RICOH

R5524N SERIES

USB HIGH-SIDE POWER SWITCH

NO.EA-188-111212

OUTLINE

The R5524N series is CMOS-based high-side MOSFET switch ICs for Universal Serial Bus (USB) applications. Using Nch FET as a switching transistor, low ON resistance (Typ.100mΩ) and reverse current protection is possible.

An Over-current limit circuit, a thermal shutdown circuit, and an under voltage lockout circuit (UVLO) 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.

In order to support easy power-line design, the over-current level is highly accurate.

The R5524N 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

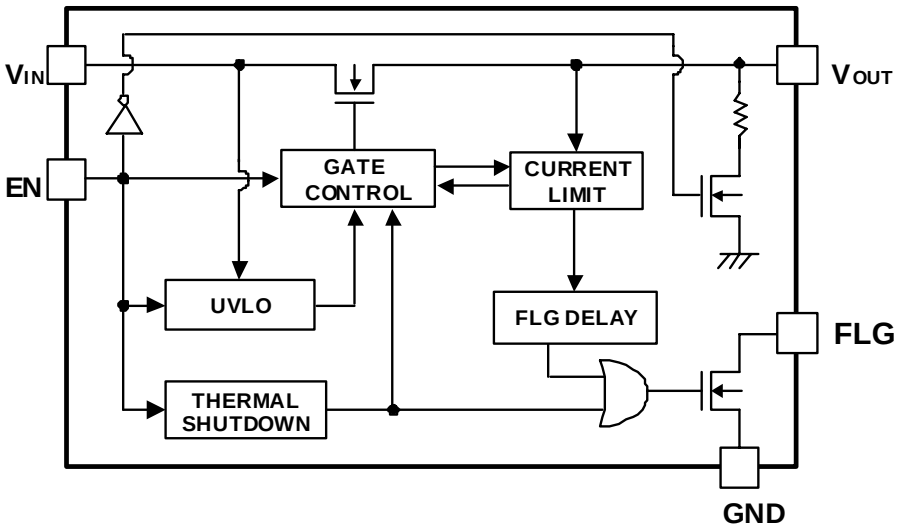
- N-channel MOS High-Side switch IC
- Switch ON Resistance .....Typ. 100mΩ (5V input)
- Current Limit Threshold .....Min. 650mA (001A/B, 002A/B), Min.1.25A (004A)
- Over-current Limit .....Min. 550mA
- Flag Delay Time .....Typ. 20ms.
- Built-in under-voltage lockout circuit (UVLO)
- Built-in Thermal Shutdown Circuit
- Built-in Reverse current protection circuit
- Package SOT-23-5
- Built-in Soft-start Function

APPLICATIONS

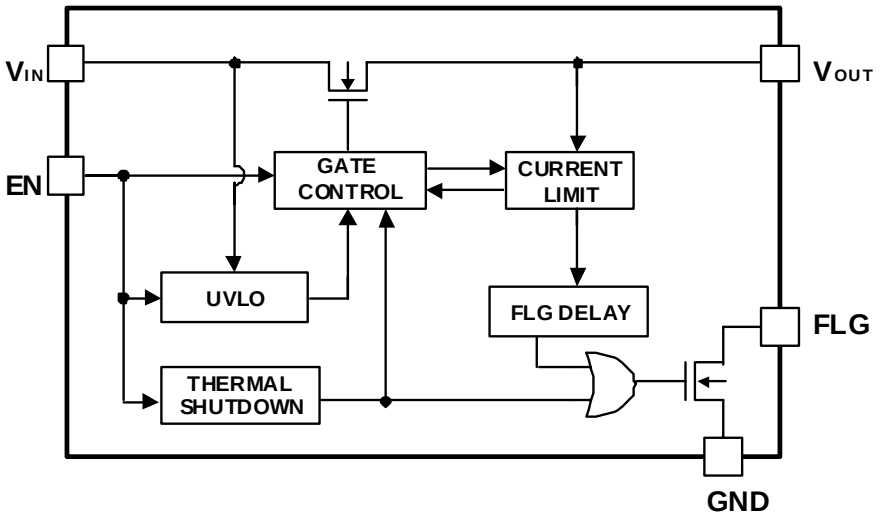
- PCs and PC peripherals
- Digital Televisions (DTV)
- Set Top Boxes (STB)
- Printers
- PDA
- Game Consoles

BLOCK DIAGRAM

R5524NxxxA



R5524NxxxB



SELECTION GUIDE

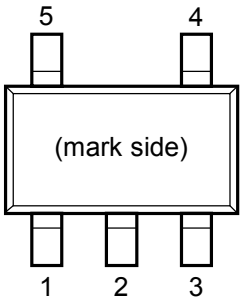
The over-current limit protection type,the Current Limit Threshold and the auto discharge function for the ICs can be selected at the user's request.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5524N00x∗-TR-FE	SOT-23-5	3,000 pcs	Yes	Yes

x : Select the combination of the over-current limit protection type and Current Limit Threshold.
1 : Latch Off Type（Current Limit Threshold Min.650mA）
2 : Constant Current Type（Current Limit Threshold Min.650mA）
4 : Constant Current Type（Current Limit Threshold Min.1.25A）（B Version for R5524N004 is not available.）
∗ : Auto discharge function at off state are options as follows.
(A) with auto discharge function at off state
(B) without auto discharge function at off state

PIN CONFIGURATIONS

● **SOT-23-5**



PIN DESCRIPTION

Pin No	Symbol	Pin Description
1	V_{IN}	Input Pin
2	GND	Ground Pin
3	EN	Enable Pin ("H" active)
4	FLG	FLG pin (Open Drain Output)
5	V_{OUT}	Output Pin

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	6.0	V
V_{EN}	Enable Pin Input Voltage	−0.3 to 6.0	V
V_{FLG}	Flag Voltage	−0.3 to 6.0	V
I_{FLG}	Flag Current	14	mA
V_{OUT}	Output Voltage	−0.3 to 6.0	V
I_{OUT}	Output Current	Internal Limited	
P_D	Power Dissipation (SOT-23-5) *	420	mW
Topt	Operating Temperature	−40 to 85	°C
Tstg	Storage Temperature	−55 to 125	°C

*) 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.

