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R5523N SERIES

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.

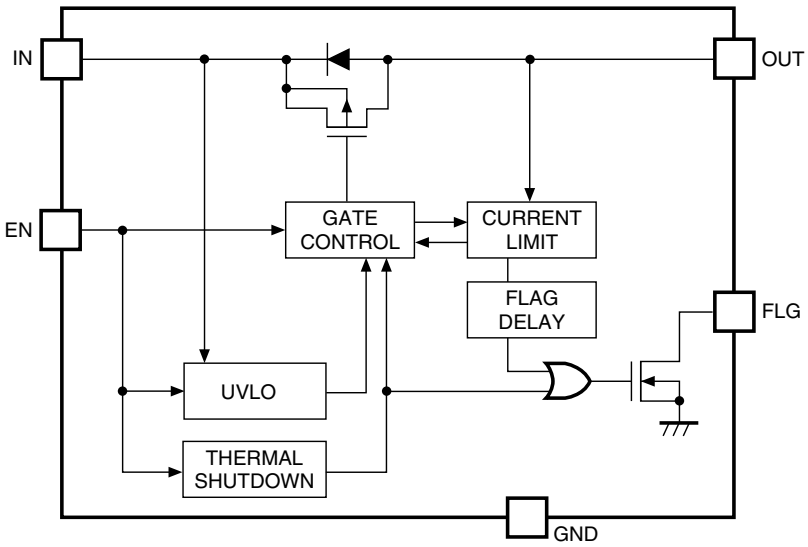
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5523N001∗-TR-FE	SOT-23-5	3,000 pcs	Yes	Yes

∗ : Designation of the logic of the enable pin.

(A) "L" active

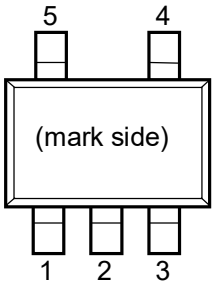
(B) "H" active

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(1) (SOT-23-5, JEDEC STD.51-7)	660	mW
Tj	Junction Temperature Range	−40 to 125	°C
Tstg	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
Ta	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.

(2) Refer to *POWER DISSIPATION* for detailed information.

ELECTRICAL CHARACTERISTICS

R5523N001A/B Electrical Characteristics **(Ta = 25°C)**

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

(1) EN="L"(R5523NxxxA)、EN="H"(R5523NxxxB)

(2) EN="H"(R5523NxxxA)、EN="L"(R5523NxxxB)

(3) Refer to "*Overcurrent Detection and Overcurrent limit*" in THEORY OF OPERATION for details.

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°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°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.

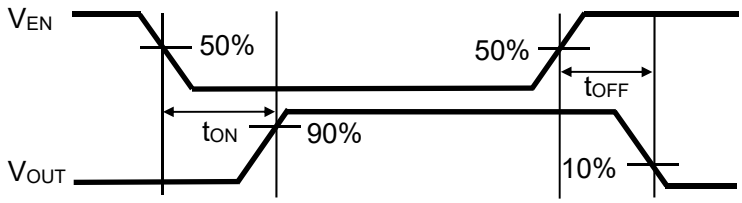
- FLG pin is Nch Open drain output. If the over-current or over-temperature is detected, FLG becomes "L". If over-current is detected, FLG becomes "L" after the flag delay time t_{FD} passes. Therefore flag signal is not out with inrush current.

- 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.

