECTRICAL CHARACTERISTICS

### R5523N001A/B Electrical Characteristics

(Ta = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
I <sub>DD1</sub>	Supply Current 1 (Enabled)	V <sub>OUT</sub> = OPEN <sup>(1)</sup>		20	45	μA
I <sub>DD2</sub>	Supply Current 2 (Disabled)	V <sub>OUT</sub> = OPEN <sup>(2)</sup>		0.1	1.0	μA
R <sub>ON</sub>	Switch On Resistance	V <sub>IN</sub> = 5V, I <sub>OUT</sub> = 500mA		130	180	mΩ
t <sub>on</sub>	Output Turn-on Delay	V <sub>IN</sub> = 5V, R <sub>L</sub> = 60Ω		1400		μs
t <sub>off</sub>	Output Turn-off Delay	V <sub>IN</sub> = 5V, R <sub>L</sub> = 60Ω		5		μs
V <sub>UVLO</sub>	UVLO Threshold	V <sub>IN</sub> at increasing	1.6	1.9		V
V <sub>HYS</sub>	UVLO Hysteresis Range	V <sub>IN</sub> at decreasing		0.1		V
I <sub>TH</sub>	Current Limit Threshold			1.0	1.5	A
I <sub>LIM</sub>	Short Current Limit	V <sub>IN</sub> =5V, 5ms after V <sub>OUT</sub> = 0V <sup>(3)</sup>	0.5	0.75	1.3	A
t <sub>FD</sub>	Over Current Flag Delay	V <sub>IN</sub> = 5V, From Over Current to FLG = "L"	5	10	20	ms
T <sub>TS</sub>	Thermal Shutdown Temperature Threshold	T <sub>j</sub> at increasing		135		°C
		T <sub>j</sub> at decreasing		120		°C
I <sub>EN</sub>	Enable Pin Input Current			0.01	1.0	μA
V <sub>EN1</sub>	Enable Pin Input Voltage 1	V <sub>EN</sub> at increasing	2.0			V
V <sub>EN2</sub>	Enable Pin Input Voltage 2	V <sub>EN</sub> at decreasing			0.8	V
I <sub>LO</sub>	Output Leakage Current			0.1	1.0	μA
V <sub>LF</sub>	Flag "L" Output Voltage	I <sub>SINK</sub> = 1mA			0.4	V
I <sub>FOF</sub>	Flag Off Current	V <sub>FLG</sub> = 5.5V		0.01	1.0	μA

<sup>(1)</sup> EN="L"(R5523NxxxA), EN="H"(R5523NxxxB)

<sup>(2)</sup> EN="H"(R5523NxxxA), EN="L"(R5523NxxxB)

<sup>(3)</sup> Refer to "Overcurrent Detection and Overcurrent limit" in THEORY OF OPERATION for details.

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## THEORY OF OPERATION

This explanation is based on the typical application.

- There is a parasitic diode between source and drain of the switch transistor. (Refer to the block diagram.) Because of this, in both cases of enable and disable, if the voltage of  $V_{OUT}$  pin is higher than  $V_{IN}$  pin, current flows from  $V_{OUT}$  to  $V_{IN}$ .
- In case that  $V_{OUT}$  pin and GND is short, if over-current would continue, the temperature of the IC would increase drastically. If the temperature of the IC is beyond  $135^{\circ}\text{C}$ , the switch transistor turns off and the FLG pin level becomes "L". Then, when the temperature of the IC decreases equal or lower than  $120^{\circ}\text{C}$ , the switch transistor turns on and FLG becomes "H". Unless the abnormal situation of  $V_{OUT}$  pin is removed, the switch transistor repeats on and off. Refer to the 24) Thermal Shutdown operation in the typical characteristics.
- Over-current level is set internally in the IC. There are three types of response against over-current: Under the condition that  $V_{OUT}$  pin is short or large capacity is loaded, if the IC is enabled, the IC becomes constant current state. After the flag delay time passes, FLG becomes "L", that means over current state. Refer to the 23) current limit transient response of typical characteristics. While the switch transistor is on, if  $V_{OUT}$  pin is short or large capacity is loaded, until the current limit circuit responds, large transient current flows. After the transient current is beyond the over-current detector threshold and delay time of the flag passes, FLG becomes "L", that means over current state. Refer to the 25), 26) over-current limit transient response of typical characteristics. In the case that load current gradually increases, the IC is not into the constant current state until the current is beyond over current limit. Once the level is beyond the over current detector threshold, load current is limited into over current limit level. Note that load current continuously flows until the load current is beyond the over-current detector threshold.
- FLG pin is Nch Open drain output. If the over-current or over-temperature is detected, FLG becomes "L". If over-current is detected, FLG becomes "L" after the flag delay time  $t_{FD}$  passes. Therefore flag signal is not out with inrush current.
- UVLO circuit prevents that the switch transistor turns on until the input voltage is beyond 1.9V. UVLO circuit can operate when the IC is enabled.