ELECTRICAL CHARACTERISTICS

- **R5524N**

Topt=25°C

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{IN}	Input Voltage			2.7		5.5	V
I_{DD1}	Supply Current (Active Mode)	V_{OUT}=OPEN,EN="H",V_{IN}=5V			110	180	μA
I_{DD2}	Supply Current (Standby Mode)	V_{OUT}=OPEN,EN="L",V_{IN}=5V			0.1	1.0	μA
R_{ON}	Switch On Resistance	V_{IN}=5V, I_{OUT}=500mA			100	150	mΩ
ton	Output Turn-on Delay	V_{IN}=5V, R_L=60Ω			400		μs
toff	Output Turn-off Delay	V_{IN}=5V, R_L=60Ω			50		μs
V_{UVLO}	UVLO Released Voltage	V_{IN}=increasing		2.3	2.5	2.7	V
V_{HYS}	UVLO Hysteresis Range	V_{IN}=decreasing			0.1		V
I_{TH}	Current Limit Threshold	001A/001B 002A/002B	V_{IN}=5V	650	800	980	mA
		004A	V_{IN}=5V	1.25	1.55	1.85	A
			V_{IN}=5V,Topt=0 ~ 70°C	1.2	1.55	1.9	
I_{LIM}		V_{IN}=5V, 5ms after V_{OUT}=0V		550	650	800	mA
t_{FD}	Flag Delay Time*1	V_{IN}=5V, From Over Current to FLG="L"		7	20	30	ms
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature			135		°C
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature			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		6.0	V
V_{EN2}	Enable Pin Input Voltage 2	V_{EN}=decreasing		-0.3		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
I_{REV}	Reverse Leakage Current	V_{IN}=0V, V_{OUT}=5.5V				50	μA
R_{LOW}	Nch. On Resistance for Auto Discharge (A Version)				450		Ω

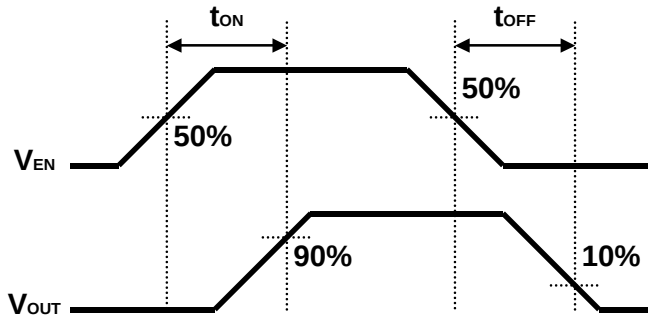
*1) Flag delay time depends on input voltage.
The specification in [ ] is checked and guaranteed by design engineering.
All of unit are tested and specified under load conditions such that Tj≈Topt=25°C except for Thermal Shutdown item.

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.

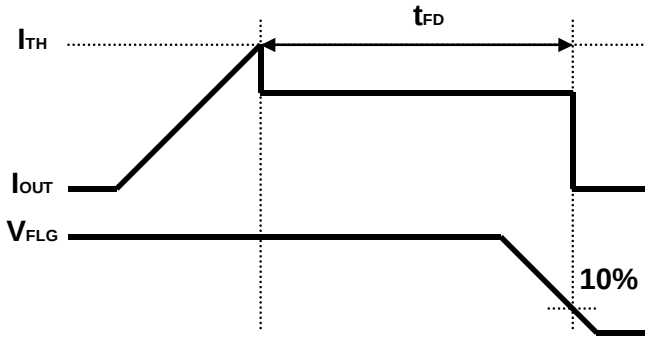
TIMING CHART

- **Output ON Time, Output OFF Time**

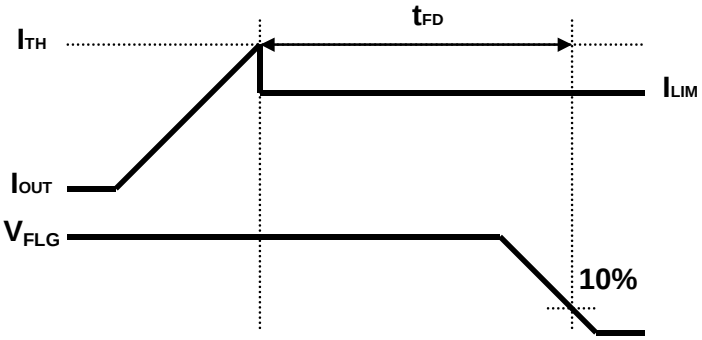


- **Flag Delay Time**

R5524N001A/001B (Latch OFF Type)



R5524N002A/002B/004A (Constant Current Type)



The Over-Current Limitation Function

R5524N001A/001B has the built-in latch-off type over-current limit circuit. When the over-current is detected, the protection circuit becomes active and the switch-transistor is turned OFF. The latch function is released if the input voltage value is exceeded in the release threshold of the UVLO circuit value after when it became lower than the detection threshold of the UVLO circuit value; or the EN pin set to the enabling condition again after set to the disabling condition.

