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# R5523N SERIES

## USB HIGH-SIDE POWER SWITCH

NO.EA-168-120921

## OUTLINE

The R5523N Series is CMOS-based 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.

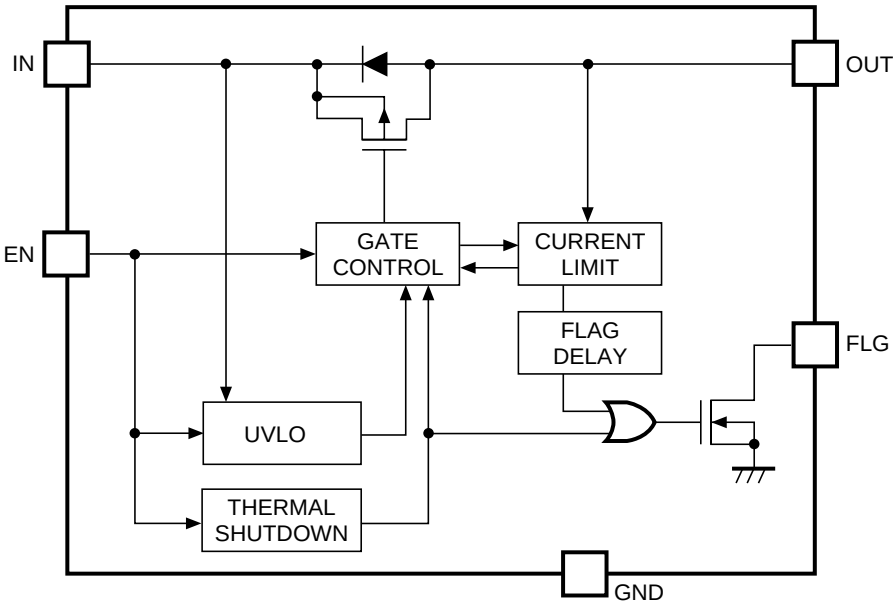
## FEATURES

- 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

## BLOCK DIAGRAM




## SELECTION GUIDE

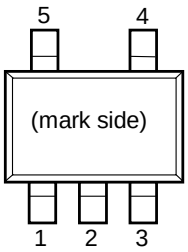
The logic of the enable pin for the ICs can be selected at the user's request.

| 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

## PIN CONFIGURATIONS

● **SOT-23-5**




## PIN DESCRIPTION

| Pin No | Symbol | Pin Description |
|---|---|---|
| 1 | EN | Enable Pin |
| 2 | GND | Ground Pin |
| 3 | FLG | FLG pin (Open Drain Output) |
| 4 | $V_{IN}$ | Power Supply Pin |
| 5 | $V_{OUT}$ | Output Pin |

## 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 (SOT-23-5) *Note1 | 420 | mW |
| Topt | Operating Temperature | −40 to +85 | °C |
| Tstg | Storage Temperature | −55 to +125 | °C |

*Note1) For Power Dissipation please refer to PACKAGE INFORMATION to be described.

**ABSOLUTE MAXIMUM RATINGS**

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the life time 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.

# POWER DISSIPATION (SOT-23-5)

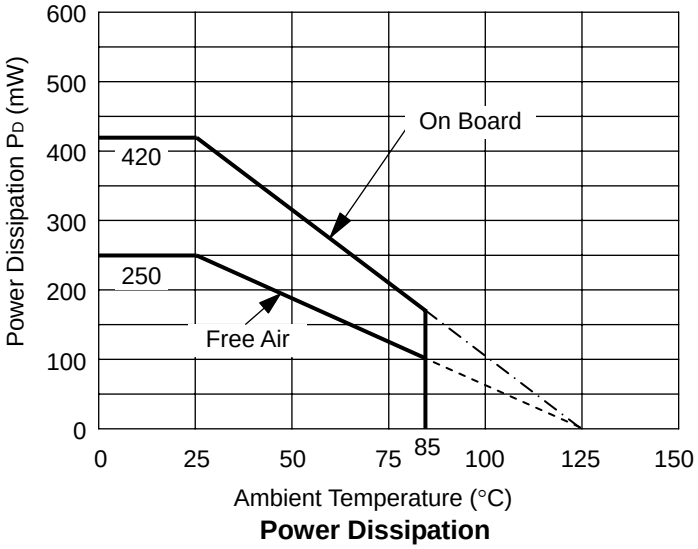
This specification is at mounted on board. Power Dissipation ($P_D$) depends on conditions of mounting on board. This specification is based on the measurement at the condition below:
(Power Dissipation (SOT-23-5) is substitution of SOT-23-6.)