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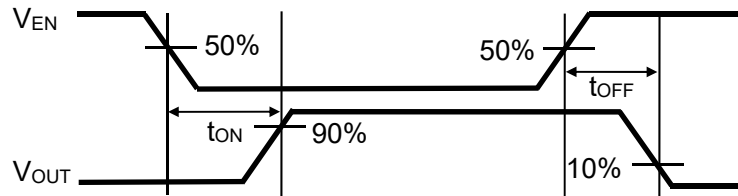
**R5523N**

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**Timing Chart****R5523N001A**

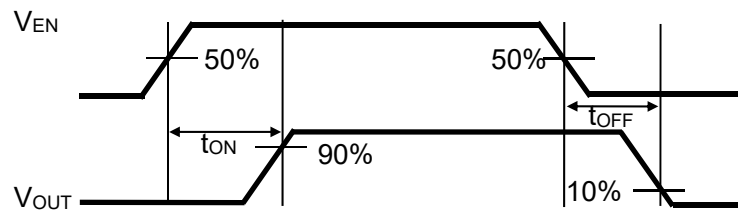
Output On time/ Output Off time



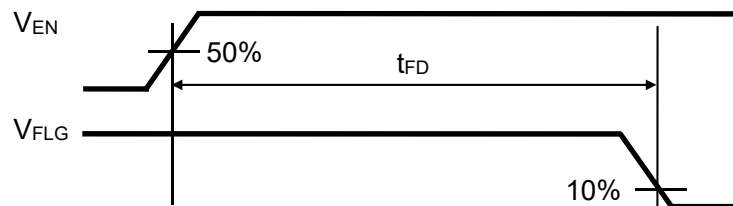
FLG Output Delay Time

**R5523N001B**

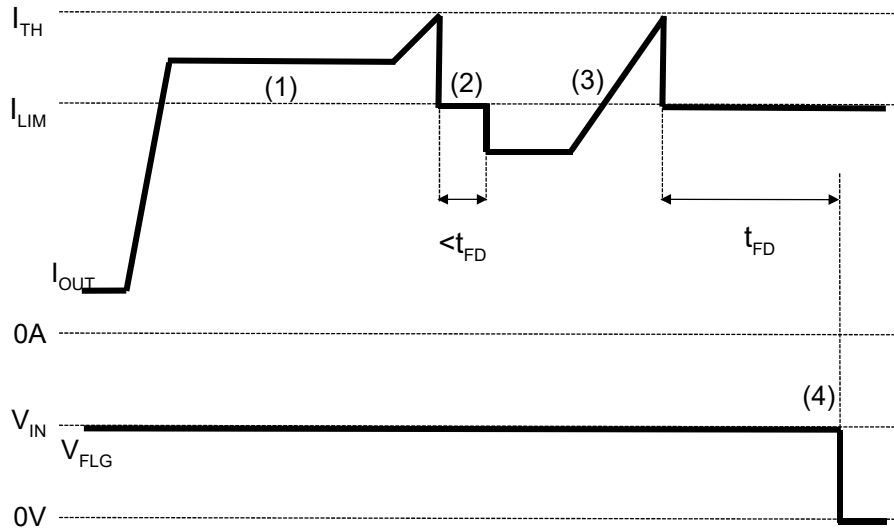
Output On time/ Output Off time



FLG Output Delay Time



### Overcurrent Detection and Overcurrent Limit

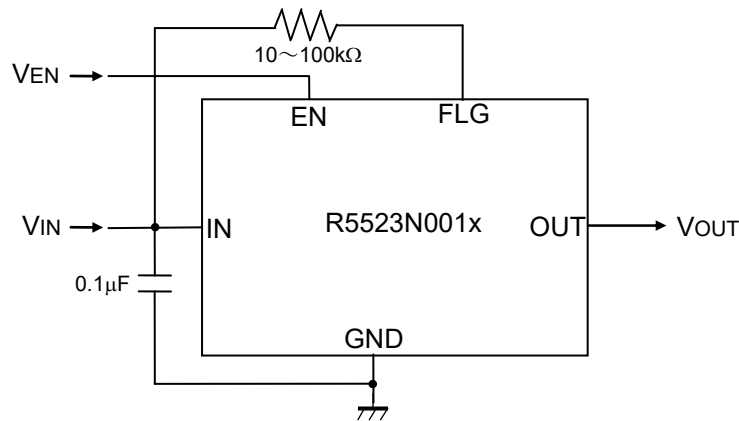


**R5523N001A / R5523N001B Overcurrent Detection and Overcurrent limit Timing Chart**

- (1) When the  $I_{OUT}$  is  $I_{TH}$  or less, the current is not limited.
- (2) Once the  $I_{OUT}$  reaches to  $I_{TH}$ , the  $I_{OUT}$  is limited by  $I_{LIM}$ .
- (3) When the  $I_{OUT}$  drops to  $I_{LIM}$  or less within the  $t_{FD}$  time, the current limit is released. The current is not limited until the  $I_{OUT}$  exceeds  $I_{TH}$  again.
- (4) When the  $I_{OUT}$  reaches to  $I_{TH}$  and it is limited by  $I_{LIM}$  for  $t_{FD}$  or more, the switch transistor turns off and  $V_{FLG}$  becomes "Low".

## APPLICATION INFORMATION TECHNICAL NOTES

### Typical Application Circuit



**R5523N001x Typical Application Circuit**

### Precautions for Selecting External Components

- **Bypass capacitor**

Put a capacitance range from 0.1μF to 1μF bypass capacitor between VIN pin and GND pin of the IC. Without a bypass capacitor, in case of output short, because of the high side inductance of VIN pin, the ringing may be generated and it might be a cause of an unstable operation.