If the over current condition occurred when the input voltage value was close to the minimum operating input voltage value. Under this condition, the voltage descends by the parasitic impedance on the power supply side, and it might fall below the detection threshold of the UVLO circuit. In this case, the switch-transistor is turned OFF and because of that the voltage drop of power line's parasitic impedance stops; the latch function is released with the UVLO and it becomes the over current condition again. The switch transistor keeps continual ON and OFF until one of the following is done; increasing the input voltage value; the setting of EN pin is disabling; or reducing the value of load current.

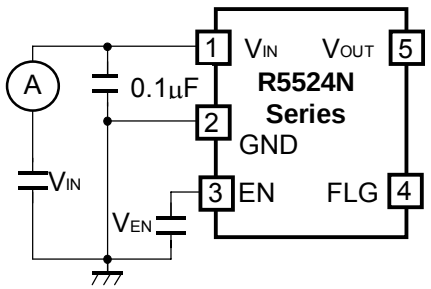
Moreover, the supply-voltage changed by the load-current dramatically changed depends upon the parasitic impedance of the wiring on the load side or the power supply side. Due to this, decreasing the parasitic impedance by the wiring on board is recommended.

The switch transistor of R5524N001A/001B is turned OFF when the latch-off-function operates under the condition of the load of the constant current as the load device, such as the electronic load and so on, connecting with the V_{OUT} pin of R5524N001A/001B. Because the load device keeps the constant current, the V_{OUT} pin voltage may become negative potential. If the V_{OUT} pin is exceed the absolute maximum rating may cause the permanent damages to the device, please avoid using in this situation.

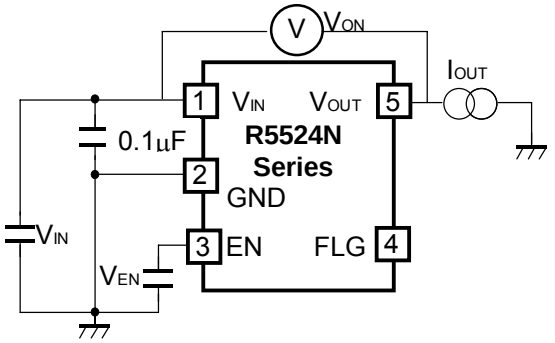
R5524N002A/002B/004A has the built-in over current protection circuit as the constant current type. It detects as the over-current condition, if the current flows as the ITH defined. Then operating the switch transistor to limit the output current to be the constant current defined by the I_{LIM}.

If the condition of the over-current limit caused by the V_{OUT} pin clamped to the GND were continued the temperature of the ICs would increase drastically. The switch-transistor is turned OFF if the temperature of the ICs becomes over 135°C (Typ.). And after this, the switch-transistor is turned ON again when the temperature of ICs decreased approximately 15°C. The switch-transistor keeps continual ON and OFF until either the switch is turned OFF or the V_{OUT} pin is removed from GND.

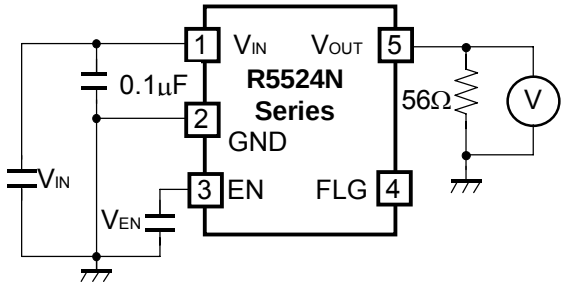
TEST CIRCUIT



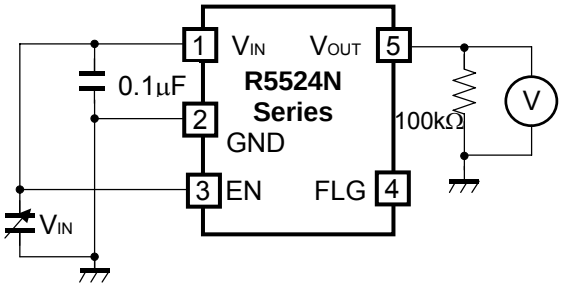
Supply Current Test Circuit



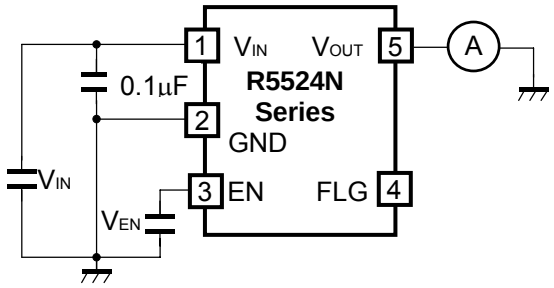
Switch ON Resistance Test Circuit



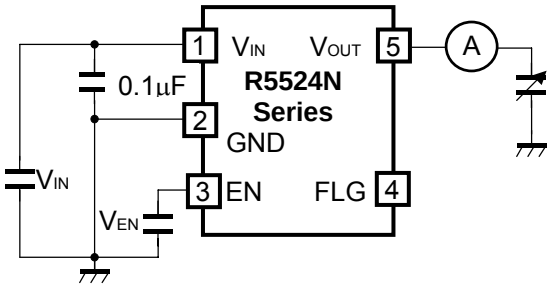
Output ON Time/Output OFF Time Test Circuit