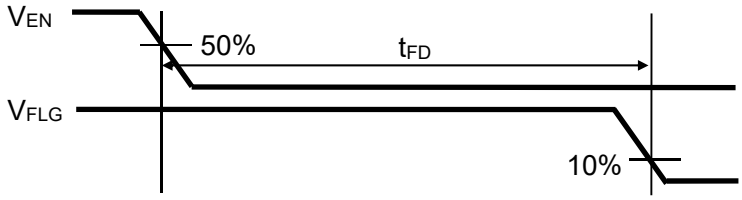
Timing Chart

R5523N001A

Output On time/ Output Off time

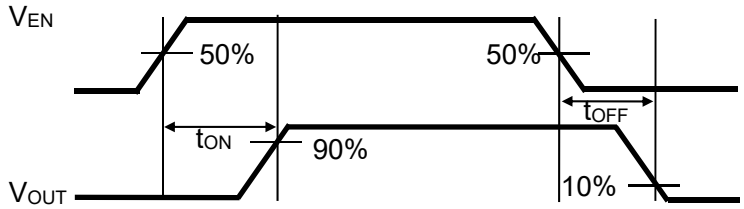


FLG Output Delay Time

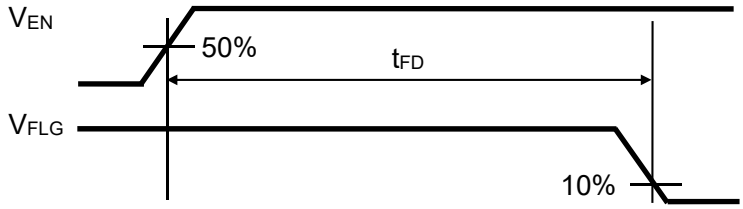


R5523N001B

Output On time/ Output Off time



FLG Output Delay Time



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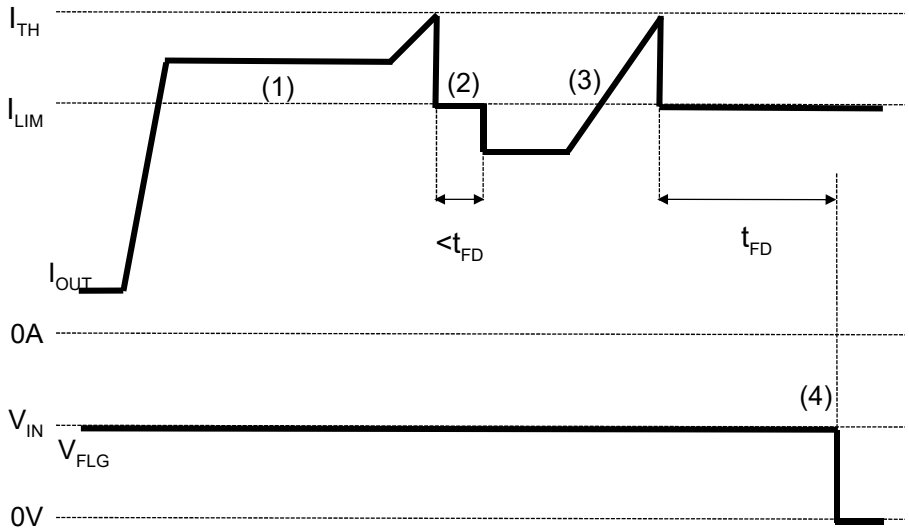
Overcurrent Detection and Overcurrent Limit



R5523N001A / R5523N001B Overcurrent Detection and Overcurrent limit Timing Chart

(1) When the I_{OUT} is I_{TH} or less, the current is not limited.

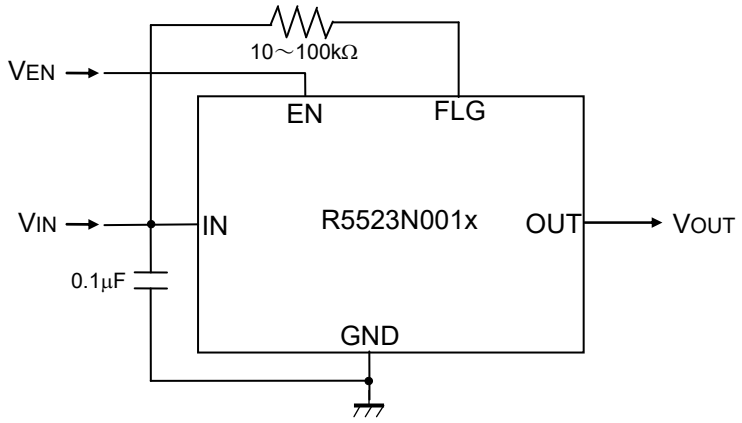
(2) Once the I_{OUT} reaches to I_{TH}, the I_{OUT} is limited by I_{LIM}.

(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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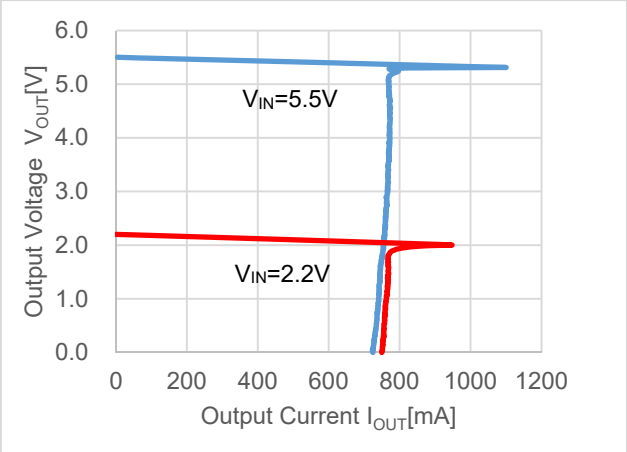
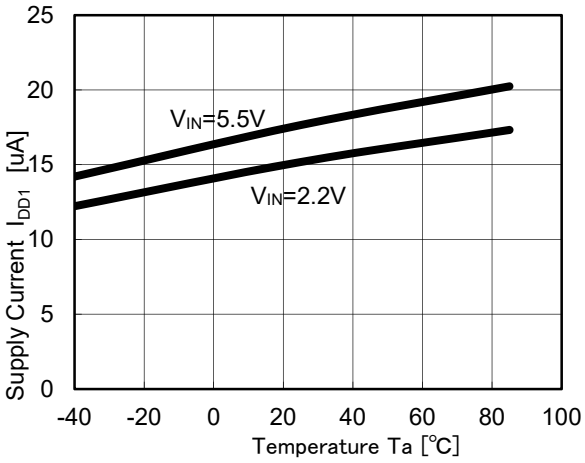
TYPICAL CHARACTERISTICS