- **Pull-up resistance value range of flag pin**

Recommended pull-up resistance value range of flag pin is from 10kΩ to 100kΩ.

- **Over-current limit Function**

In case that VOUT pin and GND is short, if over-current would continue, the temperature of the IC would increase drastically. If the temperature of the IC is equal or more than 135°C (Typ.), the switch transistor turns off because of thermal shutdown protection. In other words, when the temperature of the IC becomes equal or more than 135°C (Typ.), both the over-current limit circuit and thermal shutdown circuit work for the protection of the IC.

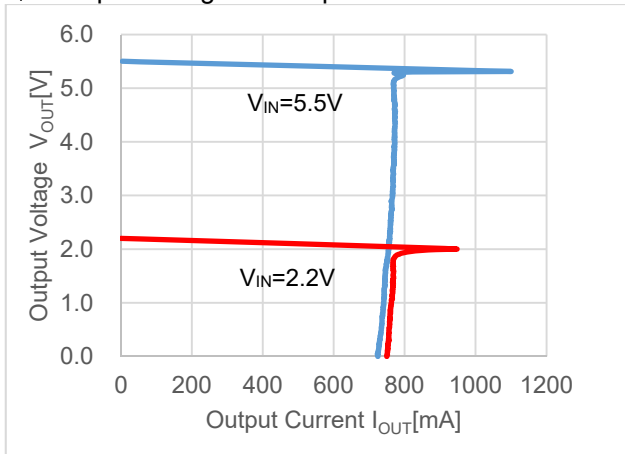


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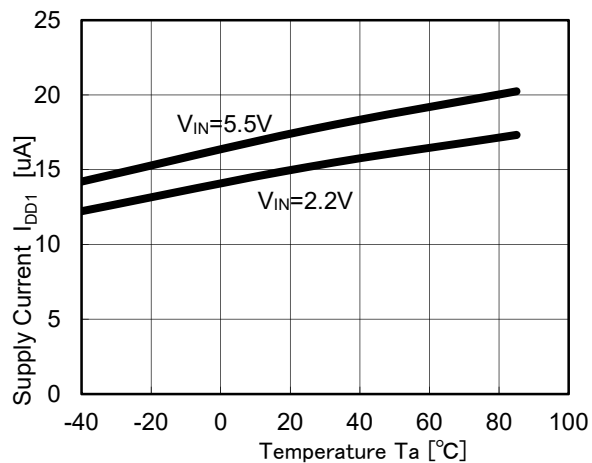
## TYPICAL CHARACTERISTICS

Typical Characteristics are intended to be used as reference data, they are not guaranteed.

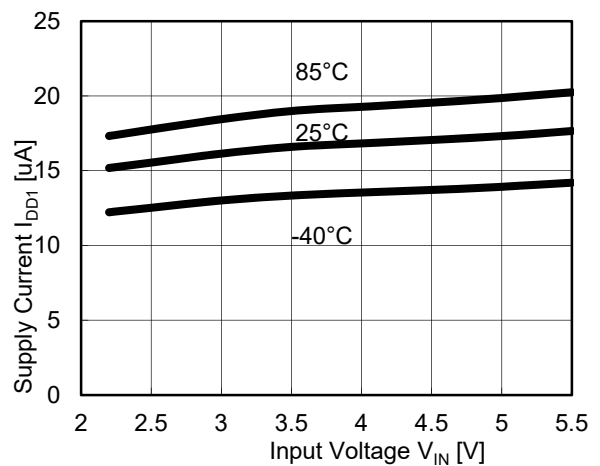
### 1) Output Voltage vs. Output Current