Measurement Conditions

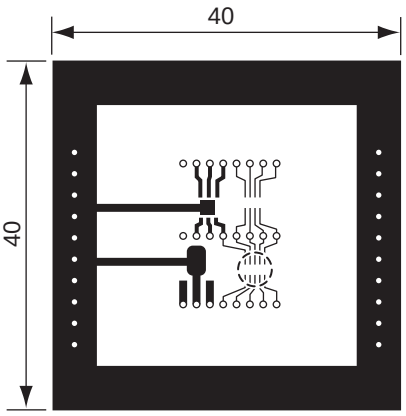
| | Standard Land Pattern |
|---|---|
| Environment | Mounting on Board (Wind velocity=0m/s) |
| Board Material | Glass cloth epoxy plastic (Double sided) |
| Board Dimensions | 40mm × 40mm × 1.6mm |
| Copper Ratio | Top side : Approx. 50% , Back side : Approx. 50% |
| Through-holes | ϕ0.5mm × 44pcs |

Measurement Results (Topt=25°C, Tjmax=125°C)

| | Standard Land Pattern | Free Air |
|---|---|---|
| Power Dissipation | 420mW | 250mW |
| Thermal Resistance | θja=(125−25°C)/0.42W=238°C/W | 400°C/W |



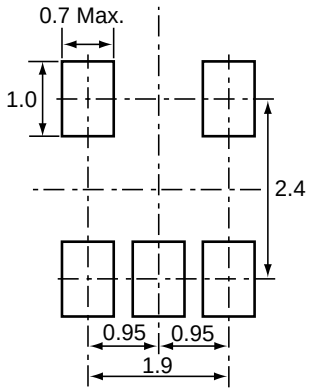

**Power Dissipation**




**Measurement Board Pattern**

IC Mount Area (Unit: mm)

## RECOMMENDED LAND PATTERN




(Unit: mm)



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# ELECTRICAL CHARACTERISTICS

- **R5523N001A/B**

(Topt=25°C)

| Symbol | Item | Conditions | MIN. | TYP. | MAX. | Unit |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Input Voltage | | 2.2 | | 5.5 | V |
| $I_{DD1}$ | 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 | $V_{IN}$=increasing | 1.6 | 1.9 | | V |
| $V_{HYS}$ | UVLO Hysteresis Range | $V_{IN}$=decreasing | | 0.1 | | V |
| $I_{TH}$ | Current Limit Threshold | | | 1.0 | 1.5 | A |
| Ilim | Short Current Limit | $V_{IN}$=5V,<br>5ms after $V_{OUT}$=0V | 0.5 | 0.75 | 1.3 | A |
| $t_{FD}$ | Over Current Flag Delay | $V_{IN}$=5V,<br>From Over Current to FLG= "L" | 5 | 10 | 20 | ms |
| $T_{TS}$ | Thermal Shutdown Temperature Threshold | TJ=increasing | | 135 | | °C |
| | | TJ=decreasing | | 120 | | °C |
| $I_{EN}$ | Enable Pin Input Current | | | 0.01 | 1.0 | µA |
| $V_{EN1}$ | Enable Pin Input Voltage 1 | $V_{EN}$=increasing | 2.0 | | | V |
| $V_{EN2}$ | Enable Pin Input Voltage 2 | $V_{EN}$=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)

**RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)**

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.

# 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.

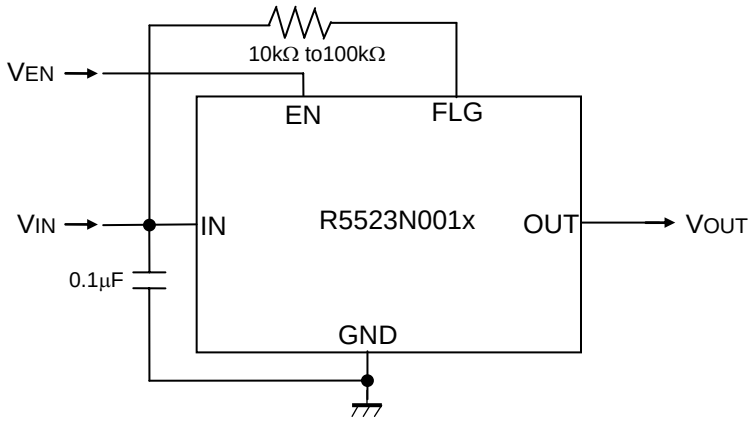
- FLG pin is Nch Open drain output. If the over-current or over-temperature is detected, FLG becomes "L". If over-current is detected, FLG becomes "L" after the flag delay time $t_{FD}$ passes. Therefore flag signal is not out with inrush current.

- 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.

# TYPICAL APPLICATION AND TECHNICAL NOTES

- **Bypass capacitor**
  - Put a capacitance range from 0.1µF to 1µF bypass capacitor between $V_{IN}$ pin and GND pin of the IC. Without a bypass capacitor, in case of output short, because of the high side inductance of $V_{IN}$ 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.




**R5523N001x Typical Application**

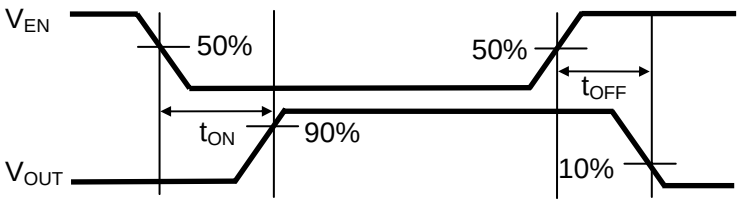
- **Over-current limit Function**

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 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.

