RICOH

R5492N Series

One-cell Li-ion Battery Protection IC with High-accuracy Overcurrent Detection

NO.EA-421-161130

OUTLINE

The R5492N is a high voltage tolerance protection IC for overcharge, overdischarge, and overcurrent of a rechargeable one-cell Lithium-ion (Li+) / Lithium-polymer battery. The R5492N supports the voltage release type at overcharging / overdischarging. Each output delay time of overcharge, overdischarge, and overcurrent is fixed internally. But, the delay shortening is able to shorten the detection and the release delay times at overcharging / overdischarging. Especially, the overcharge detection delay time can be shorten to aprrox.1/90.

FEATURES

- High Voltage Tolerant Process
  - Absolute Maximum Ratings ······ 30 V
- Low Supply Current
  - Supply Current (at normal mode) ······ Typ. 4.0 μA, Max. 8.0 μA
  - Standby Current ······ Max. 0.5 μA
- High-accuracy Voltage Detection
  - Overcharge Detection Voltage ······ 4.00 V to 4.50 V (in 5 mV steps)
  - Overcharge Detection Voltage Accuracy ······ ± 20 mV (Ta = 25°C)
± 25 mV (-5°C < Ta < 55°C)
  - Overdischarge Detection Voltage ······ 2.00 V to 3.00 V (in 0.1 V steps)
  - Overdischarge Detection Voltage Accuracy ······ ±2.5%
  - Discharge Overcurrent Detection Voltage ······ 0.05 V to 0.20 V (in 5 mV steps)
  - Discharge Overcurrent Detection Voltage Accuracy ··· ± 15 mV
  - Charge Overcurrent Detection Voltage ······ -0.05 V to -0.20 V (in 5 mV steps)
  - Charge Overcurrent Detection Voltage Accuracy ······ ±15 mV
  - Short Detection Voltage ······ 0.8 V fixed
- 0V Battery Charge Function
- Compact Package ······ SOT-23-6 (2.9 mm x 2.8 mm)

APPLICATIONS

- Li+ / Li Polymer protection of overcharge, overdischarge, and overcurrent for Battery pack
- High precision protection for smart-phones and any other gadgets using on board Li+ / Li Polymer battery

● SELECTION GUIDE

The set output voltages of overcharge, overdischarge, and discharge overcurrent are user-selectable options.

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5492Nxxx∗$-TR	SOT-23-6	3,000 pcs	Yes	Yes

xxx: Specify the combination of each detection voltage (V_{DET}) and each release voltage (V_{REL}).
Refer to *Product Code Table* for details.

Overcharge Detection Voltage (V_{DET1}): 4.00 V to 4.50 V (in 5 mV steps)
Overdischarge Detection Voltage (V_{DET2}): 2.00 V to 3.00 V (in 0.1 V steps)
Discharge Overcurrent Detection Voltage (V_{DET3}): 0.05 V to 0.20 V (in 5 mV steps)
Charge Overcurrent Detection Voltage (V_{DET4}): -0.05 V to -0.20 V (in 5 mV steps)
Overcharge Release Voltage (V_{REL1})
Overdischarge Release Voltage (V_{REL2})

∗: Specify the combination of each delay time parameter. Refer to *Delay Time Code Table* for details.

Delay Time Code Table

Code	**t_{VDET1}(s)**	**t_{VDET2} (ms)**	**t_{VDET3} (ms)**	**t_{VDET4}(ms)**	**t_{SHORT}(μs)**
K	1.0	20	12	8	300

$: Specify the function code.