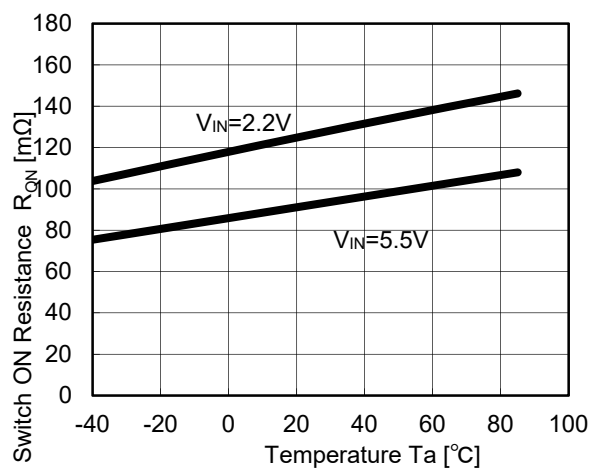
### 2) Supply Current vs. Temperature



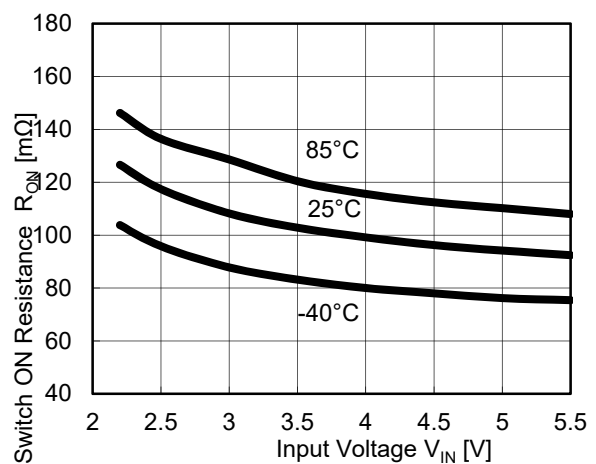
### 3) Supply Current vs. Input Voltage



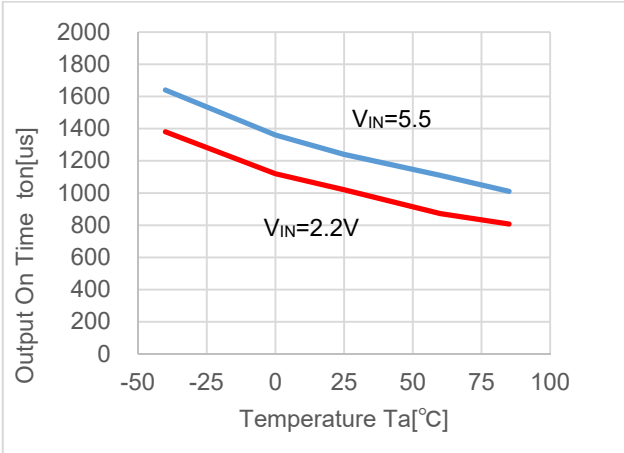
### 4) On Resistance vs. Temperature



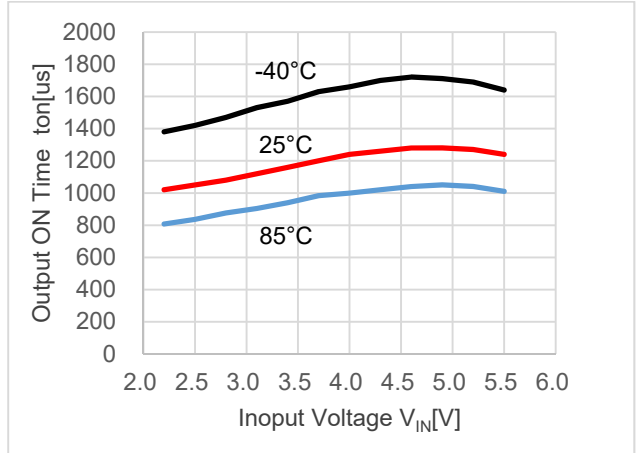
### 5) On Resistance vs. Input Voltage



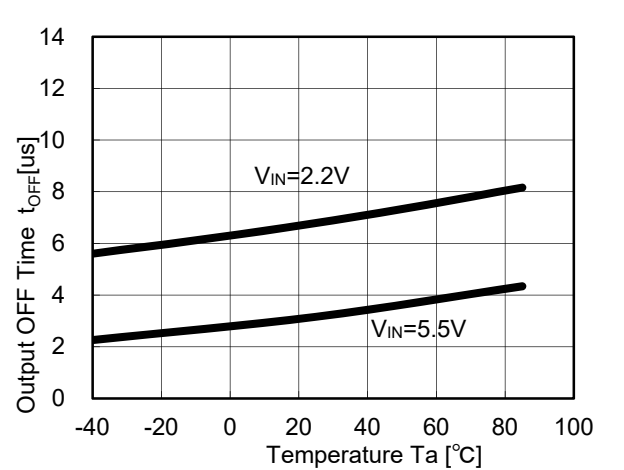
6) Output On Time vs. Temperature



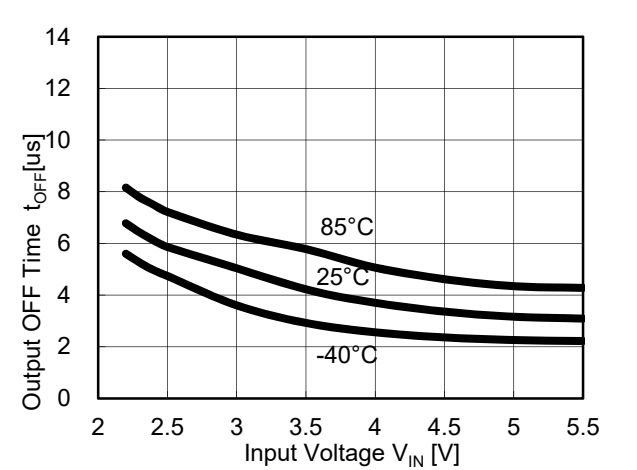
7) Output On Time vs. Input Voltage



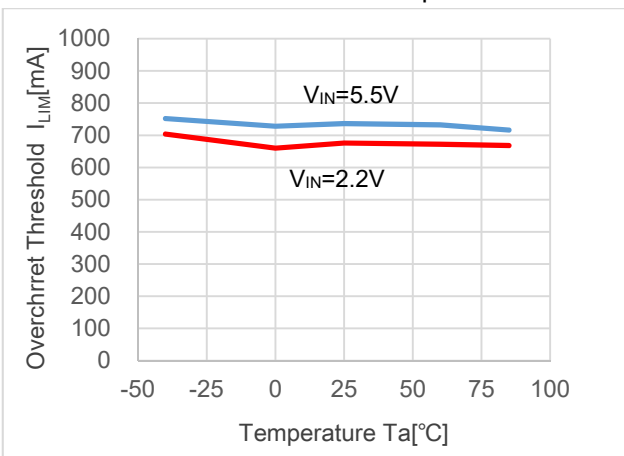