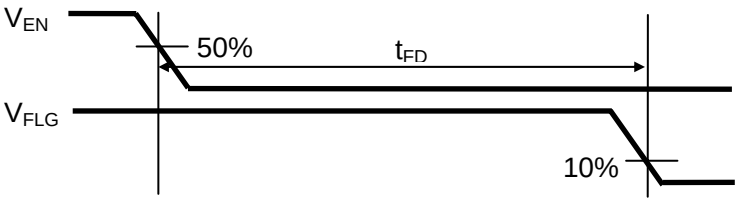
# TIMING CHART

- **R5523N001A**

Output On time/ Output Off time

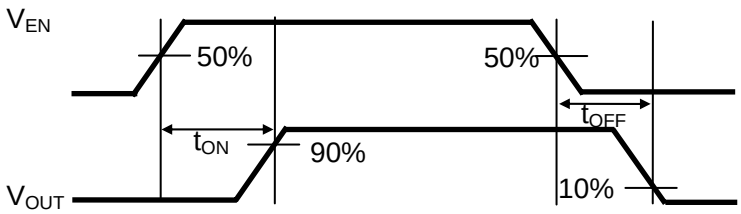



FLG Output Delay Time

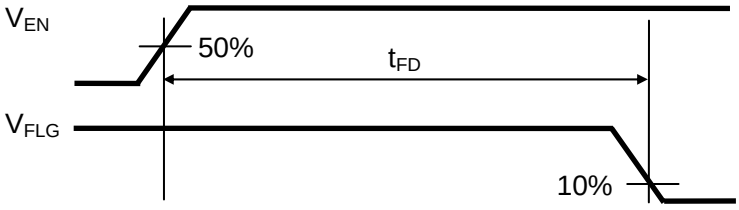



- **R5523N001B**

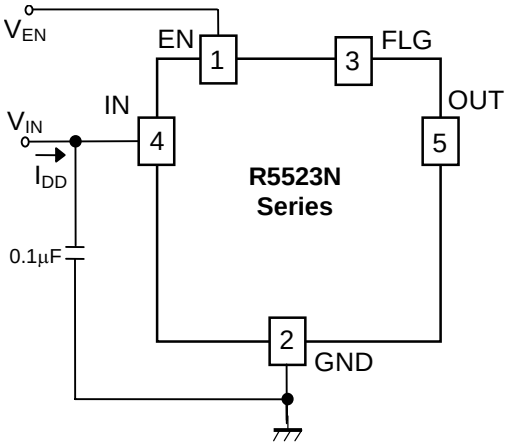
Output On time/ Output Off time



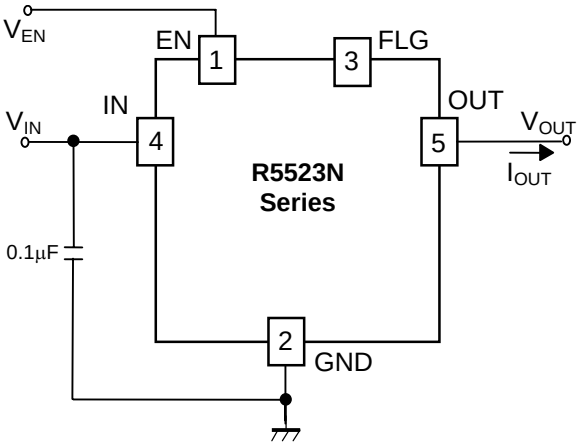

FLG Output Delay Time



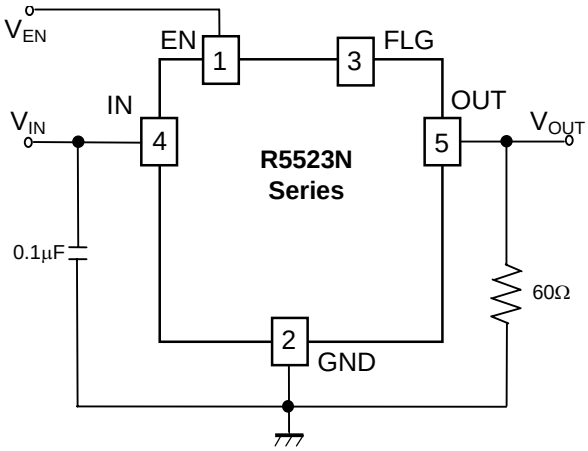
# TEST CIRCUITS



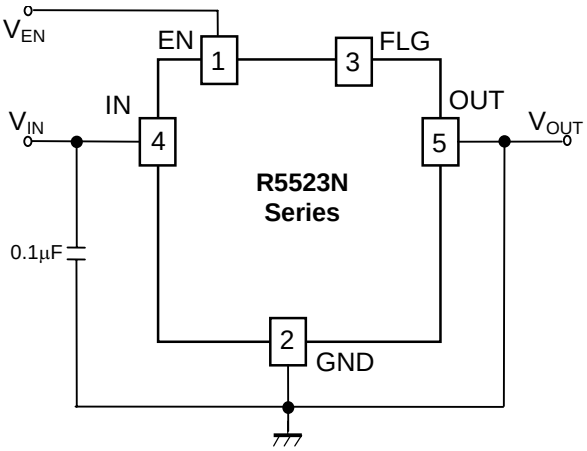