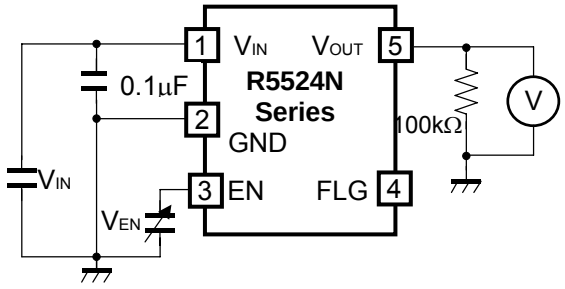
UVLO Released Voltage Test Circuit



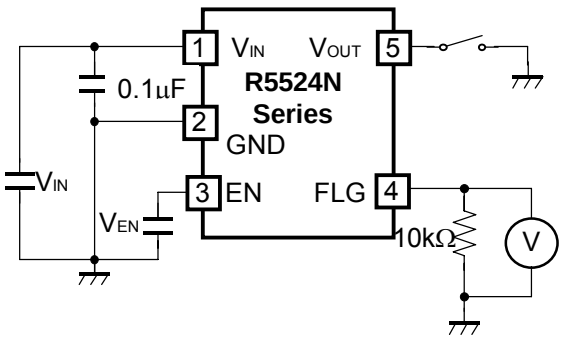
Over current Limit Test Circuit



Current Limit Threshold Test Circuit



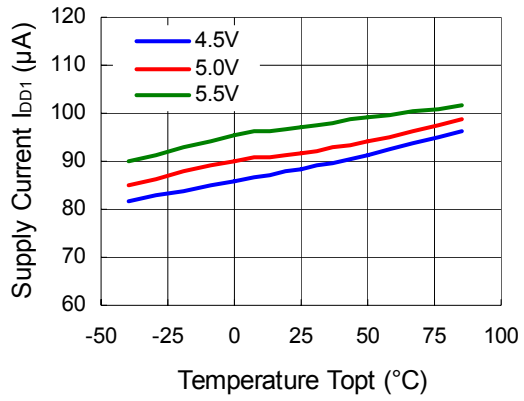
Enable Input Voltage Test Circuit



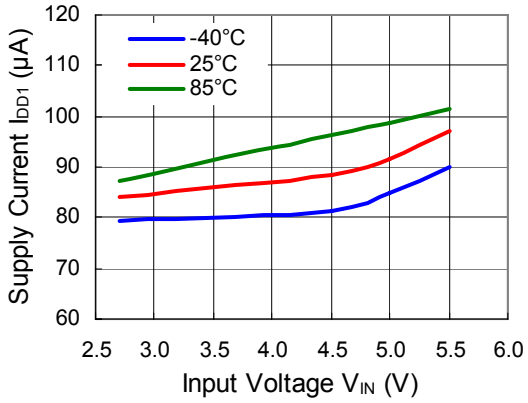
Flag Output Delay Time Test Circuit

TYPICAL CHARACTERISTICS

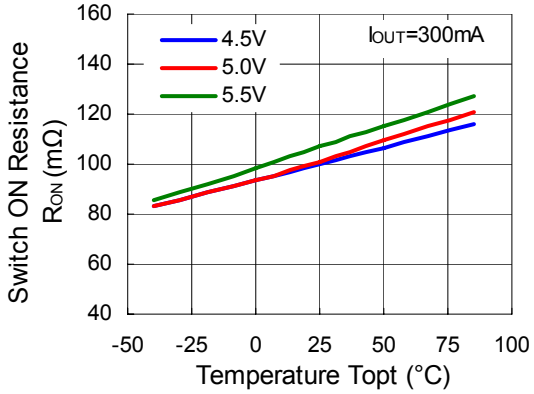
1) Supply Current vs. Temperature



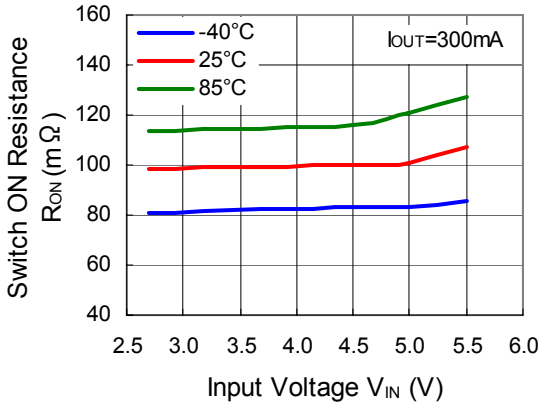
2) Supply Current vs. Input Voltage



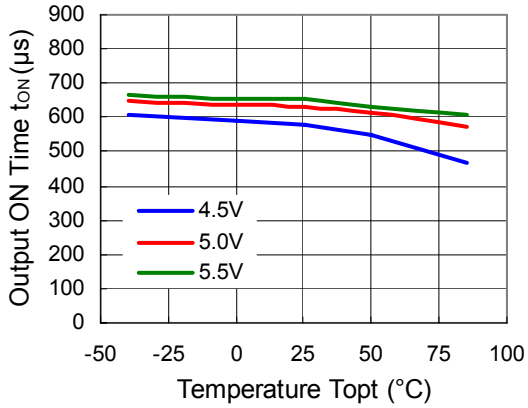
3) Switch ON Resistance vs. Temperature



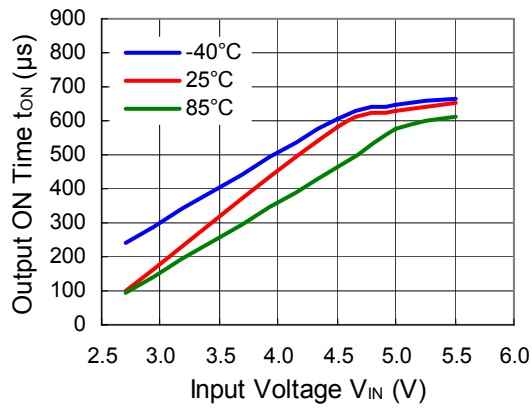
4) Switch ON Resistance vs. Input Voltage