8) Output Off Time vs. Temperature



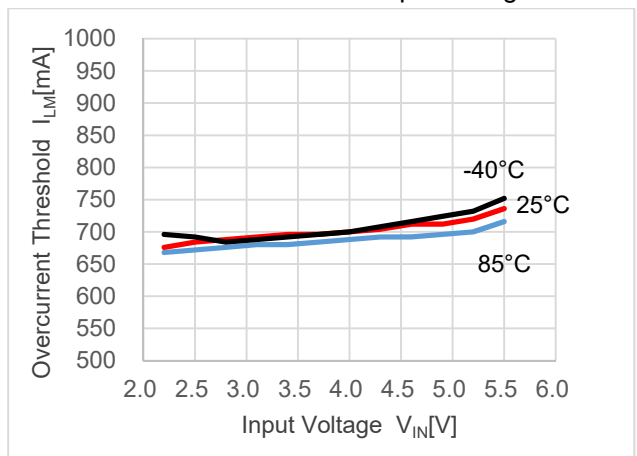
9) Output Off Time vs. Input Voltage



10) Overcurrent Threshold vs. Temperature

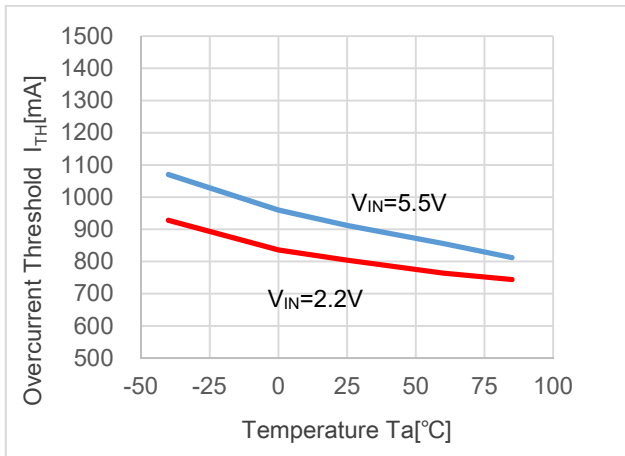


11) Overcurrent Threshold vs. Input Voltage

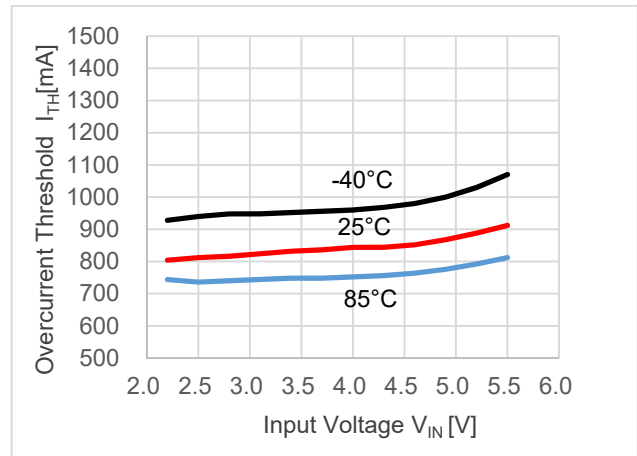


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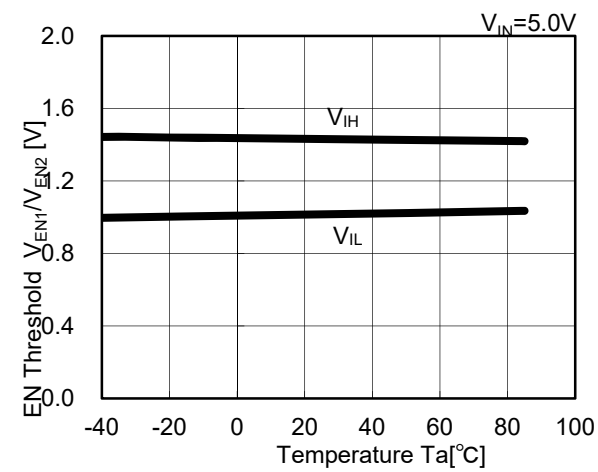
12) Overcurrent Threshold vs. Temperature



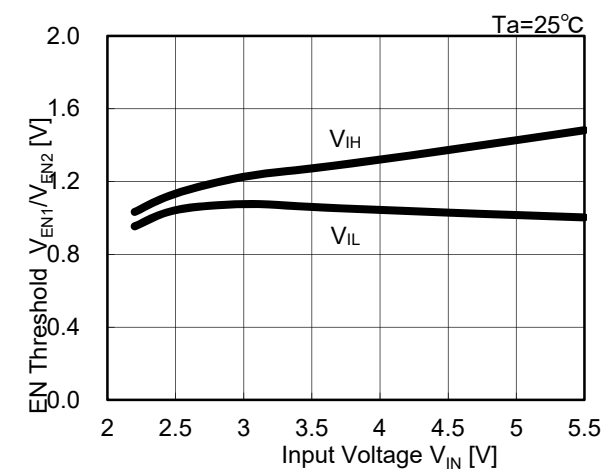
13) Overcurrent Threshold vs. Input Voltage