**Supply Current Test Circuit**



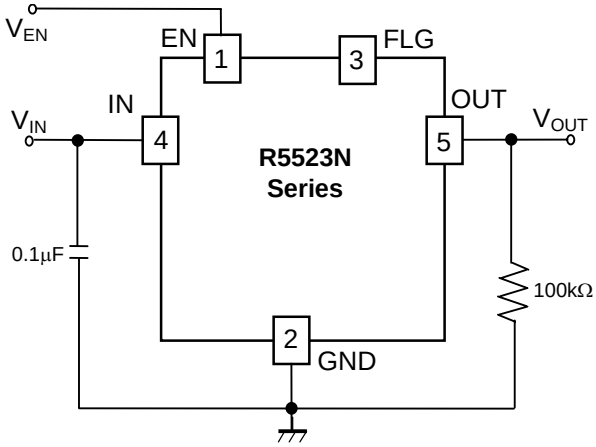

**Switch On Resistance**
**/ Over Current Limit Threshold Test Circuit**



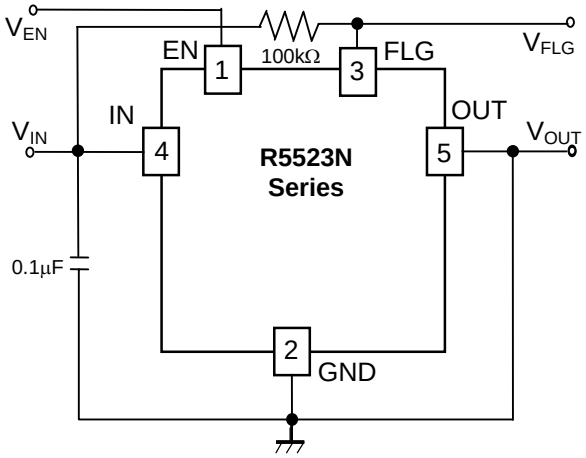

**Turn ON Speed/ Turn OFF Speed Test Circuit**




**Short Current Limit Test Circuit**



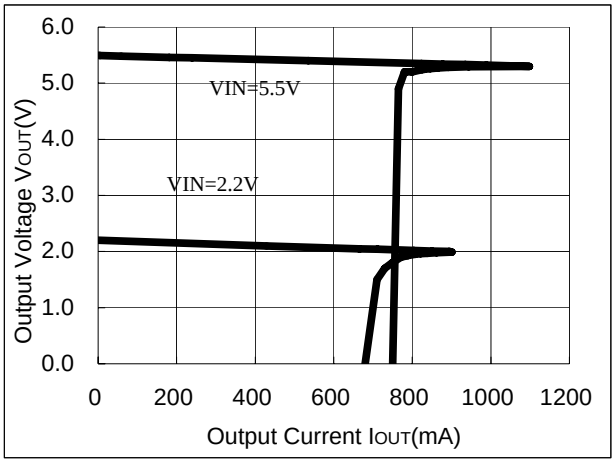

**Enable Input Voltage**
**/ UVLO Threshold Test Circuit**



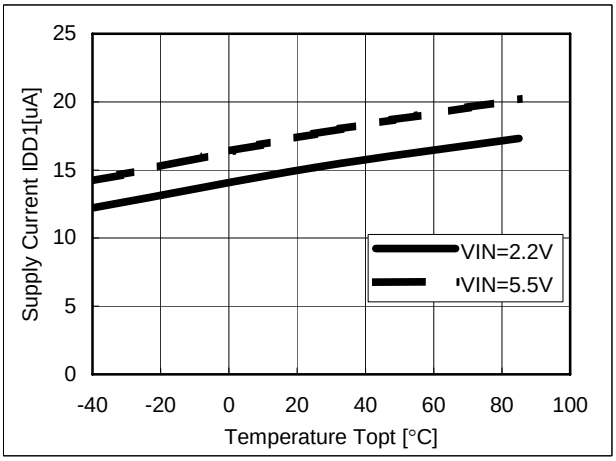

**FLG Delay Time Test Circuit**

# TYPICAL CHARACTERISTICS

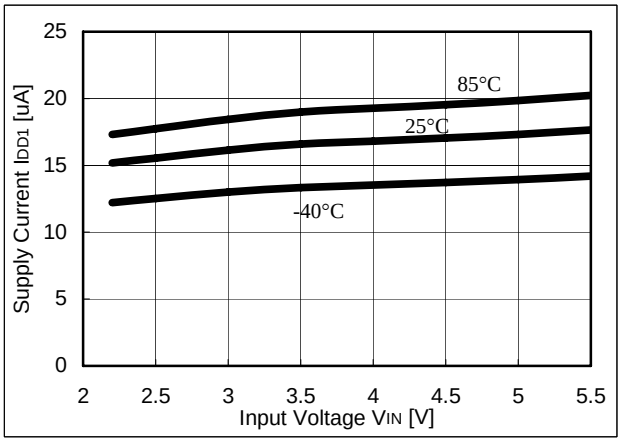