Function Code Table

Code	**Overcharge**	**Overdischarge**
L	Voltage Release Type	

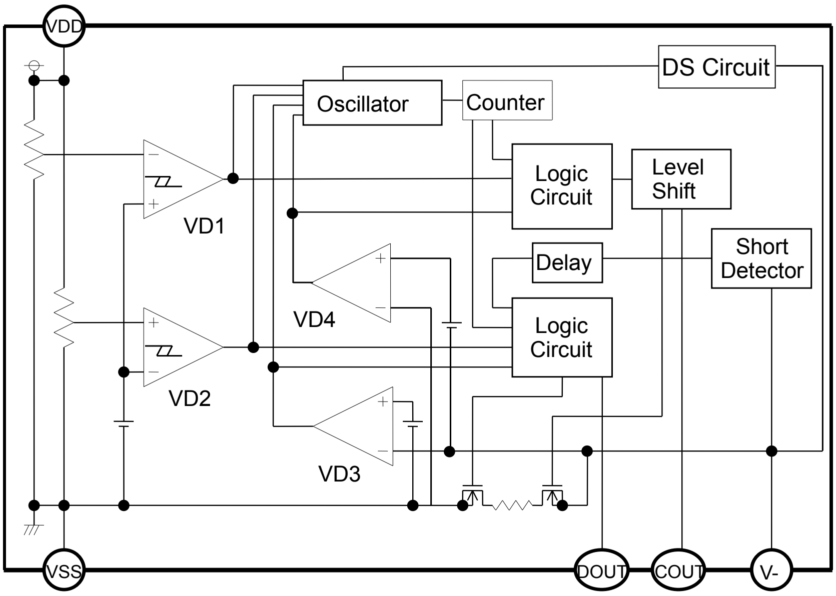
Product Code Table

The product code is determined by the combination of the set output voltage (overcharge detection / release voltage: V_{DET1} / V_{REL1}, overdischarge detection / release voltage: V_{DET2} / V_{REL2}, discharge / charge overcurrent detection voltage: V_{DET3} / V_{DET4}) and the delay time (overcharge / overdischarge detection delay time: t_{VDET1} / t_{VDET2}, discharge / charge overcurrent detection delay time: t_{VDET3} / t_{VDET4}) and the function code.

Product Code & Set Voltages Table

Product Code	Set Output Voltage (V)						DelayTime				
	V_{DET1} (V)	V_{REL1} (V)	V_{DET2} (V)	V_{REL2} (V)	V_{DET3} (V)	V_{DET4} (V)	t_{VDET1} (s)	t_{VDET2} (ms)	t_{VDET3} (ms)	t_{VDET4} (ms)	t_{SHORT} (μs)
R5492N101KL	4.250	4.050	2.500	3.000	0.200	-0.100	1	20	12	8	300
R5492N102KL	4.350	4.150	2.500	3.000	0.200	-0.100	1	20	12	8	300
R5492N110KL	4.280	4.080	2.300	3.000	0.125	-0.100	1	20	12	8	300
R5492N149KL	4.280	4.080	2.900	3.100	0.125	-0.100	1	20	12	8	300
R5492N163KL	4.280	4.100	3.000	3.200	0.100	-0.100	1	20	12	8	300
R5492N173KL	4.200	4.100	2.800	2.900	0.100	-0.100	1	20	12	8	300
R5492N187KL	4.250	4.050	3.000	3.200	0.150	-0.100	1	20	12	8	300
R5492N218KL	4.250	4.050	2.800	3.000	0.150	-0.100	1	20	12	8	300
R5492N227KL	4.375	4.175	2.500	3.000	0.200	-0.100	1	20	12	8	300
R5492N280KL	4.425	4.225	2.400	2.900	0.150	-0.100	1	20	12	8	300
R5492N345KL	4.475	4.275	2.500	2.900	0.150	-0.150	1	20	12	8	300

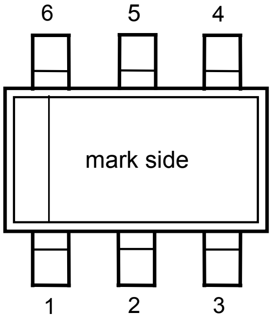
BLOCK DIAGRAM



R5492N Block Diagram

PIN DESCRIPTIONS

SOT-23-6



SOT-23-6 Pin Description

Pin No.	Symbol	Description
1	DOUT	Overdischarge detection voltage pin, CMOS output
2	V-	Negative power supply voltage pin
3	COUT	Overcharge detection voltage pin, CMOS output
4	NC	No Connection
5	VDD	Power supply voltage pin, the substrate potential of the IC.
6	VSS	Ground pin

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings (Ta = 25°C, V_{SS} = 0 V)

Symbol	Item	Rating	Unit
V_{DD}	Power supply voltage	0.3 to 12	V
V-	V- pin voltage	V_{DD}-30 to V_{DD}+0.3	V
V_{COUT}	COUT pin voltage	V_{DD}-30 to V_{DD}+0.3	V
V_{DOUT}	DOUT pin voltage	V_{SS}-0.3 to V_{DD}+0.3	V
P_D	Power Dissipation(1) (Standard Test Land Pattern)	150	mW
Tj	Junction Temperature Range	-40 to 125	°C
Tstg	Storage Temperature Range	-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 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.

RECOMMENDED OPERATING CONDITION

Symbol	Item	Rating	Unit
V_{DD1}	Operating Input Voltage	1.5 to 5.0	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.

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(1) Refer to *POWER DISSIPATION* in *SUPPLEMENTSRY ITEMS* for detail information.

ELECTRICAL CHARACTERISTICS

The specifications surrounded by ☐ are guaranteed by Design Engineering at -5°C ≤ Ta ≤ 55°C.