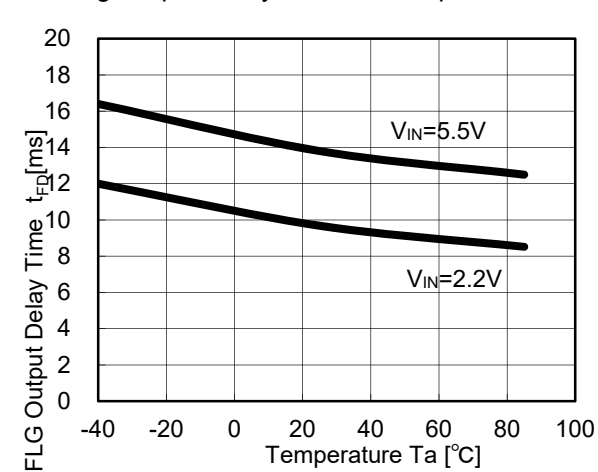
14) Enable Input Voltage vs. Temperature



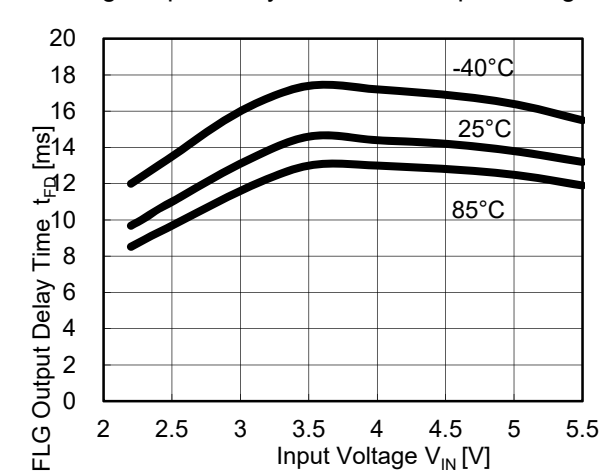
15) Enable Input Voltage vs.  $V_{IN}$  Input Voltage



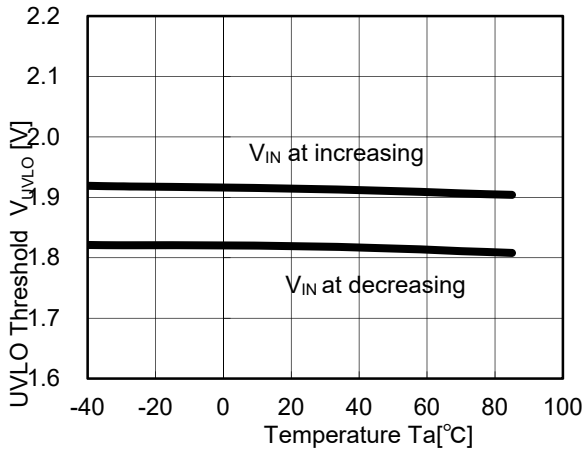
16) Flag Output Delay Time vs. Temperature



17) Flag Output Delay Time vs.  $V_{IN}$  Input Voltage

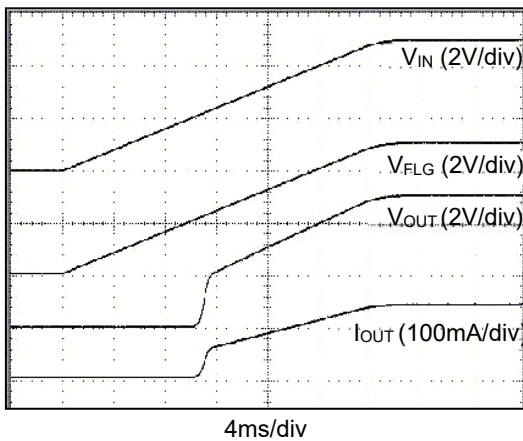


**18) UVLO Threshold vs. Temperature**



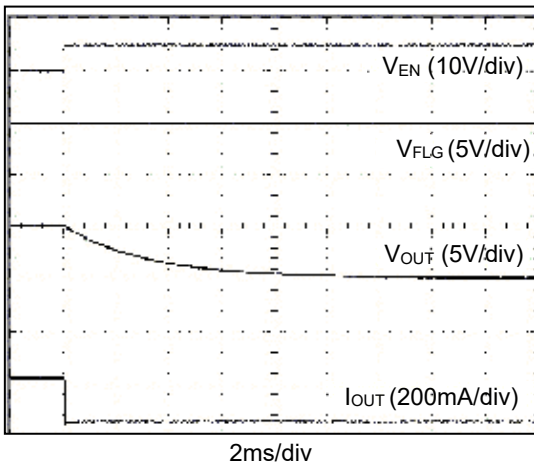
**19) UVLO Characteristic at  $V_{IN}$  increasing**