1) Output Voltage vs. Output Current



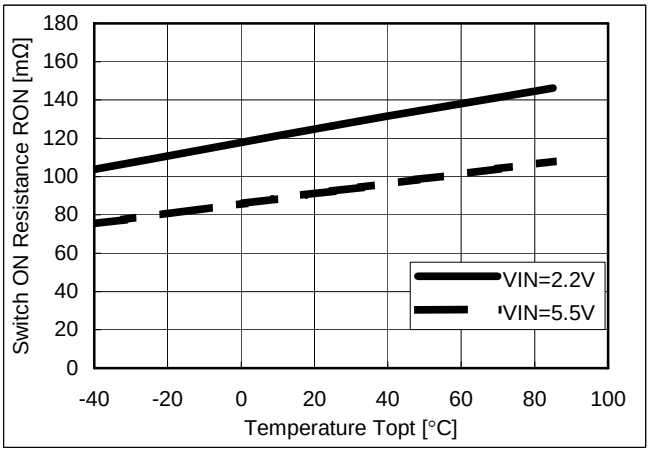

2) Supply Current vs. Temperature



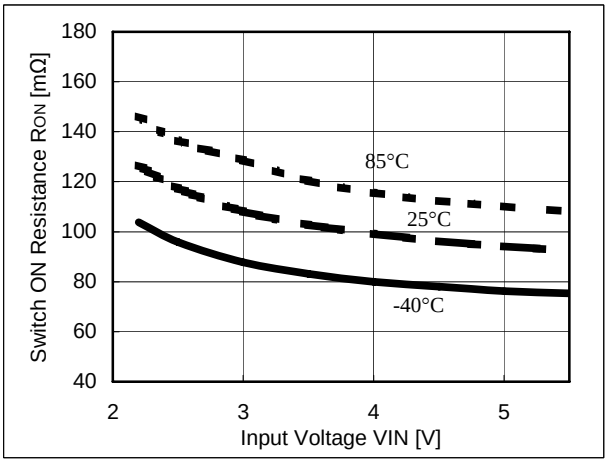

3) Supply Current vs. Input Voltage



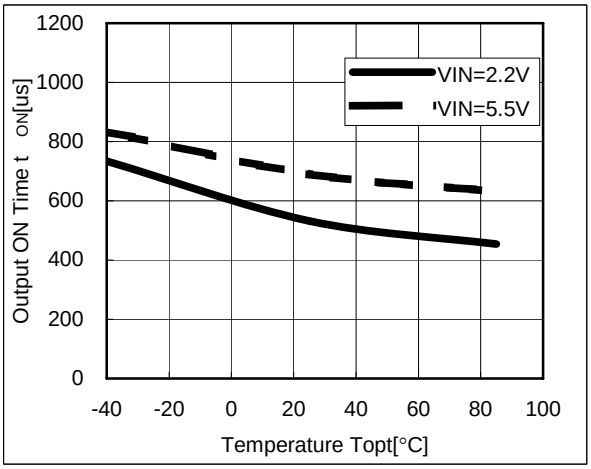

4) On Resistance vs. Temperature



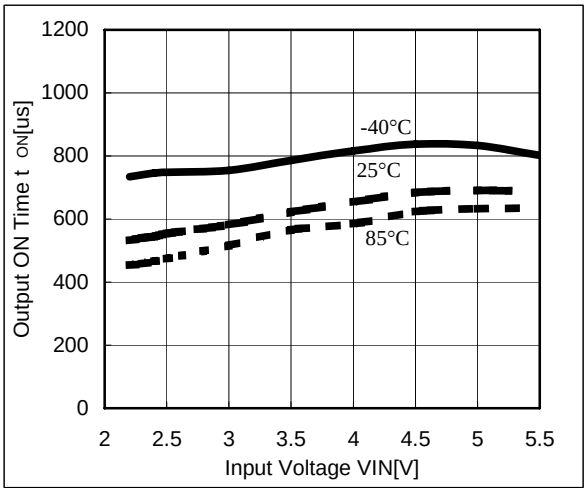

5) On Resistance vs. Input Voltage



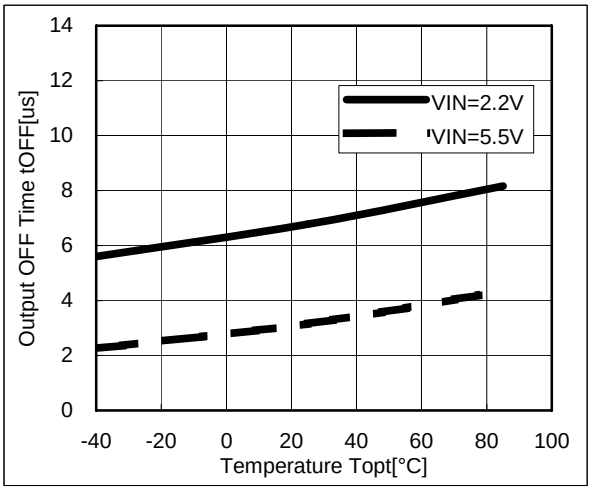

6) Output On Time vs. Temperature



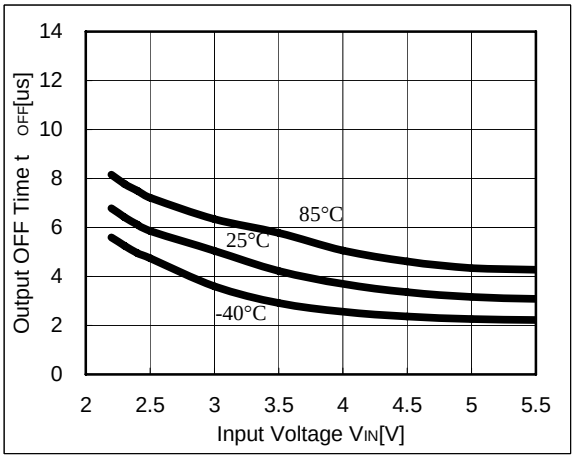
7) Output On Time vs. Input Voltage