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

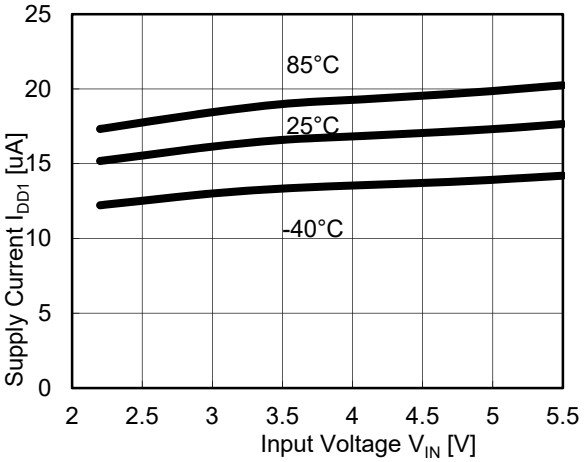
1) Output Voltage vs. Output Current



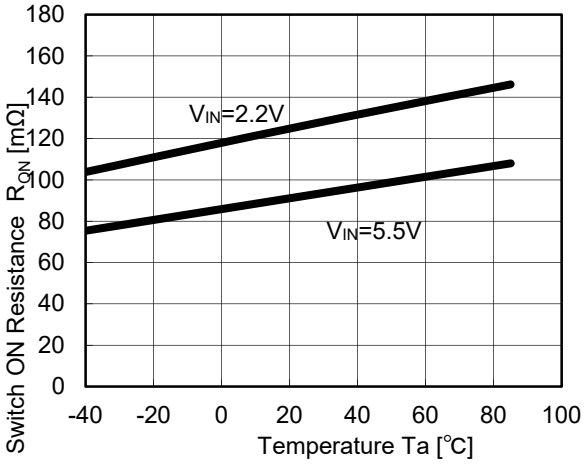
2) Supply Current vs. Temperature



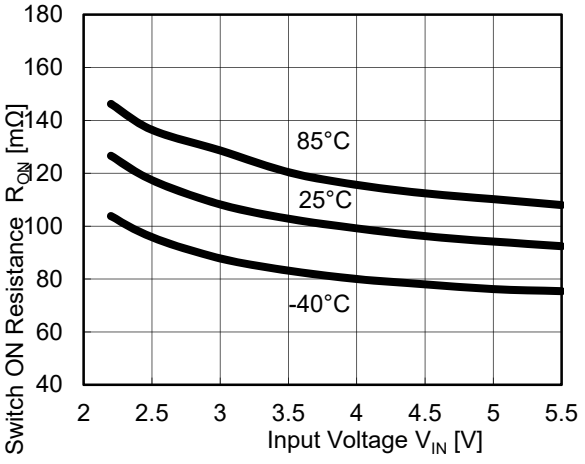
3) Supply Current vs. Input Voltage



4) On Resistance vs. Temperature



5) On Resistance vs. Input Voltage



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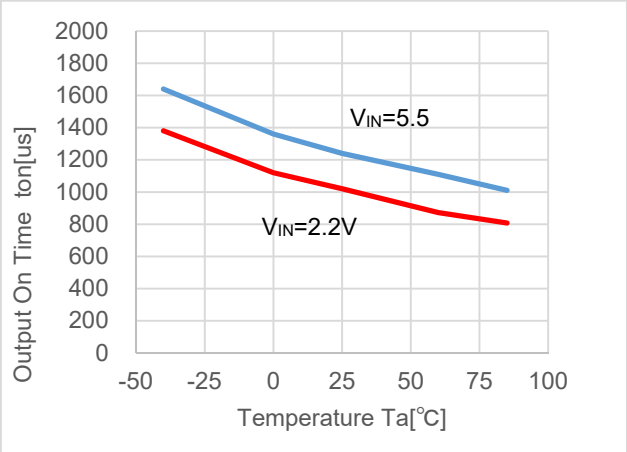
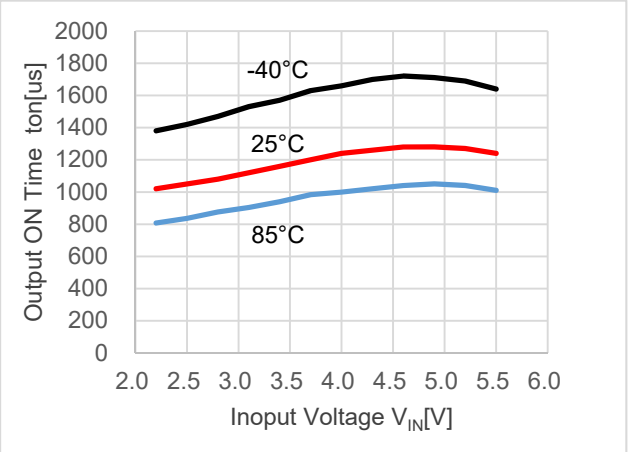
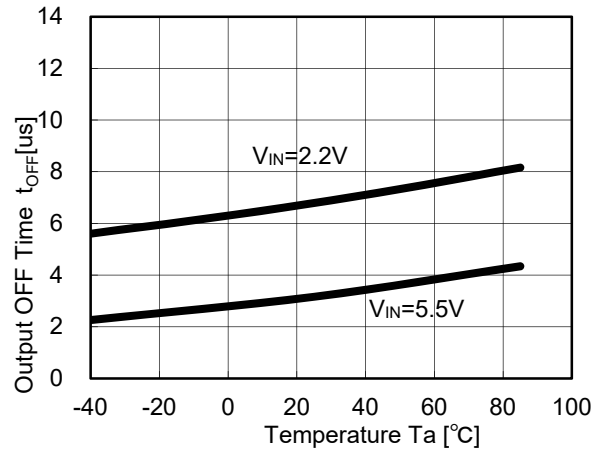
6) Output On Time vs. Temperature