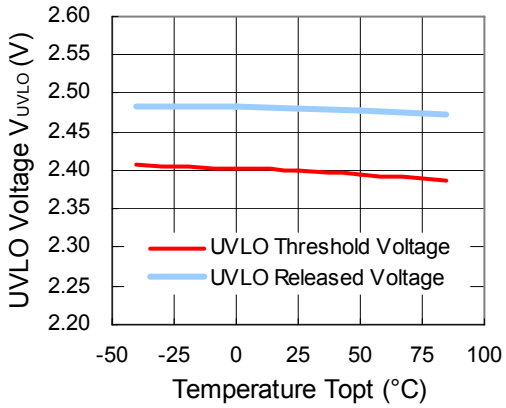
5) Output ON Time vs. Temperature (R_L=56Ω)



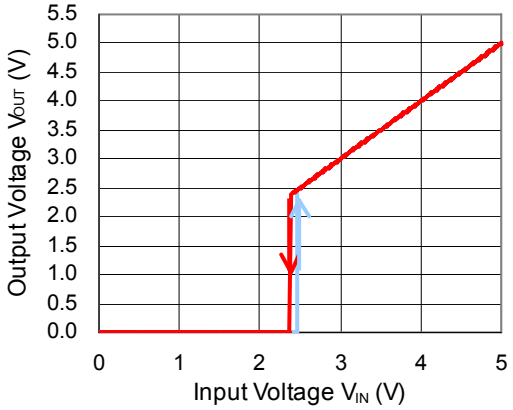
6) Output ON Time vs. Input Voltage (R_L=56Ω)



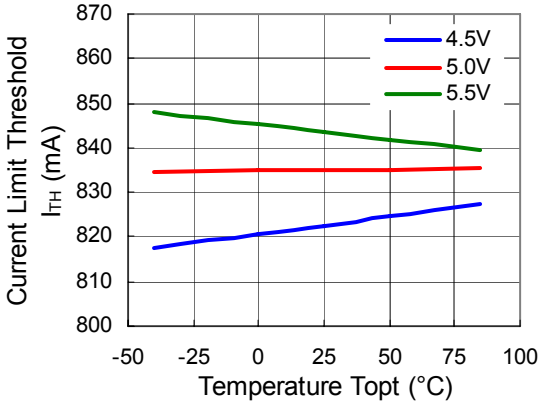
7) UVLO Voltage vs. Temperature



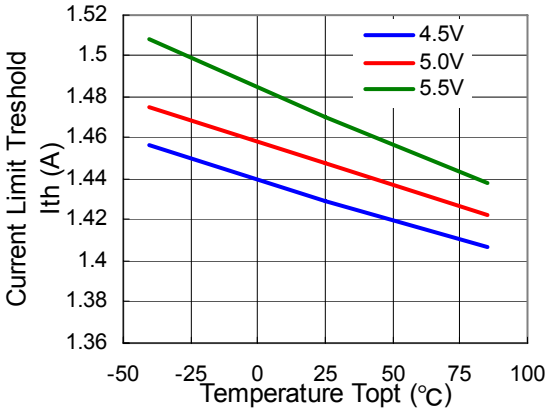
8) Output Voltage vs. Input Voltage



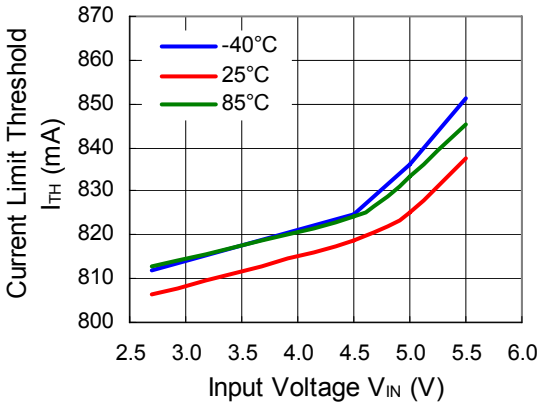
9) Current Limit Threshold vs. Temperature (001x / 002x)



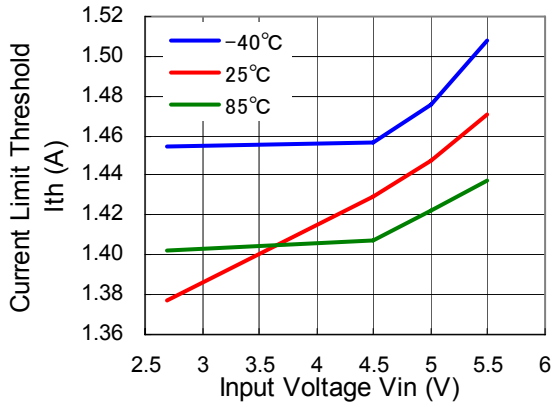
10) Current Limit Threshold vs. Temperature (004A)



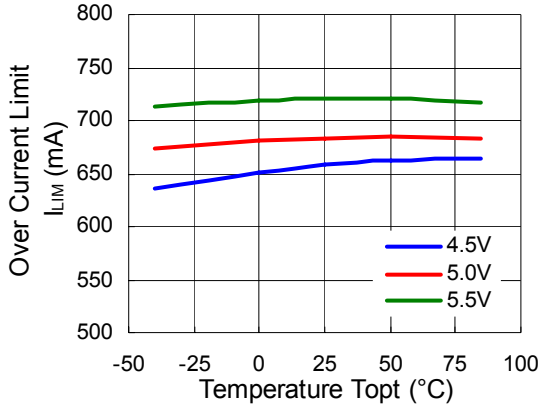
11) Current Limit Threshold vs. Input Voltage (001x / 002x)