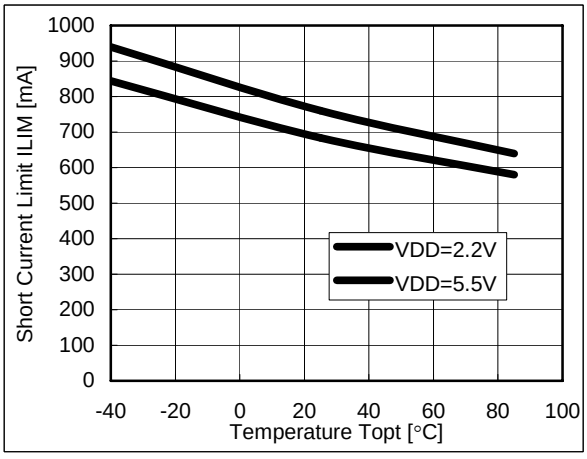

8) Output Off Time vs. Temperature



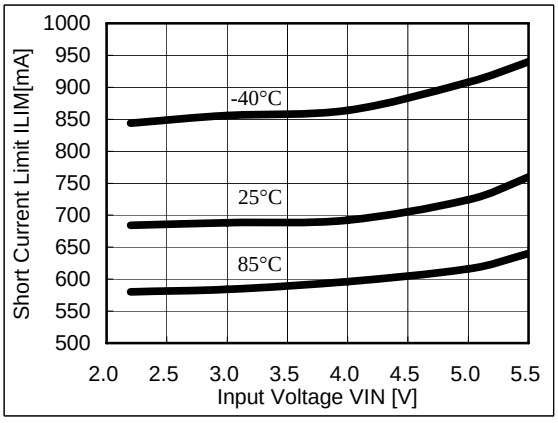

9) Output Off Time vs. Input Voltage



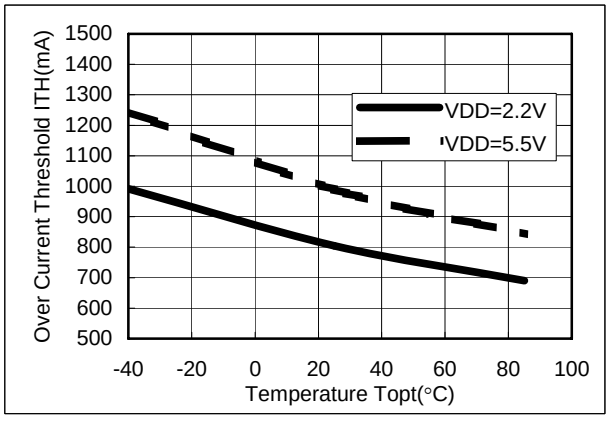

10) Short-current Limit vs. Temperature



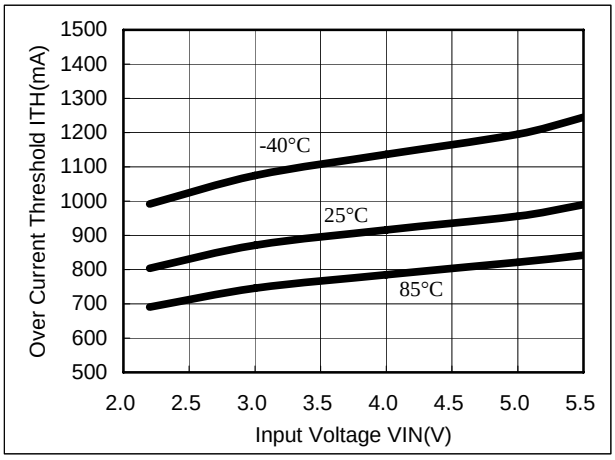

11) Short Current Limit vs. Input Voltage



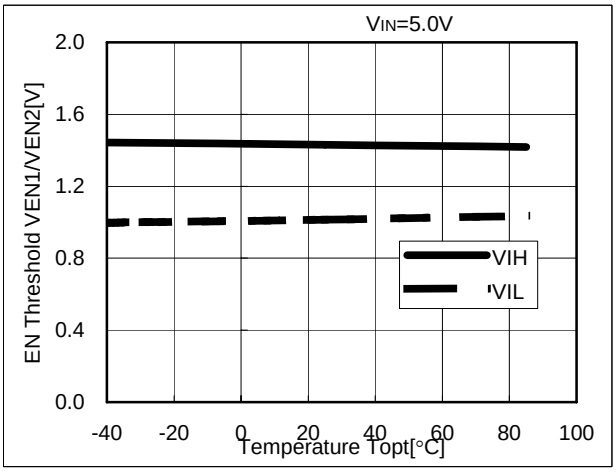

12) Over Current Threshold vs. Temperature



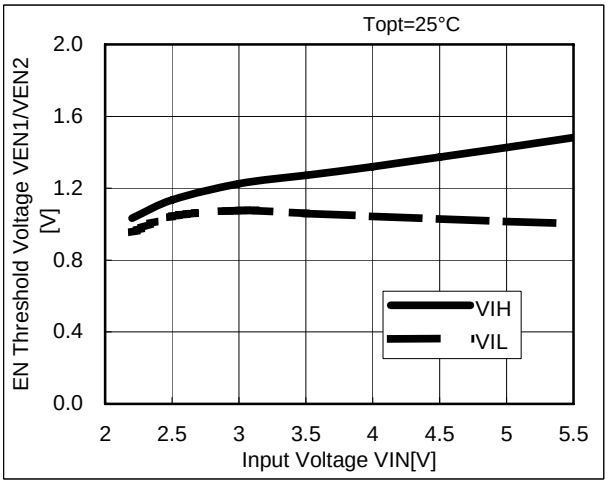
13) Over Current Threshold vs. Input Voltage