$V_{EN}=0V$ ,  $C_L=47\mu F$ ,  $R_L=35\Omega$



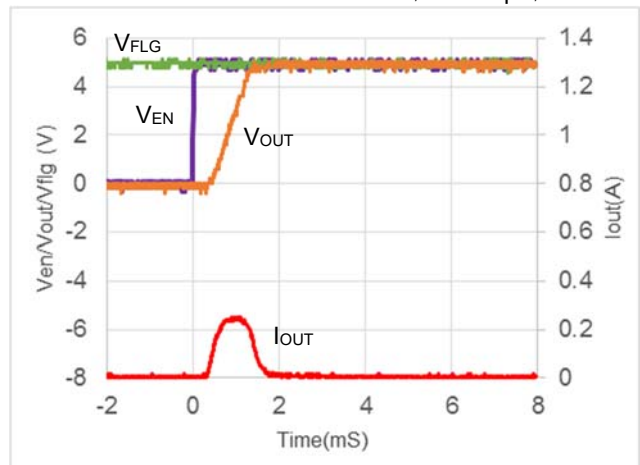
**21) Turn Off Response**

$V_{IN}=5V$ ,  $C_L=47\mu F$ ,  $R_L=35\Omega$



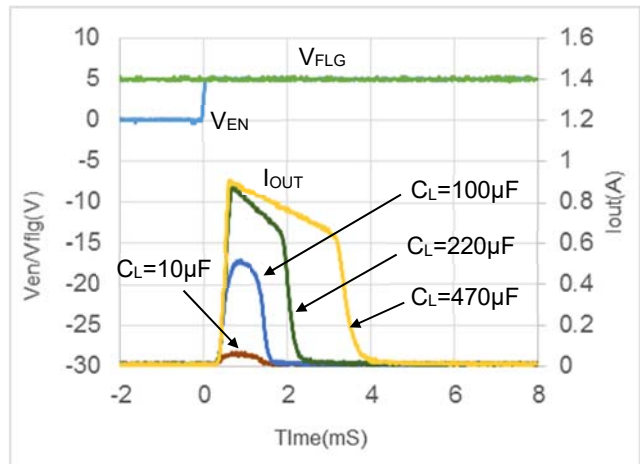
**20) Turn on Response**

$V_{IN}=5V$ ,  $C_L=47\mu F$ ,  $R_L=35\Omega$



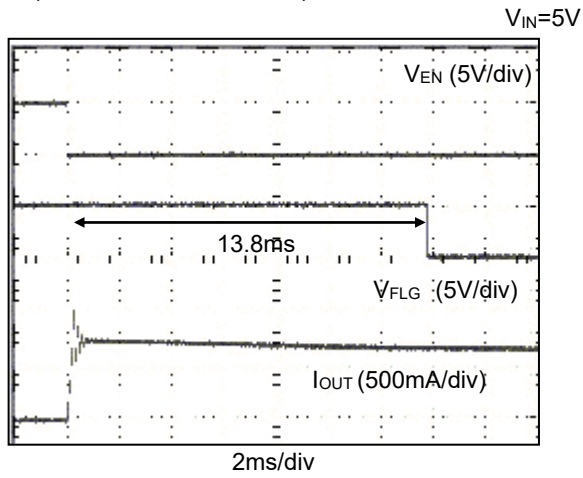
**22) Inrush Current**

$V_{IN}=5V$ ,  $R_L=35\Omega$

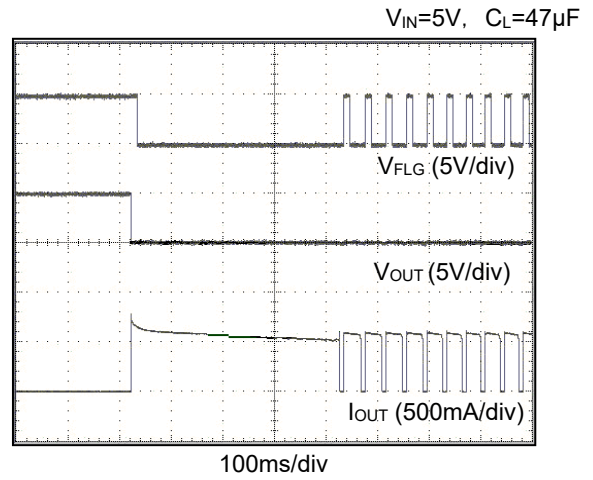


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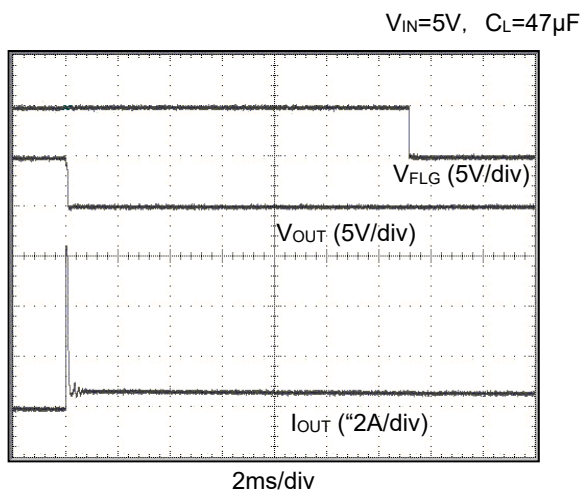
**23) Current Limit Transient Response**  
(Case: Enable to Short)



