# R5492N Series

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

NO.EA-421-190507

## 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

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# 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-FF | 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

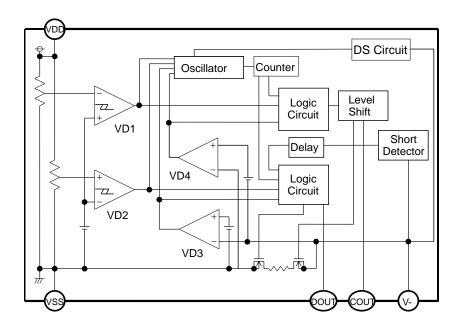| Code | Overcharge | Overdischarge |
|---|---|---|
| L | Voltage Release Type | |

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## 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 |
| R5492N350KL | 4.475 | 4.275 | 2.500 | 3.000 | 0.150 | -0.100 | 1 | 20 | 12 | 8 | 300 |
| R5492N351KL | 4.475 | 4.275 | 2.500 | 3.000 | 0.200 | -0.100 | 1 | 20 | 12 | 8 | 300 |
| R5492N352KL | 4.425 | 4.225 | 3.000 | 3.200 | 0.200 | -0.100 | 1 | 20 | 12 | 8 | 300 |

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# BLOCK DIAGRAM



**R5492N Block Diagram**

# PIN DESCRIPTION



**R5492N (SOT-23-6) Pin Configuration**

**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 |

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# 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 permanent damage 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 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 / $V_{DET1}$-0.025 | $V_{DET1}$ | $V_{DET1}$+0.020 / $V_{DET1}$+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 delay 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 delay 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 |

[1] Refer to *TEST CIRCUITS* for details.

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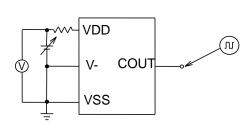The specifications surrounded by ☐ are guaranteed by Design Engineering at -5°C ≤ Ta ≤ 55°C.

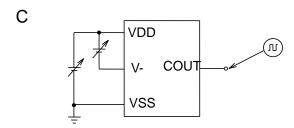**R5492NxxxKL Eectronical Characteristics (Continued)** (Ta = 25°C)

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit | Circuit (1) |
|---|---|---|---|---|---|---|---|
| $t_{VDET4}$ | Charge overcurrent detection delay time | $V_{DD}= 3.0V, V- = 0V \rightarrow -1V$ | 5 | 8 | 11 | ms | G |
| $t_{VREL4}$ | Charge overcurrent release delay time | $V_{DD}= 3.0V, V- = -1V \rightarrow 0V$ | 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 |
| $V_{OL1}$ | COUT Nch.ON voltage | $I_{OL} = 50\mu A$, $V_{DD} = 4.5$ V | | 0.4 | 0.5 | V | H |
| $V_{OH1}$ | COUT Pch.ON voltage | $I_{OH} = -50\mu A$, $V_{DD} = 3.9$ V | 3.4 | 3.7 | | V | I |
| $V_{OL2}$ | DOUT Nch.ON voltage | $I_{OL} = 50\mu A$, $V_{DD} = 2.0$ V | | 0.2 | 0.5 | V | J |
| $V_{OH2}$ | DOUT Pch.ON voltage | $I_{OH} = -50\mu A$, $V_{DD} = 3.9$ 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 |

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

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## Test Circuits

A



B



C



D



E


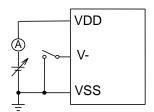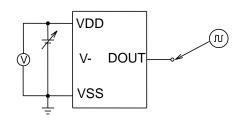
F