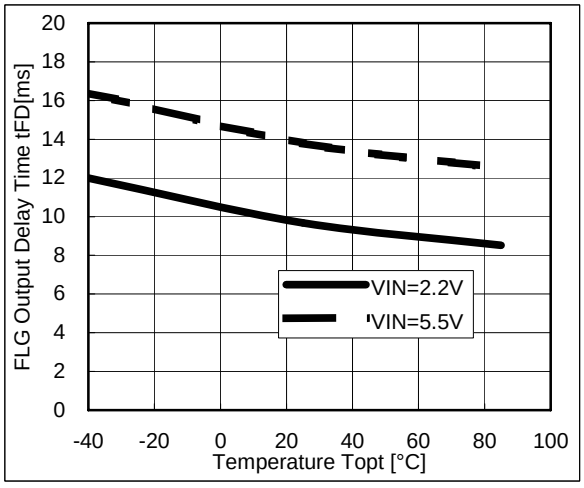

14) Enable Input Voltage vs. Temperature



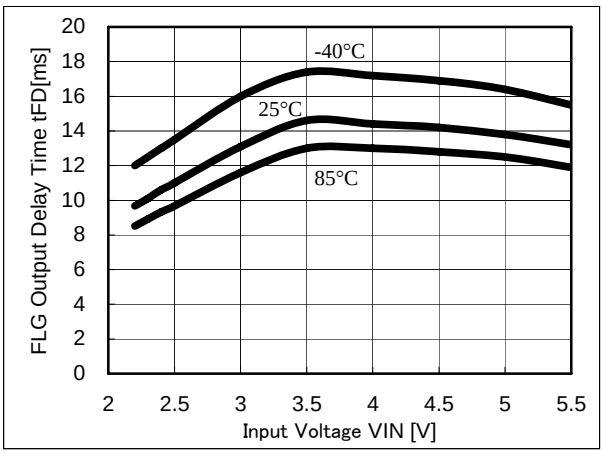

15) Enable Input Voltage vs. VIN Input Voltage



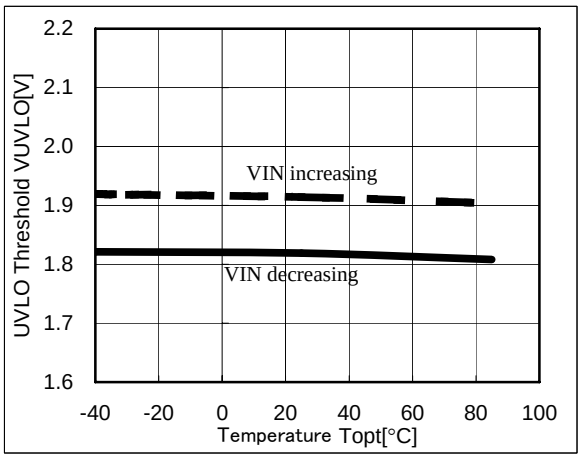

16) Flag Output Delay Time vs. Temperature




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

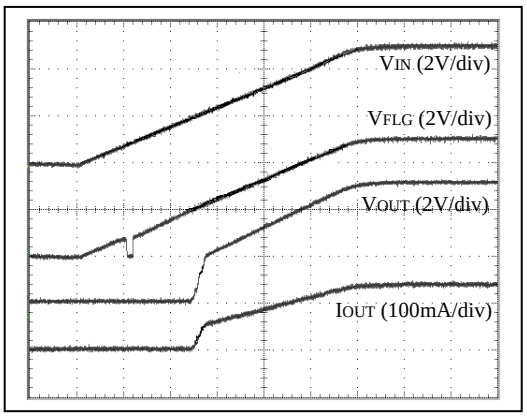



18) UVLO Threshold vs. Temperature



19) UVLO Characteristic at VIn increasing

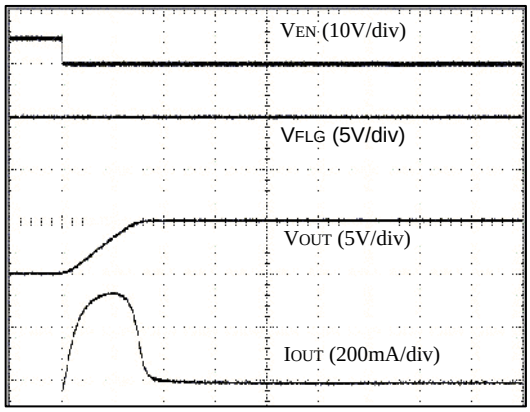
$V_{EN}$=0V,$C_L$=47µF,$R_L$=35Ω




4ms/div

20) Turn on Response

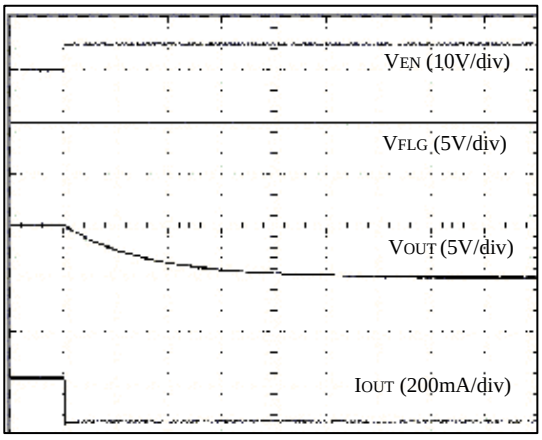
$V_{IN}$=5V,$C_L$=47µF,$R_L$=35Ω




1ms/div

21) Turn off Response

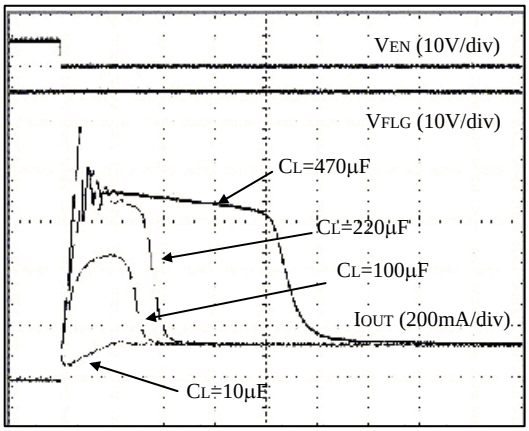