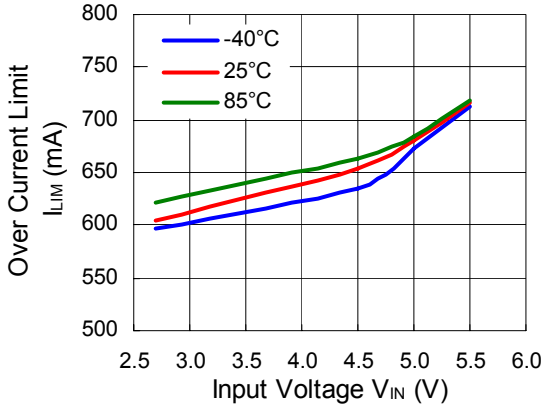
12) Current Limit Threshold vs. Input Voltage (004A)



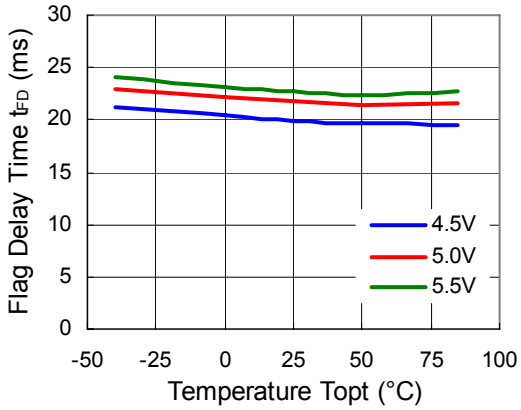
13) Over Current Limit vs. Temperature



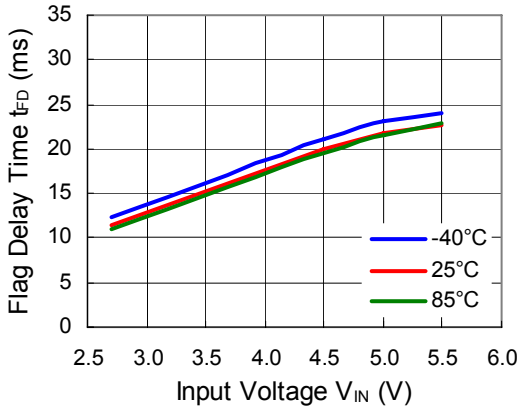
14) Over Current Limit vs. Input Voltage



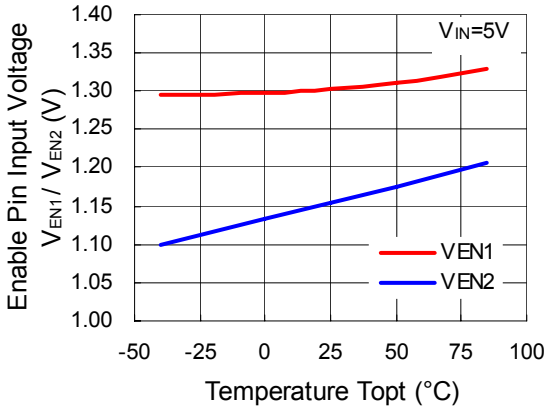
15) Flag Delay Time vs. Temperature



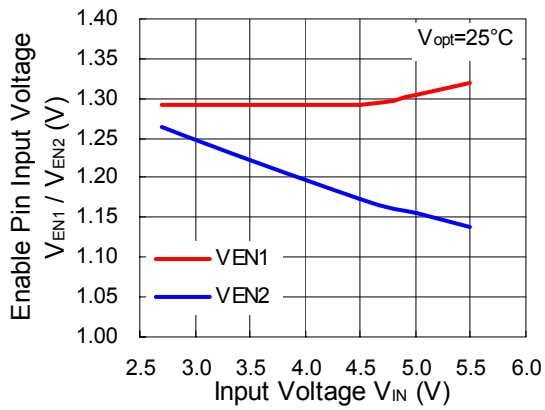
16) Flag Delay Time vs. Input Voltage



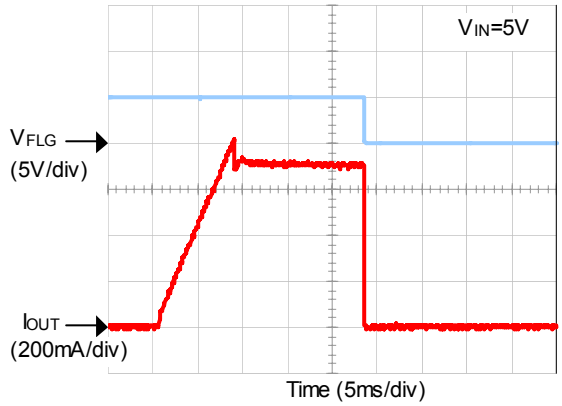
17) Enable Input Voltage vs. Temperature



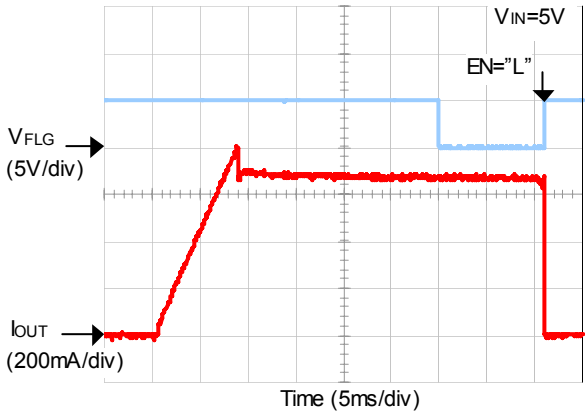
18) Enable Input Voltage vs. Input Voltage



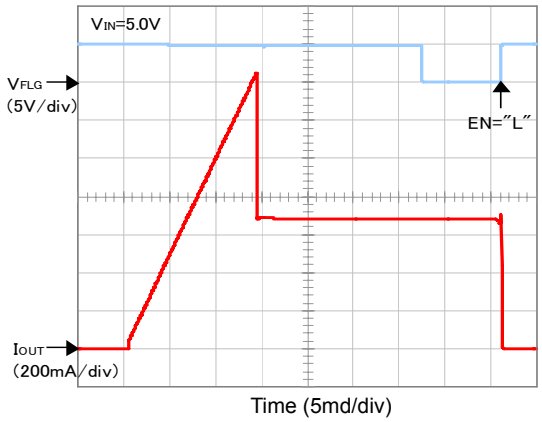
19) Over-Current Response with Ramped Load (R5524N001x)