R5492NxxxKL Eectronical Characteristics (Ta = 25°C)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit	Circuit (1)
V_{ST}	Minimum operating voltage for 0V charging	Voltage between VDD and V- pins, $V_{DD} - V_{SS} = 0$ V			1.8	V	A
V_{DET1}	Overcharge detection voltage	R1 = 330Ω	V_{DET1}-0.020 $\boxed{V_{DET1}-0.025}$	V_{DET1}	V_{DET1}+0.020 $\boxed{V_{DET1}+0.025}$	V	B
V_{REL1}	Overcharge release voltage	R1 = 330Ω	V_{REL1} -0.050	V_{REL1}	V_{REL1} +0.050	V	B
t_{VDET1}	Overcharge detection delaly time	V_{DD} = 3.6 V → 4.4 V	0.7	1.0	1.3	s	B
t_{VREL1}	Overcharge release delay time	V_{DD} = 4.5V → 3.6 V	11	16	21	ms	C
V_{DET2}	Overdischarge detection voltage	Falling edge of supply voltage	V_{DET2}×0.975	V_{DET2}	V_{DET2}×1.025	V	D
V_{REL2}	Overdischarge release voltage	Rising edge of supply voltage	V_{REL2}×0.975	V_{REL2}	V_{REL2}×1.025	V	M
t_{VDET2}	Overdischarge detection delay time	V_{DD} = 3.6 V → 2.2 V	14	20	26	ms	D
t_{VREL2}	Overdischarge release delaly time	V_{DD} = 2.2 V → 3.1 V	0.7	1.2	1.7	ms	E
V_{DET3}	Charge overcurrent detection voltage	Rising edge of V- pin voltage	V_{DET3}-0.015	V_{DET3}	V_{DET3}+0.015	V	F
t_{VDET3}	Discharge overcurrent detection delay time	V_{DD}=3.0V,V- = 0V → 0.5V	8	12	16	ms	F
t_{VREL3}	Discharge overcurrent release delay time	V_{DD}= 3.0V, V-= 3V → 0V	0.7	1.2	1.7	ms	F
V_{SHORT}	Short-circuit detection voltage	V_{DD} = 3.0 V	0.55	0.80	1.00	V	F
t_{SHORT}	Short-circuit detection delay time	V_{DD} = 3.0V, V- = 0V → 3V	230	300	500	μs	F
R_{SHORT}	Discharge overcurrent release resistance	V_{DD} = 3.6 V, V- = 1.0 V	5	15	25	kΩ	F
V_{DET4}	Charge overcurrent detection voltage	Falling edge of V- pin voltage	V_{DET4}-0.015	V_{DET4}	V_{DET4}+0.015	V	G
t_{VDET4}	Charge overcurrent detection delay time	V_{DD}= 3.0V,V- = 0V → -1V	5	8	11	ms	G
t_{VREL4}	Charge overcurrent release delay time	V_{DD}= 3.0V, V- = -1V → 0V	0.7	1.2	1.7	ms	G
V_{DS}	Short-circuit mode voltage	V_{DD} = 4.4 V	-3.15	-2.55	-1.95	V	G

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(1) Refer to *TEST CIRCUITS* for details.

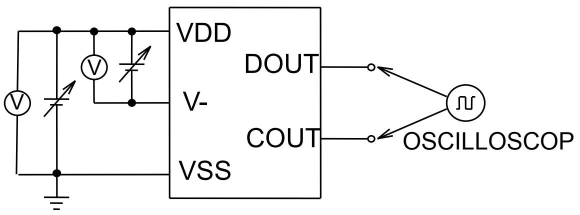
The specifications surrounded by ☐ are guaranteed by Design Engineering at -5°C ≤ Ta ≤ 55°C.

R5492NxxxKL Eectronical Characteristics (Continued) (Ta = 25°C)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit	Circuit (1)
V_{OL1}	COUT Nch.ON voltage	I_{OL} = 50μA, V_{DD} = 4.5 V		0.4	0.5	V	H
V_{OH1}	COUT Pch.ON voltage	I_{OH} = -50μA, V_{DD} = 3.9 V	3.4	3.7		V	I
V_{OL2}	DOUT Nch.ON voltage	I_{OL} = 50μA, V_{DD} = 2.0 V		0.2	0.5	V	J
V_{OH2}	DOUT Pch.ON voltage	I_{OH} = -50μA, V_{DD} = 3.9 V	3.4	3.7		V	K
I_{DD}	Supply current	V_{DD} = 3.9 V, V- = 0 V		4.0	8.0	μA	L
$I_{STANDBY}$	Standby current	V_{DD} = 1.8 V			0.5	μA	L