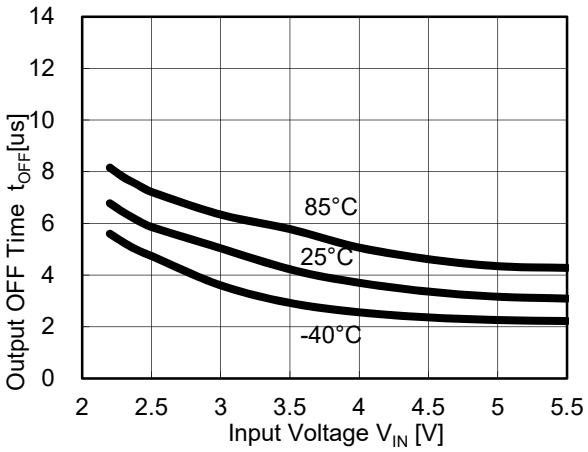
7) Output On Time vs. Input Voltage



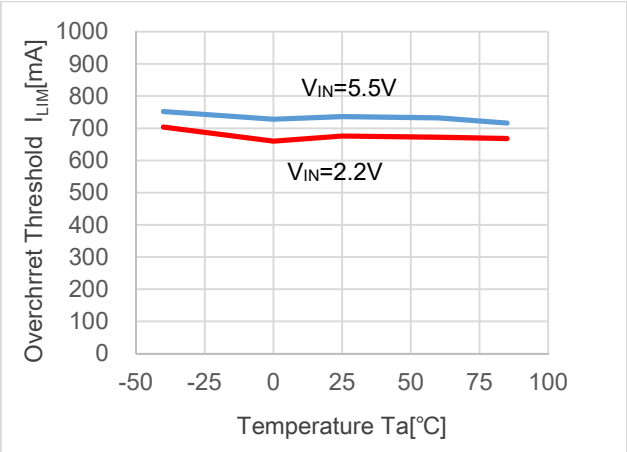
8) Output Off Time vs. Temperature



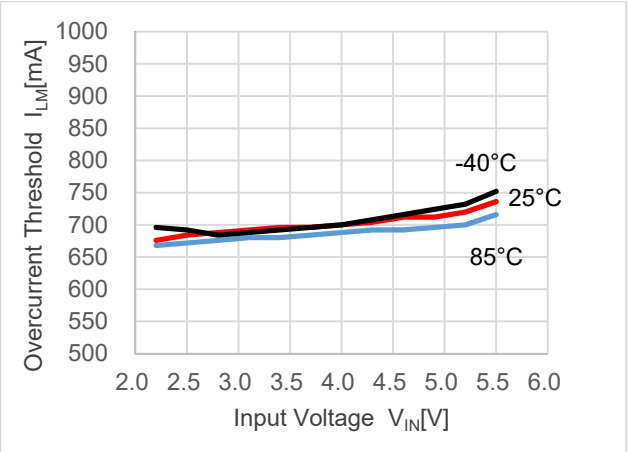
9) Output Off Time vs. Input Voltage



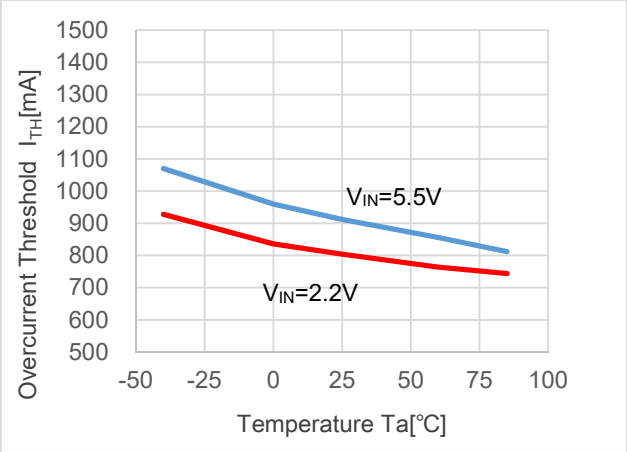
10) Overcurrent Threshold vs. Temperature