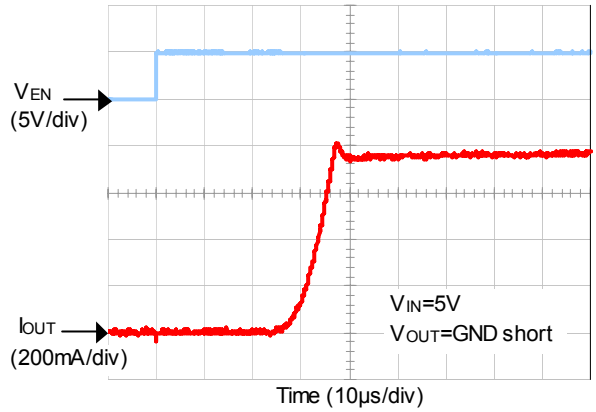
20) Over-Current Response with Ramped Load (R5524N002x)



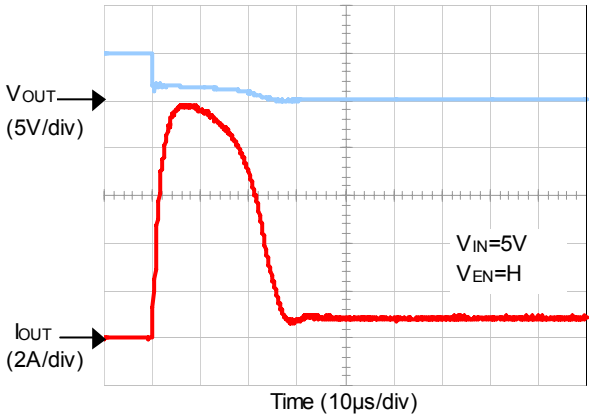
21) Over-Current Response with Ramped Load (R5524N004A)



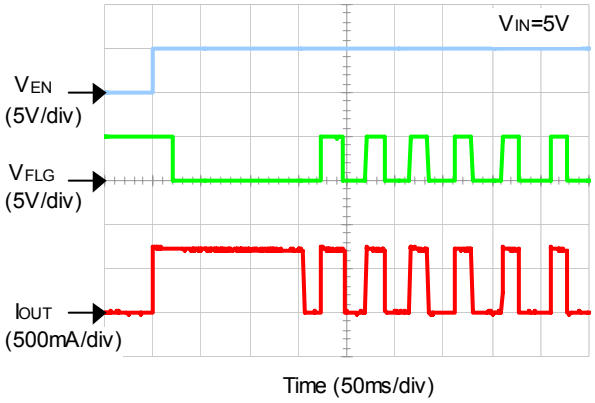
22) Over Current Limit Transient Response (Output short during enable"H")



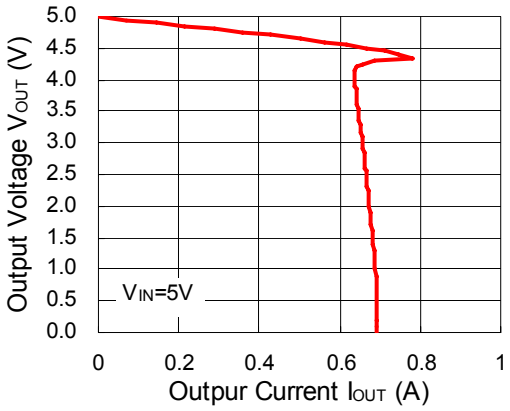
(Enable"H"during Output short)