R5492NxxxKD TEST CIRCUITS

A



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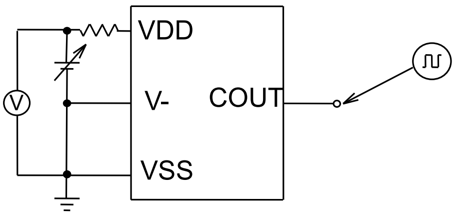

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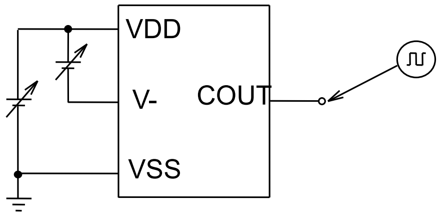

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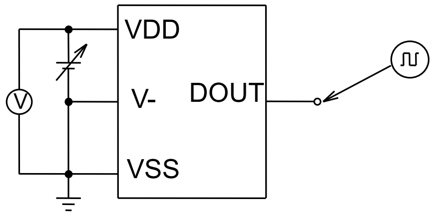

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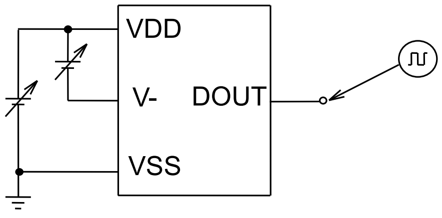

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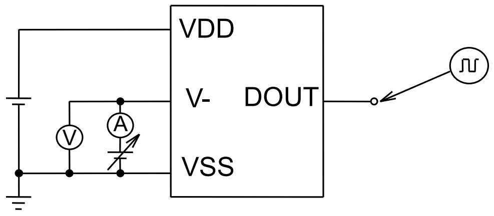

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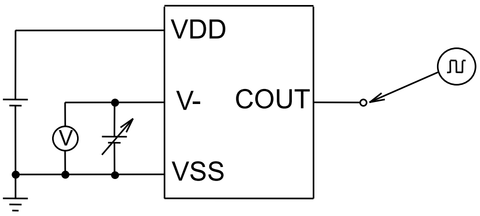
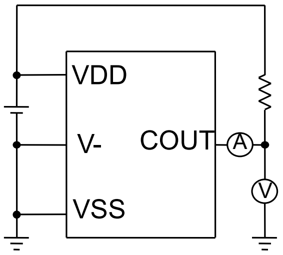
(1) Refer to *TEST CIRCUITS* for details.

G


VDD
V-
COUT
VSS
V

H


VDD
V-
COUT
VSS
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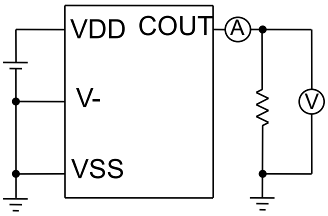
VDD
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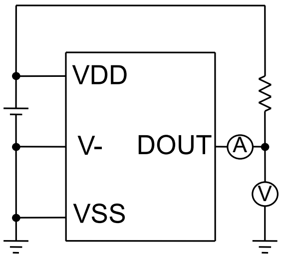
VDD
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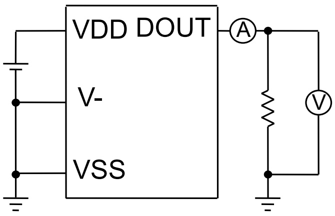
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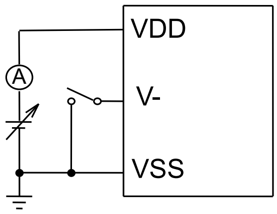
VDD
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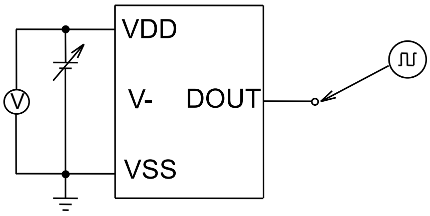

VDD
V-
DOUT
VSS
V

THEORY OF OPERATION

Overcharge Detector (VD1)

The VD1 monitors V_{DD} pin voltage during charge. When the V_{DD} voltage crosses overcharge detector threshold V_{DET1}, the VD1 can sense overcharge and the output of C_{OUT} pin becomes "L" and stop charging by turning off the external Nch. MOSFET.