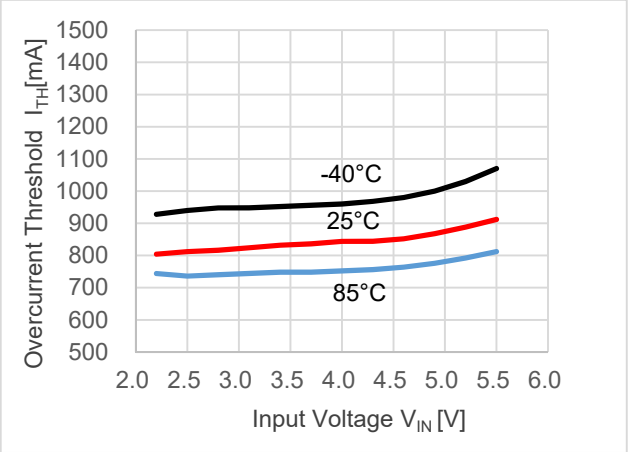
11) Overcurrent Threshold vs. Input Voltage



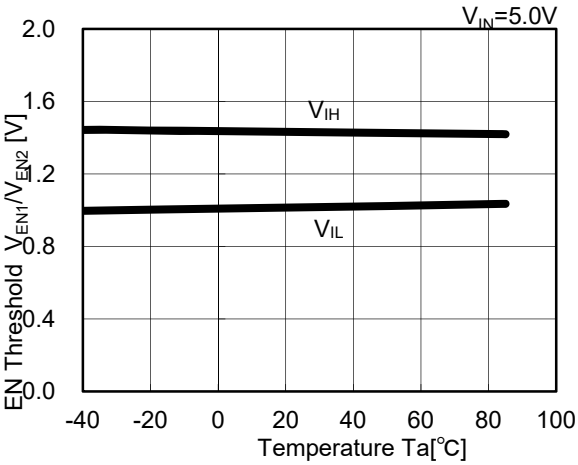
12) Overcurrent Threshold vs. Temperature



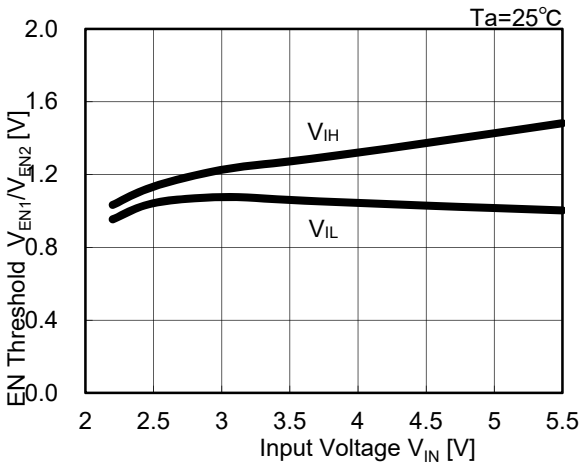
13) Overcurrent Threshold vs. Input Voltage



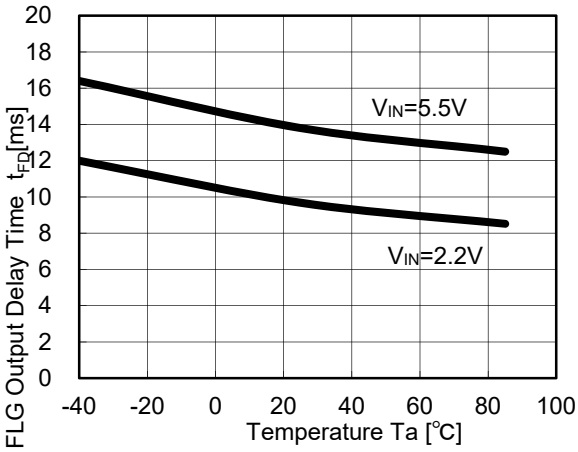
14) Enable Input Voltage vs. Temperature