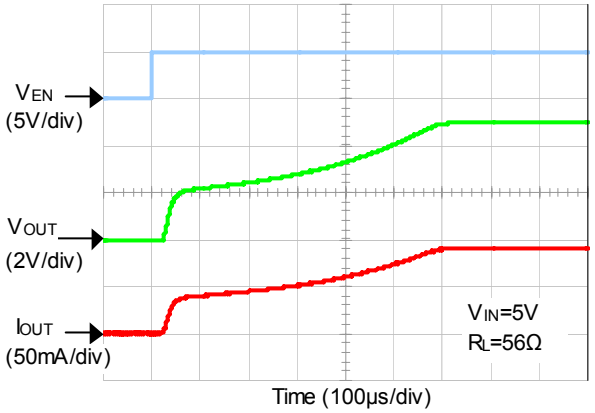
23) Thermal Shutdown Operation



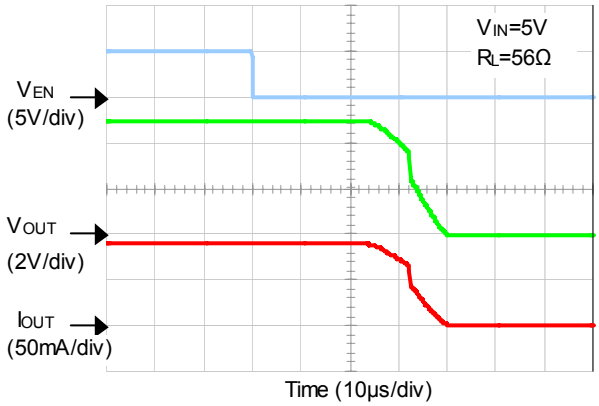
24) Output Voltage vs. Output Current



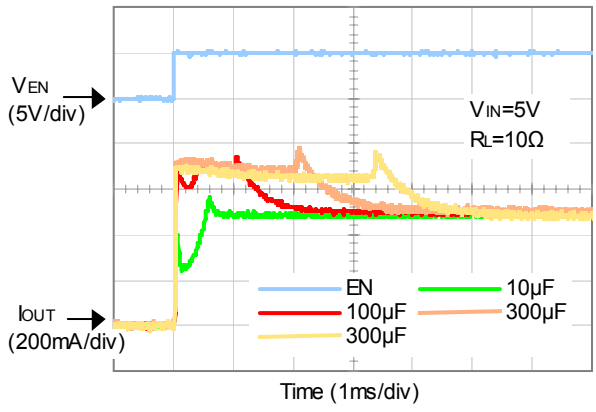
25) Output ON Time Response



26) Output OFF Time Response



27) Inrush current Characteristic

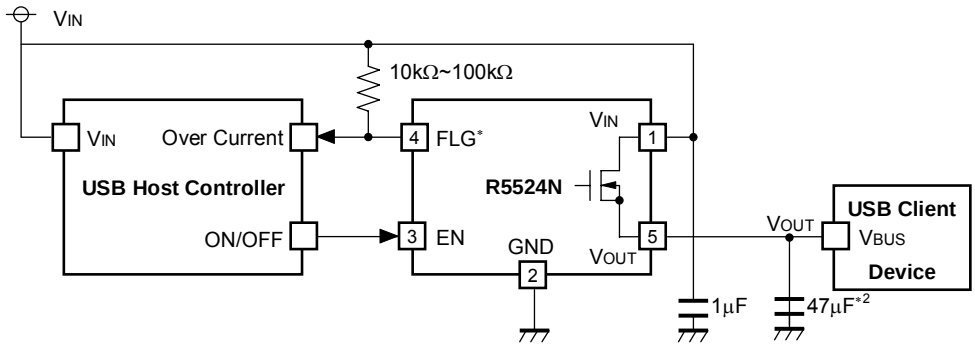


TECHNICAL NOTES

- **Bypass capacitor**
  - Put a capacitance range from 0.1µF to 1µF bypass capacitor between V_{IN} pin and GND pin of the ICs. If the

output is shorted when without a bypass capacitor, 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.



R5524N Typical Application

∗) FLG pin is Nch. open drain output.
∗2) For the USB standard, the capacitor value of 120μF or more must be connected with the output pin.

1. The products and the product specifications described in this document are subject to change or discontinuation of production without notice for reasons such as improvement. Therefore, before deciding to use the products, please refer to Ricoh sales representatives for the latest information thereon.
2. The materials in this document may not be copied or otherwise reproduced in whole or in part without prior written consent of Ricoh.
3. Please be sure to take any necessary formalities under relevant laws or regulations before exporting or otherwise taking out of your country the products or the technical information described herein.
4. The technical information described in this document shows typical characteristics of and example application circuits for the products. The release of such information is not to be construed as a warranty of or a grant of license under Ricoh's or any third party's intellectual property rights or any other rights.
5. The products listed in this document are intended and designed for use as general electronic components in standard applications (office equipment, telecommunication equipment, measuring instruments, consumer electronic products, amusement equipment etc.). Those customers intending to use a product in an application requiring extreme quality and reliability, for example, in a highly specific application where the failure or misoperation of the product could result in human injury or death (aircraft, spacevehicle, nuclear reactor control system, traffic control system, automotive and transportation equipment, combustion equipment, safety devices, life support system etc.) should first contact us.
6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, firecontainment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. Anti-radiation design is not implemented in the products described in this document.
8. Please contact Ricoh sales representatives should you have any questions or comments concerning the products or the technical information.

RICOH COMPANY., LTD. Electronic Devices Company

■Ricoh presented with the Japan Management Quality Award for 1999.
Ricoh continually strives to promote customer satisfaction, and shares the achievements of its management quality improvement program with people and society.

■Ricoh awarded ISO 14001 certification.
The Ricoh Group was awarded ISO 14001 certification, which is an international standard for environmental management systems, at both its domestic and overseas production facilities. Our current aim is to obtain ISO 14001 certification for all of our business offices.

RoHS Compliant
Ricoh completed the organization of the Lead-free production for all of our products. After Apr. 1, 2006, we will ship out the lead free products only. Thus, all products that will be shipped from now on comply with RoHS Directive.

http://www.ricoh.com/LSI/

RICOH COMPANY, LTD.
Electronic Devices Company
● Higashi-Shinagawa Office (International Sales)
3-32-3, Higashi-Shinagawa, Shinagawa-ku, Tokyo 140-8655, Japan
Phone: +81-3-5479-2857 Fax: +81-3-5479-0502

RICOH EUROPE (NETHERLANDS) B.V.
● Semiconductor Support Centre
Prof. W.H.Keesomlaan 1, 1183 DL Amstelveen, The Netherlands
P.O.Box 114, 1180 AC Amstelveen
Phone: +31-20-5474-309 Fax: +31-20-5474-791

RICOH ELECTRONIC DEVICES KOREA Co., Ltd.
11 floor, Haesung 1 building, 942, Daechidong, Gangnamgu, Seoul, Korea
Phone: +82-2-2135-5700 Fax: +82-2-2135-5705

RICOH ELECTRONIC DEVICES SHANGHAI Co., Ltd.
Room403, No.2 Building, 690#Bi Bo Road, Pu Dong New district, Shanghai 201203, People's Republic of China
Phone: +86-21-5027-3200 Fax: +86-21-5027-3299

RICOH COMPANY, LTD.
Electronic Devices Company
● Taipei office
Room109, 10F-1, No.51, Hengyang Rd., Taipei City, Taiwan (R.O.C.)
Phone: +886-2-2313-1621/1622 Fax: +886-2-2313-1623