After detecting overcharge, when the voltage of V_{DD} pin is equal or less than the released voltage from overcharge, or when the V_{DD} voltage is less than the overcharge detector threshold, if the charger is removed, VD1 is released, then the output level of C_{OUT} becomes "H" and by turning on the external Nch. MOSFET, the battery charger is ready to work again. However, depending on the characteristics of external components such as MOSFETs, release conditions may be not enough and a kind of load must be set to release the overcharge. When the Input level of V_{DD} pin is equal or more than overcharge detector threshold, and while a charger is disconnected from the battery pack, if a load system is connected to the battery pack, the output level of C_{OUT} pin is "L". However, load current can be flowed through a parasitic diode of an external Nch. MOSFET. Then, when the voltage level of V_{DD} pin becomes lower than overcharge detector threshold, the output level of C_{OUT} pin becomes "H".

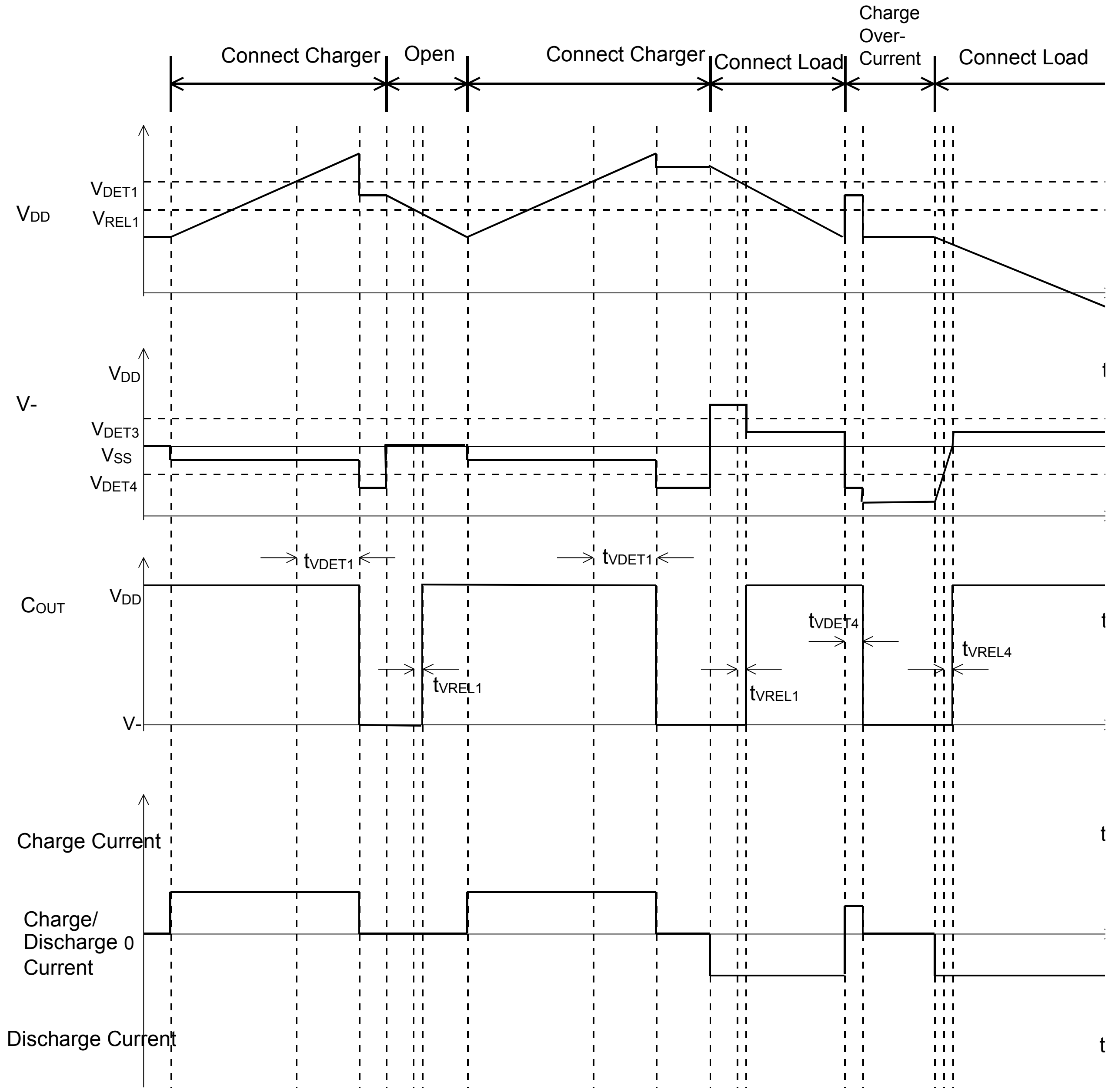
Output delay time for overcharge detect and released overcharge is internally fixed respectively. Although the V_{DD} voltage goes up to a higher level than overcharge detector threshold within the output delay time, VD1 would not work for detecting overcharge. If the action for VD1 to release is done and the condition returns to the initial one within the output delay time, VD1 cannot be released.