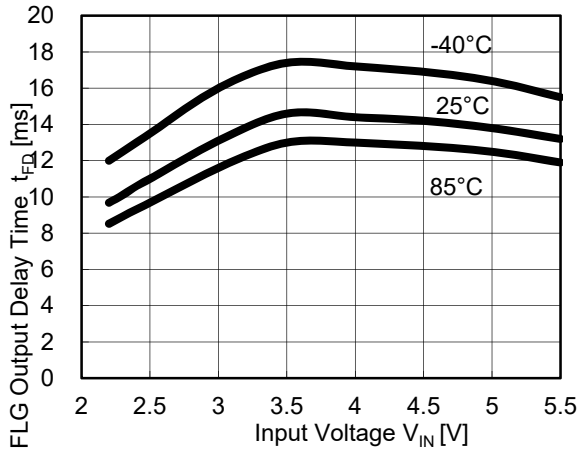
15) Enable Input Voltage vs. V_{IN} Input Voltage



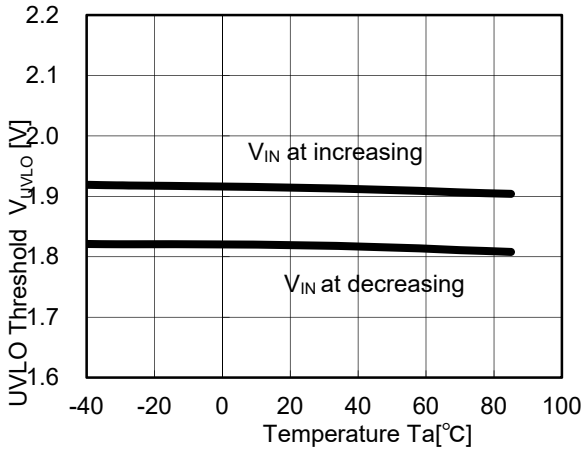
16) Flag Output Delay Time vs. Temperature



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

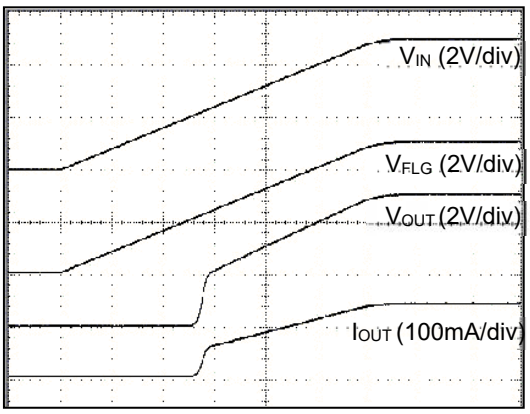


18） UVLO Threshold vs. Temperature



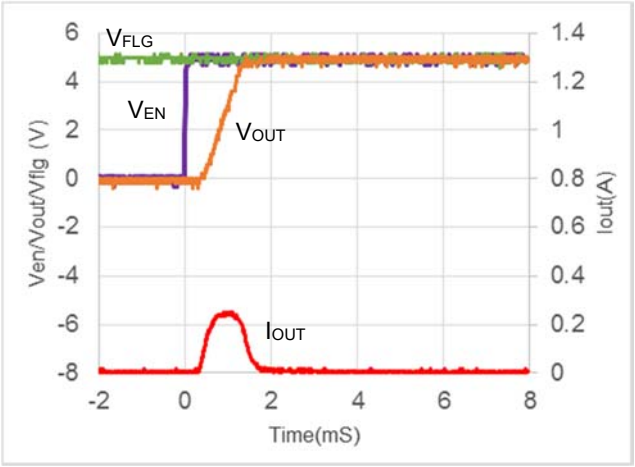
19） UVLO Characteristic at V_{IN} increasing