$V_{IN}$=5V,$C_L$=47µF,$R_L$=35Ω




2ms/div

22) Inrush current

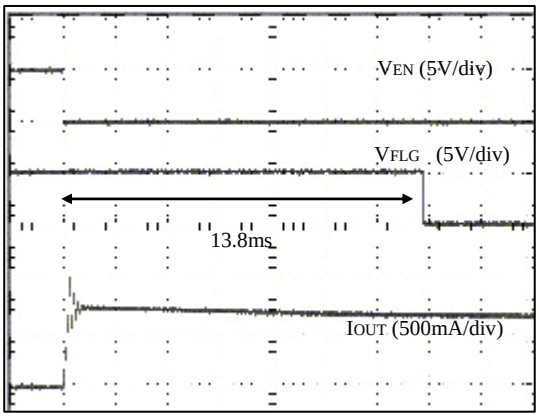
$V_{IN}$=5V, $R_L$=35Ω




1ms/div

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

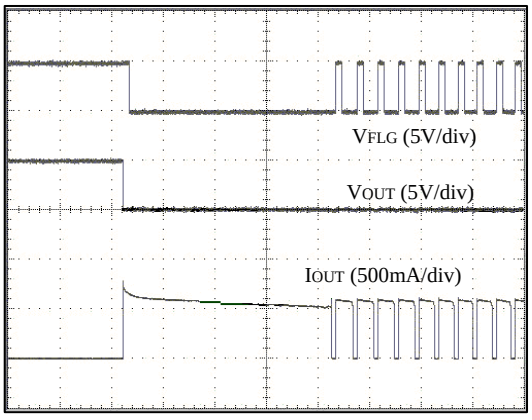
$V_{IN}$=5V




2ms/div

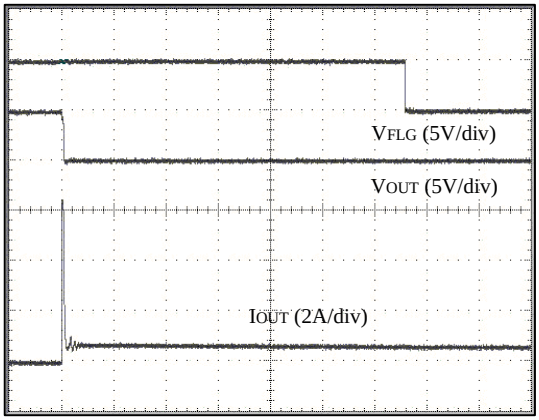
24) Thermal Shutdown Operation

$V_{IN}$=5V, $C_L$=47µF




100ms/div

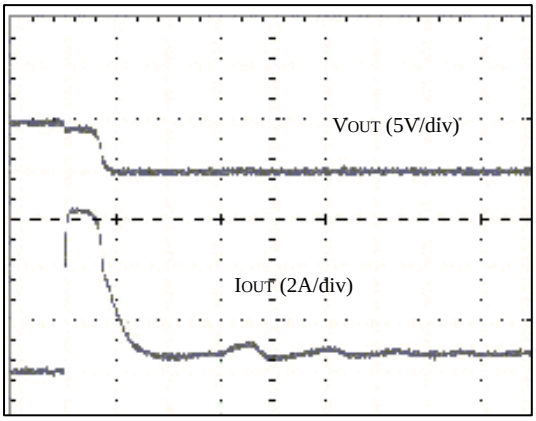
25) Current Limit Transient Response
(Case: Output short during enable)
$V_{IN}$=5V, $C_L$=47µF




2ms/div

26) Zoomed in 25)

$V_{IN}$=5V, $C_L$=47µF




100us/div

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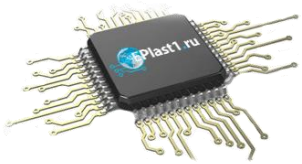


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