A level shifter is built in a buffer driver for the C_{OUT} pin, therefore, the "L" level is equal to the voltage level of V- pin. The output type of C_{OUT} pin is CMOS type. The Output level is between V_{DD} and V-.

Charge Overcurrent Detector (VD4)

While charge and discharge are acceptable with the battery pack, VD4 senses V- pin voltage. For example, if the battery pack is charged by an inappropriate charger, overcurrent flows, then the voltage of V- pin becomes less than charge overcurrent detector threshold. Then, the output of C_{OUT} becomes "L", and protects against flowing overcurrent in the circuit by turning off the external Nch. MOSFET.

Output delay of charge overcurrent is internally fixed. Even the voltage level of V- pin becomes lower than charge overcurrent detector threshold, if the voltage is higher than the VD4 threshold within the delay time, charge overcurrent state is not detected. Output delay time for release from charge overcurrent is also set internally. VD4 can be released by disconnecting a charger.



Timing Chart of Overcharging

Overdischarge Detector (VD2)

The VD2 monitors a V_{DD} pin voltage during discharge. When the V_{DD} voltage crosses the overdischarge detector threshold V_{DET2} from a high level to a lower level than V_{DET2}, the VD2 senses overdischarge and stop discharge by turning off an external Nch. MOSFET.

To reset the VD2 with the D_{OUT} pin level being “H” again after detecting overdischarge, if V_{DD} voltage is equal or less than overcharge detector threshold, a charge current flows through a parasitic diode of the external Nch. MOSFET. After that, when V_{DD} voltage is more than overdischarge threshold, D_{OUT} pin becomes "H", and by tuning on the external Nch. MOSFET, discharge is possible. In the case that a charger is connected to the battery pack, and V_{DD} level is more than overdischarge detector threshold, the output level of D_{OUT} becomes “H” immediately. Without connecting a charger, if V_{DD} pin voltage is equal or more than the released voltage from overdischarge, the output level of D_{OUT} becomes “H”.

When a cell voltage is equal to 0V, connecting a charger to the battery pack makes C_{OUT} pin become "H" and the system is allowable for charge while the voltage of the charger is more than the maximum limit of the minimum operating voltage (Vst) for 0V charge.

An output delay for overdischarge detection is fixed internally. Although the voltage of V_{DD} becomes equal or less than overdischarge detector threshold and if it becomes higher than overdischarge detector threshold within output delay time, overdischarge detector does not work. Output delay time for release from over-discharge is also set internally. After detecting overdischarge by VD2, supply current would decrease, because unnecessary circuits are halted and being standby.

The output type of D_{OUT} pin is CMOS type and its output level is in between V_{DD} and V_{SS}.

Discharge Overcurrent Detector / Short-circuit Protector (VD3 / VSHORT)