V_{EN}=0V, C_L=47μF, R_L=35Ω



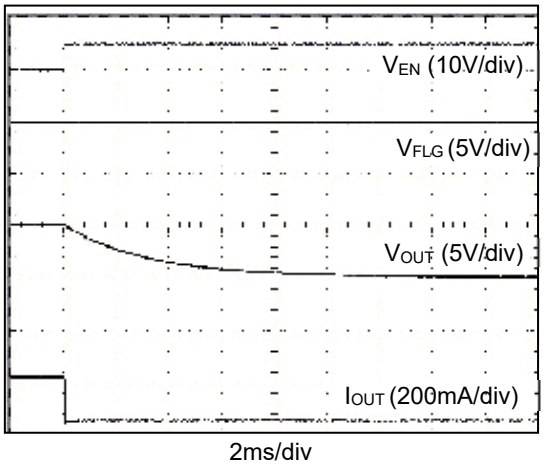
20） Turn on Response

V_{IN}=5V, C_L=47μF, R_L=35Ω



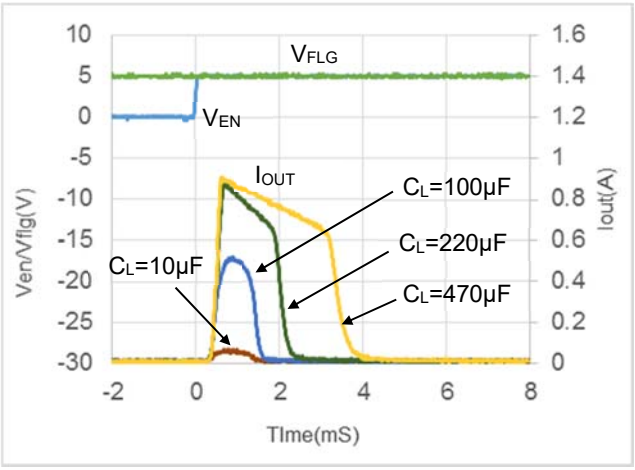
21） Turn Off Response

V_{IN}=5V, C_L=47μF, R_L=35Ω



22） Inrush Current

V_{IN}=5V, R_L=35Ω



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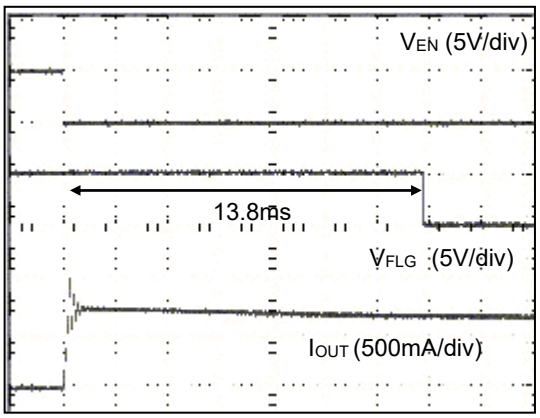
23） Current Limit Transient Response
(Case: Enable to Short)

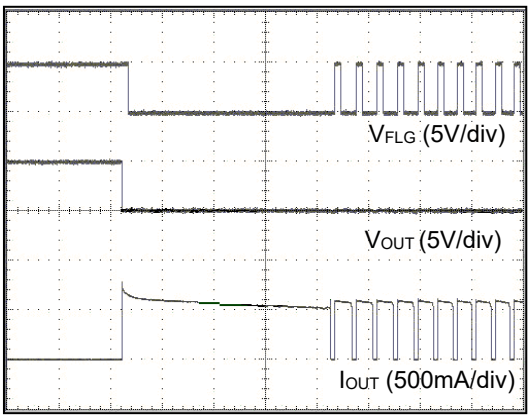
V_{IN}=5V



2ms/div

24） Thermal Shutdown Operation

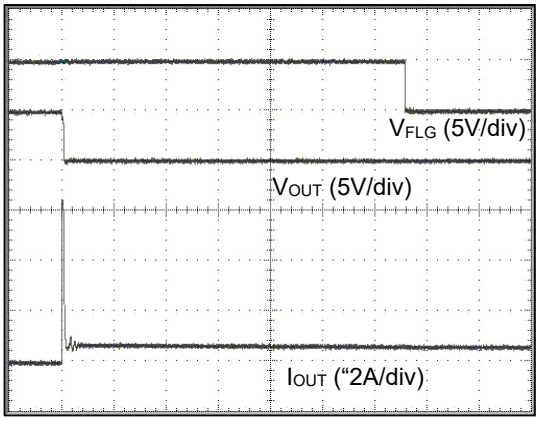
V_{IN}=5V, C_L=47µF



100ms/div

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

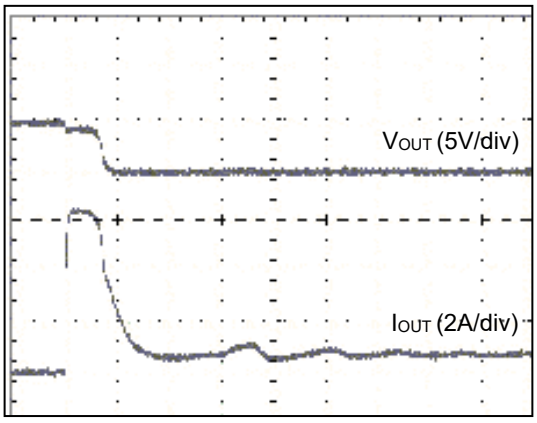
V_{IN}=5V, C_L=47µF



2ms/div

26） Zoomed in 25)