G



H



I



J

K



L



M

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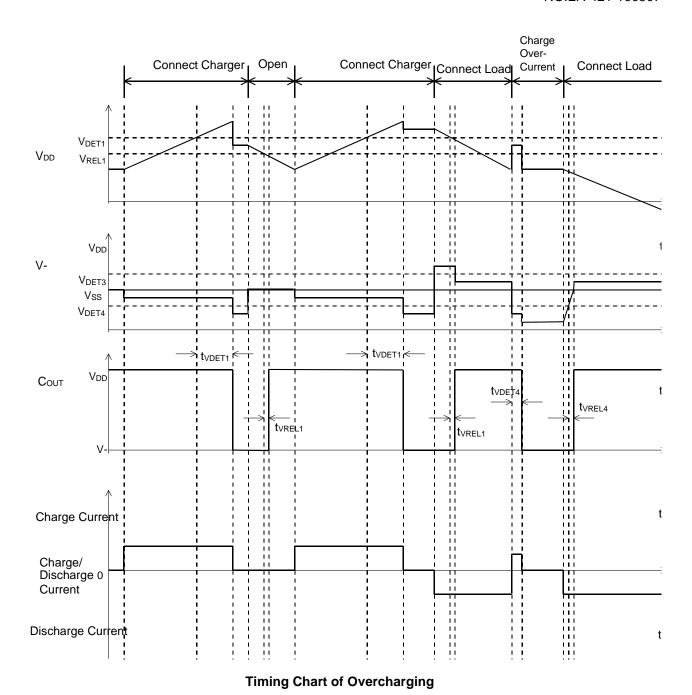
Output delay time for overcharge detect and released overcharge is internally fixed respectively. Although the $V_{DD}$ voltage goes up to a higher level than overcharge detector threshold within the output delay time, VD1 would not work for detecting overcharge. If the action for VD1 to release is done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

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### 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)**
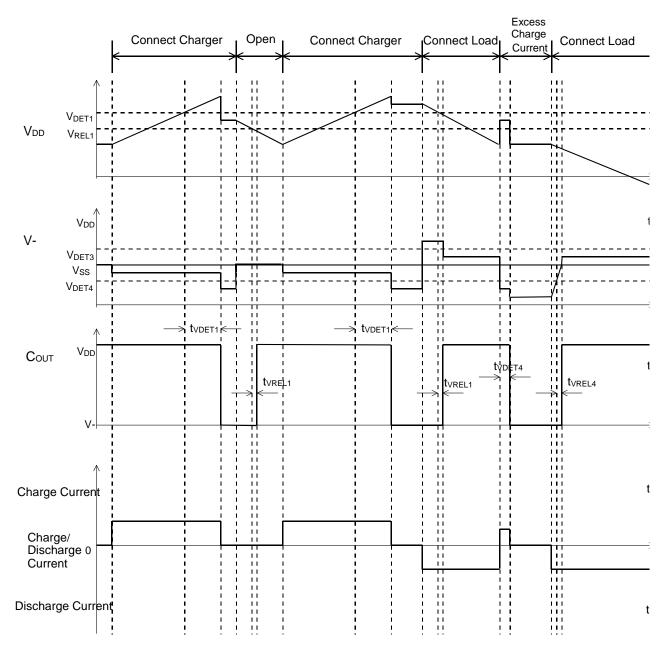
While charge and discharge are acceptable with the battery pack, VD3 monitors the voltage level of V- pin. In the cause of such as the external short circuit, if the voltage level of V- pin may become more than the discharge overcurrent detection voltage and less than the short detection voltage, the 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 Vss 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 Vss 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.
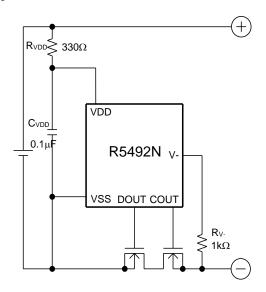
**Timing Chart of Overdischarging, Discharge Overcurrent, and Short-circuit**

### 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.

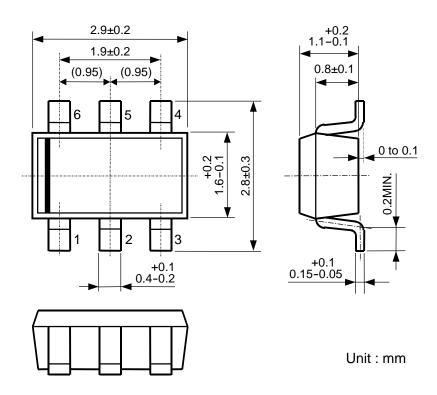# APPLICATION INFORMATION

## 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.

2.9±0.2

1.9±0.2

(0.95)  (0.95)

6  5  4

1  2  3

$1.6^{+0.2}_{-0.1}$

2.8±0.3

$0.4^{+0.1}_{-0.2}$

$1.1^{+0.2}_{-0.1}$

0.8±0.1

0 to 0.1

0.2MIN.

$0.15^{+0.1}_{-0.05}$

Unit : mm

**SOT-23-6 Package Dimensions**

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# NISSHINBO

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**Official website**
https://www.nisshinbo-microdevices.co.jp/en/

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