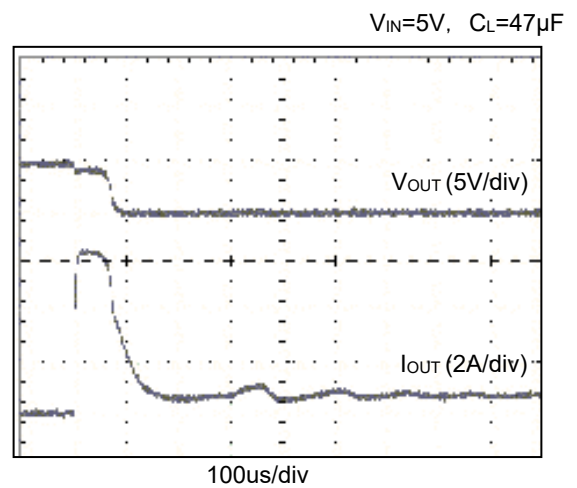
**24) Thermal Shutdown Operation**



**25) Current Limit Transient Response**  
(Case: Output short during enable)



**26) Zoomed in 25)**



The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

**Measurement Conditions**

Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	φ 0.3 mm × 7 pcs

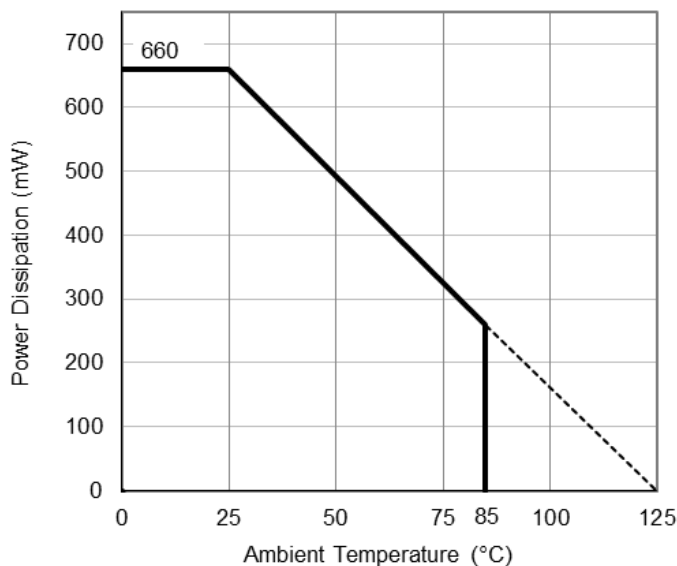
**Measurement Result**

(Ta = 25°C, Tjmax = 125°C)

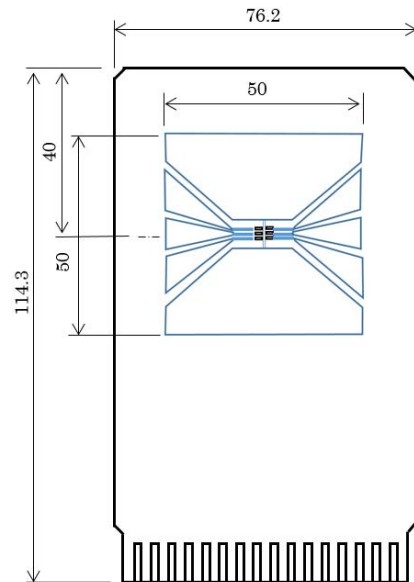
Item	Measurement Result
Power Dissipation	660 mW
Thermal Resistance (θja)	θja = 150°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 51°C/W

θja: Junction-to-Ambient Thermal Resistance

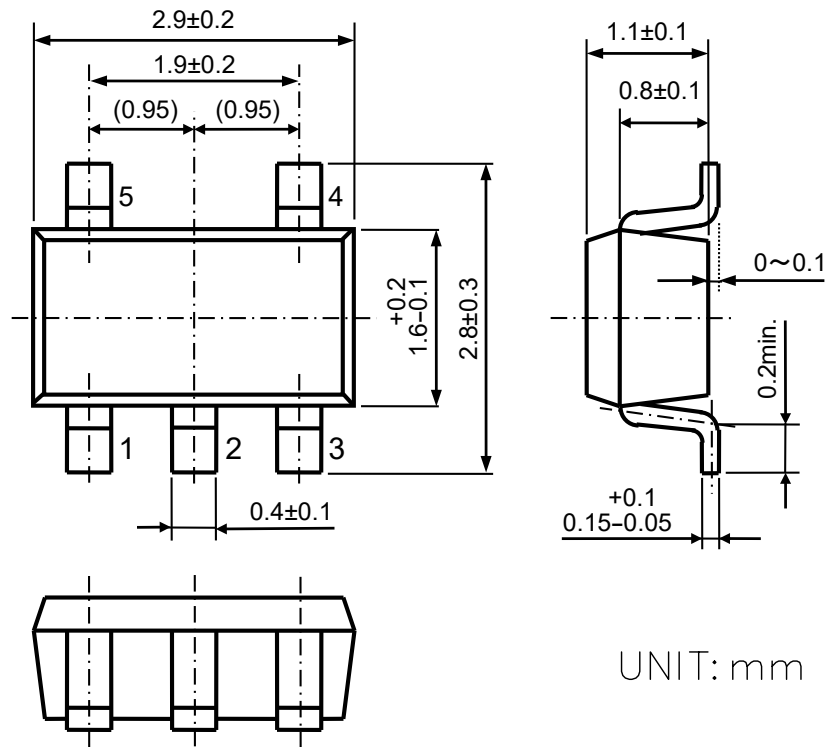
ψjt: Junction-to-Top Thermal Characterization Parameter



**Power Dissipation vs. Ambient Temperature**



**Measurement Board Pattern**



UNIT: mm

SOT-23-5 Package Dimensions



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7. Anti-radiation design is not implemented in the products described in this document.
8. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
9. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
10. There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact our sales or our distributor before attempting to use AOI.
11. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.



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