V_{IN}=5V, C_L=47µF



100us/div

Ver. A

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

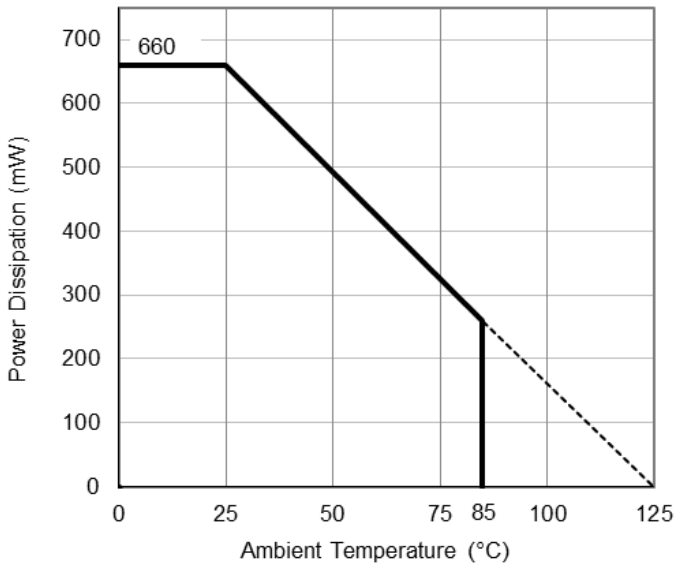
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx.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

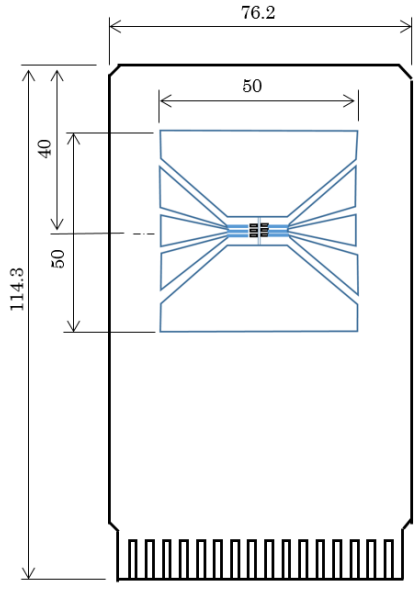
Item	Measurement Result
Power Dissipation	660 mW
Thermal Resistance (θja)	θja = 150°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 51°C/W

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

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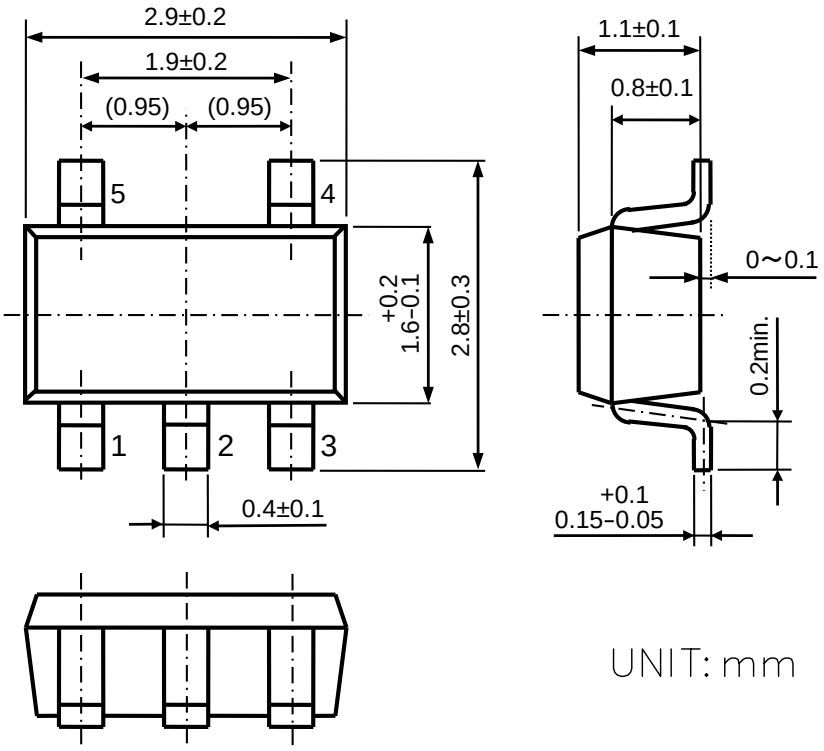

SOT-23-5 Package Dimensions

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