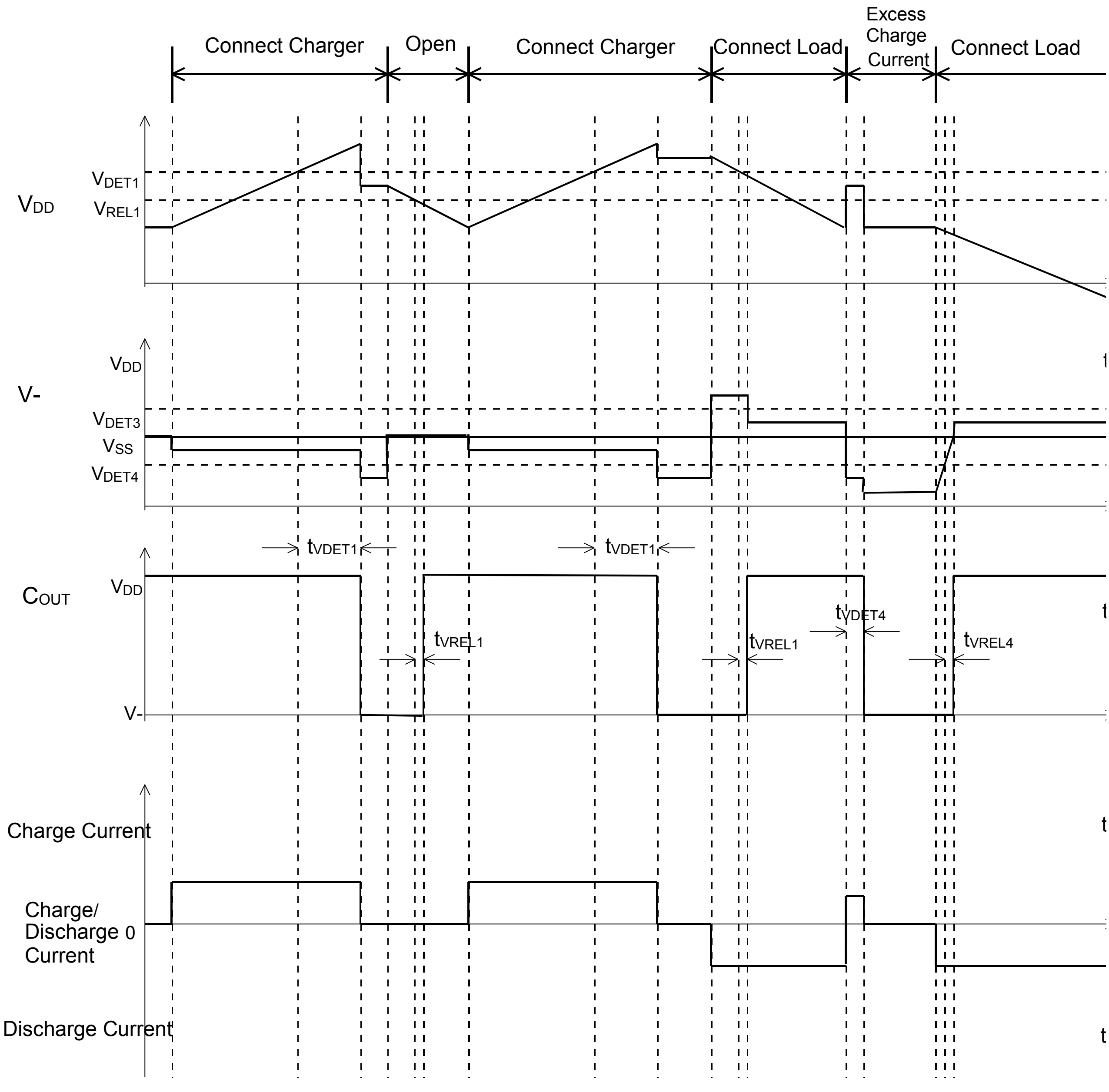
While charge and discharge are acceptable with the battery pack, VD3 monitors the voltage level of V- pin. In the cause of such as the external short circuit, if the voltage level of V- pin may become more than the discharge overcurrent detection voltage and less than the short detection voltage, the discharge overcurrent detector works. When the voltage level of V- pin becomes more than short detection voltage, the short-circuit protector works and the output level of DOUT pin becomes “L”, and by turning off an external Nch. MOSFET, VD3 protects against flowing extremely large current into the circuit.

An output delay time for the discharge overcurrent detection is internally fixed. Although the voltage of V- pin becomes more than the discharge overcurrent detection voltage and less than short detection voltage, if it becomes less than the discharge overcurrent detection voltage within the output delay time, the overcurrent detector does not work. Output delay time for release from discharge overcurrent is also set internally.

In terms of short-circuit protector, output delay time is typically 300μs. The V- pin has a built-in pull down resistor, Typ. 15kΩ connected to the V_{SS} pin.

After a discharge overcurrent or short circuit protection is detected, by removing a cause of overcurrent or external short circuit, the voltage level of V- is pulled down through the resistor for release from overcurrent to the V_{SS} level. Then, when the voltage level of V- pin becomes less than the overcurrent detection voltage, both protection circuits are released automatically. Resistor for release from discharge overcurrent is active when discharge overcurrent or short-circuit is detected. While charge and discharge are acceptable for the battery pack, or normal mode, the resistor is inactive.

Output delay time for discharge overcurrent is necessarily set shorter than output delay time for overdischarge. Therefore, if discharge overcurrent is detected, and at the same time, VDD pin voltage becomes lower than overdischarge detection voltage, discharge overcurrent detector is predominant. By disconnecting load from the battery pack, the battery pack is automatically released from overcurrent state.



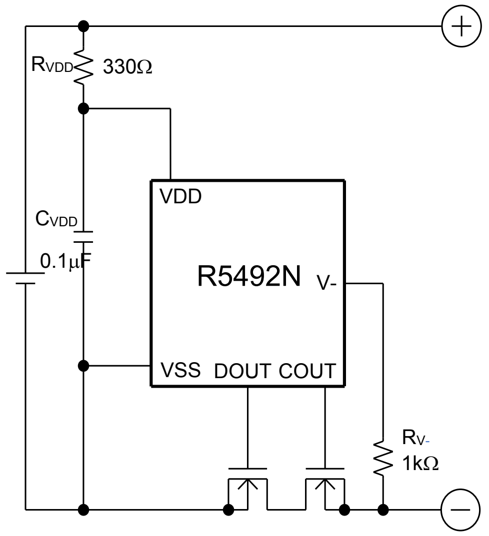
Timing Chart of Overdischarging, Discharge Overcurrent, and Short-circuit

Delay Shortening (DS)

When the COUT is "H", the output delay time of detection and release at overcharging / overdischarging can be shorter than default values by forcing lower than the delay shortening mode voltage to V- pin.

APPLICATION INFORMATION

Typical Application Circuit



R5492N Typical Application Circuit

Technical Notes on the Selection Components

- Since R_{VDD} and C_{VDD} stabilize a supply voltage to the IC, a recommended value of R_{VDD} is less than 1 kΩ. If making RVDD larger, the conduction current flowed in the IC will make the detection voltage larger. For stabilizing operation, connect the C_{VDD} of 0.01µF or more.

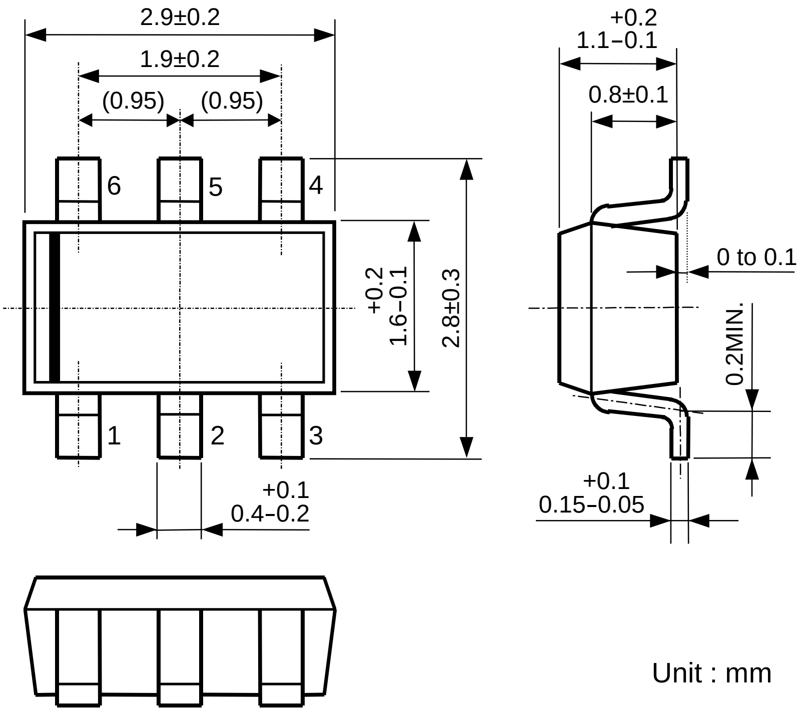
- R_{VDD} and R_{V-} limit a current when the battery pack is reverse-charged or when the charger having supply voltage exceeded the absolute maximum rating is connected. A total of R_{VDD} and R_{V-} should be 1kΩ or more. If R_{VDD} and R_{V-} become small value, the IC might exceed the power dissipation. Besides, R_{V-} should be 10kΩ or less. If R_{V-} becomes large value, a release by connecting with the charger might be impossible after overdischarging.

- Overvoltage and overcurrent exceeded the absolute maximum rating should not be forced to the protection IC and external components. If positive terminal and negative terminal of the battery pack short, even though the short-circuit protection is incorporated, during the delay time until detecting the short circuit, a large current may flow through an external MOSFET. Select an MOSFET with large enough current capacity in order to endure the large current during the delay time.

- The typical application circuit diagram is just examples. This circuit performance largely depends on the PCB layout and external components. In the actual application, fully evaluation is necessary.

PACKAGE DIMENSIONS SOT-23-6

Ver. A



Unit : mm

SOT-23-6 Package Dimensions

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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, fire containment 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. 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 Ricoh sales or our distributor before attempting to use AOI.
11. Please contact Ricoh sales representatives should you have any questions or comments concerning the products or the technical information.

RoHS Compliant
Halogen Free

Ricoh is committed to reducing the environmental loading materials in electrical devices with a view to contributing to the protection of human health and the environment.
Ricoh has been providing RoHS compliant products since April 1, 2006 and Halogen-free products since April 1, 2012.

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